SIEMENS

Numerical Differential Protection Relay

for Transformers, Generators, Motors, and Branch Points

7UT51 V3.0

Instruction Manual Order No. C53000–G1176–C99–6

Figure 1 Illustration of the numerical differential protection relay 7UT513 (housing for surface mounting)

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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

Appendix

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 current differential protection 7UT51 is a fast and selective short-circuit protection for transformers of all voltage levels, for rotating machines, or for branch points with max. three feeders. The individual application can be configured, which ensures optimum matching to the protected object.

Two models are available:

The smaller model 7UT512 (1/3 housing) is suitable for generators, motors, two-winding transformers, and branch points with two feeders. This unit contains two re-assignable trip relays, four re-assignable alarm relays, two re-assignable binary inputs, and six re-assignable LED indicators.

The larger model 7UT513 (1/2 housing) is used for three-winding transformers and branch points with three feeders. This unit contains five re-assignable trip relays, 10 re-assignable alarm relays, five re-assignable binary inputs, and 14 re-assignable LED indicators. It can also be used for generators and motors if the larger number of input and/or output functions is desired. In this case, the remaining measured current inputs can be used to protect any desired further protected object, the so-called "virtual object".

7UT51 is suitable also for single-phase systems with $16^2/_3$ Hz rated frequency. The particular conditions for this application are given in the chapters about installation and connections.

7UT513 can optionally be ordered with restricted earth fault protection for transformers, reactors, or rotating machines with earthed star point. Instead, a tank leakage protection for transformers and reactors with isolated tank can be ordered. Some restrictions are to be observed concerning the use of various functions at the same time (refer to Section 5.4.1 for more details).

Both models contain an overcurrent time protection which can be use for back-up protection and assigned to any of the windings or terminals of the protected object. Two thermal replica for monitoring the current-initiated heat losses are available and can be assigned to any of the windings or terminals of the protected object.

External signals, e.g. from a Buchholz protection, can be included in the processing of annunciations of the device. Two additional trip commands from external sources can be processed in order to be annunciated, delayed, or allocated to the integrated tripping matrix.

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

Continuous 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. The device can therefore be incorporated in Localized Substation Automation networks (LSA).

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 decision 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 input transducers, binary input and output modules and DC converter;
- insensitive against current transformer errors, transient phenomena and interferences;
- comprehensive supplementary functions can be ordered as options;
- continuous calculation of operational measured values and indication on the front display;
- simple setting and operation using the integrated operation panel or a connected personal computer with menu-guided software;
- storage of fault data, storage of instantaneous values during a fault for fault recording;
- communication with central control and storage devices via serial interfaces is possible, optionally with 2 kV insulation or for connection of fibre optic wire;
- continuous monitoring of the hardware and software of the relay.

1.3 Implemented functions

7UT51 contains the following functions:

For use as **transformer differential protection**

- current-stabilized trip characteristic,
- stabilization against inrush currents with 2nd harmonic,
- stabilization against steady-state and transient error currents, e.g. caused by overexcitation, with a selectable harmonic (3rd, 4th, or 5th harmonic),
- insensitive to d.c. components and current transformer saturation,
- high stability even with different levels of current transformer saturation,
- high-speed tripping for high-current transformer faults,
- independent of the method of earthing of the transformer neutrals,
- increased sensitivity for earth faults possible by zero sequence current correction (7UT513 only),
- integrated matching of transformer vector group,
- integrated matching of c.t. transformation ratios with consideration of different c.t. rated currents.

For use as **generator or motor differential protection**

- current-stabilized trip characteristic,
- high sensitivity,
- short trip time,
- insensitive to d.c. components and current transformer saturation,
- high stability even with different levels of current transformer saturation,
- independent of the method of earthing of the machine neutral.

For use as **branch point differential protection**

- current-stabilized trip characteristic,
- short trip time,
- insensitive to d.c. components and current transformer saturation,
- high stability even with different levels of current transformer saturation,
- c.t. secondary current monitor with operational currents.

Restricted earth fault protection (optional with 7UT513)

- for transformer windings, generators, motors, or shunt reactors, the star point of which is solidly grounded,
- high sensitivity to earth faults within the protected zone,
- high stability during external earth fault using a stabilization method which evaluates the current magnitudes as well as the current phase situation of the through flowing current.

Overcurrent time protection

- can be used as back-up protection for any selected winding or feeder, with 7UT513 even for the ”virtual object”,
- can operate as definite time or inverse time overcurrent protection with selectable characteristic;
- with independent high-set overcurrent stage;

Thermal overload protection

- two logically independent thermal overload functions can be assigned to any two desired windings or feeders of the protected object, with 7UT513 even to the ”virtual object”,
- thermal replica of current-initiated heat losses,
- r.m.s. value measurement,
- adjustable thermal warning stage,
- adjustable overcurrent warning stage.

Tank leakage protection (optional with 7UT513)

- for transformers the tank of which is installed isolated or high-resistive against ground,
- monitors the current flowing between the tank and earth, optionally by evaluation of the fundamental wave or the r.m.s. value,
- can be connected either to a ”normal” measured current input of the device or to a special highly sensitive measured current input (10 mA smallest setting).

Coupling of external binary signals

- for processing or re-transmitting of external signals or commands, e.g. ”Buchholz – protection alarm”,
- connection to signal relays, LEDs, and via serial interface to localized substation control and monitoring facility (e.g. LSA).

Coupling of external trip signals

- combining of external signals into the alarm processing,
- tripping by external signals via the integrated trip matrix, with or without delays.

Integrated trip matrix

- with 2 (7UT512) or 5 (7UT513) trip relays for any protection trip commands.

Note: Due to the possible hardware arrangement and the capability of the processor system, it is not possible to combine all functions at will. Refer also to Section 2.3 for ordering options and Section 5.2.5 for connection possibilities, as well as Section 5.4 for configuration facilities of the protection functions.

2 Design

2.1 Arrangements

Depending on the application, two basic models are available:

For two-winding transformers, generators, motors, and two-end branch points 7UT512,
For three-winding transformers (applicable also for generators and motors), and three-end branch points .... 7UT513.

In the 7UT512, all protection functions including dc/dc converter are accommodated on one basic plug-in module of Double Europa Format. In the 7UT513, an additional plug-in module is added to the basic module. In the following the data applying to the 7UT513 are given in ( ) should they deviate from the 7UT512 model.

The modules are installed in a housing 7XP20. Two different types of housings can be delivered:

– **7UT51★★–★D★★★–** in housing 7XP2030–1 (7XP2040–1) for **panel surface mounting.**

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

  Plastic guide rails are built in for the support of plug-in modules. Next to the guide rail at the bottom on the left-hand side of each module, a contact area which is electrically connected to the housing is installed to mate with the earthing spring of the module. Connection to earth is made before the plugs make contact. Earthing screws have been provided on the left hand side of the housing. Additionally, terminal 16 (26) is connected to the case.

  All external signals are connected to 60 (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 a module is 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 isolated interface to a central control and storage unit, an additional coupling facility has been provided. For the hard-wired V.24 (RS 232 C) serial interface (7UT51★★–★★★★★–★**B**), four screwed terminals are provided. For the interface for optical fibre connection (7UT51★★–★★★★★–★**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 (2.4).

– **7UT51★★–★C★★★–** in housing 7XP2030–2 (7XP2040–2) for **panel flush mounting** or **7UT51★★–★E★★★–** for **cubicle installation**.

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

  Plastic guide rails are built in for the support of plug-in modules. Next to the guide rail at the bottom on the left-hand side, a contact area which is electrically connected to the housing is installed to mate with the earthing spring of the module. Connection to earth is made before the plugs make contact. An earthing screw has 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 a module is 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 isolated interface to a central control and storage unit (7UT51★★–★★★★★–★**B**) is led to a 4-pole connection module. In the interface for optical fibre connection (7UT51★★–★★★★★–★**C**), a module with 2 F–SMA connectors is provided instead.

The plug modules are labelled according to their mounting position by means of a grid system (e.g. **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 (for cubicle installation IP 30), for the terminals IP21. For dimensions please refer to Figure 2.3 (2.5).

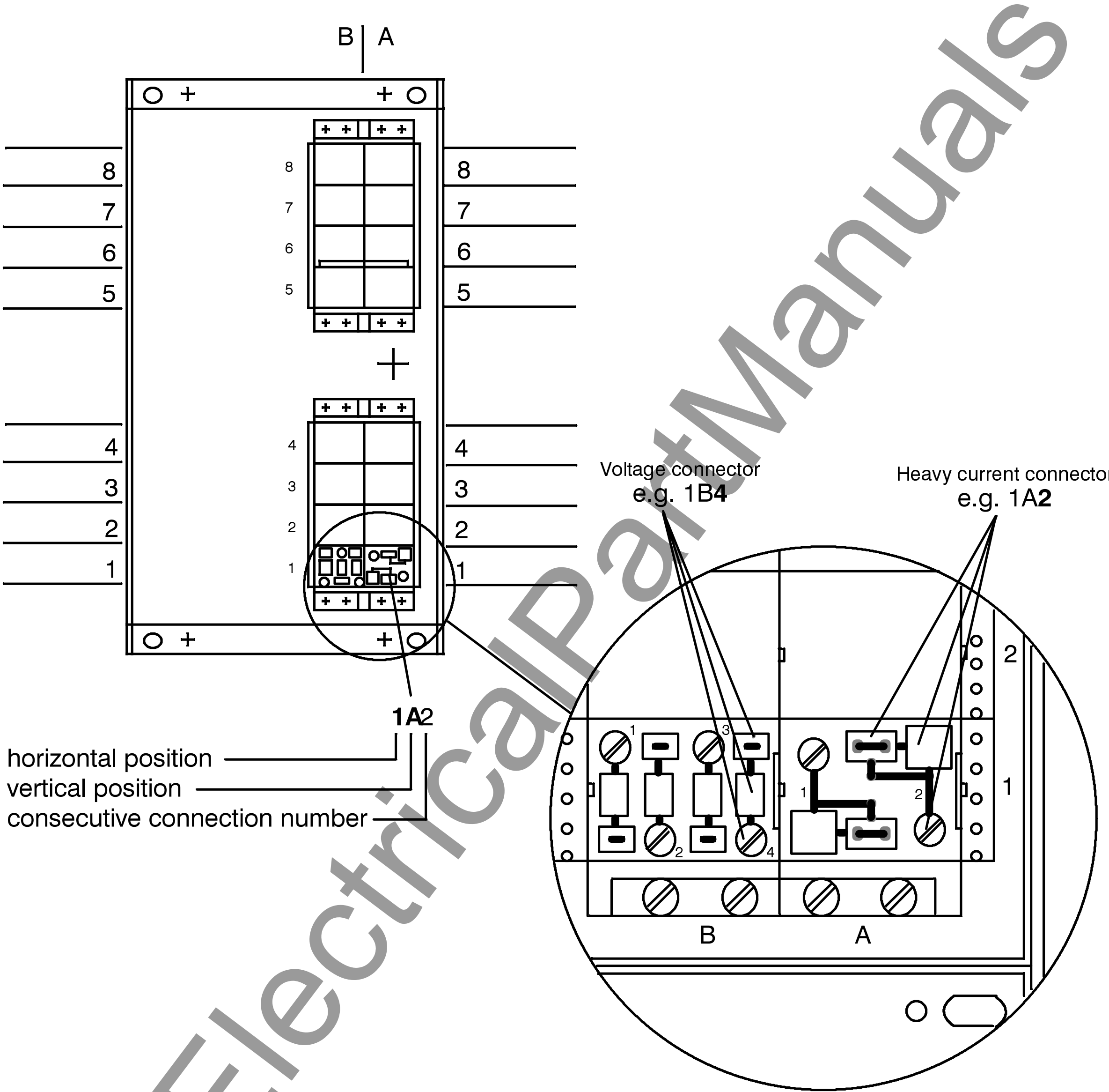
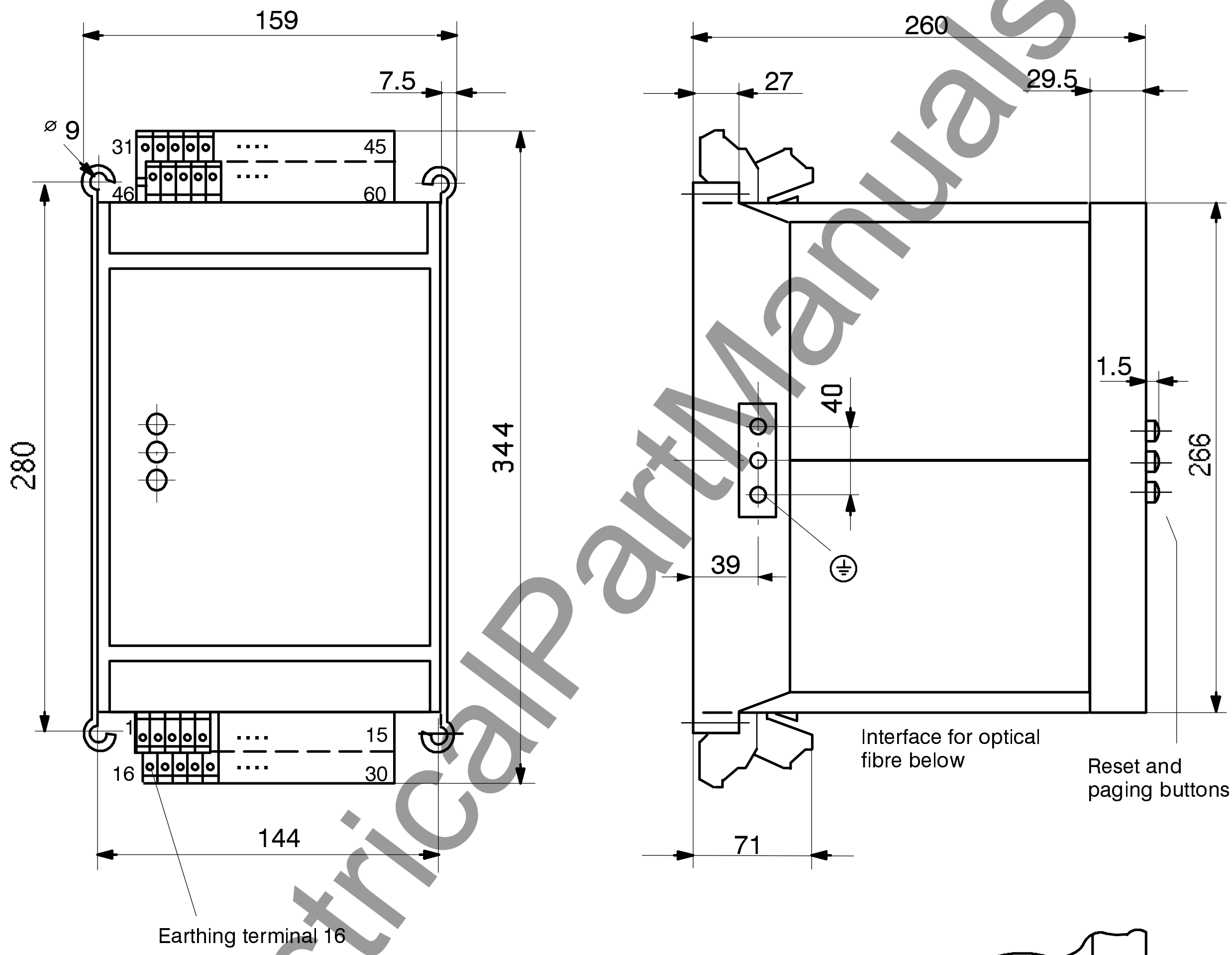


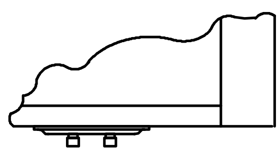
Figure 2.1 Connection plugs (rear view) – housing for flush mounting – example

2.2 Dimensions

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

7UT512 housing for **panel surface mounting** 7XP2030−1





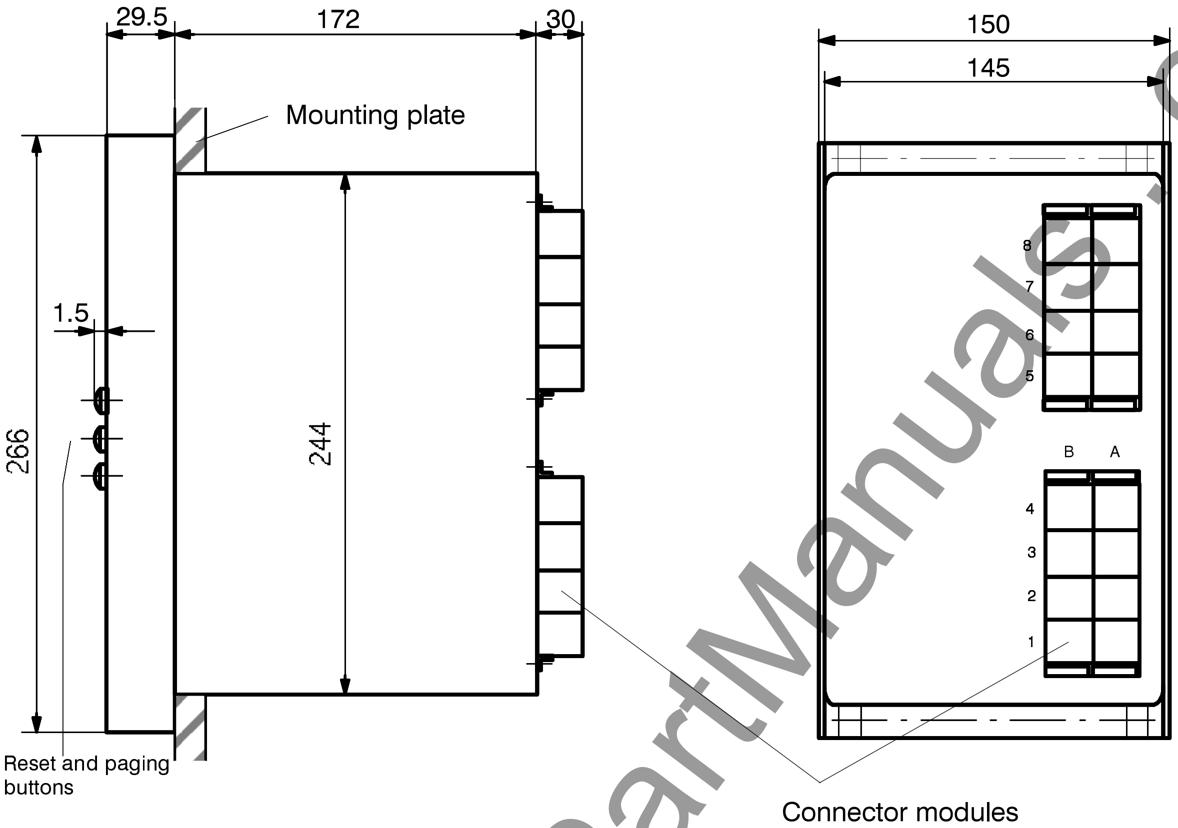
Max. 60 terminals for cross-section max. 5 mm^2 or AWG 10
Max torque value 1.7 Nm or 15 in-lb

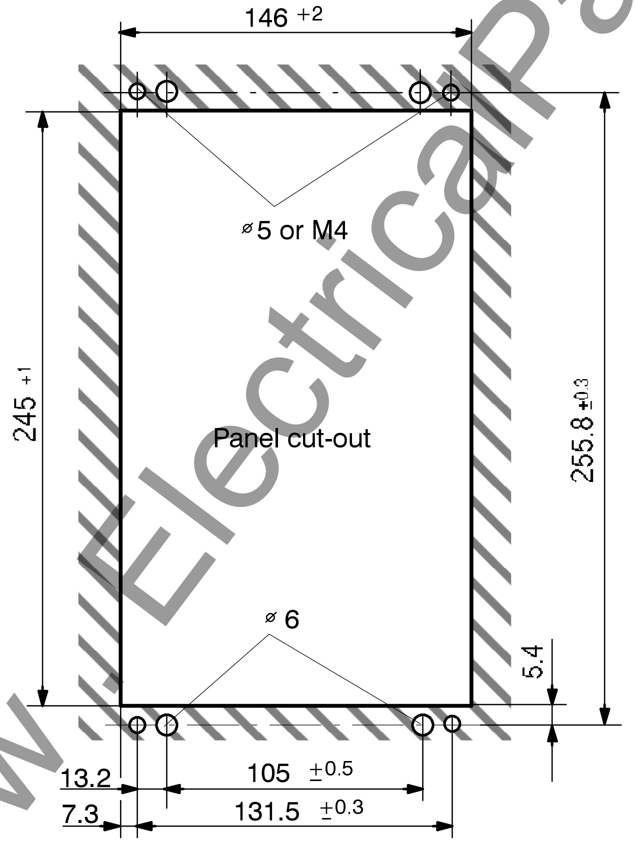
Optical fibre connectors:
integrated F−SMA connector,
with ceramic post,
e.g for glass fibre 62.5/125 μm

Dimensions in mm

Figure 2.2 Dimensions for housing 7XP2030−1 for panel surface mounting

7UT512 housing for **panel flush mounting** or **cubicle installation** 7XP2030−2





Heavy current connectors:
Screwed terminal for max. 4 mm².
Twin spring crimp connector in parallel for max. 2.5 mm² (AWG 13).

Max torque value 1.2 Nm (10.6 in-lb).

Further connectors:
Screwed terminal for max. 1.5 mm².
Twin spring crimp connector in parallel for max. 1.5 mm² (AWG 15).

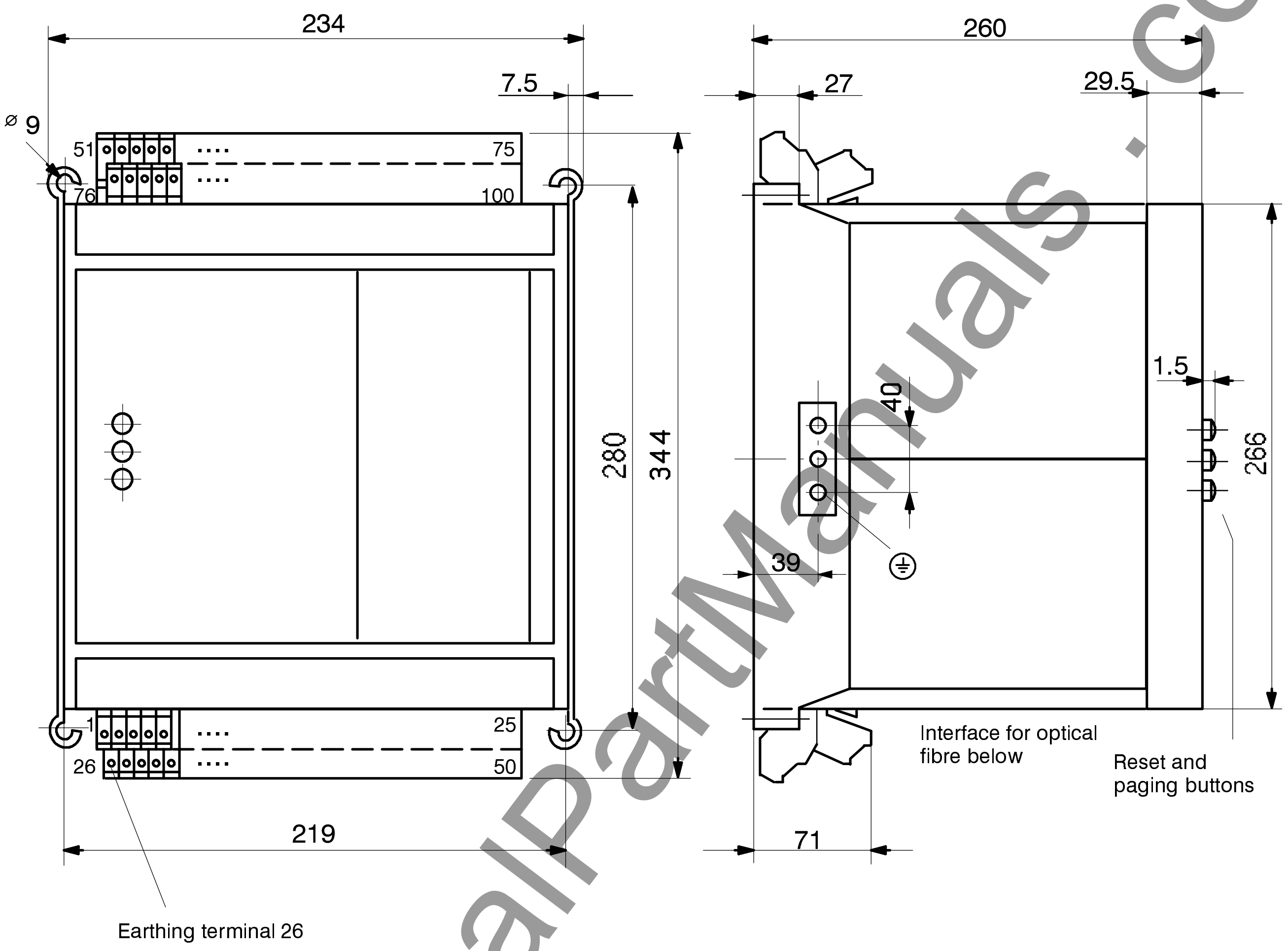
Max torque value 0.8 Nm (7 in-lb).

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

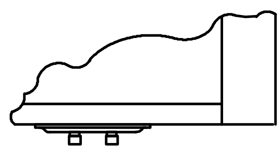
Dimensions in mm

Figure 2.3 Dimensions for housing 7XP2030−2 for panel flush mounting or cubicle installation

7UT513 Housing for **panel surface mounting** 7XP2040 – 1



Max. 100 terminals for cross-section max. 5 mm^2 or AWG 10
Max torque value 1.7 Nm or 15 in-lb

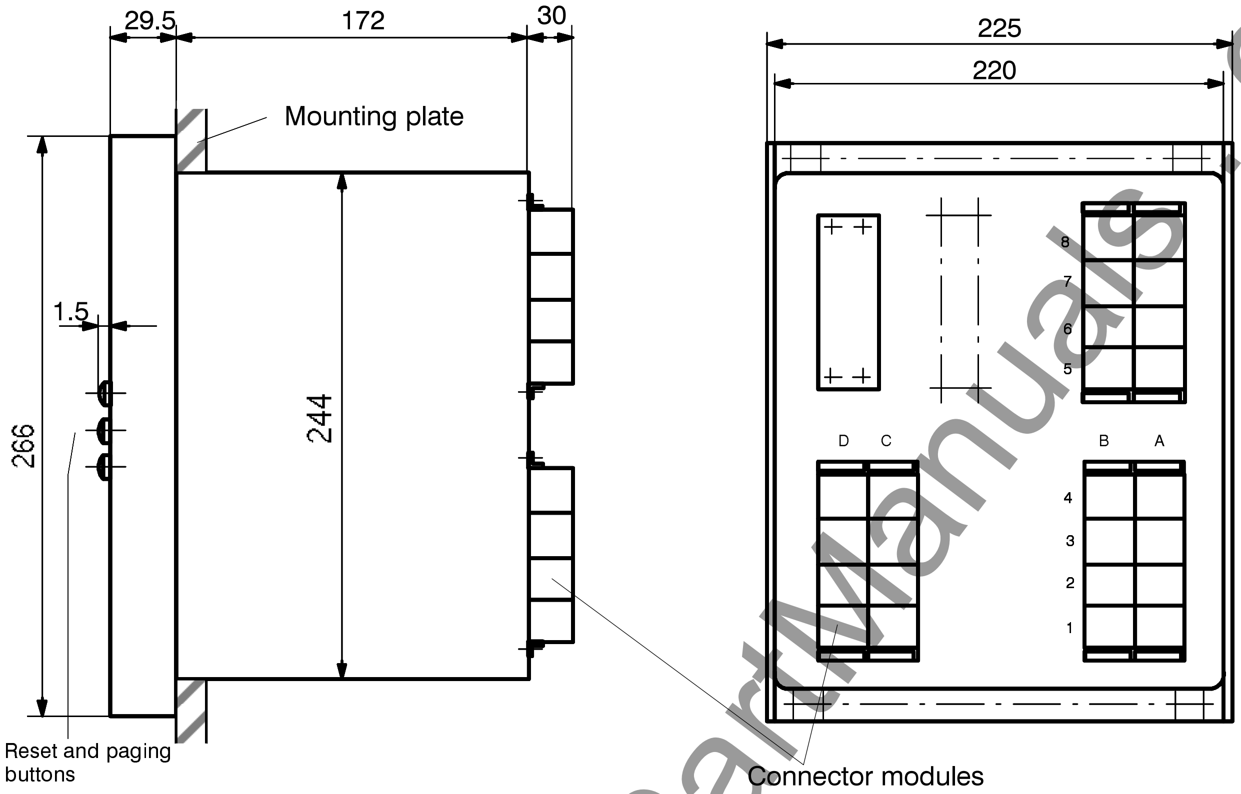


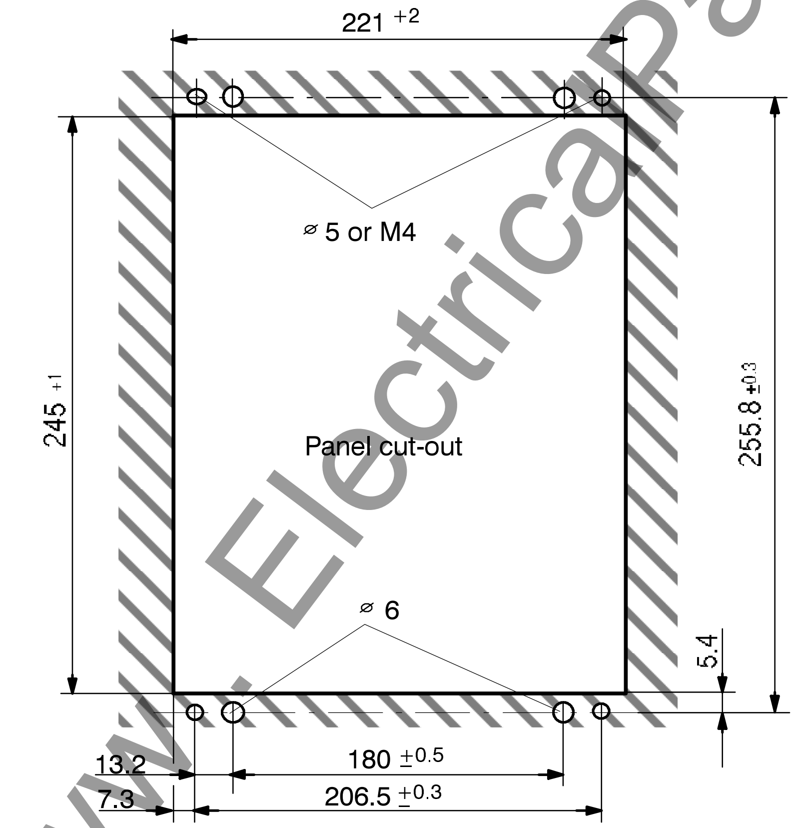
Optical fibre connectors:
integrated F – SMA connector,
with ceramic post,
e.g for glass fibre 62.5/125 µm

Dimensions in mm

Figure 2.4 Dimensions for housing 7XP2040 – 1 for panel surface mounting

7UT513 housing for **panel flush mounting** or **cubicle installation** 7XP2040−2





Heavy current connectors:

Screwed terminal for max. 4 mm^2.
Twin spring crimp connector in parallel for max. 2.5 mm^2 (AWG 13).

Max torque value 1.2 Nm (10.6 in-lb).

Further connectors:

Screwed terminal for max. 1.5 mm^2.
Twin spring crimp connector in parallel for max. 1.5 mm^2 (AWG 15).

Max torque value 0.8 Nm (7 in-lb).

Optical fibre connectors:

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

Dimensions in mm

Figure 2.5 Dimensions for housing 7XP2040−2 for panel flush mounting or cubicle installation

2.3 Ordering data

		6.	7.		8.	9.	10.	11.	12.		13.	14.	15.	16.
Differential protection	**7 U T 5 1**			–			**B**	**0**	**1**	–			**A**	**0**

for two-winding transformers, generators, motors, and branch points with two feeders 2

for three-winding transformers, branch points with three feeders, applicable also for generators, motors, two-winding transformers and two-end branch points 3

Rated current/rated frequency

1 A; 50/60 Hz, $16^2/_3$ Hz 1

5 A; 50/60 Hz, $16^2/_3$ Hz 5

Auxiliary voltage

24/48 Vdc 2

60/110/125 Vdc 4

220/250 Vdc 5

Construction

in housing 7XP20 for panel surface mounting .... D

in housing 7XP20 for panel flush mounting C

in housing 7XP20 for cubicle installation (without glass front) .... E

Additional functions

without (standard order option with 7UT512) 0

with restricted earth fault protection (standard order option with 7UT513) 1

with tank leakage protection (7UT513 with highly sensitive current input) 2

Serial interface for data transfer to a central evaluation unit

without serial interface .... A

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

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 or 16$^2/_3$ Hz (selectable)
Power consumption current path at I_N=1A	approx. 0.05 VA per phase
current path at I_N=5A	approx. 0.2 VA per phase
– for highly sensitive tank current detection at 1 A	approx. 0.05 VA
Overload capability current path	
– thermal (r.m.s.)	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
Overload capability for highly sensitive tank current detection	
– thermal (rms)	300 A for $\leq$1 s
	100 A for $\leq$10 s
	15 A continuous

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	7UT512	7UT513
quiescent	approx. 10 W	approx. 13 W
energized	approx. 14 W	approx. 22 W

Bridging time during failure/short-circuit of auxiliary voltage: $\geq$ 50 ms at $U_{rated} \geq$ 110 Vdc

Heavy duty (command) contacts

	7UT512	7UT513
Command (trip) relays, number	2	5

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

	7UT512	7UT513
Signal relays, number	5 (4 re-assignable)	11 (10 re-assignable)

Contact per relays	1 CO or 1 NO
Switching capacity MAKE/BREAK	20 W/VA
Switching voltage	250 V
Permissible current	1 A

Binary inputs

	7UT512	7UT513
Number	2	5

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

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

Current consumption — approx 1.7 mA independent on operating voltage

Serial interfaces

Operator terminal interface	non-isolated
– Connection	at the front, 25-pole subminiature connector according ISO 2110 for connection of a personal computer
– Transmission speed	as delivered 9600 Baud min. 1200 Baud, max. 19200 Baud
Floating interface for data transfer to a control centre (optional)	isolated
– Standards	similar V.24/V.28 to CCITT; RS 232 C to EIA; Protocol to VDEW/ZVEI and IEC 60870–5–103, or acc. DIN 19244
– Transmission speed	as delivered 9600 Baud min. 1200 Baud, max. 19200 Baud
– Transmission security	Hamming distance d = 4
– Connection directly	at the housing terminals; 2 core pairs, with individual and common screening e.g. LI YCY–CY/2 x 2 x 0.25 mm^2
Transmission distance	max. 1000 m
Test voltage	2 kV; 50 Hz
– 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 61000−4−2 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 61000−4−3, class III	10 V/m; 80 MHz to 1000 MHz; 80 % AM; 1 kHz
– Radio-frequency electromagnetic field, pulse modulated; IEC 61000−4−3/ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 %
– Fast transients IEC 60255−22−4 and IEC 61000−4−4, class III	2 kV; 5/50 ns; 5 kHz; burst length 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; duration 1 min
– Conducted disturbances induced by radio-frequency fields, amplitude modulated IEC 61000−4−6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
– Power frequency magnetic field IEC 61000−4−8, class IV IEC 60255−6	30 A/m continuous; 300 A/m for 3 s; 50 Hz 0.5 mT; 50 Hz

EMC tests; emission (type tests)

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

3.1.3 Mechanical stress tests

Vibration and shock during operation

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

Vibration and shock during transport

Standards:	IEC 60255−21 and IEC 60068−2
− Vibration IEC 60255−21−1, class 2 IEC 60068−2−6	sinusoidal 5 Hz to 8 Hz: ± 7.5 mm amplitude; 8 Hz to 150 Hz: 2 g acceleration sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
− Shock IEC 60255−21−2, class 1 IEC 60068−2−27	half sine acceleration 15 g, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
− Continuous shock IEC 60255−21−2, class 1 IEC 60068−2−29	half sine acceleration 10 g, duration 16 ms, 1000 shocks each direction of 3 orthogonal axes

3.1.4 Climatic stress tests

− recommended temperature during service	−5 °C	to +55 °C	(> 55 °C decreased display contrast)
− permissible temperature during service	−20 °C	to +70 °C	
permissible temperature during storage	−25 °C	to +55 °C	
permissible temperature during transport	−25 °C	to +70 °C	

Storage and transport with standard works packaging!

– Permissible humidity — mean value per year ≤ 75 % relative humidity; on 30 days per year 95 % relative humidity; Condensation not permissible!

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

3.1.5 Service conditions

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

– All contactors and relays which operate in the same cubicle or on the same relay panel as the digital protection equipment should, as a rule, be fitted with suitable spike quenching elements.

– All external connection leads in sub-stations from 100 kV upwards should be screened with a screen capable of carrying power currents and earthed at both sides. No special measures are normally necessary for sub-stations of lower voltages.

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

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

3.1.6 Design

Housing — 7XP20; refer to Section 2.1

Dimensions — refer to Section 2.2

Weight	7UT512	7UT513
– in housing for surface mounting	approx. 8.3 kg	approx. 10.0 kg
– in housing for flush mounting	approx. 6.8 kg	approx. 8.6 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 Differential protection for transformers

Setting range/steps

Differential current threshold	$I_{DIFF}>/I_{N\ transf}$	0.15 to 2.00	(steps 0.01)
High-current stage	$I_{DIFF}>>/I_{N\ transf}$	0.5 to 20.0	(steps 0.1)
Pick-up characteristics		refer to Figure 3.1	
Inrush stabilization ratio (2nd harmonic)	$\frac{I_{2fN}}{I_{fN}}$	10 % to 80 % (steps 1%) refer Figure 3.2	
Harmonic stabilization ratio (n = 3rd or 4th or 5th harmonic)	$\frac{I_{nfN}}{I_{fN}}$	10 % to 80 % (steps 1%) refer Figure 3.3	
Additional trip time delay		0.00 s to 60.00 s (steps 0.01 s); ∞	
Drop-off time delay		0.00 s to 60.00 s (steps 0.01 s)	

Times (without parallel operation of other protection functions)

	50 Hz	60 Hz	$16^2/_3$ Hz
Pick-up time with single-ended infeed			
– with $\geq$1.5 x setting value $I_{DIFF}>$, approx.	35 ms	35 ms	85 ms
– with $\geq$1.5 x setting value $I_{DIFF}\gg$, approx.	25 ms	25 ms	55 ms
– with $\geq$5 x setting value $I_{DIFF}\gg$, approx.	18 ms	17 ms	25 ms
Drop-off time, approx.	36 ms	30 ms	80 ms

Drop-off ratio approx. 0.7

Tolerances with preset transformer parameters

- Pick-up characteristic: $\pm$5 % of theoretical value (for $I < 5 \cdot I_N$)
- Inrush stabilization: $\pm$5 % of setting value ($I_{2f}/I_{fN} \geq 15$ %)
- Additional time delays: $\pm$1 % of setting value or 10 ms

Influence variables

- Auxiliary voltage in range $0.8 \leq U_H/U_{HN} \leq 1.15$: $\leq$ 1%
- Temperature in range $0\ ^\circ C \leq \ _{amb} \leq 40\ ^\circ C$: $\leq$ 0.5 %/10 K
- Frequency in range $0.95 \leq f/f_N \leq 1.05$: $\leq$ 1 % refer also to Figure 3.4

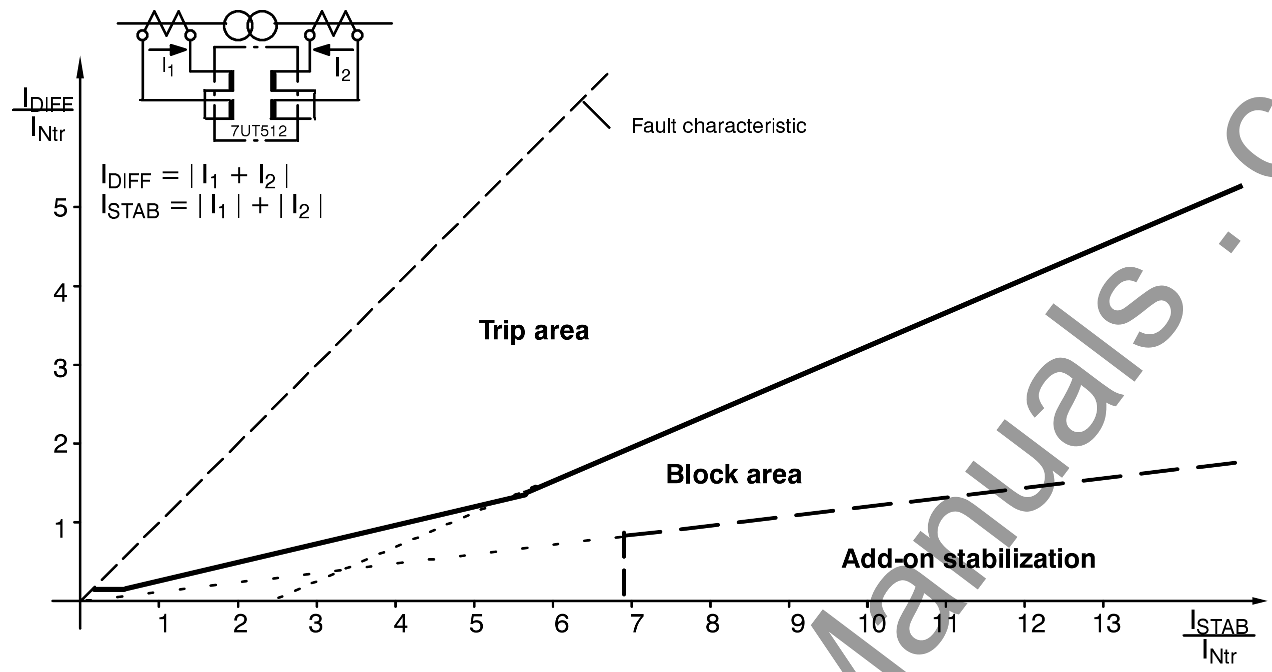


Figure 3.1 Pick-up characteristics with preset transformer parameters and two-phase fault

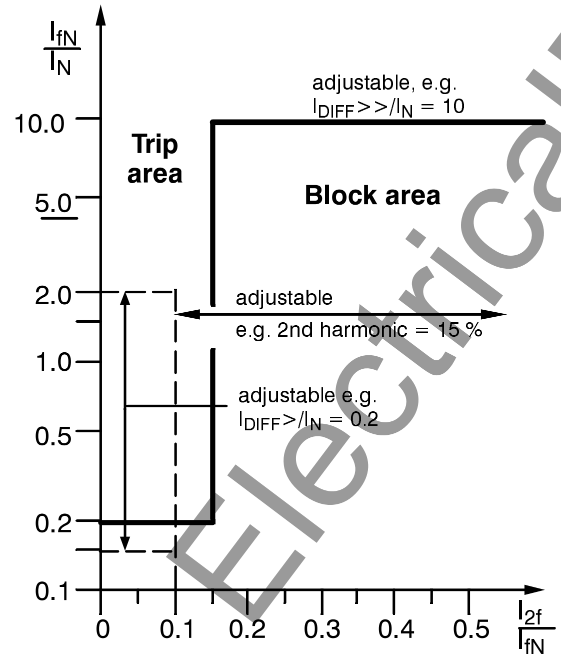


Figure 3.2 Stabilizing influence of 2nd harmonic (transformer protection)

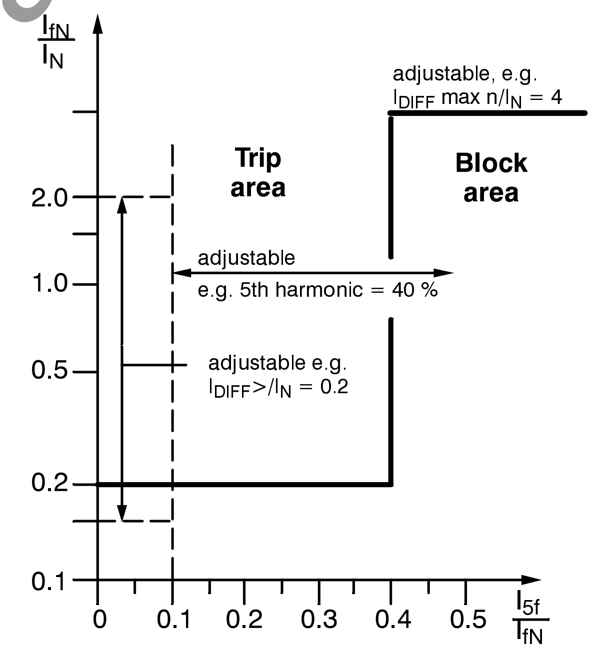


Figure 3.3 Stabilizing influence of higher harmonic, e.g. 5th

Legend:

I_{DIFF}	differential current = $\lvert I_1 + I_2 \rvert$	I_{fN}	current with rated frequency
I_{2f}	current with 2nd harmonic	I_{5f}	current with 5th harmonic

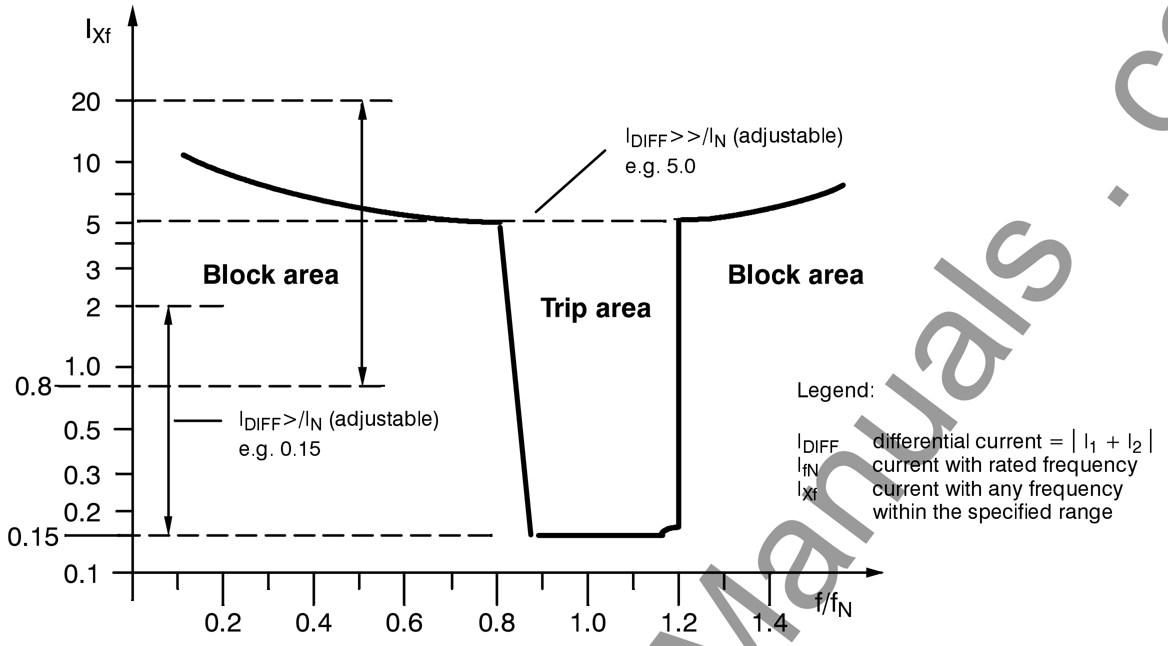


Figure 3.4 Frequency dependency (transformer protection)

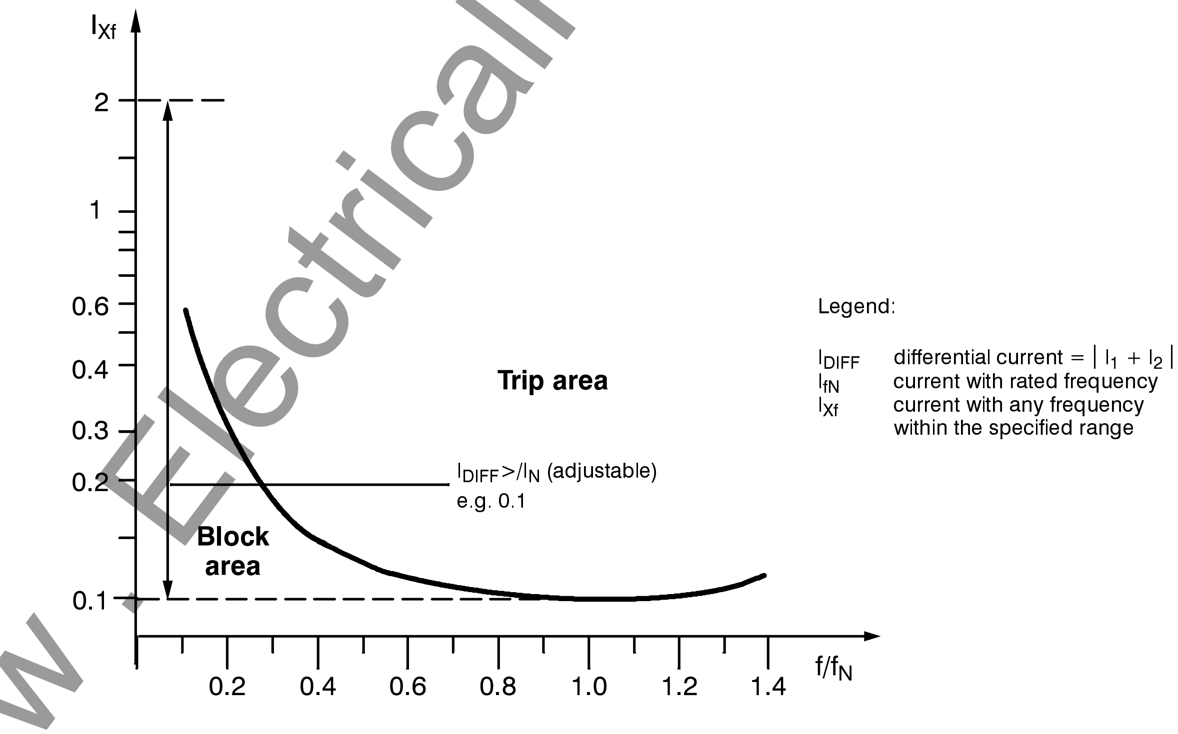


Figure 3.5 Frequency dependency (generator or motor protection)

3.3 Differential protection for generators and motors

Setting range/steps

Differential current threshold	$I_{DIFF}>/I_{N\,gen}$	0.05 to 2.00 (steps 0.01)
Pick-up characteristics		refer to Figure 3.6
Additional trip time delay		0.00 s to 60.00 s (steps 0.01 s); ∞
Drop-off time delay		0.00 s to 60.00 s (steps 0.01 s)

Times (without parallel operation of other protection functions)

	50 Hz	60 Hz	$16^2/_3$ Hz
Pick-up time with single-ended infeed			
– with 1.5 x setting value $I_{DIFF}>$, approx.	38 ms	35 ms	85 ms
– with 5 x setting value $I_{DIFF}>$, approx.	35 ms	32 ms	45 ms
Drop-off time, approx.	44 ms	38 ms	105 ms

Drop-off ratio, approx. 0.7

Tolerances

– Pick-up characteristic	$\pm$5 % of theoretical value (for $I < 5 \cdot I_N$)
– Additional time delays	$\pm$1 % of setting value or 10 ms

Influence variables

– Auxiliary voltage in range $0.8 \leq U_H/U_{HN} \leq 1.15$	$\leq$ 1%
– Temperature in range $0\,^\circ C \leq \ _{amb} \leq 40\,^\circ C$	$\leq$ 0.5 %/10 K
– Frequency in range $0.8 \leq f/f_N \leq 1.2$	$\leq$ 1 % (refer to Figure 3.5)

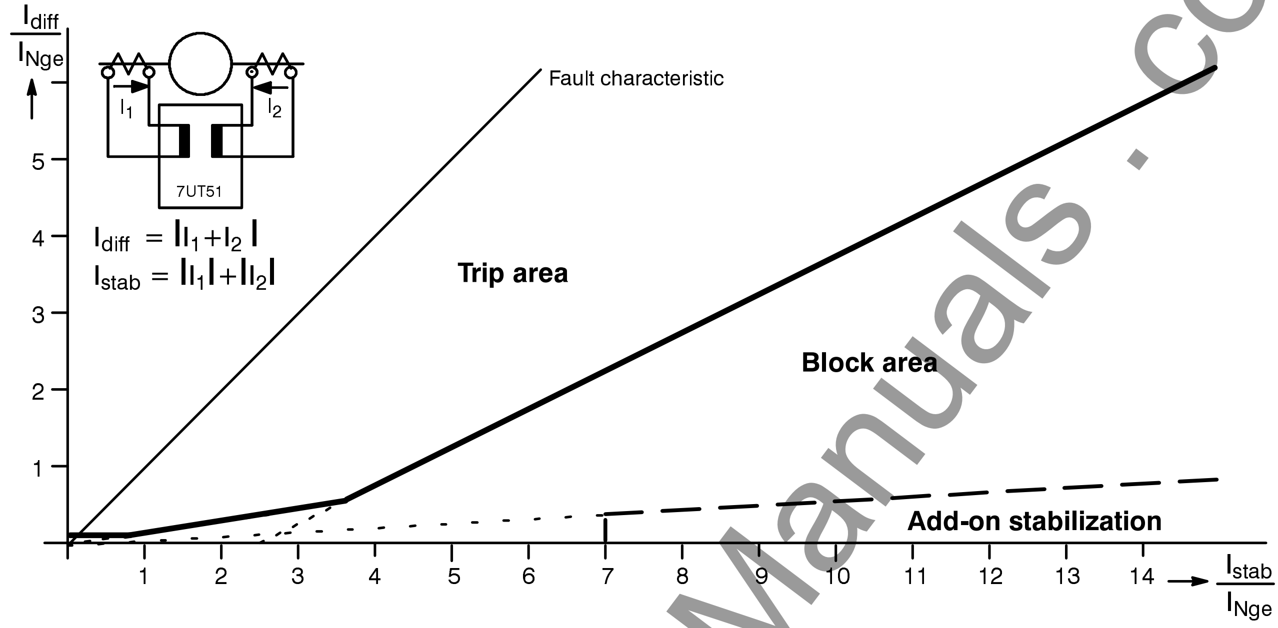


Figure 3.6 Pick-up characteristics for use as generator or motor protection

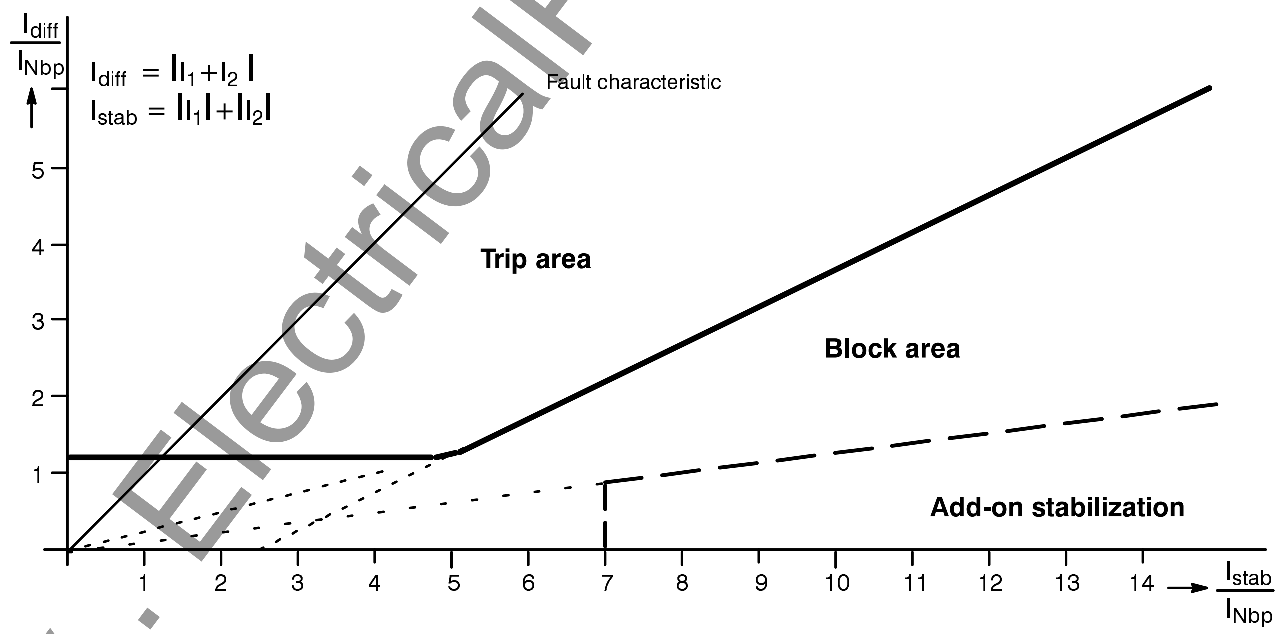


Figure 3.7 Pick-up characteristics for use as branch point protection

3.4 Differential protection for branch-points

Setting range/steps

Differential current threshold	$I_{DIFF}>/I_{N\ bp}$	0.30 to 2.50	(steps 0.01)
Monitoring stage	$I_{DIFF}>/I_{N\ bp}$	0.15 to 0.80	(steps 0.01)
Pick-up characteristics		refer to Figure 3.7	
Additional trip time delay		0.00 s to 60.00 s	(steps 0.01 s); ∞
Drop-off time delay		0.00 s to 60.00 s	(steps 0.01 s)

Times (without parallel operation of other protection functions)

	50 Hz	60 Hz	$16^2/_3$ Hz
Pick-up time with single-ended infeed			
– with 1.5 x setting value $I_{DIFF}>$, approx.	25 ms	25 ms	70 ms
– with 5 x setting value $I_{DIFF}>$, approx.	17 ms	16 ms	25 ms
Drop-off time, approx.	35 ms	30 ms	80 ms

Drop-off ratio, approx. 0.7

Tolerances

- Pick-up characteristic: ±5 % of theoretical value (for $I < 5 \cdot I_N$)
- Additional time delays: ±1 % of setting value or 10 ms

Influence variables

- Auxiliary voltage in range $0.8 \leq U_H/U_{HN} \leq 1.15$: ≤ 1%
- Temperature in range $0\ °C \leq {}_{amb} \leq 40\ °C$: ≤ 0.5 %/10 K
- Frequency in range $0.8 \leq f/f_N \leq 1.2$: ≤ 1 %

3.5 Restricted earth fault protection (optional with 7UT513)

Setting range/steps

Differential current threshold	$I_{REF}>/I_N$	0.05 to 2.00	(steps 0.01)
Limit angle	$ö_{LIMIT}$	90° to 130°	(steps 10°)
Pick-up characteristics		refer to Figures 3.8 and 3.9	
Inrush stabilization ratio		10 % to 80 %	(steps 1 %)
Additional trip time delay		0.00 s to 60.00 s (steps 0.01 s); ∞	
Drop-off time delay		0.00 s to 60.00 s (steps 0.01 s)	

Times (without parallel operation of other protection functions)

	50 Hz	60 Hz	$16^2/_3$ Hz
Pick-up time			
– with 1.5 x setting value $I_{REF}>$, approx.	25 ms	25 ms	75 ms
– with 5 x setting value $I_{REF}>$, approx.	17 ms	17 ms	25 ms
Drop-off time, approx.	30 ms	25 ms	90 ms

Drop-off ratio approx. 0.7

Tolerances

– Pick-up characteristic $\pm$5 % of theoretical value (for $I < 5 \cdot I_N$)

– Additional time delays $\pm$1 % of setting value or 10 ms

Influence variables

– Auxiliary voltage in range $0.8 \leq U_H/U_{HN} \leq 1.15$ — $\leq$ 1%

– Temperature in range $0\ °C \leq \ _{amb} \leq 40\ °C$ — $\leq$ 0.5 %/10 K

– Frequency in range $0.8 \leq f/f_N \leq 1.2$ — $\leq$ 1 %

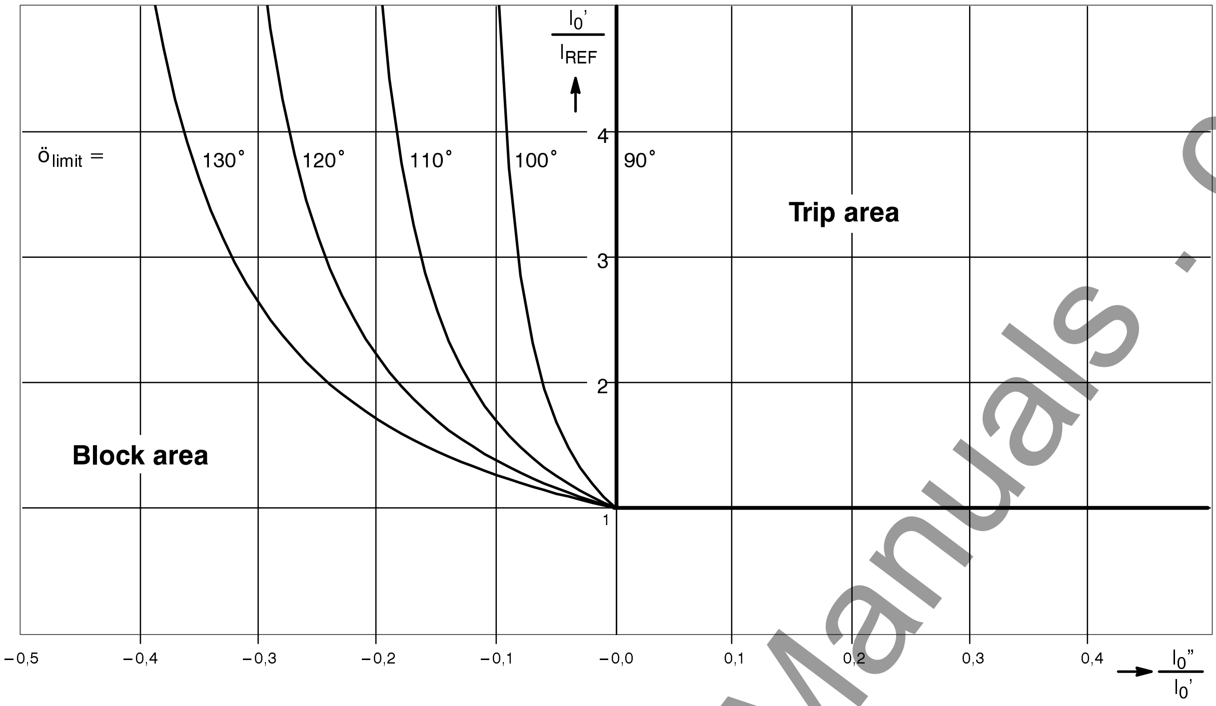


Figure 3.8 Pick-up characteristics dependent on zero sequence current ratio I_0''/I_0' (both currents in phase or counter-phase

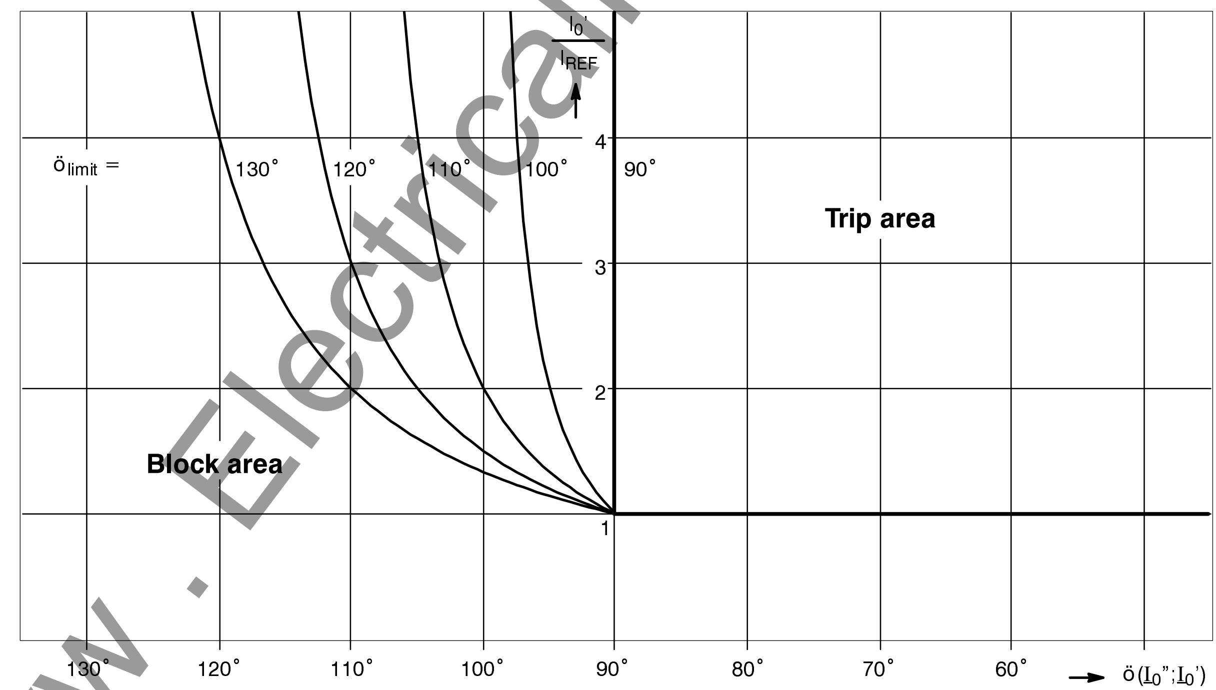


Figure 3.9 Pick-up characteristics dependent on the phase deviation between I_0'' and I_0' with $I_0'' = I_0'$ (180° corresponds to external fault)

3.6 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 to Figure 3.10

Pick-up/Times

high-current stage	$I>>/I_N$	0.10 to 30.00	(steps 0.01)
delay time $T_{I>>}$		0.00 s to 32.00 s or ∞ (stage ineffective)	(steps 0.01 s);
overcurrent stage for **definite** time	$I>/I_N$	0.10 to 30.00	(steps 0.01)
delay time $T_{I>}$		0.00 s to 32.00 s or ∞ (stage ineffective)	(steps 0.01 s);
overcurrent stage for **inverse** time	I_p/I_N	0.10 to 20.00	(steps 0.01)
time multiplier T_p		0.50 to 32.00 or ∞ (stage ineffective)	(steps 0.01);
pick-up threshold		approx. 1.1 times I_p	

All current values are based on the nominal current of the protected object.

