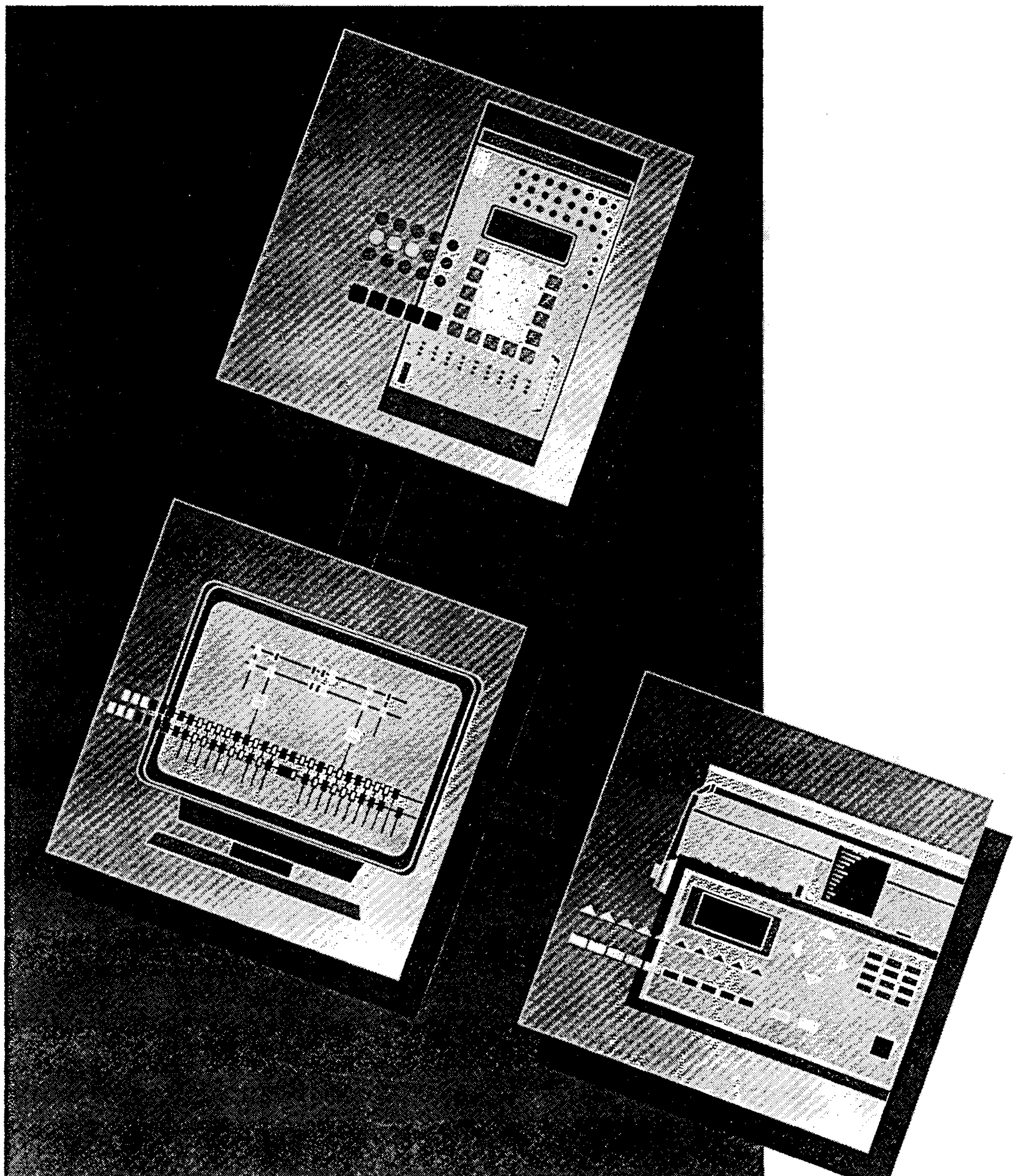
SIEMENS

7UM516 V3.0

Numerical Machine Protection



C53000-G1176-C97-2

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Numerical Machine Protection

7UM516 V3.0

Instruction Manual Order No. C53000-G1176-C97-2

– Impedance protection	$Z<$	– Unbalanced load protection	$I_2>$
– Out-of-step protection	$\Delta Z/\Delta t$	– Stator earth fault protection	$U_0>$
– Reverse power protection	$\lvert -P_r \rvert>$	– Coupling of external signals	
– Forward power supervision	$P_f><$		

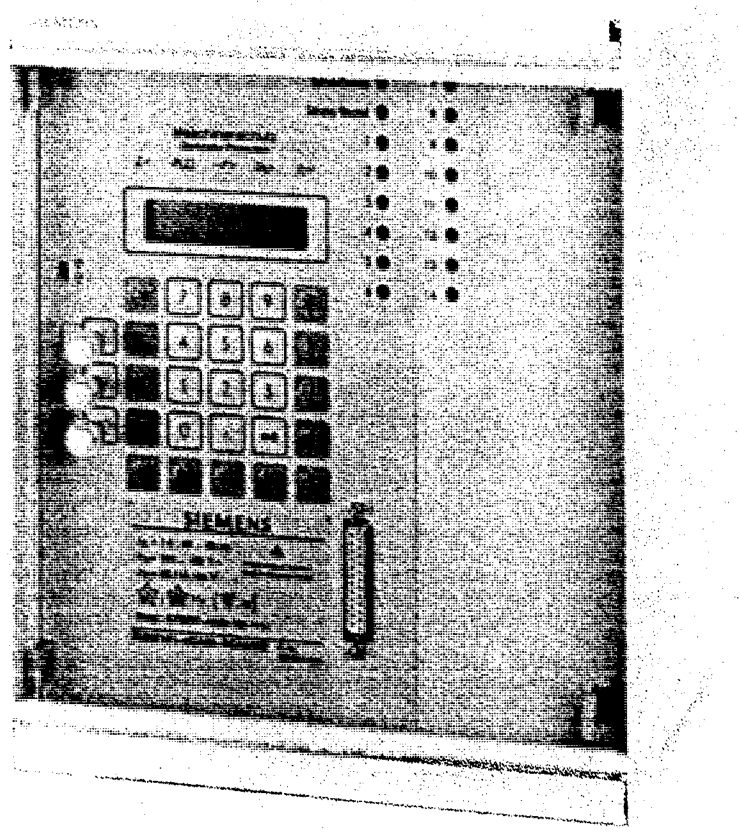

Figure 1 Illustration of the numerical machine protection relay 7UM516 (in flush mounting case)

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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).

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 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 255 and the German standards DIN 57 435 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 7UM516 is a numerical machine protection unit from the "Numerical Machine Protection series 7UM51" and provides a practical combination of protection functions especially for large electrical machines or power station blocks. A survey of this machine protection series is shown in Figure 1.1.

The unit supplements the protection and supervisory functions of the 7UM511, 7UM512, 7UM515 and 7UT51 relays and, together, they provide a complete protection system for large high-voltage generators which are block connected with a unit transformer to the power system. It is, however, completely autonomous and can, with all its functions, be operated completely independent of other protection equipment.

A large number of alarm relays and LED's 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 in accordance with VDEW/ZVEI is used, as well as according DIN 19244 (selectable). The device can therefore be incorporated in Localized Substation Automation networks (LSA).

1.2 Features

- Processor system with powerful 16-bit-microprocessor;
- Complete digital measured value processing and control from data acquisition and digitizing of the measured values up to the trip decision for the circuit breakers;
- Complete galvanic and reliable separation of the internal processing circuits from the measurement, control and supply circuits of the system, with screened analog input transducers, binary input and output modules and DC converter;
- Insensitive to v.t. and c.t. errors, transient conditions and interferences;
- High accuracy by means of process images using physical replica;
- Accurate measurement is ensured even in case of frequency deviations ($f_N \pm 10$ Hz) by frequency dependent filter correction;
- 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 signal can be processed Two trip circuit supervision channels	D.C. voltage time protection Overvoltage protection and frequency dependent undervoltage protection Earth fault protection $U_0>$, $I_0>$ directional Rotor earth fault protection, two-stage Unbalanced load protection Overcurrent/undercurrent supervision Overcurrent time protection with undervoltage seal-in Single-phase power protection Frequency protection, two-stage Four external trip signal can be processed Two trip circuit supervision channels

7UM515	7UM516
Overflux protection U/f Overvoltage protection, two-stage Undervoltage protection, inverse time Frequency protection, four-stage Earth fault protection $U_0>$ Interturn fault protection Stator earth fault 100 % protection Rotor earth fault protection, two-stage Four external trip signal 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 signal 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 signal can be processed Four external binary input signal 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 signal can be processed Four ext. binary inputs can be processed (5 trip relays, large size: $^1/_3$ 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:

Impedance protection with

- phase selective overcurrent fault detection with undervoltage seal-in (for synchronous machines which take their excitation voltage from the terminal voltage),
- two impedance zones, three time stages,
- polygonal tripping characteristic with independent setting of reach along the R- and X-axis,
- variable fault resistance tolerance,
- power swing detection by $\Delta Z/\Delta t$ measurement,
- power swing blocking in case of power swings in the system avoids unwanted trip occurrences.

Out-of-step protection

- based on the well experienced impedance measurement method,
- measurement release by the positive sequence current component, measurement blocking by the negative sequence current component,
- evaluation of the rate of change of the impedance vector,
- optimum matching to the on-site conditions by selectable characteristic parameters,
- reliable distinction between the power swing centre being in the system or in the generator unit area.

Stator earth fault protection U_0

- measurement of the displacement voltage with fundamental wave filters, for machines in block connection,
- protective range 90 % to 95 % of the stator windings,

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.

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 closed stop valve,
- 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.

Coupling of external signal

- 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.

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:

- **7UM516*-*B***-** in housing 7XP2040-1 for **panel surface mounting**

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

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

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

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

  For the isolated interface to a central control and storage unit, an additional coupling facility has been provided. For the hard-wired V.24 (RS232C) serial interface (7UM516*-*****-***B**), 4 screwed terminals are provided. For the interface for optical fibre connection (model 7UM516*-*****-***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.

- **7UM516*-*C***-** in housing 7XP2040-2 for **panel flush mounting** or **7UM516*-*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 (7UM516*-*****-***B**) is led to a 4-pole connection module. In the interface for optical fibre connection (7UM516*-*****-***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. **1**A2). The individual connections within a module are numbered consecutively from left to right (when viewed from the rear), (e.g. 1A**2**); refer Figure 2.1.

  Degree of protection for the housing is IP51, for the terminals IP21. For dimensions please refer to Figure 2.3.

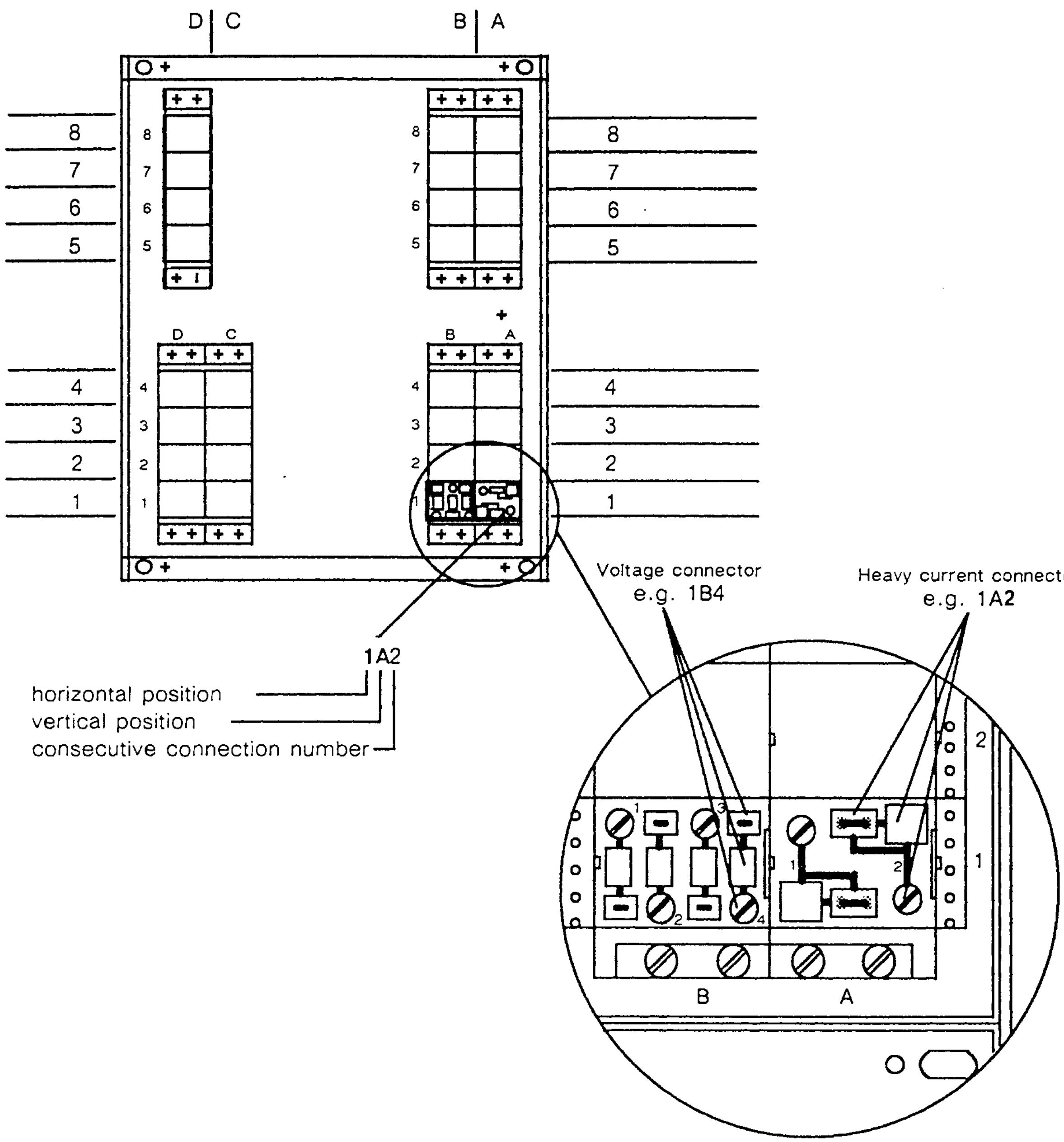
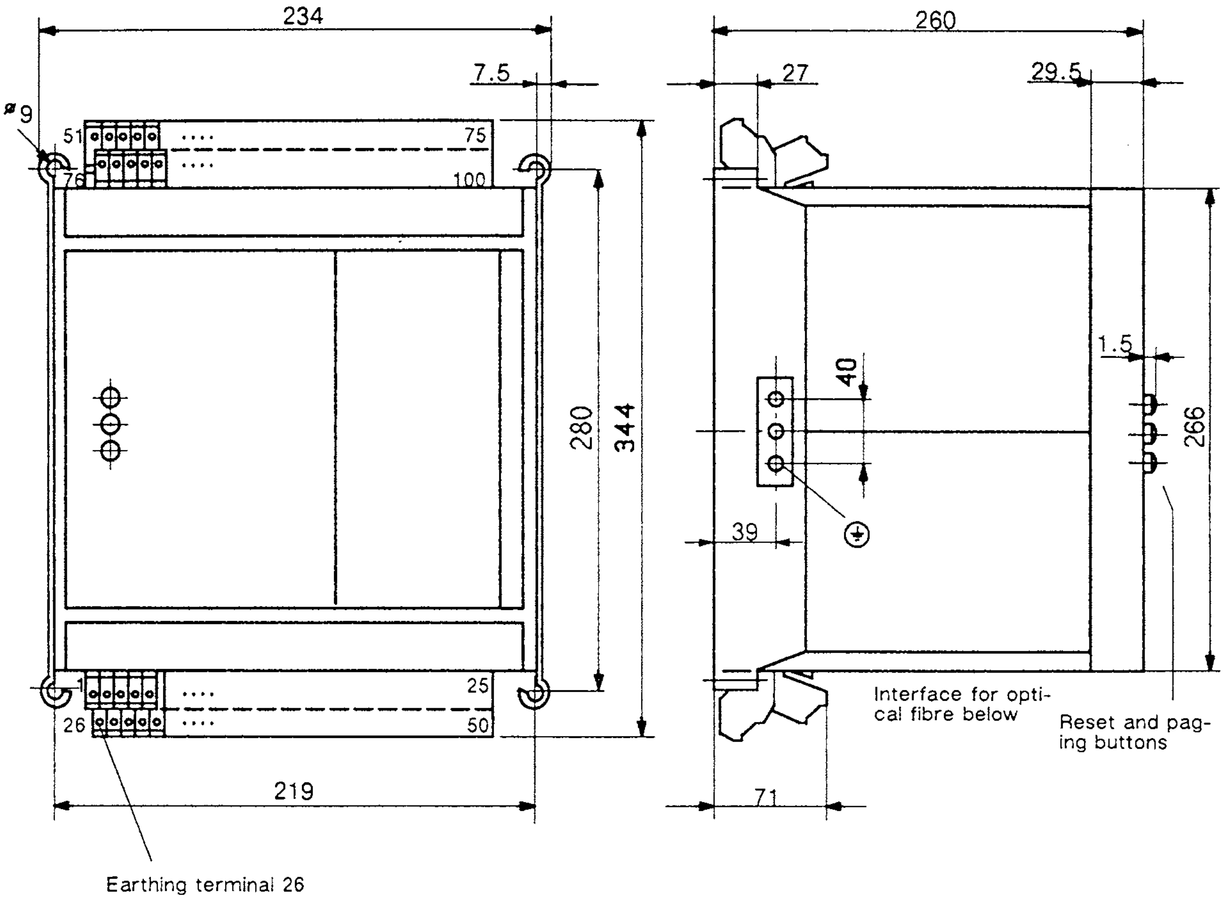


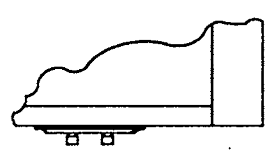
Figure 2.1 Connection plugs (rear view) - housing for flush mounting - example

2.2 Dimensions

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

7UM516 Housing for **panel surface mounting** 7XP2040-1





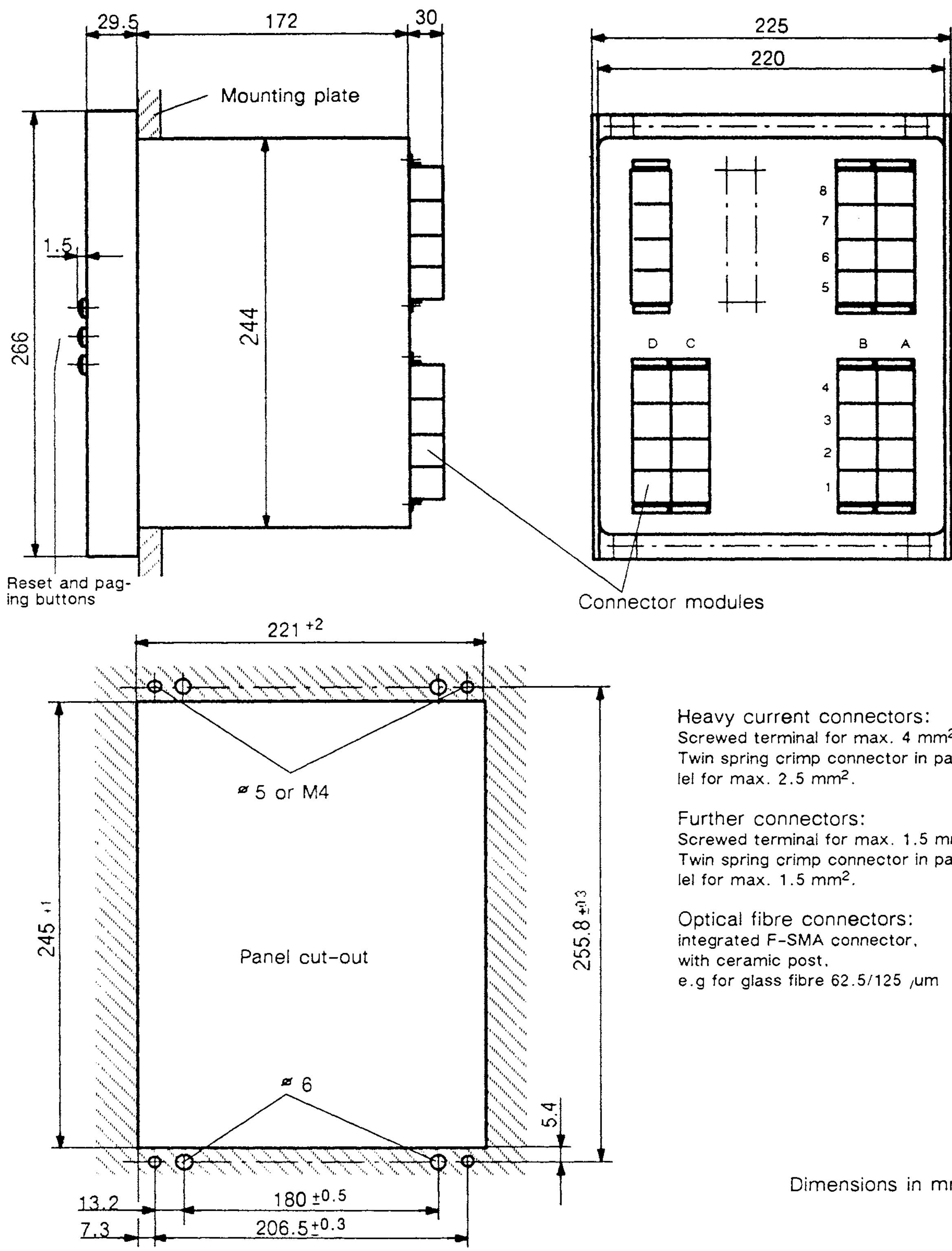
Max. 100 terminals for cross-section max. 7 mm²

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

Dimensions in mm

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

7UM516 Housing for **panel flush mounting** or **cubicle installation** 7XP2040-2



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

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

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

Dimensions in mm

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

2.3 Ordering data

Numerical Machine Protection	7.		8.	9.	10.	11.	12.		13.	14.	15.	16.
7 U M 5 1 6	☐	–	☐	☐	A	0	1	–	0	☐	A	0

Rated current; rated frequency

1 A; 50/60 Hz 1

5 A; 50/60 Hz 5

Auxiliary voltage

24/48 V dc 2

60/110/125 V dc 4

220/250 V dc 5

Construction

in housing 7XP2040-1 for panel surface mounting .... B

in housing 7XP2040-2 for panel flush mounting C

in housing 7XP2040-2 for cubicle installation
(without glass front) .... E

Serial interface for coupling to a control centre

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

serial interface for optical fibre connection C

2.4 Accessories

The measurement input for the neutral displacement voltage measurement of the earth fault protection U_0 is dimensioned for a rated voltage of 100 V. A voltage divider 500 V/100 V is required when connecting to a neutral earthing transformer or a line connected earthing transformer with a secondary voltage of 500 V. The **voltage divider 500 V/100 V** type **3PP1336-1CZ-013001** is suitable and also includes a test resistor. Refer to Figure 2.4 for schematic circuit diagram and to Figure 2.5 for dimensions.

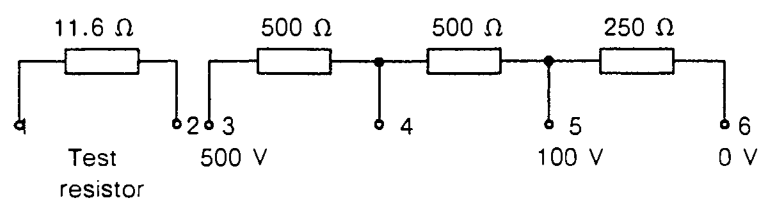
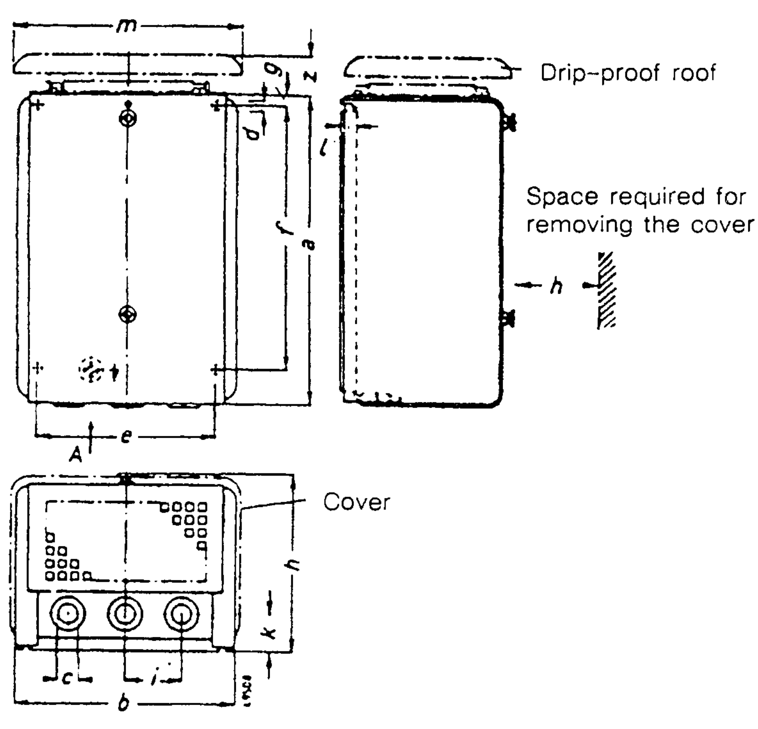


Figure 2.4 Schematic diagram of voltage divider 500 V/100 V, type 3PP1336-1CZ-013001



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

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

Figure 2.5 Dimensions of 3PP133: for voltage divider 3PP1336-1CZ-013001 (500 V/100 V)

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)
Burden: ct circuits per phase	
– at I_N = 1 A	approx 0.1 VA
– at I_N = 5 A	approx 0.4 VA
Burden: vt circuits	
– at 100 V	approx 0.5 VA
– for earth fault detection at 100 V	approx 0.5 VA
Overload capability ct circuits	
– thermal (rms)	100 $\times I_N$ for 1 second 20 $\times I_N$ for 10 seconds 4 $\times I_N$ continuous
– dynamic (impulse)	250 $\times I_N$ (half cycle)
Overload capability vt circuits	
– thermal (rms)	140 V continuous
Accuracy range (specified tolerances)	$0.9 \leq f/f_N \leq 1.1$ } at least one measuring quantity $\geq$0.1 · rated value
Operating range (all functions operate)	$0.8 \leq f/f_N \leq 1.2$ } at least one measuring quantity $\geq$0.1 · rated value

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
Operating ranges	19 to 56 V dc	48 to 144 V dc	176 to 288 V

Superimposed ac voltage, peak-to-peak	$\leq$ 12 % at rated voltage $\leq$ 6 % at the limits of the voltage ranges
Power consumption quiescent	approx 11 W
picked-up	approx 20 W
Bridging time during failure/short-circuit of auxiliary dc 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	13	
Contacts per relay	1 CO or 1 NO	
Switching capacity MAKE/BREAK	20	W/VA
Switching voltage	250	V
Permissible current	1	A

Binary inputs, number 8

Voltage range: reconnectable 24 to 250 V dc in 3 ranges:

for rated control voltage	24/48/60 Vdc	110/125 Vdc	220/250 Vdc
Pick-up value, approx.	17 Vdc	80 Vdc	160 Vdc*)

*) for production series /**CC**

Current consumption: approx 1.7 mA independent of operating voltage

Serial interfaces

Operator terminal interface	non-isolated
- Connection	at the front, 25-pole subminiature connector according ISO 2110 for connection of a personal computer or similar
- Transmission speed	as delivered 9600 Baud; min. 1200 Baud; max. 19200 Baud
Interface for data transfer to a control centre	isolated
- Standards	similar V.24/V.28 to CCITT; RS 232 C to EIA; Protocol to VDEW/ZVEI 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 with rated frequency for 1 min
- 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 255-5
– High voltage test (routine test) except d.c. voltage supply input and RS485	2 kV (rms), 50 Hz
– High voltage test (routine test) only d.c. voltage supply input and RS485	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 255-22 (product standard) EN 50082-2 (generic standard) VDE 0435 /part 303
– High frequency IEC 255-22-1 class III	2.5 kV (peak); 1 MHz; τ =15 µs; 400 shots/s; duration 2 s
– Electrostatic discharge IEC 255-22-2 class III and EN 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 255-22-3 (report) class III	10 V/m; 27 MHz to 500 MHz
– Radio-frequency electromagnetic field, amplitude modulated; ENV 50140, class III	10 V/m; 80 MHz to 1000 MHz; 80 % AM; 1 kHz
– Radio-frequency electromagnetic field, pulse modulated; ENV 50140/ENV 50204, cl. III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 %
– Fast transients IEC 255-22-4 and EN 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 ENV 50141, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
– Power frequency magnetic field EN 61000-4-8, class IV	30 A/m continuous; 300 A/m for 3 s; 50 Hz
EMC tests; emission (type tests)	
Standard:	EN 50081-* (generic standard)
– Conducted interference voltage, aux. voltage CISPR 22, EN 55022, class B	150 kHz to 30 MHz
– Interference field strength CISPR 11, EN 55011, class A	30 MHz to 1000 MHz

3.1.3 Mechanical stress tests

Vibration and shock during operation

Standards:	IEC 255-21 and IEC 68-2
- Vibration IEC 255-21-1, class 1 IEC 68-2-6	sinusoidal 10 Hz to 60 Hz: ± 0,035 mm amplitude; 60 Hz to 150 Hz: 0,5 g acceleration sweep rate 10 octaves/min 20 cycles in 3 orthogonal axes
- Shock IEC 255-21-2, class 1	half sine acceleration 5 g, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
- Seismic vibration IEC 255-21-3, class 1 IEC 68-3-3	sinusoidal 1 Hz to 8 Hz: ± 3,5 mm amplitude (hor. axis) 1 Hz to 8 Hz: ± 1,5 mm amplitude (vert. axis) 8 Hz to 35 Hz: 1 g acceleration (hor. axis) 8 Hz to 35 Hz: 0,5 g acceleration (vert. axis) sweep rate 1 octave/min 1 cycle in 3 orthogonal axes

Vibration and shock during transport

Standards:	IEC 255-21 and IEC 68-2
- Vibration IEC 255-21-1, class 2 IEC 68-2-6	sinusoidal 5 Hz to 8 Hz: ± 7.5 mm amplitude; 8 Hz to 150 Hz: 2 g acceleration sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
- Shock IEC 255-21-2, class 1 IEC 68-2-27	half sine acceleration 15 g, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
- Continuous shock IEC 255-21-2, class 1 IEC 68-2-27	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
permissible temperature during storage	–25 °C to +55 °C
permissible temperature during transport	–25 °C to +70 °C

Storage and transport with standard works packaging!

– Permissible humidity	mean value per. year $\leq$ 75 % relative humidity; on 30 days per year 95 % relative humidity; Condensation not permissible!

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

3.1.5 Service conditions

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

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

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

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

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

3.1.6 Design

Housing	7XP20; refer to Section 2.1
Dimensions	refer to Section 2.2
Weight	
– in housing for surface mounting	approx. 12.0 kg
– in housing for flush mounting	approx. 10.5 kg
Degree of protection acc. to EN 60529	
– Housing	IP 51
– Terminals	IP 21

3.2 Impedance protection

Overcurrent fault detection

Phase currents $I_{ph}>/I_N$	0.20 to 4.00 (steps 0.01)
Drop-off ratio	approx. 0.95
Measuring tolerances according VDE 0435 part 303	± 3% of set value
Undervoltage seal-in U<	30 V to 130 V (steps 1 V)
Drop-off ratio	approx. 1.05
Measuring tolerances according VDE 0435 part 303	± 3% of set value

Impedance measurement

Characteristic	polygonal, 2 independent stages
Setting values (based on I_N = 1A*)	
X = forwards reach (X_1, X_{1B})	0.05 Ω to 130.00 Ω (steps 0.01 Ω)
R = resistance tolerance (R_1, R_{1B})	0.05 Ω to 65.00 Ω (steps 0.01 Ω)
Measuring tolerances according VDE0435 part 303 with sinusoidal quantities	$\left\lvert\frac{\Delta X}{X}\right\rvert \leq 5\%$ for $30° \leq \phi_{sc} \leq 90°$ $\left\lvert\frac{\Delta R}{R}\right\rvert \leq 5\%$ for $0° \leq \phi_{sc} \leq 60°$

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

Times

Shortest tripping time	35 ms
Drop-off time	approx. 30 ms to 80 ms
Time stages: t_1, t_{1B}, t_2	0.00 s to 32.00 s (steps 0.01 s) or ∞ (i.e. stage ineffective)
Drop-off delay time t_d	0.00 s to 32.00 s (steps 0.01 s)
Holding time of undervoltage seal-in	0.00 s to 32.00 s (steps 0.01 s)
Time expiry tolerances	≤1% of set value or 10 ms

The set times are pure delay times.

Power swing blocking

Setting the difference ΔR between the polygons (secondary based on I_N = 1A *)	0.10 Ω to 10.0 Ω (steps 0.01 Ω)
Setting rate of change ΔR/ΔT	1.0 Ω/s to 200.0 Ω/s (steps 1 Ω/s)
Action time	0.00 s to 32.00 s (steps 0.01 s) or ∞ (i.e. until drop-off of the power swing polygon)

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

Influence variables

– Auxiliary d.c. voltage in range $0.8 \leq U_H/U_{HN} \leq 1.15$	≤ 1%
– Temperature in range $-5\ °C \leq \theta_{amb} \leq +40\ °C$	≤ 0.5 %/10 K
– Frequency in range $0.9 \leq f/f_N \leq 1.1$	≤ 2 %

3.3 Stator earth fault protection $U_0>$

Setting ranges/steps

Displacement voltage $U_0>$	5.0 V to 120.0 V	(steps 0.1 V)
Time delays T	0.00 s to 32.00 s	(steps 0.01 s)
Drop-off time Tr	0.00 s to 32.00 s	(steps 0.01 s)

Times

Pick-up time – $U_0>$	$\leq$ 100 ms
Drop-off time	approx 50 ms
Drop-off ratio – Displacement voltage $U_E>$	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 $-5\ °C \leq \theta_{amb} \leq +40\ °C$	$\leq$ 0.5 %/10 K
– Frequency in range $0.9 \leq f/f_N \leq 1.1$	$\leq$ 2 %

3.4 Out-of-step protection

Pick-up

Positive sequence component $I_{pos}>/I_N$	0.20 to 4.00	(steps 0.01)
Negative sequence component $I_{neg}</I_N$	0.05 to 1.00	(steps 0.01)
Drop-off ratio $I_{pos}>/I_N$	approx. 0.95	
Drop-off ratio $I_{neg}</I_N$	approx. 1.05	
Measuring tolerances according VDE 0435 part 303	± 3% of set value	

Characteristic polygonal

Setting values (based on I_N = 1A*)	
Impedance Z_a	0.20 Ω to 130.00 Ω (steps 0.01 Ω)
Impedance Z_b	0.10 Ω to 130.00 Ω (steps 0.01 Ω)
Impedance Z_c	0.10 Ω to 130.00 Ω (steps 0.01 Ω)
Impedance $Z_d - Z_c$	0.00 Ω to 130.00 Ω (steps 0.01 Ω)
inclination angle of polygon ϕ_P	60° to 90°
Number of permissible out-of-step periods	
- characteristic 1	1 to 4
- characteristic 2	1 to 8
Measuring tolerances according VDE0435 part 303 with sinusoidal quantities	$\left\lvert\frac{\Delta X}{X}\right\rvert \leq 5\%$ for $30° \leq \phi_{sc} \leq 90°$ $\left\lvert\frac{\Delta R}{R}\right\rvert \leq 5\%$ for $0° \leq \phi_{sc} \leq 60°$

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

Times

Holding time of pick-up	0.20 s to 32.00 s (steps 0.01 s)
Holding time for out-of-step annunciation	0.02 s to 0.15 s (steps 0.01 s)
Drop-off time	0.05 s to 32.00 s (steps 0.01 s)
Time expiry tolerances	≤1% of set value or 10 ms

The set times are pure delay times.

