Numerical generator protection

REG316*4

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Features

- Selectable protection functions
- Multitude of applications
- Setting menu-assisted with personal computer by means of the Windows-based operator program CAP2/316
- Fully numerical signal processing
- Continuous self-monitoring by hardware
- Cyclically executed testing routines, mostly by software
- Setting of parameters and recording of the settings
- Display of measured values
- Display of events, their acknowledgment and printout
- Disturbance recording
- Self-documentation
- Long-term stability
- Serial port for communication
- Available for 19" rack mounting in panel, surface or flush mounting.
- Four independent, user-selectable parameter sets able to be activated via binary input
- Multi-activation facility of the available functions

Application

The main areas of application of the REG316*4 terminal are the protection of generators, motors and unit transformers.

The modular design makes it extremely flexible and simple to adapt to the size of the primary system installation and the desired protection schemes to be included. Economic solutions can thus be achieved in the full range of applications for which it is intended.

Different degrees of redundancy are possible, availability and reliability of the protection can be chosen to suit the application by duplicating of REG316*4 units, but also by multiple configuration of the protection functions.

The use of standard interfaces makes REG316*4 compatible with process control systems. Different forms of data exchange with higher process control levels are possible, e.g. one-way reporting of digital states and events, measured values and protection parameters.

Application (cont'd)

Protection functions
All important protection functions required for the protection of generators, motors and unit transformers are included. The system can therefore replace several relays of a conventional protection scheme. The following table gives a survey of the most significant protection functions of REG316*4.

The desired protection functions to suit the particular application can simply be selected from a comprehensive library using the personal computer. No knowledge of programming whatsoever is required.

All setting ranges are extremely wide to make the protection functions suitable for a multitude of applications. The following main parameters can be set, among others:

- input channel or channels
- pick-up setting
- time delay
- definition of the operating characteristics
- tripping logic
- control signal logic

Setting a corresponding parameter enables the protection functions to be 'connected' to particular input channels. Digital input and output signals can also be connected together logically:

- The tripping outputs of each protection function can be allocated to channels of the tripping auxiliary relay assembly in a manner corresponding to a matrix.
- The pick-up and tripping signals can be allocated to the channels of the signalling auxiliary relay assembly.
- Provision is made for blocking each protection function with a digital signal (e. g. digital inputs or the tripping signal of another protection function).
- External signals applied to the digital inputs can be processed in any desired fashion.
- Digital signals can be combined to perform logical functions, e.g. external enabling or blocking signals with the output signals of an internal protection function and then used to block one of the other protection functions.

Protection functions:
Generator differential Transformer differential
Definite time overcurrent (undercurrent) (optionally with inrush detection)
Instantaneous overcurrent (undercurrent)
Voltage-controlled overcurrent
Inverse time overcurrent
Directional overcurrent protection with definite or inverse time characteristic
Negative phase sequence current
Definite time overvoltage (undervoltage) Stator earth fault (95%) Rotor earth fault Instantaneous overvoltage (undervoltage) with peak value evaluation Voltage balance
100% stator earth fault (+ rotor earth fault)
Underimpedance
Minimum reactance (loss of excitation)
Power
Overload
Inverse negative phase-sequence current
Overtemperature
Frequency
df/dt
Overexcitation
Logical functions
Pole slip protection

Design

The REG316*4 belongs to the generation of fully numerical generator protection terminals, i.e. analogue to digital conversion of the input variables takes place immediately after the input transformers and all further processing of the resulting numerical signals is performed by microprocessors and controlled by programs.

Standard interfaces enable REG316*4 to communicate with other control systems. Provision is thus made for the exchange of data such as reactionless reporting of binary states, events, measurements and protection parameters or the activation of a different set of settings by higher level control systems.

Because of its compact design, the very few hardware units it needs, its modular software and the integrated continuous self-diagnosis and supervision functions, REG316*4 ideally fulfils the user's expectations of a modern protection terminal at a cost-effective price. The AVAILABILITY of a terminal, i.e. the ratio between its mean time in service without failure and the total life, is most certainly the most important characteristic required of protection equipment. As a consequence of the continuous supervision of its functions, this quotient in the case of REG316*4 is typically always close to 1.

The menu-based HMI (human machine interface) and the REG316*4 small size makes the tasks of connection, configuration and setting simple. A maximum of FLEXIBILITY, i.e. the ability to adapt the protection for application in a particular power system or to coordinate with, or replace units in an existing protection scheme, is provided in REG316*4 by ancillary software functions and the assignment of input and output signals via the HMI.

REG316*4's RELIABILITY, SELECTIVITY and STABILITY are backed by decades of experience in the protection of generators and motors in transmission and distribution systems. Numerical processing ensures consistent ACCURACY and SENSITIVITY throughout its operational life.

Hardware

The hardware concept for the REG316*4 generator protection equipment comprises four different plug-in units, a connecting mother PCB and housing (Fig. 1):

- analog input unit
- central processing unit
- 1 to 4 binary input/output units
- power supply unit
- connecting mother PCB
- housing with connection terminals

In the analog input unit an input transformer provides the electrical and static isolation between the analogue input variables and the internal electronic circuits and adjusts the signals to a suitable level for processing. The input transformer unit can accommodate a maximum of nine input transformers (voltage-, protection current- or measuring transformer).

Every analog variable is passed through a first order R/C low-pass filter on the main CPU unit to eliminate what is referred to as the aliasing effect and to suppress HF interferences (Fig. 2). They are then sampled 12 times per period and converted to digital signals. The analog/digital conversion is performed by a 16 Bit converter. A DSP carries out part of the digital filtering and makes sure that the data for the protection algorithms are available in the memory to the main processor.

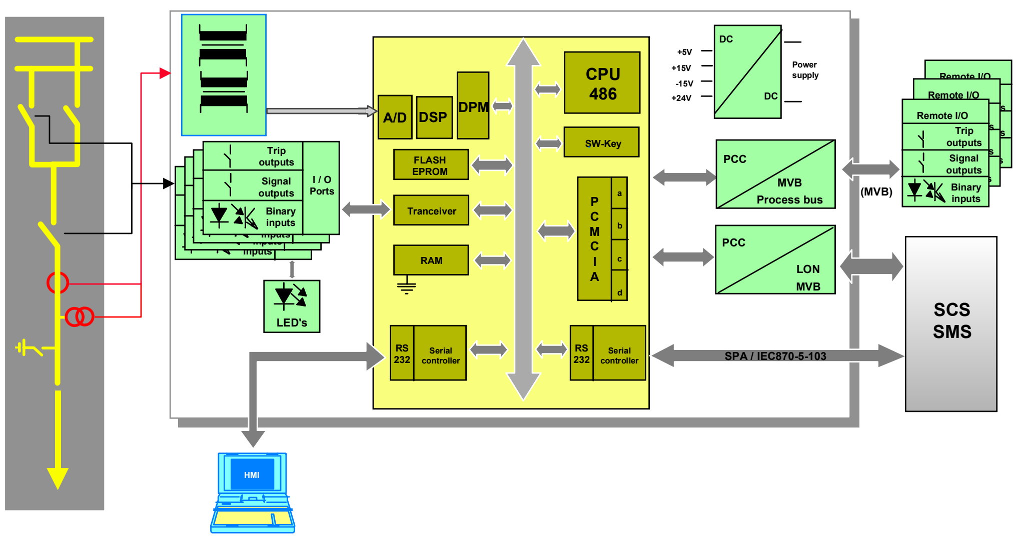


Fig. 1 Hardware platform overview

Hardware (cont'd.)

The processor core essentially comprises the main microprocessor for the protection algorithms and dual-ported memories (DPMs) for communication between the A/D converters and the main processor. The main processor performs the protection algorithms and controls the local HMI and the interfaces to the station control system. Binary signals from the main processor are relayed to the corresponding inputs of the I/O unit and thus control the auxiliary output relays and the light emitting diode (LED) signals. The main processor unit is equipped with an RS232C serial interface via which among other things the protection settings are made, events are read and the data from the disturbance recorder memory are transferred to a local or remote PC.

On this main processor unit there are two PCC slots and one RS232C interface. These serial interfaces provide remote communication to the station monitoring system (SMS) and station control system (SCS) as well as to the remote I/O's.

REG316*4 can have one to four binary I/O units each. These units are available in three versions:

a) two tripping relays with two heavy-duty contacts, 8 optocoupler inputs and 6 signalling relays Type 316DB61

b) two tripping relays with two heavy-duty contacts, 4 optocoupler inputs and 10 signalling relays Type 316DB62

c) 14 optocoupler inputs and 8 signalling relays Type 316DB63

When ordering REG316*4 with more than 2 I/O units casing size N2 must be selected.

According to whether one or two I/O units are fitted, there are either 8 LED's or 16 LED's visible on the front of the REG316*4.

Software

Both analogue and binary input signals are conditioned before being processed by the main processor: As described under hardware above, the analogue signals pass through the sequence input transformers, shunt, low-pass filter (anti-aliasing filter), multiplexer and A/D converter stages and DSP. In their digital form, they are then separated by numerical filters into real and apparent components before being applied to the main processor. Binary signals from the optocoupler inputs go straight to the main processor. The actual processing of the signals in relation to the protection algorithms and logic then takes place.

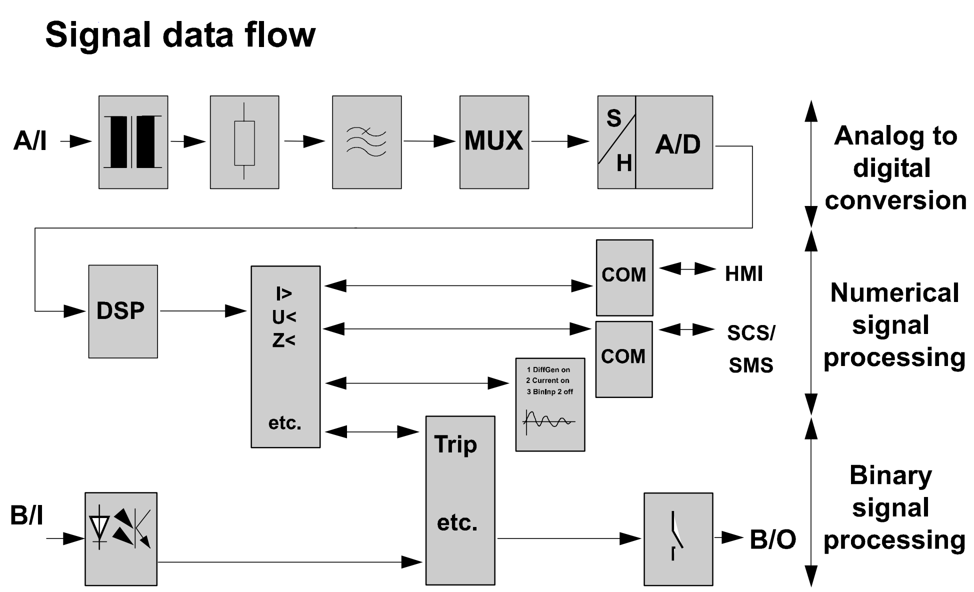


Fig. 2 Data Flow

Graphical engineering tool

The graphical programming language used in the tool CAP316 makes CAP316 a powerful and user-friendly engineering tool for the engineering of the control and protection units RE.216/316. It is similar to IEC 1131. CAP316 permits the function blocks representing the application to be directly translated into an application program (FUPLA) capable of running on the processors of the control and protection units RE.316*4. The program packet contains an extensive library of function blocks. Up to 8 projects (FUPLAs created with CAP316) are able to run simultaneously on a RE.316*4.