Measuring times (without parallel operation of other protection functions)

$I>>$, $I>$ at 2 times setting value	approx. 60 ms (approx. 150 ms at $16^2/_3$ Hz)
I_p	refer to Figure 3.10

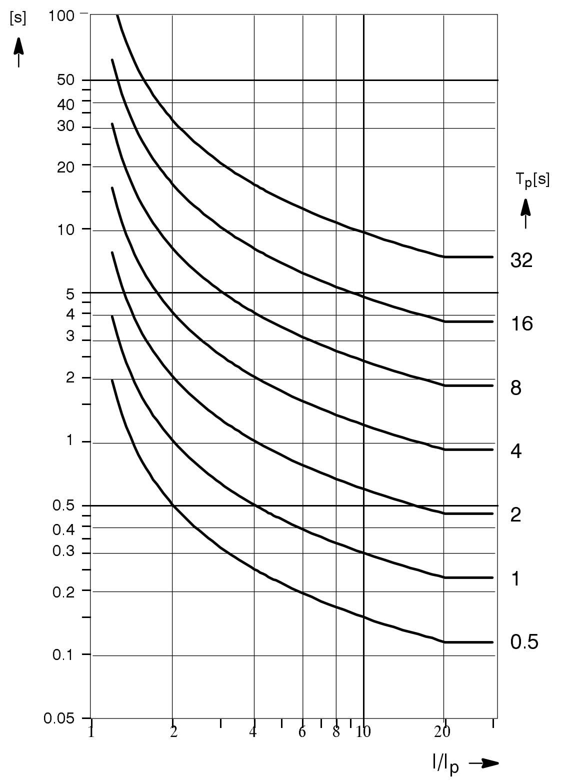
Drop-off times $I>>$, $I>$	approx. 75 ms (approx. 210 ms at $16^2/_3$ Hz)
Drop-off ratios	approx. 0.95
Overshot time	approx. 75 ms (approx. 210 ms at $16^2/_3$ Hz)

Tolerances

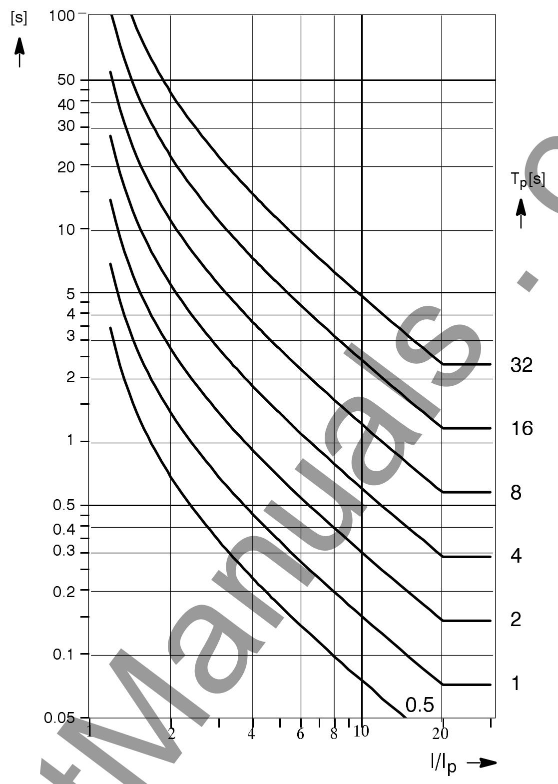
− definite time stages $I>>$, $I>$	3 % of set value
− definite time delays	1 % of set value or 10 ms
− for inverse time stages I_p, I_{Ep}	pick-up at $1.05 < I/I_p < 1.15$
− inverse time delays	5 % of set value or 30 ms

Influencing variables

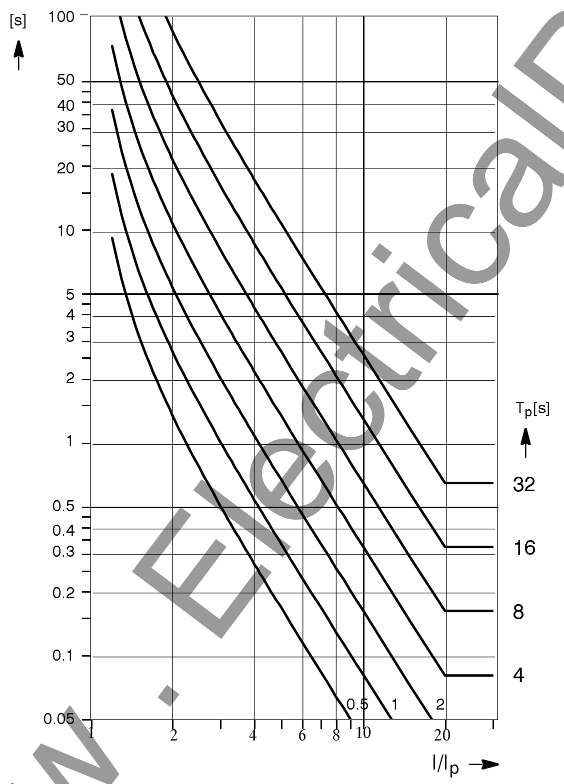
Auxiliary voltage in range $0.8 \le U/U_N \le 1.15$	≤ 1 %
Temperature in range $0\ ^\circ C \le\ _{amb} \le 40\ ^\circ C$	≤ 0.5 %/10 K
Frequency for definite time protection	
− in range $0.98 \le f/f_N \le 1.02$	≤ 1.5 %
− in range $0.95 \le f/f_N \le 1.05$	≤ 2.5 %
Frequency for inverse time protection	
− in range $0.95 \le f/f_N \le 1.05$	≤ 8 % referred to the theoretical time



Normal inverse: $t = \dfrac{0.14}{(I/I_p)^{0.02} - 1} \cdot \dfrac{T_p}{10}$ [s]



Very inverse: $t = \dfrac{13.5}{(I/I_p) - 1} \cdot \dfrac{T_p}{10}$ [s]



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

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

$T_p/10$ corresponds to the usual time multiplier TM

Figure 3.10 Tripping time characteristics of inverse time overcurrent protection

3.7 Overload protection

Setting ranges/steps

Factor k according to IEC 60255−8	0.10 to 4.00	(steps 0.01)
Time constant t	1.0 to 999.9 min	(steps 0.1 min)
Thermal warning stage Q_{warn}/Q_{trip}	50 to 100 % referred to trip temperature rise	(steps 1 %)
Current warning stage	0.10 to $4.00 \cdot I_N$	(steps $0.01 \cdot I_N$)

Trip time characteristic

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

t	trip time
t	time constant
I	load current
I_{pre}	preload current
k	factor according to IEC 60255−8 refer also to Figures 3.11 and 3.12
I_N	rated winding or feeder current

$$I_N = \frac{S_N}{\sqrt{3} \cdot U_N}$$ in three-phase systems

$$I_N = \frac{S_N}{U_N}$$ in single-phase systems

Drop-off ratios

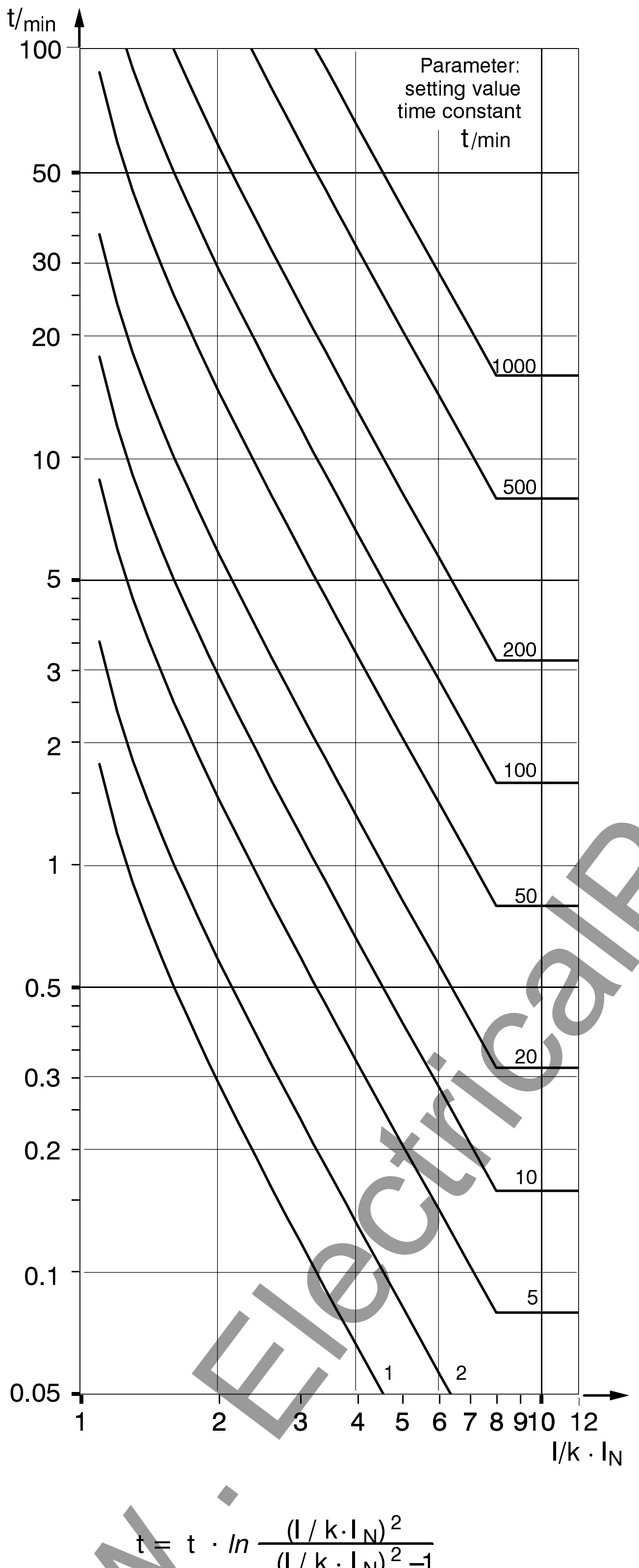
Q/Q_{trip}	approx. 0.99
Q/Q_{warn}	approx. 0.99
I/I_{warn}	approx. 0.97

Tolerances

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

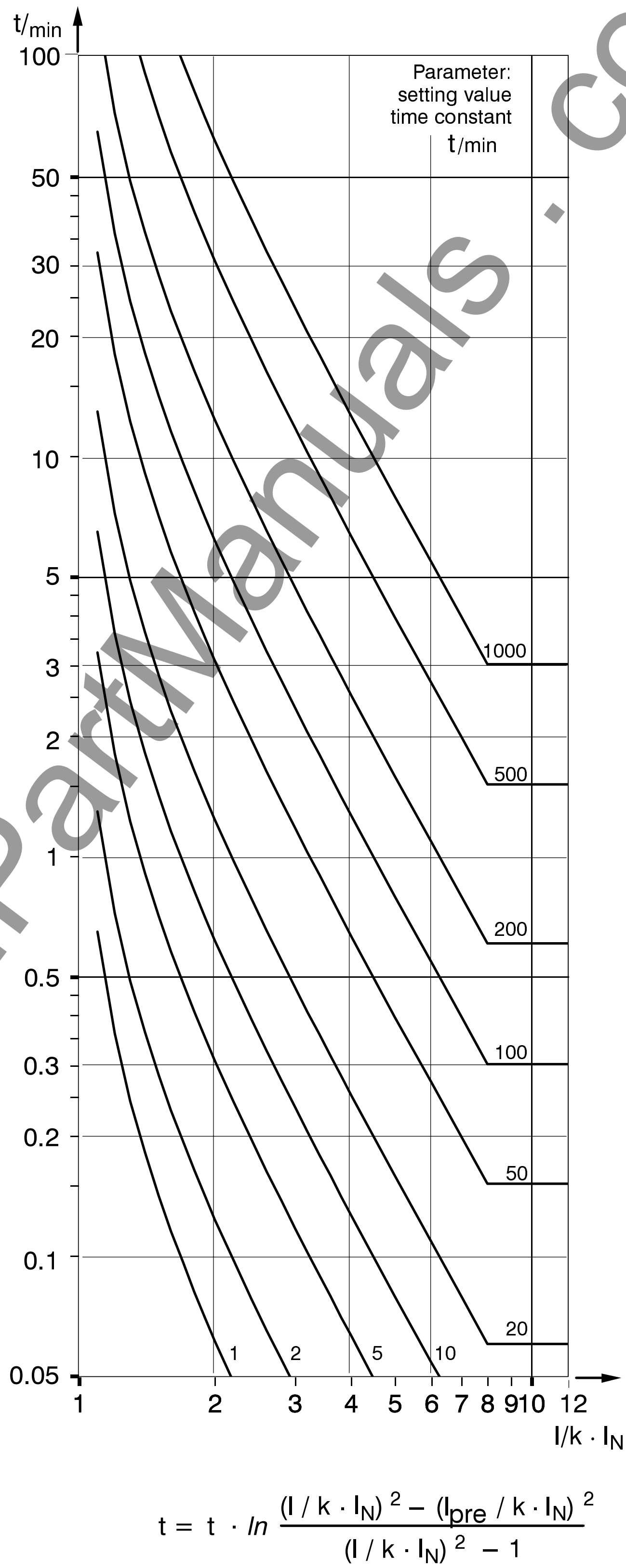
Influence variables referred to $k \cdot I_N$

− Auxiliary dc voltage in range $0.8 \leq U_H/U_{HN} \leq 1.15$	≤ 1 %
− Temperature in range $-5\ ^\circ C \leq\ _{amb} \leq +40\ ^\circ C$	$\leq$ 0.5 %/10 K
− Frequency in range $0.95 \leq f/f_N \leq 1.05$	≤ 1 %



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

Figure 3.11 Trip time characteristic of overload protection – without preload –



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

for 90 % preload

Figure 3.12 Trip time characteristic of overload protection – with 90 % preload –

3.8 Tank leakage protection (optional with 7UT513)

Measuring principle	Measurement of the leak current from the isolated tank to earth	
Setting ranges/steps		
Earth leakage current pick-up (dependent on connection)	10 mA to 1000 mA $0.1 \cdot I_N$ to $10 \cdot I_N$ (I_N = rated current of the device)	(steps 1 mA) or (steps $0.01 \cdot I_N$)
Trip delay time	0.00 s to 60.00 s or ∞ (no trip)	(steps 0.01 s)
Drop-off delay time	0.00 s to 60.00 s	(steps 0.01 s)
Drop-off ratio	0.25 to 0.95	(steps 0.01)
Measured current formation	fundamental wave or r.m.s. value	
Pick-up time at 2 · setting value (without parallel operation of other protection functions)	approx 25 to 35 ms (approx 60 ms at $16^2/_3$ Hz)	
Drop-off time	approx. 35 ms (approx. 100 ms at $16^2/_3$ Hz)	
Tolerances		
current pick-up	5 % of setting value	
delay times	1 % of setting value or 10 ms	

3.9 Direct local trip via binary input

Number of direct trip facilities	2
Setting rages/steps	
Trip delay	0.00 s to 60.00 s (steps 0.01 s) or ∞
Drop-off delay	0.00 s to 60.00 s (steps 0.01 s)
Operating times	
Pick-up time	approx. 20 ms
Drop-off time	approx. 20 ms
Tolerances	
Delay times	1 % of setting value or 10 ms

3.10 Ancillary functions

Operational value measurements

Operational current values (r.m.s.)	I_{L1}; I_{L2}; I_{L3} (feeder 1) I_{L1}; I_{L2}; I_{L3} (feeder 2) I_{L1}; I_{L2}; I_{L3} (feeder 3) (7UT513) in A primary and % I_N I_A, I_B (earth currents) in A primary and % I_N I_B in mA for highly sensitive tank protection
Tolerance	$\leq$ 2 % of respective rated value
Overload protection measured values	
Calculated temperature rise	Q/Q_{trip}
Tolerance	$\leq$ 3 % referred to Q_{trip}

Steady-state measured value supervision

Current unbalance	I_{max}/I_{min} > symmetry factor as long as $I > I_{limit}$

User definable annunciations

number	4

Fault event data log

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

Real time clock

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

Data storage for fault recording	max 8 fault occurrences
Storage period	up to 5 s at 50 Hz or $16^2/_3$ Hz up to 4 s at 60 Hz
Sampling rate	1 instantaneous value per 1.66 ms at 50 Hz 1 instantaneous value per 1.39 ms at 60 Hz 1 instantaneous value per 5 ms at $16^2/_3$ Hz

Differential protection measured values for test and commissioning

feeder currents	I_{L1}; I_{L2}; I_{L3} (feeder 1) I_{L1}; I_{L2}; I_{L3} (feeder 2) I_{L1}; I_{L2}; I_{L3} (feeder 3) (7UT513) I_A, I_B (additional currents 7UT513) phase difference between all currents
differential currents	$I_{L1\ DIFF}$, $I_{L2\ DIFF}$, $I_{L3\ DIFF}$
stabilization currents	$I_{L1\ STAB}$, $I_{L2\ STAB}$, $I_{L3\ STAB}$

Restricted earth fault protection measured values for test and commissioning (only 7UT513 with restricted earth fault)

feeder currents	I_{L1}; I_{L2}; I_{L3} of the selected feeder phase difference between the currents
zero sequence currents	I_0' (star point current) I_0" (sum of the phase currents) phase difference between I_0' and I_0" phase difference between I_0' and the phase currents
differential current	$I_{DIFF\ REF}$
stabilization current	$I_{STAB\ REF}$

4 Method of operation

4.1 Operation of complete unit

The numerical current differential protection 7UT51 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 basic structure of the unit.

The measured value input section ME transforms the currents from the measurement transformers and matches them to the internal processing level of the unit. Apart from the galvanic and low-capacitive isolation provided by the input transformers, filters are provided for the suppression of interference. The filters have been optimized with regard to bandwidth and processing speed to suit the measured value processing. The matched analog values are then passed to the analog input AE on the processor p.c.b.

The inputs are galvanically isolated from each other and from the electronic circuitry. This allows the starpoint to be formed outside the unit or to include further devices in the current circuit.

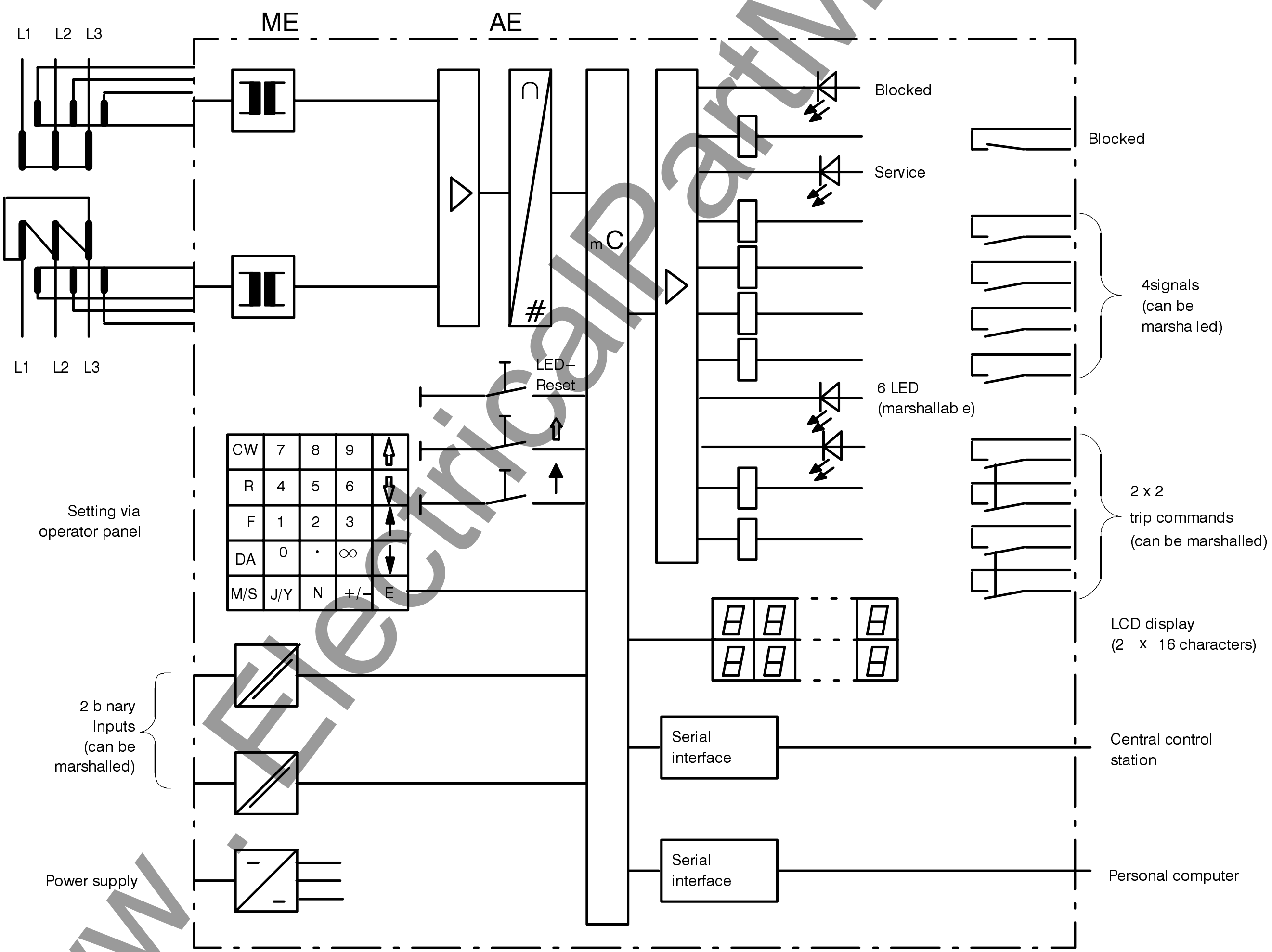


Figure 4.1 Hardware structure of current differential relay 7UT51, example for a two-winding transformer

Matching to the various power transformer and current transformer ratios and of the phase displacement according to the vector group of the protected transformer (for use as transformer protection) is performed purely mathematically. As a rule, matching transformers are not required.

The analog input module AE contains input amplifiers, sample and hold elements for each input, multiplexers, analog/digital converters and memory chips for data transmission to the microprocessor.

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

- Formation of the measured values in accordance with the vector group and transformation ratio of the protected transformer and the c.t.s (for transformer protection),
- Formation of differential and stabilizing quantities,
- Frequency analysis of the measured values,
- Calculation of r.m.s. values for overload detection and scanning of the winding temperature rise,
- Scanning of limit values and time sequences,
- Decision of trip commands,
- Storage and issue of messages and fault data for fault 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 switchgear (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 plate.

An integrated membrane keyboard in connection with the built-in alphanumerical LC 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 interfaces by means of an operator panel or a personal computer.

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

Transmission of the data is, alternatively, possible via optical fibres provided the interface is accordingly ordered (refer section 2.3 Ordering data).

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

The protective functions are described in detail in the following sections. Each function can be individually activated or rendered inoperative. As each function is realized by its own autonomous firmware, mutual interference is excluded.

The three differential protection functions – transformer differential protection, generator or motor differential protection, and branch point differential protection – from which one can be selected dependent of the protected object, are described as closed sections, i.e. functions are repeated even when they have been described in a foregoing section of another differential protection function.

Possibilities exist with 7UT513 to use the relay (which is designed for three feeders) for the protection of an object with two feeders (two winding transformers, generators, motors, or branch points with two terminals). In this case, additional functions which are suited to a third feeder (restricted earth fault protection, overcurrent time protection, thermal overload protection) can be used for a different independent protected object, the so-called ”virtual object”.

4.2 Differential protection for transformers

4.2.1 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 4.2) that the current $\underline{I}$ (dotted) leaving a healthy protected object 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 protected object under consideration.

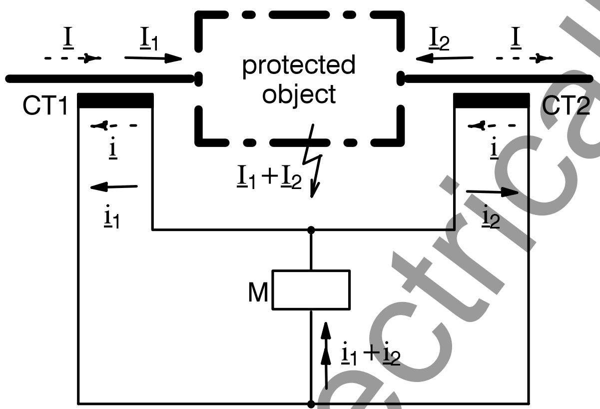


Figure 4.2 Base principle of differential protection

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 (refer to Section 4.2.3).

4.2.2 Matching of measured values

In transformers, generally, the secondary currents of the current transformers are not equal when a current flows through the power transformer, but depend on the transformation ratio and the connection group of the protected power transformer, and the rated currents of the current transformers at both sides of the power transformer. The currents must, therefore, be matched in order to become comparable.

Matching to the various power transformer and current transformer ratios and of the phase displacement according to the vector group of the protected transformer is performed purely mathematically. As a rule, matching transformers are not required.

The input currents are converted in relation to the power transformer rated current. This is achieved by entering the rated transformer data, such as rated power, rated voltage and rated primary current of the current transformers, into the protection unit.

Once the vector group has been entered, the protection unit is capable of performing the current comparison according to fixed formulae.

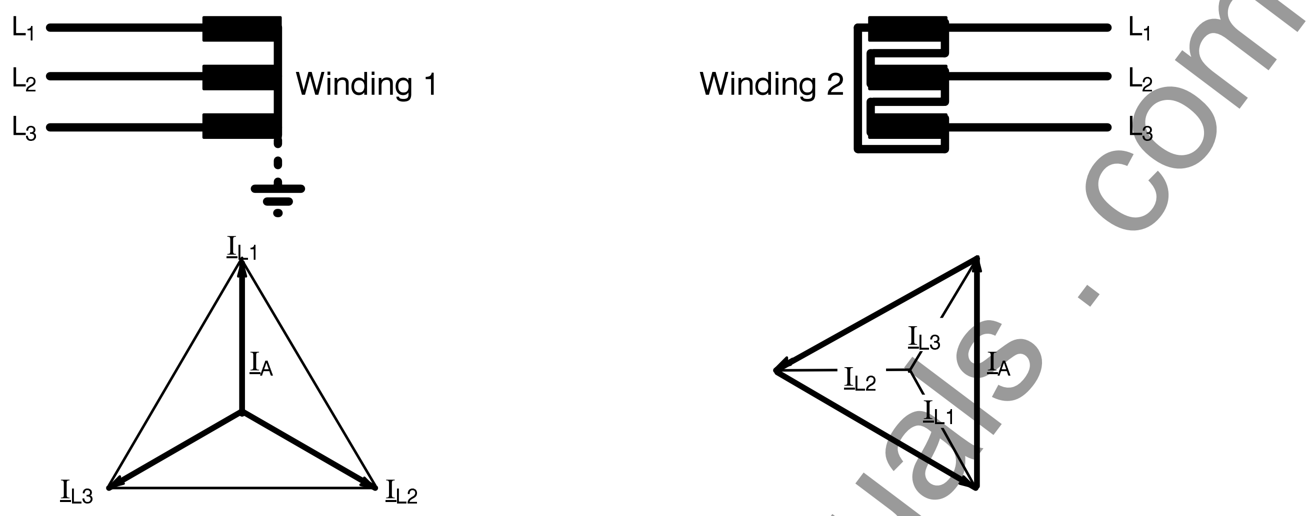
Conversion of the currents is performed by programmed coefficient matrices which simulate the difference currents in the transformer windings. All conceivable vector groups (including phase exchange) are possible. Figure 4.3 illustrates an example for a transformer Y(N)d5. The figure shows the windings and the phasor diagrams and, at the bottom, the matrix equations. The common form of these equations is

$$(\underline{I}_m) = k \cdot (K) \cdot (\underline{I}_n)$$

where

- $(\underline{I}_m)$ – matrix of the matched currents $\underline{I}_A$, $\underline{I}_B$, $\underline{I}_C$,
- k – constant factor,
- (K) – coefficient matrix, dependent on the vector group,
- $(\underline{I}_n)$ – matrix of the phase currents $\underline{I}_{L1}$, $\underline{I}_{L2}$, $\underline{I}_{L3}$.

Normally, the zero sequence currents are eliminated as shown in the left matrix in Figure 4.3; thus, fault currents which flow via the transformer during earth faults in the network in case of an earth point in the protected zone (transformer star point or star point former) are rendered harmless without any special external measures (Figure 4.4).



$$\begin{pmatrix}\underline{I}_A\\ \underline{I}_B\\ \underline{I}_C\end{pmatrix} = \frac{1}{3} \bullet \begin{pmatrix}2 & -1 & -1\\ -1 & 2 & -1\\ -1 & -1 & 2\end{pmatrix} \bullet \begin{pmatrix}\underline{I}_{L1}\\ \underline{I}_{L2}\\ \underline{I}_{L3}\end{pmatrix} \qquad \begin{pmatrix}\underline{I}_A\\ \underline{I}_B\\ \underline{I}_C\end{pmatrix} = \frac{1}{\sqrt{3}} \bullet \begin{pmatrix}-1 & 0 & 1\\ 1 & -1 & 0\\ 0 & 1 & -1\end{pmatrix} \bullet \begin{pmatrix}\underline{I}_{L1}\\ \underline{I}_{L2}\\ \underline{I}_{L3}\end{pmatrix}$$

Figure 4.3 Example for vector group matching Y(N)d5 (without amplitude matching)

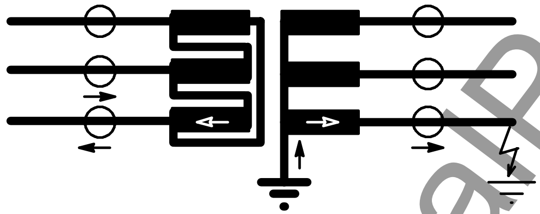


Figure 4.4 Earth fault outside the transformer

The disadvantage of elimination of the zero sequence current is that the protection becomes less sensitive (factor $^2/_3$) in case of an earth fault in the protected area.

In isolated or arc compensated systems, zero sequence current elimination is not necessary (selectable) when the star-point of the protected transformer is not earthed (not even via a Peterson coil). The matrix equation for the Y–winding is then (Figure 4.3):

$$\begin{pmatrix}\underline{I}_A\\ \underline{I}_B\\ \underline{I}_C\end{pmatrix} = 1 \cdot \begin{pmatrix}1 & 0 & 0\\ 0 & 1 & 0\\ 0 & 0 & 1\end{pmatrix} \cdot \begin{pmatrix}\underline{I}_{L1}\\ \underline{I}_{L2}\\ \underline{I}_{L3}\end{pmatrix}$$

When a double earth fault occurs with one foot-point within the protected zone, the transformer is always disconnected regardless of the double earth fault priority of the network, in this case.

The zero sequence current must be eliminated in earthed systems when an earthing point lies in the protected zone (earthed star-point or artificial star-point). Higher earth fault sensitivity can be achieved if the star-point current is available, i.e. if a current transformer is installed in the starpoint connection to earth (Figure 4.5).

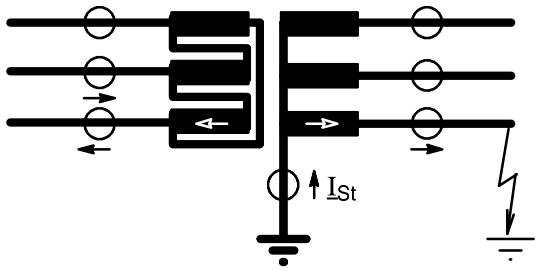


Figure 4.5 Increasing the earth fault sensitivity

The matrix equation for the Y–winding is in this case:

$$\begin{pmatrix}\underline{I}_A\\ \underline{I}_B\\ \underline{I}_C\end{pmatrix} = 1 \cdot \begin{pmatrix}1 & 0 & 0\\ 0 & 1 & 0\\ 0 & 0 & 1\end{pmatrix} \cdot \begin{pmatrix}\underline{I}_{L1}\\ \underline{I}_{L2}\\ \underline{I}_{L3}\end{pmatrix} + \frac{1}{3} \cdot \begin{pmatrix}\underline{I}_{St}\\ \underline{I}_{St}\\ \underline{I}_{St}\end{pmatrix}$$

where $\underline{I}_{St}$ is the star-point current of the earthed winding. The zero sequence current is eliminated by this correction during external fault (as illustrated in Figure 4.5) but fully recognized in case of an internal earth fault.

4.2.3 Evaluation of measured values

After the input currents are matched with regard to transformation ratio, vector group, and treatment of the zero sequence currents, the quantities which are necessary for the differential protection are calculated from $\underline{I}_A$, $\underline{I}_B$, and $\underline{I}_C$ of each winding. In the following clarifications, indices are use to discriminate the windings: 1 for the primary winding (higher voltage) of the power transformer, 2 for the secondary winding (lower voltage), and, if applicable, 3 for the tertiary winding of a three-winding transformer.

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. three-winding transformers, stabilizing is only possible with the arithmetical sum $|\underline{I}_1| + |\underline{I}_2| + |\underline{I}_3|$. The latter method is used in 7UT51 for all protected objects (i.e. for two- or three-winding transformers). This requires the formation of the vectorial sum and the arithmetical sum of the currents of each winding. The following definitions apply:

The tripping effect or differential current

$I_{diff} = |\underline{I}_1 + \underline{I}_2|$ (two windings)

or

$I_{diff} = |\underline{I}_1 + \underline{I}_2 + \underline{I}_3|$ (three windings)

and the stabilization or restraining current

$I_{stab} = |\underline{I}_1| + |\underline{I}_2|$ (two windings)

or

$I_{stab} = |\underline{I}_1| + |\underline{I}_2| + |\underline{I}_3|$ (three windings)

I_{diff} is derived from the fundamental waves and produces the tripping effect quantity, I_{stab} counteracts this effect.

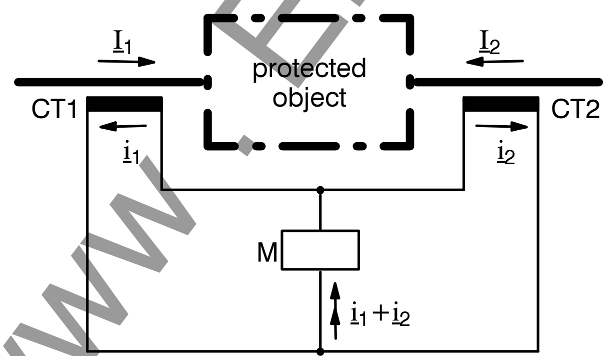


Figure 4.6 Principle of differential protection

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

a) Through flowing current through a healthy transformer 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 side:

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

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

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

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 side only:

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

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

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

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 4.7. The figure shows the complete operation characteristic of the relay. The branch a represents the sensitivity threshold of the differential protection and considers constant error current, e.g. magnetizing currents. Branch b takes into consideration current proportional errors which may result from transformation errors of the main c.t.s, the input c.t.s of the relay, or from the position of the tap changer of the voltage regulator. 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 4.2.5, branch d in 4.2.6.

The currents I_{diff} and I_{stab} are compared by the differential protection with the operating characteristic according to Figure 4.7. If the quantities result into a locus in the tripping area, trip signal is given.

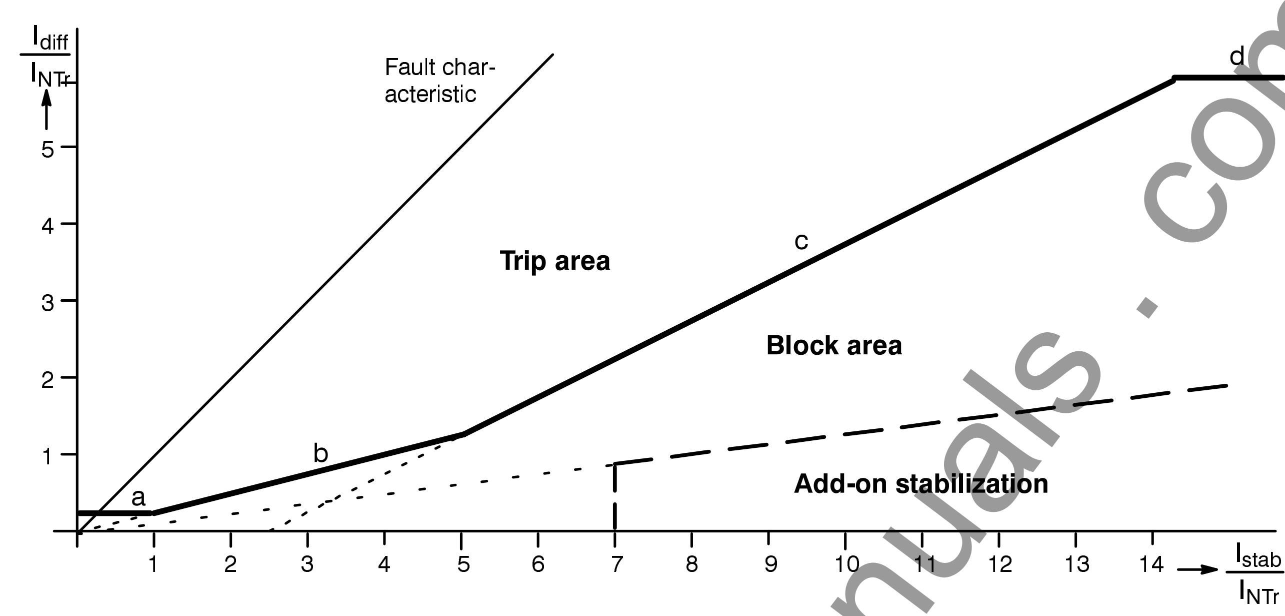


Figure 4.7 Operation characteristics of the differential protection

4.2.4 Harmonic stabilization

As differential currents can be caused not only by internal transformer faults but also by the inrush current during switch-on, paralleling of transformers, or an overexcitation of the transformer, they are examined as to their harmonic content.

The inrush current can amount to a multiple of the rated current and is characterized by a considerable 2nd harmonic content (double rated frequency) which is practically absent in the case of a short-circuit. If the second harmonic content exceeds a selectable threshold, trip is blocked.

Since the inrush stabilization operates individually per phase, the protection is fully operative even when the transformer is switched onto a single-phase fault, whereby inrush currents may possibly be present in one of the healthy phases. However, it is also possible to set the protection such that not only the phase with inrush current exhibiting harmonic content in excess of the permissible value is stabilized but also the other phases of the differential stage $I_{DIFF}>$ are blocked (so called "cross-block function"). This cross-block can be limited to a selectable duration.

Besides the second harmonic, another harmonic can be selected to cause blocking. A choice can be made between the third, fourth, and fifth.

The fourth harmonic can be found – like the second – in unsymmetrical occurrences as inrush currents.

Overexcitation of the transformer iron is characterized by the presence of odd harmonics in the current. Thus, the third or fifth harmonic are suitable to detect such phenomena. But, as the third harmonic is often eliminated in power transformers (e.g. by the delta winding), the use of the fifth is more common.

Furthermore, in case of converter transformers odd harmonics are found which are nor present during internal transformer faults.

The harmonic stabilization operates individually per phase. However, it is also possible – as it is for the inrush stabilization – to set the protection such that not only the phase with harmonic content in excess of the permissible value is stabilized but also the other phases of the differential stage $I_{DIFF}>$ are blocked (so called "cross-block function"). This cross-block can be limited to a selectable duration.

Numerical filters are used to perform a Fourier analysis of the differential current. As soon as the harmonic contents exceed the set values, a stabilization of the respective phase evaluation is introduced (refer Figure 3.2 and 3.3). The Filter algorithms are optimized with regard to their transient behaviour such that additional measures for stabilization during dynamic conditions are not necessary.

4.2.5 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 in the protected transformer), 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 4.7 is principally valid in this case, too. Of course, the fundamental wave of the differential current must exceed at least the pick-up threshold (branch a in Figure 4.7).

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 measuring points. If the quantities I_{diff}/I_{stab} result in an operating point which lies in the trip area of the operating characteristic (Figure 4.7), trip signal would be the consequence if there were no special measures.

7UT51 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 4.7. The slope of this characteristic corresponds to half the slope of the branch b.

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 4.7). 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 a selectable time (8 periods at the longest corresponding to 160 ms at 50 Hz, when the relay is delivered). 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 in the protected transformer reliably even during an external fault with current transformer saturation.

4.2.6 Speedy unstabilized trip with high current transformer fault

High-current faults in the protected transformer may be cleared instantaneously without regard of the magnitude of the the stabilizing current, when the amplitude of the differential currents can exclude that it is an external fault. This is always the case when the short-circuit current is higher than $^{1}/u_{k}$ times the nominal transformer current.

The transformer differential protection 7UT51 provides such unstabilized high-current trip stage. This can operate even when, for example, a considerable second harmonic is present in the differential current caused by current transformer saturation by a d.c. component in the short-circuit current which could be interpreted by the inrush stabilization function as an inrush current.

This high-current stage evaluates the fundamental wave of the currents as well as the instantaneous values. Instantaneous value processing ensures fast tripping even in case the fundamental wave of the current is strongly reduced by current transformer saturation.

4.2.7 Pick-up / Tripping

As soon as the fundamental wave of the differential current reaches 85 % of the set value or the stabilizing current exceeds 4 times the rated transformer current, the protection picks up. Thus, pick-up occurs also in case of external faults, so that fault recording and saturation indicator can operate.

If the trip conditions are fulfilled trip signal is issued. For special cases, the trip command can be delayed. Figure 4.8 shows a simplified tripping logic.

Reset of pick-up is initiated when, during 2 periods, pick-up is no longer recognized in the differential values, i.e. the differential current has fallen below 70 % of the set value.

If a trip command has not been initiated, the fault is considered to be over.

If a trip command has been formed, then a timer of settable duration can be started upon reset of pick-up. During this time the trip command is held in (reset time delay).

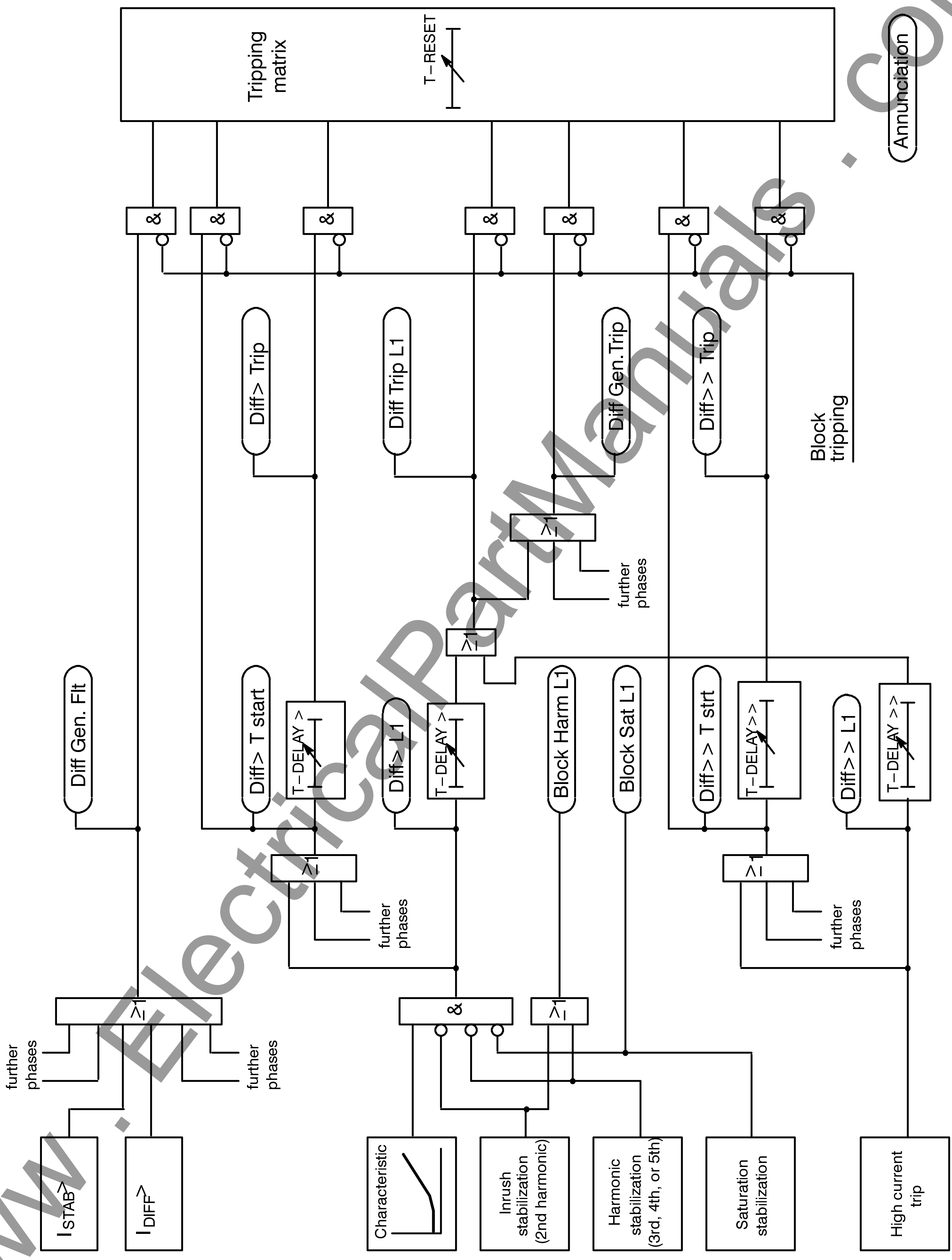


Figure 4.8 Tripping logic of transformer differential protection (one measuring system) − scheme

4.2.8 Use on single-phase transformers

Single-phase transformers can be designed with one or two phases per winding; in the latter case, the winding phases can be wound on one or two iron cores. In order to ensure that optimum matching of the currents would be possible, always two measured current inputs shall be used even if only one current transformer is installed on one phase. The currents are to be connected to the inputs L1 and L3; they are designated $\underline{I}_{L1}$ and $\underline{I}_{L3}$ in the following.

If two winding phases are available, they may be connected either in series (which corresponds to a Y–winding) or in parallel (which corresponds to a D–winding). The phase displacement between the windings can only be 0° or 180°. Figure 4.9 shows an example of a single-phase power transformer with two phases per winding with the definition of the direction of the currents.

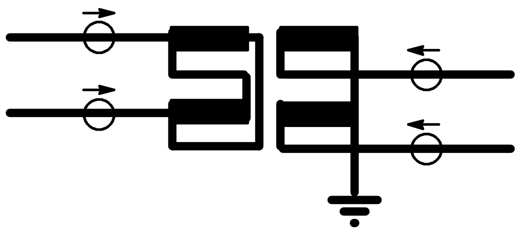


Figure 4.9 Example of a single-phase power transformer

Like with three-phase power transformers, the currents are matched by programmed coefficient matrices which simulate the difference currents in the transformer windings. The common form of these equations is

$$(\underline{I}_m) = k \cdot (K) \cdot (\underline{I}_n)$$

where
- $(\underline{I}_m)$ – matrix of the matched currents $\underline{I}_A$, $\underline{I}_C$,
- k – constant factor,
- (K) – coefficient matrix,
- $(\underline{I}_n)$ – matrix of the phase currents $\underline{I}_{L1}$, $\underline{I}_{L3}$.

Since the phase displacement between the windings can only be 0° or 180°, matching is relevant with respect to the treatment of the zero sequence current. If the "star-point" of the protected transformer winding is not earthed (Figure 4.9. left side), the phase currents can immediately be used. The matrix equation is then:

$$\begin{pmatrix} \underline{I}_A \\ \underline{I}_C \end{pmatrix} = 1 \cdot \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} \underline{I}_{L1} \\ \underline{I}_{L3} \end{pmatrix}$$

If a "star point" is earthed (Figure 4.9 right side), the zero sequence current must be eliminated by forming the current differences. Thus, fault currents which flow via the transformer during earth faults in the network in case of an earth point in the protected zone (transformer "star point") are rendered harmless without any special external measures. The matrix equation is then:

$$\begin{pmatrix} \underline{I}_A \\ \underline{I}_C \end{pmatrix} = \frac{1}{2} \cdot \begin{pmatrix} 1 & -1 \\ -1 & 1 \end{pmatrix} \cdot \begin{pmatrix} \underline{I}_{L1} \\ \underline{I}_{L3} \end{pmatrix}$$

The disadvantage of elimination of the zero sequence current is that the protection becomes less sensitive (factor $^1/_2$) in case of an earth fault in the protected area. Higher earth fault sensitivity can be achieved if the "star-point" current is available, i.e. if a current transformer is installed in the "starpoint" connection to earth (Figure 4.10).

The matrix equation for the earthed winding is then:

$$\begin{pmatrix} \underline{I}_A \\ \underline{I}_C \end{pmatrix} = 1 \cdot \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} \underline{I}_{L1} \\ \underline{I}_{L3} \end{pmatrix} + \frac{1}{2} \cdot \begin{pmatrix} \underline{I}_{St} \\ \underline{I}_{St} \end{pmatrix}$$

where $\underline{I}_{St}$ is the "star-point" current of the earthed winding. The zero sequence current is eliminated by this correction during external fault (as illustrated in Figure 4.10) but fully recognized in case of an internal earth fault.

Further processing of the measured quantities and the tripping logic do not differ from the three-phase transformer differential protection.

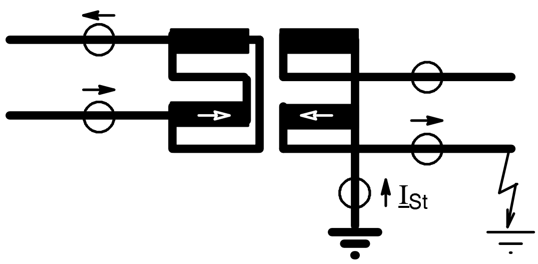


Figure 4.10 Example of a single-phase power transformer

4.3 Differential protection for generators and motors

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 protected object 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 protected object under consideration.

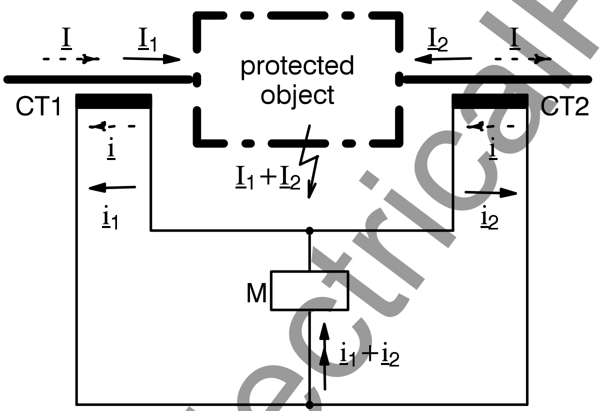


Figure 4.12 Base principle of differential protection

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 (refer to Section 4.3.3).

4.3.2 Definition of measured currents

7UT51 can be used as longitudinal differential protection or as transverse differential protection. The operation modes differ from each other only by the definition of the measured currents. Since the current direction is normally defined as positive in the direction of the protected object, the definitions as illustrated in Figure 4.13 (for longitudinal differential protection) and Figure 4.14 (for transverse differential protection) result.

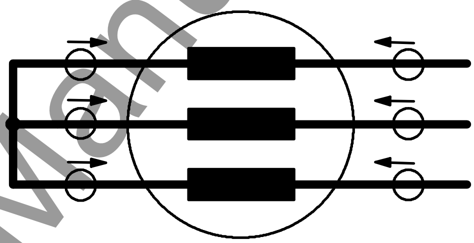


Figure 4.13 Definition of current direction for longitudinal differential protection

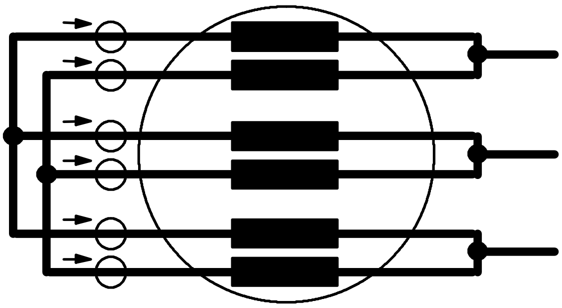


Figure 4.14 Definition of current direction for transverse differential protection

If 7UT51 is used as differential protection for generators or motors, all currents are referred to the nominal current of the protected machine. The device is informed about the rated machine data during parameterization: the rated apparent power, the rated voltage, and the rated currents of the current transformers.

4.3.3 Evaluation of measured values

After the input currents are matched with regard to rated machine current, the quantities which are necessary for the differential protection are calculated from the currents of the star-point side and the terminal side of the machine. In the following clarifications, indices are use to discriminate the side: 1 for the star-point side of the machine, 2 for the terminal side.

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. The latter method is used in 7UT51 for all protected objects. This requires the formation of the vectorial sum and the arithmetical sum of the currents. 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} is derived from the fundamental waves and produces the tripping effect quantity, I_{stab} counteracts this effect.

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

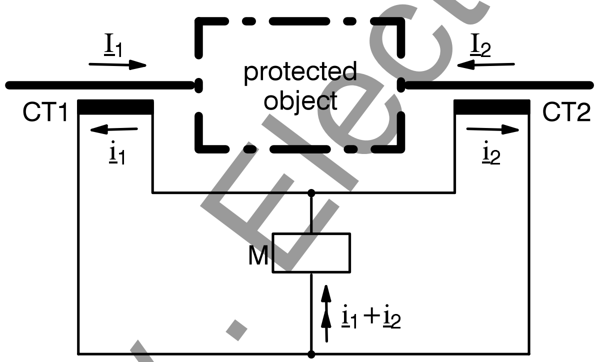


Figure 4.15 Principle of differential protection

a) Through flowing current through a healthy machine 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 both sides:

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

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

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

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 side only:

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

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

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

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 4.16. The figure shows the complete operation characteristic of the relay. The branch a represents the sensitivity threshold of the differential protection and considers constant error currents. Branch b takes into consideration current proportional errors which may result from transformation errors of the main c.t.s or from the input c.t.s 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 4.3.4.

The currents I_{diff} and I_{stab} are compared by the differential protection with the operating characteristic according to Figure 4.16. If the quantities result into a locus in the tripping area, trip signal is given.

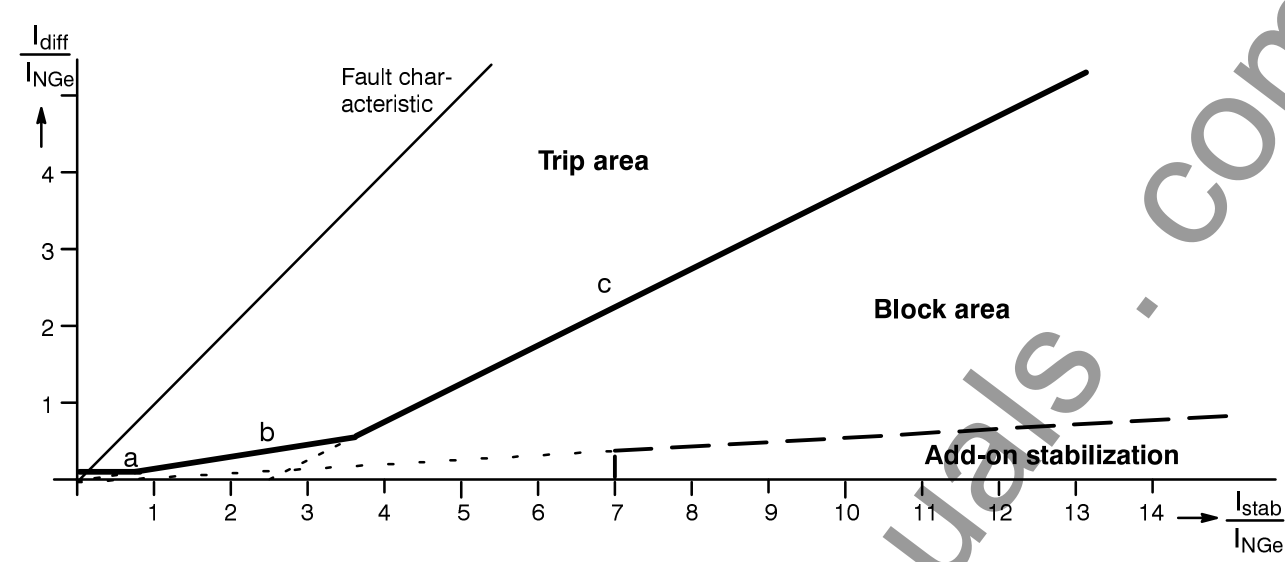


Figure 4.16 Operation characteristics of the differential protection

4.3.4 Add-on stabilization during current transformer saturation

Saturation of the current transformers caused by high fault currents and/or long machine time constants are uncritical for internal faults (fault in the protected machine), 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 4.16 is principally valid in this case, too. Of course, the fundamental wave of the differential current must exceed at least the pick-up threshold (branch a in Figure 4.16).

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 measuring points. If the quantities I_{diff}/I_{stab} result in an operating point which lies in the trip area of the operating characteristic (Figure 4.16), trip signal would be the consequence if there were no special measures.

7UT51 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 4.16. The slope of this characteristic corresponds to half the slope of the branch b.

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 4.16). 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 a selectable time (8 periods at the longest corresponding to 160 ms at 50 Hz, when the relay is delivered). 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 in the protected machine reliably even during an external fault with current transformer saturation.

4.3.5 Pick-up / Tripping

As soon as the fundamental wave of the differential current exceeds 85 % of the set value or the stabilizing current exceeds 4 times the rated machine current, the protection picks up. Thus, pick-up occurs also in case of external faults, so that fault recording and saturation indicator can operate.

If the trip conditions are fulfilled trip signal is issued. For special cases, the trip command can be delayed. Figure 4.17 shows a simplified tripping logic.

Reset of pick-up is initiated when, during 2 periods, pick-up is no longer recognized in the differential values, i.e. the differential current has fallen below 70 % of the set value.

If a trip command has not been initiated, the fault is considered to be over. If a trip command has been formed, then a timer of settable duration can be started upon reset of pick-up. During this time the trip command is held in (reset time delay).

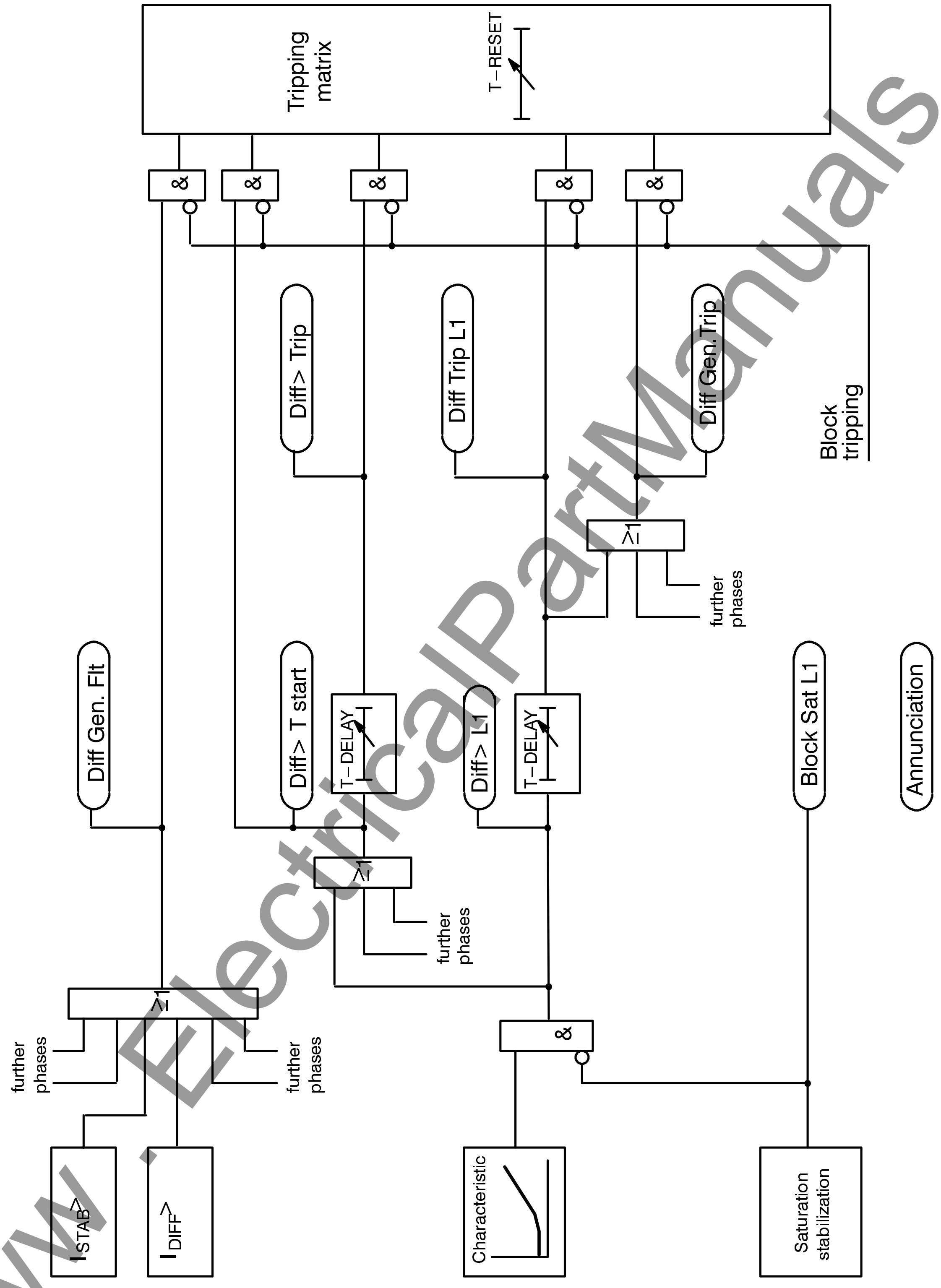


Figure 4.17 Tripping logic of generator or motor differential protection (one measuring system) – scheme

4.4 Differential protection for branch points

4.4.1 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 4.18) that the current $\underline{I}$ (dotted) leaving a healthy protected object 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 protected object under consideration.

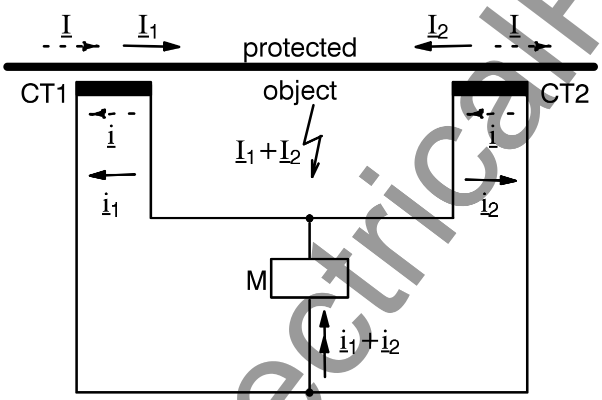


Figure 4.18 Base principle of differential protection

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 (refer to Section 4.4.3).

4.4.2 Matching of measured values

A branch point is defined here as a three-phase, coherent piece of conductor which is limited by sets of current transformers. 7UT512 is suited to such branch points with two ends (Figure 4.19, no true node), 7UT513 to branch points with three ends (Figure 4.20). Such branch points could be short stubs or mini-bus-bars. The branch point differential protection is not suited to transformers; use the function ”transformer differential protection” for this application (refer to Section 4.2). Even for other inductances, like series or shunt reactors, the branch point differential protection should not be used because of its low sensitivity.

Since the current direction is normally defined as positive in the direction of the protected object, the definitions as illustrated in Figure 4.19 (for two terminal branch point) and Figure 4.20 (for three terminal branch points) result.

If 7UT51 is used as differential protection for branch points, all currents are referred to the nominal current of the protected branch point. The device is informed about this during parameterization. Thus, if the current transformer sets at the ends of the branch point have different primary current, no external matching devices are necessary.

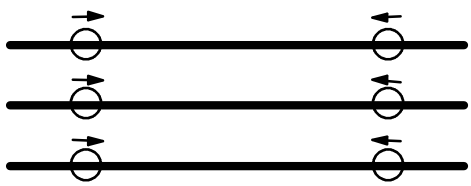


Figure 4.19 Definition of current direction with two ends

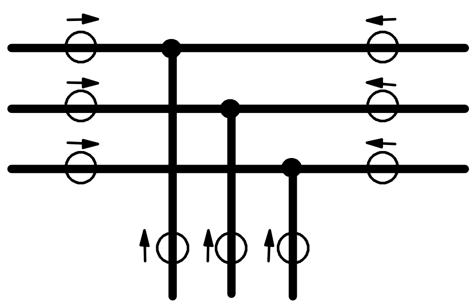


Figure 4.20 Definition of current direction with three ends

4.3.3 Evaluation of measured values

After the input currents are matched with regard to their magnitude, the quantities which are necessary for the differential protection are calculated from the currents of the two or three ends. In the following clarifications, indices are used to discriminate the sides: 1 for first, 2 for the second, and, if applicable, 3 for the third side of the branch point.

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, stabilizing is only possible with the arithmetical sum $|\underline{I}_1| + |\underline{I}_2| + |\underline{I}_3|$. The latter method is used in 7UT51 for all protected objects. This requires the formation of the vectorial sum and the arithmetical sum of the currents of each end. The following definitions apply:

The tripping effect or differential current

$I_{diff} = |\underline{I}_1 + \underline{I}_2|$ (two terminals)

or

$I_{diff} = |\underline{I}_1 + \underline{I}_2 + \underline{I}_3|$ (three terminals)

and the stabilization or restraining current

$I_{stab} = |\underline{I}_1| + |\underline{I}_2|$ (two terminals)

or

$I_{stab} = |\underline{I}_1| + |\underline{I}_2| + |\underline{I}_3|$ (three terminals)

I_{diff} is derived from the fundamental waves and produces the tripping effect quantity, I_{stab} counteracts this effect.

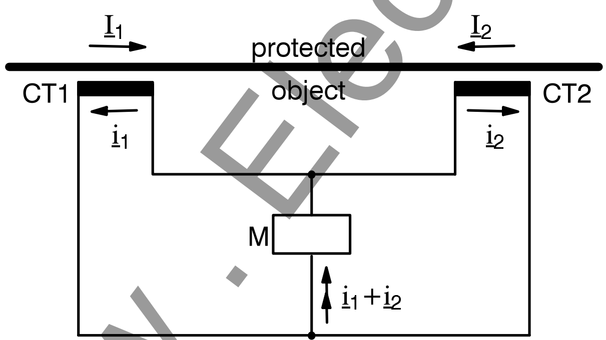


Figure 4.21 Base principle of differential protection

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

a) Through flowing current 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 side:

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

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

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

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 side only:

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

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

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

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 4.22. 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 or from the input c.t.s 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 4.4.4.

