SIEMENS

Numerical Machine Protection

7UM511 V3.1

Instruction Manual Order No. C53000–G1176–C109–4

– Underexcitation protection $\vartheta>$
– Voltage protection U><
– Earth fault protection $I_e>$
– Stator earth fault protection $U_0>$
– Frequency protection f><
– Forward power supervision $P_f><$
– Reverse power protection $|-P_r|>$
– Unbalanced load protection $I_2>$
– Overcurrent time ptotection I>
– Thermal overload protection T>

Figure 1 Illustration of the numerical machine protection 7UM511 (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).

Contents

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 7UM511 is a numerical machine protection unit from the ”Numerical Machine Protection series 7UM51” and provides a practical combination of the most important generator protection functions.

It provides comprehensive and safe protection for smaller generators such as emergency diesel generator sets, run of the river hydro plants, or private power stations.

Furthermore, the scope of functions of the relay allows to use it as network splitting device.

Additionally, the unit forms the basis for the protection of larger generators. By adding other units of the 7UM51 series, all protection requirements encountered for the smallest to the largest machines can be met. 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 VDEW/ZVEI is used, as well as in accordance with DIN 19244. The device can therefore be incorporated in Localized Substation Automation networks (LSA). The system interface is either suited to communication via a modem link.

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 shutting down 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	7UM512
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	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	7UM516
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	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	7UT513
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)	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:

Underexcitation protection

– conductance measurement from positive sequence components,

– multi–step characteristic for steady–state and dynamic stability limits,

– detection of the excitation voltage by measurement or by input of the undervoltage criterion.

Voltage protection

– calculation from positive sequence components,

– two–stage overvoltage measurement,

– separate undervoltage measurement.

Stator earth fault protection U_0>

– calculation of the displacement voltage U_0 from the sum of the fundamental waves of the three phase–to–earth voltages (zero sequence voltage),

– can be blocked on tripping of the voltage transformer secondary miniature circuit breaker,

– protective range 90 % to 95 % of the stator windings for machines in block connection.

Frequency measurement

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

– high–accuracy measurement by two–step method of calculation,

– insensitive to harmonics and phase jumps,

– adjustable undervoltage lock–out,

– adjustable number of repeated measurements.

Forward active power supervision

– calculation of forward power P_f from positive sequence components,

– supervision of over–power (P_f>) and/or under–power (P_f<) with individually adjustable power limits,

– optionally high–speed or high–accuracy power measurement.

Reverse power protection

– calculation of power from positive sequence components,

– highly sensitive active power measurement,

– high measurement accuracy and angle error compensation,

– detection of small motoring powers even with small power factor cos φ,

– insensitive to power swings,

– short–time stage with stop valve tripped,

– independent long–time stage.

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

– two–stage I> and I>> with separate time delays,

– current measurement separate in each phase,

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

Highly sensitive earth current protection

– highly sensitive earth current detection, can be used for stator earth fault or rotor earth fault detection,

– measured circuit monitoring when used for rotor earth fault protection.

Stator overload protection

– true r.m.s. measurement for each phase,

– adjustable alarm and trip stages,

– input of cooling medium or ambient temperature possible (with external temperature sensor),

– Indication of cooling medium temperature and calculated total temperature possible.

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:

– **7UM511⋆−−⋆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 (7UM511⋆−⋆⋆⋆⋆⋆−⋆**B**), 4 screwed terminals are provided. For the interface for optical fibre connection (model 7UM511⋆−⋆⋆⋆⋆⋆−⋆**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.

– **7UM511⋆−⋆C⋆⋆⋆−** in housing 7XP2040−2 for **panel flush mounting** or **7UM511⋆−⋆E⋆⋆⋆−** for **cubicle installation**

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

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

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

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

  The isolated interface to a central control and storage unit (7UM511⋆−⋆⋆⋆⋆⋆−⋆**B**) is led to a 4−pole connection module. In the interface for optical fibre connection (7UM511⋆−⋆⋆⋆⋆⋆−⋆**C**), a module with 2 F−SMA connectors is provided instead.

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

  Degree of protection for the housing is IP51 (for cubicle installation IP 20), for the terminals IP21. For dimensions please refer to Figure 2.3.

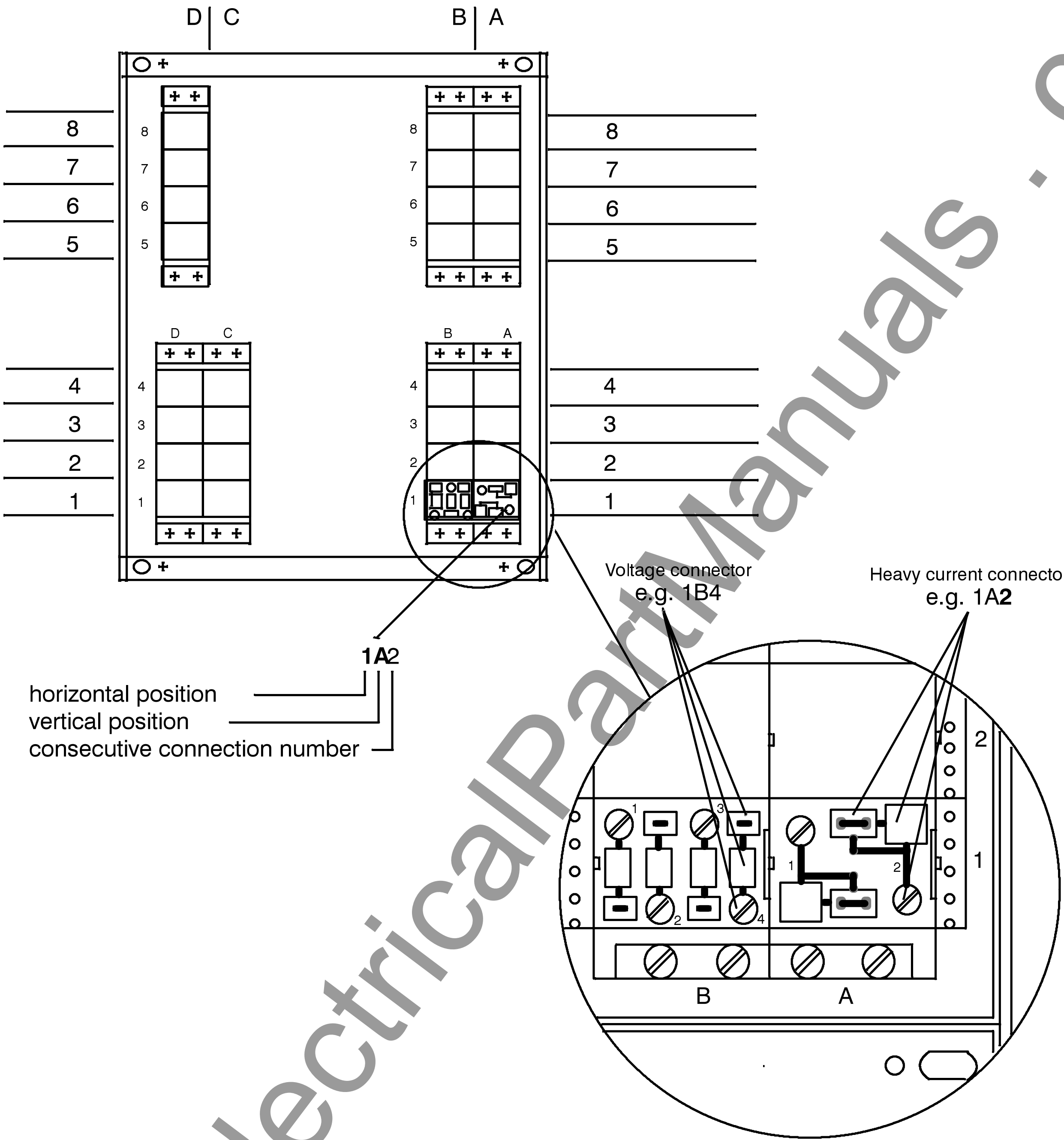
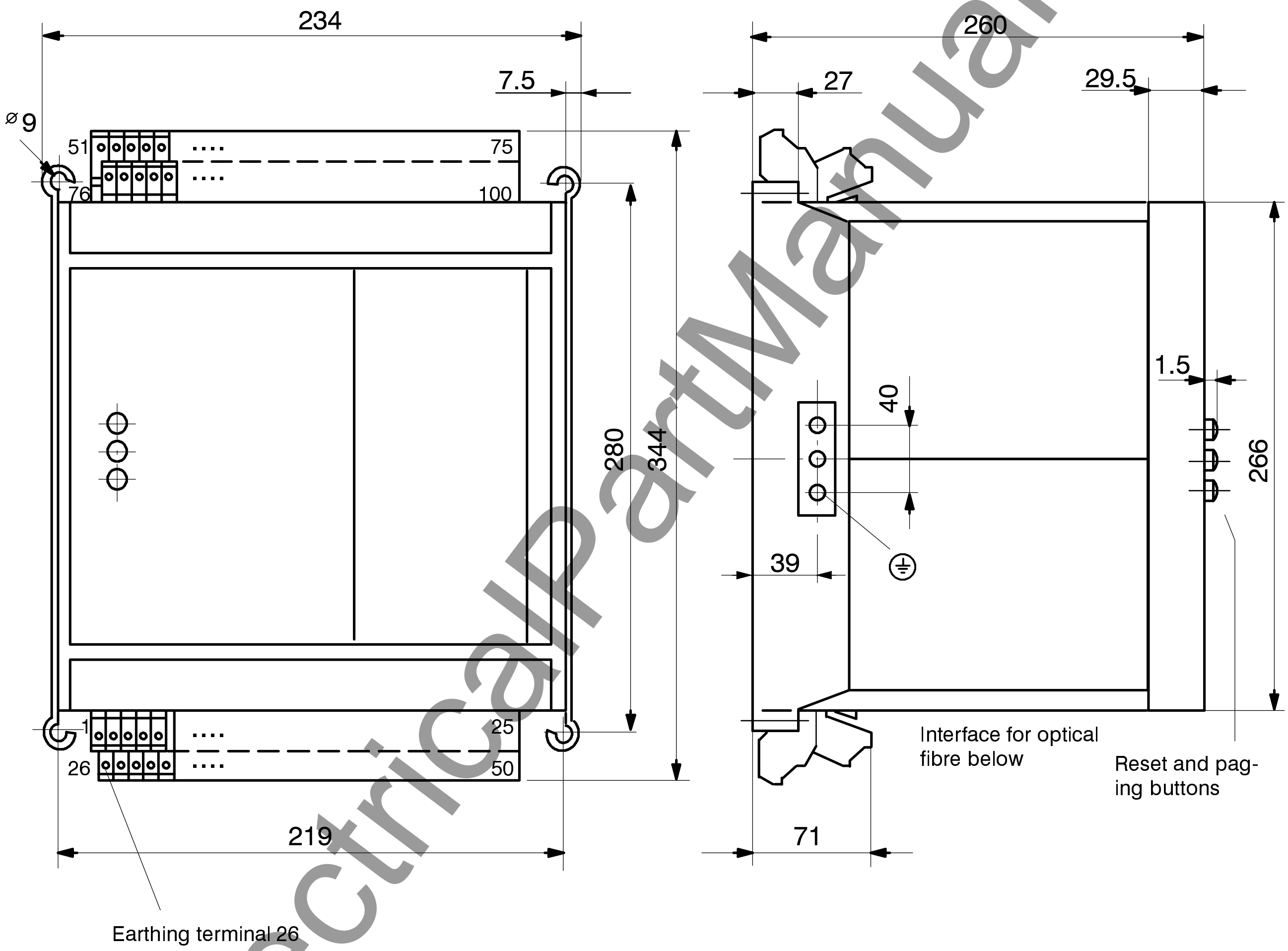


Figure 2.1 Connection plugs (rear view) – housing for flush mounting – example

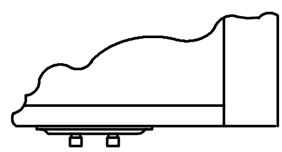
2.2 Dimensions

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

7UM511 Housing for **panel surface mounting** 7XP2040 – 1



Max. 100 terminals for cross – section max. 7 mm^2

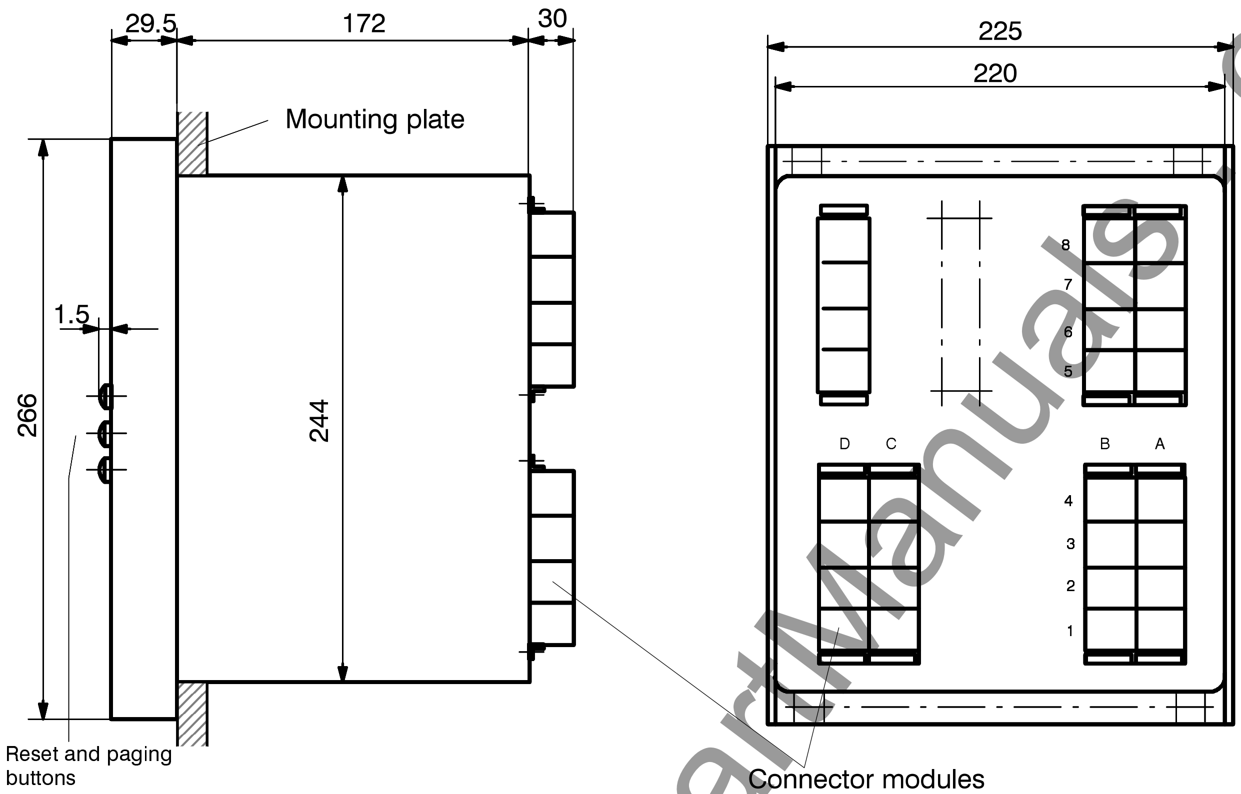


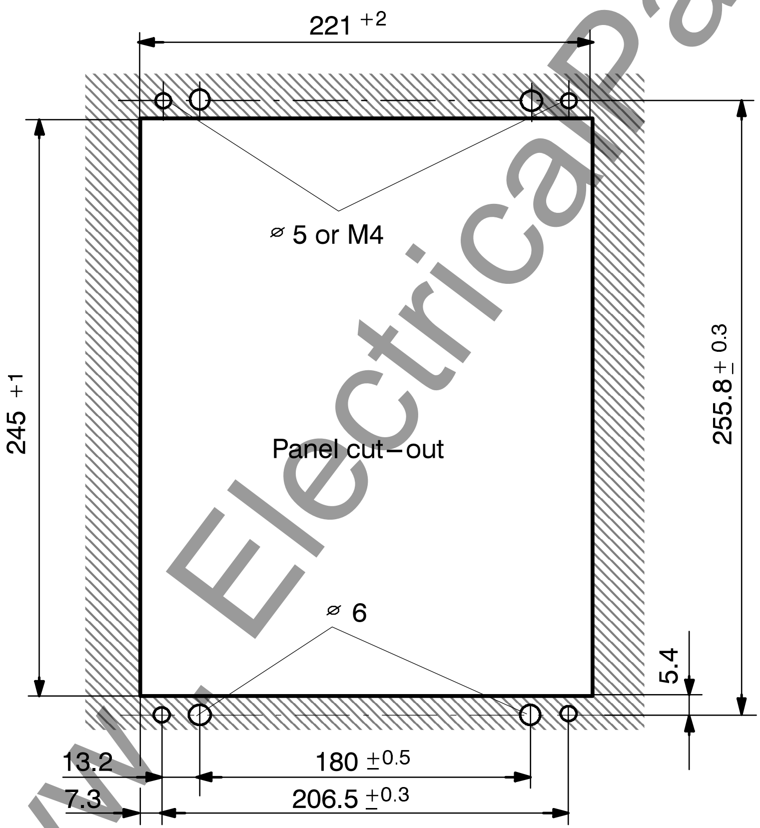
Optical fibre connectors:
integrated F – SMA connector,
with ceramic post,
e.g for glass fibre 62.5/125 μm

Dimensions in mm

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

7UM511 Housing for **panel flush mounting** or **cubicle installation** 7XP2040−2





Heavy current connectors:
Screwed terminal for max. 4 mm^2.
Twin spring crimp connector in parallel for max. 2.5 mm^2.

Further connectors:
Screwed terminal for max. 1.5 mm^2.
Twin spring crimp connector in parallel for max. 1.5 mm^2.

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

Dimensions in mm

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

2.3 Ordering data

Numerical Machine Protection

	7.	–	8.	9.	10.	11.	12.	–	13.	14.	15.	16.
7 U M 5 1 1	☐	–	☐	☐	**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 isolating amplifier for the galvanically isolated input of the d.c. excitation 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 the usual excitation voltages. For example, **voltage divider 3PP1326−0BZ--012009** is suitable for this purpose. For circuit schematic please refer to Figure 2.4, for dimensions Figure 2.8.

When the highly sensitive earth current protection is used for rotor earth fault protection, the **coupling unit** type **7XR6100−0*A00** is suitable for coupling of the rotor circuit bias voltage. This coupling unit 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 2.5 for schematic circuit diagram. The dimensions of a panel surface mouted housing is shown in Figure 2.7 the flush mounted housing in Figure 2.8.

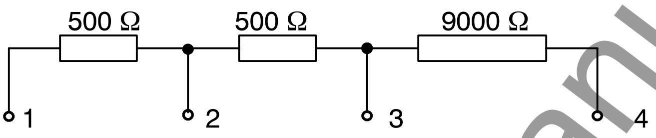


Figure 2.4 Schematic of voltage divider 3PP1326−0BZ−012009

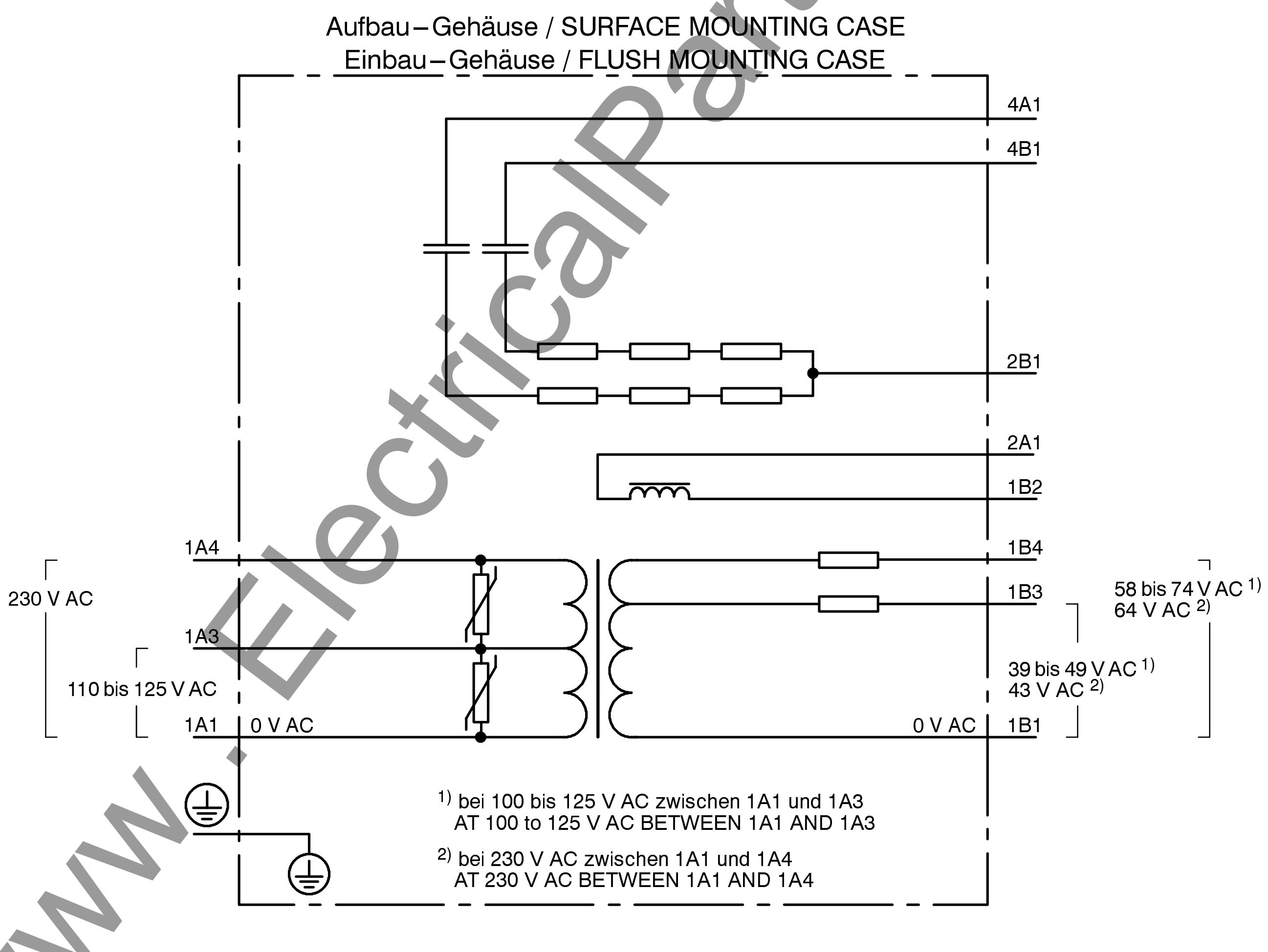
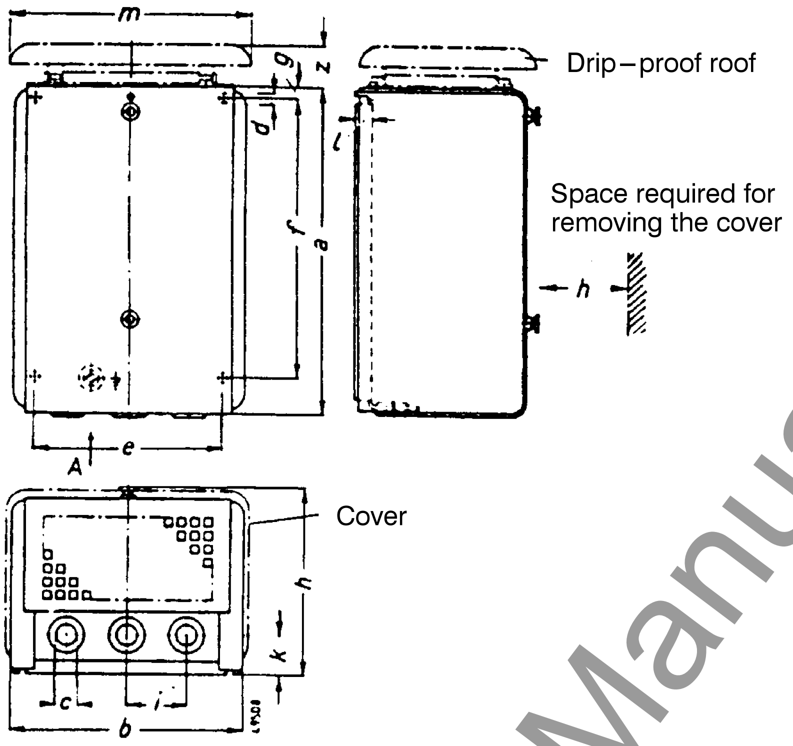


Figure 2.5 Schematic diagram of coupling unit 7XR6100−0*A00



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

Figure 2.6 Dimensions 3PP13:
3PP132 for voltage divider 3PP1326 – 0BZ – 012009 (20 : 10 : 1)

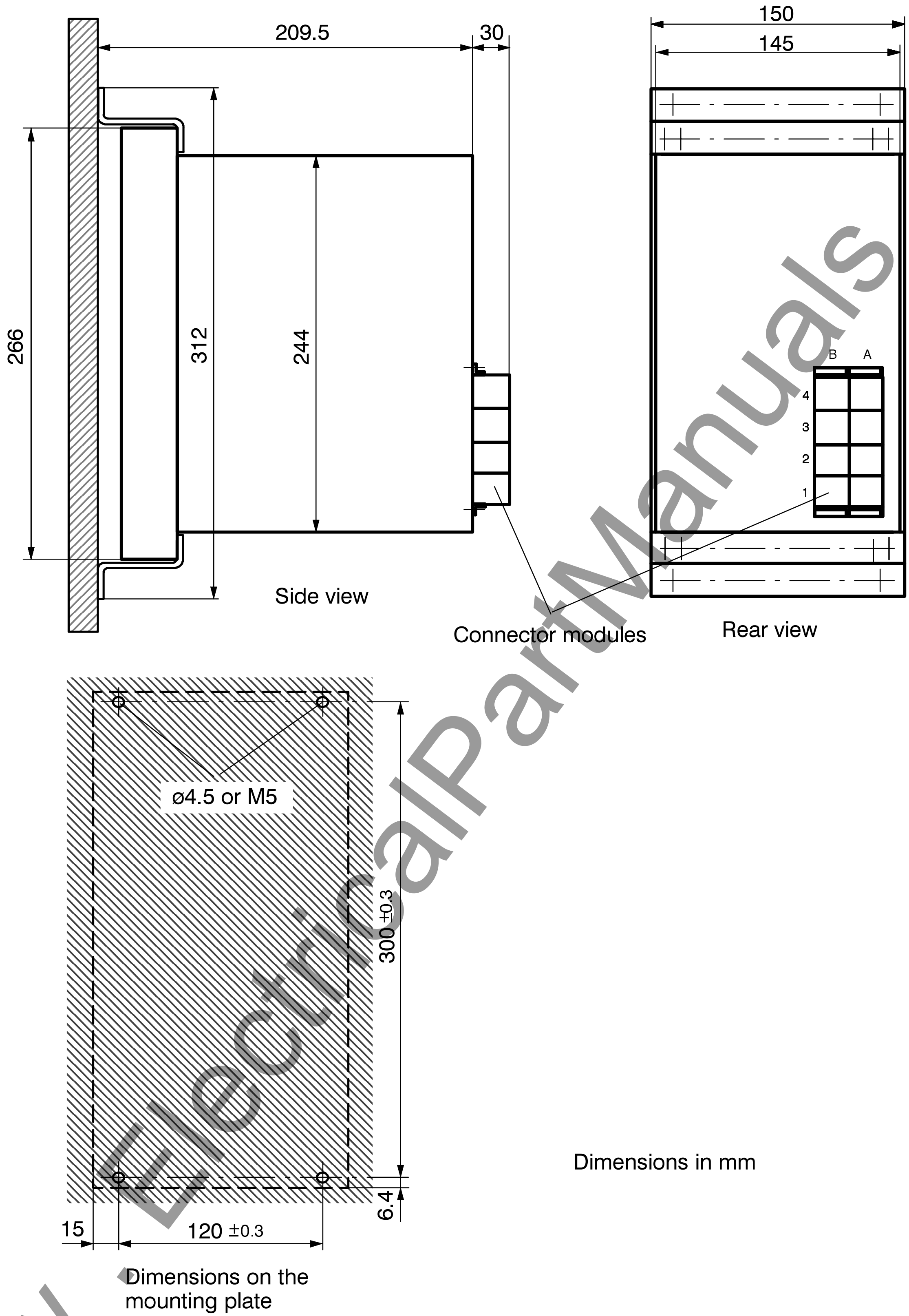
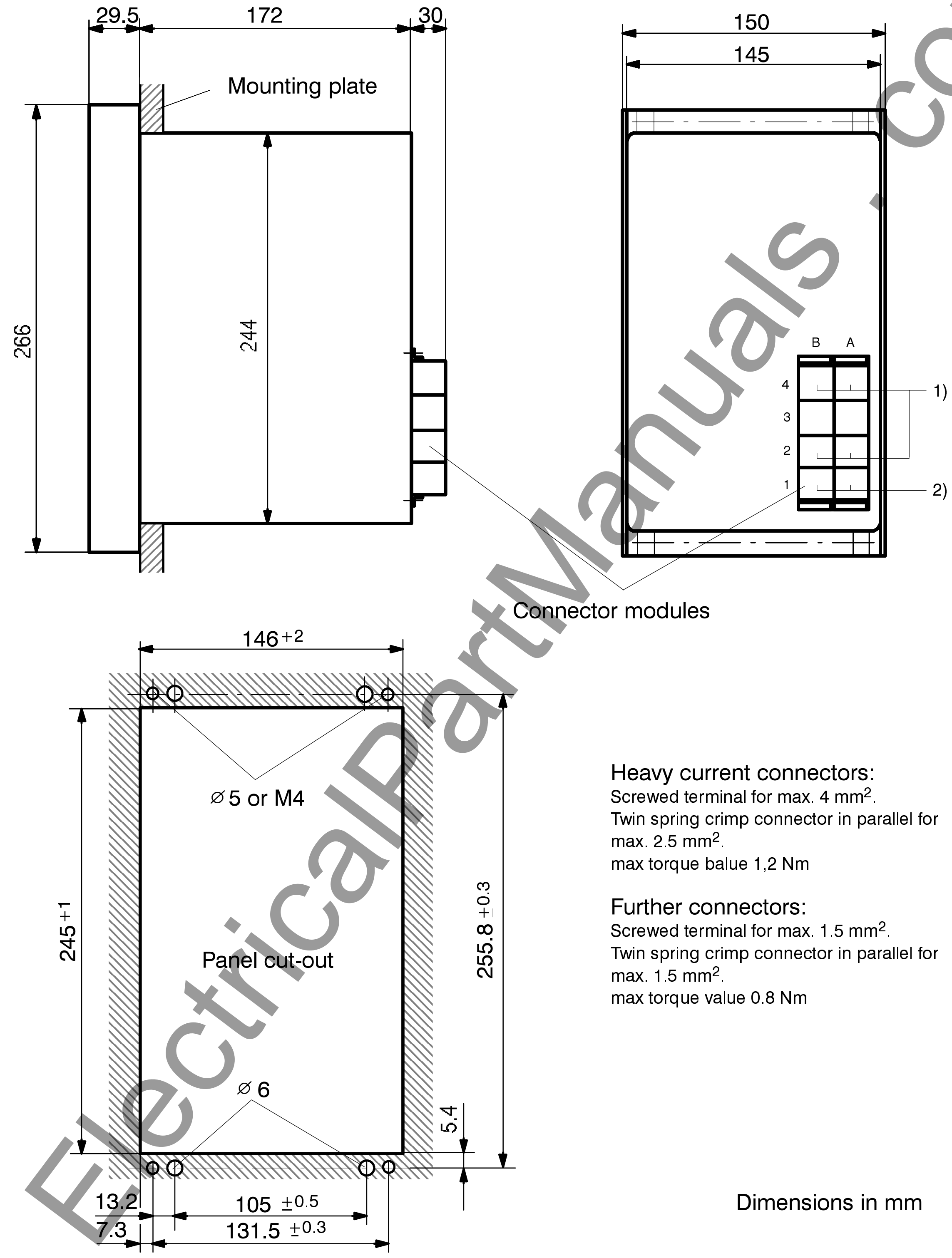


Bild 2.7 Dimensions coupling unit 7XR6100−0BA00 for panel surface mounting



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 2.8 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)
Excitation voltage input (for excitation voltage monitoring)	0 V dc to 10 V dc (from external voltage divider)
Cooling medium temperature input (for processing of cooling medium temperature)	0 V dc or 2 V dc to 10 V dc (selectable) (via external measurement transducer)
Burden: c.t. circuits per phase – at I_N = 1 A – at I_N = 5 A Burden: v.t. circuits at 100 V	$\leq$ 0.1 VA $\leq$ 0.5 VA $\leq$ 0.3 VA
Input resistance of d.c. voltage inputs	approx 1 MΩ
Overload capability c.t. circuits – thermal (r.m.s.) – dynamic (impulse)	 100 $\times I_N$ for 1 second 20 $\times I_N$ for 10 seconds 4 $\times I_N$ continuous 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 and temperature inputs – thermal	 60 V dc continuous

Auxiliary DC supply

Auxiliary dc voltage supply via integrated dc/dc converter

Auxiliary voltage U_H	24/48 V dc	60/110/125 V dc	220/250 V dc
Operating ranges	19 to 56 V dc	48 to 144 V dc	176 to 288 V dc

Superimposed a.c. voltage, peak–to–peak	$\leq$ 12 % at rated voltage $\leq$ 6 % at the limits of the voltage ranges
Power consumption quiescent picked–up	approx 12 W approx 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 — 24 to 250 V dc (as delivered)
Pick−up value reconnectable — by solder bridges in 2 ranges:

for rated control voltage	24/48/60 Vdc	110/125/220/250 Vdc
Pick−up value, approx.	16 Vdc	80 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	
− Standards	similar V.24/V.28 to CCITT; RS 232 C to EIA; Protocol to VDEW/ZVEI 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; duration 2 s
– Electrostatic discharge IEC 60255–22–2, class III and IEC 61000–4–2, class III	4 kV/6 kV contact discharge; 8 kV air discharge; both polarities; 150 pF; R_i = 330 Ω
– Radio–frequency electromagnetic field, non–modulated; IEC 60255–22–3 (report) class III	10 V/m; 27 MHz to 500 MHz
– Radio–frequency electromagnetic field, amplitude modulated; IEC 61000–4–3, class III	10 V/m; 80 MHz to 1000 MHz; 80 % AM; 1 kHz
– Radio–frequency electromagnetic field, pulse modulated; IEC 61000–4–3/ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 %
– Fast transients IEC 60255–22–4 and IEC 61000–4–4, class III	2 kV; 5/50 ns; 5 kHz; burst length 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; duration 1 min
– Conducted disturbances induced by radio–frequency fields, amplitude modulated IEC 61000–4–6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
– Power frequency magnetic field IEC 61000–4–8, class IV	30 A/m continuous; 300 A/m for 3 s; 50 Hz
IEC 60255–6	0.5 mT; 50Hz

EMC tests; emission (type tests)

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

3.1.3 Mechanical stress tests

Vibration and shock during operation

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

Vibration and shock during transport

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

3.1.4 Climatic stress tests

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

Storage and transport with standard works packaging!

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

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

3.1.5 Service conditions

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

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

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

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

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

3.1.6 Design

Housing	7XP20; refer to Section 2.1
Dimensions	refer to Section 2.2
Weight	
– 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

*) IP20 for cubicle installation; the degree of protection required for the point of installation must be ensured by the cubicle.

3.2 Underexcitation protection

Setting ranges/steps

Conductance sections λ_1, λ_2, λ_3	0.25 to 3.00	(steps 0.01)
Angle of inclination α_1, α_2, α_3	50° to 120°	(steps 1°)
Time delays T_1, T_2, T_3	0.00 s to 32.00 s	(steps 0.01 s) or ∞
Reset delay T_r	0.00 s to 32.00 s	(steps 0.01 s)
Undervoltage lock–out	25 V, fixed	
Excitation voltage (via external upstream voltage divider)	0.50 V to 8.00 V	(steps 0.01 V)

Pick–up times	
– Stator criterion λ, α	$\leq$ 60 ms at f_N
– Rotor criterion U_{exc}	$\leq$ 60 ms
– Undervoltage lock–out $U_1<$	$\leq$ 40 ms
Reset times	
– Stator criterion λ, α	$\leq$ 60 ms
Reset hysteresis	
– Stator criterion λ, α	approx 95 %
– Undervoltage seal–in $U_1<$	approx 110 %
– Rotor criterion U_{exc}	approx 105 % or 0.5 V
Output of calculated pole angle ϑ	–180° to +180°

Tolerances

– Stator criterion λ	3 % of set value
– Stator criterion α	3 ° electrical
– Rotor criterion U_{exc}	3 % of set value
– Undervoltage lock–out	3 %
– 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 f_N to 1.1 f_N	$\leq$ 1 %

3.3 Voltage protection

Setting ranges/steps

Overvoltage U>	30 V to 180 V	(steps 1 V)
Overvoltage U≫	30 V to 180 V	(steps 1 V)
Time delays T(U>), T(U≫)	0.00 s to 32.00 s	(steps 0.01 s) or ∞
Undervoltage U<	20 V to 100 V	(steps 1 V)
Time delay T(U<)	0.00 s to 32.00 s	(steps 0.01 s) or ∞
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 40 ms
− Undervoltage U<	approx 40 ms
Reset ratios	
− Overvoltage U>, U≫	approx 0.98
− Undervoltage U<	approx 1.05

Tolerances

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

Influence variables

− Auxiliary d.c. voltage in range $0.8 \leq U_H/U_{HN} \leq 1.15$	≤ 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	≤ 1 %

3.4 Stator earth fault protection U_0>

Setting ranges/steps

Displacement voltage U_0>	5.0 V to 100.0 V	(steps 0.1 V)
Time delays T	0.00 s to 32.00 s	(steps 0.01 s) or ∞
Drop−off time Tr	0.00 s to 32.00 s	(steps 0.01 s)

Pick−up times − Displacement voltage U_0>	approx 50 ms
Drop−off time	$\leq$ 50 ms
Drop−off ratio	approx 0.7

Tolerances

− Displacement voltage U_0>	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 $-5\ ^\circ C \leq \vartheta_{amb} \leq +40\ ^\circ C$	$\leq$ 0.5 %/10 K
− Frequency in range $0.9 \leq f/f_N \leq 1.1$ in range $11 \leq f/Hz \leq 69$	$\leq$ 1 % $\leq$ 3 %

3.5 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)
Number of repeated measurements	2 to 10000 (3 a.c. periods per measurement)	(steps 1)
Undervoltage lock−out U_1< for f>, f<	40 V to 100 V	(steps 1 V)

Pick−up times	
− Frequency f>, f<	dependent on frequency and number of re− peated measurements: approx 80 ms plus 3 a.c. periods per measurement (e.g. 380 ms with 5 measurements at 50 Hz)
Reset times	dependent on frequency and number of re− peated measurements: approx 100 ms plus 3 a.c. periods per measurement (e.g. 400 ms with 5 measurements at 50 Hz)
− Reset difference |pick−up value − reset value|	20 mHz
− Reset ratio undervoltage lock−out U_1<	approx 1.05

Tolerances	
− Frequency f_1, f_2, f_3, f_4	10 mHz at $f = f_N$
− Undervoltage lock−out U_1<	3 % of set value

Influence variables	
− Auxiliary d.c. voltage in range $0.8 \leq U_H/U_{HN} \leq 1.15$	$\leq 0.1\%$
− Temperature in range $-5\ °C \leq \vartheta_{amb} \leq +40\ °C$	$\leq 0.1\ \%/10\ K$
− Frequency in range 40 Hz to 69 Hz	$\leq 0.05\ \%$

3.6 Forward active power supervision

Setting ranges/steps		
Forward power $P_f<$	0.5 % to 120.0 % S_N	(steps 0.1 % S_N)
Forward power $P_f>$	1.0 % to 120.0 % S_N	(steps 0.1 % S_N)
Time delays $T(P_f<)$, $T(P_f>)$	0.00 s to 32.00 s	(steps 0.01 s) or ∞
Drop–off delays	0.00 s to 32.00 s	(steps 0.01 s)

Pick–up times – active power $P_f<$, $P_f>$	≤ 350 ms at 50 Hz ≤ 300 ms at 60 Hz	with high–accuracy measurement
	≤ 60 ms at 50 Hz ≤ 50 ms at 60 Hz	with high–speed measurement
Reset times – active power $P_f<$, $P_f>$	≤ 350 ms at 50 Hz ≤ 300 ms at 60 Hz	with high–accuracy measurement
	≤ 60 ms at 50 Hz ≤ 50 ms at 60 Hz	with high–speed measurement
Drop–off ratios/reset hysteresis – active power $P_f<$ – active power $P_f>$	approx 1.10 or 0.5 % S_N approx 0.90 or –0.5 % S_N	

Tolerances		
– active power $P_f<$, $P_f>$	0.25 % S_N ± 3 %	of set value with high–accuracy measurement
	0.5 % S_N ± 3 %	of set value with high–speed measurement
	at $Q < 0.5\ S_N$ (S_N....rated apparent power, Q.......reactive power)	
– 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 f_N to 1.1 f_N	≤ 1 %

3.7 Reverse power protection

Setting ranges/steps

Reverse power $\|-P_r\|>$	0.50 % to 30.00 %	(steps 0.01 %)
Time delays T_1 / T_2 (stop valve normal state / tripped)	0.00 s to 32.00 s	(steps 0.01 s) or ∞
Drop–off delay T_r	0.00 s to 32.00 s	(steps 0.01 s)

Pick–up times – Reverse power $\|-P_r\|>$	$\leq$ 350 ms at 50 Hz $\leq$ 300 ms at 60 Hz
Drop–off times – Reverse power $\|-P_r\|>$	$\leq$ 350 ms at 50 Hz $\leq$ 300 ms at 60 Hz
Drop–off ratio	approx 0.6