List of functions

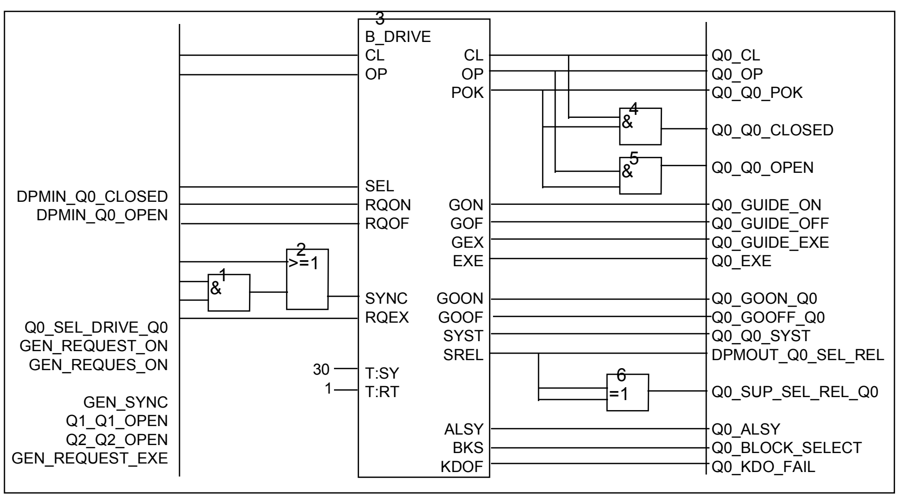
Binary functions:

AND	AND gate
ASSB	Assign binary
B23	2-out-of-3 selector
B24	2-out-of-4 selector
BINEXTIN	External binary input
BINEXOUT	External binary output
COUNTX	Shift register
CNT	Counter
CNTD	Downwards counter
OR	OR gate
RSFF	RS flip-flop
SKIP	Skip segment
TFF	T flip-flop with reset
TMOC	Monostable constant
TMOCS, TMOCL	Monostable constant short, long
TMOI	Monostable constant with interrupt
TMOIS, TMOIL	Monostable constant with interrupt short, long
TOFF	Off delay
TOFFS, TOFFL	Off delay short, long
TON	On delay
TONS, TONL	On delay short, long
XOR	Exclusive OR gate

Analogue functions:

ABS	Absolute value
ADD	Adder/subtracter
ADDL	Long integer adder/subtracter
ADMUL	Adder/multiplier
CNVIL	Integer to long integer converter
CNVLBCD	Long integer to BC converter
CNVLI	Long integer to integer converter
CNVLP	Long integer to percent converter
CNVPL	Percentage to long integer converter
DIV	Divider
DIVL	Long integer divider
FCTL	Linear function
FCTP	Polynomial function
FILT	Filter
INTS, INTL	Integrator
KMUL	Factor multiplier
LIM	Limiter
LOADS	Load shedding function
MAX	Maximum value detector
MIN	Minimum value detector
MUL	Multiplier
MULL	Long integer multiplier
NEGP	Percent negator
PACW	Pack BINARY signals into INTEGER
PDTS, PDTL	Differentiator
PT1S, PT1L	Delayed approximation
SQRT	Square root
SWIP	Percent switch
THRLL	Lower limit threshold
THRUL	Upper limit threshold
TMUL	Time multiplier
UPACW	Unpack BINARY signals from an INTEGER

Example:



Part of FUPLA application (Q0) : control and interlocking logic for three objects Q0, Q1, Q2. B_DRIVE is a macro based on binary function blocks.

Functions

This is an overview of the possible functions according to the hardware variants. These functions can be activated within the scope of the CPU capacity. One or the other function may be applied in accordance with the PT connections (e.g. three phase for minimum impedance or single phase for rotor and stator earth fault protection).

Variant

Protection Function	1	2	3	4	5	6	7
Definite time overcurrent (51)	■	■	■	■	■	■	■
Overcurrent with peak value evaluation (50)	■	■	■	■	■	■	■
Inverse time overcurrent (51)	■	■	■	■	■	■	■
Directional definite time overcurrent protection (67)		■	■	■	■	■	■
Directional inverse time overcurrent function (67)		■	■	■	■	■	■
Voltage-controlled protection (51-27)		■	■	■		■	
Thermal overload function (49)	■	■	■	■	■	■	■
Stator overload (49S)	■	■	■	■	■	■	■
Rotor overload (49R)	■	■	■	■	■	■	■
Inverse time negative phase sequence (46)	■	■	■	■	■	■	■
Negative phase sequence current (46)	■	■	■	■	■	■	■
Generator differential (87G)	■	■			■		
Transformer differential (87T)	■	■			■		
3-winding trafo differential (87T)	■						
* High-impedance REF			■		■	■	
Definite time overvoltage (27,59)		■	■	■	■	■	■
Instant. overvolt. with peak value eval. (59,27)		■	■	■	■	■	■
Undervoltage (27)		■	■	■	■	■	■
Overexcitation with inverse time delay (24)		■	■	■	■	■	■
Overexcitation (24)		■	■	■	■	■	■
Frequency (81)		■	■	■	■	■	■
df/dt		■	■	■	■	■	■
80-95% Stator earth fault		■	■	■	■	■	■
** 100% Stator earth fault (64S)							■
Pole slip (78)		■	■	■	■	■	■
*** Rotor earth fault (64R)		■	■	■	■	■	
** Rotor earth fault with injection principle							■
Minimum reactance (40)		■	■	■	■	■	■
Interturn fault		■	■	■	■	■	■
Underimpedance (21)		■	■	■		■	■
Reverse power (32)		■ 1	■	■ 1	■	■	■ 1
Voltage comparison (60)				■	■	■	■
Voltage plausibility		■	■	■		■	
Current plausibility	■	■	■	■	■	■	■
Metering		■	■	■	■	■	■
Delay	■	■	■	■	■	■	■
Counter	■	■	■	■	■	■	■
Logic	■	■	■	■	■	■	■
Project-specific control logic	■	■	■	■	■	■	■
Disturbance recorder	■	■	■	■	■	■	■

Fig. 3 Main versions

* Requires external stabilizing resistor and VDR
** Requires injection unit REX010 and injection transformer block REX011
*** Requires external measuring bridge YWX111-.. and coupling capacitors
1 minimum setting: >2%.

Variant	1	2	3	4	5	6	7	
CT's protection characteristic	9	6	3	3	6	3	3	1A, 2A or 5A
CT's measuring characteristic	-	-	3	-	1	1	-	1A, 2A or 5A
VT's	-	3	3	6	2	5	2	100 V or 200 V
VT's	-	-	-	-	-	-	4	only for 100% stator and rotor earth fault protection and for 95% stator earth fault protection

Fig. 4 Analog inputs (9 channels max.)

Directional overcurrent protection
The directional overcurrent protection function is available either with inverse time or definite time overcurrent characteristic. This function comprises a voltage memory for faults close to the relay location. The function response after the memory time has elapsed can be selected (trip or block).

Frequency function
The frequency function is based on the measurement of one voltage. This function is able to be configured as maximum or minimum function and is applied as protection function and for load shedding. By multiple configuration of this function almost any number of stages can be realized.

Rate-of-change of frequency
This function offers alternatively an enabling by absolute frequency. It contains an undervoltage blocking facility. Repeated configuration of this function ensures a multi-step setup.

Measuring
Both measuring functions measure the single- or three-phase rms values of voltage, current, frequency, real power and apparent power for display on the local HMI or transfer to the station control system. A choice can be made between phase-to-neutral and phase-to-phase voltages.

Ancillary functions
Ancillary functions such as a logic and a delay/integrator enable the user to create logical combinations of signals and pick-up and reset delays.

A run-time supervision feature enables checking the opening and closing of all kinds of breakers (circuit-breakers, isolators, ground switches...). Failure of a breaker to open or close within an adjustable time results in the creation of a corresponding signal for further processing.

Plausibility check
The current and voltage plausibility functions facilitate the detection of system asymmetries, e.g. in the secondary circuits of c.t's and v.t's.

Sequence of events recorder
The event recorder function provides capacity for up to 256 binary signals including time marker with a resolution in the order of milliseconds.

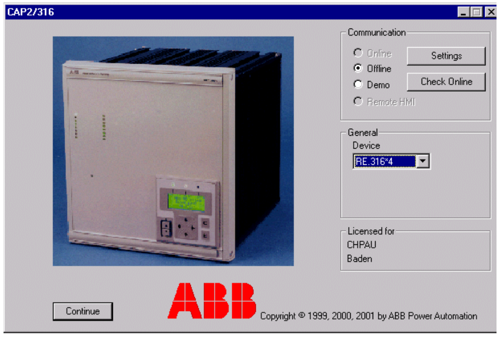
Disturbance recorder
The disturbance recorder monitors up to 9 analogue inputs, up to 16 binary inputs and internal results of protection functions. The capacity for recording disturbances depends on the duration of a disturbance as determined by its pre-disturbance history and the duration of the disturbance itself. The total recording time is approximately 5 s.

Human machine interface (HMI) - CAP2/316
For local communication with REG316*4, there is the setting software CAP2/316 available which is based on Windows. This software runs under the following operating systems:

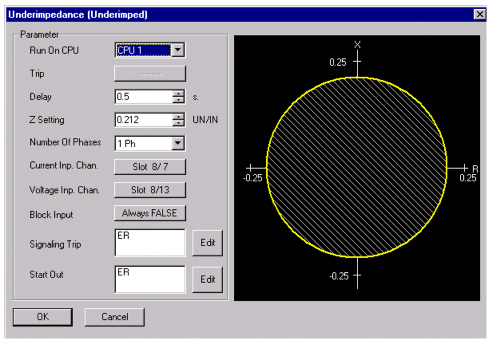
- Windows NT 4.0
- Windows 2000

This optimal programming tool is available for engineering, testing, commissioning and operation. The software can be used either ON-LINE or OFF-LINE and furthermore contains a DEMO mode.

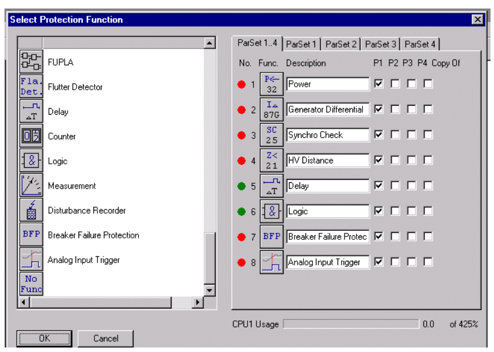
Functions (cont'd)



For each protection function a tripping characteristic is displayed. Apart from the basic understanding of the protection functions, the graphical display of these functions also makes the setting of the parameters clearer.



Any desired protection function can be selected from the software library of all released protection functions by means of the drag-and-drop feature.



Built-in HMI
The front HMI unit serves primarily for the signalling of actual events, measurands and diagnostic data. Settings are not displayed.

Features:

- Measurand display
  - Amplitude, angle, frequency of analogue channels
  - Functional measurands
  - Binary signals
- Event list
- Operating instructions
- Disturbance recorder information
- Diagnostic information
- Acknowledgment functions
  - Resetting LED's
  - Resetting latched outputs
  - Event erasing
  - Warm start

Remote communication
REG316*4 is able to communicate with a station monitoring and evaluation system (SMS) or a station control system (SCS) via an optical fibre link. The corresponding serial interface permits events, measurements, disturbance recorder data and protection settings to be read and sets of parameter settings to be switched.

Using the LON bus permits in addition the exchange of binary information between the individual bay controllers, e.g. signals for station interlocking.

Remote in- and outputs (RIO580)
Using the process bus type MVB remote in- and output units 500RIO11 can be connected to the RE.316*4 terminals. The input and output channels can be extended to a large number by using RIO580 remote input/output system. Installing 500RIO11 I/O units close to the process reduces the wiring dramatically, since they are accessible via fibre optic link from the RE.316*4 terminals.

Analog signals can also be connected to the system via the 500AXM11 from the RIO580 family:

- DC current 4...20 mA
  0...20 mA
  -20...20 mA
- DC voltage 0...10 V
  -10...10 V
- Temp. sensor Pt100, Pt250, Pt1000, Ni100, Ni250, Ni1000.

Self-diagnosis and supervision
RE.316*4's self-diagnosis and supervision functions ensure maximum availability not only of the protection terminal itself, but also of the power system it is protecting. Hardware failures are immediately signalled by an alarm contact. In particular, the external and internal auxiliary supplies are continuously supervised. The correct function and tolerance of the A/D converter are tested by cyclically converting two reference voltages. Special algorithms regularly check the processor's memories (background functions). A watchdog supervises the execution of the programs.

An important advantage of the extensive self-diagnosis and supervision functions is that periodic routine maintenance and testing are reduced.

Supporting software
The operator program facilitates configuration and setting of the protection, listing parameters, reading events and listing the various internal diagnostic data.

The evaluation programs REVAL and WINEVE (MS Windows/Windows NT) are available for viewing and evaluating the disturbances stored by the disturbance recorder. Where the disturbance data are transferred via the communications system to the disturbance recorder evaluation station, the file transfer program EVECOM (MS Windows/ Windows NT) is also used.