Influence variables

- Auxiliary d.c. voltage in range $0.8 \leq U_H/U_{HN} \leq 1.15$	≤ 1%
- Temperature in range $-5\ °C \leq \theta_{amb} \leq +40\ °C$	≤ 0.5 %/10 K
- Frequency in range $0.9\ f_N$ to $1.1\ f_N$	≤ 2 %

3.5 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
Reset times - active power P_f<, P_f>	≤ 380 ms at 50 Hz ≤ 330 ms at 60 Hz
Drop-off ratios - active power P_f< - active power P_f>	 approx 1.10 approx 0.90

Tolerances

- active power P_f<, P_f>	≤0.25 % S_N ± 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 $0.8 \leq U_H/U_{HN} \leq 1.15$	≤ 1%
- Temperature in range $-5\ °C \leq \theta_{amb} \leq +40\ °C$	≤ 0.5 %/10 K
- Frequency in range 0.9 f_N to 1.1 f_N	≤ 2 %

3.6 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 open / closed)	0.00 s to 32.00 s	(steps 0.01 s)
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 $\|-P_r\|>$	$\leq$ 380 ms at 50 Hz $\leq$ 330 ms at 60 Hz
Drop-off ratio	approx 0.6

Tolerances	
- Reverse power $\|-P_r\|>$	$\leq$ 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	$\leq$ 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 $-5\ °C \leq \theta_{amb} \leq +40\ °C$	$\leq$ 0.5 %/10 K
- Frequency in range $0.9\ f_N$ to $1.1\ f_N$	$\leq$ 2 %

3.7 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)
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

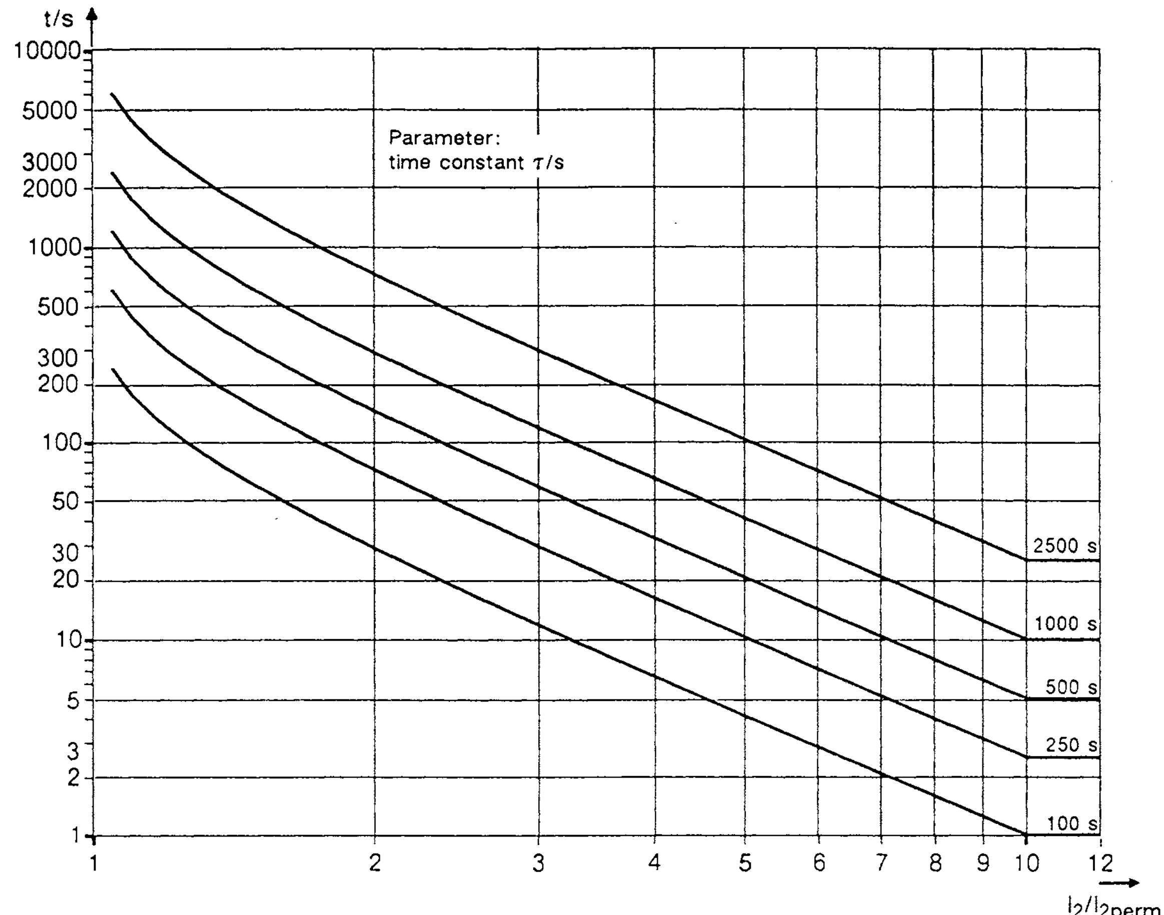
Pick-up times Warning stage $I_2>$, tripping stage $I_2\gg$	approx. 80 ms
Drop-off times Warning stage $I_2>$, tripping stage $I_2\gg$	approx. 80 ms
Drop-off ratios	
– Warning stage $I_2>$, tripping stage $I_2\gg$	approx 0.95
– Θ/Θ_{trip}	drop-off at drop-off of Θ_{warn}
– Θ/Θ_{warn}	approx 1.0

Tolerances

– thermal replica	± 5 % ref. I_2 ± 5 % ± 0.5 s ref. t
– 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 $-5\ °C \leq \theta_{amb} \leq +40\ °C$	$\leq$ 0.5 %/10 K
– Frequency in range $0.9 \leq f/f_N \leq 1.1$	$\leq$ 2 %



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

Figure 3.1 Trip characteristics of the thermal unbalanced load protection stage

3.8 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)
Drop-off delay T_r	0.00 s to 32.00 s	(steps 0.01 s)

Times

operating time (dependent on frequency)	approx 60 ms at 50 Hz approx 50 ms at 60 Hz
Drop-off times (dependent on frequency)	approx 60 ms at 50 Hz approx 50 ms at 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 $-5\ °C \leq \theta_{amb} \leq +40\ °C$	$\leq$ 0.5 %/10 K

Output of measured values

– Operational values of currents	I_{L1}, I_{L2}, I_{L3} in kA primary and in % I_N
Measurement range	0 % to 240 % I_N
Tolerance	2 % of rated value
– Positive sequence current component	I_{pos}
Measurement range	0 % to 240 % I_N
Tolerance	2 % of rated value
– Operational voltage 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
– Frequency	FREQ.
Measurement range	20 Hz to 80 Hz
Tolerance	0.2 % of rated value
– Operational values of powers	P, Q (active and reactive power) in % S_N (= $\sqrt{3} \cdot U_N \cdot I_N$)
Measurement range	–200 % to +200 %
Tolerance	1 % of rated value
– Power factor	cos ϕ
Measurement range	–1.00 to +1.00
Tolerance	0.02
– Power angle	ϕ
Measurement range	–180° to +180°
Tolerance	0,1°
– Displacement voltage	$3U_0$
Measurement range	0 % to 140 V
Tolerance	2 % of rated value
– Resistance	R/Ω
Measurement range	0 Ω to 200 Ω
Tolerance	5 % or 0.05 Ω for 0° $\leq \phi_K \leq$ 60°
– Reactance	X/Ω
Measurement range	0 Ω to 200 Ω
Tolerance	5 % or 0.05 Ω for 30° $\leq \phi_K \leq$ 90°
– Unbalanced load	I_2/I_N
Measurement range	0 % to 200 %
Tolerance	2 % of rated value

All indications ±1 digit display tolerance.

– Temperature rise calculated from unbalanced load	Θ/Θ_{trip}
Measurement range	0 % to 200 %
Tolerance	10 % referred to Θ_{trip}

All indications ±1 digit display tolerance.

Measured values plausibility checks

– Sum of currents	phases
– Sum of voltages	phases and displacement voltage

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

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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

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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} phase voltages u_{L1-N}, u_{L2-N}, u_{L3-N} displacement voltage u_0

rms values:

Storage period max.	60 s, selectable pre-trigger and post-fault time
Sampling rate	1 r.m.s. value per 20 ms at 50 Hz 1 r.m.s. value per $16^2/_3$ ms at 60 Hz
	positive sequence component of currents I_{pos} positive sequence component of phase voltages U_{pos}
	power angle ϕ
	unbalanced load current I_2/I_N
	resistance R reactance X
	active power P/S_N reactive power Q/S_N

4 Method of operation

4.1 Operation of complete unit

The numerical machine protection 7UM516 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.

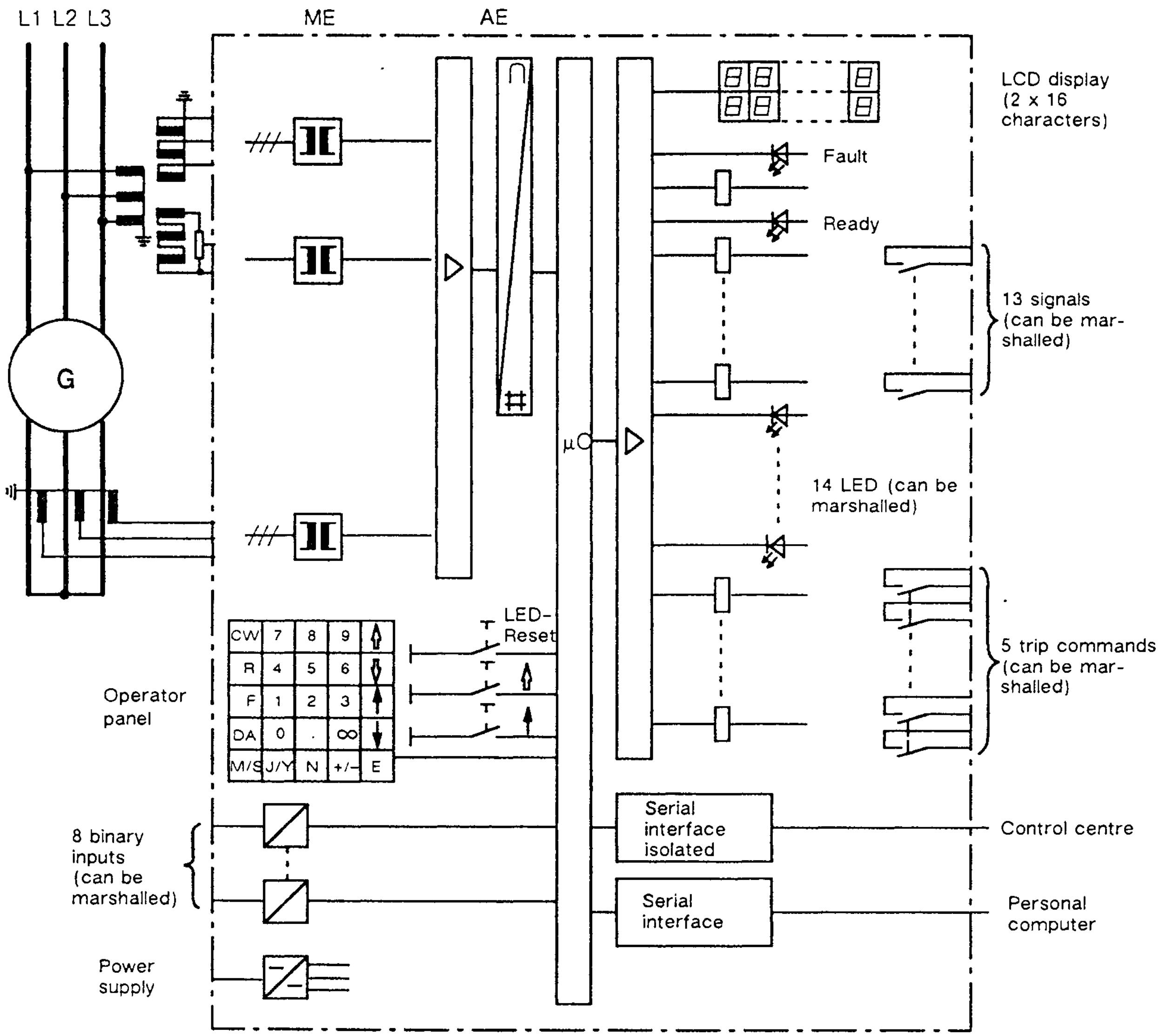


Figure 4.1 Hardware structure of machine protection relay 7UM516

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,
- evaluation of the frequency of the measured values in order to match the filters,
- calculation of the positive sequence components of current and voltage,
- calculation of the negative sequence current for unbalanced load detection,
- determination of the active and reactive components of power,
- continuous calculation of the values which are relevant for fault detection,
- determination of the faulted phases in case of a fault,
- scanning of values for the thermal replica of rotor surface,
- scanning of limit values and time sequences,
- decision about trip commands,
- storage of instantaneous current and voltage values during a fault for analysis.

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

An integrated membrane keyboard in connection with a built-in alphanumerical LCD display enables communication with the unit. All operational data such as setting values, plant data, etc. are entered into the protection from this panel (refer 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 dc supply system of the plant are bridged by a dc 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 Impedance protection

The machine impedance protection is used as a selective time graded protection to provide shortest possible tripping times for short-circuits in the synchronous machine, on the terminal leads as well as in the lower voltage winding of the machine transformer. It thus provides a fast back-up protection to the generator and transformer differential relays. The impedance protection operates as a time-delayed overcurrent protection for short-circuits on the higher-voltage side of the transformer, thus providing a back-up protection for these faults.

4.2.1 Fault detection

Fault detection has the duty to detect a faulty condition in the power system and to initiate all the necessary procedures for selective clearance of the fault:

- Start the delay times,
- Selection of the measured values,
- Release of impedance calculation,
- Release of tripping command,
- Indication/output of the faulty conductor(s).

Overcurrent fault detection is used for the machine impedance protection, which can be supplemented by an undervoltage seal-in circuit. Following numeric filtering, the currents in each phase are monitored in comparison with a set threshold value. A pick-up signal is output for that (those) phase(s) in which the set threshold has been exceeded. The overcurrent fault detector is reset when 95 % of the pick-up value is fallen below unless it is maintained by the undervoltage seal-in feature.

In case of excitation systems deriving their power from the machine terminals or from the network, the excitation voltage can rapidly decay to almost zero. This results in decreasing short-circuit current, in spite of the short-circuit, and consequently drop-off of the overcurrent fault detectors. In such cases the impedance protection pick-up is maintained for a sufficiently long period by means of an undervoltage controlled seal-in circuit using the positive sequence voltage. Fault detection will drop off only when the voltage has reappeared to a magnitude of 105 % of the predetermined value, or when the holding time has expired.

Figure 4.2 shows the logic diagram of the fault detection module of the impedance protection.

4.2.2 Determination of the short-circuit impedance

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

Pick-up in one single phase results in selection of the associated line-to-earth loop for impedance evaluation.

Pick-up in two phases results in selection of the associated phase-to-phase loop for impedance evaluation.

If three-phase pick-up occurs, the largest of the three phase currents determines the selected phase-to-earth loop for impedance evaluation. If all three currents are equal then L1-E is selected.

The tripping zones of the machine impedance protection relay have a polygonally shaped trip characteristic (see also Figure 4.3). It is a symmetrical characteristic, even though a fault in reverse direction (negative R and X values) is impossible provided the usual connection to the current transformers at the star-point side of the machine is used. The polygon is identified by two parameters: the R-intersection and the X-intersection. Reactance intersection X and resistance intersection R can be set separately and independently from each other.

As long as a fault detector has picked-up, the impedance calculation is effected continuously. This is carried out by complex division of the voltage and current phasors derived from the loop selection. When the calculated fault impedance lies within the set trip characteristic, the protection issues a trip command which may be delayed according to the time setting.

It may be desirable, dependent of the switching conditions of the power plant, to extent the rapid impedance zone Z1 to an overreaching zone. When, for example, the network circuit breaker is open, then a detected fault can only be in the power station area. If the position of the network circuit breaker is indicated to the relay by a breaker auxiliary contact via a binary input of the relay, the overreaching zone Z1B can be switched effective in this case.

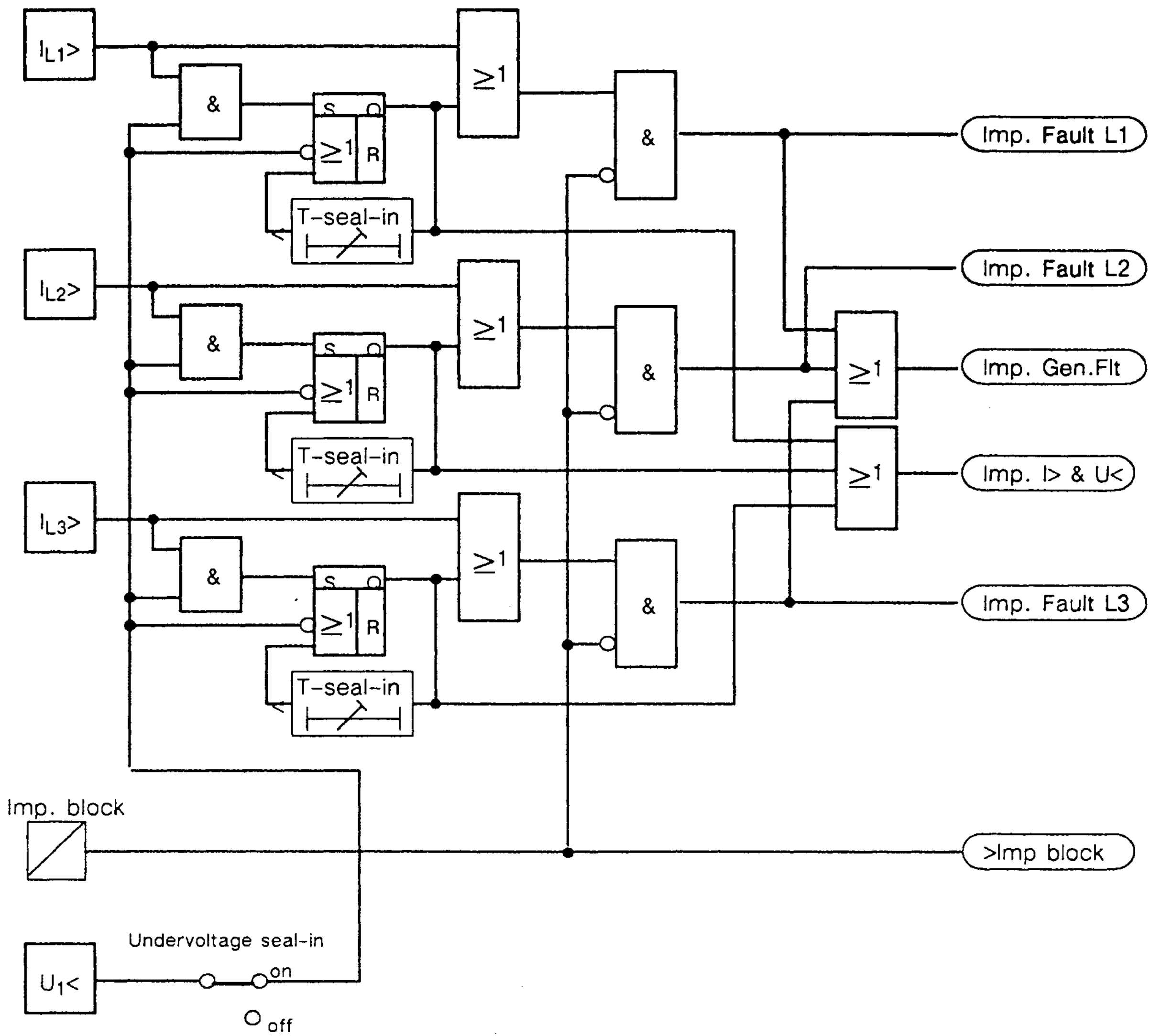


Figure 4.2 Logic diagram of the fault detection stage of the impedance protection

As shown in Figure 4.3 the relay possesses the following characteristics which can be set independently:

- 1st zone (instantaneous zone Z1), with the setting parameters:

  X1 Reactance = reach
  R1 Resistance
  T1 T1 = 0 or slightly delayed, if required.

- Overreach zone Z1B for zone extension, controlled via binary input, with the setting parameters:

  X1B Reactance = reach,
  R1B Resistance,
  T1B T1B = 0 or slightly delayed, if required.

Additionally, a non-directional final stage (T2) and a power swing blocking stage (PPOL) are available.

The power swing polygon PPOL which is required for power swing blocking of the distance protection provides a selectable distance from the tripping polygon APOL (equal Z1), refer to Section 4.2.4 for more details.

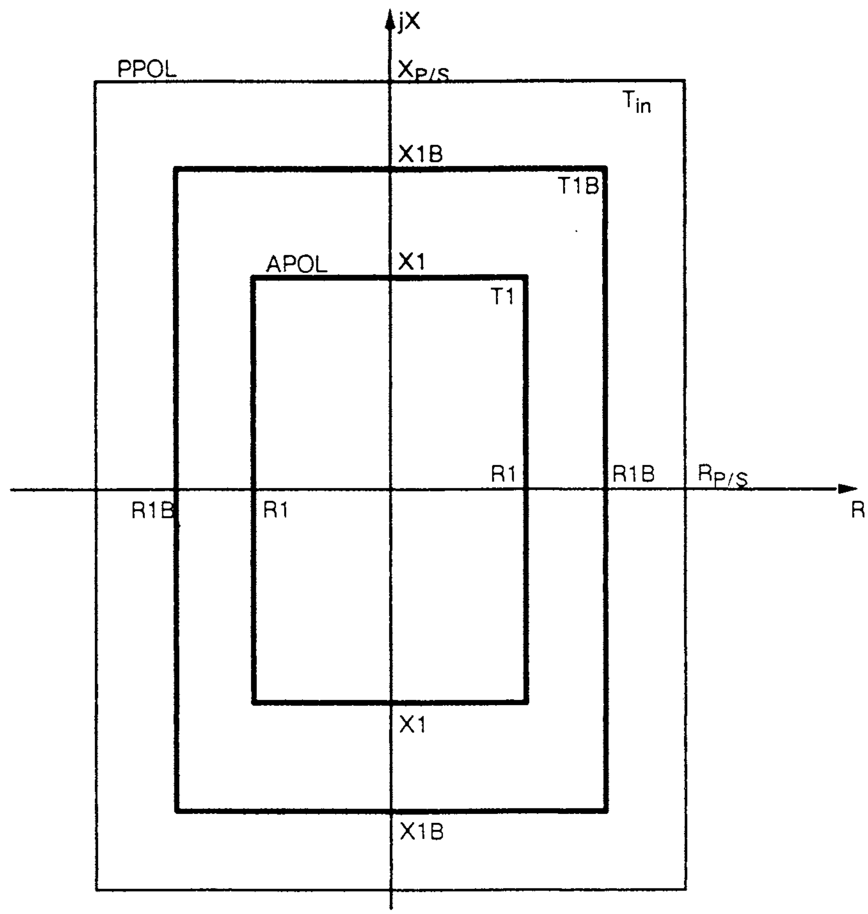


Figure 4.3 Tripping characteristics of the impedance protection and pick-up characteristic for the detection of power swings

4.2.3 Tripping logic

When the relay has detected a fault, the delay times are started. The impedance of the selected fault loop is compared with the thresholds of the set zones. Tripping occurs when the impedance is within a zone whose corresponding time stage has expired. For zone Z1 (and Z1B) the delay time can equal zero, i.e. tripping occurs as soon as it has been confirmed that the fault lies within the zone, or only a small delay may be set.

An external binary input can be used to release the overreach zone Z1B.

If a trip signal should be given when an additional external criterion be present from the power plant, then a binary input may be used to combine impedance trip AND this input.

Figure 4.4 illustrates the block diagram of the tripping logic.

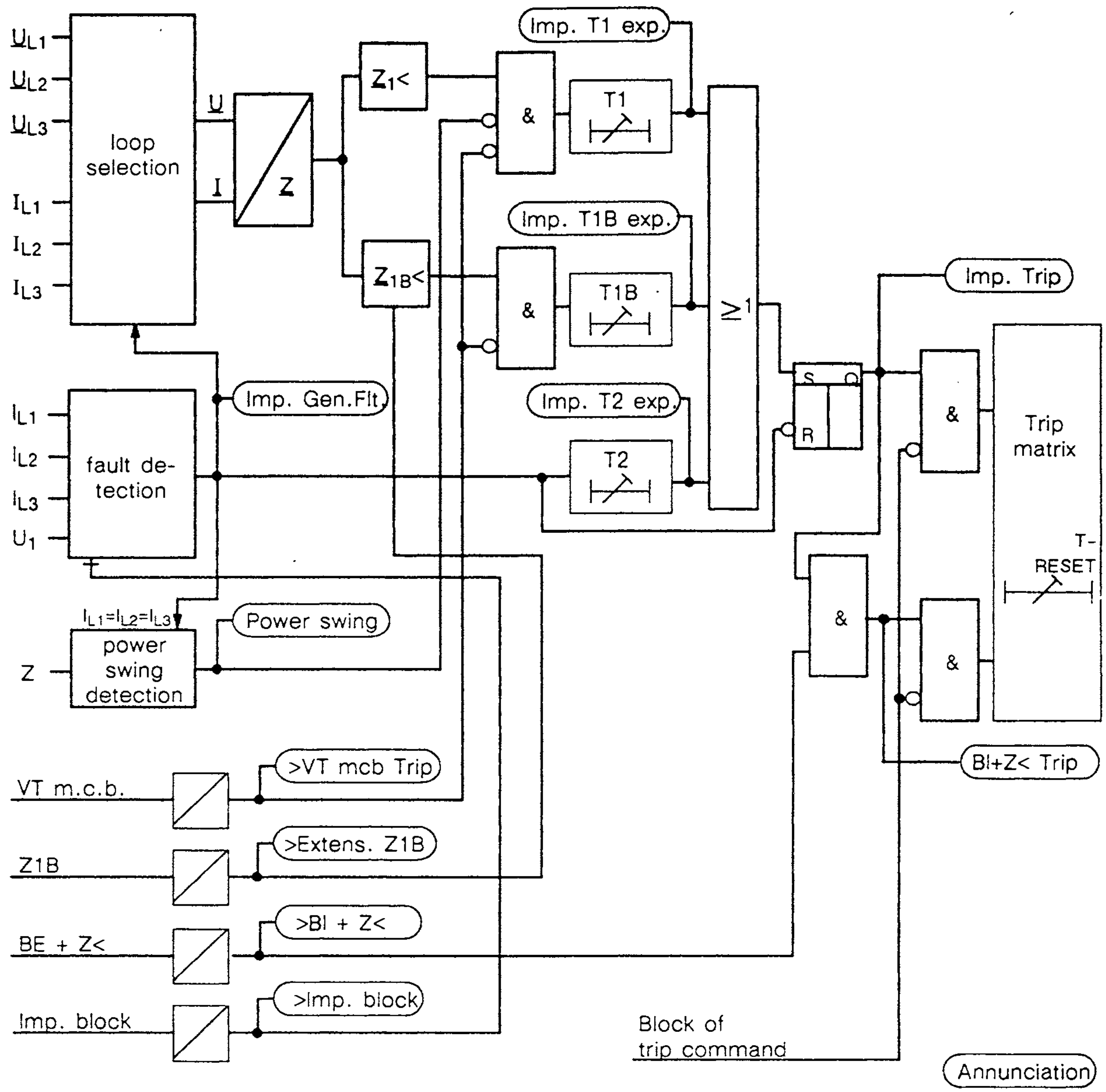


Figure 4.4 Schematic block diagram of the tripping logic of the distance protection

4.2.4 Power swing blocking

After dynamic occurrences in the system, such as load fluctuations, short circuits, auto-reclosures or switching operations, the generators may have to adjust to the new load conditions in the network.

In order to prevent uncontrolled tripping, the impedance protection is provided with a power swing blocking feature.

Power swings are three-phase symmetrical occurrences. The first prerequisite is therefore the symmetry of the currents which is verified by evaluation of the negative sequence current. Asymmetrical short circuits (i.e. all one-phase and two-phase short circuits) can therefore not result in pick-up of the power swing blocking function. Even when a power swing has been recognized, the following asymmetrical short circuit currents lead to fast release of the power swing blocking function and render possible tripping by the impedance protection.

In order to detect a power swing, the rate of change of the impedance vector is measured. Because of the symmetry conditions, evaluation of the positive sequence components is sufficient. Figure 4.5 illustrates the block diagram of the power swing blocking function.

A "power swing polygon" PPOL, which is larger than the trip polygon APOL, is used to initiate power swing detection. The distance between the two polygons is adjustable. The rate of change of the impedance vector between the two polygons is decisive for power swing detection. Power swing is detected before the impedance vector enters the trip polygon.

If the rate of change of the impedance vector is smaller than a (selectable) value $\Delta Z/\Delta t$, a power swing is recognized. The measuring time of the power swing detector is coordinated with the distance between power swing polygon PPOL and trip polygon APOL, so that trip can be blocked.

The reaction remains effective until the measured impedance vector leaves the power swing polygon PPOL or when, due to asymmetry, the power swing criteria are no longer met. The action time of the power swing blocking device can also be limited by a selectable time P/S T-ACT.

Note: Power swing blocking acts on the first zone Z1 only. When the overreach zone Z1B is active no power swing can occur because the network circuit breaker is then open. The non-directional overcurrent time back-up stage T2 is not blocked either.

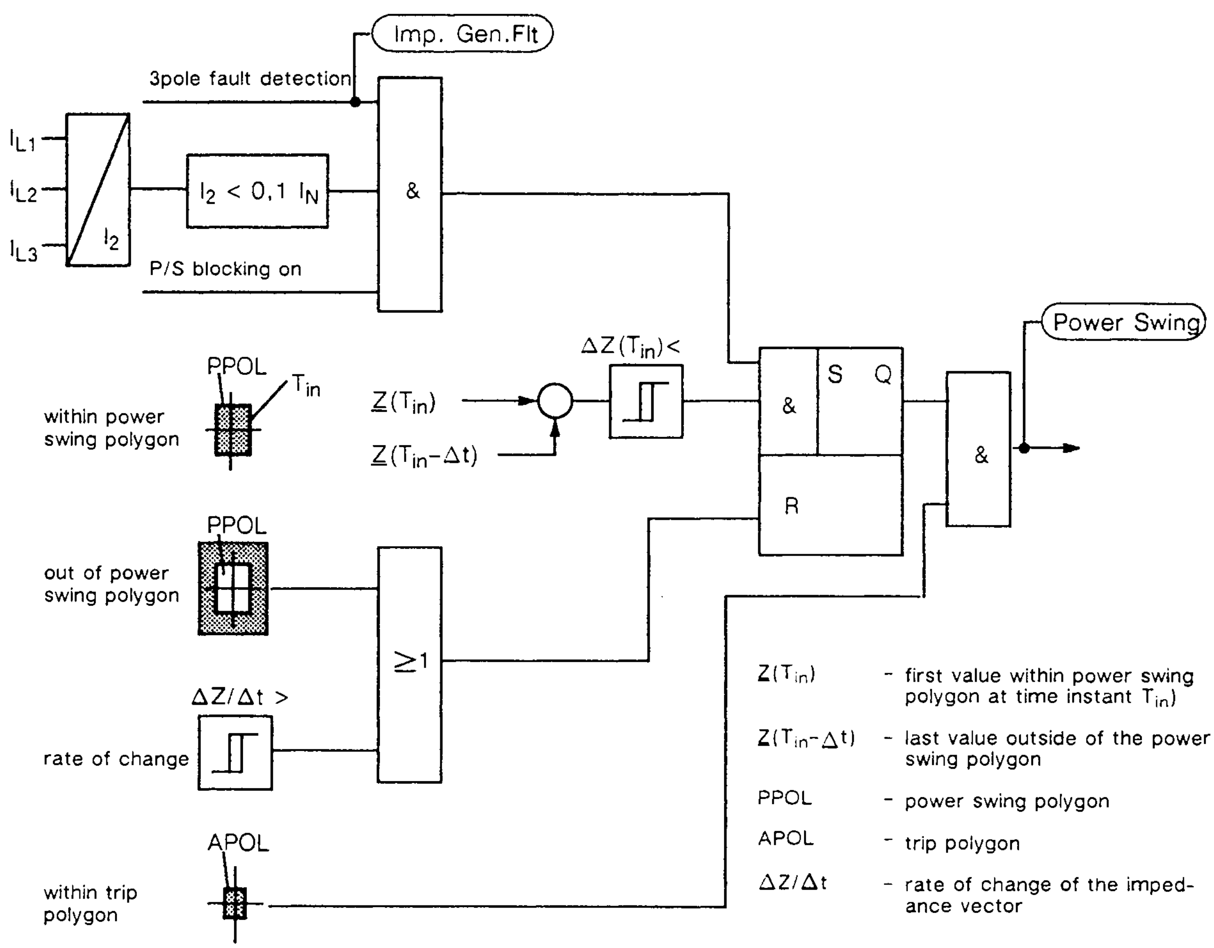


Figure 4.5 Logic diagram of power swing blocking of the impedance protection

4.3 Stator earth fault protection U_0>

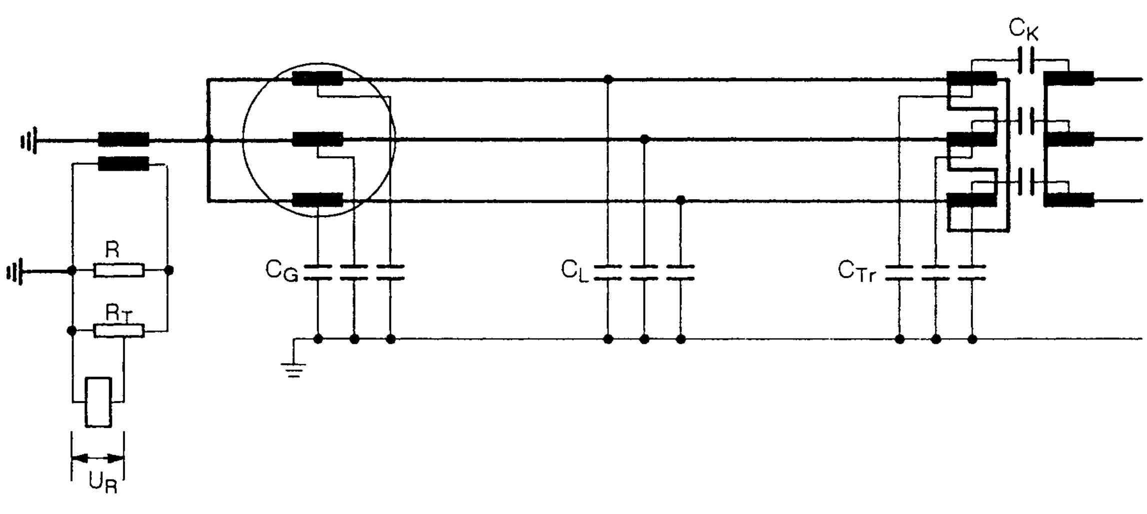
The stator earth fault protection detects earth faults in the stator windings of three-phase machines in block connection (via machine transformer). The criterion for the occurrence of an earth fault is the occurrence of a neutral displacement voltage. This principle results in a protected zone of 90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

The displacement voltage can be measured either at the machine starpoint via voltage transformers or neutral earthing transformers (Figure 4.6) or via the e–n winding (open delta winding) of a voltage transformer set or the measurement winding of a line connected earthing transformer (Figure 4.7). Since the neutral earthing transformer or the line connected earthing transformer usually supply a displacement voltage of 500 V (with full displacement), a voltage divider 500 V/100 V is to be connected in such cases.

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

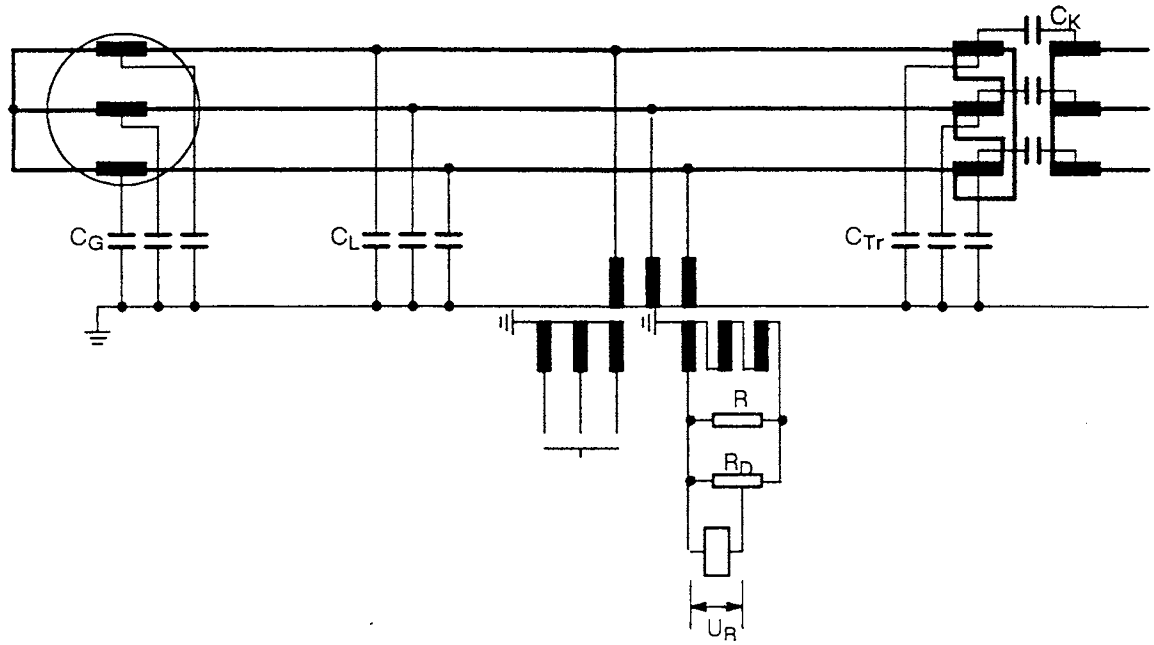
The achieved sensitivity of the protection is only limited by power frequency interference voltages during an earth fault in the network. These interference voltages are transferred to the machine side via the coupling capacitances of the block transformer. If necessary, a loading resistor can be provided 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.

