

# REG216, REG216 Compact REC216

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Edition July 2002

Numerical Generator Protection  
Numerical Control Unit

Operating Instructions

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**ABB**

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## **1. INTRODUCTION**

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# 1. INTRODUCTION

These Operating Instructions apply to the digital generator protection REG 216, REG 216 Compact and to the digital control unit REC 216. In these instructions, the designation RE. 216 is used to refer to both types.

## 1.1. *Application of the protection system*

A number of different protection functions are provided in the software permanently stored within the RE. 216 system. The functions required to protect a specific plant can be individually selected, activated and set. A particular protection function may be used several times in different protection schemes. How the signals are to be processed by the protection for the plant in question such as the assignment of tripping, signalling and logic signals to the various inputs and outputs is also determined by appropriately configuring the software.

The system hardware is modular in structure. The number of electronic devices and I/O units actually installed, for example, to increase the number of protection functions or for purposes of redundancy, can vary according to the requirements of the particular plant.

Because of its modular design and the possibility of selecting protection and other functions by configuring the software, the generator protection REG 216 can be adapted for the protection of small, medium and large generators as well as large motors, power transformers and feeders, while the control unit REC 216 can perform data acquisition and control and supervision functions in medium and high-voltage substations.

## 1.2. ***Other relevant documents***

A general description of the system and the electronic devices and I/O units installed and the corresponding technical data are to be found in [data sheet 1MRB520004-Ben](#) "Type REG 216 and Type REG 216 Compact Generator Protection".

Each RE. 216 protection system is engineered to fulfil the particular requirements of the plant concerned. A specific set of diagrams is provided for each installation, which defines the system with respect to the electronic devices and I/O units installed, their locations and the internal wiring.

The set of plant diagrams includes:

- single-line diagram of the protection: complete representation of the plant showing the c.t. and v.t. connections to the protection.
- standard cable connections: block diagram showing the protection equipment cabling (electronic equipment racks to I/O units).
- protection cubicle layout: installation and locations of the electronic equipment and I/O units.
- electronic rack layout: equipment locations within a rack.
- measurement circuits (three-phase plant diagram): connection of the c.t.'s and v.t.'s to the protection.
- auxiliary supply: external connection and internal distribution of the auxiliary d.c. voltage supply.
- I/O signals: external connection and internal wiring of the tripping and signalling outputs and the external input signals.

### 1.3. **General instructions**

The electronic units may only be inserted into or removed from the equipment rack when the auxiliary supply is switched off!

The auxiliary supply is switched off by means of a switch on the auxiliary d.c. supply units 216NG61, resp. 216NG62 or 216NG63. The following must be noted in this respect:

- Every electronic equipment rack is equipped with its own auxiliary power supply unit.
- Either one or a maximum of two redundant 216NG6. auxiliary d.c. supply units can be installed in an equipment rack.
- Where two redundant auxiliary d.c. supply units are fitted, both units must be switched off.

(See also [Section 2.2.](#))

Any work carried out on the protection such as internal adjustments, inserting soldered jumpers, wiring, connections etc., may only be performed by suitably qualified personnel.

In addition to these instructions, all applicable local regulations governing work and safety must be strictly observed when installing, wiring and commissioning the protection.

Modifications and repairs to the electronic units or software changes may not be performed by the user. No liability will be accepted and any warranty becomes invalid in the case of improper interference or tampering with the protection equipment. Defective units must be returned to ABB for repair ([see also Section 7.](#)).

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## 2. DESCRIPTION OF HARDWARE

### 2.1. *Complete system*

An RE. 216 protection system comprises at least an electronic equipment rack Type 216MB62 with the electronic modules inserted (plug-in units) and a number of I/O units, which are in effect the interface with the primary plant. The protection system is available as a **cubicle version** or as a **compact version**.

Figure 12.1 shows an example of a 216MB61 equipment rack installed in the hinged frame of a protection cubicle. The electronic modules are designed as plug-in units, which are inserted from the front. The B448C parallel bus provides communication between the electronic units and is fitted to the rear of the rack. Also situated at the rear are the connectors for the standard cables to the I/O units and for connecting a printer.

The input transformer, auxiliary relay I/O and tripping relay units are mounted on the inside of the rear panel of the protection cubicle (see Figure 12.2.).

The number and type of electronic units installed, their locations in a rack, the number of racks and the number and arrangement of I/O units varies from plant to plant.

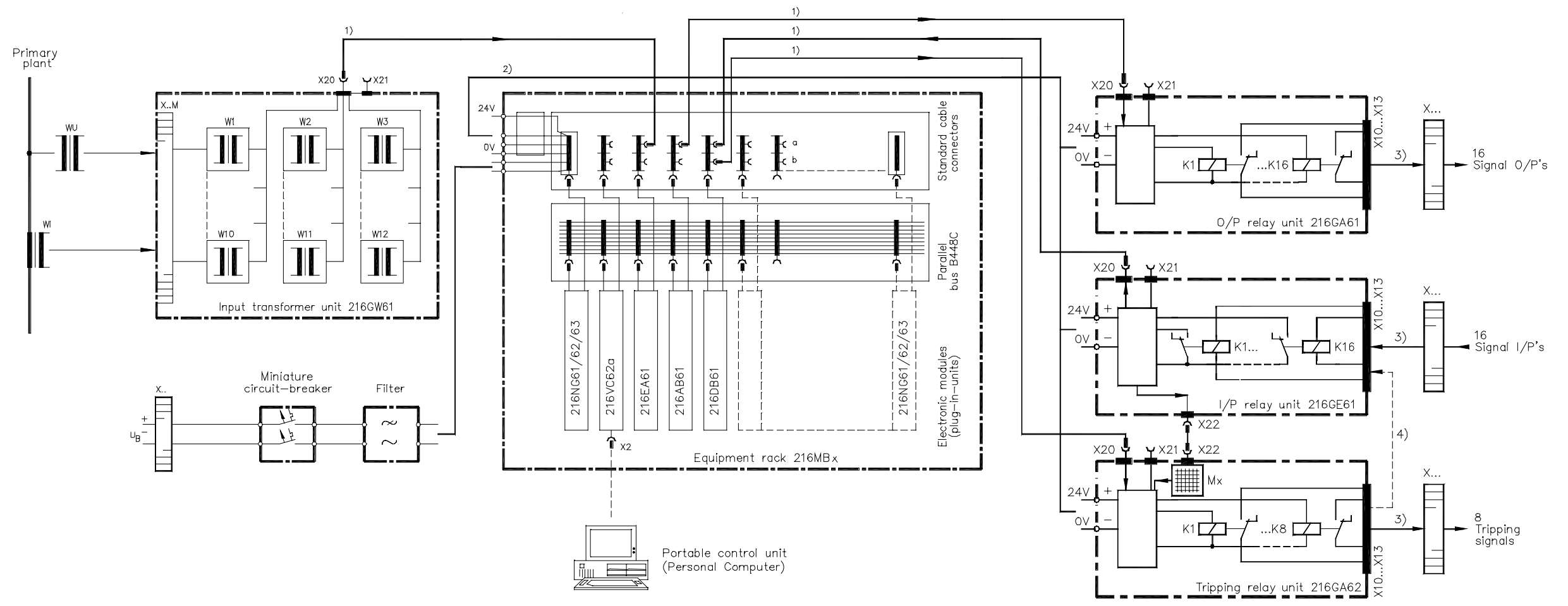
Refer to the corresponding set of diagrams for the execution of an RE. 216 system for a particular plant.

A **compact version** of the REG 216 protection is also available, which is basically a standardised equipment rack (see Section 2.3.). The compact version can be mounted either in an open frame or in a cubicle with other equipment.

### 2.2. *Cubicle version*

#### 2.2.1. *Principle of operation*

Fig. 2.1 illustrates the basic operating principle of the individual units and modules, which make up a complete protection system.



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- 216NG61/ : Auxiliary supply units; DC/DC converters
- 216NG62
- 216NG63
- 216VC62a : Processor unit
- 216EA61 : Analogue I/P unit (A/D converter)
- 216AB61 : Binary O/P unit
- 216DB61 : Binary I/P and tripping unit

Fig. 2.1 Principle of operation of the RE. 216 protection system (see next page for legend)



## Legend of Fig. 2.1:

WU, WI	:	primary v.t's and c.t's
W1...W12	:	input v.t's and c.t's
U <sub>B</sub>	:	auxiliary d.c. supply (station battery)
X...M	:	measuring input terminals
X...	:	auxiliary supply and signal terminals
X20, 21	:	25 pin standard cable connector
X22	:	15 pin standard cable connector
X10...13	:	20 pin wiring cable connector
1)	:	25 core standard cable core gauge 0.25 mm <sup>2</sup>
2)	:	single wire leads wire gauge 1.5 mm <sup>2</sup>
3)	:	20 core wiring cable core gauge 1.5 mm <sup>2</sup>
4)	:	wiring cable (only if K9...K16 in 216GE61 are used for trip circuit supervision)
a/b	:	50 pin standard cable connector on rack 216MB62 a: 25 pin upper half b: 25 pin lower half
X2	:	25 pin RS423 serial interface connector (for connecting portable control unit)
K...	:	auxiliary relays
Mx	:	single-diode matrix (tripping logic) with 10 I/P's and 10 O/P's.

The primary system c.t's and v.t's are connected directly to the 216GW61 input transformer unit. The signals of the measured input variables are stepped down to a suitable level for processing by the electronic circuits (analogue signals) and transferred via the system cable to the 216EA61 unit, which digitises them and transmits them to the B448C parallel bus.

The digitised measured variables derived from the primary system quantities are continuously compared by the processing unit 216VC62a with the pick-up settings of the protection functions. If a protection function picks up, the corresponding signal or tripping command is transmitted via the B448C bus to the 216AB61 O/P unit resp. to the 216DB61 I/O unit. The allocation of the signals and tripping commands at the O/P's of the protection functions to the various channels of the 216AB61 output unit or of the 216DB61 I/P signal and tripping unit is also determined by the software installed in the 216VC62a processor unit.

The output signals from the 216AB61 unit (signalling channels) and 216DB61 unit (trip channels) control the auxiliary relays K1...K16 of the 216GA61 O/P relay unit or 216GA62 tripping relay unit. The auxiliary relays' contacts are potentially-free and wired to terminals for connection to external signalling and tripping circuits.

The external input signals connected to the protection energise the auxiliary relays K1...K16 in the 216GE61 I/P relay unit. The potentially-free contacts of K1...K16 transmit the external signals to the 216DB61 unit and thence to the B448C bus. By appropriate configuration of the software in the 216VC62a processing unit, external signals can be assigned to the various protection functions, e.g. for logical combination (interlocking and blocking) with trip signals or for exciting the tripping channels 1...8.

Tripping circuits 1...8 can be directly energised by all or just some of the I/P channels 1...10 (K1...K10) of 216GE61 via the diode matrix (tripping logic) of 216GA62 (see [Section 2.6.](#)). Provision is also made for some of the channels 9...16 (K9...K16) of 216GE61 to be used for supervising the external tripping circuits 1...8 instead of for the connection of external inputs. This is an option, which must be specified in the order to enable the corresponding wiring to be included when engineering the protection.

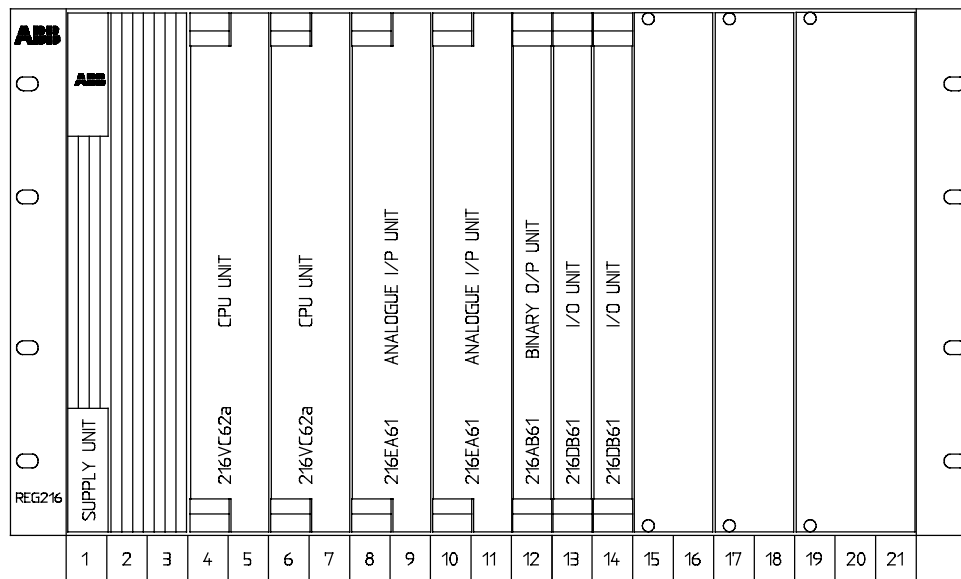
In order to supply the electronic units with power the protection must be connected to an external auxiliary d.c. supply (station battery). The auxiliary d.c. supply unit 216NG61, 216NG62 or 216NG63 (DC/DC converters) steps the station battery voltage down to 24 V and provides electrical insulation between input and output voltages. The 24 V supply is distributed to the units inserted in the protection equipment rack via the B448C parallel bus. The 216NG61, 216NG62 or 216NG63 power supply unit also supplies the electronic circuits on the I/O units. A 216MB66 equipment rack can be equipped with just one or with two redundant 216NG61, 216NG62 or 216NG63 auxiliary d.c. supply

units. Redundant units can be connected to the same or to two different station batteries.

All software configuration, i.e. selection and setting of the protection functions and the assignment of signals to the inputs and outputs, is performed via the RS-423 serial interface on the 216VC62a processing unit. The corresponding connector is the 25 pin socket X2 on the front of the unit, to which a personal computer is connected.

### 2.2.2. *Layout of equipment rack Type 216MB66*

Fig. 2.2 shows an example of the arrangement of the electronic units in the equipment rack. The equipment rack is sub-divided into 21 divisions (T). Divisions 1-3 and 19-21 are always used for auxiliary d.c. supply units 216NG61, 216NG62 or 216NG63. In principle, the electronic units may be located in any of the remaining divisions 4-18, providing that the system cable connections were correspondingly installed. For reasons of standardisation, however, the various types of units are always located at the same position in the equipment rack.



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Fig. 2.2 Locations of the electronic units in the 216MB66 equipment rack

Consult the specific set of diagrams for the layout of the electronic units in the 216MB66 equipment rack of a particular plant.

[Table 2.1](#) gives the standard slot references for the various units. For example, a maximum of two 216VC62a processing units can be installed in an equipment rack and are always located in slot 4 and 6.

The designations and numbering of the I/O signals for the I/P and O/P units of a protection system are given in the column "I/O channel definition". Note that the quantity of I/O channels given for each group of the same type of units refers to the particular equipment rack and not the entire system. The total quantity of I/O channels for the entire system is given by the number of I/O units installed ([see also Section 2.2.3.](#) and the set of specific plant diagrams).

Rack division	Unit No.	Unit Type 216	Capacity / Function	I/O channel definition	
				Connector a above	Connector b below
1-3	1.	NG61, 62, 63	Aux. supply for complete rack		
4	2.	VC62a	425% computing capacity X2		X4
5					
6	3.	VC62a	425% computing capacity X2		X4
7					
8-9	1.	EA61	24 analogue I/P's: meas. channels	CH01...CH12 <sup>1)</sup>	CH13...CH24 <sup>1)</sup>
10-11	2.	EA61	24 analogue I/P's: meas. channels	CH25...CH36 <sup>2)</sup>	CH37...CH48 <sup>2)</sup>
12	1.	AB61	32 binary O/P's: signalling channels	CHO001...CHO016	CHO017...CHO032
13	2.	AB61	32 binary O/P's: signalling channels	CHO033...CHO048	CHO049...CHO064
	3.	AB61	32 binary O/P's: signalling channels	CHO065...CHO080	CHO081...CHO096
	4.	AB61	32 binary O/P's: signalling channels	CHO097...CHO112	CHO113...CHO128
	5.	AB61	32 binary O/P's: signalling channels	CHO129...CHO144	CHO145...CHO160
	6.	AB61	32 binary O/P's: signalling channels	CHO161...CHO176	CHO177...CHO192
	1.	DB61	16 binary I/P channels 8 binary tripping O/P channels	CHI01...CHI16	CHO01...CHO08
	2.	DB61	16 binary I/P channels 8 binary tripping O/P channels	CHI17...CHI32	CHO09...CHO16
	3.	DB61	16 binary I/P channels 8 binary tripping O/P channels	CHI33...CHI48	CHO17...CHO24
	4.	DB61	16 binary I/P channels 8 binary tripping O/P channels	CHI49...CHI64	CHO25...CHO32
	5.	DB61	16 binary I/P channels 8 binary tripping O/P channels	CHI65...CHI80	CHO33...CHO40
	6.	DB61	16 binary I/P channels 8 binary tripping O/P channels	CHI81...CHI96	CHO41...CHO48
	1	AC61	16 binary O/P's 8 analogue O/P's	CHO01...CHO16	AA01...AA08
	2	AC61	16 binary O/P's 8 analogue O/P's	CHO17...CHO32	AA09...AA16
	3	AC61	16 binary O/P's 8 analogue O/P's	CHO33...CHO48	AA17...AA24
	4	AC61	16 binary O/P's 8 analogue O/P's	CHO49...CHO64	AA25...AA32
	5	AC61	16 binary O/P's 8 analogue O/P's	CHO65...CHO80	AA33...AA40
	6	AC61	16 binary O/P's 8 analogue O/P's	CHO81...CHO96	AA41...AA48

X2: connector for portable control unit

1) rack division 9

2) rack division 11

Rack division	Unit No.	Unit Type 216	Capacity / Function	I/O channel definition	
				Connector a above	Connector b below
	1	EB61	32 binary I/P's	CHI01...CHI16	CHI17...CHI32
	2	EB61	32 binary I/P's	CHI33...CHI48	CHI49...CHI64
	3	EB61	32 binary I/P's	CHI65...CHI80	CHI81...CHI96
	4	EB61	32 binary I/P's	CHI97...CHI112	CHI113...CHI128
	5	EB61	32 binary I/P's	CHI129...CHI144	CHI145...CHI160
	6	EB61	32 binary I/P's	CHI161...CHI176	CHI177...CHI192
	7	EB61	32 binary I/P's	CHI193...CHI208	CHI209...CHI224
	8	EB61	32 binary I/P's	CHI225...CHI240	CHI241...CHI256
19-21	2.	NG61, 62, 63	Redundant aux. supplies for complete rack		

Table 2.1 Locations of the units in the standard 216MB66 equipment rack

### 2.2.3. *Alternative system versions*

The number of electronic units and I/O units used in a protection system varies according to plant requirements. The maximum quantities of electronic units in one system (a single 216MB66 equipment rack) are given in Table 2.1.

The numbers of I/O signals given for the versions listed in [Table 2.2](#) to [Table 2.4](#) refer to a complete system (single system with one 216MB66 equipment rack). An equipment rack can accommodate one or two 216VC62a processing units and therefore the versions given in [Table 2.2](#) to [Table 2.4](#) can have a total computing capacity of 425% or 850%.

<b>1. Analogue I/P's</b>			
<b>Version</b>	<b>Quantity</b>	<b>Quantity</b>	<b>Max. capacity (channels)</b>
	<b>216EA61</b>	<b>216GW61</b>	<b>Analogue I/P signals</b>
1.1	1	1	12
1.2	1	2	24
1.3	2	3	36
1.4 <sup>1)</sup>	2	4	48

Table 2.2 Alternative versions: Analogue I/P signals

<b>2. Signals</b>				
<b>Version</b>	<b>Quantity</b>	<b>Quantity</b>	<b>Max. capacity (channels)</b>	
	<b>216AB61</b>	<b>216GA61</b>	<b>Signals</b>	<b>Alarms</b>
2.1	1	1	14	2
2.2	1	2	30	2
2.3	2	3	46	2
2.4	2	4	62	2

Table 2.3 Alternative versions: Signals and alarms

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<sup>1)</sup> in 2 cubicles according to version

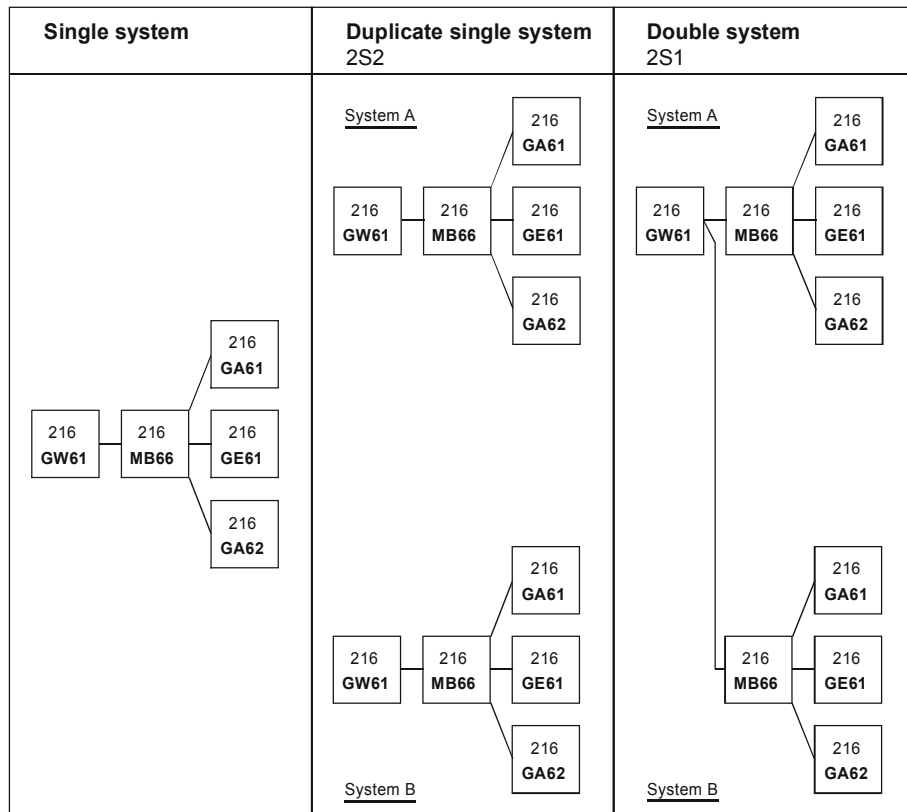
3. Tripping O/P's and external I/P's					
Version	Quantity	No. of modules		Max. capacity (channels)	
	216DB61	216GA62	216GE61	Tripping O/P's	External I/P's
3.1	1	1	---	8	---
3.2	1	1	1	8	16
3.3	2	2	---	16	---
3.4	2	2	1	16	16
3.5	2	2	2	16	32
3.6	3	3	---	24	---
3.7	3	3	1	24	16
3.8	3	3	2	24	32
3.9	3	3	3	24	48
3.10	4	4	---	32	---
3.11	4	4	1	32	16
3.12	4	4	2	32	32
3.13	4	4	3	32	48
3.14	4	4	4	32	64

Table 2.4 Alternative versions: Tripping O/P's and external I/P's

An RE. 216 protection system can comprise several 216MB66 equipment racks. The possible configurations can be seen from [Fig. 2.3](#). The table refers to the standard equipment rack and the I/O modules actually installed may be as given in [Section 2.2.3](#).

Depending on the quantity of I/O modules, one or several panels may be necessary.