The program XSCON (MS Windows) is available for conversion of the RE.316*4's disturbance recorder data to ABB's test set XS92b format. This enables reproduction of electrical quantities recorded during the disturbance.

Technical data Hardware

Table 1: Analogue input variables

Number of inputs according to version, max. 9 analogue inputs (voltages and currents, 4 mm^2 terminals)	
Rated frequency f_N	50 Hz or 60 Hz
Rated current I_N	1 A, 2 A or 5 A
Thermal rating of current circuit continuous for 10 s for 1 s dynamic (half period)	 4 x I_N 30 x I_N 100 x I_N 250 x I_N (peak)
Rated voltage U_N	100 V or 200 V
Thermal rating of voltage circuit continuous	 2.2 x U_N
Burden per phase current inputs voltage inputs	 <0.1 VA at $I_{N =}$ 1 A <0.3 VA at I_N = 5 A <0.25 VA at U_N
VT fuse characteristic	Z acc. to DIN/VDE 0660 or equivalent

Table 2: Contact data

Tripping relays	
No. of contacts	2 relays per I/O unit 316DB61 or 316DB62 with 2 N/O contacts each 1.5 mm^2 terminals
Max. operating voltage	300 V AC or V DC
Continuous rating	5 A
Make and carry for 0.5 s	30 A
Surge for 30 ms	250 A
Making power at 110 V DC	3300 W
Breaking capacity for L/R = 40 ms Breaking current with 1 contact at U <50 V DC at U <120 V DC at U <250 V DC	 1.5 A 0.3 A 0.1 A
Breaking current with 2 contacts in series at U <50 V DC at U <120 V DC at U <250 V DC	 5 A 1 A 0.3 A
Signalling contacts	
No. of contacts	6, 10 or 8 acc. to I/O unit (316DB61, 316DB62 or 316DB63), 1 contact per sig. relay with 1.5 mm^2 terminals Each interface unit equipped with 1 C/O contact and all others N/O contacts
Max. operating voltage	250 V AC or V DC
Continuous rating	5 A
Make and carry for 0.5 s	15 A
Surge for 30 ms	100 A
Making power at 110 V_{DC}	550 W
Breaking current for L/R = 40 ms at U <50 V DC at U <120 V DC at U <250 V DC	 0.5 A 0.1 A 0.04 A
The user can assign tripping and signalling contacts to protection functions	

Table 3: Optocoupler inputs

No. of optocouplers	8, 4 or 14 acc. to I/O unit (316DB61, 316DB62 or 316DB63)
Input voltage	18 to 36 V DC / 36 to 75 V DC / 82 to 312 V DC / 175 to 312 V DC
Threshold voltage	10 to 17 V DC / 20 to 34 V DC /40 to 65 V DC / 140 to 175 V DC
Max. input current	<12 mA
Operating time	1 ms
The user can assign the inputs to protection functions.	

Table 4: Light-emitting diodes

Choice of display modes: • Accumulates each new disturbance • Latching with reset by next pick-up • Latching only if protection trips with reset by next pick-up • Signalling without latching	
Colours	1 green (standby) 1 red (trip) 6 or 14 yellow (all other signals)
The user can assign the LED's to protection functions.	

Table 5: Configuration and settings

Local via the communication interface on the front port connector using an IBM-compatible PC with Windows NT 4.0 or Windows 2000. The operator program can also be operated by remote control via a modem.	
Operator program	in English or German

Table 6: Remote communication

RS232C interface Data transfer rate Protocol Electrical/optical converter (optional)	9 pin Sub-D female 9600 Bit/s SPA or IEC 60870-5-103 316BM61b
PCC interface Number	 2 plug-in sockets for type III cards
PCC (optional) Interbay bus protocol Process bus protocol (interbay and process bus can be used concurrently)	 LON or MVB (part of IEC 61375) MVB (part of IEC 61375)
LON bus Data transfer rate	PCC with fibre-optical port, ST connectors 1.25 MBit/s
MVB bus Data transfer rate	PCC with redundant fibre-optical port, ST connectors 1.5 Mbit/s
Event memory Capacity Time marker resolution	 256 events 1 ms
Time definition without synchronizing	<10 s per day
Engineering interface	integrated software interface for signal engineering with SigTOOL

Technical data Hardware (cont'd)

Table 7: Auxiliary supply

Supply voltage	
Voltage range	36 to 312 V DC
Voltage interruption bridging time	>50 ms
Fuse rating	≥4 A
Load on station battery at normal operation (1 relay energized) during a fault (all relays energized) with 1 I/O unit with 2 I/O units with 3 I/O units with 4 I/O units	<20 W <22 W <27 W <32 W <37 W
Additional load of the options SPA, IEC 60870-5-103 or LON interface MVB interface	 1.5 W 2.5 W
Buffer time of the event list and fault recorder data at loss of auxiliary supply	>2 days (typ. 1 month)

Table 8: General data

Temperature range operation storage	 -10° C to +55° C -40° C to +85° C	EN 60255-6 (1994), IEC 60255-6 (1988)
Humidity	93%, 40° C, 4 days	IEC 60068-2-3 (1969)
Seismic test	5 g, 30 s, 1 to 33 Hz (1 octave/min)	IEC 60255-21-3 (1995), IEEE 344 (1987)
Leakage resistance	>100 MΩ, 500 V DC	EN 60255-5 (2001), IEC 60255-5 (2000)
Insulation test	2 kV, 50 Hz, 1 min 1 kV across open contacts	EN 60255-5 (2001), IEC 60255-5 (2000), EN 60950 (1995)
Surge voltage test	5 kV, 1.2/50 μs	EN 60255-5 (2001), IEC 60255-5 (2000) *
1 MHz burst disturbance test	1.0/2.5 kV, Cl. 3; 1MHz, 400 Hz rep.freq.	IEC 60255-22-1 (1988), ANSI/IEEE C37.90.1 (1989)
Fast transient test	2/4 kV, Cl. 4	EN 61000-4-4 (1995), IEC 61000-4-4 (1995)
Electrostatic discharge test (ESD)	6/8 kV (10 shots), Cl. 3	EN 61000-4-2 (1996), IEC 61000-4-2 (2001)
Immunity to magnetic interference at power system frequencies	300 A/m; 1000 A/m; 50/60 Hz	EN 61000-4-8 (1993), IEC 61000-4-8 (1993)
Radio frequency interference test (RFI)	• 0.15-80 MHz, 80% amplitude modulated 10 V, Cl. 3 • 80-1000 MHz, 80% amplitude modulated 10 V/m, Cl. 3 • 900 MHz, puls modulated 10 V/m, Cl. 3	EN 61000-4-6 (1996) EN 61000-4-6 (1996), EN 61000-4-3 (1996), IEC 61000-4-3 (1996), ENV 50204 (1995)
Emission	Cl. A	EN 61000-6-2 (2001), EN 55011 (1998), CISPR 11 (1990)

* Reduced values apply for repeat tests according to IEC publication 255-5, Clauses 6.6 and 8.6.

Table 9: Mechanical design

Weight Size N1 casing Size N2 casing	 approx. 10 kg approx. 12 kg
Methods of mounting	semi-flush with terminals at rear surface with terminals at rear 19" rack mounting, height 6U, width N1: 225.2 mm (1/2 19" rack). Width N2: 271 mm.
Enclosure Protection Class	IP 50 (IP 20 if MVB PCC are used) IPXXB for terminals.

Technical Data Functions

Table 10: Thermal overload function (49)

• Thermal image for the 1st. order model. • Single or three-phase measurement with detection of maximum phase value.	
Settings:	
Base current I_B	0.5 to 2.5 I_N in steps of 0.01 I_N
Alarm stage	50 to 200% ϑ_N in steps of 1% ϑ_N
Tripping stage	50 to 200% ϑ_N in steps of 1% ϑ_N
Thermal time constant	2 to 500 min in steps of 0.1 min
Accuracy of the thermal image	±5% ϑ_N (at f_N) with protection c.t.'s ±2% ϑ_N (at f_N) with core-balance c.t.'s

Table 11: Definite time current function (51DT)

• Over and undercurrent detection. • Single or three-phase measurement with detection of the highest, respectively lowest phase current. • 2nd. harmonic restraint for high inrush currents.	
Settings:	
Pick-up current	0.02 to 20 I_N in steps of 0.01 I_N
Delay	0.02 to 60 s in steps of 0.01 s
Accuracy of the pick-up setting (at f_N)	±5% or ±0.02 I_N
Reset ratio overcurrent undercurrent	 >94 % (for max. function) <106 % (for min. function)
Max. operating time without intentional delay	60 ms
Inrush restraint pick-up setting reset ratio	optional 0.1 I_{2h}/I_{1h} 0.8

Table 12: Definite time voltage function (27/59)

• Over and undervoltage detection • Single or three-phase measurement with detection of the highest, respectively lowest phase voltage	
Also applied for detection of: • stator ground faults (95%) • rotor ground faults (requires external measuring bridge YWX111 and coupling capacitors) • inter-turn faults	
Settings:	
Pick-up voltage	0.01 to 2.0 U_N in steps of 0.002 U_N
Delay	0.02 to 60 s in steps of 0.01 s
Accuracy of the pick-up setting (at f_N)	±2% or ±0.005 U_N
Reset ratio ($U \geq 0.1\ U_N$) overvoltage undervoltage	 >96% (for max. function) <104% (for min. function)
Max. operating time without intentional delay	60 ms

Table 13: Directional definite time overcurrent protection (67)

• Directional overcurrent protection with detection of the power direction • Backup protection for distance protection scheme	
• Three-phase measurement • Suppression of DC- and high-frequency components • Definite time characteristic • Voltage memory feature for close faults	
Settings:	
Current	0.02 to 20 I_N in steps of 0.01 I_N
Angle	-180° to +180° in steps of 15°
Delay	0.02 s to 60 s in steps of 0.01 s
tWait	0.02 s to 20 s in steps of 0.01 s
Memory duration	0.2 s to 60 s in steps of 0.01 s
Accuracy of pick-up setting (at f_N) Reset ratio Accuracy of angle measurement (at 0.94 to 1.06 f_N)	±5% or ±0.02 I_N >94% ±5°
Voltage input range Voltage memory range Accuracy of angle measurement at voltage mem- ory Frequency dependence of angle measurement at voltage memory Max. Response time without delay	0.005 to 2 U_N <0.005 U_N ±20° ±0.5°/Hz 60 ms

Table 14: Directional inverse time overcurrent function (67)

• Directional overcurrent protection with detection of the power direction • Backup protection for distance protection scheme	
• Three-phase measurement • Suppression of DC- and high-frequency components • Inverse time characteristic • Voltage memory feature for close faults	
Settings:	
Current I_{Start}	1…4 I_B in steps of 0.01 I_B
Angle	-180°…+180° in steps of 15°
Inverse time characteristic (acc. to B.S. 142 with extended setting range) normal inverse very inverse extremely inverse long-time earth fault	$t = k_1 / ((I/I_B)^C - 1)$ c = 0,02 c = 1 c = 2 c = 1
k_1-setting	0.01 to 200 s in steps of 0.01 s
t-min	0 to 10 s in steps of 0.1 s
IB-value	0.04 to 2.5 I_N in steps of 0.01 I_N
tWait	0.02 s to 20 s in steps of 0.01 s

Technical Data Functions (cont'd)

Memory duration	0.2 s to 60 s in steps of 0.01 s
Accuracy of pick-up setting (at f_N) Reset ratio Accuracy of angle measurement (at 0.94 to 1.06 f_N) Accuracy class of the operating time acc. to British Standard 142	±5% >94% ±5° E 10
Voltage input range Voltage memory range Accuracy of angle measurement at voltage memory Frequency dependence of angle measurement at voltage memory Max. Response time without delay	0.005 to 2 U_N <0.005 U_N ±20° ±0.5°/Hz 60 ms

Table 15: Metering function UIfPQ

• Single-phase measurement of voltage, current, frequency, real power and apparent power • Choice of measuring phase-to-ground or phase-to phase voltages • Suppression of DC components and harmonics in current and voltage • Compensation of phase errors in main and input c.t's and v.t's	
Settings:	
Phase-angle	-180° to +180° in steps of 0.1°
Reference value of the power S_N	0.2 to 2.5 S_N in steps of 0.001 S_N

Refer to Table 46 for accuracy.