The currents I_{diff} and I_{stab} are compared by the differential protection with the operating characteristic according to Figure 4.22. If the quantities result into a locus in the tripping area, trip signal is given.

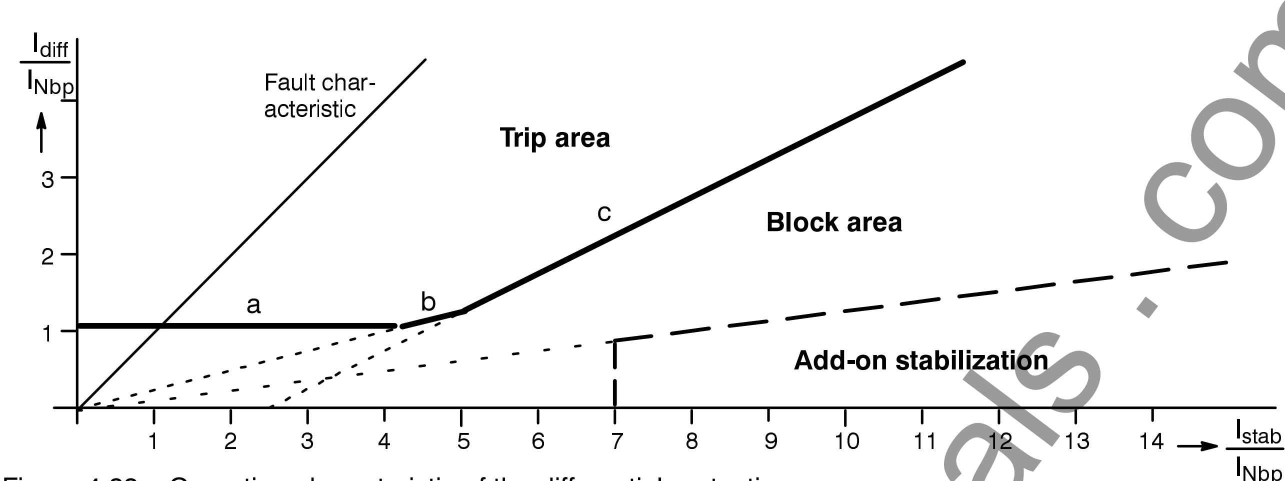


Figure 4.22 Operation characteristic of the differential protection

4.4.4 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 in the protected branch point area), 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 4.22 is principally valid in this case, too. Of course, the fundamental wave of the differential current must exceed at least the pick-up threshold (branch a in Figure 4.22).

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 measuring points. If the quantities I_{diff}/I_{stab} result in an operating point which lies in the trip area of the operating characteristic (Figure 4.22), trip signal would be the consequence if there were no special measures.

7UT51 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 4.22. The slope of this characteristic corresponds to half the slope of the branch b.

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 4.22). 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 a selectable time (8 periods at the longest corresponding to 160 ms at 50 Hz, when the relay is delivered). 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 in the protected branch point area reliably even during an external fault with current transformer saturation.

4.4.5 Pick-up / Tripping

As soon as the fundamental wave of the differential current exceeds 85 % of the set value or the stabilizing current exceeds 4 times the rated branch point current, the protection picks up. Thus, pick-up occurs also in case of external faults, so that fault recording and saturation indicator can operate.

If the trip conditions are fulfilled trip signal is issued. For special cases, the trip command can be delayed. Figure 4.23 shows a simplified tripping logic.

Reset of pick-up is initiated when, during 2 periods, pick-up is no longer recognized in the differential values, i.e. the differential current has fallen below 70 % of the set value.

If a trip command has not been initiated, the fault is considered to be over. If a trip command has been formed, then a timer of settable duration can be started upon reset of pick-up. During this time the trip command is held in (reset time delay).

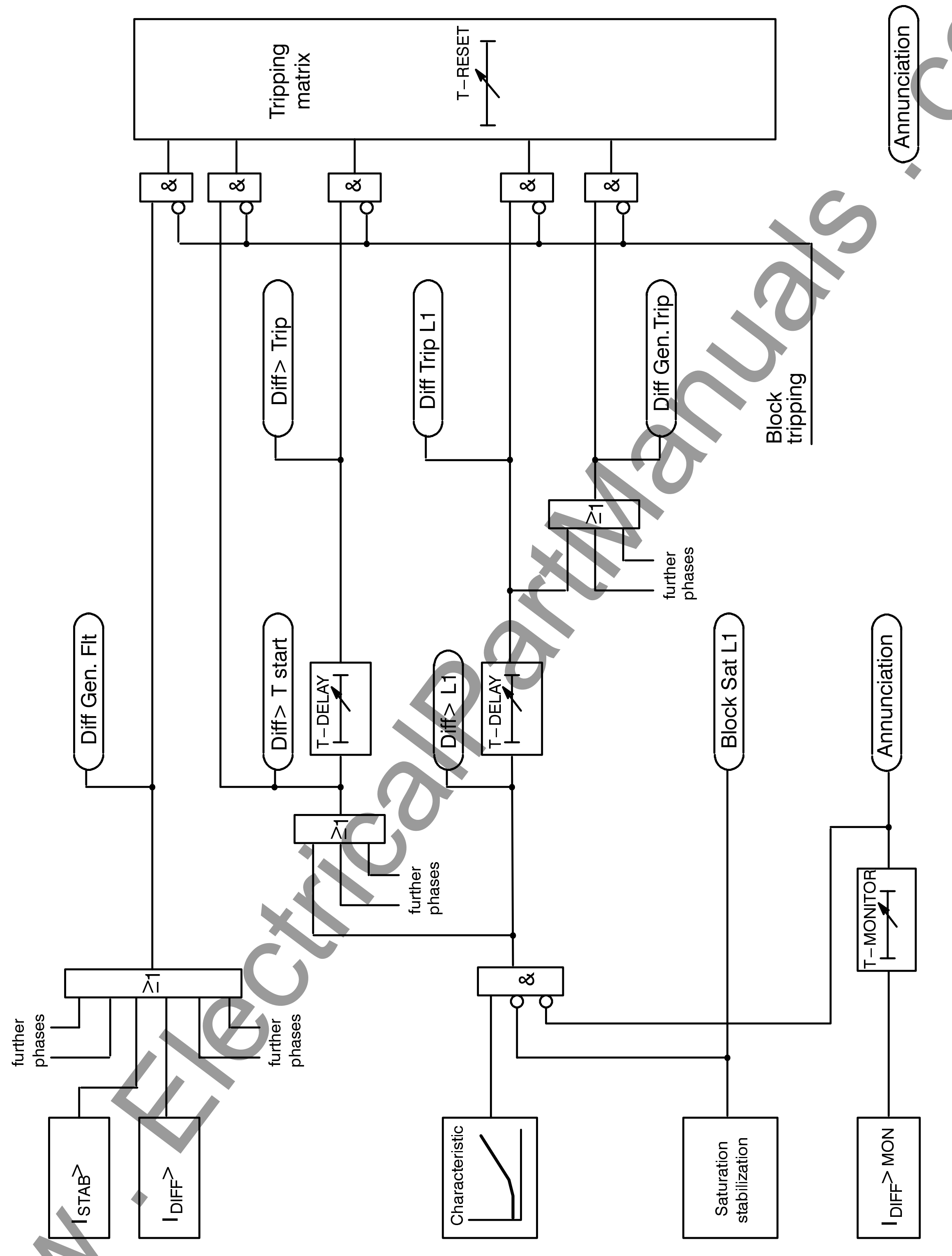


Figure 4.23 Tripping logic of branch point differential protection (one measuring system) − scheme

4.5 Restricted earth fault protection (optional with 7UT513)

4.5.1 Principle of restricted earth fault protection

The restricted earth fault protection detects earth faults in power transformers, shunt reactors, neutral grounding transformers, or rotating machines, the star point of which is led to earth. It is also suitable when an artificial star point is formed within a protected zone of a non-earthed power transformer. A pre-condition is that a current transformer is installed in the star-point lead, i.e. between the star-point and earth. The star-point c.t. and the three phase c.t.s define the limits of the protected zone exactly.

Examples are illustrated in the figures 4.24 to 4.26.

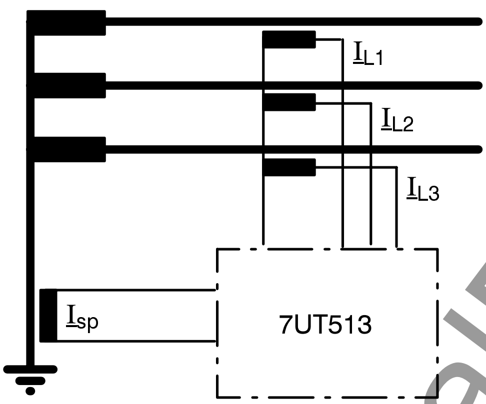


Figure 4.24 Restricted earth fault protection on an earthed transformer winding

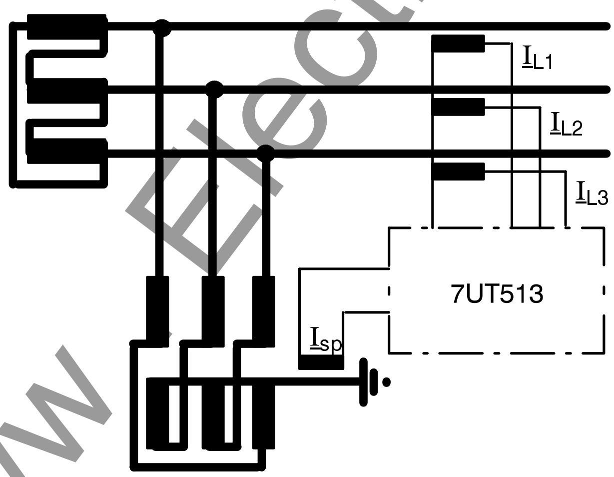


Figure 4.25 Restricted earth fault protection on a transformer delta winding with artificial star-point

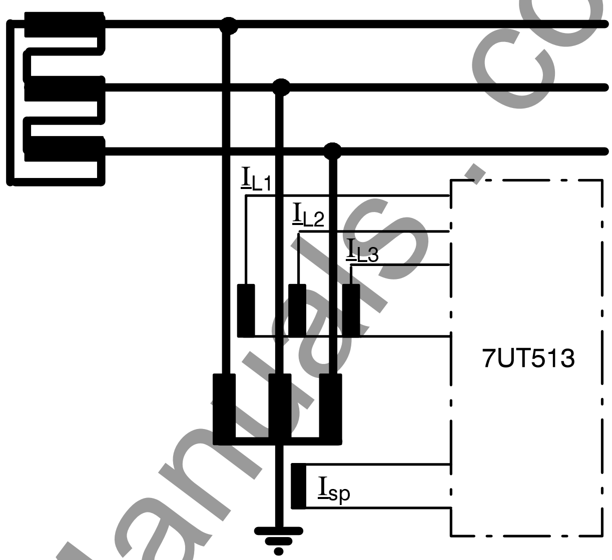


Figure 4.26 Restricted earth fault protection on a shunt reactor

During healthy operation, no star point current $\underline{I}_{sp}$ flows through the star-point lead, the sum of the phase currents $\underline{I}_{L1} + \underline{I}_{L2} + \underline{I}_{L3}$ is zero, too.

When an earth fault occurs in the protected zone, a star-point current $\underline{I}_{sp}$ will flow; depending on the earthing conditions of the power system a further earth current can be recognized in the residual current path of the phase current transformers. As all current which flow into the protected zone are defined positive, the residual current from the system will be more or less in phase with the star-point current.

When an earth fault occurs outside the protected zone, a star-point current will flow equally; but the residual current of the phase current transformers is now of equal magnitude and in phase opposition with the star-point current.

When a fault without earth connection occurs outside the protected zone, a residual current may occur in the residual current path of the phase current transformers which is caused by different saturation of the phase current transformers under strong through-current conditions. This current could simulate a fault in the protected zone. Wrong tripping must be avoided under such condition. For this, the restricted earth fault protection provides stabilization methods which differ strongly from the usual stabilization methods of differential protection schemes.

4.5.2 Evaluation of the measured quantities

The restricted earth fault protection compares the fundamental wave of the current flowing in the star-point lead, which should be designated as $\underline{I}_0'$ in the following, with the fundamental wave of the sum of the phase currents, which should be designated in the following with $\underline{I}_0''$. Thus, the following applies (Figure 4.27):

$$\underline{I}_0' = \underline{I}_{sp}$$
$$\underline{I}_0'' = \underline{I}_{L1} + \underline{I}_{L2} + \underline{I}_{L3}$$

Only $\underline{I}_0'$ act as the tripping effect quantity, during a fault within the protected zone this current is always present.

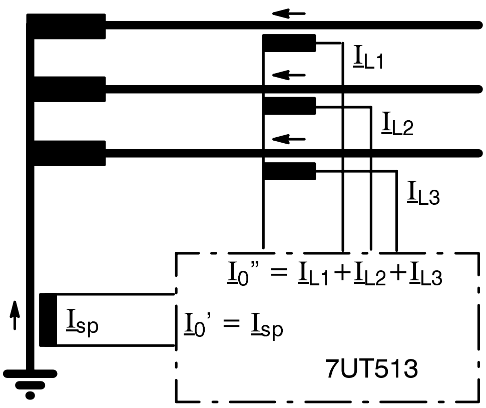


Figure 4.27 Principle of restricted earth fault protection

When an earth fault occurs outside the protected zone, another earth current $\underline{I}_0''$ flows though the phase current transformers. This is, on the primary side, in counter-phase with the star-point current and has equal magnitude. The maximum information of the currents is evaluated for stabilization: the magnitude of the currents and their phase position. The following is defined:

A tripping effect current

$$I_{REF} = |\underline{I}_0'|$$

and the stabilization or restraining current

$$I_{stab} = k \cdot \big(|\underline{I}_0' - \underline{I}_0''| - |\underline{I}_0' + \underline{I}_0''|\big)$$

where k is a stabilization factor which will be explained below, at first we assume k = 1. I_{REF} is derived from the fundamental wave and produces the tripping effect quantity, I_{stab} counteracts this effect.

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

a) Through flowing current on an external earth fault:

$\underline{I}_0''$ is in phase opposition with $\underline{I}_0'$ and of equal magnitude i.e. $\underline{I}_0'' = -\underline{I}_0'$

$$I_{REF} = |\underline{I}_0'|$$
$$I_{stab} = |\underline{I}_0' + \underline{I}_0'| - |\underline{I}_0' - \underline{I}_0'| = 2 \cdot |\underline{I}_0'|$$

The tripping effect current (I_{REF}) equals the star point current; stabilization (I_{stab}) corresponds to twice the tripping effect current.

b) Internal earth fault, fed only from the star point:

In this case $\underline{I}_0'' = 0$

$$I_{REF} = |\underline{I}_0'|$$
$$I_{stab} = |\underline{I}_0' - 0| - |\underline{I}_0' - 0| = 0$$

The tripping effect current (I_{REF}) equals the star point current; stabilization (I_{stab}) is zero, i.e. full sensitivity during internal earth fault.

c) Internal earth fault, fed from the star point and from the system, e.g. with equal earth current magnitude:

In this case $\underline{I}_0'' = \underline{I}_0'$

$$I_{REF} = |\underline{I}_0'|$$
$$I_{stab} = |\underline{I}_0' - \underline{I}_0'| - |\underline{I}_0' + \underline{I}_0'| = -2 \cdot |\underline{I}_0'|$$

The tripping effect current (I_{REF}) equals the star point current; the stabilizing quantity (I_{stab}) is negative and, therefore, set to zero, i.e. full sensitivity during internal earth fault.

This result shows that for internal fault no stabilization is effective since the stabilization quantity is either zero or negative. Thus, small earth current can cause tripping. In contrast, strong stabilization becomes effective for external earth faults. Figure 4.28 shows that the stabilization is the strongest when the residual current from the phase current transformers is high (area with negative $\underline{I}_0''/\underline{I}_0'$). With ideal current transformers, $\underline{I}_0''/\underline{I}_0'$ would be -1.

If the star point current transformer is designed weaker than the phase current transformers (e.g. by selection of a smaller overcurrent factor or by higher secondary burden), no trip will be possible under through-fault condition even in case of saturation as the magnitude of $\underline{I}_0''$ is always higher than that of $\underline{I}_0'$.

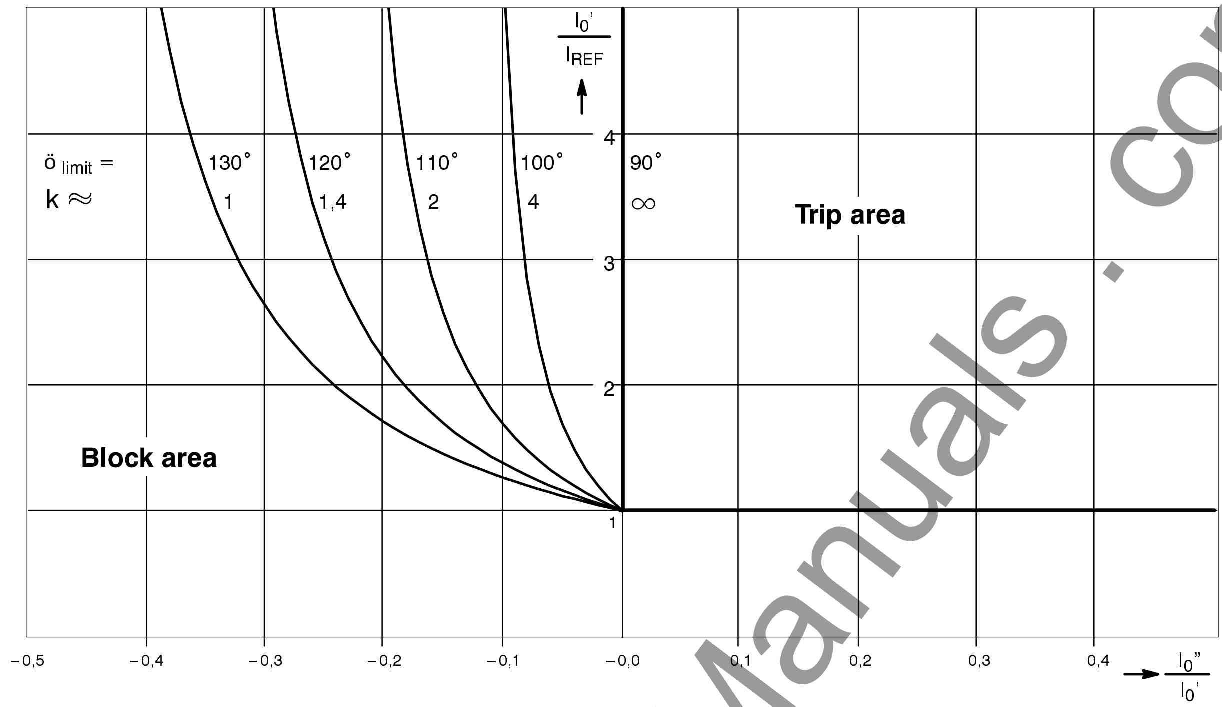


Figure 4.28 Operation characteristic of the restricted earth fault protection dependent of the earth current feeding ratio I_0''/I_0' (both currents in phase or counter-phase); I_{REF} = setting value

It was assumed in the above examples that the currents $\underline{I}_0''$ and $\underline{I}_0'$ are in counter-phase for external earth faults which is only true for the primary measured quantities. Current transformer saturation may cause phase shifting between the fundamental waves of the secondary currents which reduces the stabilization quantity. If the phase displacement ö($\underline{I}_0''$;$\underline{I}_0'$) = ±90° then the stabilizing quantity is zero. This corresponds to the conventional method of direction determination by use of the vectorial sum and difference comparison (Figure 4.29).

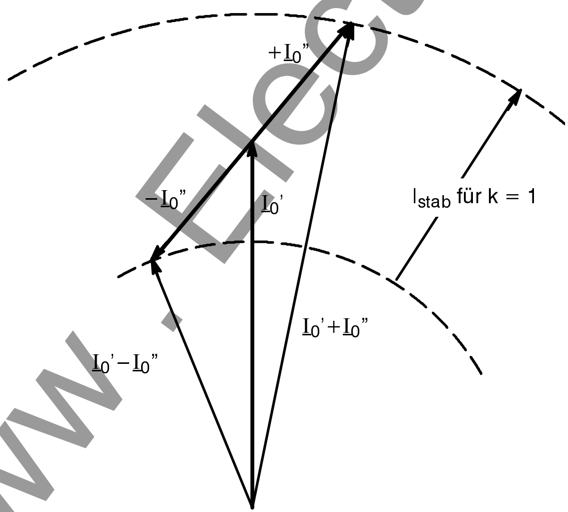


Figure 4.29 Phasor diagram of the stabilizing quantity during external earth fault

The stabilizing quantity can be influenced by means of a factor k. This factor has a certain relationship to the limit angle $ö_{limit}$ which can be selected in 7UT51. This limit angle determines, for which phase displacement between $\underline{I}_0''$ and $\underline{I}_0'$ the pick-up value grows to infinity when $\underline{I}_0''$ = $\underline{I}_0'$, i.e. no pick-up occurs. The highest stability is $ö_{limit}$ = 90°; then is k = ∞. For phase displacement −90° ≤ ($\underline{I}_0''$;$\underline{I}_0'$) ≤ +90° the tripping effect quantity is exclusively present, for other phase displacement the stabilizing quantity is ∞.

Figure 4.30 shows the operating characteristics of the restricted earth fault protection dependent of the phase displacement between $\underline{I}_0''$ and $\underline{I}_0'$, for a constant infeed ratio $|\underline{I}_0''| = |\underline{I}_0'|$. Table 1 shows the relation between the setting of the limit angle $ö_{limit}$ and the stabilization factor k.

$ö_{limit}$	130°	120°	110°	100°	90°
k ≈	1	1,4	2	4	∞

Table 4.1 Relationship between limit angle $ö_{limit}$ and stabilizing factor k

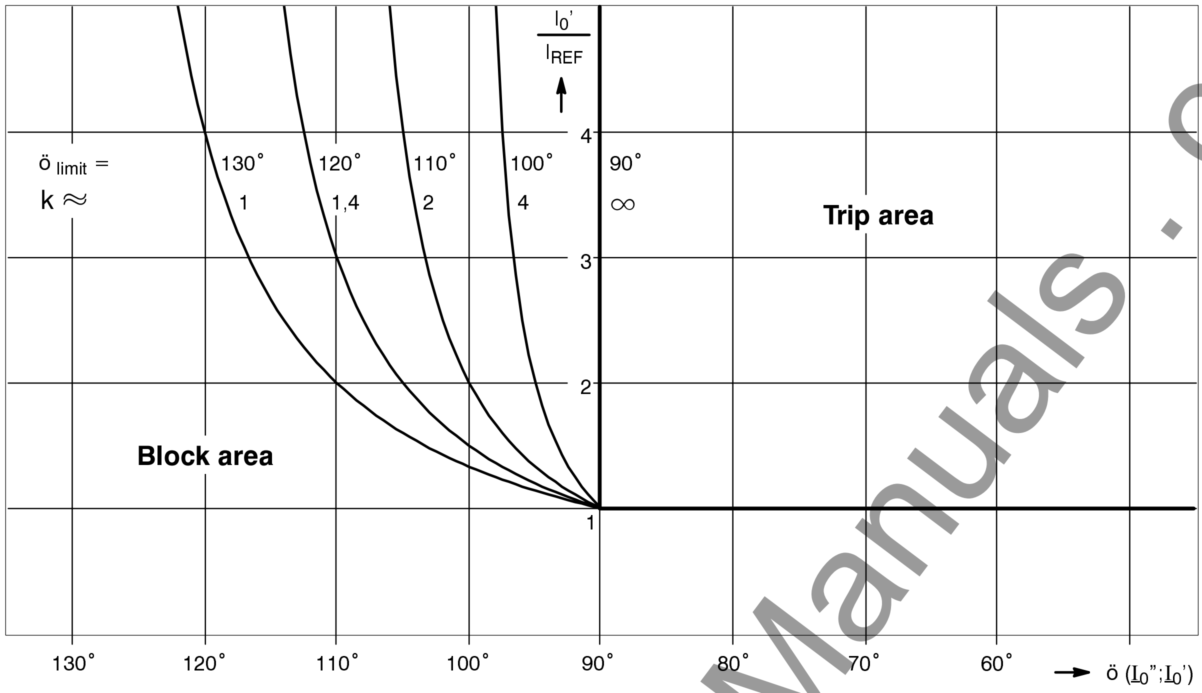


Figure 4.30 Operation characteristic of the restricted earth fault protection dependent on the phase angle between I_0" and I_0' at I_0" = I_0' (180° = external fault)

4.6 Overcurrent time protection

The differential protection 7UT51 provides an integrated overcurrent time protection. This can operate on any of the terminals of the protected object. With 7UT512, the overcurrent time protection can operate on the higher voltage side or the lower voltage side of a power transformer, or the terminal side or the star-point side of a generator or motor, or on any end of a two terminal branch point. With 7UT513, the overcurrent time protection can operate on any side of a three-winding power transformer or three-terminal branch point. If 7UT513 is used for a two-winding power transformer, a generator or motor, or a two-terminal branch point, the overcurrent time protection can operate on any other protected object, the ”virtual object”, if desired.

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 3.10, Section 3.6.

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

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

The pick-up values of the overcurrent time protection are always related on the rated current of the protected feeder. This means, in case of a transformer, the rated current of the winding which is derived from the rated power and the rated voltage of that winding, in case of generators or motors, the rated current of that machine, or, in case of a branch point, the rated current of that branch.

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.

4.7 Thermal overload protection

The overload protection prevents the protected object from damage caused by thermal overloading. In 7UT51, two overload protection functions are available, each of which can be switched on any of the terminals of the protected object.

With 7UT512, each overload protection can operate on the higher voltage side or the lower voltage side of a power transformer, or the terminal side or the star point side of a generator or motor, or on any end of a two terminal branch point. With 7UT513, any side of a three-winding power transformer or three-terminal branch point can be selected. If 7UT513 is used for a two-winding power transformer, a generator or motor, or a two-terminal branch point, the overload protection can operate on any other protected object, the "virtual object", if desired.

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

$$\frac{dQ}{dt} + \frac{1}{t} \cdot Q = \frac{1}{t} \cdot I^2$$

with Q – actual temperature rise related on the final temperature rise for the maximum permissible current $k \cdot I_N$

t – thermal time constant for heating-up of the winding

I – actual winding current (r.m.s. value) referred to the maximum permissible winding current $I_{max} = k \cdot I_N$

The temperature rises are calculated from each of the phase currents. A choice can be made whether evaluation is carried out from the highest of the three phase temperature rises, the mean value of the three temperature rises, or the temperature rise cause by the the highest of the three currents.

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 protected object can be disconnected from the network. A further overcurrent warn stage is available.

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

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

For the overload protection, I_N is the rated current of the protected feeder. For power transformers, I_N is taken from the rating of the protected winding; in case of generators or motors, I_N is the rated current of that machine; in case of a branch point, I_N is the rated current of that branch point.

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

4.8 Tank leakage protection (optional with 7UT513)

The tank leakage protection has the task to detect earth leakage – even high-ohmic – between a phase and the frame of a transformer. The tank must be isolated from earth (refer Figure 4.31). A conductor links the tank to earth, and the current through this conductor is fed to a current input of the relay. When a tank leakage occurs, a fault current (tank leakage current) will flow through the earthing conductor to earth. This tank leakage current is detected by the tank leakage protection as an overcurrent; an instantaneous or delayed trip command is issued in order to disconnect all sides of the transformer.

A choice can be made whether the tank leakage protection evaluates the fundamental wave of the tank current or its true r.m.s. value.

The model 7UT513★–★★★**2**★ provides a high-sensitivity current input for tank leakage protection which allows a setting range of 10 mA to 1000 mA. It is also possible to connect the tank leakage current to a standard current input of the relay; in this case, the setting range is 0.1 to 10 times the rated current of the relay.

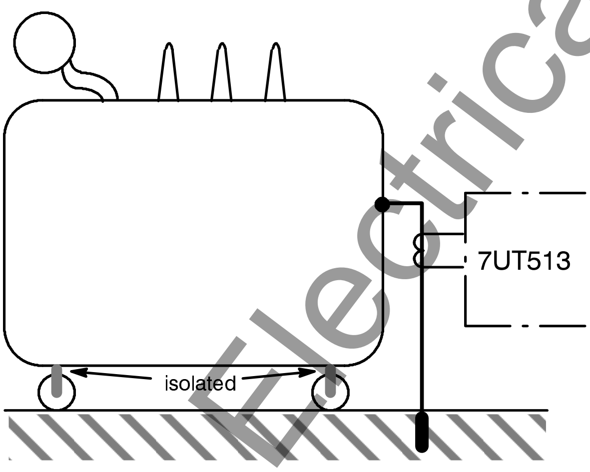


Figure 4.31 Tank leakage protection (principle)

4.9 Processing of external trip signals and user definable annunciations

Two desired trip signals from an external protection or supervision unit can be incorporated into the processing of 7UT51. The signals are coupled into the relay as ”External signals” via two binary inputs. Like the internal protection and supervision signals, they can be annunciated, delayed, and transmitted to the trip relays.

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

4.10 Tripping matrix

The digital differential protection 7UT51 includes an integrated tripping matrix. The tripping matrix represents the switching centre of the protection: The cross-bar distributor between the protection trip signals and the switching elements in the plant.

The command signals output by the different protective functions, as described in sections 4.2 to 4.9, can be marshalled to the 2 (7UT512) or 5 (7UT513) trip relays of the unit as required. External signals such as, for example, from the Buchholz protection, pressure or temperature supervision, etc., can be coupled into the 7UT51 via binary inputs and marshalled to the trip relays via the trip matrix. Each trip relay is assigned to a switching element, such as a circuit breaker, de-excitation circuit breaker, trip valve, or other control gear.

The procedure for programming the trip matrix and also the marshalling condition as delivered from factory are described in detail in Section 5.5.5.

4.11 Ancillary functions

The ancillary functions of the current differential protection 7UT51 include:

– processing of annunciations,

– storage of the short-circuit data for fault recording,

– operational current measurements,

– monitoring functions.

4.11.1 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 important for an exact analysis of the history of the fault. For this purpose, the device provides signals and indications which are effective in three levels.

4.11.1.1 Indications and binary outputs (signal relays)

Important events and conditions are indicated by optical indicators (LED) on the front plate. The unit also contains signal relays for remote indication. Most of the signals and indications can be marshalled, i.e. they can be assigned meanings other than the factory setting. Section 5.5 describes in detail the conditions as set by the factory and the marshalling facilities.

The signal relays operate in an unstored mode and reset after the indicated criterion disappears. The LED indicators can be operated in a stored or unstored mode.

The memories of the indicators can be saved against power outage. They are reset:

– locally, via the keyboard on the front,

– remotely by energizing the binary remote reset input,

– remotely via one of the serial interfaces,

– automatically on each new pick-up of the relay.

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

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

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

4.11.1.2 Information on the display panel or to a personal computer

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

In the quiescent state, i.e. as long as no network faults are present, the display outputs selectable operating information (usually an operational measured value) in each of the two lines. In the event of a network fault, selectable information on the fault appears instead of the operating information, e.g. detected phase(s) and the protection function which has tripped. 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 4.11.1.1.

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

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

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

4.11.1.3 Information to a central unit (optional)

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

4.11.2 Data storage and transmission for fault recording

The instantaneous values of the measured values

i_{L1}, i_{L2}, i_{L3}

of each transformer winding or generator or motor c.t. set or each terminal of a branch point as well as

i_A and i_B (additional inputs at 7UT513)

are sampled at 1.66 ms intervals (for 50 Hz) and stored in a circulating shift register. In case of a fault, the data are stored over a selectable time period, but max. over 5 seconds. The maximum number of fault records within this time period is 8. These data are then available for fault analysis. For each renewed fault event, the actual new fault data are stored without acknowledgement of the old data.

The data can be transferred to a connected personal computer via the operation interface at the front and evaluated by the protection data evaluation program DIGSI®. The currents 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. ”Trip”.

Additionally, the fault record data can be transmitted to a control centre via the serial system interface (if fitted). Evaluation of the data is made in the control centre, using appropriate software programs. The currents and voltages are referred to their maximum values, normalized to their rated values and prepared for graphic visualization. In addition, signals can be marked as binary traces, e.g. ”Trip”.

When the data are transferred to a control centre, recalling can proceed automatically, i.e. after each pick-up of the relay or trip command. The following then applies:

– The relay signals the availability of fault record d ata.

– The data remain available for recall until they are overwritten by new data.

– A transmission in progress can be aborted by the central unit.

4.11.3 Routine operational measurements and load data

The r.m.s. values of all phase currents are constantly available for recall locally or for remote data transfer. In the front display or via the operating interface, additionally, the currents of the restricted earth fault and the data calculated by the overload protection are constantly available.

The following applies:

– $I1_{L1}$, $I1_{L2}$, $I1_{L3}$
  phase currents of the first terminal (winding 1 of transformer, star point sided c.t.s of generator or motor, feeder 1 of branch point) in amps primary and in % of rated relay current,

– $I2_{L1}$, $I2_{L2}$, $I2_{L3}$
  phase currents of the second terminal (winding 2 of transformer, terminal sided c.t.s of generator or motor, feeder 2 of branch point) in amps primary and in % of rated relay current,

– $I3_{L1}$, $I3_{L2}$, $I3_{L3}$ in 7UT513
  phase currents of the third terminal (winding 3 of transformer, feeder 3 of branch point, or the currents of the "virtual object") in amps primary and in % of rated relay current,

– I_A, I_B in 7UT513
  currents of the earth current c.t.s in amps primary and in % of rated relay current; for the high-sensitivity input for tank leakage protection in milliamps,

– $Q/Q_{trip\ L1}$, $Q/Q_{trip\ L2}$, $Q/Q_{trip\ L3}$
  calculated temperature rise in % of the trip temperature rise for each terminal for which an overload protection function is effective,

  I_{tank} in 7UT513
  tank leakage current for models with tank leakage protection.

4.11.4 Monitoring functions

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

4.11.4.1 Hardware monitoring

The unit is supervised from the measurement inputs to the command relays. Details are as follows:

– Auxiliary and reference voltages

  The processor monitors the auxiliary voltages for the multiplexer and offset and reference voltages for the ADC (Analog/Digital Converter). The protection is blocked as soon as impermissible deviations occur; permanent faults are annunciated.

  Failure or switch-off the auxiliary voltage automatically puts the system out of operation; this status is indicated by a fail-safe contact. Transient dips in supply voltage of less than 50 ms will not disturb the function of the relay ($U_H \geq 110$ V).

– Trip circuits:

  The command relays are controlled by two command channels and one additional release channel. Discontinuities and short-circuits in the relay control circuits are monitored.

– Memory modules:

  A cyclic checksum is formed for the program memory (EPROM), the parameter assignment memory (EEPROM) and the working memory (RAM) and compared with the stored checksum. (The checksum of EEPROMs is calculated during each new parameter assignment process.)

4.11.4.2 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 the availability relay, thus indicating ”equipment fault” and simultaneously the LED ”Blocked” comes on.

4.11.4.3 Monitoring of external measuring transformer circuits

To detect interruptions or short circuits in the external measuring transformer circuits or faults in the connections (an important commissioning aid) the measured values are checked at cyclic intervals, as long as no pick-up condition exists:

– Current symmetry

In healthy operation it can be expected that the currents will be approximately symmetrical. The following applies:

$|I_{min}|/|I_{max}| < \text{SYM.Fact.I}$
if
$I_{max} / I_N > \text{SYM.Ithres} / I_N$

I_{max} is always the largest of the three phase currents and I_{min} always the smallest. The symmetry factor SYM.Fact.I represents the magnitude of asymmetry of the phase currents, and the threshold SYM.Ithres is the lower limit of the processing area of this monitoring function (see Figure 4.32). Both parameters can be set (see Section 6.3.14).

For each of the terminals of the protected object (winding of a power transformer, terminal and star-point side of a generator or motor, feeder of a branch point, and, if applicable, the ”virtual object”, a current symmetry monitor is available; asymmetry is selectively annunciated.

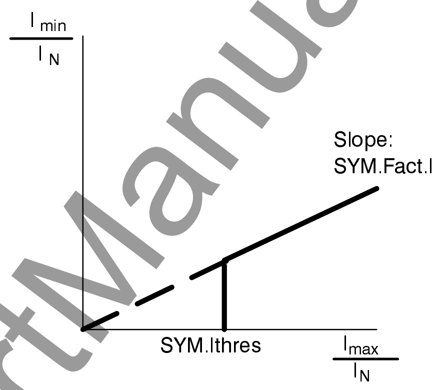


Figure 4.32 Current symmetry monitoring

– Current sum monitor

If the relay is used as branch-point protection, the differential currents are supervised on a low level. This supervision operates for each phase. A defect in the secondary circuits of the current transformers is assumed when a differential current with the magnitude of load currents is detected during normal operation. This is annunciated with a short delay and, at the same time, the differential protection is blocked.

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 7UT51★★–★D★★★ for panel surface mounting

– Secure the unit with four screws to the panel. For dimensions refer to Figure 2.2.

– Connect earthing terminal (Terminal 16 at 7UT512 or terminal 26 at 7UT513) 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 7UT51★★–★C★★★ for panel flush mounting or 7UT51★★–★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 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 rear of the unit using at least one standard screw M4, and the earthing continuity system of the panel or cubicle; recommended grounding strap DIN 72333 form A, e.g. Order-No. 15284 of Messrs Druseidt, Remscheid, Germany.

– Make connections via the screwed or snap-in terminals of the sockets of the housing. Observe labelling of the individual connector modules to ensure correct location; observe the max. permissible conductor cross-sections. The use of the screwed terminals is recommended; snap-in connection requires special tools and must not be used for field wiring unless proper strain relief and the permissible bending radius are observed.

5.2.2 Checking the rated data

The rated data of the unit must be checked against the plant data. This applies in particular to the auxiliary voltage and the rated current of the current transformers.

5.2.2.1 Different rated currents

If the current transformer sets at the terminals of the protected object have different secondary rated currents, then matching can be performed on the input/output p.c.b. In this case the following should be noted:

– It is advisable to order the 5 A model as the current inputs can be easily changed into 1 A rated by removing bridges.

– Do not insert or withdraw module(s) under voltage.

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.

It depends on the hardware state (production series) of the relay how this is carried out. This state is found on the name plate behind the complete order designation.

The following is valid for production series /**JH**:

– In order to change a 5 A input into an 1 A input, solder bridges must be removed. Cut and bend them aside. Figures 5.1 and 5.2 show reconnection of the rated currents (Figure 5.2 for 7UT513 only).

The following is valid for production series /**KK** or later:

– In order to change a 5 A input into an 1 A input, bridges or jumpers must be removed. Figure 5.5 shows reconnection of the rated currents with solder bridges, for the first and second terminal side of the protected object. Cut and bend them aside. Figure 5.6 shows reconnection of the rated currents with plug jumpers, for the third terminal side of the protected object (for 7UT513 only).

Setting for the first terminal of protected object (primary)
I_N = 5 A ac: bridges in place
I_N = 1 A ac: bridges removed

All three bridges must be in the same position!

Setting for the second terminal of the protected object (secondary)
I_N = 5 A ac: bridges in place
I_N = 1 A ac: bridges removed

All three bridges must be in the same position!

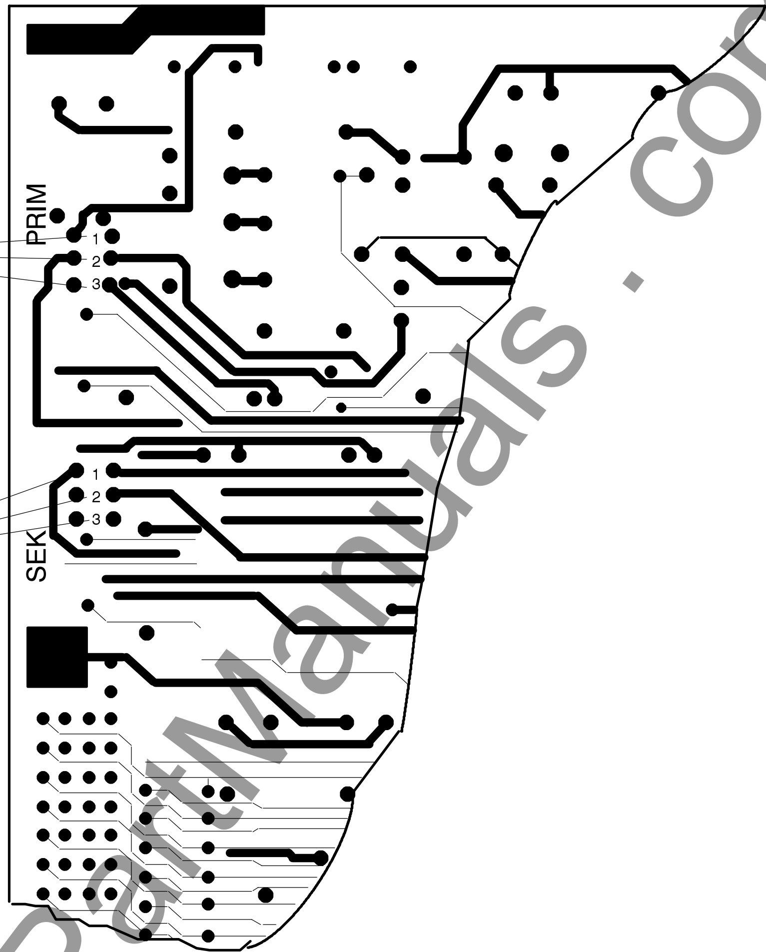


Figure 5.1 Setting of the rated current 1 A/5 A on the basic module (□ in Figures 6.1 and 6.2), up to production series /JH

Only for 7UT513:

Setting for additional current input I_B
I_N = 5 A ac: bridge in place
I_N = 1 A ac: bridge removed
(models 7UT513*–*****–1***)

Note: Bridge 5 has no influence in case I_B is the highly sensitive current input (models 7UT513*–*****–**2*****)

Setting for additional current input I_A
I_N = 5 A ac: bridge in place
I_N = 1 A ac: bridge removed
(models 7UT513*–*****–1***)

Setting for the third terminal of the protected object (tertiary)
I_N = 5 A ac: bridges in place
I_N = 1 A ac: bridges removed

All three bridges must be in the same position!

Figure 5.2 Setting of the rated currents 1 A/5 A on the additional module (□ in Figure 6.2), up to production series /JH

5.2.2.2 Control d.c. voltage of binary inputs

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

The following is valid for production series /**JH**:

The binary inputs react on control d.c. voltages in the total voltage range from 19 V to 288 V. The pick-up threshold lies near 17 V. If the rated control voltage for binary inputs is 110 V or higher, it is advisable to fit a higher pick-up threshold to these inputs to increase stability against stray voltages in the d.c. circuits.

To fit a higher pick-up threshold of approximately 65 V to a binary input a solder bridge must be removed. Figure 5.3 shows the assignment of these solder bridges for the inputs BI 1 and BI 2, and their location on the basic p.c.b. of the basic input/output module GEA–1. Figure 5.4 shows the assignment of these solder bridges for the inputs BI 3 to BI 15 and their location on the additional input/output module ZEA–1. The latter is available only in 7UT513.

The following is valid for production series /**KK** or later:

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

Order code 7UT51★★–	Rated auxiliary voltage range	Presetting of binary inputs
2★★★★–★★★★	24/48 Vdc	24 Vdc
4★★★★–★★★★	60/110/125 Vdc	60 Vdc
5★★★★–★★★★	220/250 Vdc	220 Vdc

Table 5.1 Presetting of control voltage for binary inputs for production series /KK

Table 5.2 shows the setting possibilities for the binary inputs BI 1 and BI 2 on the basic p.c.b. of the basic input/output module GEA–2, Table 5.3 for the inputs BI 3 to BI 5 on the additional input/output module ZEA–1 (7UT513 only). The figures 5.3 and 5.4 show the printed circuits boards, viewed from the component side, with the setting plugs for the control voltage of the binary inputs. They are valid for relays from production series /KK. If the actual control voltage is not found on the p.c.b., select the setting for the next lower voltage. The figures show further plugs, which must not be changed.

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

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

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

Binary input on ZEA−2	Settings for rated control voltage 24/48 Vdc	60 Vdc	110/125 Vdc	220/250 Vdc
BI 3	plug 24 V	plug 60 V	plug 110 V	plug 220 V
BI 4	plug 24 V	plug 60 V	plug 110 V	plug 220 V
BI 5	plug 24 V	plug 60 V	plug 110 V	plug 220 V

Table 5.3 Checking for control voltages of binary inputs 3 to 5 on the additional module ZEA−2 (7UT513 only), valid from production series /KK

– Open housing cover.

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

Caution!

Electrostatic discharges via the component connections, the PCB tracks or the connecting pins of the modules must be avoided under all circumstances by previously touching an earthed metal surface.

– Pull out basic module and place onto a conductive surface.

– For production series up to /JH: check the solder bridges according to Figure 5.3, remove bridges where necessary.
For production series from /KK: check the plugs according to Figure 5.5.

– Insert basic module into the housing; ensure that the releasing lever is pushed fully to the left before the module is pressed in.

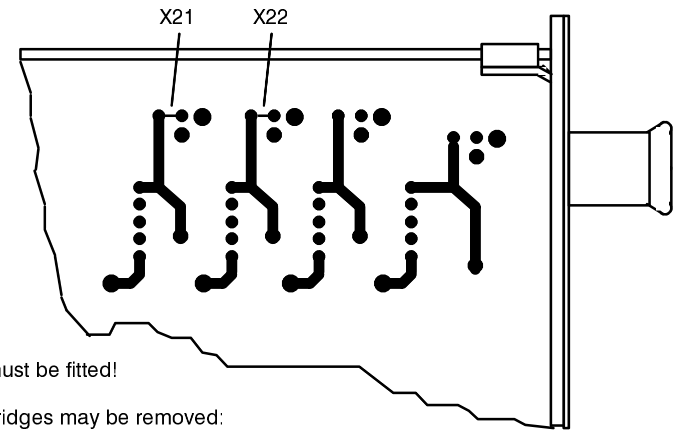
– Firmly push in the module using the releasing lever.

– Similarly check on the additional input/output module ZEA−2 (only for 7UT513).
For production series up to /JH: check solder bridges according to Figure 5.4.
For production series from /KK: check the plugs according to Figure 5.6.

– Close housing cover.

Binary input 1 : Solder bridge X21

Binary input 2 : Solder bridge X22



For rated voltages 24/48/60 V−: Solder bridges must be fitted!

For rated voltages 110/125/220/250 V−: Solder bridges may be removed: cut and bend aside

Figure 5.3 Checking for control voltages for binary inputs 1 and 2 on the basic input/output module GEA−1, up to production series /JH

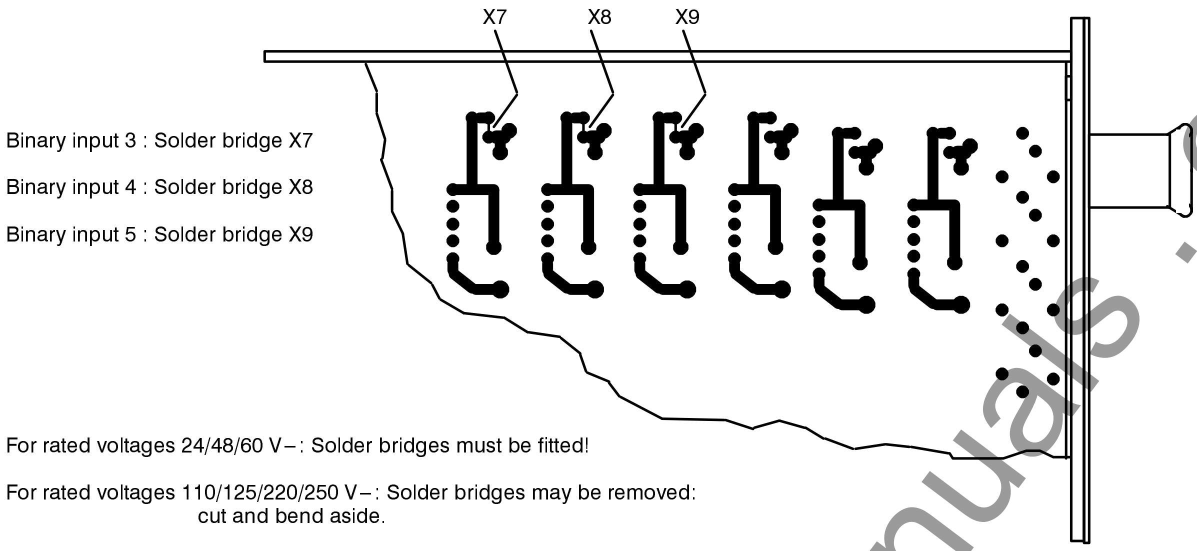


Figure 5.4 Checking for control voltages for binary inputs 3 to 5 on the additional input/output module ZEA–1 (7UT513 only), up to production series /JH

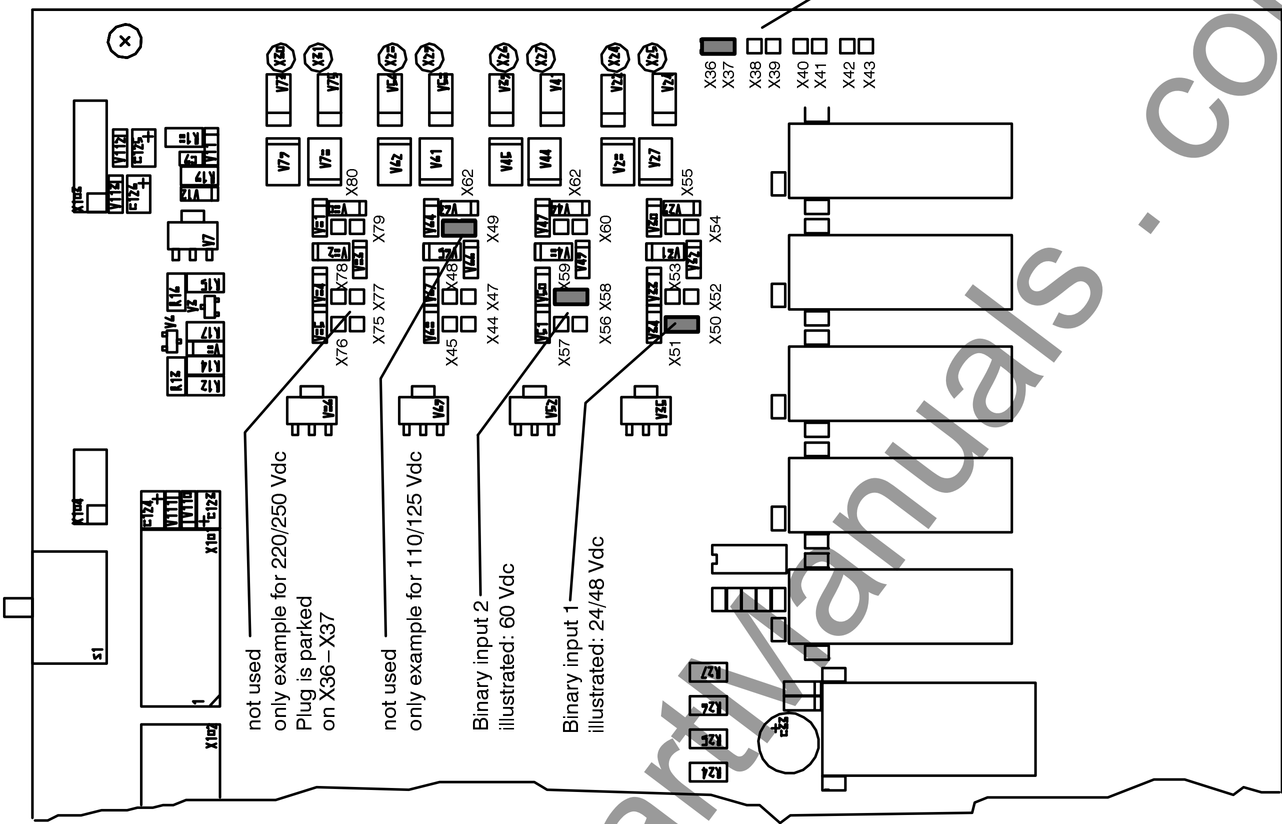
5.2.3 Inserting the back-up battery

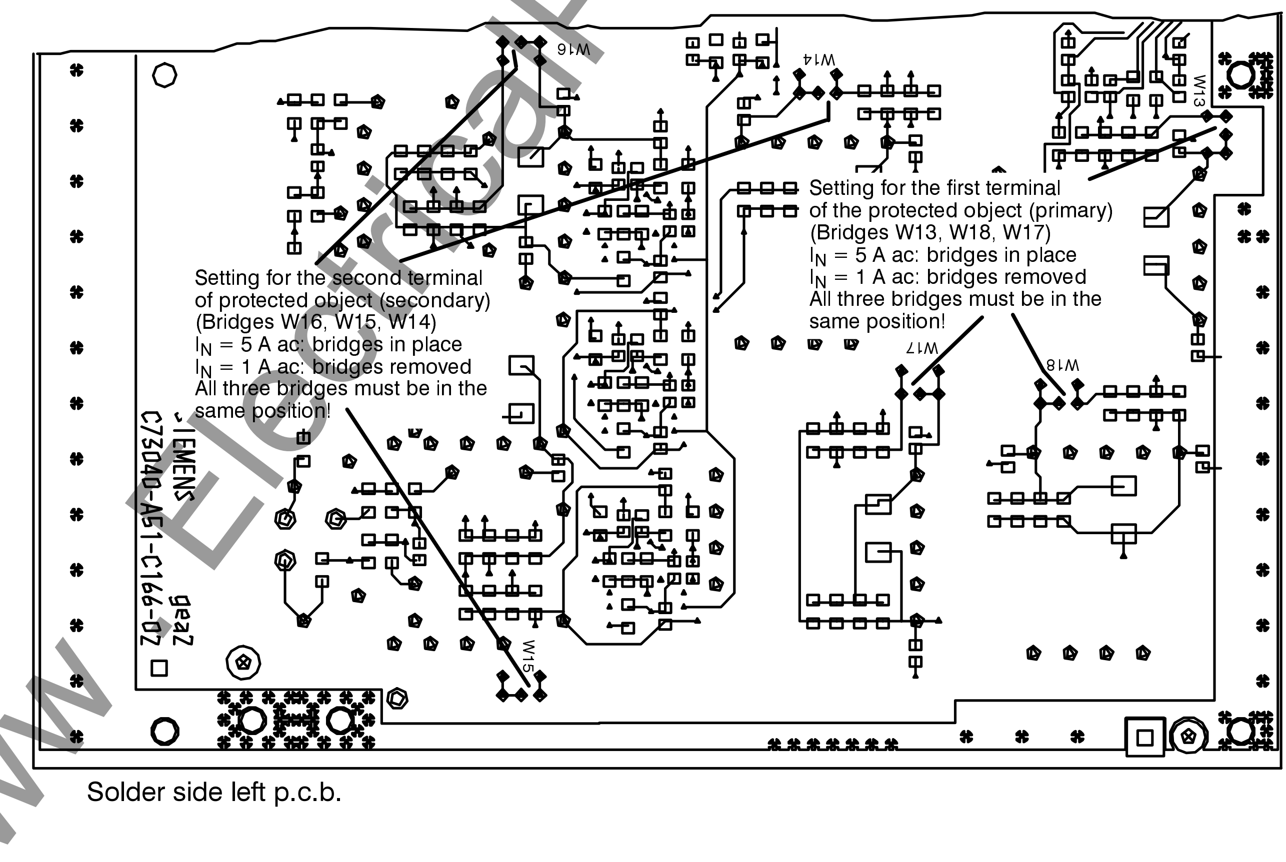
The device annunciations are stored in NV–RAMs. A back-up battery is available so that they are retained even with a longer failure of the d.c. supply voltage. The back-up battery is also required for the internal system clock with calender to continue in the event of a power supply failure.

The battery is supplied separately with relays of production series up to /JH. It should be inserted before the relay is installed. Section 7.2 explains in detail how to replace the back-up battery. Join this section accordingly when inserting the battery for the first time.

When the production series of the relay is /KK or later, the battery is installed at delivery so that no activities are necessary here.

Component side of the left p.c.b.





Solder side left p.c.b.

Figure 5.5 Setting plugs on basic input/output module GEA−2, from production series /KK

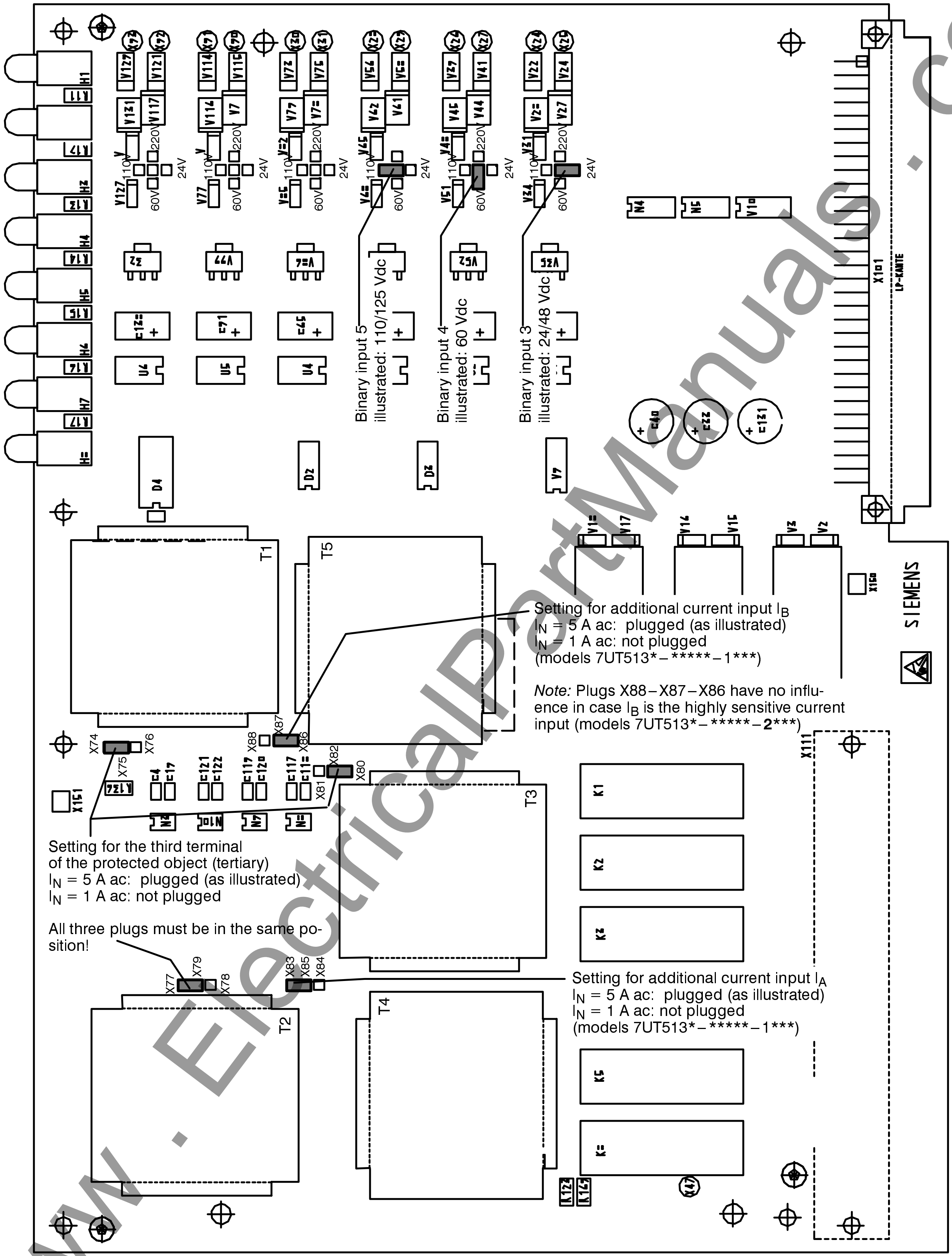


Figure 5.6 Setting plugs on additional input/output module ZEA−2 (7UT513 only), from production series /KK

5.2.4 Checking the LSA transmission link

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

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

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

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

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

Transmission via optical fibre is recommended. It is particularly insensitive against disturbances and automatically provides galvanic isolation. Transmit and receive connector are designated with the symbols —●⟶ 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 X239 which is accessible when the basic input/output module is removed from the case. The jumper is situated in the rear area of the power supply board (centre board) (Figure 5.7).

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

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

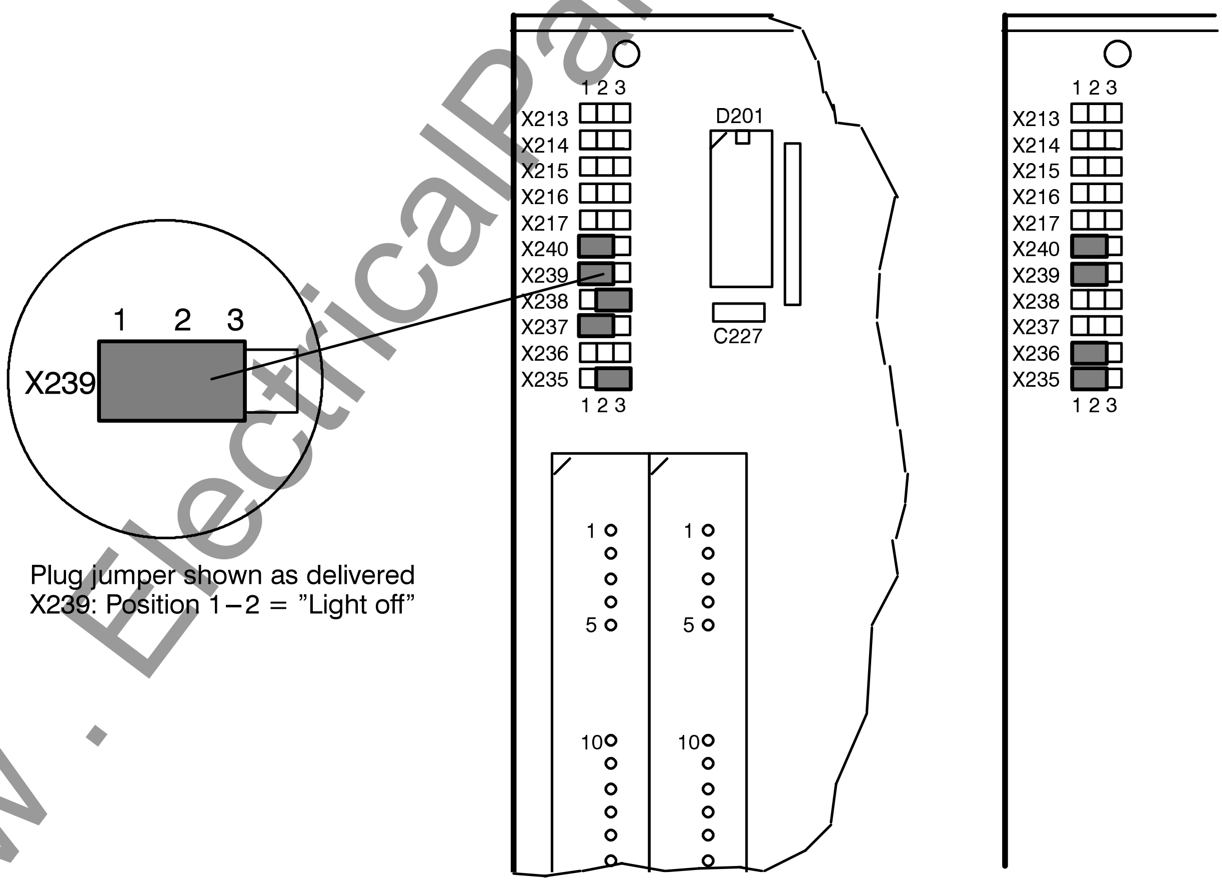


Figure 5.7 Position of the jumper X239 on the power supply board

5.2.5 Connections

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

5.2.5.1 Standard connection 7UT512

With 7UT512, one single standard connection is practically applicable: connection to the current transformer sets which limit the protected object (Figure 5.8). It is imperative to ensure the correct assignment of the current conductors. The polarity of the current transformers is not so important as it can be adapted during parameterizing of the relay.

The only difference arises when the relay is used as transverse differential protection for electrical machines (Figure 5.9). The correct assignment of the c.t. leads is the most important thing, too.

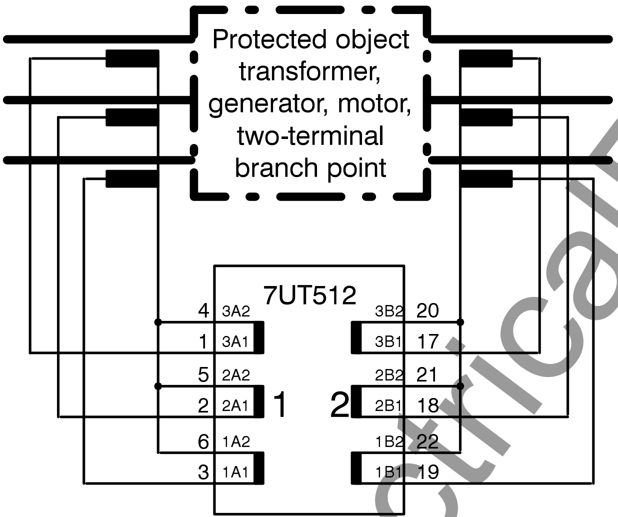


Figure 5.8 Standard connection 7UT512

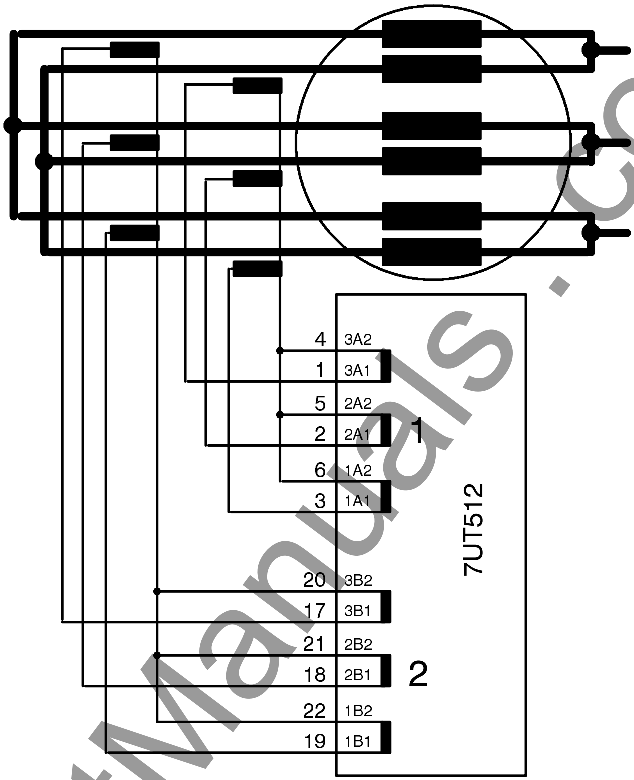


Figure 5.9 Connection of a transverse differential protection

5.2.5.2 Standard connection 7UT513

7UT513 provides three sets of current inputs for three phases each. Connection to a three-winding transformer or three-terminal branch point is shown in Figure 5.10. It is imperative to ensure the correct assignment of the current conductors. The polarity of the current transformers is not so important as it can be adapted during parameterizing of the relay.