Tolerances

– Reverse power $\|-P_r\|>$	0.25 % $S_N \pm$ 3% of set value at $Q < 0.5\ S_N$ (S_N....rated apparent power, Q...... reactive power)
– 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 %

3.8 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	(steps 0.01 s) or ∞
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 3.1)

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

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

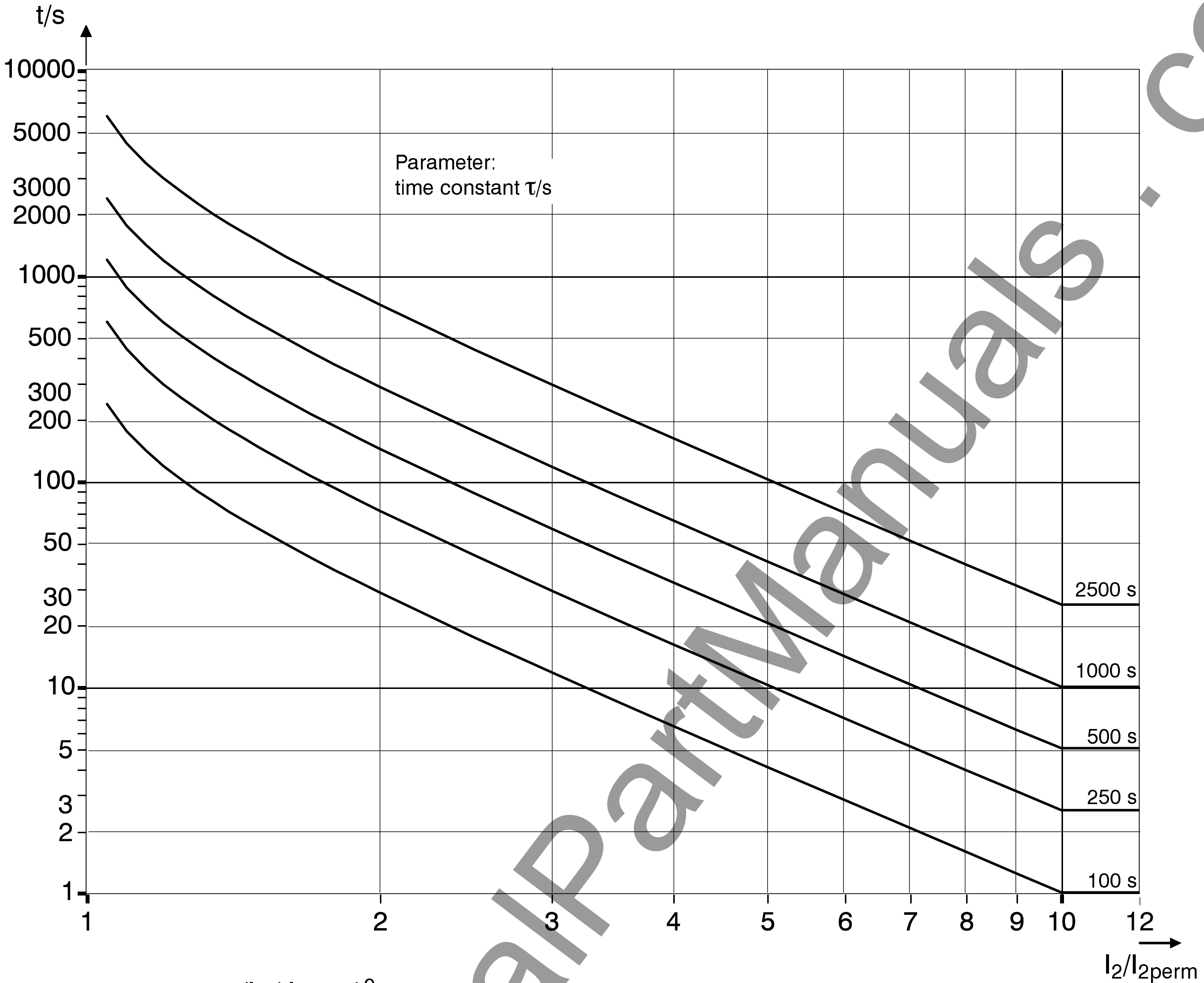
Pick–up times Warning stage $I_2>$, tripping stage $I_2\gg$	$\leq$ 60 ms
Drop–off times Warning stage $I_2>$, tripping stage $I_2\gg$	$\leq$ 60 ms
Drop–off ratios	
– Warning stage $I_2>$, tripping stage $I_2\gg$	approx 0.95
– Θ/Θ_{trip}	drop–off at 0.99 Θ_{warn}
– Θ/Θ_{warn}	approx 1.0

Tolerances

– thermal replica	± 5 %	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 %



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

Figure 3.1 Trip characteristics of the thermal unbalanced load protection stage

3.9 Overcurrent time protection and highly sensitive earth current protection

Setting ranges/steps

Overcurrent pick–up I> (phases)	I/I_N	0.10 to 8.00	(steps 0.01)
Overcurrent pick–up $I_E>$ (earth)		10 mA to 1000 mA	(steps 1 mA)
Overcurrent pick–up I>> (phases)	I/I_N	0.10 to 8.00	(steps 0.01)
Delay times	T for I>, I>>, and $I_E>$	0.00 s to 32.00 s	(steps 0.01 s) or ∞
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	(steps 0.01 s)

Pick–up times	
I>, I>>, $I_E>$ at $\geq$ 2 x setting value	approx 45 ms
Reset times	$\leq$ 40 ms
Reset ratios	
– overcurrent (phases) I>, I>>	approx 0.95
– overcurrent (earth) $I_E>$	approx 0.90
– undervoltage U<	approx 1.05

Tolerances

– Pick–up values I>, I>> (phases)	3 % of setting value
– Pick–up values $I_E>$ (highly sensitivity earth current protection)	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 $0.8 \leq U_H/U_{HN} \leq 1.15$	$\leq$ 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 %

3.10 Thermal overload protection

Setting ranges/steps

Factor k according to IEC 60255−8	0.50 to 2.50	(steps 0.01)
Thermal time constant τ_{th}	30 s to 32000 s	(steps 1 s)
Thermal warning stage $\Theta_{warn}/\Theta_{trip}$	70 to 100 % referred to trip temperature rise	(steps 1 %)
Rated temperature rise	40 °C to 200 °C	(steps 1 °C)
Cooling medium temperature (d.c. voltage input)	0 V dc to 10 V dc or 2 V dc to 10 V dc (selectable)	
Final cooling medium temperature	40 °C to 150 °C	(steps 1 °C)

Trip time characteristic

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

in the range $I/k{\cdot}I_N \leq 3$; tripping times do not decrease above $I/k{\cdot}I_N > 3$

- t trip time
- τ_{th} time constant
- I load current
- I_{pre} preload current
- k factor according to IEC 60255−8

refer also Figures 3.2 and 3.3

Reset ratios

Θ/Θ_{trip}	reset at 0.99 Θ_{warn}
Θ/Θ_{warn}	approx. 0.99

Tolerances

− referring to $k{\cdot} I_N$ (at $t\rightarrow\infty$) 5 % class 5 % acc. to IEC

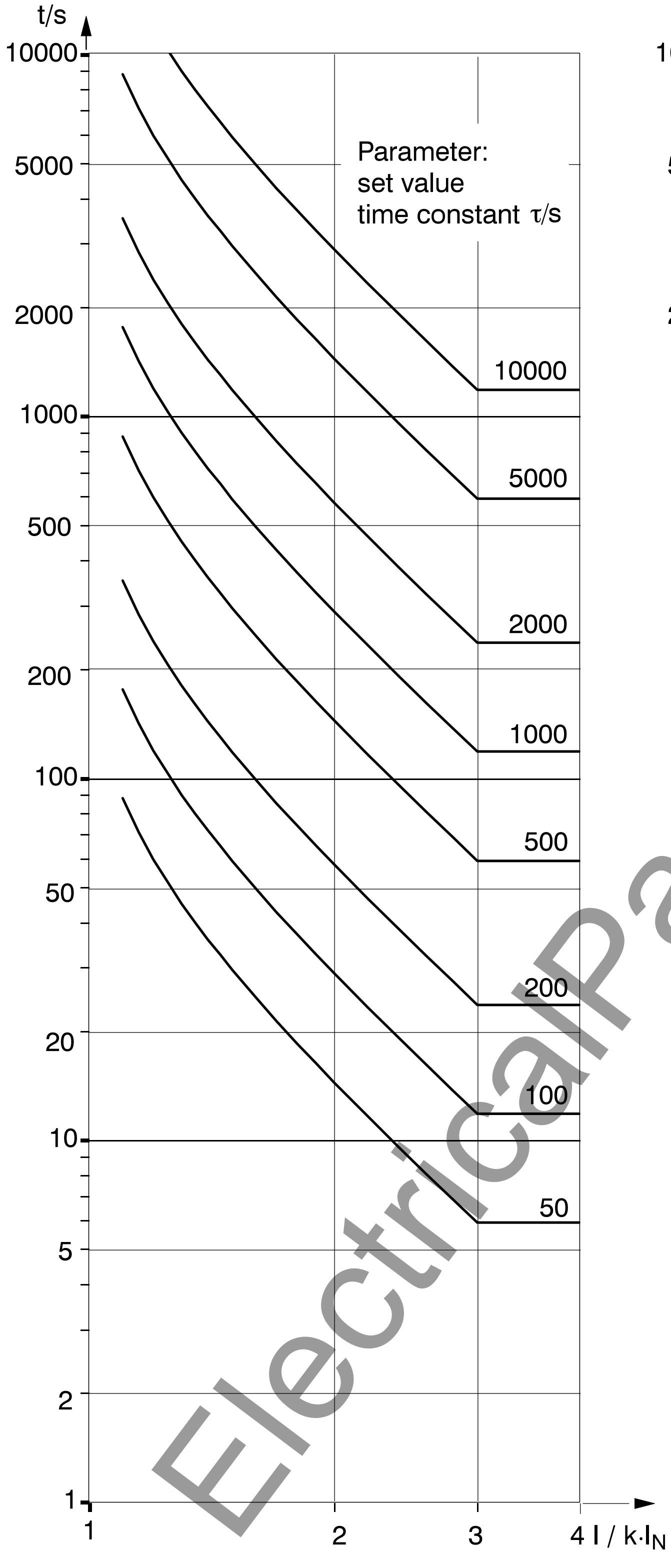
− referring to trip time: class 5 % acc. to IEC with the following multiples:

$I / k{\cdot}I_N$	multiple	tolerance in %
1.0 to 1.5	2.5	12.5
>1.5 to 2.0	1.5	7.5
>2.0 to 3.0	1.0	5.0

− d.c. voltage proport. to ambient temperature: 1 % of full−scale value

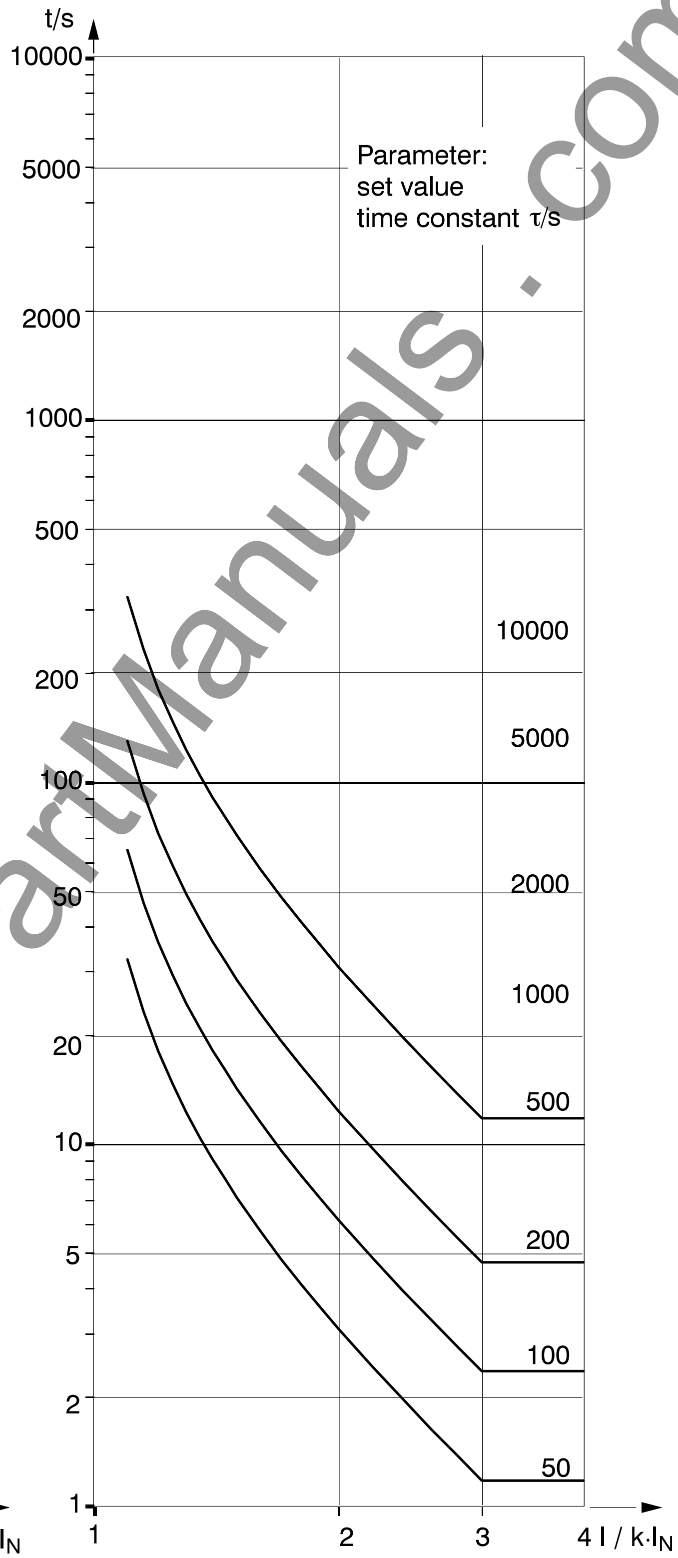
Influence variables referred to $k{\cdot}I_N$

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



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

Figure 3.2 Trip time characteristic of overload protection – without preload –



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

Figure 3.3 Trip time characteristic of overload protection – with 90 % preload –

3.11 Ancillary functions

External trip commands via binary input

Setting ranges/steps

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

Times

operating time	(dependent on frequency)	approx 12 ms at 50 Hz/60 Hz
Drop–off times	(dependent on frequency)	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 $-5\ °C \leq \vartheta_{amb} \leq +40\ °C$	$\leq$ 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
– Unbalanced load	I_2/I_N
Measurement range	0 % to 240 %
Tolerance	2 % of rated value
– Calculated temperature rise due to unbalanced load	$I_{2\ therm}$
Measurement range	0 % to 240 %
Tolerance	5 % referred to Θ_{trip}
– Operational voltage values	U_{L1-N}, U_{L2-N}, U_{L3-N} in kV primary and in V secondary
Measurement range	0 % to 140 V
Tolerance	2 % of rated value
– Positive sequence voltage component	$\sqrt{3} \cdot U_{pos}$
Measurement range	0 % to 190 V
Tolerance	2 % of rated value
– Displacement voltage	U_0
Measurement range	0 % to 140 V
Tolerance	2 % of rated value
– Earth current	I_E
Measurement range	0 mA to 1000 mA
Tolerance	2 % or 1 % of full−scale value
– Excitation voltage	U_{exc}
Measurement range	0 to 10 V dc (from upstream voltage divider)
Tolerance	1 %
– 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°
– Pole angle	θ
Measurement range	−180° to +180°
Tolerance	3°

– Frequency	f
Measurement range	40 Hz to 70 Hz
Tolerance	0.2 % of rated value
– Overload protection measured values	
Calculated temperature rise	Θ/Θ_{trip}
Measurement range	0 to 240 %
Tolerance	5 % referred to Θ_{trip}
– Cooling medium temperature	Θ_{amb}
Measurement range	0 °C to final temperature; according to the settings
Tolerance	2 %

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 $I > I_{limit}$
Voltage unbalance	U_{max}/U_{min} > symmetry factor as long as $U > U_{limit}$
Phase sequence	clockwise phase rotation

Fault event data storage

Storage of annunciations of the four last 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 > 5 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 voltages u_{L1-N}, u_{L2-N}, u_{L3-N} Excitation voltage U_{exc}
r.m.s. 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} earth current I_E positive sequence component of currents I_{pos} positive sequence component of phase voltages $\sqrt{3} \cdot U_{pos}$ phase angle φ 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
Underexcitation protection	inactive	**active**1)	**active**	inactive
Undervoltage protection	inactive2)	**active**1)	**active**	inactive2)
Overvoltage protection	inactive	**active**1)	**active**	inactive
Stator earth fault protection U_0>	inactive	**active**1)	**active**	inactive
Underfrequency protection	inactive	**active**3)	**active**	inactive4)
Overfrequency protection	inactive	**active**5)	**active**	inactive6)
Forward active power supervision	inactive	**active**1)	**active**	inactive
Reverse power protection	inactive	**active**1)	**active**	inactive
Unbalanced load protection – stepped characteristic	inactive	**active**	**active**	inactive
Unbalanced load protection – thermal replica	inactive7)	**active**	**active**	inactive7)
Overcurrent time protection I>, I>>	inactive	**active**	**active**	inactive
Sensitive earth current protection	inactive	**active**	**active**	inactive
Stator overload protection	inactive7)	**active**	**active**	inactive7)
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 exact frequency measurement possible, but pick–up is ensured due to underfrequency
4) no exact frequency measurement possible, but pick–up (when present) is reset
5) no exact frequency measurement possible, but pick–up (when present) is reset
6) no exact frequency measurement possible, but pick–up is ensured due to overfrequency
7) thermal replica registers cooling–down

Figure 3.4 Operating ranges of the protection functions

4 Method of operation

4.1 Operation of complete unit

The numerical machine protection 7UM511 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.

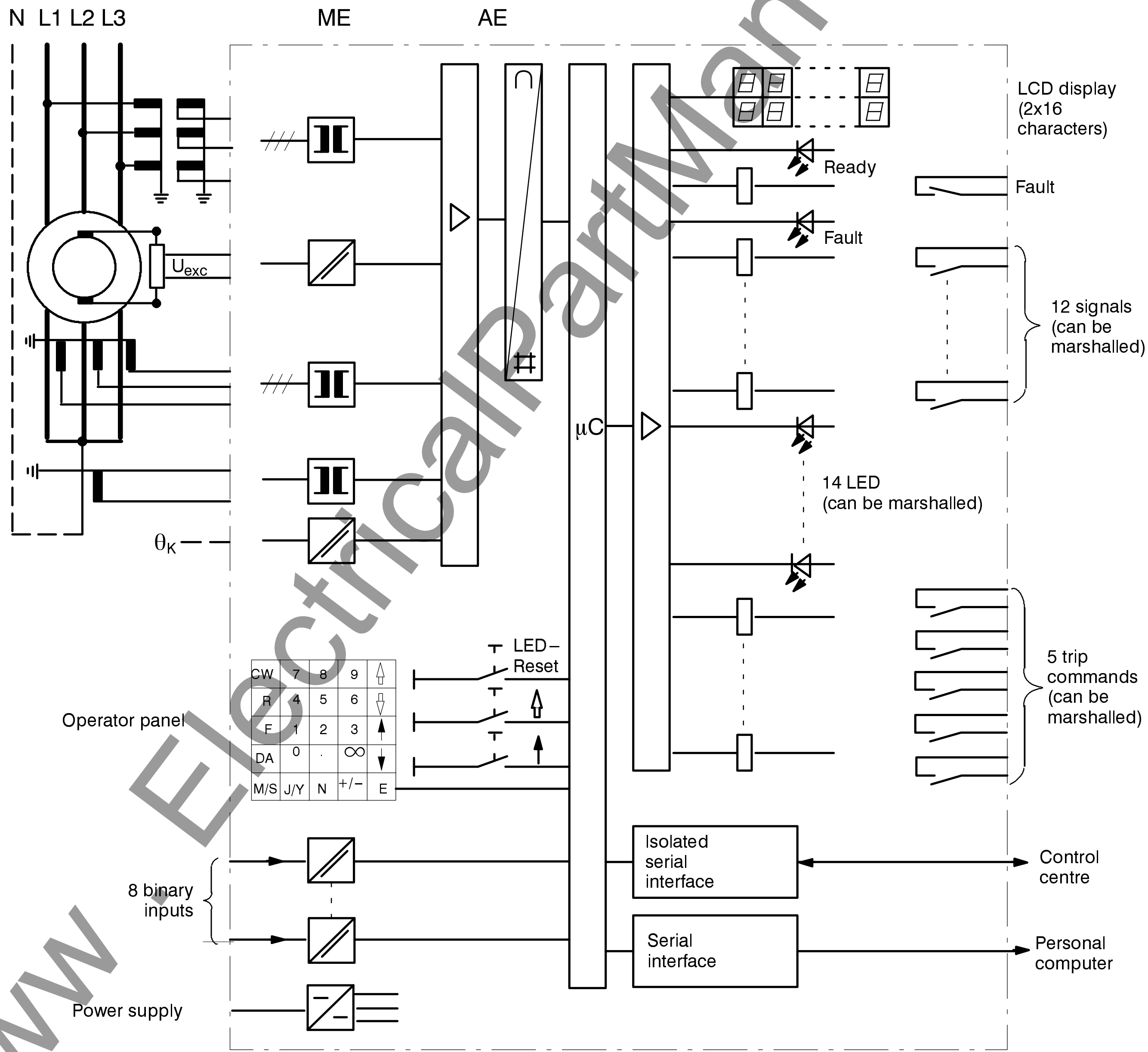


Figure 4.1 Hardware–structure of machine protection relay 7UM511

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 excitation voltage and which is also passed to the analog input section AE. Furthermore, for the stator overload protection, the cooling medium temperature can be connected to the unit as a temperature–proportional voltage. This is also galvanically isolated and then passed to the 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 voltages, the negative sequence current for unbalanced load detection and the zero sequence voltage,
– determination of the active and reactive components of power,
– calculation of r.m.s. values for overload measurement and scanning of the thermal replica,
– scanning of values for the thermal replica of rotor surface,
– 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 cannot operate (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 255 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 Underexcitation protection

The underexcitation protection protects a synchronous machine from asynchronous operation in the event of a malfunction in the excitation system and from local overheating of the rotor. Furthermore, it prevents endangering of the network stability in the case of underexcitation of large synchronous machines.

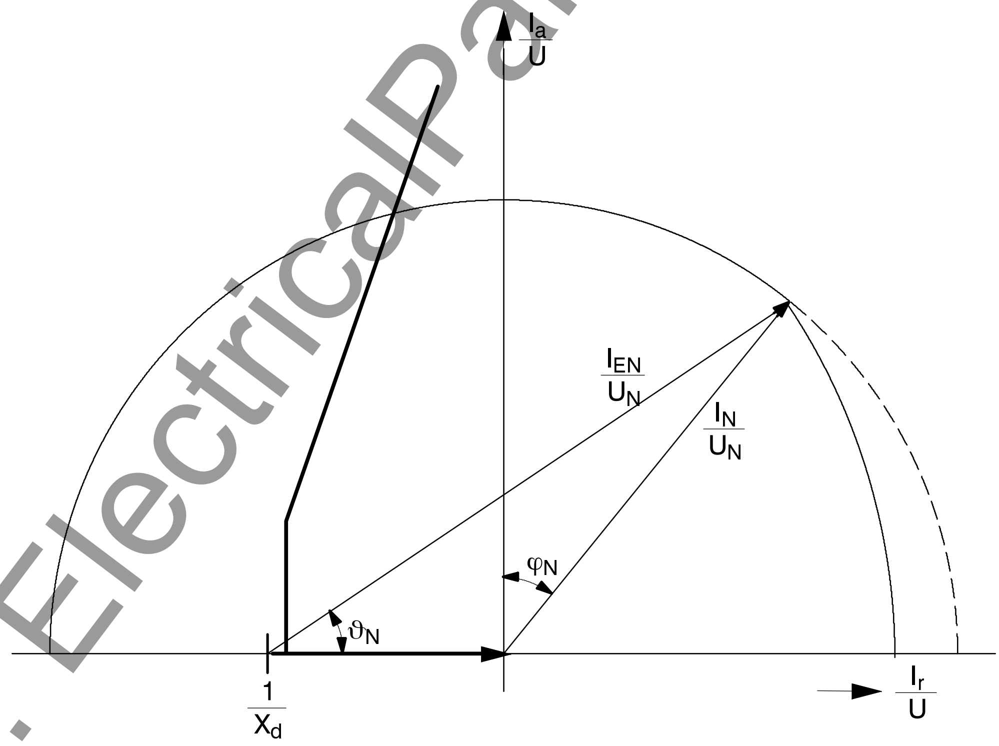
In order to detect underexcitation, the unit processes all three phase currents and all three voltages to form the stator circuit criterion. It also processes the excitation voltage and/or the signal from an external excitation voltage monitor to form the rotor circuit criterion.

For the stator circuit criterion, the admittance is calculated from the positive sequence system of the currents and voltages. In the admittance plane, the stability limit of the machine is independent of the voltage: thus, the protection characteristic can be optimally matched to the stability characteristic of the machine. By evaluating the positive sequence system, underexcitation conditions are reliably detected even during asymmetrical faults within or outside of the machine.

Figure 4.2 shows the loading diagram of the synchronous machine in the admittance plane (I_{active}/U; $I_{reactive}/U$) with the steady−state stability limit which intersects the reactive axis in close proximity to $1/X_d$ (reciprocal value of the synchronous direct reactance)

The underexcitation protection simulates the stability characteristic of the machine by means of two partial characteristics as shown in Figure 4.3. The characteristics of the partial characteristics are the distances from the origin λ1 and λ2 as well as the associated inclination angles α1 and α2.

If the resulting characteristic λ1/α1; λ2/α2 is exceeded (in Figure4.3 to the left−hand side), then an alarm or a trip signal is initiated after a time delay (e.g. 10 s). The time delay is necessary in order to allow time for the voltage regulator to increase the excitation voltage.



U_N rated voltage
I_N rated current
I_{EN} rated excitation current
ϑ_N rated pole angle
φ_N rated load angle

X_d synchronous reactance
U terminal voltage
I_a active current
I_r reactive current

Figure 4.2 Admittance diagram of turbo−generators

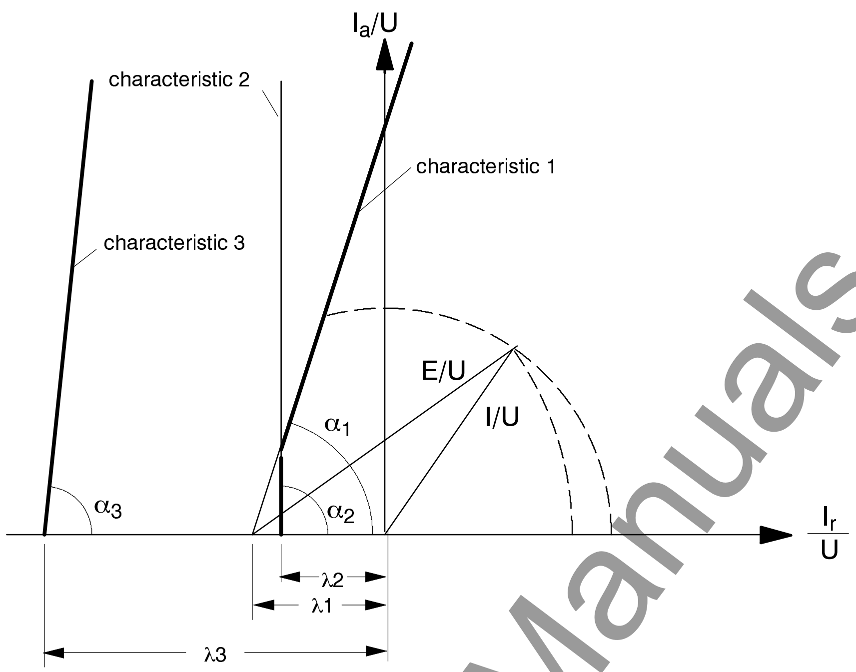


Figure 4.3 Stator criterion: pick–up characteristic in admittance diagram

Upon malfunction of the voltage regulator or failure of the excitation voltage, the machine can be disconnected after a short time delay (e.g. 1.5 s). For this, the excitation voltage can be fed into the unit via a voltage divider as the rotor criterion. If the excitation voltage falls below an adjustable minimum value, then short–time tripping is initiated.

Instead of, or in addition to the excitation voltage measurement, the signal from an external excitation voltage monitor can be fed into the unit via a binary input. In this case short–time tripping is also initiated if excitation voltage failure is signalled.

A further characteristic λ3, α3 can be matched to the dynamic stability characteristic of the synchronous machine. Since stable operation is impossible if this characteristic is exceeded, immediate tripping is required in this case.

The admittance calculation requires a minimum measurement voltage. During a severe collapse (short–circuit) or failure of the stator voltages, the protection is therefore blocked by an integrated a.c. voltage monitor (U_1 < 25 V).

When setting the machine data, the reciprocal value of the synchronous reactance $1/X_q$ is also input into the unit. The unit uses this value as well as stator current and voltage for an approximate calculation of the pole angle ϑ. This value is also available as an operational measured value (refer to Section 6.4.4).

Figure 4.4 illustrates the logic diagram of the underexcitation protection.

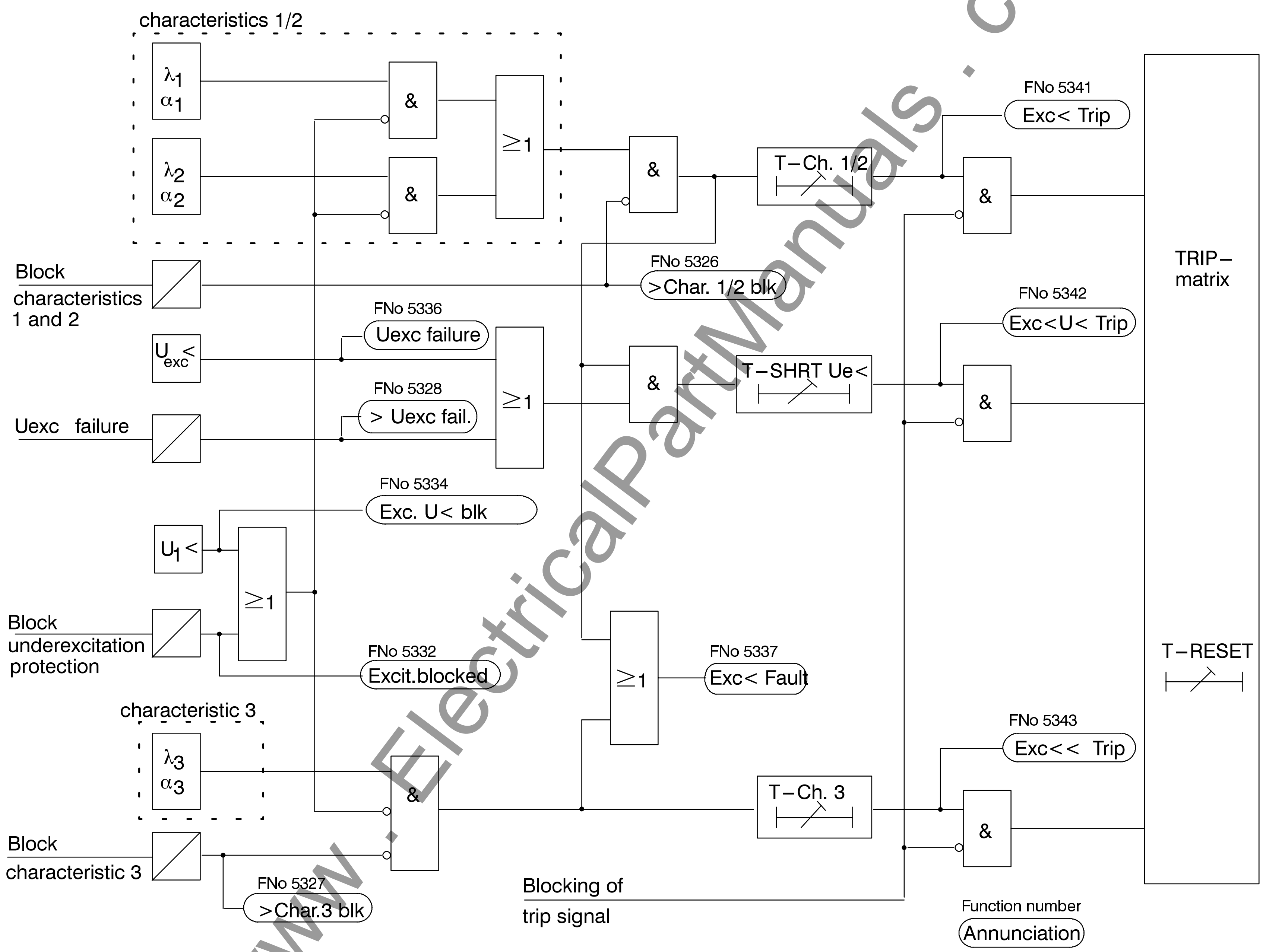


Figure 4.4 Logic diagram of underexcitation protection

4.3 Undervoltage protection

The undervoltage protection detects voltage drops in electrical machines and prevents impermissible operating conditions and possible loss of stability.

For this, the fundamental wave of the positive sequence system is paramount. The phase voltages are filtered by the protection (Fourier analysis) and only the fundamental waves are evaluated. Of these, the protection only detects the positive sequence system. This is referred to the rated voltage (phase–to–phase).

In the event of two–phase short–circuits or earth faults, asymmetrical voltage drops will occur. In contrast to three single–phase measuring systems, the measurement of the positive sequence system is not influenced by these events and has an advantage in particular when considering stability problems.

The undervoltage protection is single–stage. In order to avoid malfunction of the protection in the event of secondary voltage failure, it can be blocked via a binary input, e.g. by a voltage transformer m.c.b.

When the undervoltage protection has picked up while the relay changes to the operating condition 0 – i.e. no suitable measured quantities are present – pick–up will be sealed in. Thus, trip is ensured even after the voltages have completely collapsed. This seal–in can be cancelled only after the voltage has reverted to a value above the undervoltage drop–off value or by activating the blocking input for undervoltage protection.

Figure 4.5 shows the logic diagram of the undervoltage protection.

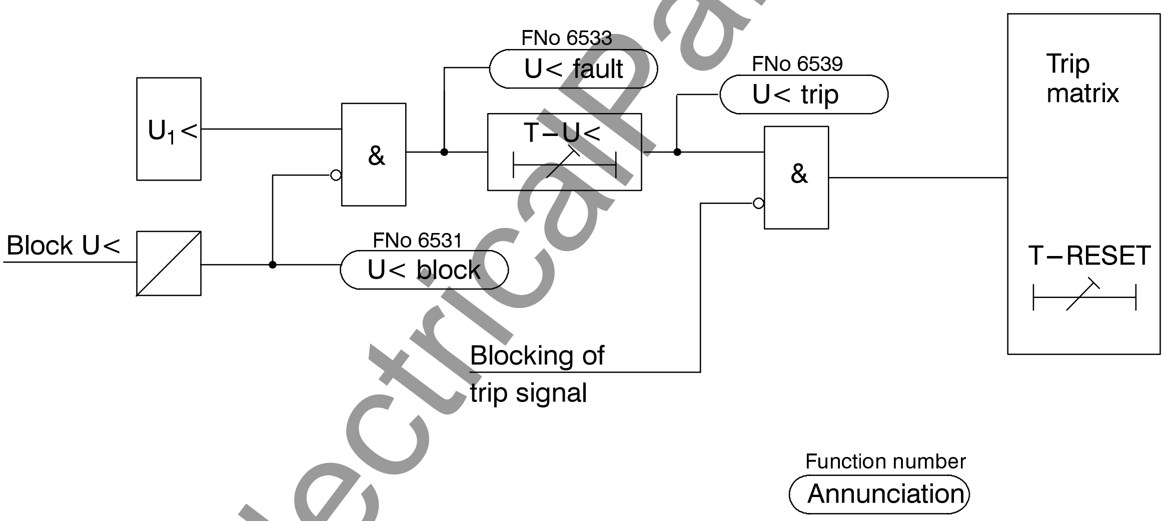


Figure 4.5 Logic diagram of the undervoltage protection

4.4 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 overvoltage protection is of two–stage design and evaluates the positive sequence component U_1 of the voltages. 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 each stage.

Figure 4.6 shows the logic diagram of the overvoltage protection.

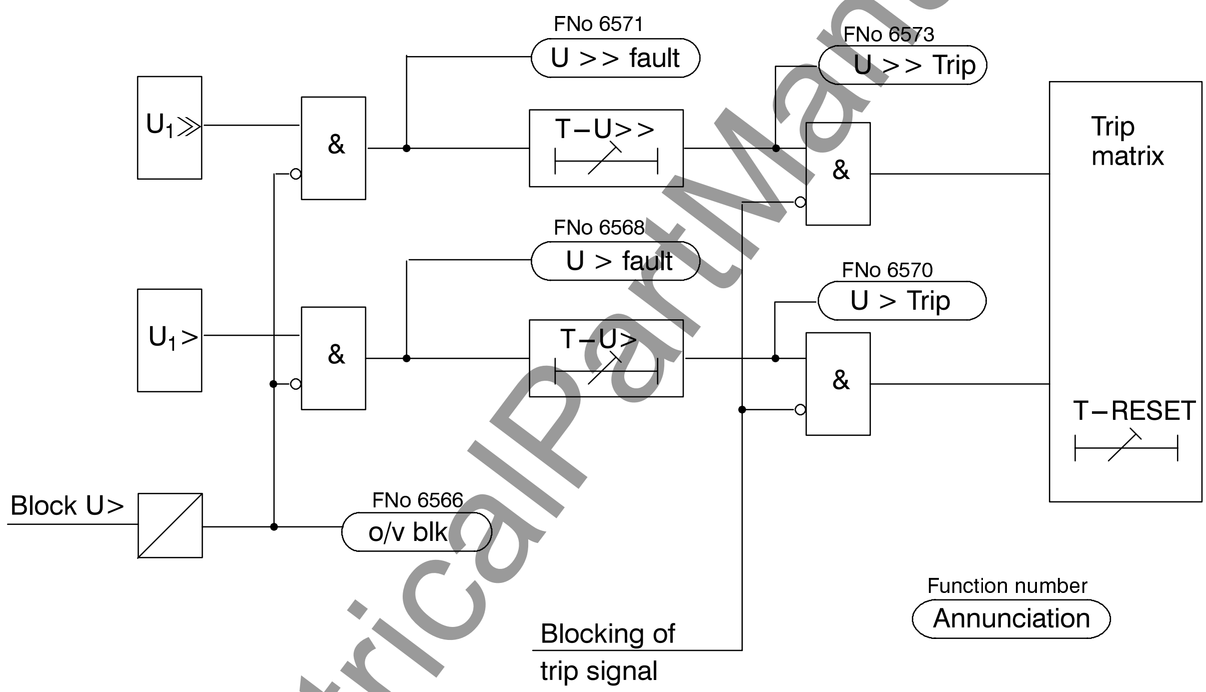


Figure 4.6 Logic diagram of the overvoltage protection

4.5 Stator earth fault protection U_0>

The stator earth fault protection detects earth faults in the stator windings of three–phase machines in block connection (via machine transformer). The criterion for the occurrence of an earth fault is the occurrence of a neutral displacement voltage. This principle results in a protected zone of 90 % to 95 % of the stator winding.

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 protected zone has been present for a set time.

The displacement voltage U_0 is calculated from the sum of the three phase–to–earth voltages according to the equation:

$$|\underline{U}_{L1} + \underline{U}_{L2} + \underline{U}_{L3}|/\sqrt{3} = \sqrt{3} \cdot U_0,$$

i.e. rated voltage at full displacement.

When one or two phase voltages fail, then a displacement voltage will be simulated either. In order to prevent from erroneous operation caused by this wrong zero sequence voltage, the relay includes a blocking input for stator earth fault protection which can be operated, for example, by an auxiliary contact of the miniature circuit breaker of the voltage transformer secondary circuit.

As 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.

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

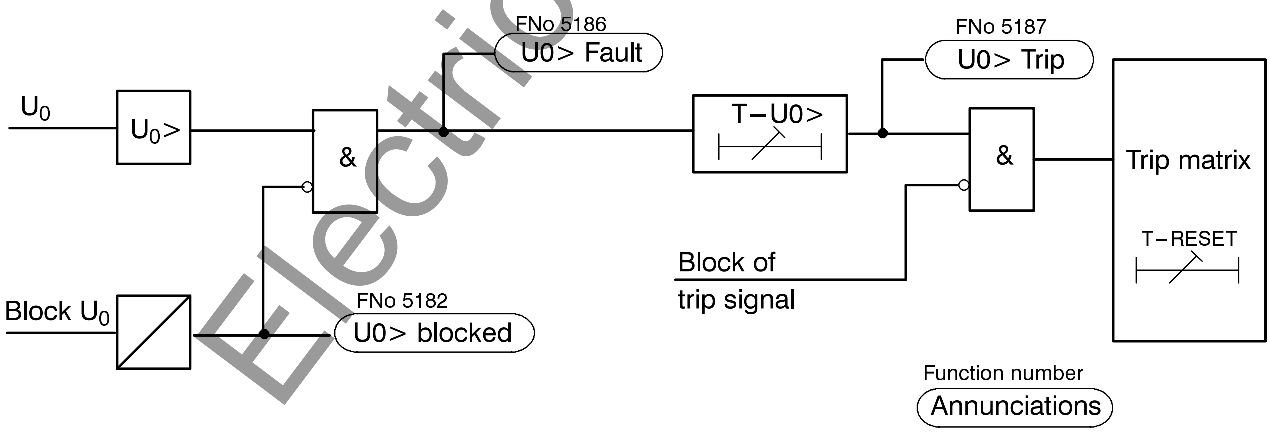


Figure 4.7 Logic diagram of the stator earth fault protection U_0>

4.6 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 7UM511 includes four high–accuracy 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.

