

REG316*4

1MRB520049-Uen
Edition July 2002

Numerical Generator Protection

Operating Instructions



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Baden

6th Edition

Applies for software version V6.3

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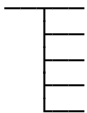
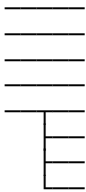
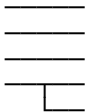
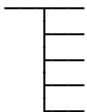
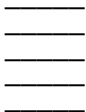
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1. INTRODUCTION

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1. INTRODUCTION

1.1. *General*

The numerical generator protection scheme REG 316*4 is one of the new generation of fully digital protection systems, i.e. the analogue-to-digital conversion of the measured input variables takes place immediately after the input transformers and the resulting digital signals are processed exclusively by programmed micro-processors.

Within the PYRAMID® system for integrated control and protection, REG 316*4 represents one of the compact generator protection units.

Because of its compact design, the use of only a few different hardware units, modular software and continuous self-monitoring and diagnostic functions, the REG 316*4 scheme optimally fulfils all the demands and expectations of a modern protection scheme with respect to efficient economic plant management and technical performance.

The AVAILABILITY — the ratio between fault-free operating time and total operational life — is certainly the most important requirement a protection device has to fulfil. As a result of continuous monitoring, this ratio in the case of REG 316*4 is almost unity.

Operation, wiring and compactness of the protection are the essence of SIMPLICITY thanks to the interactive, menu-controlled man/machine communication (HMC) program. Absolute FLEXIBILITY of the REG 316*4 scheme, i.e. adaptability to a specific primary system or existing protection (retrofitting), is assured by the supplementary functions incorporated in the software and by the ability to freely assign inputs and outputs via the HMC.

Decades of experience in the protection of generators have gone into the development of the REG 316*4 to give it the highest possible degree of RELIABILITY, DISCRIMINATION and STABILITY. Digital processing of all the signals endows the scheme with ACCURACY and constant SENSITIVITY throughout its useful life.

The designation “RE. 316*4” is used in the following sections of these instructions whenever the information applies to the entire series of devices.

1.2. **Application**

The REG 316*4 numerical generator protection has been designed for the high-speed discriminative protection of small and medium size generators. It can be applied to units with or without step-up transformer in power utility or industrial power plants.

REG 316*4 places relatively low requirements on the performance of c.t.'s and v.t.'s and is independent of their characteristics.

1.3. **Main features**

REG 316*4's library of protection functions includes the following:

• generator differential	(Diff-Gen)
• transformer differential	(Diff-Transf)
• definite time over and undercurrent	(Current-DT)
• provision for inrush blocking	
• peak value overcurrent	(Current-Inst)
• voltage-controlled overcurrent	(Imax-Umin)
• inverse time overcurrent	(Current-Inv)
• directional definite time overcurrent protection	(DirCurrentDT)
• directional inverse time overcurrent protection	(DirCurrentInv)
• definite time NPS	(NPS-DT)
• inverse time NPS	(NPS-Inv)
• definite time over and undervoltage	(Voltage-DT)
• peak value overvoltage	(Voltage-Inst)
• underimpedance	(Underimped)
• underreactance	(MinReactance)
• power protection	(Power)
• stator overload	(OLoad-Stator)
• rotor overload	(OLoad-Rotor)
• frequency	(Frequency)
• rate-of-change frequency protection	(df/dt)
• overexcitation	(Overexcitat)
• inverse time overexcitation	(U/f-Inv)
• voltage comparison	(Voltage-Bal)
• overtemperature	(Overtemp)
• 100 % stator ground fault	(Stator-EFP)
• 100 % rotor ground fault	(Rotor-EFP)
• pole slipping	(Pole-Slip)

- inverse time ground fault overcurrent (I0-Invers)
- breaker failure protection (BreakerFailure)
- supplementary logic functions such as
 - supplementary user logic programmed using CAP316 (function plan programming language FUPLA). This requires systems engineering.
 - logic
 - timers
 - metering
 - debounce.

The following measuring and monitoring functions are also available:

- single-phase measuring function UlfPQ
- three-phase measurement module
- three-phase current plausibility
- three-phase voltage plausibility
- disturbance recorder.

The scheme includes an event memory.

The allocation of the opto-coupler inputs, the LED signals and the auxiliary relay signal outputs, the setting of the various parameters, the configuration of the scheme and the display of the events and system variables are all performed interactively using the menu-driven HMC (man/machine communication).

REG 316*4 is equipped with serial interfaces for the connection of a local control PC and for remote communication with the station control system.

REG 316*4 is also equipped with continuous self-monitoring and self-diagnostic functions. Suitable testing devices (e.g. test set XS92b) are available for quantitative testing.

REG 316*4 can be semi-flush or surface mounted or can be installed in an equipment rack.

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2. DESCRIPTION OF HARDWARE

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2. DESCRIPTION OF HARDWARE

2.1. Summary

The hardware of the digital protection scheme RE. 316*4 comprises 4 to 8 plug-in units, a connection unit and the casing:

•	Input transformer unit		Type 316GW61
•	A/D converter unit		Type 316EA62
		or	Type 316EA63
•	A/D converter unit		Type 316EA62
•	Main processor unit		Type 316VC61a
		or	Type 316VC61b
•	1 up to 4 binary I/O units		Type 316DB61
		or	Type 316DB62
		or	Type 316DB63
•	Auxiliary supply unit		Type 316NG65
•	Connection unit		Type 316ML61a
		or	Type 316ML62a
•	Casing and terminals for analogue signals and connectors for binary signals.		

The A/D converter Type 316EA62 or 316EA63 is only used in conjunction with the longitudinal differential protection and includes the optical modems for transferring the measurements to the remote station.

Binary process signals are detected by the binary I/O unit and transferred to the main processor which processes them in relation to the control and protection functions for the specific project and then activates the output relays and LED's accordingly.

The analogue input variables are electrically insulated from the electronic circuits by the screened windings of the transformers in the input transformer unit. The transformers also reduce the signals to a suitable level for processing by the electronic circuits. The input transformer unit provides accommodation for nine transformers.

Essentially the main processor unit 316VC61a or 316VC61b comprises the main processor (80486-based), the A/D converter unit, the communication interface control system and 2 PCMCIA slots.

Binary process signals, signals pre-processed by the control logic, events, analogue variables, disturbance recorder files and device control settings can be transferred via the communication interface to the station control room. In the reverse direction, signals to the control logic and for switching sets of parameter settings are transferred by the station control system to the protection.

RE. 316*4 can be equipped with one up to four binary I/O units.

There are two tripping relays on the units 316DB61 and 316DB62, each with two contacts and according to version either:

8 opto-coupler inputs and 6 signalling relays
or 4 opto-coupler inputs and 10 signalling relays.

The I/O unit 316DB63 is equipped with 14 opto-coupler inputs and 8 signalling relays.

The 16 LED's on the front are controlled by the 316DB6. units located in slots 1 and 2.

2.2. Mechanical design

2.2.1. Hardware versions

RE. 316*4 is available in a number of different versions which are listed in the [data sheet](#) under "Ordering information".

2.2.2. Construction

The RE. 316*4 is 6 U standard units high (U = 44.45 mm) and either 225 mm (Order code N1) or 271 mm wide (Order code N2). The various units are inserted into the casing from the rear (see Fig. 12.3) and then screwed to the cover plate.

2.2.3. Casing and methods of mounting

The casing is suitable for three methods of mounting.

Semi-flush mounting

The casing can be mounted semi-flush in a switch panel with the aid of four fixing brackets. The dimensions of the panel cut-out can be seen from the [data sheet](#). The terminals are located at the rear.

Installation in a 19" rack

A mounting plate with all the appropriate cut-outs is available for fitting the protection into a 19" rack (see [Data Sheet](#)). The terminals are located at the rear.

Surface mounting

A hinged frame (see [Data Sheet](#)) is available for surface mounting. The terminals are located at the rear.

2.2.4. Front of the protection

A front view of the protection and the functions of the frontplate elements can be seen from [Fig. 12.2](#).

A reset button is located behind the frontplate which serves three purposes:

- resetting the tripping relays and where they are configured to latch, also the signalling relays and LED's and deleting the distance protection display when running the control program

- resetting of error messages resulting from defects detected by the self-monitoring or diagnostic functions (short press)
- resetting the entire protection (warm start, press for at least ten seconds) following the detection of a serious defect by the self-monitoring or diagnostic functions.

These control operations can also be executed using the local control unit on the front of the device. Should the latter fail, the reset button can be pressed using a suitable implement through the hole in the frontplate.

2.2.5. *PC connection*

In order to set the various parameters, read events and measurements of system voltages and currents and also for diagnostic and maintenance purposes, a personal computer (PC) must be connected to the optical serial interface ([Fig. 12.2](#)).

2.2.6. *Test facilities*

A RE. 316*4 protection can be tested using a test set Type XS92b.

2.3. *Auxiliary supply unit*

The auxiliary supply unit 316NG65 derives all the supply voltages the protection requires from the station battery. Capacitors are provided which are capable of bridging short interruptions (max. 50 ms) of the input voltage. The auxiliary supply unit is protected against changes of polarity.

In the event of loss of auxiliary supply, the auxiliary supply unit also generates all the control signals such as re-initialisation and blocking signals needed by all the other units.

The technical data of the auxiliary supply unit are to be found in the [data sheet](#).

2.4. *Input transformer unit*

The input transformer unit 316GW61 serves as input interface between the analogue primary system variables such as currents and voltages and the protection. The mounting plate of the unit can accommodate up to nine c.t's and v.t's. The shunts across the secondaries of the c.t's are also mounted in the input transformer unit.

The input transformers provide DC isolation between the primary system and the electronic circuits and also reduce (in the case of the c.t's, with the aid of a shunt) the voltage and current signals to a suitable level for processing by the A/D converters. Thus the input transformer unit produces voltage signals at its outputs for both current and voltage channels.

The c.t's and v.t's actually fitted in the input transformer unit vary according to version. Further information can be obtained from the [data sheet](#).

2.5. *Main processor unit*

The main processor runs the control and protection algorithms as determined by the particular settings. It receives its data from the A/D converter unit and the I/O unit. The results computed by the algorithms are transferred either directly or after further logical processing to the binary I/O unit.

A 80486-based microprocessor is used in the main processor unit 316VC61a or 316VC61b. The samples taken by the A/D converter are pre-processed by a digital signal processor (DSP). The interfaces for connecting an HMI PC and for communication with the station control system (SPA, IEC60870-5-103) are included. A PCMCIA interface with two slots facilitates connection to other bus systems such as LON and MVB. The flash EPROM's used as program memory enable the software to be downloaded from the PC via the port on the front.

A self-monitoring routine runs in the background on the main processor. The main processor itself (respectively the correct operation of the program) is monitored by a watchdog.

2.6. *Binary I/O unit*

The binary I/O unit 316DB6. enables binary signals received via opto-couplers from station plant to be read and tripping and other signals to be issued externally.

All the input and output units provide electrical insulation between the external signalling circuits and the internal electronic circuits.

The I/O units in slots 1 and 2 also control the statuses of 8 LED's each on the frontplate via a corresponding buffer memory.

The numbers of inputs and outputs required for the particular version are achieved by fitting from one to four binary I/O units. The relationship between the versions and the number of I/O units is given in the [data sheet](#).

The opto-coupler inputs are adapted to suit the available input voltage range by choice of resistor soldered to soldering posts. This work is normally carried at the works as specified in the order.

The technical data of the opto-coupler inputs and the tripping and signalling outputs can be seen from the [data sheet](#).

2.7. *Interconnection unit*

The wiring between the various units is established by the inter-connecting unit 316ML62a (width 271 mm) or 316ML61a (width 225 mm). It is located inside the housing behind the frontplate and carries the connectors and wiring needed by the individual units.

In addition, the interconnection unit includes the connections to the local control unit, the reset button and 16 LED's for status signals.

2.8. **Injection unit REX 010**

The injection unit Type REX 010 provides the power supply for the injection transformer block Type REX 011. The injection transformer block generates the signals needed for the 100 % stator and rotor ground fault protection schemes. The signals all have the same waveform (see Fig. 2.6).

The injection unit is installed in an REG 316*4 casing and therefore the mechanical and general data are the same as specified for the REG 316*4. Three versions of the injection unit with the designations U1, U2 and U3 are available for the following station battery voltages:

Battery voltage	Tolerance	Output
U1: 110 or 125 V DC	+10% / -20%	110 V or 125 V, 1.1 A
U2: 110; 125; 220; 250V DC	88...312 V DC	96 V, 1 A
U3: 48; 60; 110 V DC	36...140 V DC	96 V, 1 A

Versions U2 and U3 operate with a DC/DC converter.

The frequency of the injection voltage which corresponds precisely to $\frac{1}{4}$ of the rated frequency of 50 Hz or 60 Hz can be selected by positioning a plug-in jumper on PCB 316AI61. The frequency is then 12.5 Hz in position X12 and 15.0 Hz in position X11.

Controls and signals:

- Green LED READY:
Auxiliary supply switched on
- Red LED OVERLOAD:
The internal protection circuit has picked up and injection is interrupted.
- Yellow LED DISABLED:
Injection is disabled on the switch on the frontplate or via the opto-coupler input.

Only the green LED is lit during normal operation.

- Toggle switch ENABLE, DISABLE:
Position 0 : Injection enabled.
Position 1 : Injection disabled.

- Reset button RESET:

The protection circuit latches when it operates and is reset by this button upon which the red LED extinguishes.

The protection circuit guards against excessive feedback from the generator and interrupts the injection for zero-crossing currents ≥ 5 A.

The protection circuit will not reset, if the fault that caused it to pick up is still present. In such a case, switch off the supply and check the external wiring for short-circuits and open-circuits.

- Opto-coupler input:

This has the same function as the reset button and can also be used to disable injection. The latter occurs when the input is at logical '1'. Injection is resumed as soon as the input returns to logical '0'.

Important:

Ensure that the injection voltage is switched off before carrying out any work at the star-point. The toggle switch on the front of the injection unit REX 010 must be set to "disable" and the yellow LED "disabled" must be lit.

The input voltage, the injection frequency and the opto-coupler voltage must be specified in the customer's order and are then set in the works prior to delivery.

There are no controls inside the unit which have to be set by the user.

Supply failure

If the green LED 'READY' is not lit in the case of version U1 although the correct auxiliary supply voltage is applied, check and if necessary replace the fuse on the supply unit 316NE61. The fuse holder is located at the rear next to the auxiliary supply terminals.

Fuse type:	cartridge	5 x 20 mm
	2 A slow	

Faulty U2 and U3 units must be returned to the nearest ABB agent or directly to ABB Switzerland Ltd., Baden, Switzerland.

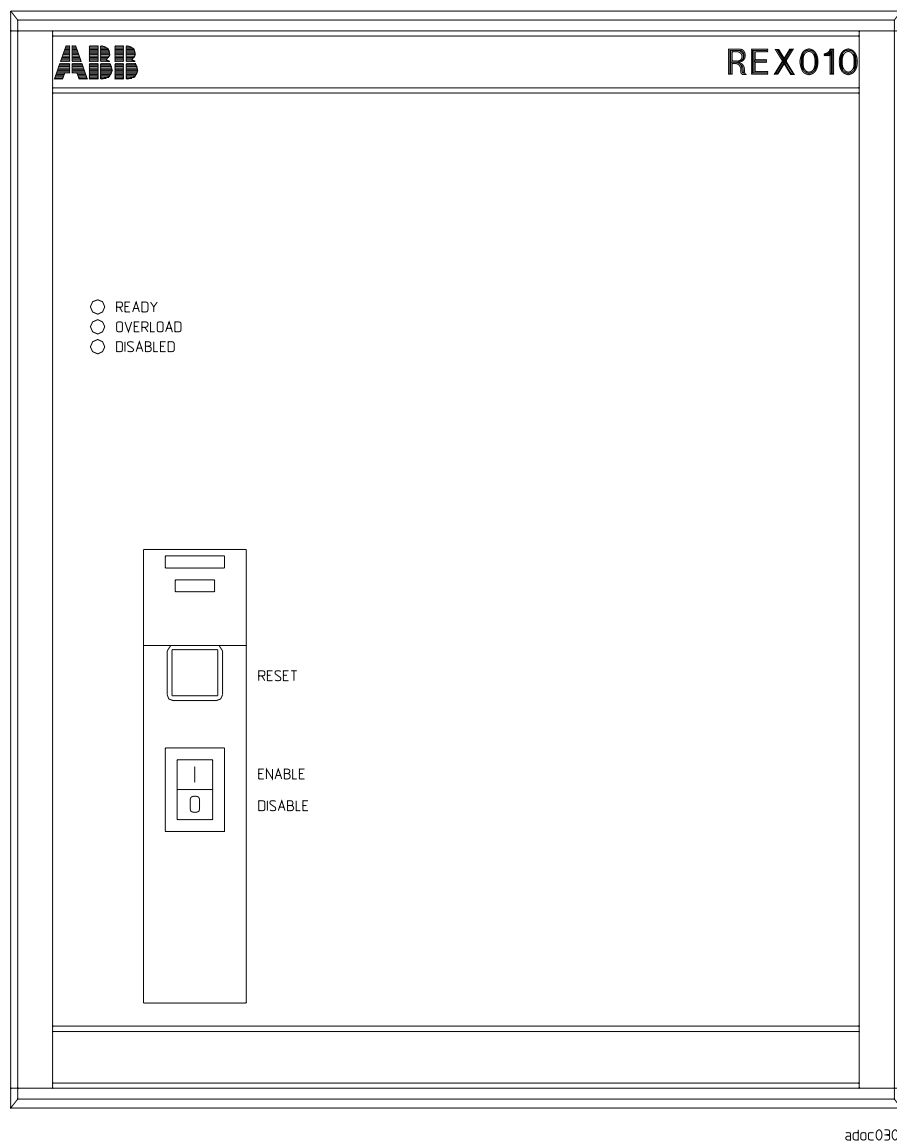
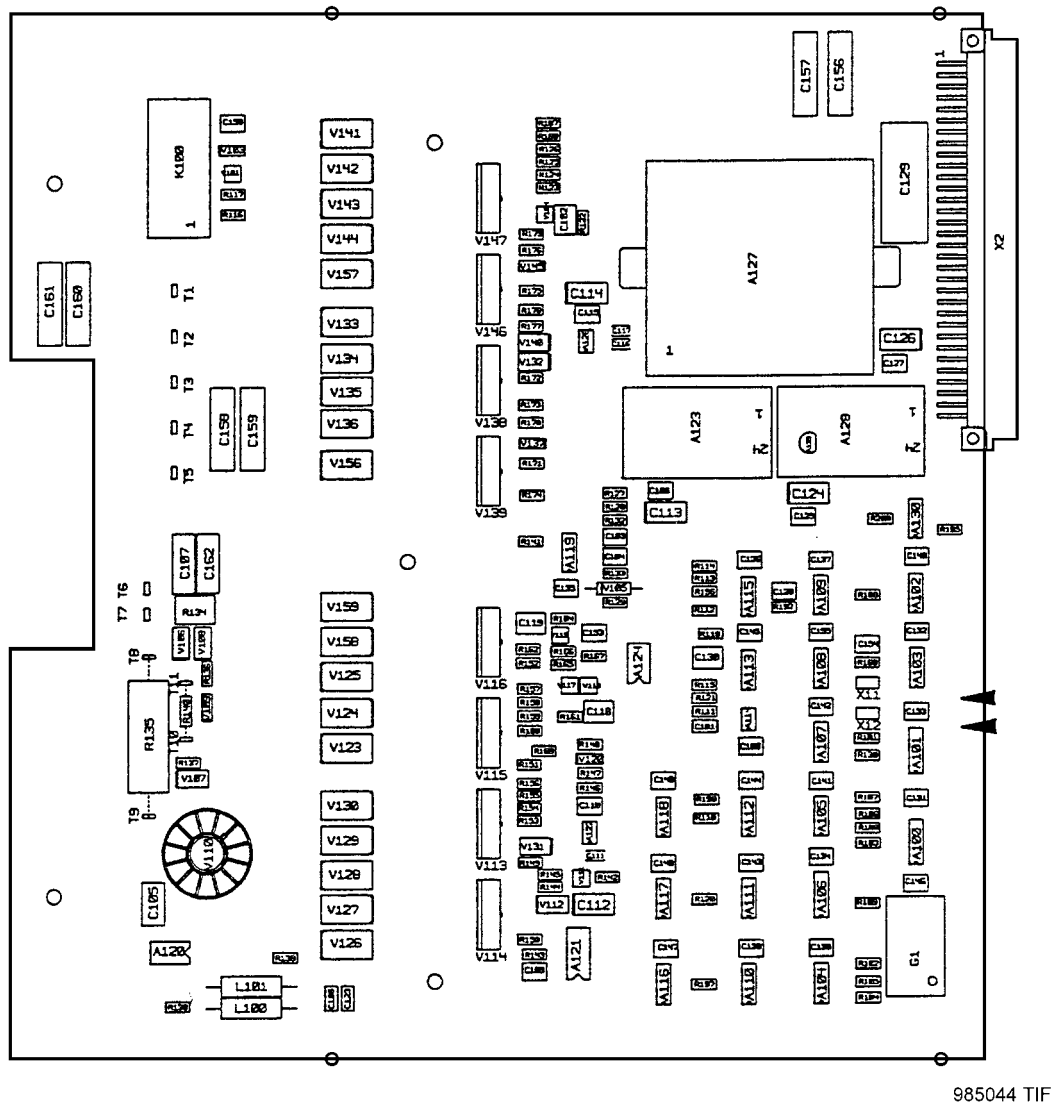


Fig. 2.1 Injection unit REX 010 (front view)
(corresponds to HESG 448 574)



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Fig. 2.2

PCB 316AI61 in the injection unit
(derived from HESG 324 366)
showing locations of X11 and X12

2.9. **Injection transformer block REX 011**

In conjunction with the injection unit Type REX 010, the injection transformer block Type REX 011 supplies the injection and reference signals for testing the 100 % stator and rotor ground fault protection schemes.

The injection transformer block used must correspond to the method of grounding the stator circuit:

primary injection at the star-point:	REX 011
secondary injection at the star-point:	REX 011-1
secondary injection at the terminals:	REX 011-2.

Each injection transformer type has three secondary windings for the following voltages:

U _{is} :	stator injection voltage
U _{ir} :	rotor injection voltage
U _i :	reference voltage connected to analogue input channel 8 of REG 316*4.

The same injection transformer is used for stator and rotor protection schemes.

The rated values of the injection voltages U_{is}, U_{ir} and U_i apply for the version REX 010 U1 and a station battery voltage of U_{Bat} = 110 V DC.

All the voltages are less by a factor of $96/110 = 0.8727$ in the case of versions U2 and U3.

Thus the primary injection voltage for the stator circuit is 96 V.

2.9.1. **REX 011**

This version is designed for primary injection at the star-point and is available with the following rated voltages:

U_{is}	110 V
U_{ir}	50 V *)
U_i	25 V

Table 2.1 REX 011

*) The winding for voltage U_{ir} has a tapping at 30 V. This enables U_{ir} to be stepped down to 30 V or 20 V where an injection voltage less than 50 V is necessary.

2.9.2. REX 011-1, -2

The injection transformers have the following ID's (see Table 2.2 and Table 2.3):

- HESG 323 888 M11, M12 or M13 for REX 011-1
- HESG 323 888 M21, M22 or M23 for REX 011-2.

The injection transformers used for secondary injection of the stator circuit have four injection voltage windings connected in parallel or series to adjust the power to suit the particular grounding resistor.

The value of the parallel resistor R'_{Ps} , respectively the maximum injection voltage determine the permissible injection voltage

R'_{Ps} [mΩ]	U_{is} [V]	Version
> 8	0.85	M11
> 32	1.7	M12
> 128	3.4	M13

Table 2.2 REX 011-1

R'_{Ps} [Ω]	U_{is} [V]	Version
> 0.45	6.4	M21
> 1.8	12.8	M22
> 7.2	25.6	M23

Table 2.3 REX 011-2

Always select the maximum possible injection voltage. For example, for a grounding resistor $R'_{Ps} = 35 \text{ m}\Omega$, $U_{is} = 1.7 \text{ V}$ is used.

In the case of versions M11, M12 and M13, the impedance of the connection between the injection transformer and the grounding resistor R'_{Ps} should be as low as possible. The resistance of both connecting cables should not exceed 5% of R'_{Ps} , e.g. for a grounding resistor of $R'_{Ps} = 35 \text{ m}\Omega$ and a length of the connecting cables of $2 \times 2 \text{ m} = 4 \text{ m}$, the cables must have a gauge of 40 mm^2 .

Voltages U_{ir} and U_i are the same as for REX 011.

The connections to the primary system are made via the two UHV heavy-duty terminals 10 and 15 which are designed for spade terminals. There are four universal terminals 11 to 14 Type UK35 between the two heavy-duty terminals that are used for the internal wiring.

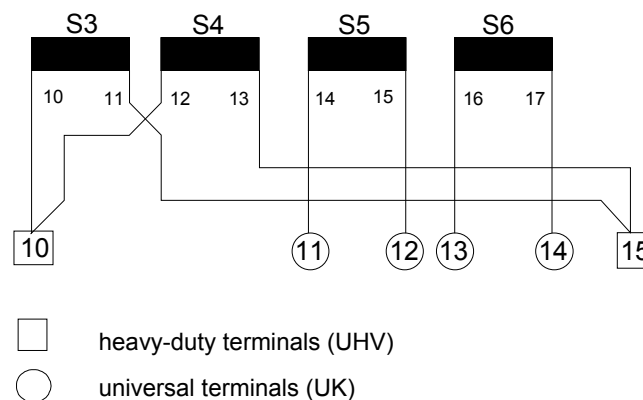
Depending on the version, the four windings must be connected to the corresponding universal or heavy current terminals.

Should the version as supplied be unsuitable for the application, the connections of the windings can be modified as required according to the following diagrams.

In the case of versions M12, M22, M13 and M23, shorting links KB-15 must be placed on the universal terminals. How this is done can be seen from the diagram "Shorting links" at the end of this section.

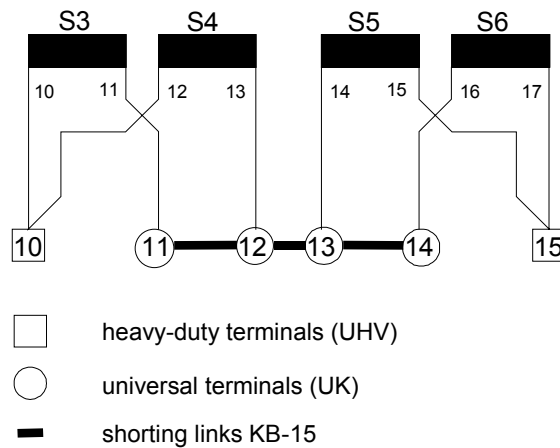
Shorting links and 3 rating plates are supplied with every transformers. The corresponding rating plate must be affixed over the old one following conversion.

Versions M11 and M21



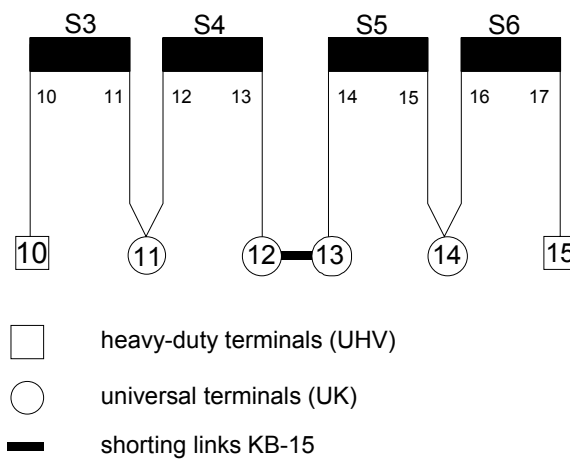
In the case of versions M11 (REX 011-1) and M21 (REX 011-2), the two windings S3 and S4 are connected in parallel across the heavy-duty terminals (10, 15). The other two windings are not used and are wired to the universal terminals. The shorting links KB-15 are not needed and must be removed.

Versions M12 and M22



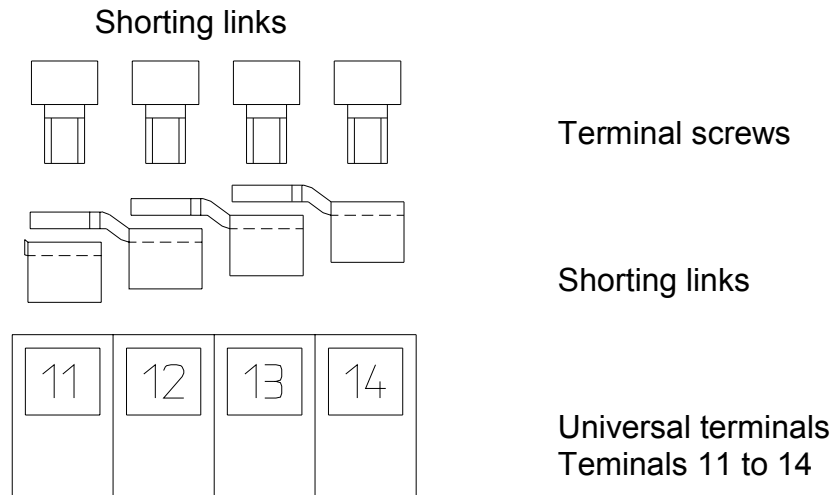
In the case of versions M12 (REX 011-1) and M22 (REX 011-2), two pairs of parallel windings are connected in series. All the universal terminals are connected together using the shorting links KB-15.

Versions M13 and M23



In the case of versions M13 (REX 011-1) and M23 (REX 011-2), all the windings S3...S6 are connected in series. Terminals M12 and M13 are bridged by a shorting link.

In the following figure the shorting links of the versions M12 and M22 are shown:



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4 terminal screws, 3 shorting links with offset and 1 flat shorting link are supplied with every transformer.

The shorting links are placed in the recesses provided on the universal terminals.

Versions M12 and M22:

First place the broken off shorting link with the opening downwards on terminal 11 and then fit 3 links one after the other. Each one must be secured using one of the screws supplied.

Versions M13 and M23:

First place the broken off shorting link with the opening downwards on terminal 12 and then fit 2 links one after the other. Each one must be secured using one of the screws supplied.

2.9.3. Figures

- Fig. 2.3 Injection signal Uis
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- Fig. 2.11 Dimensioned drawing of the injection transformer block Type REX 011

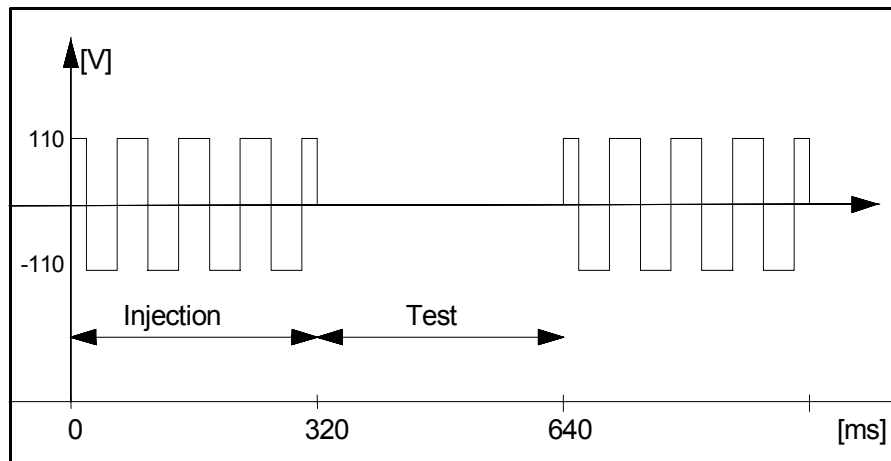


Fig. 2.3 Injection signal Uis

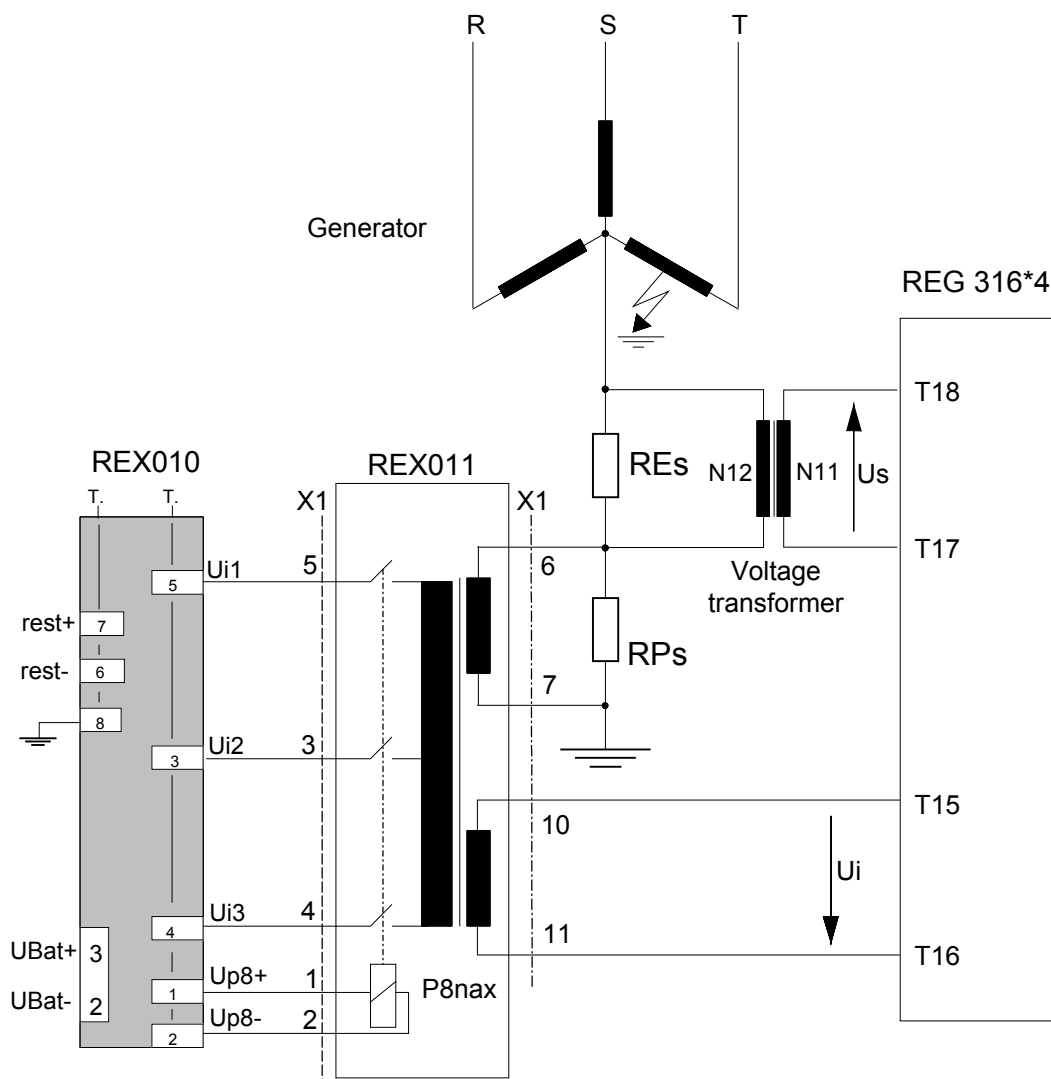


Fig. 2.4 Wiring diagram for primary injection at the stator using REX 011 (see Fig. 2.11)

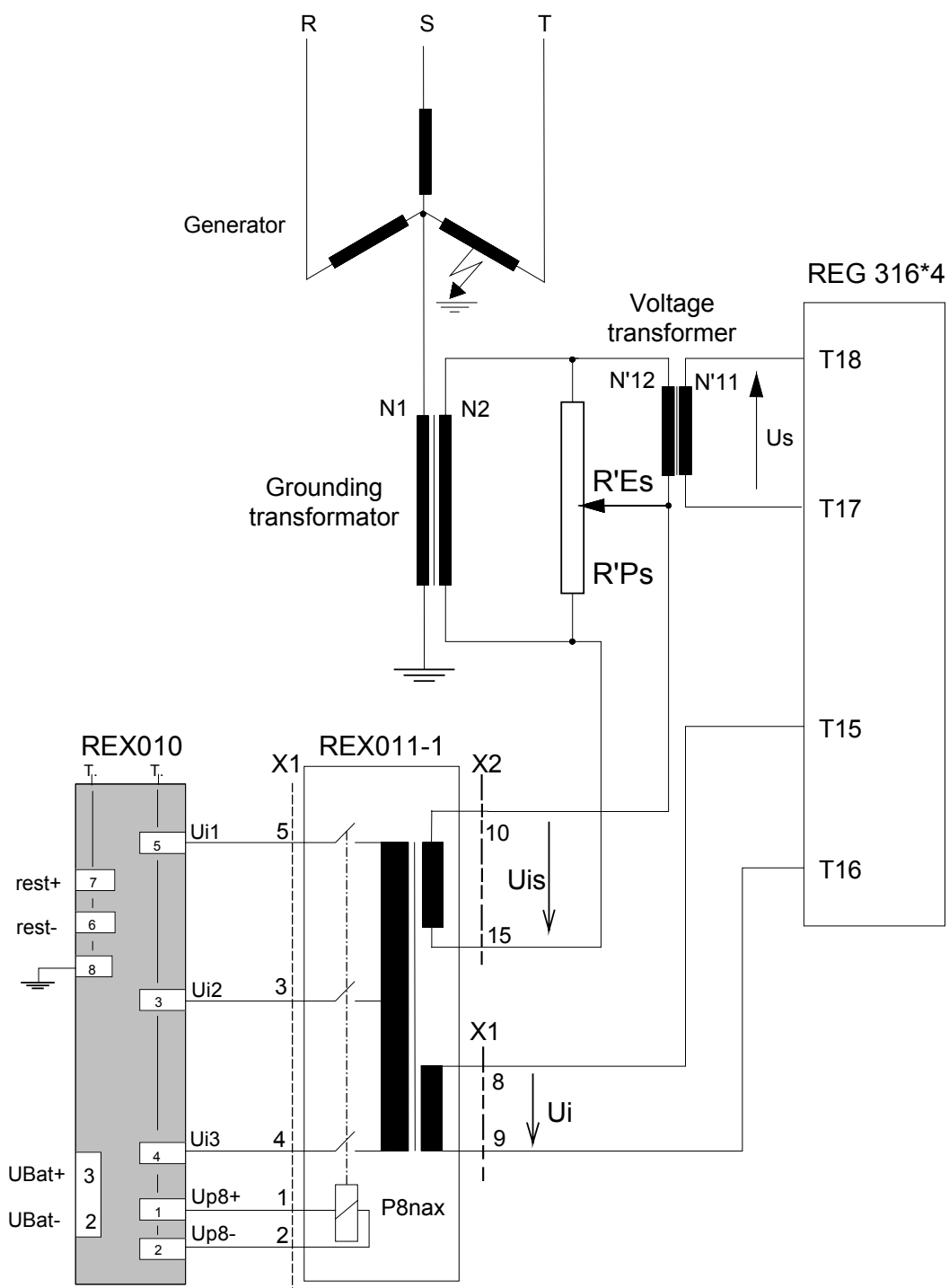


Fig. 2.5 Wiring diagram for secondary injection of the stator at the star-point using REX 011-1 (see Fig. 2.11)

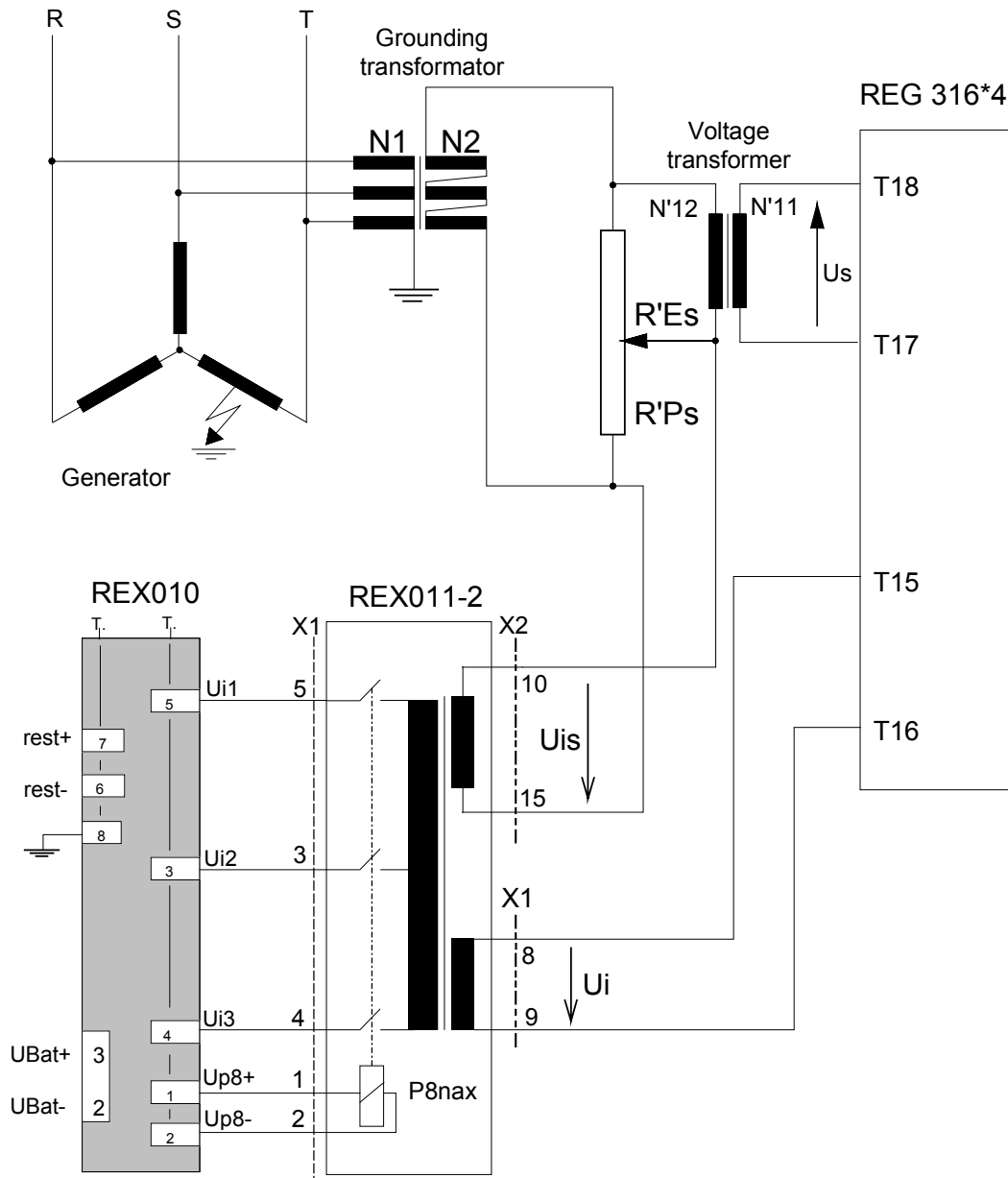


Fig. 2.6

Wiring diagram for secondary injection of the stator at the terminals using REX 011-2 (see Fig. 2.11)

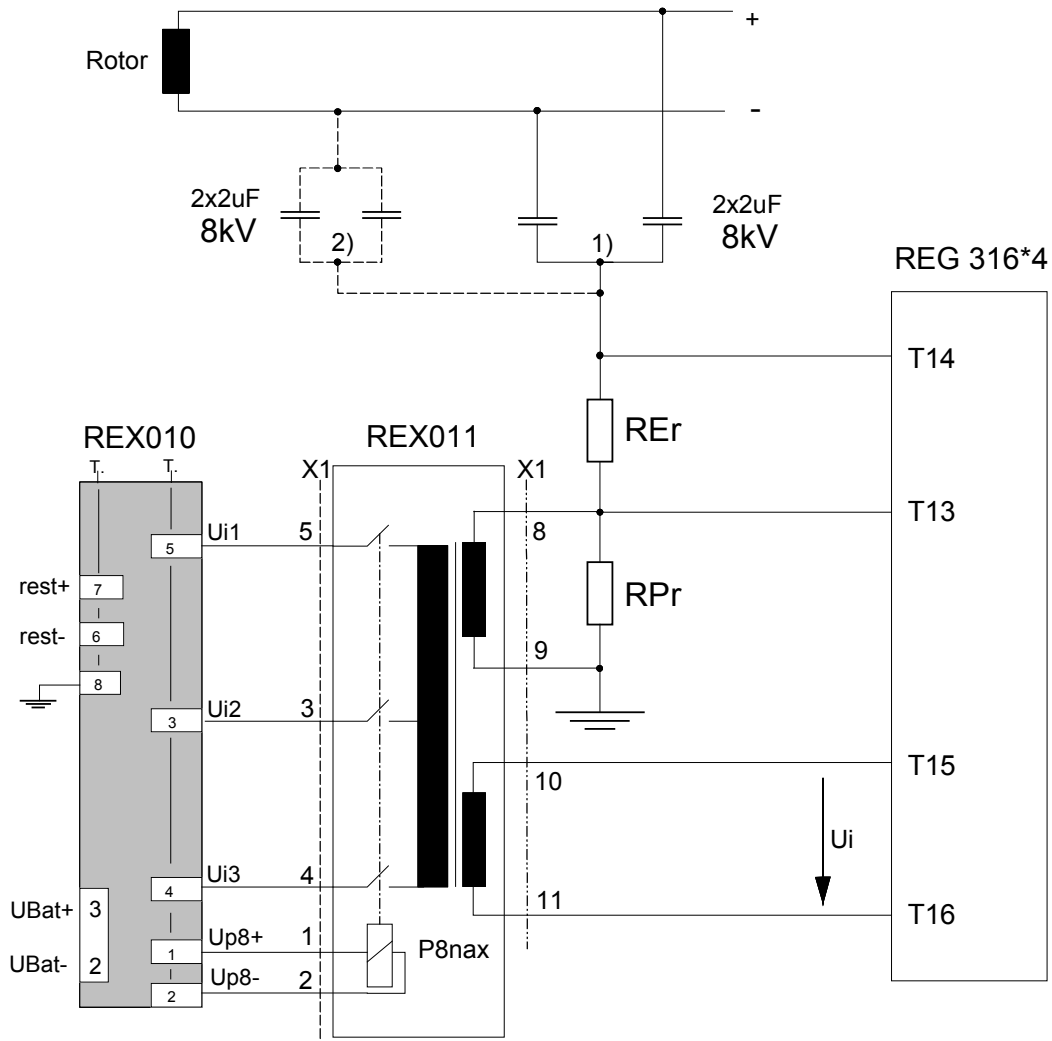


Fig. 2.7 Wiring diagram for rotor ground fault protection using REX 011 (see Fig. 2.11)

1) Injection at both poles

2) Injection at one pole for brushless excitation

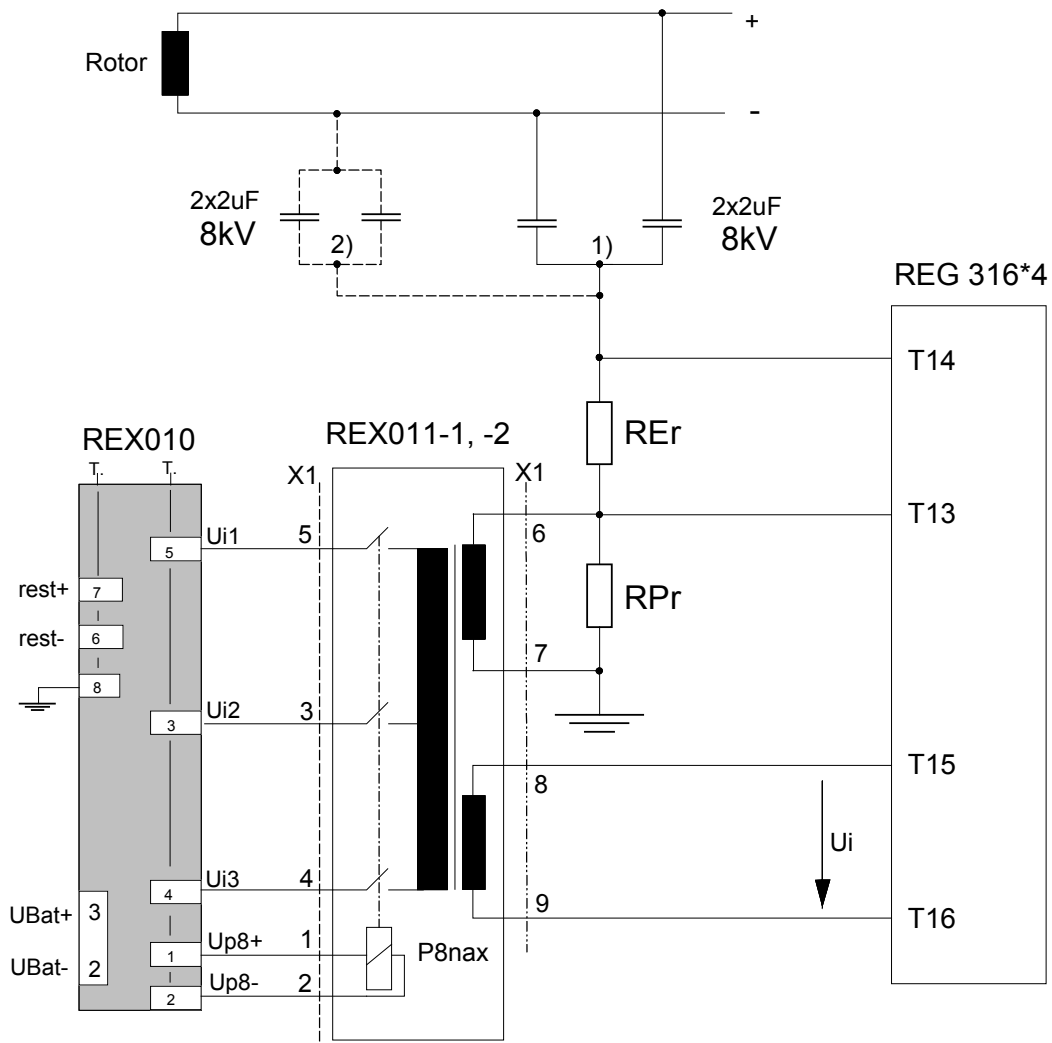


Fig. 2.8 Wiring diagram for rotor ground fault protection using REX 011-1, -2 (see Fig. 2.11)

1) Injection at both poles

2) Injection at one pole for brushless excitation

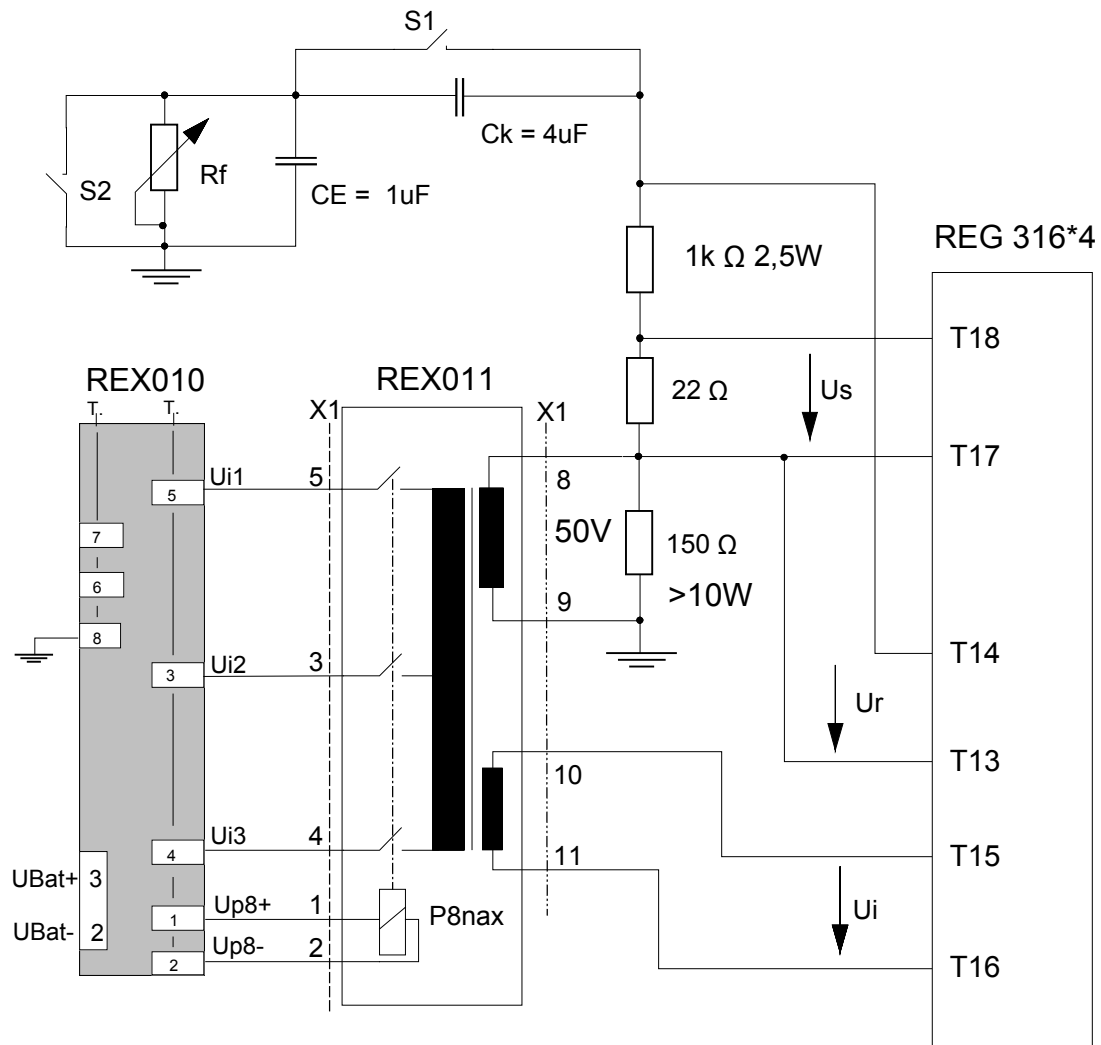


Fig. 2.9 Wiring diagram for testing without the generator using REX 011

S1: Bridging of the rotor coupling capacitor
 Ck: Rotor coupling capacitor
 CE: Rotor/stator ground capacitance
 Rf: Variable ground fault resistor
 S2: Ground fault resistor = 0 Ω .

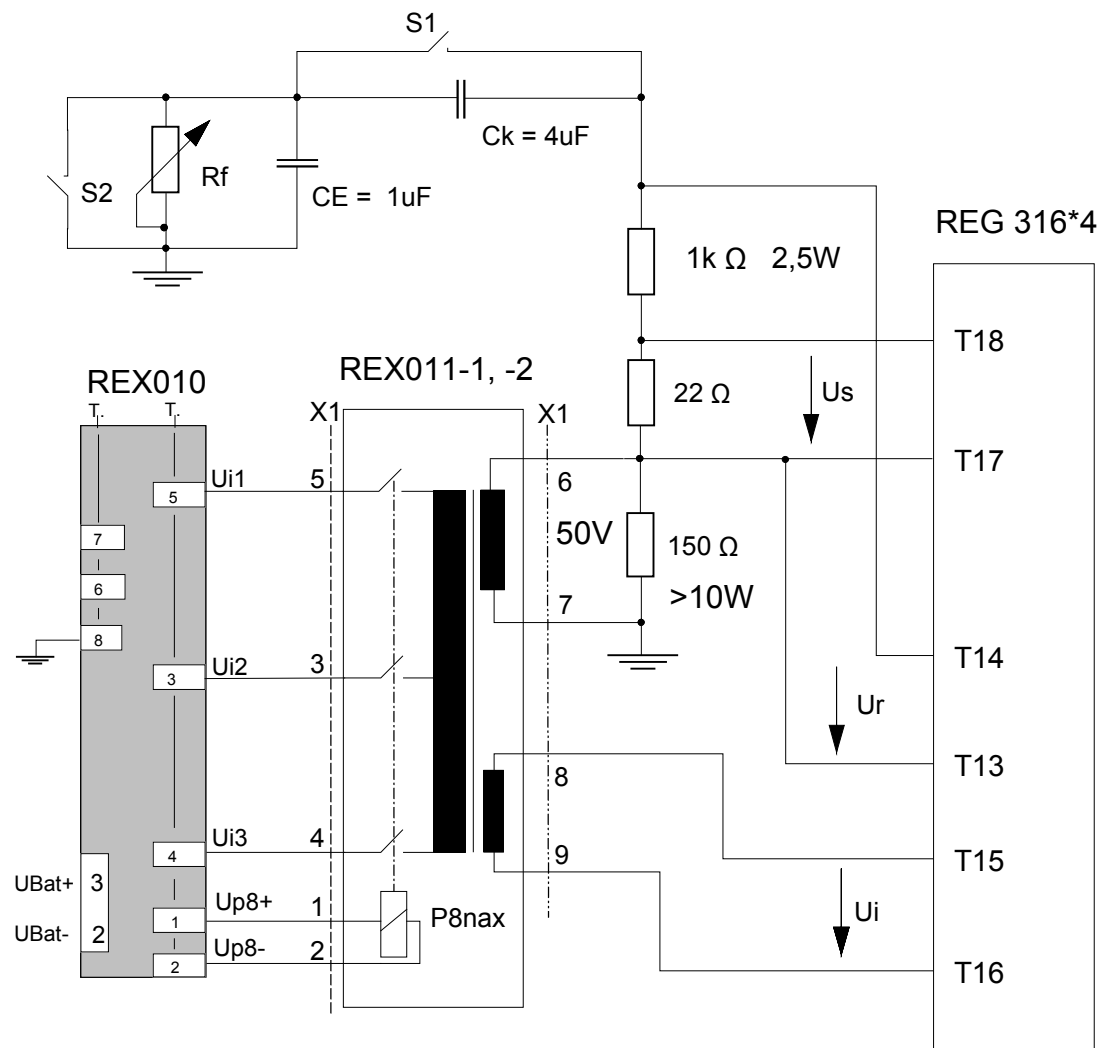


Fig. 2.10 Wiring diagram for testing without the generator using REX 011-1, -2

S1: Bridging of the rotor coupling capacitor
 Ck: Rotor coupling capacitor
 CE: Rotor/stator ground capacitance
 Rf: Variable ground fault resistor
 S2: Ground fault resistor = 0 Ω.

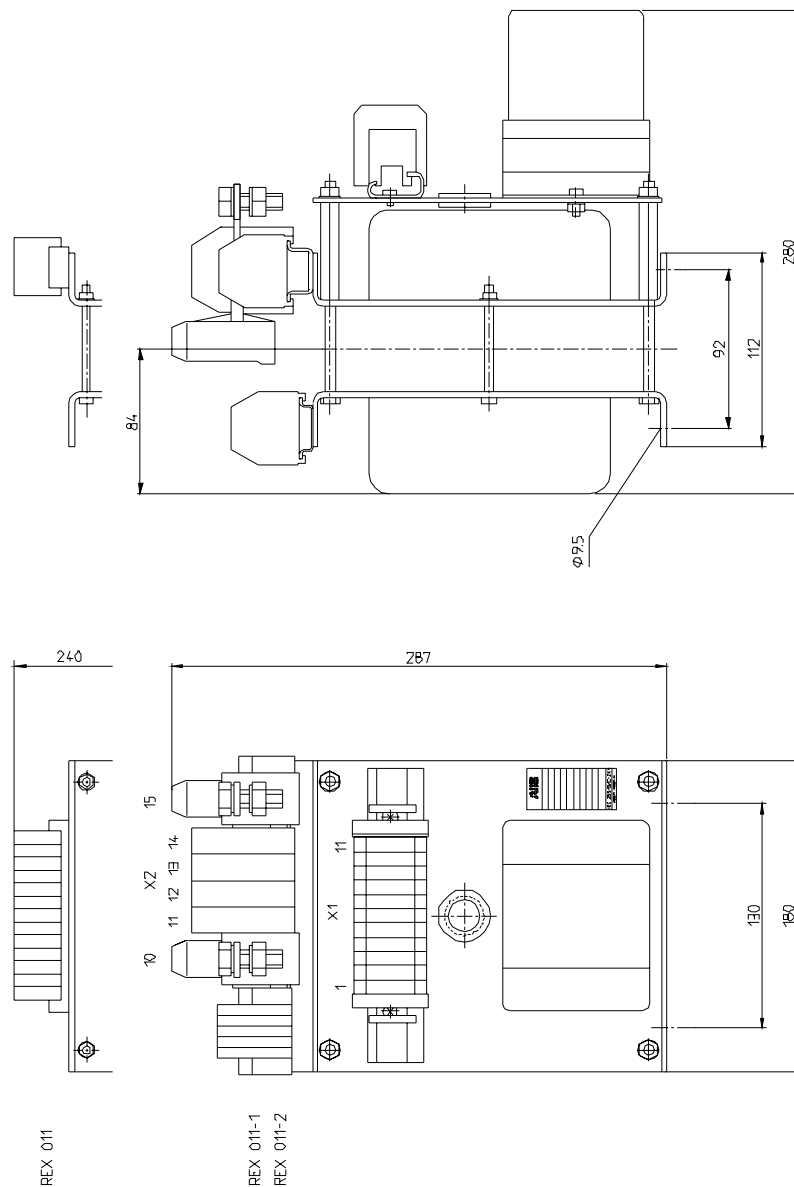


Fig. 2.11 Dimensioned drawing of the injection transformer block Type REX 011 (corresponds to HESG 324 388)

2.10. **Testing without the generator**

In order to test the operation of the injection unit Type REX 010 plus injection transformer block Type REX 011 or REX 011-1/-2 and the Stator-EFP and Rotor-EFP protection functions without them being connected to the protected unit, set up the test circuit shown in [Fig. 2.9](#) or [Fig. 2.10](#).

The two grounding resistors RE and RP are used for both stator and rotor protection schemes to simplify the circuit.

The injection voltage of 50 V is also common to both.

The ground fault resistance is simulated by the variable resistor Rf.

Stator ground fault protection:

To test the stator ground fault protection, switch S1 must be kept closed all the time.

The grounding resistor RE comprises two resistors of 1 kΩ and 22 Ω.

This is a simple method of simulating the ratio of the v.t.

Settings for MTR and REs:

The theoretical value of MTR is determined as follows:

$$\text{MTR} = \frac{22\Omega + 1000\Omega}{22\Omega} \times \frac{110\text{V}}{50\text{V}} = 102$$

The low injection voltage of 50 V increases the value of MTR by a factor 110 V/50 V.

$$\text{REs} = 1022\Omega.$$

The settings can also be determined using the setting functions 'MTR-Adjust' and 'REs-Adjust' according to [Section 3.5.24](#), which is to be preferred to the above calculation.

Rotor ground fault protection:

To test the rotor ground fault protection, the switch S1 must be kept open all the time with the exception of when the coupling capacitor is bridged for setting mode 'AdjRErInp'.

Settings:

The theoretical settings are:

$$\text{REr} = 1022\Omega$$

$$\text{Ck} = 4\mu\text{F}.$$

The settings can also be determined using the setting functions 'REs-Adjust' and 'CoupC-Adjust' according to [Section 3.5.25](#), which is to be preferred to the above calculation.

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3. SETTING THE FUNCTIONS

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3. SETTING THE FUNCTIONS

3.1. General

3.1.1. Library and settings

REG 316*4 provides a comprehensive library of protection functions for the complete protection of generators and power transformers.

The setting procedure is carried out with the aid of a personal computer and is extremely user-friendly. No knowledge of programming is necessary.

The number of protection functions active at any one time in a REG 316*4 system is limited by the available computing capacity of the main processing unit.

In each case, the control program checks whether sufficient computing capacity is available and displays an error message, if there is not.

The maximum of 48 protection functions are possible.

The settings and the software key determine which functions are active and enables the differing demands with respect to control and protection configuration to be satisfied:

- Only functions which are actually needed should be activated. Every active function entails computing effort and can influence the operating time.
- Many of the functions can be used several times, e.g.:
 - to achieve several stages of operation (with the same or different settings and time delays)
 - for use with different input channels

The following functions, however, can only be configured once per set of parameter settings:

- Disturbance recorder
- Contact bounce filter
- VDEW6.
- Functions that are active in the same set of parameters can be logically interconnected, for example, for interlocking purposes.

3.1.2. **Control and protection function sequence**

3.1.2.1. **Repetition rate**

The operation of the various protection functions is controlled entirely by the protection system software. The functions are divided into routines that are processed in sequence by the computer. The frequency at which the processing cycle is repeated (repetition rate) is determined according to the technical requirements of the scheme.

For many functions, this depends essentially on the time within which tripping is required to take place, i.e. the faster tripping has to take place, the higher the repetition rate. Typical relationships between operating time and repetition rate can be seen from Table 3.1.

Repetition rate	Explanation	Delay time
4	≥ 4 times every 20 ms ¹⁾	< 40 ms
2	≥ 2 times every 20 ms	40 ... 199 ms
1	≥ 1 times every 20 ms	≥ 200 ms

¹⁾ for 50 Hz or 60 Hz

Table 3.1 Typical protection function repetition rates

The repetition rates of some of the functions, e.g. differential protection, earth fault protection or purely logic functions, do not depend on their settings.

The scanning of the binary inputs and the setting of the signalling and tripping outputs takes place at the sampling rate of the analogue inputs.

Whilst the operating speed of the various protection functions is more than adequate for their purpose, they do operate in sequence so that the effective operating times of such outputs as starting and tripping signals are subject to some variation. This variation is determined by the repetition rate controlling the operation of the function. Typical values are given in Table 3.2.

Repetition rate	Variation
4	-2...+5 ms
2	-2...+10 ms
1	-2...+20 ms

Table 3.2 Variation in the operating time of output signals of protection functions in relation to their repetition rates

3.1.2.2. **Computation requirement of protection functions**

The amount of computation a protection function entails is determined by the following:

- complexity of the algorithms used which is characteristic for each protection function.
- Repetition rate:
The faster the operating time of a protection function, the higher its repetition rate according to [Table 3.1](#). The computation requirement increases approximately in proportion to the repetition rate.
- Already active protection functions:
The protection system is able to utilise some of the intermediate results (measured values) determined by a protection function several times. Therefore additional stages belonging to the same protection function and using the same inputs generally only involve a little more computation for the comparison with the pick-up setting, but not for conditioning the input signal.

The computation requirement of the REG 316*4 protection functions can be seen from [Table 3.3](#). The values given are typical percentages in relation to the computing capacity of a fictitious main processing unit.

According to [Table 3.1](#), the computation requirement of some of the functions increases for low settings of the time delay t and therefore a factor of 2 or 4 has to be applied in some instances. When entering the settings for a function with several stages, the one with the shortest time delay is assumed to be the first stage.

REG 316*4 units equipped with a 316VC61a respectively 316VC61b processor module have a computing capacity of 250 %. This applies to all units having a local control and display unit. Older units with a 316VC61 processor module only have a computing capacity of 200 %.

The computing load can be viewed by selecting 'List Procedure List' from the 'List Edit Parameters' menu and is given for the four sets of parameters in per thousand. The greatest value in the four sets of parameters determines the computing load.

Function	1st. stage		2nd. and higher stages		Factor for (**)	
	1 ph	3 ph	1 ph	3 ph	t<40ms	t<200ms
Diff-Gen	-	40	ditto			
Diff-Transf	-	50	ditto			
Current-DT	2	3	1		4	2
with inrush blocking		5	5		4	2
Current-Inst	3	4	2		4	2
I _{max} /U _{min}	5	8	2		4	2
Current-Inv	4	7	3			
DirCurrentDT		19	ditto		4	2
DirCurrentInv		21	ditto			
NPS-DT	-	6	1			
NPS-Inv	-	8	3			
Voltage-DT	2	3	1		4	2
Voltage-Inst	3	4	2		4	2
Voltage-Bal	4	9	ditto		4	2
Underimped	6	17	4	11		
MinReactance	6	17	4	11		
Power	5	14	3	8	4	2
OLoad-Stator	4	7	3			
OLoad-Rotor	-	6	3			
Overtemp	12	15	ditto			
Frequency	15	-	3			2
df/dt	50		5			
Overexcitat	15	-	ditto			2
U/f-Inv	25.5	-	ditto			
Stator-EFP		40	ditto			
Rotor-EFP		40	ditto			
Pole-Slip		20	ditto			
I0-Invers		4	3			
BreakerFailure	34	46	ditto			
FUPLA		1/ 2/ 4 (***)	ditto			
VDEW6		1	(*)			
Delay		8	ditto			
Counter		8	ditto			
Logic		4	ditto			
Contact bounce filter		0.1	(*)			
Analog RIO Trig		2			4	2
LDU events		4	ditto			
UIfPQ		5	ditto			
MeasureModule						
Voltage/CurrentInp		10	ditto			
Cnt		8	ditto			
Check-I3ph		5	ditto			2
Check-U3ph		5	ditto			2
Disturbance rec						
without binary inputs		20	(*)			
with binary inputs		40	(*)			

(*) can only be set once

(**) always 1 for delays ≥ 200 ms

(***) depends on repetition rate (low/medium/high)

Table 3.3 Computation requirement of protection functions
(in percent)

Example:

Table 3.4 shows the computation requirement according to Table 3.3 of a simple protection scheme with four active functions. Since functions 1 and 2 use the same analogue inputs, the amount of computing capacity required for function 2 is reduced to that of a second stage.

Function No.	Type	Input channel	Settings			Percentage incl. factor
			Phases	Pick-up	Time	
1	current	1 (,2,3)	three	$10.0 I_N$	30 ms	$3 \% \times 4 = 12 \%$
2	current	1 (,2,3)	three	$2.5 I_N$	100 ms	$1 \% \times 2 = 2 \%$
3	current	4	single	$3.5 I_N$	300 ms	$2 \% \times 1 = 2 \%$
4	voltage	7	single	$2.0 U_N$	50 ms	$2 \% \times 2 = 4 \%$
Total						20 %

Table 3.4 Example for calculating the computation requirement

3.1.2.3. *Computing capacity required by the control function*

It is not possible to state the computing capacity required by the control function directly as a percentage of the total, because it is dependent not only on the size of the code, but also by the type of control logic.

The load on the main processor due to the control and protection functions must be checked after loading by selecting 'Display AD (CT/VT) channels' from the 'Measurement values' menu.

Ed	Di	Ch.Nr.	Amplitude	Phase	Frequency
Ev	Di	1	0.000 [1A]	-.-- deg	-.--- Hz
Me	Di	2	0.000 [1A]	-.-- deg	
Te	Di	3	0.000 [1A]	-.-- deg	
Di	Di	4	0.000 [5A]	-.-- deg	
SM	Di	5	0.000 [5A]	-.-- deg	
Do	Di	6	0.000 [5A]	-.-- deg	
RE	Di	7	0.000 [100V]	-.-- deg	
	Di	8	0.000 [100V]	-.-- deg	
	Di	9	0.000 [100V]	-.-- deg	
	Di	Time: 2001-04-19 12:08;35 (2400)			

On - Line 9600 bps SCS:LON V6.2b | V6.2b

The number at the bottom right of the box (2400) is an indication of the load on the processor. This number must not exceed 20,000 when all the functions are active, i.e. none of the functions may be blocked. It applies for the normal operating condition, i.e. not while the unit is in the tripped state.

The cycling time for high-priority tasks must be set at 20 ms (default, [see Section 3.6.1.1. Control function settings FUPLA](#)).

This ensures that all the control and protection functions can run correctly.

3.2. Protection function inputs and outputs

3.2.1. C.t./v.t. inputs

(see [Section 5.5.4.1.](#))

The protection scheme can include three types of input transformers which may also have different ratings:

- protection c.t's
- metering c.t's (core-balance)
- v.t's.

The number and arrangement of the input transformers are defined by the value given for configuration code K.. or by entering K=0 and specifying the required input transformer.

Before being processed by the protection functions, the currents and voltages coming from the input transformers are digitised in the analogue section of the main processor module.

Every analogue input channel is defined as being either single or three-phase:

- C.t's:
 - three-phase protection
 - single-phase protection
 - single-phase metering (core-balance)
- V.t's:
 - three-phase Y connected
 - single-phase.

A protection function can only be used in a three-phase mode, if a corresponding three-phase group of c.t./v.t. input channels is available.

All protection function settings are based on the REG 316*4 input values (secondary ratings). The fine adjustment to suit the effective primary system quantities is accomplished by varying the reference settings of the analogue inputs.

3.2.2. **Binary inputs**

(see Section 5.5.4.4.)

REG 316*4 recognises one of the following values:

- logical “0” (fixed value) = FALSE
- logical “1” (fixed value) = TRUE
- binary input values (316DB6.)
- binary control and protection values as defined by the function number and the corresponding output signal
- binary value from the station control level.
- binary values from the distributed input units (500RIO11)
- binary values with interlocking data

All the above can also be set as binary inputs of control protection functions.

All the binary addresses set may be used either directly or inverted.

3.2.3. **Signalling outputs**

(see Section 5.5.4.2.)

All the control and protection output signals provide the following facilities:

- external signalling via LED's
- external signalling via relays
- event recording
- control of tripping relays
- external signalling via the communications interface
- external signalling via distributed output units (500RIO11)
- output of interlocking data

The following applies to external signals via a signalling relay or a LED:

- A signalling relay or LED can only be activated by one signal.
- Every signalling relay and LED can be individually set to a latching mode.

A signal can activate a maximum of two signalling outputs:

- 2 signalling relays
- 1 signalling relay and a LED
- 1 signalling relay and 1 tripping relay.

An output each can also be configured for the communication interface, the distributed output units, interlocking data and event recording.

Important signals are duplicated, e.g. ‘GeneralTrip’ and ‘General TripAux’.

3.2.4. **Tripping outputs**

(see Section 5.5.4.3.)

All protection functions can directly excite the tripping relays. A tripping logic matrix is provided for this purpose which enables any function to be connected to any tripping channel. The tripping logic matrix enables every tripping channel to be activated by any number of protection functions.

Tripping relays are only provided on the binary I/O modules 316DB61 and 316DB62 each having 2 tripping relays with 2 contacts each.

3.2.5. **Measured values**

(see Section 5.7.)

Apart from being processed internally, the analogue values measured by the REG 316*4 protection functions are also available externally for:

- display:
The input variables measured by the protection functions are available at the station control level via the communication interface.
They can also be viewed locally on a PC (personal computer) running the operator program or on the local display unit (LDU) on the frontplate. Their values are referred to the secondary voltages and currents at the input of the REG 316*4 scheme.
- recording as an event:
The instant a protection function trips, the value of the corresponding measured variable is recorded as an event.

3.3. **Frequency range**

The protection functions are designed to operate at a power system frequency f_N of either 50 Hz or 60 Hz. Which of the two is applicable is a system setting. The algorithms representing the protection functions have been optimised to produce the best results at the rated frequency f_N . Discrepancies from the rated frequency cause an additional error.

3.4. **System parameter settings**

3.4.1. **Configuring the hardware**

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
NomFreq	Hz	50	50	60	10
A/D		on VC61	(Select)		
AD Config K		00	00	99	1
Slot Nr 1		Not used	(Select)		
Slot Nr 2		Not used	(Select)		
Slot Nr 3		Not used	(Select)		
Slot Nr 4		Not used	(Select)		
SWVers SX...		X	(Select)		
SWVers S.XXX		100	1	999	1

Significance of the parameters:

NomFreq

Power system frequency setting:

- 50Hz or 60Hz.

A/D

defines the type of A/D converter. Choose either "EA62..." or "EA63..." to correspond to the A/D converter unit inserted in the longitudinal line differential protection:

- on VC61: A/D converter on 316VC61
- EA6. MasterS: short data transmission distance
- EA6. SlaveS: short data transmission distance
- EA6. MasterL: long data transmission distance
- EA6. SlaveL: long data transmission distance
- EA6. MstFoxS: short data trans. distance using FOX
- EA6. MstFoxL: long data trans. distance using FOX
- EA6. SlvFoxS: short data trans. distance using FOX
- EA6. SlvFoxL: long data trans. distance using FOX.

The setting of the data transmission distance is normally determined by the attenuation of the optical fibre cable (OFC) between the two units.

However, when using FOX optical fibre equipment, the setting is determined by the connection between the RE.316*4 and the FOX equipment.

The data transmission distance setting influences the output power of the transmission diode. It must therefore be selected such that the receiver diode at the remote end is not overloaded.

To make sure that the setting is correct, measure the optical signal strength while commissioning the system. The output power must be in the respective range given in the following table (MM = multi-mode optical cable 50/125 µm, SM = single mode optical cable 9/125 µm):

OFC type	Setting	
	EA6.....S	EA6.....L
MM	-26 ... -20 dBm	-16 ... -13 dBm
SM	-32 ... -22 dBm	-20 ... -17 dBm

Select the setting such that taking the attenuation to be expected due to the optical cable into account, the power at the receiving end is between **-34 dBm and -22 dBm**. Measure the signal strength at the receiving end to make sure that it is within this range.

Note:

- Take care when measuring the output power to set the level for the correct type of optical cable in use.
- One device must be configured as master (i.e. 'MstFox') and the other as slave.
- The same transmission distance, i.e. either 'EA62...S' or 'EA6.....L', has to be configured at both ends.
- If an A/D converter Type 316EA62 or 316EA63 is installed, the 'A/D' parameter must be set to 'EA6.....' even if the optical fibre link is not in operation yet.

AD Config K

Defines the type of input transformer module:

- 0...67: K0: transformer as specified
K61...K67: according to Data Sheet.

This parameter must be set before configuring the protection functions and cannot be changed subsequently. The setting must agree with the type of input transformer module fitted in the protection. The software does not check the type of module fitted.

A list of input transformer modules and their codes is included in the Data Sheet (see [Section 8.](#)). Examples of applying the various input transformer modules are shown in [Fig. 3.1](#) and [Fig. 3.2](#).

Slot Nr 1

Defines the type of I/O board in slot 1.

- Not used, 316DB61, 316DB62 or 316DB63.

Slot Nr 2

Defines the type of I/O board in slot 2.

- Not used, 316DB61, 316DB62 or 316DB63.

Slot Nr 3

Defines the type of I/O board in slot 3.

- Not used, 316DB61, 316DB62 or 316DB63.

Slot Nr 4

Defines the type of I/O board in slot 4.

- Not used, 316DB61, 316DB62 or 316DB63.

SWVers SX...

Defines the first part (letter) of the software code.

SWVers S.XXX

Defines the second part (figure) of the software code.

A list of protection functions and their software codes is included in the Data Sheet (see [Section 8.](#)).

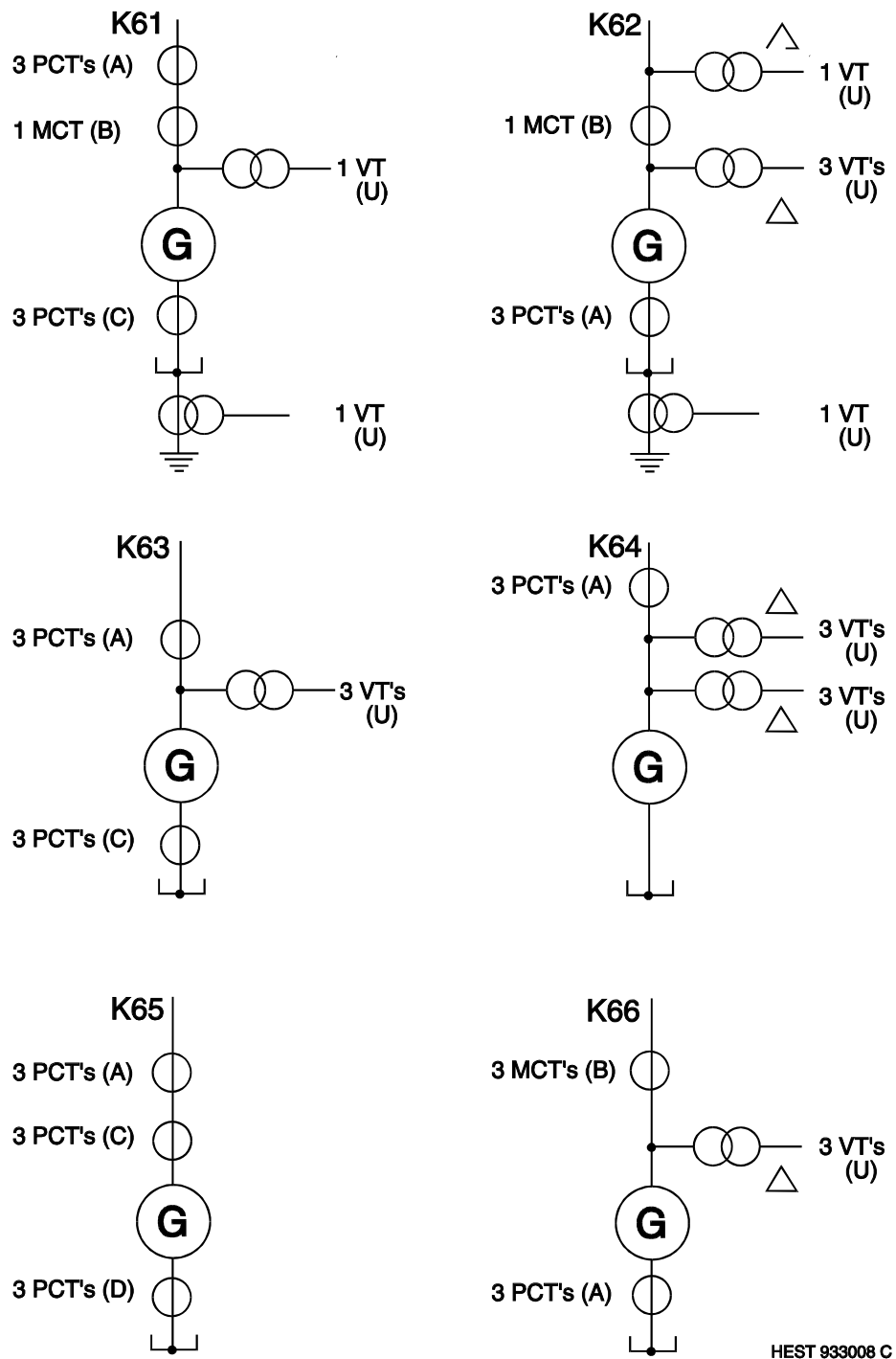


Fig. 3.1 Application examples for input transformer configuration codes K61 to K66

PCT : protection c.t.
MCT : metering c.t.
VT : v.t.

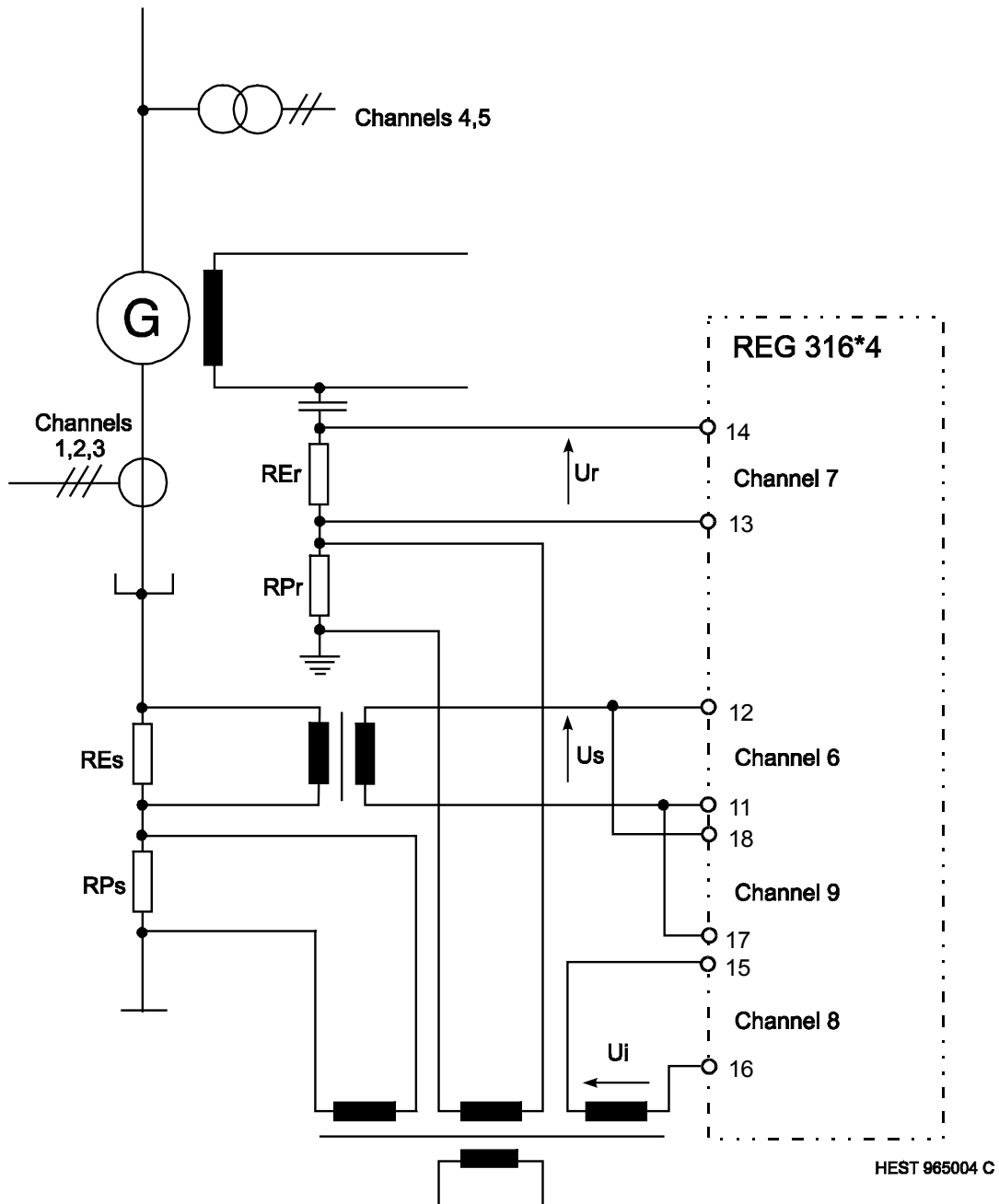


Fig. 3.2 Application of input transformer configuration K67 for 100 % ground fault protection

3.4.2. **Entering the c.t./v.t. channels**

(see Section 5.5.5.)

Edit A/D channel type

If K=00 is set for the hardware configuration, c.t. and v.t. channels can be entered in any order, providing a corresponding input transformer unit is fitted.

Edit A/D nominal value

Enter the rated values for the c.t.'s and v.t.'s in the input transformer unit (1 A, 2 A, 5 A, 100 V or 200 V). S and T phases of three-phase channels assume the same value as R phase.

Edit A/D prim/sec ratio

These values are only of relevance in connection with the IEC60870-5-103 protocol. S and T phases of three-phase c.t. and v.t. channels assume the same value as R phase.

Edit A/D channel ref. val.

The reference value settings enable differences between the ratings of protected unit, c.t. or v.t. and protection to be compensated. They are a factor which can be set in the range 0.5 to 2. The setting for R phase applies also to the other two phases of three-phase channels.

$$\text{Reference value for voltage channels} = \frac{U_{GN} \times U_{N2}}{U_{N1} \times U_N}$$

$$\text{Reference value for current channels} = \frac{I_{GN} \times I_{N2}}{I_{N1} \times I_N}$$

where:

- U_{GN}, I_{GN} - rated data of the protected unit (generator, power transformer, motor etc.)
- U_{N1}, U_{N2} - primary, respectively secondary v.t. ratings
- I_{N1}, I_{N2} - primary, respectively secondary c.t. ratings
- U_N, I_N - protection rated voltage and current

Example:

Generator	13.8 kV ;	4 kA
C.t's/v.t's	14400/120 V;	5000/5 A
Protection	100 V;	5 A

$$\text{Reference value for voltage channels} = \frac{13.8 \times 120}{14.4 \times 100} = 1.150$$

(Assumed: v.t's connected in delta)

$$\text{Reference value for current channels} = \frac{4 \times 5}{5 \times 5} = 0.800$$

The reference value of 0.8 determined in the above example for the current channels means that at a full load current of 4000 A, a current of 4 A flows on the secondary side of the c.t's which for the protection is the 100 % load current. The settings on the protection are then directly referred to the rated current of the protected unit.

Effects of changing the reference values:

The protection function settings (parameters expressed in relation to 'IN' and 'UN') are automatically adjusted to the new reference values.

Edit A/D channel comment

Facility is provided for the user to enter a comment for each analogue channel, which is displayed together with the channel type when the corresponding c.t. or v.t. input parameter of a protection function is selected.

3.4.3. **Entering comments for binary inputs and outputs** (see Section 5.5.5.)

Individual comments can be entered for each binary input and each signalling or tripping output. This operation is carried out via the menu 'Edit hardware functions' and then 'Edit binary inputs', 'Edit trip outputs' and 'Edit signal outputs'.

3.4.4. *Masking binary inputs, entering latching parameters and definition of “double indications”*

(see [Section 5.5.5.](#))

The sub-menu ‘Edit binary inputs’ provides facility for excluding (masking) binary signals from being recorded as events.

Every LED, signal and tripping command can be set to a latch or not to latch via the sub-menu ‘Edit signal outputs’ or ‘Edit trip outputs’, providing the ‘LEDSigMode’ parameter was also set to latching beforehand.

Note that the green LED1 (standby signal) cannot be set to a latching mode.

In the ‘Edit binary inputs’ menu, up to 30 pairs of consecutive binary inputs can be combined to form double signals. A runtime supervision can also be configured for each of them.

3.4.5. *Edit system parameters*

(see [Section 5.5.6.](#))

The settings made in the three sub-menus accessed via the ‘Edit system parameters’ menu apply for all control and protection functions. The three sub-menus are:

- Edit system I/O
- Edit system name
- Edit system password.

3.4.5.1. Edit system I/O

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
LEDSigMode		AccumSigAll	(Select)		
Confirm Pars		on	(Select)		
TimeSyncByPC		on	(Select)		
Relay Ready	SignalAddr				
GenTrip	SignalAddr	ER			
GenTripAux	SignalAddr				
GenStart	SignalAddr	ER			
GenStartAux	SignalAddr				
InjTstOutput.	SignalAddr				
Test active	SignalAddr				
MMC is on	SignalAddr	ER			
InjTstEnable	BinaryAddr	F			
ExtReset	BinaryAddr	F			
Enable Test	BinaryAddr	T			
Rem. Setting	BinaryAddr	F			
ParSet2	BinaryAddr	F			
ParSet3	BinaryAddr	F			
ParSet4	BinaryAddr	F			
ParSet1	SignalAddr	ER			
ParSet2	SignalAddr	ER			
ParSet3	SignalAddr	ER			
ParSet4	SignalAddr	ER			
Modem Error	SignalAddr	ER			
QuitStatus	SignalAddr	ER			
MVB PB Warn	SignalAddr	ER			
MVB PB Crash	SignalAddr	ER			
PB BA1Ready	SignalAddr	ER			
PB BA2Ready	SignalAddr	ER			
PB BA3Ready	SignalAddr	ER			
PB BA4Ready	SignalAddr	ER			
PB LA faulty	SignalAddr	ER			
PB LB faulty	SignalAddr	ER			

Explanation of parameters:**LEDSigMode:**

Display mode for LED signals:

- **AccumSigAll:**
Signals are not reset, but accumulate. In this case, events which excite the same signals are superimposed on each other.
- **ResetSigAll:**
All LED's are reset when 'GenStart' is activated.
All subsequent signals are displayed and latch, i.e. the signals always reflect the last event.
- **ResetSigTrip:**
All LED's are reset when 'GenStart' is activated.
The signals generated by the last event are reset each time the protection picks up. New signals are only displayed, if tripping takes place.
- **No latch:**
LED signals reset as soon as the condition causing them disappears.

In all three latching modes, the LED's can be reset either by selecting the menu item 'Latch Reset' in the RESET menu on the local control unit or by briefly activating the 'ExtReset' binary input.

Only those LED's latch in the on state that are configured to do so according to [Section 3.4.4](#).

Confirm Pars:

switches the parameter confirm mode on and off.

Confirmation is made with the <→> key and correction with the <Esc> key.

TimeSyncByPC:

switches the synchronisation of the REG 316*4 clock when the MMC program starts on and off.

Relay Ready:

This signal indicates that the protection is serviceable and standing by.

GenTrip, GenTripAux (see [Section 5.5.4.3](#)):

Signal generated via an OR function when any one of the protection functions assigned to the tripping logic trips.

GenStart, GenStartAux (see Section 5.5.4.2.):

Signal generated via an OR function when any one of the protection functions configured to be recorded as an event picks up.

InjTstOutput:

This signal is not used in the case of REG 316*4.

Test active (see Section 5.9.)

Signal indicating that the device is in the test mode.

This signal remains set for as long as the MMI menu 'Test functions' is open.

MMC is on:

Signal indicating that the control PC is connected and serviceable.

InjTstEnable:

This input is for enabling and disabling the test mode. It is normally used in conjunction with the test adapter Type XX93 or 316 TSS 01 and assigned to the binary input OC 101. If used with the test adapter XX93, it has to be configured to invert the signal.

F: - operating mode
T: - test mode
xx: - all binary inputs.

Caution:

- The stand-by signal (green LED 1) is not influenced by an active input.
- An active input switches the baud rate of the MMC interface to 9600 bps.

External reset:

Input for resetting latched signalling LED's and relays:

F: - no external reset
xx: - all binary inputs

Enable Test:

Input for enabling the test functions controlled by the MMC:

F: - test functions disabled
T: - test functions enabled
xx: - all binary inputs

Rem. Setting (see Section 5.11.1.):

Input for switching between sets of parameters.

- F: - Sets of parameters can only be switched by applying signals to the binary inputs "ParSet 2-4".
- T: - Sets of parameters can only be switched by signals from the station control system.
- xx: - all binary inputs

ParSet2...ParSet 4 (see Section 5.11.1.):

Individual inputs for activating the different sets of parameters.

ParSet1...ParSet 4 (see Section 5.11.1.):

Signal indicating that one of the sets of parameters 1-4 is active.

Modem Error:

Signal indicating a data transmission error on the optical link between two longitudinal differential relays. This signal is generated instantly in the event of an error (see Section 3.8. Data transmission from REL 316*4).

The diagnostic function reports this error after a delay of 80 ms, i.e. only when it is certain that the communications channel is permanently disturbed.

QuitStatus:

Signals that the reset button on the front of the unit has been operated.

MVB_PB_Warn, MVB_PB_Crash,

PB_BA1Ready...PB_BA4Ready, PB LA faulty, PB LB faulty

These messages are only generated when using an MVB process bus (see Operating Instructions for the remote I/O system RIO580, 1MRB520192-Uen).

3.4.5.2. Edit system name

A name can be entered which then appears on the first line of the HMI displays.

3.4.5.3. Edit system password

This enables an existing password to be replaced by a new one.

3.5. Protection functions

3.5.1. Transformer differential protection function (Diff-Transf)

A. Application

Differential protection of two and three-winding power transformers generator/transformer units.

B. Features

- Non-linear, current-dependent operating characteristic (see Fig. 3.5.1.1)
- High stability during through-faults and in the presence of c.t. saturation
- Short tripping times
- Three-phase measurement
- Inrush current restraint
 - using the second harmonic
 - detection of the highest phase current
 - detection of the load current to determine whether the transformer is energised or not
- Compensation of phase group
- Compensation of c.t. ratio
- Scheme for three-winding transformers
 - phase-by-phase comparison of the highest winding current with the sum of the currents of the other two windings
- d.c. current component filter
- harmonic filter.

C. Inputs and outputs

I. C.t./v.t. inputs:

- Current (2 or 3 sets of 3 inputs)

II. Binary inputs:

- Blocking

III. Binary outputs:

- tripping
- R phase trip
- S phase trip
- T phase trip

IV. Measurements:

- R phase summation current
- S phase summation current
- T phase summation current
- R phase restraining current
- S phase restraining current
- T phase restraining current

D. Transformer differential protection settings - Diff-Transf

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
Trip		00000000			
g	IN	0.2	0.1	0.5	0.1
v		0.50	0.25	0.50	0.25
b	IN	1.50	1.25	5.00	0.25
g-High	IN	2.00	0.50	2.50	0.25
I-Inst	IN	10	3	15	1
InrushRatio	%	10	6	20	1
InrushTime	s	5	0	90	1
a1		1.00	0.05	2.20	0.01
s1		Y	(Select)		
CurrentInp1	CT/VT-Addr	0			
a2		1.00	0.05	2.20	0.01
s2		y0	(Select)		
CurrentInp2	CT/VT-Addr	0			
a3		1.00	0.05	2.20	0.01
s3		y0	(Select)		
CurrentInp3	CT/VT-Addr	0			
BlockInp	BinaryAddr	F			
InrushInp	BinaryAddr	F			
HighSetInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Trip-R	SignalAddr				
Trip-S	SignalAddr				
Trip-T	SignalAddr				
Inrush	SignalAddr				
Stabilizing	SignalAddr				

Explanation of Parameters:**ParSet 4..1**

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

defines the tripping channel activated by the tripping output of the function (matrix).

g
defines the basic setting g of the operating characteristic.

v
defines the pick-up ratio v of the operating characteristic.

b
defines the value b of the operating characteristic. This should be set to approx. 1.5 times rated current.

g-High
High-set basic setting which replaces the normal basic setting when activated by the HighSetInp input.
It is used to prevent false tripping due, for example, to excessive flux (overfluxing).

I-Inst
Differential current, above which tripping takes place regardless of whether the protected unit has just been energised or not. This enables the time required to trip to be shortened for high internal fault currents.

InrushRatio
Ratio of 2nd. harmonic current content to fundamental current above which an inrush condition is detected.

InrushTime
Time during which the inrush detection function is active following initial energisation or an external fault.

a1
Amplitude compensation factor for winding 1.

s1
Connection of winding 1 (primary)
Settings provided:

- Y: star-connected
- D: delta-connected

CurrentInp1
defines the c.t. input channel for winding 1.

The first channel (R phase) of the two groups of three phases must be specified.

a2
Amplitude compensation factor for winding 2.

s2

Vector group for winding 2.

Settings provided: All usual groups of connection with

- designation of the circuit (y = star, d = delta, z = zigzag)
- phase-angle adjustment of the winding 2 voltage in relation to the winding 1 voltage in multiples of 30°.

CurrentInp2

defines the c.t. input channel for winding 2. The first channel (R phase) of the two groups of three phases must be specified.

a3

Amplitude compensation factor for winding 3.

s3

Vector group for winding 3.

Settings provided: All usual groups of connection with

- designation of the circuit (y = star, d = delta, z = zigzag)
- phase-angle adjustment of the winding 3 voltage in relation to the winding 1 voltage in multiples of 30°.

CurrentInp3

defines the c.t. input channel for winding 3. The first channel (R phase) of the two groups of three phases must be specified.

The protection operates in a two-winding mode, if a third input is not selected.

BlockInp

Binary address used as blocking input.

- F: - not blocked
- T: - blocked
- xx: - all binary inputs (or outputs of protection functions).

InrushInp

activates the inrush restraint, even though the transformer is already energised.

This enables, for example, the inrush current resulting from energising a parallel transformer to be detected and compensated.

- F: - not used
- xx: - all binary inputs (or outputs of protection functions).

HighSetInp

determines whether the normal or high-set basic setting g is used.

F: - not used

xx: - all binary inputs (or outputs of protection functions).

Trip

Output for the signalling tripping.

Trip-R

Output for signalling tripping by R phase.

Trip-S

Output for signalling tripping by S phase.

Trip-T

Output for signalling tripping by T phase.

Inrush

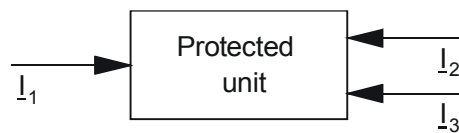
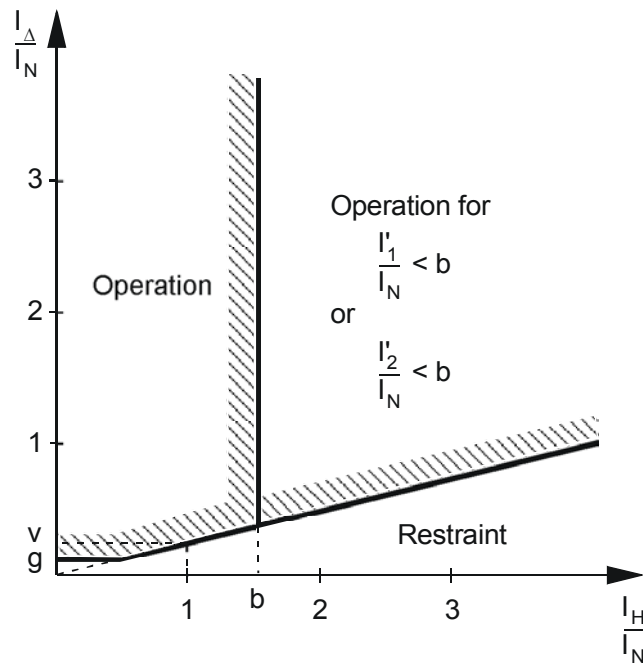
Output for signalling inrush current.

Stabilizing

Output for signalling $I_H > b$ during through-faults.

Note:

The differential protection function does not have a pick-up signal. Every time it trips, the signal 'GenStart' is set together with 'Trip', providing the tripping command is configured to be recorded as an event (ER).



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$$I_{\Delta} = |I_1 + I_2 + I_3|$$

Operating
(differential) current

$$I_H = \begin{cases} \sqrt{I'_1 \cdot I'_2 \cdot \cos \alpha} & \text{for } \cos \alpha \geq 0 \\ 0 & \text{for } \cos \alpha < 0 \end{cases}$$

Restriction current

where $I'_1 = \text{greatest of } I_1, I_2, I_3$

$$I'_2 = I_1 + I_2 + I_3 - I'_1$$

$$\alpha = \angle(I'_1; -I'_2)$$

Fig. 3.5.1.1 Operating characteristic: Diff-Transf

E. Setting instructions

Basic setting	g
Pick-up ratio	v
Operating characteristic switching point	b
Increased basic setting	g-High
Pick-up differential current (uninfluenced by inrush detection)	I-Inst
Pick-up ratio of the inrush detector	InrushRatio
Inrush detection time	InrushTime
Amplitude compensation factors	a1 a2 a3
Connection of winding 1	s1
Vector groups of windings 2 and 3	s2 s3

The purpose of the transformer differential protection is to detect phase faults in the protected zone. It may also detect earth faults and interturn faults. The protection is sensitive, fast and absolutely discriminative.

Basic setting g

The basic setting “g” defines the pick-up setting of the differential protection for internal faults.

The lowest possible value should be chosen for “g” (high sensitivity) to enable it to detect transformer earth faults and interturn faults in addition to phase faults.

The setting of “g” must not be too low, however, to avoid the danger of false tripping due to:

- c.t. errors
- the maximum off-load transformer current at the maximum short-time system voltage
- tap-changer range.

The off-load current (magnetising current) of a modern power transformer is very low, usually between 0.3 and 0.5 % of rated current at rated voltage. During short-time voltage peaks, e.g. following load shedding, the off-load current can reach as much as 10 % or more.

The tap-changer voltage range is usually between $\pm 5\%$ and $\pm 10\%$, but ranges of $\pm 20\%$ and more occur. Its influence has to be taken into account regardless of whether the tap-changer is manually operated or controlled by a voltage regulator.

All three of these influences cause a differential current, which flows during normal system conditions. The setting for “g” must be chosen above the level of this differential current. A typical setting is $g = 0.3 I_N$ (i.e. 30 % I_N).

Pick-up ratio v

The pick-up ratio “v” is decisive for the stability of the protection during external phase and earth faults, i.e. in the presence of high through-fault currents.

The value of “v” defines the ratio of the operating current to restraint current. The setting should be such that when operating under load conditions, weak faults causing only a low differential current can still be detected, but at the same time there is no risk of false tripping during through-faults. A typical setting is $v = 0.5$.

Restraint current b

The restraint current b defines the point at which the characteristic is switched.

The sloped section of the characteristic ensures that the relay remains stable during through-faults with c.t. saturation.

The ability to switch between two different slopes enables the characteristic to adapt to different conditions.

The recommended setting for “b” is 1.5. This provides high stability during high through-fault currents and sufficient sensitivity to detect fault currents in the region of the operating current.

Factors a_2 and a_3

The full setting range for the factors a_2 and a_3 for compensating current amplitude only applies, if the reference value for the c.t. input channels is set to 1.000. At all other settings, the permissible upper limit reduces in proportion to the ratio of the c.t. input channel reference values (transformer winding 1/winding 2, respectively winding 3/winding 1).

Operating characteristic

The restraint current in the case of a three-winding power transformer is derived from the currents of two windings and not three. In the interest of the best possible through-fault stability, the two largest currents of the three windings are used for this purpose.

The restrain current is either defined by the equation

$$I_H = \sqrt{I_1 \times I_2 \times \cos \alpha} \quad \text{for } -90^\circ < \alpha < 90^\circ$$

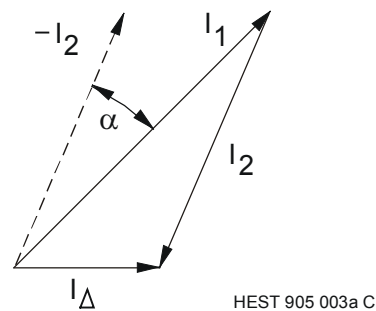
or is zero

$$I_H = 0 \quad \text{for } 90^\circ < \alpha < 270^\circ$$

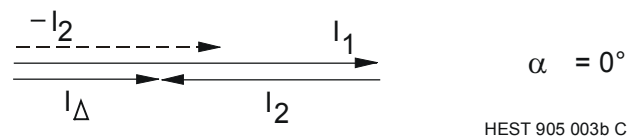
The angle

$$\alpha = \angle (I_1, -I_2)$$

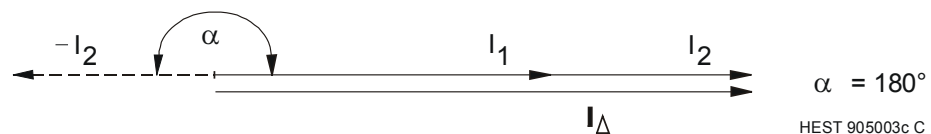
The following vector diagram of the current on primary and secondary sides and of the differential current measured for a transformer on load was assumed.



The following vector diagrams then result for a through-fault



and an internal fault



According to the equation for the restrain current, I_H becomes:

$$\text{for } (\alpha = 0) \quad : \quad I_H = \sqrt{I_1 \times I_2}$$

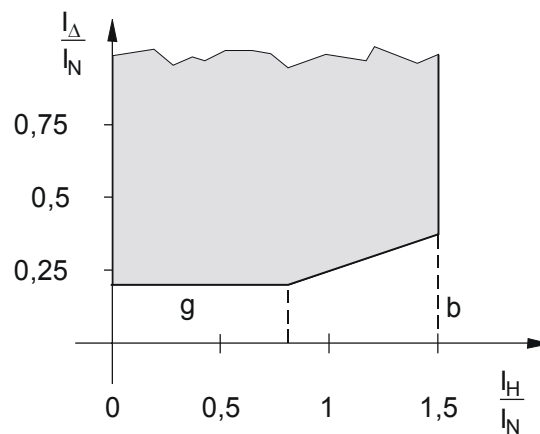
and for internal faults

$$\text{a) fed from on side } (I_2 = 0) \quad : \quad I_H = 0$$

$$\text{b) fed from both sides } (\alpha = 180^\circ) \quad : \quad I_H = 0$$

High through-fault currents can cause c.t. saturation and for this reason, the gradient of the characteristic is switched to infinity for $I_H/I_N > b$.

When measuring the operating characteristic, it should be noted that the gradient of the characteristic is only switched to infinity, if apart from I_H , I_1 and I_2 are also higher than b .



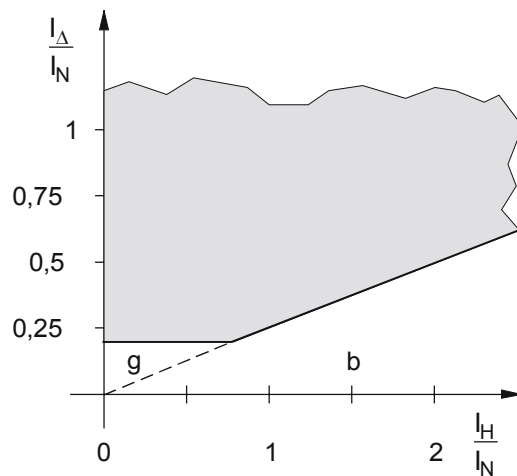
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Fig. 3.5.1.2 Operating characteristic of the transformer differential protection for high through-fault currents

This characteristic, however, would scarcely be able to detect faults in the protected zone at through currents as low as the load current. Therefore if one of the windings is conducting a current which is less than the setting of "b", i.e.

$$\frac{I_1}{I_N} \text{ or } \frac{I_2}{I_N} < b$$

the characteristic is switched back to the gradient according to "V".



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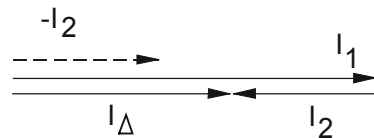
Fig. 3.5.1.3 Operating characteristic of the transformer differential protection for low through-fault currents

This characteristic provides higher sensitivity for the detection of faults in the protection zone.

Example:

Internal fault and rated current flowing through the transformer:

$$\frac{I_1}{I_N} = 4 \quad \frac{I_2}{I_N} = 1 \quad \alpha = 0$$



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$$I_{\Delta} = I_1 + I_2 = 4I_N - I_N = 3I_N$$

$$I_H = \sqrt{I_1 \times I_2 \times \cos \alpha} = \sqrt{4I_N \times 1I_N \times 1} = 2I_N$$

Internal faults will thus be reliably detected when a through-current is flowing even at the highest setting for “v”.

Increased basic setting g-High

The increased basic setting g-High has been provided as a means of preventing false tripping under particular operating conditions. It is activated by an external signal.

Situations occur during normal system operation which cause a higher differential current, e.g.

- increased magnetising current as a consequence of a higher system voltage (switching operations, following load shedding, generator regulator faults etc.)
- large variation of current ratio (tap-changer at the end of its range)

Providing special conditions of this kind are detected by a voltage relay or a saturation relay, the corresponding signal can be used to switch the differential function from “g” to “g-High”. The recommended setting is g-High = $0.75 I_N$.

The reset ratio following a trip remains unchanged at 0.8 g.

Differential current I-Inst

The differential current setting I-Inst. facilitates fast tripping of high internal fault currents (inhibits the detection of an inrush current).

The setting must be higher than any normal inrush current to be expected.

A typical value for power transformers of low to medium power is I-Inst. = $12 I_N$.

Pick-up ratio for detecting inrush

The setting of this ratio determines the sensitivity of the function for detecting inrush.

Generally the ratio of 2nd. harmonic to fundamental is greater than 15 %. Allowing a margin to ensure that an inrush condition is detected, a setting of 10 % is recommended.

Duration of active inrush detection

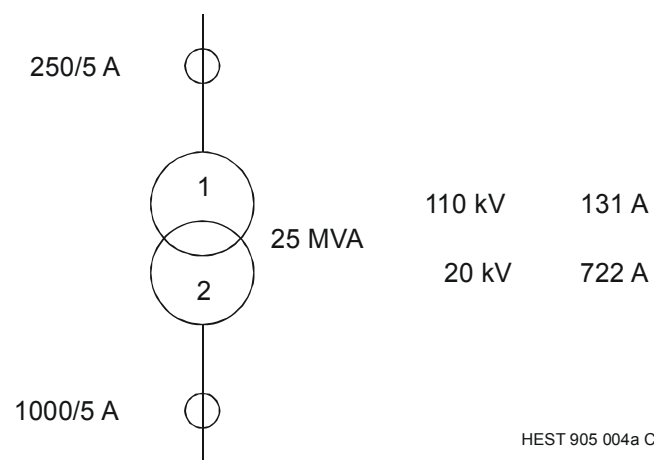
The setting for how long the inrush detection function should be active depends on how long the danger of false tripping due to an inrush current, which only flows through one winding, exists. A typical setting is 5 s.

Amplitude compensation factors a1, a2, a3

Factors a1, a2 and a3 facilitate compensating differences between the rated currents of the protected unit and the c.t.'s.

The "a" factors are defined by the ratio of the c.t. rated current to the reference current.

In the case of a two-winding transformer, both windings have the same rated power and the rated current of the transformer is taken as the reference current. Providing the factor "a" is correctly set, all the settings of g, v, b, g-High and I-Inst. are referred to the rated current of the transformer and not to the rated primary current of the c.t.



$$I_{B1} = I_{TN1} = 131 \text{ A} \quad a1 = \frac{I_{CT1}}{I_{TN1}} = \frac{250}{131} = 1.91$$

$$I_{B2} = I_{TN2} = 722 \text{ A} \quad a1 = \frac{I_{CT2}}{I_{TN2}} = \frac{1000}{722} = 1.38$$

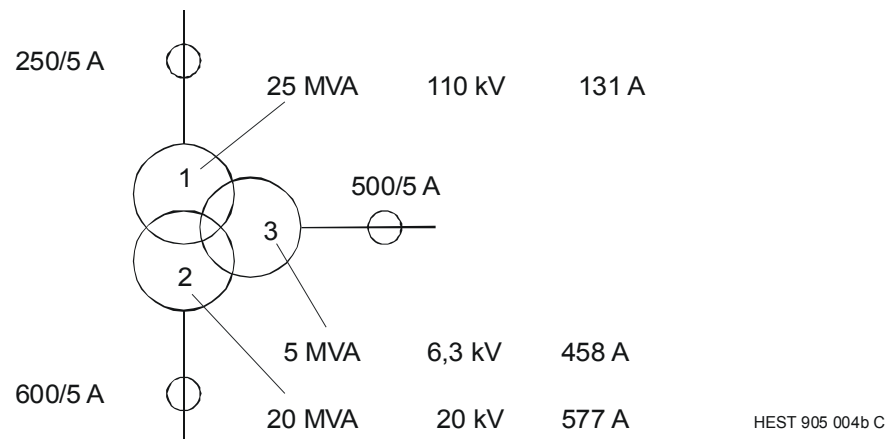
The reference current is only chosen to be different from the transformer rated current, if this should be necessary because of the setting range of factors a1 and a2.

Differences between the rated currents of the c.t.'s and a two-winding transformer may also be compensated by adjusting the reference values of the A/D channels. In this case and assuming the power ratings of the two windings to be the same, the factors are set to $a1 = a2 = 1$. The reference values in the case of the above example are:

$$\frac{I_{TN1}}{I_{CT1}} = \frac{131}{250} = 0.524 \quad \frac{I_{TN2}}{I_{CT2}} = \frac{722}{1000} = 0.722$$

A further difference lies in the fact that the "a" factors only effect the differential protection, whilst changing the reference values of the A/D channels effects the currents for the entire protection system (all functions and measured variables).

The windings of a three-winding transformer normally have different power ratings and a reference power has to be chosen, which is used for all three windings. All the settings of the protection are then referred to the reference currents calculated from the reference power.



Assuming the reference power S_B to be 25 MVA, the reference currents I_B and the "a" factors become:

$$I_{B1} \frac{S_B}{\sqrt{3} \times U_{TN1}} = \frac{25}{\sqrt{3} \times 110} = 131 \text{ A} \quad a1 = \frac{I_{CT1}}{I_{B1}} = \frac{250}{131} = 1.91$$

$$I_{B2} \frac{S_B}{\sqrt{3} \times U_{TN2}} = \frac{25}{\sqrt{3} \times 20} = 722 \text{ A} \quad a2 = \frac{I_{CT2}}{I_{B2}} = \frac{600}{722} = 0.83$$

$$I_{B3} \frac{S_B}{\sqrt{3} \times U_{TN3}} = \frac{25}{\sqrt{3} \times 6.3} = 2291 \text{ A} \quad a3 = \frac{I_{CT3}}{I_{B3}} = \frac{500}{2291} = 0.22$$

The same results are obtained by applying the formulas with the reference power S_B :

$$a1 = \frac{U_{TN1} \times I_{CT1} \times \sqrt{3}}{S_B} = \frac{110 \times 250 \times \sqrt{3}}{25000} = 1.905$$

$$a2 = \frac{U_{TN2} \times I_{CT2} \times \sqrt{3}}{S_B} = \frac{20 \times 600 \times \sqrt{3}}{25000} = 0.83$$

$$a3 = \frac{U_{TN3} \times I_{CT3} \times \sqrt{3}}{S_B} = \frac{6.3 \times 500 \times \sqrt{3}}{25000} = 0.218$$

A further possibility of compensating different rated powers in the case of three-winding transformers is to use

- the reference values of the A/D channels to match the protection to the different rated currents of c.t.'s and transformer
- factors a1, a2 and a3 to compensate the different powers of the windings.

The “a” factors compensate the signals at the inputs of the differential protection.

If the reference values of the A/D channels are changed, the changes apply to the entire protection system (i.e. all functions and measured variables).

This can be seen from the following example.

Reference values:

$$\text{Winding 1:} \quad \text{Reference value} = \frac{I_{TN1}}{I_{CT1}} = \frac{131}{250} = 0.524$$

$$\text{Winding 2:} \quad \text{Reference value} = \frac{I_{TN2}}{I_{CT2}} = \frac{577}{600} = 0.962$$

$$\text{Winding 3:} \quad \text{Reference value} = \frac{I_{TN3}}{I_{CT3}} = \frac{458}{500} = 0.916$$

Factors a1, a2 and a3:

$$a1 = \frac{I_{TN1}}{I_{B1}} = \frac{131}{131} = 1$$

$$a2 = \frac{I_{TN2}}{I_{B2}} = \frac{577}{722} = 0.799$$

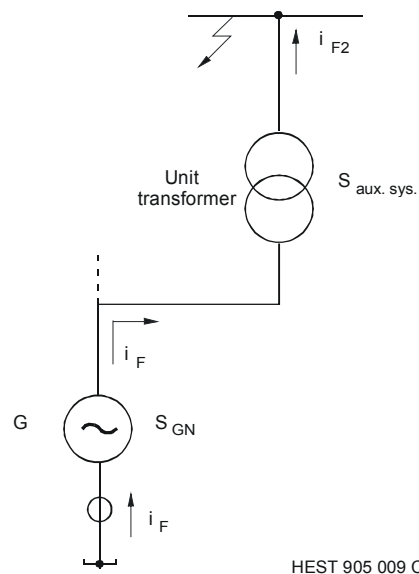
$$a3 = \frac{I_{TN3}}{I_{B3}} = \frac{458}{2291} = 0.200$$

C.t.'s in the unit transformer feeder

When designing the overall differential protection for a generator/transformer unit, there are the following alternative methods of taking account of the c.t.'s or lack of c.t.'s in the unit transformer feeder (Fig. 3.5.1.4).

Alternative No.1: No c.t.'s in the unit transformer feeder.

This alternative is mainly needed for hydroelectric power plants, which have a relatively low auxiliaries requirement. The disadvantage is that the zone of protection is unlimited in the direction of the unit transformer feeder with the possible hazard of false tripping for a fault on the unit auxiliaries supply system. This hazard can be avoided by correspondingly setting "g".



A fault on the unit auxiliaries supply system causes a current i_F (in p.u.) to flow to the generator star-point.

$$i_F = i_{F2} \frac{S_{\text{aux.sys.}}}{S_{\text{GN}}}$$

Example: $i_{F2} = 10; \quad \frac{S_{\text{aux.sys.}}}{S_{\text{GN}}} = 0.03$

$$i_F = 10 \times 0.03 = 0.3$$

It follows from this that “g” must be set higher than 0.3 to avoid the possibility of a false trip.

Alternative No. 2: C.t.’s installed in the unit transformer feeder on the generator side of the unit transformer (Fig. 3.5.1.4). These c.t.’s usually have the same ratio as the generator c.t.’s although the rating of the unit transformer is much less. The reason is the high fault level on the generator side of the unit transformer and the consequentially high thermal and dynamic stress on the c.t.’s.

The reference value of the c.t. channel of the protection is determined by the rated current of the generator and not of the unit transformer.

Alternative No. 3: C.t.’s installed in the unit transformer feeder on the auxiliaries side of the unit transformer (Fig. 3.5.1.4). In this case, the c.t.’s are specified according to the rated current of the unit transformer.

Advantages:

- clearly defined zone of protection
- reduced performance required of the c.t.’s, which are therefore cheaper.

Disadvantages:

- Interposing c.t.’s may be necessary.
- reduced sensitivity of the protection for faults in the protected zone, but on the auxiliaries side of the unit transformer.

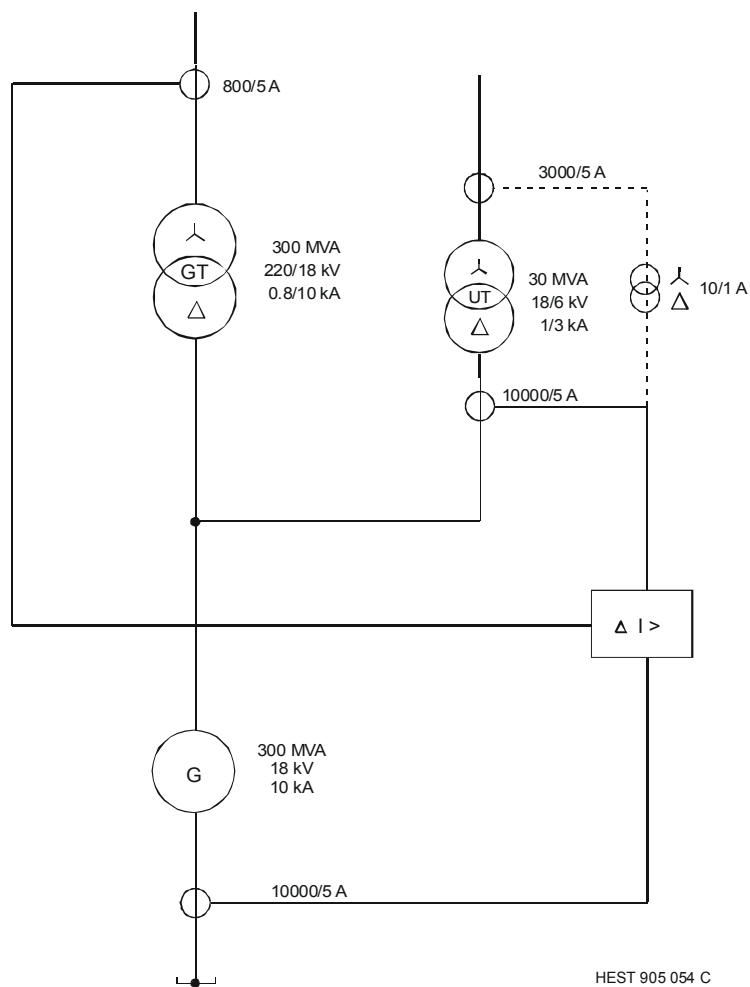
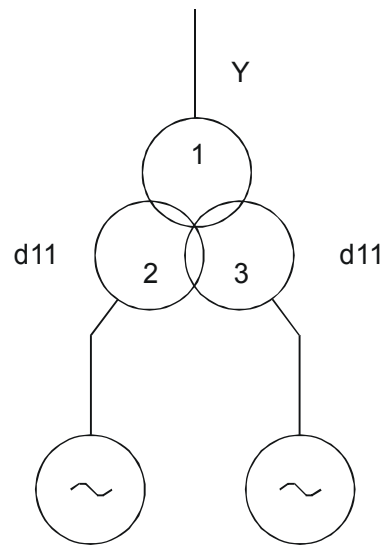


Fig. 3.5.1.4 The overall differential protection of a generator/transformer unit

Group of connection of a three-phase transformer s1, s2, s3

Factor s1 defines the connection of the three phase windings 1. Factors s2 and s3 define the group of connection of windings 2 and windings 3 respectively, i.e. they define firstly how the windings are connected and secondly their phase-angle referred to windings 1.

The following arrangement is an example for two generators with a common step-up transformer:



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The factors are correspondingly:

$$s1 = Y$$

$$s2 = d11$$

$$s3 = d11$$

Factors s2 and s3 are defined according to their phase shift in relation to the HV side, i.e. to windings 1.

Note:

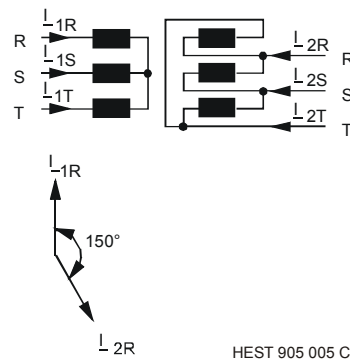
This setting for the vector group (s2 = d11, s3 = d11) assumes that in relation to the protected unit, the star-point is symmetrically formed and grounded on the secondary side of the main c.t's.

Should this not be possible for some reason (e.g. plant requirements), the group of connection has to be compensated.

Compensation for group of connection

Phase-to-phase currents are measured in order to compare primary and secondary currents without regard to the circuit of the transformer. The combination of these currents internally in the protection takes account, however, of their phase relationships. The relationships between the current vectors for different groups of connection can be seen from the following illustrations.

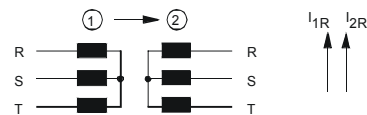
For example, for a Yd5 connected transformer



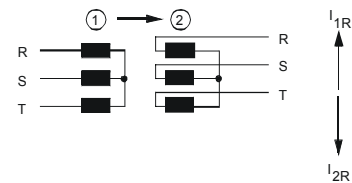
- Star-connected primary
- Delta-connected secondary
- Phase-angle between the currents of the same phase on both sides
 $5 \times 30^\circ = 150^\circ$

$$\begin{cases} I_{1r}(\text{compensated}) = 1/\sqrt{3} (-I_{1R} + I_{1S}) \\ I_{2r}(\text{compensated}) = I_{2R} \end{cases}$$

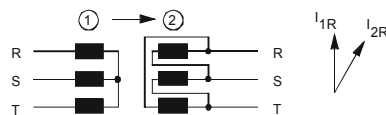
Yy0



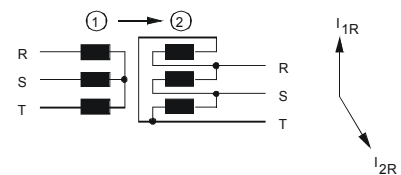
Yy6



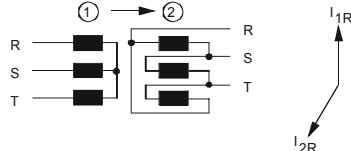
Yd1



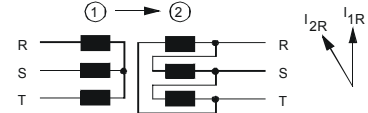
Yd5



Yd7

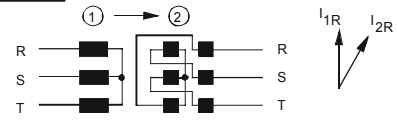


Yd11

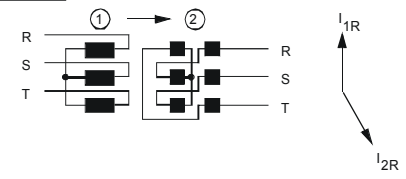


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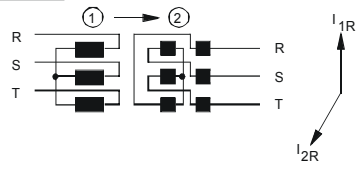
Yz1



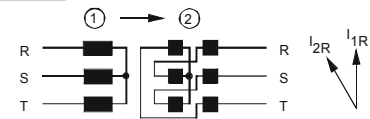
Yz5



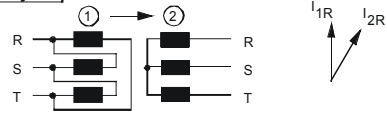
Yz7



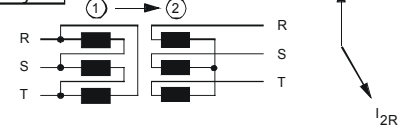
Yz11



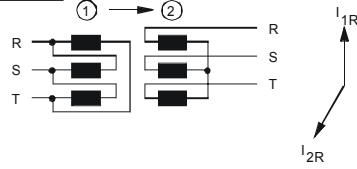
Dy1



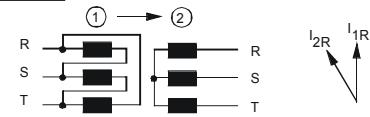
Dy5



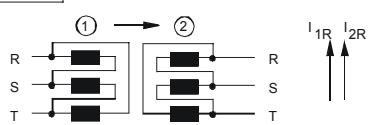
Dy7



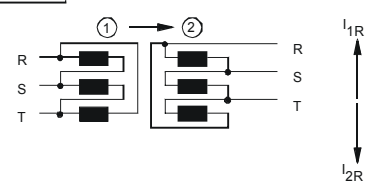
Dy11



Dd0

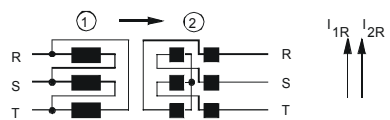


Dd6

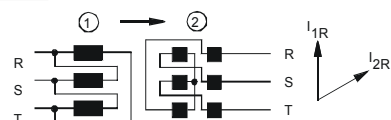


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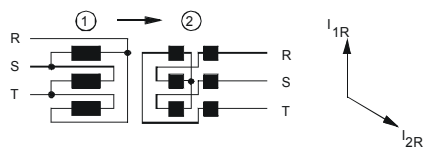
Dz0



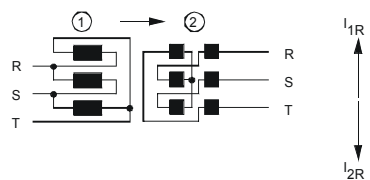
Dz2



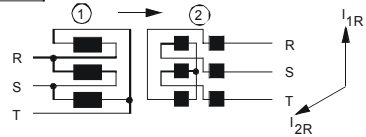
Dz4



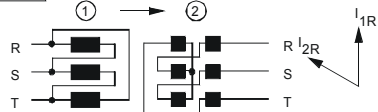
Dz6



Dz8



Dz10



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List of all the compensation matrices for R phase
(S and T phases cyclically rotated):

Compensation matrices (R phase)	Amplitude factor
A = (1 0 0)	1
B = (-1 0 0)	1
C = (1 -1 0)	$1 / \sqrt{3}$
D = (-1 1 0)	$1 / \sqrt{3}$
E = (1 0 -1)	$1 / \sqrt{3}$
F = (-1 0 1)	$1 / \sqrt{3}$
G = (2 -1 -1)	$1 / 3$
H = (-2 1 1)	$1 / 3$
J = (-1 2 -1)	$1 / 3$
K = (1 -2 1)	$1 / 3$
L = (-1 -1 2)	$1 / 3$
M = (1 1 -2)	$1 / 3$
N = (0 1 0)	1
O = (0 -1 0)	1

Table 3.5.1.1 Compensation matrices and associated amplitude factors

a) Star connection on winding 1

Two-winding transformer:

Group	Comp. matrix Winding 1	Comp. matrix Winding 2
Yy0	E	E
Yy6	E	F
Yd1	E	A
Yd5	C	B
Yd7	E	B
Yd11	C	A
Yz1	E	G
Yz5	C	H
Yz7	E	H
Yz11	C	G

Three-winding transformer:

Compensation matrix winding 1 x x x Compensation matrix winding 2 Compensation matrix winding 3										
s3 \ s2	y0	y6	d1	d5	d7	d11	z1	z5	z7	z11
y0	EEE	EEF	EEA	CCB	EEB	CCA	EEG	CCH	EEH	CCG
y6	EFE	EFF	EFA	CDB	EFB	CDA	EFG	CDH	EFH	CDG
d1	EAE	EAF	EAA	COB	EAB	COA	EAG	COH	EAH	COG
d5	CBC	CBD	CBO	CBB	CBN	CBA	CBK	CBH	CBJ	CBG
d7	EBE	EBF	EBA	CNB	EBB	CNA	EBG	CNH	EBH	CNG
d11	CAC	CAD	CAO	CAB	CAN	CAA	CAK	CAH	CAJ	CAG
z1	EGE	EGF	EGA	CKB	EGB	CKA	EGG	CKH	EGH	CKG
z5	CHC	HD	CHO	CHB	CHN	CHA	CHK	CHH	CHJ	CHG
z7	EHE	EHF	EHA	CJB	EHB	CJA	EHG	CJH	EHH	CJG
z11	CGC	CGD	CGO	CGB	CGN	CGA	CGK	CGH	CGJ	CGG

Table 3.5.1.2 Summary of the compensation matrices for a three-winding transformer with a star connection on winding 1

b) Delta connection on winding 1

Applies for two and three-winding transformers:

Group	Comp. matrix Winding 1	Comp. matrix Winding 2 (and 3)
Dy1	A	C
Dy5	A	F
Dy7	A	D
Dy11	A	E
Dd0	A	A
Dd6	A	B
Dz0	A	G
Dz2	A	K
Dz4	A	L
Dz6	A	H
Dz8	A	J
Dz10	A	M

Example:

The compensation for the currents of a three-winding transformer Yd5y0 is as follows:

$$\left. \begin{array}{l} s1 = Y \\ s2 = d5 \\ s3 = y0 \end{array} \right\} \quad \text{CBC results from Table 3.5.1.2, i.e. the}$$

compensation matrix
for winding 1

$$= C = \begin{pmatrix} 1 & -1 & 0 \end{pmatrix} \quad (\text{see Table 3.5.1.1})$$

with an amplitude factor of $1/\sqrt{3}$

compensation matrix
for winding 2

$$= B = \begin{pmatrix} -1 & 0 & 0 \end{pmatrix} \quad (\text{see Table 3.5.1.1})$$

with an amplitude factor of 1

compensation matrix
for winding 3

$$= C = \begin{pmatrix} 1 & -1 & 0 \end{pmatrix} \quad (\text{see Table 3.5.1.1})$$

with an amplitude factor of $1/\sqrt{3}$

The function currents then become:

Function currents (calculated)	Currents measured at the c.t.'s
Winding 1: $\begin{pmatrix} I_{r1} \\ I_{s1} \\ I_{t1} \end{pmatrix} = \frac{1}{\sqrt{3}}$	$\begin{pmatrix} 1 & -1 & 0 \\ 0 & 1 & -1 \\ -1 & 0 & 1 \end{pmatrix} \begin{pmatrix} I_{R1} \\ I_{S1} \\ I_{T1} \end{pmatrix}$
Winding 2: $\begin{pmatrix} I_{r2} \\ I_{s2} \\ I_{t2} \end{pmatrix} = 1$	$\begin{pmatrix} -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{pmatrix} \begin{pmatrix} I_{R2} \\ I_{S2} \\ I_{T2} \end{pmatrix}$
Winding 3: $\begin{pmatrix} I_{r3} \\ I_{s3} \\ I_{t3} \end{pmatrix} = \frac{1}{\sqrt{3}}$	$\begin{pmatrix} 1 & -1 & 0 \\ 0 & 1 & -1 \\ -1 & 0 & 1 \end{pmatrix} \begin{pmatrix} I_{R3} \\ I_{S3} \\ I_{T3} \end{pmatrix}$

Typical values:

g	$0.3 I_N$
v	0.5
b	1.5
g-High	$0.75 I_N$
I-Inst.	$12 I_N$
InrushRatio	10%
InrushTime	5 s
a1, a2, a3	have to be calculated.
s1, s2, s3	depend on plant.

3.5.2. Generator differential (Diff-Gen)

A. Application

Differential protection of generators.

B. Features

- non-linear current-dependent tripping characteristic (see Fig. 3.5.2.1)
- high stability during through-faults and c.t. saturation
- short operating times
- three-phase measurement
- optimised for the differential protection of generators, i.e.
 - no inrush restraint
 - no compensation of group of connection
 - only two measuring inputs
- suppression of DC off-set
- suppression of harmonics.

C. Inputs and outputs

I. Analogue inputs:

- current (2 sets of 3 inputs)

II. Binary inputs:

- blocking

III. Binary outputs:

- tripping
- R phase trip
- S phase trip
- T phase trip

IV. Measurements:

- R phase summation current
- S phase summation current
- T phase summation current

D. Generator differential function settings - Diff-Gen

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
Trip		000000			
g-Setting	IN	0.10	0.10	0.50	0.05
v-Setting		0.25	0.25	0.50	0.25
CurrentInp	AnalogAddr	0			
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Trip-R	SignalAddr				
Trip-S	SignalAddr				
Trip-T	SignalAddr				

Explanation of parameters:

ParSet 4..1

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

defines the Tripping channel activated by the tripping output of the function (tripping logic).

g-Setting

Basic setting (sensitivity) g of the operating characteristic.

v-Setting

Pick-up ratio (slope) of the operating characteristic.

CurrentInp

defines the A/D input channels. The first channel (R phase) of the two groups of three phases must be specified.

BlockInp

Binary address used as blocking input.

F: - Not blocked

T: - Blocked

xx: - all binary inputs (or outputs of a protection function).

Trip

Output for signalling tripping

Trip-R

signals that tripping was initiated by R phase.

Trip-S

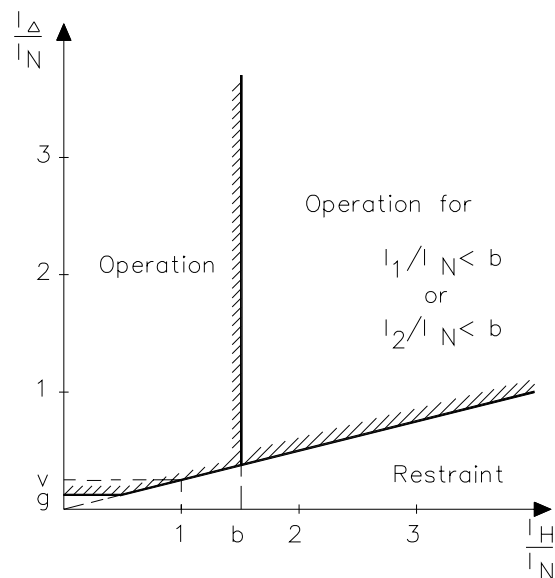
signals that tripping was initiated by S phase.

Trip-T

signals that tripping was initiated by T phase.

Note:

The differential protection function does not have a pick-up signal. Every time it trips, the signal 'GenStart' is set together with 'Trip', providing the tripping command is configured to be recorded as an event.



$$I_{\Delta} = |I_1 + I_2|$$

Operating (differential) current

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

$$\alpha = \angle (I_1; -I_2)$$

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Fig. 3.5.2.1 Operating characteristic of the generator differential protection (Diff-Gen)

E. Setting instructions

Basic setting
Pick-up ratio

g-Setting
v-Setting

The purpose of the generator differential protection is to detect phase faults in the stator zone. The protection is sensitive, fast and absolutely discriminative.

Basic setting g

The basic setting g defines the pick-up of the differential protection for internal faults. It is the section of the operating characteristic with a low restraint current I_H .

The lowest possible value should be chosen for “g” (high sensitivity) to enable it to detect the worst case faults, e.g. when excitation is low. The protection cannot detect interturn faults on the same winding, because they do not produce a differential current.

Since, however, a small differential current flows during normal operation, false tripping could result if “g” is set too low. The spurious differential current is usually due to imbalances of c.t. errors and c.t. burdens.

Allowing for an unwanted differential current, a typical setting is $0.1 I_N$. Higher values have to be set for “g” should, for example, the c.t.’s on opposite sides of the protected unit have different accuracy classes or their burdens be too high.

The level of primary current at which the protection picks up depends on the relay settings and the ratio of the c.t.’s. Assuming that there is no compensation of the A/D channels by reference value settings, it is calculated as follows:

Relay setting $g = 0.1 I_N$
(where I_N is the relay rated current)

Generator rated current $I_{GN} = 4000 \text{ A}$

C.t. rated current $I_{N1} = 5000 \text{ A}$

Calculated primary pick-up current
(referred to the generator rated current):

$$i = \frac{g}{I_N} \times \frac{I_{N1}}{I_{GN}} = 0.1 \frac{5000}{4000} = 0.125$$

Pick-up ratio v

The pick-up ratio “ v ” is decisive for the stability of the protection during through-faults. This is the section of the operating characteristic with restraint currents higher than $1.5 I_N$.

The value of “ v ” defines the pick-up current I_D for a restrain current I_H in the moderately sloped region of the operating characteristic. In the case of generator differential protection, “ b ” has a fixed setting of 1.5 (compare this with [Figures 3.5.1.2](#) and [3.5.1.3](#) for transformer differential protection).

The “ v ” setting should be low enough to make the protection sensitive to faults when load current is flowing, but high enough to avoid false tripping during through-faults. A typical setting is $v = 0.25$.

A higher setting ($v = 0.5$) is chosen in cases where the transient behaviour of the c.t.'s during through-faults can cause large differential currents. This is normally the result of under-sized c.t.'s or widely differing c.t. burdens.

Typical settings:

g-Setting	$0.1 I_N$
v-Setting	0.25

3.5.3. Definite time over and undercurrent (Current-DT)**A. Application**

General purpose current function (over and under) for

- phase fault protection
- back-up protection

or for monitoring a current minimum.

B. Features

- insensitive to DC component
- insensitive to harmonics
- single or three-phase measurement
- maximum respectively minimum value detection in the three-phase mode
- detection of inrush currents.

C. Inputs and outputs**I. C.t./v.t. inputs:**

- Current

II. Binary inputs:

- Blocking

III. Binary outputs:

- pick-up
- tripping

IV. Measurements:

- current amplitude.

D. Definite time current function settings - Current-DT

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
Trip		00000000			
Delay	s	01.00	0.02	60.00	0.01
I-Setting	IN	02.00	0.02	20.00	0.01
MaxMin		MAX (1ph)	(Select)		
NrOfPhases		001	1	3	2
CurrentInp	CT/VT-Addr	0			
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr	ER			

Explanation of parameters:

ParSet 4..1

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

defines the tripping channel activated by the tripping O/P of the function (matrix tripping logic).

Delay

Time between the function picking up and tripping.

I-Setting

Pick-up current setting.

Forbidden settings:

- $> 1.6 I_N$ when supplied from metering cores
- $< 0.2 I_N$ when supplied from protection cores.

MaxMin

defines operation as overcurrent or undercurrent or with inrush blocking. Settings:

- MIN (3ph): Undercurrent.
Three-phase functions detect the highest phase current.
Not permitted for single-phase functions.
- MIN (1ph): Undercurrent.
Three-phase functions detect the lowest phase current.

- MAX (3ph): Overcurrent.
Three-phase functions detect the lowest phase current.
Not permitted for single-phase functions.
- MAX (1ph): Overcurrent.
Three-phase functions detect the highest phase current.
- MAX-Inrush: Blocks during inrush currents if one phase exceeds setting.

NrOfPhases

defines whether single or three-phase measurement.

CurrentInp

defines the c.t. input channel. All current I/P's may be selected. In the case of three-phase measurement, the first channel (R phase) of the group of three selected must be specified.

BlockInp

I/P for blocking the function.

F: - not blocked

T: - blocked

xx: - all binary I/P's (or O/P's of protection functions).

Trip

Tripping signal.

Start

Pick-up signal.

E. Setting instructions

Settings:

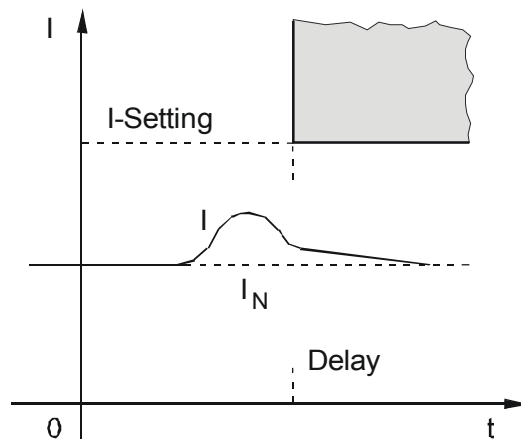
Setting	I-Setting
Delay	Delay
Over or undercurrent	MaxMin
Number of phases	NrOfPhases

Setting I-Setting

The current setting 'I-Setting' must be sufficiently high on the one hand to avoid any risk of false tripping or false signals under normal load conditions, but should be low enough on the other to detect the lowest fault current that can occur. The margin which has to be allowed between the maximum short-time load current and the setting must take account of:

- the tolerance on the current setting
- the reset ratio.

The maximum short-time load current has to be determined according to the power system conditions and must take switching operations and load surges into account.



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Fig. 3.5.3.1 Operating characteristic of the definite time over-current function

Compensating any difference between the rated currents of c.t. I_{N1} and protected unit I_{GN} is recommended. This is achieved with the aid of the reference value of the A/D channel or by correcting the overcurrent setting.

For example, for $I_{GN} = 800 \text{ A}$ and $I_{N1} = 1000 \text{ A}$, the setting for a pick-up current of $1.5 I_{GN} = 1200 \text{ A}$ would have to be

$$1.5 \frac{I_{GN}}{I_{N1}} = 1.5 \frac{800 \text{ A}}{1000 \text{ A}} = 1.2$$

CurrentInp

An interposing c.t. in the input is essential for current settings lower than $< 0.2 I_N$.

Delay

The delay is used to achieve discrimination of the overcurrent function. It is set according to the grading table for all the overcurrent units on the power system. The zone of protection of our overcurrent function extends to the location of the next downstream overcurrent relay.

Should the downstream relay fail to clear a fault, the overcurrent function trips slightly later as a back-up protection.

Setting MaxMin

This parameter enables the following operating modes to be selected:

- MIN (3ph): Pick-up when the highest phase current also falls below the setting. This setting is not permitted for single-phase measurement.
- MIN (1ph): Pick-up when the lowest phase current falls below the setting.
- MAX (3ph): Pick-up when the lowest phase current also exceeds the setting. This setting is not permitted for single-phase measurement.
- MAX (1ph): Pick-up when the highest phase current exceeds the setting.
- MAX-Inrush: Blocking of inrush currents when a phase current exceeds the setting.

Operation of the inrush blocking feature (parameter MaxMin set to 'MAX-Inrush')

The inrush detector picks up and blocks operation of the function when the amplitude of the fundamental component of the current exceeds the setting of the current function.

The inrush detector is based on the evaluation of the second harmonic component of the current I_{2h} in relation to the fundamental frequency component I_{1h} (evaluation of the amplitudes).

The output of the function is disabled when the ratio I_{2h}/I_{1h} exceeds 10 % and enabled again when it falls below 8 %.

There is no setting for the peak value of I_{2h}/I_{1h} .

The function can operate with inrush blocking in both the single and three-phase mode (parameter 'NrOfPhase').

In the three-phase mode, the phase used for evaluation is the one with the highest amplitude at rated frequency (pick-up and inrush detection).

3.5.4. Peak value overcurrent (*Current-Inst*)

A. Application

- General current monitoring with instantaneous response (over and undercurrent)
- Current monitoring where insensitivity to frequency is required (over and undercurrent).

B. Features

- processes instantaneous values and is therefore fast and largely independent of frequency
- stores the peak value following pick-up
- no suppression of DC component
- no suppression of harmonics
- single or three-phase measurement
- maximum value detection in the three-phase mode
- adjustable lower frequency limit $f_{\min}$.

C. Inputs and outputs

I. C.t./v.t. inputs

- current

II. Binary inputs

- blocking

III. Binary outputs

- pick-up
- tripping

IV. Measurements

- current amplitude (only available if function trips).

D. Peak value current function settings - Current-Inst

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
Trip		0000000			
Delay	s	00.01	0.00	60.00	0.01
I-Setting	IN	04.00	0.1	20	0.1
f-min	Hz	40	2	50	1
MaxMin		MAX	(Select)		
NrOfPhases		001	1	3	2
CurrentInp	CT/VT-Addr	0			
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr	ER			

Explanation of parameters:

ParSet 4..1

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

defines the tripping channel activated by the tripping output of the function (matrix).

Delay

Time between the function picking up and tripping.

I-Setting

Pick-up current setting.

Setting restrictions:

- not > 1.6 I_N when supplied from metering cores
- not < 0.2 I_N when supplied from protection cores.

f-min

defines the minimum frequency for which measurement is required.

Setting restriction:

not < 40 Hz when supplied from metering cores.

MaxMin

defines operation as overcurrent or undercurrent. Settings:

- MAX: overcurrent
- MIN: undercurrent.

NrOfPhases

defines whether single or three-phase measurement.

CurrentInp

defines the c.t. input channel.

All current inputs may be selected.

In the case of three-phase measurement, the first channel (R phase) of the group of three selected must be specified.

BlockInp

Binary address used as blocking input.

- F: - not blocked
- T: - blocked
- xx: - all binary inputs (or outputs of protection functions).

Trip

Output for signalling tripping.

Start

Output for signalling pick-up.

E. Setting instructions

Settings:

Current pick-up	I-Setting
Delay	Delay
Minimum frequency	f-min
Over or undercurrent	MaxMin

The instantaneous overcurrent function is a high-speed protection which operates in a wide frequency range. It is intended primarily for two applications.

A protection measuring peak value is necessary for protecting units, for which the influence of DC component and harmonics may not be neglected. This is especially the case where rectifiers with semiconductors are involved.

The measuring principle of the function is relatively insensitive to frequency and operates in a range extending from 4 to 120 % of rated frequency. It is therefore able to protect units with synchronous starting equipment during the starting sequence before reaching system frequency (e.g. gas turbine sets with solid-state starters).

The function detects when the instantaneous value of the input current exceeds the peak value corresponding to the setting. For example, for a setting of $10 I_N$, it will pick up when the input current exceeds $10 \sqrt{2} I_N = 14.14 I_N$ (see Fig. 3.5.4.1). A fault current of $6 \times 1.8 \sqrt{2} I_N = 15.27 I_N$ could reach this level as a consequence of a DC component.

The minimum frequency must be entered for every application, because it determines the reset time. A low minimum frequency means a long reset delay and since a good protection is expected to have a quick response, the reset time should be as short as possible, i.e. the minimum frequency setting should not be lower than absolutely necessary.

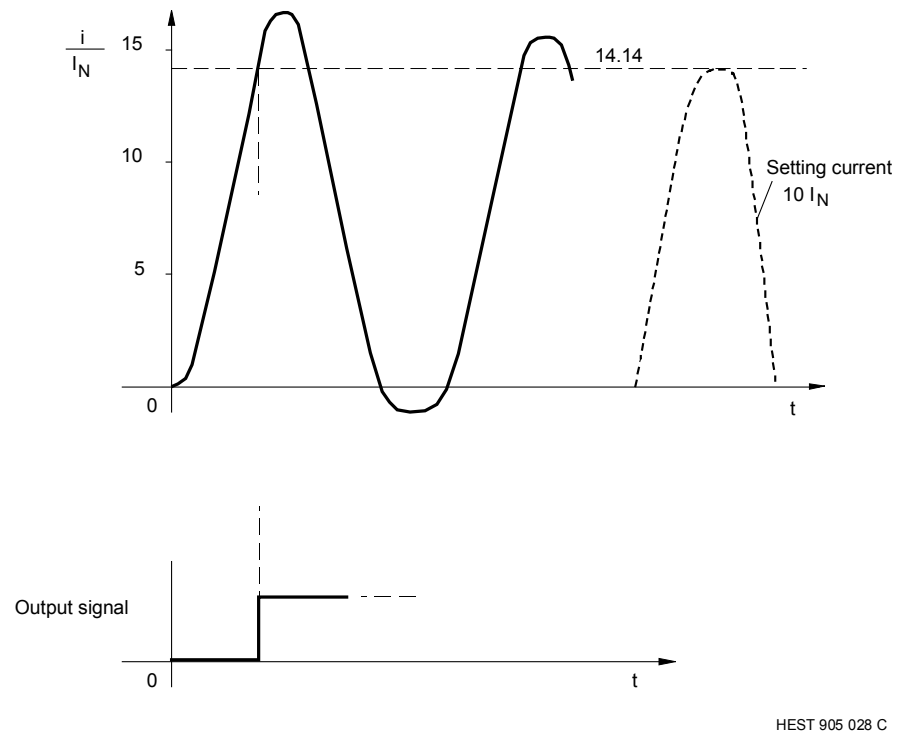


Fig. 3.5.4.1 Operation of the peak value overcurrent function

Typical settings:

a) Peak value phase fault protection

I-Setting	according to application
Delay	0.01 s
f-min	40 Hz

b) Phase fault protection of a machine with synchronous starter during start-up

I-Setting	$1.5 I_N$
Delay	5 s
f-min	2 Hz

3.5.5. Voltage-controlled overcurrent (I_{max} - U_{min})

A. Application

Phase fault protection of generators with rapidly decaying fault current such that a normal time overcurrent function could reset before its delay had expired.

B. Features

- stores the maximum current value after pick-up
- resets either after recovery of the system voltage or after tripping
- processes the positive-sequence component of the voltage
- insensitive to DC component and harmonics
- single or three-phase measurement with detection of the highest phase value in the three-phase mode.

C. Inputs and outputs

I. Analogue inputs:

- current
- voltage

II. Binary inputs:

- blocking

III. Binary outputs:

- pick-up
- tripping

IV. Measurements:

- current amplitude
- positive-sequence voltage.

D. Voltage controlled overcurrent settings - I_{max}-U_{min}

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
Trip		00000000	Trip Chan		
Delay	s	01.00	0.5	60.00	0.01
Current	IN	02.00	0.5	20	0.1
Hold-Voltage	UN	00.70	0.4	1.1	0.01
Hold-Time	s	01.00	0.1	10	0.02
NrOfPhases		001	1	3	2
CurrentInp	AnalogAddr	0			
VoltageInp	AnalogAddr	0			
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr	ER			

Explanation of parameters:**ParSet 4..1**

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

defines the tripping channel activated by the tripping output of the function (tripping logic).

Delay

Time between the function picking up and tripping.

Current

Pick-up current setting.

Setting restrictions:

- not > 1.6 I_N when supplied from metering cores

Hold-Voltage

Voltage below which the pick-up status latches, even if the current falls below the pick-up setting.

Hold-Time

defines how long the tripping signal latches when the voltage condition is fulfilled.

NrOfPhases

defines whether single or three-phase measurement.

CurrentInp

defines the analogue current input channel.

All current inputs may be selected.

In the case of three-phase measurement, the first channel (R phase) of the group of three selected must be specified.

VoltageInp

Defines the analogue voltage input channel.

All three-phase voltage inputs may be selected. A phase-to-phase voltage must be used for measurement. This is derived from the set phase and the lagging phase.

BlockInp

Binary address used as blocking input.

F: - Not blocked

T: - Blocked

xx: - all binary inputs (or outputs of a protection function).

Trip

Output for signalling tripping.

Start

Output for signalling pick-up.

E. Setting instructions

Settings:

Current pick-up
Delay
Undervoltage
Reset delay

Current
Delay
Hold-Voltage
Hold-Time

The voltage controlled overcurrent function comprises a definite time overcurrent unit which latches when the undervoltage unit responds.

The protection is intended for generators and generator/transformer units, for which a fault current can fall below the pick-up of the overcurrent protection before it has an opportunity to trip.

Apart from the influence of a DC component, a decaying AC component can only occur on a generator, the steady-state fault current of which is very low because of the large synchronous reactance X_d typical of modern generators (see Fig. 3.5.5.1).

This function is largely insensitive to DC component and harmonics.