Figure 4.8 shows the logic diagram of the earth fault protection.



R - Loading resistor
R_D - Voltage divider 1:5
U_R - Displacement voltage at the protection relay
C_G - Generator-earth capacitance
C_L - Conductor-earth capacitance of line connection
C_{Tr} - Winding-earth capacitance of block transformer
C_K - Coupling capacitance of block transformer

Figure 4.6 Block connected generator with neutral earthing transformer



R - Loading resistor
R_D - Voltage divider 1:5
U_R - Displacement voltage at the protection relay
C_G - Generator-earth capacitance
C_L - Conductor-earth capacitance of line connection
C_{Tr} - Winding-earth capacitance of block transformer
C_K - Coupling capacitance of block transformer

Figure 4.7 Block connected generator with line connected earthing transformer

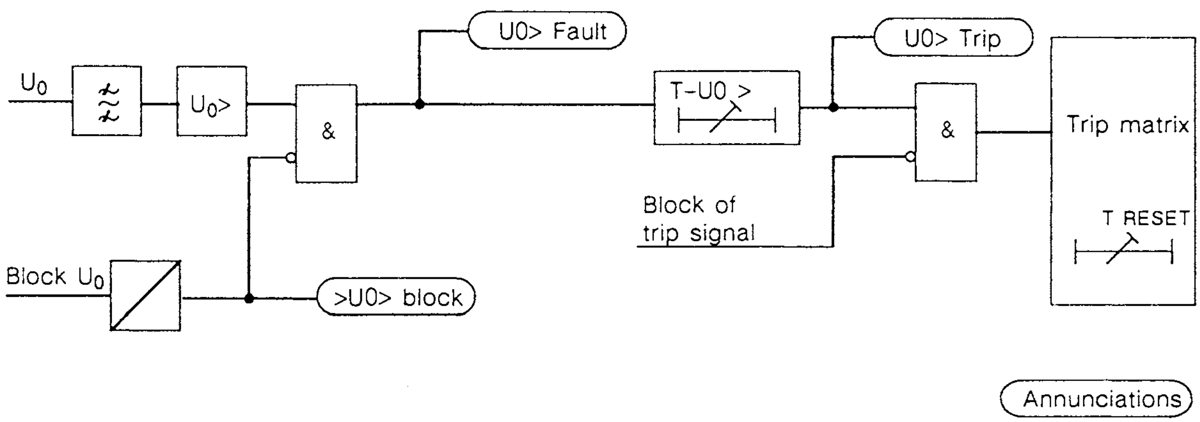


Figure 4.8 Logic diagram of the stator earth fault protection U_0>

4.4 Out-of-step protection

In extensive high-voltage networks, short-circuits which are not disconnected quickly enough, or, disconnection of coupling links which may result in an increasing of the coupling reactance, may lead to system swings. These consist of power swings which endanger the stability of the power transmission. Stability problems result in particular from active power swings which can lead to pole-slipping and thus to overloading of the synchronous machines.

The out-of-step protection detects these power swings by the well-proven impedance measurement. The trails of the complex impedance vector are evaluated. The impedance is calculated from the positive sequence components of the voltages and currents. Trip decision is made dependent of the rate of change of the impedance vector and on the location of the electrical centre of the power swing.

4.4.1 Principles of measurement

The out-of-step condition is illustrated at a simplified equivalent circuit in Figure 4.9. The generator, transformer, and system impedance is situated between the generator voltage $\underline{U}_G$ and the system equivalent voltage $\underline{U}_N$. The total of these impedances should be the impedance $\underline{Z}_{tot}$.

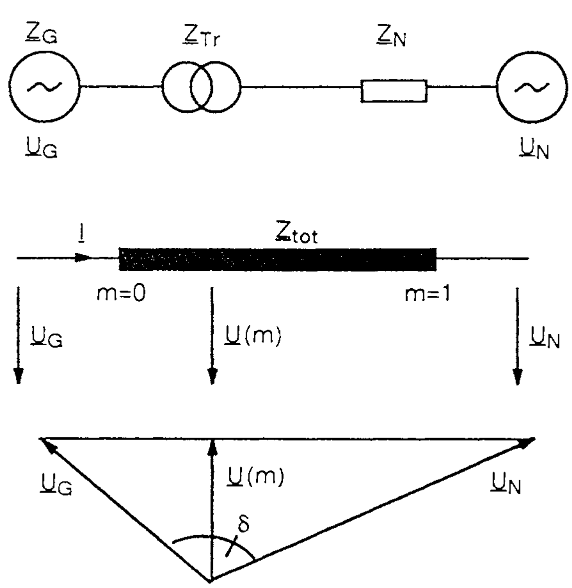


Figure 4.9 Equivalent of power swing

The measurement location divides the total impedance into the impedances $m \cdot \underline{Z}_{tot}$ and $(1 - m) \cdot \underline{Z}_{tot}$. The following applies:

$$\underline{Z}(m) = \frac{\underline{U}(m)}{\underline{I}(m)}$$

The current $\underline{I}$ is independent of the location of measurement:

$$\underline{I}(m) = \underline{I} = \frac{\underline{U}_G - \underline{U}_N}{\underline{Z}_{tot}}$$

The voltage at the location of measurement $\underline{U}$ is:

$$\underline{U}(m) = \underline{U}_G - m \cdot \underline{Z}_{ges} \cdot \underline{I}$$

Thus results with:

$$\underline{U}_G = U_G \cdot e^{j\delta_G} \qquad \underline{U}_N = U_N \cdot e^{j\delta_N}$$

$$\delta = \delta_G - \delta_N$$

$$\underline{Z}(m) = \left[\frac{1}{1 - \frac{U_N}{U_G} \cdot e^{-j\delta}} - m \right] \cdot \underline{Z}_{tot}$$

δ is the displacement angle between the generator voltage $\underline{U}_G$ and the network equivalent voltage $\underline{U}_N$. Under normal conditions, this angle depends on the load situation and is nearly constant. It fluctuates during power swings and can vary, in case of out-of-step condition, between 0° and 360°. Figure 4.10 shows the course of the impedance vector at the measurement location m according to the above mentioned formula. The origin of the coordinate system corresponds to the measurement location (voltage transformer set). When the ratio of the voltage magnitudes U_N/U_G is kept constant and the load angle δ varies, then circles result as a locus diagram. The centre and the radius of the circle are determined by the voltage ratio U_N/U_G. The centre points are situated on a line which is determined by $\underline{Z}_{tot}$. Minimum and maximum of the magnitude of the measured impedance are at load angles δ = 0° and δ = 180°. If the measurement location is the electrical centre, the measured voltage, and thus the measured impedance, becomes zero when the load angle becomes δ = 180°.

The measurement characteristic is a rectangle with adjustable widths and inclination angle. This ensures optimum matching to the conditions in the power station.

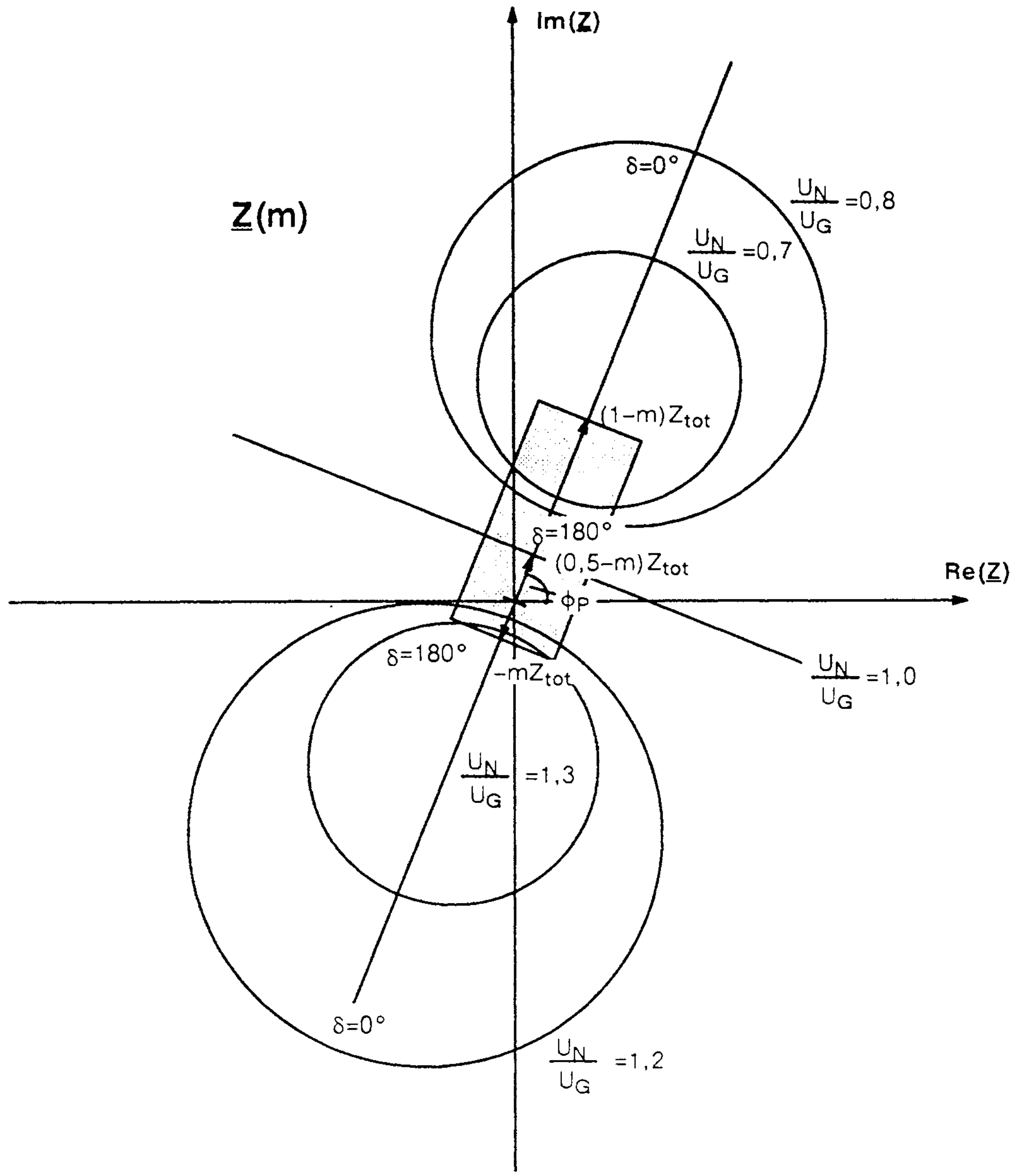


Figure 4.10 Impedances at the measurement location m

4.4.2 Out-of-step logic

Figure 4.11 shows, more detailed, the power swing detection characteristic. The inclination angle is assumed to be ϕ_P = 90 °. The setting parameters Z_a, Z_b, Z_c, and (Z_d-Z_c) determine the rectangle. It is symmetrical as to its vertical axis. The limit of Z_b reaches in reverse direction into the generator. The forward reaches are Z_c into the unit transformer, and Z_d into the network system. Two characteristics are available: the lower area, characteristic 1, covers the electrical centre being in the generator block until the unit transformer, the shaded area, characteristic 2, discriminates the electrical centre being in the network system. The point of crossing of the symmetry axis is decisive for the assignment to the characteristic.

Power swings are three-phase symmetrical occurrences. The first prerequisite is therefore the symmetry of the currents which is verified by evaluation of the negative sequence current. Condition for power swing detection is that the positive sequence component of the current exceeds an adjustable limit I_1> and the negative sequence current remains below an adjustable value I_2<.

An out-of-step condition requires, additionally, that the impedance vector enters a power swing characteristic at one side and leaves it at the other side (loss of synchronism, cases 1 and 2 in Figure 4.11). This is characterizes in that the real component of the impedance vector (or its component rectangular to the symmetrical axis) has changed its sign while passing through the characteristic.

It is also possible for the impedance vector to enter and leave the power swing polygon at the same side. In this case, power swing tends to be stabilized (case 3 in Figure 4.11).

When an out-of-step condition is recognized, i.e. when the impedance vector has passed through a power swing characteristic, an annunciation is issued which also identifies the characteristic. Additionally, a counter n1 (for characteristic 1) or n2 (for characteristic 2) is incremented.

Out-of-step protection pick-up is indicated when a counter is set to 1. Another out-of-step indication is given, for an adjustable time period, each time a counter is incremented. After an adjustable holding time, which is triggered each time a counter is incremented, pick-up resets unless a new power swing condition has been recognized.

Trip command is given when the number of out-of-step periods, i.e. one of the counters, has reached a selectable number.

Figure 4.12 shows the logic diagram of the out-of-step protection.

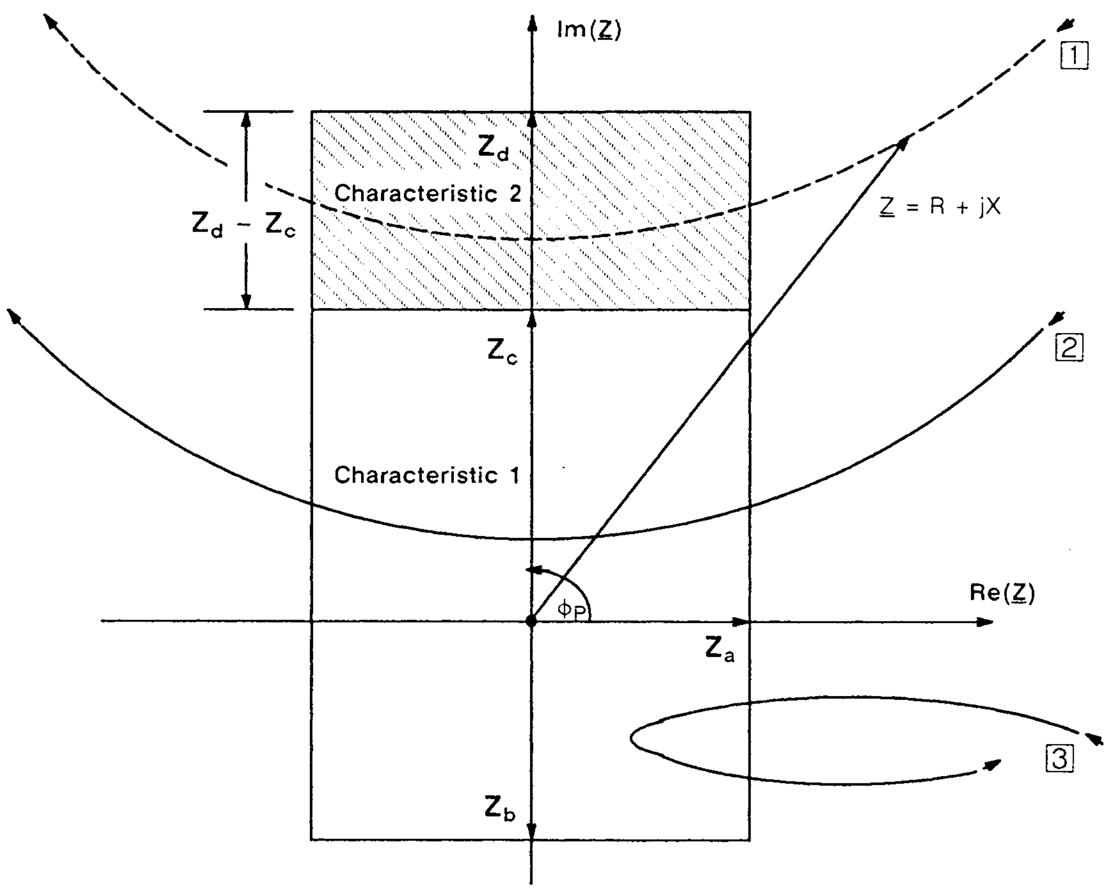
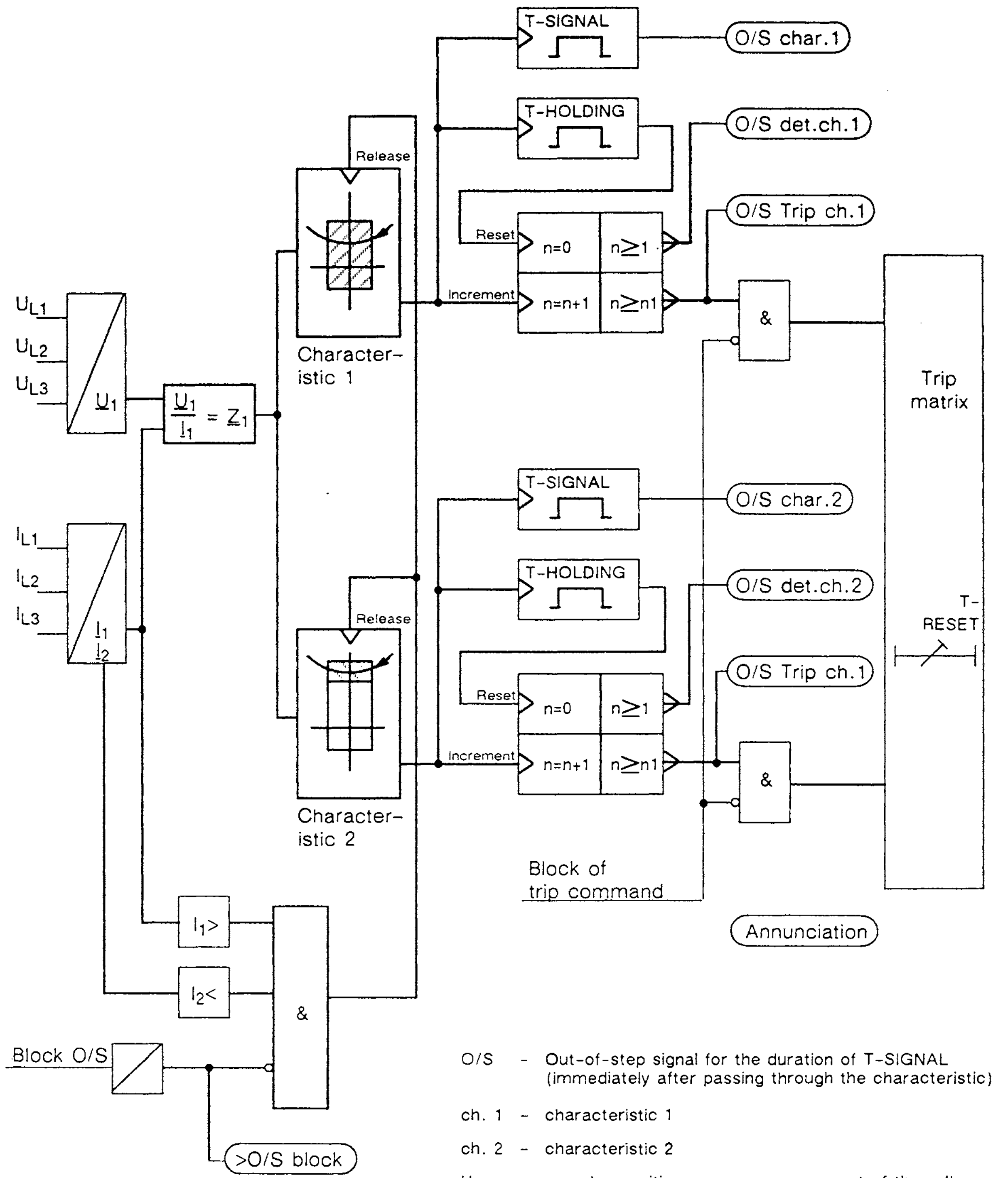


Figure 4.11 Polygonal out-of-step characteristic and typical power swing occurrences



O/S - Out-of-step signal for the duration of T-SIGNAL (immediately after passing through the characteristic)

ch. 1 - characteristic 1

ch. 2 - characteristic 2

U_1 - complex positive sequence component of the voltages

I_1 - complex positive sequence component of the currents

I_2 - complex negative sequence component of the currents

Figure 4.12 Logic diagram of the out-of-step protection

4.5 Forward active power supervision

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.

The machine protection 7UM516 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.

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.

Figure 4.13 shows the logic diagram of the forward active power supervision.

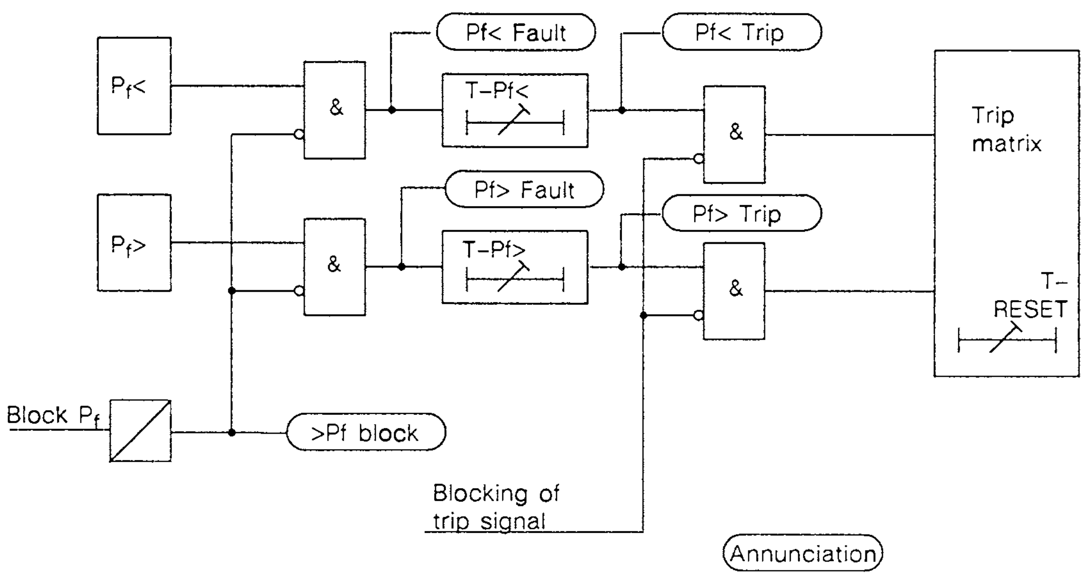


Figure 4.13 Logic diagram of the forward active power supervision

4.6 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 7UM516 precisely calculates the active power from the symmetrical components of the voltages and currents. 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. 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 is closed, 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 is closed.

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

Figure 4.14 shows the logic diagram of the reverse power protection.

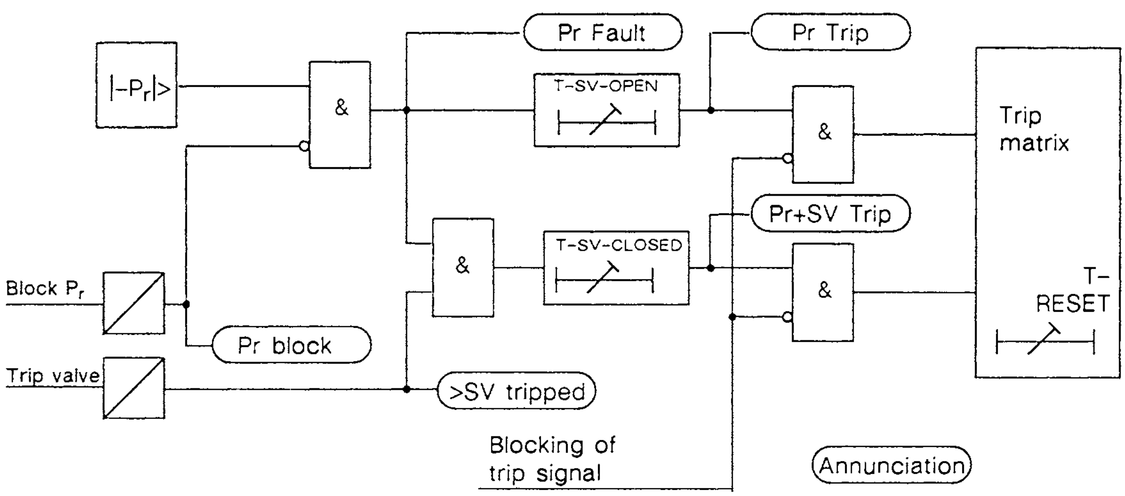


Figure 4.14 Logic diagram of the reverse power protection

4.7 Unbalanced load protection

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

In the unbalanced load protection of the 7UM516, 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 – instantaneous 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 4.15). 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 4.15). Negative sequence current above 10 times the permissible value do not reduce tripping time (see also Figure 3.1).

Figure 4.16 shows the logic diagram of the unbalanced load protection.

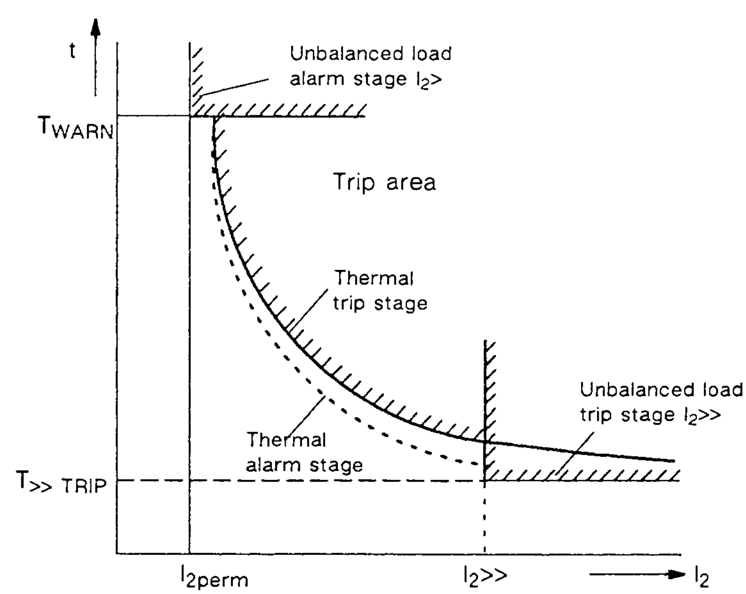


Figure 4.15 Trip characteristics of the unbalanced load protection

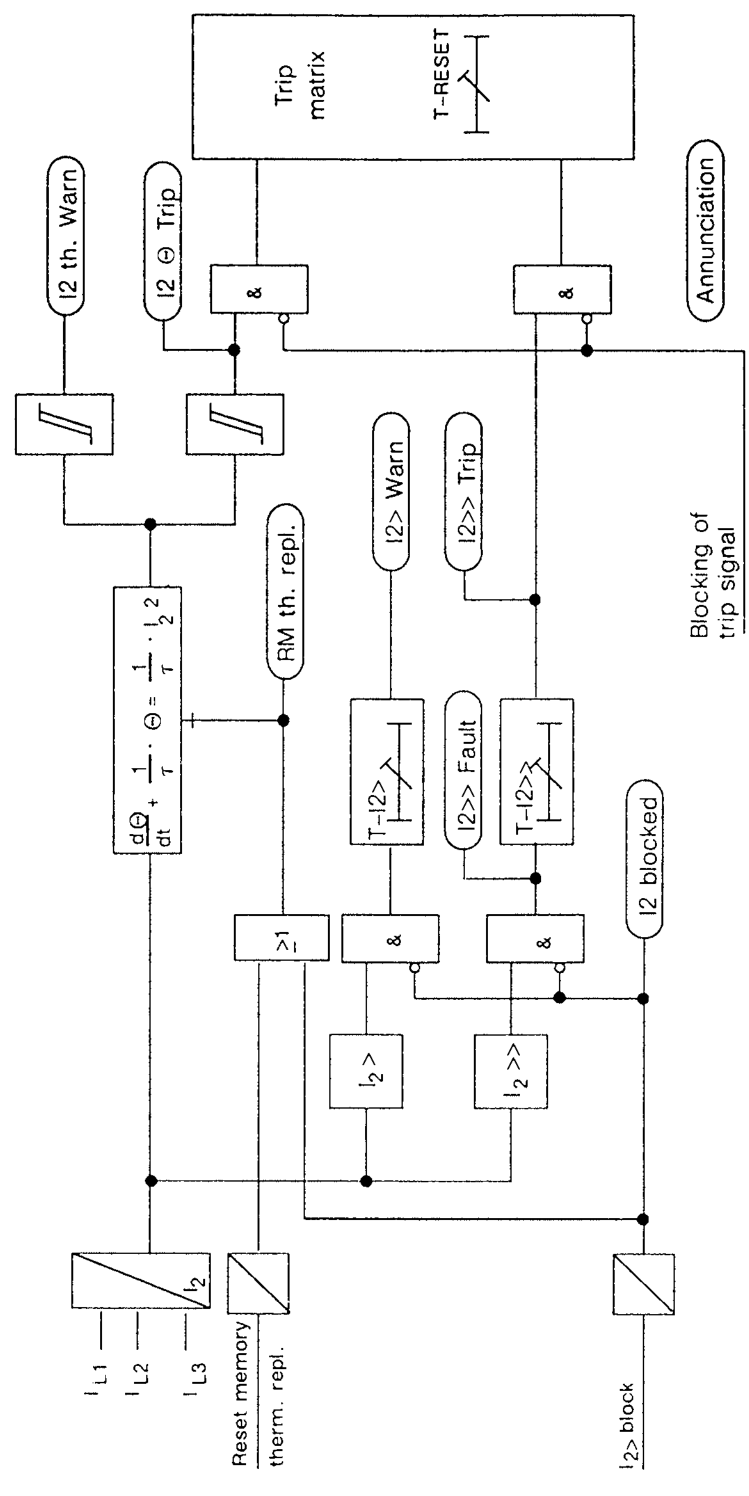


Figure 4.16 Logic diagram of the unbalanced load protection

4.8 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 4.7, 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.

4.9 Circuit breaker trip test

Numerical machine protection relay 7UM516 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.

4.10 Ancillary functions

The ancillary functions of the machine protection 7UM516 include:

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

4.10.1 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.

4.10.1.1 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.

4.10.1.2 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 4.10.1.1.

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 data of the oldest fault are overwritten in the fault memory. The data of the last three faults can be read out in the display.

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.

4.10.1.3 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.

4.10.2 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_0

are sampled at intervals of 12 values per a.c. period (at 50 Hz) and stored in a circulating shift register. In case of a fault, the data are stored over a selectable time period, but max. over 5 seconds. The maximum number of fault records within this time period is 8. These data are then available for fault analysis. For each renewed fault event, the actual new fault data are stored without acknowledgement of the old data.

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

Additionally, the fault record data can be transmitted to a control centre via the serial system interface. 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.

4.10.3 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} 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.

Additionally, the active and reactive power, the power factor and power angle, calculated impedance, the displacement voltage of the stator earth fault 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 megawatts primary and in % of $\sqrt{3} \cdot I_N \cdot U_N$,
- Q reactive power in megvars primary and in % of $\sqrt{3} \cdot I_N \cdot U_N$,
- $\cos \phi$ power factor,
- ϕ power angle,
- f frequency in Hz,
- U_0 displacement voltage,
- R measured resistance in Ω,
- X measured reactance in Ω,
- I_2/I_N unbalanced load current,
- Θ/Θ_{trip} temperature rise calculated from the unbalanced load current.

Note: 7UM516 provides a frequency dependent amplitude correction which operates in the range of ±20 % of the rated frequency. Outside of this range the displayed values are smaller according to the filter characteristics (refer also note in Section 6.6.1).

4.10.4 Monitoring functions

7UM516 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.

4.10.4.1 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 ($U_H \geqq 110$ 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 6.3.10). 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 4.17).

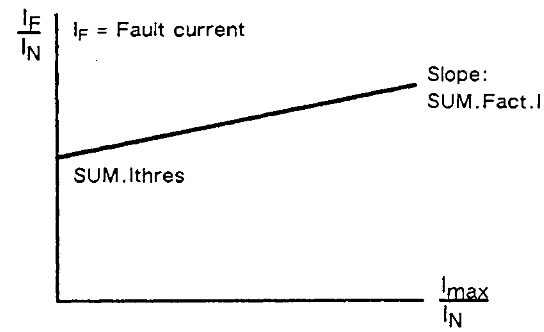


Figure 4.17 Current sum monitoring

In the **voltage path**, there are three input converters, connected to each phase-earth voltage and one further connected to the displacement voltage U_{EN}. A fault in the voltage circuits will be recognized when

$$|u_{L1} + u_{L2} + u_{L3} + k_U \cdot u_{EN}| > \text{SUM.Uthres} + \text{SUM.Fact.U} \times U_{max}$$

Factor k_U (parameter Uph/Udelta, address 1210) can be set to correct different ratios of phase and open delta voltage transformer windings. SUM.Uthres and SUM.Fact.U are setting parameters (refer 6.3.10). The component SUM.Fact.U x U_{max} takes into account permissible voltage proportional transformation errors in the input converters (Figure 4.18).

Note: Voltage sum monitoring can operate properly only when an externally formed open delta voltage U_{EN} is connected to the residual voltage input of the relay.

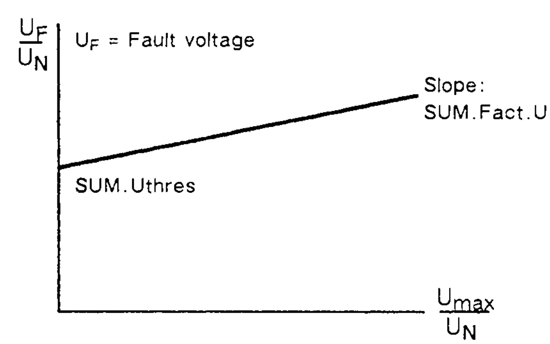


Figure 4.18 Voltage sum monitoring

- 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.

4.10.4.2 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.

4.10.4.3 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:

  $| I_{min} | / | I_{max} | <$ SYM.Fact.I

  if

  $I_{max} / I_N >$ 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 4.19). Both parameters can be set (see Section 6.3.10).

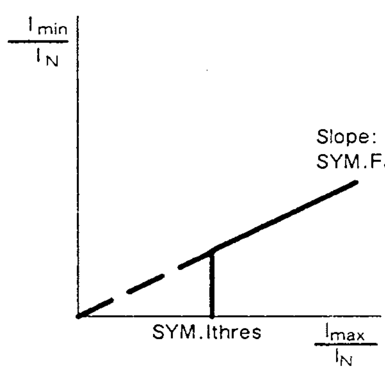


Figure 4.19 Current symmetry monitoring

- Voltage symmetry

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

The following applies:

$| U_{min} | / | U_{max} | <$ SYM.Fact.U

if

$| U_{max} | >$ 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 4.20). Both parameters can be set (see Section 6.3.10).

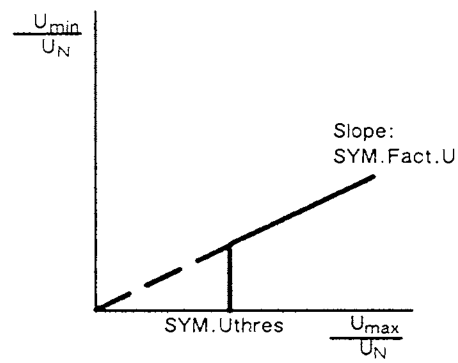


Figure 4.20 Voltage symmetry monitoring

- Phase rotation

  Since correct functioning of measured value selection and directional determination relies upon a clockwise sequence of the phase voltages, the direction of rotation is monitored:

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

  This check is carried out when the measured voltages as described in 4.10.4.1 are plausible and have a minimum value of at least

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

  Counter-clockwise rotation will cause an alarm.

Table 4.1 gives a survey of all the functions of the measured value monitoring system with annunciations. Multiple annunciations are possible. The monitoring systems do not block any protection functions.