The unit uses two operating steps to determine the frequency from the positive sequence system of the voltages:

Firstly, the frequency is roughly ascertained from the measurement of the period duration, i.e. from the distance between two zero passes. This results in the ”base frequency” f_b.

In order to accurately determine the frequency, the angular speed of the measured voltage vector (with actual frequency) referred to the base frequency is measured, i.e. the difference between actual frequency and base frequency f_b. This is done by measuring the phase angle between measured frequency vector and base frequency vector over 36 sample values, i.e. in the time interval of 3 a.c. periods.

Since the frequency is not derived directly from the sine of the voltage, but from the change in angle of two sinusoidal signals with small frequency difference, a high accuracy can be achieved.

Trip signal is initiated when the frequency has exceeded the set threshold value (for each stage separately) for a number which can be set as ”measurement repetitions”. By this way, trip delay is determined by the set number of measurement repetitions. Each measurement takes three a.c. periods. Thus, the trip delay can be derived from the formula:

$$t_{trip} = 3 \cdot \frac{n}{f_{system}} + 50\ \text{ms}$$

where: f_{system} actual system frequency
n number of repeated measure–ments, as set by the operator

A ”frequency fault” signal is given after half the number of measurement repetitions, individually for each stage. Note that this fault signal represents the start instant for fault detection: The trip time as indicated in the fault annunciations shows the time from fault detection to trip, i.e. in case of frequency protection only half the total time from under/overfrequency to trip.

The unit continuously supervises the measurement voltage. If the positive sequence component of the voltages drops below a certain value, the measurement repetition counters are reset to zero. If ”frequency fault” had been detected, this signal is equally reset.

Blocking of each frequency stage is possible as well as blocking of the entire frequency protection, by connecting external signals via binary inputs. In this case also the counters are reset to 0, as above.

If the frequency reverts to less than 39 Hz, high–accuracy measurement is not possible, but underfrequency is detected: The counters of **under**frequency protection are **in**cremented, until ”underfrequency fault” and finally trip signal are given. The **over**frequency protection counter is **de**cremented until 0 should it had been greater than 0.

If the frequency is below 11 Hz or higher than 70 Hz or, if the measured voltage is too small for frequency determination, ”operating condition 1” is not fulfilled, i.e. no suitable measured quantities are present:

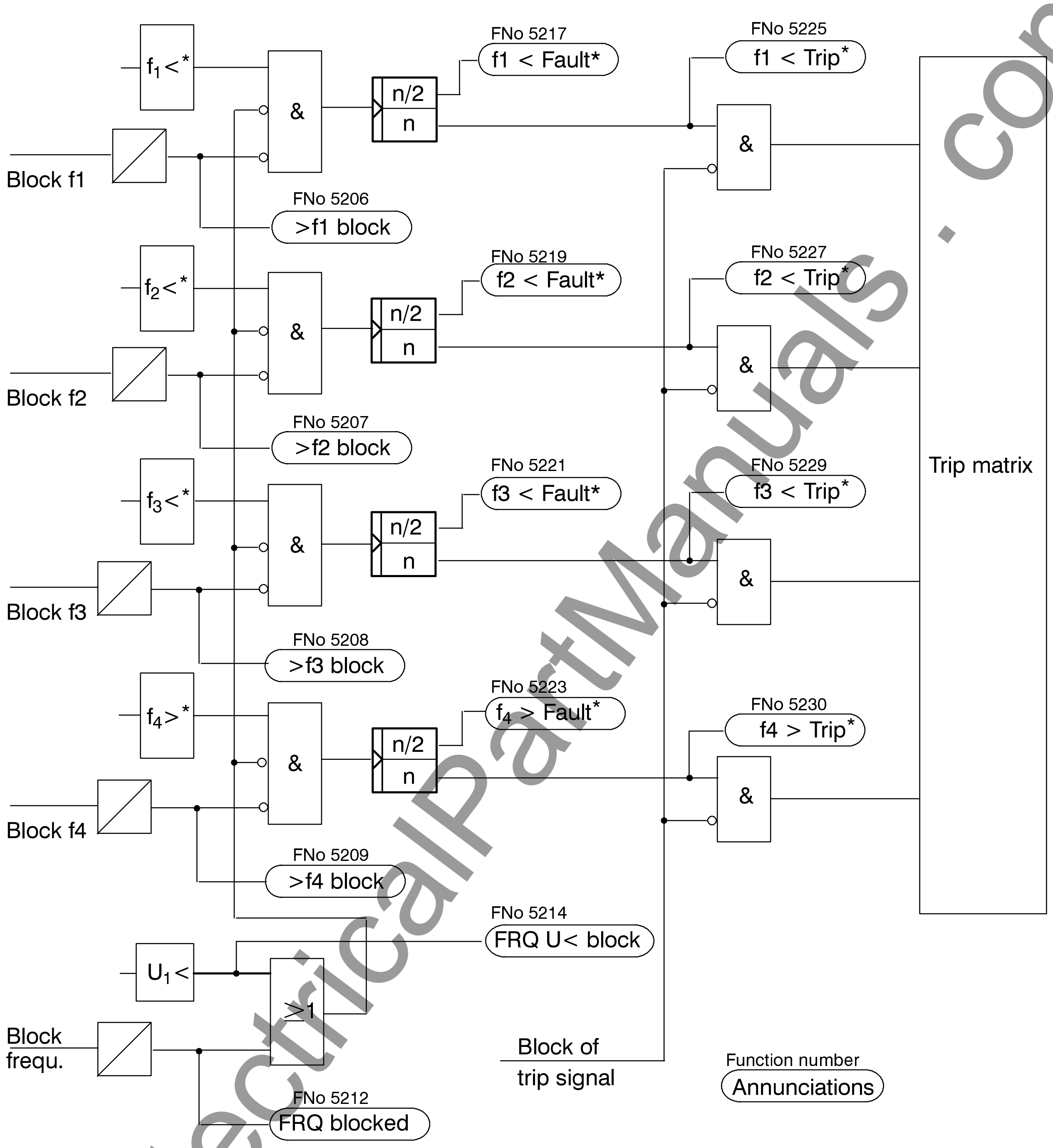
The counters of the **under**frequency protection is **de**cremented until 0. If ”frequency fault” had been detected, this signal resets when the counter is 0.

If the **over**frequency protection counter has already counted to 1 or higher, when "operating condition 1" disappears, the counter is **in**cremented every three a.c. periods provided the measured voltage is of sufficient magnitude above 66 Hz. This ensures overfrequency tripping even in case the frequency rise higher than 70 Hz. For application as overspeed protection of small hydro−electric machines or gas−turbine sets with possibly high rate−of−change in frequency $^{df}/_{dt}$, it must be ensured that overfrequency has been detected before the frequency leaves the operating range of the frequency protection , i.e. the frequency rises above 70 Hz. This is fulfilled when the rate−of−change in frequency is below 8 Hz/s.

If overfrequency is not detected before the "operating condition 1" has disappeared, or if none of the three voltages is present of sufficient magnitude, the counter is decremented until zero is reached: the protection drops off.

When a trip command has been issued before the upper operating limit of 70 Hz has been exceeded, trip is sealed in until the frequency protection stage is blocked or until suitable measured quantities (i.e. within the permissible operating range) are present again.

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

4.7 Forward active power supervision

The machine protection 7UM511 includes an active power supervision which monitors whether the active power falls below one set value as well as whether a separate second set value is exceeded. Each of these functions can initiate different control functions.

When, for example, with generators operating in parallel, the active power output of one machine becomes so small that other generators could take over this power, then it is often appropriate to shut down the lightly loaded machine. The criterion in this case is that the ”forward” power supplied into the network falls **below** a certain value.

In some applications it can be desirable to output a control signal if the active power output **exceeds** a certain value.

Another possibility to use power direction is in case of network splitting. To reduce as far as possible the effect on any network, of disturbances which occur on another network to which it is coupled, so–called decoupling or network splitting is used at the coupling point. For example, an industrial network which has certain measures of its own generation is coupled via a coupling circuit breaker with a HV utility network and should be decoupled when a fault in the utility network is not cleared within a critical time. As a criterion for decoupling, underfrequency, undervoltage, overcurrent, power direction, or combinations of these can be used. These criteria are available in 7UT511 V3.

For power measurement, two measurement method are available in 7UT511. Depending on the application either high–speed measurement or high–accuracy measurement (average about 16 a.c. period) may be selected. High–speed measurement is suitable e.g. for network splitting.

The unit calculates the active power from the positive sequence systems of the generator currents and voltages. This value is compared with the set values. Each stage can be blocked individually, as can be the complete forward active power supervision, via binary inputs.

Figure 4.9 shows the logic diagram of the forward active power supervision.

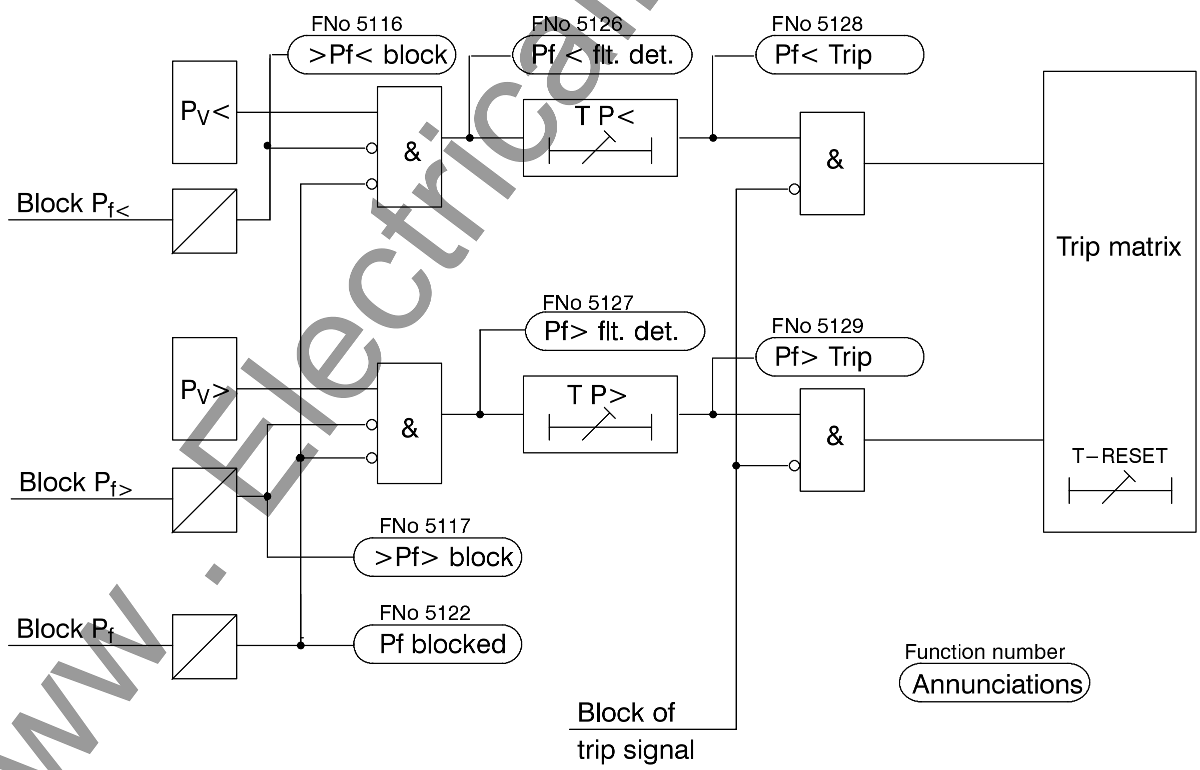


Figure 4.9 Logic diagram of the forward active power supervision

4.8 Reverse power protection

Reverse power protection is used to protect a turbo−generator unit in case of failure of energy to the prime mover. In this case the synchronous generator runs as a motor and drives the turbine whereby the required motoring energy 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.

The reverse power protection of the 7UM511 precisely calculates the active power from the symmetrical components of the voltages and currents by averaging the values of the last 16 a.c. periods. By taking the error angles of the instrument transformers into account, the active power component is calculated even with very high apparent powers and small power factor. 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 during commissioning by the relay itself and entered to the current transformer data.

By evaluating only the positive sequence system, the reverse power measurement remains independent of asymmetrical currents and voltages and represents the actual load on the drive side.

In order to bridge a possible transient reverse power during synchronizing or during power oscillations due to network faults, the trip command is delayed by an adjustable time T−SV−OPEN. However, if the stop valve has tripped, a short time delay is sufficient. By inputting the status of the stop valve via a binary input, the short time delay T−SV−CLOSED becomes effective when the stop valve has tripped.

It is possible to block tripping by means of an external signal.

Figure 4.10 shows the logic diagram of the reverse power protection.

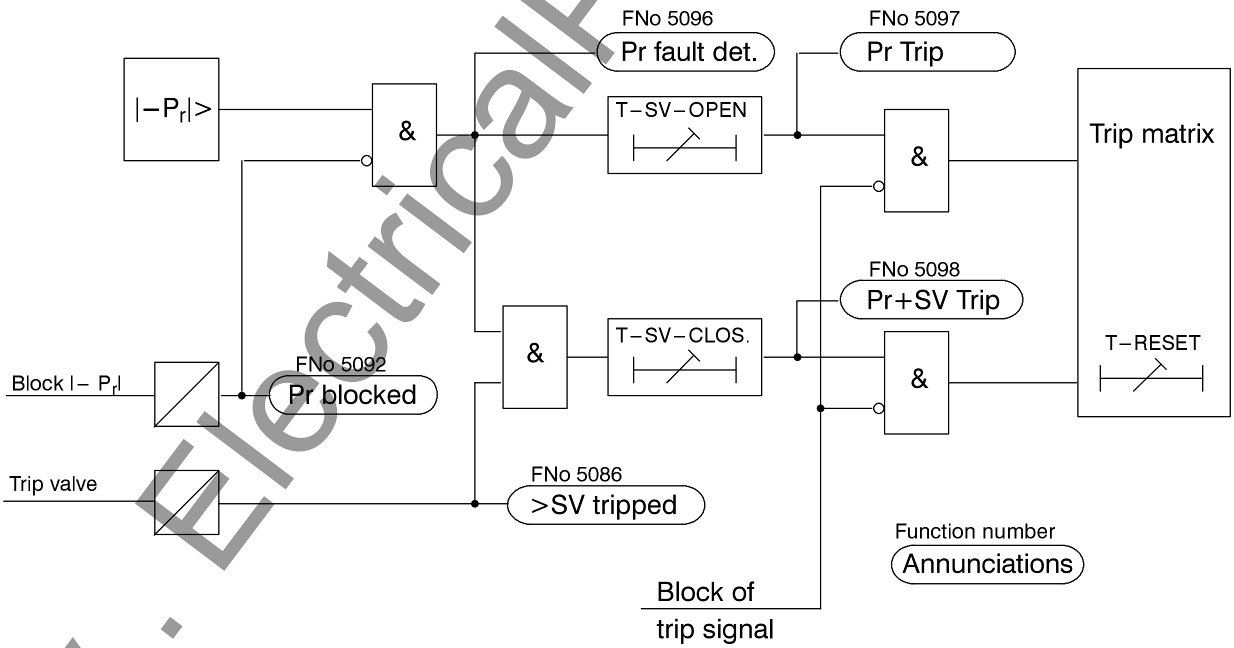


Figure 4.10 Logic diagram of the reverse power protection

4.9 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 7UM511, 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 4.11). 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 4.11). Negative sequence current above 10 times the permissible value do not reduce tripping time (see also Figure 3.1).

Figure 4.12 shows the logic diagram of the unbalanced load protection.

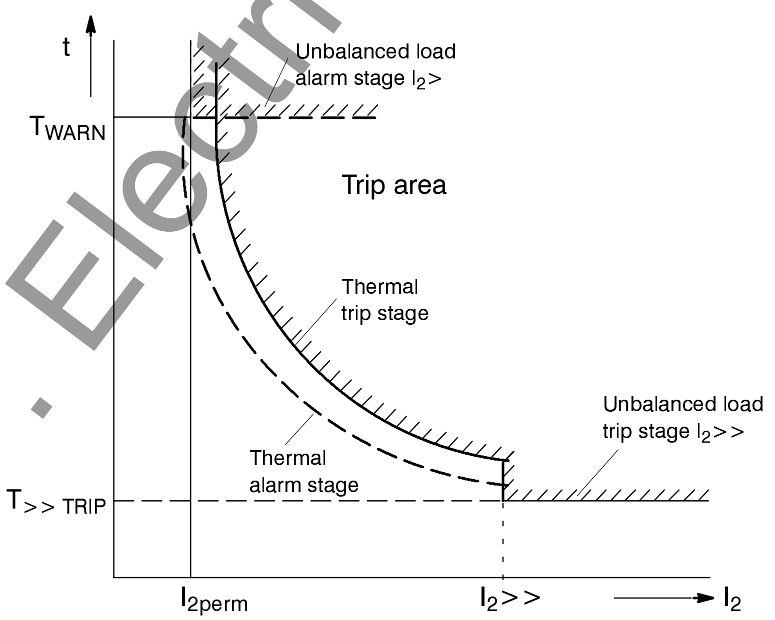


Figure 4.11 Trip characteristics of the unbalanced load protection

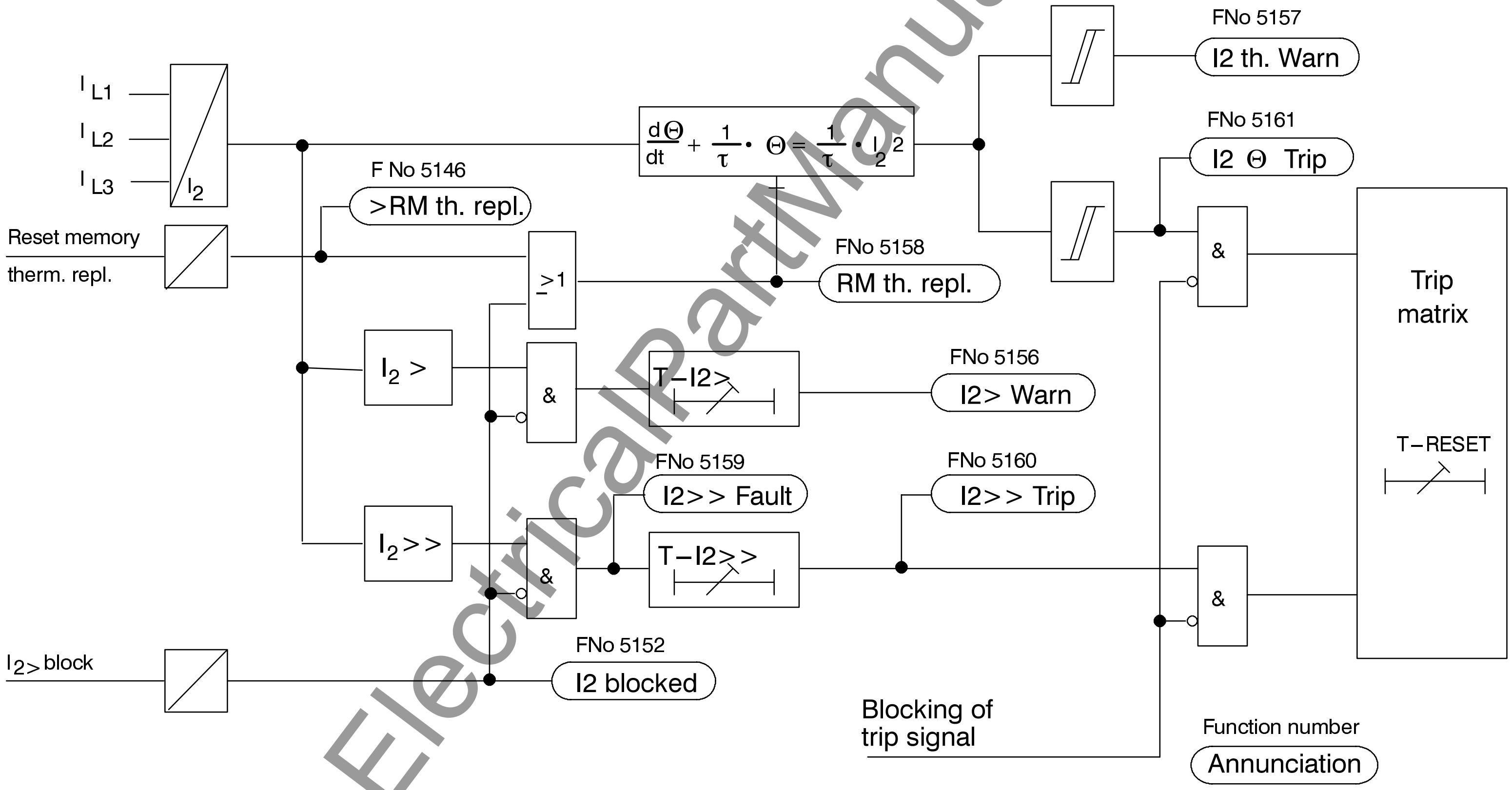


Figure 4.12 Logic diagram of the unbalanced load protection

4.10 **Overcurrent time protection** (phase currents)

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.

For these purposes, the protection is provided with two stages for phase faults.

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> and I>> which are common to each stage 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> or T–I>> has elapsed, a trip signal is initiated, which is also available individually per stage.

The pick–up values for each stage, I> (phase currents) and I>> (phase currents) and the respective time delays for each of these stages can be set individually.

Each stage can be blocked individually 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 positive sequence component of 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.

Fig 4.13 shows the logic diagram of the overcurrent time protection for phase currents.

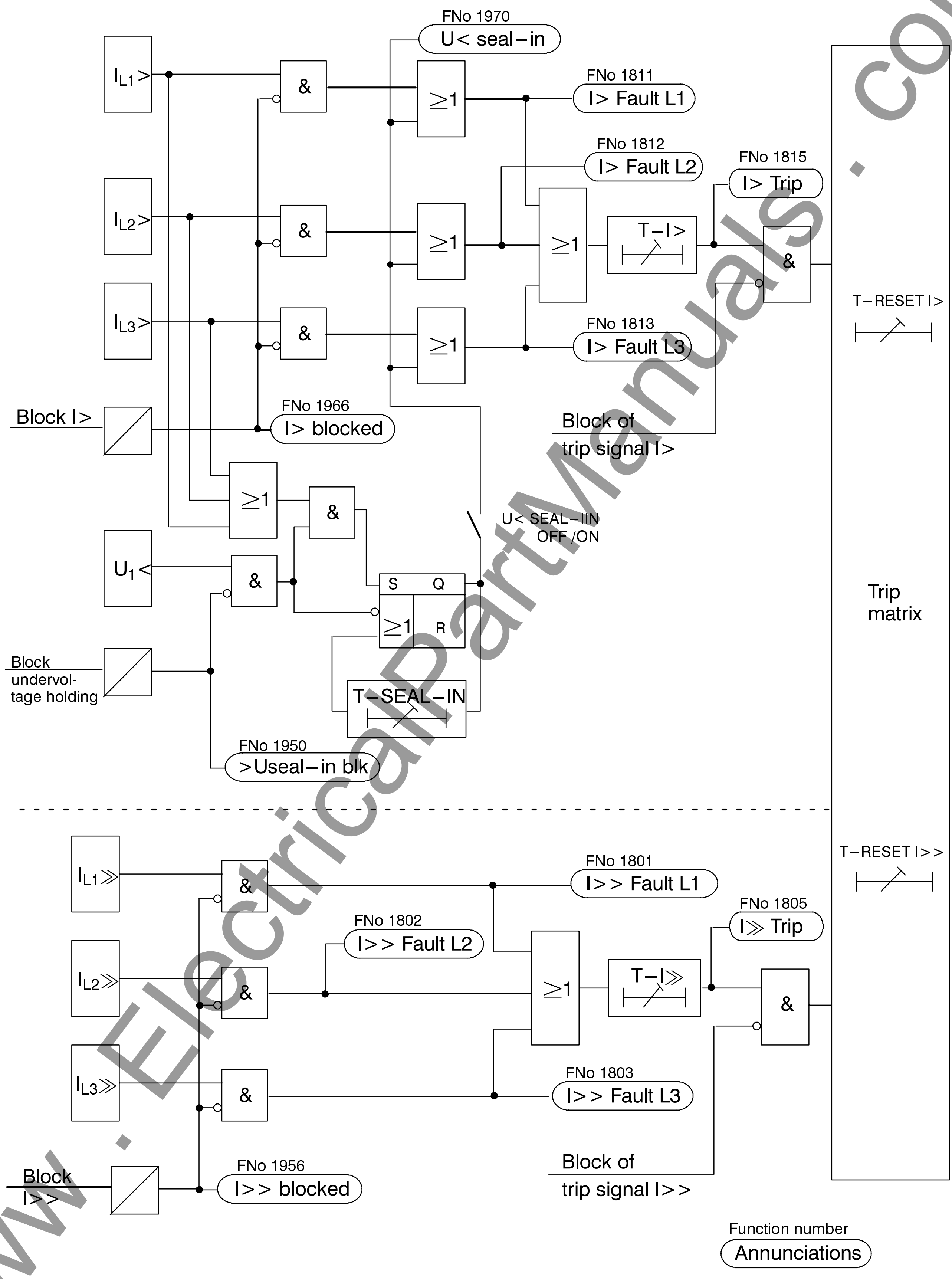


Figure 4.13 Logic diagram of the overcurrent time protection for phase currents

4.11 Highly sensitive earth current protection

The highly sensitive earth current protection has the task to detect earth fault in systems with isolated or high–impedance earthed star–point. The pick–up criterion is the magnitude of the (residual) earth current. The magnitude of the residual current allows earth fault detection, for example, on electrical machines which are directly connected to the bus–bar of an isolated power system, when in case of a network earth fault the machine supplies only a negligible earth fault current across the measurement location, which must be situated between the machine terminals and the network, whereas in case of a machine earth fault the higher earth fault current produced by the total network is available.

The measured current may be derived from special window–type summation current transformers or from three star–connected current transformers (Holmgreen connection). Furthermore, it is possible to use the displacement voltage of an earthing transformer, which is transformed into a current by means of a suitable shunt resistor.

Alternatively, this protection can be used as rotor earth fault protection when a system frequency bias voltage is applied to the rotor circuit. In this case, the measured current is determined by the magnitude of the bias voltage and the capacitance of the coupling capacitors of the rotor circuit.

A measured value supervision is provided for the application as rotor earth fault protection: The measurement circuit is assumed to be closed as long as a small earth current (settable) is flowing which is determined by the rotor–earth capacitance. If not, an alarm is issued after a short delay time of 2 s.

This protection is not suited for detection of high earth current which may arise in case of earthed system star–points (higher than approx. 1 A at the relay terminals for highly sensitive earth current protection).

Initially, the residual current is 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 harmonic content in the current.

The earth current is compared with the setting value I_E> and an annunciation is initiated when a setting value is exceeded. After the delay time T–IE> has elapsed, a trip signal is initiated.

The protection can be blocked via a binary input.

Fig 4.14 shows the logic diagram of the earth current protection.

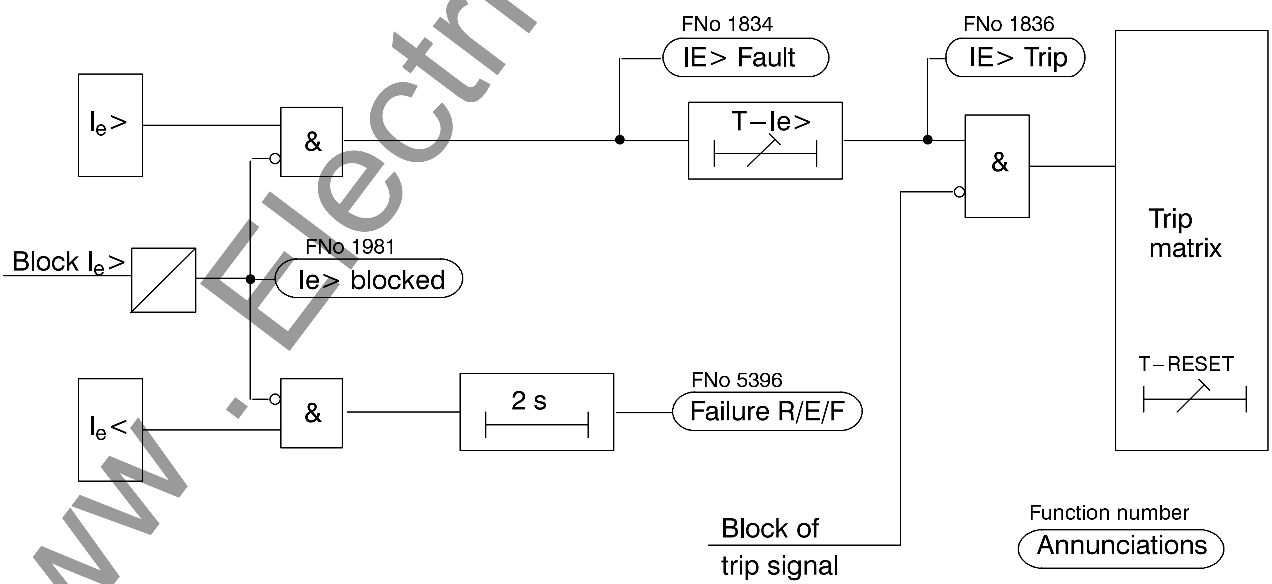


Figure 4.14 Logic diagram of the highly sensitive earth current protection

4.12 Stator overload protection

The overload protection prevents the stator windings of the protected machine from thermal overload damage.

The unit computes the temperature rise according to a thermal single–body model according to the thermal differential equation

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

whereby

- Θ – actual temperature rise referred to the steady–state temperature rise at maximum permissible phase current $k \cdot I_N$
- Θ_{amb} – ambient temperature difference to the reference temperature 40 °C
- τ – thermal time constant for heating–up of the conductors
- I – actual r.m.s. value of phase current referred to the maximum permissible phase current $I_{max} = k \cdot I_N$

When the temperature rise reaches the first set threshold, a warning alarm is given to enable an appropriate load reduction. This warning stage represents the reset value of the overload protection. If the second temperature threshold is reached, the machine can be disconnected from the network.

Additionally, a current warning stage is available, which operates when one phase current exceeds $I_{max} = k \cdot I_N$.

The temperature rise is calculated from each of the phase currents. A true r.m.s. value measurement is performed in order to include the effect of harmonics.

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

$I_{max} = k \cdot I_N$

In addition to this k–factor, the time constant τ as well as the warning temperature rise Θ_{warn} in % of trip temperature rise must be entered into the unit. Thus, the relay is able to compute the temperature rise caused by the thermal losses.

By means of an external temperature sensor, the cooling medium temperature can be input as a temperature–proportional voltage value. This enables determination of total temperature. This voltage may be derived from a measurement transducer which delivers 0 V to 10 V d.c. as a temperature–proportional voltage. Alternatively, a measurement transducer with 4 mA to 20 mA d.c. may be used. In the latter case, the current must be converted into a proportional voltage of 2 V to 10 V d.c. by means of a shunt resistor; additionally, the measurement circuit can be monitored: When the measurement circuit is interrupted or short–circuited, the voltage at the d.c. voltage input will become 0. The ambient temperature is set to 40 °C (this corresponds to the assumed ambient temperature without ambient temperature processing), and an alarm is issued.

The maximum permissible current is influenced by the cooling medium (ambient) temperature. It is smaller the higher the cooling medium temperature becomes (cf. the right term of the differential equation).

The thermal replica can be reset, i.e. the current–dependent temperature rise is set to zero. This can be accomplished either by energizing the reset input (RS th Repl = reset thermal replica) or via the blocking input (Block overload protection). In the latter case the total protection function is blocked, including the warning stages.

The logic diagram of the overload protection is illustrated in Figure 4.15.

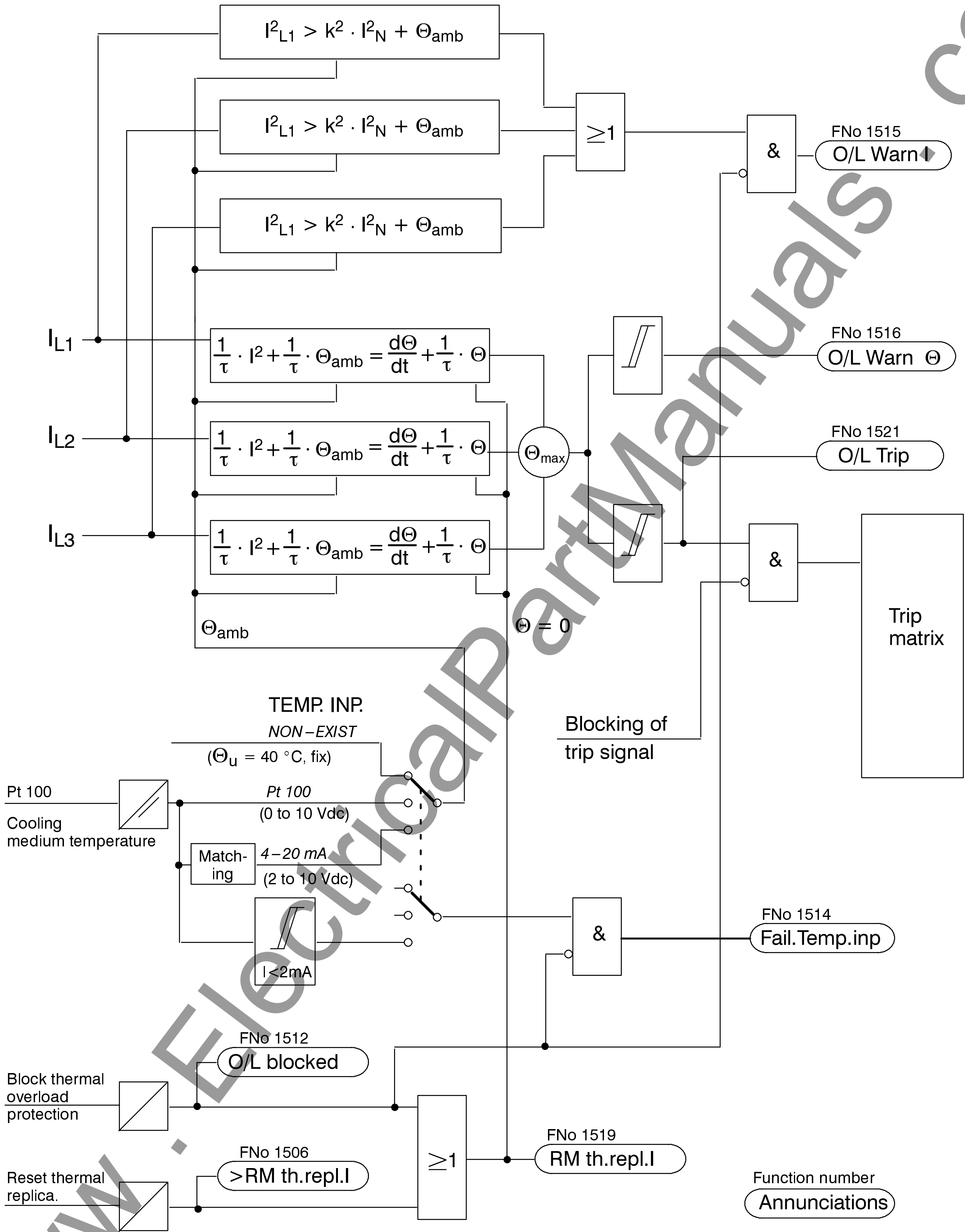


Figure 4.15 Logic diagram of the stator overload protection

4.13 External trip commands via binary inputs

Up to four desired signal from external protection or supervision units can be incorporated into the processing of 7UM511. 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 7UM511. 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 4.16. 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.

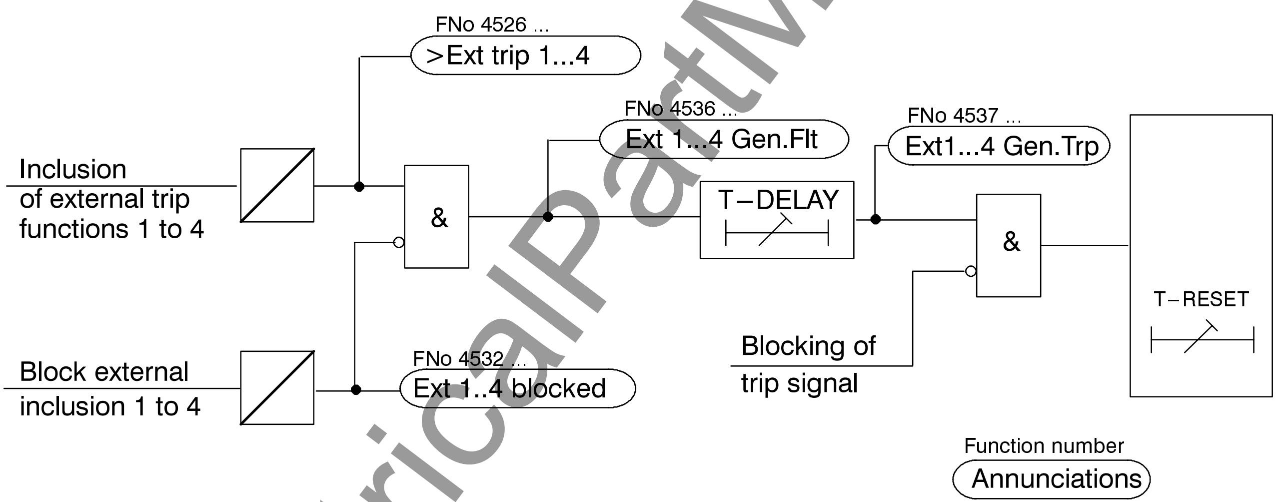


Figure 4.16 Logic diagram of one external trip command channel

4.14 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 turbo–set. 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 – might be removed during ”operating condition 1”.

But it is recommended that the reversed phase rotation signal be applied continuously, for safety reasons: Maloperation could occur when the processor system is reset, for example after alteration of the configuration parameters of the relay.

Figure 4.17 shows the logic diagram of the switch–over function of the phase rotation.

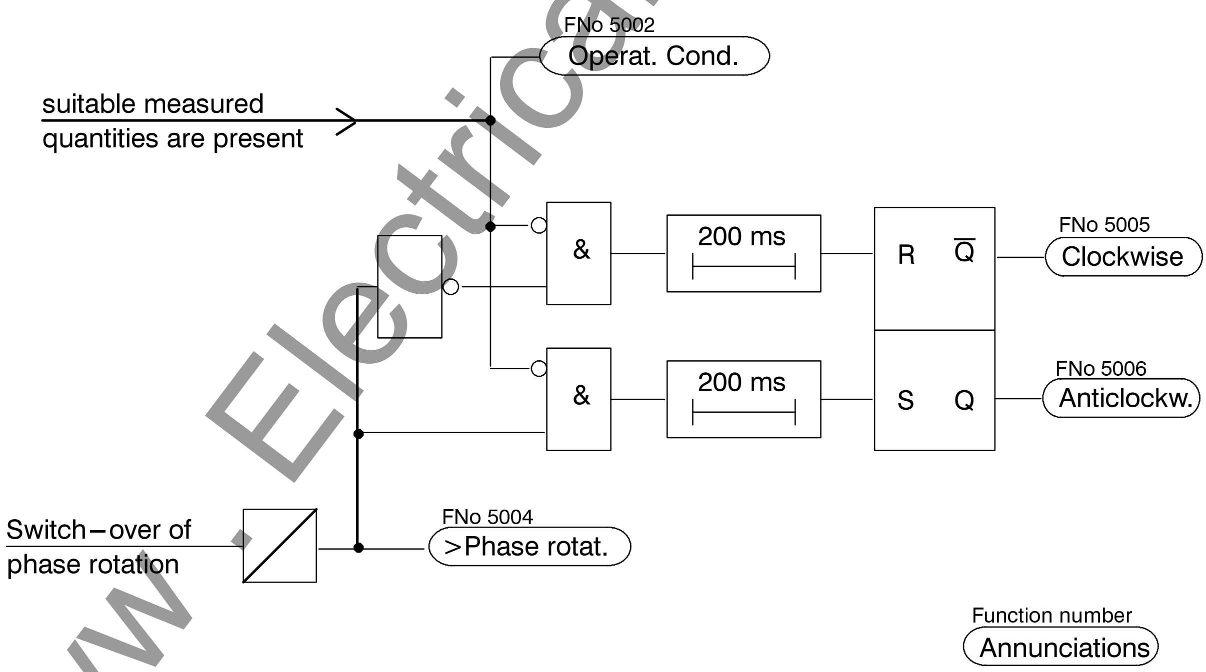


Figure 4.17 Logic diagram of the switch–over of the phase rotation

4.15 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 4.13, 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.

4.16 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 6.7.8).