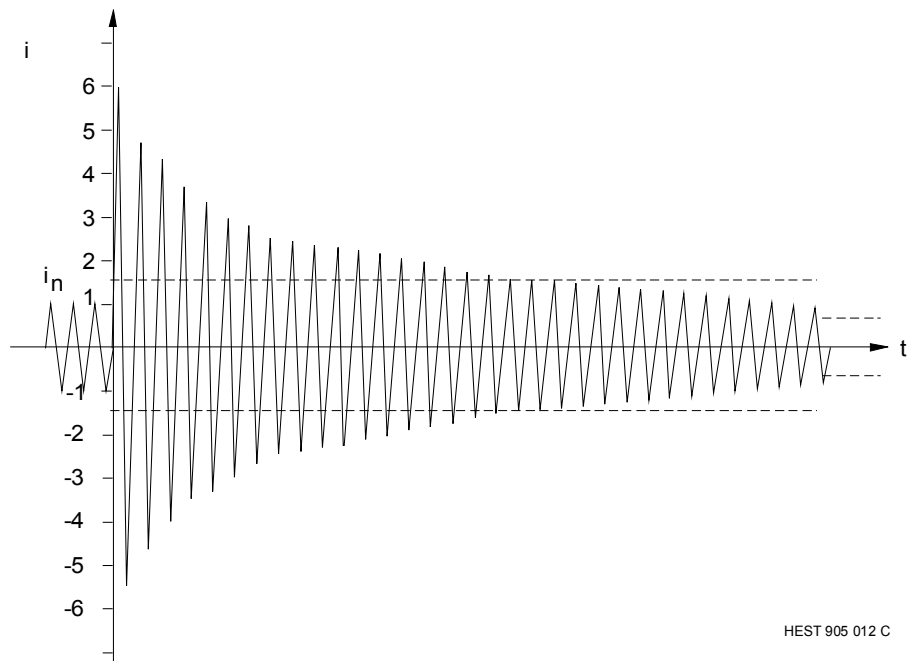


Fig. 3.5.5.1 Generator fault current

Overcurrent setting “Current”

The current setting is chosen such that neither false tripping nor false signals can occur during normal operation and yet the minimum fault current is detected. The setting must therefore be between the maximum short-time load current and the minimum fault current and allow for the tolerance on the protection setting and also its reset ratio. The maximum short-time load current is a parameter of the power system concerned and must take account of switching operations, load surges and fast response excitation (Fig. 3.5.5.2).

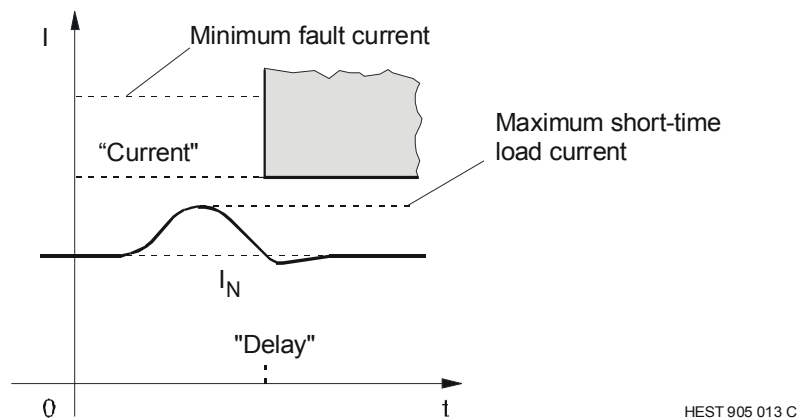


Fig. 3.5.5.2 Operating characteristic of a definite time overcurrent function

I_N = rated current of the protection

Delay

The delay is used to achieve discrimination of the overcurrent function. It is set according to the grading table for all the overcurrent units on the power system. The zone of protection of the voltage-controlled overcurrent function extends from the c.t.'s supplying it in the generator star-point to the location of the next downstream overcurrent relay.

Undervoltage setting “Hold-Voltage”

Providing the overcurrent unit has picked up and the undervoltage unit picks up as well, the undervoltage unit “Hold-Voltage” latches it in the pick-up state should the fault current fall below its pick-up setting. The setting of the undervoltage unit must be such that it can clearly distinguish between a normal load and a fault condition. Because of the different conditions prevailing during symmetrical and asymmetrical faults, the positive-sequence component of the three-phase system is evaluated. A setting well below the lowest voltage that can occur during normal load conditions is chosen (Fig. 3.5.5.3).

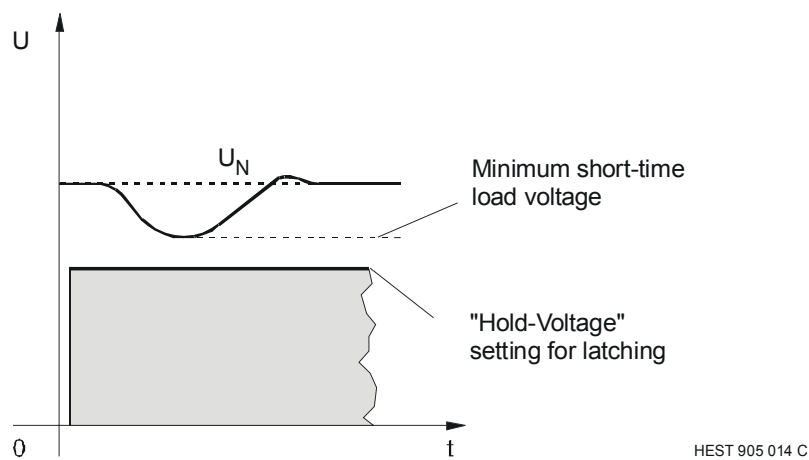


Fig. 3.5.5.3 Operating characteristic of the undervoltage control unit

U_N = rated voltage of the undervoltage unit

Reset time “Hold-Time”

The reset time defined by the parameter “Hold-Time” determines how long the overcurrent unit remains latched to ensure a tripping signal of sufficient duration. The delay starts at the instant of tripping.

Typical settings:

Current	$1.5 I_N$
Delay	3 s
Hold-Voltage	$0.7 U_N$
Hold-Time	0.5 s

Should the rated currents of generator and c.t.'s differ appreciably, compensation of the overcurrent setting is recommended, if this has not already been done with the aid of the reference value of the A/D channel.

Example:

Generator rated current	$I_{GN} = 4\,000\text{ A}$
C.t. rated current	$I_{N1} = 5\,000\text{ A}$

Typical value (referred to the rated current of the protection)	1.5

Compensated setting:

$$1.5 \frac{I_{GN}}{I_{N1}} = 1.5 \frac{4000}{5000} = 1.2$$

since the rated voltages of generator and v.t.'s are generally the same, compensation of the undervoltage setting is seldom necessary.

Should they differ, the compensated setting would be:

$$0.7 \frac{U_{GN}}{U_{N1}}$$

3.5.6. ***Inverse time overcurrent (Current-Inv)***

A. Application

Overcurrent function with time delay inversely proportional to the current and definite minimum tripping time (IDMT).

B. Features

- operating characteristics (see Fig. 3.5.6.1) according to British Standard 142:
 - c = 0.02 : normal inverse
 - c = 1 : very inverse and long time earth fault
 - c = 2 : extremely inverse.
- insensitive to DC component
- insensitive to harmonics
- single or three-phase measurement
- detection of the highest phase value in the three-phase mode
- wider setting range than specified in B.S. 142.

C. Inputs and outputs

I. C.t./v.t. inputs:

- current

II. Binary inputs:

- Blocking

III. Binary outputs:

- pick-up
- tripping

IV. Measurements:

- current amplitude.

D. Inverse time overcurrent settings - Current-Inv

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
ParSet4..1		P1	(Select)		
Trip		00000000			
c-Setting		1.00	(Select)		
k1-Setting	s	013.5	0.01	200.0	0.01
I-Start	IB	1.10	1.00	4.00	0.01
t-min	s	00.00	0.0	10.0	0.1
NrOfPhases		1	1	3	2
CurrentInp	CT/VT-Addr	0			
IB-Setting	IN	1.00	0.045	2.50	0.01
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr	ER			

Explanation of parameters:**ParSet 4..1**

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

defines the tripping channel activated by the tripping O/P of the function (matrix tripping logic).

c-Setting

Setting for the exponential factor determining the shape of the operating characteristic according to BS 142 or for selecting the RXIDG characteristic.

k1-Setting

Constant determining the parallel shift of the characteristic (time grading).

I-Start

Pick-up current at which the characteristic becomes effective.

t-min

Definite minimum tripping time.

NrOfPhases

defines the number of phases measured.

CurrentInp

defines the c.t. input channel. All current I/P's may be selected. In the case of three-phase measurement, the first channel (R phase) of the group of three selected must be specified.

IB-Setting

Base current for taking account of differences of rated current I_N .

BlockInp

defines the input for an external blocking signal.

- F: - not used
- T: - function always blocked
- xx: - all binary inputs (or outputs of protection functions).

Trip

Tripping signal.

Start

Pick-up signal.

E. Setting instructions

Settings:

Base current	IB-Setting
Characteristic enabling current	I-Start
Type of characteristic	c-Setting
Multiplier	k1-Setting

The IDMT overcurrent function is used to protect transformers, feeders and loads of the auxiliaries supply system against phase and earth faults. The function responds largely only to the fundamental component of the fault current.

Base current “IB-Setting”

An IDMT relay does not have a fixed current setting above which it operates and below which it does not, as does a definite time-overcurrent relay. Instead, its operating characteristic is chosen such that it is always above the load current. To this end, the relay has a reference current I_{B1} that is set the same as the load current of the protected unit I_{B1} . The reference current I_B determines the relative position of the relay characteristic which is enabled when the current exceeds the reference current by a given amount (“I-Start”). By setting the reference current I_B to equal the load current of the protected unit I_{B1} instead of its rated current, for

$I_{B1} < I_N$ of the protected unit: the protection is more sensitive

$I_{B1} > I_N$ of the protected unit: the protection permits maximum utilisation of the thermal capability of the protected unit.

Example:

Load current of protected unit	$I_{B1} = 800 \text{ A}$
C.t. rated current	$I_{N1} = 1000 \text{ A}$
	$I_{N2} = 5 \text{ A}$
Relay rated current	$I_N = 5 \text{ A}$

Relay reference current “IB-Setting”:

$$I_B = I_{B1} \frac{I_{N2}}{I_{N1}} = 800 \text{ A} \frac{5 \text{ A}}{1000 \text{ A}} = 4 \text{ A}$$

Setting:

$$\frac{I_B}{I_N} = \frac{4 \text{ A}}{5 \text{ A}} = 0.8$$

An alternative is to adjust the position of the IDMT characteristic to match the rated load of the protected unit and set the reference current to its rated current instead of its load current.

Enabling the characteristic 'I-Start'

The IDMT characteristic is enabled when the current exceeds the setting 'I-Start'. A typical setting for 'I-Start' is $1.1 I_B$.

Choice of characteristic 'c-Setting'

The constant 'c-Setting' determines the shape of the IDMT characteristic.

The settings for the standard characteristics according to B.S. 142 are:

"normal inverse"	: $c = 0.02$
"very inverse" and "long time earth fault"	: $c = 1.00$
"extremely inverse"	: $c = 2.00$.

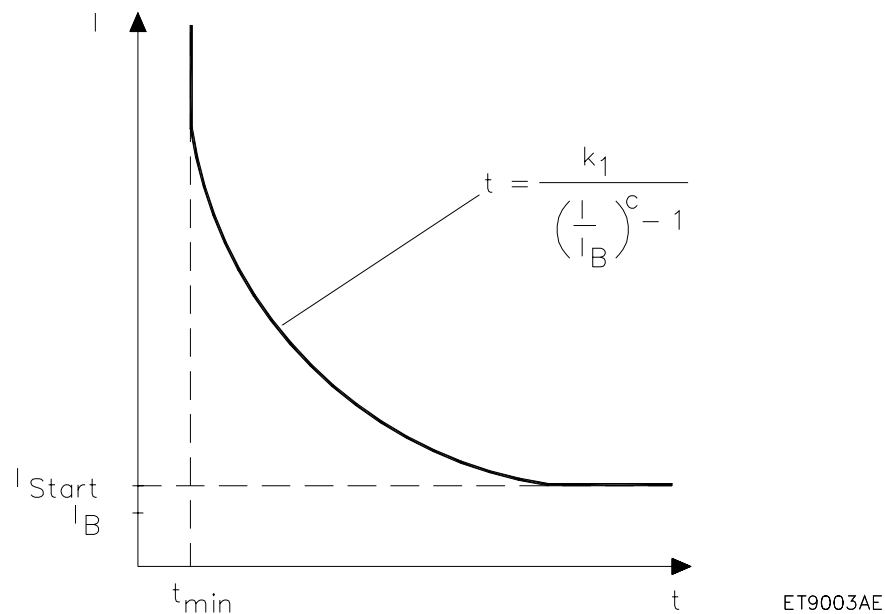


Fig. 3.5.6.1 Operating characteristic of the IDMT overcurrent function

"c-Setting" can also be set to "RXIDG", in which case the function's inverse characteristic corresponds to that of the relay Type RXIDG:

$$t [s] = 5.8 - 1.35 \ln (I/I_B)$$

The parameter "k1-Setting" has no influence in this case.

Multiplier 'k1-Setting'

The multiplier 'k1-Setting' enables the IDMT characteristic chosen by the setting of parameter c to be shifted without changing its shape. This is used for grading the operating times of a series of IDMT relays along a line to achieve discrimination.

For example, in the case of the "very inverse" characteristic, the constant $c = 1$ and the factor $k1 \leq 13.5$. The operating time t is given by the equation

$$t = \frac{k1}{\frac{I}{I_B} - 1}$$

Assuming a grading time of 0.5 s at 6 times the base current I_B is required, the factor $k1$ for each of the relays is given by

$$k1 = 5 t$$

This produces for operating times between 0.5 and 2.5 s the following settings for $k1$:

t [s]	k1 [s]
0.5	2.5
1	5
1.5	7.5
2	10
2.5	12.5

The characteristics according to BS 142 are set as follows:

"normal inverse"	: $k1 = 0.14$ s
"very inverse"	: $k1 = 13.5$ s
"extremely inverse"	: $k1 = 80$ s
"long time earth fault"	: $k1 = 120$ s.

Typical settings:

IB-Setting	corresponding to load current of the protected unit
I-Start	1.1 IB
c-Setting	according to desired characteristic for the protected unit
k1-Setting	according to the time grading calculation
t-min	0.00

3.5.7. ***Directional definite time overcurrent protection (DirCurrentDT)***

A. Application

Directional overcurrent function for

- detecting phase faults on ring lines
- detecting phase faults on double-circuit lines with an infeed at one end
- backup protection for a distance protection scheme.

B. Features

- directionally sensitive three-phase phase fault protection
- insensitive to DC component
- insensitive to harmonics
- voltage memory feature for close faults.

C. Inputs and outputs

I. C.t./v.t. inputs

- current
- voltage

II. Binary inputs

- Blocking
- PLC receive

III. Binary outputs

- start
- start R
- start S
- start T
- forwards measurement
- backwards measurement
- tripping

IV. Measurements

- current amplitude
of the three phase currents (I_R , I_S , I_T)
- active power
A positive measurement indicates the forwards direction
($I_R * U_{ST}$, $I_S * U_{TR}$, $I_T * U_{RS}$)
- voltage amplitude
Amplitudes of the phase-to-phase voltages
(U_{ST} , U_{TR} , U_{RS}).

D. Directional overcurrent settings - DirCurrentDT

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
ParSet4..1		P1	(Select)		
Trip		B00000000			
CurrentInp	CT/VT-Addr	0			
VoltageInp	CT/VT-Addr	0			
I-Setting	IN	2.0	0.1	20.0	0.01
Angle	Deg	45	-180	+180	15
Delay	s	1.00	0.02	60.00	0.01
tWait	s	0.20	0.02	20.00	0.01
MemDirMode		Trip	(Select)		
MemDuration	s	2.00	0.20	60.00	0.01
Receive	BinaryAddr	T			
Ext Block	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr				
Start R	SignalAddr	ER			
Start S	SignalAddr	ER			
Start T	SignalAddr	ER			
MeasFwd	SignalAddr				
MeasBwd	SignalAddr				

Explanation of parameters:**ParSet 4..1**

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

defines the tripping channel activated by the function's tripping output (matrix tripping logic).

CurrentInp

defines the c.t. input channel. Only three-phase c.t.'s can be set and the first channel (R phase) of the group of three selected must be specified.

VoltageInp

defines the v.t. input channel. Only three-phase v.t.'s can be set and the first channel (R phase) of the group of three selected must be specified.

I-Setting

Pick-up setting for tripping.

Angle

Characteristic angle.

Delay

Delay between pick-up and tripping.

tWait

Time allowed for the directional decision to be received from the opposite end in a blocking scheme.

MemDirMode

determines the response of the protection after the time set for memorising power direction:

- trip
- block.

MemDuration

Time during which the power direction last determined remains valid.

Receive

Input for the signal from the opposite end of the line:

T: not used

xx: all binary inputs (or outputs of protection functions).

Ext Block

F: not blocked

xx: all binary inputs (or outputs of protection functions).

Trip

Tripping signal.

Start

Pick-up signal.

Start R

R phase pick-up signal.

Start S

S phase pick-up signal.

Start T

T phase pick-up signal.

MeasFwd

signals measurement in the forwards direction.

MeasBwd

signals measurement in the backwards direction.

E. Setting instructions

Settings:

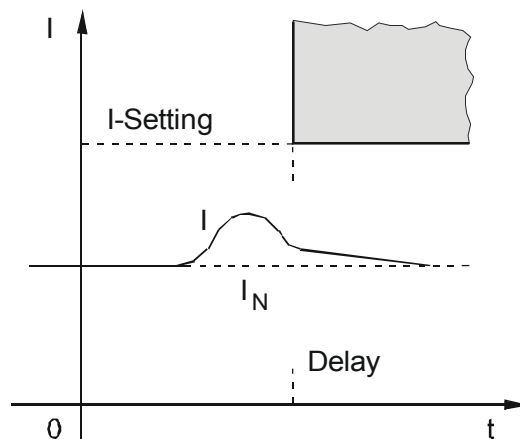
Pick-up current	I-Setting
Characteristic angle	Angle
Delay	Delay
Time allowed for receipt of signal	tWait
Response at the end of the memorised power direction time	MemDirMode
Time during which the memorised direction is valid	MemDuration

Pick-up value I-Setting

“I-Setting” must be chosen high enough to prevent false tripping or alarms from taking place and low enough to reliably detect the minimum fault current. The setting must be sufficiently above the maximum transient load current and allow for:

- c.t. and relay inaccuracies
- the reset ratio.

The maximum transient load current has to be determined according to the power system operating conditions and take account of switching operations and load surges.



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Fig. 3.5.7.1 Operating characteristic of the definite time over-current detector

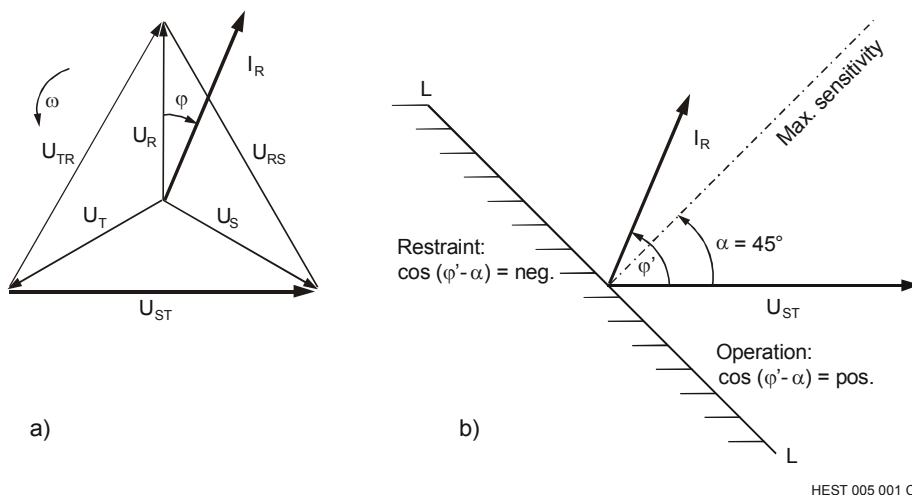
Where the rated c.t. current I_{N1} differs from the rated current I_{GN} of the protected unit, compensating the measurement to achieve a match is recommended. This is done by correcting either the reference value of the A/D input or the setting.

For example, assuming $I_{GN} = 800 \text{ A}$ and $I_{N1} = 1000 \text{ A}$, the setting to pick up at $1.5 I_{GN} = 1200 \text{ A}$ would be

$$1,5 \frac{I_{GN}}{I_{N1}} = 1,5 \frac{800 \text{ A}}{1000 \text{ A}} = 1,2$$

Characteristic angle

Determining the phase-angle of the current provides an additional criterion for preserving discrimination compared with non-directional overcurrent protection. The directional sensitivity is $\pm 180^\circ$ in relation to the reference voltage. This is illustrated in the following diagrams. The angles given apply for connection according to the connections in [Section 12](#).



ϕ' = phase-angle between current and voltage
(positive angle)

α = Characteristic angle

L = Border line between operating and restraint areas

a) Definition of current
and voltage

b) Operating characteristic

Fig. 3.5.7.2 Vector diagram for a fault in the forwards direction on R phase

The function determines the power direction by measuring the phase-angle of the current in relation to the opposite phase-to-phase voltage. Which current is compared with which voltage can be seen from the following table.

Current input	Phase-to-neutral voltage	Calculated voltage
I_R	U_S, U_T	$U_{ST} = U_S - U_T$
I_S	U_T, U_R	$U_{TR} = U_T - U_R$
I_T	U_R, U_S	$U_{RS} = U_R - U_S$

The voltage measurement automatically compensates the group of connection of the v.t.'s. For example, the phase-to-phase values are calculated for Y-connected v.t.'s (v.t. type UTS), while the input voltages are used directly for delta-connected v.t.'s (v.t. type UTD).

Delay

The delay enables the protection to be graded with other time-overcurrent relays to achieve discrimination. Its setting is thus chosen in relation to the timer settings of upstream and downstream protective devices. The zone of protection covered by this overcurrent protection extends to the next overcurrent protection device.

Should in the event of a fault in the next downstream zone, the protection for that zone fail, this protection function takes over after the time set for "Delay" and clears the fault as backup.

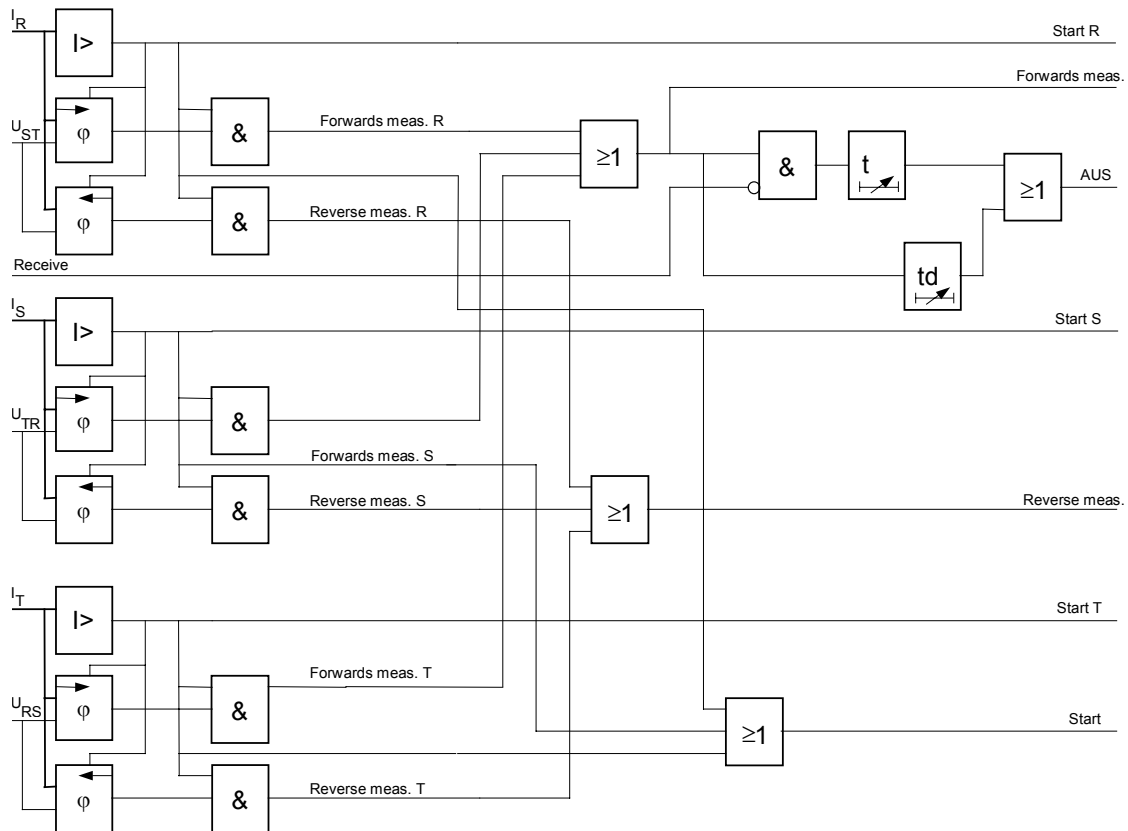


Fig. 3.5.7.3 Block diagram

td = "Delay"

t = "tWait"

Time allowed for a signal to be received

Where directional functions are configured in both line terminals, each can send a signal from its "MeasBwd" output to the "Receive" input of the function at the opposite end of the line (e.g. via a PLC channel) when it is measuring a fault in the reverse direction. This signal prevents the respective directional overcurrent function from tripping, because the fault cannot be in the zone between them. The functions therefore have to allow time, i.e. the "wait time", for the signal from the opposite line terminal to be received. If none is received within "tWait", the circuit-breakers are tripped at both ends.

The time set for "Delay" acts in this kind of scheme as a backup which does not rely on the communication channel. Thus when the "Receive" input is being used, the setting for "Delay" must be longer than the setting for "tWait":

$$\text{"Delay"} > \text{"tWait"}.$$

Response after decay of the memorised voltage

The voltage measured by the protection can quickly decay to almost zero for a close fault and make determining direction unreliable. For this reason, the function includes a voltage memory feature and for the first 200 milliseconds after the incidence of an overcurrent, the voltage measured immediately before the fault is used as reference to determine fault direction.

After this time, the last valid direction is used for an adjustable period (see next paragraph).

“MemDirMode” provides facility for setting how the protection must respond after this time or in the event that the circuit-breaker is closed onto a fault and no voltage could be memorised beforehand. The two possible settings are the protection can trip or it can block.

Time during which the memorised direction is valid

The “MemDuration” setting determines how long the last valid direction measurement shall be used. The setting should be as short as possible (200 ms) when the function is being used as backup for a distance function in an HV power system, because an actually measured voltage is only available during this time and therefore it is only possible to detect a reversal of direction during this time. For longer settings, the last valid power direction is used instead of the actually memorised voltage.

3.5.8. ***Directional inverse time overcurrent protection*** ***(DirCurrentInv)***

A. Application

Directional overcurrent function for

- detecting phase faults on ring lines
- detecting phase faults on double-circuit lines with an infeed at one end
- backup protection for a distance protection scheme.

B. Features

- directionally sensitive three-phase phase fault protection
- operating characteristics (see Fig. 3.5.8.1) according to British Standard B.S.142:
 - c = 0.02 : normal inverse
 - c = 1 : very inverse und long time earth fault
 - c = 2 : extremely inverse.
- insensitive to DC component
- insensitive to harmonics
- voltage memory feature for close faults.

C. Inputs and outputs

I. C.t./v.t. inputs

- current
- voltage

II. Binary inputs

- Blocking
- PLC receive

III. Binary outputs

- start
- start R
- start S
- start T
- forwards measurement
- backwards measurement
- tripping

IV. Measurements

- current amplitude
of the three phase currents (I_R , I_S , I_T)
- active power
A positive measurement indicates the forwards direction
($I_R * U_{ST}$, $I_S * U_{TR}$, $I_T * U_{RS}$)
- voltage amplitude
Amplitudes of the phase-to-phase voltages
(U_{ST} , U_{TR} , U_{RS}).

D. Directional overcurrent settings - DirCurrentInv

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
ParSet4..1		P1	(Select)		
Trip		B00000000			
CurrentInp	CT/VT-Addr	0			
VoltageInp	CT/VT-Addr	0			
I-Start	IN	1.10	1.00	4.00	0.01
Angle	Deg	45	-180	+180	15
c-Setting		1.00	(Select)		
k1-Setting	s	13.5	0.01	200.00	0.01
t-min	s	0.00	0.00	10.00	0.01
IB-Setting	IN	1.00	0.04	2.50	0.01
tWait	s	0.20	0.02	20.00	0.01
MemDirMode		Trip	(Select)		
MemDuration	s	2.00	0.20	60.00	0.01
Receive	BinaryAddr	T			
Ext Block	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr				
Start R	SignalAddr	ER			
Start S	SignalAddr	ER			
Start T	SignalAddr	ER			
MeasFwd	SignalAddr				
MeasBwd	SignalAddr				

Explanation of parameters:**ParSet 4..1**

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

defines the tripping channel activated by the function's tripping output (matrix tripping logic).

CurrentInp

defines the c.t. input channel. Only three-phase c.t.'s can be set and the first channel (R phase) of the group of three selected must be specified.

VoltageInp

defines the v.t. voltage input channel. Only three-phase v.t.'s can be set and the first channel (R phase) of the group of three selected must be specified.

I-Start

Pick-up current at which the characteristic becomes effective.

Angle

Characteristic angle.

c-Setting

Setting for the exponential factor determining the operating characteristic according to BS 142.

k1-Setting

Constant determining the parallel shift of the characteristic.

t-min

Definite minimum operating time, operating characteristic constant.

IB-Setting

Base current for taking account of differences of rated current I_N .

tWait

Time allowed for the directional decision to be received.

MemDirMode

determines the response of the protection after the time set for memorising power direction:

- trip
- block.

MemDuration

Time during which the power direction last determined remains valid.

Receive

Input for the signal from the opposite end of the line:

- T: not used
xx: all binary inputs (or outputs of protection functions).

Ext Block

- F: not blocked
xx: all binary inputs (or outputs of protection functions).

Trip

Tripping signal.

Start

Pick-up signal.

Start R

R phase pick-up signal.

Start S

S phase pick-up signal.

Start T

T phase pick-up signal.

MeasFwd

signals measurement in the forwards direction.

MeasBwd

signals measurement in the backwards direction.

E. Setting instructions

Settings:

Base current	IB-Setting
Characteristic enabling current	I-Start
Type of characteristic	c-Setting
Multiplier	k1-Setting
Characteristic angle	Angle
Delay	Delay
Time allowed for receipt of signal	tWait
Response at the end of the memorised power direction time	MemDirMode
Time during which the memorised direction is valid	MemDuration

Base current “IB-Setting”

A tripping current is not set on an IDMT overcurrent function as it is on a definite time overcurrent function. Instead the position of the characteristic is chosen such that it is above the load current. The function, however, has a “base current” setting which is set to the full load current I_{B1} of the protected unit. The base current setting determines the position of the basic characteristic. The characteristic is enabled when the base current is exceeded by a preset amount (I-Start). The adjustment of the base current IB to the load current I_{B1} of the protected unit instead of its rated current enables for

$I_{B1} < \text{rated current of prot. unit} : \text{more sensitive protection}$

$I_{B1} > \text{rated current of prot. unit} : \text{maximum utilisation of the thermal capability of the protected unit.}$

Example:

Load current of the protected unit	$I_{B1} = 800 \text{ A}$
C.t rated current	$I_{N1} = 1000 \text{ A}$
	$I_{N2} = 5 \text{ A}$
Protection rated current	$I_N = 5 \text{ A}$
Protection base current	

$$IB = I_{B1} \frac{I_{N2}}{I_{N1}} = 800 \text{ A} \frac{5 \text{ A}}{1000 \text{ A}} = 4 \text{ A}$$

Setting

$$\frac{IB}{I_N} = \frac{4 \text{ A}}{5 \text{ A}} = 0.8 \text{ A}$$

An alternative is to adjust the position of the IDMT characteristic to match the rated load of the protected unit and set the base current to its rated current instead of its load current.

Enabling the characteristic 'I-Start'

The IDMT characteristic is enabled when the current exceeds the setting 'I-Start'. A typical setting for 'I-Start' is $1.1 I_B$.

Choice of characteristic 'c-Setting'

The constant 'c-Setting' determines the shape of the IDMT characteristic. The settings for the standard characteristics according to B.S. 142 are:

"normal inverse"	: $c = 0.02$
"very inverse" and "long time earth fault"	: $c = 1.00$
"extremely inverse"	: $c = 2.00$.

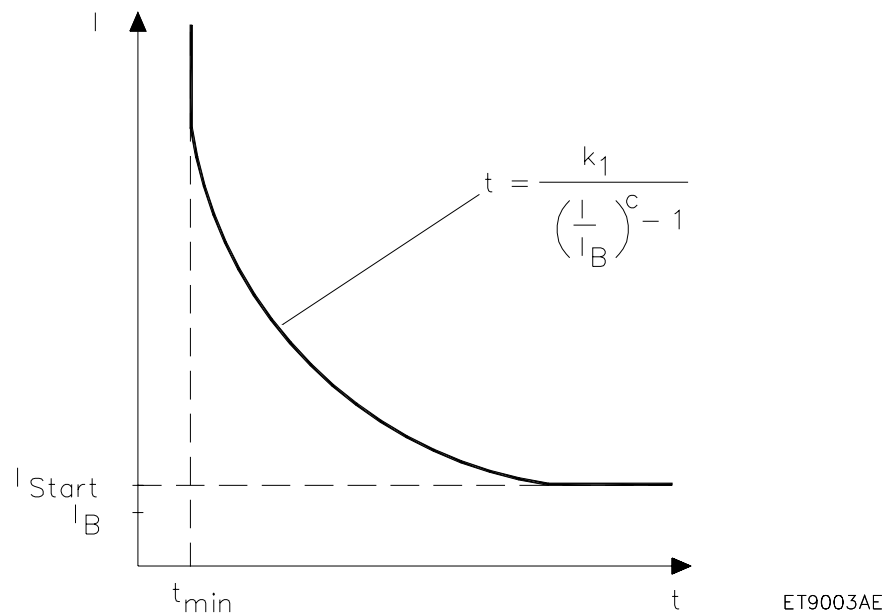


Fig. 3.5.8.1 Operating characteristic of the directional IDMT overcurrent function

Multiplier 'k1-Setting'

The multiplier 'k1-Setting' enables the IDMT characteristic chosen by the setting of parameter c to be shifted without changing its shape. This is used for grading the operating times of a series of IDMT relays along a line to achieve discrimination.

For example, in the case of the "very inverse" characteristic, the constant $c = 1$ and the factor $k1 \leq 13.5$. The operating time t is given by the equation

$$t = \frac{k1}{\left(\frac{I}{I_B} - 1\right)}$$

Assuming a grading time of 0.5 s at 6 times the base current I_B is required, the factor $k1$ for each of the relays is given by

$$k1 = 5 t.$$

This produces for operating times between 0.5 and 2.5 s the following settings for $k1$:

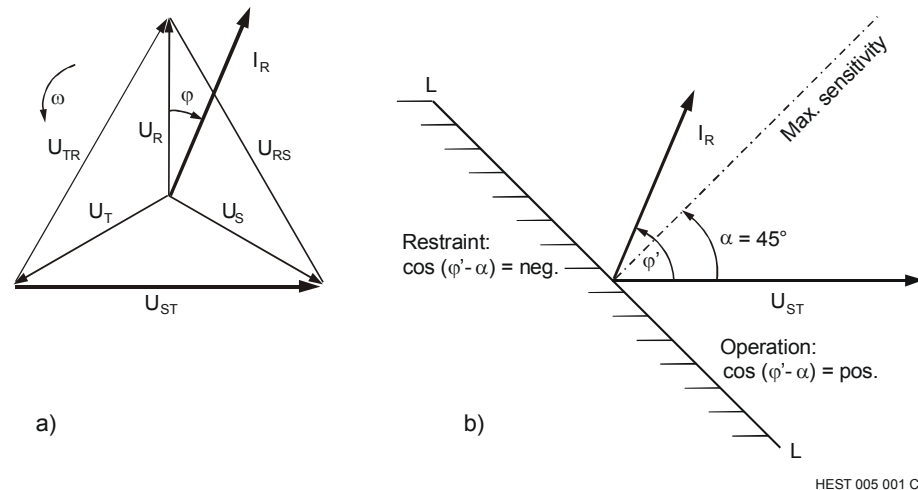
t [s]	k1 [s]
0.5	2.5
1	5
1.5	7.5
2	10
2.5	12.5

The characteristics according to BS 142 are set as follows:

"normal inverse"	: $k1 = 0.14$ s
"very inverse"	: $k1 = 13.5$ s
"extremely inverse"	: $k1 = 80$ s
"long time earth fault"	: $k1 = 120$ s.

Characteristic angle

Determining the phase-angle of the current provides an additional criterion for preserving discrimination compared with non-directional overcurrent protection. The directional sensitivity is $\pm 180^\circ$ in relation to the reference voltage. This is illustrated in the following diagrams. The angles given apply for connection according to the connections in [Section 12](#).



ϕ' = phase-angle between current and voltage
(positive angle)

α = Characteristic angle

L = Border line between operating and restraint areas

a) Definition of current
and voltage

b) Operating characteristic

Fig. 3.5.8.2 Vector diagram for a fault in the forwards direction on R phase

The function determines the power direction by measuring the phase-angle of the current in relation to the opposite phase-to-phase voltage. Which current is compared with which voltage can be seen from the following table.

Current input	Phase-to-neutral voltage	Calculated voltage
I_R	U_S, U_T	$U_{ST} = U_S - U_T$
I_S	U_T, U_R	$U_{TR} = U_T - U_R$
I_T	U_R, U_S	$U_{RS} = U_R - U_S$

The voltage measurement automatically compensates the group of connection of the v.t.'s. For example, the phase-to-phase values are calculated for Y-connected v.t.'s (v.t. type UTS), while the input voltages are used directly for delta-connected v.t.'s (v.t. type UTD).

Time allowed for a signal to be received

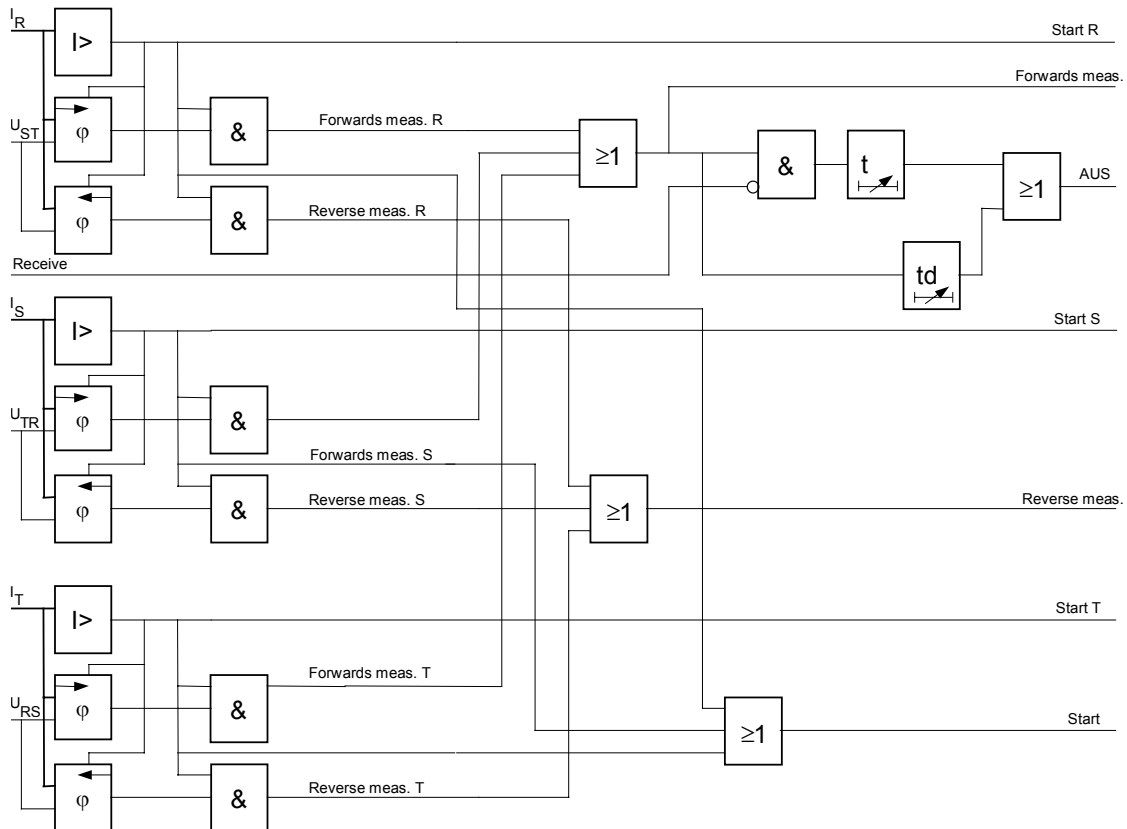


Fig. 3.5.8.3 Block diagram
 td = "Delay"
 t = "tWait"

Where directional functions are configured in both line terminals, each can send a signal from its "MeasBwd" output to the "Receive" input of the function at the opposite end of the line (e.g. via a PLC channel) when it is measuring a fault in the reverse direction. This signal prevents the respective directional overcurrent function from tripping, because the fault cannot be in the zone between them. The functions therefore have to allow time, i.e. the "wait time", for the signal from the opposite line terminal to be received. If none is received within "tWait", the circuit-breakers are tripped at both ends.

The time set for “Delay” acts in this kind of scheme as a backup which does not rely on the communication channel. Thus when the “Receive” input is being used, the setting for “Delay” must be longer than the setting for “tWait”:

“Delay” > “tWait”.

Response after decay of the memorised voltage

The voltage measured by the protection can quickly decay to almost zero for a close fault and make determining direction unreliable. For this reason, the function includes a voltage memory feature and for the first 200 milliseconds after the incidence of an overcurrent, the voltage measured immediately before the fault is used as reference to determine fault direction.

After this time, the last valid direction is used for an adjustable period (see next paragraph).

“MemDirMode” provides facility for setting how the protection must respond after this time or in the event that the circuit-breaker is closed onto a fault and no voltage could be memorised beforehand. The two possible settings are the protection can trip or it can block.

Time during which the memorised direction is valid

The “MemDuration” setting determines how long the last valid direction measurement shall be used. The setting should be as short as possible (200 ms) when the function is being used as backup for a distance function in an HV power system, because an actually measured voltage is only available during this time and therefore it is only possible to detect a reversal of direction during this time. For longer settings, the last valid power direction is used instead of the actually memorised voltage.

3.5.9. *Definite time NPS (NPS-DT)*

A. Application

Protection of generators against excessive heating of the rotor due to asymmetrical load.

B. Features

- definite time delay
- insensitive to DC component
- insensitive to harmonics
- three-phase measurement.

C. Inputs and outputs

I. Analogue inputs:

- current

II. Binary inputs:

- blocking

III. Binary outputs:

- pick-up
- tripping

IV. Measurements:

- proportion of negative-sequence current component
 $I_2 = \frac{1}{3} (I_R + a^2 I_S + a I_T).$

D. Definite time NPS function settings - NPS-DT

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
Trip		00000000			
Delay	s	01.00	0.50	60.0	0.01
I2-Setting	IN	00.20	0.02	0.50	0.01
CurrentInp	AnalogAddr	0			
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr				

Explanation of parameters:

ParSet 4..1

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

defines the tripping channel activated by the tripping output of the function (tripping logic).

Delay

time delay between pick-up and tripping.

I2-Setting

NPS current setting for tripping.

Setting restriction:

not $< 0.05 I_N$ when supplied from protection cores.

CurrentInp

defines the A/D current input channel. All three-phase current inputs may be selected. The first channel (R phase) of the group of three selected must be specified.

BlockInp

Binary address used as blocking input.

F: - Not blocked

T: - Blocked

xx: - all binary inputs (or outputs of a protection function).

Trip

Output for signalling tripping.

Start

Output for signalling pick-up.

E. Setting instructions

Settings:

Negative-sequence component of stator current	I ₂ -Setting
Delay	Delay

An NPS current is usually caused by asymmetrical loading of the three phases, but may also be the result of an open-circuit phase (single-phasing).

An asymmetrical load on a generator produces a magnetic field, which rotates in the opposite direction to the positive-sequence field. The negative-phase sequence flux induces currents in the rotor and these result in additional rotor losses and increased rotor temperature. The latter can represent a hazard for the rotor and this is the reason for applying NPS protection.

The asymmetry of the load on a generator is defined in terms of the negative-sequence stator current I_2 which is therefore the quantity monitored.

The definite time NPS function is intended for systems where asymmetries are of longer duration and do not change frequently. This generally applies in the case of small to medium generators. Two NPS stages are used, one for alarm and one for tripping.

The maximum continuous NPS current rating $I_{2\infty}$ is stated by the generator manufacturer, usually as a percentage of the generator rated current I_{GN} .

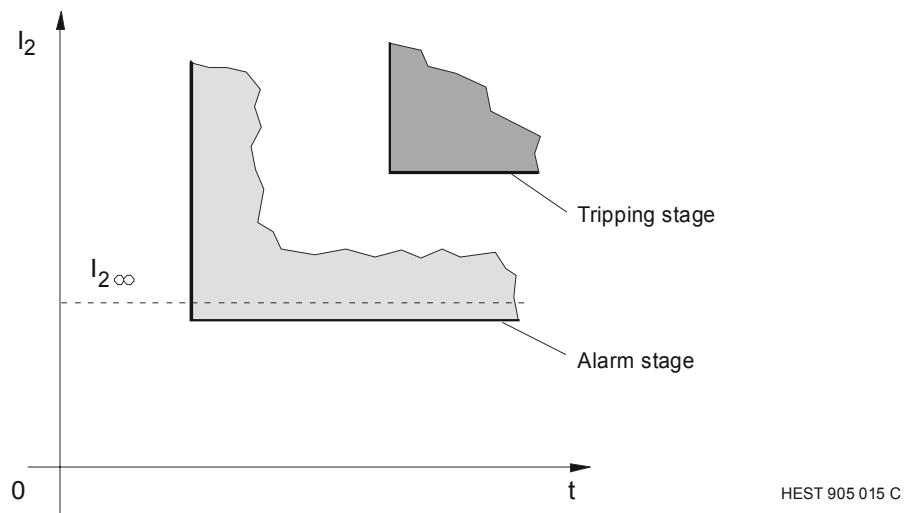
The alarm stage is normally set to $I_{2\infty}$ or somewhat lower, e.g.

for $I_{2\infty} = 10 \% I_{GN}$, "I₂-Setting" is set to $8 \% I_{GN}$.

The tripping stage is set 50 to 100 % higher than the alarm stage, e.g.

$$I_2\text{-Setting} = 15 \% I_{GN}$$

The NPS protection is always delayed to avoid false tripping during transient phenomena and especially during phase-to-phase and earth faults on the power system. The delay may be relatively long, because the rate at which the temperature of the endangered parts of the rotor rises is relatively low.



In cases where both stages are used for tripping, the one with the higher setting must be faster.

Compensating the frequently differing rated currents of generator and c.t.'s is also recommended for the NPS protection. The corresponding compensated setting is given by

$$\text{Setting} = \text{calculated setting} \frac{I_{GN}}{I_{N1}}$$

Typical settings:

1st. stage (alarm)

I2-Setting	$0.1 I_N$
Delay	5 s

2nd. stage (tripping)

I2-Setting	$0.15 I_N$
Delay	10 s

3.5.10. Inverse time NPS (NPS-Inv)

A. Application

Negative phase sequence protection especially of large generators subject to high thermal utilisation against excessive heating of the rotor due to an asymmetric load.

B. Features

- inverse time delay according to level of NPS
(see Fig. 3.5.10.1)
- wide setting ranges for the parameters determining the operating characteristic
- adjustable rate of counting backwards when the overload disappears (cooling rate of thermal image)
- insensitive to DC components
- insensitive to harmonics
- three-phase measurement.

C. Inputs and outputs

I. Analogue inputs:

- current

II. Binary inputs:

- blocking

III. Binary outputs:

- pick-up
- tripping

IV. Measurements:

- proportion of negative-sequence current component
 $I_2 = \frac{1}{3} (I_R + a^2 I_S + a I_T)$.

D. Inverse time NPS function settings - NPS-Inv

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
Trip		00000000			
k1-Setting	s	10.00	5.00	60.00	0.10
k2-Setting	I ₂ /I _B	0.05	0.02	0.20	0.01
t-min	s	010.0	1.0	120.0	0.1
t-max	s	1000	500	2000	1
t-Reset	s	0030	5	2000	1
CurrentInp	AnalogAddr	0			
IB-Setting	IN	1.00	0.50	2.50	0.01
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr				

Explanation of parameters:**ParSet 4..1**

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

defines the tripping channel activated by the tripping output of the function (tripping logic).

k1-Setting

Multiplier. Operating characteristic constant.

k2-Setting

Continuously permissible NPS (I_2/I_B) and operating characteristic constant.

Setting restrictions:

not $< 0.05 I_N/I_B$ when supplied from protection cores.

t-min

Definite minimum operating time.

t-max

Maximum delay after being enabled regardless of inverse characteristic.

t-Reset

Time taken to reset (from the operating limit). This corresponds to the time taken for the generator to cool.

CurrentInp

defines the A/D input channel.

All three-phase current inputs may be selected.

The first channel (R phase) of the group of three selected must be specified.

IB-Setting

Reference (base) current for compensating a difference in relation to I_N .

BlockInp

Binary address used as blocking input.

F: - Not blocked

T: - Blocked

xx: - all binary inputs (or outputs of a protection function).

Trip

Output for signalling tripping.

Start

Output for signalling pick-up.

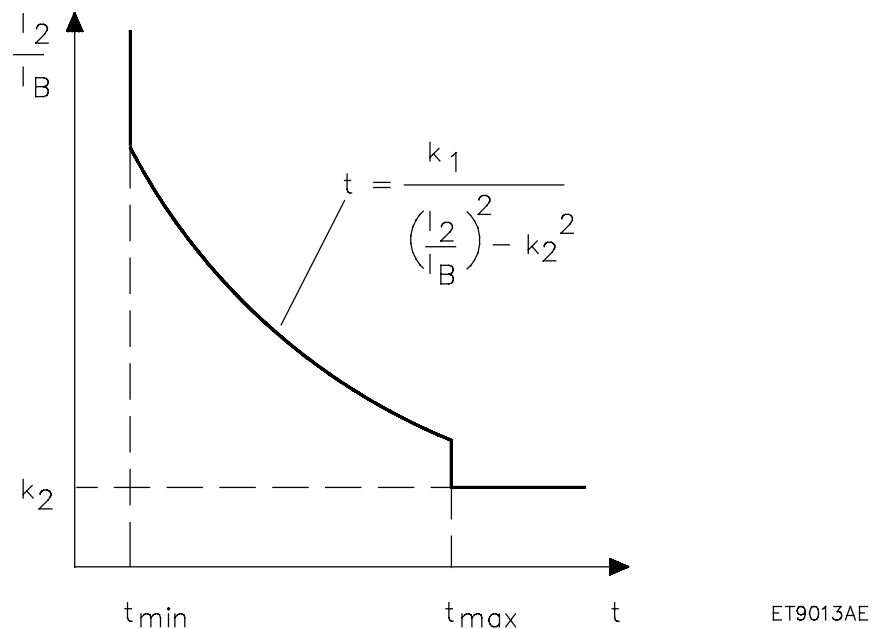


Fig. 3.5.10.1 Operating characteristic of the inverse time NPS function

E. Setting instructions

Settings:

Reference current	IB-Setting
Multiplier	k1-Setting
Continuously permissible NPS	k2-Setting
Minimum operating time	t-min
Maximum operating time	t-max
Resetting time	t-Reset

This protection is intended for large generators. It is especially recommended where the level of NPS varies frequently, because in such cases, higher levels of NPS are permissible for short periods.

Providing compensation using the reference value of the A/D channel has not been made, the reference current IB for the protection is calculated from the rated currents of the generator I_{GN} and the c.t.'s I_{N1} and I_{N2} as follows:

$$IB = I_{GN} \frac{I_{N2}}{I_{N1}}$$

The setting is the ratio IB/I_N , where I_N is the rated current of the protection, otherwise "IB-Setting" would be 1.0 I_N .

The following two parameters are required from the manufacturer of the generator in order to set k1 and k2:

- the continuously permissible NPS component $i_{2\infty}$ [p.u.]
- the permissible energy of the NPS component $i_2^2 t$ [p.u.]

Factor k1 equals the permissible energy:

$$k1 = i_2^2 t$$

Factor k2 equals the continuously permissible component $i_{2\infty}$:

$$k2 = i_{2\infty}$$

Typical settings :

IB-Setting	according to protected unit
k1-Setting	10.0 s
k2-Setting	according to protected unit
t-min	10.0 s
t-max	1000.0 s
t-Reset	10.0 s

3.5.11. *Definite time over and undervoltage (Voltage-DT)*

A. Application

General voltage monitoring (over and under).

Specific applications are:

- stator earth fault protection (95%)
- rotor earth fault protection (with ancillary unit YWX 111)
- interturn protection.

B. Features

- insensitive to DC component
- insensitive to harmonics
- single or three-phase measurement
- highest or lowest phase value detection in the three-phase mode.

C. Inputs and outputs

I. Analogue inputs:

- voltage

II. Binary inputs:

- blocking

III. Binary outputs:

- pick-up
- tripping

IV. Measurements:

- voltage amplitude.

D. Definite time voltage function settings - Voltage-DT

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
Trip		00000000			
Delay	s	02.00	0.02	60.00	0.01
V-Setting	UN	1.200	0.010	2.000	0.002
MaxMin		MAX (1ph)	(Select)		
NrOfPhases		001	1	3	1
VoltageInp	AnalogAddr	0			
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr	ER			

Explanation of parameters:

ParSet 4..1

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

defines the tripping channel activated by the tripping output of the function (tripping logic).

Delay

time delay between pick-up and tripping.

V-Setting

Voltage setting for tripping.

MaxMin

defines operation as overvoltage or undervoltage. Settings:

- MIN (3ph): undervoltage
Monitors highest phase voltage in the three-phase mode
- MIN (1ph): undervoltage
Monitors lowest phase voltage in the three-phase mode

- MAX (3ph): overvoltage
Monitors lowest phase voltage in the three-phase mode
- MAX (1ph): overvoltage
Monitors highest phase voltage in the three-phase mode.

NrOfPhases

defines whether single or three-phase measurement.

VoltageInp

defines the A/D input channel.

All voltage inputs may be selected.

In the case of three-phase measurement, the first channel (R phase) of the group of three selected must be specified.

BlockInp

Binary address used as blocking input.

F: - Not blocked

T: - Blocked

xx: - all binary inputs (or outputs of a protection function).

Trip

Output for signalling tripping.

Start

Output for signalling pick-up.

E. Setting instructions

Settings:

Voltage	V-Setting
Delay	Delay
Over or undervoltage	MaxMin
Single or three-phase meas.	NrOfPhases

By detecting excessively high voltages, the overvoltage function prevents insulation breakdown of the windings of generator stators and power transformers and also excessive temperature rise due to increased iron losses. Excessively high voltages of longer duration are especially likely in the event of voltage regulator failure. A time delay is set to prevent false tripping during transients. Usually there are two voltage stages, both of which are arranged to trip the protected unit.

Overvoltage setting (V-Setting)

The first stage is intended for moderate overvoltages of long duration.

The second stage provides protection against high overvoltages and is set to 70 % of the stator test voltage.

Where the rated voltages of the protected unit and the v.t.'s differ, the primary pick-up value in p.u. does not agree with the setting of the protection and this has to be compensated using the reference value of the A/D channel.

For example, for a generator rated voltage of $U_{GN} = 12$ kV and a primary v.t. rated voltage of $U_{1N} = 15$ kV, the setting of the second stage is

$$1.4 \frac{U_{GN}}{U_{N1}} = 1.4 \frac{12}{15} = 1.12$$

Over/undervoltage setting (MaxMin)

This parameter enables the following operating modes to be selected:

- MAX (1ph): Pick-up when the highest phase voltage exceeds the setting.
- MAX (3ph): Pick-up when the lowest phase voltage also exceeds the setting. This setting is not permitted, if the function is set to single-phase measurement.

- MIN (1ph): Pick-up when the lowest phase voltage falls below the setting.
- MIN (3ph): Pick-up when the highest phase voltage also falls below the setting. This setting is not permitted, if the function is set to single-phase measurement.

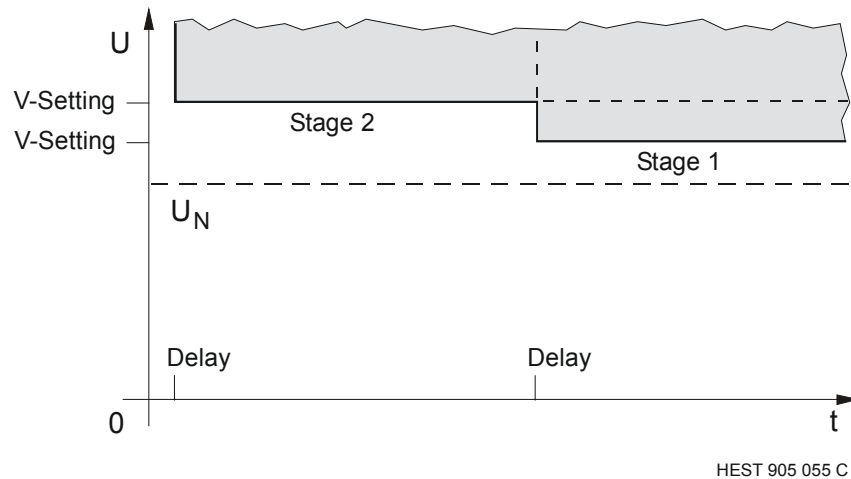


Fig. 3.5.11.1 Operating characteristic of the definite time over-voltage function
 U_N = rated voltage of the protection

Typical settings:

Stage 1

V-Setting	$1.15 U_N$
Delay	2 s
MaxMin	MAX (1ph)

Stage 2

V-Setting	$1.4 U_N$
Delay	0.1 s
MaxMin	MAX (1ph)

3.5.11.1. *Definite time stator earth fault (95 %)*

Settings:

Voltage

V-Setting

Delay

Delay

The definite time stator E/F scheme (95%) is designed for the protection of generators or generator/transformer units.

Description

The standard zone of protection in the case of generator/transformer units is 95 % of the length of the stator winding (see Fig. 3.5.11.2). It is normal to limit the zone to 95 % to avoid any risk of false tripping. The stator E/F function is connected either to the v.t. at the stator star-point or to the v.t.'s at the generator terminals. In either case, the function monitors the displacement of the star-point caused by a stator E/F. The corresponding off-set voltage becomes a maximum for an E/F at a generator terminal and zero for an E/F at the star-point (see Fig. 3.5.11.2).

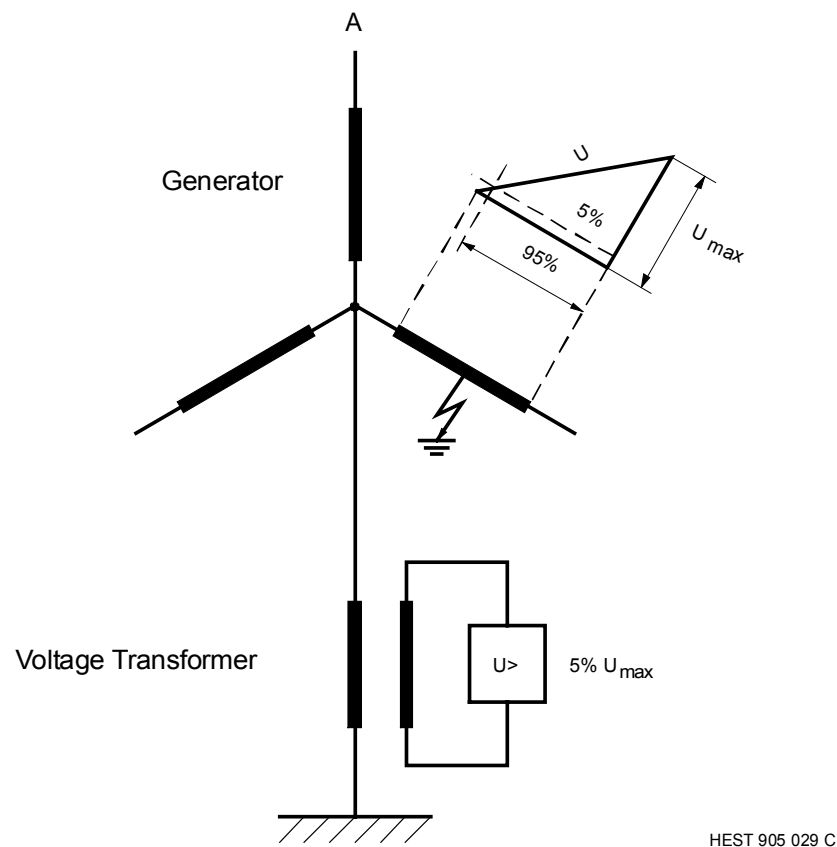
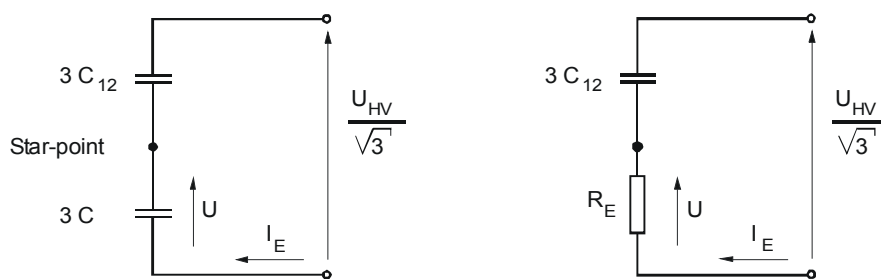


Fig. 3.5.11.2 Stator E/F protection for a generator/transformer unit

As can be seen from Fig. 3.5.11.2, the relay setting for a zone of protection of 95 % is 5 % of $U_{\max}$. The scheme detects E/F's on the generator stator winding, the cables to the step-up transformer and the delta-connected windings of the step-up transformer.

The capacitances between primary and secondary of the step-up transformer conduct currents emanating from E/F's on the HV side to the LV side and can cause false tripping of the stator E/F protection. The capacitive coupling of E/F currents on the HV side takes place regardless of whether the HV star-point is grounded or not. The capacitance C_{12} between HV and LV windings of the step-up transformer and the capacitance C of the generator circuit form a potential divider that determines the potential of the generator star-point (see Fig. 3.5.11.3a). The value of the capacitance C is usually too low to reliably hold the star-point below the pick-up setting of the protection. For this reason, the generator star-point is grounded via a resistor R_E (see Fig. 3.5.11.4) which ensures that the potential of the star-point remains below the setting of the protection for an E/F on the HV power system. Correspondingly, the value of the resistor R_E is chosen such that for a given C_{12} and an E/F at the HV terminals of the step-up transformer, the offset of the generator star-point does not reach the pick-up setting of the 95 % E/F protection.



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a) without grounding resistor

b) simplified circuit with grounding resistor

Fig. 3.5.11.3 Generator star-point off-set for an E/F on the HV side of the step-up transformer

where:

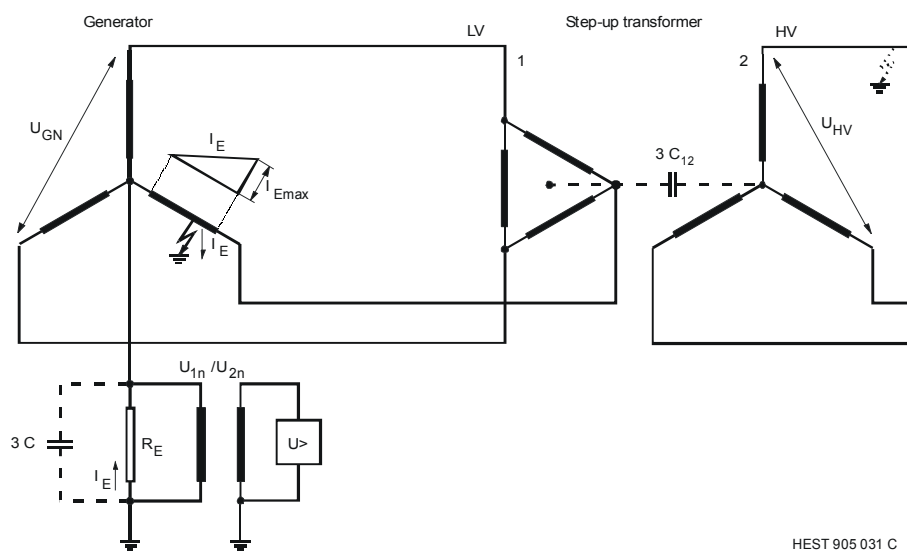
C_{12}	capacitance between primary and secondary of the step-up transformer
C	capacitance to ground of the stator windings, the cables with protection capacitors and the LV step-up transformer winding
U	star-point offset
U_{HV}	rated voltage of the step-up transformer HV windings
I_E	E/F current
R_E	grounding resistor.

The value of the grounding resistor R_E determines the E/F current. In view of the damage an E/F current can cause — especially to the laminations of the stator core — the maximum E/F current should be limited to 20 A for 10 s, i.e. the grounding resistor R_E must not be too small.

Tripping by the E/F protection is delayed by 0.5 s to avoid any risk of false tripping during transient phenomena.

Designing a scheme for connection to the generator star-point

Alternative 1 with grounding resistor and v.t. (see Fig. 3.5.11.4):



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Fig. 3.5.11.4 Stator E/F protection with a grounding resistor at the star-point

The value of the grounding resistor R_E should be chosen such that:

- the maximum E/F current $I_E \leq 20 \text{ A}$
- the offset of the generator star-point for an E/F on the HV side of the step-up transformer does not exceed half the relay setting.

The star-point v.t. is designed in relation to the maximum continuous voltage resulting from an E/F, i.e. the phase-to-neutral voltage of the generator. Arcing faults can cause higher transient voltages and consequentially saturation of the v.t. The specification of a relatively high overvoltage factor such as 1.9 is therefore recommended.

V.t. rated voltages

$$U_{1n} = \frac{U_{GN}}{\sqrt{3}} \quad (U_{GN} = \text{generator rated voltage})$$

$$U_{2n} = 100 \text{ V} \quad (\text{should nothing else be specified})$$

The minimum value of the resistor R_{Emin} :

$$R_{Emin} \geq \frac{U_{GN}}{\sqrt{3} I_{Emax}}$$

where $I_{Emax} \leq 20 \text{ A}$

The equation for determining the maximum value of the grounding resistor R_{Emax} (95 % scheme) can be derived from the simplified circuit diagram of [Fig. 3.5.11.3b](#):

$$R_{Emax} \leq \frac{0.05 U_{GN}}{6 \omega C_{12} U_{HV}}$$

where:

- 0.05 : protection sensitivity 5 % (95 % scheme)
- 6 : factor corresponding to 3 phases times 2 for half the pick-up setting

The value of the effective grounding resistor R_E is chosen between R_{Emax} and R_{Emin} and rated for 10 s.

Example 1

$U_{GN} = 12 \text{ kV}; \quad U_{HV} = 110 \text{ kV}; \quad C_{12} = 3 \times 10^{-9} \text{ F}; \quad \omega = 314 \text{ 1/s}$
 $I_{E\max} \leq 20 \text{ A}$

a) HV system ungrounded

$$R_{E\min} \geq \frac{12000}{\sqrt{3} \times 20} = 346 \, \Omega$$

$$R_{E\max} \leq \frac{0.05 \times 12}{6 \times 314 \times 3 \times 10^{-9} \times 110} = 965 \, \Omega$$

Chosen $R_E = 750 \, \Omega$

$$I_{E\max} = \frac{U_{GN}}{\sqrt{3} R_E} = \frac{12000}{\sqrt{3} \times 750} = 9.24 \text{ A}$$

Specification:

1 grounding resistor $750 \, \Omega; \quad 10 \text{ A}; \quad 10 \text{ s}$

1 v.t. $\frac{12000}{\sqrt{3}} / 100 \text{ V}; \quad \text{single-phase insulation}$

b) HV system solidly grounded

Only 1/6 of the voltage U_{HV} is effective.

$$R_{E\min} \geq \frac{12000}{\sqrt{3} \times 20} = 346 \, \Omega$$

$$R_{E\max} \leq \frac{0.05 \times 12}{6 \times 314 \times 3 \times 10^{-9} \times \frac{110}{6}} = 5790 \, \Omega$$

Chosen $R_E = 3000 \, \Omega$

$$I_{E\max} = \frac{U_{GN}}{\sqrt{3} R_E} = \frac{12000}{\sqrt{3} \times 3000} = 2.3 \text{ A}$$

Specification:

1 grounding resistor $3000 \, \Omega; \quad 2.3 \text{ A}; \quad 10 \text{ s}$

1 v.t. $\frac{12000}{\sqrt{3}} / 100 \text{ V}; \quad \text{single-phase insulation}$

Alternative 2 with grounding transformer (see Fig. 3.5.11.5):

This arrangement is widespread in North America. The maximum current for the grounding transformer is chosen to approximately equal the capacitive component of the E/F current.

$$I_{E\max} \approx I_C$$

$$I_C = 3 \times \omega \times C \times \frac{U_{GN}}{\sqrt{3}}$$

Rated data of the grounding transformer:

$$U_{1n} = \frac{U_{GN}}{\sqrt{3}}$$

$$U_{2n} = 100; \quad 200; \quad 400 \text{ V} \quad \text{or} \quad 115; \quad 230; \quad 460 \text{ V}$$

$$I_{1n} = I_{E\max}$$

$$I_{2n} = I_e$$

$$\text{where } I_e = I_{E\max} \frac{U_{1n}}{U_{2n}}$$

The grounding resistor R_e connected to the secondary is give by

$$R_e = \frac{U_{GN}}{\sqrt{3} I_{E\max}} \left(\frac{U_{2n}}{U_{1n}} \right)^2$$

$$\text{or for } U_{1n} = \frac{U_{GN}}{\sqrt{3}}$$

$$R_e = \frac{U_{2n}^2}{U_{1n} I_{E\max}}$$

Rated power of the grounding transformer:

$$S_n = U_{1n} I_{1n}$$

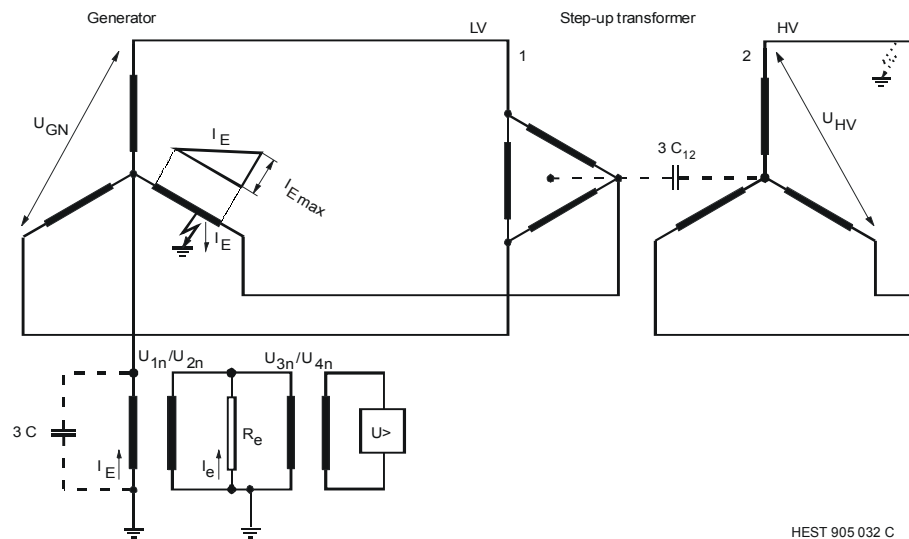


Fig. 3.5.11.5 Stator E/F protection with a grounding transformer at the star-point

Example 2

$$U_{GN} = 12 \text{ kV}; I_C = 10 \text{ A}$$

$$I_{E\max} = I_C = 10 \text{ A}$$

$$U_{1n} = \frac{12000}{\sqrt{3}} = 6930 \text{ V}$$

$$I_{1n} = 10 \text{ A}$$

$$U_{2n} = 200 \text{ V}$$

$$I_{2n} = I_e = 10 \quad \frac{6930}{200} = 346 \text{ A}$$

$$R_e = \frac{200^2}{6930 \times 10} = 0.577 \Omega$$

$$S_n = U_{1n} I_{1n} = 6930 \times 10 \geq 70 \text{ kVA}$$

Specification:

1 grounding transformer 70 kVA; 10 s; 50 Hz

6930/200 V; 10/346 A

1 resistor 0.577 Ω ; 346 A; 10 s

1 interposing v.t. 10 VA; 50 Hz; 200/100 V

(only necessary if $U_{2n} > 100 \text{ V}$)

Example 3

$U_{GN} = 12 \text{ kV}$; $I_C = 10 \text{ A}$; grounding transformer specified according to the rated voltage of the generator.

$$U_{1n} = U_{GN} = 12 \text{ kV}$$

$$U_{2n} = 230 \text{ V}$$

$$I_{1n} = I_{E\max} = I_C = 10 \text{ A}$$

$$I_{2n} = I_e = I_{E\max}$$

$$\frac{U_{1n}}{U_{2n}} = 10 \frac{12000}{230} = 522 \text{ A}$$

$$R_e = \frac{12000}{\sqrt{3} \times 10} \left(\frac{230}{12000} \right)^2 = 0.254 \, \Omega$$

$$S_n = 12000 \times 10 \geq 120 \text{ kVA}$$

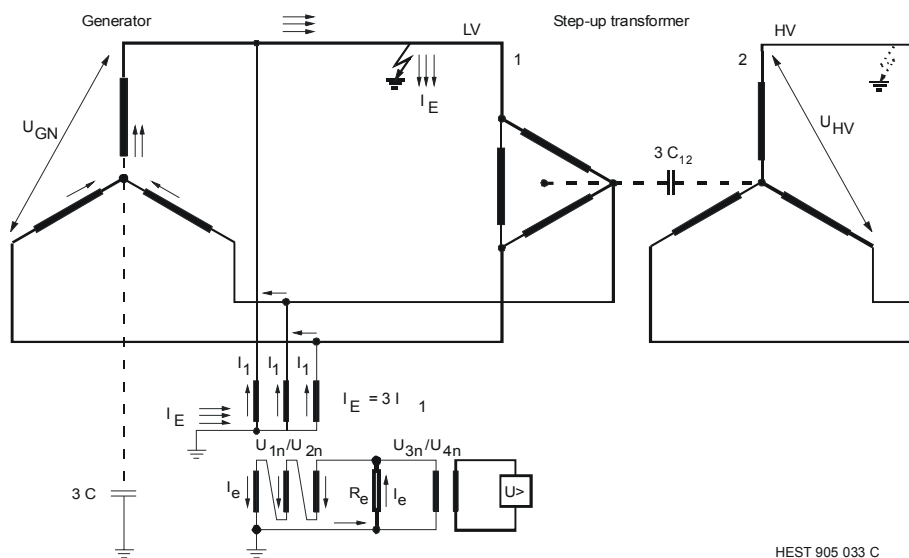
Specification:

1 grounding transformer	120 kVA;	10 s;	50 Hz
	12000/230 V;		10/522 A
1 resistor	0.254 Ω ;	522 A;	10 s
1 interposing v.t.	10 VA;	50 Hz;	230/100 V

Designing a scheme for connection to the generator terminals

If the generator star-point is inaccessible, the stator E/F protection is connected to three v.t.'s at the generator terminals (see Fig. 3.5.11.6). In this case, the E/F current is fed by the three v.t. primary windings. Assuming a permissible short-time current of the primary windings of 5 A, the E/F current must be limited to a maximum of 15 A.

The secondary rated voltage must be chosen such that it does not exceed 300 V and, wherever possible, the secondary current does not exceed 250 A.



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Fig. 3.5.11.6 Stator E/F protection with grounding transformer at the generator terminals

For an E/F at a generator terminal, the voltage of the phase concerned becomes zero and the healthy phases are at phase-to-phase potential with respect to ground. The vectorial addition of the two phase-to-phase voltages produces three times the rated voltage across the broken delta connection of the v.t. secondary windings:

$$U = 3 U_{2n}$$

where U_{2n} is the rated secondary voltage. If U is greater than 100 V, the E/F protection must be connected via an interposing v.t.

When designing the scheme, the maximum current flowing through the primaries of the v.t.'s during an E/F is determined first.

Assuming that the permissible short-time primary current of the v.t.'s is 5 A, then

$$I_{E\max} = 15 \text{ A}$$

The corresponding minimum value for the grounding resistor is

$$R_{\text{emin}} \geq \frac{U_{\text{GN}}}{\sqrt{3} I_{\max}} \left(\frac{3 U_{2n}}{U_{1n}} \right)^2 \times K$$

where K is the influence of the v.t. reactance. A mean value of 0.7 may be assumed for v.t.'s.

To ensure that the E/F protection remains stable for an E/F on the HV side of the step-up transformer, the resistor may not be less than

$$R_{\text{emax}} \leq \frac{0.05 U_{\text{GN}}}{6\omega C_{12} U_{\text{HV}}} \left(\frac{3 U_{2n}}{U_{1n}} \right)^2$$

The secondary current I_e is then chosen and the secondary rated voltage calculated:

$$U_{2n} = U_{1n} \frac{I_E}{3 I_e}$$

The maximum voltage across R_e becomes

$$U_{R_e} = R_e I_e$$

and the voltage across the broken delta windings $3U_{2n}$. This voltage must be approximately 30 % higher than the voltage $R_e I_e$ across the resistor so that the design current I_E can flow.

Example 4

$U_{GN} = 12 \text{ kV}$; $U_{HV} = 110 \text{ kV}$; $C_{12} = 3 \times 10^{-9} \text{ F}$; $\omega = 314 \text{ 1/s}$
 HV system ungrounded.

$$I_{E\max} = 15 \text{ A}$$

$$U_{1n} = \frac{U_{GN}}{\sqrt{3}} = \frac{12000}{\sqrt{3}} = 6930 \text{ V}$$

$$R_{\text{emin}} \geq \frac{12000}{\sqrt{3} \times 15} \left(\frac{3U_{2n}}{6930} \right)^2 \times 0.7 = 0.60 \times 10^{-4} \times U_{2n}^2$$

$$R_{\text{emax}} \leq \frac{0.05 \times 12}{6 \times 314 \times 3 \times 10^{-9} \times 110} \left(\frac{3U_{2n}}{6930} \right)^2 = 1.81 \times 10^{-4} \times U_{2n}^2$$

Since from this calculation R_{emax} is greater than R_{emin} , the protection is stable at the chosen current $I_{E\max}$ and the value of the resistor R_e can be determined in relation to R_{emin} .

$$I_e = 200 \text{ A}$$

$$U_{2n} = 6930 \frac{15}{3 \times 200} = 173 \text{ V}$$

It then follows that

$$R_{\text{emin}} \geq 0.60 \times 10^{-4} \times 173^2 = 1.80 \text{ } \Omega$$

$$R_{\text{emax}} \leq 1.81 \times 10^{-4} \times 173^2 = 5.42 \text{ } \Omega$$

$$R_e = 1.80 \text{ } \Omega$$

At $I_e = 200 \text{ A}$, the voltage drop across the resistor R_e is

$$U_{R_e} = R_e I_e = 1.8 \times 200 = 360 \text{ V}$$

Neglecting load current, the maximum voltage across the broken delta windings is:

$$U = 3 U_{2n} = 3 \times 173 \approx 520 \text{ V}$$

Specification:

1 resistor $1.80 \text{ } \Omega$; 200 A; 10 s

3 v.t.'s $\frac{12000}{\sqrt{3}} / 173 \text{ V}$ single-phase insulated

1 interposing v.t. 10 VA; 50 Hz; 520 / 100 V

Note:

Because of the voltage drop of the v.t.'s, the voltage does not reach 520 V at the full E/F current, but only 360 V. The setting of the protection must therefore be modified as follows:

Overvoltage setting

$$0.05 \frac{360}{520} = 0.034 \quad (3.4 \% U_N \text{ instead of } 5 \% U_N)$$

Example 5

$U_{GN} = 27 \text{ kV}$; $U_{HV} = 400 \text{ kV}$; $C_{12} = 3 \times 10^{-9} \text{ F}$; $x = 314 \text{ 1/s}$

HV system solidly grounded

$$I_E = 15 \text{ A}$$

$$U_{in} = \frac{U_{GN}}{\sqrt{3}} = \frac{27000}{\sqrt{3}} = 15600 \text{ V}$$

$$R_{emin} \geq \frac{27000}{\sqrt{3} \times 15} \left(\frac{3 U_{2n}}{15600} \right)^2 = 27 \times 10^{-6} \times U_{2n}^2$$

$$R_{emax} \leq \frac{0.05 \times 27}{6 \times 314 \times 3 \times 10^{-9} \times \frac{400}{6}} \left(\frac{3 U_{2n}}{15600} \right)^2 = 132 \times 10^{-6} \times U_{2n}^2$$

$$I_e = 250 \text{ A (chosen)}$$

$$U_{2n} = 15600 \frac{15}{3 \times 300} = 260 \text{ V}$$

The resistor R_e is chosen according to R_{emin} :

$$R_e = 27 \times 10^{-6} \times 260^2 = 1.825 \Omega$$

$$R_e I_e = 1.825 \times 300 = 547 \text{ V}$$

$$3 U_{2n} = 3 \times 260 = 780 \text{ V}$$

$$S = \sqrt{3} \times 260 \times 300 = 135 \times 10^3 \text{ VA}$$

The specification and the modification of the protection setting is similar to Example 4.

Typical settings:

V-Setting	0.05 U_N
Delay	0.5 s

Note:

If a generator circuit-breaker is installed between the generator and the step-up transformer, a second E/F protection scheme is required for the zone between the step-up transformer and the unit transformer. The second scheme is connected to the broken delta secondary windings of three v.t.'s. This scheme must also remain stable for E/F's on the HV system and during ferroresonance phenomena and for this reason there is a resistor across the broken delta as well. Frequently, the E/F protection is only required to protect the cables and bar conductors, because the transformers are protected by differential schemes and Buchholz relays. In this case, the E/F protection setting is determined by the voltage offset for an E/F at the lowest load voltage. A typical setting for reliable E/F detection in an ungrounded system is 60 % U_N , i.e.

$$V\text{-Setting} = 0.6 U_N$$

The delay can remain the same at 0.5 s. The second E/F scheme usually gives only an alarm. Since the plant remains in operation for an E/F on the cables, the resistor across the broken delta must be continuously rated.

3.5.11.2. Rotor E/F protection**Settings:**

Overvoltage	V-Setting
Delay	Delay
Over/undervoltage	Max Min

The rotor E/F function in conjunction with the ancillary unit Type YWX 111 and 2 coupling capacitors is suitable for protecting synchronous generators regardless of the method of excitation. The scheme operates according to the Wheatstone bridge principle and is uninfluenced by frequency. The harmonics of the excitation system do not therefore effect the rotor E/F protection.

The bridge is connected to the rotor circuit by one or two high-voltage capacitors. The first leg of the bridge consists of the coupling capacitors and the capacitance of the rotor winding in series. The second capacitive leg, the resistive legs and a supply transformer for stepping down the v.t. voltage (e.g. 100 V) to the 50 V needed for the measuring circuit are in the ancillary unit Type YWX 111. A second transformer isolates the bridge from the input of the E/F protection function.

An E/F short-circuits the capacitance of the rotor winding and the bridge is no longer balanced. There is thus a voltage across the bridge that is detected by the overvoltage function. Depending on the design of the scheme, the pick-up setting is between 0.5 and 3 V to detect an insulation leakage of 1 k Ω which is considered as being a rotor E/F. Since all the components influence the setting, it is determined during commissioning.

Typical settings:

V-Setting (for 1 k Ω)	1 to 3 V
Delay	1 s
MaxMin	MAX

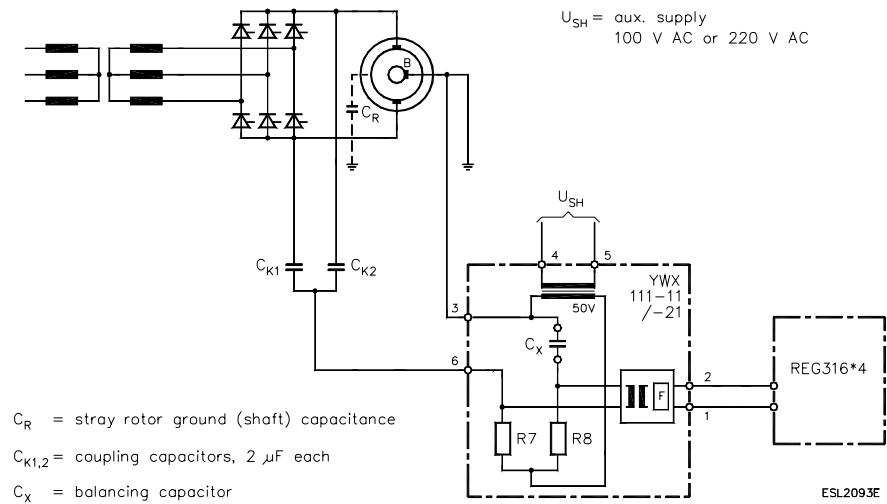


Fig. 3.5.11.7 Rotor E/F protection function
 C_1, C_2 = external coupling capacitances

3.5.11.3. Interturn protection

(voltage principle)

Settings:

Overvoltage

V-Setting

Delay

Delay

The purpose of the interturn protection is to detect short-circuits between the turns of the generator stator windings.

The scheme should be as sensitive as possible to detect the majority of interturn faults. However, because of various residual voltages caused by asymmetries, the setting may not be lower than 5 % U_N . A slight delay will prevent false tripping due to transients.

Both ends of the primaries of v.t.'s must be designed for the full HV potential!

Since the star-points of the generator and the v.t.'s are connected, the high short-circuit power of the generator would cause severe damage in the event of an interturn fault on a v.t. primary. HV fuses should therefore be inserted in the v.t. primaries.

Typical settings:

V-Setting

 $0.05 U_N$

Delay

0.5 s

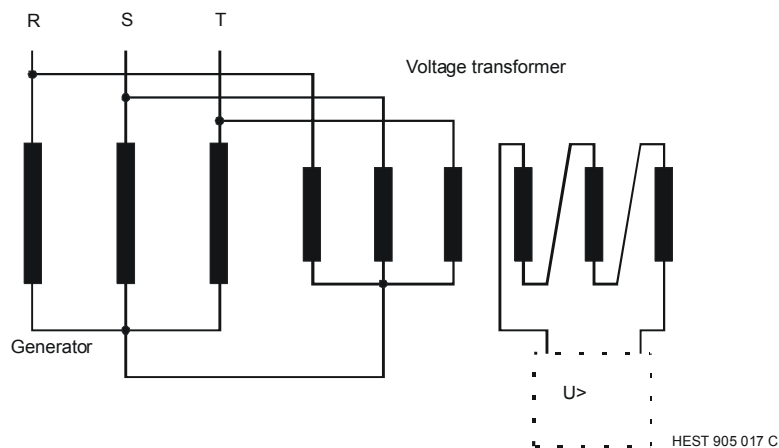


Fig. 3.5.11.8 Interturn protection according to the voltage principle

3.5.12. Peak value overvoltage (Voltage-Inst)**A. Application**

- General voltage monitoring with instantaneous response (over and undervoltage)
- Voltage monitoring where insensitive to frequency is required (over and undervoltage).

B. Features

- processes instantaneous values and is therefore fast and largely independent of frequency
- stores the peak value following pick-up
- no suppression of DC component
- no suppression of harmonics
- single and three-phase measurement
- maximum value detection in the three-phase mode
- adjustable lower frequency limit $f_{\min}$.

C. Inputs and outputs**I. C.t./v.t. inputs**

- voltage

II. Binary inputs

- blocking

III. Binary outputs

- pick-up
- tripping

IV. Measurements

- voltage amplitude (only available if function trips).

D. Peak value voltage function settings - Voltage-Inst

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
Trip		00000000			
Delay	s	00.01	0.00	60.00	0.01
V-Setting	UN	1.40	0.01	2.00	0.01
f-min	Hz	40	25	50	1
MaxMin		MAX	(Select)		
NrOfPhases		001	1	3	2
VoltageInp	CT/VT-Addr	0			
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr	ER			

Explanation of parameters:

ParSet 4..1

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

defines the tripping channel activated by the tripping O/P of the function (matrix).

Delay

Time between the function picking up and tripping.

V-Setting

Pick-up voltage setting.

f-min

defines the minimum frequency for which measurement is required.

MaxMin

defines operation as overvoltage or undervoltage. Settings:

- MAX: overvoltage
- MIN: undervoltage.

NrOfPhases

defines whether single or three-phase measurement.

VoltageInp

defines the v.t. input channel.

All voltage inputs may be selected.

In the case of three-phase measurement, the first channel (R phase) of the group of three selected must be specified.

BlockInp

Binary address used as blocking input.

F: - not blocked

T: - blocked

xx: - all binary inputs (or outputs of protection functions).

Trip

Output for signalling tripping.

Start

Output for signalling pick-up.

E. Setting instructions

Settings:

Overvoltage	V-Setting
Delay	Delay
Minimum frequency	f-min
Over or undervoltage	MaxMin

The instantaneous overvoltage function is a high-speed protection, which operates in a wide frequency range. It is intended primarily for the following applications:

- where an overvoltage protection is required, which is largely insensitive to frequency especially for $f > f_N$.
The limited capacity of the v.t's to transform low frequencies must be taken into account for $f < f_N$:

Input transformer units K01...K17 (REL 316*4) and K41...K47 (REC 316*4):

$$1.3U_N \cdot \frac{f}{f_N}$$

Input transformer units K21...K24 (RET 316*4) and K61...K68 (REG 316*4):

$$2.25U_N \cdot \frac{f}{f_N}$$

- where high-speed protection is required. The high speed is achieved by measuring the instantaneous value of the voltage and since DC components and harmonics are not suppressed, by eliminating the inertia of the digital input filter.

Compared with the normal voltage function, the instantaneous function has a larger tolerance on the pick-up setting. It should therefore only be used in the above two cases.

The measuring principle is the same as that of the peak value current function and therefore reference should be made to that Section for a description of the principle and the significance of the minimum frequency setting f-min.

Pick-up voltage (U-Setting)

Single-phase v.t.:

A setting of $1.3 U_N$ corresponds to a pick-up voltage of 130 V at the input of the v.t.

Note that although a setting of $2.0 U_N$ is possible, the range of the analogue inputs of the input transformer units K01...K17 (REL 316*4) and K41...K47 (REC 316*4) is only $1.3 U_N$ (i.e. max. 130 V or 260 V).

Y connected three-phase v.t's:

A setting of $1.3 U_N$ corresponds to a pick-up voltage of $130 V/\sqrt{3}$ at the input of the v.t.(phase-to-neutral voltage).

Typical settings:

V-Setting	according to application
Delay	according to application
f-min	40 Hz

3.5.13. *Underimpedance (Underimped)*

A. Application

Back-up phase fault protection for the generator feeder.

B. Features

- circular operating characteristic ([see Fig. 3.5.13.1](#))
- adjustable time delay
- insensitive to DC component in voltage and current
- insensitive to harmonics in voltage and current
- single or three-phase measurement
- detection of the lowest impedance in the three-phase mode
- underimpedance measurement enabled by undercurrent unit ($0.1 I_N$).

C. Inputs and outputs

I. Analogue inputs:

- current
- voltage

II. Binary inputs:

- blocking

III. Binary outputs:

- pick-up
- tripping

IV. Measurements:

- impedance (value).

D. Underimpedance function settings - Underimped

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
Trip		00000000			
Delay	s	00.50	0.20	60.00	0.01
Z-Setting	UN/IN	0.250	0.025	2.500	0.001
NrOfPhases		001	1	3	1
CurrentInp	AnalogAddr	0			
VoltageInp	AnalogAddr	0			
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr	ER			

Explanation of parameters:

ParSet 4..1

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

defines the tripping channel activated by the tripping output of the function (tripping logic).

Delay

Time between the function picking up and tripping.

Z-Setting

Pick-up impedance setting.

NrOfPhases

defines whether single or three-phase measurement.

CurrentInp

defines the analogue current input channel.

All current inputs may be selected.

In the case of three-phase measurement, the first channel (R phase) of the group of three selected must be specified.

VoltageInp

defines the analogue voltage input channel.

All voltage inputs may be selected.

In the case of three-phase measurement, the first channel (e.g. the phase-to-phase voltage R-S) of the group of three selected must be specified.

BlockInp

Binary address used as blocking input.

F: - Not blocked

T: - Blocked

xx: - all binary inputs (or outputs of a protection function).

Trip

Output for signalling tripping.

Start

Output for signalling pick-up.

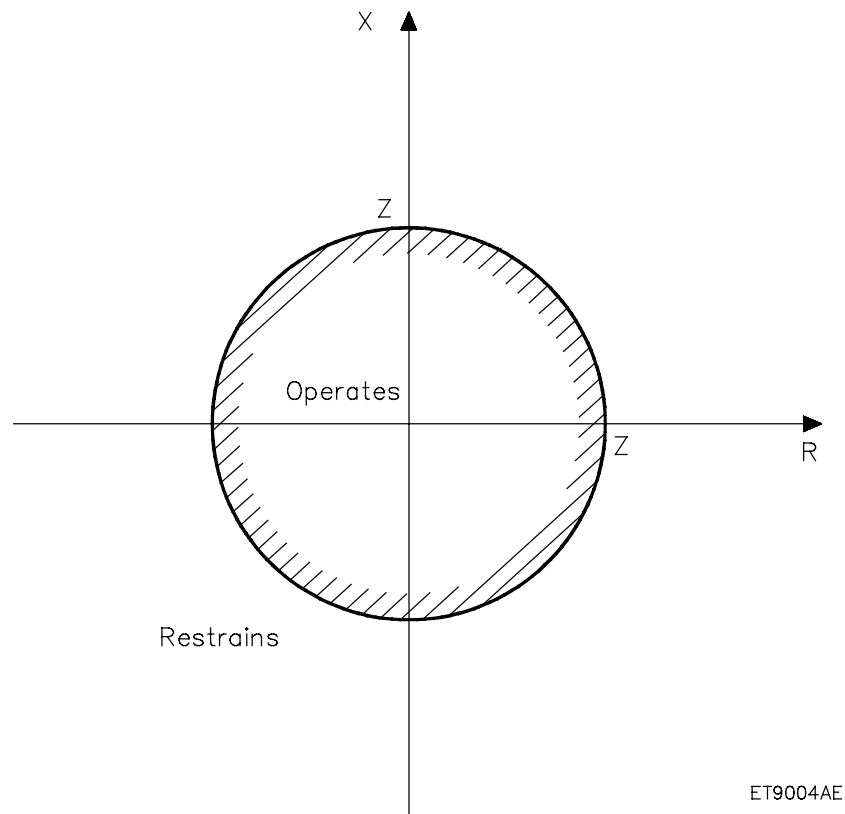


Fig. 3.5.13.1 Operating characteristic of the underimpedance function

E. Setting instructions

Settings:

Impedance	Z-Setting
Delay	Delay

The underimpedance function serves as back-up protection for phase faults on the generator/transformer unit. It is faster and more sensitive than the overcurrent protection. Its disadvantage is that the zone of protection is shorter than the differential protection, which serves as the main protection.

The underimpedance scheme is connected to the c.t's at the generator star-point and to the v.t's at the generator terminals. The underimpedance operating characteristic is a circle in the R/X plane, whereby the origin represents the location of the v.t's. The zone of protection covers the generator windings the cables and the step-up transformer.

The setting of the underimpedance function is determined by the short-circuit reactance of the step-up transformer. Otherwise, the distance between the step-up transformer and the HV circuit-breaker is mostly too short to be able to discriminate reliably with the impedance setting between faults in the generator/transformer unit zone and faults on the other side of the HV circuit-breaker. The impedance is thus set to 70 % of the transformer impedance which at least includes the transformer winding on the generator side in the zone of protection.

The setting of the underimpedance function is referred to rated voltage and current.

The impedance of the protected zone is determined by the short-circuit reactance of the step-up transformer and is given by:

$$z_1 = 0.7 \times x_T \quad [\text{p.u.}]$$

The impedance seen by the underimpedance function depends on the c.t and v.t. ratios K_i and K_u and the rated data of step-up transformer and protection:

$$K_i = \frac{I_{N1}}{I_{N2}} \qquad K_u = \frac{U_{N1}}{U_{N2}}$$

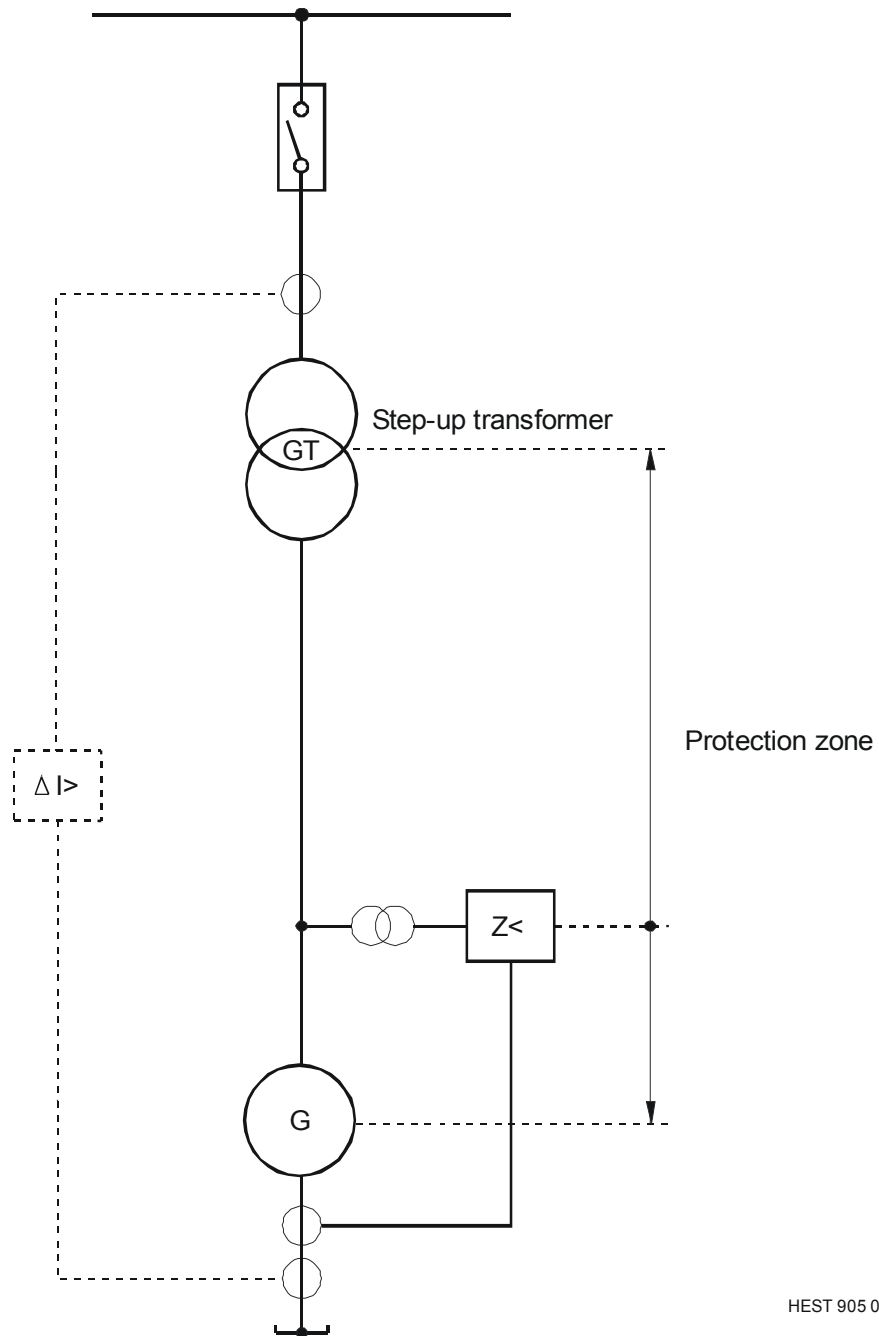


Fig. 3.5.13.2 Underimpedance protection

The impedance to be set on the protection in p.u. is:

$$Z - \text{Setting} = 0.7x_T \frac{U_{TN}}{I_{TN}} \times \frac{K_i}{K_u} \times \frac{I_N}{U_N} \quad [1; 1; V; A]$$

or

$$Z - \text{Setting} = 0.7x_T \frac{U_{TN}}{I_{TN}} \times \frac{I_{N1}}{I_{N2}} \times \frac{U_{N2}}{U_{N1}} \times \frac{I_N}{U_N} \quad [1; 1; V; A]$$

For simple cases where $U_{TN} = U_{N1}$, $I_{TN} = I_{N1}$, $U_{N2} = U_N$ and $I_{N2} = I_N$:

$$Z - \text{Setting} = 0.7 x_T \quad [1; 1]$$

where:

z_1	impedance of the protected zone
x_T	short-circuit reactance of the step-up transformer
K_i, K_u	ratios of c.t.'s and v.t.'s
I_{N1}, I_{N2}	c.t. rated currents
U_{N1}, U_{N2}	v.t. rated voltages
U_{TN}, I_{TN}	rated voltage and current of the step-up transformer
U_N, I_N	rated voltage and current of the underimpedance function

The factor of 0.7 avoids any risk of false tripping for a fault on the HV system at the cost of a zone of protection that is shorter than differential protection zone.

Example:

Transformer: 100 MVA; 12 kV; 4.8 kA; $x_T = 0.1$

C.t.'s and v.t.'s: 12000/100 V; 5000/5 A

Protection: 100 V; 5 A

$$K_i = \frac{I_{N1}}{I_{N2}} = \frac{5000}{5} = 1000$$

$$K_u = \frac{U_{N1}}{U_{N2}} = \frac{12000}{100} = 120$$

Settings:

$$Z - \text{Setting} = 0.7 \times \frac{U_{TN}}{I_{TN}} \times \frac{K_i}{K_u} \times \frac{I_N}{U_N}$$

$$Z - \text{Setting} = 0.7 \times 0.1 \times \frac{12}{4.8} \times \frac{1000}{120} \times \frac{5}{100} = 0.073$$

It must not be forgotten that a current of at least $0.1 I_N$ must flow before the underimpedance function is enabled.

Typical settings:

Z-Setting	0.07
Delay	0.5 s

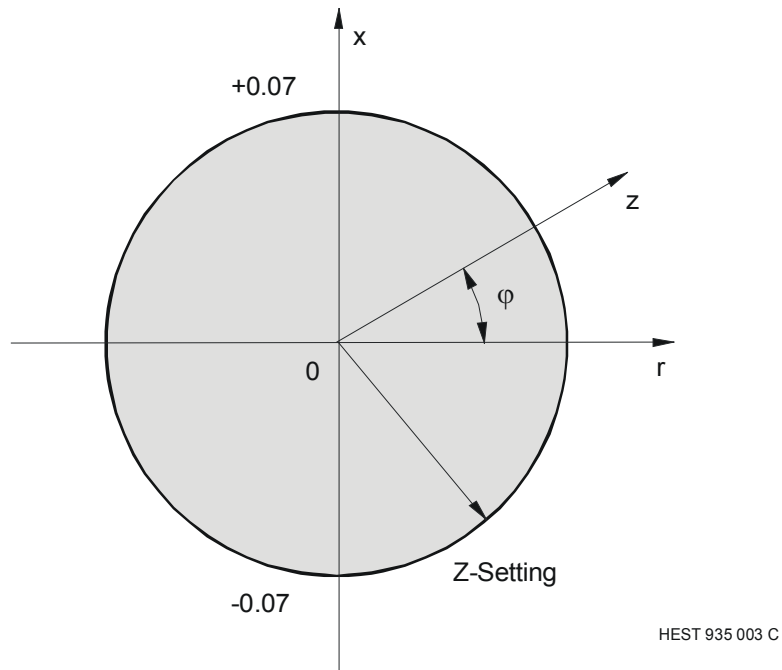


Fig. 3.5.13.3 Operating characteristic of the underimpedance function

Setting: Z-Setting = 0.07

3.5.14. Underreactance (*MinReactance*)

A. Application

- detection of inadmissible operating conditions due to under-excitation of a synchronous generator.

B. Features

- circular operating characteristic (see Fig. 3.5.14.1)
- selectable to operate inside or outside the circle
- adjustable size and position of the operating characteristic
- correction of phase errors caused by input circuit
- adjustable time delay
- insensitive to DC component in voltage and current
- insensitive to harmonics in voltage and current
- single or three-phase measurement
- detection of the lowest impedance (distance from the centre of the circle)
- underreactance measurement enabled by undercurrent unit ($0.1 I_N$).

C. Inputs and outputs

I. Analogue inputs:

- current
- voltage

II. Binary inputs:

- blocking

III. Binary outputs:

- pick-up
- tripping

IV. Measurements:

- impedance (distance from the centre of the circle).

D. Underreactance function settings - MinReactance

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
Trip		00000000			
Delay	s	00.50	0.20	60.00	0.01
XA-Setting	UN/IN	-2.00	-5.00	00.00	0.01
XB-Setting	UN/IN	-0.50	-2.50	+2.50	0.01
MaxMin		MIN	(Select)		
NrOfPhases		001	1	3	1
CurrentInp	AnalogAddr	0			
VoltageInp	AnalogAddr	0			
Angle	deg	000	-180	180	5
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr				

Explanation of parameters:

ParSet 4..1

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

defines the tripping channel activated by the tripping output of the function (tripping logic).

Delay

Time between the function picking up and tripping.

XA-Setting

defines the first intersection of the impedance circle with the reactance axis (assuming a phase correction setting of 0°).
Setting restriction: $|X_A| < |X_B|$.

XB-Setting

defines the second intersection of the impedance circle with the reactance axis (assuming a phase correction setting of 0°).

MaxMin

defines whether over or underreactance function.

Settings:

- MIN: underreactance function with tripping inside the circle
- MAX: overreactance function with tripping outside the circle

NrOfPhases

defines whether single or three-phase measurement.

CurrentInp

defines the A/D input channel.

All current inputs may be selected.

In the case of three-phase measurement, the first channel (R phase) of the group of three selected must be specified.

VoltageInp

defines the A/D input channel.

All voltage inputs may be selected.

In the case of three-phase measurement, the first channel (e.g. the phase-to-phase voltage R-S) of the group of three selected must be specified.

Angle

For compensating phase errors of the analogue input signals caused by the input circuit.

The setting can also be used to move the position of the impedance circle.

BlockInp

Binary address used as blocking input.

F: - Not blocked

T: - Blocked

xx: - all binary inputs (or outputs of a protection function).

Trip

Output for signalling tripping.

Start

Output for signalling pick-up.

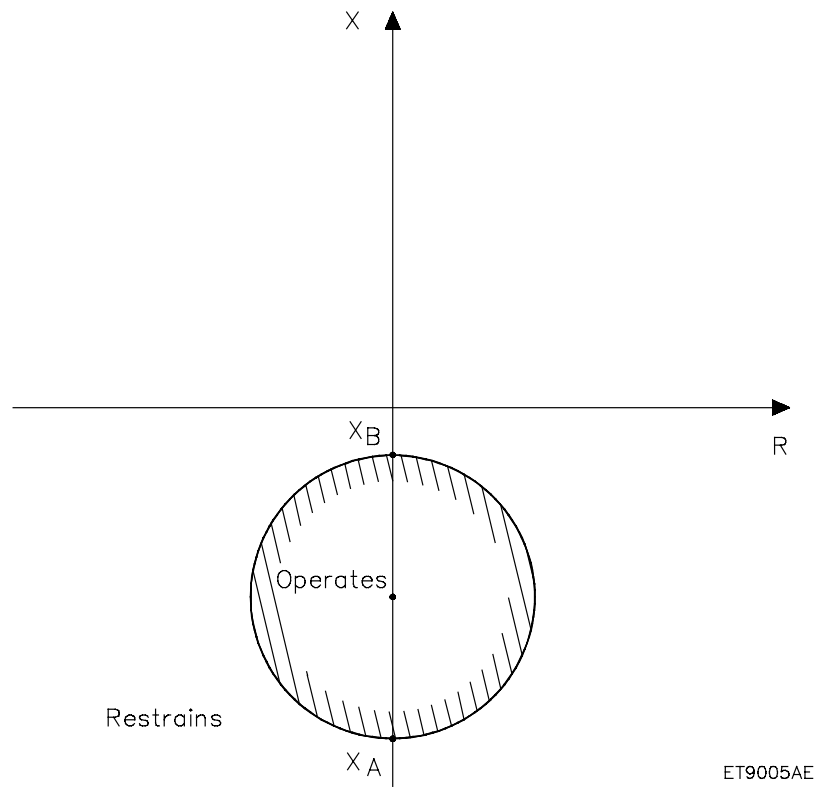


Fig. 3.5.14.1 Operating characteristic of the underreactance function with MaxMin = MIN (default)

E. Setting instructions

Settings:

Reactance X_A	XA-Setting
Reactance X_B	XB-Setting
Phase correction	Angle
Delay	Delay
Integrator (separate "Delay" function)	Trip-Delay
	Reset-Delay

Operating principle of the underreactance function

The underreactance or underexcitation function protects the generator in potentially dangerous operating conditions which can arise in the event of loss of, or reduced excitation. There is a danger in such situations of the unit becoming unstable and running out of synchronism. This causes thermal stress due to induced currents on the one hand, and mechanical stress due to surges of torque on the other.

It is general knowledge that a synchronous machine may not be loaded as much capacitively as inductively, because excessive capacitive load causes it to drop out-of-step. The reason is the steady-state stability limit as defined by the load angle $\delta = 90^\circ$, which can only be reached when the unit is underexcited, i.e. for a capacitive power factor φ . When the voltage is measured at the generator terminals, the locus of the stability limit of a generator/transformer set is a circle as shown in [Fig. 3.5.14.3](#). The circle encloses the operating points of an underexcited generator down to the extreme point X_A which represents total loss of excitation. The protection has a circular characteristic that does not normally coincide with the stability limit at the top to avoid false tripping during voltage dips caused by power system faults.

Operation of the function is delayed to allow for possible recovery of synchronism following dynamic phenomena with brief load angles of $\delta > 90^\circ$. A typical setting for the time delay is 2 s.

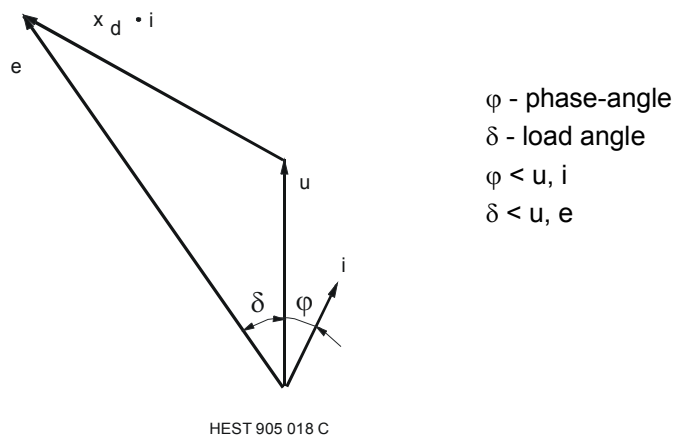
The scheme includes an integrator (separate "Delay" function) to maintain the underexcitation signal in the event of power swings. This is necessary because the normal "Delay" setting repeatedly resets during power swings and prevents tripping from taking place.

Determining the characteristic

The circular operating characteristic of the protection is defined by the two points A and B. Point A is given in the case of turboalternators by the unsaturated synchronous reactance x_d and in the case of generators with salient poles by the synchronous reactance x_q . As can be seen from Fig. 3.5.14.2, the stability of a generator with salient poles is given by x_q , because the load angle δ is also determined by this reactance. The steady-state stability limit is reached at this point when excitation is lost.

Point B is defined as half the transient reactance x_d' and determined by the voltage and current measured at the generator terminals when the unit is out-of-step and the generator is in phase opposition to the power system.

a) Turboalternator



b) Salient pole generator

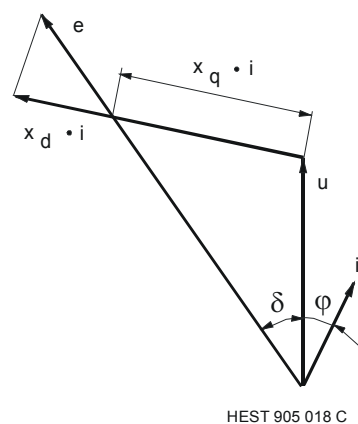


Fig. 3.5.14.2 Vector diagram of an overexcited generator. Voltages, currents and reactances are in p.u.

The reactances X_A and X_B , are defined according to the phase-to-phase voltages and calculated for turboalternators as follows:

$$X_A = x_d \times \frac{U_{GN}}{\sqrt{3} I_{GN}} \times \frac{K_i}{K_u} \sqrt{3}$$

$$X_B = \frac{x_d'}{2} \times \frac{U_{GN}}{\sqrt{3} I_{GN}} \times \frac{K_i}{K_u} \sqrt{3}$$

In the above equation, x_q is replaced by x_d for salient pole units.

$$K_i = \frac{I_{N1}}{I_{N2}}$$

$$K_u = \frac{\frac{U_{N1}}{\sqrt{3}}}{\frac{U_{N2}}{\sqrt{3}}} = \frac{I_{N1}}{I_{N2}}$$

where:

x_d, x_d'	unsaturated synchronous reactance and saturated transient reactance of the generator in p.u.
x_q	synchronous reactance in p.u.
U_{GN}, I_{GN}	rated generator voltage and current
K_i	c.t. ratio
K_u	v.t. ratio
U_{N1}, U_{N2}	v.t. rated voltages
I_{N1}, I_{N2}	c.t. rated currents

Example

Turboalternator 100 MVA; 12 kV; 4.8 kA
 $x_d = 2.0$; $x_d' = 0.25$

$$\text{V.t's} \quad K_u = \frac{\frac{U_{N1}}{\sqrt{3}}}{\frac{U_{N2}}{\sqrt{3}}} = \frac{12000}{100} = 120$$

$$\text{C.t's} \quad K_i = \frac{5000}{1} = 5000$$

$$X_A = x_d \times \frac{U_{GN}}{\sqrt{3} I_{GN}} \times \frac{K_i}{K_u} \sqrt{3} = 2.0 \times \frac{12000}{\sqrt{3} \cdot 4800} \times \frac{5000}{120} \sqrt{3} = 208.3 \, \Omega$$

$$X_B = \frac{x_d'}{2} \times \frac{U_{GN}}{\sqrt{3} I_{GN}} \times \frac{K_i}{K_u} \sqrt{3} = \frac{0.25}{2} \times \frac{12000}{\sqrt{3} \cdot 4800} \times \frac{5000}{120} \sqrt{3} = 13.02 \, \Omega$$

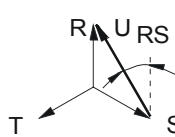
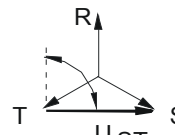
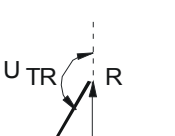
The reactance settings referred to the protection ratings U_N and I_N become:

$$X_A - \text{Setting} = \frac{X_A}{U_N} I_N = - \frac{208.3}{100} \times 1 = - 2.08$$

$$X_B - \text{Setting} = \frac{X_B}{U_N} I_N = - \frac{13.02}{100} \times 1 = - 0.130 = 0.13$$

Phase correction

The scheme can include one to three independent measuring systems, each of which is connected to a phase-to-phase voltage and a phase current. For example, there are three possible reference voltages for the R phase measuring system, i.e. U_{RS} , U_{ST} and U_{TR} . Since, however, all the measuring systems need the angle of their own phase, i.e. for R phase the angle of the voltage U_R , the angle of the voltage signal has to be corrected in any event.

Reference voltage	Vector diagram	Phase compensation "Angle"
RS		+30°
ST *)		-90°
TR *)		+150°

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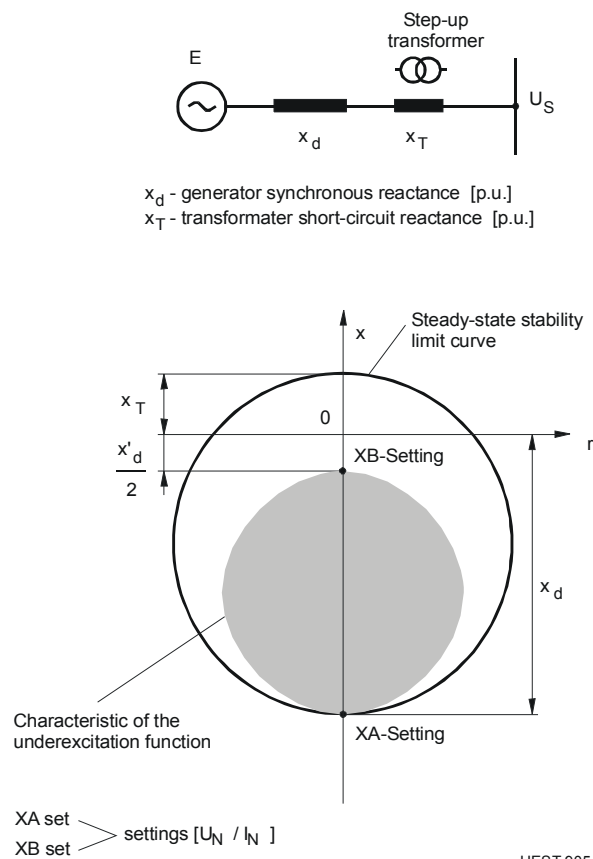
*) single-phase measurement only

The phase compensation can also be used when the characteristic needs to be shifted by a given angle or flipped over into the inductive region, e.g. for test purposes.

If the star-point of the c.t. secondaries on the generator star-point side is grounded, an angle of -180° must be added.

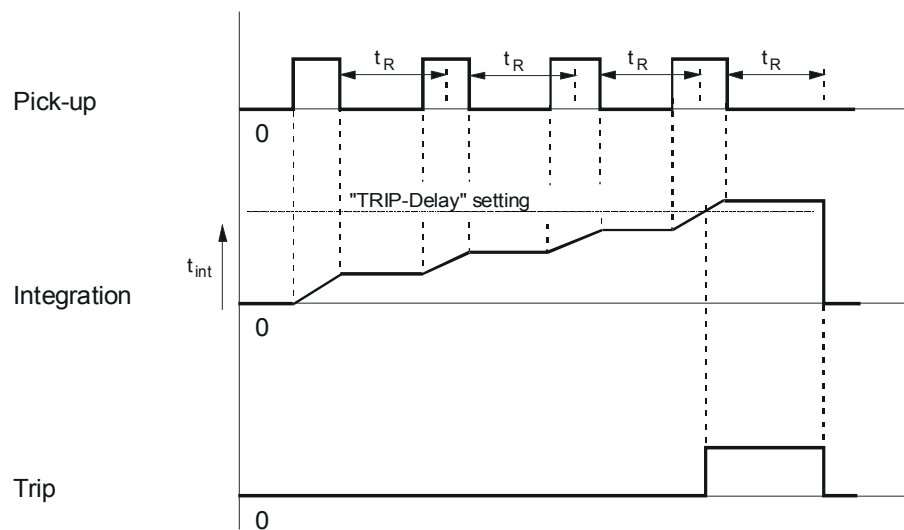
Typical settings:

XA-Setting	according to application e.g. -2.0
XB-Setting	according to application e.g. -0.13
Phase-angle (delta-connected v.t.'s)	+30°
Tripping delay timer:	
Delay	2 s
or separate integrator ("Delay" function):	
Trip-Delay	6 s
Reset-Delay	3 s



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Fig. 3.5.14.3 Setting the characteristic of the underexcitation function according to the steady-state stability limit curve of the generator/transformer set
All reactances in p.u.



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t_{int} integrated time
 t_R reset time

Fig. 3.5.14.4 Underreactance protection
 Effect of the integrator during power swings

Display of measured variable:

The display of the measured variable in the case of the underreactance protection is an impedance vector which starts at the centre of the circular characteristic. This vector and the vector of the impedance measured at the generator terminals form a triangle as shown in Fig. 3.5.14.5. The protection picks up, if the displayed impedance equals or is less than the radius of the circle:

$$z \leq \frac{1}{2} \left(x_d - \frac{X_d'}{2} \right)$$

Example:

$$x_d = 2; \quad X_d' = 0,2$$

$$z \leq \frac{1}{2} (2 - 0,1) = 0,95$$

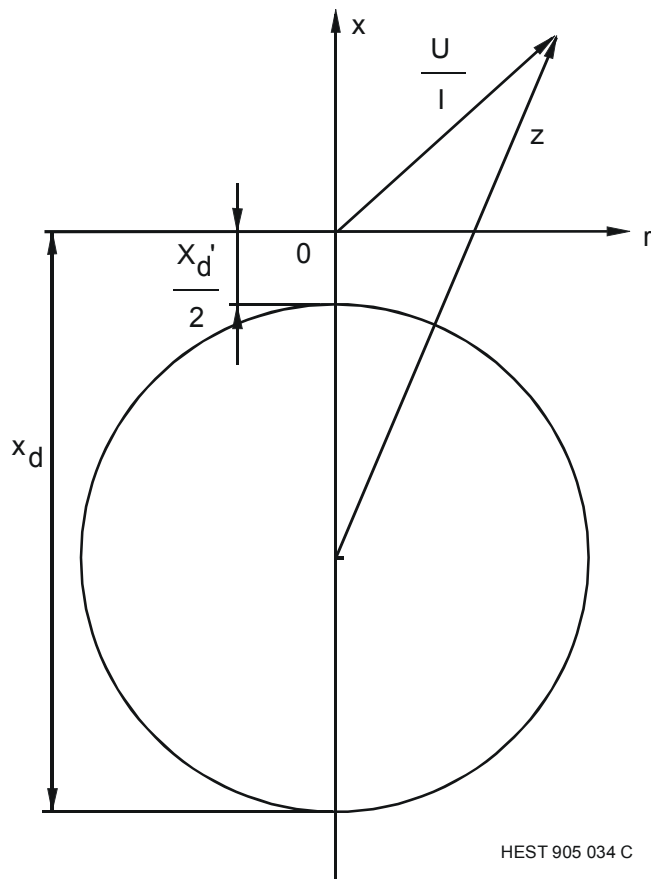


Fig. 3.5.14.5 Display of the impedance measured by the underreactance function

3.5.15. Power (Power)

A. Application

Power function for monitoring

- reverse power
- active power
- reactive power
- power direction.

B. Features

- definite time delay
- over or underpower
- adjustable characteristic angle
- provision for correction of phase errors caused by the input circuit
- one, two or three-phase measurement (two-phase only with delta connected v.t.'s)
- wide range of applications (see Fig. 3.5.15.2 and Fig. 3.5.15.3)
- correction of c.t. and v.t. phase errors
- insensitive to DC components in voltage and current
- insensitive to harmonics in voltage and current.

C. Inputs and outputs

I. C.t./v.t. inputs:

- current
- voltage

II. Binary inputs:

- Blocking

III. Binary outputs:

- pick-up
- tripping

IV. Measurements:

- power.

D. Power function settings - Power

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
Trip		00000000			
P-Setting	PN	-0.050	-0.100	1.200	0.005
Angle	deg	000.0	-180.0	180.0	5.0
Drop-Ratio	%	60	30	170	1
Delay	s	00.50	0.05	60.00	0.01
MaxMin		MIN	(Select)		
Phi-Comp	deg	0.0	-5.0	5.0	0.1
NrOfPhases		001	1	3	1
CurrentInp	CT/VT-Addr	0			
VoltageInp	CT/VT-Addr	0			
PN	UN*IN	1.000	0.500	2.500	0.001
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr				

Explanation of parameters:

ParSet 4..1

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

channel of the tripping logic (matrix) activated by the function's tripping O/P.

P-Setting

Power setting for tripping.

Forbidden settings:

- $< 0.005 P_N$ connected to metering cores
- $< 0.020 P_N$ connected to protection cores

In view of the required accuracy, the use of metering cores is recommended for settings $\leq 0.2 P_N$.

Angle

Characteristic angle between voltage and current for maximum sensitivity.

0° = active power measurement

90° = reactive power measurement (inductive),

Settings between these limits are possible, e.g. for directional measurements at locations on the power system.

The correction of phase errors caused by the input circuit is also possible.

Drop-Ratio

Reset value in relation to the pick-up value. Thus depending on the sign of the pick-up value, the setting of the reset ratio must be greater or less than 100 %.

Forbidden settings:

- Reset ratios >100 % for MAX and P-Setting >0
- Reset ratios <100 % for MAX and P-Setting <0
- Reset ratios <100 % for MIN and P-Setting >0
- Reset ratios >100 % for MIN and P-Setting <0.

A large hysteresis must be selected for low pick-up settings and a small one for high pick-up settings (see Fig. 3.5.15.1).

Forbidden settings for hysteresis ($= |100\% - \text{reset ratio}|$) settings:

- $\leq 0.5\% / (|P - \text{Setting}/P_N| + 0.01)$
- $\geq 10\% / |P - \text{Setting}/P_N|$
- These conditions are fulfilled by setting, for example,

$$\text{for } 0.2 \leq \frac{P - \text{Setting}}{P_N} \leq 1: \quad 95\%$$

and

$$\text{for } 0.005 \leq \frac{P - \text{Setting}}{P_N} \leq 0.2: \quad 60\%.$$

Delay

Time between the function picking up and tripping. The time the function takes to reset is also influenced by the delay set for operation, i.e.:

for $t > 100$ ms, the function resets after 50 ms, otherwise re-setting is instantaneous.

MaxMin

Defines the operating mode as:

- MAX: overpower
- MIN: underpower.

Caution:

The number and its sign are relevant and not just the value, i.e. "MIN" must be set for reverse power, because tripping takes place for a power less than zero (P-Setting < 0).

Phi-Comp

Input of an angle to compensate c.t. and v.t. errors in the case of highly accurate power measurements.

The setting is determined by the difference between c.t. and v.t. errors.

NrOfPhases

Number of phases measured:

- 1: single-phase
- 2: two-phase, i.e. for a three-phase measurement with V connected v.t.'s,
$$P = U_{RS} \times I_R \times \cos \varphi - U_{ST} \times I_T \times \cos \varphi$$

A two-phase power measurement is only possible when connected to delta connected v.t.'s.
- 3: three-phase
$$P = U_R \times I_R \times \cos \varphi + U_S \times I_S \times \cos \varphi + U_T \times I_T \times \cos \varphi$$

(The measurement is only correct with delta connected v.t.'s if the three phase voltages are symmetrical.)

CurrentInp

defines the c.t. input channel.

All current I/P's may be selected.

In the case of multi-phase measurement, the first channel of the group of three (R phase) must be selected.

VoltageInp

defines the v.t. input channel.

All voltage I/P's may be selected.

In the case of multi-phase measurement, the first channel of the group of three (R phase) must be selected.

PN

Rated power as given by $U_N \times I_N$. This enables the amplitude of the power being measured to be compensated, e.g. to the rated power factor of a generator.

BlockInp

I/P for blocking the function.

F: - not blocked

T: - blocked

xx: - all binary I/P's (or O/P's of protection functions).

Trip

Tripping signal.

Start

Pick-up signal.

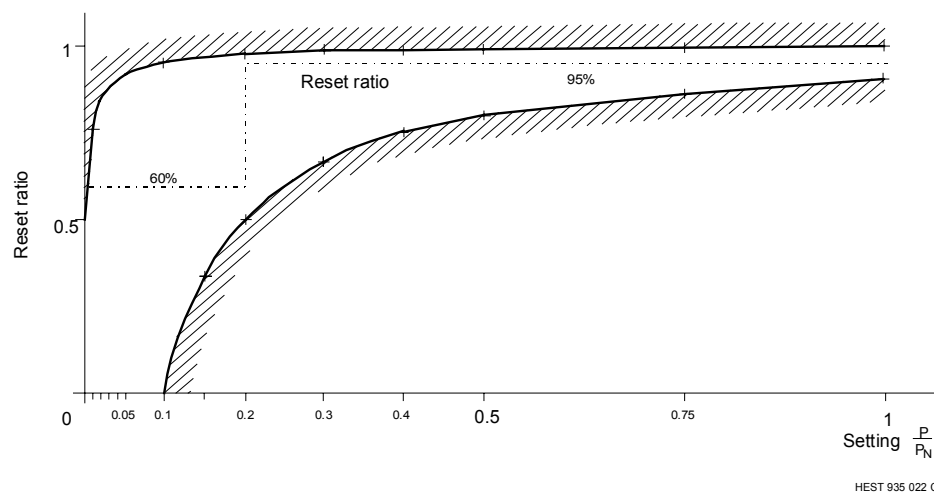


Fig. 3.5.15.1 Permissible reset ratio settings

E. Setting instructions

(function with two additional timers)

Settings:

Reference power	PN
Setting	P-Setting
Reset ratio	Drop-Ratio
Over/underpower	MaxMin
Characteristic angle	Angle
Phase error compensation	Phi-Comp
tripping delay	Delay

The power function can be used for many applications. Some examples are given in Fig. 3.5.15.2 and Fig. 3.5.15.3. The angles given apply for connection according to the connections in Index 12.

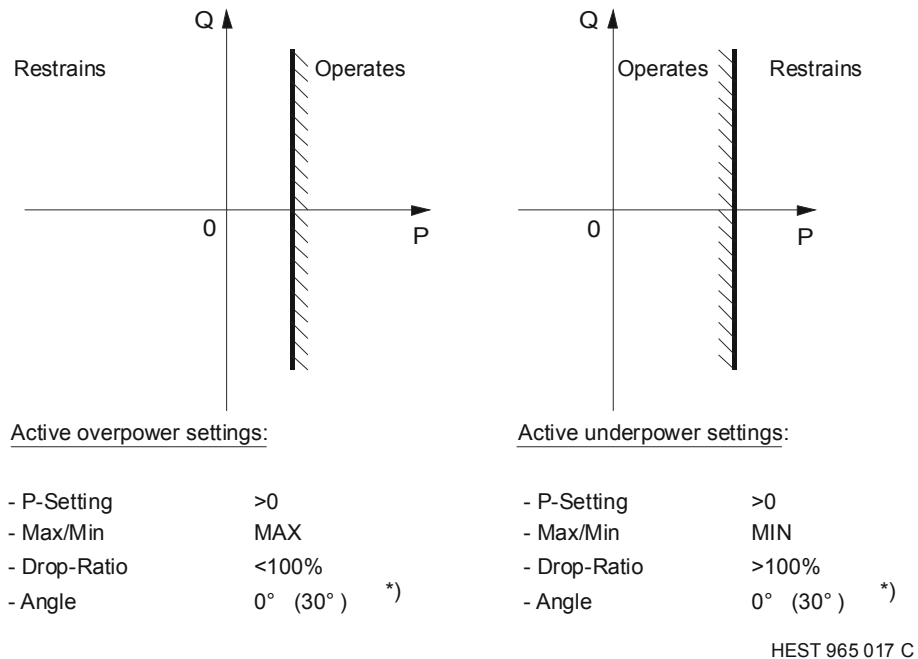
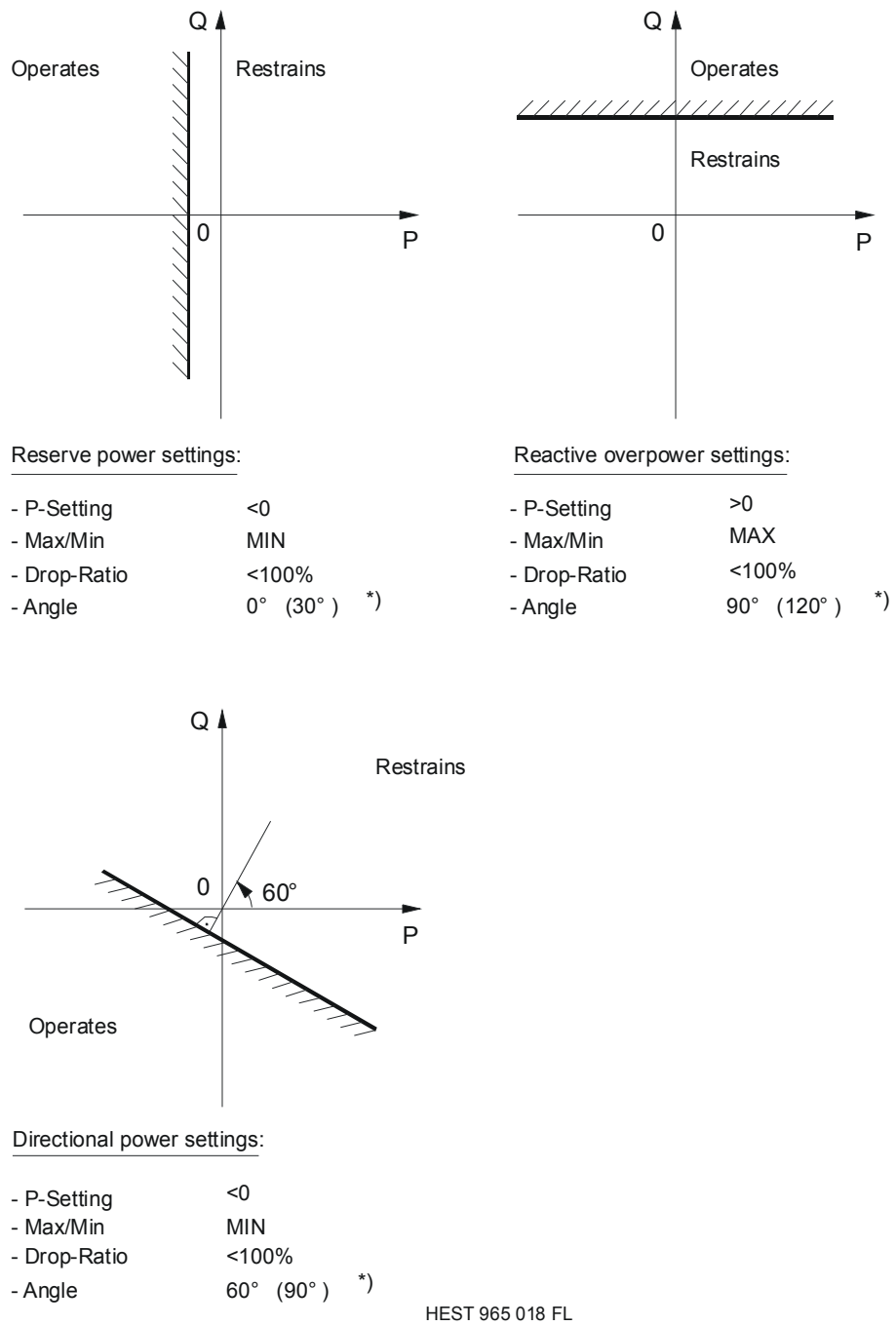


Fig. 3.5.15.2 Power function settings for different applications

*) The values in brackets apply for a single-phase measurement with the v.t. connected phase-to-phase (e.g. I_R current and U_{RS} voltage) or for a three-phase measurement with delta connected v.t.'s.



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Fig. 3.5.15.3 Power function settings for different applications

*) The values in brackets apply for a single-phase measurement with the v.t. connected phase-to-phase (e.g. I_R current and U_{RS} voltage) or for a three-phase measurement with delta connected v.t.'s.

Determining the settings

Where the rated currents and possibly also rated voltages of c.t.'s, v.t.'s and the protected unit differ, it is of advantage to refer the setting to the rated power of the protected unit. This necessitates modifying the sensitivity using the setting for P_N .

Setting the reference power P_N :

$$\frac{P_N}{U_N \times I_N} = \frac{S_{GN}}{\sqrt{3} \times U_{N1} \times I_{N1}} \quad \begin{aligned} S_{GN} &= \sqrt{3} \times U_{GN} \times I_{GN} \\ P_{GN} &= S_{GN} \times \cos \varphi_{GN} \end{aligned}$$

where:

S_{GN} , P_{GN} , U_{GN} , I_{GN} , $\cos \varphi_{GN}$: ratings of the protected unit

U_{N1} , I_{N1} : primary v.t. and c.t. ratings

P_N , U_N , I_N : protection ratings.

Example 1

Generator: 96 MVA, 13,8 kV, 4 kA, $\cos \varphi = 0,8$

V.t's/c.t's: $\frac{14.4}{\sqrt{3}} \text{ kV} / \frac{100}{\sqrt{3}} \text{ V}; \quad 5 \text{ kA} / 5 \text{ A}$

Protection: 100 V; 5 A

Reverse power: 0.5 % P_{GN}

Alternative 1: No modification of P_N

Settings:

Reference power $\frac{P_N}{U_N \times I_N} = 1.0$

Reverse power:

$$\frac{P}{P_N} = 0.005 \frac{U_{GN} \times I_{GN}}{U_{N1} \times I_{N1}} \cos \varphi_{GN} = 0.005 \frac{13.8 \times 4}{14.4 \times 5} 0.8 = 0.003$$

Alternative 2: Modification for $\cos\varphi_{GN}$

Settings:

$$\text{Reference power} \quad \frac{P_N}{U_N \times I_N} = \frac{P_{GN}}{S_{GN}} = \cos\varphi_{GN} = 0.8$$

$$\text{Reverse power:} \quad \frac{P}{P_N} = 0.005 \frac{U_{GN} \times I_{GN}}{U_{N1} \times I_{N1}} = 0.005 \frac{13.8 \times 4}{14.4 \times 5} = 0.004$$

Alternative 3: Modification for φ_{GN} and c.t./v.t.. data

Settings:

Rated power

$$\frac{P_N}{U_N I_N} = \frac{U_{GN} \times I_{GN}}{U_{N1} \times I_{N1}} \cos\varphi_{GN} = \frac{13.8 \times 4}{14.4 \times 5} \times 0.8 = 0.614$$

$$\text{Reverse power} \quad \frac{P}{P_N} = 0.005$$

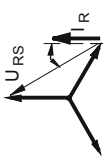
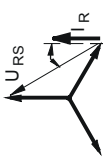
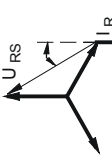
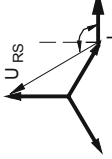
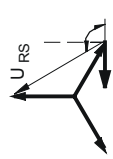
Characteristic angle

The power function is connected to the phase currents and a phase-to-neutral or phase-to-phase voltage. The purpose of the phase compensation is twofold:

- to compensate the phase difference between the phase voltage and the any measured phase-to-phase voltage
- to determine whether the function responds to active or reactive power.

The following table summarises the most important operating modes to simplify setting the corresponding parameters correctly. The angles given apply for connection according to the connections in [Index 12](#).

The phase compensation also provides facility for changing the direction of measurement or to compensate incorrect v.t. or c.t. polarity.

Function	"MaxMin"	"Drop-Ratio"			"P-Setting"	"Angle" *)
Active power	max	MAX < 100%			>0	+30°
	min	MIN > 100%				
Reverse power	max	MIN < 100%			<0	+30°
	min	MAX > 100%				
Inductive reactive power	max	MAX < 100%			>0	+120°
	min	MIN > 100%				
Capacitive reactive power	max	MIN < 100%			<0	+120°
	min	MAX > 100%				

*) Applicable for a single or three-phase measurement using phase-to-phase voltages (the setting is 30° less for a three-phase measurement with Y connected v.t's or a two-phase measurement with V connected v.t's).

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Fig. 3.5.15.4 Settings different applications when measuring phase R current in relation to the phase-to-phase voltage U_{RS}

Phase compensation

This setting is for correcting the phase error between the v.t.'s and c.t.'s, which have a considerable adverse influence on the measurement of active power at low power factors.

Example 2

The active power error at rated current and a power factor of $\cos\varphi = 0$ for a total phase error δ of 10' is

$$\Delta P = 0.03 \times \delta = 0.03 \times 10 = 0.3\% \quad [\%; 1; \text{min}]$$

This is an error which is not negligible at a setting of 0.5%.

The total error corresponds to the difference between the v.t. and c.t. errors. The case considered in this example of full reactive current (100%) would scarcely occur in practice, but currents from about 80% are possible.

Application as reverse power protection

The reverse power function is used primarily to protect the prime mover. It is necessary for the following kinds of prime mover:

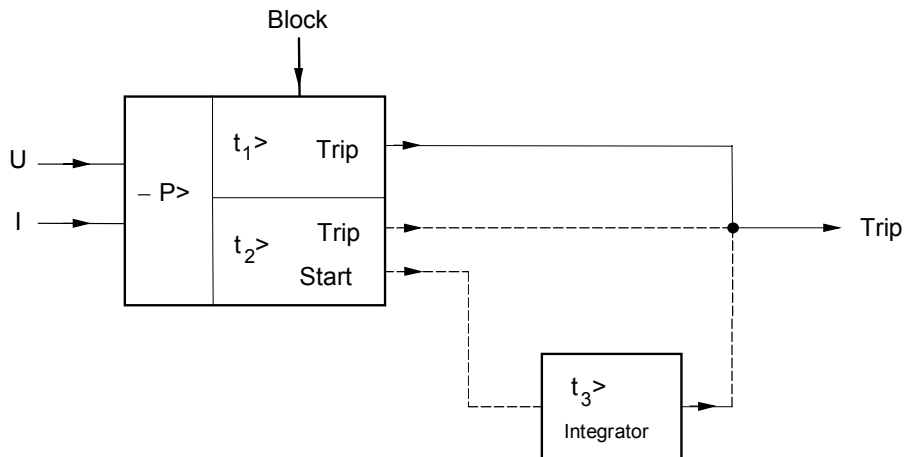
- steam turbines
- Francis and Kaplan hydro units
- gas turbines
- diesel motors.

Two reverse power functions are used for prime movers with ratings higher than 30 MW, because of their importance and value.

The reverse power function has two stages. The setting is half the slip power of the generator/prime mover unit and is the same for both stages.

The first stage has a short time delay and is intended to protect against overspeeding during the normal shutdown procedure. By tripping the main circuit-breaker via the reverse power function, the possibility of overspeeding due to a regulator failure or leaking steam valves is avoided. To prevent false tripping in the case of steam turbines, the reverse power function is enabled by auxiliary contacts on the main steam valves of the prime mover.

The purpose of the second stage is to guard against excessively high temperature and possible mechanical damage to the prime mover. The time delay can be longer in this case, because the temperature only increases slowly. Should power swings occur at low load due to the speed regulator or system instability, the second stage will not be able to trip, because the function repeatedly picks up and resets before the time delay can expire. It is for just such cases that the integrator (“Delay” function) is needed to ensure reliable tripping.



- t_1 fast stage interlocked with the main turbine steam valve
- t_2 slow stage
- t_3 slow stage with an integrator where power swings are to be expected

Fig. 3.5.15.5 Reverse power protection for steam turbines

Typical settings:

PN	determined by the generator $\cos\phi_{GN}$	
P-Setting	(steam turbines of medium power)	- 0.005
MaxMin		MIN
Drop-Ratio		60 %
Angle	connection to I_R and U_R	0°
	connection to I_R and U_{RS}	+30°
	connection to I_R and U_{ST}	-90°
	connection to I_R and U_{TR}	+150°
Phi-Comp		0.0
Stage 1:		
Delay		0.5 s
Stage 2:		
Delay		20 s
or		
Integrator ("Delay" function) for delay on operation and reset		
Trip time		20 s
Reset time		3 s
Integration		1

Note:

The following must be set for a "Minimum forward power" scheme according to Anglo-Saxon practice:

P-Setting	>0
MaxMin	MIN
Drop-Ratio	150%

3.5.16. Stator overload (OLoad-Stator)

A. Application

Overload protection for the stators of large generators.

B. Features

- delay inversely proportional to overload (see Fig. 3.5.16.1)
- operating characteristic according to ASA-C50.13 (American Standard Requirements for Cylindrical-Rotor Synchronous Generators) with extended setting range
- adjustable rate of counting backwards when the overload disappears (cooling rate of thermal image)
- insensitive to DC components
- insensitive to harmonics
- single or three-phase measurement
- detection of highest phase in the three-phase mode.

C. Inputs and outputs

I. Analogue inputs:

- current

II. Binary inputs:

- blocking

III. Binary outputs:

- pick-up
- tripping

IV. Measurements:

- current amplitude.

D. Overload function settings - OLoad-Stator

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
Trip		00000000			
k1-Setting	s	041.4	1.0	120.0	0.1
I-Start	IB	1.10	1.00	1.60	0.01
t-min	s	0010.0	1.0	120.0	0.1
tg	s	0120.0	10.0	2000.0	10.0
t-max	s	0300.0	100.0	2000.0	10.0
t-Reset	s	0120.0	10.0	2000.0	10.0
NrOfPhases		3	1	3	2
CurrentInp	AnalogAddr	0			
IB-Setting	IN	1.00	0.50	2.50	0.01
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr	ER			

Explanation of parameters:**ParSet 4..1**

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

defines the tripping channel activated by the tripping output of the function (tripping logic).

k1-Setting

Multiplier. Operating characteristic constant.

I-Start

Enabling current for operating characteristic.

t-min

Minimum operating time. Operating characteristic constant.

tg

Time during which the inverse characteristic is active. Operating characteristic constant.

This must not exceed the maximum delay time.

t-max

Maximum delay after being enabled regardless of inverse characteristic. Operating characteristic constant.

t-Reset

Time taken to reset (from the operating limit). This corresponds to the time taken by the generator to cool.

NrOfPhases

defines whether single or three-phase measurement.

CurrentInp

defines the analogue current input channel.

All current inputs may be selected.

In the case of three-phase measurement, the first channel of the group of three selected must be specified.

IB-Setting

Reference (base) current for compensating a difference in relation to I_N .

BlockInp

Binary address used as blocking input.

F: - Not blocked

T: - Blocked

xx: - all binary inputs (or outputs of a protection function).

Trip

Output for signalling tripping.

Start

Output for signalling pick-up.

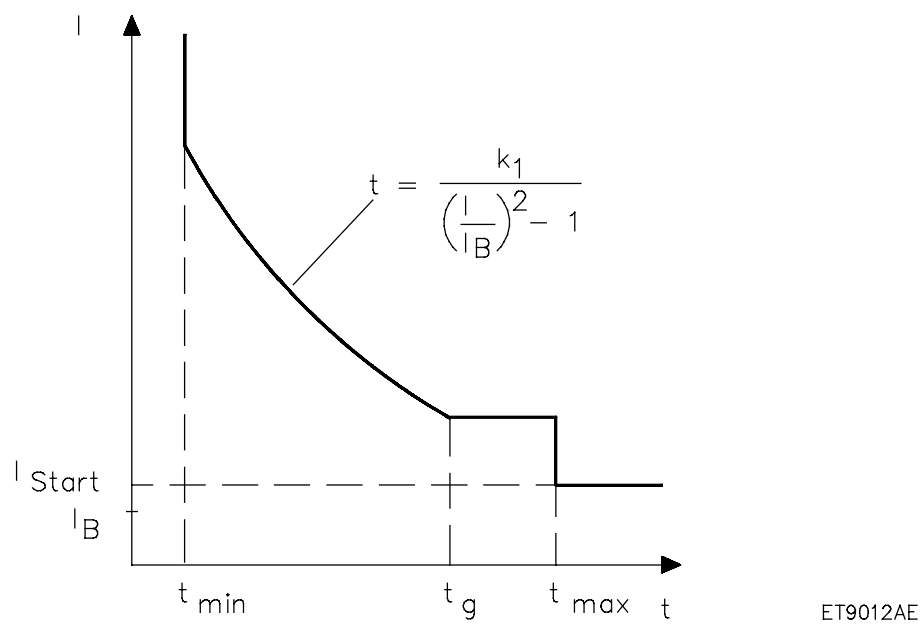


Fig. 3.5.16.1 Operating characteristic of the stator overload function

E. Setting instructions

Settings:

Reference current	IB-Setting
Enabling current	I-Start
Multiplier	k1-Setting
Minimum operating time	t-min
Time inverse characteristic effective	tg
Maximum delay	t-max
Resetting time	t-Reset

The stator overload function protects stator windings against excessive temperature rise as a result of overcurrents. The function is applicable to turbo-alternators designed according to the American standard ASA-C50.13 or a similar standard defining overload capability.

Providing compensation using the reference value of the A/D channel has not been made, the reference current IB for the protection is calculated from the generator load current I_{B1} , which is usually the same as the generator rated current, and the c.t. rated currents I_{N1} and I_{N2} as follows:

$$IB = I_{B1} \frac{I_{N2}}{I_{N1}}$$

The setting is the ratio IB/I_N , where I_N is the rated current of the protection, otherwise "IB-Setting" would be 1.0 I_N .

The multiplier k1 is 41.4 s for units designed according to ASA.

For units with a similar overload capacity:

$$k_1 = \tau \frac{\Delta \vartheta_m - \Delta \vartheta_n}{\Delta \vartheta_n} \quad [s; s; K]$$

where:

- τ : thermal time constant of the stator
- $\Delta \vartheta_m$: maximum permissible temperature rise of the stator winding
- $\Delta \vartheta_n$: rated temperature rise of the stator winding.

Example:

$$\tau = 5 \text{ min or } 300 \text{ s}$$

$$\Delta\vartheta_m = 70 \text{ K}$$

$$\Delta\vartheta_n = 60 \text{ K}$$

$$k1 = 300 \frac{70 - 60}{60} = 50 \text{ s}$$

Typical settings:

IB-Setting	according to protected unit
I-Start	1.1 IB
k1-Setting	41.4 s
t-min	10.0 s
t _g	120.0 s
t-max	300.0 s
t-Reset	120.0 s

3.5.17. Rotor overload (OLoad-Rotor)

A. Application

Overload protection for the rotors of large generators.

B. Features

- delay inversely proportional to overload ([see Fig. 3.5.17.1](#))
- operating characteristic according to ASA-C50.13 (American Standard Requirements for Cylindrical-Rotor Synchronous Generators) with extended setting range
- adjustable rate of counting backwards when the overload disappears (cooling rate of thermal image)
- three-phase measurement
- current measurement
 - three-phases of AC excitation supply
 - evaluation of the sum of the three phases (instantaneous values without digital filtering).

C. Inputs and outputs

I. Analogue inputs:

- current

II. Binary inputs:

- blocking

III. Binary outputs:

- pick-up
- tripping

IV. Measurements:

- current amplitude.

D. Overload function settings - OLoad-Rotor

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
Trip		00000000			
k1-Setting	s	033.8	1.0	50.0	0.1
I-Start	IB	1.10	1.00	1.60	0.01
t-min	s	0010.0	1.0	120.0	0.1
tg	s	0120.0	10.0	2000.0	10.0
t-max	s	0300.0	100.0	2000.0	10.0
t-Reset	s	0120.0	10.0	2000.0	10.0
CurrentInp	AnalogAddr	0			
IB-Setting	IN	1.00	0.50	2.50	0.01
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr	ER			

Explanation of parameters:**ParSet 4..1**

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

defines the tripping channel activated by the tripping output of the function (tripping logic).

k1-Setting

Multiplier. Operating characteristic constant.

I-Start

Enabling current for operating characteristic.

t-min

Minimum operating time. Operating characteristic constant.

tg

Time during which the inverse characteristic is active. Operating characteristic constant.

This must not exceed the maximum delay time.

t-max

Maximum delay after being enabled regardless of inverse characteristic. Operating characteristic constant.

t-Reset

Time taken to reset (from the operating limit). This corresponds to the time taken by the machine to cool.

CurrentInp

defines the analogue current input channel.

All current inputs may be selected.

In the case of three-phase measurement, the first channel of the group of three selected must be specified.

IB-Setting

Reference (base) current for compensating a difference in relation to I_N .

BlockInp

Binary address used as blocking input.

F: - Not blocked

T: - Blocked

xx: - all binary inputs (or outputs of a protection function).

Trip

Output for signalling tripping.

Start

Output for signalling pick-up.

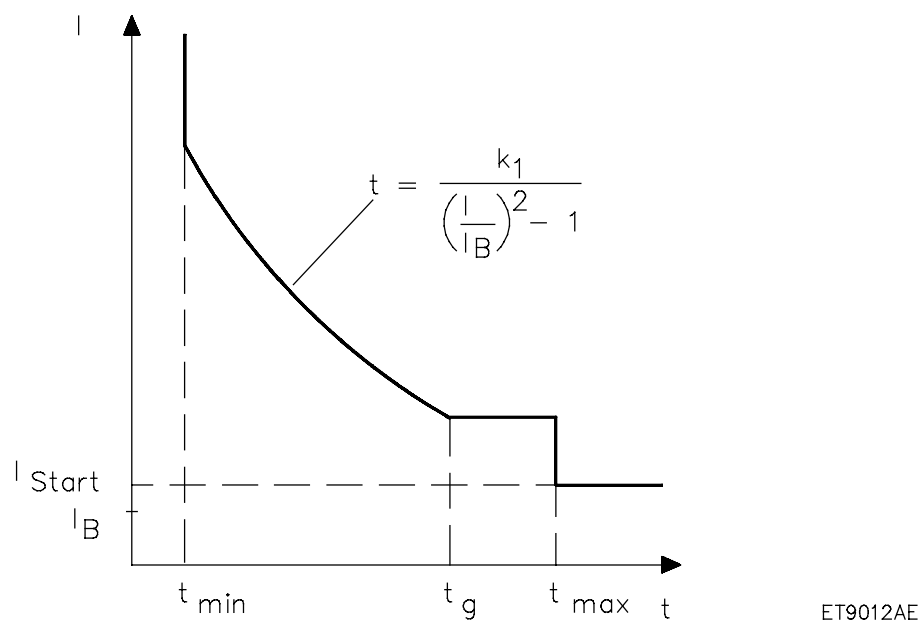


Fig. 3.5.17.1 Operating characteristic of the rotor overload function

E. Setting instructions

Settings:

Reference current	IB-Setting
Enabling current	I-Start
Multiplier	k1-Setting
Minimum operating time	t-min
Time inverse characteristic effective	tg
Maximum delay	t-max
Resetting time	t-Reset

The rotor overload function protects the rotor winding of generators against excessive temperature rise as a result of overcurrents. The function is applicable to turbo-alternators designed according to the American standard ASA-C50.13 or a similar standard defining overload capability. It is connected to c.t.'s in the AC excitation supply. It may not be used for brushless excitation systems.

Providing compensation using the reference value of the A/D channel has not been made, the reference current IB for the protection is calculated from the AC load current IB1 of the excitation supply which is usually the same as the full load excitation current and the c.t. rated currents IN1 and IN2 as follows:

$$IB = IB1 \frac{IN2}{IN1}$$

The setting is the ratio IB/IN, IN being the rated current of the protection.

The multiplier k1 is 33.8 s for units designed according to ASA. For units with a similar overload capacity:

$$k_1 = \tau \frac{\Delta\vartheta_m - \Delta\vartheta_n}{\Delta\vartheta_n} \quad [s; s; K]$$

where:

- τ : thermal time constant of the rotor
- $\Delta\vartheta_m$: maximum permissible temperature rise of the rotor winding
- $\Delta\vartheta_n$: rated temperature rise of the rotor winding.