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Fig. 2.3 System configurations

### 2.3. Compact version

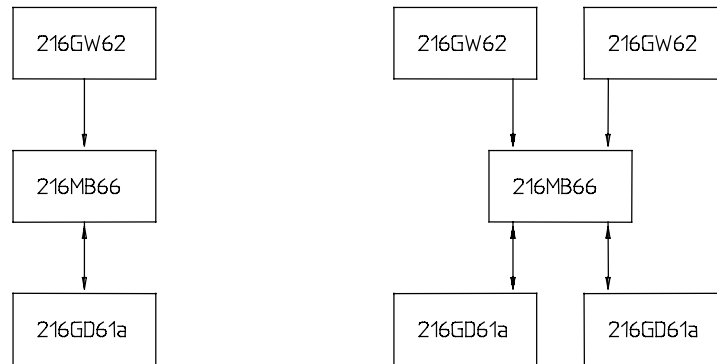
There are two main versions available:

The single system in the system rack 216MB66 and the redundant version in the system rack 216MB68. The possible system configurations are shown in Fig. 2.4.

The functional units are completely enclosed and are protected according to DIN Protection Class IP30. They are preferably mounted in a rack corresponding to the installation diagrams in Figures 12.18 to 12.22. The 216GD61a and 216GW62 units are mounted on a hinged bracket for ease of service. When installing the protection, attention must be paid that a vertical clearance of at least 90 mm must be left between the various assemblies (see Fig. 12.18 to 12.21).

The electronic units are arranged as described in Section 2.2.2.

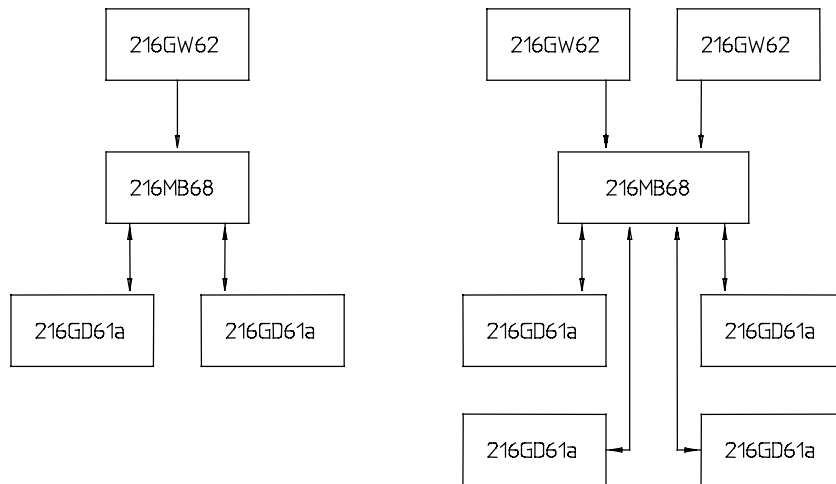
Single system



Basic version

Maximum version

Redundant system



Basic version

Maximum version

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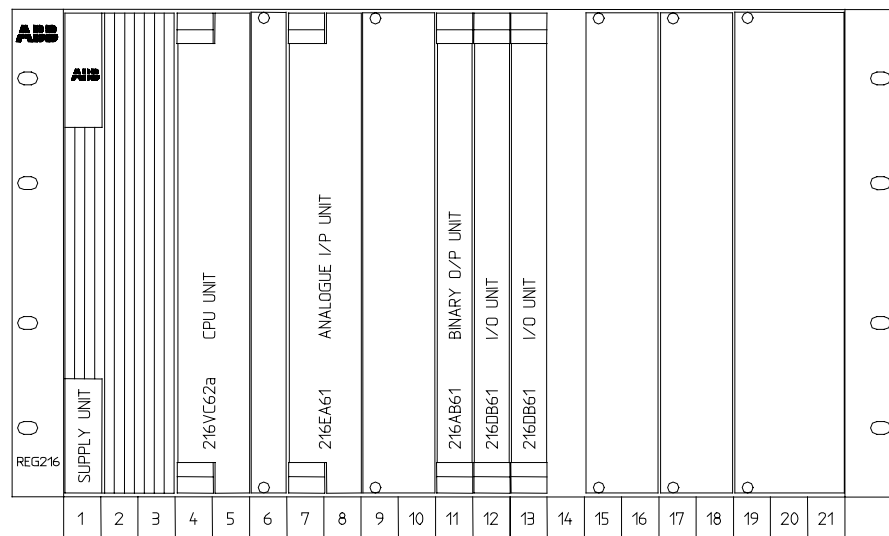
Fig. 2.4 System configuration compact version

### 2.3.1. Single system

The basic version of the single system REG 216 consists of the following components:

- 1 electronic equipment rack 216MB66 (incl. electronic units)
- 1 input transformer module 216GW62
- 1 relay- and opto-coupler module 216GD61a
- Accessories (connecting cable 216IK61, etc.).

Fig. 2.5 shows the maximum version in the equipped electronic equipment rack



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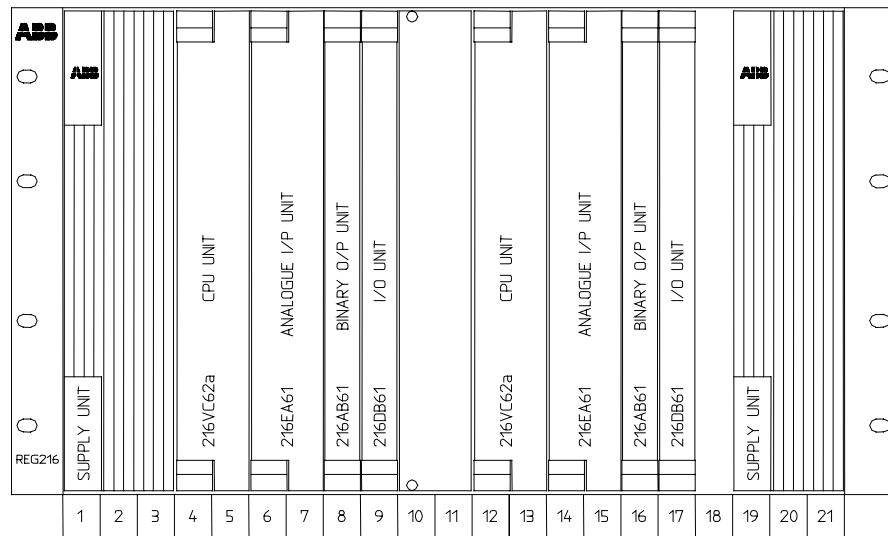
Fig. 2.5 Rack 216MB66; compact version  
(Single system)

**2.3.2. Redundant system**

The basic version of the redundant system REG 216 consists of the following components:

- 1 electronic equipment rack 216MB68 (incl. electronic units)
- 1 input transformer module 216GW62
- 1 relay- and opto-coupler module 216GD61a
- Accessories (connecting cable 216IK61, etc.).

Fig. 2.6 shows the maximum version in the equipped electronic equipment rack



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**Fig. 2.6 Rack 216MB68; compact version (redundant system)**

The following units are normally installed:

Type	LG, GV	LG, MV	RG, GV	RG, MV
216NG6.	1	1	1	1
216VC62a	1...2	1...2	1	1
216EA61	1	1	1	1
216AB61	1	1	1	1
216DB61	1	2	1	2

For the versions the following maximum values result for the number of inputs and outputs per group:

Inputs / Outputs	GV	MV
Analogue Inputs	12	24
Binary Inputs	12 + 4	24 + 8
Signalling outputs	2 + 14	2 + 30
Tripping outputs	8	16

Abbreviations: LG: left group; rack slots 1...11  
 RG: right group; rack slots 12...21  
 GV: basic version  
 MV: maximum version

The following units are normally installed:

Type	Electronic units in basic version	Electronic units in full version
216NG6.	1...2	1...2
216VC62a	1	1...2
216EA61	1	1
216AB61	1	1
216DB61	1	2

The following maximum quantities of I/P's and O/P's result:

Inputs / Outputs	Basic version	Full version
Analogue I/P's	12	24
Binary I/P's	12 + 4	24 + 8
Signalling O/P's	2 + 14	2 + 30
Tripping O/P's	8	16

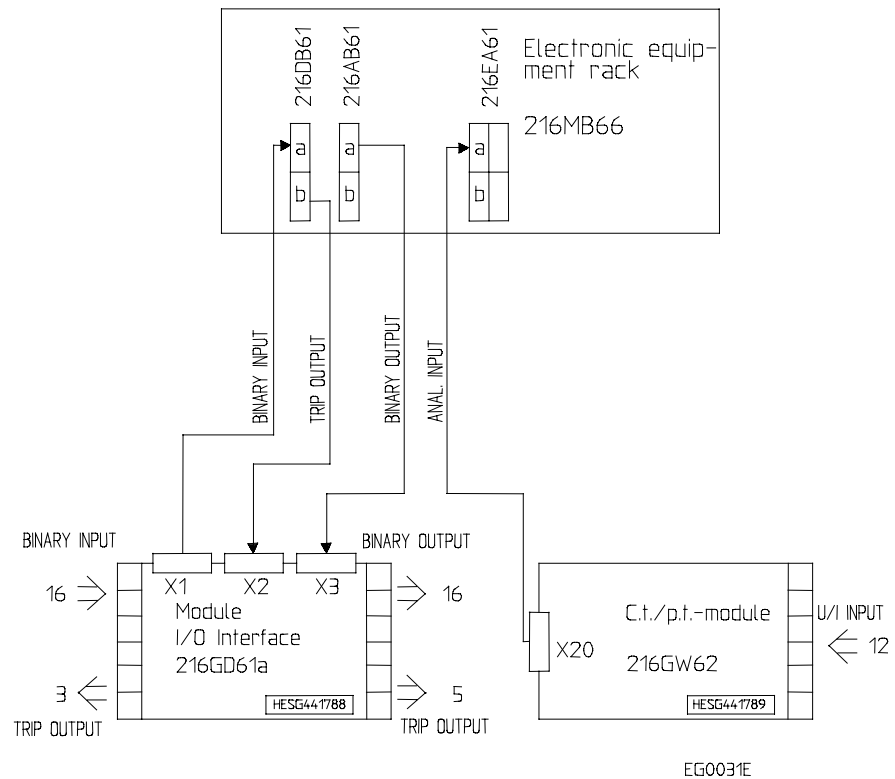


Fig. 2.7 Wiring diagram of the basic version

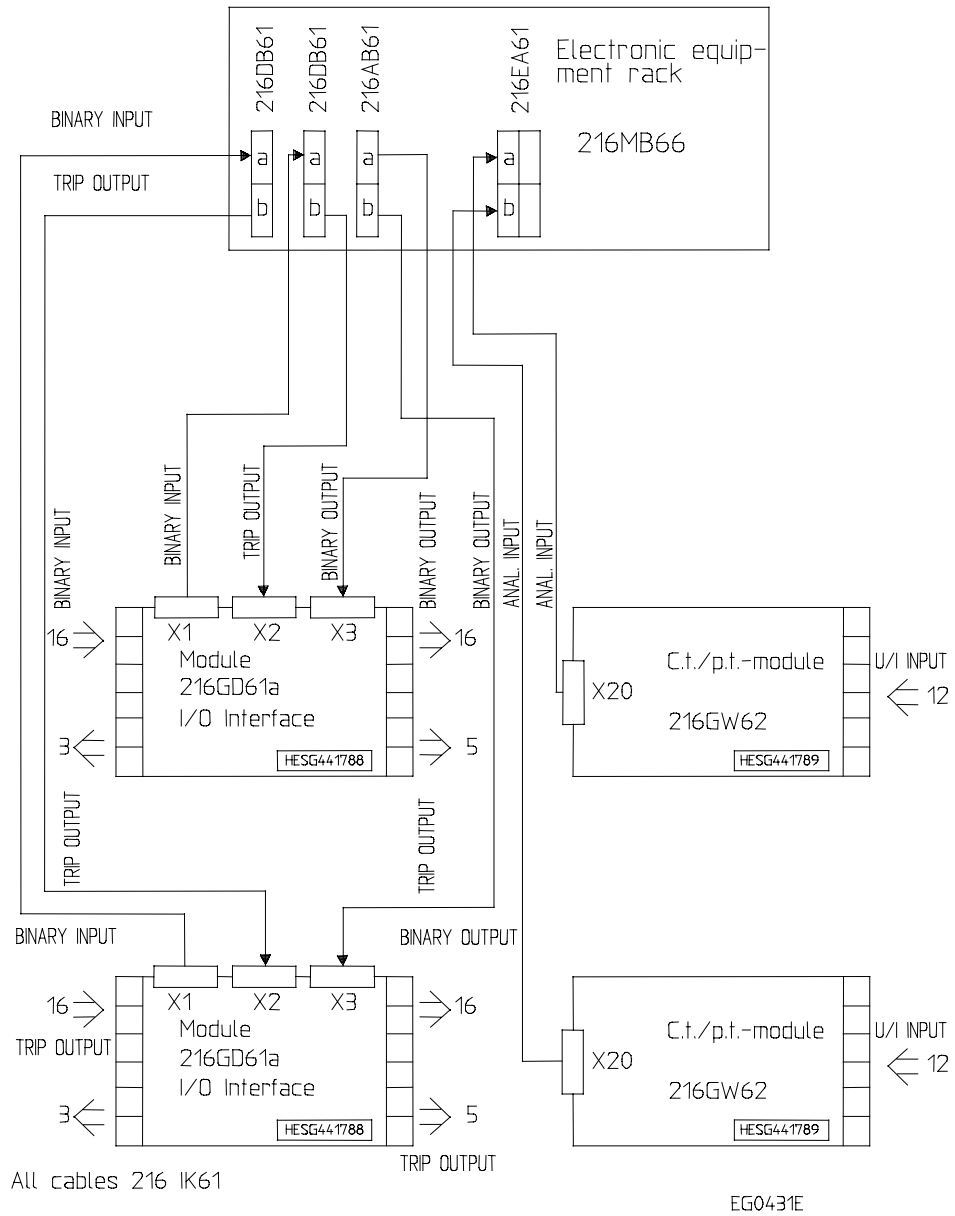
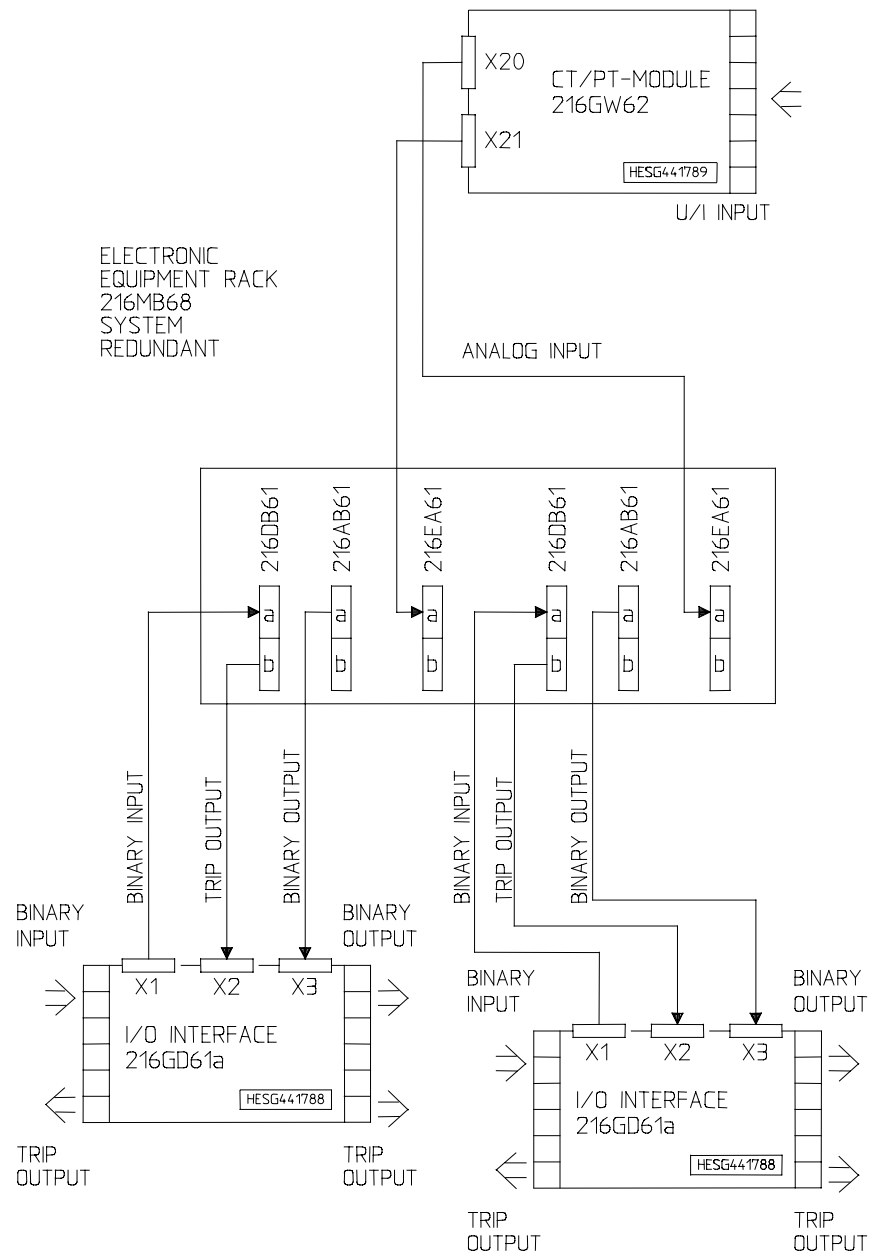


Fig. 2.8 Wiring diagram of the full version



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Fig. 2.9 Wiring diagram of the basic version



When allocating the signalling and trip relays to protection functions in the full version, note that the channel number is determined by the electronic units:

- The 216AB61 unit has 32 (2 x 16) signalling outputs. All outputs 1...16 are available for use on the 216GD61a. When using a second 216GD61a unit, signalling relay O/P's 1...16 and 17...32 can be controlled.
- Apart from the binary I/P's, the 216DB61 unit is equipped with 8 tripping O/P's. Outputs 1...8 are available for use on the 216GD61a and, when there is a second 216GD61a, outputs 9...16 as well.

216IK61 standard cables connect the electronic equipment rack to the other assemblies of the system via connectors X1, X2, X3 and X20. The wiring diagram for the basic version is shown in [Fig. 2.7](#) and for the full version in [Fig. 2.8](#).

Further details of the auxiliary relay and opto-coupler unit 216GD61a are given in [Section 2.7.2](#).

[Figure 12.40](#) shows the wiring diagram of a redundant auxiliary d.c. supply with a reset switch. Only those terminals used on lesser versions (e.g. basic version) are wired.

## 2.4. **Auxiliary supply**

### 2.4.1. **Auxiliary supply distribution**

A system resp. the 216MB6. equipment rack can be equipped with one or two redundant auxiliary d.c. supply units (DC/DC converters). Fig. 2.10 shows the auxiliary d.c. supply system with either two 216NG61, 216NG62 or 216NG63 units.

All electronic units and I/O modules have been designed to operate with redundant auxiliary d.c. supplies. As long as one of the two 24 V supplies is available, the correct operation of all the equipment's functions is assured. The B448C parallel bus has two redundant auxiliary d.c. supply lines designated USA and USB and the redundant supplies for the electronic units are achieved by connecting them to both. The 216NG6. units also provide the auxiliary d.c. supply for the I/O modules. The corresponding auxiliary voltage UP (24 V)/ZP (0 V) is distributed to the individual I/O modules via a terminal block.

Legend of Fig. 2.10:

USA, USB	:	aux. supply lines	24 V DC
ZD	:	aux. supply return line	0 V
SML	:	general alarm line	"System defect"
CK	:	stand-by signal line	"Stand-by"
Red.	:	"Redundant" circuit (connections to the redundant 216NG6.)	
F100	:	fuses:	216NG61      6.3 A slow
			216NG62      2.5 A slow
			216NG63      1.6 A slow
K100	:	aux. signalling relay	"24 V failure"
UP	:	aux. supply line for I/O modules	24 V
ZP	:	aux. supply return line for I/O modules	0 V

See legend of Fig. 2.1 for other symbols.

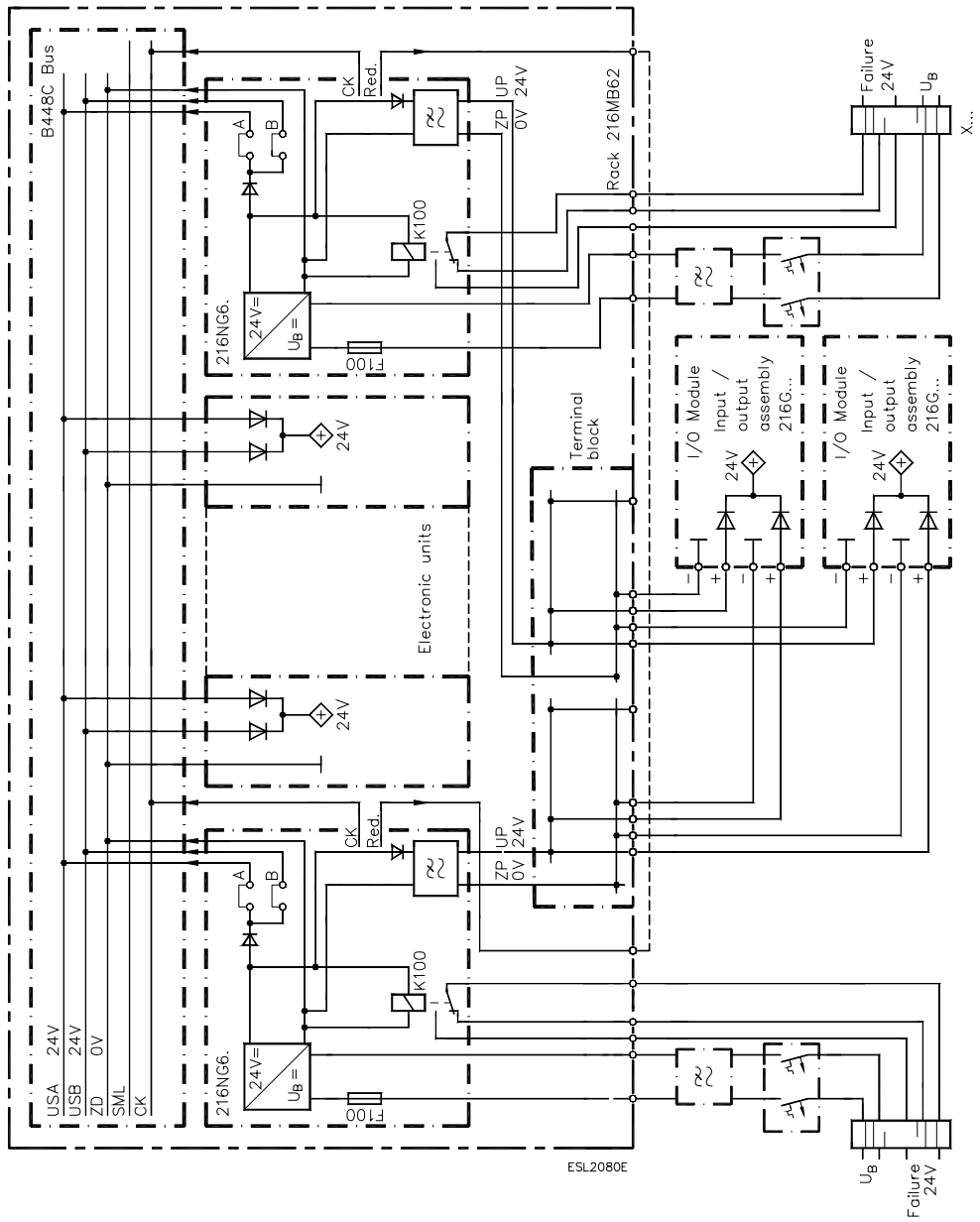


Fig. 2.10 Auxiliary supply system of the RE. 216

**216MB66 rack with 1 auxiliary supply unit Type 216NG6.:**

Plug-in jumpers A and B must both be inserted.