4.17 Trip circuit supervision

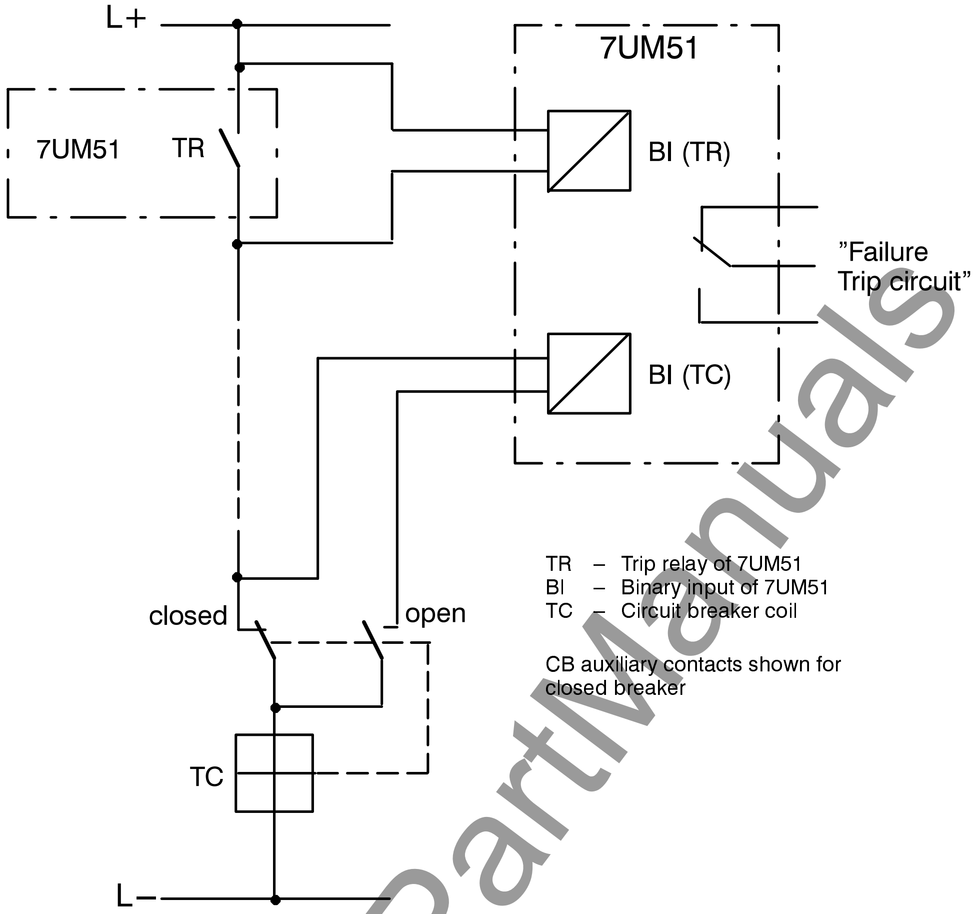
The numerical machine protection 7UM51 includes two trip circuit supervision functions. Two trip circuits can be supervised. Two binary inputs must be reserved for each trip circuit supervision. They have to be connected as shown in Figure 4.18. One input is connected in parallel to the trip relay the 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 4.18 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

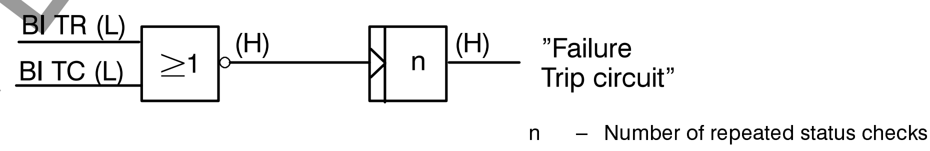


Figure 4.18 Principle of trip circuit supervision (one supervision channel)

4.18 Ancillary functions

The ancillary functions of the machine protection 7UM511 include:

– Processing of annunciations,

– Storage of short circuit data for fault recording,

– Operational measurements and testing routines,

– Monitoring functions.

4.18.1 Processing of annunciations

After a fault in the protected 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.

4.18.1.1 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.

4.18.1.2 Information on the display panel or to a personal computer

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

In the quiescent state, i.e. as long as no 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 4.18.1.1.

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.

4.18.1.3 Information to a central unit

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

4.18.2 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}, i_e, u_{L1-N}, u_{L2-N}, u_{L3-N}, u_{exc}

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}, I_e, $I_{pos\ seq}$, $U_{pos\ seq}$, φ, $f-f_N$

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, read–out can proceed automatically, optionally after each pick–up of the relay or only after a trip. The following then applies:

– The relay signals the availability of fault record data,

– The data remain available for recall until commencement of the next fault event.

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

4.18.3 Operating measurements and conversion

For local recall or transmission of data, the true r.m.s. values of the currents and voltages are always available as are the positive sequence components of the currents and voltages.

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_{L1E}, U_{L2E}, U_{L3E} voltages (phase–earth) in kilovolts primary and in V secondary,
- $\sqrt{3} \cdot U_{pos}$ positive sequence voltage,
- I_e earth currents in milliamps.

Additionally, the active and reactive power, the power factor and power angle, the pole angle, the excitation voltage, the displacement voltage calculated from the three phase–to–earth voltages, the temperature rise and ambient temperature of the thermal overload protection as well as the frequency, the unbalanced load and the calculated rotor temperature rise can be read out.

The following is valid:

- P active power in % of $\sqrt{3} \cdot I_N \cdot U_N$,
- Q reactive power in % of $\sqrt{3} \cdot I_N \cdot U_N$,
- COS PHI power factor,
- PHI power angle,
- THETA pole angle,
- $U_{excit.}$ excitation voltage,
- f [Hz] frequency in Hz,
- $\sqrt{3} \cdot U_0$ displacement voltage = $(U_{L1} + U_{L2} + U_{L3})/\sqrt{3}$,
- $I_{neg.seq}$ unbalanced load current,
- ThermRepl. temperature rise calculated from the unbalanced load current,
- Θ/Θ_{tripL*} the calculated temperature rise for each phase in % of the trip temperature rise,
- AMB.TEMP ambient temperature in °C (if connected and accordingly matched).

4.18.4 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.

4.18.4.1 Hardware monitoring

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

- Auxiliary and reference voltages

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

  Failure or switch–off of the auxiliary voltage automatically puts the system out of operation; this status is indicated by a fail–safe contact. Transient dips in supply voltage of less than 50 ms will not disturb the function of the relay (rated auxiliary voltage $\geq$ 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 6.3.15). 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 4.19).

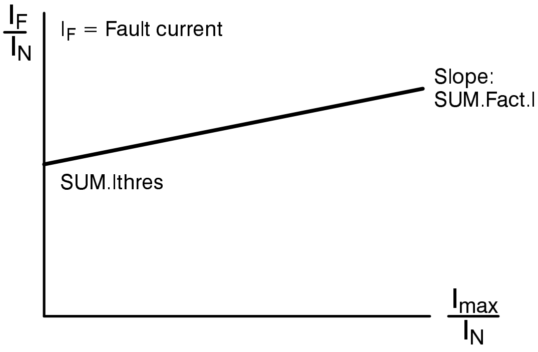


Figure 4.19 Current sum monitoring

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.

4.18.4.2 Software monitoring

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

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

4.18.4.3 Monitoring of external measuring transformer circuits

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

– Current symmetry

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

$$|I_{min}| / |I_{max}| < \text{SYM.Fact.I}$$
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 4.20). Both parameters can be set (see Section 6.3.15).

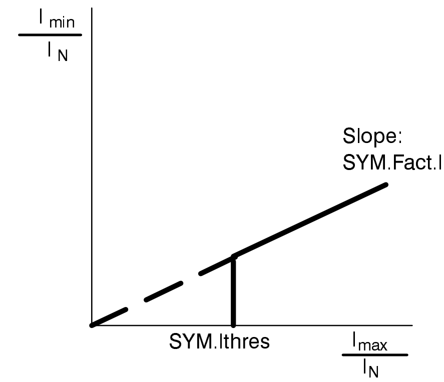


Figure 4.20 Current symmetry monitoring

– Voltage symmetry

In healthy operation it can be expected that the voltages will be approximately symmetrical. Therefore, the device checks the three phase–to–phase voltages for symmetry. Monitoring of the symmetry of the phase–to–phase voltages is not influenced by earth faults.

The following applies:

$| U_{min} | / | U_{max} | < \text{SYM.Fact.U}$
if
$| U_{max} | > \text{SYM.Uthres}$

whereby U_{max} is the largest of the three voltages and U_{min} the smallest. The symmetry factor SYM.Fact.U represents the magnitude of the asymmetry of the voltages. The threshold SYM.Uthres is the lower limit of the processing area of this monitoring function (see Figure 4.21). Both parameters can be set (see Section 6.3.15).

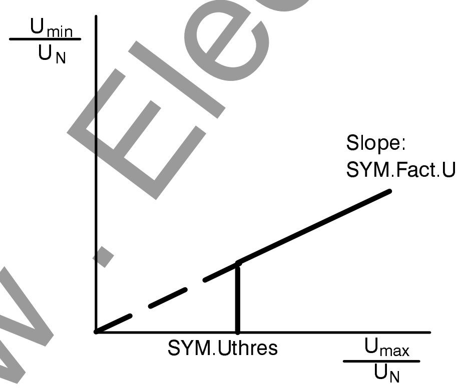


Figure 4.21 Voltage symmetry monitoring

– Phase rotation

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

U_{L1} before U_{L2} before U_{L3}

This check is carried out when the measured voltages as described in 4.18.4.1 are plausible and have a minimum value of at least

$|U_{L1}|, |U_{L2}|, |U_{L3}| > 40 \text{ V}/\sqrt{3}$

Counter–clockwise rotation will cause an alarm.

If no voltages are present for phase sequence measurement, the currents are checked for their phase rotation. This requires that each phase current is at least 0.1 times rated current.

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 4.14). 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 $\lvert i_{L1} + i_{L2} + i_{L3} \rvert >$ **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 $\frac{\lvert I_{min} \rvert}{\lvert I_{max} \rvert}$ < **SYM.Fact.I** and $\lvert I_{max} \rvert$ > **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. Voltage unbalance (phase−phase) $\frac{\lvert U_{min} \rvert}{\lvert U_{max} \rvert}$ < **SYM.Fact.U** and $\lvert U_{max} \rvert$ > **SYM.Uthres**	Short−circuit or interruption (1−phase, 2−phase) in v.t. secondary circuits or unbalanced voltage on the system delayed alarm "`Failure Usymm`"
4. Phase rotation L1 before L2 before L3, as long as $\lvert U_{L1} \rvert, \lvert U_{L2} \rvert, \lvert U_{L3} \rvert > 40\ V/\sqrt{3}$ and/or $\lvert I_{L1} \rvert, \lvert I_{L2} \rvert, \lvert I_{L3} \rvert > 0.1 \cdot I_N$ (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 7UM511*--*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 7UM511*–*C*** for panel flush mounting or 7UM511*–*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.

– The screw–type terminals should be used *without* wire end ferrules. Pin–end connectors generally must not be used. Care has to be taken for a sufficiently long bare wire: approx. 15 mm (6/10 inch), at least 10 mm (4/10 inch).

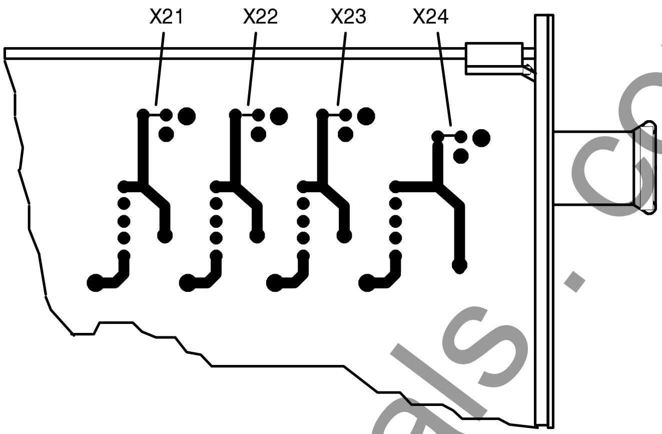
5.2.2 Checking the rated data

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

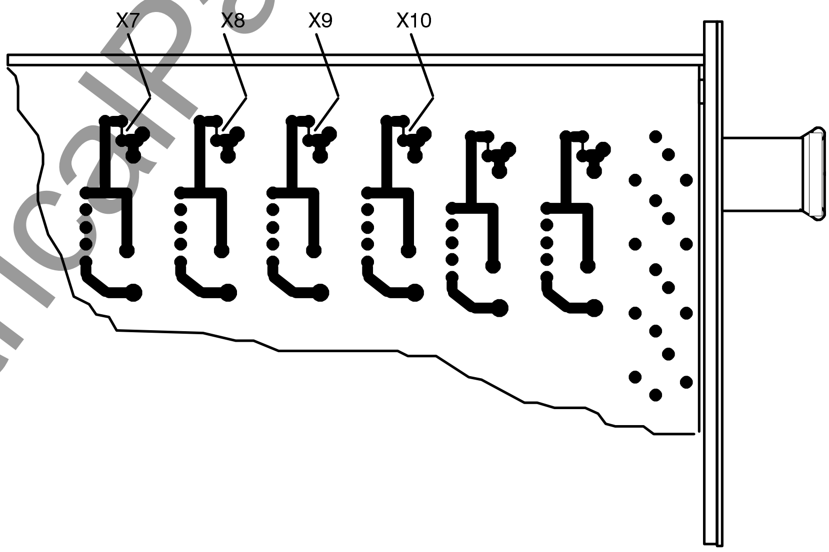
Binary input 2 : Solder bridge X22

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 threshold approx. 16 V
For rated voltages 110/125/220/250 V– :	Solder bridges may be removed: Cut and bend aside. Pick–up threshold 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 threshold approx. 16 V
For rated voltages 110/125/220/250 V– :	Solder bridges may be removed: Cut and bend aside. Pick–up threshold 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.

The battery is already installed at delivery in newer models. It should be checked according to Section 7.2 that the battery is correctly in place.

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 one line end only. This prevents circulating currents from flowing via the screen in case of potential differences.

Transmission via optical fibre is recommended. It is particularly insensitive against disturbances and automatically provides galvanic isolation. Transmit and receive connector are designated with the symbols ●⟶ 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"

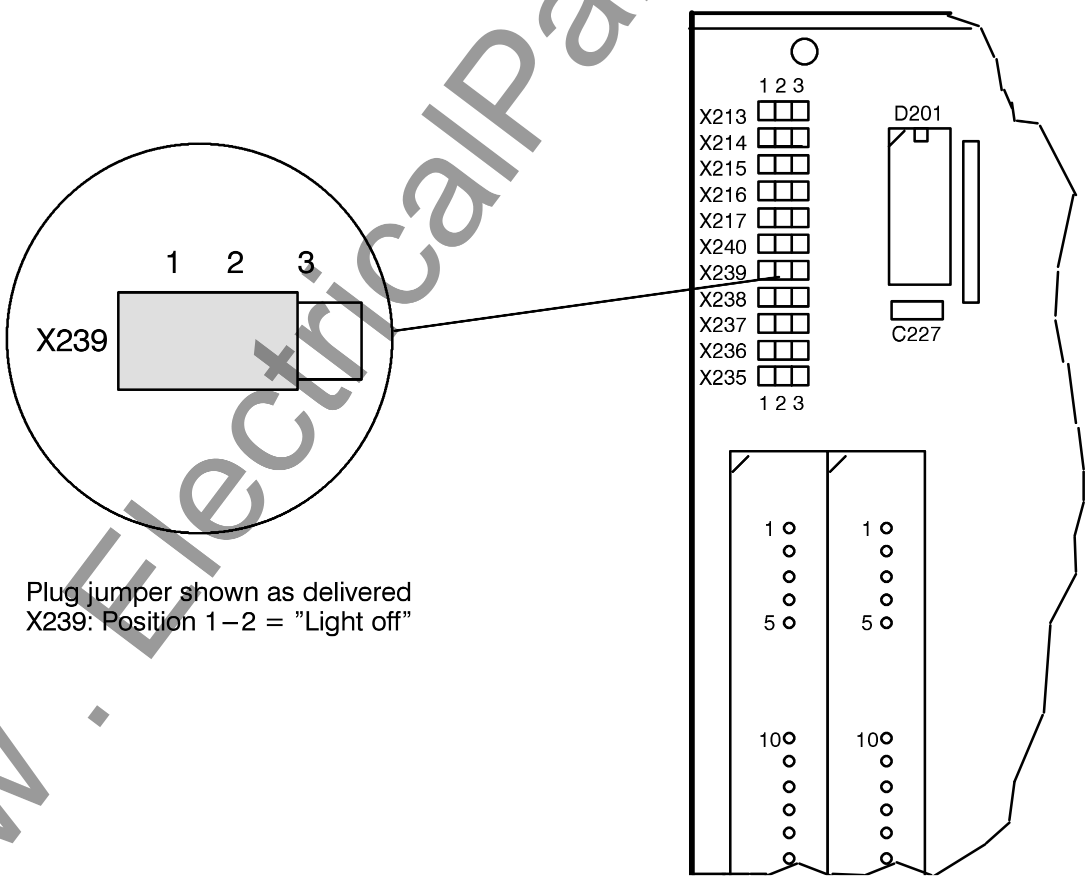


Figure 5.3 Position of the jumper X239 on the power supply board

5.2.5 Connections

General and connection diagrams are shown in Appendix B. The scope of connections between machine and 7UM511 depends on how the different protection functions are used. The connections are generally executed as follows:

Underexcitation protection, overcurrent time protection, **thermal overload protection, power protection,** and **unbalanced load protection** are connected to current transformers in the starpoint leads of the protected machine.

For processing of the excitation d.c. voltage, a voltage divider, e.g. type 3PP1326– 0BZ–012009 with ratios of 20:10:1 must be inserted, because the largest setting value is 8.0 V. The thermal overload capability of the input must be observed (Section 3.1.1).

The displacement voltage for **stator earth fault protection U_0** is calculated internally from the three phase–to–earth voltages; it needs no special connections.

The **highly sensitive earth current protection** can optionally be used for detection of stator earth faults or rotor earth faults. If it is used for **stator earth fault protection**, the earth current is supplied to the unit by a toroidal transformer. Figure 5.4 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 5.5) is also possible. 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–A1–7600.

A connection example for the highly sensitive earth current protection as **rotor earth fault protection** is shown in Figure 5.6. In this case an external a.c. voltage source of approximately 45 V is required, e.g. from the auxiliary unit 7XR6100 (Figure 5.6). 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 possible with the auxiliary unit 7XR8500–0, the coupling unit 7XR6000 and the resistor unit 3PP1336–0DZ– 013002.

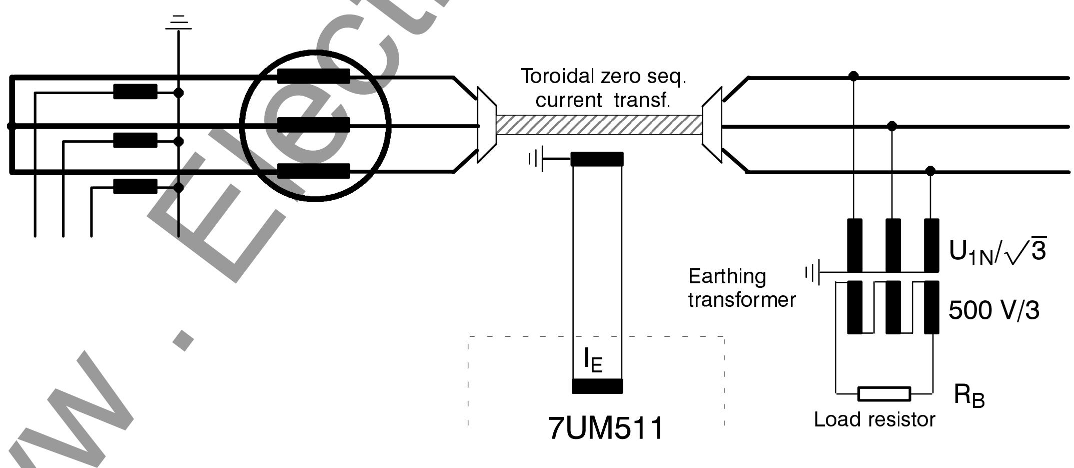


Figure 5.4 Connections for the highly sensitive earth current protection as stator earth fault protection, machines in bus–bar connection (with toroidal zero sequence current transformer)

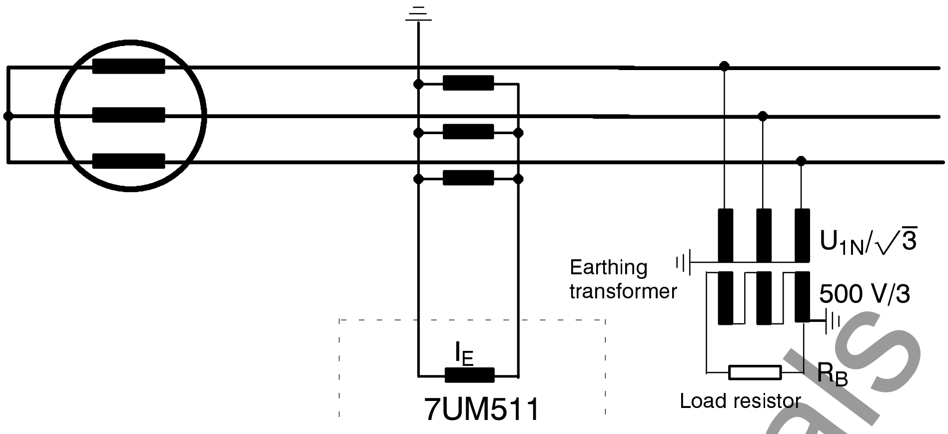


Figure 5.5 Connections for the highly sensitive earth current protection as stator earth fault protection, machines in bus–bar connection (current transformers in Holmgreen connection)

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.

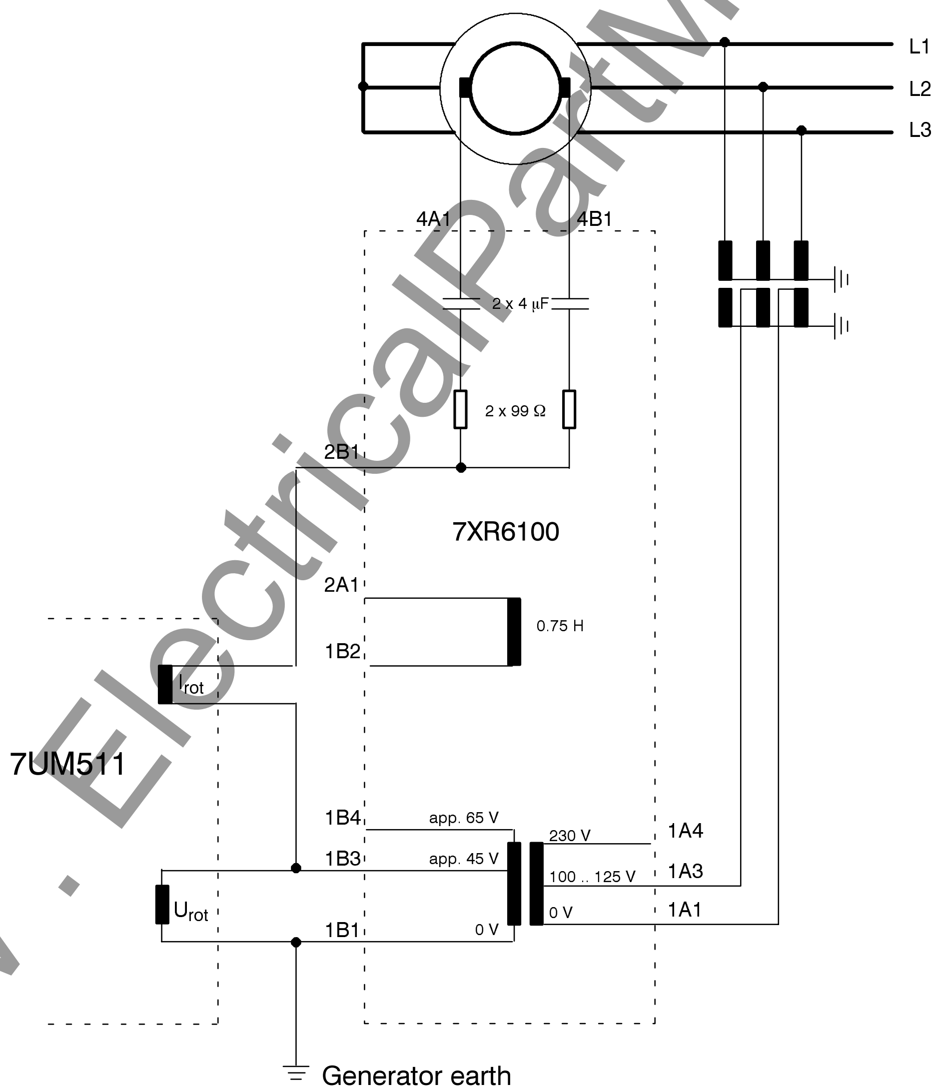


Figure 5.6 Connections for the highly sensitive earth current protection as rotor earth fault protection

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?
- Is the earth current transformer correctly earthed (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 the connection and the transformation ratio of excitation voltage divider correct (if used)?
- Is the polarity of the excitation voltage correct (if used)?
- Is the polarity of remote ambient temperature meter 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 5 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 7UM511 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.

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

```
CW ACCEPTED
```

```
CODEWORD WRONG
```

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

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

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

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

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

Beginning of the block "Operating system configuration"

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

```
⇑  7 1 0 0 █ I N T E G R A T E D
⇓  O P E R A T I O N
```

Beginning of the block "Integrated operation"

```
↑  7 1 0 1 █ L A N G U A G E
↓  D E U T S C H

   E N G L I S H
```

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
```

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

the first protection function which has picked up,

```
Prot.Trip
```

the latest protection function, which has tripped,

```
T-Fault
```

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

```
T-Trip
```

the elapsed time from pick–up to trip command.

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

etc.

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

the possibilities are the same as under address 7107.

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 pre−set 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 VDEW/ZVEI; for 7UM511 no. 70.
This address is mainly for information, it should not be changed.

```
7209█ DEVICE TYPE
14
```

Device type for identification of the device in Siemens LSA 678 and DIGSI®. For 7UM511 V3 no. 14
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	The transmission Baud–rate for communication via the PC (operating) interface at the front can be adapted to the operator's communication interface, e.g. personal computer, if necessary. The available possibilities can be displayed by repeatedly depression of the "No"–key **N**. Confirm the desired Baud–rate with the entry key **E**.
19200 BAUD	
1200 BAUD	
2400 BAUD	
4800 BAUD	

7216 PC PARITY DIGSI V3	Parity and stop–bits for the PC (operating) interface: format for Siemens protection data processing program *DIGSI®* Version *V3* with 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 *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/DIGSI V3/LSA	Parity and stop–bits for the system (LSA) interface: format for *VDEW*–protocol 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 4.18.2). Distinction must be made between the reference instant and the storage criterion (address 7402). Normally, the general fault detection signal of the protection is the reference instant. The storage criterion can be the general fault detection, too (*STORAGE BY FD*), or the trip command (*STORAGE BY TRIP*). Alternatively, the trip command can be selected as reference instant (*START WITH TRIP*), in this case, the trip command is the storage criterion, too.

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 7UM511 is capable of providing a series of protection and supplementary functions. The scope of the hard– and firm–ware is matched to these functions. Furthermore, individual functions can be set (configured) to be effective or non–effective. 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 7UM511: 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"

Underexcitation protection:

```
7801 UNDEREXCIT.
EXIST

NON-EXIST
```

Undervoltage protection:

```
7802 UNDERVOLT.
EXIST

NON-EXIST
```

Overvoltage protection:

```
7803 OVERVOLT.
EXIST

NON-EXIST
```

Stator earth fault protection:

```
7804 SEF PROT.
EXIST

NON-EXIST
```

Frequency protection:

```
7805 FREQUENCY
EXIST

NON-EXIST
```

Forward power supervision:

```
7806 FOR. POWER
EXIST

NON-EXIST
```

Reverse power protection:

```
7807 REV. POWER
EXIST

NON-EXIST
```

Unbalanced load protection:

```
7808 UNBAL. LOAD
EXIST

NON-EXIST
```

Overcurrent time protection, I> – stage:

```
7809█ O/C I>
EXIST

NON-EXIST
```

Overcurrent time protection, I>> – stage:

```
7810█ O/C I>>
EXIST

NON-EXIST
```

Highly sensitive earth current protection:

```
7811█ O/C Ie>
EXIST

NON-EXIST
```

Thermal overload protection:

```
7812█ OVERLOAD
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
```

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 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 7UM511 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 7UM511 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 a "F". The display shows, in the upper line, the physical input/output unit, this time with a three digit index number. The second display line shows the logical function which is presently allocated.

On this selection level the allocated function can be changed by pressing the "No"–key **N**. By repeated use of the key **N** all marshallable functions can be paged through the display. Back–paging is possible with the backspace key **R**. When the required function appears press the execute key **E**. After this, further functions can be allocated to the same physical input or output module (with further index numbers) by using the key ↑. **Each selection must be confirmed by pressing the key E!** If a selection place shall not be assigned to a function, selection is made with the function "`not allocated`".

You can leave the selection level by pressing the key combination **F** ↑ (i.e. depressing the function key **F** followed by the arrow key ↑). The display shows again the four digit address number of the physical input/output module. Now you can page with key ↑ to the next input/output module or with ↓ to the previous to repeat selection procedure, as above.

The logical functions are also provided with function numbers which are equally listed in the tables. If the function number is known, this can be input directly on the selection level. Paging through the possible functions is then superfluous. With direct input of the function number, leading zeros need not be entered. After input of the function number, use **the 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 several binary inputs, because an OR−logic of the signals can not be guaranteed!

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

⇑⇓
```
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

↑↓
```
002 INPUT 1
not allocated
```
No further functions are initiated by binary input 1

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

FNo	Abbreviation	Description
1	not allocated	Binary input is not allocated to any input function
3	>Time Synchro	Synchronize internal real time clock
4	>Start FltRec	Start fault recording from external command via binary input
5	>LED reset	Reset 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
1503	>O/L block	Block thermal overload protection
1506	>RM th.repl.I	Reset memory for thermal replica of stator overload protection
1721	>I>> block	Block overcurrent time protection stage I>>
1722	>I> block	Block overcurrent time protection stage I>
1725	>IE> block	Block overcurrent time protection stage IE>
1950	>Useal-in blk	Block undervoltage seal−in of overcurrent time protection
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
5083	>Pr block	Block reverse power protection $P_{rev}>$
5086	>SV tripped	Stop valve tripped
5113	>Pf block	Block forward power supervision $P_f><$
5116	>Pf< block	Block forward power supervision $P_f<$
5117	>Pf> block	Block forward power supervision $P_f>$
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 $U_0>$
5203	>Frq. block	Block frequency protection
5206	>f1 block	Block frequency protection stage f1
5207	>f2 block	Block frequency protection stage f2
5208	>f3 block	Block frequency protection stage f3
5209	>f4 block	Block frequency protection stage f4
5323	>Exc. block	Block underexcitation protection
5326	>Char.1/2 blk	Block characteristic 1/2 of underexcitation protection
5327	>Char. 3 blk	Block characteristic 1/2 of underexcitation protection
5328	>Uexc fail.	Excitation voltage failure
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 >Pf block NO	5113	Block forward power supervision
6103	BINARY INPUT 3	INPUT 3 >Pr block NO	5083	Block reverse power protection
6104	BINARY INPUT 4	INPUT 4 >f1 block NO >f2 block NO >f3 block NO	5206 5207 5208	Block frequency protection stages f1 to f3
6105	BINARY INPUT 5	INPUT 5 >Uexc fail. NO	5328	Failure of excitation voltage
6106	BINARY INPUT 6	INPUT 6 >SV tripped NO	5086	Stop valve tripped
6107	BINARY INPUT 7	INPUT 7 >Ext trip 1 NO	4526	External trip signal 1
6108	BINARY INPUT 8	INPUT 8 >Ext trip 2 NO	4546	External trip signal 2

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 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 third signal relay 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
↓ U> trip
```

Signal relay 3 has been preset for:
1st: Overvoltage protection U> trip, FNo 6570;

```
↑ 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.	At least one 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
167	Failure Usymm	Failure supervision symmetry U
171	Fail.PhaseSeq	Failure supervision phase sequence
502	Dev. Drop-off	General drop–off of device
1503	>O/L block	Block thermal overload protection
1506	>RM th.repl.I	Reset memory for thermal replica of stator overload protection
1511	O/L Prot. off	Thermal overload protection is switched off
1512	O/L/ blocked	Thermal overload protection is blocked
1513	O/L active	Thermal overload protection is active
1514	Fail.Temp.inp	Failure in cooling medium temperature input circuit
1515	O/L Warn I	Thermal overload protection: Current warning stage
1516	O/L Warn Θ	Thermal overload protection: Thermal warning stage
1519	RM th.repl.I	Reset thermal replica of stator earth fault protection
1521	O/L Trip	Thermal overload protection trip
1721	>I>> block	Block overcurrent time protection stage I>>
1722	>I> block	Block overcurrent time protection stage I>
1725	>IE> block	Block overcurrent time protection stage IE>
1801	I>> Fault L1	Overcurrent fault detection stage I>> phase L1
1802	I>> Fault L2	Overcurrent fault detection stage I>> phase L2
1803	I>> Fault L3	Overcurrent fault detection stage I>> phase L3
1805	I>> Trip	Overcurrent fault detection I>> phase trip
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
1834	IE> Fault	Overcurrent fault detection IE> earth
1836	IE> Trip	Overcurrent fault detection IE> earth trip
1950	>Useal-in blk	Block undervoltage seal–in of overcurrent time protection

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

FNo	Abbreviation	Description
1955	I>> off	Overcurrent time protection stage I>> is switched off
1956	I>> blocked	Overcurrent time protection stage I>> is blocked
1957	I>> active	Overcurrent time protection stage I>> is active
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
1980	Ie> off	High–sensitivity earth current protection is switched off
1981	Ie> blocked	High–sensitivity earth current protection is blocked
1982	Ie active	High–sensitivity earth current protection is active
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
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	Anticlockw.	Counter–clockwise phase rotation
5083	>Pr block	Block reverse power protection P_{rev}>
5086	>SV tripped	Stop valve tripped
5091	Pr off	Reverse power protection is switched off
5092	Pr blocked	Reverse power protection is blocked
5093	Pr active	Reverse power protection is active
5096	Pr fault det.	Reverse power protection: fault detection
5097	Pr Trip	Reverse power protection: trip command issued
5098	Pr+SV Trip	Reverse power protection: trip with stop valve tripped
5113	>Pf block	Block forward power supervision P_f><
5116	>Pf< block	Block forward power supervision P_f<
5117	>Pf> block	Block forward power supervision P_f>

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

FNo	Abbreviation	Description
5121	Pf off	Forward power supervision is switched off
5122	Pf blocked	Forward power supervision is blocked
5123	Pf active	Forward power supervision is active
5126	Pf< flt. det.	Forward power supervision: fault detection of Pf< stage
5127	Pf> flt. det.	Forward power supervision: fault detection of Pf> stage
5128	Pf< Trip	Forward power supervision: trip command by Pf< stage
5129	Pf> Trip	Forward power supervision: trip command by Pf> stage
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 Θ Trip	Unbalanced load protection: trip by thermal stage
5173	>U0> block	Block stator earth fault protection U_0>
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
5187	U0> Trip	Stator earth fault protection: trip command issued
5203	>Frq. block	Block frequency protection
5206	>f1 block	Block frequency protection stage f1
5207	>f2 block	Block frequency protection stage f2
5208	>f3 block	Block frequency protection stage f3
5209	>f4 block	Block frequency protection stage f4
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
5220	f3> Fault	Frequency protection: fault detection of f3>–stage
5221	f3< Fault	Frequency protection: fault detection of f3<–stage
5222	f4> Fault	Frequency protection: fault detection of f4>–stage
5223	f4< Fault	Frequency protection: fault detection of f4<–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<
5228	f3> Trip	Trip by overfrequency protection stage f3>
5229	f3< Trip	Trip by underfrequency protection stage f3<
5230	f4> Trip	Trip by overfrequency protection stage f4>
5231	f4< Trip	Trip by underfrequency protection stage f4<
5323	>Exc. block	Underexcitation protection blocked
5326	>Char.1/2 blk	Underexcitation protection: characteristic 1 and 2 are blocked
5327	>Char. 3 blk	Underexcitation protection: characteristic 3 is blocked
5328	>Uexc fail.	Excitation voltage failure

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

FNo	Abbreviation	Description
5331	Excit. off	Underexcitation protection is switched off
5332	Excit.blocked	Underexcitation protection is blocked
5333	Excit.active	Underexcitation protection is active
5334	Exc. U< blk	Underexcitation protection U< stage is blocked
5336	Uexc failure	Excitation voltage failure (underexcitation protection)
5337	Exc< Fault	Underexcitation protection: fault detection
5341	Exc< Trip	Underexcitation protection: trip general
5342	Exc<U<Trip	Underexcitation protection: trip by U< stage (char. 1&2& U_{exc}<)
5343	Exc<< Trip	Underexcitation protection: trip by U<< stage (characteristic 3)
5396	Failure R/E/F	Failure in measuring circuit of high−sensitivity earth current protection (when used as rotor earth fault protection)
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< block	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>
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 1

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	1805	Trip by overcurrent time protection: I>> phases
6203	SIGNAL RELAY 3	RELAY 3 U> trip	6570	Trip by overvoltage protection U>
6204	SIGNAL RELAY 4	RELAY 4 f1< Trip	5225	Trip by frequency protection: stage f1<
6205	SIGNAL RELAY 5	RELAY 5 Pr Trip	5097	Trip by reverse power protection
6206	SIGNAL RELAY 6	RELAY 6 Pr+SV Trip	5098	Reverse power protection: Trip command with stop valve tripped
6207	SIGNAL RELAY 7	RELAY 7 Exc< Trip	5341	Trip by underexcitation protection: characteristics 1 and/or 2 has been passed
6208	SIGNAL RELAY 8	RELAY 8 Exc<< Trip	5343	Trip by underexcitation protection: characteristic 3 have be passed
6209	SIGNAL RELAY 9	RELAY 9 O/L Trip	1521	Trip by thermal stator overload protection
6210	SIGNAL RELAY 10	RELAY 10 O/L Warn	1516	Thermal stator overload protection: Thermal warning stage
6211	SIGNAL RELAY 11 RELAY 11	RELAY 11 I2>> Trip I2 Θ Trip	5160 5161	Trip by unbalanced load protection
6212	SIGNAL RELAY 12	RELAY 12 Exc< Fault	5337	Pick–up underexcitation protection
6213	SIGNAL RELAY 13	RELAY 13*) Dev.operative	51	Device operative*); the NC contact can be used for ”Device faulty” annunciation

*) permanently assigned, cannot be altered

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 3 0 0 E**. The selection procedure is carried out as described in Section 5.5.1. Multiple annunciations are possible, i.e. one logical annunciation function can be given to several LEDs (see also Section 5.5.1).

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

The marshallable annunciation functions are the same as those listed in Table 5.3. Annunciation functions are, of course, not effective when the corresponding protection function 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.