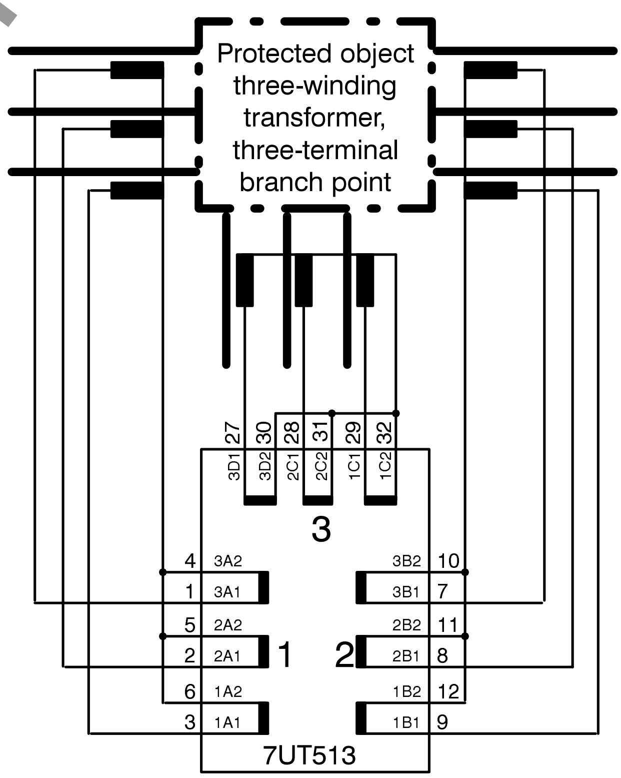


Figure 5.10 Standard connection 7UT513

5.2.5.3 Further connection possibilities 7UT513

Besides the nine current inputs for each of the three sets of three currents, 7UT513 provides two further current inputs which are designated I_A and I_B. These can be connected in different manner, depending on the application. If one of these additional current inputs is to be used, always 7UT513 must be selected even when the protected object has only two feeders.

If the relay is equipped with the tank leakage protection, a choice can be made whether the tank leakage current is connected to the additional current input I_A or I_B. Input I_A is a normal measured current input which allows a setting range of 0.1 to 10 times rated relay current. Connection to the high-sensitivity current input I_B is recommended; in this case a setting range of 10 mA to 1000 mA is possible, independent of the rated currents.. The current input I_A can then be used for another purpose (see below).

In order to increase the sensitivity for earth faults detected by the transformer protection, a current transformer is necessary in the star-point lead of the transformer. The star-point current can be measured either via the current input I_A or I_B. But, in models with tank leakage protection, current input I_A must be used since input I_B is designed for the highly sensitive tank leakage protection. Figure 5.11 show an example for a two-winding transformer. The same connection method applies for an earthed generator or motor. Corresponding connection applies for a three-winding transformer.

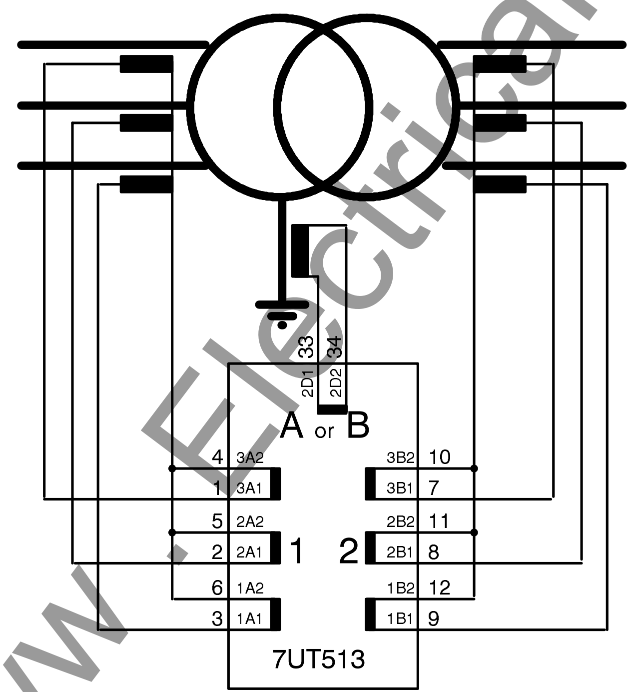


Figure 5.11 Connection to a c.t. in the star point lead

If a transformer is fitted with two earthed star-points then both star-point currents can be used to increase the earth fault sensitivity of the transformer differential protection. The star-point current are to be connected to the additional current inputs I_A and I_B. The assignment of the current inputs to the associated winding is carried out later during configuration.

It is possible to use the tank leakage protection and increased sensitivity for earth fault of *one* winding both at the same time. In this case, the tank leakage protection must be connected to current input I_B, the star-point current to I_A. No connection input remains for a second star-point current.

The connection example of Figure 5.11 is also valid for the connection of a star-point current for restricted earth fault protection. The device provides *one* restricted earth fault protection which can be assigned to any desired winding of the transformer. Combination with the increased sensitivity for a different winding is possible.

If 7UT513 is use for a protected object with two terminals, i.e. two-winding transformers, generator, motor, or a branch-point with two feeders, the connection can be made according to Figure 5.8 or 5.9, too (but observe the different terminal arrangement of 7UT513). In this case, the third measured current input set (which is normally for terminal 3), and, if applicable, the additional current inputs I_A or I_B, may be used for a different protected object, the so-called "virtual object". This "virtual object" can be protected by the integrated overcurrent time protection, one of the thermal overload protection functions, and/or the restricted earth fault protection. An example for the last may be a shunt reactor or artificial star point outside the protected zone. A pre-condition is that a star-point current transformer is available.

Figure 5.12 shows, as an example, a two-winding transformer with connection group Yd5 and an artificial star-point on the delta side, outside the protected zone. The star side of the transformer is connected to the measured current input set 1, the delta side to the measured current input set 2. The measured current input set 3 is not used for the transformer differential protection; it is connected to the phase current transformer set of the artificial star point assembly. The current transformer of the star point lead of the artificial star point assembly is connected to the additional current input I_A. Thus, besides the transformer differential protection, for the power transformer, a restricted earth fault protection for the artificial star point assembly is achieved. The additional measured current input I_B is still available.

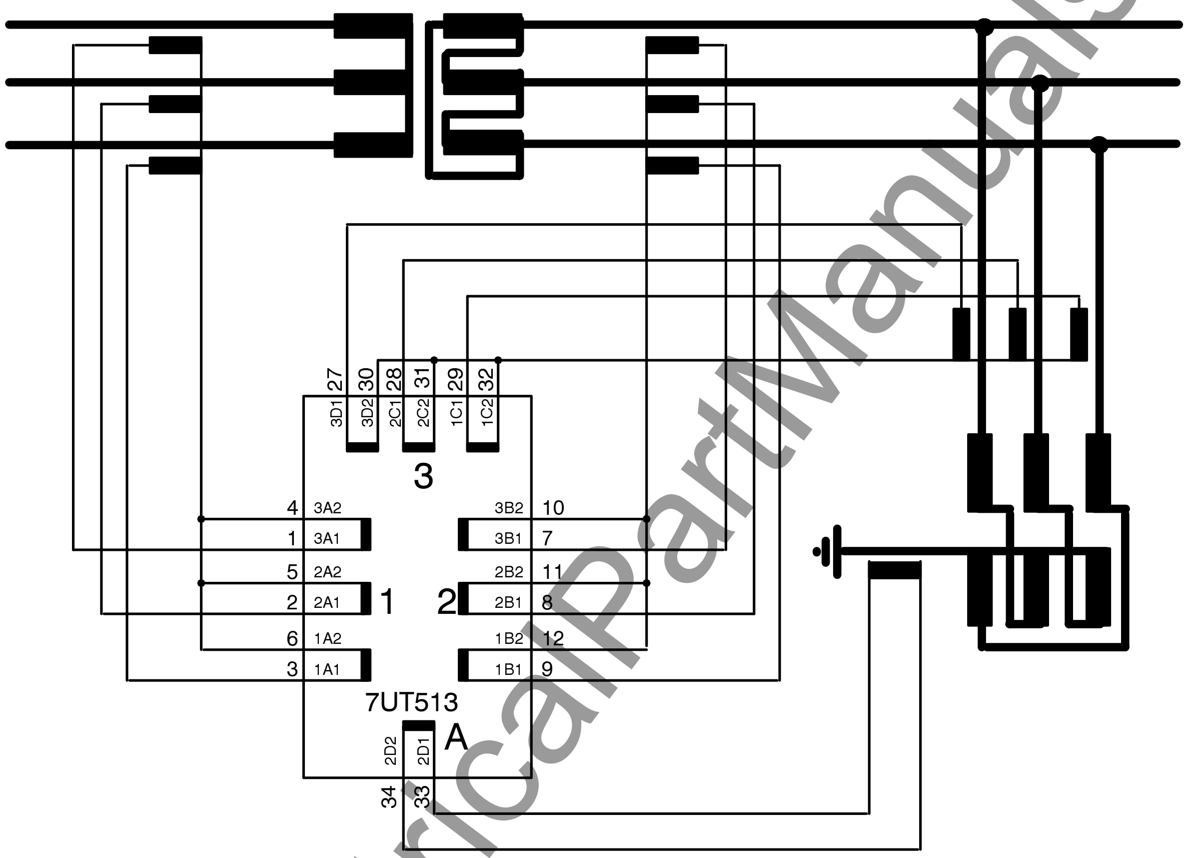


Figure 5.12 7UT513 as differential protection for a two-winding transformer and restricted earth fault protection for a different "virtual object"

5.2.5.4 Considerably different rated powers with three-winding transformers

Different transformation ratios of the current transformer sets are, normally, compensated within the relay by multiplication of the input currents with a matching factor. When the windings of a three-winding transformer have different MVA ratings, the highest power rating is used as the basis of calculation of the rated currents. If, in this case, the matching factor

$$\frac{\text{rated current at rated transformer power}}{\text{rated current of a winding}}$$

is higher than 4, the use of an interposing transformer set is recommended (for this winding) in order to improve the accuracy of the internal calculations. Since the current inputs in the 7UT51 are galvanically isolated from each other, the interposing transformers may be designed as auto-transformers. This better utilizes the power rate of the interposing transformers and the smaller transformer type 4AM5170−7AA is sufficient. A connection example is illustrated in Appendix B (Figure B.3).

The ratio of the interposing transformers is chosen such that the winding with the lower rating (usually the tertiary winding of the transformer) is roughly matched to the winding with the highest rating, i.e. the current ratio of the interposing transformers should be:

$$TR_I = \frac{S_N \text{ of the high-power winding}}{S_N \text{ of the low-power winding}}$$

Thus, the winding ratio of the interposing c.t.s is

$$\frac{N_1}{N_2} = \frac{S_N \text{ of the low-power winding}}{S_N \text{ of the high-power winding}}$$

where

N_1 – number of winding turns on the side facing the main c.t.s,

N_2 – number of winding turns on the side facing the 7UT51 relay.

The exact current matching is performed when setting the parameters for this winding according to Section 6.3.3.

Example:

The following data should apply for the winding with the highest power rating:

rated power	S_N = 57 MVA
rated voltage	U_N = 110 kV
current transformers	300 A/1 A

The following data should apply for the winding with the lowest power rating:

rated power	S_N = 12.5 MVA
rated voltage	U_N = 10 kV
current transformers	800 A/1 A

This results in a winding ratio of the interposing transformers of

$$\frac{N_1}{N_2} = \frac{S_N \text{ of the low-power winding}}{S_N \text{ of the high-power winding}}$$

$$= \frac{12.5\text{ MVA}}{57\text{ MVA}} = 0.22$$

$$\approx 11/50 \text{ turns}$$

which results in a current transformer ratio of

$$\frac{800\text{ A}/1\text{ A}}{11/50} = 3636\text{ A}/1\text{ A}$$

Thus, a primary rated current of 3636 A for the current transformers is to be set to the protection unit in this example case (refer also to Section 6.3.3).

5.2.5.5 Connection of single-phase transformers

Single-phase transformers can be designed with one or two phases per winding. In order to ensure optimum matching of the currents, always two measured current inputs shall be used even if only one current transformer is installed on the phase. The currents are to be connected to the inputs L1 and L3.

If two winding phases are available, they may be connected either in series (which corresponds to a Y−winding) or in parallel (which corresponds to a D−winding). The phase displacement between the windings can only be 0° or 180°.

Connection examples for some usual applications are illustrated in the figures 5.13 to 5.16.

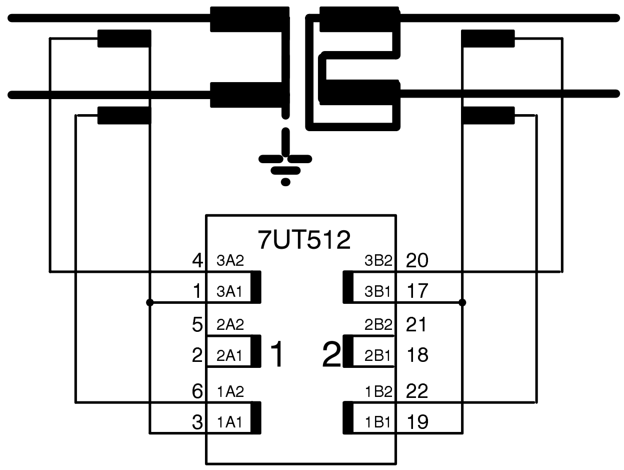


Figure 5.13 Connection example for a single-phase power transformer with one series and one parallel winding

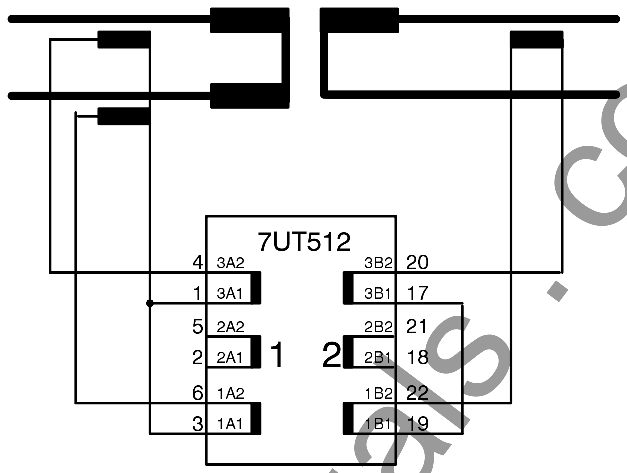


Figure 5.14 Connection example for a single-phase power transformer with one series and one I–winding

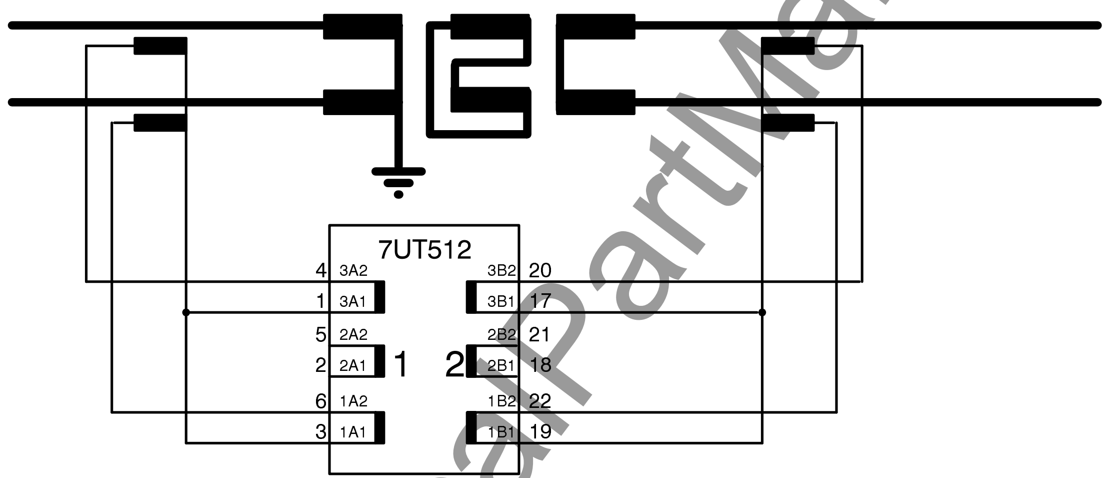


Figure 5.15 Single-phase power transformer with two series and one compensating winding

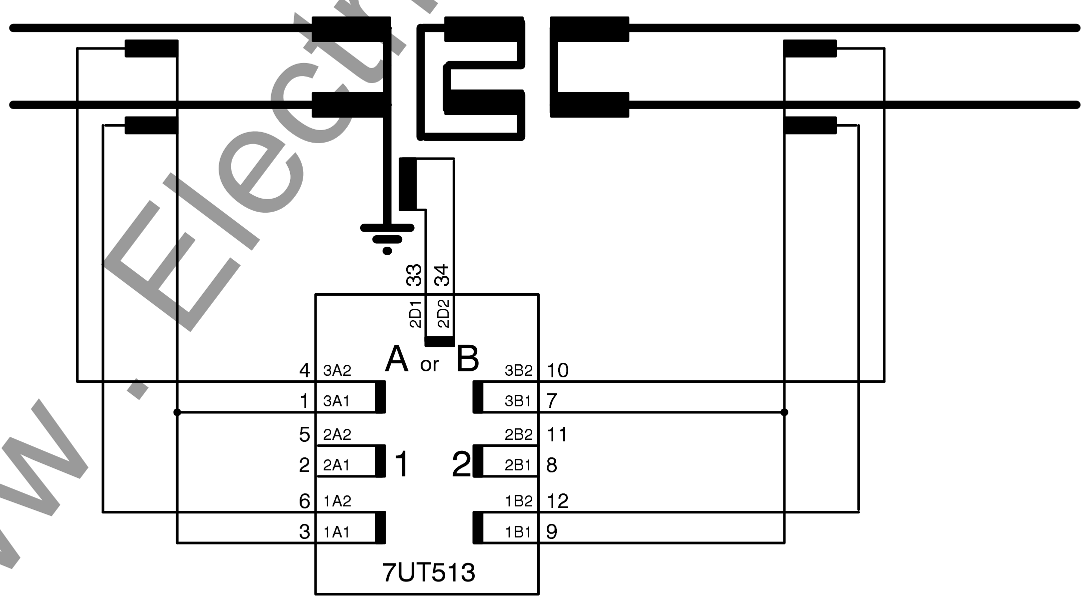


Figure 5.16 Single-phase power transformer with restricted earth fault protection

5.2.6 Checking the connections

Warning

Some of the following test steps are carried out in presence of hazardous voltages. They shall be performed by qualified personnel only which is thoroughly familiar with all safety regulations and precautionary measures and pay due attention to them. Non-observance can result in severe personal injury.

Before initial energization with supply voltage, the relay shall be situated in the operating area for at least two hours in order to ensure temperature equalization and to avoid humidity influences and condensation.

– Switch off the circuit breaker 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?
- Is the assignment of the additional current transformers I_A and I_B correct (if used)?
- Are the current transformers I_A and I_B correctly earthed (if used)?
- Are the polarities of the current transformers I_A and I_B correct (if used)?

If test switches have been fitted in the secondary circuits, check their function, particularly that in the "test" position the current transformer secondary circuits are automatically short-circuited.

– Put the miniature slide switch on the front plate of the module (Figure 6.1 or 6.2) in the OFF position ○.

– Fit a dc ammeter in the auxiliary voltage lead; range approx. 1.5 A to 3.0 A.

– Close the battery supply circuit breaker; check polarity and magnitude of voltage at the terminals or connector modules.

– The measured current consumption should be insignificant. Transient movement of the ammeter pointer only indicates the charging current of the storage capacitors.

– Put the miniature slide switch of the front plate in the "ON" position ⊙ . The unit starts up and, on completion of the run-up period, the green LED on the front comes on, the red LED gets off after at most 7 sec.

– Open the circuit breaker for the dc power supply.

– Remove dc ammeter; reconnect the auxiliary voltage leads.

– Check through the tripping circuits to the circuit breakers.

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

– Check the signal circuits.

– Reclose the dc supply circuit breaker.

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 operating language, configuration of the interfaces and the device functions,

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

– setting of functional parameters (thresholds, functions),

– initiation of test procedures.

The codeword is not required for the read-out of annunciations, operating data or fault data, or for the read-out of setting parameters.

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

```
ENTER CODEWORD:
@@@@@@
```

```
CW ACCEPTED
```

```
CODEWORD WRONG
```

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

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

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

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

```
⇑ 7000 █ OP. SYSTEM
⇓ CONFIGURATION
```

Beginning of the block "Operating system configuration"

The double arrow key ⇑ switches over to the first configuration block (see below). Use the key ↑ to find the next address. The display shows the four-digit address number, i.e. block and sequence number. The title of the requested parameter appears behind the bar (see below). The second line of the display shows the text applicable to the parameter. The present text can be rejected by the "No" – key **N**.

The next text choice then appears, as shown in the boxes below. The chosen alternative **must be confirmed with enter key E!**

The setting procedure can be ended at any time by the key combination **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"

```
7001 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 L1 =
```
```
I1 L2 =
```
etc.

Message to be displayed in the **1st** display line during operation. Any of the operational measured values according to Section 6.4.4 can be selected as messages in the quiescent state of the relay by repeatedly depressing the "No"–key **N**; The value selected by the entry key **E** under address 7105 will appear in the **first** line of the display.

```
7106 OPER. 2nd L
I2 L1 =
```
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:

first protection function which has picked up,

```
Prot.Trip
```
latest 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
T-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: 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
176
```

Function type in accordance with VDEW/ZVEI; for transformer differential protection no. **176**.
This address is mainly for information, it should not be changed.

```
7209 DEVICE TYPE
4
```

Device type for identification of the device in Siemens LSA 678 and program *DIGSI*®. For 7UT51 no. **4**; no. **35** is also permissible if the LSA system is able to process the extended scope of functions of 7UT51 version V3.

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	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**.
19200 BAUD	
1200 BAUD	
2400 BAUD	
4800 BAUD	

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. 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
```

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

transmission with *NO* parity and *1 STOP*−bit (e.g. modem)

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 is 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
```

Remote parameterizing via the system interface

NO – is not permitted

```
Y E S
```

YES – is permitted

5.3.4 Settings for fault recording – address block 74

The differential protection relay is equipped with a fault data store (see Section 4.11.2). 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.

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 as T–MAX 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 related on a system frequency of 50 Hz. They are to be matched, accordingly, for 60 Hz. For $16^2/_3$ Hz, the times are valid again.

Data storage can also be initiated via a binary input or by operator action from the membrane keyboard on the front of the relay or via the operating interface. The storage is triggered dynamically, in these cases. The length of the data storage is determined by the settings in addresses 7431 and 7432, but max. T–MAX, address 7410. Pre-trigger time and post-fault time are additive to the set values. If the storage time for start via binary input is set to ∞, then the storage time ends after de-energization of the binary input (statically), but not after T–MAX (address 7410).

7400 FAULT RECORDINGS	Beginning of block "Fault recordings"
7402 INITIATION STORAGE BY FD.	Data storage is initiated: – fault detection is reference instant fault detection is storage criterion
STORAGE BY TRIP	– fault detection is reference instant trip command is storage criterion
START WITH TRIP	– 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

```
7431█ T-BINARY IN
0.50 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)

```
7432█ T-KEYBOARD
0.50 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.

```
7490█ SYS LENGTH
660 VALUES FIX
<=3000 VAL. VAR.
```

Only for communication with a former LSA system:

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

660 values fix or

variable length with a maximum of 3000 values

5.4 Configuration of the protective functions

5.4.1 Introduction

The **device** 7UT51 is capable of providing a series of **protection** and additional functions. The scope of the hard- and firmware is matched to these functions. Furthermore, individual functions can be set (configured) to be effective or non-effective or the interaction of the functions can be modified by configuration parameters. Additionally, the relay can be adapted to the system frequency.

Example for configuration of the scope of the device:

Assume that 7UT513 is used for an earthed power transformer with a current transformer in the starpoint connection to earth; the restricted earth fault protection should be used for the earthed winding. The relay must be informed to which measured current input the star point current is connected (address 7806 or 7807), and to which winding of the transformer this star point current is to be assigned (address 7819).

The configuration parameters are input through the integrated operation keyboard at the front of the device or by means of a personal computer, connected to this front-interface. The use of the integrated operating keyboard is described in detail in Section 6.2. Alteration of the programmed parameters requires the input of the codeword (see Section 5.3.1). Without codeword, the setting can be read out but not altered.

For the purpose of configuration, addresses 78⋆⋆ 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 and explained. In the upper line of the display, behind the number and the bar, stands the associated device function. In the second line is the associated text (e.g. ”*EXIST*”). If this text is appropriate the arrow keys ↑ or ↓ can be used to page the next address. If the text should be altered press the ”No”–key **N**; an alternative text then appears (e.g. ”*NON–EXIST*”). There may be other alternatives which can then be displayed by repeated depression of the ”No”–key **N**. The required alternative **must be confirmed with the key E!**

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

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

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

NOTES for 7UT513 only:

After the configuration process has been finished, the relay checks the consistency of the configuration parameters. When inconsistent parameter states have been set a corresponding message is generated. When the relay is delivered, all these messages are assigned to LED 14. That means, if this LED comes on after configuration or parameterizing, a setting error has been detected. The applied message can then be read out in the operational annunciations (refer to Section 6.4.2). The following messages may occur:

`O/L 1 Err S3` (FNo `1576`) overload protection 1 has been assigned to a third side (terminal) of the protected object but this side does not exist (cf. addresses 7801 and 7824).

`O/L 2 Err S3` (FNo `1626`) overload protection 2 has been assigned to a third side (terminal) of the protected object but this side does not exist (cf. addresses 7801 and 7825).

`Backup Err S3` (FNo `2457`) back-up overcurrent time protection has been assigned to a third side (terminal) of the protected object but this side does not exist (cf. addresses 7801 and 7821).

`Err 2 CT star` (FNo `5711`) two star-point current transformers have been assigned to the same side (terminal) of the differential protection (cf. addresses 7806 and 7807).

`REF Err S3` (FNo `5828`) restricted earth fault protection has been assigned to a non-existing third side (terminal) of the protected object (cf. addresses 7801 and 7819).

`REF Err2CTsta` (FNo `5829`) two star-point current transformers have been assigned to the same side (terminal) of the restricted earth fault protection (cf addresses 7806 and 7807).

`REF Err0CTsta` (FNo `5830`) no star-point current transformer has been assigned to the restricted earth fault protection (cf. addresses 7806 and 7807).

`REF ErrVir ob` (FNo `5831`) restricted earth fault protection has been allocated to an impermissible side (terminal) of the protected object, e.g. side 1 or 2 of a generator or to a branch point (addresses 7801 and 7819). For these cases, the restricted earth fault protection must only be assigned to a virtual object.

Additionally, it must be considered when using 7UT513, that not all additional protection functions can operate at the same time due to calculation time limitations.

With rated frequency 60 Hz, the back-up overcurrent time protection **or** the restricted earth fault protection/tank leakage protection (dependent on the ordered model) can be used besides the differential protection (for transformers, generators, motors, or branch point). If the three-winding transformer protection is to be used, only the back-up overcurrent time protection is available.

With rated frequency 50 Hz, the back-up overcurrent time protection **or** the restricted earth fault protection/tank leakage protection (dependent on the ordered model) can be used besides the differential protection (for transformers, generators, motors, or branch point).

With rated frequency $16^2/_3$ Hz, no restriction concerning the additional functions are present.

If, during configuration, more functions have been selected than the device is able to process, the relays will give a corresponding message after configuration has been finished. These messages are also assigned to LED 14 when the relay is delivered. The individual messages can be read out in the operational annunciations (refer to Section 6.4.2). The following messages may occur:

`REF no exist` (FNo `5834`) restricted earth fault protection has been programmed as *EXIST* but cannot be processed by the relay (address 7819).

`Tank no exist` (FNo `5928`) tank leakage protection has been programmed as *EXIST* but cannot be processed by the relay (address 7827).

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 7UT51: 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"

Address 7801 determines the protected object. The options *3WIND–TRANSF* and *3END–BRANCH PT* are available only in 7UT513.

```
7801 PROT. OBJ.
2WIND-TRANSF.
```

```
3WIND-TRANSF.
GENERATOR/MOTOR
2ENDS-BRANCH PT.
3ENDS-BRANCH PT.
1PHASE-TRANSF.
```

Addresses 7806 and 7807 are available only in 7UT513.

```
7806 STARPOINT A
NO ASSIGNMENT
```

```
SIDE 1
SIDE 2
SIDE 3 / V. OBJ
```

```
7807 STARPOINT B
NO ASSIGNMENT
```

```
SIDE 1
SIDE 2
SIDE 3 / V. OBJ
```

```
7816 DIFF PROT.
EXIST
```

```
NON-EXIST
```

Address 7819 only in 7UT513 with restricted earth fault protection.

```
7819 REF PROT.
NON-EXIST
```

```
WINDING 1
WINDING 2
WINDING 3
VIRTUAL OBJECT
```

The options *REFERENCE SIDE 3* and *VIRTUAL OBJECT* in addresses 7821, 7824, and 7825 are available only in 7UT513.

```
7821 BACK-UP O/C
NON-EXIST
```
- REFERENCE SIDE 1
- REFERENCE SIDE 2
- REFERENCE SIDE 3
- VIRTUAL OBJECT

```
7824 OVERLOAD 1
NON-EXIST
```
- REFERENCE SIDE 1
- REFERENCE SIDE 2
- REFERENCE SIDE 3
- VIRTUAL OBJECT

```
7825 OVERLOAD 2
NON-EXIST
```
- REFERENCE SIDE 1
- REFERENCE SIDE 2
- REFERENCE SIDE 3
- VIRTUAL OBJECT

Address 7827 only in 7UT513 with tank leakage protection.

```
7827 TANK PROT.
NON-EXIST
```
- SENSITIVE CT B
- INSENSITIVE CT A

```
7830 EXT. TRIP 1
NON-EXIST
```
- EXIST

```
7831 EXT. TRIP 2
NON-EXIST
```
- EXIST

```
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
- fN 16 2/3 Hz

Rated system frequency *50 Hz* or *60 Hz* or *16²/₃ Hz*

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 an ”F”. The display shows, in the upper line, the physical input/output unit, this time with a three digit index number. The second display line shows the logical function which is presently allocated.

On this selection level the allocated function can be changed by pressing the ”No” – key **N**. By repeated use of the key **N** all marshallable functions can be paged through the display. Back-paging is possible with the backspace key **R**. When the required function appears press the execute key **E**. After this, further functions can be allocated to the same physical input or output module (with further index numbers) by using the key ↑. **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 ⇑⇓ 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 5 binary inputs (depending on model) which are designated INPUT 1 and INPUT 2, or INPUT 1 to INPUT 5. They can be marshalled in address block 61. The address block is reached by paging in blocks ⇑ ⇓ 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 1. Table 5.2 shows all binary inputs as preset from the factory.

```
⇑  6100█ MARSHALLING
⇓  BINARY INPUTS
```

Beginning of block "Marshalling binary inputs"

The first binary input is reached with the key ↑:

```
F↑  6101█ BINARY
 ↓  INPUT 1
```

Allocations for binary input 1

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

```
↑  001█ INPUT 1
↓  >LED reset        NO
```

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

```
↑  002█ INPUT 1
↓  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 ↑.

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
356	>Manual Close	Circuit breaker is manually closed (from discrepancy switch)
391	>Buchh. Warn	Buchholz protection warning stage [1])
392	>Buchh. Trip	Buchholz protection tripping stage [1])
393	>Buchh. Tank	Buchholz protection tank [1])
1553	>O/L 1 block	Block thermal overload protection 1
1554	>O/L 1 annunc	Switch overload protection 1 to give only annunciations
1555	>O/L1 bloTrip	Block trip command of thermal overload 1 protection
1603	>O/L 2 block	Block thermal overload protection 2
1604	>O/L 2 annunc	Switch overload protection 2 to give only annunciations
1605	>O/L2 bloTrip	Block trip command of thermal overload 2 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
4523	>Ext 1 block	Block external trip function 1
4525	>Ext1 blo Trip	Block trip command of external trip function 1
4526	>Ext Trip 1	Binary input for external trip function 1
4543	>Ext 2 block	Block external trip function 2
4545	>Ext2 blo Trip	Block trip command of external trip function 2
4546	>Ext Trip 2	Binary input for external trip function 2
5603	>Diff block	Block differential protection
5605	>Diff bloTrip	Block trip command of differential protection
5803	>REF block	Block restricted earth fault protection [2])
5805	>REF blo Trip	Block trip command of restricted earth fault protection [2])
5903	>Tank block	Block tank leakage protection [2])
5905	>Tank bloTrip	Block trip command of tank leakage protection [2])

[1]) for use as transformer protection [2]) 7UT513 only

Table 5.1 Marshalling possibilities for binary inputs

Addr	1st display line	2nd display line	FNo	Remarks
6100	MARSHALLING	BINARY INPUTS		Heading of the address block
6101	BINARY INPUT 1	INPUT 1 >LED reset NO	5	Acknowledge and reset of stored LED and display indications, LED–test
6102	BINARY INPUT 2	INPUT 2 >I>> block NO	2306	Block I>> stage of back-up overcurrent time protection
6103	BINARY INPUT 3	INPUT 3 [1]) >Annunc. 1 NO	11	User definable annunciation no. 1 [1])
6104	BINARY INPUT 4	INPUT 4 [1]) >Buchh. Warn NO	391	Buchholz protection warning stage [1])
6105	BINARY INPUT 5	INPUT 5 [1]) Buchh. Trip NO	392	Buchholz protection tripping stage [1])

[1]) 7UT513 only

Table 5.2 Preset binary inputs

5.5.3 Marshalling of the signal output relays – address block 62

7UT512 contains 5, 7UT513 contains 11 signal outputs (alarm relays). The signal relays are designated SIGNAL RELAY 1 to SIGNAL RELAY 5 or SIGNAL RELAY 1 to SIGNAL RELAY 11. 4 or 10 of them 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 is not fitted or has been programmed out ("de-configured" – refer to 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
141	Failure 24V	Failure in 24 V internal dc supply circuit
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
151	Failure I/O 1	Failure in base input/output module (GEA)
152	Failure I/O 2	Failure in additional input/output module (ZEA) [2])
161	I supervision	Failure current supervision, general
163	Failure Isymm	Failure detected by current symmetry monitor, general
356	>Manual Close	Circuit breaker is manually closed (from discrepancy switch)
391	>Buchh. Warn	Buchholz protection warning stage [1])
392	>Buchh. Trip	Buchholz protection tripping stage [1])
393	>Buchh. Tank	Buchholz protection tank [1])
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)
571	Fail. Isym 1	Failure detected by current symmetry monitor for side 1
572	Fail. Isym 2	Failure detected by current symmetry monitor for side 2
573	Fail. Isym 3	Failure detected by current symmetry monitor for side 3 [2])
1553	>O/L 1 block	Block thermal overload protection 1
1554	>O/L 1 annunc	Switch overload protection 1 to give only annunciations
1555	>O/L1 bloTrip	Block trip command of thermal overload protection 1
1561	O/L 1 off	Thermal overload protection 1 is switched off
1562	O/L 1 blocked	Thermal overload protection 1 is blocked
1563	O/L 1 active	Thermal overload protection 1 is active
1565	O/L 1 Warn I	Thermal overload protection 1 current warning stage picked up
1566	O/L 1 Warn Q	Thermal overload protection 1 thermal warning stage picked up
1567	O/L 1 F.D. Q	Thermal overload protection 1 pick-up of trip stage
1571	O/L 1 Trip	Thermal overload protection 1 trip command
1576	O/L 1 Err S3	Setting error: overload protection 1 switched to non-existing side 3 [2])
1603	>O/L 2 block	Block thermal overload protection 2
1604	>O/L 2 annunc	Switch overload protection 2 to give only annunciations
1605	>O/L2 bloTrip	Block trip command of thermal overload protection 2

[1]) for use as transformer protection
[2]) 7UT513 only

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

FNo	Abbreviation	Description
1611	O/L 2 off	Thermal overload protection 2 is switched off
1612	O/L 2 blocked	Thermal overload protection 2 is blocked
1613	O/L 2 active	Thermal overload protection 2 is active
1615	O/L 2 Warn I	Thermal overload protection 2 current warning stage picked up
1616	O/L 2 Warn Q	Thermal overload protection 2 thermal warning stage picked up
1617	O/L 2 F.D. Q	Thermal overload protection 2 pick-up of trip stage
1621	O/L 2 Trip	Thermal overload protection 2 trip command
1626	O/L 2 Err S3	Setting error: overload protection 2 switched to non-existing side 3 [2])
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
2412	Backup Flt L1	Fault detection of back-up overcurrent protection in phase L1
2413	Backup Flt L2	Fault detection of back-up overcurrent protection in phase L2
2414	Backup Flt L3	Fault detection of back-up overcurrent protection in phase L3
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 back-up 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
2457	Backup Err S3	Setting error: back-up O/C protec. switched to non-existing side 3 [2])
4523	>Ext 1 block	Block external trip function 1
4525	>Ext1 bloTrip	Block trip command of external trip function 1
4526	>Ext Trip 1	Trigger external trip function 1
4531	Ext 1 off	External trip function 1 is switched off
4532	Ext 1 blocked	External trip function 1 is blocked
4533	Ext 1 active	External trip function 1 is active
4536	Ext 1 Gen.Flt	General fault detection signal of external trip function 1
4537	Ext 1 Gen.Trp	Trip signal of external trip function 1
4543	>Ext 2 block	Block external trip function 2
4545	>Ext2 bloTrip	Block trip command of external trip function 2
4546	>Ext Trip 2	Trigger external trip function 2
4551	Ext 2 off	External trip function 2 is switched off
4552	Ext 2 blocked	External trip function 2 is blocked
4553	Ext 2 active	External trip function 2 is active
4556	Ext 2 Gen.Flt	General fault detection signal of external trip function 2
4557	Ext 2 Gen.Trp	Trip signal of external trip function 2
5603	>Diff block	Block differential protection
5605	>Diff bloTrip	Block trip command of differential protection
5615	Diff off	Differential protection is switched off
5616	Diff blocked	Differential protection is blocked
5617	Diff active	Differential protection is active
5621	Diff> T start	Differential protection start of delay time I_{diff}> (if applicable)
5622	Diff>> T strt	Differential protection start of delay time I_{diff}>> (if applicable)
5631	Diff Gen. Flt	Differential protection general fault detection

[2]) 7UT513 only

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

FNo	Abbreviation	Description
5641	Block Harm L1	Differential protection blocked by harmonic restraint L1
5642	Block Harm L2	Differential protection blocked by harmonic restraint L2
5643	Block Harm L3	Differential protection blocked by harmonic restraint L3
5651	Block Sat L1	Differential protection blocked by saturation indicator L1
5652	Block Sat L2	Differential protection blocked by saturation indicator L2
5653	Block Sat L3	Differential protection blocked by saturation indicator L3
5662	Block IfltL1	Differential protection blocked by current fault L1 (branch point)
5663	Block IfltL2	Differential protection blocked by current fault L2 (branch point)
5664	Block IfltL3	Differential protection blocked by current fault L3 (branch point)
5671	Diff Gen.Trip	Differential protection general trip
5672	Diff Trip L1	Differential protection trip by measuring system L1
5673	Diff Trip L2	Differential protection trip by measuring system L2
5674	Diff Trip L3	Differential protection trip by measuring system L3
5681	Diff> L1	Differential protection trip by I_{diff}> stage L1
5682	Diff> L2	Differential protection trip by I_{diff}> stage L2
5683	Diff> L3	Differential protection trip by I_{diff}> stage L3
5684	Diff>> L1	Differential protection trip by I_{diff}>> stage L1
5685	Diff>> L2	Differential protection trip by I_{diff}>> stage L2
5686	Diff>> L3	Differential protection trip by I_{diff}>> stage L3
5691	Diff> Trip	Differential protection trip by I_{diff}> stage general
5692	Diff>> Trip	Differential protection trip by I_{diff}>> stage general
5711	Err 2 CT star	Setting error: 2 star-point CTs selected for 1 function
5711	Err no CTstar	Setting error: no star-point CT selected for zero sequence current
5803	>REF block	Block restricted earth fault protection [2])
5805	>REF blo Trip	Block trip command of restricted earth fault protection [2])
5811	REF off	Restricted earth fault protection is switched off [2])
5812	REF blocked	Restricted earth fault protection is blocked [2])
5813	REF active	Restricted earth fault protection is active [2])
5816	REF T start	Restricted earth fault protection start of delay time (if applicable) [2])
5817	REF Gen. Flt	Restricted earth fault protection general fault detection [2])
5821	REF Gen. Trip	Restricted earth fault protection general trip [2])
5828	REF Err S3	Setting error: restricted earth fault protection switched to non-existing side 3 [2])
5829	REF Err2CTsta	Setting error: 2 star-point CTs selected for restricted E/F protection [2])
5830	REF Err0CTsta	Setting error: no star-point CT selected for restricted E/F protection [2])
5831	REF ErrVir ob	Setting error: virtual object selected for restricted earth fault protection even though all three sides are in use [2])
5834	REF no exist	Restricted earth fault protection is configured but will not operate [2])
5903	>Tank block	Block tank leakage protection [2])
5905	>Tank bloTrip	Block trip command of tank leakage protection [2])
5911	Tank off	Tank leakage protection is switched off [2])
5912	Tank blocked	Tank leakage protection is blocked [2])
5913	Tank active	Tank leakage protection is active [2])
5916	Tank T start	Tank leakage protection start of delay time [2])
5917	Tank Gen. Flt	Tank leakage protection general fault detection [2])
5921	Tank Gen.Trip	Tank leakage protection general trip [2])
5928	Tank no exist	Tank leakage protection is configured but will not operate [2])

[2]) 7UT513 only

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.Trip	 5671	Trip by differential protection
6203	SIGNAL RELAY 3	RELAY 3 Back Gen.Trip	 2451	Trip by back-up overcurrent time protection
6204	SIGNAL RELAY 4 RELAY 4 RELAY 4 RELAY 4 RELAY 4 RELAY 4	RELAY 4 Failure 24V Failure 15V Failure 5V Failure 0V Failure I/O 1 Failure I/O 1	 141 143 144 145 151 152	Measured values or device faulty
6205	SIGNAL RELAY 5	RELAY 5 Dev.operative [2]	 51	The NC contact of this relay indicates "Device fault" [2]
6206	SIGNAL RELAY 6 RELAY 6	RELAY 6 [1] O/L 1 Trip O/L 2 Trip	 1571 1621	Annunciations of thermal overload protection functions
6207	SIGNAL RELAY 7 RELAY 7	RELAY 7 [1] O/L 1 Warn Q O/L 2 Warn Q	 1566 1616	
6208	SIGNAL RELAY 8	RELAY 8 [1] REF Gen. Trip	 5821	Trip by restricted earth fault protection
6209	SIGNAL RELAY 9	RELAY 9 [1] Tank Gen.Trip	 5921	Trip by tank leakage protection
6210	SIGNAL RELAY 10	RELAY 10 [1] >Buchh. Warn	 391	Annunciations of Buchholz protection via binary inputs
6211	SIGNAL RELAY 11	RELAY 11 [1] >Buchh. Trip	 392	

[1]) 7UT513 only
[2]) fix allocated, cannot be changed

Table 5.4 Preset annunciations for signal relays

5.5.4 Marshalling of the LED indicators – address block 63

7UT512 contains 8 LEDs, 7UT513 contains 16 for optical indications, 6 or 14 of which can be marshalled. They are designated LED 1 to LED 6 or LED 1 to LED 14 and can be marshalled in address block 63. The block is reached by paging in blocks with ⇑ ⇓ or by directly addressing with **DA 6 3 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 or Figure 6.2). 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.

```
⇑ 6 3 0 0 ▌ M A R S H A L L I N G
⇓ L E D   I N D I C A T O R S
```

Beginning of the block "Marshalling of the LED indicators"

The first marshallable LED is reached with the key ↑:

```
F↑ 6 3 0 1 ▌ L E D   1
 ↓
```

Allocations for LED 1

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

```
↑ 0 0 1 ▌ L E D   1
↓ D e v i c e   T r i p       m
```

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

```
↑ 0 0 2 ▌ R E L A Y   1
↓ n o t   a l l o c a t e d
```

no further functions are preset for signal relay 1

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

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> Trip m	 5691	Trip by the indicated differential protection stage
6303	LED 3 LED 3	 Diff>> Trip m	 5692	
6304	LED 4 LED 4	 Back Gen.Trip m	 2451	Trip by back-up overcurrent time protection
6305	LED 5 LED 5 LED 5 LED 5 LED 5 LED 5 LED 5	 Failure 24V nm Failure 15V nm Failure 5V nm Failure 0V nm Failure I/O 1 nm Failure I/O 1 nm	 141 143 144 145 151 152	Measured values or device faulty
6306	LED 6 LED 6	 Param.running nm	 95	Parameters are being set
6307	LED 7 [1]) LED 7	 REF Gen. Trip nm	 5821	Trip by the indicated protection function
6308	LED 8 [1]) LED 8	 Tank Gen.Trip m	 5921	
6309	LED 9 [1]) LED 9	 O/L 1 Trip m	 1571	
6310	LED 10 [1]) LED 10	 O/L 2 Trip m	 1621	
6311	LED 11 [1]) LED 11	 >Buchh. Warn nm	 391	Annunciations of Buchholz protection via binary inputs
6312	LED 12 [1]) LED 12	 >Buchh. Trip m	 392	
6313	LED 13 [1]) LED 13	 >Annunc. 1 m	 11	user definable annunciation
6314	LED 14 [1]) LED 14 LED 14 LED 14 LED 14 LED 14 LED 14 LED 14 LED 14 LED 14 LED 14 LED 14	 Err 2 CT star Err no CTstar O/L 1 Err S3 O/L 2 Err S3 Backup Err S3 REF Err S3 REF Err2CTsta REF Err0CTsta REF ErrVir ob REF no exist Tank no exist	 5711 5712 1576 1626 2457 5828 5829 5830 5831 5834 5928	Operator error during configuration or parameterizing: Settings are not consistent

[1]) LED 7 to LED 14 only with 7UT513

Table 5.5 Preset LED indicators

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

The unit contains 2 or 5 trip relays (depending on the ordered model) which are designated TRIP RELAY 1 and TRIP RELAY 2 or TRIP RELAY 1 to TRIP RELAY 5. Each trip relay can be controlled by up to 10 logical commands. The trip relays can be marshalled in the address block 64. The block is reached by paging in blocks with ⇑ ⇓ 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).

The command functions according to Table 5.6 can be allocated to physical trip relays. 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. Figure 5.17 shows the preset command functions as a tripping matrix.

If further protection functions shall trip the same breaker, each command relay must be triggered by the corresponding 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
↓ D i f f >   T r i p
```

Trip relay 1 has been preset for:
1st: Trip by differential stage $I_{diff}>$,
FNo 5691;

```
↑ 0 0 2█ T R I P   R E L .   1
↓ D i f f > >   T r i p
```

Trip relay 1 has been preset for:
2nd: Trip by differential stage $I_{diff}>>$,
FNo 5692;

```
↑ 0 0 3█ T R I P   R E L .   1
↓ B a c k   G e n . T r i p
```

Trip relay 1 has been preset for:
3rd: Trip by back-up overcurrent time protection,
FNo 2451;

```
↑ 0 0 4█ T R I P   R E L .   1
↓ R E F   G e n .   T r i p
```

Trip relay 1 has been preset for:
4th: Trip by restricted earth fault protection (if fitted) ,
FNo 5821;

```
005▮ TRIP REL. 1
Tank Gen.Trip
```

Trip relay 1 has been preset for:
5th: Trip by tank leakage protection,
FNo 5921;

```
006▮ TRIP REL. 1
O/L 1 Trip
```

Trip relay 1 has been preset for:
6th: Trip by thermal overload protection 1,
FNo 1571;

```
007▮ TRIP REL. 1
O/L 2 Trip
```

Trip relay 1 has been preset for:
7th: Trip by thermal overload protection 2,
FNo 1621.

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

```
6401▮ TRIP
RELAY 1
```

Allocations for trip relay 1

FNo	Abbreviation	Logical command function
1	not allocated	no annunciation allocated to trip relay
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
392	>Buchh. Trip	Buchholz protection tripping stage [1])
393	>Buchh. Tank	Buchholz protection tank [1])
501	Device FltDet	General fault detection of the device
511	Device Trip	General trip of the device
1571	O/L 1 Trip	Thermal overload protection 1 trip command
1621	O/L 2 Trip	Thermal overload protection 2 trip command
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
4536	Ext 1 Gen.Flt	General fault detection signal of external trip function 1
4537	Ext 1 Gen.Trp	Trip by external trip function 1
4556	Ext 2 Gen.Flt	General fault detection signal of external trip function 2
4557	Ext 2 Gen.Trp	Trip by external trip function 2

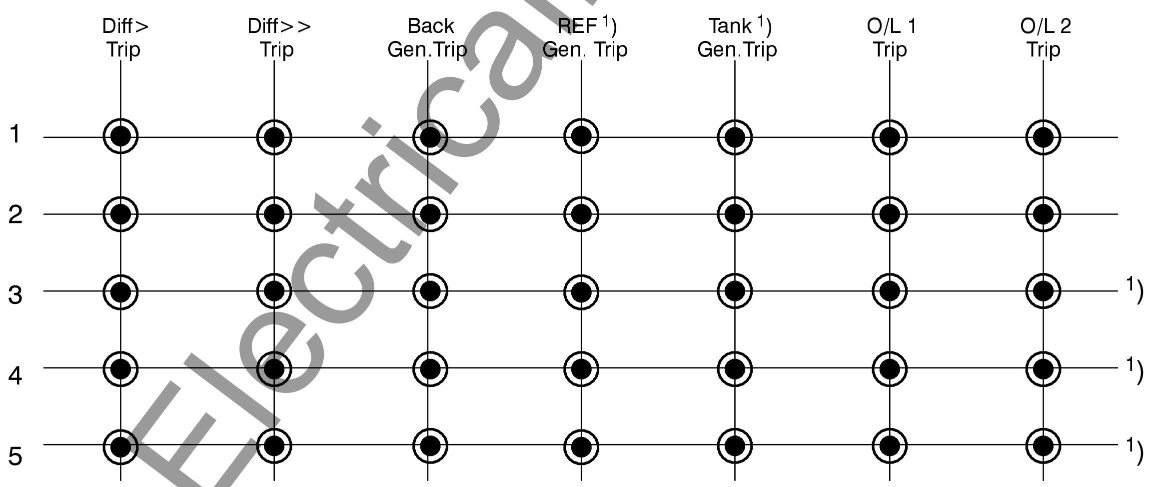
[1]) for use as transformer protection

Table 5.6 Command functions (continued next page)

FNo	Abbreviation	Logical command function
5621	Diff> T start	Differential protection start of delay time I_{diff}> (if applicable)
5622	Diff>> T strt	Differential protection start of delay time I_{diff}>> (if applicable)
5631	Diff Gen. Flt	Differential protection general fault detection
5671	Diff Gen.Trip	Differential protection general trip
5672	Diff Trip L1	Differential protection trip by measuring system L1
5673	Diff Trip L2	Differential protection trip by measuring system L2
5674	Diff Trip L3	Differential protection trip by measuring system L3
5691	Diff> Trip	Differential protection trip by I_{diff}> stage general
5692	Diff>> Trip	Differential protection trip by I_{diff}>> stage general
5816	REF T start	Restricted earth fault protection start of delay time (if applicable) [2])
5817	REF Gen. Flt	Restricted earth fault protection general fault detection [2])
5821	REF Gen. Trip	Restricted earth fault protection general trip [2])
5916	Tank T start	Tank leakage protection start of delay time [2])
5917	Tank Gen. Flt	Tank leakage protection general fault detection [2])
5921	Tank Gen.Trip	Tank leakage protection general trip [2])

[2]) 7UT513 only

Table 5.6 Command functions



[1]) 7UT513 only

Figure 5.17 Tripping matrix 7UT51 – Pre-settings

Addr	1st display line	2nd display line	FNo	Remarks
6400	MARSHALLING	TRIP RELAYS		Heading of the address block
6401	TRIP	RELAY 1		
	TRIP REL. 1	Diff> Trip	5691	
	TRIP REL. 1	Diff>> Trip	5692	
	TRIP REL. 1	Back Gen.Trip	2451	
	TRIP REL. 1	REF Gen. Trip	5821	
	TRIP REL. 1	Tank Gen.Trip	5921	
	TRIP REL. 1	O/L 1 Trip	1571	
6402	TRIP REL. 1	O/L 2 Trip	1621	
	TRIP	RELAY 2		
	TRIP REL. 2	Diff> Trip	5691	
	TRIP REL. 2	Diff>> Trip	5692	
	TRIP REL. 2	Back Gen.Trip	2451	
	TRIP REL. 2	REF Gen. Trip	5821	
	TRIP REL. 2	Tank Gen.Trip	5921	
	TRIP REL. 2	O/L 1 Trip	1571	
	TRIP REL. 2	O/L 2 Trip	1621	
6403	TRIP	RELAY 3 1)		
	TRIP REL. 3	Diff> Trip	5691	
	TRIP REL. 3	Diff>> Trip	5692	
	TRIP REL. 3	Back Gen.Trip	2451	All trip command of the protection functions; trip relays 3 to 5 only with 7UT513
	TRIP REL. 3	REF Gen. Trip	5821	
	TRIP REL. 3	Tank Gen.Trip	5921	
	TRIP REL. 3	O/L 1 Trip	1571	
	TRIP REL. 3	O/L 2 Trip	1621	
6404	TRIP	RELAY 4 1)		
	TRIP REL. 4	Diff> Trip	5691	
	TRIP REL. 4	Diff>> Trip	5692	
	TRIP REL. 4	Back Gen.Trip	2451	
	TRIP REL. 4	REF Gen. Trip	5821	
	TRIP REL. 4	Tank Gen.Trip	5921	
	TRIP REL. 4	O/L 1 Trip	1571	
	TRIP REL. 4	O/L 2 Trip	1621	
6405	TRIP	RELAY 5 1)		
	TRIP REL. 5	Diff> Trip	5691	
	TRIP REL. 5	Diff>> Trip	5692	
	TRIP REL. 5	Back Gen.Trip	2451	
	TRIP REL. 5	REF Gen. Trip	5821	
	TRIP REL. 5	Tank Gen.Trip	5921	
	TRIP REL. 5	O/L 1 Trip	1571	
	TRIP REL. 5	O/L 2 Trip	1621	

1) 7UT513 only ◆

Table 5.7 Preset command functions for trip relays

6 Operating instructions

6.1 Safety precautions

⚠ Warning

All safety precautions which apply for work in electrical installations are to be observed during tests and commissioning.

⚠ Caution!

Connection of the device to a battery charger without connected battery may cause impermissibly high voltages which damage the device. See also Section 3.1.1 under Technical data for limits.

6.2 Dialog with the relay

Setting, operation and interrogation of digital protection and automation systems can be carried out via the integrated membrane keyboard and display panel located on the front plate. All the necessary operating parameters can be entered and all the information can be read out from here. Operation is, additionally, possible via the interface socket by means of a personal computer or similar.

6.2.1 Membrane keyboard and display panel

The membrane keyboard and display panel is externally arranged similar to a pocket calculator. Figure 6.1 illustrates the front view.

A two-line, each 16 character, liquid crystal display presents the information. Each character comprises a 5 x 8 dot matrix. Numbers, letters and a series of special symbols can be displayed.

During dialog, the upper line gives a four figure number, followed by a bar. This number presents the **setting address**. The first two digits indicate the address **block**, then follows the two-digit **sequence number**. In models with parameter change-over facility, the identifier of the parameter set is shown before the setting address.

The keyboard comprises 28 keys with numbers, Yes/No and control buttons. The significance of the keys is explained in detail in the following.

Numerical keys for the input of numerals:

[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. 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 views)

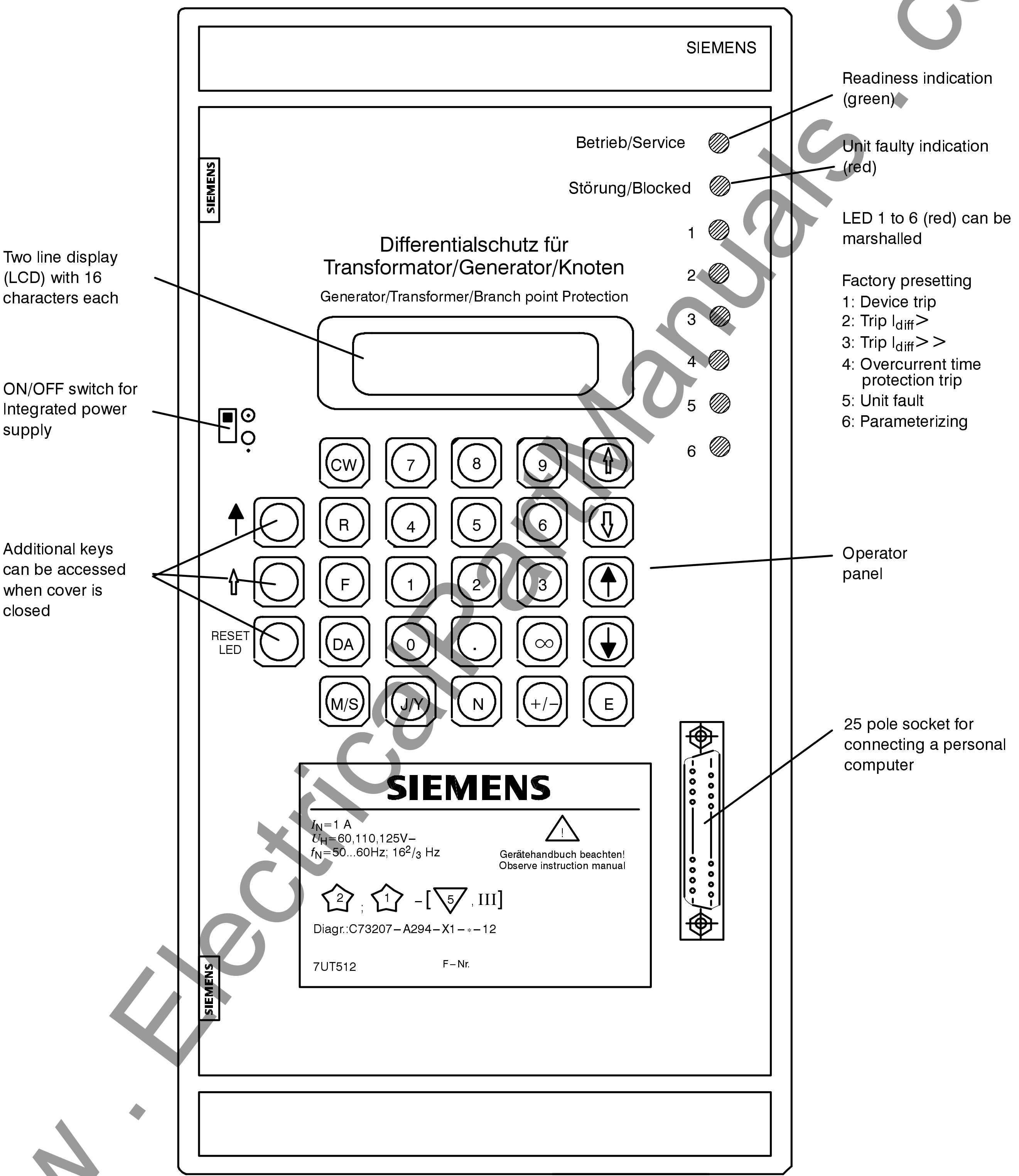
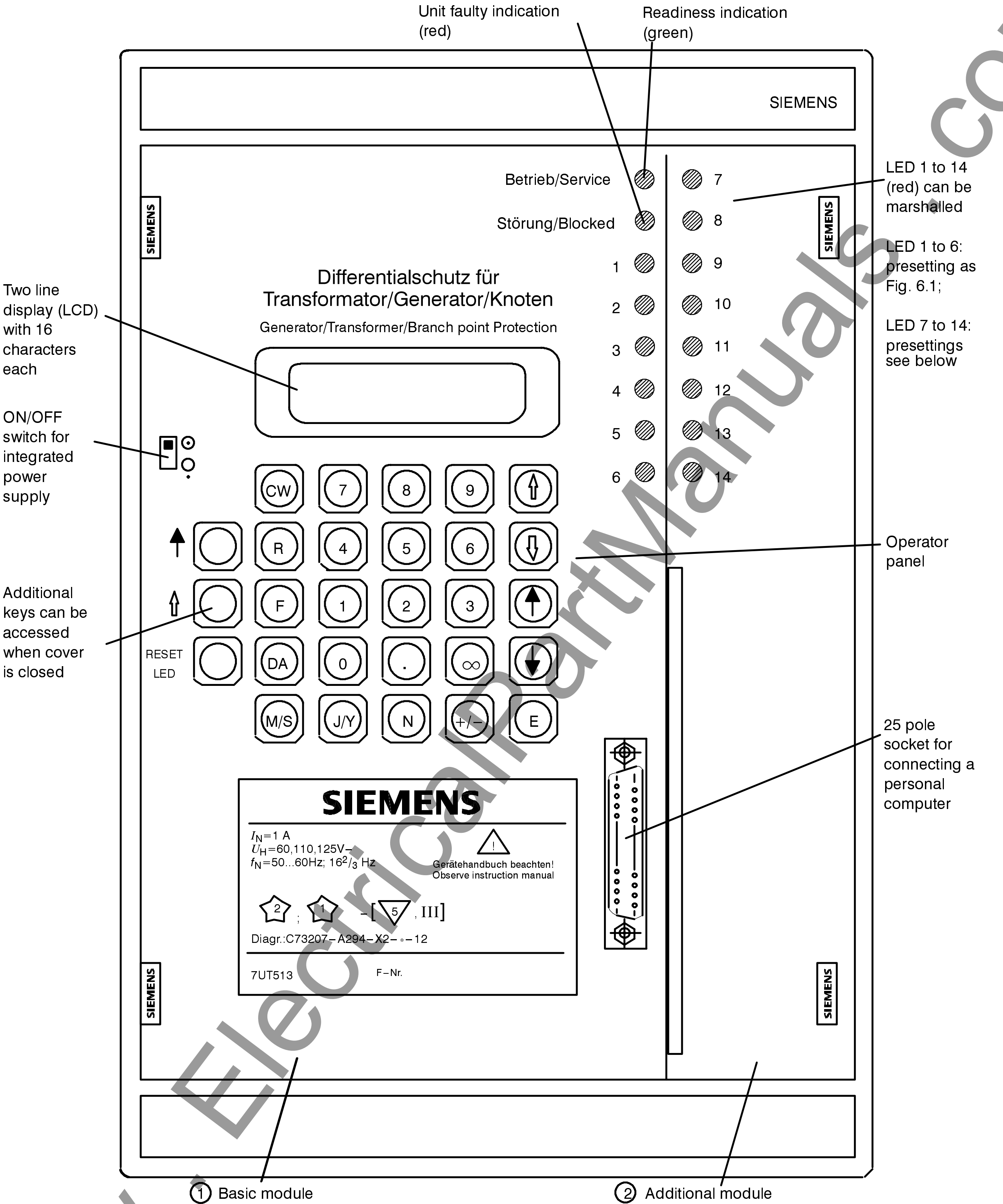


Figure 6.1 Front view 7UT512



from production series /KK:
C53207−A318−A21−. (7UT513 1A)
C53207−A318−A22−. (7UT513 5A)
C53207−A318−A23−. (7UT513 1A)
C53207−A318−A24−. (7UT513 5A)

} sensitive current input

LED 7 to 14 presettings:

7: Restricted earth fault protection trip
8: Tank leakage protection trip
9: Thermal overload protection 1 trip
10: Thermal overload protection 2 trip
11: Buchholz protection warning stage
12: Buchholz protection tripping stage
13 User definable annunciation 1
14 Setting error

Figure 6.2 Front view 7UT513

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. **1102** for block **11**, sequence number **2**). 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. **1105** for block **11**, sequence number **5**). 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 ⇑ ⇓ 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.

```
⇑  8500 █ PARAMETER
⇓  CHANGE-OVER
```

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 ↑.

```
02.05.1995
18:11:09
```

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 0 and 10

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

```
⇧ 0█ 7UT51      V3.**B
⇩ 7SD502**********
```

The relay introduces itself by giving its type number and the version of firmware with which it is equipped as well as a hardware character. 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 Transformer data – address block 11 (for use as transformer protection)

The transformer data are required if the relay is used as transformer protection. During configuration of the protection functions (refer to Section 5.4.2, address 7801) the relay had been informed that the PROTected OBJect is a *2–WIND*ing *TRANSF*ormer, a *3–WIND*ing *TRANSF*ormer (7UT513 only), or a *1–PHASE–TRANSF*ormer. If a different protected object had been selected, address block 11 is not available.

When used as transformer protection, 7UT51 automatically computes from the rated data of the protected transformer the current-matching formulae which are required to match the vector group and the different rated winding currents. The currents are converted such that the sensitivity of the protection always refers to the power rating of the transformer. Therefore, no circuitry is required for matching of the vector group and no manual calculations for converting of rated currents are normally necessary.

The unit requires the following data for each winding:

– MVA rating (apparent power) S_N in MVA,

– rated voltage U_N in kV,

– rated current of the current transformer set in A,

– the vector group numeral.

Winding 1 is defined as the reference winding. The other windings are referred to winding 1. In order to ensure the correct polarity when forming the differential currents, the polarity of the current transformer must also be stated.

The reference winding is normally that of the higher voltage. But, if a current transformer is installed in the earthing lead of an earthed star point of a winding, this is to be used as reference winding in order to ensure increased earth fault sensitivity by correction of the zero sequence current (see below). If not the higher voltage side is used as reference winding it must be considered that the vector group changes: e.g. a Dy5 transformer is regarded from the lower voltage side as Yd7.