Monitoring	Failure covered, reaction
1. Plausibility check of currents $\lvert i_{L1} + i_{L2} + i_{L3} \rvert >$ **SUM.Ithres** $\times I_N +$ **SUM.Fact.I** $\times I_{max}$	Relay failures in the signal acquisition circuits i_{L1}, i_{L2}, i_{L3} delayed alarm "Failure ΣI"
2. Plausibility check of voltages phase-earth $\lvert u_{L1} + u_{L2} + u_{L3} +$ **Uph/Udelta** $\times u_{EN} \rvert >$ **SUM.Uthres** $\times U_N +$ **SUM.Fact.U** $\times U_{max}$	Relay failures in the signal acquisition circuits u_{L1}, u_{L2}, u_{L3}, u_E delayed alarm "Failure ΣUph-e"
3. 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"
4. 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"
5. Phase rotation u_{L1} before u_{L2} before u_{L3}, as long as $\lvert U_{L1} \rvert$, $\lvert U_{L2} \rvert$, $\lvert U_{L3} \rvert > 40\ V/\sqrt{3}$	Swopped 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.

5.2 Preparations

The operating conditions must accord with VDE 0100/5.73 and VDE 0105 part 1/7.83, or corresponding national standards for electrical power installations.

Caution!

The modules of digital relays contain CMOS circuits. These shall not be withdrawn or inserted under live conditions! The modules must be so handled that any possibility of damage due to static electrical charges is excluded. During any necessary handling of individual modules the recommendations relating to the handling of electrostatically endangered components (EEC) must be observed.

In installed conditions, the modules are in no danger.

5.2.1 Mounting and connections

5.2.1.1 Model 7UM516*-*B*** for panel surface mounting

- Secure the unit with four screws to the panel. For dimensions refer to Figure 2.2.
- Connect earthing terminal (Terminal 26) of the unit to the protective earth of the panel.
- Make a solid low-ohmic and low-inductive operational earth connection between the earthing surface at the side of the unit using at least one standard screw M4, and the earthing continuity system of the panel; recommended grounding strap DIN 72333 form A, e.g. Order-No. 15284 of Messrs Druseidt, Remscheid, Germany.
- Make connections via screwed terminals.

5.2.1.2 Model 7UM516*-*C*** for panel flush mounting or 7UM516*-*E*** for cubicle installation

- Lift up both labelling strips on the lid of the unit and remove cover to gain access to four holes for the fixing screws.
- Insert the unit into the panel cut-out and secure it with the fixing screws. For dimensions refer to Figure 2.3.
- Connect earthing screw on the rear of the unit to the protective earth of the panel or cubicle.
- Make a solid low-ohmic and low-inductive operational earth connection between the earthing surface at the rear of the unit using at least one standard screw M4, and the earthing continuity system of the panel or cubicle; recommended grounding strap DIN 72333 form A, e.g. Order-No. 15284 of Messrs Druseidt, Remscheid, Germany.
- Make connections via the screwed or snap-in terminals of the sockets of the housing. Observe labelling of the individual connector modules to ensure correct location; observe the max. permissible conductor cross-sections. The use of the screwed terminals is recommended; snap-in connection requires special tools and must not be used for field wiring unless proper strain relief and the permissible bending radius are observed.

5.2.2 Checking the rated data

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

5.2.2.1 Control d.c. voltage of binary inputs

When delivered from factory, the binary inputs are designed to operate in the total control voltage range from 19 V to 288 V. The pick-up threshold lies near 17 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. It depends on the hardware state (production series) of the relay how this is carried out. This state is found on the name plate behind the complete order designation.

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.

- 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.

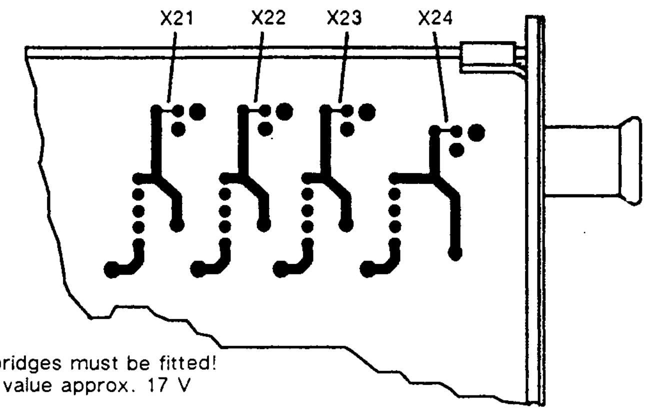
- Similarly check on the additional input/output module ZEA-1 according to Figure 5.2. (This smaller module has pulling handles instead of the releasing lever).
- Close housing cover.

Binary input 1 : Solder bridge X21

Binary input 2 : Solder bridge X22

Binary input 3 : Solder bridge X23

Binary input 4 : Solder bridge X24



For rated voltages 24/48/60 V-: Solder bridges must be fitted! Pick-up value approx. 17 V

For rated voltages 110/125/220/250 V-: Solder bridges may be removed: Cut and bend aside. Pick-up value approx. 80 V

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

Binary input 5 : Solder bridge X7

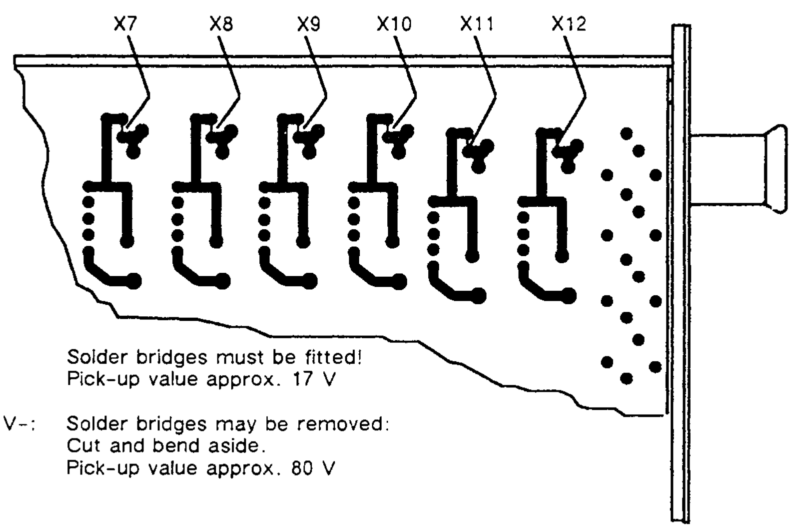
Binary input 6 : Solder bridge X8

Binary input 7 : Solder bridge X9

Binary input 8 : Solder bridge X10

Binary input 9 : Solder bridge X11

Binary input 10: Solder bridge X12



For rated voltages 24/48/60 V-: Solder bridges must be fitted! Pick-up value approx. 17 V

For rated voltages 110/125/220/250 V-: Solder bridges may be removed: Cut and bend aside. Pick-up value approx. 80 V

Figure 5.2 Checking for control voltages for binary inputs 5 to 10 on additional module ZEA-1

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 former production series. 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"

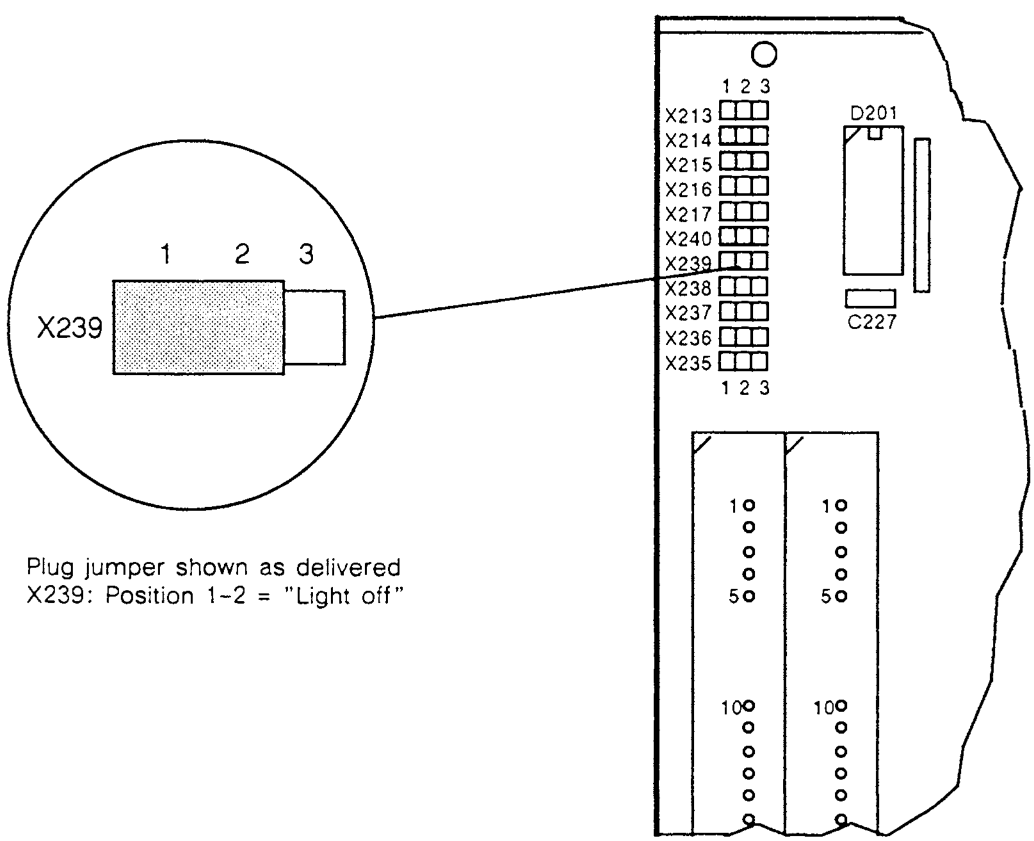


Figure 5.3 Position of the jumper X239 on the power supply board

5.2.5 Connections

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

For **stator earth fault protection** the neutral displacement voltage is supplied from a line connected earthing transformer or a neutral earthing transformer. Since the secondary windings of these transformers usually supply a voltage of 500 V (with full displacement voltage) the voltage must be connected to the unit via a voltage divider 500 V/100 V (e.g. 3PP1336-1CZ-013001).

Connection examples are shown in Figure 5.4 (neutral earthing transformer) and Figure 5.5 (line connected earthing transformer). The illustrations also show the load resistor R_B which provides a sufficiently high signal-to-noise ratio for the measured value.

Further instructions are contained in the pamphlet "Planning Machine Protection Systems", Order No. E50400-U0089-U412-A1-7600.

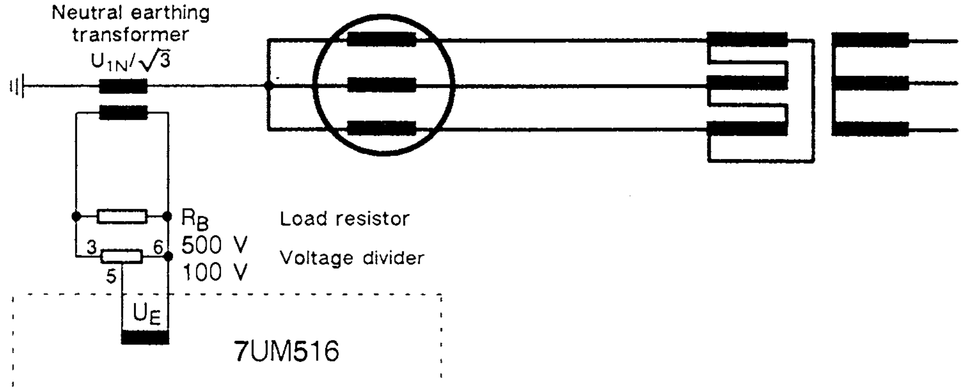


Figure 5.4 Connections for earth fault protection U_0 - example with neutral earthing transformer

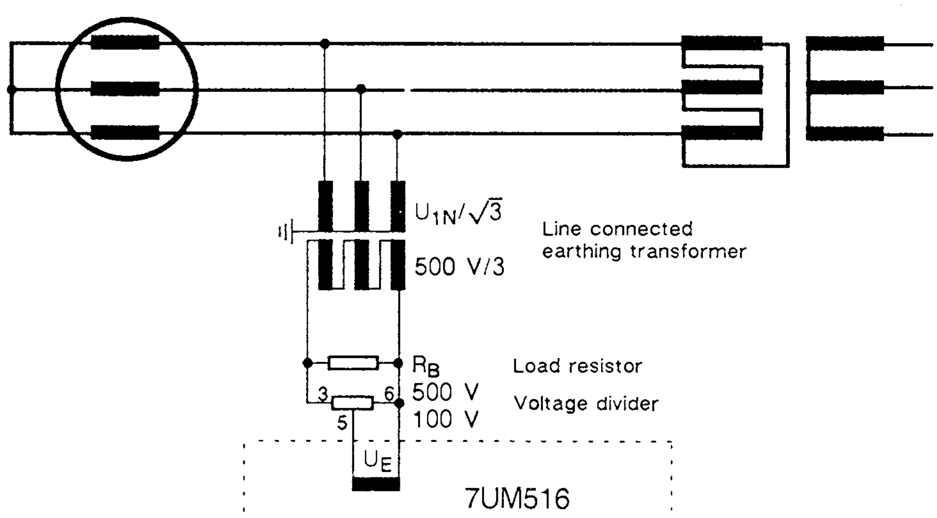


Figure 5.5 Connections for earth fault protection U_0 - example with line connected earthing transformer

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.

- Switch off the circuit breakers for the dc supply and the voltage transformer circuits!
- Check the continuity of all the current and voltage transformer circuits against the plant and connection diagrams:
  - Are the current transformers correctly earthed?
  - Are the polarities of the current transformer connections consistent?
  - Is the phase relationship of the current transformers correct?
  - Are the voltage transformers correctly earthed?
  - Are the polarities of the voltage transformer circuits correct?
  - Is the phase relationship of the voltage transformers correct?
  - Is the polarity of the open delta winding on the voltage transformers or of the earthing transformer and the connection correct?
- If test switches have been fitted in the secondary circuits, check their function, particularly that in the "test" position the current transformer secondary circuits are automatically short-circuited.
- Ensure that the miniature slide switch on the front plate is in the "OFF" O· position. (refer Figure 6.1).
- Fit a dc ammeter in the auxiliary power circuit; range approx. 1.5 A to 3 A.
- Close the battery supply circuit breaker; check polarity and magnitude of voltage at the terminals of the unit or at the connector module.
- The measured current consumption should be insignificant. Transient movement of the ammeter pointer only indicates the charging current of the storage capacitors.
- Put the miniature slide switch of the front plate in the "ON" position ⊙. The unit starts up and, on completion of the run-up period, the green LED on the front comes on, the red LED gets off after at most 7 sec.
- Open the circuit breaker for the dc power supply.
- Remove dc ammeter; reconnect the auxiliary voltage leads.
- Close the voltage transformer m.c.b. (secondary circuit).
- Check the direction of phase rotation at the relay terminals (clockwise!).
- Open the m.c.b.'s for voltage transformer secondary circuits and dc power supply.
- Check through the tripping circuits to the circuit 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,
- setting of functional parameters (thresholds, functions).
- initiation of test procedures.

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

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

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

```
CW ACCEPTED
```

```
CODEWORD WRONG
```

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

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

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

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

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

Beginning of the block "Operating system configuration"

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

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

```
7100 INTEGRATED
OPERATION
```

Beginning of the block "Integrated operation"

```
7101 LANGUAGE
DEUTSCH
```

```
ENGLISH
```

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

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

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

```
MM/DD/YYYY
```

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

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

7105 OPER. 1st L
not allocated
IL1 [%] =
IL2 [%] =
IL3 [%] =
etc.

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

7106 OPER. 2nd L
not allocated
etc.

Message to be displayed in the **2nd** display line during operation. The value selected by the entry key **E** under address 7106 will appear in the **second** line of the display.

Fault event annunciations can be displayed after a fault on the front. These can be chosen under addresses 7107 and 7108. The possible messages can be selected by repeatedly pressing the "No"-key **N**. The desired message is confirmed with the enter key **E**. These spontaneous messages are acknowledged during operation with the RESET key or via the remote reset input of the device or via the serial interfaces. After acknowledgement, the operational messages of the quiescent state will be displayed again as chosen under addresses 7105 and 7106.

7107 FAULT 1st L	After a fault event, the **first** line of the display shows:
Prot.Pick-up	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
T-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 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 is necessary (refer to Section 5.3.1). The data must be coordinated with the connected devices.

All annunciations which can be processed by the LSA are stored within the device in a separate table. This is listed in Appendix C.

```
7200 PC/SYSTEM
INTERFACES
```

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

```
7201 DEVICE ADD.
1
```

Identification number of the relay within the substation; valid for both the interfaces (operating and system interface). The number can be chosen at liberty, but must be used only once within the plant system
Smallest permissible number: **1**
Largest permissible number: **254**

```
7202 FEEDER ADD.
1
```

Number of the feeder within the substation; valid for both the interfaces (operating and system interface)
Smallest permissible number: **1**
Largest permissible number: **254**

```
7203 SUBST. ADD.
1
```

Identification number of the substation, in case more than one substation can be connected to a central device
Smallest permissible number: **1**
Largest permissible number: **254**

```
7208 FUNCT. TYPE
70
```

Function type in accordance with VDEW/ZVEI; for machine protection no. 70.
This address is mainly for information, it should not be changed.

```
7209 DEVICE TYPE
12
```

Device type for identification of the device in Siemens LSA 678. For 7UM516 V3 no. 12
This address is only for information, it cannot be changed.

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

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

7211 ▮ PC INTERF. DIGSI V3	Data format for the PC (operating) interface: format for Siemens protection data processing program *DIGSI*® Version *V3*
ASCII	ASCII format

7215 ▮ PC BAUDRATE 9600 BAUD	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

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
VDEW COMPATIBLE	only data in accordance with VDEW
DIGSI V3	format for Siemens protection data processing program *DIGSI*® Version *V3*
LSA	format of the former Siemens *LSA* version

7 2 2 2 ▮ S Y S M E A S U R . V D E W E X T E N D E D	Format of measured values for the system (LSA) interface: data in accordance with VDEW/ZVEI, extended by Siemens specified data
V D E W C O M P A T I B L E	only data in accordance with VDEW/ZVEI

7 2 2 5 ▮ S Y S B A U D R . 9 6 0 0 B A U D	The transmission Baud-rate for communication via the system interface can be adapted to the system interface, e.g. LSA, if necessary. The available possibilities can be displayed by repeatedly depression of the "No"-key **N**. Confirm the desired Baud-rate with the entry key **E**.
1 9 2 0 0 B A U D	
1 2 0 0 B A U D	
2 4 0 0 B A U D	
4 8 0 0 B A U D	

7 2 2 6 ▮ S Y S P A R I T Y V D E W / D I G S I V 3 / L S A	Parity and stop-bits for the PC (operating) interface: format for *VDEW*-protocol or Siemens protection data processing program *DIGSI®* Version *3* and former LSA
N O 2 S T O P	no parity, 2 stop-bits
N O 1 S T O P	no parity, 1 stop-bit

Address 7231 is relevant only in case the data transmitted through the system interface are in accordance with the VDEW/ZVEI protocol (address 7221 SYS INTERF. = *VDEW COMPATIBLE* or *VDEW EXTENDED*). This address determines whether all annunciations which occur during test operation are marked with the origin "test operation".

7 2 3 1 ▮ S Y S T E S T O F F	Only for VDEW compatible protocol: in *ON* position, the VDEW/ZVEI-compatible annunciations are assigned with the origin "test operation" during test operation
O N	

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

7 2 3 5 ▮ S Y S P A R A M E T N O	Remote parameterizing via the system interface *NO* – is not permitted
Y E S	*YES* – is permitted

5.3.4 Settings for fault recording – address block 74

The machine protection relay is equipped with a fault data store (see Section 4.10.2). 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 FLT*), 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. 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 FLT
```

Data storage is initiated:

- fault detection is reference instant
  fault detection is storage criterion

```
STORAGE BY TRIP
```

- fault detection is reference instant
  trip command is storage criterion

```
START WITH TRIP
```

- trip command is reference instant
  trip command is storage criterion

```
7410█ T-MAX
1.00 s
```

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

```
7411█ T-PRE
0.10 s
```

Pre-trigger time before the reference instant
Smallest setting value: **0.05** s
Largest setting value: **0.50** s
The times are **multiplied by 12** in case of storage of **r.m.s. values** (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: **0.50** s
The times are **multiplied by 12** in case of storage of **r.m.s. values** (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** (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** (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.

```
7490 SYS LENGTH
660 VALUES FIX
```

```
<=3000 VAL. VAR
```

Only for communication with a former LSA system:

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

660 values fix or

variable length with a maximum of 3000 values

5.4 Configuration of the protective functions

5.4.1 Introduction

The **device** 7UM516 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 (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 7UM516: 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"

Impedance protection:

```
7801 IMP. PROT.
EXIST
```

```
NON-EXIST
```

Stator earth fault protection:

```
7804 SEF PROT.
EXIST
```

```
NON-EXIST
```

Out-of-step protection:

```
7806 OUT-OF-STEP
EXIST
```

```
NON-EXIST
```

Forward power supervision:

```
7807 FOR. POWER
EXIST
```

```
NON-EXIST
```

Reverse power protection:

```
7808 REV. POWER
EXIST
```

```
NON-EXIST
```

Unbalanced load protection:

```
7810 UNBAL. LOAD
EXIST
```

```
NON-EXIST
```

External trip facilities via binary input:

```
7830 EXT. TRIP 1
EXIST
```

```
NON-EXIST
```

```
7831 EXT. TRIP 2
EXIST
```

```
NON-EXIST
```

External trip facilities via binary input:

```
7832 EXT.   TRIP  3
EXIST

NON-EXIST
```

```
7833 EXT.   TRIP  4
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 7UM516 programs are running the specific logic functions will be allocated to the physical input and output modules or LEDs in accordance with the selection.

Example: Trip command is registered from the stator earth fault protection. This event is generated in 7UM516 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 11, the processor must be advised that the logical signal "`U0> Trip`" should be transmitted to the signal relay 11. 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 restart. 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**.

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

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

Beginning of block "Marshalling binary inputs"

The first binary input is reached with the key ↑:

```
F↑ 6101 BINARY
 ↓ INPUT 1
```

Allocations for binary input 1

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

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

Reset of stored LED indications, FNo 5;
"normally open" operation:
LEDs are reset when control voltage present

0 0 2 ▮ I N P U T 1	No further functions are initiated by binary input 1
n o t a l l o c a t e d	

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

6 1 0 1 ▮ B I N A R Y	Marshalling binary input 1
I N P U T 1	

FNo	Abbreviation	Description
1	not allocated	Binary input is not allocated to any input function
3	>Time Synchro	Synchronize internal real time clock
4	>Start FltRec	Start fault recording from external command via binary input
5	>LED reset	Reset 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
361	>VT mcb Trip	Voltage transformer m.c.b. has tripped
3953	>Imp. block	Block impedance protection
3956	>Extens. Z1B	Release overreaching zone of impedance protection
3957	>BI + Z<	AND combination with additional impedance protection trip command
4523	>Ext 1 block	Block external trip command 1
4526	>Ext trip 1	External trip signal 1
4543	>Ext 2 block	Block external trip command 2
4546	>Ext trip 2	External trip signal 2
4563	>Ext 3 block	Block external trip command 3
4566	>Ext trip 3	External trip signal 3
4583	>Ext 4 block	Block external trip command 4
4586	>Ext trip 4	External trip signal 4
5053	>O/S block	Block out-of-step protection
5083	>Pr block	Block reverse power protection P_{rev}>
5086	>SV tripped	Stop valve tripped
5113	>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>

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 >RM th.repl. NO	5146	Reset memory of thermal replica of unbalanced load protection
6103	BINARY INPUT 3	INPUT 3 >Pr block NO	5083	Block reverse power protection
6104	BINARY INPUT 4	INPUT 4 >SV tripped NO	5086	Stop valve tripped
6105	BINARY INPUT 5	INPUT 5 >VT mcb Trip NO	361	Voltage transformer secondary m.c.b. has tripped
6106	BINARY INPUT 6	INPUT 6 >Extens. Z1B NO	3956	Release overreaching stage of impedance protection
6107	BINARY INPUT 7	INPUT 7 >Ext trip 1 NO	4526	External trip signals
6108	BINARY INPUT 8	INPUT 8 >Ext trip 2 NO	4546	

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). The signal relays are designated SIGNAL RELAY 1 to SIGNAL RELAY 13 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 which comprises two annunciation functions on one signal relay. 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 ↑:

```
6203 SIGNAL
RELAY 3
```

Allocations for signal relay 3

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

```
001 RELAY 3
O/S Trip ch.1
```

Signal relay 3 has been preset for:
1st: out-of-step protection trip by characteristic 1, FNo 5071;

```
002 RELAY 3
O/S Trip ch.2
```

Signal relay 3 has been preset for:
2nd: out-of-step protection trip by characteristic 2, FNo 5072.

```
003 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
51	Dev.operative	Protection relay operative
52	Prot. operat.	At least one protection function operative
56	Initial start	Initial start of the processorsystem
60	LED reset	Stored indications 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
165	Failure ΣUp-e	Failure supervision ΣU phase-earth
167	Failure Usymm	Failure supervision symmetry U
171	Fail.PhaseSeq	Failure supervision phase sequence
361	>VT mcb Trip	Voltage transformer secondary m.c.b. has tripped
3953	>Imp. block	Block impedance protection
3956	>Extens. Z1B	Release overreaching zone of impedance protection
3957	>BI + Z<	AND combination with additional impedance protection trip command
3961	Imp. off	Impedance protection is switched off
3962	Imp. blocked	Impedance protection is blocked
3963	Imp. active	Impedance protection is active
3966	Imp. Gen.Flt	Impedance protection: general fault detection
3967	Imp. Fault L1	Impedance protection: fault detection phase L1
3968	Imp. Fault L2	Impedance protection: fault detection phase L2
3969	Imp. Fault L3	Impedance protection: fault detection phase L3
3970	Imp. I> & U<	Impedance protection: fault detection with undervoltage sea-in
3971	Imp. T1 exp.	Impedance protection: delay time T1 (first stage) expired
3972	Imp. T2 exp.	Impedance protection: delay time T2 (final stage) expired
3973	Imp. T1B exp.	Impedance protection: delay time T1B (extended stage) expired
3974	Imp. Trip	Impedance protection: trip command issued
3975	BI+Z< Trip	Impedance protection: trip with binary input signal (AND-combined)
3976	Power swing	Impedance protection: power swing detected
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

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

FNo	Abbreviation	Description
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
4592	Ext 4 blocked	External trip signal 4 is switched off
4593	Ext 4 active	External trip signal 4 is blocked
4596	Ext 4 Gen.Flt	External trip signal 4 is active
4597	Ext 4 Gen.Trp	External trip signal 4: general fault detection signal
5001	Operat. range	External trip signal 4: general trip command issued
5053	>O/S block	Block out-of-step protection
5061	O/S off	Out-of-step protection is switched off
5062	O/S blocked	Out-of-step protection is blocked
5063	O/S active	Out-of-step protection is active
5067	O/S char.1	Out-of-step protection: characteristic 1 has been passed
5068	O/S char.2	Out-of-step protection: characteristic 2 has been passed
5069	O/S det.ch.1	Out-of-step detection by characteristic 1
5070	O/S det.ch.2	Out-of-step detection by characteristic 1
5071	O/S Trip ch.1	Out-of-step trip command by characteristic 1
5072	O/S Trip ch.2	Out-of-step trip command by characteristic 2
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 closed stop valve
5113	>Pf block	Block forward power supervision P_f><
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 Trip	Unbalanced load protection: trip by thermal stage

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

FNo	Abbreviation	Description
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

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 O/S char.1	5067	Out-of-step protection: characteristic 1 or 2 has been passed
6202	SIGNAL RELAY 2	RELAY 2 O/S char.2	5068	
6203	SIGNAL RELAY 3 RELAY 3	RELAY 3 O/S Trip ch.1 O/S Trip ch.2	5071 5072	Out-of-step protection: trip command
6204	SIGNAL RELAY 4	RELAY 4 Imp. Trip	3974	Impedance protection: trip command
6205	SIGNAL RELAY 5	RELAY 5 Imp. Gen.Flt	3966	Impedance protection: pick-up signal
6206	SIGNAL RELAY 6	RELAY 6 Power swing	3976	Impedance protection: power swing blocking
6207	SIGNAL RELAY 7	RELAY 7 Pr+SV Trip	5098	Reverse power protection: trip command with closed stop valve
6208	SIGNAL RELAY 8	RELAY 8 Pr Trip	5097	Reverse power protection: trip command
6209	SIGNAL RELAY 9 RELAY 9	RELAY 9 I2>> Trip I2 Θ Trip	5160 5161	Load unbalanced protection: trip command
6210	SIGNAL RELAY 10 RELAY 10	RELAY 10 I2> Warn I2 th. Warn	5156 5157	Load unbalanced protection: warning stages
6211	SIGNAL RELAY 11	RELAY 11 U0> Trip	5187	Stator earth fault protection: trip command
6212	SIGNAL RELAY 12	RELAY 12 Ext 1 Gen.Trp	4537	External trip command
6213	SIGNAL RELAY 13	RELAY 13 Dev.operative	51	Device operative; the NC contact can be used for "Device faulty" annunciation

Table 5.4 Preset annunciations for signal relays

5.5.4 Marshalling of the LED indicators - address block 63

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

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

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

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

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

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

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

The assignment of the LEDs as preset by the factory is shown in the front of the unit (Figure 6.1). The following boxes show, as an example, the assignment for LED 13. 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 3 ▮ L E D   1 3
```

Allocations for LED 13

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

```
0 0 1 ▮ L E D   1 3
E x t   1   G e n . T r p   m
```

LED 13 has been preset for:
1st: Trip by external trip signal 1 via binary input, memorized, FNo 4537

```
0 0 2 ▮ L E D   1 3
E x t   2   G e n . T r p   m
```

LED 13 has been preset for:
2nd: Trip by external trip signal 2 via binary input, memorized, FNo 4557

```
0 0 3 ▮ L E D   1 3
E x t   3   G e n . T r p   m
```

LED 13 has been preset for:
3rd: Trip by external trip signal 3 via binary input, memorized, FNo 4577

```
0 0 4 ▮ L E D   1 3
E x t   4   G e n . T r p   m
```

LED 13 has been preset for:
4th: Trip by external trip signal 4 via binary input, memorized, FNo 4597

```
0 0 5 ▮ L E D   1 3
n o t   a l l o c a t e d
```

no further allocation for LED 13

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

```
6 3 1 3 █ L E D   1 3
```

Allocations for LED 13

Addr	1st display line	2nd display line	FNo	Remarks
6300	MARSHALLING	LEDs		Heading of the address block
6301	LED 1 LED 1	 Imp. Gen.Flt nm	 3966	Impedance protection: pick-up
6302	LED 2 LED 2	 Imp. T1 exp. m	 3971	Impedance protection: delay time expired
6303	LED 3 LED 3	 Imp. T2 exp. m	 3972	
6304	LED 4 LED 4 LED 4	 O/S det.ch.1 nm O/S det.ch.2 nm	 5069 5070	Out-of-step protection: pick-up
6305	LED 5 LED 5	 O/S Trip ch.1 m	 5071	Out-of step protection: trip
6306	LED 6 LED 6	 O/S Trip ch.2 m	 5072	
6307	LED 7 LED 7	 Pr Trip m	 5097	Reverse power protection: trip
6308	LED 8 LED 8	 Pr+SV Trip m	 5098	
6309	LED 9 LED 9	 I2> Warn nm	 5156	Load unbalanced protection: warning stages
6310	LED 10 LED 10	 I2 th. Warn nm	 5157	
6311	LED 11 LED 11 LED 11	 I2 Θ Trip m I2>> Trip m	 5161 5160	Load unbalanced protection: trip
6312	LED 12 LED 12	 U0> Trip m	 5187	Stator earth fault protection: trip
6313	LED 13 LED 13 LED 13 LED 13 LED 13	 Ext 1 Gen.Trp m Ext 2 Gen.Trp m Ext 3 Gen.Trp m Ext 4 Gen.Trp m	 4537 4557 4577 4597	Trip by one of the external trip signals
6314	LED 14 LED 14 LED 14 LED 14 LED 14	 Failure 24V nm Failure 15V nm Failure 5V nm Failure 0V nm	 141 143 144 145	Failure in one of the internal d.c. supply circuits

Table 5.5 Preset LED indicators

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

The unit contains 5 trip relays which are designated TRIP RELAY 1 to TRIP RELAY 5. The trip relays can be marshalled in the address block 64. The block is reached by paging in blocks with ⇑ ⇓ or by directly addressing with **DA**, input of the address number **6 4 0 0** and pressing the enter key **E**. The selection procedure is carried out as described in Section 5.5.1. Multiple commands are possible, i.e. one logical command function can be given to several trip relays (see also Section 5.5.1).

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

The following boxes show an example for marshalling of trip relays 2. Table 5.7 shows all trip relays as preset from the factory. Figure 5.8, at the end of this section, illustrates the preset assignment as a tripping matrix.

⇑⇓ 6400 ▮ MARSHALLING TRIP RELAYS	Beginning of the block "Marshalling of the trip relays"

The desired trip relay is reached with the key ↑:

↑↓ 6402 ▮ TRIP RELAY 2	Allocations for trip relay 2

Change over to the selection level with F ↑:

↑↓ 001 ▮ TRIP REL. 2 Test Trip 2	Trip relay 2 has been preset for: 1st: Trip by test trip function for trip relay 2, FNo 1176; this function is fix allocated and cannot be changed!
↑↓ 002 ▮ TRIP REL. 2 BI+Z< Trip	Trip relay 2 has been preset for: 2nd: Trip by impedance protection stage with AND combination via binary input, FNo 3975
↑↓ 003 ▮ TRIP REL. 2 O/S Trip ch.1	Trip relay 2 has been preset for: 3rd: Trip by characteristic 1 of the out-of-step protection, FNo 5071
↑↓ 004 ▮ TRIP REL. 2 Pr Trip	Trip relay 2 has been preset for: 4th: Trip by reverse power protection, FNo 5097
↑↓ 005 ▮ TRIP REL. 2 Pr+SV Trip	Trip relay 2 has been preset for: 5th: Trip by reverse power protection with tripped stop valve, FNo 5098

```
0 0 6 █ T R I P   R E L .   2
U 0 >   T r i p
```

Trip relay 2 has been preset for:
6th: Trip by stator earth fault protection, FNo 5187

```
0 0 7 █ T R I P   R E L .   2
I m p .   T r i p
```

Trip relay 2 has been preset for:
7th: Trip by impedance protection, FNo 3974

```
0 0 8 █ T R I P   R E L .   2
n o t   a l l o c a t e d
```

Trip relay 2 has been preset for:
8th: 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
3974	Imp. Trip	Trip by impedance protection
3975	BI+Z< Trip	Trip by impedance protection stage AND-combined with binary input
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
5071	O/S Trip ch.1	Trip by out-of-step protection characteristic 1
5072	O/S Trip ch.2	Trip by out-of-step protection characteristic 2
5097	Pr Trip	Trip by reverse power protection
5098	Pr+SV Trip	Trip by reverse power protection with closed stop valve
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

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	O/S Trip ch.2	5072	
6402	TRIP	RELAY 2		
	TRIP REL. 2	Test Trip 2 [1])	1176	
	TRIP REL. 2	BI+Z< Trip	3975	
	TRIP REL. 2	O/S Trip ch.1	5071	
	TRIP REL. 2	Pr Trip	5097	e.g. trip for generator circuit breaker
	TRIP REL. 2	Pr+SV Trip	5098	
	TRIP REL. 2	U0> Trip	5187	
	TRIP REL. 2	Imp. Trip	3974	
6403	TRIP	RELAY 3		
	TRIP REL. 3	Test Trip 3 [1])	1177	
	TRIP REL. 3	BI+Z< Trip	3975	
	TRIP REL. 3	Pr Trip	5097	
	TRIP REL. 3	Pr+SV Trip	5098	e.g. trip for stop valve
	TRIP REL. 3	U0> Trip	5187	
	TRIP REL. 3	Imp. Trip	3974	
6404	TRIP	RELAY 4		
	TRIP REL. 4	Test Trip 4 [1])	1178	
	TRIP REL. 4	BI+Z< Trip	3975	
	TRIP REL. 4	Pr Trip	5097	
	TRIP REL. 4	Pr+SV Trip	5098	e.g. trip for de-excitation
	TRIP REL. 4	U0> Trip	5187	
	TRIP REL. 4	Imp. Trip	3974	
6405	TRIP	RELAY 5		
	TRIP REL. 5	Test Trip 5 [1])	1179	
	TRIP REL. 5	BI+Z< Trip	3975	e.g. trip for station auxiliary supply
	TRIP REL. 5	U0> Trip	5187	change-over
	TRIP REL. 5	Imp. Trip	3974	

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

Table 5.7 Preset command functions for trip relays

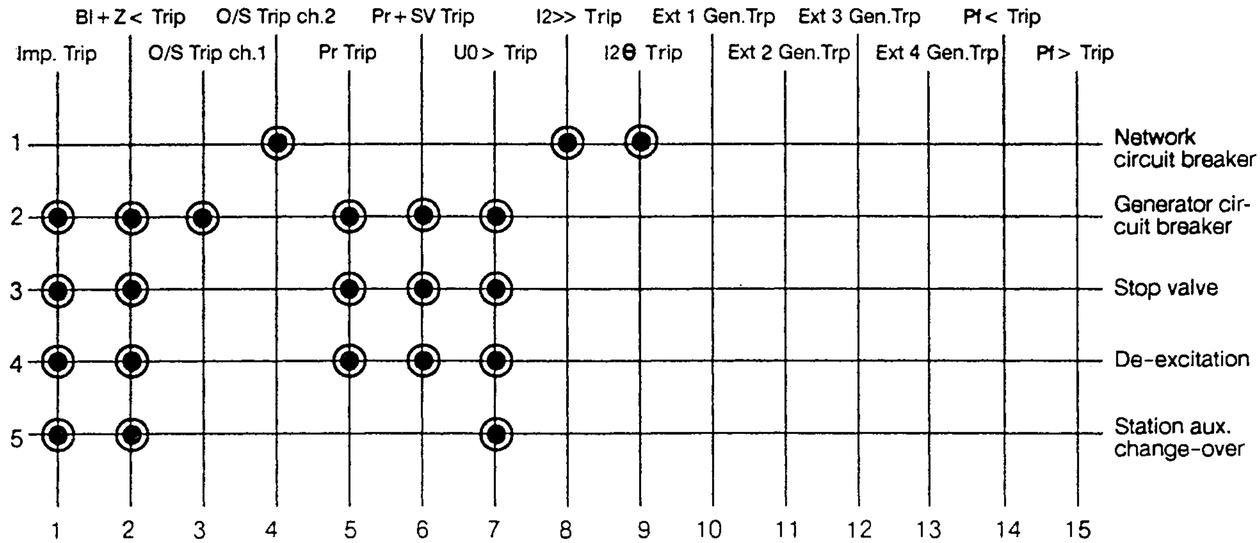


Figure 5.6 Tripping matrix – pre-settings

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.