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

Beginning of the block "Marshalling of the LED indicators"

The desired marshallable LED is reached with the key ↑:

```
6 3 1 4 █ L E D   1 4
```

Allocations for LED 14

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

```
0 0 1 █ L E D   1 4
F a i l u r e   5 V       n m
```

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

```
0 0 2 █ L E D   1 4
F a i l u r e   1 5 V     n m
```

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

```
0 0 3 █ L E D   1 4
F a i l u r e   2 4 V     n m
```

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

```
0 0 4 █ L E D   1 4
F a i l u r e   0 V       n m
```

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

```
0 0 5 █ L E D   1 4
n o t   a l l o c a t e d
```

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	 U> trip m	 6570	Trip by overvoltage protection U>
6303	LED 3 LED 3	 f1< Trip m	 5225	Trip by frequency protection: stage f1<
6304	LED 4 LED 4	 Pr Trip m	 5097	Trip by reverse power protection
6305	LED 5 LED 5	 Pr+SV Trip m	 5098	Reverse power protection: Trip with tripped stop valve
6306	LED 6 LED 6	 Pf< Trip m	 5128	Forward power supervision: trip command by Pf< stage
6307	LED 7 LED 7	 Exc< Trip m	 5341	Underexcitation protection trip by the indicated stage
6308	LED 8 LED 8	 Exc<< Trip m	 5343	
6309	LED 9 LED 9	 O/L Trip m	 1521	Trip by thermal stator overload protection
6310	LED 10 LED 10	 I> Fault L1 nm	 1811	Fault detections of overcurrent time protection
6311	LED 11 LED 11	 I> Fault L2 nm	 1812	
6312	LED 12 LED 12	 I> Fault L3 nm	 1813	
6313	LED 13 LED 13	 IE> Fault nm	 1834	Fault detection of highly sensitive earth current protection
6314	LED 14 LED 14 LED 14 LED 14 LED 14	 Failure 5V nm Failure 15V nm Failure 24V nm Failure 0V nm	 144 143 141 145	Failure in one of the internal d.c. supply circuits

Tabelle 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 3. 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.

```
6 4 0 0█ M A R S H A L L I N G
T R I P   R E L A Y S
```

Beginning of the block "Marshalling of the trip relays"

The desired trip relay is reached with the key ↑:

```
6 4 0 3█ T R I P
R E L A Y   3
```

Allocations for trip relay 3

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

```
0 0 1█ T R I P   R E L .   3
T e s t   T r i p   3
```

Trip relay 3 has been preset for:
1st: Trip by test trip function for trip relay 3, FNo 1177; this function is **fix allocated and cannot be changed!**

```
0 0 2█ T R I P   R E L .   3
I >   T r i p
```

Trip relay 3 has been preset for:
2nd: Trip by overcurrent time protection I> phases, FNo 1815

```
0 0 3█ T R I P   R E L .   3
P r   T r i p
```

Trip relay 3 has been preset for:
3rd: Trip by reverse power protection, FNo 5097

```
0 0 4█ T R I P   R E L .   3
P r + S V   T r i p
```

Trip relay 3 has been preset for:
4th: Trip by reverse power protection with tripped stop valve, FNo 5098

```
0 0 5█ T R I P   R E L .   3
U >   t r i p
```

Trip relay 3 has been preset for:
5th: Trip by overvoltage protection U>, FNo 6570

```
0 0 6█ T R I P   R E L .   3
U > >   T r i p
```

Trip relay 3 has been preset for:
6th: Trip by overvoltage protection U>>, FNo 6573

```
007█ TRIP REL. 3
Exc<U<Trip
```

Trip relay 3 has been preset for:
7th: Trip by underexcitation protection, characteristics 1/2 and U_{exc} failure,
FNo 5342

```
008█ TRIP REL. 3
Exc<< Trip
```

Trip relay 3 has been preset for:
8th: Trip by underexcitation protection,characteristic 3, FNo 5343

```
009█ TRIP REL. 3
not allocated
```

Trip relay 3 has been preset for:
9th: 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
1521	O/L Trip	Trip by thermal stator overload protection
1805	I>> Trip	Trip by overcurrent time protection I>> phases
1815	I> Trip	Trip by overcurrent time protection I> phases
1836	IE> Trip	Trip by high−sensitivity earth current protection
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
5097	Pr Trip	Trip by reverse power protection
5098	Pr+SV Trip	Trip by reverse power protection with stop valve tripped
5128	Pf< Trip	Trip by forward power supervision stage P_f<
5129	Pf> Trip	Trip by forward power supervision stage P_f>
5160	I2>> Trip	Trip by load unbalanced protection stage I2>>
5161	I2 Θ Trip	Trip by load unbalanced protection thermal stage
5187	U0> 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<
5228	f3> Trip	Trip by frequency protection, stage f3>
5229	f3< Trip	Trip by frequency protection, stage f3<
5230	f4> Trip	Trip by frequency protection, stage f4>
5231	f4< Trip	Trip by frequency protection, stage f4<
5341	Exc< Trip	Underexcitation protection: trip general
5342	Exc<U<Trip	Underexcitation protection: trip by U< stage (char. 1&2& U_{exc}<)
5343	Exc<< Trip	Underexcitation protection: trip by U<< stage (characteristic 3)
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	I2>> Trip	5160	
	TRIP REL. 1	I2 Θ Trip	5161	e.g. trip for network circuit breaker
	TRIP REL. 1	U< Trip	6539	
	TRIP REL. 1	f1 < Trip	5225	
6402	TRIP	RELAY 2		
	TRIP REL. 2	Test Trip 2 [1])	1176	
	TRIP REL. 2	I> Trip	1815	
	TRIP REL. 2	Pr Trip	5097	
	TRIP REL. 2	Pr+SV Trip	5098	
	TRIP REL. 2	U> Trip	6570	e.g. trip for generator circuit breaker
	TRIP REL. 2	U>> Trip	6573	
	TRIP REL. 2	Exc<U<Trip	5342	
	TRIP REL. 2	Exc<< Trip	5343	
	TRIP REL. 2	O/L Trip	1521	
6403	TRIP	RELAY 3		
	TRIP REL. 3	Test Trip 3 [1])	1177	
	TRIP REL. 3	I> Trip	1815	
	TRIP REL. 3	Pr Trip	5097	
	TRIP REL. 3	Pr+SV Trip	5098	e.g. trip for stop valve
	TRIP REL. 3	U> Trip	6570	
	TRIP REL. 3	U>> Trip	6573	
	TRIP REL. 3	Exc<U<Trip	5342	
	TRIP REL. 3	Exc<< Trip	5343	
6404	TRIP	RELAY 4		
	TRIP REL. 4	Test Trip 4 [1])	1178	
	TRIP REL. 4	I> Trip	1815	
	TRIP REL. 4	Pr Trip	5097	
	TRIP REL. 4	Pr+SV Trip	5098	e.g. trip for de−excitation
	TRIP REL. 4	U> Trip	6570	
	TRIP REL. 4	U>> Trip	6573	
	TRIP REL. 4	Exc<U<Trip	5342	
	TRIP REL. 4	Exc<< Trip	5343	
6405	TRIP	RELAY 5		
	TRIP REL. 5	Test Trip 5 [1])	1179	
	TRIP REL. 5	I> Trip	1815	
	TRIP REL. 5	U> Trip	6570	e.g. trip for station auxiliary supply change−over
	TRIP REL. 5	U>> Trip	6573	
	TRIP REL. 5	Exc<U<Trip	5342	
	TRIP REL. 5	Exc<< Trip	5343	

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

Table 5.7 Preset command functions for trip relays

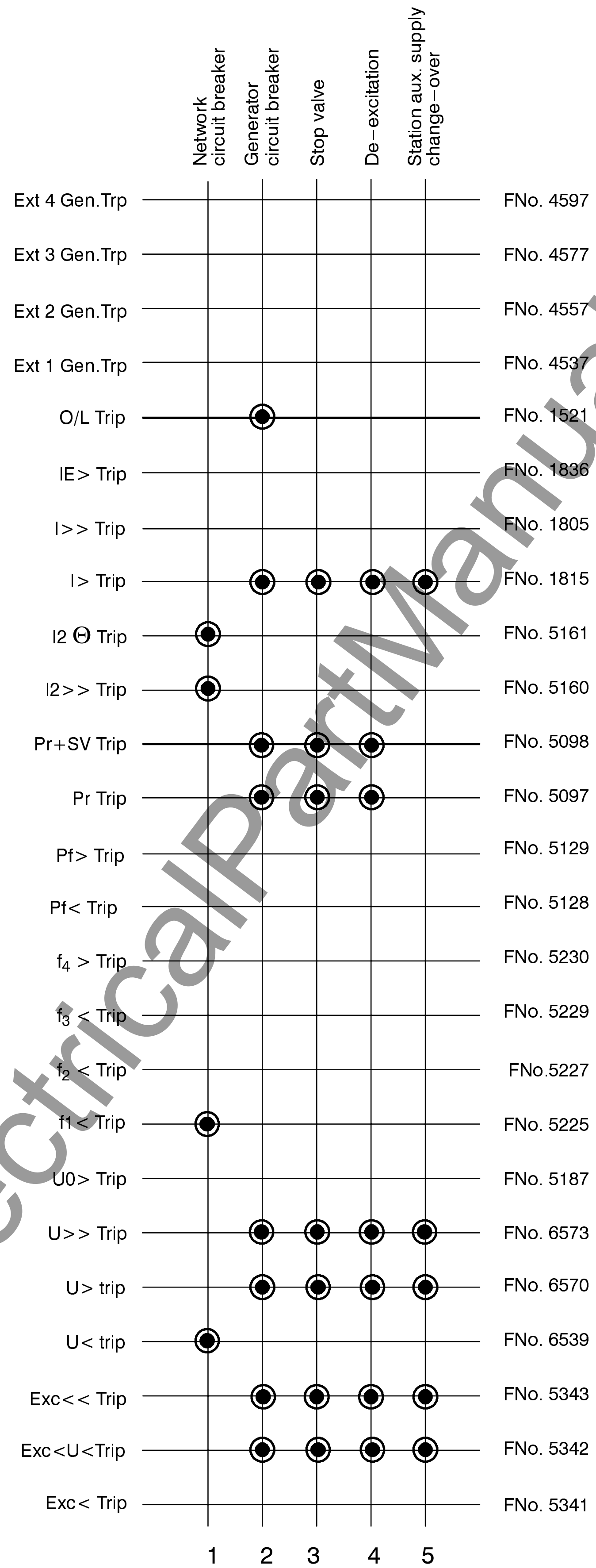


Figure 5.9 Tripping matrix − pre−settings

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,

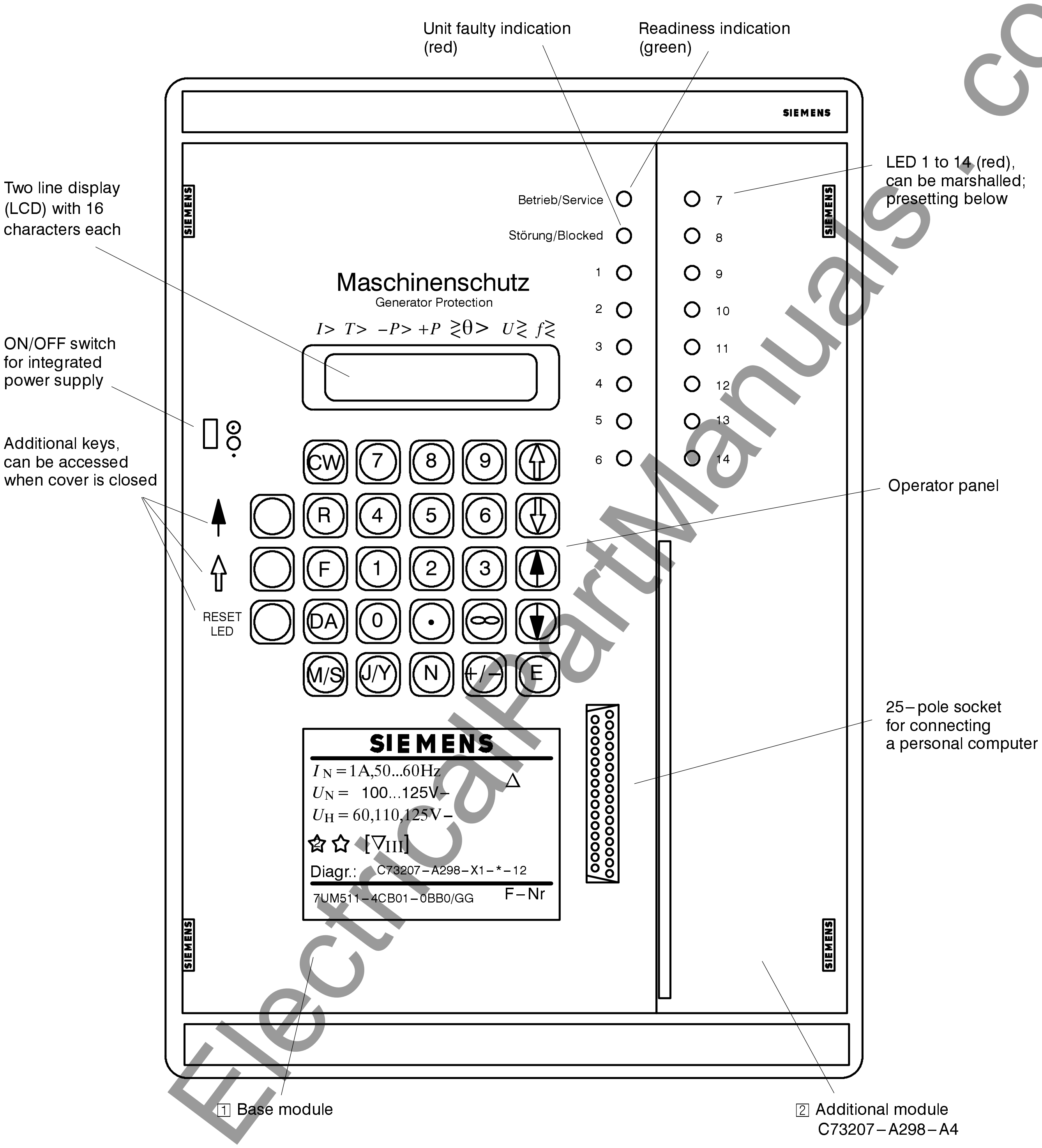
– configuration parameters for operating language, interface and device configuration,

– 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	Iph> Trip	6	Pf< Trip	11	IL2 Fault
2	U> Trip	7	Exc< Trip	12	IL3 Fault
3	f1< Trip	8	Exc<< Trip	13	Ie Fault
4	Pr Trip	9	O/L Trip	14	Device fault (hardware fault)
5	Pr+SV Trip	10	IL1 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	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 ↑.

```
↑ ↓
25.05.1996
15:58:26
```

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

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

```
 1 1 0 6 █ U n
1 0 . 5 0   k V
```

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

```
1107 ADMIT.1/xd
0.33
```

Reciprocal value of synchronous reactance
Setting range: **0.20** to **3.00**

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

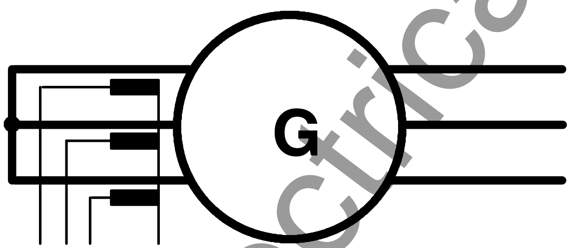
```
LOW-RESISTANCE
```

Type of starpoint earthing of machine

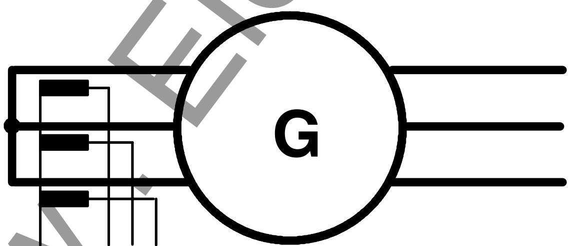
```
1200 INSTRUMENT
TRANSFORMER DATA
```

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.



a) CT STARPNT = *TOWARDS MACHINE*



b) CT STARPNT= *TOWRDS STARPOINT*

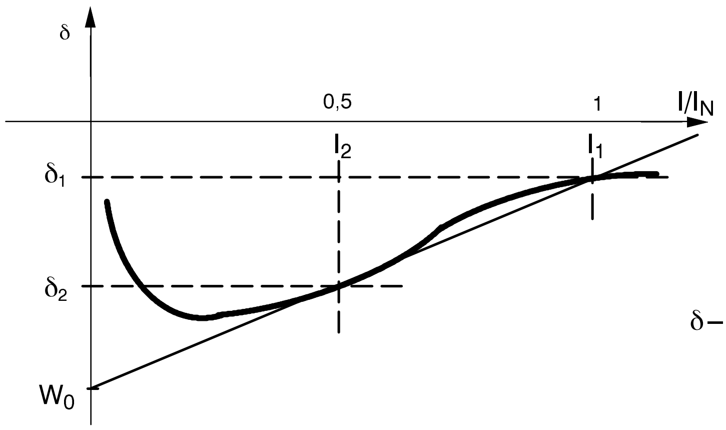
Figure 6.2 Generator/motor c.t. orientation – address 1205

The secondary rated voltage of the transformers (address 1204) is necessay for power protection and underexcitation protection.

For the 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 δ–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 6.7.6.2).



Characteristics of the line:

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

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 for current transformer
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 Section 6.7.6.2) .

6.3.4 Settings for underexcitation protection − address blocks 14 and 15

```
1400 UNDEREXCI.
FUNCTION
```

Beginning of the block
”Underexcitaton protection characteristic lines”

```
1401 UNDEREXCI.
OFF
```

Switch *OFF* of underexcitation protection function

```
ON
```

Switch *ON* of underexcitation protection function

```
BLOCK TRIP REL
```

Underexcitation protection operates but *TRIP REL*ay is *BLOCK*ed.

The instrument transformer data must be parameterized correctly as under Section 6.3.3.

The excitation voltage supervision is set to approximately 60 % to 70 % of the no−load excitation voltage. It must be noted that the unit, as a rule, is connected to the excitation voltage via a voltage divider.

Note: If very short delay times are would be set, undervoltage blocking may not operate fast enough to avoid tripping in case of secondary voltage collapse. It is recommended not to undergo the minimum delay times given below.

Setting the excitation voltage limit:

$$\text{EXCIT.VOLT. [V]} \approx 0.70 \times \frac{U_{exc-0}\ [V]}{k_U}$$

where U_{exc-0} – No−load excitation voltage
k_U – Voltage divider ratio

Example:

U_{exc-N} = 80 V
U_{exc-0} = 30 V
k_U = 10 : 1

$$\text{EXCIT.VOLT. [V]} \approx 0.70 \times \frac{30\ V}{10} = \underline{\underline{2.1\ V}}$$

```
1402 EXCI.VOLT.
OFF
```

Switch *OFF* of underexcitation voltage supervision

```
ON
```

Switch *ON* of underexcitation voltage supervision

```
1403 Uexcit.
2.00 V
```

Setting of excitation voltage supervision
Setting range: **0.50** V to **8.00** V

```
1404 T-Ch. 1/2
10.00 s
```

Long−time delay when exceeding characteristic 1 or 2 (steady−state stability limit)
Setting range: **0.05** s to **32.00** s
and ∞ (no trip with characteristics 1, 2)

```
1405 T-SHRT Ue<
1.50 s
```

Short−time delay when exceeding characteristic 1 or 2 (steady−state stability limit) and simultaneous excitation failure
Setting range: **0.05** s to **32.00** s
and ∞ (no trip)

```
1406 T-Ch. 3
1.50 s
```

Short−time delay when exceeding characteristic 3 (dynamic stability limit)
Setting range: **0.05** s to **32.00** s
and ∞ (no trip with characteristic 3)

```
1407 T-RESET.
2.00       s
```

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

The trip characteristics of the underexcitation protection are made up of straight lines in the admittance diagram. They are defined by their conductance intersect λ (= distance from the coordinate origin) and their angle of inclination α. The straight lines λ1/α1 (characteristic1) and λ2/α2 (characteristic 2) form the steady−state underexcitation limit (refer Figure 6.4). λ1 corresponds to the reciprocal value of the per unit synchronous reactance

$$\frac{1}{x_d} = \frac{1}{X_d} \times \frac{U_N}{\sqrt{3} \cdot I_N}$$

If the voltage regulator of the synchronous machine includes an underexcitation limiter, then the steady−state characteristics are adjusted such that the underexcitation limiter has a chance to operate before the protection picks up (refer Figure 6.5).

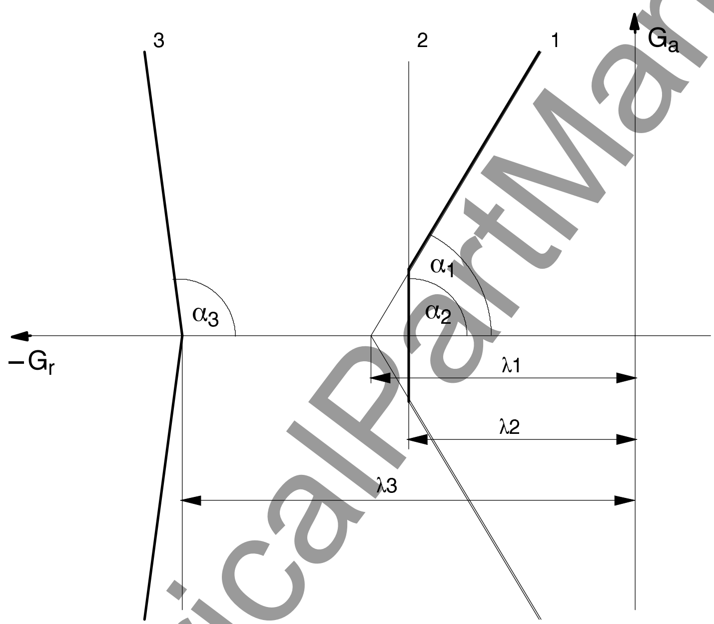


Figure 6.4 Underexcitation protection characteristics in the admittance plane

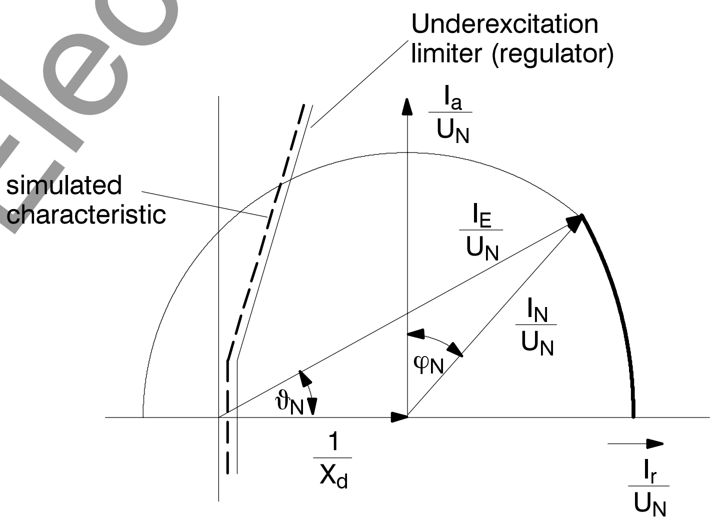


Figure 6.5 Admittance diagram of a turbo−generator

The rated machine data must be referred to secondary values to enable setting. Furthermore, it must be noted, that rated current and rated voltage of the machine in general are not equal to the rated data of the instrument transformers. Matching is performed according to the following formula:

$$\lambda = \frac{1}{x_{dsec}}$$

$$= \frac{1}{x_{dmach}} \cdot \frac{U_{Nsec}}{I_{Nsec}} \cdot \frac{I_{Nmach}}{U_{Nmach}} \cdot \frac{TR_U}{TR_I}$$

whereby:

- x_{dsec} – secondary per unit synchronous reactance
- x_{dmach} – per unit synchronous reactance of machine
- U_{Nsec} – secondary rated voltage (v.t. and unit)
- I_{Nsec} – secondary rated current (c.t. and unit)
- I_{Nmach} – Rated machine current
- U_{Nmach} – Rated machine voltage
- TR_U – Transformation ratio of voltage transformers
- TR_I – Transformation ratio of current transformers

Instead of $1/x_{dmach}$ one can set I_{K0}/I_N as an approximation.

Setting example:

Machine data: U_N = 10,500 V
I_N = 1,099 A
x_d = 230 % = 2.3

Current transformers: 1,200 A/1 A $TR_I = 1{,}200$

Voltage transformers: $\frac{10{,}000\ V}{\sqrt{3}} \Big/ \frac{100\ V}{\sqrt{3}}$

$TR_U = 100$

This results is a setting value of

$$\frac{1}{x_{dsec}} = \frac{1}{2.3} \cdot \frac{100\ V}{1\ A} \cdot \frac{1099\ A}{10500\ V} \cdot \frac{100}{1200}$$

$$= 0.38$$

$$\lambda 1 = \underline{\underline{0.40}}$$

which includes a safety factor of 1.05.

For α1, the angle of the underexcitation limiter of the voltage regulator is chosen or else the inclination angle is taken from the stability characteristic of the machine. α1 lies normally between 60° to 80°.

Characteristic 2 should intersect characteristic 1 at a small active load. λ2 is therefore set to approximately 0.9 x λ1, α2 to 90°. This results in the bent trip limit line as shown in Figure 6.4 (Characteristic 1, characteristic 2).

The protection can be matched to the dynamic stability limits of the machine with characteristic 3. If no other information is available, then a value between the synchronous reactance x_d and the transient reactance x_d' is chosen. However, the value should be greater than 1.

90° to 110° is usually chosen for angle α3, in order to ensure that only a dynamic instability leads to pick–up with characteristic 3.

```
1500 UNDEREXCI.
CHARACTERISTICS
```

Beginning of the block "Underexcitation protection – characteristic angles"

```
1501 LAMBDA 1
0.40
```

Conductance intersect λ1 of characteristic 1 Setting range: **0.25** to **3.00**

```
1502 ALPHA 1
80 deg
```

Inclination angle α1 of characteristic 1
Settting range: **50**° to **120**°

```
 1503█ LAMBDA  2
0.35
```

Conductance intersect λ2 of characteristic 2
Setting range: **0.25** to **3.00**

```
 1504█ ALPHA  2
90 deg
```

Inclination angle α2 of characteristic 2
Setting range: **50**° to **120**°

```
 1505█ LAMBDA  3
1.10
```

Conductance intersect λ3 of characteristic 3
Setting range: **0.25** to **3.00**

```
 1506█ ALPHA  3
90 deg
```

Inclination angle α3 of characteristic 3
Setting range: **50**° to **120**°

When steady−state limit characteristic consisting of characteristics 1 and 2 is exceeded, then the voltage regulator should be given an opportunity to increase the excitation. Therefore, a ”long−time” delayed alarm is initiated due to this criterion (at least 10 s). If, at the same time, the excitation voltage is absent, then the excitation circuit criterion also picks up (according to address 1402 /1403 or via binary input). In this case tripping can be executed with a short delay. The commonly used settings for alarms and trip commands are shown in the table below.

Characteristic 1 and 2 steady−state stability	not delayed	Annunciation: ”Pick−Up”
characteristic 1 and 2 steady−state stability	long−time delayed T−Ch. 1/2 ≈ 10 s	Alarm
characteristic 1 and 2 and excitation voltage failure	short−time delayed T−Ch. 1/2 + U< ≈ 1,5 s	Trip
characteristic 3 dynamic stability	short−time delayed T−Ch. 3 ≈ 1,5 s	Trip

Table 6.2 Setting of the underexcitation protection

Finally, the reset time of the underexcitation protection after tripping, can be set. All set delay times are additional delay times which do not include the operating times (measuring time, reset time) of the protection function itself.

6.3.5 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 REL*ay is *BLOCK*ed

---

The **undervoltage protection** is usually set to approximately 75 % of rated machine voltage. The time setting must be chosen such that voltage drops, which lead to unstable operation, are disconnected. The delay, however, should be long enough to avoid disconnection during permissible short–time voltage drops.

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

```
1602█ U<
75 V
```

Pick–up value of U< stage of undervoltage protection
Setting range: **20** V to **100** 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
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 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 **180** V

```
 1703 U>>
130 V
```

Pick–up value of U>> stage of overvoltage protection
Setting range: **30** V to **180** 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

6.3.7 Settings for stator earth fault protection U_0> – address block 19

```
1900█
EARTH FAULT U0>
```

Beginning of the block
"Earth fault protection U_0>"

```
1901█ 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 criterion for the inception of an earth fault in the stator circuit is the occurrence of a neutral displacement voltage. Exceeding the setting value U_0> (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. 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. The full displacement voltage corresponds to the rated secondary voltage of the voltage transformers.

Additionally, the pick–up value has to be chosen such that displacements during network earth faults which are transferred via the coupling capacitances of the unit 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.

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 6.7.4.

The earth fault trip is delayed by the time set under address 1903.

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

```
1902█ U0>
10.0 V
```

Pick–up value of earth fault detection
Setting range: **5.0** V to **100.0** V

```
1903█ T-U0>
0.30 s
```

Time delay for trip
Setting range: **0.00** s to **32.00** s
and ∞ (no trip with U_0>)

```
1904█ T-RESET
1.00 s
```

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

6.3.8 Settings for frequency protection − address block 21

```
 2100 OVER/UNDER
FREQUENCY
```

Beginning of the block
"Overfrequency and underfrequency protection"

```
 2101 f> / f<
OFF
```

Switch *OFF* of the frequency protection

```
ON
```

Switch *ON* of the frequency protection

```
BLOCK TRIP REL
```

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

Four high−accuracy 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.

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.

The operating time of the frequency protection stages depends on the set number of repeated measurements n, where the time period of the actual cycle must be considered. High−accuracy frequency calculation takes 3 a.c. cycles; thus, the operating time corresponds to 3 · n · cycle period. 2 to 10000 repeated measurements can be set for each frequency stage; this corresponds to approximately the following time delays:

at f = 50 Hz : 0.12 s to 600 s
at f = 60 Hz : 0.10 s to 500 s

```
 2102 f STAGE 1
49.50 Hz
```

Pick−up value of the frequency stage f_1
Setting range: **40.00** Hz to **65.00** Hz
The preset value results in an underfrequency stage

```
 2103 MEA.REP.f1
10
```

Number of measurement repetitions (3 a.c. periods each) for frequency stage f_1
Setting range: **2** to **10000**

```
 2104█ f  STAGE  2
49.00  Hz
```

Pick–up value of the frequency stage f_2
Setting range: **40.00** Hz to **65.00** Hz
The preset value results in an underfrequency stage

```
 2105█ MEA.REP.f2
10
```

Number of measurement repetitions (3 a.c. periods each) for frequency stage f_2
Setting range: **2** to **10000**

```
 2106█ f  STAGE  3
48.00  Hz
```

Pick–up value of the frequency stage f_3
Setting range: **40.00** Hz to **65.00** Hz
The preset value results in an underfrequency stage

```
 2107█ MEA.REP.f3
10
```

Number of measurement repetitions (3 a.c. periods each) for frequency stage f_3
Setting range: **2** to **10000**

```
 2108█ f  STAGE  4
51.00  Hz
```

Pick–up value of the frequency stage f_3
Setting range: **40.00** Hz to **65.00** Hz
The preset value results with rated frequency f_N = 50 Hz in an overfrequency stage

```
 2109█ MEA.REP.f4
10
```

Number of measurement repetitions (3 a.c. periods each) for frequency stage f_3
Setting range: **2** to **10000**

```
 2110█ BLOCK  U1<
65  V
```

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

6.3.9 Settings for forward power supervision – address block 22

```
  2200█ FORW.POWER
SUPERVISION
```

Beginning of the block ”Forward power supervision”

```
  2201█ FORW.POWER
OFF
```

Switch *OFF* of forward power supervision

```
ON
```

Switch *ON* of forward power supervision

```
BLOCK TRIP REL
```

forward power supervision operates but *TRIP RELay* is *BLOCKed*

Setting of the forward power supervision is very much dependent on the application. General setting recommendations cannot be made. The stages operate independent of each other. 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

Under address 2207, it can be selected whether forward power measurement should be carried out by an accurate algorithm or by a fast algorithm. The accurate algorithm is preferred in power stations, whereas the fast algorithm is intended for use as network splitting relay.

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

```
  2202█ Pf<
10.0  %
```

Supervision of decrease in forward active power
Setting range: **0.5** % to **120.0** %
of secondary rated apparent power

```
  2203█ Pf>
100.0  %
```

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

```
  2204█ T-Pf<
10.00  s
```

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

```
  2205█ T-Pf>
10.00  s
```

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

```
  2206█ T-RESET
5.00  s
```

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

```
  2207█ MEA.METHOD
ACCURATE
```

```
FAST
```

Selection of the measurement algorithm:

ACCURATE measurement, e.g. for use as forward power protection

FAST measurement, e.g. for use as network splitting relay

6.3.10 Settings for reverse power protection – address block 23

```
  2300█
REVERSE  POWER
```

Beginning of the block "Reverse power protection"

```
  2301█ REV. POWER
OFF
```

```
ON
```

```
BLOCK  TRIP  REL
```

Switch *OFF* of reverse power protection

Switch *ON* of reverse power protection

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

If reverse power operation occurs, then the turbine–generator set must be disconnected from the network 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 with the stop valve in normal state, 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. 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 set times are additional time delays which do not include the relay operating times (measurement time, reset time).

The reverse power is measured by the protection unit itself during the primary tests (refer section 6.7.5.2). Approximately 0.5 times the measured reverse power value is chosen as the setting value. This value must be entered with its negative sign. In cases of large machines with small motoring power it is advisable to correct the angle error of the instrument transformers (see Section 6.3.3).

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:

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

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

```
2302 P>   REVERSE
-1.00  %
```

Pick–up value of reverse power in percent of secondary rated apparent power.
Setting range: **–30.00** % to **–0.50** %

```
2303 T-SV-OPEN
10.00  s
```

Trip delay for reverse power with stop valve normal state
Setting range: **0.00** s to **32.00** s
and ∞ (no trip)

```
2304 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)

```
2305 T-RESET
3.00  s
```

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

6.3.11 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 7UM511. 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.

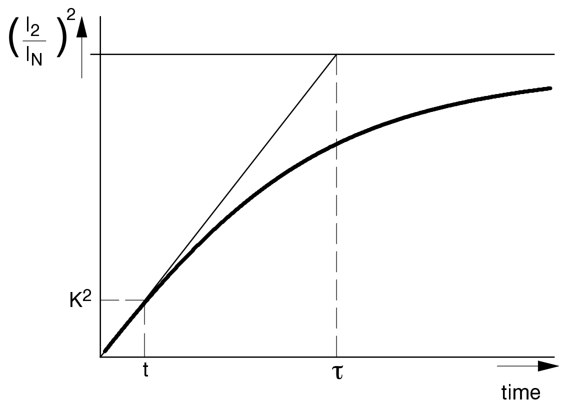


Figure 6.6 $I_2^2 - t$ characteristic

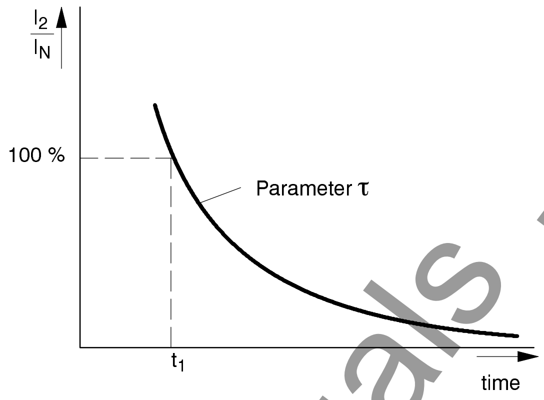


Figure 6.7 Thermal unbalanced load characteristic

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:

$$C = 3.17\ \text{s}$$

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

Then it follows that

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

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

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

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.

```
  2 4 0 2▌ I 2 >
6   %
```

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

```
  2 4 0 3▌ T - I 2 >
2 0 . 0 0   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)

```
  2 4 0 4▌ T I M E   C O N S T
7 5 0   s
```

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

```
  2 4 0 5▌ T H E R M . W A R N
9 0   %
```

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

```
  2 4 0 6▌ I 2 > >
6 0   %
```

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

```
  2 4 0 7▌ T - I 2 > >
3 . 0 0   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)

```
  2 4 0 8▌ T - R E S E T
0 . 1 0   s
```

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

6.3.12 Settings for overcurrent time protection – address blocks 25 and 26

```
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_1< (positive sequence component) 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.

```
2502 I>
1.20        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>
3.00 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
3.10 s
```

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

The high–current instantaneous trip stage I>> can be set to be operative or inoperative independently of the I> stage.

```
2600 OVERCURR.
I>>
```

Beginning of the
"High–current instantaneous trip I>> stage"

```
2601 O/C I>>
OFF
```

Switch *OFF* of the high–current stage I>>

```
ON
```

Switch *ON* of the high–current stage I>>

```
BLOCK TRIP REL
```

overcurrent time stage I>> operates but *TRIP RELay* is *BLOCKed*

The high–current instantaneous trip stage I>> is usually used for current grading with large impedances which are normally present in generators, motors or block transformers. The I>> stage is set such that it picks up for short–circuit currents, graded, for example, into the block transformer:

$$\text{Setting } \frac{I>>}{I_N} : \qquad \frac{1}{x'_d} \cdot \frac{I_{Nmachine}}{I_{Nc.t.}} > \frac{I>>}{I_N} \geq \frac{1}{0.7 \cdot u_{KTransf} + x'_d} \cdot \frac{I_{Nmachine}}{I_{Nc.t.}}$$

Decaying d.c. components in the current are strongly reduced in 7UM511. Nevertheless, it can be advisable to delay the I>> stage by the delay time T–I>> if a relatively sensitive setting of I>> is used. For generators or motors, 50 ms to 100 ms is usually sufficient. The set times are additional time delays which do not include the operating times (measuring, reset time).

```
2602 I>>
2.50 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

```
2603 T-I>>
0.10 s
```

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

```
2604 T-RESET
0.10 s
```

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

6.3.13 Settings for the highly sensitive earth current protection – address block 27

```
2700 OVERCURR.
Ie>>
```

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

```
2701 O/C Ie>
OFF
```

Switch *OFF* of overcurrent time stage I_e>

```
ON
```

Switch *ON* of overcurrent time stage I_e>

```
BLOCK TRIP REL
```

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

The highly sensitive earth current protection can be used to detects earth fault either in the stator or in the rotor winding of the machine. A precondition is that the magnitude of the measured current is a sufficient criterion. When the protected winding is isolated or high–resistance earthed, sufficient magnitude of the earth current must be produced. When, for example, used as rotor earth fault protection, a system frequency bias voltage must be applied to the rotor circuit (cf. Section 4.11). In this case, the measured current is determined by the magnitude of the bias voltage and the capacitance of the coupling capacitors of the rotor circuit, which can be measured in order to ensure a closed measuring circuit (address 2705).

The earth current pick–up value (address 2792) is chosen such that an earth resistance lower than approximately 1000 Ω is covered. On the other hand, the setting value shall correspond to at least twice the interference current caused by the earth capacitances of the rotor circuit.

For use as stator earth fault protection, a sufficient current must be produced by an earthing transformer, if necessary. Further information about dimensioning of the earthing transformer and load resistor is contained in the pamphlet "Planning Machine Protection Systems" Order No. E50400–U0089–U412–A1–7600.

If the displacement voltage U_{en} of an earthing transformer is to be used as measuring criterion, this must be converted into a proportional current I_E by an external resistor R_d. The following equation is applicable:

$$R_d = \frac{U_{en\ min}}{I_{E\ min}} \qquad P_v = \frac{(U_{en\ max})^2}{R_v}$$

$U_{en\ min}$ minimum displacement voltage to be detected

$U_{en\ max}$ maximum displacement voltage

$I_{E\ min}$ earth current to be detected at mini–mum displacement voltage (address 2702)

For low–voltage motors with neutral conductor (4–wire system) or machines with low–ohmic earthed neutrals, the overcurrent time protection provides earth fault detection. Should the highly sensitive earth current protection be used for earth fault protection in systems with earthed neutral, then it must be ensured that the thermal limits (cf. Section 3.1.1) are not exceeded during earth fault. If necessary, an intermediate current transformer must be installed in order to reduce the current to the relay input.

```
2702 Ie>
20 mA
```

Pick–up value of Ie>–stage
Setting range: **10** mA to **1000** mA

```
  2 7 0 3█ T - I e >
3 . 0 0   s
```

Trip delay of Ie>–stage
Setting range: **0,00** s to **32,00** s
and ∞ (no trip with Ie>–stage)

```
  2 7 0 4█ T - R E S E T
0 . 1 0   s
```

Reset delay time after trip signal has been initiated
Setting range: **0,00** s to **32,00** s

```
  2 7 0 5█ I e <
0 . 0   m A
```

Pick–up value of the measuring circuit supervision stage Ie<
Setting range: **2.0** mA to **50.0** mA
and **0.0** mA, i.e. supervision stage is ineffective)

6.3.14 Settings for the stator overload protection – address block 28

```
  2 8 0 0█ T H E R M A L
O V E R L O A D   P R O T .
```

Beginning of the block
"Thermal stator overload protection"

```
  2 8 0 1█ O V E R L O A D
O F F
```

Switch *OFF* of the overload protection

```
O N
```

Switch *ON* of the overload protection

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

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

The maximum permissible continuous current of the machine is decisive for overload detection. This must be matched to the rated current conditions of the current transformers since the relay uses its rated current as the base current for detection of an overload. The rated relay current should equal the rated secondary current of the current transformers. The following is valid concerning the machine:

$$k_{machine} = \frac{I_{maxmachine}}{I_{Nmachine}}$$

The setting value K_FACTOR is the determined:

$$\text{K–FACTOR} = k_{machine} \times \frac{I_{Nmachine}}{I_{Nctprim}}$$

$$\text{K–FACTOR} = \frac{I_{maxmachine}}{I_{Nmachine}} \times \frac{I_{Nmachine}}{I_{Nctprim}}$$

whereby

$k_{machine}$ – overload factor of the machine
$I_{maxmachine}$ – maximum permissible continuous current of the machine
$I_{Nmachine}$ – rated current of the machine
$I_{Nctprim}$ – primary rated current of the c.t.'s

The maximum permissible continuous thermal machine current should be specified by the manufacturer. If no other information is available, 1.1 x the rated machine current is chosen.

Example:

Machine: $I_{Nmachine}$ = 1,099 A
$I_{maxmachine}$ = 1.2 x I_{Nmach}

Current transformers: 1,200 A/1 A

$$\text{K–FACTOR} = 1.2 \times \frac{1{,}099\ \text{A}}{1{,}200\ \text{A}} = 1.1$$

The overload protection simulates the temperature rise of the thermal differential equation, the solution of which represents an e–function in steady–state operation. The time constant τ is decisive for the time to reach the temperature rise threshold and thus for the trip time (address 2803).

If the overload characteristic of the protected machine is known, then the trip characteristic of the protection must be chosen such that it matches the machine overload characteristic, at least for small overloads.

Similar considerations apply if the permissible operating time for a particular overload value is stated.

```
2802 K-FACTOR
1.10
```

Setting value of k–factor = I_{max}/I_N
Setting range: **0.50** to **2.50**

An overcurrent alarm is issued when one of the three phase currents exceeds the value $I_{max} = k \cdot I_N$.

```
2803 T-CONSTANT
120 s
```

Setting value of time constant τ
Setting range: **30** to **32 000** s

By setting a warning stage for the temperature rise (address 2804), an alarm can be output before the trip temperature rise is reached. Prompt load shedding, for example, may then prevent tripping.

Remark: With the usual k–value of 1.1 and with rated machine current and correct matching of the c.t. current, the following steady–state temperature rise is obtained (in percent of trip temperature rise):

$$\Theta/\Theta_{trip} = \frac{1}{(1.1)^2} = 83\ \%$$

Therefore, the alarm stage should be set between the steady–state temperature rise at rated current and trip temperature rise.

```
2804 Θ WARN
90 %
```

Warning temperature rise in percent of trip temperature rise $\Theta_{WARN}/\Theta_{TRIP}$
Setting range: **70** % to **100** %

The above data are sufficient to simulate the temperature rise. The machine protection also provides the possibility to process the ambient temperature or the cooling medium temperature. This temperature must be input as a temperature–proportional d.c. voltage via the in–built analog input. The relay must be informed whether this d.c. voltage is produced by a measurement transducer with 0 V to 10 V output or by a a measurement transducer with life–zero signal 4 mA to 20 mA (address 2806). In the latter case and external measurement shunt must be available which converts the current into a voltage 2 V to 10 V. The conversion factor between the input d.c. voltage at the relay and the temperature depends on the available measurement transducer and is set under address 2807.

It must be noted in this case that the setting factor k refers to an ambient temperature of 40 °C, i.e. it corresponds to the continuous permissible current at 40 °C.

