SIEMENS

Numerical Machine Protection

7UM512 V3.1

Instruction Manual Order No. C53000−G1176−C110−3

- Voltage protection $U><$
- Stator earth fault protection $U_0>$ ($I_0\downarrow$)
- Frequency protection $f><$
- Active power protection $P_a>$
- Reactive power protection $P_r>$; $Pr>>$
- Unbalanced load protection $I_2>$
- Overcurrent time ptotection $I>$
- Overcurrent/undercurrent supervision $I><$
- Rotor earth fault protection $R_E<$
- DC voltage time protection $U_{dc}><$

Figure 1 Illustration of the numerical machine protection 7UM512 (in housing for surface mounting)

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CE

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).

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NOTE:

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

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

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

1 Introduction

1.1 Application

The 7UM512 is a numerical machine protection unit from the ”Numerical Machine Protection series 7UM51” and provides a practical combination of protection functions for electrical machines or power station units.

The unit supplements the protection and supervisory functions of the 7UM511 relay and, together, they provide a complete protection system for medium-sized high-voltage machines, e.g. industrial machines, community heating power stations, hydroelectric generators. It is, however, completely autonomous and can, with all its functions, be operated completely independent of other protection equipment.

Further units of its series offer additional functions which satisfy the requirements for up to the largest machines. A survey of this machine protection series is shown in Figure 1.1.

A large number of alarm relays and LEDs on the front panel of the unit provide information about the detected faults, the monitored operating conditions of the protected machine and about the unit itself. Five trip relays are available for direct tripping of circuit breakers and other control devices.

Space-saving construction and sensible mounting and connection techniques permit easy exchange with conventional protection equipment in existing plants. Comprehensive internal monitoring of hardware and software reduces the time required for testing and provides an extremely high availability of the protection system.

Serial interfaces allow comprehensive communication with other digital control and storage devices. For data transmission a standardized protocol according IEC 60870–5–103 is used, as well as in accordance with DIN 19244 (selectable). 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 analog input transducers, binary input and output modules and d.c. converter;

– insensitive to v.t. and c.t. errors, transient conditions and interferences;

– large frequency range (operates above 11 Hz): therefore also operative during run-up and shutdown of the generator;

– 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 or r.m.s. values during a fault for fault recording;

– communication with central control and storage devices via serial interfaces is possible, optionally with 2 kV insulation or for connection of optical fibre;

– continuous monitoring of the measured values and the hardware and software of the relay.

7UM511

Underexcitation protection
Overvoltage protection, two-stage
Undervoltage protection
Stator earth fault protection U_0>
Frequency protection, four-stage
Forward power supervision
Reverse power protection
Unbalanced load protection
Overcurrent time protection, two-stage
High-sensitivity earth current protection
Thermal stator overload protection
Four external trip signals can be processed
Two trip circuit supervision channels

7UM512

Overvoltage protection and frequency dependent undervoltage protection
Earth fault protection U_0>, I_0> directional
Frequency protection, two-stage
Single-phase power protection
Unbalanced load protection
Overcurrent time protection with undervoltage seal-in
Overcurrent/undercurrent supervision
Rotor earth fault protection, two-stage
D.C. voltage time protection
Four external trip signals can be processed
Two trip circuit supervision channels

7UM515

Overflux protection U/f
Undervoltage protection, inverse time
Overvoltage protection, two-stage
Stator earth fault 100 % protection
Earth fault protection U_0>
Frequency protection, four-stage
Interturn fault protection
Rotor earth fault protection, two-stage
Four external trip signals can be processed
Two trip circuit supervision channels

7UM516

Impedance protection
Power swing blocking
Stator earth fault protection U_0>
Out-of-step protection
Forward power supervision
Reverse power protection
Unbalanced load protection
Four external trip signals can be processed
Two trip circuit supervision channels

7UT512

Differential protection for generators and motors
or
Differential protection for two-winding transformers or units
Overcurrent time protection
Thermal overload protection
Two external trip signals can be processed
(2 trip relays, small size: $^1/_3$ case)

7UT513

Differential protection for generators and motors
or
Differential protection for three−winding transformers or units
Restricted earth fault protection or
Tank leakage protection
Overcurrent time protection
Thermal overload protection
Two external trip signals can be processed
(5 trip relays, large size: $^1/_2$ case)

Figure 1.1 Survey of the numerical machine protection series

1.3 Implemented functions

The protective and supervisory functions of the numerical machine protection unit can be individually switched to be operative or inoperative. The unit comprises the following functions:

Voltage protection

– phase-to-phase voltage measurement,

– undervoltage detection with or without adjustable frequency dependency,

– overvoltage detection, frequency-independent.

Stator earth fault protection

– with 90 % to 95 % protected zone of stator winding,

– measurement of filtered neutral displacement voltage for machines in block connection,

– additional measurement of filtered earth fault current for machines directly connected to bus-bars,

– optional high-sensitivity directional determination with adjustable slope of directional characteristic.

Frequency measurement

– supervision of underfrequency (f<) and/or overfrequency (f>) with individually adjustable frequency limits,

– insensitive to harmonics and phase jumps,

– adjustable undervoltage lock-out.

Power supervision

– power calculation from one phase-to-phase voltage and one phase current,

– supervision of rise in active power (P>) and in reactive power (Q>) with individually adjustable power limits,

– high measurement accuracy and angle error compensation,

– suitable for detection of rise of active power (P>) and reactive power (Q>), with separate pick-up thresholds,

– active power detection either in forward or in reverse direction

– reverse power detection possible with two-stage design, dependent on the position of the stop valve,

– reactive power detection with two separate pick-up thresholds.

Unbalanced load protection

– evaluation of negative sequence component of currents,

– insensitive to frequency fluctuations,

– alarm stage when a set unbalanced load is exceeded,

– thermal replica for rotor temperature rise with adjustable heating-up time constant,

– with thermal alarm and trip stage,

– high-speed trip stage for large unbalanced loads.

Overcurrent time protection

– current measurement separate in each phase,

– undervoltage seal-in for synchronous machines, the excitation voltage of which is derived from the machine terminals.

Overcurrent/undercurrent supervision

– current measurement separate for each phase,

– can be set for overcurrent I> or undercurrent I<,

– can be blocked by external signal (e.g. I< during start-up),

– external signals can be logically combined with AND.

Rotor earth fault protection

– 100 % protection range over the entire excitation circuit,

– symmetrical capacitive coupling into the excitation circuit of a.c. voltage of system frequency,

– considers the operational earth impedances and series (e.g. brush) resistances,

– calculation of the fault resistance from the total measured complex impedance,

– alarm stage and trip stage directly adjustable in Ohms (rotor–earth resistance),

– measurement circuit supervision and fault indication.

D.C. voltage time protection

– d.c. voltage detection via integrated isolating amplifier,

– can be set for overvoltage or undervoltage,

– optional average value or true r.m.s. value formation, the latter is suited to a.c. voltage measurement.

Coupling of external binary signals

– for processing or re-transmitting of external signals or commands,

– 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 up to 4 externals signal into the annunciation processing,

– tripping by up to 4 external signals via the integrated trip matrix,

– time delay possible.

Integrated tripping matrix

– with 5 trip relays (each with 2 NO contacts) for up to 20 protection commands.

Integrated trip test

– initiation of live tripping by the operator panel or via the operating interface.

Integrated trip circuit supervision

– detection of interruptions, short-circuits, and voltage failure for two tripping circuits.

2 Design

2.1 Arrangements

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

– **7UM512★–★D★★★–** in housing 7XP2040–1 for **panel surface mounting**

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

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

  All external signals are connected to 100 screwed terminals which are arranged over cut-outs on the top and bottom covers. The terminals are numbered consecutively from left to right at the bottom and top.

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

  For the isolated interface to a central control and storage unit, an additional coupling facility has been provided. For the hard-wired V.24 (RS232C) serial interface (7UM512★–★★★★★–★**B**), 4 screwed terminals are provided. For the interface for optical fibre connection (model 7UM512★–★★★★★–★**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.

– **7UM512★–★C★★★–** in housing 7XP2040–2 for **panel flush mounting** or **7UM512★–★E★★★–** for **cubicle installation**

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

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

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

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

  The 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.

  The isolated interface to a central control and storage unit (7UM512★–★★★★★–★**B**) is led to a 4-pole connection module. In the interface for optical fibre connection (7UM512★–★★★★★–★**C**), a module with 2 F–SMA connectors is provided instead.

  Degree of protection for the housing is IP51 (for cubicle installation IP 30), for the terminals IP21. For dimensions please refer to Figure 2.3.

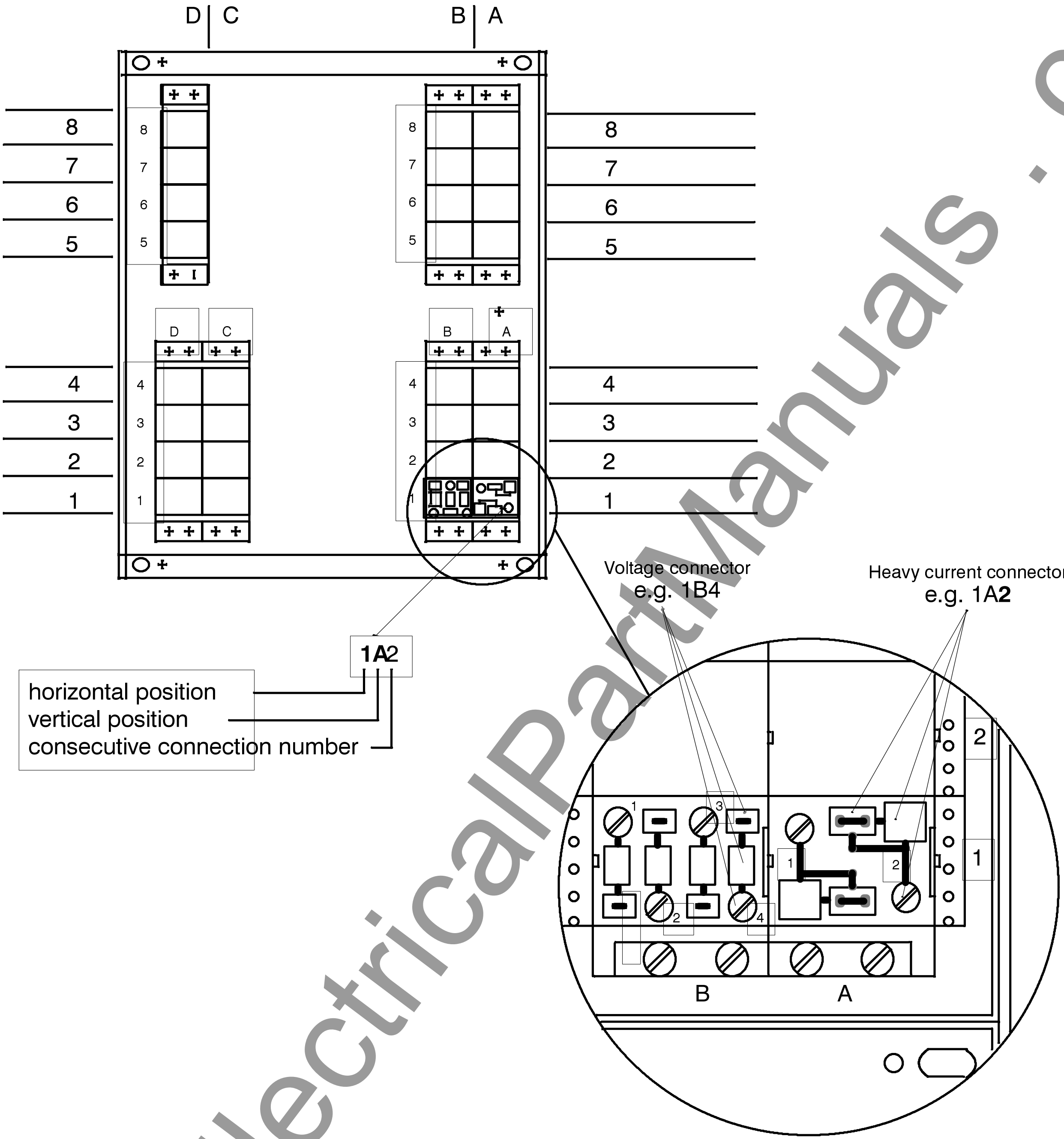
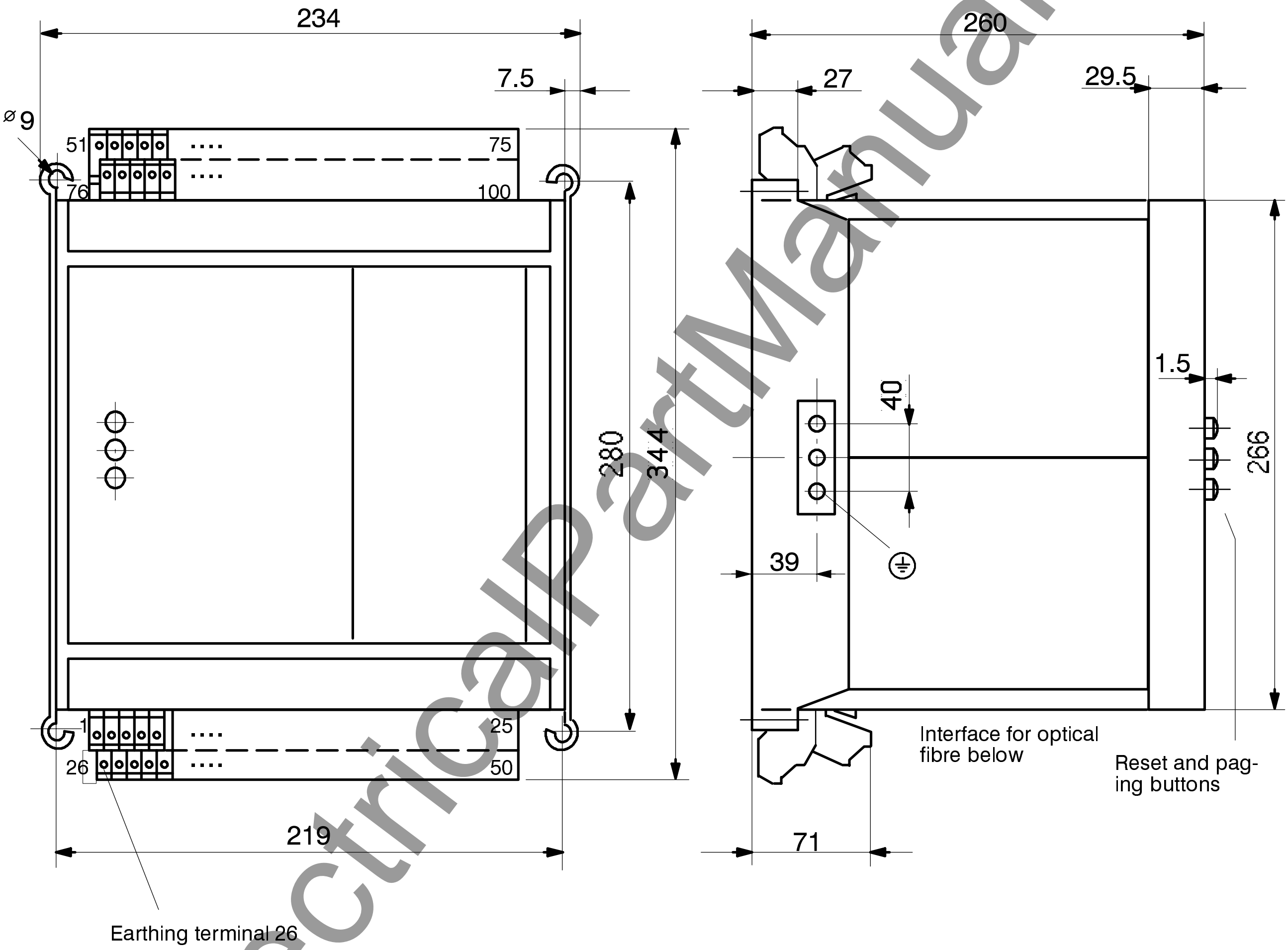


Figure 2.1 Connection plugs (rear view) – housing for flush mounting – example

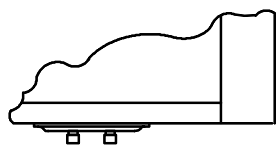
2.2 Dimensions

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

7UM512 Housing for **panel surface mounting** 7XP2040 – 1



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



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

Dimensions in mm

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

7UM512 Housing for **panel flush mounting** or **cubicle installation** 7XP2040−2

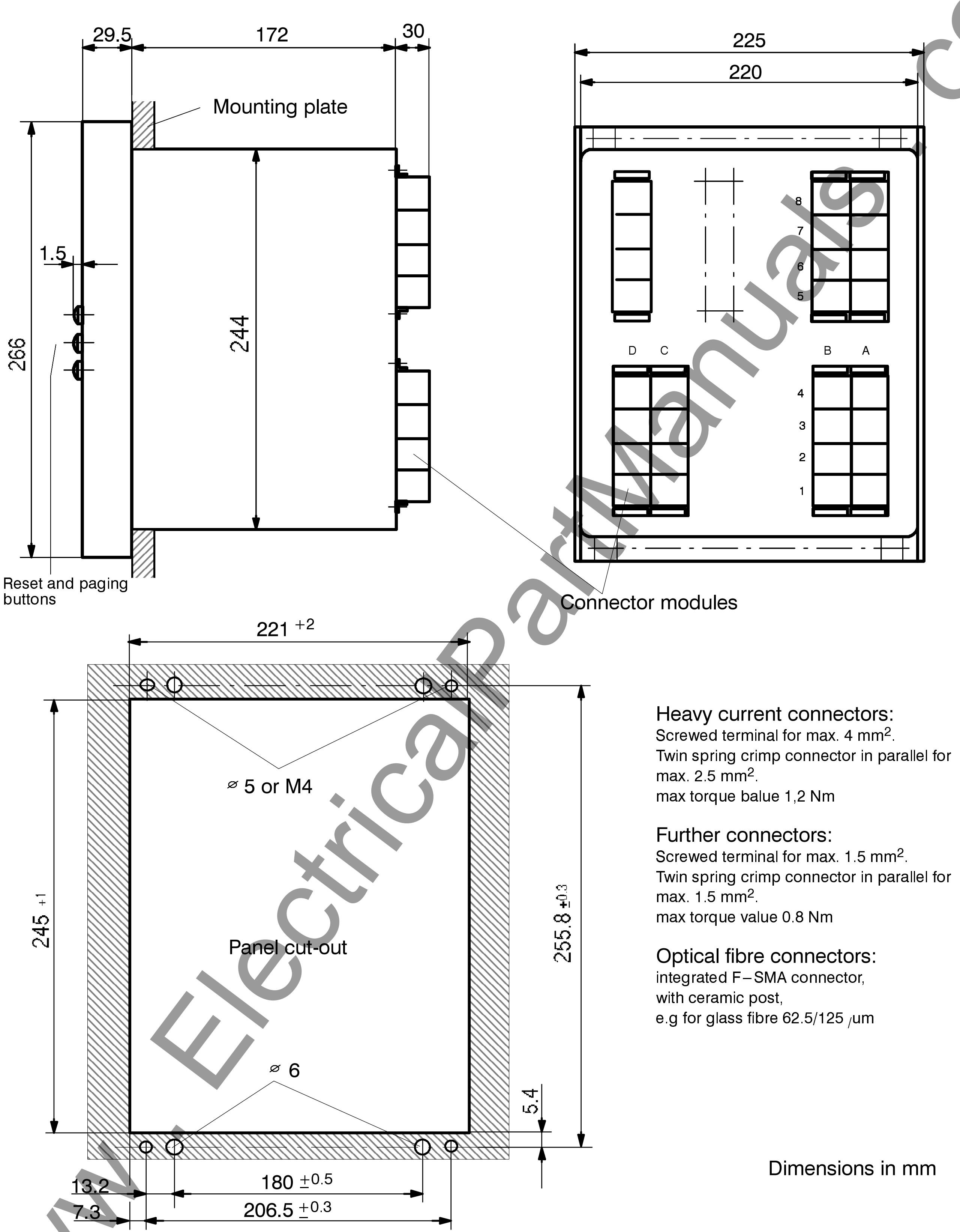


Figure 2.3 Dimensions for housing 7XP2040−2 for panel flush mounting or cubicle installation

2.3 Ordering data

Numerical Machine Protection	7.		8.	9.	10.	11.	12.		13.	14.	15.	16.
7 U M 5 1 2	☐	–	☐	☐	B	0	1	–	0	☐	B	0

Rated current; rated frequency (position 7)

1 A; 50/60 Hz 1

5 A; 50/60 Hz 5

Auxiliary voltage (position 8)

24/48 V dc 2

60/110/125 V dc 4

220/250 V dc 5

Construction (position 9)

in housing 7XP2040−1 for panel surface mounting . . . . D

in housing 7XP2040−2 for panel flush mounting C

in housing 7XP2040−2 forcubicle installation
(without glass front) . . . . E

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

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

serial interface for optical fibre connection C

2.4 Accessories

The measurement input for the neutral displacement voltage measurement for the stator earth fault protection is dimensioned for a rated voltage of 100 V. A voltage divider 500 V/100 V is used when connecting to a neutral earthing transformer or a line connected earthing transformer with a secondary voltage of 500 V. The **voltage divider 500 V/100 V** type **3PP1336--1CZ--013001** is suitable and also includes a test resistor. Refer to Figure 2.4 for schematic circuit diagram and to Figure 2.7 for dimensions.

The isolating amplifier for the galvanically isolated input of the d.c. voltage is designed for a voltage range of 0 to 10 V. A suitable ohmic voltage divider 10 : 1 or 20 : 1 is required for matching to higher d.c. voltages, e.g. to usual excitation voltages. For example, **voltage divider 3PP1326--0BZ--012009** is suitable for this purpose. For circuit schematic please refer to Figure 2.5, for dimensions Figure 2.7.

The bias voltage for the rotor circuit – used for rotor earth fault protection – is generated and coupled to the rotor circuit via a **coupling unit 7XR6100–0*A00**. This contains two coupling capacitors 4μF + 4μF together with two protective resistors as well as a filter choke which may be used in case of high ripple content in the excitation voltage. This unit provides also the connection between the protection device and the rotor circuit. Refer to Figure 2.6 for schematic circuit diagram. The dimensions of a panel surface mouted housing is shown in Figure 2.8 the flush mounted housing in Figure 2.9.

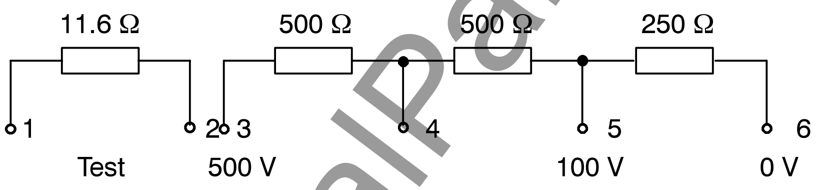


Figure 2.4 Schematic diagram of voltage divider 500 V/100 V 3PP1336–1CZ–013001

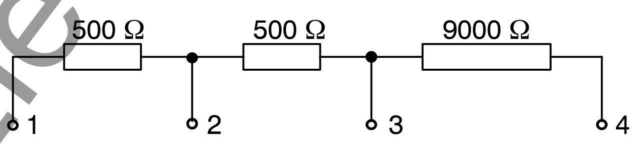


Figure 2.5 Schematic diagram of voltage divider 3PP1326–0BZ–012009

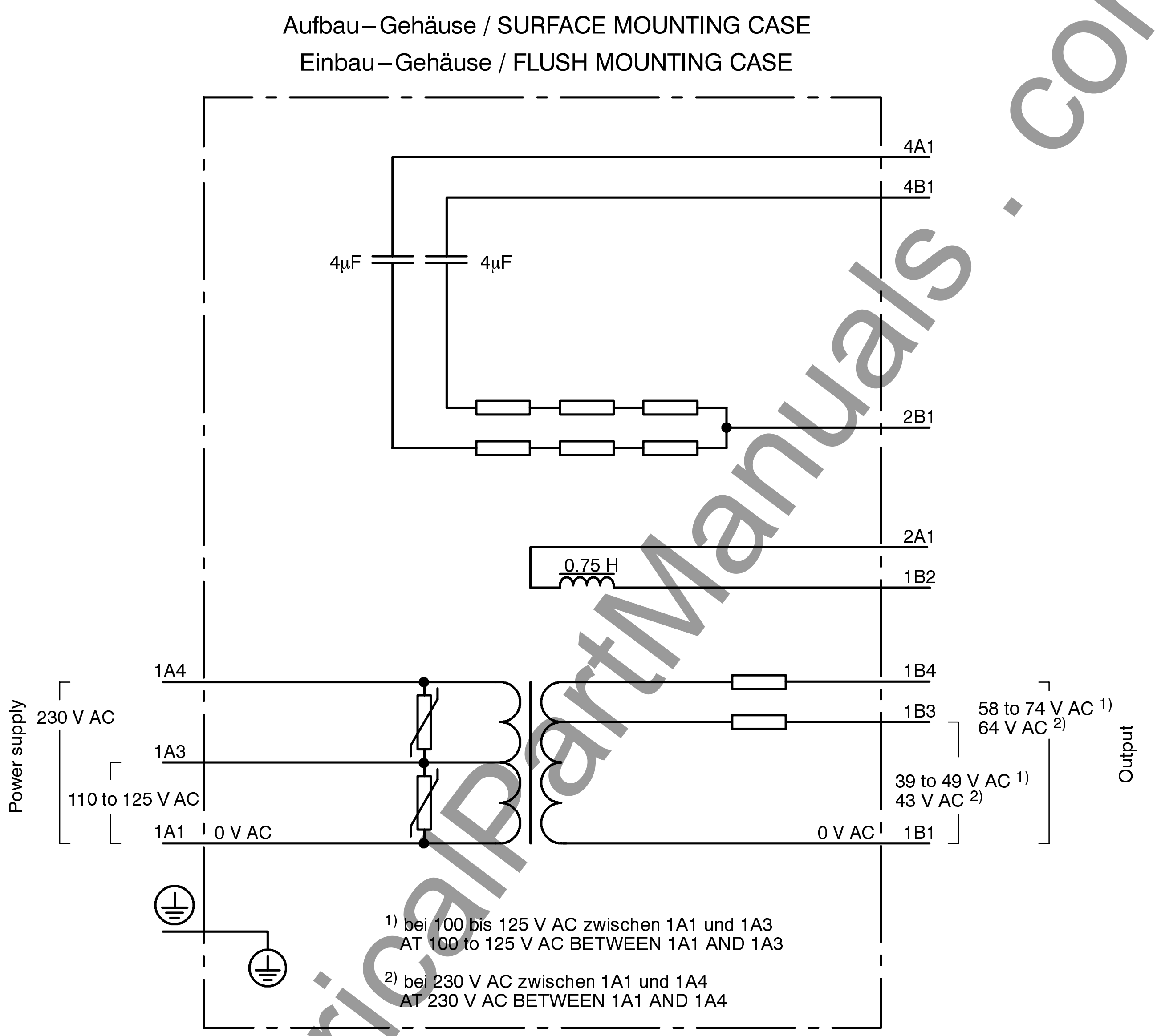
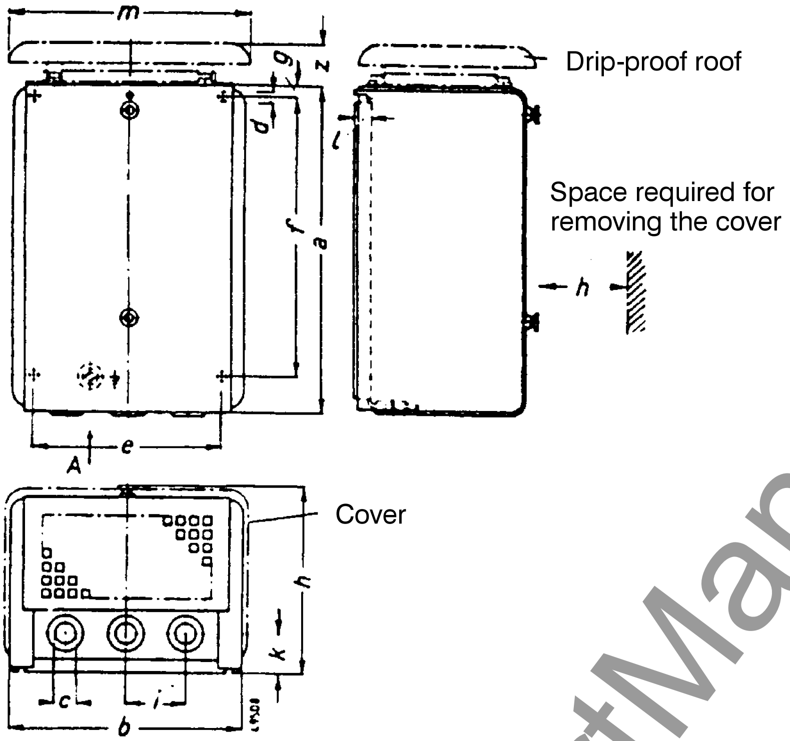


Figure 2.6 Schematic diagram of coupling unit 7XR6100 – 0*A00



3PP1, degree of protection IP 20 (with drip-proof roof IP 23) Dimensions in mm

Type	a	b	c	d	e	f	g	h	i	k	l	m	z
3PP1 32	267	187	3 x 16	7	160	230	10	110	50	30	10	196	33
3PP1 33	267	187	3 x 16	7	160	230	10	146	50	30	10	196	33

Figure 2.7 Dimensions 3PP13:
3PP132 for voltage divider 3PP1326−0BZ−012009 (20 : 10 : 1)
3PP133 for voltage divider 3PP1336−1CZ−013001 (500 V/100 V)

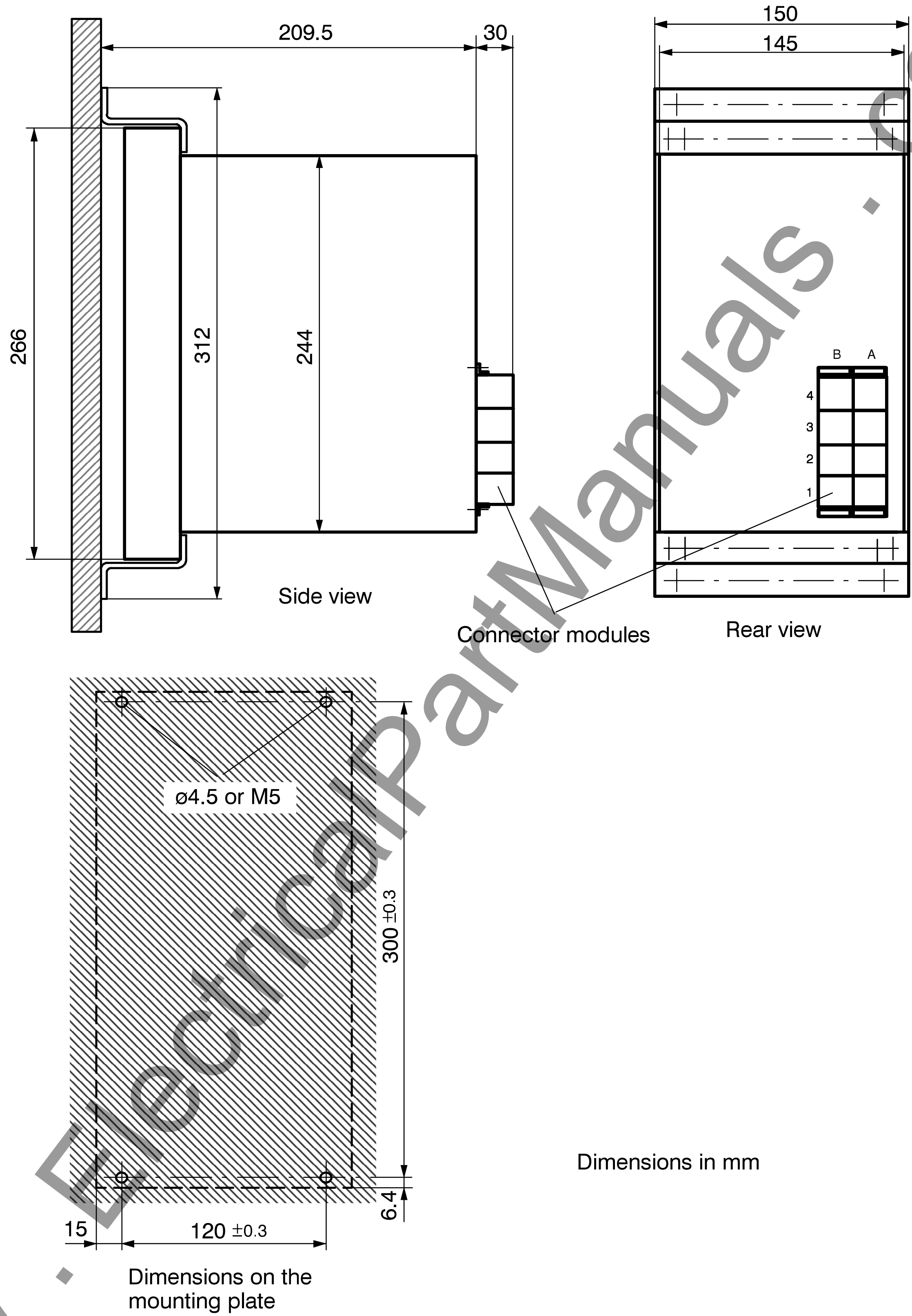
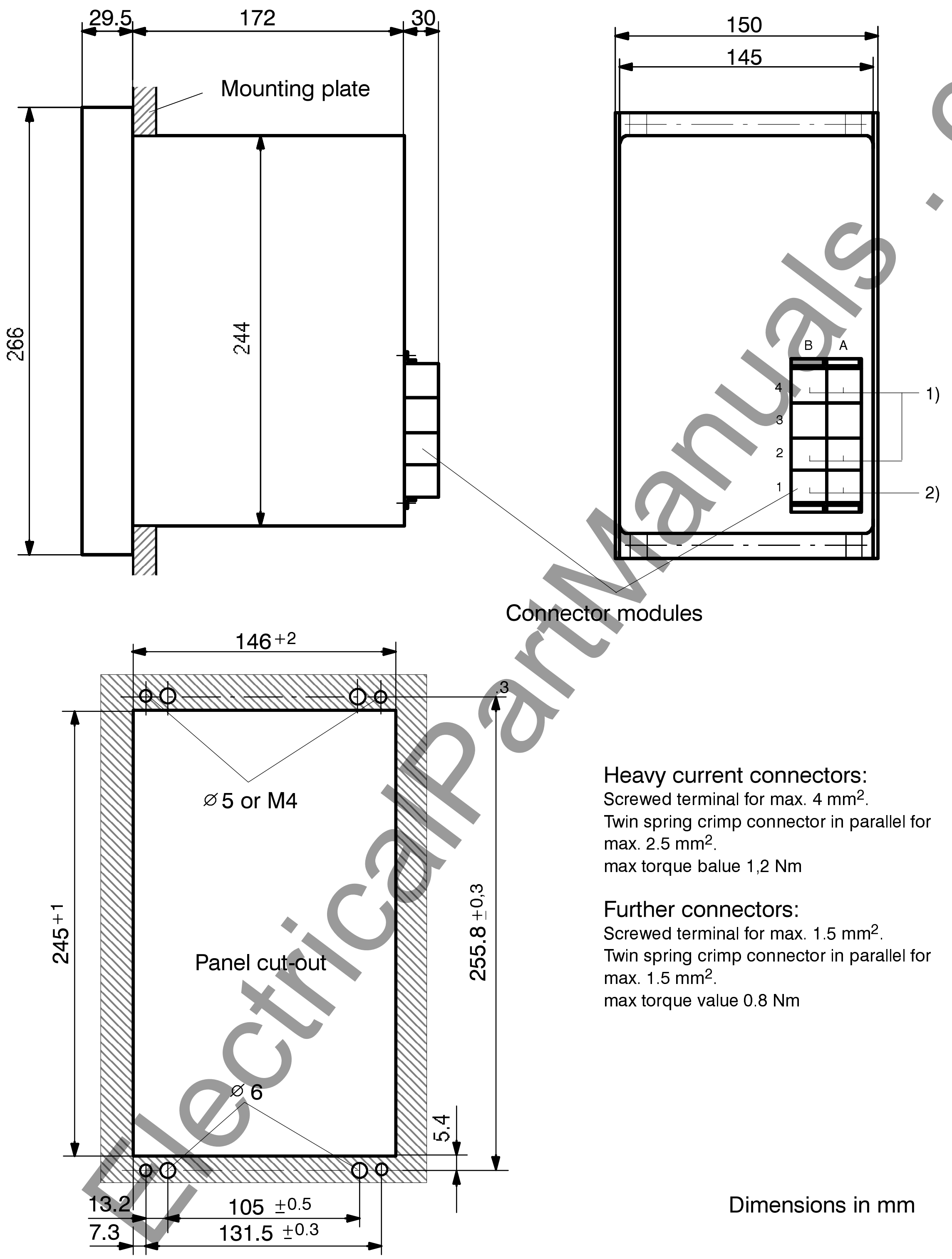


Bild 2.8 Dimensions coupling unit 7XR6100−0BA00 for panel surface mounting



Heavy current connectors:

Screwed terminal for max. 4 mm^2.
Twin spring crimp connector in parallel for max. 2.5 mm^2.
max torque balue 1,2 Nm

Further connectors:

Screwed terminal for max. 1.5 mm^2.
Twin spring crimp connector in parallel for max. 1.5 mm^2.
max torque value 0.8 Nm

Dimensions in mm

Bild 2.9 Dimensions coupling unit 7XR6100−0CA00 for panel flush mounting

3 Technical data

3.1 General data

3.1.1 Inputs/outputs

Measuring circuits

Rated current I_N — 1 A or 5 A

Rated voltage U_N — 100 V to 125 V (selectable)

Rated frequency f_N — 50 Hz or 60 Hz (selectable)

D.C. voltage — 0 V dc to 10 V dc (from external voltage divider)

Burden: c.t. circuits per phase	– at I_N = 1 A	$\leq$ 0.1 VA
	– at I_N = 5 A	$\leq$ 0.5 VA
Burden: earth current c.t.	– at I = 1 A	$\leq$ 0.3 VA
Burden: v.t. circuits per phase	– at 100 V	$\leq$ 0.3 VA

Input resistance of d.c. voltage input — approx 1 MΩ

Overload capability c.t. circuits

– thermal (r.m.s.)	100	$\times I_N$ for 1 second
	20	$\times I_N$ for 10 seconds
	4	$\times I_N$ continuous
– dynamic (impulse)	250	$\times I_N$ (half cycle)

Overload capability for highly sensitive earth current protection input

– thermal (r.m.s.)	300	A for $\leq$1 s
	100	A for $\leq$10 s
	15	A continuous

Overload capability v.t. circuits
– thermal (r.m.s.) — 140 V continuous

Overload capability excitation voltage
– thermal — 60 V dc continuous

Auxiliary DC supply

Auxiliary dc voltage supply via integrated dc/dc converter

Rated auxiliary voltage U_{aux}	24/48 V dc	60/110/125 V dc	220/250 V dc
Operating ranges	19 to 56 V dc	48 to 144 V dc	176 to 288 V dc

Superimposed a.c. voltage, peak-to-peak — $\leq$ 12 % at rated voltage; $\leq$ 6 % at the limits of the voltage ranges

Power consumption quiescent — approx 12 W
picked-up — approx 22 W

Bridging time during failure/short-circuit of auxiliary d.c. voltage — $\geq$ 50 ms at U $\geq$ 110 V dc

Heavy duty (trip) contacts

Trip relays, number		5
Contacts per relay		3 x 2 NO, 2 x 1 NO
Switching capacity	MAKE	1000 W/VA
	BREAK	30 W/VA
Switching voltage		250 V
Permissible current		5 A continuous
		30 A for 0.5 s

Signal contacts

Signal relays, number		12 plus 1 device fault
Contacts per relay		1 CO or 1 NO
Switching capacity	MAKE/BREAK	20 W/VA
Switching voltage		250 V
Permissible current		1 A

Binary inputs, number — 8

Voltage range — reconnectable 24 to 250 V dc in 2 ranges:

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

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

Serial interfaces

Operator terminal interface	non-isolated
– Connection	at the front, 25-pole subminiature connector according ISO 2110 for connection of a personal computer or similar
– Transmission speed	as delivered 9600 Baud; min. 1200 Baud; max. 19200 Baud
Interface for data transfer to a control centre	isolated
– Standards	similar V.24/V.28 to CCITT; RS 232 C to EIA; Protocol to VDEW/ZVEI/IEC 60870–5–103 or according DIN 19244
– Transmission speed	as delivered 9600 Baud; min. 1200 Baud; max. 19200 Baud
– Transmission security	Hamming distance d = 4
– Connection, directly	at housing terminals; 2 core pairs, with individual and common screening; e.g. LI YCY–CY/2 x 2 x 0.25 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; R_i = 200 Ω, 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; R_i = 150 Ω
– 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 $\leq$ 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	
– in housing for surface mounting	approx. 12.0 kg
– in housing for flush mounting	approx. 10.5 kg
Degree of protection acc. to EN 60529	
– Housing	IP 51 *)
– Terminals	IP 21

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

3.2 **Voltage protection** with/without frequency influence

Setting ranges/steps

Overvoltage $U>$, $U>>$	30 V to 140 V	(steps 1 V)
Undervoltage $U<$ at f_N	20.0 V to 100.0 V	(steps 0.1 V)
Frequency influence with underfrequency $U_{fN} + c \cdot (f - f_N)^2$; max. 130 V	factor c = 0 to 6 (refer to characteristics Figure 3.1)	(steps1)
Time delays $T(U>)$, $T(U\gg)$, $T(U<)$	0.00 s to 32.00 s or ∞	(steps 0.01 s)
Reset delays T_r	0.00 s to 32.00 s	(steps 0.01 s)

Pick-up times	
– Overvoltage $U>$, $U>>$	approx 50 ms
– Undervoltage $U<$	approx 50 ms
Reset times	
– Overvoltage $U>$, $U>>$	approx 50 ms
– Undervoltage $U<$	approx 40 ms
Reset ratios	
– Overvoltage $U>$, $U>>$	approx 0.98
– Undervoltage $U<$	reset value 2 to 6 V above pick-up value dependent on set value and frequency factor c

Tolerances

– Voltage limit values at f_N	3 % of set value or 0.5 V
– Time delays T	1 % but min. 10 ms

Influence variables

– Auxiliary d.c. voltage in range $0.8 \leq U_H/U_{HN} \leq 1.15$	$\leq$ 1%
– Temperature in range $-5\ ^\circ C \leq \vartheta_{amb} \leq +40\ ^\circ C$	$\leq$ 0.5 %/10 K
– Frequency in range 0.9 f_N to 1.1 f_N	$\leq$ 1 %

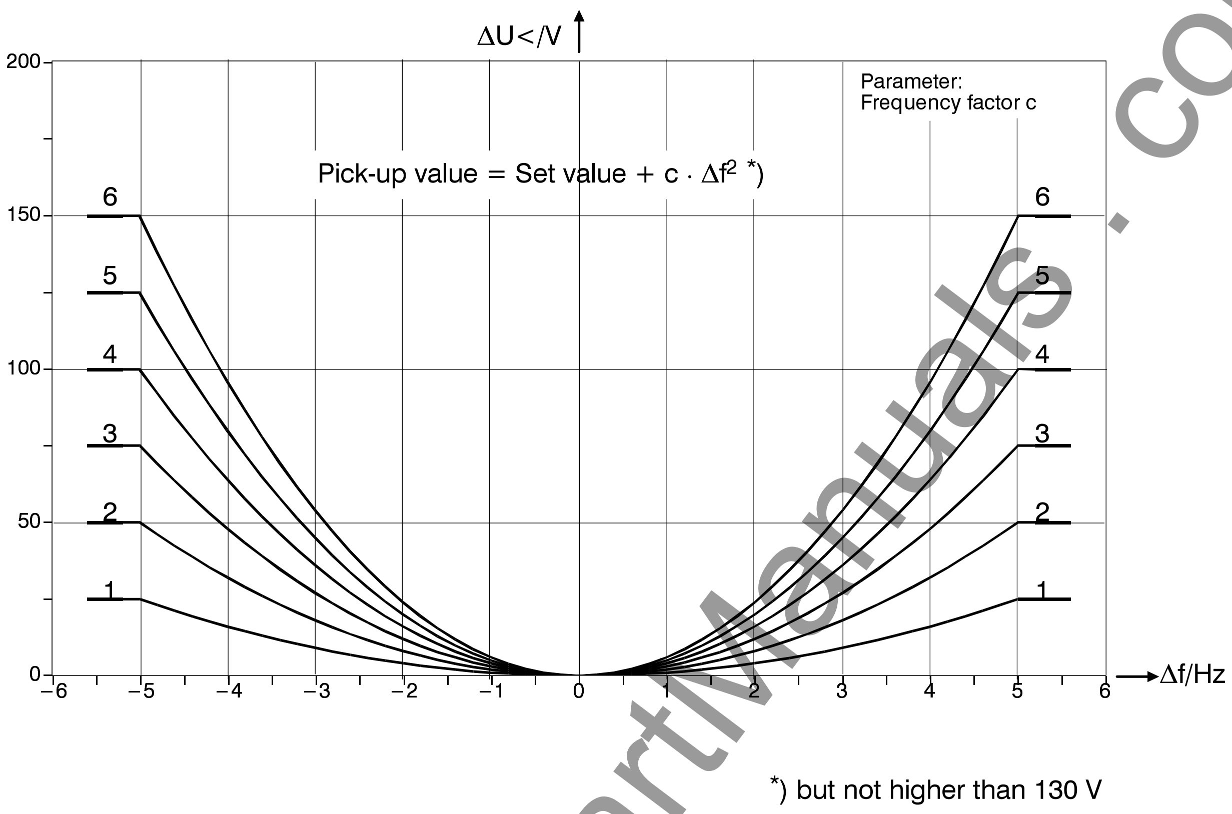


Figure 3.1 Increase of pick-up voltage caused by frequency deviation with undervoltage protection

3.3 Stator earth fault protection

Setting ranges/steps

Displacement voltage U_E>	5.0 V to 120.0 V	(steps 0.1 V)
Residual current I_E>	2 mA to 100 mA	(steps 1 mA)
Inclination of directional characteristic	0° to 360°	(steps 1°)
Time delays T	0.00 s to 32.00 s or ∞	(steps 0.01 s)
Drop-off time Tr	0.00 s to 32.00 s	(steps 0.01 s)

Pick-up times	
– U_E>, I_E>	≤ 60 ms
– Directional determination	≤ 60 ms
Drop-off time	approx 50 ms
Drop-off ratios	
– Displacement voltage U_E>	approx 0.70
– Residual current I_E>	approx 0.70
– Hysteresis of directional characteristic	approx 10°

Tolerances

– Displacement voltage U_E>	3 % of set value
– Residual current I_E>	3 % of set value but min. 0.15 mA
– Directional angle	5° electrical
– Time delays T	1 % but min. 10 ms

Influence variables

– Auxiliary d.c. voltage in range $0.8 \leq U_H/U_{HN} \leq 1.15$	≤ 1%
– Temperature in range $-5\ °C \leq \vartheta_{amb} \leq +40\ °C$	≤ 0.5 %/10 K
– Frequency in range $0.9 \leq f/f_N \leq 1.1$	≤ 1 %

3.4 Frequency protection

Setting ranges/steps

Overfrequency f>	40.00 Hz to 65.00 Hz	(steps 0.01 Hz)
Underfrequency f<	40.00 Hz to 65.00 Hz	(steps 0.01 Hz)
Time delays T(f><)	0.00 s to 32.00 s or ∞	(steps 0.01 s)
Drop-off delays	0.00 s to 32.00 s	(steps 0.01 s)
Undervoltage lock-out U< for f>, f<	40 V to 100 V	(steps 1 V)

– Pick-up times f_1, f_2	≤ 90 ms
– Reset times f_1, f_2	≤ 70 ms
– Reset difference |pick-up value – reset value|	approx 0.1 Hz
– Reset ratio undervoltage lock-out U<	approx 1.05

Tolerances

– Frequency f_1, f_2	100 mHz
– Undervoltage lock-out U< for f>, f<	3 % of set value
– time delays T	1 % but min. 10 ms

Influence variables

– Auxiliary d.c. voltage in range $0.8 \leq U_H/U_{HN} \leq 1.15$	≤ 0.1%
– Temperature in range $-5\ °C \leq \vartheta_{amb} \leq +40\ °C$	≤ 0.1 %/10 K
– Frequency (additional influence) in range 40 Hz to 69 Hz	≤ 0.1 %

3.5 Power supervision

Setting ranges/steps

Active power P>	(positive or negative)	1.0 % to 120.0 % S_N	(steps 0.1 % S_N)
Reactive power Q>; Q>>	(positive or negative)	1.0 % to 120.0 % S_N	(steps 0.1 % S_N)
Time delays T(P>), T(Q>), T(Q>>)		0.00 s to 32.00 s or ∞	(steps 0.01 s)
Drop-off delays		0.00 s to 32.00 s	(steps 0.01 s)

Pick-up times – Power P>, Q>, Q>>	≤ 190 ms at 50 Hz ≤ 160 ms at 60 Hz
Reset times – Power P>, Q>, Q>>	≤ 190 ms at 50 Hz ≤ 160 ms at 60 Hz
Drop-off ratios – active power P>	approx 0.95 or 0.5 % S_N
– reactive power Q>, Q>>	approx 0.95 or 0.5 % S_N

Tolerances

– active power P>	0.3 % S_N ± 3 % of set value at Q < 0.5 S_N (S_N....rated apparent power, Q.......reactive power)
– reactive power Q>, Q>>	0.3 % S_N ± 3 % of set value at P < 0.5 S_N (S_N....rated apparent power, P.......active power)
– time delays T	1 % but min. 10 ms

Influence variables

– Auxiliary d.c. voltage in range 0.8 ≤ U_H/U_{HN} ≤ 1.15	≤ 1%
– Temperature in range –5 °C ≤ ϑ_{amb} ≤ +40 °C	≤ 0.5 %/10 K
– Frequency in range 0.9 f_N to 1.1 f_N	≤ 0.2 %/Hz

3.6 Unbalanced load protection

Setting ranges/steps

Permissible unbalanced load	$I_2>/I_N$	3 % to 30 %	(steps 1 %)
Thermal time constant	τ	100 s to 2500 s	(steps 1 s)
Thermal warning stage	$\Theta_{warn}/\Theta_{trip}$	70 % to 99%	(steps 1 %)
Tripping stage (definite time)	$I_2>>/I_N$	10 % to 80 %	(steps 1 %)
Time delays	$T(I_2>)$, $T(I_2>>)$	0.00 s to 32.00 s or ∞	(steps 0.01 s)
Drop-off delays	Tr	0.00 s to 32.00 s	(steps 0.01 s)

Trip characteristics of the thermal replica (refer also to Figure 3.2)

$$t = \tau \cdot ln \frac{(I_2 / I_{2perm})^2}{(I_2 / I_{2perm})^2 - 1}$$

for $1 \leq I_2/I_{2perm} \leq 10$ and $I_2/I_N \leq 1$

t – tripping time
τ – thermal time constant
I_2 – Negative sequence current
I_{2perm} – continuously permissible negative sequence current

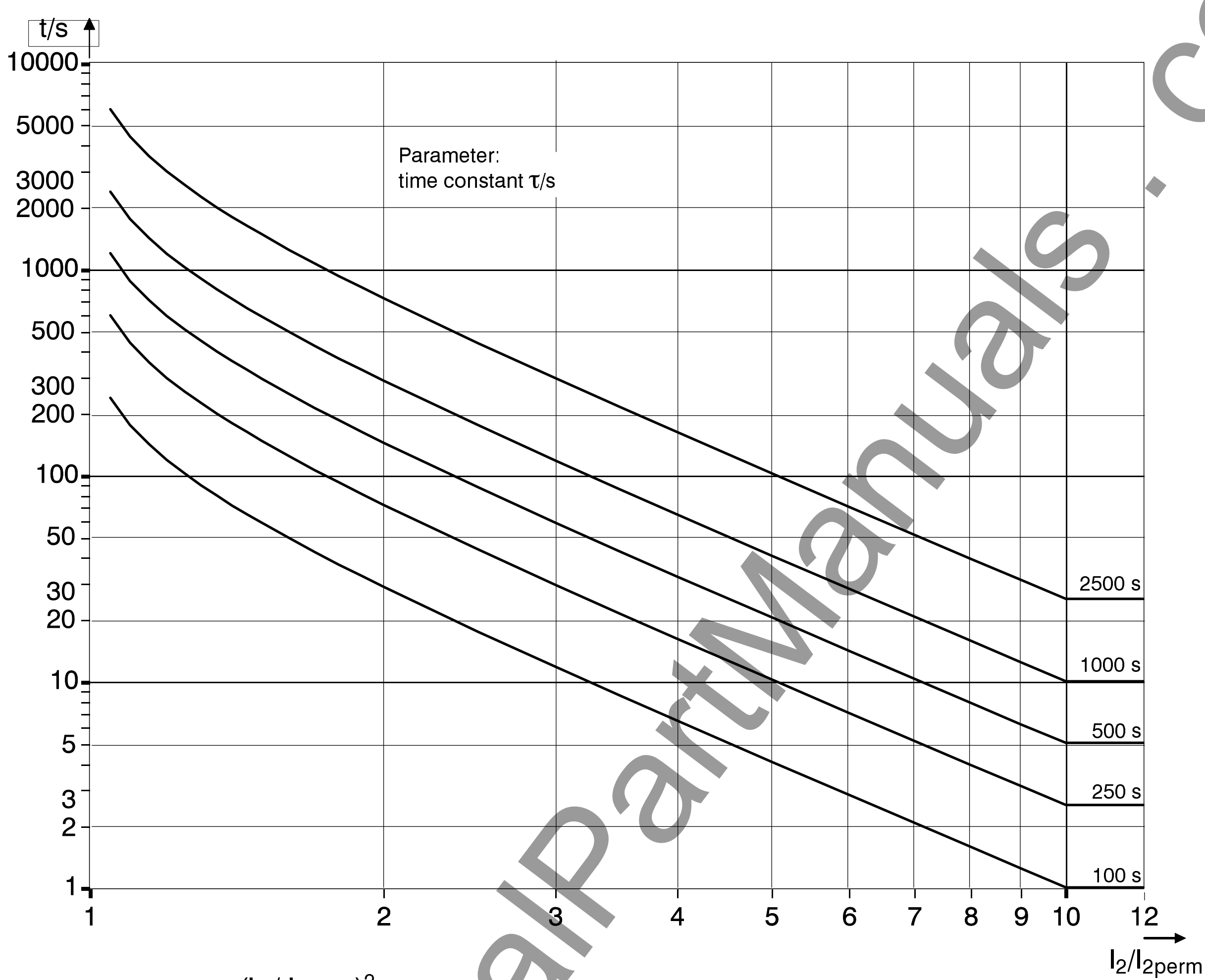
Pick-up times Warning stage $I_2>$, tripping stage $I_2\gg$	$\leq$ 60 ms
Drop-off times Warning stage $I_2>$, tripping stage $I_2\gg$	$\leq$ 60 ms
Drop-off ratios	
– Warning stage $I_2>$, tripping stage $I_2\gg$	approx 0.95
– Θ/Θ_{trip}	drop-off at 0.99 Θ_{warn}
– Θ/Θ_{warn}	approx 0.99

Tolerances

– thermal replica	5 % ± 0.4 s referred to I_2 (class 5 % acc. IEC)
– to pick-up values $I_2>$, $I_2\gg$	5 % of set value
– to stage times	1 % but min. 10 ms

Influence variables

– Auxiliary d.c. voltage in range $0.8 \leq U_H/U_{HN} \leq 1.15$	$\leq$ 1 %
– Temperature in range $-5\ ^\circ C \leq \vartheta_{amb} \leq +40\ ^\circ C$	$\leq$ 0.5 %/10 K
– Frequency in range $0.9 \leq f/f_N \leq 1.1$	$\leq$ 1 %



$$t = \tau \cdot ln \frac{(I_2 / I_{2perm})^2}{(I_2 / I_{2perm})^2 - 1} \qquad \text{for } I_2/I_N \leq 1$$

Figure 3.2 Trip characteristics of the thermal unbalanced load protection stage

3.7 Overcurrent time protection

Setting ranges/steps

Overcurrent pick-up I>	I/I_N	0.10 to 8.00	(steps 0.01)
Reset ratio of overcurrent pick-up I>		0.90 to 0.99	(steps 0.01)
Delay times	T for I>	0.00 s to 32.00 s or ∞	(steps 0.01 s)
Reset delay	T_r	0.00 s to 32.00 s	(steps 0.01 s)
Undervoltage seal-in (phase-to-phase)		20.0 V to 100.0 V	(steps 0.1V)
Undervoltage seal-in duration		0.10 s to 32.00 s or 0 (inactive)	(steps 0.01 s)

Pick-up time Overcurrent pick-up I> at ≥ 2 x setting value	approx 40 ms
Reset time	≤ 40 ms
Reset ratio of undervoltage U<	approx 1.05

Tolerances

– Pick-up values I>	3 % of setting value
– Undervoltage	3 % of setting value
– Delay times T	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 $-5\ °C \leq \vartheta_{amb} \leq 40\ °C$	≤ 0.5 %/10 K
– Frequency in range $0.9 \leq f/f_N \leq 1.1$	≤ 1 %

3.8 Overcurrent/Undercurrent supervision

Setting ranges/steps

Current pick-up I><	I/I_N	0.05 to 8.00	(steps 0.01)
Delay times	$T_{I><}$	0.00 s to 32.00 s or ∞	(steps 0.01 s)
Reset delay	T_r	0.00 s to 32.00 s	(steps 0.01 s)
Processing of binary input		AND-combination possible	

Pick-up times Current pick-up I><	approx 40 ms
Reset times – of overcurrent pick-up I> – of undercurrent pick-up I<	 approx 60 ms approx 30 ms
Reset ratios – of overcurrent pick-up I> – of undercurrent pick-up I<	 approx 0.95 or −0.025 A approx 1.05 or +0.025 A

Tolerances

– Pick-up values I><	3 % of setting value
– Delay times T	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 $-5\ °C \leq \vartheta_{amb} \leq 40\ °C$	$\leq$ 0.5 %/10 K
– Frequency in range $0.9 \leq f/f_N \leq 1.1$	$\leq$ 1 %

3.9 Rotor earth fault protection

Setting ranges/steps		
Warning stage R_E<	3.0 kΩ to 30.0 kΩ	(steps 0.1 kΩ)
Tripping stage R_E<<	1.0 kΩ to 5.0 kΩ	(steps 0.1 kΩ)
Time delays T	0.00 s to 32.00 s or ∞	(steps 0.01 s)
Reset delays T_r	0.00 s to 32.00 s	(steps 0.01 s)
Reactance of coupling capacitances	10 Ω to 800 Ω	(steps 1 Ω)
Series resistance (brush resistance)	0 Ω to 999 Ω	(steps 1 Ω)
Pick-up value of measuring circuit monitor I<	1.0 mA to 50.0 mA and 0.0 mA (monitor ineffective)	(steps 0.1 mA)
Phase angle shifting for rotor bias quantity	−15,0 ° to +15,0 °	

Permissible **rotor earth capacitance** C_E (with respect to specified tolerances and detection of measuring circuit fault)	$0.15\ \mu F \leq C_E \leq 3.0\ \mu F$
Permissible operating range of rotor bias voltage	20 V ac to 100 V ac

Times	
– Warning stage, tripping stage	≤ 80 ms
Reset times – Warning stage, tripping stage	≤ 80 ms
Reset ratios	
– R_E<, R_E<<	approx 1.25
– measuring circuit monitor I<	approx 1.20 or 0.5 mA reset difference
– measuring circuit monitor U<	approx 5 V reset difference

Tolerances	
– Warning stage, tripping stage	5 % for $R_E \leq 5$ kΩ and $0.15 \leq C_E/\mu F \leq 3$ 10 % for $R_E \leq 10$ kΩ and $0.15 \leq C_E/\mu F \leq 3$ 10 % for $10 \leq R_E/k\Omega \leq 30$ and $C_E \leq 1\ \mu F$
– Time delays T	1 % but min. 10 ms

Influence variables	
– Auxiliary d.c. voltage in range $0.8 \leq U_H/U_{HN} \leq 1.15$	≤ 1%
– Temperature in range $-5\ °C \leq \vartheta_{amb} \leq +40\ °C$	≤ 0.5 %/10 K
– Frequency in range $0.9 \leq f/f_N \leq 1.1$	≤ 3 % for $C_E \leq 0.15\ \mu F$ ≤ 10 % for $0.15 < C_E/\mu F \leq 1$

3.10 D.C. voltage time protection

Setting ranges/steps

Overvoltage $U_{dc}>$ or undervoltage $U_{dc}<$	0.1 V to 8.5 V dc	(steps 0.1 V)
permissible setting range when sinusoidal values are to be measured	0.1 V to 7.0 V r.m.s.	(steps 0.1 V)
Time delays $T(U_{dc}><)$	0.00 s to 32.00 s or ∞	(steps 0.01 s)
Reset delays T_r	0.00 s to 32.00 s	(steps 0.01 s)

Pick-up times

– overvoltage U> in operational condition 1	$\leq$ 60 ms	at rated frequency
– overvoltage U> in operational condition 0	$\leq$ 200 ms	
– undervoltage U< in operational condition 1	$\leq$ 60 ms	at rated frequency
– undervoltage U< in operational condition 0	$\leq$ 200 ms	

Reset times — as pick-up times

Reset ratios

– overvoltage $U_{dc}>$	approx 0.9 or −0.05 V
– undervoltage $U_{dc}<$	approx 1.1 or +0.05 V

Tolerances

– Voltage thresholds $U_{dc}>$, $U_{dc}<$	3 % of set value
– Time delays T	1 % but min. 10 ms

Influence variables

– Auxiliary d.c. voltage in range $0.8 \leq U_H/U_{HN} \leq 1.15$	$\leq$ 1%
– Temperature in range $-5\ °C \leq \vartheta_{amb} \leq +40\ °C$	$\leq$ 0.5 %/10 K
– Frequency in range $0.9 \leq f/f_N \leq 1.1$	$\leq$ 1 %

3.11 Ancillary functions

External trip commands via binary input

Setting ranges/steps

Time delays T	0.00 s to 32.00 s or ∞	(steps 0.01 s)
Drop-off delay T_r	0.00 s to 32.00 s	(steps 0.01 s)

Times

operating time	approx 12 ms at 50 Hz/60 Hz
Drop-off times	approx 8 ms at 50 Hz/60 Hz

Tolerance

– Time delays T, T_r	1 % but min. 10 ms

Influence variables

– Auxiliary d.c. voltage in range $0.8 \leq U_H/U_{HN} \leq 1.15$	$\leq$ 1%
– Temperature in range $-5\ ^\circ C \leq \vartheta_{amb} \leq +40\ ^\circ C$	$\leq$ 0.5 %/10 K
– Frequency in range 40 Hz to 69 Hz	$\leq$ 15 ms

Output of measured values

– Operational values of currents	I_{L1}, I_{L2}, I_{L3} in kA primary and in % I_N
Measurement range	0 % to 240 % I_N
Tolerance	2 % of rated value
– Positive sequence current component	I_{pos}
Measurement range	0 % to 240 % I_N
Tolerance	2 % of rated value
– Operational voltage value (phase-to-phase)	U_{L-L}
Measurement range	0 V to 140 V
Tolerance	2 % of rated value
– Operational values of powers	P, Q (active and reactive power) in % S_N (= $\sqrt{3} \cdot U_N \cdot I_N$)
Measurement range	−200 % to +200 %
Tolerance	3 % of rated value
– Power factor	cos φ
Measurement range	−1.000 to +1.000
Tolerance	0.020
– Power angle	φ
Measurement range	−180° to +180°
Tolerance	0.2°
– Displacement voltage	U_0
Measurement range	0 % to 140 V
Tolerance	2 % or 1 V
– Earth current	I_E
Measurement range	0 mA to 320 mA
Tolerance	2 % but min. 1 mA
– D.C. voltage	U_{dc}
Measurement range	0 V to 10 V dc at the measured value input
Tolerance	2 %
– Frequency	f
Measurement range	40 Hz to 70 Hz
Tolerance	0.5 % of rated value
– Rotor earth resistance	R_{rotor}
Measurement range	0.0 kΩ to 99.9 kΩ
Tolerance	10 % for 10 kΩ $\leq R_E \leq$ 30 kΩ and $C_E \leq$ 1 μF
– Bias voltage for rotor circuit	U_{rotor}
Measurement range	0 V to 140 V
Tolerance	2 % or 2 V
– Earth current in rotor circuit	I_{rotor}
Measurement range	0 mA to 320 mA
Tolerance	2 % of rated value but min. 1 mA

– Resistance of rotor earth circuit	R_{input}
Measurement range	0.0 kΩ to 99.9 kΩ
Tolerance	10 % for $1 \leq R_E \leq 10$ kΩ, or 0.5 kΩ
– Reactance of rotor earth circuit	X_{input}
Measurement range	0.0 kΩ to 99.9 kΩ
Tolerance	10 % for $1 \leq R_E \leq 10$ kΩ, or 0.5 kΩ
– Unbalanced load	I_2/I_N
Measurement range	0 % to 200 %
Tolerance	2 % of rated value
– Temperature rise calculated from unbalanced load	Θ/Θ_{trip}
Measurement range	0 to 240 %
Tolerance	5 % referred to Θ_{trip}

All indications ±1 digit display tolerance.