Table 16: Three-phase measuring module

• Three-phase measurement of voltage (star or delta), current, frequency, real and apparent power and power factor. • Two independent impulse counter inputs for calculation of interval and accumulated energy. The three-phase measurement and the impulse counters can be used independently and may also be disabled. • This function may be configured four times.	
Settings:	
Angle	-180° to +180° in steps of 0.1°
Reference value for power	0.2 to 2.5 S_N in steps of 0.001 S_N
t1-Interval	1 min., 2 min., 5 min., 10 min., 15 min., 20 min., 30 min., 60 min. or 120 min.
Scale factor of power	0.0001 to 1
Max. impulse frequency	25 Hz
Min. impulse duration Accuracy of time interval	10 ms ±100 ms

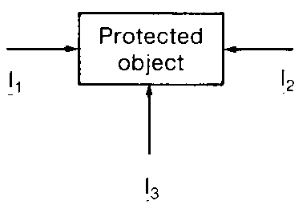
See Table 46 for accuracy

Table 17: Generator differential (87G)

Features: • Three-phase function • Current-adaptive characteristic • High stability for external faults and current transformer saturation	
Settings:	
g-setting (basic sensitivity)	0.1 to 0.5 I_N in steps of 0.05 I_N
v-setting (slope)	0.25 or 0.5
Max. trip time - for I_Δ >2 I_N - for I_Δ ≤2 I_N	 ≤30 ms ≤50 ms
Accuracy of pick-up value of g	±5% I_N (at f_N)

Table 18: Transformer differential (87T)

<table>
<tr><td colspan="2">Features:
• For two- and three-winding transformers
• Three-phase function
• Current-adaptive characteristic
• High stability for external faults and current transformer saturation
• No auxiliary transformers necessary because of vector group and CT ratio compensation
• Inrush restraint using 2nd harmonic</td></tr>
<tr><td>Settings:</td><td></td></tr>
<tr><td>g-setting</td><td>0.1 to 0.5 I_N in steps of 0.1 I_N</td></tr>
<tr><td>v-setting</td><td>0.25 or 0.5</td></tr>
<tr><td>b-setting</td><td>1.25 to 5 in steps of 0.25 I_N</td></tr>
<tr><td>Max. trip time (protected transformer loaded)</td><td></td></tr>
<tr><td>- for I_Δ > 2 I_N
- for I_Δ ≤ 2 I_N</td><td>≤30 ms
≤50 ms</td></tr>
<tr><td>Accuracy of pick-up value</td><td>±5% I_N (at f_N)</td></tr>
<tr><td>Reset conditions</td><td>I_Δ <0.8 g-setting</td></tr>
<tr><td>Differential protection definitions:



$I\Delta = |\underline{I}_1 + \underline{I}_2 + \underline{I}_3|$

$$I_H = \begin{cases} \sqrt{I_1' \cdot I_2' \cdot \cos\alpha} & \text{for } \cos\alpha \geq 0 \\ 0 & \text{for } \cos\alpha < 0 \end{cases}$$

$\alpha = \arg(\underline{I}_1' - \underline{I}_2')$

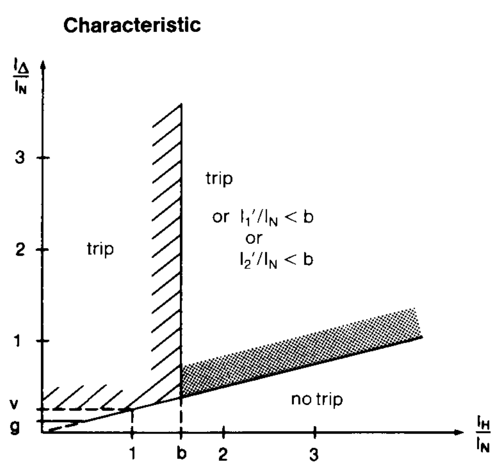
2-winding: $\underline{I}_1' = \underline{I}_1$, $\underline{I}_2' = \underline{I}_2$
3-winding: $\underline{I}_1' = \mathrm{MAX}(\underline{I}_1, \underline{I}_2, \underline{I}_3)$
$\underline{I}_2' = \underline{I}_1 + \underline{I}_2 + \underline{I}_3 - \underline{I}_1'$</td><td>


Fig. 5 Differential protection characteristic</td></tr>
</table>

Technical Data Functions (cont'd)

Table 19: Instantaneous overcurrent (50)

Features: • Maximum or minimum function (over- and undercurrent) • Single- or three-phase measurements • Wide frequency range (0.04 to 1.2 f_N) • Peak value evaluation	
Settings:	
Current	0.1 to 20 I_N in steps of 0.1 I_N
Delay	0 to 60 s in steps of 0.01 s
Accuracy of pick-up value (at 0.08 to 1.1 f_N)	±5% or ±0.02 I_N
Reset ratio	>90% (for max. function) <110% (for min. function)
Max. trip time with no delay (at f_N)	≤30 ms (for max. function) ≤60 ms (for min. function)

Table 20: Voltage-controlled overcurrent (51-27)

Features: • Maximum current value memorized after start • Reset of function after voltage return or after trip • Single- or three-phase measurement for current • Positive-sequence voltage evaluation	
Settings:	
Current	0.5 to 20 I_N in steps of 0.1 I_N
Voltage	0.4 to 1.1 U_N in steps of 0.01 U_N
Delay	0.5 to 60 s in steps of 0.01 s
Hold time	0.1 to 10 s in steps of 0.02 s
Accuracy of pick-up value	±5% (at f_N)
Reset ratio	>94%
Starting time	≤80 ms

Table 21: Inverse time-overcurrent function (51)

• Single or three-phase measurement with detection of the highest phase current • Stable response to transients	
Inverse time characteristic (acc. to B.S. 142 with extended setting range) normal inverse very inverse extremely inverse long time inverse	$t = k_1 / ((I/I_B)^C - 1)$ c = 0.02 c = 1 c = 2 c = 1
or RXIDG characteristic	$t = 5.8 - 1.35 \cdot \ln (I/I_B)$
Settings:	
Number of phases	1 or 3
Base current I_B	0.04 to 2.5 I_N in steps of 0.01 I_N
Pick-up current I_{start}	1 to 4 I_B in steps of 0.01 I_B
Min. time setting t_{min}	0 to 10 s in steps of 0.1 s
k_1 setting	0.01 to 200 s in steps of 0.01 s
Accuracy classes for the operating time according to BritishStandard 142 RXIDG characteristic	 E 5.0 ±4% (1 - I/80 I_B)
Reset ratio	>94 %

Table 22: Inverse time ground fault overcurrent function (51N)

• Neutral current measurement (derived externally or internally) • Stable response to transients	
Inverse time characteristic (acc. to B.S. 142 with extended setting range) normal inverse very inverse extremely inverse long time inverse	$t = k_1 / ((I/I_B)^C - 1)$ c = 0.02 c = 1 c = 2 c = 1
or RXIDG characteristic	$t = 5.8 - 1.35 \cdot \ln (I/I_B)$
Settings:	
Number of phases	1 or 3
Base current I_B	0.04 to 2.5 I_N in steps of 0.01 I_N
Pick-up current I_{start}	1 to 4 I_B in steps of 0.01 I_B
Min. time setting t_{min}	0 to 10 s in steps of 0.1 s
k_1 setting	0.01 to 200 s in steps of 0.01 s
Accuracy classes for the operating time according to British Standard 142 RXIDG characteristic	 E 5.0 ±4% (1 - I/80 I_B)
Reset ratio	>94%

Table 23: Negative phase sequence current (46)

Features: • Protection against unbalanced load • Definite time delay • Three-phase measurement	
Settings:	
Negative phase-sequence current (I_2)	0.02 to 0.5 I_N in steps of 0.01 I_N
Delay	0.5 to 60 s in steps of 0.01 s
Accuracy of pick-up value	±2% I_N (at f_N, $I \leq I_N$) (with measuring transformers)
Reset ratio $I_2 \geq 0.2\ I_N$ $I_2 < 0.2\ I_N$	 >94% >90%
Starting time	≤80 ms

Table 24: Instantaneous overvoltage prot. function (59, 27) with peak value evaluation

Features: • Evaluation of instantaneous values, therefore extremely fast and frequency-independent on a wide scale • Storing of the highest instantaneous value after start • No suppression of d. c. components • No suppression of harmonics • 1- or 3phase • Maximum value detection for multi-phase functions • Variable lower limiting frequency f_{min}	
Settings:	
Voltage	0.01 to 2.0 U_N in steps of 0.01 U_N
Delay	0.00 to 60 s in steps of 0.01 s
Limiting f_{min}	25 to 50 Hz in steps of 1 Hz
Accuracy of pick-up value (at 0.08 to 1.1 f_N)	±3% or ±0,005 U_N
Reset ratio	>90% (for max. function) <110% (for min. function)
Max. trip time at no delay (at f_N)	<30 ms (for max. function) <50 ms (for min. function)

Technical Data Functions (cont'd)

Table 25: Underimpedance (21)

Features:
- Detection of two- and three-phase short circuits (back-up protection)
- Single- or three-phase measurement
- Circular characteristic centered at origin of R-X diagram
- Lowest phase value evaluation for three-phase measurement

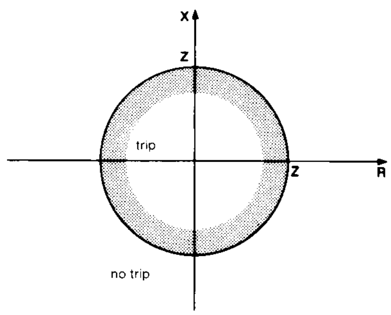


Fig. 6 Underimpedance protection function characteristics

Settings:	
Impedance	0.025 to 2.5 U_N/I_N in steps of 0.001 U_N/I_N
Delay	0.2 to 60 s in steps of 0.01 s
Reset ratio	<106%
Starting time	<50 ms (at f_N)
Accuracy of pick-up values	±5%

Table 26: Minimum reactance (40)

Features:
- Detection of loss-of-excitation failure of synchronous machines
- Single- or three-phase measurement
- Out-of-step detection with additional time delay or count logic
- Circular characteristic
- Tripping possible inside or outside the circle

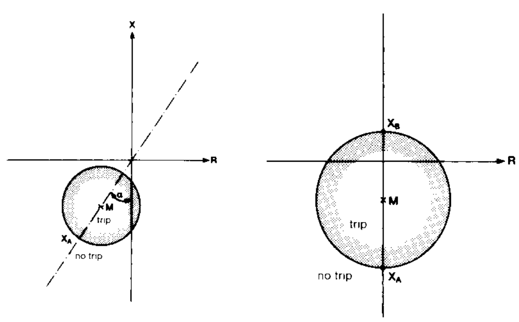


Fig. 7 Minimum reactance protection function characteristics

Settings:	
Reactance X_A	-5 to 0 U_N/I_N in steps of 0.01 U_N/I_N
Reactance X_B	-2.5 to +2.5 U_N/I_N in steps of 0.01 U_N/I_N
Delay	0.2 to 60 s in steps of 0.01 s
Angle α	-180° to +180° in steps of 5°
Accuracy of pick-up values	±5% of highest absolute value of X_A, X_B (at f_N)
Reset ratio	(related to origin of circle), 105% for min. function, 95% for max. function.
Starting time	<50 ms

Table 27: Stator overload (49S)

Features:
- Single- or three-phase measurement
- Operating characteristics according to ASA-C50.13
- Highest phase value for three-phase measurement
- Wide time multiplier setting.