If a transformer winding is regulated, then the actual rated voltage of the winding is not used as U_N, but rather the voltage which corresponds to the average current of the regulated range. The following applies:

$$\text{voltage to be set } U_N = 2 \times \frac{U_{max} \times U_{min}}{U_{max} + U_{min}} = \frac{2}{\frac{1}{U_{min}} + \frac{1}{U_{max}}}$$

(Both formulae are equivalent.)

For three-winding transformers with different MVA ratings of the windings, the unit automatically refers all currents to the power of the largest winding. When the power ratings of the windings differ strongly from each other (more than the factor 4), interposing transformers are recommended. If an interposing transformer set 4MA5170–7AA is used for one winding, the transformation ratio of the interposing transformers must be considered when entering the setting for this winding. This is done by dividing the actual primary current transformer rated current by the winding ratio of the interposing transformers. The result is entered as ”IN CT” (e.g. address 1104).

The matching factors which are calculated by the relay from the entered rated data can be read out in the operational annunciations (refer to Section 6.4.2) after parameterizing has been finished. These factors are for winding 1:

$$\text{k CT 1} = \frac{\text{current processed by 7UT51}}{\text{current through the relay terminals}}$$

and similar for the other windings:

k CT 2 =

k CT 3 = (only 7UT513)

ksCT 1 = (only 7UT513)

ksCT 2 = (only 7UT513)

ksCT 3 = (only 7UT513)

where ksCT are the factors for inputs from the current transformer in the star-point connection of an earthed transformer winding as far as they are used.

If the setting of the protection should be performed with secondary values only (e.g. because external matching transformers are present) then the factory-set parameters for transformer data can remain unchanged. The presets for transformer data apply for a ratio of 1 : 1 without phase displacement.

The treatment of the winding star-point is of no concern as long as the zero sequence currents are eliminated from the phase currents (e.g. address 1106 Io HANDLE = *Io ELIMINATION*. In this case the zero sequence currents, which will flow through an earthed winding star-point in the protected zone of the transformer even when an external network earth fault occurs, are rendered harmless.

The disadvantage of this zero sequence current elimination is that the differential protection be less sensitive in case of an internal earth fault in the protected zone (factor $^2/_3$). The following possibilities exist to increase sensitivity for internal earth faults:

In systems with isolated or arc compensated star-point, the elimination of the zero sequence current may be set ineffective (Io HANDLE = *WITHOUT*) provided the star-point of the protected transformer winding is has no connection to earth, not even via the Petersen coil! In this case, each earth fault or double earth fault with one foot-point in the protected zone will be cleared by the relay regardless of any double earth fault priority if this is used in non-earthed systems.

In earthed systems, the zero sequence current must be eliminated for all windings whose star-point is earthed in the protected zone (even if an artificial star-point coil is used). Increased earth fault sensitivity can then be achieved only when the star-point current is available, i.e. when a current transformer is installed in the earthing lead between the winding star-point and earth. Figure 6.3 shows an example for a two-winding transformer. 7UT513 must be used even when the transformer has only two windings since 7UT512 does not provide current inputs for the star-point current.

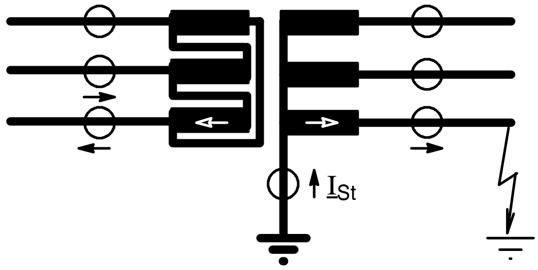


Figure 6.3 Earth fault outside the protected zone

In order to allow processing of the star-point current one of the additional current inputs I_A or I_B of 7UT513 can be used (refer to Section 5.4.2, addresses 7806 or 7807). If the model with tank leakage protection is used then current input I_A must be assigned for zero sequence current correction because the input I_B is then designed for the highly sensitive tank leakage protection.

```
  1 1 0 0█
T R A N S F O R M E R   D A T
A
```

Beginning of block "Transformer data"

Data of **winding 1** (reference winding):

```
  1 1 0 2█ U N   W I N D   1
1 1 0 . 0   k V
```

Rated voltage of winding 1 of the transformer (phase-to-phase)
Setting range: **0.4** kV to **800.0** kV

```
  1 1 0 3█ P N   W I N D   1
3 8 . 1   M V A
```

Rated apparent power of winding 1
Setting range: **0.2** MVA to **5000.0** MVA

```
  1 1 0 4█ I N   C T   W I N 1
2 0 0   A
```

Primary rated current of c.t. of winding 1
Setting range: **1** A to **100000** A

```
  1 1 0 5█ C T 1   S T A R P T
T O W A R D S   T R A N S F .
```

Star-point formation of c.t.s winding 1:
towards transformer side

```
T W D S . L I N E / B U S B A R
```

towards line/bus-bar side

```
  1 1 0 6█ I o   H A N D L E
I o - E L I M I N A T I O N
```

Processing of the zero sequence current of winding 1:
zero sequence current is eliminated

```
I o - C O R R E C T I O N
```

zero sequence current is eliminated but corrected by means of the star-point current (7UT513 only [1])

```
W I T H O U T
```

without special processing of the zero sequence current (only when star-point is not earthed)

```
  1 1 0 7█ I N   C T   S T P 1
2 0 0   A
```

Primary rated current of the star-point c.t. of winding 1 (7UT513 only)
Setting range: **1** A to **100000** A

```
  1 1 0 8█ C T 1   E A R - P T
T O W A R D S   T R A N S F .
```

Earthing point of the star-point c.t. winding 1 (7UT513 only):
towards transformer side

```
T O W A R D S   E A R T H
```

towards earth side

[1]) If no star-point c.t. had been configured for winding 1, an error message is issued after parameterizing procedure has been finished: "`Err no CT star`" (FNo `5712`), LED 14 at delivery (refer also Section 6.4.2).

Data of **winding 2**:

1121 VECTOR GR2 0	Vector group numeral of winding 2: **0** to **11** (x 30°) (not for single-phase transformers)
1122 UN WIND 2 11.0 kV	Rated voltage of winding 2 of the transformer (phase-to-phase) Setting range: **0.4** kV to **800.0** kV
1123 PN WIND 2 38.1 MVA	Rated apparent power of winding 2 Setting range: **0.2** MVA to **5000.0** MVA
1124 IN CT WIN2 2000 A	Primary rated current of c.t. of winding 2 Setting range: **1** A to **100000** A
1125 CT2 STARPT TOWARDS TRANSF.	Star-point formation of c.t.s winding 2: towards transformer side
TWDS.LINE/BUSBAR	towards line/bus-bar side
1126 Io HANDLE Io-ELIMINATION	Processing of the zero sequence current of winding 2: zero sequence current is eliminated
Io-CORRECTION	zero sequence current is eliminated but corrected by means of the star-point current (7UT513 only [1])
WITHOUT	without special processing of the zero sequence current (only when star-point is not earthed)
1127 IN CT STP2 2000 A	Primary rated current of the star-point c.t. of winding 2 (7UT513 only) Setting range: **1** A to **100000** A
1128 CT2 EAR-PT TOWARDS TRANSF.	Earthing point of the star-point c.t. winding 2 (7UT513 only): towards transformer side
TOWARDS EARTH	towards earth side

[1]) If no star-point c.t. had been configured for winding 2, an error message is issued after parameterizing procedure has been finished: "`Err no CT star`" (FNo `5712`), LED 14 at delivery (refer also to Section 6.4.2).

Data of **winding 3**, only with 7UT513, if the PROTected OBJect had been set to *3WIND−TRANSF* under address 7801 (refer to Section 5.4.2):

```
  1141 VECTOR GR3
0
```

Vector group numeral of winding 3:
0 to **11** (x 30°)

```
  1142 UN WIND 3
11.0 kV
```

Rated voltage of winding 3 of the transformer (phase-to-phase)
Setting range: **0.4** kV to **800.0** kV

```
  1143 PN WIND 3
10.0 MVA
```

Rated apparent power of winding 3
Setting range: **0.2** MVA to **5000.0** MVA

```
  1144 IN CT WIN3
2000 A
```

Primary rated current of c.t. of winding 3
Setting range: **1** A to **100000** A

```
  1145 CT3 STARPT
TOWARDS TRANSF.
```

Star-point formation of c.t.s winding 3:
towards transformer side

```
TWDS.LINE/BUSBAR
```

towards line/bus-bar side

```
  1146 Io HANDLE
Io-ELIMINATION
```

Processing of the zero sequence current of winding 3:
zero sequence current is eliminated

```
Io-CORRECTION
```

zero sequence current is eliminated but corrected by means of the star-point current [1])

```
WITHOUT
```

without special processing of the zero sequence current (only when star-point is not earthed)

```
  1147 IN CT STP3
200 A
```

Primary rated current of the star-point c.t. of winding 3
Setting range: **1** A to **100000** A

```
  1148 CT3 EAR-PT
TOWARDS TRANSF.
```

Earthing point of the star-point c.t. winding 3
:
towards transformer side

```
TOWARDS EARTH
```

towards earth side

[1]) If no star-point c.t. had been configured for winding 3, an error message is issued after parameterizing procedure has been finished: "`Err no CT star`" (FNo `5712`), LED 14 at delivery (refer also to Section 6.4.2).

6.3.4 Generator or motor data – address block 12 (for use as generator or motor protection)

When used as generator or motor protection, the relay had been informed that the PROTected OBJect is a *GENERATOR/MOTOR* during configuration of the protection functions (refer to Section 5.4.2, address 7801). If a different protected object had been selected, address block 12 is not available.

The most important setting is the position of the star-points of the c.t. sets relative to each other (address 1206). If the star-points of both the c.t. sets are formed on the side of the c.t.s facing the machine then they are on the *SAME SIDE* (cf. Figure 6.4 a). The same applies if both c.t. star-points are formed on the side away from the machine. *OPPOSITE SIDES* means one C.T. star-point is towards the machine and one is away from the machine (cf. Figure 6.4 b). One exception is, when the relay is used as transverse differential protection: In this case, *OPPOSITE SIDES* must be set, when the c.t. star-points are formed at the same side.

Additionally, the rated data of the machine are requested. All setting values are referred to these rated data. Furthermore, these data are used for the calculation of the primary measured values (refer to Section 6.4.4).

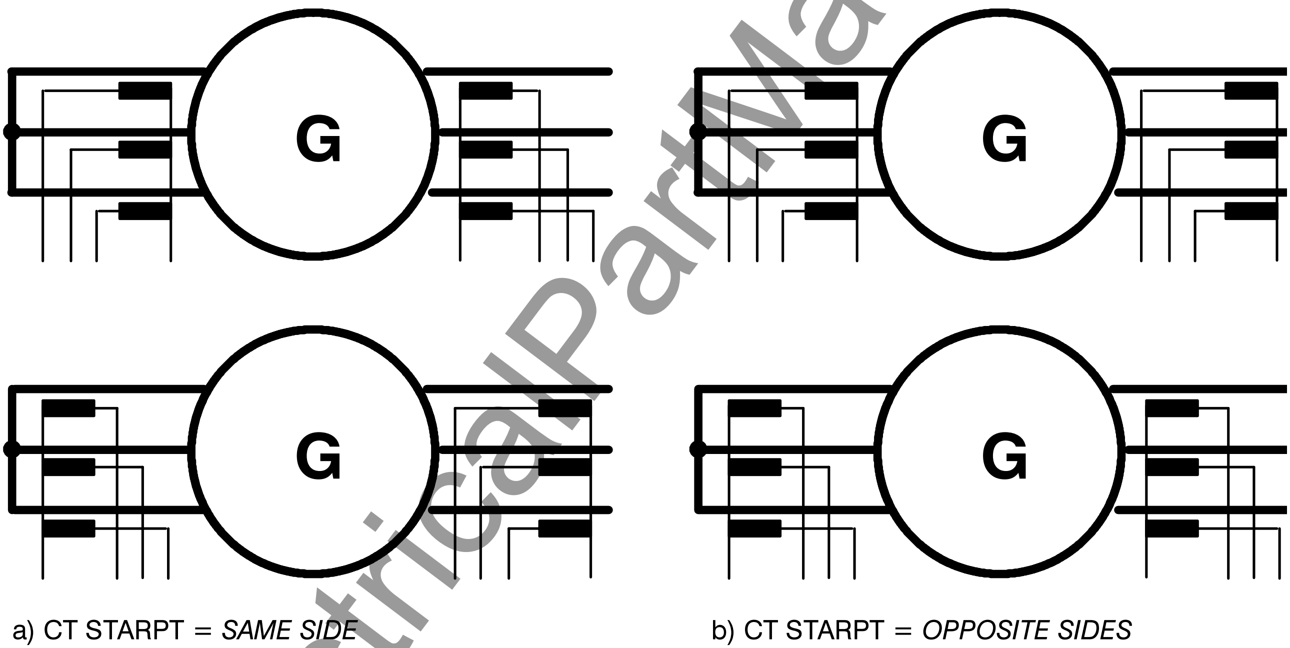


Figure 6.4 Generator/motor c.t. orientation – address 1206

```
1200 GENERATOR
OR MOTOR DATA
```

Beginning of block "Generator or motor data"

```
1202 UN GEN/MOT
21.0 kV
```

Rated voltage of the generator or motor (phase-to-phase)
Setting range: **0.4** kV to **800.0** kV

```
 1203█ PN GEN/MOT
400.0 MVA
```

Rated apparent power of the generator or motor
Setting range: **0.2** MVA to **5000.0** MVA

```
 1206█ CT STARPT
SAME SIDE
```

```
OPPOSITE SIDES
```

This parameter indicates the polarity of the c.t. currents.

Correct setting is a prerequisite for the correct formation of the differential currents

```
 1207█ IN CT 1
11000 A
```

Primary rated current of c.t. set 1, i.e. star-point side of the machine
Setting range: **1** A to **100000** A

```
 1208█ IN CT 2
11000 A
```

Primary rated current of c.t. set 2, i.e. terminal side of the machine
Setting range: **1** A to **100000** A

6.3.5 Branch point data – address block 13 (for use as branch point protection)

When used as branch point protection, the relay had been informed that the PROTected OBJect is a *2ENDS BRANCH PT* or *3ENDS BRANCH PT* (7UT513 only) during configuration of the protection functions (refer to Section 5.4.2, address 7801). If a different protected object had been selected, address block 13 is not available.

As the feeders of a branch point may have different rated primary currents, a standard rated branch point current is defined in address 1301. This is used as reference current for all measured currents. The feeder currents are matched to this current so that the operating characteristic of the relay is referred to the rated branch point current. External matching transformers are, normally, not required. In most cases, the highest rated primary current of the c.t. sets is used as the rated branch point current.

The individual rated feeder currents are matched to the rated branch point current. In order to ensure the correct polarity for the differential current, the polarities of all current transformer sets must be stated either.

```
 1300█ BRANCH
POINT DATA
```

Beginning of block ”Branch point data”

```
 1301█ IN BRAN-PT
2000 A
```

Primary rated current of the branch point
Setting range: **1** A to **100000** A

Data of side **1** of the branch point (1st feeder):

```
1302█ IN CT 1
2000 A
```

Primary rated current of c.t. of side 1
Setting range: **1** A to **100000** A

```
1303█ CT1 STARPT
TOWARDS BUSBAR
```

Star-point formation of c.t.s side 1:
towards bus-bar (branch point) side

```
TOWARDS LINE
```

towards line (feeder) side

Data of side **2** of the branch point (2nd feeder):

```
1304█ IN CT 2
2000 A
```

Primary rated current of c.t. of side 2
Setting range: **1** A to **100000** A

```
1305█ CT2 STARPT
TOWARDS BUSBAR
```

Star-point formation of c.t.s side 2:
towards bus-bar (branch point) side

```
TOWARDS LINE
```

towards line (feeder) side

Data of side **3** of the branch point (3rd feeder), only with 7UT513 if the protected object is declared as *3ENDS BRANCH PT* under address 7801 (refer to Section 5.4.2):

```
1306█ IN CT 3
2000 A
```

Primary rated current of c.t. of side 3
Setting range: **1** A to **100000** A

```
1307█ CT3 STARPT
TOWARDS BUSBAR
```

Star-point formation of c.t.s side 3:
towards bus-bar (branch point) side

```
TOWARDS LINE
```

towards line (feeder) side

6.3.6 Data of a virtual object – address block 14 (7UT513 only)

7UT513 provides the facility to use the relay (which is designed for three terminals) for a protected object with only two terminals (two-winding transformers, generators, motors, two-feeder branch points) while the third set of current inputs is used for a different, independent protected object (the so-called virtual object) in order to form a separate protection function, e.g. restricted earth fault protection, overcurrent time protection, or overload protection.

The primary rated data (addresses 1401 to 1404) are used to convert the currents into primary values. The rated current of the virtual object is the reference value for the characteristics of the protection functions. All setting values are referred to these rated data.

The polarity of the star-point c.t. (address 1405) is relevant only in case the protection function needs this star-point current (restricted earth fault protection). The position of the phase current c.t. set in relation to the position of the star-point c.t. must be stated. If both the c.t. sets are earthed on the side facing the protected object then they are on the *SAME SIDE*. The same applies if both c.t. sets are earthed on the side away from the protected object. Otherwise they are on *OPPOSITE SIDES*.

```
1400
VIRT. OBJECT
```

Beginning of block "Data of a virtual object"

```
1401 IN VIRT OB
2000 A
```

Primary rated current of the virtual object
Setting range: **1** A to **100000** A

```
1402 IN CT
2000 A
```

Primary rated current of the phase current transformer set of the virtual object
Setting range: **1** A to **100000** A

```
1404 IN CT STPT
2000 A
```

Primary rated current of the star-point current transformer of the virtual object, if used
Setting range: **1** A to **100000** A

```
1405 CT STARPT
SAME SIDE
OPPOSITE SIDES
```

This parameter indicates the polarity of the c.t. currents against each other.

Correct setting is a prerequisite for the correct formation of the differential currents of the restricted earth fault protection, if used

6.3.7 Settings for the transformer differential protection – address block 16

A precondition for the operation of the transformer differential protection is that it is configured as DIFF PROT = *EXIST* under address 7816 (refer to Section 5.4.2). Additionally, the PROTected OBJect (address 7801) must be *2WIND–TRANSF* or *1PHASE–TRANSF* or *3WIND–TRANSF* (7UT513 only). In other cases, address block 16 is not available. 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 1601.

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 connection group and the matching factors of the protected transformer have been set before. Without correct setting the relay may show unexpected reactions (incl. tripping)!

```
  1600█ TRANSFORM.
DIFF-PROTECTION
```

Beginning of block "Transformer differential protection"

```
  1601█ DIFF PROT.
OFF
```

```
ON
```

```
BLOCK TRIP REL
```

Transformer 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 1603 to 1608. Figure 6.5 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 1603) is the pick-up value of the differential current. This is the total fault current, regardless of the way this is divided between the protected windings. The pick-up value is referred to the rated current of the transformer corresponding to the rated power (refer to Section 6.3.3).

In addition to the pick-up limit I–DIFF> set under address 1603, the differential current is subjected to a second pick-up threshold. If this threshold (I–DIFF>>, address 1604) is exceeded then tripping is initiated regardless of the magnitude of the stabilizing current (unstabilized instantaneous high-set trip). This stage must be set higher than the I–DIFF> stage. As a guide: above $1/u_K$ of the transformer.

The tripping characteristic forms two more branches (Figure 6.5). The slope of the first branch is determined by the address 1606 SLOPE 1, its base point is the origin of the coordinate system. This branch covers current proportional errors. These are mainly transformation errors of the main current transformers and, especially, the differential currents which may occur due to the transformer regulating range. The preset slope 0.25 should be sufficient for regulating ranges up to $\pm$20 %. If the transformer has a larger regulated range, then the slope must be increased accordingly.

The second branch produces a higher stabilization in the range of high currents which may lead to current transformer saturation. Its base point is set under address 1607 BASE PT 2 and is referred to the rated power transformer current. The slope is set under address 1608 SLOPE 2. The stability of the relay during current transformer saturation can be influenced by this parameter. A higher slope results in a higher stability.

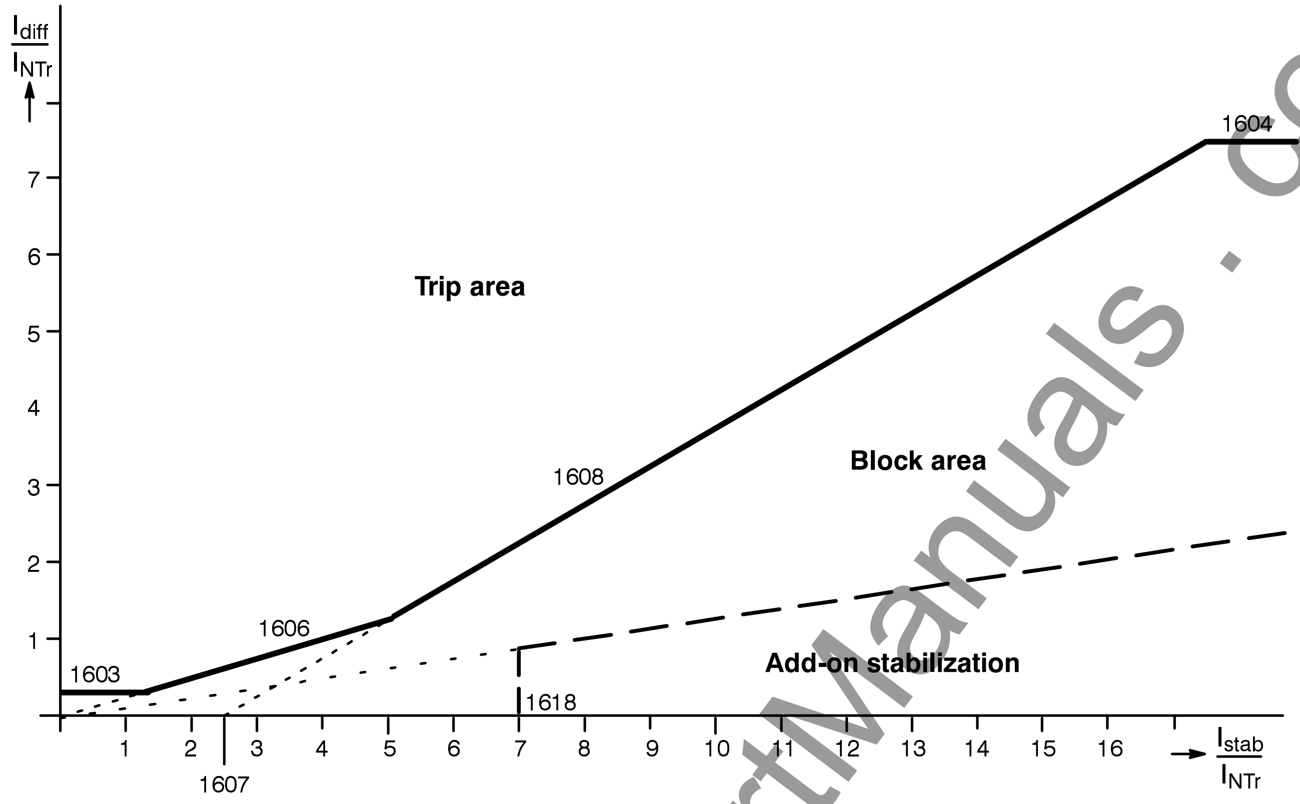


Figure 6.5 Shape of the tripping characteristic and relevant parameters

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 1618 SAT−RESTR (saturation restraint). This value is referred to the rated power transformer current, too. Its slope is $^1/_2$ of the slope of the branch 1606. It should be noted that the stabilizing quantity during through-flowing condition is the arithmetical sum of the currents through the windings, i.e. twice the through-flowing current. The maximum duration of this add-on stabilization can be set under address 1617 as a multiple of the a.c. periods.

```
1603 I-DIFF>
0.20 I/InTr
```

Pick-up value of differential current, referred to the rated transformer current
Smallest setting: **0.15** · $I_{N\ transformer}$
Largest setting: **2.00** · $I_{N\ transformer}$

```
1604 I-DIFF>>
7.20 I/InTr
```

Pick-up value of unstabilized high-set differential current, referred to the rated transformer current
Smallest setting: **0.5** · $I_{N\ transformer}$
Largest setting: **20.0** · $I_{N\ transformer}$

```
1606 SLOPE 1
0.25
```

Slope of the first declined branch of the tripping characteristic
Smallest setting: **0.10**
Largest setting: **0.50**

```
 1607▌BASE PT 2
2.5  I/InTr
```

Base point of the second declined branch of the tripping characteristic
Smallest setting: **0.0** · $I_{N\ transformer}$
Largest setting: **10.0** · $I_{N\ transformer}$

```
 1608▌SLOPE 2
0.50
```

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

Stabilization of the unit during transformer switch-on can be switched off or on under address 1610. It is based on the evaluation of the second harmonic content of the inrush current. A ratio of I_{2fN}/I_{fN} = 15 % has been preset by the factory and can – as a rule – be retained without change. The magnitude which is needed for stabilizing, however, can be parameterized in order to provide for a more stable setting in exceptional cases under especially unfavourable switch-on conditions (address 1611).

Since the harmonic stabilization operates individually per phase, the protection is fully operative even when the transformer is switched onto a single-phase fault, whereby inrush currents may possibly be present in one of the healthy phases. However, it is also possible to activate a ”cross-block” function. This means that not only the phase with inrush current exhibiting harmonic content in excess of the permissible value is stabilized but also the other phases of the differential stage I_{DIFF}> are blocked. The duration for which the cross-block function is operative after the differential current threshold has been exceeded, is set under address 1612. Setting is in multiple of the a.c. period. 0 periods (preset value) means that the cross-block function is not effective. When set to ∞, then the cross-block function is always effective.

Besides the second harmonic, 7UT51 can provide stabilization with a further harmonic: the n-th harmonic. Address 1613 allows to select this n-th harmonic: the third, fourth, or fifth harmonic; or to switch this n-th harmonic stabilization off.

The fourth harmonic can be found – like the second – in unsymmetrical occurrences like inrush currents.

Steady state overexcitation of the transformer is characterized by odd harmonic content. The third or fifth harmonic is suitable to detect overexcitation. As the third harmonic is often eliminated in the transformer windings (e.g. in a delta connected winding group), the fifth harmonic is usually used for stabilization.

Converter transformers also produce odd harmonic content which is practically absent in the fault currents.

The harmonic content which blocks the differential stage I_{DIFF}> can be set under address 1614. For example, if the 5th harmonic stabilization is used to avoid trip during overexcitation, 30 % are convenient.

Stabilization by the n-th harmonic operates individual per phase. But possibility exist – as with the inrush stabilization – to set the relay such that not only the phase with harmonic content in excess of the permissible value is stabilized but also the other phases of the differential stage I_{DIFF}> are blocked (cross-block function).

If the differential current exceeds the high-set differential stage I_{DIFF}>> (address 1616) no n-th harmonic stabilization takes place.

```
 1610▌2nd HARMON
ON

OFF
```

Inrush stabilization with the second harmonic is

ON switched on or

OFF switched off

```
1611█ 2nd HARMON
15 %
```

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

```
1612█ CROSSB 2HM
0 *1P
```

Duration of the cross-block function with the 2nd harmonic: 0 means that the cross-block function is ineffective, i.e. 2nd harmonic stabilization operates for each individual phase.
Smallest setting: **0** a.c. periods
Largest setting: **1000** a.c. periods
or ∞ (cross-block is always effective)

```
1613█ n.HARMON
5th HARMONIC
```

Stabilization with a further harmonic; this n-th harmonic may be:
the *5th HARMONIC* or

```
4th HARMONIC
```

the *4th HARMONIC* or

```
3rd HARMONIC
```

the *3rd HARMONIC* or

```
OFF
```

this stabilization is switched *OFF*

```
1614█ n. HARMON
80 %
```

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

```
1615█ CROSSB nHM
0 *1P
```

Duration of the cross-block function with the n-th harmonic: 0 means that the cross-block function is ineffective, i.e. harmonic stabilization operates for each individual phase.
Smallest setting: **0** a.c. periods
Largest setting: **1000** a.c. periods
or ∞ (cross-block is always effective)

```
1616█ IDIFFmax n
1.5 I/InTr
```

Stabilization with the n-th harmonic is effective up to this differential current limit
Smallest setting: **0.5** · $I_{N\ transformer}$
Largest setting: **20.0** · $I_{N\ transformer}$

```
1617█ T-SAT-BLO.
8 *1P
```

maximum duration of the add-on stabilization during detected current transformer saturation
Smallest setting: **2** a.c. periods
Largest setting: **250** a.c. periods
or ∞ (until drop-off of the differential stage I_{DIFF}>)

```
1618█ SAT-RESTR.
7.00 I/InTr
```

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

In special cases it may be advantageous to delay the trip signal of the protection. For this, an additional time delay can be set. The timer is started when an internal fault has been detected. Each differential stage provides a separate timer: address 1625 for the I_{DIFF}> stage and address 1626 for the I_{DIFF}>> stage.

Additionally, a drop-off delay after trip can be set under address 1627 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 windings. All times are pure delay times which do not include the inherent operating time.

```
1625 T-DELAY >
0.00 s
```

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

```
1626 T-DELAY >>
0.00 s
```

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

```
1627 T-RESET
0.10 s
```

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

6.3.8 Settings for the generator or motor differential protection − address block 17

A precondition for the operation of the generator or motor differential protection is that it is configured as DIFF PROT = *EXIST* under address 7816 (refer to Section 5.4.2). Additionally, the PROTected OBJect (address 7801) must be *GENERATOR/MOTOR*. In other cases, address block 17 is not available. 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 1701.

Attention! When delivered from factory, the differential protection is switched *OFF*. All desired protection functions are switched effective one after the other during commissioning.

```
1700 GEN/MOTOR
DIFF-PROTECTION
```

Beginning of block ”Generator or motor differential protection”

```
1701 DIFF PROT.
OFF
```

```
ON
```

```
BLOCK TRIP REL
```

Generator or motor 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 1703 to 1708. Figure 6.6 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 1703) is the pick-up value of the differential current. The pick-up value is referred to the rated current of the machine corresponding to the rated power (refer to Section 6.3.4, addresses 1202 and 1203).

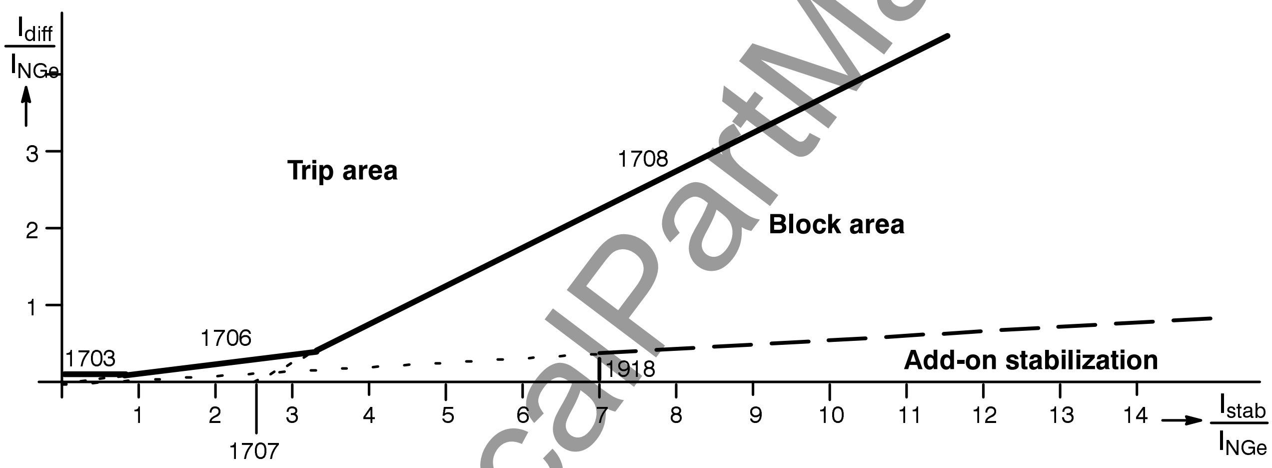


Figure 6.6 Shape of the tripping characteristic and relevant parameters

The tripping characteristic forms two more branches (Figure 6.6). The slope of the first branch is determined by the address 1706 SLOPE 1, its base point is the origin of the coordinate system. This branch covers current proportional errors. These are mainly transformation errors of the main current transformers and the input transducers of the relay.

The second branch produces a higher stabilization in the range of high currents which may lead to current transformer saturation. Its base point is set under address 1707 BASE PT 2 and is referred to the rated machine current. The slope is set under address 1708 SLOPE 2. The stability of the relay during current transformer saturation can be influenced by this parameter. A higher slope results in a higher stability.

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 1718 SAT−RESTR (saturation restraint). This value is referred to the rated power machine current, too. Its slope is $^1/_2$ of the slope of the branch 1706. It should be noted that the stabilizing quantity during through-flowing condition is the arithmetical sum of the currents through the windings, i.e. twice the through-flowing current. The maximum duration of this add-on stabilization can be set under address 1717 as a multiple of the a.c. periods.

```
 1703█ I-DIFF>
0.10  I/InGe
```

Pick-up value of differential current, referred to the rated generator or motor current
Smallest setting: **0.05** · $I_{N\ generator/motor}$
Largest setting: **2.00** · $I_{N\ generator/motor}$

```
 1706█ SLOPE 1
0.12
```

Slope of the first declined branch of the tripping characteristic
Smallest setting: **0.10**
Largest setting: **0.50**

```
 1707█ BASE PT 2
2.5  I/InGe
```

Base point of the second declined branch of the tripping characteristic
Smallest setting: **0.0** · $I_{N\ generator/motor}$
Largest setting: **10.0** · $I_{N\ generator/motor}$

```
 1708█ SLOPE 2
0.50
```

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

```
 1717█ T-SAT-BLO.
8  *1P
```

maximum duration of the add-on stabilization during detected current transformer saturation
Smallest setting: **2** a.c. periods
Largest setting: **250** a.c. periods
or ∞ (until drop-off of the differential stage I_{DIFF}>)

```
 1718█ SAT-RESTR.
7.00  I/InGe
```

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

In special cases it may be advantageous to delay the trip signal of the protection. For this, an additional time delay can be set. The timer is started when an internal fault has been detected (address 1725).

Additionally, a drop-off delay after trip can be set under address 1627 T–RESET. All times are pure delay times which do not include the inherent operating time.

```
 1725█ T-DELAY
0.00  s
```

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

```
 1727█ T-RESET
0.10  s
```

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

6.3.9 Settings for the branch point differential protection − address block 18

A precondition for the operation of the branch point differential protection is that it is configured as DIFF PROT = *EXIST* under address 7816 (refer to Section 5.4.2). Additionally, the PROTected OBJect (address 7801) must be *2ENDS−BRANCH PT* or *3ENDS−BRANCH PT* (7UT513 only). In other cases, address block 18 is not available. 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 1801.

Attention! When delivered from factory, the differential protection is switched *OFF*. All desired protection functions are switched effective one after the other during commissioning.

```
1800 BRANCH PT.
DIFF-PROTECTION
```

Beginning of block "Branch point differential protection"

```
1801 DIFF PROT.
OFF
```

```
ON
```

```
BLOCK TRIP REL
```

Branch point 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 1803 to 1808. Figure 6.7 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 1803) is the pick-up value of the differential current. This is the total fault current, regardless of the way this is divided between the protected ends. The pick-up value is referred to the rated current of the branch point corresponding to address 1301 (refer to Section 6.3.5).

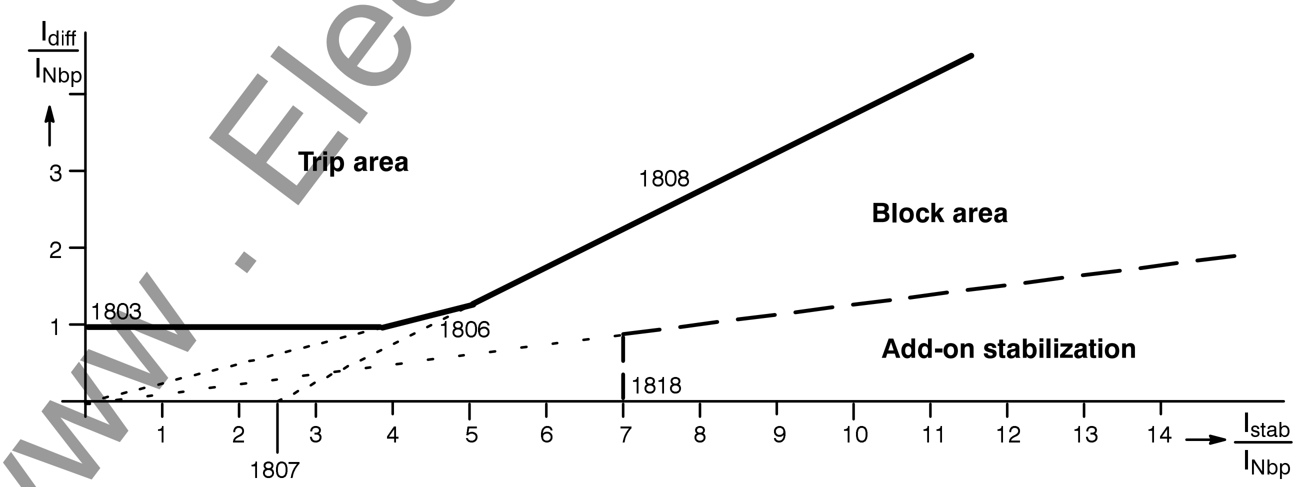


Figure 6.7 Shape of the tripping characteristic and relevant parameters

The tripping characteristic forms two more branches (Figure 6.7). The slope of the first branch is determined by the address 1806 SLOPE 1, its base point is the origin of the coordinate system. This branch covers current proportional errors. These are mainly transformation errors of the main current transformers and the input transducers of the relay or tolerances in the matching factors when the branch point feeders have different rated primary currents.

The second branch produces a higher stabilization in the range of high currents which may lead to current transformer saturation. Its base point is set under address 1807 BASE PT 2 and is referred to the rated branch point current. The slope is set under address 1808 SLOPE 2. The stability of the relay during current transformer saturation can be influenced by this parameter. A higher slope results in a higher stability.

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 1818 SAT−RESTR (saturation restraint). This value is referred to the rated branch point current, too. Its slope is $^1/_2$ of the slope of the branch 1806. It should be noted that the stabilizing quantity during through-flowing condition is the arithmetical sum of the currents through the windings, i.e. twice the through-flowing current. The maximum duration of this add-on stabilization can be set under address 1817 as a multiple of the a.c. periods.

```
  1803█ I-DIFF>
1.00  I/InPt
```

Pick-up value of differential current, referred to the rated branch point current
Smallest setting: **0.30** · $I_{N\ branch\ point}$
Largest setting: **2.50** · $I_{N\ branch\ point}$

```
  1806█ SLOPE 1
0.25
```

Slope of the first declined branch of the tripping characteristic
Smallest setting: **0.10**
Largest setting: **0.50**

```
  1807█ BASE PT 2
2.5  I/InPt
```

Base point of the second declined branch of the tripping characteristic
Smallest setting: **0.0** · $I_{N\ branch\ point}$
Largest setting: **10.0** · $I_{N\ branch\ point}$

```
  1808█ SLOPE 2
0.50
```

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

```
  1817█ T-SAT-BLO.
8  *1P
```

maximum duration of the add-on stabilization during detected current transformer saturation
Smallest setting: **2** a.c. periods
Largest setting: **250** a.c. periods
or ∞ (until drop-off of the differential stage I_{DIFF}>)

```
  1818█ SAT-RESTR.
7.00  I/InPt
```

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

In special cases it may be advantageous to delay the trip signal of the protection. For this, an additional time delay can be set. The timer is started when an internal fault has been detected (address 1825).

Additionally, a drop-off delay after trip can be set under address 1827 T–RESET. All times are pure delay times which do not include the inherent operating time.

```
  1 8 2 5 █ T - D E L A Y
0 . 0 0   s
```

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

```
  1 8 2 7 █ T - R E S E T
0 . 1 0   s
```

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

When the relay is used as branch point protection, the differential currents of each phase are continuously monitored on a low level. When, during normal load conditions, a differential current flows which corresponds to the load current of a feeder, this indicates a missing secondary current, i.e. a fault in the secondary current leads. This occurrence is annunciated by the relay with a delay, and the differential protection of the concerned phase is blocked.

The pick-up value of this low level monitor is set under address 1831, address 1832 determines the delay until the differential protection is blocked and alarm is issued. The current pick-up value is referred to the rated branch point current (refer to address 1301, Section 6.3.5).

The current pick-up value should be high enough to avoid false pick-up due to transformation errors or tolerances of the current matching when the rated c.t. currents are different. The alarm delay must ensure that the differential protection is not blocked during a real fault in the network. It must be considerably longer than the trip delay time (address 1825).

```
  1 8 3 1 █ I   D I F F > M O N
0 . 2 0   I / I n P t
```

Fault current during fault in the secondary current transformer circuits, referred to the rated branch point current
Smallest setting: **0.15** · $I_{N\ branch\ point}$
Largest setting: **0.80** · $I_{N\ branch\ point}$

```
  1 8 3 2 █ T - M O N I T O R
2   s
```

Delay time for blocking and alarm after a secondary c.t. fault has been detected; must be longer than a trip delay if set
Smallest setting: **1** s
Largest setting: **10** s
and ∞ (no blocking)

6.3.10 Settings for the restricted earth fault protection − address block 19

The restricted earth fault protection is an order option of 7UT513. A precondition for the operation is that it is configured under address 7819 (refer to Section 5.4.2) to one of the windings or to the virtual object. Additionally, one of the additional current inputs I_A or I_B must be allocated to the same winding or the virtual object (addresses 7806 or 7807). The restricted earth fault 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 1901.

Attention! When delivered from factory, the restricted earth fault protection is switched *OFF*. The reason is that this protection must not be in operation unless at least the correct allocation and polarity of the current transformers have been set before. Without correct setting the relay may show unexpected reactions (incl. tripping)!

```
 1900█ REST.EARTH
FAULT PROTECTION
```

Beginning of block ”Restricted earth fault protection”

```
 1901█ RESTR. E/F
OFF
```

```
ON
```

```
BLOCK TRIP REL
```

restricted earth fault protection

ON is switched on or

OFF is switched off or

BLOCK TRIP RELAY operates but trip relay is blocked

The sensitivity of the restricted earth fault protection is determined by the pick-up value I−REF> (address 1903). The earth fault current, which flows through the star-point lead of the protected transformer, is decisive. A further earth fault current which may be supplied from the network does not influence the sensitivity.

The critical limit angle (address 1904) determines the stability of the protection. It indicates at which phase displacement between the star-point current and the sum of the phase currents the stability grows to infinity when the currents are of the same magnitude and flow through the protected object. 180° means that the currents have equal phase because of the definition that all currents entering the protected zone are positive. The smaller the critical limit angle the higher the stability.

The preset critical limit angle corresponds to a stabilizing factor k = 1 in the stability equation as it is explained in Section 4.5.2.

```
 1903█ I-REF>
0.10 I/In
```

Pick-up value of restricted earth fault protection, referred to the rated current of the protected object

Smallest setting: **0.05** $\cdot I_{N\ object}$

Largest setting: **2.00** $\cdot I_{N\ object}$

```
 1904█ CRIT.ANGLE
110 °
```
```
90 °
```
```
100 °
```
```
120 °
```
```
130 °
```

Critical limit angle for absolute stabilization during through-flowing earth current

110° corresponds to stabilizing factor k ≈ 2

90° corresponds to stabilizing factor k → ∞

100° corresponds to stabilizing factor k ≈ 4

120° corresponds to stabilizing factor k ≈ 1.4

130° corresponds to stabilizing factor k ≈ 1

Stabilization of the unit during transformer switch-on can be switched off or on under address 1910. It is based on the evaluation of the second harmonic content of the inrush current. Normally, the inrush current is a through-flowing current, as registered by the restricted earth fault protection; that is why it is preset as switched off. For exceptional conditions it can be switched on under address 1910, and the second harmonic content which is necessary to block the protection can be parameterized under address 1911.

If the differential current exceeds a certain multiple of the rated current of the protected object (address 1912) no more stabilization by the second harmonic takes place.

```
 1910█ 2nd HARMON
OFF
```
```
ON
```

Inrush stabilization with the second harmonic is

OFF switched off or

ON switched on

```
 1911█ 2nd HARMON
15 %
```

2nd harmonic content in differential current, which just initiates blocking, in % of fundamental wave of the differential current

Smallest setting: **10** %

Largest setting: **80** %

```
 1912█ IREFmax 2
10.0 I/In
```

Stabilization with the 2nd harmonic is effective up to this differential current limit, referred to the rated current of the protected object

Smallest setting: **1.0** · $I_{N\ object}$

Largest setting: **20.0** · $I_{N\ object}$

In special cases it may be advantageous to delay the trip signal of the protection. For this, an additional time delay can be set (address 1925). Normally, it is set to 0. Additionally, a drop-off delay after trip can be set under address 1927 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. All times are pure delay times which do not include the inherent operating time.

```
 1925█ T-DELAY
0.00 s
```

Additional trip time delay

Smallest setting: **0.00** s

Largest setting: **60.00** s

and ∞ (no trip with the I_{REF}> stage)

```
 1927█ T-RESET
0.10 s
```

Reset delay after trip signal has been disappeared

Smallest setting: **0.00** s

Largest setting: **60.00** s

6.3.11 Settings for back-up overcurrent time protection – address block 21

The back-up overcurrent time protection operates independent of the differential protection. A pre-condition is that the back-up protection had been allocated under address 7821 BACK–UP O/C to one of the sides of the protected object or to the virtual object (refer to Section 5.4.2). The back-up overcurrent time protection 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 2101.

The parameters of the back-up overcurrent time protection are set in block 21. All current values are referred to the rated current of the protected object, with transformers to the rated current of the assigned winding.

At first, the high-set overcurrent stage I>> is set under addresses 2103 and 2104. This stage is always a definite time stage, independent on which characteristic is set for the overcurrent stage. On transformers, it is set to approximately 1.5 times the factor $^1/u_k$ so that it does not operate on faults within the connected network but only on faults with in the protected zone.

The overcurrent stage can be used as definite time overcurrent protection or inverse time overcurrent protection. This function mode can be selected in address 2111. For inverse time, a choice can be made between three tripping time characteristics defined in IEC 60255–3. The pick-up value I> (address 2112 for definite time) or I_p (address 2114 for inverse time) must be set above the maximum expected (over)load current (approximately 1.4 times).

The setting of the delay times must be in accordance with the grading plan of the galvanically interconnected system. If a stage is not to be used, its time delay is set to ∞.

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.

```
2100█ BACK-UP
OVERCURRENT PROT
```

Beginning of block
"Back-up overcurrent time protection"

```
2101█ BACKUP O/C
OFF
```

```
ON
```

```
BLOCK TRIP REL
```

Back-up overcurrent time protection, can be

OFF switched off or

ON switched on or

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

```
2103█ I>>
4.00 I/In
```

High-current pick-up threshold I>>, referred to the rated current of the protected object or winding
Smallest setting value: **0.10** · $I_{N\ object}$
Largest setting value: **30.00** · $I_{N\ object}$

```
2104█ 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)

```
2111█ CHARACT
DEFINITE TIME
```

```
NORMAL INVERSE
```

```
VERY INVERSE
```

```
EXTREMELY INVERS
```

Characteristic of the overcurrent stage

DEFINITE TIME characteristic

NORMAL INVERSE time (type A acc. IEC 60255–3)

VERY INVERSE time (type B acc. IEC 60255–3)

EXTREMELY INVERSe time (type C acc. IEC 60255–3)

```
2112 I>
2.00 I/In
```

Only for definite time protection:
Pick-up threshold I>, referred to the rated current of the protected object or winding
Smallest setting value: **0.10** · $I_{N\ object}$
Largest setting value: **30.00** · $I_{N\ object}$

```
2113 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 HARMON*ics 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.

```
2114 Ip
2.00 I/In
```

Only for inverse time protection:
Pick-up threshold Ip
Smallest setting value: **0.10** · $I_{N\ object}$
Largest setting value: **20.00** · $I_{N\ object}$

```
2115 T-Ip
0.50 s
```

Time multiplier for phase currents
Smallest setting value: **0.50** s
Largest setting value: **32.00** s
and ∞ (no trip with I_p stage)

```
2116 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)

```
2118 T-RESET
0.10 s
```

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

Address 2121 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 2103 to 2115.

```
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

6.3.12 Settings for thermal overload protection – address blocks 24 and 25

The relay includes two thermal overload protection functions, which can each be assigned to any of the sides (feeders) of the protected object. With 7UT512, this may be the higher voltage and/or the lower voltage side of a transformer, the star-point or terminal side of a generator or motor, or any end of a two-terminal branch point. With 7UT513, any desired winding of a three-winding transformer or any desired end of a three-terminal branch-point can be selected. When 7UT513 is used for a two-winding transformer, generator, motor, or two-terminal branch point, then one of the overload protection functions can be assigned either to any desired protected object, the virtual object.

Overload protection 1 operates as it is configured under address 7824, overload protection 2 as under address 7825 (refer to Section 5.4.2).

Overloads which endanger the protected object cannot and should not be detected by the short-circuit protection. The 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 object nor to utilize its (limited) overload capability.

For transformer overload protection, the rated current of the protected transformer winding is always used as the base current for the detection of an overload. If the windings have different MVA ratings, then the overload function always refers to the rated current of the protected winding. Due to the input of the transformer and the current transformer data for the differential protection function (Section 6.3.3) the unit is able to calculate the rated currents of the windings referred to the largest winding (these being relevant for the differential protection function) as well as the rated currents of each winding which are relevant for the overload function. This enables optimum matching even when a three-winding transformer has a weak tertiary winding with small MVA rating. For generators and motors, the rated machine current derived from the rated power and rated voltage (Section 6.3.4) are used as the base current for overload processing. For branch points or a virtual object, the stated rated current of these is used (Section 6.3.5 or 6.3.6).

The parameters of the thermal overload protection 1 are set in address block 24, those of the thermal overload protection 2 in address block 25.

Each 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 2401 or 2501).

The setting factor k is determined by the ratio of the continuously permissible thermal current I_{max} to the rated current of the protected object:

$$k = \frac{I_{max}}{I_{N\ object}}$$

As the rated data of the protected object have been set correctly (let's hope so), no further calculations are necessary. The permissible continuous current is to be stated by the manufacturer. If no data are available, one selects 1.1 times the rated current of the protected object (i.e. k = 1.1).

The overload protection simulates the temperature rise characteristic of the thermal differential equation, the solution of which represents an e–function in steady-state operation. The time constant t is decisive for the time to reach the temperature rise threshold and thus for the trip time. Since the thermal replica simulates the heating-up characteristic of a single-body model, the relatively long iron time constant of the protected machine can be set for small overloads (up to approximately 1.2 I_N). For larger overloads, it is sufficient to set a slightly shorter time constant which considers the faster warm-up of the winding as compared to the iron.

If the 1 s current, i.e. the maximum permissible current for 1 s duration, is known or can be taken from tables, then the time constant can be calculated according to the following formula:

Setting value t [min] =

$$\frac{1}{60} \cdot \left(\frac{\text{permissible 1 s current}}{\text{continuously permissible current}}\right)^2$$

If the short-term 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:

Setting value t [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.

By setting a warning temperature rise (addresses 2404 and 2504), 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 (addresses 2405 and 2505). This can be set as a factor of the rated current of the protected object 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 Q_{warn}/Q_{trip} to 100 %, the temperature warning is practically ineffective.

A choice can be made whether the temperature rise which is decisive for the threshold stages, is the maximum calculated temperature rise of the three conductors, the mean value of the calculated temperature rises of the three conductors, or the temperature rise calculated from the maximum current of the three conductors (addresses 2406 and 2506).

Settings for **thermal overload protection 1**:

```
 2400█ THERMAL
OVERLOAD PROT. 1
```

Beginning of block ”Thermal overload protection 1”

```
 2401█ THERMAL OL
OFF
```

```
ON
```

```
BLOCK TRIP REL
```

```
ALARM ONLY
```

Thermal overload protection 1, can be

ON switched on or

OFF switched off or

BLOCK TRIP REL trip relay is blocked but the protection is operative or

ALARM ONLY set to give only alarms

```
 2402█ K-FACTOR
1.10
```

Setting value of k−factor = $I_{max}/I_{N\ object}$
Smallest setting: **0.10**
Largest setting: **4.00**

```
 2403█ T-CONSTANT
100.0 min
```

Time constant t
Smallest setting: **1.0** min
Largest setting: **999.9** min

```
 2404█ Q WARN
90 %
```

Warning temperature rise in % of trip temperature rise Q_{warn}/Q_{trip}
Smallest setting: **50** %
Largest setting: **100** %

```
 2405█ I WARN
1.00 I/In
```

Current warning stage; set as a multiple of $I_{N\ object}$
Smallest setting: **0.10** $\cdot I_{N\ object}$
Largest setting: **4.00** $\cdot I_{N\ object}$

```
 2406█ O/L CALCUL
Q MAX
```

```
Q MEAN
```

```
Q FROM IMAX
```

Calculation mode decisive for thermal thresholds

*MAX*imum of the *temperature* rises of the three conductors

MEAN value of the *temperature* rises of the three conductors

temperature rise calculated *FROM* the *MAX*imum conductor *current*

Settings for **thermal overload protection 2**:

```
 2500 THERMAL
OVERLOAD PROT. 2
```

Beginning of block "Thermal overload protection 2"

```
 2501 THERMAL OL
OFF
ON
BLOCK TRIP REL
ALARM ONLY
```

Thermal overload protection 2, can be

ON switched on or

OFF switched off or

BLOCK TRIP REL trip relay is blocked but the protection is operative or

ALARM ONLY set to give only alarms

```
 2502 K-FACTOR
1.10
```

Setting value of k−factor = $I_{max}/I_{N\ object}$
Smallest setting: **0.10**
Largest setting: **4.00**

```
 2503 T-CONSTANT
100.0 min
```

Time constant t
Smallest setting: **1.0** min
Largest setting: **999.9** min

```
 2504 Q WARN
90 %
```

Warning temperature rise in % of trip temperature rise Q_{warn}/Q_{trip}
Smallest setting: **50** %
Largest setting: **100** %

```
 2505 I WARN
1.00 I/In
```

Current warning stage; set as a multiple of $I_{N\ object}$
Smallest setting: **0.10** · $I_{N\ object}$
Largest setting: **4.00** · $I_{N\ object}$

```
 2506 O/L CALCUL
Q MAX
Q MEAN
Q FROM IMAX
```

Calculation mode decisive for thermal thresholds

*MAX*imum of the *temperature* rises of the three conductors

MEAN value of the *temperature* rises of the three conductors

temperature rise calculated *FROM* the *MAX*imum conductor *current*

6.3.13 Settings for the tank leakage protection – address block 27

The tank leakage protection is an order option of 7UT513. A precondition for the operation is that it is configured under address 7827 (refer to Section 5.4.2) to one of the two additional current inputs I_A or I_B. The setting range of the tank leakage protection depends on the connection of the tank earth current: If the additional current input I_A is used, the tank leakage protection can be set to 0.1 to 10 times the rated relay current; if the highly sensitive current input I_B is used, the setting range of the tank leakage protection is independent of any rated currents and amounts 10 mA to 1000 mA.

The tank leakage protection 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 2701.

For tank leakage protection, the current between the isolated installed transformer tank and earth is monitored. The sensitivity of the protection is set in address 2703 when current input I_A is used or in address 2704 when current input I_B is used. Dependent of the configuration (address 7827) only one of the two setting addresses is available.

A choice can be made whether the true r.m.s. value or the fundamental wave of the tank earth current will be processed (address 2705). Normally, the fundamental wave *WITHOUT HARMON*ics is selected.

The drop-off to pick-up ratio is set under address 2709. A high drop-off to pick-up ratio should be avoided since arc faults within the tank produce considerable current fluctuations.

The trip command can be delayed under address 2725. Normally, this delay time is set to 0. Additionally, a drop-off time relay can be set under address 2727.

```
2700█ TRANSFORM.
TANK PROTECTION
```

Beginning of block "Transformer tank leakage protection"

```
2701█ TANK
OFF
```

```
ON
```

```
BLOCK TRIP REL
```

Tank leakage protection

ON is switched on or

OFF is switched off or

BLOCK TRIP RELAY operates but trip relay is blocked

```
2703█ I> TANK
0.50 I/In
```

Only with connection to the normal current input I_A:
Pick-up value of tank earth current, referred to the rated relay current

Smallest setting:	**0.10** · $I_{N\ relay}$
Largest setting:	**10.00** · $I_{N\ relay}$

```
2704█ I> TANK
500 mA
```

Only with connection to the highly sensitive current input I_B:
Pick-up value of tank earth current in mA

Smallest setting:	**10** mA
Largest setting:	**1000** mA

```
 2705▮ RMS  FORMAT
WITHOUT  HARMON.
```

```
WITH  HARMONICS
```

Method of processing the tank current

The fundamental wave of the measured current is evaluated *WITHOUT HARMON*ics

The true r.m.s. value of the measured current is evaluated *WITH HARMONICS*

```
 2709▮ D.OFF  TNK>
0.50
```

Drop-off to pick-up ratio for I> TANK
Smallest setting: **0.25**
Largest setting: **0.95**

```
 2725▮ T-DELAY
0.00  s
```

Additional trip time delay
Smallest setting: **0.00** s
Largest setting: **60.00** s
and ∞ (no trip with the I> TANK)

```
 1927▮ T-RESET
0.10  s
```

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

6.3.14 Settings for measured value monitoring – address block 29

The different monitoring functions of the protective relay are described in Section 4.11.4. 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. When using 7UT51 as protection for a single-phase transformer, both parameters should be set to the highest value since otherwise alarm could be given continuously.

```
 2900▮ MEAS.VALU
E SUPERVISION
```

Beginning of block
"Measured value supervision"

```
 2903▮ SYM.Ithres
0.50  I/In
```

Current threshold above which the symmetry monitoring (refer Figure 4.32) reacts (absolute content, referred to I_N of the device only)
Smallest setting value: **0.10**
Largest setting value: **1.00**

```
 2904▮ SYM.Fact.I
0.50
```

Relative content (referred to the maximum of the three currents) for operation of the current symmetry monitoring (refer Figure 4.32)
Smallest setting value: **0.00**
Largest setting value: **0.95**

6.3.15 Coupling external trip signals − address blocks 30 and 31

Up to two desired signals from external protection or supervision units can be incorporated into the processing of 7UT51. The signals are coupled as ”External signals” via binary inputs. Like the internal protection and supervision signals, they can be annunciated as ”External trip”, time delayed and transmitted to the trip matrix. A precondition is that they are configured as EXT. TRIP 1 = *EXIST* under address 7830 and/or EXT. TRIP 2 = *EXIST* under address 7831 (refer to Section 5.4.2).

```
3000 EXTERNAL
TRIP FUNCTION 1
```

Beginning of the block ”Incorporating of an external trip function 1”

```
3001 EXT.TRIP 1
OFF
```

Switch *OFF* of external trip function 1

```
ON
```

Switch *ON* of external trip function 1

```
BLOCK TRIP REL
```

external trip function operates but *TRIP REL*ay is *BLOCK*ed

```
3002 T-DELAY
0.00 s
```

Time delay for external trip function 1
Setting range: **0.00** s to **60.00** s
and ∞ (no trip)

```
3003 T-RESET
0.10 s
```

Reset delay after trip signal has been initiated
Setting range: **0.00** s to **60.00** s

```
3100 EXTERNAL
TRIP FUNCTION 2
```

Beginning of the block ”Incorporating of an external trip function 2”

```
3101 EXT.TRIP 2
OFF
```

Switch *OFF* of external trip function 2

```
ON
```

Switch *ON* of external trip function 2

```
BLOCK TRIP REL
```

external trip function operates but *TRIP REL*ay is *BLOCK*ed

```
3102 T-DELAY
0.00 s
```

Time delay for external trip function 2
Setting range: **0.00** s to **60.00** s
and ∞ (no trip)

```
3103 T-RESET
0.10 s
```

Reset delay after trip signal has been initiated
Setting range: **0.00** s to **60.00** s

6.4 Annunciations

6.4.1 Introduction

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

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

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

– LED indications in the front plates of the relay (Figure 6.1 or 6.2),

– 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 57 Indication of operational measured values (currents).

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.

```
⇑ 5100█ OPERATIONAL
⇓ ANNUNCIATIONS
```

Beginning of the block "Operational annunciations"

```
↑ 31.05.95   14:32
↓ O/L 2 Warn Q :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:

`>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)
`>Buchh. Warn`	Buchholz protection warning stage (C/G)
`>Buchh. Trip`	Buchholz protection tripping stage (C/G)

`>Buchh. Tank`	Buchholz protection tank supervision (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 Ip 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)
`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
`Manual Close`	Manual close command registered (impulse) (C)
`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)

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)
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 24V	Failure in internal supply voltage 24 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 1	Failure in trip relay circuit on base input/output p.c.b. (C/G)
Failure I/O 2	Failure on additional input/output p.c.b. (7UT513 only) (C/G)
Failure RKA	Failure on output relay p.c.b. (C/G)
LSA disrupted	Serial system link to LSA disrupted (C/G)
Fail. Isym 1	Failure detected by current symmetry monitor of side (feeder, winding) 1 (C/G)
Fail. Isym 2	Failure detected by current symmetry monitor of side (feeder, winding) 2 (C/G)
Fail. Isym 3	Failure detected by current symmetry monitor of side (feeder, winding) 3 (7UT513 only) (C/G)

Operational annunciations after configuration or parameterizing error (7UT513 only):

Err 2 CT star	Configuration error: two star-point c.t.s have been assigned to the same side (terminal) of the differential protection (C)
Err no CTstar	Parameterizing error: zero sequence current correction is set but no star-point c.t. is configured (C)
REF Err S3	Configuration error: restricted earth fault protection is assigned to non-existing side 3 (C)
REF Err2CTsta	Configuration error: restricted earth fault protection is assigned to 2 star-point c.t.s (C)
REF Err0CTsta	Configuration error: restricted earth fault protection is not assigned to any star-point c.t. (C)
REF ErrVir ob	Configuration error: restricted earth fault protection is assigned to a virtual object though all 3 ends are already used (C)
REF no exist	Restricted earth fault protection is configured but cannot operate (C)
Backup Err S3	Configuration error: Back-up overcurrent time protection is assigned to non-existing side 3 (C)
O/L 1 Err S3	Configuration error: Thermal overload protection 1 is assigned to non-existing side 3 (C)
O/L 2 Err S3	Configuration error: Thermal overload protection 2 is assigned to non-existing side 3 (C)
Tank no exist	Tank leakage protection is configured but cannot operate (C)

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)
Diff Iflt.L1	Differential protection is blocked in phase L1 because of detected c.t. fault (branch point protection only (C/G)
Diff Iflt.L2	Differential protection is blocked in phase L2 because of detected c.t. fault (branch point protection only (C/G)
Diff Iflt.L3	Differential protection is blocked in phase L3 because of detected c.t. fault (branch point protection only (C/G)
k CT 1 =	Current matching factor of side 1 of the protected object (value)
k CT 2 =	Current matching factor of side 2 of the protected object (value)
k CT 3 =	Current matching factor of side 3 of the protected object (7UT513 only) (value)

`ksCT  1 =`	Current matching factor of the star-point c.t. of side 1 of the protected object (7UT513 only) (value)
`ksCT  2 =`	Current matching factor of the star-point c.t. of side 2 of the protected object (7UT513 only) (value)
`ksCT  3 =`	Current matching factor of the star-point c.t. of side 3 of the protected object (7UT513 only) (value)

Annunciations of the restricted earth fault protection (7UT513 only):

`REF off`	Restricted earth fault protection is switched off (C/G)
`REF blocked`	Restricted earth fault protection is blocked (C/G)
`REF active`	Restricted earth fault protection is active (C/G)
`REFk CT =`	Current matching factor of the line c.t.s for restricted earth fault protection (value)
`REFksCT =`	Current matching factor of the star-point c.t. for restricted earth fault protection (value)

Annunciations of the tank leakage protection (7UT513 only):

`Tank off`	Tank leakage protection is switched off (C/G)
`Tank blocked`	Tank leakage protection is blocked (C/G)
`Tank active`	Tank leakage protection is active (C/G)

Operational annunciations of external trip facility via binary input:

`Ext 1 off`	External trip function 1 is switched off (C/G)
`Ext 1 blocked`	External trip function 1 is blocked (C/G)
`Ext 1 active`	External trip function 1 is active (C/G)
`Ext 2 off`	External local trip function 2 is switched off (C/G)
`Ext 2 blocked`	External trip function 2 is blocked (C/G)
`Ext 2 active`	External trip function 2 is active (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 Ip 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 functions:

`O/L 1 off`	Thermal overload protection 1 is switched off (C/G)
`O/L 1 blocked`	Thermal overload protection 1 is blocked (C/G)
`O/L 1 active`	Thermal overload protection 1 is active (C/G)
`O/L 1 Warn I`	Thermal overload protection 1 current warning stage picked up (C/G)
`O/L 1 Warn Q`	Thermal overload protection 1 thermal warning stage picked up (C/G)
`O/L 1 F.D. Q`	Thermal overload protection 1 thermal trip stage picked up (C/G)
`O/L 2 off`	Thermal overload protection 2 is switched off (C/G)
`O/L 2 blocked`	Thermal overload protection 2 is blocked (C/G)
`O/L 2 active`	Thermal overload protection 2 is active (C/G)
`O/L 2 Warn I`	Thermal overload protection 2 current warning stage picked up (C/G)
`O/L 2 Warn Q`	Thermal overload protection 2 thermal warning stage picked up (C/G)
`O/L 2 F.D. Q`	Thermal overload protection 2 thermal trip stage picked up (C/G)

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█ 31.05.95
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█ 16:17:28.359
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
`Dev. Drop-off`	Drop-off of the device, general

Fault annunciations of differential protection:

`Diff Gen. Flt`	General fault detection of differential protection
`Diff> T start`	Delay time of differential protection stage I_{diff}> started (when a delay is set)
`Diff>> T strt`	Delay time of differential protection stage I_{diff}>> started (when a delay is set)
`Block Harm L1`	Differential protection L1 blocked by excessive current harmonic content
`Block Harm L2`	Differential protection L2 blocked by excessive current harmonic content
`Block Harm L3`	Differential protection L3 blocked by excessive current harmonic content
`Block Sat L1`	Differential protection L1 blocked by current transformer saturation indicator
`Block Sat L2`	Differential protection L2 blocked by current transformer saturation indicator
`Block Sat L3`	Differential protection L3 blocked by current transformer saturation indicator
`Diff> L1`	Differential protection stage I_{diff}> picked up in L1
`Diff> L2`	Differential protection stage I_{diff}> picked up in L2
`Diff> L3`	Differential protection stage I_{diff}> picked up in L3
`Diff>> L1`	Differential protection stage I_{diff}>> picked up in L1
`Diff>> L2`	Differential protection stage I_{diff}>> picked up in L2
`Diff>> L3`	Differential protection stage I_{diff}>> picked up in L3
`Diff> Trip`	Trip by differential protection stage I_{diff}>
`Diff>> Trip`	Trip by differential protection stage I_{diff}>>
`Dif L1 =`	Differential current L1 at trip instant (value)

`Dif L2 =`	Differential current L2 at trip instant (value)
`Dif L3 =`	Differential current L3 at trip instant (value)
`Res L1 =`	Stabilizing (restraint) current L1 at trip instant (value)
`Res L2 =`	Stabilizing (restraint) current L2 at trip instant (value)
`Res L3 =`	Stabilizing (restraint) current L3 at trip instant (value)

Fault annunciations of restricted earth fault protection:

`REF Gen. Flt`	Fault detection of restricted earth fault protection
`REF T start`	Delay time of restricted earth fault protection started (when a delay is set)
`REF Gen.Trip`	Trip by restricted earth fault protection
`REF D=`	Restricted earth fault protection tripping measure at trip instant (value)
`REF S=`	Restricted earth fault protection angle measure at trip instant (value)

Fault annunciations of tank leakage protection:

`Tank Gen. Flt`	Fault detection of tank leakage protection
`Tank T start`	Delay time of tank leakage protection started (when a delay is set)
`Tank Gen.Trip`	Trip by tank leakage protection
`Tank=`	Tank leakage (earth) current at trip instant (value)

Fault annunciation of external trip facility via binary input:

`Ext 1 Gen.Flt`	General fault detection signal of external trip function 1
`Ext 1 Gen.Trp`	General trip by external trip function 1
`Ext 2 Gen.Flt`	General fault detection signal of external trip function 2
`Ext 2 Gen.Trp`	General trip by external trip function 2

Fault annunciations of back-up overcurrent time protection:

`Backup Flt L1`	Fault detection L1 of back-up overcurrent time protection
`Backup Flt L2`	Fault detection L2 of back-up overcurrent time protection
`Backup Flt L3`	Fault detection L3 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 functions:

`O/L 1 Trip`	Trip by thermal overload protection 1
`O/L 2 Trip`	Trip by thermal overload protection 2

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.