Measured values plausibility checks

– Sum of currents	phases

Steady-state measured value supervision

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

Fault event data storage

Storage of annunciations of the last four fault events, 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 > 10 years

Data storage for fault recording	optionally instantaneous values or r.m.s. values	
Instantaneous values:		
Storage period (pick-up or trip command = 0 ms)	max. 5 s, selectable pre-trigger and post-fault time	
Sampling rate	1 instantaneous value per 1.67 ms at 50 Hz 1 instantaneous value per 1.39 ms at 60 Hz	
	phase currents	i_{L1}, i_{L2}, i_{L3}
	earth current	i_E
	phase-to-phase voltage	u_{L-L}
	Bias voltage for rotor circuit	U_{rotor}
	Displacement voltage	U_0
	Earth current in rotor circuit	I_{rotor}
rms values:		
Storage period	max. 60 s, selectable pre-trigger and post-fault time	
Sampling rate	1 r.m.s. value per 20 ms at 50 Hz 1 r.m.s. value per $16^2/_3$ ms at 60 Hz	
	phase currents	I_{L1}, I_{L2}, I_{L3}
	phase-to-phase voltage	u_{L-L}
	Displacement voltage	U_0
	earth current	I_E
	Unbalanced load	I_2/I_N
	frequency deviation	$f - f_N$

3.12 Operating ranges of the protection functions

	Operat. cond. 0	Operating condition 1		Operat. cond. 0
Protection function	f ≤ 10 Hz	11≤f/Hz≤40	40≤f/Hz≤70	f ≥ 70 Hz
Undervoltage protection	inactive[2)]	**active**[1)]	**active**	inactive[2)]
Overvoltage protection	inactive	**active**[1)]	**active**	inactive
Stator earth fault protection U_0>	inactive	**active**[1)]	**active**	inactive
Underfrequency protection	inactive	**active**[3)]	**active**	inactive[4)]
Overfrequency protection	inactive	**active**[5)]	**active**	inactive[6)]
Active power supervision P>	inactive	inactive	**active**	inactive
Reactive power supervision Q>	inactive	inactive	**active**	inactive
Unbalanced load protection – stepped characteristic	inactive	**active**	**active**	inactive
Unbalanced load protection – thermal replica	inactive[7)]	**active**	**active**	inactive[7)]
Overcurrent time protection I>	inactive	**active**	**active**	inactive
Over-/undercurrent supervision	inactive	**active**	**active**	inactive
Rotor earth fault protection	**active**	**active**	**active**	**active**
D.C. voltage time protection	**active**	**active**	**active**	**active**
External trip commands	**active**	**active**	**active**	**active**

1) voltages are measured too small below 25 Hz (input saturation)
2) pick-up – when already present – is maintained
3) no frequency measurement possible, but pick-up is maintained due to underfrequency
4) no frequency measurement possible, but pick-up (when present) is reset
5) no frequency measurement possible, but pick-up (when present) is reset
6) no frequency measurement possible, but pick-up is maintained due to overfrequency
7) thermal replica registers cooling-down

Figure 3.3 Operating ranges of the protection functions

3.13 Accessories

Coupling unit 7XR61

Auxiliary DC supply

Rated auxiliary voltage U_{aux} ac	100/125 V ac; 50/60 Hz	230 V ac; 50/60 Hz
Operating ranges	88 to 144 V ac	176 to 265 V ac

Power consumption during earth fault	max. 15 VA (with choke) max. 5 VA (without choke)

Capability of the capacitive coupling circuit

Terminals (4A1 – 4B1)	
permissible dc voltage, continuous	max. 3.5 kV dc
permissible ac voltage r.m.s.	220 V ac (≤ 300 Hz)
test voltage	4.5 kV dc for 2 s

Output voltages

Terminals (1B1 – 1B3)	39 V to 49 V ac (dependent on supply voltage)
Terminals (1B1 – 1B4)	58 V to 74 V ac (dependent on supply voltage)

Capability of the outputs

continuous	100 mA (without choke)
Terminals (1B1 – 1B3)	175 mA (with choke) for ≤ 1 h
Terminals (1B1 – 1B4)	230 mA for ≤ 0.5 h

4 Method of operation

4.1 Operation of complete unit

The numerical machine protection 7UM512 is equipped with a powerful and proven 16-bit microprocessor. This provides fully digital processing of all functions from data acquisition of measured values to the trip signals for the circuit breakers.

Figure 4.1 shows the base structure of the unit.

The transducers of the measured value input section ME transform the currents and voltages from the measurement transformers of the switch-gear and match them to the internal processing level of the unit. Apart from the galvanic and low-capacitive isolation provided by the input transformers, filters are provided for the suppression of interference. The filters have been optimized with regard to bandwidth and processing speed to suit the measured value processing. The matched analog values are then passed to the analog input section AE.

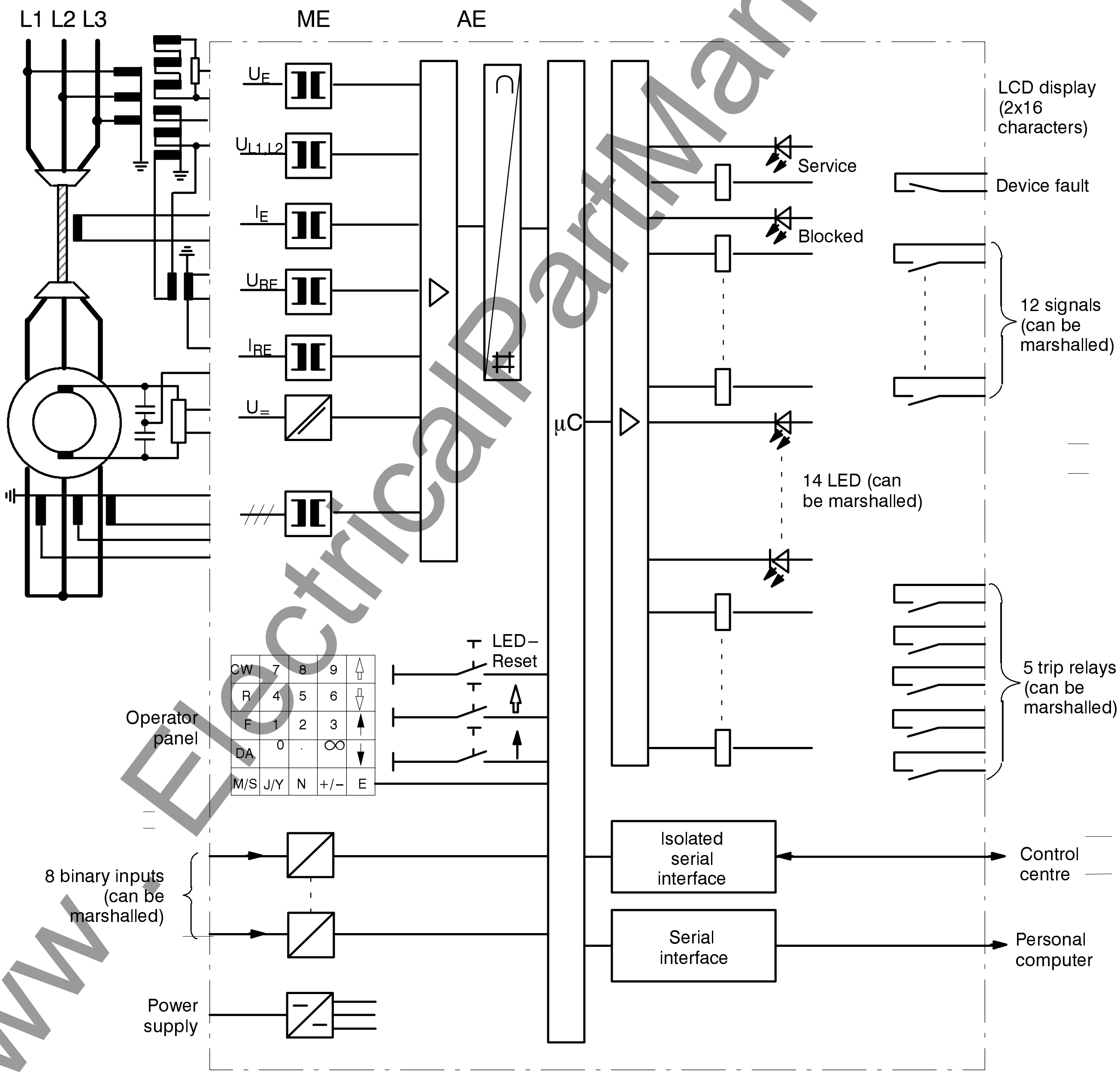


Figure 4.1 Hardware−structure of machine protection relay 7UM512

A d.c. voltage, e.g. the excitation voltage, can be fed to the unit via a voltage divider. Via a d.c. voltage transformer, a galvanically isolated value is produced which is proportional to the d.c. voltage and which is also connected to the analog input section AE.

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

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

– filtering and formation of the measured quantities,
– calculation of the positive sequence components of currents and the negative sequence current for unbalanced load detection,
– scanning of values for the thermal replica of rotor surface,
– determination of the active and reactive components of power,
– calculation of the rotor insulation resistance using the complex equivalent circuit,
– frequency measurement,
– continuous calculation of the values which are relevant for fault detection,
– scanning of limit values and time sequences,
– decision about trip commands,
– storage and issue of messages and fault event data for fault analysis.

The frequency of the measured quantities is continuously measured and used in an integrated follow-up circuit; this ensures that the protection functions are always processed with algorithms matched to the actual frequency. Thus, a wide frequency range from 40 Hz to 69 Hz is specified with small frequency influence. In general, processing is even possible from approx 11 Hz on but with respectively slower speed.

The frequency follow-up circuit can, however, operate only when at least one a.c. measured quantity is present at one of the the analog inputs, with an amplitude of at least 10 % of rated value ("operational condition 1").

If no suitable a.c. measured values are present, or if the frequency is below 11 Hz or above 70 Hz, the relay indicates this as "operating condition 0". With the exception of d.c. voltage protection and rotor earth fault detection, processing of measured values is not possible during this time (refer to Section 3.12).

Binary inputs and outputs to and from the processor are channelled via the input/output elements. From these the processor receives information from the switch-gear (e.g. remote resetting) or from other equipment (e.g. blocking signals). Outputs include, in particular, trip commands to the circuit breakers, signals for remote signalling of important events and conditions as well as visual indicators (LEDs) and an alphanumerical display on the front.

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

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

Communication via this interface is alternatively possible by means of fibre optic links, provided this interface is accordingly ordered (refer to 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 d.c. voltage storage element (rated auxiliary voltage $\geq$ 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.

4.2 Undervoltage protection

The pick-up threshold of the undervoltage protection depends on the actual frequency.The frequency-dependent undervoltage protection mainly protects consumers (induction machines) from the consequences of dangerous voltage or frequency drops in island networks. It can also be used as a criterion for load shedding in interconnected networks.

The limit value for undervoltage is set for rated frequency. The frequency dependency can be varied by choosing between seven frequency factors (c = 0 to 6) (refer to Figure 3.1 in Technical data under Section 3.2). Frequency factor c = 0 means no frequency influence. Frequency factor c = 6 indicates the strongest frequency influence. The pick-up value is then increased by the square of the frequency deviation from rated frequency. The pick-up value does not change with a deviation of more than 5 Hz or above 130 V.

The protection evaluates a phase-to-phase voltage, e.g. U_{L1-L2}. An adjustable delay time is provided to bridge short-time voltage drops.

The undervoltage protection has one stage. In order to avoid maloperation due to failure in the voltage transformer secondary circuit, the voltage protection can be blocked via a binary input, e.g. upon tripping of the voltage transformer m.c.b.

When the undervoltage protection has picked up before the “operation condition 0” occurs (i.e. no suitable measured quantities are present or frequency out of range), pick-up is maintained so that trip is ensured even in this case. The protection will drop off after the voltage has reappeared above the drop-off value or the blocking input has been activated.

Figure 4.2 shows the logic diagram.

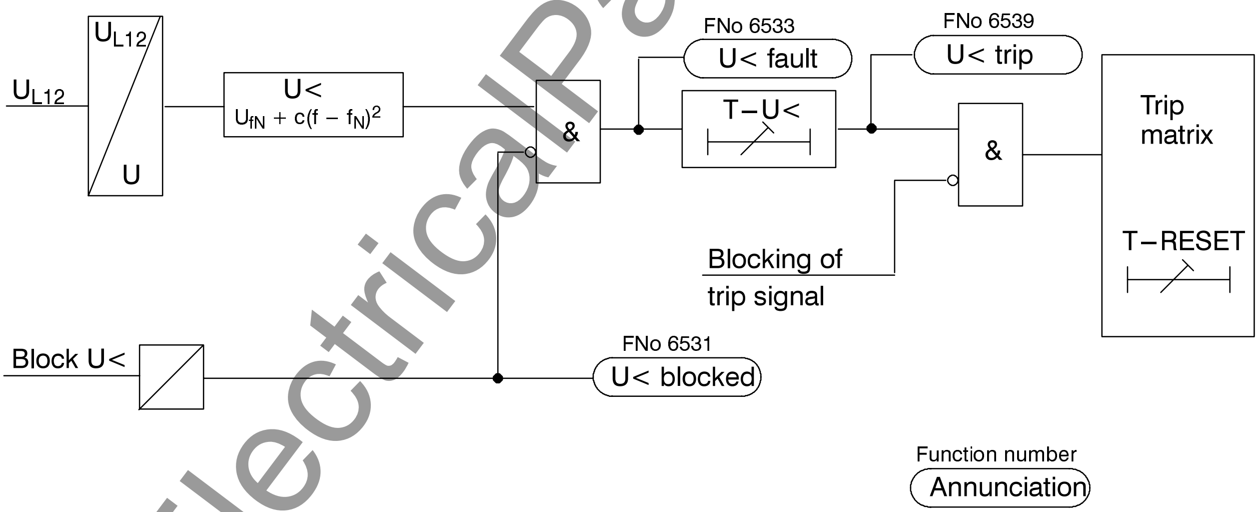


Figure 4.2 Logic diagram of the frequency-dependent undervoltage protection

4.3 Overvoltage protection

Overvoltage protection has the task of protecting the electrical machine, and the associated electrical plant connected to it, from the effects of impermissible voltage increases.

Overvoltages can be caused by incorrect manual operation of the excitation system, faulty operation of the automatic voltage regulator, (full) load shedding of a generator, separation of the generator from the system or during island operation.

The protection evaluates a phase-to-phase voltage, e.g. U_{L1-L2}. The overvoltage protection is of two-stage design: A large overvoltage initiates a fast trip; a small overvoltage initiates a slow trip. Voltage limit values and time delays can be set individually for both stages.

The voltage protection can be blocked via a binary input. Figure 4.3 shows the logic diagram of the overvoltage protection.

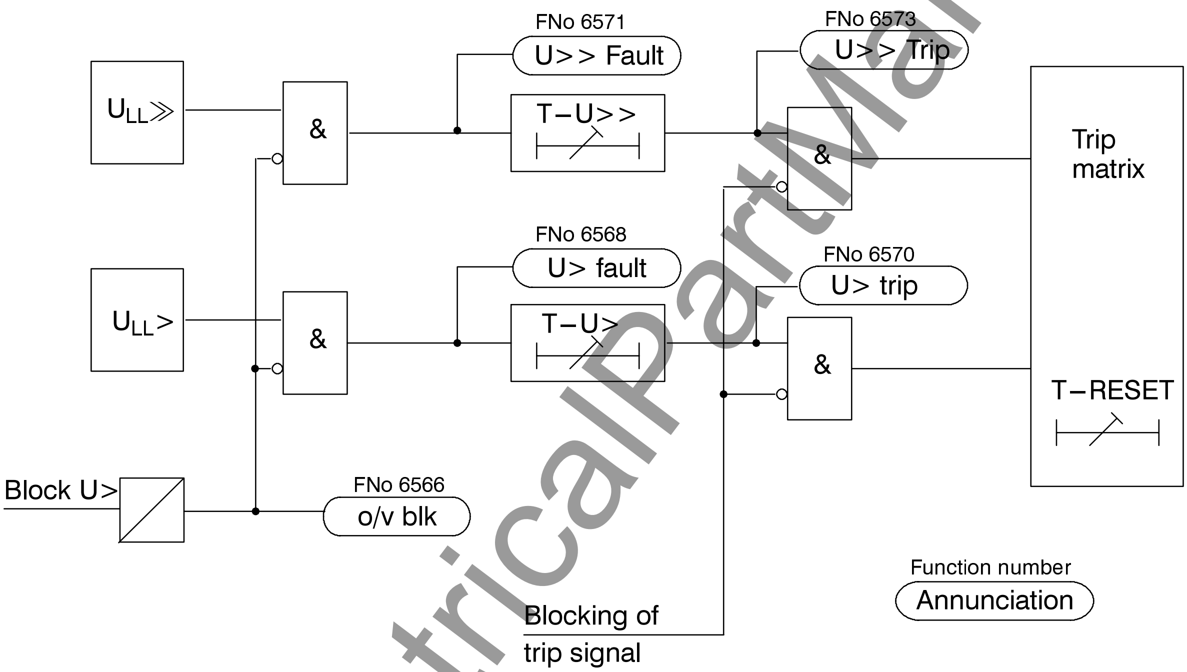


Figure 4.3 Logic diagram of the overvoltage protection

4.4 Stator earth fault protection

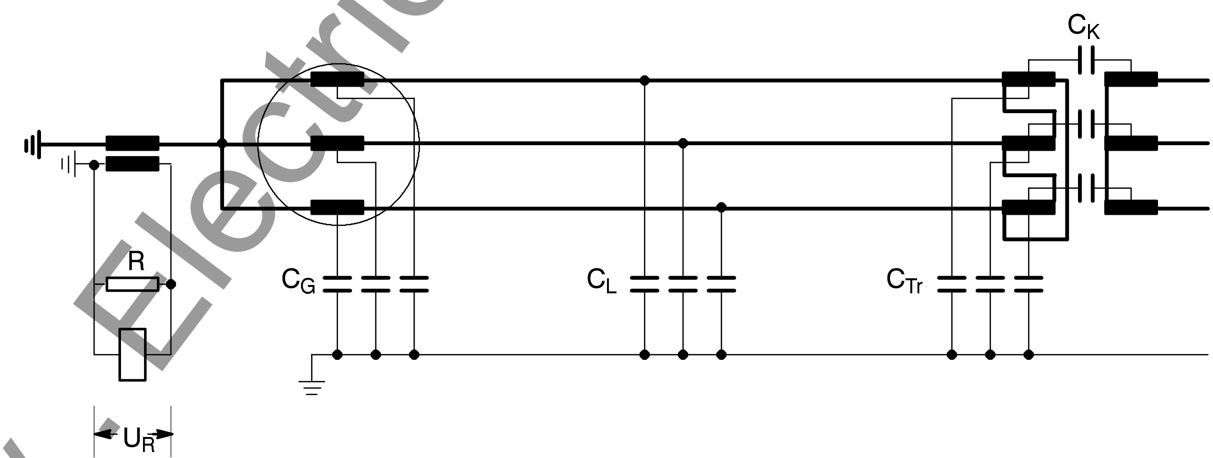
The stator earth fault protection detects earth faults in the stator windings of three-phase machines. The machine can be operated in bus-bar connection (directly connected to the network) or in block connection (via machine transformer). The criterion for the occurrence of an earth fault is mainly the occurrence of a neutral displacement voltage. This principle results in a protected zone of 90 % to 95 % of the stator winding.

The displacement voltage can be measured either at the machine star-point via voltage transformers or neutral earthing transformers (Figure 4.4) or via the e – n winding (open delta winding) of a voltage transformer set or the measurement winding of a line connected earthing transformer (Figure 4.5). Since the neutral earthing transformer or the line connected earthing transformer usually supply a displacement voltage of 500 V (with full displacement), a voltage divider 500 V/100 V is to be connected in such cases.

In all kinds of displacement voltage formation, the components of the third harmonic in each phase are summed since they are in phase in the three-phase system. In order to obtain reliable measured quantities, only the fundamental of the displacement voltage is evaluated in the stator earth fault protection. Harmonics are filtered out by numerical filter algorithms.

For machines in block connection the evaluation of the displacement voltage is sufficient. The achieved sensitivity of the protection is only limited by power frequency interference voltages during an earth fault in the network. These interference voltages are transferred to the machine side via the coupling capacitances of the unit transformer. If necessary, a loading resistor can be provided to reduce these interference voltages. The protection initiates disconnection of the machine when an earth fault in the machine zone has been present for a set time.

For machines in bus-bar connection, it is not possible to differentiate between a network earth fault or a machine earth fault by the displacement voltage alone. In this case the earth fault current is used as a further criterion. During a network earth fault, the machine supplies only a negligible earth fault current across the measurement location, which must be situated between the machine and the network. During a machine earth fault, the earth fault current of the network is available. However, since the network conditions generally vary according to the switching status of the network, a loading resistor, which supplies an increased earth fault current on the occurrence of a displacement voltage, is used in order to obtain definite measurement conditions independent of the switching status of the network. The earth fault current produced by the loading resistor must always flow across the measurement location.



R – Loading resistor
U_R – Displacement voltage
C_G – Generator – earth capacitance
C_L – Conductor – earth capacitance of line connection
C_{Tr} – Winding – earth capacitance of block transformer
C_K – Coupling capacitance of block transformer

Figure 4.4 Block connected generator with neutral earthing transformer

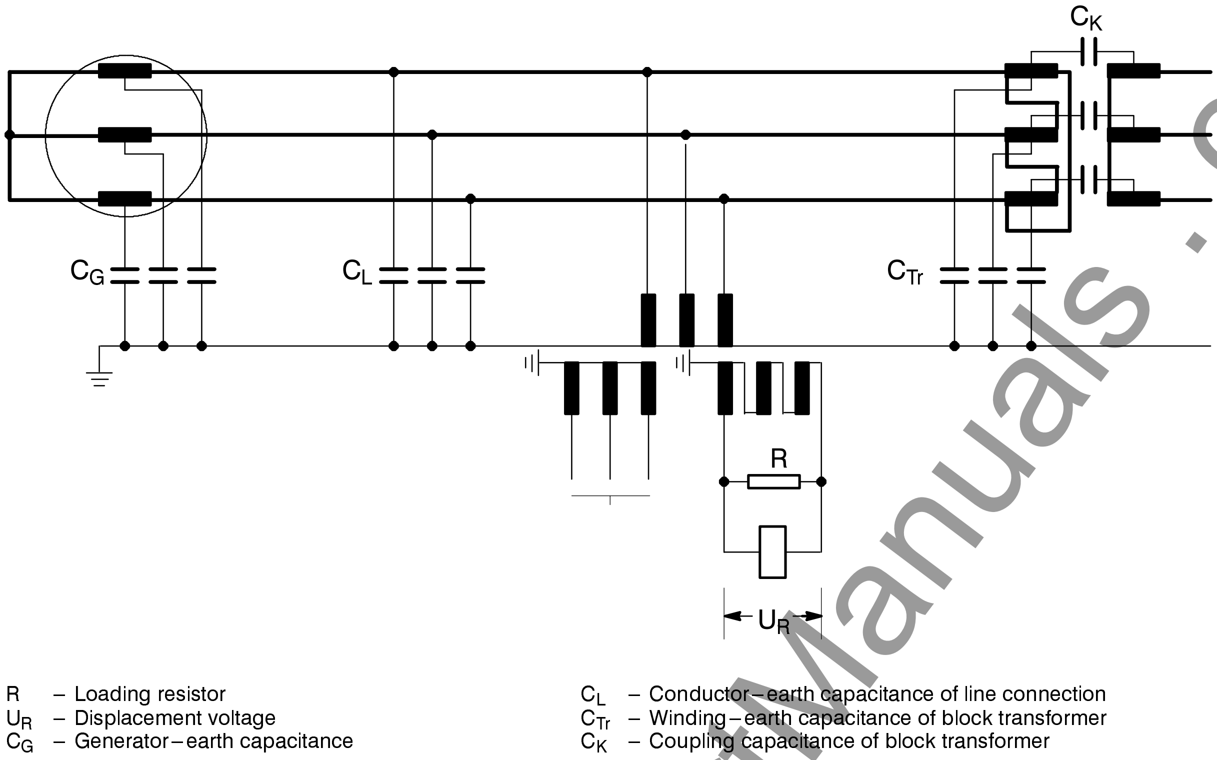


Figure 4.5 Block connected generator with line connected earthing transformer

Consequently, the loading resistor must be situated on the other side of the measurement location (current transformer, toroidal current transformer) when viewed from the machine (refer to Figure 5.6 or 5.7). Apart from the magnitude of the earth fault current, the direction of this current in relation to the displacement voltage can be used for the safe recognition of a machine earth fault in the case of bus-bar connection. The directional border between “machine direction” and “network direction” can be altered in the 7UM512 (refer to Figure 4.6 and setting hints in Section 6.3.6). The protection decides on machine earth fault when all three criteria are met, i.e.

– displacement voltage larger than set value Uearth >,
– earth fault current across the measurement location larger than set value Iearth >,
– earth fault current is flowing in the direction of the protected machine.

On the occurrence of earth fault in the machine zone, the disconnection of the machine is initiated after a set delay time.

When the earth current is not decisive to detect an earth fault, e.g. because the circuit breaker is open, the earth current detection can be switched off by a control signal via a binary input of the relay. During this time, the displacement voltage stage is fully operative as the only earth fault protection (e.g. during run-up of the machine).

Figure 4.7 shows the logic diagram of the stator earth fault protection.

The earth fault protection provides, additionally, a faulty phase detector. This determines the phase angle between the displacement voltage and a phase-to phase voltage. As a result, the faulty phase is indicated in the fault annunciations, and may be assigned to a signal relay or LED.

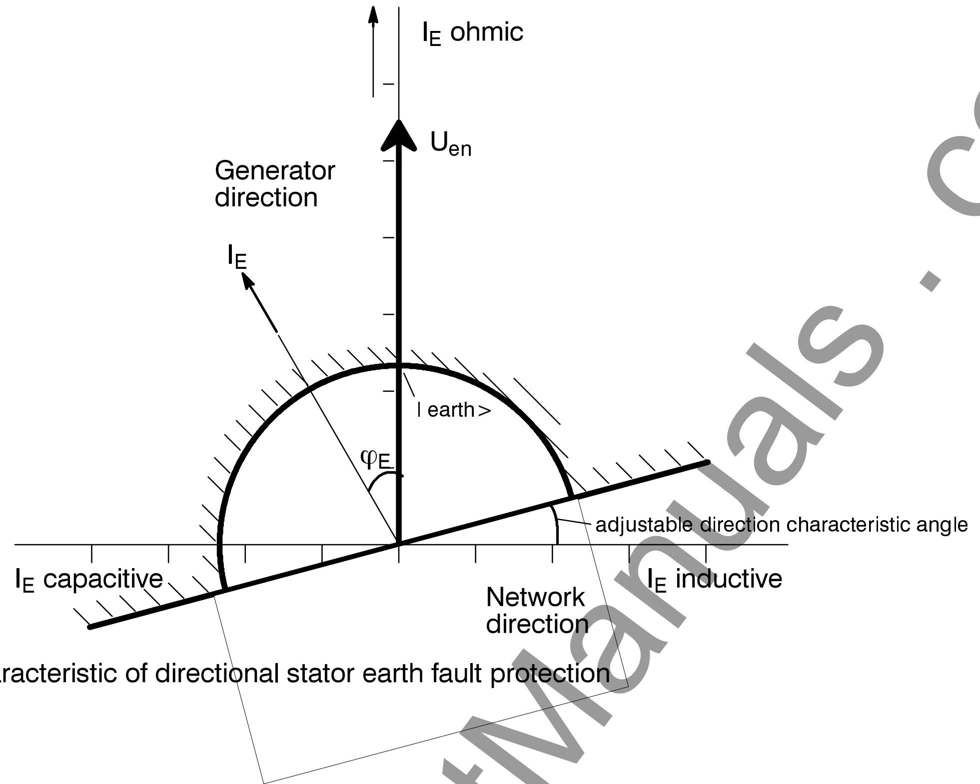


Figure 4.6 Characteristic of directional stator earth fault protection

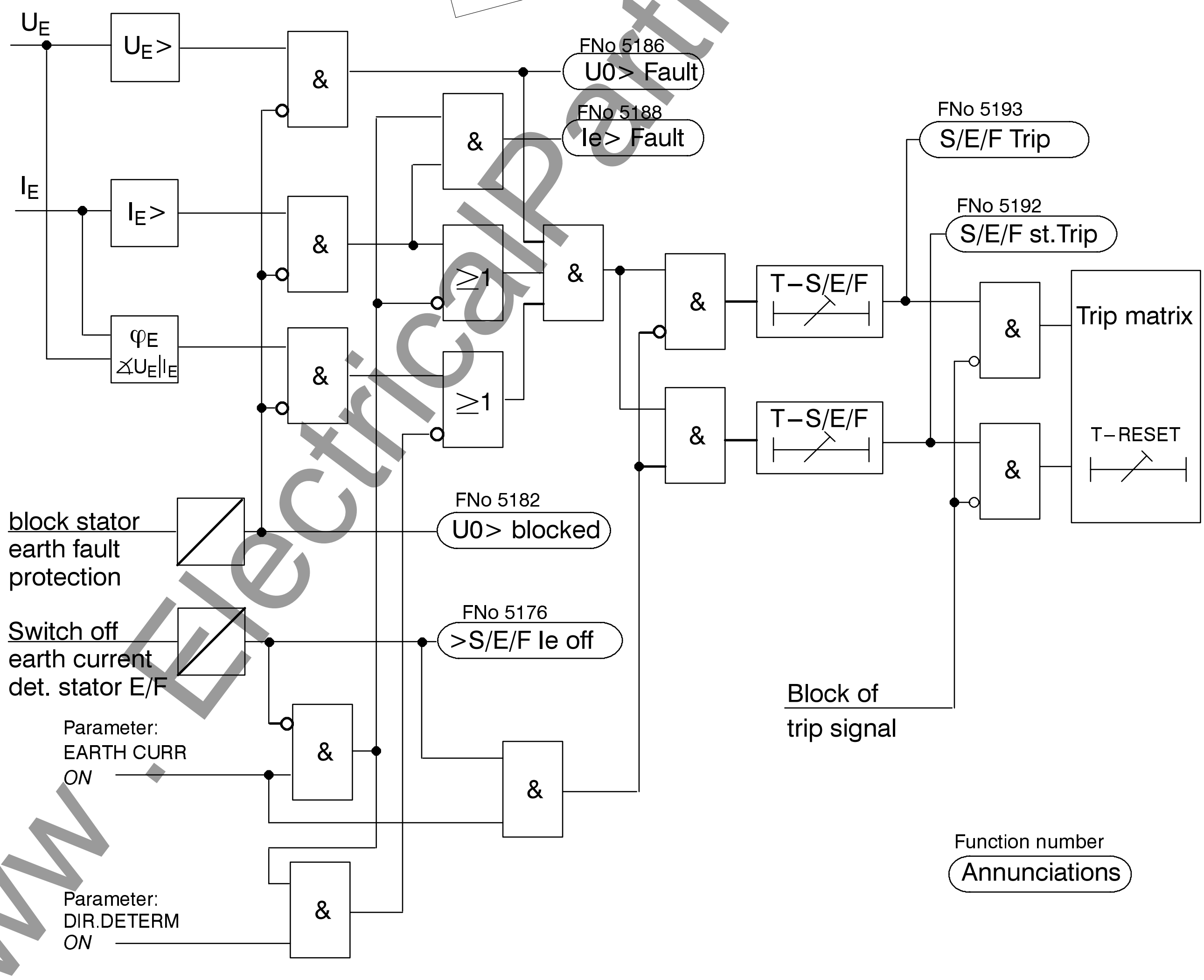


Figure 4.7 Logic diagram of the stator earth fault protection

4.5 Frequency protection

Frequency protection is used to disconnect electrical machines from the network in the event of an impermissible underfrequency or overfrequency condition.

The cause of **under**frequency is either an excessive demand of active power from the network, or faulty operation of the governor or of the frequency regulator. Underfrequency protection is also applied on generators which operate (temporarily) in an island network. In island operation the reverse power protection cannot operate should the prime mover fail. The underfrequency protection can be used to separate the generator from the network.

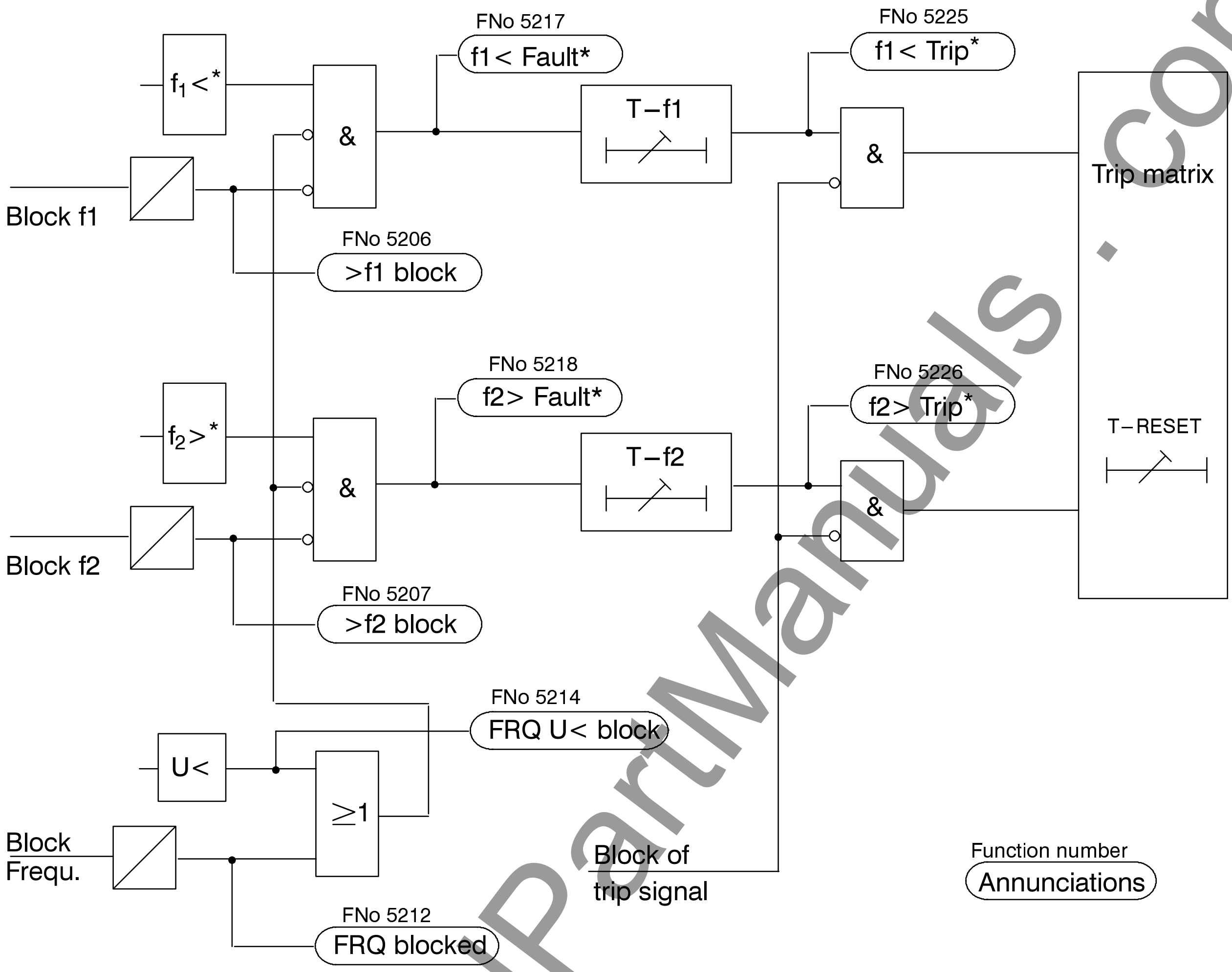
Overfrequency is caused, for example, by load shedding (island operation) or by faulty operation of the frequency regulator. The danger in this case is that machines connected to long unloaded lines may commence to self-excite.

The machine protection 7UM512 includes two frequency stages. Each stage can be set individually as an underfrequency or overfrequency stage and is independently from the other stages and can initiate different control functions.

For frequency measurement the protection uses the duration of the period, i.e. the distance between two zero passes, from a phase-to-phase voltage, e.g. U_{L1-L2}. The frequency can be determined as long as this voltage is present with sufficient magnitude and the frequency lies within the operating range. When the measured quantity is out of the operating range, no measurement is possible ("operating condition 0"). But, if the protection has already detected overfrequency when "operating condition 0" occurs, pick-up is maintained.

The trip commands can be delayed by an adjustable timer for each of the frequency stages. Blocking of each stage is possible as well as blocking of the total frequency protection, by external signals via binary inputs.

Figure 4.8 shows the logic diagram of the frequency protection.



* The pick-up symbols and the annunciations are illustrated for the preset configuration of the frequency protection. If the configuration is changed, the symbols < and > may appear interchanged.

Figure 4.8 Logic diagram of the frequency protection

4.6 Power supervision

The apparent power of a generator is limited in all directions of the complex power diagram. When the permissible **forward active** power (+P) is exceeded, the stator and rotor windings are thermally endangered. When the driving power fails and the synchronous generator runs as a motor driving the turbine, this **reverse** power (−P) is taken from the network; this condition leads to overheating of the turbine blades and must be interrupted within a short time by tripping the network circuit breaker.

Impermissible **capacitive** power (−Q) leads to underexcitation of a synchronous machine; furthermore, excessively high **inductive** power (+Q) is undesirable.

The machine protection relay 7UM512 includes a power supervision which monitors whether set limits for active power and reactive power (two stages) are exceeded. A choice can be made whether positive or the negative powers are monitored. Each of these functions can initiate different control functions.

The unit calculates the active and the reactive power from a phase-to-phase voltage (e.g. U_{L1-L2}) and an assigned phase current (e.g. I_{L3}). These values are compared with the set values. By taking the error angles of the instrument transformers into account, small active power and reactive power components are calculated even with very high apparent powers. Correction of the error angle is carried out by a constant correction angle W0 and a current proportional correction angle W1 as explained in Section 6.3.3 (Figure 6.3). These parameters can be examined by the relay itself during commissioning, and entered to the current transformer data. Each stage can be blocked individually via binary inputs.

Figures 4.9 and 4.10 show the logic diagrams of the active power supervision, Figure 4.11 shows the logic diagram of the reactive power supervision.

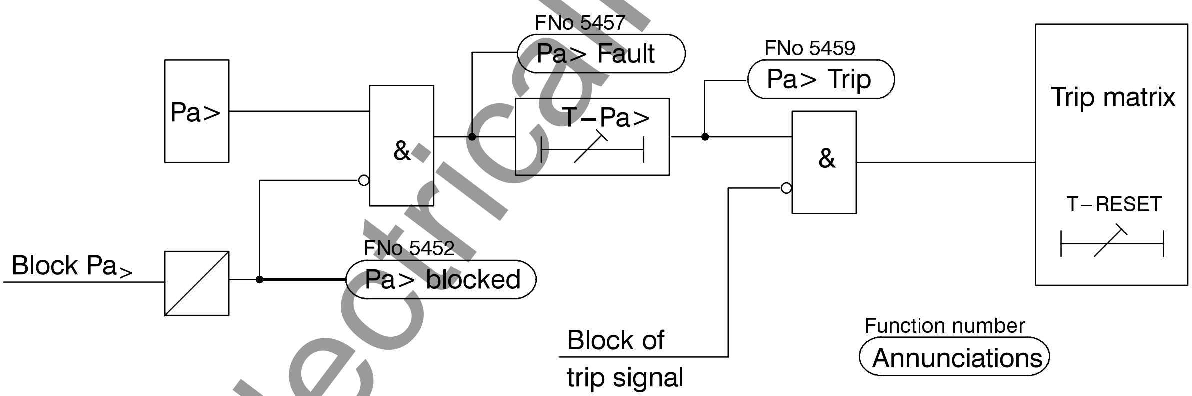


Figure 4.9 Logic diagram of the active power function as an forward power supervision

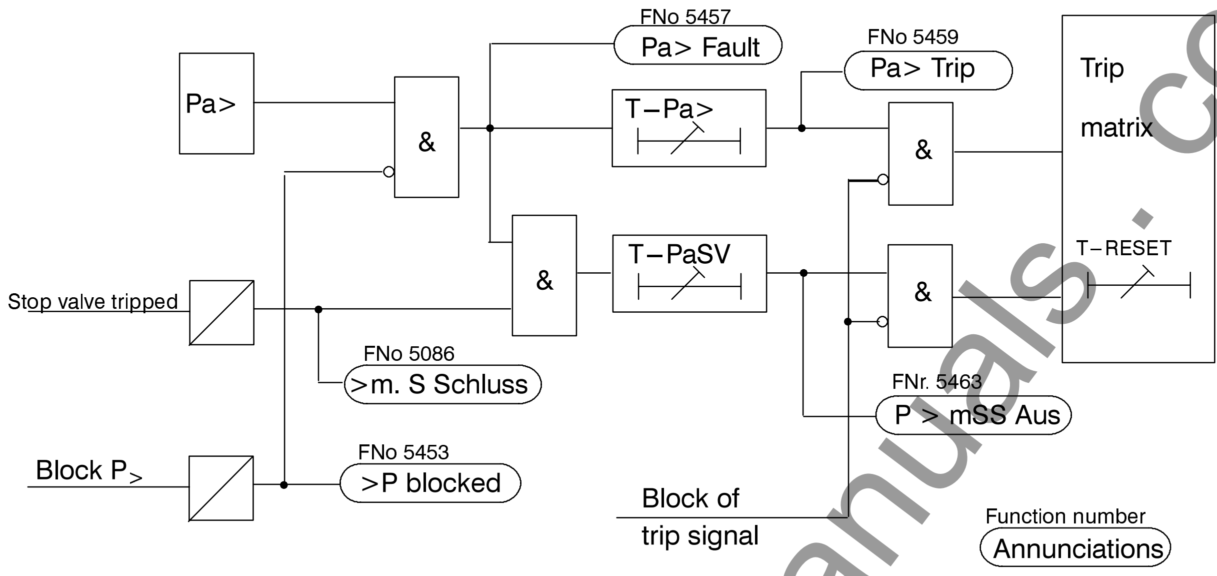


Figure4.10 Logic diagram of the active power function as a reverse power protection

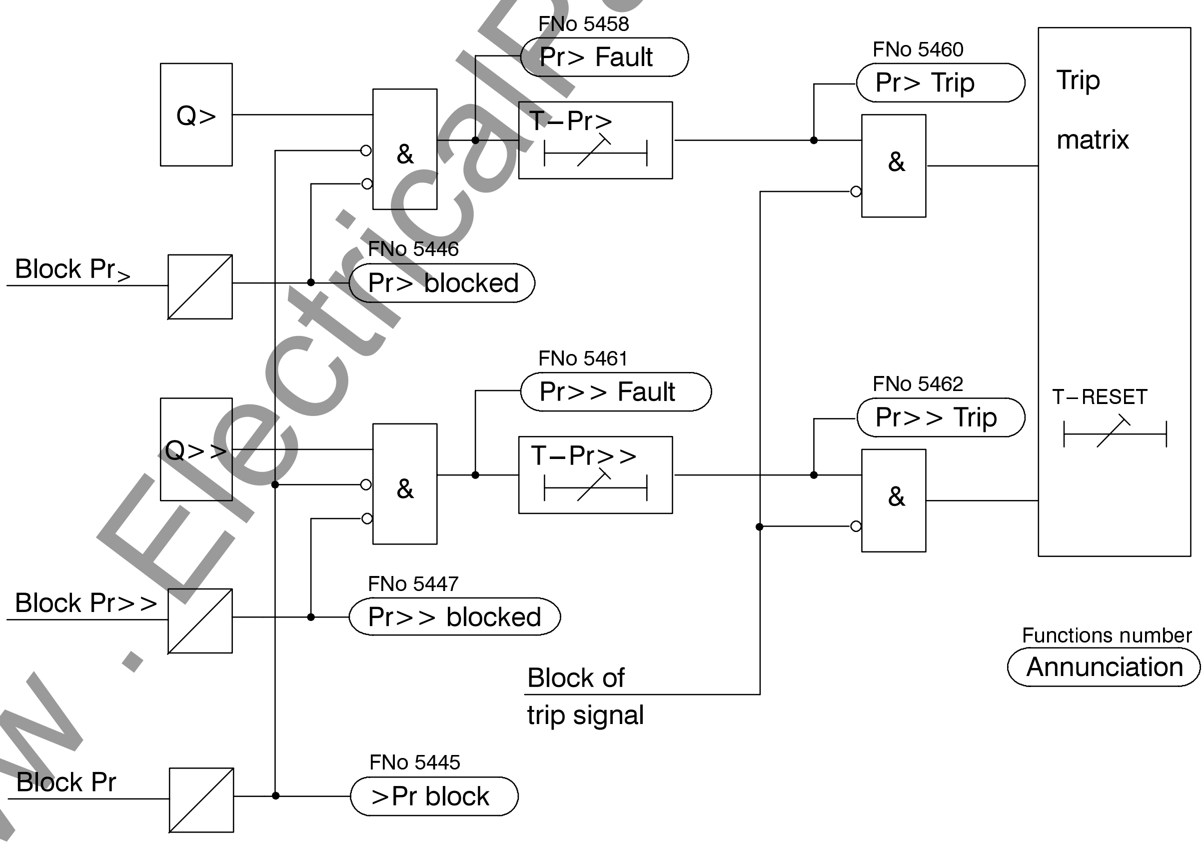


Figure 4.11 Logic diagram of the two-stage reactive power supervision

4.7 Unbalanced load protection

Unbalanced load protection is used to detect asymmetrical loading on three-phase induction machines. Asymmetrical loading produces an inverse (negative sequence) rotating field which acts, with double frequency, on the rotor. Eddy currents are induced on the surface of the rotor which lead to localized overheating in the rotor end zones and in the slot wedges.

In the unbalanced load protection of the 7UM512, the fundamental waves of the phase currents are filtered out and separated into symmetrical components. Only the negative sequence component, the inverse current I_2, is evaluated.

The unbalanced load protection uses a thermal replica – utilizing the negative sequence current I_2 – in order to simulate heating-up of the rotor. The referred temperature rise is calculated according to the following thermal differential equation:

$$\frac{d\Theta}{dt} + \frac{1}{\tau} \cdot \Theta = \frac{1}{\tau} \cdot I_2^2$$

whereby:

- Θ – actual temperature rise referred to end temperature rise at maximum permissible negative sequence current I_2
- τ – thermal time constant of heating-up of rotor surface
- I_2 – actual negative sequence current I_2 referred to maximum permissible negative sequence current

If the first adjustable temperature rise threshold is reached, an alarm is initiated. If the second temperature limit is reached, the machine can be disconnected from the network.

Since the temperature rise during steady-state operation is proportional to the square of the negative sequence current, it is not necessary to know the permissible temperature rise. The maximum continuously permissible negative sequence current $I_2>$ and the time constant (time-dependent unbalanced load capability) are the only parameters to be set.

If the value of the continuously permissible negative sequence current is exceeded, an alarm is initiated (refer to Figure 4.12). After the time corresponding to the actual negative sequence current and the time constant has elapsed, the machine is disconnected.

If large negative sequence currents occur, a two-phase network short-circuit can be assumed which must be disconnected in accordance with the time grading plan of the network. Therefore, an adjustable, definite-time, negative sequence current time stage is superimposed on the thermal characteristic (refer to Figure 4.12). Negative sequence current above 10 times the permissible value do not reduce tripping time (see also Figure 3.1).

Figure 4.13 shows the logic diagram of the unbalanced load protection.

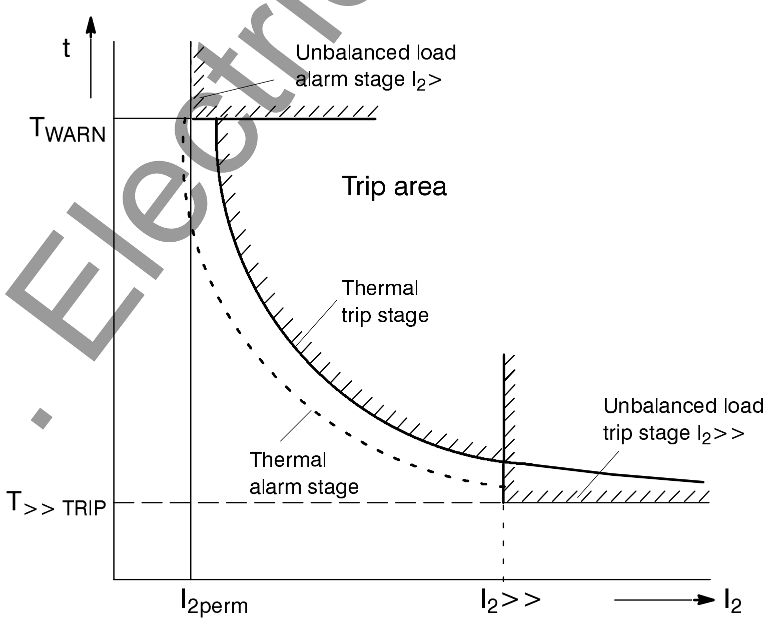
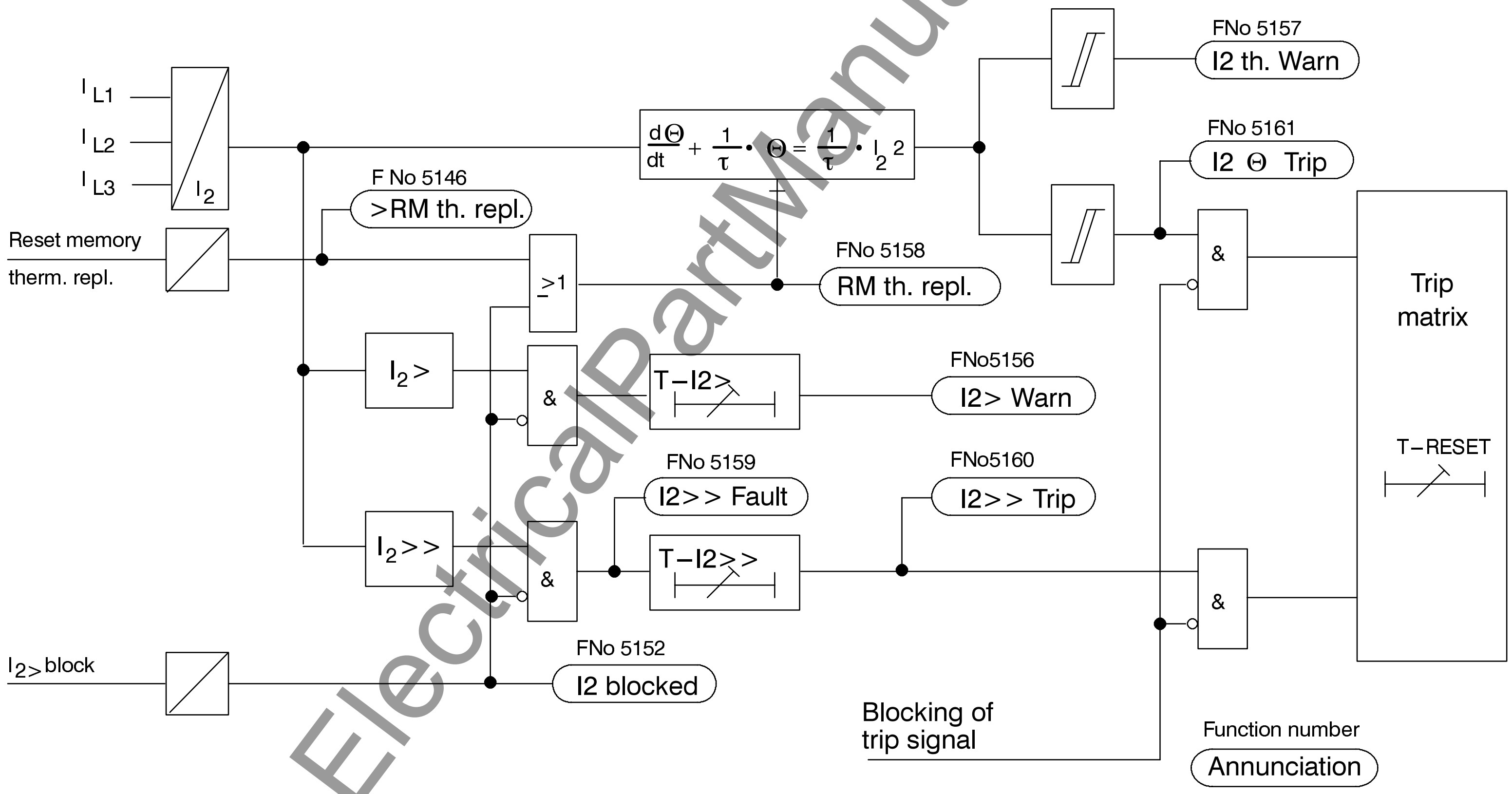


Figure 4.12 Trip characteristics of the unbalanced load protection



$$\frac{d\Theta}{dt} + \frac{1}{\tau}\cdot\Theta = \frac{1}{\tau}\cdot I_2^{\,2}$$

Figure 4.13 Logic diagram of the unbalanced load protection

4.8 Overcurrent time protection

The overcurrent time protection represents the short-circuit protection for small or low-voltage machines. For larger machines it is used as back-up protection for the machine short-circuit protection (differential protection and/or impedance protection). It provides back-up protection for network faults which are not promptly disconnected and thus may endanger the machine.

In order to ensure that pick-up always occurs even with internal faults, the protection – for generators – is always connected to the current transformer set in the neutral leads of the machine.

Initially, the currents are numerically filtered so that only the fundamental wave of the current is used for the measurement. This makes the measurement insensitive to transient conditions at the inception of a short-circuit and to offset short-circuit currents (d.c. component).

Each phase-current is individually compared with the setting values I> which are common and a phase-selective annunciation is initiated when a setting value is exceeded in any of the phases. After the associated delay time T–I> has elapsed, a trip signal is initiated.

The overcurrent time protection can be blocked via a binary input

In generators where the excitation voltage is taken from the machine terminals, the short-circuit current subsides very quickly in the event of close-up faults (i.e. in the generator or unit transformer range) due to the absence of excitation current and decreases within a few seconds to a value below the pick-up value of the overcurrent time protection. For this reason the overcurrent time protection includes a (disconnectable) undervoltage stage which maintains the pick-up signal for a set seal-in time if the voltages drops below a set level following pick-up of the overcurrent time protection, even if the overcurrent drops below the set value. In this way, the running of the trip delay time and tripping of the associated circuit breakers is ensured even for those cases. If the voltage recovers before the seal-in time has elapsed, then the protection resets. The undervoltage seal-in feature can be blocked via a binary input, e.g. in case of the voltage transformer secondary m.c.b. has tripped or the machine is switched off.

Furthermore, undervoltage seal-in can be coupled into the relay via a binary input, from an external three-phase undervoltage relay, e.g. from a 7UM511 relay.

Fig 4.14 shows the logic diagram of the overcurrent time protection.

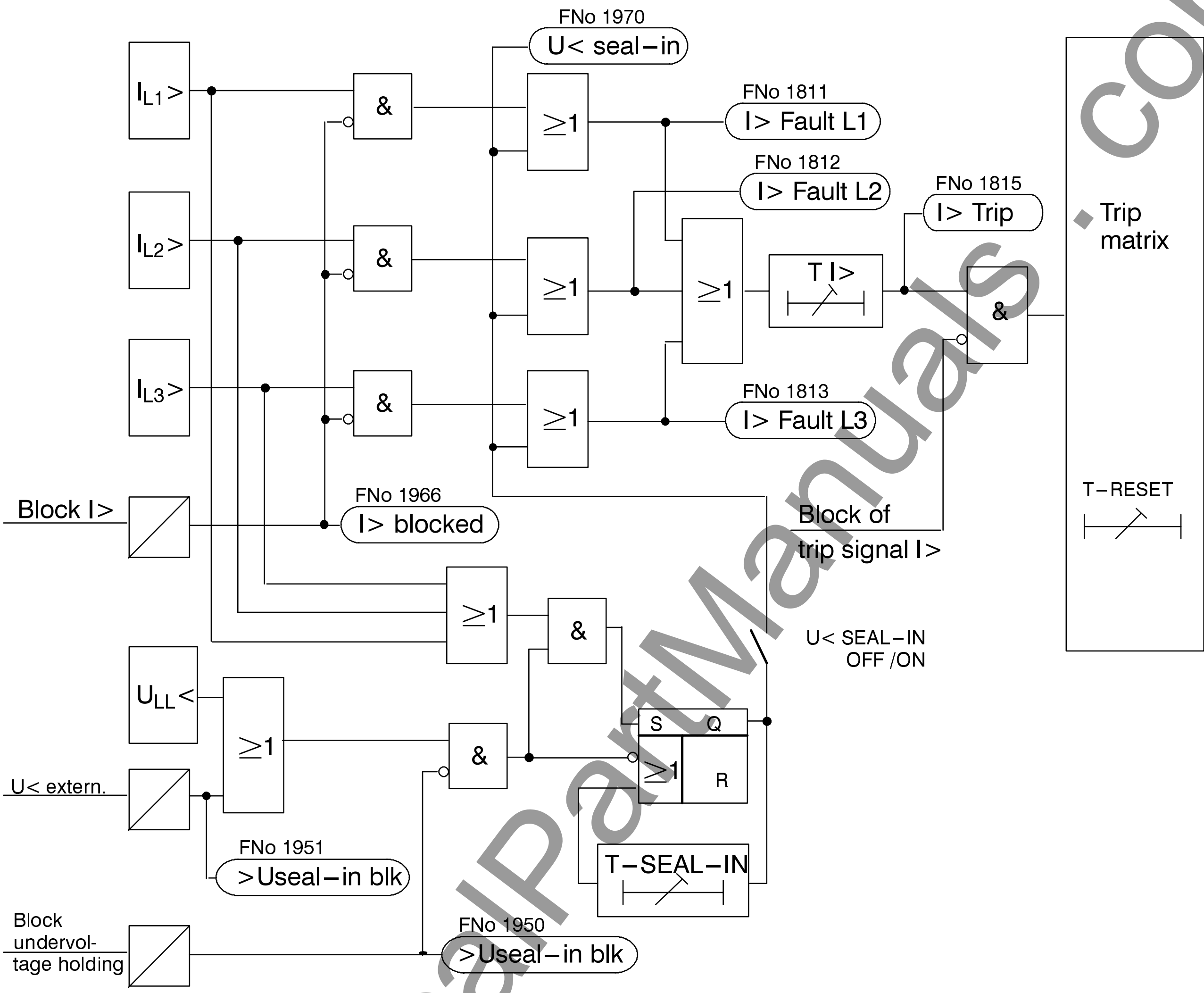


Figure 4.14 Logic diagram of the overcurrent time protection

4.9 Overcurrent/undercurrent supervision

The overcurrent or undercurrent supervision can be used for a variety of protection and supervisory tasks. As an overcurrent stage it can, for example, be used as further stage for the overcurrent time protection or as a simplified circuit breaker failure back-up protection. As an undercurrent stage it can serve, for example, as no-load supervision or to recognize disconnected or interrupted lines. Furthermore, control and regulating tasks are feasible.