- The 216NG6. feeds both auxiliary supply lines USA and USB on B448C.
- The I/O modules have a single supply.

**216MB66 rack with 2 auxiliary supply units Type 216NG6.:**

Plug-in jumpers A and B on all 216NG6.'s must both be inserted.

- The auxiliary supply lines USA and USB are supplied separately by the two redundant 216NG6. units.
- The I/O modules are supplied separately by the two redundant 216NG6. units.

It is also possible for the first 216NG6. unit to supply just the parallel bus and electronic units and the second 216NG6. to supply just the I/O modules (i.e. single supply). In this case:

- plug-in jumpers A and B on the first 216NG6. must be inserted
- plug-in jumpers A and B on the second 216NG6. must be withdrawn.

Refer to the specific set of installation diagrams for the wiring of the auxiliary d.c. supply circuit for a particular plant.

Should the 24 V auxiliary d.c. supply fail, none of the stored functions or user settings are lost.

**2.4.2. Auxiliary d.c. supply units 216NG61, 216NG62 and 216NG63**

The 216NG6. auxiliary d.c. supply unit transforms the station battery voltage  $U_B$  to 24 V d.c. and provides electrical insulation between I/P and O/P. The technical data are given in the data sheet (refer to [Section 1.2.](#) for the data sheet number). Depending on the station battery voltage  $U_B$ , one of the following types is installed:

216NG61 :	for $U_B$	= 48 / 60 V DC $\pm$ 25 %, i.e. 36...75 V DC
216NG62 :	for $U_B$	= 110 / 125 V DC $\pm$ 25 %, i.e. 82.5...156 V DC
216NG63 :	for $U_B$	= 220 / 250 V DC $\pm$ 25 %, i.e. 165...312.5 V DC

## Design

Figures 12.3 and 12.4 show the front and rear views of the auxiliary d.c. supply units. The units have a width of 3 divisions (3T). The operation and the construction of the three types 216NG61, 62 and 63 are identical.

### Frontplate signals and controls (see Fig. 12.3)

LED "U IN" (green):

Lights when the I/P voltage (station battery voltage  $U_B$ ) is available.

LED "U OUT" (green):

Lights when the O/P voltage (24 V DC before the plug-in jumpers A and B) is available.

Both LED's "U IN" and "U OUT" must be lit during normal operation, i.e. when the protection is on-line and functioning.

Switch "I/O":

Main ON/OFF switch for the auxiliary d.c. supply unit.

I : ON

O : OFF

### Settings (see Fig. 12.4)

The states of the plug-in jumpers A and B at the rear of the unit determine whether one or both of the auxiliary d.c. supply lines USA and USB are supplied. Fig. 2.11 shows the corresponding plug-in jumper positions (see also Fig. 2.10).

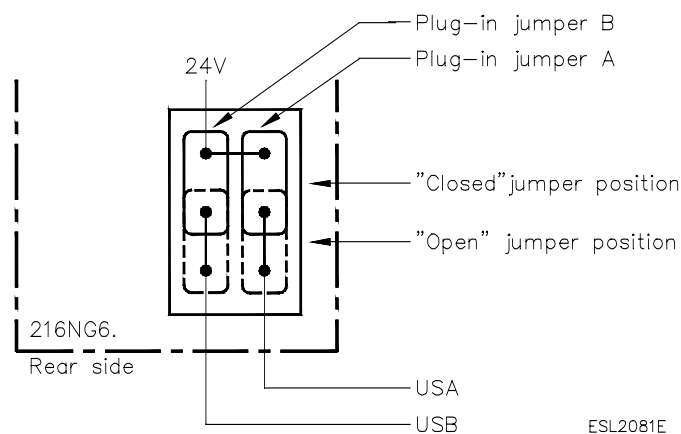


Fig. 2.11 Plug-in jumpers A and B on 216NG6.

"Closed" position: USA or USB supplied with 24 V

"Open" position : USA or USB not supplied

**"24 V failure" signal**

The failure of the 24 V output voltage is signalled on the front of the unit concerned by the LED "U OUT".

The failure of the 24 V output voltage is signalled remotely in three ways (see [Fig. 2.10](#)):

- a) By auxiliary signalling relay K100 in 216NG6. .  
K100 is continuously energised in normal operation, i.e. when the 216NG6. is switched on, and resets in the event of a failure of the 24 V output voltage.
- b) By the stand-by signal line (bus conductor) CK.  
CK is at logical "1" during normal operation (O/P CHO02 energised). O/P CHO02 resets in the event of a failure of the 24 V output voltage.  
**Note:** If two 216NG6. auxiliary supply units are installed in an equipment rack and the jumpers are set for redundant supply, the failure of the 24 V output voltage of just one of the units is not signalled by the CK bus conductor.
- c) In the event of an auxiliary supply failure, the first binary O/P unit energises the SML "System defect" signal line on the B448 parallel bus. This is signalled remotely via channel CHO01.

## **2.5. Parallel bus and electronic units**

### **2.5.1. Equipment rack 216MB66 with parallel bus B448C**

Figures 12.5 and 12.6 show the equipment rack without the plug-in electronic units. The 19" rack is 21T (T = 17 mm) wide and 6U (U = 44.55 mm) high. The rack, the B448C parallel bus, the connectors for the standard cables and the terminal block form an invariable unit.

#### **Settings**

No settings have to be made to the equipment rack.

Care should be taken that the standard cables go to the appropriate connectors for the electronic units actually inserted. Refer also to [Sections 2.2.1. and 2.2.2.](#) and the set of specific plant diagrams.

### **2.5.2. Processing unit 216VC62a**

All the available protection and logic functions described in Section 3 are stored as a software module library in the 216VC62a processing unit. All the user settings for the activated functions and the configuration of the protection, i.e. assignment of I/P and O/P signals (channels) to the protection functions, are also stored in this unit. The software is downloaded using the operator program.

The protection functions and their associated settings necessary for a particular plant are selected and stored with the aid of the portable user interface (PC). Every activated function requires a certain percentage of the total available computing capacity of the processing unit ([see Section 3](#)).

The processing unit 216VC62a has a computing capacity of 425%.

The 216VC62a is used both as a processor and as an interface to the interbay bus (IBB) in the substation monitoring system (SMS) and the substation automation system. The available communication protocols are:

- SPA BUS
- LON BUS
- MCB interbay bus
- MVB process bus.

The SPA BUS interface is always available. The LON and MVB protocols are transferred by PC cards.

The supply to the memory in the 216VC62a is maintained in the event of an interruption by a gold condenser so that the event list and disturbance recorder data remain intact. The disturbance recorder data can be read via either the interface on the front of the 216VC62a or the object bus. The data can be evaluated using the "EVECOM" evaluation program. The internal clock of the RE. 216 can be synchronised via the object bus interface of SMS/SCS systems or by a radio clock.

I/P signals (channels) from the B448C bus:

- digitised measured variables: primary system currents and voltages
- logic signals: external I/P signals
- 24 V auxiliary supply and data exchange with the B448C bus.

O/P signals (channels) to the B448C bus:

- signal O/P's from the protection and logic functions selected
- tripping O/P's from the protection and logic functions selected
- data exchange with the B448C bus.

The designation of the I/O channels is identical to that of the I/O unit (see [Table 2.1](#)).

The main components of the unit are:

- Processor type; 80486 DX-2, 50MHz  
for running the programs
- Bus interface (DPM/RAM) for data 64 kByte  
exchange with the B448C bus
- Program memory (Flash EPROM) for 4 MByte  
storing protection and logic functions  
(software module library)
- Data memory (RAM), main memory 2 MByte  
for running programs
- Data memory (Flash EEPROM) 2 MByte  
for recording selected functions and  
settings



- Serial interface (RS 232) for connection of the portable user interface
- PCMCIA interface for LON / MVB buses
- Serial interface (RS 232) for SPA bus,

### Frontplate signals and controls (see Fig. 12.7)

LED "AL" (red):

Alarm. Lights for an internal defect. See Section 6.1. for possible causes.

LED "MST" (yellow):

Master. Lights when the unit is communicating with the bus and data are being exchanged. (May light only briefly or flash.)

LED's "L1-L6" (yellow):

L1, L2: System status (see Section 6.2.)

L3, L4: Communication (with the user interface (PC) )  
(see Section 6.2.)

L5: LON wink telegram received

L6: Flash EEPROM's in write mode.

Socket "PSV":

Passive. The unit's functions are blocked when the shorting pin is inserted.

Socket "RES":

Reset. The program is restarted by briefly inserting the shorting pin. All other units are reinitialised at the same time. The list of events is not deleted.

### Settings

No (hardware) settings are necessary on the 216VC62a unit itself.

### 2.5.3. **Analogue I/P unit 216EA61**

The 216EA61 input unit receives the analogue measured variables from the 216GW61 input transformer module, digitises them and transfers them to the B448C bus.

The unit has 24 analogue I/P channels, i.e. a maximum of two 216GW61 input transformer modules can be connected to a 216EA61 I/P unit (see also [Section 2.6.1.](#)).

- connector "a" (upper) : channels CH01...CH12
- connector "b" (lower) : channels CH13...CH24

Within the protection system, the designations of the O/P channels correspond to those of the I/P channels. Where a system requires several 216EA61 units, the measurement channels are designated within the system according to [Table 2.1.](#)

#### **Design**

[Figure 12.8](#) shows the front view of the 216EA61 I/P unit, which is a plug-in unit with a width of 2 standard divisions (2T). The internal auxiliary supply voltage is 5 V and is derived inside the unit from the 24 V auxiliary d.c. supply. The unit's main components are:

- a 24 (measurement) channel analogue (-40 V...+40 V)-to-digital converter
- a processor for pre-processing the measured variables (80C186)
- a bus interface (64 kByte DPM/RAM)
- a program memory (128 kByte EPROM)
- a main memory (64 kByte RAM)
- an electrically deletable and programmable data memory (8 kByte EEPROM).

#### **Frontplate signals and controls (see [Fig. 12.8](#))**

LED "ALARM" (red):

Lights when the unit has an internal defect. [See Section 6.1.](#) for possible causes.

LED "MST" (yellow):

Master. Lights when the unit communicates with the bus and exchanges data. (May light only briefly or flash.)

**LED "RUN" (green):**

Operation. Lights when the program is running, i.e. it lights continuously during normal operation. (The digitised measured variables are not transferred to the bus, if this LED is not lit.)

**Socket "PASSIVE":**

The A/D converter is blocked and no data (digitised measured variables) are transferred to the bus when the shorting pin is inserted. The already stored data and measured variables are not deleted.

**Socket "RESET":**

The program is restarted by briefly inserting the shorting pin. All the units are reinitialised and the stored measured variable tables are deleted.

**Settings**

No (hardware) settings are necessary on the 216EA61 unit itself.

The measuring channels are assigned to the activated protection functions (configuration) with the aid of the portable user interface (PC) connected to the 216VC62a unit.

Refer to the set of specific plant diagrams for the configuration of the particular plant.

**2.5.4. Binary O/P unit 216AB61**

The 216AB61 output unit transfers signals generated by the activated protection functions to the auxiliary relays K1...K16 in the 216GA61 O/P relay unit for purposes of remote signalling.

The unit has 32 O/P channels, i.e. a single 216AB61 unit can control two 216GA61 O/P relay units (see also Section 2.4.2.).

- connector "a" (upper) : channels CHO01...CHO16
- connector "b" (lower) : channels CHO17...CHO32

If there are several 216AB61 units in a system, the O/P channels are designated within the system according to Table 2.1.

O/P channels CHO01 and CHO02 of the first 216AB61 unit in a system (at rack division 12; see Fig. 2.2) are reserved for system alarm signals.

- CHO01 : Stand-by (general alarm line SML); active during normal fault-free operation.
- CHO02 : No system defect (stand-by signal line CK); active during normal operation.

Refer to [Section 6.2.](#) for the significance of the system alarm signals.

All 32 O/P channels of the second 216AB61 unit in a system are available for the signals of active protection functions.

## Design

[Figure 12.10](#) shows the front view of the binary O/P unit, which is a plug-in unit with a width of 1 standard division (1T). The internal auxiliary supply voltage is 5 V and is derived inside the unit from the 24 V auxiliary d.c. supply. The unit's main components are:

- a bus interface
- an O/P register and O/P monitor
- O/P driver stages.

### Frontplate signals and controls (see [Fig. 12.10](#))

LED "AL" (red):

Alarm. Lights when the unit has an internal defect. See [Section 6.1.](#) for possible causes.

LED's "CH OUT" (yellow):

O/P channels. Indicate which of the activated protection or logic functions have picked up. The LED's remain lit for as long as the functions remain the picked up.

- 01...32 of the first unit corresponding to CHO01...CHO32
- 01 and 02 of the first unit light continuously during normal operation (system alarm signal).
- 01...32 of the second unit corresponding to CHO33...CHO64

Socket "PSV":

Passive. All O/P channels are blocked when the shorting pin is inserted. None of the LED's light. The statuses stored in the O/P register are not deleted.

### Settings (see Fig. 12.11)

The position of the plug-in jumper XJ1 on the PCB determines whether the unit's system alarm signals ("System defect" and "Stand-by" signals CHO01, CHO02) are operational or not. They must be in operation in the first O/P unit of a system.

- 1st 216AB61 (at rack division 12): XJ1 in position X4-X5
- 2nd 216AB61 (at rack division 13): XJ1 in position X3-X4

The signalling channels are assigned to the activated protection functions (configuration) with the aid of the portable user interface (PC) connected to the 216VC62a unit.

Refer to the set of specific plant diagrams for the configuration of the particular plant.

#### 2.5.5. *Analogue/binary O/P unit 216AC61*

O/P unit 216AC61 has 8 analogue and 16 binary O/P channels. The analogue O/P's supply impressed currents in the range 0 - 20 mA, e.g. for driving instruments. They are thus used for displaying the variables measured by protection functions or an SCS. The analogue and binary O/P channels are neither electrically insulated from each other nor from the auxiliary supply.

The binary O/P signals generated by the active protection functions (protection and control) can be transferred to the auxiliary relays K1...K16 in the O/P relay unit 216GA61 for purposes of remote signalling.

- connector "a" (upper) : binary channels CHO01...CHO16
- connector "b" (lower) : analogue channels AA001...AA008

Where a system requires several 216AB61 and/or 216AC61 units, the O/P channels are designated within the system according to [Table 2.1](#).

If the system does not include a 216AB61 unit, the binary O/P channels CHO01 and CHO02 of the first 216AC61 unit (at rack division 12; see [Fig. 2.2](#)) are used for the system alarms (the unit can thus be used instead of a 216AB61).

- CHO01 : Stand-by (general alarm line SML); active during normal fault-free operation.
- CHO02 : No system defect (stand-by signal line CK); active during normal operation.

Refer to [Section 6.2](#). for the significance of the system alarm signals.

All 16 O/P channels of the second 216AC61 unit in a system are available for the signals of active protection functions.

## Design

[Figure 12.43](#) shows the front view of the analogue/binary O/P unit, which is a plug-in unit with a width of 1 standard division (1T). The internal auxiliary supply voltages are 5 V and  $\pm 15$  V for the analogue O/P circuits and are derived inside the unit from the 24 V auxiliary d.c. supply. The unit's main components are:

- a bus interface
- an O/P register and O/P monitor for binary signals
- O/P driver stages for binary signals
- an O/P register for analogue signals
- a D/A converter
- O/P driver stages for analogue O/P currents.

### Frontplate signals and controls (see [Fig. 12.43](#))

LED "AL" (red):

Alarm. Lights when the unit has an internal defect. See [Section 6.1](#). for possible causes.

LED's "CH OUT" (yellow):

O/P channels. Indicate which of the activated protection or logic functions have picked up. The LED's remain lit for as long as the functions remain picked up.

CH OUT 01...16 of the first unit corresponding to

CHO01...CHO16

CH OUT 01 and 02 of the first unit light continuously during normal operation (system alarm signal)

CH OUT 01...16 of the second unit corresponding to

CHO17...CHO32

Socket "PSV":

Passive. All O/P channels are blocked when the shorting pin is inserted. None of the LED's light. The statuses stored in the O/P register are not deleted. None of the analogue O/P's conducts current (0 mA).

**Settings (see Fig. 12.44):**

The position of the plug-in jumper XJ1 on the PCB determines whether the unit's system alarm signals ("System defect" and "Stand-by" signals CHO01, CHO02) are operational or not. They must be in operation in the first O/P unit of a system.

- 216AB61/216AC61 (at rack division 12):  
XJ1 in position X4-X5 (active)
- Additional O/P units (from rack division 13 onwards):  
XJ1 in position X3-X4

The signalling channels are assigned to the activated protection functions (configuration) with the aid of the portable user interface (HMI) connected to the 216VC62a unit.

The analogue channels are assigned to variables measured by either an SCS or protection functions using the HMI (Function AC61). The scale of the O/P current range can be varied within  $\pm 400\%$  of its nominal range of 0...20 mA, the minimum and maximum percentages being set separately.

Example: Display of the measured value of a current function with a rated current  $I_n = 1\text{ A}$ .

Scale: Minimum = 0 %, Maximum = 200 %. The O/P of 0...20 mA corresponds to 0...2 A.

Example: Display of the measured value of a power function from -50 % to +150 %  $P_n$ .

Scale: Minimum = -50 %, Maximum = 150 %  
0 mA corresponds to  $P = -50\%$ , 5 mA corresponds to  $P = 0\%$  and 20 mA corresponds to  $P = +150\%$ .

When displaying SCS measure variables, 100 % O/P current corresponds to a value of 160. The range of values is limited to  $\pm 320$ , i.e. the practical scaling value for SCS measured variables is  $\pm 200\%$ .

**2.5.6. Binary I/P and tripping unit 216DB61**

The binary I/P and tripping unit comprises 16 I/P and 8 O/P channels. The O/P channels are used to transfer the tripping commands of activated protection functions to the 216GA62 tripping relay module (see also Section 2.6.3.). The I/P channels are used for external signals from the 216GE61 I/P relay module, which it transfers to the 216VC62a processing unit via the bus (see also Section 2.6.4.).

- connector "a" (upper) : I/P channels CHI01...CHI16
- connector "b" (lower) : channels CHO01...CHO08.

If there are several 216DB61 units in a system, the I/P and O/P channels are designated within the system according to [Table 2.1](#).

The position of the plug-in jumper BR1 on the PCB of 216DB61 determines whether the "ENABLE" and "BLOCK CH OUT" functions are operational or not, i.e. whether the tripping channels CHO01...CHO08 are enabled or disabled. The enabling and blocking functions only concern the 216DB61 unit.

BR1 in position X4: (B/E inactive, [see Fig. 5.21d](#))

The ENABLE 1/2 and BLOCK 1/2 functions are disabled. I/P channels CHI13...CHI16 function as normal external I/P's, i.e. the signals are transferred via the bus to the 216VC62a unit as in the case of channels CHI01...12.

BR1 in position X3: (B/E active)

The ENABLE 1/2 and BLOCK 1/2 functions are enabled.

The ENABLE 1 and 2 I/P's (CHI13 and CHI14) both have to be enabled (AND gate) for O/P channels CHO01...08 to be enabled.

In order to disable channels CHO01...08, a logical "1" must be applied to either the BLOCK 1 I/P or the BLOCK 2 I/P (CHI15 or CHI16; OR gate).

The tripping channels are also disabled, should a short-circuit occur in one of the tripping channel driving stages. Either channel group CHO01, 03, 05, 07 is disabled or channel group CHO02, 04, 06, 08, depending on in which group the short-circuit is.

## Design

[Figure 12.12](#) shows the front view of the binary I/P and tripping unit, which is a plug-in unit with a width of 1 standard division (1T). The internal auxiliary supply voltage is 5 V and is derived inside the unit from the 24 V auxiliary d.c. supply. The unit's main components are:

- a bus interface
- an I/P register
- an O/P register and O/P monitor
- O/P driver stages
- fault detector.



**Frontplate signals and controls (see Fig. 12.12)**

LED "AL" (red):

Alarm. Lights when the unit has an internal defect. See [Section 6.1](#) for possible causes.

LED's "CH IN" (yellow):

01...12

I/P channels. Indicate which of the I/P's CHI01...CHI12 are energised.

LED's "ENABLE" (yellow):

1/2

**BR1 in position X4:** (B/E inactive)

Light when I/P's CHI13...CHI14 are energised.

**Caution:**

**BR1 in position X3:** (B/E active)

LED's 1 and 2 must be continuously lit during normal operation. (CH OUT enabled).

LED's "BLOCK" (yellow):

1/2

**BR1 in position X4:** (B/E inactive)

Light when I/P's CHI15...CHI16 are energised.

**BR1 in position X3:** (B/E active)

LED's 1 and 2 must not light during normal operation. (CH OUT enabled)

LED's "CH OUT" (yellow):

01...08

Tripping signals. Light according to which of the channels CHO01...CHO08 are energised.

**Settings (see Fig. 12.13)**

The position of the plug-in jumper BR1 on the PCB determines whether the functions for enabling and disabling the tripping channels are in operation or not.

The tripping channels are assigned to the activated protection functions (configuration) with the aid of the portable user interface (PC) connected to the 216VC62a unit.

The earmarking of the various I/P's to be recorded as events is also performed via the HMI (binary inputs).

Refer to the set of specific plant diagrams for the configuration of the particular plant.

### 2.5.7. **Binary I/P unit 216EB61**

The I/P unit has 32 I/P channels, which are used to transfer the external signals from the I/P relay unit 216GE61 to the processing unit 216VC62a via the bus (see also Section 2.6.4.). The I/P's are neither electrical insulated from each other nor from the auxiliary supply.

- connector "a" (upper) : I/P channels CHI01...CHI16
- connector "b" (lower) : I/P channels CHI17...CHI32

Where a system requires several 216EB61 units, the I/P channels are designated within the system according to Table 2.1.

#### **Design**

Figure 12.45 shows the front view of the binary I/P unit, which is a plug-in unit with a width of 1 standard division (1T). The internal auxiliary supply voltage of 5 V is derived inside the unit from the 24 V auxiliary d.c. supply. The unit's main components are:

- a bus interface (64 kByte DPM/RAM)
- an I/P register
- a microprocessor for pre-processing signals (80C188)
- a program memory (128 kByte EPROM)
- a main memory (64 kByte RAM).

#### **Frontplate signals and controls (see Fig. 12.45)**

LED "AL" (red):

Alarm. Lights when the unit has an internal defect. See Section 6.1. for possible causes.

LED "MST" (yellow):

Lights (usually only briefly or weakly) when the unit communicates with the bus and exchanges data.

LED's "L1-L4" (yellow):

System status, error messages: None of these LED's should light apart from briefly after the unit is initialised.

LED's "BINARY CH IN" (yellow):

I/P channels. Indicate which of the I/P's CHI01...CHI32 are energised.

The I/P channels are assigned to the activated protection functions with the aid of the portable user interface (HMI) connected to the 216VC62a unit.

The exclusion of individual I/P's from the event recording function and the definition of the filter time are also performed using the HMI (Edit/List edit parameters/List binary input channels).

## **2.6. I/P and O/P units for the cubicle version**

### **2.6.1. Input transformer unit 216GW61**

The input transformer unit contains 12 input c.t.'s and v.t.'s for connecting directly to the primary system c.t.'s and v.t.'s (see also [Fig. 2.1](#)).