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

All data can be read in from, or copied onto, magnetic data carrier (floppy disc) (e.g. for settings and configuration).

Additionally, all the data can be documented on a connected printer. It is also possible, by connecting a plotter, to print out the fault history traces.

For operation of the personal computer, the instruction manuals of this device are to be observed. The PC program DIGSI® is available for setting and processing of all digital protection data. Further information about facilities on request.

6.2.3 Operational preconditions

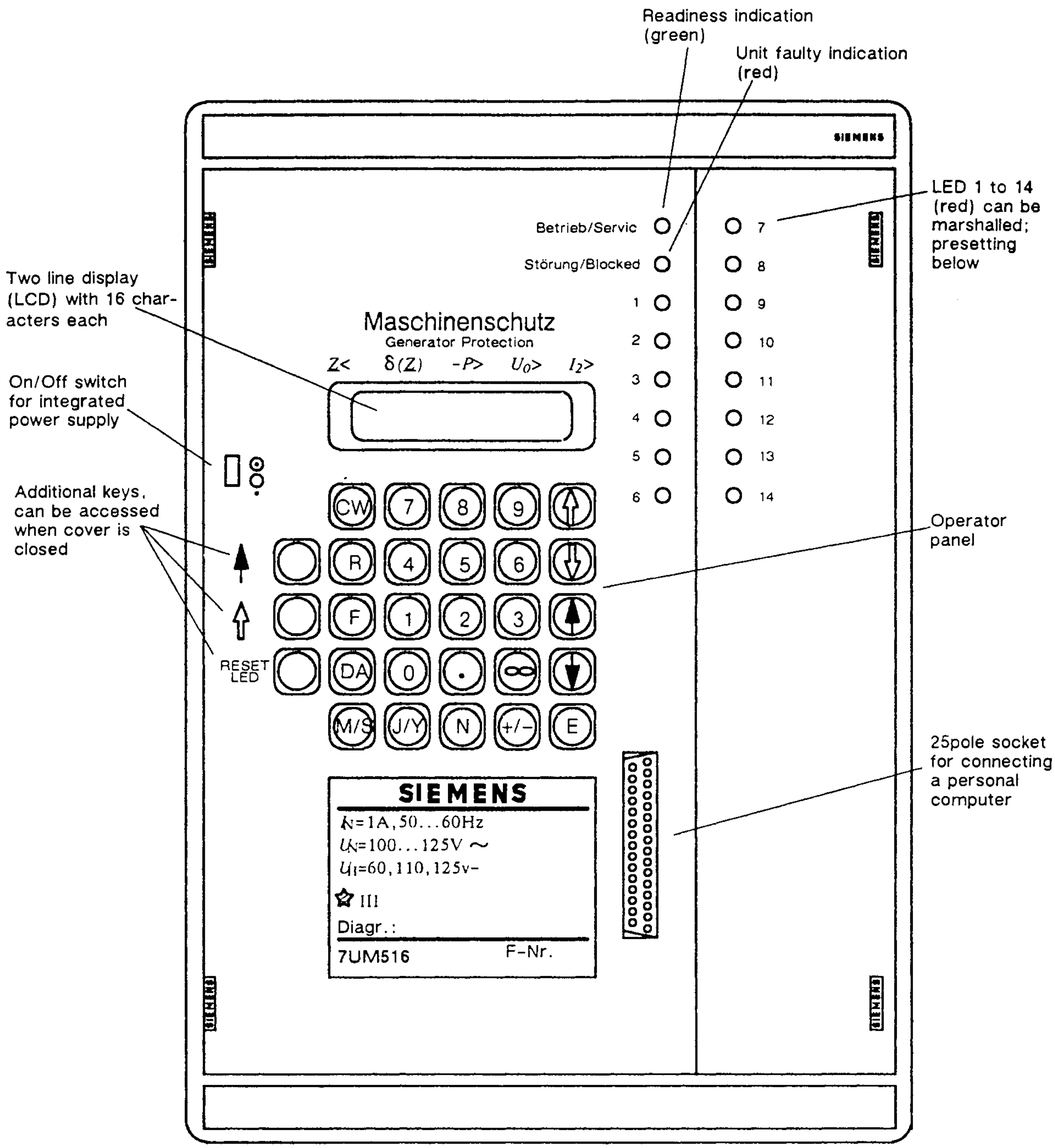
For most operational functions, the input of a codeword is necessary. This applies for all entries via the membrane keyboard or front interface which concern the operation on the relay, for example

- setting of functional parameters (thresholds, functions),
- allocation or marshalling of 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 Impedance protection pick-up
2 Impedance protection T1 expired
3 Impedance protection T2 expired
4 Out-of-step protection pick-up (char. 1 or 2)
5 Out-of-step protection trip (char. 1)
6 Out-of-step protection trip (char. 1)
7 Reverse power protection trip
8 Reverse power protection trip with closed stop valve
9 Load unbalanced protection warning stage $I_2>$
10 Load unbalanced protection thermal warning stage
11 Load unbalanced protection trip
12 Stator earth fault protection trip
13 External trip via binary input
14 Device fault (hardware 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 (see 5.3.1). Without codeword entry, parameters can be read out but not be changed.

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

- Addresses without request for operator input

  The address is identified by the block number followed by 00 as sequence number (e.g. **1100** for block **11**). Displayed text forms the heading of this block. No input is expected. By using keys ⇑ 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 6.5.3 for more details.

The parameter sets are processed in address block 85. The most simple manner to come to this block is using direct addressing:

- press direct address key **DA**,
- enter address, e.g. **8 5 0 0**,
- press enter key **E**.

The heading of the block for processing the parameter sets then appears.

It is possible to scroll through the individual addresses using the ↑ key. The copying facilities are summarized in Table 6.1.

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

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

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

Table 6.1 Copying parameter sets

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

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

6.3.1.3 Setting of date and time

The date and time can be set when 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.

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

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

```
2 9 . 1 1 . 1 9 9 4
1 5 : 5 8 : 2 6
```

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

```
8 1 0 2█D A T E
```

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

```
8 1 0 3█T I M E
```

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

```
8 1 0 4█D I F F .   T I M E
```

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

6.3.2 Initial displays – address blocks 00 and 10

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

```
⇧ | 0█ 7 U M 5 1 6     V 3 . * * B |
⇩ | 7 U M 5 1 6 * * * * * * * * * * |
```

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

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

```
⇧ |   1 0 0 0█                     |
⇩ | P A R A M E T E R S            |
```

Commencement of functional parameter blocks

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

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

```
⇧ |   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"

```
↑ |   1 1 0 8█ S T A R P O I N T   |
↓ | H I G H - R E S I S T A N C E  |

  | L O W - R E S I S T A N C E    |
```

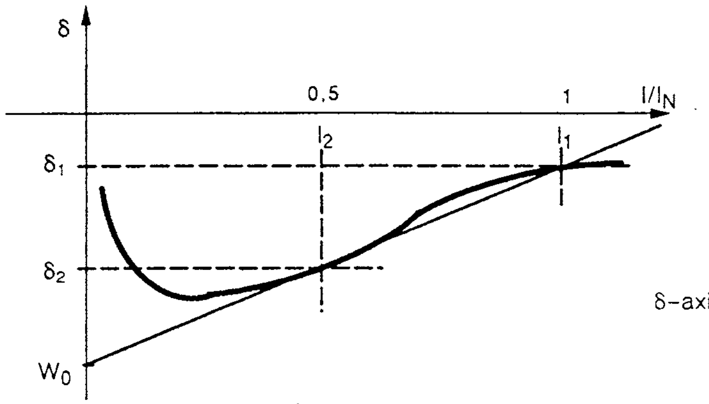
Type of star-point earthing of the machine

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 star-point 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. 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.

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 6.2 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 6.7.5.2).



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

```
1200 INSTRUMENT
TRANSFORMER DATA
```

Beginning of block "Instrument transformer data"

```
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
```

```
TOWRDS STARPOINT
```

Polarity of current transformers:

Starpoint formed on machine terminal side

Starpoint formed on machine starpoint side.

```
1206 CT ANG. W0
4.30 deg
```

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

```
1207 CT ANGLEW1
-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 6.7.5.2) .

With addresses 1209 and 1210, the device is instructed as to how the residual path of the voltage transformers is connected. This information is important for the earth fault protection and the monitoring of measured values.

If the voltage transformer set or earthing transformer has e-n (open-delta) windings, and if these are connected to the device, then this has to be recorded in address 1209. Since the ratio of the voltage transformers is normally

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

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

```
1209 VT DELTA
CONNECTED
```

```
NOT CONNECTED
```

The measured displacement voltage input Udelta of the device is

CONNECTED to the e-n (open delta) windings of the voltage transformer set or

NOT CONNECTED

```
1210 Uph/Udelta
1.73
```

Matching factor for residual voltage:

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

normally 1.73

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

6.3.4 Settings for impedance protection - address blocks 13 to 15

```
1300 IMP. PROT.
GENERAL SETTINGS
```

Beginning of the block
"Distance protection general settings"

```
1301 IMP. PROT.
OFF
```

```
ON
```

```
BLOCK TRIP REL
```

Impedance protection

Switch *OFF* of impedance protection

Switch *ON* of impedance protection

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

6.3.4.1 Setting of the impedance stages – address block 13

The relevant parameters are set for each distance stage. The reactance X determines the reach of its associated zone. The resistance R forms the allowance for fault resistance.

As it can be presupposed that the distance zone is set to measure into the unit transformer, the setting must be selected so that it takes the regulating range of the transformer into account.

The zone Z1 is therefore set to approximately 70 % of the protected range, i.e. 0.7 times the transformer reactance. The impedance protection operates instantaneously or with only a small delay T1 for short-circuits within this zone. If the reactance measured during a short-circuit is larger than this set value, the protection trip normally with its back-up time.

The following is valid for the primary reactance:

$$\boxed{X_{prim} = \frac{k_R}{100} \cdot \frac{u_K}{100} \cdot \frac{U_N^2}{S_N}}$$

where:

- k_R – zone reach of zone Z1 in %
- u_K – percent impedance voltage of the unit transformer
- S_N – rated apparent power of the unit transformer
- U_N – rated voltage of the unit transformer

The values determined such must be converted for the secondary side of current and voltage transformers. In general:

$$Z_{secondary} = \frac{\text{Current transformer ratio}}{\text{Voltage transformer ratio}} \cdot Z_{primary}$$

The secondary values given to the relay must be related to a current of 1 A. Thus the conversion formula for reach for any distance zone is:

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

Where
- N_{ct} – c.t. ratio
- N_{vt} – v.t. ratio
- I_N/A – rated relay current in Ampere = secondary rated current of current transformers
- X_{prim} – the primary reactance

Calculation Example

Unit transformer:

u_K = 12.1 %

S_N = 150 MVA

U_N = 10.5 kV

Current transformers 12,000 A/5 A

Voltage transformers 10 kV/0.1 kV

Which gives the data for zone 1 (70 % of transformer reactance):

$$X1_{prim} = \frac{70}{100} \cdot \frac{12{,}1}{100} \cdot \frac{(10{,}5)^2}{150} = 0.0623\ \Omega$$

Thus results the setting for zone 1 in secondary values:

$$X1_{sec} = \frac{12{,}000\ \text{A}/5\ \text{A}}{10{,}000\ \text{V}/100\ \text{V}} \cdot 0.0623 \cdot 5$$

$$X1_{sec} = \underline{7.5\ \Omega}$$

Resistance setting

Resistance setting R allows a margin for fault resistance, which appears as an in-phase resistance addition to the fault impedance, at the point of fault. It comprises, for example, arc resistances in case of arcing faults. The setting should take these fault resistances into account but not be set higher than absolutely necessary. An adequate difference from the operating impedance must be ensured, even under conditions of temporary overload.

Normally, a resistance setting equal to the reactance setting is adequate to form sufficient arc resistance allowance, in this example:

$$R1_{sec} = \underline{7.5\ \Omega}$$

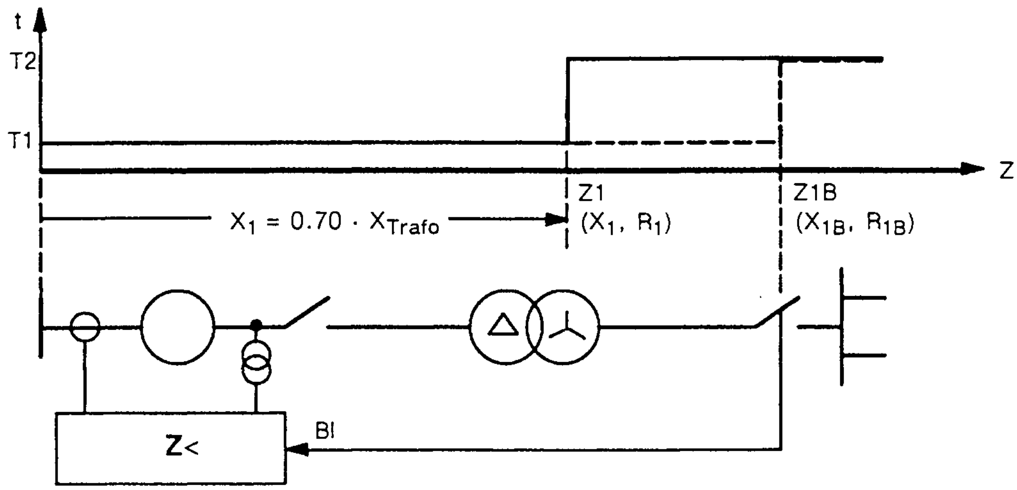


Figure 6.3 Time grading for machine impedance protection - example

Independent zone Z1

1302 R1 7.50 Ω	Resistance value Smallest setting value: Largest setting value:	 **0.05 Ω** **65.00 Ω**
1303 X1 7.50 Ω	Reactance value (reach) Smallest setting value: Largest setting value:	 **0.05 Ω** **130.00 Ω**
1304 T1 0.50 s	Delay for zone Z1 Smallest setting value: Largest setting value: and ∞ (no trip in zone Z1)	 **0.00 s** **32.00 s**

Controlled (overreach) zone Z1B

The overreach zone Z1B is a controlled stage. It does not influence the normal zone Z1. There is, therefore, no switch-over, rather the overreach zones will be switched effective or non-effective via a binary input.

Zone Z1B is normally made effective when the network circuit breaker is in off position. In this case, each pick-up of the impedance protection indicates an internal fault within the power station unit since the system is interrupted from the power station. Thus, 100 % rapid clearance without loss of selectivity.

Zone Z1B can be activated via a binary input of the device which is controlled by the network circuit breaker auxiliary contact. It may be delayed by the time T1B.

```
 1305█R1B
10.00 Ω
```

Resistance value
Smallest setting value: **0.05 Ω**
Largest setting value: **65.00 Ω**

```
 1306█X1B
10.00 Ω
```

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

```
 1307█T1B
0.50 s
```

Delay for zone Z1B
Smallest setting value: **0.00** s
Largest setting value: **32.00** s
and ∞ (no trip in zone Z1B)

Back-up stage

The impedance protection operates as back-up overcurrent time protection for faults on the upper voltage side of the unit transformer and in the system. The back-up time T2 is set to grade above the time of the second or third stage of the neighbouring system protection relays. Additionally, a drop-off time of the impedance protection can be set under address 1309.

```
 1308█T2
5.00 s
```

Delay for T2 (fault detection undirectional trip)
Smallest setting value: **0.00 s**
Largest setting value: **32.00 s**
and ∞ (no undirectional trip)

```
 1309█T-RESET
1.00 s
```

Drop-off delay
Smallest setting value: 0.00 s
Largest setting value: **32.00** s

6.3.4.2 Settings for fault detection - address block 14

```
 1400█IMP. PROT.
FAULT DETECTION
```

Beginning of the block "Fault detection for impedance protection"

The determining factor for overcurrent setting is the maximum possible operating current. Pick-up under conditions of permissible overload must be excluded! The threshold value (address 1401) must therefore be set above the maximum anticipated (over-)load current (at least 1.3 times, preferred value: approx. 1.5 times).

```
 1401█I>
1.50 I/In
```

Overcurrent detection threshold value I>
Smallest setting value: **0.20** $\cdot I_N$
Largest setting value: **4.00** $\cdot I_N$

In case of excitation systems deriving their power from the generator terminals, when the short-circuit current can rapidly decay below the pick-up value (address 1401), the undervoltage seal-in circuit is to be used.

The undervoltage value (address 1403) is set below the smallest line-to-line voltage that can occur during normal operation, e.g. U< = 75 V. The holding time (address 1404) must be set to cover the longest fault clearance time in back-up case, recommended setting: T-HOLDING = T2 + 1 s.

```
1402 U<   SEAL-IN
OFF
```
```
ON
```

Undervoltage seal-in is

switched *OFF*

switched *ON*

```
1403 U<
75  V
```

Undervoltage value for seal-in (phase-to-phase)
Smallest setting value: **30** V
Largest setting value: **130** V

```
1404 T-SEAL-IN
10.00  s
```

Holding time of seal-in; must be longer than backup time plus circuit breaker opening time
Smallest setting value: **0.00** s
Largest setting value: **32.00** s

6.3.4.3 Settings for power swing blocking

```
1500 IMP.  PROT.
POWER  SWING
```

Beginning of the block "Power swing blocking for impedance protection"

```
1501 P/S
OFF
```
```
ON
```

Power swing blocking is

switched *OFF*

switched *ON*

For the detection of power swings, the following considerations are of importance (see also Section 4.2.4):

To set the rate of change of the impedance vector (address 1502), both the maximum power swing frequency in the instant of entry of the impedance vector into the power swing polygon and the time required by 7UM516 for the detection of the power swing must be taken into consideration. Under the most difficult conditions, at least 35 ms should be allowed for the detection of a power swing. Additionally, the trip time delay T1 must be taken into account. The following condition should be maintained:

$$\boxed{T1 > \frac{Z_{max}}{dZ/dt}}$$

where: T1 delay time zone Z1 (address 1304)
dZ/dt rate of change (address 1502)
$Z_{max} = 2 \cdot \sqrt{R_1^2 + X_1^2}$
(R_1, X_1 = settings 1302 and 1304)

Power swing blocking can be limited to the time P/S T-ACT (address 1503). With this setting ∞, power swing blocking is effective until the impedance vector has left the power swing polygon again.

The distance between power swing polygon and fault detection polygon (phase-phase) should be as large as possible; the R-intersection is decisive.

On the other hand, the power swing polygon **must** not extend into the operational impedance!

```
1502 dZ/dT
50.0  Ω/s
```

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

Smallest setting value: **1.0** Ω/s
Largest setting value: **200.0** Ω/s

```
1503 P/S  T-ACT.
2.00  s
```

Power swing action time:
Smallest setting value: **0.01** s
Largest setting value: **32.00** s
and ∞ (only after discontinuation of the power swing criterion)

```
1504 DELTA  Z
2.00  Ω
```

Distance between power swing polygon and trip polygon (secondary) in Ω
Smallest setting value: **0.10** Ω
Largest setting value: **10.00** Ω

6.3.5 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.

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.

Hints for dimensioning the load resistor are contained in the pamphlet "Planning Machine Protection Systems", Order No. E50400-U0089-U412-A1-7600.

The setting value is twice the displacement value which is coupled in at full network displacement. Final determination of the setting value occurs during commissioning with primary values according to Section 6.7.4.

The earth fault trip is delayed by the time set under address 1903. When setting the delay time, the overload capability of the loading equipment must be considered.

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

Example:

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

With full neutral displacement voltage, the load resistor supplies:

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

For a protected zone of 90 %, the protection should already operate at 1/10 of the full displacement voltage. For the displacement voltage setting, 1/10 of the full displacement voltage is used (because of the 90 % protected zone). Considering a voltage divider of 500 V/100 V, this results in:

Setting U0> = 10 V

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

```
1902 ▮ U0>
10.0 V
```

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

```
1903 ▮ T-Uo>
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

6.3.6 Settings for out-of-step protection – address block 20

```
2000 OUT-O-STEP
PROTECTION
```

Beginning of the block "Out-of-step protection"

```
2001 OUT-O-STEP
OFF
```

Switch *OFF* of out-of-step protection

```
ON
```

Switch *ON* of out-of-step protection

```
BLOCKED
```

out-of-step protection operates but *TRIP RELay* is *BLOCKed*

The out-of-step protection operates only when an adjustable current value has been exceeded (address 2002). The positive sequence component of the currents is decisive for this pick-up. As out-of-step conditions are symmetrical occurrences, a maximum value of negative sequence current must not be exceeded (address 2003).

The determining factor for overcurrent setting is the maximum possible operating current. Pick-up under conditions of permissible overload should be excluded! The setting should therefore be set above the maximum anticipated (over-)load current (at least 1.2 times). In general, the same value as for the impedance protection is chosen.

```
2002 I1>  Meas.
1.20  I/In
```

Overcurrent pick-up (positive sequence component)

Setting range: **0.20** I_1/I_N to **4.00** I_1/I_N

```
2003 I2<  Meas.
0.20  I/In
```

Symmetry condition for measurement release (negative sequence component)
Setting range: **0.05** I_2/I_N to **1.00** I_2/I_N

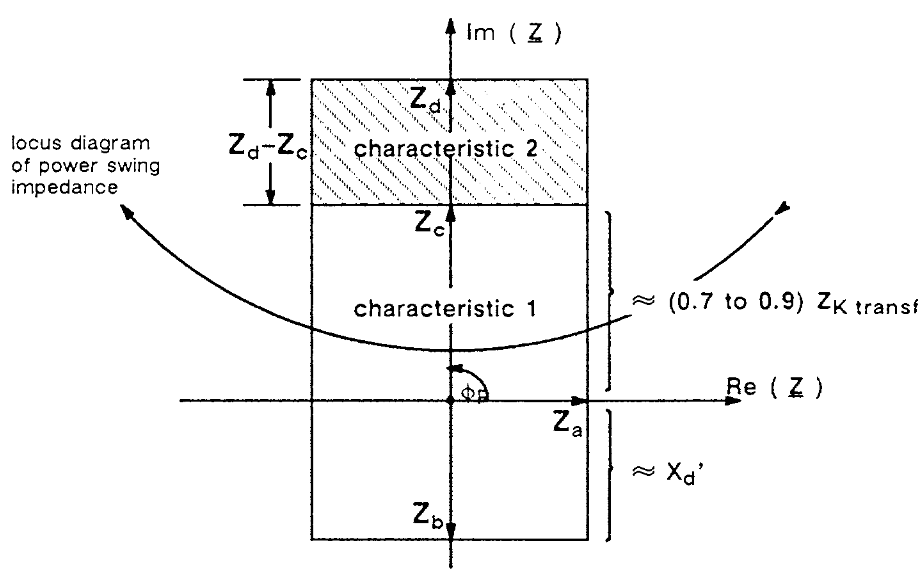


Figure 6.4 Power swing polygon

The measured impedances during power swing condition are decisive for the settings. For the direction to the machine (as vied from the location of the voltage transformers), the power swing reactance of the machine must be considered, which is approximately the transient reactance X_d' of the machine. Consequently, setting for Z_b should be $Z_b \approx X_d'$ (cf. Figure 6.4).

X_d' can be calculated from the per unit reactance x_d' as follows:

$$X_d' = \frac{U_{N\,gen}}{\sqrt{3}\,I_{N\,gen}} \cdot x_d' \cdot \frac{N_{ct}}{N_{vt}} \cdot \frac{I_N}{A}$$

where:

- X_d' – the transient reactance of the machine
- x_d' – the transient per unit reactance
- $U_{N\,gen}$ – the rated machine voltage
- $I_{N\,gen}$ – the rated machine current
- N_{ct} – the current transformer transformation ratio
- N_{vt} – the voltage transformer transformation ratio

Usual values are listed in Table 6.1 for I_N = 1 A. For I_N = 5 A the values must be divided by 5.

Rotor type	x_d'	X_d' U_N = 100 V / I_N = 1 A	X_d' U_N = 125 V / I_N = 1 A
turbo rotor	0.13.....0.22	7.5 Ω......12.7 Ω	9.4 Ω......15.9 Ω
salient-pole rotor	0.20.....0.45	11.5 Ω......26.0 Ω	14.4 Ω......32.5 Ω

Table 6.1 Transient machine reactances (referred to rated values of the machine)

As it is presupposed that the machine is connected with the network via a unit transformer, the setting in the network direction is chosen such that the reactance reach of characteristic 1 is approximately 70 % to 90 % of the transformer impedance, and the reach of characteristic 2 is into the network. Thus, Z_c (address 2006) is set to 70 % to 90 % of the transformer reactance; Z_d is set to cover at least the unit transformer, eventually a part of the network system.

Table 6.2 shows typical values of the characteristics of unit transformers for secondary rated current I_N = 1 A. For I_N = 5 A the secondary impedances must be divided by 5. The relationship of the values is according to the following equation:

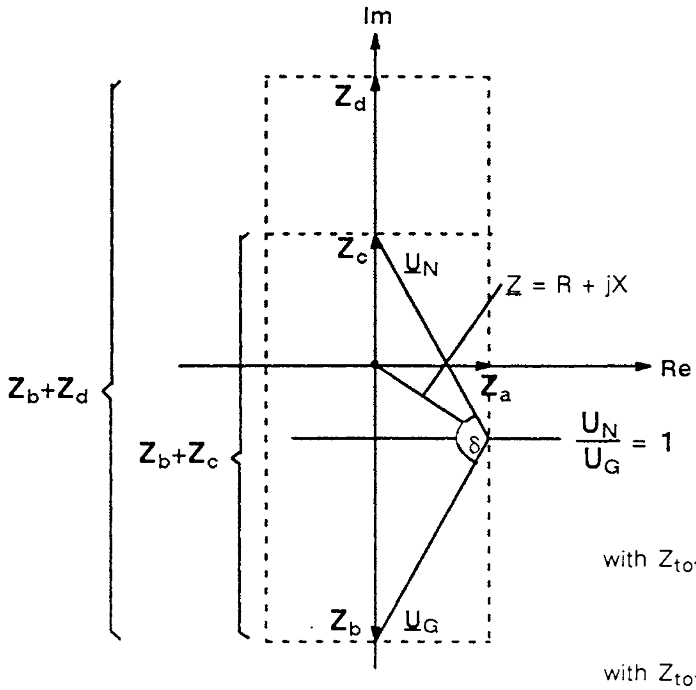
$$X_{Kprim} = \frac{U_K}{\sqrt{3}\,I_N} = \frac{u_K \cdot U_N}{100 \cdot \sqrt{3} \cdot I_N} = \frac{u_K \cdot U_N^2}{100 \cdot S_N}$$

$$X_{Ksec} = X_{K\,prim} \cdot \frac{N_{ct}}{N_{vt}} \cdot \frac{I_N}{A}$$

Transformer type	$u_K = U_K/U_N$	X_K U_N = 100 V / I_N = 1 A	X_K U_N = 125 V / I_N = 1 A
unit transformer	8 % ... 13 %	4.6 Ω ... 7.5 Ω	5.8 Ω ... 19.4 Ω
general	3 % ... 16 %	1.7 Ω ... 9.2 Ω	2.2 Ω ... 11.5 Ω

Table 6.2 Per unit impedance voltages and impedances of transformers

The setting Z_a is decisive for the width of the power swing polygon. This setting value is determined by the total impedance Z_{tot} and can be derived from the equation in Figure 6.5. Z_{tot} can be calculated from the sum of $Z_b + Z_d$; then the power swing angle is valid between the machine e.m.f. and the network. Optionally, Z_{tot} can be calculated from $Z_b + Z_c$; in this case the power swing angle is valid between the machine e.m.f. and the unit transformer. The pre-setting of address 2004 corresponds to the latter case. Usually, the power swing angle 120° is chosen since the generator voltage and the system voltage equal the voltage difference.



$$Z_a = \frac{Z_{tot}/2}{\tan(\delta/2)}$$

with $\delta = 120°$

$$Z_a = \frac{Z_{tot}/2}{\tan(120°/2)}$$

$$Z_a \approx 0.289 \cdot Z_{tot}$$

with $Z_{tot} = Z_b + Z_c$ power swing angle between generator and unit transformer (as illustrated) or

with $Z_{tot} = Z_b + Z_d$ power swing angle between generator and network

Figure 6.5 Power swing polygon and impedance vectors with power swing angle δ

The polygon width Z_a determines also the maximum detectable power swing frequency. The consideration that, at maximum power swing frequency, at least two impedance measurements must have been carried out within the power swing polygon, leads to the following formula:

$$f_P = \frac{4}{\pi} \cdot \frac{1}{T} \cdot \frac{Z_a}{Z_{tot}} \qquad \text{with } T = \text{a.c. period}$$

For a rated frequency of 50 Hz (i.e. T = 20 ms), for example, the above formula delivers with $Z_a \approx 0.289 \cdot Z_{tot}$ (cf. Figure 6.5) the maximum detectable power swing frequency $f_{P/S}$:

$f_{P/S}$ = 18 Hz.

The inclination angle ϕ of the power swing polygon can be set in address 2008 and thus matched to the conditions. It should be approximately the vector angle of Z_{tot}.

Calculation example

Generator data:
x_d' = 0.20
U_N = 10.5 kV
I_N = 8.1 kA

Unit transformer data:
u_K = 12.1 %
S_N = 150 MVA
U_N = 10.5 kV

Instrument transformers:
c.t. ratio
N_{ct} = 12,000 A/5 A
v.t. ratio

$$N_{vt} = \frac{10\,000\ \text{V}}{\sqrt{3}} \Big/ \frac{100\ \text{V}}{\sqrt{3}}$$

Thus, the secondary transient reactance

$$X_d' = \frac{U_{N\,gen}}{\sqrt{3}\, I_{N\,gen}} \cdot x_d' \cdot \frac{N_{ct}}{N_{vt}} \cdot \frac{I_N}{A}$$

$$X_d' = \frac{10.5 \cdot 10^3}{\sqrt{3} \cdot 8.1 \cdot 10^3} \cdot 0.20 \cdot \frac{12 \cdot 10^3/5}{10 \cdot 10^3/100} \cdot 5 = 18\ \Omega$$

The setting of address 2005 is thus determined because of $Z_b \approx X_d'$

The secondary reactance of the unit transformer is derived from the primary reactance by considering the instrument transformer ratios:

$$X_K = \frac{u_K \cdot U_N^2}{100 \cdot S_N} \cdot \frac{N_{ct}}{N_{vt}} \cdot \frac{I_N}{A}$$

$$= \frac{12.1}{100} \cdot \frac{(10.5 \cdot 10^3)^2}{150 \cdot 10^6} \cdot \frac{12 \cdot 10^3/5}{10 \cdot 10^3/100} \cdot 5 = 10.7\ \Omega$$

Assuming that the characteristic 1 should cover 75 % of the transformer reactance, the setting of Z_c results in:

$$Z_c = 0.75 \cdot 10.7\ \Omega \approx 8.0\ \Omega.$$

Assuming that the remaining transformer reactance and the covered system reactance should be 20 Ω, the setting of $Z_d - Z_c$ results in:

$$Z_d - Z_c = 12\ \Omega.$$

The width Z_a of the polygon is determined by the total impedance Z_{tot}. In this example, the total impedance is that of characteristic 1, i.e. the sum of generator reactance and 75 % of the unit transformer reactance; that is the sum of the setting values for Z_b and Z_c: 18 Ω + 8 Ω = 26 Ω. Thus:

$$Z_a \approx 0.289 \cdot 26\ \Omega \approx 7.5\ \Omega.$$

```
2004▮Za
7.50 Ω
```

Half width of the power swing polygon
Setting range: **0.20 Ω** to **130.00 Ω**

```
2005▮Zb
18.00 Ω
```

Impedance reach in reverse direction (machine)
Setting range: **0.10 Ω** to **130.00 Ω**

```
2006▮Zc
8.00 Ω
```

Impedance reach in forward direction (characteristic 1 in direction of the unit transformer)
Setting range: **0.10 Ω** to **130.00 Ω**

```
2007▮Zd-Zc
12.00 Ω
```

Impedance reach in forward direction (characteristic 2 in network direction) as difference Z_d-Z_c
Setting range: **0.00 Ω** to **130.00 Ω**

```
2008▮PHI POLYG.
90.0 °
```

Inclination angle of the power swing polygon
Setting range: **60.0°** to **90.0°**

Address 2009 determines the number of out-of-step periods for characteristic 1 which shall lead to trip, i.e. how often this characteristic must have been passed through. Address 2010 determines the number of out-of-step periods for characteristic 2 which shall lead to trip, i.e. how often this characteristic must have been passed through.

For characteristic 1, 1 to 2 passes are normally adequate as out-of-step conditions with the electrical centre within the power station unit should not be tolerated too long time and the power swing frequency tends to accelerate during out-of-step condition so that the electrical and dynamic stress of the machine increases. On the other hand, for out-of-step conditions with the electrical centre being in the network system a higher number of slip period can be tolerated.

The holding time (address 2011) determines how long time a detected out-of-step condition (passing through) is maintained so that the counter is incremented with the next passing through. When no renewed pick-up occurs with in this time, the out-of-step condition is 'forgotten'. This time should be set higher than the longest expected slip period (i.e. smallest slip frequency). Conventional values lie between 20 s and 30 s.

With each detected out-of-step condition the corresponding counter is incremented and an annunciation "Out-of-step characteristic 1" or "Out-of-step characteristic 2" is issued. These annunciations disappear after the time which is set under address 2012. If this time is set higher than the holding time (address 2011) then the out-of-step annunciation begins with the first out-of-step detection and ends after the last detected out-of-step condition, prolonged with this annunciation time.

The drop-off delay time (address 2013) begins after trip command is given and pick-up has dropped off.