Pick-up as well as reset of these functions can be time-delayed.

The currents are numerically filtered so that only the fundamental wave of the currents is used for the measurement. Further criteria can be coupled in via binary inputs and logically processed. Figures 4.15 and 4.16 show examples.

The logic diagram of the overcurrent/undercurrent supervision is illustrated in Figure 4.17.

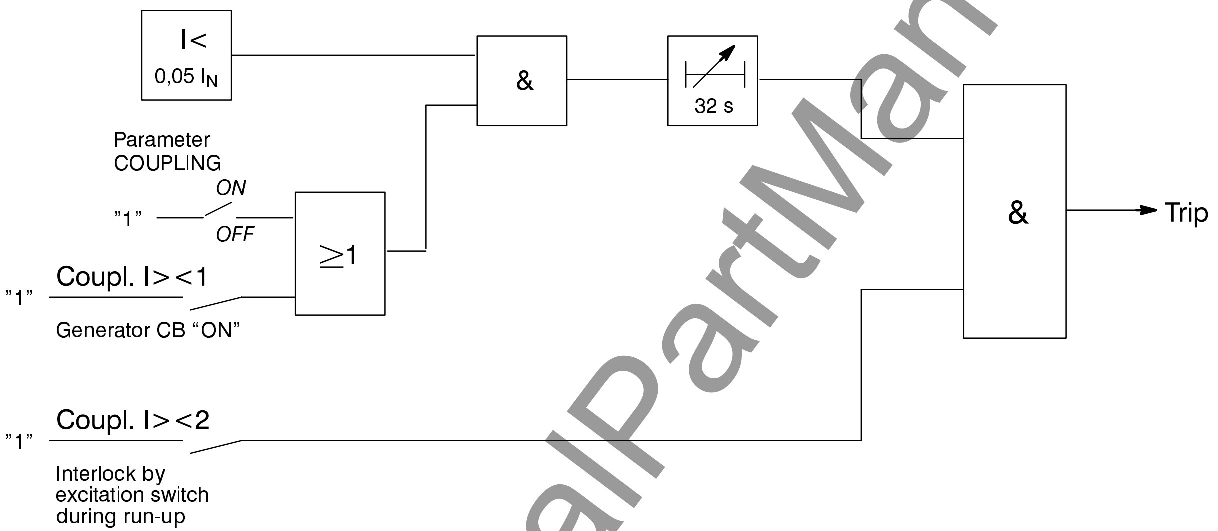


Figure 4.15 Example for disconnection at no-load status

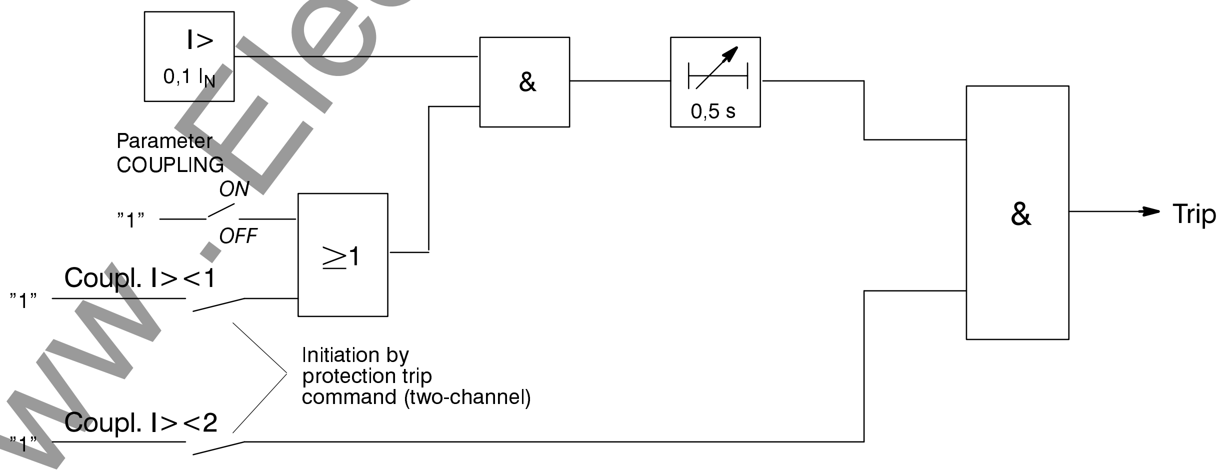


Figure 4.16 Example for circuit breaker failure protection

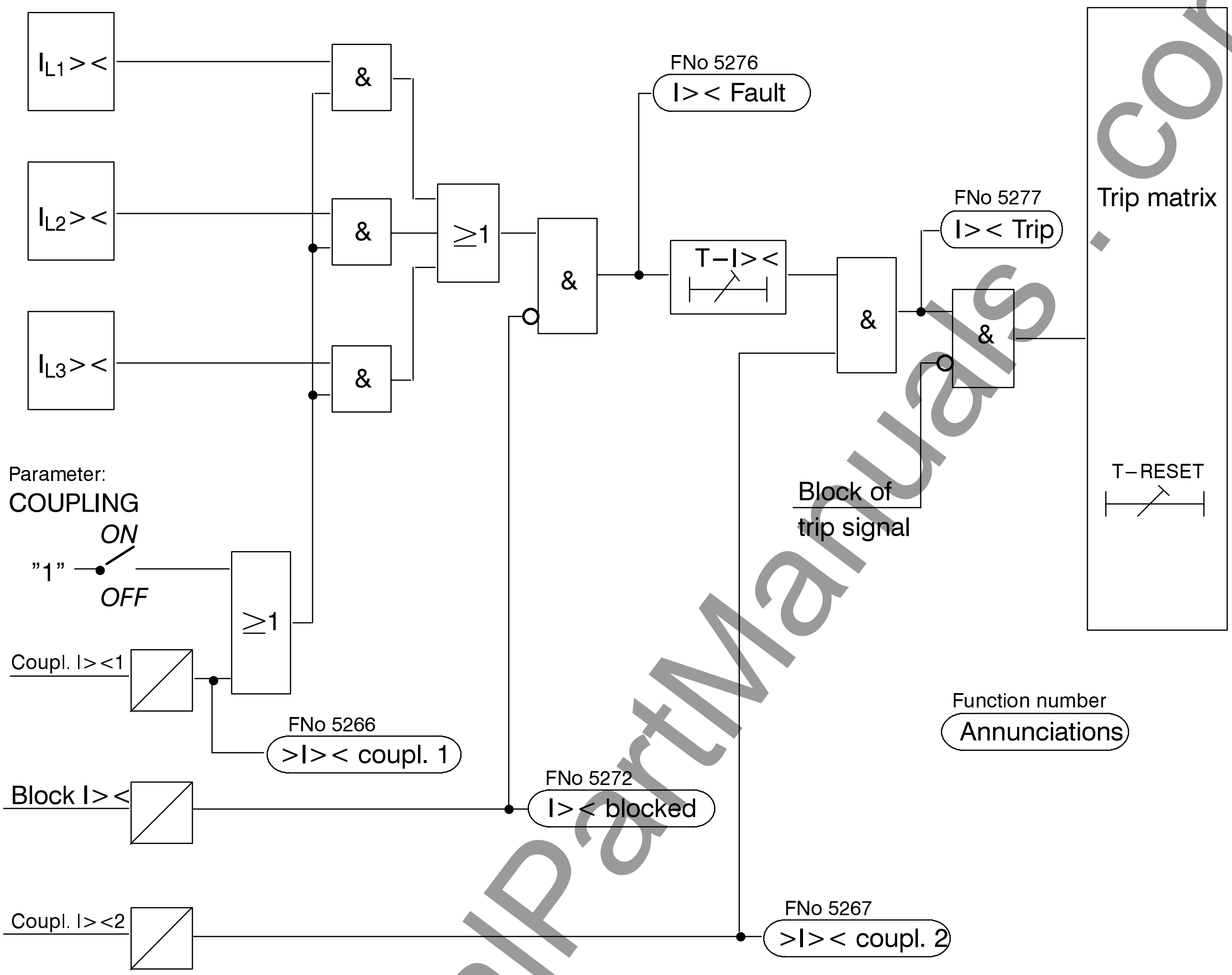


Figure 4.17 Logic diagram of the overcurrent/undercurrent supervision

4.10 Rotor earth fault protection

Rotor earth fault protection is used to detect earth faults in the excitation circuit of synchronous machines. One earth fault in the excitation winding does not cause immediate damage; however, if a second earth fault occurs, then this represents a winding short-circuit of the excitation circuit. Magnetic unbalances can occur resulting in extreme mechanical forces which can lead to the destruction of the machine.

The rotor earth fault protection in the 7UM512 uses an external auxiliary voltage of approximately 45 V a.c., which can be taken from the voltage transformers via a coupling unit (e.g. 7XR6100−0*A00). This voltage is symmetrically coupled to the excitation circuit via the capacitors of the coupling unit and simultaneously connected to the measurement input of the 7UM512. The capacitors are protected by series resistors and − in case high harmonic content is expected in the excitation circuit (e.g. excitation by thyristor circuits) − by an additional filter choke.

This auxiliary a.c. voltage drives a small charging current through the coupling unit, brush resistance and capacitance to earth of the excitation circuit. The current amounts to only a few mA during normal operation and is measured by the unit (Figure 4.18).

The rotor earth fault protection calculates the complex earth impedance from the auxiliary a.c. voltage and the current. The earth resistance of the excitation circuit is then calculated from the earth impedance. The unit also considers the coupling capacitance of the coupling unit, the series (e.g. brush) resistance and the capacitance to the earth excitation circuit. This method ensures that even relatively high-ohmic earth faults can be detected.

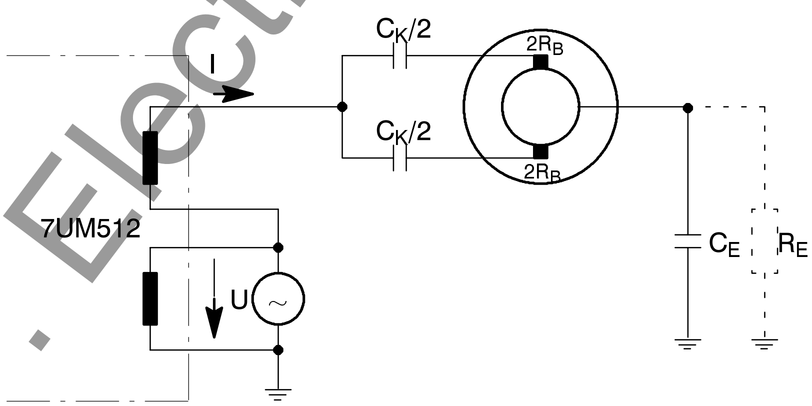
In order to eliminate the influence of harmonics − such as occur in static excitation equipment (thyristors or rotating rectifiers) − the measured quantities are filtered prior to their evaluation.

The earth resistance supervision is of two-stage design. Usually an alarm is initiated if the earth resistance falls below an initial high-resistance stage (e.g. 10 kΩ). If the value falls below the second low-resistace stage (e.g. 2 kΩ), then tripping will be initiated after a short time delay.

An additional current stage (100 mA) decides independent on the resistance calculation on earth fault.

Since a current flows even during healthy operation, i.e. the capacitive charging current, the protection can recognize and alarm an interruption in the measurement circuit, provided the capacitance to earth is at least 0.15 μF.

Figure 4.19 shows the logic diagram of the rotor earth fault protection.



C_K – Coupling capacitance
R_B – Series resistance (brushes)
C_E – Earth capacitance
R_E – Earth resistance
U, I – Measured quantities

Figure 4.17 Determination of the rotor earth resistance

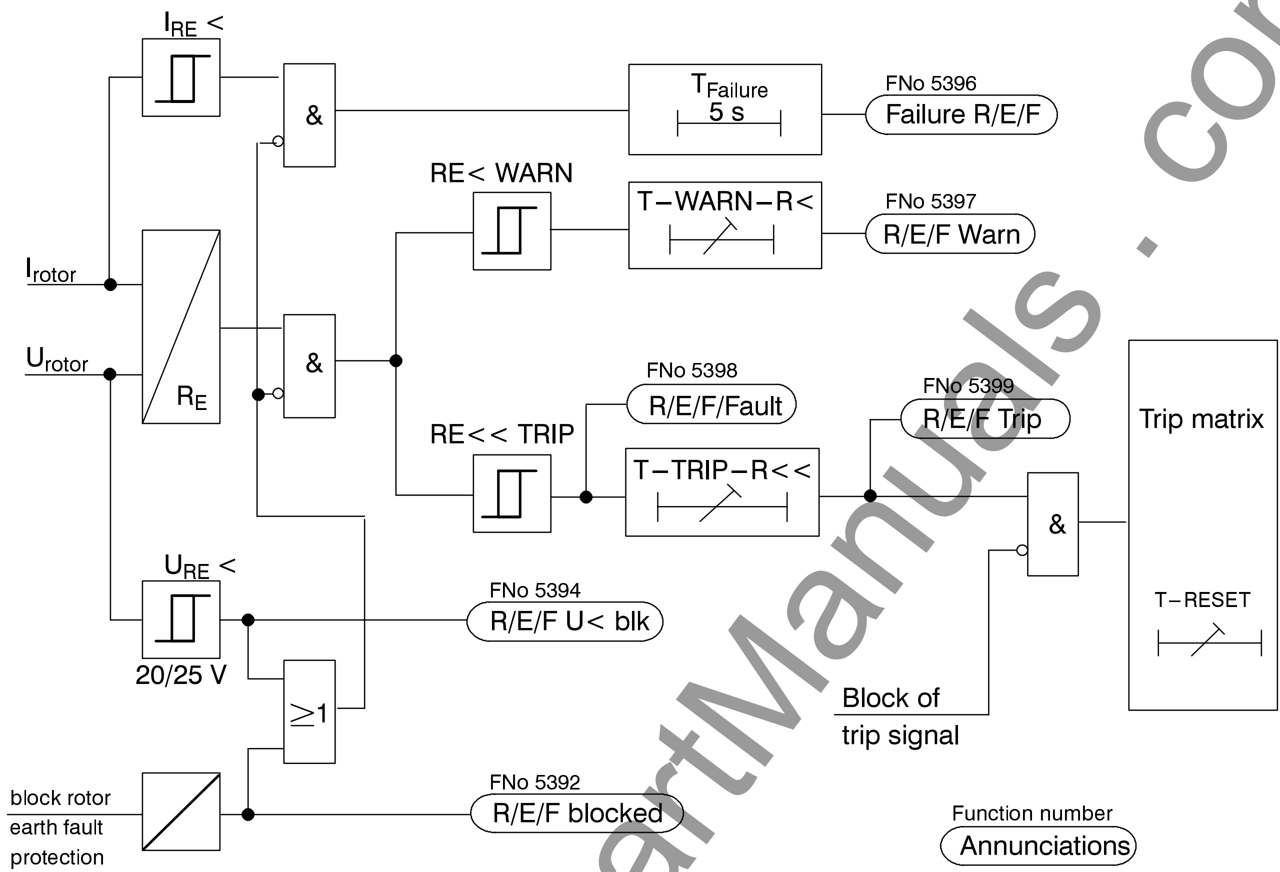


Figure 4.19 Logic diagram of the rotor earth fault protection

4.11 D.C. voltage time protection

To detect d.c. voltages the unit is equipped with a d.c. voltage input rated at 10 V and fitted with isolating amplifier. Higher d.c. voltages are connected via an external voltage divider. The d.c. voltage time protection can be used, for example, for the supervision of the excitation voltage of synchronous machines or for the detection of earth faults in the d.c. section of the start-up converter of a gas−turbine set.

A mean value filter is integrated against high ripple content or non-periodic peaks in the measurement voltage, which integrates the voltage over 40 ms (at 50 Hz); 24 samples are used. Since the absolute values are sampled the result is always positive. Thus, the polarity of the voltage is of no concern. When no suitable measured a.c. quantities are present ("operating condition 0"), the d.c. voltage time protection is operative, nevertheless. The mean value is then calculated over 4 x 24 measured value samples.

If, in special cases, an a.c. voltage should be measured via this analog input, then the r.m.s. value can be set on the protection; the factor 1.11 between r.m.s. and mean value is recognized within the protection function.

The protection can be set to operate for overvoltage $U_{dc}>$ or undervoltage $U_{dc}<$. The output signal can be time delayed.

Figure 4.20 shows the logic diagram of the d.c. voltage time protection.

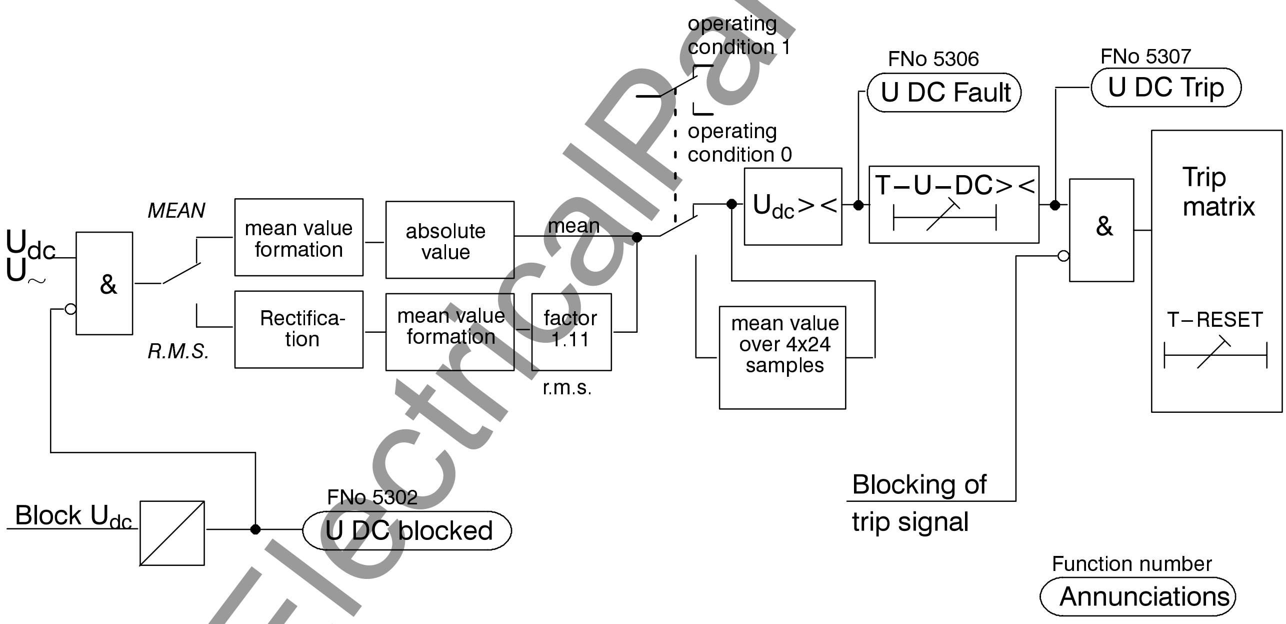


Figure 4.20 Logic diagram of the d.c. voltage time protection

4.12 External trip commands via binary inputs

Up to four desired signal from external protection or supervision units can be incorporated into the processing of 7UM512. The signals are coupled as "External signal" via binary inputs. Like the internal protection and supervision signals, they can be annunciated, time delayed, transmitted to the trip matrix, and blocked. By means of these signals it is possible to include external protection commands, e.g. from Buchholz protection or shaft current supervision, into the processing of annunciations and trip commands of 7UM512. Furthermore, an interaction of protection functions of different numerical machine protection relays of the series 7UM51 can be performed.

The status of the assigned inputs is checked in cyclic intervals. Alteration of the input status is considered only after two subsequent status checks with equal result. An additional time delay T–DELAY is available for each of the external trip command channels, a drop-off delay T–RESET can equally be set.

The logic diagram of one external trip command channel is illustrated in Figure 4.21. In total, the relay incorporates four such channels, i.e. four times this logic. The illustrated function numbers are valid for the first external trip command channel.

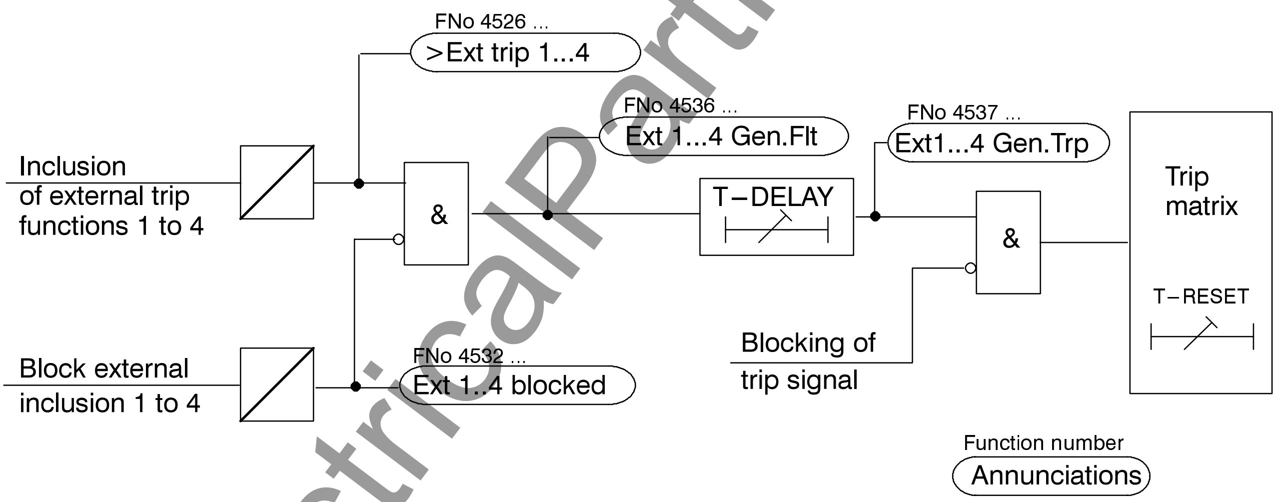


Figure 4.21 Logic diagram of one external trip command channel

4.13 Switch-over of the phase rotation

The relay provides the facility to change the phase rotation via energization of a binary input. This allows to use all protection functions in case the phase rotation is counter-clockwise without interchanging of phases. This is useful, for example, when the relay is used for the protection of generator–motors in a pumped–storage power station, where the rotation is reversed during pumping operation of the turboset. When the assigned binary input is energized, all protection functions which operate dependent on the phase sequence are internally switched over to counter-clockwise phase rotation.

Switch-over of the phase rotation is registered by the relay only while its state is "operating condition 0" (no suitable measured quantities present). Furthermore, the switch-over signal must be present for at least 200 ms. After this, the phase quantities of the phases L2 and L3 are swapped. But this is relevant only for the internal calculation of the symmetrical components; the phase dedicated annunciations, fault recordings, and measured values are not affected.

During "operating condition 0" the phase rotation is determined by the state of the assigned binary input for phase rotation provided the status change of the binary input lasts 200 ms or longer. When the status change is shorter than 200 ms, it is not registered. The status change is neither registered when the "operating condition 0" is left before the 200 ms have elapsed. During "operating condition 1" (suitable measured quantities are present), switch-over of the phase rotation is not possible. An applied signal to the binary input – once having been registered – may be removed during "operating condition 1". But it is recommended to maintain the control signal for phase rotation reversal in oder to ensure correct funtionig even in case of abnormal occurrences, e.g. processor reset after alterations of configuration parameters.

Figure 4.22 shows the logic diagram of the switch-over function of the phase rotation.

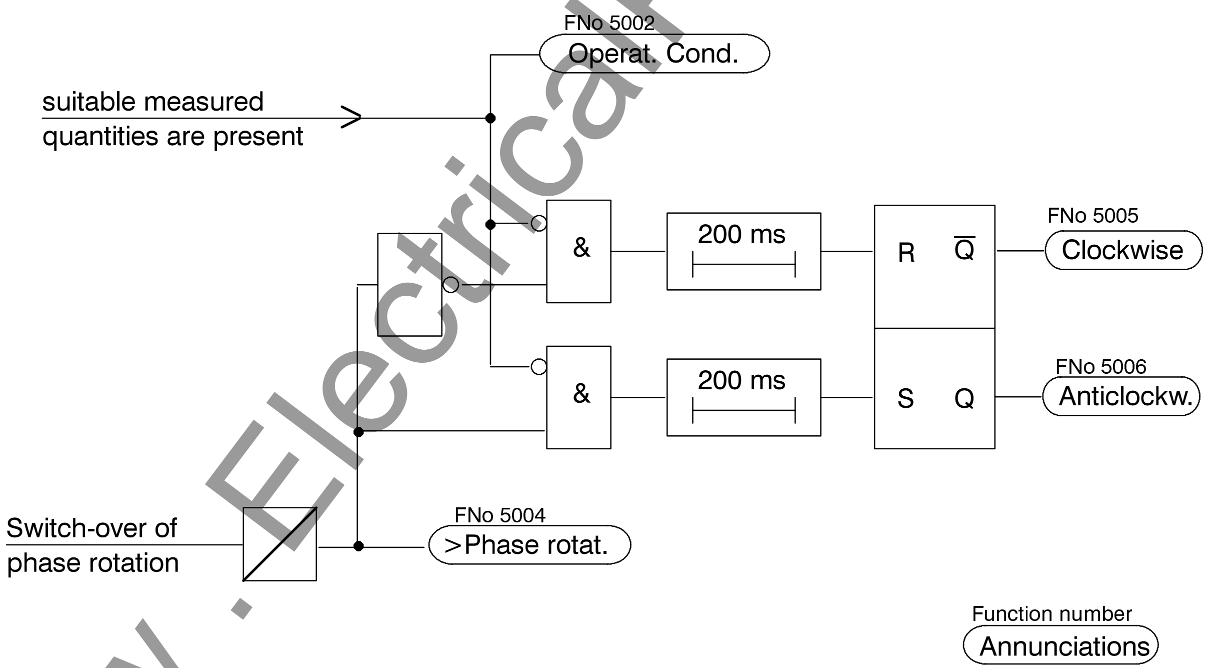


Figure 4.22 Logic diagram of the switch-over of the phase rotation

4.14 Trip matrix

The numerical machine protection 7UM51 includes an integrated trip matrix. The trip 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 4.12, can be marshalled to the 5 trip relays of the unit as required. External signals such as, for example, from the Buchholz protection, pressure or temperature supervision, shaft vibration measurement, etc., can be coupled into the 7UM51 via a binary input and marshalled to the trip relays via the trip matrix. Each trip relay can be assigned to a switching element, such as a circuit breaker, de-excitation circuit breaker, trip valve, or other control gear. Alternatively, five different tripping programs can be realized by using external master trip relays.

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.

4.15 Circuit breaker trip test

Numerical machine protection relay 7UM51 allows simple checking of the tripping circuits and the circuit breakers.

Prerequisite for the start of a test cycle is that no protective function has picked up.

Initiation of the test cycle can be given from the operator keyboard or via the front operator interface (as described in Section 6.7.9).

4.16 Trip circuit supervision

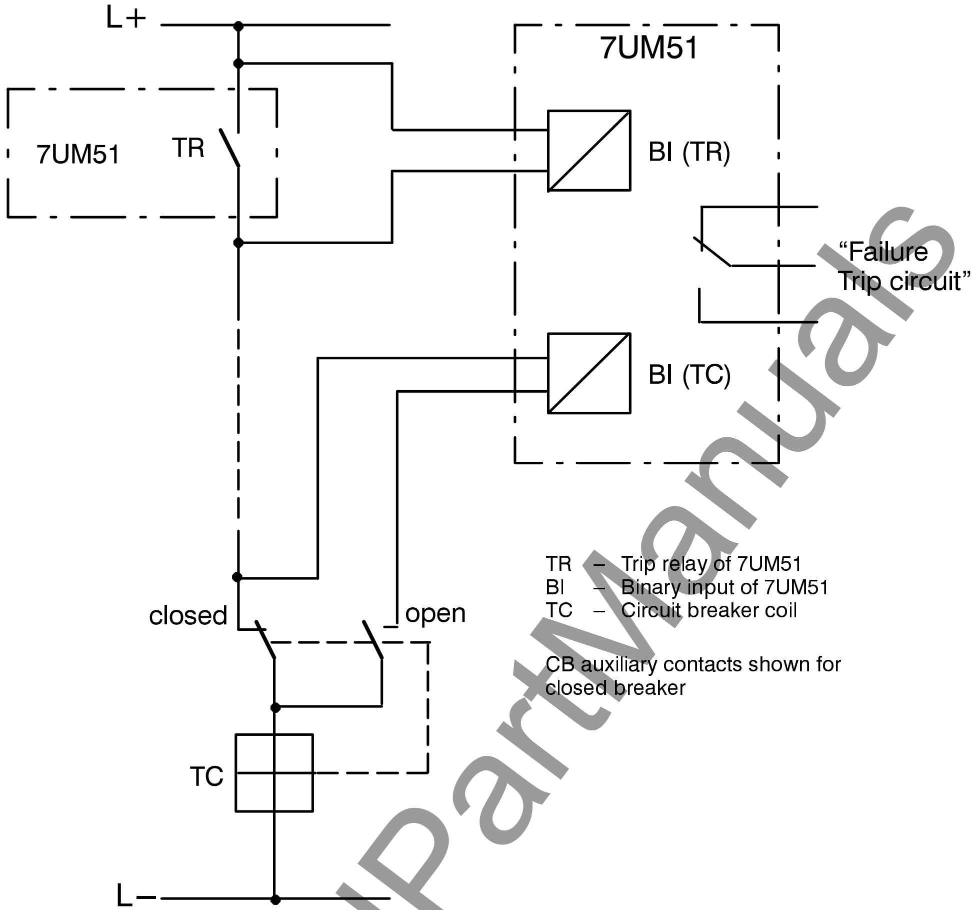
The numerical machine protection 7UM51 includes two trip circuit supervision functions. Two trip circuits can be supervised. Two binary inputs must be reserved for each trip circuit supervision. They have to be connected as shown in Figure 4.23. One input is connected in parallel to the trip relay the circuit of which is to be supervised; the other input is connected in parallel to the circuit breaker auxiliary contact or over the NO and NC auxiliary contacts as Figure 4.23 shows.

The binary inputs are energized (logical “H”) or short-circuited (logical “L”) depending on the status of the trip relay and the circuit breaker.

During normal operation it is not possible that both the binary inputs are de-energized (logical “L”) at the same time unless for the short time where the trip relay has already closed but the breaker is not yet open.

If both the binary inputs are de-energized continuously, this indicates that either the trip circuit is interrupted, or the trip circuit is short-circuited, or the control voltage for tripping is absent, or the breaker has not properly operated. Thus, this status indicates a fault in the trip circuit.

The status of the two binary inputs is checked twice to three times per second. An intentional time delay for alarm can be produced by setting the number of repeated status checks before an alarm is given.



No	Trip relay	CB position	BI (TR)	BI (TC)
1	open	CLOSED	H	L
2	open	OPEN	H	H
3	closed	CLOSED	L	L
4	closed	OPEN	L	H

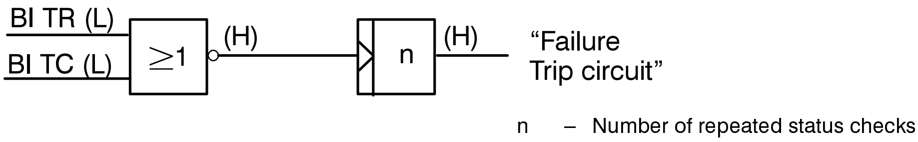


Figure 4.23 Principle of trip circuit supervision (one supervision channel)

4.17 Ancillary functions

The ancillary functions of the machine protection 7UM512 include:

– Processing of annunciations,

– Storage of short circuit data for fault recording,

– Operational measurements and testing routines,

– Monitoring functions.

4.17.1 Processing of annunciations

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

4.17.1.1 Indicators and binary outputs (signal relays)

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

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

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

– locally, by operation of the reset button on the relay,
– remotely by energization of the remote reset input,
– remotely via one of the interfaces.

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.

4.17.1.2 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 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 fault, selectable information on the fault appears instead of the operating information, e.g. detected phase(s) and elapsed time from fault detection to trip command. The quiescent information is displayed again once these fault annunciations have been acknowledged. The acknowledgement is identical to resetting of the stored LED displays as in Section 4.17.1.1.

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

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

A fault begins with recognition of the fault by pick-up of any protection function and ends with the latest reset of a protection function.

4.17.1.3 Information to a central unit

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

4.17.2 Data storage and transmission for fault recording

The device incorporates a data store which can optionally store the instantaneous values or the r.m.s. values of various measured quantities.

The instantaneous values of the measured values

i_{L1}, i_{L2}, i_{L3}, u_{LL}, u_0, i_0, u_{LES}, i_{LES}

can be sampled at intervals of 12 values per a.c. period 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 r.m.s. values of the quantities

I_{L1}, I_{L2}, I_{L3}, U_{LL}, U_0, I_0, $I_{neg.seq}$, $f-f_N$

can alternatively be sampled in intervals of 1 a.c. period and stored in a circulating shift register. In case of a fault, the data are stored over a selectable time period, but max. over 60 seconds.

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

The data can be transferred to a connected personal computer via the operation interface at the front and evaluated by the protection data evaluation program DIGSI®. The currents and voltages are referred to their maximum values, normalized to their rated values and prepared for graphic visualization. In addition, signals can be marked as binary traces, e.g. “Pick-up” and “Trip”.

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

When the data are transferred to a central unit, readout can proceed automatically, optionally after each pick-up of the relay or only after a trip. The following then applies:

– The relay signals the availability of fault record data,
– The data remain available for recall until commencement of the next fault event.
– A transmission in progress can be aborted by the central unit.

4.17.3 Operating measurements and conversion

For local recall or transmission of data, the true r.m.s. values of the currents are always available as are the positive sequence component of the currents. Additionally, the true r.m.s. value of the phase-to-phase voltage, the displacement voltage and the earth current can be read out.

The following is valid:

- I_{L1}, I_{L2}, I_{L3} phase currents in amps primary and in % of rated current I_N,
- $I_{pos.seq}$ positive sequence current.
- U_{LL} voltage (phase-phase) in volts secondary,
- U_0 displacement voltage,
- I_e earth currents in milliamps.

Additionally, the active and reactive power, the power factor and power angle, the d.c. voltage, the frequency, the displacement voltage and the earth current of the rotor as well as the calculated impedance components or the rotor earth circuit, the rotor earth resistance, the unbalanced load and the calculated rotor temperature rise can be read out:

- Pa active power in % of $\sqrt{3} \cdot I_N \cdot U_N$,
- Pr reactive power in % of $\sqrt{3} \cdot I_N \cdot U_N$,
- COS PHI power factor,
- PHI power angle,
- f [Hz] frequency in Hz,
- U_{dc} D.C. voltage in volts,
- R_E rotor earth resistance in kΩ,
- U_{rotor} displacement voltage of the rotor,
- I_{rotor} earth current (rotor) in milliamps,
- $R_{ges.}$ active component of the total rotor earth impedance in kΩ,
- $X_{ges.}$ reactive component of the total rotor earth impedance in kΩ.
- $I_{neg.seq}$ unbalanced load current in % I_N,
- ThermRepl. temperature rise calculated from the unbalanced load current in % of trip temperature rise.

4.17.4 Monitoring functions

7UM51 incorporates comprehensive monitoring functions which cover both hardware and software; furthermore, the measured values are continuously checked for plausibility so that the current and voltage transformer circuits are also included in the monitoring system.

4.17.4.1 Hardware monitoring

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

- Auxiliary and reference voltages

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

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

- Measured value acquisition

  The complete chain, from the input transformers up to and including the analog/digital converters are monitored by the plausibility check of the measured values.

  In the **current path**, there are three input converters; the digitized sum of the outputs of these must be almost zero under normal operation. When the star-point of the machine is not or high-ohmic earthed (address 1108), current sum check is carried out. A fault in the current path is then recognized when

  $$|i_{L1} + i_{L2} + i_{L3}| > \text{SUM.Ithres} \times I_N + \text{SUM.Fact.I} \times I_{max}$$

  SUM.Ithres and SUM.Fact.I are setting parameters (refer 6.3.13). The component SUM.Fact.I x I_{max} takes into account permissible current proportional transformation errors in the input converters which may particularly occur under conditions of high currents (Figure 4.24).

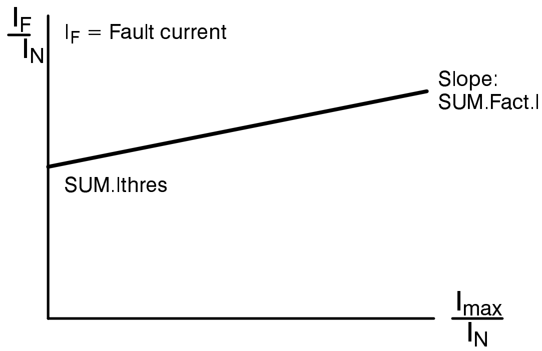


Figure 4.24 Current sum monitoring

Current sum monitoring is not effective when the star-point of the machine is low-resistance earthed (cf. parameter address 1108).

– Command output channels:

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

– Memory modules:

The memory modules are periodically checked for fault by:

- Writing a data bit pattern for the working memory (RAM) and reading it,
- Formation of the modulus for the program memory (EPROM) and comparison of it with a reference program modulus stored there,
- Formation of the modulus of the values stored in the parameter store (EEPROM) then comparing it with the newly determined modulus after each parameter assignment process.

4.17.4.2 Software monitoring

For continuous monitoring of the program sequences, a watchdog timer is provided which will reset the processor in the event of processor failure or if a program falls out of step. Further, internal plausibility checks ensure that any fault in processing of the programs, caused by interference, will be recognized. Such faults lead to reset and restart of the processor.

If such a fault is not eliminated by restarting, further restarts are initiated. If the fault is still present after three restart attempts the protective system will switch itself out of service and indicate this condition by drop-off of the availability relay, thus indicating "equipment fault" and simultaneously the LED "Blocked" comes on.

4.17.4.3 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 4.25). Both parameters can be set (see Section 6.3.13).

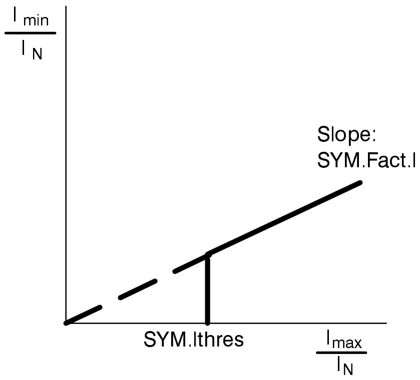


Figure 4.25 Current symmetry monitoring

– Phase rotation

Since correct functioning of the protection functions relies upon a clockwise sequence of the currents (symmetrical components), the direction of rotation is monitored:

I_{L1} before I_{L2} before I_{L3}

This check is carried out when the measured voltages as described in 4.17.4.1 are plausible and have a minimum value of at least

$|I_{L1}|, |I_{L2}|, |I_{L3}| > 0.1\ I_N$

Counter-clockwise rotation will cause an alarm.

In those cases where counter-clockwise phase rotation can occur during operation, e.g. in pumped-storage power stations, the relay must be informed about the reversal of the phase sequence via a appropriately assigned binary input. When this input is energized, the phases L2 and L3 are internally swapped in order to ensure correct symmetrical component calculation (see also Section 4.13). The phase dedicated annunciations, fault recordings, and measured values are not affected.

Table 4.1 gives a survey of all the functions of the measured value monitoring system, together with the possible causes and the associated annunciations. It is possible that more than one monitoring function operates during a certain disturbance. Blocking of any protection function does not take place.

Monitoring	Failure covered, reaction
1. Plausibility check of currents $\|i_{L1} + i_{L2} + i_{L3}\| >$ **SUM.Ithres** x I_N + **SUM.Fact.I** x I_{max}	Relay failures in the signal acquisition circuits i_{L1}, i_{L2}, i_{L3} delayed alarm "`Failure ΣI`"
2. Current unbalance $\frac{\|I_{min}\|}{\|I_{max}\|}$ < **SYM.Fact.I** and $\|I_{max}\| >$ **SYM.Ithres**	Single, or phase-to-phase short circuits or broken conductors in the c.t. circuits i_{L1}, i_{L2}, i_{L3} or Unbalanced load delayed alarm "`Failure Isymm`"
3. Phase rotation L1 before L2 before L3, as long as $\|I_{L1}\|, \|I_{L2}\|, \|I_{L3}\| > 0.1 \cdot I_N$ (Operating condition 1) and counter-clockwise rotation is not indicated via a binary input	Swapped voltage connections or reverse rotation sequence delayed alarm "`Fail.PhaseSeq`"

Bolted figures are setting values.

Table 4.1 Summary of measuring circuit monitoring

5 Installation instructions

Warning

The successful and safe operation of this device is dependent on proper handling and installation by qualified personnel under observance of all warnings and hints contained in this manual.

In particular the general erection and safety regulations (e.g. IEC, DIN, VDE, or national standards) regarding the correct use of hoisting gear must be observed. Non-observance can result in death, personal injury or substantial property damage.

5.1 Unpacking and repacking

When dispatched from the factory, the equipment is packed in accordance with the guidelines laid down in IEC 255–21, 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 255–21–1 class 2 and IEC 255–21–2 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 7UM51★★–★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 26) of the unit to the protective earth of the panel.

– Make a solid low-ohmic and low-inductive operational earth connection between the earthing surface at the side of the unit using at least one standard screw M4, and the earthing continuity system of the panel; recommended grounding strap DIN 72333 form A, e.g. Order-No. 15284 of Messrs Druseidt, Remscheid, Germany.

– Make connections via screwed terminals. Observe labelling of the individual connectors and the max. permissible conductor cross-sections.

5.2.1.2 Model 7UM51★★–★C★★★ for panel flush mounting or 7UM51★★–★E★★★ for cubicle installation

– Lift up both labelling strips on the lid of the unit and remove cover to gain access to four holes for the fixing screws.

– Insert the unit into the panel cut-out and secure it with the fixing screws. For dimensions refer to Figure 2.3.

– Connect earthing screw on the rear of the unit to the protective earth of the panel or cubicle.

– Make a solid low-ohmic and low-inductive operational earth connection between the earthing surface at the rear of the unit using at least one standard screw M4, and the earthing continuity system of the panel or cubicle; recommended grounding strap DIN 72333 form A, e.g. Order-No. 15284 of Messrs Druseidt, Remscheid, Germany.

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

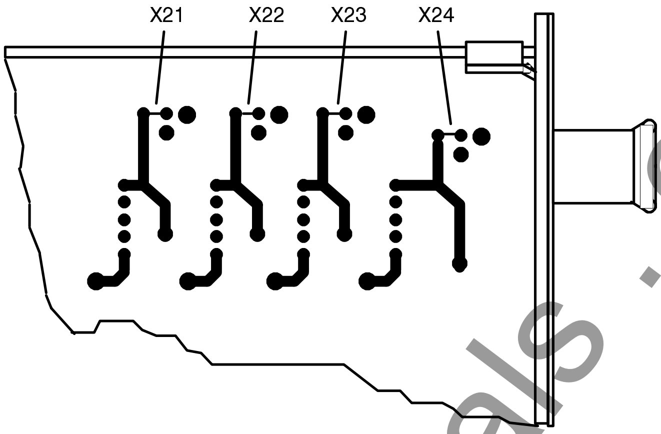
5.2.2 Checking the rated data

The rated data of the unit must be checked against the plant data. This applies in particular to the auxiliary voltage and the rated current of the current transformers. The voltage divider for the measurement of the excitation voltage should be dimensioned such that under rated excitation no more than 8 V appear at the unit input (if the excitation voltage input is used).

5.2.2.1 Control d.c. voltage of binary inputs

When delivered from factory, the binary inputs are designed to operate in the total control voltage range from 19 V to 288 V. The pick-up threshold lies near 16 V. In order to optimize the operation of the inputs, they should be matched to the real control voltage to increase stability against stray voltages in the d.c. circuits.

To fit a higher pick-up threshold of approximately 80 V to a binary input a solder bridge must be removed. Figure 5.1 shows the assignment of these solder bridges for the inputs BI 1 to BI 4, and their location on the basic p.c.b. of the basic input/output module GEA–1. Figure 5.2 shows the assignment of these solder bridges for the inputs BI 5 to BI 8 and their location on the additional input/output module ZEA–1.



Binary input 1 : Solder bridge X21

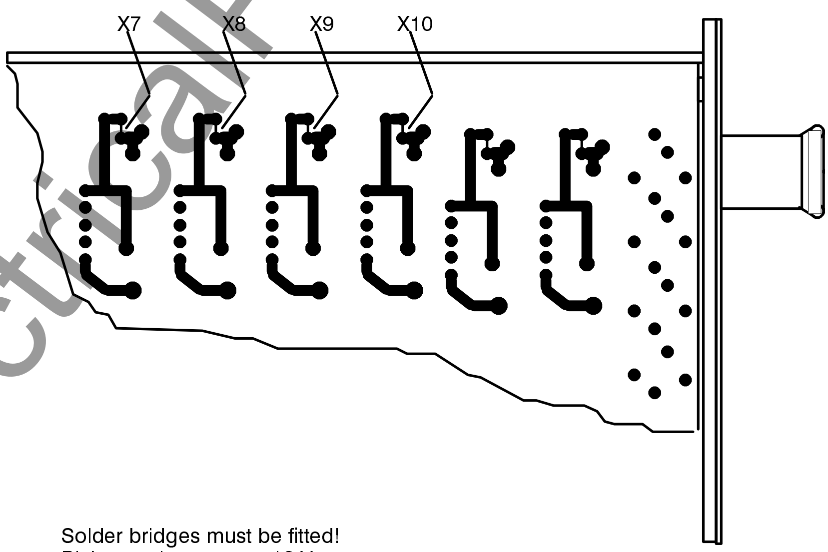
Binary input 2 : Solder bridge X22

Binary input 3 : Solder bridge X23

Binary input 4 : Solder bridge X24

For rated voltages 24/48/60 V– :	Solder bridges must be fitted! Pick-up value approx. 16 V
For rated voltages 110/125/220/250 V– :	Solder bridges may be removed: Cut and bend aside. Pick-up value approx. 80 V

Figure 5.1 Checking for control voltages for binary inputs 1 to 4 on basic module GEA–1



Binary input 5 : Solder bridge X7

Binary input 6 : Solder bridge X8

Binary input 7 : Solder bridge X9

Binary input 8 : Solder bridge X10

For rated voltages 24/48/60 V– :	Solder bridges must be fitted! Pick-up value approx. 16 V
For rated voltages 110/125/220/250 V– :	Solder bridges may be removed: Cut and bend aside. Pick-up value approx. 80 V

Figure 5.2 Checking for control voltages for binary inputs 5 to 8 on additional module ZEA–1

– Open housing cover.

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

Caution!

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

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

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

– 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–1 according to Figure 5.2. (This smaller module has pulling handles instead of the releasing lever).

– Close housing cover.

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

In later production series, the battery is installed at delivery so that no activities are necessary here. The correct location can be checked according to Section 7.2.

5.2.4 Checking 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

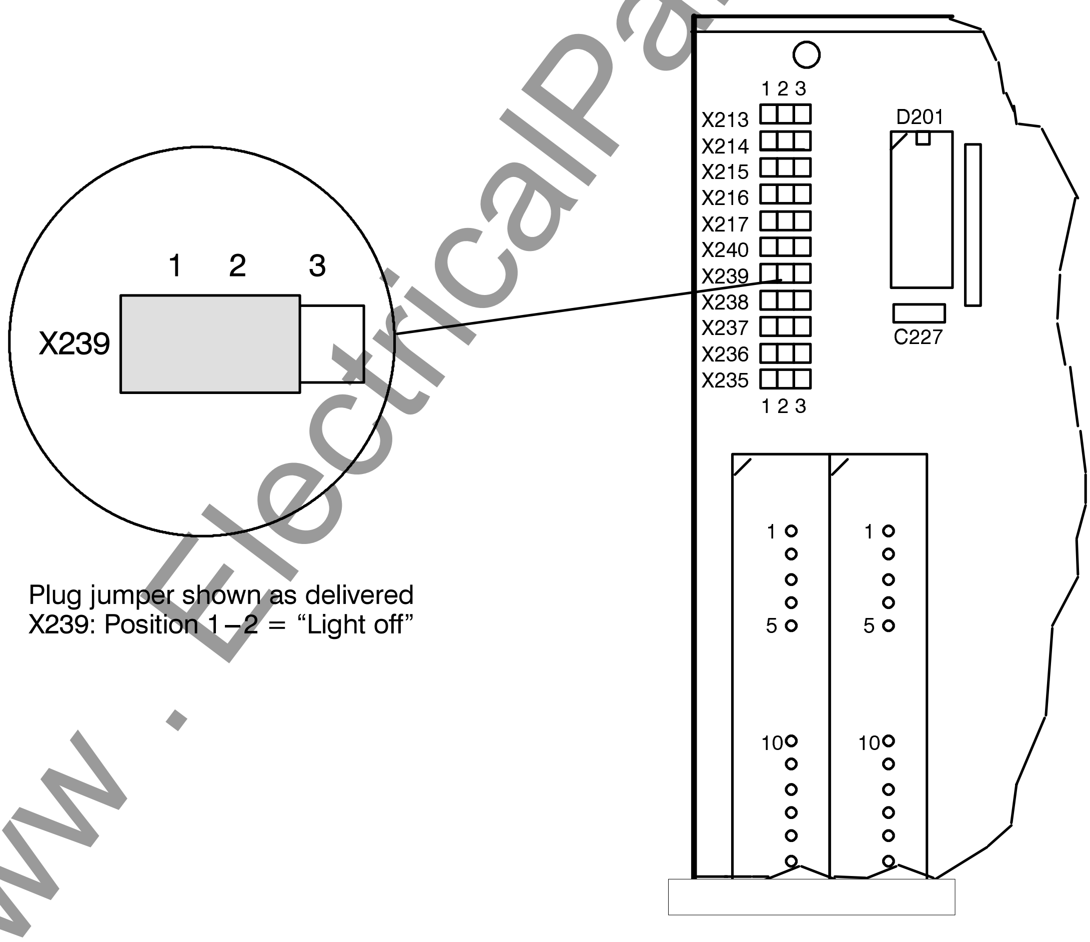
RXD Receive line of the respective unit
MR Frame reference for the receive line

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 5.3).

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



Plug jumper shown as delivered
X239: Position 1 – 2 = "Light off"

Figure 5.3 Position of the jumper X239 on the power supply board

5.2.5 Connections

General and connection diagrams are shown in Appendix B. The scope of connections between machine and 7UM512 depends on how the different protection functions are used. The connections are generally executed as follows:

Overcurrent time protection, **overcurrent and undercurrent supervision**, **unbalanced load protection** and **power supervision** are connected to current transformers in the starpoint leads of the machine.

Voltage protection (overvoltage or undervoltage) functions are connected to a phase-to-phase voltage, e.g. L1 – L2.

For the **d.c. voltage time protection**, the unit can be directly connected to the voltage to be monitored, provided the rated d.c. voltage is below 10 V (largest setting value is 8.5 V). For higher voltages, a voltage divider, e.g. type 3PP1326 – 0BZ – 012009 with ratios of 20:10:1 must be inserted. The thermal overload capability of the input must be observed (Section 3.1.1).

In the case of **stator earth fault protection**, a differentiation must be made between block connection and bus-bar connection.

In block connection (the machine is connected to the network via a block transformer) the neutral displacement voltage is supplied from an earthing transformer or a neutral earthing transformer. Since the secondary windings of these transformers usually supply a voltage of 500 V (with full displacement voltage) the voltage must be connected to the unit via a voltage divider 500 V/100 V (e.g. 3PP1336 – 1CZ – 013001). Connection examples are shown in Figures 5.4 (line connected earthing transformer) and 5.5 (neutral earthing transformer). The illustrations also show the load resistor R_B which provides a sufficiently high signal-to-noise ratio for the measured value. Further instructions are contained in the pamphlet “Planning Machine Protection Systems”, Order No. E50400 – U0089 – U412 – * – 7600.

In bus-bar connection (the machine is directly connected to the bus-bar) the displacement voltage is supplied to the unit by an earthing transformer, and the earth current by a toroidal transformer. Figure 5.6 illustrates a connection example. If the magnitude of the earth current in the event of a generator earth fault is sufficiently higher than the operational asymmetrical currents, connection in the residual circuit of three current transformers (Holmgreen connection, Figure 5.7) is also possible. If the secondary current is too high, an intermediate c.t. should be installed between main c.t.s and relay input. The current transformers must always be located between the generator and the bus-bar. In order to increase the earth fault current to approximately 10 A, a load resistor R_B is usually connected to the earthing transformer. Since network earth faults are generally not immediately disconnected, the load resistor may only remain connected for a limited time. In compensated networks the load resistor should only become effective after a time delay in order not to hinder the extinguishing process. Further information is contained in the pamphlet “Planning Machine Protection Systems” Order No. E50400 – U0089 – U412 – * – 7600.

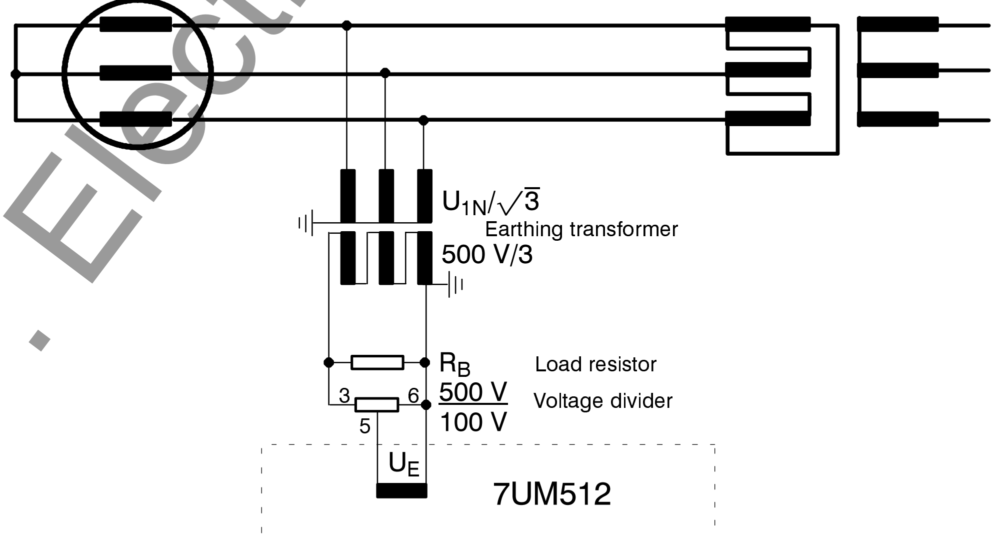


Figure 5.4 Connections for stator earth fault protection to line connected earthing transformer, for machines in block connection

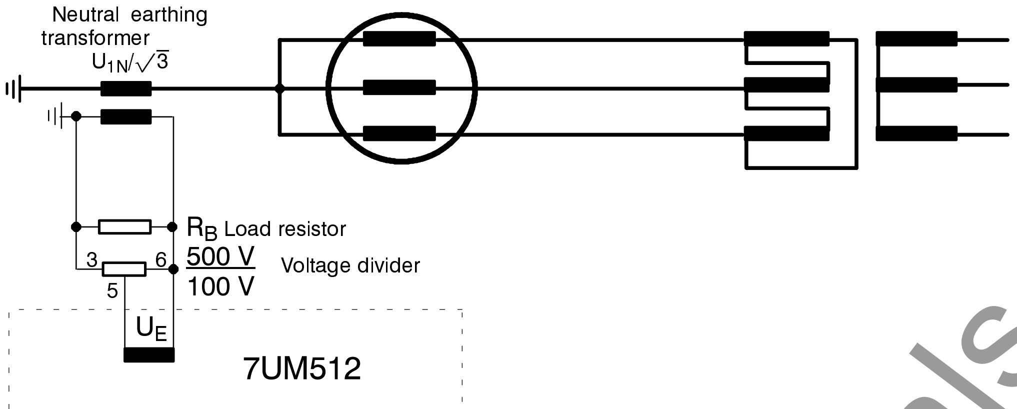


Figure 5.5 Connections for stator earth fault protection to neutral earthing transformer, for machines in block connection

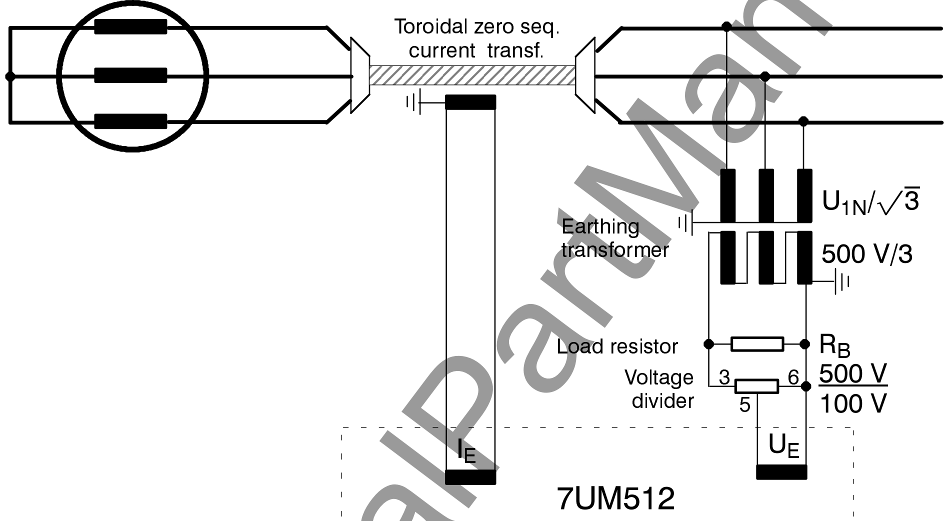


Figure 5.6 Connections for stator earth fault protection, machines in bus-bar connection (with toroidal zero sequence current transformer)

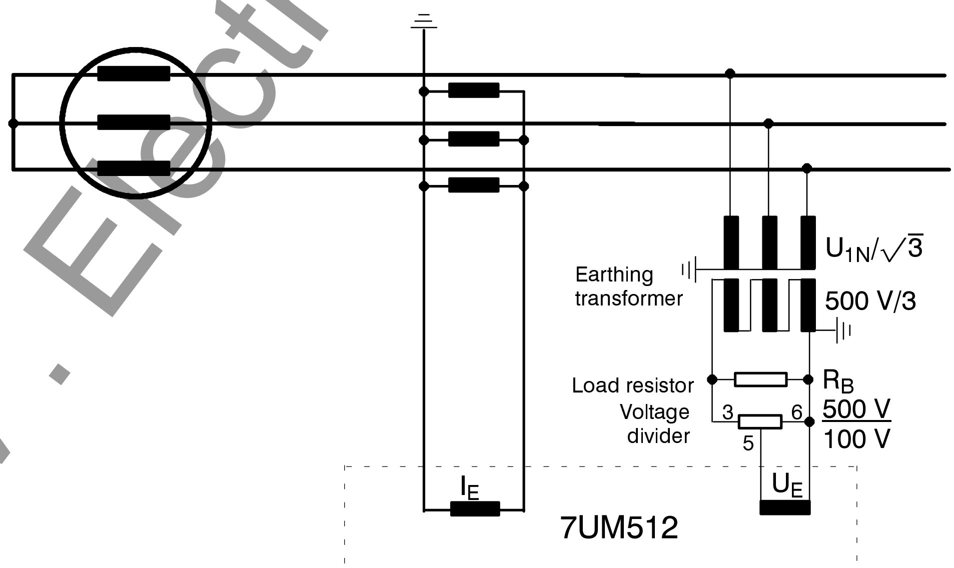


Figure 5.7 Connections for stator earth fault protection, machines in bus-bar connection (current transformers in Holmgreen connection)

A connection example for the **rotor earth fault protection** is shown in Figure 5.8. In this case an external a.c. voltage source of approximately 45 V is required, e.g. from the coupling unit 7XR6100. This draws its power requirements from the voltage transformers (e.g. U_{L2-L3}) and supplies the measured voltage and the measured current for the rotor earth resistance calculation. The measured voltage is capacitively coupled between the excitation circuit via the coupling unit and earth (e.g. earthing brushes of the shaft). The capacitor of the coupling unit is protected by the series resistors of the coupling unit.

Alternative coupling is poosible with the coupling unit 7XR6000 and the resistor unit 3PP1336−0DZ−013002.

If the excitation voltage is thyristor controlled, the series reactor (terminals 2A1 – 1B2) shall be connected in series to the coupling circuit in order to reduce the high harmonic content in the excitation voltage.

Examples for the complete connection of the 7UM512 are included in Appendix B.