[Figure 12.14](#) shows the design of the 216GW61 module. Either c.t.'s or v.t.'s can be fitted at positions W1...W12. The types and ratings of the c.t.'s and v.t.'s in a 216GW61 module are chosen to suit the requirements of the specific plant.

The c.t.'s and v.t.'s transform the secondary currents and voltages coming from the primary system c.t.'s and v.t.'s to proportional voltage signals in a range of -40 V...+40 V. These signals are conducted to the 216EA61 analogue I/P unit by a standard system cable (see also [Section 2.5.3](#)). The individual instrument transformer positions W1...W12 correspond to the I/P's CH01...CH12 on the 216EA61 unit, resp. CH13...CH24, CH25...CH36 or CH37...CH48, where a system includes several 216GW61 units (see [Table 2.1](#)).

Refer to the set of specific plant diagrams for the instrument transformers actually fitted in a 216GW61 module and the connections between the module and the primary system.

Refer to the corresponding data sheet for the technical data of the transformers (see [Section 1.2](#) for the data sheet No.).

[Table 12.1](#) lists the wiring (secondary circuit) of the 216GW61 module and the assignment of the instrument transformer channels (analogue I/P's) to the one or more 216EA61 units.

#### **Settings**

The 216GW61 unit does not have any settings.

### **2.6.2. O/P relay unit 216GA61**

The 216GA61 has 16 auxiliary relays K1...K16 with potentially-free contacts for remote signalling. [Figure 12.15](#) shows the design of the unit.

The auxiliary signalling relays K1...K16 are controlled by the 216AB61 binary O/P unit and obtain their auxiliary supply from the auxiliary d.c. voltage UP. [Fig. 2.12](#) shows the basic control circuit for the signalling relays in the 216GA61 unit. How the contacts are wired varies from plant to plant. The different ways of wiring the contacts of the relays K1...K16 can be seen from [Table 12.2](#).

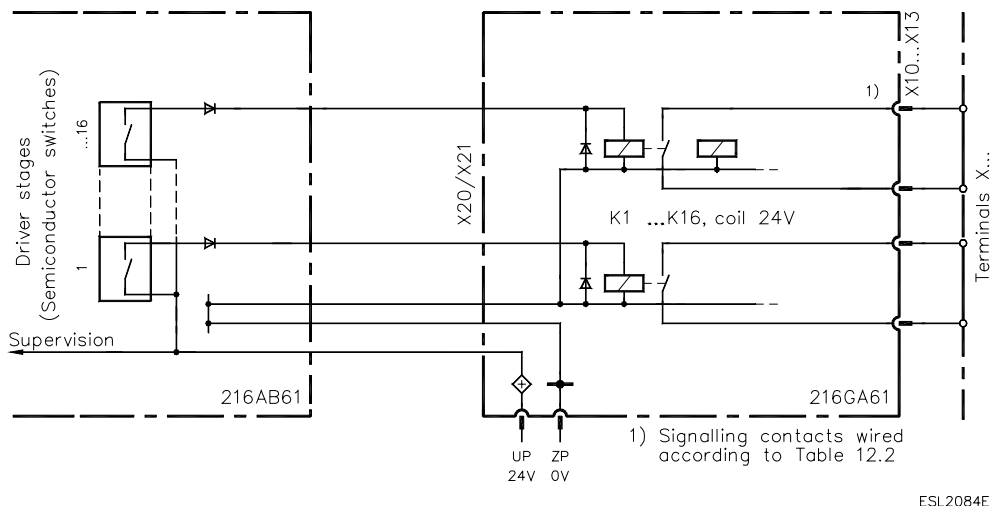


Fig. 2.12 Basic control circuit for the auxiliary signalling relays K1...K16

The relationship between the signalling relays K1...K16 and the numbering of the O/P channels is:

- 1st. 216GA61 unit, K1...K16 correspond to CHO01...CHO16
- 2nd. 216GA61 unit, K1...K16 correspond to CHO17...CHO32
- 3rd. 216GA61 unit, K1...K16 correspond to CHO33...CHO48
- 4th. 216GA61 unit, K1...K16 correspond to CHO49...CHO64.

Refer also to [Section 2.5.4.](#) and [Table 2.1.](#)

Refer to the set of specific plant diagrams for the signalling contacts and the assignment of the signalling channels for the particular plant.

### Settings:

The 216GA61 unit does not have any settings.

### 2.6.3. *Tripping relay unit 216GA62*

The 216GA62 has 8 auxiliary relays K1...K8 with potentially-free contacts for tripping signals. [Figure 12.16](#) shows the design of the unit.

The auxiliary tripping relays K1...K8 are controlled by the 216DB61 binary I/P and tripping unit. Fig. 2.13 shows the basic control circuit for the tripping relays.

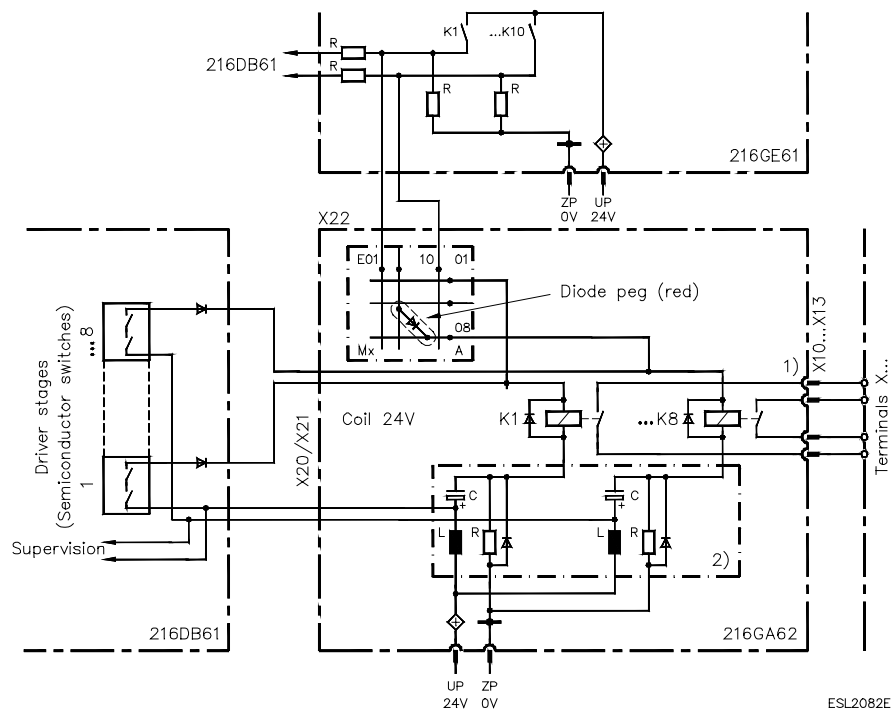


Fig. 2.13 Basic control circuit for the auxiliary tripping relays K1...K8

- K1...K8 : tripping relays; rated coil voltage 12 V DC
- 1) : wiring of the tripping contacts according to Table 12.3
- 2) : surge circuit for accelerating K1...K8
- Mx : diode matrix tripping logic for direct tripping (O/P's A09, A10 not used)

How the tripping relay contacts are wired varies from plant to plant. The different ways of wiring the contacts of the relays K1...K8 can be seen from [Table 12.3](#).

The relationship between the tripping relays and the numbering of the tripping channels is:

1st. 216GA62 unit, K1...K8	correspond to CHO01...CHO08
2nd. 216GA62 unit, K1...K8	correspond to CHO09...CHO16
3rd. 216GA62 unit, K1...K8	correspond to CHO17...CHO24
4th. 216GA62 unit, K1...K8	correspond to CHO25...CHO32

Refer also to [Section 2.5.5.](#) and [Table 2.1.](#)

### Direct tripping

In addition to being controlled by 216DB61, the diode matrix tripping logic on 216GA62 also permits tripping relays K1...K8 to be directly controlled by the external input signals from the 216GE61 unit (see [Fig. 2.13](#) and [Section 2.6.4.](#)).

The first 10 channels (K1...K10) of the 216GE61 input relay assembly are wired to the diode matrix tripping logic to facilitate direct tripping.

Direct tripping is enabled by inserting diode pegs in the desired channels.

Refer to the set of specific plant diagrams for execution, alternative wiring of the tripping contacts, assignment of the tripping channels and arrangement of the diode pegs.

### Settings:

- Insert the diode pegs to achieve the desired tripping logic.
- There are no other settings on the 216GA62 unit.

### Checks

- Check that the correct auxiliary tripping relays with a rated coil voltage of 12 V DC are inserted in positions K1...K8.

#### **2.6.4. I/P relay unit 216GE61**

The 216GE61 has 16 auxiliary relays K1...K16 with potentially-free contacts, for example, for incoming external:

- logic signals
- blocking signals
- tripping signals from other devices for distribution to the HV circuit-breakers by the RE. 216's matrix tripping logic.

[Figure 12.17](#) shows the design of the unit.

The auxiliary relays K1...K16 are energised by the external auxiliary supply. The signals are then relayed to the binary I/P and tripping unit 216DB61 or 216EB61 by contacts, which are isolated from the coil circuits and obtain their auxiliary supply from the auxiliary d.c. voltage UP. Fig. 2.14 shows the basic circuit of the 216GE61 unit.

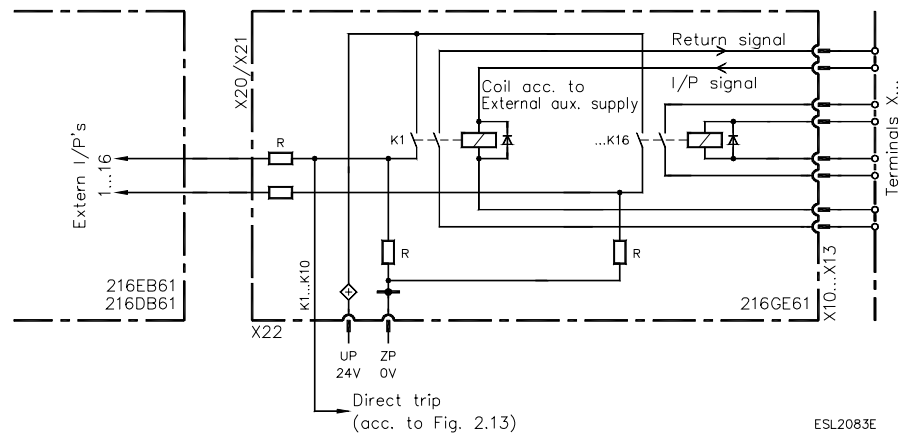


Fig. 2.14 Basic control circuit for the external signal I/P relays K1...K16

K1...K16 : auxiliary I/P relays; rated coil voltage = external auxiliary supply

The auxiliary relay channels K1...K10 are also connected to the matrix tripping logic to enable them to directly energise tripping relays.

A second contact on each of the relays K1...K16 is wired to terminals to remotely signal that the corresponding channel is energised.

The relationship between the auxiliary relays and the numbering of the I/P channels is:

- 1st. 216GE62 unit, K1...K16 correspond to CHI01...CHI16
- 2nd. 216GE62 unit, K1...K16 correspond to CHI17...CHI32
- 3rd. 216GE62 unit, K1...K16 correspond to CHI33...CHI48
- 4th. 216GE62 unit, K1...K16 correspond to CHI49...CHI64

Refer also to [Section 2.5.5.](#) and [Table 2.1.](#)

### Settings:

There are no settings on the 216GE61 unit.



**Checks:**

Check that the auxiliary relays fitted for K1...K16 have the correct rated coil voltage (= external auxiliary supply voltage).

## 2.7. I/P and O/P units for the compact version

### 2.7.1. Input transformer unit 216GW62

The input transformer unit Type 216GW62 corresponds to the 216GW61 unit described in [Section 2.6.1.](#); the only difference is that it complies with DIN Protection Class IP 30. [Figures 12.23 to 12.35](#) shows the c.t.'s and v.t.'s fitted and the terminal connections for the alternative versions available. In the case of the typical version K1 ([Fig. 12.23](#)), 6 protection c.t.'s enable the currents at the generator terminals to be measured and differential protection for the generator becomes possible. One metering c.t. measures the current more accurately, for example, for the reverse power function. Two v.t.'s are used to detect stator and rotor E/F's and three v.t.'s measure the voltage at the generator terminals.

### 2.7.2. Auxiliary relay and opto-coupler unit 216GD61

The 216GD61 unit combines various binary I/P's and O/P's:

- 16 opto-coupler I/P's:  
for controlling the tripping unit 216DB61.  
Channel 1 is designed for an I/P voltage of 24 V DC and channels 2 to 16 for the voltage range of 82...312 V DC (see [Figures 12.36](#)). Channel 1 is intended as a reset I/P and is activated by the optional reset button (see [Figures 12.22 and 12.40](#)). All the I/P's can be adapted for other voltages in the range 20 V DC to 312 V DC by fitting a series resistor with the corresponding value:

Resistance		Permissible voltage range	Remarks
R <sub>A</sub>	R <sub>B</sub>		
4k7	1k0	20... 30 V	standard for channel 1
27k	2k7	36... 75 V	
82k	15k	82...312 V	standard for channels 2...16

Channel	R <sub>A</sub>	R <sub>B</sub>	Channel	R <sub>A</sub>	R <sub>B</sub>
1	R133	R117	9	R141	R125
2	R134	R118	10	R142	R126
3	R135	R119	11	R143	R127
4	R136	R120	12	R144	R128
5	R137	R121	13	R145	R129
6	R138	R122	14	R146	R130
7	R139	R123	15	R147	R131
8	R140	R124	16	R148	R132

- 6 tripping relays:  
controlled by the tripping unit 216DB61. In each case, one circuit is connected to terminals, which is made by two contacts in series.
- 14 signalling relays:  
controlled by the binary O/P unit 216AB61. The N/O contact of all the relays and the N/C contact of relays 1..4 are connected to terminals.

The unit is supplied at 24 V DC and provision is made for redundant supplies. A fuse F101 (2 A fast, 5 x 20 mm) is fitted to protect the 24 V supply against short-circuits on the unit. The location of the 216GD61 unit and its wiring diagram can be seen from [Fig. 12.38](#).

### 2.7.3. **Relays- and Opto-coupler module 216GD61a**

The 216GD61 unit combines various binary in- and outputs:

- 16 opto-coupler inputs:  
for controlling the tripping unit 216DB61.  
Contrary to the unit 216GD61, the unit 216GD61a all channels 1 to 16 are designed for the voltage range 82...312 V DC (see [Fig. 12.37](#)). Channel 1 is intended as a reset I/P and is activated by the optional reset button (see [Figures 12.22 and 12.40](#)). All the I/P's can be adapted for other voltages in the range 20 V DC to 312 V DC by fitting a series resistor with the corresponding value:

Resistance		Permissible voltage range	Remarks
R <sub>A</sub>	R <sub>B</sub>		
4k7	1k0	20... 30 V	standard for channels 1...16
27k	2k7	36... 75 V	
82k	15k	82...312 V	
220k	15k	165...312 V	

Channel	R <sub>A</sub>	R <sub>B</sub>	Channel	R <sub>A</sub>	R <sub>B</sub>
1	R402	R403	9	R602	R603
2	R412	R413	10	R612	R613
3	R422	R423	11	R622	R623
4	R432	R433	12	R632	R633
5	R502	R503	13	R702	R703
6	R512	R513	14	R712	R713
7	R522	R523	15	R722	R723
8	R532	R533	16	R732	R733

- 8 tripping relays:  
controlled by the tripping unit 216DB61. In each case, one circuit is connected to terminals, which is made by two contacts in series.
- 16 signalling relays:  
controlled by the binary O/P unit 216AB61. The N/O contact of all the relays and the N/C contact of relays 1...4 are connected to terminals.

The unit is supplied at 24 V DC and provision is made for redundant supplies. The location of the 216GD61 unit and its wiring diagram can be seen from [Fig. 12.38](#).

## 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. 2.21).

The injection unit is installed in an REG 316 casing and therefore the mechanical and general data are the same as specified for the REG 316. 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. In position X12 the frequency is then 12.5 Hz and in position X11 15.0 Hz.

### **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 is enabled.  
Position 1 : Injection is disabled.

- reset button RESET:  
This resets the protection circuit, which latches when it operates, and the red LED extinguishes.  
  
The protection circuit guards against excessive feedback from the generator and interrupts the injection for zero-crossing currents  $\geq 5$  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' and resumes when it is returned to logical '0'.

### **Important:**

**Ensure that the injection voltage is switched off before carrying out any work on 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.

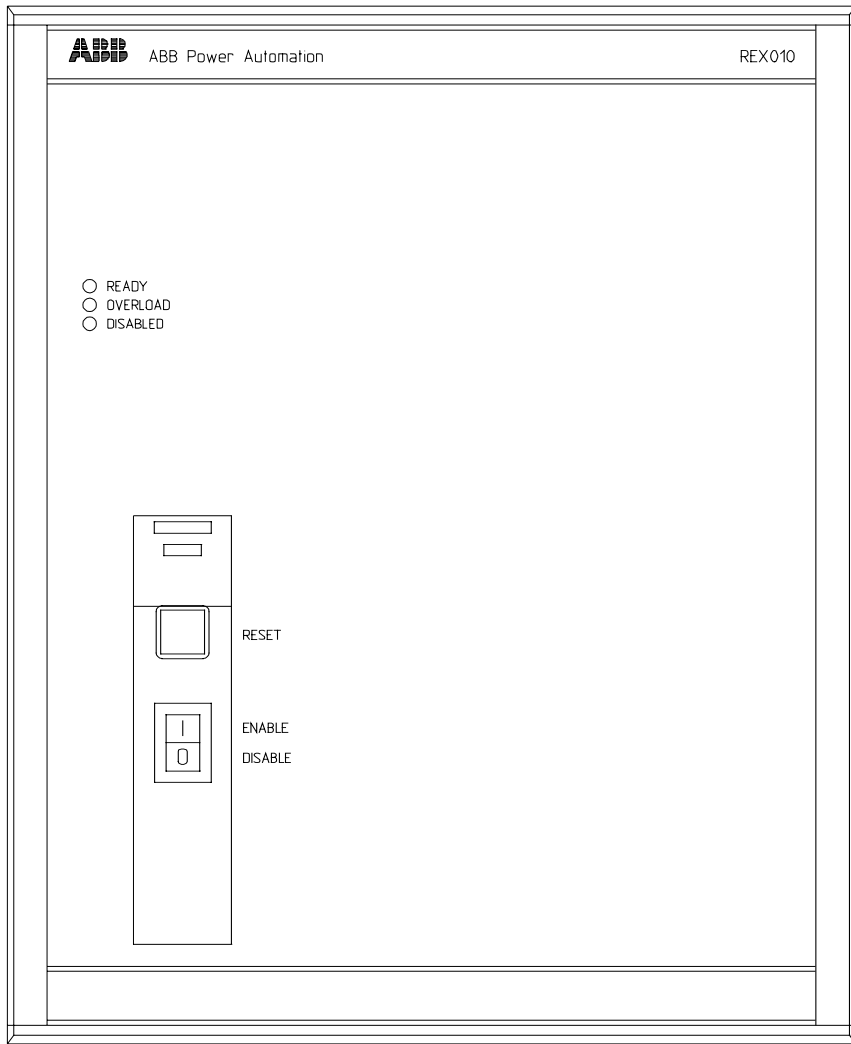
There are no controls inside the unit which have to be set by the user.

### **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 m.c.b. is located at the rear next to the auxiliary supply terminals.

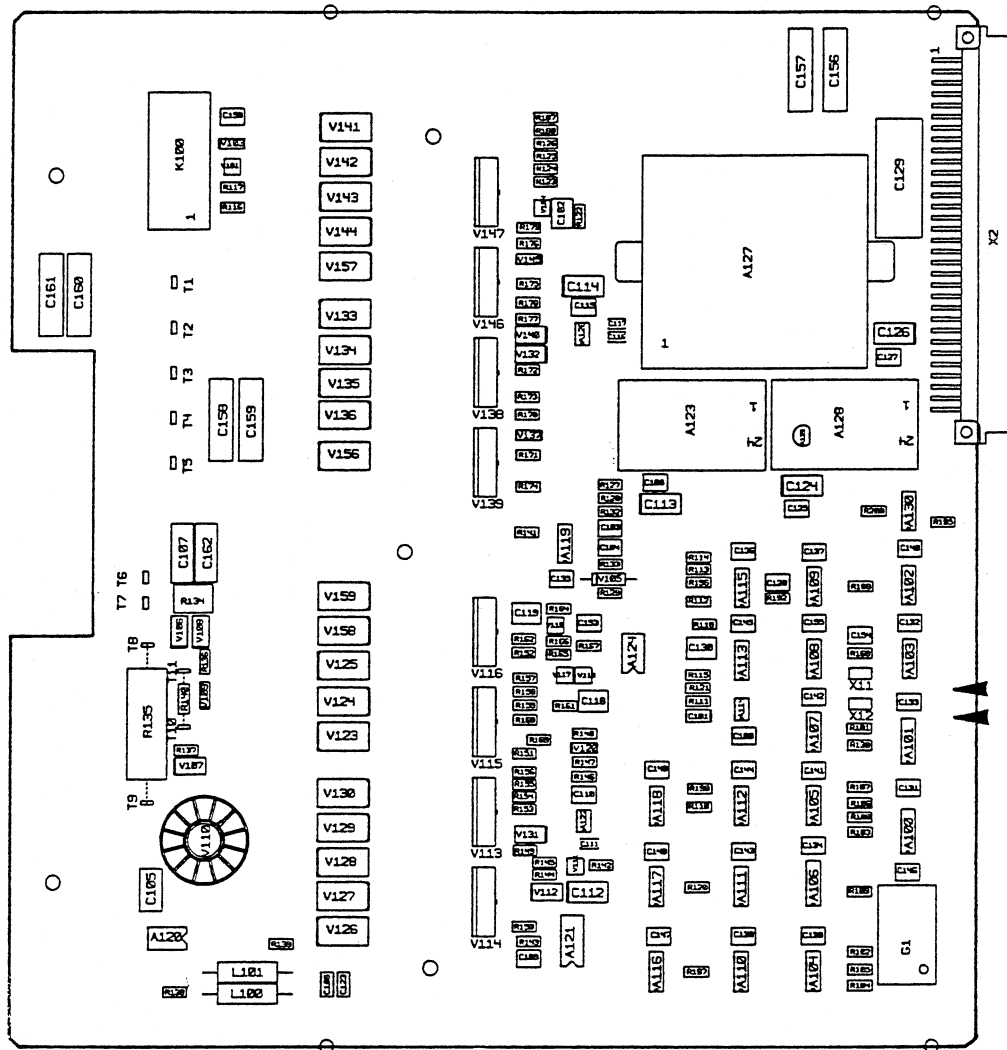
Fuse type:                   cartridge 5 x 20 mm  
  1.25 A slow

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



EG057X

Fig. 2.15 Injection unit REX 010 (front view)



985039 TIF

Fig. 2.16 PCB 316A161 in the injection unit  
(derived from HESG 324 366)  
Position X11, Position 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 <sub>is</sub> :	stator injection voltage
U <sub>ir</sub> :	rotor injection voltage
U <sub>i</sub> :	reference voltage.