Typical settings:

IB-Setting	according to protected unit
I-Start	1.1 IB
k1-Setting	33.8 s
t-min	10.0 s
t _g	120.0 s
t-max	300.0 s
t-Reset	120.0 s

3.5.18. *Frequency protection (Frequency)***A. Application**

- Under and overfrequency
- Load-shedding.

B. Features

- measurement of one voltage
- frequency calculation based on the complex voltage vector
- insensitive to DC component
- insensitive to harmonics
- undervoltage blocking.

C. Inputs and outputs**I. C.t./v.t. inputs:**

- voltage

II. Binary inputs:

- blocking

III. Binary outputs:

- undervoltage blocking
- start
- trip

IV. Measurements:

- frequency
- voltage.

D. Frequency function settings - Frequency

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
Trip		00000000			
Frequency	Hz	48.00	40.00	65.00	0.01
BlockVoltage	UN	0.20	0.20	0.80	0.10
Delay	s	01.00	0.10	60.00	0.01
MaxMin		MIN	(Select)		
VoltageInp	CT/VT-Addr	0			
Blocked (U<)	SignalAddr				
BlockingInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr				

Explanation of parameters:

ParSet 4..1

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

defines the tripping relay activated by the tripping output of the function (matrix).

Frequency

Operating value.

Setting restrictions:

- underfrequency not $\geq f_N$
- overfrequency not $\leq f_N$

BlockVoltage

Peak value of the voltage for blocking.

(reset ratio approx. 1.05)

Delay

Time between the function picking up and tripping.

MaxMin

defines operation as overfrequency or underfrequency.

Settings:

- MAX: Overfrequency.
- MIN: Underfrequency.

VoltageInp

defines the voltage input channel.
All voltage inputs may be selected.

Blocked (U<)

defines the output for signalling blocking by undervoltage.
(signal address)

BlockingInp

Binary address used as blocking input.

F: - not blocked

T: - blocked

xx: - all binary inputs (or outputs of protection functions).

Trip

Output for signalling tripping.

Start

Output for signalling pick-up.

E. Setting instructions

There are often several stages of frequency protection using several single-stage relays.

Settings:

Frequency	Frequency
Delay	Delay
Undervoltage blocking	BlockVoltage
Under or over frequency	MaxMin

Frequency protection is used either to protect synchronous machines and prime-movers against the effects of operating at under or overfrequency or for load-shedding in the event of an overload.

The adverse effects in the former case prevented by the frequency protection are:

- excessive temperature rise and additional iron losses in the generator
- damage to the generator and the prime-mover by vibration.

Some synchronous machines are subject to severe vibration if they are operated at speeds other than their rated speed.

Vibration occurs more usual at speeds below rated frequency, but can occur both above and below. A complete scheme often comprises therefore 4 stages, two for alarm and tripping for overfrequency and two for alarm and tripping for underfrequency. Tripping is delayed to avoid the risk of maloperation during transients.

Typical settings:

1. Protection of machines

	1st. stage	2nd. stage	3rd. stage	4th. stage
	Alarm	Tripping	Alarm	Tripping
Frequency (Hz)	51.0	52.0	49.0	48.0
Delay (s)	1.5	3	1.5	3
BlockVoltage	0.6	0.6	0.6	0.6
MaxMin	MAX	MAX	MIN	MIN

Table 3.5.18.1 Typical settings for alarm and tripping stages

2. Load-shedding

	1st. stage	2nd. stage	3rd. stage	4th. stage	5th. stage
	Alarm	Load-shed.	Alarm	Load-shed.	Load-shed.
Frequency (Hz)	49.8	49.0	48.7	48.8	47.5
Delay (s)	0.5	0.0	0.0	0.0	0.0
BlockVoltage	0.6	0.6	0.6	0.6	0.6
MaxMin	MIN	MIN	MIN	MIN	MIN

Table 3.5.18.2 Typical settings for alarm and tripping stages

3.5.19. Rate-of-change of frequency protection (df/dt)**A. Application**

- Static, dynamic and adaptive load shedding in power utility and industrial distribution systems
- Generator protection.

B. Features

- one phase voltage as input variable
- supervises the rate-of-change df/dt of the frequency
- provision for enabling by absolute frequency
- insensitive to DC component
- insensitive to harmonics and other high-frequency signals
- undervoltage blocking.

C. Inputs and outputs**I. C.t./v.t. inputs**

- voltage

II. Binary inputs

- blocking

III. Binary outputs

- blocked by undervoltage
- tripping

IV. Measurements

- rate-of-change of frequency
- absolute frequency
- voltage amplitude.

D. Rate-of-change frequency settings – df/dt

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
ParSet4..1		P1	Select		
Trip		00000000			
df/dt	Hz/s	-1.0	-10.0	+10.0	0.1
Frequency	Hz	48.00	00.00	65.00	0.01
BlockVoltage	UN	0.2	0.2	0.8	0.1
Delay	s	00.10	00.10	60.00	0.01
VoltageInp	CT/VT-Addr.	0			
Blocked (U<)	SignalAddr				
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			

Explanation of parameters:

ParSet 4..1

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

defines the tripping channel activated by the tripping O/P of the function (matrix tripping logic).

df/dt

Rate-of-change of frequency pick-up setting.

Inadmissible settings:

- $df/dt = 0$
- $df/dt > 0$ for absolute frequency settings $< f_N$
- $df/dt < 0$ for absolute frequency settings $> f_N$.

Frequency

Setting of the absolute frequency enabling criterion.

Operation for overfrequency or underfrequency is determined by the absolute frequency setting:

- Underfrequency for frequency settings $< f_N$
- Overfrequency for frequency settings $> f_N$

The absolute frequency criterion is disabled for a setting of 'Frequency' = 0. In this case, tripping is dependent solely on the rate-of-change setting df/dt .

Inadmissible settings:

- Frequency = f_N
- Frequency $< f_N - 10$ Hz
- Frequency $> f_N + 5$ Hz.

BlockVoltage

Pick-up setting for undervoltage blocking (reset ratio approx. 1.05, reset time approx. 0.1 s).

Delay

Delay from the instant the function picks up to the generation of a tripping command.

VoltageInp

defines the voltage input channel. All voltage inputs may be selected with the exception of the special voltage inputs for the 100% ground stator fault protection.

Blocked (U<)

signals when the function is blocked by the undervoltage criterion.

BlockInp

defines the input for an external blocking signal.

F: - enabled

T: - disabled

xx: - all binary inputs (or outputs of protection functions).

Trip

Output for signalling tripping.

E. Setting instructions

Several rate-of-change of frequency stages are often needed and the additional stages are achieved by configuring the function as many times as is necessary.

Settings:

Rate-of-change of frequency	df/dt
Absolute frequency	Frequency
Undervoltage	BlockVoltage
Delay	Delay

The rate-of-change of frequency function only trips when the rate-of-change is higher than setting, the absolute frequency criterion picks up and the voltage is not lower than the undervoltage setting.

The additional absolute frequency criterion prevents unwanted operation of the rate-of-change function during power system transients. Where it is desired that the rate-of-change function should operate without regard to the absolute frequency, this is achieved by setting the absolute frequency criterion to '0'.

3.5.20. *Overfluxing (Overexcitat)***A. Application**

Protection of generators and power transformers against excessive flux.

B. Features

- evaluation of the voltage/frequency ratio
- single-phase measurement
- definite time delay
- determination of frequency from the complex voltage vector
- insensitive to DC components
- insensitive to harmonics
- over or underexcitation mode.

C. Inputs and outputs**I. C.t./v.t. inputs:**

- voltage

II. Binary inputs:

- blocking

III. Binary outputs:

- pick-up
- tripping

IV. Measurements:

- voltage/frequency
- frequency.

D. Overfluxing function settings - Overexcitat

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
Trip		00000000			
Delay	s	01.00	0.10	60.00	0.01
VoltageInp	CT/VT-Addr	0			
V/f-Setting	UN/fN	01.20	0.20	2.00	0.01
MaxMin		MAX	(Select)		
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr				

Explanation of parameters:

ParSet 4..1

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

defines the tripping channel activated by the tripping output of the function (tripping logic).

Delay

time delay between pick-up and tripping.

VoltageInp

defines the v.t. input channel.

All voltage inputs may be selected.

V/f-Setting

Setting of the voltage/frequency ratio for tripping.

MaxMin

defines operation as overfluxing or underfluxing. Settings:

MAX: overfluxing

MIN: underfluxing.

BlockInp

Binary address used as blocking input.

F: - Not blocked

T: - Blocked

xx: - all binary inputs (or outputs of a protection function).

Trip

Output for signalling tripping.

Start

Output for signalling pick-up.

E. Setting instructions

Settings :

Magnetic flux	V/f-Setting
Delay	Delay
Over/underfluxing	MaxMin

The overfluxing function is primarily intended to protect the iron cores of power transformers. Tripping by the function is delayed to avoid false operation during system transients such as load shedding.

The magnetic flux is not measured directly. Instead the voltage/frequency ratio which is proportional to the flux and easier to measure is monitored.

Overfluxing can result from either an increase of system voltage or a reduction of system frequency.

For example, 10 % overfluxing at constant frequency is equivalent to increasing the value of the U/f ratio to $1.1 U_N/f_N$.

Typical settings:

V/f-Setting	$1.1 U_N/f_N$
Delay	5 s
MaxMin	MAX

3.5.21. *Inverse time overfluxing (U/f-Inv)*

A. Application

Protection of generators and power transformers against excessive flux, especially in heavily loaded non-laminated metal parts, and the associated excessive heating of the unit.

B. Features

- evaluation of the voltage/frequency ratio
- single-phase measurement
- inverse time delay according to U/f ratio
- determination of frequency from the complex voltage vector
- insensitive to DC components
- insensitive to harmonics
- delay determined by integrating function response
- input of delay table facilitates matching the operating characteristic to a specific machine according to IEEE Guideline C 37.91-1985.
- adjustable rate of counting backwards when the overfluxing disappears.

C. Inputs and outputs

I. C.t./v.t. inputs:

- voltage

II. Binary inputs:

- blocking

III. Binary outputs:

- pick-up
- tripping

IV. Measurements:

- voltage/frequency
- frequency.

D. Inverse time overfluxing function settings - U/f-Inv

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
Trip		00000000			
VoltageInp	CT/VT-Addr	0			
V/f-Setting	UB/fN	01.10	1.05	1.20	0.01
VB-Setting	UN	01.00	0.80	1.20	0.01
t-min	min	0.20	0.01	2.00	0.01
t-max	min	60.0	5.0	100	0.1
t [V/f=1.05]	min	70.0	0.01	100	0.01
t [V/f=1.10]	min	70.0	0.01	100	0.01
t [V/f=1.15]	min	06.0	0.01	100	0.01
t [V/f=1.20]	min	01.00	0.01	100	0.01
t [V/f=1.25]	min	00.480	0.01	30	0.001
t [V/f=1.30]	min	00.300	0.01	30	0.001
t [V/f=1.35]	min	00.220	0.01	30	0.001
t [V/f=1.40]	min	00.170	0.01	30	0.001
t [V/f=1.45]	min	00.140	0.01	30	0.001
t [V/f=1.50]	min	00.140	0.01	30	0.001
t-Reset	min	60.0	0.02	100	0.1
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr				

Explanation of parameters:**ParSet 4..1**

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

defines the tripping channel activated by the tripping output of the function (matrix).

VoltageInp

defines the v.t. input channel.

All voltage inputs may be selected.

V/f-Setting

Voltage/frequency ratio setting referred to U_B / f_N .

VB-Setting

Reference (base) voltage for compensating a difference between the v.t. rating and the rating of the generator or transformer.

t-min

Minimum operating time after being enabled regardless of inverse characteristic. Operating characteristic constant.

t-max

Maximum operating time after being enabled regardless of inverse characteristic. Operating characteristic constant.

t [V/f = 1.05] ... t [V/f = 1.50]

Table of 10 values (data input) for defining a specific inverse operating characteristic.

t-Reset

Time taken to reset (from the operating point). This corresponds to the time taken by the generator to cool.

BlockInp

Binary address used as blocking input.

F: - Not blocked

T: - Blocked

xx: - all binary inputs (or outputs of a protection function).

Trip

Output for signalling tripping.

Start

Output for signalling pick-up.

E. Setting instructions

Settings :

Magnetic flux for enabling char.	V/f-Setting
Reference value	VB-Setting
Minimum operating time	t-min
Maximum operating time	t-max
10 values defining the inverse time operating characteristic	t [V/f = 1.05] ... t [V/f = 1.50]
Reset time	t-Reset

The overfluxing function protects the iron cores of generators and power transformers against excessive flux.

The magnetic flux is not measured directly. Instead the voltage/frequency ratio which is proportional to the flux and easier to measure is monitored.

Overfluxing can result from either an increase of system voltage or a reduction of system frequency.

For example, 10 % overfluxing at constant frequency is equivalent to increasing the value of the V/f ratio to $1.1 \text{ VB} / f_N$.

The limit curve for the maximum magnetic flux (V/f) permissible for electrical machines is defined in

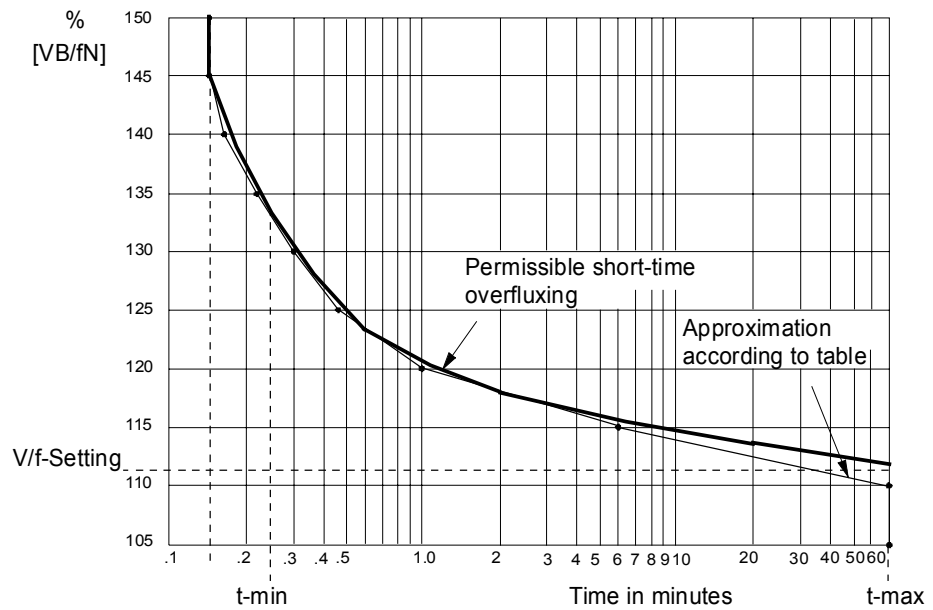
- standards
- data supplied by manufacturers.

Providing compensation using the reference value of the A/D channel has not been made, the reference voltage VB for the protection is calculated from transformer rated voltage U_{TN} and the v.t. rated voltages U_{N1} and U_{N2} as follows:

$$VB = U_{TN} \frac{U_{N2}}{U_{N1}}$$

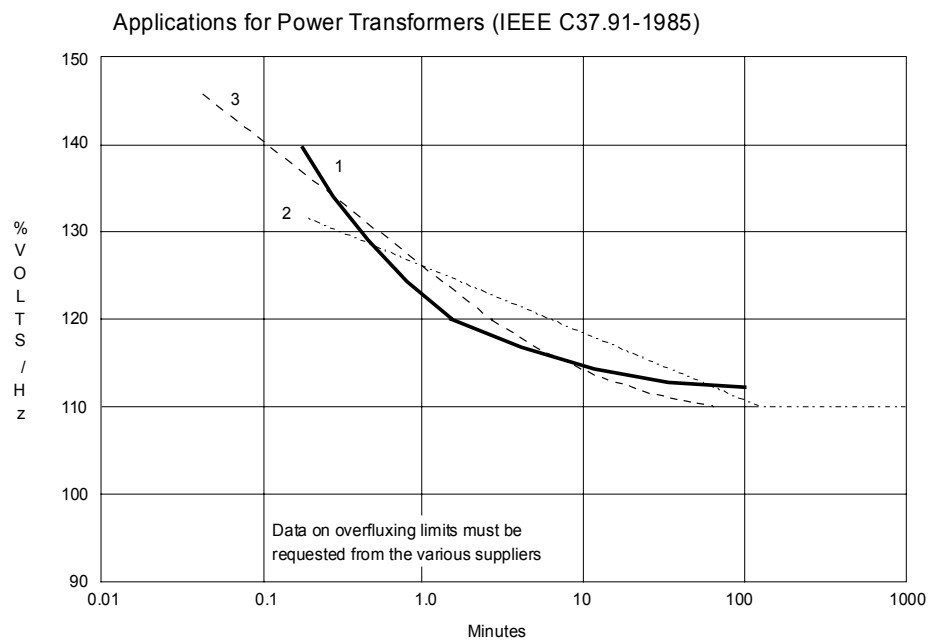
The setting is the ratio VB/UN, where UN is the rated voltage of the protection, otherwise "VB-Setting" would be 1.0 UN.

The overfluxing curve of the generator must be known in order to set the times t-min and t-max and enter the table of 10 values t [V/f = 1.05] ... t [V/f = 1.50].



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Fig. 3.5.21.1 Example of an overfluxing curve



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Fig. 3.5.21.2 Transformer overfluxing limits of three manufacturers

Typical settings:

V/f-Setting	1.1 VB/f _N
VB-Setting	according to protected unit
t-min	0.2 min
t-max	60 min
t [V/f = 1.05...1.50]	according to protected unit ¹⁾
t-Reset	according to protected unit

¹⁾ Refer to [Fig. 3.5.21.1](#) for typical settings for a Westinghouse unit.

3.5.22. **Balanced voltage (Voltage-Bal)**

A. Application

Monitoring/comparison of two groups of single or three-phase voltage inputs to detect voltage measurement errors.

B. Features

- comparison of the amplitudes of two groups of voltage inputs (e.g. line 1 and line 2)
- single or three-phase voltage measurement
- indication of group with the lower voltage
- evaluation of voltage balance per phase in the three-phase mode with selection by OR gate for tripping
- adjustable delays for operation and reset
- insensitive to DC components
- insensitive to harmonics.

C. Inputs and outputs

I. Analogue inputs:

- voltage (2 sets of 1 or 3 inputs)

II. Binary inputs:

- blocking

III. Binary outputs:

- pick-up
- tripping
- line 1 trip (voltage input U_1)
- line 2 trip (voltage input U_2)

IV. Measurements:

Single-phase mode

- difference between voltage amplitudes ($U_1 - U_2$)

Three-phase mode

- voltage amplitude difference for R phase ($U_{1R} - U_{2R}$)
- voltage amplitude difference for S phase ($U_{1S} - U_{2S}$)
- voltage amplitude difference for T phase ($U_{1T} - U_{2T}$).

D. Balanced voltage function settings - Voltage-Bal

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
ParSet 4..1		P1	(selectable)		
Trip		00000000			
V-Unbalance	UN	0.20	0.10	0.50	0.05
Delay	s	0.04	0.00	1.00	0.01
t-Reset	s	1.50	0.10	2.00	0.01
NrOfPhases	s	003	1	3	2
VoltInpLine1	AnalogAddr	00000			
VoltInpLine2	AnalogAddr	00000			
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr	ER			
Trip-Line1	SignalAddr				
Trip-Line2	SignalAddr				

Explanation of parameters:**ParSet 4..1**

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

defines the tripping channel activated by the tripping output of the function (tripping logic).

V-Unbalance

Voltage difference setting for tripping.

Difference between the amplitudes of the two voltage input channels which results in tripping. The setting applies to all three phases in the three-phase mode.

Delay

time delay between pick-up and tripping.

t-Reset

Time required for the measurement to reset after the tripping condition has disappeared (reset ratio: 0.90).

NrOfPhases

defines whether single or three-phase measurement.

VoltInpLine1

defines the 1st. analogue voltage input channel U_1 (line 1).
In the case of three-phase measurement, the first channel (R phase) of the group of three selected must be specified.

VoltInpLine2

defines the 2nd. analogue voltage input channel U_2 (line 2).
In the case of three-phase measurement, the first channel (R phase) of the group of three selected must be specified.

BlockInp

Binary address used as blocking input.

F: - Not blocked

T: - Blocked

xx: - all binary inputs (or outputs of a protection function).

Trip

Output for signalling tripping.

Start

Output for signalling pick-up.

Trip-Line1

Same as Trip, but only if the amplitude of the voltage at input U_1 is less than that at input U_2 (determination of the voltage difference per phase in the three-phase mode).

Trip-Line2

Same as Trip, but only if the amplitude of the voltage at input U_2 is less than that at input U_1 (determination of the voltage difference per phase in the three-phase mode).

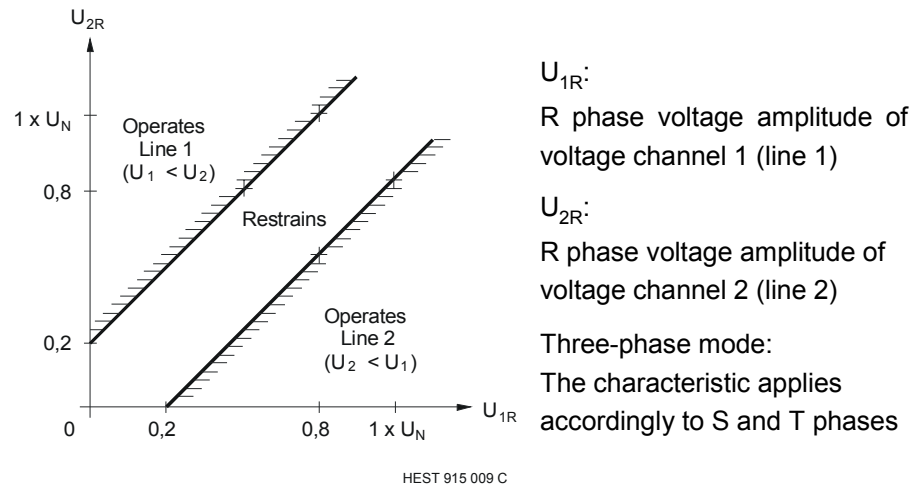


Fig. 3.5.22.1 Operating characteristic of the balanced voltage function (show for R phase and the setting V-Unbalance = $0.2 \times U_N$)

E. Setting instructions

Settings:

Max. voltage difference	V-Unbalance
Delay	Delay
Reset delay	t-Reset

The balanced voltage function is intended mainly for detecting voltage measurement errors by other devices.

It compares the voltages (amplitudes) of two generally identical voltage sources connected to the same busbar phase-by-phase.

The function picks up when the difference between voltages of the same phase exceeds a set pick-up value (V-Unbalance).

A tripping signal is emitted for the source with the lower voltage (Trip-Line1 or Trip-Line2) and a general tripping signal (Trip) generated after a set time delay (Delay), providing the tripping condition remains fulfilled throughout the delay time. These signals are available for blocking protection and instrumentation connected to the faulty source and thus prevent false tripping or measurements.

The tripping signals are maintained for the setting of the reset time (t-Reset) after the tripping condition is no longer fulfilled.

The function is thus suitable for detecting v.t. circuit faults (fuse failure) and faults on the protection and metering circuits connected to them.

Notes:

- Only the voltages of similar sources that have coincident amplitudes and phase-angles and are connected to the same busbar should be compared.

Wherever possible the voltages should also be processed by neighbouring sampling devices and the same analogue input unit. The purpose of this is to limit signal conditioning errors should the power system frequency deviate from the rated frequency f_N and during transients. To prevent false tripping during extreme variations of frequency, either the pick-up setting can be increased or the balanced voltage function can be blocked by a frequency function.

- Differing primary rated voltages of the v.t.'s can be compensated by appropriately setting the reference values of the corresponding A/D channels. The adjusted reference values then apply for all the protection functions connected to the same channels.

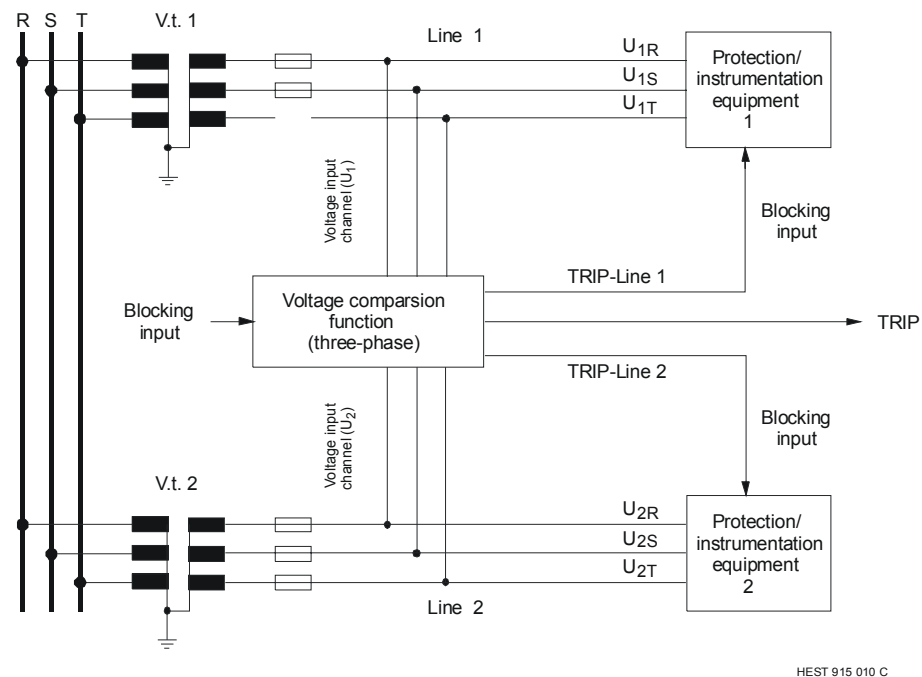
Application example:

Fig. 3.5.22.2 Three-phase balanced voltage scheme (one measured voltage failed)

The protection monitors the voltages of the two v.t.'s 1 and 2:

In the event of a fault (in this example an open-circuit lead in the circuit of v.t. 1), the protection function detects an unbalance and after the set delay time generates the tripping signals 'Trip' and 'Trip-Line1'.

These then initiate blocking of the metering and protection devices (such as underimpedance, voltage-controlled overcurrent and distance protections etc.) connected to v.t. 1.

Typical settings:

Max. voltage difference (V-Unbalance)	0.20 U_N
Delay	0.04 s
Reset time (t-Reset)	0.50 s

3.5.23. *Overtemperature protection (Overtemp.)***A. Application**

Overtemperature protection with accurate thermal image of the protected unit.

B. Features

- 1st. order thermal model
- alarm and tripping stages
- adjustable initial temperature
- DC component filter
- harmonic filter
- single or three-phase current measurement
- maximum value detection for three-phase measurement
- temperature rise calculated 40 times for each thermal time constant setting.

C. Inputs and outputs**I. C.t./v.t. inputs**

- Current

II. Binary inputs

- Blocking

III. Binary outputs

- Alarm
- Tripping

IV. Measurements

- Temperature rise
- Power dissipation
- Current.

D. Overtemperature protection settings - Overtemp.

Summary of parameters:

Text	Units	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
Trip		00000000			
Theta-Begin	%	100	000	100	001
Theta-Warn	%	105	050	200	001
Theta-Trip	%	110	050	200	001
NrOfPhases		1	1	3	2
CurrentInp	CT/VT-Addr	0			
IB-Setting	IN	1.00	0.50	2.50	0.01
BlockInp	BinaryAddr	F			
Warning	SignalAddr	ER			
Trip	SignalAddr	ER			
TimeConstant	min	005.0	002.0	500.0	000.1

Explanation of parameters:**ParSet 4..1**

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

Tripping logic (matrix) for this function.

Theta-Begin

Initial temperature rise. This temperature rise is set every time the function is initiated, e.g. when the protection is switched on or settings are changed.

Theta-Warn

Temperature rise at which alarm is given.

Theta-Trip

Temperature rise at which tripping takes place.

NrOfPhases

No. of phase currents measured.

CurrentInp

defines c.t. input channel.

All the current channels are available for selection. In the case of a three-phase measurement, the first channel (R phase) of the group of three must be selected.

IB-Setting

Reference current: Normal operating current of the protected unit referred to the rated current of the protection.

BlockInp

I/P for blocking the function

F: - not blocked

T: - blocked

xx: - all binary I/P's (or O/P's of protection functions).

Warning

Alarm signal.

Trip

Tripping signal.

TimeConstant

Thermal time constant for calculating the temperature rise.

Settings < 2 minutes are not permitted.

E. Setting instructions

Settings:

Initial temperature rise	Theta-Begin
Temperature rise for alarm	Theta-Warn
Temperature rise for tripping	Theta-Trip
No. of phase currents measured	NrOfPhases
Reference current	IB-Setting
Thermal time constant	TimeConstant

The overtemperature function guards against inadmissible temperature rise caused by overcurrents. The temperature rise is modelled on the basis of the influence of the current flowing through the protected unit on a thermal image of the protected unit. In contrast to the overload protection, this function can protect units of any power rating and thermal capacity. It monitors the temperature rise and not the absolute temperature. It takes account therefore neither of the ambient temperature nor the effectiveness of a cooling system.

The protection operates with a thermal image of the temperature rise. A current change causes the temperature of the protected unit to rise from an initial value to a final value according to one or several exponential functions. The various influences on the temperature rise are the thermal response of, for example in the case of a power transformer, the cooling water, the oil, the windings etc. One exponential function such as that of the transformer oil is always more dominant than the others. The thermal image used in the protection for modelling the transient temperature rise operates according to an exponential function.

The excursion of the temperature rise modelled by the protection is determined by the following:

- the final steady-state temperature corresponding to the current
- the increased temperature rise due to the transfer functions.

The protection assumes that at the rated current I_{GN} of the protected unit, the temperature rise represents 100 %. Neglecting any compensation of the A/D channel or the base current I_B , the protection measures a current I_R determined by the rated current of the c.t's:

$$I_R = I_{GN} \frac{I_{N2}}{I_{N1}}$$

where

I_{GN} : rated current of the protected unit
 I_{N1}, I_{N2} : rated primary and secondary c.t. currents.

The current referred to the rated current I_N of the protection is:

$$i_R = \frac{I_R}{I_N} = \frac{I_{GN}}{I_N} \times \frac{I_{N2}}{I_{N1}}$$

The steady-state temperature rise becomes:

$$\Delta \vartheta_W = \left(\frac{I_{GN}}{I_N} \times \frac{I_{N2}}{I_{N1}} \right)^2 \times 100\%$$

At a constant current, the tripping time is:

$$t = \tau \ln \left(\frac{\vartheta_0 [\%] - 100 \times \left(\frac{I}{I_B} \right)^2}{\vartheta [\%] - 100 \times \left(\frac{I}{I_B} \right)^2} \right)$$

where

ϑ_0 : initial temperature rise
 ϑ : pick-up temperature rise
 τ : thermal time constant.

The variables in the submenu 'DISPLAY OPERATING VALUES' are the calculated temperature rise, the power dissipation and the current. The first two are mean values over the period of calculation ($= \tau / 40$).

The values shown in the event list is the power dissipation at the instant of tripping.

Example:

Rated current of the protected unit	$I_{GN} = 8000 \text{ A}$
C.t. ratings	$I_{N1} = 10000 \text{ A}$
	$I_{N2} = 5 \text{ A}$
Rated relay current	$I_N = 5 \text{ A}$

The temperature rise measured by the protection at a rated current of I_{GN} is:

$$\Delta\vartheta_W = \left(\frac{8000}{5} \times \frac{5}{10000} \right)^2 \times 100\% = 64\%$$

The settings for overtemperatures of 5% and 10% respectively are:

$$\text{Theta-Warn} = 67\%$$

$$\text{Theta-Trip} = 70\%$$

Normally the protection is configured such that the initial temperature rise is 100 % ('Theta-Begin' = 100 %).

With I_B adjusted, the settings become:

$$\text{Base current: } \frac{I_B}{I_N} = \frac{I_{GN}}{I_N} \times \frac{I_{N2}}{I_{N1}} = \frac{8000}{5} \times \frac{5}{10000} = 0.8$$

The settings for alarm and tripping are then:

$$\text{Theta-Warn} = 105\%$$

$$\text{Theta-Trip} = 110\%$$

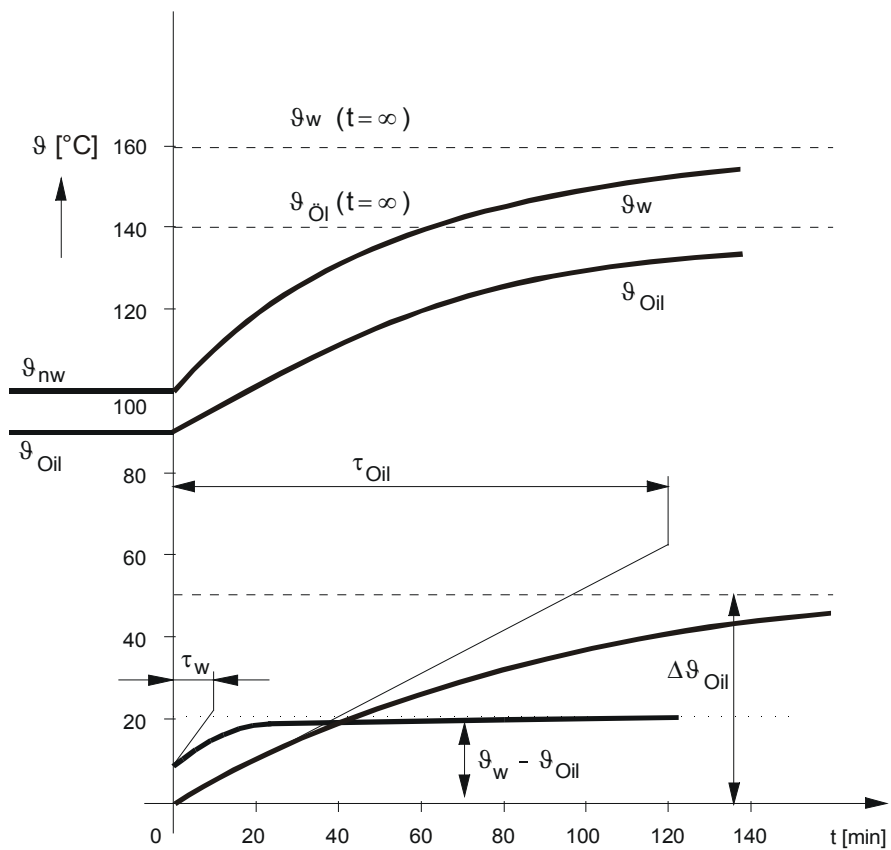
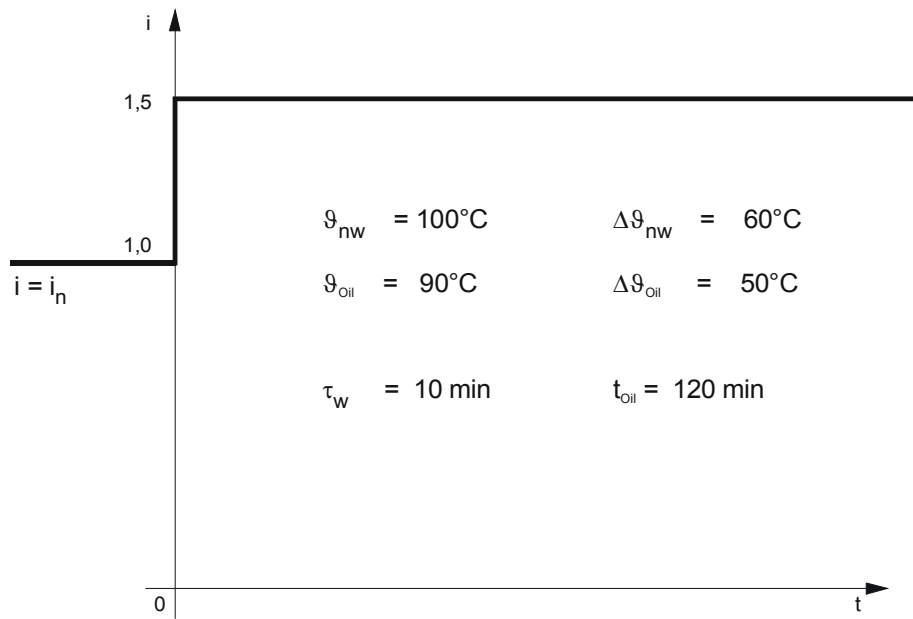
Transformers have two distinct exponential functions, one for the oil and one for the winding. The corresponding mean values are:

$$\text{Oil} \quad : \Delta\vartheta_{oil} = 50 \text{ K} \quad \tau_{oil} = 120 \text{ min}$$

$$\text{Winding} \quad : \Delta\vartheta_W - \Delta\vartheta_{oil} = 10 \text{ K} \quad \tau_W = 10 \text{ min}$$

The total temperature rise of the winding is thus $\Delta\vartheta_W = 60 \text{ K}$.

Since however the model operates with just a single exponential function, its temperature rise has to follow the best possible equivalent exponential function as shown in [Fig. 3.5.23.1](#). The steady-state temperature rise of this equivalent function is identical to the total temperature rise of the winding, i.e. $\Delta\vartheta_W = 60 \text{ K}$ in the example above. Its time constant, however, is typically 60 to 80% of the temperature rise of the oil (see [Fig. 3.5.23.2](#)).



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Fig. 3.5.23.1 Temperature rise of a transformer winding

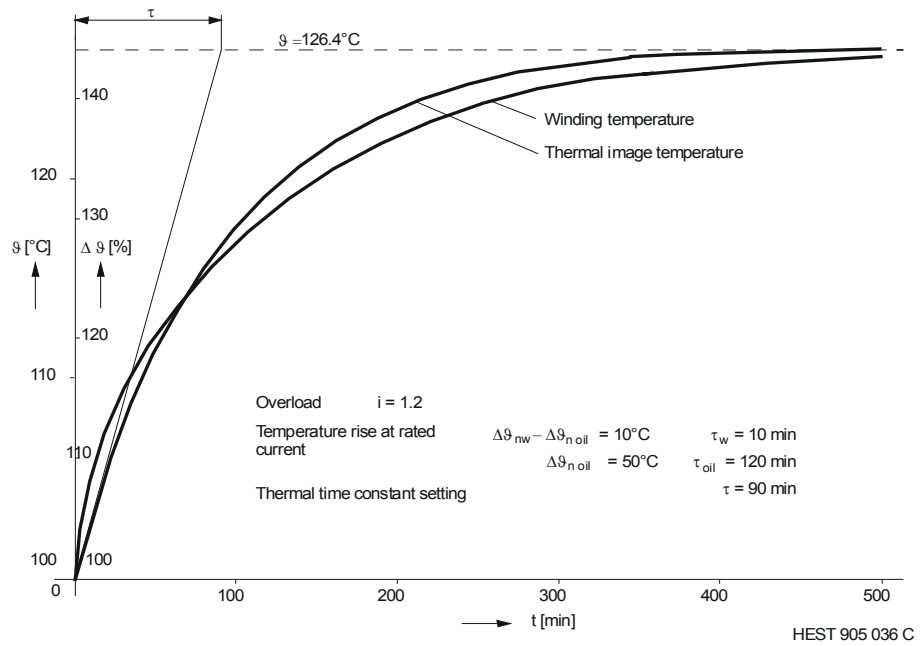


Fig. 3.5.23.2 Actual temperature rise of the winding compared to the temperature rise of the thermal image

Typical settings:

IB-Setting	to be calculated
Theta-Beginn	100%
Theta-Warn	105%
Theta-Trip	110%

3.5.24. Stator ground fault (Stator-EFP)

A. Application

Ground fault protection function for detecting ground faults close to the star-point of a generator. The scheme is based on the principle of biasing the potential of the generator star-point by injecting a coded low-frequency signal. The injection signal is generated by the injection unit REX 010 and fed into the stator circuit by the injection transformer block REX 011. In conjunction with the voltage function 'Voltage' that covers 95 % of the winding, this protection completes detection of ground faults over 100 % of the winding. Compensation is provided for the influence of a second high-resistance grounded star-point in the zone of protection.

Stator ground faults producing a current at the star-point > 5 A cause the P8 contactor to reset which separates the injection unit Type REX 010 from the injection transformer block REX 011 and interrupts injection in both stator and rotor circuits. The 95 % stator ground fault protection then clears the fault on its own.

B. Features

- protects the star-point and a part of the stator winding depending on the ground fault current. The entire winding is protected when the generator is stationary.
- biases the star-point in relation to ground by injecting a signal generated in the REX 010 unit
- computes the ground fault resistance
- monitors the amplitude and frequency of the injection signal
- monitors the measuring circuit with respect to open-circuit and correct connection of the grounding resistor.

C. Inputs and outputs

I. C.t./v.t. inputs:

- voltage (2 inputs)

II. Binary inputs:

- blocking
- 2nd. parallel star-point
- MTR adjustment
- REs adjustment

III. Binary outputs:

- alarm stage pick-up
- alarm
- trip stage pick-up
- trip
- 2nd. parallel star-point
- MTR adjustment active
- REs adjustment active
- injection open-circuit internally
- injection open-circuit externally

IV. Measurements:

- ground fault resistance Rfs
- measurement transformer ratio MTR"
- grounding resistor REs".

Explanation of measurements:**Rfs:**

Ground fault resistances between 0 and 29.8 k Ω can be determined and displayed. A display of 29.9 k Ω or 30 k Ω indicates a ground fault resistance >29.8 k Ω . A value of 29.9 k Ω or 30 k Ω is displayed when there is no ground fault. A whole number fault code between 100 and 111 is displayed in cases when it is not possible to compute the ground fault resistance.

- **100.0** means no injection for more than 5 s.
- **101.0** means incorrect frequency. Either the injection frequency on the REX 010 or the rated frequency on the REG 316*4 is incorrectly set.
- **102.0** means external open-circuit.
- **109.0** means that both the binary inputs 'AdjREsInp' and 'AdjMTRInp' are enabled.

No other codes will normally be generated, but if they are, they are a diagnostic aid for service people.

MTR":

The value measured for MTR is displayed when the input 'MTR-Adjust' is enabled.

During normal operation, the value entered for MTR via the HMC is displayed.

REs":

When the input 'AdjREsInp' is enabled, the error code 123.0 is displayed initially until the resistance has been calculated. It can take up to 10 s before the value measured for REs is displayed.

During normal operation, the value entered for REs via the HMC is displayed.

Normal operation: Neither of the two inputs 'AdjMTRInp' and 'AdjREsInp' is enabled and injection is taking place.

Note: Only one of the binary inputs may be enabled at any one time, otherwise an error code is generated for the measurements Rfs, MTR and REs (see table below).

AdjMTRInp	AdjREsInp	
0	0	Protection active and Rfs is computed
1	0	Determination of MTR and Rfs
0	1	Determination of REs and Rfs
1	1	Error codes: MTR = 1090.0, REs = 109.0, Rfs = 109.0

0: binary input disabled

1: binary input enabled

D. Stator ground fault settings - Stator-EFP

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
Trip		000000			
Alarm-Delay	s	0.5	0.20	60.00	0.01
Trip-Delay	s	0.5	0.20	60.00	0.01
RFsAlarmVal	kΩ	10.0	0.1	20.0	0.1
RFsTripVal	kΩ	1.0	0.1	20.0	0.1
REs	kΩ	1.00	0.80	5.00	0.01
REs-2.Starpt	kΩ	1.00	0.90	5.00	0.01
RFs-Adjust	kΩ	10.0	8.000	12.00	0.01
MTransRatio		100.0	10.0	200.0	0.1
NrOfStarpt		1	1	2	1
VoltageInpUi	CT/VT-Addr.	0 *)			
VoltageInpUs	CT/VT-Addr.	0 *)			
2.StarptInp	BinaryAddr	F			
AdjMTRInp	BinaryAddr	F			
AdjREsInp	BinaryAddr	F			
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
StartTrip	SignalAddr				
Alarm	SignalAddr	ER			
StartAlarm	SignalAddr				
InterruptInt.	SignalAddr				
InterruptExt.	SignalAddr				
2.Starpt.	SignalAddr				
MTR-Adjust	SignalAddr				
REs-Adjust	SignalAddr				
Extern-Block	SignalAddr				

*) REG 316*4 requires an input transformer unit Type 316GW61 K67 assigned to the following voltage input channels:

VoltageInpUi: Channel 8

VoltageInpUs: Channel 9

Explanation of parameters:**ParSet 4..1**

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

defines the tripping channel activated by the tripping output of the function (tripping logic).

Alarm-Delay

Time between pick-up of the alarm stage and an alarm.

Trip-Delay

Time between pick-up of the tripping stage and a trip.

RFs-AlarmVal

Ground fault resistance setting for alarm.

RFs for alarm must be higher than RFs for tripping.

RFs-TripVal

Ground fault resistance setting for tripping.

REs

Grounding resistor REs for primary system grounding.

Where the grounding resistor is connected to the secondary of a v.t., its value related to the primary system R'Es has to be calculated and entered.

REs-2.Starpt

The total grounding resistance of a 2nd. star-point in the zone of protection.

RFs-Adjust

Simulated ground fault resistance used as a reference value for calculating REs in the 'REs-Adjust' mode.

MTransRatio

V.t. ratio for a directly grounded primary system.

NrOfStarpt

Number of star-points in the zone of protection.

VoltageInpUi

defines the voltage input channel for the reference voltage.
Channel 8 must be used.

VoltageInpUs

defines the voltage input channel for the measured voltage.
Channel 9 must be used.

2.StarptInp

Binary address used as status input. It determines whether the second star-point is connected in parallel to the first.

(F → FALSE, T → TRUE, binary input or output of a protection function).

AdjMTRInp

switches the protection function to the MTR determination mode.

(F → FALSE, T → TRUE, binary input or output of a protection function).

AdjREsInp

switches the protection function to the REs determination mode.

(F → FALSE, T → TRUE, binary input or output of a protection function).

BlockInp

Binary address used as blocking input.

(F → FALSE, T → TRUE, binary input or output of a protection function).

Trip

Output for signalling tripping.
(signal address)

StartTrip

Output for signalling the pick-up of the tripping stage.
(signal address)

Alarm

Output for signalling an alarm.
(signal address)

StartAlarm

Output for signalling the pick-up of the alarm stage.
(signal address)

InterruptInt

Output for signalling an open-circuit injection circuit.
(signal address)

InterruptExt.

Output for signalling an open-circuit measuring circuit.
(signal address)

2.Starpt

Output for signalling a second star-point in parallel.
(signal address)

MTR-Adjust

Output for signalling the binary status of 'AdjMTRInp'.
(signal address)

REs-Adjust

Output for signalling the binary status of 'AdjREsInp'.
(signal address)

Extern-Block

Output for signalling that the function is disabled by an external signal.
(signal address)

E. Setting instructions

The value of 'RF-Setting' for alarm must always be higher than that of 'RF-Setting' for tripping.

Both alarm and tripping stages have their own timers.

Typical delays used for the 100 % ground fault protection are in the range of seconds.

Settings:

'RFs-Setting' for tripping

'RFs-Setting' for alarm

Delay for tripping

Delay for alarm

Grounding resistor REs

Measuring transformer ratio (MTR).

Typical settings:

Alarm stage:

RFs-Setting 5 k Ω

Delay 2 s

Tripping stage:

RFs-Setting 500 Ω

Delay 1 s

Setting procedure:

The accuracy of the Rfs calculation depends on the values entered for REs and MTR. Therefore check the settings and correct them if necessary by connecting resistors between 100 Ω and 10 k Ω between the star-point and ground while the generator is not running.

The protection function provides a convenient way of setting these two parameters in the software by switching its mode using the input 'AdjMTRInp' or 'AdjREsInp'. This is the recommended procedure. In this mode, the settings of the parameters 'MTR' and 'REs' are calculated with the aid of simulated ground fault resistances. The two parameters are displayed continuously in the measured values window.

Should the values of REs and MTR determined by the adjustment modes differ from their nominal values, the calculated values are the preferred values.

Determination of 'MTR':

- Ground the star-point ($R_f = 0 \Omega$).
- Apply a logical '1' to the binary input 'AdjMTRInp'.
- Open the HMC menu 'Display function measurements' and note the value for 'MTR'. Return to the 'Editor' menu, select the function 'Stator-EFP' in the sub-menu 'Present prot funcs' and enter and save the value noted for the 'MTR'.
- Remove the connection between the star-point and ground.
- Remove the logical '1' from the binary input 'AdjMTRInp'.

Determination of 'Res':

Select the menus and items as for 'Determination of MTR'.

- Apply a logical '1' to the binary input 'AdjRESInp'.
- Enter an approximate value for REs.
- Simulate a ground fault R_f by connecting a resistor between the star-point and ground: $8 \text{ k}\Omega < R_f < 12 \text{ k}\Omega$
- Open the HMC menu 'Edit function parameters':
Enter the value for the setting 'RFs-Adjust'.
Enter the approximate value for 'REs'. If the grounding resistor is on the secondary system side, the value entered must be referred to the primary side. (Refer also to the Sections concerning REs and MTR in the case of secondary injection at the star-point, respectively at the terminals.) Save the settings entered.
- Open the menu 'Display function measurements' and note the value of 'REs'.
- Enter and save the value noted for the setting of 'REs' in the 'Edit function parameters' sub-menu.
- Remove the simulated ground fault.
- Remove the logical '1' from the binary input 'AdjRESInp'.

The protection function will only switch back from the determination mode to the normal protection mode when both binary Inputs have been reset.

Check the settings by connecting resistors of 100Ω to $20 \text{ k}\Omega$ ($P \geq 5 \text{ W}$) between the star-point and ground and compare their values with the readings of the measured values on the screen.

Important note:

The tripping and alarm outputs are disabled as long as one of the two binary Inputs 'AdjMTRInp' or 'AdjRESInp' is enabled, i.e. the protection will not trip if the stator circuit is grounded. The two signals 'InterruptInt' and 'InterruptExt', however, are not disabled.

REs and MTR in the case of primary injection at the generator star-point

An injection transformer block Type REX 011 is needed for this circuit.

Fig. 3.5.24.1 shows the wiring diagram for primary injection (peak value of U_{is} 110 or 96 V DC) at the generator star-point. The star-point is grounded via the resistor R_{Es} and the parallel resistor R_{Ps} . The current at the star-point must not exceed 20 A. It is recommended, however, to select the resistors such that the star-point current is ≤ 5 A to protect as much of the winding as possible.

The total resistance is thus:

$$\text{Condition 1: } R_{Es} + R_{Ps} \geq \frac{U_{Gen}}{\sqrt{3} \times I_{E\max}}$$

where: U_{Gen} phase-to-phase voltage at the generator terminals
 $I_{E\max}$ max. star-point current = 20 A

The following conditions must also be fulfilled:

Condition 2: $R_{Ps} \geq 130 \Omega$ and $R_{Ps} \leq 500 \Omega$

Condition 3: $R_{Es} \geq 4.5 \times R_{Ps}$

Condition 4: $R_{Es} \geq 0.7 \text{ k}\Omega$ and $R_{Es} \leq 5 \text{ k}\Omega$

The v.t. must be designed such that for a solid ground fault at the generator terminals, the rated frequency component voltage $U_s = 100 \pm 20 \%$, i.e. the ratio $MTR = N_{12}/N_{11}$ must lie within the following range:

Condition 5:

$$1.2 \times n \geq \frac{N_{12}}{N_{11}} \geq 0.8 \times n, \text{ where } n = \frac{U_{Gen}}{\sqrt{3} \times 100 \text{ V}} \times \frac{R_{Es}}{R_{Es} + R_{Ps}}$$

A v.t. $\frac{N_{12}}{N_{11}} = \frac{U_{Gen}}{\sqrt{3} \times 100 \text{ V}}$ will fulfil condition 5 in most cases.

Design example:

$$U_{\text{Gen}} = 8 \text{ kV}$$

$$\text{Assumed: } I_{\text{Emax}} \leq 5 \text{ A}$$

Determination of the grounding resistors:

$$\text{Condition 1: } R_{\text{Es}} + R_{\text{Ps}} \geq \frac{8 \text{ kV}}{\sqrt{3} \times 5 \text{ A}} \geq 924 \Omega$$

$$\text{Condition 2: } R_{\text{Ps}} \geq 130 \Omega$$

$$\text{Assumed: } R_{\text{Ps}} = 150 \Omega$$

$$\text{Condition 3: } R_{\text{Es}} \geq 4.5 \times 150 \Omega = 675 \Omega$$

$$\text{Condition 4: } R_{\text{Es}} \geq 700 \Omega$$

In order to fulfil conditions 1, 3 and 4: $R_{\text{Es}} = 800 \Omega$

Determination of the v.t.:

$$\text{Assumed: } \frac{N_{12}}{N_{11}} = \frac{8 \text{ kV}}{\sqrt{3} \times 100 \text{ V}} = 46.188$$

Condition 5 is fulfilled because:

$$1.2 \times n \geq \frac{N_{12}}{N_{11}} \geq 0.8 \times n = 46.7 \geq 31.1 \text{ where}$$

$$n = \frac{8 \text{ kV}}{\sqrt{3} \times 100 \text{ V}} \times \frac{800 \Omega}{800 \Omega + 150 \Omega} = 38.9$$

The following values are permissible:

$$R_{\text{Ps}} = 150 \Omega$$

$$R_{\text{Es}} = 800 \Omega$$

$$N_{12}/N_{11} = 8 \text{ kV} / \sqrt{3} / 100 \text{ V}$$

Design instructions:

When supplied from a 110 V battery, the maximum power injected into the stator circuit is 110 VA. The injection unit is equipped with a converter to accommodate battery voltages between 48 V and 250 V. The peak injection voltage is $\pm 96 \text{ V}$.

Giving due account to the available power, typical resistance values for most applications are $R_{Es} = 1000 \, \Omega$ and $R_{Ps} = 150 \, \Omega$. Both R_{Ps} and R_{Es} must be able to conduct the maximum star-point current for 10 s. The resistor R_{Ps} must also be continuously rated for the injection voltage (injected power < 100 VA).

The maximum generator star-point current is determined by the resistors R_{Es} and R_{Ps} . Using the above resistors, this current would be, for example, 5.3 A for $U_{Gen} = 10.5 \, \text{kV}$ or 13.5 A for $U_{Gen} = 27 \, \text{kV}$.

REs and MTR in the case of secondary injection at the star-point

An injection transformer block Type REX 011-1 is needed for this circuit.

The bias voltage can also be injected across part of the grounding resistor connected to the secondary of a grounding v.t. (see Fig. 3.5.24.2).

The two resistors R'_{Es} and R'_{Ps} limit the maximum current at the star-point which must not exceed 20 A. The total resistance is thus:

$$\text{Condition 1: } R'_{Es} + R'_{Ps} \geq \frac{U_{\text{Gen}}}{\sqrt{3} \times I_{\text{Emax}}} \times \left(\frac{N_2}{N_1} \right)^2$$

where: U_{Gen} phase-to-phase voltage at the generator terminals

I_{Emax} max. star-point current = 20 A

N_1/N_2 ratio of the grounding transformer.

The following conditions must also be fulfilled:

$$\text{Condition 2: } R'_{Ps} \geq 130 \Omega \times \left(\frac{N_2}{N_1} \right)^2 \text{ and } R'_{Ps} \leq 500 \Omega \times \left(\frac{N_2}{N_1} \right)^2$$

$$\text{Condition 3: } R'_{Es} \geq 4.5 \times R'_{Ps}$$

$$\text{Condition 4: } R'_{Es} \geq 0.7 \text{ k}\Omega \times \left(\frac{N_2}{N_1} \right)^2 \text{ and } R'_{Es} \leq 5.0 \text{ k}\Omega \times \left(\frac{N_2}{N_1} \right)^2$$

The v.t. must be designed such that for a solid ground fault at the generator terminals, the rated frequency component voltage $U_s = 100 \text{ V} \pm 20 \%$, i.e. the ratio $\text{MTR}' = N'_{12}/N'_{11}$ must lie within the following range:

Condition 5:

$$1.2 \times n \geq \frac{N'_{12}}{N'_{11}} \geq 0.8 \times n, \text{ where } n = \frac{U_{\text{Gen}}}{\sqrt{3} \times 100 \text{ V}} \times \frac{N_2}{N_1} \times \frac{R'_{Es}}{R'_{Es} + R'_{Ps}}$$

$$\text{A v.t. } \frac{N'_{12}}{N'_{11}} = \frac{U_{\text{Gen}}}{\sqrt{3} \times 100 \text{ V}} \times \frac{N_2}{N_1} \text{ will fulfil condition 5 in most cases.}$$

The settings for R_{Es} and MTR must be entered via the HMC, i.e. the values of R'_{Es} and MTR' reflected to the primary of the grounding transformer:

$$R_{Es} = R'_{Es} \times \left(\frac{N_1}{N_2} \right)^2 \geq 0.7 \text{ k}\Omega$$

$$MTR = MTR' \times \frac{110 \text{ V}}{U_{is}} = \frac{N'_{12}}{N'_{11}} \times \frac{110 \text{ V}}{U_{is}}$$

The injection voltage U_{is} depends on the value of the parallel resistor R'_{ps} and can be either 0.85 V, 1.7 V or 3.4 V.

The minimum value of the resistor R'_{ps} in relation to the corresponding injection voltage U_{is} can be seen from the following table. The maximum possible injection voltage should be chosen in each case.

R'_{ps} [mΩ]	U_{is} [V]
> 8	0.85
> 32	1.7
> 128	3.4

Table REX011-1

The two determination modes 'REs-Adjust' and 'MTR-Adjust' determine and display the values for REs and MTR, i.e. they present the secondary circuit reflected on the primary system side. Inaccuracies due to contact resistance, grounding resistor tolerances etc., are thus automatically compensated.

Determining the values for REs and MTR by means of the determination modes 'REs-Adjust' and 'MTR-Adjust' during commissioning is recommended in preference to calculating their values.

As a check, calculate the values of R'_{Es} and MTR' from the values given for RE and MTR in the measured value window as follows:

$$R'_{Es} = R_{Es} \times \left(\frac{N_2}{N} \right)^2$$

$$MTR' = MTR \times \frac{U_{is}}{110 \text{ V}}$$

In most cases, the calculated and determined values will not agree. Discrepancies of $\pm 20\%$ are acceptable. Where the discrepancies — especially in the case of REs — are large, check the actual values of the grounding resistors and the grounding transformer.

Design example:

$$U_{\text{Gen}} = 18 \text{ kV}$$

$$\frac{N_1}{N_2} = \frac{14.4 \text{ kV}}{240 \text{ V}} = 60$$

$$\text{Assumed: } I_{\text{Emax}} \leq 6.6 \text{ A}$$

Determination of the grounding resistors:

$$\text{Condition 1: } R'_{\text{Es}} + R'_{\text{Ps}} \geq \frac{18 \text{ kV}}{\sqrt{3} \times 6.6 \text{ A}} \times \left(\frac{1}{60}\right)^2 = 440 \text{ m}\Omega$$

$$\text{Condition 2: } R'_{\text{Ps}} \geq 130 \text{ }\Omega \times \left(\frac{1}{60}\right)^2 = 36 \text{ m}\Omega$$

$$\text{Assumed: } R'_{\text{Ps}} = 42 \text{ m}\Omega$$

$$\text{Condition 3: } R'_{\text{Es}} \geq 4.5 \times 42 \text{ m}\Omega = 189 \text{ m}\Omega$$

$$\text{Condition 4: } R'_{\text{Es}} \geq 700 \text{ }\Omega \times \left(\frac{1}{60}\right)^2 = 194 \text{ m}\Omega$$

In order to fulfil Conditions 1, 3 and 4:

$$R'_{\text{Es}} = 400 \text{ m}\Omega$$

Determination of the v.t.:

$$\text{Assumed: } \frac{N'_{12}}{N'_{11}} = \frac{18 \text{ kV}}{\sqrt{3} \times 100 \text{ V}} \times \frac{1}{60} = \frac{173.2 \text{ V}}{100 \text{ V}} = \sqrt{3}$$

Condition 5 is fulfilled because:

$$1.2 \times n \geq \frac{N'_{12}}{N'_{11}} \geq 0.8 \times n = 1.88 \geq 1.732 \geq 1.254$$

$$\text{where } n = \frac{18 \text{ kV}}{\sqrt{3} \times 100 \text{ V}} \times \frac{1}{60} \times \frac{400 \text{ m}\Omega}{400 \text{ m}\Omega + 42 \text{ m}\Omega} = 1.567$$

The following values are permissible:

$$R'_{\text{Ps}} = 42 \text{ m}\Omega$$

$$R'_{\text{Es}} = 400 \text{ m}\Omega$$

$$N_{12}/N_{11} = 173 \text{ V}/100 \text{ V}$$

Calculation of the settings REs and MTR:

$$R_{Es} = 400 \text{ m}\Omega \times (60)^2 = 1.44 \text{ k}\Omega$$

$$MTR = \frac{N'_{12}}{N'_{11}} \times \frac{110 \text{ V}}{1.7 \text{ V}} = 112$$

for an injection voltage of $U_{is} = 1.7 \text{ V}$.

Installations with a second star-point in the zone of protection

The following parameters settings have to be made:

- 'NrOfStarpt' = 2.
- '2.StarptInp' = T
in cases in which the second star-point is always connected in parallel to the first.
- '2.StarptInp' = binary system input
in cases where the second star-point is connected to the first by a switch, the closed position of the switch being signalled a logical '1' applied to a binary input.
- REs-2.Starpt = value of the grounding resistor connected to the second star-point.

Note:

The stator ground fault protection scheme sees the grounding resistor of the second star-point as a ground fault with the value 'REs-2.Starpt'.

Assuming a ground fault of resistance R_{fs} occurs, the total resistance of the parallel resistors R_{fs} and 'REs-2.Starpt' is calculated first. The value of R_{fs} can be simply determined from this, providing the value of 'REs-2.Starpt' is known.

This procedure is subject, however, to certain restrictions.

The maximum ground fault resistance that can be detected is approximately ten times the value of 'REs-2.Starpt'.

Assuming the grounding resistor of the second star-point to be $1 \text{ k}\Omega$, ground faults with a resistance less than $10 \text{ k}\Omega$ can be detected. For this reason, choosing a grounding resistor 'REs-2.Starpt' $\geq 2 \text{ k}\Omega$ is recommended wherever possible.

REs and MTR in the case of secondary injection at the generator terminals

An injection transformer block Type REX 011-2 is needed for this circuit.

The bias voltage can also be injected across part of the grounding resistor connected to the broken-delta secondaries of a grounding v.t.'s at the generator terminals (see Fig. 3.5.24.3).

The two resistors R'_{Es} and R'_{Ps} limit the maximum current at the star-point which must not exceed 20 A. The total resistance is thus :

$$\text{Condition 1: } R'_{Es} + R'_{Ps} \geq \frac{U_{Gen}}{\sqrt{3} \times I_{E\max}} \times \left(\frac{3 \times N_2}{N_1} \right)^2$$

where: U_{Gen} phase-to-phase voltage at the generator terminals

$I_{E\max}$ max. star-point current = 20 A

N_1/N_2 ratio of the grounding transformer.

The grounding resistors R'_{Es} and R'_{Ps} must fulfil the following conditions:

$$\text{Condition 2: } R'_{Ps} \geq 130 \, \Omega \times \left(\frac{3 \times N_2}{N_1} \right)^2 \quad \text{and} \quad R'_{Ps} \leq 500 \, \Omega \times \left(\frac{3 \times N_2}{N_1} \right)^2$$

$$\text{Condition 3: } R'_{Es} \geq 4.5 \times R'_{Ps}$$

$$\text{Condition 4: } R'_{Es} \geq 0.7 \, \text{k}\Omega \times \left(\frac{3 \times N_2}{N_1} \right)^2 \quad \text{and} \quad R'_{Es} \leq 5.0 \, \text{k}\Omega \times \left(\frac{3 \times N_2}{N_1} \right)^2$$

The v.t. must be designed such that for a solid ground fault at the generator terminals, the rated frequency component voltage $U_s = 100 \, \text{V} \pm 20 \, \%$, i.e. the ratio $\text{MTR}' = N'_{12} / N'_{11}$ must lie within the following range:

Condition 5:

$$1.2 \times n \geq \frac{N'_{12}}{N'_{11}} \geq 0.8 \times n, \quad \text{where} \quad n = \frac{U_{Gen}}{\sqrt{3} \times 100 \, \text{V}} \times \frac{3 \times N_2}{N_1} \times \frac{R'_{Es}}{R'_{Es} + R'_{Ps}}$$

$$\text{A v.t. } \frac{N'_{12}}{N'_{11}} = \frac{U_{Gen}}{\sqrt{3} \times 100 \, \text{V}} \times \frac{3 \times N_2}{N_1} \quad \text{will fulfil condition 5 in most cases.}$$

The settings for R_{Es} and MTR must be entered via the HMC, i.e. the values of R'_{Es} and MTR' reflected to the primary of the grounding transformer:

$$R_{Es} = R'_{Es} \times \left(\frac{N_1}{3 \times N_2} \right)^2 \geq 0.7 \text{ k}\Omega$$

$$MTR = MTR' \times \frac{110 \text{ V}}{U_{is}} = \frac{N'_{12}}{N'_{11}} \times \frac{110 \text{ V}}{U_{is}}$$

The injection voltage U_{is} depends on the value of the parallel resistor R'_{Ps} and can be either 6.4 V, 12.8 V or 25.6 V.

The minimum value of the resistor R'_{Ps} in relation to the corresponding injection voltage U_{is} can be seen from the following table. The maximum possible injection voltage should be chosen in each case.

$R'_{Ps} [\Omega]$	$U_{is} [\text{V}]$
> 0.45	6.4
> 1.8	12.8
> 7.2	25.6

Table REX011-2

Design example:

$$U_{\text{Gen}} = 12 \text{ kV}$$

$$\frac{N_1}{N_2} = \frac{\frac{12 \text{ kV}}{\sqrt{3}}}{\frac{600 \text{ V}}{3}}$$

Assumed: $I_{\text{Emax}} \leq 5 \text{ A}$

Determination of the grounding resistors:

Condition 1:

$$R'_{Es} + R'_{Ps} \geq \frac{12 \text{ kV}}{\sqrt{3} \times 5 \text{ A}} \times \left(\frac{3 \times \frac{600 \text{ V}}{3}}{\frac{12 \text{ kV}}{\sqrt{3}}} \right)^2 = \frac{3 \times (600 \text{ V})^2}{\sqrt{3} \times 5 \text{ A} \times 12 \text{ kV}} = 10.4 \Omega$$

$$\text{Condition 2: } R'_{Ps} \geq 130 \Omega \times \left(\frac{3 \times \frac{600 \text{ V}}{3}}{\frac{12 \text{ kV}}{\sqrt{3}}} \right)^2 = 0.98 \Omega$$

Assumed: $R'_{Ps} = 1.0 \Omega$

Condition 3: $R'_{Es} \geq 4.5 \times 1 \Omega = 4.5 \Omega$

$$\text{Condition 4: } R'_{Es} \geq 700 \Omega \times \left(\frac{3 \times \frac{600 \text{ V}}{3}}{\frac{12 \text{ kV}}{\sqrt{3}}} \right)^2 = 5.25 \Omega$$

In order to fulfil conditions 1, 3 and 4: $R'_{Es} = 10.0 \Omega$

Determining the v.t.:

$$\text{Assumed: } \frac{N'_{12}}{N'_{11}} = \frac{12 \text{ kV}}{\sqrt{3} \times 100 \text{ V}} \times \frac{3 \times \frac{600 \text{ V}}{3}}{\frac{12 \text{ kV}}{\sqrt{3}}} = \frac{\sqrt{3} \times 600 \text{ V}}{100 \text{ V}} = 6.0$$

Condition 5 is fulfilled because:

$$1.2 \times n \geq \frac{N'_{12}}{N'_{11}} \geq 0.8 \times n = 6.6 \geq 6.0 \geq 4.4 \quad \text{where}$$

$$n = \frac{12 \text{ kV}}{\sqrt{3} \times 100 \text{ V}} \times \frac{3 \times \frac{600 \text{ V}}{3}}{\frac{12 \text{ kV}}{\sqrt{3}}} \times \frac{10 \Omega}{10 \Omega + 1 \Omega} = 6 \times 0.91 = 5.5$$

The following values are permissible:

$$R'_{Ps} = 1 \Omega$$

$$R'_{Es} = 10 \Omega$$

$$N'_{12}/N'_{11} = \sqrt{3} \times 600 \text{ V}/100 \text{ V}$$

Calculation of the settings REs and MTR:

$$R_{Es} = 10 \Omega \times \left(\frac{\frac{12 \text{ kV}}{\sqrt{3}}}{\frac{3 \times 600 \text{ V}}{3}} \right)^2 = 1.33 \text{ k}\Omega$$

$$\text{MTR} = \frac{N'_{12}}{N'_{11}} \times \frac{110 \text{ V}}{6.4 \text{ V}} = 103.1$$

for an injection voltage $U_{is} = 6.4 \text{ V}$.

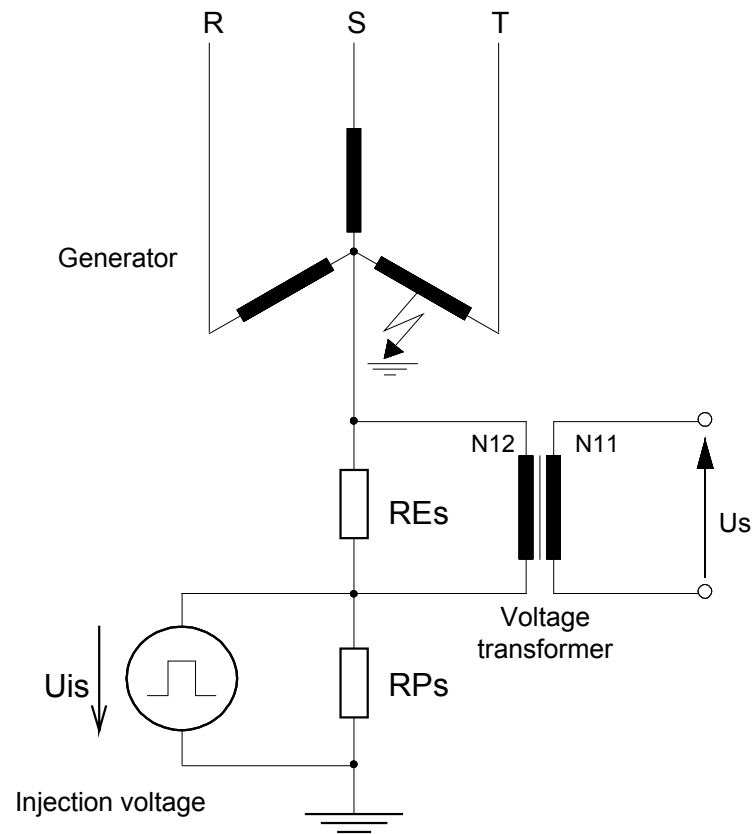


Fig. 3.5.24.1 Stator ground fault protection with primary injection

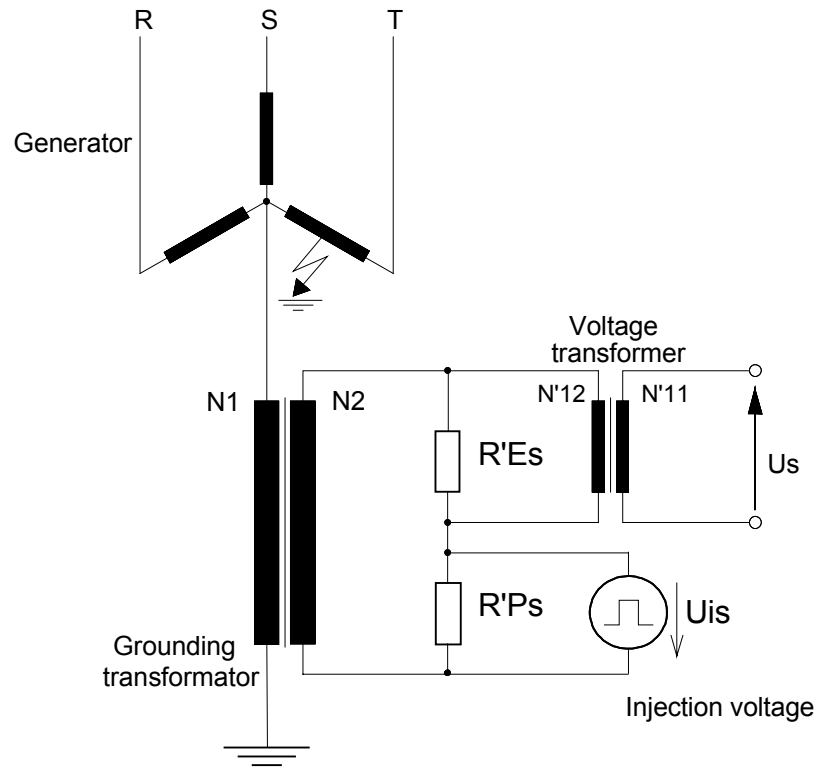


Fig. 3.5.24.2 Stator ground fault protection with secondary injection at the generator star-point

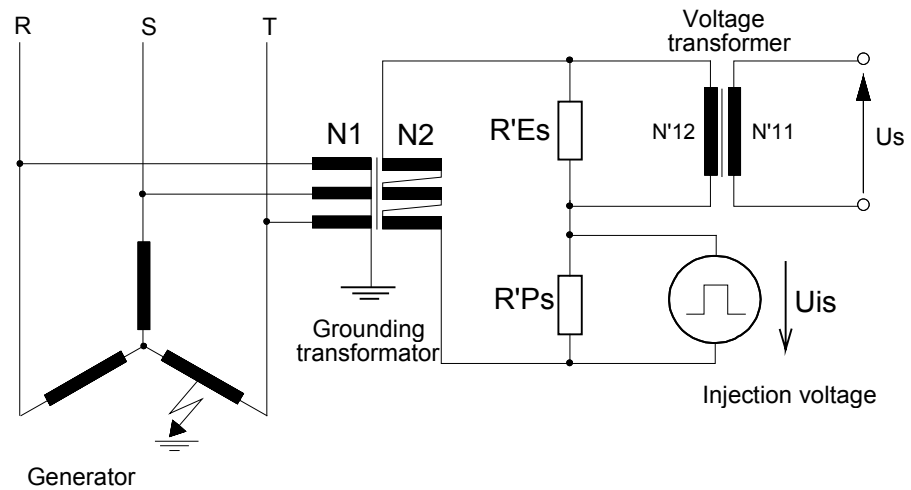


Fig. 3.5.24.3 Wiring diagram for secondary injection of the stator (grounding transformer at the generator terminals)

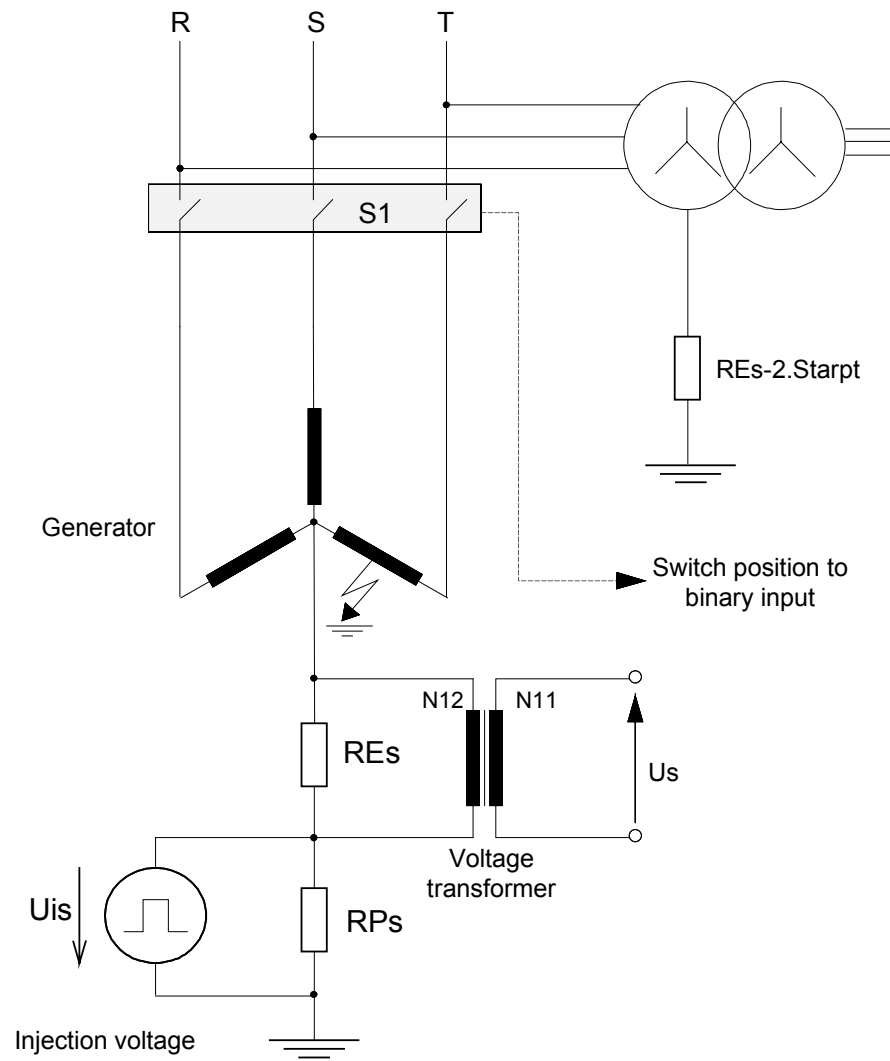


Fig. 3.5.24.4 Stator ground fault protection for installations with two star-points

3.5.25. Rotor ground fault protection by injection (Rotor-EFP)

A. Application

For the detection of ground faults on the rotor windings of generators. Because of its low sensitivity to spurious signals, this scheme can be used for all kinds of excitation systems.

B. Features

- detection of ground faults on rotor windings
- injection voltage applied via resistors and coupling capacitors to both poles of the rotor
- computes the resistance of the ground fault
- monitors the amplitude and frequency of the injection signal
- monitors the measuring circuit with respect to open-circuit and correct connection of the grounding resistor.

C. Inputs and outputs

I. C.t./v.t. inputs:

- voltage (2 inputs)

II. Binary inputs:

- blocking
- coupling capacitor adjustment
- REr adjustment

III. Binary outputs:

- alarm stage pick-up
- alarm
- trip stage pick-up
- trip
- coupling capacitor adjustment active
- REr adjustment active
- injection open-circuit internally
- injection open-circuit externally
- external blocking

IV. Measurements:

- ground fault resistance RFr
- coupling capacitor Ck"
- grounding resistor REr".

Explanation of measurements:**Rfr:**

Ground fault resistances between 0 and 29.8 k Ω can be determined and displayed. A display of 29.9 k Ω or 30 k Ω indicates a ground fault resistance >29.8 k Ω . A value of 29.9 k Ω or 30 k Ω is displayed when there is no ground fault.

A whole number fault code between 100 and 111 is displayed in cases when it is not possible to compute the ground fault resistance.

- **100.0** means no injection for more than 5 s.
- **101.0** means incorrect frequency. Either the injection frequency on the REX 010 or the rated frequency on the REG 316*4 is incorrectly set.
- **102.0** means external open-circuit.
- **109.0** means that both the binary inputs 'AdjRErInp' and 'AdjCoupCInp' are enabled.
- **111.0** means that the binary input 'AdjRErInp' is enabled.

No other codes will normally be generated, but if they are, they are a diagnostic aid for the service people.

Ck":

When the input 'AdjCoupCInp' is enabled, 133.00 is displayed initially until the coupling capacitor has been computed. This can take a maximum of 10 s after which the value measured for C is displayed.

During normal operation, the value entered for the coupling capacitor C via the HMC is displayed.

REr":

When the input 'AdjRErInp' is enabled, the error code 133.00 is displayed initially until the resistance has been calculated. It can take up to 10 s before the value measured for REr is displayed. The value measured for Rf is 97.0.

During normal operation, the value entered for REr on the HMC is displayed.

Normal operation: Neither of the two inputs 'AdjCoupCInp' and 'AdjRErInp' is enabled and injection is taking place.

Note: Only one of the binary inputs may be enabled at any one time, otherwise an error code is generated for the measurements Rf, C and REr (see table below).

AdjCoupCInp	AdjRErInp	
0	0	Protection active and Rf is computed
1	0	Determination of C and Rf
0	1	Determination of REr (Rf = 111.0)
1	1	Error codes: 109.00 and 109.00 (Rf = 109.0)

0: binary input disabled
1: binary input enabled.

D. Rotor ground fault settings - Rotor-EFP

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
Trip		00000000			
Alarm-Delay	s	0.50	0.20	60.00	0.01
Trip-Delay	s	0.50	0.20	60.00	0.01
RFrAlarmVal	k Ω	10.0	0.1	25.0	0.1
RFrTripVal	k Ω	1.0	0.1	25.0	0.1
REr	k Ω	1.00	0.90	5.00	0.01
Uir	V	50	(Select)		
RFr-Adjust	k Ω	10.0	8.000	12.00	0.01
CouplingCap	μ F	4.00	2.00	10.00	0.01
VoltageInpUi	CT/VT-Addr.	0 *)			
VoltageInpUr	CT/VT-Addr.	0 *)			
AdjRErInp	BinaryAddr	F			
AdjCoupCInp	BinaryAddr	F			
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
StartTrip	SignalAddr				
Alarm	SignalAddr	ER			
StartAlarm	SignalAddr				
InterruptInt	SignalAddr				
InterruptExt	SignalAddr				
REr-Adjust	SignalAddr				
CoupC-Adjust	SignalAddr				
Extern-Block	SignalAddr				

*) REG 316*4 requires an input transformer unit Type 316GW61 K67 assigned to the following voltage input channels:

VoltageInpUi: Channel 8

VoltageInpUr: Channel 7.

Explanation of parameters:**ParSet 4..1**

Parameter for determining in which set of parameters a particular function is active (see Section 5.11.).

Trip

defines the tripping channel activated by the tripping output of the function (tripping logic).

Alarm-Delay

Time between pick-up of the alarm stage and an alarm.

Trip-Delay

Time between pick-up of the tripping stage and a trip.

RFr-AlarmVal

Ground fault resistance setting for alarm.

RFr for alarm must be higher than RFr for tripping.

RFr-TripVal

Ground fault resistance setting for tripping.

REr

Grounding resistor REr.

Uir

The normal rotor injection voltage is 50 V. Provision is also made for an injection voltage of 20 or 30 V by appropriately changing the wiring on the injection transformer unit Type REX 011.

RFr-Adjust

Simulated ground fault resistance used as a reference value for calculating REr in the 'REr-Adjust' mode.

CouplingCap

The total capacitance C of the two coupling capacitors in parallel.

VoltageInpUi

defines the voltage input channel for the reference voltage Ui. Channel 8 must be used.

VoltageInpUr

defines the voltage input channel for the measured voltage Ur. Channel 7 must be used.

AdjRErInp

switches the protection function to the REr determination mode.

(F → FALSE, T → TRUE, binary input or output of a protection function).

AdjCoupCInp

switches the protection function to the C determination mode.

(F → FALSE, T → TRUE, binary input or output of a protection function).

BlockInp

Binary address used as blocking input.

(F → FALSE, T → TRUE, binary input or output of a protection function).

Trip

Output for signalling tripping.

StartTrip

Output for signalling the pick-up of the tripping stage.

Alarm

Output for signalling alarm.

StartAlarm

Output for signalling the pick-up of the alarm stage.

InterruptInt

Output for signalling an open-circuit injection circuit.

InterruptExt.

Output for signalling an open-circuit measuring circuit.

Output for signalling an open-circuit injection circuit. Both pick-up and reset of this signal are delayed by 5s.

REr-Adjust

Output for signalling the binary status of 'AdjRErInp'.

CoupC-Adjust

Output for signalling the binary status of 'AdjCoupCInp'.

Extern-Block

Output for signalling that the function is disabled by an external signal.

E. Setting instructions

The value of 'R_{Fr}-Setting' for alarm must always be higher than that of 'R_{Fr}-Setting' for tripping. Both alarm and tripping stages have their own timers. Typical delays used for the rotor ground fault protection are in the range of seconds.

Recommended resistances:

$$R_{Er} = 1000 \, \Omega$$

$$R_{Pr} = 100 \, \Omega.$$

Settings:

Grounding resistor R_{Er}
Coupling capacitor C
'R_{Fr}-Setting' for tripping
'R_{Fr}-Setting' for alarm
Delay for alarm
Delay for tripping.

Typical settings:

Alarm stage:

R _{Fr} -Setting	5 k Ω
Delay	2 s

Tripping stage:

R _{Fr} -Setting	500 Ω
Delay	1 s.

Setting procedure:

How accurately R_{fr} is measured depends on the values entered for R_{Er} and C. Therefore check the settings and correct them if necessary by connecting resistors between 100 Ω and 10 k Ω between the rotor and ground while the generator is not running.

The protection function provides a convenient way of setting these two parameters in the software by switching its mode using the input 'AdjR_{Er}Inp' or 'AdjCoupCInp'. In this mode, the settings of the parameters 'R_{Er}' and 'C' are calculated with the aid of simulated ground fault resistances.

Determination of R_{Er}

- Apply a logical '1' to the binary input 'AdjR_{Er}Inp'.
- Short-circuit the coupling capacitors.
- Simulate a ground fault R_f by connecting a resistor to the rotor: $8 \, \text{k}\Omega < R_f < 12 \, \text{k}\Omega$

- Open the HMC menu 'Editor' and the sub-menu 'Present prot funcs', and enter and save the value of the simulated ground fault for 'RFR-Adjust' and the nominal value for REr.

Open the menu 'Display function measurements' and note the value of 'REr'. Enter and save the value noted for the setting of 'REr' in the 'Present prot funcs' window.

- Remove the short-circuit from across the coupling capacitors and remove the simulated ground fault.
- Remove the logical '1' from the binary input 'AdjRErInp'.

Determination of C

- Apply a logical '1' to the binary input 'AdjCoupCInp'.
- Ground the rotor winding ($R_f = 0 \Omega$).
- Enter and save the value the nominal value of C, in the sub-menu 'Present prot funcs'.

Open the menu 'Display function measurements' and note the value of Ck. Enter and save the value noted for the setting of 'CouplingCapC' in the window 'Present prot funcs'.

- Remove the simulated ground fault from the rotor.
- Remove the logical '1' from the binary input 'AdjCoupCInp'.

Design instructions:

The grounding resistors and coupling capacitors have to fulfil the following conditions:

$$\text{Rotor grounding resistor } R_{pr} : 150 \Omega \leq R_{pr} \leq 500 \Omega$$

$$\text{Rotor grounding resistor } R_{Er} : 900 \Omega \leq R_{Er} \leq 5 \text{ k}\Omega$$

Coupling capacitors

$$C = C_1 + C_2 : 2\mu\text{F} \leq C \leq 10\mu\text{F}$$

$$\text{Time constant } \tau = R_{Er} \times C : 3 \text{ ms} \leq \tau \leq 10 \text{ ms}$$

The grounding resistor R_{pr} must be continuously rated for the

$$\text{injection current } I = \frac{50 \text{ V}}{R_{pr}}.$$

The coupling capacitors must be designed for the maximum excitation voltage.

Application examples:

$$R_{pr} = 200 \, \Omega, P = 15 \, W$$

$$R_{Er} = 1 \, k\Omega$$

$$C = 2 \times 2 \, \mu F, \quad 8 \, kV$$

$$\tau = 4 \, ms$$

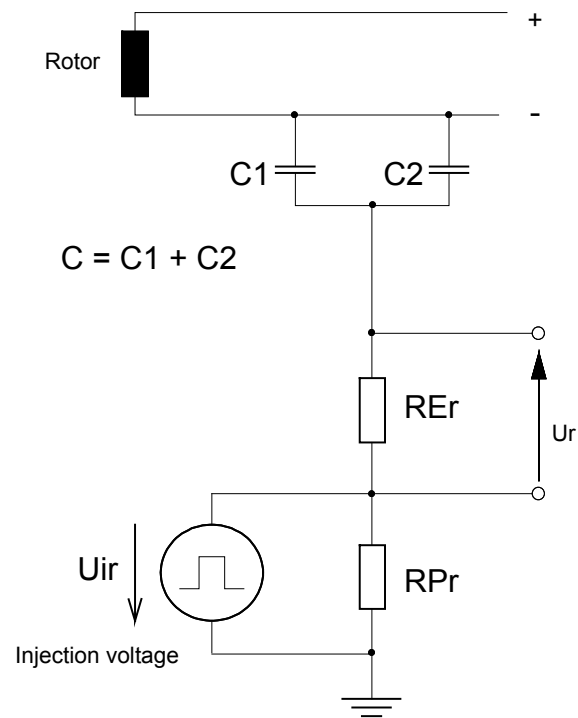


Fig. 3.5.25.1 Injection at one pole of the rotor winding

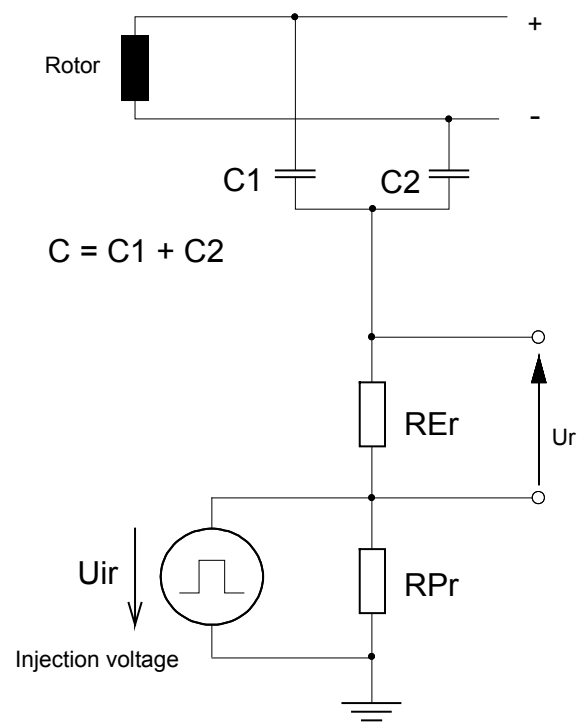


Fig. 3.5.25.2 Injection at both poles of the rotor winding

3.5.26. Pole slipping (Pole-Slip)

A. Application

The pole slipping function detects the condition of a generator that is completely out-of-step with the power system.

B. Features

- detection of slip frequencies in relation to the power system of 0.2 to 8 Hz
- alarm before the first slip (rotor angle pick-up setting)
- discriminates generating and motoring directions of rotor phase-angle
- discriminates an internal and an external power swing centre
- trips after a set number of slips
- trips within a set rotor angle.

C. Inputs and outputs

I. Analogue inputs:

- current
- voltage

II. Binary inputs:

- blocking of the entire function
- blocking operation in generating direction (to left)
- blocking operation in motoring direction (to right)
- external enable for zone1.

III. Binary outputs:

- alarm before the first slip
- operation for generating slip (to left)
- operation for motoring slip (to right)
- first operation in zone 1
- first operation in zone 2
- nth. operation in zone 1 (tripping)
- nth. operation in zone 2.

IV. Measurements:

- slip impedance
- slip frequency.

D. Pole slip settings - Pole-Slip

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
Trip1		00000000			
ZA	UN / IN	0,00	0,000	5,000	0,001
ZB	UN / IN	0,00	-5,000	0,000	0,001
ZC	UN / IN	0,00	0,000	5,000	0,001
Phi	deg	090	60	270	1
WarnAngle	deg	000	0	180	1
TripAngle	deg	090	0	180	1
n1		1	0	20	1
n2		1	0	20	1
t-Reset	s	5,000	0,500	25,000	0,010
CurrentInp	AnalogAddr	0			
VoltageInp	AnalogAddr	0			
BlockGen	BinaryAddr	F			
BlockMot	BinaryAddr	F			
BlockInp	BinaryAddr	F			
EnableZone1	BinaryAddr	F			
Warning	SignalAddr	ER			
Generator	SignalAddr	ER			
Motor	SignalAddr	ER			
Zone1	SignalAddr	ER			
Zone2	SignalAddr	ER			
Trip1	SignalAddr	ER			
Trip2	SignalAddr	ER			

Explanation of parameters:**ParSet 4..1**

Parameter for determining in which set of parameters a particular function is active (see [Section 5.11.](#)).

Trip1

defines the tripping channel activated by the tripping output of stage 1 of the function (tripping logic).

ZA

Forwards impedance ¹⁾. ZA marks the end of zone 2 and is also used for determining phase-angle.

ZB

Reverse impedance ¹⁾. ZB marks the beginning of zone 1 and is also used for determining phase-angle.

ZC

Impedance of the zone limit ¹⁾. ZC is the end of zone 1 between ZB and ZC and the beginning of zone 2 between ZC and ZA.

Phi

Angle of the slipping characteristic and of ZA, ZB and ZC. Phi also determines the energy direction:

60°...90° c.t. neutral on the line side

240°...270° c.t. neutral on the generator side.

WarnAngle

Rotor angle above which alarm of potential slipping is given (rotor angle > WarnAngle).

TripAngle

Rotor angle below which first 'Trip1' and the 'Trip2' are issued (rotor angle < TripAngle).

¹⁾ The impedance unit 1.000 UN/IN represents an impedance of 100%. Thus if the impedance setting in percent is known, it can be set directly, e.g. the setting for 10% is 0.100.

An impedance of 1.000 UN/IN corresponds to a current of 1 I_N at the rated phase-to-neutral voltage $U_N / \sqrt{3}$ in all three phases. The respective positive-sequence impedance is $U_N / \sqrt{3} / I_N$:

U_N	I_N	Impedance unit
100 V	1 A	57.735 Ω/ph
100 V	2 A	28.868 Ω/ph
100 V	5 A	11.547 Ω/ph
200 V	1 A	115.470 Ω/ph
200 V	2 A	57.735 Ω/ph
200 V	5 A	23.094 Ω/ph

n1

Number of slips for zone 1, i.e. number of slips before 'Trip1' is issued and signalled.

n2

Number of slips for zone 2, i.e. number of slips before 'Trip2' is signalled.

t-Reset

The reset time 't-Reset' prevents the function from resetting between two slips providing n1 or n2 is greater than 1.

CurrentInp

defines the A/D input channel.

VoltageInp

defines the A/D input channel.

BlockGen

Blocking input for detecting pole slip to the left, i.e. the generator is faster than the power system.

BlockMot

Blocking input for detecting pole slip to the right, i.e. the generator is slower than the power system.
(The power system drives the generator as if it were a motor.)

BlockInp

Blocking input for the entire pole slipping function.

EnableZone1

Zone 1 is enabled for slipping in zone 2 as well, i.e. independently of ZC.

Warning

Detection of variations of rotor angle (before the first slip occurs).

Generator

Signals rotor movement to the left, i.e. the generator is faster than the system.

Motor

Signals rotor movement to the right, i.e. the generator is slower than the system. (The power system drives the generator as if it were a motor.)

Zone1

First slip between ZB and ZC or between ZB and ZA, providing the input 'EnableZone1' is enabled.

Zone2

First slip between ZC and ZA.

Trip1

Tripping and signalling when the counter for zone 1 reaches the value n1.

Trip2

Signalling when the counter for zone 2 reaches the value n2.
If Trip2 is to control tripping, the signal Trip2 has to be assigned to a tripping relay ([see also Section 5.5.4.2.](#)).

E. Detecting rotor slip and shift

Rotor shift is detected by monitoring the voltage $U \cdot \cos \varphi$, i.e. the component of the voltage in phase with the current.

If the generator is faster than the power system, the rotor movement in the impedance and voltage diagram is from right to left and generating is signalled. If the generator is slower than the power system, the rotor movement is from left to right and motoring is signalled (the power system drives the generator as if it were a motor).

The movements in the impedance plane can be seen from [Fig. 3.5.26.1](#). The transient behaviour is described by the transient e.m.f's E_A and E_B , and by X_d' , X_T and the transient system impedance Z_S .

The detection of rotor angle is enabled when

- the minimum current exceeds $0.10 I_N$
- the maximum voltage falls below $0.92 U_N$
- the voltage $U \cdot \cos \varphi$ has an angular velocity of 0.2...8 Hz and
- the corresponding direction is not blocked.

An alarm is given when movement of the rotor in relation to the slip line and the rotor angle exceeds the angle set for 'WarnAngle'.

Slipping is detected when

- a change of rotor angle is detected
- the slip line is crossed between Z_A and Z_B
- the direction of movement has remained the same since pick-up and has lasted at least for the time 't-slip'
- the direction of movement has remained the same throughout 't-slip'.

When the impedance crosses the slip line between Z_B and Z_C it counts as being in zone 1 and between Z_C and Z_A in zone 2. The entire distance Z_A - Z_B becomes zone 1 when 'EnableZone1' is enabled (external device detects the direction of the centre of slipping).

After the first slip, the signals 'Zone1' or 'Zone2' and - depending on the direction of slip - either 'Generator' or 'Motor' are issued.

Every time pole slipping is detected, the impedance of the point where the slip line is crossed and the instantaneous slip frequency are displayed as measurements.

Further slips are only detected, if they are in the same direction and if the rate of rotor movement has reduced in relation to the preceding slip or the slip line is crossed in the opposite direction outside Z_A - Z_B .

A further slip in the opposite direction within Z_A - Z_B resets all the signals and is then signalled itself as a first slip.

The 'Trip1' tripping command and signal are generated after n_1 slips in zone 1, providing the rotor angle is less than 'TripAngle'.

The 'Trip2' signal is generated after n_2 slips in zone 2, providing the rotor angle is less than 'TripAngle'.

All signals are reset if:

- the direction of movement reverses
- the rotor angle detector resets without a slip being counted or
- no rotor relative movement was detected during the time 't-Reset'.

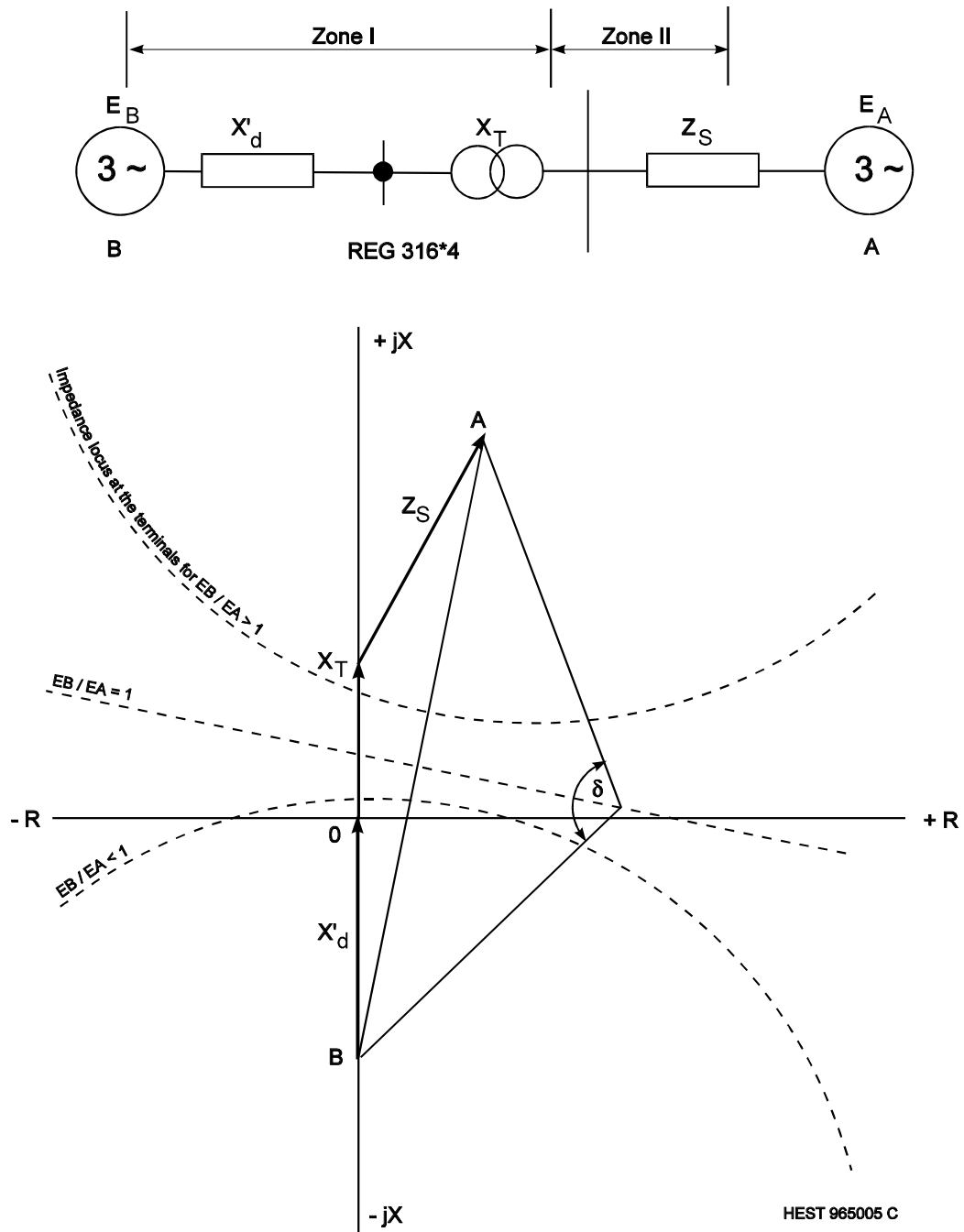


Fig. 3.5.26.1 Locus of the impedance measured at the generator terminals during pole slipping in relation to the power system A

- X'_d : transient reactance of the generator
- X_T : short-circuit reactance of the step-up transformer
- Z_S : transient impedance of the power system A

F. Setting instructions

Settings: Current and voltage inputs

A three-phase group must be used for the current input.

The following can be set for the voltage input:

- single-phase input using U_{RS}
- three-phase delta group
- three-phase star group.

Setting: Phi

The angle Phi determines the angle of the slip line and is monitored to detect slip. The impedances Z_A , Z_B and Z_C lie on this line.

Phi is also used to check power direction, i.e. the polarity of the c.t.'s:

60°... 90°	c.t. neutral on the line side i.e. connection according to Fig. 12.4
240°...270°	c.t. neutral on the generator side.

Setting: Z_A

Z_A is the impedance of the slip line and marks the limit of zone 2. It is also used for measuring phase-angle (see 'WarnAngle' and 'TripAngle').

Z_A should be set to the impedance between the location of the protection and the off-load voltage of the equivalent circuit for the entire power system.

Setting: Z_B

Z_B is the impedance of the slip line in the reverse direction and marks the limit of zone 1. It is also used for measuring phase-angle (see 'WarnAngle' and 'TripAngle').

Z_B should be set to the generator reactance X_d' in the reverse direction (negative sign).

Setting: Z_C

Z_C divides the slip line into two zones. Zone 1 lies between Z_B and Z_C and zone 2 between Z_C and Z_A .

Z_C should be set to the impedance from the location of the protection up to the first busbar.

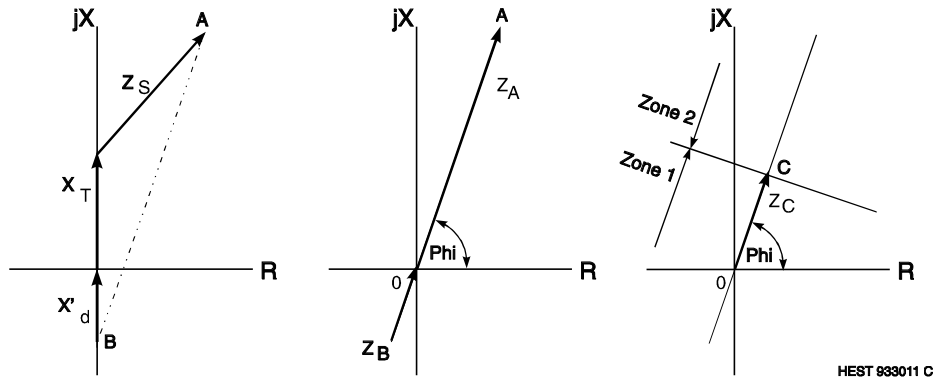


Fig. 3.5.26.2 Determining the settings for Z_A , Z_B , Z_C , and Φ according to X_d' , X_T and Z_S .

Setting: WarnAngle

The rotor angle is given by the triangle bounded by the instantaneous impedance and the impedances Z_A and Z_B . The protection, however, measures the angle between the instantaneous voltage and the rotor voltages E_A and E_B , which closely approximates the impedance triangle.

The setting for 'WarnAngle' can be set between 0° and 180° and determines the rotor angle above which alarm of imminent slipping is given.

With the 'WarnAngle' = 0° , alarm is given immediately the rotor angle changes, providing it lies within the pick-up range.

'WarnAngle' enables the operating status of the generator to be corrected, because its rotor angle setting is reached before the first slip. The machine can normally be stabilised for rotor angles up to 135° , for example, by changing the excitation or switching in compensators.

For a setting of 'WarnAngle' = 180° , alarm is not given until the first slip takes place, i.e. at the same time as the signal for zone 1 or zone 2.

Typical setting: WarnAngle = 110° .

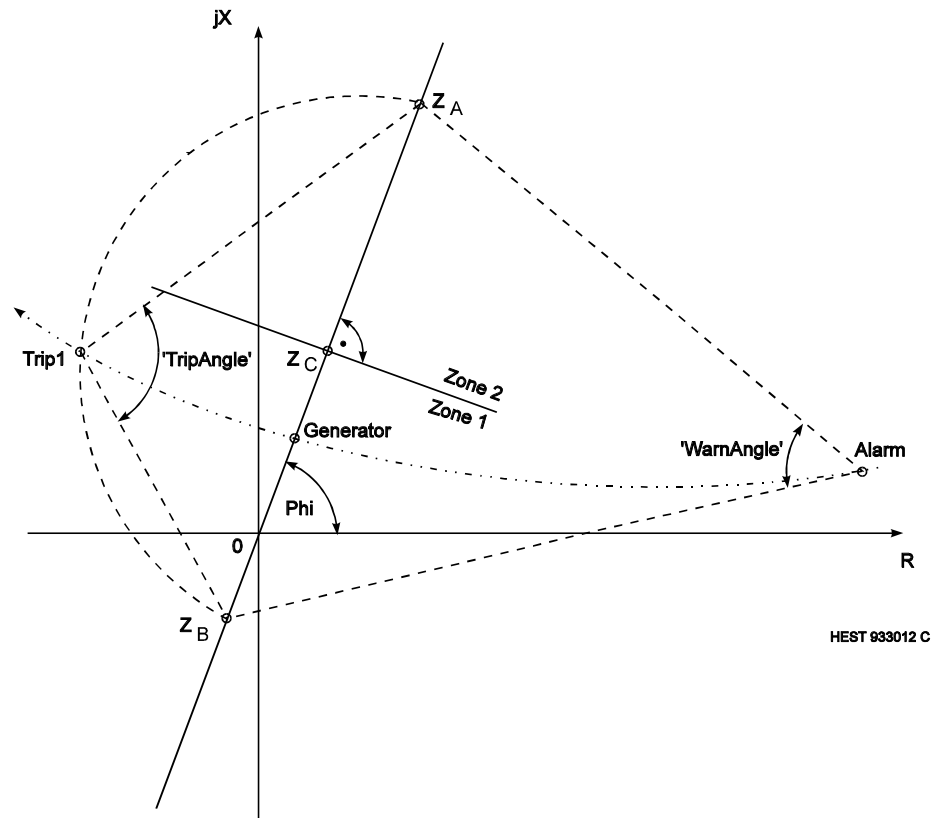


Fig. 3.5.26.3 Example of the operation for $n1 = 1$,
WarnAngle = 53° and TripAngle = 96°

Setting: TripAngle

Phi is evaluated in relation to 'TripAngle' when one of the zones has reached its number of slips, i.e. $n \geq n1$ or $n2$.

For a setting of 'TripAngle' = 180°, the tripping command 'Trip1' and the signals 'Trip1' and 'Trip2' are issued immediately.

For a setting of 'TripAngle' = 0°, these signals are only issued when the slip detector has reset, i.e. when the generator is again close to synchronism with the power system.

A setting of 'TripAngle' between 180° and 0° (typically 90°) determines the rotor angle at which tripping takes place and the signals are generated.

The setting at which tripping should take place is determined according to an operating point that

- occurs shortly after the last permissible slip
- is favourable for the circuit-breaker (least stress due to reignition)

Typical setting: 'TripAngle' = 90°.

Settings: n1, n2, t-Reset

The number of slips $n1$ or $n2$ that may be considered permissible depends on the generator being protected and must be stated by the manufacturer.

For settings of $n1$ and $n2 \leq 1$, the reset time 't-Reset' can be set to any low value.

For settings of $n1$ or $n2 > 1$, 't-Reset' must not be set lower than the period $1/f_S$ of the lowest slip frequency f_S to be detected. Slip frequencies from 0.2 Hz upwards are reliably detected using the typical setting of 5 seconds.

3.5.27. *Inverse definite minimum time earth fault overcurrent function (I0-Invers)*

A. Application

Overcurrent function with IDMT characteristic. A typical application is as back-up for the E/F protection function, in which case it measures $3 I_0$ either supplied from an external source or internally derived.

B. Features

- Tripping characteristic according to British Standard 142 (see Fig. 3.5.27.1):
 - $c = 0.02$: normal inverse
 - $c = 1$: very inverse and long time earth fault
 - $c = 2$: extremely inverse.
- DC component filter
- harmonic filter
- external $3 I_0$ signal or $3 I_0$ internally derived from the three phase currents
- wider setting range than specified in BS 142.

C. Inputs and outputs

I. C.t./v.t. inputs

- Current

II. Binary inputs

- Blocking

III. Binary outputs

- Starting
- Tripping

IV. Measurements

- Neutral current.

D. IDMT function settings - I0-Invers

Summary of parameters:

Text	Units	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
Trip		00000000			
c-Setting		1.00	(Select)		
k1-Setting	s	013.5	0.01	200.0	0.01
I-Start	IB	1.10	1.00	4.00	0.01
t-min.	s	00.0	00.0	10.0	0.1
NrOfPhases		1	1	3	2
CurrentInp	CT/VT-Addr	0			
IB-Setting	IN	1.00	0.04	2.50	0.01
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr	ER			

Explanation of parameters:**ParSet 4..1**

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

Tripping logic (matrix).

c-Setting

Setting for the exponential factor determining the shape of the operating characteristic according to BS 142 or for selecting the RXIDG characteristic.

k1-Setting

Constant determining the tripping characteristic.

I-Start

Pick-up setting (initiates the tripping characteristic).

t-min.

Definite minimum time of the tripping characteristic.

NrOfPhases

Number of phases evaluated for measurement:

- 1 : neutral current direct from an c.t. input
- 3 : neutral current derived internally from the three phases.

CurrentInp

defines the c.t. input channel. All the current channels are available for selection. In the case of a three-phase measurement, the first channel (R phase) of the group of three must be selected.

IB-Setting

Reference current to take account of discrepancies with respect to I_N .

BlockingInp

I/P for the external blocking signal.

- F: - unused
- T: - function always blocked
- xx: - all binary I/P's (or O/P's of protection functions).

Trip

Tripping signal.

Start

Pick-up signal.

E. Setting instructions

Protection function enable 'I-Start'

The IDMT function starts to run when the current applied to the function exceeds the setting 'I-Start'. 'I-Start' is normally set to $1.1 I_B$.

Choice of tripping characteristic 'c'

The shape of the IDMT characteristic is determined by the constant 'c'.

The standard IDMT characteristics according to BS 142 are:

"normal inverse"	: $c = 0.02$
"very inverse" and "long time earth fault"	: $c = 1.00$
"extremely inverse"	: $c = 2.00$

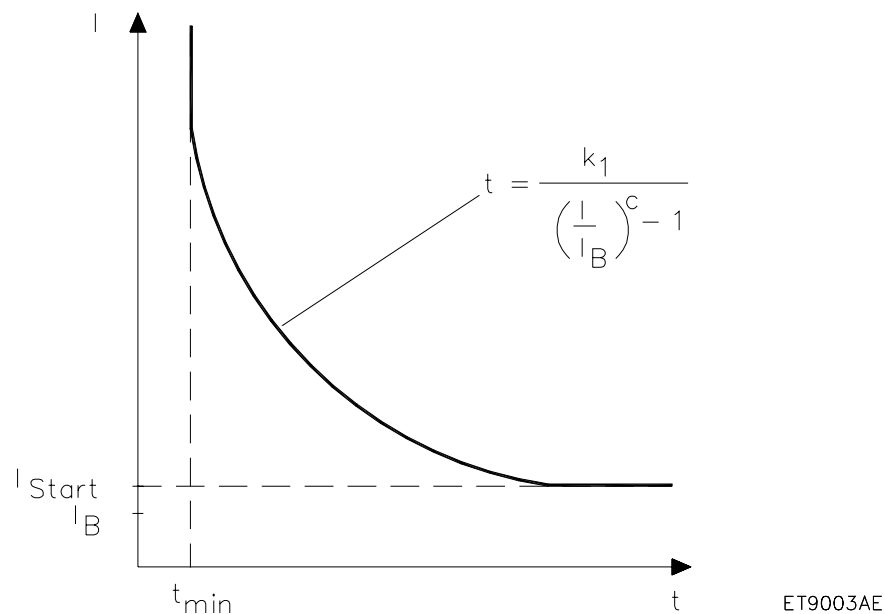


Fig. 3.5.27.1 IDMT tripping characteristic for 'I0-Invers' ($I = 3 I_0$)

"c-Setting" can also be set to "RXIDG", in which case the function's inverse characteristic corresponds to that of the relay Type RXIDG:

$$t [s] = 5.8 - 1.35 \ln (I/I_B)$$

The parameter "k1-Setting" has no influence in this case.

Time multiplier 'k1-Setting'

Discriminative operation of the relays along a line is achieved by time-grading. Assuming all the relays to be set to the same I_B , this involves setting the time multiplier in equal steps (grading time), increasing from the load towards the source.

For example, in the case of the "very inverse" characteristic, the constant $c = 1$ and the factor $k1 \leq 13.5$. The operating time t is then given by

$$t = \frac{k1}{\left(\frac{3I_0}{I_B}\right)^c - 1}$$

Assuming the grading time of the protection functions to be 0.5 s at $6 \times I_B$, the settings of $k1$ according to the formula

$$k1 = 5 t$$

for operating times between 0.5 and 2.5 s become:

t [s]	k1 [s]
0.5	2.5
1	5
1.5	7.5
2	10
2.5	12.5

The characteristics according to BS 142 are set as follows:

"normal inverse"	: $k1 = 0.14$ s
"very inverse"	: $k1 = 13.5$ s
"extremely inverse"	: $k1 = 80$ s
"long time earth fault"	: $k1 = 120$ s.

Definite minimum time 't-min.'

Where the IDMT function is being applied as back-up protection for a directional E/F protection, the definite minimum time 't-min.' must be set as follows

$$t_{\text{min.}} = t_{\text{basic}} + t_{\text{comp}}$$

t_{basic} = basic time of the E/F function

t_{comp} = comparison time of the E/F function (1 s).

Interconnections between IDMT and directional E/F functions

The IDMT protection is non-directional.

Directional operation can, however, be achieved by linking the directional signal ('MeasFwd', i.e. fault in forwards direction) from the E/F protection to the blocking I/P of the IDMT function. The I/P must be inverted so that blocking of the IDMT function is cancelled by an active forwards signal.

When using this arrangement, it must be noted that, when 'MeasFwd' does not pick up, the IDMT function cannot trip when the reference voltage of the E/F function is too low. If tripping is required for this case, the directional E/F signal 'MeasBwd' must be applied to the blocking input.

Applications with single-phase reclosure

In schemes involving single-phase reclosure, the 'IO-Invers' function has to be blocked for the time that one pole of a circuit-breakers is open if the minimum tripping time 'tmin' is set less than the single-phase dead time. This avoids false three-phase tripping due to the load currents in the healthy phases.

Typical settings:

IB	to be calculated
I-Start	1.1 IB
c	depends on the protected unit
k1	to be calculated
t-min.	0.00

3.5.28. Breaker failure protection (*BreakerFailure*)

A. Application

- Redundant tripping schemes (RED ¹⁾)
- Repeated tripping attempts (BFP ²⁾)
- Backup tripping (BFP)
- End fault protection (EFP ³⁾)
- Unconditional tripping (UT ⁴⁾)
- External trip initiation.

B. Features

- insensitive to DC component
- insensitive to harmonics
- single or three-phase operation
- blocking
- two independent timers (t1, t2)
- transfer tripping
- provision for disabling features (RED, BFP, EFP, UT)
- unique ID for each binary input and output.

C. Inputs and outputs

I. C.t./v.t. inputs

- current.

II. Binary inputs

- 13205 Block BFP
- 13710 Start L1
- 13720 Start L2
- 13730 Start L3
- 13740 Start L1L2L3
- 13705 External start
- 13770 CB Off
- 13775 CB On
- 13780 Ext. trip t2
- 13785 Ext. trip EFP

¹⁾ Redundant

²⁾ Breaker failure protection

³⁾ End fault protection

⁴⁾ Unconditional trip

III. Binary outputs

- 23305 Trip t1
- 23315 Trip t1 L1
- 23320 Trip t1 L2
- 23325 Trip t1 L3
- 23310 Trip t2
- 23340 Remote trip
- 23345 Red. Trip L1
- 23350 Red. Trip L2
- 23355 Red. Trip L3
- 23375 EFP Rem trip
- 23370 EFP Bus trip
- 23330 Repeat trip after t1
- 23360 Unconditional trip after t1
- 23380 External trip after t1
- 23335 Backup trip after t2
- 23365 Unconditional trip after t2

IV. Measurements

- Current amplitude L1
- Current amplitude L2
- Current amplitude L3

D. Breaker failure protection settings – BreakerFailure

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
CB commands					
TRIP t1		B00000000			
TRIP t1 L1		B00000000			
TRIP t1 L2		B00000000			
TRIP t1 L3		B00000000			
TRIP t2		B00000000			
REMOTE TRIP		B00000000			
RED TRIP L1		B00000000			
RED TRIP L2		B00000000			
RED TRIP L3		B00000000			
EFP REM TRIP		B00000000			
EFP BUS TRIP		B00000000			

General parameters

ParSet4..1		P1	(Select)		
I Setting	IN	1.20	0.20	5.00	0.01
Delay t1	s	0.15	0.02	60.00	0.01
Delay t2	s	0.15	0.02	60.00	0.01
Delay tEFP	s	0.04	0.02	60.00	0.01
t Drop Retrip	s	0.05	0.02	60.00	0.01
t Drop BuTrip	s	0.05	0.02	60.00	0.01
t Puls RemTrip	s	0.05	0.02	60.00	0.01
t1 active		on	(Select)		
t2 active		on	(Select)		
RemTrip active		on	(Select)		
EFP active		on	(Select)		
Red active		on	(Select)		
Start Ext act.		on	(Select)		
RemTrip after		t1	(Select)		
NrOfPhases		3	1	3	2
CurrentInp	CT/VT-Addr	0			
Block BFP	BinaryAddr	F			

Text	Unit	Default	Min.	Max.	Step
Start L1	BinaryAddr	F			
Start L2	BinaryAddr	F			
Start L3	BinaryAddr	F			
Start L1L2L3	BinaryAddr	F			
External Start	BinaryAddr	F			
CB Off	BinaryAddr	F			
CB On	BinaryAddr	F			
Ext Trip t2	BinaryAddr	F			
Ext Trip EFP	BinaryAddr	F			
Trip t1	SignalAddr	ER			
Trip t1 L1	SignalAddr	ER			
Trip t1 L2	SignalAddr	ER			
Trip t1 L3	SignalAddr	ER			
Trip t2	SignalAddr	ER			
Remote Trip	SignalAddr	ER			
Red Trip L1	SignalAddr	ER			
Red Trip L2	SignalAddr	ER			
Red Trip L3	SignalAddr	ER			
EFP Rem Trip	SignalAddr	ER			
EFP Bus Trip	SignalAddr	ER			
Retrip t1	SignalAddr	ER			
Uncon Trip t1	SignalAddr	ER			
Ext Trip t1	SignalAddr	ER			
Backup Trip t2	SignalAddr	ER			
Uncon Trip t2	SignalAddr	ER			

Explanation of parameters:

TRIP t1

defines the tripping channel activated by the function's tripping output TRIP t1 (matrix tripping logic). This output is activated for a 'Retrip', 'External Trip Initiate' or 'Unconditional Trip'.

TRIP t1 L1, L2 or L3

defines the tripping channel activated by the function's tripping outputs TRIP t1 L1, L2 or L3 (matrix tripping logic). This output is activated for a phase segregated 'Retrip'.

TRIP t2

defines the tripping channel activated by the function's tripping output TRIP t2 (matrix tripping logic). This output is activated for a 'Backup Trip' or 'Unconditional Trip' the after second time step t2.

REMOTE TRIP

defines the tripping channel activated by the function's tripping output REMOTE TRIP (matrix tripping logic).

RED TRIP L1, L2 or L3

defines the tripping channel activated by the function's tripping outputs RED TRIP L1, L2 or L3 (matrix tripping logic).

EFP REM TRIP

defines the tripping channel activated by the function's tripping output EFP REM TRIP (matrix tripping logic).

EFP BUS TRIP

defines the tripping channel activated by the function's tripping output EFP BUS TRIP (matrix tripping logic).

ParSet 4..1

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

I Setting

Pick-up of the current criterion for the breaker failure protection (BFP), end fault protection (EFP) and the redundant tripping logic (RED).

Delay t1

'Retrip' tripping delay

Delay t2

Backup tripping delay.

Delay tEFP

End fault protection delay.

t Drop Retrip

Reset delay for 'Retrip', 'Redundant Trip' and 'External Trip Initiate'.

t Drop BuTrip

Reset delay for backup tripping attempt.

t Puls RemTrip

Transfer tripping impulse width.

t1 active

defines whether timer t1 is enabled or disabled.

'on' Timer t1 enabled

'off' Timer t1 disabled.

t2 active

defines whether timer t2 is enabled or disabled.

'on' Timer t2 enabled

'off' Timer t2 disabled.

RemTrip active

defines whether transfer tripping is enabled or disabled.

'on' Transfer tripping enabled

'off' Transfer tripping disabled.

EFP active

defines whether the end fault protection is enabled or disabled.

'on' End fault protection enabled

'off' End fault protection disabled.

Red active

defines whether the redundant logic is enabled or disabled.

'on' Redundant tripping logic enabled

'off' Redundant tripping logic disabled.

Start Ext active

defines whether the unconditional tripping logic is enabled or disabled.

'on' Unconditional tripping logic enabled

'off' Unconditional tripping logic disabled.

RemTrip after

defines the delay for transfer tripping.

't1' after BFP time t1

't2' after BFP time t2.

NrOfPhases

defines the number of phases supervised.

'1' single-phase operation

'3' three-phase operation.

CurrentInp

defines the c.t. input channel. Single and three-phase c.t.'s can be set. The first channel (R phase) of the group of three selected must be specified for three-phase c.t.'s.

Block BFP

Input for blocking the function.

F: not blocked

T: blocked

xx: all binary inputs (or outputs of protection functions).

Start L1, L2 or L3

BFP or RED Start in phase L1, L2 or L3

F: disabled

T: enabled

xx: all binary inputs (or outputs of protection functions).

Start L1L2L3

BFP or RED Start in all three phases

F: disabled

T: enabled

xx: all binary inputs (or outputs of protection functions).

External Start

starts the unconditional trip.

F: disabled

T: enabled

xx: all binary inputs (or outputs of protection functions).

CB Off

signals that the circuit-breaker is fully open and also used to start the end zone fault protection.

F: CB not fully open

T: CB fully open

xx: all binary inputs (or outputs of protection functions).

CB On

signals that the circuit-breaker is fully closed.

F: CB not fully closed

T: CB fully closed

xx: all binary inputs (or outputs of protection functions).

Ext Trip t2

Input for signals from the other BFP units in the station.

- F: No external trip after t2
T: External trip after t2
xx: all binary inputs (or outputs of protection functions).

Ext Trip EFP

Input for signals from the end zone fault outputs of the other BFP units in the station.

- F: No trip for end zone fault
T: Trip for end zone fault
xx: all binary inputs (or outputs of protection functions).

Trip t1

signals a trip which is activated by one of the following logics:

- Repeat trip (see "Retrip t1")
- External trip (see "Ext Trip t1")
- Unconditional trip (see "UnconTrip t1").

Trip t1 L1, L2 or L3

signals a repeat trip of phase L1, L2 or L3.

Trip t2

signals a backup trip. This signal is activated by the following logics:

- Backup trip after t2 (see "Backup Trip t2")
- Unconditional trip after t2 (see "UnconTrip t2").

Remote Trip

signals a transfer trip.

Red Trip L1, L2 or L3

signals a redundant trip of phase L1, L2 or L3.

EFP Rem Trip

signals an end zone trip. This signal is an impulse of length 't Puls Rem Trip' generated when the EFP timer has timed out.

EFP Bus Trip

signals an end zone trip. This signal is generated when the EFP timer has timed out and resets 'tDrop Bu Trip' after the initiating signal has reset.

Retrip t1

signals a repeat trip after t1. This signal is generated when the BFP timer t1 in one of the phases has timed out.

Uncon Trip t1

signals an unconditional trip after t1. This signal is generated when the UT timer t1 has timed out.

Ext Trip t1

signals an external trip. This signal is generated when either the input "Ext Trip t2" or "Ext Trip EFP" is enabled.

Backup Trip t2

signals a backup trip after t2. This signal is generated when the BFP timer t2 has timed out.

Uncon Trip t2

signals an unconditional trip after t2. This signal is generated when the UT timer t2 has timed out.

E. Setting instructions

Settings:

Pick-up current setting:	I Setting
Tripping delay:	Delay t1 Delay t2 Delay tEFP
Rest delay:	t Drop Retrip t Drop BuTrip
Impulse:	t Puls RemTrip
Enabled signals:	t1 active t2 active RemTrip active EFP active Red active Start Ext active.

Pick-up current setting “I Setting”

If the BFP current detector pick-up setting is too low, there is a possibility that the detectors may reset too late after it has successfully tripped the circuit-breaker. This can be caused by damped oscillations on the secondary side of the c.t.

On the other hand, if the setting is too high, the BFP may fail to operate at all should, for example, the current fall below pick-up again due to severe c.t. saturation. A typical setting for the pick-up current is just below the minimum fault current that can occur on the respective line.

Tripping delays t1 and t2

The tripping delay settings enable the BFP to be adapted to its particular operating environment (e.g. circuit-breaker characteristics etc.). Fig. 3.5.28.1 shows a typical timing diagram for clearing a fault.

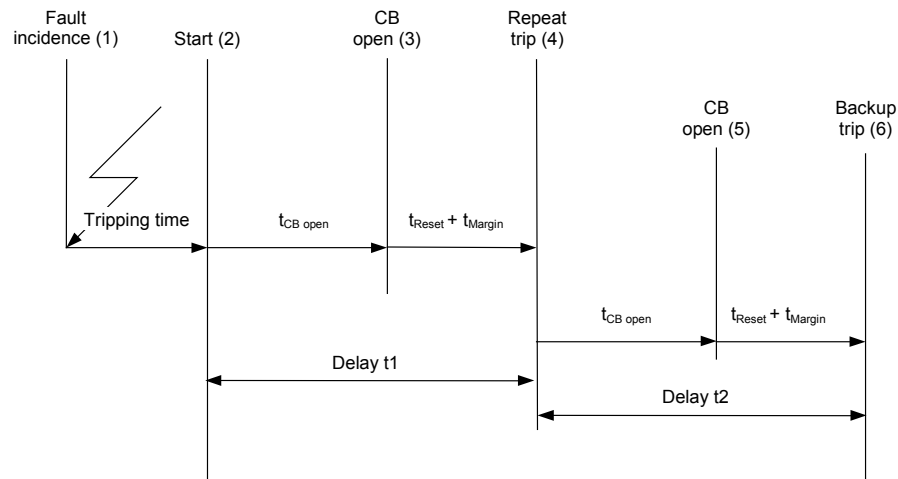


Fig. 3.5.28.1 Operation of the BFP/UT timers t1 and t2

Timing in the case of breaker failure:

- (1) A fault has occurred and been detected by a protective device.
- (2) A tripping command is transmitted to the circuit-breaker after the unit protection operating time which also starts the BFP. The tripping command can be either single (Start Lx) or three-phase (Start L1L2L3). The redundant signals are also activated at the same time.
- (3) The circuit-breaker ruptures the fault current.
- (4) After the reset delay t_{Reset} plus a safety margin t_{Margin} , the BFP either detects that the fault current has been interrupted and the protection function resets, or the fault current continues to flow and a second attempt is made by the BFP to trip the circuit-breaker.
- (5) The second attempt to trip the circuit-breaker is successful and the fault current is interrupted.

- (6) After a further reset delay t_{Reset} plus a safety margin t_{Margin} , the BFP either detects that the fault current has been interrupted and the protection function resets, or the fault current continues to flow and the BFP initiates backup tripping.

If the BFP is only required to carry out a single breaker failure step, timer t_1 can be disabled (see 't1 active'). The response of the BFP corresponds once again to Fig. 3.5.28.1, but with timer t_1 set to zero.

Timing in the case of an unconditional trip:

- (1) A fault has occurred and been detected by a protective device.
- (2) A signal at input 'Ext Start' starts the UT function.
- (3) The circuit-breaker ruptures the fault current.
- (4) If after the reset delay t_{Reset} plus a safety margin t_{Margin} , the CB auxiliary contact "CB On" still signals to the UT that the CB is closed, a second attempt is made by the UT function to trip the circuit-breaker.
- (5) The second attempt to trip the circuit-breaker is successful and the fault current is interrupted.
- (6) If after a further reset delay t_{Reset} plus a safety margin t_{Margin} the CB auxiliary contact "CB On" still signals to the UT that the CB is closed, backup tripping is initiated by the UT function.

$$\text{Delay } t_1 \geq t_{\text{CB open}} + t_{\text{Reset}} + t_{\text{Margin}}$$

$$\text{Delay } t_2 \geq t_{\text{CB open}} + t_{\text{Reset}} + t_{\text{Margin}}$$

$t_{\text{CB open}}$ CB opening time including arc extinction time

t_{Reset} Reset time of the current criterion ¹⁾

t_{Margin} Allowance for variations in normal fault clearing times ²⁾

¹⁾ see reset time of the current detector t_{Reset}

²⁾ see safety margin t_{Margin}

Tripping delay tEFP

The setting for tEFP can be seen from Fig. 3.5.28.2 which shows a typical timing diagram for tripping a fault.

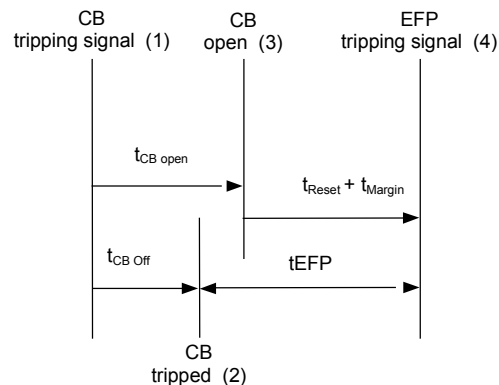


Fig. 3.5.28.2 Timing diagram for an end zone fault

- (1) Tripping command applied to the CB.
- (2) CB auxiliary contact sends a signal that the CB is open to the “CB Off” input of the function which is used to start the EFP.
- (3) The circuit-breaker ruptures the fault current.
- (4) After a reset delay plus a safety margin, the current unit either detects that the fault current has been interrupted and the EFP function resets, or the fault current continues to flow and an EFP signal is issued.

$$t_{EFP} \geq t_{CB\ open} - t_{CB\ Off} + t_{Reset} + t_{Margin}$$

$t_{CB\ open}$ CB opening time including arc extinction time

$t_{CB\ Off}$ CB opening time of the CB auxiliary contact (Signal „CB open“)

t_{Reset} Reset time of the current detector ³⁾

t_{Margin} Allowance for variations in normal fault clearing time ⁴⁾

³⁾ see reset time of the current detector t_{Reset}

⁴⁾ see Margin time t_{Margin}

Reset time of the current detector t_{Reset}

The current detector reset time is determined by the power system configuration as follows:

- Power system time constant up to 300 ms
- Fault current up to $40 I_N$

Primary c.t.'s TPX: $t_{\text{Reset}} = 28 \text{ ms } (I_{\text{Setting}} \geq 0.2 I_N)$

Primary c.t.'s TPY: $t_{\text{Reset}} = 28 \text{ ms } (I_{\text{Setting}} \geq 1.2 I_N)$
 $t_{\text{Reset}} = 38 \text{ ms } (I_{\text{Setting}} \geq 0.4 I_N)$

Safety margin t_{Margin}

A safety margin of 20 ms is recommended.

Reset times 't Drop Retrip' and 't Drop BuTrip'

The function includes two independently adjustable signal reset delays.

't Drop Retrip' determines the reset delay for the following signals:

23305 Trip t1
23315 Trip t1 L1
23320 Trip t1 L2
23325 Trip t1 L3
23345 Red Trip L1
23350 Red Trip L2
23355 Red Trip L3
23330 Retrip t1
23360 Uncon Trip t1
23380 Ext Trip t1.

't Drop BuTrip' determines the reset delay for the following signals:

23310 Trip t2
23370 EFP Bus Trip
23335 Backup Trip t2
23365 Uncon Trip t2.

Impulse ‘t Puls RemTrip’

‘t Puls RemTrip’ determines the width of the transfer tripping impulse for the following signals:

23340 Remote Trip

23375 EFP Rem Trip.

Enabling and disabling the various features

A number of the function’s features can be enabled and disabled.

t1 active

This setting provides facility for disabling the timer t1. When it is disabled, none of the “repeat trip” group of signals is generated.

t2 active

This setting provides facility for disabling the timer t2. When it is disabled, none of the “backup trip” group of signals is generated.

RemTrip active

This setting provides facility for disabling transfer tripping. When it is disabled, none of the “remote trip” group of signals is generated.

EFP active

This setting provides facility for disabling the end fault protection. When it is disabled, none of the “end fault” group of signals is generated.

Red active

This setting provides facility for disabling the redundant protection. When it is disabled, none of the “redundant” group of signals is generated.

Start Ext act.

This setting provides facility for disabling the unconditional trip feature. When it is disabled, none of the “unconditional trip” group of signals is generated.

3.6. Control functions

3.6.1. Control function (FUPLA)

A. Application

The control function is designed to perform data acquisition, monitoring, and control functions in MV and HV substations. The control logic of a switchgear bay can be configured for SF₆ gas-insulated switchgear (GIS), for indoor and outdoor switchgear and for single, double or multiple busbar stations.

The control function registers and processes the switchgear position signals, the measured variables and the alarms occurring in a switchgear bay. The corresponding data are then made available at the communication interface (IBB).

The control function receives instructions from the station control system (SCS) or from the local mimic, processes them in relation to the bay control logic configuration and then executes them.

The interlocks included in the control function device prevent inadmissible switching operations, which could cause damage to plant or endanger personnel.

B. Features

The control function depends on the particular application for which it is specifically created using CAP 316. It includes essentially:

- detection and plausibility check of switchgear position signals
- switchgear control
- interlocks
- monitoring of switchgear commands
- run-time supervision
- integration of the local mimic
- detection of alarms and alarm logic
- processing of measured variables.

Eight FUPLA functions can be configured. The total maximum size of FUPLA code for all the functions is 128 kB. The FUPLA function cannot be copied and not configured as 48th function. The function plan programming language CAP 316 is described in the publication 1MRB520059-Uen.

C. Inputs and outputs**I. C.t./v.t. inputs:**

- Constants, measured protection variables, IBB inputs and sampled values

II. Analogue outputs:

- Measured variable outputs

III. Binary inputs:

- Blocking input, binary input for blocking FUPLA
- Binary inputs from the IBB, the system and protection functions

IV. Binary outputs:

- Binary outputs to the IBB, the system, protection functions and for event processing

V. Measurements:

- Measured variable outputs.

3.6.1.1. Control function settings - FUPLA

When reconfiguring the FUPLA function, the directory where the files 'project1.bin' and 'project.cfg' are located must be entered before all other parameters. The project name in the file 'project1.bin' is used automatically as the name of the FUPLA function, but the name can be changed later.

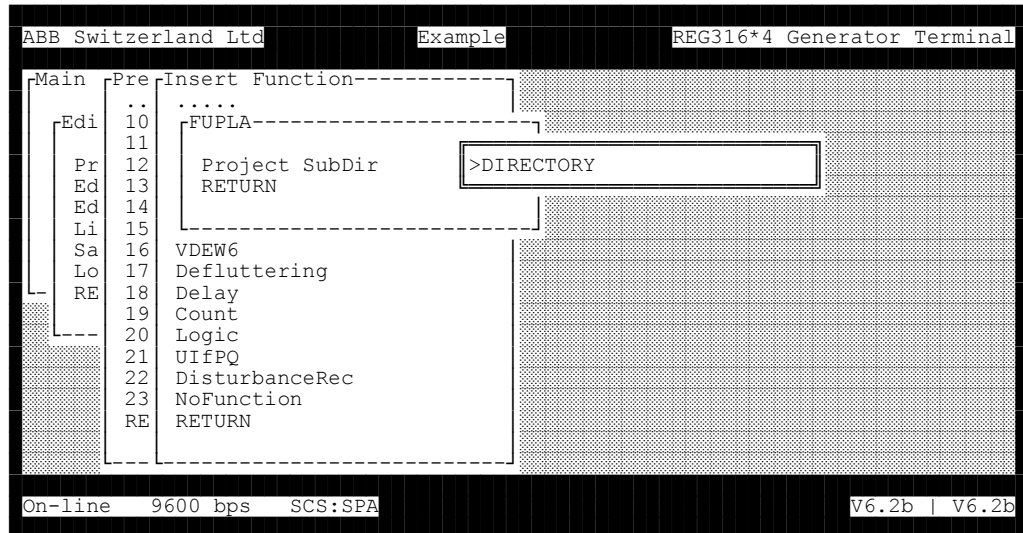


Fig. 3.6.1.1 Entering the FUPLA directory

The individual parameters can then be entered.

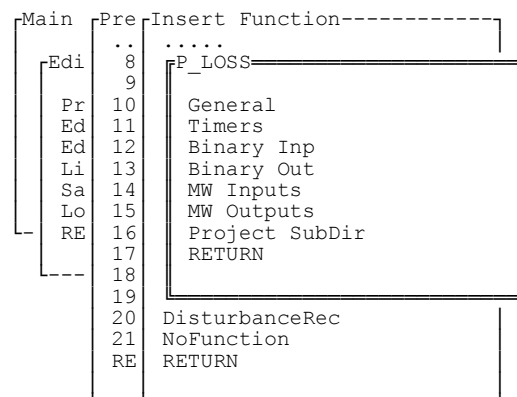


Fig. 3.6.1.2 Entering the individual parameters

3.6.1.1.1. General

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
RepetitRate		low	low	high	1
Cycl. time ho	ms	20	0	1000	1
Blocking	BinaryAddr	F			

Explanation of parameters:**ParSet 4..1**

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

RepetitRate

Determines the number of FUPLA runs per cycle.

high: four FUPLA runs per cycle

medium: two FUPLA runs per cycle

low: one FUPLA run per cycle.

Cycl. time

Determines the interval between FUPLA starts.

Blocking

(F → FALSE, T → TRUE, system binary input, protection function binary output or input via the IBB).

This blocks FUPLA.

3.6.1.1.2. **Timers**

EXTIN signals of the time factor type and signals belonging to the TMSEC group are displayed in this window.

The signals can be connected to the following sources:

- **Measured variable constant**

Setting range and resolution:

TMSEC signal group:	0...60.000 s,	for TON
	0...50.00 s,	for TONS
TIMEFACTOR signal group:	0...4000 s,	for TONL

- **Protection function binary output (measured variable)**

Observe the factors ms (TON), 10 ms (TONS), 1 s (TONL).

- **Input from the IBB**

Observe the factors ms (TON), 10 ms (TONS), 1 s (TONL).

3.6.1.1.3. **Binary inputs**

Binary inputs can be connected to the following sources:

- Always ON ("1")
- Always OFF ("0")
- Binary system inputs
- Protection function binary outputs
- Inputs from the IBB: 768 inputs in 24 groups of 32 signals each.

3.6.1.1.4. **Binary signals**

Binary signals can be connected to the following sinks:

- LED's
- Signalling relays
- Event processor (excluding 'BinExtOut' blocks)
- Protection function binary inputs
- Tripping channels
- Outputs to the IBB: 768 inputs in 24 groups of 32 signals each.

3.6.1.1.5. Measurement inputs

Measurement inputs can be connected to the following sources:

- Measured variable constant, integer or percent range.
- Protection function measured variable, the range for angles is $\pm 180.00^\circ$ and currents and voltages are transferred in the corresponding units.
- Input from the IBB, integer range.
- C.t./v.t. input channels.

3.6.1.1.6. Measurement outputs

Measurement outputs can be connected to the following sinks:

- Measurements Nos. 1...64.

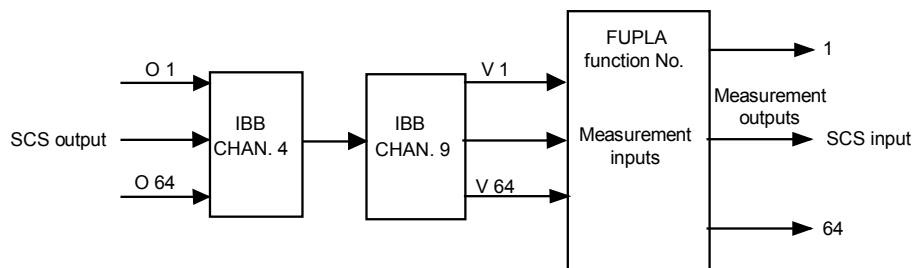
3.6.1.1.7. Flow chart for measurement inputs and outputs

Fig. 3.6.1.3 Flowchart for measured variable inputs and outputs

IBB channel No. 4 is write-only and IBB channel No. 9 read-only. The range of values for IBB channel No. 4 is -32768...+32767 which corresponds to a 16 Bit integer.

3.6.1.2. **Loading FUPLA**

The FUPLA code has to be loaded again each time the FUPLA configuration is changed. After making internal FUPLA changes and copying the new versions of the files 'project1.bin' and 'project.cfg' to the FUPLA directory, select "Editor" from the main menu and then 'RETURN' to load the new FUPLA code.

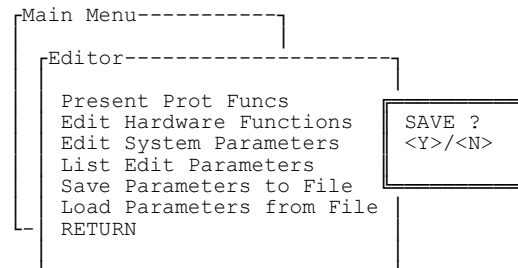


Fig. 3.6.1.4 Editor, Save ?

3.6.2. **Logic (Logic)**

A. Application

Logical combination of binary input signals or of output signals from the protection functions, e.g. for

- specific signals required by the application
- supplementary protection functions.

B. Features

- binary I/P channels assignable to
 - binary I/P signals
 - protection function O/P signals
- All I/P channels can be inverted
- Following logic functions available for selection:
 - OR gate with 4 I/P's
 - AND gate with 4 I/P's
 - R/S flip-flop with 2 I/P's for setting and 2 I/P's for resetting:
 - The O/P is "0", if at least one of the reset I/P's is "1".
 - The O/P is "1", if at least one of the set I/P's is "1" AND none of the reset I/P's is "1".
 - The O/P status is sustained when all the I/P's are at "0".
- Every logic has an additional blocking I/P, which when activated switches the O/P to "0".

C. Inputs and outputs

I. C.t./v.t. inputs:

- none

II. Binary inputs:

- 4 logic inputs
- blocking

III. Binary O/P's:

- tripping

IV. Measurements:

- none.

D. Logic function settings - Logic

Summary of parameters:

Text	Units	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
Trip		00000000			
Logic Mode		OR	(Select)		
BinOutput	SignalAddr	ER			
BlockInp	BinaryAddr	F			
BinInp1 (R1)	BinaryAddr	F			
BinInp2 (R2)	BinaryAddr	F			
BinInp3 (S1)	BinaryAddr	F			
BinInp4 (S2)	BinaryAddr	F			

Explanation of parameters:

ParSet 4..1

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

Definition of the tripping circuit excited by the function's O/P (tripping matrix).

Logic Mode

Definition of the logic function to be performed by the 4 binary I/P's. Possible settings:

- OR: OR gate with all 4 binary I/P's
- AND: AND gate with all 4 binary I/P's
- R/S flip-flop: Flip-flop with 2 set I/P's (S1 and S2) and 2 reset I/P's (R1 and R2). The O/P is set or reset when at least one of the corresponding I/P's is at logical "1" (OR gate). Reset I/P's take priority over the set I/P's.

BinOutput

Output for signalling a trip.

BlockInp

Input for blocking the function.

- F: - not used
- xx: - all binary inputs (or outputs of protection functions).

The O/P is always at logical "0" when the blocking I/P is at logical "1".

The blocking I/P acts as a reset I/P for the flip-flop function.

BinInp1 (R1), BinInp2 (R2), BinInp3 (S1), BinInp4 (S2)

Binary inputs 1 to 4 (AND or OR function)

Reset inputs 1 and 2 and set inputs 1 and 2 (RS flip-flop)

- F: - not used (OR logic or RS flip-flop)
- T: - not used (AND logic)
- xx: - all binary inputs (or outputs of protection functions).

3.6.3. ***Delay / integrator (Delay)***

A. Application

General purpose timer for

- integration of pulsating binary signals to obtain a continuous signal, e.g. output of the loss-of-excitation function (out-of-step protection) or reverse power protection
- extension of short I/P signals (pulse prolongation)
- simple time delay.

B. Features

- I/P channel and blocking input assignable to
 - binary I/P signals
 - protection function output signals
- I/P channel and blocking input can be inverted.
- adjustable reset time
- 2 types of time delay
 - Integration: Only the time during which the I/P signal is at logical "1" counts at the end of the time delay.
 - No integration: The total time from the instant the timer starts until it is either reset or expires counts.

C. Inputs and outputs

I. C.t./v.t. inputs:

- none

II. Binary inputs:

- input signal
- blocking

III. Binary outputs:

- pick-up
- tripping

IV. Measurements:

- time from the instant the timer starts.

D. Delay/integrator function settings - Delay

Summary of parameters:

Text	Units	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
Trip		00000000			
Trip-Delay	s	01.00	00.00	300.00	0.01
Reset-Delay	s	00.01	00.00	300.00	0.01
Integration	0/1	0	0	1	1
BinaryInp	BinaryAddr	F			
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr	ER			

Explanation of parameters:

ParSet 4..1

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

Definition of the tripping logic (matrix) excited by the function's output.

Trip-Delay

Time between start signal at the input and the tripping signal at the output.

Reset-Delay

Time required for the timer to reset after the input signal has disappeared.

Integration

Determination of the response of the function in the presence of a pulsating I/P signal:

- 0: The delay continues to run, providing the I/P signal does not disappear for longer than the reset time ([see Fig. 3.6.3.1](#)).
- 1: The time during which the I/P is at logical "1" is integrated, i.e. tripping does not take place until the sum of logical "1" time equals the set delay time ([see Fig. 3.6.3.2](#)).

BinaryInp

Timer input.

xx: - all binary inputs (or outputs of protection functions).

BlockInp

Input for blocking the function.

F: - enabled

T: - disabled

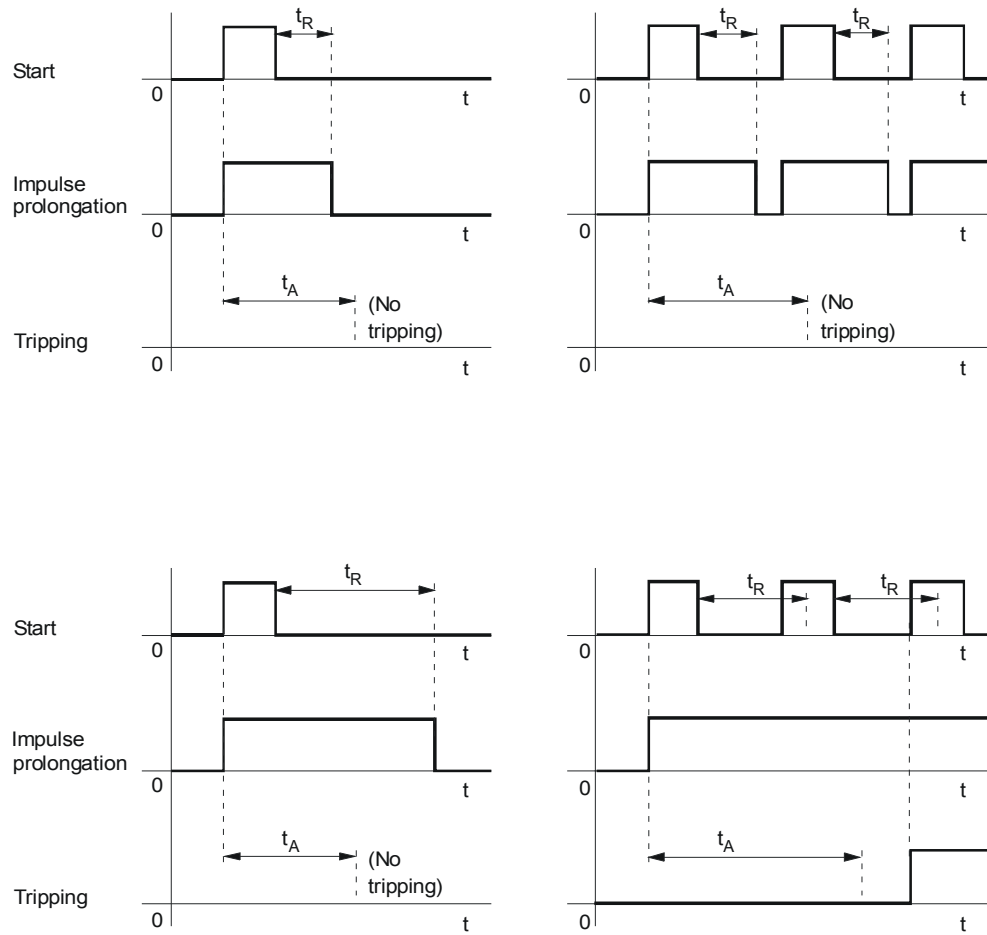
xx: - all binary inputs (or outputs of protection functions).

Trip

Tripping signal.

Start

Pick-up signal.



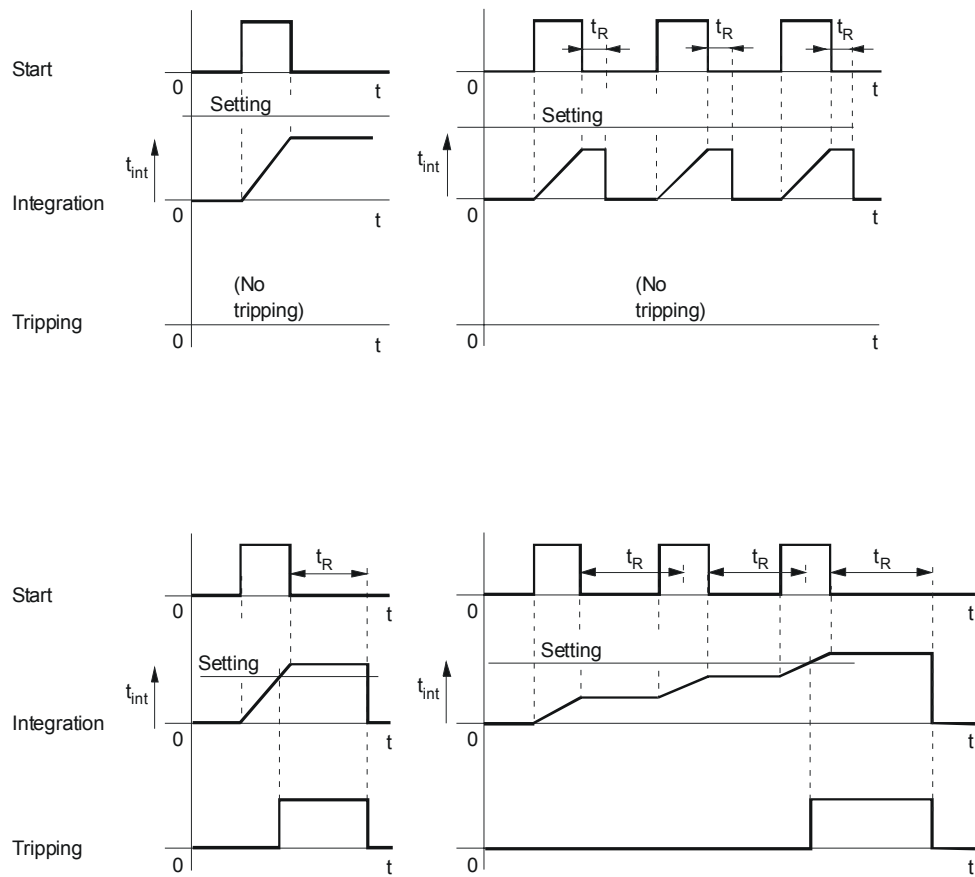
HEST 935 019 C

Note: Tripping only takes place, if a start also occurs within the time t_R .

t_A tripping time ("Trip-Delay")

t_R reset time ("Reset-Delay")

Fig. 3.6.3.1 Operation of the "Delay" function without integration



HEST 935 020 C

t_{int} integrated time for tripping
 t_R reset time ("Reset-Delay")
 Setting "Trip-Delay"

Fig. 3.6.3.2 Operation of the "Delay" function with integration

3.6.4. *Contact bounce filter (Debounce)*

A. Application

Suppresses the contact bounce phenomena of binary signals. This function is only used for the signals of binary input modules.

B. Features

- Adjustable maximum bounce time
- The first edge of the respective input signal is prolonged by the time 'SupervisTime'.

C. Inputs and outputs

I. C.t./v.t. inputs:

- none

II. Binary inputs:

- Binary signals (input signals)
- blocking

III. Binary outputs:

- none

IV. Measurements:

- none.

D. Contact bounce filter settings - Debounce

Summary of parameters:

Text	Units	Default	Min.	Max.	Step
BinInp 1	BinaryAddr	F			
SupervisTime	Setting	1 ms	1 ms	10000 ms	1 ms
BinInp 2	BinaryAddr	F			
SupervisTime	Setting	1 ms	1 ms	10000 ms	1 ms
BinInp 3	BinaryAddr	F			
SupervisTime	Setting	1 ms	1 ms	10000 ms	1 ms
.					
.					
BinInp 16	BinaryAddr	F			
SupervisTime	Setting	1 ms	1 ms	10000 ms	1 ms

Explanation of parameters:

BinInp 1...16

Binary inputs Nos. 1...16

F: - not used

xx: - all binary inputs.

SupervisTime

Maximum bounce time setting.

E. Setting instructions

The first edge of the input signal is prolonged by the time set for 'SupervisTime'.

Connect functions requiring filtered signals to the correct binary inputs to start with.

The contact bounce filter 'Debounce' may only be configured once per set of parameters.

3.6.5. LDU events (*LDUevents*)

A. Application

Generates events that can be viewed on the local display unit (LDU) and provides facility for setting a user name.