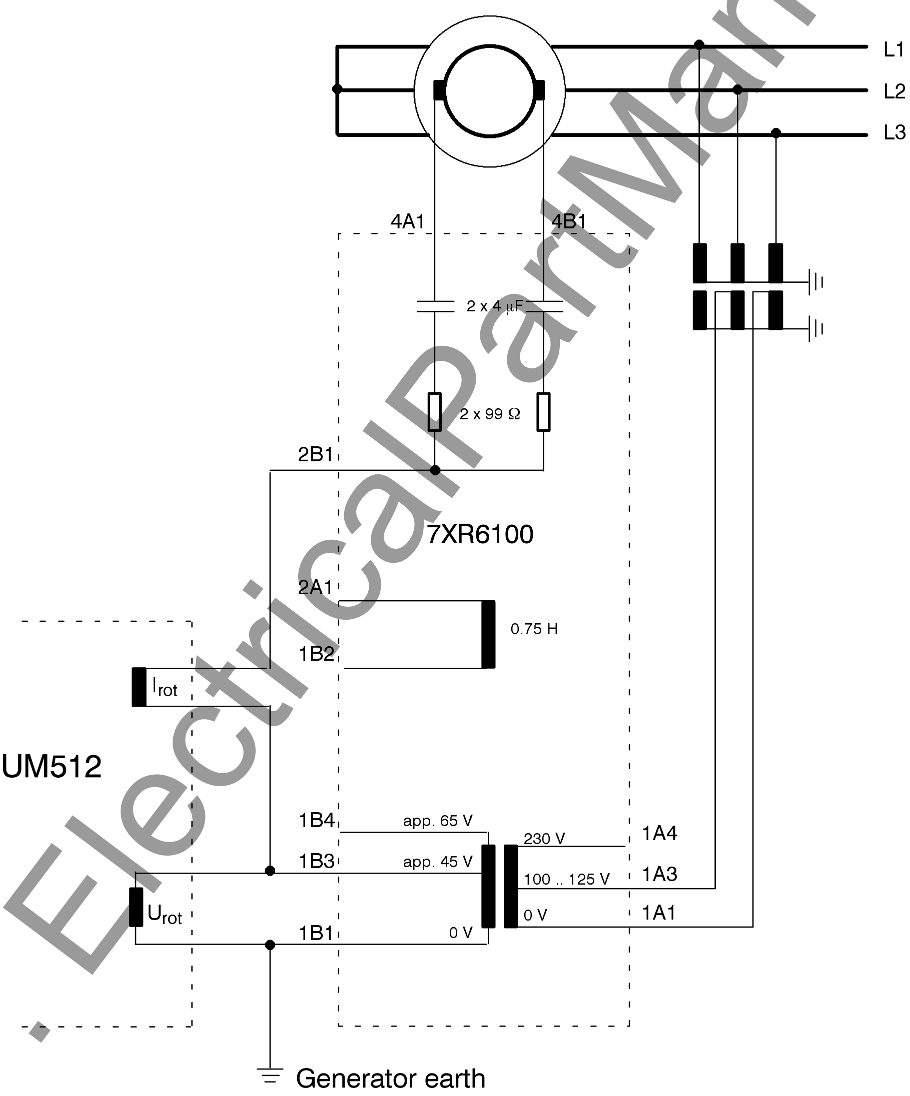


Figure 5.8 Connections for rotor earth fault protection

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 breakers for the d.c. supply and the voltage transformer circuits!

– Check the continuity of all the current and voltage transformer circuits against the plant and connection diagrams:

- Are the current transformers correctly earthed?
- Are the polarities of the current transformer connections consistent?
- Is the phase relationship of the current transformers correct?
- Are connections and polarity for earth current (zero sequence current transformer) correct (if used)?
- Are the voltage transformers correctly earthed?
- Are the polarities of the voltage transformer circuits correct?
- Is the phase relationship of the voltage transformers correct?
- Are connections and polarity of the displacement voltage correct?
- Are connections and ratio of the voltage divider from displacement voltage correct?
- Are connections and polarity of the measuring input for rotor earth fault protection correct?
- Are the connection and the transformation ratio of d.c. voltage divider correct (if used)?

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

– Ensure that the miniature slide switch on the front plate is in the “OFF” ○ position. (refer Figure 6.1).

– Fit a d.c. ammeter in the auxiliary power circuit; range approx. 1.5 A to 3 A.

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

– The measured current consumption should 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 at last 0.5 sec, the red LED gets off after at most 7 sec.

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

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

– Close the voltage transformer m.c.b. (secondary circuit).

– Check the direction of phase rotation at the relay terminals (clockwise!).

– Open the m.c.b.’s for voltage transformer secondary circuits and d.c. power supply.

– Check through the tripping circuits to the circuit breakers.

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

– Check the signal circuits.

– Reclose the protective m.c.b.’s.

5.3 Configuration of operation and memory functions

5.3.1 Operational preconditions and general

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

- configuration parameters for operation language, interface configuration and device configuration,
- allocation or marshalling of annunciation signals, binary inputs, optical indications, trip commands,
- 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. The operator panel of the device is explained in Section 6.2.

The 7UM512 disposes of four different code levels, i.e. different authorization levels. **Code level 1** releases the setting of the time clock, creating of a measuring record and switch-over of the active parameter set. That means with a codeword the operator can carry out specific settings, which are typical for normal operation conditions.

For operations of special importance, like the parameterization of functions and pick-up values, the start of test routines, reset of annunciation buffers, etc. **code level 2** is required. The codeword for this level comprises the items from code level 1, too.

For the configuration, i.e. the marshalling and configuration of the relay, **code level 3** is applicable.

The codewords pre-set upon delivery of the relay can be substituted by self-selected codewords. Changing of the codewords is done under addresses 7151 to 7154. These addresses are visible only when **code level 4** is fulfilled. The procedure is described in Section 5.3.3.

To indicate authorized operator use, press key **CW**, enter the codeword and confirm with **E**. The code“word” is a number of up to 6 digits. Upon delivery of the relay the number “0” is pre-set for all code levels. Codeword entry can also be made retrospectively after paging or direct addressing to any setting address.

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

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

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

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

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

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

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

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

Beginning of the block “Operating system configuration”

The double arrow key ⇑ switches over to the first configuration block (see below). Use the key ↑ to find the address 7101. 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 (code level 3).

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

```
⇑ 7100▮ INTEGRATED
⇓ OPERATION
```

Beginning of the block “Integrated operation”

```
↑ 7101▮ LANGUAGE
↓ DEUTSCH

  ENGLISH
```

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

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

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

```
MM/DD/YYYY
```

The date in the display is preset to the European format Day.Month.Year. Switch-over to the American format Month/Day/Year is achieved by depressing the "No"–key **N**; then confirm with the entry key **E**.

DD two figures for the day
MM two figures for the month
YYYY four figures for the year (incl. century)

```
7105 OPER.  1st  L
not  allocated
```

```
IL1[%]=
```

```
IL2[%]=
```

```
IL3[%]=
```

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 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
not  allocated
```

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 serial interfaces. 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
```

```
Prot.Trip
```

```
T-Fault
```

```
T-Trip
```

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

the first protection function which has picked up,

the latest protection function, which has tripped,

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

the elapsed time from pick-up to trip command.

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

etc.

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

the possibilities are the same as under address 7107.

5.3.3 Changing the codewords – address block 71

The codewords can be changed in addresses 7151 to 7154 for all four available code levels. This allows a downgrading of the operating authorization.

These four addresses are visible and changeable only when codeword level 4 (highest authorization stage) is fulfilled. This requires entry of the level 4 codeword.

It applies for all code levels that the higher level always includes the operation facilities of the lower code levels.

Codewords can be abbreviated to less than six digits. Then they have to be entered with exactly the same number of digits for each code word entry.

If the user does not change the codewords, then the pre-set code words remain valid. They are "0" for all four code levels. Entry of the previously used preset code word "000000" is accepted, too.

Attention! Do not forget the codewords! Forgetting a codeword is like loosing a key. Access to the relay is not possible without knowledge of the corresponding codeword. Without knowledge of the codeword of level 4, you never will have the chance to set new codewords.

```
7151  CW-LEVEL  1
0
```

Code level 1: this authorization level allows operations for the normal operating procedures (starting fault recording, setting the clock, selecting the active parameter set).

Smallest setting value: **0**
Largest setting value: **999999**

```
7152  CW-LEVEL  2
0
```

Code level 2: this authorization level allows operations of specific importance: functional parameters (address blocks 11 to 39), test routines (address blocks 44 to 49), reset of annunciation buffers (address block 82), and process parameter sets (address block 85).

Smallest setting value: **0**
Largest setting value: **999999**

```
7153  CW-LEVEL  3
0
```

Code level 3: this authorization level allows the configuration: marshalling (address blocks 61 to 64), interfaces (address blocks 71 to 72), fault recording (address block 74), scope of functions (address block 78), configuration of the relay (address block 79)

Smallest setting value: **0**
Largest setting value: **999999**

```
7154  CW-LEVEL  4
0
```

Code level 4: this is the highest authorization level for the user and allows alteration of the code words (addresses 7151 to 7154)

Smallest setting value: **0**
Largest setting value: **999999**

5.3.4 Configuration of the serial interfaces – address block 72

The device provides two serial interfaces: one PC interface for operation by means of a operator terminal or personal computer in the front and a further system interface for connection of a central control and storage unit, e.g. Siemens LSA 678. Communication via these interfaces requires some data prearrangements: identification of the relay, transmission format, transmission speed.

These data are entered to the relay in address block 72. Codeword input of code level 3 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 station or 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 station or 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 station or substation, in case more than one station or substation can be connected to a central device
Smallest permissible number: **1**
Largest permissible number: **254**

```
7208 FUNCT. TYPE
70
```

Function type in accordance with with IEC 60870–5–103 and VDEW/ZVEI; for 7UM512 no. 70.
This address is mainly for information, it should not be changed.

```
7209 DEVICE TYPE
15
```

Device type for identification of the device in Siemens LSA 678 and DIGSI®. For 7UM512 V3 no. 15.
This address is only for information, it cannot be changed.

Addresses 7211 to 7216 are valid for the operating (PC) interface on the front of the relay.

Note: For operator panel 7XR5, the PC−interface format (address 7211) must be *ASCII*, the PC Baud-rate (address 7215) must be *1200 BAUD*, the PC parity (address 7216) must be *NO 2 STOP*.

The setting of the PC GAPS (address 7214 for the operating interface) or the SYS GAPS (address 7224 for the system interface) is relevant only when the relay is intended to communicate via a modem. The settings are the maximum time period which is tolerated by the relay when gaps occur during transmission of a telegram. Gaps may occur, when modems are used, by compression of data, error correction, and differences of the Baud-rate. With good transmission quality, 1.0 s is adequate. The value should be increased when transmission quality is not so good. It must be noted that GAPS must be smaller than the setting of ”reaction time protection relay” in the protection software DIGSI® V3. Recommended value:

$$\text{GAPS} \approx \frac{\text{''reaction time protection relay''}}{2}$$

Higher values for ”reaction time protection relay” reduce the transmission speed in case of transmission errors. If the relay interface is connected directly to a personal computer, then GAPS may be set to 0.0 s.

```
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

```
7214 PC GAPS
0.0 s
```

Maximum time period of data gaps within telegrams which may occur during data transmission via modem on the operating (PC) interface

Smallest setting value: **0.0** s

Largest setting value: **5.0** s

```
7215 PC BAUDRATE
 9600 BAUD
19200 BAUD
 1200 BAUD
 2400 BAUD
 4800 BAUD
```

The transmission Baud-rate for communication via the PC (operating) interface at the front can be adapted to the operator’s communication interface, e.g. personal computer, if necessary. The available possibilities can be displayed by repeatedly depression of the “No”−key **N**. Confirm the desired Baud-rate with the entry key **E**.

```
7216 PC PARITY
DIGSI V3
```

Parity and stop-bits for the PC (operating) interface:

format for Siemens protection data processing program *DIGSI®* Version *V3* with odd parity and 1 stop-bit

```
NO 2 STOP
```

NO parity, *2 STOP*−bits

```
NO 1 STOP
```

NO parity, *1 STOP*−bit, e.g. modem

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

```
7221 SYS INTERF.
VDEW EXTENDED
```

Data format for the system (LSA) interface:

data in accordance with *VDEW*, *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

```
7222 SYS MEASUR.
VDEW EXTENDED
```

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

data in accordance with IEC 60870–5–103 and *VDEW*/ZVEI, *EXTENDED* by Siemens specified data

```
7224 SYS GAPS
0.0 s
```

Maximum time period of data gaps within telegrams which may occur during data transmission via modem on the system (LSA) interface

Smallest setting value: **0.0** s
Largest setting value: **5.0** s

```
7225 SYS BAUDR.
 9600 BAUD
```

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**.

```
19200 BAUD
```

```
 1200 BAUD
```

```
 2400 BAUD
```

```
 4800 BAUD
```

```
7226 SYS PARITY
VDEW/DIGSIV3/LSA
```

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

```
NO 2 STOP
```

NO parity, *2 STOP*–bits

```
NO 1 STOP
```

NO parity, *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 it shall be permitted to change parameters via this interface.

```
7235 SYS PARAMET
NO
```

Remote parameterizing via the system interface

NO – is not permitted

```
YES
```

YES – is permitted

5.3.5 Settings for fault recording – address block 74

The machine protection relay is equipped with a fault data store (see Section 4.17.2). 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 under address 7410. Altogether 5 s are available for fault recording of instantaneous values, 60 s for recording of r.m.s. values (cf. address 7420). In this time range up to 8 fault records can be stored.

Note: The set times are related on a system frequency of 50 Hz. They are to be matched, accordingly, for different frequencies.

Note: In the illustration below, the time values are displayed for storage of instantaneous values. When r.m.s. values are stored, the times appear as 12 times the illustrated values.

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.

STORAGE BY TRIP

START WITH TRIP
```

Data storage is initiated:

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

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

Maximum time period of a fault record
Smallest setting value: **0.30** s
Largest setting value: **5.00** s
The times are **multiplied by 12** in case of storage of **r.m.s. values** (cf. address 7420)

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

Pre-trigger time before the reference instant
Smallest setting value: **0.05** s
Largest setting value: **4.00** s
The times are **multiplied by 12** in case of storage of **r.m.s. values** (cf. address 7420)

```
7412 T-POST
0.10 s
```

Post-fault time after the storage criterion disappears
Smallest setting value: **0.05** s
Largest setting value: **1.00** s

The times are **multiplied by 12** in case of storage of **r.m.s. values** (cf. address 7420)

```
7420 FAULT VALUE
INSTANTANEOUS
```
```
RMS VALUES
```

The stored fault values should be:

INSTANTANEOUS values with 12 values per a.c. cycle

RMS VALUES with one value per cycle

```
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)

The times are **multiplied by 12** in case of storage of **r.m.s. values** (cf. address 7420)

```
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

The times are **multiplied by 12** in case of storage of **r.m.s. values** (cf. address 7420)

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. But, if the relay is connected to a former LSA system, the relay must be informed how long a transmitted fault record must be, so that the former LSA system receives the correct number of fault record values.

Only for communication with a former LSA system:

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

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 7UM512 is capable of providing a series of protection and supplementary 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. Additionally, the relay can be adapted to the system frequency.

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 of code level 3 (see Section 5.3.1). Without codeword, the setting can be read out but not altered.

For the purpose of configuration, address block 78 is 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.

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 7UM512: 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.

```
7800 SCOPE OF
FUNCTIONS
```

Beginning of the block "scope of functions"

Undervoltage protection:

```
7816 UNDERVOLT.
EXIST

NON-EXIST
```

Active power supervision:

```
7822 P-active
EXIST

NON-EXIST
```

Overvoltage protection:

```
7817 OVERVOLT.
EXIST

NON-EXIST
```

Reactive power supervision:

```
7823 P-reactive
EXIST

NON-EXIST
```

Stator earth fault protection:

```
7819 SEF PROT.
EXIST

NON-EXIST
```

Unbalanced load protection:

```
7824 UNBAL. LOAD
EXIST

NON-EXIST
```

Frequency protection:

```
7820 FREQUENCY
EXIST

NON-EXIST
```

Overcurrent time protection, I>–stage:

```
7825 O/C I>
EXIST

NON-EXIST
```

Overcurrent/undercurrent supervision:

```
7826 CURRENT I><
EXIST
---
NON-EXIST
```

External trip facilities via binary input:

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

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

```
7832 EXT. TRIP 3
EXIST
---
NON-EXIST
```

```
7833 EXT. TRIP 4
EXIST
---
NON-EXIST
```

Rotor earth fault protection:

```
7835 ROTOR E/F
EXIST
---
NON-EXIST
```

D.C. voltage time protection:

```
7836 DC VOLTAGE
EXIST
---
NON-EXIST
```

Trip circuit supervision:

```
7839 TRP SUPERV
EXIST
---
NON-EXIST
```

Parameter change-over:

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

The rated system frequency must comply with the setting under address 7899. If the system frequency is not 50 Hz, address 7899 must be changed.

```
7899 FREQUENCY
fN 50 Hz
---
fN 60 Hz
```

Rated system frequency *50 Hz* or *60 Hz*

5.5 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 (code level 3) is required for marshalling (refer Section 5.3.1). Without codeword entry, parameters can be read out but not be changed. During codeword operation, i.e. from codeword entry until the termination of the marshalling procedure, the solid bar in the display flashes.

When the 7UM51 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: Overcurrent is registered in phase L1. This event is generated in 7UM51 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 “I> L1” should be transmitted to the signal relay 1. Thus, when marshalling is performed two statements of the operator are important: **Which** (logical) annunciation generated in the protection unit program should trigger **which** (physical) signal relay? Up to 20 logical annunciations can trigger one (physical) signal relay.

A similar situation applies to binary inputs. In this case external information (e.g. voltage transformer m.c.b. tripped) is connected to the unit via a (physical) input module and should initiate a (logical) function, namely blocking. The corresponding question to the operator is then: **Which** signal from a (physical) input relay should initiate **which** reaction in the device? One physical input signal can initiate up to **10** logical functions.

The trip relays can also be assigned different functions. Each trip relay can be controlled by each command function or combination of up to **20** 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 enter key E**. Immediately the associated identification of the function appears for checking purposes. This can be altered either by entering a different function number or by paging through the possible functions, forwards with the "No" – key **N** or backwards with the backspace key **R**. If the function has been changed, another confirmation is necessary with **the enter key E**.

In the following paragraphs, allocation possibilities for binary inputs, binary outputs and LED indicators are given. The arrows ⇑⇓ 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 8 binary inputs which are designated INPUT 1 to INPUT 8. 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 has been programmed out ("de-configured", refer Section 5.4.2).

With direct input of the function number, leading zeros need not be used. To indicate the contact mode the function number can be extended by a decimal point followed by **0** or **1**, whereby

.0 means "normally open" mode, corresponds to "NO" as above.

.1 means "normally closed" mode, corresponds to "NC" as above.

If the extension with .0 or .1 is omitted the display first indicates the function designation in "normally open" mode NO. By pressing the "No"–key **N** the mode is changed to NC. After direct input other functions can be selected by paging through the functions forwards with the "No"–key **N** or backwards with the backspace key **R**. The changed function then must be re-confirmed by the entry key **E**.

Note: One logical function must not be marshalled to more than one binary input because an OR–logic of the signals can not be guaranteed!

The assignment of the binary inputs as delivered from factory is shown in the general diagrams in Appendix A. The following boxes show, as an example, the allocation for binary input 1. Table 5.2 shows all binary inputs as preset from the factory.

```
⇑ 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 LED indications, FNo 5;
"normally open" operation:
LEDs are reset when control voltage present

```
0 0 2▮ I N P U T   1
n o t   a l l o c a t e d
```

No further functions are initiated by binary input 1

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

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 stored 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
15	`>Sys-Test`	System interface messages/values are marked with “Test operation”
16	`>Sys-MM-block`	System interface messages and measured values are blocked
1722	`>I> block`	Block overcurrent time protection stage I>
1950	`>Useal-in blk`	Block undervoltage seal-in of overcurrent time protection
1951	`>Useal-in ext`	Undervoltage seal-in for overcurrent time protection from external
4523	`>Ext 1 block`	Block external trip command 1
4526	`>Ext trip 1`	External trip signal 1 [1)]
4543	`>Ext 2 block`	Block external trip command 2
4546	`>Ext trip 2`	External trip signal 2 [1)]
4563	`>Ext 3 block`	Block external trip command 3
4566	`>Ext trip 3`	External trip signal 3 [1)]
4583	`>Ext 4 block`	Block external trip command 4
4586	`>Ext trip 4`	External trip signal 4 [1)]
5004	`>Phase rotat.`	Phase rotation is reversed to counter-clockwise
5086	`>SV tripped`	Stop valve tripped (for reverse power protection)
5143	`>I2 block`	Block load unbalanced protection I_2>
5146	`>RM th.repl.`	Reset thermal replica of unbalanced load protection
5173	`>U0> block`	Block stator earth fault protection U_0>
5176	`>S/E/F Ie off`	Switch off stator earth fault protection current detection
5203	`>Frq. block`	Block frequency protection
5206	`>f1 block`	Block frequency protection stage f1
5207	`>f2 block`	Block frequency protection stage f2
5263	`>I>< block`	Block overcurrent/undercurrent supervision
5266	`>I>< coupl. 1`	External signal 1, AND−combined with pick-up of I>< supervision
5267	`>I>< coupl. 2`	External signal 2, AND−combined with trip of I>< supervision
5293	`>U DC block`	Block d.c. voltage protection
5383	`>R/E/F block`	Block rotor earth fault protection
5443	`>Pa block`	Block active power protection
5445	`>Pr block`	Block reactive power protection (complete)
5446	`>Pr> block`	Block reactive power stage Pr>
5447	`>Pr>> block`	Block reactive power stage Pr>>
6506	`>u< block`	Block undervoltage protection
6513	`>o/v block`	Block overvoltage protection
6872	`>Trip rel 1`	Trip circuit supervision 1: input in parallel to trip relay
6873	`>CBaux 1`	Trip circuit supervision 1: input in parallel to CB auxiliary contact
6892	`>Trip rel 2`	Trip circuit supervision 2: input in parallel to trip relay
6893	`>CBaux 2`	Trip circuit supervision 2: input in parallel to CB auxiliary contact

1) recommended contact mode: NO operation

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	5263	Block overcurrent/undercurrent supervision
6103	BINARY INPUT 3	INPUT 3 >u< block NO	6506	Block undervoltage protection
6104	BINARY INPUT 4	INPUT 4 >I2 block NO	5143	Block unbalanced load protection I_2> and reset thermal replica
6105	BINARY INPUT 5	INPUT 5 >Ext trip 1 NO	4526	External trip signal 1
6106	BINARY INPUT 6	INPUT 6 >I>< coupl. 1 NO	5266	External signal 1, AND–combined with pick-up of I>< supervision
6107	BINARY INPUT 7	INPUT 7 >I>< coupl. 2 NO	5267	External signal 2, AND–combined with trip of I>< supervision
6108	BINARY INPUT 8	INPUT 8 >Frq. block NO	5203	Block frequency protection

Table 5.2 Preset binary inputs

5.5.3 Marshalling of the signal output relays – address block 62

The unit contains 13 signal outputs (alarm relays). One signal relay is permanently assigned and annunciates the readiness for operation of the unit. The other signal relays are designated SIGNAL RELAY 1 to SIGNAL RELAY 12 and can be marshalled in address block 62. The block is reached by paging in blocks with ⇑ ⇓ or by directly addressing **DA 6 2 0 0 E**. The selection procedure is carried out as described in Section 5.5.1. Multiple annunciations are possible, i.e. one logical annunciation function can be given to several physical signal relays (see also Section 5.5.1).

Table 5.3 gives a listing of all annunciation functions with the associated function numbers **FNo**. Annunciation functions are naturally not effective when the corresponding protection function has been programmed out ("de-configured" – refer to Section 5.4.2).

Note as to Table 5.3: Annunciations which are indicated by a leading ">" sign, represent the direct confirmation of the binary inputs and are available as long as the corresponding binary input is energized.

Further information about annunciations see Section 6.4.

The assignment of the output signal relays as delivered from factory is shown in the general diagrams in Appendix A. The following boxes show an example for marshalling signal relay 3. Table 5.4 shows all signal relays as preset from the factory.

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

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

The desired signal relay (e.g. the third) is reached with the key ↑:

```
F↑ 6203█ SIGNAL
 ↓ RELAY  3
```

Allocations for signal relay 3

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

```
↑ 001█ RELAY  3
↓ S/E/F  Trip
```

Signal relay 3 has been preset for:
1st: Stator earth fault trip, FNo 5193;

```
↑ 002█ RELAY  3
↓ not  allocated
```

no further functions are preset for signal relay 3

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

```
↑ 6203█ SIGNAL
↓ RELAY  3
```

Allocations for signal relay 3

FNo	Abbreviation	Description
1	not allocated	No annunciation allocated
3	>Time Synchro	Synchronize internal real time clock
4	>Start FltRec	Start fault recording from external command via binary input
5	>Reset LED	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
15	>Sys-Test	System interface messages/values are marked with "Test operation"
16	>Sys-MM-block	System interface messages and measured values are blocked
51	Dev.operative	Protection relay operative
52	Prot. operat.	any protection function operative
60	Reset LED	Stored LED are reset
95	Param.running	Parameters are being set
96	Param. Set A	Parameter Set A is activated
97	Param. Set B	Parameter Set B is activated
98	Param. Set C	Parameter Set C is activated
99	Param. Set D	Parameter Set D is activated
141	Failure 24V	Failure 24 V internal dc supply
143	Failure 15V	Failure 15 V internal dc supply
144	Failure 5V	Failure 5 V internal dc supply
145	Failure 0V	Failure 0 V A/D converter
161	I supervision	Measured value supervision currents, general
162	Failure ΣI	Failure supervision ΣI (measured currents)
163	Failure Isymm	Failure supervision symmetry I
171	Fail.PhaseSeq	Failure supervision phase sequence
502	Dev. Drop-off	General drop-off of device
1722	>I> block	Block overcurrent time protection stage I>
1811	I> Fault L1	Overcurrent fault detection stage I> phase L1
1812	I> Fault L2	Overcurrent fault detection stage I> phase L2
1813	I> Fault L3	Overcurrent fault detection stage I> phase L3
1815	I> Trip	Overcurrent fault detection I> phase trip
1950	>Useal-in blk	Block undervoltage seal-in of overcurrent time protection
1951	>Useal-in ext	Undervoltage seal-in for overcurrent time protection from external
1965	I> off	Overcurrent time protection stage I> is switched off
1966	I> blocked	Overcurrent time protection stage I> is blocked
1967	I> active	Overcurrent time protection stage I> is active
1970	U< seal in	Undervoltage seal-in for overcurrent time protection operated
4523	>Ext 1 block	Block external trip command 1
4526	>Ext trip 1	External trip signal 1
4531	Ext 1 off	External trip signal 1 is switched off
4532	Ext 1 blocked	External trip signal 1 is blocked
4533	Ext 1 active	External trip signal 1 is active
4536	Ext 1 Gen.Flt	External trip signal 1: general fault detection signal
4537	Ext 1 Gen.Trp	External trip signal 1: general trip command issued
4543	>Ext 2 block	Block external trip command 2
4546	>Ext trip 2	External trip signal 2
4551	Ext 2 off	External trip signal 2 is switched off
4552	Ext 2 blocked	External trip signal 2 is blocked
4553	Ext 2 active	External trip signal 2 is active
4556	Ext 2 Gen.Flt	External trip signal 2: general fault detection signal
4557	Ext 2 Gen.Trp	External trip signal 2: general trip command issued
4563	>Ext 3 block	Block external trip command 3
4566	>Ext trip 3	External trip signal 3

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

FNo	Abbreviation	Description
4571	Ext 3 off	External trip signal 3 is switched off
4572	Ext 3 blocked	External trip signal 3 is blocked
4573	Ext 3 active	External trip signal 3 is active
4576	Ext 3 Gen.Flt	External trip signal 3: general fault detection signal
4577	Ext 3 Gen.Trp	External trip signal 3: general trip command issued
4583	>Ext 4 block	Block external trip command 4
4586	>Ext trip 4	External trip signal 4
4591	Ext 4 off	External trip signal 4 is switched off
4592	Ext 4 blocked	External trip signal 4 is blocked
4593	Ext 4 active	External trip signal 4 is active
4596	Ext 4 Gen.Flt	External trip signal 4: general fault detection signal
4597	Ext 4 Gen.Trp	External trip signal 4: general trip command issued
5002	Operat. Cond.	Operating condition 1: suitable measured values are present
5004	>Phase rotat.	Phase rotation is reversed to counter-clockwise
5005	Clockwise	Clockwise phase rotation
5006	Counter-clock	Counter-clockwise phase rotation
5086	>SV tripped	Stop valve tripped (for reverse power protection)
5143	>I2 block	Block load unbalanced protection $I_2>$
5146	>RM th.repl.	Reset thermal replica of unbalanced load protection
5151	I2 off	Unbalanced load protection is switched off
5152	I2 blocked	Unbalanced load protection is blocked
5153	I2 active	Unbalanced load protection is active
5156	I2> Warn	Unbalanced load protection: current warning stage
5157	I2 th. Warn	Unbalanced load protection: thermal warning stage
5158	RM th. repl.	Unbalanced load protection: memory of thermal replica reset
5159	I2>> Fault	Unbalanced load protection: fault detection of high current stage
5160	I2>> Trip	Unbalanced load protection: trip by high current stage
5161	I2 Trip	Unbalanced load protection: trip by thermal stage
5173	>U0> block	Block stator earth fault protection $U_0>$
5176	>S/E/F Ie off	Earth current detection for stator E/F off
5181	U0> off	Stator earth fault protection $U_0>$ is switched off
5182	U0> blocked	Stator earth fault protection $U_0>$ is blocked
5183	U0> active	Stator earth fault protection $U_0>$ is active
5186	U0> Fault	Stator earth fault protection: fault detection $U_0>$
5188	Ie> Fault	Stator earth fault protection: fault detection $I_0>$
5189	Uearth L1	Stator earth fault $U_0>$ in phase L1
5190	Uearth L2	Stator earth fault $U_0>$ in phase L2
5191	Uearth L3	Stator earth fault $U_0>$ in phase L3
5192	S/E/F st.Trip	Trip by start-up earth fault protection
5193	S/E/F trip	Trip by stator earth fault protection
5203	>Frq. block	Block frequency protection
5206	>f1 block	Block frequency protection stage f1
5207	>f2 block	Block frequency protection stage f2
5211	FRQ off	Frequency protection is switched off
5212	FRQ blocked	Frequency protection is blocked
5213	FRQ active	Frequency protection is active
5214	FRQ U< block	Frequency protection is blocked due to unsuitable voltage
5216	f1> Fault	Frequency protection: fault detection of f1>–stage
5217	f1< Fault	Frequency protection: fault detection of f1<–stage
5218	f2> Fault	Frequency protection: fault detection of f2>–stage
5219	f2< Fault	Frequency protection: fault detection of f2<–stage
5224	f1> Trip	Trip by overfrequency protection stage f1>
5225	f1< Trip	Trip by underfrequency protection stage f1<
5226	f2> Trip	Trip by overfrequency protection stage f2>
5227	f2< Trip	Trip by underfrequency protection stage f2<
5263	>I>< block	Block overcurrent/undercurrent supervision
5266	>I>< coupl. 1	External signal 1, AND–combined with pick-up of I>< supervision

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

FNo	Abbreviation	Description
5267	>I>< coupl. 2	External signal 2, AND−combined with trip of I>< supervision
5271	I>< off	Overcurrent/undercurrent supervision is switched off
5272	I>< blocked	Overcurrent/undercurrent supervision is blocked
5273	I>< active	Overcurrent/undercurrent supervision is active
5276	I >< Fault	Overcurrent/undercurrent fault detection I><
5277	I >< Trip	Trip by overcurrent/undercurrent I><
5293	>U DC block	Block DC voltage time protection
5301	U DC off	DC voltage time protection is switched off
5302	U DC blocked	DC voltage time protection is blocked
5303	U DC active	DC voltage time protection is active
5306	U DC Fault	DC voltage time protection: fault detection Udc> or Udc<
5307	U DC Trip	Trip by DC voltage time protection Udc> or Udc<
5383	>R/E/F block	Block rotor earth fault protection
5391	R/E/F off	Rotor eath fault protection is switched off
5392	R/E/F blocked	Rotor eath fault protection is blocked
5393	R/E/F active	Rotor eath fault protection is active
5394	R/E/F U< blk	Rotor eath fault protection is blocked by undervoltage (U_{RE}<)
5396	Failure R/E/F	Failure in measuring circuit of rotor earth fault protection
5397	R/E/F Warn	Rotor eath fault protection warning stage
5398	R/E/F Fault	Rotor eath fault protection
5399	R/E/F Trip	Trip by rotor eath fault protection
5443	>Pa block	Block active power supervision
5445	>Pr block	Block reactive power protection (complete)
5446	>Pr> block	Block reactive power stage Pr>
5447	>Pr>> block	Block reactive power stage Pr>>
5451	Pa> off	Active power supervision is switched off
5452	Pa> blocked	Active power supervision is blocked
5453	Pa> active	Active power supervision is active
5454	Pr> off	Reactive power supervision is switched off
5455	Pr> blocked	Reactive power supervision is blocked
5456	Pr> active	Reactive power supervision is active
5457	Pa> Fault	Active power fault detection P_a>
5458	Pr> Fault	Reactive power stage Pr> fault detection
5459	Pa> Trip	Trip by active power protection
5460	Pr> Trip	Trip by reactive power stage Pa>
5461	Pr>> Fault	Reactive power stage Pr>> fault detection
5462	Pr>> Trip	Trip by reactive power stage Pa>>
5463	Pa+SV Trip	Trip by active power protection with tripped stop valve
6506	>u< block	Block undervoltage protection U<
6513	>o/v block	Block overvoltage protection U>
6530	U< off	Undervoltage protection is switched off
6531	U< blocked	Undervoltage protection is blocked
6532	U< active	Undervoltage protection is active
6533	U< fault	Undervoltage protection fault detection U<
6539	U< trip	Undervoltage protection trip U<
6565	o/v off	Overvoltage protection is switched off
6566	o/v blk	Overvoltage protection is blocked
6567	o/v active	Overvoltage protection is active
6568	U> fault	Overvoltage protection fault detection U>
6570	U> trip	Overvoltage protection U> trip U>
6571	U>> Fault	Overvoltage protection fault detection U>>
6573	U>> Trip	Overvoltage protection U>> trip U>>
6872	>Trip rel 1	Trip circuit supervision 1: input in parallel to trip relay
6873	>CBaux 1	Trip circuit supervision 1: input in parallel to CB auxiliary contact
6879	Failure Trip1	Failure detected in trip circuit 1
6892	>Trip rel 2	Trip circuit supervision 2: input in parallel to trip relay
6893	>CBaux 2	Trip circuit supervision 2: input in parallel to CB auxiliary contact
6899	Failure Trip2	Failure detected in trip circuit 2

Table 5.3 Marshalling possibilities for signal relays and LEDs

Addr	1st display line	2nd display line	FNo	Remarks
6200	MARSHALLING	SIGNAL RELAYS		Heading of the address block
6201	SIGNAL RELAY 1	RELAY 1 I> Trip	 1815	Trip by overcurrent time protection: I> phases
6202	SIGNAL RELAY 2	RELAY 2 I>< Trip	 5277	Trip by overcurrent/undercurrent supervision I><
6203	SIGNAL RELAY 3	RELAY 3 S/E/F Trip	 5193	Trip by stator earth fault protection
6204	SIGNAL RELAY 4	RELAY 4 R/E/F Trip	 5399	Trip by rotor earth fault protection
6205	SIGNAL RELAY 5	RELAY 5 R/E/F Warn	 5397	Warning stage R_E< of rotor earth fault protection
6206	SIGNAL RELAY 6	RELAY 6 U< trip	 6539	Trip by undervoltage protection
6207	SIGNAL RELAY 7 RELAY 7 RELAY 7 RELAY 7	RELAY 7 Ext 1 Gen.Trp Ext 2 Gen.Trp Ext 3 Gen.Trp Ext 4 Gen.Trp	 4537 4557 4577 4597	Trip by externally coupled trip signals via binary inputs
6208	SIGNAL RELAY 8	RELAY 8 U DC Trip	 5307	Trip by d.c. voltage time protection
6209	SIGNAL RELAY 9 RELAY 9	RELAY 9 I2 Θ Trip I2>> Trip	 5161 5160	Trip by unbalanced load protection
6210	SIGNAL RELAY 10 RELAY 10	RELAY 10 I2 th. Warn I2> Warn	 5157 5156	Warning stages of unbalanced load protection
6211	SIGNAL RELAY 11 RELAY 11	RELAY 11 f1< Trip f2> Trip	 5225 5226	Trip by frequency protection
6212	SIGNAL RELAY 12	RELAY 12 Failure R/E/F	 5396	Failure in measuring circuit of rotor earth fault protection
6213	SIGNAL RELAY 13	RELAY 13*) Dev.operative	 51	Device operative*); the NC contact can be used for "Device faulty" annunciation

*) permanently assigned

Table 5.4 Preset annunciations for signal relays

5.5.4 Marshalling of the LED indicators – address block 63

The unit contains 16 LEDs for optical indications, 14 of which can be marshalled. They are designated LED 1 to LED 14 and can be marshalled in address block 63. The block is reached by paging in blocks with ⇑ ⇓ or by directly addressing with **DA 6 2 0 0 E**. The selection procedure is carried out as described in Section 5.5.1. Multiple annunciations are possible, i.e. one logical annunciation function can be given to several LEDs (see also Section 5.5.1).

Apart from the logical function, each LED can be marshalled to operate either in the stored mode (`m` for **m**emorized) or unstored mode (`nm` for "**n**ot **m**emorized"). Each annunciation function is displayed with the index `m` or `nm` when proceeding with the **N**–key.

The marshallable annunciation functions are the same as those listed in Table 5.3. Annunciation functions are, of course, not effective when the corresponding protection function has been programmed out (de-configured).

With direct input of the function number it is not necessary to input the leading zeros. To indicate whether the stored or unstored mode shall be effective the function number can be extended by a decimal point followed by 0 or 1, whereby

.0 unstored indication (not memorized) corresponds to "`nm`" as above,

.1 stored indication (memorized) corresponds to "`m`" as above.

If the extension with .0 or .1 is omitted the display shows first the function designation in unstored mode with "`nm`". Press the "No"–key **N** to change to stored mode "`m`". After direct input other functions can be selected by paging through the functions forwards with the "No"–key **N** or backwards with the backspace key **R.** The changed function then must be re-confirmed by the enter-key **E**.

The assignment of the LEDs as preset by the factory is shown in the front of the unit (Figure 6.1). The following boxes show, as an example, the assignment for LED 14. Table 5.5 shows all LED indicators as they are preset from the factory.

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

Beginning of the block "Marshalling of the LED indicators"

The desired marshallable LED is reached with the key ↑:

```
6314 LED 14
```

Allocations for LED 14

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

```
001 LED 14
Failure 5V      nm
```

LED 14 has been preset for:
1st: Failure of internal 5 Vdc power supply,
FNo `144`

```
002 LED 14
Failure 15V     nm
```

LED 14 has been preset for:
2nd: Failure of internal 15 Vdc power supply,
FNo `143`

```
003 LED 14
Failure 24V     nm
```

LED 14 has been preset for:
3rd: Failure of internal 24 Vdc power supply,
FNo `141`

```
004 LED 14
Failure 0V      nm
```

LED 14 has been preset for:
4th: Failure of internal 0 Vdc power supply,
FNo `145`

```
005 LED 14
not allocated
```

no further allocation for LED 14

After input of all annunciation functions for LED 14, change-back to the marshalling level is carried out with **F** ↑:

```
6 3 1 4█ L E D   1 4
```

Allocations for LED 14, Meaning: “Failure in one of the internal d.c. supply circuits”.

Addr	1st display line	2nd display line		FNo	Remarks
6300	MARSHALLING	LEDs			Heading of the address block
6301	LED 1 LED 1	 I> Trip	 m	 1815	Trip by overcurrent time protection: I> phases
6302	LED 2 LED 2	 I>< Trip	 m	 5277	Trip by overcurrent/undercurrent supervision I><
6303	LED 3 LED 3	 S/E/F Trip	 m	 5193	Trip by stator earth fault protection
6304	LED 4 LED 4	 R/E/F Trip	 m	 5399	Trip by rotor earth fault protection
6305	LED 5 LED 5	 R/E/F Warn	 m	 5397	Warning stage of rotor earth fault protection
6306	LED 6 LED 6 LED 6 LED 6	 U> Trip U>> Trip U< Trip	 m m m	 6570 6571 6539	Trip by voltage protection
6307	LED 7 LED 7 LED 7	 Pa> Trip Pr> Trip	 m m	 5459 5460	Trip by power supervision
6308	LED 8 LED 8	 U DC Trip	 m	 5307	Trip by d.c. voltage time protection
6309	LED 9 LED 9 LED 9 LED 9	 I> Fault L1 I> Fault L2 I> Fault L3	 nm nm nm	 1811 1812 1813	Fault detections of overcurrent time protection
6310	LED 10 LED 10	 U0> Fault	 nm	 5186	Fault detection of stator earth fault protection
6311	LED 11 LED 11 LED 11	 I2>> Trip I2 Θ Trip	 m m	 5160 5161	Trip by unbalanced load protection
6312	LED 12 LED 12 LED 12	 I2 th. Warn I2> Warn	 nm nm	 5157 5156	Warning stages of unbalanced load protection
6313	LED 13 LED 13 LED 13 LED 13 LED 13	 Ext 1 Gen.Trp Ext 2 Gen.Trp Ext 3 Gen.Trp Ext 4 Gen.Trp	 m m m m	 4537 4557 4577 4597	Trip by externally coupled trip signals via binary inputs
6314	LED 14 LED 14 LED 14 LED 14 LED 14	 Failure 5V Failure 15V Failure 24V Failure 0V	 nm nm nm nm	 144 143 141 145	Failure in one of the internal d.c. supply circuits

Table 5.5 Preset LED indicators

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

The unit contains 5 trip relays which are designated TRIP RELAY 1 to TRIP RELAY 5. 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).

Table 5.6 shows the list of all the command functions with their associated function number **FNo**. Input functions naturally have no effect if the corresponding protection function has been programmed out ("de-configured", refer Section 5.4.2).

The following boxes show an example for marshalling of trip relays 1. Table 5.7 shows all trip relays as preset from the factory. Figure 5.9, at the end of this section, illustrates the preset assignment as a tripping matrix.

```
6400 MARSHALLING
TRIP RELAYS
```

Beginning of the block "Marshalling of the trip relays"

The desired trip relay is reached with the key ↑:

```
6401 TRIP
RELAY 1
```

Allocations for trip relay 1

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

```
001 TRIP REL. 1
Test Trip 1
```

Trip relay 1 has been preset for:
1st: Trip by test trip function for trip relay 1, FNo 1175; this function is **fix allocated and cannot be changed!**

```
002 TRIP REL. 1
U< trip
```

Trip relay 1 has been preset for:
2nd: Trip by undervoltage protection U<, FNo 6539

```
003 TRIP REL. 1
I2>> Trip
```

Trip relay 1 has been preset for:
3rd: Trip by unbalanced load protection, high current definitive stage I_2>>, FNo 5160

```
004 TRIP REL. 1
 I2Θ Trip
```

Trip relay 1 has been preset for:
4th: Trip by unbalanced load protection, thermal trip stage, FNo 5161

```
005 TRIP REL. 1
f1< Trip
```

Trip relay 1 has been preset for:
5th: Trip by frequency protection, stage f1<, FNo 5225

```
0 0 6▌ T R I P   R E L .   1
S / E / F   T r i p
```

Trip relay 1 has been preset for:
6th: Trip by stator earth fault protection, FNo 5193

```
0 0 7▌ T R I P   R E L .   1
n o t   a l l o c a t e d
```

Trip relay 1 has been preset for:
7th: no function allocated

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

FNo	Abbreviation	Logical command function
1	not allocated	no command function allocated
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
1815	I> Trip	Trip by overcurrent time protection I> phases
4537	Ext 1 Gen.Trp	Trip by external trip signal 1 via binary input
4557	Ext 2 Gen.Trp	Trip by external trip signal 2 via binary input
4577	Ext 3 Gen.Trp	Trip by external trip signal 3 via binary input
4597	Ext 4 Gen.Trp	Trip by external trip signal 4 via binary input
5160	I2>> Trip	Trip by load unbalanced protection stage I2>>
5161	I2 Θ Trip	Trip by load unbalanced protection thermal stage
5192	S/E/F st.Trip	Trip by start-up earth fault protection
5193	S/E/F Trip	Trip by stator earth fault protection
5224	f1> Trip	Trip by frequency protection, stage f1>
5225	f1< Trip	Trip by frequency protection, stage f1<
5226	f2> Trip	Trip by frequency protection, stage f2>
5227	f2< Trip	Trip by frequency protection, stage f2<
5277	I>< Trip	Trip by overcurrent/undercurrent supervision I><
5307	U DC Trip	Trip by d.c. voltage time protection Udc> or Udc<
5399	R/E/F/Trip	Trip by rotor eath fault protection
5459	Pa> Trip	Trip by active power protection
5460	Pr> Trip	Trip by reactive power stage Pa>
5462	Pr>> Trip	Trip by reactive power stage Pa>>
5463	Pa+SV Trip	Trip by active power protection with tripped stop valve
6539	U< trip	Trip by undervoltage protection U<
6570	U> trip	Trip by overvoltage protection U>
6573	U>> Trip	Trip by overvoltage protection U>>

Table 5.6 Marshalling possibilities for command functions

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	Test Trip 1 [1]	1175	
	TRIP REL. 1	U< trip	6539	
	TRIP REL. 1	I2>> Trip	5160	e.g. trip for network circuit breaker
	TRIP REL. 1	I2 Θ Trip	5161	
	TRIP REL. 1	f1 < Trip	5225	
	TRIP REL. 1	S/E/F Trip	5193	
6402	TRIP	RELAY 2		
	TRIP REL. 2	Test Trip 2 [1]	1176	
	TRIP REL. 2	S/E/F Trip	5193	
	TRIP REL. 2	I> Trip	1815	
	TRIP REL. 2	R/E/F Trip	5399	
	TRIP REL. 2	Pa> Trip	5459	e.g. trip for generator circuit breaker
	TRIP REL. 2	U> Trip	6570	
	TRIP REL. 2	U>> Trip	6573	
	TRIP REL. 2	f2> Trip	5226	
	TRIP REL. 2	Ext 1 Gen.Trp	4537	
	TRIP REL. 2	Pr> Trip	5460	
6403	TRIP	RELAY 3		
	TRIP REL. 3	Test Trip 3 [1]	1177	
	TRIP REL. 3	S/E/F Trip	5193	
	TRIP REL. 3	I> Trip	1815	
	TRIP REL. 3	R/E/F Trip	5399	e.g. trip for stop valve
	TRIP REL. 3	Pa> Trip	5459	
	TRIP REL. 3	U> Trip	6570	
	TRIP REL. 3	U>> Trip	6573	
	TRIP REL. 3	f2> Trip	5226	
	TRIP REL. 3	Ext 1 Gen.Trp	4537	
	TRIP REL. 3	Pr> Trip	5460	
6404	TRIP	RELAY 4		
	TRIP REL. 4	Test Trip 4 [1]	1178	
	TRIP REL. 4	S/E/F Trip	5193	
	TRIP REL. 4	I> Trip	1815	
	TRIP REL. 4	R/E/F Trip	5399	e.g. trip for de-excitation
	TRIP REL. 4	Pa> Trip	5459	
	TRIP REL. 4	U> Trip	6570	
	TRIP REL. 4	U>> Trip	6573	
	TRIP REL. 4	f2 > Trip	5226	
	TRIP REL. 4	Ext 1 Gen.Trp	4537	
	TRIP REL. 4	Pr> Trip	5460	
6405	TRIP	RELAY 5		
	TRIP REL. 5	Test Trip 5 [1]	1179	
	TRIP REL. 5	S/E/F Trip	5193	e.g. trip for station auxiliary supply change-over
	TRIP REL. 5	I> Trip	1815	
	TRIP REL. 5	f2 > Trip	5226	
	TRIP REL. 5	Ext 1 Gen.Trp	4537	

[1] Trip test for each trip relay is fix allocated and cannot be altered

Table 5.7 Preset command functions for trip relays

Signal	1 Network circuit breaker	2 Generator circuit breaker	3 Stop valve	4 De−excitation	5 Station aux. supply change−over	FNo.
>Annunc. 1						FNo. 0011
>Annunc. 2						FNo. 0012
>Annunc. 3						FNo. 0013
>Annunc. 4						FNo. 0014
I> Trip		●	●	●	●	FNo. 1815
Ext 1 Gen.Trp		●	●	●	●	FNo. 4537
Ext 2 Gen.Trp						FNo. 4557
Ext 3 Gen.Trp						FNo. 4577
Ext 4 Gen.Trp						FNo. 4597
I2>> Trip	●					FNo. 5160
I2 Θ Trip	●					FNo. 5161
S/E/F st.Trip						FNo. 5192
S/E/F Trip	●	●	●	●	●	FNo. 5193
f1> Trip						FNo. 5224
f1< Trip	●					FNo. 5225
f_2 > Trip		●	●	●	●	FNo. 5226
f_2 < Trip						FNo.5227
I>< Trip						FNo. 5277
U DC Trip						FNo. 5307
R/E/F Trip		●	●	●		FNo. 5399
Pa> Trip		●	●	●		FNo. 5459
Pr> Trip		●	●	●		FNo. 5460
U< trip	●					FNo. 6539
U> trip		●	●	●		FNo. 6570
U>> Trip		●	●	●		FNo. 6573

Figure 5.9 Tripping matrix − pre-settings

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

6.2.1 Membrane keyboard and display panel

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

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

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

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

Numerical keys for the input of numerals:

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

Yes/No keys for text parameters:

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

Keys for paging through the display:

[↑]	Paging forwards: the next address is displayed
[↓]	Paging backwards: the previous address is displayed
[⇧]	Block paging forwards: the beginning of the next address block is displayed
[⇩]	Block paging backwards: the beginning of previous address block is displayed

Confirmation key:

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

Control and special keys:

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

The three keys ↑ ; ⇑ ; RESET which are somewhat separated from the rest of the keys, can be accessed when the front cover is closed. The arrows have the same function as the keys with identical symbols in the main field and enable paging in forward direction. Thus all setting values and event data can be displayed with the front cover closed. Furthermore, stored LED indications on the front can be erased via the RESET key without opening the front cover. During reset operation all LEDs on the front will be illuminated thus performing a LED test. With this reset, additionally, the fault event indications in the display on the front panel of the device are acknowledged; the display shows then the operational values of the quiescent state. The display is switched over to operating mode as soon as one of the keys **DA**, **M/S**, **CW** or ⇑ is pressed.

6.2.2 Operation with a personal computer

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

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

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

6.2.3 Operational preconditions

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

– setting of functional parameters (thresholds, functions),

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

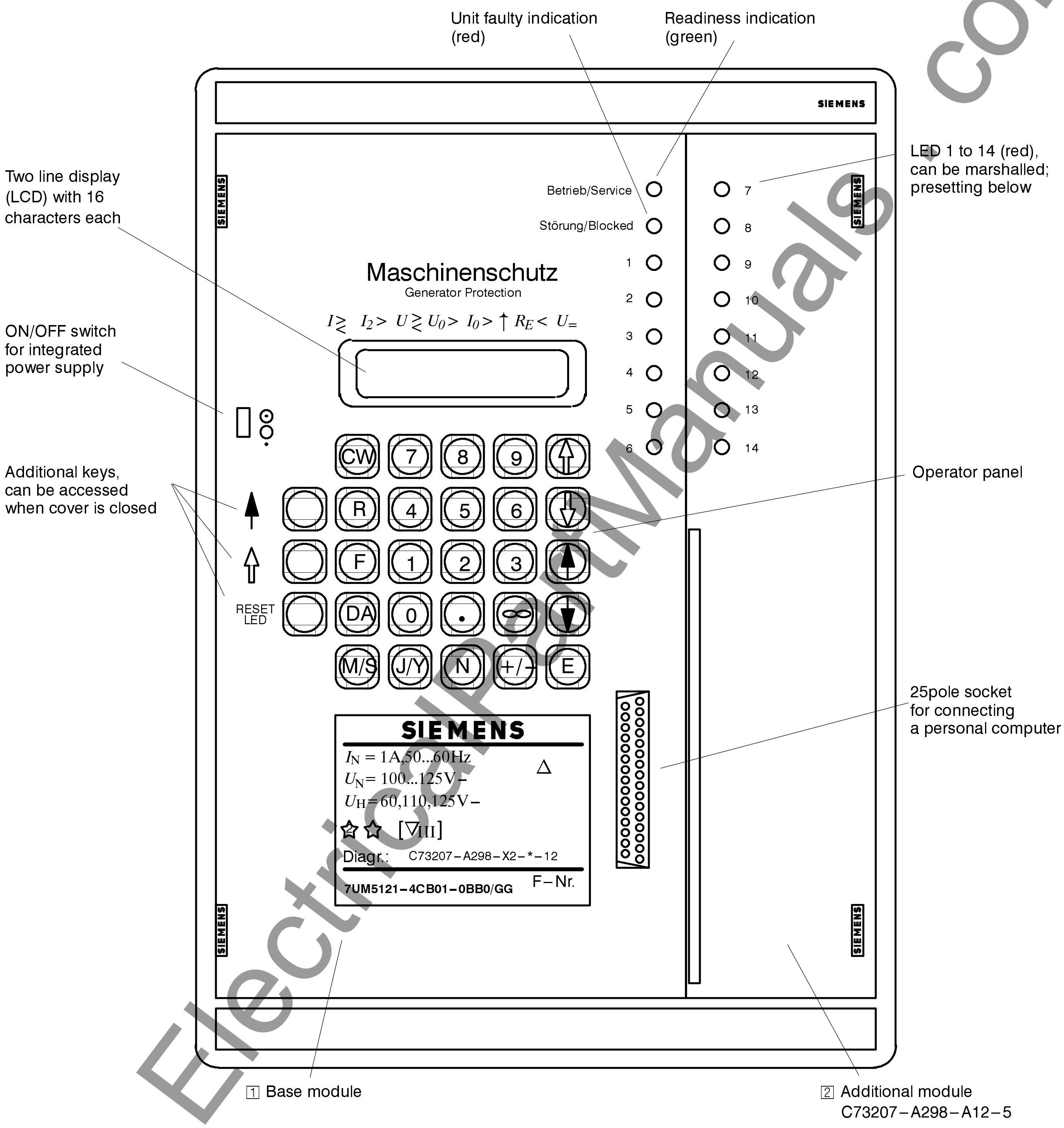
– configuration parameters for operating language, interface and device configuration,

– initiation of test procedures.

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

The method of entry of the codeword is explained in detail in the installation instructions under Section 5.3.

6.2.4 Representation of the relay (front view)



Factory presetting LEDs:

1	I> Trip	6	U> Trip	11	I2>> or I2 Θ Trip
2	I>< Trip	7	Pa> or Pr>Trip	12	I2> Warn
3	S/E/F Trip	8	U DC Trip	13	Ext Gen. Trip
4	R/E/F Trip	9	I> Fault	14	Device fault (hardware fault)
5	R/E/F Warn	10	U0> Fault		

Figure 6.1 Front view of operating key board and display panel

6.3 Setting the functional parameters

6.3.1 Introduction

6.3.1.1 Parameterizing procedure

For setting the functional parameters it is necessary to enter the codeword of code level 2 (see Section 5.3.1). Without codeword entry, parameters can be read out but not be changed.

If the codeword is accepted, parameterizing can begin. In the following sections each address is illustrated in a box and is explained. There are three forms of display:

– Addresses without request for operator input

  The address is identified by the block number followed by 00 as sequence number (e.g. **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. **1201** for block **12**, sequence number **1**). Behind the bar appears the meaning of the required parameter, in the second display line, the value of the parameter. When the relay is delivered a value has been preset. In the following sections, this value is shown. If this value is to be retained, no other input is necessary. One can page forwards or backwards within the block or to the next (or previous) block. If the value needs to be altered, it can be overwritten using the numerical keys and, if required, the decimal point and/or change sign (**+**/**–**) or, where appropriate, infinity sign ∞. The permissible setting range is given in the following text, next to the associated box. Entered values beyond this range will be rejected. The setting steps correspond to the last decimal place as shown in the setting box. Inputs with more decimal places than permitted will be truncated down to the permissible number. **The value must be confirmed with the entry key E!** The display then confirms the accepted value. The changed parameters are only saved after termination of parameterizing (refer below).

– Addresses which require text input

  The display shows the four-digit address, i.e. block and sequence number (e.g. **1205** for block **12**, 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 functional 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 parameterizing. If you press the “Yes”–key **J/Y** instead, another question appears: “SAVE NEW SETTINGS ?”. Now you can confirm with **J/Y** or abort with **N**, as above.

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

6.3.1.2 Selectable parameter sets

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 if the the real time clock is available. 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 ↑.

```
↑  25.04.1996
↓  11:58:26
```

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 ▮ 7 U M 5 1 2     V 3 . * * B
7 U M 5 1 2 * * * * * * * * * *
```

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

After address 1000, the functional parameters begin. If switch-over of parameter sets is used, the identifier of the parameter set is indicated as a leading character. Further address possibilities are listed under "Annunciations" and "Tests".

```
A 1 0 0 0 ▮
P A R A M E T E R S
```

Commencement of functional parameter blocks (example illustrated for parameter set A)

6.3.3 Machine and power system data − address blocks 11 and 12

The relay requests basic data of the power system and of the protected machine. They are not absolutely necessary for the actual protection functions, however, they are used for the determination of operational data.

```
  1 1 0 0 ▮ M A C H I N E   &
P O W E R S Y S T E M   D A T A
```

Beginning of the block "Machine and power system data"

For example, the calculated approximate pole angle can only be correctly indicated if rated output, rated current, rated voltage and the reciprocal value of the quadrature reactance have been correctly parameterized.

```
  1 1 0 3 ▮ P O W E R
 2 0 . 0   M V A
```

Rated apparent power of machine
Setting range: **0.1** MVA to **2000.0** MVA

```
  1 1 0 4 ▮ C O S   P H I
0 . 8 5 0
```

Rated power factor cos φ
Setting range: **0.000** to **1.000**

```
  1 1 0 5 ▮ I n
1 . 0 9 9   k A
```

Rated current of machine
Setting range: **0.050** kA to **50.000** kA

```
 1106 Un
10.50 kV
```

Rated voltage of machine
(phase-to-phase)
Setting range: **0.30** kV to **100.00** kV

```
 1108 STAR-POINT
HIGH-RESISTANCE
```

```
LOW-RESISTANCE
```

Type of star-point earthing of machine

```
 1200 INSTRUMENT
TRANSFORMER DATA
```

Beginning of block
"Instrument transformer data"

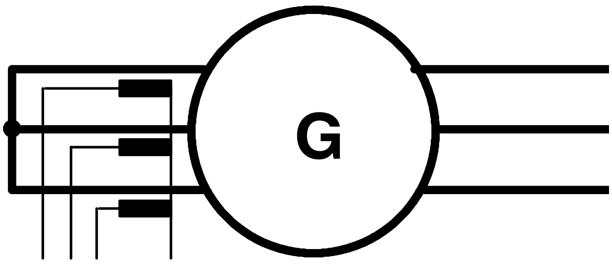
The instrument transformer data are entered in block 12. Of particular importance here is the correct polarity, which is determined by the input of the starpoint side of the current transformers (address 1205). The descriptions *TOWARDS MACHINE* and *TOWARDS STARPOINT* presuppose that the current transformers are located between the machine and the machine starpoint (see Figure 6.2). Furthermore, **generator** operation is assumed. If the current transformers are arranged differently or if the protected machine is a synchronous **motor**, then the entry must be changed accordingly.

The secondary rated voltage of the voltage transformers (address 1204) and the reference voltage (U_{L1-L2} or U_{L2-L3} or U_{L3-L1}, address 1208) is necessary for power protection and stator earth fault protection.

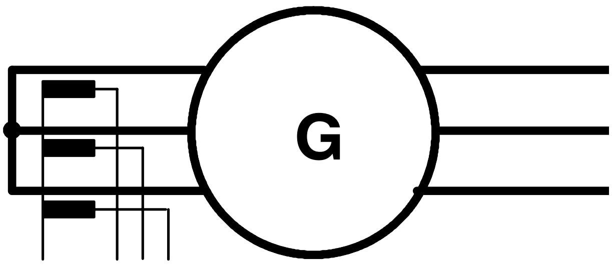
With respect to the use as reverse power protection in particular, angle error correction for the current and voltage transformers is of importance (addresses 1206 and 1207), as here a very small active power must be calculated from a considerable apparent power in case of small power factor.

The sum δ of the angle errors of current and voltage transformers is used for the correction angle. The angle is composed of a constant component as the voltage transformer voltage and thus its angle can be assumed to be constant, and a current dependent component.

The dependence of the current is approximated by a straight curve as illustrated in Figure 6.3 which shows the angle error as a function of the current magnitude. This correction curve is defined by the intersection of the $\delta-$axis W_0 and the slope W_1. When the angle error curve is known, the values W0 and W1 must be entered in addresses 1206 and 1207 with reversed sign. The total angle error can also be determined during commissioning and entered (refer to Section 6.7.7.2).

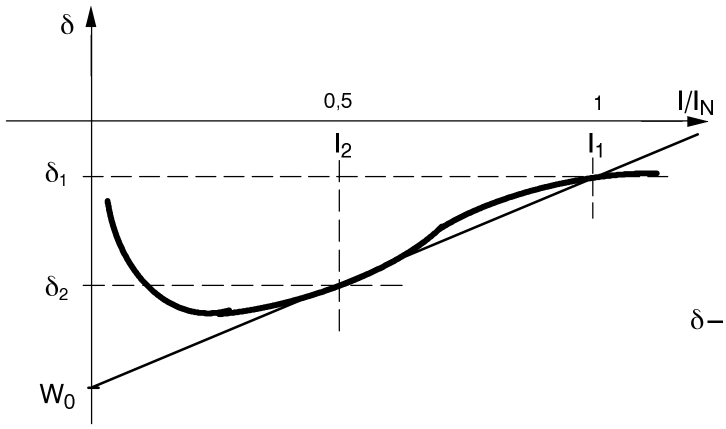


a) CT STARPNT = *TOWARDS MACHINE*



b) CT STARPNT = *TOWRDS STARPOINT*

Figure 6.2 Generator/motor c.t. orientation – address 1205



Characteristics of the line:

Slope: $W_1 = \frac{\delta_1 - \delta_2}{I_1 - I_2}$

δ−axis intersection: $W_0 = \delta_1 - W_1 \cdot I_1$

Figure 6.3 Example for angle error δ as a function of the current I/I_N

```
 1201█IN  CT  PRIM
1.200  kA
```

Primary rated current of current transformers
Setting range: **0.050** kA to **50.000** kA

```
 1202█UN  VT  PRIM
10.00  kV
```

Primary rated voltage of voltage transformers (phase-to-phase)
Setting range: **0.30** kV to **50.00** kV

```
 1204█Un  SECOND.
100  V
```

Secondary rated voltage of voltage transformers (phase-to-phase)
Setting range: **100** V to **125** V

```
 1205█CT  STARPNT
TOWARDS  MACHINE
```

Polarity of current transformers:

Starpoint formed on machine terminal side

```
TOWRDS  STARPOINT
```

Starpoint formed on machine starpoint side.

```
 1206█CT  ANG.  W0
4.30  deg
```

Correction angle W_0 for the instrument transformers
Setting range: **−2.50**° el to **+7.50**° el
The presetting corresponds to the angle deviation of the internal transducers

```
 1207█CT  ANG.  W1
-1.70  deg
```

Current dependent correction W_1 for the instrument transformers
Setting range **−2.50**° el to **+0.00**° el

The presetting corresponds to the angle deviation of the internal transducers. Exact test of the angle error is possible during commissioning with the machine (refer to Section 6.7.7.2).