```
⇧ 5 3 0 0█ 2 n d   T O   L A S T
⇩ F A U L T
```

etc.

Beginning of the block ”Fault annunciations of the second to last system fault”

The data of the **third to last** system fault can be found under address 5400. The available annunciations are the same as for the last fault.

```
⇧ 5 4 0 0█ 3 r d   T O   L A S T
⇩ F A U L T
```

etc.

Beginning of the block ”Fault annunciations of the third to last system fault”

6.4.4 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 blocks 11 to 14 as described in Section 6.3.3 to 6.3.6.

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

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

```
⇑  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 L1 [%] =  81 %
```

Page on with the ↑ key to read off the next address with the next measured value, or page back with ↓

```
↑  5702█ MEAS.VALUE
↓  I1 L2 [%] =  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 current of the protected object (terminal or winding)

```
↑  5703█ MEAS.VALUE
↓  I1 L3 [%] =  80 %
```

The first index (behind the `I`) indicates the side (feeder, terminal, winding) of the protected object; behind `IL` follows the measuring system

```
↑  5704█ MEAS.VALUE
↓  I2 L1 [%] =  82 %
```

```
↑  5705█ MEAS.VALUE
↓  I2 L2 [%] =  82 %
```

```
5706█ MEAS.VALUE
I2 L3 [%] = 82 %
```

```
5707█ MEAS.VALUE
I3 L1 [%] = 0 %
```

Addresses 5707 to 5709 only for for 7UT513 on protected objects with three sides (windings, terminals, feeders) or a virtual object

```
5708█ MEAS.VALUE
I3 L2 [%] = 0 %
```

```
5709█ MEAS.VALUE
I3 L3 [%] = 0 %
```

```
5710█ MEAS.VALUE
IA [%] = 0 %
```

Addresses 5710 and 5711 only with 7UT513, if additional current inputs are used and assigned

```
5711█ MEAS.VALUE
IB [%] = 0 %
```

```
5721█ MEAS.VALUE
I1 L1 = 162 A
```

The primary values (addresses 5721 to 5731) are referred to the primary rated c.t. current as it is parameterized for the protected object

```
5722█ MEAS.VALUE
I1 L2 = 164 A
```

```
5723█ MEAS.VALUE
I1 L3 = 160 A
```

```
5724█ MEAS.VALUE
I2 L1 = 1640 A
```

```
5725 MEAS.VALUE
I2 L2 = 1640 A
```

```
5726 MEAS.VALUE
I2 L3 = 1640 A
```

```
5727 MEAS.VALUE
I3 L1 = 0 A
```

Addresses 5727 to 5729 only with 7UT513 on protected objects with three sides (windings, terminals, feeders) or a virtual object

```
5728 MEAS.VALUE
I3 L2 = 0 A
```

```
5729 MEAS.VALUE
I3 L3 = 0 A
```

```
5730 MEAS.VALUE
IA = 0 A
```

Addresses 5730 and 5731 only with 7UT513, if additional current inputs are used and assigned

```
5731 MEAS.VALUE
IB = 0 A
```

If I_B is a normal measured current input, the measured current is referred to the primary value in amps

```
5731 MEAS.VALUE
IB = 0 mA
```

If I_B is a highly sensitive input, the connected current is indicated in milliamps

The calculated temperature rise of each of the two thermal overload protection functions can be read out in address block 59. This block is again reached by further scrolling with the keys ⇑ ⇓ or by direct addressing with **DA 5 9 0 0 E**. Input of the codeword is not necessary. The values are not actualized during read-off. When paging on with the keys ↑ or ↓, or leaving and re-entering the address block, or pressing the enter key **E**, the actual values are displayed.

```
5911 MEAS.VALUE
Q1/Qtrp=  54  %
```

Addresses 5911 to 5914 indicate the temperature rise calculated by the thermal overload protection function 1 (corresponding to address block 24).

The percentage is referred to the trip temperature rise

```
5912 MEAS.VALUE
Q1/QtrpL1=  54  %
```

The calculated temperature rise of each phase do not appear when the calculation method Q WITH IMAX has been selected under address 2406

```
5913 MEAS.VALUE
Q1/QtrpL2=  56  %
```

```
5914 MEAS.VALUE
Q1/QtrpL3=  53  %
```

```
5921 MEAS.VALUE
Q2/Qtrp=  56  %
```

Addresses 5921 to 5924 indicate the temperature rise calculated by the thermal overload protection function 2 (corresponding to address block 25).

The percentage is referred to the trip temperature rise

```
5922 MEAS.VALUE
Q2/QtrpL1=  56  %
```

The calculated temperature rise of each phase do not appear when the calculation method Q WITH IMAX has been selected under address 2506

```
5923 MEAS.VALUE
Q2/QtrpL2=  56  %
```

```
5924 MEAS.VALUE
Q2/QtrpL3=  56  %
```

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. 7UT51 comprises facilities, e.g. to re-adjust the real time clock, to erase stored informations, 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.**

```
⇑  8 0 0 0█ D E V I C E
⇓  C O N T R O L
```

Beginning of the block ”Device control”

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

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

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

```
⇑  8 1 0 0█ S E T T I N G
⇓  R E A L   T I M E   C L O C K
```

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

```
↑  0 1 . 0 6 . 1 9 9 5
↓  0 8 : 5 7 : 0 3
```

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

```
↑  8 1 0 2█ D A T E
↓
```

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

```
↑  8 1 0 3█ T I M E
↓
```

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

```
↑  8 1 0 4█ D I F F .   T I M E
↓
```

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

6.5.2 Erasing stored annunciations and counters – address block 82

The 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 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.

⇑⇓
```
8 2 0 0
R E S E T
```

Beginning of block "Reset"

↑↓
```
8 2 0 1  R E S E T
L E D   ?
```

Request whether the LED memories should be reset

↑↓
```
8 2 0 2  R E S E T
O P E R A T . A N N U N C .   ?
```

Request whether the operational annunciation buffer store should be erased

↑↓
```
8 2 0 3  R E S E T
F A U L T   A N N U N C .   ?
```

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

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

```
8 2 0 2  R E S E T
S U C C E S S F U L
```

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 (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 may 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:

⇑ ⇓ `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 6.8. 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

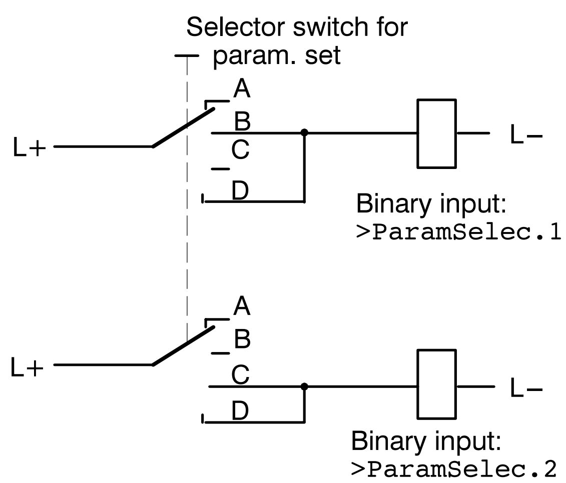


Figure 6.8 Connection scheme for parameter change-over via binary inputs

6.6 Testing and commissioning

6.6.1 General

Prerequisite for commissioning is the completion of the preparation procedures detailed in Chapter 5.

Warning

Hazardous voltages are present in this electrical equipment during operation. Non–observance of the safety rules can result in severe personal injury or property damage.

Only qualified personnel shall work on and around this equipment after becoming thoroughly familiar with all warnings and safety notices of this manual as well as with the applicable safety regulations.

Particular attention must be drawn to the following:

- The earthing screw of the device must be connected solidly to the protective earth conductor before any other connection is made.
- Hazardous voltages can be present on all circuits and components connected to the supply voltage or to the measuring and test quantities.
- Hazardous voltages can be present in the device even after disconnection of the supply voltage (storage capacitors!).
- The limit values given in the Technical data (Section 3.1) must not be exceeded at all, not even during testing and commissioning.

When testing the unit with a secondary injection test set, it must be ensured that no other measured values are connected and that the tripping leads to the circuit breaker trip–coils have been interrupted.

DANGER!

Secondary connections of the current transformers must be short--circuited before the current leads to the relay are interrupted!
If a test switch is installed which automatically short–circuits the current transformer secondary leads, it is sufficient to set this switch to the ”Test” position. The short–circuit switch must be checked beforehand (refer Section 5.2.6).

It is recommended that the actual settings for the relay be used for the testing procedure. If these values are not (yet) available, test the relay with the factory settings. In the following description of the test sequence the preset settings are assumed unless otherwise noted; for different setting values formulae are given, where necessary.

For the functional test a 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 255 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.

Remark: The tolerances listed in the Technical data refer to the preset data of the protected object, whereby the rated unit current equals the rated object current. If the rated object current (referred to the rated current transformer current) deviates considerably from the rated unit current, then larger pick–up tolerances must be expected.

During all the tests it is important to ensure that the correct command (trip) contacts close, that the proper indications appear at the LEDs and the output relays for remote signalling. If the relay is connected to a central memory device via the serial interface, correct communication between the relay and the master station must be checked.

After tests which cause LED indications to appear, these should be reset, at least once by each of the possible methods: the reset button on the front plate and via the remote reset relay (see connection diagrams, Appendix B). 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 transformer differential protection

For testing the differential protection, this function must have been configured as *EXIST* (address 7816) and the protected object (address 7801) must be a *2WIND–TRANSF* or a *3WIND–TRANSF* (7UT513 only) or a *1PHASE–TRANSF*. Additionally, it must be parameterized as operative, i.e. DIFF PROT = *ON* or DIFF PROT = *BLOCK TRIP REL* under address 1601.

The pick–up value of the differential protection can be checked by means of a secondary test set. The test current can be applied separately for each winding, i.e. in each case a transformer fault with single–ended infeed is simulated.

The preset parameter for I–DIFF> as pick–up value (address 1603) applies for three or two–phase testing. The pick–up value for single–phase testing depends on the method the zero sequence current is treated within the relay:

If the zero sequence current is eliminated (i.e. address 1106 Io HANDLE = *Io–ELIMINATION* as preset by the factory), then the pickup value is increased to 1.5 times the set value because of the elimination of the zero sequence current; this corresponds with conventional circuitry when the current is fed in via matching transformers.

If the zero sequence current is not eliminated (i.e. address 1106 Io HANDLE = *WITHOUT* or *Io–CORRECTION*), the pick–up value corresponds to the setting value I–DIFF> even during single–phase test.

Checking the pick–up value is performed by slowly increasing the test current for each winding. Trip occurs when the pick–up value, converted according the matching factor, is reached. When the test current falls below approximately 0.7 times the pick–up value, the relay drops off.

⚠ **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!

In the method described above, the pick–up values for single–ended infeed are tested. It is also possible to check the entire characteristic. Since trip current and stabilizing current cannot be fed in separately, (however they can be read out separately on the operator unit, refer to Section 6.7.3.1), a separate test current has to be applied to each of two windings. The characteristics I_2/I_1 in Figure 6.9 show the pick–up limits. I_1 is the test current flowing into winding 1 and I_2 is the test current flowing into winding 2. The currents are in phase.

When testing with the operational parameters it should be heeded that the setting value I–DIFF> refers to the rated current of the transformer, i.e. current which results from

$$I_{N\ transformer} = \frac{P_{N\ transformer}\ [MVA] \times 1000}{\sqrt{3} \times U_{N\ Winding}\ [kV]} \quad [A]$$

for three–phase transformers

or

$$I_{N\ transformer} = \frac{P_{N\ transformer}\ [MVA] \times 1000}{U_{N\ Winding}\ [kV]} \quad [A]$$

for single–phase transformers

with

$P_{N\ transformer}$ – MVA rating of transformer; if the windings have different MVA ratings then the winding with the largest MVA rating is taken as the basis.

$U_{N\ winding}$ – Rated voltage of the respective winding; if a winding is regulated, then the parameterized voltage according to Section 6.3.3 applies (address 1102 for winding 1, address 1122 for winding 2 and, if applicable, address 1142 for winding 3).

Furthermore, the pick–up values can change with single and two–phase testing depending on the vector group of the protected transformer; this corresponds to conventional circuitry, when currents are applied via matching current transformers. Table 6.3 shows these changes as a factor k_{VG} depending on the vector group and the type of fault, for three–phase transformers.

In order to obtain the pick–up value, the setting value I–DIFF> (parameter address 1603) must be multiplied by the factor:

$$\frac{I_{N\ transformer}}{I_{N\ CT\ (primary)}} \times k_{VG}$$

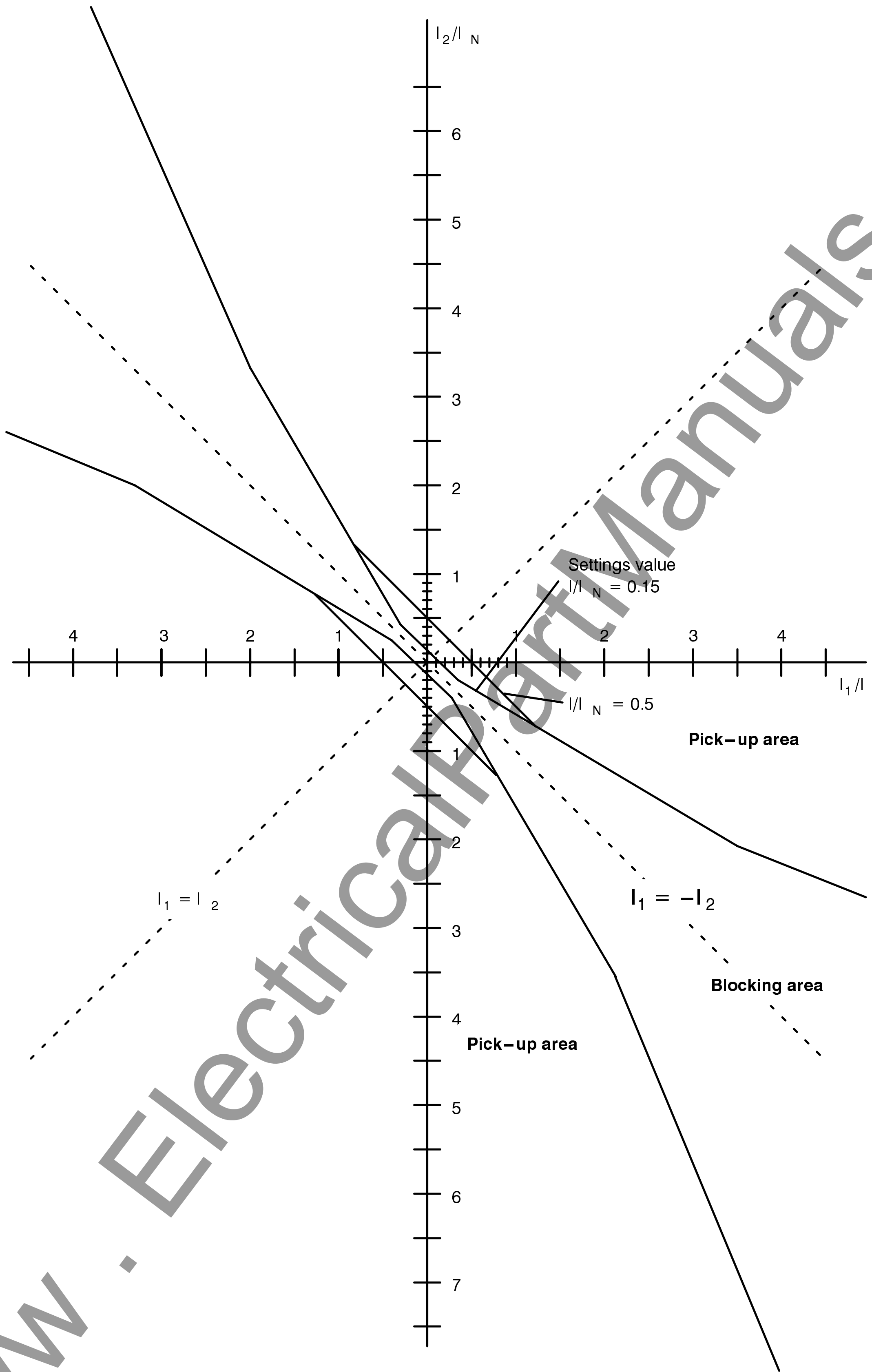


Figure 6.9 Characteristic of transformer differential protection $I_2 = f(I_1)$

Type of fault	Reference winding (upper voltage)	Even VG–numeral 0, 2, 4, 6, 8, 10	Odd VG–numeral 1, 3, 5, 7, 9, 11
three–phase	1	1	1
two–phase	1	1	$\frac{\sqrt{3}}{2} \approx 0.866$
single–phase with I_0–elimination	$\frac{3}{2} = 1.5$	$\frac{3}{2} = 1.5$	$\sqrt{3} \approx 1.73$
single–phase without I_0–elimination	1	1	$\sqrt{3} \approx 1.73$

Table 6.3 Correction factor k_{VG} depending of vector group and fault type

The pick–up values are checked for each winding by slowly increasing the test current with the secondary test set. Tripping is initiated when the converted pick–up value is reached.

Example 1:

Transformer P_N = 57 MVA, vector group Yd5

Primary (higher) voltage	110 kV
Current transformers	300 A/1 A
Secondary (lower) voltage	25 kV
Current transformers	1500 A/1 A

The following applies for the primary winding:

$$I_{N\ transformer} = \frac{P_{N\ transformer}\ [MVA] \times 1000}{\sqrt{3} \times U_{N\ Winding}\ [kV]}\ [A]$$

$$= \frac{57\ [MVA] \times 1000}{\sqrt{3} \times 110\ [kV]}\ [A] = \underline{299,2}\ [A]$$

In this case the rated current of the winding is practically equal to the current transformer rated current. Thus, the pick–up value (referred to the rated relay current) complies with the set I–DIFF> of the relay when three or two–phase testing is performed (k_{VG} = 1 for reference winding). With single–phase testing and zero sequence current elimination, a pick–up value 1.5 times higher must be expected.

The following applies for the secondary winding:

$$I_{Ntransformer} = \frac{P_{Ntransformer}\ [MVA] \times 1000}{\sqrt{3} \times U_{NWinding}\ [kV]}\ [A]$$

$$= \frac{57\ [MVA] \times 1000}{\sqrt{3} \times 25\ [kV]}\ [A] = \underline{1316}\ [A]$$

When testing this winding the pick–up value (referred to the rated relay current) will amount to:

$$\frac{I_{pick-up}}{I_{N\ relay}} = \frac{I_{N\ transformer}}{I_{CT\ (primary)}} \times k_{VG} \times I\text{–}DIFF >$$

$$= \frac{1316A}{1500A} \times I\text{–}DIFF > \times k_{VG}$$

$$= \underline{0.877 \times k_{VG} \times I\text{–}DIFF >}$$

Because of the odd vector group numeral, the following pick–up values (referred to the rated relay current) apply:

three–phase $k_{VG} = 1 \quad \frac{I_{pick-up}}{I_{N\ relay}} = 0.877 \cdot I\text{–}DIFF >$

two–phase $k_{VG} = \frac{\sqrt{3}}{2} \quad \frac{I_{pick-up}}{I_{N\ relay}} = 0.760 \cdot I\text{–}DIFF >$

single–phase$k_{VG} = \sqrt{3} \quad \frac{I_{pick-up}}{I_{N\ relay}} = 1.521 \cdot I\text{–}DIFF >$

Example 2:

Three−winding transformer, windings 1 and 2 same as in example 1, however:

Winding 3 P_N = 22 MVA, vector group d5

Rated voltage	10 kV
Current transformers	1500 A/1 A

For the test, the MVA rating of winding 1 and 2 must be considered, since all currents are referred to the maximum transformer power rating in the unit, in order to allow a comparison.

$$I_{Ntransformer} = \frac{P_{Ntransformer}\ [MVA] \times 1000}{\sqrt{3} \times U_{NWinding}\ [kV]}\ [A]$$

$$= \frac{57\ [MVA] \times 1000}{\sqrt{3} \times 10\ [kV]}\ [A] = \underline{3291}\ [A]$$

When testing this winding the pick−up value (referred to the rated relay current) will amount to:

$$\frac{I_{pick-up}}{I_{N\ relay}} = \frac{I_{N\ transformer}}{I_{CT\ (primary)}} \times k_{VG} \times I-DIFF >$$

$$= \frac{3291A}{1500A} \times I-DIFF > \times k_{VG}$$

$$= \underline{2.194 \times k_{VG} \times I-DIFF >}$$

Because of the odd vector group numeral, the following pick−up values (referred to the rated relay current) apply:

three−phase $k_{VG} = 1 \quad \frac{I_{pick-up}}{I_{N\ relay}} = 0.877 \cdot I-DIFF >$

two−phase $k_{VG} = \frac{\sqrt{3}}{2} \quad \frac{I_{pick-up}}{I_{N\ relay}} = 0.760 \cdot I-DIFF >$

single−phase $k_{VG} = \sqrt{3} \quad \frac{I_{pick-up}}{I_{N\ relay}} = 1.521 \cdot I-DIFF >$

6.6.3 Testing the generator or motor differential protection

For testing the differential protection, this function must have been configured as *EXIST* (address 7816) and the protected object (address 7801) must be a *GENERATOR/MOTOR*. Additionally, it must be parameterized as operative, i.e. DIFF PROT = *ON* or DIFF PROT = *BLOCK TRIP REL* under address 1701.

The pick−up value of the differential protection can be checked by means of a secondary test set. The test current can be applied separately for each side, i.e. in each case a fault with single−ended infeed is simulated.

The preset parameter for I−DIFF> as pick−up value (Address 1703) applies.

Checking the pick−up value is performed by slowly increasing the test current. Trip occurs when the pick−up value, converted according the matching factor, is reached. When the test current falls below approximately 0.7 times the pick−up value, the relay drops off.

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!

In the method described above, the pick−up values for single−ended infeed are tested. It is also possible to check the entire characteristic. Since trip current and stabilizing current cannot be fed in separately, (however they can be read out separately on the operator unit, refer Section 6.7.3.1), a separate test current has to be applied to each of two sides. The characteristics I_2/I_1 in Figure 6.9 show the pick−up limits. I_1 is the test current flowing into the machine star−point and I_2 is the test current flowing into the machine terminals. The currents are in phase.

When testing with the operational parameters it should be heeded that the setting value I−DIFF> refers to the rated current of the machine, i.e. current which results from

$$I_{N\ maschine} = \frac{P_{N\ maschine}\ [MVA] \times 1000}{\sqrt{3} \times U_{N\ maschine}\ [kV]}\ [A]$$

with

$P_{N\ machine}$ – MVA rating of the protected machine

$U_{N\ machine}$ – Rated voltage of the protected machine.

6.6.4 Testing the branch point differential protection

For testing the differential protection, this function must have been configured as *EXIST* (address 7816) and the protected object (address 7801) must be a *2ENDS−BRANCH POINT* or a *3ENDS−BRANCH POINT* (7UT513 only). Additionally, it must be parameterized as operative, i.e. DIFF PROT = *ON* or DIFF PROT = *BLOCK TRIP REL* under address 1801.

The pick−up value of the differential protection can be checked by means of a secondary test set. The test current can be applied separately for each branch point terminal, i.e. in each case a fault with single−ended infeed is simulated.

The preset parameter for I−DIFF> as pick−up value (Address 1803) applies.

Checking the pick−up value is performed by slowly increasing the test current. Trip occurs when the pick−up value, converted according the matching factor, is reached. When the test current falls below approximately 0.7 times the pick−up value, the relay drops off.

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!

6.6.5 Testing the restricted earth fault protection (if fitted)

For testing the restricted earth fault protection, this function must have been assigned to one side of the protected object or to the virtual object (address 7819) and one of the additional current inputs must have been assigned to the same side (address 7806 or 7807). Additionally, this function must be parameterized as operative, i.e. RESTR. E/F = *ON* or RESTR. E/F = *BLOCK TRIP REL* under address 1901.

The pick−up value of the differential protection can be checked by means of a secondary test set.

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 test current is applied via one phase current input and the additional current input. It is important to ensure equal polarity. The preset parameter for I−REF> as pick−up value (Address 1903) applies.

A counter−check is performed with opposite phase polarity. Trip must not occur. **It is particularly important to take care that the thermal limits of the current inputs are not exceeded, during this counter−check!**

6.6.6 Testing the back–up overcurrent time protection

For testing the back–up overcurrent time protection, this function must have been assigned to one side of the protected object or to the virtual object (address 7821). Additionally, this function must be switched effective, i.e. address 2101 BACK–UP O/C = *ON* or *BLOCK TRIP REL*, the latter means that no trip command is given to any trip relay even if it is assigned to.

6.6.6.1 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 is referred to the rated current of the protected object or transformer winding.

Caution!

Test currents larger than 4 times I_N may overload and damage the relay if applied continuously (refer to Section 3.1.1 for overload capability). Observe a cooling down period!

For testing the I>> stages, therefore, measurement shall be performed dynamically. It should be stated that the relay picks up at 1.1 times setting value and does not at 0.9 times setting value.

When the test current is injected, the pick–up indication of the I>> stage (annunciation ”`Backup I>>`”) appears. After expiry of the time delay, trip signal is given (LED 4 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.

6.6.6.2 Testing the definite time overcurrent stage I>

For this test the *DEFINITE TIME* mode must be selected in addresses 2111.

The rated object current is to be considered.

When the set value for I> (address 2112) is exceeded, the pick–up indication ”`Backup I>/Ip`” appears.

After expiry of the time delay (address 2113 T–I>), trip signal is given (LED 4 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.

6.6.6.3 Testing the inverse time overcurrent stage I_p

For these tests, one of the *INVERSE* time modes must be selected in addresses 2111.

The rated object current is 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!

When the test current is increased above 1.1 times the set value Ip (address 2114 Ip), pick–up indication appears (”`Backup I>/Ip`”).

The time delay depends on which characteristic has been selected in address 2111 and the set time multiplier in address 2115. The expected time delays can be calculated from the formulae given in the Technical data or read from the characteristic curves in Figure 3.10 (Section 3.6). Consider current matching factors!.

6.6.7 Testing the thermal overload protection functions

Two thermal overload protection functions are available, each of which can be assigned to any desired side of the protected object or to the virtual object. When setting the configuration parameters (refer to Section 5.4.2) the relay was informed to which side of the protected object the first overload protection (address 7824) and the second overload protection (address 7825) is assigned. Each overload protection can, additionally, be parameterized as operative, i.e. it must be set under address 2401 or 2501 THERMAL OL = *ON* or *BLOCK TRIP REL*.

The basis current for the detection of overload is the rated current of the protected object.

For use as transformer protection, the basis current is the rated current of the protected transformer winding. If the windings have different MVA ratings, then the overload function always refers to the rated current of the respective winding. It is assumed that the transformer data for each winding have been correctly parameterized according to Section 6.3.3.

For use as generator or motor protection, overload protection is based on the rated current of the protected machine which is derived from the data according Section 6.3.4.

For use as branch point protection, overload protection is based on the rated current of the branch point according Section 6.3.5.

If the overload protection is used for a virtual object, overload is based on the rated current of the virtual object according Section 6.3.6.

Depending on the selected calculation method (address 2406 for overload protection 1 and address 2506 for overload protection 2) the protection processes a maximum or the average value. In the latter case the test currents must be either symmetrical (three–phase) or, if only a single–phase current source is available, the current must be injected through all three phases. For the other calculation methods a single–phase current through one phase is sufficient.

When applying a test current which corresponds to the maximum permissible current tripping must not occur. After an appropriate time (approximately 5 x t) a steady–state temperature rise according to the following relationship is established:

$$\frac{Q}{Q_{trip}} = \frac{1}{k^2}$$

This value can be read out in address block 59.

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!

To check the time constant, the current input is simply subjected to 1.6 x the pick–up value, i. e. $1.6 \cdot I_{N\,object} \cdot k$. 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 3.11, refer to Section 3.7). 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 2401 or 2501) or by blocking the overload protection for a short time via binary inputs (FNo `1553` or `1603`) or by observing a current free period of at least 5 x t.

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 t.

6.6.8 Testing the tank leakage protection (if fitted)

One of the additional measured current input I_A or I_B can be allocated to the tank leakage protection (address 2827). Dependent of which input is used, the pick–up value of the protection had been set under address 2703 (setting range 0.10 to 10 times rated relay current) or address 2704 (setting range 10 mA to 1000 mA independent of the rated current). For testing the tank leakage protection, this function must be parameterized as operative, i.e. TANK = *ON* or TANK = *BLOCK TRIP REL* under address 2701.

Apply test current to the current input which is assigned to the tank leakage protection.

Caution!

Test currents larger than 4 times I_N or 15 A (highly sensitive input) may overload and damage the relay if applied continuously (refer to Section 3.1.1 for overload capability). Observe a cooling down period!

Testing with higher currents, therefore, 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 set pick–up value is exceeded, pick–up indication ”`Tank Gen. Flt`” occurs (not allocated when delivered from factory).

After expiry of the set delay time (address 2725) trip signal is issued (annunciation ”`Tank Gen. Trip`”, LED 8 when delivered).

6.6.9 Testing the coupling of external trip functions

Two desired signals from external protection or supervisory units can be connected into the processing of the 7UT51 via binary inputs. Like the internal signals, they can be annunciated, delayed and transmitted to the trip matrix.

The external signals can be checked when they have been configured as *EXIST* under addresses 7830 and/or 7831 (refer to Section 5.4.2) and parameterized as operative (addresses 3001 and/or 3101) Additionally, binary inputs must be allocated to these functions (refer to Section 5.5.2).

After the binary input of the tested external trip function has been activated, annunciation ”`>Ext. Trip *`” is given; this is a straight acknowledgement message by the binary input as operational indication. Annunciation ”`Ext. * Gen.Flt`” is the actual fault event annunciation.

After T–DELAY (address 3002 or 3102) annunciation ”`Ext. * Gen.Trp`” will occur.

For the input of annunciations of the Buchholz protection (when the relay is used as transformer protection), three binary inputs are reserved already. When these are allocated to physical inputs, their correct function can be tested, too.

6.7 Commissioning using primary tests

6.7.1 General hints

All secondary testing sets and equipment must be removed. Reconnect current transformers.

Since external matching transformers have been eliminated and since the digital protection unit 7UT51 offers a number of commissioning aids, commissioning can be performed quickly and without external instruments.

Before commencement of the actual primary tests it is advisable to re–check that the matching factors for the rated currents of the protected object are correct. These factors are presented in the operational annunciation each time the parameterizing process has been terminated.

Select the operational annunciations either by direct addressing with **DA 5 1 0 0 E** or by pressing the key **M/S** and continue with ⇑, so that address 5100 appears. By paging with the key ↑ the messages can be read out. The following factors are available:

$$\text{k CT 1} = \frac{\text{current processed by 7UT51}}{\text{current through the relay terminals}}$$

for side 1 of the protected object and similar for the other sides:

`k CT 2 =`

`k CT 3 =` (only 7UT513)

`ksCT 1 =` (only 7UT513)

`ksCT 2 =` (only 7UT513)

`ksCT 3 =` (only 7UT513)

where ksCT are the factors for inputs from the current transformer in the star–point connection of an earthed transformer winding as far as they are used.

When 7UT513 is used, check that LED 14 does not light. When the relay is delivered, this LED indicates that combinations of configuration or function parameters are not consistent. Thus, when this LED is illuminated, look up in the operational indications which is the cause of this inconsistence. The following messages may appear:

`O/L 1 Err S3` (FNo 1576)	overload protection 1 has been assigned to a third side (terminal) of the protected object but this side does not exist (cf. addresses 7801 and 7824).
`O/L 2 Err S3` (FNo 1626)	overload protection 2 has been assigned to a third side (terminal) of the protected object but this side does not exist (cf. addresses 7801 and 7825).
`Backup Err S3` (FNo 2457)	back–up overcurrent time protection has been assigned to a third side (terminal) of the protected object but this side does not exist (cf. addresses 7801 and 7821).
`Err 2 CT star` (FNo 5711)	two star–point current transformers have been assigned to the same side (terminal) of the differential protection (cf. addresses 7806 and 7807).
`REF Err S3` (FNo 5828)	restricted earth fault protection has been assigned to a non–existing third side (terminal) of the protected object (cf. addresses 7801 and 7819).
`REF Err2CTsta` (FNo 5829)	two star–point current transformers have been assigned to the same side (terminal) of the restricted earth fault protection (cf addresses 7806 and 7807).
`REF Err0CTsta` (FNo 5830)	no star–point current transformer has been assigned to the restricted earth fault protection (cf. addresses 7806 and 7807).
`REF ErrVir ob` (FNo 5831)	restricted earth fault protection has been allocated to an impermissible side (terminal) of the protected object, e.g. side 1 or 2 of a generator or to a branch point (addresses 7801 and 7819). For these cases, the restricted earth fault protection must only be assigned to a virtual object.

`REF no exist` (FNo `5834`) restricted earth fault protection has been programmed as *EXIST* but cannot be processed by the relay (address 7819).

`Tank no exist` (FNo `5928`) tank leakage protection has been programmed as *EXIST* but cannot be processed by the relay (address 7827).

`Err no CTstat` (FNo `5712`) Zero sequence current correction has been parameterized for one transformer winding, but no current input is assigned to the transformer star–point current (address 7806 or 7807 as well as addresses 1106 or 1126 or 1146).

6.7.2 Preparation of symmetrical current tests

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.)

First, the differential protection is switched to *BLOCK TRIP REL* (address 1601 for transformer, 1701 for generator/motor, 1801 for branch–point) or the trip commands to the circuit breakers are interrupted. The restricted earth fault protection remains (or is switched) *OFF* (address 1901).

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.

At first commissioning, current checks must be performed before the protected object is energized for the first time. This ensures that the differential protection is operative as a short–circuit protection during the first excitation of the protected object with voltage. If current tests are only possible with the protected object under voltage (e.g. power transformers in networks when no low voltage test equipment is available), it is imperative that a back–up short–circuit protection, e.g. overcurrent time protection, be commissioned before, which operates at least at the feeding side and acts on the circuit breaker of the feeding side. The trip circuits of other protection devices (e.g. Buchholz protection) must either remain operative as back–up protection.

The test arrangement varies dependent of the application.

DANGER!

Operations in the primary area must only be performed with plant sections voltage–free and earthed!

On <u>network power transformers</u> or <u>asynchronous machines</u>, a low voltage test equipment is preferably used. A low–voltage current source is used to energize the protected object, which is completely disconnected from the network (see Figure 6.10). A short–circuit bridge, which is capable to carry the test current, is installed outside of the protected zone and allows the symmetrical test current to flow.

On <u>power station unit transformers</u> and <u>synchronous machines</u>, the checks are performed during the current tests. The generator itself forms the test current source (see Figure 6.11). The current is produced by a three–pole short–circuit bridge which is installed outside of the protected zone and is capable to carry rated current for a short time. The machine is started but not yet excited. Check by means of remanence currents that no current transformer is open or short–circuited. In order to achieve this, read out the operational measured values (address block 57) one after the other. Even when the currents and the measurement accuracy is still very small, the described errors can be already detected.

On branch points, a low–voltage test source can be used. Alternatively, load current test is possible. In the latter case the above hints about back–up protection must be observed!

The test current must be at least 2 % of the rated relay current.

When 7UT513 is used on a protected object with three terminals (three–winding transformers, three–terminal branch points) or when a virtual object is included, the test currents are always fed over two sides: first side 1 to side 2, then side 1 to side 3.

Current tests are initiated by a measurement request by the operator. The measured test values are stored but not continuously actualized to ensure comparable results. If the test arrangement is changed, a new measurement request will be necessary.

During test operation, the differential protection and, if applicable, the restricted earth fault protection remain operational when they are switched *ON*. Note that trip may occur due to connection or configuration errors if trip signals are not interrupted.

When no activities are carried out during more than 60 minutes – i.e. no measurement request nor any change in the address block 41 – the relay terminates the test operation automatically. Of course, it is possible to terminate test operation at any time (refer to Section 6.7.7 for details).

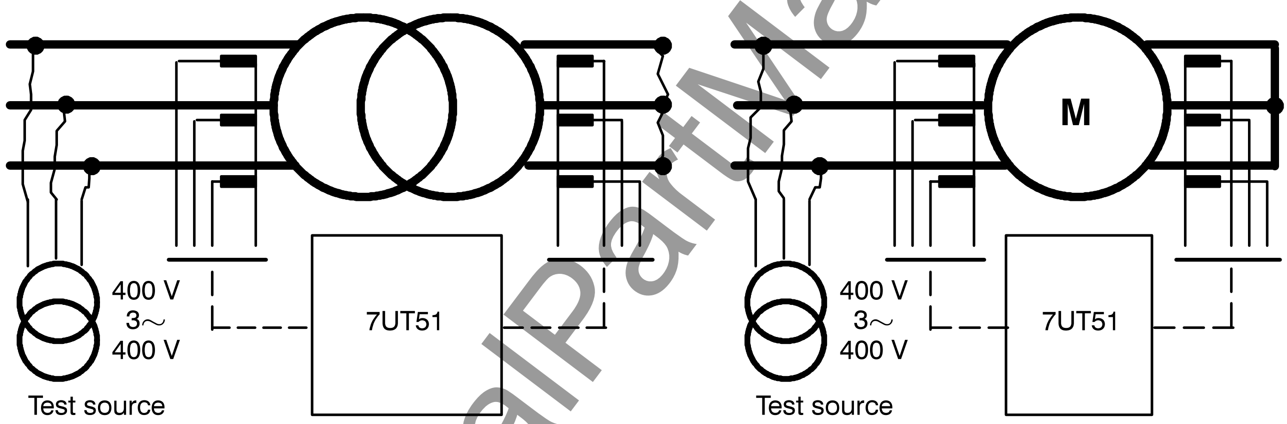


Figure 6.10 Current tests with low–voltage test source

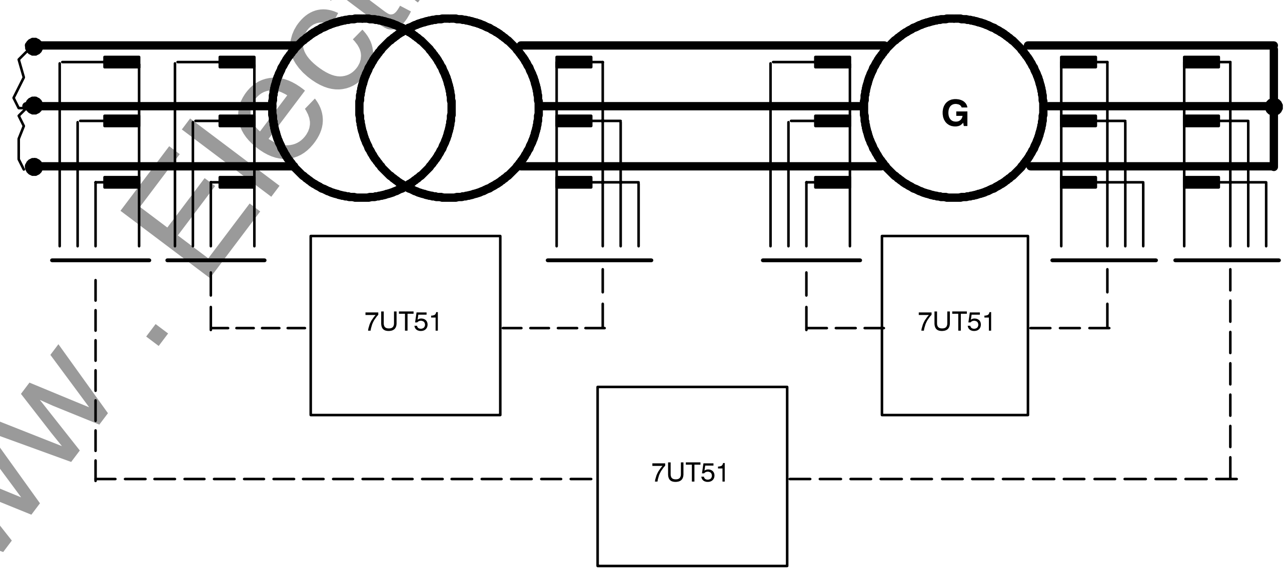


Figure 6.11 Current tests in a power station

6.7.3 Realization of the symmetrical current tests – address block 41

Initiation of the tests is made via operator keyboard or personal computer. Tests are listed from address 4000, the commissioning measurements for the differential protection 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.

All measured values are stored immediately after the operator has started measurement request and are available for read–out. They are not actualized in order to ensure comparable results. When the test conditions have been changed, a new measurement request must be started.

For starting a measurement request, codeword entry is required (refer to Section 5.3.1 for details).

```
⇑  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   T E S T   D I F F
↓  T E S T   ?
```

After confirmation with the "Yes"–key **J/Y** measurement is carried out

Confirm with the "Yes"–key **J/Y**. The relay measures all currents and phase angle of this test address 4101. As soon as the first measured value appears in the display, the test current can be switched off. The values can be read out by repeatedly depressing the "No"–key **N**, the backspace key **R** allows for reading out the preceding value.

After start, the relay first checks whether measurement can be carried out. If a protection function has picked up before, measurement is rejected (see below). When the measured quantities are too small, a corresponding message is given. In these cases, address 4101 must be left (e.g. by paging with key ↓ back to address 4100), and the test arrangement must be re–checked. Increase the test current if necessary. Finally go back to address 4101 and repeat the procedure.
The indices of the measured current are defined as follows:

Behind the symbol I, the index of the side of the protected object (e.g. transformer winding) is given, after this the line symbol L and the phase, e.g.

I1 L1 current of side 1 in phase L1.

Compare the displayed currents with the test currents. If deviations occur which cannot be explained by tolerances, either the connection or the test arrangement is wrong:

- disconnect the protected object (shut–down generator) and earth,
- check connections and test arrangement,
- repeat test.

6.7.3.1 Tests concerning all applications

```
4101█ TEST  DIFF
I1  L1=  12.4  %
```

Display of the measured current of side 1, phase L1, referred to rated relay current, e.g. 12.4 %

```
4101█ TEST  DIFF
INVALID
```

Error messages after measurement request:

invalid result (e.g. because of network fault)

```
CURRNT  TOO  SMALL
```

all currents too small for evaluation

```
I1  L1=  ****
```

when the current for an individual measurement is too small, this is indicated by "★★★★"

When no INVALID or CURRNT TOO SMALL message, the further currents can be read out by using the "No"−key **N**:

```
4101█ TEST  DIFF
I1  L2=  12.0  %
```

Display of the measured current of side 1, phase L2, referred to rated relay current, e.g. 12.0 %

```
4101█ TEST  DIFF
I1  L3=  12.3  %
```

Display of the measured current of side 1, phase L3, referred to rated relay current, e.g. 12.3 %

```
4101█ TEST  DIFF
I2  L1=  12.0  %
```

Display of the measured current of side 2, phase L1, referred to rated relay current, e.g. 12.0 %

```
4101█ TEST  DIFF
I2  L2=  11.6  %
```

Display of the measured current of side 2, phase L2, referred to rated relay current, e.g. 11.6 %

```
4101█ TEST  DIFF
I2  L3=  11.8  %
```

Display of the measured current of side 2, phase L3, referred to rated relay current, e.g. 11.8 %

If 7UT513 is configured for a protected object with three sides (tertiary winding, third branch point feeder, address 7801), the measured values of the third side are stored, too. But, as no currents flow through this side, the display shows ★★★★ now. If the additional current inputs are not assigned to a transformer winding (addresses 7806 and/or 7807), or if the protected object is not a transformer (address 7801), the currents of the additional current inputs do not appear at all.

```
4 1 0 1█ T E S T   D I F F
I 3   L 1 =   * * * *
```

Display of the measured current of side 3, phase L1, not defined at this moment

```
4 1 0 1█ T E S T   D I F F
I 3   L 2 =   * * * *
```

Display of the measured current of side 3, phase L2, not defined at this moment

```
4 1 0 1█ T E S T   D I F F
I 3   L 3 =   * * * *
```

Display of the measured current of side 3, phase L3, not defined at this moment

```
4 1 0 1█ T E S T   D I F F
I A =   * * * *
```

Display of the measured current of the additional current input I_A, not defined at this moment

```
4 1 0 1█ T E S T   D I F F
I B =   * * * *
```

Display of the measured current of the additional current input I_B, not defined at this moment

---

If the current magnitudes are consistent, page on to address 4121 with the key ↑. The phase angle relations are now displayed. It is not necessary to request for a new measurement. The phase angle differences are displayed in 30° increments, thus, small deviations (up to ± 10°) are tolerated. When the measured angle is outside of this tolerance range, the display shows "inval". The angle differences are defined for clockwise phase rotation. At first, the angle differences of the three currents of side 1 against each other:

```
4 1 2 1█ T E S T   A N G L   L
T E S T   ?
```

Display of the results of angle measurement of the line currents? Confirm with the "Yes"–key **J/Y** or abort with the "No"–key **N**, or page on with key ↑.

```
4 1 2 1█ T E S T   A N G L   L
I 1 L 2 - I 1 L 1 =   2 4 0   °
```

Display of the phase angle between the currents of side 1, phase L2 against phase L1,
should be **240°**

```
4 1 2 1█ T E S T   A N G L   L
I 1 L 3 - I 1 L 1 =   1 2 0   °
```

Display of the phase angle between the currents of side 1, phase L3 against phase L1,
should be **120°**

If the values are not correct, wrong polarity or phase interchange at side 1 is the cause:

- disconnect the protected object (shut–down generator) and earth,
- check connections and test arrangement,
- repeat test by renewed measurement request.

The phase angle relations of side 2 are now displayed:

```
4121█ TEST ANGL L
I2L2-I2L1=  240 °
```

Display of the phase angle between the currents of side 2, phase L2 against phase L1, should be **240°**

```
4121█ TEST ANGL L
I2L3-I2L1=  120 °
```

Display of the phase angle between the currents of side 2, phase L3 against phase L1, should be **120°**

If the values are not correct, wrong polarity or phase interchange at side 2 is the cause. Proceed as above for side 1.

If 7UT513 is configured for a protected object with three sides (tertiary winding, third branch point feeder, address 7801), the measured values of the third side are stored, too. But, as no currents flow through this side, the display shows ★★★★ now.

```
4121█ TEST ANGL L
I3L2-I3L1=  ****
```

Display of the phase angle between the currents of side 3, phase L2 against phase L1, not defined at this moment

```
4121█ TEST ANGL L
I3L3-I3L1=  ****
```

Display of the phase angle between the currents of side 3, phase L3 against phase L1, not defined at this moment

---

The polarities of the through–flowing currents are here defined to be equal, i.e when currents of equal phase flow through the protected object, the angle difference is 0 provided the connections are correct. But the theoretical angle value depends on the protected object and – on transformers – on the connection group. Table 6.4 lists these angles. The measured angles must be equal for all three phases. If not, individual phases are interchanged.

The polarity of the current connections and the parameterized polarity are taken into consideration when the angles are displayed. Thus, if all three angles differ by 180° from the theoretical value, the polarity of one complete current transformer set is wrong. This can be corrected by checking and changing the corresponding plant parameters:

address 1105 for the primary winding of a transformer,

address 1125 for the secondary winding of a transformer,

address 1206 for generators or motors, note that this parameter must be *OPPOSITE SIDES* when the relay is used as transverse differential protection,

address 1303 for side 1 of a branch point,

address 1305 for side 2 of a branch point.

NOTE: The connection group of power transformers is defined from the higher voltage side to the lower voltage side. The angle (CG · 30°) is valid only when measurement is carried out in this way, i.e. the test source is on the higher voltage side and the short–circuit bridges are on the lower voltage side. If measurement is carried out from the lower voltage side, the angle must be: 360° – CG · 30°.

```
4121█ TEST ANGL L
I1L1-I2L1=  0 °
```

Display of the phase angle between the currents of side 1, phase L1 against side 2, phase L1, refer to Table 6.4

```
4121█ TEST ANGL L
I1L2-I2L2=  0 °
```

Display of the phase angle between the currents of side 1, phase L2 against side 2, phase L2, refer to Table 6.4

```
4121█ TEST ANGL L
I1L3-I2L3=  0 °
```

Display of the phase angle between the currents of side 1, phase L3 against side 2, phase L3, refer to Table 6.4

Protected object	Generator/Motor/ branch point	Transformer with connection group numeral 1)											
		0	**1**	2	3	4	**5**	**6**	**7**	8	9	10	**11**
Phase angle of the tested phase	**0°**	**0°**	**30°**	60°	90°	120°	**150°**	**180°**	**210°**	240°	270°	300°	**330°**

1) Values are valid for measurement from the higher voltage side; when measuring from the lower voltage side: 360° minus the stated angle is valid

Table 6.4 Displayed phase angle dependent on the protected object

If 7UT513 is configured for a protected object with three sides (tertiary winding, third branch point feeder, address 7801), the measured values of the third side are stored, too. But, as no currents flow through this side, the display shows ★★★★ now.

```
4121█ TEST ANGL L
I1L1-I3L1=  ****
```

Display of the phase angle between the currents of side 1, phase L1 against side 3, phase L1, not defined at this moment

```
4121█ TEST ANGL L
I1L2-I3L2=  ****
```

Display of the phase angle between the currents of side 1, phase L2 against side 3, phase L2, not defined at this moment

```
4121█ TEST ANGL L
I1L3-I3L3=  ****
```

Display of the phase angle between the currents of side 1, phase L3 against side 3, phase L3, not defined at this moment

Before the tests with symmetrical currents are terminated, the differential and stabilizing currents are checked. Even though the tests which have been carried out till now should have detected all connection errors, nevertheless, errors are possible concerning current matching and the assignment of the connection group.

Switch over to address 4161 by pressing the key ↑ twice. In this address, the calculated values can be read out by scrolling through the display with the ”No”–key **N** or backspace key **R**. When assessing the currents note that the differential and stabilizing values are referred to the rated current of the protected object.

If considerable differential currents occur, recheck the concerned parameters:

For transformer protection refer to Section 6.3.3, addresses 1102 to 1104 (matching of transformer winding 1), addresses 1121 to 1124 (matching of transformer winding 2).

For generator or motor protection refer to Section 6.3.4, addresses 1202 and 1203 (matching of the rated machine values).

For branch point protection refer to Section 6.3.5, addresses 1301 and 1302 (matching of side 1) and 1304 (matching of side 2).

```
4161█ TEST DIF/ST
TEST ?
```

Display of the results of calculation of the differential and stabilizing currents? Confirm with the "Yes"–key **J/Y** or abort with the "No"–key **N**, or page on with key ↑.

```
4161█ TEST DIF/ST
IL1diff= 0.4 %
```

Display of the differential current of measuring system L1, referred to the rated current of the protected object, e.g. 0.4 %
The value should be negligible against the magnitude of the line currents

```
4161█ TEST DIF/ST
IL2diff= 0.4 %
```

Display of the differential current of measuring system L2, referred to the rated current of the protected object, e.g. 0.4 %
The value should be negligible against the magnitude of the line currents

```
4161█ TEST DIF/ST
IL3diff= 0.5 %
```

Display of the differential current of measuring system L3, referred to the rated current of the protected object, e.g. 0.5 %
The value should be negligible against the magnitude of the line currents

```
4161█ TEST DIF/ST
IL1rest= 24.4 %
```

Display of the stabilizing (restraint) current of measuring system L1, referred to the rated current of the protected object, e.g. 24.4 %
The value should be approximately twice the test current

```
4161█ TEST DIF/ST
IL2rest= 23.6 %
```

Display of the stabilizing (restraint) current of measuring system L2, referred to the rated current of the protected object, e.g. 23.6 %
The value should be approximately twice the test current

```
4161█ TEST DIF/ST
IL3rest= 24.1 %
```

Display of the stabilizing (restraint) current of measuring system L3, referred to the rated current of the protected object, e.g. 24.1 %
The value should be approximately twice the test current

If 7UT51 is configured for a protected object with two sides (generators, motors, two–winding transformers, two–terminal branch points), the symmetrical current tests are thus completed. Disconnect the protected object (shut–down generator) and earth, disconnect test arrangement. Section 6.7.3.2 is not of interest.

6.7.3.2 Tests concerning protected objects with three terminals

Modify the test arrangement such that the test current will flow from side 1 to side 3 of the protected object. Side 2 must be isolated: The short–circuit bridges at side 2 must be removed and inserted at side 3.

After the test current has been switched on, measurement request is initiated: Leave address 4161 by paging back to address 4101 with the key ↓ and perform measurement request.

As soon as the first measured value appears in the display, the test current can be switched off.

```
4101█ TEST  DIFF
TEST  ?
```

After confirmation with the "Yes"–key **J/Y** measurement is carried out

Confirm with the "Yes"–key **J/Y**. The relay measures all currents and phase angle of this test address 4101. The values can be read out by repeatedly depressing the "No"–key **N**. The order is the same are shown in the preceding sub–section. Since the test current is now flowing from side 1 to side 3, all results which concern side 2 are indifferent. When some results are not plausible, proceed as in Section 6.7.3.1 accordingly.

```
4101█ TEST  DIFF
I1  L1=  12.4  %
```

Display of the measured current of side 1, phase L1, referred to rated relay current, e.g. 12.4 %

```
4101█ TEST  DIFF
I1  L2=  12.0  %
```

Display of the measured current of side 1, phase L2, referred to rated relay current, e.g. 12.0 %

```
4101█ TEST  DIFF
I1  L3=  12.3  %
```

Display of the measured current of side 1, phase L3, referred to rated relay current, e.g. 12.3 %

```
4101█ TEST  DIFF
I2  L1=  ****
```

Display of the measured current of side 2, phase L1, referred to rated relay current, not defined as no current I2 flows

```
4101█ TEST  DIFF
I2  L2=  ****
```

Display of the measured current of side 2, phase L2, referred to rated relay current, not defined as no current I2 flows

```
4101█ TEST  DIFF
I2  L3=  ****
```

Display of the measured current of side 2, phase L3, referred to rated relay current, not defined as no current I2 flows

```
4 1 0 1█ T E S T   D I F F
I 3   L 1 =   1 2 . 0   %
```

Display of the measured current of side 3, phase L1, e.g. 12.0 %

```
4 1 0 1█ T E S T   D I F F
I 3   L 2 =   1 1 . 7   %
```

Display of the measured current of side 3, phase L2, e.g. 11.7 %

```
4 1 0 1█ T E S T   D I F F
I 3   L 3 =   1 1 . 9   %
```

Display of the measured current of side 3, phase L3, e.g. 11.9 %

```
4 1 0 1█ T E S T   D I F F
I A =   * * * *
```

Display of the measured current of the additional current input I_A, not defined at this moment

```
4 1 0 1█ T E S T   D I F F
I B =   * * * *
```

Display of the measured current of the additional current input I_B, not defined at this moment

---

If the current magnitudes are consistent, page on to address 4121 with the key ↑. The phase angle relations are now displayed. It is not necessary to request for a new measurement. At first, again, the angle differences of the three currents against each other:

```
4 1 2 1█ T E S T   A N G L   L
T E S T   ?
```

Display of the results of angle measurement of the line currents? Confirm with the "Yes"–key **J/Y** or abort with the "No"–key **N**, or page on with key ↑.

```
4 1 2 1█ T E S T   A N G L   L
I 1 L 2 - I 1 L 1 =   2 4 0   °
```

Display of the phase angle between the currents of side 1, phase L2 against phase L1,
should be **240°**

```
4 1 2 1█ T E S T   A N G L   L
I 1 L 3 - I 1 L 1 =   1 2 0   °
```

Display of the phase angle between the currents of side 1, phase L3 against phase L1,
should be **120°**

```
4 1 2 1█ T E S T   A N G L   L
I 2 L 2 - I 2 L 1 =   * * * *
```

Display of the phase angle between the currents of side 2, phase L2 against phase L1,
not defined as no current I2 flows

```
4 1 2 1█ T E S T   A N G L   L
I 2 L 3 - I 2 L 1 =   * * * *
```

Display of the phase angle between the currents of side 2, phase L3 against phase L1, not defined as no current I2 flows

```
4 1 2 1█ T E S T   A N G L   L
I 3 L 2 - I 3 L 1 =   2 4 0  °
```

Display of the phase angle between the currents of side 3, phase L2 against phase L1, should be **240°**

```
4 1 2 1█ T E S T   A N G L   L
I 3 L 3 - I 3 L 1 =   1 2 0  °
```

Display of the phase angle between the currents of side 3, phase L3 against phase L1, should be **120°**

The phase angles between the currents of the sides of the protected object follow again. The same definitions are valid as during test of the sides 1 against 2. The theoretical angle value depends on the protected object and – on transformers – on the connection group as shown in Table 6.4. The measured angles must be equal for all three phases. If not, individual phases are interchanged.

The polarity of the current connections and the parameterized polarity are taken into consideration when the angles are displayed. Thus, if all three angles differ by 180° from the theoretical value, the polarity of one complete current transformer set is wrong. This can be corrected by checking and changing the corresponding plant parameters:

address 1105 for the primary winding of a transformer; this should have already been verified during the tests according to Section 6.7.3.1. If this parameter is changed now, the complete tests concerning winding 1 against winding 2 would have to be repeated!

address 1145 for the tertiary winding of a transformer.

address 1303 for side 1 of a branch point; this should have already been verified during the tests according to Section 6.7.3.1. If this parameter is changed now, the complete tests concerning side 1 against side 2 would have to be repeated!

address 1307 for side 3 of a branch point.

NOTE: The connection group of power transformers is defined from the higher voltage side to the lower voltage side. The angle (CG · 30°) is valid only when measurement is carried out in this way, i.e. the test source is on the higher voltage side and the short–circuit bridges are on the lower voltage side. If measurement is carried out from the lower voltage side, the angle must be: 360° – CG · 30°.

```
4 1 2 1█ T E S T   A N G L   L
I 1 L 1 - I 2 L 1 =   * * * *
```

Display of the phase angle between the currents of side 1, phase L1 against side 2, phase L1, not defined as no current I2 flows

```
4 1 2 1█ T E S T   A N G L   L
I 1 L 2 - I 2 L 2 =   * * * *
```

Display of the phase angle between the currents of side 1, phase L2 against side 2, phase L2, not defined as no current I2 flows

```
4121█ TEST ANGL L
I1L3-I2L3=  ****
```

Display of the phase angle between the currents of side 1, phase L3 against side 2, phase L3, not defined as no current I2 flows

```
4121█ TEST ANGL L
I1L1-I3L1=  0  °
```

Display of the phase angle between the currents of side 1, phase L1 against side 3, phase L1, refer to Table 6.4

```
4121█ TEST ANGL L
I1L2-I3L2=  0  °
```

Display of the phase angle between the currents of side 1, phase L2 against side 3, phase L2, refer to Table 6.4

```
4121█ TEST ANGL L
I1L3-I3L3=  0  °
```

Display of the phase angle between the currents of side 1, phase L3 against side 3, phase L3, refer to Table 6.4

Before the tests with symmetrical currents are terminated, the differential and stabilizing currents are checked. Even though the tests which have been carried out till now should have detected all connection errors, nevertheless, errors are possible concerning current matching and the assignment of the connection group.

Switch over to address 4161 by pressing the key † twice. In this address, the calculated values can be read out by scrolling through the display with the ”No”–key **N**. When assessing the currents note that the differential and stabilizing values are referred to the rated current of the protected object.

If considerable differential currents occur, recheck the concerned parameters:

For transformer protection refer to Section 6.3.3, addresses 1102 to 1104 (matching of transformer winding 1); this should have already been verified during the tests according to Section 6.7.3.1. If these parameter are changed now, the complete tests concerning winding 1 against winding 2 would have to be repeated! Check addresses 1141 to 1144 (matching of transformer winding 3).

For branch point protection refer to Section 6.3.5. Addresses 1301 and 1302 (matching of side 1) must not be changed; this should have already been verified during the tests according to Section 6.7.3.1. If this parameters are changed now, the complete tests concerning side 1 against side 2 would have to be repeated! Check address 1306 (matching of side 3).

```
4161█ TEST DIF/ST
TEST ?
```

Display of the results of calculation of the differential and stabilizing currents? Confirm with the ”Yes”–key **J/Y** or abort with the ”No”–key **N**, or page on with key †.

```
4161█ TEST DIF/ST
IL1diff=  0.4  %
```

Display of the differential current of measuring system L1, referred to the rated current of the protected object, e.g. 0.4 %
The value should be negligible against the magnitude of the line currents

```
4161█ TEST DIF/ST
IL2diff= 0.3 %
```

Display of the differential current of measuring system L2, referred to the rated current of the protected object, e.g. 0.3 %
The value should be negligible against the magnitude of the line currents

```
4161█ TEST DIF/ST
IL3diff= 0.4 %
```

Display of the differential current of measuring system L3, referred to the rated current of the protected object, e.g. 0.4 %
The value should be negligible against the magnitude of the line currents

```
4161█ TEST DIF/ST
IL1rest= 24.4 %
```

Display of the stabilizing (restraint) current of measuring system L1, referred to the rated current of the protected object, e.g. 24.4 %
The value should be approximately twice the test current

```
4161█ TEST DIF/ST
IL2rest= 23.7 %
```

Display of the stabilizing (restraint) current of measuring system L2, referred to the rated current of the protected object, e.g. 23.7 %
The value should be approximately twice the test current

```
4161█ TEST DIF/ST
IL3rest= 24.2 %
```

Display of the stabilizing (restraint) current of measuring system L3, referred to the rated current of the protected object, e.g. 24.2 %
The value should be approximately twice the test current

The symmetrical current tests are thus completed. Disconnect the protected object and earth, disconnect test arrangement.

6.7.4 Preparation of zero sequence current tests

The zero sequence current tests are necessary with 7UT513, if

– zero sequence current correction by means of one of the additional measured current inputs I_A or I_B is carried out with transformer differential protection, i.e. addresses 7806 and/or 7807 are assigned to a transformer winding, which is parameterized to *Io – CORRECTION* (addresses 1106 or 1126 or 1146), or

– the restricted earth fault protection is used, i.e. addresses 7806 and/or 7807 are assigned to a side of the protected object or virtual object, which is also assigned to the restricted earth fault protection.

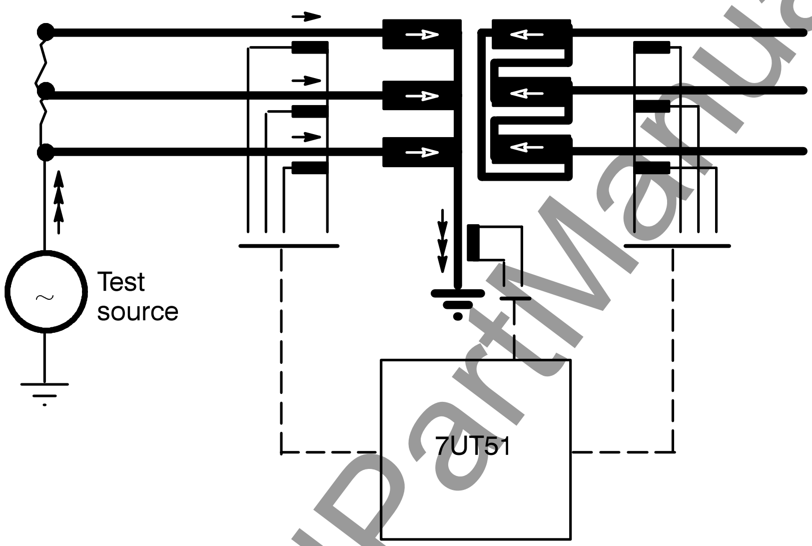


Figure 6.12 Zero sequence current measurement on a star – delta transformer

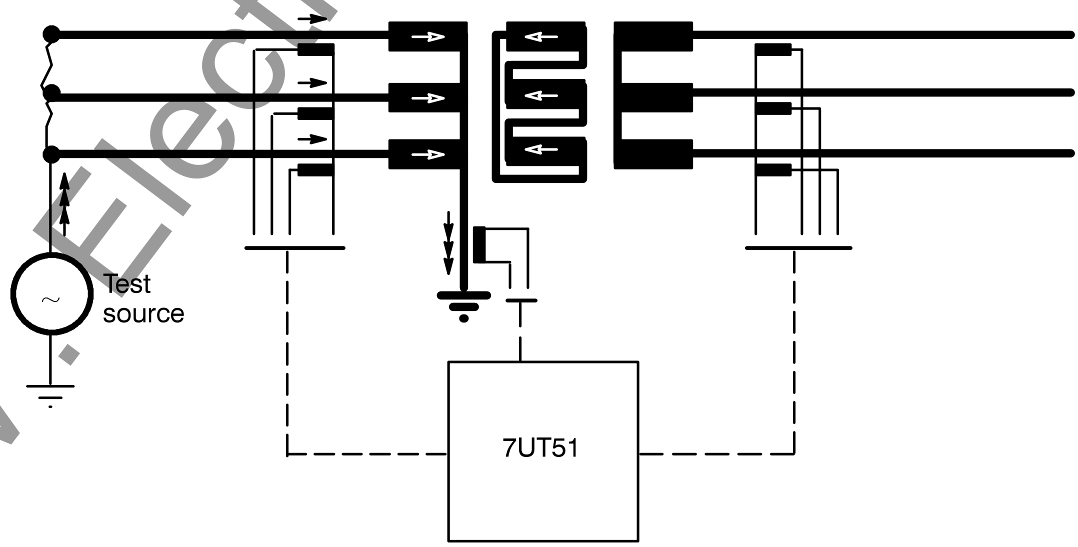


Figure 6.13 Zero sequence current measurement on a star – star transformer with delta winding

Besides this, the star–point of the respective winding must be earthed and a current transformer must be installed in the earthing lead of that star–point.