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

The rated values of the injection voltages U<sub>is</sub>, U<sub>ir</sub> and U<sub>i</sub> apply for the version REX 010 U1 and a station battery voltage of U<sub>Bat</sub> = 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:

<b>U<sub>is</sub></b>	110 V
<b>U<sub>ir</sub></b>	50 V *)
<b>U<sub>i</sub></b>	25 V

Table 2.5 REX 011

---

\*) The winding for voltage U<sub>ir</sub> has a tapping at 30 V. This enables U<sub>ir</sub> 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**

These injection transformers bear the following identifications (see also Table 2.6 and Table 2.7):

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

The injection transformers used for secondary injection of the stator circuit have four injection voltage windings which are 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

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

Table 2.6 REX 011-1

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

Table 2.7 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.

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

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

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

Should the version supplied not be the correct one, the connections from the windings to the terminals must be changed as shown in the following diagrams.

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

Shorting links and 3 rating plates are enclosed with every transformer. After modification the appropriate rating plate should be stuck over the old one.

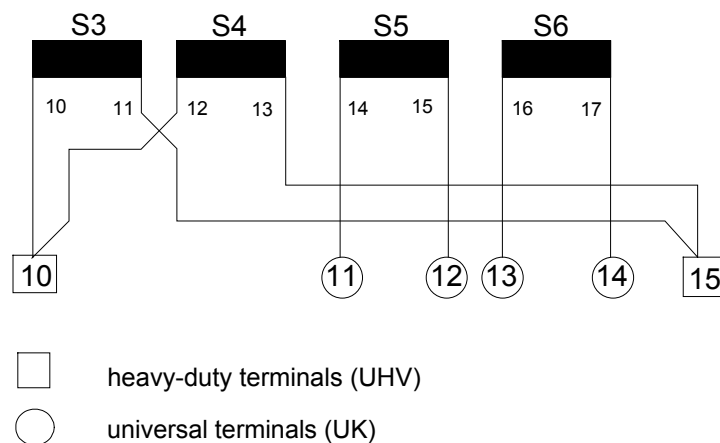


Fig. 2.17 Versions M11, M21

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. There are no KB-15 shorting links.

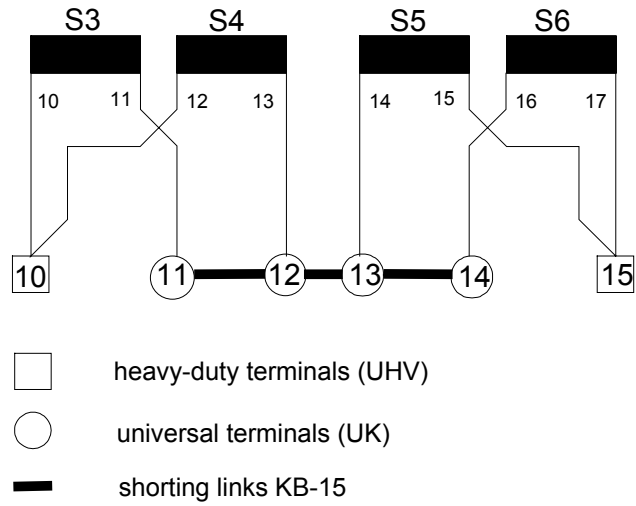


Fig. 2.18 Versions M12, M22

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.

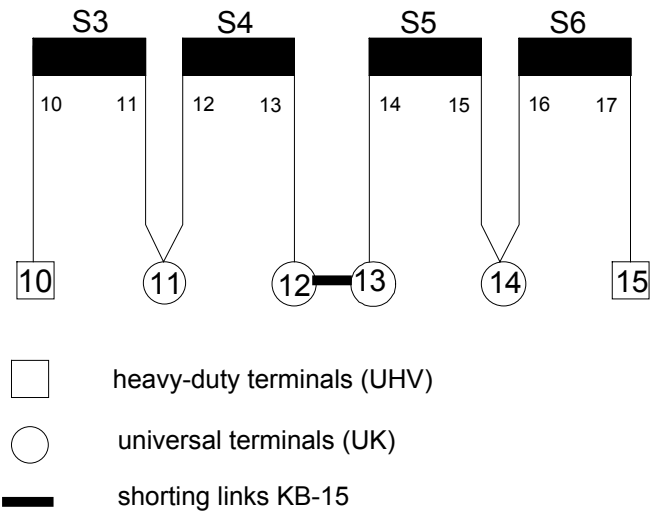
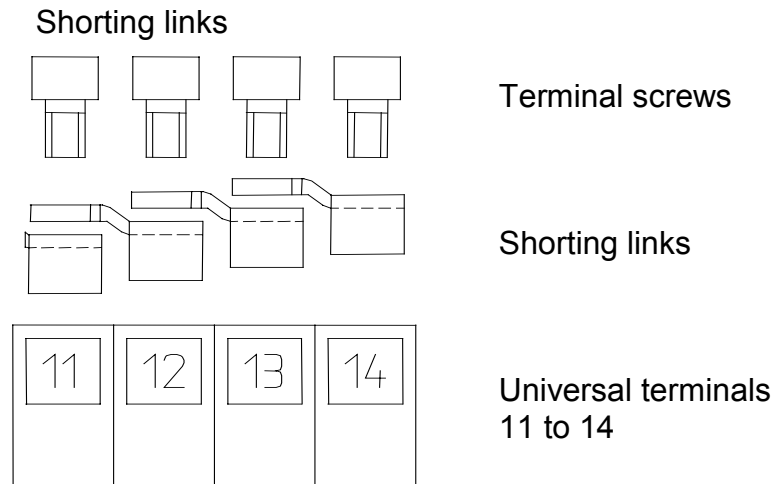


Fig. 2.19 Versions M13, M23

In the case of versions M13 (REX 011-1) and M23 (REX 011-2), all the windings S3...S6 are connected in series. Terminals 12 and 13 are bridged by a Type KB-15 shorting link.

The diagram below shows the shorting links used for versions M12 and M22:



ET9053

Fig. 2.20 shorting links used for versions M12 and M22

4 terminal screws, 3 shorting links and 1 dummy link are enclosed with every transformer.

The shorting links are inserted into the recesses provided on the universal terminal block.

#### **Versions M12 and M22:**

The dummy link is fitted first with the opening downwards into terminal 11 and then the 3 complete shorting links one after the other. Each one must be secured using the screws provided.

#### **Versions M13 and M23:**

The dummy link is fitted first with the opening downwards into terminal 12 and then the second complete shorting link. Both must be secured using the screws provided.

**2.9.3.****Figures**

- Fig. 2.21 Injection signal  
Fig. 2.22 Wiring diagram for REX 011 for primary injection of the stator  
Fig. 2.23 Wiring diagram for REX 011-1 for secondary injection of the stator at the star-point  
Fig. 2.24 Wiring diagram for REX 011-2 for secondary injection of the stator at the terminals  
Fig. 2.25 Wiring diagram for REX 011 for rotor ground fault protection  
Fig. 2.26 Wiring diagram for REX 011-1, -2 for rotor ground fault protection  
Fig. 2.27 Wiring diagram for REX 011 for testing without the generator  
Fig. 2.28 Wiring diagram for REX 011-1, -2 for testing without the generator  
Fig. 2.29 Dimensioned drawing of the injection transformer block Type REX 011

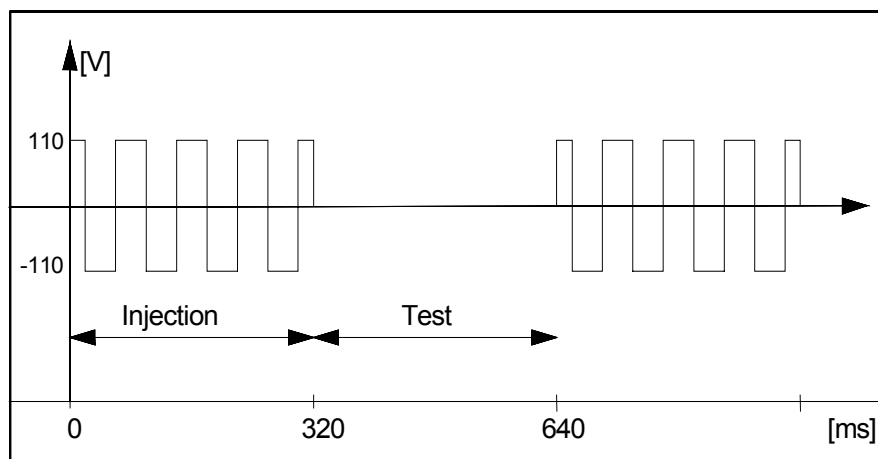


Fig. 2.21 Injection signal  $U_{is}$

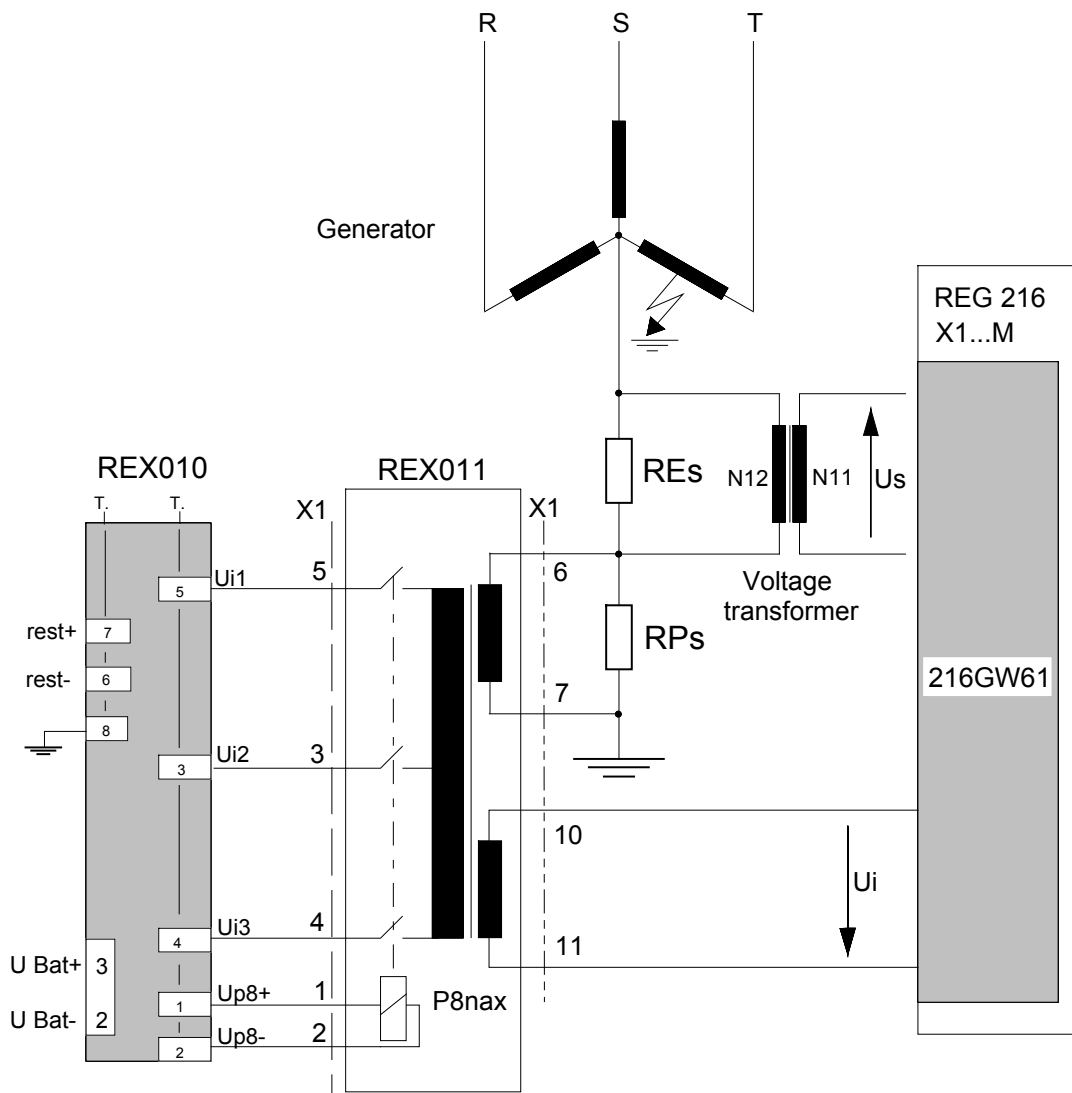


Fig. 2.22 Wiring diagram for REX 011 for primary injection of the stator (see also Fig. 2.29)

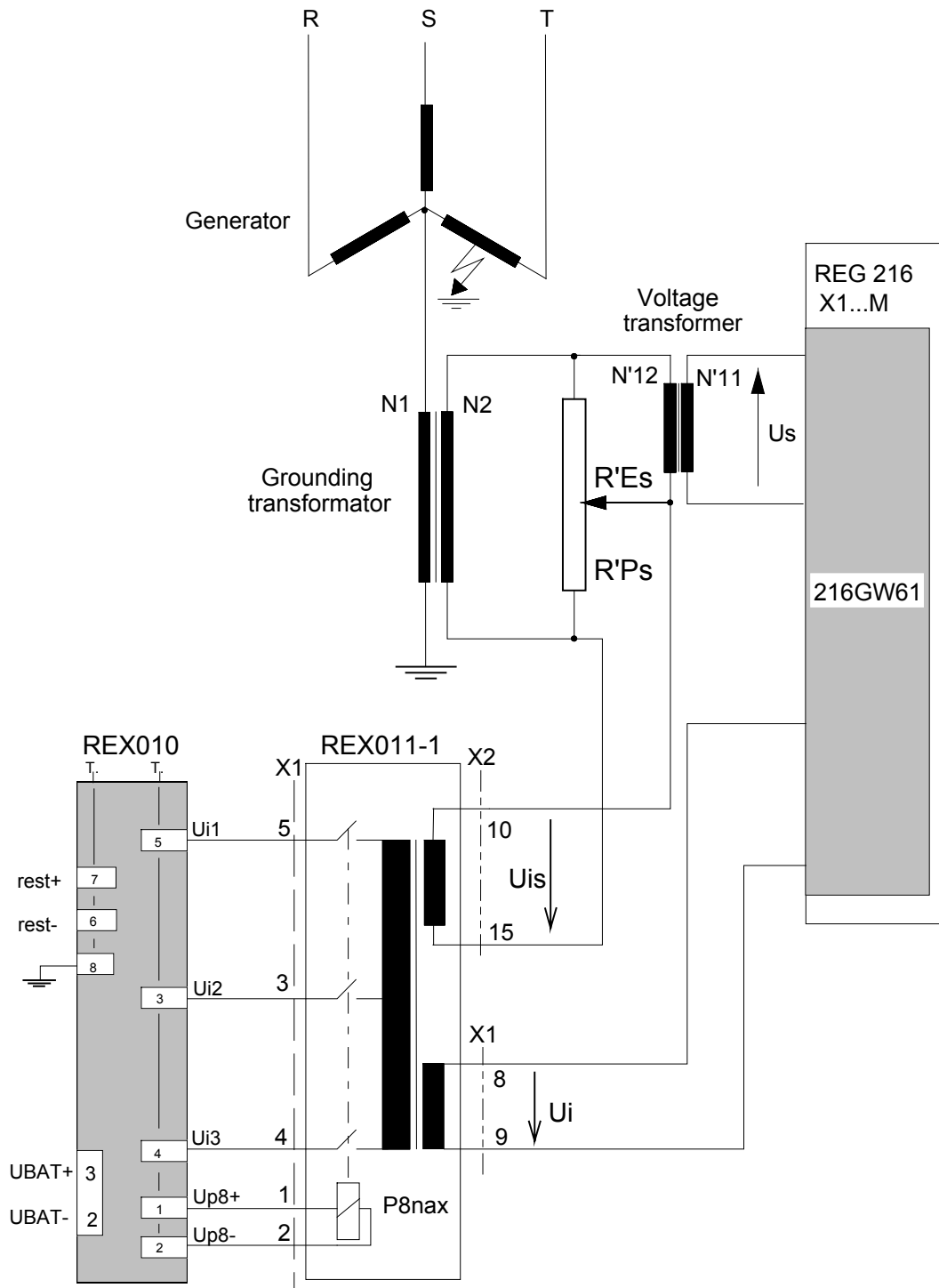


Fig. 2.23 Wiring diagram for REX 011-1 for secondary injection of the stator at the star-point (see also Fig. 2.29)



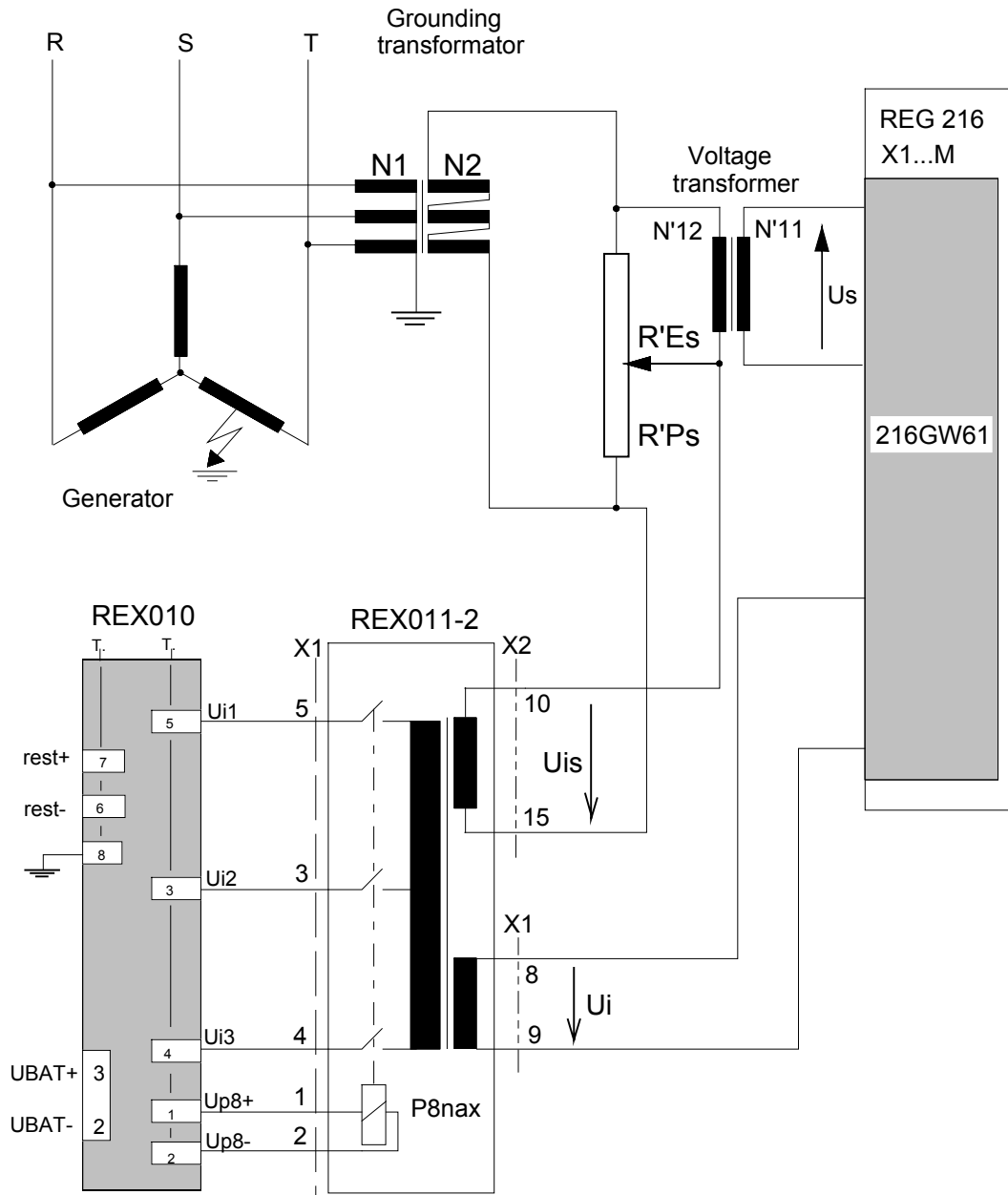


Fig. 2.24 Wiring diagram for REX 011-2 for secondary injection of the stator at the terminals (see also Fig. 2.29)

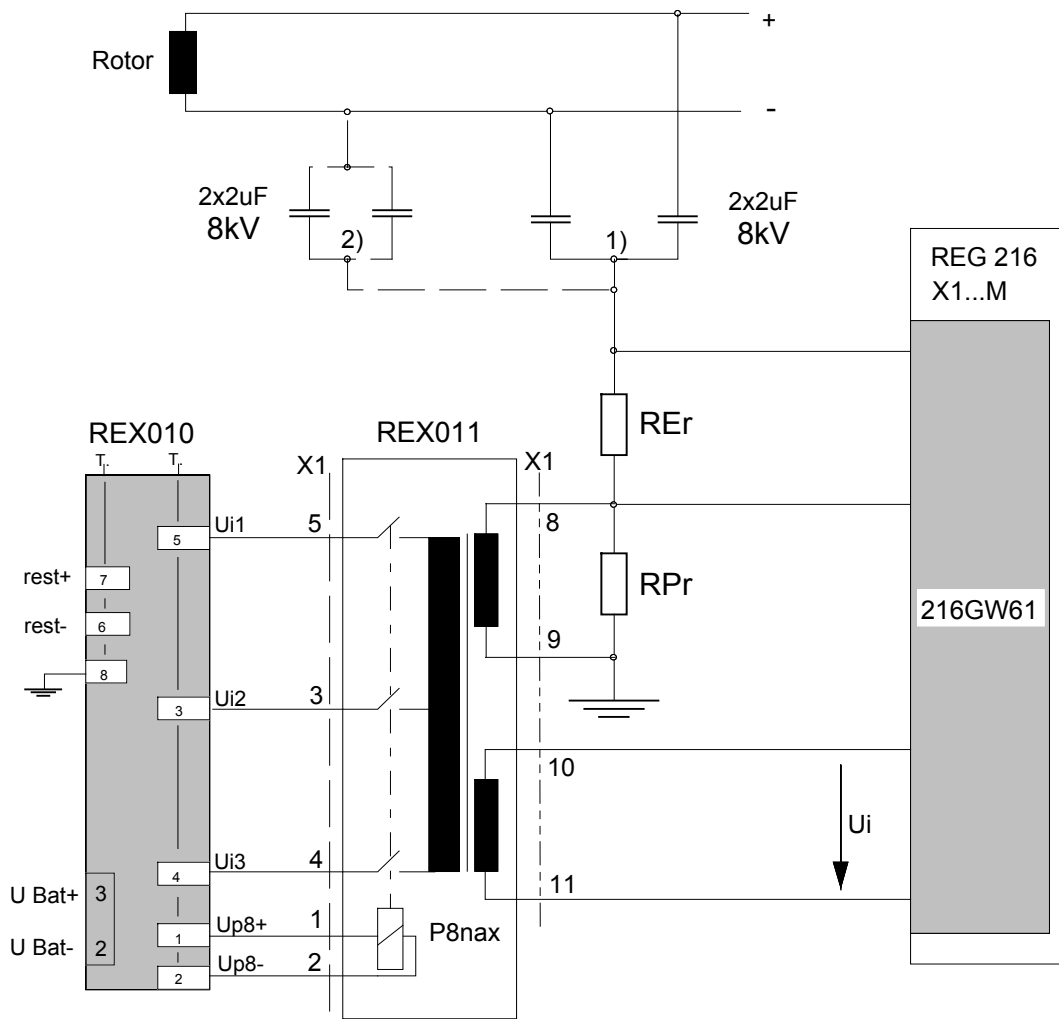


Fig. 2.25 Wiring diagram for REX 011 for rotor ground fault protection (see also Fig. 2.29)