In address 1208, the relay is informed about the connection mode of the voltage. This is important for correct determination of the powers.

The displacement voltage ration is set in address 1210. Since the ratio of the voltage transformers is normally

$$\frac{U_{Nprim}}{\sqrt{3}} : \frac{U_{Nsek}}{\sqrt{3}} : \frac{U_{Nsec}}{3}$$

the factor Uph/Uen (secondary values, address 1210) shall be set as $3/\sqrt{3} = \sqrt{3} \approx 1.73$ when the delta windings are connected. If the ratio is different, e.g. when the displacement voltage is formed by intermediate transformers, the factor has to be selected accordingly.

```
1208 REF.VOLT.
UL1L2
```
Connected reference voltage for power calculation and phase determination of the earth fault protection
$U_{L1} - U_{L2}$

```
UL2L3
```
$U_{L2} - U_{L3}$

```
UL3L1
```
$U_{L3} - U_{L1}$

```
1210 Uph/Uen
1.73
```
Matching factor for residual voltage:

$$\frac{\text{rated secondary voltage of v.t. phase winding}}{\text{rated secondary voltage of open delta winding}}$$

normally 1.73

Setting range: **-9.99** to **9.99**

6.3.4 Settings for undervoltage protection – address block 16

```
1600 UNDER-
VOLTAGE
```
Beginning of the block "Undervoltage protection"

```
1601 UNDERVOLT.
OFF
```
Switch *OFF* of the voltage protection

```
ON
```
Switch *ON* of the voltage protection

```
BLOCK TRIP REL
```
Undervoltage protection operates but *TRIP RELay* is *BLOCKed*

The frequency-dependent undervoltage protection mainly protects consumers (induction machines) from the consequences of voltage or frequency drops in island networks. Also in interconnected networks, it can be used as a load shedding criterion. The frequency influence can be varied by selecting between seven different frequency factors FREQ.FACTOR = 0 to 6 (refer to Figure 3.1 in Technical data under Section 3.2). Frequency factor 0 signifies no frequency influence; frequency factor 6 signifies the strongest frequency influence. The formula for frequency dependency is

$$\Delta U = c \cdot \Delta f^2$$

with Δf – deviation from rated frequency in Hz
c – frequency factor address 1605
ΔU – difference between pick-up value and setting value address 1602 in V secondary

Depending on the type of the machine and the network, different points need to be considered when setting the parameters:

In asynchronous machines, the pull-out torque is normally 2 to 2.5 times the rated torque. It decreases with the square of the voltage. This means that the machine will stall at 60 % to 70 % rated voltage. However, asynchronous motors can run up again after recovery of a sufficiently high voltage, albeit with increased starting current.

The setting for the voltage limit value should, therefore, lie slightly (approx. 5 %) above the ratio

$$\sqrt{\frac{\text{rated torque}}{\text{pull-out torque}}} \cdot U_N.$$

Since the above considerations assume rated frequency, power values can be inserted in place of torques.

In synchronous machines, the torque decreases linearly with the voltage. However, synchronous machines are more sensitive with regard to voltage decreases since they – contrary to asynchronous machines – fall out-of-step if the pull-out torque has been reached. Therefore the safety margin should be slightly higher. Also in this case, the voltage should not drop below 60 % to 70 % of rated voltage. For the setting of the voltage limit value, a value equal to 10 % above the ratio

$$\frac{\text{rated torque}}{\text{pull-out torque}} \cdot U_N$$

is recommended.

Power values can be inserted instead of torques.

Frequency decreases – as well as voltage drops – occur when the power requirements of the consumers exceed the active power supplied by the generators. For the selection of the characteristic, the voltage/frequency characteristic of the network is the main consideration. In stable interconnected networks frequency factor 0 (no frequency influence) is chosen, whereas in smaller island networks a higher frequency factor is recommended. The voltage/frequency relation of the characteristics can be taken from Fig 3.1 in the Technical data (Section 3.2).

For induction motors, the voltage/frequency behaviour not only of the motor itself but also the influence on the driven side must be considered. For example, a high frequency influence would be set for feed pumps since the head is reduced with the cube of the frequency.

The delay time should be sufficiently long to avoid protection trips during permissible short-term voltage drops. All setting times are additional delay times which do not include the operating time (measurement time, reset time) of the protection function itself.

```
 1602 U<
60.0  V
```

Pick-up value of U< stage of undervoltage protection
Setting range: **20.0** V to **100.0** V

```
 1603 T-U<
1.50  s
```

Trip delay of undervoltage protection U<
Setting range: **0.00** s to **32.00** s
and ∞ (no trip)

```
 1604 T-RESET
0.10  s
```

Reset delay after trip signal has been initiated
Setting range: **0.00** s to **32.00** s

```
 1605 FREQ.FAC.
0
```

Frequency factor of the voltage/frequency characteristic according to characteristics shown in Figure 3.1, section 3.2

$\Delta U = c \cdot \Delta f^2$

0 – independent of frequency
1 to **6** – increasing frequency dependence with increasing frequency factor

6.3.5 Settings for overvoltage protection – address block 17

```
 1700▮ OVER-
VOLTAGE
```

Beginning of the block "Overvoltage protection"

```
 1701▮ OVERVOLT.
OFF
```

Switch *OFF* of the voltage protection

```
ON
```

Switch *ON* of the voltage protection

```
BLOCK TRIP REL
```

Overvoltage protection operates but *TRIP REL*ay is *BLOCK*ed

---

The setting of the overvoltage protection depends on the speed with which the voltage regulator can regulate voltage changes. The protection must not interfere in the operation of a correctly operating voltage regulator. The two-stage characteristic, therefore, must always lie above the voltage/time characteristic of the regulator.

The U> stage (long-time stage) should intervene in the event of steady-state overvoltages. It is set to approximately 110 % U_N and, depending on the regulating speed, to 1.5 s to 2 s.

If the generator sheds full load, the voltage initially increases depending on the transient voltage and is then reduced back to the rated value by the voltage regulator. The U>> stage as a short-time stage is usually set such that the transients after full-load rejection do not initiate tripping. A common setting is, e.g. 130 % U_N with a delay of 0.1 s.

All setting times are additional delay times, which do not include the normal operating times (measuring time, reset time) of the protection function itself.

```
 1702▮ U>
110 V
```

Pick-up value of U> stage of overvoltage protection
Setting range: **30** V to **140** V

```
 1703▮ U>>
130 V
```

Pick-up value of U>> stage of overvoltage protection
Setting range: **30** V to **140** V

```
 1704▮ T-U>
1.50 s
```

Trip delay of overvoltage protection
U> (long-time stage)
Setting range: **0.00** s to **32.00** s
and ∞ (no trip with overvoltage U>)

```
 1705▮ T-U>>
0.00 s
```

Trip delay of overvoltage protection
U>> (short-time stage)
Setting range: **0.00** s to **32.00** s
and ∞ (no trip with overvoltage U>>)

```
 1706▮ T-RESET
1.00 s
```

Reset delay after trip signal has been initiated
Setting range: **0.00** s to **32.00** s

6.3.6 Settings for stator earth fault protection – address block 19

1 9 0 0 █ EARTH FAULT U0>	Beginning of the block "Earth fault protection U_0>"
1 9 0 1 █ SEF PROT. OFF	Switch *OFF* of earth fault protection U_0>
ON	Switch *ON* of earth fault protection U_0>
BLOCK TRIP REL	Earth fault protection operates but *TRIP REL*ay is *BLOCK*ed

The correct entry of the rated secondary voltage (address 1204) and the (address 1208) are essential for the correct operation of the stator earth fault protection.

The criterion for the inception of an earth fault in the stator circuit is the occurrence of a neutral displacement voltage. Exceeding the setting value Uearth (address 1902) therefore represents the pick-up for this protection.

The setting must be chosen such that the protection does not pick-up during operational asymmetries. This is particularly important for machines in bus-bar connection since all voltage asymmetries of the network affect the voltage system of the machine. The pick-up value should be at least twice the value of the operational asymmetry. A value of 5 % to 10 % of the full displacement value is normal.

For machines in block connection, the pick-up value has to be chosen such that displacements during network earth faults which are transferred via the coupling capacitances of the block transformer to the stator circuit, do not lead to pick-up. The damping effect of the load resistor must also be considered in this case. Hints for dimensioning the load resistor are contained in the pamphlet "Planning Machine Protection Systems", Order No. E50400–U0089–U412–A1–7600. The setting value is twice the displacement value which is coupled in at full network displacement. Final determination of the setting value occurs during commissioning with primary values according to section 6.7.5.

The setting under address 1903 determines whether or not the earth fault current should be considered for the earth fault detection. For block connection EARTH CURR. = *OFF* is set. For machines in bus-bar connection EARTH CURR. = *ON* must be set because a differentiation between network earth fault and machine earth fault can only be made via the earth current.

The stator earth fault trip is delayed by the time set under address 1907. When setting the delay time, the overload capability of the loading equipment must be considered. All set times are additional delay times and do not include operating times (measurement times, reset times) of the protection function itself.

Addresses 1904 to 1906 are only of importance for machines in bus-bar connection, when EARTH CURR. = *ON* has been set. The following considerations are not applicable for machines in block connection.

If it is possible to differentiate between a network earth fault and a machine earth fault from the magnitude of the earth fault current alone, then the DIR.DETERM. (directional determination) can be switched to *OFF* (address 1905). The setting of the characteristic angle (address 1906) for the determination of the direction is then also without consequence. If apart from the magnitude of the earth fault current, its direction in relation to the displacement voltage should also be considered for the proper recognition of a machine earth fault, then address 1905 is set to DIR.DETERM. = *ON*.

The directional angle DIR.ANGLE (address 1906) indicates the phase displacement between the neutral displacement voltage and the perpendicular to the directional characteristic (Figure 6.4), i.e. it is equal to the inclination of the directional characteristic to the reactive axis.

If, in an isolated networks, the capacitances to earth of the network are mainly decisive for the earth fault protection, the angle is set to approximately 90°, in a compensated network to approx. 0°.

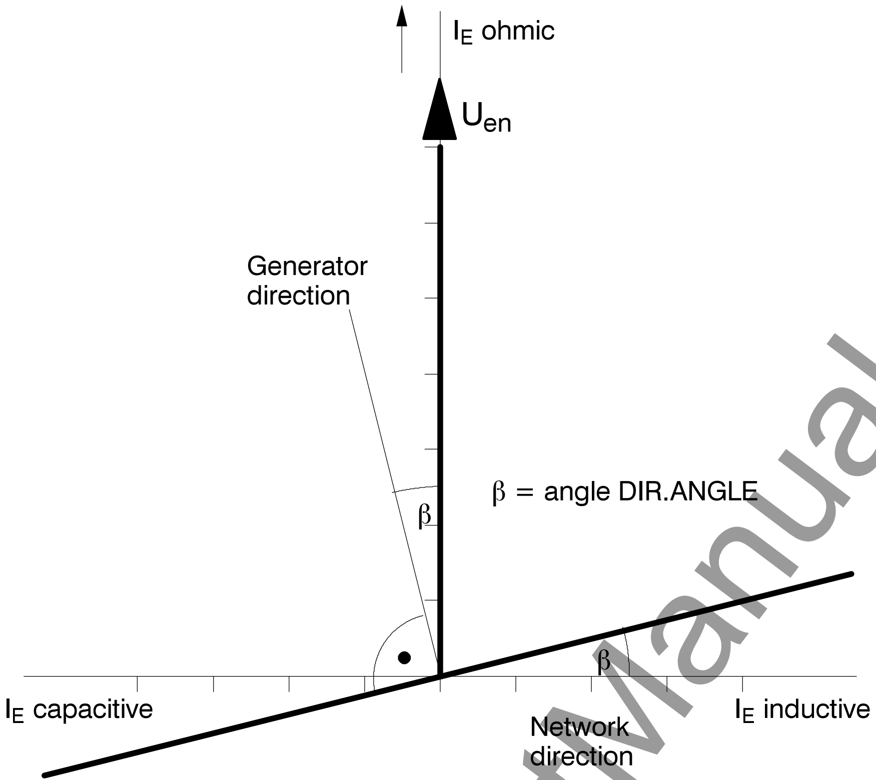


Figure 6.4 Directional characteristic of the stator earth fault protection

Since the residual earth current in a compensated network is very small, an earthing transformer with an ohmic loading resistor is normally provided to increase the residual wattmetric current in the event of an earth fault. This arrangement also makes the protection independent of network conditions. Instructions for the dimensioning of the earth current transformer and the loading resistor are contained in the pamphlet "Planning Machine Protection Systems", Order No. E50400−U0089−U412−A1−7600.

Since the magnitude of earth fault current in this case is determined mainly by the loading resistor, a small angle is set for DIR.ANGLE, e.g. 15°. If the network capacitances in an isolated network are also to be considered, then a larger angle can be set which corresponds to the superimposition of the capacitance network current onto the loading current.

The pick-up value Iearth> (address 1904) is set such that for an earth fault in the protected zone, the earth current safely exceeds the setting.

Example:

Earthing transformer	$\frac{10\ \text{kV}}{\sqrt{3}} \Big/ \frac{500\ \text{V}}{3}$
	27 kVA
Loading resistor	10 Ω 10 A continuous 50 A for 20 s
Voltage divider	500 V/100 V
Toroidal c.t.	60 A/1 A
Protected zone	90 %

With full neutral displacement voltage, the load resistor supplies:

$$\frac{500\ \text{V}}{10\ \Omega} = 50\ \text{A}$$

Referred to the 10 kV side, this results in:

$$I_{E\ prim} = 50\ \text{A} \cdot \frac{500/3}{10000/\sqrt{3}} \cdot 3 = 4.33\ \text{A}$$

The secondary current of the toroidal transformer supplies to the input of the unit:

$$I_{E\ sec} = \frac{I_{E\ prim}}{60\ \text{A}/1\ \text{A}} = \frac{4.33\ \text{A}}{60} = 72\ \text{mA}$$

For a protected zone of 90 %, the protection should already operate at 1/10 of the full displacement voltage, whereby only 1/10 of the earth fault current is generated:

$$\text{Setting Iearth} > = \frac{72\ \text{mA}}{10} = \underline{\underline{7.2\ \text{mA}}}$$

In this example Iearth > is set to 7 mA. For the displacement voltage setting, 1/10 of the full displacement voltage is used (because of the 90 % protected zone). Considering a voltage divider of 500 V/100 V, this results in:

Setting Uearth > = 10 V

The time delay must lie below the 50 A capability time of the loading resistor, i.e. below 20 s. The overload capability of the earthing transformer must also be considered if it lies below that of the loading resistor.

The earth faulted phase can be indicated if the protection is informed which voltage has been connected to the relay for voltage protection (address 1208). If no voltage is present, faulted phase detection is not possible.

```
1902 Uearth>
10.0 V
```

Pick-up value of earth (displacement) voltage
Setting range: **5.0** V to **120.0** V

```
1903 EARTH CURR
OFF
```
```
ON
```

Switching the earth current detection

OFF for machines in block unit connection

ON for machines in direct bus-bar connection

```
1904 Iearth >
5 mA
```

Pick-up value for (residual) earth current
Setting range: **2** mA to **100** mA

```
1905 DIR.DETERM
ON
```
```
OFF
```

Inclusion of directional determination for earth fault detection
ON – with directional determination
OFF – only amplitude detection according to address 1904

```
1906 DIR. ANGLE
45 °
```

Reference angle for directional determination
Setting range: **0**° to **360** °

```
1907 T-S/E/F
0.30 s
```

Time delay for trip
Setting range: **0.00** s to **32.00** s
and ∞ (no trip with stator earth fault protection)

```
1908 T-RESET
0.10 s
```

Reset delay after trip signal has ben initiated
Setting range: **0.00** s to **32.00** s

6.3.7 Settings for frequency protection − address block 20

```
  2 0 0 0 █ O V E R / U N D E R
F R E Q U E N C Y
```

Beginning of the block
"Overfrequency and underfrequency protection"

```
  2 1 0 1 █ f >   /   f <
O F F
```

Switch *OFF* of the frequency protection

```
O N
```

Switch *ON* of the frequency protection

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

Frequency protection operates but *TRIP REL*ay is *Block*ed

Two frequency stages are available. Each stage can be set as overfrequency stage or underfrequency stage. This is determined by the rated frequency as configured under address 7899 (refer to Section 5.4.2) and the set limit value. When the limit value is set smaller than the rated frequency, the stage operates as underfrequency stage; when the limit value is set higher than the rated frequency, the stage operates as overfrequency stage. **When the limit value is set equal to the rated frequency, the concerned stage is ineffective**.

As a matter of principle, the setting values for frequency and delay times depend on the values supplied by the power station operator. If the setting for the pick-up value of the underfrequency protection is e.g. 47.5 Hz (at 50 Hz rated frequency) then it can be assumed that unloading of the generator by a network frequency relay has already occurred, so that a quick increase in frequency can be expected. Therefore, the delay time setting should be as short as permissible.

In power stations, the **underfrequency** protection usually has the task of maintaining the power station auxiliary supply by promptly disconnecting it from the network. The turbine regulator then regulates the generator set to rated speed so that the power station auxiliary supply can be maintained with rated frequency.

In general, turbine−generator sets can be continuously operated at down to 95 % of rated frequency provided that the apparent power is reduced by the same amount. For the inductive consumers, however, the reduction in frequency does not only result in increased current intake but also endangers the operational stability. Therefore, only a short-time frequency reduction down to 48 Hz (at f_N = 50 Hz) or 58 Hz (f_N = 60 Hz) is usually permitted.

Overfrequency can occur, for example, during load shedding or faulty operation of the speed regulator (e.g. in island operation). Thus the overfrequency stage can be used e.g. as overspeed protection.

All setting times are additional delay times, which do not include the normal operating times (measuring time, reset time) of the protection function itself.

```
  2 0 0 2 █ f   S T A G E   1
4 9 . 5   H z
```

Pick-up value of the frequency stage f_1
Setting range: **40.0** Hz to **65.0** Hz
The preset value results in an underfrequency stage

```
  2 0 0 3 █   T - f 1
1 . 0 0   s
```

Trip time delay of the frequency stage f_1
Setting range: **0.00** s to **32.00** s
and ∞ (no trip with frequency stage f_1)

```
2004█ f STAGE 2
50.5 Hz
```

Pick-up value of the frequency stage f_2
Setting range: **40.0** Hz to **65.0** Hz
The preset value results in an overfrequency stage

```
2005█ T-f2
1.00 s
```

Trip time delay of the frequency stage f_2
Setting range: **0.00** s to **32.00** s
and ∞ (no trip with frequency stage f_2)

```
2006█ T-RESET
0.50 s
```

Reset delay after trip signal has ben initiated
Setting range: **0.00** s to **32.00** s

```
2010█ BLOCK U1<
65 V
```

Minimum operating voltage, below which frequency measurement f>< is blocked
Setting range: **40** V to **100** V

6.3.8 Settings for active power protection – address block 22

```
2200█ ACTIVE
POWER Pa>
```

Beginning of the block "Active power protection"

```
2201█ PaPROT.
OFF
```

Switch *OFF* of active power protection

```
ON
```

Switch *ON* of active power protection

```
BLOCK TRIP REL
```

active power protection operates but *TRIP REL*ay is *BLOCK*ed

Setting of the active power supervision is very much dependent on the application. Address 2203 determines whether the active power supervision operates on increased power delivery (forward active power +P) or on increased power demand (reverse power −P).

General setting recommendations cannot be made. As a matter of principle, the setting values for power and delay times depend on the values supplied by the power station operator.

Under address 2202, the direction of the active power which is to be determined must be set: Either forward power or reverse power.

In case of reverse power protection, the turbine−generator set must be disconnected from the network after occurrence of reverse power since operation of the turbine without a certain minimum steam throughput (cooling effect) is impermissible. In case of a gas turbine, the motoring load may become too large for the network. In the event of reverse power a suitable time delay must be provided in order to bridge a possible transient reverse power intake following synchronizing or during power oscillations after network faults (e.g. three-pole short-circuit).

Usually the time delay is set to approximately t = 10 s.

In the event of faults that lead to a trip of the stop valve, disconnection by the reverse power protection is performed after a short time delay following confirmation that the stop valve has successfully operated. This confirmation is normally via an oil pressure switch or a limit switch on the stop valve which is connected to the associated binary input of the device. It must be a condition for tripping, that the reverse power is caused solely by the failure of energy to the turbine. A time delay is required to bridge out the active power oscillations caused by a rapid closure of the valves, i.e. to wait until a steady-state active power value has been reached. A time delay of 2 to 3 s is sufficient in this case; approximately 0.5 s are recommended for gas turbines.

The pick-up values must be set as a percentage of the secondary rated power $S_{Nsec} = \sqrt{3} \cdot U_{Nsec} \cdot I_{Nsec}$.

The machine output must therefore be referred to secondary values:

$$\frac{P_{sec}}{S_{Nsec}} = \frac{P_{mach}}{S_{Nmach}} \cdot \frac{U_{Nmach}}{U_{Npri}} \cdot \frac{I_{Nmach}}{I_{Npri}}$$

whereby

- P_{sec} – secondary active power according to setting value
- S_{Nsec} – secondary rated apparent power $= \sqrt{3} \cdot U_{Nsec} \cdot I_{Nsec}$
- P_{mach} – active power of machine according to setting value
- S_{Nmach} – rated apparent power of machine
- U_{Nmach} – rated voltage of machine
- I_{Nmach} – rated current of machine
- U_{Npri} – primary rated voltage of voltage transformers
- I_{Npri} – primary rated current of current transformers

Power calculation in 7UM512 is derived from the connected phase-to-phase voltage and (e.g. U_{L1-L2} and one phase current (e.g. I_{L3}). The relay is informed about the connected voltage in address 1208 (see Section 6.3.3).

All setting times are additional delay times, which do not include the normal operating times (measuring time, reset time) of the protection function itself.

```
2202█ DIR. Pa>
Pa FORW. (+Pa)
```

Selection of the active power sign:

forward active power (positive, +P)

```
Pa BACK. (-Pa)
```

reverse active power (negative, –P)

```
2203█ Pa>
100.0 %
```

Supervision of increase in active power Pa>
Setting range: **1.0** % to **120.0** %
of secondary rated apparent power

```
2204█ T-Pa>
10.00 s
```

Trip delay on increase of active power Pa>
Setting range: **0.00** s to **32.00** s
and ∞ (no trip)

```
2305█ T-SV-CLOS.
3.00 s
```

Trip delay for reverse power with stop valve tripped
Setting range: **0.00** s to **32.00** s
and ∞ (no trip with short time stage)

```
  2205█ T-RESET
5.00  s
```

Drop-off time after trip signal has been issued
Setting range: **0.00** s to **32.00** s

6.3.9 Settings for reactive power supervision – address block 23

```
  2300█ REACTIVE
POWER Pr>
```

Beginning of the block "Reactive power protection"

```
  2301█ Pr>
OFF
```

Switch *OFF* of reactive power protection

```
ON
```

Switch *ON* of reactive power protection

```
BLOCK TRIP REL
```

reactive power protection operates but *TRIP REL*ay is *BLOCK*ed

Setting of the reactive power supervision is very much dependent on the application. Address 2203 determines whether the reactive power supervision operates on increased inductive power (+Q) or on increased capacitive power (–Q).

General setting recommendations cannot be made. As a matter of principle, the setting values for power and delay times depend on the values supplied by the power station operator.

With excessive capacitive power demand (–Q), i.e. when a synchronous machine is under-excited, there is risk that the machine falls out-of-step. In this application the reactive power pick-up value should be selected such that it lies below the limits of static stability of the machine (see Figure 6.5).

The pick-up value must be set as a percentage of the secondary rated apparent power $S_{Nsec} = \sqrt{3} \cdot U_{Nsec} \cdot I_{Nsec}$. The machine output must therefore be referred to secondary values:

$$\frac{Q_{sec}}{S_{Nsec}} = \frac{Q_{mach}}{S_{Nmach}} \cdot \frac{U_{Nmach}}{U_{Npri}} \cdot \frac{I_{Nmach}}{I_{Npri}}$$

whereby

- Q_{sec} – secondary reactive power according to setting value Pr
- S_{Nsec} – secondary rated apparent power $= \sqrt{3} \cdot U_{Nsec} \cdot I_{Nsec}$
- Q_{mach} – reactive power of machine according to setting value
- S_{Nmach} – rated apparent power of machine
- U_{Nmach} – rated voltage of machine
- I_{Nmach} – rated current of machine
- U_{Npri} – primary rated voltage of voltage transformers
- I_{Npri} – primary rated current of current transformers

Power calculation in 7UM512 is derived from the connected phase-to-phase voltage and (e.g. U_{L1-L2} and one phase current (e.g. I_{L3}). The relay is informed about the connected voltage in address 1208 (see Section 6.3.3).

All setting times are additional delay times, which do not include the normal operating times (measuring time, reset time) of the protection function itself.

```
 2302█ DIR.  Pr>
Pr  BACK.  (-Pr)
```

```
Pr  FORW.  (+Pr)
```

Selection of the reactive power sign:

capacitive power (negative, −Q = −Pr)

inductive power (positive, +Q = +Pr)

```
 2303█ Pr>
40.0  %
```

Pick-up value of reactive power in percent of secondary rated apparent power.
Setting range: **1.0** % to **120.0** %

```
 2304█ T-Pr>
10.00  s
```

Trip delay for reactive power
Setting range: **0.00** s to **32.00** s
and ∞ (no trip with reactive power protection)

```
 2305█ Pr>>
80.0  %
```

Pick-up value of reactive power in percent of secondary rated apparent power.
Setting range: **1.0** % to **120.0** %

```
 2306█ T-Pr>
10.00  s
```

Trip delay for reactive power
Setting range: **0.00** s to **32.00** s
and ∞ (no trip with reactive power protection)

```
 2307█ T-RESET
2.00  s
```

Drop-off time after trip command has been issued
Setting range: **0.00** s to **32.00** s

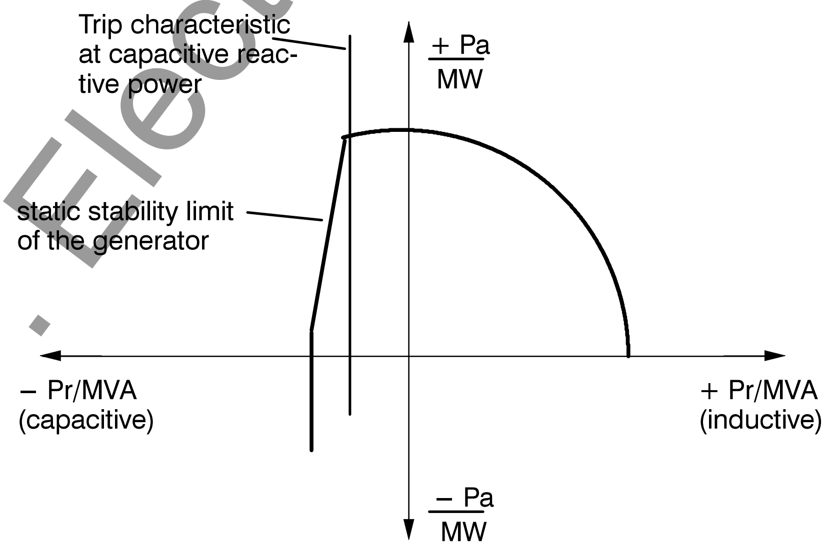


Figure 6.5 Conductance diagram of a turbo−generator

6.3.10 Settings for unbalanced load protection – address block 24

```
2400
UNBALANCED LOAD
```

Beginning of the block “Unbalanced load protection”

```
2401 UNBAL.LOAD
OFF
```

Switch *OFF* of unbalanced load protection

```
ON
```

Switch *ON* of unbalanced load protection

```
BLOCK TRIP REL
```

unbalanced load protection operates but *TRIP REL*ay is *BLOCK*ed

---

The maximum continuously permissible negative sequence current is decisive for the thermal replica. From experience, this current amounts to approximately 6 % to 8 % of rated machine current for machines up to 100 MVA and with turbo rotors and at least 12 % of the rated machine current for machines with salient-pole rotors. For larger machines and in cases of doubt, the data supplied by the manufacturer should prevail.

The values must be converted to the secondary quantities when setting the 7UM512. The following applies:

$$\text{Setting value I2>} = \frac{I_{2maxmach}}{I_{Nmach}} \cdot \frac{I_{Nmach}}{I_{Npri}}$$

whereby: $I_{2maxmach}$ – maximum continuously permissible thermal negative sequence current
I_{Nmach} – rated machine current
I_{Npri} – primary rated c.t. current

This value I2> is set under address 2402. It also represents the pick-up value of a current-dependent alarm stage, the definite delay time of which T–I2> is set under address 2403.

<u>Example:</u>

Machine: $I_N = 1099$ A
$I_{2max} = 6.5$ %

Current transformer: 1200 A/1 A

$$I2> = 6.5\ \% \cdot \frac{1099\ \text{A}}{1200\ \text{A}} = 6\ \%$$

The unbalanced load protection simulates the temperature rise according to the thermal differential equation, the solution of which is an e–function in steady state operation. The time constant τ is decisive for the time to reach the limit temperature and thus for the trip time.

If the time constant is stated by the manufacturer, then that value is set (address 2404). The thermal capability time can also be expressed by the constant $C = (I_2/I_N)^2 \cdot t$ or by the thermal unbalanced load characteristic.

The constant C is proportional to the permissible loss energy. Strictly speaking it only applies if a constant loss energy is supplied without heat dissipating. This corresponds to a linear temperature characteristic as present in the initial stage of the e–function, i.e. during a large unbalanced load. Under this provision, the gradient triangle according Figure 6.6 results in the following equation

$$\frac{(I_2/I_N)^2}{\tau} = \frac{k^2}{t} \quad \text{or} \quad (I_2/I_N)^2 \cdot t = k^2 \cdot \tau$$

whereby:
- I_2/I_N any unbalanced load,
- τ the thermal time constant,
- k the permissible unbalanced load of the machine,
- t the time at which k is reached.

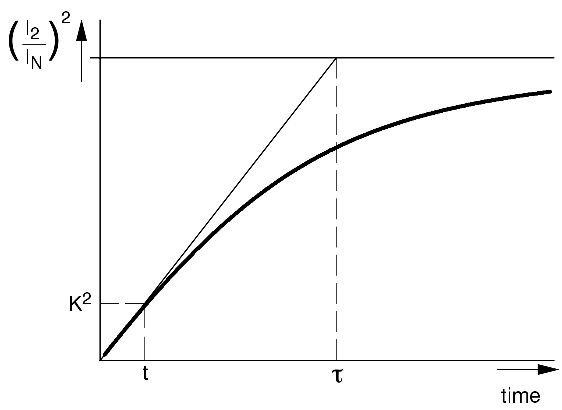


Figure 6.6 $I_2^2 - t$ characteristic

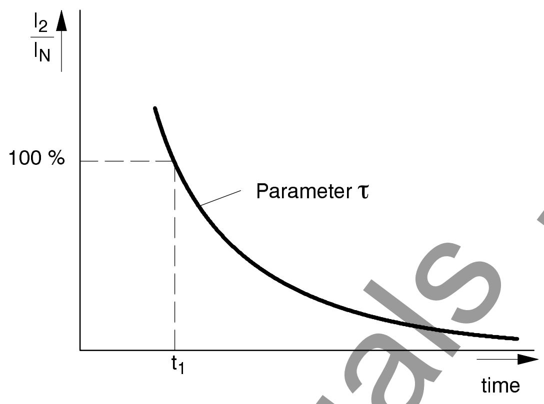


Figure 6.7 Thermal unbalanced load characteristic

If $(I_2/I_N)^2 \cdot t$ is replaced by the constant C, then it follows that

$$\tau = \frac{C}{k^2}$$

Since the constant C applies for the machine, the permissible unbalanced load referred to rated machine current must be inserted for k and not the value referred to the secondary side.

Example:

$$C = 3.17\ s$$

$$k = \frac{I_2}{I_N} = 6.5\ \% = 0.065$$

Then it follows that

$$\tau = \frac{3.17\ s}{0.065^2} = \underline{\underline{750\ s}}$$

If the thermal unbalanced load characteristic is provided, the protection characteristic must be matched to coincide with it as far as possible. Also in this case a linear e–function characteristic can be assumed on the basis of a large unbalanced load; most simply $I_2/I_N = 1$. The negative sequence current/time coordinates for e.g. $I_2/I_N = 1$ are read from the characteristic (Figure 6.7) and the time constant τ is calculated according to the following formula:

$$\tau = \frac{t_1}{k^2}$$

whereby t_1 is the permissible duration at $I_2/I_N = 1$ and k is the permissible continuous unbalanced load.

Example:

From the unbalanced load characteristic:
t_1 = 3.17 s at
I_2/I_N = 1

Continuous permissible unbalanced load
I_2/I_N = 6.5 % = 0.065

$$\tau = \frac{3.17\ s}{0.065^2} = \underline{\underline{750\ s}}$$

The calculated time constant is set as TIME CONST under address 2404.

The characteristic of the thermal unbalanced load protection does not further reduce for high negative sequence currents (above 10 times the permissible negative sequence current). Therefore, the thermal characteristic is intersected by a definite time negative sequence current characteristic I2>> (address 2406). A setting to approx. 60 % ensures that in the event of a phase failure (unbalanced load always smaller than $100/\sqrt{3}$ %, i.e. $I_2 < 58$ %) tripping always occurs according to the thermal characteristic. On the other hand, a two-phase short-circuit can be assumed to be present if more than 60 % unbalanced load exists. Consequently, the time delay T–I2>> (address 2407) is coordinated according to the time grading for phase short-circuits.

The set times are additional delay times which do not include the operating times (measurement time, reset time) of the protection function itself.

```
2402█I2>
6 %
```

Maximum continuously permissible negative sequence current in % of I_N
Setting range: **3** % to **30** %

```
2403█T-I2>
20.00 s
```

Time delay for definite time warning stage (operates after pick-up of I2>, address 2402)
Setting range: **0.00** s to **32.00** s
and ∞ (no warning with I_2> stage)

```
2404█TIME CONST
750 s
```

Thermal time constant τ
Setting range: **100** s to **2500** s

```
2405█THERM.WARN
90 %
```

Thermal warning temperature rise in % of tripping temperature rise
Setting range: **70** % to **99** %

```
2406█I2>>
60 %
```

Pick-up value for high current definite time trip stage
Setting range: **10** % to **80** %

```
2407█T-I2>>
3.00 s
```

Time delay for high current definite time trip stage I2>> (address 2406)
Setting range: **0.00** s to **32.00**
and ∞ (no trip with I_2>> stage)

```
2408█T-RESET
0.10 s
```

Drop-off time after trip signal has been issued
Setting range: **0.00** s to **32.00** s

6.3.11 Settings for overcurrent time protection – address block 25

```
2500 OVERCURR.
I>
```

Beginning of the block
"Overcurrent time protection I> stage"

```
2501 O/C I>
OFF
```

Switch *OFF* of overcurrent time stage I>

```
ON
```

Switch *ON* of overcurrent time stage I>

```
BLOCK TRIP REL
```

overcurrent time stage I> operates but *TRIP REL*ay is *BLOCK*ed

---

The overcurrent time protection is a short-circuit protection. It is the last back-up for network faults and represents the back-up protection for the differential protection. For small machines it is often the only short-circuit protection. The overcurrent stage I> should be set at least 20 % above the maximum operational current that can be expected. Increased load currents are detected by the overload protection.

The trip delay time T–I> must be coordinated with the time grading plan of the network, so that the protection unit which is closest to the fault location is the first to trip (selectivity). All set times are additional time delays which do not include operating times (measuring time, reset time).

The undervoltage seal-in feature U< (measuring of a phase-to-phase voltage) should operate below the smallest operation voltage phase-phase, e.g. setting value 75 V.

The holding time T–SEAL–IN provides the time limit of the undervoltage seal-in.

The reset ratio r can be set under address 2508. It should be considered that a high reset ratio (near 1) bears the risk of intermittent pick-up occurrences, especially when a low pick-up values (address 2502) is set. In order to avoid such intermittent pick-up, the reset ratio should be set according to the following equation:

$$(\text{pick-up value I>}) \cdot (1 - r) > 0.005 \cdot I_N$$

```
2502 I>
1.40 I/In
```

Pick-up value of I> stage referred to rated current of protection unit
Setting range: **0.10** I_N to **8.00** I_N

```
2503 T-I>
2.50 s
```

Trip delay of I> stage
Setting range: **0.00** s to **32.00** s
and ∞ (no trip)

```
2504 T-RESET
0.10 s
```

Reset delay after trip signal has been initiated.
Setting range: **0.00** s to **32.00** s

```
 2505█U<   SEAL-IN
OFF
```

Switch *OFF* of undervoltage seal-in circuit

```
ON
```

Switch *ON* of undervoltage seal-in circuit

```
 2506█U<
75.0  V
```

Pick-up value of undervoltage seal-in
Setting range: **20.0** V to **100.0** V

```
 2507█T-SEAL-IN
3.00  s
```

Duration of undervoltage sea-in; must be longer than trip delay time (address 2503) plus circuit breaker opening time
Setting range: **0.10** s to **32.00** s

```
 2508█RESET  I>
0.95
```

Reset-to-pick-up ratio of overcurrent pick-up I>
Setting range: **0,90** to **0,99**

6.3.12 Settings for overcurrent/undercurrent supervision – address block 26

```
 2600█CURRENT
SUPERVISION  I><
```

Beginning of the block "Overcurrent/undercurrent supervision I><"

```
 2601█CURR.  I><
OFF
```

Switch *OFF* of overcurrent/undercurrent supervision

```
ON
```

Switch *ON* of overcurrent/undercurrent supervision

```
BLOCK  TRIP  REL
```

overcurrent/undercurrent supervision operates but *TRIP REL*ay is *BLOCK*ed

---

General setting instructions for this protection or supervisory function can not be given because of the many possible applications.

If used as a definite time O/C stage I>, the considerations for the time grading of overcurrent protection apply. If used as circuit breaker failure back-up protection, the protection must also detect smaller fault currents which have not been cleared by the circuit breaker; 0.1 I_N to 0.2 I_N are normal. The maximum circuit breaker opening time and the reset time of the I> stage must be considered when setting the time delay. The trip signal is coupled in via binary inputs I>< coupl. 1 and I>< coupl. 2. This coupling logic must then be set ON in address 2606.

For no-load supervision, I< can be set relatively sensitive; for conductor breakage supervision a reliable differentiation must be made between operational condition and conductor interruption. The delay time depends on the control or alarm functions which should be initiated after the undercurrent condition has been detected.

It should be noted that the set currents refer to the unit rated current. The set times are additional delay times, which do not include the operating times (measurement time, reset time) of the protection function itself.

If the binary inputs are not used for coupling, then COUPLING = *OFF* (address 2606) is chosen. Otherwise no trip would be necessary because of missing AND−condition.

```
2602 I><
OVERCURRENT
```

```
UNDERCURRENT
```

I>< function operates as

OVERCURRENT supervision or protection

UNDERCURRENT supervision

```
2603 I><
0.10 I/In
```

Pick-up threshold for I> or I<
Setting range: **0.05** I_N to **8.00** I_N

```
2604 T-I><
0.50 s
```

Delay time for I> or I<
Setting range: **0.00** s to **32.00** s
and ∞ (no trip with overcurrent/undercurrent supervision)

```
2605 T-RESET
0.10 s
```

Reset delay after trip signal has been initiated
Setting range: **0.00** s to **32.00** s

```
2606 COUPLING
ON
```

```
OFF
```

Logic AND processing of binary input "`>I>< coupl. 1`" (FNo `5266`) with pick-up I> or I<

Coupling *ON*

Coupling *OFF*

Note: A precondition for tripping is always the energization of the binary input "`>I>< coupl. 2`" (FNo `5267`), independent of address 2606

6.3.13 Settings for measured value monitoring – address block 29

The different monitoring functions of the protective relay are described in Section 4.17.4. They partly monitor the relay itself, partly the steady-state measured values of the transformer circuits.

The sensitivity of the measured value monitoring can be changed in block 29. The factory settings are sufficient in most cases. If particularly high operational asymmetries of the currents and/or voltages are expected, or if, during operation, one or more monitoring functions react sporadically, then the sensitivity should be reduced.

```
2900 MEAS.VALU
E SUPERVISION
```

Beginning of block "Measured value supervision"

```
2901 M.V.SUPERV
OFF
```

```
ON
```

Measured value monitoring is

OFF switched off

ON switched on

```
2903 SYM.Ithres
0.50 I/In
```

Current threshold above which the symmetry monitoring is effective (refer to Figure 4.24)

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

```
2904 SYM.Fact.I
0.50
```

Symmetry factor for the current symmetry = slope of the symmetry characteristic (see Figure 4.24)

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

```
2905 SUM.Ithres
0.10 I/In
```

Current threshold above which the summation monitoring (refer to Figure 4.23) reacts (constant content, referred to I_N only)

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

```
2906 SUM.Fact.I
0.10
```

Relative content (referred to the maximum conductor current) for operation of the current summation monitoring (refer to Figure 4.23)

Smallest setting value:	**0.00**
Largest setting value:	**0.95**

6.3.14 Coupling external trip signals – address blocks 30 to 33

Up to four desired signals from external protection or supervision units can be included into the processing of 7UM512. 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.

```
 3000 EXTERNAL
TRIP FUNCTION 1
```

Beginning of the block “Including 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
1.00 s
```

Time delay for external trip function 1
Setting range: **0.00** s to **32.00** s
and ∞ (no trip)

```
 3003 T-RESET
0.10 s
```

Reset delay after trip signal has been initiated
Setting range: **0.00** s to **32.00** s

```
 3100 EXTERNAL
TRIP FUNCTION 2
```

Beginning of the block “Including 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
1.00 s
```

Time delay for external trip function 2
Setting range: **0.00** s to **32.00** s
and ∞ (no trip)

```
 3103 T-RESET
0.10 s
```

Reset delay after trip signal has been initiated
Setting range: **0.00** s to **32.00** s

Display	Description
3200 ▮ EXTERNAL TRIP FUNCTION 3	Beginning of the block "Including of an external trip function 3"
3201 ▮ EXT.TRIP 3 OFF	Switch *OFF* of external trip function 3
ON	Switch *ON* of external trip function 3
BLOCK TRIP REL	external trip function operates but *TRIP REL*ay is *BLOCK*ed
3202 ▮ T-DELAY 1.00 s	Time delay for external trip function 3 Setting range: **0.00** s to **32.00** s and ∞ (no trip)
3203 ▮ T-RESET 0.10 s	Reset delay after trip signal has been initiated Setting range: **0.00** s to **32.00** s

Display	Description
3300 ▮ EXTERNAL TRIP FUNCTION 4	Beginning of the block "Including of an external trip function 4"
3301 ▮ EXT.TRIP 4 OFF	Switch *OFF* of external trip function 4
ON	Switch *ON* of external trip function 4
BLOCK TRIP REL	external trip function operates but *TRIP REL*ay is *BLOCK*ed
3302 ▮ T-DELAY 1.00 s	Time delay for external trip function 4 Setting range: **0.00** s to **32.00** s and ∞ (no trip)
3303 ▮ T-RESET 0.10 s	Reset delay after trip signal has been initiated Setting range: **0.00** s to **32.00** s

6.3.15 Settings for rotor earth fault protection − address block 35

3500 █ ROTOR EARTH FAULT	Beginning of the block “Rotor earth fault protection”
3501 █ ROTOR E/F OFF	Switch *OFF* of rotor earth fault protection
ON	Switch *ON* of rotor earth fault protection
BLOCK TRIP REL	rotor earth fault protection operates but *TRIP REL*ay is *BLOCK*ed

Since the protection calculates the ohmic rotor−earth resistance from the values caused by the applied bias voltage, the limit values of the warning stage (address 3502) and for the trip stage (address 3503) can be directly set as resistance values. The pre-set values are sufficient for the majority of cases. These values can be changed depending on the insulation resistance and the cooling medium. Care must be taken to allow a sufficient margin between the setting value and the actual insulation resistance.

The time delay for the alarm stage (address 3504) is mostly set to approximately 10 s, and for the trip stage (address 3505) to approximately 0.5 s. The set times are additional delay times which do not include the operating times (measurement time, reset time) of the protection function itself.

3502 █ RE< WARN 10.0 kΩ	Pick-up value of the warning stage $R_E<$ Setting range: **3.0** kΩ to **30.0** kΩ
3503 █ RE<< TRIP 2.0 kΩ	Pick-up value of the tripping stage $R_E<<$ Setting range: **1.0** kΩ to **5.0** kΩ
3504 █ T-WARN-R< 10.00 s	Time delay for warning stage $R_E<$ Setting range: **0.00** s to **32.00** s and ∞ (no warning)
3505 █ T-TRIP-R<< 0.50 s	Time delay for tripping stage $R_E<<$ Setting range: **0.00** s to **32.00** s and ∞ (no trip with $R_E<<$)
3506 █ T-RESET 0.10 s	Reset time after trip signal has been initiated Setting range: **0.00** s to **32.00** s

The setting of the coupling reactance (address 3507) and the series resistance (address 3508) enable the protection to calculate the earth resistance from the complex equivalent diagram of the coupling capacitance of the coupling unit, the series (e.g. measuring brush) resistance, the capacitance to earth of the excitation circuit, and the earth resistance of the excitation circuit; please refer to Figure 4.17 (Section 4.10). The equivalent circuit according to Figure 6.8 applies.

The series resistor for the protection of the coupling capacitors can be considered with the total series resistance (address 3508) since the brush resistance and the series resistance are connected in series in the measurement circuit. The resultant resistance applies for R–SERIES, i.e. the parallel connection in each case of the series resistors and of the resistance of the two brushes. Similarly, the coupling reactance is calculated from the parallel connection of the two coupling capacitors.

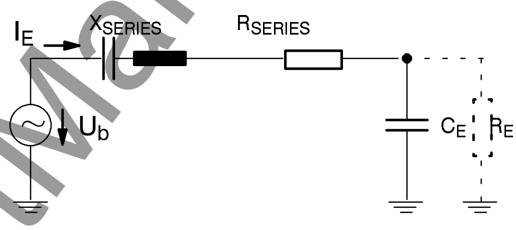
In some cases, a series inductance is included in the coupling circuit which reduces very high harmonic content of the excitation voltage. This forms, together with the coupling capacitance, a band pass for the system frequency. In these cases the following must be considered:

– Since the series inductance compensates for the coupling capacitance to a high extent, the earth fault current in case of a rotor earth fault would grow impermissibly high. An additional damping resistor R_d must, therefore, be included in the coupling circuit of the rotor earth fault protection. This increases the total series resistance R_{SERIES} and must be added to the brush resistance. The total series resistance must be dimensioned such that the earth current I_E in case of a bolted rotor earth fault ($R_E = 0$) does not exceed 300 mA. That means, with an injected bias voltage of 45 V, that the total series impedance must be higher than 450 Ω ($\sqrt{R_{SERIES}^2 + X_{SERIES}^2}$).

– The total resulting reactance must not be greater than 50 Ω inductive.

Coupling reactance and series resistance can be measured by the protection itself during commissioning (section 6.7.2). It may be advantageous to compensate for the angle error of the measured inputs of the relay in order to increased accuracy. This can be done in address 3510. The angle error can be measured by the relay during commissioning, too.

If a sufficiently high rotor capacitance ($C_E \geq 0.15\ \mu F$) is available an interruption in the measurement circuit can also be recognized. Address 3509 determines, below which current a measurement circuit interruption is assumed provided the bias voltage is at least 25 V. The alarm is reset 0.5 mA or 20 % above the setting value or when the voltages falls below 20 V.



where:

U_b	bias voltage of the rotor circuit
I_E	earth current
X_{SERIES}	total series reactance of the coupling circuit, consisting of coupling capacitance and inductance (if applicable)
R_{SERIES}	total resistance of the coupling circuit consisting of brush resistance, protection resistance (if applicable) and damping resistance (if applicable)
C_E	rotor earth capacitance
R_E	rotor earth resistance

Figure 6.8 Equivalent measuring circuit for rotor earth fault protection

```
  3507█ X COUPL.
398  Ω
```

Total reactance (capacitive) of the coupling circuit; note that the set value has reversed sign: – inductive, + capacitive
the preset value corresponds to the rated coupling reactance of the coupling unit 7XR6100 at 50 Hz (2 x 4 μF)
Setting range: **–50** Ω to **800** Ω

```
  3508█R SERIES
0 Ω
```

Series resistance (e.g. measuring brushes)
Setting range: **0** Ω to **999** Ω

```
  3509█I RE<
2.0 mA
```

Pick-up value of annunciation of faulty measured circuit (interrupted circuit)
Setting range: **1.0** mA to **50.0** mA
and 0.0 mA, i.e. fault annunciation ineffective

```
  3510█CT ANG. W0
8.0 °
```

Correction angle of measured earth current of rotor earth fault protection
Setting range: **−15.0** ° to **+15.0** °

6.3.16 Settings for DC voltage time protection − address block 36

```
  3600█DC VOLTAGE
TIME PROTECTION
```

Beginning of the block
"D.C. voltage time protection"

```
  3601█DC VOLTAGE
OFF
```

Switch *OFF* of d.c. voltage time protection

```
ON
```

Switch *ON* of d.c. voltage time protection

```
BLOCK TRIP REL
```

D.c. voltage time protection operates but *TRIP REL*ay is *BLOCK*ed

Normally an integrated mean value filter is switched on. A high ripple content or non-periodic peaks are averaged in this manner. The polarity of the measured voltage is of no concern since the absolute value is taken.

Alternatively, a sinusoidal a.c. voltage can be measured (address 3602). The protection then multiplies the rectified mean value with 1.11. The frequency of the a.c. voltage must match to the frequency of other a.c. quantities because the latter determine the sampling rate. The maximum a.c. amplitude must not exceed 10 V. Thus, the maximum reasonable setting is 7 V.

The measured voltage must be matched to these input conditions by means of an upstreams voltage divider when it does not meet the input conditions.

```
  3602█MEAS.METH.
MEAN VALUES
```

```
RMS VALUES
```

Measurement method:
d.c. *MEAN VALUES* are measured

a.c. *R.M.S. VALUES* are measured

The d.c. voltage/time protection can be set to operate on voltage increase U DC >/< = *OVERVOLTAGE* or on voltage decrease U DC >/< = *UNDERVOLTAGE* (address 3603).

When setting the pick-up values (address 3604) the ratio of a voltage divider – if fitted – is to be considered.

The set times are additional delay times and do not include the operating times (measurement time, reset time) of the protection function itself.

Note that the operating times of the d.c. voltage time protection are prolonged by the factor 4 when “operating condition 0” occurs, i.e. when no suitable measured a.c. quantities are present.

```
  3603█DC VOLTAGE
OVERVOLTAGE
```

```
UNDERVOLTAGE
```

D.C. voltage time protection is used as

d.c. overvoltage protection

d.c. undervoltage protection

```
  3604█U DC ><
2.0 V
```

Pick-up value of d.c. voltage protection
Setting range: **0.1** V to **8.5** V d.c.
For a.c. voltage measurement the setting range is reduced to: **0.1** V to **7.0** V a.c.

```
  3605█T-U-DC><
2.00 s
```

Trip time delay for Udc> or Udc<
Setting range: **0.00** s to **32.00** s
and ∞ (no trip with d.c. voltage time protection)

```
  3606█T-RESET
0.10 s
```

Reset delay after trip signal has been initiated
Setting range: **0.00** s to **32.00** s

6.3.17 Settings for trip circuit supervision − address block 39

Binary inputs of the device can be used for the two trip circuit supervision functions (refer Section 4.16). Each trip circuit supervision needs two binary inputs.

The trip circuit is supervised for open-circuit, short-circuit and control voltage failure.

The trip circuits are checked approx. two to three times per second. Alarm delay is determined by the number of measurement repetitions (address 3903). Higher number of measurement repetitions corresponds to longer alarm delay and, of course, to increased safety against faulty alarm. Equally, the time delay can bridge out short interruptions during breaker operation.

```
3900 TRIP CIR'T
SUPERVISION
```

Beginning of the block “Trip circuit supervision”

```
3901 TRP SUPERV
OFF
```

```
ON
```

Trip circuit supervision is
OFF switched off
ON switched on

```
3902 No.CIRCT.
1
```

Number of supervised trip circuits;
Setting range: **1** to **2**

```
3903 MEA.REPET.
3
```

Number of measurement repetitions
Setting range: **2** to **6**
(corresponding to an alarm delay of approx. 600 ms to 1800 ms)

6.4 Annunciations

6.4.1 Introduction

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

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

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

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

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

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

– Transmission via the serial interface to local or remote control facilities.

Most of these annunciations can be relatively freely allocated to the LEDs and binary outputs (see Section 5.5). Also, within specific limitations, group and multiple indications can be formed.

To call up annunciations on the operator panel, the following possibilities exist:

– Block paging with the keys ⇑ forwards or ⇓ backwards up to address 5000,

– Direct selection with address code, using key **DA**, address **5 0 0 0** and execute with key **E**,

– Press key **M/S** (M stands for "messages", S for "signals"); then the address 5000 appears automatically as the beginning of the annunciation blocks.

For configuration of the transfer of annunciations via the serial interfaces, the necessary data are entered in block 72 (see Section 5.3.4).

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 fault begins with pick-up of any fault detector and ends after drop-off of the last fault detector.

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, voltages, frequency).

Block 58 Indication of operational measured values of the rotor earth fault protection and the power supervision.

Block 59 Indication of operational measured values of the unbalanced load protection (negative sequence current, calculated thermal values).

```
⇑ 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 machine are only indicated as "`Fault`" together with the sequence number of the fault. Detailed information about the history of the fault is contained in blocks "Fault annunciations"; refer 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█ OPERATIONA
⇓  LANNUNCIATIONS
```

Beginning of the block "Operational annunciations"

```
↑  09.05.96   15:43
↓  I2 blocked    :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)
`>Useal-in blk`	Undervoltage seal-in of overcurrent time protection is blocked (C/G)
`>Useal-in ext`	Undervoltage seal-in of overcurrent protection pick-up from external (C/G)

>Ext trip 1	External trip signal 1 via binary input (C/G)
>Ext trip 2	External trip signal 2 via binary input (C/G)
>Ext trip 3	External trip signal 3 via binary input (C/G)
>Ext trip 4	External trip signal 4 via binary input (C/G)
>Phase rotat.	Change-over to counter-clockwise phase rotation via binary input (C/G)
>SV tripped	Stop valve tripped, via binary input (C/G)
>Pr> block	Block reactive power stage Pr> via binary input (C/G)
>Pr>> block	Block reactive power stage Pr>> via binary input (C/G)
>f1 block	Block frequency protection stage f_1 via binary input (C/G)
>f2 block	Block frequency protection stage f_2 via binary input (C/G)
>I>< coupl. 1	AND−condition for pick-up of overcurrent/undercurrent supervision I>< (C/G)
>I>< coupl. 2	AND−condition for trip of overcurrent/undercurrent supervision I>< (C/G)
>Trip rel 1	Trip circuit supervision 1: input in parallel to contact of trip relay (C/G)
>CBaux 1	Trip circuit supervision 1: input in parallel to CB auxiliary contact (C/G)
>Trip rel 2	Trip circuit supervision 1: input in parallel to contact of trip relay (C/G)
>CBaux 2	Trip circuit supervision 2: input in parallel to CB auxiliary contact (C/G)

General operational annunciations of the protection device:

Dev.operative	Device operative / healthy (C/G)
Prot. operat.	Any protection function is operative (C/G)
Initial start	Initial start of the processor system (C)
LED reset	Stored LED indications reset (C)
LogMeterBlock	Logging and measuring functions blocked (C/G)
Test mode	Test mode via system interface (C/G)

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	Power system fault (C/G), detailed information in the fault annunciations
Flt.RecDatDel	Fault recording data deleted (C)
Flt.Rec.viaBI	Fault recording triggered via binary input (C)
Flt.Rec.viaKB	Fault recording triggered via the front keyboard (C)
Flt.Rec.viaPC	Fault recording triggered via operating (PC) interface (C)
Operat. Cond.	Operating condition 1, i.e. suitable measured values are present (C/G)
Clockwise	Clockwise phase rotation (C)
Counter-clock	Counter-clockwise phase rotation (C)

Annunciations of monitoring functions:

Wrong SW-vers	Software version of the device is wrong (C)
Wrong dev. ID	Device identification number is wrong (C)
Annunc. lost	Annunciations lost (buffer overflow) (C)
Annu. PC lost	Annunciations for PC lost (buffer overflow) (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	VDEW state (acc. IEC 60870–5–103) 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)
`Fail.TripRel`	Failure on trip relay (C/G)
`LSA disrupted`	LSA−link disrupted (system interface) (C/G)
`Failure ΣI`	Failure detected by current plausibility monitor ΣI (C/G)
`Failure Isymm`	Failure detected by current symmetry monitor (C/G)
`Fail.PhaseSeq`	Failure detected by phase sequence monitor (C/G)
`Failure Trip1`	Failure in trip circuit 1 (C/G)
`Failure Trip2`	Failure in trip circuit 2 (C/G)

Annunciations of undervoltage protection:

`U< off`	Undervoltage protection is switched off (C/G)
`U< blocked`	Undervoltage protection is blocked (C/G)
`U< active`	Undervoltage protection is active (C/G)

Annunciations of overvoltage protection:

o / v o f f	Overvoltage protection is switched off (C/G)
o / v b l k	Overvoltage protection is blocked (C/G)
o / v a c t i v e	Overvoltage protection is active (C/G)

Annunciations of stator earth fault protection:

U 0 > o f f	Stator earth fault protection is switched off (C/G)
U 0 > b l o c k e d	Stator earth fault protection is blocked (C/G)
U 0 > a c t i v e	Stator earth fault protection is active (C/G)

Annunciations of frequency protection:

F R Q o f f	Frequency protection is switched off (C/G)
F R Q b l o c k e d	Frequency protection is blocked (C/G)
F R Q a c t i v e	Frequency protection is active (C/G)
F R Q U < b l o c k	Frequency protection is blocked due to insufficient voltage magnitude (C/G)

Annunciations of active power supervision:

P a > o f f	Active power supervision is switched off (C/G)
P a > b l o c k e d	Active power supervision is blocked (C/G)
P a > a c t i v e	Active power supervision is active (C/G)

Annunciations of reactive power protection:

Pr> off	Reactive power protection is switched off (C/G)
Pr> blocked	Reactive power protection is blocked (C/G)
Pr> active	Reactive power protection is active (C/G)

Annunciations of unbalanced load protection:

I2 off	Unbalanced load protection is switched off (C/G)
I2 blocked	Unbalanced load protection is blocked (C/G)
I2 active	Unbalanced load protection is active (C/G)
I2> Warn	Unbalanced load protection current warning stage operated (C/G)
I2 th. Warn	Unbalanced load protection thermal warning stage operated (C/G)
RM th. repl.	Thermal replica of thermal stage of unbalanced protection reset (C)

Annunciations of overcurrent time protection:

I> off	Overcurrent time protection I>−stage is switched off (C/G)
I> blocked	Overcurrent time protection I>−stage is blocked (C/G)
I> active	Overcurrent time protection I>−stage is active (C/G)

Annunciations of overcurrent/undercurrent supervision:

I>< off	Overcurrent/undercurrent supervision I>< is switched off (C/G)
I>< blocked	Overcurrent/undercurrent supervision I>< is blocked (C/G)
I>< active	Overcurrent/undercurrent supervision I>< is active (C/G)

Annunciations of rotor earth fault protection:

R/E/F off	Rotor earth fault protection is switched off (C/G)
R/E/F blocked	Rotor earth fault protection is blocked (C/G)
R/E/F active	Rotor earth fault protection is active (C/G)
R/E/F U< blk	Rotor earth fault protection blocked by undervoltage in bias voltage (C/G)
Failure R/E/F	Failure in measuring circuit of rotor earth fault protection (C/G)
R/E/F Warn	Rotor earth fault protection warning stage operated (C/G)

Annunciations of D.C. voltage time protection:

U DC off	D.c. voltage time protection is switched off (C/G)
U DC blocked	D.c. voltage time protection is blocked (C/G)
U DC active	D.c. voltage time protection is active (C/G)

Annunciations of the external trip functions:

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 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)
Ext 3 off	External trip function 3 is switched off (C/G)
Ext 3 blocked	External trip function 3 is blocked (C/G)
Ext 3 active	External trip function 3 is active (C/G)

`Ext 4 off`	External trip function 4 is switched off (C/G)
`Ext 4 blocked`	External trip function 4 is blocked (C/G)
`Ext 4 active`	External trip function 4 is active (C/G)

Annunciations of trip test functions:

`Test Trip 1`	Test trip relay 1 is in progress (C/G)
`Test Trip 2`	Test trip relay 2 is in progress (C/G)
`Test Trip 3`	Test trip relay 3 is in progress (C/G)
`Test Trip 4`	Test trip relay 4 is in progress (C/G)
`Test Trip 5`	Test trip relay 5 is in progress (C/G)

Annunciations of trip circuit supervision:

`Failure Trip1`	Failure in trip circuit 1 (C/G)
`Failure Trip2`	Failure in trip circuit 2 (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 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.

For these purposes, the “fault” means the period from first pick-up of any protection function up to last drop-off of a protection function.

In the following clarification, all the available fault annunciations are indicated. In the case of a specific fault, of course, only the associated annunciations appear in the display. At first, an example is given for a system fault, and explained.

```
⇑  5200█ LAST
⇓  FAULT
```

Beginning of the block “Fault annunciations of the last system fault”

```
↑  001█ 15.03.96
↓  System Flt 6
```

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

```
↑  002█ 12:41:33.587
↓  Fault             :C
```

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

```
↑  003█ 0 ms
↓  I> Fault L1       :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 first fault detection.

```
↑  004█ 1 ms
↓  I> Fault L2       :C
```

```
↑  005█ 137 ms
↓  U< seal in        :C
```

```
↑  006█ 2503 ms
↓  I> Trip           :C
```

```
↑  007█ 2714 ms
↓  Dev. Drop-off     :C
```

etc.