Zero sequence current measurement is always performed from that side of the protected object where the star–point is earthed. The transformer must have a delta winding. The sides which are not included in the tests can remain open as the delta winding ensures that the zero sequence current path is low–ohmic circuited.

The restricted earth fault protection – if used – is switched to *BLOCK TRIP REL* (address 1901).

During test operation, the differential protection and, if applicable, the restricted earth fault protection remain operational when they are switched *ON*. Note that trip may occur due to connection or configuration errors if trip signals are not interrupted.

Figures 6.12 to 6.16 illustrate examples for the test arrangement.

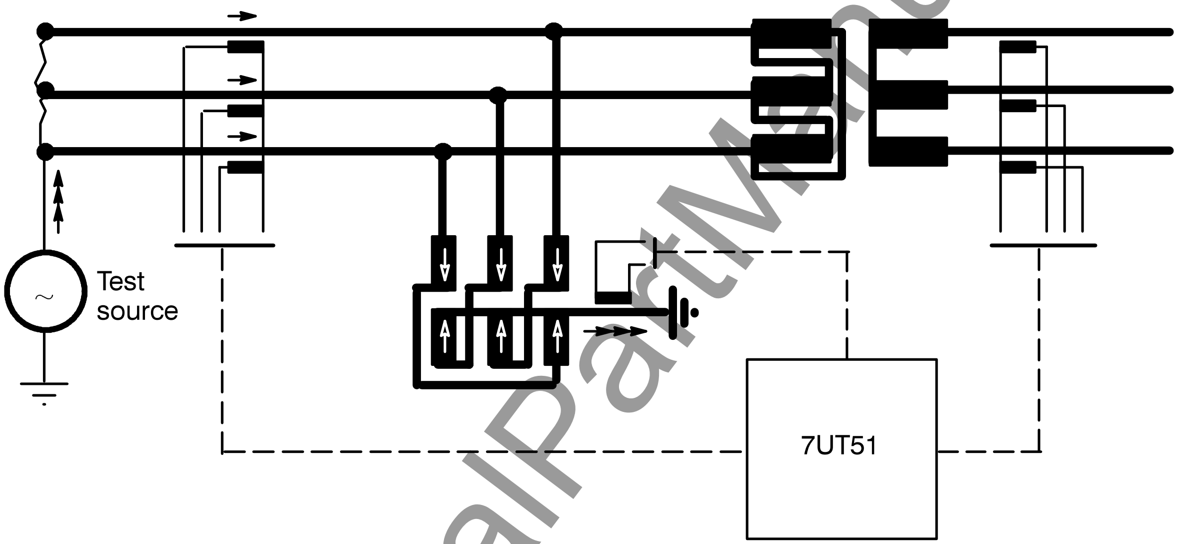


Figure 6.14 Zero sequence measurement on a delta winding with artificial star–point

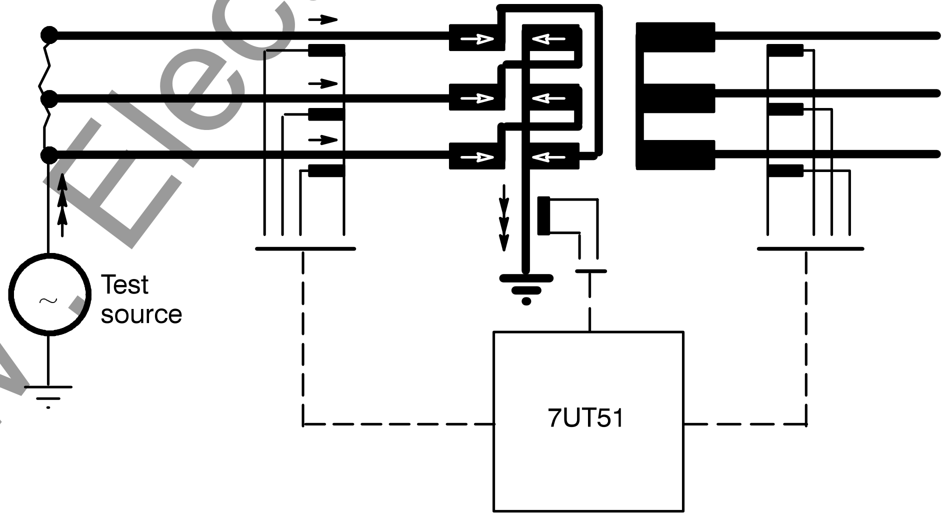


Figure 6.15 Zero sequence current measurement on a zig–zag winding

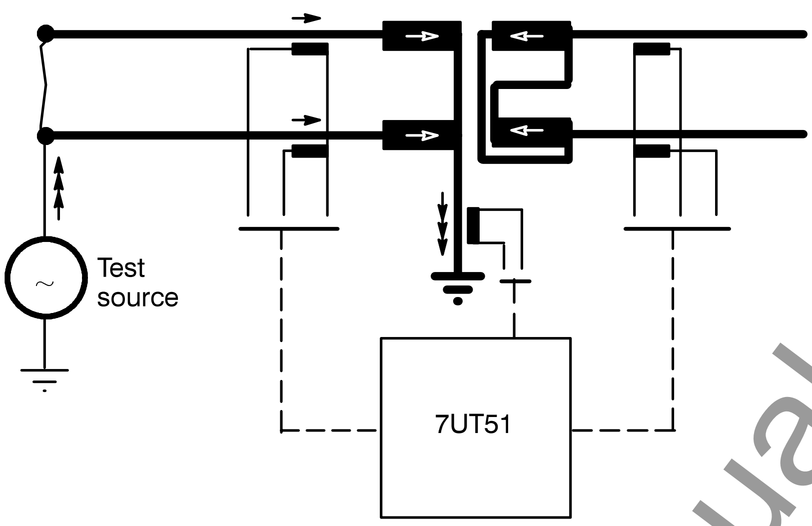


Figure 6.16 Example for a single–phase transformer

6.7.5 Realization of the zero sequence current tests – address block 41

Initiation of the tests is again made via operator keyboard or personal computer by a measurement request by the operator. The measured test values are stored but not continuously actualized to ensure comparable results. If the test arrangement is changed, a new measurement request is necessary.

As soon as the first measured value appears in the display the test current can be switched off.

Since the results of the symmetrical current tests have already been checked, only the results of the zero sequence current tests are relevant now. The remaining results can be by–passed by pressing the "No"–key **N**. The displayed currents are referred to the rated current of the relay.

```
4 1 0 1█ T E S T   D I F F
T E S T   ?
```

Are the test for differential protection to be carried out? Confirm with the "Yes"–key **J/Y** or abort with the "No"–key **N**, or page on with key ↑.

After confirmation with the "Yes"–key **J/Y** measurement is carried out. The relay measures all currents and phase angles of this test address. The values can be read out by repeatedly depressing the "No"–key **N**, the backspace key **R** allows for reading out the preceding value.

If wrong values occur for the additional currents I_A and/or I_B, the test arrangement must be re–checked. Additionally, re–check and correct the relevant configuration parameters according to Section 5.4.2: address 7806 for measured current I_A, address 7807 for measured current I_B.

```
4 1 0 1█ T E S T   D I F F
I x   L 1 =   6 . 4   %
```

Display of the measured current of side x, phase L1, referred to rated relay current,
e.g. 6.4 %
For the sides which are not included in the test, ⋆⋆⋆⋆ will appear because of missing current

```
4 1 0 1█ T E S T   D I F F
I x   L 2 =   6 . 0   %
```

Display of the measured current of side x, phase L2, referred to rated relay current,
e.g. 6.0 %
For the sides which are not included in the test, ⋆⋆⋆⋆ will appear because of missing current

```
4 1 0 1█ T E S T   D I F F
I x   L 3 =   6 . 3   %
```

Display of the measured current of side 1, phase L3, referred to rated relay current,
e.g. 6.3 %
For the sides which are not included in the test, ⋆⋆⋆⋆ will appear because of missing current

```
4 1 0 1█ T E S T   D I F F
I A =   1 8 . 6   %
```

Display of the measured current of the additional current input I_A, e.g. 18.6 %
The value should be approximately three times the line currents; if this additional current input is not connected or configured, ⋆⋆⋆⋆ will be displayed

```
4 1 0 1█ T E S T   D I F F
I B =   * * * *
```

Display of the measured current of the additional current input I_B, in this example not defined (assumed that only I_A be connected)

Switch over with the key ↑ to address 4121. The phase angle relation of the phase currents need not be checked now. The phase angles of all phase currents of the winding under test against each other are zero, those against different windings are not defined because of missing current. Therefore, page on with ↑ to address 4141. The phase angles as shown below are displayed and can be scrolled by means of the "No"–key **N**. Numerical values are to be expected only for those current inputs which are included in the test current path, for the remaining currents, ⋆⋆⋆⋆ are displayed. In the illustration of the following examples it is assumed that the zero sequence current tests are carried out via the winding 1 of a transformer and the associated star–point current connected to I_A.

If an additional current input is not assigned to any side of the protected object (addresses 7806 and/or 7807), then the associated measured values do not appear at all.

If considerable deviations occur, re–check the corresponding parameters and correct them where necessary:

Address 1108, when the additional current input is assigned to winding 1 of a transformer,

Address 1128, when the additional current input is assigned to winding 2 of a transformer,

Address 1148, when the additional current input is assigned to winding 3 of a transformer,

Address 1405, when the additional current input is assigned to a virtual object.

```
4 1 4 1█ T E S T   A N G L   S
T E S T   ?
```

Display of the results of angle measurement of the star–point to line currents? Confirm with the "Yes"–key **J/Y** or abort with the "No"–key **N**, or page on with key ↑.

```
4141█ TEST ANGL S
IA-I1L1=  0 °
```

Display of the phase angle between the star–point current connected to input I_A against the phase current of side 1, phase L1
should be **0°**, when these currents are under test

```
4141█ TEST ANGL S
IA-I1L2=  0 °
```

Display of the phase angle between the star–point current connected to input I_A against the phase current of side 1, phase L2
should be **0°**, when these currents are under test

```
4141█ TEST ANGL S
IA-I1L3=  0 °
```

Display of the phase angle between the star–point current connected to input I_A against the phase current of side 1, phase L3
should be **0°**, when these currents are under test

```
4141█ TEST ANGL S
IA-I2L1=  ****
```

Display of the phase angle between the star–point current connected to input I_A against the phase current of side 2, phase L1
undefined, when these currents are not under test

```
4141█ TEST ANGL S
IA-I2L2=  ****
```

Display of the phase angle between the star–point current connected to input I_A against the phase current of side 2, phase L2
undefined, when these currents are not under test

```
4141█ TEST ANGL S
IA-I2L3=  ****
```

Display of the phase angle between the star–point current connected to input I_A against the phase current of side 2, phase L3
undefined, when these currents are not under test

```
4141█ TEST ANGL S
IA-I3L1=  ****
```

Display of the phase angle between the star–point current connected to input I_A against the phase current of side 3, phase L1
undefined, when these currents are not under test

```
4141█ TEST ANGL S
IA-I3L2=  ****
```

Display of the phase angle between the star–point current connected to input I_A against the phase current of side 3, phase L2
undefined, when these currents are not under test

```
4141█ TEST ANGL S
IA-I3L3=  ****
```

Display of the phase angle between the star–point current connected to input I_A against the phase current of side 3, phase L3
undefined, when these currents are not under test

```
4141█ TEST ANGL S
IB-I1L1=  ****
```

Display of the phase angle between the star–point current connected to input I_B against the phase current of side 1, phase L1
undefined, when these currents are not under test

```
4141█ TEST ANGL S
IB-I1L2=   ****
```

Display of the phase angle between the star–point current connected to input I_B against the phase current of side 1, phase L2
undefined, when these currents are not under test

```
4141█ TEST ANGL S
IB-I1L3=   ****
```

Display of the phase angle between the star–point current connected to input I_B against the phase current of side 1, phase L3
undefined, when these currents are not under test◆

```
4141█ TEST ANGL S
IB-I2L1=   ****
```

Display of the phase angle between the star–point current connected to input I_B against the phase current of side 2, phase L1
undefined, when these currents are not under test

```
4141█ TEST ANGL S
IB-I2L2=   ****
```

Display of the phase angle between the star–point current connected to input I_B against the phase current of side 2, phase L2
undefined, when these currents are not under test

```
4141█ TEST ANGL S
IB-I2L3=   ****
```

Display of the phase angle between the star–point current connected to input I_B against the phase current of side 2, phase L3
undefined, when these currents are not under test

```
4141█ TEST ANGL S
IB-I3L1=   ****
```

Display of the phase angle between the star–point current connected to input I_B against the phase current of side 3, phase L1
undefined, when these currents are not under test

```
4141█ TEST ANGL S
IB-I3L2=   ****
```

Display of the phase angle between the star–point current connected to input I_B against the phase current of side 3, phase L2
undefined, when these currents are not under test

```
4141█ TEST ANGL S
IB-I3L3=   ****
```

Display of the phase angle between the star–point current connected to input I_B against the phase current of side 3, phase L3
undefined, when these currents are not under test

When on the winding of a transformer, which has been included in the performed zero sequence current tests, the zero sequence current correction is used, then the differential and stabilizing currents of the differential protection must even be checked now.

Switch over to address 4161 by pressing the key ↑. In this address, the calculated values can be read out by scrolling through the display with the "No"–key **N**. When assessing the currents note that the differential and stabilizing values are referred to the rated current of the protected object.

```
4161█ TEST DIF/ST
TEST ?
```

Display of the results of calculation of the differential and stabilizing currents? Confirm with the "Yes"–key **J/Y** or abort with the "No"–key **N**, or page on with key ↑.

```
4161█ TEST DIF/ST
IL1diff= 0.4 %
```

Display of the differential current of measuring system L1, referred to the rated current of the protected object, e.g. 0.4 %
The value should be negligible against the magnitude of the line currents

```
4161█ TEST DIF/ST
IL2diff= 0.3 %
```

Display of the differential current of measuring system L2, referred to the rated current of the protected object, e.g. 0.3 %
The value should be negligible against the magnitude of the line currents

```
4161█ TEST DIF/ST
IL3diff= 0.4 %
```

Display of the differential current of measuring system L3, referred to the rated current of the protected object, e.g. 0.4 %
The value should be negligible against the magnitude of the line currents

```
4161█ TEST DIF/ST
IL1rest= 0.4 %
```

Display of the stabilizing (restraint) current of measuring system L1, referred to the rated current of the protected object, e.g. 0.4 %
The value should be negligible against the magnitude of the line currents

```
4161█ TEST DIF/ST
IL2rest= 0.4 %
```

Display of the stabilizing (restraint) current of measuring system L2, referred to the rated current of the protected object, e.g. 0.4 %
The value should be negligible against the magnitude of the line currents

```
4161█ TEST DIF/ST
IL3rest= 0.5 %
```

Display of the stabilizing (restraint) current of measuring system L3, referred to the rated current of the protected object, e.g. 0.4 %
The value should be negligible against the magnitude of the line currents

---

If considerable differential currents occur, recheck the concerned parameters for zero sequence current processing and the matching factors: addresses 1106 to 1108 when the zero sequence current is associated with winding 1, addresses 1126 to 1128 when the zero sequence current is associated with winding 2, and addresses 1146 to 1188 when the zero sequence current is associated with winding 3. If the differential current corresponds to $^1/_3$ of the test current, the star–point current correction is not effective. If the differential current corresponds to $^2/_3$ of the test current, the star–point current has wrong polarity.

If the restricted earth fault protection is not available or not used, the zero sequence current tests are thus completed. Disconnect the protected object and earth, disconnect test arrangement. Section 6.7.6 may then be by–passed.

6.7.6 Current tests for restricted earth fault protection – address block 41

If the relay is equipped with the restricted earth fault protection and this is to be used, a further zero sequence current test must be carried out.

If the restricted earth fault protection operates on a side of the protected object which is already checked according to Section 6.7.3, sub–section 6.7.6.1 can be passed over since these checks have already be done. In this case, only sub–section 6.7.6.2 is relevant.

But, if the restricted earth fault protection operates on a side which has not yet been included in the foregoing tests, e.g. on a virtual object, first the tests according sub–section 6.7.6.1 are necessary.

The test arrangement is according Section 6.7.4; only the tested side of the protected object is of interest.

A renewed measurement request of the operator is necessary. The measured values are then stored but not continuously actualized to ensure comparable results. If the test arrangement is changed, a new measurement request is necessary.

As soon as the first measured value appears in the display the test current can be switched off.

```
⇧  4 1 0 0 █
⇩  C O M M I S S I O N   T E S T
```

Block ”Commissioning tests”
Switch over to address 4181 by repeatedly depressing the key ↑

```
↑  4 1 8 1 █  T E S T   R E F
↓  T E S T   ?
```

After confirmation with the ”Yes”–key **J/Y** measurements for the restricted earth fault protection is carried out

---

Confirm with the ”Yes”–key **J/Y**. The relay measures all currents and phase angles of this test address 4181. As soon as the first measured value appears in the display, the test current can be switched off. The values can be read out by repeatedly depressing the ”No”–key **N**, the backspace key **R** allows for reading out the preceding value.

6.7.6.1 Measurement of the phase current relationship

During zero sequence current test, the three phase currents must be approximately equal and without phase difference. Otherwise wrong polarities are present in the current transformer connections.

If one angle is 180° instead of 0°, wrong polarity is present as explained below.

- Disconnect the protected object and earth,
- check connections and test arrangement,
- repeat test.

```
4 1 8 1 █  T E S T   R E F
I L 1 =   6 . 4   %
```

Display of the measured current of phase L1, referred to rated relay current,
e.g. 6.4 %

```
4181 TEST  REF
IL2 =  6.0  %
```

Display of the measured current of phase L2, referred to rated relay current,
e.g. 6.0 %

```
4181 TEST  REF
IL3 =  6.3  %
```

Display of the measured current of phase L3, referred to rated relay current,
e.g. 6.3 %

```
4181 TEST  REF
IL2-IL1 =  0  °
```

Display of the phase angle between the current of phase L2 against phase L1,
should be **0°**; 180° may indicate wrong polarity in L2

```
4181 TEST  REF
IL3-IL1 =  0  °
```

Display of the phase angle between the current of phase L3 against phase L1,
should be **0°**; 180° may indicate wrong polarity in L3

6.7.6.2 Measured values of the restricted earth fault protection

The currents I0* and I0** are referred to the rated relay current; besides this, they correspond to the values I_0' and I_0" which are relevant for the actual protection function.

I0* is the current which flows through the star−point current transformer, I0** is the sum of the phase currents. When the rated primary currents of all these c.t.s are equal, then I0* and I0** are almost equal.

If the display shows undefined values, i.e. ★★★★, the test arrangement must be checked as well as the assignment of the additional measured current inputs I_A and I_B (addresses 7806 and 7807, refer to Section 5.4.2).

```
4181 TEST  REF
I0* =  18.4  %
```

Display of the measured current of the star−point, referred to rated relay current, should be approximately the star−point current
e.g. 18.4 %

```
4181 TEST  REF
I0** =  18.6  %
```

Display of the sum of the phase currents, referred to rated relay current, should be approximately three times the phase current
e.g. 18.6 %

The phase angle between I0* and I0** must be 0°. If it is 180°, the star−point c.t. has wrong polarity. Re−check and correct the concerned parameters:

– Address 1108, when winding 1 is assigned to the restricted earth fault protection, i.e. address 7806 on *SIDE 1* for current input I_A or address 7807 on *SIDE 1* for current input I_B.

– Address 1128, when winding 2 is assigned to the restricted earth fault protection, i.e. address 7806 on *SIDE 2* for current input I_A or address 7807 on *SIDE 2* for current input I_B.

– Address 1148, when winding 3 is assigned to the restricted earth fault protection, i.e. address 7806 on *SIDE 3/V. OBJ* for current input I_A or address 7807 on *SIDE 3/V. OBJ* for current input I_B.

– Address 1405, when a virtual object is assigned to the restricted earth fault protection, i.e. address 7806 on *SIDE 3/V. OBJ* for current input I_A or address 7807 on *SIDE 3/V. OBJ* for current input I_B.

```
4181█ TEST  REF
I0*-I0**=  0  °
```

Display of the phase angle between the current of the star–point c.t. against the sum of the currents of the phase c.t.s,
should be **0°**

Before the tests are terminated, the differential and stabilizing currents are checked. When assessing the currents note that the differential and stabilizing values are referred to the rated current of the protected object. If considerable differential currents occur, recheck the concerned parameters:

– Address 1107, when winding 1 is assigned to the restricted earth fault protection, i.e. address 7806 on *SIDE 1* for current input I_A or address 7807 on *SIDE 1* for current input I_B.

– Address 1127, when winding 2 is assigned to the restricted earth fault protection, i.e. address 7806 on *SIDE 2* for current input I_A or address 7807 on *SIDE 2* for current input I_B.

– Address 1147, when winding 3 is assigned to the restricted earth fault protection, i.e. address 7806 on *SIDE 3/V. OBJ* for current input I_A or address 7807 on *SIDE 3/V. OBJ* for current input I_B.

– Address 1404, when a virtual object is assigned to the restricted earth fault protection, i.e. address 7806 on *SIDE 3/V. OBJ* for current input I_A or address 7807 on *SIDE 3/V. OBJ* for current input I_B.

```
4181█ TEST  DIF/ST
Diff=  0.6  %
```

Display of the differential current $|\underline{I}_{L1}+\underline{I}_{L2}+\underline{I}_{L3}+\underline{I}_{sp}|$ (I_{sp} negative), referred to the rated current of the protected object,
e.g. 0.6 %
The value should be negligible against the magnitude of the test currents

```
4181█ TEST  DIF/ST
Rest=  36.9  %
```

Display of the stabilizing (restraining) current $|\underline{I}_{L1}| + |\underline{I}_{L2}| + |\underline{I}_{L3}| + |\underline{I}_{sp}|$, referred to the rated current of the protected object,
e.g. 36.9 %
The value should correspond approximately to twice the star–point current

The zero sequence current test are now completed. Disconnect the protected object and earth. Remove the test arrangement.

6.7.7 Leaving test operation − address block 48

When no activities are carried out during more than 60 minutes − i.e. no measurement request nor any change in the address block 41 − the relay terminates the test operation automatically. No valid test values are indicated thereafter.

It is, nevertheless, recommended, that the test mode be definitely finished after the tests have been completed.

Leaving the test mode is carried out in address block 4800, which is reached by direct addressing **DA 4 8 0 0**, or by paging in block with the keys ⇑ or ⇓. Page on with the key ↑ to the next (and only) address of this block, where the question of terminating the test operation is answered with the ”Yes”−key **J/Y**. If one presses the ”No”−key **N**, the relay continues the test mode.

The used protection functions must be switched to the *ON*−position in case they were in position *BLOCK TRIP REL* during commissioning, in order to be effective (address 1601 for transformer, 1701 for generator/motor, 1801 for branch−point).

⇑⇓ 4800 COMMISSION TEST STOP	Block ”Commissioning tests to stop” Switch over to address 4801 by depressing the key ↑
↑↓ 4801 TEST STOP ?	After confirmation with the ”Yes”−key **J/Y** the test operation of the relay is terminated

6.7.8 Checking the coupling of external trip signals

If the coupling of external functions for alarm and/or trip processing is used in 7UT51, then one or more of these functions must be configured as *EXIST* in the addresses 7830 and/or 7831. Additionally, the respective function must be switched to *BLOCK TRIP REL* in address 3001 and/ or 3101 EXT. TRIP *.

The operation of the coupling is to be checked for one after another. For this, the source object of the coupled signal is operated and the effect is checked.

Finally, the used functions are parameterized to *ON* in the associated addresses 3001 and/or 3101.
If further annunciations − like Buchholz protection signals or user definable annunciations − are used, these must either be checked. The origin of each annunciation is operated and the reaction of the relay is checked.

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"`).

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 ↑:

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 important for use on transformers where large inrush currents can be produced by transient saturation of the transformer iron. Since a large inrush current may have the same effect as a single–ended infeed fault but which must not initiate tripping, the effectiveness of the inrush stabilization is checked by energizing the power transformer several times.

The differential protection should be switched to *BLOCK TRIP REL* (address 1601) during these switching tests in order to avoid tripping.

As the "pick–up" signal of the relay is not stabilized, the inrush current will start fault recording automatically, provided the initiation mode (address 7402) was set to *STORAGE BY FD* (factory setting, refer also to Section 5.3.4). Otherwise a fault record is only stored if the relay has tripped. Nevertheless, a fault record can always be triggered via a binary input provided this is allocated.

Conclusions as to the effectiveness of the inrush stabilization can be drawn from the recording of the differential currents and the harmonic contents. If necessary, the inrush current stabilization effect can be increased (smaller value of the second harmonic in address 1611), when trip occurs or when the recorded data show that the second harmonic content does not safely exceed the set stabilizing threshold (address 1611). A further method to increase inrush stability is to set the cross–block function effective or to increase the duration of the cross–block function (address 1612, refer to Section 6.3.7).

⇑ ⇓
```
4900█ TEST
FAULT RECORDING
```
Beginning of block "Test fault recording" page on with ↑ to address 4901

↑
```
4901█ FAULT REC.
START ?
```
Start fault recording? Confirm with "**J/Y**"– key or abort with page–on key ↑

```
SUCCESSFUL
```
The relay acknowledges successful completion of the test recording

---

After tests **do not forget to switch the differential protection** *ON* (address 1601 for transformer protection**)**.

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 block 78, refer Section 5.4) and that all desired protection functions have been switched *ON*.

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 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 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 battery should be replaced after at most 10 years of operation (refer to Section 7.2). This recommendation is valid independent on whether the battery has been discharged by occasional supply voltage failures or not.

As the protection is almost completely self-monitored, from the measuring inputs to the command output relays, hardware and software faults are automatically annunciated. This ensures the high availability of the relay and allows a more corrective rather than preventive maintenance strategy. Tests at short intervals become, therefore, superfluous.

With detected hardware faults the relay blocks itself; drop-off of the availability relay signals ”equipment fault”. If there is a fault detected in the external measuring circuits, generally an alarm is given only.

Recognized software faults cause the processor to reset and restart. If such a fault is not eliminated by restarting, further restarts are initiated. If the fault is still present after three restart attempts the protective system will switch itself out of service and indicate this condition by the red LED ”Blocked” on the front plate. Drop-off of the availability relay signals ”equipment fault”.

The reaction to defects and indications given by the relay can be individually and in chronological sequence read off as operational annunciations under the address 5100, for defect diagnosis (refer to Section 6.4.2).

If the relay is connected to a local substation automation system (LSA), defect indications will also be transferred via the serial interface to the central control system.

⚠ Warning

Ensure that the connection modules are not damaged when removing or inserting the device modules! Hazardous voltages may occur when the heavy current plugs are damaged!

7.1 Routine checks

Routine checks of characteristics or pick-up values are not necessary as they form part of the continuously supervised firmware programs. The planned maintenance intervals for checking and maintenance of the plant can be used to perform operational testing of the protection equipment. This maintenance serves mainly for checking the interfaces of the unit, i.e. the coupling with the plant. The following procedure is recommended:

– Read-out of operational values (address block 57) and comparison with the actual values for checking the analog interfaces.

– Simulation of an internal short-circuit with 4 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!

7.2 Replacing the back-up battery

The device annunciations are stored in NV–RAMs. A back-up battery is inserted so that they are retained even with a longer failure of the d.c. supply voltage. The back-up battery is also required for the internal system clock with calender to continue in the event of a power supply failure.

The back-up battery should be replaced at the latest after 10 years of operation. The way of displacement depends on the production series of the relay. This production series is found on the name plate behind the complete order designation.

Recommended battery:

Lithium battery 3 V/1 Ah, type CR 1/2 AA, e.g.
- VARTA Order No. 6127 501 501 for relays until production series /**JH**,
- VARTA Order No. 6127 101 501 for relays from production series /**KK** or later.

The battery is located at the rear edge of the processor board of the basic module GEA. The basic module must be removed from the housing in order to replace the battery.

- Prepare area of work: provide conductive surface for the basic module.

- Open housing cover.

- Read out device annunciations, i.e. all addresses which commence with 5 (5000 onwards). This is carried out most convenient using the front operating interface and a personal computer with the DIGSI® protection data processing program; the information is thus stored in the PC.

  Note: All configuration data and settings of the device are stored in EEPROMs protected against switching off of the power supply. They are stored independent of the back-up battery. They are, therefore, neither lost when the battery is replaced nor when the device is operated without a battery.

- **Only for relay until production series /JH**: Prepare the battery as in Figure 7.1:

Caution!

Do not short-circuit battery! Do not reverse battery polarities! Do not charge battery!

Shorten the legs to 15 mm (6/10 inch) each and bend over at a length of 40 mm (16/10 inch).

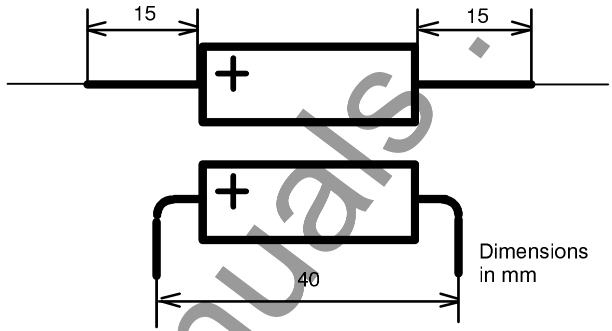


Figure 7.1 Bending the back-up battery, up to production series /JH

Relays from production series /**KK** or later have no axial legs.

- Loosen the basic module using the pulling aids provided at the top and bottom. (Figure 7.5).

Warning

Hazardous voltages can be present in the device even after disconnection of the supply voltage or after removal of the modules from the housing (storage capacitors)!

Caution!

Electrostatic discharges via the component connections, the PCB tracks or the connecting pins of the modules must be avoided under all circumstances by previously touching an earthed metal surface.

- Pull out basic module and place onto the conductive surface.

- Unscrew used battery from the terminals or remove it from the holder; **do not place on the conductive surface!** Refer to Figure 7.2 for relay until production series /**JH** and to Figure 7.3 from production series /**KK**.

- Insert the prepared battery into the terminals or holder as in Figure 7.2 (until production series /**JH**) and tighten the screws or as in Figure 7.3 (from production series /**KK**).

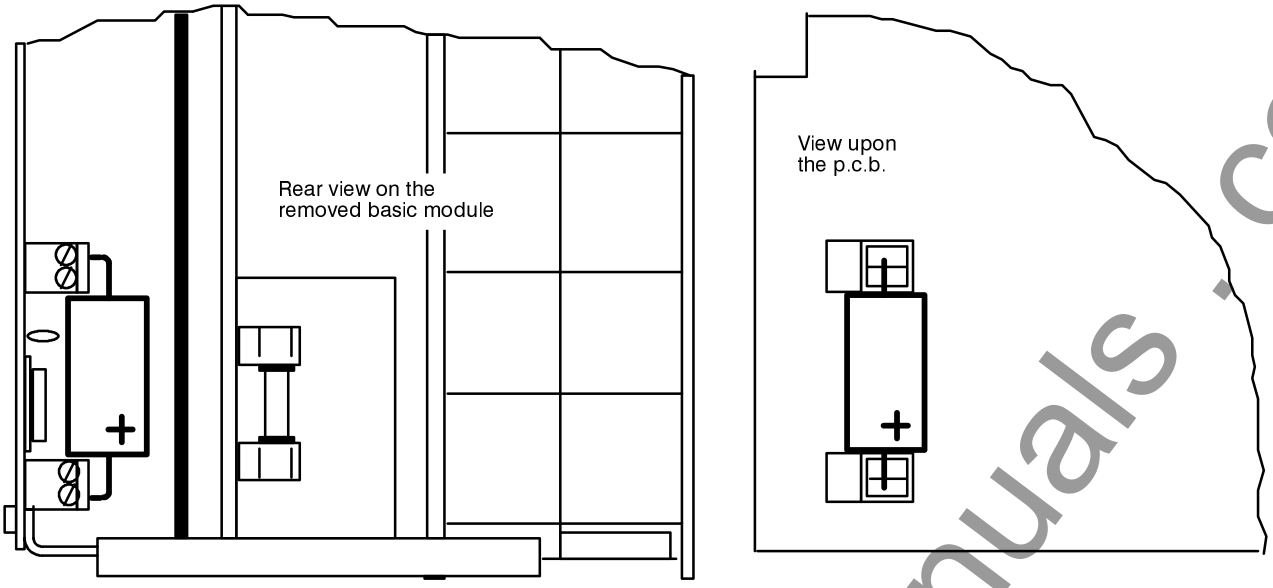


Figure 7.2 Installation of the back-up battery for relay up to production series /JH

– Insert basic module into the housing; ensure that the releasing lever is pushed fully to the left before the module is pressed in.

– Firmly push in the module using the releasing lever. (Figure 7.5).

Warning

The discharged battery contains Lithium. It must only be disposed off in line with the applicable regulations!

Do not reverse polarities! Do not recharge! Do not throw into fire! Danger of explosion!

– Provided the internal system clock is not automatically synchronized via the LSA interface, it can now be set or synchronized as described in Section 6.5.1

– Close housing cover.

The replacement of the back-up battery has thus been completed.

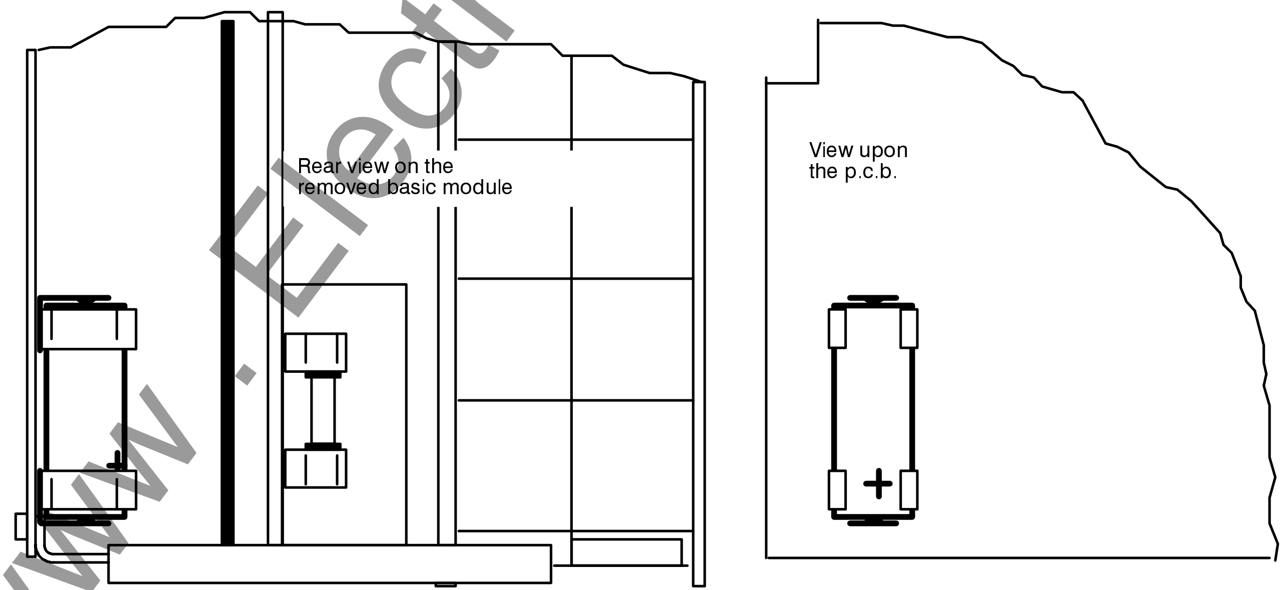


Figure 7.3 Installation of the back-up battery for relay from production series /KK

7.3 Fault tracing

If the protective device indicates a defect, the following procedure is suggested:

If none of the LEDs on the front plate of the module is on, then check:

– Have the modules been properly pushed in and locked?

– Is the ON/OFF switch on the front plate in the ON position ⊙ ?

– Is the auxiliary voltage available with the correct polarity and of adequate magnitude, connected to the correct terminals (General diagrams in Appendix A)?

– Has the mini-fuse in the power supply section blown (see Figure 7.4)? If appropriate, replace the fuse according to Section 7.3.1.

If the red fault indicator "Blocked" on the front is on and the green ready LED remains dark, the device has recognized an internal fault. Re-initialization of the protection system could be tried by switching the d.c. auxiliary voltage off and on again. This, however, results in loss of fault data and messages 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 7.4).

– Prepare area of work: provide conductive surface for the basic module.

– Open housing cover.

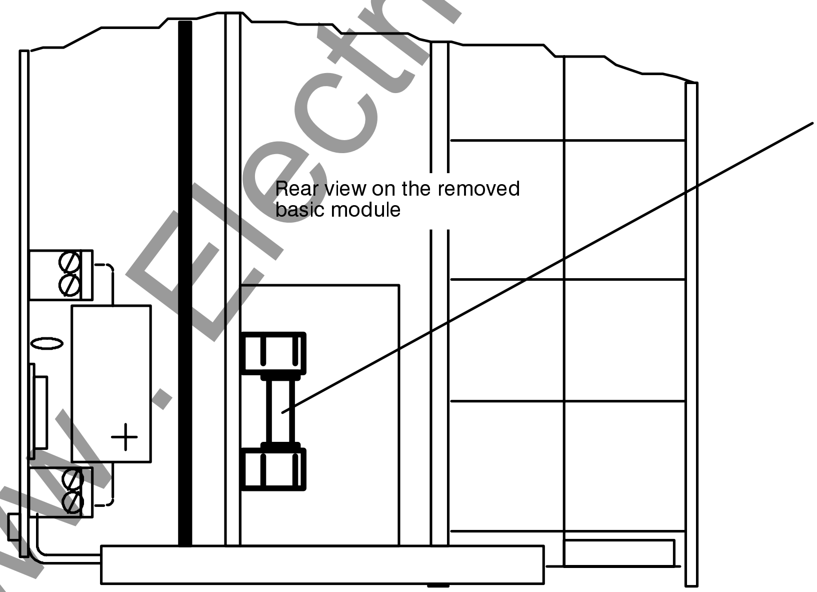
Warning

Hazardous voltages can be present in the device even after disconnection of the supply voltage or after removal of the modules from the housing (storage capacitors)!

– Loosen the basic module using the pulling aids provided at the top and bottom. (Figure 7.5).

Caution!

Electrostatic discharges via the component connections, the PCB tracks or the connecting pins of the modules must be avoided under all circumstances by previously touching an earthed metal surface.



at U_{HN}/V–	rated value
24/48	2 A/E
60/110/125	1,6 A/E
220/250	1 A/G

Figure 7.4 Mini-fuse of the power supply

– Pull out basic module and place onto the conductive surface.

– Remove blown fuse from the holder (Figure 7.4).

– Fit new fuse into the holder (Figure 7.4).

– Insert basic module into the housing; ensure that the releasing lever is pushed fully to the left before the module is pressed in (Figure 7.5).

– Firmly push in the module using the releasing lever. (Figure 7.5).

– Close housing cover.

Switch on the device again. If a power supply failure is still signalled, a fault or short-circuit is present in the internal power supply. The device should be returned to the factory (see Chapter 8).

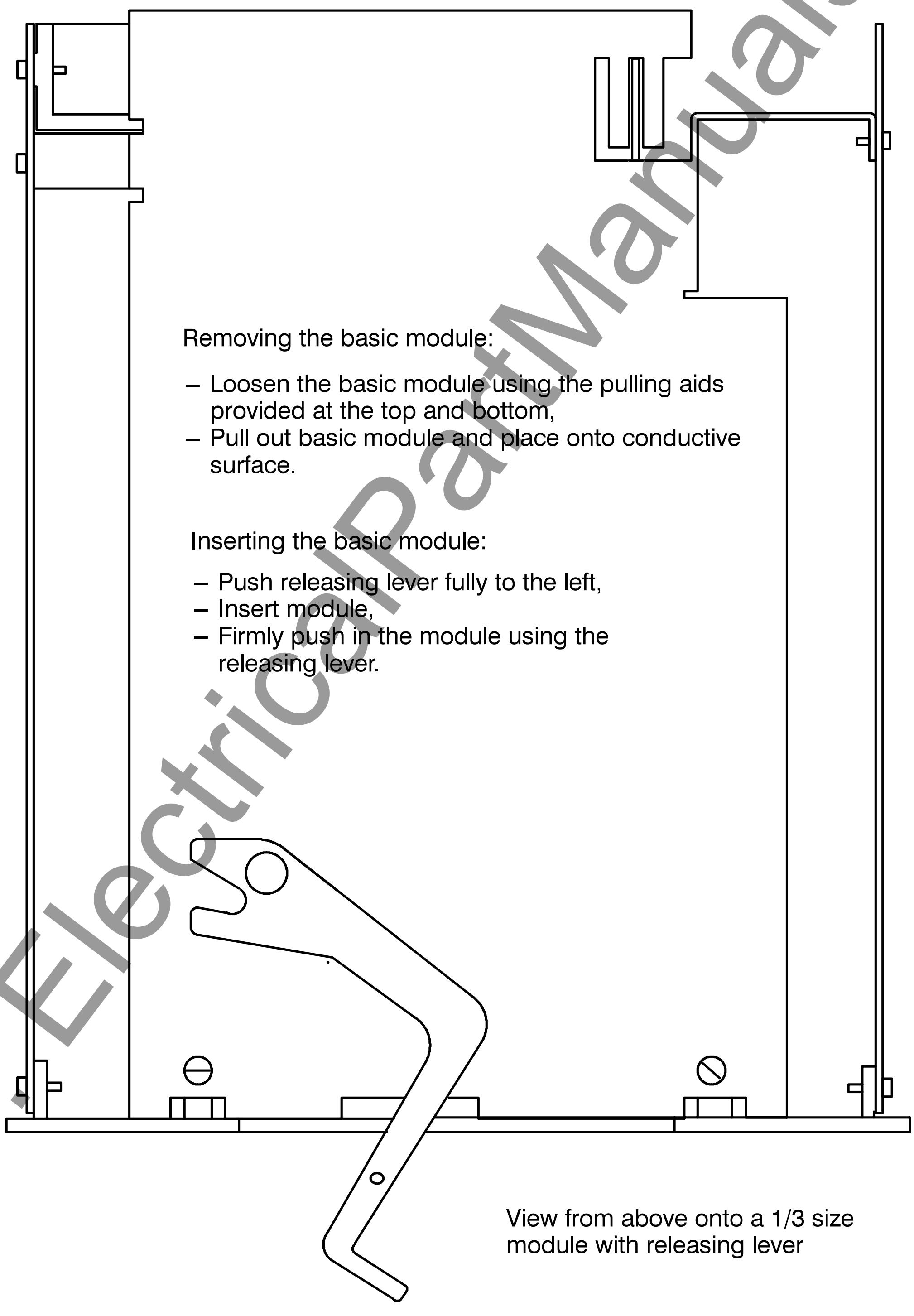


Figure 7.5 Aid for removing and inserting basic module

8 Repairs

Repair of defective modules is not recommended at all because specially selected electronic components are used which must be handled in accordance with the procedures required for **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 CT connections

C Tables

A General diagrams

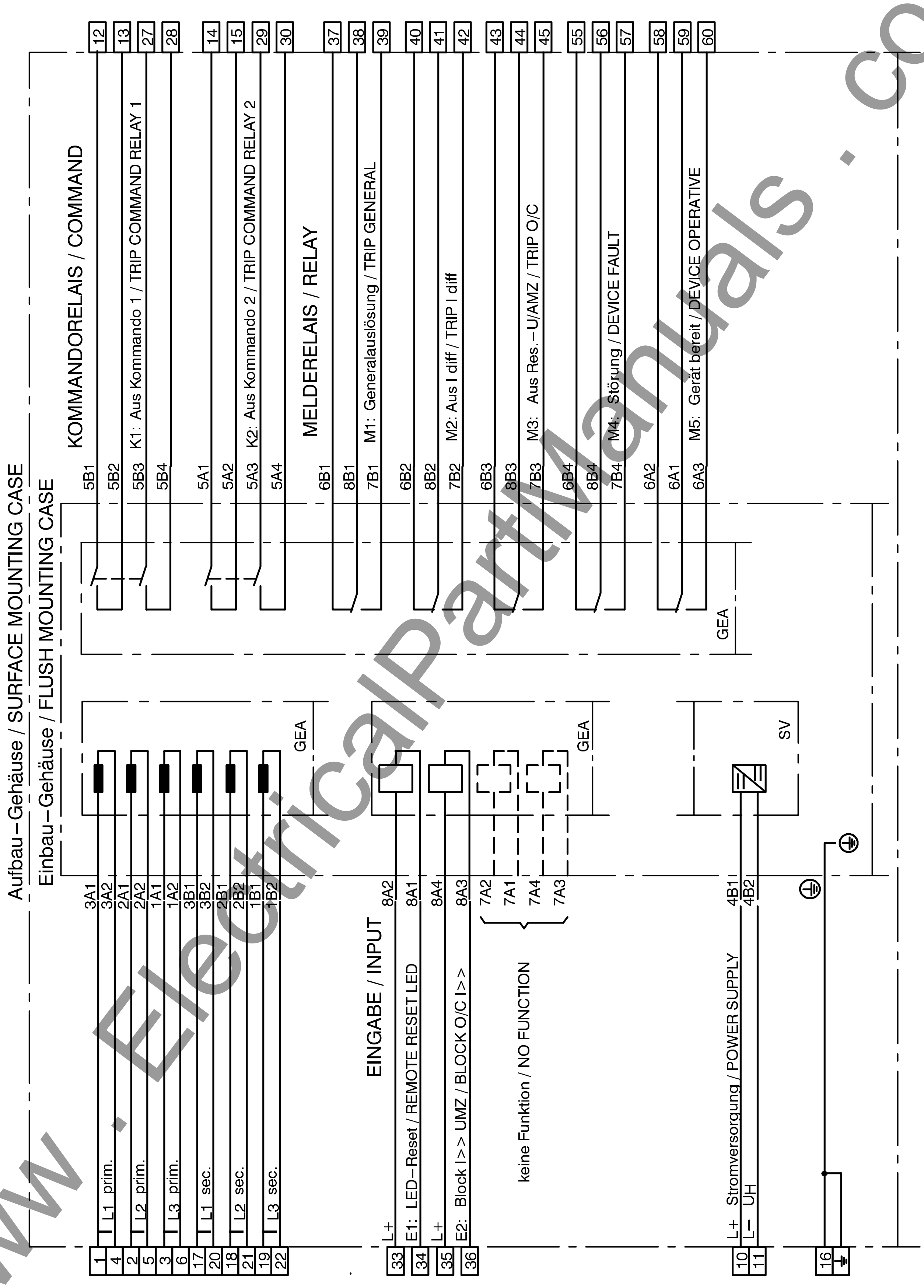
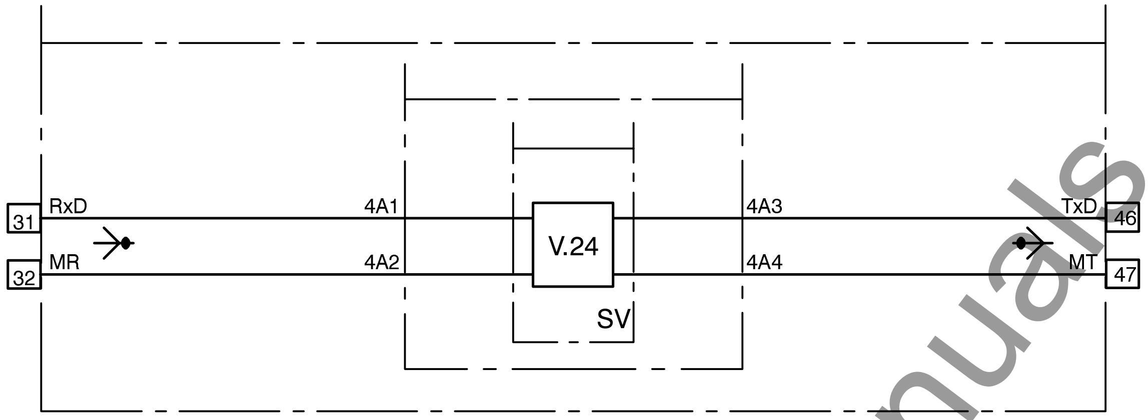
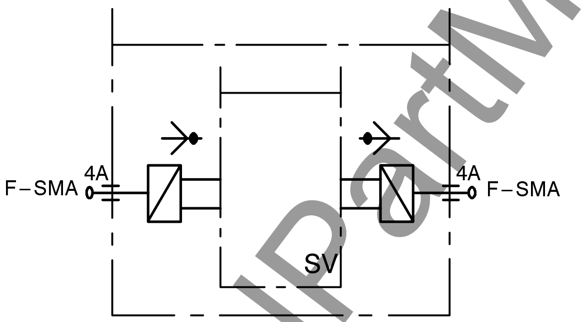


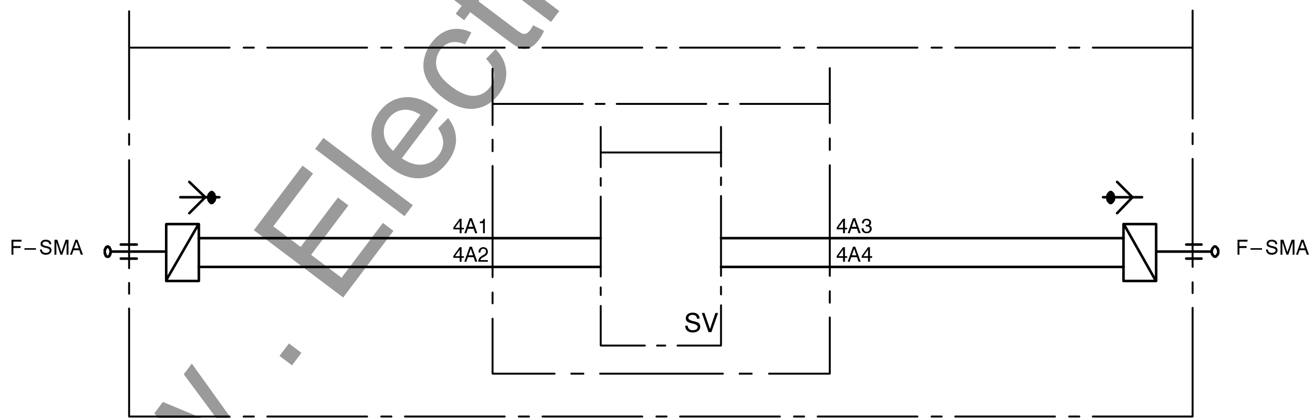
Figure A.1 General diagram 7UT51**2** (sheet 1 of 2)

Einbau- und Aufbaugehäuse mit V24–Schnittstelle
FLUSH AND SURFACE MOUNTING CASE WITH V24 DATA LINK
7UT512*–*D***–*B **/
7UT512*–*C***–*B **/
7UT512*–*E***–*B **/





Einbaugehäuse mit LWL–Modul
FLUSH MOUNTING CASE WITH FIBER OPTIC INTERFACE
7UT512*–*C***–*C**/
7UT512*–*E***–*C**/



Aufbaugehäuse mit LWL–Modul
SURFACE MOUNTING CASE WITH FIBER OPTIC INTERFACE
7UT512*–*D***–*C**/

Figure A.2 General diagram 7UT51**2** (sheet 2 of 2)

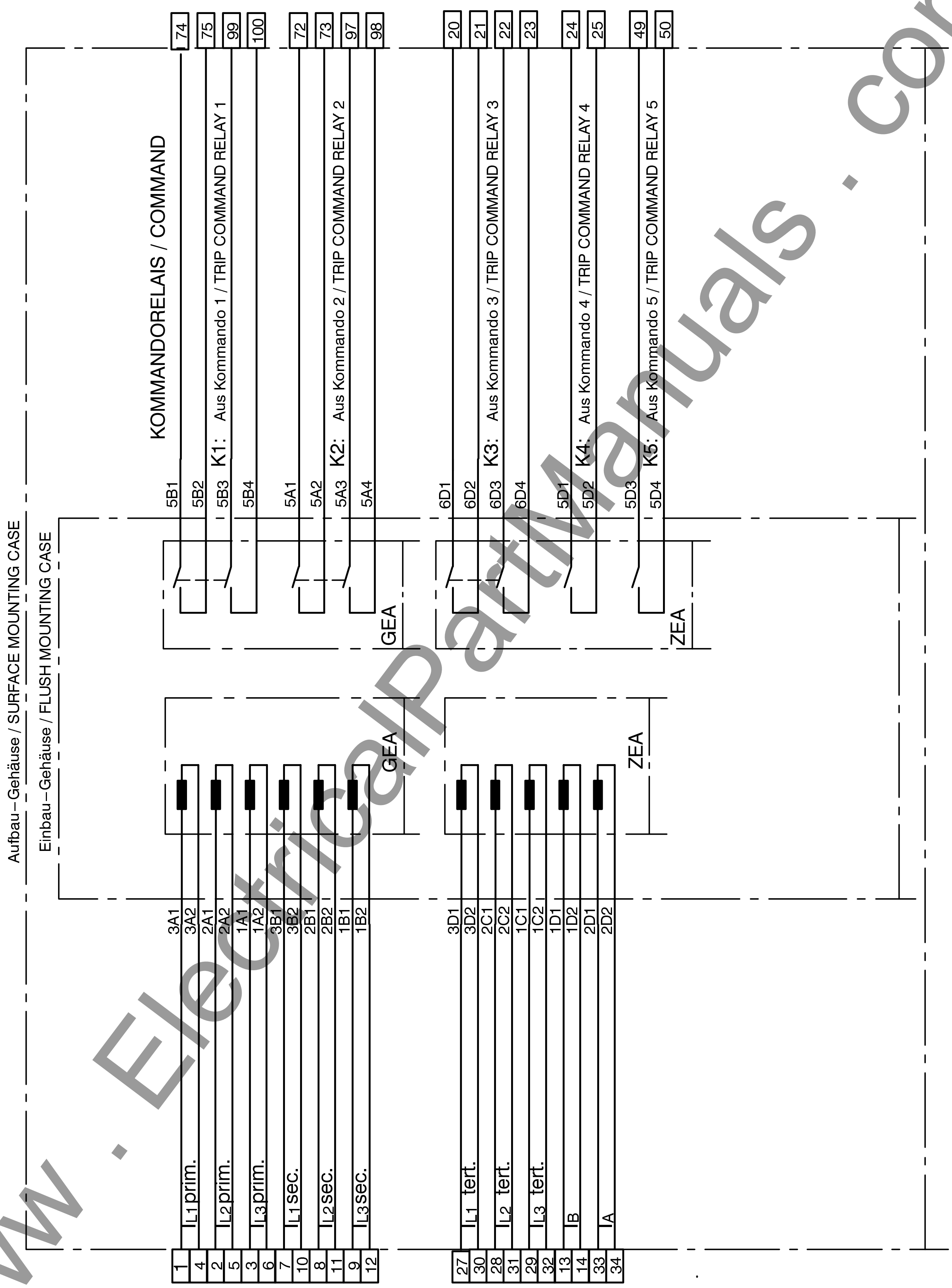


Figure A.3 General diagram 7UT51**3** (sheet 1 of 3)

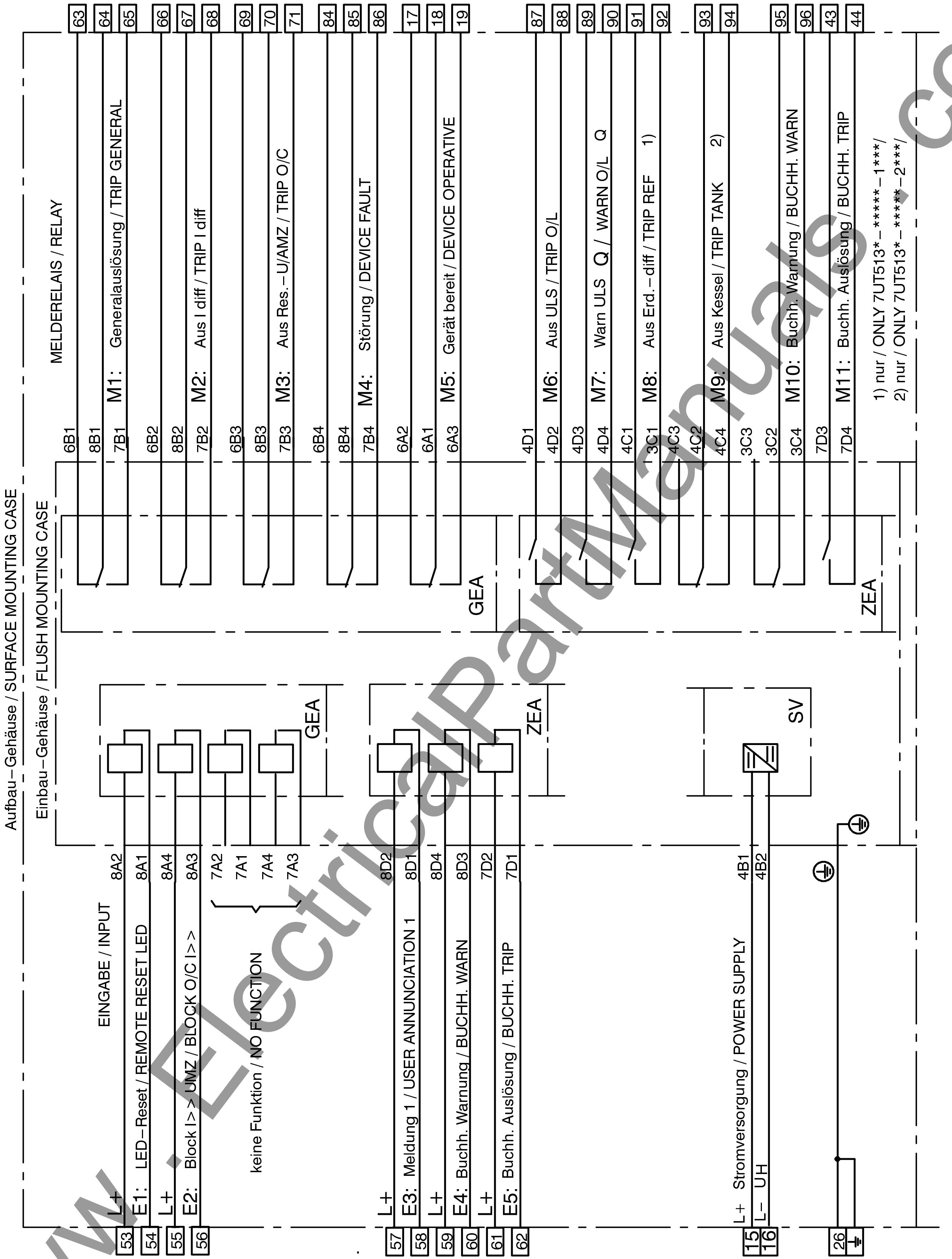
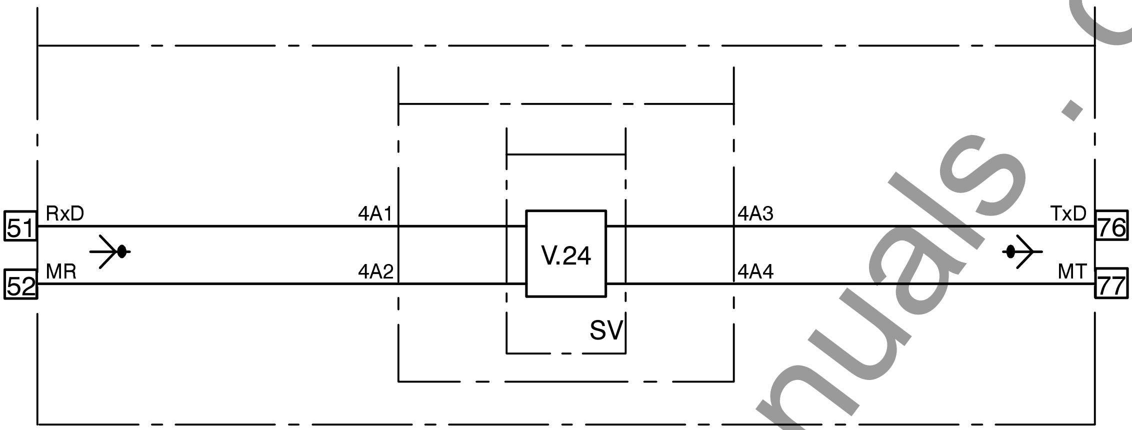
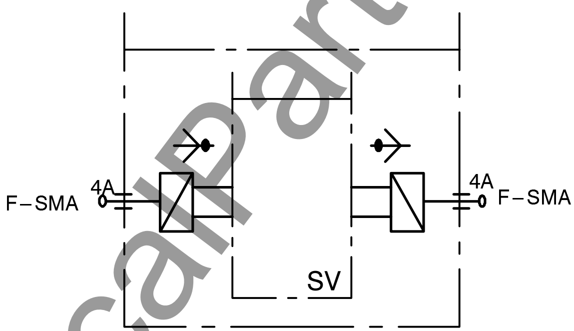


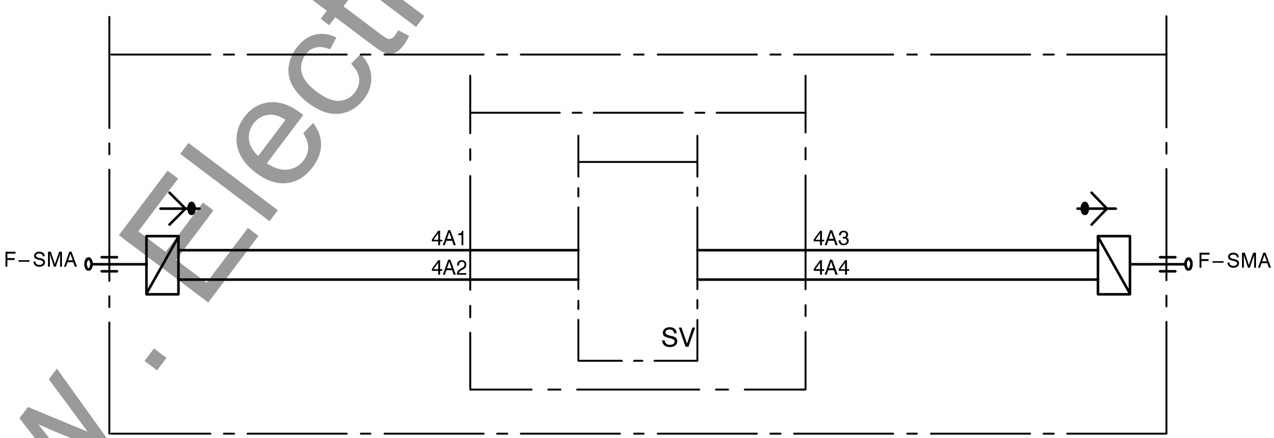
Figure A.4 General diagram 7UT51**3** (sheet 2 of 3)

Einbau- und Aufbaugehäuse mit V24–Schnittstelle
FLUSH AND SURFACE MOUNTING CASE WITH V24 DATA LINK
7UT513*–*D***–*B* */
7UT513*–*C***–*B** /
7UT513*–*E***–*B** /



Einbaugehäuse mit LWL–Modul
FLUSH MOUNTING CASE WITH FIBER OPTIC INTERFACE
7UT513*–*C***–*C** /
7UT513*–*E***–*C** /





Aufbaugehäuse mit LWL–Modul
SURFACE MOUNTING CASE WITH FIBER OPTIC INTERFACE
7UT513*–*D***–*C** /

Figure A.5 General diagram 7UT51**3** (sheet 3 of 3)