B. Features

- binary input that can be set by
- a binary input signal
- an output signal from a protection function
- provision for inverting signals applied to the inputs
- direct connection of input to output: input 1 controls output 1, input 2 control output 2 etc.
- additional blocking input for entire function: all outputs are reset to logical "0" when blocking input at logical "1".

An event lists the name of the signal connected to the input and not the name of the output.

C. Inputs and outputs

I. C.t./v.t. inputs:

- none

II. Binary inputs:

- 4 independent inputs
- blocking

III. Binary outputs:

- 4 independent outputs

IV. Measurements

- none.

D. LDU event function settings – LDUEvents

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
Trip		000000000			
BlockInp	BinaryAddr	F			
BinInput1	BinaryAddr	F			
BinInput2	BinaryAddr	F			
BinInput3	BinaryAddr	F			
BinInput 4	BinaryAddr	F			
BinOutput1	SignalAddr	ER			
BinOutput2	SignalAddr	ER			
BinOutput3	SignalAddr	ER			
BinOutput4	SignalAddr	ER			

Explanation of parameters:

ParSet 4..1

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

Does not perform any function, always “0”.

BlockInp

Binary address used as blocking input.

F: - not used

xx: - all binary inputs (or outputs of a protection function).

All outputs at logical “0” when the blocking input is active.

BinInput1, BinInput2, BinInput3, BinInput4

Binary inputs 1 to 4: Every input acts directly on the corresponding output and can only be influenced by the inversion and blocking parameters.

BinOutput1, BinOutput2, BinOutput3, BinOutput4

Signalling outputs 1 to 4: Every input acts directly on the corresponding output. Whether an output is recorded as an event can be enabled or disabled. When it is enabled, it appears on the local display.

Note:

In contrast to all other functions, the name of the signal connected to the corresponding input appears in the event list instead of the name of the output. A function can therefore be given a descriptive, easily understood name that appear in the event list and on the local display.

3.6.6. Counter (Counter)

A. Application

General counters, e.g. for

- counting the output impulses of the field failure or reverse power protection functions
- prolongation of short input signals.

B. Features

- Input channel and blocking input can be set by
 - Binary input signals
 - Output signal from a protection function
- Provision for inverting signals applied to the inputs.

C. Inputs and outputs

I. C.t./v.t. inputs

- None

II. Binary inputs

- Input signal
- Blocking

III. Binary outputs

- Start
- Trip

IV. Measurements

- Count reached.

D. Counter settings - Count

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
Trip		00000000			
Count-Thresh		1	1	100	1
Drop-Time	s	00.04	00.01	30.00	00.01
Reset delay	s	010.0	000.1	300.0	000.1
BinaryInp	BinaryAddr	F			
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr	ER			

Explanation of parameters:

ParSet 4..1

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

defines the tripping channel activated by the tripping O/P of the function (matrix tripping logic).

Count-Thresh

Number of input impulses counted by the counter before it trips.

Drop time

Time the counter output signal is maintained after the input signal causing it has reset.

Reset-Delay

Time after the input signal has reset before the counter is reset to zero if it did not trip.

BinaryInp

Counter input

xx: - all binary inputs (or outputs of protection functions).

BlockInp

defines the input for an external blocking signal.

F: - function enabled

T: - function disabled

xx: - all binary inputs (or outputs of protection functions).

Trip

Tripping signal.

Start

Pick-up signal.

3.7. Measurement functions

3.7.1. Measurement function (UlfPQ)

A. Application

Measurement of voltage, current, real and apparent power and frequency, e.g. for display on the monitor of the control unit or for transferring to a high level station control system for further processing.

B. Features

- single-phase measurement (1 voltage and 1 current I/P)
- phase-to-ground or optionally phase-to-phase voltage measurement (providing three-phase Y connected v.t's are installed)
- evaluation of the fundamental frequency components
- high accuracy in the frequency range $(0.9 \dots 1.1) f_N$
- frequency of voltage measured unless voltage too low, in which case current is measured; if both are too low, the result is set to rated frequency
- at least 1 measurement per second
- filters for voltage and current DC components
- filters for voltage and current harmonics
- provision for compensation of connection and measurement phase errors.

C. Inputs and outputs

I. C.t./v.t. inputs

- voltage
- current

II. Binary inputs

- none

III. Binary outputs

- none

IV. Measurements:

- voltage (unit UN)
- current (unit IN)
- real power (unit PN (P))
- apparent power (unit PN (Q))
- frequency (unit Hz).

D. Measurement function settings - UlfPQ

Summary of parameters:

Text	Units	Default	Min.	Max.	Step
ParSet. 4..1		P1	(Select)		
CurrentInp	CT/VT-Addr	0			
Angle	degrees	0.000	-180.0	180.0	0.1
VoltageInp.	CT/VT-Addr	0			
PN-Setting	UN*IN	1.000	0.200	2.500	0.001
Voltage mode		direct	(Select)		

Explanation of parameters

ParSet 4..1

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

CurrentInp

Defines the c.t. input channel.

All current inputs are available for selection.

Angle

Characteristic angle for measuring real power. The phase-angle is also taken into account when measuring apparent power.

The default setting of 0.0 degrees should not be changed, when voltage and current I/P's are in phase when measuring purely real power, e.g. when measuring the phase-to-ground voltage and current of the same conductor.

The setting may vary from 0.0 in the following cases:

- compensation of c.t. and v.t. phase errors
- compensation of the phase-shift between phase-to-ground and phase-to-phase voltages
- compensation of the phase-shift between voltage and current in general (e.g. when measuring S-T voltage and R current).

VoltageInp

Defines the v.t. input channel.

All voltage I/P's are available for selection.

PN

Rated power corresponding to $U_N \times I_N$.

This enables the amplitude of the measured power to be adjusted, for example, to equal the rated power factor of a generator.

Voltage mode

Definition of the method of voltage measurement and therefore also the calculation of power. Possible settings:

- direct The voltage of the selected voltage I/P is measured directly.
- delta The phase-to-phase voltage formed by the selected voltage I/P and the cyclically lagging voltage channel is measured.
This setting is not permitted when only a single-phase is connected or when phase-to-phase voltages are connected.

E. Setting instructions

The measurement function must be carefully set to obtain the best accuracy. The following must be observed:

- C.t./v.t. input channel reference values
The reference values for the voltage and current input channels must be set such that, when the rated values are applied to the inputs, 1.000 UN and 1.000 IN are measured by the function.

In most cases it will be possible to retain the default reference setting (1.000) for the c.t. and v.t. input channels. Note that any changes made to the reference value of a three-phase voltage or current I/P applies to all phases.
- “Angle” setting for phase error compensation
The parameter “Phase-angle” must be correctly set in order to measure real and apparent power correctly. In most cases it will be possible to retain the default reference setting of 0.0 degrees when measuring the phase-to-ground voltage and current of the same conductor.

Other settings may be necessary in the following cases:

- a) A phase-to-phase voltage is being measured, e.g. measurement of the R phase current in relation to the R - S voltage:
=> phase compensation: $+30.0^\circ$
- b) Compensation of c.t. and v.t. phase errors.
=> phase compensation: according to calibration, e.g. $(-5.0^\circ \dots +5.0^\circ)$
- c) Change of measuring direction or correction of c.t. or v.t. polarity.
=> phase compensation: $+180.0^\circ$ or -180°

Where several of these factors have to be taken into consideration, the phase compensation in all the cases must be added and the resultant set.

The angles given apply for connection according to the connections in [Section 12](#).

- Power reference value “PN”
In most cases it will be possible to retain the default reference setting (1.000). Since the errors in the voltage and current reference values add geometrically, a fine setting is recommended to achieve the best possible accuracy.

Check the settings for “Angle” and “PN” using an accurate test set according to the following procedure:

- a) Inject purely active power at rated voltage and current.
- b) The active power measurement must be as close as possible to 1.000 or oscillate symmetrically to either side of it.
→ Adjust the value of “PN” as necessary.
- c) The reactive power measurement must be as close as possible to 0.000 or oscillate symmetrically to either side of it.
→ Adjust the value of “Angle” as necessary.

3.7.2. *Three-phase current plausibility (Check-I3ph)*

A. Application

Checking the plausibility of the three-phase current inputs for

- monitoring the symmetry of the three-phase system
- detection of a residual current
- supervision of the c.t. input channels.

B. Features

- evaluation of
 - the sum of the three phase currents
 - the sequence of the three phase currents
- provision for comparing the sum of the three phase currents with a residual current I/P
- adjustment of residual current amplitude
- blocking at high currents (higher than $2 \times I_N$)
- blocking of phase-sequence monitoring at low currents (below $0.05 \times I_N$)
- insensitive to DC components
- insensitive to harmonics.

C. Inputs and outputs

I. C.t./v.t. inputs:

- phase currents
- neutral current (optional)

II. Binary inputs:

- blocking

III. Binary outputs:

- tripping

IV. Measurements:

- difference between the vector sum of the three phase currents and the neutral current.

D. Current plausibility function settings - Check-I3ph

Summary of parameters:

Text	Units	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
Trip		00000000			
I-Setting	IN	0.20	0.05	1.00	0.05
Delay	s	10.0	0.1	60.0	0.1
CT-Compens		01.00	-2.00	+2.00	0.01
CurrentInp	CT/VT-Addr	0			
SumInp.	CT/VT-Addr	0			
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			

Explanation of parameters:

ParSet 4..1

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

Definition of the tripping logic (matrix) excited by the function's O/P.

I-Setting

Current setting for tripping.

Delay

Time between start signal at the I/P and the tripping signal at the O/P.

Forbidden settings:

≤ 1 s for current settings $\leq 0.2 I_N$.

CT-Compens

Amplitude compensation factor for the residual current I/P, enabling different transformation ratios of the main c.t.'s for phase and residual currents to be equalised.

The polarity of the residual current can be reversed by entering negative values.

CurrentInp

Defines the current input channel.

Any of the three-phase current I/P's may be selected.

The first channel (R phase) of a three-phase group is entered.

SumInp

Defines the neutral current input channel.

Any of the single-phase current I/P's may be selected.

BlockInp

Input for blocking the function.

F: - enabled

T: - disabled

xx: - all binary inputs (or outputs of protection functions).

Trip

Tripping signal.

Note:

If the phase sequence is incorrect, tripping takes place regardless of setting (I-Setting).

3.7.3. *Three-phase voltage plausibility (Check-U3ph)*

A. Application

Checking the plausibility of the three-phase voltage inputs for

- detection of residual voltage
- monitoring the asymmetry of the three-phase voltage system due to the zero-sequence component
- supervision of the v.t. input channels.

B. Features

Evaluation of

- the sum of the three phase voltages
- the sequence of the three phase voltages
- provision for comparing the sum of the three phase voltages with a residual voltage I/P
- adjustment of residual voltage amplitude
- blocking at high voltages (higher than $1.2 \times U_N$)
- blocking of phase-sequence monitoring at low voltages (below $0.4 \times U_N$ phase-to-phase)
- insensitive to DC components
- insensitive to harmonics.

Evaluation of the phase voltages is only possible in the case of Y connected input transformers, otherwise the residual component cannot be detected.

C. Inputs and outputs

I. C.t./v.t. inputs:

- phase voltages
- neutral voltage (optional)

II. Binary inputs:

- Blocking

III. Binary outputs:

- tripping

IV. Measurements:

- Difference between the vector sum of the three phase voltages and the neutral voltage.

D. Voltage plausibility function settings - Check-U3ph

Summary of parameters:

Text	Units	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
Trip	00000000				
V-Setting	UN	0.20	0.05	1.20	0.1
Delay	s	10.0	0.1	60.0	0.1
VT-Compens		01.00	-2.00	+2.00	0.01
VoltageInp	CT/VT-Addr	0			
SumInp	CT/VT-Addr	0			
BlockInp	BinaryAddr	F			
Trip	Signaladdr	ER			

Explanation of parameters:

ParSet 4..1

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

Trip

Definition of the tripping logic (matrix) excited by the function's output.

V-Setting

Voltage setting for tripping.

Delay

Time between start signal at the I/P and the tripping signal at the O/P.

Forbidden setting:

$\leq 1 \text{ s}$ for voltage settings $\leq 0.2 U_N$.

VT-Compens

Amplitude compensation factor for the residual voltage I/P, enabling different transformation ratios of the main v.t's for phase and residual voltages to be equalised.

The polarity of the residual voltage can be reversed by entering negative values.

VoltageInp

Defines the voltage input channel.

Any of the three-phase voltage inputs may be selected.

The first channel (R phase) of a three-phase group is entered.

Not applicable with delta connected v.t's.

SumInp

Defines the neutral voltage input channel.

Any of the single-phase voltage inputs may be selected.

BlockInp

Input for blocking the function.

F: - enabled

T: - disabled

xx: - all binary inputs (or outputs of protection functions).

Trip

Tripping signal.

Note:

If the phase sequence is incorrect, tripping takes place regardless of setting (U-Setting).

3.7.4. Disturbance recorder (*Disturbance Rec*)

A. Application

Recording current and voltage wave forms and the values of function variables before, during and after operation of a protection function.

B. Features

- records up to 9 c.t. and v.t. inputs
- records up to 12 measured function variables
- records up to 16 binary inputs
- sampling rate of 12 samples per period (i.e. 600, respectively 720 Hz)
- 9 analogue and 8 binary signals recorded in approx. 5 seconds
- function initiated by the general pick-up or general trip signals, or by any binary signal (binary I/P or O/P of a protection function).
- data recorded in a ring shift register with provision for deleting the oldest record to make room for a new one.
- choice of procedure if memory full: either 'stop recording' or 'Overwrite oldest records'.

C. Inputs and outputs

I. C.t./v.t. inputs:

- all installed inputs available

II. Measured variable inputs:

- all installed measured function variables available

III. Binary inputs:

- all installed inputs available (also outputs of protection functions)

IV. Binary outputs:

- start of recording
- memory full

V. Measurements:

- none.

D. Disturbance recorder function settings - Disturbance Rec

Summary of parameters:

Text	Units	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
StationNr		1	0	99	1
preEvent	ms	40	40	400	20
Event	ms	100	100	3000	50
postEvent	ms	40	40	400	20
recMode		A	(Select)		
TrigMode		TrigOnStart	(Select)		
StorageMode		StopOnFull	(Select)		
BinOutput	SignalAddr	ER			
MemFullSign	SignalAddr	ER			
AnalogInp 1	CT/VT-Addr				
AnalogInp 2	CT/VT-Addr				
.					
.					
AnalogInp 12	CT/VT-Addr				
BinInp 1	BinaryAddr	F			
BinInp 2	BinaryAddr	F			
.					
.					
BinInp 16	BinaryAddr	F			
BinInp 1		no trig	(Select)		
BinInp 2		no trig	(Select)		
.					
.					
BinInp 16		no trig	(Select)		
MWAImp 1	MeasVar				
.					
.					
MWAImp 12	MeasVar				
MWAScale1	Factor	1	1	1000	1
.					
.					
MWAScale12	Factor				

Explanation of parameters:**ParSet 4..1**

Parameter for determining in which set of parameters a particular function is active (see [Section 5.11.](#)).

Only the original function in each set may be active. The following must be observed, however, if a disturbance recorder is active in every set of parameters or the original function was copied:

The old record is deleted when switching to a different set of parameters to avoid misinterpretation. A record must therefore be read out before switching sets of parameters.

StationNr

Number of the disturbance recorder for identifying records for subsequent evaluation.

preEvent

Definition of how long the recorder runs before a possible event.

Event

Definition of the maximum limit for the duration of an event (recording mode A). In recording mode B, the same parameter sets the duration of recording.

postEvent

Definition of how long the recorder runs after an event (after EventDur).

recMode (Recording mode)

Definition of how events should be recorded. Possible settings:

- A: Recording only while the trigger signal is active. (minimum time = 100 ms, maximum time = event duration setting).
- B: Recording from the instant of the trigger signal for the event duration setting.

TrigMode

Definition of the instant of triggering and how binary signals are recorded. The configured c.t. and v.t. channels are always recorded. Possible settings:

- TrigByStart: The disturbance recorder is triggered when a protection function picks up (general pick-up). Binary signals are not recorded.

- TrigByTrip: The disturbance recorder is triggered when a protection function trips (general trip). Binary signals are not recorded.
- TrigByBin1: The disturbance recorder is triggered by the binary I/P 1. Binary signals are not recorded.
- TrigAnyBin: Defined binary signals are recorded and recording is triggered by any of them via an OR gate.
- TrStrt&Bin: Defined binary signals are recorded and recording is triggered by any of them via an OR gate and also when a protection function picks up (general pick-up).
- TrTrip&Bin: Defined binary signals are recorded and recording is triggered by any of them via an OR gate and also when a protection function trips (general pick-up).

Note:

If the trigger conditions are connected to an OR gate and one of them is fulfilled, the other trigger conditions bear no influence and no further records are made. In this situation, a record is initiated when the disturbance recorder is reset.

StorageMode

determines the procedure when the memory is full:

- StopOnFull: No further data are recorded when the memory is full.
- Overwrite: The oldest records are overwritten and therefore lost.

BinOutput

O/P signalling that recording is taking place.

MemFullSign

Warning that the memory is $\frac{3}{4}$ full. Normally, there remains sufficient room for at least one more record after this signal is generated.

AnalogInp 1...AnalogInp 12

Defines the c.t. and v.t. inputs to be recorded. The setting is the number of the I/P.

The numbers of the c.t. and v.t. inputs do not necessarily have to agree with the numbers of the c.t. and v.t. channels, however, no gaps are permitted (setting zero).

BinInp 1...BinInp 16

Binary inputs to be recorded (for triggering modes "TrStrt&Bin, TrigAnyBin and TrTrip&Bin"). Binary address (binary input or output of a protection function). No recording takes place for F→FALSE or T→TRUE.

A particular order is not necessary. There may also be gaps.

BinInp 1...BinInp 16

Definition of a corresponding binary signal as one of the trigger signals for initiating recording. All the trigger signals thus defined, are connected to an OR gate so that any one of them can start recording. Possible settings are:

- No trigger: The corresponding signal has no influence on the start of recording.
- Trigger: A positive-going edge of the corresponding signal from logical '0' to logical '1' initiates recording.
- Inv. trigger: A negative-going edge of the corresponding signal from logical '1' to logical '0' initiates recording.

MWAImp 1...MWAImp 12

Measured variables to be recorded.

Possible settings are:

- Disconnect, no input
- Constant measured variable, analogue value as a constant
- Binary output of a protection function, measured variable of the selected function
- Input from IBB, input variable of IBB channel 4, inputs 1...64.

MWAScale1...MWAScale12

Scaling factors for reading the disturbance records.

E. Setting instructions

General:

The disturbance recorder function may only be configured once for each set of parameters.

The special “disturbance recorder” function serves to record current and voltage waveforms and measured function variables when a protection function picks up. A battery buffered 64 kByte memory is provided for this purpose, which enables 9 analogue and 8 binary signals to be recorded within a maximum of approx. 5 seconds.

To ensure that the memory is not filled by useless data, recording only takes place after a starting signal (trigger signal). Each time a start signal is generated, the data are recorded for a pre-defined time and saved as an “event”. Thus depending on the definitions of the relevant times, the memory has capacity for between 1 and approx. 56 events.

To enable the circumstances leading up to an event and also the responses after an event to be studied, an event comprises three parts, the pre-event data (recorded before the start signal), the data of the event itself and the post-event data. The durations of these three periods can be independently defined.

How the data prior to an event is obtained requires a little more explanation. Data are continuously recorded from the instant the programming of the perturbograph function has been completed. They are fed into a ring shift register, the older data at the beginning being overwritten as soon as the register is full. This cyclic overwriting of the ring register continues until a start signal initiates the recording of an event (trigger signal). Thus the circumstances immediately prior to the actual event are available in the ring register.

The duration of the record of the actual event is determined by the tripping signal (trigger signal), i.e. recording continues for as long as it is active (recording mode A). If the tripping signal is very short, recording lasts for at least 100 milliseconds and if it is very long, recording is discontinued upon reaching the maximum duration (set event time). A second mode of operation is also provided (recording mode B), for which the duration of recording always equals the set event time regardless of the duration of the trigger signal.

The post-event circumstances are of less importance, especially in recording mode B, in which case simply the duration of recording is extended. The essential thing is that during post-event recording, a new trigger signal can initiate the recording of new events. This, however, means that two events overlap and it may not always be possible to fully reconstruct the circumstances of both events (part of the pre-event data is in the preceding event).

The entire event memory operates as a ring register. This means that a single event can be deleted to make room for a new one without having to delete the others.

The procedure followed when the memory is full can be selected. Either recording is discontinued and no new events are recorded, or the oldest records are overwritten so that the memory always contains the latest events. It must be noted that in this mode, a record can be deleted before it has been transferred to an operator station. Even if transfer of a record is in progress, it will be interrupted to make room for a new record.

Application programs

Disturbance recorder data (currents, voltages and measured variables) can be transferred back to the RE. 316*4 device using the conversion program INTERFAC (in conjunction with the test set XS92b) (see INTERFAC Operating Instructions CH-ES 86-11.53 E).

Refer to [Section 9.3.](#) for the procedure for transferring disturbance data via the IBB.

Disturbance recorder data files are stored in a binary format and can only be evaluated using the WinEVE program (see WinEVE Operating Instructions *BHT 450 045 D0000) or the REVAL program (see REVAL Operating Instructions 1MDU10024-EN).

Measured function variables may have values which cannot be entirely reproduced by the evaluation software. Such variables can be reduced using the scaling factors 'MeasScale'. The highest number the evaluation software can reproduce faithfully is ± 16535 . The evaluation software automatically takes account of the scaling factors.

The following table shows scaling examples for the most important measured function variables.

Function	Meas. variable	Nominal value	'MeasScale'
UIfPQ	f (50Hz)	20000	2
UIfPQ	P	820698	52
UIfPQ	Q	820698	52
SynchroCheck	degrees (180°)	31415	2
Power	PN	1641397	105

'MeasScale' is given by: $\frac{\text{Nominal value}}{16535} + \text{Margin}$

Processor capacity:

The disturbance recorder function runs on the same central processing unit (CPU) as the protection functions. The processor capacity required by the disturbance recorder function as a percentage of the total capacity and in relation to the number of signals is:

- 20% for 9 analogue and 0 binary signals
- 40% for 9 analogue and 16 binary signals.

The disturbance recorder function will thus be generally confined to recording the analogue variables and be triggered by the general start or general trip signals. Changes in the states of binary signals are nevertheless registered by the event recorder.

Recording duration:

The time during which data are recorded can be determined from the following relationship:

$$t_{\text{rec}} = \frac{65535 - ((n + 1) \times 22)}{(2a + b) \times 12} \times p$$

where t_{rec} : max. recording time

n: Number of events recorded

a: Number of c.t. and v.t. channels recorded

b: Number of Bytes required for binary channels (one Byte per eight binary signals)

p: duration of one cycle at power system frequency (e.g. 20 ms for 50 Hz).

Example:

$$n = 10$$

$$a = 9$$

$$b = 2 \text{ (i.e. 9 to 16 signals)}$$

$$p = 20 \text{ ms}$$

$$t_{\text{rec}} = \frac{65535 - ((10 + 1) \times 22)}{(2 \times 9 + 2) \times 12} \times 20 \text{ ms} = 5.44 \text{ s}$$

It follows that for the given number of channels and power system frequency, the capacity is sufficient for 10 events of 540 ms duration each.

File PLOT.TXT

PLOT.TXT for WinEVE, REVAL (programs for evaluating disturbance recorder data) and INTERFAC (data conversion program for running disturbance data on the test set XS92b).

General remarks

The programs (WinEVE, REVAL and INTERFAC) need the file PLOT.TXT to be able to process the disturbance recorder data. For INTERFAC, all disturbance recorder data RExxxx.xxx must start with the letters RE.

Example PLOT.TXT

Hardware configuration: A/D config: K9
 Overcurrent: A1 (IN = 1A)
 Overvoltage: U1 (UN = 100V)

N: 001

S: ABB_Relays_Ltd

D 0	:	D 0	/CO:	1
D 1	:	D 1	/CO:	2
D 2	:	D 2	/CO:	3
D 3	:	D 3	/CO:	4
D 4	:	D 4	/CO:	5
D 5	:	D 5	/CO:	6
D 6	:	D 6	/CO:	7
D 7	:	D 7	/CO:	8
D 8	:	D 8	/CO:	9
D 9	:	D 9	/CO:	10
D10	:	D10	/CO:	11
D11	:	D11	/CO:	12
D12	:	D12	/CO:	13
D13	:	D13	/CO:	14
D14	:	D14	/CO:	15
D15	:	D15	/CO:	1

U 0	:	UR	/CO:	2	/TR:	0.1981	/UN:	UN
U 1	:	US	/CO:	4	/TR:	0.1981	/UN:	UN
U 2	:	UT	/CO:	11	/TR:	0.1981	/UN:	UN
I 3	:	I0	/CO:	10	/TR:	10.83	/UN:	IN
U 4	:	U	/CO:	7	/TR:	0.1981	/UN:	UN
U 5	:	U	/CO:	13	/TR:	0.1981	/UN:	UN
I 6	:	IR	/CO:	8	/TR:	10.83	/UN:	IN
I 7	:	IS	/CO:	12	/TR:	10.83	/UN:	IN
I 8	:	IT	/CO:	9	/TR:	10.83	/UN:	IN

where:

N: station number: text
 S: station name: text
 Dnn binary channels: text (max. 8 char.)
 Unn:, Inn: voltage channel, current channel: text (max. 8 char.)
 /CO 1 to 15: number of the plot colour for WinEVE
 (In the case of REVAL the plotting colour is determined by the particular layout.)

/TR: conversion ratio for WinEVE, REVAL

/UN: unit for WinEVE, REVAL: text.

Note:

'Unn:' and 'Inn:' are needed by INTERFAC to indicate whether a channel is being used for voltage or current.

All c.t. and v.t. channels 'Ann:' may be chosen for WinEVE.

Ratio TR

Voltage channels for REL 316*4 and REC 316*4

100 V:	TR = 19.81	in V	
200 V:	TR = 39.62	in V	
	TR = 0.1981	times UN	(PLOT.TXT)

Voltage channels for REG 316*4 and RET 316*4

15 V:	TR = 5.144	in V	
100 V:	TR = 34.312	in V	
200 V:	TR = 68.624	in V	
	TR = 0.34312	times UN	(PLOT.TXT)

Current channels RE. 316*4

Protection:	1 A:	TR = 10.83	
	2 A:	TR = 21.66	
	5 A:	TR = 54.11	
		TR = 10.83	times IN (PLOT.TXT)

Metering:	1 A:	TR = 0.2506	
	2 A:	TR = 0.5011	
	5 A:	TR = 1.253	
		TR = 0.2506	times IN (PLOT.TXT)

These ratios enable WinEVE to determine the secondary values. These ratios must be multiplied by the ratio of the main c.t's and v.t's to obtain the primary system values.

INTERFAC does not evaluate CO, TR and UN.

Automatic creation of the file plotxxx.txt:

The file plotxxx.txt is automatically saved in the current directory from which the operator program (MMI) was started when saving the RE. 316*4 settings or in any directory given in the configuration file 'rexx.cfg', e.g.:

EVEDATA = .\RE2

Several files plotxxx.txt with different station numbers (xxx) can be combined to a single plot.txt. The file plot.txt must be at the same location as the disturbance recorder data for the REVAL evaluation program.

Example:

PLOT.TXT (existing file), plot020.txt (data for station No. 20) and plot021.txt (data for station No. 21) can be combined using the DOS command:

```
C:\REL316
```

```
C>copy PLOT.TXT+plot020.txt+plot021.txt PLOT.TXT
```

The file **PLOT.TXT** can be modified using an editor.

The evaluation is based on data expressed as multiples of UN or IN.

Instructions for installing the data evaluation program

The data evaluation program must be installed in strict accordance with the relative operating instructions.

WINEVE

Copy the file "PLOT.TXT" to the directory:

```
C:\I650\EVENTS
```

A disturbance should be recorded during the commissioning of every relay and the record stored in the directory given above.

The procedure for installing the station parameter files is as follows:

- Start the WINEVE program.
- Open a fault record
The following error message appears:

```
C:\I650\STATION\ST0xx.PAR  
Could not find file.
```
- Click on OK.
- Select the menu item "Import station file" in the "Parameter" menu.
- Select the file PLOT.TXT belonging to this disturbance recording.

- Select the menu item “Save station” in the “Parameter” menu.

This procedure must be repeated for all the relays. The configuration file PLOT.TXT is no longer necessary and the error message concerning the missing station file does not appear. WINEVE provides facility for editing and resaving all the station parameters (texts, colours etc.).

Exception: The ratios TR have to be changed in the file PLOT.TXT and the file re-imported and saved again as described above.

REVAL

Copy the file “PLOT.TXT” to the following directory:

C:\SMS\REVAL\EVENTS

REVAL rereads the file PLOT.TXT every time a disturbance record is loaded, however, any colours specified in PLOT.TXT are ignored. Instead, the colours are assigned by REVAL and can be edited after a disturbance record has been loaded.

3.7.5. Measurement module (*MeasureModule*)

A. Application

Measurement of 3 phase voltages, 3 phase currents, active and reactive power, power factor $\cos \varphi$ ($\cos \phi$) and frequency, e.g. for display on an operating device or transmission to a station monitoring system.

B. Features

- Measurement of 3 phase voltages (Y and delta), currents, active and reactive power, power factor $\cos \varphi$ and frequency.
- Provision for using the 3 phase current inputs in combination with either 3 phase-to-phase voltages or 3 phase-to-earth voltages.
- 2 independent impulse counter inputs for calculation of interval and accumulated energy
- The three-phase measurement and impulse counters can be used independently and may also be disabled.
- Up to 4 measurement module functions can be configured on one RE..16 device.
- All inputs and outputs can be configured by the user.

C. Inputs and Outputs

I. C.t./v.t. inputs

- Voltage
- Current

II. Binary inputs

- 2 impulse inputs
- 2 reset inputs

III. Binary outputs

- 2 outputs for the new counter value

IV. Measurement values

- Voltage URS (Unit UN)
- Voltage UST (Unit UN)
- Voltage UTR (Unit UN)
- Voltage UR (Unit UN)
- Voltage US (Unit UN)
- Voltage UT (Unit UN)
- Current R (Unit IN)
- Current S (Unit IN)
- Current T (Unit IN)
- Active power P (Unit PN)
- Reactive power Q (Unit QN)
- Power factor $\cos \varphi$ (Unit $\cos \phi$)
- Frequency f (Unit Hz)
- Interval energy value 1 (E1Int)
- Interval pulse number 1 (P1Int)
- Accumulated energy value 1 (E1Acc)
- Accumulated pulse number (P1Acc)
- Interval energy value 2 (E2Int)
- Interval pulse number 2 (P2Int)
- Accumulated energy value 2 (E2Acc)
- Accumulated pulse number 2 (P2Acc).

D. Measurement module function settings (MeasureModule)

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
ParSet 4..1		P1	(Select)		
VoltageInp		0			
CurrentInp	CT/VT-Addr	0			
PN	$UN \cdot IN \cdot \sqrt{3}$	1.000	0.200	2.500	0.001
AngleComp	Deg	0.000	-180	180	0.1
t1-Interval	Select	15 min			
PulseInp1	BinaryAddr	F			
Reset1	BinaryAddr	F			
ScaleFact1		1.0000	0.0001	1.0000	0.0001
Cnt1New	SignalAddr				
t2-Interval	Select	15 min			
PulseInp2	BinaryAddr	F			
Reset2	BinaryAddr	F			
ScaleFact2		1.0000	0.0001	1.0000	0.0001
Cnt2New	SignalAddr				

Explanation of parameters:**ParSet4..1**

Parameter for determining in which set of parameters a particular function is active ([see Section 5.11.](#)).

VoltageInp

defines the voltage input channel. Only three-phase v.t.'s can be set and the first channel (R phase) of the group of three selected must be specified.

Voltage and current inputs must be assigned before the three-phase measurement part of the function can be activated. If only the pulse counter part of the function is to be used, both c.t. and v.t. inputs must be disabled.

CurrentInp

defines the current input channel. Only three-phase c.t.'s can be set and the first channel (R phase) of the group of three selected must be specified.

Current and voltage input signals must come from the same c.t./v.t. input module.

PN

Reference value for measuring power. It enables the amplitude of the power values to be adjusted to take account, for example, of the rated power factor $\cos \varphi$ or to compensate the amplitude errors of the input transformers.

AngleComp

Angular setting for compensating the phase error. It is set to obtain the best possible power measuring accuracy. In many cases, the default setting of 0.0 degrees will be acceptable, but a different setting may be necessary to compensate the following:

- a) c.t. and v.t phase errors
→ typical setting: $-5^\circ \dots +5^\circ$
- b) correction of c.t. or v.t. polarity
→ typical setting: -180° or $+180^\circ$.

t1-Interval

Interval set for accumulating pulses assigned to $E1_{acc\_interval}$ and $Pulse1_{acc\_interval}$.

The following settings are possible: 1 min, 2 min, 5 min, 10 min, 15 min, 20 min, 30 min, 60 min and 120 min.

PulseInp1

Input for energy counter impulse.

- F: not used
- T: always active. This setting should not be used.
- xx: all binary inputs (or outputs of protection functions).

Note: Minimum pulse-width is 10 ms.

Reset1

Input to reset $E1_{accumulate}$ and $Pulse1_{accumulate}$ outputs.

- F: no reset
- T: always reset
- xx: all binary inputs (or outputs of protection functions).

ScaleFact1

Factor for scaling E1 outputs in relation to pulse counter output:

$$E1_{\text{acc\_interval}} = \text{Pulse1}_{\text{acc\_interval}} \times \text{ScaleFact1}$$

$$E1_{\text{accumulate}} = \text{Pulse1}_{\text{accumulate}} \times \text{ScaleFact1}.$$

Cnt1New

Output to indicate that new values are available at impulse counter 1 outputs and have been frozen. The binary output is cleared 30 s after the interval starts.

t2-Interval

See t1-Interval.

PulseInp2

See PulseInp1.

Reset2

See Reset1.

ScaleFact2

See ScaleFact1.

Cnt2New

See Cnt1New.

E. Setting Instructions

To get the best performance from the measurement module, be sure to set it properly. The following notes should help to decide the correct settings:

- Reference values for the analogue input channels
The settings in this case should be chosen such that the functions measures 1.000 UN and 1.000 IN when rated voltage and current are being applied. In many cases the default setting (1.000) will be satisfactory.
- Phase compensation "Angle comp"
This setting is important for correct measurement of active and reactive power and the power factor $\cos \varphi$. For most cases, it is possible to accept the default value 0.0°.

A different setting may be necessary to compensate the following:

- a) c.t. and v.t. phase errors
→ typical setting: between -5.0° and +5.0°
- b) correction of direction of the measurement or c.t. or v.t. polarity
→ typical setting: -180.0° or +180.0°

Add multiple errors to obtain the correct compensation setting.

The angles given apply for connection according to the connections in [Section 12](#).

- Voltage measurement
The zero-sequence component in case of delta-connected v.t.'s is assumed to be zero, but with Y-connected v.t.'s the zero-sequence voltage does have an influence on the phase-to-ground measurements. In an ungrounded power system, the phase-to-ground voltages will float in relation to ground.
- Power and frequency measurements
A power measurement is obtained by summing the powers of the three-phase system: $3 \times \underline{S} = \underline{U}_R \times \underline{I}_R^* + \underline{U}_S \times \underline{I}_S^* + \underline{U}_T \times \underline{I}_T^*$.
The measurement is largely insensitive to frequency in the range (0.8...1.2) f_N . The frequency measured is that of the positive sequence voltage. Should the voltage be too low, the frequency is not measured and a value of 0.0 Hz results.
- Where only the impulse counter is in use, both analogue inputs (current and voltage) must be disabled.

- Where only the measurement part of the function is in use, the binary impulse and reset inputs of both impulse counters must be disabled, i.e. “always FALSE”.

3.7.5.1. *Impulse counter inputs*

The impulses counted are normally generated by a measuring or metering device (see Fig. 3.7.5.1).

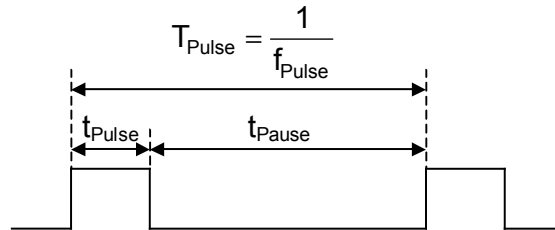


Fig. 3.7.5.1 Impulse counter input signal

The maximum impulse repetition rate is 25 Hz (see Fig. 3.7.5.1). Thus the minimum time between the positive-going edges of two input impulses is $T_{Puls, \min} = \frac{1}{25} \text{ Hz} = 40 \text{ ms}$.

The pulse-width is determined by the function generating the impulses and the ratio between the pulse-width and the interval between lagging and leading edges should be in the range 1:3 to 1:1, i.e.:

$$t_{Pulse, \min} = \frac{1}{1+3} \times T_{Pulse, \min} = \frac{1}{4} \times T_{Pulse, \min} = 10 \text{ ms}.$$

Since the impulse counter is polled approximately every 5 ms, impulses are reliably detected with a safety factor of about 2.

The impulse counter evaluates the positive-going edges (0→1) of the input signal.

To filter any contact bounce (debouncing) phenomena, only the first positive-going edge is evaluated within a given period (typically 10 ms).

3.7.5.2. *Impulse counter operation*

Fig. 3.7.5.2 shows the principles of impulse counter operation.

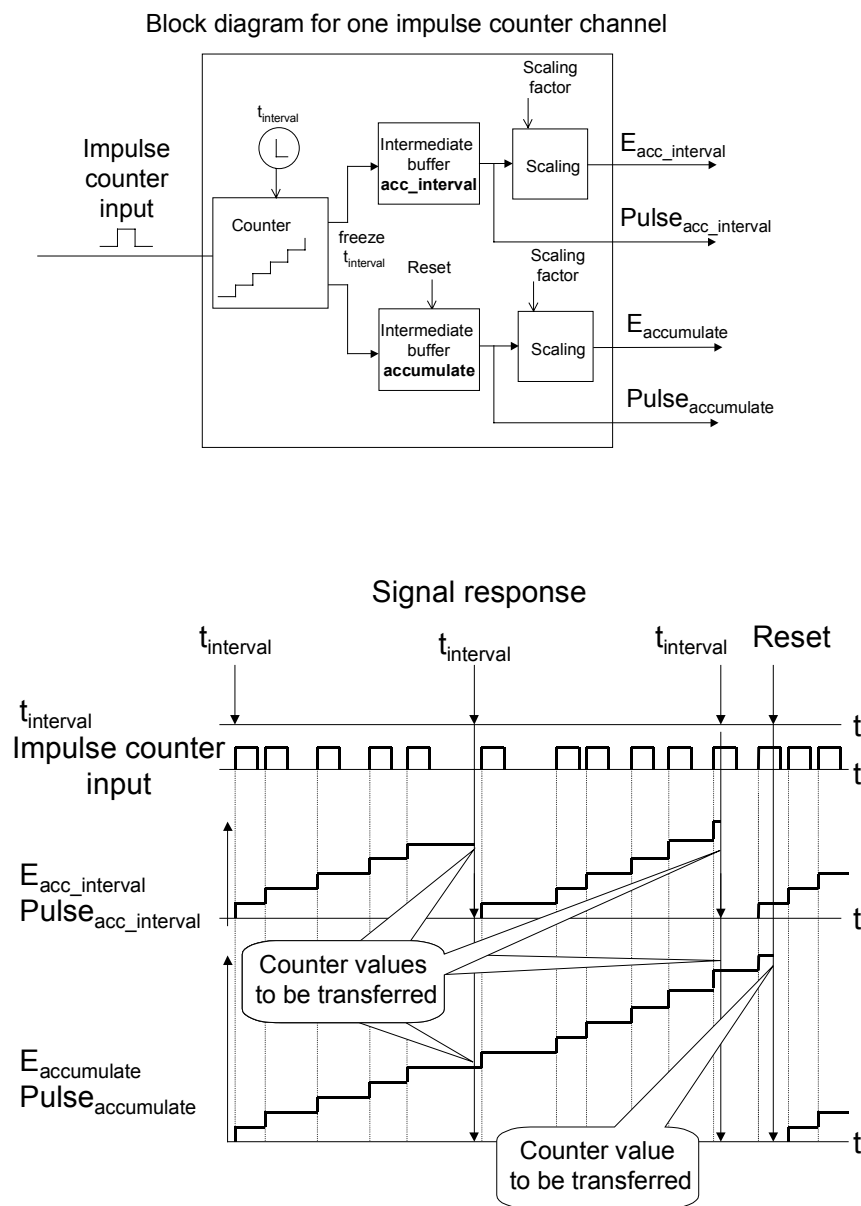


Fig. 3.7.5.2 Block diagram for one impulse counter channel and signal response

3.7.5.3. *Impulse counter operating principle*

The binary inputs “Reset1” and “Reset2” reset the counter values $E_{accumulate}$ and $Pulse_{accumulate}$ to zero. The interval values $E_{acc\_interval}$ and $Pulse_{acc\_interval}$ are not reset.

When a reset command is applied to binary input “Reset1” or “Reset2”, measurement events with the values of $E_{\text{accumulate}}$ and $\text{Pulse}_{\text{accumulate}}$ are created for the respective channel before its counters are reset.

Impulse counter values are stored in a RAM with a battery supply and are not lost should the auxiliary supply fail. Impulses arriving at the inputs while the software is being initialised, e.g. after settings have been made, are lost.

- Capacity for $\text{Pulse}_{\text{accumulate}}$:
At the maximum impulse repetition rate, the total number of impulses counted during a year is $25 \text{ pps} \times 3,600 \text{ s/h} \times 8,760 \text{ h/year} = 788,400,000$ impulses per year. The output is reset to zero when a counter reaches 2,000,000,000, i.e. 2×10^9 . Unless special measures taken or a counter is reset, it can overflow at the worst after approx. 2,5 years.
- Should an impulse counter overflow, the value of $\text{Pulse}_{\text{accumulate}}$ is recorded in the event list. No further measures have been included, because
 - 1) an overflow is hardly likely to occur.
 - 2) should an overflow occur, it is obvious providing the counters are checked regularly, for example, by an SCS. If necessary, the total number of impulses counted since the last reset can be determined even after an overflow.

3.7.5.4. Interval processing

The interval starts at a full hour plus a even multiple of t_{Interval} and is synchronised to a full minute by the internal RE..16 clock.

Assuming t_{Interval} is set to 120 min, the interval is started at even hours throughout the day.

Impulse counter and energy outputs are set at the start of the first regular interval, even if the previous interval was incomplete. This ensures that no impulses are lost after starting the function.

When t_{interval} expires, the following takes place:

- The counter values $E_{\text{accumulate}}$, $\text{Pulse}_{\text{accumulate}}$, $E_{\text{acc\_interval}}$ and $\text{Pulse}_{\text{acc\_interval}}$ are stored in the intermediate buffers and remain unchanged until the end of the next interval.

- When the new impulse counter results are frozen at the end of the interval, the binary output “Cnt1New”, respectively “Cnt2New” is set to TRUE. It is reset after 30 s regardless of interval duration and can be used to initiate reading of a new set of frozen interval values.
- If selected for transmission, transmission of the counter values via the LON interface is initiated by the positive-going edge of this output.
- The values $E_{\text{acc\_interval}}$ and $\text{Pulse}_{\text{acc\_interval}}$ of the respective channel are only recorded as measurement events providing the output “Cnt1New”, respectively “Cnt2New” is being used, for example, to control an event recorder, LED or signalling relay.

The freezing of results, resetting and event recording of the interval counters is illustrated in Fig. 3.7.5.3.

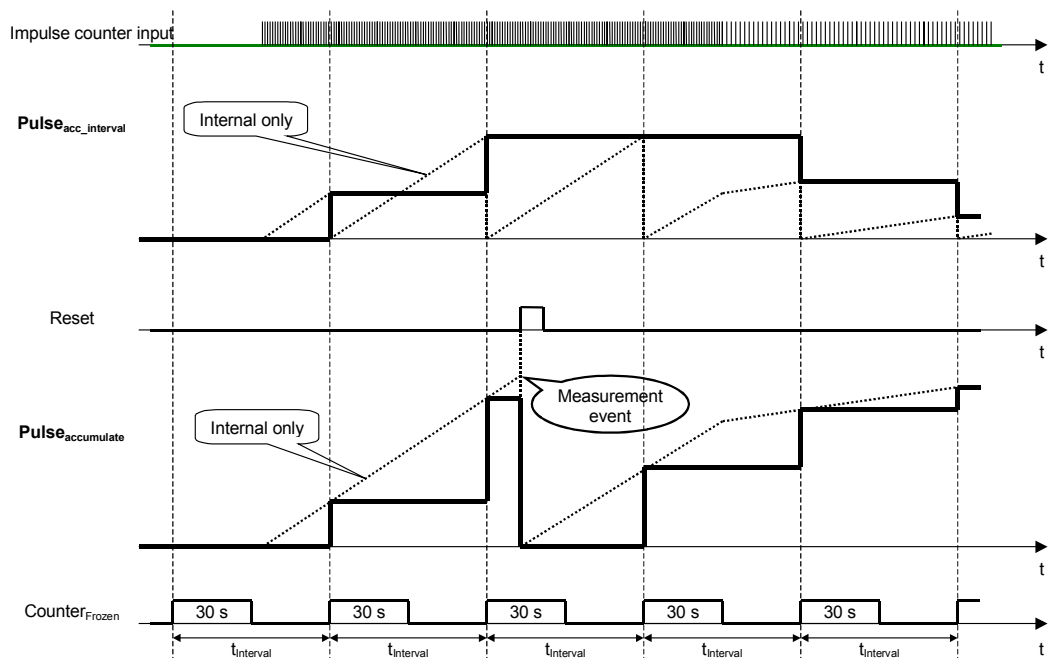


Fig. 3.7.5.3 Interval processing

August 00

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4. DESCRIPTION OF FUNCTION AND APPLICATION

4.1. *Summary*

Both analogue and binary input signals pass through a signal conditioning stage before being processed by the CPU and logic processor.

As described in [Section 2](#). “Description of hardware”, analogue signals are conditioned by the chain comprising the input transformer, shunt, low-pass filter (anti-aliasing filter), amplifier, sample and hold stage, multiplexer and A/D converter. The resulting digital signals are then separated by digital filters into real and apparent components before arriving at the main processor. Opto-couplers in the inputs of the binary signals act as a fire wall to electrically separate internal and external circuits. The binary signals are then logically processed by the main processor. Only after the signals have been properly conditioned does processing of the protection function algorithms commence.

An additional logic programmed using FUPLA (function block programming language) provides convenient facility for achieving special circuits needed for specific applications.

The memory of the event recorder function has sufficient capacity for up to 256 binary signals and their time tags.

The memory of the disturbance recorder registers 9 analogue and 16 binary signals. The number of events it can actually record depends on the total duration of an event as determined by the amount of pre-event data (event history) and the duration of the event itself.

Where necessary, a large variety of supplementary protection and logic functions is available in the RE. 216 and RE. 316*4 function software libraries.

4.2. Protection functions

4.2.1. High-impedance

4.2.1.1. General

In a high-impedance scheme, the measurement circuit represents a high-impedance across a circulating current circuit. High-impedance protection is used for

- phase and possibly earth fault protection for generators, motors and compensators
- restricted E/F protection for power transformers.

The main advantage of a high-impedance scheme compared with a normal differential scheme is its better stability for relatively low through-fault currents (between I_N and $5 I_N$).

The disadvantages are

- the high voltage across the circulating current circuit during internal faults
- the special requirements to be fulfilled by the c.t.'s.

A high-impedance scheme is used to advantage where

- fault currents are relatively low
- discrimination is absolutely essential.

This is the case for phase faults on air-cored compensators and earth faults on power transformers that are grounded via an impedance. In some instances solidly grounded transformers can also be protected.

Either an overcurrent function with a series resistor or an over-voltage function can be used in a high-impedance scheme. The restricted earth fault protection (R.E.F.) described in the next Section is an example for the application of an overcurrent function.

The required level of through-fault stability is determined by the value of the high impedance presented by the protection measuring circuit.

4.2.1.2. *Restricted E/F protection for a transformer*

4.2.1.2.1. *Basic requirements*

A restricted E/F scheme must be able to

- detect E/F's in the protection zone
- remain stable during both phase and earth through-faults.

The scheme is designed to remain stable

- in the case of a solidly grounded star-point for an external E/F current
- in the case of an impedance grounded star-point for the highest external phase and earth fault current.

When designing a scheme, it is assumed that one c.t. is fully saturated and none of the others.

4.2.1.2.2. *Components of a restricted E/F scheme*

A restricted E/F scheme comprises the following items:

- linear stabilising resistor R_S
- REG 316*4 overcurrent function
- non-linear resistor
- shorting contacts where necessary.

4.2.1.2.3. *Design*

The E/F current is determined by

- a) the generator and step-up transformer reactances when the HV circuit-breaker is open (see Fig. 4.1).
- b) in addition to a) by the HV power system when the HV circuit-breaker is closed (see Fig. 4.2).

As a result of the current distribution for a through-fault, the star-point c.t. conducts the highest current in the case of a solidly grounded transformer as shown in Fig. 4.2. Apart from the burden of the cables, the high fault level results in a high c.t. flux and a high probability of it saturating.

The influence of external phase faults on the circulating current circuit is limited, especially if the connections between the c.t. cores can be kept short. Phase faults are therefore neglected when designing a scheme for a solidly grounded system. They may not be neglected, however, where a system is impedance grounded.

The value of the stabilising resistor is chosen such that the voltage drop caused by the highest external E/F and possibly phase fault current across the secondary winding and leads of the saturated c.t. cannot reach the pick-up setting of the protection (see Fig. 4.3).

The knee-point voltage of the c.t.'s is specified such that they can supply sufficient current during an internal fault to enable the protection to trip. The knee-point voltage U_k of the c.t.'s must therefore be appreciably higher than the voltage drop ΔU_a .

Symbols used:

I_E	primary star-point current (AC component) for a through-fault
I_2	secondary current of the non-saturated c.t.'s
I_{2N}	c.t. secondary rated current
I_{1N}	c.t. primary rated current
I_N	protection rated current
R_2	secondary resistance of the saturated c.t. at 75°C
R_L	lead resistance according to the Figure
$\Delta U_a, \Delta U_i$	voltage drops across the circulating current circuit for external and internal faults
U_k	c.t. knee-point voltage
I	current setting
R_S	stabilising resistor
I_F	highest primary fault current (AC component) for an internal E/F.

Equations:

$$\Delta U_a = (R_2 + 2 R_L) I_2$$

$$U_k \geq 2 \Delta U_a$$

$$I = 0.25 I_{2N} \quad (\text{solidly grounded star-point})$$

$$I = 0.10 I_{2N} \quad (\text{impedance grounded star-point})$$

$$R_S \geq \frac{\Delta U_a}{I}$$

$$\Delta U_i = R_S I_2 \quad (I_2 \text{ results from } I_F)$$

$$U_{\max} = 2\sqrt{2 U_k (\Delta U_i - U_k)}$$

4.2.1.2.4. **Example**

Determination of the stabilising resistor:

$$C.t's \quad 1000/1 \text{ A}$$

$$R_2 = 5 \Omega$$

$$R_L = \frac{100m}{50 \times 4 \text{ mm}^2} = 0.5 \Omega$$

(c.t. lead gauge 4 mm²)

Maximum earth fault through current:

$$I_E = 10,000 \text{ A}$$

This would be the current for an E/F on an HV system with the following data:

$$x_d'' = x_2 = 0.2 ; \quad x_T = x_{T0} = 0.1 ; \quad x_{\text{sys}} = x_{\text{sys } 0} = 0.01$$

$$I_2 = 10,000 \frac{1}{1000} = 10 \text{ A}$$

$$\Delta U_a = (5 + 2 \times 0.5) \times 10 = 60 \text{ V}$$

$$U_k \geq 2 \Delta U_a = 120 \text{ V}$$

Chosen

$$U_k = 200 \text{ V}$$

Settings for a solidly grounded system:

$$I = 0.25 I_N = 0.25 \text{ A}$$

(The setting $I = 0.1 \cdot I_N$ is usually chosen for a impedance grounded system.)

Stabilising resistor

$$R_S \geq \frac{\Delta U}{I} = \frac{60}{0.25} = 240 \text{ } \Omega$$

$$\text{Chosen} \quad R_S = 300 \text{ } \Omega$$

Check of the overvoltage at maximum fault current

$$I_F = \frac{3 I_N}{2x_{\text{sys}} + x_{\text{sys}0}} = \frac{3 \times 1000}{0.02 + 0.01} = 100,000 \text{ A}$$

$$I_2 = 100,000 \frac{1}{1,000} = 100 \text{ A}$$

$$\Delta U_i = R_S I_2 = 300 \times 100 = 30,000 \text{ V}$$

$$\begin{aligned} U_{\text{max}} &= 2\sqrt{2} \sqrt{U_k (\Delta U_i - U_k)} \\ &= 2\sqrt{2} \sqrt{200 (30,000 - 200)} = 6,905 \text{ V} \end{aligned}$$

Since this value exceeds the permissible maximum peak value of 2,000 V, a non-linear resistor must be connected across the circulating current circuit to limit the voltage. Shorting contacts may also be necessary.

C.t specification:

Rated currents 1000/1 A

Winding resistance $R_2 \leq 5 \text{ } \Omega$

Knee-point voltage $U_k = 200 \text{ V}$

Magnetising current $I_{2m} \leq 2\% I_{2N}$

$$\text{i.e. } I_{2m} \leq 0.02 \text{ A} \quad \text{at } U_2 = 60 \text{ V}$$

The c.t.'s must conform to British Standard 3938, Class X.

The c.t.'s should also:

- have evenly distributed secondary windings on a toroidal core (i.e. to minimise the secondary leakage flux)
- not have any winding correction.

Stabilising resistor specification:

300 Ω ; 0.5 A

Test voltage: 2 kV

Non-linear resistor specification:

E.g. Metrosil Type 600 A/S1.

Shorting contacts:

The circulating current circuit must be short-circuited within the thermal rating time of the two resistors, if an internal fault cannot be tripped in a shorter time.

Overcurrent function settings:

I-Setting 0.25 I_N

Delay 0.02 s

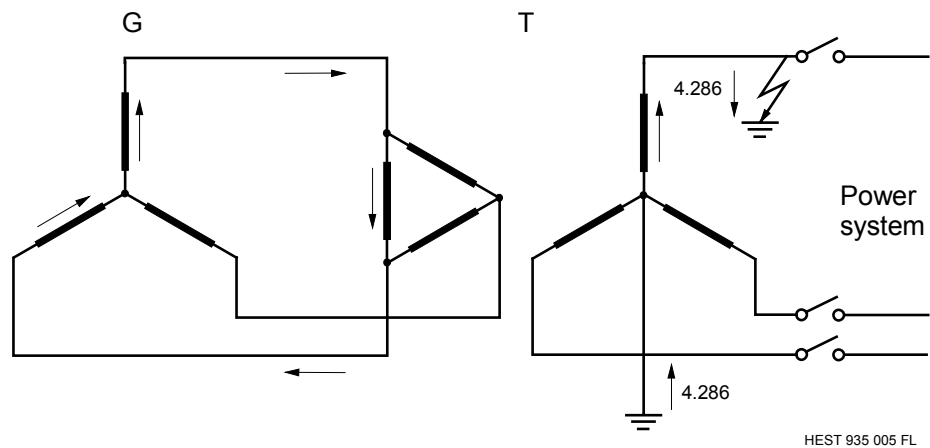


Fig. 4.1 E/F on the HV system supplied by the generator

$$x_d'' = x_2 = 0.2 ; \quad x_T = x_{T0} = 0.1$$

The current values are referred to the rated current of the transformer.

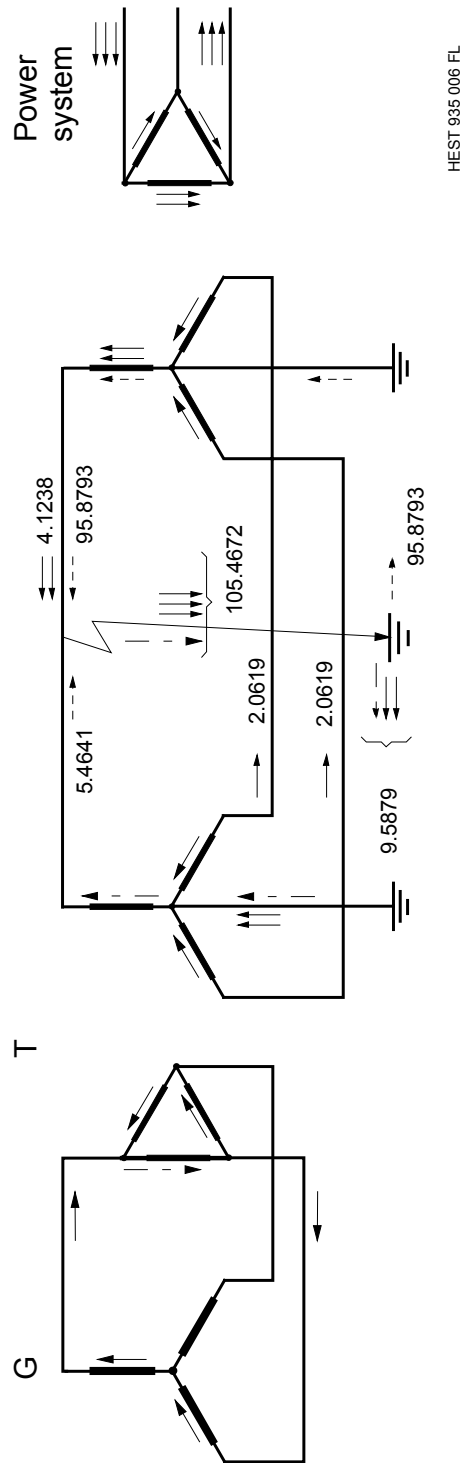
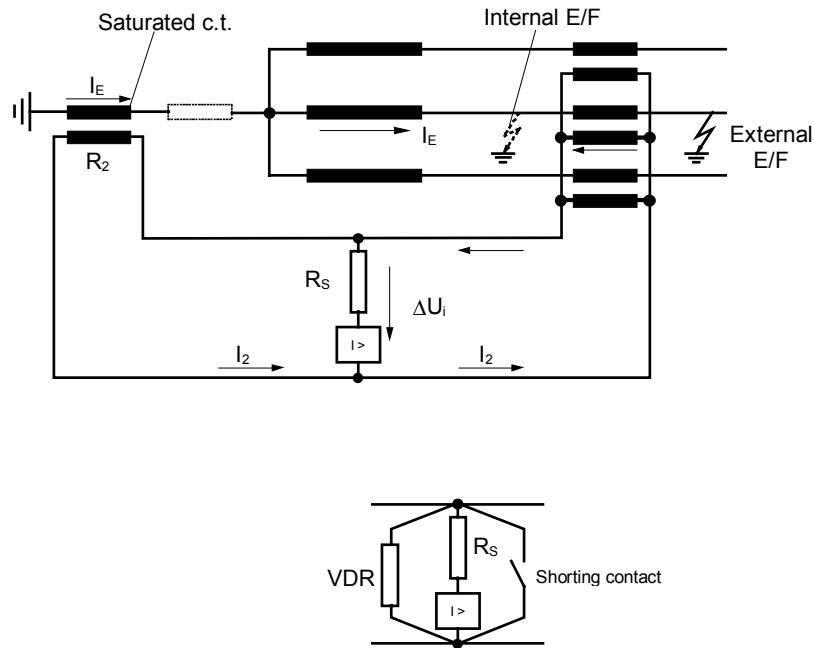


Fig. 4.2 E/F on the HV system supplied by the generator and the HV system

$$x_d'' = x_2 = 0.2 ; \quad x_T = x_{T0} = 0.1 ;$$

$$x_{sys} = x_{sys 0} = 0.01$$



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Fig. 4.3 Restricted E/F protection of a Y connected transformer winding

4.2.2. Standstill protection

4.2.2.1. General

The purpose of the standstill protection is to isolate the generator from the system as quickly as possible, if it is connected to the system by mistake, e.g. when stationary, during start-up or when running without voltage.

The protection must have a short operating time to minimise the mechanical stress on the rotors and bearings of generator and turbine, should the unit be connected to the system suddenly under these conditions. Nevertheless, it must remain stable during external faults and transients.

Standstill protection can be provided by a fast overcurrent or power function. Function modules for both alternatives are included in the REG 316*4 function library. The following example shows the overcurrent alternative.

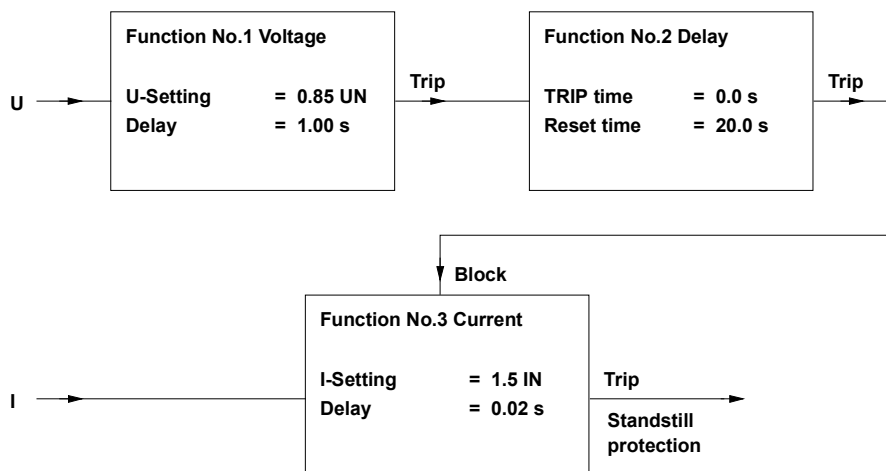
4.2.2.2. *Standstill protection using an overcurrent function*

The overcurrent function is enabled by an undervoltage function, if the period without voltage exceeds a given time.

The standstill protection scheme comprises the following items:

- an overcurrent function "Current"
- an undervoltage function "Voltage"
- a timer "Delay".

The block diagram can be seen from Fig. 4.4. The computing requirement is 23 %.



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Fig. 4.4 Block diagram of a standstill protection scheme based on an overcurrent function

4.2.3. Rotor ground fault protection

4.2.3.1. Application

Ground faults on the rotor windings of synchronous generators and motors can be detected by the protection function "Voltage" in combination with an ancillary unit Type YWX111-11 or YWX111-21.

The scheme is connected by coupling capacitors (electrical insulation) to positive and negative poles of the rotor winding and to the shaft ground. The ancillary unit Type YWX111-11/-21, the coupling capacitors and the natural capacitance of the rotor winding form a balanced R/C bridge. In the event of a ground fault, the fault resistance shunts the capacitance of the rotor winding to the shaft and disturbs the balance of the bridge. The voltage difference across the bridge is applied to an input v.t. on the REG 316*4 and causes its voltage function to trip.

Mechanical design

The ancillary unit Type YWX111-11/-21 is accommodated in a casing of dimensions 183 × 113 × 81 mm for surface mounting on a panel.

4.2.3.2. Determining the settings

Since it is not possible with this scheme to set the value of leakage resistance directly, a voltage corresponding to the leakage resistance has to be determined for setting on the REG 316*4 (U-Setting). The time delay t [s] before tripping takes place must also be set. The normal setting range for the leakage resistance R is between 0 and 5000 Ω:

- U-Setting = 0.5...3 V
- t = 0.5...5 s

R: leakage resistance between
the rotor winding and ground (shaft)

U-Setting: voltage setting

t: operating time.

4.2.3.2.1. Required data

No special data are required in order to determine the settings for the protection. Determining the settings by calculation is somewhat difficult and therefore they are determined by measurement.

4.2.3.2.2. Recommended settings for R_f , respectively 'U-Setting' and t

Basically any value may be set for R_f and the time delay t within their available ranges.

Very sensitive settings are not recommended to prevent mal-operation of the protection during fast load regulation on the power system. This is especially the case in schemes which trip the field switch and shut the machine down.

Recommendation:

- Stage 2: "Trip"

$$R \leq 2000 \, \Omega$$

$$t \geq 1.5 \, \text{s}$$

- Stage 1: "Alarm"

$$R \leq 5000 \, \Omega$$

$$t \geq 1.5 \, \text{s}.$$

Note that the difference voltage across the bridge is low for high leakage resistances and high for low leakage resistances.

4.2.3.3. Functional check

The procedure for checking the function of the protection prior to installation or connection is given in [Section 4.2.3.5.3](#). Alternatively a test circuit can be set up as shown in [Fig. 4.7](#) and the procedure followed according to [Section 4.2.3.5.4](#).

4.2.3.4. Installation and wiring

4.2.3.4.1. Location and ambient conditions

The ancillary unit Type YWX111-11/-21 must be mounted as close as possible to the REG 316*4 (same cubicle or panel) to minimise the probability of interference.

The coupling capacitors C_K , on the other hand, should not be in the relay room, but as close as possible to the machine. The connecting cables to the primary system must be suitable for the insulation level of the rotor circuit.

4.2.3.4.2. Checking the wiring

Check the conformity of all connections with the wiring diagram for the plant.

Check that the rated frequency and supply voltage of 100 V AC or 220 V AC agree with the data on the rating plate of the ancillary unit Type YWX111-11/-21.

Connecting up the YWX111-11/-21

The supply voltage of 100 V AC or 220 V AC can be provided by the normal power distribution network or a v.t. connected to the generator concerned. The auxiliary supply can also be taken from the input terminals of an input transformer module of the REG 316*4 used for measuring the generator voltage.

Since duplicate grounds can be problematical, it may be necessary to interrupt the ground connection to terminal 3 of YWX111-11/-21 (connection to the shaft ground) in the cubicle or on the panel.

4.2.3.4.3. Connection of a two-stage scheme

A two-stage protection scheme requires two "Voltage" functions and one ancillary unit Type YWX111-11/-21.

Usual utilisation:

- Stage 1: "Alarm"
- Stage 2: "Trip".

The wiring must be in strict accordance with [Fig. 4.9](#).

4.2.3.4.4. Connection to excitation systems with shaft-mounted diodes

Schemes for protecting excitation circuits with diodes mounted on the shaft of the generator (rotating diodes) must have a connection via a slip-ring to just one pole of the rotor circuit.

The two coupling capacitors C_{K1} and C_{K2} must thus be connected in parallel to either the positive or negative pole. Where there is a choice (several slip-rings), the connection of $C_{K1/2}$ to the minus pole is to be preferred.

The remaining connections must be in accordance with [Fig. 4.8](#) or [Fig. 4.9](#).

4.2.3.4.5. Adaptation of the scheme in the case of shaft filters

If the rotor circuit includes a so-called shaft filter to prevent damage to the bearings, the filter reduces the sensitivity of the protection.

In such cases, the sensitivity can be restored to the desired level by increasing the value of R9 in the ancillary unit Type YWX111-11/-21.

YWX111-11/-21

- Standard: $R\ 9 = 120\ \Omega$
(normal sensitivity)
- With shaft filter: $R\ 9 = 1\ k\Omega$
(increased sensitivity)

Location of resistor R9: [see Fig. 4.11](#).

4.2.3.5. Commissioning

The commissioning procedure is described in Sections 4.2.3.5.1. to [4.2.3.5.4](#). The tripping circuits of the REG 316*4 should be interrupted while performing the tests according to [Sections 4.2.3.5.3.](#) and [4.2.3.5.4.](#)

4.2.3.5.1. Pre-commissioning checks

- Check the wiring according to [Section 4.2.3.4.](#)
- Check that the YWX111-11/-21 is connected to the correct auxiliary supply voltage of 100 V AC or 220 V AC.

Check that the shaft grounding brush of the generator makes proper contact and is in good working order.

4.2.3.5.2. Calibration of the ancillary unit Type YWX111-11/-21

The measuring bridge of which the YWX111-11/-21 is part must be balanced with the unit connected by appropriately selecting the values of the capacitors C_X .

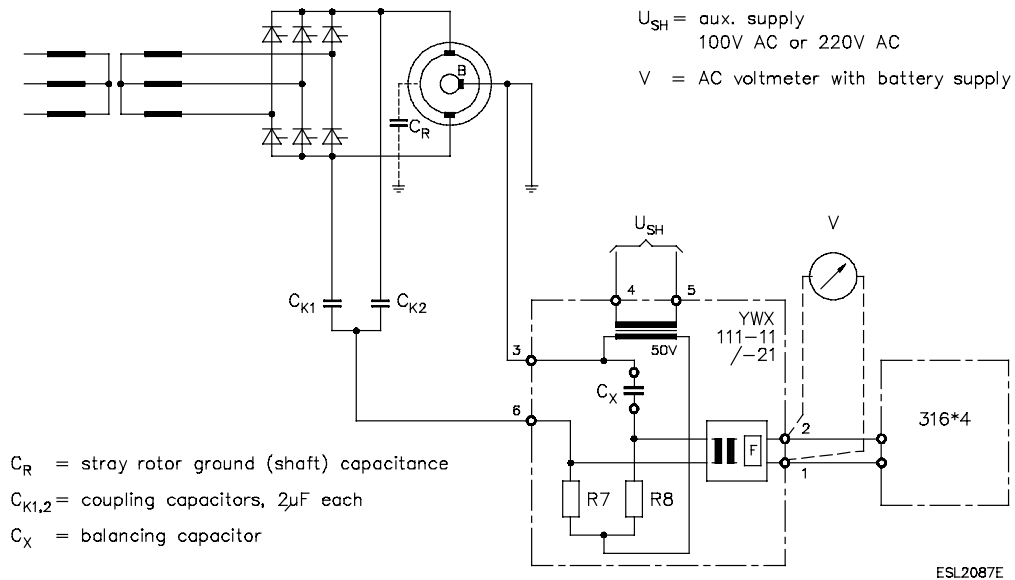


Fig. 4.5 Calibration of the YWX111-11/-21

Calibration capacitor C_X : Polyester, $\geq 400 V$

Calibration can be carried out while the machine is stationary.

Procedure:

- Interrupt the REG 316*4 tripping circuits.
- Connect an AC voltmeter to terminals 1 and 2 of YWX111-11/-21.
- Connect a decade capacitor in place of C_X .
- Close the excitation switch.
- Switch on the auxiliary supply U_{SH} .
- Vary C_X until the output voltage across terminals 1 and 2 of YWX111-11/-21 becomes a minimum; typically $\leq 50 \text{ mV}_{r.m.s.}$.

Note: It is possible that the $50 \text{ mV}_{r.m.s.}$ will not be reached in the case of schemes with shaft filters and increased YWX111-11/-21 sensitivity ($R9 = 1 \text{ k}\Omega$).

- Solder in a capacitor or combination of capacitors with the total value determined for C_X .

Theoretical value of C_X

- a) Circuit according to Fig. 4.8a (or Fig. 4.5):

$$C_X = \frac{(C_{K1} + C_{K2}) \times C_R}{C_{K1} + C_{K2} + C_R}$$

- b) Circuit according to Fig. 4.8b:

$$C_X = \frac{3C_K \times (3C_S + C_R)}{3C_K + 3C_S + C_R}$$

4.2.3.5.3. Measuring the voltage values

The value of the voltage across the bridge as measured on the YWX 111 in relation to different leakage resistances is determined by measurement with a variable resistor inserted in place of the leakage resistance as shown in Fig. 4.6.

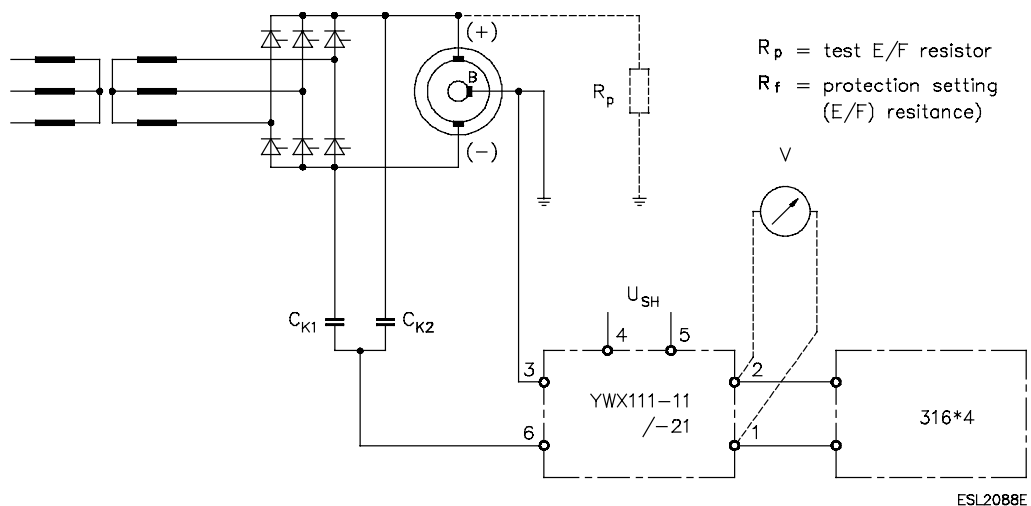


Fig. 4.6 Measuring the voltages corresponding to leakage resistance

Leakage resistor R_p :

- 0 Ω , solid ground fault
- 2000 Ω , ≥ 2.5 W
- 5000 Ω , ≥ 2.5 W.

The measurement can be carried out with the machine stationary.

Procedure:

- Interrupt the REG 316*4 tripping circuits.
- Connect $R_p = 5000 \Omega$, 2000Ω or 0Ω to the positive pole of the excitation circuit.
- Close the excitation switch.
- Switch on the auxiliary supply U_{SH} .
- Measure the voltage for different values of leakage resistance.
- Set the voltage measured for 2000Ω or 5000Ω on the REG 316*4. The voltages are usually in the range of 0.5 and 3 V.
- Repeat the procedure for $R_p = 5000 \Omega$, 2000Ω or 0Ω , but connected to the minus pole.

4.2.3.5.4. Testing in operation

This test checks that the REG 316 and the ancillary unit function correctly with the generator in operation. Once again a rotor fault is simulated by installing a leakage resistor. The protection must effectively trip.

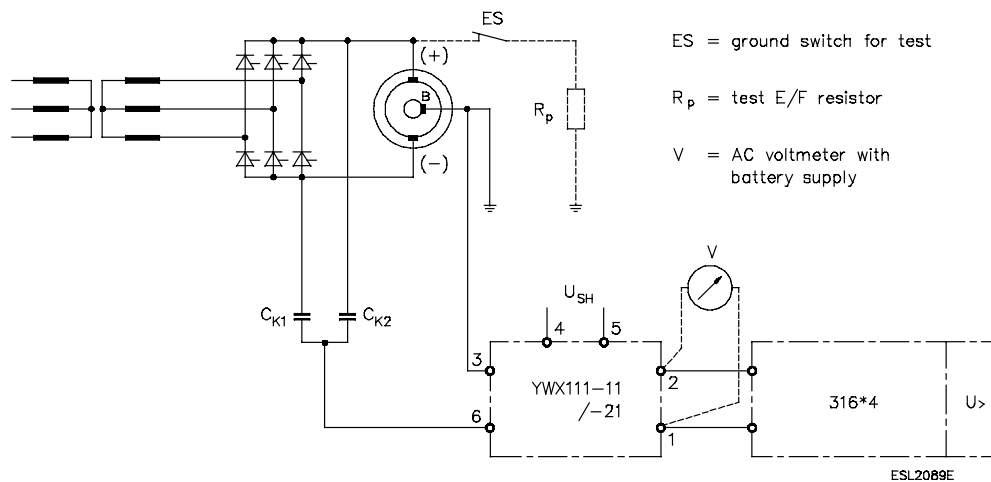


Fig. 4.7 Circuit for testing in operation

Leakage resistor R_p : 1000Ω , $\geq 10 \text{ W}$, insulation voltage according to IEC recommendations (for different excitation voltages).

Procedure:

- Test conditions: machine at rated speed with excitation and on load, grounding test switch ES open.
- Interrupt the REG 316*4 tripping circuits.
- Set the voltage on the REG 316*4 as measured according to [Section 4.2.3.5.3](#).
- Close the grounding switch ES.
- Slowly reduce the voltage setting “U-Setting” in steps until the protection trips.

Caution: The tripping signal is delayed.

- Connect the test resistor R_P to the minus pole of the excitation circuit and repeat the above procedure.
- Measure and record the voltage across terminals 1 and 2 of YWX111-11/-21 during the test.
- After the test has been completed, open the grounding switch ES and close the REG 316*4 tripping circuits.

Checking the calibration of YWX111-11/-21

Measure the voltage across the bridge at terminals 1 and 2 of YWX111-11/-21 with the machine running on load with excitation. The reading should be $\leq 150 \text{ mV}_{\text{r.m.s.}}$ in normal operation (ES open). If it is higher,

- check the contact resistance of the shaft grounding brush ([see Section 4.2.3.6.](#)).
- repeat the calibration of YWX111-11/-21 according to [Section 4.2.3.5.2](#).

Note: It is possible that the $150 \text{ mV}_{\text{r.m.s.}}$ will not be reached in the case of schemes with shaft filters and increased YWX111-11/-21 sensitivity ($R_9 = 1 \text{ k}\Omega$).

4.2.3.6. Maintenance

4.2.3.6.1. Likely causes of problems

Should the protection become defective, i.e. operate incorrectly, the cause may be one of the following

- The shaft grounding brush is making poor contact → see Section 4.2.3.6.2.
- The calibration of the YWX111-11/-21 is incorrect → [see Sections 4.2.3.5.2. and 4.2.3.5.4.](#)
- The YWX111-11/-21 is grounded in the cubicle (terminal 3) causing a duplicate ground → [see Section 4.2.3.4.2.](#)
- The protection is too sensitive (the setting for the level of leakage resistance is too high) or the time delay t is too short.

4.2.3.6.2. Maintenance

The ancillary unit requires no special maintenance. As with all safety systems, however, it should be tested at regular intervals. This can be carried out as described in [Section 4.2.3.5.](#)

The shaft grounding brush should be checked and cleaned at frequent intervals and the contact pressure adjusted as necessary.

4.2.3.7. Fault-finding

Fault-finding is confined to testing the device according to [Section 4.2.3.5.](#) to determine whether it operates correctly. Faulty units should be returned to the nearest ABB agent or directly to ABB Switzerland Ltd., Baden, Switzerland.

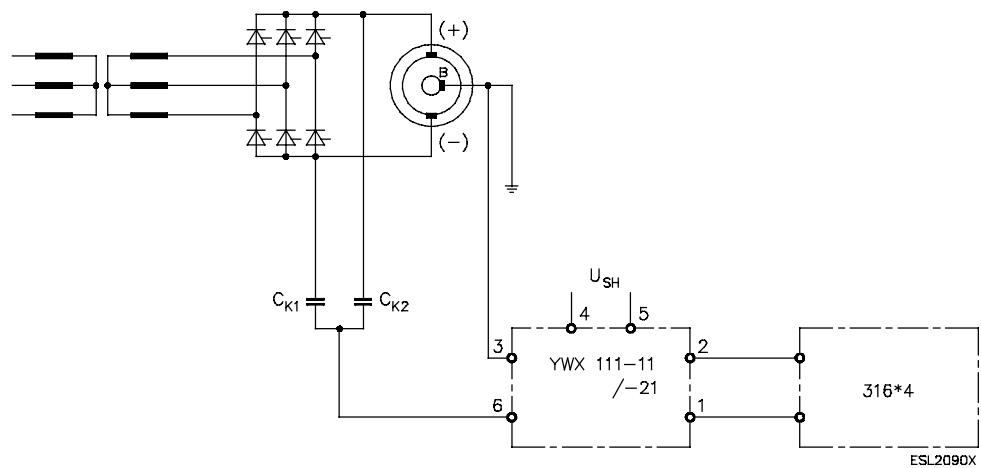
4.2.3.8. Accessories and spares

When ordering accessories or spares, state the type and serial number of the unit for which they are intended. If a number of identical units is installed in a plant, keeping a spare unit on stock is recommended.

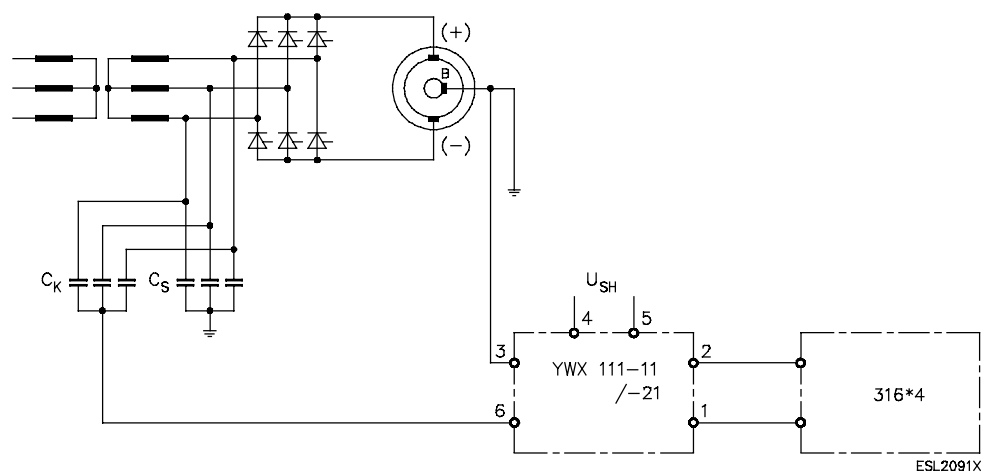
Spare material must be stored in a clean dry room at moderate temperatures. Testing spare units in conjunction with the routine testing of units in operation is recommended.

4.2.3.9. Appendices

- [Fig. 4.8](#) Wiring diagram of the REG 316 and the ancillary unit Type YWX111-11/-21
- [Fig. 4.9](#) Wiring diagram for a two-stage protection scheme
- [Fig. 4.10](#) Internal operation and terminals of the YWX111-11/-21
- [Fig. 4.11](#) Component side of the PCB in the YWX111-11/-21



a) Connection to the DC side of the rotor circuit



b) Connection to the AC side of the rotor circuit

Fig. 4.8 Wiring diagram of the REG 316*4 and the ancillary unit Type YWX111-11/-21

C_{K1}, C_{K2} : coupling capacitors; $2 \times 2 \mu\text{F}$, 8-20 kV, 0.55 A

C_K : coupling capacitors; $3 \times 0.5 \mu\text{F}$, 8-20 kV, 0.55 A

C_S : filter capacitors for thyristor excitation

U_{SH} : auxiliary supply; 100 V or 220 V, 50/60 Hz

B: shaft grounding brush

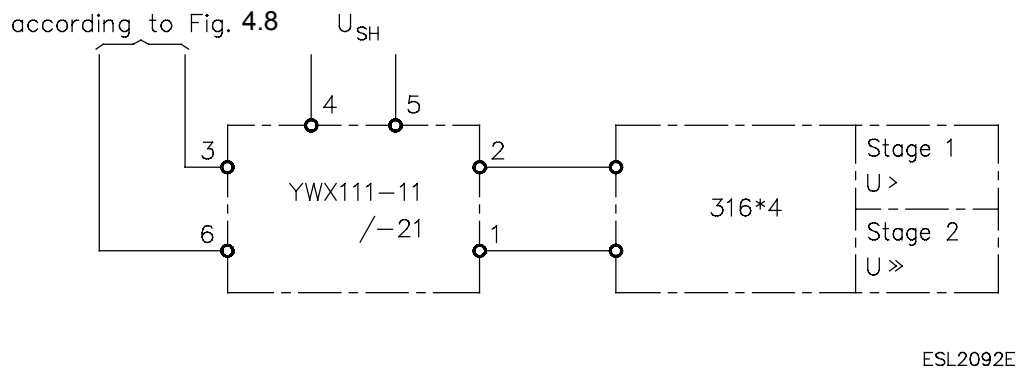


Fig. 4.9 Wiring diagram for a two-stage protection scheme

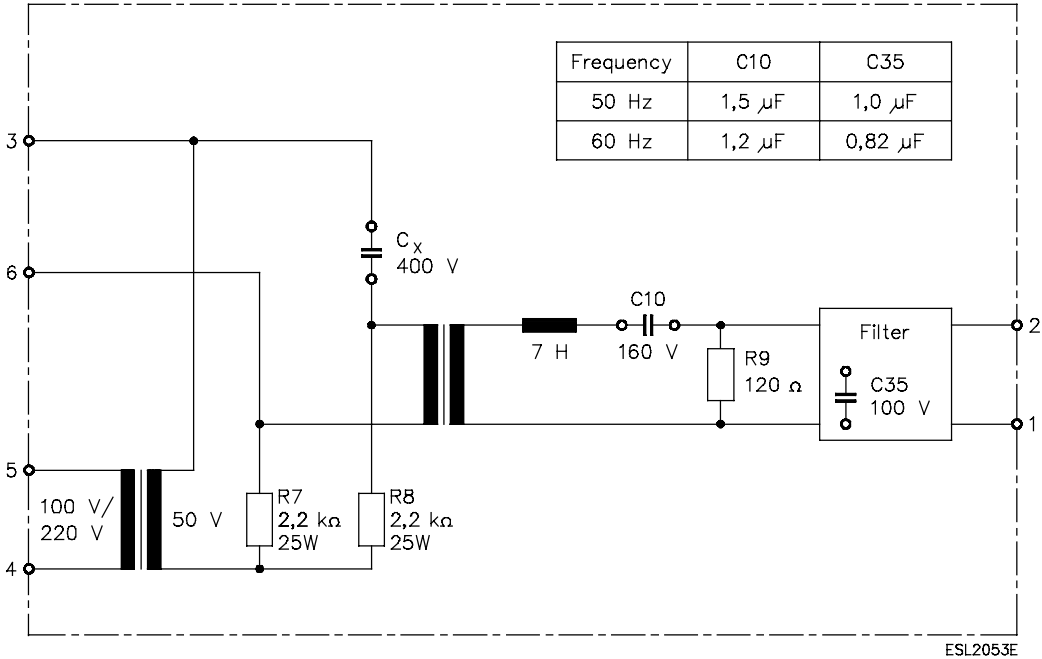


Fig. 4.10 Internal operation and terminals of the YWX111-11/-21

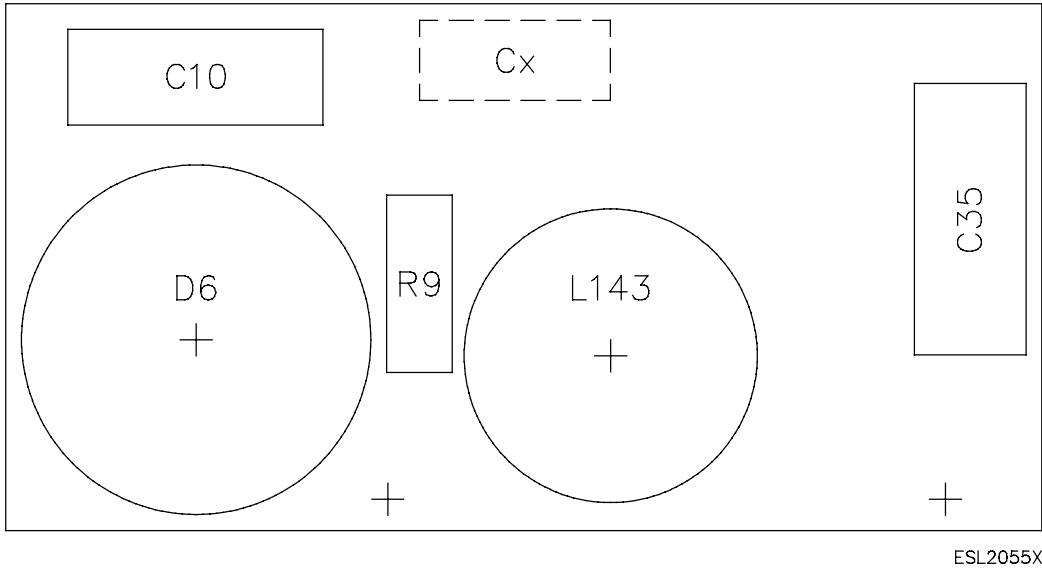


Fig. 4.11 Component side of the PCB in the YWX111-11/-21, (derived from HESG 437 807)

4.2.4. Application of the underreactance protection function

4.2.4.1. Introduction

The underreactance protection function can be used for a number of purposes. It is normally used, however, to detect out-of-step conditions for load angles $\delta \geq 90^\circ$. It is similarly applicable to monitoring a maximum load angle, e.g. $\delta = 70^\circ$.

4.2.4.2. Out-of-step conditions

The stability limit of a turbo-alternator with or without step-up transformer is illustrated at the upper left in Fig. 4.12 as a function of the impedance measured at the generator terminals and at the upper right as a power diagram. The operation of the protection is set to the circle (lower left of Fig. 4.12) to avoid tripping during a fault or power swings on the power system. The setting range permits the protection characteristic to be adjusted to the stability limit curve (see upper left of Fig. 4.12) which is applicable whether the generator is connected to a step-up transformer or directly to a busbar.

4.2.4.3. Monitoring a given load angle

The setting range also facilitates monitoring a given load angle, e.g. $\delta < 90^\circ$, for:

- alarm purposes when a certain maximum load angle is reached
- fulfilling special requirements, e.g. to take account of the influence of differing values of X_d and X_q at the stability limit
- salient pole machines.

A load angle of $\delta < 90^\circ$ represents an offset circle in the impedance plane (see left of Fig. 4.13). The centre of the circle lies on a straight line which is displaced from the R axis by the angle δ . The circle is the locus of the operating points with the load angle δ . The corresponding characteristic in the power diagram is a straight line with a slope of δ .

The value of the load angle δ is set by means of the phase-angle compensation setting which must be increased by the amount $(90 - \delta)$. For $\delta = 70^\circ$, the reference voltage R-S and the R phase current, the following phase-angle compensation must be set:

$$30^\circ + (90^\circ - 70^\circ) = 50^\circ.$$

The reactance X_A is set either to the synchronous reactance X_d or a value which takes account of differing values of X_d and X_q .

The following general statement applies:

$$X_A = \frac{X}{\sin \delta}$$

$X_B = 0$ in [Fig. 4.13](#). X_B can also be positive or negative and represented in an impedance plane by circles which do not pass through the origin. In a power diagram, these circles correspond to circles to the left and right of the straight lines through points C', A' and E'. Point A is common to all circles with the same load angle δ and the same X_A setting ([see Fig. 4.12](#)).

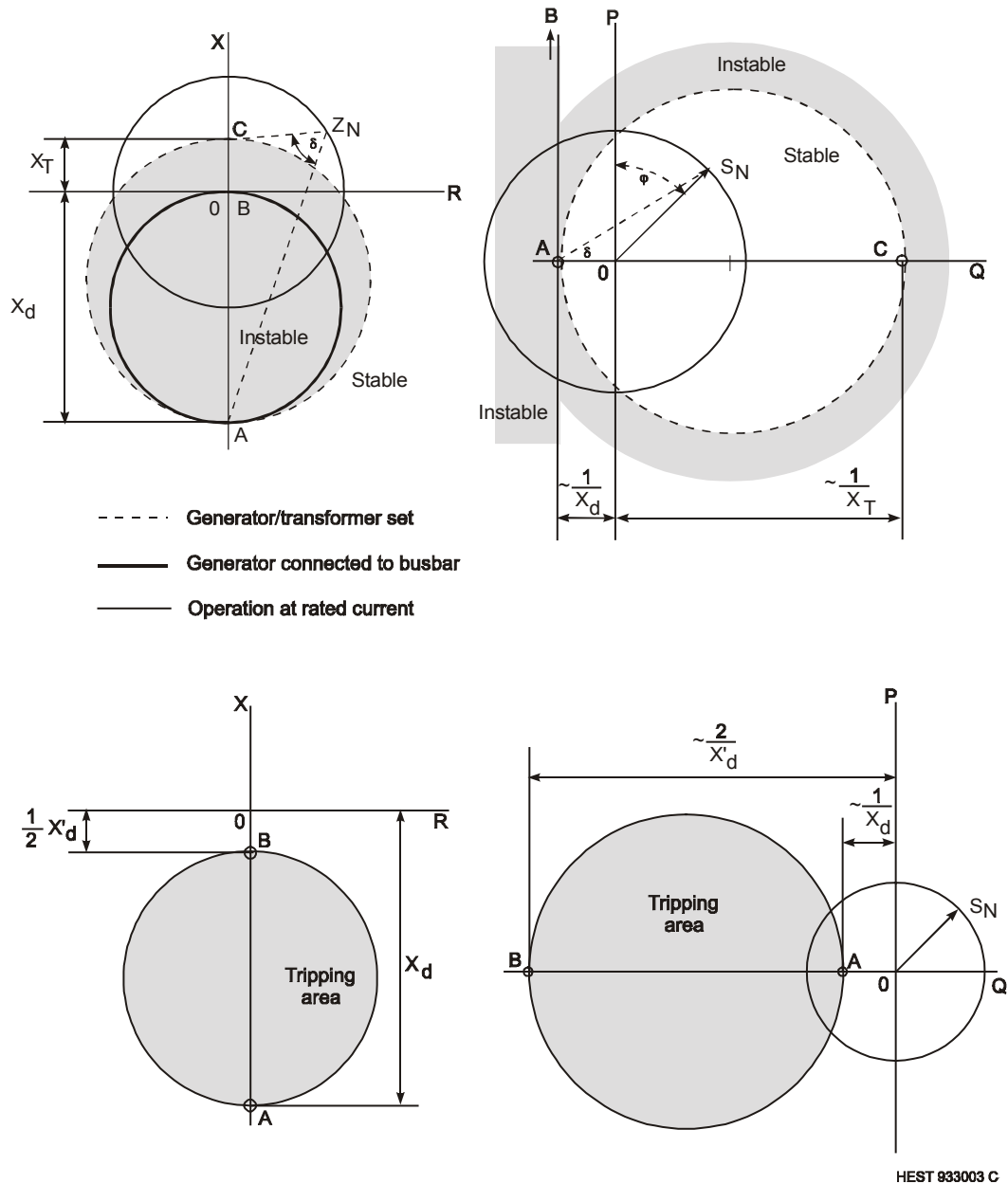
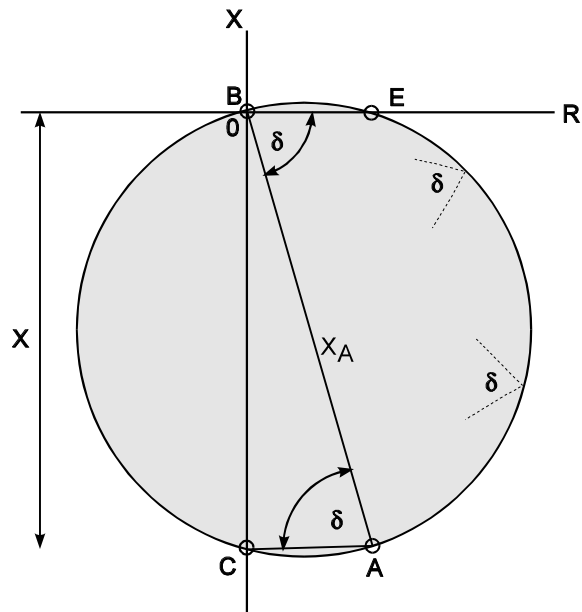
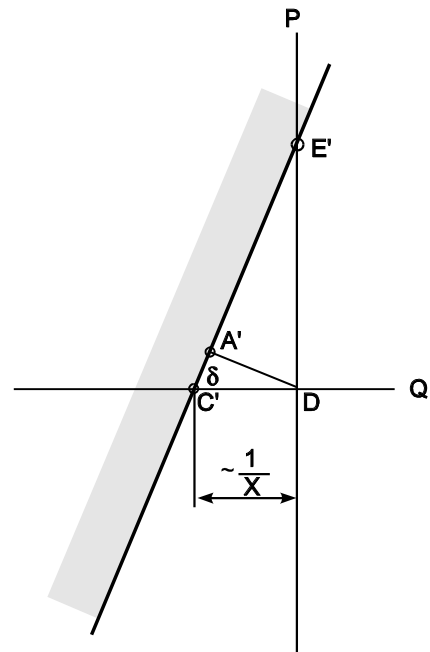


Fig. 4.12 Stability limit of a generator/transformer set and the characteristic of the 'Minreactance' protection function



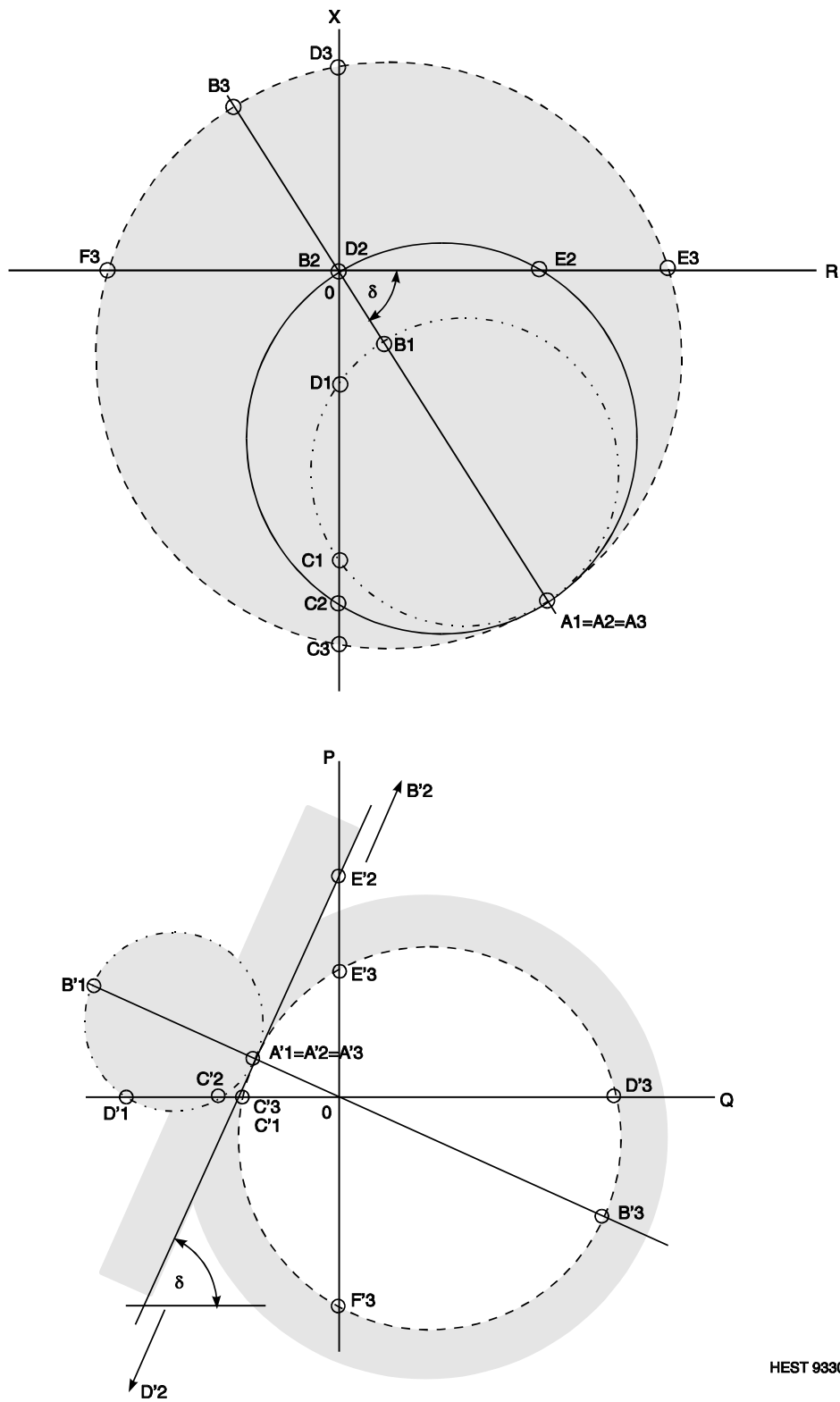
The diameter $\overline{AB}$ is set :

$$X_A = \frac{X}{\sin \delta}$$



HES 933004 C

Fig. 4.13 Locus of the load angle $\delta < 90^\circ$



HEST 933005 C

Fig. 4.14 Operating characteristic for different settings of 'XB-Setting' and a load angle $\delta < 90^\circ$

4.2.5. Stator ground fault protection for generators in parallel

This is a discriminative ground fault scheme for generators with ungrounded star-points. It covers 80 % of the winding and operates on the basis of a directional zero-sequence component in the various generator feeders. Since the capacitive component of a ground fault current does not usually provide a sufficiently reliable criterion for determining the feeder concerned, the ground fault current is artificially increased by adding a real power component. The latter is generated either by three single-phase v.t.'s or a three-phase v.t. Whichever is the case, the secondaries are connected as a broken delta and a resistor (R_e) is switched briefly into the delta after a ground fault has been detected. The combined v.t. and grounding transformer are connected to the continuously energised busbars. The number of generator feeders can vary.

The protection scheme comprises two parts:

The first part is a non-discriminative ground fault detector on each busbar comprising a:

- grounding transformer
- ferroresonance damping resistor R_p
- switched grounding resistor R_e
- zero-sequence voltage detector for switching in the resistor
- contactor
- interposing v.t.

The second part comprises the power function and either a core-balance or three bushing c.t.'s to measure the zero-sequence current and discriminatively locate the ground fault after the real power component has been added.

4.2.5.1. Principle of operation

Initially a ground fault is detected non-discriminately due to the occurrence of a neutral voltage measured by a sensitively set voltage function. The grounding resistor R_e is switched in circuit after a short delay ($t_1 = 0.1$ s) to prevent operation during power system transients. Only then is the ground fault current large enough to enable the power functions on the generators to decide whether the ground fault is on their generator feeder or not. The delay for the power function is set to isolate the fault after 0.5 s. The grounding resistor R_e is connected for 1.9 s. The resistor R_e is switched out of circuit again after a delay of 2 s initiated by the voltage function.

Two timers ensure correct operation of the scheme:

- T1 prevents operation during transients, $t_1 = 0.1 \text{ s}$
- T2 prevents “pumping” when the grounding resistor R_e is switched in and out of circuit, $t_2 = 1 \text{ s}$.

The protection operates with a maximum real power component in the ground fault current of 12...20 A for a ground fault at the generator terminals. The neutral voltage is then a maximum. The ground fault current is proportional to the neutral voltage and is a maximum for a ground fault at the generator terminals and a minimum for a ground fault at the star-point.

An offset of the of the neutral of the three phase voltages is caused:

- a) in normal operation by:
 - asymmetries of the phase-to-ground
 - the presence of a third harmonic component
- b) under abnormal operating conditions by
 - switching transients
 - internal and external ground faults

To avoid any risk of mal-operation, the setting of the ground fault detector must be higher than any voltage offset which can occur during normal operation.

Under abnormal conditions, the voltage offset can be increased by the ferroresonance of the capacitance with the inductance of the v.t's.

The danger of mal-operation of the ground fault detector due to switching operations is minimised or even eliminated altogether by adding the resistor R_p and also a delay. The effectiveness of this measure depends on how low the resistor R_p can be. A low resistor, however, increases the current, the power of the resistor and the load on the v.t's or grounding transformer.

4.2.5.2. Busbar ground faults

Should no ground fault be located on one of the generator feeders, it has to be on the busbars or possibly an outgoing feeder. In such a case, the voltage function operates and the alarm "Busbar ground fault" is generated after the set delay of 2 s.

4.2.5.3. Ground fault protection during start-up

The power function can only detect a ground fault on the generator feeder when the circuit-breaker is closed. For the time that the circuit-breaker is open, ground fault protection is afforded by a sensitive voltage function which trips the excitation switch in the event of a stator ground fault after a delay of 0.5 s. This ground fault protection scheme is blocked once the circuit-breaker closes.

4.2.5.4. Grounding transformer

The following arrangements can be used to increase the ground fault current:

- 3 single-phase v.t.'s with a maximum rating of 100 kVA for 10 s. This arrangement can be used at 6.66 A up to a rated generator voltage of 12 kV, at 5 A up to 16 kV and at 4 A up to 20 kV.
- 3 single-phase dry v.t.'s can conduct 6.66 A at voltages higher than 12 kV.

Apart from a higher overload rating, a 3 single-phase grounding transformer also has the advantage of a negligible voltage drop.

Example for generators with a rated voltage of 10.5 kV and a ground fault current of 20 A (6.66 A per phase):

Voltage transformers			Short-time sec. rating
U_{1N} [V]	U_{2N} [V]	S [kVA]	[A] 10 s
$\frac{10500}{\sqrt{3}}$	167	70	240

4.2.5.5. Ferroresonance damping resistor R_p

For a ground fault in the busbar zone, the ground fault detector issues an alarm without interrupting operation. The resistor R_p must therefore be rated for continuous operation. It generally has a rating of 1 or 2 A, which is permissible for most v.t.'s, but has

only a limited damping capacity. The output power of the v.t. in the example varies at a continuous current of 2 A between 577 and 831 VA.

When the main priority is to prevent mal-operation, the resistor R_p is chosen according to the maximum continuous rating of the v.t.'s which is usually in the range of 5 to 10 % of the permissible 10 s current. Where the v.t.'s are also used for metering, it should be noted that the voltage and phase errors increase at the maximum continuous current.

4.2.5.6. **Grounding resistor R_e**

The grounding resistor must be rated for 10 s. A voltage drop of 20 % is allowed if a v.t. is used as grounding transformer. For a ground fault current of 20 A and a rated voltage of $U_N = 10.5$ kV, the recommended value of the resistor is:

U_N	$U_{\text{broken } \Delta}$	R_p		R_e	I_2
[V]	[V]	[Ω]	[A]	v.t.	[A] 10 s
10,500	500	250	2	1.7 Ω	240

4.2.5.7. **Contactor**

The contactor switches both ends of the grounding resistor R_e .

4.2.5.8. **Residual current c.t.**

Alternative I:

1 core-balance c.t. 100/1 A, rated burden 2.5 Ω .

Alternative II:

3 bushing c.t.'s, .../5 A - 33/1 A, rated burden 1.5 Ω .

The above burdens apply for c.t. leads of 2 x 100 m with a gauge of 4 mm².

4.2.5.9. Required REG 316*4 functions

The following REG 316*4 functions are required for a discriminative ground fault scheme:

- 1 100 V voltage input
- 1 metering current input
- 1 to 4 tripping channels
depending on the number of circuit-breaker tripping coils and whether redundancy is required or not
- 1 "Ground fault" signalling channel
- 2 signalling inputs.

The start-up scheme requires:

- 1 100 V voltage input
- 1 or 2 tripping channels for the de-excitation switch
- 1 "Start-up ground fault" signalling channel
- 1 "Generator CB closed" signalling input.

4.2.5.10. Protection sensitivity

For a ground fault at the generator terminals, a real power current of 20 A results in a voltage of approximately 80 V, respectively 100 V at the input of the REG 316*4. The lower of the two voltages takes the voltage drops of three single-phase v.t.'s into account. A current of 4 A and a voltage of 16 V are produced by a ground fault at 20 % of the winding from the start-point. The current at the input of the REG 316*4 in the case of a core-balance c.t. with a ratio of 100/1 A is 0.04 A which corresponds to a power of 0.64 W at 16 V. This is detected by the power function with a setting of 0.5 % or 0.5 W at $U_{RN} = 100 \text{ V}$ and $I_{RN} = 1 \text{ A}$.

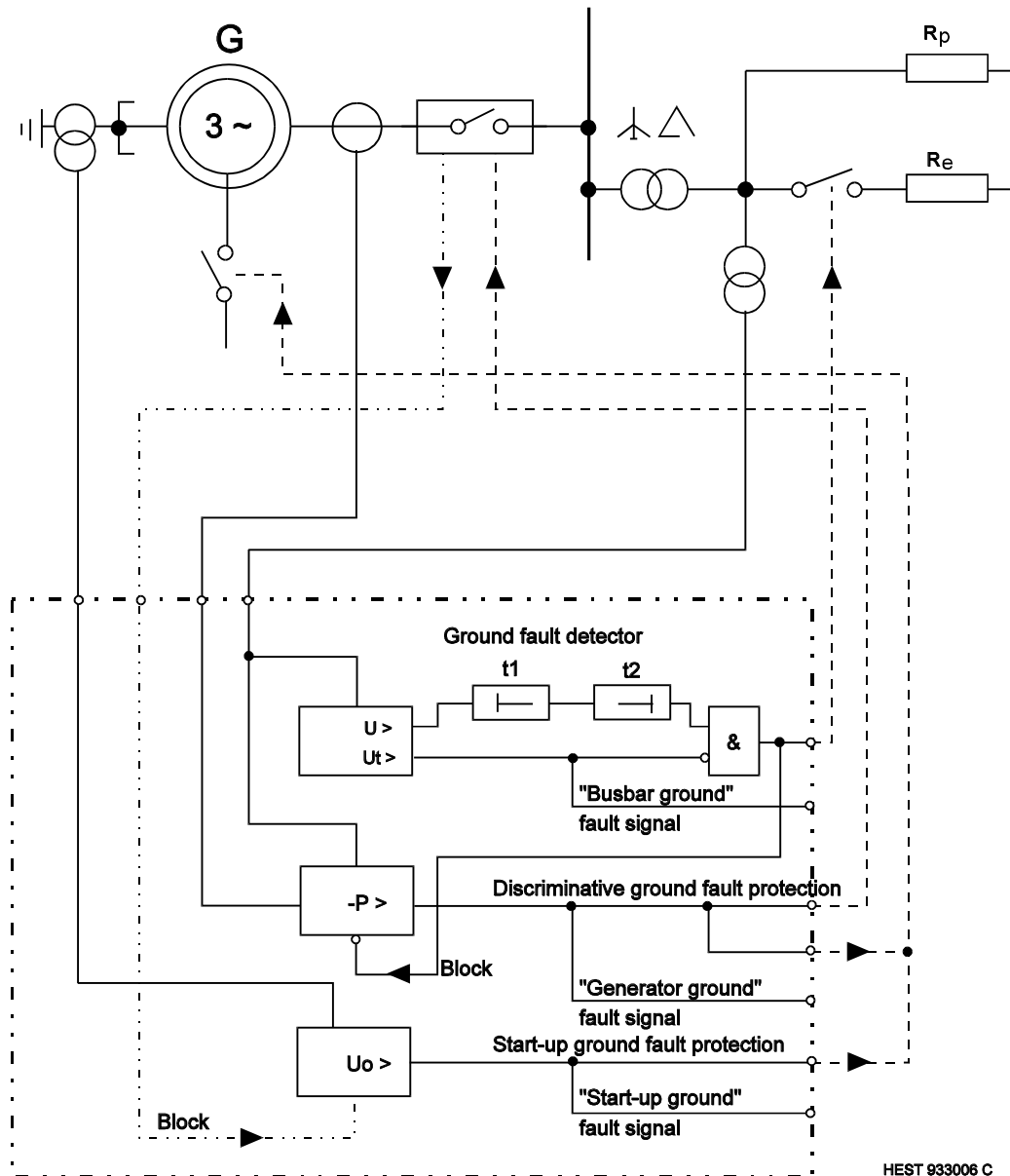


Fig. 4.15 Discriminative ground fault and start-up schemes for a generator feeder

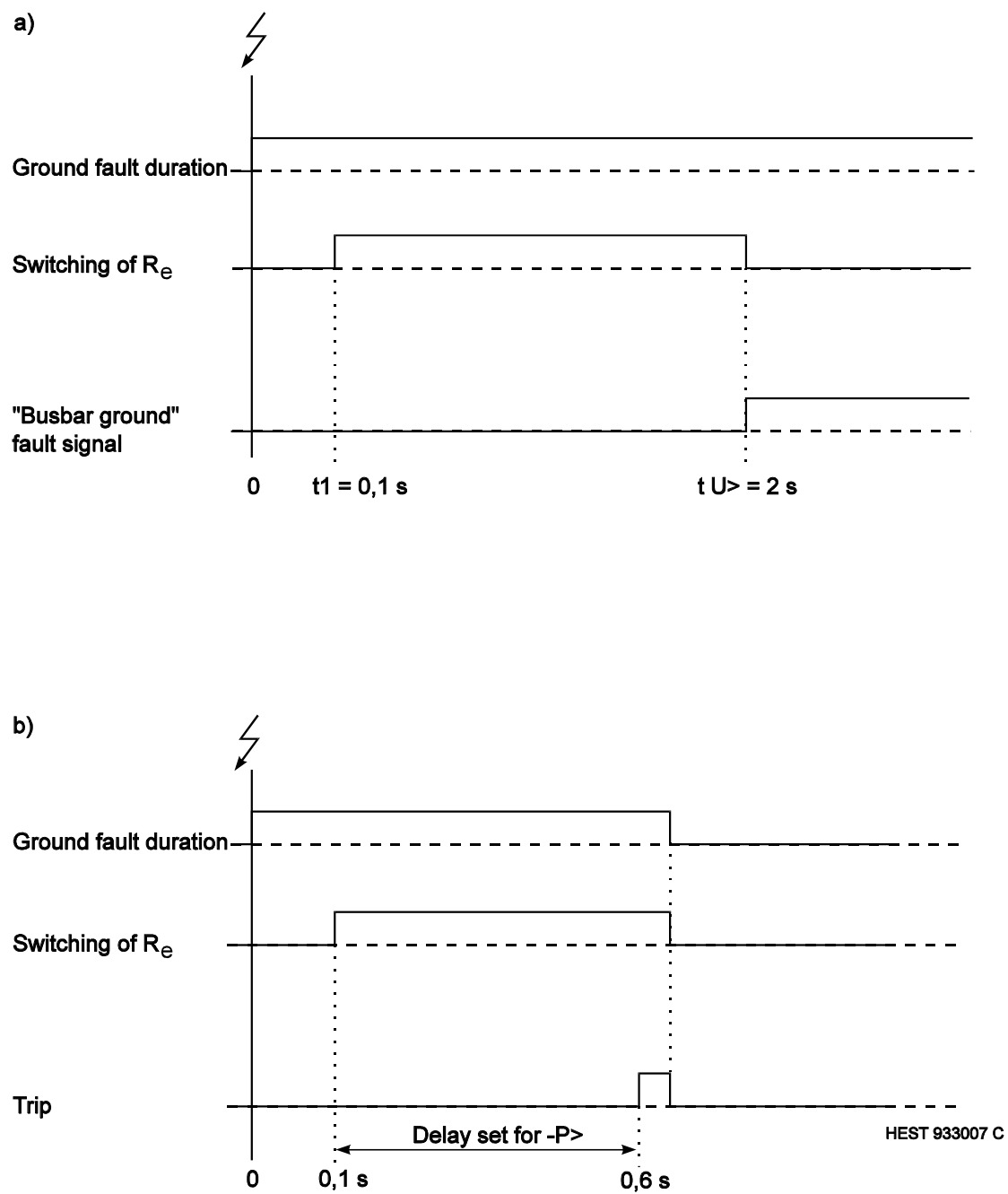
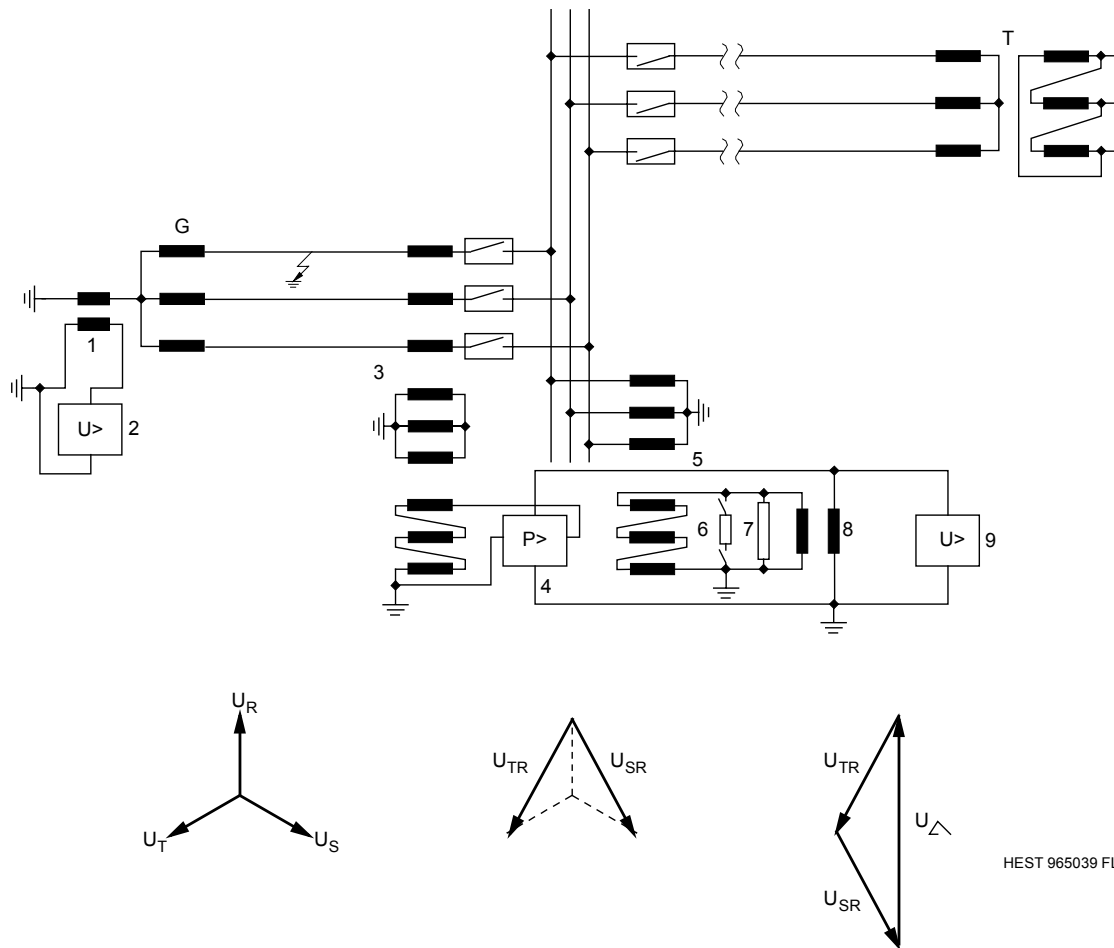


Fig. 4.16 Operation of the ground fault protection for a fault

- a) on the busbar
- b) on a feeder



Legend:

- 1 Generator star-point v.t.
- 2 Start-up scheme v.t.
- 3 3 neutral c.t.'s for the generator ground fault current
- 4 Power relay for the generator ground fault protection
- 5 Grounding transformer
- 6 Grounding resistor R_e
- 7 Ferroresonance damping resistor R_p
- 8 Interposing v.t.
- 9 Voltage relay for the busbar ground fault protection

Fig. 4.17 Three-phase diagram and vector diagram of the protection

4.2.6. **100% stator and rotor ground fault protection**

Stator ground fault protection

The ground fault protection of the entire stator winding comprises a 95 % scheme and a 100 % scheme (see Fig. 4.18). The zones of the two schemes overlap in the stator windings. Ground faults in the region of the generator terminals are detected primarily by the 95 % stator ground fault scheme. Ground faults near the star-point, on the other hand, can only be detected by the 100 % stator ground fault scheme.

The functions required for the two schemes are

- a “Voltage” function for the 95 % stator ground fault protection
- the “Stator-EFP” for the star-point zone protection.

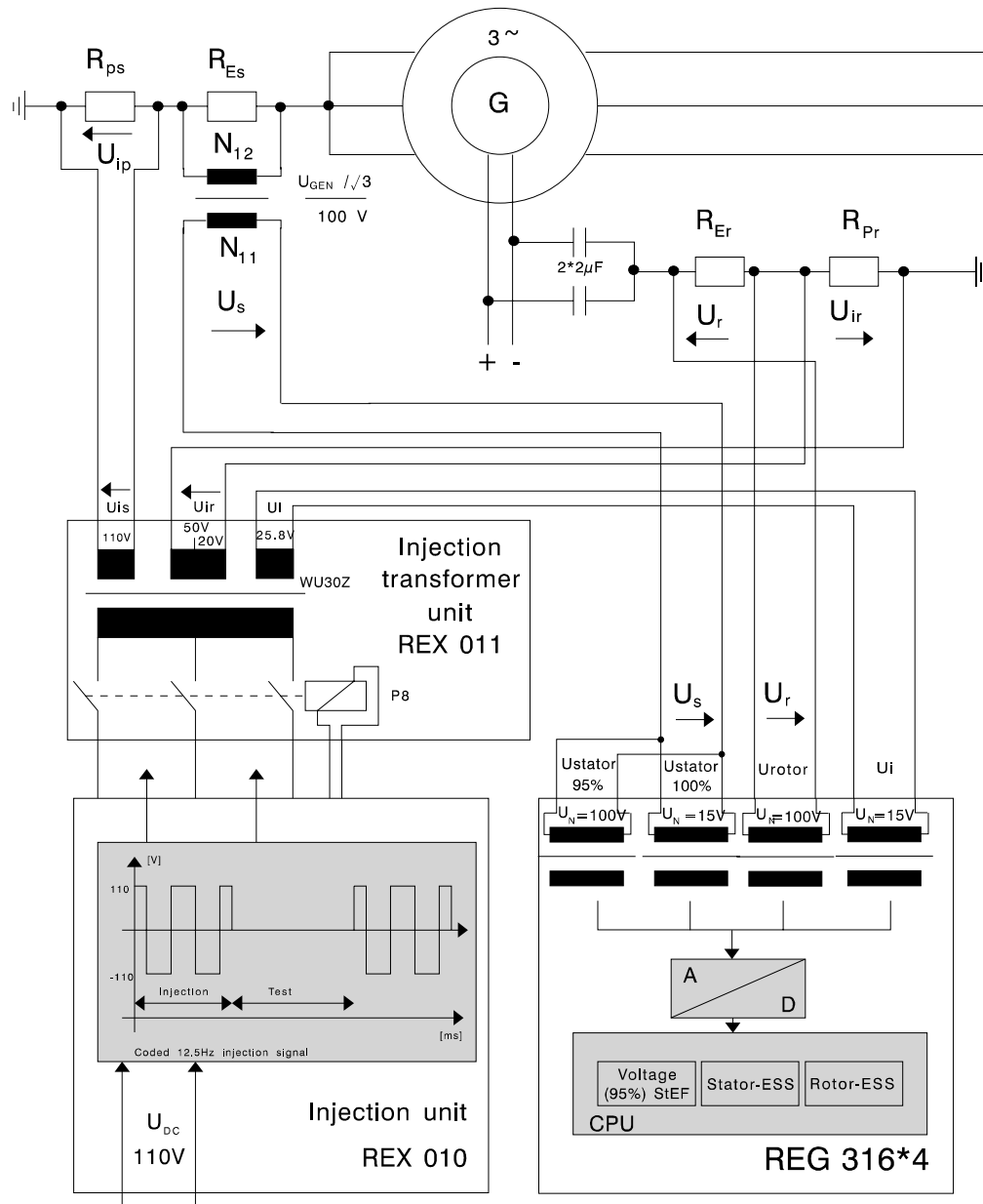
The 95 % scheme uses the generator voltage and detects a ground fault on the basis of the displacement of the star-point voltage it causes.

The 100 % star-point scheme injects a voltage to permanently bias the star-point. The injection voltage has an impulse waveform with an amplitude of about 100 V and a frequency of 12.5 or 15 Hz. It is provided by an injection unit Type REX 010 and an injection transformer unit REX 011. The scheme measures the ground fault leakage resistance.

The sensitivities of the two schemes can be set in the case of the

- 95 % scheme by the pick-up voltage (typically 5 V)
- 100 % star-point scheme by settings for the ground fault resistance (typically 5 k Ω for alarm and 500 Ω for tripping).

The zone of the 100 % scheme depends on the maximum zero-sequence current at fundamental frequency flowing at the star-point. This occurs for a fault at the generator terminals. The low-frequency injection voltage is switched off when the zero-sequence current component at power system frequency exceeds 5 A. For a current of $I_{E \max} = 20$ A, the pick-up current of 5 A is reached for a ground fault at 25 % of the winding from the star-point. It is of advantage to limit the ground fault current to $I_{E \max} \leq 5$ A so that the zone of the 100 % scheme extends over the whole stator winding.



ESS 935005 HG

Fig. 4.18 100% stator and rotor ground fault protection

Rotor ground fault protection

The rotor ground fault protection injects a voltage with an amplitude of 50 V and a frequency of 12.5 or 15 Hz to permanently bias the potential of the rotor circuit in relation to ground. The scheme signals a ground fault when the leakage resistance of the rotor circuit falls below the value set on the protection.

The injection voltage of 50 V is supplied by the same injection unit Type REX 010 and injection transformer unit Type REX 011 as are used for the stator ground fault scheme.

4.2.7. Breaker failure protection

4.2.7.1. Introduction

This function provides backup protection to clear a fault after being enabled by the unit protection for the case that the circuit-breaker (CB) should fail. It has to operate as quickly and reliably as possible especially on EHV systems where stability is crucial.

To this end, current detectors continuously monitor the line currents and if they do not reset after a preset time, which allows for the operating times of the unit protection and the circuit-breaker, a tripping command is issued to either attempt to trip the same circuit-breaker again or trip the surrounding circuit-breakers.

Resetting of current detectors is influenced by the following factors:

- Even after the main CB contacts open, the current does not immediately drop to zero, but to a level determined by the fault resistance and the resistance of the arc across the open CB contacts. The current only becomes zero after the de-ionisation time of the CB arc.
- The pick-up setting of the detector.
- The fault level prior to operation of the CB.
- Whether the main c.t.'s saturate. If a c.t. saturates, its secondary current may not pass through zero at the same time as its primary current and if the primary current is interrupted at zero, the c.t. flux may be at some positive or negative value. The secondary current therefore decays through the burdens of the relays thus increasing the reset time.

The resetting time varies typically between 20 and 30 ms.

Since for the above application, the current detectors should reset as quickly as possible, Fourier filter algorithms are included to minimise the affect of c.t. saturation and eliminate completely or substantially any DC offset.

The block diagram below shows the basic functions, which are explained in the following Sections.

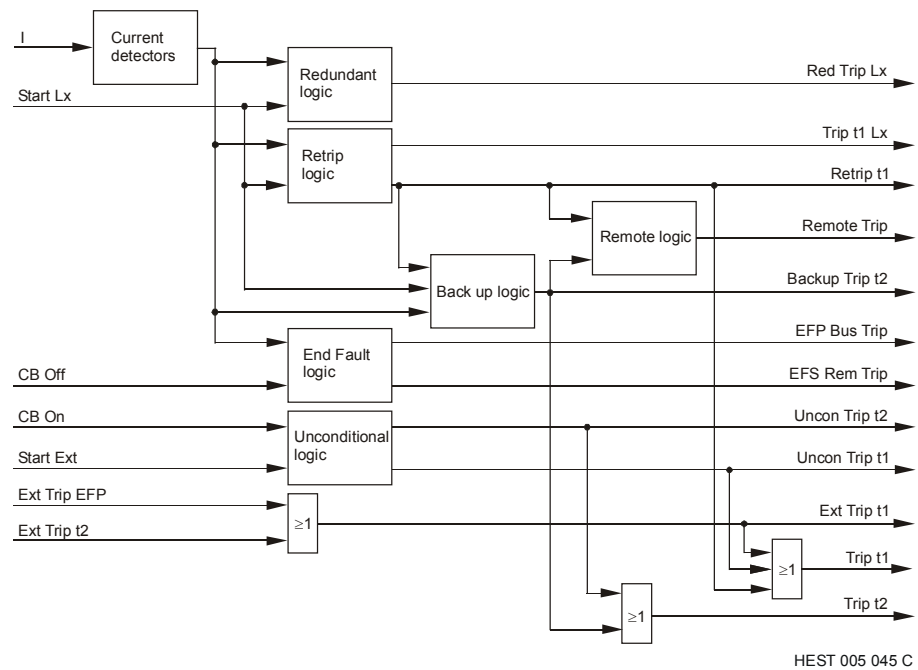


Fig. 4.19 Block diagram

4.2.7.2. **Three-phase/ single-phase mode**

The function has three current detectors. When it is used in the three-phase mode, each current detector measures the current in each of the three phases.

In order to accommodate a fourth current detector measuring the neutral current, this function has to be duplicated and the second function set to the single-phase mode and the appropriate current pick-up. The two functions then operate in parallel.

This arrangement also covers the two special cases of phase-to-phase-to-ground and three-phase-to-ground faults.

4.2.7.3. **'Redundant Trip'**

The 'Redundant Trip' logic performs phase-segregated direct tripping of the same circuit-breaker without any intentional time delay, if the Start inputs are active and the corresponding current detectors have picked up. This ensures that the breaker receives a tripping command in the event of a unit protection trip circuit failure, which would otherwise cause a second attempt to trip the same breaker or backup tripping of the surrounding breakers.

4.2.7.4. 'Retrip'

The unit protection issues a trip command and simultaneously starts individual phases or all three phases of the breaker fail function.

A second attempt is made to trip the corresponding phase or phases after the first time step (t_1), providing the current detectors have not reset.

The 'Retrip' logic can be disabled if not required.

Separate timers for each phase ensure correct operation during evolving faults.

4.2.7.5. 'Backup Trip'

A second time step (t_2) follows the first time step (t_1) and initiates backup tripping which is always of all three phases. If the first time step is disabled, the second time step is started immediately, providing the current detectors have activated by the starting signal from the protection.

The backup trip logic trips all surrounding breakers feeding the fault.

4.2.7.6. 'Remote Trip'

The 'Remote Trip' logic trips the breaker at the remote end of the line.

Remote tripping can take place concurrently with the 'Retrip' or 'Backup' functions or not at all as desired.

In contrast to the other tripping commands which remain activate for a given period after the initiating signal has reset, the remote tripping signal is an impulse with a width which is adjustable irrespective of when the starting signal from the protection resets.

4.2.7.7. 'Unconditional Trip'

This feature was introduced to respond to low-level faults with currents too low for the current detectors to pick up or do not initially cause any fault current at all such as mechanical protection devices like Buchholz, etc.

The start input bypasses the current detectors and activates the time steps if the breaker is in the closed position. In all other respects, this logic is similar to the 'Retrip' and 'Backup' logics.

4.2.7.8. 'End Fault Trip'

While in the case of a fault between a circuit-breaker and a single set of c.t.'s, the circuit-breaker may not fail, the affect on the power system and the action that has to be taken are the same as if the circuit-breaker had failed.

Where there is only a single set of c.t.'s on the busbar side of a circuit-breaker, the zones of protection do not overlap and a fault between the circuit-breaker and the c.t.'s is seen as a line fault, although it belongs to the busbar zone and persists after the circuit-breaker has been tripped. The breaker failure protection's 'End Fault Trip' logic ultimately clears such faults at the end of the second time step.

This logic is enabled if the breaker is open and the current detectors are still picked up, indicating a fault between the breaker and the c.t.'s. The speed of tripping is determined by the time delay setting.

Depending on whether the single set of c.t.'s is on the line side or bus side of the circuit-breaker, either the section of busbar or the circuit-breaker at the remote end of the line is tripped.

4.2.7.9. 'External Trip'

This function has been included to make the breaker fail protection more user-friendly and reduce the amount of systems engineering required. It generates an instantaneous trip when either of the following inputs is activated:

- The input connected to the second time steps of other breaker fail protection devices in the station.
- The input connected to the end fault outputs of other breaker fail protection devices in the station.

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5. OPERATION (HMI)

5.1. *Summary*

The user shell for the RE. 316*4 has been designed to be largely self-sufficient and requires a minimum of reference to the manual. This approach achieves a number of advantages:

- functions selected from extremely user-friendly menus with full screen displays and a combination of overlapping windows.
- 'pop-up' prompts wherever practical to guide the user and avoid errors.
- provision for creating, editing and checking sets of parameters off-line, i.e. without being connected to the protection equipment.
- provision for transferring sets of parameters to and from files.
- self-explanatory texts using a minimum of codes.
- provision for the user to enter his own descriptions of functions, inputs and outputs.

5.2. *Installation and starting the operator program*

5.2.1. *PC requirements*

The HMI for the RE. 316*4 runs in the protected mode. The minimum requirements for the PC are 16 MB of RAM, 12 MB free hard disc space and an operating system MS Windows 3.x, Windows 95 or Windows NT4.0 or higher. A 486 series processor or higher is recommended.

The HMI communicates with the RE. 316*4 at a baud rate of 9600 Baud. A problem can be encountered with some PC's if the memory manager EMM386 is active.

Temporarily disable the EMM386 memory manager by entering 'REM' at the beginning of the corresponding line in the 'config.sys' file:

REM DEVICE=.....\EMM386.....

Disabling the EMM386 memory manager is recommended. The consequence is less PC main memory below 640 kB, because the device drivers are loaded there instead of in the upper memory range. This, however, has no influence on the operation of the HMI.

5.2.2. *Installing the operator program*

We recommend the strict observation of the following points before installing the software on a your hard disc:

1. Ensure that your original floppy discs are write-protected.
2. Make backup copies of the original discs. Store the original program discs in a safe place and use the copies to install the program.

The program is located on the floppy discs labelled "RE.316*4 Software" in compressed form. There is also an installation program on the disc to simplify the installation program.

Installation on a hard disc under Windows 3.1 / 3.11:

1. Insert the first disc "Disk 1/4" into drive A.
2. Select 'Run' in the 'File' menu and enter 'a:\setup' in the window that opens.

Installation on a hard disc under Windows 95 / NT 4.0:

1. Insert the first disc "Disk 1/4" into drive A.
2. Click on 'Start' on the task bar at the bottom of the screen.
Select 'Run' in the menu that then opens and enter 'a:\setup'.

Simply follow the instructions on the screen for the remainder of the procedure. The installation of the remote HMI shell is optional. Respond appropriately to the requests for language, drive, directory and program group.

HMI files and configuration

After installation, the following files amongst others are in the HMI directory:

- pcgc91.exe: operator program.
- re*.cfg: configuration file.
- readme.e: text file with explanations of the installation procedure and the latest information about new SW versions.
- diststd.bin: distance protection function logic.
- aurestd.bin: auto-reclosure function logic.
- Sub-directory VDEW6: VDEW6 function logic.

Before the operator program can be executed, the device driver "ansi.sys" has to be loaded. The installation program automatically modifies the configuration files for the operating system.

DOS, Windows 3.x:

In the file C:\CONFIG.SYS:
device=c:\dos\ansi.sys.

Windows 95:

In the file C:\CONFIG.W40:
device=c:\win95\command\ansi.sys

Windows NT 4.0:

In the file C:\WINNT\SYSTEM32\CONFIG.NT:
device=%SystemRoot%\system32\ansi.sys

When the operator program is started, it searches for the configuration file 're*.cfg' which contains the settings it needs.

Example for a configuration file 're2.cfg':

```
;program parameters: (* 13-Mar-1998 16:36 *)
;RETP={REG216, REC216, RET316, REC316, REL316}
;LANG={ENG, DEU, FRA}
;COLOR={BW80,RGB}
;COMT={RDM,SRIO,TC57,SPA,MDM}
;BAUD={1200,2400,4800,9600,19200}
;SLVE={10...890} (Default slave No.)
;TNR={T..., P....}
;MPAR=AT&FE0
;
RETP=REC316
LANG=DEU
COLOR=RGB
EVEDATA=
ONHOOK=~~~~~+++~~~~~ATH0
CPUTYPE=PENTIUM
SLVE=2
SRIO_ADDR=950
COMT=TC57
TNR=T581625
MPAR=AT&D0E0M0S0=0
PORT=1
BAUD=9600
BAUD_XX=BAUD96
```

The following parameters are of consequence in order to communicate with the RE. 316*4 via the interface on the front of the unit:

```
RETP=
LANG=
COMT=TC57
PORT=
BAUD_XX=
```


5.2.3. Starting and shutting down the operator program

To start the operator program click on the icon created during the installation procedure.

The corresponding sequence can be seen from the flow chart below (Fig. 5.1). The program starts in the off-line mode or with a new ("empty") relay as REC 316*4. The choice of relay type and the main configuration parameters can be entered or edited by selecting the menu item 'Edit hardware functions'.

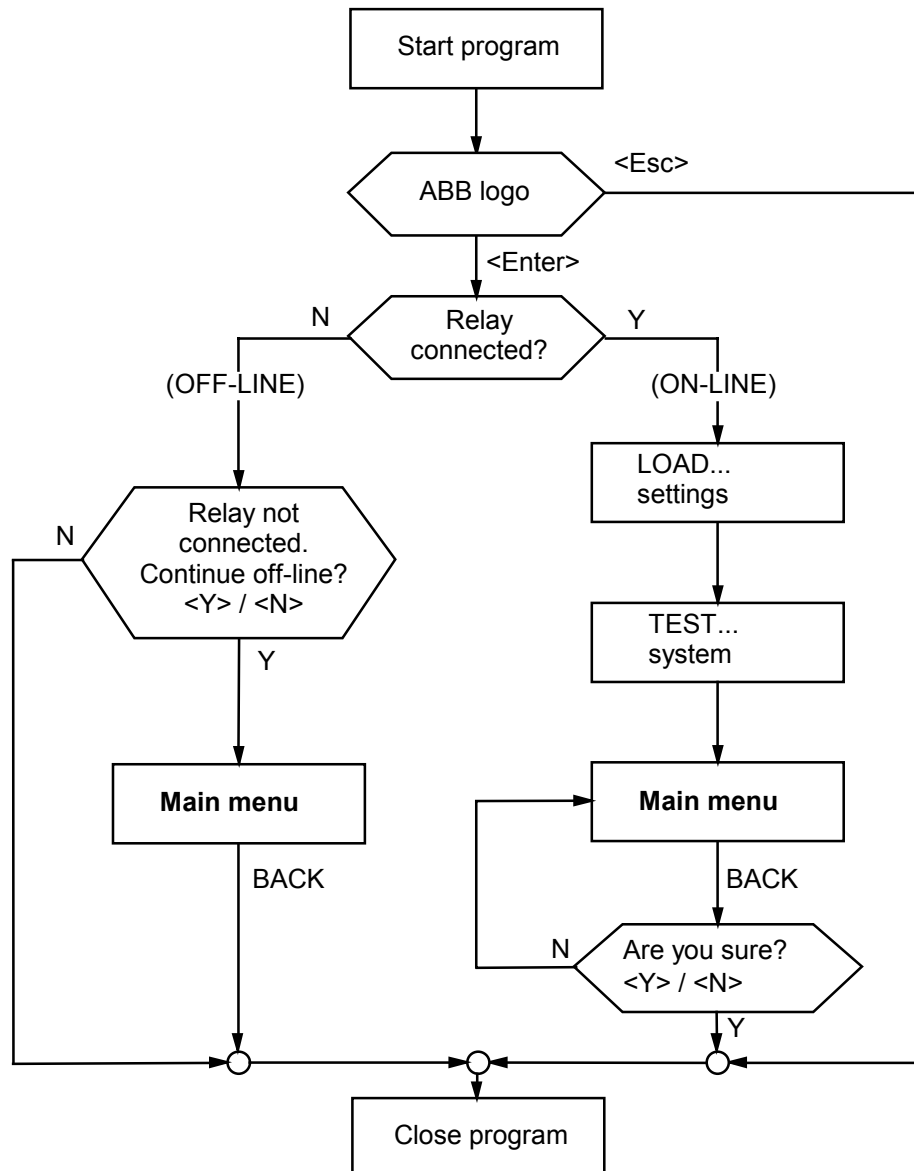


Fig. 5.1 Flow chart of the operator program start-up and shut-down sequence

Note:

If the system is required to operate on-line to exchange data between the PC and the RE. 316*4, the two must be connected by a serial data cable. The cable connects the serial port COM 1 or COM 2 on the PC to the optical connector on the front of the RE. 316*4. The protection must be in operation, i.e. the green stand-by LED must be lit or flashing.

Units that are not synchronised by the station control system via the interbay bus adopt the PC time when the HMI is started.

5.3. Operation

5.3.1. General

The HMI can be in one of four modes:

- Menu: waiting for the user to select a menu item.
- Operation: waiting for the user to enter data, e.g. parameter settings, confirmation of prompts, password etc.
- Output: display of measured variables, event lists etc. These windows are closed by pressing <Enter>.
- Wait: while the program executes a command (keyboard disabled). This can occur in any of the above modes.

A menu presents the user with a list of functions to choose from. A menu item is selected by moving the selection bar up or down using the up and down arrow keys and then pressing <Enter>.

As the user moves down the menu structure, the menus overlap each other on the screen. The whole screen is used to display data. Auxiliary menus and messages are displayed in pop-up windows and editing functions uses a combination of windows and full screen.

5.3.2. Standard key functions applicable to all menus

Except while setting parameters, responding to prompts and executing special functions, the user is always confronted by a menu, from which a menu item or line normally has to be selected. The following keys perform the same functions for all menus:

<↑>	Previous line
<↓>	Next line
<PgUp>	Scroll up
<PgDn>	Scroll down
<Home>	Go to the beginning of the menu
<End>	Go to the end of the menu
<Enter>	Execute the operation described by the line
<Esc>	Back to the previous window.

5.3.3. *Using the mouse*

Menus can be opened and closed and menu items selected using the mouse instead of the keyboard. The mouse and the mouse buttons are equivalent to the following keys:

Arrow keys Movement of the mouse.

<Enter> Left mouse button

<Insert> Right mouse button.

5.3.4. *Information displayed on the screen*

The following information is displayed at the bottom of the screen:

- Status of the connection to the RE. 316*4:
"On-line" or "Off-line".
- Interface baud rate:
"4800 bps", "9600 bps" or "19200 bps".
- Active protocol for communication with the station control system (SCS):
"SCS:SPA" or "SCS:VDEW" or "SCS:LON" or "SCS:MVB".
- Software version:
The version of the operator program is on the left and that of the device software on the right.
- An activity indicator is located between the two version numbers. A rotating dash indicates that the operator program is communicating with the device.

5.4. **Main menu and sub-menus**

The main menu gives the user the choice of performing one of the following operations:

1. Editor	loads the editor and enables all the protection and system functions to be listed, changed and saved.
2. Event handling	lists all the events in the event memory and enables the events to be deleted.
3. Measurements	displays protection variables including the A/D converter inputs.
4. Test functions	checks the protection functions in the various sets of parameters and the operation of the LED signals, tripping relays and signalling relays.
5. Diagnostics	provides fault-finding information for the protection system.
6. SMS010 editor	enables events and measured variables to be configured for processing by SMS010.
7. Documentation	the device configuration can be can be exported as a text file for use when engineering the SCS.
8. RETURN	closes the operator program.

All the above options are available when the PC is connected on-line, but only 1, 6, 7 and 8 when it is off-line.

Note:

With the exception of the editor, all the menu items are only relevant when the PC is connected on-line to the protection equipment, e.g. for transferring data. All printed and displayed data are identical to those loaded in the protection and not related to those being processed using the editor.

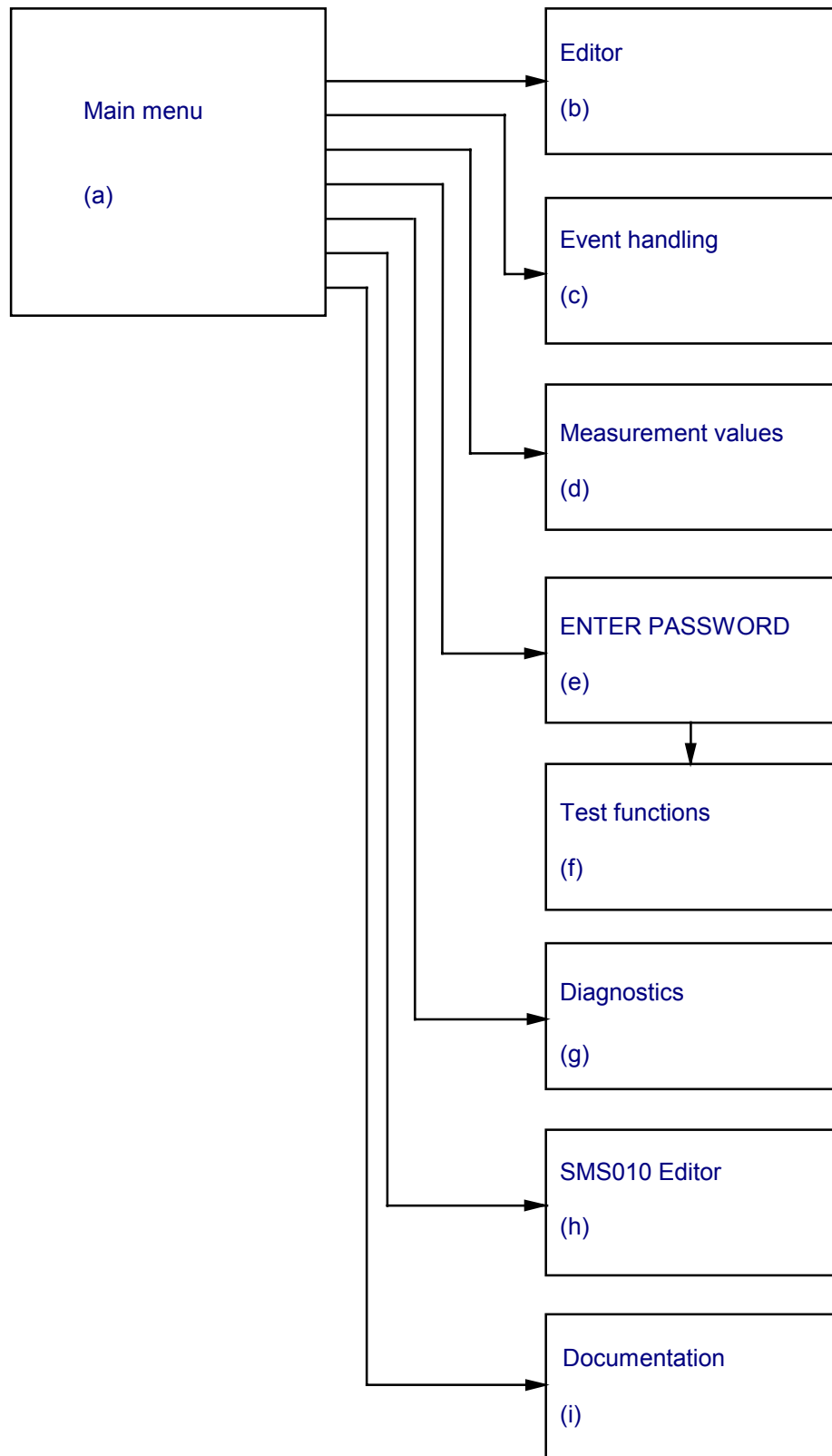


Fig. 5.2 Main and sub-menu structure
(see displays a to i on the following pages)

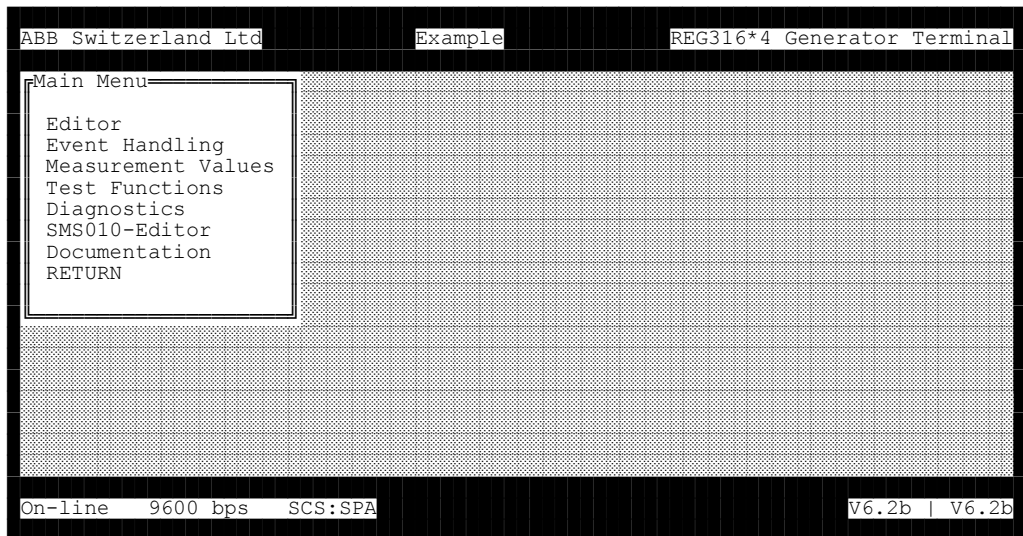
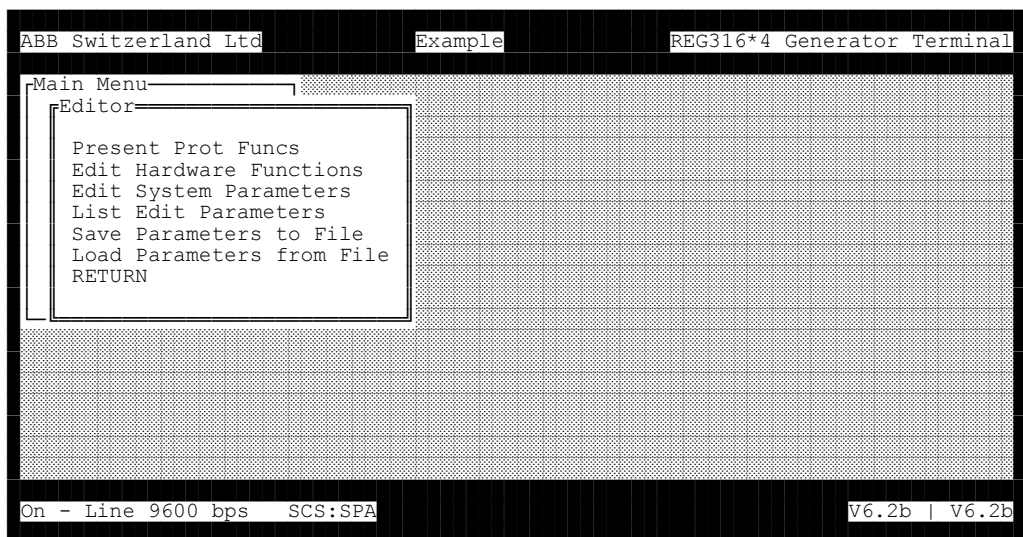


Fig. 5.2 a Main menu

Fig. 5.2 b Editor
(see Section 5.5.)

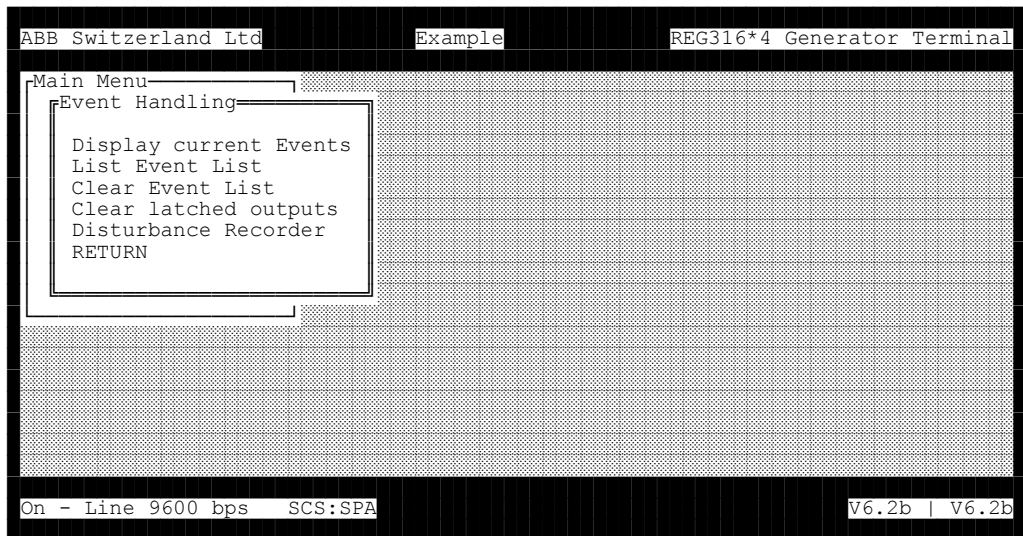


Fig. 5.2 c Event handling
(see Section 5.6.)

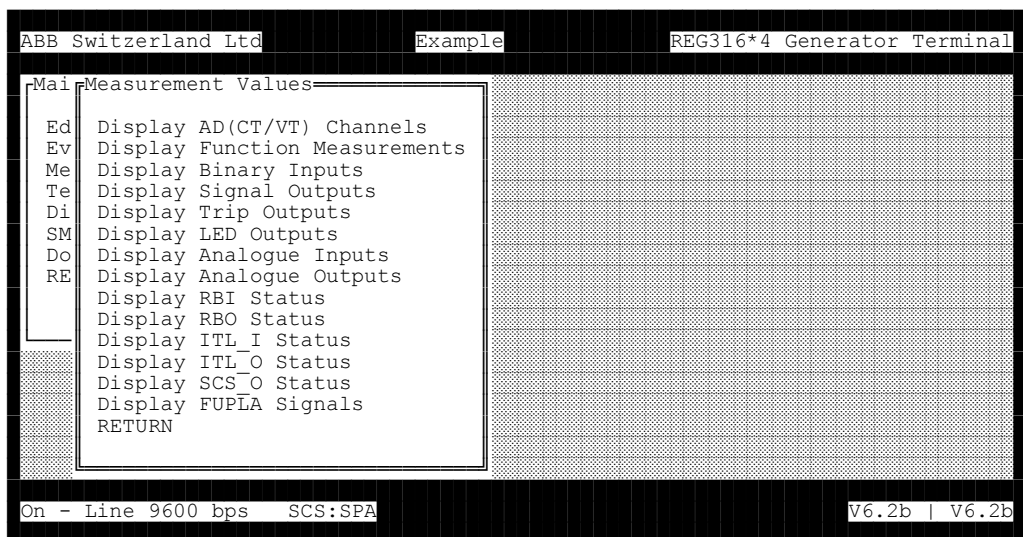


Fig. 5.2 d Measurement values
(see Section 5.7.)