In order to determine the limit temperature, the protection also requires the rated temperature rise, i.e. the temperature rise of the machine at rated current (address 2805). It should also be noted here, that generally the rated machine current differs from the rated c.t. current and therefore the set k–factor does not correspond to the machine's k–factor. Accordingly, the temperature rise at rates machine current must be adjusted as follows:

$$\Theta_{Nsec} = \Theta_{Nmach} \times \left(\frac{I_{Npri}}{I_{Nmach}}\right)^2$$

whereby

- Θ_{Nsec} – temperature rise of machine at secondary rated current = setting value in 7UM511 (address 2707)
- Θ_{Nmach} – temperature rise of machine at rated machine current
- I_{Npri} – primary rated current of c.t.'s
- I_{Nmach} – rated machine current

Furthermore, the the tripping time depends on ambient temperature if this is to be taken into account. The internal calculations are based on ambient temperature of 40 °C. The actual trip temperature can be calculated according to the following formula when the ambient temperature differs from 40 °C:

$$t = \tau \cdot ln \frac{\left(\frac{I}{k \cdot I_N}\right)^2 + \frac{\Theta_U - 40\ °C}{k^2 \cdot \vartheta_N} - \left(\frac{I_{pre}}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 + \frac{\Theta_U - 40\ °C}{k^2 \cdot \Theta_N} - 1}$$

with

- τ – time constant (addresse 2803)
- k – K–FACTOR (addresse 2802)
- I_N – rated current of the relay
- I – actually flowing secondary current
- I_{pre} – preload current
- Θ_N – rated temperature rise at rated relay current I_N (addresse 2805)
- Θ_{amb} – measured ambient temperature (referred to addresse 2807)

<u>Example:</u>

Machine:
- I_N = 1,099 A
- I_{max} = $1.2 \cdot I_N$ at Θ_{amb} = 40 °C
- Θ_N = 84 degrees temperature rise at I_N

Current transformers: 1,200 A/1 A

$$k = 1.2 \times \frac{1{,}099\ A}{1{,}200\ A} = 1.1 \quad \text{(address 2802)}$$

$$\Theta_{Nsek} = 84\ deg. \times \left(\frac{1{,}200}{1{,}099}\right)^2 = 100\ deg. \quad \text{(address 2805)}$$

The following example shows the influence of the ambient temperature on the trip time. Assuming a current of 1.5 times rated relay current without preload I_{pre} = 0):

at Θ_{amb} = 40 °C:

$$t = 600\ s \cdot ln \frac{\left(\frac{1.5}{1.1}\right)^2 + \frac{40\ °C - 40\ °C}{1.1^2 \cdot 100\ °C} - 0}{\left(\frac{1.5}{1.1}\right)^2 + \frac{40\ °C - 40\ °C}{1.1^2 \cdot 100\ °C} - 1} \approx 463\ s$$

at Θ_{amb} = 80 °C:

$$t = 600\ s \cdot ln \frac{\left(\frac{1.5}{1.1}\right)^2 + \frac{80\ °C - 40\ °C}{1.1^2 \cdot 100\ °C} - 0}{\left(\frac{1.5}{1.1}\right)^2 + \frac{80\ °C - 40\ °C}{1.1^2 \cdot 100\ °C} - 1} \approx 366\ s$$

at Θ_{amb} = 0 °C:

$$t = 600\ s \cdot ln \frac{\left(\frac{1.5}{1.1}\right)^2 + \frac{0\ °C - 40\ °C}{1.1^2 \cdot 100\ °C} - 0}{\left(\frac{1.5}{1.1}\right)^2 + \frac{0\ °C - 40\ °C}{1.1^2 \cdot 100\ °C} - 1} \approx 637\ s$$

```
 2805█ TMP.RISE I
100 deg
```

Temperature rise at rated current (secondary)
Setting range: **40** degrees to **200** degrees

```
 2806█ TEMP. INP.
NON-EXIST
```

```
PT 100
```

```
4-20 mA
```

Remote measurement transducer for cooling medium temperature measurement.
NON−EXIST, ie. not installed or connected or

PT 100 − remote thermometer Pt100 installed and connected (output 0 V to 10 V) or

4−20 mA − remote measurement transducer with output 4 mA to 20 mA, converted to 2 V to 10 V

```
 2807█ TEMP. MAX
100 °C
```

Ambient temperature at 10 V at the temperature in put of the relay
Setting range: **40** degrees to **150** degrees

Finally, it should be noted that when considering the cooling medium temperature, the percentage of the warning temperature refers to the difference between trip temperature and 40 °C, i.e. 40 °C corresponds to 0 %; trip temperature corresponds to 100 %.

The trip temperature of the above example is then:

Θ_{trip} = 40 °C + 1.1^2 x 100 deg. = 161 °C (secondary) or
Θ_{trip} = 40 °C + 1.2^2 x 84 deg. = 161 °C (referred to machine values).

This temperature value corresponds to the display Θ/Θ_{trip} = 100 % under the operational values (address block 59).

6.3.15 Settings for measured value monitoring – address block 29

The different monitoring functions of the protective relay are described in Section 4.18.4. They partly monitor the relay itself, partly the steady–state measured values of the transformer circuits.

The sensitivity of the measured value monitoring can be changed in 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.

NOTE: Prerequisite for correct function of the measured value monitors is the proper setting of the general power system data (Section 6.3.3), especially the parameters concerning voltage connections and the matching factor.

```
 2900 MEAS.VALUE
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 4.20)
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 to Figure 4.20)
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 4.19) reacts (absolute content, related 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 (related to the maximum conductor current) for operation of the current summation monitoring (refer to Figure 4.19)
Smallest setting value: **0.00**
Largest setting value: **0.95**

```
 2907 SYM.Uthres
50  V
```

Voltage threshold (phase–phase) above which the symmetry monitoring is effective (refer to Figure 4.21)
Smallest setting value: **10** V
Largest setting value: **100** V

```
 2908 SYM.Fact.U
0.75
```

Symmetry factor for the voltage symmetry = slope of the symmetry characteristic (refer to Figure 4.21)
Smallest setting value: **0.58**
Largest setting value: **0.95**

6.3.16 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 7UM511. 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

```
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

```
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

6.3.17 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 4.18). 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;
possible: **1** to **2**

```
3903 MEA.REPET.
3
```

Number of measurement repetitions
Setting range: **2** to **6**
(corresponding to an alarm delay of approx. 0.2 s to 1.5 s)

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 (power, power factor, pole angle, excitation voltage).

Block 59 Indication of operational measured values of overload protection and 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 █ OPERATIONAL ANNUNCIATIONS	Beginning of the block "Operational annunciations"
↑↓ 19.02.96 17:02 Pr 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)
>Sys-Test	Testing via system–interface (C/G)
>Sys-MM-block	Blocking of monitoring dir. via system–interface (C/G)

`>Useal-in blk`	Undervoltage seal–in of overcurrent time protection is blocked (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 (K/G)
`>SV tripped`	Stop valve tripped (C/G)
`>Pf< block`	Block forward power P_f< supervision (C/G)
`>Pf> block`	Block forward power P_f> supervision (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)
`>f3 block`	Block frequency protection stage f_3 via binary input (C/G)
`>f4 block`	Block frequency protection stage f_4 via binary input (C/G)
`>Char.1/2 blk`	Block characteristic 1/2 of underexcitation protection (C/G)
`>Char. 3 blk`	Block characteristic 1/2 of underexcitation protection (C/G)
`>Uexc fail.`	Excitation voltage failure indicated by binary input (C/G)
`>Trip rel 1`	Trip circuit supervision 1: input in parallel to 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 2: input in parallel to 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`	Messages and measured values via the system interface are blocked (C/G)
`Test mode`	Messages and measured value via the system interface are marked with ”Test operation” (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)
`Anticlockw.`	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 operating (PC) interface lost (C)
Oper.Ann.Inva	Operational annunciations invalid (C/G)
Flt.Ann.Inval	Fault annunciations invalid (C/G)
LED Buff.Inva	Buffer for stored LEDs invalid (C/G)
VDEW StateInv	VDEW state 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 24 V	Failure in internal supply voltage 24 V (C/G))
Failure 15 V	Failure in internal supply voltage 15 V (C/G))
Failure 5 V	Failure in internal supply voltage 5 V (C/G))
Failure 0 V	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)
Failure Usymm	Failure detected by voltage symmetry monitor (C/G)
Fail.PhaseSeq	Failure detected by phase sequence monitor (C/G)

Annunciations of underexcitation protection:

Excit. off	Underexcitation protection is switched off (C/G)
Excit.blocked	Underexcitation protection is blocked (C/G)

Excit.active	Underexcitation protection is active (C/G)
Exc. U< blk	Underexcitation protection is blocked due to insufficient positive sequence voltage magnitude (C/G)
Uexc failure	Excitation voltage failure recognized (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 off	Overvoltage protection is switched off (C/G)
o/v blk	Overvoltage protection is blocked (C/G)
o/v active	Overvoltage protection is active (C/G)

Annunciations of stator earth fault protection:

U0> off	Stator earth fault protection is switched off (C/G)
U0> blocked	Stator earth fault protection is blocked (C/G)
U0> active	Stator earth fault protection is active (C/G)

Annunciations of frequency protection:

FRQ off	Frequency protection is switched off (C/G)
FRQ blocked	Frequency protection is blocked (C/G)
FRQ active	Frequency protection is active (C/G)
FRQ U1<block	Frequency protection is blocked due to insufficient positive sequence voltage magnitude (C/G)

Annunciations of forward power supervision:

`Pf off`	Forward power supervision is switched off (C/G)
`Pf blocked`	Forward power supervision is blocked (C/G)
`Pf active`	Forward power supervision is active (C/G)

Annunciations of reverse power protection:

`Pr off`	Reverse power protection is switched off (C/G)
`Pr blocked`	Reverse power protection is blocked (C/G)
`Pr active`	Reverse 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)
`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 the highly sensitive earth fault protection:

`Ie> off`	Highly sensitive earth fault protection I_E is switched off (C/G)
`Ie> blocked`	Highly sensitive earth fault protection I_E is blocked (C/G)
`Ie> active`	Highly sensitive earth fault protection I_E is active (C/G)
`Failure R/E/F`	Failure in measuring circuit of high–sensitivity earth current protection (when used as rotor earth fault protection) (C/G)

Annunciations of thermal overload protection:

`O/L Prot. off`	Thermal overload protection is switched off (C/G)
`O/L blocked`	Thermal overload protection is blocked (C/G)
`O/L active`	Thermal overload protection is active (C/G)
`Fail.Temp.inp`	Failure in temperature input (C/G)
`O/L Warn I`	Thermal overload protection: Current warning (C/G)
`O/L Warn Θ`	Thermal overload protection: Thermal warning (C/G)
`RM th.repl.I`	Thermal overload protection: Reset memory for thermal replica (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
Exc<  Fault    :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█ 8  ms
Uexc  failure  :C
```

```
005█ 1512  ms
Exc<U<Trip     :C
```

```
006█ 3514  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 underexcitation protection:

`Exc< Fault`	Fault detection of underexcitation protection
`Exc< Trip`	Trip by underexcitation protection, characteristics 1 and 2
`Exc<U<Trip`	Trip by underexcitation protection, characteristics 1 and 2, and undervoltage in excitation circuit
`Exc<< Trip`	Trip by underexcitation protection, characteristic 3

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 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 of stator earth fault protection
`U0> Trip`	Trip by stator earth fault protection

Fault annunciations of frequency protection:

`f 1 > Fault`	Fault detection of frequency protection, stage f_1>
`f 1 < Fault`	Fault detection of frequency protection, stage f_1<
`f 2 > Fault`	Fault detection of frequency protection, stage f_2>
`f 2 < Fault`	Fault detection of frequency protection, stage f_2<
`f 3 > Fault`	Fault detection of frequency protection, stage f_3>
`f 3 < Fault`	Fault detection of frequency protection, stage f_3<
`f 4 > Fault`	Fault detection of frequency protection, stage f_4>
`f 4 < Fault`	Fault detection of frequency protection, stage f_4<
`f 1 > Trip`	Trip by frequency protection, stage f_1>
`f 1 < Trip`	Trip by frequency protection, stage f_1<
`f 2 > Trip`	Trip by frequency protection, stage f_2>
`f 2 < Trip`	Trip by frequency protection, stage f_2<
`f 3 > Trip`	Trip by frequency protection, stage f_3>
`f 3 < Trip`	Trip by frequency protection, stage f_3<
`f 4 > Trip`	Trip by frequency protection, stage f_4>
`f 4 < Trip`	Trip by frequency protection, stage f_4<

Fault annunciation of forward power supervision:

`Pf< flt. det.`	Forward power supervision picked up on Pf<
`Pf> flt. det.`	Forward power supervision picked up on Pf>
`Pf< Trip`	Forward power supervision trip by Pf< stage
`Pf> Trip`	Forward power supervision trip by Pf> stage

Fault annunciations of reverse power protection:

`Pr fault det.`	Reverse power protection picked up

`Pr Trip`	Reverse power protection trip
`Pr+SV Trip`	Reverse power protection trip with tripped stop valve

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 on high current stage I>>, phase L1
`I>> Fault L2`	Fault detection on high current stage I>>, phase L2
`I>> Fault L3`	Fault detection on high current stage I>>, phase L3
`I>> Trip`	Trip by high current stage I>> of overcurrent 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 highly sensitive earth current protection:

`IE> Fault`	Pick–up of highly sensitive earth current protection
`IE> Trip`	Trip by highly sensitive earth current protection

Fault annunciation of thermal overload protection:

`O/L Trip`	Trip by thermal overload 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 text at the right of the boxes. Values beyond the limits are shown as ⋆⋆⋆⋆.

Further measured or calculated values are displayed in address blocks 58 and 59.

```
5700█ OPERATIONAL
MEASURED VALUES
```

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
UL1E=  6.09  kV
```

```
5705█ MEAS.VALUE
UL2E=  6.08  kV
```

```
5706█ MEAS.VALUE
UL3E=  6.08  kV
```

```
5707█ MEAS.VALUE
IL1[%]=  86.7  %
```

The percentage is referred to rated current

```
5708█ MEAS.VALUE
IL2[%]=  87.1  %
```

```
5709█ MEAS.VALUE
IL3[%]=  86.8  %
```

```
5710█ MEAS.VALUE
Ie  =  0  mA
```

```
5711█ MEAS.VALUE
UL1E  =  60.9  V
```

The secondary voltages (addresses 5711 to 5713) are referred to the voltages applied to the relay terminals

```
5712█ MEAS.VALUE
UL2E  =  60.8  V
```

```
5713█ MEAS.VALUE
UL3E  =  60.8  V
```

```
5714█ MEAS.VALUE
U0  =  0.2  V
```

Displacement voltage calculated from the three phase−to−earth voltages $|\underline{U}_{L1} + \underline{U}_{L2} + \underline{U}_{L3}| / \sqrt{3} = \sqrt{3} \cdot U_0$

```
5715█ MEAS.VALUE
Ipos[%]=  86.9  %
```

The percentage is referred to rated current

```
5716█ MEAS.VALUE
Upos  =  105  V
```

The percentage is referred to the phase−to−phase voltage, i.e. $\sqrt{3} \cdot U_{pos}$

```
5717█ MEAS.VALUE
f  =  50.0  Hz
```

Frequency in Hz can only displayed when an a.c. measured quantity is present

Display	Description
5800 OPERATIONAL MEASURED VALUES	Beginning of the block "Operational measured values (b)": powers and impedances
5801 MEAS.VALUE P[%] = 89.0	The percentage of active power P and reactive power Q is referred to rated apparent power $\sqrt{3} \cdot U_N \cdot I_N$
5802 MEAS.VALUE Q[%] = 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 THETA = 22 deg	Pole angle, calculated from stator data
5806 MEAS.VALUE Uexcit.= 2.3 V	Excitation voltage (behind the voltage divider, i.e. at the relay terminals)

Further measured values are displayed in address block 59.

```
5900█ OPERATIONAL
MEAS.  VALUES  C
```

Beginning of the block "Operational measured values C": negative sequence values

```
5901█ MEAS.VALUE
Θ/ΘtripL1=  000%
```

Temperature rise in % of trip temperature rise

```
5902█ MEAS.VALUE
Θ/ΘtripL2=  000%
```

```
5903█ MEAS.VALUE
Θ/ΘtripL3=  000%
```

```
5904█ MEAS.VALUE
AMB.TEMP=  000%
```

Cooling medium temperature in ˚C, if its processing is effective and a temperature proportional voltage is connected to the respective input

```
5905█ MEAS.VALUE
Ineg.seq=  0  %
```

Calculated negative sequence current in % of rated relay current

```
5906█ MEAS.VALUE
ThermRepl.=  0  %
```

Calculated temperature rise in % of the thermal trip value; if unbalanced load protection is switched off then 0 is indicated

NOTE: Without input of the cooling medium temperature, the temperature values displayed are the temperature rises calculated from the current characteristic and referred to the trip temperature rise corresponding to the parameterized k−factor.

If the cooling temperature is considered, then the percentage refers to the difference between trip temperature and 40 ˚C, i.e. 40 ˚C corresponds to 0 %, and the trip temperature corresponds to 100 %. The trip temperature results from the parameterized k−factor and the parameterized rated temperature rise (= temperature rise at rated current). The following relationship applies:

$$\Theta/\Theta_{trip} = \frac{\Theta + \Theta_K - 40\ ^\circ C}{k^2 \cdot \Theta_N}$$

whereby:

Θ/Θ_{trip}	displayed temperature
Θ	temperature rise calculated from current and k−factor
Θ_K	cooling medium temperature input via analog input
k	parameterized k−factor (address 2802)
Θ_N	parameterized rated temperature rise (address 2805)

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. 7UM511 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 to Section 5.5.2 Marshalling of the binary inputs).

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

– by block paging with the keys ⇑ forwards or ⇓ backwards up to address 8000, or

– by direct selection with address code, using key **DA**, address **8 0 0 0** and execute with key **E.**

```
⇑  8 0 0 0█ D E V I C E
⇓  C O N T R O L
```

Beginning of the block ”Device control”

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

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

Input of the codeword is required to change the data (code level 1). Selection of the individual addresses is by further scrolling using ↑ ↓ as shown below. Each modification must be confirmed with the enter key **E**.

```
⇑  8 1 0 0█ S E T T I N G
⇓  R E A L   T I M E   C L O C K
```

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

```
↑  1 5 . 0 2 . 1 9 9 6
↓  1 7 : 0 4 : 5 5
```

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

```
↑  8 1 0 2█ D A T E
↓
```

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

```
↑  8 1 0 3█ T I M E
↓
```

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

```
↑  8 1 0 4█ D I F F .   T I M E
↓
```

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

6.5.2 Erasing stored annunciations – 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 is necessary (code level 2) 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.

```
⇑  8200█
⇓  RESET
```

Beginning of block ”Reset”

```
↑  8201█ RESET
↓  LED ?
```

Request whether the LED memories should be reset

```
↑  8202█ RESET
↓  OPERAT.ANNUNC. ?
```

Request whether the operational annunciation buffer store should be erased

```
↑  8203█ RESET
↓  FAULT ANNUNC. ?
```

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

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

```
8202█ RESET
SUCCESSFUL
```

6.5.3 Information to LSA during test operation – address block 83

When the relay is connected to a central storage device or localized substation automation system and the protocol according VDEW/ZVEI 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”

```
↑ 8301 █SYS TEST
↓ OFF

  ON
```

Only for VDEW/ZVEI compatible protocol:

in *ON* position, the VDEW/ZVEI–compatible annunciations are assigned with the origin ”test operation”

```
↑ 8302 █SYS BLOCK
↓ OFF

  ON
```

Only for VDEW/ZVEI compatible protocol:

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
```

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