```
2009 REP.CHAR.1
1
```

Number of out-of-step conditions detected by characteristic 1 which should cause tripping
Setting range: **1** to **4**

```
2010 REP.CHAR.2
4
```

Number of out-of-step conditions detected by characteristic 2 which should cause tripping
Setting range: **1** to **8**

```
2011 T-HOLDING
32.00 s
```

Pick-up holding time (valid for both characteristics 1 & 2
Setting range: **0.20** s to **32.00** s

```
2012 T-SIGNAL
0.05 s
```

Holding time for out-of-step annunciation (valid for both characteristics 1 & 2
Setting range: **0.02** s to **0.15** s

```
2013 T-RESET
0.10 s
```

Drop-off time after trip command has been issued
Setting range: **0.05** s to **32.00** s

6.3.7 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

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

6.3.8 Settings for reverse power protection - address block 23

2300 ▮ REVERSE POWER	Beginning of the block "Reverse power protection"
2301 ▮ REV. POWER OFF	Switch *OFF* of reverse power protection
ON	Switch *ON* of reverse power protection
BLOCK TRIP REL	reverse power protection operates but *TRIP RE*Lay 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 open, 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 to 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).

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 <u>open</u> Setting range: **0.00** s to **32.00** s and ∞ (no trip with open stop valve)
2304 ▮ T-SV-CLOS. 3.00 s	Trip delay for reverse power with stop valve <u>closed</u> Setting range: **0.00** s to **32.00** s and ∞ (no trip with closed stop valve)
2305 ▮ T-RESET 3.00 s	Drop-off time after trip command has been issued Setting range: **0.00** s to **32.00** s

6.3.9 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 RELay* is *BLOCKed*

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 7UM516. 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.

Example:

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

Current transformer: 1200 A/1 A

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

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.

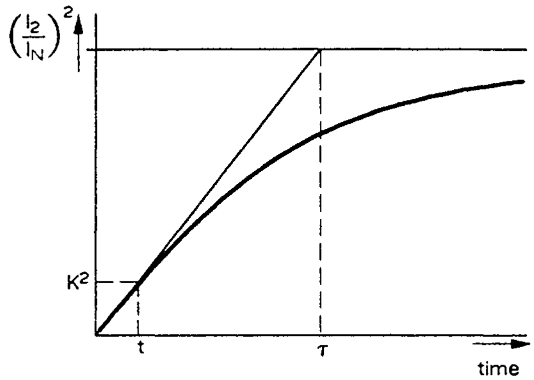


Figure 6.6 I_2^2–t characteristic

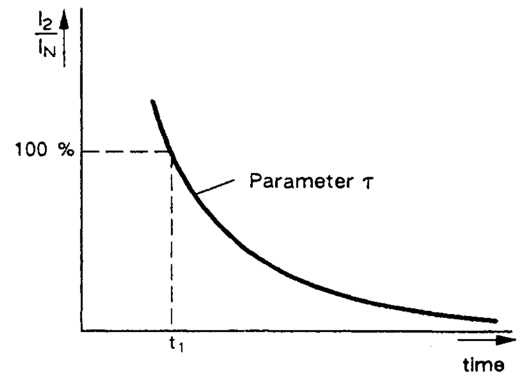


Figure 6.7 Thermal unbalanced load characteristic

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.

```
2402 I2>
6 %
```

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

```
2403 T-I2>
20.00 s
```

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

```
2404 TIME CONST
750 s
```

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

```
2405 THERM.WARN
90 %
```

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

```
2406 I2>>
60 %
```

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

```
2407 T-I2>>
3.00 s
```

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

```
2408 T-RESET
0.10 s
```

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

6.3.10 Settings for measured value monitoring - address block 29

The different monitoring functions of the protective relay are described in Section 4.10.4. 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 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	Measured value monitoring is *OFF* switched off
ON	*ON* switched on
2903 SYM.Ithres 0.50 I/In	Current threshold above which the symmetry monitoring is effective (refer Figure 4.19) Smallest setting value: **0.10** $\cdot I_N$ Largest setting value: **1.00** $\cdot I_N$
2904 SYM.Fact.I 0.50	Symmetry factor for the current symmetry = slope of the symmetry characteristic (see Figure 4.19) 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 Figure 4.17) reacts (absolute content, related to I_N only) is effective Smallest setting value: **0.10** $\cdot I_N$ Largest setting value: **2.00** $\cdot I_N$
2906 SUM.Fact.I 0.10	Relative content (related to the maximum conductor current) for operation of the current summation monitoring (refer Figure 4.17) 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 Figure 4.20) 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 Figure 4.20) Smallest setting value: **0.58** Largest setting value: **0.95**
2909 SUM.Uthres 10 V	Voltage threshold (phase-to-phase) above which the summation monitoring (refer Figure 4.18) reacts (absolute content) is effective Smallest setting value: **10** V Largest setting value: **200** V
2910 SUM.Fact.U 0.75	Relative content (related to the maximum voltage) for operation of the voltage summation monitoring (refer Figure 4.18) Smallest setting value: **0.60** Largest setting value: **0.95**

6.3.11 Coupling external trip signals - address blocks 30 to 33

Up to four desired signals from external protection or supervision units can be incorporated into the processing of 7UM516. 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 "Incorporating of an external trip function 1"

```
3001 EXT.TRIP 1
OFF
```

Switch *OFF* of external trip function 1

```
ON
```

Switch *ON* of external trip function 1

```
BLOCK TRIP REL
```

external trip function operates but *TRIP REL*ay is *BLOCK*ed

```
3002 T-DELAY
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 "Incorporating of an external trip function 2"

```
3101 EXT.TRIP 2
OFF
```

Switch *OFF* of external trip function 2

```
ON
```

Switch *ON* of external trip function 2

```
BLOCK TRIP REL
```

external trip function operates but *TRIP REL*ay is *BLOCK*ed

```
3102 T-DELAY
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 "Incorporating 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 "Incorporating 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

6.4 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 5.3.3).

The annunciations are arranged as follows:

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

Block 52 Event annunciations for the last fault; pick-up, trip, expired times or similar. As defined, a 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, impedances).

Block 59 Indication of operational measured values of the unbalanced load protection (negative sequence current, calculated thermal value).

```
⇑ 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** = "Coming") or a status is announced "Coming" and "Going" (**C/G**). The first listed message is, as example, assigned with date and time in the first line; the second line shows the beginning of a condition with the character **C** to indicate that this condition occurred at the displayed time.

⇑⇓
```
5100 OPERATIONAL
ANNUNCIATIONS
```
Beginning of the block "Operational annunciations"

↑↓
```
19.01.95    17:02
O/S blocked    :C
```
1st line: Date and time of the event or status change

2nd line: Annunciation text, in the example Coming

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:

`>Time Synchro`	Synchronize internal real time clock (C)
`>Start FltRec`	Fault recording started via binary input (C)
`>Annunc. 1`	User defined annunciation No 1 received via binary input (C/G)
`>Annunc. 2`	User defined annunciation No 2 received via binary input (C/G)
`>Annunc. 3`	User defined annunciation No 3 received via binary input (C/G)
`>Annunc. 4`	User defined annunciation No 4 received via binary input (C/G)
`>VT mcb Trip`	Voltage transformer secondary m.c.b. tripped (C/G)
`>Imp. block`	Block Impedance protection from an external device (C/G)

>Extens. Z1B	Switch impedance protection to extended zone Z1B from external signal (C/G)
>BI + Z<	AND combination of impedance protection and binary input signal (C/G)
>Ext 1 block	Block external trip signal 1 (C/G)
>Ext trip 1	External trip signal 1 via binary input (C/G)
>Ext 2 block	Block external trip signal 2 (C/G)
>Ext trip 2	External trip signal 2 via binary input (C/G)
>Ext 3 block	Block external trip signal 3 (C/G)
>Ext trip 3	External trip signal 3 via binary input (C/G)
>Ext 4 block	Block external trip signal 4 (C/G)
>Ext trip 4	External trip signal 4 via binary input (C/G)
>O/S block	Block out-of-step protection (C/G)
>Pr block	Block reverse power protection (C/G)
>SV tripped	Stop valve tripped (C/G)
>Pf block	Block forward power supervision (C/G)
>I2 block	Block unbalanced load protection (C/G)
>RM th. repl.	Reset memory of thermal replica of unbalanced load protection (C)
>U0> block	Block stator earth fault protection U_0> (C/G)

General operational annunciations of the protection device:

Dev.operative	Device operative (C/G)
Prot. operat.	At least one protection function is operative (C/G)
Initial start	Initial start of the processor system (C)
LED reset	Stored LED indications reset (C)
Param.running	Parameters are being set (C/G)
Param. Set A	Parameter set A is active (C/G)

`Param. Set B`	Parameter set B is active (C/G)
`Param. Set C`	Parameter set C is active (C/G)
`Param. Set D`	Parameter set D is active (C/G)
`System Flt`	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. range`	Protection in operating range, i.e. suitable measured values are present (C/G)

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 24V	Failure in internal supply voltage 24 V (C/G))
Failure 15V	Failure in internal supply voltage 15 V (C/G))
Failure 5V	Failure in internal supply voltage 5 V (C/G))
Failure 0V	Failure in offset voltage 0 V (C/G)
Fail. TrpRel	Failure on trip relay p.c.b. (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 ΣUp-e	Failure detected by voltage plausibility monitor ΣU_{ph-e} (C/G)
Failure Usymm	Failure detected by voltage symmetry monitor (C/G)
Fail.PhaseSeq	Failure detected by phase sequence monitor (C/G)

Operational annunciation of impedance protection:

Imp. off	Impedance protection is switched off (C/G)
Imp. blocked	Impedance protection is blocked (C/G)
Imp. active	Impedance protection active (C/G)

Operational 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)

Operational annunciations of out-of-step protection:

`O/S off`	Out-of-step protection is switched off (C/G)
`O/S blocked`	Out-of-step protection is blocked (C/G)
`O/S active`	Out-of-step protection is active (C/G)

Operational annunciations of forward power supervision:

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

Operational 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)

Operational 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)

Operational 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)

Operational 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)

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█15.12.94
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
Imp. Fault L1  :C
```

The following items indicate all fault annunciations which have occurred from fault detection until drop-off of the device, in chronological sequence. These annunciations are tagged with the relative time in milliseconds, starting with the first fault detection.

```
004█3 ms
Imp. Fault L2  :C
```

```
005█103 ms
Imp. T1 exp.   :C
```

```
006█103 ms
Imp. Trip      :C
```

```
006█187 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 annunciation of impedance protection:

Imp. Gen.Flt.	General fault detection of impedance protection
Imp. Fault L1	Fault detection of impedance protection, phase L1
Imp. Fault L2	Fault detection of impedance protection, phase L2
Imp. Fault L3	Fault detection of impedance protection, phase L3
Imp. I> & U<	Fault detection of impedance protection with under-voltage seal-in
Imp. T1 exp.	Impedance protection time T1 (first stage) expired
Imp. T2 exp.	Impedance protection time T2 (back-up stage) expired
Imp. T1B exp.	Impedance protection time T1B (extended stage) expired
Imp. Trip	Trip by impedance protection
BI+Z< Trip	Trip by impedance protection, AND combined with binary input
Power Swing	Power swing detected, imprdance protection blocked

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

Fault annunciation of out-of step protection:

`O/S char.1`	Out-of-step protection characteristic 1 passed through
`O/S char.2`	Out-of-step protection characteristic 2 passed through
`O/S det.ch.1`	Out-of-step detection by characteristic 1
`O/S det.ch.2`	Out-of-step detection by characteristic 2
`O/S Trip ch.1`	Out-of-step trip by characteristic 1
`O/S Trip ch.2`	Out-of-step trip by characteristic 2

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 annunciation 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 closed stop valve

Fault annunciation of unbalanced load protection:

`I 2 > > F a u l t`	Fault detection of the stepped characteristic
`I 2 > > T r i p`	Trip by the stepped characteristic
`I 2 Θ T r i p`	Trip by the thermal characteristic

Fault annunciation of stator earth fault protection:

`U 0 > F a u l t`	Fault detection of stator earth fault protection
`U 0 > T r i p`	Trip by stator earth fault protection

Further messages:

`T a b l e e m p t y`	means that no fault event has been recorded
`T a b l e o v e r f l o w`	means that other fault data have occurred, however, memory is full
`T a b l e s u p e r c e d e d`	a new fault event has occurred during read-out: page on with ↑ or ↓; the display shows the first annunciation in the actualized order
`E n d o f t a b l e`	If not all memory places are used the last message is `End of table`.

The data of the **second to last** fault can be found under address 5300. The available annunciations are the same as for the last fault.

⇧⇩ `5 3 0 0 ▌ 2 n d T O L A S T F A U L T`	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.

⇧⇩ `5 4 0 0 ▌ 3 r d T O L A S T F A U L T`	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. Values outside the frequency operation range (f_N ± 20 %) seem too small.

Further measured or calculated values are displayed in address blocks 58 and 59. Block 58 indicates values of the impedance protection, block 59 those of the unbalanced load protection.

```
5700 OPERATIONAL
MEAS. VALUES A
```

Beginning of the block "Operational measured values A"

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

```
5701 MEAS.VALUE
IL1 = 10.400 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 = 10.450 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 = 10.420 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 UL1E = 60.9 V	The secondary voltages (addresses 5710 to 5713) are referred to the voltages applied to the relay terminals
5711 ▮ MEAS.VALUE UL2E = 60.8 V	
5712 ▮ MEAS.VALUE UL3E = 60.8 V	
5713 ▮ MEAS.VALUE U0 = 0.2 V	
5714 ▮ MEAS.VALUE Ipos[%] = 86.9 %	The percentage is referred to rated current
5715 ▮ MEAS.VALUE Upos = 105 V	The percentage is referred to the phase-to-phase voltage, i.e. $\sqrt{3} \cdot U_{pos}$
5716 ▮ MEAS.VALUE f = 50.0 Hz	Frequency in Hz can only displayed when an a.c. measured quantity is present

```
5800 OPERATIONAL
MEAS. VALUES B
```

Beginning of the block "Operational measured values B": powers and impedances

```
5801 MEAS.VALUE
P[%] = 89.7 %
```

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[%] = 18.2 %
```

```
5803 MEAS.VALUE
COS PHI= 0.980
```

Power factor of the machine

```
5804 MEAS.VALUE
PHI = 11.48 deg
```

Power angle of the machine

```
5805 MEAS.VALUE
R = 67.98 Ω
```

Measured resistance from $U/I \cdot \cos\phi$

```
5806 MEAS.VALUE
X = 13.80 Ω
```

Measured reactance from $U/I \cdot \sin\phi$

The negative sequence current and the calculated rotor surface temperature rise 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
Ineg = 0 %
```

Calculated negative sequence current in % of rated relay current

```
5902 MEAS.VALUE
Ineg th = 0 %
```

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

6.5 Operational control facilities

During operation of the protection relay it may be desired to intervene in functions or annunciations manually or from system criteria. 7UM516 comprises facilities, e.g. to re-adjust the real time clock, to erase stored informations, or to change over preselected sets of function parameters.

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

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

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

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

```
⇑  8000█DEVICE
⇓  CONTROL
```

Beginning of the block "Device control"

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

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

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

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

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

```
↑  15.12.1994
↓  15:54:12
```

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

```
↑  8102█DATE
↓
```

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

```
↑  8103█TIME
↓
```

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

```
↑  8104█DIFF. TIME
↓
```

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

6.5.2 Erasing stored annunciations - 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 to erase the stored items. Reset is separate for the different groups of memories and annunciations. One reaches the individual items by paging ↑ ↓. Erasure requires confirmation with the key **J/Y**. The display then confirms the erasure. If erasure is not required, press key **N** or simply page on.

```
⇑  8 2 0 0 █
⇓  R E S E T
```

Beginning of block "Reset"

```
↑  8 2 0 1 █ R E S E T
↓  L E D  ?
```

Request whether the LED memories should be reset

```
↑  8 2 0 2 █ R E S E T
↓  O P E R A T . A N N U N C .  ?
```

Request whether the operational annunciation buffer store should be erased

```
↑  8 2 0 3 █ R E S E T
↓  F A U L T  A N N U N C .  ?
```

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

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

```
8 2 0 2 █ R E S E T
S U C C E S S F U L
```

6.5.3 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.

6.5.3.1 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.**

6.5.3.2 Change-over of the active parameter set from the operating panel

For **change over to a different parameter set,** i.e. if a different set shall be activated, the address block 85 is to be used. For this, codeword entry is required.

The block for processing parameter sets is reached by pressing the direct address key **DA** followed by the address **8 5 0 0** and enter key **E** or by paging through the display with ⇑ or ⇓. The heading of the block will appear:

⇑⇓ 8 5 0 0 █ P A R A M E T E R C H A N G E - O V E R	Beginning of the block "Parameter change-over": processing of parameter sets

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 ACTIVATION
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 6.5.3.3)

```
SET BY LSA CONTR
```

If you select *SET BY LSA CONTR*, then the parameter set can be changed-over via the system interface

6.5.3.3 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 6.5.3.2).
- 2 logical binary inputs are available for control of the 4 parameter sets. These binary inputs are designated ">Param.Selec.1" and ">Param.Selec.2" (FNo 7 and 8).
- The logical binary inputs must be allocated to 2 physical input modules (refer Section 5.5.2) in order to allow control. An input is treated as not energized when it is not assigned to any physical input.
- The control input signals must be continuously present as long as the selected parameter set shall be active.

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

A simplified connection example is shown in Figure 6.8. Of course, the binary inputs must be declared in normally open ("NO") mode.

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

no = input not energized
yes = input energized

Table 6.3 Parameter selection via binary input

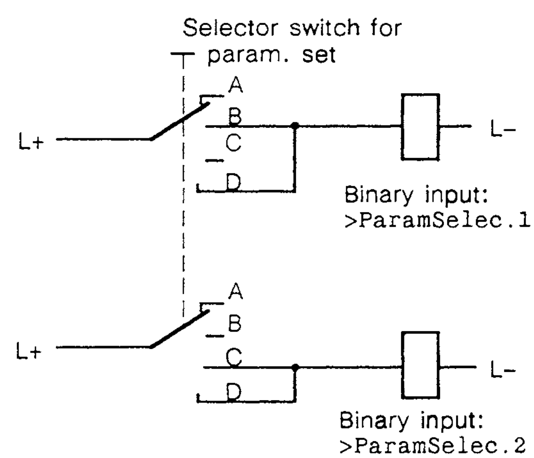


Figure 6.8 Connection scheme for parameter change-over via binary inputs

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 correction of the amplitudes. The following frequency ranges are defined (refer also to the Technical data, Section 3.1):

The tolerances as stated are maintained in the **accuracy range**. This is defined within ±10 % of the rated frequency.

The **operating range** is defined within ±20 % of the rated frequency. Amplitude correction is carried out in this range.

No amplitude correction is carried out **without the operating range**. This results in reduction of the measured a.c quantities because of the amplitude response of the filters. All protection functions which operate on increase of measured values become, therefore, less sensitive. Protection functions, which operate on decrease of measured quantities, are blocked outside of the operating range.

If **none** of the measured a.c. quantities is present, all protection functions which operate with measured quantities are ineffective. A trip signal, once issued, of course, is maintained for at least the duration of the parameterized reset time. The active state requires that at least one measured a.c. quantity be present and that the frequency lies in the range 20 Hz to 80 Hz. The pure logical functions which do not use a.c. quantities, i.e. the external trip function via binary inputs, can operate even in case of the ineffective state.

NOTE:
If, from the ineffective state, a measurement value is switched from 0 to the unit without a different measurement value having been present beforehand, an additional time delay is incurred since the unit must firstly calculate the frequency from the measurement value. In addition, the measured quantity must be at least 10 % of its rated value when no different measured quantity is present. This must be considered when testing the relay.

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 overcurrent fault detection stage of the impedance protection

The overcurrent fault detection stage can only be tested when the impedance protection is configured under address 7801 as IMP. PROT = *EXIST* (refer to Section 5.4.2) and switched to IMP.PROT = *ON* or IMP. PROT = *BLOCK TRIP REL* (address 1301).

Apply symmetrical rated voltages to all three phases to avoid immediate trip after pick-up.

Testing can be performed with two-phase or three-phase test current without difficulties.

Setting parameter I> (address 1401) is decisive for the phase currents. For setting values up to 4 x I_N, the current can be increased gradually until the stage picks up.

Caution!

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

For tests currents above 4 x I_N measurement shall be performed dynamically. It should be ensured that the relay picks up at 1.1 times setting value and does not pick up at 0.9 times setting value. The reset value should lie at 95% of the pick-up value.

When the set value for I> (factory setting 1.5 x I_N) is exceeded the pick-up indications for I> of the the phases under test appear:

- Annunciation "`Imp. Fault L1`" for phase L1 (not allocated when delivered),
- Annunciation "`Imp. Fault L2`" for phase L2 (not allocated when delivered),
- Annunciation "`Imp. Fault L3`" for phase L3 (not allocated when delivered),
- Annunciation "`Imp. Gen.Flt.`" independent of phase (LED 1 and signal relay 5 when delivered).

The final time is normally tested at 2 x setting value. It must be noted that the set times are pure delay times; operating times of the measurement functions are not included.

Switch on test current of 2 times (at least 1.2 times) pick-up value I> (address 1401):
- Annunciation "`Imp. Fault L*`" (depending on phase, see above).
- After T2 (5 s; address 1308), annunciation "`Imp. T2 exp.`" (LED 3 and signal relay 4 as delivered).
- Trip relays (K2 to K5).

Switch off test current.

If the undervoltage seal-in circuit is used (address 1402 U< SEAL-IN = *ON*, contrary to the state as delivered) this can be tested dynamically.

Switch on test current of 2 times (at least 1.2 times) pick-up value I> (address 1401):
- Annunciation "`Imp. Fault L*`" (depending on phase, see above).

Reduce applied voltage (three-phase) at least below the set value U< (address 1403, 75 V at delivery) and immediately switch of test current; pick-up signal will be maintained.
- Annunciation "`Imp. I> & U<`" (not allocated when delivered).
- After T2 (5 s; address 1308), annunciation "`Imp T2 exp`" (LED 3 and signal relay 4 as delivered).
- Trip relays (K2 to K5).
- After the holding time T-SEAL-IN (address 1404, 10 s when delivered) the signal "`Imp. I> & U<`" disappears. The output relays reset.

When the voltage is re-established before the holding time has been elapsed, the annunciation "`Imp. I> + U<`" will either disappear.

Further checks are performed with primary values during commissioning (refer to Section 6.7.2 and 6.7.3).

6.6.3 Testing the impedance zones

Close voltage transformer m.c.b.

Always apply three-phase test voltage; ensure clockwise phase rotation. Keep the voltage(s) in the untested phase(s) at approximately rated value. Set the back-up stage T2 to ∞ in order to avoid trip by this stage.

Feed a test current $I_P = 2 \times I_N$ into the loop under test. If the test voltage would exceed rated voltage when the threshold is reached, reduce test current, but only so far that operation of the overcurrent pick-up stage I> (address 1401) is guaranteed. The test current must be kept constant during a test!

Determine the threshold point by slow reduction of the voltage. Check indicators and outputs. Since the tripping polygon is made up of straight lines (Figure 6.9), different formulae must be used for the threshold voltages dependent upon the intersection of these lines. The general formulae are:

- For the reactance intersections (X-reach)

$$U_P/V = K_X \cdot X_{Zone} \cdot I_P/I_N$$

- For the resistance intersections (R-limitation)

$$U_P/V = K_R \cdot R_{Zone} \cdot I_P/I_N$$

where I_P – test current
I_N – rated current of relay
U_P – test voltage at threshold
X_{Zone} – setting value X of the distance zone to be checked
R_{Zone} – setting value R of the distance zone to be checked
K_X – factor for X intersection according Table 6.3
K_R – factor for R intersection according Table 6.3

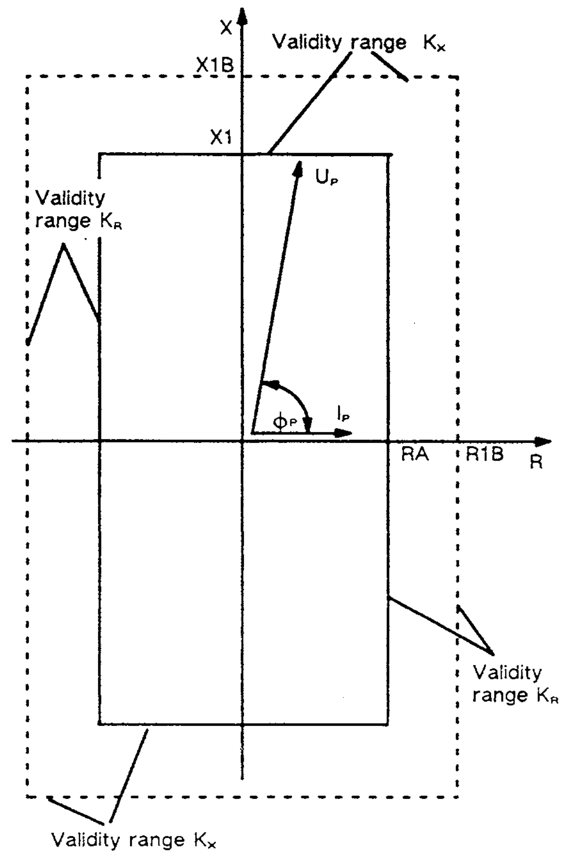


Figure 6.9 Impedance characteristic

For testing phase-to-phase the current must flow through the tested phases in opposite directions. It is essential to ensure absolute symmetry of the two phase voltages, otherwise error will occur! For the factory set values and $I_P/I_N = 2$ the resultant voltages will be as Table 6.4.

with fault type	K_X		K_R	
	ϕ_P = 90°/270°	general	ϕ_P = 0°/180°	general
3-phase	1	$\frac{1}{\sin \phi_P}$	1	$\frac{1}{\cos \phi_P}$
2-phase	2	$\frac{2}{\sin \phi_P}$	2	$\frac{2}{\cos \phi_P}$

Table 6.3 Test factors K_X and K_R for individual settings

with fault type	zone Z1 ϕ_P = 90°/270°	zone Z1 ϕ_P = 0°/180°	zone Z1B ϕ_P = 90°/270°	zone Z1B ϕ_P = 0°/180°
3-phase	U_P = 15 V	U_P = 15 V	U_P = 20 V	U_P = 20 V
2-phase	U_P = 30 V	U_P = 30 V	U_P = 40 V	U_P = 40 V

Table 6.4 Test voltages U_P with test current $I_P = 2 \cdot I_N$ and presetting

Table 6.3 gives the factors K_X and K_R for your own settings, for test angles ϕ_P = 90° and 0°, and the generally applicable formulae.

Overreach zone Z1B can only be checked under steady-state conditions, when an input relay has been allocated to the input function "Extens. Z1B" and is energized (FNo 3956, allocated to binary input 6 at delivery).

Activate binary input. Feed a test current $I_P = 2 \cdot I_N$ into the loop under test. If the test voltage would exceed rated voltage when the threshold is reached, reduce test current, but only so far that operation of the overcurrent detection is guaranteed. The test current must be kept constant during a test!

Determine the threshold point by slow reduction of the voltage. Check indicators and outputs. For the factory set values and $I_P/I_N = 2$ the resultant voltages will be as Table 6.4, Table 6.3 gives the generally applicable values.

De-energize binary input.

For each stage at least one additional dynamic test should be made to check the correct signalling of the time stages. Time T1 (address 1304) is applicable for zone Z1, T1B (address 1307) for the overreach zone Z1B. When measuring the response times, do not forget that the programmed values are delay times. The inherent measurement and trip time of the relay is additional. Refer also to the notes in Section 6.6.1.

6.6.4 Testing the power swing blocking function

Power swing blocking of the impedance protection can only be tested when three symmetrical currents and three symmetrical voltages are available. The voltages must <u>together</u> be infinitely adjustable.

Prerequisite: Power swing option is effective (address 1501, contrary to the state at delivery).

Adjust the voltages symmetrically to the level of the rated voltage, currents symmetrically to $2 \cdot I_N$. The angle between currents and voltages: $\phi_P \approx$ 0°.

Slowly reduce the voltages <u>symmetrically</u> down to 0 V.

- Annunciation "Power Swing" (not allocated at delivery).

Tripping by the first zone Z1 does not occur. But the overreach zone Z1B and the back-up stage are not affected by power swing blocking.

Power swing blocking of Z1B is effective as long as the impedance vector simulated by the test quantities remains within the power swing polygon and the active time P/S T-ACT (address 1503) has not yet elapsed.

6.6.5 Testing the out-of-step protection

The out-of-step protection can only be tested if it has been configured as OUT-OF-STEP = *EXIST* (address 7806, refer to Section 5.4.2) and parameterized as operative, under address 2001. Additionally, three symmetrical currents and three symmetrical voltages must be available. The voltages must together be infinitely adjustable.

Adjust the voltages symmetrically to the level of the rated voltage, currents symmetrically to $2 \cdot I_N$. The angle between currents and voltages: $\phi_P \approx 0°$.

Slowly reduce the voltages symmetrically down to 0 V. Reverse polarity of voltages. Then increase voltages again. This has simulated one passing through the power swing polygon (characteristic 1) of the out-of-step protection. When the polygon has been left, pick-up of the out-of-step protection occurs:

- Annunciation "O/S char.1" (signal relay 1 at delivery).
- Annunciation "O/S det.ch.1" (LED 4 at delivery).

If one out-of-step cycle has been set for n_1 under address 2209 (as delivered), trip will occur:

- Annunciation "O/S Trip ch.1" (LED 5 and signal relay 3 at delivery).
- Trip relay (2 at delivery).

If more than one out-of-step cycles have been parameterized, the procedure must be followed so often until trip occurs.

Activate binary input ">O/S block" (not allocated when delivered from factory). Slowly reduce the voltages symmetrically down to 0 V. Reverse polarity of voltages. Then increase voltages again.

- Annunciation "O/S blocked" (not allocated when delivered).
- No annunciations concerning out-of-step protection

Switch off test quantities. Deactivate binary input.

6.6.6 Testing the stator earth fault protection U_0>

The stator earth fault protection function can only be tested if this function has been configured as SEF PROT = *EXIST* (address 7804, refer to Section 5.4.2) and parameterized as operative (address 1901), contrary to the position as delivered from factory.

The stator earth fault protection processes the displacement voltage which is produced by the earth fault.

When checking the delay times it must be noted that the set times are pure delay times; operating times of the measurement function are not included.

Note: Rated voltage should be connected to at least one voltage measurement input for the dynamic testing of the neutral displacement voltage (refer also to note in Section 6.6.1).

Connect voltage of 1.2 times setting value U0> (address 1902) to measurement input for the neutral displacement voltage .

- Annunciation "U0> Fault" (not allocated when delivered from factory).
- After T-U0> (address 1903, 0.3 s when delivered from factory) annunciation "U0> Trip" (LED 12 and signal relay 11).
- Trip relays (2, 3, 4, 5).

Disconnect voltage.

Activate binary input ">U0 block" (not allocated when delivered from factory). Connect voltage.

- Annunciation "U> blocked" (not allocated when delivered).
- No annunciations concerning earth fault protection

Disconnect voltage. Deactivate binary input.

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

6.6.7 Testing the power protection functions

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

The function of the forward power supervision can only be tested if it has been configured as FOR. POWER = *EXIST* (address 7807, refer to Section 5.4.2) and parameterized as operative, contrary to the condition as delivered from factory (address 2201 FORW. POWER = *ON*).

The function of the reverse power protection can only be tested if it has been configured as REV. POWER = *EXIST* (address 7808, refer to Section 5.4.2) and parameterized as operative, contrary to the condition as delivered from factory (address 2301 REV. POWER = *ON*).

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. *Note: Reverse power protection is a power increase protection since it measures the rise 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.

◆ **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" (not allocated at delivery). 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:**

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 7 and signal relay 8).
- Trip relays (2, 3, and 4)

Disconnect test current.

Activate binary input ">SV tripped" (input 4). Connect test current.

- Annunciation "Pr fault det." (not allocated at delivery).
- After T-SV-CLOS (3 s; address 2304), annunciation "Pr+SV Trip" (LED 8 and signal relay 7).
- 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.

6.6.8 Testing the unbalanced load protection

The unbalanced load protection can only be tested if this function has been configured as UNB. LOAD = *EXIST* (address 7810, 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 corresponding to three times the setting value 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 % in this case.

When the pick-up value is exceeded (test current greater than 3 x I2>):
- Time T-I2> (address 2403) elapses,
- Annunciation "I2> Warn" (LED 9 and signal relay 10).

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" (LED 11 and signal relay 9).
- 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" (LED 10 and signal relay 10).
- On reaching the thermal trip stage after a time which corresponds to half the time constant: annunciation "I2 Θ Trip" (LED 11 and signal relay 9).
- Trip relay (1).

Disconnect test current.

Note: Before measuring the thermal trip time it must be ensured that the thermal memory is reset to 0. This is performed via the binary input ">RM th. repl" (reset memory of thermal replica). This function is allocated to binary input 2 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.

6.6.9 Testing the coupling of external trip functions

Four desired signals from external protection or supervisory units can be connected into the processing of the 7UM516 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" (LED 13 for all external trip functions and signal relay 12 for the first).
- Trip relays (not allocated when delivered from factory).

De-activate binary input.

6.7 Commissioning using primary tests

6.7.1 General advices

All secondary test equipment must be removed. Connect measurement values. All installation preparations according to Section 5.2 must have been completed. Primary tests are performed with the machine.

Warning

Primary tests shall be performed only by qualified personnel which is trained in commissioning of protection systems and familiar with the operation of the protected object as well as the rules and regulations (switching, earthing, etc.)

Primary testing is usually performed in the following order:

- 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-EXISTing*.

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) to *BLOCK TRIP REL.*

With the primary plant voltage-free and earthed, install a three-pole short-circuit bridge which is capable of carrying rated current (e.g. earthing isolator) to the machine line-side terminals.

DANGER!

Operations in primary area must only be performed with the machine at standstill and with plant sections voltage-free and earthed!

Slowly excite generator, however, stator current must not increase to above machine rated current.

Read out current values in all three phases under address block 57. They refer to 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. The unbalanced load can be read out under address 5901. It must be practically zero. If this is not the case, check for crossed current transformer leads:

If the unbalanced load amounts to about **1/3** of the phase currents then current is flowing in **only one** or in **only two** of the phases.

If the unbalanced load amounts to about **2/3** of the phase currents, then one current transformer has **wrong polarity**.

If the unbalanced load is about **the same** as the phase currents, then two phases have been **crossed**.

- Shut-down and de-excite generator,
- apply plant earths,
- short-circuit current transformers,
- check current transformer circuits and make corrections.
- repeat test.

Remove short-circuit bridges.

Switch impedance protection (address 1301) 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) behind the unit transformer.

DANGER!

Operations in primary area must only be performed with the machine at standstill and with plant sections voltage-free and earthed!

Slowly excite generator, however, stator current must not increase to above machine rated current.

The relay calculates from the currents and voltages the impedance between the point of installation (voltage transformers) and the short-circuit bridge, i.e. normally the short-circuit impedance of the unit transformer. Read out the reactance and resistance values in the measured values B, under addresses 5805 and 5806. They refer to the secondary values, based on 1 A. In the case of the transformer impedance, the following results:

Primary transformer impedance:

$$Z_{Tprim} = u_{sc} \cdot \frac{U_N^2}{S_{Ntr}}$$

where u_{sc} percent impedance voltage of transformer
U_N rated voltage of transformer
S_N rated apparent power of transformer

In secondary values:

$$Z_{Tsec} = Z_{Tprim} \cdot \frac{N_{ct}}{N_{vt}} \cdot \frac{I_N}{A}$$

$$= u_{sc} \cdot \frac{U_N^2}{S_{Ntr}} \cdot \frac{N_{ct}}{N_{vt}} \cdot \frac{I_N}{A}$$

where N_{ct} current transformer ratio
N_{vt} voltage transformer ratio
I_N rated relay current

If substantial deviations or wrong sign occur, then the voltage transformer connections are incorrect.

Shut down the generator. Remove short-circuit bridges. Switch the unbalanced load protection and the impedance protection operative (addresses 2401 and 1301 = *ON*). The latter serves from now on as short-circuit protection.

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.

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 must be almost $\sqrt{3}$ 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). If the machine has counter-clockwise rotation, two phases must be interchanged.
- Shut down turbo-set and de-excite generator,
- apply plant earths,
- check voltage transformer circuits and make corrections,
- repeat test.

Blocking of the impedance 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 the binary input 5 (as delivered from factory).
- Switch voltage transformer m.c.b. to tripped position,
- Check that the message "`VT mcb trip`" is indicated in the operational annunciations with the Coming 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 "`VT mcb trip`" is indicated in the operational annunciations, but now with the Going 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.

The voltage tests are completed after the generator has been shut-down. The out-of-step protection - if used - should be switched effective now (address 2001).

6.7.4 Checking the earth fault protection

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 6.10) 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 6.11); 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 6.12), whereby $U_{NU}/\sqrt{3}$ is the neutral displacement voltage with a full displacement of the network (upper-voltage) neutral. The following applies:

$$R_B' : \frac{1}{\omega C_K} = U_R' : \frac{U_{NU}}{\sqrt{3}}$$

$$U_R' = R_B' \cdot \omega C_K \cdot U_{NU}/\sqrt{3}$$

Inserting the voltage transformation ratio TR of the earthing transformer:

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

we obtain

$$U_R = \frac{TR}{3} \cdot R_B \cdot \omega C_K \cdot U_{NU}/\sqrt{3}$$

Together with the voltage divider 500V/100V this corresponds to a displacement voltage of

$$U_E = \frac{1}{5} \cdot \frac{TR}{3} \cdot R_B \cdot \omega C_K \cdot U_{NU}/\sqrt{3}$$

at the input of the unit.

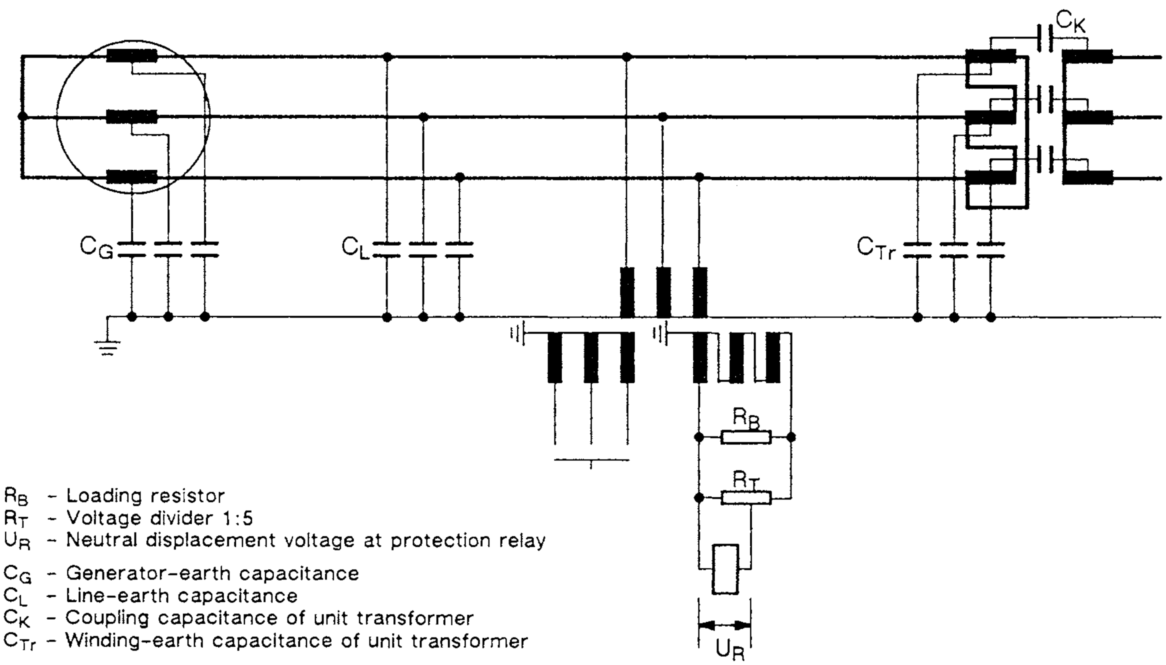
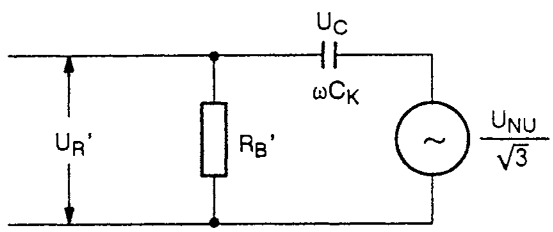


Figure 6.10 Block diagram with earthing transformer

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



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 6.11 Equivalent diagram

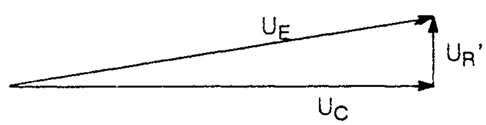


Figure 6.12 Vector diagram

Example:

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

Earthing transformer:
TR = 36

Loading resistor:
R_B = 10 Ω

$$U_E = \frac{1}{5} \cdot \frac{TR}{3} \cdot R_B \cdot \omega C_K \cdot U_{NU}/\sqrt{3}$$

$$U_E = \frac{1}{5} \cdot \frac{36}{3} \cdot 10\ \Omega \cdot 314\ s^{-1} \cdot 0.01 \cdot 10^{-6}\ F \cdot \frac{110}{\sqrt{3}} \cdot 10^3\ V$$

$$= 4.8\ V$$

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 only one winding.

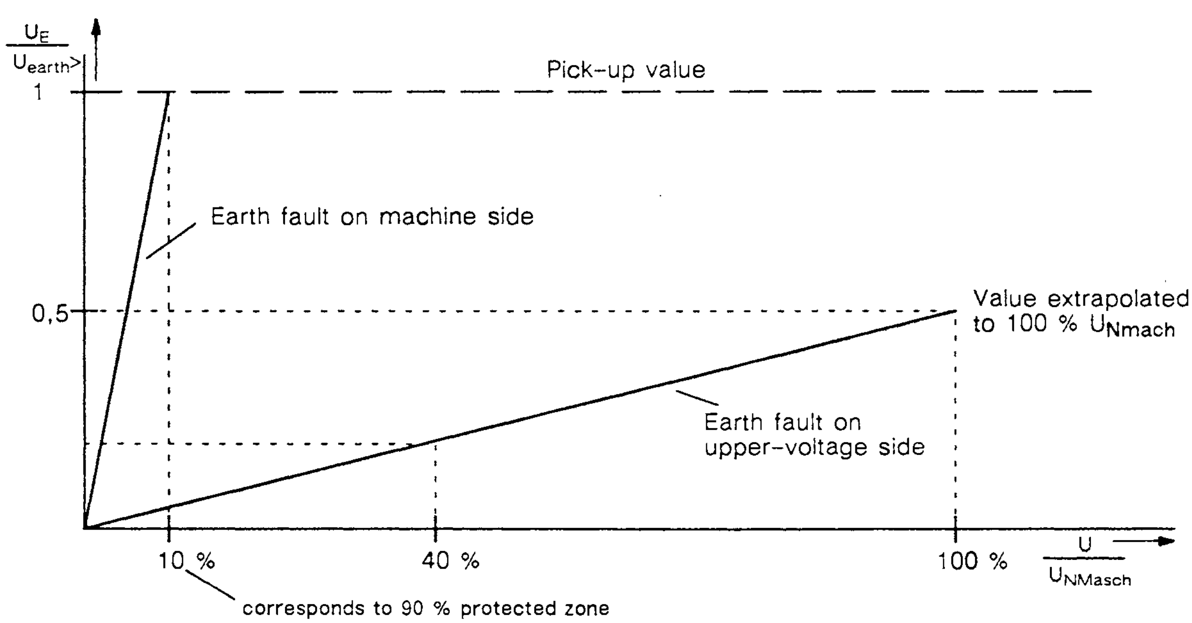


Figure 6.13 Neutral displacement voltage during earth faults

6.7.4.2 Checking for machine earth fault

Switch stator earth fault protection (address 1901) to *BLOCK TRIP REL.*

With the primary plant voltage-free and earthed, install a single-pole earth fault in the proximity of the machine terminals.

DANGER!

Operations in primary area must only be performed with the machine at standstill and with plant sections voltage-free and earthed!

Start-up machine and slowly excite (however, not above $U_N/\sqrt{3}$) until the earth fault protection U_0 picks up (LED 12 when delivered from factory).

Read out U0 in OPERATIONAL MEAS. VALUES A (address 5713). If the connections are correct, this value corresponds with the machine terminal voltage in percent, referred to rated machine voltage (if applicable, deviating rated primary voltage of earthing transformer or neutral earthing transformer must be taken into account). This value also corresponds with the setting value U0> under address 1902 (see Figure 6.13).

The protection zone is 100 % - U0 [V], e.g.

Machine voltage at pick-up:	$0.1 \cdot U_N$
Measured value U0	10 %
Setting value U0>	10 V
Protected zone	90 %

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 standstill 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 B (address 5713). This value is extrapolated to rated machine voltage (Figure 6.13 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.

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*.

6.7.5 Tests with the machine connected to the network

6.7.5.1 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.

6.7.5.2 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 shout be measured at three measuring points of the power diagram and the correction parameters W0 and W1 should be established:

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!

If possible reduce excitation to approximately 0.3 times rated apparent power of generator.

Caution!

Underexcitation may cause the generator fall out of step!

The motoring power is read out as active power Pa in the operational measured values under address 5801; the reactive power Pr (address 5802) also read out.

- Note down motoring power as P_3, observe sign;
- note down reactive power as Q_3 with polarity (negative sign).

If possible slowly increase excitation to 0.3 times rated apparent power of generator.

The motoring power is read out as active power Pa in the operational measured values under address 5801; the reactive power Pr (address 5802) is also read out.

- Note down motoring power as P_2, observe sign;
- note down reactive power as Q_2 with polarity (positive sign).

If possible slowly increase excitation to 0.6 times rated apparent power of generator.

The motoring power is read out as active power Pa in the operational measured values under address 5801; the reactive power Pr (address 5802) is also read out.

- Note down motoring power as P_1, observe sign;
- note down reactive power as Q_1 with polarity (positive sign).

Adjust generator to no-load excitation and shut down.

If the read-out measured values P_3, and P_2, and P_1 deviate by more than 10 % from each, then an angle correction of the instrument transformer error must be performed (addresses 1206 and 1207). The angles are calculated according to the following formulae:

$$\tan \delta_2 = \frac{P_3 - P_2}{Q_3 - Q_2}$$

$$\tan \delta_1 = \frac{P_1 - P_2}{Q_1 - Q_2}$$

The power values must be inserted with their correct polarity as read out! Otherwise faulty result!

These angles are inserted into the formulae of the correction quantities W_0 and W_1 as follows:

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

$$W_0' = \delta_1 - W_1' \cdot I_1$$

where I_1 and I_2 are the currents which are assigned with the corresponding measuring points. These values are compared with the preset correction angles W0 and W1 under addresses 1206 and 1207. The Differences between the preset values W0, W1 and the calculated values W_0', W_1' are finally set under addresses 1206 and 1207, as follows:

New setting W1 = presetting W1 − W_1'

New setting W0 = presetting W0 − W_0'

A quarter of the sum of the measured values $P_3 + P_2$ is set as pick-up value of the reverse power protection P> REVERSE under address 2302 (negative sign).

6.7.5.3 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 7 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-CLOSED (address 2304) annunciation "Pr+SV Trip" (LED 8 as delivered).

Shut down machine.

Switch *ON* the reverse power protection (address 2301) and - if used - the forward power supervision (address 2201).

6.7.6 Checking the coupling of external trip signals

If the coupling of external functions for the alarm and/or trip processing is used in the 7UM516, 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.

6.7.7 Tripping test including circuit breaker - address block 44

Machine protection 7UM516 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** . Then the codeword input is necessary.

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. Leaving the block with keys ⇑ or ⇓ is only possible after this procedure.