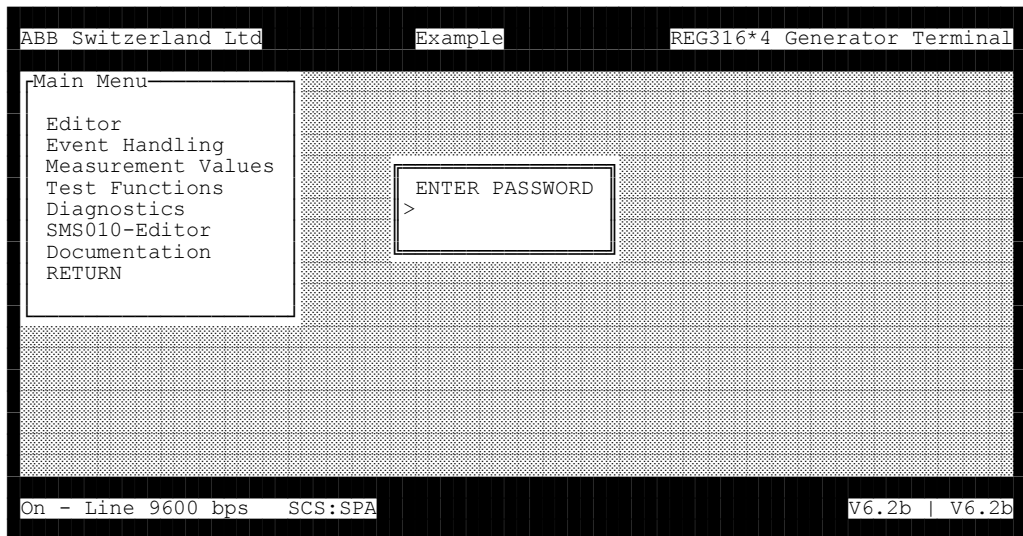
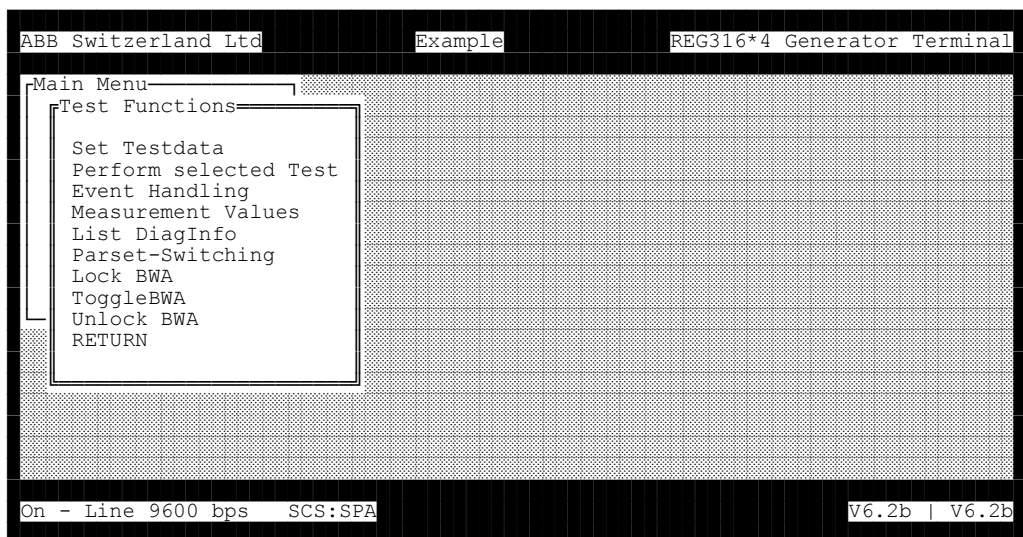


Fig. 5.2 e ENTER PASSWORD

Fig. 5.2 f Test functions
(see Section 5.9.)

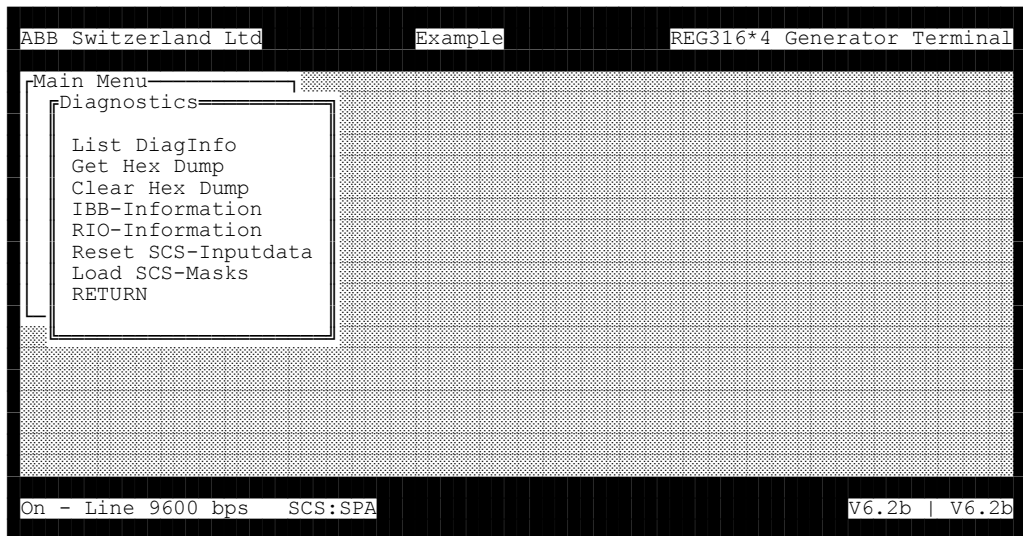


Fig. 5.2 g Diagnostics
(see Section 5.8.)

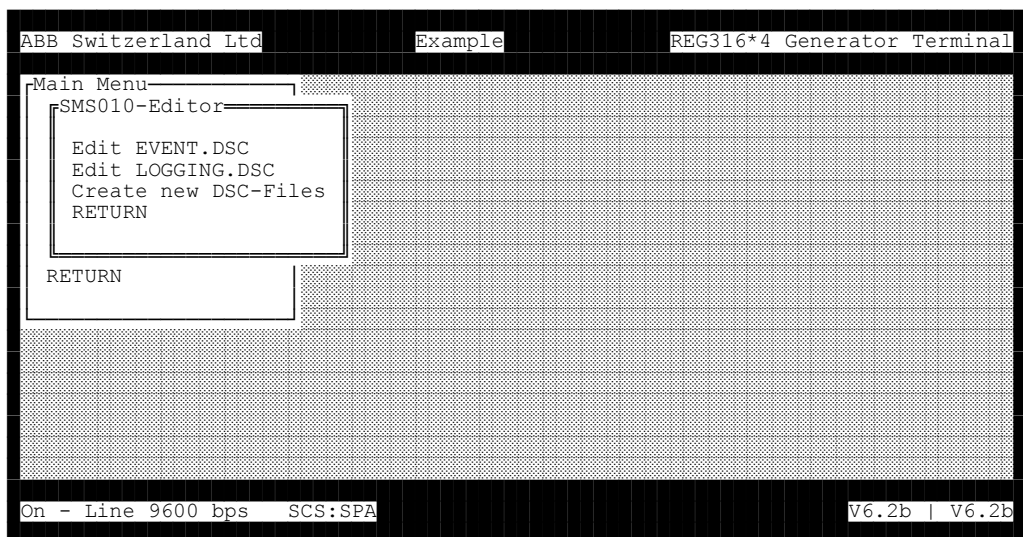


Fig. 5.2 h SMS010 editor
(see Section 5.14.)

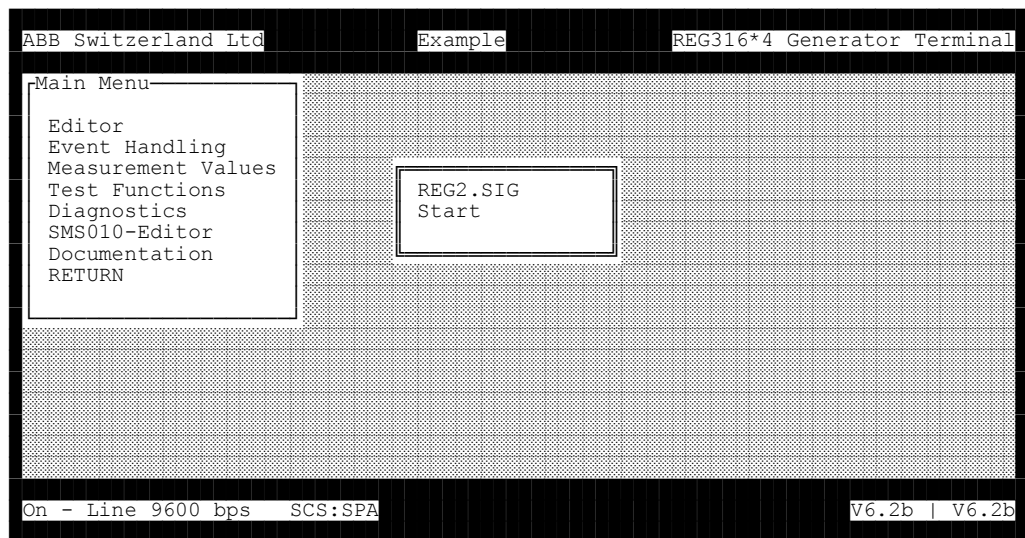


Fig. 5.2 i Documentation
(see Section 5.10.)

5.5. *Editor*

Edited data are stored in a separate buffer memory and nothing is changed in the protection until the save routine is executed. Thus a complete set of parameters can be created off-line without the PC being connected to the device. The only difference between off-line and on-line editing is that in the on-line mode, the user starts with copy of the current parameters and settings downloaded from the device. The "Editor" menu provides the following options:

1. "Present prot. funcs":
Edit, copy or delete a currently active function in the system or insert a new function.
2. "Edit hardware functions":
Edit parameters which effect the device hardware, e.g. configuration, analogue, binary, tripping and signalling channels and the OBI configuration.
3. "Edit system parameters":
Edit parameters not connected with functions.
4. "List edit parameters":
A list of the settings can be displayed on the screen, saved in a file or printed on a printer connected to the parallel port of the PC.
5. "Save parameters to file":
Saves the complete set of parameters (entire contents of the editor buffer) in a file.
6. "Load parameters from file":
Reverse operation of 5. A previously saved set of data is loaded from a file to the editor.
7. "RETURN":
Saves the edited set of parameters and returns the user to the main menu.

5.5.1. **Present prot. funcs.**

The settings and name of every active function can be changed or the function can be copied or deleted. The procedure is given in Fig. 5.3.

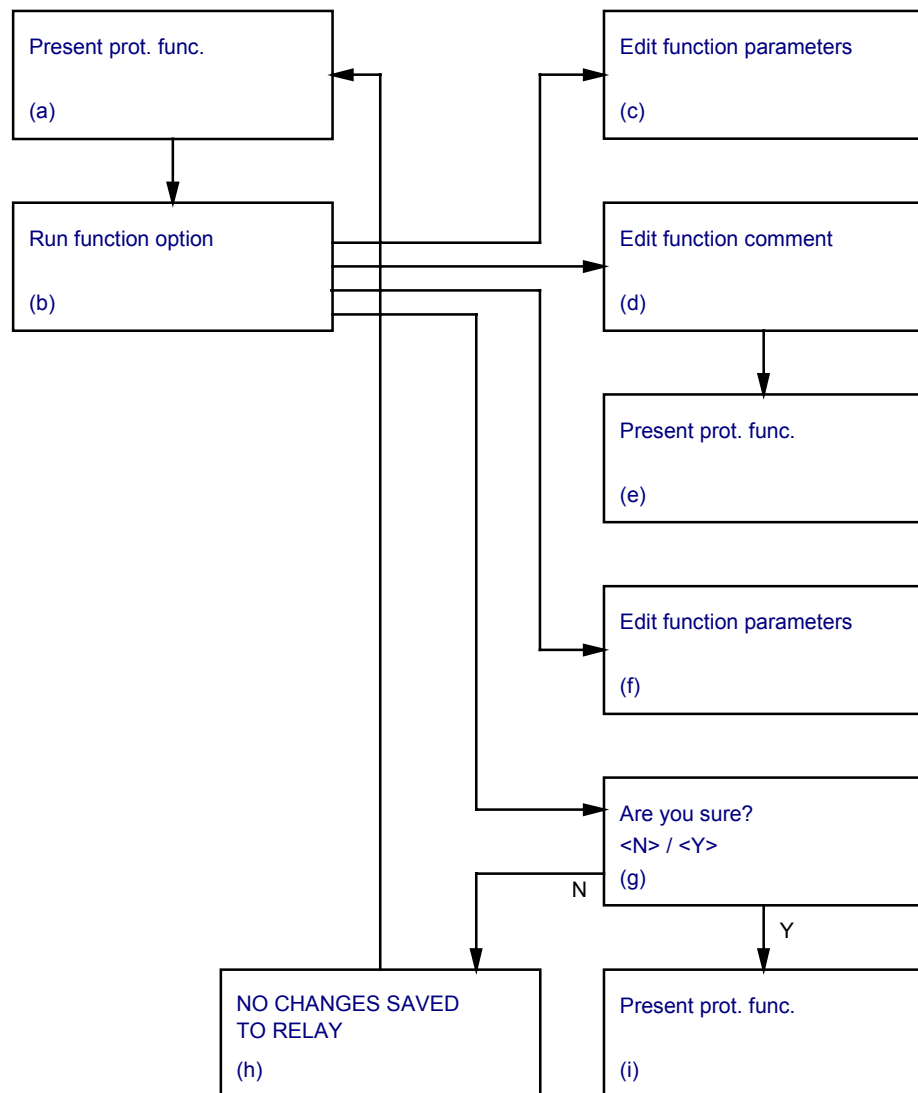


Fig. 5.3 Editing an active protection function
(see displays a to i on the following pages)

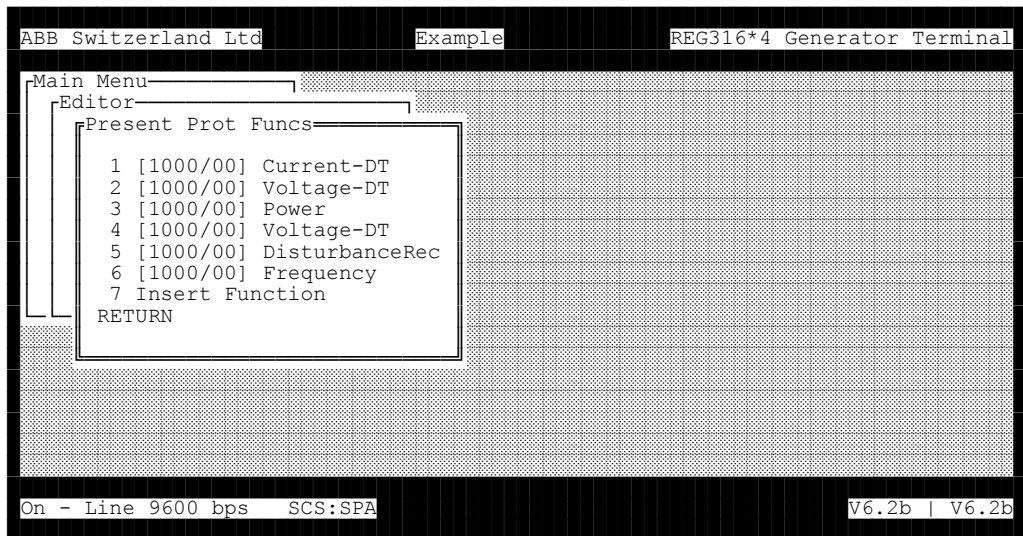


Fig. 5.3 a Present prot. funcs.

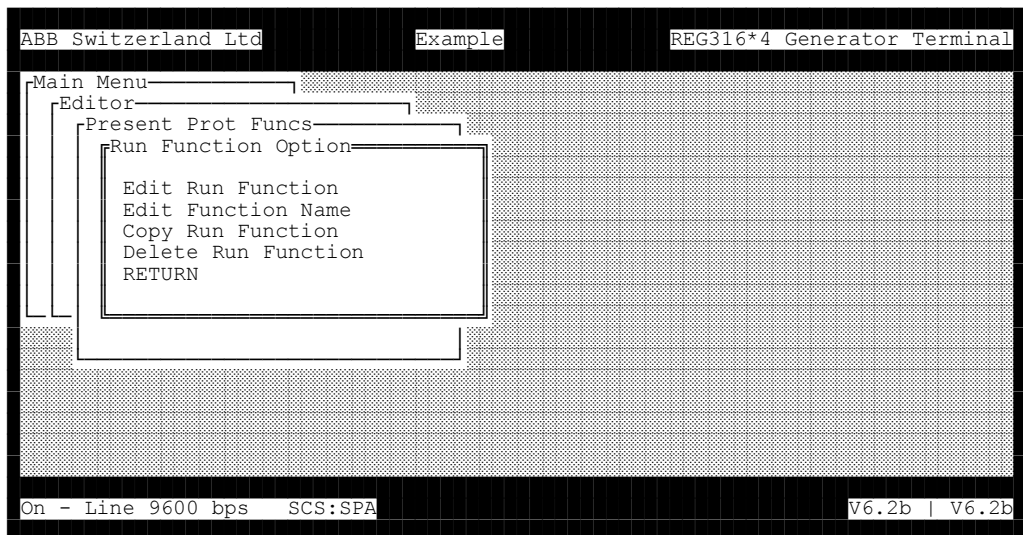


Fig. 5.3 b Run function option

5.5.1.1. *Changing the settings of a function*

Function settings are changed using the “Edit function parameters” window. How this is done for the different kinds of parameters is explained in [Sections 5.5.3.](#) and [5.5.4.](#)

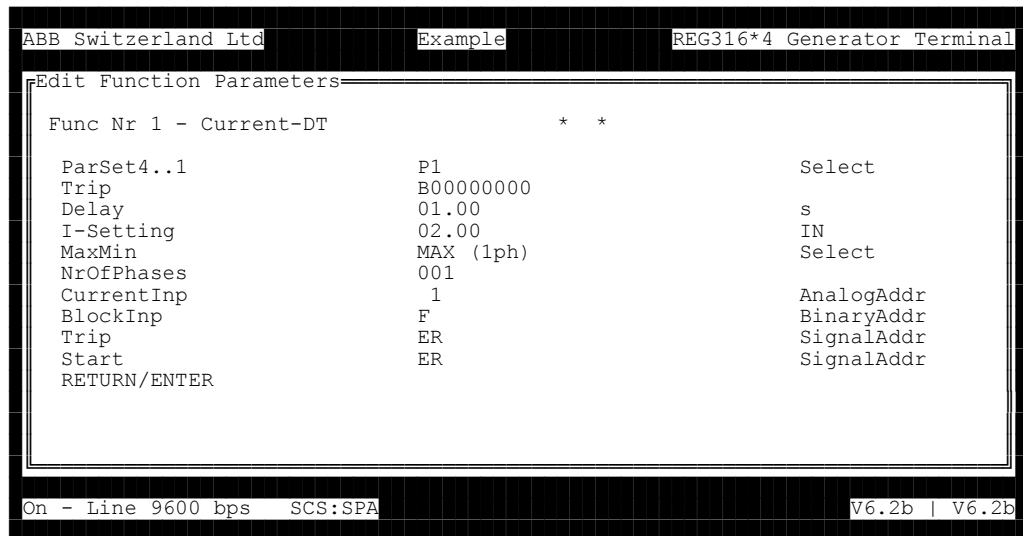


Fig. 5.3 c Edit function parameters

5.5.1.2. *Changing a function comment*

The “Edit function comment” window provides facility for entering a comment of up to 25 characters. Press <ENTER> to terminate the input. A comment either complements or replaces the function name in all windows. A comment that is no longer needed is deleted in the same window using the space bar. Comments are downloaded to the device together with the settings.

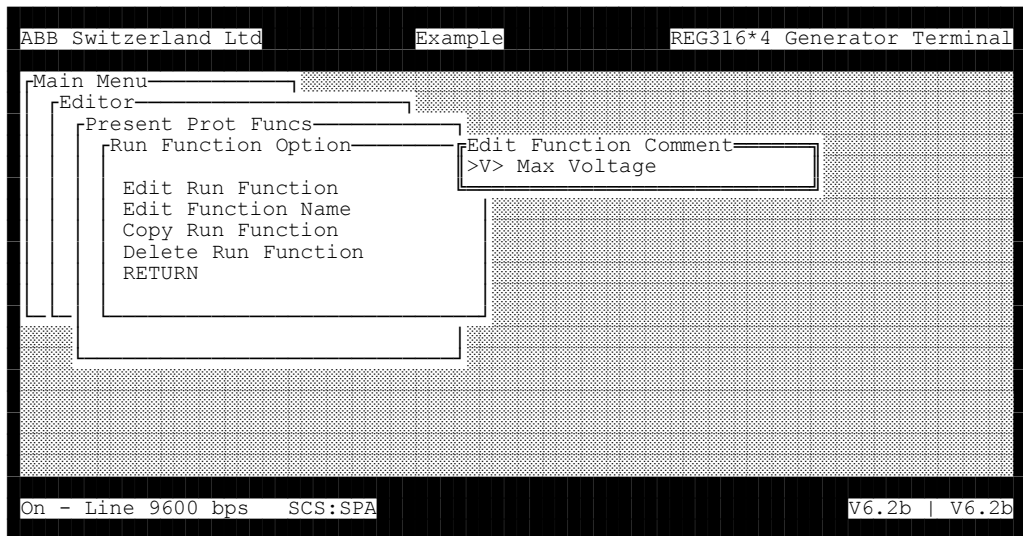


Fig. 5.3 d Edit function comment

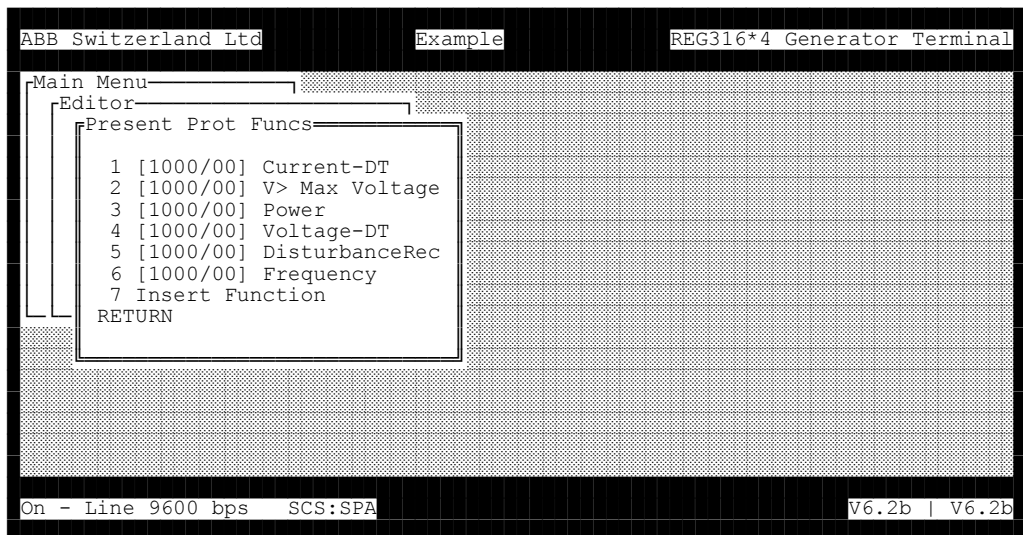


Fig. 5.3 e Present prot. funcs.

5.5.1.3. Copying a function

If a function's settings in a second set of parameters are largely the same as in a first, the function can be copied.

The settings of the copied function are the same as the original, but the following parameters can not be changed subsequently:

- all analogue inputs
- all signalling channels
- all tripping channels.

These parameters are not listed for this reason in the copied function's list of parameters (see Figures 5.3 c and e). However, if they are changed in the original, they are also automatically changed in the copy.

The settings for the binary inputs and parameters "ParSet4..1" have to be re-entered for the copy. The binary input sources must be active in the same set of parameters as the copy. The copied function must not be active in the same set of parameters as the original and the parameter set number of the original must be lower:

$$P1 \leq pO \leq P4 \quad \text{and} \quad pO < pK \leq P4$$

where

pO = parameter set number of the original function

pK = parameter set number of the copied function.

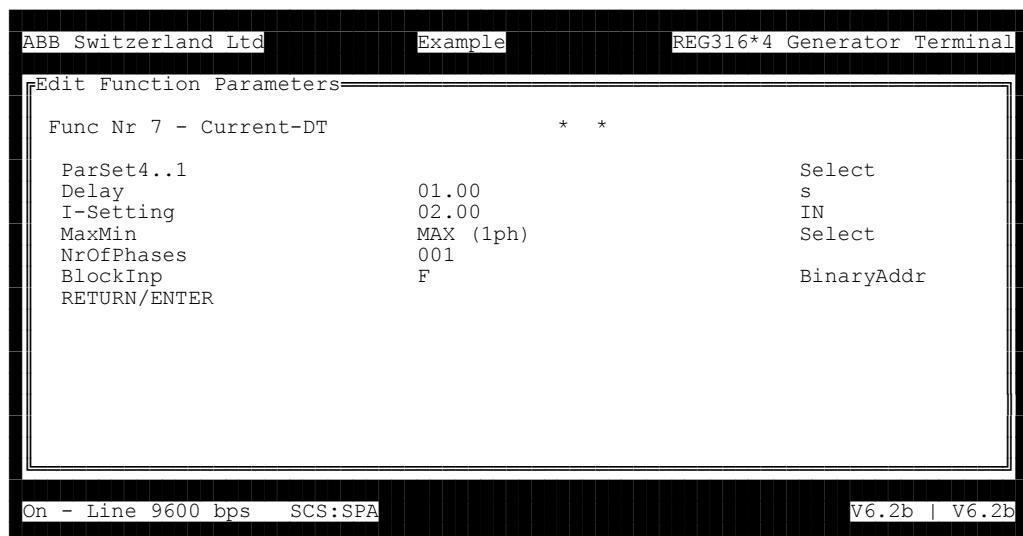


Fig. 5.3 f Edit function parameters

5.5.1.4. *Deleting a function*

A function can only be deleted, if there are no copies of it and it is not needed by another function (e.g. a binary output used to block another function). As a safety precaution, the user is requested to confirm the deletion in response to the question “Are you sure?”. If the particular function is at the bottom of the list, it disappears altogether, otherwise its description is replaced by “Not used” to avoid having to renumber the functions.

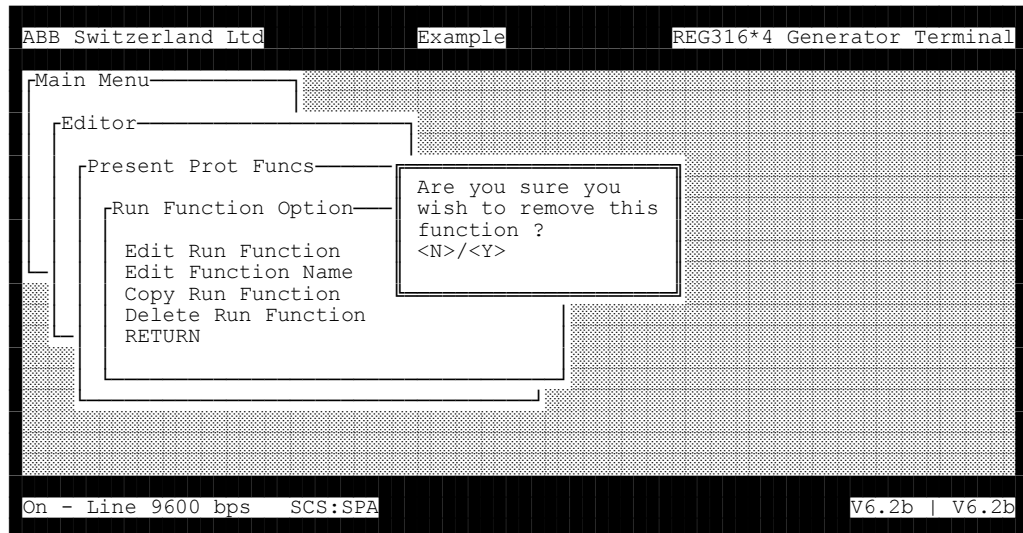


Fig. 5.3 g Are you sure?

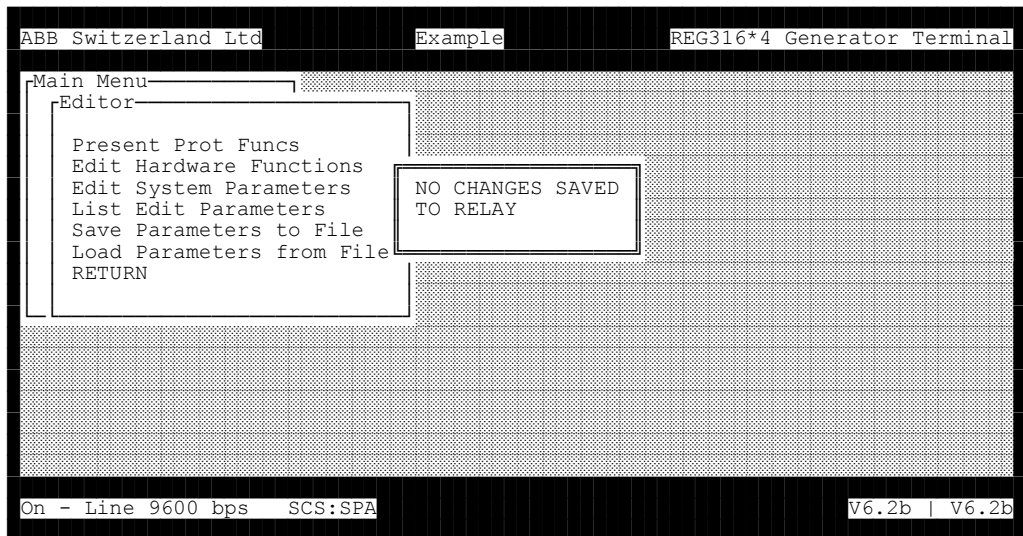


Fig. 5.3 h NO CHANGES SAVED TO RELAY

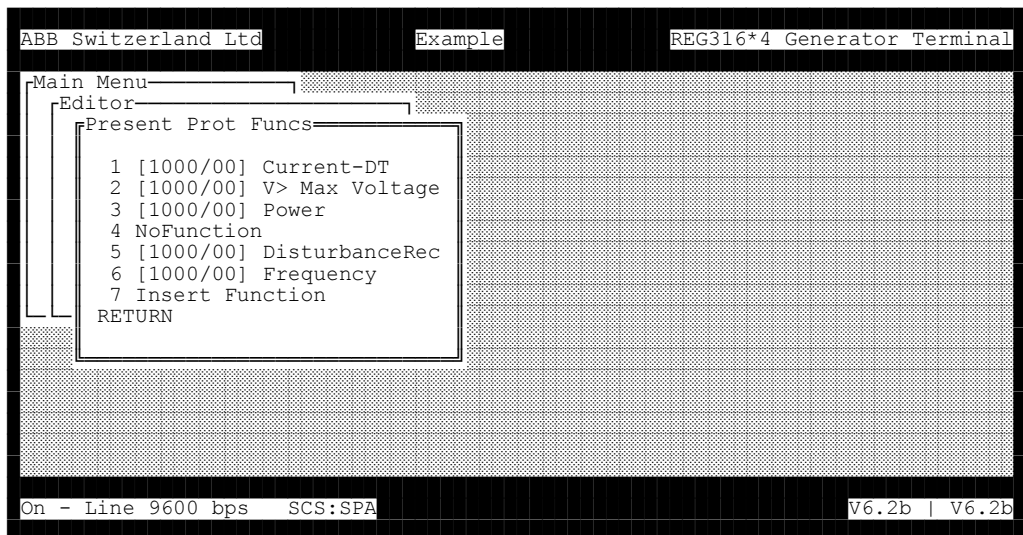


Fig. 5.3 i Present prot. funcs.

5.5.2. Adding a new function

An additional function is added either by selecting the second last menu item "Insert function" from the "Present prot. funcs." menu (see Fig. 5.3 i) or a "No function" line if there is one. Upon pressing <Enter>, a list of the available functions appears. Select the desired function from the list and press <Enter> again. This opens the "Edit function parameters" window (see Fig. 5.3 c) and the parameters can be set. The procedure for the different kinds of parameters is explained in Sections 5.5.3. and 5.5.4.

The last entry in the list of available functions is "No function". Selecting this line and pressing <Enter> adds a "No function" line to the list of active functions. This method can be used, for example, to adjust the list so that a given function has the same number in all the relays although.

5.5.3. General information on editing parameters

There are two types of parameters, which have to be entered:

1. those requiring the entry of a numerical value, e.g. current or voltage settings
2. those requesting selection from a list of alternatives, e.g. options or channels

Window used for both types of parameters:

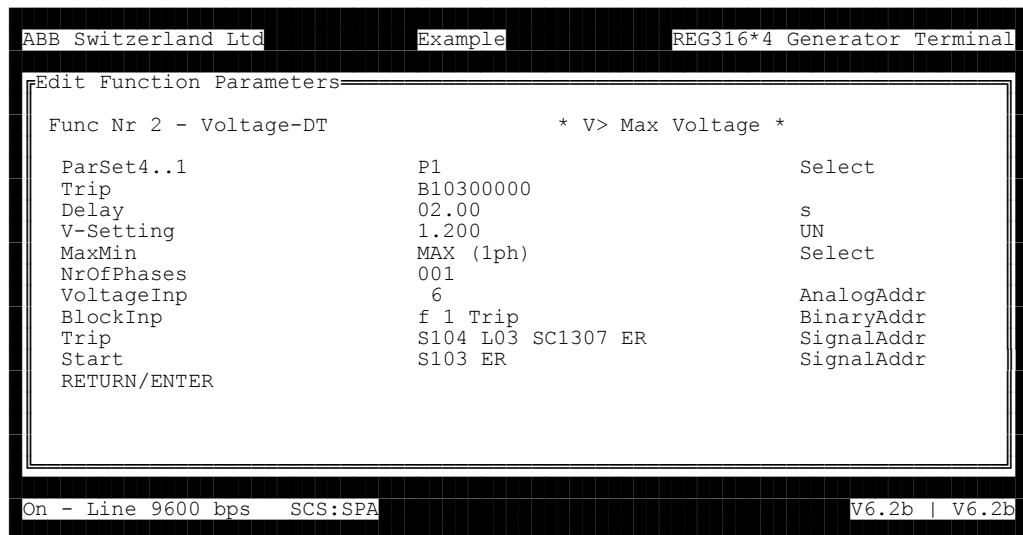


Fig. 5.4 List of parameters

Keys used for both types of parameters:

List of parameters:

- <↑> - Up a line
- <↓> - Down a line
- <PgUp> - One page up
- <PgDn> - One page down
- <Home> - Go to the beginning
- <End> - Go to the end
- <Enter> - Display the data entry/option select window
- <Esc> - Return to previous window without saving changes
- <Enter> - "Return/Input" - check and save parameters and return to previous menu.

Input/Selection window:

- <Enter> - Return to the list of parameters and insert the setting from the "Input/Selection" window.
- <Esc> - Return to the list of parameters without inserting the setting from the "Input/Selection" window.

5.5.3.1. Entering numerical settings

The data input window appears on the right of the list of parameters:

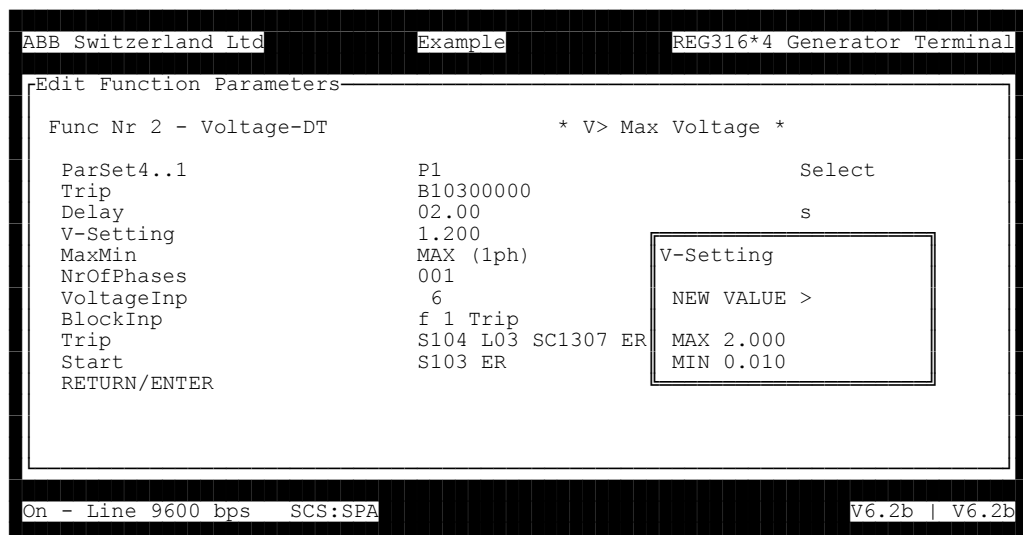


Fig. 5.5 Window for entering numerical settings

Keys:

<0...9>, <.>, <+>, <->, - entry of new numerical setting

Each parameter only has a given number of decimal places and the number entered is rounded accordingly.

A warning is displayed, if a setting outside the permissible range is entered. The user is requested to accept the next permissible value or to try again.

Closest allowed value 20.00
Should it be entered?
 <Y>/<N>

HEST 905 076 FL

5.5.3.2. *Selecting from a list of alternatives*

There are two alternative selection procedures:

- Option: Selection of a **single** option from a list.
- Channel: Selection of one or several of the available channels.

Option selection:

The “Option selection” window is used when a **single** choice has to be made from a list of alternatives. The selected option is indicated by a single chevron “>”.

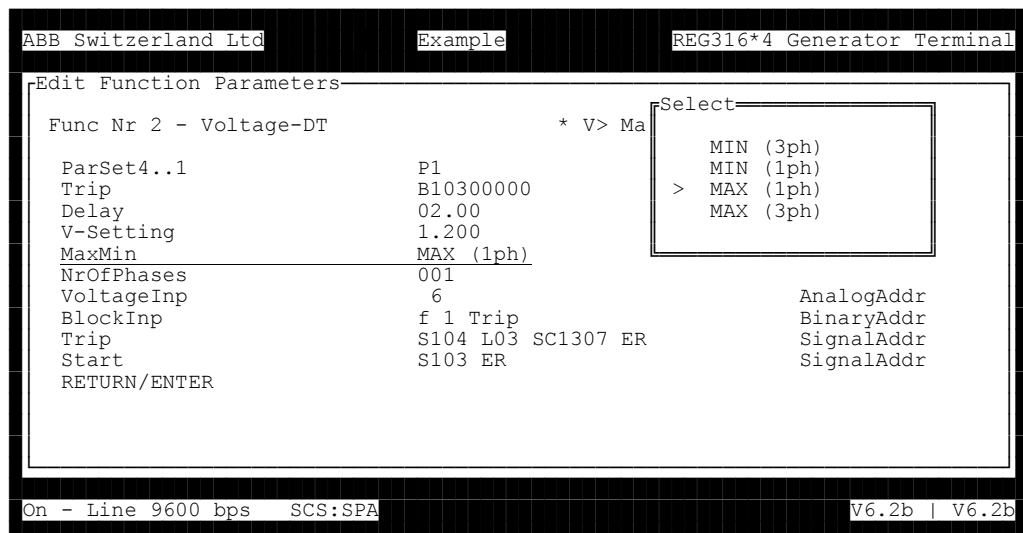


Fig. 5.6 Option selection window

Keys:

- <↑>, <↓>, <PgUp>, <PgDn> - Move the cursor in the selection window
- <Ins> - Selects a channel.

Channel selection:

The available alternatives in the “Channel selection” window are shown as rows of boxes, which apart from the channel number, also contain a field for up to 2 characters (see Fig. 5.7). The channel description consists of an explanatory text and/or a comment entered by the user when configuring the hardware functions (see Section 5.5.5). The corresponding information is displayed as the selection bar is moved from one option to the next.

There are two methods of selection:

1. Multiple selection - All the channels, which have just been selected with the aid of the cursor and the <Ins> key, are indicated by “X”. The cursor jumps to the first available channel upon opening the window.
2. Single selection - The channel selected is indicated by “X” and the “X” moves automatically, if a new selection is made. The cursor jumps to the first available channel upon opening the window.

Keys:

- <←>, <→> - Move the cursor in the selection window
- <Ins> - Selects a channel
- <Del> - De-selects an option (multiple selection only)
- <-> - Inverts a channel
(binary inputs only).

The system only permits channels to be selected it considers to be plausible, otherwise a warning beep sounds (but there is no error message). Examples of implausible selections are setting a channel defined as a current input as a voltage input, or attempting to assign a signal to an output (relay or LED) which is already occupied.

5.5.4. Explanation of the types of channels

There are four types of channels which conform generally to the rules given in the preceding sections. Each one, however, has in addition characteristics and abbreviations peculiar to itself.

5.5.4.1. C.t./v.t. input channels

The c.t. and v.t. input channels are assigned in the “A-D Input Channels” selection window:

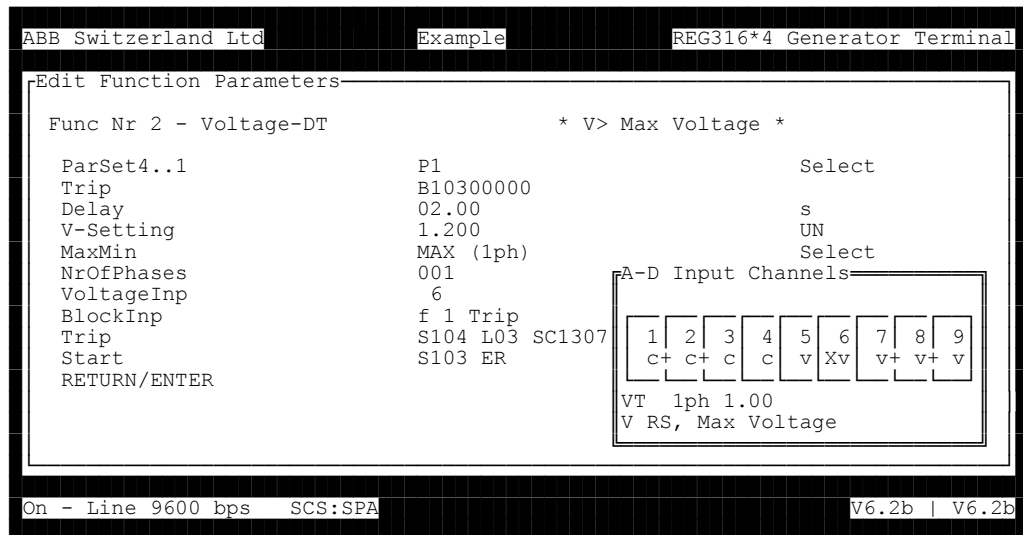


Fig. 5.7 “A-D Input Channels” selection window

The nine boxes in the selection window representing the c.t. and v.t. input channels available are designated as follows:

Top: 1...9 : Channel No.

Bottom: c : c.t.

v : v.t.

o : no input transformer connected

+ : two “+” signs link a three-phase input transformer group

X : selected channel.

The input transformer type and any user comment are displayed in the lower part of the window for the field currently selected.

The arrangement of the c.t. and v.t. input channels is established by the ordering code (K...). Prior to assigning the c.t. and v.t. input channels, the K code in the menu “Edit Relay Configuration” must be set (see Section 3.4.1.).

Only the first phase of a three-phase group may be selected; the other two phases are automatically included without any special indication. Any channel may be selected, on the other hand, for a single-phase function.

The channel number is indicated in the parameter value column of the “Edit function parameters” window.

5.5.4.2. Signalling channels

Signals can be assigned individually to the event recorder, up to two physical outputs (LED's, signalling and tripping relays and distributed outputs) and an output to a station control system (SCS) and for interlocking purposes (ITL). The bleep sounds if an attempt is made to use more than two physical outputs.

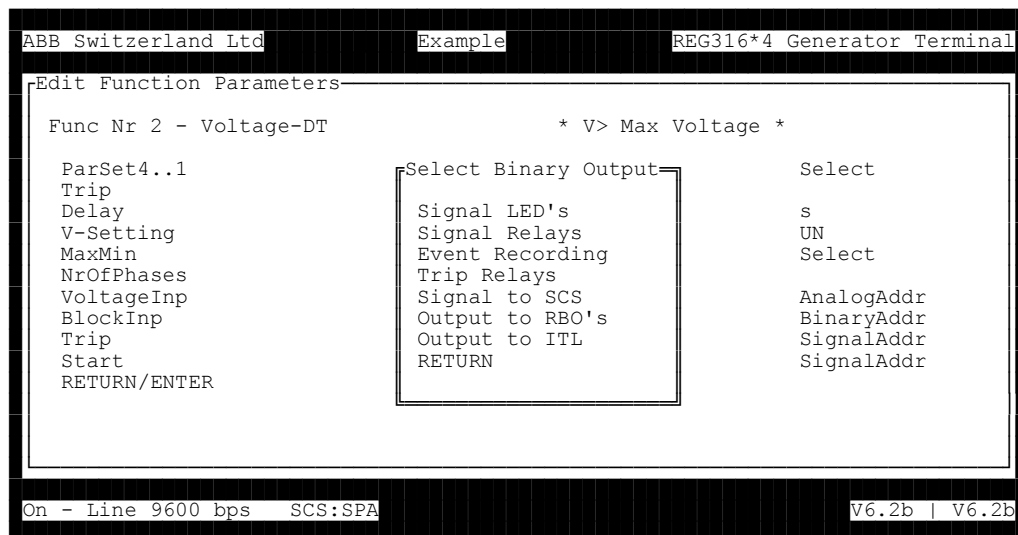


Fig. 5.8 Setting signalling channels

LED signals

Before LED's can be assigned, the respective I/O unit (1 for LED's 1 to 8 or 2 for LED'S 9 to 16) must be selected in the “Select I/O slot” window. The “LED's” selection window then appears.

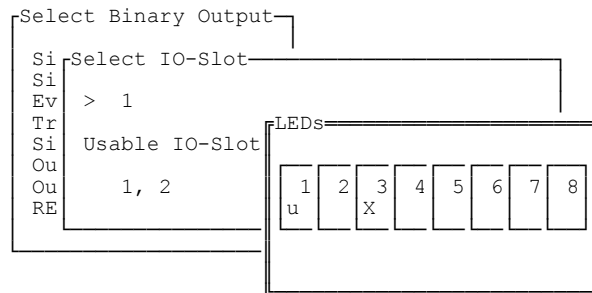


Fig. 5.9 “LED’s” selection window

The eight boxes representing the LED’s in the selection window are designated as follows:

Top: 1...16 : Channel No.

Bottom: u (used) : channel in use

X : selected channel.

Note that channel 1 is not available for assignment, because LED 1 is always assigned to the standby alarm signal.

The number of the selected LED (e.g. L03) is indicated in the parameter value column of the “Edit function parameters” window.

Signalling relays

Before signalling relays can be assigned, the respective I/O unit (1 to 4) must be selected in the “Select I/O slot” window. The “Signal relays” selection window then appears.

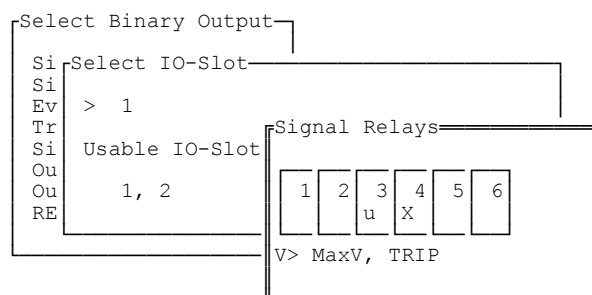


Fig. 5.10 “Signal relays” selection window

The boxes representing the signalling relays in the selection window are designated as follows:

Top: 1...10 : Channel No.

Bottom: u (used) : channel in use

X : selected channel.

Any user comment is displayed in the lower part of the window for the field currently selected.

The plug-in unit and channel numbers for the selected signalling relay (e.g. S104) are indicated in the parameter value column of the "Edit function parameters" window.

Sxxy: x = plug-in unit number (1...4)
yy = channel number (1...10).

Event recording

The flag which determines whether a signal is recorded as an event is set in the "Event recording" window:

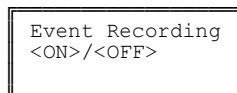


Fig. 5.11 Setting and resetting the event recording flag

"ER" is displayed in the parameter value column of the "Edit function parameters" window to indicate that the corresponding signal is recorded as an event.

Caution:

A function 'Pick-up' signal will normally only generate a general start alarm, if it is set to be recorded as an event (ER). Exceptions are the distance function, because its general start signal 'Start R+S+T' always counts as an event and therefore always initiates a general start alarm, and the differential functions, the tripping signals of which set the general start alarm when they are configured to be recorded as events.

Caution:

A function's tripping command will normally only generate a general tripping alarm, if it is assigned to the tripping logic (matrix) and configured to be recorded as an event (ER). The distance function is an exception, because it always sets the general tripping alarm.

Tripping relays

Tripping relays can be used for signalling purposes. From Version V4.2 signals can be assigned to tripping relays to which a signal ('u' indication in the signalling channel selection window) or a tripping logic (signals and trips OR logic) has already been assigned. The procedure for assigning tripping relays is the same as for [signalling relays](#) above.

The plug-in unit and channel numbers for the selected tripping relay (e.g. C201) are indicated in the parameter value column of the "Edit function parameters" window.

Cxyy: x = plug-in unit number (1...4)
 yy = channel number (1...2).

SCS signals

Before a signal can be assigned to the SCS, the respective group (1 to 24) must be selected in the "Select SCS group" window. The SCS signal groups 1c...24c are intended for transmitting short signals via the interbay bus(signal capturing). The "Signals to SCS" selection window then appears.

Select Binary Output
↗

Select SCS-Group
↗

Si
Si
Ev > 13
Tr
Si Usable SCS-Group
Ou
Ou 1..24,1c..24c
RE

Signals To SCS
Select Binary Output

1	2	3	4	5	6	7 X	8	9	10	11 u	12	13	14	15	16	17	18	19	20	
21	22	23	24	25	26	27	28	29	30	31	32									

Fig. 5.12 “Select SCS group” and “Signals to SCS” selection windows

The fields in the selection window are designated as follows:

Top: 1...32 : Channel No.

Bottom: u (used) : channel in use

X : selected channel.

The SCS assignment (e.g. SC1307) is indicated in the parameter value column of the “Edit function parameters” window.

SCxxyy: xx = SCS group number (1...24)

yy = data node within a group (1...32).

Signal to RBO (remote binary output)

When assigning signals to the RBO (distributed output system), first select the group (1 to 80) in the “Select RBO No.” window.

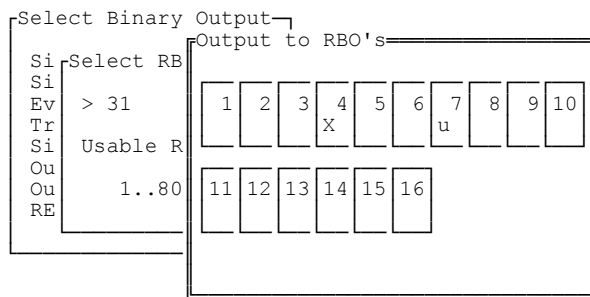


Fig. 5.13 “Select RBO group” and “Signals to RBO” selection windows

The fields in the selection window are designated as follows:

Top: 1...16 : Channel No.

Bottom: u (used) : channel in use

X : selected channel.

The RBO assignment (e.g. R101) is indicated in the parameter value column of the “Edit function parameters” window.

Ryyxx: y = RBO group number (1...80)

xx = output relay within a group (1...16).

Signal to ITL (interlocking)

When assigning signals to the ITL (interlocking data), first select the group (1 to 3) in the “Select ITL group” window.

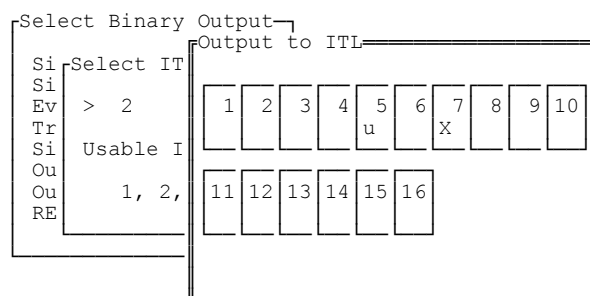


Fig. 5.14 “Select ITL group” and “Signals to ITL” selection windows

The fields in the selection window are designated as follows:

Top: 1...16 : Channel No.

Bottom: u (used) : channel in use

X : selected channel.

The ITL assignment (e.g. I101) is indicated in the parameter value column of the “Edit function parameters” window.

lyxx: y = ITL group number (1...3)

xx = data node within a group (1...16).

5.5.4.3. Tripping channels

The tripping signals of the various functions can be assigned to one or several tripping channels in order to achieve the required tripping logic:

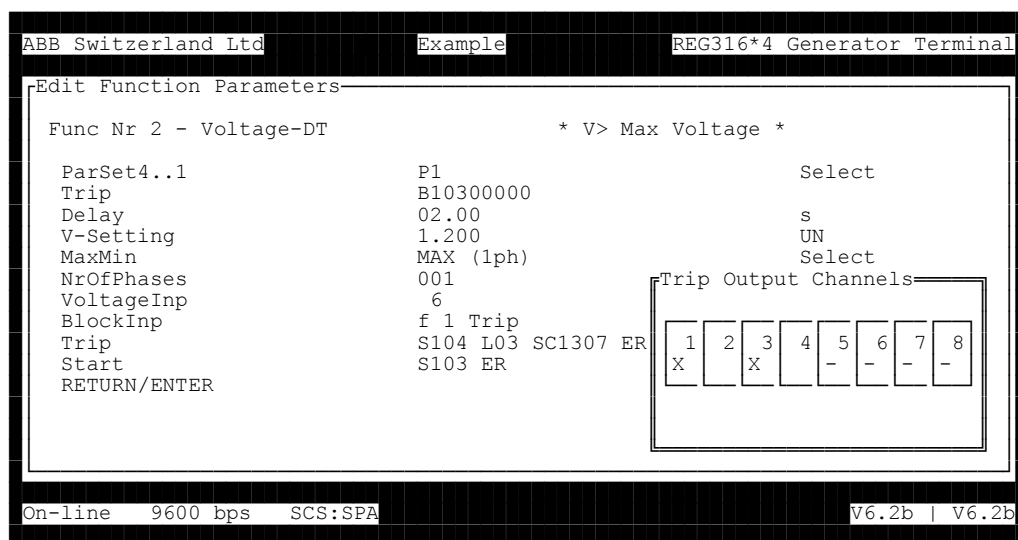


Fig. 5.15 “Trip output channel” selection window

The fields representing the tripping channels in the selection window are designated as follows:

Top: 1...8 : Channel No.

Bottom: - : Non-existent tripping channel

X : selected channel.

Any user comment is displayed in the lower part of the window for the channel currently selected.

Only I/O units types 316DB61 and 316DB62 are equipped with two tripping relays.

The selected channels appear in the parameter value column of the “Edit function parameters” window as a bit string with ‘1’ to ‘8’ indicating the currently selected channel and ‘0’ the inactive channels (e.g. 10300000).

Caution:

A function’s tripping command will normally only generate a general tripping alarm, if it is assigned to the tripping logic (matrix) and configured to be recorded as an event (ER). The distance function is an exception, because it always sets the general tripping alarm.

5.5.4.4. Binary channels

Binary inputs of functions can either be switched permanently on or off or be connected to the system binary input, a binary output of another function, an SCS input, an RBI input (distributed input system) or an ITL input. The corresponding setting is made in the “Select binary input” window:

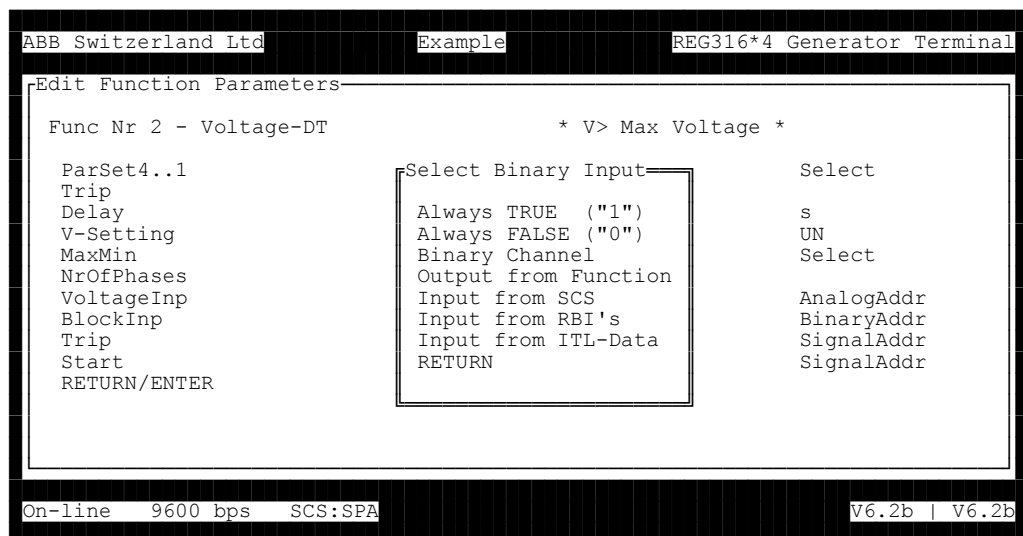


Fig. 5.16 “Select binary input” window

Always TRUE or Always FALSE

The binary inputs of functions can be set permanently on (logical 1) or off (logical 0) by moving the selection bar to the corresponding line and pressing <Enter>.

“T” (true) in the parameter value column of the “Edit function parameters” window indicates a permanently switched on input and “F” (false) a permanently switched off input.

System binary input

Every function input can be assigned either inverted or non-inverted to a system binary input (opto-coupler input). The respective I/O unit (1 to 4) is selected first and then the “Binary input channels” selection window opens:

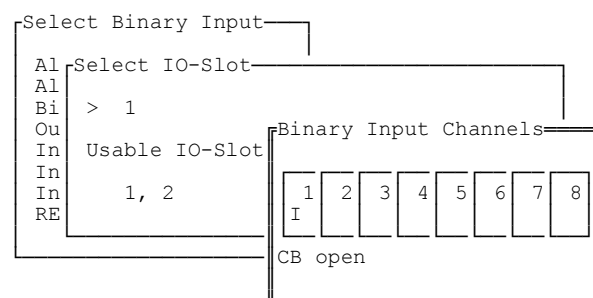


Fig. 5.17 “Binary input channels” selection window

The fields representing the binary input channels in the selection window are designated as follows:

Top: 1...14 : Channel No.

Bottom: X : selected channel (<Ins> key)

I : selected channel inverted (<-> key).

Any user comment is displayed in the lower part of the window for the field currently selected.

The plug-in unit and channel number of the selected binary input and a minus sign if it is inverted (e.g. -101) are indicated in the parameter value column of the “Edit function parameters” window.

xyzz: x = non-inverted () or inverted (-) input
 y = plug-in unit number (1...4)
 zz = channel number (1...14).

Note:

To cancel the selection of a channel, select “Always FALSE” or “Always TRUE” in the “Select Binary Input” window.

Since channels can have several inputs assigned to them, channel with inputs already assigned to them are not especially indicated in the channel selection window.

Output of another function

Every function input can be assigned either inverted or non-inverted to output of another function. The respective function is first selected in the “Output from function” window and then the selection window with all the outputs of the corresponding function opens:

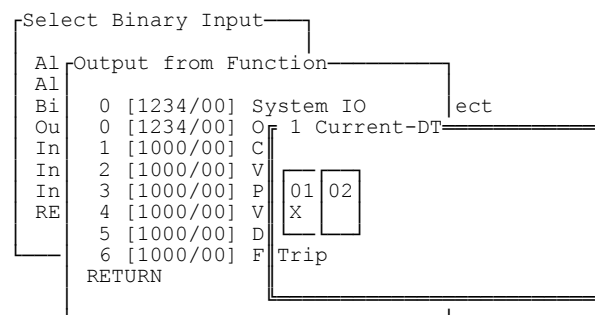


Fig. 5.18 “Output from function” selection window

The fields in the selection window are designated as follows:

Top: 1...47 : Channel No.

Bottom: X : selected channel (<Ins> key)

 I : selected channel inverted (<-> key).

The signal name is displayed in the lower part of the window for the field currently selected.

The function number and signal name of the selected output and a minus sign if it is inverted (e.g. -f 1 TRIP) are indicated in the parameter value column of the “Edit function parameters” window.

xf y z: x = non-inverted () or inverted (-) input
 y = function number
 z = signal name.

Caution:

Care must be taken when connecting binary signals as mistakes can cause mal-operation of the protection.

SCS input

Every function input can be assigned to an SCS input in either an inverted or non-inverted sense. The respective group (1 to 24) is first selected in the “Select SCS group” window:

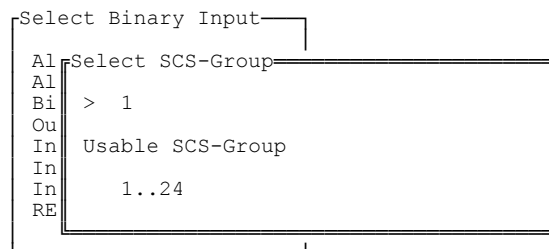


Fig. 5.19 “Select SCS group” selection window

The “Inputs from SCS” window appears after the group has been selected:

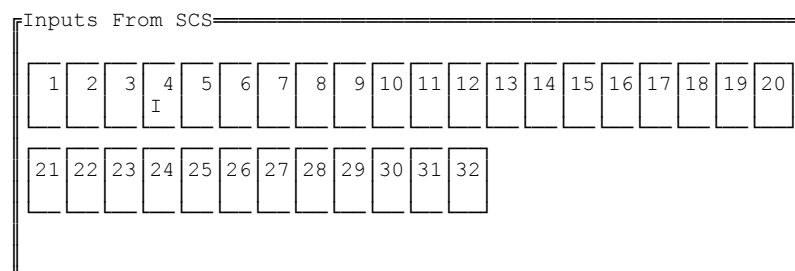


Fig. 5.20 “Inputs from SCS” selection window

The fields in the SCS input selection window are designated as follows:

Top: 1...32 : Channel No.

Bottom: X : selected channel (<Ins> key)

I : selected channel inverted (<-> key).

The SCS assignment (e.g. -SCSI2104) is indicated in the parameter value column of the “Edit function parameters” window.

xSCSIyyzz: x = non-inverted () or inverted (-) input

yy = SCS group number (1...24)

zz = data node within the group (1...32).

RBI input (distributed input system)

Every function input can be assigned to an RBI input in either an inverted or non-inverted sense. The respective group (1 to 80) is first selected in the “Select RBI No.” window, after which the “Inputs from RBI” appears:

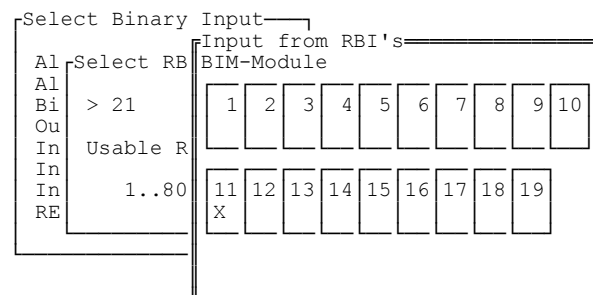


Fig. 5.21 “Select RBI group” and “Inputs from RBI” selection windows

The fields in the RBI input selection window are designated as follows:

Top: 1...19 : Channel No.

Bottom: X : selected channel (<Ins> key)

I : selected channel inverted (<-> key).

The RBI assignment (e.g. -R12111) is indicated in the parameter value column of the “Edit function parameters” window.

xRlyyyz: x = non-inverted () or inverted (-) input

yy = RBI device No. (1...80)

zz = input in the device (1...19).

Note:

Special information is available at inputs 17, 18 and 19:

- Input 17: A “1” at this input indicates that the device is transferring data (“Device connected”).
- Input 18: A “1” at this input indicates that the device is signalling a defect on line A (“Line A fault”).
- Input 19: A “1” at this input indicates that the device is signalling a defect on line B (“Line B fault”).

ITL data input (interlocking data)

Every function input can be assigned to an ITL input in either an inverted or non-inverted sense. The respective group (1 to 64) is first selected in the “Select ITL No.” window:

Fig. 5.22 “Select ITL group” selection window

The “Inputs from ITL” selection window then appears:

Fig. 5.23 “Input from ITL-Data” selection window

The fields in the ITL input selection window are designated as follows:

Top: 1...49 : Channel No.

Bottom: X : selected channel (<Ins> key)

I : selected channel inverted (<-> key).

The ITL assignment (e.g. -ITL2225) is indicated in the parameter value column of the "Edit function parameters" window.

xITLyyzz: x = non-inverted () or inverted (-) input
yy = ITL group No. (1...64)
zz = data node within the group (1...49).

Note:

A signal is available at input No. 49 that indicates that the respective device is active or not ("1" respectively "0").

5.5.5. *Editing hardware functions*

The hardware functions include all the hardware device settings. The menu structure can be seen from Fig. 5.24:

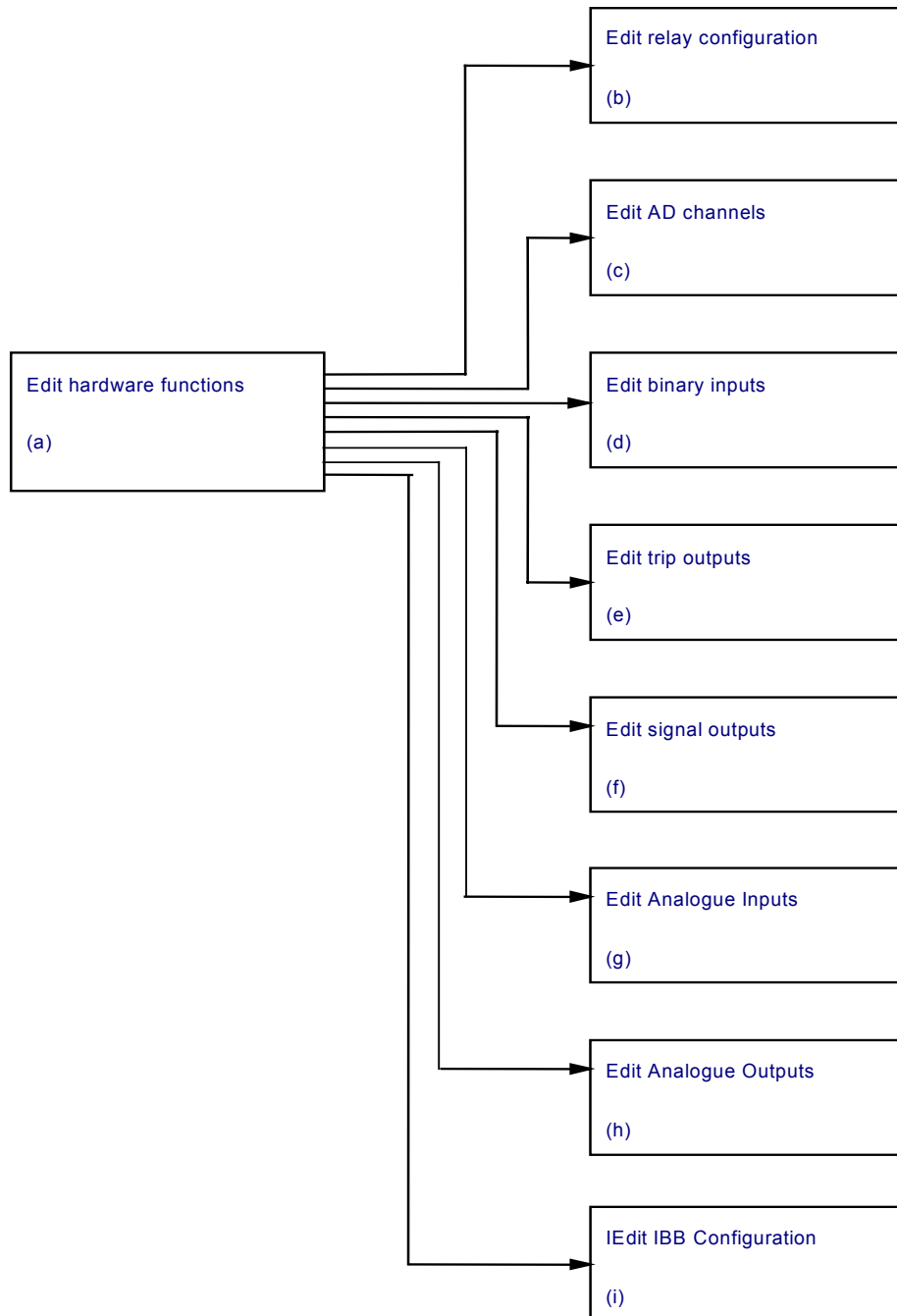


Fig. 5.24 Editing hardware functions
(see displays a to i on the following pages)

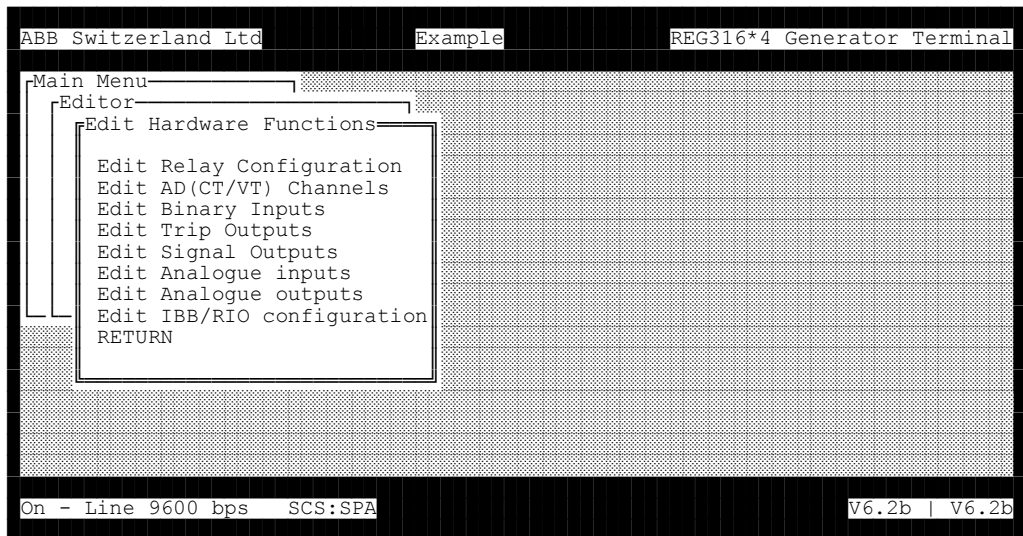


Fig. 5.24 a Edit hardware functions

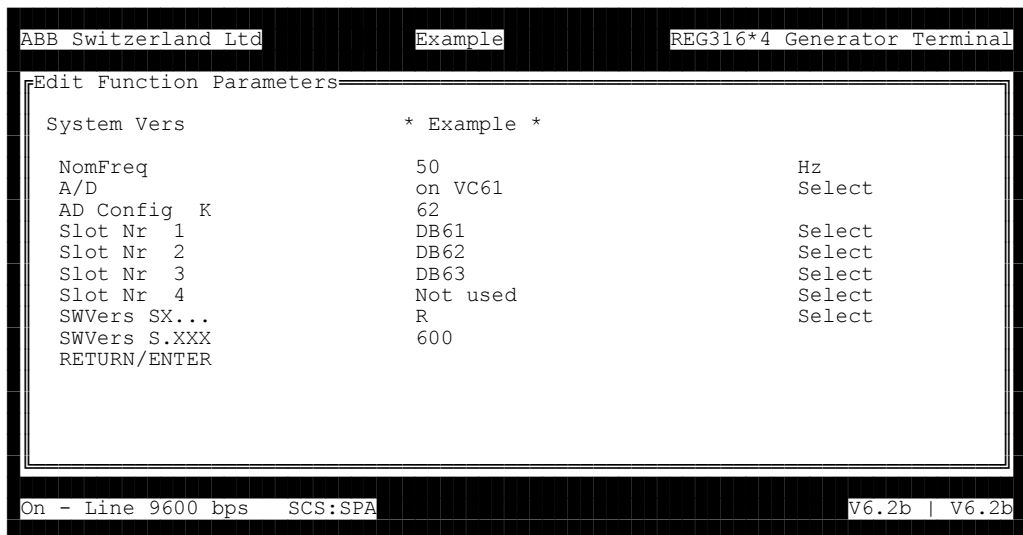


Fig. 5.24 b Edit relay configuration

The parameters are explained in [Section 3.4.1](#).

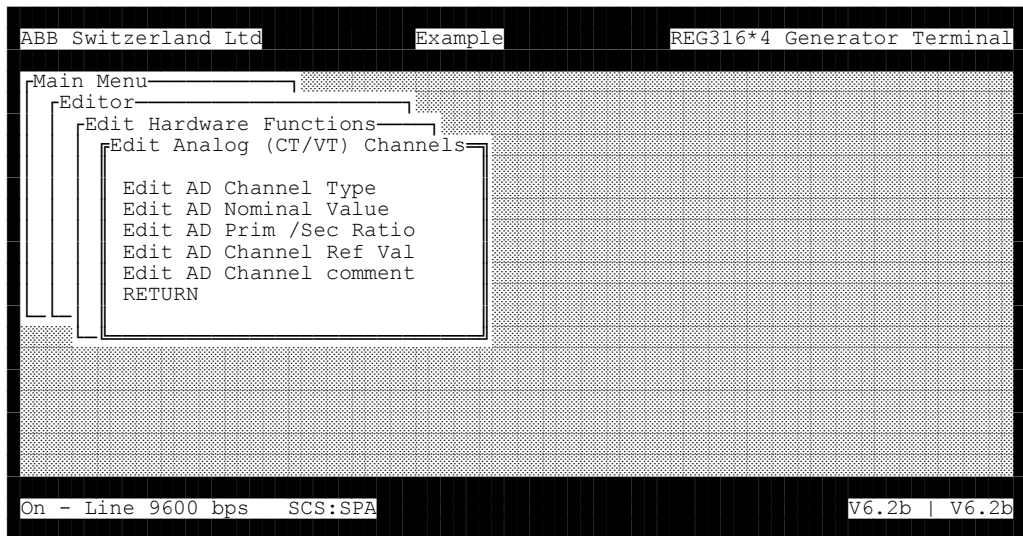


Fig. 5.24 c Edit AD(CT/VT) channels

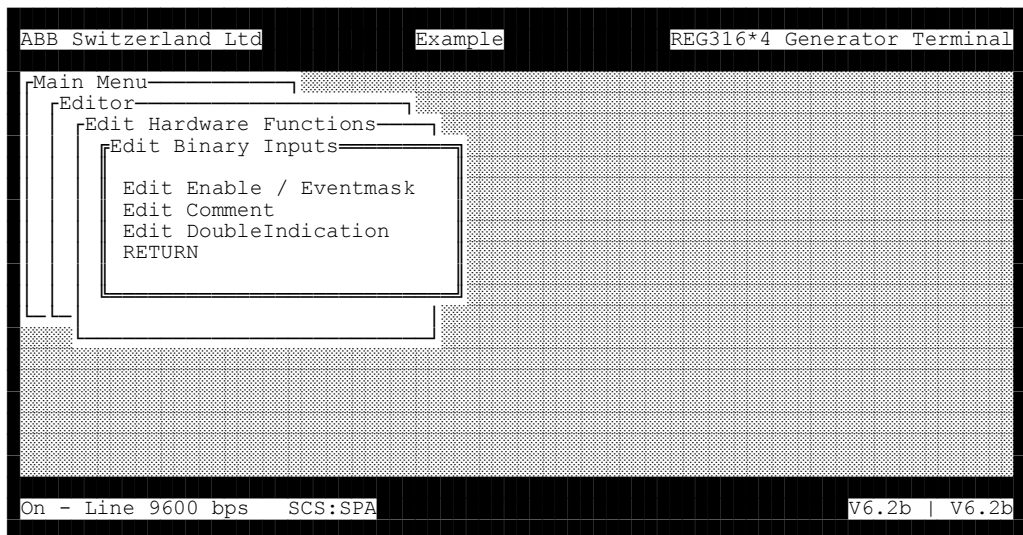


Fig. 5.24 d Edit binary inputs

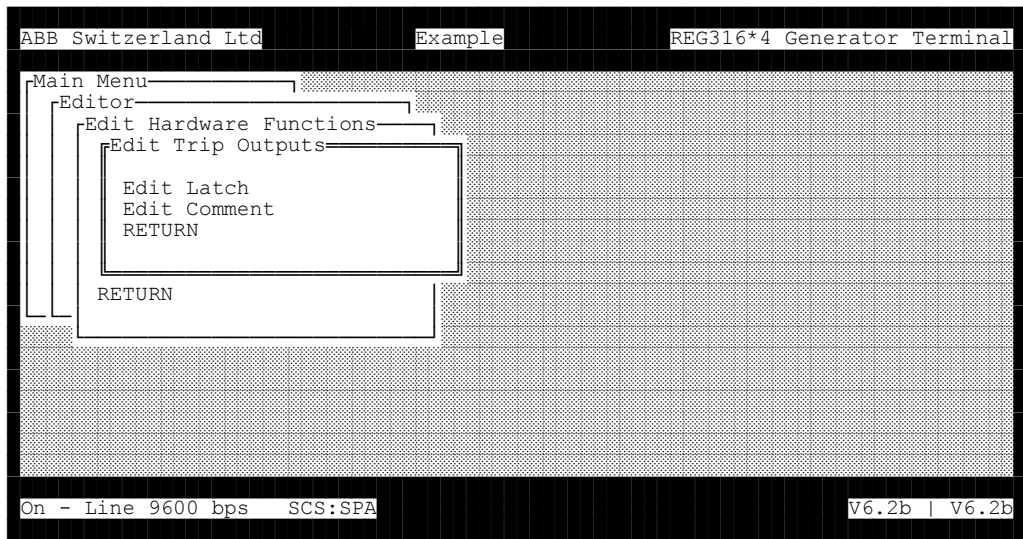


Fig. 5.24 e Edit trip outputs

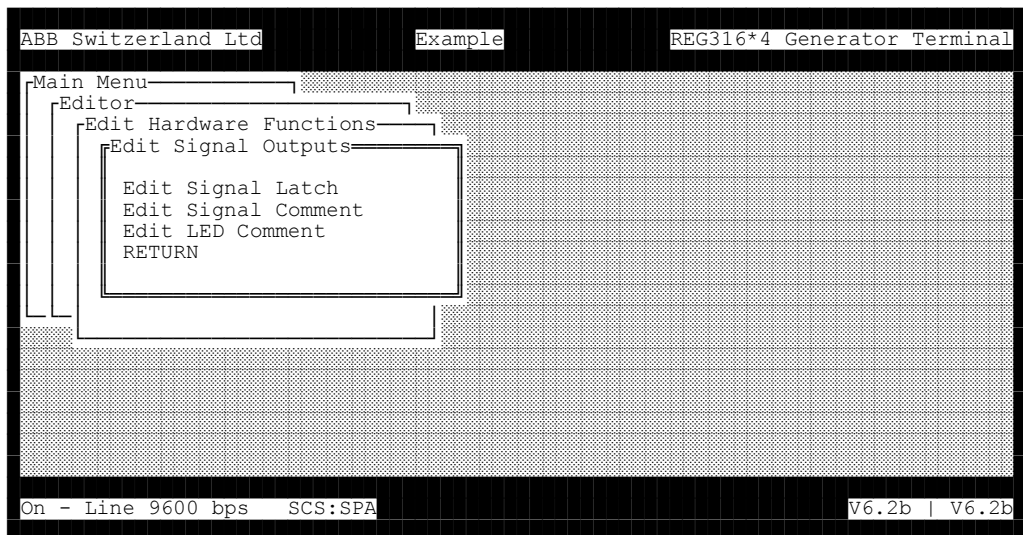


Fig. 5.24 f Edit signal outputs

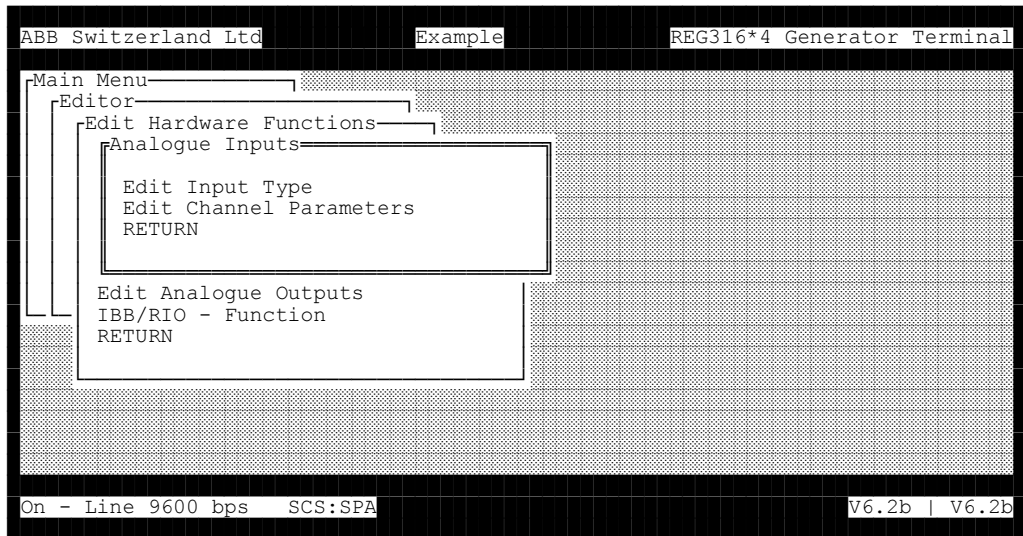


Fig. 5.24 g Edit Analogue Inputs

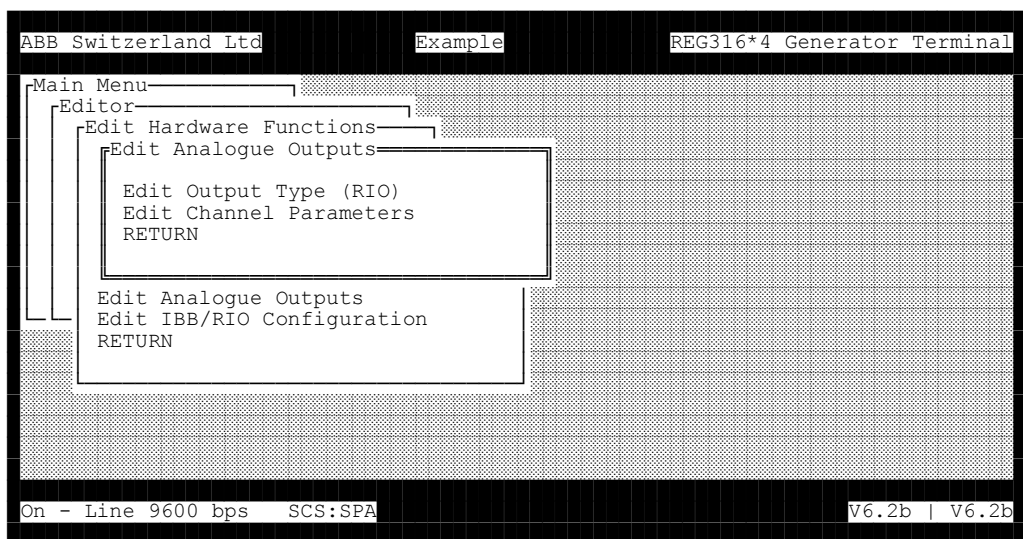


Fig. 5.24 h Edit Analogue Outputs

Refer to the Operating Instructions 1MRB520192-Uen for the distributed input/output system RIO580 for the various sub-menus and the parameters for configuring the analogue inputs and outputs.

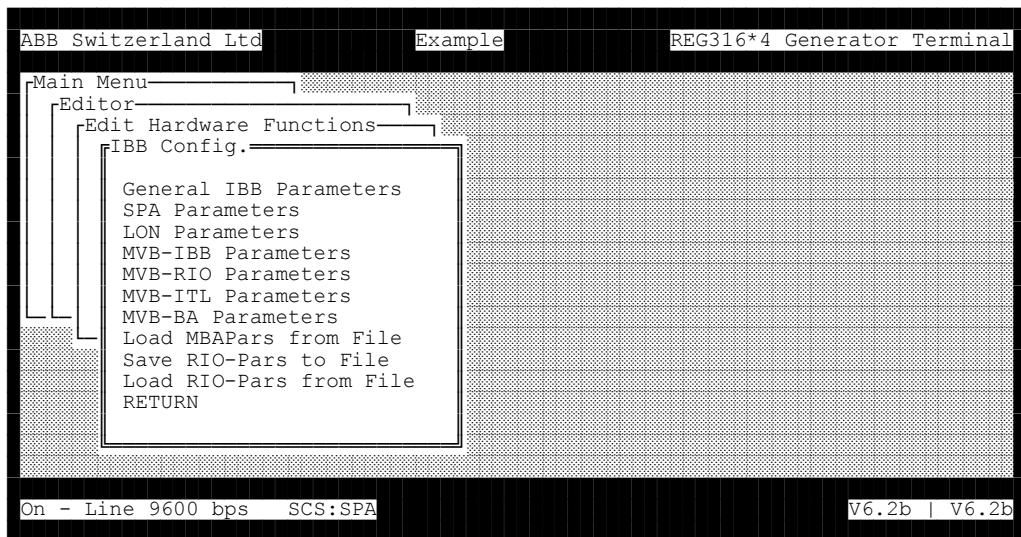


Fig. 5.24 i Edit IBB Configuration

The various submenus and the parameters in them are explained in [Section 9.2](#). Refer to publication 1MRB520225-Uen for the LON interbay bus settings, to publication 1MRB520270-Uen for the MVB interbay bus settings and to publication 1MRB520192-Uen for the MVB process bus settings.

5.5.5.1. *Inserting a channel comment*

A comment of up to 25 characters can be entered for every channel by selecting the menu item "Edit comments". The procedure is different to that for the binary, tripping and signalling channels.

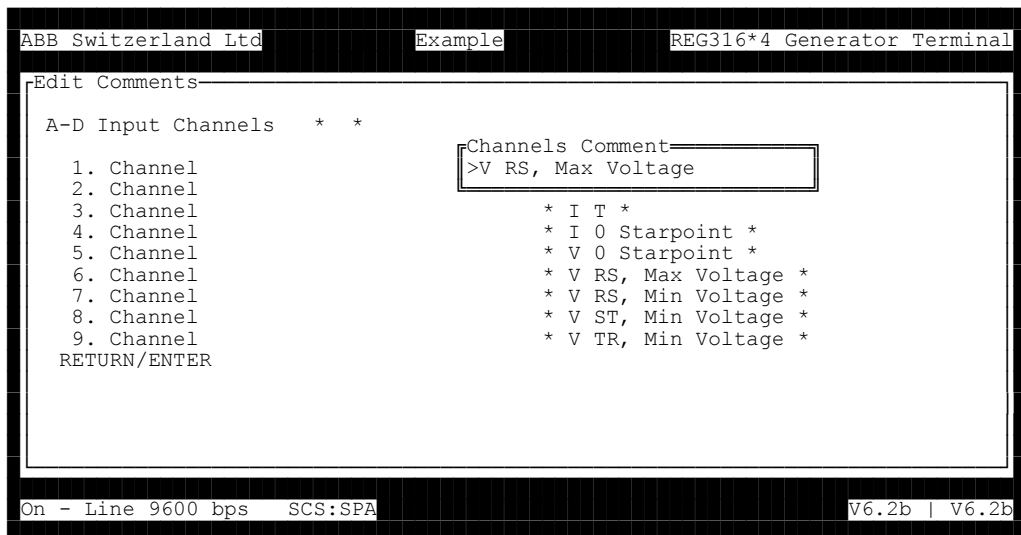


Fig. 5.25 Editing the comments of analogue channels

Press <Enter> to open the data input window for editing channel comments.

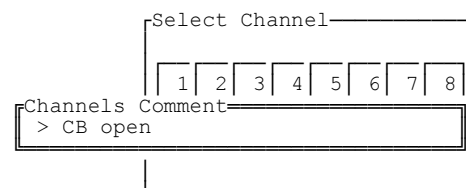
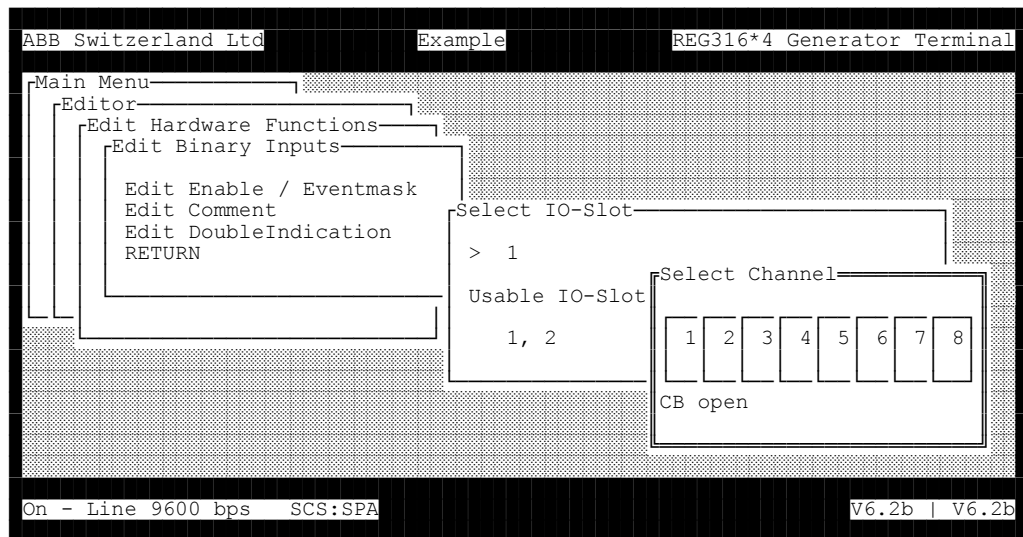


Fig. 5.26 Editing comments for binary, tripping and signalling channels

After selecting the corresponding plug-in unit, the available channels are displayed in the “Select channel” window. The comment for the selected channel appears in the lower part of the window and the data input window for editing it can be opened by pressing <Return>.

5.5.5.2. **Analog (CT/VT) Channels**

The “Edit Analog (CT/VT) Channels” menu provides facility for making the following settings which are described in detail in [Section 3.4.2.](#):

- **Channel type:**
If the parameter “AD config” was set to K = 00 when configuring the relay, a type of input transformer can be selected for every analogue channel. Three-phase groups of input transformers can only be assigned to channels 1...3, 4...6 or 7...9.
- **Rated value:**
The rating of the input c.t. or v.t. must be entered. The values of all three channels of a three-phase group change when one is changed.

- Primary/secondary ratio:
These values are only of consequence in connection with the VDEW6 protocol. The ratio of all three channels of a three-phase group change when one is changed.
- Change reference value:
Reference values enable the protection ratings to be adjusted to those of the primary plant. The reference values of all three channels of a three-phase group change when one is changed.

5.5.5.3. *Excluding (masking) binary channels as events*

Binary channels can be excluded from counting as events and appearing in the event list.

Upon selecting the menu item “Edit enable / event mask”, the window opens for changing the corresponding settings. The channels are displayed in groups of eight and each one can be selected and the mask set by pressing <Ins> or removed by pressing <Del>.

The channels appear in the parameter value column of the “Edit function parameters” window as a bit string with ‘1’ to ‘8’ indicating the masked channels and ‘0’ the non-masked channels (e.g. 12300670). The parameters that start with “R” concern the distributed input system.

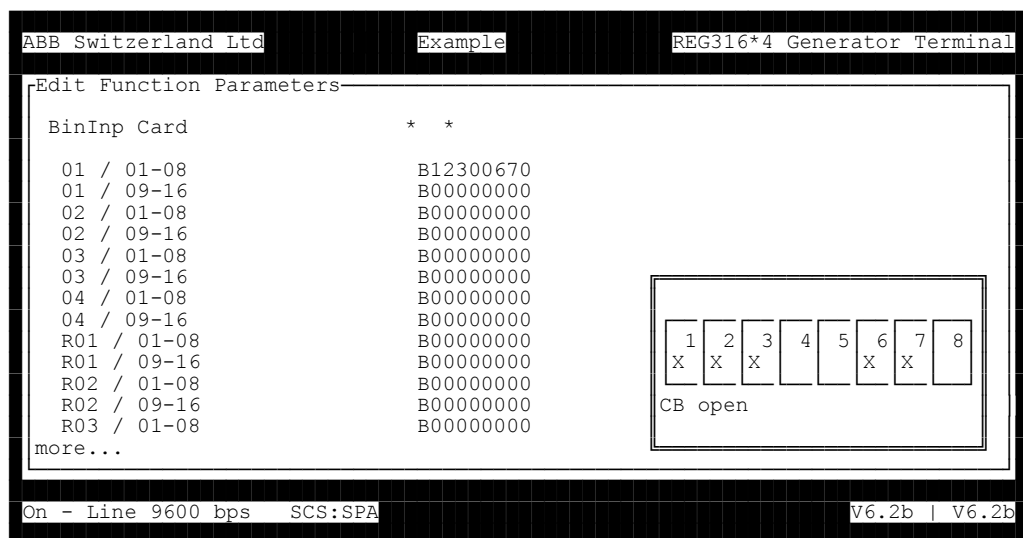


Fig. 5.27 Changing the event masking settings

5.5.5.4. *Tripping and signalling channel latching*

Every LED and tripping and signalling relay can be individually set to latch by selecting the menu item “Change latching mode”.

The procedure is the same as the one described above for excluding binary channels from counting as events.

5.5.5.5. *Definition of double signals*

Up to 30 double signals can be defined for binary channels.

Upon selecting the menu item “Edit double signals”, a menu appears with a choice of either local inputs or distributed input system inputs (process bus inputs).

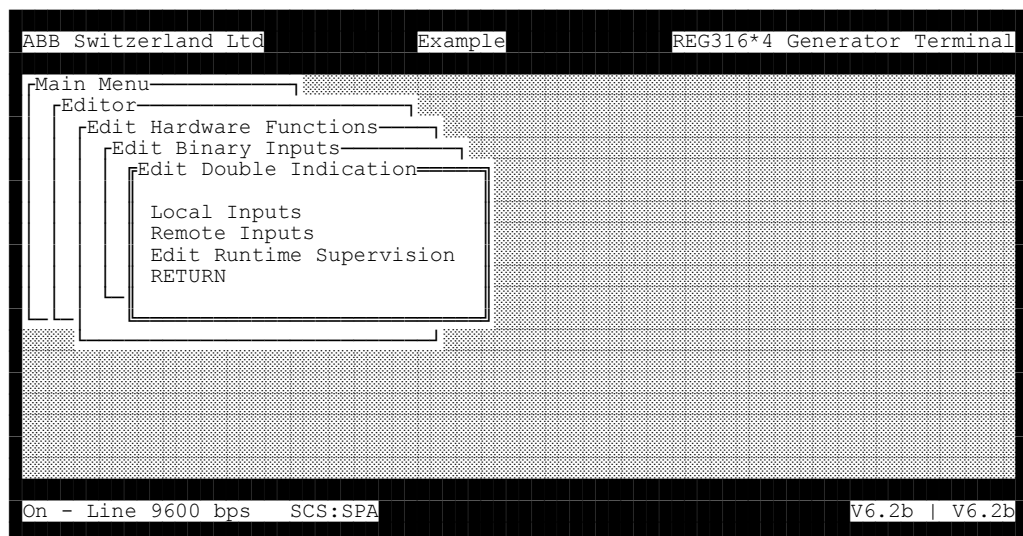


Fig. 5.28 Menu for selecting the kind of double signal

You then have to select the device you wish to edit to open the settings window. Now mark the respective channel using the <Ins> key. This defines it and the channel immediately following it as a double channel. Press the <Del> key to cancel the marking. When on of the channels marked as a double channel changes, a double record appears in the event list. It should be noted that double signals are automatically excluded from being recorded as normal events.

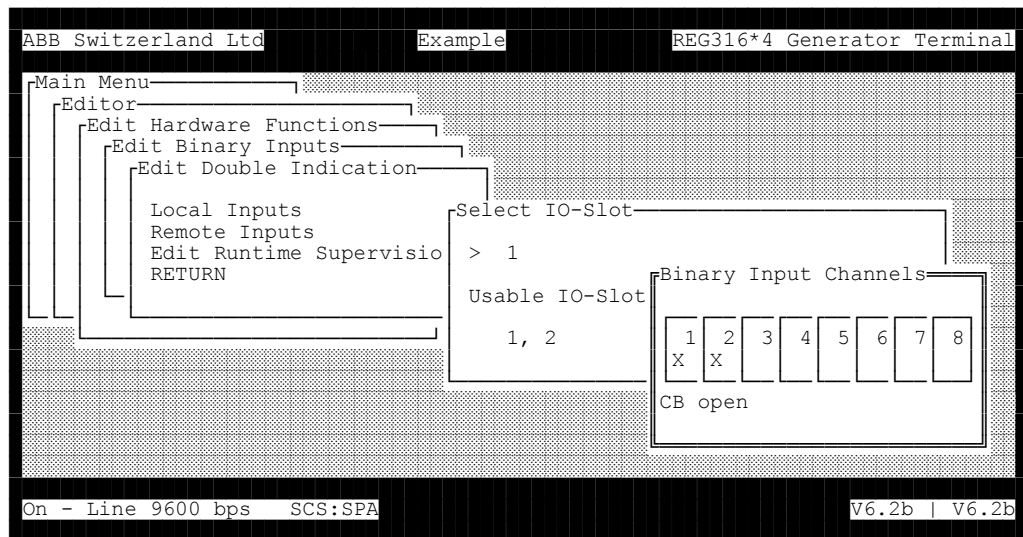


Fig. 5.29 Defining double signals

Edit runtime supervision:

The “Edit runtime supervision” dialogue provides facility for enabling or disabling the runtime supervision for each double indication.

What does the runtime supervision function do?:

Double signals are needed to unequivocally determine the status (position) of switchgear. For this purpose, the two signals detecting the end positions of the switch are connected to two consecutive inputs and form a “double indication”. Double indications are presented in a somewhat different form in the event list. Instead of “on” or “off”, the signals are listed as “0-0”, “0-1”, “1-0” or “1-1”, whereby “0-1” means that the switch is closed and “1-0” that it is open. The switch is moving when the signals produce “0-0”, while the combination “1-1” should not occur at all in normal operation.

The event “0-0” only signifies a transitory status while the switch (CB or isolator) is actually moving. Providing everything is functioning normally this signal is less interesting and therefore can be suppressed. Should on the other hand, the switch stick in an intermediate position, this signal suddenly becomes more important. The runtime supervision enables these two conditions to be distinguished. It can be set independently for each double indication and is active for a setting other than zero. The event “0-0” is thus initially suppressed and remains so as long as the switch reaches either its open or closed limit position before the end of the runtime supervision setting. This prevents the event

list from becoming overburdened with unnecessary data. The “0-0” event is subsequently added to the event list, should a switch not reach its end position within the specified time. The time stamp corresponds to the start of the switch movement. The status “1-1” is never suppressed even during the period of the runtime and appears in the event list immediately.

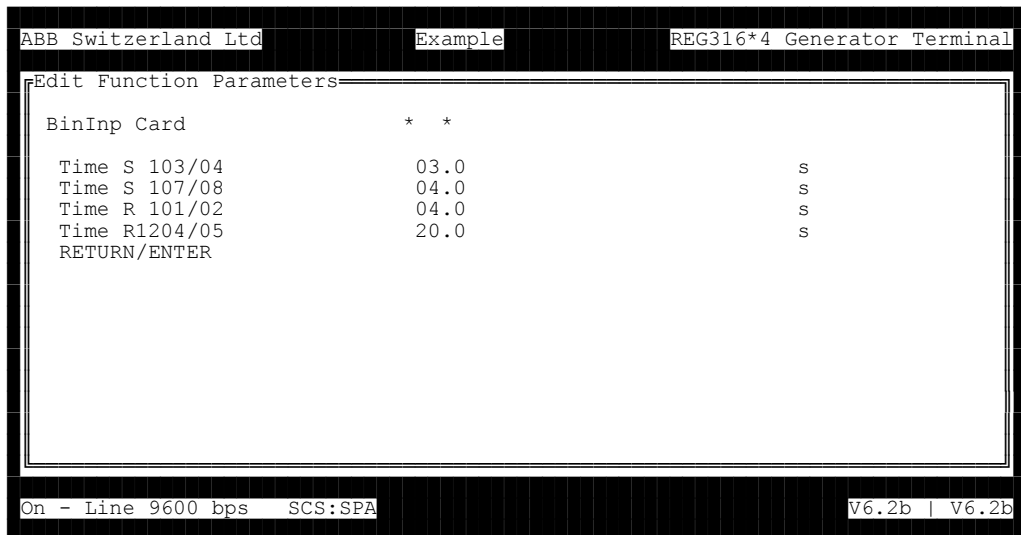


Fig. 5.30 Editing the runtime supervision

The runtime setting is entered in the dialogue “Edit runtime supervision” for each of the double indications that has been defined.

“S” signifies a double indication configured for a local input and an “R” one for a series RIO580 input unit.

The device number and the two inputs used for a double indication are given in the following form:

xxy1/y2

where xx = device number
 y1 = number of the first input
 y2 = number of the second input.

Timer data:

Min. setting: 0.0 s
Max. setting: 60.0 s
Increments: 0.1 s
Default setting: 0.0 s (i.e. runtime disabled).

5.5.6. *Editing system functions*

System functions include all the settings common to all functions. The menu structure can be seen from Fig. 5.31.

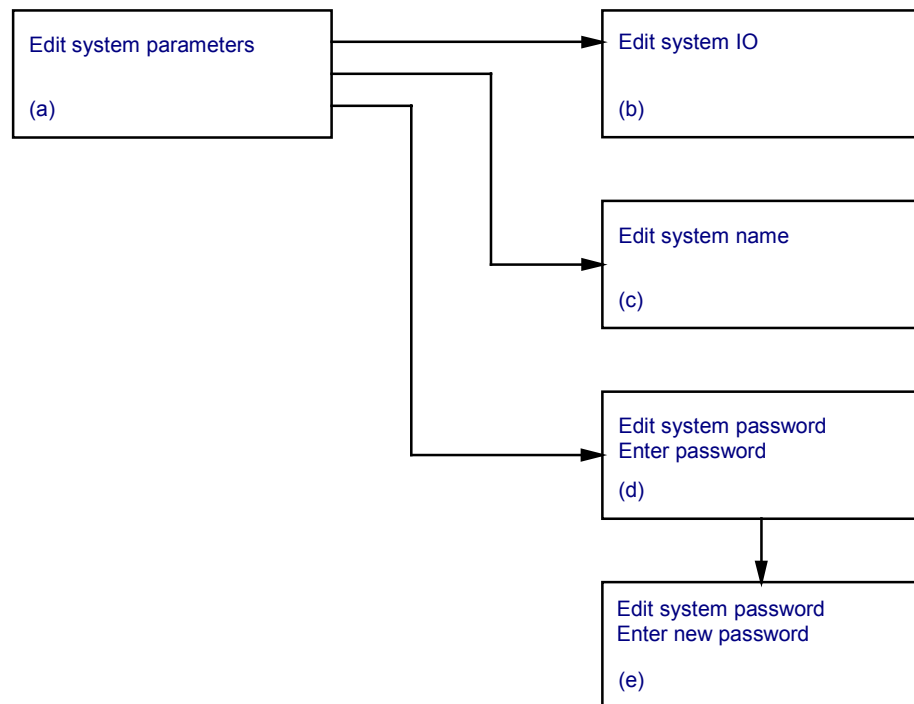


Fig. 5.31 Editing system functions
(see displays a to e on the following pages)

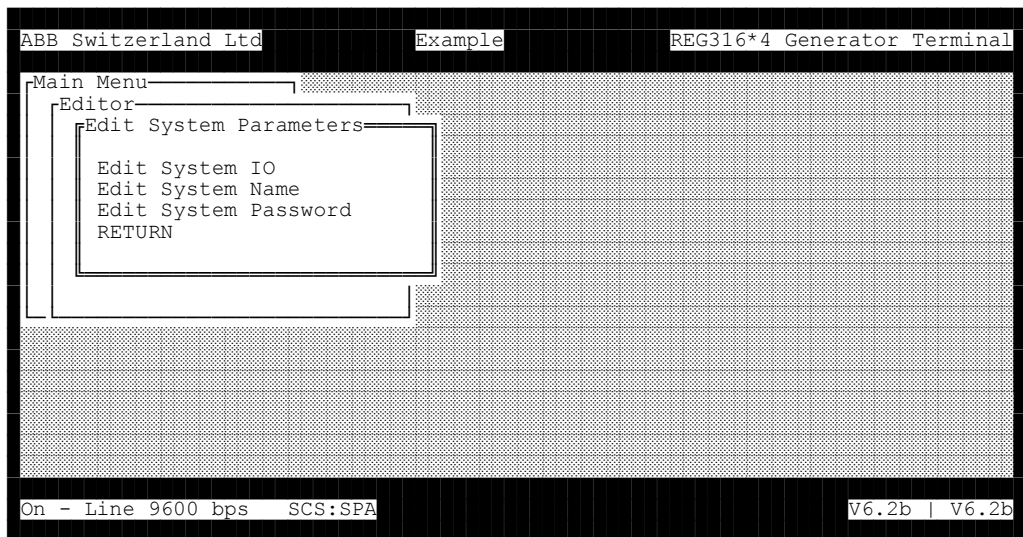


Fig. 5.31 a Edit system parameters

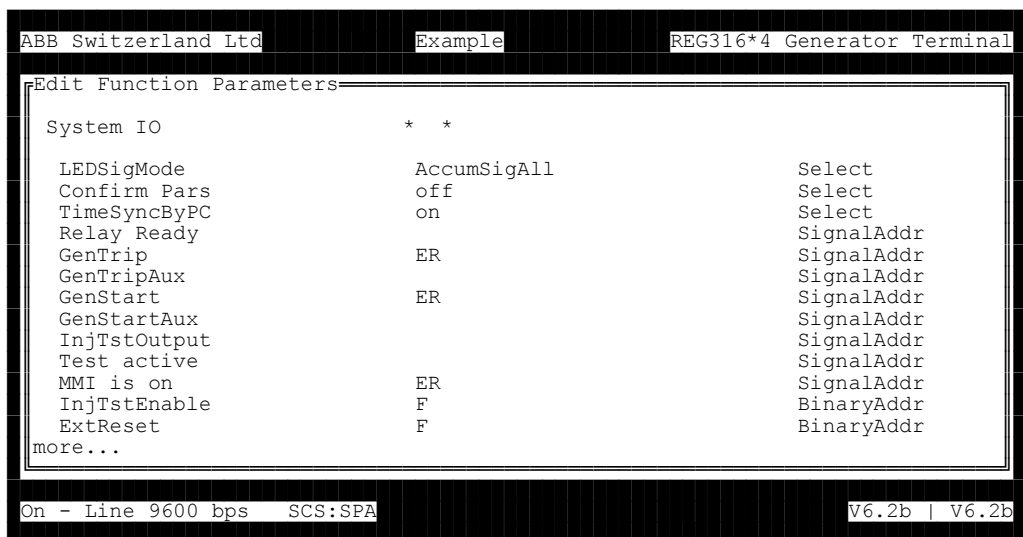


Fig. 5.31 b Edit function parameters

System settings concern those independent of functions, binary inputs and signals. Refer to [Section 3.4.5.1](#) for the significance of the various parameters.

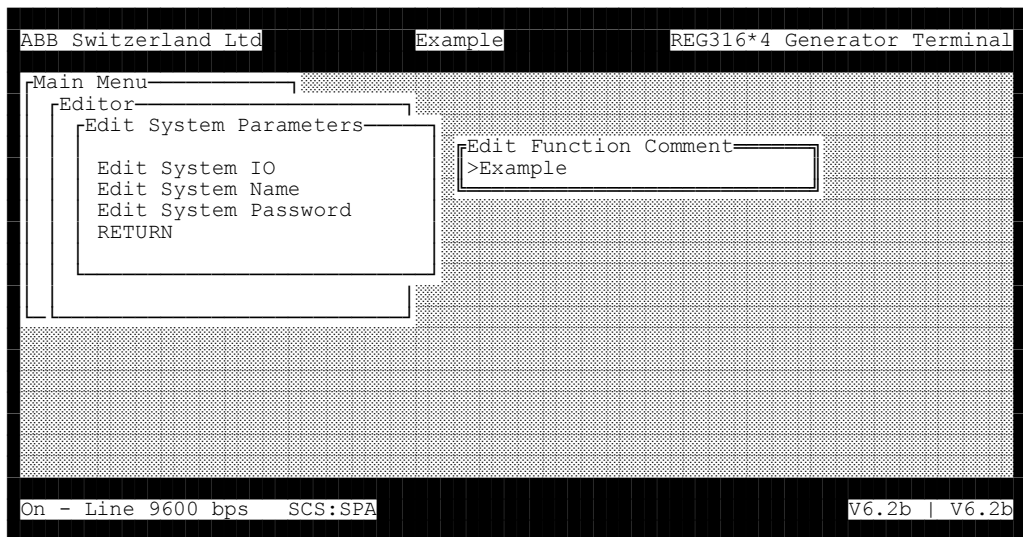


Fig. 5.31 c Edit system name

A name of up to 25 characters can be entered for every device which then appears in the header of the HMI window.

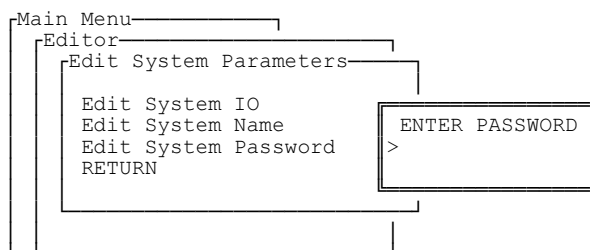


Fig. 5.31 d Edit system password, entering the old password

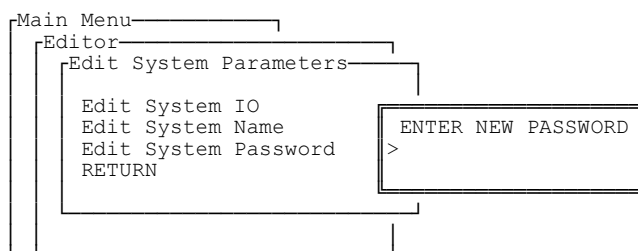


Fig. 5.31 e Edit system password, entering the new password

After entering the old password, the user can enter a new one of up to 6 characters.

The default password is blank, i.e. it is only necessary to press <Enter>.

If a password has been forgotten, a new one can be entered by entering SYSMAN for the old password.

5.5.7. Listing settings

All the settings or groups of settings can be viewed on the screen, printed or saved in a file. The various possibilities can be seen from Fig. 5.32.

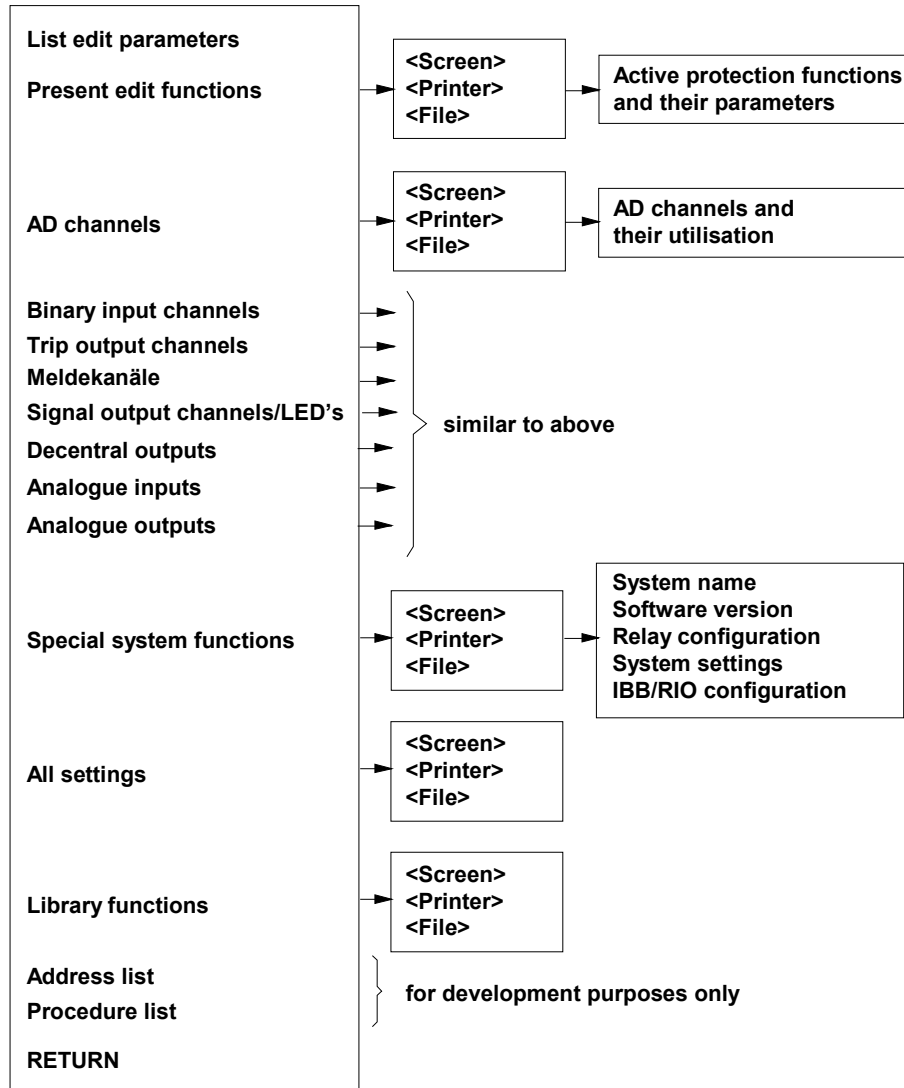


Fig. 5.32 Listing relay settings

5.5.8. Saving the contents of the editor

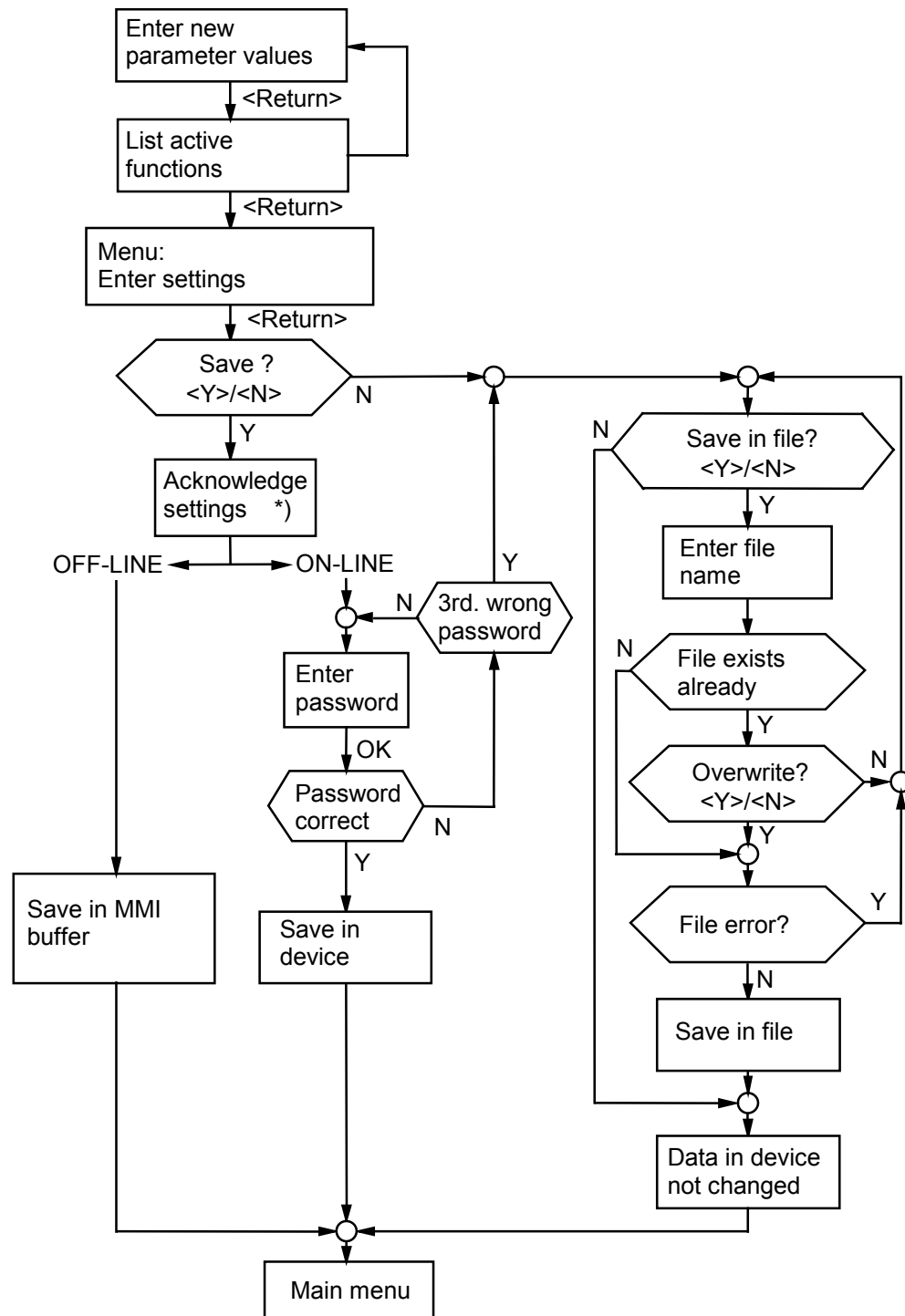


Fig. 5.33 Flow chart for saving the contents of the editor

*) Only if the "ParamConf" parameter is set.

5.5.8.1. *Downloading to the device*

The contents of the editor is downloaded to the device by repeatedly selecting the "RETURN" line in the editor window. The procedure can be seen from [Fig. 5.33](#).

As this operation is an extremely important one, a number of internal checks are carried out (e.g. comparison of the software code which is set with the existing software key). The downloading procedure is aborted if errors are discovered (a corresponding message is displayed) and the existing device settings are not changed.

Confirming parameters

If the "ParamConf" parameter is set, every new or changed parameter has to be individually confirmed by pressing the <→> key before it is saved. The corresponding menu for correcting a parameter can be opened by pressing <Esc>.

5.5.8.2. *Saving in and loading from a file*

The complete set of parameters including the hardware and system configuration data can be saved in a file either on a floppy or on the hard disc by one of the following:

- selecting the menu item "Save Parameters to File"
- repeatedly selecting "RETURN" as illustrated in [Fig. 5.33](#).

The user is requested to enter a file name which must conform to the DOS format (max. 8 characters of file name and 3 characters extension). The file is created in the current directory, if a path is not entered (max. 35 characters). Corresponding error messages are displayed should problems be encountered during the saving operation.

Loading a file from a drive is the reverse process of saving one. The user is requested to enter the name of the file. If a file of that name is found, it is first checked for compatibility and then loaded into the editor with the new set of parameters.

Note:

Loading a set of parameters from a file overwrites any data in the editor beforehand. Therefore if you do not wish to lose the existing data in the editor, they must be saved in a file before any other file is loaded.

5.6. *Event handling and operation of the disturbance recorder*

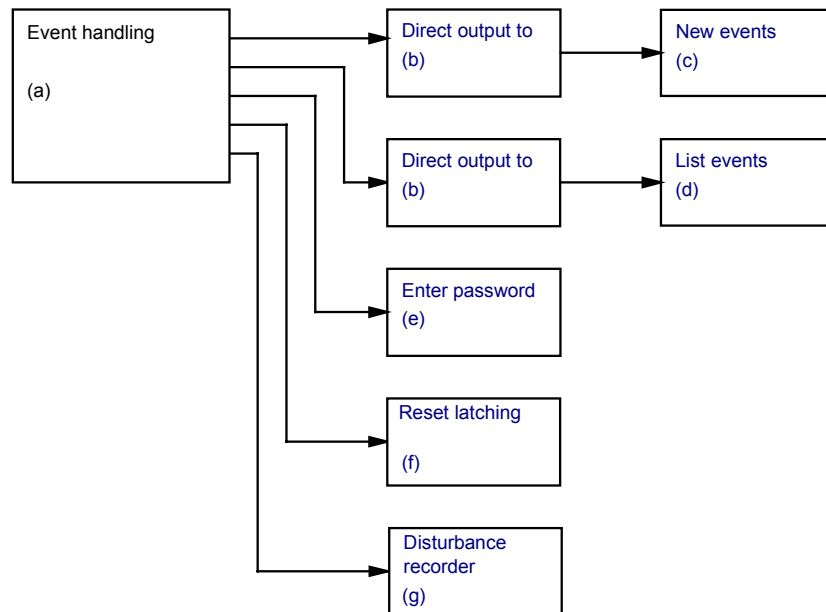


Fig. 5.34 Event handling
(see displays a to g on the following pages)

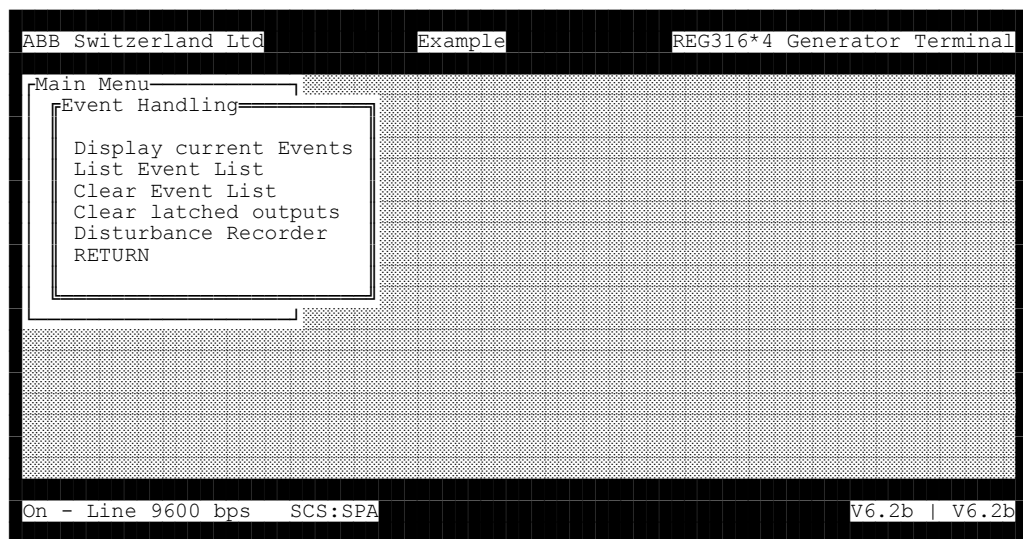


Fig. 5.34 a Event handling

Events can be viewed in two different ways as determined by the two sub-menus "Display new events" and "List events".

In both cases, an invalid time stamp is indicated by a red 'T' between the date and the time. An invalid time stamp results from the failure of the synchronisation signal on the interbay bus. The events of units that are not connected to the station automation system are all marked as invalid following an interruption of the auxiliary supply until the respective unit is resynchronised to the PC time by running the HMI.

Display new events

In this mode, both the current relay events and the latest relay events are displayed.

All the events are recorded in chronological order together with the actual times they occurred (i.e. the time of the PC clock). The events are only displayed once, i.e. if the sub-menu is closed and then reopened, the display is empty until new events are recorded.

If the transfer of the events to <Printer> or <File> was chosen, all the events detected by the protection can be recorded over any period of time. However, the HMI is busy and therefore blocked while this is going on. A "Load" or "Print" window indicates that the continuous display or printing mode is active. It remains so until <Esc> is pressed. Do not switch the printer off, before leaving the continuous printing mode.

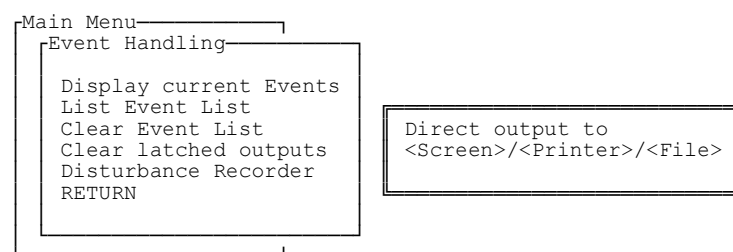


Fig. 5.34 b Direct output to

ABB Switzerland Ltd			Example	REG316*4 Generator Terminal		
33	1998-03-27	13:28;48.991	1 Current-DT	Trip	OFF	
34	1998-03-27	13:28;48.991	1 Current-DT	Start	OFF	
35	1998-03-27	13:28;48.991		GenStart	OFF	
36	1998-03-27	13:28;49.261		GenStart	ON	
37	1998-03-27	13:28;49.261	1 Current-DT	Start	ON	
38	1998-03-27	13:28;49.265	5 DisturbanceR	BinOutput	ON	
39	1998-03-27	13:28;49.365	5 DisturbanceR	BinOutput	OFF	
40	1998-03-27	13:28;50.261	1 Current-DT	Trip	ON	
41	1998-03-27	13:28;50.261	1 Current-DT			4.036 IN

On-line 9600 bps SCS:SPA V6.2b | V6.2b

Fig. 5.34 c New events

List events

The entire contents of the even memory (255 records) listed displayed in the display mode.

Should the signal 'General start' pick up, the events are listed with times in relation to the occurrence of the general start signal, otherwise their actual times are given. The list can be viewed any number of times until it is deleted.

The display can be moved up or down line-by-line or scrolled page-by-page using the keys <↑>, <↓> or <PgUp>, <PgDn>. The keys <Home> and <End> jump to the beginning, respectively end of the list.

ABB Switzerland Ltd			Example	REG316*4 Generator Terminal		
28	D:	00000 00:00;00.000	1 Current-DT	Start	ON	
29	D:	00000 00:00;00.000	5 DisturbanceR	BinOutput	ON	
30	D:	00000 00:00;00.100	5 DisturbanceR	BinOutput	OFF	
31	D:	00000 00:00;01.000	1 Current-DT	Trip	ON	
32	D:	00000 00:00;01.000	1 Current-DT			4.036 IN
33	D:	00000 00:00;24.770	1 Current-DT	Trip	OFF	
34	D:	00000 00:00;24.770	1 Current-DT	Start	OFF	
35	1998-03-27	13:28;48.991		GenStart	OFF	
36	1998-03-27	13:28;49.261		GenStart	ON	
37	D:	00000 00:00;00.000	1 Current-DT	Start	ON	
38	D:	00000 00:00;00.003	5 DisturbanceR	BinOutput	ON	
39	D:	00000 00:00;00.103	5 DisturbanceR	BinOutput	OFF	
40	D:	00000 00:00;01.000	1 Current-DT	Trip	ON	
41	D:	00000 00:00;01.000	1 Current-DT			4.036 IN
42	D:	00000 00:00;09.680	1 Current-DT	Trip	OFF	
43	D:	00000 00:00;09.680	1 Current-DT	Start	OFF	
44	1998-03-27	13:28;58.941		GenStart	OFF	

On-line 9600 bps SCS:SPA V6.2b | V6.2b

Fig. 5.34 d Event list

Deleting events

Providing a valid password is entered, the event list can be deleted as follows.

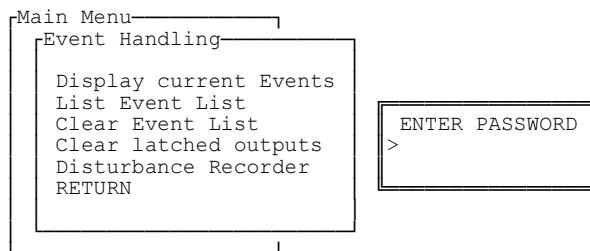


Fig. 5.34 e Enter password

Resetting latched outputs

After entering your password, you can reset the outputs that latch.

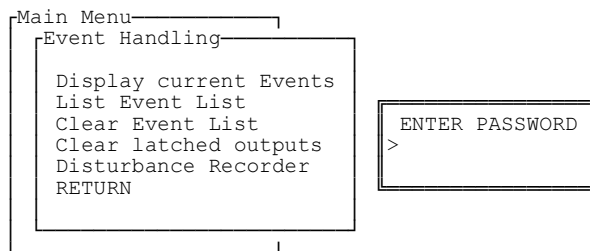


Fig. 5.34 f Enter password

Disturbance recorder

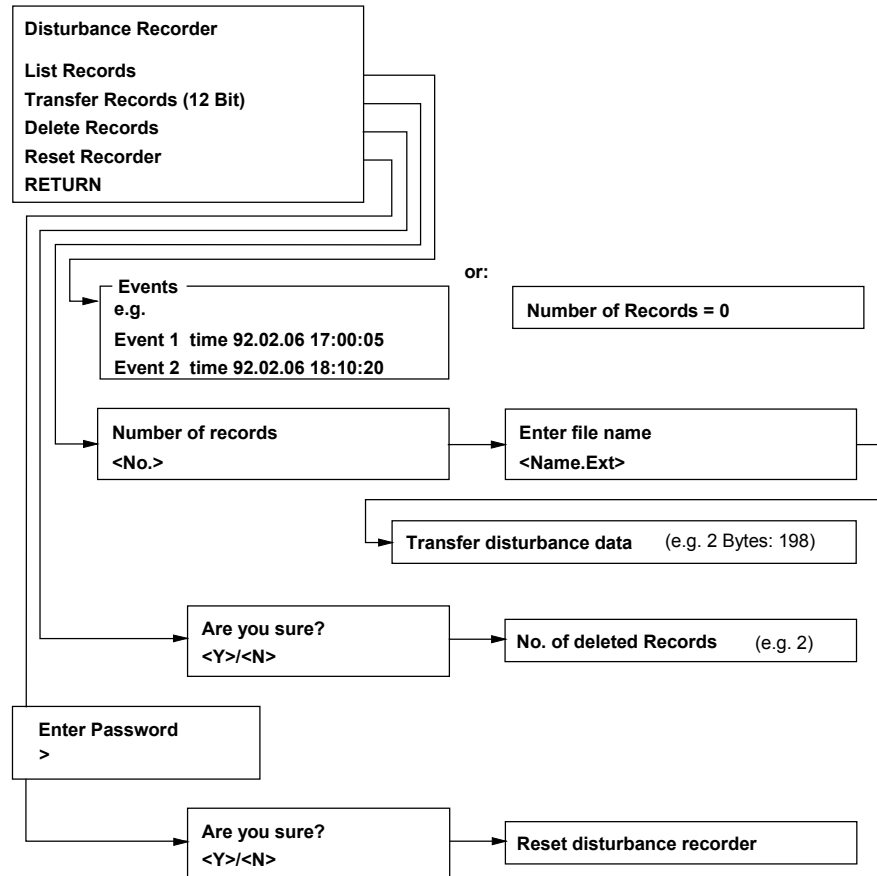


Fig. 5.34 g Operation of the disturbance recorder

According to the above diagram, the disturbance recorder can operate in one of the following modes:

List records:

All the records in the memory are displayed.

Transfer records (12 Bit):

One of the records is transferred. The number of the record and the name of the file in which it should be stored must be given.

Delete records:

The oldest record is deleted.

Reset disturbance recorder:

The disturbance recorder is reinitialised and all the old records are deleted.

5.7. Displaying variables

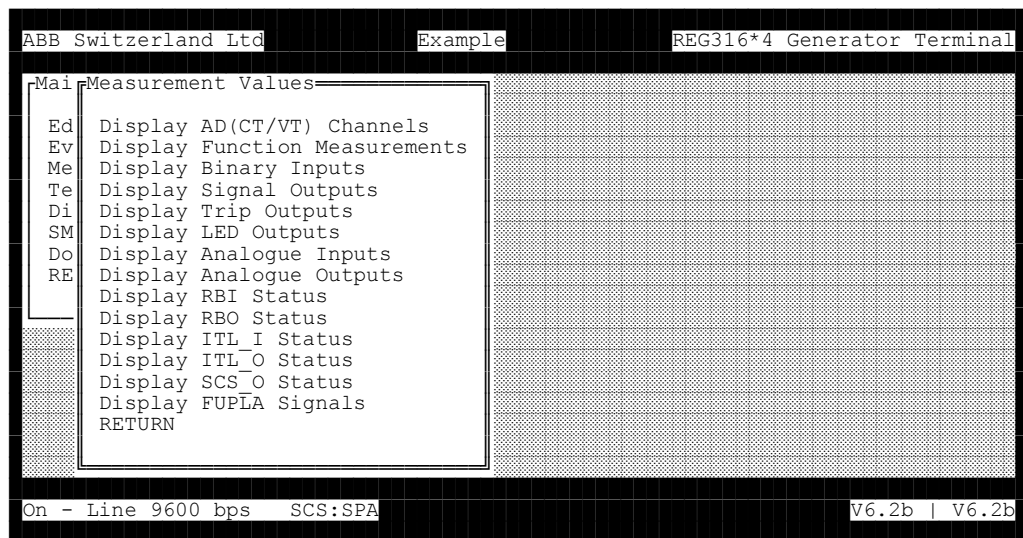


Fig. 5.35 Processing measurements

The load values measured by the protection functions and all the device inputs and outputs can be displayed.

The logic signals of all the FUPLA segments can be checked by selecting the menu item “Display FUPLA signals”. This is used primarily for testing at the works.

5.7.1. Displaying AD(CT/VT) channels

All 9 c.t. and p.t. inputs can be viewed at the same time:

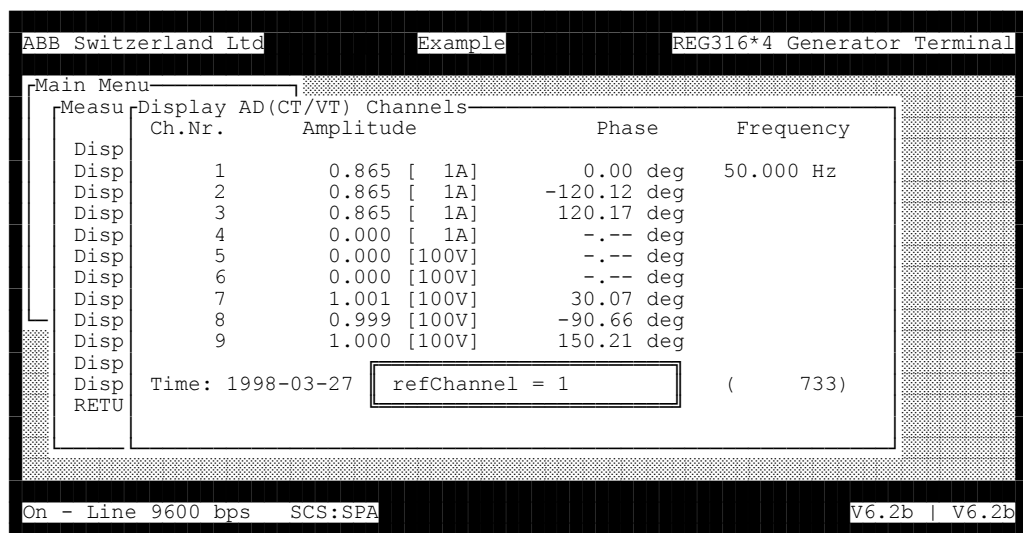


Fig. 5.36 Display AD(CT/VT) channels

Press an arrow key to open the reference channel window and select the reference channel by entering its number. The reference channel measures the frequency and provides the reference for angular measurements.

5.7.2. *Displaying load values*

Load values are measured by every protection function with a measurement algorithm. The desired function can be selected via the sub-menu "Display load values".

Note that the list includes all the active functions for all the sets of parameters, i.e. also those which do not measure load values such as:

- auto-reclosure
- remote binary
- FUPLA
- VDEW6
- defluttering
- logic
- disturbance recorder.

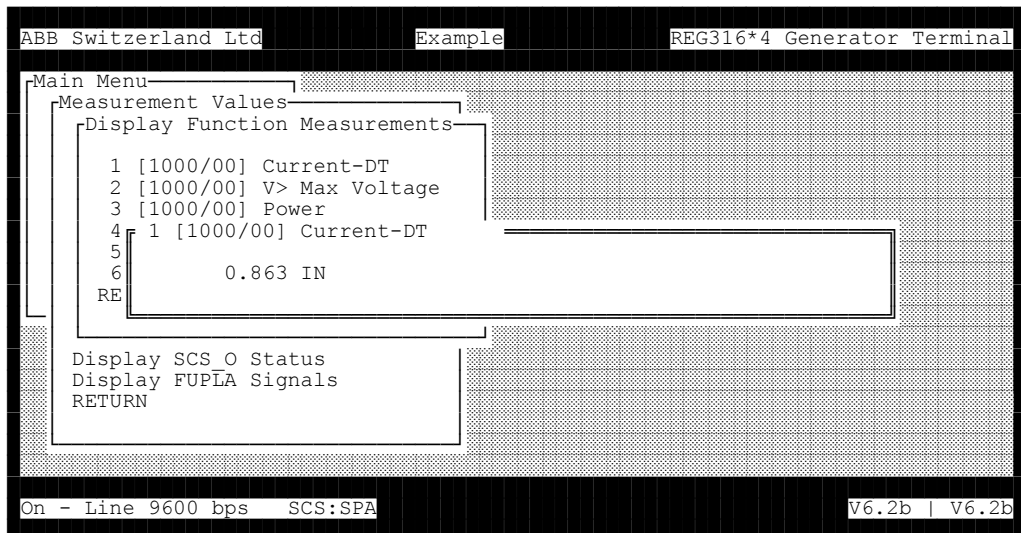


Fig. 5.37 Display function measurements (load values)

5.7.3. *Displaying binary inputs, signalling relays, LED's or tripping relays*

The inputs or outputs are displayed upon entering the number of the corresponding local or distributed input/output plug-in unit. Active inputs and outputs are indicated by an "X".

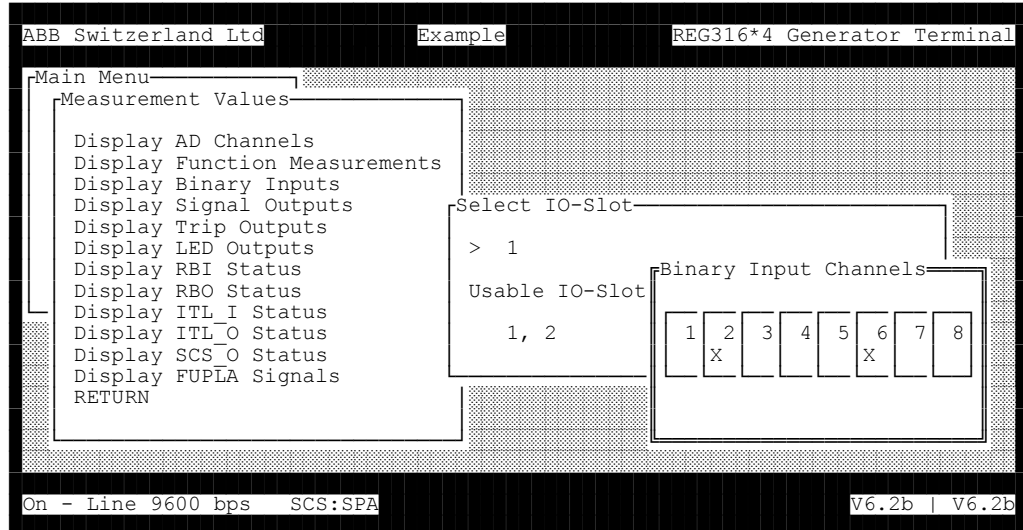


Fig. 5.38 Display binary inputs

5.7.4. *Displaying analogue inputs and outputs*

Enter the device number to view the associated inputs or outputs.

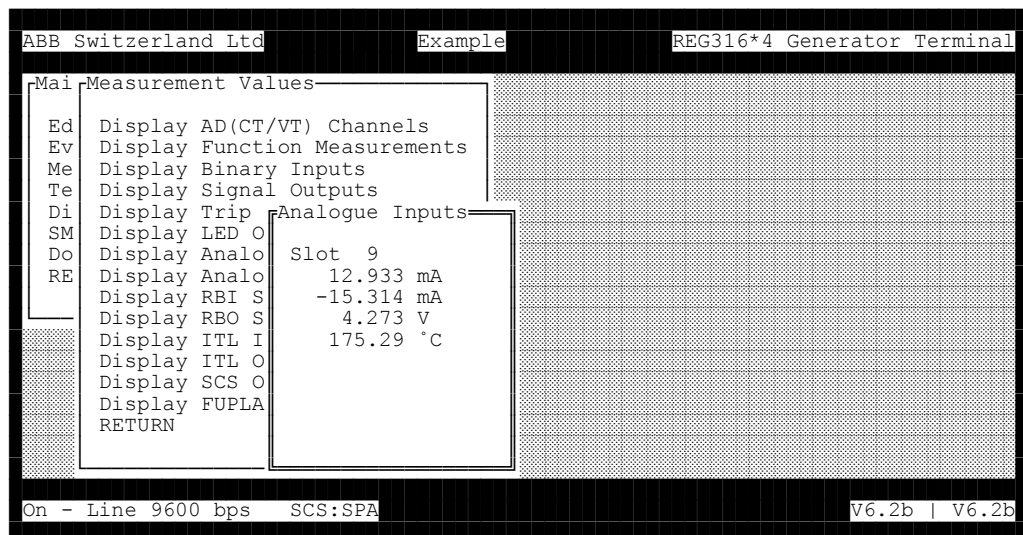


Fig. 5.39 Display analogue inputs

5.7.5. *Displaying ITL inputs and outputs*

ITL data can also be displayed. There are 48 outputs altogether (3 groups of 16 outputs each) and 3072 inputs (64 groups of 48 inputs each). The data belonging to a group are displayed when the group is selected, active signals being marked by “X”. The counter transferred with the data to check the transmission is also displayed. In the case of outputs, it is the one belonging to the output itself, while for inputs the input’s own and the transmitter counter are both displayed.

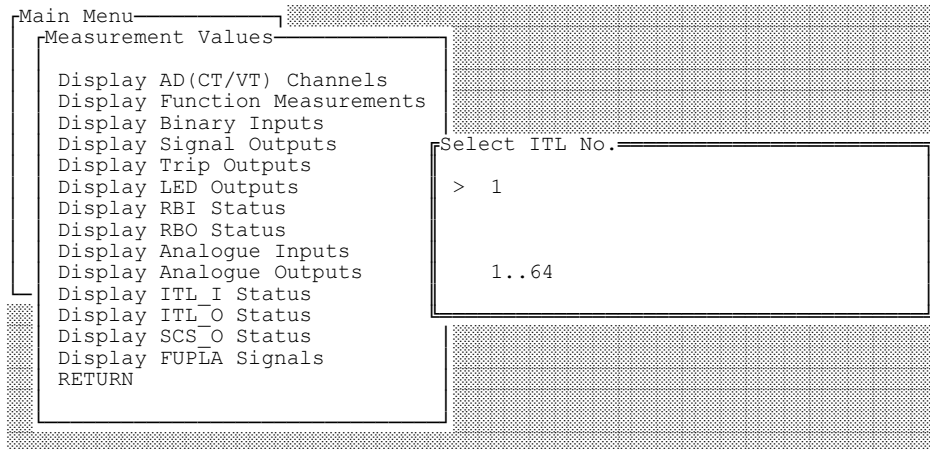


Fig. 5.40 Selecting the ITL data group

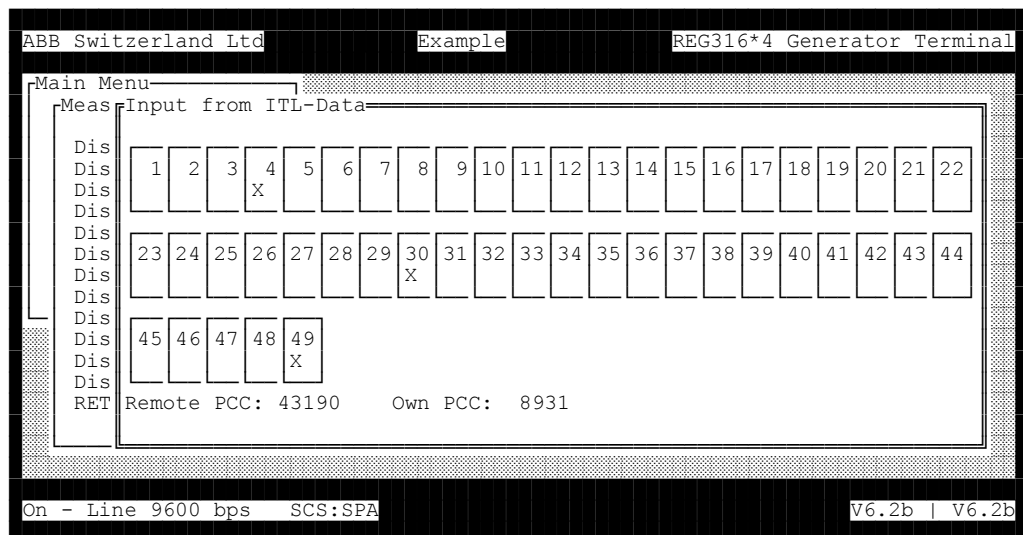


Fig. 5.41 Displaying ITL data inputs

The two counters indicate whether the corresponding data are refreshed.

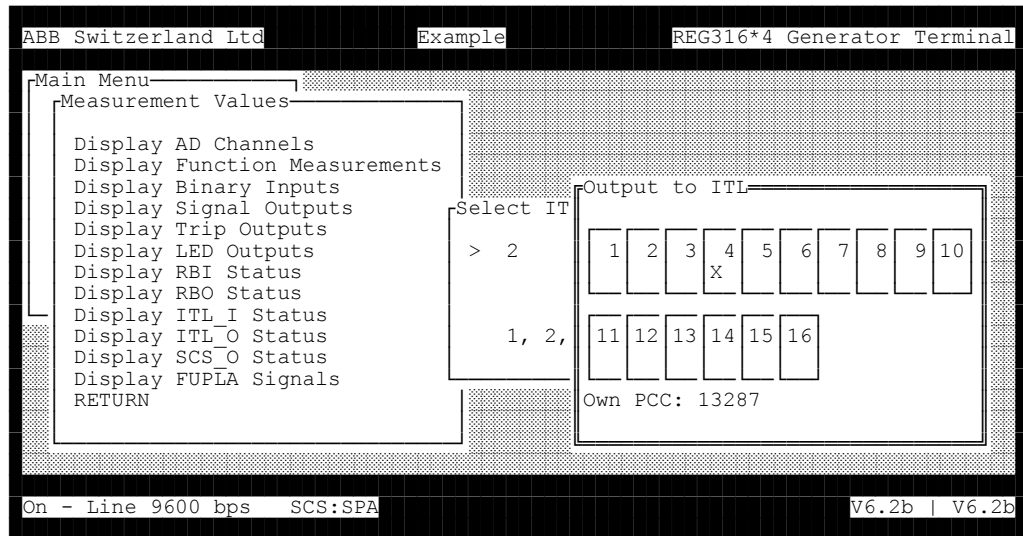


Fig. 5.42 Displaying ITL data outputs

5.7.6. *Displaying SCS outputs*

SCS outputs are displayed in 3 groups of 8 times 32 signals each. Use the <↑> and <↓> keys to switch between the groups. The SCS group (1...3) is displayed at the upper edge of the window.



Fig. 5.43 Displaying SCS outputs

Active outputs are marked by "I".

5.7.7. *Displaying FUPLA signals*

FUPLA signals can also be displayed. For this purpose, the FUPLA file with the extension “xx.BIN” must be available in a format that the HMI program can read.

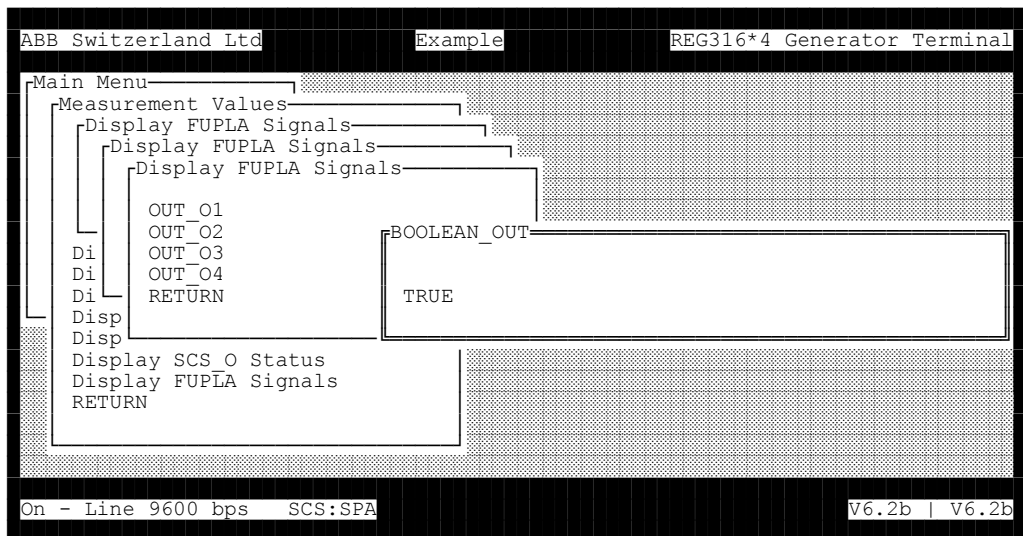


Fig. 5.44 Displaying FUPLA data

5.8. **Diagnostics**

The diagnostics menu includes the following:

- “Display diagnostic data”
The results of the self-monitoring function for the entire device, the main processor, the analogue input unit 316EA62 (where fitted) and the analogue inputs on the main processor unit are displayed. The time when the settings were last changed is also given.
The names and statuses of all the FUPLA logics loaded in the device are also displayed.
- “Load HEX dump”, “Delete HEX dump”
This information is only intended for development purposes.
- “IBB information”
Information concerning the status of the IBB link. The data displayed depend on the type of bus protocol in use (LON, VDEW, SPA or MVB).
- “RIO information”
Information concerning the status of the process bus and the distributed input/output system (from V5.0).
- “Reset SCS data”
The SCS input data are deleted after entering a password (from V4.04).
- “Load SCS forms”
Enables forms in a file created by the HMI documentation function to be saved so that the signalling of events can be controlled via the SCS (from V5.0).

Refer to [Section 6](#) for further details.

5.9. Test functions

Since some of them can disrupt the normal operation of the device, test functions can only be accessed after entering the valid password. They are used mainly during commissioning and may only be activated when the plant is out of service, or with the tripping and signalling circuits externally disconnected if in service.

The protection is re-initiated upon closing the “Test functions” menu and the set of parameters previously used in operation re-activated.

The procedure for using the test functions can be seen from the following figures.

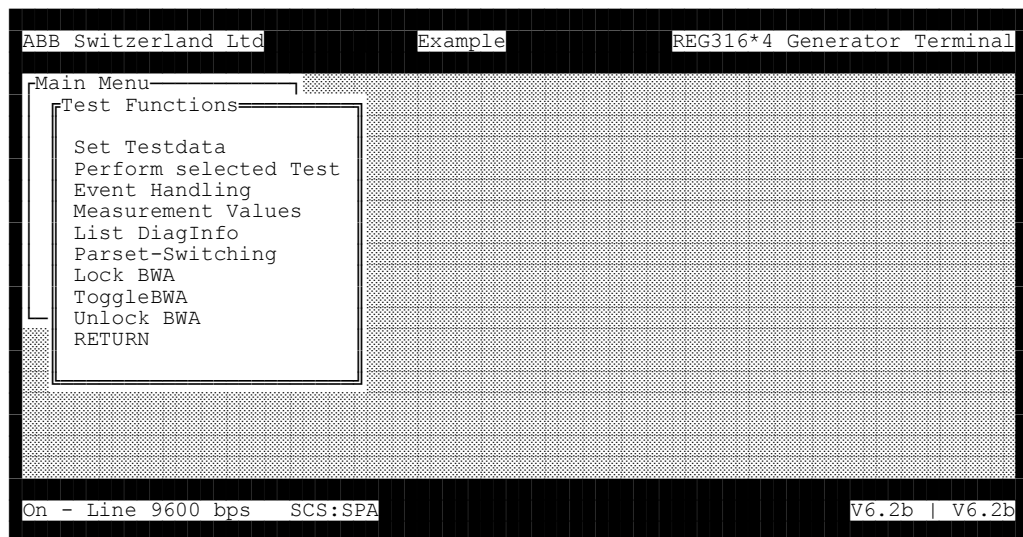


Fig. 5.45 Test functions

Set test data

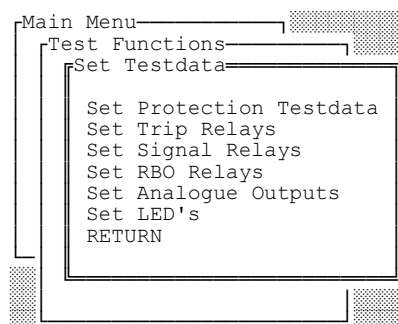


Fig. 5.46 Set test data

1. Testing the protection functions:

A protection function is selected for testing (using <Ins>) from the list of “active functions”. The list contains all the active functions occurring in all the sets of parameters, including those which cannot be tested such as

- Check-I3ph
- Check-U3ph
- Distance
- Auto-reclosure
- Pole slipping
- EarthFltGnd2
- Remote binary
- FUPLA.
- VDEW6
- Flutter detection
- Delay
- Counter
- Logic
- UIFPQ
- Disturbance recorder

The next window requires the input of one or several test values. The simulation of the input signals checks the operation of the function and its tripping and signalling channels.

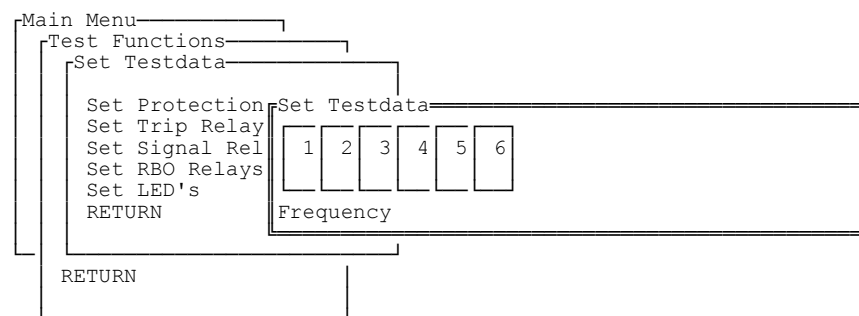


Fig. 5.47 Set protection test data

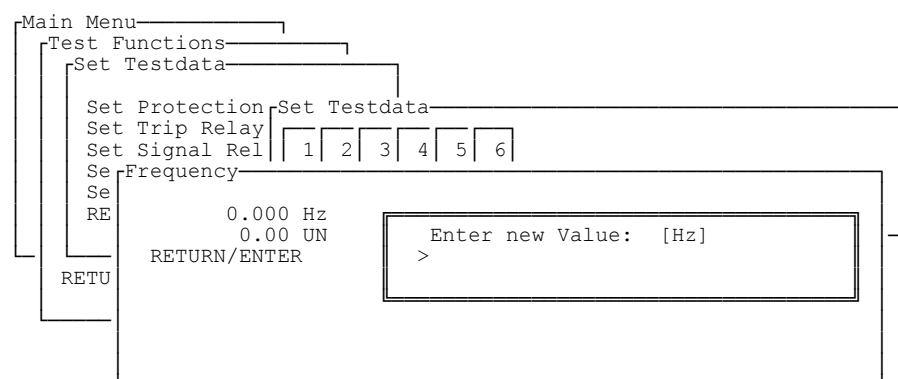


Fig. 5.48 Enter measurement value

2. Testing the tripping relays, signalling relays or LED's:

After entering the slot number, one or several tripping channels may be selected for testing (by pressing <Ins>). Upon executing the command, the corresponding tripping relays, signalling relays and LED's of the channels concerned are energised.

It is only possible to set tripping commands and signals of one input/output unit at a time and the signals must be of the same type, e.g. either signalling relays or LED's.