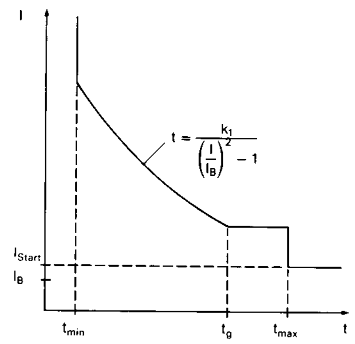


Fig. 8 Stator overload protection function characteristics

Settings:

Base current (I_B)	0.5 to 2.5 I_N in steps of 0.01 I_N
Time multiplier k_1	1 to 50 s in steps of 0.1 s
Pick-up current (I_{start})	1.0 to 1.6 I_B in steps of 0.01 I_B
t_{min}	1 to 120 s in steps of 0.1 s
t_g	10 to 2000 s in steps of 10 s
t_{max}	100 to 2000 s in steps of 10 s
t_{reset}	10 to 2000 s in steps of 10 s
Accuracy of current measurement	±5% (at f_N), ±2% (at f_N) with measuring transformer
Starting time	≤80 ms

Table 28: Rotor overload (49R)

Features:
Same as stator overload function, but three-phase measurement

Settings:
Same as for stator overload function

Technical Data Functions (cont'd)

Table 29: Inverse time negative phase sequence current (46)

Features:
- Protection against unbalanced load
- Inverse time delay
- Three-phase measurement

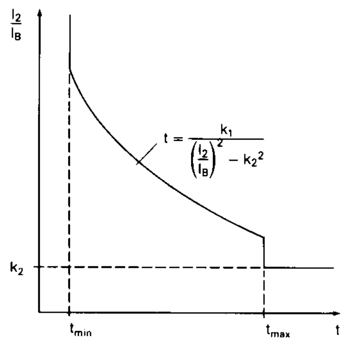


Fig. 9 Inverse time negative phase sequence current protection function characteristics

Settings:	
Base current (I_B)	0.5 to 2.5 I_N in steps of 0.01 I_N
Time multiplier k_1	5 to 30 s in steps of 0.1 s
Factor k_2 (pick-up)	0.02 to 0.20 in steps of 0.01
t_{min}	1 to 120 s in steps of 0.1 s
t_{max}	500 to 2000 s in steps of 1 s
t_{reset}	5 to 2000 s in steps of 1 s
Accuracy of NPS current (I_2) measurement	±2% (at f_N) with measuring transformers
Starting time	≤80 ms

Table 30: Frequency (81)

Features:
- Maximum or minimum function (over-, underfrequency)
- Minimum voltage blocking

Settings:	
Frequency	40 to 65 Hz in steps of 0.01 Hz
Delay	0.1 to 60 s in steps of 0.01 s
Minimum voltage	0.2 to 0.8 U_N in steps of 0.1 U_N
Accuracy of pick-up value	±30 mHz at U_N and f_N
Reset ratio	100%
Starting time	<130 ms

Table 31: Rate-of-change of frequency df/dt (81)

Features: • Combined pick-up with frequency criterion possible • Blocking by undervoltage	
Settings:	
df/dt	-10 to +10 Hz/s in steps of 0.1 Hz/s
Frequency	40 to 55 Hz in steps of 0.01 Hz at f_N = 50 Hz 50 to 65 Hz in steps of 0.01 Hz at f_N = 60 Hz
Delay	0.1 to 60 s in steps of 0.01 s
Minimum voltage	0.2 to 0.8 U_N in steps of 0.1 U_N
Accuracy of df/dt (at 0.9 to 1.05 f_N)	±0.1 Hz/s
Accuracy of frequency (at 0.9 to 1.05 f_N)	±30 mHz
Reset ratio df/dt	95% for max. function 105% for min. function

Table 32: Overexcitation (24)

Features: • U/f measurement • Minimum voltage blocking	
Settings:	
Pick-up value	0.2 to 2 U_N/f_N in steps of 0.01 U_N/f_N
Delay	0.1 to 60 s in steps of 0.01 s
Frequency range	0.5 to 1.2 f_N
Accuracy (at f_N)	±3% or ±0.01 U_N/f_N
Reset ratio	>97% (max.), <103% (min.)
Starting time	≤120 ms

Table 33: Overexcitation function with inverse time delay (24)

Features: • Single-phase measurement • Inverse time delay according to IEEE Guide C37.91-1985 • Setting made by help of table settings	
Settings:	
Table settings	U/f values: (1.05; 1.10 to 1.50) U_N/f_N
Start value U/f	1.05 to 1.20 U_N/f_N in steps of 0.01 U_N/f_N
t_{min}	0.01 to 2 min in steps of 0.01 min
t_{max}	5 to 100 min in steps of 0.1 min
Reset time	0.2 to 100 min in steps of 0.1 min
Reference voltage	0.8 to 1.2 U_N in steps of 0.01 U_N
Accuracy of pick-up value	±3% U_N/f_N (at f_N)
Frequency range	0.5 to 1.2 f_N
Reset ratio	100%
Starting time	<120 ms

Technical Data Functions (cont'd)

Table 34: Voltage balance function (60)

Features:
- Comparing of the voltage amplitudes of two groups of voltage inputs (line 1, line 2)
- 1- or 3-phase voltage measurement
- Signalling of the group having the lower voltage
- Evaluation of the voltage differences per phase for the 3-phase function and logic OR connection for the tripping decision
- Variable tripping and reset delay
- Suppression of d. c. components
- Suppression of harmonics

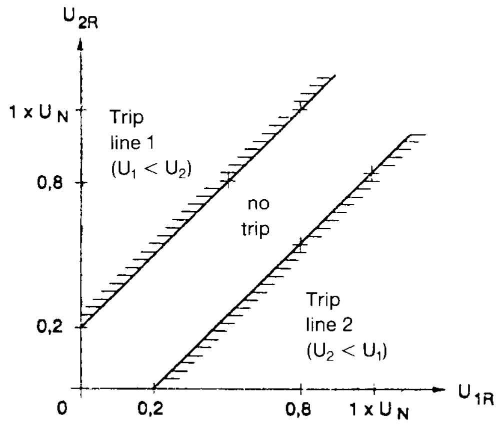


Fig. 10 Tripping characteristic Voltage comparison (shown for the phases R and the setting value volt. diff. = $0.2 \cdot U_N$)

Settings:	
Voltage difference	0.1 to 0.5 U_N in steps of 0.05 U_N
Trip delay	0.00 to 1.0 s in steps of 0.01 s
Reset delay	0.1 to 2.0 s in steps of 0.01 s
Reset ratio	>90%
Accuracy of pick-up value (at f_N)	±2% or ±0.005 U_N
Numbers of phases	1 or 3
Maximum tripping time without delay	≤50 ms
U_{1R}: U_{2R}:	phase R voltage amplitude, voltage channel 1 (line 1) phase R voltage amplitude, voltage channel 2 (line 2)
For 3-phase function: the characteristic is valid accordingly for the phases S and T	

Table 35: Dead machine protection (51, 27)

Features: • Quick separation from network at accidental energization of generator (e.g. at stand-still or on turning gear) • Instant overcurrent measurement • Voltage-controlled overcurrent function e.g. blocked at voltage values >0.85 U_N This function does not exist in the library, it must be combined from the voltage, current and time function	
Settings:	
Voltage	0.01 to 2 U_N in steps of 0.002 U_N
Reset delay	0 to 60 s in steps of 0.01 s
Current	0.02 to 20 I_N in steps of 0.02 I_N
Delay	0.02 to 60 s in steps of 0.01 s

Table 36: 100% Stator earth fault protection (64S)

Features: • Protection of the entire stator winding, including star points, even at standstill. Works also for most of the operating conditions. • Also suitable when 2 earthings (groundings) are in the protection zone • Permanent supervision of the alsostate of the insulation • Based on the earth (ground) voltage displacement principle and calculation of the earth (ground) fault resistance • Alarm and tripping values are entered, resp. measured and displayed in kΩ	
Type of earthings (groundings): • Star point earthing with resistors (requires REX011) • Star point earthing with grounding transformer (requires REX011-1) • Earthing transformers on generator terminals (requires REX011-2)	
Settings:	
Alarm stage	100 Ω to 20 kΩ in steps of 0.1kΩ
Delay	0.2 s to 60 s in steps of 0.1 s
Tripping stage	100 Ω to 20 kΩ in steps of 0.1kΩ
Delay	0.2 s to 60 s in steps of 0.1 s
R_{ES}	400 Ω to 5 kΩ in steps of 0.01kΩ
Number of star points	2
R_{ES}-2. starpoint	900 Ω to 30 kΩ in steps of 0.01kΩ
Reset ratio	110% for setting values of ≤10 kΩ
Accuracy	0.1 kΩ to 10 kΩ: <±10%
Starting time	1.5 s
Functional requirements:	
- max.earthing current	I_0 <20A (recommended I_0 = 5A)
- stator earthing capacity	0.5 µF to 6 µF
- stator earthing resistance R_{PS}	130 Ω to 500 Ω
- stator earthing resistance R_{ES}	700 Ω to 5 k Ω (≥4.5 x R_{PS})
(All values are based on the starpoint side)	
The actual earthing resistances R_{ES} + R_{PS} have to be calculated in accordance with the User’s Guide: The 100% stator earth fault protection function always requires an injection unit type REX010, an injection transformer block type REX011 and a 95% stator earth fault protection function.	

Technical Data Functions (cont'd)

Table 37: Rotor earth fault protection (64R)

Features: • Continuous supervision of the insulation level and calculation of the earthing (grounding) resistance • Alarm and tripping values are entered resp. measured and displayed in kΩ	
Settings:	
Alarm stage	100 Ω to 25 kΩ in steps of 0.1kΩ
Delay	0.2 s to 60 s in steps of 0.1 s
Tripping stage	100 Ω to 25 kΩ in steps of 0.1kΩ
Delay	0.2 s to 60 s in steps of 0.1 s
R_{ER}	900 Ω to 5 kΩ in steps of 0.01kΩ
Coupling capacity	2 μF to 10 μF
Reset ratio	110%
Accuracy	0.1 kΩ to 10 kΩ <10%
Starting time	1.5 s
Functional requirements:	
- total rotor earthing capacity	200 nF to 1μF
- rotor earthing resistance R_{PR}	100 Ω to 500 Ω
- rotor earthing resistance R_{ER}	900 Ω to 5 kΩ
- coupling capacity	4 μF to 10 μ F
- time constant	T = R_{ER}, x C = 3 to 10 ms
The actual earthing resistance $R_{ER} + R_{PR}$ have to be calculated in accordance with the User's Guide. The 100% rotor earth fault protection function always requires an injection unit type REX010 and an injection transformer block type REX011 which are connected to the plant via coupling capacitors.	

Table 38: Pole slip protection (78)

Features:
- Recording the pole wheel movements from 0.2 Hz to 8 Hz
- Differentiation of the pendulum center inside or outside of the generator-transformer block zone by two independent tripping stages
- Adjustable warning angle for pole wheel movements
- Number of slips adjustable before tripping

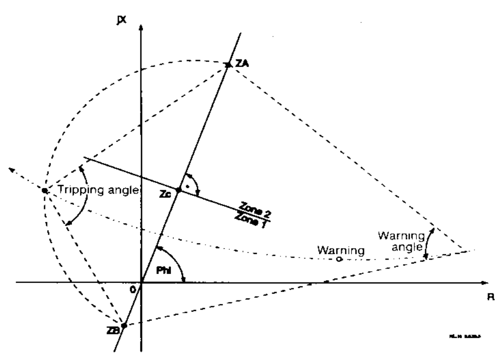


Fig. 11 Characteristic of the function

Settings:	
ZA (system impedance)	0 to 5.0 U_N/I_N in steps of 0.001
ZB (generator impedance)	-5.0 to 0 U_N/I_N in steps of 0.001
ZC (impedance step 1)	0 to 5.0 U_N/I_N in steps of 0.001
Phi	60° to 270° in steps of 1°
warning angle	0° to 180° in steps of 1°

tripping angle	0° to 180° in steps of 1°
n1	0 to 20 in steps of 1
n2	0 to 20 in steps of 1
t-reset	0.5 s to 25 s in steps of 0.01 s

Table 39: Power function (32)

• Measurement of real or apparent power • Protection function based on either real or apparent power measurement • Reverse power protection • Over and underpower • Single, two or three-phase measurement • Suppression of DC components and harmonics in current and voltage • Compensation of phase errors in main and input c.t's and v.t's	
Settings:	
Power pick-up	-0.1 to 1.2 S_N in steps of 0.005 S_N
Characteristic angle	-180° to +180° in steps of 5°
Delay	0.05 to 60 s in steps of 0.01 s
Phase error compensation	-5° to +5° in steps of 0.1°
Rated power S_N	0.5 to 2.5 $U_N \bullet I_N$ in steps of 0.001 $U_N \bullet I_N$
Reset ratio	30% to 170% in steps of 1%
Accuracy of the pick-up setting	±10% of setting or 2% $U_N \bullet I_N$ (for protection c.t.'s) ±3% of setting or 0.5% $U_N \bullet I_N$ (for core-balance c.t.'s)
Max. operating time without intentional delay	70 ms

Table 40: Breaker-failure protection (50BF)