General fault annunciations of the device:

`Flt.Buff.Over`	Fault annunciations lost (buffer overflow)
`System Flt`	System fault with consecutive number
`Fault`	Beginning of fault
`Device FltDet`	Fault detection of the device, general
`Device Trip`	Trip by the device, general
`Dev. Drop-off`	Drop-off of the device, general

Fault annunciations of undervoltage protection:

`U< fault`	Undervoltage fault detection U<
`U< trip`	Trip by undervoltage protection U<

Fault annunciations of overvoltage protection:

`U> fault`	overvoltage fault detection, stage U>
`U>> fault`	overvoltage fault detection, stage U>>
`U> trip`	Trip by overvoltage protection U>
`U>> Trip`	Trip by overvoltage protection U>>

Fault annunciations of stator earth fault protection:

`U0> Fault`	Fault detection U_0> of stator earth fault protection
`Ie> Fault`	Fault detection I_0> of stator earth fault protection
`Uearth L1`	Stator earth fault in phase L1
`Uearth L2`	Stator earth fault in phase L2
`Uearth L3`	Stator earth fault in phase L3
`S/E/F st.Trip`	Trip by start-up earth fault protection
`S/E/F Trip`	Trip by stator earth fault protection

Fault annunciations of frequency protection:

f1> Fault	Fault detection of frequency protection, stage f_1>
f1< Fault	Fault detection of frequency protection, stage f_1<
f2> Fault	Fault detection of frequency protection, stage f_2>
f2< Fault	Fault detection of frequency protection, stage f_2<
f1> Trip	Trip by frequency protection, stage f_1>
f1< Trip	Trip by frequency protection, stage f_1<
f2> Trip	Trip by frequency protection, stage f_2>
f2< Trip	Trip by frequency protection, stage f_2<

Fault annunciation of active power supervision:

Pa> Fault	Active power supervision picked up on Pa>
Pa> Trip	Active power supervision trip by Pa>
Pr+SV Trip	Reverse power protection trip with tripped stop valve

Fault annunciation of reactive power supervision:

Pr> Fault	Reactive power supervision picked up on Pr>
Pr> Trip	Reactive power supervision trip by Pr>
Pr>> Fault	Reactive power supervision picked up on Pr>
Pr>> Trip	Reactive power supervision trip by Pr>

Fault annunciations of unbalanced load protection:

I2>> Fault	Fault detection of the stepped characteristic
I2>> Trip	Trip by the stepped characteristic
I2 Θ Trip	Trip by the thermal characteristic

Fault annunciations of overcurrent time protection:

I> Fault L1	Fault detection stage I>, phase L1
I> Fault L2	Fault detection stage I>, phase L2
I> Fault L3	Fault detection stage I>, phase L3
I> Trip	Trip by overcurrent stage I>
U< seal in	Undervoltage seal-in has operated

Fault annunciations of the overcurrent/undercurrent supervision:

I>< Fault	Pick-up of overcurrent/undercurrent supervision
I>< Trip	Trip by overcurrent/undercurrent supervision

Fault annunciation of rotor earth fault protection:

R/E/F Fault	Fault detection of rotor earth fault protection
R/E/F Trip	Trip by rotor earth fault protection

Fault annunciations of d.c. voltage time protection:

U DC Fault	Fault detection of d.c. voltage time protection
U DC Trip	Trip by d.c. voltage time protection

Fault annunciations for trip from external source via binary input:

Ext 1 Gen.Flt	External trip function 1 picked up
Ext 1 Gen.Trp	Trip by external trip function 1
Ext 2 Gen.Flt	External trip function 2 picked up
Ext 2 Gen.Trp	Trip by external trip function 2

`Ext 3 Gen.Flt`	External trip function 3 picked up
`Ext 3 Gen.Trp`	Trip by external trip function 3
`Ext 4 Gen.Flt`	External trip function 4 picked up
`Ext 4 Gen.Trp`	Trip by external trip function 4

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** fault can be found under address 5300. The available annunciations are the same as for the last fault.

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

etc.

The data of the **third to last** fault can be found under address 5400. The available annunciations are the same as for the last fault.

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

etc.

6.4.4 Read-out of operational measured values – address blocks 57 to 59

The steady state r.m.s. operating values can be read out at any time under the address blocks 57 to 59. The first address block 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 second intervals.

The data are displayed in absolute primary values and in percent of the rated device values. To ensure correct primary values, the rated data must be entered to the device under address block 12 as described in Section 6.3.3.

In the following example, some typical values have been inserted. In practice the actual values appear. The possible ranges are given in Section 3.11. Values beyond the limits are shown as ★★★★.

Further measured or calculated values are displayed in address blocks 58 and 59.

⇑⇓
```
5700█OPERATIONAL
MEAS.  VALUES  A
```

Beginning of the block "Operational measured values (a)"

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

⇑⇓
```
5701█MEAS.VALUE
IL1  =  1.040  kA
```

Page on with the ↑ key to read off the next address with the next measured value, or page back with ↓

↑↓
```
5702█MEAS.VALUE
IL2  =  1.045  kA
```

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**

↑↓
```
5703█MEAS.VALUE
IL3  =  1.042 kA
```

The primary values (addresses 5701 to 5706) are referred to the primary rated values as parameterized under addresses 1201 (for I_N) and 1202 (for U_N) (refer Section 6.3.3)

↑↓
```
5704█MEAS.VALUE
IL1[%] =  86.7  %
```

The percentage is referred to rated current

↑↓
```
5705█MEAS.VALUE
IL2[%] =  87.1  %
```

↑↓
```
5706█MEAS.VALUE
IL3[%] =  86.8  %
```

```
5707█ MEAS.VALUE
Uph-ph=  105  V
```

The secondary voltage (address 5707) is referred to the voltage applied to the relay terminals. It is not influenced by the parameters of addresses 1202 and 1204

```
5708█ MEAS.VALUE
U0  =  0.2  V
```

Displacement voltage (stator earth fault protection) at the relay terminals

```
5709█ MEAS.VALUE
Ie  =  0  mA
```

```
5710█ MEAS.VALUE
Ipos[%]=  86.9  %
```

The percentage is referred to rated current

```
5711█ MEAS.VALUE
U DC  =  4.7  V
```

D.C. voltage at the relay terminals

```
5712█ MEAS.VALUE
f   =  50.0  Hz
```

Frequency in Hz can only displayed when an a.c. measured quantity is present

---

The operational measured values B are particularly helpful during commissioning of the machine protection unit using primary tests (refer to Section 6.7.2). From these measured values, the setting values for the rotor earth fault protection can be easily checked or derived. Additionally, the angle error correction for the power protection functions can be derived from these values.

```
5800█ OPERATIONAL
MEAS.  VALUES B
```

Beginning of the block “Operational measured values (b)”: powers and impedances

```
5801█ MEAS.VALUE
Pa[%]=  89.0
```

The percentage of active power P_a and reactive power P_r is referred to rated apparent power $\sqrt{3} \cdot U_N \cdot I_N$

```
5802█ MEAS.VALUE
Pr[%]=  45.6
```

```
5803█ MEAS.VALUE
COS PHI=  0.890
```

Power factor of the machine

```
5804█ MEAS.VALUE
PHI   =  27.13 deg
```

Power angle of the machine

```
5805█ MEAS.VALUE
Rrotor  =  10.0 kΩ
```

Calculated rotor earth resistance R_E

```
5806█ MEAS.VALUE
Urotor  =  45 V
```

Bias a.c. voltage for rotor earth fault protection

```
5807█ MEAS.VALUE
Irotor  =  5 mA
```

Rotor earth measuring current caused by bias a.c. voltage

```
5808█ MEAS.VALUE
Rinput  =  8.18 kΩ
```

Active component of the calculated total impedance of the rotor−earth measuring circuit

```
5809█ MEAS.VALUE
Xinput  =  4.37 kΩ
```

Reactive component of the calculated total impedance of the rotor−earth measuring circuit
positive = capacitive

Further measured values are displayed in address block 59.

```
5900█ OPERATIONAL
MEAS.  VALUES  C
```

Beginning of the block "Operational measured values C": values of the unbalanced load protection

```
5901█ MEAS.VALUE
Ineg.seq=  2  %
```

Calculated negative sequence current in % of rated relay current

```
5902█ MEAS.VALUE
ThermRepl.=  11  %
```

Calculated rotor temperature rise in % of the thermal trip value; if unbalanced load protection is switched *OFF* then 000 % is indicated

---

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. 7UM512 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 functions can be controlled from the operating panel on the front of the device, via the operating interface in the front as well as via binary inputs.

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

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

– by block paging with the keys ⇑ forwards or ⇓ backwards up to address 8000, or

– by direct selection with address code, using key **DA**, address **8 0 0 0** and execute with key **E.**

```
⇑  8000█ DEVICE
⇓  CONTROL
```

Beginning of the block "Device control"

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

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

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

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

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

```
↑  15.12.1999
↓  17:04:55
```

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

```
↑  8102█ DATE
↓  29.02.00
```

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
↓  14.00.00
```

Enter the new time: hours (24 h), minutes, seconds, each with 2 digits, separated by a dot:
HH.MM.SS

```
↑  8104█ DIFF. TIME
↓
```

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

6.5.2 Erasing stored annunciations − 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 installed. 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 (code level 2) 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 or IEC 60870–5–103 is used, then the informations which are transmitted to the central computing system can be influenced.

The standardized protocol allows all annunciations, messages, and measured values to be tagged with the origin "test operation", which occur while the relay is tested. Thus, these messages can be distinguished from those which occur during real operation. Additionally, it is possible to block all annunciations, messages and measured values to LSA during test operation.

This features can be accomplished via binary inputs or using the integrated operating keyboard or via the operating (PC) interface.

In order to accomplish switch-over via binary inputs, the respective inputs must have been assigned during marshalling (refer to Section 5.5.2). The following input functions are suitable:

FNo `15` `>Sys-Test` for tagging the messages and measured values with the origin "Test operation",

FNo `16` `>Sys-MM-block` for blocking all messages and measured values.

In order to carry out switch-over by the operator, entry of the codeword (code level 1) is necessary (refer to Section 5.3.1). For this purpose, address block 83 is available provided the VDEW/ZVEI protocol has been chosen during configuration of the serial system interface (Section 5.3.4, address 7221 and/ or 7222 *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 **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.

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

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

↑↓
```
8301█ SYS  TEST
OFF
```
```
ON
```

Only for VDEW/ZVEI compatible protocol (acc. IEC 60870–5–103):

in *ON* position, the VDEW/ZVEI–compatible annunciations (acc. IEC 60870–5–103) are assigned with the origin "test operation"

↑↓
```
8302█ SYS  BLOCK
OFF
```
```
ON
```

Only for VDEW/ZVEI compatible protocol (acc. IEC 60870–5–103):

in *ON* position, no annunciations and measured values are transmitted to the system interface

Do not forget to switch the addresses back to *OFF* after having finished test operations!

6.5.4 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.

The first parameter set is identified as set A, the other sets are B, C and D. Each of these sets has been set during parameterizing (Section 6.3.1.2) provided the switch-over facility is used.

6.5.4.1 Read-out of settings of a parameter set

In order to **look up** the settings of a parameter set **in the display** it is sufficient to go to any address of the function parameters (i.e. addresses above 1000 and below 4000), either by direct addressing using key **DA**, entering the four-figure address code and terminating with enter key **E**, or by paging through the display with ⇑ or ⇓. You can switch over to look up a different parameter set, e.g.

– Press key combination **F 2**, i.e. first the function key **F** and then the number key **2**. All displayed parameters now refer to parameter set B.

The parameter set is indicated in the display by a leading character (A to D) before the address number indicating the parameter set identification.

The corresponding procedure is used for the other parameter sets:

- Key combination **F 1**: access to parameter set **A**
- Key combination **F 2**: access to parameter set **B**
- Key combination **F 3**: access to parameter set **C**
- Key combination **F 4**: access to parameter set **D**

The relay operates always with the active parameter set even during read-out of the parameters of any desired parameter set. The change-over procedure described here is, therefore, only valid for **read-out** of parameters **in the display**.

6.5.4.2 Change-over of the active parameter set from the operating panel

For **change over to a different parameter set**, i.e. if a different set shall be activated, the address block 85 is to be used. For this, codeword entry (code level 1) 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. 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
```

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

```
SET B
```

```
SET C
```

```
SET D
```

```
SET BY BIN.INPUT
```

```
SET BY LSA CONTR
```

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

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`” and “`>Param Selec.2`” (FNo `7` and `8`).

– The logical binary inputs must be allocated to 2 physical input modules (refer Section 5.5.2) in order to allow control. An input is treated as not energized when it is not assigned to any physical input.

– The control input signals must be continuously present as long as the selected parameter set shall be active.

The active parameter sets are assigned to the logical binary inputs as shown in Table 6.2.

A simplified connection example is shown in Figure 6.9. Of course, the binary inputs must be declared in normally open (“`NO`”) mode.

Binary input		causes active set
ParamSelec.1	ParamSelec.2	
no	no	Set A
yes	no	Set B
no	yes	Set C
yes	yes	Set D

no = input not energized
yes = input energized

Table 6.2 Parameter selection via binary input

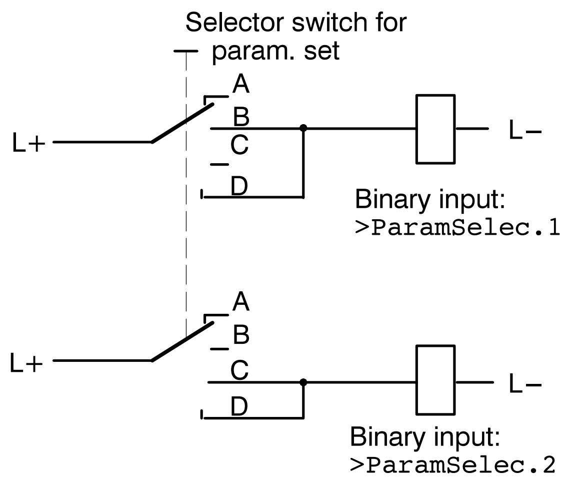


Figure 6.9 Connection scheme for parameter change-over via binary inputs

6.6 Testing and commissioning

6.6.1 General

Prerequisite for commissioning is the completion of the preparation procedures detailed in Chapter 5.

Warning

Hazardous voltages are present in this electrical equipment during operation. Non-observance of the safety rules can result in severe personal injury or property damage.

Only qualified personnel shall work on and around this equipment after becoming thoroughly familiar with all warnings and safety notices of this manual as well as with the applicable safety regulations.

Particular attention must be drawn to the following:

- The earthing screw of the device must be connected solidly to the protective earth conductor before any other connection is made.
- Hazardous voltages can be present on all circuits and components connected to the supply voltage or to the measuring and test quantities.
- Hazardous voltages can be present in the device even after disconnection of the supply voltage (storage capacitors!).
- The limit values given in the Technical data (Section 3.1) must not be exceeded at all, not even during testing and commissioning.

When testing the unit with a secondary injection test set, it must be ensured that no other measured values are connected and that the tripping leads to the circuit breaker trip-coils have been interrupted.

DANGER!

Secondary connections of the current transformers must be short-circuited before the current leads to the relay are interrupted!
If a test switch is installed which automatically short-circuits the current transformer secondary leads, it is sufficient to set this switch to the "Test" position. The short-circuit switch must be checked beforehand (refer to Section 5.2.6).

It is recommended that the actual settings for the relay be used for the testing procedure. If these values are not (yet) available, test the relay with the factory settings. In the following description of the test sequence the preset settings are assumed unless otherwise noted; for different setting values formulae are given, where necessary.

For the functional test a three-phase symmetrical voltage source with adjustable voltage outputs, together with a three-phase symmetrical current source with adjustable currents, should be available. Phase displacement between test currents I_P and test voltages U_P should preferably be continuously adjustable.

If unsymmetrical currents and voltages occur during the tests it is likely that the asymmetry monitoring will frequently operate. This is of no concern because the condition of steady-state measured values is monitored and, under normal operating conditions, these are symmetrical; under short circuit conditions these monitoring systems are not effective.

NOTE! The accuracy which can be achieved during testing depends on the accuracy of the testing equipment. The accuracy values specified in the Technical data can only be reproduced under the reference conditions set down in IEC 60255 resp. VDE 0435/part 303 and with the use of precision measuring instruments. The tests are therefore to be looked upon purely as functional tests.

During all the tests it is important to ensure that the correct command (trip) contacts close, that the proper indications appear at the LEDs and the output relays for remote signalling. In the testing hints the annunciations as set by the factory are stated. Additional annunciations which can be generated by other protection functions or part functions are not mentioned. If the relay is connected to a central memory device via the serial interface, correct communication between the relay and the master station must be checked.

After tests which cause LED indications to appear, these should be reset, at least once by each of the possible methods: the reset button on the front plate and via the remote reset relay (see connection diagrams, Appendix A).

NOTE:
The unit contains an integrated frequency follow-up circuit; this ensures that the protection functions are always processed with algorithms matched to the actual frequency. This explains the wide frequency range and the small frequency influence. However, it requires that measurement values be present before a dynamic test can take place, so that the frequency follow-up can operate. If a measurement value is switched from 0 to the unit without a different measurement value having been present beforehand, an additional time delay of approximately 120 ms is incurred since the unit must firstly calculate the frequency from the measurement value. In addition, no output signal is possible if no measurement value is connected. A trip signal, once issued, of course, is maintained for at least the duration of the parameterized reset time (refer also to Section 3.12).

NOTE:
When the unit is delivered from the factory, all protective functions have been switched off. This has the advantage that each function can be separately tested without being influenced by other functions. The required functions must be activated for testing and commissioning.

6.6.2 Testing the voltage protection functions

The functions of the under- and overvoltage protections can only be tested if these functions are configured as *EXIST*, in address 7816 for undervoltage protection (as delivered, refer to Section 5.4.2) and/or in address 7817 for overvoltage protection. Additionally, they must have been parameterized as operative (addresses 1601 UNDERVOLT = *ON* or = *BLOCK TRIP REL* for undervoltage protection and/or 1701 OVERVOLT = *ON* or = *BLOCK TRIP REL* for overvoltage protection) – contrary to the condition as delivered from factory.

The set voltages are always referred to phase-to-phase voltages! Therefore, when checking the pick-up values, the phase-to-phase voltage must be measured. If the pick-up values of the undervoltage protection are measured it must be considered that this protection function is frequency-dependent. Refer to the characteristics shown in Section 3.2 for frequency dependency.

⚠ **Caution!**

Test voltages larger than 140 V may overload and damage the relay if applied continuously (refer to Section 3.1.1 for overload capability).

The time delays for overvoltages are checked with approximately 1.2 x pick-up value; for undervoltage by switching the voltage to 0 V. It must be noted that the set times are pure delay times; operating times of the measurement functions are not included.

<u>Note:</u> During voltage testing a current of 0.5 I_N should be applied (refer also *NOTE* in Section 6.6.1).

Connect voltage of 1.2 x pick-up value U> (address 1702)

- Annunciation "`U> fault`" (not marshalled when delivered from factory)
- After T–U> (1.5 s; address 1704), annunciation "`U> trip`"(LED 6).
- Trip relays (2, 3 and 4).

Disconnect voltage. Activate binary input "`>u> block`" (not marshalled when delivered from factory). Set voltage to 1.2 x pick-up value U>.

- Annunciation "`U> block`" (not marshalled when delivered from factory).
- No further alarms regarding overvoltage protection.

De-activate binary input.

Disconnect voltage.

- Annunciation "`U< fault`" (not marshalled when delivered from factory).
- After T–U< (3 s; address 1603), annunciation "`U< trip`"(LED 6 and signal relay 6).
- Trip relay (1).

Set voltage to approximately rated voltage. Activate binary input "`>u< block`" (binary input 3 when delivered from factory). Disconnect voltage.

- Annunciation "`U< blocked`" (not marshalled when delivered from factory).
- No further alarms regarding undervoltage protection.

De-activate binary input.

Set voltage to 1.2 x pick-up value U>> (address 1703).

- Annunciation "`U>> fault`" (not marshalled when delivered from factory)
- After T–U>> (0 s; address 1705), annunciation "`U>> Trip`" (LED 6).
- Trip relays (2, 3 and 4).

Disconnect voltage and current.

Attention! If setting values have been changed for testing, reset to correct values (addresses 1602 to 1604 abbr. 1702 to 1704).

Further checks are performed with primary values during commissioning (Section 6.7.4).

6.6.3 Testing the stator earth fault protection

The functions of the stator earth fault protection can only be tested if this protection is configured as *EXIST* in address 7819 (as delivered, refer to Section 5.4.2) and has been parameterized as operative – contrary to the condition as delivered from factory (address 1901 SEF PROT = *ON* or = *BLOCK TRIP REL*).

The stator earth fault protection comprises three functions, which may be operative depending on the kind of application:

– Measurement of the neutral displacement voltage U_E>,
– Measurement of the earth fault current I_E>,
– Determination of the direction of the earth fault: ∡(U_E; I_E).

For machines in block connection, only the measurement of the neutral displacement voltage is important; the other two functions must be switched off (address 1903 EARTH CURR. = *OFF*, and 1905 DIR.DETERM. = *OFF*).

When checking the delay times it must be noted that the set times are pure delay times; operating times of the measurement function are not included.

Note: Rated voltage should be connected to the voltage measurement input U_{L-L} for the dynamic testing of the neutral displacement voltage (refer also note in section 6.6.1).

Connect voltage of 1.2 times setting value Uearth > (address 1902) to measurement input for the neutral displacement voltage .

- Annunciation "`U0> Fault`" (LED 10 when delivered from factory).
- After T–S/E/F (address 1907, 0.3 s when delivered from factory) annunciation "`S/E/F Trip`" (LED 3 and signal relay 3).
- Trip relays (1, 2, 3, 4 and 5).

Disconnect voltage.

For machines in bus-bar connection, EARTH CURR must be switched to *ON* (address 1903). If in address 1905 DIR.DETERM. is switched to *OFF*, the following testing procedure applies:

Set voltage at the measurement input for the neutral displacement voltage to 1.2 times setting value Uearth > (Address 1902).

- Annunciation "`U0> Fault`" (LED 10 when delivered from factory); no further annunciations.

In addition, switch current at the measurement input for the earth current to 2 times the setting value Iearth > (address 1904).

- Annunciation "`Ie> Fault`" (not marshalled when delivered from factory).
- After T–S/E/F (address 1907; 0.3 s when delivered from factory) annunciation "`S/E/F Trip`" (LED 3 and signal relay 3).
- Trip relays (1, 2, 3, 4 and 5).

Disconnect current and voltage.

If earth current detection should be made ineffective via a binary input (e.g. during start-up of the machine), then the following tests may should be performed:

Activate binary input "`>S/E/F Ie off`" (FNo 5176, not marshalled when delivered from factory). Set voltage to 1.2 x pick-up value Uearth >(address 1902).

- Annunciation "`U0> Fault`" (LED 10 when delivered from factory);
  no further annunciations.

In addition, switch current at the measurement input for the earth current to 2 times the setting value Iearth > (address 1904).

- Annunciation "`Ie> Fault`" (not marshalled when delivered from factory).
- After T–S/E/F (address 1907; 0.3 s when delivered from factory) annunciation "`S/E/F st.Trip`" (not marshalled when delivered from factory).
- Trip relays (not marshalled when delivered from factory).

Disconnect current and voltage. De-activate binary input.

If in address 1905 DIR.DETERM is switched to *ON* for machines in bus-bar connection, the following testing procedure applies:

Set voltage at the measurement input for the neutral displacement voltage to 1.2 times setting value Uearth > (address 1902).

- Annunciation "`U0> Fault`" (LED 10 when delivered from factory); no further annunciations.

Switch current – in phase with the neutral displacement voltage – at the measurement input for the earth current to 2 times the setting value Iearth > (address 1904).

- Annunciation "`Ie> Fault`" (not marshalled when delivered from factory).

- After T−S/E/F (address 1907; 0.3 s when delivered from factory). Annunciation "S/E/F Trip" (LED 3 and signal relay 3).
- Trip relays (1, 2, 3, 4 and 5).

Disconnect current and voltage.

Connect current – in phase opposition to the neutral displacement voltage – at the measurement input of the earth current to 2 times the setting value Iearth > (address 1904).

- Annunciation "Ie> Fault" (not marshalled when delivered from factory).
- No trip indications, no trip signals.

Disconnect current and voltage.

Activate binary input ">U0> block" (FNo 5173, not marshalled when delivered from factory). Connect voltage. Switch current – in phase with the neutral displacement voltage – at the measurement input for the earth current to 2 times the setting value Iearth > (address 1904).

- annunciation "U0> blocked" (not marshalled when delivered from factory).
- No further alarms regarding stator earth fault protection.

Disconnect current and voltage. De-energize binary input.

Attention! If setting values have been changed for these tests, make sure that the original settings are restored (addresses 1901 to 1908)!

Further checks are performed with primary values during commissioning (Section 6.7.5).

6.6.4 Testing the frequency protection functions

The functions of the frequency protection can only be tested if this protection is configured as *EXIST* in address 7820 (as delivered, refer to Section 5.4.2) and has been parameterized as operative – contrary to the condition as delivered from factory (address 2001 f> / f< = *ON* or = *BLOCK TRIP REL*).

The simplest function check is a read-out of the frequency as measured by the unit. This value is found in the operational measured values A under address 5712.

If a voltage source with adjustable frequency is available, then the limits of the overfrequency f> and of the underfrequency stages can be checked without difficulties.

When checking the delay times it must be noted that the set times are pure delay times; operating times of the measurement function are not included.

Connect rated voltage, increase frequency until overfrequency protection (f_2) picks up:

- Annunciation "f2> Fault" (not marshalled when delivered from factory).
- After T−f2 (address 2005; 1 s when delivered from factory). Annunciation "f2> Trip" (signal relay 11).
- Trip relay (2, 3, 4 and 5).

Activate binary input ">f2 block" (FNo 5207, not marshalled when delivered from factory).

- The blocking annunciation appears (not marshalled when delivered from factory).
- Annunciations "f2> Fault" and "f2> Trip" disappear; wait for reset delay (T−RESET = 0,5 s; address 2006) for trip signals to elapse.

Bring frequency back to rated frequency. De-activate binary input.

Further reduce frequency until the underfrequency protection stage (f_1<; address 2002) picks up.

- Annunciation "f1< Fault" (not marshalled when delivered from factory).
- After T−f1 (address 2003; 1 s when delivered from factory). Annunciation "f1< Trip" (signal relay 11).
- Trip relay (1).

Activate binary input ">Frq. block" (binary input 8 at delivery).

- The blocking annunciation appears (not marshalled when delivered from factory).
- Annunciations "f1< Fault" and "f1< Trip" disappear; wait for reset delay (T−RESET = 0,5 s; address 2006) for trip signals to elapse.

Bring frequency back to rated frequency. De-activate binary input. Switch off test quantity.

Further checks are performed with primary values during commissioning (Section 6.7.4).

6.6.5 Testing the power protection functions

The active power supervision and the reactive power protection can be tested simultaneously.

The active power supervision can be tested if it is configured as *EXIST* in address 7822 (refer to Section 5.4.2) and parameterized as operative, contrary to the condition as delivered from factory (address 2201 Pa> = *ON* or = *BLOCK TRIP REL*).

The reactive power protection can be tested if it is configured as *EXIST* in address 7823 (refer to Section 5.4.2) and parameterized as operative, contrary to the condition as delivered from factory (address 2301 Pr> = *ON* or = *BLOCK TRIP REL*).

The internal processing of the power values uses the one phase-to-phase voltage and an assigned current according to Table 6.3.

phase–phase voltage	assigned phase current for power calculation
UL1 – UL2	IL3
UL2 – UL3	IL1
UL3 – UL1	IL2

Table 6.3 Assignment of phase–phase voltages and currents for power calculation

The relay must be informed to which phase-to-phase voltage it is connected. If the power protection functions are tested with a single-phase test set, the phase-to-phase voltage as parameterized under address 1208 must be applied; the test current must be injected dependent on this reference voltage, according to Table 6.3. If the test are performed three-phase, the relay takes automatically the current which is associated with the parameterized voltage for power calculation.

The monitored power direction must have been determined – separately for active and reactive power – under addresses 2202 and 2302. Dependent on these settings, the active power supervision monitors either forward power or reverse power, the reactive power supervision monitors either overexcitation or underexcitation.

Polarity of power is defined for *generator* operation, i.e.

+Pa	Forward power	Machine delivers active power
−Pa	Reverse power	Machine takes up active power
+Pr	overexcited operation	Machine delivers inductive power
−Pr	underexcited operation	Machine takes up inductive power or delivers capacitive power

<u>Note</u>*:* Reverse active power protection (−Pa) and underexcitation protection (−Pr) are power <u>increase</u> protections since they measure the <u>rise</u> of a negative power.

It must be noted that the set times are pure delay times; operating times of the measuring functions are not included. The delay times for power increase are tested with twice the pick-up value.

◆ **Forward power (+Pa>):**

The forward active power supervision can be tested when it has been set under address 2202 to DIR. Pa> = *Pa forw. (+Pa)*.

Test current and test voltage in phase (symmetrical test condition); voltage at U_N.

Connect test current 2 x I_N (for condition as delivered from factory).
- Annunciation "`Pa> Fault`" (not allocated by factory).
- After T−Pa> (10 s; address 2204), annunciation "`Pa> Trip`" (LED 7).
- Trip relays (2, 3 and 4).

Disconnect test current.

Activate binary input "`>Pa block`" (not allocated at delivery). Connect test current.
- Annunciation "`Pa> blocked`" (not allocated at delivery).
- No further alarms regarding forward power supervision.

Disconnect test current.
De-activate binary input.

◆ **Reverse power (–Pa>):**

If the active power protection is to be used as reverse power protection it is advisable to perform an angle error correction in order to meet the high accuracy requirements (refer also to Section 6.3.3). If a high–accuracy test equipment is available (e.g. CMC 56 of Messrs. Omicron), a first correction step can be performed now. The final correction, including the main measurement transformers, is carried out during primary tests, refer to Section 6.7.7.2.

Angle error correction: Connect three-phase test quantities; voltages to approx. U_N, phase angle to 180°.

Set the correction factors on the device to zero: W0 = 0 (address 1206) and W1 = 0 (address 1207).

Adjust test current to $I_1 = 1 \cdot I_N$ and read out and note the associated phase angle deviation φ_1 under address 5804. Do the same for $I_2 = 0{,}2 \cdot I_N$ and the associated phase angle deviation φ_2.

Calculate the new correction factors W1 and W0 according the following formulae and set them in addresses 1207 and 1206:

$W1 = (\varphi_1 - \varphi_2) / (I_1 - I_2)$ address 1207
$W0 = \varphi_1 - W1 \cdot I_1$ address 1206

Repeat the tests; the angle errors must be now near zero.

Function check: The reverse power protection can be tested if it has been parameterized under address 2203 as DIR. Pa> = *Pa back. (–Pa)*.

Test current and test voltage in phase opposition (symmetrical test condition); set voltage to U_N.
Connect test current of $2 \cdot I_N$

- Annunciation "`Pa> Fault`" (not allocated at delivery).
- After T–Pa> (10 s: address 2204), annunciation "`Pa> Trip`" (LED 7).
- Trip relays (2, 3, and 4)

Disconnect test current.

Activate binary input "`>SV tripped`" (FNo `5086`, not allocated when delivered). Connect test current.

- Annunciation "`Pa fault`" (not allocated at delivery).
- After T–SV–CLOS. (3 s; address 2205), annunciation "`Pa+SV Trip`" (FNo `5463`; not allocated when delivered).

Disconnect test current. De-activate binary input.

Activate binary input "`>Pa> block`" (not allocated at delivery). Connect test current.

- Annunciation "`Pa> blocked`" (not allocated at delivery).
- No further alarms regarding reverse power protection.

Switch off test quantities. De-activate binary input.

Further checks are performed with primary values during commissioning (Section 6.7.3).

◆ **Reactive power (+Pr>, overexcited operation):**

The inductive power supervision can be tested if it has been parameterized under address 2303 as DIR. Pr> = *Pr forw. (+Pr)*.

The test current lags the test voltage by 90° (symmetrical test condition); voltage set to U_N.
Connect test current of $0.6 \cdot I_N$.

- Annunciation "`Pr> Fault`" (not allocated at delivery).
- After T–Pr> (10 s: address 2304), annunciation "`Pr> Trip`" (LED 7).
- Trip relays (2, 3 and 4).

Increase test current to $1.66 \cdot I_N$.

- Annunciation "`Pr>> Fault`" (not allocated at delivery).
- After T–Pr>> (1.5 s: address 2306), annunciation "`Pr>> Trip`" (not allocated at delivery).

Disconnect test current.

Activate binary input "`>Pr> block`" and "`>Pr> block`" (not allocated at delivery). Connect test current of $1.6 \cdot I_N$.

- Annunciation "`Pr> blocked`" (not allocated at delivery).
- No further alarms regarding reactive power protection.

Switch off test quantities. De-activate binary input.

◆ **Reactive power (– Pr>, underexcited operation):**

The capacitive power supervision can be tested if it has been parameterized under address 2302 as DIR. Pr> = *Pr back. (–Pr)*.

The test current leads the test voltage by 90° (symmetrical test condition); voltage set to U_N.
Connect test current of 0.6 · I_N
- Annunciation "Pr> Fault" (not allocated at delivery).
- After T–Pr> (10 s: address 2304), annunciation "Pr> Trip" (LED 7).
- Trip relays (2, 3 and 4)

Disconnect test current.

Increase test current to 1.66 · I_N.
- Annunciation "Pr>> Fault" (not allocated at delivery).
- After T–Pr>> (1.5 s: address 2306), annunciation "Pr>> Trip" (not allocated at delivery).

Activate binary input ">Pr> block" and ">Pr> block" (not allocated at delivery). Connect test current of 1.6 · I_N.
- Annunciation "Pr> blocked" (not allocated at delivery).
- No further alarms regarding reactive power protection.

Switch off test quantities. De-activate binary input.

Further checks are performed with primary values during commissioning (Section 6.7.7).

6.6.6 Testing the unbalanced load protection

The unbalanced load protection can only be tested if this function is configured as *EXIST* in address 7824 (as delivered, refer to Section 5.4.2) and parameterized as operative (address 2401), contrary to the condition as delivered from factory.

The unbalanced load protection has two definite time delay stages and two thermal stages.

The setting value I2> (address 2402) represents the pick-up value of the unbalanced load alarm stage and at the same time the base current for the thermal replica.

– I2> (address 2402) with
  T–I2> (address 2403):
  definite time alarm stage
– I2>> (address 2406) with
  T–I2>> (address 2407):
  definite time trip stage
– I2> (address 2402) with
  TIME CONST (ADDRESS 2404):
  thermal trip stage
– THERM.WARN (address 2405)
  as a percentage of the thermal trip stage:
  thermal alarm stage

The unbalanced load protection can easily be tested with a symmetrical three-phase test current. In this case the unbalanced load amounts to the test current which is referred to the rated unit current. Tripping must not occur if a current smaller than the setting value (address 2402) is connected. After an appropriate time (approximately 5 x τ) a thermal steady-state value is obtained.

If a single phase current is used, the unbalanced load amounts to one third of the test current which is referred to the rated unit current.

The following can be read out under the Operational Measured Values C (address block 59):

– The negative sequence current in % of rated unit current as unbalanced load; it should correspond to approximately the test current;

– the thermal steady-state value of the thermal replica, which should amount to approximately 100 % if a test current corresponding to three times the setting value is connected.

When the pick-up value is exceeded (test current greater than I2> for three-phase test):
- Time T–I2> (address 2403) elapses,
- Annunciation "I2> Warn" (LED 12 and signal relay 10).

Note: Rated voltage should be connected to the voltage measurement input during the dynamic tests (refer also to note in Section 6.6.1).

Switch current to approx. 1,2 x setting value I2>> (for three-phase test) (address 2406).
- Annunciation "I2>> Fault" (not allocated at delivery).
- After T−I2>> (3 s; address 2407) annunciation "I2>> Trip" (LED 11 and signal relay 9).
- Trip relay (1).

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!

Note: Depending on the setting of the time delay T−I>> (address 2407), the thermal stages "I2 th.Warn" and/or "I2 Θ Trip" may pick up earlier and remain so after the disconnection of the test current.

The thermal stages are tested with a three-phase current of 1.6 times setting value I2> (address 2402).

Note: Depending on the setting of the time constant (address 2404), the definite time stages "I2>" and/or "I2>>" may pick up earlier.

Switch on test current.
- After reaching the thermal warning stage (address 2405) annunciation "I2 th. Warn" (LED 12 and signal relay 10).
- On reaching the thermal trip stage after a time which corresponds to half the time constant: annunciation "I2 Θ Trip" (LED 11 and signal relay 9).
- Trip relay (1).

Disconnect test current.

Note: Before measuring the thermal trip time it must be ensured that the thermal memory is reset to 0. This is performed via the binary input ">RM th.repl." (reset memory of thermal replica). This function is not allocated when delivered from factory. An alternative approach is to observe a current-free pause of at least 5 x τ.

If testing with preload is performed, it must be ensured that a thermal equilibrium has been established prior to the start of the time measurement. This is the case only when the pre-load has been continuously connected for a period of at least 5 x τ.

6.6.7 Testing the overcurrent time protection and the overcurrent/undercurrent supervision

The functions of the overcurrent time protection can only be tested if these functions are configured as *EXIST* in address 7825, as delivered and have been parameterized as operative (contrary to the condition as delivered from factory) (address 2501 O/C I> = *ON* or *BLOCK TRIP REL*).

The overcurrent/undercurrent supervision can only be tested if these functions are configured as *EXIST* in address 7826, as delivered and have been parameterized as operative (contrary to the condition as delivered from factory) (address 2601 CURR. I><= *ON* or *BLOCK TRIP REL*.

If some functions have not been used the respective paragraphs below can be skipped.

Testing can be performed single-phase, two-phase or three-phase without difficulties. For setting values under 4 · I_N, the current in any phase can be slowly increased until the stage picks up.

Caution!

Test currents larger than 4 times I_N may overload and damage the relay if applied continuously (refer to Section 3.1.1 for overload capability). Observe a cooling down period!

For tests currents above 4 x I_N measurement shall be performed dynamically. It should be ensured that the relay picks up at 1.1 times setting value and does not pick up at 0.9 times setting value. The drop-off value of the overcurrent time protection depends on the setting of address 2508; it lies between approximately 0.90 and 0.99. The overcurrent supervision I> drops off at approximately 0.95 time pick-up value, the undercurrent supervision I< at approximately 1.05 times pick-up value.

The following applies for the overcurrent time protection:

Switch on test current of 2 times pick-up value I> (address 2502).

- Annunciation "I> Fault L1" for L1,
- Annunciation "I> Fault L2" for L2,
- Annunciation "I> Fault L3" for L3.

These annunciations are on LED 9 at delivery.

The delay times are checked at approx 2 times pick-up value. It must be noted that the set times are pure delay times; operating times of the measurement functions are not included.

Note: Rated voltage should be connected to the voltage input U_{L-L} during dynamic current testing (refer also note in section 6.6.1).

Switch on test current of 2 times (at least 1.2 times) pick-up value I>> (address 2502):
- Annunciation "I> Fault L★" (depending on phase, see above).
- After expiry of T−I> (2.5 s, address 2503) annunciation "I> Trip" (LED 1 and signal relay 1).
- Trip relays (2, 3, 4 and 5).

Switch off test current.

If the undervoltage seal-in circuit is used (address 2505 U< SEAL−IN = *ON*) this can be tested dynamically. Seal-in can be initiated by an internal voltage measurement or via a binary input.

Apply line-to-line test voltage U_{LL} above setting value U< (address 2506). Switch on a test current e.g. in phase L1 (above I>, address 2502).

Switch off test voltage U_{LL} before the time T−I> has expired.

Switch off test current:
- Annunciation "U< seal in" (not marshalled when delivered).

Pick-up signal will be maintained and trip will occur after T−I> (address 2503) as above.

After the holding time T−SEAL−IN (address 2507), pick-up and trip signals disappear.

Repeat the test with an externally produced undervoltage signal. Revert the measured voltage of the relay to rated value. Switch on a test current e.g. in phase L1 (above I>, address 2502).

Energize binary input ">Useal-in ext" (not allocated when delivered) before the time T−I> has expired.

Switch off test current:
- Annunciation "U< seal in" (not marshalled when delivered).

Pick-up signal will be maintained and trip will occur after T−I> (address 2503) as above.

After the holding time T−SEAL−IN (address 2507), pick-up and trip signals disappear.

Keep the binary input ">Useal-in ext" energized. Additionally, energize binary input ">Useal-in blk" (not allocated when delivered). Repeat the latest test.

- Annunciation ">Useal-in blk" (not allocated when delivered).
- Annunciation "I> Fault L1" for when phase L1 is tested LED 9).

After the current is switched off, pick-up will reset immediately, without seal-in. No further annunciations concerning the overcurrent time protection.

De-energize both binary inputs. Switch off measured quantities.

Attention! Should setting parameters have been changed during these tests, re-adjust them to their correct values (addresses 2502 to 2507)!

The following applies for the overcurrent supervision:
Address 2602 I>< = *OVERCURRENT.*

The status of two externally coupled conditions ("I>< coupl. 1" and "I>< coupl. 2", FNo 5266 and 5267) are to be heeded. With COUPLING = *ON* (address 2606), this function can pick up only when the respective binary input "I>< coupl. 1" (as delivered from factory INPUT 6, address 6106) is activated. Trip can occur only when the second binary input "I>< coupl. 2" (as delivered from factory INPUT 7, address 6107) is activated.

Connect test current (setting value address 2603).
- Annunciation "I>< Fault" (not marshalled when delivered from factory).

Disconnect test current.

In case of COUPLING = *ON* perform cross-check:
Deactivate input signal "I>< coupl. 1".

Connect test current.

- No alarm without input signal.

With COUPLING = *OFF*, pick-up occurs even when the binary input “`I>< coupl. 1`” is not energized. Trip will, nevertheless, <u>not</u> occur without energization of the binary input “`I>< coupl. 2`”:

- After T−I>< (address 2604) annunciation “`I>< Trip`” (LED 2 and signal relay 2).
- Trip relay (not marshalled when delivered from factory).

Disconnect test current.
By inputting the signal “`I>< block`” (input 2, address 6102 as delivered from factory) the function is blocked.
Connect test current. Activate binary inputs “`I>< coupl. 1`” and “`I>< coupl. 2`”.

- Annunciation “`I>< block`” (not marshalled when delivered from factory).
- No fault indication, no trip indication, no trip.

Disconnect test current. Deactivate binary inputs.

The following applies for the <u>undercurrent supervision</u>: Address 2602 I>< = *UNDERCURRENT*

The status of two externally coupled conditions (“`I>< coupl. 1`” und “`I>< coupl. 2`”) are to be heeded. With COUPLING = *ON* (address 2606), this function can pick up only when the respective binary input “`I>< coupl. 1`” (as delivered from factory, INPUT 6, address 6106) is activated. Trip can occur only when the second binary input “`I>< coupl. 2`” (as delivered from factory INPUT 7, address 6107) is activated.

Set test current in all three phases (if single phase test set, connect all three phase inputs in series) to approximately 1.2 x setting value I>< (address 2603). If necessary, reset existing LED indications (RESET LED on front plate).

Disconnect test current of at least one phase.

- Annunciation “`I>< Fault`” (not marshalled when delivered from factory).
- After T−I>< (address 2604) annunciation “`I >< Trip`” (LED 2 and signal relay 2).
- Trip relay (not marshalled when delivered from factory).

Connect test current.

With COUPLING = *ON* perform cross-check:
Deactivate input signal “`I>< coupl. 1`”. Disconnect test current of at least one phase.

- No annunciation without input signal.

Connect test current.

With COUPLING = *OFF*, the above annunciations appear without the input signal “`I>< coupl. 1`”. Trip will, nevertheless, <u>not</u> occur without energization of the binary input “`I>< coupl. 2`”:

- After T−I>< (address 2604) annunciation “`I >< Trip`” (LED 2 and signal relay 2).
- Trip relay (not marshalled when delivered from factory).

By inputting the signal “`I>< block`” (input 2, address 6102 as delivered from factory) the function is blocked.

Disconnect test current of at least one phase.

- Annunciation “`I>< block`” (not marshalled when delivered from factory).
- No fault indication, no trip indication, no trip.

Deactivate binary input “`I>< block`”. Fault indication and tripping occurs because of the missing current.

Further checks are performed with primary values during commissioning (Section 6.7.3).

6.6.8 Testing the rotor earth fault protection

The rotor earth fault protection can only be tested if this function is configured as *EXIST* in address 7835 (as delivered, refer to Section 5.4.2) and parameterized as operative (address 3501), contrary to the condition as delivered from factory.

The checking of the rotor earth fault protection is performed by connecting an a.c. voltage of 45 V to the voltage measurement input of the rotor earth fault protection and feeding a current – in phase with the voltage – of 10 mA into the current measurement input. With the preset coupling reactance (address 3507) and the preset series resistance (address 3508), this corresponds to a rotor resistance of approx. 4.5 kOhm. The following values can be read out for the rotor earth fault protection under Operational Measured Values B, address block 58:

– Rrotor	approx.	4.5	kΩ
– Urotor	approx.	45	V
– Irotor	approx.	10	mA
– Rinput	approx.	4.5	kΩ
– Xinput	approx.	0.0	kΩ

If 0.0 kΩ is displayed for the Rrotor, or if the display shows 0.0 kΩ for Rinput, then test current and test voltage are not in phase, but in phase opposition. The polarity of one of the test parameters must be changed and the measurement repeated.

For different setting values for coupling reactance and series resistance, the displayed rotor resistance can be calculated according to the following formula:

$$\text{Rrotor} \approx \frac{\text{Urotor}}{\text{Irotor}} - R_{series} + \frac{X_c^{\,2}}{\text{Urotor/Irotor} - R_{series}}$$

whereby:
- Urotor = connected measurement voltage
- Irotor = measurement current (in phase with Urotor
- X_c = set coupling resistance (address 3507)
- R_{series} = set series resistance (address 3508)

The warning stage must pick-up with the above mentioned values.

- After T−WARN−R< (address 3504; 10 s when delivered from factory) annunciation "`R/E/F WARN`" (LED 5 and signal relay 5 when delivered from factory)

Disconnect measurement parameters.

Note: Rated voltage should be connected to the voltage measurement input U_{L-L} during the dynamic tests (refer also to note in section 6.6.1). The set times are pure delay times, operating times of the measuring functions are not included.

A further test is performed with 45 V and 90 mA; connected voltage and current must be in phase.

- Annunciation "`R/E/F Fault`" (not marshalled when delivered from factory).
- After T−TRIP−R<< (address 3505; 0.5 s when delivered from factory), annunciation "`R/E/F Trip`" (LED 4 and signal relay 4).
- Trip relays (2, 3 and 4).

Disconnect measuring parameters.

A further test concerns the measuring circuit failure alarm.
Connect measurement voltage of 45 V, do not connect measurement current.

- After a time delay of approximately 5 s annunciation "`Failure R/E/F`" (signal relay 12).

Activate binary input "`>R/E/F block`" (not marshalled when delivered from factory).Apply an inphase test current of 90 mA.

- Alarm disappears.
- Annunciation "`R/E/F blocked`" (not marshalled when delivered from factory).
- No further annunciations relating to rotor earth fault protection.

Disconnect measuring parameters.
De-activate binary input.

Further checks are performed with primary values during commissioning (Sections 6.7.2 and 6.7.6).

6.6.9 Testing the d.c. voltage time protection

The d.c. voltage time protection can only be tested if this function is configured as *EXIST* in address 7836 (as delivered, refer to Section 5.4.2) and parameterized as operative (address 3601), contrary to the condition as delivered from factory.

The d.c. voltage time protection can be set to act on voltage increase or voltage decrease (address 3603). Furthermore, an average value formation or r.m.s. value formation can be parameterized (address 3602). In the latter case, the mean value is multiplied with the factor 1.11 within the protection.

Caution!

Testing with peak voltage values in excess of 60 V causes overloading of the input circuit and must not be performed. (refer to Technical Data, Section 3.1.1)

The delay times for d.c. overvoltage can be measured at approximately 1.2 times pick-up value, for undervoltage by switching the voltage to 0 V. It must be noted that the set times are pure delay times; operating times of the measurement functions in particular for the average value formation are are not included.

Note: The d.c. voltage time protection is effective even in case no a.c. measured quantity is present at any terminal of the relay, i.e. during “operating condition 0”. In this case, additional mean value calculation takes place which lead to fourfold operating time.

The following applies for overvoltage:
Address 3603 DC VOLTAGE = *OVERVOLTAGE*

Switch voltage to 1.2 times pick-up value Udc>< (address 3604).
- Annunciation “`Udc Fault`” (not marshalled when delivered from factory).
- After T−Udc>< (address 3605; 2 s when delivered from factory), annunciation “`Udc Trip`” (LED 8 and signal relay 8).
- Trip relay (not marshalled when delivered from factory).

Disconnect voltage.

The following applies for undervoltage:
Address 3603 DC VOLTAGE = *UNDERVOLTAGE*.

Set voltage to approximately 12 V d.c.
Disconnect voltage.
- Annunciation “`Udc Fault`”(not marshalled when delivered from factory).
- After T− Udc >< (address 3605; 2 s when delivered from factory) annunciation “`Udc Trip`” (LED 8 and signal relay 8).
- Trip relay (not marshalled when delivered from factory).

Further checks are performed with primary values during commissioning (Section 6.7.4).

6.6.10 Testing the coupling of external trip functions

Four desired signals from external protection or supervisory units can be connected into the processing of the 7UM512 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 EXT. TRIP = *EXIST* (addresses 7830, 7831, 7832, and/or 7833, refer to Section 5.4.2) and parameterized as operative (addresses 3001, 3101, 3201, and/or 3301), contrary to the condition as delivered from factory).

At the time of delivery, one of the external trip functions (>Ext trip 1) is parameterized to INPUT 5 (address 6105). The set times are pure delay times.

Activate binary input of the tested external trip function.

- Annunciation "`>Ext trip *`"; this is a straight acknowledgement message by the binary input as operational indication (not allocated when delivered from factory).
- Annunciation "`Ext * Gen.Flt`"; this is the actual fault event annunciation (not allocated when delivered from factory).
- After T−DELAY (address 3002 or 3102 or 3202 or 3302; 1 s when delivered from factory) annunciation "`Ext * Gen.Trp`" (LED 13 and signal relay 7).
- Trip relays (2, 3, 4 and 5).

De-activate binary input.

6.6.11 Testing the trip circuit supervision

Two binary inputs can be used for one channel of the trip circuit supervision. Address 3902 (see Section 6.3.17) determines whether one or two such trip circuit supervision circuits shall be used.

The supervised trip circuit is detected as faulty if none of the inputs is energized at the same time (refer to Section 4.16). Alarm is given after a time delay which is specified by the set number of repeated measurements.

The trip circuit supervision can only be tested if this function is parameterized as operative (address 3901 TRP SUPERV = *ON*, Section 6.3.17), contrary to the position as delivered from factory.

Energize the two binary inputs which belong to the tested channel, individually one after the other by applying a d.c. voltage of >16 Vdc. But if a higher pick-up threshold has been set for the binary inputs (refer to Section 5.2.2.1), apply a voltage of >80 Vdc. As long as only one of the inputs is energized, no trip circuit alarm is given.

Energize both binary inputs which belong to the tested channel.

- No alarm annunciation concerning trip circuit supervision.

De-energize both binary inputs which belong to the tested channel.

- Annunciation "`Failure Trip*`" (not allocated when delivered) after a short delay which is specified by the number of repeated measurements. address 3903). Since the supervision operates 3 times to 4 times a second, one can expect a delay of approx. 0.75 s to 1 s per repeated measurement.

Test the second channel in the same way.

6.7 Commissioning using primary tests

6.7.1 General advices

All secondary test equipment must be removed. Connect measurement values. All installation preparations according to Section 5.2 must have been completed. Primary tests are performed with the machine.

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.).

Primary testing is usually performed in the following order:

– Tests with the machine at stand-still,
– short-circuit tests,
– voltage tests,
– tests with the machine connected to the network.

The following hints are arranged in this order. All protection functions should be initially switched *OFF* (condition as delivered from factory) so that they do not influence one another. During primary testing the functions are progressively switched to being operative.

If a particular protection function is not required at all, it should be "de-configured" (refer to Section 5.4.2). It is then treated as *NON–EXIST*ing.

Switching on of a particular function can be 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 and measured values. However, the trip command is blocked and it is not transmitted to the trip matrix.

– Protection function *ON:* The protection function is operative and outputs annunciations and measured values. 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.

6.7.2 Checking the rotor earth fault protection at stand-still

The rotor earth fault protection can be checked with the machine at stand-still. The coupling unit, however, must be supplied with an external a.c. voltage 100 V to 110 V, or 220 V to 230 V (please refer also to connection diagram Figure 5.8 in Section 5.2.5.).

Switch rotor earth fault protection (address 3501) to *BLOCK TRIP REL*.

In the case of machines with rotating rectifier excitation (Figure 6.10), an earth fault is installed between the two measurement slip rings with the measurement brushes in place. In case of machines with excitation via slip rings (Figure 6.11), the earth fault is installed between one slip ring and earth. The unit now measures as earth impedance only the reactance of the coupling unit and the brush resistance (in series with a protective resistor for the coupling capacitors and/or a damping resistor). These values can be read out under the Operational Measured Values B (address 5808 and 5809):

Rinput = x.xx kΩ
Xinput = y.yy kΩ

Rinput corresponds to the series resistance (brushes plus protective resistor) and Xinput corresponds to the capacitive reactance (a negative value indicates an inductive reactance). If both values are indicated as 0, then the connections of U_{rotor} or I_{rotor} have wrong polarity. Change the polarity of one of the connections and repeat the measurement. It must then be checked that the setting values

R–SERIES = xxx Ω (address 3508)
X COUPL. = yyy Ω (address 3507)

correspond with the above values. Remove earth fault bridge.

An earth fault is now fitted as described above via a resistor of the warning resistance, i.e. 10 kΩ when delivered from factory).

The earth resistance calculated by the unit can be read out under the Operational Measured Values B (address 5805) as Rrotor. If substantial deviation occurs between the actual rotor earth resistance and the indicated resistance, the accuracy can be improved by correction of the c.t. angle error, address 5310 CT ANG. W0.

An earth fault is now fitted as described above via a resistor of approximately 90 % of the trip resistance (RE<< TRIP, address 3503, 2 kΩ when delivered). The rotor earth fault protection initiates a pick-up signal and after T−TRIP−R<< (0.5 s when delivered from factory) a trip annunciation (LED 4 and signal relay 4).

In the case of machines with excitation via slip rings, the above test is repeated for the other slip ring.

Remove earth fault resistor.

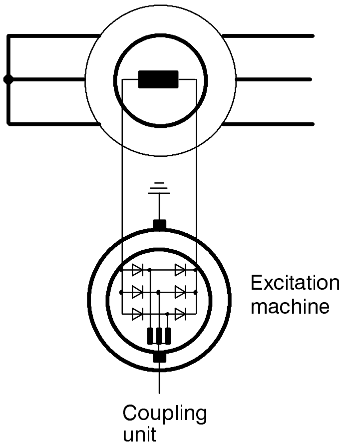


Figure 6.10 Excitation via rotating rectifiers with measurement brushes

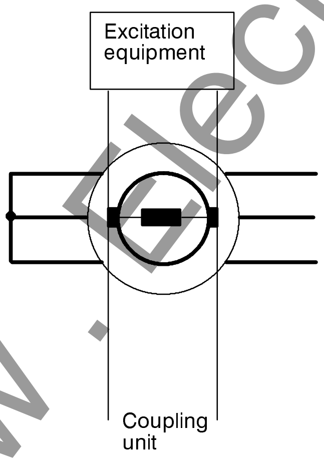


Figure 6.11 Excitation equipment fed via slip rings

Lift measurement brushes or interrupt measurement circuit. Alarm "`Failure R/E/F`" is indicated after a time delay of approx. 5 s (signal relay 12). Close measurement circuit.

If the alarm "`Failure R/E/F`" is also present with the measurement circuit closed, then the rotor−earth capacitance is less than 0.15 µF. In this case, a measurement circuit supervision is not possible; the alarm "`Failure R/E/F`" then should not be marshalled to any binary output.

After the completion of the test, check that all provisional measures for testing have been reversed:

Earthing bridge or resistor has been removed,

measurement circuit has been closed,

controller unit connected to its operational supply a.c. voltage (refer also connection diagram in Figure 5.8 in Section 5.2.5).

Tests with the running machine are described later under section 6.7.6.

6.7.3 Checking the current circuits

Switch unbalanced load protection (address 2401), overcurrent time protection (address 2501) and overcurrent/undercurrent supervision (if used) to *BLOCK TRIP REL*.

With the primary plant voltage-free and earthed, install a three-pole short-circuit bridge which is capable of carrying rated current (e.g. earthing isolator) to the machine line-side terminals.

DANGER!

Operations in primary area must only be performed with the machine at standstill and with plant sections voltage-free and earthed!

Slowly excite generator, however, stator current should not increase to above machine rated current.

Read out current values in all three phases under address block 57. They are displayed in primary values as well as in % of the unit rated current and can be compared with the actual currents flowing. If substantial deviations occur, then the current transformer connections are incorrect.

The phase sequence must be clockwise. If the machine has counter-clockwise rotation, two phases must be interchanged, or the accordingly allocated binary input “`>Phase rotat`” must be energized at generator stand-still. The unbalanced load can be read out under address 5901. It must be practically zero. If this is not the case, check for crossed current transformer leads:

If the unbalanced load amounts to about **1/3** of the phase currents then current is flowing in **only one** or in **only two** of the phases.

If the unbalanced load amounts to about **2/3** of the phase currents, then one current transformer has **wrong polarity**.

If the unbalanced load is about **the same** as the phase currents, then two phases have been **crossed**.

– Shut down and de-excite generator,
– apply plant earths,
– short-circuit current transformers,
– check current transformer circuits and make corrections,
– repeat test.

If no unbalanced load is present, then the thermal replica under address 5902 must also show 0 %.

The short-circuit tests are completed after the generator has been shut down and de-excited and after the short-circuit bridge has been removed. No further tests are required for the overcurrent time protection, the overcurrent/undercurrent supervision and the unbalanced load protection; these functions were tested thoroughly under 6.6.6 and 6.6.7. The overcurrent time protection is made operative (address 2501: O/C I> = *ON*) and serves from now on as short-circuit protection for all further tests. The unbalanced load protection is also made operative (address 2401: UNBAL.LOAD = *ON*).

If used, the overcurrent or undercurrent supervision is also switched to be operative (address 2601 CURR. I>< = *ON*) and parameterized to the desired function (address 2602 I>< = *OVERCURRENT* or *UNDERCURRENT*). Function and peripherals (blocking, coupled condition) have already been checked under 6.6.7.

6.7.4 Checking the voltage circuits

Check in the unexcited condition of the machine with the help of remanent currents, that current transformer circuits are not open nor short-circuited and all short-circuit bridges are removed.

If the d.c. voltage time protection is used for the supervision of the excitation voltage, it can be tested together with the voltage tests. Under address 3601 DC VOLTAGE is set to *BLOCK TRIP REL*.

Switch under- and overvoltage protection (addresses 1601 and 1701) and frequency protection (address 2001) to *BLOCK TRIP REL*.

If the unit is to be used as undervoltage protection, then blocking of this function on tripping of the voltage transformer m.c.b. should also be tested during the voltage tests. It is assumed that the auxiliary contact of the m.c.b. is marshalled to a binary input “`>u< block`” (INPUT 3 when delivered from factory).

– Switch voltage transformer m.c.b. to tripped position,
– check that the message “`U< blocked`” is indicated in the operational annunciations (address block 51) with the **C**oming index,
– slowly excite generator to rated voltage,
– check that the voltage in address 5707 is almost zero,
– switch on voltage transformer m.c.b.
– check that the message “`U< blocked`” is indicated in the operational annunciations, but this time with the **G**oing index.

Should the message not be given then check the connection of the voltage transformer secondary circuits, and check correct marshalling of the binary input from the auxiliary contact of the m.c.b. (refer to Section 5.5.2).

If the indices “`C`” for “Coming” and “`G`” for “Going” are interchanged, check and correct the contact mode of the binary inputs (“`NO`” or “`NC`” contact) in accordance with Section 5.5.2.

With the generator excited to rated voltage, read out voltage in address 5707. It can be compared with the actual voltage. As a rule, the phase-to-phase voltage U_{L1-L2} is connected. If substantial deviations occur, then the voltage transformer connections are incorrect.

– Shut down and de-excite generator,
– apply plant earths,
– check voltage transformer circuits and make corrections,
– repeat test.

The following applies to undervoltage protection: Adjust machine to rated speed and slowly de-excite generator. When the generator voltage (phase-to-phase) drops below the value set for U< (address 1602), pick-up alarm “U< Fault” (not marshalled when delivered from factory) appears, and after T–U< (address 1603), trip signal “U< Trip” appears (LED 6 and signal relay 6).

If desired, a point on the voltage/frequency characteristic (Figure 3.1 in Section 3.2) can be tested by changing the speed while keeping the undervoltage constant. Switch machine speed regulation to “manual” operation. Slowly change machine speed, so that undervoltage protection just picks up. Compare pick-up value and frequency with the theoretical value determined from the characteristic.

At this point, the frequency protection can be checked:

Increase machine speed, so that overfrequency protection just picks up (at delivery frequency stage f_2, address 2004):

- Annunciation “f2> Fault” (not marshalled when delivered from factory)
- After T–f2 (address 2005; 1 s when delivered from factory) annunciation “f2> Trip” (signal relay 11 when delivered from factory).

If a binary input is used for blocking the frequency stage f_2 (“>f2 block”, not marshalled when delivered from factory) or for blocking of the total frequency protection (“>Frq. block”, INPUT 8 when delivered from factory), activate the block:

- Annunciations of the frequency stage f_2 disappear.

De-activate binary input.

Reduce machine speed, so that underfrequency protection stage f_1 (address 2002) pick up:

- Annunciations “f1< Fault” (not marshalled when delivered from factory).
- After T–f1 (address 2003; 1 s when delivered from factory) annunciation “f1< Trip” (signal relay 11 when delivered from factory).