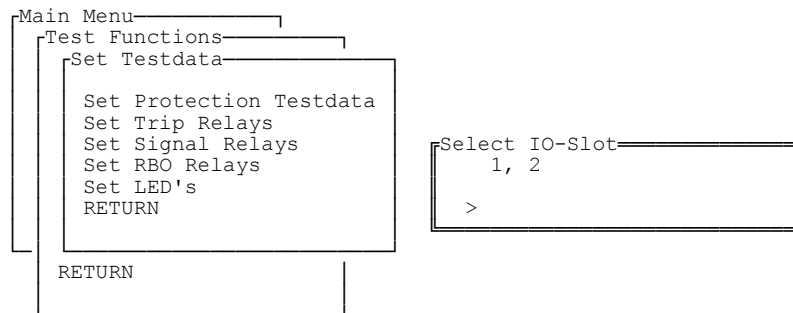


Fig. 5.49 Select IO slot

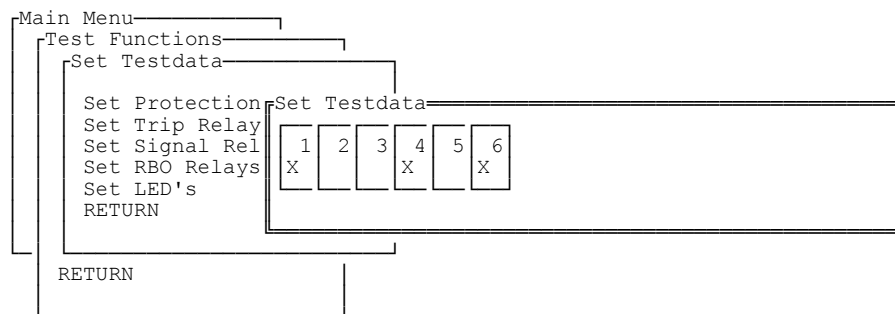


Fig. 5.50 Set test data

3. Energising RBO relays (distributed output):

After entering the device number, one or several output channels can be selected (using <Ins>). The corresponding channels energise the relays when the operation is executed. Only relays belonging to the same device can be set at a time and it is not possible to set two different kinds of signals at the same time, e.g. signalling relays in the RE.316*4 and in one of the distributed units.

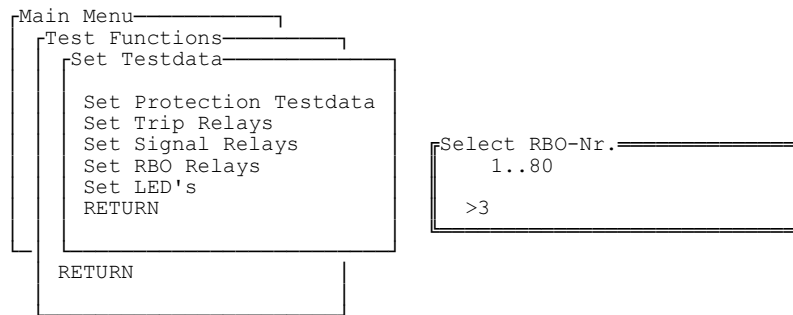


Fig. 5.51 Selecting an RBO No.

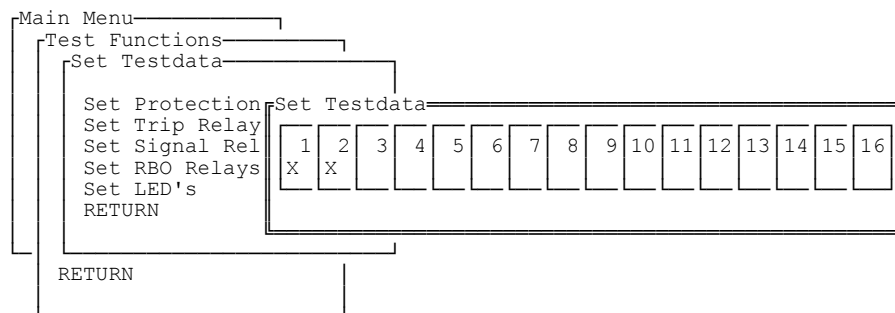


Fig. 5.52 Entering test data

4. Testing the analogue outputs (distributed output):

The desired output channel can be selected (using <Ins>) after entering the device number. The output is the value entered when the test is performed.

Only one output per device can be controlled.

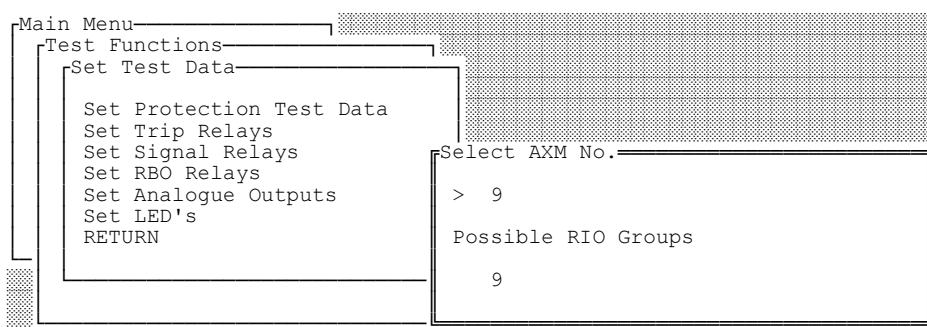


Fig. 5.53 Selecting the AXM No.

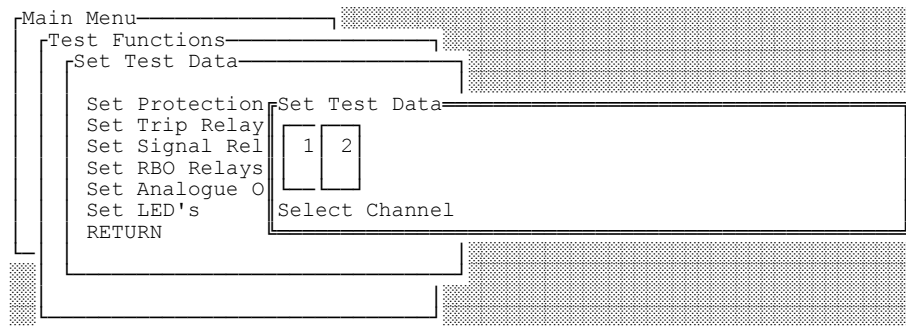


Fig. 5.54 Selecting the channel

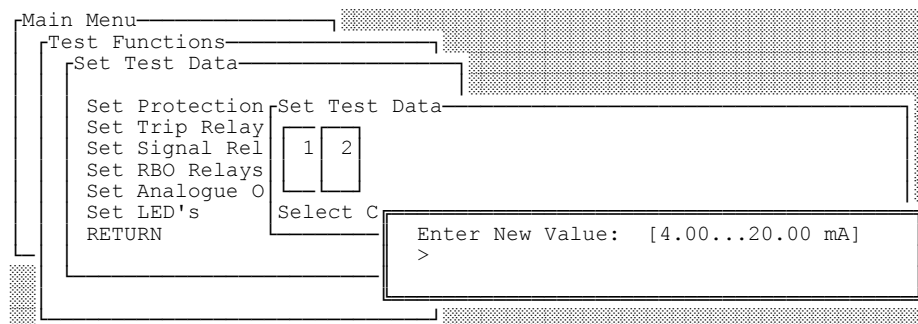


Fig. 5.55 Setting the output value

Perform selected test

After entering the test data, repeatedly press the <End> and <Enter> keys to return to the “Test functions” menu.

Select the menu item “Perform selected test” to start the test and apply the test data which has been set.

“Event handling”, “Measurement values” and “List diag. info.”

These menu items enable the corresponding functions to be used in the test mode and provide the facilities described in [Sections 5.6. to 5.8.](#)

Parset switching

To test a protection function belonging to another set of parameters, the respective set of parameters has to be activated first. Menu item “Parset switching” enables the parameter set to be selected and activated after entering the valid password.

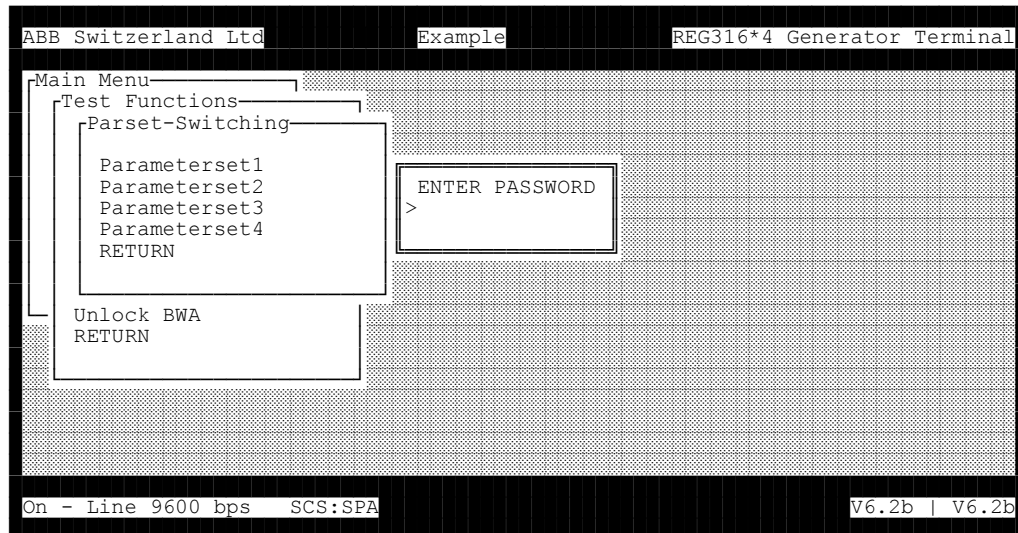


Fig. 5.56 Switching sets of parameters

Lock, Toggle, Unlock BWA

BWA is a memory range in the device in which the statuses of the binary outputs (signalling and tripping relays etc.) and the functions are stored. “Toggle BWA” inverts, i.e. toggles, the status of the selected binary output. The latter is determined by the index in the BWA as defined in the file Siglist.txt, which is created by the HMI ‘Documentation’ function (see [Section 5.10.](#)).

“Lock BWA” prevents functions from changing the statuses of the binary outputs during the test procedure. The “Lock BWA” condition is indicated by the fact that the test window is shifted to the right. “Unlock BWA” cancels the locked conditions. Closing the test function also unlocks the BWA.

The changed status is displayed by entering the BWA index and pressing <ENTER>.

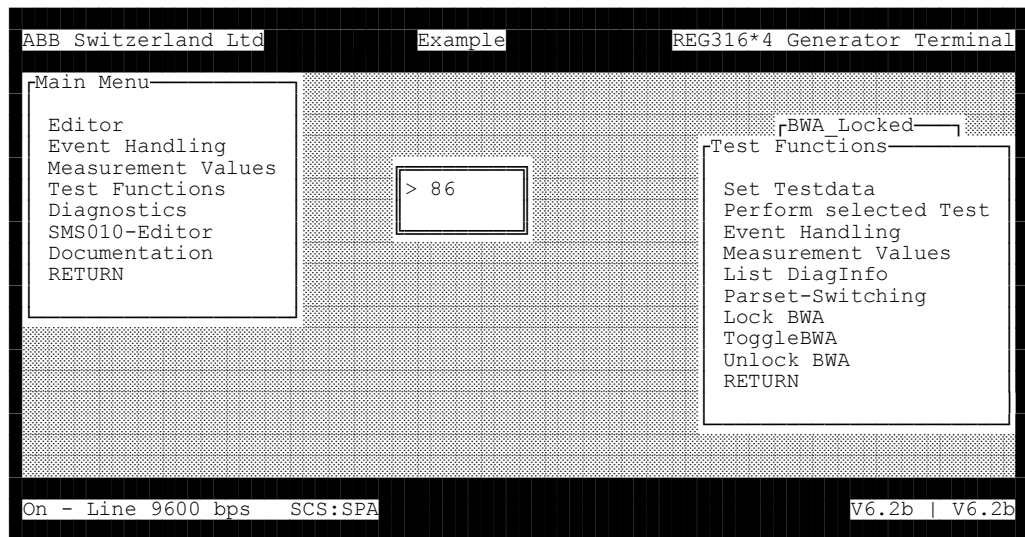


Fig. 5.57 Toggle BWA: selecting the signal to toggle

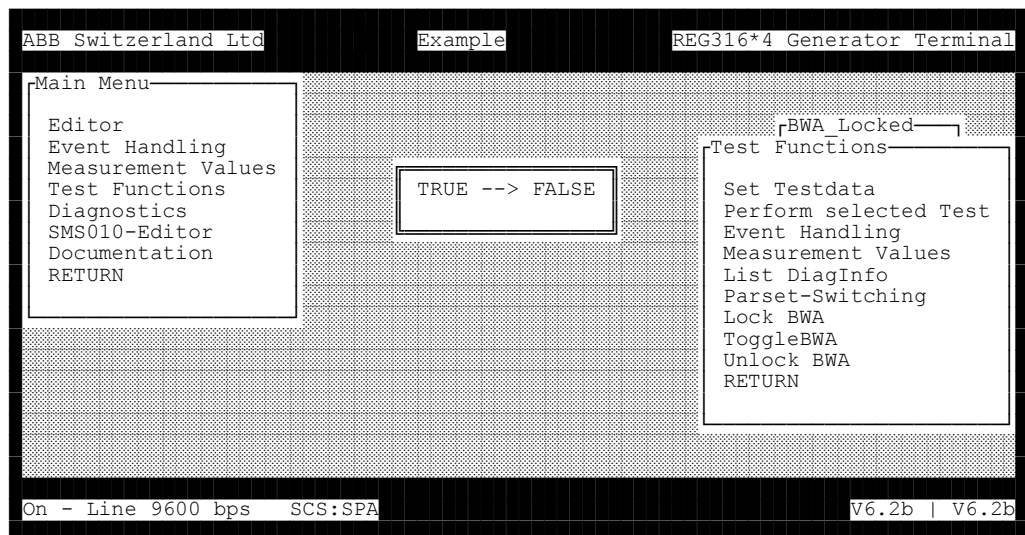


Fig. 5.58 Toggle BWA: displaying the signal status change

Extract from the file Siglist.txt :

For BWA index 27, for example, "Toggle BWA" switches the current function "TRIP" signal on and off.

FunctionName	FuncType	SignalStdName	BWAIndex	SigType
System IO	34	GenTrip	3	SI
System IO	34	GenStart	5	SI
Logic	31	BinOutput	26	SI
Current	3	TRIP	27	SI
Current	3	Start	28	SI

5.10. **Documentation**

This menu item provides facility for generating various files required when engineering an SCS system.

The files generated are as follows:

recxx.evt	List of all the possible events with provision for defining whether an event should be recorded as such (masking).
recxx.inp	List of all the binary inputs used.
recxx.out	List of all the binary outputs used.
recxx.pbi	List of distributed input/output modules with details of type and configuration.
recxx.sig	List of all signals and their main data (name, address, event No., BWA index etc.)

xx = device address on the SCS bus.

5.11. **Operation with several sets of parameters**

The units of the RE. 316*4 series permit up to four independent sets of relay settings or protection configurations to be defined. Only one of these sets of parameters can be active at any one time when the protection is in operation. Provision is made for switching between sets of parameters.

5.11.1. **Switching sets of parameters**

One of the four sets of parameters is selected by

- a) applying a signal to a binary input (opto-couplers)
- b) a signal from the station automation system (SCS).

Setting binary inputs

A maximum of four binary inputs are used for switching sets of parameters. They are configured by selecting the menu item "Edit inputs/outputs" in the "Edit system functions" menu.

If when configuring the inputs using the HMI they are left at their default setting of "F" (FALSE = always OFF), the protection can only operate with parameter set 1.

"Remote sel." : If this I/P is activated, a signal from the station control system (SCS) is necessary to switch between sets of parameters, otherwise the I/P's "ParSet2", "ParSet3" and "ParSet4" determine which set of parameters is active.

"ParSet2", "ParSet3" and "ParSet4":

These three I/P's enable one of the four sets of parameters to be selected.

ParSet2	ParSet3	ParSet4	Active set of para.
F	F	F	1
T	F	F	2
F	T	F	3
T	T	F	no change
F	F	T	4
T	F	T	no change
F	T	T	no change
T	T	T	no change

As can be seen from the table, the current set of parameters remains effective, if a signal is applied to more than one of the I/P's at the same time.

Setting signalling outputs

Four outputs ("ParSet1" ... "ParSet4") are needed to indicate externally via a signalling relay or a LED and/or record in the event list which of the four sets of parameters is currently active. These outputs are configured via the HMI in the same way as all other signalling outputs.

5.11.2. Creating sets of parameters

5.11.2.1. Assigning a protection function to a set of parameters

All protection functions have a parameter "ParSet4..1". The corresponding setting determines in which set of parameters the function is effective.

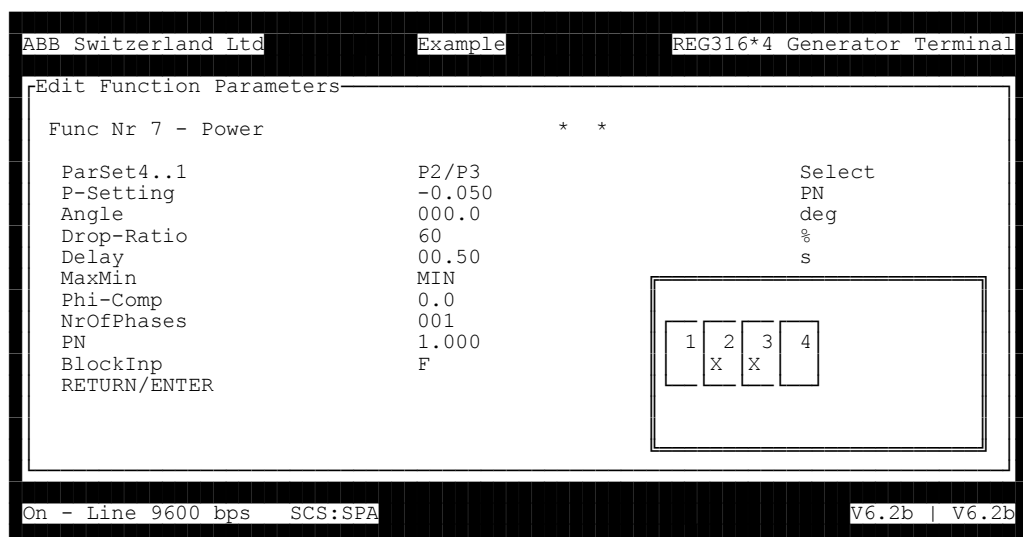


Fig. 5.59 Assigning sets of parameters

5.11.2.2. ***Copying a protection function with its settings***

A protection function can be copied together with its settings from one set of parameters to another, if its settings in the second set of parameters remain mostly the same. The procedure is described in [Section 5.5.1.3](#).

The copied Version of the protection function assumes precisely the same settings as the original function. The following parameters of a copied function cannot be changed subsequently

- all analogue inputs
- all signalling outputs
- all tripping channels.

The copied function must not be active in the same set of parameters as the original and the parameter set number of the original function must be lower:

RULE: $P1 \leq pO \leq P4 \quad \text{<--->} \quad pO < pK \leq P4$

pO = parameter set number of the original function

pK = parameter set number of the copied function.

The originals of existing copied functions cannot be deleted.

5.11.2.3. *Displaying a function with its settings*

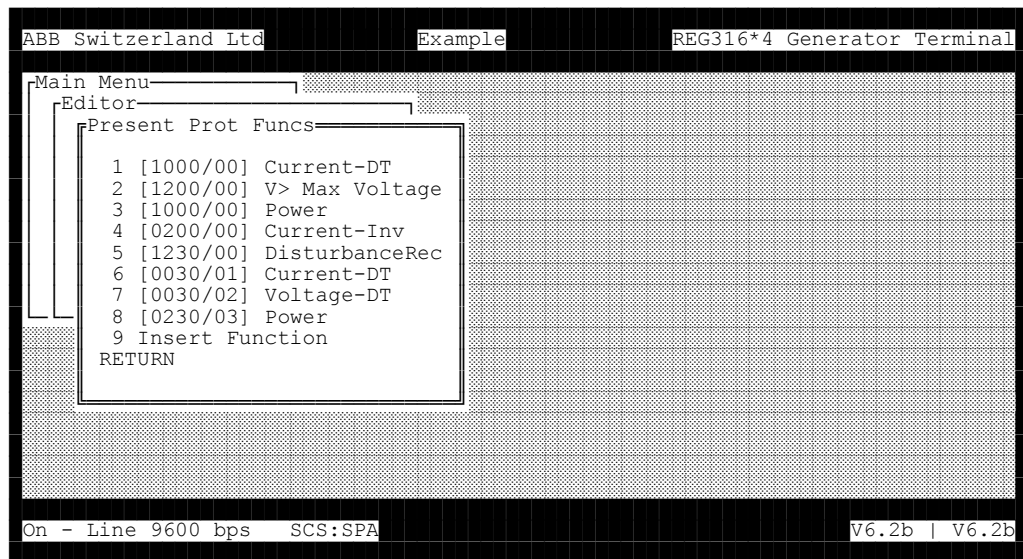


Fig. 5.60 Presentation by the HMI of the protection functions

The list of functions and their settings are presented as follows:

A [B / C] D (e.g. 1 [1000/00] Current-DT)

- A: Function No.
- B: active in parameter set No., e.g.
0030: parameter set 1
1230: parameter sets 1, 2 and 3
- C: 0 = original function
n = copy of function n
- D: function name.

5.11.3. *Logics*

Where several protection functions are related by a common logic, they must all be active in the same set of parameters.

Note:

Outputs of copied distance protection functions can only be connected to inputs of functions listed after the distance function in the function list.

5.12. Remote HMI

5.12.1. Summary

The firmware provides facility for controlling RE.316*4 devices grouped according to stations. All the HMI functions are available. User access via the remote HMI to such functions as 'Load setfile', 'Test function', 'Time synchronisation' and 'SPA communication' can be restricted.

We do not recommend loading and downloading 'Setfiles' via a modem link as all the device settings will be lost should the line be interrupted during file transfer.

Remote HMI facilities:

- local control of a device via the interface on the front
- control of several devices in an SPA_BUS loop via a modem and the SPA-BUS interface
- control of several devices in an SPA_BUS loop via the SPA-BUS interface
- control of several devices in an SPA_BUS loop via an SRIO. In this operating mode, the HMI sets the SRIO clock and synchronises the device clocks.
- control of several devices in an SPA_BUS loop via a modem link and an SRIO. In this operating mode, the HMI sets the SRIO clock and synchronises the device clocks.
- safe operation since the simultaneous access by local and remote HMI's is excluded
- system of access rights to restrict the operations possible on the HMI
- event recording transferred to a pre-defined individual directory for each device
- convenient HMI user shell for easy control.

5.12.2. Modem requirements

A modem used in conjunction with the remote HMI must be suitable for asynchronous operation and the interface baud rate must be independent of the line baud rate. It must be possible to set the interface baud rate to correspond to the SPA/SRIO baud rate.

The modem must be set to answer automatically when it receives a call.

Initialisation string for the remote modem:

Fixed DTE rate:	&B1
DTE async speed:	9600 Baud
DTR ignored:	&D0
RTS ignored	&R1
DSR always on	&S0
Auto answer:	S0=2
Handshake off:	&H0

Save modem settings: AT&W0.

5.12.3. *Remote HMI shell*

The HMI shell requires an operating system Windows 3.xx, Windows 95 or Windows NT 4.x. Menus guide the user through the procedures for configuring stations and devices. The device HMI is started in a DOS window.

5.12.3.1. *Installation*

Place installation disc No. 1 in drive A and select 'Run' in the 'File' menu to start the installation.

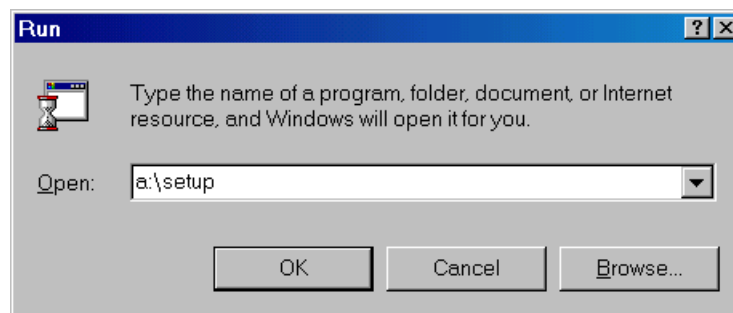


Fig. 5.61 Starting the installation of the HMI

5.12.3.2. *Configuring a new station*

After starting the remote HMI, select 'New station' in the 'File' menu to open the dialogue for entering the station name.

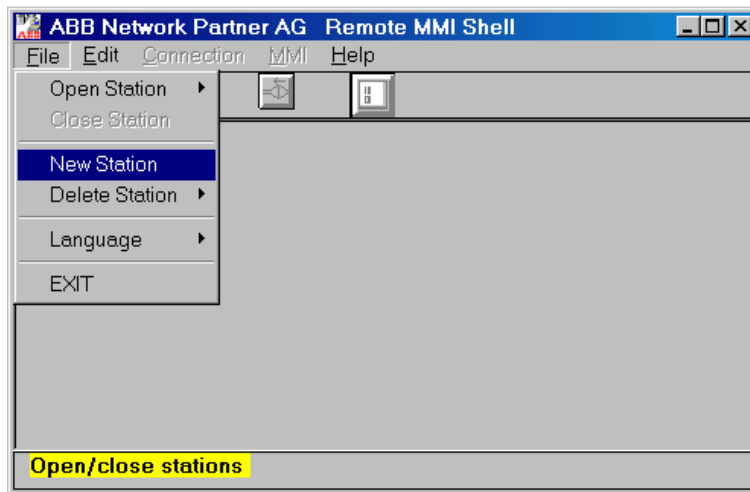


Fig. 5.62 Configuring a new station

Enter the station new in the dialogue (max. 8 characters) and click on OK.

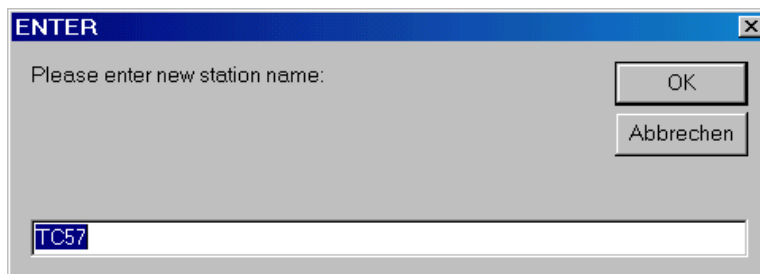


Fig. 5.63 Entering the name of the new station

Then select the new station from the list that appears when the 'Edit' menu is opened and the station configuration dialogue appears.

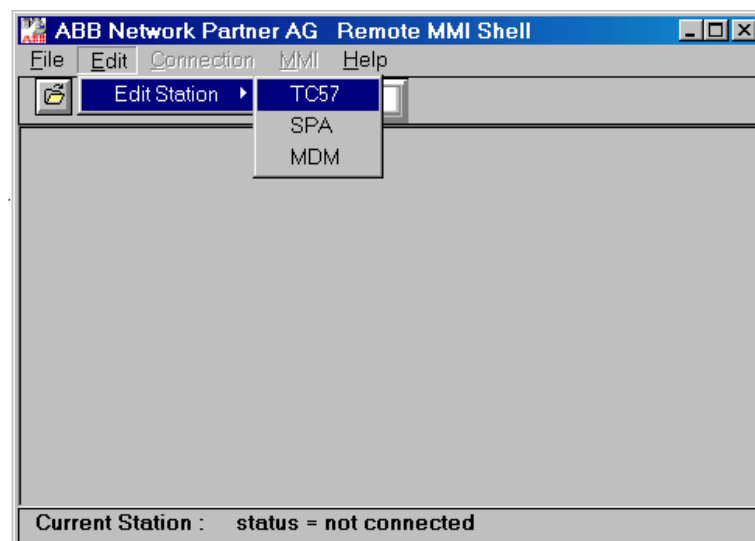


Fig. 5.64 List for selecting the station to be configured

The next task is to edit the files 'Station.cfg' and 'MMKShell.mnu' in the configuration dialogue.

The following parameters are set in 'Station.cfg':

COMT : Communication parameters
 TC57 = communication via interface at the front
 SPA = communication via the SPA-BUS interface
 MDM = communication via modem and SPA-BUS interface
 SRIO = direct communication via SRIO
 RDM = communication via modem and SRIO.

BAUD : Baud rate.

TNR : Station telephone number (T...tone dialling,
 P...impulse dialling)

MPAR : Modem initialisation parameters; in most cases the default settings are satisfactory.

Select SAVE to confirm the parameter settings and update the file.

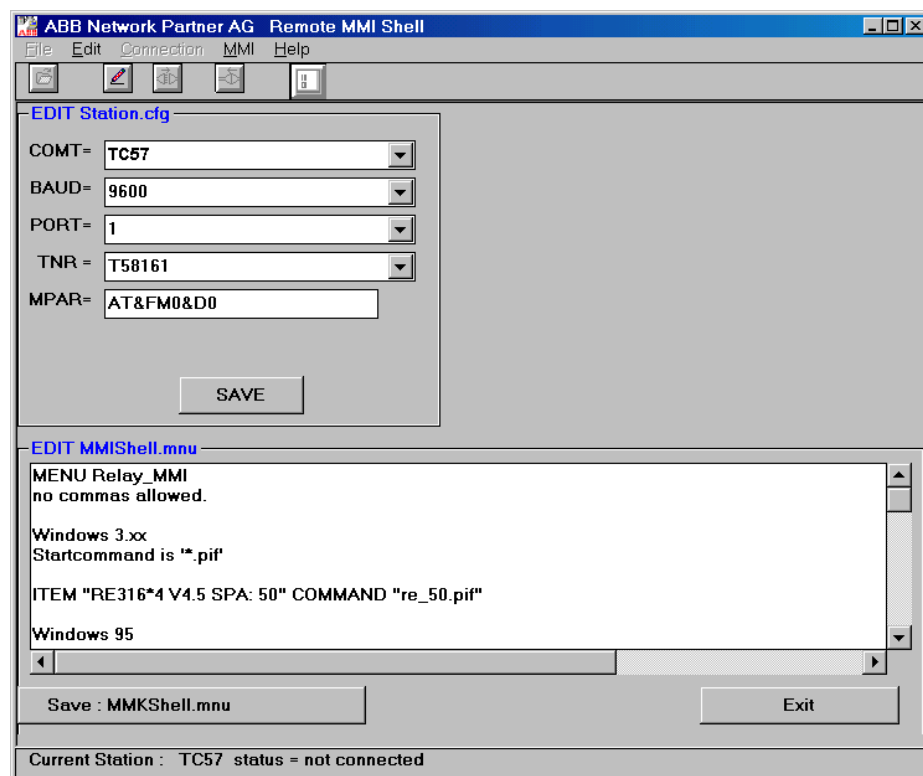


Fig. 5.65 Window for editing the station configuration

An entry for each device in the station has to be made in the file 'MMKShell.mnu'. The actual entry varies according to Windows version.

Windows 3.xx :

ITEM "Text" COMMAND "Filename.pif".

The text entered in the first pair of inverted commas appears in the 'HMI' menu. Windows 3.xx uses *.pif files in which the characteristics of the DOS program are entered. Start the PIF editor after saving 'MMKShell.mnu'.

The following entries have to be made:

Program file name: Path to the HMI file pcgc91.exe, e.g.
C:\MMK\PCGC91

Program title: Name of the window in which the HMI is running

Program parameters: Write the 'Default' is replaced by the desired name for the *.cfg file.

Save the *.pif file.

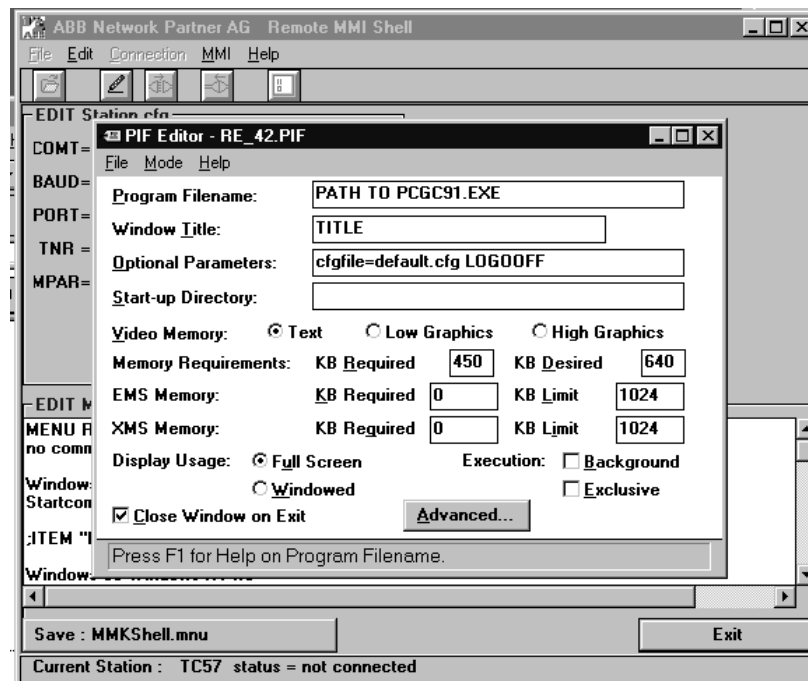


Fig. 5.66 Pif editor

Entry in 'MMKShell.mnu' for Windows 95 and Windows NT:

ITEM "Text" COMMAND "Path to MMK\PCGC91
CFGFILE=NAME.CFG LOGOOFF"

The 'NAME.CFG' file is created after saving the 'MMKShell.mnu' file and can be edited in the dialogue 'Edit NAME.CFG' by selecting it from the 'HMI' menu:

RETP	Device type, e.g. REG316
LANG	HMI language
COLOR	RGB = colour screen
EVEDATA	Directory where the HMI saves disturbance recorder data. The directory will be created if it does not already exist.
SLVE	SPA slave address.
BAUD	Only in conjunction with communication parameter TC57, 9600 Baud or 19200 Baud.

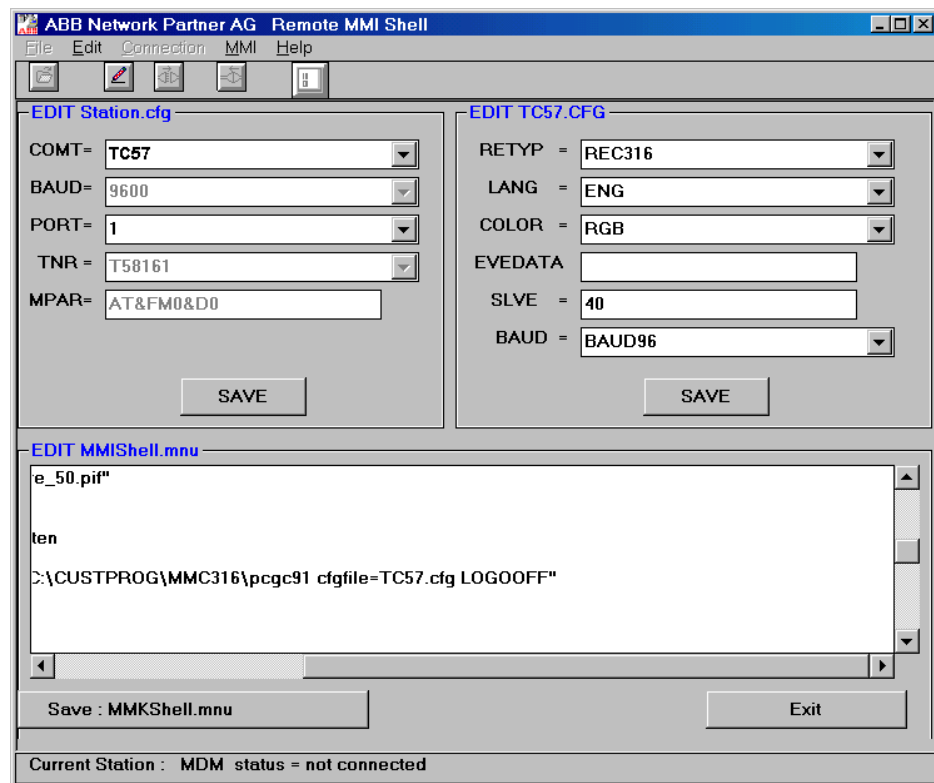


Fig. 5.67 Editing *.cfg

Click on 'Exit' to terminate the edit mode.

5.12.3.3. *Establishing the connection to the station*

Select the desired station via 'File' and 'Open station'.

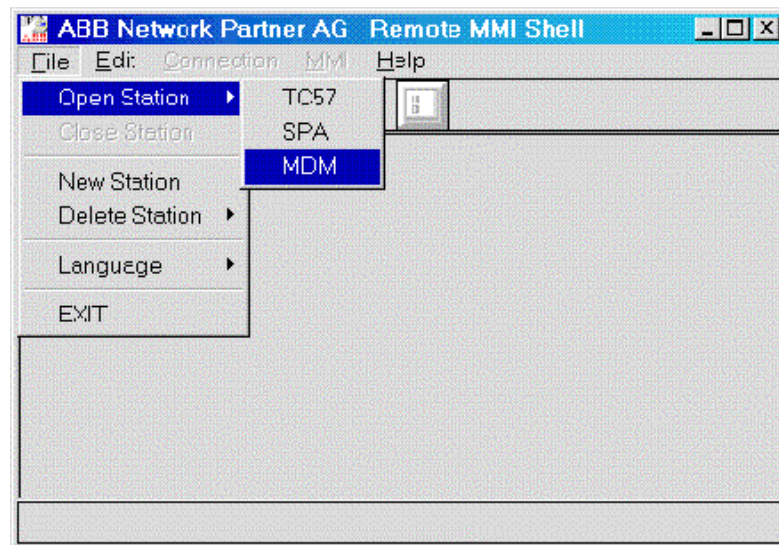


Fig. 5.68 Establishing the connection to the station

Depending on the communication parameter that has been set, the HMI can be started either directly or, once the link has been established, via the modem.

If the communication parameter is set to RDM or MDM, connection has to be established via the modem. The HMI menu is not available (grey) until the link is in operation. After clicking on 'Connect' in the 'Connection' menu, a script window opens in which the exchange of data between the modem and the remote HMI is logged.

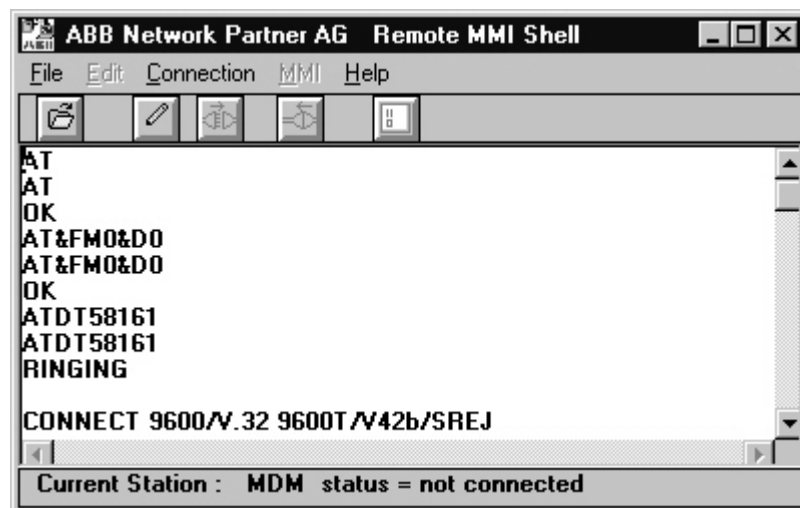


Fig. 5.69 Script window

The following confirmation dialogue is displayed providing the connection is established within the timeout period set on the modem:



Fig. 5.70 Confirming the connection

After clicking on 'OK', the script window closes and the 'HMI' menu becomes available.

You can now start the desired HMI.

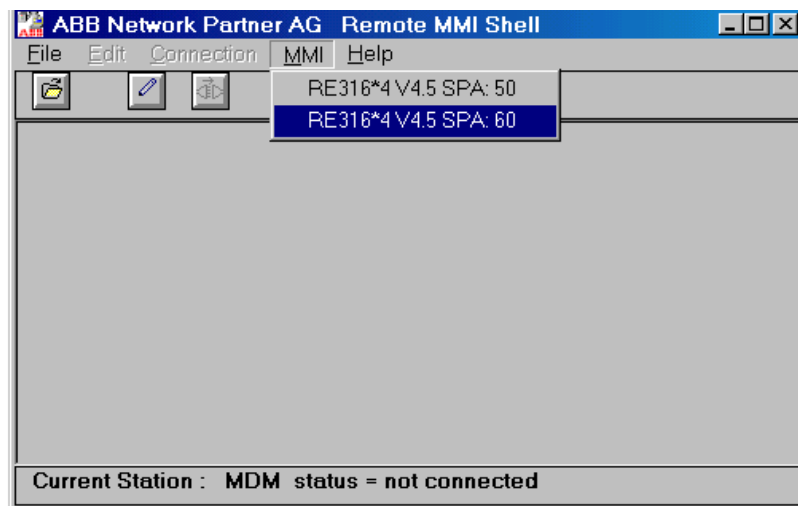


Fig. 5.71 Starting the HMI

Select 'Disconnect' in the 'Connection' menu to close the link.

5.12.4. ***Configuring a remote HMI for operation via the SPA-BUS interface***

5.12.4.1. ***Remote HMI connected directly to the electro-optical converter***

COMT=SPA enables several devices to be controlled in an SPA-BUS loop. A suitable electro-optical converter (SPA-ZC22) must be inserted between the SPA-BUS loop and the PC.

Providing synchronisation is enabled, the clocks in the devices are synchronised to the PC clock by a broadcast telegram when the remote HMI is started.

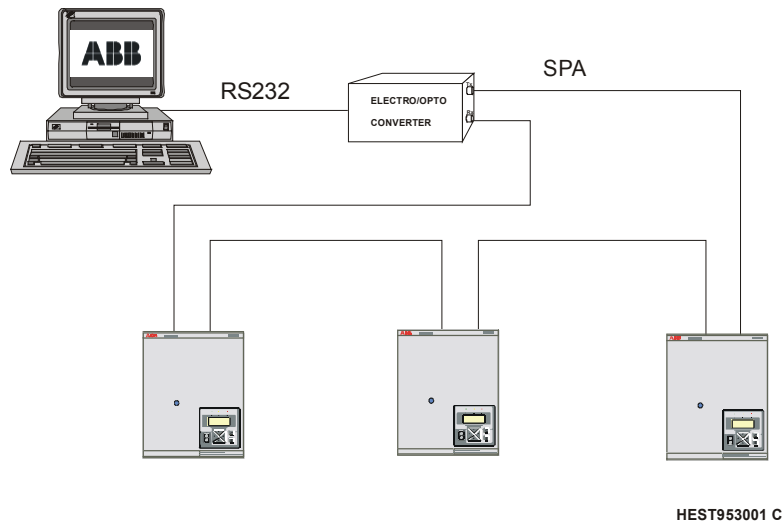


Fig. 5.72 Remote HMI connected directly to an electro-optical converter

5.12.4.2. **Remote HMI connected via a modem to the electro-optical converter**

COMT=MDM enables several devices to be controlled in an SPA-BUS loop via a modem. A suitable electro-optical converter (SPA-ZC22) must be inserted between the SPA-BUS loop and the modem.

Providing synchronisation is enabled, the clocks in the devices are synchronised to the PC clock by a broadcast telegram when the remote HMI is started.

A genuine hardware handshake with the remote modem is not possible in this mode and the DTR signal is therefore not set.

The modem handshake must be switched off and the DTR line ignored. The line baud rate must not be higher than that of the SPA-BUS.

Modem settings:

DTR = ignored

Handshake=off

Consult the manual supplied with your modem for the modem parameters.

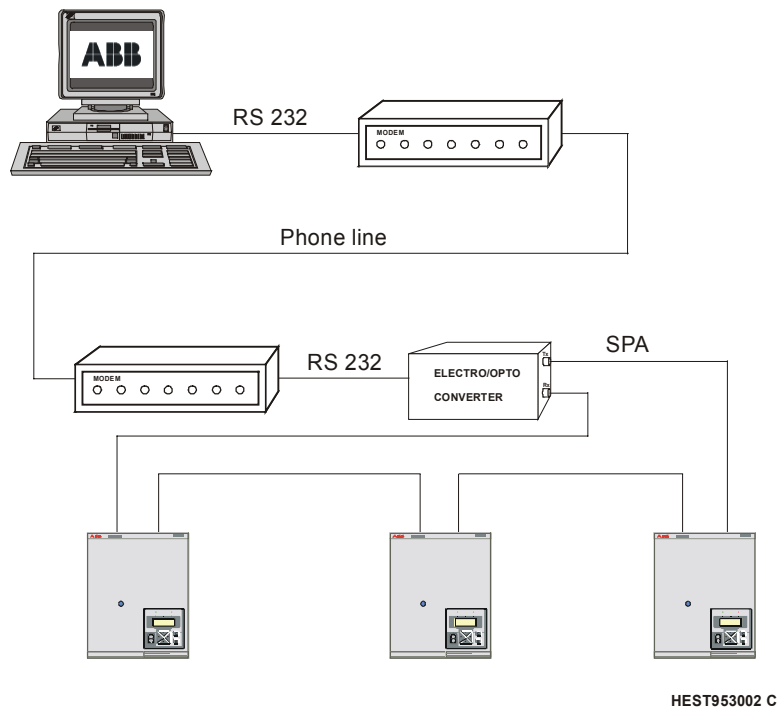


Fig. 5.73 Remote HMI connected via a modem to the electro-optical converter

5.12.5. **Configuring a remote HMI connected to an SRIO**

5.12.5.1. **Remote HMI connected directly to the SRIO**

COMT = SRIO.

A bus master Type SRIO 500/1000M is used to synchronise the device clocks once a second. Providing the remote HMI is on-line and time synchronisation is enabled, the SRIO clock is synchronised to the PC clock.

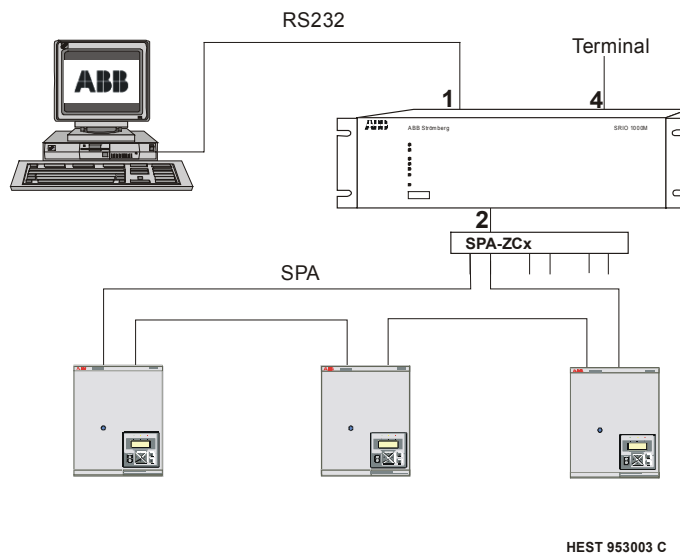


Fig. 5.74 Remote HMI connected directly to the SRIO

5.12.5.2. **Remote HMI connected via a modem to the SRIO**

COMT = RDM.

The control of several devices via an SRIO can be expanded using a modem connection.

SRIO only provides a full hardware handshake for BUS 1.

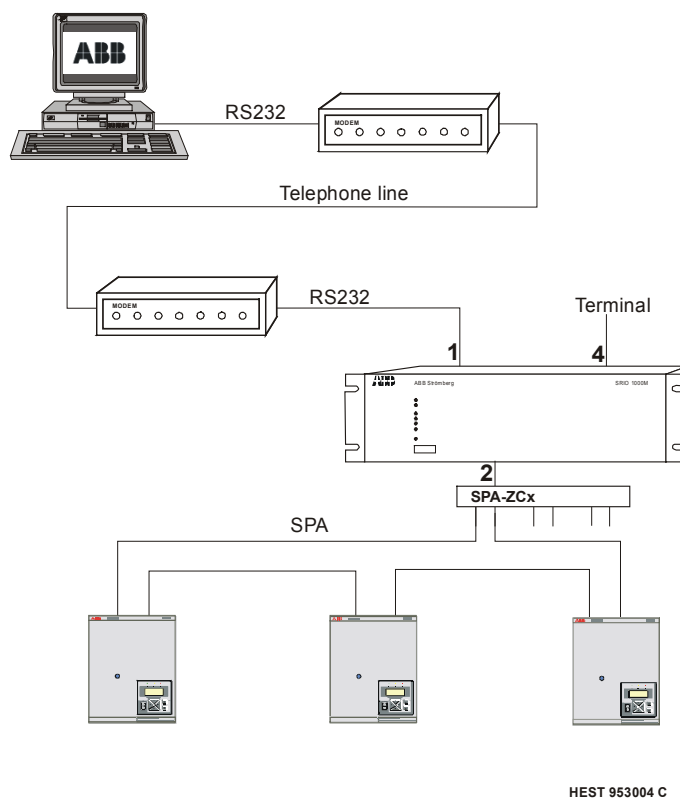


Fig. 5.75 Remote HMI connected via a modem to the SRIO

5.12.6. *Local control of a device via the interface at the front*

All the HMI menu items are available in this operating mode. It is also possible to read and change passwords and assign access rights.

5.12.6.1. *Remote HMI right of access to device functions*

Provision is made for restricting access by the remote HMI. After successively selecting the menu items 'Edit hardware functions', 'Edit special functions' and 'OBI function', the following menu items are accessible for COMT=TC57:

RemoteMMI	enabled / disabled Determines access in general by the remote HMI via the SPA-BUS.
TimeSync	enabled / disabled Determines time synchronisation by the remote HMI.
SPAComm	enabled / disabled Determines access to the SPA communication window in the remote HMI.
Testfunction	enabled / disabled Determines access to the test functions in the remote HMI.
Downloading	enabled / disabled Determines access by the remote HMI to the download function for parameter settings. When downloading is disabled, changes to parameter settings can still be made, but only saved in a file.

5.12.7. *Control via an SPA-BUS or an SRIO*

The slave control window appears after the program starts and a check is made to determine whether the corresponding device is ready.

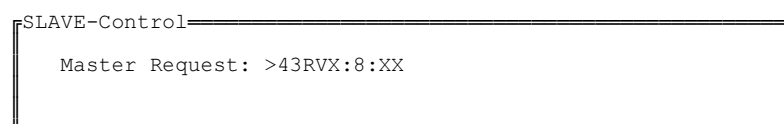


Fig. 5.76 Master request

Providing the selected device is ready, it replies by sending its device address and type.

```
Slave-Control
Master Request: >43RVX:8:XX
Slave Response: <43D:REG316:1C
```

Fig. 5.77 Slave response

The device's response is checked and the HMI start window opens if it is correct.

```
SLAVE-Control
Master Request: >43RVX:8:XX
Slave Response : ERROR
```

Fig. 5.78 ERROR

If a valid response is not received within 15 seconds, the message 'ERROR' is displayed and the program proposes the off-line mode after a further 5 seconds.

5.12.7.1. **HMI start-up**

The exchange of data via the modem, SRIO etc., is much slower than when directly connected to the front of the device. To avoid having to read all the device data every time the HMI is started, a file called ReXX.dat is created and a reference written in the device every time device data are changed and saved. XX is the device's SPA address. After the HMI is started, it reads the reference in the device and searches for the ReXX.dat file in the working directory with the same reference. Providing the file is found, the HMI uses the data in the file and does not have to read the data in the device. The connection is thus established much more quickly.

As the device data are not normally saved via the remote HMI, the ReXX.dat files have to be expressly copied to the station directory after everything has been finally configured.

As soon as the device data have been loaded, the HMI displays the main menu, to which the menu item 'SPAComm' has been added.

5.12.7.2. SPAComm window

The SPAComm window provides facility for sending SPA-BUS commands to the device specifically selected and also to all the other devices in the same SPA-BUS loop.

Details of the SPA syntax are to be found in 'SPA-BUS COMMUNICATION PROTOCOL V2.4', 34 SPACOM 2EN1C.

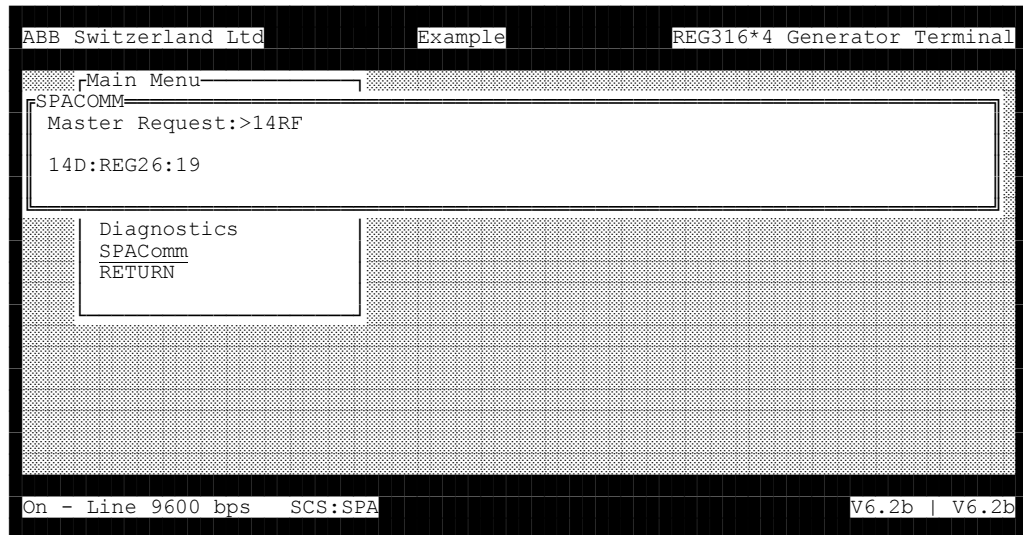


Fig. 5.79 SPAComm window

To enter a command, press <ENTER> and enter it on the REQUEST line. Press <ENTER> again to terminate the input. Press <ESC> to quit the input mode without making an entry.

Entering EXIT and pressing <ENTER> closes the window.

It is not necessary to enter the default address.

By entering the character 'F' before a command, all the commands entered before it are transferred in a continuous string until a command not preceded by an 'F' is encountered.

5.12.8. SRIO settings

Refer to 'Programming manual SRIO 1000M and 500M' having the No. '34 SRIO 1000M 2 EN1 B' for how to program the SRIO 500/1000M.

SRIO 500/1000M must be configured as follows:

BUS_MODE:

BUS	Code	MODE
1	9	Saco 100M Slave mode
2	6	Fast SPA Master mode
3	0	Null mode
4	10	Terminal mode

BUS-Setup:

setup	BUS 1	BUS 2	BUS 4
baud	9600	9600	9600
parity	2	2	0
stopbit	1	1	1
cts	1	0	0
dcd	1	0	0
aut.lf	1	0	1
timeout	60000	3000	0
resend	0	3	0

ANSI_SETUP must be set to 'half-duplex'; the other parameters in ANSI_SETUP are of no consequence.

After the new BUS modes have been saved (STORE F), the system has to be restarted.

The SRIO slave address must agree with the address in the file re-01.cfg (950). The SRIO address is set in SYSPAR P4.

A (dummy) data point must be entered in the SRIO data base for every device in the SPA-BUS loop.

5.13. Local display unit

5.13.1. Summary

The local display unit (LDU), i.e. local human/machine interface (HMI), is a simpler alternative to the HMI running on a PC and forms an integral part of an RE.316*4. It provides service personnel with facility for viewing statuses and events and reading measurements. The hierarchically structured menus give limited access to process and system data. The unit is operated with the aid of just a few pushbuttons. Three light-emitting diodes (LED's) indicate the status of the system independently of the menu being displayed.

5.13.2. Limitations

The local display unit forms an integral part of an RE.316*4 device and provides a number of facilities for service personnel.

Information about the process and the state of the device can be viewed on the LDU, but it is not possible to either change or copy device settings. The device can be restarted, however, by selecting the corresponding menu item.

5.13.3. General description

The LDU is primarily intended for service personnel so that they can obtain brief information on the status of the RE.316*4 device and the protected unit.

A general indication is provided by the three LED's and details can be read via the various menus on the LCD. It is neither possible to configure the functions of the LED's or the menu structure nor edit the texts of the different displays, however, the latter correspond to the texts on the HMI on the PC and vary to suit the configuration of the particular RE.316*4.

5.13.3.1. Mechanical assembly and front view

The LDU is fitted at the bottom right of the frontplate. The LED's that are familiar from older units are at the top left and the reset button is accessible through a small hole in the frontplate.

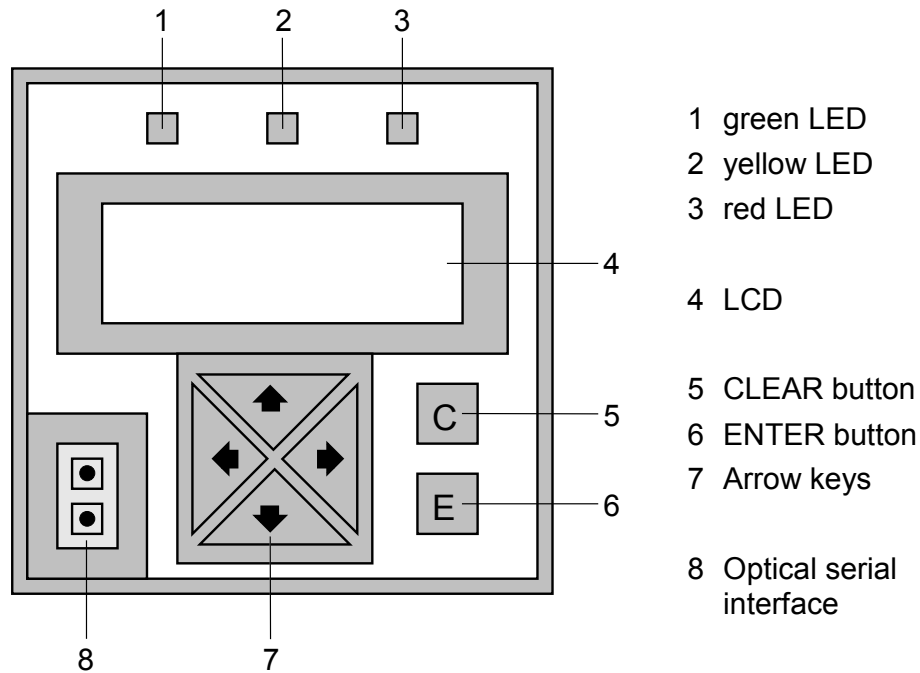


Fig. 5.80 Front view of the local display unit (LDU)

5.13.3.2. **Electrical connections**

The HMI running on the PC is connected to the device via the optical interface on the LDU. PC and device are thus electrically insulated.

A special cable has to be used to connect the PC that converts electrical into optical signals and vice versa.

5.13.3.3. **Password**

Password protection is unnecessary for the LDU.

5.13.3.4. **Passive operation**

The user communicates with the RE.316*4 via the LDU in a passive role, i.e. device and process data can be viewed, but none of the data or parameters displayed can be changed in any way. Changes can only be made using the HMI on the PC.

The only exception to this rule is the reset function which is accessed via the corresponding menu item.

5.13.3.5. *LDU keypad*

The LDU keypad comprises six pushbuttons which are only ever pressed one at a time to perform the various control functions. Pressing a second button has no effect as long as the first button remains pressed. The function of the second button is only executed after the first one has been released.

There are two ways of navigating within the menu structure:

- Step-by-step: A button is pressed to perform a first operation and then a second button to perform the next operation and so on.
- Holding a button depressed: An operation can be repeated by holding the corresponding button depressed longer than the normal response time (fixed setting of 0.5 seconds).

The pushbuttons perform the following functions:

“E”

executes an operation (ENTER function), i.e. a menu item is executed which in the case of the LDU means moving down a level in the menu structure. The button has no function on the lowest level in the menu structure.

“C”

corresponds to the ESCAPE button on a PC. It is used to close an active menu. It returns the user from every menu item to the entry menu.

“↑”, “↓”

The upwards and downwards arrow keys are used either for selecting a desired menu item at the same level in the menu structure or for selecting a value to be viewed in the active menu (e.g. different events in the event list). These keys are represented in the text by the symbols “^” and “v”.

“→”

The right arrow key performs the same function as the “E” button. It is represented in the text by the symbol “>”.

“←”

The left arrow key closes the active menu and returns the user to the next level up in the menu structure. It is represented in the text by the symbol “<”.

5.13.4. The three status LED's

5.13.4.1. General

A RE.316*4 unit can be in different statuses, the most important of which are indicated by the three LED's on the LDU. They have the colours green, yellow and red and each can be either off, flashing or continuously lit.

In the diagrams below, the LED's are represented by squares. An empty square indicates that the respective LED is off, a black square that it is lit and a diagonally half black, half empty square that it is flashing.

■ = lit ▤ = flashing □ = off

The three LED's are described on the first line of the entry menu.

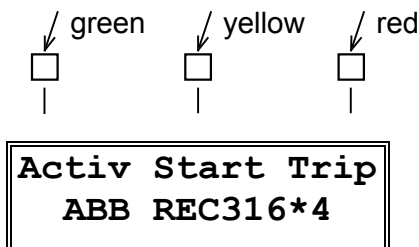


Fig. 5.81 LED markings

5.13.4.2. Starting RE.316*4

The yellow and green LED's flash throughout the initialisation procedure to indicate that the device is not operational. The green LED in the row of LED's at the top left of the device flashes as well.

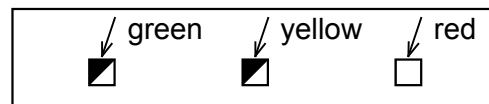


Fig. 5.82 LED statuses when starting the RE.316*4

5.13.4.3. No active protection functions

If none of the protection functions is active (none programmed or all blocked), the initialisation procedure is completed and no errors were found, the device is not standing by. In this status, the green LED on the LDU flashes and the green LED in the row of LED's at the top left of the device lights continuously.

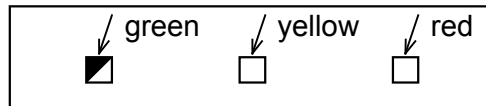


Fig. 5.83 LED statuses when none of the protection functions is active

5.13.4.4. Normal operation

When the device is active and there are no errors or faults, the green, yellow and red LED's are all off.

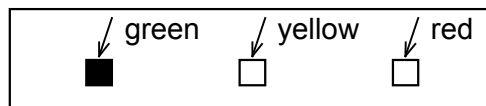


Fig. 5.84 LED statuses in normal operation

5.13.4.5. Pick-up of a protection function (General start)

The pick-up of at least one protection function (General start signal active) is indicated by the fact that the green and yellow LED's light. The yellow LED remains lit after the general start has reset and only extinguishes after it has been actively reset (see Section 5.13.8.6.).

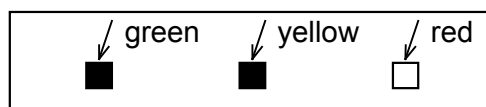


Fig. 5.85 LED statuses for a general start

5.13.4.6. Protection function trip (General Trip)

The trip of at least one protection function (General Trip signal active) is indicated by the fact that the green, yellow and red LED's light. The yellow and red LED's remain lit after the general

trip has reset and only extinguish after they have been actively reset (see [Section 5.13.8.6](#)).

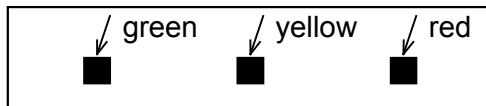


Fig. 5.86 LED statuses for a general trip

5.13.4.7. **Fatal device error**

All three LED's flash when a serious error is detected that disables the device.

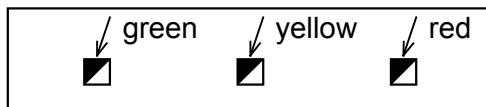


Fig. 5.87 LED statuses for a fatal error

5.13.5. **Text display (LCD)**

5.13.5.1. **General**

Upper and lower case characters are displayed and all the characters needed for German, English and French are installed.

The display of variables (measurements, binary signals etc.) is refreshed at intervals of approximately a second.

5.13.5.2. **Language**

The LDU supports a number of languages, however, the language used by the HMI on the PC during commissioning is the language set on the LDU and cannot be changed during normal operation. The LDU language is programmed automatically to that of the HMI on the PC. Care must therefore be taken when changing parameter settings that the HMI on the PC is operating in the desired language.

5.13.5.3. **Interdependencies**

The menus are not dependent on changes in the process or the status of the device, i.e. a menu text remains on the display until the user selects a different menu item. The only exceptions are the start-up procedure and downloading parameter settings from

the PC to the device during which time the entry menu is displayed. No menus can be selected while text is being downloaded from the PC to the RE.316*4.

For measuring values the display is refreshed approximately every second.

5.13.5.4. Configuration

The menu structure described below is largely fixed and nothing needs to be configured. It is neither possible to add a menu item nor change a menu text. Certain menu items and texts vary with system configuration and are therefore indirectly variable. For example, if an additional protection function is configured, the menu items needed to view its measurements are automatically inserted. The signal texts are copied from the HMI on the PC.

5.13.6. Menu structure

The information displayed on the LDU is accessed via a menu structure with five levels. An overview of the menu structure is given in the diagram below. The user can only move from one menu item to another in a vertical direction, i.e. it is impossible to go directly from one menu item to another on the same level, but in a different branch.

Every menu item consists of two parts:

- Header (first line on the LCD): The header shows the name of the active menu. A menu name starts and finishes with a hyphen to distinguish it from the menu items available for selection. The header with the menu name is always displayed even if there are more than three items in the menu and it is necessary to scroll through them.
- Menu lines: The menu items available for selection are displayed on lines two, three and four. Note: An arrow pointing downwards at the end of line 4 means that the menu contains more menu items below the one displayed. These can be viewed by pressing the arrow key "v". An arrow pointing upwards at the end of line 2 means that the menu contains more menu items above the one displayed. These can be viewed by pressing the arrow key "^".

ENTRY MENU

MAIN MENU

MEASURANDS

AD-Channels

Nominal values

Prim.Values

Sec.Values

Function Measurands

1st. Function

:

n. Function

Binary Signals

Input Signals

RBI Inputs

ITL Inputs

Signal Relays

Trip Relays

RBO Outputs

ITL Outputs

Analog Signals

Input signals

Output signals

EVENT LIST

USER'S GUIDE

DISTURBANCE RECORDER

DIAGNOSIS MENU

Diagnosis Info

IBB Status Info

Process Bus Info

LED Description

RESET MENU

LED Reset

Latch Reset

Clear Eventlist

System Restart

Fig. 5.88 Menu structure

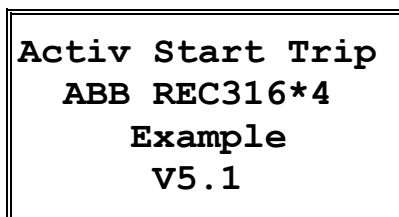
5.13.7. **Entry menu**

The entry menu is at the top of the menu structure. It is displayed every time the system is started or after pressing the “C” button to exit a menu item and does not have a header, but simply four lines of text. The user accesses the main menu from the entry menu by pressing either button “E” or “>”.

The entry menu comprises two parts:

- The first line states the significance of the three LED's:
green LED: “Active”
yellow LED: “Start”
red LED: “Trip”.
- Lines two to four show the name of the device, the system name assigned to it and the software version. The main menu is accessed by pressing either the “E” or “>” button.

The entry menu always comprises four lines and the buttons “C”, “^” and “v” have no effect. There is nothing to select in this display. If the RE.316*4 has not been configured, “Local Display” appears on line 3, otherwise the name assigned to the device using the HMI on the PC. Fig. 5.89 shows a typical entry menu:



```
Activ Start Trip
  ABB REC316*4
    Example
      V5.1
```

Fig. 5.89 Entry menu

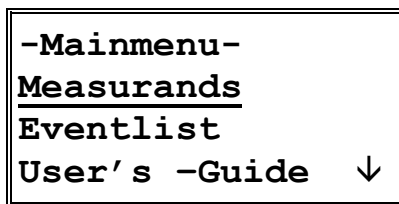
5.13.8. **Main menu**

The main menu lists the groups of submenus that can be selected to obtain more information on the device and the primary process. The name “Main Menu” is in the header and three of the submenus on the three lines below. Unless the submenus shown are at the top or the bottom of the list there is an arrow at the end of line four pointing downwards and/or at the end of line two pointing upwards to show in which direction the user can scroll to see the other menu items. The first of the menu items (line 2 of the display) is always underlined which means that it is selected. The list can be scrolled using the arrow keys “^” and

“v” so that a different menu item is moved to line 2 and is under-scored. One of the menu items is always underscored, i.e. is al-ways selected. The function of a selected menu item is executed by pressing either button “E” or “>”.

The main menu includes the following menu items:

- Measurands
- Event list
- User’s guide
- Disturbance recorder
- Diagnostic menu
- Reset menu.

A rectangular display box with a double border. Inside, the text is as follows: the first line is "-Mainmenu-", the second line is "Measurands", the third line is "Eventlist", and the fourth line is "User's -Guide" followed by a downward-pointing arrow (↓) on the right side.

```
-Mainmenu-  
Measurands  
Eventlist  
User's -Guide ↓
```

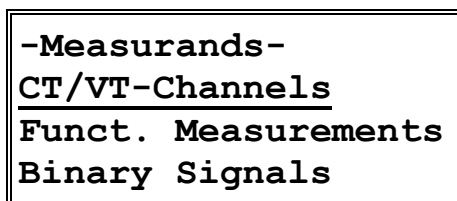
Fig. 5.90 Main menu

5.13.8.1. *Measurands*

The measurands menu lists all the menu items associated with measurements. The name “Measurands” is in the header and the available submenus on the three lines below.

The measurements menu includes the following menu items:

- AD-Channels
- Funct. measurands
- Binary signals
- Analogue signals.

A rectangular display box with a double border. Inside, the text is as follows: the first line is "-Measurands-", the second line is "CT/VT-Channels", the third line is "Funct. Measurements", and the fourth line is "Binary Signals".

```
-Measurands-  
CT/VT-Channels  
Funct. Measurements  
Binary Signals
```

Fig. 5.91 Measurements menu

5.13.8.1.1. AD-Channels

This menu provides facility for choosing between displaying rated, primary or secondary values.

```

-CT/VT-Channels-
Nominal values
Prim.Values
Sec.Values
  
```

Fig. 5.92 AD-Channels

The three submenus all list the c.t. and v.t. input signals available for display. Their headers are “Rated values”, Primary values” and “Secondary values” respectively and the measurements are shown on the three lines below. You can scroll through the list using the “^” and “v” keys. The “E” and “>” have no effect, because this is the lowest level of this branch of the menu structure. An arrow at the end of line four pointing downwards and/or at the end of line two pointing upwards indicate in which direction the user can scroll to see the other values.

The values and text shown (units etc.) vary according to the configuration of the RE.316*4. Nine current or voltage input values can be listed and the phase-angle of the measured value in relation to the reference channel is given on each line.

```

-Nominal values-
3  0.865IN 120°↑
4  1.102UN  0°
5  1.021UN-120°↓
  
```

Fig. 5.93 Rated values

Frequency display and setting the reference channel

The tenth measurement is the frequency of the reference channel.

To change the reference channel, scroll to line 11 using the arrow key “v”. The reference channel is set on this line. Each time the arrow key “v” is pressed after reaching line 11 selects the next higher input as reference channel. After the ninth input, the selection cycles back to the first. Press the arrow key “^” to complete the selection of the last pre-selected input as reference channel and exit. Input 1 is the default reference channel when initially selecting this menu item.

```

-AD-Channels-
9  0.77IN-120°↑
10 51.11Hz
11 Ref.Channel 1

```

Fig. 5.94 C.t. and p.t. inputs and selection of reference channel

5.13.8.1.2. Load values

This menu lists all the configured functions. The name “Funct. measurands” is in the header and the configured functions on the three lines below.

There are fewer or more lines of load values depending on the protection functions that are configured. ‘No function’ is on the second line where no function has been configured.

```

-Funct.Measurand
1.Current-DT
2.U>High Voltage
3.Power ↓

```

Fig. 5.95 Menu for selecting load values

Load values display

The menu lists all the measurements by the selected function that can be viewed. The name of the function is in the header and its measurements on the three lines below. If there are more than three measurements, the entire list can be viewed using the arrow keys “^” and “v”. The buttons “E” and “>” have no effect, because this is the lowest level of this branch of the menu structure. Lines 2 to 4 are empty for functions that do not have measurements.

The values and text shown (units etc.) vary according to the function selected.

```

-10.UifPQ-
1  0.997 UN
2  4.014 IN
3 10.999 P(PN) ↓

```

Fig. 5.96 Measurements by the UifPQ function

5.13.8.1.3. **Binary signals**

The binary signals menu lists all the different types of binary signals that can be viewed. The name “Binary Signals” is in the header and the different types of binary signals on the three lines below.

The menu includes the following menu items:

- Input signals
- RBI inputs
- ITL inputs
- Signal relays
- Trip relays
- RBO outputs
- ITL outputs.

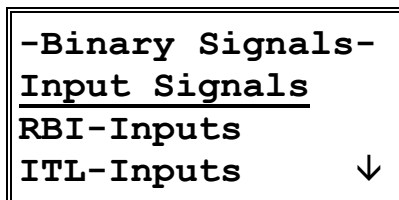


Fig. 5.97 Binary signals menu

Input signals, signalling relays and tripping relays

The selection and display of the binary inputs, signalling relays and tripping relays is very similar and therefore only the procedure for the binary inputs is explained as an example.

Selecting the menu item “Input signals” opens a submenu with the numbers of all input/output modules, the input signals of which can be viewed. The name “Input signals” is in the header and any binary input/output modules that are fitted are on the three lines below.

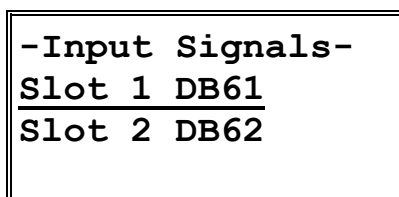


Fig. 5.98 Binary inputs

The module's binary values

The effective values, i.e. the statuses, of the inputs are displayed. The designation "Slot 1 DB6." is in the header and the values of the inputs are displayed on line 3. The buttons "E" and ">" have no effect, because this is the lowest level of this branch of the menu structure. As only a single line is needed, the arrow keys "v" and "^" are also ineffective. To make the statuses of the inputs easier to assimilate, a logical '0' is represented by a hyphen '-' and a logical '1' by an 'X'. The LSB is on the extreme left and the order is the same as on the HMI on the PC.

```
-Slot 1 DB61
-X-X---X
↑LSB
```

Fig. 5.99 Binary input statuses

RBI and ITL inputs and outputs

Since the selection and display of the RBI and ITL inputs and outputs is very similar, the procedure for the RBI inputs will be explained and applies for all the others.

When opened, the "RBI inputs" display shows the current statuses of the RBI inputs of the first module. If no input module is assigned to this number, all the inputs indicate a zero. The display can be switched from one module to the next using the arrow keys "v" and "^".

To make the statuses of the inputs easier to assimilate, a logical '0' is represented by a hyphen '-' and a logical '1' by an 'X'. The LSB is on the extreme left and the order is the same as on the HMI on the PC.

```
-RBI-Inputs-
1
-X-X---X-----
↑LSB
```

Fig. 5.100 RBI inputs

Analogue inputs and outputs

Since the selection and display of the analogue inputs and analogue outputs are very similar, the following example only illustrates the selection and presentation for analogue inputs.

The “Analogue Signals” menu provides a choice between inputs and outputs. The “Input Signals” menu shows the numbers of all the devices that have been configured to enable the one to be selected for which the input signals should be displayed.

```

-Analogue Signals
Input signals
Output signals
  
```

Fig. 5.101 Analogue signals

```

-Input signals
Device No.  9
Device No. 10
  
```

Fig. 5.102 Input signals

Displaying analogue variables

This menu lists all the measurements of the device selected which can be displayed. The device number is in the menu header and the measurements are listed below. The measurements in the list can be viewed using the “^” and “v” buttons. Since this is the lowest menu level in this branch, the buttons “E” and “>” have no effect.

```

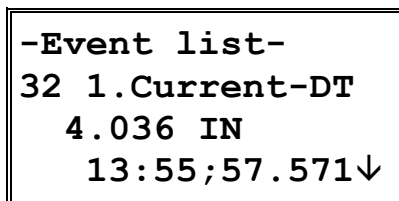
-Device No.  9-
1  14.01 mA
2   2.52 V
3 143.42 °      ↓
  
```

Fig. 5.103 Viewing the input variables of device No. 9

5.13.8.2. *Event list*

This menu item opens a list with the last 20 events together with the tripping values of the corresponding protection functions and also the special “LDU events” function. The name “Event List” is in the header and the latest event is displayed below it. The older events can be viewed using the arrow keys. The numbers of the events are the same on the LDU and the HMI on the PC. Note that an event cannot be wholly displayed because it needs 4 lines and only 3 are available. It is thus always necessary to use the arrow keys “v” and “^” to view all the information related to one event.

The text (function name and unit) is the same as that in the event list on the HMI on the PC.

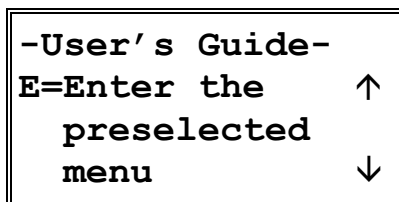


```
-Event list-  
32 1.Current-DT  
4.036 IN  
13:55;57.571↓
```

Fig. 5.104 Event list

5.13.8.3. *User's guide*

This menu item gives access to brief instructions on how to use the LDU, e.g. the functions of the buttons.



```
-User's Guide-  
E=Enter the      ↑  
preselected  
menu             ↓
```

Fig. 5.105 User's guide

5.13.8.4. Disturbance recorder list

The menu item 'Disturbance recorder' opens a list with the data stored in the disturbance recorder. Where there are several entries, they can all be viewed using the arrow keys "v" and "Λ". The oldest record is displayed first when the list is opened. '0 events' is displayed if no disturbance recorder data is stored.

```

-Disturb.Rec.
Event 1
    98-03-17
    13:55;56.575↓
  
```

Fig. 5.106 List of disturbance records

5.13.8.5. Diagnostics menu

This menu item gives access to the different kinds of diagnostic information that can be viewed. The name "Diagnosis Menu" is in the header and the list of menu items below.

The following kinds of information are available for selection:

- DiagnosisInfo
- IBB StatusInfo
- ProcessbusInfo
- LED descriptions.

```

-Diagnosis Menu-
DiagnosisInfo
IBB-StatusInfo
ProcessbusInfo ↓
  
```

Fig. 5.107 Diagnostics

5.13.8.5.1. Diagnosis information

Selecting this menu item displays the diagnostic information in a similar form to the HMI on the PC. The name "DiagnosisInfo" is in the header and the diagnostic information is displayed on the three lines below. The entire list can be viewed using the arrow keys "Λ" and "v".

The status of the device is at the top of the list followed by the time when the software was downloaded, the time when settings were last changed and finally the statuses of an FUP programs that are loaded.

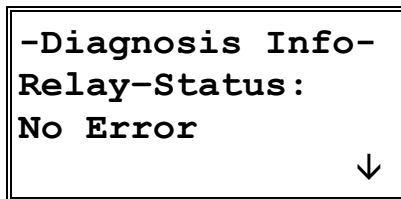


Fig. 5.108 General status information

5.13.8.5.2. **IBB status information**

Select this menu item to view information on the interbay bus (LON, MVB etc.). The name "IBB StatusInfo" is in the header followed by three lines with the IBB diagnostic information. You can scroll through the list using the "↑" and "↓" keys:

- The interbay bus connected (SPA, VDEW, LON or MVB) is shown on the second line together with the information 'Ready' (operational), 'No response' (if no telegrams are transferred, but the device is ready) or 'Inactive' (this appears, for example, when the corresponding interface is not fitted). The HMI on the PC must be used to obtain more detailed information.
- Station number and the time
- Neuron chip ID (LON only)

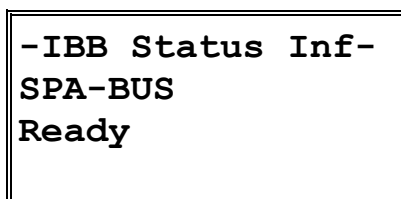


Fig. 5.109 Interbay bus information

5.13.8.5.3. **Process bus information**

Here information about the process bus can be viewed in a similar manner to information about the station bus. The name "ProcessbusInfo" is in the header and the operating mode, the status of the PC card, the PC card type, the software version and the PC card counter appear below.

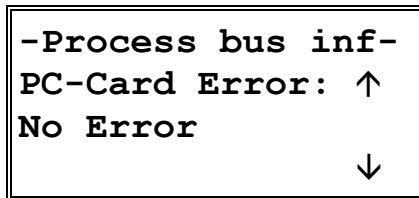


Fig. 5.110 Information about the process bus (PC card error)

5.13.8.5.4. LED descriptions

The significance of the LED's at the top left of the frontplate can be viewed on the LDU by selecting this menu item.

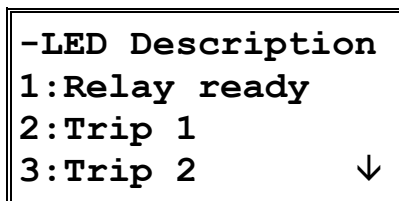


Fig. 5.111 Significance of the LED's

Entering the LED function texts

The texts describing the significance of the LED's displayed on the LDU is entered via the HMI. The corresponding dialogue is accessed in the HMI on the PC by selecting 'Editor' / 'Edit hardware functions' / 'Edit signal outputs' and then the menu item 'Edit LED description. The procedure is the same as for the existing menu item 'Edit signal comment'.

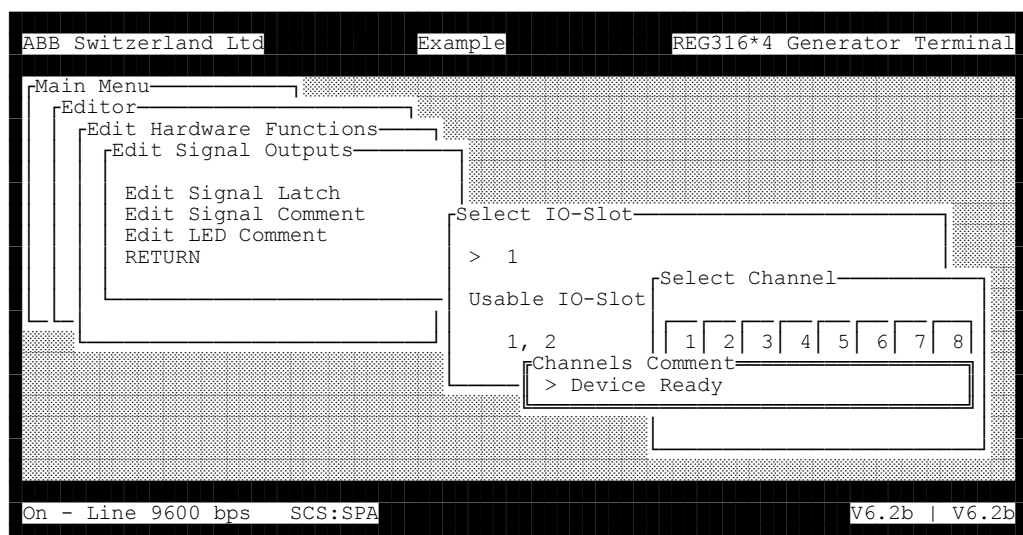


Fig. 5.112 Entering a comment to describe a LED

The text entered is then downloaded to the RE.316*4 together with all the other data and can be viewed on the LDU.

5.13.8.6. **RESET menu**

This menu item opens a submenu that enables the user to delete different kinds of obsolete information or execute a warm start.

The menu includes the following four items:

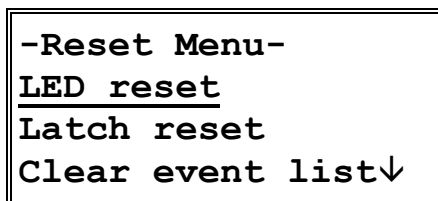
- LED reset
- Latch reset
- Clear event list
- System restart.

The first menu item (LED reset) resets the two LED's 'Start' and 'Trip' on the front of the LDU.

The second menu item (Latch reset) resets all the latched LED's on the frontplate and all latched outputs.

The third menu item deletes the event list (only the one in the LDU and not the one in the PC).

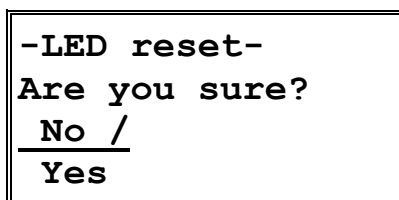
The fourth menu item restarts the RE.316*4.



```
-Reset Menu-  
LED reset  
Latch reset  
Clear event list↓
```

Fig. 5.113 Reset menu

Upon selecting any of the above menu items, a dialogue appears requesting confirmation that you wish to execute the action 'Are you sure? Yes/No?'. The default response is 'No'. Select the appropriate response using the arrow keys "v" and "^" (in the same way as selecting a menu item) and execute by pressing "E" or ">".



```
-LED reset-  
Are you sure?  
No /  
Yes
```

Fig. 5.114 Are you sure?

5.13.9. Automatic display

5.13.9.1. General description

In addition to the manual procedure for selecting information for display, there is an automatic display routine that cyclically presents the available information. It runs whenever the PC is not connected and no buttons on the LDU are being pressed.

5.13.9.2. Automatic display sequence

After the system has been started, the entry menu appears. The automatic display cycle starts providing no buttons are pressed for a minute. A particular menu item (e.g. measurements) that has been selected manually remains on the display even if no buttons are pressed. The automatic display routine only starts from the entry menu providing no buttons are pressed and the PC with the HMI is not connected.

5.13.9.3. Stopping the automatic display routine

Stop the automatic display routine by pressing the button "C" (clear button). The entry menu appears and you can navigate through the menu structure in the normal way.

5.13.9.4. Automatic display cycle

The sequence of the automatic display cycle is as follows:

- Entry menu
- Measurement(s) of 1st. function
- Measurement(s) of 2nd. function
-
- Measurement(s) of last function
- Event list.

In each case, the information remains visible for about 15 seconds before switching to the next block of information. Where a function generates more than three measurements, all of them are shown in sequence before the display proceeds to the next function. The same applies when there are more than three events in the event list.

5.14. SMS010

5.14.1. *Installing SMS010 and 'Reporting' and 'SM/RE.316*4' for SMS010*

Installation sequence

1. Install SMS010.
2. Install 'Reporting' for SMS010.
3. Install 'RE.316*4' for SMS010.

SMS010 must be installed before attempting to install 'Reporting' and 'RE.316*4', otherwise they cannot be installed.

The SMS010 installation program is on SMS Base, Disc 1. The installation program creates all the directories needed and copies all the files to the hard disc. Program examples are to be found on Disc 2.

The 'Reporting' installation program is on Reporting Program, Disc 1. The installation program creates all the directories needed and copies all the files to the hard disc. Program examples are to be found on Disc 2.

The 'HMI RE-316*4 for SMS010' installation program is on SM/RE.316, Disc 1. The installation program creates all the directories needed and copies all the files to the hard disc. If SMS010 is not in the default directory, a request appears to enter the directory where SMS010 is located. The program must be installed from a floppy drive.

The following files are copied to the hard disc:

- RE_316#4.EXE is copied to the directory \SMS010\Base\Support\, providing \SMS010\Base was the directory created when installing SMS010.
- The directory REC316 is created in \SMS010\Base\Modules.
- Files Rec316.CNF, Rec316.DEF and Rec316.SUP are copied to the directory \SMS010\Base\Modules\REC316.
- The file devices in directory \SMS010\Base\Modules are updated.

5.14.2. SMS010 Editor

5.14.2.1. Main menu

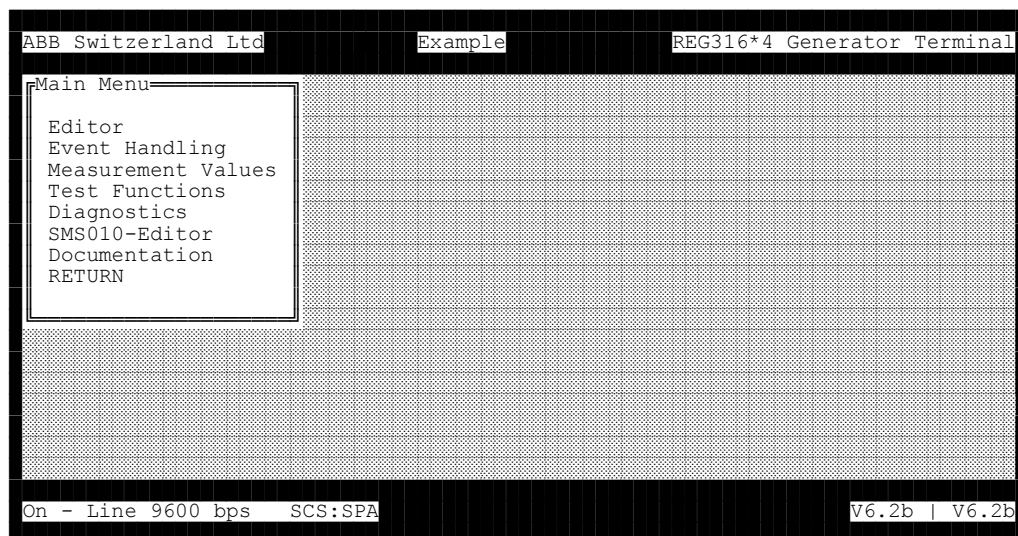


Fig. 5.115 Main menu

The menu item 'SMS010 editor' is added to the main menu when installing SMS010.

5.14.3. Sub-menu 'SMS010 editor'

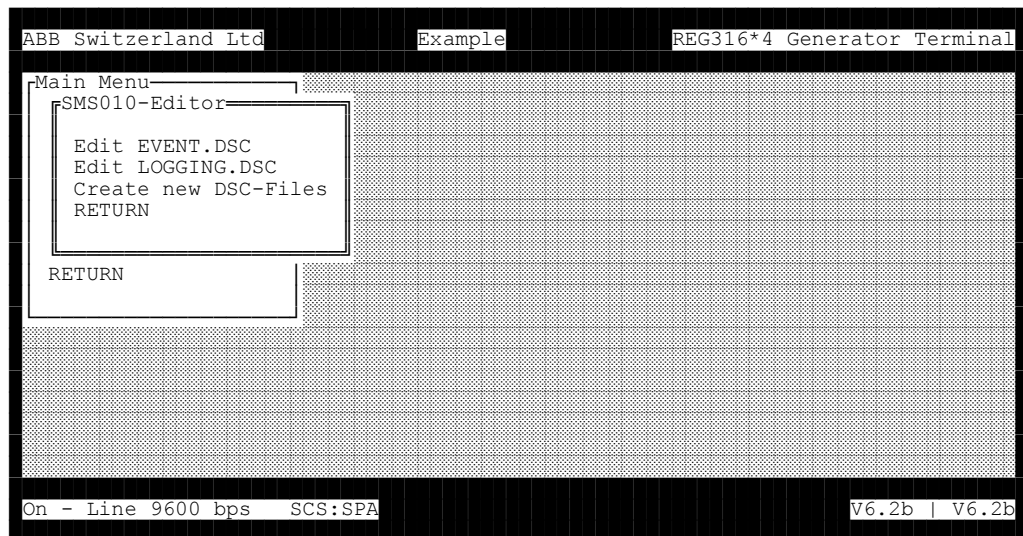


Fig. 5.116 SMS010 editor

The menu items in the 'SMS010 editor' sub-menu are used for creating and processing the files needed for integrating SMS010. Concerned are the 'Reporting' files EVENT.DSC, LOGGING.DSC and CHANNEL.DSC.

The menu items perform the following:

- Edit Event.dsc ⇒ for processing the file Event.DSC.
- Edit Logging.dsc ⇒ for processing the file Logging.DSC.
- Create New Dsc Files ⇒ for creating and configuring the files needed for 'Reporting' in the set of device parameter settings.

(In the off-line mode, a parameter file must be downloaded first using the editor's 'Load from file' function, since the 'Create new DSC files' function requires the currently active set of parameter settings.)

5.14.4. Descriptions of the various menu items

5.14.4.1. Menu item 'Edit Event. Dsc' for processing Event.DSC

ABB Switzerland Ltd

Example

REG316*4 Generator Terminal

SMS Edit

Relay address = 45

CHANNEL = 21

Page 19 of 28

45.021 Frequency

Code	Description		Report	Alarm	Audible	Reset
1	Blocked (U<)	ON	No	No	Yes	Yes
2	Blocked (U<)	OFF	Report	Yes	No	No
3	Trip	ON	Report	Yes	No	No
4	Trip	OFF	Report	Yes	No	No
5	Start	ON	Report	Yes	No	No
6	Start	OFF	Report	Yes	No	No

On - Line 9600 bps

SCS:SPA

V6.2b | V6.2b

Fig. 5.117 A typical page of the Event.DSC file.

Default settings:

- Report = Report
- Alarm = Yes
- Audible = No
- Reset = NO.

The number displayed for 'Relay address' is the slave address set for the relay and the one for 'Channel' the function number in the parameter list. The function type is also shown in the header.

- Code = Event number
- Description = Event designation
- Report = An occurrence of an event is only listed in the SMS010 report, if 'Report' is specified in this column.
- Alarm = Determines whether an alarm appears in the list or not.
- Audible = 'Yes' in this column causes the acoustic alarm to be given as well.
- Reset = Reset function (Yes/No).

The above settings can be changed using the space bar once they have been selected (Report/No. or Yes/No). None of the other settings can be changed.

Refer to the Section 'Reporting' in the SMS010 manual for a detailed explanation of the settings.

Keys:

- Page Up ⇒ previous page
- Page Down ⇒ next page
- Arrow key ↑ ⇒ one line up
- Arrow key ↓ ⇒ one line down
- Arrow key → ⇒ moves the cursor to the right
- Arrow key ← ⇒ moves the cursor to the left
- Space bar ⇒ for editing settings
- F1 ⇒ help
- ESC ⇒ for terminating the program. If changes were made, you are requested to confirm that they should be saved.

5.14.4.2. Menu item 'Edit Logging. Dsc' for processing Logging.DSC

ABB Switzerland Ltd

Example

REG316*4 Generator Terminal

Logging Edit

Page 1 of 2

Code	Addr	Parameter description	Show logging
14V1	45	Value of Addr. 45 Current-DT IN	Yes
15V1	45	Value of Addr. 45 Current-DT IN	No
17V1	45	Value of Addr. 45 UIfPQ UN	No
17V2	45	Value of Addr. 45 UIfPQ IN	No
17V3	45	Value of Addr. 45 UIfPQ P (PN)	No
17V4	45	Value of Addr. 45 UIfPQ Q (PN)	No
17V5	45	Value of Addr. 45 UIfPQ Hz	No
18V1	45	Value of Addr. 45 Frequency Hz	No
18V2	45	Value of Addr. 45 Frequency UN	No
20V1	45	Value of Addr. 45 Delay s	No
21V1	45	Value of Addr. 45 Frequency Hz	No
21V2	45	Value of Addr. 45 Frequency UN	No
22V1	45	Value of Addr. 45 Distance [refLength]	No
22V2	45	Value of Addr. 45 Distance Z (RE)	No
22V3	45	Value of Addr. 45 Distance Z (RE)	No

On - Line 9600 bps SCS:SPA

V6.2b | V6.2b

Fig. 5.118 A typical page in a logging file

After creating the Logging.dsc file, all the parameters are at the default setting 'No' in the 'Show Logging' column.

Meanings of the columns:

- Code = Number of the measured variable.
- Addr = Relay slave address.
- Parameter description = Description of the measured variable. This description also appears in the logging window of the SMS010 report.
- Show logging = Only measured variables with 'Yes' in this column appear in the SMS010 report.

The 'Show logging' parameter can be changed using the space bar once they have been selected (Yes/No). None of the other settings can be changed. The 'Reporting' function' can list a maximum of 16 measured variables.

Refer to the Section 'Reporting' in the SMS010 manual for a detailed explanation of the settings.

Keys:

- Page Up ⇒ previous page.
- Page Down ⇒ next page.
- Arrow key ↑ ⇒ one line up.
- Arrow key ↓ ⇒ one line down.
- Space bar ⇒ for editing settings.
- F1 ⇒ help.
- ESC ⇒ for terminating the program. If changes were made, you are requested to confirm that they should be saved.

5.14.4.3. Menu item ‘Create New DSC Files’

This menu item is for creating the files needed from the parameter list of the particular device the first time the HMI is started. It is also needed every time the device parameter settings are changed.

In the off-line mode, a parameter file must be downloaded first using the editor's ‘Load from file’ function, since the ‘Create new DSC files’ function requires the currently active set of parameter settings.

The following files are created:

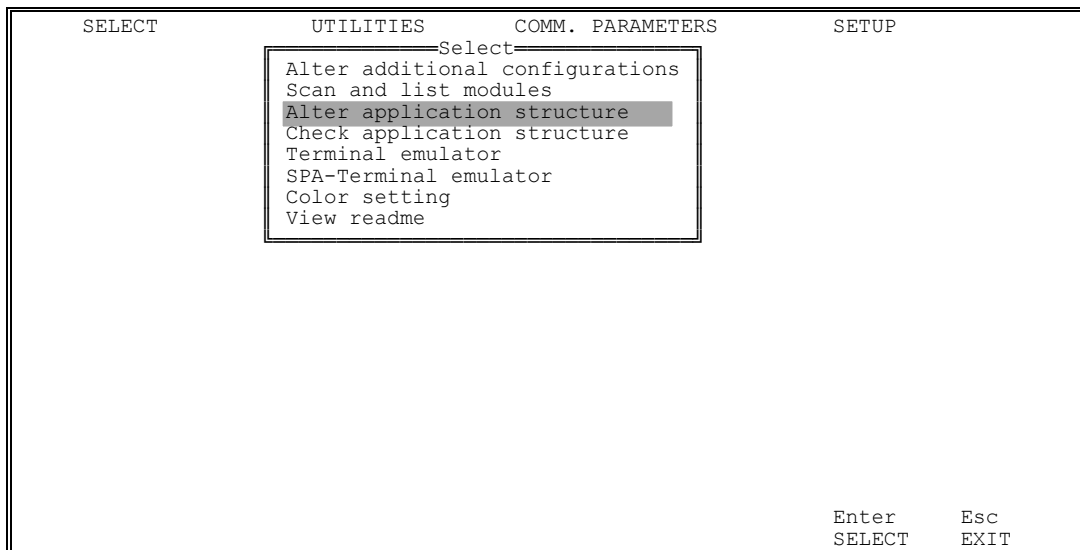
- Event.DSC ⇒ event handling file for ‘Reporting’
- Logging.DSC ⇒ logging window file for ‘Reporting’
- Channel.DSC ⇒ file with the function designations
- Functyp.DSC ⇒ required for updating files.

5.14.5. Creating a station after installing SMS010

When SMS is started for the first time, a message is displayed to the effect that the file 'Spacom.CNF' does not exist and the application structure is invalid.

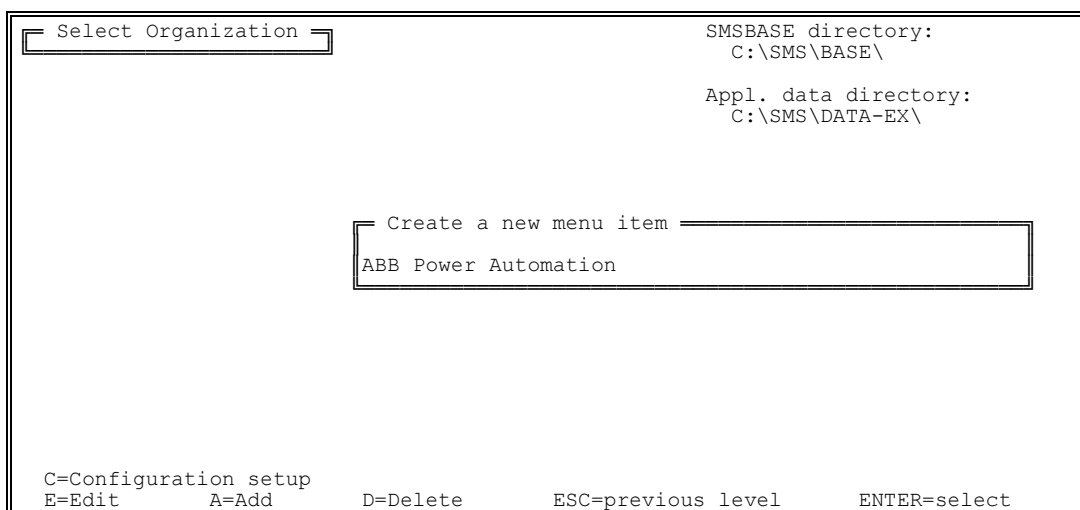
5.14.5.1. Creating the application structure

- Select *Alter application structure* from the *Utilities* menu to create a new application structure. There are five levels.



- **Level 1:**

A name for an organisation can be entered after entering 'a' (= add) in *Select organisation*.



- **Level 2:**

The next level and the *Select station* window are reached by pressing <Enter>. Press 'a' to enter a station name.

Select Organization ABB Po		Select Station	SMSBASE directory: C:\SMS\BASE\ Appl. data directory: C:\SMS\DATA-EX\ Create a new menu item ABB Baden
Organiz: ABB Power Automation Ltd			
E=Edit A=Add D=Delete ESC=previous level ENTER=select			

- **Level 3:**

The next level and the *Select object/bay* window are reached by pressing <Enter>. Press 'a' to enter a bay name. The Spin.CNF file is also created at this level by entering 'c' (*Create communications parameters*). Provision is also made at this level for changing the SPA protocol to SRIO.

Select Organization ABB Po		Select Station ABB Ba	Select Object/Bay	SMSBASE directory: C:\SMS\BASE\ Appl. data directory: C:\SMS\DATA-EX\ Create a new menu item NTP-2 REC316 45
Organiz: ABB Power Automation Ltd Station: ABB Baden				
C=Create communication parameters E=Edit A=Add D=Delete ESC=previous level ENTER=select				

- Creating the Spin.CNF file after entering 'c'.

Select Organization ABB Po Select Station ABB Ba Select Object/Bay NTP-2 REC316 45	SMSBASE directory: C:\SMS\BASE\ Appl. data directory: C:\SMS\DATA-EX\
Edit communication parameters	
Phone no: 161707 Connection: Direct Serial port: COM1 Protocol: SPA Baud rate: 9600 Parity: EVEN Data bits: 7	161707 Direct COM1 SRIO 9600 EVEN 7
C=Create communication parameters SPACE=next value ESC=quit ENTER=save	

- **Level 4:**

The next level and the *Select unit* window are reached by pressing <Enter>. Press 'a' to open the selection window. Select for example *REC 316* from this menu. Then select *Report station* to if you wish to create one.

Select Organization ABB Po Select Station ABB Ba Select Object/Bay NTP-2 REC316 45	SMSBASE directory: C:\SMS\BASE\ Appl. data directory: C:\SMS\DATA-EX\
A Manual Entry MODEM OTHER REC316 REPORT STATION	
Organiz: ABB Power Automation Ltd Station: ABB Baden Obj/Bay: NTP-2 REC316 45	
C=Create communication parameters ESC=quit ENTER=select	

- **Level 5:**

The next level, the *Select module/part of unit* window and the data input window *Setting Spacom slave address* are reached by pressing <Enter>. Now enter the SPA address for the device.

Select Organization	SMSBASE directory:
ABB Po	C:\SMS\BASE\
Select Station	
ABB Ba	
Select Object/Bay	
NTP-2	
Select Unit	a directory:
REC31	
Select Module/Part of Unit	
REC316 REC316	Control & Protection Terminal

Organiz: ABB Power Automation Ltd
 Station: ABB Baden
 Obj/Bay: NTP-2 REC316 45
 Unit: REC316 C Control & Protection Terminal

C=Create communication parameters S=Show transducer file
 E=Edit A=Add D=Delete ESC=previous level ENTER=select

- **Entering the address.**

Select Organization	SMSBASE directory:
ABB Po	C:\SMS\BASE\
Select Station	
ABB Ba	
Select Object/Bay	
NTP-2	
Select Unit	a directory:
REC31	
Select Module/Part of Unit	
REC316 REC316	Control & Protection Terminal

Setting SPACOM slave address

The module address is: 001
 New address: 045

Organiz: ABB Power Automation Ltd
 Station: ABB Baden
 Obj/Bay: NTP-2 REC316 45
 Unit: REC316 C Control & Protection Terminal
 Mod/Part: REC316 REC316 Control & Protection Terminal

C=Create communication parameters S=Show transducer file
 E=Edit A=Add D=Delete ESC=previous level ENTER=select

If your wish to add further stations, return to the corresponding level. For example, to insert another device, repeat all steps from level 3.

5.14.5.2. Updating the Spin.CNF file

- Select *Edit communication parameter file* from the *Comm parameters* menu.

SELECT	UTILITIES	COMM. PARAMETERS	SETUP
Select			
Edit communication parameter file			
Print communication parameter file			

Enter Esc
SELECT EXIT

- Select the desired station and respond with 'Yes' to the question '*Continue with this file?*'.

SELECT	UTILITIES	COMM. PARAMETERS	SETUP
Select			
Edit communication parameter file			
Print communication parameter file			

Organiz	Station	Obj/Bay	Unit
ABB Power Automation ABB Baden			

Enter Esc
SELECT EXIT

- Select '*SRIO*' from the *Protocol* sub-menu.

SELECT	UTILITIES	COMM. PARAMETERS	SETUP
		Select Edit communication parameter file Print communication parameter file	
		Comment Interface type Communication port Protocol Secondary protocol	
		RAW SPA SRIO	
Enter Esc SELECT EXIT			

- Select **NOT USED** from the *Secondary protocol* sub-menu

SELECT	UTILITIES	COMM. PARAMETERS	SETUP
		Select Edit communication parameter file Print communication parameter file	
		Comment Interface type Communication port Protocol Secondary protocol Baud rate	
		RAW SPA SRIO Not used	
Enter Esc SELECT EXIT			

- All other settings can be left at their default values.

Note that all the above settings must agree with the SRIO settings (Syspar 4).

5.14.5.3. Creating a report station

- Select *Alter application structure* from the *Utilities* menu.
- Omit levels 1 and 2 by pressing <Enter>.
- **Level 3:** To enter a bay name for the report station, select *Select object/bay* and enter 'a'.

The screenshot shows a multi-level menu structure. At the top left, a path is indicated: 'Select Organization' -> 'ABB Po' -> 'Select Station' -> 'ABB Ba' -> 'Select Object/Bay'. The 'Select Object/Bay' menu is open, showing two options: 'NTP-2 REC316 45' and 'NTP-2 REC316 94'. To the right, the 'SMSBASE directory:' is 'C:\SMS\BASE\' and the 'Appl. data directory:' is 'C:\SMS\DATA-EX\'.

In the center, there is a box titled 'Create a new menu item' with the text 'Report NTP' inside it.

At the bottom left, the following information is displayed:

```

Organiz:  ABB Power Automation Ltd
Station:  ABB Baden

```

At the bottom, a legend explains the navigation keys:

```

C/ALT+D=Change/Delete comm. parameter
E=Edit      A=Add      D=Delete      ESC=previous level      ENTER=select

```

- **Level 4:** Press <Enter> to proceed to the *Select unit* window and enter 'a'. Now select *Report station* from the list which appears.

The screenshot shows the next step in the menu structure. The path is now: 'Select Organization' -> 'ABB Po' -> 'Select Station' -> 'ABB Ba' -> 'Select Object/Bay' -> 'NTP-2' -> 'Select'. The 'Select' menu is open, showing four options: 'A Manual Entry', 'MODEM', 'OTHER', and 'REC316'. The 'Report NTP' option is highlighted in the previous menu.

To the right, the 'SMSBASE directory:' is 'C:\SMS\BASE\' and the 'Appl. data directory:' is 'C:\SMS\DATA-EX\'.

At the bottom left, the following information is displayed:

```

Organiz:  ABB Power Automation Ltd
Station:  ABB Baden
Obj/Bay:  Report NTP

```

At the bottom, a legend explains the navigation keys:

```

C=Create communication parameters      ESC=quit      ENTER=select

```

- **Level 5:**

Press <Enter> to proceed to the *Select module/part of unit* window and then the data input window *Set Spacom slave address*. The default values in this window can be accepted.

```

Select Organization  [
ABB Po  [
  Select Station  [
    ABB Ba  [
      Select Object/Bay  [
        NTP-2  [
          Select Unit  [
            NTP 2  [
              Select Module/Part of Unit  [
                Report  [
                  REPORT STATION Configuration
                ]
              ]
            ]
          ]
        ]
      ]
    ]
  ]
]
SMSBASE directory:
C:\SMS\BASE\
Appl. data directory:
SMS\DATA-EX\

Setting SPACOM slave address
The module address is: 001
New address: 001

Organiz:  ABB Power Automation Ltd
Station:  ABB Baden
Obj/Bay:  Report NTP
Unit:     REPORT STATION Configuration
Mod/Part: REPORT STATION Configuration
C=Create communication parameters    S=Show transducer file
E=Edit      A=Add      D=Delete      ESC=previous level    ENTER=select

```

Take care not to enter a device address in this window.

5.14.5.4. *Entering the SRIO address for 'Reporting'*

- Select the menu item *Select* from the main menu and then the *Select object/bay* window (Level 3). Now select the report station.

```

Select Organization  [
ABB  [
  Select Station  [
    ABB  [
      Select Object/Bay  [
        NTP-2 REC316 45
        NTP 2 REC316 94
        Report NTP
      ]
    ]
  ]
]

Organiz:  ABB Power Automation Ltd
Station:  ABB Baden

F3          F5          Enter  Esc
MODEM      PASSWORD    SELECT  EXIT

```

- Select Report station configuration in the Select unit window (Level 4).

Select Organization	ABB	Select Station	ABB	Select Object/Bay	NTP	Select Unit	REPORT STATION Configuration
					NTP		
					Rep		

Organiz: ABB Power Automation Ltd
 Station: ABB Baden
 Obj/Bay: Report NTP

Enter Esc
 SELECT EXIT

- Select Report station configuration in the Select module/part of unit window (Level 5).

SELECT		UTILITIES		COMM. PARAMETERS		SETUP	
Select Organization	ABB	Select Station	ABB	Select Object/Bay	NTP	Select Unit	REPORT STATION Configuration [1]
					NTP	REP	
					Rep		

Organiz: ABB Power Automation Ltd
 Station: ABB Baden
 Obj/Bay: Report NTP
 Unit: REPORT STATION Configuration

Enter Esc
 SELECT EXIT

- Select the menu item *Select function* and then *Report station settings* (Level 6).

SELECT	UTILITIES	COMM. PARAMETERS	SETUP
Select Organization			
ABB	Select Station		
ABB	Select Object/Bay		
NTP	Select Unit		
NTP	REP	Select Module/Part of Unit	
Rep	REP	Select function	[1]
		REPORT station settings	

Organiz: ABB Power Automation Ltd
 Station: ABB Baden
 Obj/Bay: Report NTP
 Unit: REPORT STATION Configuration
 Mod/Part: REPORT STATION Configuration [1]

F7 F8 Enter Esc
 REPORT DOS SELECT EXIT

- The SRIO address can now be entered and all the 'Reporting' settings made in the window which opens.

REPORT STATION v 1.0		Screen 1 of 1
REPORT station settings		22.09.1993
Present values ----- [-Station unit address-----] SACO/SRIO address = 950 [-Report station printouts-----] Alarm print/save = No Event print/save = No Logging print/save = No Print day report = 7 Print week report = Monday Print month report = 1 Logging save to file = No [-Station polling settings-----] Poll retry = 3 times Poll start = 12.00 hh.mm Poll interval = 0.01 hh.mm	PC-file time 05.03.1996 06:37 ---- New values ----- [-Station unit address-----] SACO/SRIO address = 950 [-Report station printouts-----] Alarm print/save = No Event print/save = No Logging print/save = No Print day report = 7 Print week report = Monday Print month report = 1 Logging save to file = No [-Station polling settings-----] Poll retry = 3 times Poll start = 12.00 hh.mm Poll interval = 0.01 hh.mm	
Set the address of the SACO/SRIO at the station. Range: 900..999		
PgDn PgUp NEXT PREV	F7 REPORT	Enter Esc CHANGE EXIT

Refer to the Section 'Reporting' in the SMS010 manual for a further information.

March 01

6. SELF-TESTING AND MONITORING

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6. SELF-TESTING AND MONITORING

6.1. *Summary*

The continuous self-monitoring and diagnostic features incorporated in RE. 316*4 assure high availability both of the protection functions and the power system it is protecting. Hardware failures are signalled instantly via an alarm contact.

Special importance has been given to monitoring the external and internal auxiliary supply circuits. The correct operation and maintenance of tolerances of the A/D converter (both on external c.t./v.t. input boards Type 316EA62 or 316EA63 or in the CPU itself) are checked by making it continuously convert two precisely known reference voltages.

The execution of the program itself is monitored by a watchdog.

Security when transferring data by serial communication between the protection and a local control and setting unit (PC) or with a remote system (station control system) is provided by a communication protocol with a "Hamming" distance of 4.

Special functions are provided for monitoring the integrity of the v.t. connections and for checking the symmetry of the three phase voltages and currents.

6.2. *Monitoring the auxiliary supply*

Both the external auxiliary supply applied to the protection and the internal electronic supplies are continuously monitored. The supply unit is capable of bridging supply interruptions up to 50 ms. After this time, the O/P's are blocked and the unit is reset and reinitialised.

6.3. *Monitoring the firmware*

A hardware timer (watchdog) monitors the execution of the program. Providing the program runs correctly, the timer is reset at regular intervals. Should for some reason the execution of the program be interrupted and the timer not be reset, the O/P's are blocked and the unit reinitialised.

6.4. *Monitoring the hardware*

For the most part, the hardware is either monitored or self-testing both while the system is being initialised after switching on and afterwards during normal operation. Upon switching on the auxiliary supply, a test routine completely checks the hardware including the RAM and the flash EPROM checksums. The function and accuracy of the A/D converter is tested by converting a 10 V reference voltage to a digital value and checking that the result lies within $\pm 1\%$.

The switch-on test takes about 10 seconds while the green (stand-by) LED does not light and the protection functions are blocked. Upon successful completion of the test, the stand-by LED flashes and the start-up routine commences. As soon as the standby LED lights continuously, the device is operational.

The above routine continues to run as a background function during normal operation, checking the memories (excepting the RAM) at frequent intervals. The reference voltage is also repeatedly converted together with the current and voltage channels to monitor the A/D converters.

6.5. *Diagnostic events*

A corresponding entry is made in the event list whenever the diagnostic function detects a failure.

The following entries in the list are possible:

- System start
The device was switched on.
- Protection restart
The protection and control functions were activated.
- System warm start
The device was restarted after the reset button was pressed or a watchdog time-out.
- Protection stop
The protection and control functions were stopped by the parameters being re-entered.
- Supply failure
The device was switched off or there was a supply failure.

- Diagnosis: main processor 316VC61a/316VC61b ready (0001H).
- Diagnosis: A/D processor EA6. not ready.
The external A/D processor 316EA62 or 316EA63 is not ready. This occurs during normal operation, because the A/D processor on the 316VC61a/316VC61b is active.
- Diagnosis: internal A/D ready (0001H)
The A/D processor on the 316VC61a/316VC61b is ready.
- Diagnosis: system status: OK.

The above list of diagnostic messages reflects the operating state when the device is standing by. The following messages and hexadecimal weightings can be generated by a fault.

Designation	Function	Weighting
RDY	Device standing by	0001H
WDTO	Watchdog time-out	0002H
WDDIS	Watchdog disabled	0004H
HLT	Stop procedure initiated	0008H
SWINT	Software interrupt	0010H
RAM	RAM error	0100H
ROM	ROM error	0200H
VREF	Reference voltage out-of-tolerance	0400H
ASE	A/D converter error	0800H
EEPROM	Parameter memory error	2000H

The hexadecimal weighting of an error message may also be the addition of simpler errors. For example, VREF and ASE are recorded as $0400H + 0800H = 0C00H$.

Failures with a weighting less than 080H are listed as 'minor errors', e.g. a warm start after pressing the reset button.

Failures with a weighting higher than 0100H are 'fatal errors' and result in blocking of the protection and control functions.

Note: Normally, a fatal error always concerns the entire device. An exception to this rule occurs when an EEPROM error is detected on a 316EA62 or 316EA63.

The A/D converter 316EA62 or 316EA63 generates a number of diagnostic messages:

Designation	Function	Weighting
RDY	Device ready	0001H
Gr2Err	Local value error	0020H
Gr3Err	Error in the values received from the transmitting device	0040H
Param	Parameter error	0080H

Example

Event list after switching the device off and on:

```

MODURES - Events          EXAMPLE
-----
0 1998-03-30 11:37:08.338 Supply failure      CPU 1
1 1998-03-30 11:37:08.338 System start
2 1998-03-30 11:37:08.338 Diagnosis: Main processor VC61 ready (0001H)
3 1998-03-30 11:37:08.338 Diagnosis: A/D processor EA6. not ready
4 1998-03-30 11:37:08.338 Diagnosis: Internal A/D ready (0001H)
5 1998-03-30 11:37:08.338 Diagnosis: System status: OK
6 1998-03-30 11:37:09.050                               ParSatz2    ACTIVE
7 1998-03-30 11:37:09.056 Protection restart
8 1998-03-30 11:37:09.058                               Relay ready  ACTIVE
9 1998-03-30 11:37:09.058 Bin.I/P. No. 1/ 2 (Q0_OPEN                ) ACTIVE
                               Bin.I/P. No. 1/ 4 (Q1_OPEN                ) ACTIVE
                               Bin.I/P. No. 1/ 6 (Q2_OPEN                ) ACTIVE
                               Bin.I/P. No. 1/ 8 (Q9_OPEN                ) ACTIVE
                               Bin.I/P. No. 1/10 (Q8_OPEN                ) ACTIVE
                               Bin.I/P. No. 1/12 (Q51_OPEN               ) ACTIVE
                               Bin.I/P. No. 1/14 (Q52_OPEN               ) ACTIVE
10 1998-03-30 11:37:09.058 Bin.I/P. No. 2/10 (BUS-TIE_OPEN            ) ACTIVE
                               Bin.I/P. No. 2/12 (Q51_OPEN               ) ACTIVE
                               Bin.I/P. No. 2/14 (Q52_OPEN               ) ACTIVE
11 1998-03-30 11:37:40.051                               MMC active  ACTIVE.

```

6.6. *Device diagnosis*

Device diagnostic data can be viewed by selecting 'Diagnostics' from the MMI main menu.

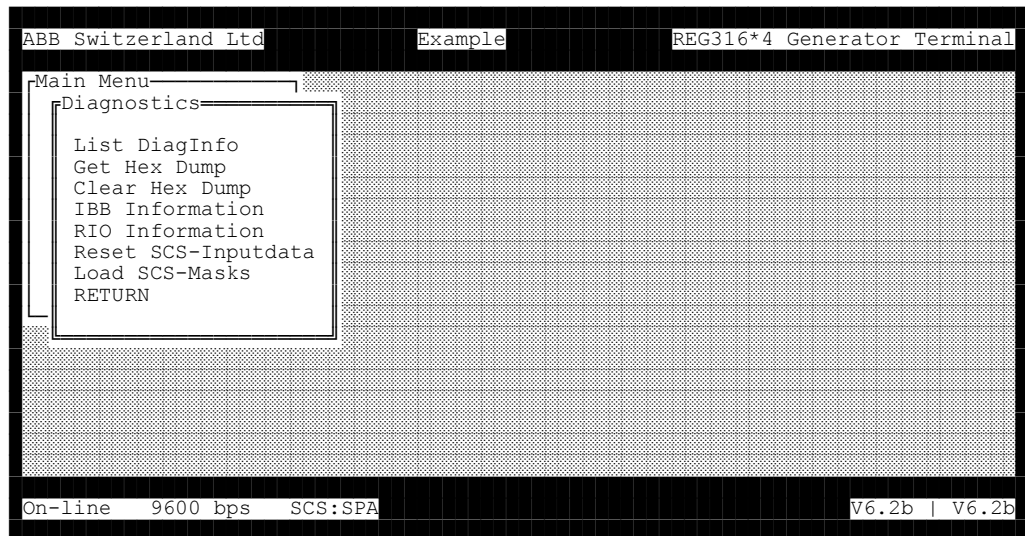


Fig. 6.1 Diagnostics menu

Status messages can be deleted using the reset button or the reset menu on the local display unit.

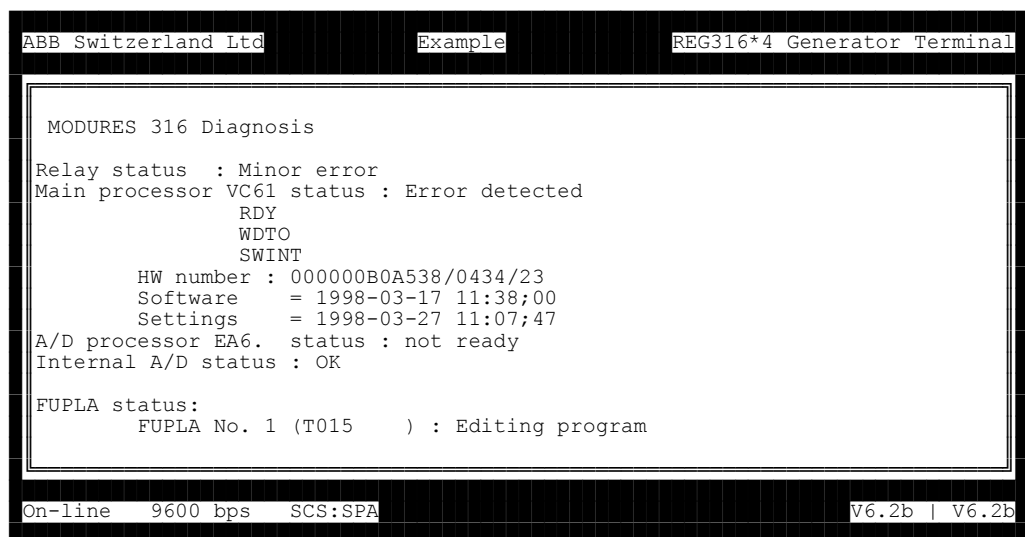


Fig. 6.2 Device diagnosis after a warm start

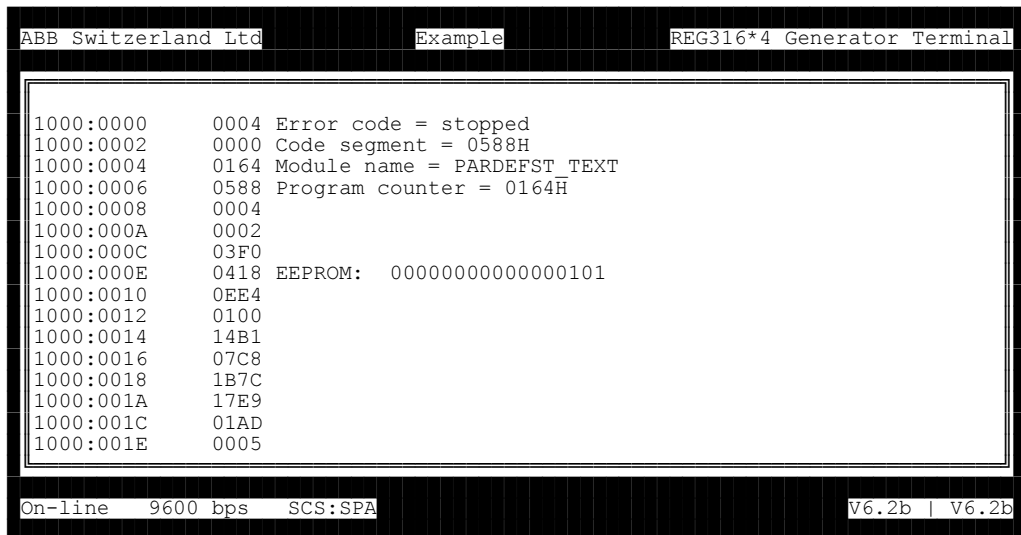
Fig. 6.2 shows the diagnostic data of a device after a warm start. The significance of the various parameters is as follows:

- HW number: 000000B0A538/0434/23
Every 316VC61a or 316VC61b processor board has a unique number. To this are added the codes for the microprocessor and the PCMCIA controller (PC card).
- Software = 1998-03-17 11:38;00
Date and time when the device firmware was created.
- Settings = 1998-03-27 11:07;47
Date and time when the parameter settings were last downloaded.
- A/D processor EA6. Status: not ready
The external 316EA62 or 316EA63 A/D processor is not fitted.
- Internal A/D Status: OK
The A/D processor on the 316VC61a or 316VC61b is standing by.
- FUPLA status: FUPLA No. 1 (T015): Editing program
Name of the FUPLA in the device. This uniquely identifies the FUPLA code loaded in the device. The FUPLA code can be processed either in the program ('Prog') or the parameter ('Para') memory. After the FUPLA code has been loaded, processing commences in the parameter memory. It is then copied to the program memory and runs in the background. The processing speed of the program memory is higher. Up to eight different FUPLA logics can be loaded at the same time and the status of each one is displayed. The following statuses are possible:

Blocked	The blocking input is preventing the execution of the FUPLA logic.
Halted	The execution of the FUPLA logic has been halted because, for example, the FUPLA code cannot be accessed temporarily.
Processing	The FUPLA logic is being processed.
Initialised	The FUPLA logic is already initialised, but inactive.
Inactive	The FUPLA logic is loaded, but is not running.

6.7. *HEX dump*

Additional information to the diagnostic information is available by selecting 'Diagnostics' from the main menu and then 'Load HEX dump'. Most of this data cannot be evaluated by the user, but they are frequently useful to ABB personnel for fault-finding. Once the data has been read, it should be deleted again by selecting 'Delete HEX dump' to make room for saving new data.



```
ABB Switzerland Ltd      Example      REG316*4 Generator Terminal

1000:0000      0004 Error code = stopped
1000:0002      0000 Code segment = 0588H
1000:0004      0164 Module name = PARDEFST_TEXT
1000:0006      0588 Program counter = 0164H
1000:0008      0004
1000:000A      0002
1000:000C      03F0
1000:000E      0418 EEPROM: 00000000000000101
1000:0010      0EE4
1000:0012      0100
1000:0014      14B1
1000:0016      07C8
1000:0018      1B7C
1000:001A      17E9
1000:001C      01AD
1000:001E      0005

On-line 9600 bps SCS:SPA      V6.2b | V6.2b
```

Fig. 6.3 HEX dump

6.8. *IBB information*

Depending on the firmware installed and therefore the choice of the interbay bus, various data on the status of the bus in relation to the station control system and the PC card can be obtained via this menu item.

6.8.1. *SPA bus*

No special information is available about the SPA bus.

6.8.2. LON bus

In the case of LON bus, information about the PC card and the number of messages transmitted and received is provided.

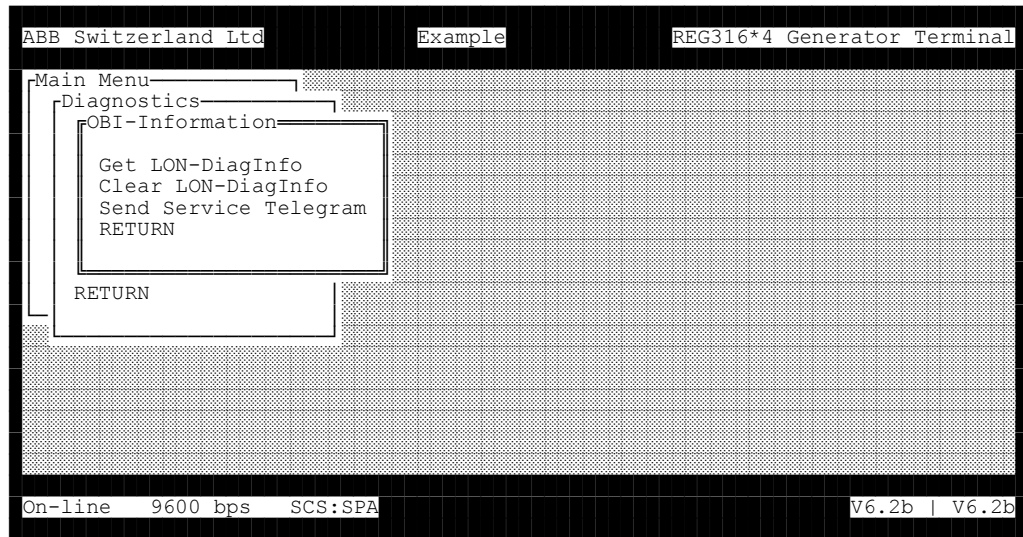


Fig. 6.4 Diagnostic menu for the LON bus

LON bus information

Note: The data displayed is static and not refreshed after it is called.

```

LONDiagInfo:

Neuron Chip ID-Nr.: 000058340300
LON-Interface ID:  DP_MIP
Domain 0: SubnetNr:  1
           NodeNr:   1

LON-Interface Status:
Transmission Errors:          0
Transaction Timeouts:        4
Receiver Transaction Timeouts: 0
Lost Messages:                0
Missed Messages:             0
Reset Cause:                  Software Reset
Interface State:              Configured and Online
Version Number:               4
Error Number:                 0
Model Number:                 0

LON-Driver Status:
Driver State:                  ok!
Cross Table for NetVariables: Valid
No. of Semaphore Hits:        6421
No. of Semaphore Misses:      1227
No. of Semaphore Fails:       3
No. of InBuffer Overflow:     0
No. of transmitted Messages:  4
No. of received Messages:     0
No. of Transmission Fails:    4
No. of OutBuffer Overflow:    0
No. of EventBuffer Overflow:  0
No. of lost incoming Messages: 0
  
```

Fig. 6.5 LON bus information

The table below explains the significance of the various items of information.

Neuron Chip ID-No.	Hardware number of the neuron chip on the PC card
LON interface ID	Must always be set to "DP_MIP".
Domain	Number of the domain to which the device belongs (can be set via the LON bus).
Subnet No.	Number of the sub-network to which the device belongs (can be set via the LON bus).
Node No.	Device node number (can be set via the LON bus).
Transmission errors	Number of errors detected during reception.
Transaction timeouts	Number of transaction confirmations not received.
Receiver transaction timeouts	Number of messages received that were lost, because of incorrect settings at the receiving end.
Lost messages	Number of messages lost, because the receive memory in the RE.316*4 was full.
Missed messages	Number of messages lost, because the receive memory on the PC card was full.
Reset cause	Reason for the last restart executed by the PC card.
Interface Status	Normal: "Configured and on-line".
Version number	PC card firmware version
Error number	0 = no error or error on the PC card.
Model number	Always 0
Driver state	OK or error message
Cross table for network variables	Valid or invalid (table loaded via the LON bus).
No. of semaphore hits	Information for ABB purposes
No. of semaphore misses	Information for ABB purposes
No. of semaphore fails	Information for ABB purposes
No. of IN buffer overflows	Number of messages lost, because the driver buffer was full.
No. of transmitted messages	Total number of messages transmitted since the information was deleted.
No. of received messages	Total number of messages received since the information was deleted.

No. of OUT buffer overflows	Number of messages that could not be transmitted, because the buffer on the PC card was full.
No. of event buffer overflows	Number of events that could not be transmitted, because the buffer on the PC card was full.
No. of lost incoming messages	Number of messages lost, because the driver receive buffer was full.

Delete LON diag. info

Selecting this menu item resets the various diagnostic information counters to zero.

Send service telegram

The menu item causes the PC card to send a service telegram which corresponds to pressing the service button on the PC card. It is needed when configuring the network.

6.8.3. MVB

This menu item provides information about the PC card and the number of messages transmitted and received.

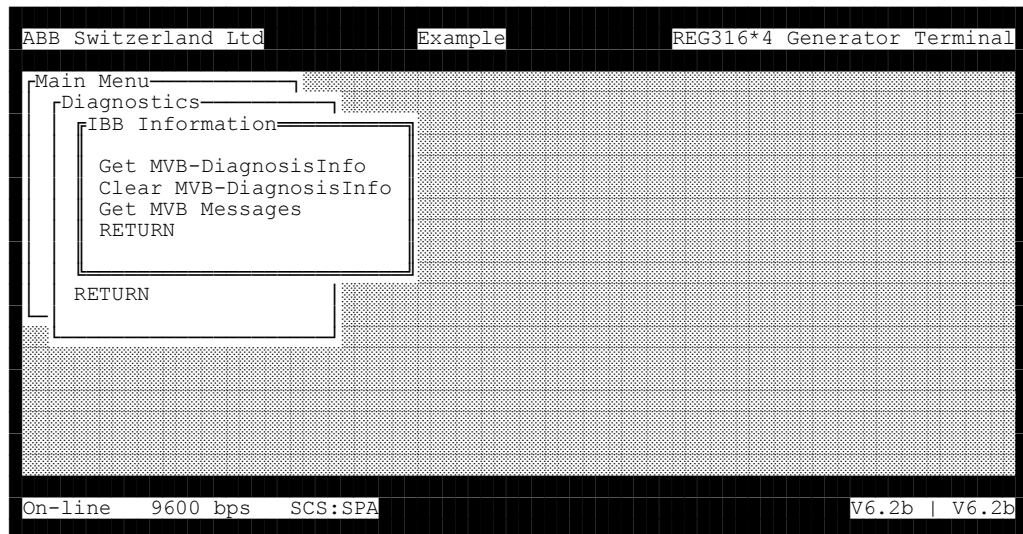


Fig. 6.6 MVB diagnostics menu

MVB information

Note that the information is continuously refreshed.

MVB-IBB-DiagInfo:

```

Working Mode:      InterbayBus
PC-Card Status:    Ready
PC-Card Error:     No Error
PC-Card Type:      InterbayBus
PC-Card SW-Vers:   1.11  1997-12-15
PC-Card HeartBeat: 55384
Driver State:      Ready
Driver Heartbeat:   4877
Nr. of received Messages: 12
Nr. of transmitted Messages: 12
Nr. of Transmission Fails: 0
Nr. of lost incoming Messages: 0
  
```

Fig. 6.7 MVB information

The table below explains the significance of the various items of information.

Working mode	Indicates the function of the PC card as connection to the inter-bay bus. If a PC card is not inserted, "Not connected" is displayed on this line.
PC-Card Status	Initialising, Ready, Minor error, Fatal error
PC-Card Error	No error, Unknown error, No response, Init. Error, Subsystem error etc.
PC-Card Type	Inter-bay bus. If a PC card is not inserted, "Software unknown" is displayed.
PC-Card SW-Vers.	PC card firmware date and version
PC-Card Heartbeat	Signals whether the PC card firmware is active or not.
Driver State	Initialising, Ready, Minor error, Fatal error
Driver Heartbeat	Signals whether the driver software in the RE.316*4 is active or not.
No. of received messages	Total number of messages received since the information was deleted.
No. of transmitted messages	Total number of messages received since the information was deleted.

No. of transmission fails	Number of errors while transmitting a message, for example, because the buffer on the PC card was not available.
No. of lost incoming messages	Number of messages lost, because the driver receive buffer was full.

Delete MVB diag. info

Selecting this menu item resets the various diagnostic information counters to zero.

Load MVB messages

Selecting this menu item displays the last message sent or received and also the last event transmitted. These data are only needed for development purposes and are not described in more detail for that reason.

6.8.4. VDEW bus

No special information is available for the VDEW bus.

6.9. RIO information

Information is displayed on the status of the process bus and the distributed input/output system. A detailed description of the data is given in publication 1MRB520192-Uen.

6.10. Resetting SCS data

After entering his password, an authorised user can delete the SCS input data.

6.11. Load SCS mask

This menu item provides facility to import a form (mask) from a file that was created using the MMI documentation function to configure the transfer of events via the SCS.

Part of a file of this kind is given below. In this case, the file only contains text and it can therefore be edited if necessary using a normal editor. Every possible event is listed with channel and event number (see [Index 9](#)). “OFF” means that an event is “masked”, i.e. it cannot be transferred to be recorded as an event. Conversely “ON” that it is transferred and recorded. The file is created automatically by the MMI and enables all the events that have been configured.

Extract from the file “recxx.evt”:

```
0E1  OFF
0E2  OFF
0E3  OFF
0E4  OFF
0E5  OFF
0E6  OFF
0E7  OFF
0E8  OFF
```

.....

February 00

7. INSTALLATION AND MAINTENANCE

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7. INSTALLATION AND MAINTENANCE

7.1. *Summary*

The place of installation and the ambient conditions must conform to the data given in the data sheet ([see Index 8](#)). Sufficient room must be left in front and behind the equipment to allow access for maintenance or adding to the system. Air must be allowed to circulate freely around the unit.

During the course of commissioning, all the wiring to the unit must be checked and the auxiliary supply voltage and the voltage for the opto-coupler inputs must be measured.

Functional testing can be carried out with the aid of the test set Type XS92b.

All the essential functions of the protection are subject to continuous self-testing and monitoring and therefore periodic maintenance and testing are not normally necessary.

It is recommended, however, to check the values of the voltages and currents of the external circuits from time to time using the on the input channel display on the HMI. The tripping circuits should be tested at the same time.

7.2. Installation

7.2.1. Checking the shipment

Check that the consignment is complete upon receipt. The nearest ABB agent must be notified immediately should there be any discrepancies in relation to the delivery note, shipping papers or the order.

Visually check the state of all items when unpacking them. Should any damage be found, the last carrier must be informed immediately followed by a claim in writing pointing out his responsibility for the damage. Also inform your nearest ABB office or agent and ABB Switzerland Ltd, Department UTAAA-P, CH-5401 Baden, Switzerland.

If the equipment is not going to be installed immediately, it must be stored in a suitable room in its original packing.

7.2.2. Place of installation and ambient conditions

When choosing the place of installation, ensure that there is sufficient space in front of the equipment, i.e. that the serial interface connector and the local control and display unit are easily accessible.

In the case of semi-flush mounting or installation in 19" equipment racks, space behind the equipment must be provided for adding ancillary units (e.g. 316DB61 and 316DB62), replacing units and changing electronic components (firmware).

Since every piece of technical equipment can be damaged or destroyed by inadmissible ambient conditions,

- the relay location should not be exposed to excessive air pollution (dust, aggressive substances)
- severe vibration, extreme changes of temperature, high levels of humidity, surge voltages of high amplitude and short rise time and strong induced magnetic fields should be avoided as far as possible
- air should be allowed to circulate freely around the equipment.

The equipment may be mounted in any attitude, but is normally mounted vertically (for reading the display and frontplate markings).

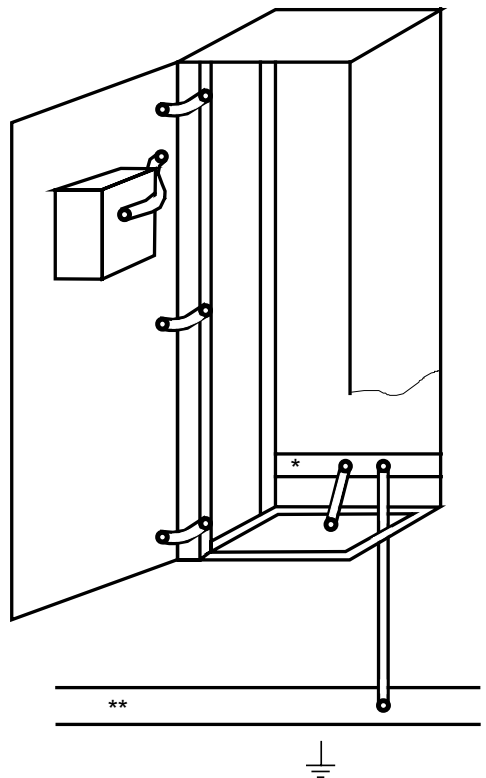
7.2.2.1. Guidelines for RF grounding

Grounding the casing in a cubicle

Connect the rear of the casing (individual unit or rack) to the hinged frame in the cubicle by a braided copper strip (at least 2 cm wide) which should be as short as possible. To prevent corrosion, a **Cupal disc** (copper-plated aluminium) must be inserted between aluminium and copper parts.

Connect the ground rail in the cubicle to the plant ground.

The interconnecting cable must have at least the same gauge as the ground rail in the cubicle.



HEST 965 021 FL

- non-insulated connection
- * ground rail
- ** plant ground

Fig. 7.1 RF grounding in a cubicle

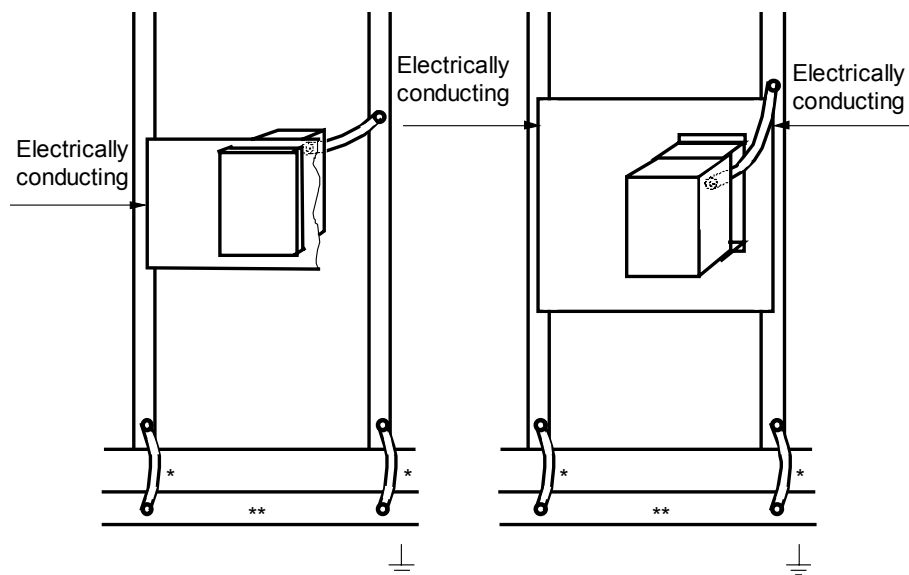
Grounding a casing in a rack

The equipment is fitted with a grounding screw ($\perp$) to which a flexible copper braiding (at least 2 cm wide) must be connected.

A suitable tinned copper braided connection of the correct length and fitted with lugs is available from ABB Switzerland Ltd (Order No. 1MRB 400047).

Choose the shortest possible route to the nearest grounding point on the cubicle frame or mounting plate, which must have a direct connection to the station ground.

All metal surfaces used for the ground connections must be protected against corrosion and be good electrical conductors, i.e. no paint or non-conducting agents.



HEST 965 022 FL

- non-insulated connection
- * braided copper (at least 3 cm wide)
- ** plant ground

Fig. 7.2 RF grounding for semi-flush mounting

Fig. 7.3 RF grounding for surface mounting

7.2.2.2. Guidelines for wiring rack assemblies

Where **digital protection devices** (individual units) or **protection systems** are supplied in a rack, it is essential that the binary inputs and outputs (BIO's) and the auxiliary supply which have to be wired from the rack to the cubicle terminals be run separately from the c.t. and v.t. cables (**not** in the same duct or loom).

This precaution reduces the parallel coupling of conducted interference.

Should this not be possible along the whole route, parallel coupling can be reduced by crossing at right angles. **Complete separation, however, is to be preferred.**

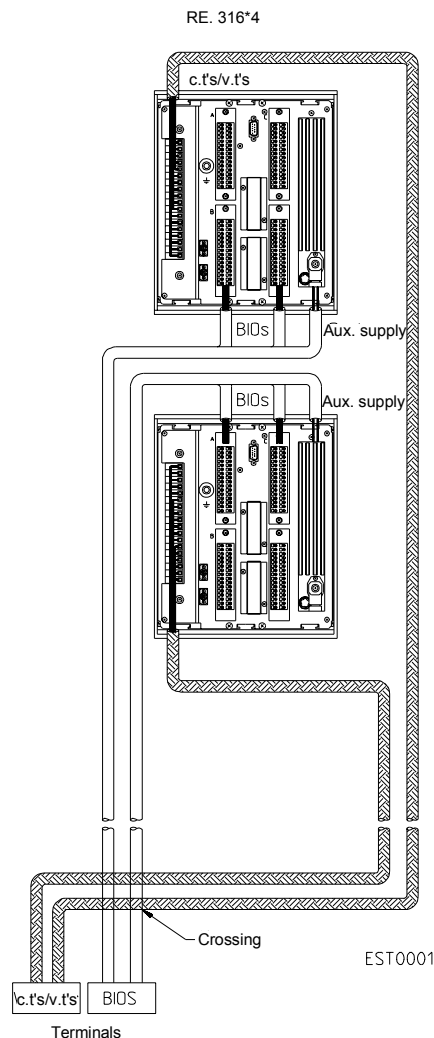


Fig. 7.4 Separation of rack wiring in a cubicle

Screened leads must be used for the c.t. and v.t. wiring from the terminals to the equipment.

Recommendation

It is also recommended to use screened leads for the binary inputs and outputs (BIO's) and the auxiliary supply.

The following applies if the equipment is not installed in a cubicle:

The terminals should be as close as possible to the equipment terminals so that the unscreened lengths of cables are very short!

Screened c.t., v.t., binary input and output and auxiliary supply cables can be secured in one of the following ways:

Assemblies fitted into panels:

C.t. and v.t. leads to the terminals can be secured, for example, to a surface (steel rail) using cable clamps. The surface must be in direct contact with the plant ground and the cable screens must make good contact with the cable clamps all the way round.

This, however, is not always the case and the screen is frequently not in contact at the sides which impairs the screening effect. To overcome this drawback, a **special ** copper braid tape** can be wound on top of the cable screen in the region of the clamps. This then ensures maximum screening efficiency.

****** Suitable tinned copper braid tape is available from **3M** under the designation:

"Scotch No. 24"

(Fitting instructions should also be requested.)

Assemblies fitted into cubicles: (2 alternatives)

- a) The c.t. and v.t. cables going to the terminals can pass through cable glands. Again the cable screens must be in good contact with the gland all the way round and the gland with the plant ground (e.g. via the panel or strip material in which the gland is fitted).

C.t. and v.t. leads to the terminals can be secured, for example, to a surface (steel or copper) using conduit clamps. The surface (e.g. floor plate) must be in direct contact with the plant ground and the cable screens must make good contact with the conduit clamps all the way round.

- b) This, however, is not always the case and the screen is frequently not in contact at the sides which impairs the screening effect. To overcome this drawback, a **special ** copper braid tape** can be wound on top of the cable screen in the region of the clamps. This then ensures maximum screening efficiency.

To prevent corrosion, a **Cupal disc** (copper-plated aluminium) must be inserted between aluminium and copper parts.

7.2.3. ***Checking the c.t. connections***

The c.t.'s must be connected in strict accordance with diagram supplied with the equipment.

The following checks must be carried out to check the c.t.'s and c.t. circuits:

- polarity check
- primary injection test
- plot the excitation curve
- c.t. circuit grounding.

The polarity check (as close as possible to the protection equipment) not only checks the current input circuit as a whole, it also checks the phase-angle of the c.t.

Primary injection checks for a ratio error and the wiring to the protection equipment. Each phase-to-neutral and phase-to-phase circuit should be injected. In each case, the phase currents **and** the neutral current should be measured.

The relative polarities of the c.t.'s and their ratios can also be checked using load current.

Plotting the excitation curve verifies that the protection is connected to a protection core and not a metering core.

Each electrically independent current circuit may only be earthed in one place, in order to avoid balancing currents created by potential differences.

Core-balance c.t.'s

If the residual current is obtained from a core-balance c.t., the ground for the cable screen must first be taken back through the core-balance c.t. before connecting it to ground. The purpose of this is to ensure that any spurious E/F current flowing along the screen of the cable cancels itself and is not measured falsely as an E/F on the relay's own feeder.

7.2.4. **Checking the v.t. connections**

The v.t.'s must be connected in strict accordance with diagram supplied with the equipment.

The following checks must be carried out to check the v.t. circuits:

- polarity check
- wiring check
- v.t. circuit grounding.

The rated voltage of an E/F protection scheme is defined as the voltage which occurs between the terminals “e” and “n” for a solid phase-to-ground fault. An E/F of this kind, e.g. on T phase (see Fig. 7.5), causes the voltages of R and S phases to increase from phase-to-neutral to phase-to-phase potential and these add vectorially to produce a voltage between terminals “e” and “n”, which is three times the phase-to-neutral voltage.

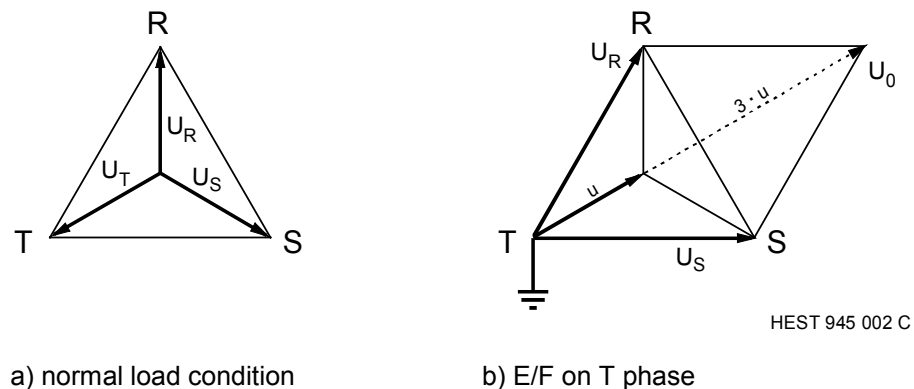


Fig. 7.5 Voltages in an ungrounded three-phase power system

7.2.5. **Checking the auxiliary supply connections**

Check that the supply is connected with the correct polarity. The d.c. supply voltage must lie within the permissible operating range of the power supply unit installed under all operating conditions (see Technical Data for the respective power supply unit).

The power supply unit, type 316NG65 is protected by a fuse, type T 3.15 A.

7.2.6. *Checking the duty of the tripping and signalling contacts*

Check that the loads connected to all the contacts are within the specified ratings given in the “Contact ratings” section of the data sheet.

7.2.7. *Checking the opto-coupler inputs*

Check the polarity and supply voltage of all opto-coupler inputs in relation to the ordering code (also given on the rating plate at the rear of the equipment).

7.3. Commissioning

Before commencing commissioning, i.e. before the station is energised, carry out the checks given in [Section 7.2](#).

7.3.1. Connecting the setting and control PC

Connect the serial interface of the PC to the interface connector on the front of the equipment. Details of the communication parameters and the connector pins are given in the following Sections.

7.3.1.1. Minimum PC requirements

The minimum requirements to be fulfilled by the HMI PC are:

- MS Windows 3.1x, Windows 95 or Windows NT4.0 operating system or higher
- 16 MByte RAM
- 1 floppy drive (3½"; 1.44 MByte) and a hard disc with at least 12 MByte of free space
- 1 serial interface (RS-232C)
- 1 parallel interface (Centronics).

7.3.1.2. Serial interface parameters

The HMI initialises the serial interface and automatically sets the corresponding parameters.

7.3.1.3. PC connecting cable

The connecting cable between the serial interface connectors on the frontplate of the protection equipment (optical connector on the front of the local control and display unit) and on the PC (9-pin SUB-D plug) is an optical fibre cable with the order No. 1MRB380084-R1 ([see Data Sheet](#)).

7.3.2. **Connecting the equipment to the auxiliary d.c. supply**

The plug for the auxiliary supply is inserted upon delivery in the connector at the rear of the power supply unit. This plug must be fitted to the power supply cable as shown in Fig. 7.6.

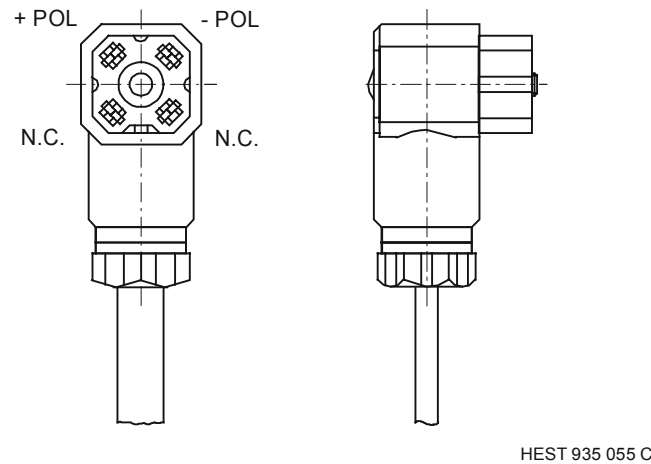


Fig. 7.6 Auxiliary supply plug

7.3.3. **Connecting the binary inputs and outputs**

In the case of the narrow casing (N1), the binary inputs and outputs have to be wired to connectors C and D at the rear for the first unit and to connectors A and B for the second unit.

In the case of the wide casing (N2), the binary inputs and outputs have to be wired to connectors G and H at the rear for the first unit, to connectors E and F for the second, to connectors C and D for the third unit and to connectors A and B for the fourth unit.

All external auxiliary relays or other inductances controlled by signals from the protection must be fitted with free-wheel diodes across their coils.

Instructions for wiring the terminals

- **Type and gauge of wire:**
The signal connections to the terminals are made with 1.5 mm² stranded wire. Do **not** use crimped sleeves or other terminations; the flexible cores are protected by the design of the terminals.
- **Terminating the wires:**
Do not strip more than 10 mm of insulation from the ends of

the wires. Insert the stripped ends of the cores perpendicularly to the rear of the device into the terminals and secure them by tightening the screw next to each one. As the channel for the wire in the terminals is slightly curved, twisting the wires slightly when inserting them is a help. Only insert one stranded wire into each terminal.

Take care that no strands protrude that may cause arcing or short-circuits.

- Bridging terminals:
Where it is necessary to bridge terminals, do so at external terminals on the cubicle.

7.3.4. *Connecting v.t. and c.t. circuits*

Instructions for wiring the terminals

- Type and gauge of wire:
The v.t. and c.t. connections to the terminals are made with 2.5 mm² stranded wire (e.g. H07V-K). The ends of the wires in this case must be fitted with crimped sleeves.
V.t. and c.t. connections may be made alternatively by 4 mm² solid wire.
- Terminating the wires:
Insert the ends of the wires perpendicularly to the rear of the device into the terminals and secure them by tightening the screw next to each one.
Take care that no strands protrude that may cause arcing or short-circuits.
- Bridging terminals:
Where it is necessary to bridge neighbouring terminals, do so directly at the protective device using standard links (e.g. as manufactured by PHOENIX). The terminals are designed to accommodate these in addition to a 2.5 mm² gauge lead. Alternatively, circuits have to be bridged at external terminals on the cubicle.

7.3.5. ***Connecting optical fibre cables for the longitudinal differential protection***

Optical fibre cables are connected using Type FC connectors.

Take care when inserting the connectors that only to tighten the screw fitting after checking that the nose on the plug is properly seated in the groove of the base.

To exclude any risk of false tripping when connecting or disconnecting a cable in operation, only do so after the auxiliary supply to at least one of the terminal units has been switched off.

In cases where the terminal units are connected via communications devices such as FOX-U, ensure that the communication in both directions is via the same route (equal lengths).

7.3.6. ***Commissioning tests***

For the protection scheme as a whole to operate correctly, it is not enough for just the protection equipment itself to be in order, the reliable operation of the other items of plant in the protection chain such as circuit-breakers, c.t's and v.t's (e.g. protection and metering core leads exchanged), station battery (earth fault), alarm and signalling circuits etc. and all the cabling is equally important.