B CT connections

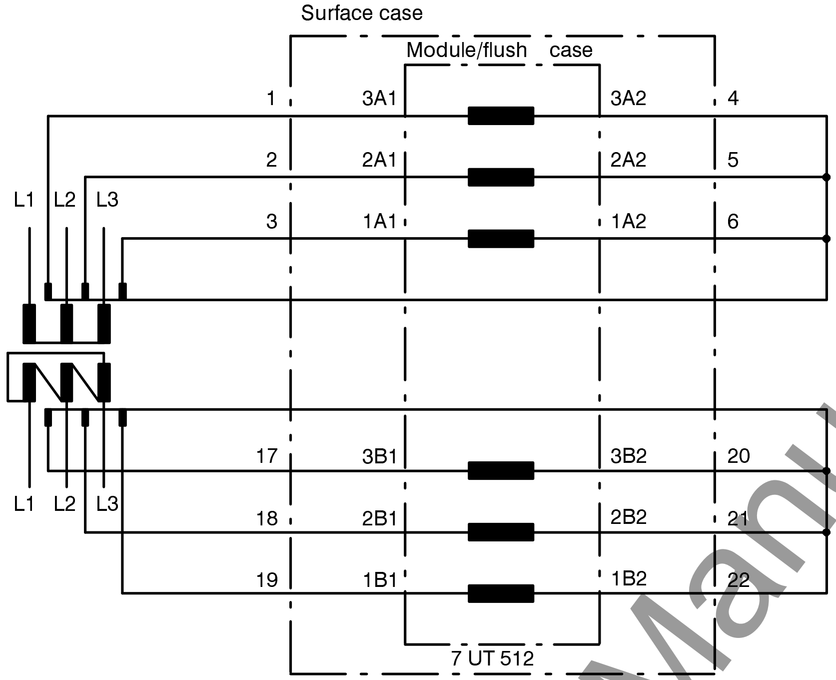


Figure B.1 CT connection example 7UT512 for a two-winding transformer

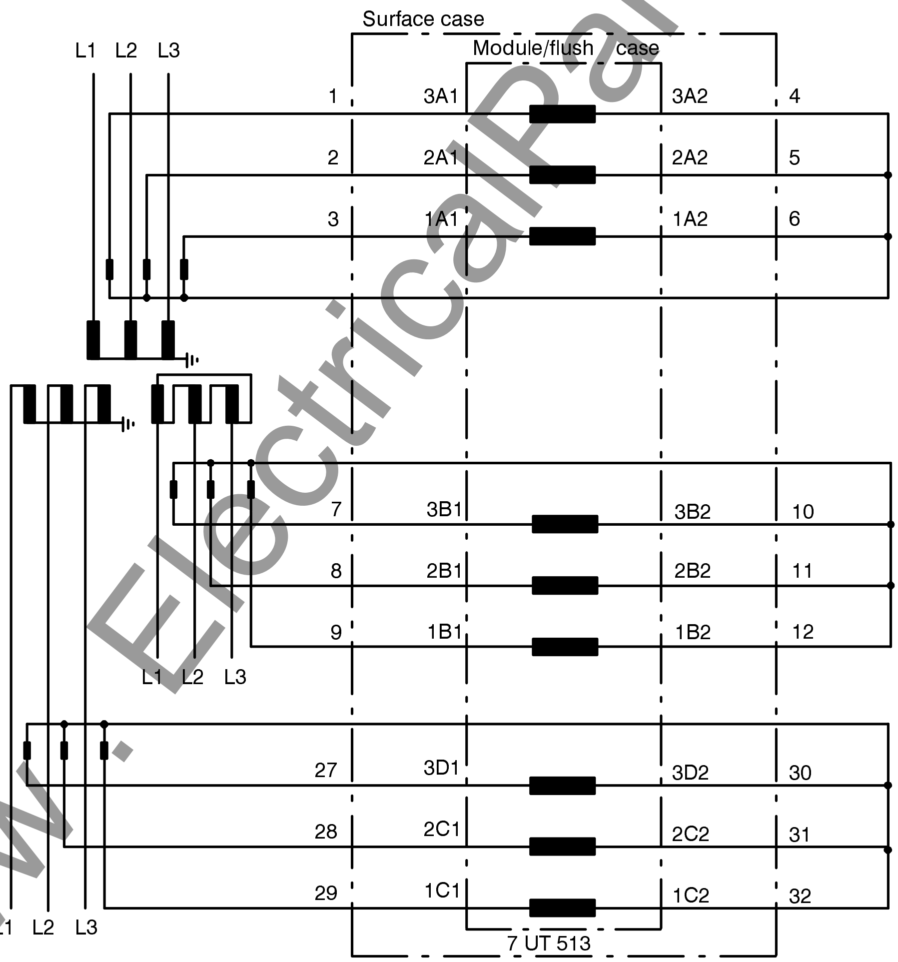


Figure B.2 CT connection example 7UT513 for a three-winding transformer

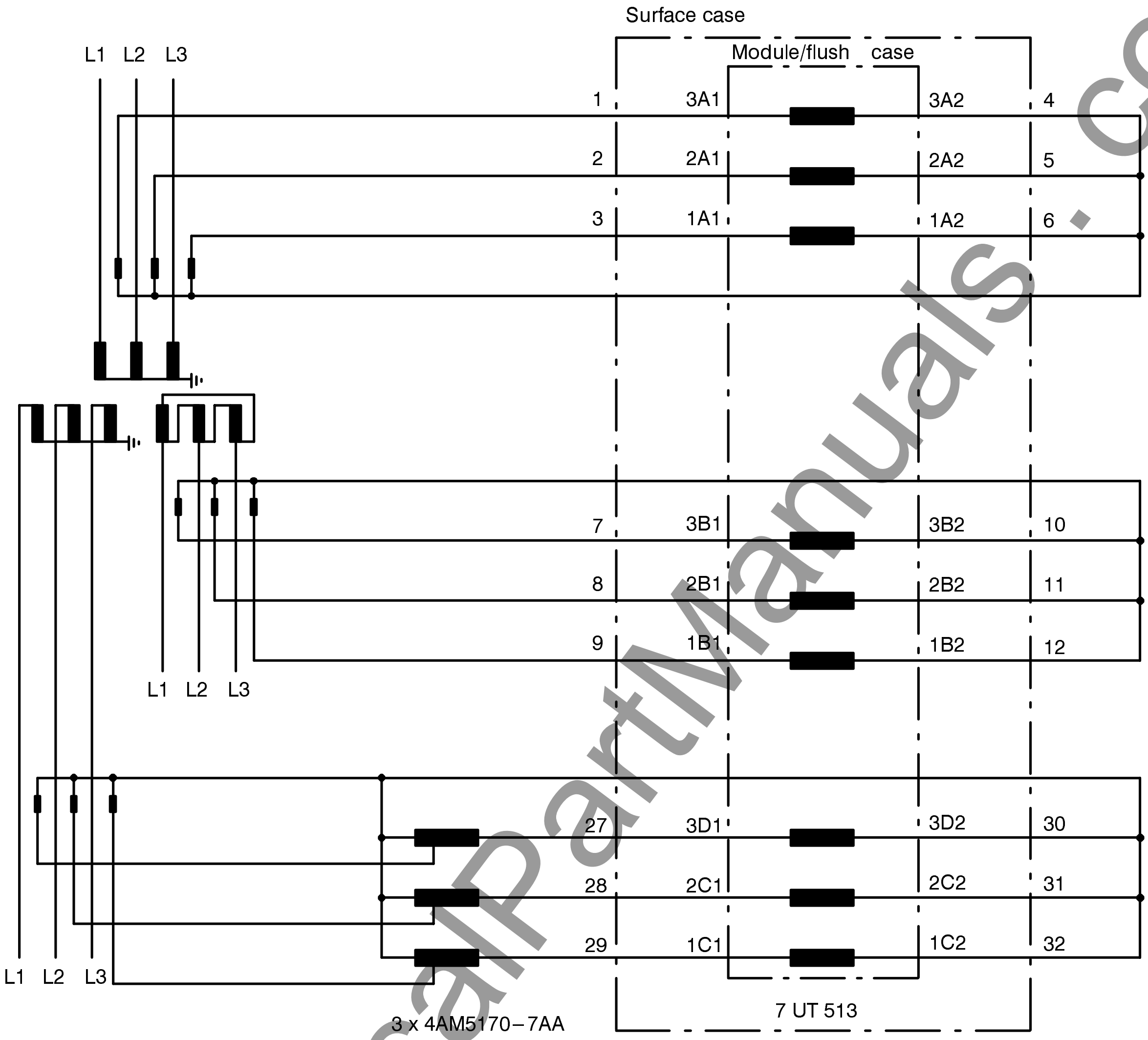


Figure B.3 CT connection example 7UT513 for a three-winding transformer with matching transformers

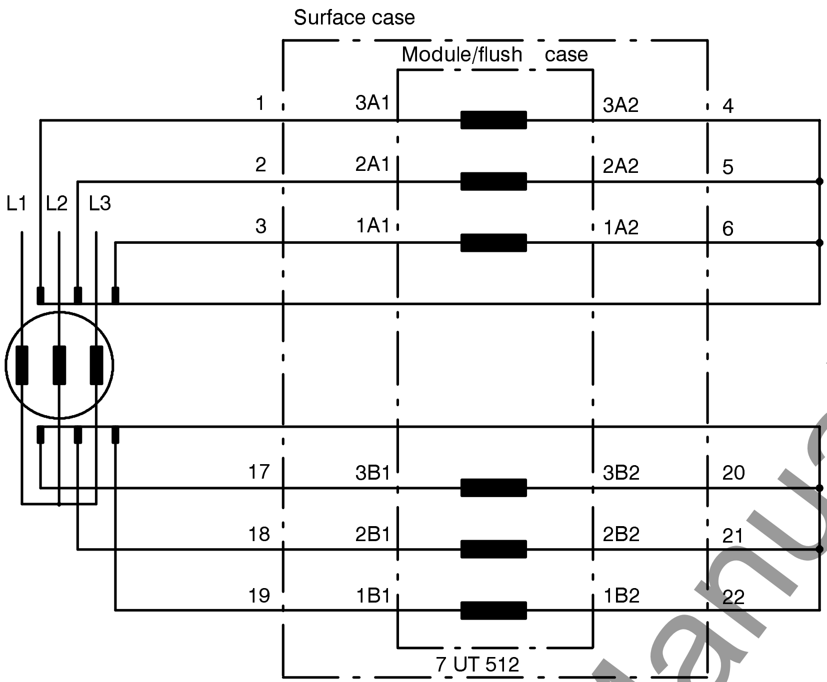


Figure B.4 CT connection example 7UT512 for a generator or motor

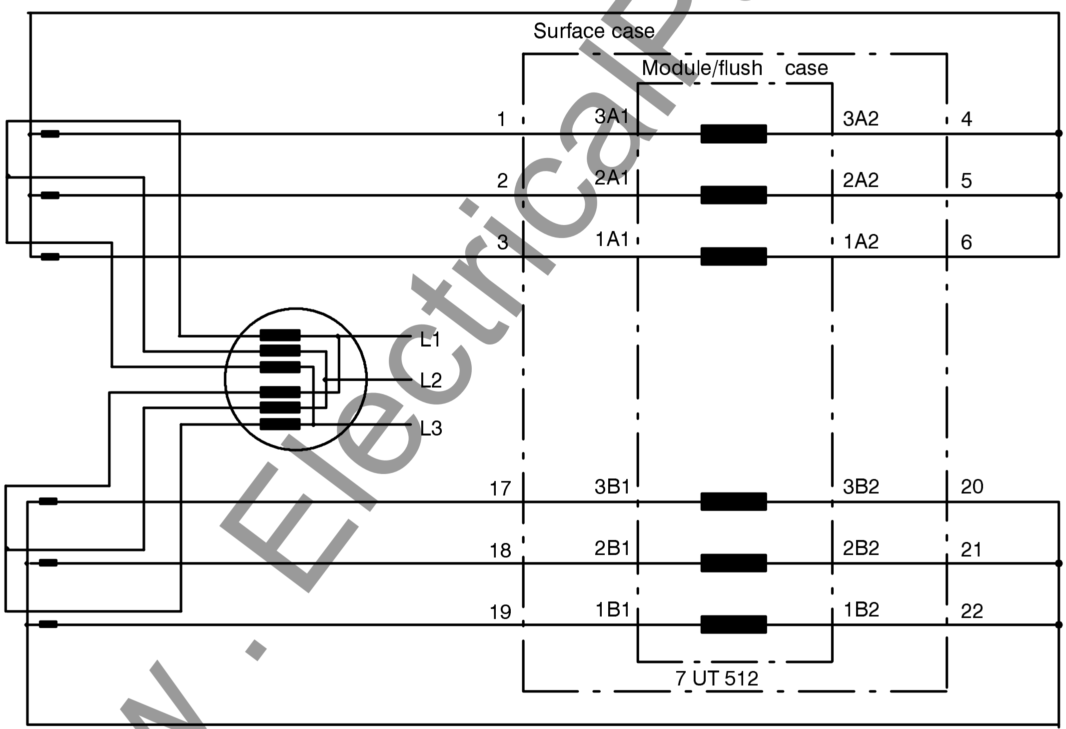


Figure B.5 CT connection example 7UT512 for generator transverse differential protection

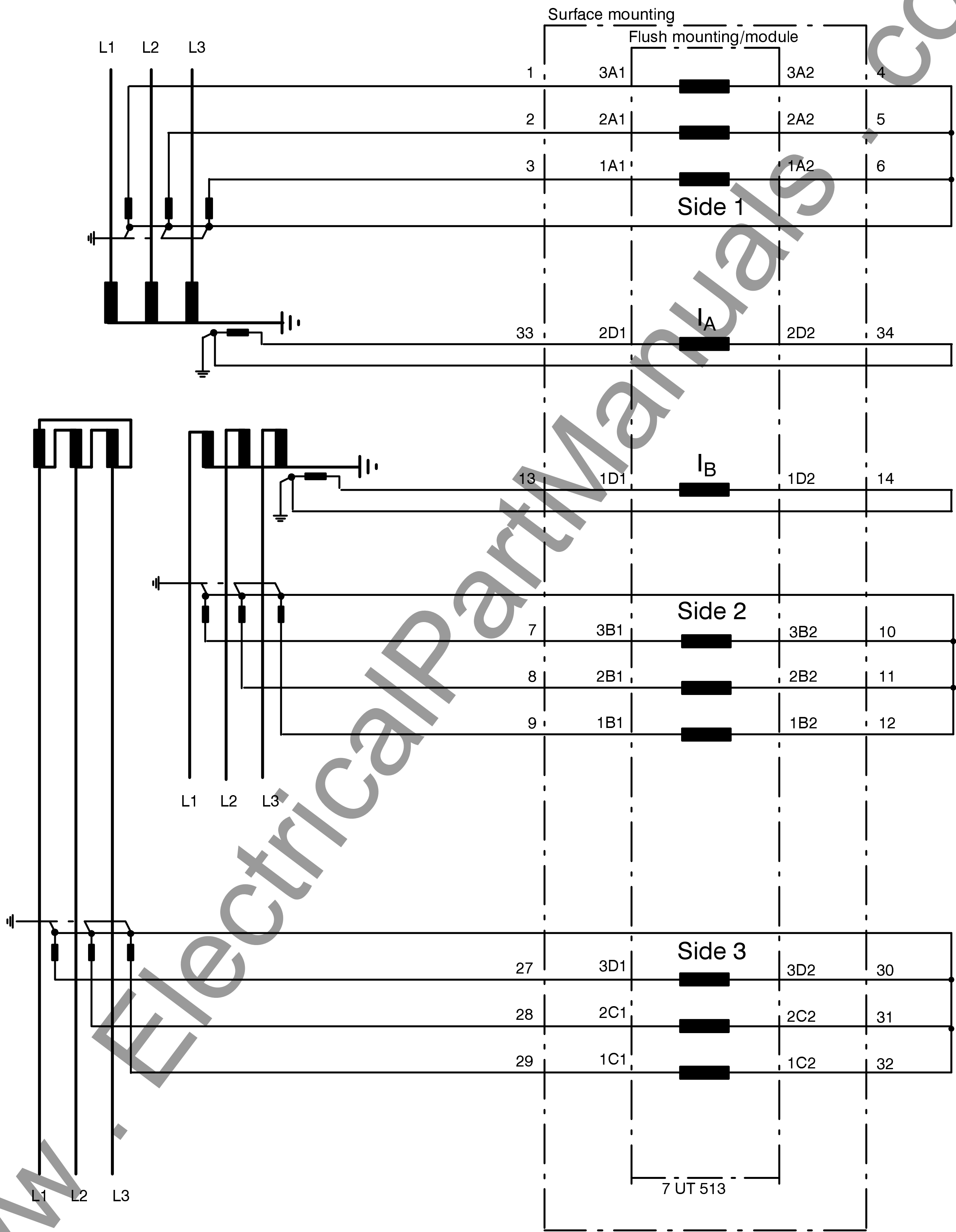


Figure B.6 Connection example 7UT513 for a three-winding transformer with star-point c.t.s

C Tables

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 7UT51X for LSA (DIN 19244 and according IEC 60870-5-103)

FNo. - Function number of annunciation
Op/Ft - Operation/Fault annunciation
C/CG: Coming/Coming and Going annunciation
V : Annunciation with Value
M : Measurand
LSA No.- Number of annunciation for former LSA (DIN 19244)

according to IEC 60870-5-103:
CA - Compatible Annunciation
GI - Annunciation for General Interrogation
BT - Binary Trace for fault recordings
Typ - Function type (p: according to the configured "Function type")
Inf - Information number

FNo.	Meaning	Ann. Op	Ann. Ft	LSA No.	IEC 60870-5-103 CA	GI	BT	Typ	Inf
11	>User defined annunciation 1	CG		50	CA	GI	BT	p	27
12	>User defined annunciation 2	CG		56	CA	GI	BT	p	28
13	>User defined annunciation 3	CG		57	CA	GI	BT	p	29
14	>User defined annunciation 4	CG		58	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		193	CA			p	4
56	Initial start of processor system	C		194	CA			p	5
59	Real time response to LSA	C		192					
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		46	CA	GI		p	23
97	Parameter set B is active	CG		47	CA	GI		p	24
98	Parameter set C is active	CG		48	CA	GI		p	25
99	Parameter set D is active	CG		49	CA	GI		p	26
110	Annunciations lost (buffer overflow)	C		196				135	130
112	Annunciations for LSA lost	C		76				135	131
140	General internal failure of device	CG			CA	GI		p	47
141	Failure of internal 24 VDC power supply	CG		88		GI		135	161
143	Failure of internal 15 VDC power supply	CG		83		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
151	Failure in I/O module 1	CG		91		GI		135	166
152	Failure in I/O module 2	CG		92		GI		135	167
154	Failure in the RKA module	CG		90	CA	GI		p	36
160	Common alarm	CG			CA	GI		p	46
161	Measured value supervision of currents	CG			CA	GI		p	32
163	Failure: Current symmetry supervision	CG		86				135	183
301	Fault in the power system		CG	2				135	231
302	Fault event with consecutive number		C					135	232
391	>Warning stage from Buchholz protection	CG		22		GI		150	41
392	>Trip stage from Buchholz protection	CG		21		GI		150	42
393	>Tank supervision from Buchholz protec.	CG		23		GI		150	43
501	General fault detection of device		C	142			BT	150	151
502	General drop-off of device		C	240				150	152
511	General trip of device		C	230			BT	150	161
561	Circuit breaker manually closed (pulse)	CG		45		GI		150	211
721	Operat. meas. current L1 side 1 [%] is	M						134	145

FNo.	Meaning	Ann.		LSA	IEC 60870-5-103				
		Op	Ft	No.	CA	GI	BT	Typ	Inf
722	Operat. meas. current L2 side 1 [%] is	M						134	145
723	Operat. meas. current L3 side 1 [%] is	M						134	145
724	Operat. meas. current L1 side 2 [%] is	M						134	145
725	Operat. meas. current L2 side 2 [%] is	M						134	145
726	Operat. meas. current L2 side 2 [%] is	M						134	145
727	Operat. meas. current L1 side 3 [%] is	M						134	145
728	Operat. meas. current L2 side 3 [%] is	M						134	145
729	Operat. meas. current L3 side 3 [%] is	M						134	145
730	Operat. meas. current IA [%] is	M						134	145
731	Operat. meas. current IB [%] is	M						134	145
1561	Thermal overload protec. 1 switched off	CG		161				167	61
1562	Thermal overload protection 1 blocked	CG		162				167	62
1563	Thermal overload protection 1 active	CG		163		GI		167	63
1565	Thermal overload prot.1: Current warn.	CG		11		GI		167	65
1566	Thermal overload prot.1: Warning stage	CG		12		GI		167	66
1567	Thermal overload prot.1: Pick-up stage	CG						167	67
1571	Trip by thermal overload protection 1		CG	10			BT	167	71
1576	Thermal overload prot.1 err.: no side 3	C				GI		167	76
1611	Thermal overload protec. 2 switched off	CG		164				167	111
1612	Thermal overload protection 2 blocked	CG		165				167	112
1613	Thermal overload protection 2 active	CG		166		GI		167	113
1615	Thermal overload prot.2: Current warn.	CG		167		GI		167	115
1616	Thermal overload prot.2: Warning stage	CG		168		GI		167	116
1617	Thermal overload prot.2: Pick-up stage	CG						167	117
1621	Trip by thermal overload protection 2		CG	169			BT	167	121
1626	Thermal overload prot.2 err.: no side 3	C				GI		167	126
2306	>Block I>> stage of back-up overcurrent	CG		175				62	6
2307	>Block I>/Ip stage of back-up overcurr.	CG		174				62	7
2401	Back-up overcurr. prot. is switched off	CG		171				62	101
2402	Back-up overcurrent prot. is blocked	CG		172				62	102
2403	Back-up overcurrent prot. is active	CG		173		GI		62	103
2411	Back-up overcurrent: Gen. fault det.		CG	180			BT	62	111
2412	Back-up overcurrent: Fault detection L1		CG	181				62	112
2413	Back-up overcurrent: Fault detection L2		CG	182				62	113
2414	Back-up overcurrent: Fault detection L3		CG	183				62	114
2421	Back-up overcurrent: Fault det. I>>		C	186				62	121
2422	Back-up overcurrent: Fault det. I>/Ip		C	187				62	122
2441	Back-up overcurrent: Time TI>> expired		C	184				62	141
2442	Back-up overcurrent: Time TI>/Tp exp.		C	185				62	142
2451	Back-up overcurrent: General Trip		C	188			BT	62	151
2457	Back-up O/C error: Side 3 no exist	C				GI		62	157
4526	>External trip 1	CG		51					
4531	External trip 1 is switched off	CG		151				51	131
4532	External trip 1 is blocked	CG		152				51	132
4533	External trip 1 is active	CG		153		GI		51	133
4536	External trip 1: General fault det.		CG	241			BT	51	136
4537	External trip 1: General trip		C	243			BT	51	137
4538	External trip 1: Drop-off		C	244					
4546	>External trip 2	CG		53					
4551	External trip 2 is switched off	CG		156				51	151
4552	External trip 2 is blocked	CG		157				51	152
4553	External trip 2 is active	CG		158		GI		51	153
4556	External trip 2: General fault det.		CG	245			BT	51	156
4557	External trip 2: General trip		C	247			BT	51	157
4558	External trip 2: Drop-off		C	248					
5605	>Block trip signal of diff. protection	CG		25					
5615	Differential protection is switched off	CG		101				75	15

		Ann.		LSA	IEC 60870-5-103				
FNo.	Meaning	Op	Ft	No.	CA	GI	BT	Typ	Inf
5616	Differential protection is blocked	CG		102				75	16
5617	Differential protection is active	CG		103		GI		75	17
5621	Diff. prot.: IDIFF> time delay started		C	237				75	21
5622	Diff. prot.: IDIFF>> time delay started		C	238				75	22
5631	Diff. prot.: General fault detected		CG	223			BT	75	31
5632	Differential protection: Drop-off		C	239					
5641	Diff. prot.: Blocked by harmonics L1		CG					75	41
5642	Diff. prot.: Blocked by harmonics L2		CG					75	42
5643	Diff. prot.: Blocked by harmonics L3		CG					75	43
5651	Diff. prot.: Blocked by ext. fault L1		CG					75	51
5652	Diff. prot.: Blocked by ext. fault L2		CG					75	52
5653	Diff. prot.: Blocked by ext. fault.L3		CG					75	53
5662	Diff. prot.: Blocked by CT fault L1	CG		104				75	62
5663	Diff. prot.: Blocked by CT fault L2	CG		105				75	63
5664	Diff. prot.: Blocked by CT fault L3	CG		106				75	64
5671	Differential protection: General trip		C		CA			p	68
5672	Differential protection: Trip L1		C	107	CA			p	86
5673	Differential protection: Trip L2		C	108	CA			p	87
5674	Differential protection: Trip L3		C	109	CA			p	88
5681	Diff. prot.: IDIFF> L1 (without Tdelay)		CG					75	81
5682	Diff. prot.: IDIFF> L2 (without Tdelay)		CG					75	82
5683	Diff. prot.: IDIFF> L3 (without Tdelay)		CG					75	83
5684	Diff. prot: IDIFF>> L1 (without Tdelay)		CG					75	84
5685	Diff. prot: IDIFF>> L2 (without Tdelay)		CG					75	85
5686	Diff. prot: IDIFF>> L3 (without Tdelay)		CG					75	86
5691	Differential prot.: Trip by IDIFF>		C	18			BT	75	91
5692	Differential prot.: Trip by IDIFF>>		C	8			BT	75	92
5701	Diff. curr. of L1 at trip (fundamental)		V	111				75	101
5702	Diff. curr. of L2 at trip (fundamental)		V	112				75	102
5703	Diff. curr. of L3 at trip (fundamental)		V	113				75	103
5704	Restr. curr. of L1 at trip (average DC)		V	114				75	104
5705	Restr. curr. of L2 at trip (average DC)		V	115				75	105
5706	Restr. curr. of L3 at trip (average DC)		V	116				75	106
5711	Diff. prot. error: 2 star-pointCT for 1	C				GI		75	111
5712	Diff. prot. error: No star-point CT	CG				GI		75	112
5811	Restricted earth fault is switched off	CG		121				76	11
5812	Restricted earth fault is blocked	CG		122				76	12
5813	Restricted earth fault is active	CG		123		GI		76	13
5816	Restr. earth flt.: Time delay started		C	124				76	16
5817	Restr. earth flt.: Gen. fault detected		CG	125			BT	76	17
5821	Restr. earth flt.: General trip		C	127	CA		BT	p	89
5826	Restr. earth flt.: Value D at trip		V	128				76	26
5827	Restr. earth flt.: Value S at trip		V	129				76	27
5828	Restr. earth flt. err.: Use not side 3	C				GI		76	28
5829	Restr. earth flt. err.: 2 starpoint CT	C				GI		76	29
5830	Restr. earth flt. err.: No starpoint CT	C				GI		76	30
5831	Restr. earth flt. err.: Only virt. obj.	C				GI		76	31
5834	Restricted earth fault error: Non-exist	C				GI		76	34
5911	Transformer tank protec. switched off	CG		131				76	111
5912	Transformer tank protection is blocked	CG		132				76	112
5913	Transformer tank protection is active	CG		133		GI		76	113
5916	Transf. tank prot.: Time delay started		C	134				76	116
5917	Transf. tank prot.: Gen. fault detected		CG	135			BT	76	117
5921	Transformer tank prot.: General trip		C	137			BT	76	121
5926	Transformer tank prot.: Value at trip		V	138				76	126
5928	Transformer tank prot. error: Non exist	C				GI		76	128

Annunciations 7UT51X 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
Ear - Earth fault annunciation
IO - I: can be marshalled to binary input
O: can be marshalled to binary output (LED, trip/signal relais)

FNo.	Abbreviation	Meaning	Op	Ft	Ear	IO
3	>Time Synchro	>Time synchronization	C			IO
4	>Start FltRec	>Start fault recording				IO
5	>LED reset	>LED reset				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			IO
12	>Annunc. 2	>User defined annunciation 2	CG			IO
13	>Annunc. 3	>User defined annunciation 3	CG			IO
14	>Annunc. 4	>User defined annunciation 4	CG			IO
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			
124	LED Buff.Inva	LED annunciation buffer invalid	CG			
129	VDEW-StateInv	VDEW state invalid	CG			
135	Chs Error	Error in check sum	CG			
136	Chs.A Error	Error in check sum for parameter set A	CG			
137	Chs.B Error	Error in check sum for parameter set B	CG			
138	Chs.C Error	Error in check sum for parameter set C	CG			
139	Chs.D Error	Error in check sum for parameter set D	CG			
141	Failure 24V	Failure of internal 24 VDC power supply	CG			O
143	Failure 15V	Failure of internal 15 VDC power supply	CG			O
144	Failure 5V	Failure of internal 5 VDC power supply	CG			O
145	Failure 0V	Failure of internal 0 VDC power supply	CG			O
151	Failure I/O 1	Failure in I/O module 1	CG			O
152	Failure I/O 2	Failure in I/O module 2	CG			O
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
163	Failure Isymm	Failure: Current symmetry supervision	CG			O
203	Flt.RecDatDel	Fault recording data deleted	C			
204	Flt.Rec.viaBI	Fault recording initiated via bin.input	C			
205	Flt.Rec.viaKB	Fault recording initiated via keyboard	C			
206	Flt.Rec.viaPC	Fault recording initiated via PC interf	C			
301	System Flt	Fault in the power system	CG	C		

FNo.	Abbreviation	Meaning	Op	Ft	Ear	IO
302	Fault	Fault event with consecutive number		C		
356	>Manual Close	>Manual close				IO
391	>Buchh. Warn	>Warning stage from Buchholz protection	CG			IO
392	>Buchh. Trip	>Trip stage from Buchholz protection	CG			IO
393	>Buchh. Tank	>Tank supervision from Buchholz protec.	CG			IO
501	Device FltDet	General fault detection of device				O
502	Dev. Drop-off	General drop-off of device		C		
511	Device Trip	General trip of device				O
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)	CG			O
571	Fail. Isym 1	Fail.: Current symm. supervision side 1	CG			O
572	Fail. Isym 2	Fail.: Current symm. supervision side 2	CG			O
573	Fail. Isym 3	Fail.: Current symm. supervision side 3	CG			O
721	I1 L1[%]=	Operat. meas. current L1 side 1 [%] is	M			
722	I1 L2[%]=	Operat. meas. current L2 side 1 [%] is	M			
723	I1 L3[%]=	Operat. meas. current L3 side 1 [%] is	M			
724	I2 L1[%]=	Operat. meas. current L1 side 2 [%] is	M			
725	I2 L2[%]=	Operat. meas. current L2 side 2 [%] is	M			
726	I2 L3[%]=	Operat. meas. current L2 side 2 [%] is	M			
727	I3 L1[%]=	Operat. meas. current L1 side 3 [%] is	M			
728	I3 L2[%]=	Operat. meas. current L2 side 3 [%] is	M			
729	I3 L3[%]=	Operat. meas. current L3 side 3 [%] is	M			
730	IA[%]=	Operat. meas. current IA [%] is	M			
731	IB[%]=	Operat. meas. current IB [%] is	M			
741	I1 L1 =	Operat. meas. current L1 side 1 [A] is	M			
742	I1 L2 =	Operat. meas. current L2 side 1 [A] is	M			
743	I1 L3 =	Operat. meas. current L3 side 1 [A] is	M			
744	I2 L1 =	Operat. meas. current L1 side 2 [A] is	M			
745	I2 L2 =	Operat. meas. current L2 side 2 [A] is	M			
746	I2 L3 =	Operat. meas. current L3 side 2 [A] is	M			
747	I3 L1 =	Operat. meas. current L1 side 3 [A] is	M			
748	I3 L2 =	Operat. meas. current L2 side 3 [A] is	M			
749	I3 L3 =	Operat. meas. current L3 side 3 [A] is	M			
750	IA =	Operat. meas. current IA [A] is	M			
751	IB =	Operat. meas. current IB [A] is	M			
811	Θ1/Θtrp=	Temperature rise 1 for warning and trip	M			
812	Θ1/ΘtrpL1=	Temperature rise 1 for phase L1	M			
813	Θ1/ΘtrpL2=	Temperature rise 1 for phase L2	M			
814	Θ1/ΘtrpL3=	Temperature rise 1 for phase L3	M			
821	Θ2/Θtrp=	Temperature rise 2 for warning and trip	M			
822	Θ2/ΘtrpL1=	Temperature rise 2 for phase L1	M			
823	Θ2/ΘtrpL2=	Temperature rise 2 for phase L2	M			
824	Θ2/ΘtrpL3=	Temperature rise 2 for phase L3	M			
1553	>O/L 1 block	>Block thermal overload protection 1				IO
1554	>O/L 1 annunc	>Only annunciat. from thermal overload				IO
1555	>O/L1 bloTrip	>Block trip signal of thermal overload				IO
1561	O/L 1 off	Thermal overload protec. 1 switched off	CG			O
1562	O/L 1 blocked	Thermal overload protection 1 blocked	CG			O
1563	O/L 1 active	Thermal overload protection 1 active	CG			O
1565	O/L 1 Warn I	Thermal overload prot.1: Current warn.	CG			O
1566	O/L 1 Warn Θ	Thermal overload prot.1: Warning stage	CG			O
1567	O/L 1 F.D. Θ	Thermal overload prot.1: Pick-up stage	CG			O
1571	O/L 1 Trip	Trip by thermal overload protection 1		CG		O
1576	O/L 1 Err S3	Thermal overload prot.1 err.: no side 3	C			O
1603	>O/L 2 block	>Block thermal overload protection 2				IO
1604	>O/L 2 annunc	>Only annunciat. from thermal overload				IO
1605	>O/L2 bloTrip	>Block trip signal of thermal overload				IO

FNo.	Abbreviation	Meaning	Op	Ft	Ear	IO
1611	O/L 2 off	Thermal overload protec. 2 switched off	CG			O
1612	O/L 2 blocked	Thermal overload protection 2 blocked	CG			O
1613	O/L 2 active	Thermal overload protection 2 active	CG			O
1615	O/L 2 Warn I	Thermal overload prot.2: Current warn.	CG			O
1616	O/L 2 Warn Θ	Thermal overload prot.2: Warning stage	CG			O
1617	O/L 2 F.D. Θ	Thermal overload prot.2: Pick-up stage	CG			O
1621	O/L 2 Trip	Trip by thermal overload protection 2		CG		O
1626	O/L 2 Err S3	Thermal overload prot.2 err.: no side 3	C			O
2303	>Backup block	>Block back-up overcurrent time prot.				IO
2304	>Back bloTrip	>Block trip signal of back-up overcurr.				IO
2306	>I>> block	>Block I>> stage of back-up overcurrent	CG			IO
2307	>I>/Ip block	>Block I>/Ip stage of back-up overcurr.	CG			IO
2401	Backup off	Back-up overcurr. prot. is switched off	CG			O
2402	Backup block	Back-up overcurrent prot. is blocked	CG			O
2403	Backup active	Back-up overcurrent prot. is active	CG			O
2411	Back Gen. Flt	Back-up overcurrent: Gen. fault det.				O
2412	Backup Flt L1	Back-up overcurrent: Fault detection L1		CG		O
2413	Backup Flt L2	Back-up overcurrent: Fault detection L2		CG		O
2414	Backup Flt L3	Back-up overcurrent: Fault detection L3		CG		O
2421	Backup I>>	Back-up overcurrent: Fault det. I>>		C		O
2422	Backup I>/Ip	Back-up overcurrent: Fault det. I>/Ip		C		O
2441	Backup TI>>	Back-up overcurrent: Time TI>> expired		C		O
2442	Backup TI>/Tp	Back-up overcurrent: Time TI>/Tp exp.		C		O
2451	Back Gen.Trip	Back-up overcurrent: General Trip		C		O
2457	Backup Err S3	Back-up O/C error: Side 3 no exist	C			O
4523	>Ext 1 block	>Block external trip 1				IO
4525	>Ext1 bloTrip	>Block trip signal of external trip 1				IO
4526	>Ext trip 1	>External trip 1				IO
4531	Ext 1 off	External trip 1 is switched off	CG			O
4532	Ext 1 blocked	External trip 1 is blocked	CG			O
4533	Ext 1 active	External trip 1 is active	CG			O
4536	Ext 1 Gen.Flt	External trip 1: General fault det.		CG		O
4537	Ext 1 Gen.Trp	External trip 1: General trip		C		O
4543	>Ext 2 block	>Block external trip 2				IO
4545	>Ext2 bloTrip	>Block trip signal of external trip 2				IO
4546	>Ext trip 2	>External trip 2				IO
4551	Ext 2 off	External trip 2 is switched off	CG			O
4552	Ext 2 blocked	External trip 2 is blocked	CG			O
4553	Ext 2 active	External trip 2 is active	CG			O
4556	Ext 2 Gen.Flt	External trip 2: General fault det.		CG		O
4557	Ext 2 Gen.Trp	External trip 2: General trip		C		O
5603	>Diff block	>Block differential protection				IO
5605	>Diff bloTrip	>Block trip signal of diff. protection				IO
5615	Diff off	Differential protection is switched off	CG			O
5616	Diff blocked	Differential protection is blocked	CG			O
5617	Diff active	Differential protection is active	CG			O
5621	Diff> T start	Diff. prot.: IDIFF> time delay started		C		O
5622	Diff>> T strt	Diff. prot.: IDIFF>> time delay started		C		O
5631	Diff Gen. Flt	Diff. prot.: General fault detected		CG		O
5641	Block Harm L1	Diff. prot.: Blocked by harmonics L1		CG		O
5642	Block Harm L2	Diff. prot.: Blocked by harmonics L2		CG		O
5643	Block Harm L3	Diff. prot.: Blocked by harmonics L3		CG		O
5651	Block Sat L1	Diff. prot.: Blocked by ext. fault L1		CG		O
5652	Block Sat L2	Diff. prot.: Blocked by ext. fault L2		CG		O
5653	Block Sat L3	Diff. prot.: Blocked by ext. fault.L3		CG		O
5662	Block Iflt.L1	Diff. prot.: Blocked by CT fault L1	CG			O
5663	Block Iflt.L2	Diff. prot.: Blocked by CT fault L2	CG			O
5664	Block Iflt.L3	Diff. prot.: Blocked by CT fault L3	CG			O

FNo.	Abbreviation	Meaning	Op	Ft	Ear	IO
5671	Diff Gen.Trip	Differential protection: General trip				O
5672	Diff Trip L1	Differential protection: Trip L1				O
5673	Diff Trip L2	Differential protection: Trip L2				O
5674	Diff Trip L3	Differential protection: Trip L3				O
5681	Diff> L1	Diff. prot.: IDIFF> L1 (without Tdelay)		C		O
5682	Diff> L2	Diff. prot.: IDIFF> L2 (without Tdelay)		C		O
5683	Diff> L3	Diff. prot.: IDIFF> L3 (without Tdelay)		C		O
5684	Diff>> L1	Diff. prot: IDIFF>> L1 (without Tdelay)		C		O
5685	Diff>> L2	Diff. prot: IDIFF>> L2 (without Tdelay)		C		O
5686	Diff>> L3	Diff. prot: IDIFF>> L3 (without Tdelay)		C		O
5691	Diff> Trip	Differential prot.: Trip by IDIFF>		C		O
5692	Diff>> Trip	Differential prot.: Trip by IDIFF>>		C		O
5701	Dif L1 =	Diff. curr. of L1 at trip (fundamental)		C		
5702	Dif L2 =	Diff. curr. of L2 at trip (fundamental)		C		
5703	Dif L3 =	Diff. curr. of L3 at trip (fundamental)		C		
5704	Res L1 =	Restr. curr. of L1 at trip (average DC)		C		
5705	Res L2 =	Restr. curr. of L2 at trip (average DC)		C		
5706	Res L3 =	Restr. curr. of L3 at trip (average DC)		C		
5711	Err 2 CT star	Diff. prot. error: 2 star-pointCT for 1	C			O
5712	Err no CTstar	Diff. prot. error: No star-point CT	CG			O
5713	k CT 1=	Adaption factor CT winding 1	C			
5714	k CT 2=	Adaption factor CT winding 2	C			
5715	k CT 3=	Adaption factor CT winding 3	C			
5716	ksCT 1=	Adaption factor CT star point winding 1	C			
5717	ksCT 2=	Adaption factor CT star point winding 2	C			
5718	ksCT 3=	Adaption factor CT star point winding 3	C			
5803	>REF block	>Block restricted earth fault prot.				IO
5805	>REF blo Trip	>Block trip signal of restr. earth flt.				IO
5811	REF off	Restricted earth fault is switched off	CG			O
5812	REF blocked	Restricted earth fault is blocked	CG			O
5813	REF active	Restricted earth fault is active	CG			O
5816	REF T start	Restr. earth flt.: Time delay started		C		O
5817	REF Gen. Flt	Restr. earth flt.: Gen. fault detected		CG		O
5821	REF Gen. Trip	Restr. earth flt.: General trip		C		O
5826	REF D=	Restr. earth flt.: Value D at trip		C		
5827	REF S=	Restr. earth flt.: Value S at trip		C		
5828	REF Err S3	Restr. earth flt. err.: Use not side 3	C			O
5829	REF Err2CTsta	Restr. earth flt. err.: 2 starpoint CT	C			O
5830	REF Err0CTsta	Restr. earth flt. err.: No starpoint CT	C			O
5831	REF ErrVir ob	Restr. earth flt. err.: Only virt. obj.	C			O
5832	REF k CT=	REF: Adaption factor CT winding	C			
5833	REF ksCT=	REF: Adaption factor CT starpoint wind.	C			
5834	REF no exist	Restricted earth fault error: Non-exist	CG			O
5903	>Tank block	>Block transformer tank protection				IO
5905	>Tank bloTrip	>Block trip signal of transformer tank				IO
5911	Tank off	Transformer tank protec. switched off	CG			O
5912	Tank blocked	Transformer tank protection is blocked	CG			O
5913	Tank active	Transformer tank protection is active	CG			O
5916	Tank T start	Transf. tank prot.: Time delay started		C		O
5917	Tank Gen. Flt	Transf. tank prot.: Gen. fault detected		CG		O
5921	Tank Gen.Trip	Transformer tank prot.: General trip		C		O
5926	Tank=	Transformer tank prot.: Value at trip		C		
5928	Tank no exist	Transformer tank prot. error: Non exist	C			O

Reference Table for Functional Parameters 7UT51X

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1000 PARAMETERS
________________________________________________________________________

1100 TRANSFORMER DATA

1102 UN WIND 1              Rated voltage of winding 1 of the transformer
     min. 0.4               kV
     max. 800.0       ____

1103 PN WIND 1              Rated apparent power of winding 1
     min. 0.2               MVA
     max. 5000.0      ____

1104 IN CT WIN1             Primary rated current of CT winding 1
     min. 1                 A
     max. 100000      ____

1105 CT1 STARPT             Starpoint formation of CT winding 1
     TOWARDS TRANSF.    [ ] Towards transformer
     TWDS.LINE/BUSBAR   [ ] Towards line/busbar

1106 Io HANDLE              Processing of zero sequence current of wind. 1
     Io-ELIMINATION     [ ] Io-elimination
     Io-CORRECTION      [ ] Io-correction
     WITHOUT            [ ] Without

1107 IN CT STP1             Prim. rated current of starpoint CT winding 1
     min. 1                 A
     max. 100000      ____

1108 CT1 EAR-PT             Earth point formation of starpoint CT wind. 1
     TOWARDS TRANSF.    [ ] Towards transformer
     TOWARDS EARTH      [ ] Towards earth

1121 VECTOR GR2             Vector group numeral of winding 2
     min. 0
     max. 11          ____

1122 UN WIND 2              Rated voltage of winding 2 of the transformer
     min. 0.4               kV
     max. 800.0       ____

1123 PN WIND 2              Rated apparent power of winding 2
     min. 0.2               MVA
     max. 5000.0      ____

1124 IN CT WIN2             Primary rated current of CT winding 2
     min. 1                 A
     max. 100000      ____

1125 CT2 STARPT             Starpoint formation of CT winding 2
     TOWARDS TRANSF.    [ ] Towards transformer
     TWDS.LINE/BUSBAR   [ ] Towards line/busbar

1126 Io HANDLE              Processing of zero sequence current of wind. 2
     Io-ELIMINATION     [ ] Io-elimination
     Io-CORRECTION      [ ] Io-correction
     WITHOUT            [ ] Without
```

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1127 IN CT STP2          Prim. rated current of starpoint CT winding 2
     min. 1              A
     max. 100000    ____

1128 CT2 EAR-PT          Earth point formation of starpoint CT wind. 2
     TOWARDS TRANSF.  [ ] Towards transformer
     TOWARDS EARTH    [ ] Towards earth

1141 VECTOR GR3          Vector group numeral of winding 3
     min. 0
     max. 11        ____

1142 UN WIND 3           Rated voltage of winding 3 of the transformer
     min. 0.4            kV
     max. 800.0     ____

1143 PN WIND 3           Rated apparent power of winding 3
     min. 0.2            MVA
     max. 5000.0    ____

1144 IN CT WIN3          Primary rated current of CT winding 3
     min. 1              A
     max. 100000    ____

1145 CT3 STARPT          Starpoint formation of CT winding 3
     TOWARDS TRANSF.  [ ] Towards transformer
     TWDS.LINE/BUSBAR [ ] Towards line/busbar

1146 Io HANDLE           Processing of zero sequence current of wind. 3
     Io-ELIMINATION   [ ] Io-elimination
     Io-CORRECTION    [ ] Io-correction
     WITHOUT          [ ] Without

1147 IN CT STP3          Prim. rated current of starpoint CT winding 3
     min. 1              A
     max. 100000    ____

1148 CT3 EAR-PT          Earth point formation of starpoint CT wind. 3
     TOWARDS TRANSF.  [ ] Towards transformer
     TOWARDS EARTH    [ ] Towards earth
```

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1200 GENERATOR OR MOTOR DATA

1202 UN GEN/MOT          Rated voltage of the generator or motor
     min. 0.4            kV
     max. 800.0     ____

1203 PN GEN/MOT          Rated apparent power of generator/motor
     min. 0.2            MVA
     max. 5000.0    ____

1206 CT STARPT           Indication of polarity of the CT currents
     SAME SIDE        [ ] Same side
     OPPOSITE SIDES   [ ] Opposite sides

1207 IN CT 1             Primary rated current of CT side 1
     min. 1              A
     max. 100000    ____
```

```
1208 IN CT 2                 Primary rated current of CT side 2
     min. 1                  A
     max. 100000     ____
```

```
1300 BRANCH POINT DATA

1301 IN BRAN-PT              Nominal current of the branch point
     min. 1                  A
     max. 100000     ____

1302 IN CT 1                 Primary rated current of CT side 1
     min. 1                  A
     max. 100000     ____

1303 CT1 STARPT              Starpoint formation of CT side 1
     TOWARDS BUSBAR     [ ]  Towards busbar
     TOWARDS LINE       [ ]  Towards line

1304 IN CT 2                 Primary rated current of CT side 2
     min. 1                  A
     max. 100000     ____

1305 CT2 STARPT              Starpoint formation of CT side 2
     TOWARDS BUSBAR     [ ]  Towards busbar
     TOWARDS LINE       [ ]  Towards line

1306 IN CT 3                 Primary rated current of CT side 3
     min. 1                  A
     max. 100000     ____

1307 CT3 STARPT              Starpoint formation of CT side 3
     TOWARDS BUSBAR     [ ]  Towards busbar
     TOWARDS LINE       [ ]  Towards line
```

```
1400 VIRT. OBJECT

1401 IN VIRT OB              Nominal current of the virtual object
     min. 1                  A
     max. 100000     ____

1402 IN CT                   Primary rated current of CT
     min. 1                  A
     max. 100000     ____

1404 IN CT STPT              Primary rated current of starpoint CT
     min. 1                  A
     max. 100000     ____

1405 CT STARPT               Earth point of the CT currents
     SAME SIDE          [ ]  Same side
     OPPOSITE SIDES     [ ]  Opposite sides
```

```
1600 TRANSFORM. DIFF-PROT. DATA

1601 DIFF PROT.              State of differential protection
     OFF                 [ ] off
     ON                  [ ] on
     BLOCK TRIP REL      [ ] Block trip relay

1603 I-DIFF>                 Pick-up value of differential current
     min. 0.15               I/InTr
     max. 2.00          ____

1604 I-DIFF>>                Pick-up value of high set trip
     min. 0.5                I/InTr
     max. 20.0          ____

1606 SLOPE 1                 Slope 1 of tripping characteristic
     min. 0.10
     max. 0.50          ____

1607 BASE PT 2               Base point 2 for slope 2 of tripping charact.
     min. 0.0                I/InTr
     max. 10.0          ____

1608 SLOPE 2                 Slope 2 of tripping characteristic
     min. 0.25
     max. 0.95          ____

1610 2nd HARMON              State of 2nd harmonic restraint
     ON                  [ ] on
     OFF                 [ ] off

1611 2nd HARMON              2nd harmonic content in the different. current
     min. 10                 %
     max. 80            ____

1612 CROSSB 2HM              Time for cross-blocking with 2nd harmonic
     min. 0                  *1P
     max. 1000/∞        ____

1613 n. HARMON               Choice of a further (n-th) harmonic restraint
     5th HARMONIC        [ ] 5th harmonic
     4th HARMONIC        [ ] 4th harmonic
     3rd HARMONIC        [ ] 3rd harmonic
     OFF                 [ ] off

1614 n. HARMON               n-th harmonic content in the differen. current
     min. 10                 %
     max. 80            ____

1615 CROSSB nHM              Active time for cross-blocking with n-th harm.
     min. 0                  *1P
     max. 1000/∞        ____

1616 IDIFFmax n              Limit IDIFFmax of n-th harmonic restraint
     min. 0.5                I/InTr
     max. 20.0          ____

1617 T-SAT-BLO.              Max. blocking time at CT saturation
     min. 2                  *1P
     max. 250/∞         ____
```

```
1618 SAT-RESTR.             Min. restr. current for blocking at CT satur.
     min. 5.00              I/InTr
     max. 15.00      _____

1625 T-DELAY >              Trip time delay of diff. current stage IDIFF>
     min. 0.00              s
     max. 60.00/∞    _____

1626 T-DELAY >>             Trip time delay of diff. current stage IDIFF>>
     min. 0.00              s
     max. 60.00/∞    _____

1627 T-RESET                Reset delay after trip has been initiated
     min. 0.00              s
     max. 60.00      _____
```

```
1700 GEN/MOTOR DIFF-PROTECTION

1701 DIFF PROT.             State of differential protection
     OFF                [ ] off
     ON                 [ ] on
     BLOCK TRIP REL     [ ] Block trip relay

1703 I-DIFF>                Pick-up value of differential current
     min. 0.05              I/InGe
     max. 2.00       _____

1706 SLOPE 1                Slope 1 of tripping characteristic
     min. 0.10
     max. 0.50       _____

1707 BASE PT 2              Base point 2 for slope 2 of tripping charact.
     min. 0.0               I/InGe
     max. 10.0       _____

1708 SLOPE 2                Slope 2 of tripping characteristic
     min. 0.25
     max. 0.95       _____

1717 T-SAT-BLO.             Max. blocking time at CT saturation
     min. 2                 *1P
     max. 250/∞      _____

1718 SAT-RESTR.             Min. restr. current for blocking at CT satur.
     min. 5.00              I/InGe
     max. 15.00      _____

1725 T-DELAY                Trip time delay of differential protection
     min. 0.00              s
     max. 60.00/∞    _____

1727 T-RESET                Reset delay after trip has been initiated
     min. 0.00              s
     max. 60.00      _____
```

```
1800 BRANCH PT. DIFF-PROTECTION

1801 DIFF PROT.               State of differential protection
     OFF                 [ ] off
     ON                  [ ] on
     BLOCK TRIP REL      [ ] Block trip relay

1803 I-DIFF>                  Pick-up value of differential current
     min. 0.30                I/InPt
     max. 2.50          ____

1806 SLOPE 1                  Slope 1 of tripping characteristic
     min. 0.10
     max. 0.50          ____

1807 BASE PT 2                Base point 2 for slope 2 of tripping charact.
     min. 0.0                 I/InPt
     max. 10.0          ____

1808 SLOPE 2                  Slope 2 of tripping characteristic
     min. 0.25
     max. 0.95          ____

1817 T-SAT-BLO.               Max. blocking time at CT saturation
     min. 2                   *1P
     max. 250/∞         ____

1818 SAT-RESTR.               Min. restr. current for blocking at CT satur.
     min. 5.00                I/InPt
     max. 15.00         ____

1825 T-DELAY                  Trip time delay of differential protection
     min. 0.00                s
     max. 60.00/∞       ____

1827 T-RESET                  Reset delay after trip has been initiated
     min. 0.00                s
     max. 60.00         ____

1831 I DIFF>MON               Pick-up value of diff. current monitoring
     min. 0.15                I/InPt
     max. 0.80          ____

1832 T-MONITOR                Time delay of blocking by monitoring
     min. 1                   s
     max. 10/∞          ____
```

```
1900 REST.EARTH FAULT PROTECTION

1901 RESTR. E/F               State of restricted earth fault protection
     OFF                 [ ] off
     ON                  [ ] on
     BLOCK TRIP REL      [ ] Block trip relay

1903 I-REF>                   Pick-up value I REF> of restricted earth fault
     min. 0.05                I/In
     max. 2.00          ____
```

```
1904 CRIT.ANGLE                Critical angle of charact. trip-curve by REF
     110 °               [ ] 110 °
     90  °               [ ] 90 °
     100 °               [ ] 100 °
     120 °               [ ] 120 °
     130 °               [ ] 130 °

1910 2nd HARMON                State of 2nd harmonic restraint
     OFF                 [ ] off
     ON                  [ ] on

1911 2nd HARMON                2nd harmonic contend in the REF-current
     min. 10                   %
     max. 80            ____

1912 I REFmax 2                Limit IREFmax of 2nd harmonic restraint
     min. 1.0                  I/In
     max. 20.0          ____

1925 T-DELAY                   Trip time delay of restricted earth fault
     min. 0.00                 s
     max. 60.00/∞       ____

1927 T-RESET                   Reset delay after trip has been initiated
     min. 0.00                 s
     max. 60.00         ____
```

```
2100 BACK-UP OVERCURRENT TIME

2101 BACKUP O/C                State of back-up overcurrent protection
     OFF                 [ ] off
     ON                  [ ] on
     BLOCK TRIP REL      [ ] Block trip relay

2103 I>>                       Pick-up value for high current stage I>>
     min. 0.10                 I/In
     max. 30.00         ____

2104 T-I>>                     Delay time for I>> (definite time)
     min. 0.00                 s
     max. 32.00/∞       ____

2111 CHARACT                   Overcurrent time stage characteristic
     DEFINITE TIME       [ ] Definite time
     NORMAL INVERSE      [ ] Normal inverse
     VERY INVERSE        [ ] Very inverse
     EXTREMELY INVERS    [ ] Extremely inverse

2112 I>                        Pick-up value of overcurrent time stage I>
     min. 0.10                 I/In
     max. 30.00         ____

2113 T-I>                      Delay time for I> (definite time)
     min. 0.00                 s
     max. 32.00/∞       ____

2114 Ip                        Pick-up value of overcurrent time stage Ip
     min. 0.10                 I/In
     max. 20.00         ____
```

```
2115 T-Ip                   Time multiplier for Ip (inverse time)
     min. 0.50              s
     max. 32.00/∞      ____

2116 RMS FORMAT             Method of RMS calculation for IDMT
     WITHOUT HARMON.   [ ] Without harmonics
     WITH HARMONICS    [ ] With harmonics

2118 T-RESET                Reset delay after trip has been initiated
     min. 0.00              s
     max. 60.00        ____

2121 MAN.CLOSE              Effective stage after manual closing of CB
     INEFFECTIVE       [ ] Ineffective
     I>> UNDELAYED     [ ] I>> undelayed
     I>/Ip UNDELAYED   [ ] I>/Ip undelayed
```

```
2400 THERMAL OVERLOAD PROT. 1

2401 THERMAL OL             State of thermal overload protection 1
     OFF               [ ] off
     ON                [ ] on
     BLOCK TRIP REL    [ ] Block trip relay
     ALARM ONLY        [ ] Alarm only

2402 K-FACTOR               K-factor for thermal overload protection 1
     min. 0.10
     max. 4.00         ____

2403 T-CONSTANT             Time constant for thermal overload protection1
     min. 1.0               min
     max. 999.9        ____

2404 Θ WARN                 Thermal warning stage
     min. 50                %
     max. 100          ____

2405 I WARN                 Current warning stage
     min. 0.10              I/In
     max. 4.00         ____

2406 O/L CALCUL             Calculation method for thermal stages
     Θ MAX             [ ] max. value of temperature rises of the phases
     Θ MEAN            [ ] mean value of temperature rises of the phases
     Θ FROM IMAX       [ ] temperature rise from max. current
```

```
2500 THERMAL OVERLOAD PROT. 2

2501 THERMAL OL             State of thermal overload protection 2
     OFF               [ ] off
     ON                [ ] on
     BLOCK TRIP REL    [ ] Block trip relay
     ALARM ONLY        [ ] Alarm only

2502 K-FACTOR               K-factor for thermal overload protection 2
     min. 0.10
     max. 4.00         ____
```

```
2503 T-CONSTANT             Time constant for thermal overload protection2
     min. 1.0               min
     max. 999.9       _____

2504 Θ WARN                 Thermal warning stage
     min. 50                %
     max. 100         _____

2505 I WARN                 Current warning stage
     min. 0.10              I/In
     max. 4.00        _____

2506 O/L CALCUL             Calculation method for thermal stages
     Θ MAX              [ ] max. value of temperature rises of the phases
     Θ MEAN             [ ] mean value of temperature rises of the phases
     Θ FROM IMAX        [ ] temperature rise from max. current
```

```
2700 TRANSFORM. TANK PROTECTION

2701 TANK                   State of transformer tank protection
     OFF                [ ] off
     ON                 [ ] on
     BLOCK TRIP REL     [ ] Block trip relay

2703 I> TANK                Pick-up value of transformer tank current
     min. 0.10              I/In
     max. 10.00       _____

2704 I> TANK                Pick-up value of transformer tank current
     min. 10                mA
     max. 1000        _____

2705 RMS FORMAT             Method of RMS calculation
     WITHOUT HARMON.    [ ] Without harmonics
     WITH HARMONICS     [ ] With harmonics

2709 D.OFF TNK>             Drop-off to pick-up ratio for I tank>
     min. 0.25
     max. 0.95        _____

2725 T-DELAY                Time delay of trip
     min. 0.00              s
     max. 60.00/∞     _____

2727 T-RESET                Reset delay after trip has been initiated
     min. 0.00              s
     max. 60.00       _____
```

```
2900 MEAS.VALUE SUPERVISION

2903 SYM.Ithres             Symmetry threshold for current monitoring
     min. 0.10              I/In
     max. 1.00        _____

2904 SYM.Fact.I             Symmetry factor for current monitoring
     min. 0.00
     max. 0.95        _____
```

```
3000 EXTERNAL TRIP FUNCTION 1

3001 EXT.TRIP 1              State of external trip function 1
     OFF                 [ ] off
     ON                  [ ] on
     BLOCK TRIP REL      [ ] Block trip relay

3002 T-DELAY                 Time delay of external trip function 1
     min. 0.00               s
     max. 60.00/∞       ____

3003 T-RESET                 Reset delay after trip
     min. 0.00               s
     max. 60.00         ____
```

```
3100 EXTERNAL TRIP FUNCTION 2

3101 EXT.TRIP 2              State of external trip function 2
     OFF                 [ ] off
     ON                  [ ] on
     BLOCK TRIP REL      [ ] Block trip relay

3102 T-DELAY                 Time delay of external trip function 2
     min. 0.00               s
     max. 60.00/∞       ____

3103 T-RESET                 Reset delay after trip
     min. 0.00               s
     max. 60.00         ____
```

Tests and Commissioning Aids 7UT51X

4000 TESTS

4100 COMMISSION TESTS

4101 TEST DIFF	Measuring and indication of current values
4121 TEST ANGL L	Indication of angles of line currents
4141 TEST ANGL S	Indication of angles of star point current
4161 TEST DIF/ST	Indication of diff. and restr. current values
4181 TEST REF	Meas. / ind. of current-/ angle values of REF

4800 COMMISSION TESTS STOP

4801 TEST STOP	Stop the commission tests

4900 TEST FAULT RECORDING

4901 FAULT REC.	Initiation of fault recording

Annunciations, Measured Values etc. 7UT51X

5000 ANNUNCIATIONS

5100 OPERATIONAL ANNUNCIATIONS

5200 LAST FAULT

5300 2nd TO LAST FAULT

5400 3rd TO LAST FAULT

5700 OPERATIONAL MEASURED VALUES

5701 I1 L1[%]=	Operat. meas. current L1 side 1 [%] is
5702 I1 L2[%]=	Operat. meas. current L2 side 1 [%] is
5703 I1 L3[%]=	Operat. meas. current L3 side 1 [%] is
5704 I2 L1[%]=	Operat. meas. current L1 side 2 [%] is
5705 I2 L2[%]=	Operat. meas. current L2 side 2 [%] is
5706 I2 L3[%]=	Operat. meas. current L2 side 2 [%] is
5707 I3 L1[%]=	Operat. meas. current L1 side 3 [%] is
5708 I3 L2[%]=	Operat. meas. current L2 side 3 [%] is
5709 I3 L3[%]=	Operat. meas. current L3 side 3 [%] is
5710 IA[%]=	Operat. meas. current IA [%] is
5711 IB[%]=	Operat. meas. current IB [%] is
5721 I1 L1 =	Operat. meas. current L1 side 1 [A] is
5722 I1 L2 =	Operat. meas. current L2 side 1 [A] is
5723 I1 L3 =	Operat. meas. current L3 side 1 [A] is
5724 I2 L1 =	Operat. meas. current L1 side 2 [A] is
5725 I2 L2 =	Operat. meas. current L2 side 2 [A] is
5726 I2 L3 =	Operat. meas. current L3 side 2 [A] is
5727 I3 L1 =	Operat. meas. current L1 side 3 [A] is
5728 I3 L2 =	Operat. meas. current L2 side 3 [A] is
5729 I3 L3 =	Operat. meas. current L3 side 3 [A] is
5730 IA =	Operat. meas. current IA [A] is
5731 IB =	Operat. meas. current IB [A] is

5900 OVERLOAD MEASURED VALUES

5911 Θ1/Θtrp=	Temperature rise 1 for warning and trip
5912 Θ1/ΘtrpL1=	Temperature rise 1 for phase L1
5913 Θ1/ΘtrpL2=	Temperature rise 1 for phase L2
5914 Θ1/ΘtrpL3=	Temperature rise 1 for phase L3
5921 Θ2/Θtrp=	Temperature rise 2 for warning and trip
5922 Θ2/ΘtrpL1=	Temperature rise 2 for phase L1
5923 Θ2/ΘtrpL2=	Temperature rise 2 for phase L2
5924 Θ2/ΘtrpL3=	Temperature rise 2 for phase L3

Reference Table for Configuration Parameters 7UT51X

6000 MARSHALLING

6100 MARSHALLING BINARY INPUTS

6101 BINARY INPUT 1 Binary input 1

___ ___ ___
___ ___ ___
___ ___ ___

6102 BINARY INPUT 2 Binary input 2

___ ___ ___
___ ___ ___
___ ___ ___

6103 BINARY INPUT 3 Binary input 3

___ ___ ___
___ ___ ___
___ ___ ___

6104 BINARY INPUT 4 Binary input 4

___ ___ ___
___ ___ ___
___ ___ ___

6105 BINARY INPUT 5 Binary input 5

___ ___ ___
___ ___ ___
___ ___ ___

6200 MARSHALLING SIGNAL RELAYS

6201 SIGNAL RELAY 1 Signal relay 1

___ ___ ___
___ ___ ___
___ ___ ___

6202 SIGNAL RELAY 2 Signal relay 2

6203 SIGNAL RELAY 3 Signal relay 3

6204 SIGNAL RELAY 4 Signal relay 4

6205 SIGNAL RELAY 5 Signal relay 5

6206 SIGNAL RELAY 6 Signal relay 6

6207 SIGNAL RELAY 7 Signal relay 7

6208 SIGNAL RELAY 8 Signal relay 8

6209 SIGNAL RELAY 9 Signal relay 9

6210 SIGNAL RELAY 10 Signal relay 10

6211 SIGNAL RELAY 11 Signal relay 11

6300 MARSHALLING LED INDICATORS

6301 LED 1 LED 1

6302 LED 2 LED 2

6303 LED 3 LED 3

6304 LED 4 LED 4

6305 LED 5 LED 5

6306 LED 6 LED 6

6307 LED 7 LED 7

6308 LED 8 LED 8

6309 LED 9 LED 9

6310 LED 10 LED 10

6311 LED 11 LED 11

6312 LED 12 LED 12

6313 LED 13 LED 13

6314 LED 14 LED 14

6400 MARSHALLING COMMAND RELAYS

6401 TRIP RELAY 1 Trip relay 1

6402 TRIP RELAY 2 Trip relay 2

6403 TRIP RELAY 3 Trip relay 3

6404 TRIP RELAY 4 Trip relay 4

```
6405 TRIP RELAY 5          Trip relay 5

     _________________    _________________    _________________

     _________________    _________________    _________________

     _________________    _________________    _________________
```

```
7000 OP. SYSTEM CONFIGURATION
```

```
7100 INTEGRATED OPERATION

7101 LANGUAGE                  Language
     DEUTSCH              [ ]  deutsch
     ENGLISH              [ ]  english
     US-ENGLISH           [ ]  us-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

7801 PROT. OBJ.             Selection of the protected object
     2WIND-TRANSF.     [ ] 2winding-transformer
     3WIND-TRANSF.     [ ] 3winding-transformer
     GENERATOR/MOTOR   [ ] Generator/motor
     2ENDS-BRANCH PT.  [ ] 2ends-branch point
     3ENDS-BRANCH PT.  [ ] 3ends-branch point
     1PHASE-TRANSF.    [ ] 1phase-transformer

7806 STARPOINT A            Selection of star point transformer A
     NO ASSIGNMENT     [ ] No assignment
     SIDE 1            [ ] Side 1
     SIDE 2            [ ] Side 2
     SIDE 3 / V. OBJ   [ ] Side 3 / virt. obj.

7807 STARPOINT B            Selection of star point transformer B
     NO ASSIGNMENT     [ ] No assignment
     SIDE 1            [ ] Side 1
     SIDE 2            [ ] Side 2
     SIDE 3 / V. OBJ   [ ] Side 3 / virt. obj.

7816 DIFF PROT.             Differential protection
     EXIST             [ ] Existent
     NON-EXIST         [ ] Non-existent

7819 REF PROT.              Restricted earth fault protection
     NON-EXIST         [ ] Non-existent
     WINDING 1         [ ] Winding 1
     WINDING 2         [ ] Winding 2
     WINDING 3         [ ] Winding 3
     VIRTUAL OBJECT    [ ] Virtual object

7821 BACK-UP O/C            Back-up overcurrent protection
     NON-EXIST         [ ] Non-existent
     REFERENCE SIDE 1  [ ] Reference side 1
     REFERENCE SIDE 2  [ ] Reference side 2
     REFERENCE SIDE 3  [ ] Reference side 3
     VIRTUAL OBJECT    [ ] Virtual object
```

```
7824 OVERLOAD 1             Thermal overload protection 1
     NON-EXIST          [ ] Non-existent
     REFERENCE SIDE 1   [ ] Reference side 1
     REFERENCE SIDE 2   [ ] Reference side 2
     REFERENCE SIDE 3   [ ] Reference side 3
     VIRTUAL OBJECT     [ ] Virtual object

7825 OVERLOAD 2             Thermal overload protection 2
     NON-EXIST          [ ] Non-existent
     REFERENCE SIDE 1   [ ] Reference side 1
     REFERENCE SIDE 2   [ ] Reference side 2
     REFERENCE SIDE 3   [ ] Reference side 3
     VIRTUAL OBJECT     [ ] Virtual object

7827 TANK PROT.             Transformer tank protection
     NON-EXIST          [ ] Non-existent
     SENSITIVE CT B     [ ] Sensitive CT B
     INSENSITIVE CT A   [ ] Insensitive CT A

7830 EXT. TRIP 1            External trip function 1
     NON-EXIST          [ ] Non-existent
     EXIST              [ ] Existent

7831 EXT. TRIP 2            External trip function 2
     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
     fN 16 2/3 Hz       [ ] fn 16 2/3 Hz
```

Operational Device Control Facilities 7UT51X

```
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
```

```
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

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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.

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Corrections/Suggestions

Substantial alterations against previous issue:

Errors corrected in section 2.2

Subject to technical alteration

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