```
SET BY LSA CONTR
```

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 ”`>ParamSelec.2`” (FNo `7` and `8`).

– The logical binary inputs must be allocated to 2 physical input modules (refer Section 5.5.2) in order to allow control. An input is treated as not energized when it is not assigned to any physical input.

– The control input signals must be continuously present as long as the selected parameter set shall be active.

The active parameter sets are assigned to the logical binary inputs as shown in Table 6.3.

A simplified connection example is shown in Figure 6.7. Of course, the binary inputs must be declared in normally open (”`NO`”) mode.

Binary input ParamSelec.1	Binary input ParamSelec.2	causes active set
no	no	Set A
yes	no	Set B
no	yes	Set C
yes	yes	Set D

no = input not energized
yes = input energized

Table 6.3 Parameter selection via binary input

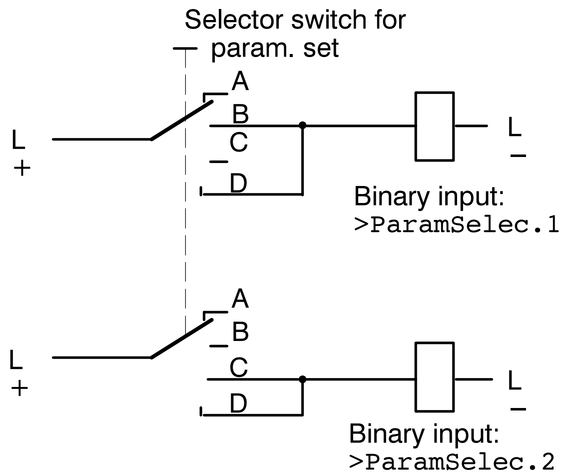


Figure 6.8 Connection scheme for parameter change–over via binary inputs

6.6 Testing and commissioning

6.6.1 General

Prerequisite for commissioning is the completion of the preparation procedures detailed in Chapter 5.

Warning

Hazardous voltages are present in this electrical equipment during operation. Non–observance of the safety rules can result in severe personal injury or property damage.

Only qualified personnel shall work on and around this equipment after becoming thoroughly familiar with all warnings and safety notices of this manual as well as with the applicable safety regulations.

Particular attention must be drawn to the following:

- The earthing screw of the device must be connected solidly to the protective earth conductor before any other connection is made.
- Hazardous voltages can be present on all circuits and components connected to the supply voltage or to the measuring and test quantities.
- Hazardous voltages can be present in the device even after disconnection of the supply voltage (storage capacitors!).
- The limit values given in the Technical data (Section 3.1) must not be exceeded at all, not even during testing and commissioning.

When testing the unit with a secondary injection test set, it must be ensured that no other measured values are connected and that the tripping leads to the circuit breaker trip–coils have been interrupted.

DANGER!

Secondary connections of the current transformers must be short–circuited before the current leads to the relay are interrupted!
If a test switch is installed which automatically short–circuits the current transformer secondary leads, it is sufficient to set this switch to the "Test" position. The short–circuit switch must be checked beforehand (refer 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 255 resp. VDE 0435/part 303 and with the use of precision measuring instruments. The tests are therefore to be looked upon purely as functional tests.

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 underexcitation protection

The function of the underexcitation protection can only be tested if this function is configured as *EXIST* in address 7801 (as delivered, refer to Section 5.4.2) and has been parameterized as operative (contrary to the condition as delivered from factory)(address 1401 UNDEREXCI = *ON* or = *BLOCK TRIP REL*).

The internal measurement formation of the conductance values utilizes the positive sequence system of currents and voltages. Measurements with the underexcitation protection should therefore be performed with three–phase symmetrical values. If asymmetrical values are connected, deviations must be expected. With single–phase measurements, the pick–up values theoretically do not change, since the positive sequence component in the current as well as in the voltage amounts to 1/3. However, the undervoltage blocking feature could be caused to pick–up due to the reduced voltages and block the underexcitation protection.

Simple function testing is possible by connecting rated symmetrical voltages as well as symmetrical currents which lead the voltages by 90°. The protection then picks up when the currents are increased to a value which corresponds to $\lambda 2 \times I_N$; for $\lambda 2 = 0.35$, i.e. $0.35 \times I_N$. It is assumed that the following applies for the settings: $\lambda 3 > \lambda 1 > \lambda 2$.

- Annunciation ”`Exc< Fault`” (factory setting is signal relay 12 and LED 7).

The delay times are checked with twice the pick–up value; for the steady–state characteristic therefore with approximately 0.7 I_N, and for the dynamic characteristic with approximately 2.2 I_N. It must be noted that the set times are pure delay times; operating times of the measurement functions are not included.

Connect approximately 10 V d.c. to the excitation voltage input. Inject test current of 2.2 I_N.

- Annunciation ”`Exc< Fault`” (signal relay 12 and LED 7),
- After T–Ch. 3 (1.5 s; address 1406), annunciation”`Exc<< Trip`”(signal relay 8 and LED 8).
- Trip relays (2, 3, 4, and 5)

Disconnect test current.

Connect test current of 0.7 I_N.

- Annunciation ”`Exc< Fault`” (signal relay 12 and LED 7).
- After T–Ch. 1/2 (10 s; address 1404), annunciation ”`Exc< Trip`” (signal relay 7 and LED 7).

Disconnect test current.

Energize binary input ”`>Uexc fail.`” (input 5). Connect test current.

- Annunciation ”`Uexc failure`” (not marshalled by factory).
- Annunciation”`Exc< Fault`” (signal relay 12 and LED 7).
- After T–SHRT Ue< (1.5 s; address 1405), annunciation ”`Exc<U<Trip`” (not marshalled by factory).
- Trip relays (2, 3, 4 and 5).

Disconnect test current. De–energize binary input.

Decrease d.c. voltage to 1 V. Connect test current (0.7 I_N).

- Annunciation ”`Exc< Fault`” (signal relay 12 and LED 7).
  After T–SHRT Ue< (1.5 s; address 1405), annunciation ”`Exc<U<Trip`” (not marshalled by factory).
- Trip relays (2, 3, 4 and 5).

Disconnect test current.

Further checks are performed with primary values during commissioning (Section 6.7.6.4).

6.6.3 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 7802 for undervoltage protection (as delivered, refer to Section 5.4.2)and in address 7803 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 positive sequence component of the voltages is used for the internal formation of the measured value. Measurements on the voltage protection functions should therefore be performed with three–phase symmetrical measurement values. If asymmetrical values are used, deviations must be expected.

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. Single–phase measurement is not possible for overvoltage measurement with usual pick–up values, since the voltage to be connected would have to be increased by the factor $\sqrt{3}$ since the positive sequence component amounts to $1/\sqrt{3}$ only (referred to phase–to–phase values); such values lie outside the operating range of the unit! Should it be unavoidable to test with single–phase voltage, the pick–up values must be decreased (e.g. to 30 V).

⚠ **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.

Note: 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 2 and signal relay 3).
- Trip relays (2, 3, 4 and 5).

Disconnect voltage.
- Annunciation ”`U< fault`” (not marshalled when delivered from factory).
- After T–U< (1.5 s; address 1603), annunciation ”`U< trip`”(not marshalled when delivered from factory).
- Trip relay (1).

Set voltage to approximately rated voltage. Activate binary input ”`>u< block`” (not marshalled when delivered from factory). Disconnect voltage.
- Annunciation ”`U< block`” (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`” (not marshalled when delivered from factory).
- Trip relays (2, 3, 4 and 5).

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 6.7.3).

6.6.4 Testing the stator earth fault protection U_0>

The functions of the stator earth fault protection can only be tested if this protection is configured as *EXIST* in address 7804 (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 relay calculates the displacement voltage by forming the sum of the vectors of the phase–to–earth voltages according to the following formula

$$U_0 = |(\underline{U}_{L1} + \underline{U}_{L2} + \underline{U}_{L3})| / \sqrt{3}$$

Thus the protection function can be tested using a three–phase voltage source with individually controlled phase voltages. One of the three voltages is decreased, starting with rated voltage, until the voltage triangle is so deformed that the protection picks up. This happens according to above formula when decreasing the voltage by $\sqrt{3}$ times the parameterized pick–up threshold U0> (address 1902). Eventually the threshold has to be set to a lower value for this test.

Testing is possible with a single–phase test voltage. In this case, the initial test voltage must be higher than $\sqrt{3}$ times the parameterized pick–up threshold U0> (address 1902). Eventually the threshold has to be set to a lower value for this test. Pick–up occurs when the test voltage is decreased below $\sqrt{3}$ times the parameterized pick–up value.

- annunciation "`U0> Fault`" (not marshalled when delivered from factory).
- after T–U0> (0.3 s; address 1903) annunciation "`U0> Trip`" (not marshalled when delivered from factory).
- command relay (not marshalled when delivered from factory).

Disconnect voltage.

Activate binary input "`>U0> block`" (not marshalled when delivered from factory). Connect voltage. One of the three voltages is decreased to zero, starting with rated voltage.

- annunciation "`U0> blocked`" (not marshalled when delivered from factory).
- No further alarms regarding stator earth fault protection.

Disconnect 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 1904)!

It must be noted that the set times are pure delay times; operating times of the measurement functions are not included.

Note: During displacement voltage testing a current of 0.5 I_N should be applied (refer also *NOTE* in Section 6.6.1).

Further checks are performed with primary values during commissioning (Section 6.7.4).

6.6.5 Testing the frequency protection functions

The functions of the frequency protection can only be tested if this protection is configured as *EXIST* in address 7805 (as delivered, refer to Section 5.4.2) and has been parameterized as operative – contrary to the condition as delivered from factory (address 2101 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 5717.

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 measuring times, it must be considered that the delay time of the frequency protection is determined by the number of repeated measurements. Each measurement takes 3 a.c. periods. Thus, the delay is 3/f times the set number of repeated measurements. Note that the tripping time as indicated in the fault annunciations starts with the fault detection signal which occurs after half the number of repeated measurements. Thus, the indicated tripping time corresponds to the other half of the number of repeated measurements.

Connect rated voltage, increase frequency until overfrequency protection (f_4) picks up.

- Annunciation ”`f4> Fault`” (not marshalled when delivered from factory) after half the time for the set measurement repetitions (address 2109 MEA.REP.f4 = 10 at delivery).
- Annunciation ”`f4> Trip`” after the full time for the set measurement repetitions (not marshalled when delivered from factory).
- Trip relay (not marshalled when delivered).

Reduce frequency until annunciation disappears; note that the number of repeated measurements is valid for reset delay, too.

Set to rated voltage, reduce frequency until the first underfrequency protection stage (f_1<) (address 2102) picks up.

- Annunciation ”`f1< Fault`” (not marshalled when delivered from factory) after half the time for the set measurement repetitions (address 2103 MEA.REP.f1 = 10 at delivery).
- Annunciation ”`f1< Trip`” after the full time for the set measurement repetitions (LED 3 and signal relays 4).
- Trip relay 1.

Further reduce frequency until the second underfrequency stage f_2< picks up.

- Annunciation ”`f2< Fault`” (not marshalled when delivered from factory) after half the time for the set measurement repetitions (address 2105 MEA.REP.f2 = 10 at delivery).
- Annunciation ”`f2< Trip`” after the full time for the set measurement repetitions (not marshalled when delivered from factory).
- Trip relays (not marshalled when delivered from factory).

Further reduce frequency until the third underfrequency stage f_3< picks up.

- Annunciation ”`f3< Fault`” (not marshalled when delivered from factory) after half the time for the set measurement repetitions (address 2107 MEA.REP.f3 = 10 at delivery).
- Annunciation ”`f3< Trip`” after the full time for the set measurement repetitions (not marshalled when delivered from factory).
- Trip relays (not marshalled when delivered from factory).

Activate binary input 4 (”`>f1 block`”, ”`>f2 block`”, and ”`>f3 block`”).

- The blocking annunciations appear (not marshalled when delivered from factory).
- Annunciations ”`f1< Fault`”, ”`f2< Fault`”, ”`f3< Fault`” and ”`f1< Trip`”, ”`f2< Trip`” and ”`f3< Trip`” disappear.

Bring frequency back to rated frequency. De–activate binary input. Switch off test quantity.

Further checks are performed with primary values during commissioning (Section 6.7.3).

6.6.6 Testing the power protection functions

The forward power supervision and the reverse power protection can be tested simultaneously.

The forward power supervision can be tested if it is configured as *EXIST* in address 7806 (refer to Section 5.4.2) and parameterized as operative, contrary to the condition as delivered from factory (address 2201 FORW. POWER = *ON* or = *BLOCK TRIP REL*).

The reverse power protection can be tested if it is configured as *EXIST* in address 7807 (refer to Section 5.4.2) and parameterized as operative, contrary to the condition as delivered from factory (address 2301 REV. POWER = *ON* or = *BLOCK TRIP REL*).

The internal processing of the power values uses the positive sequence components of the currents and voltages. Testing of the power functions should therefore be with three–phase symmetrical values. If asymmetrical measurement values are used then deviations are to be expected. If single phase measurements are performed, then the power values will be lower by the factor 1/9, since the positive sequence component amounts to 1/3 in the current as well as in the voltage.

Polarity of power is defined for generator operation, i.e.

+P	Forward power	Machine delivers active power
–P	Reverse power	Machine takes up active power
+Q	overexcited operation	Machine delivers inductive power
–Q	underexcited operation	Machine takes up inductive power

The delay times for power increase are tested with twice the pick–up value, for power decrease by switching the current to 0. *<u>Note:</u> Reverse power protection is a power <u>increase</u> protection since it measures the <u>rise</u> of a negative active power.* It must be noted that the set times are pure delay times; operating times of the measuring functions are not included.

In case accuracy tests should be performed on the reverse power protection, it is advisable to adjust the angle error correction before because of the high accuracy demand (refer also to Section 6.3.3). This requires a high–accuracy test set (e.g. type CMC of Messrs. Omicron). The angle error of the internal input transducers are then measured and corrected as follows. The external error are corrected in a later step according to Section 6.7.6.2).

◆ **Angle correction:**

Set the angle correction parameters of the relay (W0 in address 1206 and W1 in address 1207) to 0.

Connect three–phase test current and test voltage to the relay. Adjust test voltages to rated voltage; adjust phase angle to 0.

Adjust test current I_1 to rated current; read out and note as φ_1 the phase angle under the operational measured values under address 5804.

Adjust test current I_2 to 0.2 times rated current; read out and note as φ_2 the phase angle under the operational measured values under address 5804.

Calculate the correction factors according the following formulae and set them **with reversed sign** in addresses 1206 and 1207:

$W1 = (\varphi_1 - \varphi_2)/(I_1 - I_2)$ (address 1207)
$W0 = \varphi_1 - W1 \bullet I_1$ (address 1206)

Repeat above test; now the displayed angles should be negligible.

◆ **Forward power:**

Test current and test voltage in phase; voltage at U_N. Disregard initial LED indications.

Connect test current 2 x I_N (for condition as delivered from factory).
- Annunciation `"Pf> flt. det."` (not allocated by factory).
- After T–Pf> (10 s; address 2205), annunciation `"Pf> Trip"` (not allocated at delivery).
- Trip relays (not allocated when delivered).

Disconnect test current.
- Annunciation `"Pf< flt. det."` (not allocated at delivery).
- After T–Pf< (10 s; address 2204), annunciation `"Pf< Trip"` (not allocated at delivery).
- Trip relays (not allocated at delivery).

Activate binary input `">Pf block"` (input 2). Connect test current.
- Annunciation `"Pf blocked"` (not allocated at delivery).
- No further alarms regarding forward power supervision.

Disconnect test current.
- Annunciation `"Pf blocked"`(not allocated at delivery) remains.
- No further alarms regarding forward power supervision.

De–activate binary input.

◆ **Reverse power:**

Note: These tests cause the forward power supervision to pick up when it is effective.

Test current and test voltage in phase opposition. Voltage set to 0.2 U_N.
Connect test current of 0.1 I_N
- Annunciation ”`Pr fault det.`” (not allocated at delivery).
- After ”T−SV−OPEN”(10 s: address 2303), annunciation ”`Pr Trip`” (LED 4 and signal relay 5).
- Trip relays (2, 3, and 4)

Disconnect test current.

Activate binary input ”`>SV tripped`” (input 6). Connect test current.
- Annunciation ”`Pr fault det.`” (not allocated at delivery).
- After T−SV−CLOS. (3 s; address 2304), annunciation ”`Pr+SV Trip`” (LED 5 and signal relay 6).
- Trip relays (2, 3, and 4).

Disconnect test current. De−activate binary input.

Activate binary input ”`>Pr block`” (input 3). Connect test current.
- Annunciation ”`Pr 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 6.7.6.3).

6.6.7 Testing the unbalanced load protection

The unbalanced load protection can only be tested if this function is configured as *EXIST* in address 7808 (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 is tested with a single phase current. In this case the unbalanced load amounts to one third of the test current which is referred to the rated unit current. Tripping must not occur if a current smaller than three times the setting value (address 2402) is connected. After an appropriate time (approximately 5 x τ) a thermal steady−state value is obtained. 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 one third of 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 3 x I2>):
- Time T−I2> (address 2403) elapses,
- Annunciation ”`I2> Warn`” (not allocated at delivery).

Note: Rated voltage should be connected to one of the voltage measurement inputs during the dynamic tests (refer also to note in Section 6.6.1).

Switch current to approx. 3.6 x setting value I2>> (address 2406).
- Annunciation ”`I2>> Fault`” (not allocated at delivery).
- After T−I2>> (3 s; address 2407) annunciation ”`I2>> Trip`” (signal relay 11).
- Trip relay (1).

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 single phase current of 4.8 times setting value I2> (address 2402) (corresponding to an unbalanced load of 1.6 times setting value).

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” (not allocated at delivery).
- On reaching the thermal trip stage after a time which corresponds to half the time constant: annunciation ”I2 Θ Trip” (not allocated at delivery).
- 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.

Caution!

Test currents larger than 4 times I_N may overload and damage the relay if applied continuously (refer to Section 3.1.1 for overload capability). Observe a cooling down period!

If testing with preload is performed, 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.

6.6.8 Testing the overcurrent time protection

The functions of the overcurrent time protection can only be tested if these functions are configured as *EXIST* in address 7810 (for the I> stage, as delivered, refer to Section 5.4.2) and/or in address 7811 (for the I>> stage, as delivered, refer to Section 5.4.2) and have been parameterized as operative: for the I> stage (address 2501 O/C I> = *ON* or = *BLOCK TRIP REL*, for the I>> stage (address 2601 O/C I>> = *ON* or = *BLOCK TRIP REL*).

Testing can be performed single–phase, two–phase or three–phase without difficulties.

Setting parameter I> (address 2502) is decisive for the I> stage. For setting values up to 4 x I_N, the current can be increased gradually in any phase until the I> 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 reset value should lie at 95 % of the pick–up value.

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: During dynamic current tests, at least one phase of the unit should be connected to rated voltage (refer also to *NOTE* in Section 6.6.1).

Switch on test current of 2 times pick–up value I> (address 2502).

- Annunciation ”I> Fault L1” for L1 (LED 10).
- Annunciation ”I> Fault L2” for L2 (LED 11).
- Annunciation ”I> Fault L3” for L3 (LED 12).
- After expiry of T–I> (3 s, address 2503) annunciation ”I> Trip” (LED 1 and signal relays 1).
- Trip relays (2, 3, 4 and 5).

Switch off test current.

Setting parameter I>> (address 2602) is decisive for the high set overcurrent stage I>>.

Tests are performed dynamically as suggested above for higher currents.
Note: During dynamic current tests, at least one phase of the unit should be connected to rated voltage (refer also to *NOTE* in Section 6.6.1).

Switch on test current of 2 times (at least 1.2 times) pick–up value I>> (address 2602):
- Annunciation ”`I> Fault L*`” (depending on phase, see above).
- After T–I>> (0.1 s; address 2603), annunciation ”`I>> Trip`” (signal relay 2).
- Trip relays (not marshalled when delivered).

Switch off test current.

If the undervoltage seal–in circuit is used (address 2505 U< SEAL–IN = *ON*) this can be tested dynamically.

Apply three–phase test voltage above setting value U< (address 2506). Switch on a test current e.g. in phase L1 (above I>, address 2502).

Switch off test voltages before the time T–I> has expired.

Switch off test current;
- Annunciation ”`I> + U<`” (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.

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 10).

After the current is switched off, pick–up will reset immediately, without seal–in. No further annunciations concerning the overcurrent time protection.

De–energize binary input. Switch off measured quantities.

Attention! Should setting parameters have been changed during these test, re–adjust them to their correct values (addresses 2502 to 2507 and 2602 to 2604)!

Further checks are performed with primary values during commissioning (Section 6.7.2).

6.6.9 Testing the highly sensitive earth current protection

The function of the highly sensitive earth current protection can only be tested if this function is configured as *EXIST* in address 7811 (as delivered, refer to Section 5.4.2) and has been parameterized as operative (address 2701 O/C Ie> = *ON* or = *BLOCK TRIP REL*).

Note: During dynamic current tests, at least one phase of the unit should be connected to rated voltage (refer also to *NOTE* in Section 6.6.1).

Setting parameter Ie> (address 2702) is decisive for the Ie> stage.

Switch on test current of 2 times pick–up value Ie>.
- Annunciation ”`IE> Fault`” (LED 13).
- After expiry of T–IE> (3 s, address 2703) annunciation ”`IE> Trip`” (not marshalled when delivered).
- Trip relays (not marshalled when delivered).

Energize binary input ”`>IE> block`” (not allocated when delivered). Switch on test current.
- Annunciation ”`>IE> block`” (not allocated when delivered).
- No further alarms regarding the highly sensitive earth current protection.

If the highly sensitive earth current protection is used for rotor earth fault protection, then the measured circuit failure alarm should be checked.

Reduce the measured current below 2 mA.
- After 2 s annunciation ”`Failure R/E/F`” (not allocated when delivered).

Switch off test current and test voltage.

Further checks are performed with primary values during commissioning (Sections 6.7.4.3 and 6.7.5).

6.6.10 Testing the stator overload protection

The integrated overload protection can only be tested if this function is configured as *EXIST* in address 7812 (as delivered, refer to Section 5.4.2) and has been parameterized as operative – contrary to the position as delivered from factory (address 2801 OVERLOAD = *ON* or OVERLOAD = *BLOCK TRIP REL*).

The basis current for the detection of overload is the rated current of the unit. An overload calculation is performed in the unit individually per phase.

When applying rated current tripping must not occur (with factory setting). After an appropriate time (approximately 5 x τ) a steady–state temperature value according to the following relationship is established:

$$\frac{\Theta}{\Theta_{trip}} = \frac{1}{k^2}$$

The following must be noted concerning the alarm and trip times:

Without cooling medium temperature measurement (TEMP. INP. = *NON–EXIST* under address 2806; condition as delivered from factory) all calculated values of the thermal replica correspond to the temperature **rise** referred to the trip temperature **rise**. Calculation of the actual temperature is therefore not necessary. Only the temperature rise as a percentage of the trip temperature rise (which is defined by $k^2 \times I_N^2$) is of interest. Therefore, 100 % means trip temperature rise; the warning temperature rise is set as a percentage of the trip temperature rise (address 2804).

If the cooling medium temperature is considered TEMP. INP. = *PT 100* or *4–20 mA* under address 2806), then the same conditions as described above apply for a cooling medium temperature of 40 °C. Deviating cooling medium temperatures generate an appropriate correction. However, the warning temperature percentage always refers – just as do the overload measured values displayed under address block 59 – to the difference between the trip temperature and 40 °C (i.e. 40 °C corresponds to 0%; trip temperature corresponds to 100 %).
The conversion factor between the input d.c. voltage at the relay and the temperature depends on the available measurement transducer and is determined by the settings under addresses 2807 and 2807 (refer to Section 6.3.14). With the preset values, 100 °C correspond to 10 V input voltage at the relay terminals. That means that, with the Pt 100 thermometer, 0 V correspond to 0 °C, 4 V correspond to 40 °C. If a measurement transducer with 4 mA to 20 mA with measuring shunt 500 Ω is used, then 2 V correspond to 0 °C, 5.2 V correspond to 40 °C.

Note: A sudden change in the input cooling medium temperature is considered in the thermal replica of the unit with a delay corresponding to the thermal time constant; this is also physically correct.

For a simple check of the time constant, it is presupposed that the ”cold” condition applies at the commencement of the measurement; i.e. the memory of the thermal replica is empty and the cooling medium temperature is 40 °C or TEMP.INP = *NON–EXIST*. The memory of the thermal replica can be cleared via the binary input function ”`RM th.repl.I`” (reset memory of thermal replica); this function is, however, not marshalled in the unit as delivered from the factory. It is easier to reset the memory by de–activating and re–activating the overload protection (address 2801). The unit is then connected to 1.6 x pick–up value, i.e. 1.6 x k x I_N. This results in the trip temperature being reached after a time which corresponds to half the time constant.

- After reaching the alarm temperature rise (address 2804), annunciation ”`O/L Warn Θ`” (signal relay 10).
- After reaching the trip temperature rise, annunciation ”`O/L Trip`” (LED 9, signal relay 9).
- Trip relay (2).

If the trip characteristic (Figure 3.2) is to be checked, then before each measurement the temperature rise must be reduced to zero. The memory of the thermal replica can be cleared via the binary input function ”`RM th.repl.I`” (reset memory of thermal replica); this function is, however, not marshalled in the unit as delivered from the factory. It is easier to deactivate and re–activate the overload function (address 2801). Otherwise, a current–free period of at least 5 x τ must be observed.

Caution!

Test currents larger than 4 times I_N may overload and damage the relay if applied continuously (refer to Section 3.1.1 for overload capability). Observe a cooling down period!

If testing with preload is performed, it must be ensured that a condition of thermal equilibrium has been established before time measurement commences. This is the case, when the preload has been applied constantly for a period of 5 x τ.

If the measurement transducer 4 mA to 20 mA is used, then the measuring circuit can be checked by the relay. To simulate this, switch off the d.c. voltage input for cooling medium temperature.

- Annunciation ”`Fail.Temp.inp`” (not allocated when delivered).

The relay will switch over to a cooling medium temperature of 40 °C.

6.6.11 Testing the coupling of external trip functions

Four desired signals from external protection or supervisory units can be connected into the processing of the 7UM511 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, two of the external trip functions are parameterized to INPUT 7 (address 6107) and INPUT 8 (address 6108). 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`” (not allocated when delivered from factory).
- Trip relays (not allocated when delivered from factory).

De–activate binary input.

6.6.12 Testing the trip circuit supervision

The trip circuit supervision can be checked when it has been configured as TRP SUPERV = *EXIST* (addresses 7839 set as delivered, refer to Section 5.4.2) and parameterized as operative (address 3901), contrary to the condition as delivered from factory).

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 4.15). 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. In case a voltage, corresponding to the cooling medium temperature, is connected to the unit via a transducer from a temperature sensor (Pt100), it is assumed that the output voltage of the measurement transducer and the parameterized input quantities are properly matched according to Section 6.3.14. 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:

– short–circuit tests,
– earth fault 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 current circuits

Switch unbalanced load protection (address 2401), overcurrent time protection (addresses 2501 and 2601) and overload protection (address 2801) 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 stand–still and with plant sections voltage–free and earthed!

Slowly excite generator, however, stator current must 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 5905. 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.

The relative temperature rises as indicated under address block 59 must be the same for all three phases. If the analog input for the cooling medium temperature is connected, then a positive cooling medium temperature must be indicated. If this is not the case, check connections and matching of the measurement transducer for the cooling medium temperature.

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, unbalanced load protection and the overload protection; these functions were tested already under 6.6.8, 6.6.7 or 6.6.10. The overcurrent time protection is switched to be operative (address 2501: O/C I> = *ON*) and serves from now on as short–circuit protection for all further tests. If used, the I>> stage (address 2601:O/C I>> = *ON*), the overload protection (address 2801: OVERLOAD = *ON*) and the unbalanced load protection (address 2401: UNBAL.LOAD = *ON*) can be switched to be operative. Otherwise, they are set to *OFF*.

Shut–down and de–excite generator. Remove short–circuit bridges.

6.7.3 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.

Switch under– and overvoltage protection (addresses 1601 and 1701) and frequency protection (address 2101) to *BLOCK TRIP REL*.

Blocking of the undervoltage protection on tripping of the VT m.c.b. should also be checked during voltage testing. It is assumed that the auxiliary contact of the m.c.b. is marshalled to a binary input ">u< block" (not allocated when delivered).

– 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 voltages in address block 57 are 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.

Then, slowly excite generator to rated voltage. Read out voltages in all three phases in address block 57. They can be compared with the actual voltages. The voltage of the positive sequence system (address 5716) must be approximately $\sqrt{3}$ times the indicated phase voltages (it is referred to the phase–to–phase voltage), the negative sequence voltage should be almost zero. If this is not, the voltage transformer connections are incorrect (crossovers).

The phase sequence at the relay must be clockwise. If not, the annunciation ”Fail.PhaseSeq” appears in the operational annunciation (address block 51). The phase rotation is indicated in the operational measured values under address 5907, too. If the machine has counter–clockwise rotation, two phases must be interchanged, or a binary input must be allocated to the input function ”>Phase rotat” and energized at generator stand–still. If deviations occur, proceed as follows:

– Shut down turbo–set and de–excite generator,
– apply plant earths,
– check voltage transformer circuits and make corrections,
– repeat test.

If the highly sensitive earth current protection is used for rotor earth fault protection, the voltage tests can be used to check the measured circuit supervision:

Start–up machine and excite to rated voltage. If applicable place measurement brushes into operation. A bias a.c. voltage is produced by the connection unit 7XR8500 and applied to the rotor circuit via the coupling unit 7XR 6000. The current caused by the rotor–earth capacitance is now measured and displayed in the operational measured values under address 5710.

Read out this current Ie and set the setting value Ie< (address 2705) to approximately half this measured current. Additionally, check that the set pick–up value Ie> (address 2702) is at least twice this measured current. Change the setting if necessary.

Switch machine speed regulation to ”manual ” operation.

Increase machine speed, so that overfrequency protection just picks up (at delivery frequency stage f4, address 2108):

- Annunciation ”f4> Fault” (not marshalled when delivered from factory)
- After a delay time determined by the number of repeated measurements (address 2109), annunciation ”f4> Trip” (not marshalled when delivered from factory).

Reduce machine speed, so that all underfrequency protection stages (at delivery frequency stages f1, f2, and f3) pick up (addresses 2102, 2104, and 2106):

- Annunciations ”f*< Fault” (not marshalled when delivered from factory).
- After a delay time determined by the number of repeated measurements, annunciation ”f1< Trip” (LED 3 and signal relays 4 when delivered from factory), annunciation ”f2< Trip” and ”f3< Trip” (not marshalled when delivered from factory).

If a binary input is used for blocking the underfrequency stages (input 4 when delivered from factory), activate the block: Annunciations of the underfrequency protection disappear. De–activate binary input.

Adjust machine to rated speed and slowly de–excite the generator. When the generator voltage (phase–to–phase voltage) drops below the value set for U< (address 1601): pick–up annunciation ”U< Fault” appears (not marshalled when delivered from factory) after T–U< (address 1603), trip command ”U< Trip” appears (not marshalled when delivered from factory).

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).

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 2101: 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).

6.7.4 Checking the earth fault protection U_0>

In order to check interference suppression of the loading resistor, and in order to verify the protected zone of the earth fault protection, primary tests are suggested, once with an earth fault at the machine terminals and once with a network earth fault.

6.7.4.1 Calculation of protected zone

The protected zone should first be verified by calculation:

In the event of an external (high–voltage side) short–circuit, an interference voltage is transmitted via the coupling capacitance C_K (Figure 6.9) 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 of the earth fault protection U_0> (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.

Coupling capacitance C_K and loading resistor R_B represent a voltage divider (equivalent circuit diagram Figure 6.10); 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 6.11), 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:

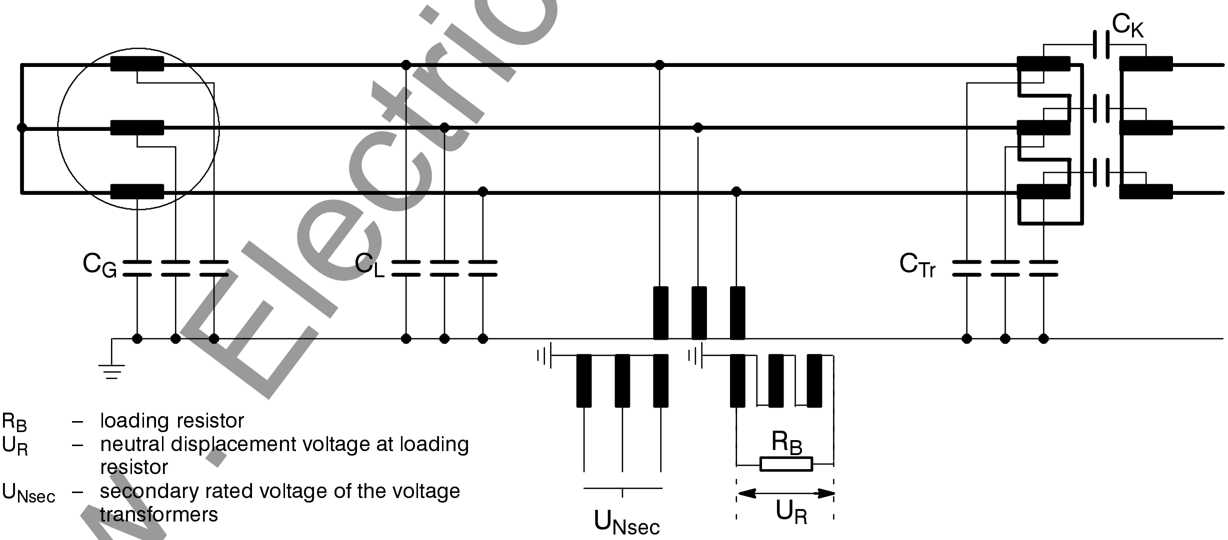
$$R_B' = \left(\frac{TR}{3}\right)^2 \cdot R_B$$

we obtain

$$U_R' = \left(\frac{TR}{3}\right)^2 \cdot R_B \cdot \omega C_K \cdot U_{NU}/\sqrt{3}$$

The earth fault protection calculates the displacement voltage U_E from the sum of the phase–to–earth voltages in the following way:

$$\underline{U}_E = \frac{\underline{U}_{L1} + \underline{U}_{L2} + \underline{U}_{L3}}{\sqrt{3}} = \sqrt{3} \cdot \underline{U}_0$$

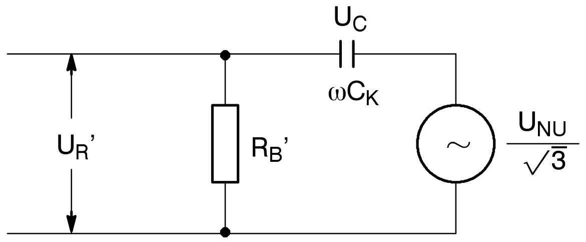


R_B – loading resistor
U_R – neutral displacement voltage at loading resistor
U_{Nsec} – secondary rated voltage of the voltage transformers
C_G – generator–earth capacitance
C_L – line–earth capacitance
C_{Tr} – winding–earth capacitance of unit transformer
C_K – coupling capacitance of unit transformer

Figure 6.9 Block diagram with earthing transformer

When one considers the transformation of the voltage transformers with U_{Nprim} as the primary rated voltage and U_{Nsec} as the secondary rated voltage, then the interference voltage caused by an earth fault in the network, as processed in the relay, amounts to:

$$U_i = \frac{U_{Nsec} \cdot \sqrt{3}}{U_{Nprim}} \cdot \left(\frac{TR}{3}\right)^2 \cdot R_B \cdot \omega C_K \cdot \frac{U_{NU}}{\sqrt{3}}$$



U_{NU} Rated voltage on upper–voltage side of unit 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 6.10 Equivalent diagram

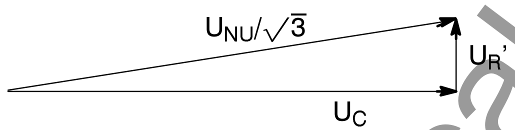


Figure 6.11 Vector diagram

$$U_i = \frac{U_{Nsec}}{U_{Nprim}} \cdot \frac{TR^2}{9} \cdot R_B \cdot \omega C_K \cdot U_{NU}$$

The pick–up value U0> for the neutral displacement voltage should amount to at least twice the value of this interference voltage.

<u>Example:</u>

Network:	U_{NU}	=	110	kV
	f_N	=	50	Hz
	C_K	=	0.01	µF

Voltage transformers: 10 kV/0.1 kV

Earthing transformer:
TR = 36

Loading resistor:
R_B = 10 Ω

$$U_i = \frac{U_{Nsec}}{U_{Nprim}} \cdot \frac{TR^2}{9} \cdot R_B \cdot \omega C_K \cdot U_{NU}$$

$$U_i = \frac{100\ V}{10 \cdot 10^3\ V} \cdot \frac{36^2}{9} \cdot 10\ \Omega \cdot 314\ s^{-1} \cdot 0.01 \cdot 10^{-6}\ F \cdot 110 \cdot 10^3\ V = 5.0\ V$$

If, e.g., 10 V has been chosen as the setting value for U0> in address 1902 then this 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 one winding.

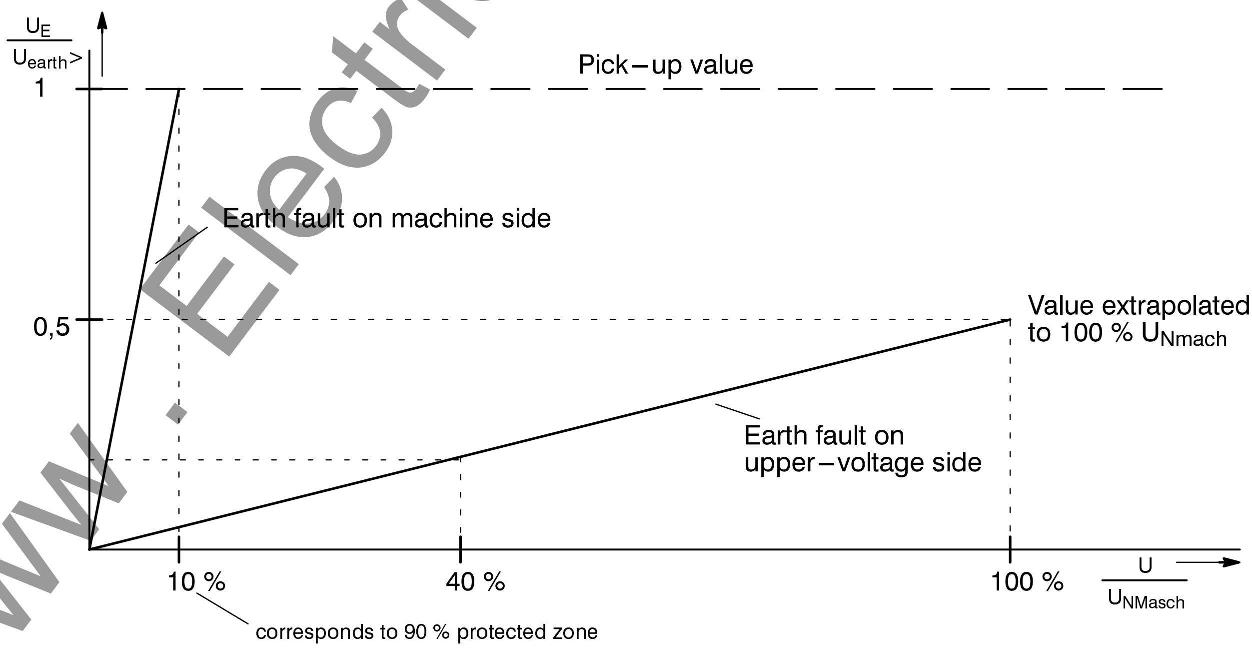


Figure 6.12 Neutral displacement voltage during earth faults

6.7.4.2 Checking for machine earth fault

Switch stator earth fault protection (address 1901) to *BLOCK TRIP REL*. If the high–sensitivity earth current protection is used for stator earth fault protection, switch it to *BLOCK TRIP REL* (address 2701).

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 stand–still and with plant sections voltage–free and earthed!

Start–up machine and slowly excite (however, not above $U_N/\sqrt{3}$) until the earth fault protection U_0> picks up (not marshalled when delivered from factory).

Read out U0 in OPERATIONAL MEAS. VALUES (address 5714). If the connections are correct, this value corresponds with the machine terminal voltage in percent, referred to rated machine voltage . This value also corresponds with the setting value U0> under address 1902 (see Figure 6.12).

The protection zone is:

$$Z = \frac{U_{Nsec} - U0> [V]}{U_{Nsec}} \cdot 100\ \%$$

Machine voltage at pick–up:		$0.1 \cdot U_N$
rated v.t. voltage	U_{Nsec}	100 V
Measured value	U_0	10 %
Setting value	U0>	10 V
Protected zone	Z	90 %

If the high–sensitivity earth current protection is used for stator earth fault protection, read out the current Ie in address 5710. The protection trips when its pick–up value Ie> (address 2702) is exceeded. Annunciation is "`IE> Fault`" (not allocated when delivered).

Shut down machine. Remove earth fault bridge.

6.7.4.3 Check using network earth fault

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 stand–still and with plant sections voltage–free and earthed!

Caution!

The star–points of the transformer must not be connected to earth during this test!

Start–up machine and slowly excite to 40 % of rated machine voltage (max. 60 %). Earth fault protection does not pick–up.

Read out U0 in the OPERATIONAL MEAS. VALUES (address 5714). This value is extrapolated to rated machine voltage (Figure 6.12 as an example). The voltage value thus calculated should correspond, at the most, to half the pick–up value U0> (address 1902), in order to achieve the desired safety margin.

If the high–sensitivity earth current protection is used for stator earth fault protection, read out the current Ie in address 5710 again. This value, again extrapolated to the current at rated machine voltage, should be insignificant, i.e. not higher than half the set pick–up value (address 2702).

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 earth fault protection to be operative: address 1901 SEF PROT = *ON* or address 2701 O/C Ie> = *ON*.

6.7.5 Checking the highly sensitive earth current protection as rotor earth fault protection

If the highly sensitive earth current protection is used for rotor earth fault protection, switch it effective: address 2701 O/C Ie> = *BLOCK TRIP REL*.

⚠ **Caution!**

The excitation circuit must be free of any earth connection during this test!

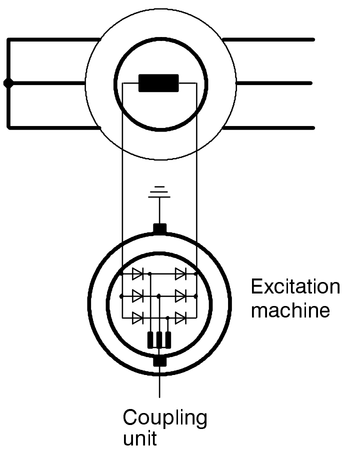


Figure 6.13 Excitation via rotating rectifiers with measurement brushes

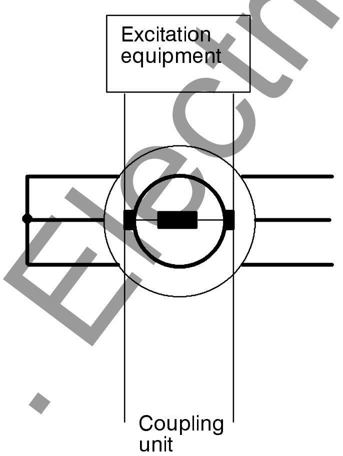


Figure 6.14 Excitation equipment fed via slip rings

An earth fault is installed via a resistor which corresponds to the desired trip resistance. In the case of machines with rotating rectifier excitation (Figure 6.13), the 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 6.14), the earth fault is installed between one slip ring and earth.

Start–up machine and excite to rated voltage. If applicable place measurement brushes into operation. It is irrelevant whether the protection trips or not. The earth current can be read out in the operational measured values A under address 5710.

Check that this measured current corresponds to the pick–up value of the high–sensitivity earth current protection Ie> under address 2702. This setting **must not be reduced** below the value as determined during the voltage checks according to Section 6.7.3!

For machines with excitation via slip rings, the test is repeated for the other slip ring.

Shut–down machine. Remove earth fault resistor.

<u>Example:</u>

protection resistance	R_E	<	1000 Ω
measured earth current	I_E	=	40 mA
set address 2702 to	Ie>	=	40 mA

but not below the actual setting acc. 6.7.3.

If desired, the above mentioned check can be repeated in order to make the rotor earth fault protection giving trip signal. Reduce the rotor earth resistance to approximately 90 % of the desired pick–up resistance. The protection will pick–up (annunciation ”`Ie> Fault`”, not allocated when delivered), and after expiry of the delay time T–Ie (address 2703) annunciation ”`Ie> trip`”.

Shut–down machine. Remove earth fault resistor.

Switch the highly sensitive earth current protection O/C Ie> = *ON* under address 2701.

6.7.6 Tests with the machine connected to the network

6.7.6.1 Checking the correct connection polarity

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.

6.7.6.2 Measurement of motoring power and angle error correction

For a generator, leave the reverse power protection switched to *OFF* (address 2301) 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 should be established. In conjunction with the secondary tests as described in Section 6.6.6, the angle error can be minimized.

The successful angle correction procedure as described in Section 6.6.6 is a precondition for the correct results of the following primary tests!

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. Fit the excitation current, so that the reactive power amounts to 0. For a check, read out and note it down in the table below: under address 5801 the active power $\mathbf{P_0}$ and under address 5802 the reactive power $\mathbf{Q_0}$.

1. If possible increase excitation to approximately 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 $\mathbf{P_1}$ in the table below.

Read out the reactive power with polarity (positive sign) in the operational measured values under address 5802 and note it down as $\mathbf{Q_1}$ in the table below.

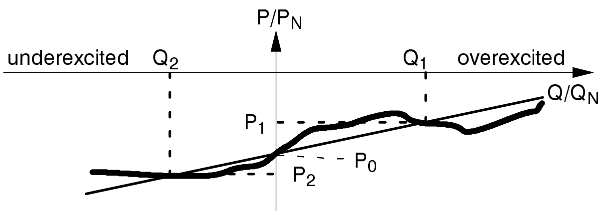
2. If possible slowly decrease excitation to 0.3 times rated apparent power of generator (underexcited).

> ⚠ **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 $\mathbf{P_2}$ in the table below.

Read out the reactive power with polarity (negative sign) in the operational measured values under address 5802 and note it down as $\mathbf{Q_2}$ in the table below.

3. Adjust generator to no–load excitation and shut it down, or adjust it to the desired condition.



Item	motoring power	reactive power
1	P_3	Q_3
2	P_2	Q_2
3	P_1	Q_1

Perform angle error correction in the following way: Calculate the correction value ϑ_{corr} using the pairs of values as determined before according to the formula:

$$\tan \delta_{corr} = \frac{P_1 - P_2}{Q_1 - Q_2}$$

The power values must be inserted with their correct polarity as read out! Otherwise faulty result!

This angle δ_{corr} is used to calculate a new setting value W0 in address 1206:

$$\text{New setting W0} = \text{presetting W0} - \delta_{corr}$$

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 2302 (negative sign).

6.7.6.3 Checking the 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 2301) is set to *BLOCK TRIP REL* 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 ”`Pr fault det.`” (not allocated when delivered from factory).
- After T–SV–OPEN (address 2303), trip signal ”`Pr Trip`” (LED 4 and signal relay 5 as delivered).

Increase driving power.

The last test with the stop valve can be performed with a live trip. It is assumed that the binary input ”`>SV tripped`” is marshalled correctly and is controlled by the stop valve status (by a pressure switch or a limit switch at the stop valve).

Close stop valve.
- Annunciation ”`Pr fault det.`” (not allocated when delivered from factory).
- After T–SV–CLOS. (address 2304) annunciation ”`Pr+SV Trip`” (LED 5 and signal relay 6 as delivered).

If this test has not been carried out with a live trip, shut down machine.

Switch *ON* the reverse power protection (address 2301) and – if used – the forward power supervision (address 2201).

6.7.6.4 Checking the underexcitation protection

Switch underexcitation protection (address 1401) to *BLOCK TRIP REL.*

The correct functioning is tested by approaching a load point on the set steady–state limit characteristic (characteristics 1 and 2). 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 ”`Exc< Fault`”.
- After T–Ch. 1/2 (address 1404), trip signal ”`Exc< Trip`” (LED 7 and signal relay 7).

Example: (Figure 6.15):

Machine		S_N	=	20 MVA
Settings	(referred to the machine)	$\lambda 1$ $\alpha 1$	= =	0.4 80°
Active power		P	=	17 MVA

(It is presumed that the machine values are correctly converted to the secondary values, refer to Section 6.3.4.)

The underexcitation protection will pick up at:

$$Q = \lambda 1 \times S_N - \frac{P}{\tan \alpha 1}$$

$$= 0.4 \times 20\ \text{MVA} - \frac{17\ \text{MW}}{\tan 80°}$$

$$= \underline{\underline{5\ \text{MVAr}}}$$

Note: Rated machine volts have been assumed. If different voltage used, the pick–up power changes in proportion to the voltage.

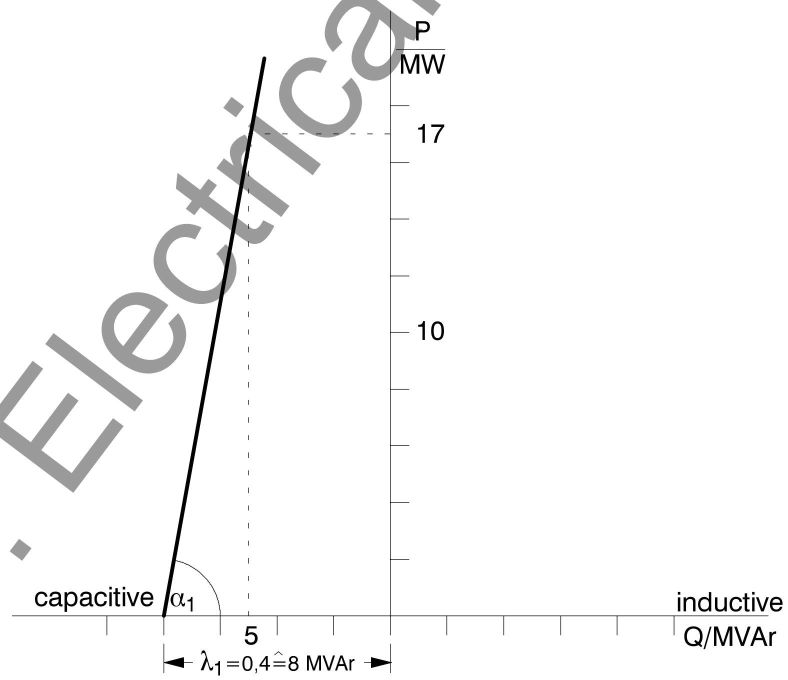


Figure 6.15 Power diagram with underexcitation characteristic

The angle error corrections which are determined according to Section 6.7.6.2 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 re–parameterized (address 1205). Thus, the characteristics of the underexcitation protection are mirrored around the origin. It must be noted that the reverse power protection must also be switched *OFF* (address 2301) as its characteristic is also mirrored from the motor into the generator range.

Do not forget to set the polarity of the instrument transformers to the correct parameter (address 1205) and switch reverse power protection *ON* (address 2301) after completion of the test.

A last test with an excitation voltage trip can be performed with a live trip. The underexcitation protection (address 1401) is switched to *ON* . It is assumed that either the binary input ">Uexc fail." is correctly marshalled and controlled by an external excitation voltage supervision; or that the excitation voltage has been correctly connected to the respective input of the unit with correct polarity and correctly matched.

Disconnect excitation voltage

- Annunciation "Exc< Fault".
- After T–SHRT Ue<, trip by the trip relays marshalled via the trip matrix.

If this last test had not been carried out with a live trip, shut down machine.

6.7.7 Checking the coupling of external trip signals

If the coupling of external functions for the alarm and/or trip processing is used in the 7UM511, 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.

6.7.8 Tripping test including circuit breaker – address block 44

Machine protection 7UM511 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

6.7.9 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 ↑:

```
⇑ 4 9 0 0 █ T E S T
⇓ F A U L T   R E C O R D I N G
```

Beginning of block "Test fault recording" page on with ↑ to address 4901

```
↑ 4 9 0 1 █ F A U L T   R E C .
  S T A R T   ?