The correct operation of the equipment itself is determined by the following tests:

- secondary injection of every current and voltage input
- activating and deactivating every binary input (opto-coupler)
- energising and de-energising every auxiliary tripping and signalling relay
- checking the settings (printed by the HMI).

These tests confirm that none of the protection hardware is defective. The actual protection functions are contained in the software and are continuously monitored. They do not therefore need to be especially tested during commissioning.

The following is a list of some of the tests and the faults they are intended to disclose.

Test	Faults disclosed
Injection of rated value at all c.t. and v.t. inputs (e.g. using test set Type XS 92b)	Hardware defective Wrong rated current Wrong rated voltage Wrong reference value
Activation/deactivation of all binary inputs (opto-couplers)	Hardware defective Incorrect setting (not inverted) Incorrect assignment
Energisation of all auxiliary tripping relays (using the test function)	Hardware defect Incorrect assignment
Energisation/de-energisation of all auxiliary signalling relays (using the test function)	Hardware defect Incorrect assignment

A further useful facility is provided by the “Display analogue values” menu which enables the currents and voltages applied to the protection to be viewed. It can thus be seen whether the amplitude and phase of the currents and voltages are correct. The Appendix in [Index 12](#) includes a test report.

7.4. Maintenance

Because of the self-testing and monitoring features included, the equipment requires neither special maintenance nor periodic testing.

Where testing is considered necessary, the following procedure is recommended:

- Measure the currents and voltages in the secondaries of the main c.t's and v.t's and compare the results with the values displayed by the HMI.
- Test the external circuits using the test functions provided by the HMI ([see Section 5.9.](#)).

The life of the wet electrolytic condensers is about 20 years. This assumes a mean ambient temperature outside the casing of 40 °C. An increase of 10 °C shortens the life by half and a decrease of 10 °C extends it by half.

7.4.1. Fault-finding

7.4.1.1. Stand-by LED on the frontplate

The following may be possible causes, should the green stand-by LED not light continuously, but be extinguished or flash although the auxiliary supply is switched on:

Stand-by LED extinguished

- The auxiliary supply unit Type 316N65 is not properly inserted or is defective. Insert properly or replace the unit.
- The input/output unit Type 316DB6. is not properly inserted or defective. Insert properly or replace the unit.
- The logic processor Type 316VC61a or 316VC61b is defective. Replace either the main processor unit or the complete equipment.

Green stand-by LED flashes

- The equipment does not have a valid set of parameter settings.
- The active set of parameters and the 'software key' do not agree.

- A hardware fault has been discovered by the diagnostic function on either the Type 316VC61a/316VC61b or 316EA62 unit.

To determine whether a set of settings has been downloaded to the equipment, connect it to a PC and start the HMI. Check via the menus 'Editor' and 'Edit function parameters' and 'Edit hardware functions' whether functions have settings and whether the hardware has been configured.

If the settings appear in order, check whether parameters or functions have been entered which are not permitted by the 'software key'.

Should it appear that there is a disagreement with the 'software key', proceed as follows:

- Connect the equipment to a PC and start the HMI.
- Download a slightly changed set of settings to the equipment. The HMI then compares the 'software key' with the programmed functions before it actually downloads the settings and reports an error if they do not agree (EPLD error).

7.4.1.2. Human/machine interface

If communication between the protection equipment and the PC this is not possible in spite of the fact that the stand-by LED is lit, first check the serial interface connectors and connecting cable. Where the connection appears to be in order, reboot the PC by switching it off and on and then restart the HMI.

Should this also prove unsuccessful, restart the device either by selecting the menu item 'Warm start' in the RESET menu on the local control and display unit (see [Section 5.13.8.6.](#)) or by holding the reset button depressed until the stand-by LED (green) starts to flash (about 10 seconds). This is a software restart, which is equivalent to switching the auxiliary supply off and on.

In the event of a defect, send the diagnostic information obtained via 'List DiagInfo' and 'Get Hex Dump' together with the device settings to your local support centre.

The following example is of a ROM defect in the main processor unit:

List DiagInfo:

```

MODURES 316 Diagnosis

Relay status : fatal error
Main processor VC61 status : Fault detected
  ROM
    HW number : 000000B0A538
    Software   = 1995-08-11 11:38;00
    Setting    = 1992-01-03 09:44;05
    Protection stop
A/D processor EA6. status : not ready
internal A/D status : no error

FUPLA status: FUPLA not loaded

Press any button to continue; press <ESC> to close.
```

Get Hex Dump:

```

1000:0000      0004 Error code = stopped
1000:0002      0000 Code segment = 00D8H
1000:0004      06D9 Module name = RUNPROT TEXT
1000:0006      00D8 Program counter = 06D9H
1000:0008      0004
1000:000A      0052
1000:000C      01F1
1000:000E      0178 EEPROM: 00000000000000101
1000:0010      0199
1000:0012      00A0
1000:0014      00E1
1000:0016      0730
1000:0018      0000
1000:001A      0000
1000:001C      0000
1000:001E      0005.
```

7.4.1.3. *Restarting*

The detection of an error or defect by the self-testing and monitoring functions during normal operation initiates the following:

- Processing by the protection functions is stopped and their operation blocked.
- The binary outputs are reset and further operation blocked. This includes resetting the 'Relay ready' signal, if it was activated.
- The stand-by signal (green LED on the frontplate) flashes.

Communication between the PC and the protection equipment remains intact, however, and provides facility for localising the cause of the problem.

Blocking of the protection is maintained until an attempt is made to restart it by pressing the reset button on the frontplate. Should restarting be successful, but the original defect still exists, the same sequence is repeated and the protection is blocked once again.

Either the 316VC61a or 316VC61b unit or the complete equipment has to be replaced in the case of error messages concerning the main or logic processors.

Should the diagnostic function report an error in the A/D processor (type 316EA62) although none is fitted, the message can be ignored. If one is fitted, however, it must be replaced.

An entry is made in the event list every time the protection is restarted.

7.5. Software updates

Updating the software with the latest version and where necessary also the hardware can add new functions or new features to the device.

The software version can be is given in the bottom right-hand corner of the HMI screen when it is operating on-line (the first number is the version of the HMI and the second number the version of the software in the equipment).

The HMI is compatible with the equipment software when the first digit after the point is the same in both numbers.

The equipment software can be updated without opening the equipment, because it is stored in a read/write memory (flash EPROM's).

Generally the software must be updated by ABB personnel. Nevertheless, the procedure is described below so that it can be performed by correspondingly qualified personnel (PC experience essential) if necessary.

7.5.1. Settings

Make a backup copy of the settings using the HMI (menu items 'Enter function parameters' and 'Save in file'). Then close the HMI.

7.5.2. Deleting the settings and the program and downloading a new program

The following additional files which are necessary to update the firmware are in the HMI directory after installation:

- spa316a.h26, lon316a.h26, vdew316a.h26: Software for the processor unit 316VC61a, depends on communications protocol.
- spa316b.h26, lon316b.h26, vdew316b.h26: Software for the processor unit 316VC61b, depends on communications protocol.

- spa316a.bat, lon316a.bat, vdew316a.bat: Batch file for loading the software into the processor unit 316VC61a, depends on communications protocol.
- spa316b.bat, lon316b.bat, vdew316b.bat: Batch file for loading the software into the processor unit 316VC61b, depends on communications protocol.

The type of processor board can be determined using the HMI diagnostic function. Upon selecting 'Show diagnostic data', one of the lines displayed is 'HW No.', which in the case of 316VC61**a** includes the code '0434':

HW-No.: xxxx/**0434**/xx

or for 316VC61**b** the code '04Ax':

HW-No.: xxxx/**04Ax**/xx

The new software is loaded into devices with the existing software version V5.0 is accomplished by running the corresponding batch file. For this purpose, make the active directory the HMI directory via the File Manager (Windows 3.1 or 3.11) or Explorer (Windows 95, 98 or NT 4.0) and execute the appropriate batch file. The version, type of processor board (316VC61a or 316VC61b) and the desired communication protocols are then displayed again. Click on N (no) to abort or on Y (yes) to continue.

The HMI proper does not then start, but simply a window appears with the question 'Are you sure? <Y>/<N>' as a safety precaution. If you enter 'N' the normal HMI starts; if you enter 'Y' the settings and the program are instantly deleted. The deleting procedure takes about twenty seconds. During this time 'Saving restart relay' flashes on the screen.

At the end of this operation, the file '*.h26' is transferred to the equipment. This takes about 5 minutes. During this time the progress is indicated by numbered lines and dots:

33.....

After transfer has been completed, the new program starts automatically and the time stamp of the *.h26 file is saved in the equipment.

During the whole of this operation do not make any entries at the keyboard of the PC, as this interrupts the automatic procedure.

7.5.3. *Problems transferring the new software*

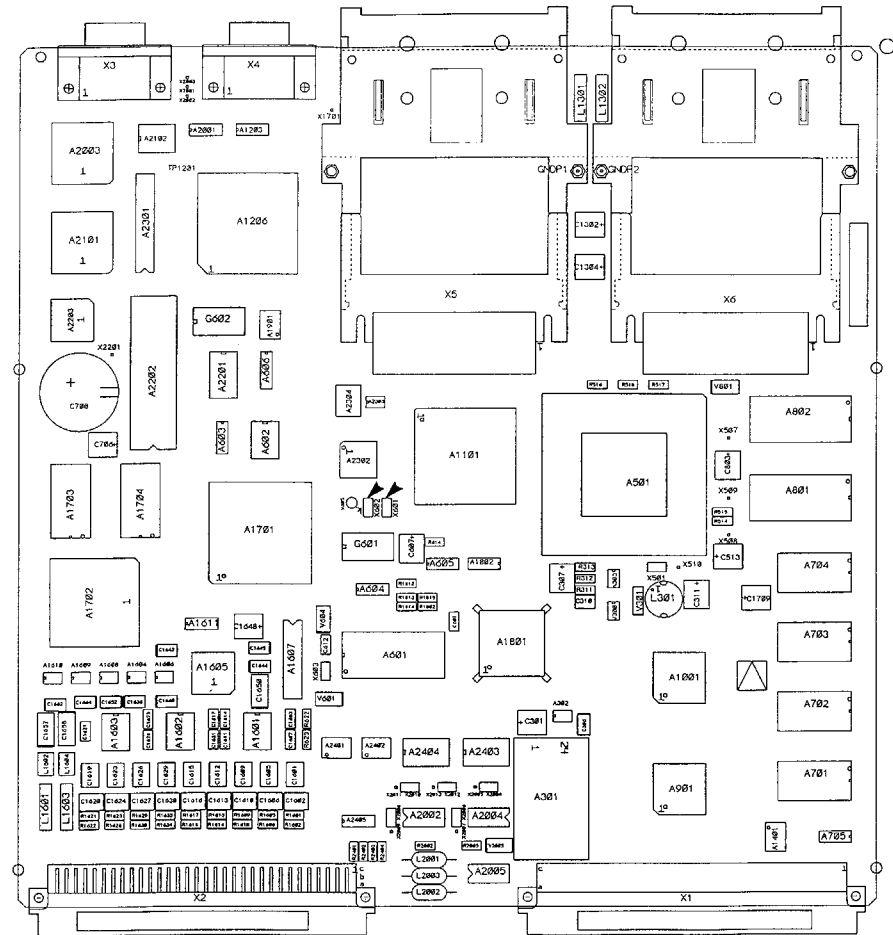
Problems and errors can never be excluded when transferring and saving new software (e.g. supply failure during transfer). Should something of this kind occur, an attempt can be made to repeat the transfer by executing the batch file again. If the equipment responds neither to the call by the batch file nor the HMI, try to reinitialise the equipment by switching the auxiliary supply off and back again and then repeat the transfer of the program file.

Should this also prove unsuccessful, the following procedure must be executed to delete the contents of the program memory in the main processor unit:

Devices with the main processor unit 316VC61a have to be opened and the main processor unit removed from them. Fit the two jumpers X601 and X602 and reinsert the main processor unit. Switch on the auxiliary supply and wait for thirty seconds. Switch off the auxiliary supply and withdraw the main processor again. The program is now deleted. Remove the two jumpers, plug the main processor in again, reassemble the equipment and repeat the program transfer procedure.

Switch of the auxiliary supply to devices equipped with main processor 316VC61b and then insert the pin supplied into the socket below the SPA or VDEW6 communication interface. Switch on the auxiliary supply for about thirty seconds, switch it off again and withdraw the pin. This procedure deletes the program and the new program can be loaded after switching on the auxiliary supply again.

Should the pin not be available, the same procedure can be used as described in the previous paragraph for the 316VC61a with the exception that the jumper marked 'TEST' has to be inserted instead of X601 and X602.



985041 TIF

Fig. 7.7 Main processor unit 316VC61a showing the jumpers X601 and X602 (derived from HESG 324 502)

7.6. ***Replacing hardware units***

Qualifications

Hardware units may only be replaced by suitably qualified personnel. Above all it is essential for the basic precautions concerning protection against electrostatic discharge be observed.

It may be necessary to transfer existing settings from the relay or download new ones to the relay, procedures which assume familiarity with the HMI.

Note that incorrect handling of the devices and their component parts can cause damage (to the devices or the plant) such as:

- false tripping of items of plant in operation
- destruction of main c.t's and v.t's etc.

The following are basic precautions which have to be taken to guard against electrostatic discharge:

- Before handling units, discharge the body by touching the station ground (cubicle).
- Hold units only at the edges, do not touch contacts or components.
- Only store and transport units in or on the original packing.

Tools required

Relays can be opened at the rear. The backplates are secured either Philips screws or Torx screws. Accordingly one of the following is required:

- Philips screwdrivers No. 1 and No. 2

or

- Torx screwdrivers No. 10 and No. 20.

Terminal screws are always of the normal slotted type. No other tools are required.

Procedure

Follow the check list in the Appendix of [Index 12](#) when replacing hardware units.

The check list is primarily intended for replacing defective units by ones of the same type (same code). If a different relay configuration is desired or necessary, units may have to be re-

placed. A change of software may also be involved. At least the codes in the relay and on the rating plate will have to be corrected. Where problems arise, consult ABB Switzerland Ltd.

In order to keep records of the PCB's installed up-to-date, the corresponding data should be forwarded to ABB Switzerland Ltd, when PCB's are changed ([see Appendix](#)).

Caution:

When replacing a processor board Type 316VC61a, the positions of the jumpers must be checked in relation to Fig. 7.8.

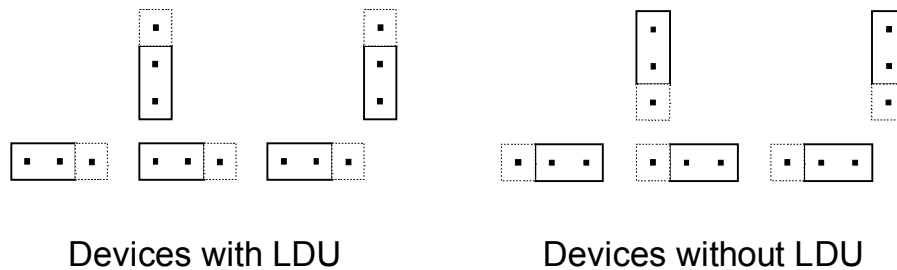
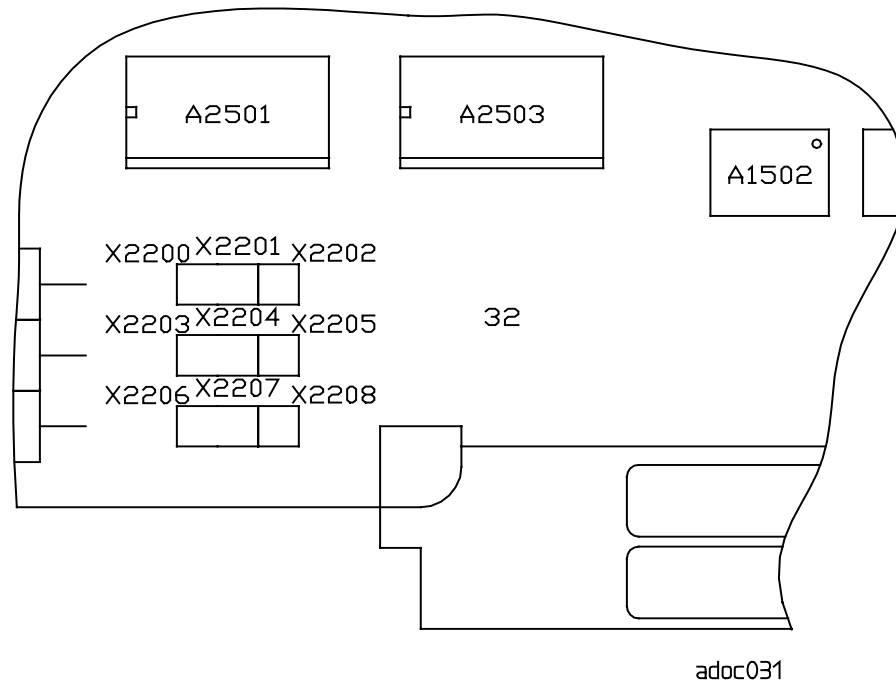


Fig. 7.8 Jumper positions on the processor board 316CV61a for devices with and without the local control and display unit (LDU)

Caution:

If a processor board, type 316VC61b is replaced in a unit, check the jumpers according to Fig. 7.9. These jumpers are located between the two connectors.



Including LDU: X2200 – X2201
X2203 – X2204
X2206 – X2207

Excluding LDU: X2201 – X2202
X2204 – X2205
X2207 – X2208

Fig. 7.9 Jumper positions on the 316VC61b processor board for devices including and excluding a local control and display unit (LDU) on the front (derived from HESG 324 526)

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8. TECHNICAL DATA

Data Sheet REG 316*4.....1MRK502004-Ben

Data Sheet REX 010 / REX 011 1MRB520123-Ben

C.t. requirements for the differential
protection of power transformers CH-ES 30-32.10 E

C.t. requirements for the differential
protection of generators..... CH-ES 30-32.20 E



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 applica-

tion 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 sig-

nals 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.

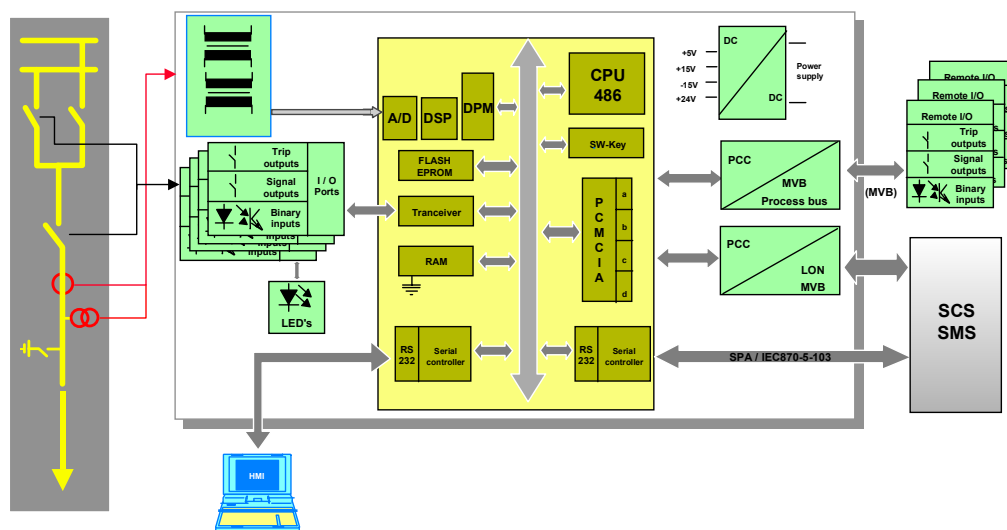


Fig. 1 Hardware platform overview

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 sepa-

rated 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.

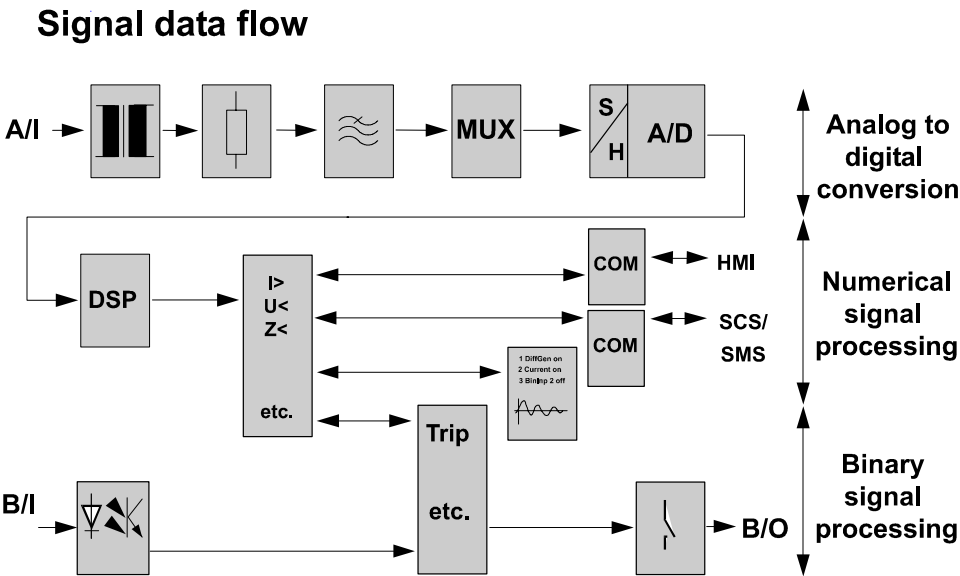


Fig. 2 Data Flow

Graphical
engineering tool

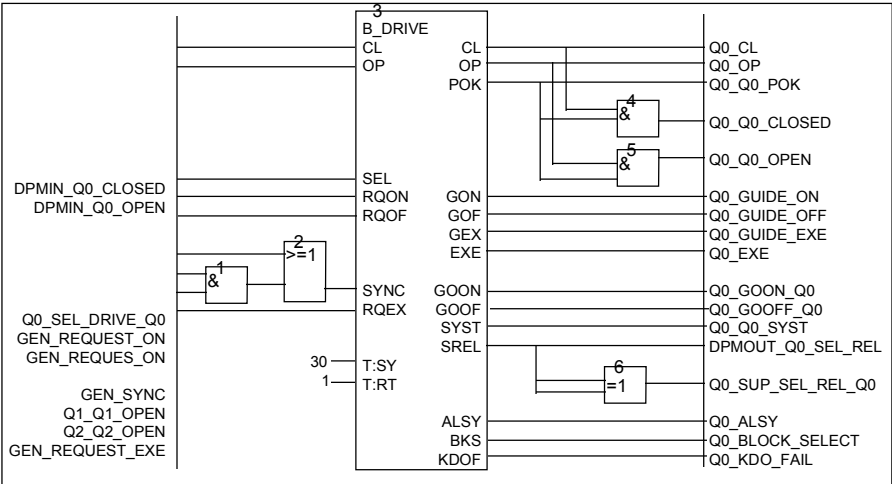
The graphical programming language used in the tool CAP316 makes CAP316 a powerful and user-friendly engineering tool for the engineering of the control and protection units RE.216/316. It is similar to IEC 1131. CAP316 permits the function blocks representing the application to be directly translated 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/subtractor
ADDL	Long integer adder/subtractor
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
PTIS, PTIL	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 under-voltage 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:

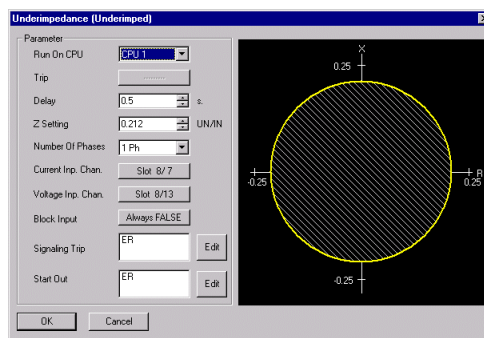
- Windows NT 4.0
- Windows 2000

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.

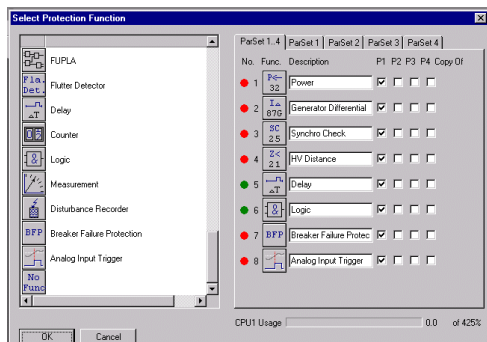
Functions (cont'd)



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 WIN-EVE (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 Hard-
ware (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)	<20 W
during a fault (all relays energized)	
with 1 I/O unit	<22 W
with 2 I/O units	<27 W
with 3 I/O units	<32 W
with 4 I/O units	<37 W
Additional load of the options SPA, IEC 60870-5-103 or LON interface	1.5 W
MVB interface	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	-10° C to +55° C	EN 60255-6 (1994),
storage	-40° C to +85° C	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 interfer- ence at power system frequen- cies	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% I_N in steps of 1% I_N
Tripping stage	50 to 200% I_N in steps of 1% I_N
Thermal time constant	2 to 500 min in steps of 0.1 min
Accuracy of the thermal image	$\pm 5\%$ I_N (at f_N) with protection c.t.'s $\pm 2\%$ I_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)	$\pm 5\%$ or $\pm 0.02 I_N$
Reset ratio	
overcurrent	>94 % (for max. function)
undercurrent	<106 % (for min. function)
Max. operating time without intentional delay	60 ms
Inrush restraint	optional
pick-up setting	0.1 I_{2h}/I_{1h}
reset ratio	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)	$\pm 2\%$ or $\pm 0.005 U_N$
Reset ratio ($U \geq 0.1 U_N$)	
overvoltage	>96% (for max. function)
undervoltage	<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)	±5% or ±0.02 I_N
Reset ratio	>94%
Accuracy of angle measurement (at 0.94 to 1.06 f_N)	±5°
Voltage input range	0.005 to 2 U_N
Voltage memory range	<0.005 U_N
Accuracy of angle measurement at voltage memory	±20°
Frequency dependence of angle measurement at voltage memory	±0.5°/Hz
Max. Response time without delay	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
I_B -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)	$\pm 5\%$
Reset ratio	$> 94\%$
Accuracy of angle measurement (at 0.94 to 1.06 f_N)	$\pm 5^\circ$
Accuracy class of the operating time acc. to British Standard 142	E 10
Voltage input range	0.005 to 2 U_N
Voltage memory range	$< 0.005 U_N$
Accuracy of angle measurement at voltage memory	$\pm 20^\circ$
Frequency dependence of angle measurement at voltage memory	$\pm 0.5^\circ/\text{Hz}$
Max. Response time without delay	60 ms

Table 15: Metering function UlfPQ

• 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 $+180^\circ$ 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

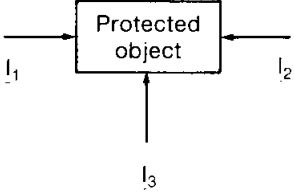
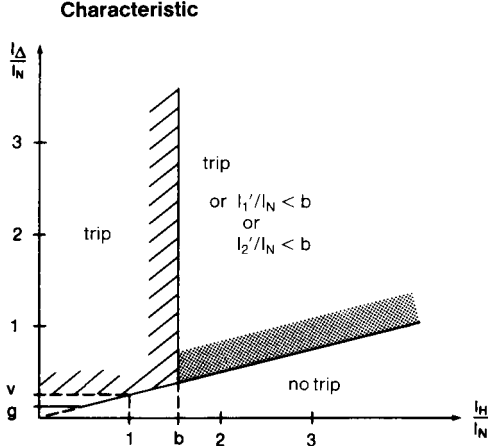
• Three-phase measurement of voltage (star or delta), current, frequency, real and apparent power and power factor. • Two independent impulse counter inputs for calculation of interval and accumulated energy. The three-phase measurement and the impulse counters can be used independently and may also be disabled. • This function may be configured four times.	
Settings:	
Angle	-180° to $+180^\circ$ 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	10 ms
Accuracy of time interval	± 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 $I_{\Delta} > 2 I_N$	≤ 30 ms
- for $I_{\Delta} \leq 2 I_N$	≤ 50 ms
Accuracy of pick-up value of g	$\pm 5\% I_N$ (at f_N)

Table 18: Transformer differential (87T)

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	
Settings:	
g-setting	0.1 to 0.5 I_N in steps of 0.1 I_N
v-setting	0.25 or 0.5
b-setting	1.25 to 5 in steps of 0.25 I_N
Max. trip time (protected transformer loaded)	
- for $I_{\Delta} > 2 I_N$	≤ 30 ms
- for $I_{\Delta} \leq 2 I_N$	≤ 50 ms
Accuracy of pick-up value	$\pm 5\% I_N$ (at f_N)
Reset conditions	$I_{\Delta} < 0.8$ g-setting
Differential protection definitions:	
 $I_{\Delta} = I_1 + I_2 + I_3$ $I_H = \sqrt{I_1' \cdot I_2' \cdot \cos \alpha}$ for $\cos \alpha \geq 0$ 0 for $\cos \alpha < 0$ $\alpha = \arg(I_1' - I_2')$ 2-winding: $I_1' = I_1, I_2' = I_2$ 3-winding: $I_1' = \text{MAX}(I_1, I_2, I_3)$ $I_2' = I_1 + I_2 + I_3 - I_1'$	
 Characteristic Fig. 5 Differential protection characteristic	

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)	$\pm 5\%$ or $\pm 0.02 I_N$
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	$\pm 5\%$ (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)	$t = k_1 / ((I/I_B)^C - 1)$
normal inverse	$c = 0.02$
very inverse	$c = 1$
extremely inverse	$c = 2$
long time inverse	$c = 1$
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 $\pm 4\%$ (1 - I/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 $\pm 4\%$ ($1 - I/80 I_B$)
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	$\pm 2\%$ 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)	$\pm 3\%$ or $\pm 0.005 U_N$
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)

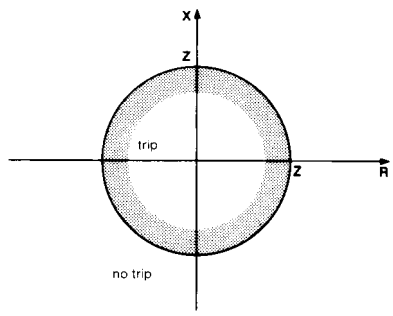
Features: • Detection of two- and three-phase short circuits (back-up protection) • Single- or three-phase measurement • Circular characteristic centered at origin of R-X diagram • Lowest phase value evaluation for three-phase measurement	
	
Fig. 6 Underimpedance protection function characteristics	
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)

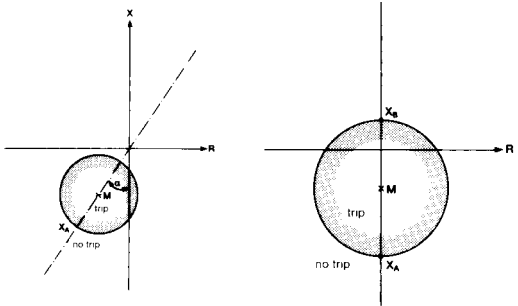
Features: • Detection of loss-of-excitation failure of synchronous machines • Single- or three-phase measurement • Out-of-step detection with additional time delay or count logic • Circular characteristic • Tripping possible inside or outside the circle	
	
Fig. 7 Minimum reactance protection function 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)

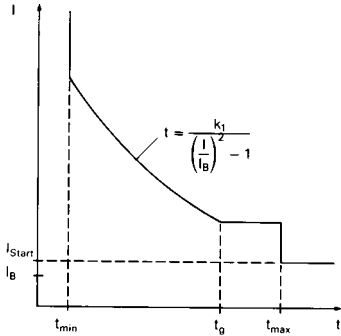
Features: • Single- or three-phase measurement • Operating characteristics according to ASA-C50.13 • Highest phase value for three-phase measurement • Wide time multiplier setting.	
 The graph illustrates the stator overload protection function characteristics. The vertical axis represents current (I) and the horizontal axis represents time (t). A curve starts at a point labeled I_start on the vertical axis and decays towards a horizontal dashed line at I_B. The equation for the curve is given as $t = \frac{k_1}{\left(\frac{I}{I_B}\right)^2 - 1}$. Three specific time points are marked on the horizontal axis: t_min, t_g, and t_max. The curve passes through t_min and t_g, and ends at t_max.	
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)

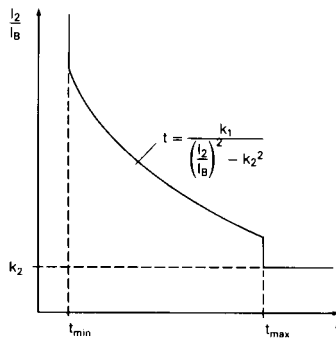
Features: • Protection against unbalanced load • Inverse time delay • Three-phase measurement	
 Fig. 9 Inverse time negative phase sequence current protection function characteristics	
Settings:	
Base current (I_B)	0.5 to 2.5 I_N in steps of 0.01 I_N
Time multiplier k_1	5 to 30 s in steps of 0.1 s
Factor 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	$\pm 2\%$ (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)	$\pm 3\%$ 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	$\pm 3\%$ 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 · UN)	
Settings:	
Voltage difference	0.1 to 0.5 UN in steps of 0.05 UN
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 fN)	±2% or ±0.005 UN
Numbers of phases	1 or 3
Maximum tripping time without delay	≤50 ms
U1R: U2R:	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 $k\Omega$	
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 $k\Omega$ in steps of 0.1 $k\Omega$
Delay	0.2 s to 60 s in steps of 0.1 s
Tripping stage	100 Ω to 20 $k\Omega$ in steps of 0.1 $k\Omega$
Delay	0.2 s to 60 s in steps of 0.1 s
R_{ES}	400 Ω to 5 $k\Omega$ in steps of 0.01 $k\Omega$
Number of star points	2
R_{ES-2} starpoint	900 Ω to 30 $k\Omega$ in steps of 0.01 $k\Omega$
Reset ratio	110% for setting values of $\leq 10 k\Omega$
Accuracy	0.1 $k\Omega$ to 10 $k\Omega$: $<\pm 10\%$
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 $k\Omega$ ($\geq 4.5 \times R_{PS}$)
(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 k Ω in steps of 0.1k Ω
Delay	0.2 s to 60 s in steps of 0.1 s
Tripping stage	100 Ω to 25 k Ω in steps of 0.1k Ω
Delay	0.2 s to 60 s in steps of 0.1 s
R _{ER}	900 Ω to 5 k Ω in steps of 0.01k Ω
Coupling capacity	2 μ F to 10 μ F
Reset ratio	110%
Accuracy	0.1 k Ω to 10 k Ω <10%
Starting time	1.5 s
Functional requirements:	
- total rotor earthing capacity	200 nF to 1 μ F
- rotor earthing resistance R _{PR}	100 Ω to 500 Ω
- rotor earthing resistance R _{ER}	900 Ω to 5 k Ω
- coupling capacity	4 μ F 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 $U_N \cdot I_N$ in steps of 0.001 $U_N \cdot I_N$
Reset ratio	30% to 170% in steps of 1%
Accuracy of the pick-up setting	±10% of setting or 2% $U_N \cdot I_N$ (for protection c.t.'s) ±3% of setting or 0.5% $U_N \cdot I_N$ (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)	$\pm 15\%$
Reset ratio of current measurement	$> 85\%$
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 $\geq 1,2 I_N$) ≤ 38 ms (with main c.t.s TPY and current setting $\geq 0,4 I_N$)

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	$70 \times I_N, 2.2 \times U_N$
Resolution	12 bits
Settings:	
Recording periods	
Pre-event	40 to 400 ms in steps of 20 ms
Event	100 to 3000 ms in steps of 50 ms
Post-event	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 $2 \times I_N$, respectively voltages exceeding $1.2 U_N$	
Accuracy of the pick-up setting at rated frequency	$\pm 2\% I_N$ (at 0.2 to $1.2 I_N$) $\pm 2\% U_N$ (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 UlfPQ 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	$\pm 0.5\% U_N$	$\pm 1\% U_N$	0.2 to 1.2 U_N $f = f_N$
Current	$\pm 0.5\% I_N$	$\pm 2\% I_N$	0.2 to 1.2 I_N $f = f_N$
Real power	$\pm 0.5\% S_N$	$\pm 3\% S_N$	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	$\pm 0.5\% S_N$	$\pm 3\% S_N$	
Power factor	± 0.01	± 0.03	$S = S_N, f = f_N$
Frequency	$\pm 0.1\% f_N$	$\pm 0.1\% f_N$	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

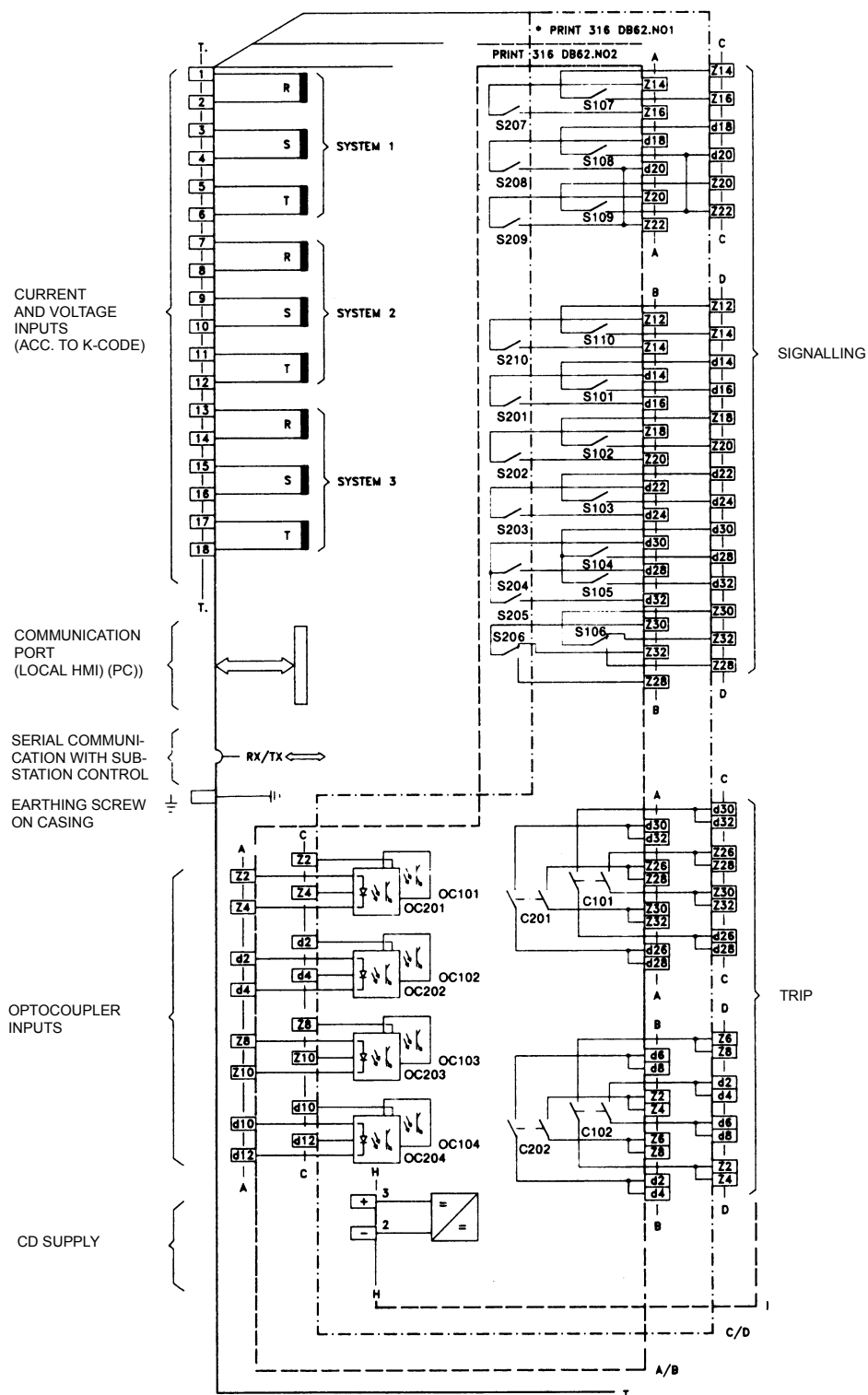


Fig. 12 Typical wiring diagram of REG316*4 in size N1 casing with two input/output units 316DB62

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. HESG448750M0004	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
	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 K62 K63 K64 K65 K66 K67	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-) 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-) 3 CTs (3ph Code A-) 3 CTs (3ph Code C-) 3 VTs (3ph delta Code U-) 3 CTs (3ph Code A-) 3 VTs (3ph delta Code U-) 3 VTs (3ph delta Code U-) 3 CTs (3ph Code A-) 3 CTs (3ph Code C-) 3 CTs (3ph Code D-) 3 CTs (3ph Code A-) 3 MTs (3ph Code B-) 3 VTs (3ph delta Code U-) 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)	CT = current transformer VT = voltage transformer MT = metering transformer	see previous table
E- E1 E2 E3	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	1. binary input/output unit Type 316DB61 1.binary input/output unit Type 316DB62 1.binary input/output unit Type 316DB63	see previous table

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:					
1 REG316*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

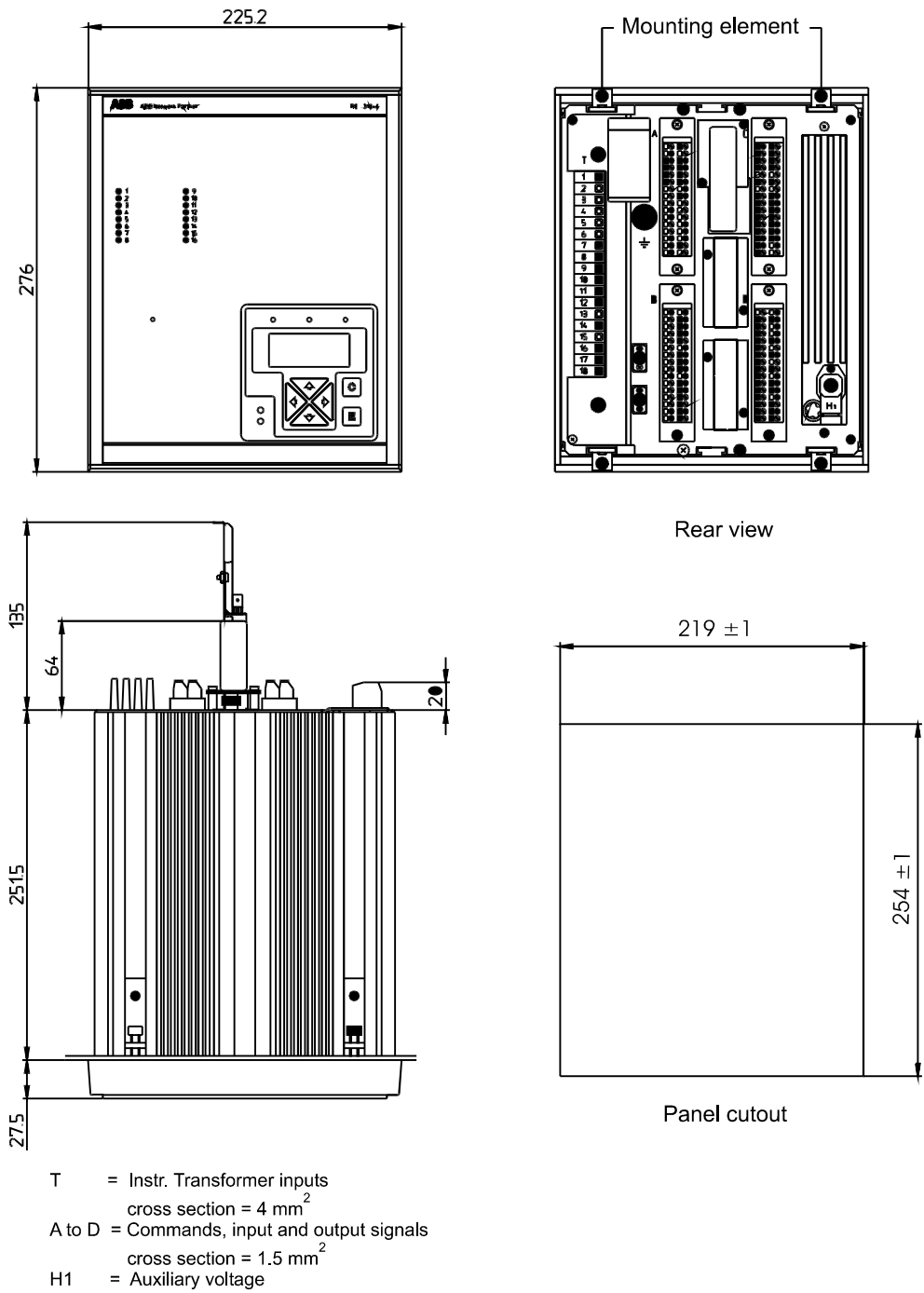


Fig. 13 Semi-flush mounting, rear connections. Size N1 casing.

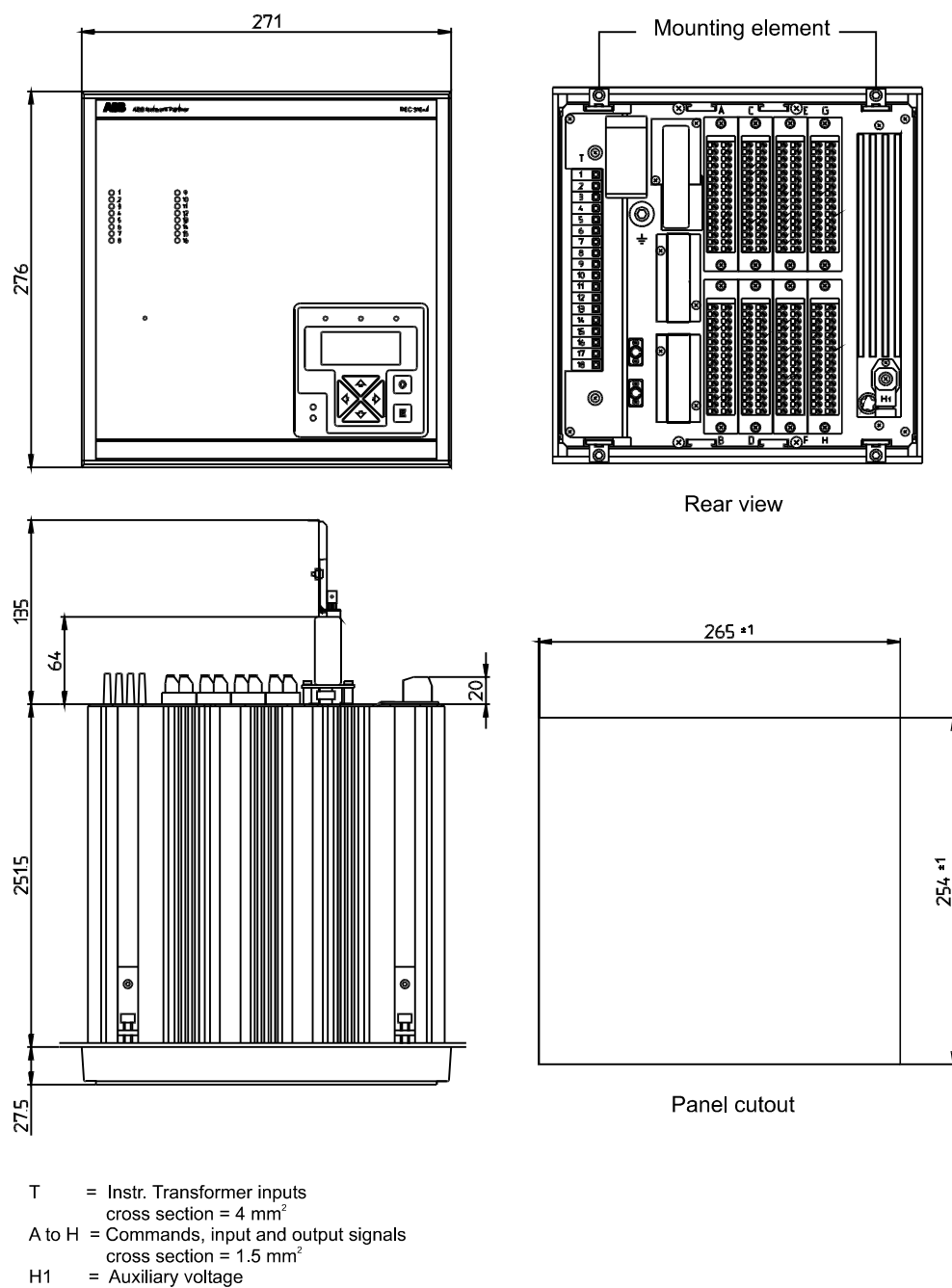


Fig. 14 Semi-flush mounting, rear connections. Size N2 casing

Dimensioned drawings (cont'd)

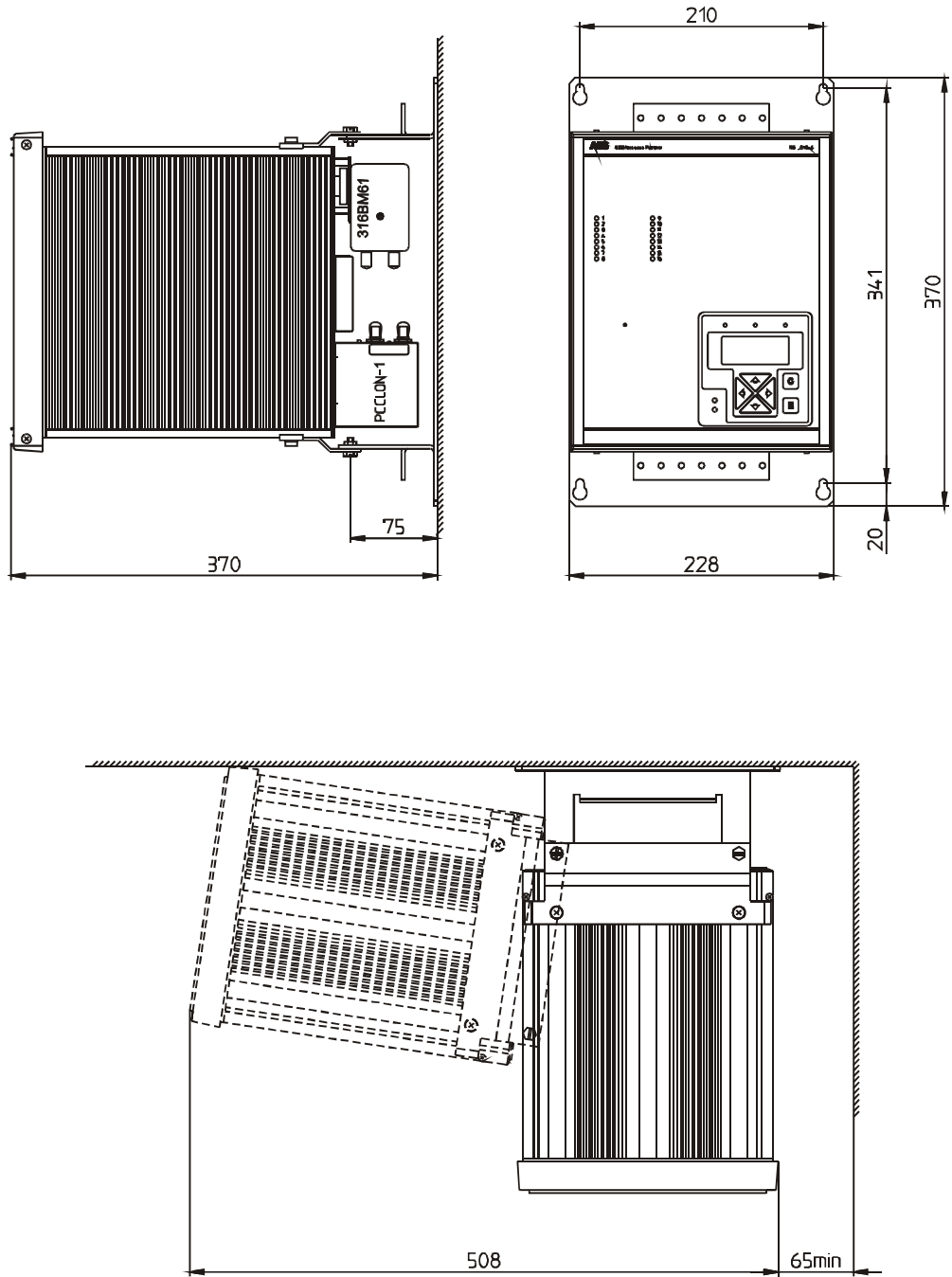


Fig. 15 Surface mounting, casing able to swing to the left, rear connections. Size N1 casing

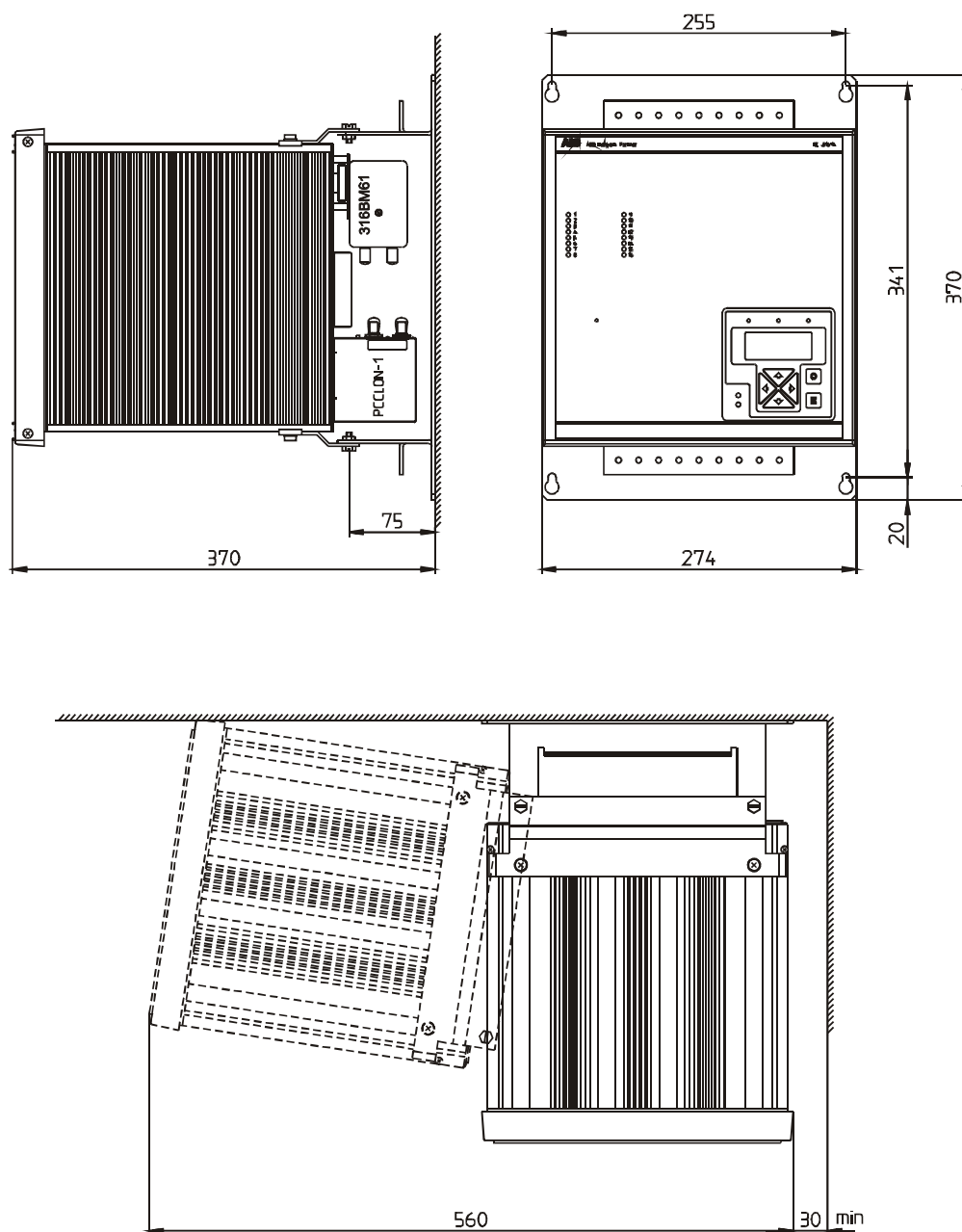


Fig. 16 Surface mounting, casing able to swing to the left, rear connections. Size N2 casing

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

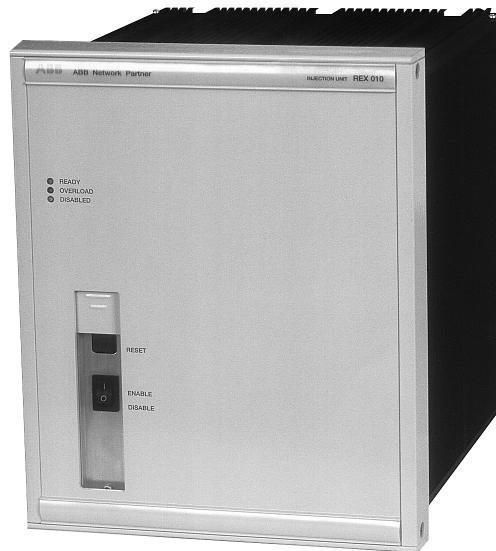
The Operating instructions are available in English or German.
(Please state when ordering).

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www.abb.com/substationautomation

Printed in Switzerland (0203-1000-0)





Features

- Compact design
- Perfectly matched for the REG216/REG316*4
- Provides protection of the whole stator winding including the neutral point
- Continuous supervision of the injection voltage and the primary earthing system
- Suitable for two separate earthing points within the protected zone
- Continuous self-supervision of the injection signal with respect to amplitude and frequency
- Auxiliary DC power supply from station battery from 36 to 312 V DC
- Applicable for all commonly used earthing- and excitation-systems for generators
- Continuous supervision of the insulation resistance and calculation of the earth fault resistance
- The principle is based on the well-known offset method, using injection of a low frequency signal
- Suitable for updating existing plants
- Insensitive to external disturbances

Application

The unit is applied for the protection of generators in block configuration for earth faults on the generator side. For the implementation of the 100% stator and rotor earth fault protection using a REG216/316*4, an injection unit REX010 and the injection trans-

former REX011 are required. This injection equipment can be applied to all common generator earthing- and excitation-systems. The protection is active during all states of the machine, standstill as well as run-up and run-down

Design

General

The earth fault protection is based on the injection of a coded signal. The resulting offset voltage is utilized to calculate the earth resistance (R_f).

The injection signal is produced in the injection unit REX010 and applied to the generator through the transformer unit REX011. For the coupling to the protected unit resistors (R_E , R_P) are used. For the rotor earth fault protection two capacitors are required in addition.

The measurement signals for earth fault protection are processed by the REG216 or the REG316*4 respectively.

The equipment described protects 100% of the generator stator winding. Two indepen-

dent protection functions are applied: one for 95% and one, using a different algorithm, for 100% of the stator winding. The 100% function is calculating the earth resistance and the 95% function is measuring the neutral voltage displacement of the generator.

- The 100% function protects 35% of the stator windings from the neutral point for $R_f = 0$ and $I_{0max} = 15$ A
- The 95% function (U_N) protects 95% of the generator stator winding from the terminals. This results in an overlap (redundancy) of the two protection functions as seen in Fig. 1.

The 100% function increases in sensitivity with increasing earth fault resistance and decreasing earth fault current.

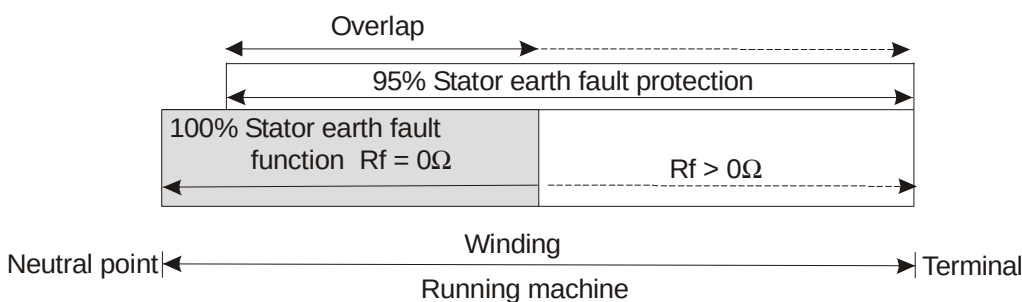


Fig. 1

At standstill the full stator winding (100%) is protected by the 100% function as seen in Fig. 2. At the same time the entire excitation winding is protected for earth faults. Because of the excellent rejection of external interferences, the REX010/011 can be applied to all types of excitation systems including thyristor type.

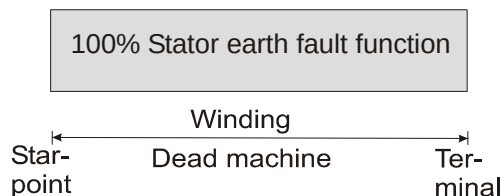


Fig. 2

Hardware

The protection equipment consists of the following units (Figures 4 – 8):

REG216/316*4: Numerical generator protection
REX010: Injection unit
REX011: Injection transformer unit with auxiliary contactor

In addition the following components are required:

- Earthing resistors in the generator neutral point (R_{ES} , R_{PS}) and in the excitation circuit (R_{EP} , R_{PP})
- Coupling capacitors in the excitation circuit of the rotor

- Voltage transformers

The injection unit (REX010) together with the injection transformer (REX011) produces three coded square wave signals (U_{is} , U_{ir} , U_i) with a frequency $f_N/4$. These square wave signals are injected into the protected object via the coupling components. The three square waves have different amplitudes: U_{is} (Injection signal for the stator), U_{ir} (Injection signal for the rotor) and U_i (reference signal for the REG216/316*4). The injection unit REX010 is connected to the station battery and the injection signal voltage is generated either by the battery or by an internal DC/DC converter.

The coding is achieved by alternating the transmission of the square wave with a quiescent period, as seen in Fig. 3.

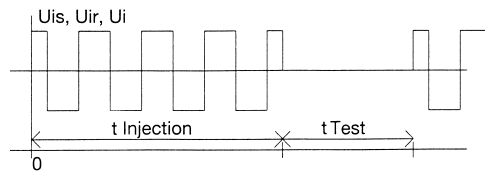


Fig. 3

The REG216/316*4 evaluates and compares the measured injected voltage with the reference voltage during the transmitting period. In the quiescent period the evaluation of possible interferences is active, ensuring the correct protection response. The injection transformer REX011 is equipped with a contactor,

type P8. In the case that the earth fault current exceeds 5 A the contactor will open the input circuit to the injection unit to protect it against high voltages during earth faults near the generator terminals. The 95% function is always active and will detect any earth faults.

The resistors R_{ES} , R_{PS} are used to provide high-resistance earthing of the generator neutral point and for coupling the injection signal to R_{PS} as well as the measurement signal to R_{ES} . A similar arrangement applies for the generator rotor where coupling is made with the resistors R_{ER} and R_{PR} ; however, two additional capacitors C_1 and C_2 are required.

There are three connection variants for the stator and two for the rotor earth fault protection.

Software

Three protection functions are available in the REG216/316*4 library:

- 100% Stator earth fault protection Stator EFP
- Rotor earth fault protection Rotor EFP
- 95% Stator earth fault protection Overvoltage $U >$

During the transmitting period, the digital filter algorithms are calculating the instantaneous earth fault resistance from the input signal pairs U_{is} , U_i and U_{ir} , U_i respectively.

During the quiescent period the filtered signals U_{is} and U_{ir} are examined for interference from the protected object or the connected network. This examination is used to validate the previous calculation of the earth fault resistance.

The reference signal U_i is continuously supervised with respect to amplitude and frequency. This ensures that the injection signal is correct and that it has the correct frequency.

The primary earth connection of the protected machine is checked through evaluation of the capacitive component of the earth fault current during the transmitting period.

100% Stator earth fault protection function

This function consists of an alarm level and a trip level with corresponding signalling and tripping outputs.

It is possible to compensate for a second high-resistance earth to neutral point within

the protected zone by including the monitoring of the generator circuit breaker status.

The function is capable of measuring the effective value of R_{ES} and of the transformation ratio of the voltage transformer while the machine is at standstill. This allows optimizing the function with the actual parameters of the protected machine.

Alarm and trip levels are entered and read out in $k\Omega$.

Settings:

Alarm level	100 Ω to 20 $k\Omega$
Delay	0.2 s to 60s
Trip level	100 Ω to 20 $k\Omega$
Delay	0.2 s to 60 s
R_{ES}	400 Ω to 5 $k\Omega$
Number of neutral points	2
R_{ES-2} , neutral point	900 Ω to 30 $k\Omega$
Reset ratio	110% (with settings of <10 $k\Omega$) 120% (with settings of >10 $k\Omega$)
Accuracy	100 Ω to 10 $k\Omega$: < $\pm 10\%$ 0 to 100 Ω , 10 $k\Omega$ to 20 $k\Omega$: < $\pm 20\%$
Operating time	1.5 s

Machine and system parameters:

- Max. earth fault current $I_0 < 20$ A (recommended $I_0 \leq 5$ A)
- Stator earth capacitance 0.5 μF to 6 μF

Software (cont'd)

- Stator earth resistance R_{PS}	130 Ω to 500 Ω	Coupling capacitance	2 μ F to 10 μ F
- Stator earth resistance R_{ES}	700 Ω to 5 k Ω ($\geq 4.5 \cdot R_{PS}$)	Reset ratio	110% (with settings of <10 k Ω) 120% (with settings of >10 k Ω)
The effective earth resistances R_{ES} , R_{PS} and the transformation ratio of the voltage transformer must be calculated in accordance with the Operating Instructions.		Accuracy	100 Ω to 10 k Ω : < $\pm 10\%$ 0 to 100 Ω , 10 k Ω to 25 k Ω : < $\pm 20\%$
Further details about settings of the various functions can be obtained from the REG216/316*4 data sheet.		Operating time	1.5 s
Rotor earth fault protection		Machine and system parameters:	
This function incorporates an alarm as well as a trip level with separate tripping and signalling outputs.		- Rotor earth capacitance	200 nF to 1 μ F
The function allows the measurement of the actual coupling capacitance while the machine is standing still. This measurement permits optimum settings with respect to the protected machine.		- Rotor earth resistance R_{Pr}	100 Ω to 500 Ω
Alarm and trip levels are entered and read out in k Ω .		- Rotor earth resistance R_{Er}	900 Ω to 5 k Ω
Settings:		- Coupling capacitance	4 μ F to 10 μ F
Alarm level	100 Ω to 25 k Ω	- Time constant	$T = R_{Er} \times C$ = 3 to 10 ms
Delay	0.2 s to 60 s	The effective earth resistances R_{Er} and R_{Pr} must be calculated in accordance with the User's Guide.	
Trip level	100 Ω to 25 k Ω	Further details about settings of the various functions can be obtained from the REG216/316*4 Data Sheet.	
Delay	0.2 s to 60 s		
R_{Er}	900 Ω to 5 k Ω		

Technical data

REX010 Injection unit

The injection unit REX010 is contained in a REG316*4 housing, therefore the specifications of the design details and the general data of the REG316*4 are applicable. (Exception: Insulation voltage for REX010: Supply = 2.8 kV DC)

Supply voltage range:	36 to 312 V DC (refer to table below)
Power consumption	<150 VA
Optocoupler inputs:	18 to 312 V DC (refer to table below)
Connection terminals:	HDFK (type Phoenix) 4 mm ²
Control and signalling devices:	
green LED on:	Device ready
red LED on:	Overload
yellow LED on:	No injection
ENABLE switch:	Injection on
DISABLE switch:	Injection off
RESET push button:	Reset after interruption of injection
Optocoupler input:	Interruption of injection, reset after interruption of injection

REX011 Injection transformer

Type of auxiliary transformer	WU30Z
Primary voltage	2 x 110 V
Secondary voltage	
REX011	110 V / 50 V Terminals UK5 (Phoenix) 5 mm ²
REX011-1	4 x 0.86 V / 50 V Terminals UHV50 (Phoenix) 50 mm ²
REX011-2	4 x 6.4 V / 50 V Terminals UHV50 (Phoenix) 50 mm ²
Auxiliary contactor	P8nax (8 normally open contacts)
HV test	2.5 kV common mode
Dimensions	
REX011	Mounting surface, 180 x 290 mm and 245 mm high
REX011-1, -2	Mounting surface, 180 x 290 mm and 275 mm high

Diagrams

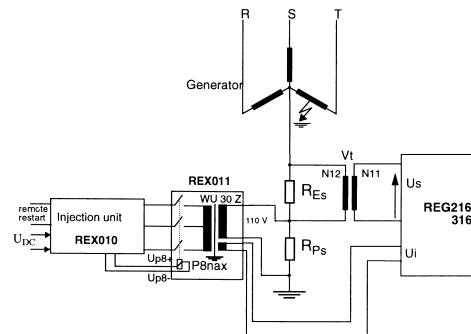


Fig. 4 Stator earth fault protection, star point

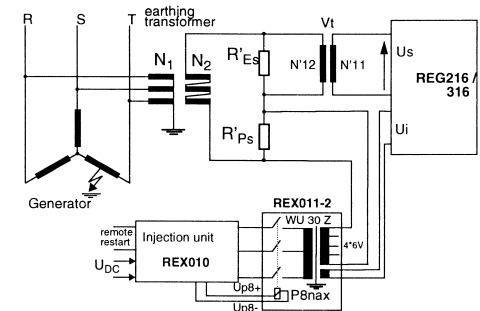


Fig. 5 Stator earth fault protection with earthing transformer on generator terminals

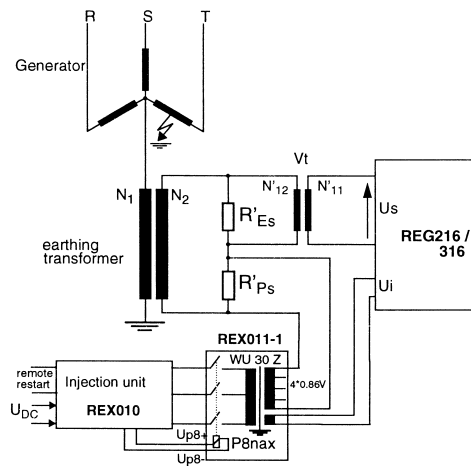


Fig. 6 Stator earth fault protection with earthing transformer on star point

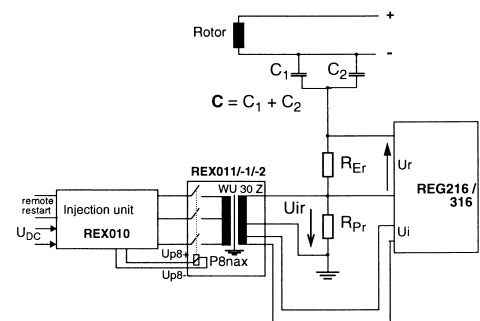


Fig. 7 Single pole rotor connection earthing with resistors

Diagrams (cont'd)

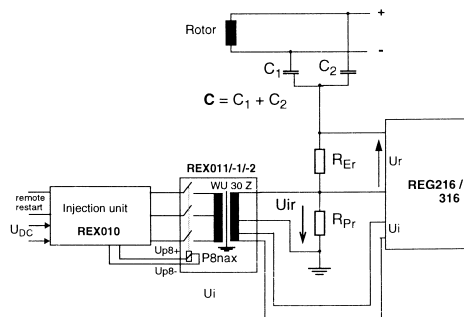


Fig. 8 Two pole rotor connection

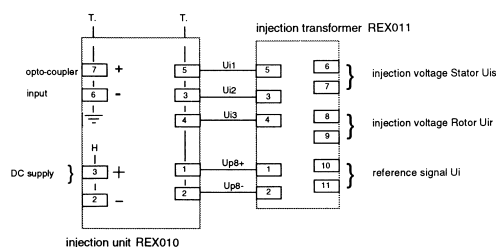


Fig. 9 Connection diagram REX010/REX011

Dimensions

All dimensions in mm

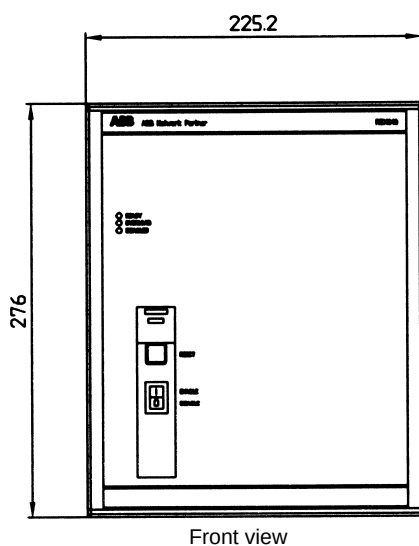


Fig. 10 REX010 T = Input and output voltages cross-section = 4 mm²
H = Auxiliary supply

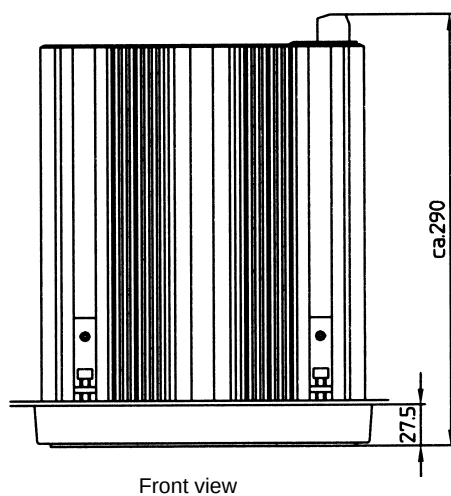
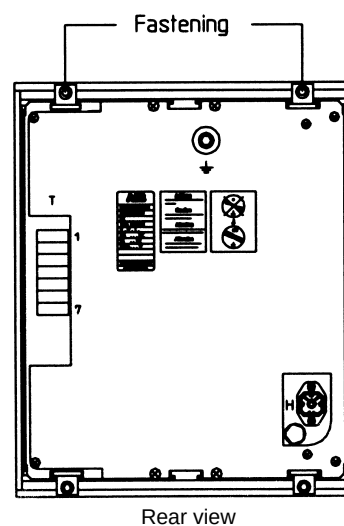
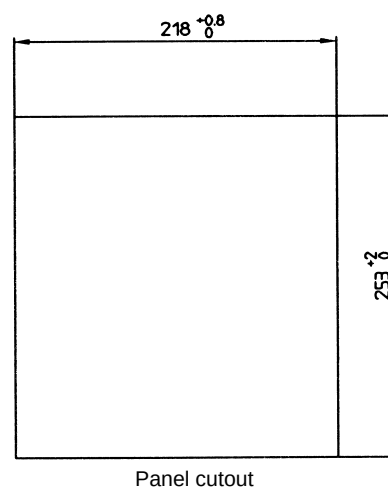


Fig. 11 REX010



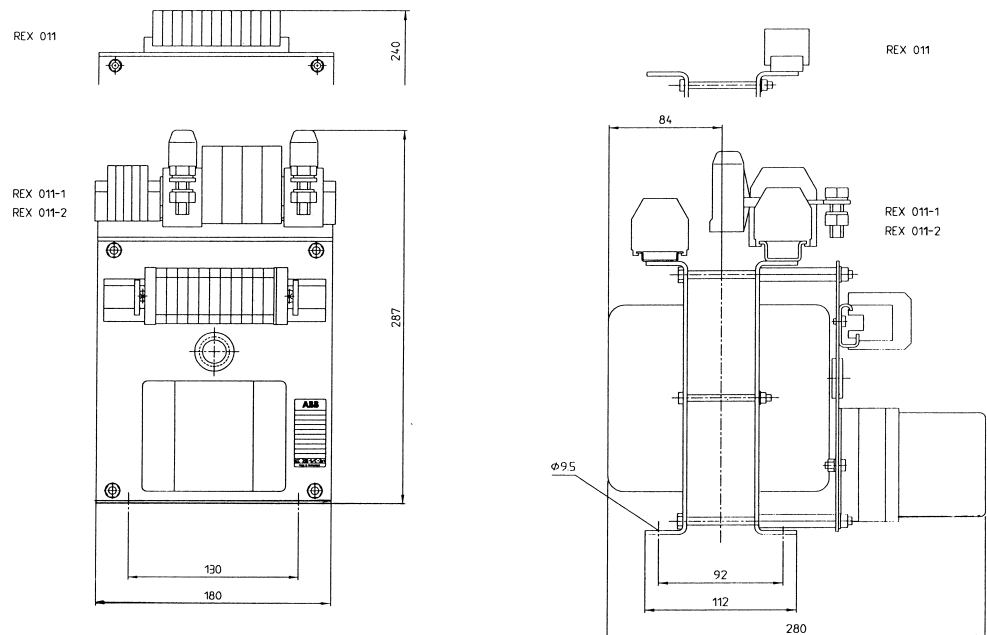


Fig. 12 Dimensions REX011, -1, -2

Ordering

Order codes for REX010/REX011

REX011 Injection transformer unit

REX011		HESG 323888 M1	Starpoint earthing with resistors	Fig. 4
REX011-1	$R'_{ps} > 8 \text{ m}\Omega$	HESG 323888M11	Starpoint earthing with earthing transformer	Fig. 6
REX011-1	$R'_{ps} > 32 \text{ m}\Omega$	HESG 323888 M12	Starpoint earthing with earthing transformer	Fig. 6
REX011-1	$R'_{ps} > 128 \text{ m}\Omega$	HESG 323888 M13	Starpoint earthing with earthing transformer	Fig. 6
REX011-2	$R'_{ps} > 0.45 \text{ }\Omega$	HESG 323888 M21	Earthing transformer on generator terminals	Fig. 5
REX011-2	$R'_{ps} > 1.8 \text{ }\Omega$	HESG 323888 M22	Earthing transformer on generator terminals	Fig. 5
REX011-2	$R'_{ps} > 7.2 \text{ }\Omega$	HESG 323888 M23	Earthing transformer on generator terminals	Fig. 5

If R'_{ps} is not yet known when ordering, please order M11 resp. M21. The version required later may be rewired.

The coil voltage for the P8 contactor must be stated and can be found in the following table!

REX010 Injection unit

Function	Value	Code	P8 contactor
Battery voltage	88 to 312 V DC (with int. DC/DC conv.) 36 to 140 V DC (with int. DC/DC conv.)	U2 U3	110 V DC 110 V DC
Frequency	50 Hz 60 Hz	F5 F6	
Optocoupler. volt.	82 to 312 V DC 36 to 75 V DC 18 to 36 V DC	I3 I4 I5	

Order-No. HESG324426M0001 + Code

REX010 offers two options according to the available battery voltage.

Ordering (cont'd)

Ordering example

Generator with the earthing transformer at the neutral point ($R'_{ps} > 32 \text{ m}\Omega$), system frequency 50 Hz, battery voltage 110 V DC, which is also used for optocoupler inputs.

Order description:

1 REX010 - HESG324426M0001
Code U2/ F5 /13
1 REX011- HESG323888M12
1 P8nax contactor = 110 V DC

The associated earthing resistors as well as the coupling capacitors $2 \times 2 \text{ }\mu\text{F}$ (Leclanche MIH 800-2) for the rotor earth fault protection may be ordered through ABB Switzerland Ltd.

The associated protection package/system REG216/REG316*4 must be ordered separately, according to the appropriate Data Sheet.

References

REG 316*4 Data Sheet	1MRK502004-Ben
REG316*4 Operating Instructions (printed)	1MRB520049-Uen
REG316*4 Operating Instructions (CD)	1MRB260030M0001
REG216 Data Sheet	1MRB520004-Ben
REG216 Operating Instructions (printed)	1MRU02005-EN
REG216 Operating Instructions (CD)	1MRB260030M0001

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DEMANDS ON MEASURING TRANSFORMERS FOR RET 316 / RET 316*4

Version 3.10
and higher

Introduction

The operation of any transformer protection is influenced by distortion in the measuring quantities. The current to the protection will be heavily distorted when the current transformer is saturated. In most cases it is not possible to avoid current transformer saturation for all fault conditions, therefore measures are taken in the transformer protections to allow for current transformer saturation with maintained proper operation. RET 316 / RET 316*4 can allow for heavy current transformer saturation but not an unlimited one.

Requirements on current transformers

Choice of current transformers

The current transformer should be to type TPS, TPX or TPY with accuracy class 5P20 or better. The use of the linearized current transformer type TPZ leads only to a small phase angle shift and they can be used without problems, if the same type is on both sides of the transformer. Possibly ABB Switzerland Ltd, Utility Automation can be contacted for confirmation that the actual type can be used.

The current transformer ratio should be selected so that the current to the protection is larger than the minimum operating value for all faults that shall be detected. Minimum operating current for the transformer protection in RET 316 / RET 316*4 is 10% of nominal current.

Conditions for the CT requirements

The requirements for RET 316 / RET 316*4 are a result of investigations performed in our network simulation program. The tests have been performed with a digital current transformer model.

The setting of the current transformer model was representative for current transformers type TPX and TPY.

The performance of the transformer protection was checked for internal and external both symmetrical and fully asymmetrical fault currents. A source with a time constant from 40 up to 300 milliseconds was used at the tests. The current requirements below are thus applicable both for symmetrical and asymmetrical fault currents.

Both phase to ground, and three phase faults were tested.

Released:		Department:		Rev.: E
		UTAST		

The protection was checked with regard to security to block. All testing was made with and without remanence flux in the current transformer core. It is difficult to give general recommendations for additional margins for remanence flux. It depends on the demands of reliability and economy.

When current transformers of type TPY are used, practically no additional margin is needed due to the anti remanence air gap. For current transformer of Type TPX, the small probability of a fully asymmetrical fault together with maximum remanence flux in the same direction as the flux generated by the fault has to be kept in mind at the decision of an additional margin. Fully asymmetrical fault current will be achieved when the fault occurs at zero voltage (0°). Investigations have proved that 95% of the faults in the network will occur when the voltage is between 40° and 90°.

Fault current

The current transformer requirements are based on the maximum fault current for faults in different positions. Maximum fault current will occur for three phase faults or single phase to ground faults. The current for a single phase to ground fault will exceed the current for a three phase fault when the zero sequence impedance in the total fault loop is less than the positive sequence impedance.

When calculating the current transformer requirements, the maximum fault current should be used and therefore both fault types have to be considered.

Cable resistance and additional load

The current transformer saturation is directly affected by the voltage at the current transformer secondary terminals. This voltage, for a ground fault, is developed in a loop containing the phase and neutral conductor and additional load in this loop. For three phase faults, the neutral current is zero, and only the phase conductor and additional phase load have to be considered.

In the calculation, the loop resistance should be used for phase to ground faults and the phase resistance for three phase faults.

RET 316 / RET 316*4 current transformer requirements

The current transformer effective overcurrent factor should meet the two requirement below. The requirement assume 40 to 300 msec maximum dc time constant for the network.

$$1. \quad n' \leq n \times \frac{Pr + PE}{PB + PE} \times \frac{I_{N \text{ of ct.}}}{I_N}$$

- n : rated overcurrent factor (ALF = accuracy limit factor)
- n' : necessary effective overcurrent factor, as a function of fault current I_K , (at nominal frequency and time constant of the network)
- PB : connected burden at rated current
- PE : ct losses of secondary windings
- Pr : rated ct burden
- I_N : nominal current related to the protected object

and 2.

the dependence of the curves of fig 1 and 2, where:

for fault currents $\leq 3 \cdot I_N$ the CT's should not saturate

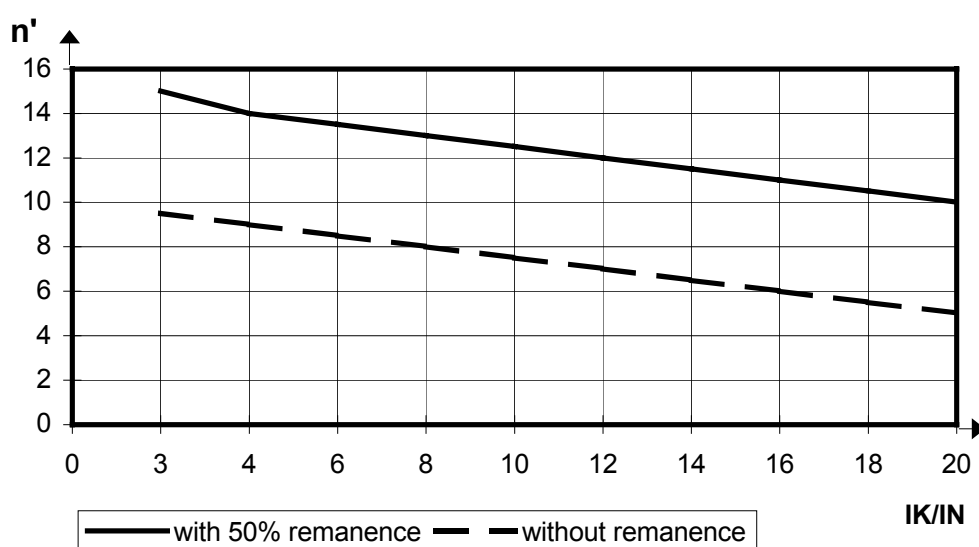


Figure 1: Transformer with 2 windings

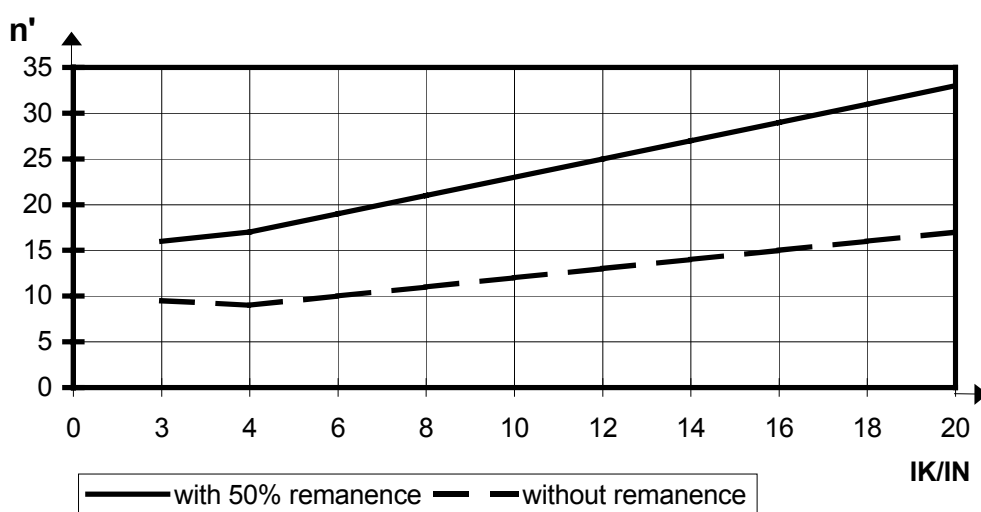


Figure 2: Transformer with 3 windings

DEMANDS ON MEASURING TRANSFORMERS FOR GENERATOR-DIFFERENTIAL-PROTECTION FOR REG 316 / REG 316*4 / REG 216

Version 3.01
and higher

Introduction

The operation of any generator differential protection is influenced by distortion in the measuring quantities. The current to the protection will be heavily distorted when the current transformer is saturated. In most cases it is not possible to avoid current transformer saturation for all fault conditions, therefore measures are taken in the generator differential protections to allow for current transformer saturation with maintained proper operation. REG 316 / REG 316*4 / REG 216 can allow for heavy current transformer saturation but not an unlimited one.

For transformer differential protection see document CH-ES 30-32.10 E for RET 316 / RET 316*4.

Requirements on current transformers

Choice of current transformers

The current transformer should be to type TPS, TPX or TPY with accuracy class 5P20 or better. The use of the linearized current transformer type TPZ leads only to a small phase angle shift and they can be used without problems, if the same type is on both sides of the generator. Possibly ABB Switzerland Ltd, Utility Automation can be contacted for confirmation that the actual type can be used.

The current transformer ratio should be selected so, that the current to the protection is larger than the minimum operating value for all faults that shall be detected. Minimum operating current for the generator differential protection in REG 316 / REG 316*4 / REG 216 is 10% of nominal current.

Conditions for the CT requirements

The requirements for REG 316 / REG 316*4 / REG 216 are a result of investigations performed in our network simulation program. The tests have been performed with a digital current transformer model.

The setting of the current transformer model was representative for current transformers type TPX and TPY.

The performance of the generator differential protection was checked for internal and external both symmetrical and fully asymmetrical fault currents. A source with a time constant from 40 up to 300 milliseconds was used at the tests. The current requirements below are thus applicable both for symmetrical and asymmetrical fault currents.

Both phase to ground, and three phase faults were tested.

Released:		Department:		Rev.: B
		UTAST		

The protection was checked with regard to security to block. All testing was made with and without remanence flux in the current transformer core. It is difficult to give general recommendations for additional margins for remanence flux. It depends on the demands of reliability and economy.

When current transformers of type TPY are used, practically no additional margin is needed due to the anti remanence air gap. For current transformer of Type TPX, the small probability of a fully asymmetrical fault together with maximum remanence flux in the same direction as the flux generated by the fault has to be kept in mind at the decision of an additional margin. Fully asymmetrical fault current will be achieved when the fault occurs at zero voltage (0°). Investigations have proved that 95% of the faults in the network will occur when the voltage is between 40° and 90° .

Fault current

The current transformer requirements are based on the maximum fault current for faults in different positions. Maximum fault current will occur for three phase faults or single phase to ground faults. The current for a single phase to ground fault will exceed the current for a three phase fault when the zero sequence impedance in the total fault loop is less than the positive sequence impedance.

When calculating the current transformer requirements, the maximum fault current should be used and therefore both fault types have to be considered.

Cable resistance and additional load

The current transformer saturation is directly affected by the voltage at the current transformer secondary terminals. This voltage, for a ground fault, is developed in a loop containing the phase and neutral conductor and additional load in this loop. For three phase faults, the neutral current is zero, and only the phase conductor and additional phase load have to be considered.

In the calculation, the loop resistance should be used for phase to ground faults and the phase resistance for three phase faults.

REG 316 / REG 316*4 / REG 216 current transformer requirements

The current transformer effective overcurrent factor should meet the two requirement below. The requirement assume 40 to 300 msec maximum dc time constant for the network.

$$1. \quad n' \leq n \times \frac{Pr + PE}{PB + PE} \times \frac{I_{N \text{ of ct.}}}{I_N}$$

- n : rated overcurrent factor (ALF = accuracy limit factor)
 n' : necessary effective overcurrent factor, as a function of fault current I_K , (at nominal frequency and time constant of the network)
 PB : connected burden at rated current
 PE : ct losses of secondary windings
 Pr : rated ct burden
 I_N : nominal current related to the protected object

and 2.

the dependence of the curves of fig 1, where:

for fault currents $\leq 3 * I_N$ the CT's should not saturate, respectively the exact boundary is at $b * \sqrt{3}$ (b = setting value of the characteristic).

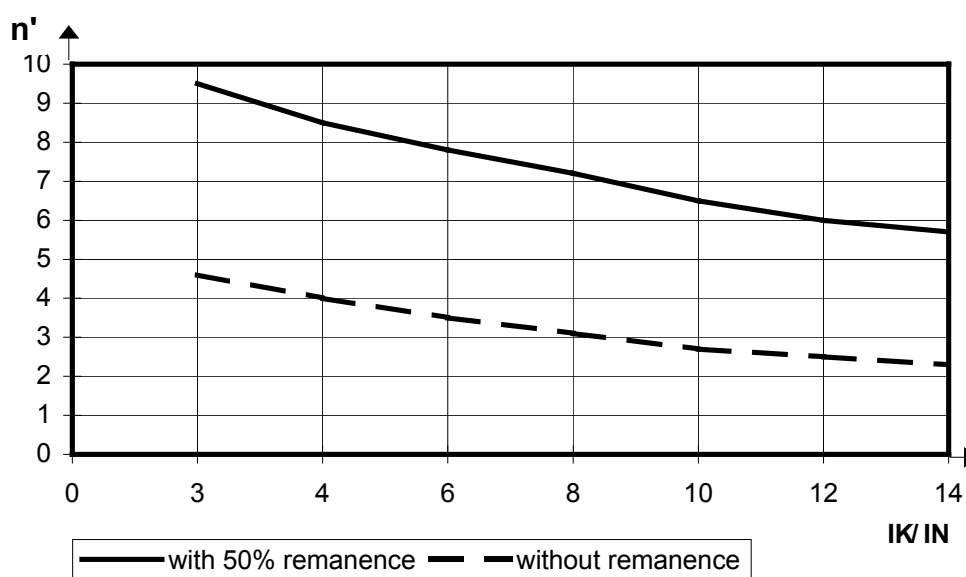


Figure 1: Overcurrent factors

March 01

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9. INTERBAY BUS (IBB) INTERFACE

9.1. Connection to a station control system

An electrical-to-optical converter Type 316BM61b is plugged onto the rear of the protection to convert the electrical RS232 signals from the 316VC61a or 316VC61b into optical signals.

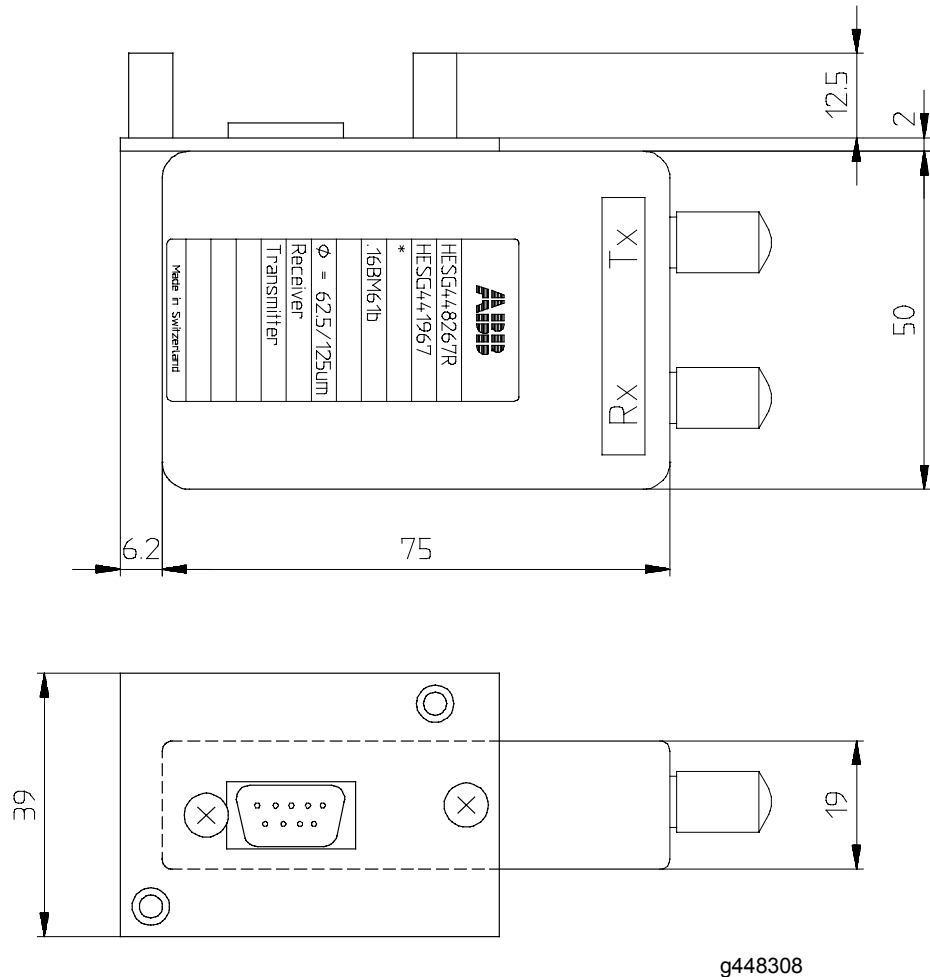


Fig. 9.1 Electrical-to-optical converter Type 316BM61b RS232 interface:

Pin 2:	Rx
Pin 3:	Tx
Pin 4:	+12 V
Pin 5:	0 V
Pin 9:	-12 V

Optical cable connections:

Optical fibre cables with bayonet connectors (ST) are used for the SPA bus (62.5 μ m fibres for 316BM61b).

Screw connectors (SMA plugs) are used instead of the bayonet connectors for the IEC60870-5-103 bus.

9.2. **Setting the IBB/RIO function**

The settings for the IBB/RIO are made via the following HMI menus:

- Main menu
- Editor
- Edit hardware functions
- IBB/RIO configuration.

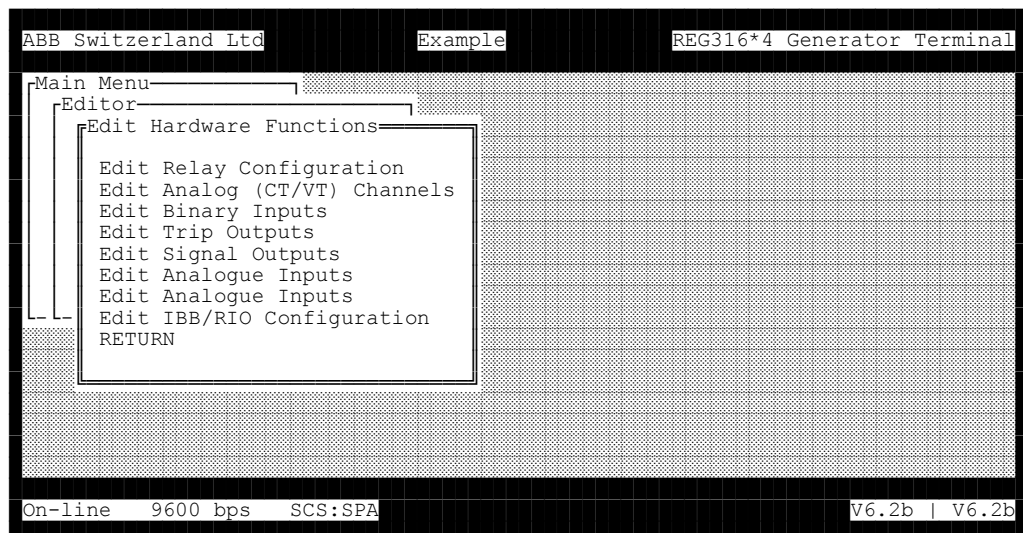


Fig. 9.2 Opening the “IBB/RIO configuration” window

The IBB/RIO function menu lists the following items (see Fig. 9.3):

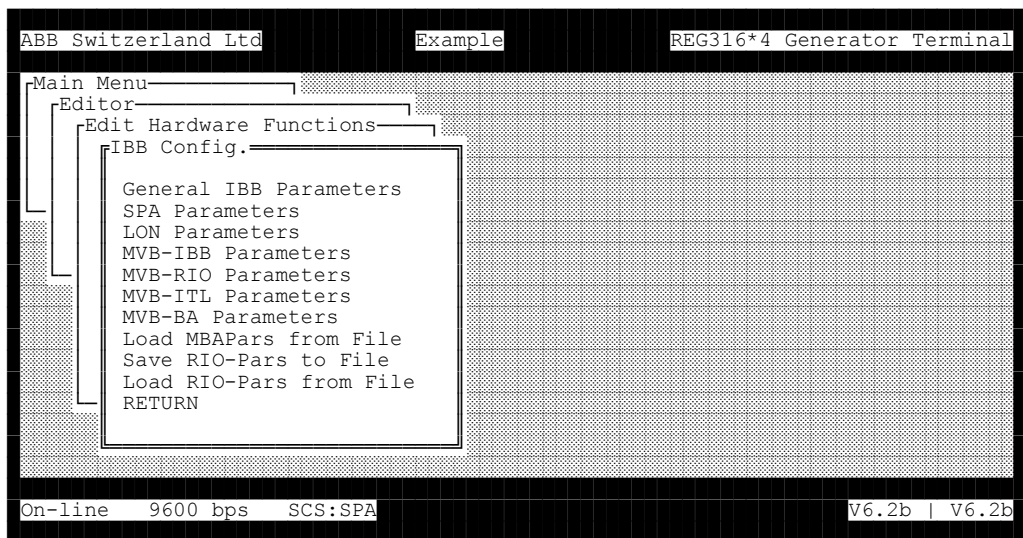


Fig. 9.3 IBB configuration

Caution:

The settings for the LON interbay bus are to be found in publication 1MRB520225-Uen, for the MVB interbay bus in 1MRB520270-Uen and for the MVB process bus in 1MRB520192-Uen.



Fig. 9.4 General IBB parameters

Slave/NodeAddr

Range 2- 255. Must be set to the correct SPA bus address.

TouchScreen/SMS

Setting determines whether the touch screen or an SMS has to be controlled:

- inactive Connection not in operation (default)
- active Connection in operation.

Note that this parameter has no influence in the versions for the SPA and IEC60870-5-103 buses.

The versions for the LON and MVB buses have a fully functional SPA interface in parallel with the interbay bus for connecting either a touch screen or an SMS. The parameter 'Touch-Screen/SMS' should only be set to 'active', when the second interface is in use, because the response time of the LON or MVB bus is somewhat longer.

Read Distr. Data

This parameter defines what has access to the disturbance recorder data:

- by IBB The disturbance recorder data can be read via the interbay bus (SCS).
- by SMS The disturbance recorder data can be read by the SMS.

Disturbance recorder data can always be read by the HMI regardless of the setting.

Note that this parameter has no influence in the versions for the SPA and IEC60870-5-103 buses.

TimeSynchr.

Defines the time for synchronisation via the IBB when the summer time bit is set:

- Standard time Only the summer time bit is set and standard time is used for synchronisation (preferred setting).
- Summer time Summer time is used for synchronisation in spite of the fact that the summer time bit is also set.

'Standard time' has to be selected when the summer time bit is not set (e.g. as in the case of the SPA bus).

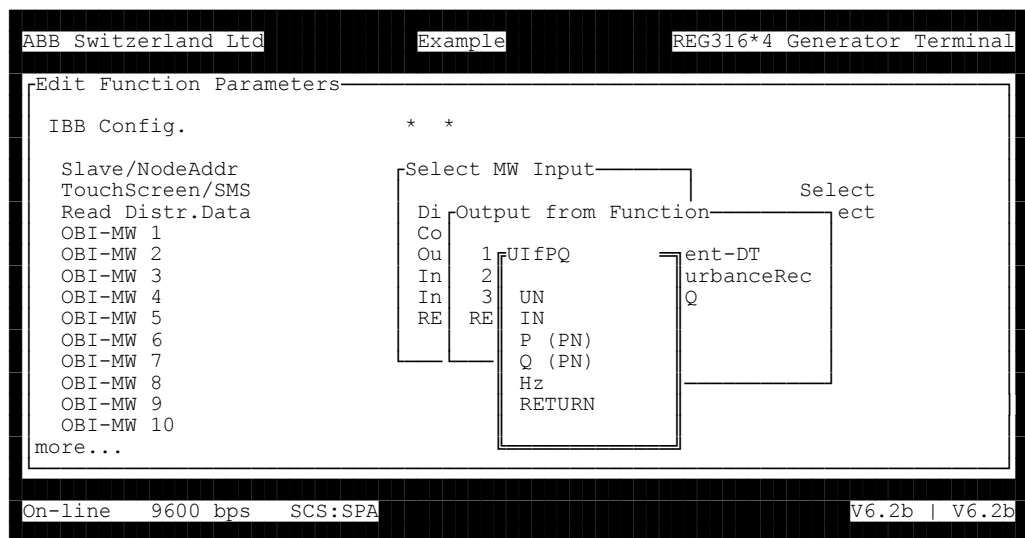


Fig. 9.5 Connecting an IBB measurement

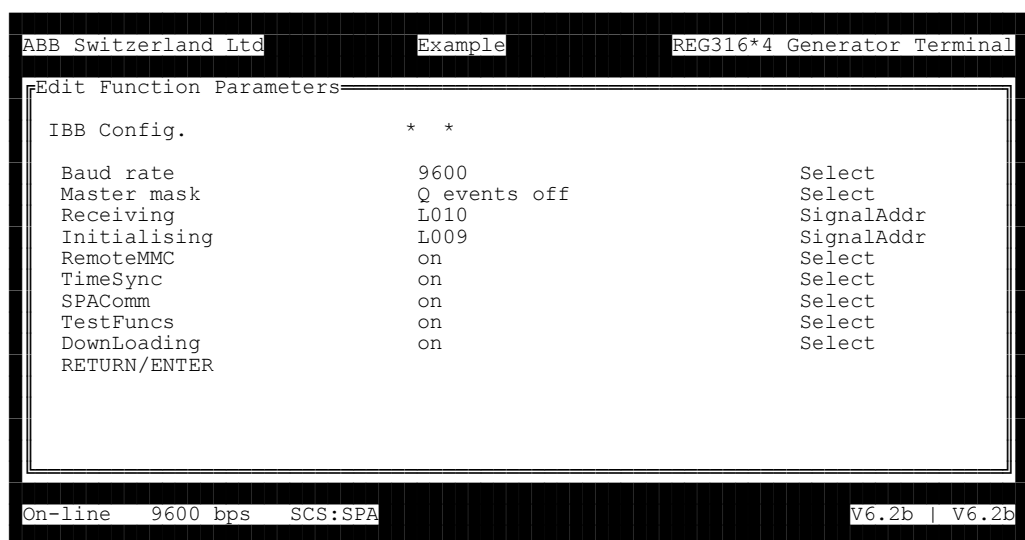


Fig. 9.6 SPA parameters

The parameters must be set as follows:

Baud rate

Default 9600 for SPA bus. Do not change.

Master mask

- Bit masks.
The bit masks set for every function via the SPA bus apply for all binary events. No masks are used for analogue events.
- Q events off
As above, but all analogue events are blocked. This is the default setting and must always be used when the device is connected to an **SCS100**.
- Event off
All events are masked (not recorded).
This setting is intended for testing and during commissioning when it is not wanted that events be transmitted to the control room.

Receiving

Indicates that valid SPA telegrams have been received.

Initialising

Indicates that the device is being initialised.

The following parameters determine the access rights of the remote HMI and can only be configured on the local HMI ([see Section 5.12.](#)):

- RemoteMMC on / off
Enables or disables the remote HMI.
- TimeSync on / off
Enables or disables synchronisation by the remote HMI.
- SPAComm on / off
Enables or disables the SPA communication window on the remote HMI.
- TestFunct. on / off
Enables or disables the test function on the remote HMI.
- Load code on / off
Enables or disables the downloading of a 'setfile' from the remote HMI.

9.3. ***Transferring disturbance recorder data via the IBB***

Disturbance recorder data (records) can be read and transferred via the SPA bus with the aid of the EVECOM program. Further details are contained in the Operating Instructions for EVECOM.

The data are made available in the EVE format when transfer is requested. Data transfer is controlled using the SPA BUS variables V20, M28, M30, M31, V16 and V17.

V20:

Write: WV20:1 starts the transmission of a telegram.

Read: RV20 returns the number of disturbance recorder records available.

V17:

Write: WV17:1...5 determines the compression factor, i.e. 1%...5%.

Read: RV17 returns the compression factor.

Compression reduces the number of periods that have to be transferred per channel. Assuming the 12 points of a period deviate by less than the specified compression factor from the corresponding points of the preceding period, the points themselves are not transferred, but simply the number of repeats in relation to the preceding period. For example, if a record consists of 100 periods all the same, then only the 12 points of one period and the number of repeats are transferred. Compression is applied independently for each individual channel.

M28:

Write: WM28:n selects a disturbance recorder record for transfer. n has a value between 1 and the number of records that can be read using RV20. The conversion of the record to the EVE format starts and the first response is NAK. WM28:n has to be repeated until the response is ACK. (From firmware V4.0.)

Read: RM28 returns the directory information, time stamp and record number.
1995-05-10 12.34;23.423 RE001.001

M29:

Write: NAK.

Read: returns the number of lines in a record (0...1023). A line contains 26 Byte of data. 0 is returned if a record has not been selected (M28).

M30:

Write: WM30:n moves the pointer to the line to be transferred. The pointer is automatically incremented by one every time a line is transferred until there are no lines left. The pointer is set to 1 at the commencement of data transfer (WM28:n).

Read: RM30 returns the number of the line that was transferred last.

M31:

Write: NAK.

Read: RM31 transfers the line indicated by the pointer.

V16:

Write: WV16:1, WV16:0, deletes the oldest record.

Read: RV16 returns the status of the disturbance recorder.
0: Disturbance recorder not full.
1: Disturbance recorder full.

V20:

Write: WV20:0 terminates data transfer.

9.4. **Synchronisation**

The internal clock is synchronised either by the station control system (SCS 100) or a radio clock (DCF77). Synchronisation via the IBB takes priority over synchronisation by the HMI.

After the device is switched off and on again, the clock continues at the time before it was switched off until the next time telegram is received.

9.5. **SPA bus address format**

The structure of the SPA bus telegram is as follows:

<slave address><operation><channel No.><data type><data/event No.>

The slave address identifies the device.

The default address is 2. The slave address can be changed using the operator program (HMI). The HMI has to be used to assign an address to the device as defined in the station control system. The device also responds to data with the address 900 which is used to synchronise all the devices in an SPA bus loop simultaneously.

Possible **operations** are:

Read data from the device (R) and write data in the device (W).

The channel number identifies the active functions.

All channel numbers from 0 to 13 are reserved for system functions. Channel numbers from 14 to 60 are used for numbering the protection and control functions configured for the device.

Data type enables the different kinds of data in a device to be addressed specifically. The following types of data are used:

- S settings
- I binary or analogue inputs
- O binary or analogue outputs
- E single events
- V measurements, system variables and event masking
- Q measurements stored at the instant of tripping
- T time
- D date
- L event memory
- B back-up event memory.

Data and event numbers are needed to designate individual items of data and events in data channels.

The table below shows the channel number mapping for a typical configuration:

Function	Funct. No.	Chan. No.	Comment
Current	14	14	First protection function
Voltage	15	15	Second protection function
Delay	16	16	Third protection function

The function numbers in the above table correspond to the HMI numbers.

The measured variable of the first function (current) in a device with the slave address 2 is read as follows:

2R14V1.

The SPA bus syntax is defined in SPA BUS COMMUNICATION PROTOCOL V2.x, 34 SPACOM EN1C.

9.5.1. Masking events

Once all those binary inputs, IBB output signals and system and protection function events which are not to be recorded as events (masked) have been loaded into the device (e.g. using W14V155), they have to be copied to the non-volatile memory using the save command W255V255:1 so that they are not lost should the auxiliary supply fail.

9.6. SPA address list**9.6.1. Channel 0****Summary of parameters:**

Address	Access	Text	Default	Step
V102	R	VC type identification	316VC61	
V104	R	VC software version		
V110	R, W	Master event mask	1 Q events masked	0 Bit mask active 2 All events masked
V115	R	Time telegram counter		
V116	R	Date telegram counter		
V120	R	Restart counter	0	
V200	R, W	SPA address	2	2...255
V201	R, W	Baud rate	9600	4800, 9600, 19200
F	R	Module Type	REC316	REG316, REL316, RET316
S0	R	Number of functions	0	1...60
S1	R	Function type number		S1...S60
S100	R, W	Parameter set switch	1	1...4
T	R, W	Time		
D	R, W	Date and time		
L	R	Read event		
B	R	Read event again		

Date format: YY-MM-DD hh.mm;ss.sss

9.6.2. Channel 0 event list

Event No.	Cause	Event mask	Enable code
0E1	No error	V155	1
0E2	Minor error	V155	2
0E4	Major error	V155	4
0E8	Fatal error	V155	8
0E47	Protection stopped	V155	16
0E48	Protection restarted	V155	32
0E49	Warm protection start	V155	64
0E50	Cold protection start	V155	128
0E51	Event buffer overflow	V155	256

9.6.3. Channel 1 event list

Event No.	Cause	Event mask	Enable code
1E11	AD error	V155	1
1E31	Bus failure	V155	256
1E41	Supply failure	V155	4096

9.6.4. Channel 3 event list

Event No.	Cause	Event mask	Enable code
3E1	CPU OK	V155	1
3E2	CPU failure	V155	2
3E3	CPU RAM failure	V155	4
3E4	CPU ROM failure	V155	8
3E11	EA62 OK	V155	16
3E12	EA62 failure	V155	32
3E13	EA62 RAM failure	V155	64
3E14	EA62 ROM failure	V155	128
3E21	Internal AD OK	V155	256
3E22	Internal AD failure	V155	512
3E23	Internal AD RAM failure	V155	1024
3E24	Internal AD ROM failure	V155	2048

9.6.5. Channel 4 event list

Event No	Cause	Event mask	Enable code
4E21	PC-Card No failure	V156	16
4E22	PC-Card Fatal error	V156	32
4E23	PC-Card Non-urgent error	V156	64
4E24	PC-Card Not ready	V156	128

9.6.6. Channel 4 analogue input

Channel 4 provides 64 data points which are available either for analogue FUPLA inputs or analogue outputs via the distributed input/output unit 500AXM11. The numerical range is -32768...+32767 (16 Bit integers).

The data can be entered in decimal or 4-digit hexadecimal format.

The data remains intact in the event of a supply failure.

Real values are converted to integers,
 $\text{integer} = \text{real} \times 100$.

Input format: nnn.mm.
 FFFFH

Data point number: O1...O64

9.6.7. Binary input signals

The significance of the events, for standard as well as for double signals, is explained in [Section 9.6.14](#).

Channel	Inputs	Events	Slot
101	I1 - I16	E1 - E32	1
102	I1 - I16	E1 - E32	2
103	I1 - I16	E1 - E32	3
104	I1 - I16	E1 - E32	4

9.6.8. IBB input signals

Channel	Inputs	Group	No.
121	I1 - I32	1	1-32
122	I1 - I32	2	33-64
123	I1 - I32	3	65-96
124	I1 - I32	4	97-128
125	I1 - I32	5	129-160
126	I1 - I32	6	161-192
71	I1 - I32	7	193-224
72	I1 - I32	8	225-256
73	I1 - I32	9	257-288
74	I1 - I32	10	289-320
75	I1 - I32	11	321-352
76	I1 - I32	12	353-384
77	I1 - I32	13	385-416
78	I1 - I32	14	417-448
79	I1 - I32	15	449-480
80	I1 - I32	16	481-512
81	I1 - I32	17	513-544
82	I1 - I32	18	545-576
83	I1 - I32	19	577-608
84	I1 - I32	20	609-640
85	I1 - I32	21	641-672
86	I1 - I32	22	673-704
87	I1 - I32	23	705-736
88	I1 - I32	24	737-768

9.6.9. Binary output signals

Channel	Outputs	Events	Slot
101	O1 - O16	None	1
102	O1 - O16	None	2
103	O1 - O16	None	3
104	O1 - O16	None	4

9.6.10. Tripping signals

Channel	Outputs	Events	Slot
101	M1 - M16	None	1
102	M1 - M16	None	2
103	M1 - M16	None	3
104	M1 - M16	None	4

9.6.11. LED signals

Channel	Outputs	Events
120	O1 - O16	None

9.6.12. IBB output signals

Channel	Outputs	Group	Event No.
121	O1 - O32	1	121E1...E64
122	O1 - O32	2	122E1...E64
123	O1 - O32	3	123E1...E64
124	O1 - O32	4	124E1...E64
125	O1 - O32	5	125E1...E64
126	O1 - O32	6	126E1...E64
71	O1 - O32	7	71E1...E64
72	O1 - O32	8	72E1...E64
73	O1 - O32	9	73E1...E64
74	O1 - O32	10	74E1...E64
75	O1 - O32	11	75E1...E64
76	O1 - O32	12	76E1...E64
77	O1 - O32	13	77E1...E64
78	O1 - O32	14	78E1...E64
79	O1 - O32	15	79E1...E64
80	O1 - O32	16	80E1...E64
81	O1 - O32	17	81E1...E64
82	O1 - O32	18	82E1...E64
83	O1 - O32	19	83E1...E64
84	O1 - O32	20	84E1...E64
85	O1 - O32	21	85E1...E64
86	O1 - O32	22	86E1...E64
87	O1 - O32	23	87E1...E64
88	O1 - O32	24	88E1...E64

9.6.13. IBB output signal event masks

Output	Event	Event No.	Mask	Enable code
O1	On	1	V155	1
	Off	2	V155	2
O2	On	3	V155	4
	Off	4	V155	8
O3	On	5	V155	16
	Off	6	V155	32
O4	On	7	V155	64
	Off	8	V155	128
O5	On	9	V155	256
	Off	10	V155	512
O6	On	11	V155	1024
	Off	12	V155	2048
O7	On	13	V155	4096
	Off	14	V155	8192
O8	On	15	V155	16384
	Off	16	V155	32768
O9	On	17	V156	1
	Off	18	V156	2
O10	On	19	V156	4
	Off	20	V156	8
O11	On	21	V156	16
	Off	22	V156	32
O12	On	23	V156	64
	Off	24	V156	128
O13	On	25	V156	256
	Off	26	V156	512
O14	On	27	V156	1024
	Off	28	V156	2048
O15	On	29	V156	4096
	Off	30	V156	8192

Output	Event	Event No.	Mask	Enable code
O16	On	31	V156	16384
	Off	32	V156	32768
O17	On	33	V157	1
	Off	34	V157	2
O18	On	35	V157	4
	Off	36	V157	8
O19	On	37	V157	16
	Off	38	V157	32
O20	On	39	V157	64
	Off	40	V157	128
O21	On	41	V157	256
	Off	42	V157	512
O22	On	43	V157	1024
	Off	44	V157	2048
O23	On	45	V157	4096
	Off	46	V157	8192
O24	On	47	V157	16384
	Off	48	V157	32768
O25	On	49	V158	1
	Off	50	V158	2
O26	On	51	V158	4
	Off	52	V158	8
O27	On	53	V158	16
	Off	54	V158	32
O28	On	55	V158	64
	Off	56	V158	128
O29	On	57	V158	256
	Off	58	V158	512
O30	On	59	V158	1024
	Off	60	V158	2048

Output	Event	Event No.	Mask	Enable code
O31	On	61	V158	4096
	Off	62	V158	8192
O32	On	63	V158	16348
	Off	64	V158	327680

9.6.14. *Binary input event masks*

Channel	Event	Event No.	Mask	Enable code
I1	On	E1	V155	1
	Off	E2	V155	2
I2	On	E3	V155	4
	Off	E4	V155	8
I3	On	E5	V155	16
	Off	E6	V155	32
I4	On	E7	V155	64
	Off	E8	V155	128
I5	On	E9	V155	256
	Off	E10	V155	512
I6	On	E11	V155	1024
	Off	E12	V155	2048
I7	On	E13	V155	4096
	Off	E14	V155	8192
I8	On	E15	V155	16384
	Off	E16	V155	32768
I9	On	E17	V156	1
	Off	E18	V156	2
I10	On	E19	V156	4
	Off	E20	V156	8
I11	On	E21	V156	16
	Off	E22	V156	32

Channel	Event	Event No.	Mask	Enable code
I12	On	E23	V156	64
	Off	E24	V156	128
I13	On	E25	V156	256
	Off	E26	V156	512
I14	On	E27	V156	1024
	Off	E28	V156	2048
I15	On	E29	V156	4096
	Off	E30	V156	8192
I16	On	E31	V156	16384
	Off	E32	V156	32768

In the case of a double signal the significance of the events changes as shown in the following example where the inputs 2 and 3 are configured as double signal.

Input	Event No.	Significance	Significance at double signal
I2	E3	on	1-0
	E4	off	0-1
I3	E5	on	0-0
	E6	off	1-1

9.6.15. Hardware 35

Summary of parameters:

Address	Access	Text	Unit	Default	Min.	Max.	Step
1S1	R	SWVers SX...	<Select>	X	1	25	1
		A	1				
		B	2				
		C	3				
		...	...				
		Y	25				

9.6.16. Channel 8 system I/O's 34**Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
8S1	R	LEDSigMode	<Select>	AccumSigAll	1	4	1
		AccumSigAll	1				
		ResetOnStart	2				
		ResetOnTrip	3				
		NoLatching	4				
8S2	R	Confirm Pars	<Select>	on	0	1	1
		off	0				
		on	1				
8S3	R	TimeFromPC	<Select>	on	0	1	1
		off	0				
		on	1				

Event list

Event No.	Cause	Event mask	Enable code
8E1	GenTrip Set	V155	1
8E2	Ditto Reset	V155	2
8E3	GenStart Set	V155	4
8E4	Ditto Reset	V155	8
8E5	Test active Set	V155	16
8E6	Ditto Reset	V155	32
8E7	InjTstOP Set	V155	64
8E8	Ditto Reset	V155	128
8E9	Relay Ready Set	V155	256
8E10	Ditto Reset	V155	512
8E11	ParSet1 Set	V155	1024
8E12	Ditto Reset	V155	2048
8E13	ParSet2 Set	V155	4096
8E14	Ditto Reset	V155	8192

Event No.	Cause	Event mask	Enable code
8E15	ParSet3 Set	V155	16384
8E16	Ditto Reset	V155	32768
8E17	ParSet4 Set	V156	1
8E18	Ditto Reset	V156	2
8E19	HMI is on Set	V156	4
8E20	Ditto Reset	V156	8
8E21	Modem error Set	V156	16
8E22	Ditto Reset	V156	32
8E23	QuitStatus Set	V156	64
8E24	Ditto Reset	V156	128
8E25	MVB_PB_Warn Set	V156	256
8E26	Ditto Reset	V156	512
8E27	MVB_PB_Crash Set	V156	1024
8E28	Ditto Reset	V156	2048
8E29	PB_BA1Ready Set	V156	4096
8E30	Ditto Reset	V156	8192
8E31	PB_BA2Ready Set	V156	16384
8E32	Ditto Reset	V156	32768
8E33	PB_BA3Ready Set	V157	1
8E34	Ditto Reset	V157	2
8E35	PB_BA4Ready Set	V157	4
8E36	Ditto Reset	V157	8
8E37	PB LA faulty Set	V157	16
8E38	Ditto Reset	V157	32
8E39	PB LB faulty Set	V157	64
8E40	Ditto Reset	V157	128

9.6.17. IBB I/O 43**Event list**

Event No.	Cause	Event mask	Enable code
9E1	Receive Set	V155	1
9E2	Ditto Reset	V155	2
9E3	Initialisation Set	V155	4
9E4	Ditto Reset	V155	8
9E5	PrDatBlckSig Set	V155	16
9E6	Ditto Reset	V155	32

Measured variables

Function 9 (IBB I/O) makes measured variables available the number and significance of which depend on the FUPLA configuration. The number of measured variables is limited to 64.

Address	Access	Text	Format
9V1	R	IBBMW 1	Longinteger
9Vn	R	IBBMW n	Longinteger
9V64	R	IBBMW 64	Longinteger

9.6.18. Current-DT 2**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	Delay	s	00.01	0.00	60.00	0.01
14S10	R	I-Setting	IN	04.00	0.1	20	0.1
14S11	R	f-min	Hz	040.0	2	50	1
14S12	R	MaxMin	<Select>	MAX	-1	1	2
		MIN	-1				
		MAX	1				
14S13	R	NrOfPhases		001	1	3	2

Measured variables

Address	Access	Text	Dec.
14V1	R	IN	2

Tripping levels

Address	Access	Text	Dec.
14Q1	R	IN	2

Event list

Event No.	Cause		Event mask	Enable code	Status
14E1	Trip	Set	V155	1	14I1
14E2	Ditto	Reset	V155	2	
14E3	Start	Set	V155	4	14I2
14E4	Ditto	Reset	V155	8	

9.6.19. Current 3**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	Delay	s	01.00	0.02	60.00	0.01
14S10	R	I-Setting	IN	02.00	0.02	20.00	0.01
14S11	R	MaxMin	<Select>	MAX (1ph)	-3	5	2
		MIN (3ph)	-3				
		MIN (1ph)	-1				
		MAX (1ph)	1				
		MAX (3ph)	3				
		Max-Inrush	5				
14S12	R	NrOfPhases		001	1	3	2

Measured variables

Address	Access	Text	Dec.
14V1	R	IN	3

Tripping levels

Address	Access	Text	Dec.
14Q1	R	IN	3

Event list

Event No.	Cause	Event mask	Enable code	Status
14E1	Trip Set	V155	1	14I1
14E2	Ditto Reset	V155	2	
14E3	Start Set	V155	4	14I2
14E4	Ditto Reset	V155	8	

9.6.20. Diff-Transf 4**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	g	IN	0.20	0.10	0.50	0.10
14S10	R	v		0.50	0.25	0.50	0.25
14S11	R	b	1	1.50	1.25	5.00	0.25
14S12	R	g-High	IN	2.00	0.50	2.50	0.25
14S13	R	I-Inst	IN	10	3	15	1
14S14	R	a1		1.00	0.05	2.20	0.01
14S15	R	s1	<Select>	Y	0	1	1
		Y	0				
		D	1				
14S16	R	a2		1.00	0.05	2.20	0.01
14S17	R	s2	<Select>	y0	00	21	1
		y0	0				
		y1	1				
		y5	2				
		y6	3				
		y7	4				
		y11	5				
		d0	6				
		d1	7				
		d5	8				
		d6	9				
		d7	10				
		d11	11				
		z0	12				
		z1	13				
		z2	14				

Address	Access	Text	Unit	Default	Min.	Max.	Step
		z4	15				
		z5	16				
		z6	17				
		z7	18				
		z8	19				
		z10	20				
		z11	21				
14S18	R	a3		1.00	0.05	2.20	0.01
14S19	R	s3	<Select>	y0	00	21	1
		y0	0				
		y1	1				
		y5	2				
		y6	3				
		y7	4				
		y11	5				
		d0	6				
		d1	7				
		d5	8				
		d6	9				
		d7	10				
		d11	11				
		z0	12				
		z1	13				
		z2	14				
		z4	15				
		z5	16				
		z6	17				
		z7	18				
		z8	19				
		z10	20				
		z11	21				

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S20	R	InrushRatio	%	10	6	20	1
14S21	R	InrushTime	s	5	0	90	1

Measured variables

Address	Access	Text	Dec.	Address	Access	Text	Dec.
14V1	R	IN (Id-R)	2	14V4	R	IN (IhR)	2
14V2	R	IN (Id-S)	2	14V5	R	IN (IhR)	2
14V3	R	IN (Id-T)	2	14V6	R	IN (IhR)	2

Tripping levels

Address	Access	Text	Dec.
14Q1	R	IN (Id-R)	2
14Q2	R	IN (Id-S)	2
14Q3	R	IN (Id-T)	2

Event list

Event No.	Cause		Event mask	Enable code	Status
14E1	Trip	Set	V155	1	14I1
14E2	Ditto	Reset	V155	2	
14E3	Trip-R	Set	V155	4	14I2
14E4	Ditto	Reset	V155	8	
14E5	Trip-S	Set	V155	16	14I3
14E6	Ditto	Reset	V155	32	
14E7	Trip-T	Set	V155	64	14I4
14E8	Ditto	Reset	V155	128	
14E9	Inrush	Set	V155	256	14I5
14E10	Ditto	Reset	V155	512	
14E11	Stabil	Set	V155	1024	14I6
14E12	Ditto	Reset	V155	2048	

9.6.21. Underimped 5**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	Delay	s	00.50	0.20	60.00	0.01
14S10	R	Z-Setting	UN/IN	0.250	0.025	2.500	0.001
14S11	R	NrOfPhases		001	1	3	1

Measured variables

Address	Access	Text	Dec.
14V1	R	UN/IN	3

Tripping levels

Address	Access	Text	Dec.
14Q1	R	UN/IN	3

Event list

Event No.	Cause		Event mask	Enable code	Status
14E1	Trip	Set	V155	1	14I1
14E2	Ditto	Reset	V155	2	
14E3	Start	Set	V155	4	14I2
14E4	Ditto	Reset	V155	8	

9.6.22. MinReactance 6**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	Delay	s	00.50	0.20	60.00	0.01
14S10	R	XA-Setting	UN/IN	-2.00	-5.00	00.00	0.01
14S11	R	XB-Setting	UN/IN	-0.50	-2.50	+2.50	0.01
14S12	R	NrOfPhases		001	1	3	1
14S13	R	Angle	deg	000	-180	180	005
14S14	R	MaxMin	<Select>	MIN	-1	1	2
		MIN	-1				
		MAX	1				

Measured variables

Address	Access	Text	Dec.
14V1	R	UN/IN	3

Tripping levels

Address	Access	Text	Dec.
14Q1	R	UN/IN	3

Event list

Event No.	Cause	Event mask	Enable code	Status
14E1	Trip Set	V155	1	14I1
14E2	Ditto Reset	V155	2	
14E3	Start Set	V155	4	14I2
14E4	Ditto Reset	V155	8	

9.6.23. NPS-DT 7**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	Delay	s	01.00	0.50	60.0	0.01
14S10	R	I2-Setting	IN	00.20	0.02	0.50	0.01

Measured variables

Address	Access	Text	Dec.
14V1	R	IN	3

Tripping levels

Address	Access	Text	Dec.
14Q1	R	IN	3

Event list

Event No.	Cause		Event mask	Enable code	Status
14E1	Trip	Set	V155	1	14I1
14E2	Ditto	Reset	V155	2	
14E3	Start	Set	V155	4	14I2
14E4	Ditto	Reset	V155	8	

9.6.24. NPS-Inv 11**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	k1-Setting	s	10.00	5.00	60.00	0.10
14S10	R	k2-Setting	I2/IB	0.05	0.02	0.20	0.01
14S11	R	t-min	s	010.0	1.0	120.	0 0.1
14S12	R	t-max	s	1000	500	2000	1
14S13	R	t-Reset	s	0030	5	2000	1
14S14	R	IB-Setting	IN	1.00	0.50	2.50	0.01

Measured variables

Address	Access	Text	Dec.
14V1	R	IN	3

Tripping levels

Address	Access	Text	Dec.
14Q1	R	IN	3

Event list

Event No.	Cause		Event mask	Enable code	Status
14E1	Trip	Set	V155	1	14I1
14E2	Ditto	Reset	V155	2	
14E3	Start	Set	V155	4	14I20
14E4	Ditto	Reset	V155	8	

9.6.25. Voltage 12**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	Delay	s	02.00	0.02	60.00	0.01
14S10	R	U-Setting	UN	1.200	0.010	2.000	0.002
14S11	R	MaxMin	<Select>	MAX (1ph)	-3	3	2
		MIN (3ph)	-3				
		MIN (1ph)	-1				
		MAX (1ph)	1				
		MAX (3ph)	3				
14S12	R	NrOfPhases		001	1	3	1

Measured variables

Address	Access	Text	Dec.
14V1	R	UN	3

Tripping levels

Address	Access	Text	Dec.
14Q1	R	UN	3

Event list

Event No.	Cause		Event mask	Enable code	Status
14E1	Trip	Set	V155	1	14I1
14E2	Ditto	Reset	V155	2	
14E3	Start	Set	V155	4	14I2
14E4	Ditto	Reset	V155	8	

9.6.26. Current-Inv 13**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	c-Setting	<Select>	1.00	0	2	1
		0.02	0				
		1.00	1				
		2.00	2				
		RXIDG	3				
14S10	R	k1-Setting	s	013.50	0.01	200.00	0.01
14S11	R	I-Start	IB	1.10	1.00	2.00	0.01
14S12	R	NrOfPhases		1	1	3	2
14S13	R	IB-Setting	IN	1.00	0.20	2.50	0.01
14S14	R	t-min	s	00.00	00.00	10.00	00.10

Measured variables

Address	Access	Text	Dec.
14V1	R	IN	3

Tripping levels

Address	Access	Text	Dec.
14Q1	R	IN	3

Event list

Event No.	Cause	Event mask	Enable code	Status
14E1	Trip Set	V155	1	14I1
14E2	Ditto Reset	V155	2	
14E3	Start Set	V155	4	14I2
14E4	Ditto Reset	V155	8	

9.6.27. OLoad-Stator 14**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	k1-Setting	s	041.4	1.0	120.0	0.1
14S10	R	I-Start	IB	1.10	1.00	1.60	0.01
14S11	R	t-min	s	0010.0	1.0	120.0	0.1
14S12	R	tg	s	0120.0	10.0	2000.0	10.0
14S13	R	t-max	s	0300.0	100.0	2000.0	10.0
14S14	R	t-Reset	s	0120.0	10.0	2000.0	10.0
14S15	R	IB-Setting	IN	1.00	0.50	2.50	0.01
14S16	R	NrOfPhases		3	1	3	2

Measured variables

Address	Access	Text	Dec.
14V1	R	IN	3

Tripping levels

Address	Access	Text	Dec.
14Q1	R	IN	3

Event list

Event No.	Cause	Event mask	Enable code	Status
14E1	Trip Set	V155	1	14I1
14E2	Ditto Reset	V155	2	
14E3	Start Set	V155	4	14I2
14E4	Ditto Reset	V155	8	

9.6.28. OLoad-Rotor 15**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	k1-Setting	s	033.8	1.0	50.0	0.1
14S10	R	I-Start	IB	1.10	1.00	1.60	0.01
14S11	R	t-min	s	0010.0	1.0	120.0	0.1
14S12	R	tg	s	0120.0	10.0	2000.0	10.0
14S13	R	t-max	s	0300.0	100.0	2000.0	10.0
14S14	R	t-Reset	s	0120.0	10.0	2000.0	10.0
14S15	R	IB-Setting	IN	1.00	0.50	2.50	0.01

Measured variables

Address	Access	Text	Dec.
14V1	R	IN	3

Tripping levels

Address	Access	Text	Dec.
14Q1	R	IN	3

Event list

Event No.	Cause		Event mask	Enable code	Status
14E1	Trip	Set	V155	1	14I1
14E2	Ditto	Reset	V155	2	
14E3	Start	Set	V155	4	14I2
14E4	Ditto	Reset	V155	8	

9.6.29. Power 18**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	P-Setting	PN	-0.050	-0.100	1.200	0.005
14S10	R	Angle	deg	000.0	-180.0	180.0	5.0
14S11	R	Drop-Ratio	%	60	30	170	1
14S12	R	Delay	s	00.50	0.05	60.00	0.01
14S13	R	MaxMin	<Select>	MIN	-1	+1	2
		MIN	-1				
		MAX	1				
14S14	R	Phi-Comp.	deg	0.0	-5.0	5.0	0.1
14S15	R	NrOfPhases		001	1	3	1
14S16	R	PN	UN*IN	1.000	0.500	2.500	0.001

Measured variables

Address	Access	Text	Dec.
14V1	R	PN	3

Tripping levels

Address	Access	Text	Dec.
14Q1	R	PN	3

Event list

Event No.	Cause	Event mask	Enable code	Status
14E1	Trip Set	V155	1	14I1
14E2	Ditto Reset	V155	2	
14E3	Start Set	V155	4	14I2
14E4	Ditto Reset	V155	8	

9.6.30. *I_{max}-U_{min}* 20**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	Delay	s	01.00	0.5	60.00	0.01
14S10	R	Strom	IN	02.00	0.5	20	0.1
14S11	R	Hold-Voltage	UN	00.70	0.4	1.1	0.01
14S12	R	Hold-Time	s	01.00	0.1	10	0.02
14S13	R	NrOfPhases		001	1	3	2

Measured variables

Address	Access	Text	Dec.
14V1	R	IN	3
14V2	R	UN	3

Tripping levels

Address	Access	Text	Dec.
14Q1	R	IN	3

Event list

Event No.	Cause		Event mask	Enable code	Status
14E1	Trip	Set	V155	1	14I1
14E2	Ditto	Reset	V155	2	
14E3	Start	Set	V155	4	14I2
14E4	Ditto	Reset	V155	8	

9.6.31. Delay 22**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	Trip-Delay	s	01.00	0.00	300.00	0.01
14S10	R	Reset-Delay	s	00.01	0.00	300.00	0.01
14S11	R	Integration	0/1	0	0	1	1

Measured variables

Address	Access	Text	Dec.
14V1	R	s	3

Tripping levels

Address	Access	Text	Dec.
14Q1	R	s	3

Event list

Event No.	Cause		Event mask	Enable code	Status
14E1	Trip	Set	V155	1	14I1
14E2	Ditto	Reset	V155	2	
14E3	Start	Set	V155	4	14I2
14E4	Ditto	Reset	V155	8	

9.6.32. Diff-Gen 23**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	g-Setting	IN	0.10	0.10	0.50	0.05
14S10	R	v-Setting		0.25	0.25	0.50	0.25

Measured variables

Address	Access	Text	Dec.
14V1	R	IN (Id-R)	2
14V2	R	IN (Id-S)	2
14V3	R	IN (Id-T)	2

Tripping levels

Address	Access	Text	Dec.
14Q1	R	IN (Id-R)	2
14Q2	R	IN (Id-S)	2
14Q3	R	IN (Id-T)	2

Event list

Event No.	Cause	Event mask	Enable code	Status
14E1	Trip-R Set	V155	1	14I1
14E2	Ditto Reset	V155	2	
14E3	Trip-S Set	V155	4	14I2
14E4	Ditto Reset	V155	8	
14E5	Trip-T Set	V155	16	14I3
14E6	Ditto Reset	V155	32	
14E7	Trip Set	V155	64	14I4
14E8	Ditto Reset	V155	128	

9.6.33. Distance 24**Basic channel No.: 14****Summary of parameters:**

The starter and measurement settings (in columns Min., Max. and Step) with the unit 'ohms/phase' have to be divided by 10 for relays with a rated current of 5 A.

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP CB R		00000000B			
14S6	R	TRIP CB S		00000000B			
14S7	R	TRIP CB T		00000000B			
14S9	R	X (1)	Ω/ph	000.00	-300	300	0.01
14S10	R	R (1)	Ω/ph	000.00	-300	300	0.01
14S11	R	RR (1)	Ω/ph	000.00	-300	300	0.01
14S12	R	RRE (1)	Ω/ph	000.00	-300	300	0.01
14S13	R	k0 (1)	1	001.00	0	8	0.01
14S14	R	k0Ang(1)	deg	000.00	-180	90	0.01
14S15	R	Delay(1)	s	000.000	0	10	0.001
14S16	R	X (2)	Ω/ph	000.00	-300	300	0.01
14S17	R	R (2)	Ω/ph	000.00	-300	300	0.01
14S18	R	RR (2)	Ω/ph	000.00	-300	300	0.01
14S19	R	RRE (2)	Ω/ph	000.00	-300	300	0.01
14S20	R	k0 (2)	1	001.00	0	8	0.01
14S21	R	k0Ang(2)	deg	000.00	-180	90	0.01
14S22	R	Delay(2)	s	000.00	0	10	0.01
14S23	R	X (3)	Ω/ph	000.00	-300	300	0.01
14S24	R	R (3)	Ω/ph	000.00	-300	300	0.01
14S25	R	RR (3)	Ω/ph	000.00	-300	300	0.01
14S26	R	RRE (3)	Ω/ph	000.00	-300	300	0.01
14S27	R	k0 (3)	1	001.00	0	8	0.01
14S28	R	k0Ang(3)	deg	000.00	-180	90	0.01
14S29	R	Delay(3)	s	000.00	0	10	0.01

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S30	R	X (4/OR)	Ω/ph	000.00	-300	300	0.01
14S31	R	R (4/OR)	Ω/ph	000.00	-300	300	0.01
14S32	R	RR (4/OR)	Ω/ph	000.00	-300	300	0.01
14S33	R	RRE (4/OR)	Ω/ph	000.00	-300	300	0.01
14S34	R	k0 (4/OR)	1	001.00	0	8	0.01
14S35	R	k0Ang(4/OR)	deg	000.00	-180	90	0.01
14S36	R	Delay(4/OR)	s	000.00	0	10	0.01
14S37	R	X (BACK)	Ω/ph	000.00	-300	0	0.01
14S38	R	R (BACK)	Ω/ph	000.00	-300	0	0.01
14S39	R	RR (BACK)	Ω/ph	000.00	-300	0	0.01
14S40	R	RRE (BACK)	Ω/ph	000.00	-300	0	0.01
14S41	R	StartMode	<Select>	l>	2	6	2
		UZ	4				
		OC	6				
14S42	R	PhasSelMode	<Select>	solid ground	0	8	1
		Solid ground	0				
		RTS(R) cycl	1				
		TRS(T) cycl	2				
		RTS acycl	3				
		RST acycl	4				
		TSR acycl	5				
		TRS acycl	6				
		SRT acycl	7				
		STR acycl	8				
14S43	R	ComMode	<Select>	off	0	5	1
		off	0				
		PUTT Nondir	1				
		PUTT Fward	2				
		PUTT OR2	3				
		POTT	4				
		BLOCK OR	5				

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S44	R	VTSupMode	<Select>	off	0	4	1
		off	0				
		I0	1				
		I2	2				
		I0*I2	3				
		Special	4				
14S45	R	Ref Length	Ω/ph	01.000	0.01	30.000	0.001
14S46	R	CT Neutral	<Select>	Busside	-1	1	2
		Busside	-1				
		Lineside	1				
14S47	R	k0m	1	000.00	0	8	0.01
14S48	R	k0mAng	deg	000.00	-90	90	0.01
14S49	R	Imin	IN	000.20	0.1	2	0.01
14S50	R	3I0min	IN	000.20	0.1	2	0.01
14S51	R	U0 VTSup	UN	000.20	0.01	0.5	0.01
14S52	R	I0 VTSup	IN	000.07	0.01	0.5	0.01
14S53	R	U2 VTSup	UN	000.20	0.01	0.5	0.01
14S54	R	I2 VTSup	IN	000.07	0.01	0.5	0.01
14S55	R	Istart	IN	004.00	0.5	10	0.01
14S56	R	XA	Ω/ph	000.0	0	999	0.1
14S57	R	XB	Ω/ph	000.0	-999	0	0.1
14S58	R	RA	Ω/ph	000.0	0	999	0.1
14S59	R	RB	Ω/ph	000.0	-999	0	0.1
14S60	R	RLoad	Ω/ph	000.0	0	999	0.1
14S61	R	AngleLoad	deg	045.0	0	90	0.1
14S62	R	Delay(Def)	s	002.00	0	10	0.01
14S63	R	UminFault	UN	000.05	0.01	2	0.01
14S64	R	MemDirMode	<Select>	Trip	0	2	1
		Block	0				
		Trip	1				
		Cond Trip	2				

Address	Access	Text	Unit	Default	Min.	Max.	Step
15S1	R	SOFT	<Select>	off	0	2	1
		off	0				
		Non-dir	1				
		Fwards OR2	2				
15S2	R	EventRecFull	<Select>	off	0	1	1
		off	0				
		on	1				
15S3	R	3U0min	UN	000.00	0	2	0.01
15S4	R	U Weak	UN	000.00	0	2	0.01
15S5	R	I OC BU	IN	000.00	0	10	0.01
15S6	R	Del OC BU	s	005.00	0	10	0.01
15S7	R	GndFaultMode	<Select>	I0	0	3	1
		I0	0				
		I0 OR U0	1				
		I0 AND U0	2				
		Blocked	3				
15S9	R	Dir Def	<Select>	Non-dir	1	2	1
		Non-dir	1				
		Fwards	2				
15S10	R	TripMode	<Select>	1PhTrip	1	3	1
		1PhTrip	1				
		3PhTrip	2				
		3PhTripDel3	3				
15S11	R	SOFT10sec	<Select>	off	0	1	1
		off	0				
		on	1				
15S12	R	t1EvolFaults	s	003.00	0	10	0.01
15S13	R	ZExtension	<Select>	off	0	1	1
		off	0				
		on	1				
15S14	R	Weak	<Select>	off	0	1	1
		off	0				
		on	1				

Address	Access	Text	Unit	Default	Min.	Max.	Step
15S15	R	Unblock	<Select>	off	0	1	1
		off	0				
		on	1				
15S16	R	Block Z1	<Select>	off	0	1	1
		off	0				
		on	1				
15S17	R	Echo	<Select>	off	0	1	1
		off	0				
		on	1				
15S18	R	TransBl	<Select>	off	0	1	1
		off	0				
		on	1				
15S19	R	t1TransBl	s	000.05	0	0.25	0.01
15S20	R	t2TransBl	s	003.00	0	10	0.01
15S21	R	t1Block	s	000.04	0	0.25	0.01
15S22	R	tPSblock	s	000.00	0	10	0.01
15S23	R	VTSupBlkDel	<Select>	off	0	1	1
		off	0				
		on	1				
15S24	R	VTSupDebDel	<Select>	off	0	1	1
		off	0				
		on	1				
15S25	R	TIMER_1	ms	0	0	30000	1
15S26	R	TIMER_2	ms	0	0	30000	1
15S27	R	TIMER_3	ms	0	0	30000	1
15S28	R	TIMER_4	ms	0	0	30000	1
15S29	R	TIMER_5	ms	0	0	30000	1
15S30	R	TIMER_6	ms	0	0	30000	1
15S31	R	TIMER_7	ms	0	0	30000	1
15S32	R	TIMER_8	ms	0	0	30000	1

Measured variables

Address	Access	Text	Dec.
14V1	R	[Ref Length]	2
14V2-14V3	R	Z (RE)	2
14V4-14V5	R	Z (SE)	2
14V6-14V7	R	Z (TE)	2
14V8-14V9	R	Z (RS)	2
14V10-14V11	R	Z (ST)	2
14V12-14V13	R	Z (TR)	2

Tripping levels

Address	Access	Text	Dec.
14Q1	R	[Ref Length]	2
14Q2-14Q3	R	Z (RE)	2
14Q4-14Q5	R	Z (SE)	2
14Q6-14Q7	R	Z (TE)	2
14Q8-14Q9	R	Z (RS)	2
14Q10-14Q11	R	Z (ST)	2
14Q12-14Q13	R	Z (TR)	2

Note:

A tripping value will only be overwritten (e.g.: Z(RS)) if the same loop (RS) trips again.