- 1) Injection on both poles
- 2) Injection on one pole for brushless excitation

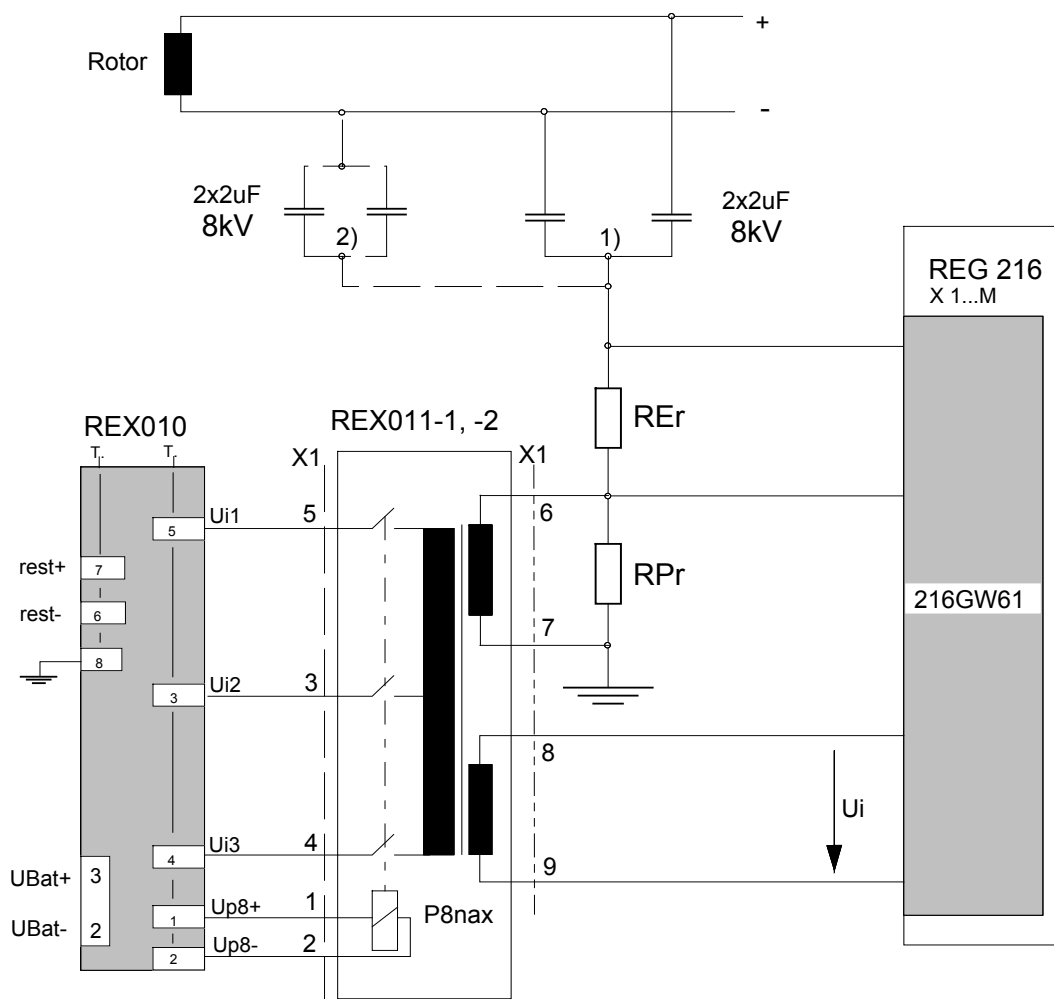


Fig. 2.26 Wiring diagram for REX 011-1, -2 for rotor ground fault protection (see also Fig. 2.29)

- 
- 1) Injection on both poles
  - 2) Injection on one pole for brushless excitation
-

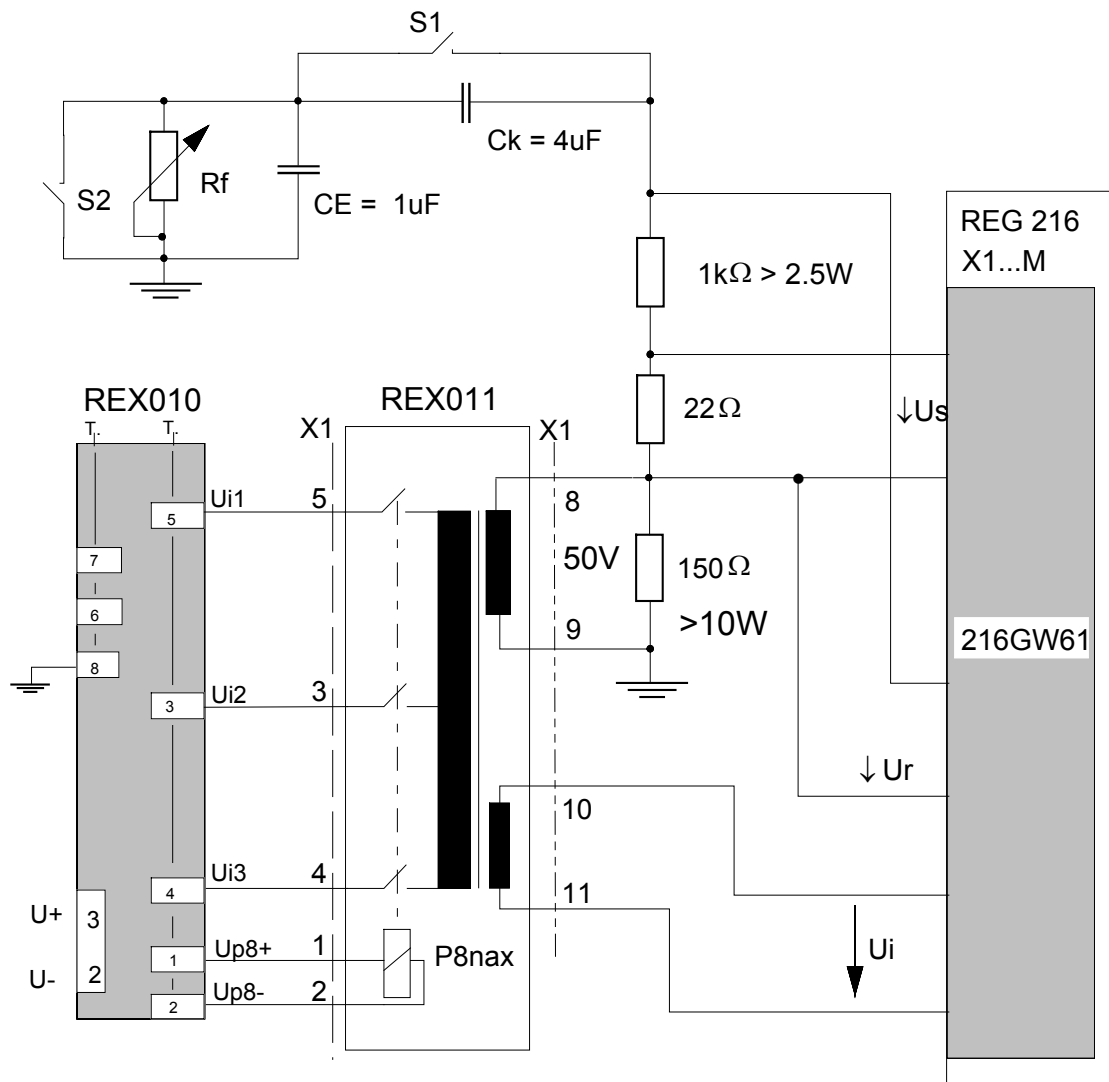


Fig. 2.27 Wiring diagram for REX 011 for testing without the generator

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

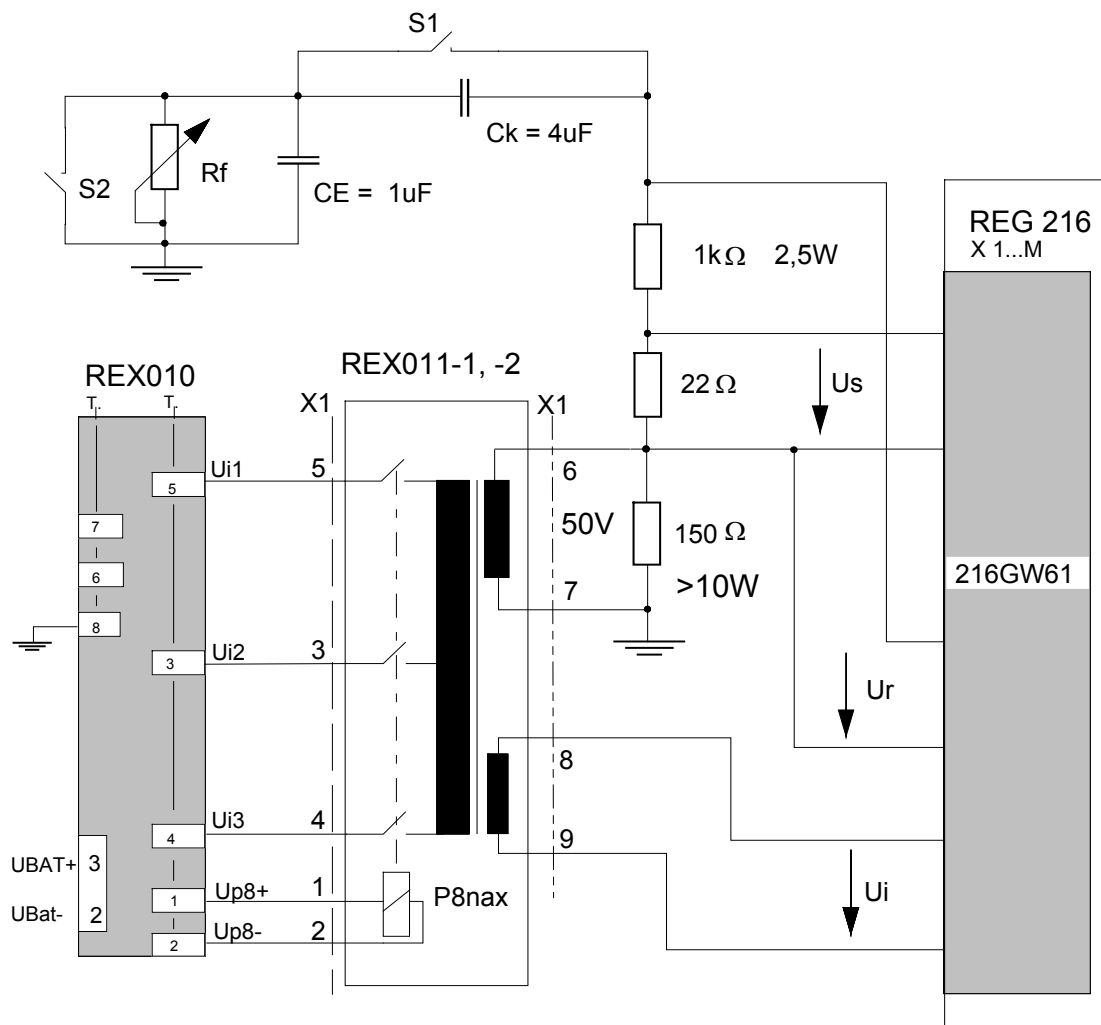


Fig. 2.28 Wiring diagram for REX 011-1, -2 for testing without the generator

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

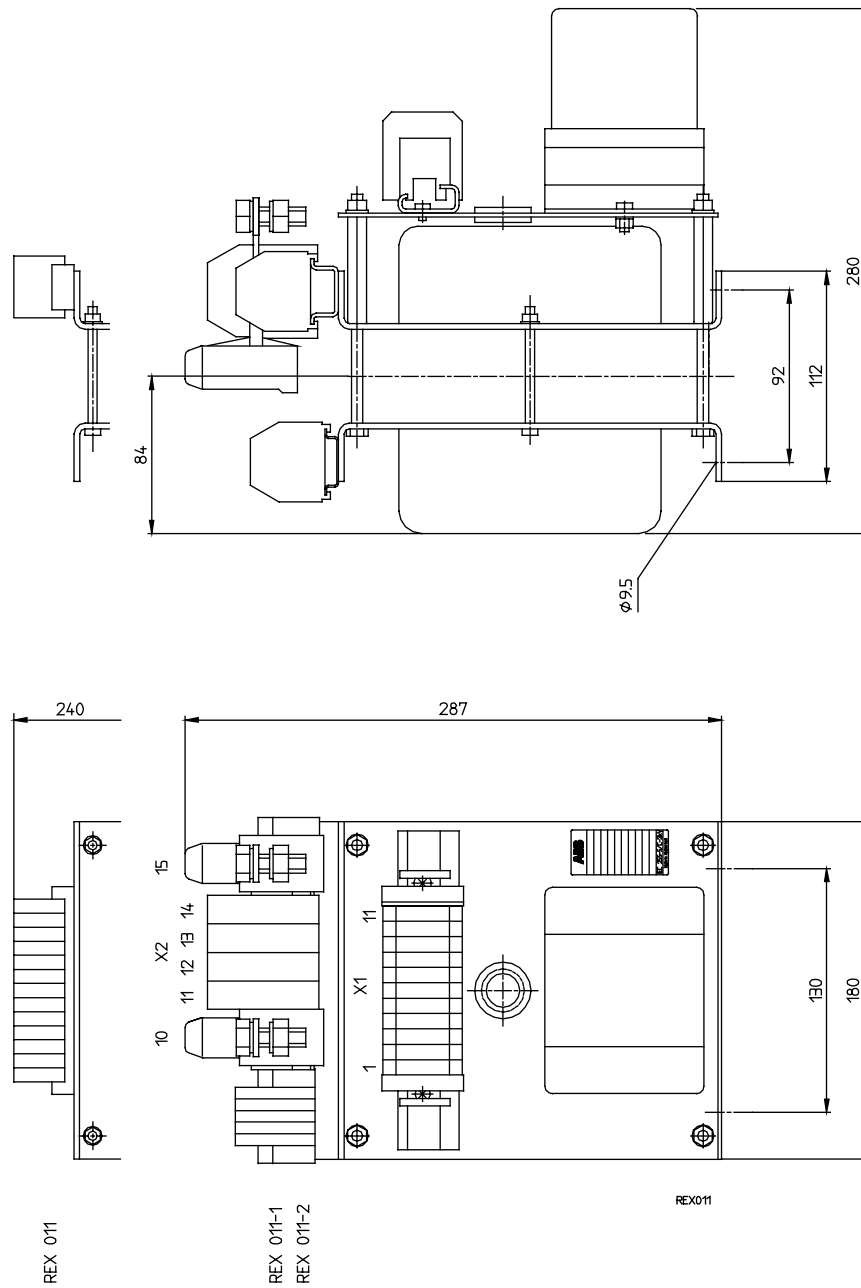


Fig. 2.29 Dimensioned drawing of the injection transformer block Type REX 011 (HESG 324 388)

## 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 and rotor ground fault protection functions without them being connected to the protected unit, set up the test circuit shown in (Fig. 2.27 or Fig. 2.28). 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 (see Fig. 2.21).

The ground fault resistance is simulated by the variable resistor R<sub>f</sub>.

### **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 MTR and REs:

The theoretical value of MTR is determined as follows:

$$\text{MTR} = \frac{22 \, \Omega + 1000 \, \Omega}{22 \, \Omega} \times \frac{110 \, \text{V}}{50 \, \text{V}} = 102.2$$

The value of MTR is increased by a factor 110 V/50 V, because of the low injection voltage of 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 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.



March 2001

### 3. SETTING THE FUNCTIONS

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### **3. SETTING THE FUNCTIONS**

#### **3.1. General**

##### **3.1.1. Library and settings**

RE. 216 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 programming is required.

The number of protection functions active in a RE. 216 system is limited by the available computing capacity of the 216VE61 processing units, the max. possible number of active protection functions is 48.

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

The settings determine which functions are active. This procedure enables the many demands with respect to different protection scheme configurations to be satisfied:

- Only functions which are actually needed should be activated. Every active function entails a computing effort as given in Table 3.3.
- Many of the functions can be used for multiple purposes, e.g.:
  - to achieve several stages of operation (with the same or different settings and time delays)
  - for use with different input channels
- Functions can be logically interconnected, for example, for interlocking purposes.

##### **3.1.2. Protection function sequence**

###### **3.1.2.1. Repetition rate**

The protection system software controls the operating sequence of the protection functions completely independently. The functions are divided into routines, which are processed in sequence by the computer. The frequency at which the processing cycle takes place (repetition rate) is determined according to the technical requirements of the scheme.

For many functions, this will depend essentially on the tripping delay. From this follows that the faster tripping should take place, the higher will be the repetition rate. Typical relationships between tripping delay and repetition rate can be seen from Table 3.1.

Repetition rate	Explanation	Delay time
4	$\geq 4$ times every 20 ms <sup>1)</sup>	< 40 ms
2	$\geq 2$ times every 20 ms	40 ... 199 ms
1	$\geq 1$ times every 20 ms	$\geq 200$ ms

<sup>1)</sup> 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 function, do not depend on their settings.

Also protection functions, which are basically only a logic, are independent of settings.

The scanning of the binary inputs and the setting of the signaling and tripping outputs takes place at the sampling rate of the c.t./v.t. 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 signals
- tripping signals

are subject to some variation. This variation is determined by the repetition rate controlling the operation of the function (see Table 3.1). 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 factors:

- 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 use certain intermediate results (measured values) determined by a protection function several times. In consequence, additional stages of the same protection function with 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 RE. 216 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 used 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. The computation requirement for the second and further stages is only reduced, providing all the stages are processed by the same processor.

The computing capacity required can be viewed by selecting 'Diagnosis' from the 'List programs' menu. It is displayed for each processor and for the four sets of settings in per thousand. Relevant for the computing capacity is the highest value in the four sets of settings.

Function	1st		2nd. and higher stages		t factor (**)		
	1ph	stage	3ph	1ph	3ph	<40ms	<200ms
Diff-Gen			40	ditto			
Diff-Transf			100	ditto			
Current-DT	2		3	1		4	2
with inrush blocking		5		5		4	2
DirCurrentDT		19		ditto		4	2
DirCurrentInv		21		ditto			
Current-Inst	3		4	2		4	2
I <sub>max</sub> /U <sub>min</sub>	5		8	2		4	2
Current-Inv	4		7	3			
NPS-DT	-		6	1			
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			
NPS-Inv	-		8	3			
Frequency	15		-	3			2
df/dt	50		-	5			
Overexcitat	15		-	ditto			2
U/f-Inv	25,5		-	ditto			
Overtemp	12		15	ditto			
Stator-EFP		40		ditto			
Rotor-EFP		40		ditto			
Pole-Slip		20		ditto			
SynchroCheck		16		ditto			
Delay		8		ditto			
Counter		8		ditto			
Logic		4		ditto			
Defluttering		4		ditto			
FUPLA		1/ 2/ 4	(***)	(*)			
BreakerFailure	34		46	ditto			
UifPQ		5		ditto			
Check-I3ph	-	5		ditto			2
Check-U3ph	-	5		ditto			2
Distur. rec.							
Without bin I/P		20					
With bin I/P		40					



Function	1st stage		2nd. and higher stages		t factor (**)	
	1ph	3ph	1ph	3ph	<40ms	<200ms
Distance		50				
Z<start		20				
Meas Bward		5				
VTSup NPS		3				
Power swing		15				
HV distance		70				
Meas Bward		5				
VTSup NPS		3				
Power swing		15				
EarthFaultIsol		5		ditto	4	2
Autoreclosure		1		ditto		
EarthFitGnd2		10		ditto	4	2
IO-Invers		4		3		
Analog RIO Trig		2			4	2
MeasureModule						
Voltage/CurrentInp		10		ditto		
Cnt		8		ditto		

(\*) can only be set once (\*\*\*) always 1 for delays  $\geq 200$  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 for 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	Phases	Settings Pick-up	Time	Percentage incl. factor
1	current	1 (,2,3)	three	10.0 $I_N$	30 ms	3% x 4
2	current	1 (,2,3)	three	2.5 $I_N$	100 ms	1% x 2
3	current	4	single	3.5 $I_N$	300 ms	2% x 1
4	voltage	7	single	2.0 $U_N$	50 ms	2% x 2
Total						20 %

**Table 3.4** Example for calculating the computation requirement

### 3.1.2.3. Computing requirement of the control functions

It is not possible to state the computing requirement of the control functions directly in percent of the total computing capacity. Apart from the size of the code, the type of control logic also determines the computing requirement.

The protection and control function load on the main processor must be checked after loading the program by selecting 'Display AD channels' from the 'Measurement values' menu.

```

ABB Switzerland Ltd                                REC216 - Control Unit
Main Menu
Measu Display AD(CT/VT) Channels
Ch.Nr. Amplitude Phase Frequency
Disp 1 0.000 [100V] --- deg --- Hz
Disp 1 0.000 [100V] --- deg
Disp 2 0.000 [100V] --- deg
Disp 3 0.000 [100V] --- deg
Disp 4 0.000 [ 1A] --- deg
Disp 5 0.000 [ 1A] --- deg
Disp 6 0.000 [ 1A] --- deg
Disp 7 0.000 [ 1A] --- deg
Disp 8 0.000 [ 1A] --- deg
Disp 9 0.000 [ 1A] --- deg
Disp
RETU Time: 2002-03-22 10:20;43 ( 1133)
On - Line 9600 bps SCS:LON V6.2b| V6.2b

```

The number ( 1133) at the bottom right of the window is a gauge for the computing requirement. When all the functions are active, i.e. none are disabled, this number must not be higher than 20000. The number must be read when the device is in the normal operating state and not when tripped.

Set the cycling time of the high-priority task to 20 ms (default, see [Section 3.6.4.1](#). 'Control function FUPLA').

This ensures the correct processing of the protection and control functions.

## 3.2. Protection function inputs and outputs

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

#### 3.2.1.1. Input transformers

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

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

Protection c.t's have a wide dynamic range and are especially designed for measuring fault currents.

Metering c.t's (core-balance) have a low dynamic range, but a high accuracy. They are intended for measurement under steady-state conditions.

Table 3.5 shows the measuring ranges for the corresponding RE. 216 c.t./v.t input for sinusoidal signals.

Input	V.t's	C.t's	
		Protection	Metering
Measuring range for $f = f_N$  with a d.c. component time const. up to 150 ms  t < 30 ms t < 100 ms t < 200 ms t > 200 ms  time const. up to 300 ms  t < 30 ms t < 100 ms t < 200 ms t > 200 ms	2.25 $U_N$	60 $I_N$  30 $I_N$ 23 $I_N$ 16 $I_N$ 14 $I_N$  30 $I_N$ 20 $I_N$ 12 $I_N$ 8 $I_N$	4 $I_N$

Table 3.5 Measuring ranges of the analogue I/P's

The measuring ranges must be taken into account when setting the protection functions. The system may check their plausibility.

### 3.2.1.2. *Analogue protection system inputs*

Before being processed by the protection functions, the currents and voltages coming from the input transformers are digitised in the analogue input unit 216EA61.

An RE. 216 system can have a maximum of two 216EA61 units with a total of 48 I/P's. Every input can be used by any number of protection functions.

The type of every channel must be defined:

- Voltages:
  - single-phase
  - three-phase delta-connected
  - three-phase Y-connected
- Currents:
  - single-phase metering
  - single-phase protection
  - three-phase metering
  - three-phase protection.

All protection function settings are based on the input values (secondary ratings) of the RE. 216. The fine adjustment to suit the effective primary system quantities is accomplished by varying the reference settings of the c.t/v.t inputs (see "Setting the c.t/v.t inputs").

Three-phase I/P's must be wired consecutively to adjacent I/P channels. The first channel (R phase) must thus be connected to either channel 1, 4 or 7 etc.