```
4000▮
TESTS
```

Commencement of the test blocks

```
4400▮ENERGIZE
TRIP RELAYS
```

Beginning of the block "trip circuit breaker"

```
4401▮ENERGIZE
TRIP RELAY 1 ?
```

Test trip circuit of trip relay 1?
Confirm with "J/Y"-key or abort with "N"-key

```
4402▮ENERGIZE
TRIP RELAY 2 ?
```

Test trip circuit of trip relay 2?
Confirm with "**J/Y**"-key or abort with "**N**"-key

```
4403▮ENERGIZE
TRIP RELAY 3 ?
```

Test trip circuit of trip relay 3?
Confirm with "**J/Y**"-key or abort with "**N**"-key

```
4404▮ENERGIZE
TRIP RELAY 4 ?
```

Test trip circuit of trip relay 4?
Confirm with "J/Y"-key or abort with "N"-key

```
4405▮ENERGIZE
TRIP RELAY 5
```

Test trip circuit of trip relay 5?
Confirm with "**J/Y**"-key or abort with "**N**"-key

6.8 Putting the relay into operation

All setting values should be checked again, in case they were altered during the tests. Particularly check that all desired protection functions have been programmed in the configuration parameters (address blocks 78 and 79, refer to Section 5.4) and all desired protection functions have been switched *ON*. 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 least 5 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.

7.1 Routine checks

Routine checks of characteristics or pick-up values are not necessary as they form part of the continuously supervised firmware programs. The planned maintenance intervals for checking and maintenance of the plant can be used to perform operational testing of the protection equipment. This maintenance serves mainly for checking the interfaces of the unit, i.e. the coupling with the plant. The following procedure is recommended:

- Read-out of operational values (address block 57) and comparison with the actual values for checking the analog interfaces.

- Simulation of an internal short-circuit with 4 x I_N for checking the analog input at high currents.

⚠ Warning

Hazardous voltages can be present on all circuits and components connected with the supply voltage or with the measuring and test quantities!

⚠ Caution!

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

- Circuit-breaker trip circuits are tested by actual live tripping. Respective notes are given in Section 6.7.7.

7.2 Replacing the back-up battery

The device annunciations are stored in NV-RAMs. A back-up battery is inserted so that they are retained even with a longer failure of the d.c. supply voltage. The back-up battery is also required for the internal system clock with 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 produktion series of the relay. This production series is found on the name plate behind the complete order designation.

Recommended battery:

Lithium battery 3 V/1 Ah, type CR 1/2 AA, e.g.
- VARTA Order No. 6127 501 501 for relays with screwed terminal for the battery,
- VARTA Order No. 6127 101 501 for relays snap-on battery holder.

The battery is located at the rear edge of the processor board of the basic module GEA. The basic module must be removed from the housing in order to replace the battery.

- Prepare area of work: provide conductive surface for the basic module.

- Open housing cover.

- Read out device annunciations, i.e. all addresses which commence with 5 (5000 onwards). This is carried out most convenient using the front operating interface and a personal computer with the DIGSI® protection data processing program; the information is thus stored in the PC.

  Note: All configuration data and settings of the device are stored in EEPROMs protected against switching off of the power supply. They are stored independent of the back-up battery. They are, therefore, neither lost when the battery is replaced nor when the device is operated without a battery.

- **Only for relays with screwed terminal for the battery**: Prepare the battery as in Figure 7.1:

⚠ Caution!

Do not short-circuit battery! Do not reverse battery polarities! Do not charge battery!

Shorten the legs to 15 mm (6/10 inch) each and bend over at a length of 40 mm (16/10 inch).

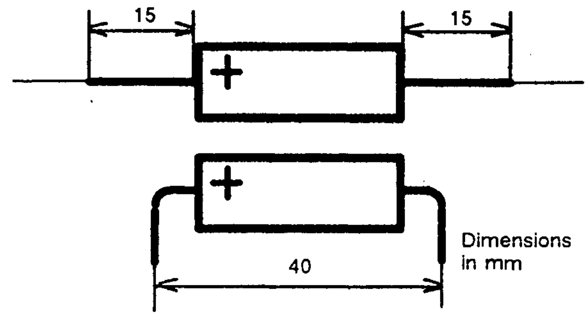


Figure 7.1 Bending the back-up battery for relays with screwed terminal for the battery

Later version do not have axial legs but are snapped on a battery holder.

- Loosen the basic module using the pulling aids provided at the top and bottom. (Figure 7.5).

⚠ Warning

Hazardous voltages can be present in the device even after disconnection of the supply voltage or after removal of the modules from the housing (storage capacitors)!

⚠ Caution!

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

- Pull out basic module and place onto the conductive surface.

- Unscrew used battery from the terminals or remove it from the holder; **do not place on the conductive surface!**

- Insert the prepared battery into the terminals or holder as in Figure 7.2 and tighten the screws or as in Figure 7.3.

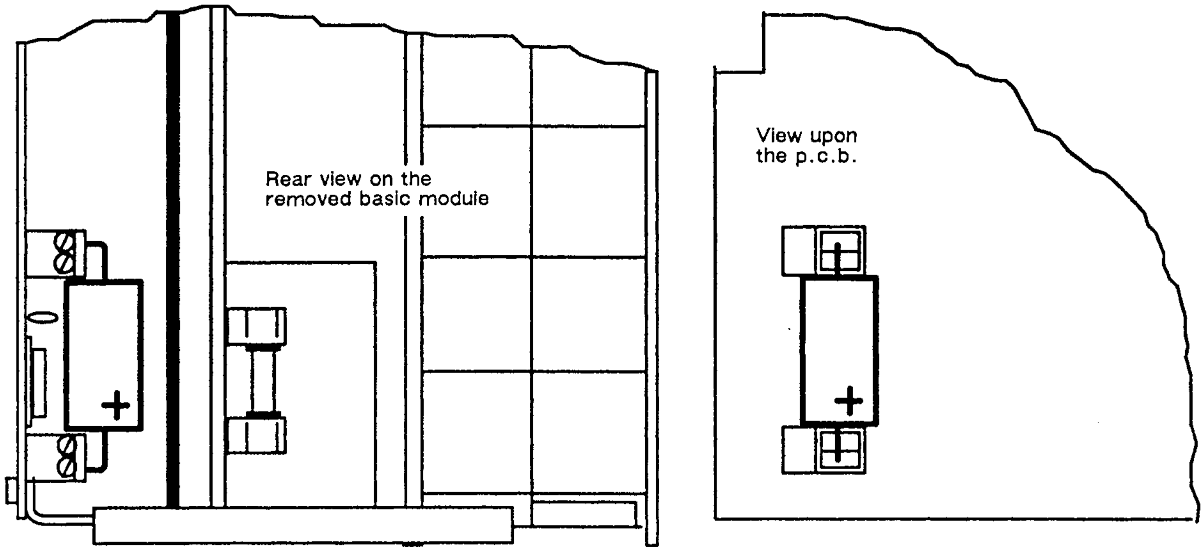


Figure 7.2 Installation of the back-up battery for relays with screwed battery teminals

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

- Firmly push in the module using the releasing lever. (Figure 7.5).

⚠ Warning

The discharged battery contains Lithium. It must only be disposed off in line with the applicable regulations!

Do not reverse polarities! Do not recharge! Do not throw into fire! Danger of explosion!

- Provided the internal system clock is not automatically synchronized via the LSA interface, it can now be set or synchronized as described in Section 6.5.1

- Close housing cover.

The replacement of the back-up battery has thus been completed.

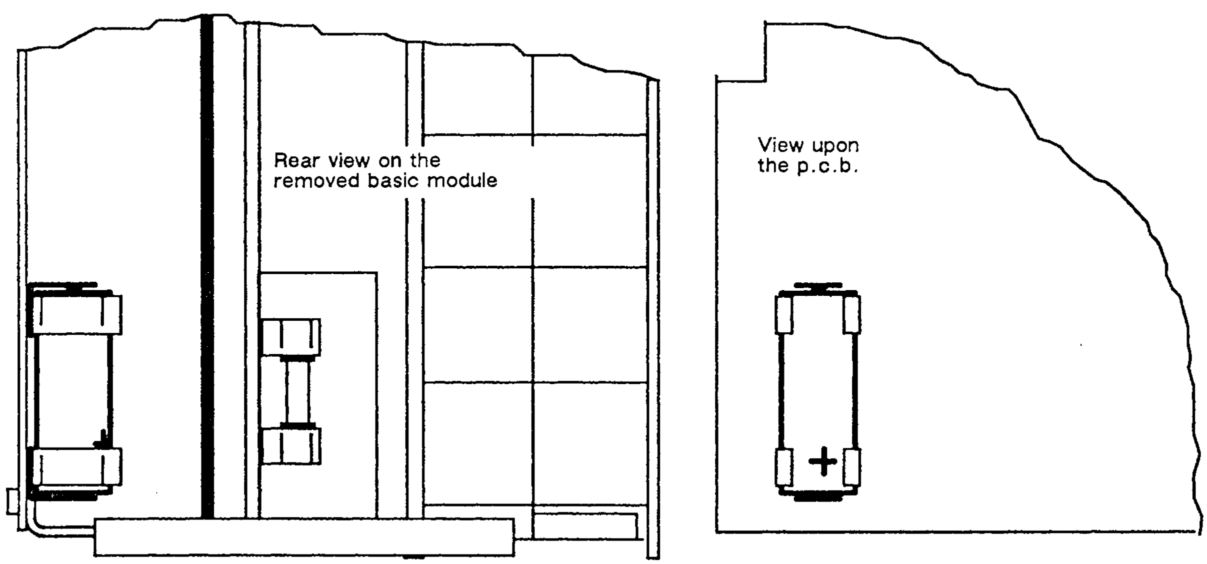


Figure 7.3 Installation of the back-up battery for relays with snap-on battery holder

7.3 Fault tracing

If the protective device indicates a defect, the following procedure is suggested:

If none of the LEDs on the front plate of the module is on, then check:

- Have the modules been properly pushed-in and locked?
- Is the ON/OFF switch on the front plate in the ON position ⊙ ?
- Is the auxiliary voltage available with the correct polarity and of adequate magnitude, connected to the correct terminals (General diagrams in Appendix A)?
- Has the mini-fuse in the power supply section blown (see Figure 7.4)? If appropriate, replace the fuse according to Section 7.3.1.

If the red fault indicator "Blocked" on the front is on and the green ready LED remains dark, the device has recognized an internal fault. Re-initialization of the protection system could be tried by switching the d.c. auxiliary voltage off and on again. This, however, results in loss of fault data and messages if the relay is not equipped with a buffer battery, and, if a parameterizing process has not yet been completed, the last parameters are not stored.

7.3.1 Replacing the mini-fuse

- Select a replacement fuse 5 × 20 mm. Ensure that the rated value, time lag (medium slow) and code letters are correct. (Figure 7.4).
- Prepare area of work: provide conductive surface for the basic module.
- Open housing cover.

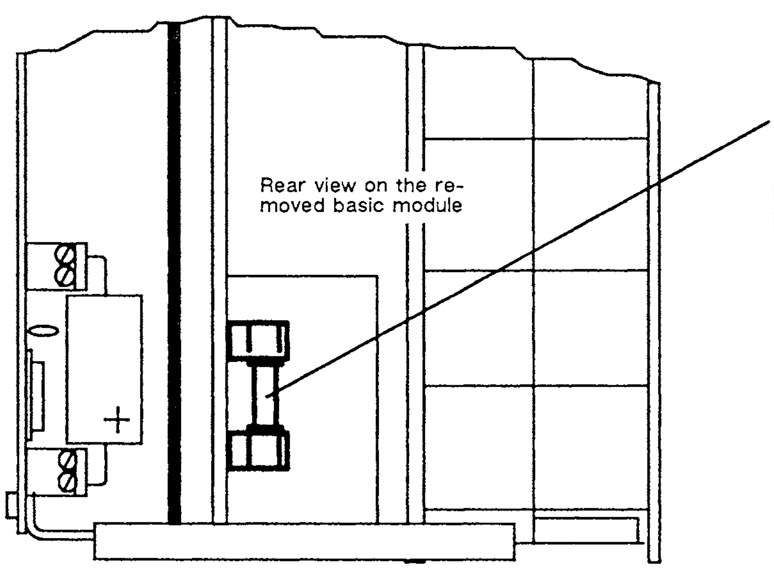
⚠ Warning

Hazardous voltages can be present in the device even after disconnection of the supply voltage or after removal of the modules from the housing (storage capacitors)!

- Loosen the basic module using the pulling aids provided at the top and bottom. (Figure 7.5).

⚠ Caution!

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



Mini-fuse of the power supply; medium slow (M)

at U_{HN}/V–	rated value
24/48	2 A/E
60/110/125	1,6 A/E
220/250	1 A/G

Figure 7.4 Mini-fuse of the power supply

- Pull out basic module and place onto the conductive surface.
- Remove blown fuse from the holder (Figure 7.4).
- Fit new fuse into the holder (Figure 7.4).
- Insert basic module into the housing; ensure that the releasing lever is pushed fully to the left before the module is pressed in (Figure 7.5).
- Firmly push in the module using the releasing lever. (Figure 7.5).
- Close housing cover.

Switch on the device again. If a power supply failure is still signalled, a fault or short-circuit is present in the internal power supply. The device should be returned to the factory (see Chapter 8).

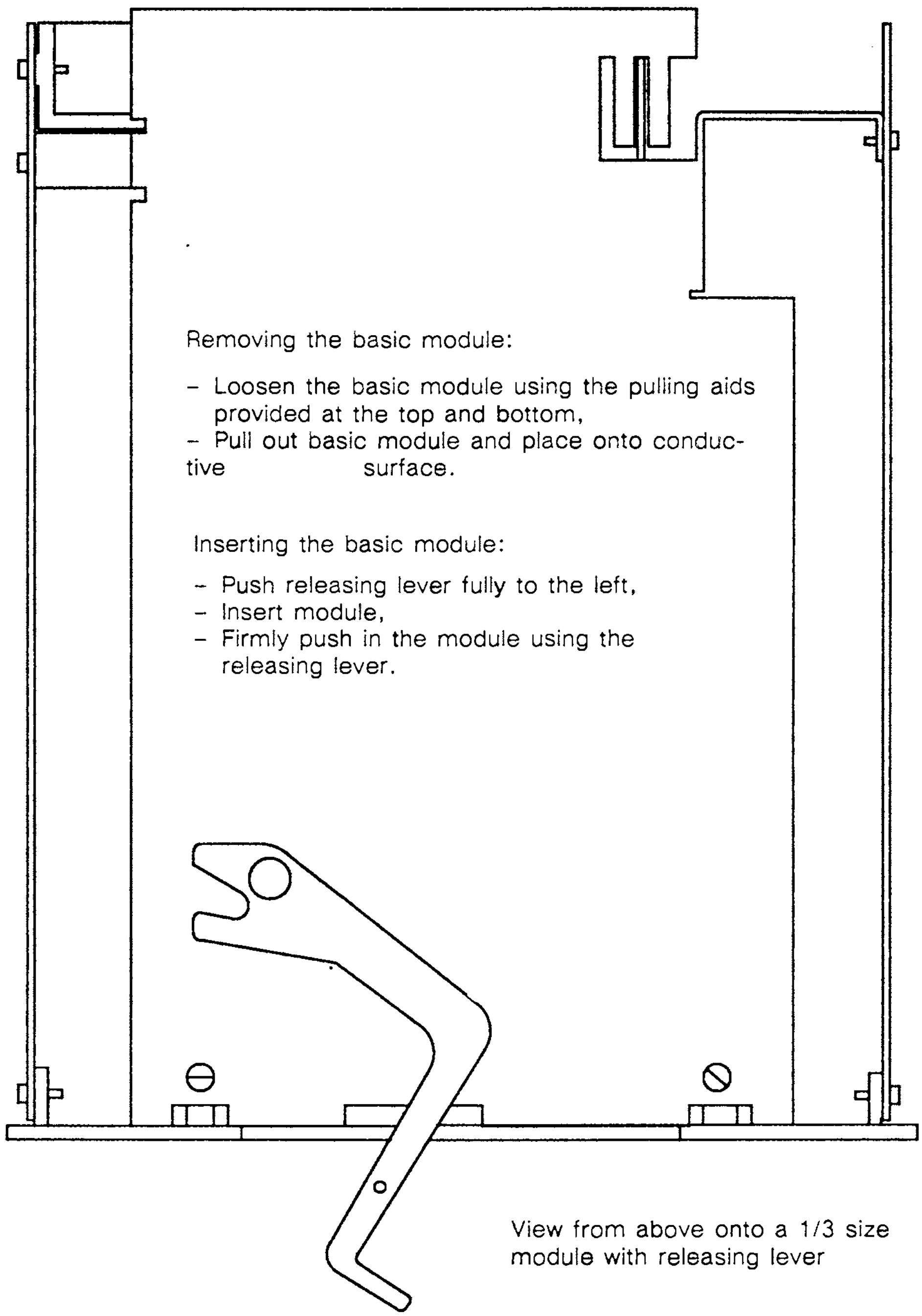


Figure 7.5 Aid for removing and inserting basic module

8 Repairs

Repair of defective modules is not recommended at all because specially selected electronic components are used which must be handled in accordance with the procedures required for Electrostatically Endangered Components (EEC). Furthermore, special manufacturing techniques are necessary for any work on the printed circuit boards in order to do not damage the bath-soldered multilayer boards, the sensitive components and the protective finish.

Therefore, if a defect cannot be corrected by operator procedures such as described in Chapter 7, it is recommended that the complete relay should be returned to the manufacturer. Use the original transport packaging for return. If alternative packing is used, this must provide the degree of protection against mechanical shock, as laid down in IEC 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 Electrostatically Endangered Components are observed.

⚠ Warning

Hazardous voltages can be present in the device even after disconnection of the supply voltage or after removal of the module from the housing (storage capacitors)!

⚠ Caution!

Electrostatic discharges via the component connections, the PCB tracks or the connecting pins of the modules must be avoided under all circumstances by previously touching an earthed metal surface. This applies equally for the replacement of removable components, such as EPROM or EEPROM chips. For transport and returning of individual modules electrostatic protective packing material must be used.

Components and modules are not endangered as long as they are installed within the relay.

Should it become necessary to exchange any device or module, the complete parameter assignment should be repeated. Respective notes are contained in Chapter 5 and 6.

9 Storage

Solid state protective relays shall be stored in dry and clean rooms. The limit temperature range for storage of the relays or associated spare parts is -25 °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.

Appendix

A General diagrams

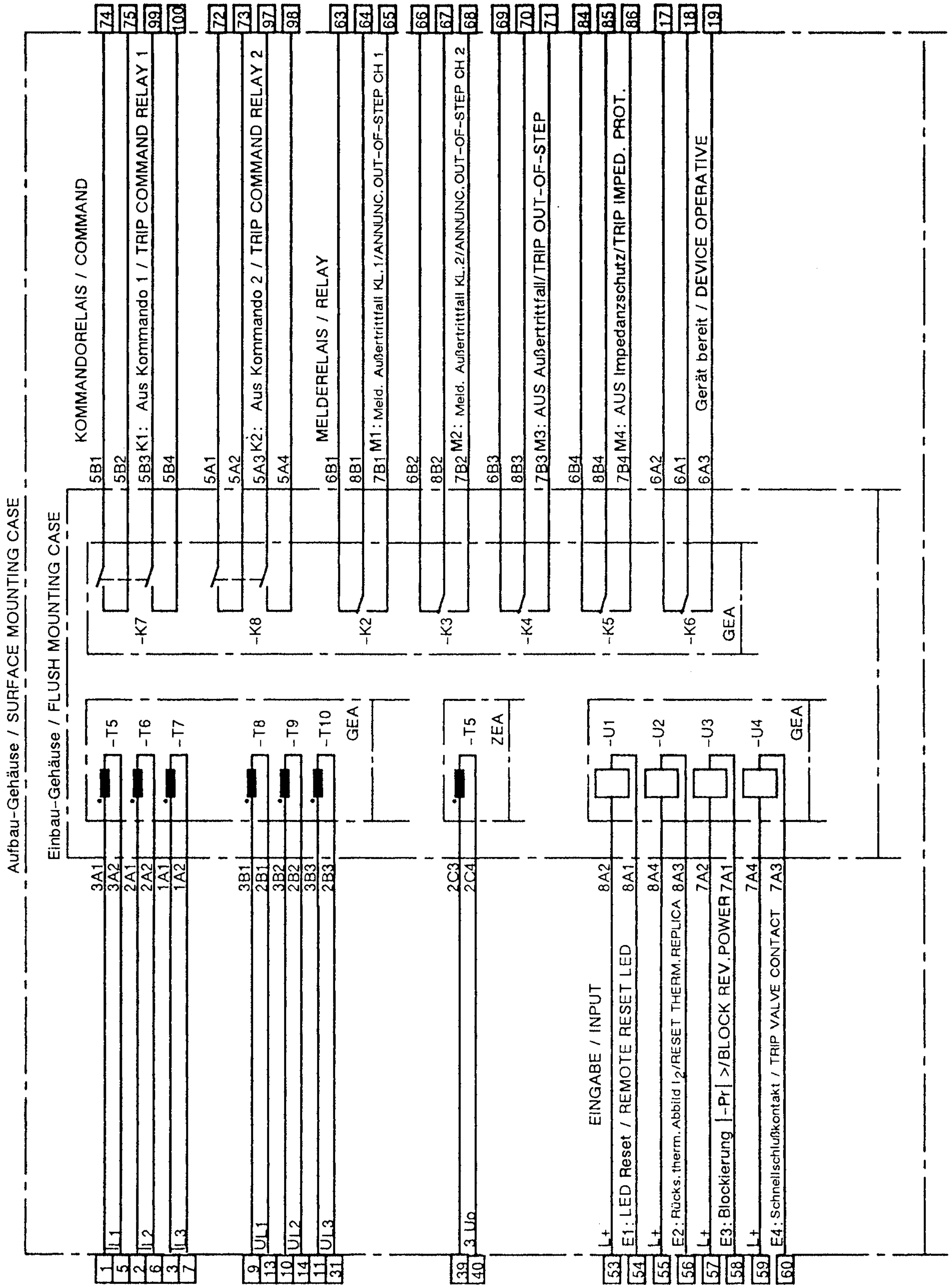


Figure A.1 General diagram 7UM516 (sheet 1 of 3)

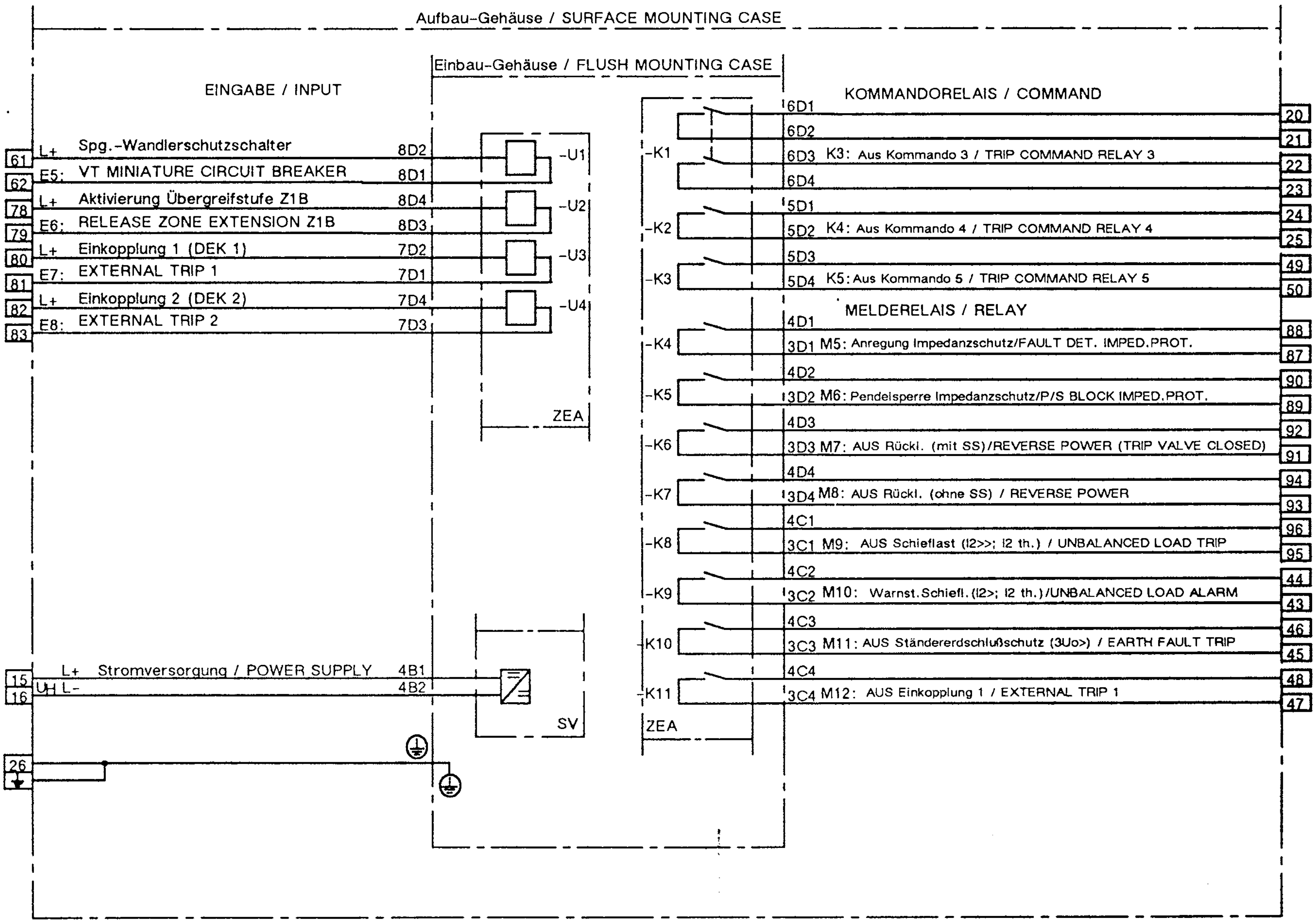
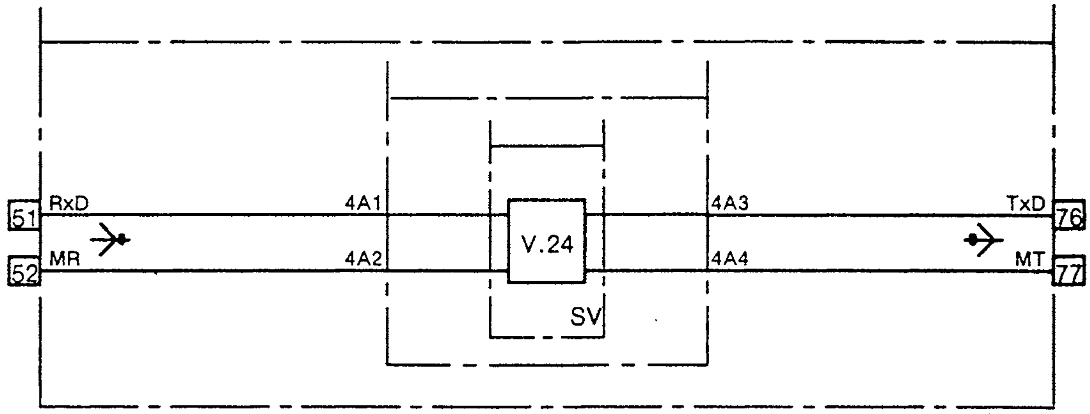
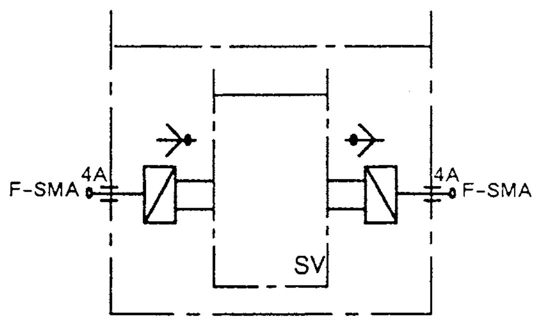


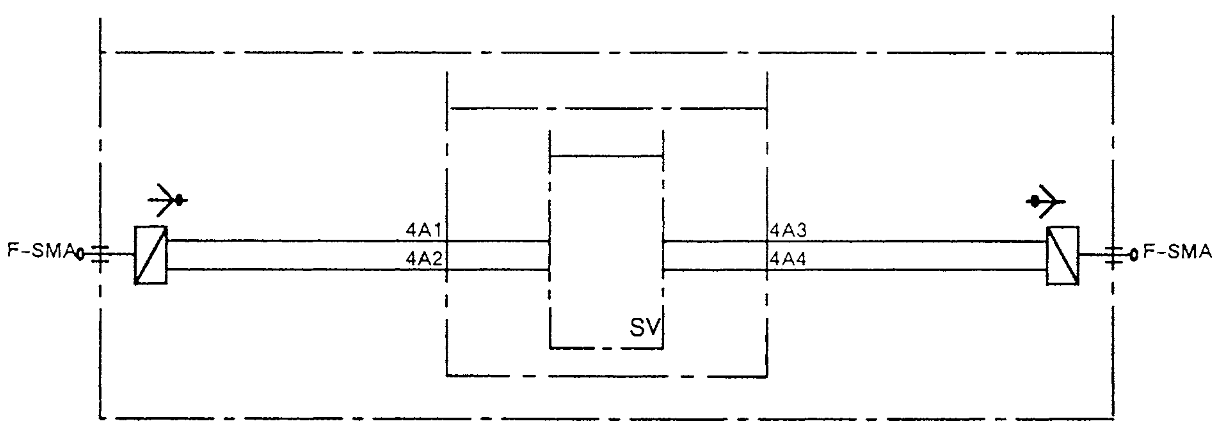
Figure A.2 General diagram 7UM516 (sheet 2 of 3)



Einbau- und Aufbaugehäuse mit V24 - Schnittstelle
FLUSH AND SURFACE MOUNTING CASE WITH V24 DATA LINK
7UM516*-*B***-*B* */
7UM516*-*C***-*B **/
7UM516*-*E***-*B **/



Einbau- Gehäuse mit LWL - Modul
FLUSH MOUNTING CASE WITH FIBER OPTIC INTERFACE
7UM516*-*C***-*C** /
7UM516*-*E***-*C** /



Aufbau- Gehäuse mit LWL - Modul
SURFACE MOUNTING CASE WITH FIBER OPTIC INTERFACE
7UM516*-*B***-*C** /

Figure A.3 General diagram 7UM516 (sheet 3 of 3)

B Connection diagram

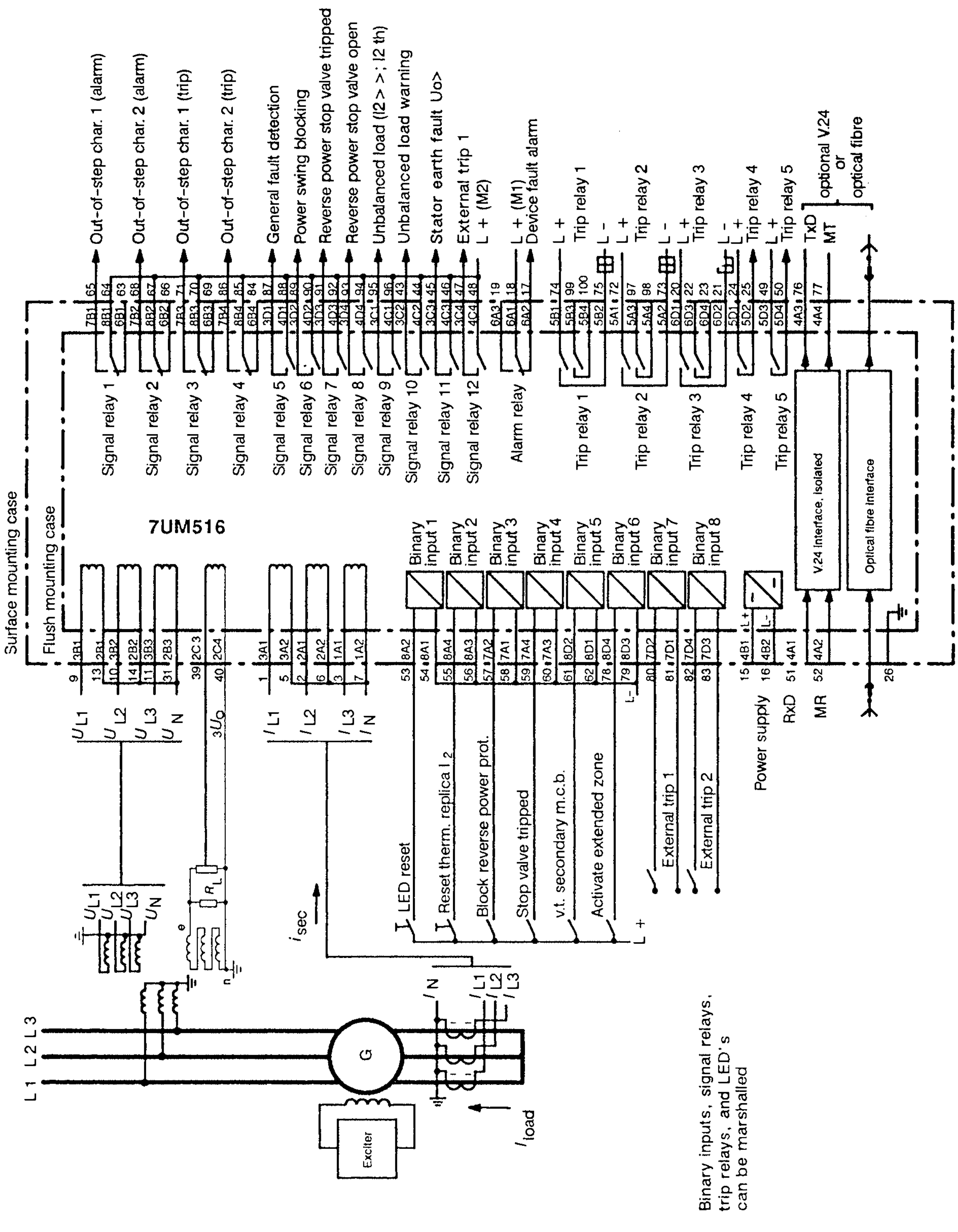


Figure B.1 Connection example 7UM516

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 7UM516 for LSA (DIN 19244 and according VDEW/ZVEI)

FNo. - Function number of annunciation
Op/Ft - Operation/Fault annunciation
C/CG: Coming/Coming and Going annunciation
V : Annunciation with Value
M : Measurand
LSA No.- Number of annunciation for former LSA (DIN 19244)
according to VDEW/ZVEI:
CA - Compatible Annunciation
GI - Annunciation for General Interrogation
BT - Binary Trace for fault recordings
Typ - Function type (p: according to the configured "Function type")
Inf - Information number

		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
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				GI		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				135	161
143	Failure of internal 15 VDC power supply	CG		83				135	163
144	Failure of internal 5 VDC power supply	CG		89				135	164
145	Failure of internal 0 VDC power supply	CG		84				135	165
154	Failure in the RKA module	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				135	182
163	Failure: Current symmetry supervision	CG		107				135	183
165	Failure: Voltage sum superv. (ph-e)	CG		105				135	184
167	Failure: Voltage symmetry supervision	CG		108				135	186
169	Fuse failure monitor operated	CG		110				135	188
171	Failure: Phase sequence supervision	CG		111	CA	GI		p	35
301	Fault in the power system		CG	2				135	231
302	Fault event with consecutive number		C					135	232
361	>U Line side VT MCB tripped	CG		19				p	38
501	General fault detection of device	C					BT	150	151
502	General drop-off of device	C						150	152
511	General trip of device	C					BT	150	161

FNo.	Meaning	Ann. Op	Ann. Ft	LSA No.	VDEW/ZVEI CA	GI	BT	Typ	Inf
601	IL1 [%] =	M							
602	IL2 [%] =	M							
603	IL3 [%] =	M							
694	f [Hz] =	M							
771	Secondary voltage UL1E is	M							
772	Secondary voltage UL2E is	M							
773	Secondary voltage UL3E is	M							
774	Secondary earth voltage U0 is	M							
930	IL1 [%] =	M						134	144
931	IL2 [%] =	M						134	144
932	IL3 [%] =	M						134	144
933	Secondary voltage UL1E is	M						134	144
934	Secondary voltage UL2E is	M						134	144
935	Secondary voltage UL3E is	M						134	144
936	Secondary earth voltage U0 is	M						134	144
937	f [Hz] =	M						134	144
938	Positive sequence voltage	M						134	144
939	Positive sequence current	M						134	144
940	Negative sequence current/unbalanced lo	M						134	144
941	Power factor of the machine	M						134	144
942	Resistance	M						134	144
943	Reactance	M						134	144
944	Pa [%] =	M						134	144
945	Pr [%] =	M						134	144
1175	Trip test for trip relay 1 in progress	CG		70				151	90
1176	Trip test for trip relay 2 in progress	CG		71				151	91
1177	Trip test for trip relay 3 in progress	CG		72				151	92
1178	Trip test for trip relay 4 in progress	CG		73				151	93
1179	Trip test for trip relay 5 in progress	CG		74				151	94
3953	>Block impedance protection	CG				GI		28	221
3956	>Zone 1B extension for impedance prot.	CG		76				28	222
3957	>Binary input for trip (BI+Z< Trip)	CG		77				28	223
3961	Impedance protection is switched off	CG		20				28	226
3962	Impedance protection is blocked	CG		51				28	227
3963	Impedance protection is active	CG		30		GI		28	228
3966	Imp.: General fault detection		CG	208			BT	28	229
3967	Imp.: Fault detection , phase L1		CG	210			BT	28	230
3968	Imp.: Fault detection , phase L2		CG	212			BT	28	231
3969	Imp.: Fault detection , phase L3		CG	214			BT	28	232
3970	Imp.: Overcurrent with undervol.seal-in		CG	220			BT	28	233
3971	Imp.: Time T1 (zone Z1) expired		C	153			BT	28	234
3972	Imp.: Time T2 (final time) expired		C	154			BT	28	235
3973	Imp.: Time T1B (zone Z1B) expired		C	158			BT	28	236
3974	Imp.: Trip		C	235			BT	28	237
3975	Imp.: Trip with binary input (BI+Z<)		C	236			BT	28	238
3976	Power swing detection		CG	80			BT	28	239
4523	>Block external trip 1	CG				GI		51	123
4526	>External trip 1	CG		65				51	126
4531	External trip 1 is switched off	CG		21				51	131
4532	External trip 1 is blocked	CG		60				51	132
4533	External trip 1 is active	CG		31		GI		51	133
4536	External trip 1: General fault det.		CG	200			BT	51	136
4537	External trip 1: General trip		C	244			BT	51	137
4543	>Block external trip 2	CG				GI		51	143
4546	>External trip 2	CG		66				51	146
4551	External trip 2 is switched off	CG		22				51	151
4552	External trip 2 is blocked	CG		61				51	152

FNo.	Meaning	Ann.		LSA	VDEW/ZVEI				
		Op	Ft	No.	CA	GI	BT	Typ	Inf
4553	External trip 2 is active	CG		32		GI		51	153
4556	External trip 2: General fault det.		CG	201			BT	51	156
4557	External trip 2: General trip		C	245			BT	51	157
4563	>Block external trip 3	CG				GI		51	163
4566	>External trip 3	CG		67				51	166
4571	External trip 3 is switched off	CG		23				51	171
4572	External trip 3 is blocked	CG		62				51	172
4573	External trip 3 is active	CG		33		GI		51	173
4576	External trip 3: General fault det.		CG	202			BT	51	176
4577	External trip 3: General trip		C	246			BT	51	177
4583	>Block external trip 4	CG				GI		51	183
4586	>External trip 4	CG		68				51	186
4591	External trip 4 is switched off	CG		24				51	191
4592	External trip 4 is blocked	CG		63				51	192
4593	External trip 4 is active	CG		34		GI		51	193
4596	External trip 4: General fault det.		CG	203			BT	51	196
4597	External trip 4: General trip		C	247			BT	51	197
5001	Operating range of v,i	CG		44				70	1
5053	>Block out-of-step protection	CG				GI		70	51
5061	Out-of-step protection is switched off	CG		25				70	56
5062	Out-of-step protection is blocked	CG		52				70	57
5063	Out-of-step protection is active	CG		35		GI		70	58
5067	Out-of-step: Pulse of characteristic 1		CG	81			BT	70	60
5068	Out-of-step: Pulse of characteristic 2		CG	82			BT	70	61
5069	Out-of-step: Pick-up characteristic 1		CG	205			BT	70	62
5070	Out-of-step: Pick-up characteristic 2		CG	206			BT	70	63
5071	Out-of-step: Trip characteristic 1		C	252			BT	70	64
5072	Out-of-step: Trip characteristic 2		C	253			BT	70	65
5083	>Block reverse power protection	CG				GI		70	76
5086	>Stop valve tripped	CG		55				70	77
5091	Reverse power protection switched off	CG		26				70	81
5092	Reverse power protection is blocked	CG		49				70	82
5093	Reverse power protection is active	CG		36		GI		70	83
5096	Reverse power: Fault detection		CG	228			BT	70	84
5097	Reverse power: Trip		C	248			BT	70	85
5098	Reverse power: Trip w/ stop valve trip		C	249			BT	70	86
5113	>Block forward power supervision	CG				GI		70	101
5121	Forward power supervision switched off	CG		27				70	106