Features • Individual phase current recognition • Single or three-phase operation • External blocking input • Two independent time steps • Remote tripping adjustable simultaneously with retripping or backup tripping • Possibility of segregated activating/deactivating each trip (Redundant trip, retrip, backup trip and remote trip).	
Settings	
Current	0.2 to 5 I_N in steps of 0.01 I_N
Delay t1 (repeated trip)	0.02 to 60 s in steps of 0.01 s
Delay t2 (backup trip)	0.02 to 60 s in steps of 0.01 s
Delay tEFS (End fault protection)	0.02 to 60 s in steps of 0.01 s
Reset time for retrip	0.02 to 60 s in steps of 0.01 s
Reset time for backup trip	0.02 to 60 s in steps of 0.01 s
Pulse time for remote trip	0.02 to 60 s in steps of 0.01 s

Technical Data Functions (cont'd)

Number of phases	1 or 3
Accuracy of pick-up current (at f_N) Reset ratio of current measurement	±15% >85%
Reset time (for power system time constants up to 300 ms and short-circuit currents up to $40 \cdot I_N$)	≤28 ms (with main c.t.s TPX) ≤28 ms (with main c.t.s TPY and current setting ≥1,2 I_N) ≤38 ms (with main c.t.s TPY and current setting ≥0,4 I_N)

Table 41: Disturbance recorder

• Max. 9 c.t./v.t. channels • Max. 16 binary channels • Max. 12 analogue channels of internal measurement values • 12 samples per period (sampling frequency 600 or 720 Hz at a rated frequency of 50/60 Hz) • Available recording time for 9 c.t./v.t.- and 8 binary signals approximately 5 s • Recording initiated by any binary signal, e.g. the general trip signal.	
Data format	EVE
Dynamic range	70 x I_N, 2.2 x U_N
Resolution	12 bits
Settings:	
Recording periods Pre-event Event Post-event	 40 to 400 ms in steps of 20 ms 100 to 3000 ms in steps of 50 ms 40 to 400 ms in steps of 20 ms

Ancillary functions

Table 42: Logic

Logic for 4 binary inputs with the following 3 configurations: 1. OR gate 2. AND gate 3. Bistable flip-flop with 2 set and 2 reset inputs (both OR gates), resetting takes priority
All configurations have an additional blocking input. Provision for inverting all inputs.

Table 43: Delay/integrator

• For delaying pick-up or reset or for integrating 1 binary signal • Provision for inverting the input	
Settings:	
Pick-up or reset time	0 to 300 s in steps of 0.01 s
Integration	yes/no

Table 44: Plausibility check

A plausibility check function is provided for each three-phase current and three-phase voltage input which performs the following: • Determination of the sum and phase sequence of the 3 phase currents or voltages • Provision for comparison of the sum of the phase values with a corresponding current or voltage sum applied to an input • Function blocks for currents exceeding 2 x $I_{N,}$ respectively voltages exceeding 1.2 U_N	
Accuracy of the pick-up setting at rated frequency	±2% I_N (at 0.2 to 1.2 I_N ±2% U_N (at 0.2 to 1.2 U_N
Reset ratio	>90% >95% (at U >0.1 U_N or I >0.1 I_N)
Current plausibility settings: Pick-up differential for sum of internal summation current or between internal and external summation currents	0.05 to 1.00 I_N in steps of 0.05 I_N
Amplitude compensation for summation c.t.	-2.00 to +2.00 in steps of 0.01
Delay	0.1 to 60 s in steps of 0.1 s
Voltage plausibility settings: Pick-up differential for sum of internal summation voltage or between internal and external summation voltages	0.05 to 1.2 U_N in steps of 0.05 U_N
Amplitude compensation for summation v.t.	- 2.00 to +2.00 in steps of 0.01
Delay	0.1 to 60 s in steps of 0.1 s

Table 45: Run-time supervision

The run-time supervision feature enables checking the opening and closing of all kinds of breakers (circuit-breakers, isolators, ground switches...). Failure of a breaker to open or close within an adjustable time results in the creation of a corresponding signal for further processing.	
Settings	
Setting time	0 to 60 s in steps of 0.01 s
Accuracy of run time supervision	±2 ms

Technical Data Functions (cont'd)

Table 46: Accuracy of the metering function UIfPQ and three-phase measuring module (including input voltage and input current c.t.)

Input variable	Accuracy		Conditions
	Core balance c.t.s with error compensation	Protection c.t.s without error compensation	
Voltage	±0.5% U_N	±1% U_N	0.2 to 1.2 U_N $f = f_N$
Current	±0.5% I_N	±2% I_N	0.2 to 1.2 I_N $f = f_N$
Real power	±0.5% S_N	±3% S_N	0.2 to 1.2 S_N 0.2 to 1.2 U_N 0.2 to 1.2 I_N $f = f_N$
Apparent power	±0.5% S_N	±3% S_N	
Power factor	±0.01	±0.03	$S = S_N$, $f = f_N$
Frequency	±0.1% f_N	±0.1% f_N	0.9 to 1,1 f_N 0.8 to 1,2 U_N

$S_N = \sqrt{3} \cdot U_N \cdot I_N$ (three-phase)
$S_N = 1/3 \cdot \sqrt{3} \cdot U_N \cdot I_N$ (single-phase)

Wiring diagram

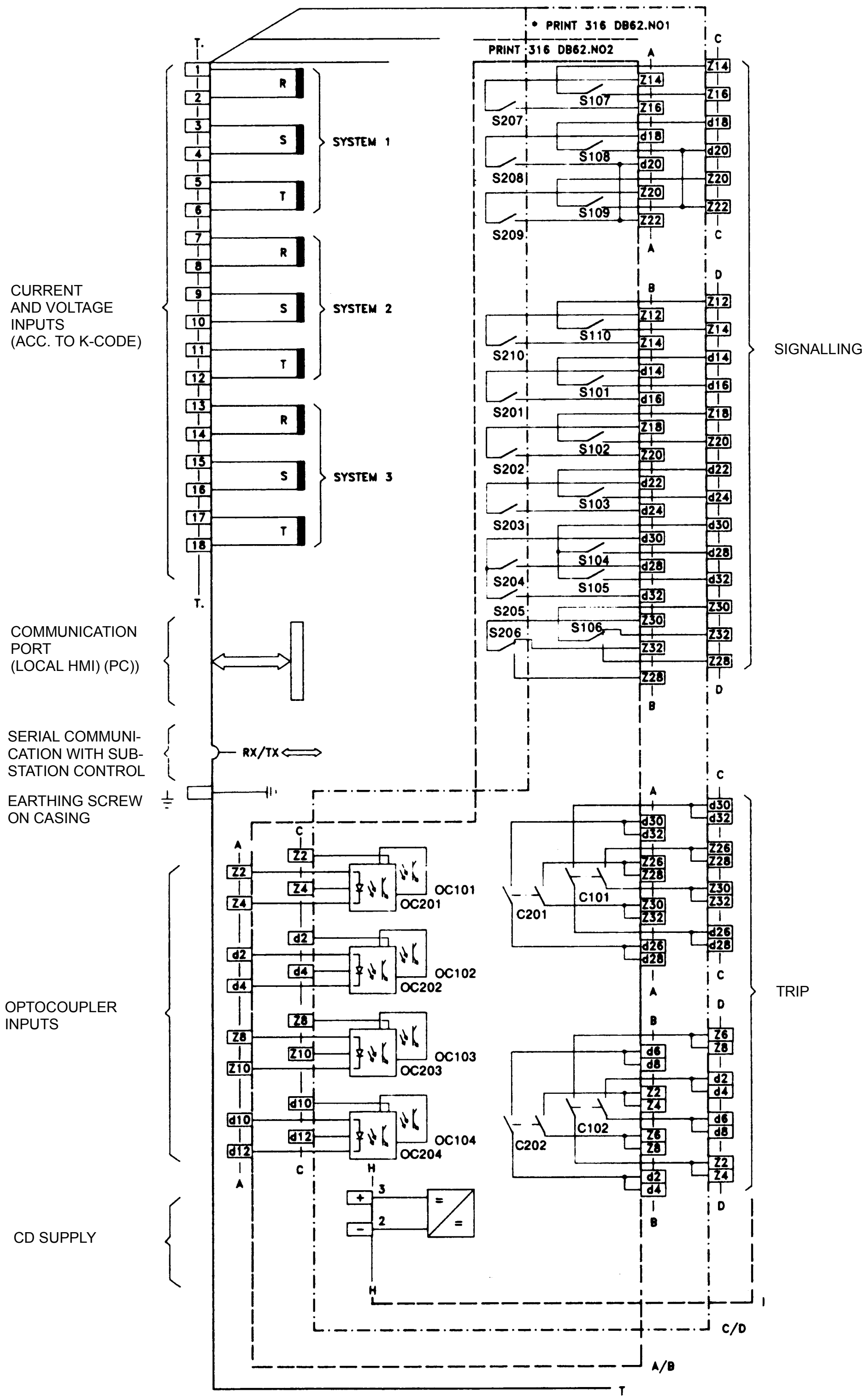


Fig. 12 Typical wiring diagram of REG316*4 in size N1 casing with two input/output units 316DB62

Ordering

Specify:

- Quantity
- Ordering number
  (Basic version ordering number + stand alone unit ordering number, or only stand alone unit ordering number)
- ADE code + key (see table below)

The following basic versions can be ordered:

Stand alone units REG316*4 with built-in HMI (see table below) HESG448750M0004

Table 47: REG316*4 basic versions

Order No.	Relay ID code	OCDT (REF)	OCDT Dir	OC Inv Dir	VTDT	VTDT(EFStat)	VTDT(EFrot)	VTInst	>I<U	Freq	df/dt	U/f(inv)	Vbal	Power	LossEx	UZ	Polsl	DiffT	DiffG	EFStat100	EFRot100	Basic-SW
HESG448750M0004	A*B0C*D*U0K65E*I*F*J*Q*V*R*W*Y* N*M*SR100 T***																	X	X			X
	A*B0C*D0U*K63E*I*F*J*Q*V*R*W*Y* N*M*SR200 T***		X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X			X
	A*B*C0D0U*K66E*I*F*J*Q*V*R*W*Y* N*M*SR300 T***	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X					X
	A*B0C0D0U*K64E*I*F*J*Q*V*R*W*Y* N*M*SR400 T***	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					X
	A*B*C*D0U*K61E*I*F*J*Q*V*R*W*Y* N*M*SR500 T***	X	X	X	X	X	X	X		X	X	X	X	X	X		X	X	X			X
	A*B*C0D0U*K62E*I*F*J*Q*V*R*W*Y* N*M*SR600 T***	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					X
	A*B0C0D0U*K67E*I*F*J*Q*V*R*W*Y* N*M*SR700 T***	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X			X	X	X

Legend

*	required sub-codes in Table 48
OCDT(REF)	definite time over current function for high-impedance differential protection
OCDT Dir	Directional definite time overcurrent protection
OC Inv Dir	Directional inverse time overcurrent function
VTDT	definite time voltage function
VTDT (EFStat)	definite time voltage function for stator ground fault protection
VTDT (EFrot)	definite time voltage function for rotor ground fault protection
VTinst	instantaneous overvoltage function with peak value evaluation
>I<U	combined overcurrent undervoltage
Freq.	frequency protection (minimum, maximum)
df/dt	rate-of-change of frequency protection
U/f(inv)	overexcitation protection with inverse time delay
Vbal	voltage balance protection
Power	power function
LossEx	minimum reactance protection
UZ	minimum impedance protection
Polsl	pole slip protection
DiffT	transformer differential protection
DiffG	generator differential protection
EFStat100	100% stator ground fault protection
EFRot100	100% rotor ground fault protection

Basic-SW	Basic software including the following functions:
OCDT	definite time overcurrent
OCInst	overcurrent protection with peak value evaluation
IoInv	inverse time ground fault current
TH	thermal overload
OCInv	inverse time overcurrent protection
Ucheck	voltage plausibility (only if 3-phase voltage is available)
Icheck	current plausibility
UIfPQ	metering (only if at least 1 voltage is available)
MeasMod	three-phase measuring module
Delay	delay/integrator
Count	counter
Logic	logic interconnection
NPSDT	negative phase sequence current protection
NPSInv	inverse time negative phase sequence current protection
OLStat	stator overload
OLRot	rotor overload
CAP316	project-specific control logic
DRec	disturbance recorder
BFP	breaker-failure protection
RTS	run-time supervision

All the functions of the basic version can be applied in any combination providing the maximum capacity of the processor and the number of analogue channels is not exceeded.