Event list

Event No.	Cause	Event mask	Enable code	Status
14E1	Start I0 Set	V155	1	14I1
14E2	Ditto Reset	V155	2	
14E3	Start U0 Set	V155	4	14I2
14E4	Ditto Reset	V155	8	
14E5	Meas Oreach Set	V155	16	14I3
14E6	Ditto Reset	V155	32	
14E7	Trip O/C Set	V155	64	14I4
14E8	Ditto Reset	V155	128	
14E9	Power Swing Set	V155	256	14I5
14E10	Ditto Reset	V155	512	
14E11	Trip CB R Set	V155	1024	14I6
14E12	Ditto Reset	V155	2048	
14E13	Trip CB S Set	V155	4096	14I7
14E14	Ditto Reset	V155	8192	
14E15	Trip CB T Set	V155	16384	14I8
14E16	Ditto Reset	V155	32768	
14E17	Trip SOFT Set	V156	1	14I9
14E18	Ditto Reset	V156	2	
14E19	Start O/C Set	V156	4	14I10
14E20	Ditto Reset	V156	8	
14E21	Meas Main Set	V156	16	14I11
14E22	Ditto Reset	V156	32	
14E23	Trip CB Set	V156	64	14I12
14E24	Ditto Reset	V156	128	
14E25	Start R+S+T Set	V156	256	14I13
14E26	Ditto Reset	V156	512	
14E27	Com Send Set	V156	1024	14I14
14E28	Ditto Reset	V156	2048	
14E29	Dist Blocked Set	V156	4096	14I15
14E30	Ditto Reset	V156	8192	

Event No.	Cause	Event mask	Enable code	Status
14E31	FreqDev Set	V156	16384	14I16
14E32	Ditto Reset	V156	32768	
14E33	Start R Set	V157	1	14I17
14E34	Ditto Reset	V157	2	
14E35	Start S Set	V157	4	14I18
14E36	Ditto Reset	V157	8	
14E37	Start T Set	V157	16	14I19
14E38	Ditto Reset	V157	32	
14E39	Start E Set	V157	64	14I20
14E40	Ditto Reset	V157	128	
14E41	Start I> Set	V157	256	14I21
14E42	Ditto Reset	V157	512	
14E43	Start Z< Set	V157	1024	14I22
14E44	Ditto Reset	V157	2048	
14E45	Delay 2 Set	V157	4096	14I23
14E46	Ditto Reset	V157	8192	
14E47	Delay 3 Set	V157	16384	14I24
14E48	Ditto Reset	V157	32768	
14E49	Delay 4 Set	V158	1	14I25
14E50	Ditto Reset	V158	2	
14E51	Delay Def Set	V158	4	14I26
14E52	Ditto Reset	V158	8	
14E53	Start RST Set	V158	16	14I27
14E54	Ditto Reset	V158	32	
14E55	Weak infeed Set	V158	64	14I28
14E56	Ditto Reset	V158	128	
14E57	Meas Bward Set	V158	256	14I29
14E58	Ditto Reset	V158	512	
14E59	Trip CB 3P Set	V158	1024	14I30
14E60	Ditto Reset	V158	2048	
14E61	Trip CB 1P Set	V158	4096	14I31
14E62	Ditto Reset	V158	8192	

Event No.	Cause	Event mask	Enable code	Status
15E1	Trip RST Set	V155	1	15I1
15E2	Ditto Reset	V155	2	
15E3	Trip Com Set	V155	4	15I2
15E4	Ditto Reset	V155	8	
15E5	Delay 1 Set	V155	16	15I3
15E6	Ditto Reset	V155	32	
15E7	Com Boost Set	V155	64	15I4
15E8	Ditto Reset	V155	128	
15E9	Trip Stub Set	V155	256	15I5
15E10	Ditto Reset	V155	512	
15E11	VTSup Set	V155	1024	15I6
15E12	Ditto Reset	V155	2048	
15E13	VTSup Delay Set	V155	4096	15I7
15E14	Ditto Reset	V155	8192	
15E15	Start R Aux Set	V155	16384	15I8
15E16	Ditto Reset	V155	32768	
15E17	Start S Aux Set	V156	1	15I9
15E18	Ditto Reset	V156	2	
15E19	Start T Aux Set	V156	4	15I10
15E20	Ditto Reset	V156	8	
15E21	Start E Aux Set	V156	16	15I11
15E22	Ditto Reset	V156	32	
15E23	Start RST Aux Set	V156	64	15I12
15E24	Ditto Reset	V156	128	
15E25	Trip RST Aux Set	V156	256	15I13
15E26	Ditto Reset	V156	512	
15E27	Start SOFT Set	V156	1024	15I14
15E28	Ditto Reset	V156	2048	
15E29	Delay >= 2 Set	V156	4096	15I15
15E30	Ditto Reset	V156	8192	

Event No.	Cause	Event mask	Enable code	Status
15E31	Meas Fward Set	V156	16384	15I16
15E32	Ditto Reset	V156	32768	
15E33	BOOL_OUT1 Set	V157	1	15I17
15E34	Ditto Reset	V157	2	
15E35	BOOL_OUT2 Set	V157	4	15I18
15E36	Ditto Reset	V157	8	
15E37	BOOL_OUT3 Set	V157	16	15I19
15E38	Ditto Reset	V157	32	
15E39	BOOL_OUT4 Set	V157	64	15I20
15E40	Ditto Reset	V157	128	
15E41	BOOL_OUT5 Set	V157	256	15I21
15E42	Ditto Reset	V157	512	
15E43	BOOL_OUT6 Set	V157	1024	15I22
15E44	Ditto Reset	V157	2048	
15E45	BOOL_OUT7 Set	V157	4095	15I23
15E46	Ditto Reset	V157	8192	
15E47	BOOL_OUT8 Set	V157	16384	15I24
15E48	Ditto Reset	V157	32768	
15E49	Start 1ph Set	V158	1	15I25
15E50	Ditto Reset	V158	2	
15E51	DelDistBlock Set	V158	4	15I26
15E52	Ditto Reset	V158	8	

9.6.34. Frequency 25**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	Frequency	Hz	48.00	40.00	65.00	0.01
14S10	R	U-Block	UN	0.20	0.20	0.80	0.10
14S11	R	Delay	s	01.00	0.10	60.00	0.01
14S12	R	MaxMin	<Select>	MIN	-1	1	2
		MIN	-1				
		MAX	1				

Measured variables

Address	Access	Text	Dec.
14V1	R	Hz	3
14V2	R	UN	2

Tripping levels

Address	Access	Text	Dec.
14Q1	R	Hz	3

Event list

Event No.	Cause	Event mask	Enable code	Status
14E1	Block.(U<) Set	V155	1	14I1
14E2	Ditto Reset	V155	2	
14E3	Trip Set	V155	4	14I2
14E4	Ditto Reset	V155	8	
14E5	Start Set	V155	16	1I3
14E6	Ditto Reset	V155	32	

9.6.35. Overexcitat 26**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	Delay	s	01.00	0.10	60.00	0.01
14S10	R	U/f-Setting	UN/fN	01.20	0.20	2.00	0.01
14S11	R	MaxMin	<Select>	MAX	-1	1	2
		MIN	-1				
		MAX	1				

Measured variables

Address	Access	Text	Dec.
14V1	R	UN/fN	2
14V2	R	Hz	2

Tripping levels

Address	Access	Text	Dec.
14Q1	R	UN/fN	2

Event list

Event No.	Cause		Event mask	Enable code	Status
14E1	Trip	Set	V155	1	14I1
14E2	Ditto	Reset	V155	2	
14E3	Start	Set	V155	4	14I2
14E4	Ditto	Reset	V155	8	

9.6.36. Count 27**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	CountThresh		1	1	100	1
14S10	R	Drop time	s	00.04	00.01	30.00	00.01
14S11	R	Reset-Delay	s	010.0	000.1	300.0	000.1

Measured variables

Address	Access	Text	Dec.
14V1	R		0

Tripping levels

Address	Access	Text	Dec.
14Q1	R		0

Event list

Event No.	Cause		Event mask	Enable code	Status
14E1	Trip	Set	V155	1	14I1
14E2	Ditto	Reset	V155	2	
14E3	Start	Set	V155	4	14I2
14E4	Ditto	Reset	V155	8	

9.6.37. Overtemp. (RE. 316*4) 28**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	Theta-Beginn	%	100	000	100	001
14S10	R	Theta-Warn	%	105	050	200	001
14S11	R	Theta-Trip	%	110	050	200	001
14S12	R	NrOfPhases		1	1	3	2
14S13	R	TimeConstant	min	005.0	002.0	500.0	000.1
14S14	R	IB-Setting	IN	1.00	0.50	2.50	0.01

Measured variables

Address	Access	Text	Dec.
14V1	R	Theta-Nom	3
14V2	R	Pv-Nom	3
14V3	R	IN	3

Tripping levels

Address	Access	Text	Dec.
14Q1	R	Theta-Nom	3
14Q2	R	Pv-Nom	3
14Q3	R	IN	3

Event list

Event No.	Cause	Event mask	Enable code	Status
14E1	Alarm Set	V155	1	14I1
14E2	Ditto Reset	V155	2	
14E3	Trip Set	V155	4	14I2
14E4	Ditto Reset	V155	8	

9.6.38. Check-I3ph 29**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	I-Setting	IN	0.20	0.05	1.00	0.05
14S10	R	Delay	s	10.0	0.1	60.0	0.1
14S11	R	CT-Compens		+1.00	-2.00	+2.00	0.01

Measured variables

Address	Access	Text	Dec.
14V1	R	IN	3

Tripping levels

Address	Access	Text	Dec.
14Q1	R	IN	3

Event list

Event No.	Cause	Event mask	Enable code	Status
14E1	Trip Set	V155	1	14I1
14E2	Ditto Reset	V155	2	

9.6.39. Check-U3ph 30**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	U-Setting	UN	0.20	0.05	1.20	0.05
14S10	R	Delay	s	10.0	0.1	60.0	0.1
14S11	R	VT-Compens		+1.00	-2.00	+2.00	0.01

Measured variables

Address	Access	Text	Dec.
14V1	R	UN	3

Tripping levels

Address	Access	Text	Dec.
14Q1	R	UN	3

Event list

Event No.	Cause	Event mask	Enable code	Status
14E1	Trip Set	V155	1	14I1
14E2	Ditto Reset	V155	2	

9.6.40. Logic 31**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	Logic Mode	<Select>	OR	0	2	1
		OR	0				
		AND	1				
		RS-Flipflop	2				

Event list

Event No.	Cause	Event mask	Enable code	Status
14E1	BinOutput Set	V155	1	14I1
14E2	Ditto Reset	V155	2	

9.6.41. Disturbance Rec 32**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S9	R	StationNr	No.	01	00	99	01
14S10	R	preEvent	ms	40	40	400	20
14S11	R	Event	ms	100	100	3000	50
14S12	R	postEvent	ms	40	40	400	20
14S13	R	recMode	<Select>	A	0	1	1
		A	0				
		B	1				
14S14	R	TrigMode	<Select>	TrigOnStart	0	5	1
		TrigOnStart	0				
		TrigOnTrip	1				
		TrigOnBin	2				
		TrigAnyBi	3				
		TrigStart&Bi	4				
		TrigTrip&Bin	5				
14S15	R	BinInp 1	<Select>	No trig	0	2	1
		No trig	0				
		Trigger	1				
		Inv. Trigger	2				
14S16	R	BinInp 2	<Select>	No trig	0	2	1
		No trig	0				
		Trigger	1				
		Inv. Trigger	2				
14S17	R	BinInp 3	<Select>	No trig	0	2	1
		No trig	0				
		Trigger	1				
		Inv. Trigger	2				
14S18	R	BinInp 4	<Select>	No trig	0	2	1

Address	Access	Text	Unit	Default	Min.	Max.	Step
		No trig	0				
		Trigger	1				
		Inv. Trigger	2				
14S19	R	BinInp 5	<Select>	No trig	0	2	1
		No trig	0				
		Trigger	1				
		Inv. Trigger	2				
14S20	R	BinInp 6	<Select>	No trig	0	2	1
		No trig	0				
		Trigger	1				
		Inv. Trigger	2				
14S21	R	BinInp 7	<Select>	No trig	0	2	1
		No trig	0				
		Trigger	1				
		Inv. Trigger	2				
14S22	R	BinInp 8	<Select>	No trig	0	2	1
		No trig	0				
		Trigger	1				
		Inv. Trigger	2				
14S23	R	BinInp 9	<Select>	No trig	0	2	1
		No trig	0				
		Trigger	1				
		Inv. Trigger	2				
14S24	R	BinInp 10	<Select>	No trig	0	2	1
		No trig	0				
		Trigger	1				
		Inv. Trigger	2				
14S25	R	BinInp 11	<Select>	No trig	0	2	1
		No trig	0				
		Trigger	1				
		Inv. Trigger	2				

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S26	R	BinInp 12	<Select>	No trig	0	2	1
		No trig	0				
		Trigger	1				
		Inv. Trigger	2				
14S27	R	BinInp 13	<Select>	No trig	0	2	1
		No trig	0				
		Trigger	1				
		Inv. Trigger	2				
14S28	R	BinInp 14	<Select>	No trig	0	2	1
		No trig	0				
		Trigger	1				
		Inv. Trigger	2				
14S29	R	BinInp 15	<Select>	No trig	0	2	1
		No trig	0				
		Trigger	1				
		Inv. Trigger	2				
14S30	R	BinInp 16	<Select>	No trig	0	2	1
		No trig	0				
		Trigger	1				
		Inv. Trigger	2				
14S31	R	StorageMode	<Select>	StopOnFull	0	1	1
		StopOnFull	0				
		Overwrite	1				

Event list

Event No.	Cause	Event mask	Enable code	Status
14E1	Bin output Set	V155	1	1411
14E2	Ditto Reset	V155	2	
14E3	Mem full Set	V155	4	1412
14E4	Ditto Reset	V155	8	

9.6.42. Voltage-Inst 36**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	Delay	s	00.01	0.00	60.00	0.01
14S10	R	U-Setting	UN	1.40	0.01	2.00	0.01
14S11	R	f-min	Hz	040.0	25	50	1
14S12	R	MaxMin	<Select>	MAX	-1	1	2
		MIN	-1				
		MAX	1				
14S13	R	NrOfPhases		001	1	3	2

Measured variables

Address	Access	Text	Dec.
14V1	R	UN	2

Tripping levels

Address	Access	Text	Dec.
14Q1	R	UN	2

Event list

Event No.	Cause	Event mask	Enable code	Status
14E1	Trip Set	V155	1	1411
14E2	Ditto Reset	V155	2	
14E3	Start Set	V155	4	1412
14E4	Ditto Reset	V155	8	

9.6.43. Autoreclosure 38**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
1S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S6	R	CB2 close		00000000B			
14S9	R	1. AR Mode	<Select>	1. 1P3P-1P3P	1	5	1
		1. 1P-1P	1				
		1. 1P-3P	2				
		1. 1P3P-3P	3				
		1. 1P3P-1P3P	4				
		ExtSelection	5				
14S10	R	2..4AR Mode	<Select>	off	0	3	1
		off	0				
		2 AR	1				
		3 AR	2				
		4 AR	3				
14S11	R	Master Mode	<Select>	off	0	1	1
		off	0				
		on	1				
14S12	R	ZE Prefault	<Select>	on	0	1	1
		off	0				
		on	1				
14S13	R	ZE 1. AR	<Select>	off	0	1	1
		off	0				
		on	1				
14S14	R	ZE 2. AR	<Select>	off	0	1	1
		off	0				
		on	1				
14S15	R	ZE 3. AR	<Select>	off	0	1	1
		off	0				
		on	1				

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S16	R	ZE 4. AR	<Select>	off	0	1	1
		off	0				
		on	1				
14S17	R	SCBypass 1P	<Select>	off	0	1	1
		off	0				
		on	1				
14S18	R	SCBypass1P3P	<Select>	off	0	1	1
		off	0				
		on	1				
14S19	R	t Dead1 1P	s	001.20	0.05	300	0.01
14S20	R	t Dead1 3P	s	000.60	0.05	300	0.01
14S21	R	t Dead1 Ext	s	001.00	0.05	300	0.01
14S22	R	t Dead2	s	001.20	0.05	300	0.01
14S23	R	t Dead3	s	005.00	0.05	300	0.01
14S24	R	t Dead4	s	060.00	0.05	300	0.01
14S25	R	t Oper.	s	000.50	0.05	300	0.01
14S26	R	t Inhibit	s	005.00	0.05	300	0.01
14S27	R	t Close	s	000.25	0.05	300	0.01
14S28	R	t Discrim.1P	s	000.60	0.10	300	0.01
14S29	R	t Discrim.3P	s	000.30	0.10	300	0.01
14S30	R	t Timeout	s	001.00	0.05	300	0.01
14S31	R	t AR Block.	s	005.00	0.05	300	0.01
14S32	R	TMSEC_Timer1	ms	0	0	30000	1
14S33	R	TMSEC_Timer2	ms	0	0	30000	1
14S34	R	TMSEC_Timer3	ms	0	0	30000	1
14S35	R	TMSEC_Timer4	ms	0	0	30000	1
14S36	R	TMSEC_Timer5	ms	0	0	30000	1
14S37	R	TMSEC_Timer6	ms	0	0	30000	1
14S38	R	TMSEC_Timer7	ms	0	0	30000	1
14S39	R	TMSEC_Timer8	ms	0	0	30000	1

Event list

Event No.	Cause	Event mask	Enable code	Status
14E1	CB Close Set	V155	1	14I1
14E2	Ditto Reset	V155	2	
14E3	CB2 Close Set	V155	4	14I2
14E4	Ditto Reset	V155	8	
14E5	Trip 3-Pol Set	V155	16	14I3
14E6	Ditto Reset	V155	32	
14E7	ZExtension Set	V155	64	14I4
14E8	Ditto Reset	V155	128	
14E9	Def. Trip Set	V155	256	14I5
14E10	Ditto Reset	V155	512	
14E11	Delay Flwr. Set	V155	1024	14I6
14E12	Ditto Reset	V155	2048	
14E13	Blk. to Flwr Set	V155	4096	14I7
14E14	Ditto Reset	V155	8192	
14E15	Inhibit Outp Set	V155	16384	14I8
14E16	Ditto Reset	V155	32768	
14E17	AR Ready Set	V156	1	14I9
14E18	Ditto Reset	V156	2	
14E19	AR Blocked Set	V156	4	14I10
14E20	Ditto Reset	V156	8	
14E21	AR in Prog Set	V156	16	14I11
14E22	Ditto Reset	V156	32	
14E23	First AR 1P Set	V156	64	14I12
14E24	Ditto Reset	V156	128	
14E25	First AR 3P Set	V156	256	14I13
14E26	Ditto Reset	V156	512	
14E27	Second AR Set	V156	1024	14I14
14E28	Ditto Reset	V156	2048	
14E29	Third AR Set	V156	4096	14I15
14E30	Ditto Reset	V156	8192	

Event No.	Cause	Event mask	Enable code	Status
14E31	Fourth AR Set	V156	16384	14I16
14E32	Ditto Reset	V156	32768	
14E33	P_OUTPUT1 Set	V157	1	14I17
14E34	Ditto Reset	V157	2	
14E35	P_OUTPUT2 Set	V157	4	14I18
14E36	Ditto Reset	V157	8	
14E37	P_OUTPUT3 Set	V157	16	14I19
14E38	Ditto Reset	V157	32	
14E39	P_OUTPUT4 Set	V157	64	14I20
14E40	Ditto Reset	V157	128	
14E41	P_OUTPUT5 Set	V157	256	1421
14E42	Ditto Reset	V157	512	
14E43	P_OUTPUT6 Set	V157	1024	1422
14E44	Ditto Reset	V157	2048	
14E45	P_OUTPUT7 Set	V157	4096	1423
14E46	Ditto Reset	V157	8192	
14E47	P_OUTPUT8 Set	V157	16384	14I24
14E48	Ditto Reset	V157	32768	

9.6.44. EarthFaultsol 40**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
149	R	P-Setting	PN	0.050	0.005	0.100	0.001
14S10	R	Angle	deg	000.00	-180.00	180.00	0.01
14S11	R	Drop-Ratio	%	60	30	95	1
14S12	R	Delay	s	00.50	0.05	60.00	0.01
14S13	R	Phi-Comp.	deg	0.00	-5.00	5.00	0.01
14S14	R	PN	UN*IN	1.000	0.500	2.500	0.001

Measured variables

Address	Access	Text	Dec.
14V1	R	PN	3

Tripping levels

Address	Access	Text	Dec.
14Q1	R	PN	3

Event list

Event No.	Cause	Event mask	Enable code	Status
14E1	Trip Set	V155	1	14I1
14E2	Ditto Reset	V155	2	
14E3	Start Set	V155	4	14I2
14E4	Ditto Reset	V155	8	

9.6.45. Voltage-Bal 41**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	V-Unbalance	UN	0.20	0.10	0.50	0.05
14S10	R	Delay	s	0.04	0.00	1.00	0.01
14S11	R	t-Reset	s	1.50	0.10	2.00	0.01
14S12	R	NrOfPhases		003	1	3	2

Measured variables

Address	Access	Text	Dec.
14V1	R	UN (Ud-1)	2
14V2	R	UN (Ud-2)	2
14V3	R	UN (Ud-3)	2

Tripping levels

Address	Access	Text	Dec.
14Q1	R	UN (Ud-1)	2
14Q2	R	UN (Ud-2)	2
14Q3	R	UN (Ud-3)	2

Event list

Event No.	Cause	Event mask	Enable code	Status
14E1	Trip Set	V155	1	14I1
14E2	Ditto Reset	V155	2	
14E3	Start Set	V155	4	14I2
14E4	Ditto Reset	V155	8	
14E5	Trip-Line1 Set	V155	16	14I3
14E6	Ditto Reset	V155	32	
14E7	Trip-Line2 Set	V155	64	14I4
14E8	Ditto Reset	V155	28	

9.6.46. U/f-Inv 47**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	V/f-Setting	UN/fN	01.10	1.05	1.20	0.01
14S10	R	t-min	min	0.20	0.01	2.00	0.01
14S11	R	t-max	min	60.0	5.0	100.0	0.1
14S12	R	t-Reset	min	60.0	0.2	100.0	0.1
14S13	R	t[V/f=1.05]	min	70.00	00.01	100.00	0.01
14S14	R	t[V/f=1.10]	min	70.00	00.01	100.00	0.01
14S15	R	t[V/f=1.15]	min	06.00	00.01	100.00	0.01
14S16	R	t[V/f=1.20]	min	01.000	00.001	30.000	0.001
14S17	R	t[V/f=1.25]	min	00.480	00.001	30.000	0.001
14S18	R	t[V/f=1.30]	min	00.300	00.001	30.000	0.001
14S19	R	t[V/f=1.35]	min	00.220	00.001	30.000	0.001
14S20	R	t[V/f=1.40]	min	00.170	00.001	30.000	0.001
14S21	R	t[V/f=1.45]	min	00.140	00.001	30.000	0.001
14S22	R	t[V/f=1.50]	min	00.140	00.001	30.000	0.001
14S23	R	UB-Setting	UN	01.00	0.80	1.20	0.01

Measured variables

Address	Access	Text	Dec.
14V1	R	UN/fN	2
14V2	R	Hz	2

Tripping levels

Address	Access	Text	Dec.
14Q1	R	UN/fN	2

Event list

Event No.	Cause	Event mask	Enable code	Status
4E1	Trip Set	V155	1	14I1
14E2	Ditto Reset	V155	2	
14E3	Start Set	V155	4	14I2
14E4	Ditto Reset	V155	8	

9.6.47. UlfPQ 48**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S9	R	Angle	deg	000.0	-180.0	180.0	0.1
14S10	R	PN	UN*IN	1.000	0.200	2.500	0.001
14S11	R	Voltage mode	<Select>	direct	1	2	1
		direct	1				
		ph-to-ph	2				

Measured variables

Address	Access	Text	Dec.
14V1	R	UN	3
14V2	R	IN	3
14V3	R	P (PN)	3
14V4	R	Q (PN)	3
14V5	R	Hz	3

9.6.48. SynchroCheck 49**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	maxVoltDif	UN	0.20	0.05	0.40	0.05
14S10	R	maxPhaseDif	deg	10.0	05.0	80.0	05.0
14S11	R	maxFreqDif	Hz	0.20	0.05	0.40	0.05
14S12	R	minVoltage	UN	0.70	0.60	1.00	0.05
14S13	R	maxVoltage	UN	0.30	0.10	1.00	0.05
14S14	R	Operat.-Mode	<Select>	SynChck only	0	4	1
		SynChck only	0				
		DBus + LLine	1				
		LBus + DLine	2				
		DBus DLine	3				
		DBus + DLine	4				
14S15	R	SupervisTime	s	0.20	0.05	5.00	0.05
14S16	R	t-Reset	s	0.05	0.00	1.00	0.05
14S17	R	LiveBus	<Select>	1ph R-S	0	7	1
		1ph R-S	0				
		1ph S-T	1				
		1ph T-R	2				
		1ph R-E	3				
		1ph S-E	4				
		1ph T-E	5				
		3ph-delta	6				
		3ph-Y	7				

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S18	R	LiveLine	<Select>	3ph-Y	0	7	1
		1ph R-S	0				
		1ph S-T	1				
		1ph T-R	2				
		1ph R-E	3				
		1ph S-E	4				
		1ph T-E	5				
		3ph-delta	6				
		3ph-Y	7				

Measured variables

Address	Access	Text	Dec.
14V1	R	UN (dU)	2
14V2	R	deg (dPhi)	2
14V3	R	Hz (df)	2
14V4	R	UN (max. bus V)	2
14V5	R	UN (min. bus V)	2
14V6	R	UN (max. line V)	2
14V7	R	UN (min. line V)	2

Tripping levels

Address	Access	Text	Dec.
14Q1	R	UN (dU)	2
14Q2	R	deg (dPhi)	2
14Q3	R	Hz (df)	2

Event list

Event No.	Cause	Event mask	Enable code	Status
4E1	PermitToClos Set	V155	1	1411
14E2	Ditto Reset	V155	2	
14E3	Start Set	V155	4	1412
14E4	Ditto Reset	V155	8	
14E5	SyncBlockd Set	V155	16	1413
14E6	Ditto Reset	V155	32	
14E7	TrigBlockd Set	V155	64	1414
14E8	Ditto Reset	V155	128	
14E9	SyncOverrid Set	V155	256	1415
14E10	Ditto Reset	V155	512	
14E11	AmplDifOK Set	V155	1024	1416
14E12	Ditto Reset	V155	2048	
14E13	PhaseDifOK Set	V155	4096	1417
14E14	Ditto Reset	V155	8192	
14E15	FreqDifOK Set	V155	16384	1418
14E16	Ditto Reset	V155	32768	
14E17	LiveBus Set	V156	1	1419
14E18	Ditto Reset	V156	2	
14E19	DeadBus Set	V156	4	14110
14E20	Ditto Reset	V156	8	
14E21	LiveLine Set	V156	16	14111
14E22	Ditto Reset	V156	32	
14E23	DeadLine Set	V156	64	14112
14E24	Ditto Reset	V156	128	

9.6.49. Rotor-EFP 51**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	Alarm-Delay	s	0.50	0.20	60.00	0.05
14S10	R	Trip-Delay	s	0.50	0.20	60.00	0.05
14S11	R	RFr-AlarmVal	kOhm	10.0	0.1	25.0	0.1
14S12	R	RFr-TripVal	kOhm	01.0	0.1	25.0	0.1
14S13	R	REr	kOhm	1.00	0.90	5.00	0.01
14S14	R	Uir	<Select>	50 Volt	1	3	1
		20 Volt	1				
		30 Volt	2				
		50 Volt	3				
14S15	R	RFr-Adjust	kOhm	10.00	8.00	12.00	0.01
14S16	R	CoupC-Adjust	uF	4.00	2.00	10.00	0.01

Measured variables

Address	Access	Text	Dec.
14V1	R	Rfr (kOhm)	1
14V2	R	Ck" (uF)	2
14V3	R	REr" (kOhm)	2

Tripping levels

Address	Access	Text	Dec.
14Q1	R	Rfr (kOhm)	1
14Q2	R	Ck" (uF)	2
14Q3	R	REr" (kOhm)	2

Event list for Rotor-EFP

Event No.	Cause	Event mask	Enable code	Status
14E1	Trip Set	V155	1	14I1
14E2	Ditto Reset	V155	2	
14E3	Start Trip Set	V155	4	14I2
14E4	Ditto Reset	V155	8	
14E5	Alarm Set	V155	16	14I3
14E6	Ditto Reset	V155	32	
14E7	Start Alarm Set	V155	64	14I4
14E8	Ditto Reset	V155	128	
14E9	InterruptInt Set	V155	256	14I5
14E10	Ditto Reset	V155	512	
14E11	InterruptExt Set	V155	1024	14I6
14E12	Ditto Reset	V155	2048	
14E13	Rer-Adjust Set	V155	4096	14I7
14E14	Ditto Reset	V155	8192	
14E15	CoupC-Adjust Set	V155	16384	14I8
14E16	Ditto Reset	V155	32768	
14E17	Extern-Block Set	V156	1	14I9
14E18	Ditto Reset	V156	2	

9.6.50. Stator-EFP 52**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	Alarm-Delay	s	0.50	0.20	60.00	0.05
14S10	R	Trip-Delay	s	0.50	0.20	60.00	0.05
14S11	R	RFs-AlarmVal	kOhm	10.0	0.1	20.0	0.1
14S12	R	RFs-TripVal	kOhm	01.0	0.1	20.0	0.1
14S13	R	REs	kOhm	1.00	0.70	5.00	0.01
14S14	R	REs-2.Starpt	kOhm	1.00	0.90	30.00	0.01
14S15	R	RFs-Adjust	kOhm	10.00	8.00	12.00	0.01
14S16	R	MTransRatio	100.0	10.0	200.0	0.1	
14S17	R	NrOfStarpt		1	1	2	1

Measured variables

Address	Access	Text	Dec.
14V1	R	Rfs (kOhm)	1
14V2	R	Inst. trans. ratio	1
14V3	R	REs" (kOhm)	2

Tripping levels

Address	Access	Text	Dec.
14Q1	R	Rfs (kOhm)	1
14Q2	R	Inst. trans. ratio	1
14Q3	R	REs" (kOhm)	2

Event list

Event No.	Cause		Event mask	Enable code	Status
14E1	Trip	Set	V155	1	14I1
14E2	Ditto	Reset	V155	2	
14E3	Start Trip	Set	V155	4	14I2
14E4	Ditto	Reset	V155	8	
14E5	Alarm	Set	V155	16	14I3
14E6	Ditto	Reset	V155	32	
14E7	Start Alarm	Set	V155	64	14I4
14E8	Ditto	Reset	V155	128	
14E9	InterruptInt	Set	V155	256	14I5
14E10	Ditto	Reset	V155	512	
14E11	InterruptExt	Set	V155	1024	14I6
14E12	Ditto	Reset	V155	2048	
14E13	2.Starpt	Set	V155	4096	14I7
14E14	Ditto	Reset	V155	8192	
14E15	MTR-Adjust	Set	V155	16384	14I8
14E16	Ditto	Reset	V155	32768	
14E17	Res-Adjust	Set	V156	1	14I9
14E18	Ditto	Reset	V156	2	
14E19	Extern-Block	Set	V156	4	14I10
14E20	Ditto	Reset	V156	8	

9.6.51. I0-Invers 53**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	c-Setting	<Select>	1	0	2	1
		0.02	0				
		1.00	1				
		2.00	2				
		RXIDG	3				
14S10	R	k1-Setting	s	013.50	0.01	200.00	0.01
14S11	R	I-Start	IB	1.10	1.00	2.00	0.01
14S12	R	NrOfPhases		1	1	3	2
14S13	R	IB-Setting	IN	1.00	0.20	2.50	0.01
14S14	R	t-min	s	00.00	00.00	10.00	00.10

Measured variables

Address	Access	Text	Dec.
14V1	R	IN	3

Tripping levels

Address	Access	Text	Dec.
14Q1	R	IN	3

Event list

Event No.	Cause	Event mask	Enable code	Status
14E1	Trip Set	V155	1	14I1
14E2	Ditto Reset	V155	2	
14E3	Start Set	V155	4	14I2
14E4	Ditto Reset	V155	8	

9.6.52. Pole-Slip 55**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP1		00000000B			
14S9	R	ZA	UN/IN	0.00	0.000	5.000	0.001
14S10	R	ZB	UN/IN	0.00	-5.000	0.000	0.001
14S11	R	ZC	UN/IN	0.00	0.000	5.000	0.001
14S12	R	Phi	deg	090	60	270	1
14S13	R	WarnAngle	deg	000	0	180	1
14S14	R	TripAngle	deg	090	0	180	1
14S15	R	n1		01	0	20	1
14S16	R	n2		01	0	20	1
14S17	R	t-Reset	s	5.000	0.500	25.000	0.010

Measured variables

Address	Access	Text	Dec.
14V1	R	UN/IN	3
14V2	R	Hz	2

Tripping levels

Address	Access	Text	Dec.
14Q1	R	UN/IN	3
14Q2	R	Hz	2

Event list

Event No.	Cause	Event mask	Enable code	Status
14E1	Warning Set	V155	1	14I1
14E2	Ditto Reset	V155	2	
14E3	Generator Set	V155	4	14I2
14E4	Ditto Reset	V155	8	
14E5	Motor Set	V155	16	14I3
14E6	Ditto Reset	V155	32	
14E7	Zone1 Set	V155	64	14I4
14E8	Ditto Reset	V155	128	
14E9	Zone2 Set	V155	256	14I5
14E10	Ditto Reset	V155	512	
14E11	Trip1 Set	V155	1024	14I6
14E12	Ditto Reset	V155	2048	
14E13	Trip2 Set	V155	4096	14I7
14E14	Ditto Reset	V155	8192	

9.6.53. Diff-Line 56**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	g	IN	0.20	0.10	0.50	0.10
14S10	R	v		0.50	0.25	0.50	0.25
14S11	R	b	1	1.50	1.25	5.00	0.25
14S12	R	g-High	IN	2.00	0.50	2.50	0.25
14S13	R	I-Inst	IN	10	3	15	1
14S14	R	a1		1.00	0.05	2.20	0.01
14S15	R	s1	<Select>	D	0	1	1
		Y	0				
		D	1				
14S16	R	a2		1.00	0.05	2.20	0.01
14S17	R	s2	<Select>	d0	00	21	1
		y0	0				
		y1	1				
		y5	2				
		y6	3				
		y7	4				
		y11	5				
		d0	6				
		d1	7				
		d5	8				
		d6	9				
		d7	10				
		d11	11				

Address	Access	Text	Unit	Default	Min.	Max.	Step
		z0	12				
		z1	13				
		z2	14				
		z4	15				
		z5	16				
		z6	17				
		z7	18				
		z8	19				
		z10	20				
		z11	21				
14S18	R	InrushRatio	%	10	6	20	1
14S19	R	InrushTime	s	0	0	90	1

Measured variables

Address	Access	Text	Dec.	Address	Access	Text	Dec.
14V1	R	IN (Id-R)	2	14V4	R	IN (IhR)	2
14V2	R	IN (Id-S)	2	14V5	R	IN (IhS)	2
14V3	R	IN (Id-T)	2	14V6	R	IN (IhT)	2

Tripping levels

Address	Access	Text	Dec.
14Q1	R	IN (Id-R)	2
14Q2	R	IN (Id-S)	2
14Q3	R	IN (Id-T)	2

Event list

Event No.	Cause	Event mask	Enable code	Status
14E1	Trip Set	V155	1	14I1
14E2	Ditto Reset	V155	2	
14E3	Trip-R Set	V155	4	14I2
14E4	Ditto Reset	V155	8	
14E5	Trip-S Set	V155	16	14I3
14E6	Ditto Reset	V155	32	
14E7	Trip-T Set	V155	64	14I4
14E8	Ditto Reset	V155	128	
14E9	Inrush Set	V155	256	14I5
14E10	Ditto Reset	V155	512	
14E11	Stabil Set	V155	1024	14I6
14E12	Ditto Reset	V155	2048	

9.6.54. RemoteBin 57**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	RemTRIP 1		00000000B			
14S6	R	RemTRIP 2		00000000B			
14S7	R	RemTRIP 3		00000000B			
14S8	R	RemTRIP 4		00000000B			

Event list

Event No.	Cause	Event mask	Enable code	Status
14E1	RemChan 1 Set	V155	1	14I1
14E2	Ditto Reset	V155	2	
14E3	RemChan 2 Set	V155	4	14I2
14E4	Ditto Reset	V155	8	
14E5	RemChan 3 Set	V155	16	14I3
14E6	Ditto Reset	V155	32	
14E7	RemChan 4 Set	V155	64	14I4
14E8	Ditto Reset	V155	128	
14E9	RemChan 5 Set	V155	256	14I5
14E10	Ditto Reset	V155	512	
14E11	RemChan 6 Set	V155	1024	14I6
14E12	Ditto Reset	V155	2048	
14E13	RemChan 7 Set	V155	4096	14I7
14E14	Ditto Reset	V155	8192	
14E15	RemChan 8 Set	V155	16384	14I8
14E16	Ditto Reset	V155	32768	
14E17	RemBinError Set	V156	1	14I9
14E18	Ditto Reset	V156	2	

9.6.55. EarthFltGnd2 58**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	V-Setting	UN	0.200	0.003	0.100	0.001
14S10	R	I-Setting	IN	0.10	0.10	1.00	0.01
14S11	R	Angle	deg	60.0	0.0	90.0	5.0
14S12	R	tBasic	s	0.050	0.000	1.000	0.001
14S13	R	tWait	s	0.050	0.000	0.500	0.001
14S14	R	tTransBl	s	0.100	0.000	0.500	0.001
14S15	R	CT Neutral	<Select>	Lineside	0	1	1
		Lineside	0				
		Busside	1				
14S16	R	ComMode	<Select>	Permissive	0	1	1
		Permissive	0				
		Blocking	1				
14S17	R	SendMode	<Select>	MeasBwd	0	1	1
		Non-dir	0				
		MeasBwd	1				
14S18	R	1 Channel	<Select>	off	0	1	1
		off	0				
		on	1				
14S19	R	Echo	<Select>	off	0	3	1
		off	0				
		Weak	1				
		Bkr	2				
		Weak & Bkr	3				

Measured variables

Address	Access	Text	Dec.
14V1	R	UN	2
14V2	R	IN	2
14V3	R	Forwards	0

Note: This function does not provide tripping levels (Q).

Event list

Event No.	Cause		Event mask	Enable code	Status
14E1	Trip	Set	V155	1	14I1
14E2	Ditto	Reset	V155	2	
14E3	Start	Set	V155	4	14I2
14E4	Ditto	Reset	V155	8	
14E5	MeasFwd	Set	V155	16	14I3
14E6	Ditto	Reset	V155	32	
14E7	MeasBwd	Set	V155	64	14I4
14E8	Ditto	Reset	V155	128	
14E9	Senden	Set	V155	256	14I5
14E10	Ditto	Reset	V155	512	
14E11	Recve Inh	Set	V155	1024	14I6
14E12	Ditto	Reset	V155	2048	

9.6.56. FUPLA 59**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S8	R	NoFUPMV	x	0	0		1
14S9	R	RepRate	x	low (2)	low (2)	high (0)	1
14S10	R	CycleTime	x	20	0	1000	1

Measured variables

The number of FUPLA measured variables depends on the configuration. Within this total configured, the order of the FUPLA measured variables measured variable numbers can be determined by assigning numbers to them.

Address	Access	Text	Dec.
14V1	R	FUPMV 1	2
14V2	R	FUPMV 2	2
14Vn	R	FUPMV n	2

Events

FUPLA events can only be configured as IBB events. Events are not recorded under the FUPLA function number. Because of the variable number of signals/events, FUPLA would require a variable number of channels.

IBB events

FUPLA 'Extout' to IBB channel and ER:

Events are recorded under their SPA address, IBB group and event number,

Addr 121 E1 .

Binary signals are assigned to IBB channels using the HMI. It is not possible to mask IBB events.

9.6.57. FlatterRecog 60**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S9	R	SupervisTime	s	1.0	0.1	60.0	0.1
14S10	R	NoOfChanges		2	2	100	1

Event list

Event No.	Cause	Event mask	Enable code	Status
14E1	InputStatus1 Set	V155	1	14I1
14E2	Ditto Reset	V155	2	
14E3	InputStatus2 Set	V155	4	14I3
14E4	Ditto Reset	V155	8	
14E5	InputStatus3 Set	V155	16	14I5
14E6	Ditto Reset	V155	32	
14E7	InputStatus4 Set	V155	64	14I7
14E8	Ditto Reset	V155	128	
14E9	FlatterSig1 Set	V155	256	14I2
14E10	Ditto Reset	V155	1024	
14E11	FlatterSig2 Set	V155	512	14I4
14E12	Ditto Reset	V155	2048	
14E13	FlatterSig3 Set	V155	4096	14I6
14E14	Ditto Reset	V155	8192	
14E15	FlatterSig4 Set	V155	16384	14I8
14E16	Ditto Reset	V155	32768	

9.6.58. HV distance 63**Basic channel No.: 14****Summary of parameters:**

The starter and measurement settings (in columns Min., Max. and Step) with the unit 'ohms/phase' have to be divided by 10 for relays with a rated current of 5 A.

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP CB R		00000000B			
14S6	R	TRIP CB S		00000000B			
14S7	R	TRIP CB T		00000000B			
14S9	R	X (1)	Ω/ph	000.00	-300	300	0.01
14S10	R	R (1)	Ω/ph	000.00	-300	300	0.01
14S11	R	RR (1)	Ω/ph	000.00	-300	300	
14S12	R	RRE (1)	Ω/ph	000.00	-300	300	
14S13	R	k0 (1)	1	001.00	0	8	0.01
14S14	R	k0Ang(1)	deg	000.00	-180	90	0.01
14S15	R	Delay(1)	s	000.000	0	10	0.001
14S16	R	X (2)	Ω/ph	000.00	-300	300	0.01
14S17	R	R (2)	Ω/ph	000.00	-300	300	0.01
14S18	R	RR (2)	Ω/ph	000.00	-300	300	0.01
14S19	R	RRE (2)	Ω/ph	000.00	-300	300	0.01
14S20	R	k0 (2)	1	001.00	0	8	0.01
14S21	R	k0Ang(2)	deg	000.00	-180	90	0.01
14S22	R	Delay(2)	s	000.00	0	10	0.01
14S23	R	X (3)	Ω/ph	000.00	-300	300	0.01
14S24	R	R (3)	Ω/ph	000.00	-300	300	0.01
14S25	R	RR (3)	Ω/ph	000.00	-300	300	0.01
14S26	R	RRE (3)	Ω/ph	000.00	-300	300	0.01
14S27	R	k0 (3)	1	001.00	0	8	0.01
14S28	R	k0Ang(3)	deg	000.00	-180	90	0.01
14S29	R	Delay(3)	s	000.00	0	10	0.01

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S30	R	X (4/OR)	Ω/ph	000.00	-300	300	0.01
14S31	R	R (4/OR)	Ω/ph	000.00	-300	300	0.01
14S32	R	RR (4/OR)	Ω/ph	000.00	-300	300	0.01
14S33	R	RRE (4/OR)	Ω/ph	000.00	-300	300	0.01
14S34	R	k0 (4/OR)	1	001.00	0	8	0.01
14S35	R	k0Ang(4/OR)	deg	000.00	-180	90	0.01
14S36	R	Delay(4/OR)	s	000.00	0	10	0.01
14S37	R	X (BACK)	Ω/ph	000.00	-300	0	0.01
14S38	R	R (BACK)	Ω/ph	000.00	-300	0	0.01
14S39	R	RR (BACK)	Ω/ph	000.00	-300	0	0.01
14S40	R	RRE (BACK)	Ω/ph	000.00	-300	0	0.01
14S41	R	PhasSelMode	<Select>	Non-dir	9	10	1
		Non-dir	9				
		Fward OR	10				
14S42	R	ComMode	<Select>	off	0	5	1
		off	0				
		PUTT Nondir	1				
		PUTT Fward	2				
		PUTT OR2	3				
		POTT	4				
		BLOCK OR	5				
14S43	R	VTSupMode	<Select>	off	0	4	1
		off	0				
		I0	1				
		I2	2				
		I0*I2	3				
		Special	4				
14S44	R	Ref Length	Ω/ph	01.000	0.01	30.000	0.001
14S45	R	CT Neutral	<Select>	Busside	-1	1	2
		Busside	-1				
		Lineside	1				

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S46	R	k0m	1	000.00	0	8	0.01
14S47	R	k0mAng	deg	000.00	-90	90	0.01
14S48	R	lmin	IN	000.20	0.1	2	0.01
14S49	R	3l0min	IN	000.20	0.1	2	0.01
14S50	R	U0 VTSup	UN	000.20	0.01	0.5	0.01
14S51	R	I0 VTSup	IN	000.07	0.01	0.5	0.01
14S52	R	U2 VTSup	UN	000.20	0.01	0.5	0.01
14S53	R	I2 VTSup	IN	000.07	0.01	0.5	0.01
14S54	R	XA	Ω/ph	000.0	0	999	0.1
14S55	R	XB	Ω/ph	000.0	-999	0	0.1
14S56	R	RA	Ω/ph	000.0	0	999	0.1
14S57	R	RB	Ω/ph	000.0	-999	0	0.1
14S58	R	RLoad	Ω/ph	000.0	0	999	0.1
14S59	R	AngleLoad	deg	045.0	0	90	0.1
14S60	R	SR error	deg	0.00	-2.00	2.00	0.01
14S61	R	TR error	deg	0.00	-2.00	2.00	0.01
14S62	R	Delay(Def)	s	002.00	0	10	0.01
14S63	R	UminFault	UN	000.05	0.01	2	0.01
14S64	R	MemDirMode	<Select>	Trip	0	2	1
		Block	0				
		Trip	1				
		Cond Trip	2				
15S1	R	SOFT	<Select>	off	0	2	1
		off	0				
		Non-dir	1				
		Fwards OR2	2				
15S2	R	EventRecFull	<Select>	off	0	1	1
		off	0				
		on	1				
15S3	R	3U0min	UN	000.00	0	2	0.01
15S4	R	U Weak	UN	000.00	0	2	0.01

Address	Access	Text	Unit	Default	Min.	Max.	Step
15S5	R	I OC BU	IN	000.00	0	10	0.01
15S6	R	Del OC BU	s	005.00	0	10	0.01
15S7	R	GndFaultMode	<Select>	I0	4	7	1
		I0	4				
		I0 OR U0	5				
		I0(I2)	6				
		I0(I2) OR U0	7				
15S9	R	Dir Def	<Select>	Non-dir	1	2	1
		Non-dir	1				
		Fwards	2				
15S10	R	TripMode	<Select>	1PhTrip	1	3	1
		1PhTrip	1				
		3PhTrip	2				
		3PhTripDel3	3				
15S11	R	SOFT 10sec	<Select>	off	0	1	1
		off	0				
		on	1				
15S12	R	t1EvolFaults	s	003.00	0	10	0.01
15S14	R	Weak	<Select>	off	0	1	1
		off	0				
		on	1				
15S15	R	Unblock	<Select>	off	0	1	1
		off	0				
		on	1				
15S16	R	Echo	<Select>	off	0	1	1
		off	0				
		on	1				
15S17	R	TransBl	<Select>	off	0	1	1
		off	0				
		on	1				
15S18	R	t1TransBl	s	000.05	0	0.25	0.01

Address	Access	Text	Unit	Default	Min.	Max.	Step
15S19	R	t2TransBl	s	003.00	0	10	0.01
15S20	R	t1Block	s	000.04	0	0.25	0.01
15S21	R	tPSblock	s	000.00	0	10	0.01
15S22	R	VTSupBlkDel	<Select>	off	0	1	1
		off	0				
		on	1				
15S23	R	VTSupDebDel	<Select>	off	0	1	1
		off	0				
		on	1				
15S24	R	TIMER_1	ms	0	0	30000	1
15S25	R	TIMER_2	ms	0	0	30000	1
15S26	R	TIMER_3	ms	0	0	30000	1
15S27	R	TIMER_4	ms	0	0	30000	1
15S28	R	TIMER_5	ms	0	0	30000	1
15S29	R	TIMER_6	ms	0	0	30000	1
15S30	R	TIMER_7	ms	0	0	30000	1
15S31	R	TIMER_8	ms	0	0	30000	1
15S32	R	I Load	IN	0.5	0	2	0.1

Measured variables

Address	Access	Text	Dec.
14V1	R	[Ref Length]	2
14V2-14V3	R	Z (RE)	2
14V4-14V5	R	Z (SE)	2
14V6-14V7	R	Z (TE)	2
14V8-14V9	R	Z (RS)	2
14V10-14V11	R	Z (ST)	2
14V12-14V13	R	Z (TR)	2

Tripping levels

Address	Access	Text	Dec.
14Q1	R	[Ref Length]	2
14Q2-14Q3	R	Z (RE)	2
14Q4-14Q5	R	Z (SE)	2
14Q6-14Q7	R	Z (TE)	2
14Q8-14Q9	R	Z (RS)	2
14Q10-14Q11	R	Z (ST)	2
14Q12-14Q13	R	Z (TR)	2

Note:

A tripping value will only be overwritten (e.g.: Z(RS)) if the same loop (RS) trips again.

Event list

Event No.	Cause	Event mask	Enable code	Status
14E1	Start I0 Set	V155	1	14I1
14E2	Ditto Reset	V155	2	
14E3	Start U0 Set	V155	4	14I2
14E4	Ditto Reset	V155	8	
14E5	Meas Oreach Set	V155	16	14I3
14E6	Ditto Reset	V155	32	
14E7	Trip O/C Set	V155	64	14I4
14E8	Ditto Reset	V155	128	
14E9	Power Swing Set	V155	256	14I5
14E10	Ditto Reset	V155	512	
14E11	Trip CB R Set	V155	1024	14I6
14E12	Ditto Reset	V155	2048	
14E13	Trip CB S Set	V155	4096	14I7
14E14	Ditto Reset	V155	8192	
14E15	Trip CB T Set	V155	16384	14I8
14E16	Ditto Reset	V155	32768	
14E17	Trip SOFT Set	V156	1	14I9
14E18	Ditto Reset	V156	2	
14E19	Start O/C Set	V156	4	14I10
14E20	Ditto Reset	V156	8	
14E21	Meas Main Set	V156	16	14I11
14E22	Ditto Reset	V156	32	
14E23	Trip CB Set	V156	64	14I12
14E24	Ditto Reset	V156	128	
14E25	Start R+S+T Set	V156	256	14I13
14E26	Ditto Reset	V156	512	
14E27	Com Send Set	V156	1024	14I14
14E28	Ditto Reset	V156	2048	
14E29	Dist Blocked Set	V156	4096	14I15
14E30	Ditto Reset	V156	8192	

Event No.	Cause	Event mask	Enable code	Status
14E31	FreqDev Set	V156	16384	14I16
14E32	Ditto Reset	V156	32768	
14E33	Start R Set	V157	1	14I17
14E34	Ditto Reset	V157	2	
14E35	Start S Set	V157	4	14I18
14E36	Ditto Reset	V157	8	
14E37	Start T Set	V157	16	14I19
14E38	Ditto Reset	V157	32	
14E39	Start E Set	V157	64	14I20
14E40	Ditto Reset	V157	128	
14E41	Delay 2 Set	V157	256	14I21
14E42	Ditto Reset	V157	512	
14E43	Delay 3 Set	V157	1024	14I22
14E44	Ditto Reset	V157	2048	
14E45	Delay 4 Set	V157	4096	14I23
14E46	Ditto Reset	V157	8192	
14E47	Delay Def Set	V157	16384	14I24
14E48	Ditto Reset	V157	32768	
14E49	Start RST Set	V158	1	14I25
14E50	Ditto Reset	V158	2	
14E51	Weak Set	V158	4	14I26
14E52	Ditto Reset	V158	8	
14E53	Meas Bward Set	V158	16	14I27
14E54	Ditto Reset	V158	32	
14E55	Trip CB 3P Set	V158	64	14I28
14E56	Ditto Reset	V158	128	
14E57	Trip CB 1P Set	V158	256	14I29
14E58	Ditto Reset	V158	512	
14E59	Trip RST Set	V158	1024	14I30
14E60	Ditto Reset	V158	2048	

Event No.	Cause		Event mask	Enable code	Status
14E61	Trip Com	Set	V158	4096	14I31
14E62	Ditto	Reset	V158	8192	
15E1	Delay 1	Set	V155	1	15I1
15E2	Ditto	Reset	V155	2	
15E3	Com Boost	Set	V155	4	15I2
15E4	Ditto	Reset	V155	8	
15E5	Trip Stub	Set	V155	16	15I3
15E6	Ditto	Reset	V155	32	
15E7	VTSup	Set	V155	64	15I4
15E8	Ditto	Reset	V155	128	
15E9	VTSup Delay	Set	V155	256	15I5
15E10	Ditto	Reset	V155	512	
15E11	Start R Aux	Set	V155	1024	15I6
15E12	Ditto	Reset	V155	2048	
15E13	Start S Aux	Set	V155	4096	15I7
15E14	Ditto	Reset	V155	8192	
15E15	Start T Aux	Set	V155	16384	15I8
15E16	Ditto	Reset	V155	32768	
15E17	Start E Aux	Set	V156	1	15I9
15E18	Ditto	Reset	V156	2	
15E19	Start RST Aux	Set	V156	4	15I10
15E20	Ditto	Reset	V156	8	
15E21	Trip RST Aux	Set	V156	16	15I11
15E22	Ditto	Reset	V156	32	
15E23	Start SOFT	Set	V156	64	15I12
15E24	Ditto	Reset	V156	128	
15E25	Delay >= 2	Set	V156	256	15I13
15E26	Ditto	Reset	V156	512	
15E27	Meas Fward	Set	V156	1024	15I14
15E28	Ditto	Reset	V156	2048	

Event No.	Cause		Event mask	Enable code	Status
15E29	BOOL_OUT1	Set	V156	4096	15I15
15E30	Ditto	Reset	V156	8192	
15E31	BOOL_OUT2	Set	V156	16384	15I16
15E32	Ditto	Reset	V156	32768	
15E33	BOOL_OUT3	Set	V157	1	15I17
15E34	Ditto	Reset	V157	2	
15E35	BOOL_OUT4	Set	V157	4	15I18
15E36	Ditto	Reset	V157	8	
15E37	BOOL_OUT5	Set	V157	16	15I19
15E38	Ditto	Reset	V157	32	
15E39	BOOL_OUT6	Set	V157	64	15I20
15E40	Ditto	Reset	V157	128	
15E41	BOOL_OUT7	Set	V157	256	15I21
15E42	Ditto	Reset	V157	512	
15E43	BOOL_OUT8	Set	V157	1024	15I22
15E44	Ditto	Reset	V157	2048	
15E45	Start 1ph	Set	V157	4096	15I23
15E46	Ditto	Reset	V157	8192	
15E47	DelDistBlock	Set	V157	16384	15I24
15E48	Ditto	Reset	V157	32768	

9.6.59. LDU events 67**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			

Event list

Event No.	Cause	Event mask	Enable code	Status
14E1	BinOutput1 Set	V155	1	14I1
14E2	Ditto Reset	V155	2	
14E3	BinOutput2 Set	V155	4	14I2
14E4	Ditto Reset	V155	8	
14E5	BinOutput3 Set	V155	16	14I3
14E6	Ditto Reset	V155	32	
14E7	BinOutput4 Set	V155	64	14I4
14E8	Ditto Reset	V155	128	

9.6.60. Debounce 68**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S9	R	SupervisTime1	ms	1	1	10000	1
14S10	R	SupervisTime2	ms	1	1	10000	1
14S11	R	SupervisTime3	ms	1	1	10000	1
14S12	R	SupervisTime4	ms	1	1	10000	1
14S13	R	SupervisTime5	ms	1	1	10000	1
14S14	R	SupervisTime6	ms	1	1	10000	1
14S15	R	SupervisTime7	ms	1	1	10000	1
14S16	R	SupervisTime8	ms	1	1	10000	1
14S17	R	SupervisTime9	ms	1	1	10000	1
14S18	R	SupervisTime10	ms	1	1	10000	1
14S19	R	SupervisTime11	ms	1	1	10000	1
14S20	R	SupervisTime12	ms	1	1	10000	1
14S21	R	SupervisTime13	ms	1	1	10000	1
14S22	R	SupervisTime14	ms	1	1	10000	1
14S23	R	SupervisTime15	ms	1	1	10000	1
14S24	R	SupervisTime16	ms	1	1	10000	1

9.6.61. df/dt 69**Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	TRIP		00000000B			
14S9	R	df/dt	Hz/s	-1.0	-10.0	10.0	0.1
14S10	R	Frequency	Hz	48.00	00.00	65.00	0.01
14S11	R	BlockVoltage	UN	0.2	0.2	0.8	0.1
14S12	R	Delay	s	00.10	0.10	60.00	0.01

Measured variables

Address	Access	Text	Dec.
14V1	R	Hz/s	2
14V2	R	Hz	3
14V3	R	UN	2

Tripping levels

Address	Access	Text	Dec.
14Q1	R	Hz/s	2
4Q2	R	Hz	3

Event list

Event No.	Cause	Event mask	Enable code	Status
14E1	Blocked(U<) Set	V155	1	14I1
14E2	Ditto Reset	V155	2	
14E3	TRIP Set	V155	4	14I2
14E4	Ditto Reset	V155	8	

9.6.62. DirCurrentDT 70**Basisc channel No.: 14****Summery of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip		00000000B			
14S9	R	I-Setting	IN	2.00	0.20	20.00	0.01
14S10	R	Angle	deg	45	-180	+180	15
14S11	R	Delay	s	01.00	0.02	60.00	0.01
14S12	R	tWait	s	0.20	0.02	20.00	0.01
14S13	R	MemDirMode	<Select>	Trip	0	1	1
		Trip	0				
		Block	1				
14S14	R	MemDuration	s	2.00	0.20	60.00	0.01

Measured variables

Address	Access	Text	Dec.
14V1	R	IN (R)	3
14V2	R	IN (S)	3
14V3	R	IN (T)	3
14V4	R	PN (I_R , U_{ST})	3
14V5	R	PN (I_S , U_{TR})	3
14V6	R	PN (I_T , U_{RS})	3
14V7	R	UN (ST)	3
14V8	R	UN (TR)	3
14V9	R	UN (RS)	3

Tripping levels

Address	Access	Text	Dec.
14Q1	R	IN (R)	3
14Q2	R	IN (S)	3
14Q3	R	IN (T)	3
14Q4	R	PN (I_R , U_{ST})	3
14Q5	R	PN (I_S , U_{TR})	3
14Q6	R	PN (I_T , U_{RS})	3
14Q7	R	UN (ST)	3
14Q8	R	UN (TR)	3
14Q9	R	UN (RS)	3

Event list

Event No.	Cause	Event mask	Enable code	Status
14E1	Trip Set	V155	1	14I1
14E2	Ditto Reset	V155	2	
14E3	Start Set	V155	4	14I2
14E4	Ditto Reset	V155	8	
14E5	Start R Set	V155	16	14I3
14E6	Ditto Reset	V155	32	
14E7	Start S Set	V155	64	14I4
14E8	Ditto Reset	V155	128	
14E9	Start T Set	V155	256	14I5
14E10	Ditto Reset	V155	512	
14E11	MeasFwd Set	V155	1024	14I6
14E12	Ditto Reset	V155	2048	
14E13	MeasBwd Set	V155	4096	14I7
14E14	Ditto Reset	V155	8192	

9.6.63. DirCurrentInv 71**Basisc channel No.: 14****Summery of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip		00000000B			
14S9	R	I-Start	IB	1.10	1.00	4.00	0.01
14S10	R	Angle	deg	45	-180	+180	15
14S11	R	c-Setting	<Select>	1.00	0	2	1
		0.02	0				
		1.00	1				
		2.00	2				
14S12	R	k1-Setting	s	13.50	0.01	200.00	0.01
14S13	R	t-min	s	0.00	0.00	10.00	0.01
14S14	R	IB-Setting	IN	1.00	0.04	2.50	0.01
14S15	R	tWait	s	0.20	0.02	20.00	0.01
14S16	R	MemDirMode	<Select>	Trip	0	1	1
		Trip	0				
		Block	1				
14S17	R	MemDuration	s	2.00	0.20	60.00	0.01

Measured variables

Address	Access	Text	Dec.
14V1	R	IN (R)	3
14V2	R	IN (S)	3
14V3	R	IN (T)	3
14V4	R	PN (I_R , U_{ST})	3
14V5	R	PN (I_S , U_{TR})	3
14V6	R	PN (I_T , U_{RS})	3
14V7	R	UN (ST)	3
14V8	R	UN (TR)	3
14V9	R	UN (RS)	3

Tripping levels

Address	Access	Text	Dec.
14Q1	R	IN (R)	3
14Q2	R	IN (S)	3
14Q3	R	IN (T)	3
14Q4	R	PN (I_R , U_{ST})	3
14Q5	R	PN (I_S , U_{TR})	3
14Q6	R	PN (I_T , U_{RS})	3
14Q7	R	UN (ST)	3
14Q8	R	UN (TR)	3
14Q9	R	UN (RS)	3

Event list

Event No.	Cause	Event mask	Enable code	Status
14E1	Trip Set	V155	1	14I1
14E2	Ditto Reset	V155	2	
14E3	Start Set	V155	4	14I2
14E4	Ditto Reset	V155	8	
14E5	Start R Set	V155	16	14I3
14E6	Ditto Reset	V155	32	
14E7	Start S Set	V155	64	14I4
14E8	Ditto Reset	V155	128	
14E9	Start T Set	V155	256	14I5
14E10	Ditto Reset	V155	512	
14E11	MeasFwd Set	V155	1024	14I6
14E12	Ditto Reset	V155	2048	
14E13	MeasBwd Set	V155	4096	14I7
14E14	Ditto Reset	V155	8192	

9.6.64. BreakerFailure 72**Basisc channel No.: 14****Summery of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	23105 TRIP t1		00000000B			
14S9	R	23110 TRIP t1 L1		00000000B			
14S13	R	23115 TRIP t1 L2		00000000B			
14S17	R	23120 TRIP t1 L3		00000000B			
14S21	R	23125 TRIP t2		00000000B			
14S25	R	23130 REMOTE TRIP		00000000B			
14S29	R	23135 RED TRIP L1		00000000B			
14S33	R	23140 RED TRIP L2		00000000B			
14S37	R	23145 RED TRIP L3		00000000B			
14S41	R	23150 EFS REM TRIP		00000000B			
14S45	R	23155 EFS BUS TRIP		00000000B			
14S49	R	I Setting	IN	1.20	0.2	5	0.01
14S50	R	Delay t1	s	0.15	0.02	60	0.01
14S51	R	Delay t2	s	0.15	0.02	60	0.01
14S52	R	Delay tEFP	s	0.04	0.02	60	0.01
14S53	R	t Drop Retrip	s	0.05	0.02	60	0.01
14S54	R	t Drop BuTrip	s	0.05	0.02	60	0.01
14S55	R	t Pulse RemTrip	s	0.05	0.02	60	0.01
14S56	R	t1 active	<Select>	on	0	1	1
		off	0				
		on	1				
14S57	R	t2 active	<Select>	on	0	1	1
		off	0				
		on	1				
14S58	R	RemTrip active	<Select>	on	0	1	1
		off	0				
		on	1				

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S59	R	EFP active	<Select>	on	0	1	1
		off	0				
		on	1				
14S60	R	Red active	<Select>	on	0	1	1
		off	0				
		on	1				
14S61	R	Start Ext act.	<Select>	on	0	1	1
		off	0				
		on	1				
14S62	R	RemTrip after	<Select>	t1	0	1	1
		t2		0			
		t1		1			
14S63	R	NrOfPhases		001	1	3	2

Event list

Event No.	Cause	Event mask	Enable code	Status
14E1	23305 Trip t1 Set	V155	1	14I1
14E2	Ditto Reset	V155	2	
14E3	23315 Trip t1 L1 Set	V155	4	14I2
14E4	Ditto Reset	V155	8	
14E5	23320 Trip t1 L2 Set	V155	16	14I3
14E6	Ditto Reset	V155	32	
14E7	23325 Trip t1 L3 Set	V155	64	14I4
14E8	Ditto Reset	V155	128	
14E9	23310 Trip t2 Set	V155	256	14I5
14E10	Ditto Reset	V155	512	
14E11	23340 Remote trip Set	V155	1024	14I6
14E12	Ditto Reset	V155	2048	
14E13	23345 Red Trip L1 Set	V155	4096	14I7
14E14	Ditto Reset	V155	8192	

Event No.	Cause	Event mask	Enable code	Status
14E15	23350 Red Trip L2 Set	V155	16384	14I8
14E16	Ditto Reset	V155	32768	
14E17	23355 Red Trip L3 Set	V156	1	14I9
14E18	Ditto Reset	V156	2	
14E19	23375 EFP Rem Trip Set	V156	4	14I10
14E20	Ditto Reset	V156	8	
14E21	23370 EFP Bus Trip Set	V156	16	14I11
14E22	Ditto Reset	V156	32	
14E23	23330 Retrip t1 Set	V156	64	14I12
14E24	Ditto Reset	V156	128	
14E25	23360 Uncon Trip t1 Set	V156	256	14I13
14E26	Ditto Reset	V156	512	
14E27	23380 Ext Trip t1 Set	V156	1024	14I14
14E28	Ditto Reset	V156	2048	
14E29	23335 Backup Trip t2 Set	V156	4096	14I15
14E30	Ditto Reset	V156	8192	
14E31	23365 Uncon Trip t2 Set	V156	16384	14I16
14E32	Ditto Reset	V156	32768	

9.6.65. MeasureModule 74**Basic channel number: 14****Parameter summary:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S4	R	ParSet4..1	Select	P1	00000010B	000111110B	
14S9	R	PN	UN*IN*√3	1.000	0.200	2.500	0.001
14S10	R	AngleComp	Deg	0.000	-180.0	180.0	0.1
14S11	R	t1-Interval	Select		0	8	
		1 min	0				
		2 min	1				
		5 min	2				
		10 min	3				
		15 min	4				
		20 min	5				
		30 min	6				
		60 min	7				
		120 min	8				
14S12	R	ScaleFact1	1	1.0000	0.0001	1.0000	0.0001
14S13	R	t2-Interval	Select	4	0	8	
		1 min	0				
		2 min	1				
		5 min	2				
		10 min	3				
		15 min	4				
		20 min	5				
		30 min	6				
		60 min	7				
		120 min	8				
14S14	R	ScaleFact2	1	1.0000	0.0001	1.0000	0.0001

Measured variables

Address	Access	Text	Dec.
14V1	R	URS(UN)	3
14V2	R	UST(UN)	3
14V3	R	UTR(UN)	3
14V4	R	UR(UN)	3
14V5	R	US(UN)	3
14V6	R	UT(UN)	3
14V7	R	IR(IN)	3
14V8	R	IS(IN)	3
14V9	R	IT(IN)	3
14V10	R	P (PN)	3
14V11	R	Q (PN)	3
14V12	R	cos phi	3
14V13	R	Hz	3
14V14	R	E1Int	3
14V15	R	P1Int	0
14V16	R	E1Acc	3
14V17	R	P1Acc	0
14V18	R	E2Int	3
14V19	R	P2Int	0
14V20	R	E2Acc	3
14V21	R	P2Acc	0

Tripping levels

Address	Access	Text	Dec.
14Q16	R	E1Acc	3
14Q17	R	P1Acc	0
14Q20	R	E2Acc	3
14Q21	R	P2Acc	0

Event list

Event No.	Cause	Event mask	Enable code	Status
14E1	Cnt1New Set	V155	1	14I1
14E2	Ditto Reset	V155	2	
14E3	Cnt2New Set	V155	4	14I2
14E4	Ditto Reset	V155	8	

July 02

10. SUPPLEMENTARY INFORMATION

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10. SUPPLEMENTARY INFORMATION

10.1. *Changes in Version 5.0 in relation to Version 4.5*

10.1.1. *Local display unit (LDU)*

From Version V5.0, the software supports the local display unit (see [Section 5.13.](#)).

10.1.2. *New 'LDU events' function*

The LDU events list only includes tripping levels. The new function 'LDU events' enables additional events to be selected for listing (see [Section 3.6.5.](#)).

10.1.3. *New processor unit 316VC61a*

All devices equipped with the local display unit (LDU) also have the new processor unit 316VC61a; devices not equipped with the LDU can have either the 316VC61 or 316VC61a.

Whether there is a 316VC61a in a device not equipped with a local control and display unit can be determined using the HMI diagnostic function. Upon selecting 'Show diagnostic data', one of the lines displayed is 'HW No.', which in the case of 316VC61a includes the code '0434':

HW-Nr.: xxxx/**0434**/xx

The computing capacity of the 316VC61a is 250% (compared with 200% in the case of 316VC61).

10.2. *Known software weaknesses in V5.0*

10.2.1. *Year 2000 conformity*

Version V5.0 is influenced to a minor extent by the year 2000 problem, but the correct operation of the devices during and after the change of the century is assured. The only shortcoming concerns the time stamp, which retains '19' in the year instead of changing to '20'. All other data is correct and the events are listed in the correct chronological order.

10.2.2. *'LDU events' function*

The 'LDU events' function is not available when the HMI is operating off-line.

10.3. Changes in Version 5.1 in relation to Version 5.0**10.3.1. Distributed input/output system RIO580**

From Version V5.1, the software supports the distributed input/output system RIO580. The latter comprises a number of distributed input/output units that are connected to an RE.316*4 device via an MVB (multipurpose vehicle bus) and an MVB PC board. Refer to Data Sheet 1MRB520176-Ben and Operating Instructions 1MRB520192-Ben for further details.

10.3.2. Year 2000 conformity

With the exception of the VDEW version, for which the synchronisation of the time will not function via the VDEW bus in the year 2000, all Version V5.1 devices are fully immune to the year 2000 problem.

10.3.3. 'LDU events' function

The 'LDU events' function is also now available when the HMI is operating off-line.

10.4. Changes in Version 5.1a in relation to Version 5.1**10.4.1. 'I0-Invers' function**

The 'I0-Invers' is always enabled regardless of the software key in use.

10.5. Changes in Version 5.1b in relation to Version 5.1a**10.5.1. 'Min-Reactance' function**

The underreactance function can now also be connected to Y-connected v.t's.

10.6. Changes in Version 5.1c in relation to Version 5.1b**10.6.1. Year 2000 conformity**

All devices are immune to the year 2000 problem from Version V5.1c onwards.

10.7. Changes in Version 5.2 in relation to Version 5.1c**10.7.1. Frequency rate of change protection**

A df/dt function has been added to the function block library. Because of an error, however, it is not displayed for all the software keys there are (see Section 10.8.1.).

10.7.2. Touch screen or SMS in parallel with the SCS connection

Where a station control system (SCS) is connected via a LON or MVB bus, there is a second fully functional SPA interface available in parallel which can be used for connecting a touch screen an SMS.

10.8. Changes in Version 5.2a in relation to Version 5.2**10.8.1. Frequency rate of change protection 'df/dt'**

V5.2a of the HMI shows the 'df/dt' function for all software keys, for which the 'Frequency' function has been enabled.

10.9. Changes in Version 6.0 in relation to Version 5.2(a)**10.9.1. Directional overcurrent functions 'DirCurrentDT' and 'DirCurrentInv'**

Two directional overcurrent functions 'DirCurrentDT' with definite time and 'DirCurrentInv' with inverse time characteristic have been added to the function block library. They are accessible for all software keys for which the current and voltage functions are enabled.

10.9.2. Breaker failure protection 'BreakerFailure'

A 'BreakerFailure' function has been added to the function block library which is accessible to all software keys.

10.9.3. Runtime supervision

A runtime supervision function can be specified for pairs of inputs that have been configured as "double indications" (see Section 5.5.5.5.).

10.9.4. New processor unit 316VC61b

Version 6.0 supports the new 316VC61b processor unit. To determine whether a device contains a 316VC61b processor unit or not, open 'List diagnostic information' in the HMI diagnostic function and check the code '04Ax' on line 'HW No.':

HW No.: xxxx/**04Ax**/xx

10.10. Changes in Version Version 6.2 in relation to Version 6.0**10.10.1. Analogue input/output unit 500AXM11**

Versions from V6.2 onwards support the analogue input/output unit 500AXM11 of the distributed input/output system RIO580.

10.10.2. 'Analogue RIO Trigger' function

An 'Analogue RIO Trigger' function has been added to the function block library which is available for all software keys and facilitates the supervision of the input signals of the analogue input/output unit 500AXM11. Refer to the Operating Instructions for the distributed input/output system RIO580, Publication 1MRB520192-Uen, for further details.

10.10.3. Measurement module

The 'MeasureModule' function has been added to the function block library. It is available for all software keys and facilitates the three-phase measurement of voltage, current, active and reactive power, power factor and frequency. Two counter impulse inputs are also provided for metering energy.

10.10.4. Commands via a Stage 2 LON bus

In automation systems equipped with a Stage 2 LON interbay bus, commands can be transferred from the automation system to the bay units.

10.11. Changes in Version 6.3 in relation to Version 6.2**10.11.1. A/D converter unit 316EA63**

From Version V6.3, the software supports the new A/D converter unit 316EA63 which supersedes the previous plug-in unit 316EA62.

10.11.2. *Updating the 316EA63 firmware*

The new A/D converter unit 316EA63 allows the firmware to be downloaded without opening the unit. If updating is necessary, this is done in a similar fashion as updating the main processor firmware ([see Section 7.5.](#)). After each update of the main processor firmware, the 316EA63 firmware must also be updated.

When applying the DOS HMI, updating is made by calling up the batch file 'loadEA63.bat', which is listed in the HMI directory.

When applying the Windows HMC CAP2/316, the item 'EA63 download' in the menu 'Options' must be selected.

March 01

12. APPENDICES

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Fig. 12.5	Example of the input transformer connections for the differential protection functions ('Diff-Transf', and 'Diff-Gen')	12-6

Check list for replacing hardware units

Report to be used when replacing hardware units

TEST REPORT

Typical wiring diagram for the digital generator protection REG 316*4

Notification

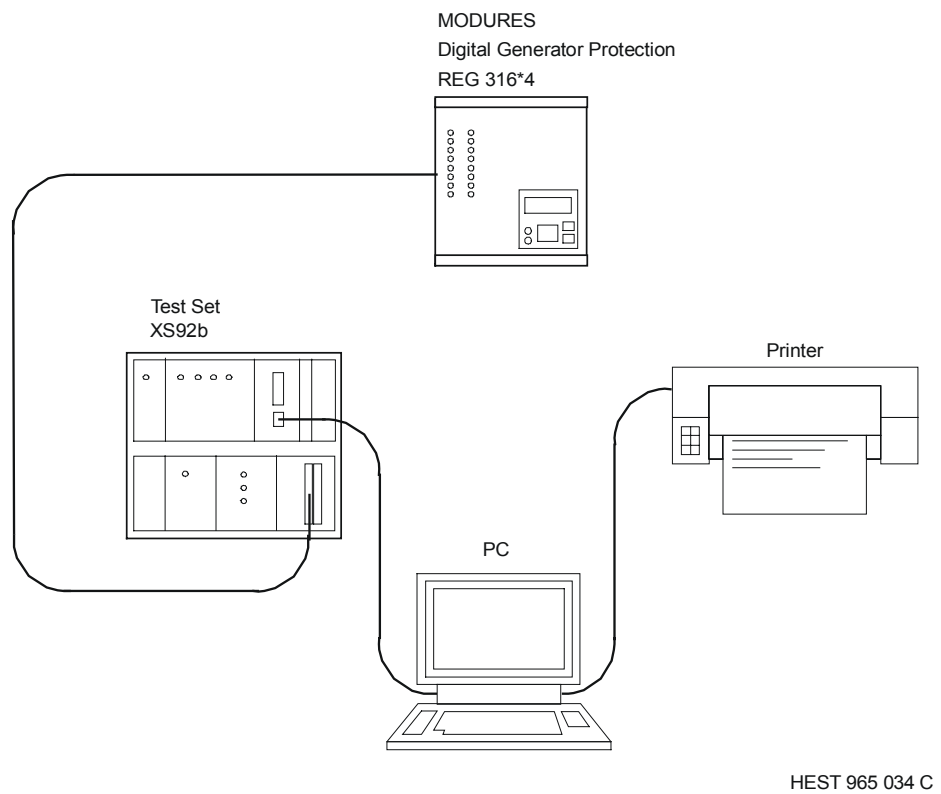
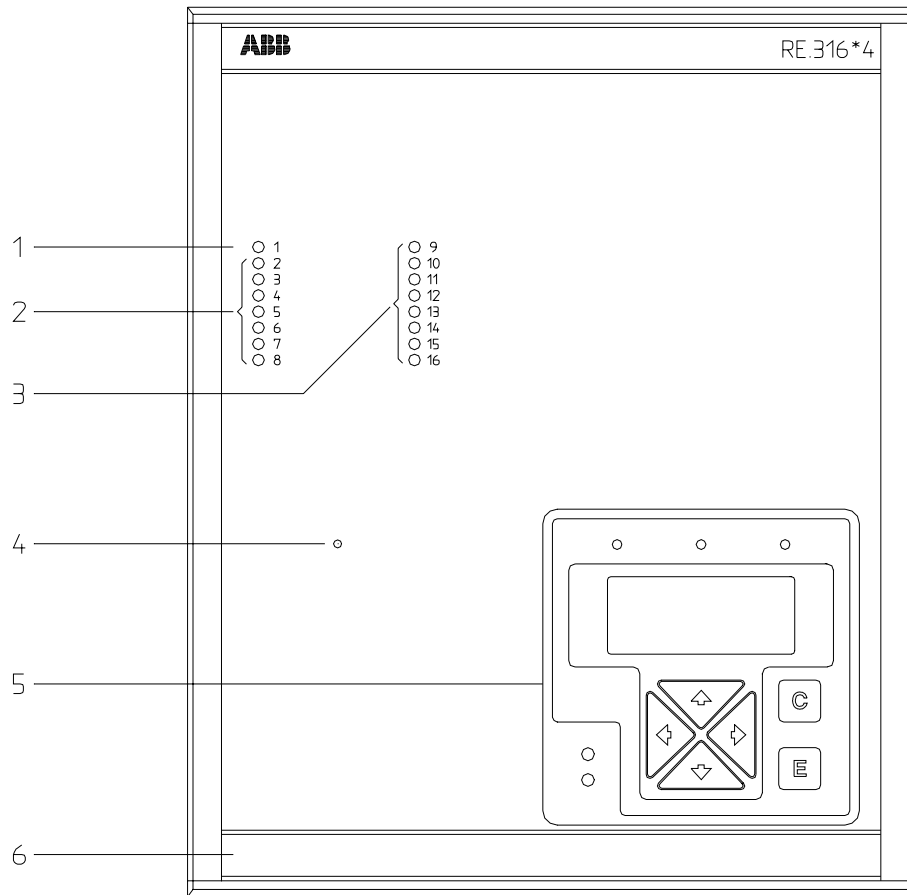


Fig. 12.1 Test set-up using test set Type XS92b



adoc024

Fig. 12.2 Digital generator protection REG 316*4
(front view)

- 1 Green LED (stand-by)
- 2 LED's belonging to first I/O unit
- 3 LED's belonging to second I/O unit
- 4 Reset button behind frontplate
- 5 Local display unit (LDU) with optical serial interface
- 6 Marking space

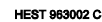
316GW61
316EA62/316EA63
316DB61/316DB62/316DB63
316VC61a/316VC61b
316DB61/316DB62/316DB63
316NG65

HES 965023 C

316GW61
316EA62/316EA63
316VC61a/316VC61b
316DB61/316DB62/316DB63
316DB61/316DB62/316DB63
316DB61/316DB62/316DB63
316DB61/316DB62/316DB63
316NG65

HES 965024 C

Fig. 12.3 Digital generator protection REG 316*4, showing the location of units (rear view) in the narrow casing N1 (top) and wide casing N2 (bottom).



The star-point c.t.'s may also be used (dotted connections).

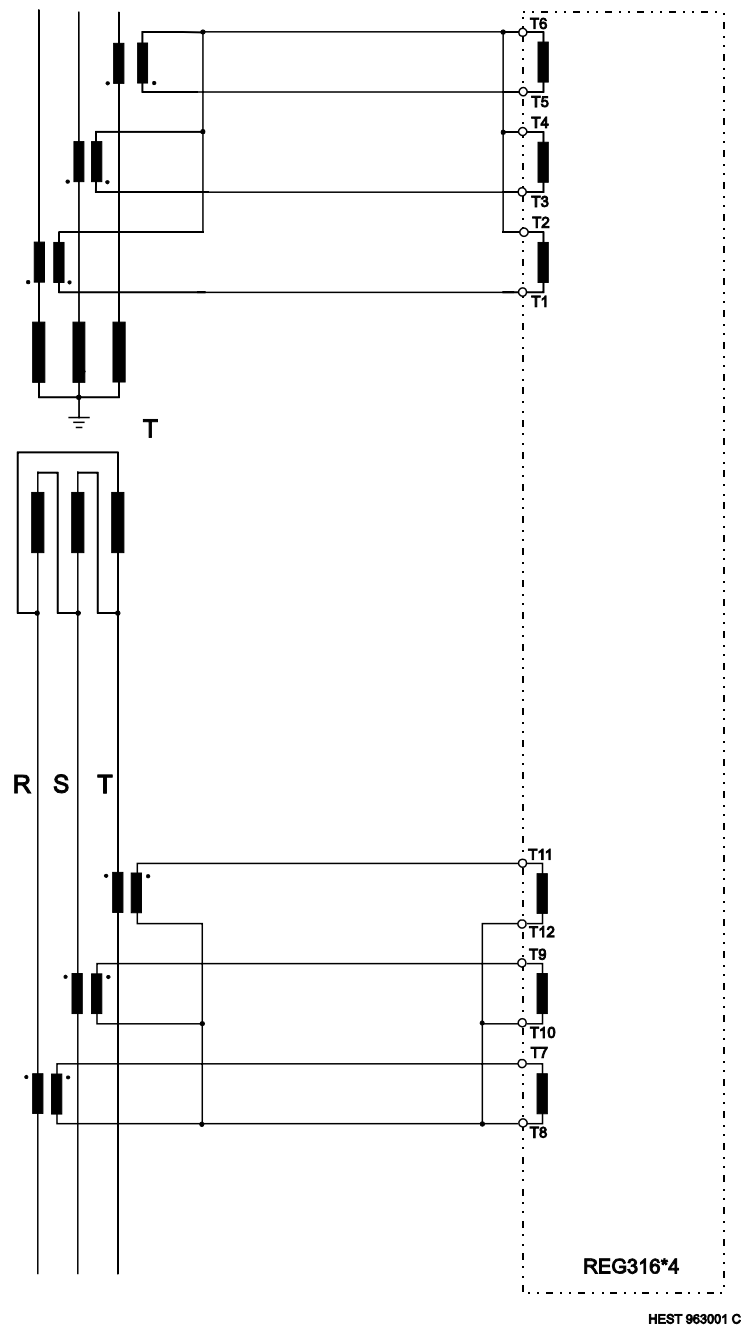


Fig. 12.5 Example of the input transformer connections for the differential protection functions ('Diff-Transf', and 'Diff-Gen')

Providing the c.t.'s, and input transformers are connected as shown in Fig. 12.5, the details given in [Sections 3.5.1](#). ('Diff-Transf') and [3.5.2](#). ('Diff-Gen') apply, i.e. the differential current becomes zero for a through-fault.



Checklist for replacing hardware modules in RE . 316*4 units

99-06

	Not applicable Not fitted	Completed
Read out and save the existing unit settings (always necessary when replacing the 316VC61).	☐	☐
Read out or print the diagnostic and event lists (for defects)	☐	☐
Switch off the auxiliary supply.		☐
Short-circuit the external c.t. leads and then disconnect them.	☐	☐ 1)
Disconnect the external v.t. leads.	☐	☐ 1)
Disconnect the current and voltage circuits from the unit.	☐	☐ 1)
Unscrew the electrical-to-optical converter Type 316BM61 (OBI) or withdraw the PC card.	☐	☐
If necessary, fit a coupling device to loop the optical fibre cable so that the rest of the system can continue to operate.		
Remove the covers from the unit.		☐ 2)
Mark the slot of the module to be replaced and withdraw it.		☐ 3)
Make a note of the module's technical data.		☐
Compare the ordering code and software of old and new modules.		☐
Make a note of the technical data of the new module.		☐
Insert the new module in the slot previously marked.		☐
Refit the covers on the unit.		☐
Refit the electrical-to-optical converter Type 316BM61 (OBI) or reinsert the PC card.	☐	☐
Reconnect the ground to the unit if it was removed.	☐	☐
Reconnect c.t. and v.t. circuits.	☐	☐
Switch on the auxiliary supply.		☐
Download to the unit the settings previously saved (always necessary when replacing the 316VC61) and also any FUPLA logic on the disc.	☐	☐
Check the operation of the unit (e.g. check the voltages and currents in the "Display analogue channels" menu. Depending on the type of module that has been replaced, other checks may be necessary such as for a 316DB61/62/63 the alarms, tripping signals and binary inputs).		☐

1) Only necessary when replacing the input transformer module 316GW61.

2) **Flush-mounted version:** Remove the auxiliary supply plug, unscrew the backplate (4 large and 4 small screws around the edge, 2 screws holding the power supply unit and 2 screws holding the RS232 interface; the connectors do not have to be removed).

Surface-mounted version: Swing the relay out on its hinges and remove the backplate as for the flush-mounted version.

3) Refer to the respective Operating Instructions for the locations of the modules (slots).



Report to be filled in after replacing hardware modules in RE . 316*4 units

02-05

To enable a record of the modules to be kept (traceability), please forward the following information to ABB Power Automation Ltd (by fax or mail) whenever modules are replaced:

Address

ABB Switzerland Ltd
Utility Automation
Department UTAAA-P
Bruggerstrasse 71a
CH-5401 Baden
Switzerland

Fax ++ 41 58 585 31 30

General data

Client Station Feeder

RE. 316*4 data (sticker on unit)

Type of unit
Unit ID
Serial No. Item
Drawing No. / Revision index
Ordering code
Software version FW: MMC:
(sticker below reset button)

Module data

	Old module	New module
Type of module / Revision		
Module ID		
Serial No.		
Drawing No. / Revision index		
Barcode No.		
Software version of IC's (if any)		A Vers. A Vers. A Vers. A Vers.

Date when hardware replaced

Remarks:
.....
.....

Name:

Signature:

Date:

Generator Protection Type REG316*4

Checklist

Kind of check	Remarks	Page
Relay number		
Visual check for transport damage		
Visual check of external wiring		
Check of relay grounding		
Check of supply voltage (DC/AC)		
Check of settings (calculated by)		
Check of C.T. circuits		
Check of P.T. circuits		
Secondary injection with test set type		
Check of input signals		
Check of signalisation/alarms		
Check of starting breaker failure protection		
Check of tripping		
Primary tests		
Final check		

If non test sets were used, note type, number, calibration date:

Date:	Signature:	Client	Date:	Signature:

STATION:

UNIT:

99-01

Generator Protection Type REG316*4

Generator datas

Manufacturer

Type of turbine

Type

(Steam, hydro etc.)

Rated power MVA

Synchronous reactance X_d p.u.

Rated voltage kV

Transient reactance X_d' p.u.

Rated current A

Settings

According to separate print out

Software version of the relay

Secondary injection

Channel number	Main C.T./P.T. ratio [A/A], [kV/V]	AD channel rated value * [A], [V]	AD channel ref. value [-]	Injected value [A], [V]	Display AD calculated [UN], [IN]	Channels displayed [UN], [IN]
1						
2						
3						
4						
5						
6						
7						
8						
9						

* 100/200 V or 1/2/5 A respectively

Remark: If the AD channel reference value is not 1.0 it is advisable to inject rated value * ref. value to get on the display 1.00 * UN/IN.

Example: Rated current generator = 540 A, C.T. ratio = 600/5 ---> Ref. value = 0.9

Injected current = 5 * 0.9 A = 4.5 A ---> Display = 1.00 * [4.50A]

Date:

Signature:

Client

Date:

Signature:

Generator Protection Type REG316*4

Activation/Deactivation of Binary Inputs

☐ DB61 ☐ DB62 ☐ DB63

	Function/Remarks	Result
OC 101		
OC 102		
OC 103		
OC 104		
OC 105		
OC 106		
OC 107		
OC 108		
OC 109		
OC 110		
OC 111		
OC 112		
OC 113		
OC 114		

☐ DB61 ☐ DB62 ☐ DB63

	Function/Remarks	Result
OC 201		
OC 202		
OC 203		
OC 204		
OC 205		
OC 206		
OC 207		
OC 208		
OC 209		
OC 210		
OC 211		
OC 212		
OC 213		
OC 214		

☐ DB61 ☐ DB62 ☐ DB63

	Function/Remarks	Result
OC 301		
OC 302		
OC 303		
OC 304		
OC 305		
OC 306		
OC 307		
OC 308		
OC 309		
OC 310		
OC 311		
OC 312		
OC 313		
OC 314		

☐ DB61 ☐ DB62 ☐ DB63

	Function/Remarks	Result
OC 401		
OC 402		
OC 403		
OC 404		
OC 405		
OC 406		
OC 407		
OC 408		
OC 409		
OC 410		
OC 411		
OC 412		
OC 413		
OC 414		

Date:

Signature:

Client

Date:

Signature:

STATION:

UNIT:

99-01

Generator Protection Type REG316*4

Activation/Deactivation of Alarm Relays

		Function/Remarks	Result
☐ DB61	S 101		
☐ DB62	S 102		
☐ DB63	S 103		
	S 104		
	S 105		
	S 106		
	S 107		
	S 108		
	S 109		
	S 110		
☐ DB61	S 201		
☐ DB62	S 202		
☐ DB63	S 203		
	S 204		
	S 205		
	S 206		
	S 207		
	S 208		
	S 209		
	S 210		
☐ DB61	S 301		
☐ DB62	S 302		
☐ DB63	S 303		
	S 304		
	S 305		
	S 306		
	S 307		
	S 308		
	S 309		
	S 310		
☐ DB61	S 401		
☐ DB62	S 402		
☐ DB63	S 403		
	S 404		
	S 405		
	S 406		
	S 407		
	S 408		
	S 409		
	S 410		

Date:

Signature:

Client

Date:

Signature:

STATION:

UNIT:

99-01

Generator Protection Type REG316*4

Activation of Tripping Relays

		Function/Remarks	Result
☐ DB61	C 101 Contact 1		
☐ DB62	C 101 Contact 2		
	C 102 Contact 1		
	C 102 Contact 2		
☐ DB61	C 201 Contact 1		
☐ DB62	C 201 Contact 2		
	C 202 Contact 1		
	C 202 Contact 2		
☐ DB61	C 301 Contact 1		
☐ DB62	C 301 Contact 2		
	C 302 Contact 1		
	C 302 Contact 2		
☐ DB61	C 401 Contact 1		
☐ DB62	C 401 Contact 2		
	C 402 Contact 1		
	C 402 Contact 2		

Date:

Signature:

Client

Date:

Signature:



ABB Schweiz AG

Utility Automation

NUMERISCHER GENERATOSCHUTZ
NUMERICAL GENERATOR PROTECTION
PROTECTION GENERATEUR NUMERIQUE
PROTECCION DE GENERADOR NUMERICO

REG316*4

TYPISCHES ANSCHLUSS-SCHEMA
TYPICAL CONNECTION DRAWING
SCHEMA DE RACCORDEMENT TYPIQUE
ESQUEMA DE CONEXION TIPICO

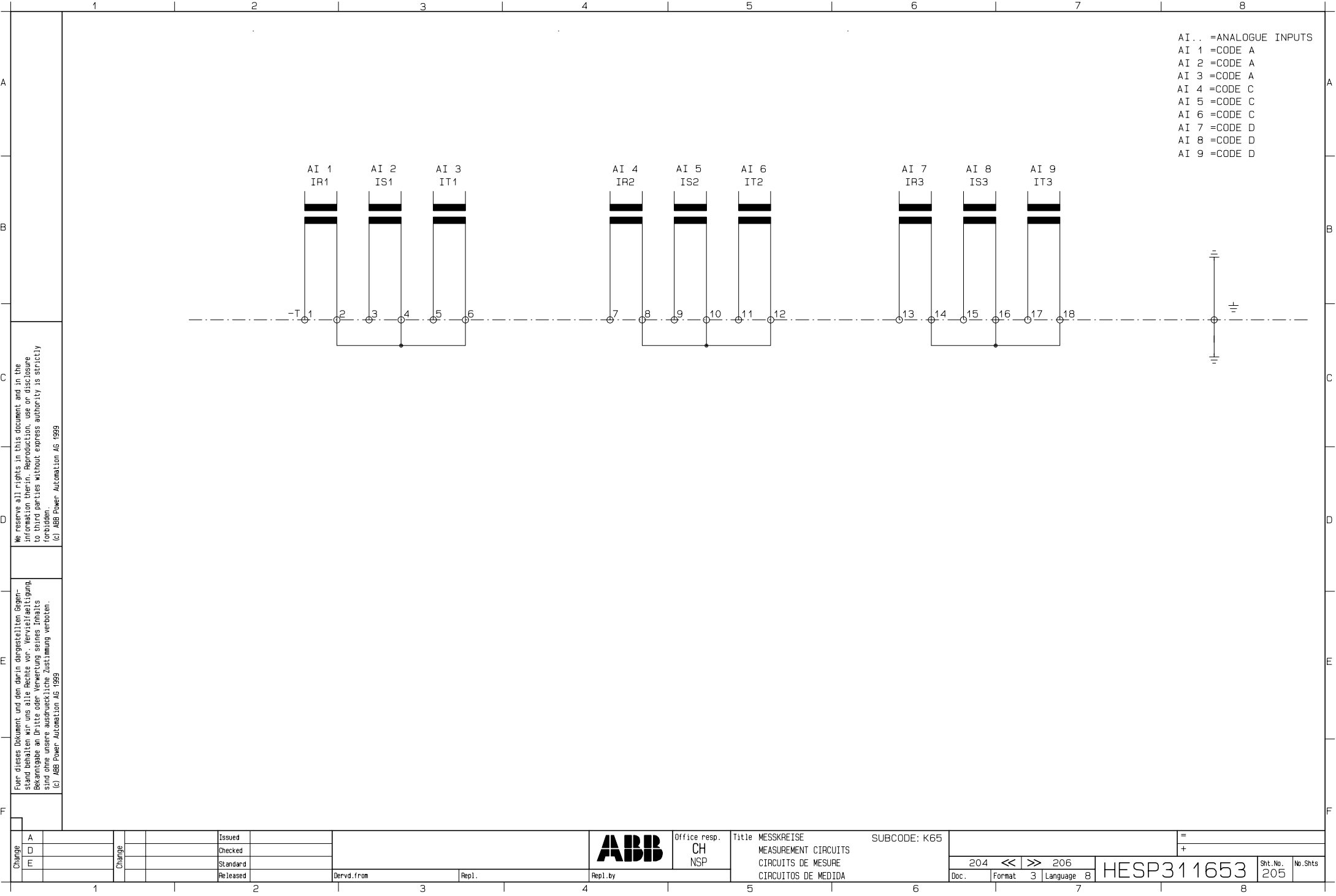
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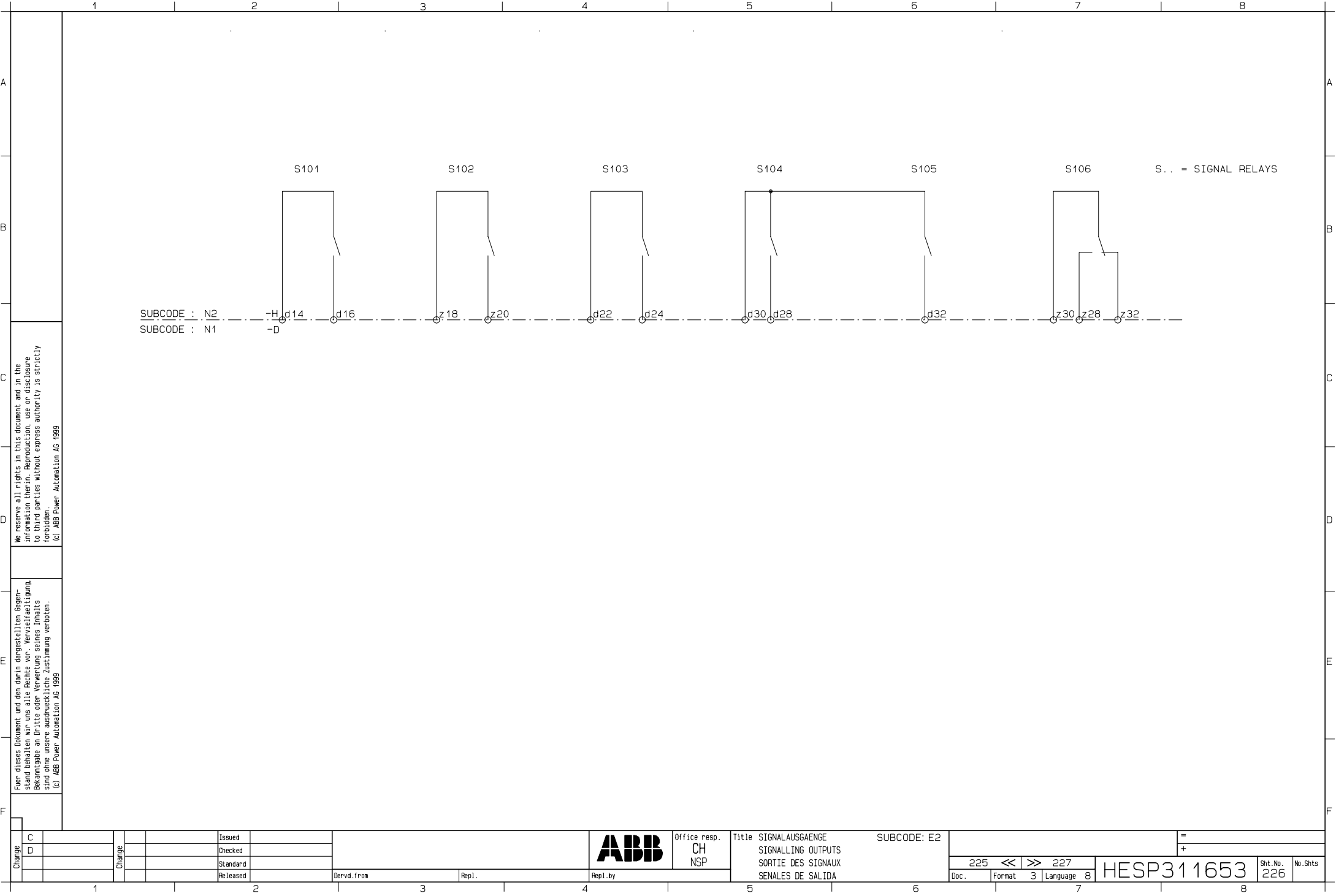
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	221	KOMMANDOKREISE	COMMAND CIRCUITS		CIRCUITS DE COMMANDE		CIRCUITO DE COMANDO		D						
	222	SIGNALAUSGAENGE	SIGNALLING OUTPUTS		SORTIE DES SIGNAUX		SENALES DE SALIDA		D						
	223	OPTOKOPPLEREING.	OPTOCOUPLER INPUT		ENTREES D'OPTOCOUPLEURS		ENTRADA DE ACOP.OPTICOS		D						
	224	OPTOKOPPLEREING.	OPTOCOUPLER INPUT		ENTREES D'OPTOCOUPLEURS		ENTRADA DE ACOP.OPTICOS		D						
	225	KOMMANDOKREISE	COMMAND CIRCUITS		CIRCUITS DE COMMANDE		CIRCUITO DE COMANDO		D						
	226	SIGNALAUSGAENGE	SIGNALLING OUTPUTS		SORTIE DES SIGNAUX		SENALES DE SALIDA		D						
	227	SIGNALAUSGAENGE	SIGNALLING OUTPUTS		SORTIE DES SIGNAUX		SENALES DE SALIDA		D						
	228	OPTOKOPPLEREING.	OPTOCOUPLER INPUT		ENTREES D'OPTOCOUPLEURS		ENTRADA DE ACOP.OPTICOS		D						
D	232	SIGNALAUSGAENGE	SIGNALLING OUTPUTS		SORTIE DES SIGNAUX		SENALES DE SALIDA		D						
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	234	OPTOKOPPLEREING.	OPTOCOUPLER INPUT		ENTREES D'OPTOCOUPLEURS		ENTRADA DE ACOP.OPTICOS		D						
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	242	SIGNALAUSGAENGE	SIGNALLING OUTPUTS		SORTIE DES SIGNAUX		SENALES DE SALIDA		D						
	243	OPTOKOPPLEREING.	OPTOCOUPLER INPUT		ENTREES D'OPTOCOUPLEURS		ENTRADA DE ACOP.OPTICOS		D						
	244	OPTOKOPPLEREING.	OPTOCOUPLER INPUT		ENTREES D'OPTOCOUPLEURS		ENTRADA DE ACOP.OPTICOS		D						
E	251	KOMMANDOKREISE	COMMAND CIRCUITS		CIRCUITS DE COMMANDE		CIRCUITO DE COMANDO		D						
	252	SIGNALAUSGAENGE	SIGNALLING OUTPUTS		SORTIE DES SIGNAUX		SENALES DE SALIDA		D						
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	254	OPTOKOPPLEREING.	OPTOCOUPLER INPUT		ENTREES D'OPTOCOUPLEURS		ENTRADA DE ACOP.OPTICOS		D						
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F	271	KOMMANDOKREISE	COMMAND CIRCUITS		CIRCUITS DE COMMANDE		CIRCUITO DE COMANDO		D						
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	281	KOMMANDOKREISE	COMMAND CIRCUITS		CIRCUITS DE COMMANDE		CIRCUITO DE COMANDO		D						
	282	SIGNALAUSGAENGE	SIGNALLING OUTPUTS		SORTIE DES SIGNAUX		SENALES DE SALIDA		D						
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	284	OPTOKOPPLEREING.	OPTOCOUPLER INPUT		ENTREES D'OPTOCOUPLEURS		ENTRADA DE ACOP.OPTICOS		D						
	292	SIGNALAUSGAENGE	SIGNALLING OUTPUTS		SORTIE DES SIGNAUX		SENALES DE SALIDA		D						
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F	294	OPTOKOPPLEREING.	OPTOCOUPLER INPUT		ENTREES D'OPTOCOUPLEURS		ENTRADA DE ACOP.OPTICOS		D						
	295	OPTOKOPPLEREING.	OPTOCOUPLER INPUT		ENTREES D'OPTOCOUPLEURS		ENTRADA DE ACOP.OPTICOS		D						
	296	OPTOKOPPLEREING.	OPTOCOUPLER INPUT		ENTREES D'OPTOCOUPLEURS		ENTRADA DE ACOP.OPTICOS		D						
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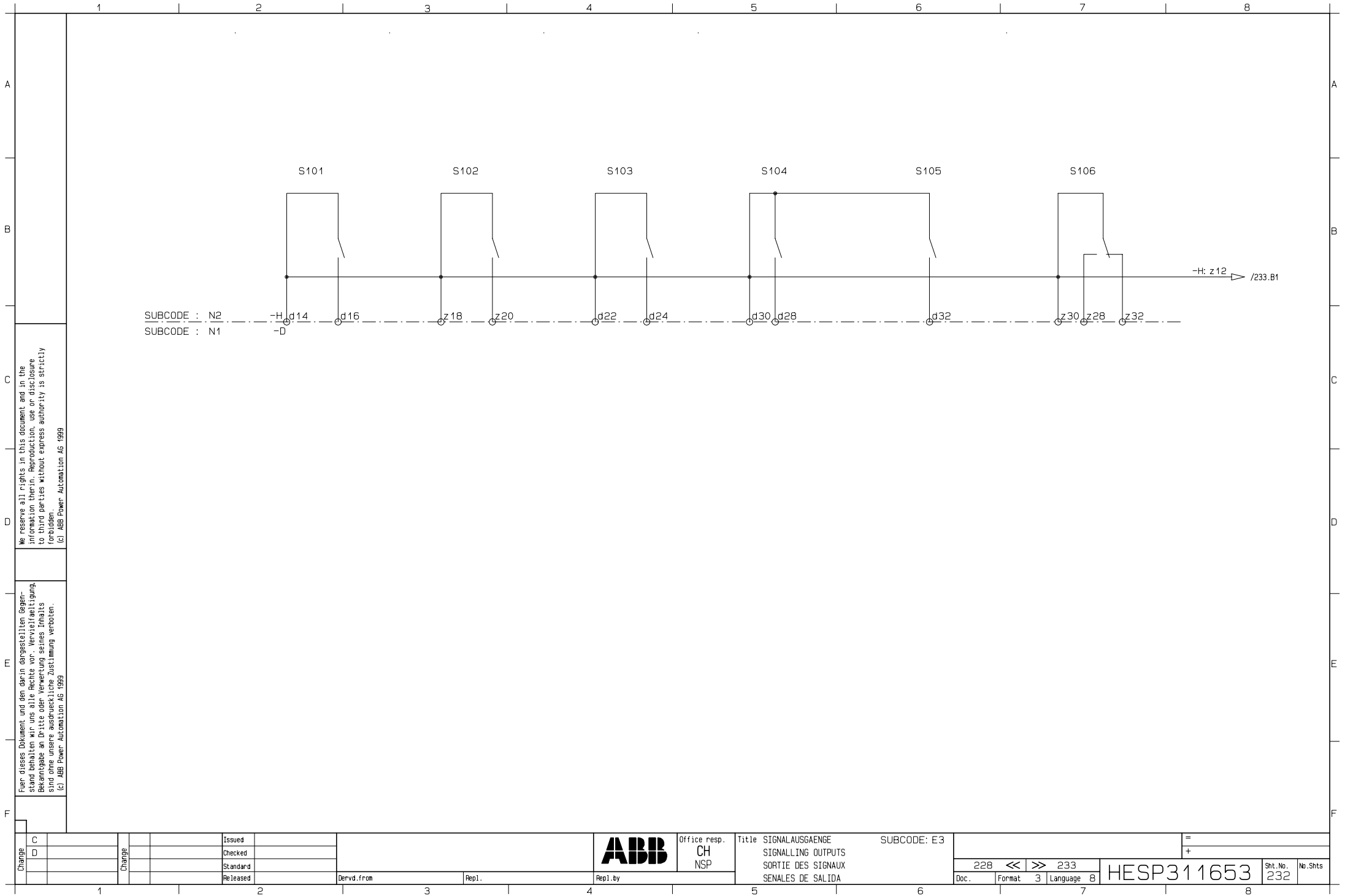
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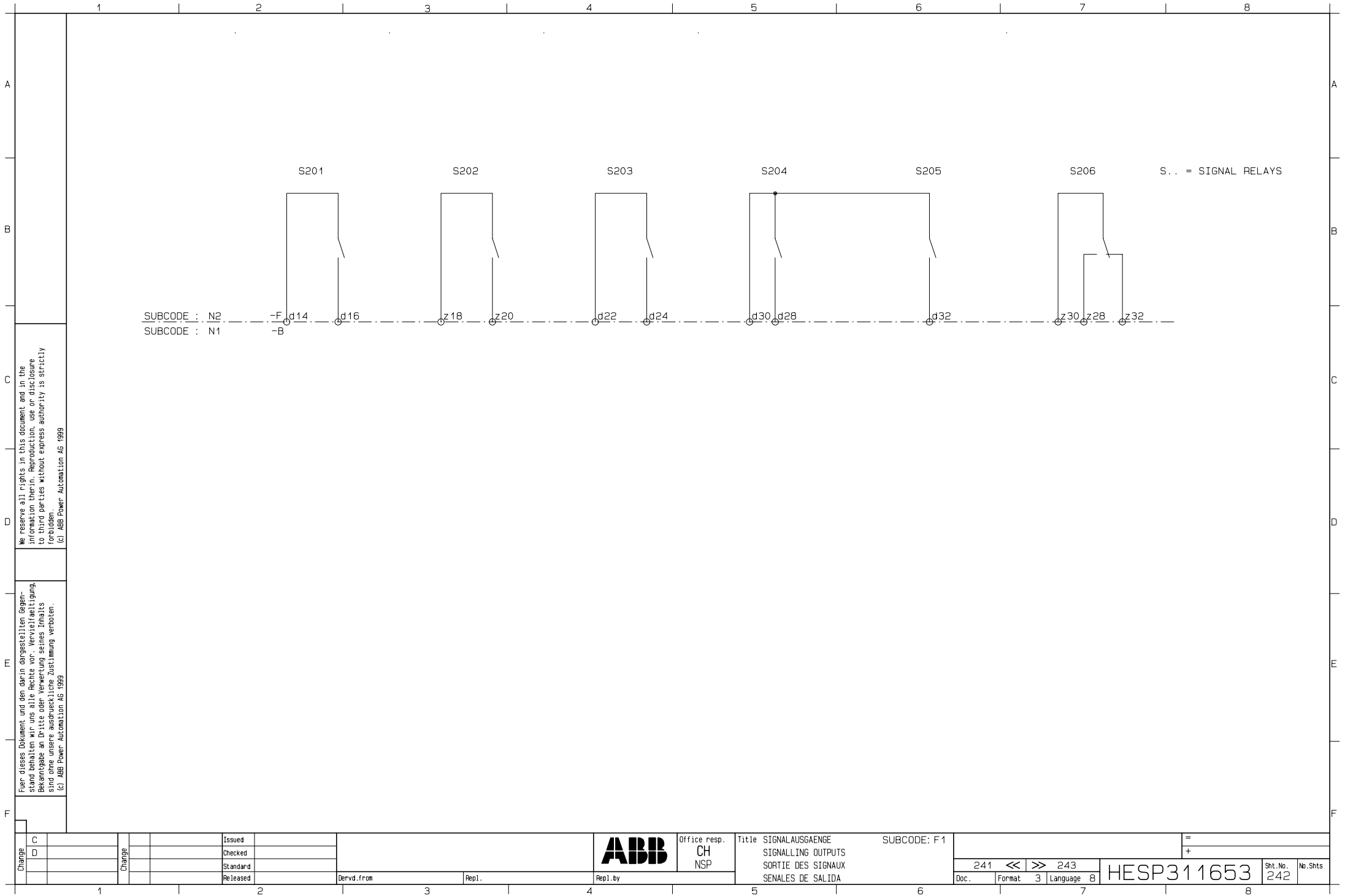
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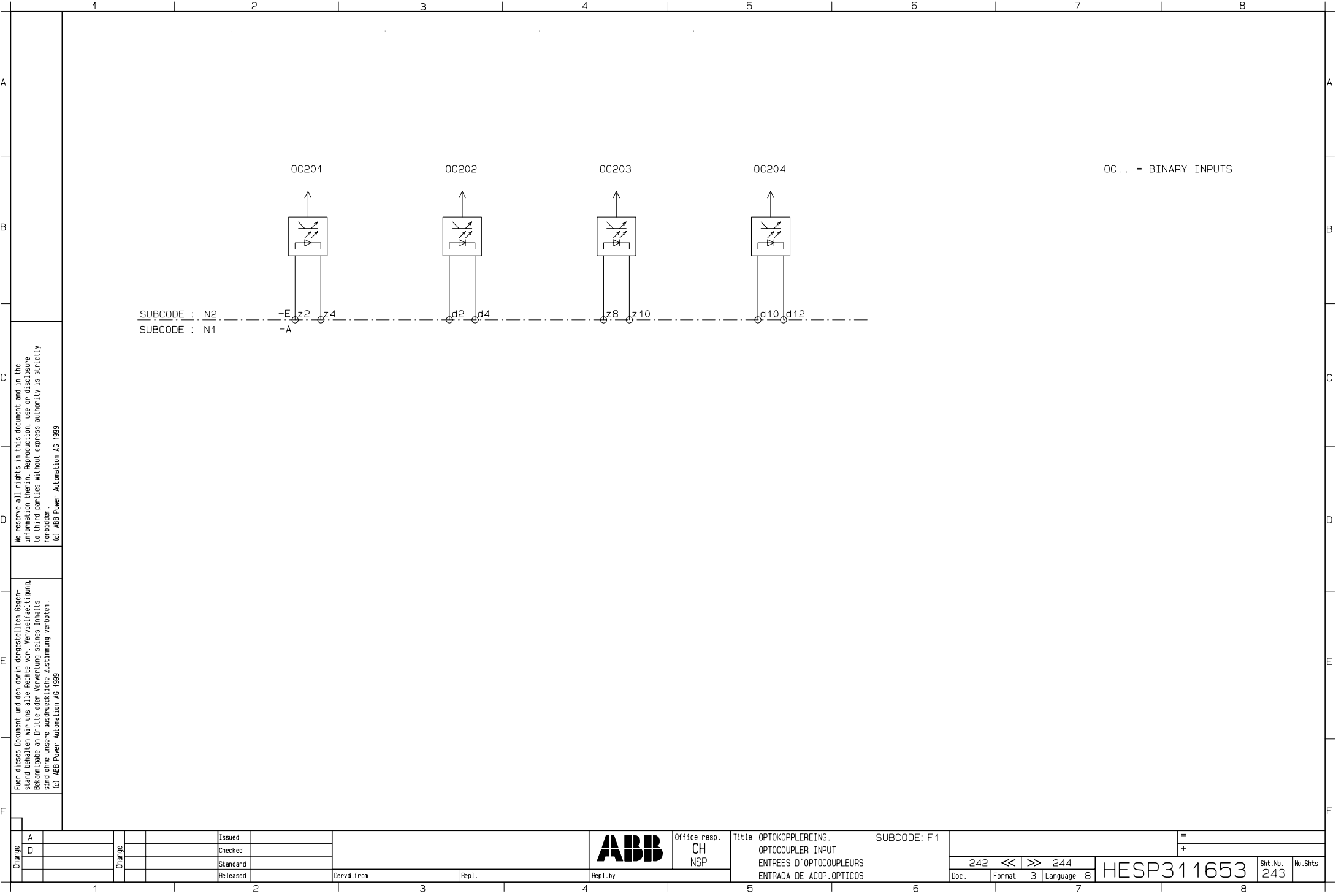
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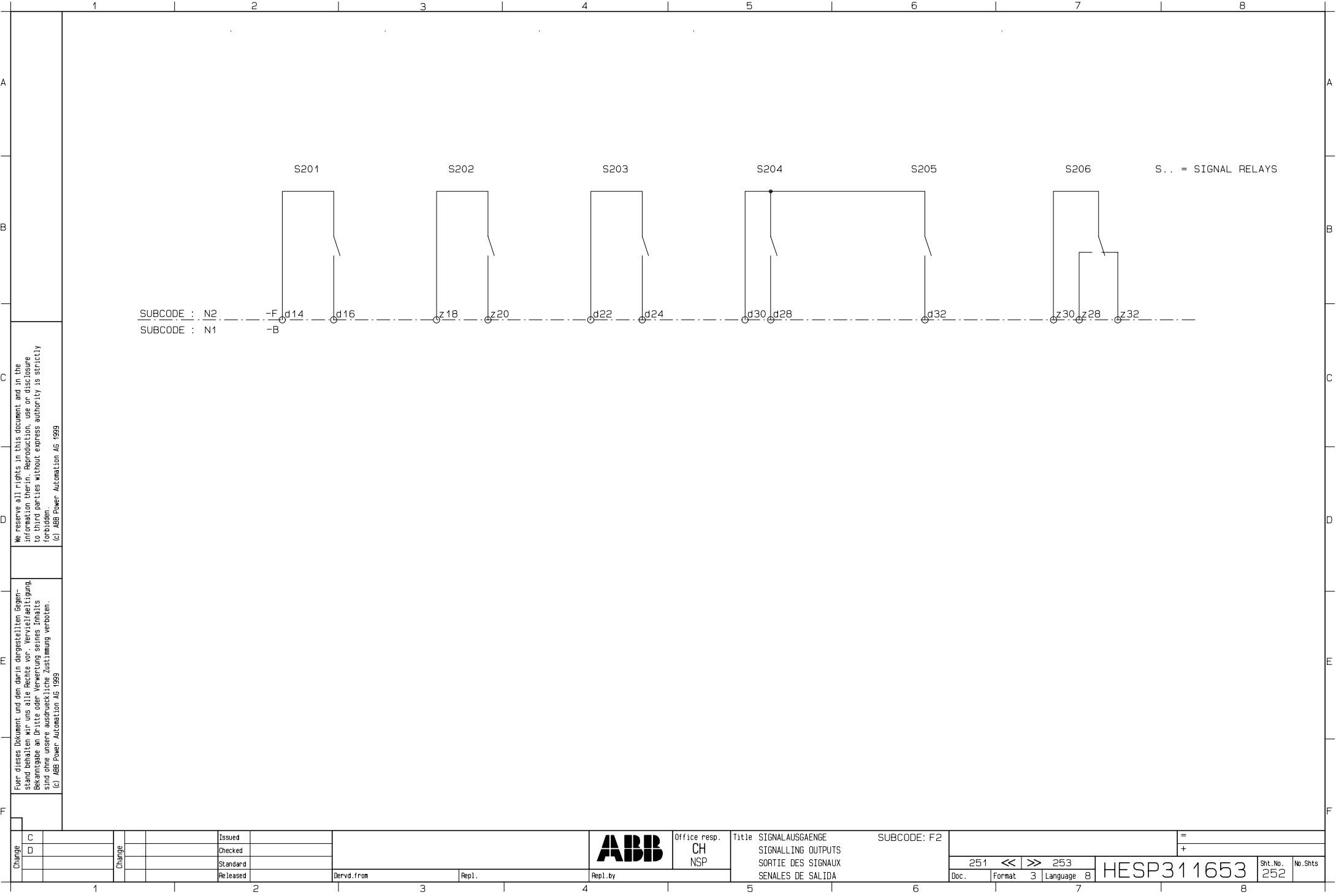
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Title: OPTOKOPPLEREING.
OPTOCOUPLER INPUT
ENTREES D'OPTOCOUPLEURS
ENTRADA DE ACOP. OPTICOS

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ABB

Office resp.

CH

NSP

Title

SIGNALAUSGAENGE

SIGNALLING OUTPUTS

SORTIE DES SIGNAUX

SENALES DE SALIDA

SUBCODE: F2

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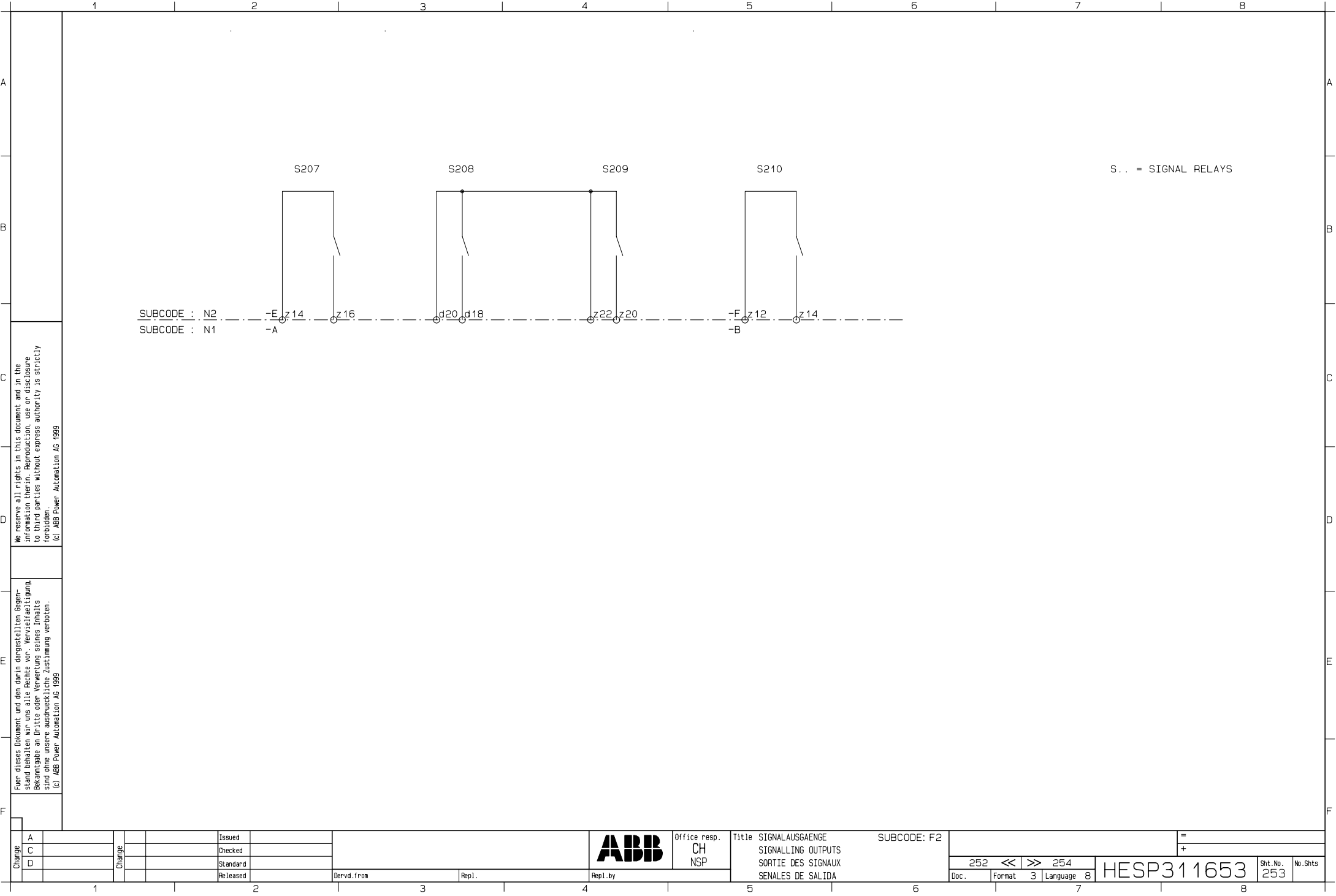
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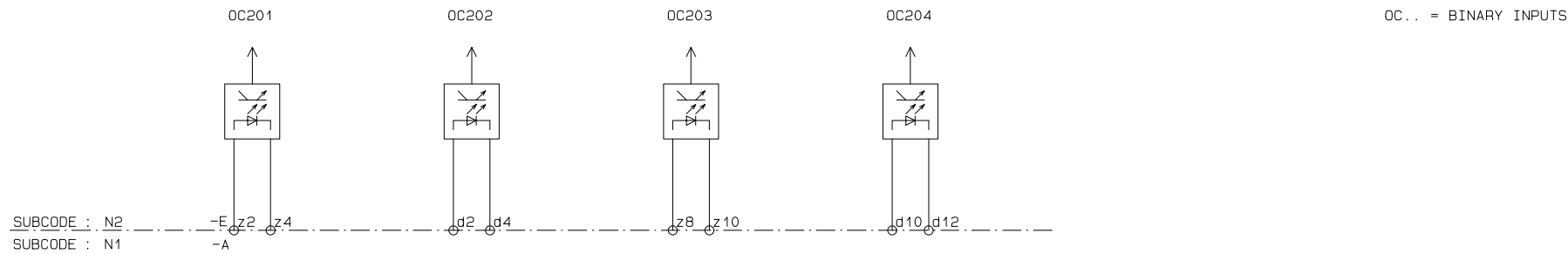
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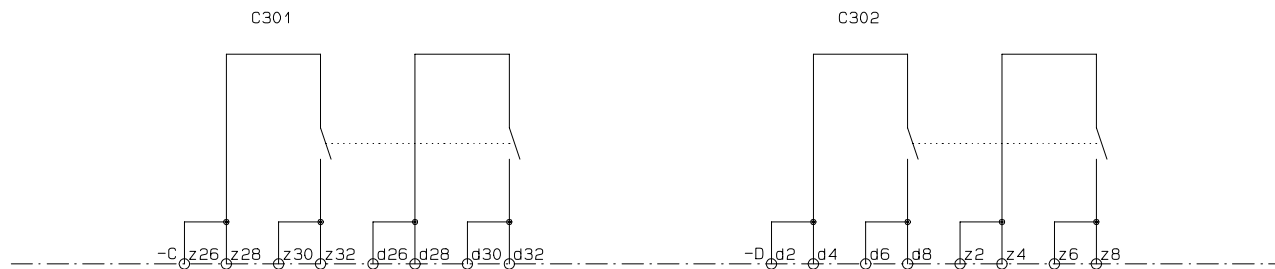


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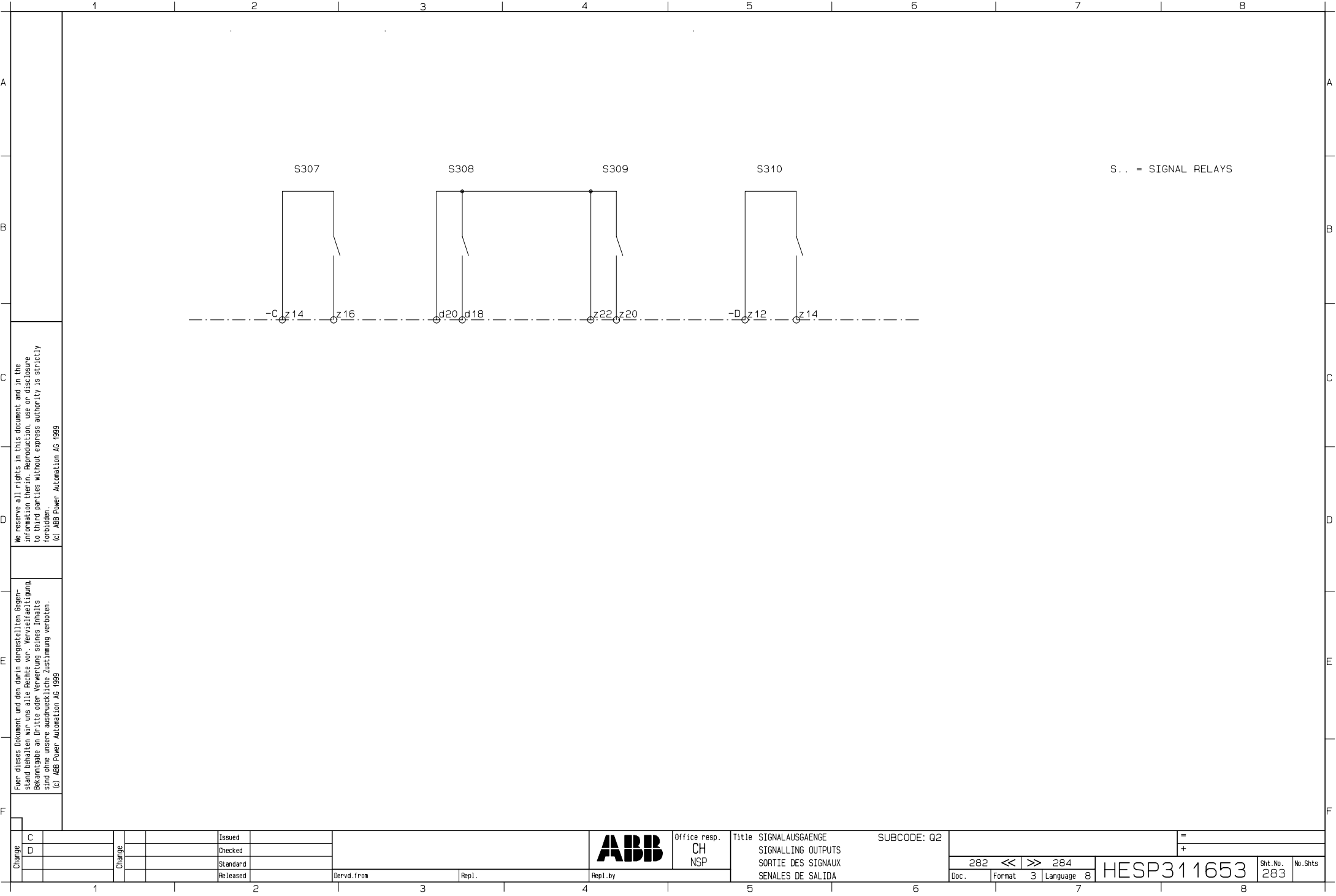
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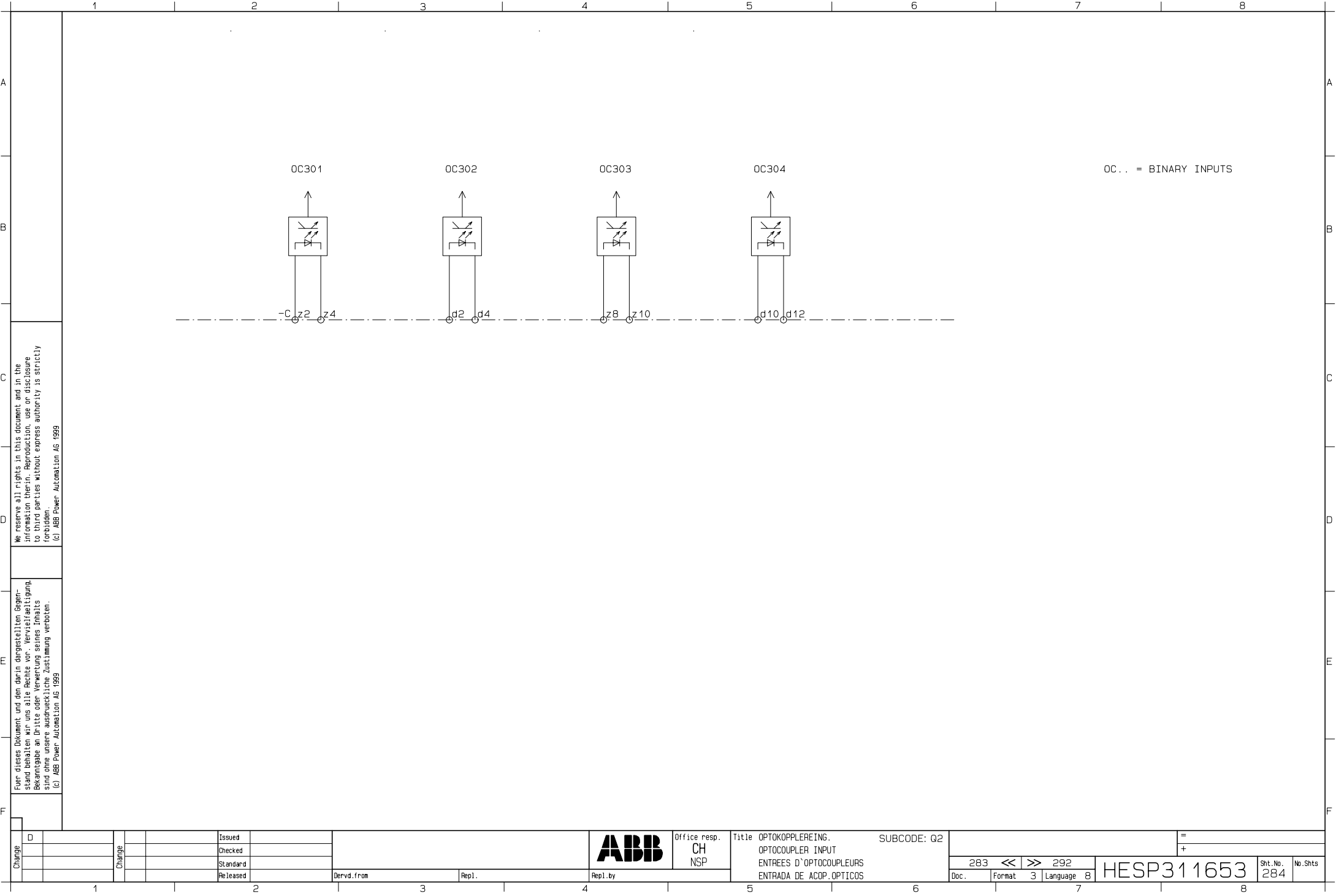
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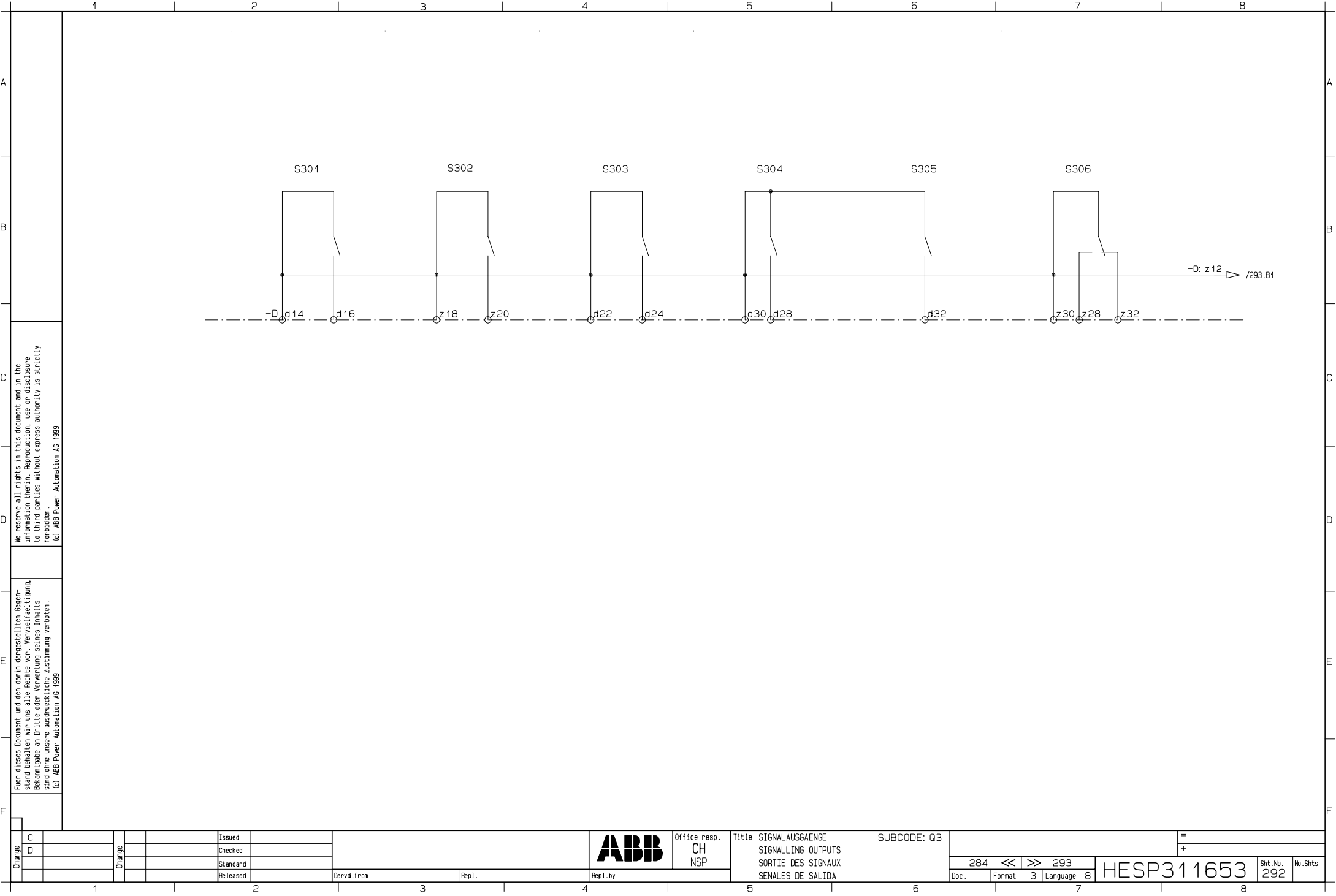
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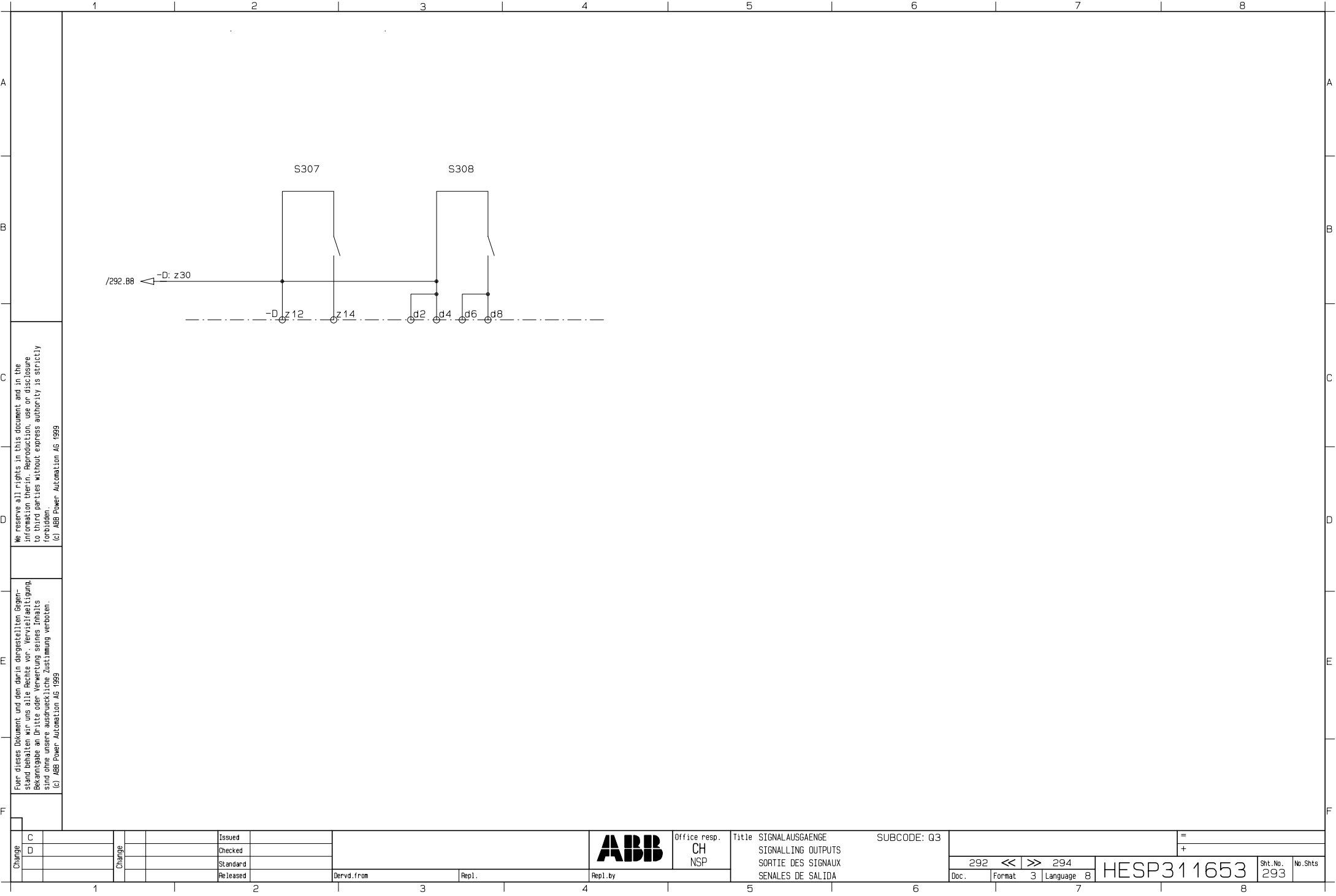
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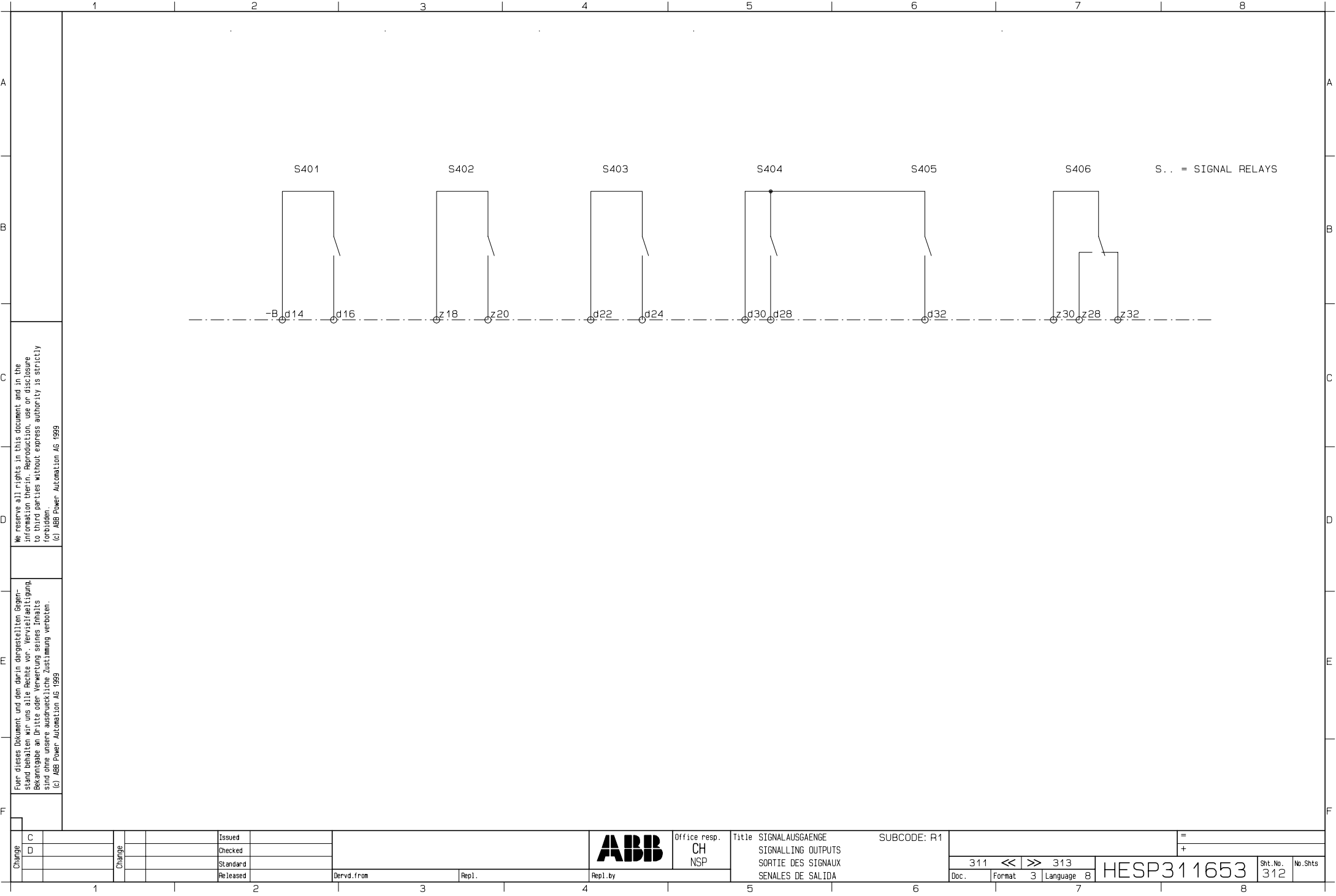
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Title SIGNALAUSGAENGE
SIGNALLING OUTPUTS
SORTIE DES SIGNAUX
SENALES DE SALIDA

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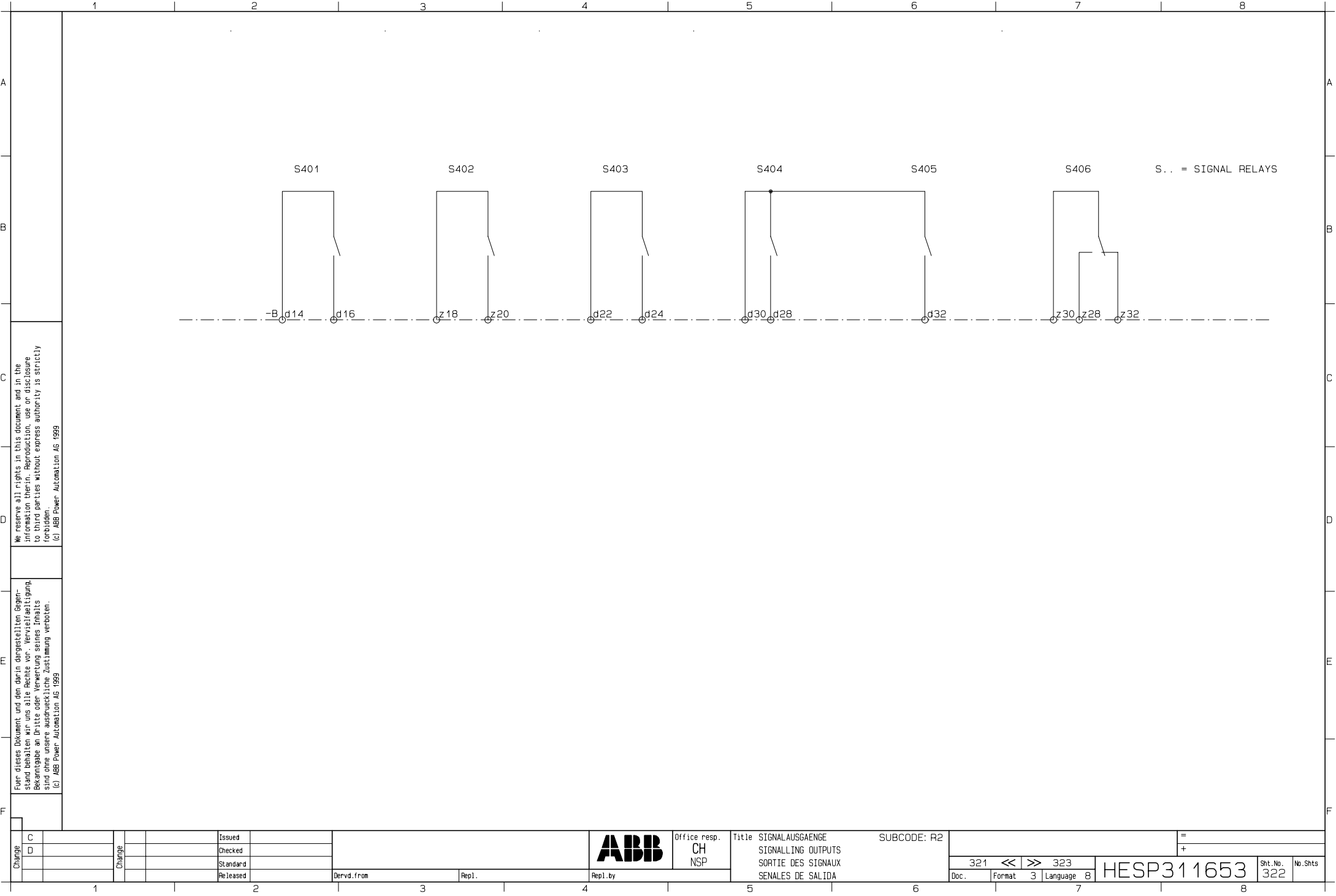
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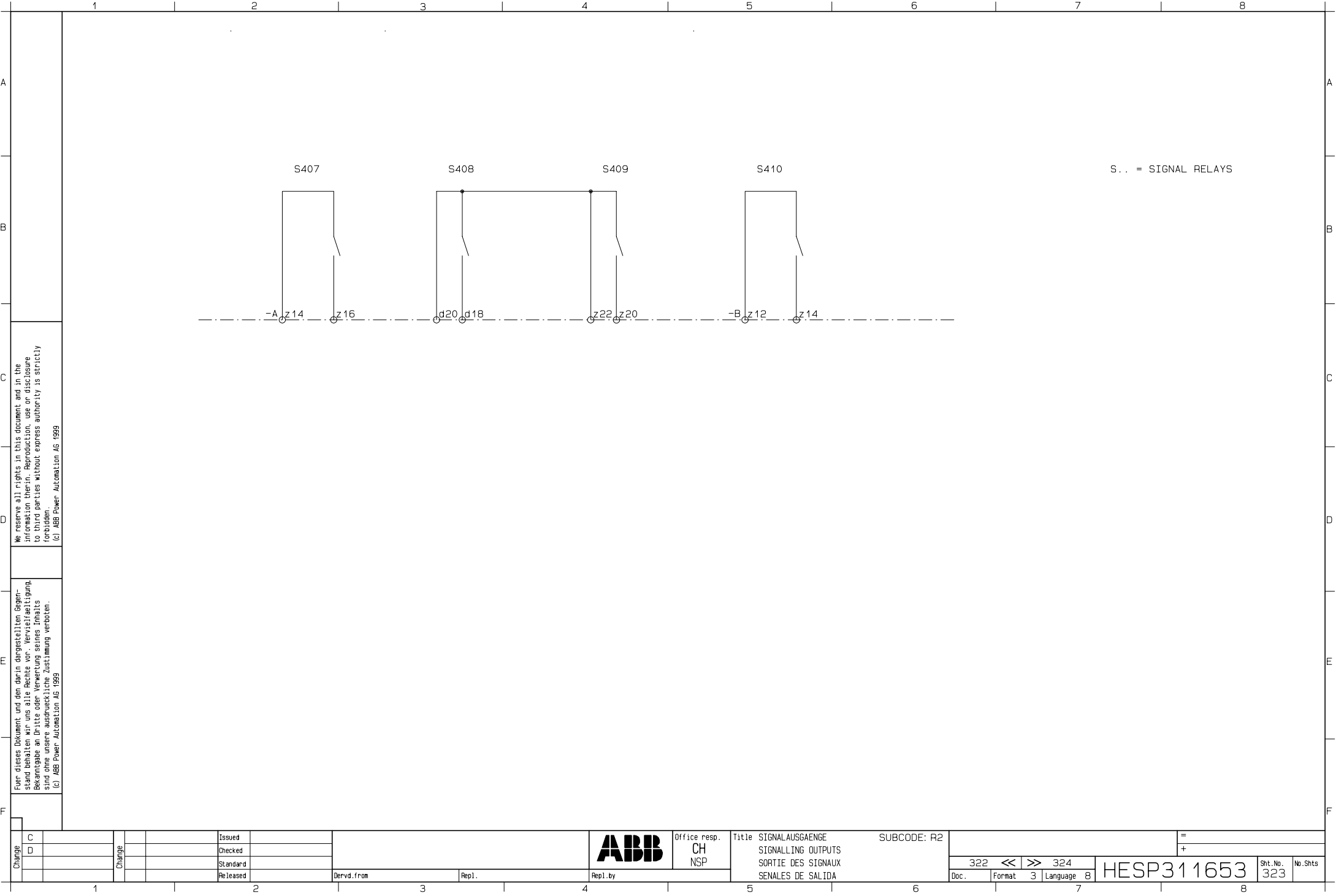
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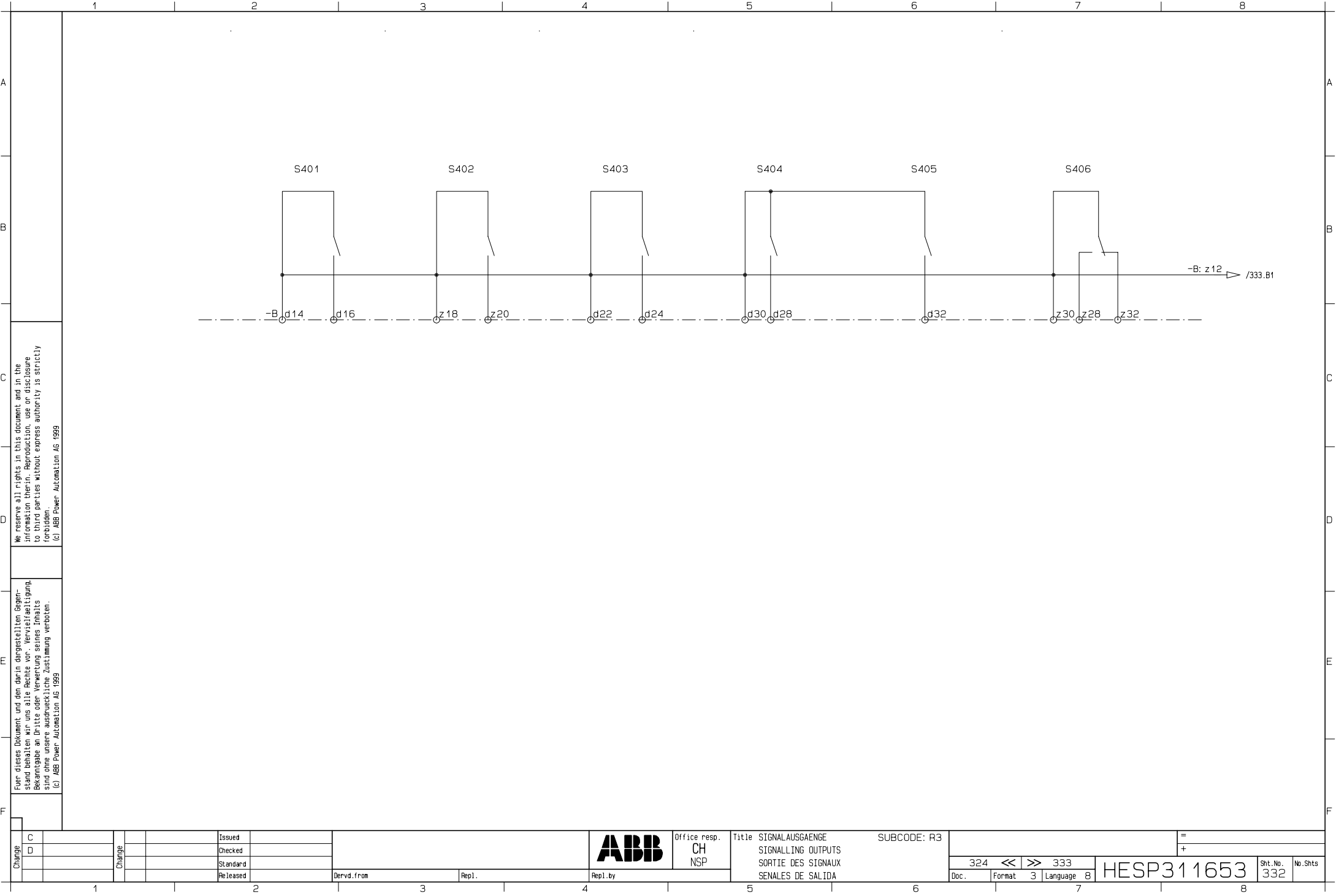
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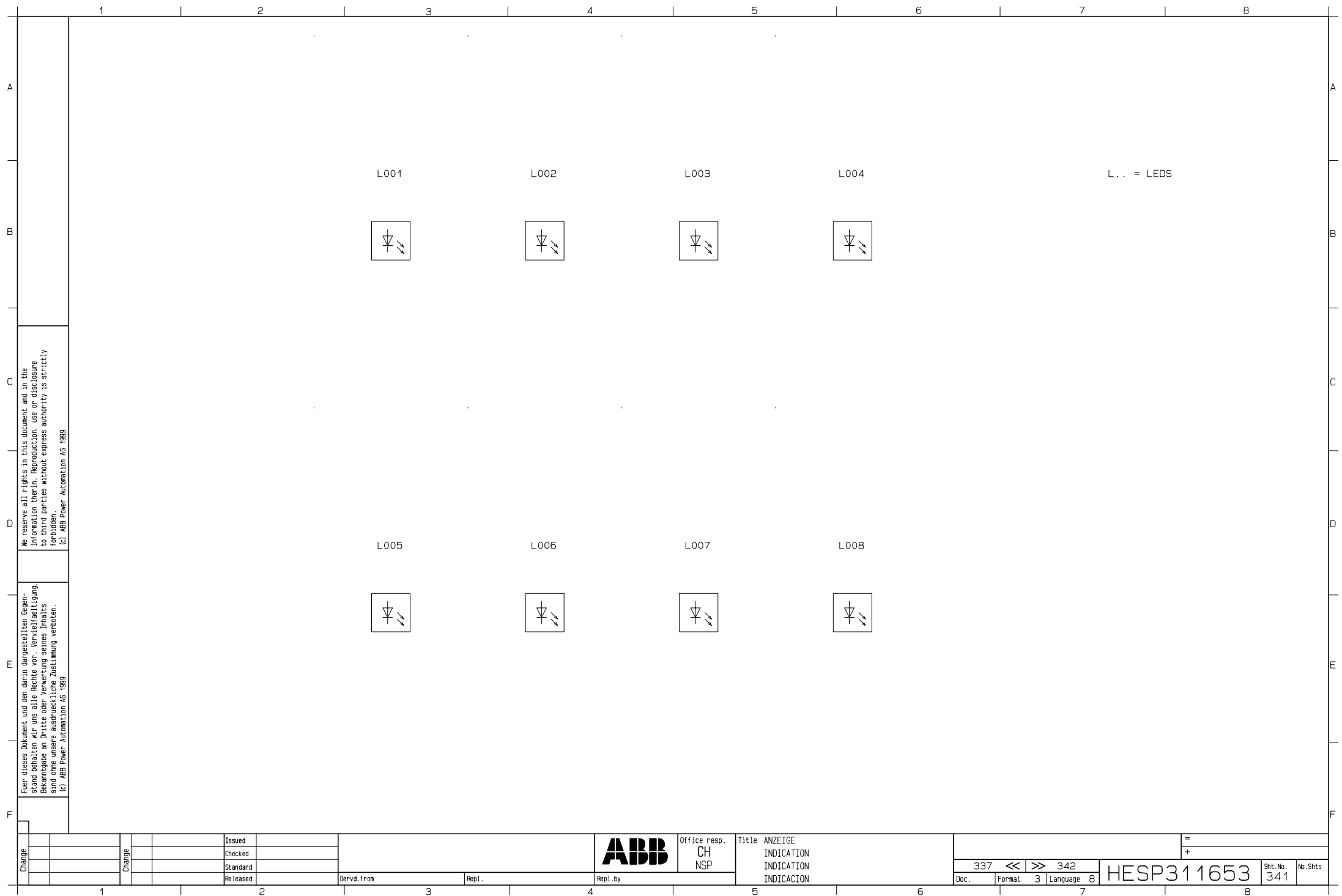


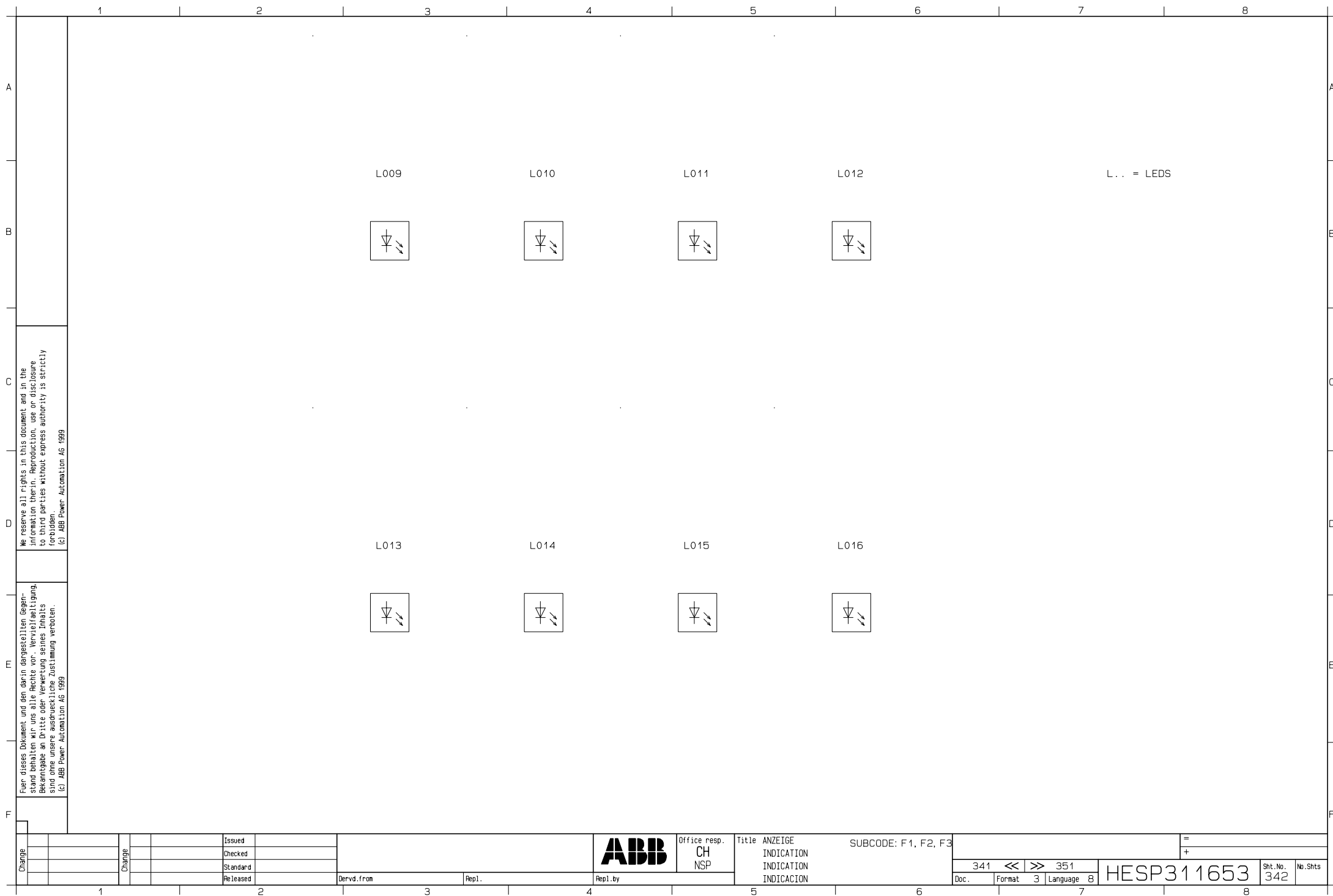


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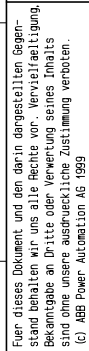
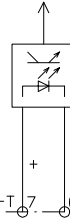




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Is the information sufficient for the purpose of the publication? If not, what is missing and where should it be included?

Name: Date:

Company:

Postal code: Town: Country:

Notification Form for Equipment Faults and Problems

Dear User,

Should you be obliged to call on our repair service, please attach a note to the **unit** describing the fault as precisely as possible. This will help us to carry out the repair swiftly and reliably, which after all is to your own advantage.

Please attach a completed form to every unit and forward them to the address below.

Place of delivery Baden/Switzerland:

ABB Switzerland Ltd
Utility Automation
Repair Center, UTAAA-P
Warenannahme Terminal CA
CH-5401 Baden

Equipment data:

Unit type:

Serial No.:

In operation since:

Reason for return: (tick where applicable)

- ☐ Overfunction
- ☐ No function
- ☐ Outside tolerance
- ☐ Abnormal operating temperature
- ☐ Sporadic error
- ☐ Unit for checking

Remarks/Description of fault:

Customer: Date:

Address:

Please contact: Phone: Fax:

Notification Form for Software Errors and Problems

Dear User,

As we all know from practice, software does not always function as expected for all applications. A precise description of the problem and your observations will help us to improve and maintain the software. Please complete this form and send it together with any supporting information or documents to the address below.

ABB Switzerland Ltd
Utility Automation
Betreuung Software, Abt. UTASS
Bruggerstrasse 71a
CH-5401 Baden
Telefax +41 58 585 86 57
e-mail: SA-LEC-Support@ch.abb.com

Unit/	☐ REC 316*4	SW Version:	☐ REC 216	SW Version:
System:	☐ REG 316*4	SW Version:	☐ REG 216	SW Version:
	☐ REL 316*4	SW Version:	☐ HMI	SW Version:
	☐ RET 316*4	SW Version:	☐ other:	SW Version:
	☐ XS92a / XS92b	SW Version:		

Problem: ☐ Program error (unit/system) ☐ Program error (HMI /PC)
☐ Error in manual ☐ Suggestion for improvement
☐ other:

Can the error be reproduced at will? ☐ yes ☐ no

Particulars of hardware and software (unit/system configuration including jumper positions, type of PC etc.):

Problem located? ☐ yes ☐ no
Suggested changes enclosed? ☐ yes ☐ no

The following are enclosed (floppy with settings etc.):

☐ Floppy ☐ Unit/system settings, file name:
☐ other:

Description of problem:

Customer: Date:

Address:

Please contact: Phone: Fax:

DESCRIPTION OF PROBLEM: (continuation)

ACTION (internal use of ABB Switzerland Ltd, Dept. UTASS only)

Received by: Date:
Answered by: Date:

Problem solved? ☐ yes ☐ no

Week: Name: Position: Consequence:

IMPORTANT NOTICE!

Experience has shown that reliable operation of our products is assured, providing the information and recommendations contained in these Operating Instructions are adhered to.

It is scarcely possible for the instructions to cover every eventuality that can occur when using technical devices and systems. We would therefore request the user to notify us directly or our agent of any unusual observations or instances, in which these instructions provide no or insufficient information.

In addition to these instructions, any applicable local regulations and safety procedures must always be strictly observed both when connecting up and commissioning this equipment.

Any work such as insertion or removal of soldered jumpers or setting resistors, which may be necessary, may only be performed by appropriately qualified personnel.

We expressly accept no responsibility for any direct damage, which may result from incorrect operation of this equipment, even if no reference is made to the particular situation in the Operating Instructions.



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Printed in Switzerland (0207-0000-0)