5122	Forward power supervision is blocked	CG		48				70	107
5123	Forward power supervision is active	CG		37		GI		70	108
5126	Forward power: Fault detection in Pf<		CG	230			BT	70	109
5127	Forward power: Fault detection in Pf>		CG	232			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	CG						70	127
5151	Unbalanced load protection is switched	CG		28				70	131
5152	Unbalanced load protection is blocked	CG		50				70	132
5153	Unbalanced load protection is active	CG		38		GI		70	133
5156	Unbalanced load: Current warning stage	CG		13				70	134
5157	Unbalanced load: Thermal warning stage	CG		14				70	135
5158	Reset memory of thermal replica	CG		53				70	137
5159	Unbalanced load: Fault detec. current		CG	226			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 protec. switched off	CG		29				70	156

FNo.	Meaning	Ann. Op	Ann. Ft	LSA No.	VDEW/ZVEI CA	GI	BT	Typ	Inf
5182	Stator earth fault protection blocked	CG		57				70	157
5183	Stator earth fault protection active	CG		39		GI		70	158
5186	Stator earth fault: Fault detection		CG	216			BT	70	159
5187	Stator earth fault: Trip		C	237			BT	70	160

Annunciations 7UM516 for PC, LC-display and binary inputs/outputs

FNo. - Function number of annunciation
Op/Ft - Operation/Fault annunciation
C/CG: Coming/Coming and Going annunciation
M : Measurand
Ear - Earth fault annunciation
IO - I: can be marshalled to binary input
O: can be marshalled to binary output (LED, trip/signal relais)

FNo.	Abbreviation	Meaning	Op	Ft	Ear	IO
3	>Time Synchro	>Time synchronization	C			IO
4	>Start FltRec	>Start fault recording	C			IO
5	>LED reset	>LED reset				IO
7	>ParamSelec.1	>Parameter set selection 1 (with No.8)				IO
8	>ParamSelec.2	>Parameter set selection 2 (with No.7)				IO
11	>Annunc. 1	>User defined annunciation 1	CG			IO
12	>Annunc. 2	>User defined annunciation 2	CG			IO
13	>Annunc. 3	>User defined annunciation 3	CG			IO
14	>Annunc. 4	>User defined annunciation 4	CG			IO
51	Dev.operative	Device operative / healthy	CG			O
56	Initial start	Initial start of processor system	C			
60	LED reset	LED Reset	C			
95	Param.running	Parameters are being set	CG			O
96	Param. Set A	Parameter set A is active	CG			O
97	Param. Set B	Parameter set B is active	CG			O
98	Param. Set C	Parameter set C is active	CG			O
99	Param. Set D	Parameter set D is active	CG			O
100	Wrong SW-vers	Wrong software-version	C			
101	Wrong dev. ID	Wrong device identification	C			
110	Annunc. lost	Annunciations lost (buffer overflow)	C			
111	Annu. PC lost	Annunciations for PC lost	C			
115	Flt.Buff.Over	Fault annunciation buffer overflow		C		
120	Oper.Ann.Inva	Operational annunciations invalid	CG			
121	Flt.Ann.Inval	Fault annunciations invalid	CG			
124	LED Buff.Inva	LED annunciation buffer invalid	CG			
129	VDEW-StateInv	VDEW state invalid	CG			
135	Chs Error	Error in check sum	CG			
136	Chs.A Error	Error in check sum for parameter set A	CG			
137	Chs.B Error	Error in check sum for parameter set B	CG			
138	Chs.C Error	Error in check sum for parameter set C	CG			
139	Chs.D Error	Error in check sum for parameter set D	CG			
141	Failure 24V	Failure of internal 24 VDC power supply	CG			O
143	Failure 15V	Failure of internal 15 VDC power supply	CG			O
144	Failure 5V	Failure of internal 5 VDC power supply	CG			O
145	Failure 0V	Failure of internal 0 VDC power supply	CG			O
154	Failure RKA	Failure in the RKA module	CG			
159	LSA disrupted	LSA (system interface) disrupted	CG			
161	I supervision	Measured value supervision of currents				O
162	Failure ΣI	Failure: Current summation supervision	CG			O
163	Failure Isymm	Failure: Current symmetry supervision	CG			O
165	Failure ΣUp-e	Failure: Voltage sum superv. (ph-e)	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			
301	System Flt	Fault in the power system	CG	C		
302	Fault	Fault event with consecutive number		C		
361	>VT mcb Trip	>U Line side VT MCB tripped	CG			IO
501	Device FltDet	General fault detection of device		C		
502	Dev. Drop-off	General drop-off of device		C		
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[%] =	IL1 [%] =	M			
602	IL2[%] =	IL2 [%] =	M			
603	IL3[%] =	IL3 [%] =	M			
641	Pa[%]=	Pa [%] =	M			
642	Pr[%]=	Pr [%] =	M			
651	IL1 =	IL1 =	M			
652	IL2 =	IL2 =	M			
653	IL3 =	IL3 =	M			
671	UL1E=	UL1E =	M			
672	UL2E=	UL2E =	M			
673	UL3E=	UL3E =	M			
694	f [Hz]=	f [Hz] =	M			
771	UL1E =	Secondary voltage UL1E is	M			
772	UL2E =	Secondary voltage UL2E is	M			
773	UL3E =	Secondary voltage UL3E is	M			
774	U0 =	Secondary earth voltage U0 is	M			
901	COS PHI=	Power factor of the machine	M			
902	PHI=	Power angle	M			
903	R=	Resistance	M			
904	X=	Reactance	M			
905	Ipos.seq=	Positive sequence current	M			
906	Ineg.seq=	Negative sequence current/unbal. load	M			
907	Upos.seq=	Positive sequence voltage	M			
910	ThermRepl.=	Calculated rotor temperature (unb.load)	M			
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			
3953	>Imp. block	>Block impedance protection	CG			IO
3956	>Extens. Z1B	>Zone 1B extension for impedance prot.	CG			IO
3957	>BI + Z<	>Binary input for trip (BI+Z< Trip)	CG			IO
3961	Imp. off	Impedance protection is switched off	CG			O
3962	Imp. blocked	Impedance protection is blocked	CG			O
3963	Imp. active	Impedance protection is active	CG			O
3966	Imp. Gen.Flt.	Imp.: General fault detection		CG		O
3967	Imp. Fault L1	Imp.: Fault detection , phase L1		CG		O
3968	Imp. Fault L2	Imp.: Fault detection , phase L2		CG		O
3969	Imp. Fault L3	Imp.: Fault detection , phase L3		CG		O
3970	Imp. I> & U<	Imp.: Overcurrent with undervol.seal-in		CG		O
3971	Imp. T1 exp.	Imp.: Time T1 (zone Z1) expired		C		O
3972	Imp. T2 exp.	Imp.: Time T2 (final time) expired		C		O
3973	Imp. T1B exp.	Imp.: Time T1B (zone Z1B) expired		C		O

FNo.	Abbreviation	Meaning	Op	Ft	Ear	IO
3974	Imp. Trip	Imp.: Trip		C		O
3975	BI+Z< Trip	Imp.: Trip with binary input (BI+Z<)		C		O
3976	Power Swing	Power swing detection		CG		O
4523	>Ext 1 block	>Block external trip 1	CG			IO
4526	>Ext trip 1	>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	CG			IO
4546	>Ext trip 2	>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	CG			IO
4566	>Ext trip 3	>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	CG			IO
4586	>Ext trip 4	>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
5001	Operat. range	Operating range of v,i	CG			O
5053	>O/S block	>Block out-of-step protection	CG			IO
5061	O/S off	Out-of-step protection is switched off	CG			O
5062	O/S blocked	Out-of-step protection is blocked	CG			O
5063	O/S active	Out-of-step protection is active	CG			O
5067	O/S char.1	Out-of-step: Pulse of characteristic 1		CG		O
5068	O/S char.2	Out-of-step: Pulse of characteristic 2		CG		O
5069	O/S det.ch.1	Out-of-step: Pick-up characteristic 1		CG		O
5070	O/S det.ch.2	Out-of-step: Pick-up characteristic 2		CG		O
5071	O/S Trip ch.1	Out-of-step: Trip characteristic 1		C		O
5072	O/S Trip ch.2	Out-of-step: Trip characteristic 2		C		O
5083	>Pr block	>Block reverse power protection	CG			IO
5086	>SV tripped	>Stop valve tripped	CG			IO
5091	Pr off	Reverse power protection switched off	CG			O
5092	Pr blocked	Reverse power protection 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 w/ stop valve trip		C		O
5113	>Pf block	>Block forward power supervision	CG			IO
5121	Pf off	Forward power supervision 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 detection in Pf<		CG		O
5127	Pf> flt. det.	Forward power: Fault detection in Pf>		CG		O
5128	Pf< Trip	Forward power: Trip Pf< stage		C		O
5129	Pf> Trip	Forward power: Trip Pf> stage		C		O

FNo.	Abbreviation	Meaning	Op	Ft	Ear	IO
5143	>I2 block	>Block unbalanced load protection	CG			IO
5146	>RM th.repl.	>Reset memory for thermal replica	CG			IO
5151	I2 off	Unbalanced load protection is switched	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	CG			O
5159	I2>> Fault	Unbalanced load: Fault detec.current st		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	CG			IO
5181	U0> off	Stator earth fault protec. switched off	CG			O
5182	U0> blocked	Stator earth fault protection blocked	CG			O
5183	U0> active	Stator earth fault protection is active	CG			O
5186	U0> Fault	Stator earth fault: Fault detection		CG		O
5187	U0> Trip	Stator earth fault: Trip		C		O

1000 PARAMETERS

1100 MACHINE & POWERSYSTEM DATA

1108 STAR-POINT Earthing condition of the machine star-point
HIGH-RESISTANCE [ ] Starpt. high resist.
LOW-RESISTANCE [ ] Starpt. low resist.

1200 INTRUMENT TRANSFORMER DATA

1201 IN CT PRIM Primary rated CT current
min. 0.050 kA
max. 50.000 ____

1202 UN VT PRIM Primary rated VT current
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
min. -2.50 °
max. 7.50 ____

1207 CT ANG. W1 Correction angle CT W1
min. -2.50 °
max. 0.00 ____

1209 VT DELTA VT for open delta winding connected
CONNECTED [ ] Connected
NOT CONNECTED [ ] Not connected

1210 Uph/Udelta Matching factor for open delta voltage
min. -9.99
max. 9.99 ____

1300 IMP. PROT. GENERAL SETTINGS

1301 IMP. PROT. State of the impedance protection
OFF [ ] off
ON [ ] on
BLOCK TRIP REL [ ] Block trip rel

1302 R1 Zone 1: Resistance
min. 0.05 Ω
max. 65.00 ____

1303	X1		Zone 1: Reactance
	min. 0.05		Ω
	max. 130.00	____	
1304	T1		Zone 1: Time delay
	min. 0.00		s
	max. 32.00/∞	____	
1305	R1B		Zone 1B: Resistance
	min. 0.05		Ω
	max. 65.00	____	
1306	X1B		Zone 1B: Reactance
	min. 0.05		Ω
	max. 130.00	____	
1307	T1B		Zone 1B: Time delay
	min. 0.00		s
	max. 32.00/∞	____	
1308	T2		Final time delay T2
	min. 0.00		s
	max. 32.00/∞	____	
1309	T-RESET		Reset delay after trip
	min. 0.00		s
	max. 32.00	____	

1400 IMP. PROT. FAULT DETECTION

1401	I>		Overcurrent detection threshold value I>
	min. 0.20		I/In
	max. 4.00	____	
1402	U< SEAL-IN		Undervoltage seal-in ON/OFF
	OFF	[ ]	off
	ON	[ ]	on
1403	U<		Undervoltage value for seal-in
	min. 30		V
	max. 130	____	
1404	T-SEAL-IN		Duration of undervoltage seal-in
	min. 0.00		s
	max. 32.00	____	

1500 IMP. PROT. POWER SWING

1501	P/S		Power swing detection ON/OFF
	OFF	[ ]	off
	ON	[ ]	on
1502	dZ/dt		Rate of change of the power swing vector
	min. 1.0		Ω/s
	max. 200.0	____	

1503 P/S T-ACT. — Power swing action time
min. 0.00 — s
max. 32.00/∞ ______

1504 DELTA Z — Impedance between P/S polygon and polygon Z1
min. 0.10 — Ω
max. 10.00 ______

1900 EARTH FAULT U0>

1901 SEF PROT. — State of the stator earth fault protection
OFF [ ] off
ON [ ] on
BLOCK TRIP REL [ ] Block trip rel

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 ______

2000 OUT-O-STEP PROTECTION

2001 OUT-O-STEP — State of the out-of-step protection
OFF [ ] off
ON [ ] on
BLOCK TRIP REL [ ] Block trip rel

2002 I1> Meas. — Pick-up current (pos.seq.) for O/S detc. I1>
min. 0.20 — I/In
max. 4.00 ______

2003 I2< Meas. — Max. neg.seq. current for O/S detection I2<
min. 0.05 — I/In
max. 1.00 ______

2004 Za — Resistance of the polygon
min. 0.20 — Ω
max. 130.00 ______

2005 Zb — Reactance of the polygon (reverse direction)
min. 0.10 — Ω
max. 130.00 ______

2006 Zc — Reactance of the polygon (forward dir. char.1)
min. 0.10 — Ω
max. 130.00 ______

2007 Zd-Zc — Reactance char.1 - reactance char.2 (forw.dir)
min. 0.00 — Ω
max. 130.00 ______

2008 PHI POLYG.		Angle of inclination of the polygon
min. 60.0		°
max. 90.0	____	
2009 REP.CHAR.1		Repetition of characteristic 1
min. 1		
max. 4	____	
2010 REP.CHAR.2		Repetition of characteristic 2
min. 1		
max. 8	____	
2011 T-HOLDING		Holding time of fault detection
min. 0.20		s
max. 32.00	____	
2012 T-SIGNAL		Minimum time for signal
min. 0.02		s
max. 0.15	____	
2013 T-RESET		Reset delay after trip
min. 0.05		s
max. 32.00	____	

2200 FORW.POWER SUPERVISION

2201 FORW.POWER		State of the forward power supervision
OFF	[ ]	off
ON	[ ]	on
BLOCK TRIP REL	[ ]	Block trip rel
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	____	

2300 REVERSE POWER

2301 REV. POWER		State of the reverse power protection
OFF	[ ]	off
ON	[ ]	on
BLOCK TRIP REL	[ ]	Block trip rel

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 UNBALACED LOAD

2401 UNBAL.LOAD — State of the unbalanced load protection
OFF [ ] off
ON [ ] on
BLOCK TRIP REL [ ] Block trip rel

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 ______

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	____	
2909	SUM.Uthres		Voltage threshold for voltage summation
	min. 10		V
	max. 200	____	
2910	SUM.Fact.U		Factor for voltage summation monitoring
	min. 0.60		
	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 rel
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 rel
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 rel

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 rel

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 ______

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 REALY5	Trip of relay #5

4900 TEST FAULT RECORDING

4901 FAULT REC.	Initiation of fault recording

5000 ANNUNCIATIONS

5100 OPERATIONAL ANNUNCIATIONS

5200 LAST FAULT

5300 2nd TO LAST FAULT

5400 3rd TO LAST FAULT

5700 OPERATIONAL MEASURED VALUES

5701 IL1 =	IL1 =
5702 IL2 =	IL2 =
5703 IL3 =	IL3 =
5704 UL1E=	UL1E =
5705 UL2E=	UL2E =
5706 UL3E=	UL3E =
5707 IL1[%] =	IL1 [%] =
5708 IL2[%] =	IL2 [%] =
5709 IL3[%] =	IL3 [%] =
5710 UL1E =	Secondary voltage UL1E is
5711 UL2E =	Secondary voltage UL2E is
5712 UL3E =	Secondary voltage UL3E is
5713 U0 =	Secondary earth voltage U0 is
5714 Ipos.seq=	Positive sequence current
5715 Upos.seq=	Positive sequence voltage
5716 f [Hz]=	f [Hz] =

5800 OPERATIONAL MEASURED VALUES

5801 Pa[%]=	Pa [%] =
5802 Pr[%]=	Pr [%] =
5803 COS PHI=	Power factor of the machine
5804 PHI=	Power angle
5805 R=	Resistance
5806 X=	Reactance

5900 OPERATIONAL MEAS. VALUES C

5901 Ineg.seq=	Negative sequence current/unbalanced load
5902 ThermRepl.=	Calculated rotor temperature (unbal. load)

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 COMMAND RELAYS

6401 TRIP RELAY 1 Trip relay 1

______________ ______________ ______________

______________ ______________ ______________

______________ ______________ ______________

6402 TRIP RELAY 2 Trip relay 2

______________ ______________ ______________

______________ ______________ ______________

______________ ______________ ______________

6403 TRIP RELAY 3 Trip relay 3

______________ ______________ ______________

______________ ______________ ______________

______________ ______________ ______________

6404 TRIP RELAY 4 Trip relay 4

______________ ______________ ______________

______________ ______________ ______________

______________ ______________ ______________

6405 TRIP RELAY 5 Trip relay 5

______________ ______________ ______________

______________ ______________ ______________

______________ ______________ ______________

7000 OP. SYSTEM CONFIGURATION

7100 INTEGRATED OPERATION

7101 LANGUAGE Language
DEUTSCH [ ] deutsch
ENGLISH [ ] english

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
	________________		______________________________

7200 PC/SYSTEM INTERFACES

7201	DEVICE ADD.		Device address
	min. 1		
	max. 254	____	
7202	FEEDER ADD.		Feeder address
	min. 1		
	max. 254	____	
7203	SUBST. ADD		Substation address
	min. 1		
	max. 254	____	
7208	FUNCT. TYPE		Function type in accordance with VDEW/ZVEI
	min. 1		
	max. 254	____	
7209	DEVICE TYPE		Device type
	min. 1		
	max. 254	____	
7211	PC INTERF.		Data format for PC-interface
	DIGSI V3	[ ]	DIGSI V3
	ASCII	[ ]	ASCII
7215	PC BAUDRATE		Transmission baud rate for PC-interface
	9600 BAUD	[ ]	9600 Baud
	19200 BAUD	[ ]	19200 Baud
	1200 BAUD	[ ]	1200 Baud
	2400 BAUD	[ ]	2400 Baud
	4800 BAUD	[ ]	4800 Baud
7216	PC PARITY		Parity and stop-bits for PC-interface
	DIGSI V3	[ ]	DIGSI V3
	NO 2 STOP	[ ]	no parity,2 stopbits
	NO 1 STOP	[ ]	No parity,1 stopbit

7221	SYS INTERF.		Data format for system-interface
	VDEW COMPATIBLE	[ ]	VDEW compatible
	VDEW EXTENDED	[ ]	VDEW extended
	DIGSI V3	[ ]	DIGSI V3
	LSA	[ ]	LSA
7222	SYS MEASUR.		Measurement format for system-interface
	VDEW COMPATIBLE	[ ]	VDEW compatible
	VDEW EXTENDED	[ ]	VDEW extended
7225	SYS BAUDR.		Transmission baud rate for system-interface
	9600 BAUD	[ ]	9600 Baud
	19200 BAUD	[ ]	19200 Baud
	1200 BAUD	[ ]	1200 Baud
	2400 BAUD	[ ]	2400 Baud
	4800 BAUD	[ ]	4800 Baud
7226	SYS PARITY		Parity and stop-bits for system-interface
	VDEW/DIGSIV3/LSA	[ ]	VDEW/DIGSI V3/LSA
	NO 2 STOP	[ ]	no parity,2 stopbits
	NO 1 STOP	[ ]	No parity,1 stopbit
7231	SYS TEST		Testing via system-interface
	OFF	[ ]	off
	ON	[ ]	on
7235	SYS PARAMET		Parameterizing via system-interf
	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 value
	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	IMP. PROT.		Impedance protection
	EXIST	[ ]	Existant
	NON-EXIST	[ ]	Non-existant
7804	SEF PROT.		Stator earth fault protection
	EXIST	[ ]	Existant
	NON-EXIST	[ ]	Non-existant
7806	OUT-OF-STEP		Out-of-step protection
	EXIST	[ ]	Existant
	NON-EXIST	[ ]	Non-existant
7807	FOR. POWER		Forward power supervision
	EXIST	[ ]	Existant
	NON-EXIST	[ ]	Non-existant
7808	REV. POWER		Reverse power protection
	EXIST	[ ]	Existant
	NON-EXIST	[ ]	Non-existant
7810	UNBAL. LOAD		Unbalanced load protection
	EXIST	[ ]	Existant
	NON-EXIST	[ ]	Non-existant
7830	EXT. TRIP 1		External trip function 1
	EXIST	[ ]	Existant
	NON-EXIST	[ ]	Non-existant
7831	EXT. TRIP 2		External trip function 2
	EXIST	[ ]	Existant
	NON-EXIST	[ ]	Non-existant
7832	EXT. TRIP 3		External trip function 3
	EXIST	[ ]	Existant
	NON-EXIST	[ ]	Non-existant
7833	EXT. TRIP 4		External trip function 4
	EXIST	[ ]	Existant
	NON-EXIST	[ ]	Non-existant
7885	PARAM. C/O		Parameter change-over
	NON-EXIST	[ ]	Non-existant
	EXIST	[ ]	Existant
7899	FREQUENCY		Rated system frequency
	fN 50 Hz	[ ]	fN 50 Hz
	fN 60 Hz	[ ]	fN 60 Hz

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

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

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