If a binary input is used for blocking the frequency stage f_1 (“>f1 block”, not marshalled when delivered from factory) or for blocking of the total frequency protection (“>Frq. block”, INPUT 8 when delivered from factory), activate the block:

- Annunciations of the frequency stage f_1 disappear.

De-activate binary input.

By connecting the excitation voltage to the d.c. voltage measurement input, the function of the d.c. voltage time protection can also be tested: Adjust machine to rated speed and slowly de-excite the generator, so that d.c. voltage protection just picks up.

- Annunciation “U DC Fault” (not marshalled when delivered from factory);
- After T–U–DC>< (address 3605) annunciation “U DC Trip” (LED 8 and signal relay 8).

Adjust machine to rated speed and slowly de-excite the generator. The annunciations remain after the machine has been completely de-excited. They can be reset by energizing the accordingly allocated binary input “>u< block” (FNo 6506).

If the d.c. voltage measurement circuit has not yet been tested as described above, then the respective plant voltage must be changed according to the required conditions and the reaction of the protection unit must be tested. On exceeding or falling below (according to address 3603) the limit voltage (address 3604) annunciation “U DC Fault” appears (not marshalled when delivered from factory), and after T–U–DC>< (address 3605) annunciation “U DC Trip” (LED 8 and signal relay 8 at delivery).

Afterwards, the d.c. voltage protection is made operative (address 3601 DC VOLTAGE = *ON*) or – if not used – is switched to be inoperative (DC VOLTAGE = *OFF*).

The voltage tests are completed after the generator has been shut down.

The required voltage and frequency protection functions are switched to be operative (address 1601: UNDERVOLT = *ON* or *OFF),* (address 1701: OVERVOLT = *ON* or *OFF*) and (address 2001: f> /f< = *ON* or *OFF).* Partial functions can be switched to be inoperative by appropriate limit value settings (e.g. f* set to rated frequency).

6.7.5 Checking the stator earth fault protection

The procedure for checking the stator earth fault protection depends mainly on whether the machine is connected to the network in block connection or in bus-bar connection. In both cases correct functioning and protected zone must be checked.

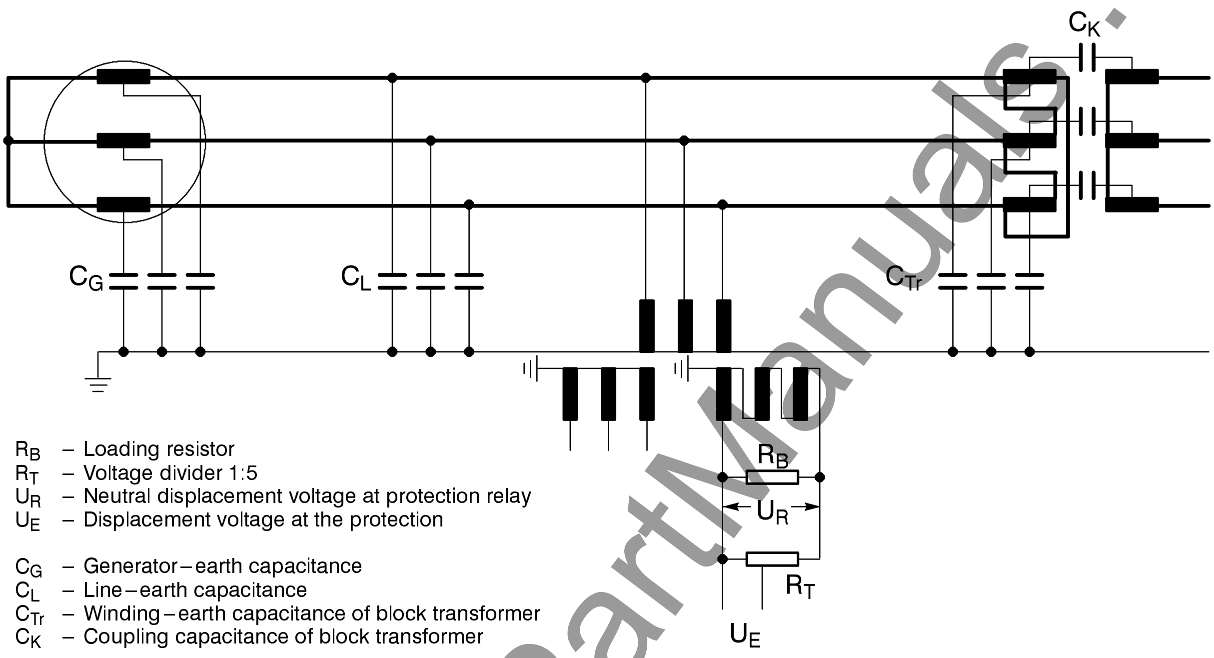


Figure 6.12 Block connection with earthing transformer

6.7.5.1 Block connection

In the event of an external (high-voltage side) short-circuit, an interference voltage is transmitted via the coupling capacitance C_K (Figure 6.12) which induces a neutral displacement voltage on the machine side. To ensure that this voltage is not interpreted by the protection as an earth fault within the machine, it is reduced by a suitable loading resistor to a value which corresponds to approximately one half the pick-up voltage Uearth > (address 1902). On the other hand, the earth fault current resulting from the loading resistor in the event of an earth fault at the machine terminals should not exceed 10 A.

Checking the protected zone

Coupling capacitance C_K and loading resistor R_B represent a voltage divider (equivalent circuit diagram Figure 6.13); whereby R_B' is the resistance R_B referred to the machine terminal circuit. Since the reactance of the coupling capacitance is much larger than the referred resistance of the loading resistor R_B', U_C can be assumed to be $U_{NU}/\sqrt{3}$ (compare also vector diagram Figure 6.14), whereby $U_{NU}/\sqrt{3}$ is the neutral displacement voltage with a full displacement of the network (upper-voltage) neutral. The following applies:

$$R_B' : \frac{1}{\omega C_K} = U_R' : \frac{U_{NU}}{\sqrt{3}}$$

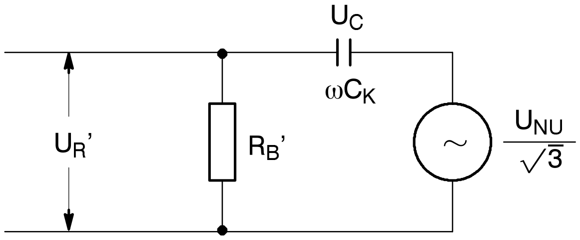
$$U_R' = R_B' \cdot \omega C_K \cdot U_{NU}/\sqrt{3}$$

Inserting the voltage transformation ratio TR of the earthing transformer:

$$U_R' = \frac{TR}{3} \cdot U_R \quad \text{and} \quad R_B' = \left(\frac{TR}{3}\right)^2 \cdot R_B$$

we obtain:

$$U_R = \frac{TR}{3} \cdot R_B \cdot \omega C_K \cdot U_{NU}/\sqrt{3}$$



U_{NU} Rated voltage on upper-voltage side of block transformer
U_C Voltage at coupling capacitance C_K
C_K Total coupling capacitance between upper-voltage and lower-voltage windings.
U_R' Voltage across loading resistor
R_B' Loading resistor of earthing transformer, referred to machine circuit.

Figure 6.13 Equivalent diagram

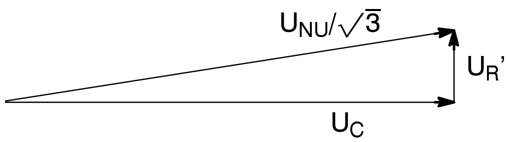


Figure 6.14 Vector diagram

Together with the voltage divider 500V/100V this corresponds to a displacement voltage of

$$U_E = \frac{1}{5} \cdot \frac{TR}{3} \cdot R_B \cdot \omega C_K \cdot U_{NU}/\sqrt{3}$$

at the input of the unit.

The pick-up value for the neutral displacement voltage should amount to at least twice the value of this interference voltage.

Example:

Network:	U_{NU}	= 110	kV
	f_N	= 50	Hz
	C_K	= 0.01	µF

Earthing transformer: TR = 36

$$U_E = \frac{1}{5} \cdot \frac{TR}{3} \cdot R_B \cdot \omega C_K \cdot U_{NU}/\sqrt{3}$$

$$U_E = \frac{1}{5} \cdot \frac{36}{3} \cdot 10\ \Omega \cdot 314\ s^{-1} \cdot 0.01 \cdot 10^{-6}\ F \cdot \frac{110}{\sqrt{3}} \cdot 10^3\ V$$

$$= 4.8\ V$$

10 V has been chosen as the setting value for Uearth > in address 1902 which corresponds to a protective zone of 90 %.

Note: When using a neutral earthing transformer, TR must be inserted as the voltage transformation ratio instead of TR/3. The result is the same since the neutral earthing transformer has only one winding.

Checking for machine earth fault

Switch stator earth fault protection (address 1901) to *BLOCK TRIP REL*. Furthermore, the EARTH CURR under address 1903 must be switched *OFF*.

With the primary plant voltage-free and earthed, install a single-pole earth fault in the proximity of the machine terminals.

DANGER!

Operations in primary area must only be performed with the machine at standstill and with plant sections voltage-free and earthed!

Start up machine and slowly excite (however, not above $U_N/\sqrt{3}$) until the stator earth fault protection picks-up (LED 3 when delivered from factory), refer also Figure 6.15.

Read out Uearth in OPERATIONAL MEASURED VALUES A (address 5708). If the connections are correct, this value corresponds with the machine terminal voltage in percent, referred to rated machine voltage (if applicable, deviating rated primary voltage of earthing transformer or neutral earthing transformer must be taken into account). This value also corresponds with the setting value Uearth > under address 1902.

The protection zone is 100 % – Uearth [%], e.g.

Machine voltage at pick-up:	$0.1 \cdot U_N$
Measured value Uearth	10 %
Setting value Uearth >	10 V
Protected zone	90 %

Read out the indication "`Uearth Lx`" in the fault annunciations (address 5200). The "`Lx`" indicates the faulted phase provided voltage is connected to the voltage protection input and the reference voltage is set correctly in address 1208.

Shut down machine. Remove earth fault bridge.

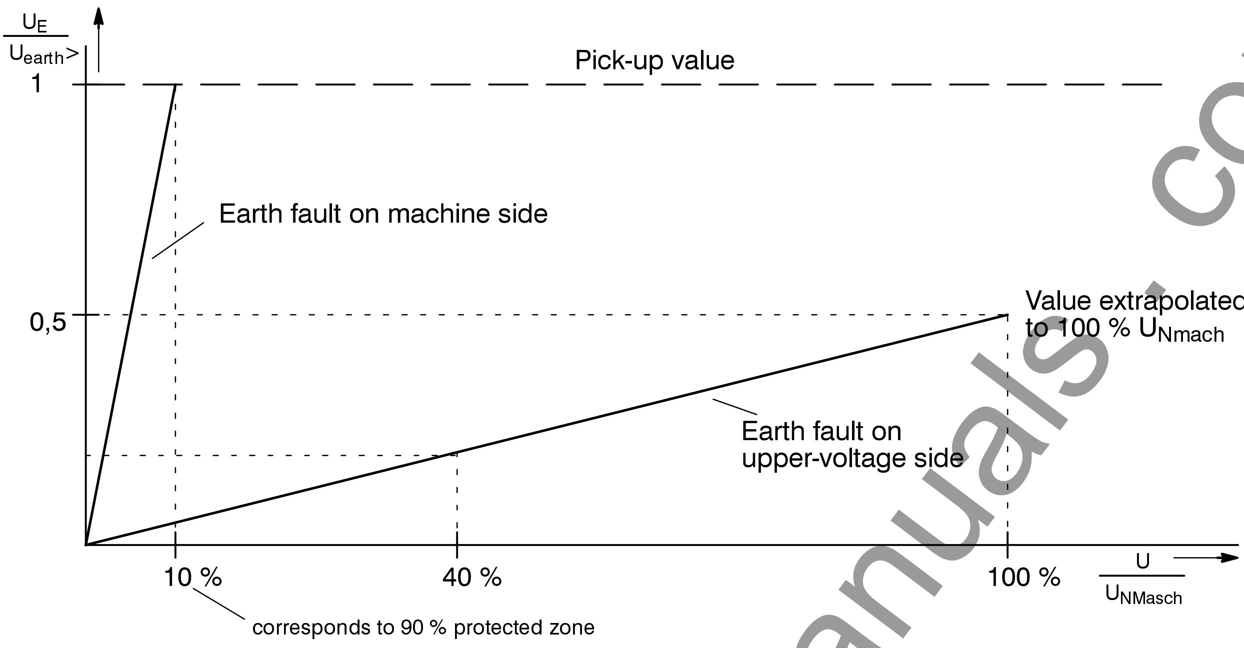


Figure 6.15 Neutral displacement voltage during earth faults

<u>Check using network earth fault</u>

With the primary plant voltage-free and earthed, install a single-pole earth fault bridge on the high-voltage side of the block transformer.

DANGER!

Operations in primary area must only be performed with the machine at standstill and with plant sections voltage-free and earthed!

Caution!

The star-points of the transformer must <u>not</u> be connected to earth during this test!

Start up machine and slowly excite to 40 % of rated machine voltage (max. 60 %). Stator earth fault protection does not pick-up.

Read out U0 in the OPERATIONAL MEASURED VALUES A (address 5708). This value is extrapolated to rated machine voltage (Figure 6.15). The fault value thus calculated should correspond, at the most, to half the pick-up value Uearth > (address 1902), in order to achieve the desired safety margin.

Shut down machine. Remove earth fault bridge.

If the starpoint of the high-voltage side of the block transformer is to be earthed during normal operation, re-establish starpoint earthing.

Switch stator earth fault protection to be operative: address 1901 SEF PROT. = *ON*.

6.7.5.2 Bus-bar connection

Firstly, the correct functioning of the loading equipment must be checked: sequencing, time limit, etc.

Switch stator earth fault protection (address 1901) to *BLOCK TRIP REL*. Furthermore, the EARTH CURRent under address 1903 must be switched *ON*. Under address 1905, the DIR.DETERM can be switched to *OFF* or *ON*.

With the primary plant earthed and voltage-free, install earth fault bridge between machine terminals and toroidal current transformer (Fig. 6.16).

DANGER!

Operations in primary area must only be performed with the machine at standstill and with plant sections voltage-free and earthed!

Start up machine and slowly excite (up to a maximum of $U_N/\sqrt{3}$) until the stator earth fault protection picks up: alarm "`U0> Fault`" (LED 10 when delivered from factory). At the same time the alarm "`Ie> Fault`" should appear, if marshalled.

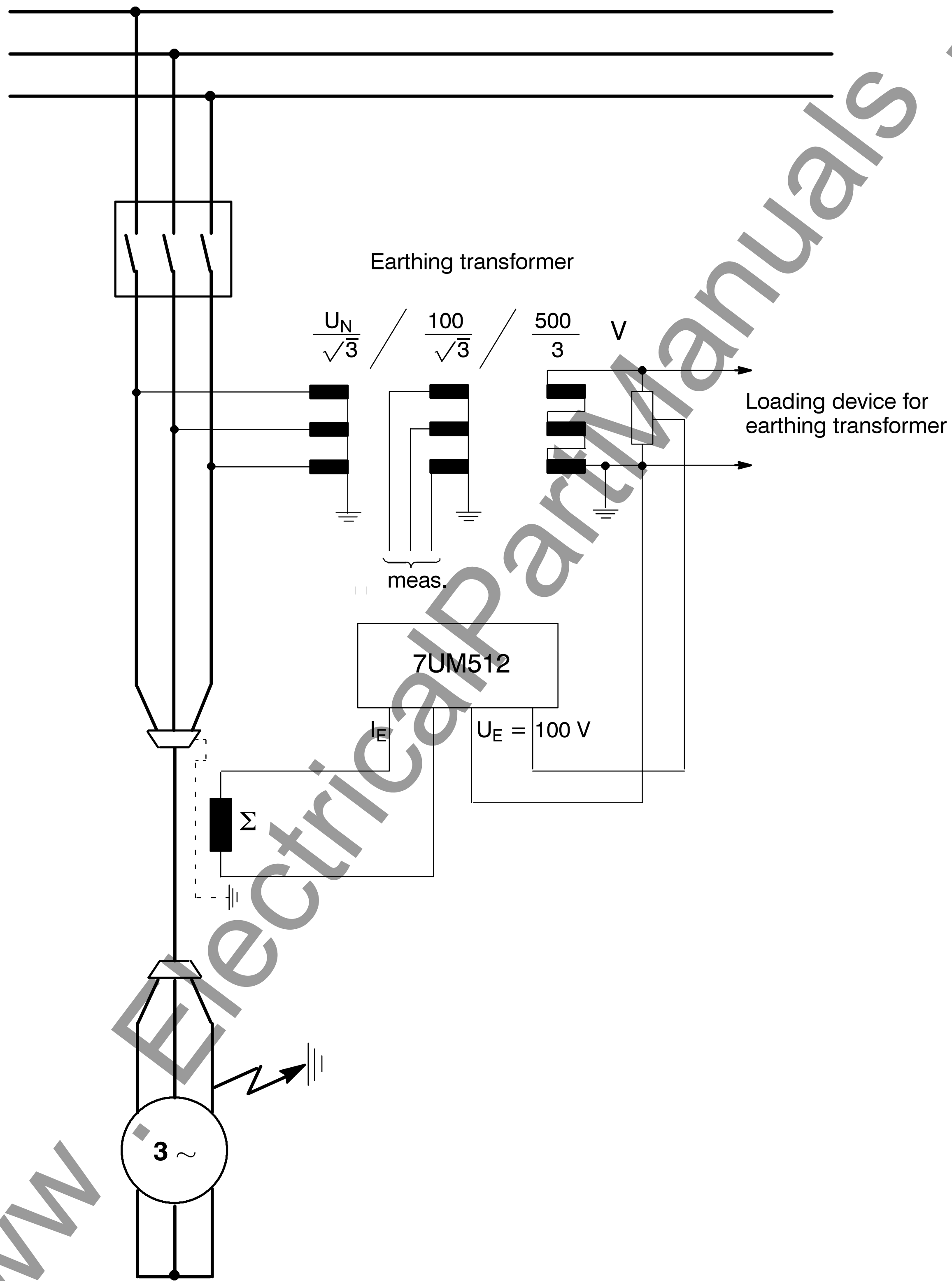


Figure 6.16 Earth fault with bus-bar connection

Read out Uearth under OPERATIONAL MEASURED VALUES A (address 5708). If the connections are correct, this measured value is equal to the machine terminal voltage in percent, referred to rated machine voltage (if applicable, deviating rated primary voltage of earthing transformer or voltage transformer must be taken into account). This value also corresponds to the setting value Uearth > in address 1902.

Read out Iearth under OPERATIONAL MEASURED VALUES A (address 5709). This measured value should be approximately equal to or slightly higher than the setting value Iearth > under address 1904.

The value 100 % – Uearth [%] should correspond to the desired protected zone, e.g.

Machine voltage at pick-up:	$0.1 \cdot U_N$
Measuring value Uearth	10 %
Setting value Uearth>	10 V
Protected zone	90 %

A cross check is then performed. After the machine has been de-excited and shut down, the earth fault bridge is installed on the other side of the current transformers (as viewed from the machine).

DANGER!

Operations in primary area must only be performed with the machine at standstill and with plant sections voltage-free and earthed!

After restarting and exciting the machine above the pick-up value of the displacement voltage, "`Ue Fault`" picks up (LED 10 when delivered from factory), however "`Ie Fault`" does not pick up and tripping does not occur. The measured value Iearth should be negligible and on no account should it be larger then half the setting value Iearth>.

Shut down and de-excite machine. Remove earth fault bridge. If the directional measurement is not activated (address 1905 DIR.DETERM = *OFF*),then the checking of the stator earth fault connection is completed; the stator earth fault protection switched to be operative (address 1901 SEF PROT. = *ON*); the remainder of this section is then of no concern.

If the earth fault directional measurement is activated (address 1905 DIR.DETERM = *ON*), then the correct connection and polarity of the current and voltage connections must be checked.

With the primary plant earthed and voltage-free, install earth fault bridge between machine terminals and toroidal current transformer. The machine is excited to a voltage corresponding to the neutral displacement voltage above the pick-up value. With correct polarity, the trip signal "`S/E/F Trip`" appears (LED 3 and signal relay 3 when delivered from factory).

Shut down and de-excite machine. Remove earth fault bridge.

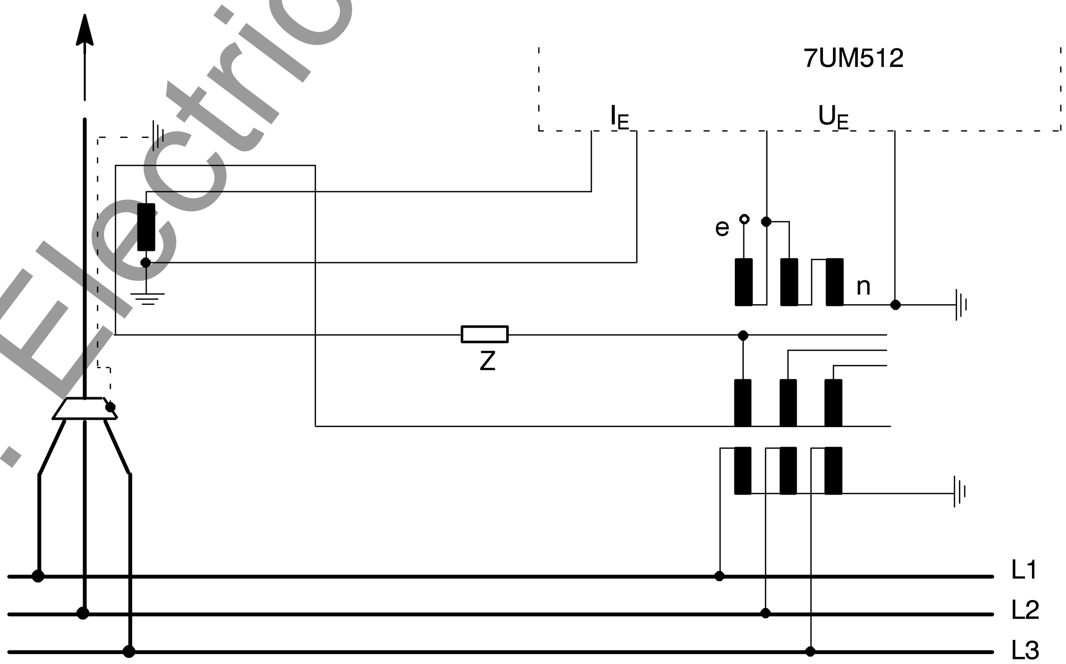


Figure 6.17 Directional check with toroidal residual current transformers

If loading equipment is not available and if an earth fault test with the network is not possible, then the following test can be performed with secondary measures, however with the symmetrical primary load current:

With current supplied from a toroidal residual current transformer, a voltage transformer (e.g. L1) is by-passed which simulates the formation of a neutral displacement voltage (Figure 6.17). From the same phase, a test current is fed via a current-limiting resistor Z through the toroidal transformer. The connection and direction of the current conductor through the toroidal transformer is to be closely checked. If the current is too small for the relay to pick-up, then its effect can be increased by feeding the conductor several times through the toroidal transformer.

For Z either a resistor (30 to 500 Ω) or a capacitor (10 to 100 μF) in series with an inrush-current-limiting resistor (approximately 50 to 100 Ω) is used. With correct connections, the described circuit results in the alarms: "`U0 > Fault`", "`Ie> Fault`" and finally "`S/E/F Trip`" (LED 3 and signal relay 3).

If the current is supplied from a set of c.t.'s in Holmgreen connection (Figure 6.18), the displacement voltage is obtained in the same manner as in the above circuit. Only the current of that current transformer which is in the same phase as the by-passed voltage transformer in the delta connection is fed into the current path. In case of active power in machine direction, the same conditions apply for the relay – in principle – as with an earth fault in machine direction in a compensated network and vice versa.

If, in an isolated network, the voltage connections for the reactive current measurement should be maintained for testing, then it should be noted that with a power flow with inductive component in forwards direction results in a backwards direction for the earth fault relay (contrary to an earth fault in this direction).

Shut down machine after completion of the directional tests. **Correct connections must be re-established and re-checked.**

Switch stator earth fault protection to be operative: address 1901 SEF PROT. = *ON*.

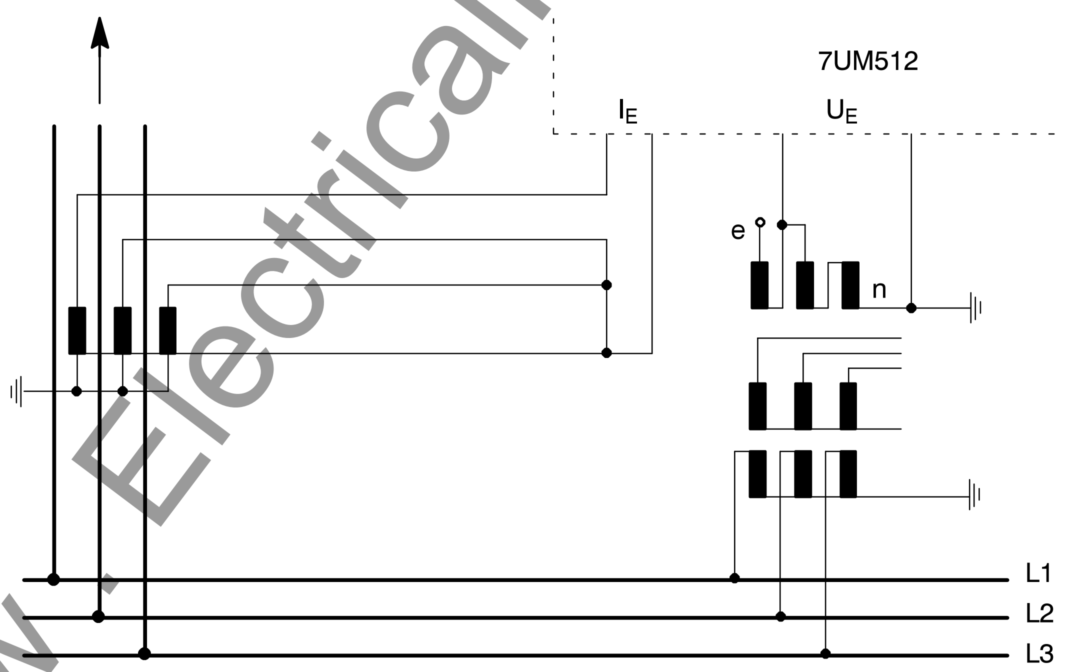


Figure 6.18 Directional check with current transformers in Holmgreen connection

6.7.6 Checking the rotor earth fault protection during operation

In Section 6.7.2, the rotor earth fault protection was checked with the machine at stand-still. In order to exclude possible interference on the measurement circuit by the running machine, an additional test during operation is recommended.

Caution!

The excitation circuit must be free of any earth connection during this test!

An earth fault is simulated via a resistor of approximately 90 % of the trip resistance (RE<< TRIP, address 3503). In machines with rotating rectifier excitation (Figure 6.19), the resistor is placed between the measurement slip rings; in machines with excitation via slip rings (Figure 6.20) between one slip ring and earth.

Start up machine and excite to rated voltage. If applicable place measurement brushes into operation.

The rotor earth fault protection initiates pick-up and, after T−TRIP−R<< (0.5 s when delivered from factory), trip annunciation (LED 4 and signal relay 4).

The earth resistance Rrotor as calculated by the unit can be read out in the OPERATIONAL MEASURED VALUES B (address 5805).

For machines with excitation via slip rings, the test is repeated for the other slip ring.

Shut down machine. Remove earth fault resistor.

Switch the rotor earth fault protection ROTOR E/F = *ON* under address 3501.

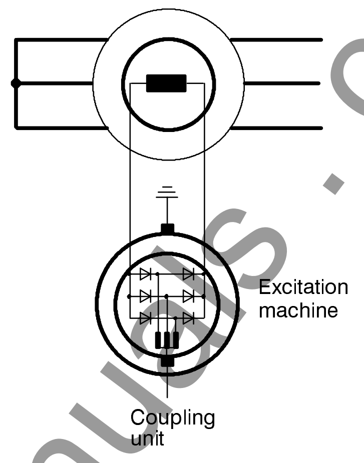


Figure 6.19 Excitation via rotating rectifiers with measurement brushes

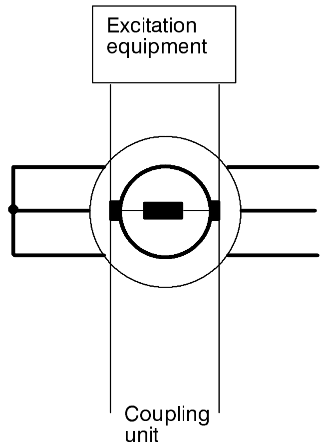


Figure 6.20 Excitation equipment fed via slip rings

6.7.7 Tests with the machine connected to the network

6.7.7.1 Checking the correct connection polarity

The a.c. voltage which is connected to the relay must be correctly parameterized in address 1208. It is important that this connection is checked, particularly for the power protection functions.

The following test instructions apply to a synchronous **generator**.

Run up generator and synchronize with network. Slowly increase driving power input (up to approximately 5 %). The active power is read out under the operational measured values under address 5801 as a positive active power Pa.

If a negative active power value should be read out, then the actual polarity relationship between current transformers and voltage transformers does not accord with the polarity parameterized under address 1205. Re-parameterize address 1205. If the power reading is still incorrect, the fault must be in the instrument transformer connections (e.g. cyclic exchange of phases):

– Shut down and de-excite generator,
– apply plant earths,
– short-circuit current transformers,
– correct fault in instrument transformer leads (c.t. and/or v.t.),
– repeat test.

6.7.7.2 Measurement of motoring power and angle error correction

If the active power protection shall be used as reverse power protection (address 2202 = *Pa BACK. (−Pa)* for a synchronous generator, then correction of the angle error of the instrument transformers is essential. Leave the active power protection switched to *OFF* (address 2201) for the moment. This function and the following measurements are not required for motors.

The motoring power is – as an active power – almost constant and independent of the reactive power, i.e. independent of the excitation current. However, the protection relay may calculate different active power values dependent of the excitation because of possible angle errors of the current and voltage transformers. The motoring power curve then would not be a straight line in parallel to the real axis of the power diagram of the machine. Therefore, the angle deviations should be measured at three measuring points of the power diagram and the correction parameters W0 and W1 should be established. In conjunction with the preparations according to Section 6.6.5, the angle errors are thus minimized.

Reduce driving power to zero by closing the regulating valves. The generator now takes motoring energy from the network.

Caution!

For a turbine set, the intake of reverse power is only permissible for a short time, since operation of the turbine without a certain throughput of steam (cooling effect) can lead to overheating of the turbine blades!

0. Adjust excitation until the reactive power amount to approximately 0.

Read out the active power with sign (negative) in the operational measured values under address 5801 and note it down as $\mathbf{P_0}$ (see table below).

Read out the reactive power with sign in the operational measured values under address 5801 and note it down as $\mathbf{Q_0}$ (see table below).

1. If possible slowly increase excitation to 0.3 times rated apparent power of generator (overexcited).

Read out the motoring power with polarity (negative sign) in the operational measured values under address 5801 and note it down as $\mathbf{P_1}$ (see table below).

Read out the reactive power with polarity (positive sign) in the operational measured values under address 5802 and note it down as $\mathbf{Q_1}$ (see table below).

2. If possible reduce excitation to approximately 0.3 times rated apparent power of generator (underexcited).

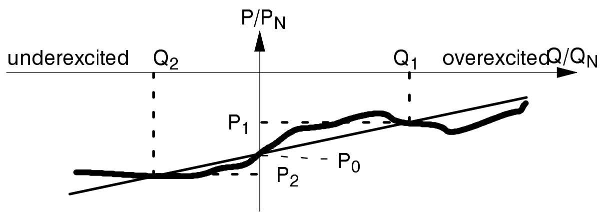
Caution!

Underexcitation may cause the generator fall out of step!

Read out the motoring power with polarity (negative sign) in the operational measured values under address 5801 and note it down as $\mathbf{P_2}$ (see table below).

Read out the reactive power with polarity (negative sign) in the operational measured values under address 5802 and note it down as $\mathbf{Q_2}$ (see table below).

3. Adjust generator to no-load excitation and shut down.



Item	active power		reactive power	
0	P_0		Q_0	
1	P_1		Q_1	
2	P_2		Q_2	

The read-out measured values P_1, and P_2 are now used to carry out angle error correction. calculate according to the following formula:

$$\varphi_{corr} = \arctan \frac{P_1 - P_2}{Q_1 - Q_2}$$

The power values must be inserted with their correct polarity as read out! Otherwise faulty result!

This correction angle φ_{corr} is used to correct address 1206:

New setting W0 = presetting W0 – φ_{corr}

A quarter of the sum of the measured values $P_1 + P_2$ is set as pick-up value of the reverse power protection P> REVERSE under address 2202 (without negative sign). The relay is instructed that it is an reverse power protection by the set power direction under address 2203.

6.7.7.3 Checking the active power supervision as a reverse power protection

If the generator is connected with the network, reverse power can be caused by

– closing of the regulating valves,
– closing of the trip valve.

Because of possible leakages in the valves, the reverse power test should – if possible – be performed for both cases.

In order to confirm the correct settings, repeat reverse power test again. For this, the reverse power protection (address 2201) is set to *BLOCK TRIP REL* and DIR. Pa> (address 2203) is set to *Pa back. (–Pa)* in order to check its effectiveness (using the annunciations).

Start up generator and synchronize with network. Close regulating valves.
- At approximately 50% motoring power, annunciation “`Pa> Fault`” (not allocated when delivered from factory).
- After T–Pa> (address 2204), trip signal “`Pa> Trip`” (LED 7 as delivered).

Increase driving power.

Shut down machine.

Switch *ON* the active power protection (address 2201).

6.7.7.4 Checking the reactive power supervision as an underexcitation protection

Switch reactive power protection (address 2301) to *BLOCK TRIP REL* and set DIR. Pr> (address 2303) to *Pr BACK. (−Pr).*

The correct functioning is tested by approaching the set reactive power. The active power is kept constant while the reactive power is changed (underexcited) until the protection picks up.

Caution!

Underexcitation may cause the generator to fall out of step, in particular with increased active power!

- Annunciation "`Pr> Fault`".
- After T−Pr> (address 2304), trip signal "`Pr> Trip`" (LED 7).

NOTE:
The angle error corrections which are determined according to Section 6.7.7.2 and set under the addresses 1206 and 1207, are effective also for the underexcitation protection.

If operation with capacitive load is not possible, then the load point can also be checked in the inductive (overexcited) range. In this case, the polarity of the instrument transformer connections must be reparameterized (address 1205). Thus, the characteristics of the underexcitation protection are mirrored around the origin. It must be noted that the active power protection must also be switched *OFF* (address 2201) as its characteristic is also mirrored from the motor into the generator range. Alternatively, the direction of the reactive power supervision can be changed in address 2303.

Do not forget to set the polarity of the instrument transformers to the correct parameter (address 1205) or the reactive power (address 2303) to the correct direction.

Check that the desired power supervision functions are switched on, the non-desired off: active power in address 2201 and reactive power in address 2301.

6.7.8 Checking the coupling of external trip signals

If the coupling of external functions for the alarm and/or trip processing is used in the 7UM512, then one or more of these functions must be configured as *EXIST* in the addresses 7830 to 7833. The used function is, additionally, switched in address 3001, 3101, 3201, and/or 3301: EXT. TRIP ⋆ = *BLOCK TRIP REL*.

The function 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 checked.

Finally the used functions are parameterized to *ON* in the associated addresses 3001, 3101, 3201, and/ or 3301.

6.7.9 Tripping test including circuit breaker – address block 44

Machine protection 7UM51 allows simple checking of the tripping circuit and each trip relay.

Initiation of the test can be given from the operator keyboard or from the front operator interface. The procedure is started with address 4400 which can be reached by paging with ⇑ or ⇓, or by direct dialling **DA 4 4 0 0 E** . Codeword input is necessary (code level 2).

By further paging with ↓ ↑ each of the trip relays can be selected for test.

After confirmation by the "Yes" – key **J/Y** the selected relay closes its contacts for 1 s.

⚠ **Warning**

After confirmation by the operator the switching device will be operated. Ensure before each test, that switching is permissible under the actual switchgear status. E.g. isolate circuit breaker by opening isolators at each side.

The test procedure can be ended or aborted by pressing the "No" – key **N** after the question "ENERGIZE TRIP RELAY n ?" appears.

⇑⇓
```
4000█
TESTS
```
Commencement of the test blocks

⇑⇓
```
4400█ CB  TEST
LIVE  TRIP
```
Beginning of the block "trip circuit breaker test: Live trip"

↑↓
```
4401█ ENERGIZE
TRIP  RELAY1  ?
```
Test trip circuit of trip relay 1?
Confirm with "**J/Y**" – key or abort with "**N**" – key

↑↓
```
4402█ ENERGIZE
TRIP  RELAY2  ?
```
Test trip circuit of trip relay 2?
Confirm with "**J/Y**" – key or abort with "**N**" – key

↑↓
```
4403█ ENERGIZE
TRIP  RELAY3  ?
```
Test trip circuit of trip relay 3?
Confirm with "**J/Y**" – key or abort with "**N**" – key

↑↓
```
4404█ ENERGIZE
TRIP  RELAY4  ?
```
Test trip circuit of trip relay 4?
Confirm with "**J/Y**" – key or abort with "**N**" – key

↑↓
```
4405█ ENERGIZE
TRIP  RELAY5
```
Test trip circuit of trip relay 5?
Confirm with "**J/Y**" – key or abort with "**N**" – key

6.7.10 Starting a test fault record – address block 49

A fault record storage can be started at any time using the operating panel or via the operating interface. Starting a test fault record is also possible via a binary input provided this is accordingly allocated (FNo 4 ">Start FltRec").

The configuration parameters as set in address block 74 are decisive for this fault recording (refer to Section 5.3.5): Selection is made under address 7420 whether instantaneous values or r.m.s. values should be scanned; 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.

If the fault record is triggered via a binary input, recording starts automatically with an external event, e.g. at the instant of a switching command.

Manual starting of a fault record can be carried out in address block 49, which can be reached by paging with ⇑ or ⇓, or by direct dialling with **DA 4 9 0 0 E**. The start address is reached with ↑:

⇑⇓ `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

---

6.8 Putting the relay into operation

All setting values should be checked again, in case they were altered during the tests. Particularly check that all desired protection functions have been programmed in the configuration parameters (address blocks 78 and 79, refer to Section 5.4). Ensure that the trip times are not set to ∞ for those functions or stages which should trip and that all desired protection functions have been switched *ON*. Those functions which should only give information may be switched to *BLOCK TRIP REL*.

Push the key **M/S** on the front. The display shows the beginning of the annunciation blocks. Thus, it is possible that the measured values for the quiescent state of the relay can be displayed (see below). These values have been chosen during configuration (refer to Section 5.3.2) under the addresses 7105 and 7106.

Stored indications on the front plate should be reset by pressing the push-button “RESET LED” on the front so that from then on only real faults are indicated. From that moment the measured values of the quiescent state are displayed. During pushing the RESET button, the LEDs on the front will light up (except the “Blocked” – LED); thus, a LED test is performed at the same time.

Check that the modules are properly inserted. The green LED must be on on the front; the red LED must not be on.

Close housing cover.

All terminal screws – even those not in use – must be tightened.

If a test switch is available, then this must be in the operating position.

The 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 blocks 57 to 59) 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 for overload capability). Observe a cooling down period!

– Circuit breaker trip circuits are tested by actual live tripping. Respective notes are given in Section 6.7.9.

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 applied battery holder.

Recommended battery:

Lithium battery 3 V/1 Ah, type CR 1/2 AA, e.g.
– VARTA Order No. 6127 501 501 for relays with screwed terminal for the battery,
– VARTA Order No. 6127 101 501 for relays snap-on battery holder.

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 relays with screwed terminal for the battery**: 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).

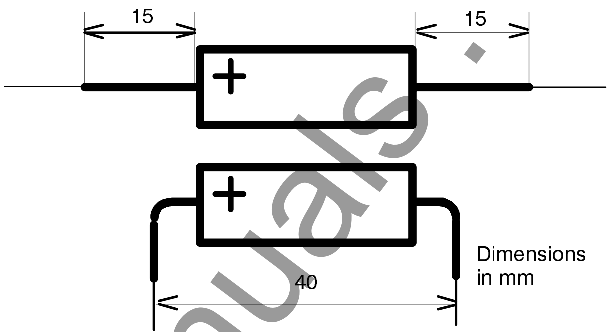


Figure 7.1 Bending the back-up battery for relays with screwed terminal for the battery

Later version do not have axial legs but are snapped on a battery holder.

– 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!**

– Insert the prepared battery into the terminals or holder as in Figure 7.2 and tighten the screws or as in Figure 7.3.

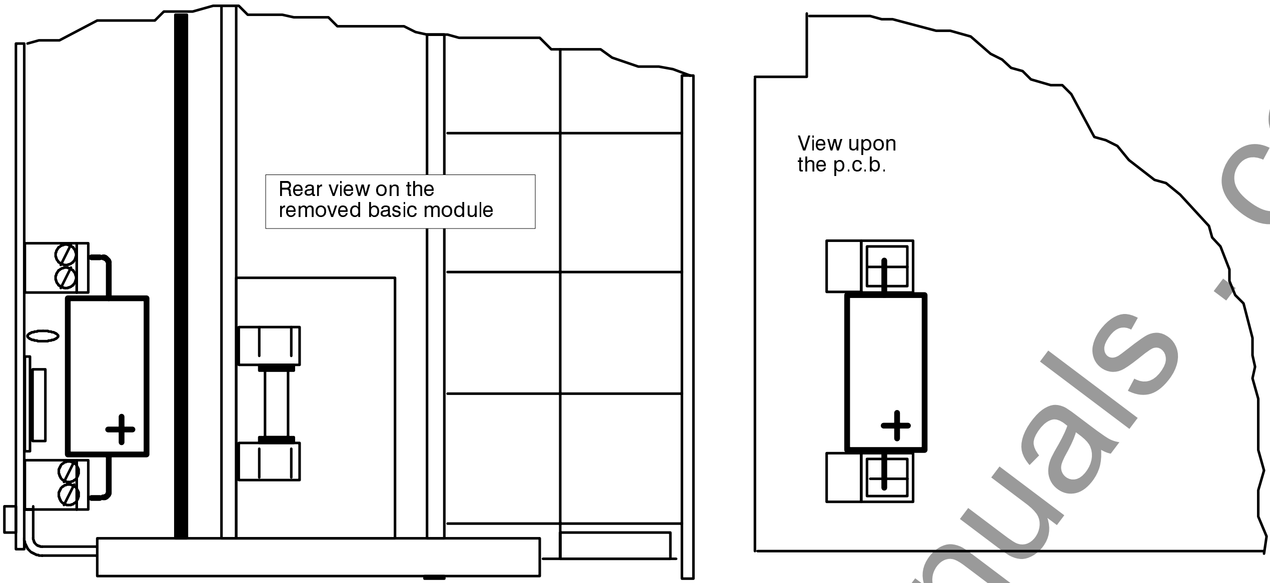


Figure 7.2 Installation of the back-up battery for relays with screwed battery teminals

– 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.

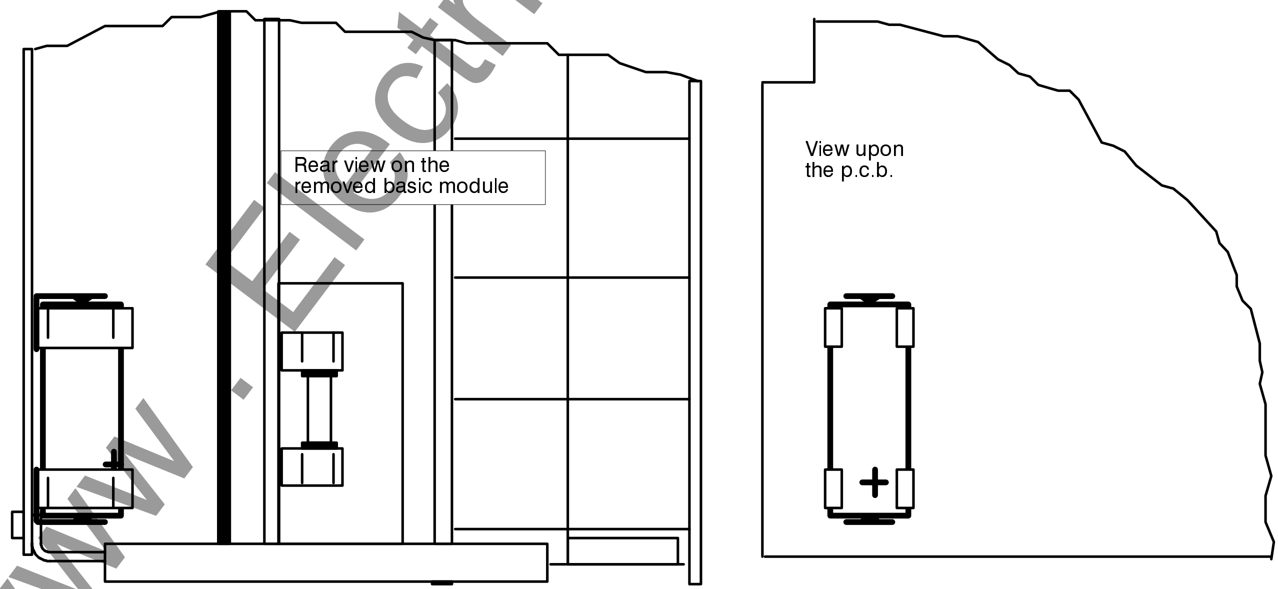


Figure 7.3 Installation of the back-up battery for relays with snap-on battery holder

7.3 Fault tracing

If the protective device indicates a defect, the following procedure is suggested:

If none of the LEDs on the front plate of the module is on, then check:

– Have the modules been properly pushed in and locked?

– Is the ON/OFF switch on the front plate in the ON position ⊙ ?

– Is the auxiliary voltage available with the correct polarity and of adequate magnitude, connected to the correct terminals (General diagrams in Appendix A)?

– Has the mini-fuse in the power supply section blown (see Figure 7.4)? If appropriate, replace the fuse according to Section 7.3.1.

If the red fault indicator “Blocked” on the front is on and the green ready LED remains dark, the device has recognized an internal fault. Re-initialization of the protection system could be tried by switching the d.c. auxiliary voltage off and on again. This, however, results in loss of fault data and messages if the relay is not equipped with a buffer battery, and, if a parameterizing process has not yet been completed, the last parameters are not stored.

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.

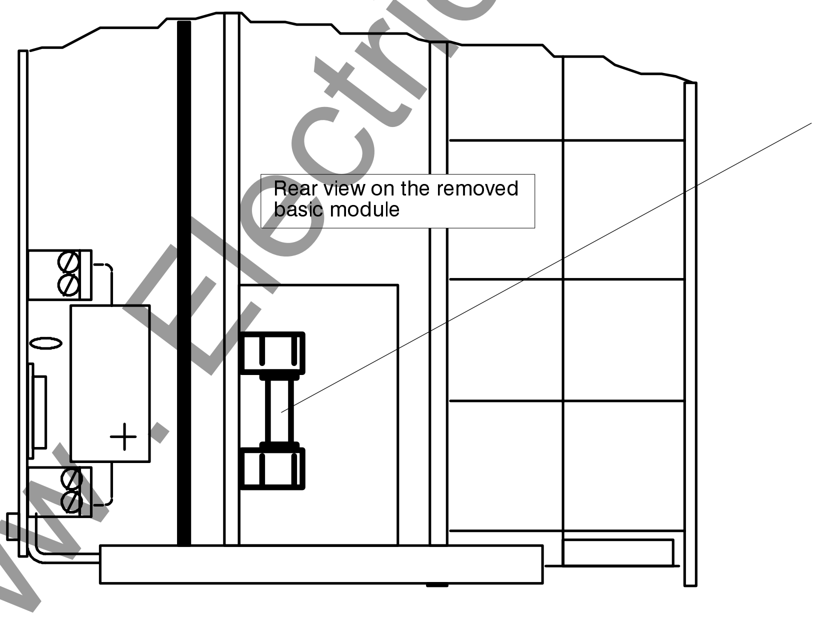
Warning

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).

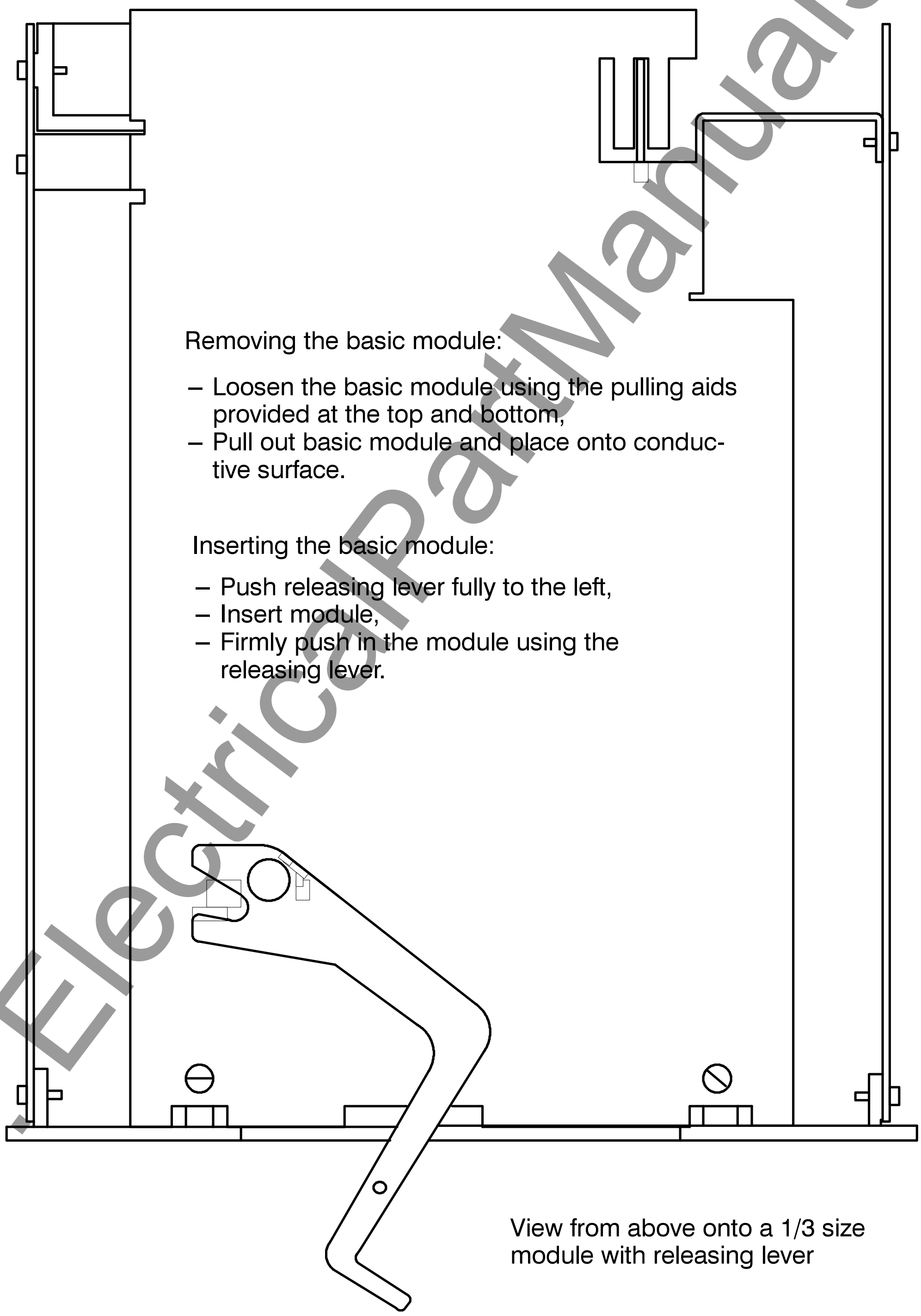


Figure 7.5 Aid for removing and inserting basic module

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 bathsoldered multilayer boards, the sensitive components and the protective finish.

Therefore, if a defect cannot be corrected by operator procedures such as described in Chapter 7, it is recommended that the complete relay should be returned to the manufacturer. Use the original transport packaging for return. If alternative packing is used, this must provide the degree of protection against mechanical shock, as laid down in IEC 60255 – 21 – 1 class 2 and IEC 60255 – 21 – 2 class 1.

If it is unavoidable to replace individual modules, it is imperative that the standards related to the handling of **E**lectrostatically **E**ndangered **C**omponents are observed.

Warning

Hazardous voltages can be present in the device even after disconnection of the supply voltage or after removal of the module from the housing (storage capacitors)!

Caution!

Electrostatic discharges via the component connections, the PCB tracks or the connecting pins of the modules must be avoided under all circumstances by previously touching an earthed metal surface. This applies equally for the replacement of removable components, such as EPROM or EEPROM chips. For transport and returning of individual modules electrostatic protective packing material must be used.

Components and modules are not endangered as long as they are installed within the relay.

Should it become necessary to exchange any device or module, the complete parameter assignment should be repeated. Respective notes are contained in Chapter 5 and 6.

9 Storage

Solid state protective relays shall be stored in dry and clean rooms. The limit temperature range for storage of the relays or associated spare parts is –25 °C to +55 °C (refer Section 3.1.4 under the Technical data), corresponding to –12 °F to 130 °F.

The relative humidity must be within limits such that neither condensation nor ice forms.

It is recommended to reduce the storage temperature to the range +10 °C to +35 °C (50 °F to 95 °F); this prevents from early ageing of the electrolytic capacitors which are contained in the power supply.

For very long storage periods, it is recommended that the relay should be connected to the auxiliary voltage source for one or two days every other year, in order to regenerate the electrolytic capacitors. The same is valid before the relay is finally installed. In extreme climatic conditions (tropics) pre-warming would thus be achieved and condensation avoided.