  S U C C E S S F U L
```

Start fault recording? Confirm with "**J**/**Y**"− key or abort with page−on key ↑

The relay acknowledges successful completion of the test recording

6.8 Putting the relay into operation

All setting values should be checked again, in case they were altered during the tests. Particularly check that all desired protection functions have been programmed in the configuration parameters (address blocks 78 and 79, refer to Section 5.4). 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 3.1.1 for overload capability). Observe a cooling down period!

– Circuit–breaker trip circuits are tested by actual live tripping. Respective notes are given in Section 6.7.8.

7.2 Replacing the 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).

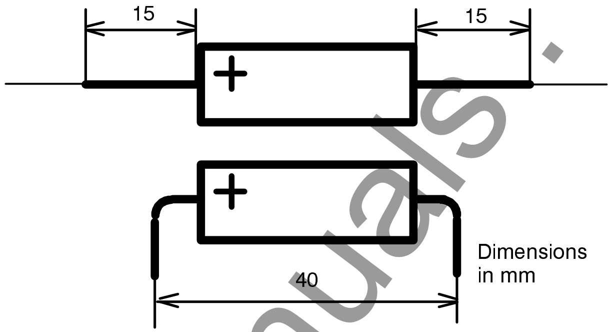


Figure 7.1 Bending the back–up battery for relays with screwed terminal for the battery

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 as in Figure 7.2 and tighten the screws or snap it onto the holder as in Figure 7.3.

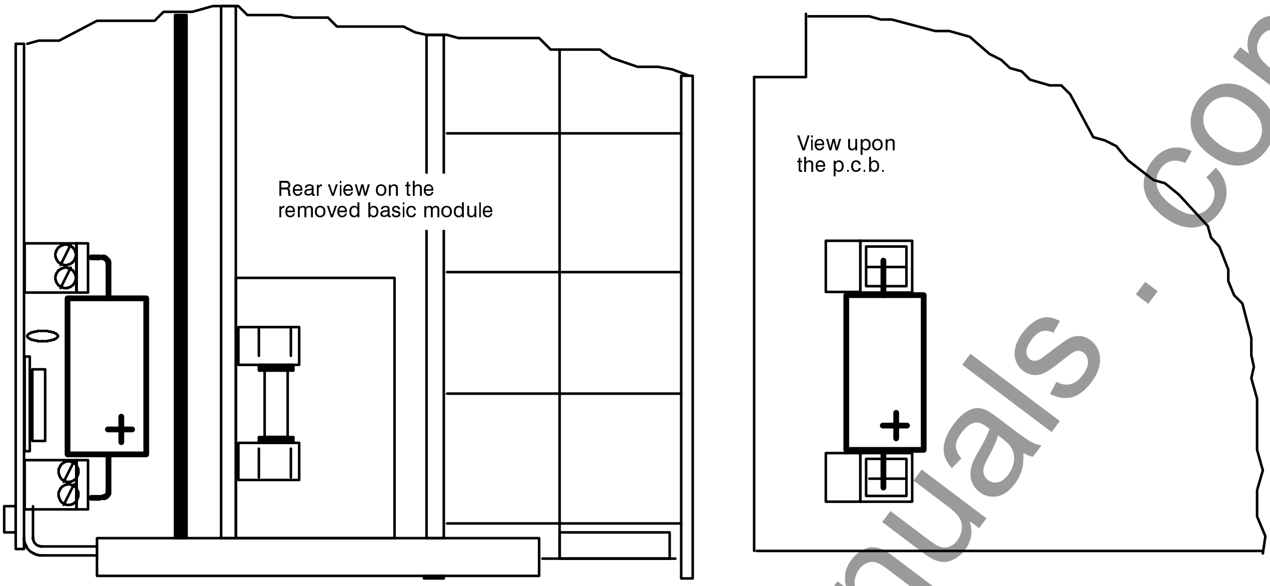


Figure 7.2 Installation of the back – up battery for relays with screwed battery terminals

– 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.

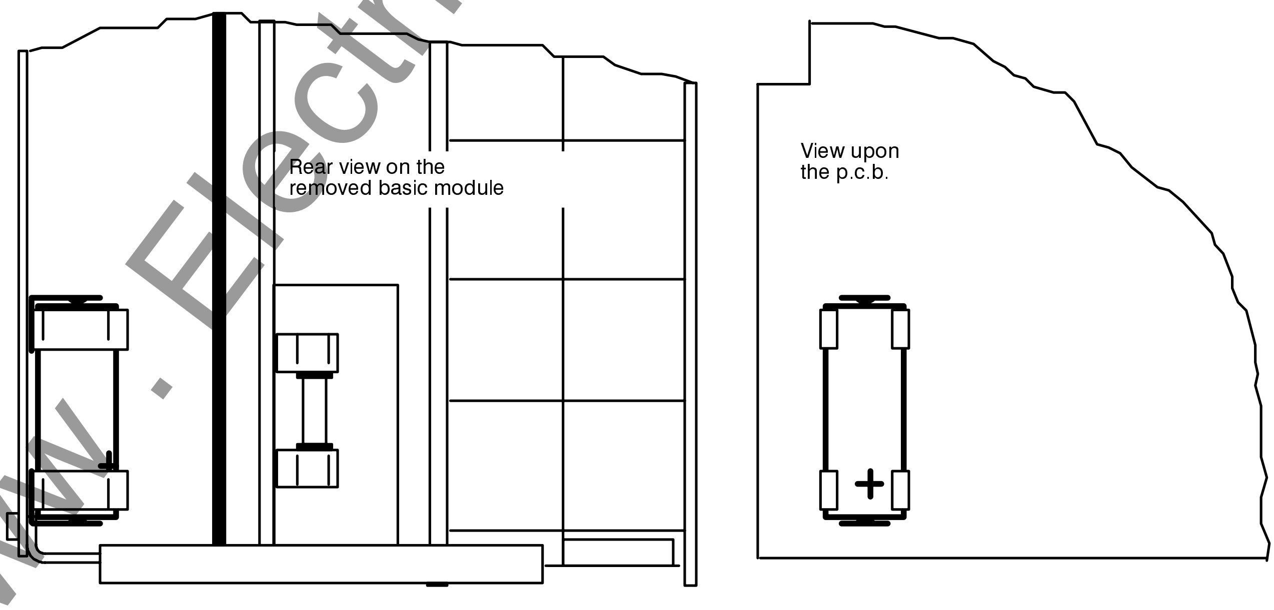


Figure 7.3 Installation of the back – up battery for relays with snap – on battery holder

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.

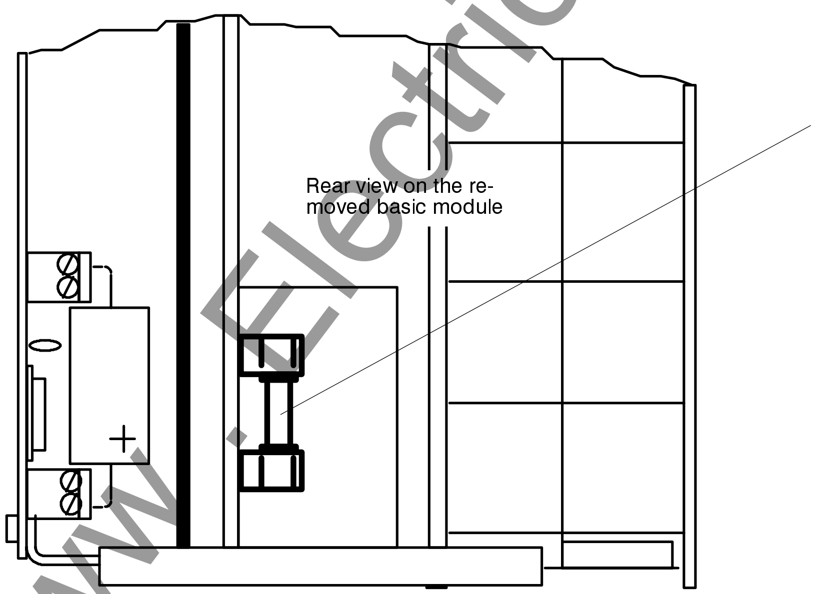
Warning

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).

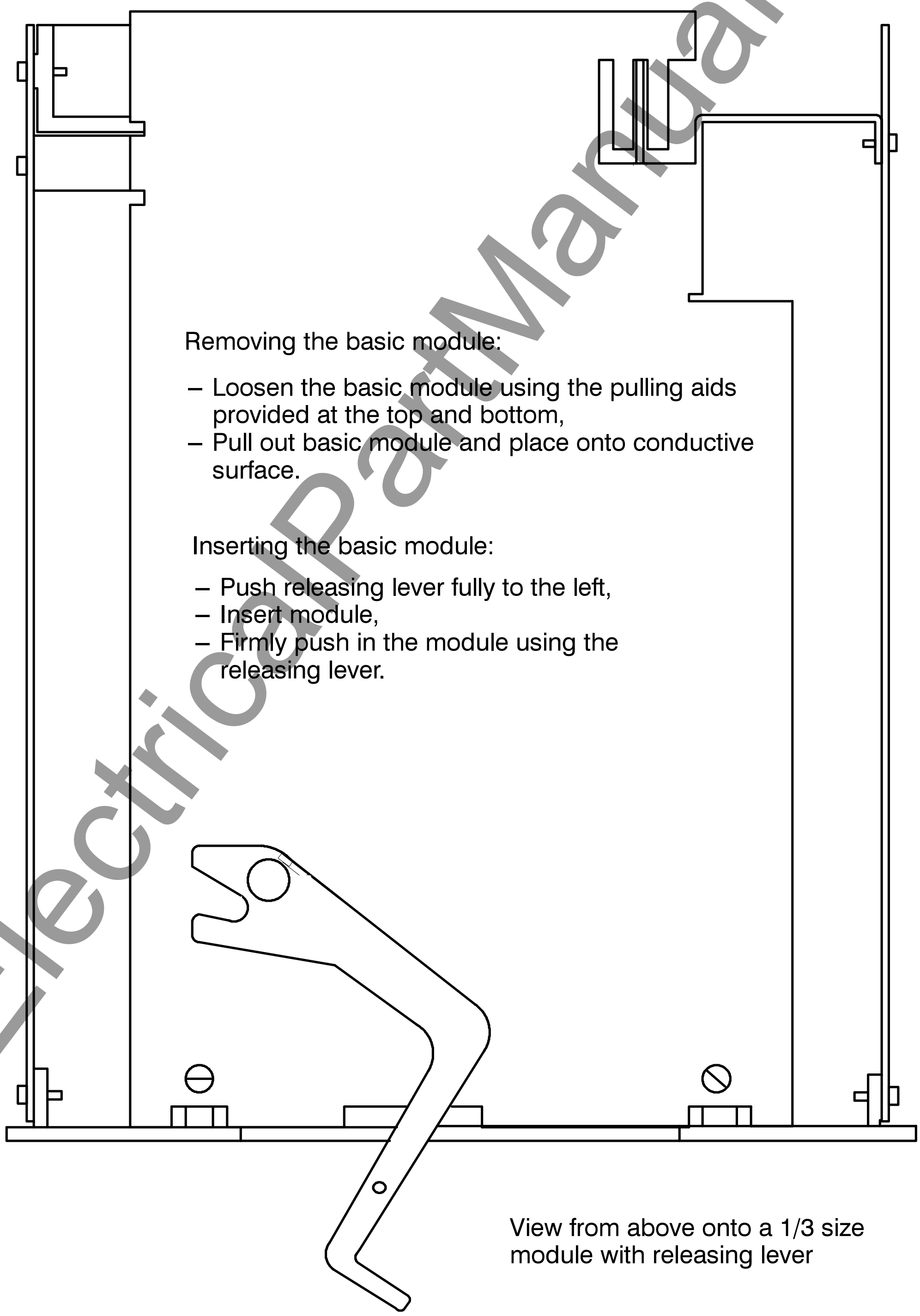


Figure 7.5 Aid for removing and inserting basic module

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 bath–soldered multilayer boards, the sensitive components and the protective finish.

Therefore, if a defect cannot be corrected by operator procedures such as described in Chapter 7, it is recommended that the complete relay should be returned to the manufacturer. Use the original transport packaging for return. If alternative packing is used, this must provide the degree of protection against mechanical shock, as laid down in IEC 255–21–1 class 2 and IEC 255–21–2 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 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

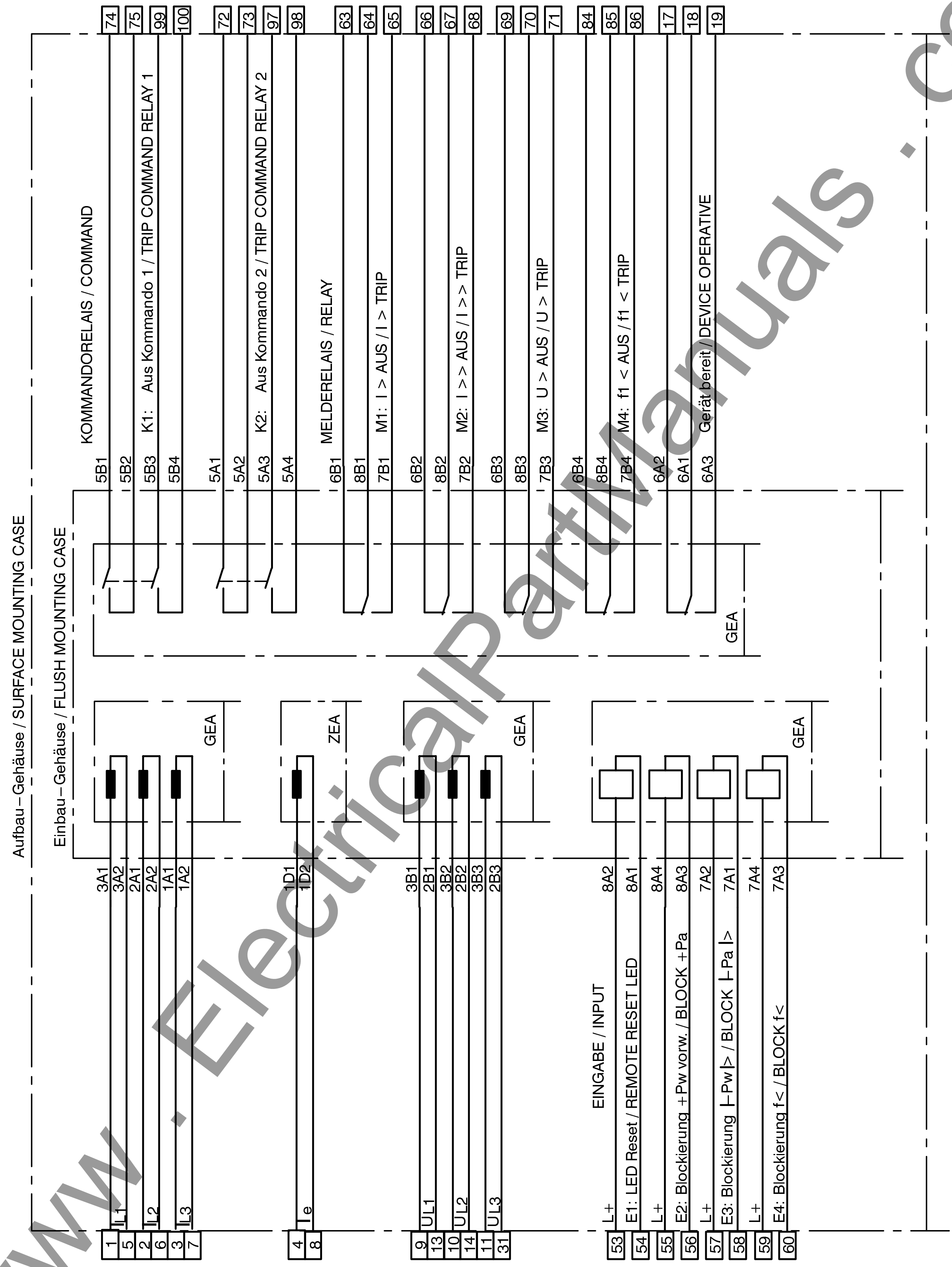


Figure A.1 General diagram 7UM511 (sheet 1 of 3)

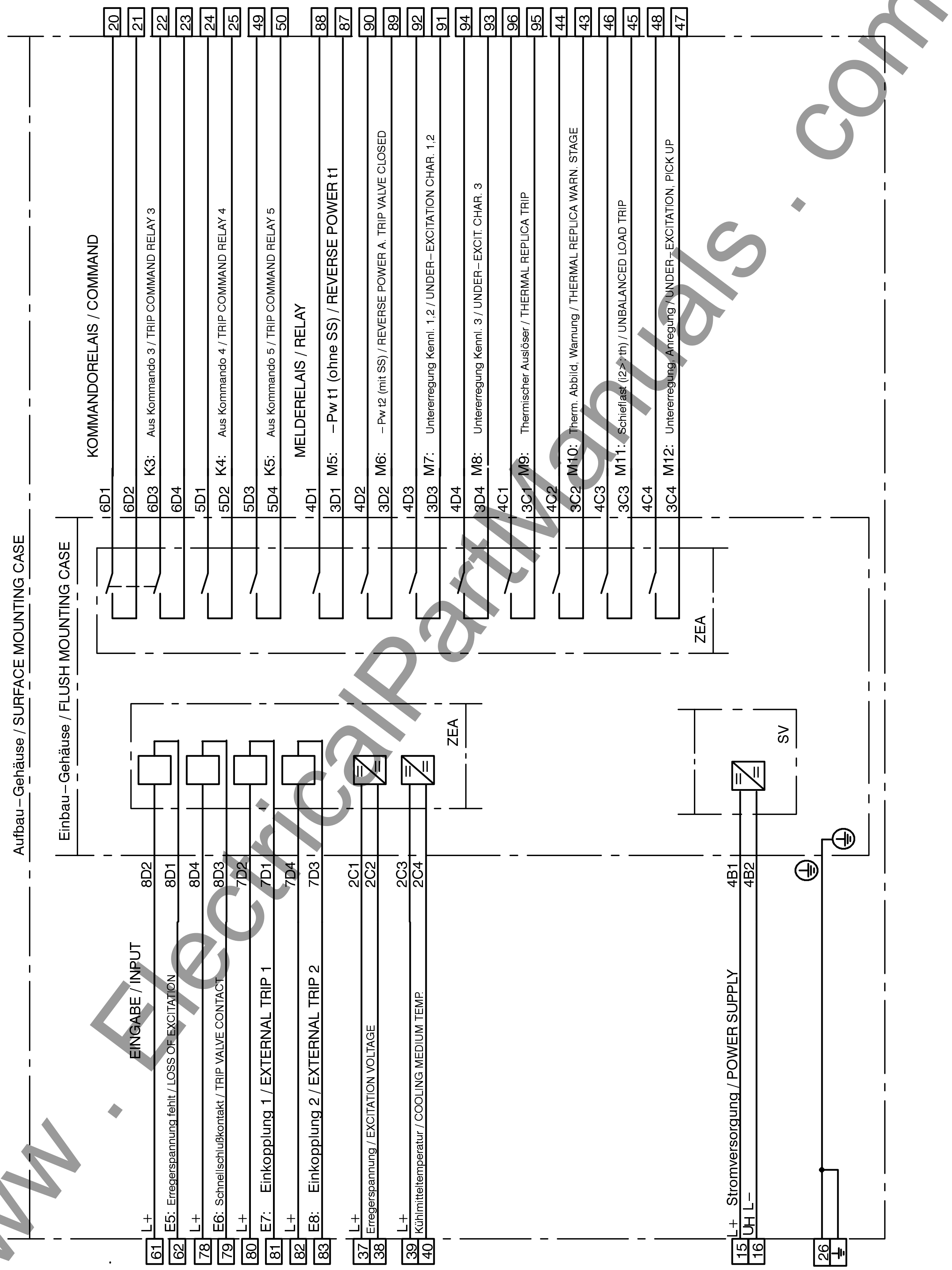
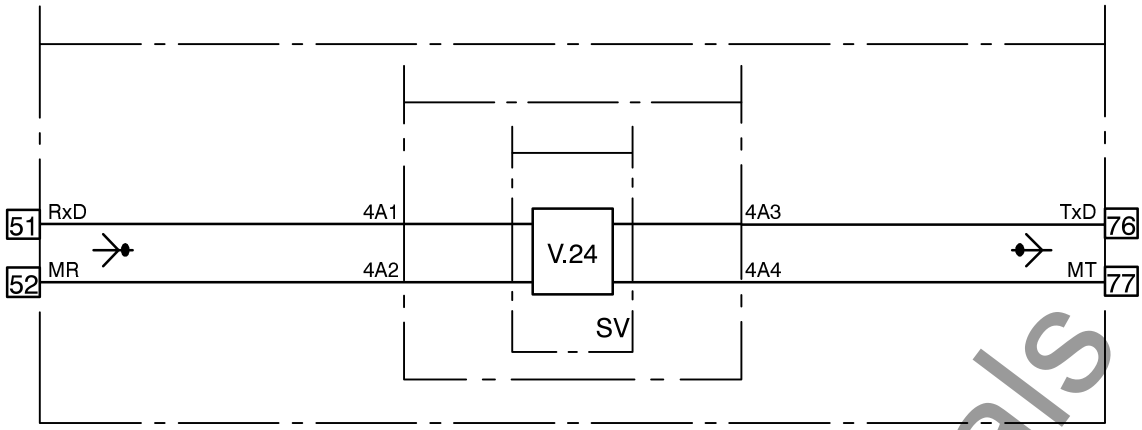
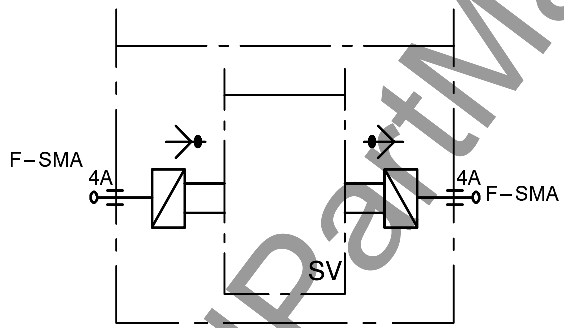


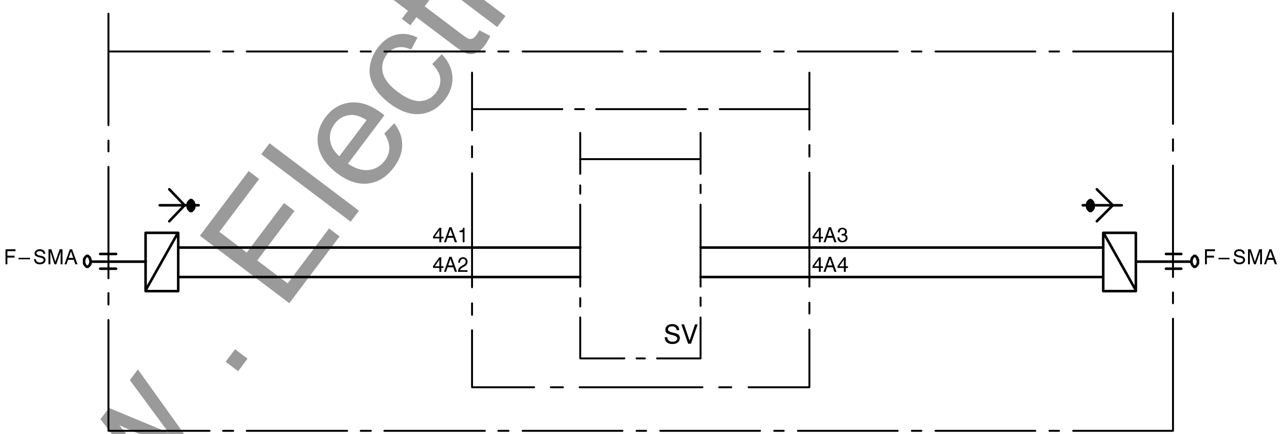
Figure A.2 General diagram 7UM511 (sheet 2 of 3)



Einbau– und Aufbaugehäuse mit V24 – Schnittstelle
FLUSH AND SURFACE MOUNTING CASE WITH V24 DATA LINK
7UM511*–*DB01–0BB0 /
7UM511*–*CB01–0BB0 /
7UM511*–*EB01–0BB0 /



Einbau– Gehäuse mit LWL – Modul
FLUSH MOUNTING CASE WITH FIBER OPTIC INTERFACE
7UM511*–*CB01–0CB0 /
7UM511*–*EB01–0CB0 /



Aufbau– Gehäuse mit LWL – Modul
SURFACE MOUNTING CASE WITH FIBER OPTIC INTERFACE
7UM511*–*DB01–0CB0 /

Figure A.3 General diagram 7UM511 (sheet 3 of 3)

B Connection diagram

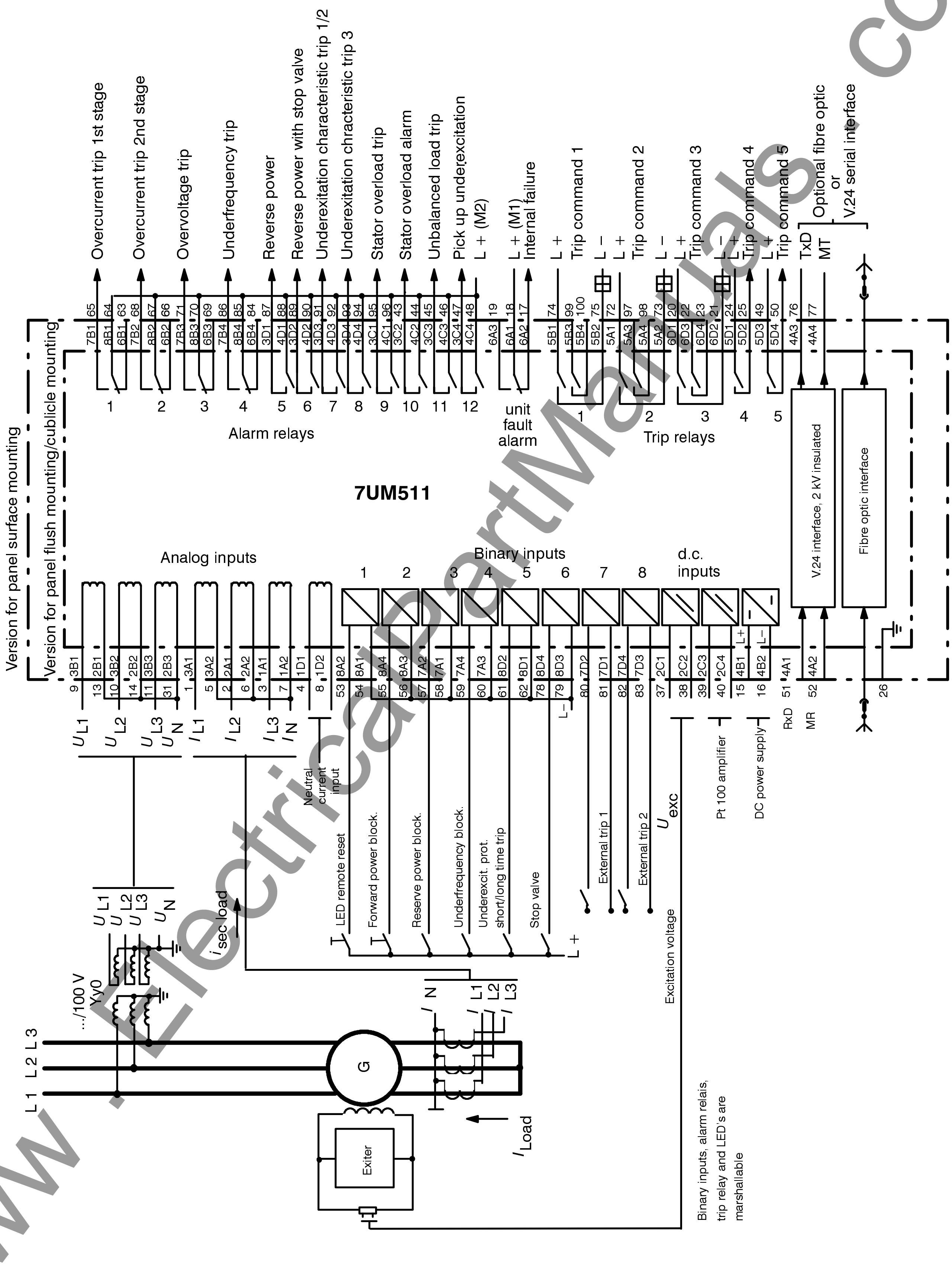


Figure B.1 Connection example 7UM511

C Tables

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 7UM511 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

		Ann.		LSA	VDEW/ZVEI				
FNo.	Meaning	Op	Ft	No.	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							135	53
16	>Block. of monitoring dir. via sys.-int							135	54
51	Device operative / healthy	CG		1		GI		135	81
52	Any protection operative	CG			CA	GI		p	18
55	Re-start of processor system	C		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							
771	Secondary voltage UL1E is	V							
772	Secondary voltage UL2E is	V							
773	Secondary voltage UL3E is	V							
774	Secondary earth voltage U0	V							
930	Current phase IL1 [%] =	V						134	144
931	Current phase IL2 [%] =	V						134	144
932	Current phase IL3 [%] =	V						134	144
933	Secondary voltage UL1E is	V						134	144
934	Secondary voltage UL2E is	V						134	144
935	Secondary voltage UL3E is	V						134	144
936	Secondary earth voltage U0 is	V						134	144
937	Frequency f [Hz] = (only LSA)	V						134	144
938	Positive sequence voltage	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
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
1503	>Block thermal overload protection	CG				GI		167	3
1506	>Reset memory for thermal replica	CG				GI		167	6
1511	Thermal overload prot. is switched off	CG		115		GI		167	11
1512	Thermal overload protection is blocked	CG		135		GI		167	12
1513	Thermal overload protection is active	CG		125		GI		167	13
1514	Failure temperature input	CG				GI		167	14
1515	Thermal overload prot.: Current warning	CG		16		GI		167	15
1516	Thermal overload prot.: Thermal warning	CG		17		GI		167	16
1519	Reset memory for thermal replica	CG		54		GI		167	19
1521	Thermal overload protection trip		C	250			BT	167	21
1721	>Overcurrent protection:block stage I>>	CG				GI		60	1
1722	>Overcurrent protection:block stage I>	CG				GI		60	2
1725	>Overcurrent protection:block stage IE>	CG				GI		60	5
1801	O/C fault detection stage I>> phase L1		CG	222		GI	BT	60	46
1802	O/C fault detection stage I>> phase L2		CG	223		GI	BT	60	47
1803	O/C fault detection stage I>> phase L3		CG	224		GI	BT	60	48
1805	O/C protection I>> phase trip		C	243			BT	60	70
1811	O/C fault detection stage I> phase L1		CG	209		GI	BT	60	50
1812	O/C fault detection stage I> phase L2		CG	211		GI	BT	60	51
1813	O/C fault detection stage I> phase L3		CG	213		GI	BT	60	52
1815	O/C protection I> phase trip		C	242			BT	60	71
1834	O/C fault detection IE> earth		CG	215		GI	BT	60	62
1836	O/C protection IE> earth trip		C	251			BT	60	72
1950	>O/C prot. : Block undervoltage seal-in	CG				GI		60	200
1955	O/C prot. stage I>> is switched off	CG		117		GI		60	205
1956	O/C prot. stage I>> is blocked	CG		137		GI		60	206
1957	O/C prot. stage I>> is active	CG		127		GI		60	207
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
1980	O/C prot. stage Ie> is switched off	CG		118		GI		60	230
1981	O/C prot. stage Ie> is blocked	CG		138		GI		60	231

FNo.	Meaning	Ann. Op	Ann. Ft	LSA No.	VDEW/ZVEI CA	GI	BT	Typ	Inf
1982	O/C prot. stage Ie> is active	CG		128		GI		60	232
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
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
5083	>Block reverse power protection	CG				GI		70	76
5086	>Stop valve tripped	CG		55		GI		70	77
5091	Reverse power prot. is switched off	CG		26		GI		70	81
5092	Reverse power protection is blocked	CG		49		GI		70	82
5093	Reverse power protection is active	CG		36		GI		70	83
5096	Reverse power: Fault detection		CG	228		GI	BT	70	84
5097	Reverse power: Trip		C	248			BT	70	85
5098	Reverse power: Trip with stop valve		C	249			BT	70	86
5113	>Block forward power supervision	CG				GI		70	101
5116	>Block forw. power superv. Pf< stage	CG				GI		70	102
5117	>Block forw. power superv. Pf> stage	CG				GI		70	103
5121	Forward power supervis. is switched off	CG		27		GI		70	106
5122	Forward power supervision is blocked	CG		48		GI		70	107
5123	Forward power supervision is active	CG		37		GI		70	108
5126	Forward power: Fault detect. Pf< stage		CG	230		GI	BT	70	109
5127	Forward power: Fault detect. Pf> stage		CG	232		GI	BT	70	110
5128	Forward power: Trip Pf< stage		C	254			BT	70	111
5129	Forward power: Trip Pf> stage		C	255			BT	70	112
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

FNo.	Meaning	Ann. Op	Ann. Ft	LSA No.	VDEW/ZVEI CA	GI	BT	Typ	Inf
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
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
5187	Stator earth fault: Trip U0 stage		C	237			BT	70	160
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
5208	>Block frequency prot. f3 stage	CG				GI		70	179
5209	>Block frequency prot. f4 stage	CG				GI		70	180
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
5220	Frequency protection: Fault stage f3>		CG	174		GI	BT	70	189
5221	Frequency protection: Fault stage f3<		CG	175		GI	BT	70	190
5222	Frequency protection: Fault stage f4>		CG	176		GI	BT	70	191
5223	Frequency protection: Fault stage f4<		CG	177		GI	BT	70	192
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
5228	Frequency protection: Trip stage f3>		C	184			BT	70	197
5229	Frequency protection: Trip stage f3<		C	185			BT	70	198
5230	Frequency protection: Trip stage f4>		C	186			BT	70	199
5231	Frequency protection: Trip stage f4<		C	187			BT	70	200
5323	>Block underexcitation protection	CG				GI		71	51
5326	>Block underexc. prot. char. 1+2	CG				GI		71	52
5327	>Block underexc. prot. char. 3	CG				GI		71	53
5328	>Exc. voltage failure recognized	CG				GI		71	54
5331	Underexc. prot. is switched off	CG		120		GI		71	55
5332	Underexc. prot. is blocked	CG		140		GI		71	56
5333	Underexc. prot. is active	CG		130		GI		71	57
5334	Underexc. prot. blocked by U<	CG				GI		71	58
5336	Exc. voltage failure recognized	CG				GI		71	59
5337	Underexc. prot. fault detection		CG	207		GI	BT	71	60
5341	Underexc. prot. trip char. 1+2		C	231			BT	71	61
5342	Underexc. prot. trip char. 1+2+Uexc<		C	233			BT	71	62
5343	Underexc. prot. trip char. 3		C	234			BT	71	63
5396	Failure rotor earth fault protection	CG		98		GI		71	126
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

FNo.	Meaning	Ann. Op	Ann. Ft	LSA No.	VDEW/ZVEI CA	GI	BT	Typ	Inf
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 7UM511 for PC, LC-display and binary inputs/outputs

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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)
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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				IO
16	>Sys-MM-block	>Block. of monitoring dir. via sys.-int				IO
51	Dev.operative	Device operative / healthy	CG			O
52	Prot. operat.	Any protection operative	CG			O
56	Initial start	Initial start of processor system	C			
60	LED reset	LED Reset	C			O
61	LogMeasBlock	Logging and measuring functions blocked	CG			
62	Test mode	Test mode	CG			
95	Param.running	Parameters are being set	CG			O
96	Param. Set A	Parameter set A is active	CG			O
97	Param. Set B	Parameter set B is active	CG			O
98	Param. Set C	Parameter set C is active	CG			O
99	Param. Set D	Parameter set D is active	CG			O
100	Wrong SW-vers	Wrong software-version	C			
101	Wrong dev. ID	Wrong device identification	C			
110	Annunc. lost	Annunciations lost (buffer overflow)	C			
111	Annu. PC lost	Annunciations for PC lost	C			
115	Flt.Buff.Over	Fault annunciation buffer overflow		C		
120	Oper.Ann.Inva	Operational annunciations invalid	CG			
121	Flt.Ann.Inval	Fault annunciations invalid	CG			
123	Stat.Buff.Inv	Statistic annunciation buffer invalid	CG			
124	LED Buff.Inva	LED annunciation buffer invalid	CG			
129	VDEW-StateInv	VDEW state invalid	CG			
135	Chs Error	Error in check sum	CG			
136	Chs.A Error	Error in check sum for parameter set A	CG			
137	Chs.B Error	Error in check sum for parameter set B	CG			
138	Chs.C Error	Error in check sum for parameter set C	CG			
139	Chs.D Error	Error in check sum for parameter set D	CG			
141	Failure 24V	Failure of internal 24 VDC power supply	CG			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 ∑I	Failure: Current summation supervision	CG			O
163	Failure Isymm	Failure: Current symmetry supervision	CG			O
167	Failure Usymm	Failure: Voltage symmetry supervision	CG			O

FNo.	Abbreviation	Meaning	Op	Ft	Ear	IO
171	Fail.PhaseSeq	Failure: Phase sequence supervision	CG			O
203	Flt.RecDatDel	Fault recording data deleted	C			
204	Flt.Rec.viaBI	Fault recording initiated via bin.input	C			
205	Flt.Rec.viaKB	Fault recording initiated via keyboard	C			
206	Flt.Rec.viaPC	Fault recording initiated via PC interf	C			
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			
671	UL1E=	Voltage UL1E =	V			
672	UL2E=	Voltage UL2E =	V			
673	UL3E=	Voltage UL3E =	V			
694	f [Hz]=	Frequency f [Hz] =	V			
771	UL1E =	Secondary voltage UL1E is	V			
772	UL2E =	Secondary voltage UL2E is	V			
773	UL3E =	Secondary voltage UL3E is	V			
774	U0 =	Secondary earth voltage U0	V			
802	Θ/ΘtripL1=	Temperature rise for phase L1	V			
803	Θ/ΘtripL2=	Temperature rise for phase L2	V			
804	Θ/ΘtripL3=	Temperature rise for phase L3	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			
907	Upos.seq=	Positive sequence voltage	V			
908	THETA=	Pole angle	V			
909	Uexcit.=	Excitation voltage	V			
910	ThermRep.=	Calculated rotor temp. (unbal. load)	V			
911	AMB.TEMP=	Cooling medium temperature	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			
1503	>O/L block	>Block thermal overload protection				IO
1506	>RM th.repl.Θ	>Reset memory for thermal replica				IO
1511	O/L Prot. off	Thermal overload prot. is switched off	CG			O
1512	O/L blocked	Thermal overload protection is blocked	CG			O
1513	O/L active	Thermal overload protection is active	CG			O
1514	Fail.Temp.inp	Failure temperature input	CG			O
1515	O/L Warn I	Thermal overload prot.: Current warning	CG			O
1516	O/L Warn Θ	Thermal overload prot.: Thermal warning	CG			O
1519	RM th.repl.Θ	Reset memory for thermal replica	CG			O
1521	O/L Trip	Thermal overload protection trip		C		O
1721	>I>> block	>Overcurrent protection:block stage I>>				IO

FNo.	Abbreviation	Meaning	Op	Ft	Ear	IO
1722	>I> block	>Overcurrent protection:block stage I>				IO
1725	>IE> block	>Overcurrent protection:block stage IE>				IO
1801	I>> Fault L1	O/C fault detection stage I>> phase L1		CG		O
1802	I>> Fault L2	O/C fault detection stage I>> phase L2		CG		O
1803	I>> Fault L3	O/C fault detection stage I>> phase L3		CG		O
1805	I>> Trip	O/C protection I>> phase trip		C		O
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
1834	IE> Fault	O/C fault detection IE> earth		CG		O
1836	IE> Trip	O/C protection IE> earth trip		C		O
1950	>Useal-in blk	>O/C prot. : Block undervoltage seal-in	CG			IO
1955	I>> off	O/C prot. stage I>> is switched off	CG			O
1956	I>> blocked	O/C prot. stage I>> is blocked	CG			O
1957	I>> active	O/C prot. stage I>> is active	CG			O
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
1980	Ie> off	O/C prot. stage Ie> is switched off	CG			O
1981	Ie> blocked	O/C prot. stage Ie> is blocked	CG			O
1982	Ie> active	O/C prot. stage Ie> is active	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
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
5083	>Pr block	>Block reverse power protection				IO
5086	>SV tripped	>Stop valve tripped	CG			IO
5091	Pr off	Reverse power prot. is switched off	CG			O

FNo.	Abbreviation	Meaning	Op	Ft	Ear	IO
5092	Pr blocked	Reverse power protection is blocked	CG			O
5093	Pr active	Reverse power protection is active	CG			O
5096	Pr Fault det.	Reverse power: Fault detection		CG		O
5097	Pr Trip	Reverse power: Trip		C		O
5098	Pr+SV Trip	Reverse power: Trip with stop valve		C		O
5113	>Pf block	>Block forward power supervision				IO
5116	>Pf< block	>Block forw. power superv. Pf< stage	CG			IO
5117	>Pf> block	>Block forw. power superv. Pf> stage	CG			IO
5121	Pf off	Forward power supervis. is switched off	CG			O
5122	Pf blocked	Forward power supervision is blocked	CG			O
5123	Pf active	Forward power supervision is active	CG			O
5126	Pf< Flt. det.	Forward power: Fault detect. Pf< stage		CG		O
5127	Pf> Flt. det.	Forward power: Fault detect. Pf> stage		CG		O
5128	Pf< Trip	Forward power: Trip Pf< stage		C		O
5129	Pf> Trip	Forward power: Trip Pf> stage		C		O
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
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
5187	U0> Trip	Stator earth fault: Trip U0 stage		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
5208	>f3 block	>Block frequency prot. f3 stage	CG			IO
5209	>f4 block	>Block frequency prot. f4 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
5218	f2> Fault	Frequency protection: Fault stage f2>		CG		O
5219	f2< Fault	Frequency protection: Fault stage f2<		CG		O
5220	f3> Fault	Frequency protection: Fault stage f3>		CG		O
5221	f3< Fault	Frequency protection: Fault stage f3<		CG		O
5222	f4> Fault	Frequency protection: Fault stage f4>		CG		O
5223	f4< Fault	Frequency protection: Fault stage f4<		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
5228	f3> Trip	Frequency protection: Trip stage f3>		C		O
5229	f3< Trip	Frequency protection: Trip stage f3<		C		O
5230	f4> Trip	Frequency protection: Trip stage f4>		C		O
5231	f4< Trip	Frequency protection: Trip stage f4<		C		O
5323	>Exc. block	>Block underexcitation protection				IO

FNo.	Abbreviation	Meaning	Op	Ft	Ear	IO
5326	>Char.1/2 blk	>Block underexc. prot. char. 1+2	CG			IO
5327	>Char. 3 blk	>Block underexc. prot. char. 3	CG			IO
5328	>Uexc fail.	>Exc. voltage failure recognized	CG			IO
5331	Excit. off	Underexc. prot. is switched off	CG			O
5332	Excit.blocked	Underexc. prot. is blocked	CG			O
5333	Excit.active	Underexc. prot. is active	CG			O
5334	Exc. U< blk	Underexc. prot. blocked by U<	CG			O
5336	Uexc failure	Exc. voltage failure recognized	CG			O
5337	Exc< Fault	Underexc. prot. fault detection		CG		O
5341	Exc< Trip	Underexc. prot. trip char. 1+2		C		O
5342	Exc<U<Trip	Underexc. prot. trip char. 1+2+Uexc<		C		O
5343	Exc<< Trip	Underexc. prot. trip char. 3		C		O
5396	Failure R/E/F	Failure rotor earth fault protection	CG			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
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	CG			IO
6873	>CBaux 1	>Trip circuit superv. CBaux 1	CG			IO
6879	Failure Trip1	Failure trip circuit 1	CG			O
6892	>Trip rel 2	>Trip circuit superv. trip relay 2	CG			IO
6893	>CBaux 2	>Trip circuit superv. CBaux 2	CG			IO
6899	Failure Trip2	Failure trip circuit 2	CG			O

Reference Table for Functional Parameters 7UM511

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      ____

1107 ADMIT.1/xd               Reciprocal value of synchronous reactance
     min. 0.20
     max. 3.00        ____

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        ____
```

```
1400 UNDEREXCIT PROTECTION

1401 UNDEREXCI.              State of the underexcitation protection
     OFF                 [ ] off
     ON                  [ ] on
     BLOCK TRIP REL      [ ] Block trip relay

1402 EXCI.VOLT.              State of the excitation voltage supervision
     OFF                 [ ] off
     ON                  [ ] on

1403 Uexcit.                 Setting of excitation voltage supervision
     min. 0.50               V
     max. 8.00          ____

1404 T-Ch. 1/2               Long time delay (characteristic 1 or 2)
     min. 0.00               s
     max. 32.00/∞       ____

1405 T-SHRT Ue<              Short time delay (characteristic 1 or 2)
     min. 0.00               s
     max. 32.00/∞       ____

1406 T-Ch. 3                 Time delay (characteristic 3)
     min. 0.00               s
     max. 32.00/∞       ____

1407 T-RESET                 Reset delay after trip
     min. 0.00               s
     max. 32.00         ____
```

```
1500 UNDEREXCIT CHARACTERISTICS

1501 LAMBDA 1                Conductance intersect of char. 1
     min. 0.25
     max. 3.00          ____

1502 ALPHA 1                 Inclination angle of char. 1
     min. 50                 °
     max. 120           ____

1503 LAMBDA 2                Conductance intersect of char. 2
     min. 0.25
     max. 3.00          ____

1504 ALPHA 2                 Inclination angle of char. 2
     min. 50                 °
     max. 120           ____

1505 LAMBDA 3                Conductance intersect of char. 3
     min. 0.25
     max. 3.00          ____

1506 ALPHA 3                 Inclination angle of char. 3
     min. 50                 °
     max. 120           ____
```

```
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                 V
     max. 100           ____

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         ____
```

```
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. 180           ____

1703 U>>                     Pick-up value of the U>> stage
     min. 30                 V
     max. 180           ____

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 U0>                     Pick-up value of displacement voltage U0>
     min. 5.0                V
     max. 100.0         ____
```

```
1903 T-U0>                   Time delay for trip
     min. 0.00               s
     max. 32.00/∞      _____

1904 T-RESET                 Reset delay after trip
     min. 0.00               s
     max. 32.00        _____
```

```
2100 OVER/UNDER FREQUENCY

2101 f> / f<                 State of the frequency protection
     OFF              [ ] off
     ON               [ ] on
     BLOCK TRIP REL   [ ] Block trip relay

2102 f STAGE 1               Pick-up value for stage f1
     min. 40.00              Hz
     max. 65.00        _____

2103 MEA.REP.f1              Number of meas. repetitions stage f1
     min. 2
     max. 10000        _____

2104 f STAGE 2               Pick-up value for stage f2
     min. 40.00              Hz
     max. 65.00        _____

2105 MEA.REP.f2              Number of meas. repetitions stage f2
     min. 2
     max. 10000        _____

2106 f STAGE 3               Pick-up value for stage f3
     min. 40.00              Hz
     max. 65.00        _____

2107 MEA.REP.f3              Number of meas. repetitions stage f3
     min. 2
     max. 10000        _____

2108 f STAGE 4               Pick-up value for stage f4
     min. 40.00              Hz
     max. 65.00        _____

2109 MEA.REP.f4              Number of meas. repetitions stage f4
     min. 2
     max. 10000        _____

2110 BLOCK. U<               Minimum operating voltage for frequency prot.
     min. 40                 V
     max. 100          _____
```

```
2200 FORW.POWER SUPERVISION

2201 FORW.POWER              State of the forward power supervision
     OFF              [ ] off
     ON               [ ] on
     BLOCK TRIP REL   [ ] Block trip relay
```

```
2202 Pf<                    Supervision of decrease in forw. active power
     min. 0.5               %
     max. 120.0         ____

2203 Pf>                    Supervision of increase in forw. active power
     min. 1.0               %
     max. 120.0         ____

2204 T-Pf<                  Time delay for trip Pf<
     min. 0.00              s
     max. 32.00/∞       ____

2205 T-Pf>                  Time delay for trip Pf>
     min. 0.00              s
     max. 32.00/∞       ____

2206 T-RESET                Reset delay after trip
     min. 0.00              s
     max. 32.00         ____

2207 MEA.METHOD             Method of operation
     ACCURATE           [ ] Method: Accurate
     FAST               [ ] Method: Fast
```

```
2300 REVERSE POWER

2301 REV. POWER             State of the reverse power protection
     OFF                [ ] off
     ON                 [ ] on
     BLOCK TRIP REL     [ ] Block trip relay

2302 P> REVERSE             Pick-up value of reverse power
     min. -30.00            %
     max. -0.50         ____

2303 T-SV-OPEN              Time delay for trip with stop valve open
     min. 0.00              s
     max. 32.00/∞       ____

2304 T-SV-CLOS.             Time delay for trip with stop valve closed
     min. 0.00              s
     max. 32.00/∞       ____

2305 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       ____
```

```
2600 OVERCURR. I>>

2601 O/C I>>                  State of O/C I>> stage
     OFF                [ ] off
     ON                 [ ] on
     BLOCK TRIP REL     [ ] Block trip relay

2602 I>>                      Pick-up value I>>
     min. 0.10                I/In
     max. 8.00          ____

2603 T-I>>                    Time delay for trip I>>
     min. 0.00                s
     max. 32.00/∞       ____

2604 T-RESET                  Reset delay after trip
     min. 0.00                s
     max. 32.00         ____
```

```
2700 OVERCURR. Ie>>

2701 O/C Ie>                  State of O/C Ie> stage
     OFF                [ ] off
     ON                 [ ] on
     BLOCK TRIP REL     [ ] Block trip relay

2702 Ie>                      Pick-up value of earth current
     min. 10                  mA
     max. 1000          ____

2703 T-Ie>                    Time delay for trip Ie>
     min. 0.00                s
     max. 32.00/∞       ____

2704 T-RESET                  Reset delay after trip
     min. 0.00                s
     max. 32.00         ____

2705 Ie<                      Setting Ie< supervision
     min. 2.0                 mA
     max. 50.0          ____
```

```
2800 THERMAL OVERLOAD PROT.

2801 OVERLOAD                 State of the stator overload protection
     OFF                [ ] off
     ON                 [ ] on
     BLOCK TRIP REL     [ ] Block trip relay

2802 K-FACTOR                 K-factor for thermal overload protection
     min. 0.50
     max. 2.50          ____

2803 T-CONSTANT               Time constant for thermal overload protection
     min. 30                  s
     max. 32000         ____
```

```
2804 Θ WARN                  Thermal warning stage
     min. 70                 %
     max. 100        _____

2805 TMP.RISE I              Temperature rise at rated secondary current
     min. 40                 ˚C
     max. 200        _____

2806 TEMP. INP.              Temperature input (PT100/4..20mA)
     NON-EXIST           [ ] Non-existent
     PT 100              [ ] PT100
     4-20 mA             [ ] 4..20 mA

2807 TEMP. MAX               Maximum temperature (PT100/4..20mA)
     min. 40                 ˚C
     max. 150        _____
```

```
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       _____

2907 SYM.Uthres              Symmetry threshold for voltage monitoring
     min. 10                 V
     max. 100        _____

2908 SYM.Fact.U              Symmetry factor for voltage monitoring
     min. 0.58
     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       _____
```

```
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 7UM511

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. 7UM511

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 UL1E=	Voltage UL1E =
5705 UL2E=	Voltage UL2E =
5706 UL3E=	Voltage UL3E =
5707 IL1[%] =	Current in phase IL1 [%] =
5708 IL2[%] =	Current in phase IL2 [%] =
5709 IL3[%] =	Current in phase IL3 [%] =
5710 Ie=	Earth current
5711 UL1E =	Secondary voltage UL1E is
5712 UL2E =	Secondary voltage UL2E is
5713 UL3E =	Secondary voltage UL3E is
5714 U0 =	Secondary earth voltage U0
5715 Ipos.seq=	Positive sequence current
5716 Upos.seq=	Positive sequence voltage
5717 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 THETA=	Pole angle
5806 Uexcit.=	Excitation voltage

5900 OPERATIONAL MEAS. VALUES C

5901 Θ/ΘtripL1=	Temperature rise for phase L1
5902 Θ/ΘtripL2=	Temperature rise for phase L2
5903 Θ/ΘtripL3=	Temperature rise for phase L3
5904 AMB.TEMP=	Cooling medium temperature
5905 Ineg.seq=	Negative sequence current/unbal. load
5906 ThermRep.=	Calculated rotor temp. (unbal. load)

Reference Table for Configuration Parameters 7UM511

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

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

7801 UNDEREXCIT.              Underexcitation protection
     EXIST              [ ]   Existent
     NON-EXIST          [ ]   Non-existent

7802 UNDERVOLT.               Undervoltage protection
     EXIST              [ ]   Existent
     NON-EXIST          [ ]   Non-existent

7803 OVERVOLT.                Overvoltage protection
     EXIST              [ ]   Existent
     NON-EXIST          [ ]   Non-existent

7804 SEF PROT.                Stator earth fault protection
     EXIST              [ ]   Existent
     NON-EXIST          [ ]   Non-existent

7805 FREQUENCY                Frequency protection
     EXIST              [ ]   Existent
     NON-EXIST          [ ]   Non-existent

7806 FOR. POWER               Forward power supervision
     EXIST              [ ]   Existent
     NON-EXIST          [ ]   Non-existent

7807 REV. POWER               Reverse power protection
     EXIST              [ ]   Existent
     NON-EXIST          [ ]   Non-existent

7808 UNBAL. LOAD              Unbalanced load protection
     EXIST              [ ]   Existent
     NON-EXIST          [ ]   Non-existent
```

```
7809 O/C I>                    Overcurrent protection I>
     EXIST                 [ ] Existent
     NON-EXIST             [ ] Non-existent

7810 O/C I>>                   Overcurrent protection I>>
     EXIST                 [ ] Existent
     NON-EXIST             [ ] Non-existent

7811 O/C Ie>                   Overcurrent protection Ie>
     EXIST                 [ ] Existent
     NON-EXIST             [ ] Non-existent

7812 OVERLOAD                  Stator overload protection
     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

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 7UM511

7900 DEVICE CONFIGURATION

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

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Dept. EV S D PSN

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Germany

Dear reader,

printing errors can never be entirely eliminated: therefore, should you come across any when reading this manual, kindly enter them in this form together with any comments or suggestions for improvement that you may have.

From

Name

Company/Dept.

Address

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Corrections/Suggestions

Substantial alterations against previous issue:

Accessory device 7XR6100 for rotor earth fault protection.

Subject to technical alteration

Siemens Aktiengesellschaft

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