Ordering (cont'd)

Table 48: Definitions of the relay ID codes in Table 47

Sub code		Significance	Description	Remarks
A-	A0 A1 A2 A5	none 1A 2A 5A	rated current	state
B-	B0 B1 B2 B5	none 1A 2A 5A	rated current	state
C-	C0 C1 C2 C5	none 1A 2A 5A	rated current	state
D-	D0 D1 D2 D5	none 1A 2A 5A	rated current	state
U-	U0 U1 U2	none 100 V AC 200 V AC	rated voltage	state
K-	K61	3 CTs (3ph Code A-) 3 CTs (3ph Code C-) 1 MT (1ph Code B-) 1 VT (1ph Code U-) 1 VT (1ph Code U-)	CT = current transformer VT = voltage transformer MT = metering transformer	see previous table
	K62	3 CTs (3ph Code A-) 1 MT (1ph Code B-) 1 VT (1ph Code U-) 1 VT (1ph Code U-) 3 VTs (3ph delta Code U-)		
	K63	3 CTs (3ph Code A-) 3 CTs (3ph Code C-) 3 VTs (3ph delta Code U-)		
	K64	3 CTs (3ph Code A-) 3 VTs (3ph delta Code U-) 3 VTs (3ph delta Code U-)		
	K65	3 CTs (3ph Code A-) 3 CTs (3ph Code C-) 3 CTs (3ph Code D-)		
	K66	3 CTs (3ph Code A-) 3 MTs (3ph Code B-) 3 VTs (3ph delta Code U-)		
	K67	3 CTs (3ph Code A-) 1 VT (1ph Code U-) 1 VT (1ph Code U-) 1 VT (1ph Code U-) 3 VTs (special for 100% EFP)		
E-	E1	8 optocoupler 6 signal. relays 2 command relays 8 LED's	1. binary input/output unit Type 316DB61	see previous table
	E2	4 optocoupler 10 signal. relays 2 command relays 8 LED's	1.binary input/output unit Type 316DB62	
	E3	14 optocoupler 8 signal. relays 8 LED's	1.binary input/output unit Type 316DB63	

I-	I3 I4 I5 I9	82 to 312 V DC 36 to 75 V DC 18 to 36 V DC 175 to 312 V DC	1. binary input/output unit optocoupler input voltage	state
F-	F0 F1 F2 F3	none 8 optocoupler 6 signal. relays 2 command relays 8 LED's 4 optocoupler 10 signal. relays 2 command relays 8 LED's 14 optocoupler 8 signal. relays 8 LED's	 2. binary input/output unit Type 316DB61 2. binary input/output unit Type 316DB62 2. binary input/output unit Type 316DB63	 see previous table
J-	J0 J3 J4 J5 J9	none 82 to 312 V DC 36 to 75 V DC 18 to 36 V DC 175 to 312 V DC	2. binary input/output unit optocoupler input voltage	state
Q-	Q0 Q1 Q2 Q3	none 8 optocoupler 6 signal. relays 2 command relays 4 optocoupler 10 signal. relays 2 command relays 14 optocoupler 8 signal. relays	 3. binary input/output unit Type 316DB61 3. binary input/output unit Type 316DB62 3. binary input/output unit Type 316DB63	 see previous table
V-	V0 V3 V4 V5 V9	none 82 to 312 V DC 36 to 75 V DC 18 to 36 V DC 175 to 312 V DC	 3. binary input/output unit optocoupler input voltage	state
R-	R0 R1 R2 R3	none 8 optocoupler 6 signal. relays 2 command relays 4 optocoupler 10 signal. relays 2 command relays 14 optocoupler 8 signal. relays	 4. binary input/output unit Type 316DB61 4. binary input/output unit Type 316DB62 4. binary input/output unit Type 316DB63	 see previous table
W-	W0 W3 W4 W5 W9	none 82 to 312 V DC 36 to 75 V DC 18 to 36 V DC 175 to 312 V DC	 4. binary input/output unit optocoupler input voltage	 state
Y-	Y0 Y1 Y2 Y3 Y4[1)]	no comm. protocol SPA IEC 60870-5-103 LON MVB (part of IEC 61375)	Interbay bus protocol	

Ordering (cont'd)

N-	N1 N2	casing width 225.2 mm casing width 271 mm		see previous table
M-	M1 M5[1)]	Semi-flush mounting Surface mounting, standard terminals		Order M1 and separate assembly kit for 19" rack mounting
S-	SR000 to SS990	basic versions REG316*4		see previous table
T-	T0000 T0001x to T9999x T0990x	none FUPLA logic FUPLA logic written by others	Customer-specific logic x = version of the FUPLA logic	Defined by ABB Switzerland Ltd

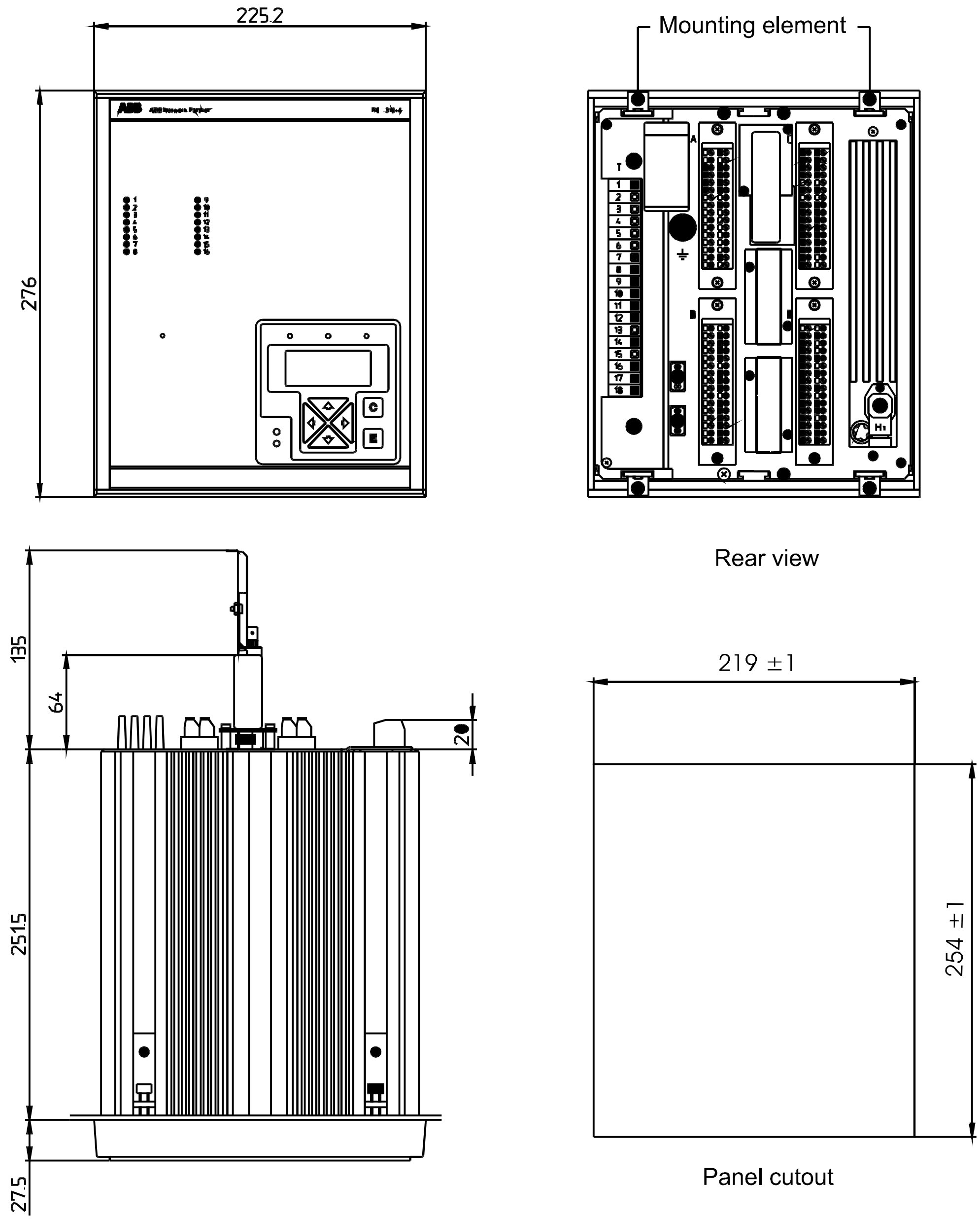
[1)] The MVB interface (for interbay or process bus) is not applicable for the surface-mounted version

The order number has been defined for the basic version as above und the required accessories can be ordered according to the following Table.

Table 49: Accessories

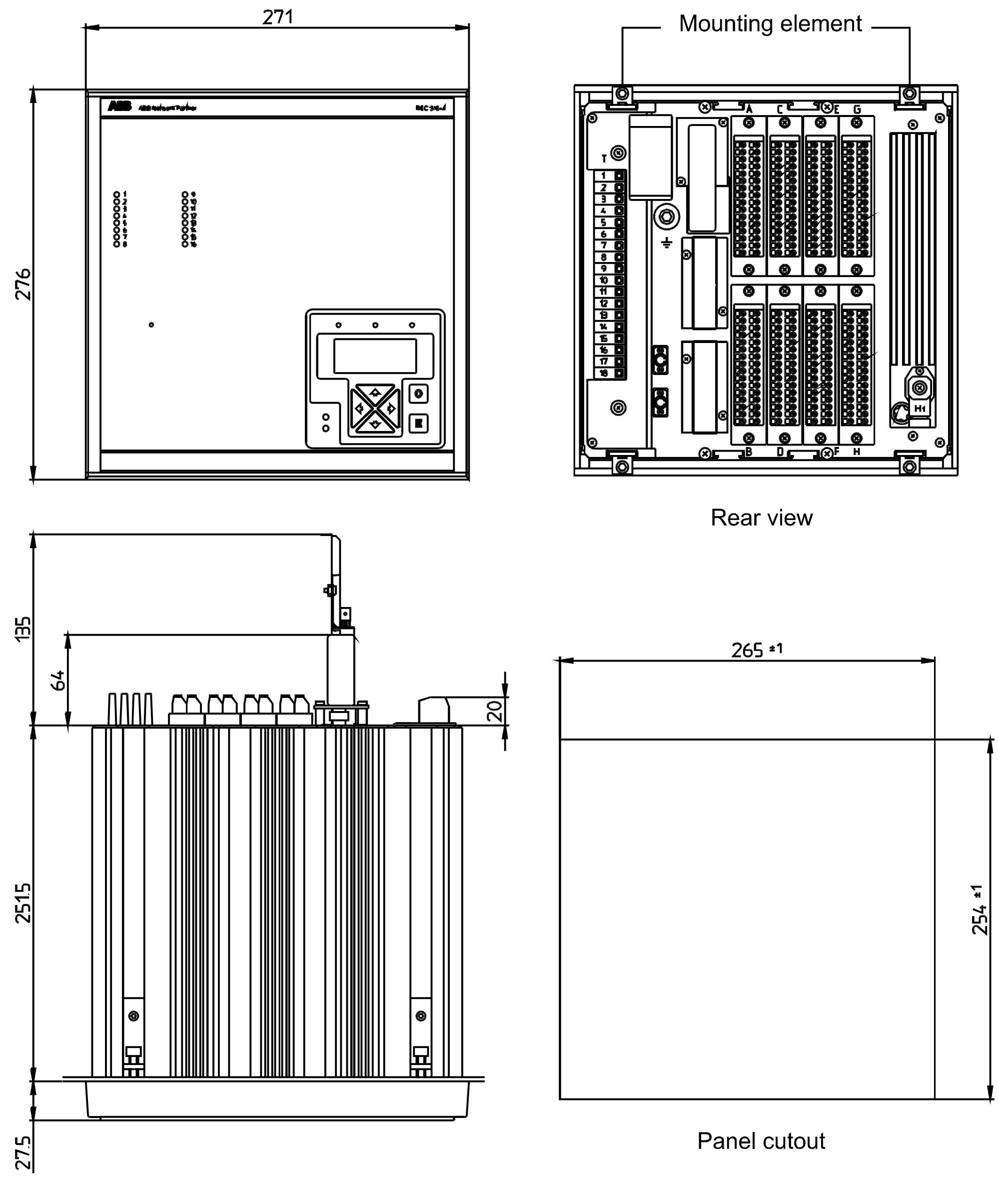
Assembly kits					
Item Description					Order No.
19"-mounting plate for hinged frames, light-beige for use with:					
1REG316*4 (size 1 casing)					HESG324310P1
2 REG316*4 (size 1 casing)					HESG324310P2
1 REG316*4 (size 2 casing					HESG324351P1
REG316*4 size 1 surface mounting kit					HESG448532R0001
REG316*4 size 2 surface mounting kit					HESG448532R0002
PCC card interface					
Type	Protocol	Connector	Optical fibre*	Gauge **	Order No.
For interbay bus: PCCLON1 SET	LON	ST (bajonet)	G/G	62.5/125	HESG448614R0001
500PCC02	MVB	ST (bajonet)	G/G	62.5/125	HESG448735R0231
For process bus: 500PCC02	MVB	ST (bajonet)	G/G	62.5/125	HESG 448735R0232
RS232C interbay bus interface					
Type	Protocol	Connector	Optical fibre*	Gauge **	Order No.
316BM61b	SPA	ST (bajonet)	G/G	62.5/125	HESG448267R401
316BM61b	IEC 60870-5-103	SMA (screw)	G/G	62.5/125	HESG448267R402
316BM61b	SPA	Plug/plug	P/P		HESG448267R431
* receiver Rx / transmitter Tx, G = glass, P = plastic **optical fibre conductor gauge in µm					
Human machine interface					
Type		Description			Order No.
CAP2/316		Installation CD	German/English		1MRB260030M0001
** Unless expressly specified the latest version is supplied.					
Optical fibre PC connecting cable					
Type					Order No.
500OCC02 communication cable for device with LDU					1MRB380084-R1
Disturbance recorder evaluation program					
Type, description					Order No.
REVAL English	3½“-Disk				1MRK000078-A
REVAL German	3½“-Disk				1MRK000078-D
WINEVE	English/German				Basic version
WINEVE	English/German				Full version
SMS-BASE Module for RE.316*4					
					Order No.
SM/RE.316*4					HESG448645R1