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

Appendix

A General diagrams

B Connection diagrams

A Tables

A General diagrams

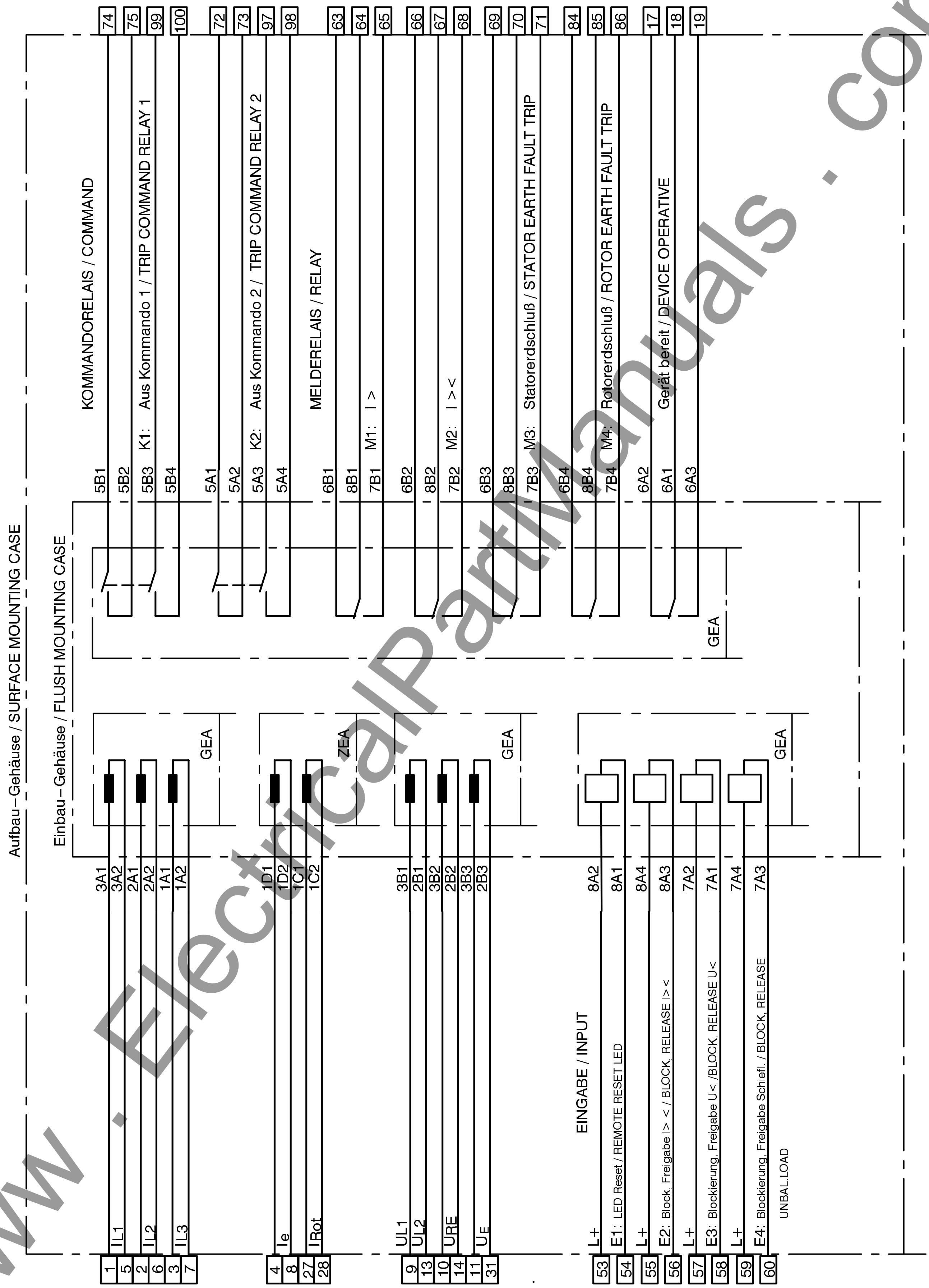


Figure A.1 General diagram 7UM512 (sheet 1 of 3)

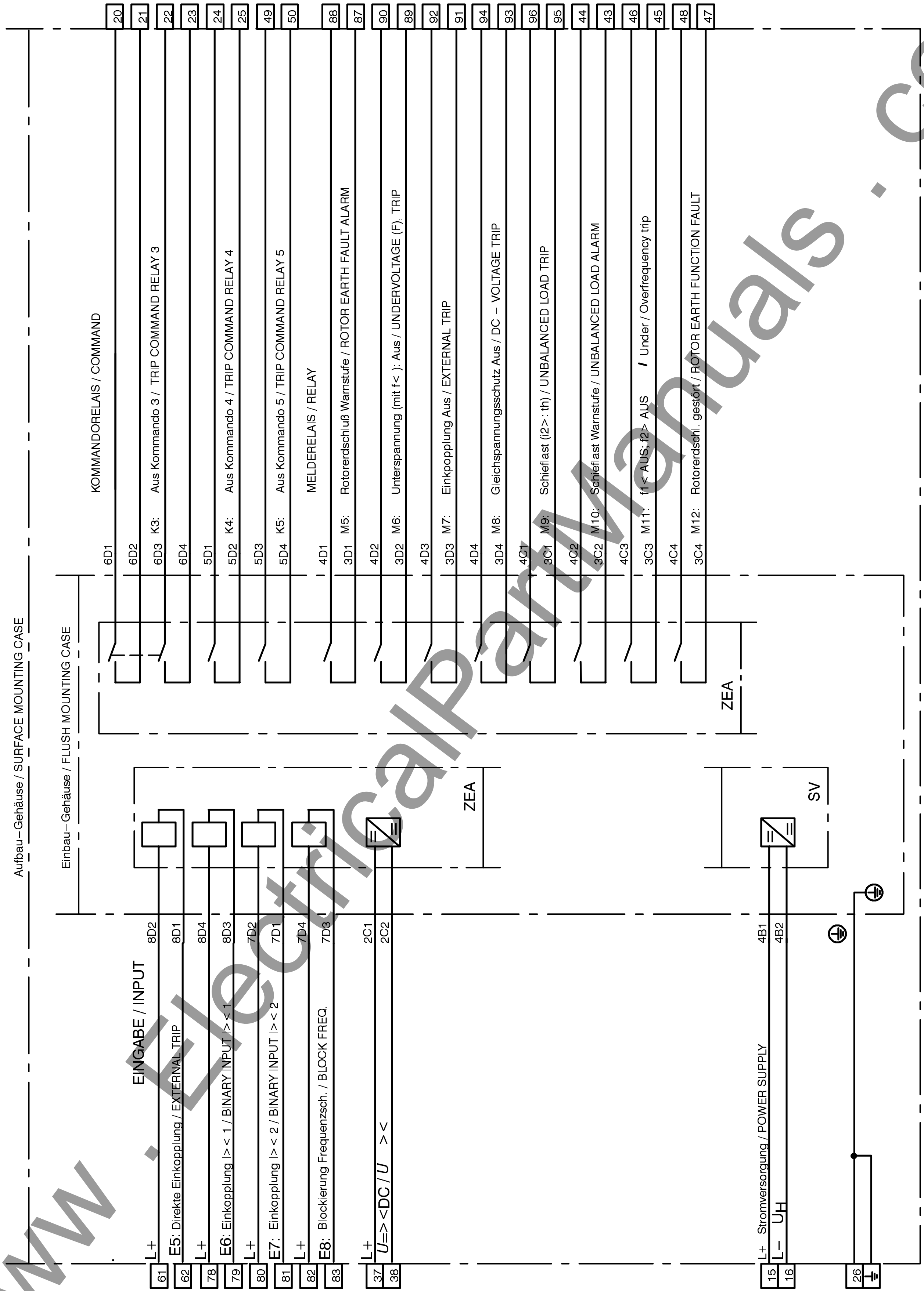
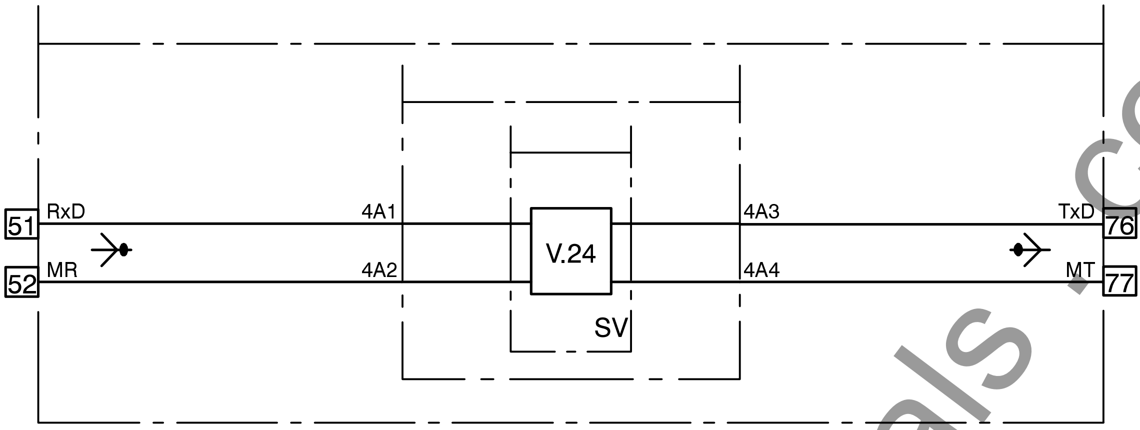
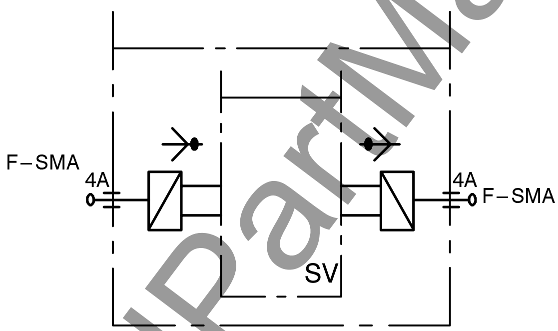


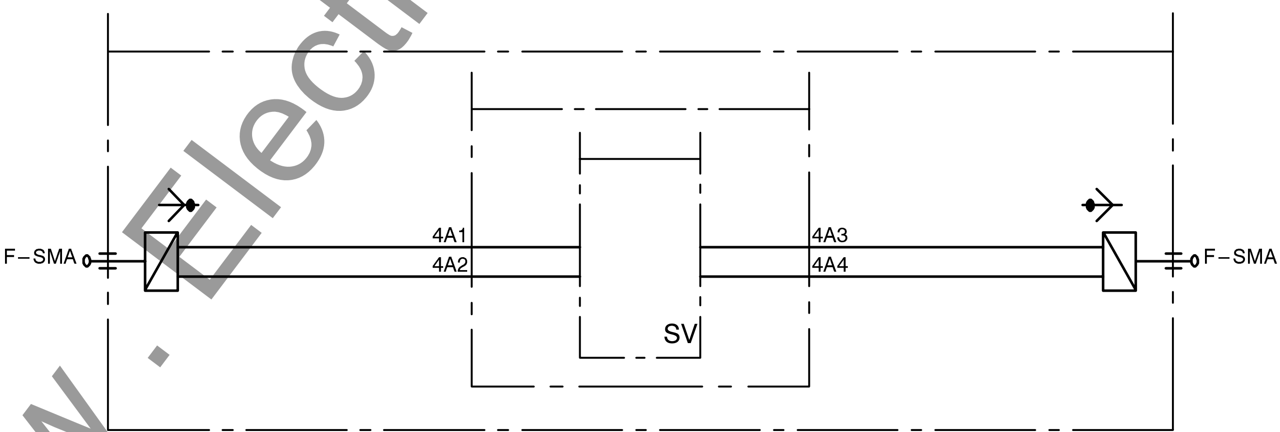
Figure A.2 General diagram 7UM512 (sheet 2 of 3)



Einbau– und Aufbaugehäuse mit V24 – Schnittstelle
FLUSH AND SURFACE MOUNTING CASE WITH V24 DATA LINK
7UM512*–*DB01–0BB0 /
7UM512*–*CB01–0BB0 /
7UM512*–*EB01–0BB0 /



Einbau– Gehäuse mit LWL – Modul
FLUSH MOUNTING CASE WITH FIBER OPTIC INTERFACE
7UM512*–*CB01–0CB0 /
7UM512*–*EB01–0CB0 /



Aufbau– Gehäuse mit LWL – Modul
SURFACE MOUNTING CASE WITH FIBER OPTIC INTERFACE
7UM512*–*DB01–0CB0 /

Figure A.3 General diagram 7UM512 (sheet 3 of 3)

B Connection diagram

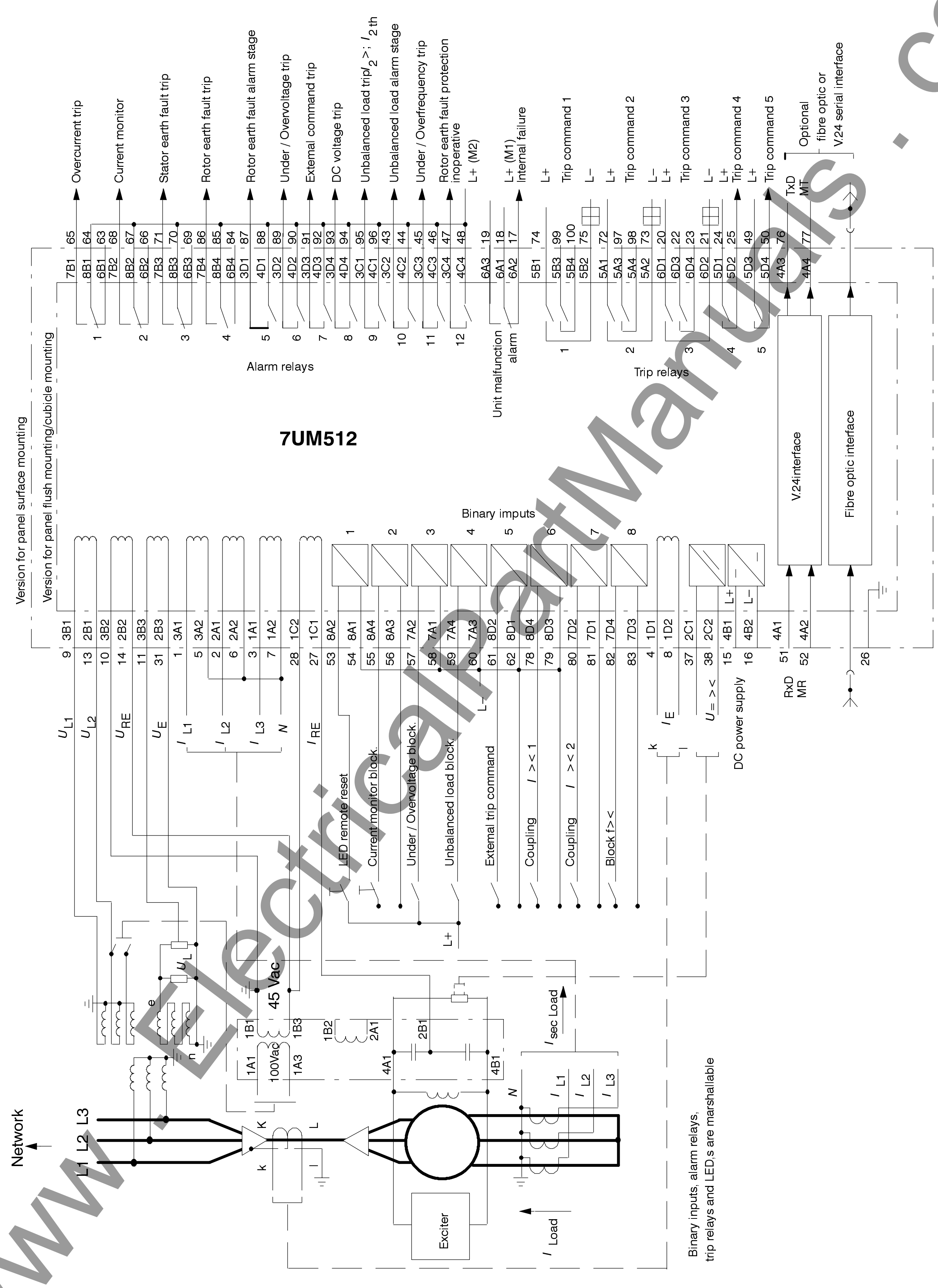


Figure B.1 Connection example 7UM512

C Tables

Table C.1 Annunciations for LSA 208

Table C.2 Annunciations for PC, LC−display, and binary inputs/outputs 212

Table C.3 Reference table for functional parameters (address blocks 11 to 39) 217

Table C.4 Tests and commissioning aids (address blocks 40 to 49) 226

Table C.5 Annunciations, measured values, etc. (address blocks 50 to 59) 227

Table C.6 Reference table for configuration parameters (address blocks 60 to 79) 228

Table C.7 Operational device control facilities (address blocks 80 to 89) 238

NOTE: The following tables list all data which are available in the maximum complement of the device. Dependent on the ordered model and configuration, only those data may be present which are valid for the individual version.

NOTE: The actual tables are attached to the purchased relay.

Annunciations 7UM512 for LSA (DIN 19244 and according VDEW/ZVEI)

FNo. - Function number of annunciation
Op/Ft - Operation/Fault annunciation
C/CG: Coming/Coming and Going annunciation
V : Annunciation with Value
LSA No.- Number of annunciation for former LSA (DIN 19244)
according to VDEW/ZVEI:
CA - Compatible Annunciation
GI - Annunciation for General Interrogation
BT - Binary Trace for fault recordings
Typ - Device type (p: according to the configured device type)
Inf - Information number

FNo.	Meaning	Ann. Op	Ft	LSA No.	VDEW/ZVEI CA	GI	BT	Typ	Inf
11	>User defined annunciation 1	CG		90	CA	GI	BT	p	27
12	>User defined annunciation 2	CG		91	CA	GI	BT	p	28
13	>User defined annunciation 3	CG		92	CA	GI	BT	p	29
14	>User defined annunciation 4	CG		93	CA	GI	BT	p	30
15	>Testing via system-interface	CG						135	53
16	>Block. of monitoring dir. via sys.-int	CG						135	54
51	Device operative / healthy	CG		1		GI		135	81
52	Any protection operative	CG			CA	GI		p	18
55	Re-start of processor system	C		193	CA			p	4
56	Initial start of processor system	C		3	CA			p	5
59	Real time response to LSA	C		192					
60	LED Reset	C		12	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		40	CA	GI		p	23
97	Parameter set B is active	CG		41	CA	GI		p	24
98	Parameter set C is active	CG		42	CA	GI		p	25
99	Parameter set D is active	CG		43	CA	GI		p	26
110	Annunciations lost (buffer overflow)	C		195				135	130
112	Annunciations for LSA lost	C		196				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
154	Supervision trip circuit	CG		100	CA	GI		p	36
160	Common alarm	CG			CA	GI		p	46
161	Measured value supervision of currents	CG			CA	GI		p	32
162	Failure: Current summation supervision	CG		104		GI		135	182
163	Failure: Current symmetry supervision	CG		107		GI		135	183
167	Failure: Voltage symmetry supervision	CG		108		GI		135	186
171	Failure: Phase sequence supervision	CG		111	CA	GI		p	35
301	Fault in the power system		CG	2				135	231
302	Flt. event w. consecutive no.		C					135	232
501	General fault detection of device	C		5			BT	150	151
502	General drop-off of device	C		6				150	152
511	General trip of device	C		7			BT	150	161
601	Current in phase IL1 [%] =	V							
602	Current in phase IL2 [%] =	V							
603	Current in phase IL3 [%] =	V							

FNo.	Meaning	Ann. Op	Ann. Ft	LSA No.	VDEW/ZVEI CA	GI	BT	Typ	Inf
694	Frequency f [Hz] =	V							
774	Secondary earth voltage U0	V							
893	Secondary phase-phase voltage	V							
895	Rotor earth resistance	V							
906	Negative sequence current/unbal. load	V							
930	Current phase IL1 [%] =	V						134	144
931	Current phase IL2 [%] =	V						134	144
932	Current phase IL3 [%] =	V						134	144
936	Secondary earth voltage U0 is	V						134	144
937	Frequency f [Hz] = (only LSA)	V						134	144
939	Positive sequence current	V						134	144
940	Negative sequence current/unbal. load	V						134	144
941	Power factor of the machine	V						134	144
944	Active power Pa [%] =	V						134	144
945	Reactive power Pr [%] =	V						134	144
946	Phase-phase voltage	V						134	144
947	Rotor earth resistance	V						134	144
1175	Trip test for trip relay 1 in progress	CG		70		GI		151	90
1176	Trip test for trip relay 2 in progress	CG		71		GI		151	91
1177	Trip test for trip relay 3 in progress	CG		72		GI		151	92
1178	Trip test for trip relay 4 in progress	CG		73		GI		151	93
1179	Trip test for trip relay 5 in progress	CG		74		GI		151	94
1722	>Overcurrent protection:block stage I>	CG				GI		60	2
1811	O/C fault detection stage I> phase L1		CG	210		GI	BT	60	50
1812	O/C fault detection stage I> phase L2		CG	212		GI	BT	60	51
1813	O/C fault detection stage I> phase L3		CG	214		GI	BT	60	52
1815	O/C protection I> phase trip		C	235			BT	60	71
1950	>O/C prot. : Block undervoltage seal-in	CG				GI		60	200
1951	>O/C prot. : extern undervolt. seal-in	CG		79		GI		60	201
1965	O/C prot. stage I> is switched off	CG		116		GI		60	215
1966	O/C prot. stage I> is blocked	CG		136		GI		60	216
1967	O/C prot. stage I> is active	CG		126		GI		60	217
1970	O/C prot. undervoltage seal-in		CG	221		GI	BT	60	220
4523	>Block external trip 1	CG				GI		51	123
4526	>Trigger external trip 1	CG		65		GI		51	126
4531	External trip 1 is switched off	CG		21		GI		51	131
4532	External trip 1 is blocked	CG		60		GI		51	132
4533	External trip 1 is active	CG		31		GI		51	133
4536	External trip 1: General fault det.		CG	200		GI	BT	51	136
4537	External trip 1: General trip		C	244			BT	51	137
4543	>Block external trip 2	CG				GI		51	143
4546	>Trigger external trip 2	CG		66		GI		51	146
4551	External trip 2 is switched off	CG		22		GI		51	151
4552	External trip 2 is blocked	CG		61		GI		51	152
4553	External trip 2 is active	CG		32		GI		51	153
4556	External trip 2: General fault det.		CG	201		GI	BT	51	156
4557	External trip 2: General trip		C	245			BT	51	157
4563	>Block external trip 3	CG				GI		51	163
4566	>Trigger external trip 3	CG		67		GI		51	166
4571	External trip 3 is switched off	CG		23		GI		51	171
4572	External trip 3 is blocked	CG		62		GI		51	172
4573	External trip 3 is active	CG		33		GI		51	173
4576	External trip 3: General fault det.		CG	202		GI	BT	51	176
4577	External trip 3: General trip		C	246			BT	51	177
4583	>Block external trip 4	CG				GI		51	183
4586	>Trigger external trip 4	CG		68		GI		51	186
4591	External trip 4 is switched off	CG		24		GI		51	191

FNo.	Meaning	Ann. Op	Ann. Ft	LSA No.	VDEW/ZVEI CA	GI	BT	Typ	Inf
4592	External trip 4 is blocked	CG		63		GI		51	192
4593	External trip 4 is active	CG		34		GI		51	193
4596	External trip 4: General fault det.		CG	203		GI	BT	51	196
4597	External trip 4: General trip		C	247			BT	51	197
5002	Suitable measured quantities present	CG		45		GI		71	2
5004	>Phase rotation counter-clockwise	CG				GI		71	4
5005	Phase rotation is clockwise	C						71	5
5006	Phase rotation is counter-clockwise	C						71	6
5086	>Stop valve tripped	CG		55		GI		70	77
5143	>Block unbalanced load protection	CG				GI		70	126
5146	>Reset memory for thermal replica I2	CG				GI		70	127
5151	Unbalanced load prot. is switched off	CG		28		GI		70	131
5152	Unbalanced load protection is blocked	CG		50		GI		70	132
5153	Unbalanced load protection is active	CG		38		GI		70	133
5156	Unbalanced load: Current warning stage	CG		13		GI		70	134
5157	Unbalanced load: Thermal warning stage	CG		14		GI		70	135
5158	Reset memory of thermal replica I2	CG		53		GI		70	137
5159	Unbalanced load: Fault detec. I2>>		CG	226		GI	BT	70	138
5160	Unbalanced load: Trip of current stage		C	238			BT	70	139
5161	Unbalanced load: Trip of thermal stage		C	15			BT	70	140
5173	>Block stator earth fault protection	CG				GI		70	151
5176	>Switch off earth current detec.(S/E/F)	CG		78		GI		70	152
5181	Stator earth fault prot. is switch off	CG		29		GI		70	156
5182	Stator earth fault protection is block.	CG		57		GI		70	157
5183	Stator earth fault protection is active	CG		39		GI		70	158
5186	Stator earth fault: Fault detection U0		CG	216		GI	BT	70	159
5188	Stator earth fault: Fault detection Ie		CG	215		GI	BT	70	168
5189	Earth fault in phase L1		CG			GI	BT	70	169
5190	Earth fault in phase L2		CG			GI	BT	70	170
5191	Earth fault in phase L3		CG			GI	BT	70	171
5192	Stator earth fault start-up trip		C	179			BT	70	172
5193	Stator earth fault protection trip		C	237			BT	70	173
5203	>Block frequency protection	CG				GI		70	176
5206	>Block frequency prot. f1 stage	CG				GI		70	177
5207	>Block frequency prot. f2 stage	CG				GI		70	178
5211	Frequency protection is switched off	CG		119		GI		70	181
5212	Frequency protection is blocked	CG		139		GI		70	182
5213	Frequency protection is active	CG		129		GI		70	183
5214	Frequency protection blocked by U<	CG				GI		70	184
5216	Frequency protection: Fault stage f1>		CG	170		GI	BT	70	185
5217	Frequency protection: Fault stage f1<		CG	171		GI	BT	70	186
5218	Frequency protection: Fault stage f2>		CG	172		GI	BT	70	187
5219	Frequency protection: Fault stage f2<		CG	173		GI	BT	70	188
5224	Frequency protection: Trip stage f1>		C	180			BT	70	193
5225	Frequency protection: Trip stage f1<		C	181			BT	70	194
5226	Frequency protection: Trip stage f2>		C	182			BT	70	195
5227	Frequency protection: Trip stage f2<		C	183			BT	70	196
5263	>Block current supervision	CG				GI		70	203
5266	>Coupling signal 1 for I>< supervision	CG				GI		70	206
5267	>Coupling signal 2 for I>< supervision	CG				GI		70	207
5271	Current supervision is switched off	CG		123		GI		70	211
5272	Current supervision is blocked	CG		46		GI		70	212
5273	Current supervision is active	CG		133		GI		70	213
5276	Current supervision: Fault detection		CG	199		GI	BT	70	216
5277	Current supervision: Trip		C	188			BT	70	217
5293	>Block DC voltage protection	CG				GI		71	173
5301	DC voltage protection is switched off	CG		124		GI		71	181

FNo.	Meaning	Ann. Op	Ann. Ft	LSA No.	VDEW/ZVEI CA	GI	BT	Typ	Inf
5302	DC voltage protection is blocked	CG		47		GI		71	182
5303	DC voltage protection is active	CG		134		GI		71	183
5306	DC voltage protection: Fault detection		CG	204		GI	BT	71	186
5307	DC voltage protection: Trip		C	189			BT	71	187
5383	>Block rotor earth fault protection	CG				GI		71	113
5391	Rotor earth fault prot. is switched off	CG		144		GI		71	121
5392	Rotor earth fault prot. is blocked	CG		150		GI		71	122
5393	Rotor earth fault prot. is active	CG		147		GI		71	123
5394	Rotor earth fault prot. blocked by U<	CG				GI		71	124
5396	Failure rotor earth fault protection	CG		98		GI		71	126
5397	Rotor earth fault prot.: Warning stage	CG		18		GI		71	127
5398	Rotor earth fault prot.: Fault detec.		CG	227		GI	BT	71	128
5399	Rotor earth fault prot.: Trip		C	229			BT	71	129
5443	>Block active power protection	CG				GI		71	203
5445	>Block reactive power protection	CG				GI		71	205
5446	>Block reactive power prot. Pr> stage	CG				GI		71	206
5447	>Block reactive power prot. Pr>> stage	CG				GI		71	207
5451	Active power prot. is switched off	CG		145		GI		71	211
5452	Active power protection is blocked	CG		151		GI		71	212
5453	Active power protection is active	CG		148		GI		71	213
5454	Reactive power prot. is switched off	CG		146		GI		71	214
5455	Reactive power protection is blocked	CG		152		GI		71	215
5456	Reactive power protection is active	CG		149		GI		71	216
5457	Active power protection: Fault detec.		CG	197		GI	BT	71	217
5458	Reactive power protection: Fault detec.		CG	198		GI	BT	71	218
5459	Active power protection: Trip		C	190			BT	71	219
5460	Reactive power protection: Trip		C	191			BT	71	220
5461	Reactive power prot.: Fault detec. Pr>>		CG	198		GI	BT	71	221
5462	Reactive power prot.: Trip Pr>>		C	191			BT	71	222
5463	Active power: Trip with stop valve		C	249			BT	71	223
6506	>Block undervoltage protection U< stage	CG				GI		74	6
6513	>Block overvoltage protection	CG				GI		74	13
6530	Undervoltage protection is switched off	CG		121		GI		74	30
6531	Undervoltage protection is blocked	CG		141		GI		74	31
6532	Undervoltage protection is active	CG		131		GI		74	32
6533	Undervoltage fault detection U<		CG	219		GI	BT	74	33
6539	Undervoltage protection, U< trip		C	241			BT	74	39
6565	Overvoltage protection is switched off	CG		122		GI		74	65
6566	Overvoltage protection is blocked	CG		142		GI		74	66
6567	Overvoltage protection is active	CG		132		GI		74	67
6568	Overvoltage fault detection U>		CG	217		GI	BT	74	68
6570	Overvoltage protection U> trip		C	239			BT	74	70
6571	Overvoltage prot. fault detec. U>>		CG	218		GI	BT	74	71
6573	Overvoltage protection U>> trip		C	240			BT	74	73
6872	>Trip circuit superv. trip relay 1	CG				GI		153	10
6873	>Trip circuit superv. CBaux 1	CG				GI		153	11
6879	Failure trip circuit 1	CG		101		GI		153	12
6892	>Trip circuit superv. trip relay 2	CG				GI		153	13
6893	>Trip circuit superv. CBaux 2	CG				GI		153	14
6899	Failure trip circuit 2	CG		102		GI		153	15

Annunciations 7UM512 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
        V   : Annunciation with Value
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				IO
4	>Start FltRec	>Start fault recording	C			IO
5	>LED reset	>Reset LED indicators				IO
7	>ParamSelec.1	>Parameter set selection 1 (with No.8)				IO
8	>ParamSelec.2	>Parameter set selection 2 (with No.7)				IO
11	>Annunc. 1	>User defined annunciation 1	CG			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
15	>Sys-Test	>Testing via system-interface	CG			IO
16	>Sys-MM-block	>Block. of monitoring dir. via sys.-int	CG			IO
51	Dev.operative	Device operative / healthy	CG			O
52	Prot. operat.	Any protection operative	CG			O
56	Initial start	Initial start of processor system	C			
60	LED reset	LED Reset	C			O
61	LogMeasBlock	Logging and measuring functions blocked	CG			
62	Test mode	Test mode	CG			
95	Param.running	Parameters are being set	CG			O
96	Param. Set A	Parameter set A is active	CG			O
97	Param. Set B	Parameter set B is active	CG			O
98	Param. Set C	Parameter set C is active	CG			O
99	Param. Set D	Parameter set D is active	CG			O
100	Wrong SW-vers	Wrong software-version	C			
101	Wrong dev. ID	Wrong device identification	C			
110	Annunc. lost	Annunciations lost (buffer overflow)	C			
111	Annu. PC lost	Annunciations for PC lost	C			
115	Flt.Buff.Over	Fault annunciation buffer overflow		C		
120	Oper.Ann.Inva	Operational annunciations invalid	CG			
121	Flt.Ann.Inval	Fault annunciations invalid	CG			
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
154	Fail. TripRel	Supervision trip circuit	CG			
159	LSA disrupted	LSA (system interface) disrupted	CG			
161	I supervision	Measured value supervision of currents				O
162	Failure ΣI	Failure: Current summation supervision	CG			O
163	Failure Isymm	Failure: Current symmetry supervision	CG			O
167	Failure Usymm	Failure: Voltage symmetry supervision	CG			O
171	Fail.PhaseSeq	Failure: Phase sequence supervision	CG			O

FNo.	Abbreviation	Meaning	Op	Ft	Ear	IO
203	Flt.RecDatDel	Fault recording data deleted	C			
204	Flt.Rec.viaBI	Fault recording initiated via bin.input	C			
205	Flt.Rec.viaKB	Fault recording initiated via keyboard	C			
206	Flt.Rec.viaPC	Fault recording initiated via PC interf	C			
244	D Time=	Diff. time of clock synchronism	V			
301	Syst.Flt	Fault in the power system	CG	C		
302	Fault	Flt. event w. consecutive no.		C		
501	Device FltDet	General fault detection of device		C		
502	Dev. Drop-off	General drop-off of device		C		O
511	Device Trip	General trip of device		C		
545	T-Drop	Time from fault detection to drop-off				
546	T-Trip	Time from fault detection to trip				
601	IL1[%] =	Current in phase IL1 [%] =	V			
602	IL2[%] =	Current in phase IL2 [%] =	V			
603	IL3[%] =	Current in phase IL3 [%] =	V			
641	Pa[%]=	Active power Pa [%] =	V			
642	Pr[%]=	Reactive power Pr [%] =	V			
651	IL1 =	Current in phase IL1 =	V			
652	IL2 =	Current in phase IL2 =	V			
653	IL3 =	Current in phase IL3 =	V			
694	f [Hz]=	Frequency f [Hz] =	V			
774	U0 =	Secondary earth voltage U0	V			
893	Uph-ph =	Secondary phase-phase voltage	V			
894	U DC =	DC voltage	V			
895	Rrotor =	Rotor earth resistance	V			
896	Urotor =	Bias AC voltage for rotor earth fault	V			
897	Irotor =	Rotor earth current caused by Urotor	V			
898	Rinput =	Active component of input impedance	V			
899	Xinput =	Reactive component of input impedance	V			
901	COS PHI=	Power factor cos phi	V			
902	PHI=	Power angle	V			
905	Ipos.seq=	Positive sequence current	V			
906	Ineg.seq=	Negative sequence current/unbal. load	V			
910	ThermRep.=	Calculated rotor temp. (unbal. load)	V			
915	Ie=	Earth current	V			
1175	Test Trip 1	Trip test for trip relay 1 in progress	CG			
1176	Test Trip 2	Trip test for trip relay 2 in progress	CG			
1177	Test Trip 3	Trip test for trip relay 3 in progress	CG			
1178	Test Trip 4	Trip test for trip relay 4 in progress	CG			
1179	Test Trip 5	Trip test for trip relay 5 in progress	CG			
1722	>I> block	>Overcurrent protection:block stage I>				IO
1811	I> Fault L1	O/C fault detection stage I> phase L1		CG		O
1812	I> Fault L2	O/C fault detection stage I> phase L2		CG		O
1813	I> Fault L3	O/C fault detection stage I> phase L3		CG		O
1815	I> Trip	O/C protection I> phase trip		C		O
1950	>Useal-in blk	>O/C prot. : Block undervoltage seal-in	CG			IO
1951	>Useal-in ext	>O/C prot. : extern undervolt. seal-in	CG			IO
1965	I> off	O/C prot. stage I> is switched off	CG			O
1966	I> blocked	O/C prot. stage I> is blocked	CG			O
1967	I> active	O/C prot. stage I> is active	CG			O
1970	U< seal in	O/C prot. undervoltage seal-in		CG		O
4523	>Ext 1 block	>Block external trip 1				IO
4526	>Ext trip 1	>Trigger external trip 1	CG			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

FNo.	Abbreviation	Meaning	Op	Ft	Ear	IO
4543	>Ext 2 block	>Block external trip 2				IO
4546	>Ext trip 2	>Trigger external trip 2	CG			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
4563	>Ext 3 block	>Block external trip 3				IO
4566	>Ext trip 3	>Trigger external trip 3	CG			IO
4571	Ext 3 off	External trip 3 is switched off	CG			O
4572	Ext 3 blocked	External trip 3 is blocked	CG			O
4573	Ext 3 active	External trip 3 is active	CG			O
4576	Ext 3 Gen.Flt	External trip 3: General fault det.		CG		O
4577	Ext 3 Gen.Trp	External trip 3: General trip		C		O
4583	>Ext 4 block	>Block external trip 4				IO
4586	>Ext trip 4	>Trigger external trip 4	CG			IO
4591	Ext 4 off	External trip 4 is switched off	CG			O
4592	Ext 4 blocked	External trip 4 is blocked	CG			O
4593	Ext 4 active	External trip 4 is active	CG			O
4596	Ext 4 Gen.Flt	External trip 4: General fault det.		CG		O
4597	Ext 4 Gen.Trp	External trip 4: General trip		C		O
5002	Operat. Cond.	Suitable measured quantities present	CG			O
5004	>Phase rotat.	>Phase rotation counter-clockwise	CG			IO
5005	Clockwise	Phase rotation is clockwise	C			O
5006	Counter-clock	Phase rotation is counter-clockwise	C			O
5086	>SV tripped	>Stop valve tripped	CG			IO
5143	>I2 block	>Block unbalanced load protection				IO
5146	>RM th.repl.	>Reset memory for thermal replica I2				IO
5151	I2 off	Unbalanced load prot. is switched off	CG			O
5152	I2 blocked	Unbalanced load protection is blocked	CG			O
5153	I2 active	Unbalanced load protection is active	CG			O
5156	I2> Warn	Unbalanced load: Current warning stage	CG			O
5157	I2 th. Warn	Unbalanced load: Thermal warning stage	CG			O
5158	RM th. repl.	Reset memory of thermal replica I2	CG			O
5159	I2>> Fault	Unbalanced load: Fault detec. I2>>		CG		O
5160	I2>> Trip	Unbalanced load: Trip of current stage		C		O
5161	I2 Θ Trip	Unbalanced load: Trip of thermal stage		C		O
5173	>U0> block	>Block stator earth fault protection				IO
5176	>S/E/F Ie off	>Switch off earth current detec.(S/E/F)	CG			IO
5181	U0> off	Stator earth fault prot. is switch off	CG			O
5182	U0> blocked	Stator earth fault protection is block.	CG			O
5183	U0> active	Stator earth fault protection is active	CG			O
5186	U0> Fault	Stator earth fault: Fault detection U0		CG		O
5188	Ie> Fault	Stator earth fault: Fault detection Ie		CG		O
5189	Uearth L1	Earth fault in phase L1		CG		O
5190	Uearth L2	Earth fault in phase L2		CG		O
5191	Uearth L3	Earth fault in phase L3		CG		O
5192	S/E/F st.Trip	Stator earth fault start-up trip		C		O
5193	S/E/F Trip	Stator earth fault protection trip		C		O
5203	>Frq. block	>Block frequency protection				IO
5206	>f1 block	>Block frequency prot. f1 stage	CG			IO
5207	>f2 block	>Block frequency prot. f2 stage	CG			IO
5211	FRQ off	Frequency protection is switched off	CG			O
5212	FRQ blocked	Frequency protection is blocked	CG			O
5213	FRQ active	Frequency protection is active	CG			O
5214	FRQ U< block	Frequency protection blocked by U<	CG			O
5216	f1> Fault	Frequency protection: Fault stage f1>		CG		O
5217	f1< Fault	Frequency protection: Fault stage f1<		CG		O

FNo.	Abbreviation	Meaning	Op	Ft	Ear	IO
5218	f2> Fault	Frequency protection: Fault stage f2>		CG		O
5219	f2< Fault	Frequency protection: Fault stage f2<		CG		O
5224	f1> Trip	Frequency protection: Trip stage f1>		C		O
5225	f1< Trip	Frequency protection: Trip stage f1<		C		O
5226	f2> Trip	Frequency protection: Trip stage f2>		C		O
5227	f2< Trip	Frequency protection: Trip stage f2<		C		O
5263	>I>< block	>Block current supervision				IO
5266	>I>< coupl. 1	>Coupling signal 1 for I>< supervision	CG			IO
5267	>I>< coupl. 2	>Coupling signal 2 for I>< supervision	CG			IO
5271	I>< off	Current supervision is switched off	CG			O
5272	I>< blocked	Current supervision is blocked	CG			O
5273	I>< active	Current supervision is active	CG			O
5276	I>< Fault	Current supervision: Fault detection		CG		O
5277	I>< Trip	Current supervision: Trip		C		O
5293	>U DC block	>Block DC voltage protection				IO
5301	U DC off	DC voltage protection is switched off	CG			O
5302	U DC blocked	DC voltage protection is blocked	CG			O
5303	U DC active	DC voltage protection is active	CG			O
5306	U DC Fault	DC voltage protection: Fault detection		CG		O
5307	U DC Trip	DC voltage protection: Trip		C		O
5383	>R/E/F block	>Block rotor earth fault protection				IO
5391	R/E/F off	Rotor earth fault prot. is switched off	CG			O
5392	R/E/F blocked	Rotor earth fault prot. is blocked	CG			O
5393	R/E/F active	Rotor earth fault prot. is active	CG			O
5394	R/E/F U< blk	Rotor earth fault prot. blocked by U<	CG			O
5396	Failure R/E/F	Failure rotor earth fault protection	CG			O
5397	R/E/F Warn	Rotor earth fault prot.: Warning stage	CG			O
5398	R/E/F Fault	Rotor earth fault prot.: Fault detec.		CG		O
5399	R/E/F Trip	Rotor earth fault prot.: Trip		C		O
5443	>Pa block	>Block active power protection				IO
5445	>Pr block	>Block reactive power protection				IO
5446	>Pr> block	>Block reactive power prot. Pr> stage	CG			IO
5447	>Pr>> block	>Block reactive power prot. Pr>> stage	CG			IO
5451	Pa> off	Active power prot. is switched off	CG			O
5452	Pa> blocked	Active power protection is blocked	CG			O
5453	Pa> active	Active power protection is active	CG			O
5454	Pr> off	Reactive power prot. is switched off	CG			O
5455	Pr> blocked	Reactive power protection is blocked	CG			O
5456	Pr> active	Reactive power protection is active	CG			O
5457	Pa> Fault	Active power protection: Fault detec.		CG		O
5458	Pr> Fault	Reactive power protection: Fault detec.		CG		O
5459	Pa> Trip	Active power protection: Trip		C		O
5460	Pr> Trip	Reactive power protection: Trip		C		O
5461	Pr>> Fault	Reactive power prot.: Fault detec. Pr>>		CG		O
5462	Pr>> Trip	Reactive power prot.: Trip Pr>>		C		O
5463	Pa+SV Trip	Active power: Trip with stop valve		C		O
6506	>U< block	>Block undervoltage protection U< stage				IO
6513	>o/v block	>Block overvoltage protection				IO
6530	U< off	Undervoltage protection is switched off	CG			O
6531	U< blocked	Undervoltage protection is blocked	CG			O
6532	U< active	Undervoltage protection is active	CG			O
6533	U< Fault	Undervoltage fault detection U<		CG		O
6539	U< Trip	Undervoltage protection, U< trip		C		O
6565	o/v off	Overvoltage protection is switched off	CG			O
6566	o/v blk	Overvoltage protection is blocked	CG			O
6567	o/v active	Overvoltage protection is active	CG			O
6568	U> Fault	Overvoltage fault detection U>		CG		O
6570	U> Trip	Overvoltage protection U> trip		C		O

FNo.	Abbreviation	Meaning	Op	Ft	Ear	IO
6571	U>> Fault	Overvoltage prot. fault detec. U>>		CG		O
6573	U>> Trip	Overvoltage protection U>> trip		C		O
6872	>Trip rel 1	>Trip circuit superv. trip relay 1				IO
6873	>CBaux 1	>Trip circuit superv. CBaux 1				IO
6879	Failure Trip1	Failure trip circuit 1	CG			O
6892	>Trip rel 2	>Trip circuit superv. trip relay 2				IO
6893	>CBaux 2	>Trip circuit superv. CBaux 2				IO
6899	Failure Trip2	Failure trip circuit 2	CG			O

Reference Table for Functional Parameters 7UM512

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1000 PARAMETERS
________________________________________________________________________

1100 MACHINE & POWERSYSTEM DATA

1103 POWER                   Rated apparent power of the machine
     min. 0.1                MVA
     max. 2000.0     ____

1104 COS PHI                 Rated power factor of the machine
     min. 0.000
     max. 1.000      ____

1105 In                      Rated current of the machine
     min. 0.050              kA
     max. 50.000     ____

1106 Un                      Rated voltage of the machine (phase-phase)
     min. 0.30               kV
     max. 100.00     ____

1108 STAR-POINT              Earthing condition of the machine star-point
     HIGH-RESISTANCE   [ ] Starpt. high resist.
     LOW-RESISTANCE    [ ] Starpt. low resist.
________________________________________________________________________

1200 INSTRUMENT TRANSFORMER DATA

1201 IN CT PRIM              Primary rated CT current
     min. 0.050              kA
     max. 50.000     ____

1202 UN VT PRIM              Primary rated VT voltage
     min. 0.30               kV
     max. 50.00      ____

1204 Un SECOND.              Secondary rated voltage
     min. 100                V
     max. 125        ____

1205 CT STARPNT              Polarity of current transformers
     TOWARDS MACHINE   [ ] Starpt. toward mach.
     TOWRDS STARPOINT  [ ] Starpt. toward stapt

1206 CT ANG. W0              Correction angle CT W0 (base angle)
     min. -2.50              °
     max. 7.50       ____

1207 CT ANG. W1              Correction angle CT W1 (slope)
     min. -2.50              °
     max. 0.00       ____

1208 REF.VOLT.               Reference voltage (phase-phase)
     UL1L2             [ ] Voltage UL1L2
     UL2L3             [ ] Voltage UL2L3
     UL3L1             [ ] Voltage UL3L1
```

```
1210 Uph/Udelta              Matching factor for open delta voltage
     min. -9.99
     max. 9.99         _____
```

```
1600 UNDER VOLTAGE

1601 UNDERVOLT.              State of the undervoltage protection
     OFF              [ ] off
     ON               [ ] on
     BLOCK TRIP REL   [ ] Block trip relay

1602 U<                      Pick-up value of the U<-protection
     min. 20.0               V
     max. 100.0        _____

1603 T-U<                    Time delay for trip U<
     min. 0.00               s
     max. 32.00/∞      _____

1604 T-RESET                 Reset delay after trip
     min. 0.00               s
     max. 32.00        _____

1605 FREQ.FAC.               Frequency factor U(f)-characteristic
     min. 0
     max. 6            _____
```

```
1700 OVER VOLTAGE

1701 OVERVOLT.               State of the overvoltage protection
     OFF              [ ] off
     ON               [ ] on
     BLOCK TRIP REL   [ ] Block trip relay

1702 U>                      Pick-up value of the U> stage
     min. 30                 V
     max. 140          _____

1703 U>>                     Pick-up value of the U>> stage
     min. 30                 V
     max. 140          _____

1704 T-U>                    Time delay for trip U>
     min. 0.00               s
     max. 32.00/∞      _____

1705 T-U>>                   Time delay for trip U>>
     min. 0.00               s
     max. 32.00/∞      _____

1706 T-RESET                 Reset delay after trip
     min. 0.00               s
     max. 32.00        _____
```

```
1900 EARTH FAULT U0>

1901 SEF PROT.              State of the stator earth fault protection
     OFF               [ ] off
     ON                [ ] on
     BLOCK TRIP REL    [ ] Block trip relay

1902 Uearth >               Pick-up value of earth voltage
     min. 5.0               V
     max. 120.0       ____

1903 EARTH CURR             State of the earth current detection
     OFF               [ ] off
     ON                [ ] on

1904 Iearth >               Pick-up value of earth current
     min. 2                 mA
     max. 300         ____

1905 DIR.DETERM             State of the directional determination
     ON                [ ] on
     OFF               [ ] off

1906 DIR. ANGLE             Reference angle for directional determination
     min. 0                 °
     max. 360         ____

1907 T-S/E/F                Time delay for trip stator earth fault
     min. 0.00              s
     max. 32.00/∞     ____

1908 T-RESET                Reset delay after trip
     min. 0.00              s
     max. 32.00       ____
```

```
2000 OVER/UNDER FREQUENCY

2001 f> / f<                State of the frequency protection
     OFF               [ ] off
     ON                [ ] on
     BLOCK TRIP REL    [ ] Block trip relay

2002 f STAGE 1              Pick-up value for stage f1
     min. 40.0              Hz
     max. 65.0        ____

2003 T-f1                   Time delay for trip f1 stage
     min. 0.00              s
     max. 32.00/∞     ____

2004 f STAGE 2              Pick-up value for stage f2
     min. 40.0              Hz
     max. 65.0        ____

2005 T-f2                   Time delay for trip f2 stage
     min. 0.00              s
     max. 32.00/∞     ____
```

```
2006 T-RESET              Reset delay after trip
     min. 0.00            s
     max. 32.00       ____

2010 BLOCK. U<            Minimum operating voltage for frequency prot.
     min. 40              V
     max. 100         ____
```

```
2200 ACTIVE POWER Pa>

2201 Pa PROT.             State of the active power protection
     OFF              [ ] off
     ON               [ ] on
     BLOCK TRIP REL   [ ] Block trip relay

2202 DIR. Pa>             Direction of operation (+Pa or -Pa)
     Pa FORW. (+Pa)   [ ] Pa forward (+Pa)
     Pa BACK. (-Pa)   [ ] Pa backward (-Pa)

2203 Pa>                  Pick-up value for active power protection
     min. 1.0             %
     max. 120.0       ____

2204 T-Pa>                Time delay for trip active power protection
     min. 0.00            s
     max. 32.00/∞     ____

2205 T-SV-CLOS.           Time delay for trip with stop valve closed
     min. 0.00            s
     max. 32.00/∞     ____

2206 T-RESET              Reset delay after trip
     min. 0.00            s
     max. 32.00       ____
```

```
2300 REACTIVE POWER Pr>

2301 Pr PROT.             State of the reactive power protection
     OFF              [ ] off
     ON               [ ] on
     BLOCK TRIP REL   [ ] Block trip relay

2302 DIR. Pr>             Direction of operation (+Pr or -Pr)
     Pr BACK. (-Pr)   [ ] Pr backward (-Pr)
     Pr FORW. (+Pr)   [ ] Pr forward (+Pr)

2303 Pr>                  Pick-up value for reac. power prot. Pr>
     min. 1.0             %
     max. 120.0       ____

2304 T-Pr>                Time delay for trip reac. power prot. Pr>
     min. 0.00            s
     max. 32.00/∞     ____

2305 Pr>>                 Pick-up value for reac. power prot. Pr>>
     min. 1.0             %
     max. 120.0       ____
```

2306 T-Pr>>		Time delay for trip reac. power prot. Pr>>
min. 0.00		s
max. 32.00/∞	____	
2307 T-RESET		Reset delay after trip
min. 0.00		s
max. 32.00	____	

2400 UNBALANCED LOAD

2401 UNBAL.LOAD		State of the unbalanced load protection
OFF	[ ]	off
ON	[ ]	on
BLOCK TRIP REL	[ ]	Block trip relay
2402 I2>		Continously permissible neg. sequence current
min. 3		%
max. 30	____	
2403 T-I2>		Time delay for warning stage
min. 0.00		s
max. 32.00/∞	____	
2404 TIME CONST		Thermal time constant
min. 100		s
max. 2500	____	
2405 THERM.WARN		Thermal warning stage in % of trip temperature
min. 70		%
max. 99	____	
2406 I2>>		Pick-up value for high current stage
min. 10		%
max. 80	____	
2407 T-I2>>		Trip time delay for high current stage
min. 0.00		s
max. 32.00/∞	____	
2408 T-RESET		Reset delay after trip
min. 0.00		s
max. 32.00	____	

2500 OVERCURR. I>

2501 O/C I>		State of overcurrent I> stage
OFF	[ ]	off
ON	[ ]	on
BLOCK TRIP REL	[ ]	Block trip relay
2502 I>		Pick-up value I> stage
min. 0.10		I/In
max. 8.00	____	
2503 T-I>		Time delay for trip I>
min. 0.00		s
max. 32.00/∞	____	

```
2504 T-RESET                 Reset delay after trip
     min. 0.00               s
     max. 32.00        ____

2505 U< SEAL-IN              State of undervoltage seal-in
     OFF               [ ] off
     ON                [ ] on

2506 U<                      Pick-up value of undervoltage seal-in
     min. 20.0               V
     max. 100.0        ____

2507 T-SEAL-IN               Duration of undervoltage seal-in
     min. 0.10               s
     max. 32.00        ____

2508 RESET I>                Reset to pick-up ratio of I> pick-up
     min. 0.90
     max. 0.99         ____
```

```
2600 CURRENT SUPERVISION I><

2601 CURR. I><               State of the current supervision
     OFF               [ ] off
     ON                [ ] on
     BLOCK TRIP REL    [ ] Block trip relay

2602 I><                     Method of operation (I> or I<)
     OVERCURRENT       [ ] Overcurrent
     UNDERCURRENT      [ ] Undercurrent

2603 I><                     Pick-up value for current supervision
     min. 0.05               I/In
     max. 8.00         ____

2604 T-I><                   Time delay for trip current supervision
     min. 0.00               s
     max. 32.00/∞      ____

2605 T-RESET                 Reset delay after trip
     min. 0.00               s
     max. 32.00        ____

2606 COUPLING                State of the coupling logic (on/off)
     ON                [ ] on
     OFF               [ ] off
```

```
2900 MEAS.VALUE SUPERVISION

2901 M.V.SUPERV              State of measured values supervision
     OFF               [ ] off
     ON                [ ] on

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. 0.10
     max. 0.95        ____

2905 SUM.Ithres            Summation threshold for current monitoring
     min. 0.10             I/In
     max. 2.00        ____

2906 SUM.Fact.I            Factor for current summation 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. 32.00/∞     ____

3003 T-RESET               Reset delay after trip
     min. 0.00             s
     max. 32.00       ____
```

```
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. 32.00/∞     ____

3103 T-RESET               Reset delay after trip
     min. 0.00             s
     max. 32.00       ____
```

```
3200 EXTERNAL TRIP FUNCTION 3

3201 EXT.TRIP 3            State of external trip function 3
     OFF              [ ]  off
     ON               [ ]  on
     BLOCK TRIP REL   [ ]  Block trip relay

3202 T-DELAY               Time delay of external trip function 3
     min. 0.00             s
     max. 32.00/∞     ____

3203 T-RESET               Reset delay after trip
     min. 0.00             s
     max. 32.00       ____
```

```
3300 EXTERNAL TRIP FUNCTION 4

3301 EXT.TRIP 4              State of external trip function 4
     OFF                [ ] off
     ON                 [ ] on
     BLOCK TRIP REL     [ ] Block trip relay

3302 T-DELAY                 Time delay of external trip function 4
     min. 0.00               s
     max. 32.00/∞       ____

3303 T-RESET                 Reset delay after trip
     min. 0.00               s
     max. 32.00         ____
```

```
3500 ROTOR EARTH FAULT

3501 ROTOR E/F               State of the rotor earth fault protection
     OFF                [ ] off
     ON                 [ ] on
     BLOCK TRIP REL     [ ] Block trip relay

3502 RE< WARN                Pick-up value of the warning stage Re<
     min. 3.0                kΩ
     max. 30.0          ____

3503 RE<< TRIP               Pick-up value of the tripping stage Re<<
     min. 1.0                kΩ
     max. 5.0           ____

3504 T-WARN-R<               Time delay for warning stage Re<
     min. 0.00               s
     max. 32.00/∞       ____

3505 T-TRIP-R<<              Time delay for trip Re<< stage
     min. 0.00               s
     max. 32.00/∞       ____

3506 T-RESET                 Reset delay after trip
     min. 0.00               s
     max. 32.00         ____

3507 X COUPL.                Coupling reactance of the coupling unit
     min. -50                Ω
     max. 800           ____

3508 R SERIES                Series resistance (e.g. measuring brushes)
     min. 0                  Ω
     max. 999           ____

3509 I RE<                   Pick-up value of failure detection Ie<
     min. 1.0                mA
     max. 50.0          ____

3510 CT ANG. W0              Correction angle CT W0 (base angle)
     min. -15.0              °
     max. 15.0          ____
```

```
3600 DC VOLTAGE TIME PROTECTION

3601 DC VOLTAGE               State of the DC voltage protection
     OFF                  [ ] off
     ON                   [ ] on
     BLOCK TRIP REL       [ ] Block trip relay

3602 MEAS.METH.               Measurement method (MEAN/RMS values)
     MEAN VALUES          [ ] Mean values
     RMS VALUES           [ ] RMS values

3603 U DC >/<                 Method of operation (U-DC >/<)
     OVERVOLTAGE          [ ] Overvoltage
     UNDERVOLTAGE         [ ] Undervoltage

3604 U DC ><                  Pick-up value for DC voltage protection
     min. 0.1                 V
     max. 8.5            ____

3605 T-U-DC><                 Time delay for trip DC voltage protection
     min. 0.00                s
     max. 32.00/∞        ____

3606 T-RESET                  Reset delay after trip
     min. 0.00                s
     max. 32.00          ____
```

```
3900 TRIP CIR'T SUPERVISION

3901 TRP SUPERV               State of the trip circuit supervision
     OFF                  [ ] off
     ON                   [ ] on

3902 No.CIRCT.                Number of supervised circuits
     min. 1
     max. 2              ____

3903 MEA.REPET.               Number of meas. repetitions
     min. 2
     max. 6              ____
```

Tests and Commissioning Aids 7UM512

4000 TESTS

4400 CB TEST LIVE TRIP

4401 TRIP RELAY1	Trip of relay #1
4402 TRIP RELAY2	Trip of relay #2
4403 TRIP RELAY3	Trip of relay #3
4404 TRIP RELAY4	Trip of relay #4
4405 TRIP RELAY5	Trip of relay #5

4900 TEST FAULT RECORDING

4901 FAULT REC.	Initiation of fault recording

Annunciations, Measured Values etc. 7UM512

5000 ANNUNCIATIONS

5100 OPERATIONAL ANNUNCIATIONS

5200 LAST FAULT

5300 2nd TO LAST FAULT

5400 3rd TO LAST FAULT

5700 OPERATIONAL MEAS. VALUES A

5701 IL1 =	Current in phase IL1 =
5702 IL2 =	Current in phase IL2 =
5703 IL3 =	Current in phase IL3 =
5704 IL1[%] =	Current in phase IL1 [%] =
5705 IL2[%] =	Current in phase IL2 [%] =
5706 IL3[%] =	Current in phase IL3 [%] =
5707 Uph-ph =	Secondary phase-phase voltage
5708 U0 =	Secondary earth voltage U0
5709 Ie=	Earth current
5710 Ipos.seq=	Positive sequence current
5711 U DC =	DC voltage
5712 f [Hz]=	Frequency f [Hz] =

5800 OPERATIONAL MEAS. VALUES B

5801 Pa[%]=	Active power Pa [%] =
5802 Pr[%]=	Reactive power Pr [%] =
5803 COS PHI=	Power factor cos phi
5804 PHI=	Power angle
5805 Rrotor =	Rotor earth resistance
5806 Urotor =	Bias AC voltage for rotor earth fault
5807 Irotor =	Rotor earth current caused by Urotor
5808 Rinput =	Active component of input impedance
5809 Xinput =	Reactive component of input impedance

5900 OPERATIONAL MEAS. VALUES C

5901 Ineg.seq=	Negative sequence current/unbal. load
5902 ThermRep.=	Calculated rotor temp. (unbal. load)

Reference Table for Configuration Parameters 7UM512

6000 MARSHALLING

6100 MARSHALLING BINARY INPUTS

6101 BINARY INPUT 1 Binary input 1

6102 BINARY INPUT 2 Binary input 2

6103 BINARY INPUT 3 Binary input 3

6104 BINARY INPUT 4 Binary input 4

6105 BINARY INPUT 5 Binary input 5

6106 BINARY INPUT 6 Binary input 6

6107 BINARY INPUT 7 Binary input 7

6108 BINARY INPUT 8 Binary input 8

6200 MARSHALLING SIGNAL RELAYS

6201 SIGNAL RELAY 1 Signal relay 1

6202 SIGNAL RELAY 2 Signal relay 2

6203 SIGNAL RELAY 3 Signal relay 3

6204 SIGNAL RELAY 4 Signal relay 4

6205 SIGNAL RELAY 5 Signal relay 5

6206 SIGNAL RELAY 6 Signal relay 6

6207 SIGNAL RELAY 7 Signal relay 7

6208 SIGNAL RELAY 8 Signal relay 8

6209 SIGNAL RELAY 9 Signal relay 9

6210 SIGNAL RELAY 10 Signal relay 10

6211 SIGNAL RELAY 11 Signal relay 11

6212 SIGNAL RELAY 12 Signal relay 12

6213 SIGNAL RELAY 13 Signal relay 13

6300 MARSHALLING LED INDICATORS

6301 LED 1 LED 1

6302 LED 2 LED 2

6303 LED 3 LED 3

6304 LED 4 LED 4

6305 LED 5 LED 5

6306 LED 6 LED 6

6307 LED 7 LED 7

6308 LED 8 LED 8

6309 LED 9 LED 9

6310 LED 10 LED 10

6311 LED 11 LED 11

6312 LED 12 LED 12

6313 LED 13 LED 13

6314 LED 14 LED 14

______ ______ ______
______ ______ ______
______ ______ ______

6400 MARSHALLING TRIP RELAYS

6401 TRIP RELAY 1 Trip relay 1

______ ______ ______
______ ______ ______
______ ______ ______

6402 TRIP RELAY 2 Trip relay 2

______ ______ ______
______ ______ ______
______ ______ ______

6403 TRIP RELAY 3 Trip relay 3

______ ______ ______
______ ______ ______
______ ______ ______

6404 TRIP RELAY 4 Trip relay 4

______ ______ ______
______ ______ ______
______ ______ ______

6405 TRIP RELAY 5 Trip relay 5

______ ______ ______
______ ______ ______
______ ______ ______

7000 OP. SYSTEM CONFIGURATION

7100 INTEGRATED OPERATION

7101 LANGUAGE Language
DEUTSCH [ ] German
ENGLISH [ ] English

```
7102 DATE FORMAT            Date format
     DD.MM.YYYY         [ ] dd.mm.yyyy
     MM/DD/YYYY         [ ] mm/dd/yyyy

7105 OPER. 1st L            Operational message for 1st display line

     _________________      _______________________________________

7106 OPER. 2nd L            Operational message for 2nd display line

     _________________      _______________________________________

7107 FAULT 1st L            Fault message for 1st display line

     _________________      _______________________________________

7108 FAULT 2nd L            Fault message for 2nd display line

     _________________      _______________________________________

7151 CW-LEVEL 1             Codeword for level 1
     min. 1
     max. 999999      ____

7152 CW-LEVEL 2             Codeword for level 2
     min. 1
     max. 999999      ____

7153 CW-LEVEL 3             Codeword for level 3
     min. 1
     max. 999999      ____

7154 CW-LEVEL 4             Codeword for level 4
     min. 1
     max. 999999      ____
```

```
7200 PC/SYSTEM INTERFACES

7201 DEVICE ADD.            Device address
     min. 1
     max. 254         ____

7202 FEEDER ADD.            Feeder address
     min. 1
     max. 254         ____

7203 SUBST. ADD.            Substation address
     min. 1
     max. 254         ____

7208 FUNCT. TYPE            Function type in accordance with VDEW/ZVEI
     min. 1
     max. 254         ____

7209 DEVICE TYPE            Device type
     min. 1
     max. 254         ____
```

```
7211 PC INTERF.                Data format for PC-interface
     DIGSI V3           [ ] DIGSI V3
     ASCII              [ ] ASCII

7214 PC GAPS                Transmission gaps for PC-interface
     min. 0.0               s
     max. 5.0           ____

7215 PC BAUDRATE            Transmission baud rate for PC-interface
     9600 BAUD          [ ] 9600 Baud
     19200 BAUD         [ ] 19200 Baud
     1200 BAUD          [ ] 1200 Baud
     2400 BAUD          [ ] 2400 Baud
     4800 BAUD          [ ] 4800 Baud

7216 PC PARITY              Parity and stop-bits for PC-interface
     DIGSI V3           [ ] DIGSI V3
     NO 2 STOP          [ ] No parity,2 stopbits
     NO 1 STOP          [ ] No parity,1 stopbit

7221 SYS INTERF.            Data format for system-interface
     VDEW EXTENDED      [ ] VDEW extended
     DIGSI V3           [ ] DIGSI V3
     LSA                [ ] LSA

7222 SYS MEASUR.            Measurement format for system-interface
     VDEW EXTENDED      [ ] VDEW extended
     VDEW COMPATIBLE    [ ] VDEW compatible

7224 SYS GAPS               Transmission gaps for system-interface
     min. 0.0               s
     max. 5.0           ____

7225 SYS BAUDR.             Transmission baud rate for system-interface
     9600 BAUD          [ ] 9600 Baud
     19200 BAUD         [ ] 19200 Baud
     1200 BAUD          [ ] 1200 Baud
     2400 BAUD          [ ] 2400 Baud
     4800 BAUD          [ ] 4800 Baud

7226 SYS PARITY             Parity and stop-bits for system-interface
     VDEW/DIGSIV3/LSA   [ ] VDEW/DIGSI V3/LSA
     NO 2 STOP          [ ] No parity,2 stopbits
     NO 1 STOP          [ ] No parity,1 stopbit

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. 4.00         ____

7412 T-POST                 Post-fault time for fault recording
     min. 0.05              s
     max. 1.00         ____

7420 FAULT VALUE            Fault values
     INSTANT. VALUES    [ ] Instantaneous values
     R.M.S. VALUES      [ ] R.M.S. values

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

7816 UNDERVOLT.             Undervoltage protection
     EXIST              [ ] Existent
     NON-EXIST          [ ] Non-existent

7817 OVERVOLT.              Overvoltage protection
     EXIST              [ ] Existent
     NON-EXIST          [ ] Non-existent

7819 SEF PROT.              Stator earth fault protection
     EXIST              [ ] Existent
     NON-EXIST          [ ] Non-existent

7820 FREQUENCY              Frequency protection
     EXIST              [ ] Existent
     NON-EXIST          [ ] Non-existent

7822 P-ACTIVE               Active power protection
     EXIST              [ ] Existent
     NON-EXIST          [ ] Non-existent

7823 P-REACTIVE             Reactive power protection
     EXIST              [ ] Existent
     NON-EXIST          [ ] Non-existent

7824 UNBAL. LOAD            Unbalanced load protection
     EXIST              [ ] Existent
     NON-EXIST          [ ] Non-existent

7825 O/C I>                 Overcurrent protection I>
     EXIST              [ ] Existent
     NON-EXIST          [ ] Non-existent
```

```
7826 CURRENT I><          Current supervision
     EXIST            [ ] Existent
     NON-EXIST        [ ] Non-existent

7830 EXT. TRIP 1          External trip function 1
     EXIST            [ ] Existent
     NON-EXIST        [ ] Non-existent

7831 EXT. TRIP 2          External trip function 2
     EXIST            [ ] Existent
     NON-EXIST        [ ] Non-existent

7832 EXT. TRIP 3          External trip function 3
     EXIST            [ ] Existent
     NON-EXIST        [ ] Non-existent

7833 EXT. TRIP 4          External trip function 4
     EXIST            [ ] Existent
     NON-EXIST        [ ] Non-existent

7835 ROTOR E/F            Rotor earth fault protection
     EXIST            [ ] Existent
     NON-EXIST        [ ] Non-existent

7836 DC VOLTAGE           DC voltage protection
     EXIST            [ ] Existent
     NON-EXIST        [ ] Non-existent

7839 TRP SUPERV           Trip circuit supervision
     EXIST            [ ] Existent
     NON-EXIST        [ ] Non-existent

7885 PARAM. C/O           Parameter change-over
     NON-EXIST        [ ] Non-existent
     EXIST            [ ] Existent

7899 FREQUENCY            Rated system frequency
     fN 50 Hz         [ ] fN 50 Hz
     fN 60 Hz         [ ] fN 60 Hz
```

Operational Device Control Facilities 7UM512

```
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

8302 SYS BLOCK             Blocking of monitoring direction via sys.-int.
     OFF               [ ] off
     ON                [ ] on
```

```
8500 PARAMETER CHANGE-OVER

8501 ACTIV PARAM           Actual active parameter set

8503 ACTIVATING            Activation of parameter set
     SET A             [ ] Set a
     SET B             [ ] Set b
     SET C             [ ] Set c
     SET D             [ ] Set d
     SET BY BIN.INPUT  [ ] Set via binary input
     SET BY LSA CONTR  [ ] Set by lsa control

8510 COPY                  Copy original parameter set to set A

8511 COPY                  Copy original parameter set to set B

8512 COPY                  Copy original parameter set to set C
```

8513 COPY	Copy original parameter set to set D
8514 COPY	Copy parameter set A to set B
8515 COPY	Copy parameter set A to set C
8516 COPY	Copy parameter set A to set D
8517 COPY	Copy parameter set B to set A
8518 COPY	Copy parameter set B to set C
8519 COPY	Copy parameter set B to set D
8520 COPY	Copy parameter set C to set A
8521 COPY	Copy parameter set C to set B
8522 COPY	Copy parameter set C to set D
8523 COPY	Copy parameter set D to set A
8524 COPY	Copy parameter set D to set B
8525 COPY	Copy parameter set D to set C

9800 OPERATING SYSTEM CONTROL

9802 MONITOR	Monitor

To

SIEMENS AKTIENGESELLSCHAFT

Dept. EV S SUP 2

D – 13623 BERLIN

Germany

Dear reader,

printing errors can never be entirely eliminated: therefore, should you come across any when reading this manual, kindly enter them in this form together with any comments or suggestions for improvement that you may have.

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Name

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Corrections/Suggestions

Substantial alterations against previous issue:

Complete revision with regard to firmware version 3.1

Subject to technical alteration

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