Since c.t/v.t I/P's are scanned simultaneously in groups of 6 channels, associated channels should be in the same group wherever possible (e.g. channels 1 to 6, 7 to 12 etc.).

The following applies with respect to the allocation of c.t/v.t inputs to protection functions:

- Generally, only the first I/P (R phase) of three-phase I/P's is stated.
- In the case of functions with several c.t/v.t inputs, all I/P's must be processed by the same 216EA61 unit.
- For certain functions, all the c.t/v.t inputs must belong to the same scanning group (e.g. generator differential protection). For others (e.g. power) the I/P's must belong to the same scanning group to achieve maximum sensitivity.

### 3.2.2. **Binary inputs (binary addresses)**

In a RE. 216 scheme, a binary signal can have one of the following values:

- logical "0" (fixed value) = FALSE
- logical "1" (fixed value) = TRUE
- binary input values (216DB61, 216EB61)
- Double indication signals; two consecutive binary inputs are combined.
- binary protection values (trips) as defined by the function number and the corresponding signalling output.

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

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

### 3.2.3. **Signalling outputs (signal addresses)**

All the RE. 216 signalling outputs (signal addresses) can be configured for one of the following modes of operation:

- 1) Control a signalling relay and be recorded as an event.
  - Full information in relation to important signals.
  - Pick-up signals activate "General start" (signal and event)
  - Tripping signals activate "General trip" (signal and event)
- 2) Be recorded as an event without control of a signalling relay.
  - No signalling relay needed.
  - Information nevertheless available on changes in the status of the signal.
  - Pick-up signals activate "General start" (only event)
  - Tripping signals activate "General trip" (only event)
- 3) Neither control of a signalling relay nor record as an event.
  - No signalling relay needed.
  - No information available on changes of status, i.e. no memory space occupied by unnecessary information.
  - No influence on "General start" or "General trip".

The auxiliary signalling relays are energised via the binary O/P unit 216AB61/216AC61. RE. 216 can have a maximum of six 216AB61 and six 216AC61 units.

The following applies regarding the control of signalling relays:

- An energised signalling relay is indicated on the front of the respective 216AB61/216AC61 unit by a LED.
- Every signalling channel can be configured to latch.  
Exception: The defect signal using channels 1 and 2 of the first 216AB61.
- A signal from a protection function can excite a maximum of two signalling channels of the first and second 216AB61 units located at divisions 12 and 13 (only up to channel CHO31 in the case of the second unit), otherwise only a one signalling channel.
- Exciting of two signalling channels by a common signal:  
If CHO31 and CHO32 have to be excited by a common signal, then the channels have to be entered in the sequence CHO32, CHO31. All other channels may be entered at random.

#### **3.2.4. *Tripping commands***

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. A tripping channel can be activated by any number of protection functions.

A RE. 216 scheme is equipped with a maximum of six 216DB61 units corresponding to 48 tripping circuits.

Tripping signals can be processed by other protection functions.

#### **3.2.5. *Measured values***

Apart from being processed internally, the analogue values measured by the RE. 216 protection functions can also be viewed externally as:

- a value:  
The input variables measured by the protection functions can be accessed and displayed on the VDU of the control unit (personal computer). Their values are generally referred to the secondary voltages and currents at the input of the RE. 216 scheme.
- a recorded event:  
The instant a protection function trips, the value of the corresponding measured variable is recorded as an event.

### 3.3. ***Frequency range***

The RE. 216 protection system can be set to operate at a power system frequency  $f_N$  of either 50 Hz or 60 Hz. The algorithms representing the protection functions have been optimised to produce the best results at the rated frequency  $f_N$ . Deviation from the rated frequency cause an additional error.

The O/P of the frequency function can be used to block other protection functions in the event of excessive frequency variation.

### **3.4. System parameter settings**

#### **3.4.1. Entering the relay configuration**

The relay configuration only has to be entered when making settings 'off-line' or when the hardware or software of the RE. 216 scheme has to be changed. The configuration does not have to be entered when making settings 'on-line'.

The corresponding parameters are to be found in the sub-menu "Relay configuration" of the "Change hardware functions" menu. The units fitted in a rack, the rated frequency, the software key and the type designation for a particular application are entered under "Relay configuration".

#### **3.4.2. Entering the parameters for the c.t./v.t channels**

The following two sub-menus are used in conjunction with the c.t./v.t. inputs:

##### **C.t./v.t. channel type**

The type of c.t./v.t. channel is determined by the input transformers installed. The entry of the type specifies:

- c.t. or v.t.
- single or three-phase
- metering or protection core
- Y or delta connection.

##### **C.t./v.t. channel reference value**

A separate reference value can be entered for every c.t./v.t. channel. They enable the rated voltages and currents and also small differences of the primary system c.t.'s and v.t.'s to be compensated. Note that three-phase voltages (or currents) assume the value of the R phase channel.

If, for example, the rated voltage of the primary system v.t. is neither 100 V nor 200 V, reference values have to be entered for the corresponding channels. Assuming a rated voltage of 110 V, the reference value to be entered becomes:

$$\text{Reference value for voltage channel} = \frac{110 \text{ V}}{100 \text{ V}} = 1.100$$

##### **Comment for an c.t./v.t. channel**

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./v.t. input parameter of a protection function is selected.

### 3.4.3. **Entering latching parameters**

Every tripping and signalling channel can be set to a latching or non-latching mode via the sub-menu "Change tripping or signalling channel".

### 3.4.4. **Entering the system parameters**

Three sub-menus can be accessed via the 'SYSTEM FUNCTIONS' menu (see [Section 5.5.6](#)).

## **Changing inputs and outputs**

This sub-menu is for defining signalling O/P's and binary I/P's.

- **Confirm Pars:**  
Switches the parameter confirm mode on and off.  
Default: Confirm parameters ON.
- **TimeSyncByPC:**  
Switches the synchronisation of the REG 216 clock by the PC on and off when the MMC program starts.  
Default: Synchronisation by PC ON.
- **GenTrip:** General trip (SignalAddr)  
Signal generated when a protection function trips  
Default: Record as event (ER).
- **GenStart:** General start (SignalAddr)  
Signal generated when a protection function picks up  
Default: Record as event (ER).
- **GenTrip latch:** General trip latches (SignalAddr)  
As general trip, but signal latches until reset. This is not recorded as an event.
- **GenStart latch.:** General start latches (SignalAddr)  
As general start, but signal latches until reset. This is not recorded as an event.
- **Test active:** (SignalAddr)  
Signals that the system is in the test mode.  
Default: Disabled.
- **MMC is on:** (SignalAddr)  
Signal indicating that the control PC is connected and serviceable.  
Default: Record as event (ER)

- **Reset 1**, Reset 1 (BinaryAddr)  
Resets all latched signals and tripping commands.  
Default: Logical "0" (F)
- **Reset 2**: Reset 2 (BinaryAddr)  
Resets all latched signals and tripping commands.  
Default: Logical "0" (F)
- **BlockSigs**: Block signals (BinaryAddr)  
All signalling relays and indicating devices are blocked, but events are still recorded.  
Default: Logical "0" (F)
- **BlockTrip 1**: Block trip 1, (BinaryAddr)  
All tripping relays and trip indicating devices are blocked, but signalling relays are still enabled and events still recorded.  
Default: Logical "0" (F)
- **BlockTrip 2**, Block trip 2, (BinaryAddr)  
All tripping relays and trip indicating devices are blocked, but signalling relays are still enabled and events still recorded.  
Default: Logical "0" (F)
- **EnableTrip 1**: Enable tripping (BinaryAddr)  
Enables the tripping relays.  
Default: Logical "1" (T)
- **EnableTrip 2**: Enable tripping (BinaryAddr)  
Enables the tripping relays.  
Default: Logical "1" (T)
- **EnableTest**: Enable test mode (BinaryAddr)  
Enables activation of the test mode by the MMC.  
Default: Logical "1" (T)
- **Rem. Setting**: Remote selection of the parameter set (BinaryAddr)  
Enables switching of the parameter set via the IBB.  
Default: Logical "0" (F)
- **ParSet2**: (BinaryAddr)  
Binary input for switching to parameter set 2.  
Default: Logical "0" (F)

- **ParSet3:** (BinaryAddr)  
Binary input for switching to parameter set 3  
Default: Logical "0" (F)
- **ParSet4:** (BinaryAddr)  
Binary input for switching to parameter set 4  
Default: Logical "0" (F)
- **ParSet1,** (SignalAddr)  
Signals that parameter set 1 is selected.  
Default: Record as event (ER)
- **ParSet2:** (SignalAddr)  
Signals that parameter set 2 is selected.  
Default: Record as event (ER)
- **ParSet3:** (SignalAddr)  
Signals that parameter set 3 is selected.  
Default: Record as event (ER)
- **ParSet4:** (SignalAddr)  
Signals that parameter set 4 is selected.  
Default: Record as event (ER)
- **MVB\_PB\_Warn, MVB\_PB\_Alarm,**  
PB\_BA1\_Ready...PB\_BA4\_Ready, PB LA Fault, PB LB Fault  
These signals only occur when using the MVB process bus  
(see Operating Instructions for the distributed I/O system  
RIO 580, 1MRB520192-Uen).

### Changing the system name

The system name is displayed at the upper edge of the MMC.

### Changing the password

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

#### 3.4.5. *Analogue outputs*

The analogue output channels on the 216AC61 can be assigned to and scaled for either protection functions or SCS measured variables.

The output current (0...20 mA) can be scaled as follows:

- SCS measured variables, analogue signals entering via channel 4 of the IBB from the SCS. The range of values is  $\pm 320$  and the O/P current scale is  $\pm 200\%$ .

- protection function O/P's and measured variables. The O/P current scale is  $\pm 400\%$ .

**Channel No.**

defines to which analogue O/P channels of the 216AC61 unit a measured variable is allocated. Where a system includes several 216AC61 units, the channels are designated according to unit and channel number (e.g. 2001).

**MinValue**

scale factor determining the minimum value of the current O/P (0 mA).

**MaxValue**

scale factor determining the maximum value of the current O/P (20 mA).

**Examples of scaling:**

Display of the measurement by a current function with a rated current  $I_n = 1$  A.

- Scale:  
Minimum = 0 %, Maximum = 200 %. The O/P of 0...20 mA corresponds to 0...2 A.

Display of the measured value of a power function from -50%...+150%  $P_n$ .

- Scale:  
Minimum = - 50%, Maximum = 150%  
0 mA corresponds to  $P_n = -50$  %  
5 mA corresponds to  $P_n = 0$  %  
20 mA corresponds to  $P_n = +150$  %.

When displaying an SCS measured variable, 100% corresponds to a value of 160. The range of values is limited to  $\pm 320$ , i.e. the practical scale for SCS measured variables is  $\pm 200\%$ .

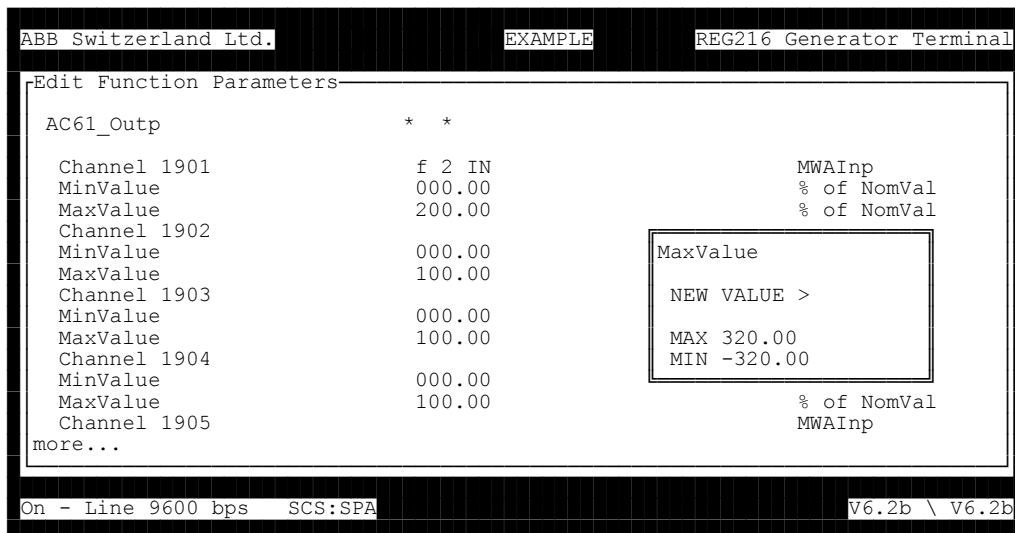


Fig. 3.4.5.1 Edit analogue outputs

### 3.4.6. Binary channels

The following settings can be changed in the 'Edit binary channels' menu:

#### Enable/Change event mask

- Create event ON/OFF. This can be set individually for every binary input.
- 216DB61 enable/disable.
- 216EB61 filter times.

#### Edit comment

A user comment of 25 characters can be entered for every binary input.

#### Edit double indication signals

Two consecutive binary inputs can be configured as a 'duplicate signal'.

The SCS displays an input as follows:

```

E1                1-0
E2                0-1
E3                0-0
E4                1-1

```

In the event list of the MMC, signals appear as 1-0, 0-1, 1-1 and 0-0 (instead of ON and OFF).



### **3.5. Protection functions**

The following Sections contain the data concerning the individual protection functions.

#### **3.5.1. Generator differential (Diff-Gen)**

##### **A. Application**

Differential protection of generators.

##### **B. Features**

- non-linear current-dependent tripping characteristic (see Fig. 3.5.1.1)
- 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. C.t./v.t. 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
RunOnCPU		CPU1		(Select)	
ParSet 4..1		P1		(Select)	
Trip 01-08		00000000			
Trip 09-16		00000000			
Trip 17-24		00000000			
Trip 25-32		00000000			
g-Setting	IN	0.10	0.10	0.50	0.05
v-Setting		0.25	0.25	0.50	0.25
CurrentInp	c.t./v.t.. I/P	00000			
BlockInp	logical 1/0	F			
Trip	Signal	ER			
Trip-R	Signal				
Trip-S	Signal				
Trip-T	Signal				

### Explanation of parameters:

#### RunOnCPU

defines the processing unit which runs the function.

#### ParSet 4..1

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

#### Trip 01-08

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

#### Trip 09-16

corresponds to Trip 01-08 (providing tripping unit fitted).

#### Trip 17-24

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 25-32**

corresponds to Trip 01-08 (providing tripping unit fitted).

**g-Setting**

Basic setting (sensitivity) g of the operating characteristic.

**v-Setting**

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

**CurrentInp**

defines the current input channels. The first channel (R phase) of the two groups of three phases with the same reference values from the same scanning group must be specified, i.e. channel 1 or 7.

**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)

ER means event recorder.

**Trip-R**

corresponds to Trip, but indicates that tripping was initiated by R phase.

**Trip-S**

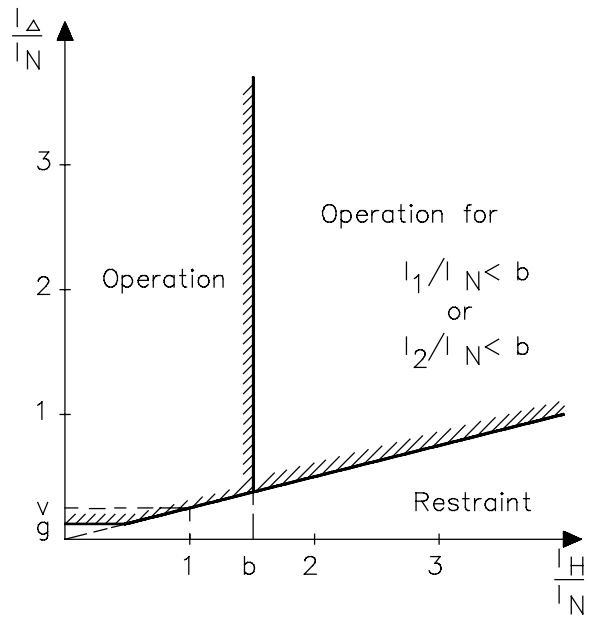
corresponds to Trip, but indicates that tripping was initiated by S phase.

**Trip-T**

corresponds to Trip, but indicates 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

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

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

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Fig. 3.5.1.1 Operating characteristic of the generator differential protection (Diff-Gen)

## E. Setting instructions

Basic setting	g-Setting
Pick-up ratio	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 setting of the differential protection for internal faults. This is the section of the operating characteristic with 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 along the same winding, because they do not produce a differential current.

Since, however, there is a small differential current during normal operation, false tripping could result, if "g" is set too low. A spurious differential current is usually due to unequal c.t. errors and unequal 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 values, it is calculated as follows:

Relay setting (where $I_N$ is the relay rated current)	$g = 0.1 I_N$
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 for restraint currents higher than  $1.5 I_N$ .

The value of " $v$ " defines the pick-up current  $I_D$  for a restraint 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 3.5.2.2](#) and [3.5.2.3](#) for transformer differential protection).

The " $v$ " setting should be low enough to make the protection sensitive to faults when load current is flowing without mal-operating 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



### 3.5.2. **Transformer differential (Diff-Transf)**

#### **A. Application**

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

#### **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
- inrush restraint
  - evaluation of the ratio of 2nd harmonic to fundamental
  - detection of the largest phase current
  - detection of energised transformers using the load current
- compensation for group of connection
- compensation for current amplitude (c.t. ratio)
- measurement for three-winding transformers:
  - comparison of the greatest current with the sum of the currents of the other two windings (per phase measurement)
- suppression of DC off-set
- suppression of harmonics

#### **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 restraint current
- S phase restraint current
- T phase restraint current.



**D. Transformer differential function settings - Diff-Transf**

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
RunOnCPU		CPU1		(Select)	
ParSet 4..1		P1		(Select)	
Trip 01-08		00000000			
Trip 09-16		00000000			
Trip 17-24		00000000			
Trip 25-32		00000000			
g	IN	0.20	0.10	0.50	0.10
v		0.50	0.25	0.50	0.25
b		1.50	1.25	5.0	0.25
g-High	IN	2.00	0.50	2.50	0.25
I-Inst	IN	10	5	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.	00000			
a2		1.00	0.05	2.20	0.01
s2		y0		(Select)	
CurrentInp2	CT/VT-Addr.	00000			
a3		1.00	0.05	2.20	0.01
s3		y0		(Select)	
CurrentInp3	CT/VT-Addr.	00000			
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:****RunOnCPU**

defines the processing unit which runs the function.

**ParSet 4..1**

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

**Trip 01-08**

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

**Trip 09-16**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 17-24**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 25-32**

corresponds to Trip 01-08 (providing tripping unit fitted).

**g**

Basic setting g (sensitivity) of the operating characteristic.

**v**

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

**b**

defines the point b on the operating characteristic.

This should be set to approx. 1.5 times the load current.

**g-High**

Increased basic setting used instead of the normal one as controlled by the binary signal HighSetInp.

This enables, for example, false tripping from occurring as a result of a temporarily increased flux (overexcitation).

**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 in the case of 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**

Circuit of winding 1 (primary).

Settings provided:

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

**CurrentInp1**

defines the current input channel for winding 1. The first channel (R phase) of three phases must be specified.

**a2**

Amplitude compensation factor for winding 2.

**s2**

Group of connection 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 current input channel for winding 2. The first channel (R phase) of three phases must be specified.

**a3**

Amplitude compensation factor for winding 3.

**s3**

Group of connection 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 current 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 I/P is not selected.

**BlockInp**

Binary address used as blocking input.

(F→FALSE, T→TRUE, binary input or output of a protection function).

**InrushInp**

determines whether the inrush restraint is activated, 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→FALSE, T→TRUE, binary input or output of a protection function)

The I/P must be energised for the entire expected duration of the inrush current.

**HighSetInp**

determines with the normal or increased basic setting g is used. (F→FALSE, T→TRUE, binary input or output of a protection function).

**Trip**

Output for signalling tripping  
(signal address)

ER means event recorder.

**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.

**Trip-R**

corresponds to Trip, but indicates that tripping was initiated by R phase.

**Trip-S**

corresponds to Trip, but indicates that tripping was initiated by S phase.

**Trip-T**

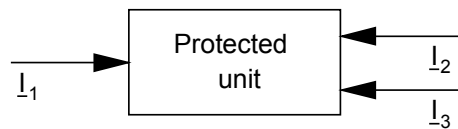
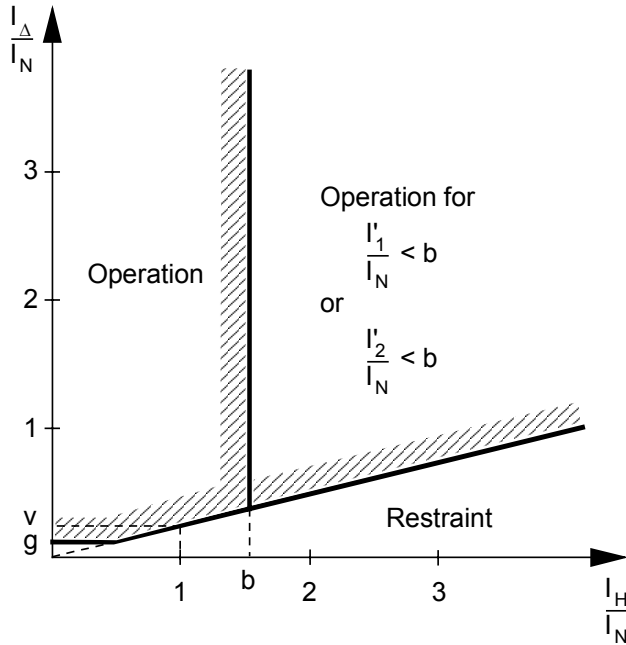
corresponds to Trip, but indicates that tripping was initiated by T phase.

**Inrush**

O/P for signalling the presence of an inrush current (signal address).

**Stabilizing**

O/P for signalling  $I_H > b$  during through-faults (signal address).



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

Operating (differential) current

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

Restrain current

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

$$I'_2 = I_{\Delta} - I'_1$$

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

Fig. 3.5.2.1 Operating characteristic of the transformer differential protection (Diff-Transf)

## E. Setting instructions

Basic setting	g setting
Pick-up ratio	v setting
Operating char. switching point	b
Increased basic setting	g-High
Pick-up differential current (no influence on inrush detection)	I-Inst
Pick-up ratio of the inrush detector	InrushRatio
Inrush detection time	InrushTime
Amplitude compensation factors	a1 a2 a3
Transformer circuit on winding 1	s1
Group of connection on windings 2 and 3	s2 s3

The purpose of the transformer differential protection is to detect phase faults in the protection 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 of a modern power transformer is very low and usually lies 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 do 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 also there is no risk of mal-operation 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 channels is set to 1.000. At all other settings, the permissible upper limit reduces in proportion to ratio of the channel reference values (transformer winding 2/winding 1, 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 restraint current is either defined by the equation

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

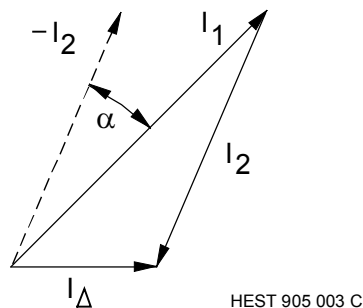
or it is zero

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

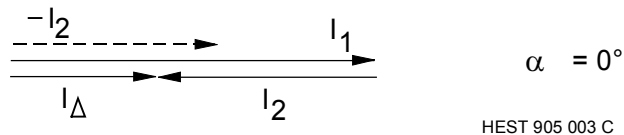
The angle

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

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.