Dimensioned drawings



T = Instr. Transformer inputs
cross section = 4 mm^2
A to D = Commands, input and output signals
cross section = 1.5 mm^2
H1 = Auxiliary voltage

Fig. 13 Semi-flush mounting, rear connections. Size N1 casing.



T = Instr. Transformer inputs
cross section = 4 mm²
A to H = Commands, input and output signals
cross section = 1.5 mm²
H1 = Auxiliary voltage

Fig. 14 Semi-flush mounting, rear connections. Size N2 casing

Dimensioned drawings (cont'd)

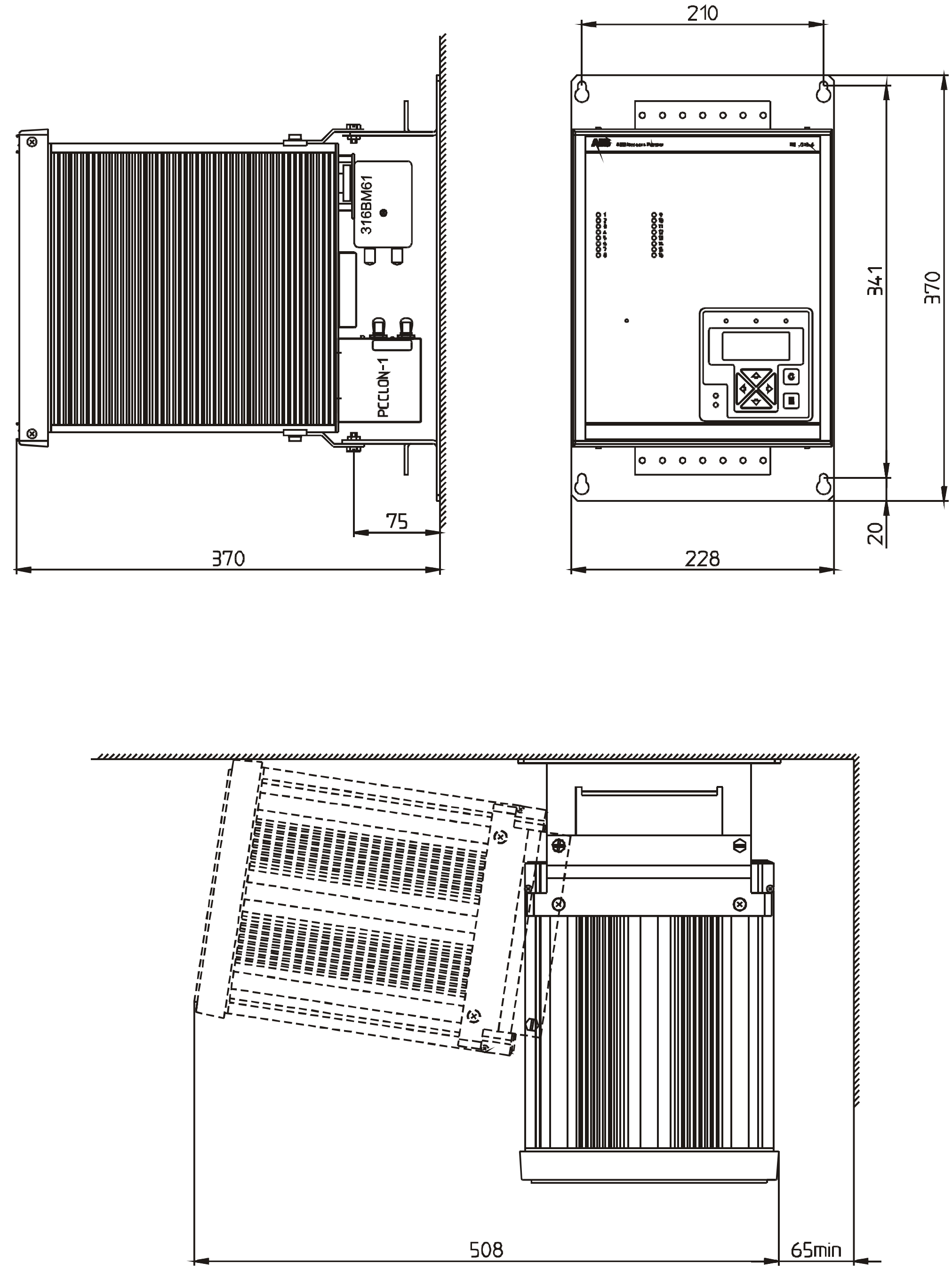


Fig. 15 Surface mounting, casing able to swing to the left, rear connections. Size N1 casing

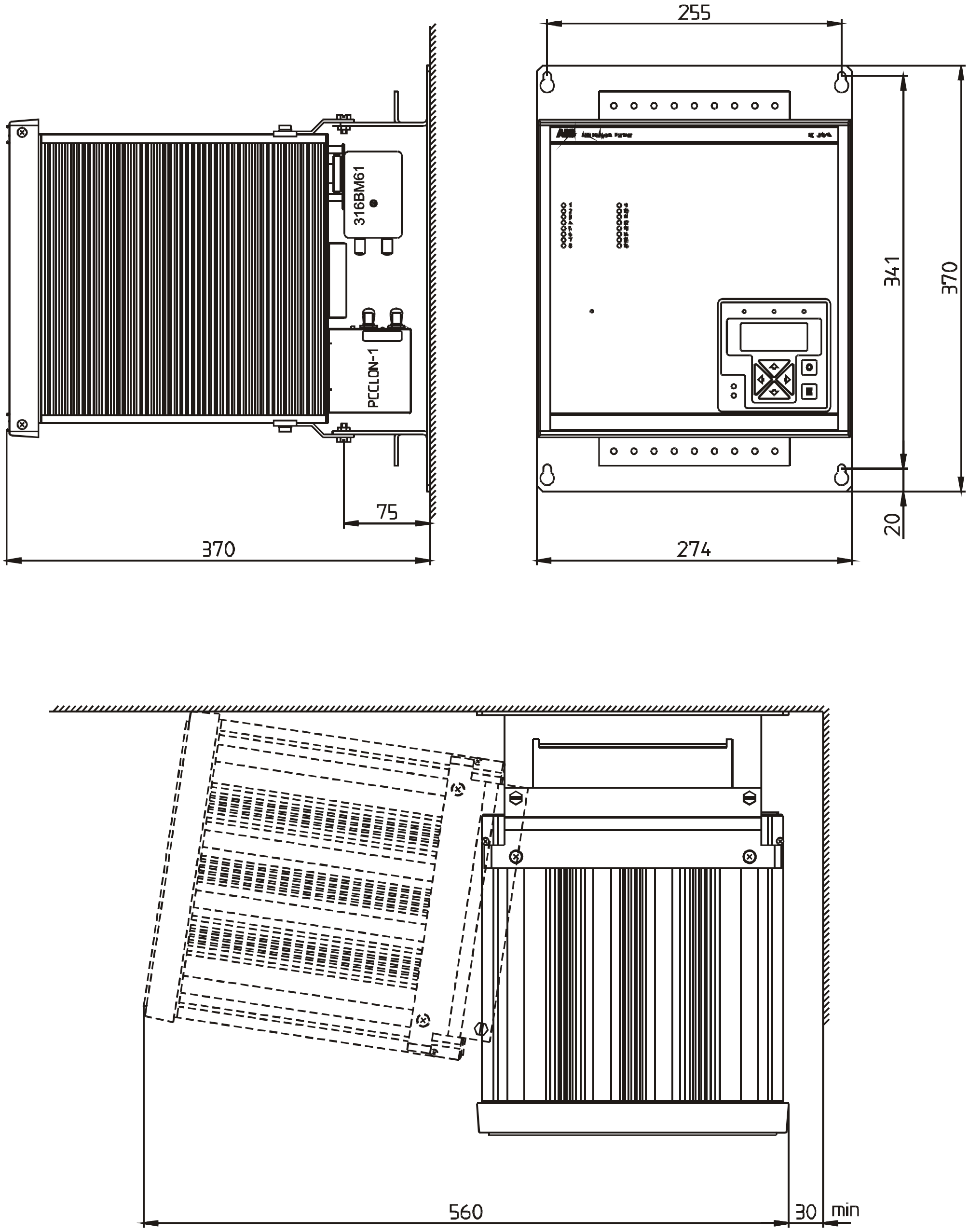


Fig. 16 Surface mounting, casing able to swing to the left, rear connections. Size N2 casing

Example of an order

- Rated current 1 A, rated voltage 100 V_{AC}
- 3 phase voltages, 6 phase currents
- 110 V DC aux. supply
- 4 heavy duty relays (3 tripping, 1 CB closing) 20 signalling relays
- 8 opto-coupler inputs (110 V_{DC})
- 1 relay for 19" rack mounting
- Communication with the station control system (e.g. LON)
- Operator program on CD

The corresponding order is as follows:

- 1 REG316*4, HESG448750M0004
- 110 V DC aux. supply
- Opto-coupler input voltage 110 V_{DC}
- Rated current 1 A
- Rated voltage 100 V AC
- 1 mounting kit HESG324310P1
- 1 PC card LON
- 1 CD, RE.216 / RE.316*4 1MRB260030M0001
- 1 PC connecting cable (if not already available) 1MRB380084-R1

Alternatively, the relay ID code may be given instead. In this case the order would be:

- 1 REG316*4, A1B0C1D0U1K63E2I-3F2J3Q0V0R0W0Y1N1M1SR200T0
- 1 mounting kit HESG324310P1
- 1 CD, RE.216 / RE.316*4 1MRB260030M0001
- 1 PC card HESG448614R1
- 1 PC connecting cable (if not already available) 1MRB380084-R1

Relay ID codes are marked on all relays. The significance of the sub-codes can be seen from Table 48.

References

Operating instructions (printed)	1MRB520049-Uen
Operating instructions (CD)	1MRB260030M0001
Reference list REG316/REG316*4	1MRB520210-Ren
CAP316 Data sheet	1MRB520167-Ben
REX010/011 Data sheet	1MRB520123-Ben
Test Set XS92b Data sheet	1MRB520006-Ben
SigTOOL Data sheet	1MRB520158-Ben
RIO580 Data sheet	1MRB520176-Ben

The Operating instructions are available in English or German.
(Please state when ordering).

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