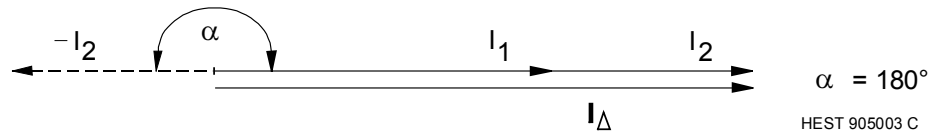


The following vector diagrams then result for a through-fault





and an internal fault



According to the equation for the restrain current,  $I_H$  for through-faults ( $\alpha = 0$ ) becomes

$$: I_H = \sqrt{I_1 \times I_2}$$

and for internal faults

- a) fed from one side ( $I_2 = 0$ ) :  $I_H = 0$   
 b) fed from both sides ( $\alpha = 180^\circ$ ) :  $I_H = 0$

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  $b$ .

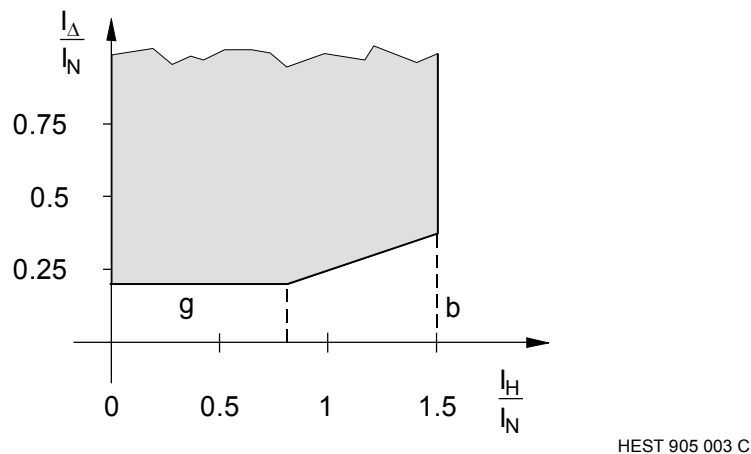
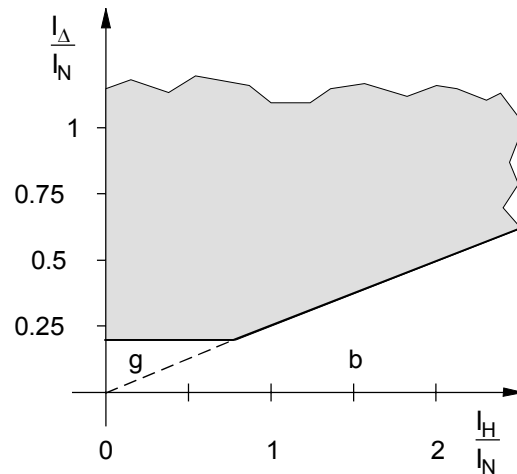


Fig. 3.5.2.2 Operating characteristic of the transformer differential protection for high through-fault currents

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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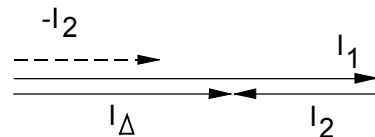
Fig. 3.5.2.3 Operating characteristic of the transformer differential protection for low through-fault currents

This characteristic provides high 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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$$I_{\Delta} = I_1 + I_2 = 4 I_N - I_N = 3 I_N$$

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

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 one 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  $g\text{-High} = 0.75 I_N$ .

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.

The typical value for power transformers of low to medium power is  $I\text{-Inst} = 12 I_N$ .

### **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**

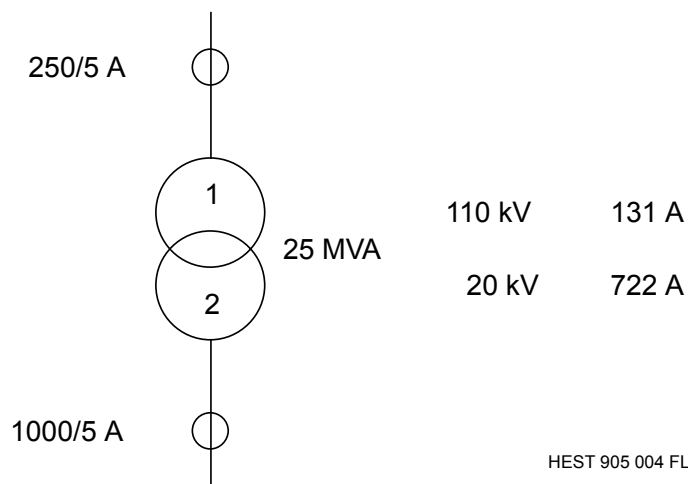
The setting for how long the inrush detection function should be active depends on how long the danger of false tripping due to an inrush current, which only flows through one winding, exists. A typical setting is 5 s.

### Amplitude compensation factors a1, a2, a3

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

The factors "a" 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 for 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.



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

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

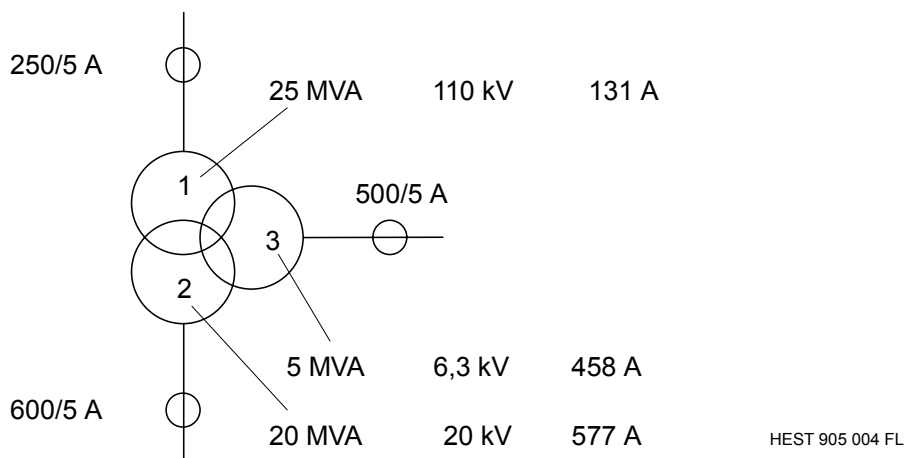
The reference current is only chosen to be different from the transformer rated current, if this should be necessary because of the setting range of factors a1 and a2.

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 corresponding to the above example are:

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

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:

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

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

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

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:

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

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

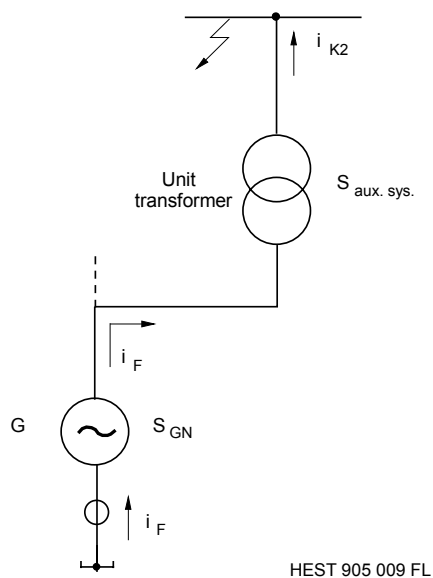
$$a3 = \frac{I_{TN3}}{I_{B3}} = \frac{458}{2291} = 0.200$$

### 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. 3.5.2.4).

#### 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. 3.5.2.4). 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. 3.5.2.4). 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.



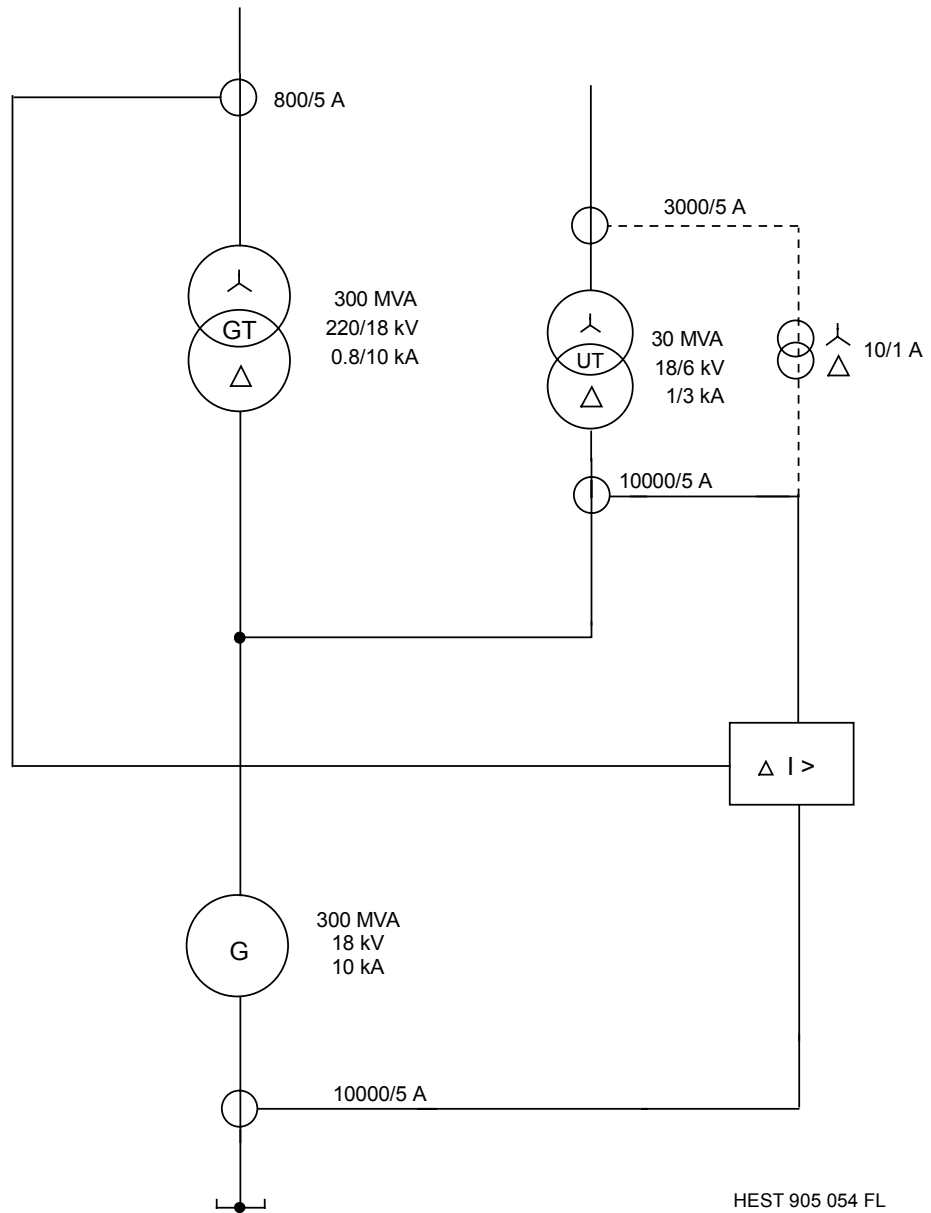
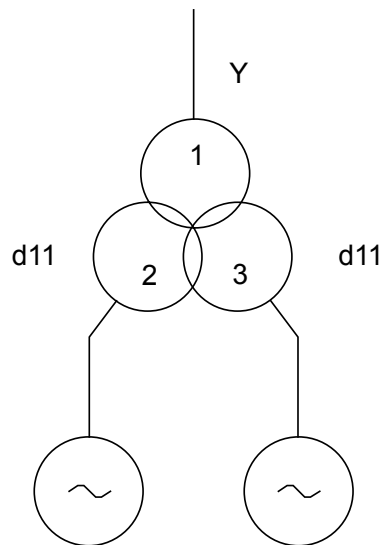


Fig. 3.5.2.4 The overall differential protection of a generator/transformer unit

**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:

$$s1 = Y$$

$$s2 = d11$$

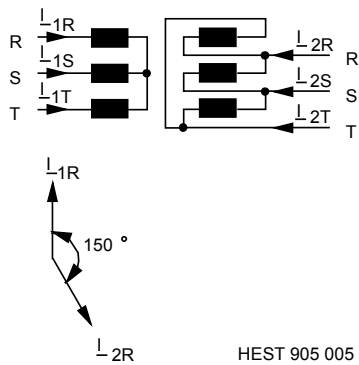
$$s3 = d11$$

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

### 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.

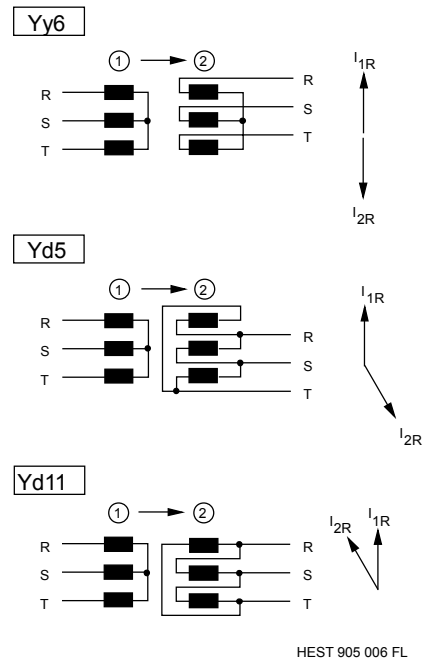
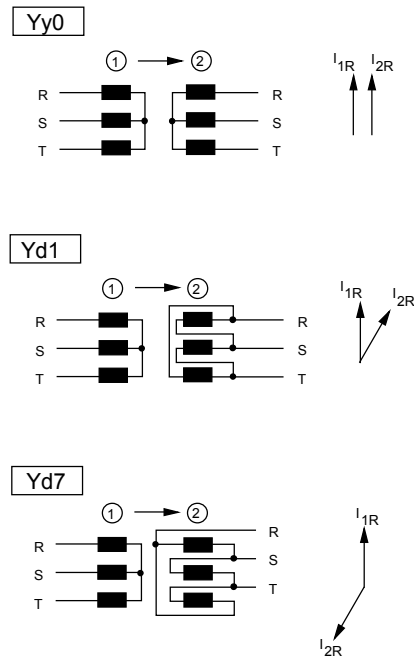
For example, for a Yd5 connected transformer

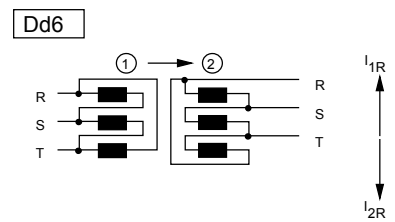
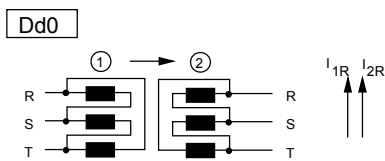
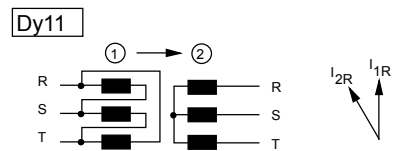
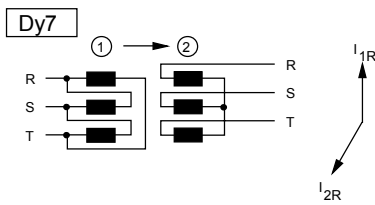
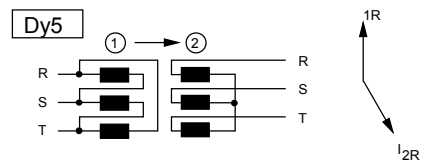
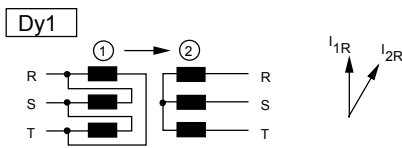
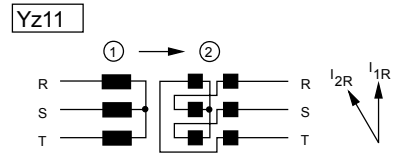
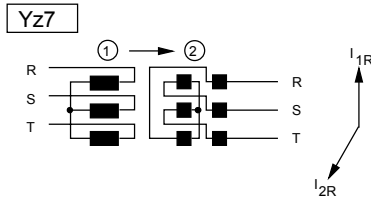
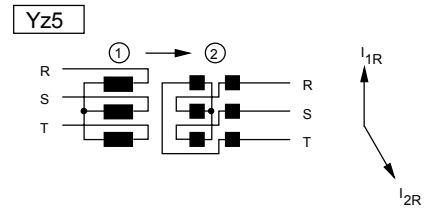
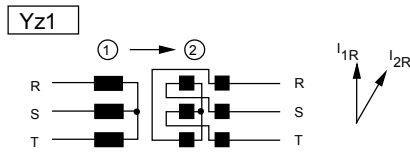


- Y-connected primary
- Delta-connected secondary
- Phase-angle between the currents of the same phase on both sides  $5 \times 30^\circ = 150^\circ$

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

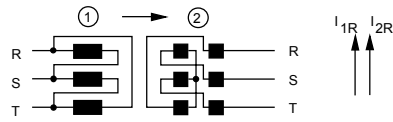
$$I_{2r(\text{compensated})} = I_{2R}$$



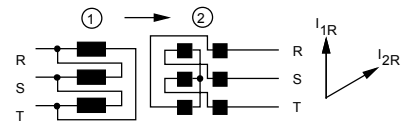


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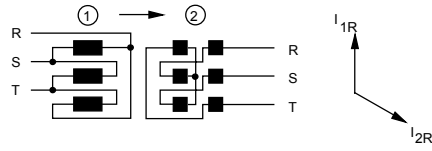
Dz0



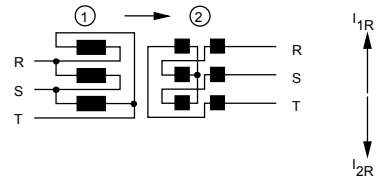
Dz2



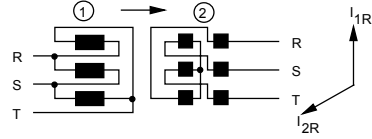
Dz4



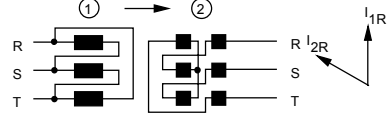
Dz6



Dz8



Dz10



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List of all the compensation matrices: Vectors 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 3.5.2.1 Compensation matrices and associated amplitude factors

### a) Y connection on side 1

Two-winding transformer:

Group	Comp. matrix Side 1	Comp. matrix Side 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:

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	EBH	CJA	EHG	CJH	EHH	CJG	
z11	CGC	CGD	CGO	CGB	CGN	CGA	CGK	CGH	CGJ	CGG	

Table 3.5.2.2 Summary of the compensation matrices for a three-winding transformer with a Y connection on Side 1

### b) Delta connection on Side 1

Applies for two and three-winding transformers:

Group	Comp. matrix Side 1	Comp. matrix Side 2 (and Side 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:

$$\left. \begin{array}{l} s1 = Y \\ s2 = d5 \\ s3 = y0b \end{array} \right\} \text{CBC results from Table 3.5.2.2, i.e. the}$$

compensation matrix on Side 1 = C = (1 -1 0) (see Table 3.5.2.1)  
with an amplitude factor of  $1/\sqrt{3}$

compensation matrix on Side 2 = B = (-1 1 0) (see Table 3.5.2.1)  
with an amplitude factor of 1

compensation matrix on Side 3 = C = (1 -1 0) (see Table 3.5.2.1)  
with an amplitude factor of  $1/\sqrt{3}$

The function currents then become:

Function currents (calculated)	Currents measured at the c.t's
Side 1:	$\begin{pmatrix} I_{r1} \\ I_{s1} \\ I_{t1} \end{pmatrix} = \frac{1}{\sqrt{3}} \begin{pmatrix} 1 & -1 & 0 \\ 0 & 1 & -1 \\ -1 & 0 & 1 \end{pmatrix} \begin{pmatrix} I_{R1} \\ I_{S1} \\ I_{T1} \end{pmatrix}$
Side 2:	$\begin{pmatrix} I_{r2} \\ I_{s2} \\ I_{t2} \end{pmatrix} = 1 \begin{pmatrix} -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{pmatrix} \begin{pmatrix} I_{R2} \\ I_{S2} \\ I_{T2} \end{pmatrix}$
Side 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 <sub>N</sub>
v	0.5
b	1.5
g-High	0.75 I <sub>N</sub>
I-Inst	12 I <sub>N</sub>
InrushRatio	10%
InrushTime	5 s
a1, a2, a3	Have to be calculated.
s1, s2, s3	Depend on plant.



### 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
- earth fault 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
RunOnCPU		CPU1		(Select)	
ParSet 4..1		P1		(Select)	
Trip 01-08		00000000			
Trip 09-16		00000000			
Trip 17-24		00000000			
Trip 25-32		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.	00000			
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr	ER			

**Explanation of parameters:****RunOnCPU**

defines the processing unit which runs the function.

**ParSet 4..1**

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

**Trip 01-08**

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

**Trip 09-16**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 17-24**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 25-32**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Delay**

Time between the function picking up and tripping.

**I-Setting**

Pick-up current setting.

Setting restrictions:

- not  $> 2.5 I_N$  when supplied from metering cores
- not  $< 0.2 I_N$  when supplied from protection cores.

**MaxMin**

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

- MAX: overcurrent
- MIN: undercurrent
- MAX-Inrush: 1 phase exceeds the MAX setting and blocks for an inrush current.

**NrOfPhases**

defines whether single or three-phase measurement.

**CurrentInp**

defines the current 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**

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).

**Start**

Output for signalling pick-up (signal address).

## E. Setting instructions

### Settings:

Current pick-up	I-Setting
Delay	Delay
Over or undercurrent	MaxMin

The definite time overcurrent function protects transformers, various parts of the auxiliaries supply system and possibly also generators against overcurrents caused by overloads, phase faults and earth faults. The filter at the input suppresses any DC component and harmonics so that the overcurrent function responds essentially just to the fundamental.

The function is also suitable for sensitive current measurements such as are necessary, for example, to detect low earth fault currents.

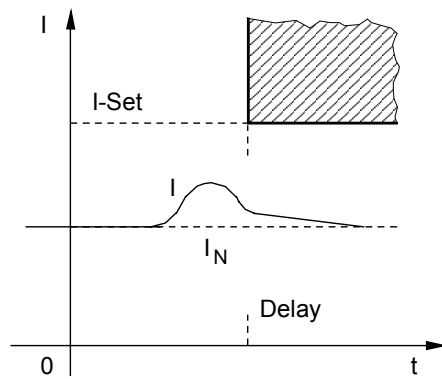
Connected across an external high-impedance circuit, the function can also be used as restricted earth fault (REF) scheme.

### Current pick-up 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 which 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

Should the rated currents of c.t.  $I_{N1}$  and protected unit  $I_{TN}$  differ, compensation 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  $I_{TN} = 800$  A and  $I_{N1} = 1000$  A, the setting for a pick-up current of  $1.5 I_{TN} = 1200$  A would have to be

$$1.5 \frac{I_{TN}}{I_{N1}} = 1.5 \frac{800}{1000} = 1.2$$

### CurrentInp

An interposing c.t. in the input is essential for low current settings ( $< 0.2 I_N$ , i.e. from  $0.19 I_N$  downwards).

### 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:

- MAX (1ph): Pick-up when the highest phase current exceeds the setting.
- MAX (3ph): Pick-up when the lowest phase current 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 current falls below the setting.
- MIN (3ph): Pick-up when the highest phase current also falls below the setting. This setting is not permitted, if the function is set to single-phase measurement.
- MAX-Inrush: Pick-up when the highest phase current exceeds the setting with blocking for inrush currents.

### 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).

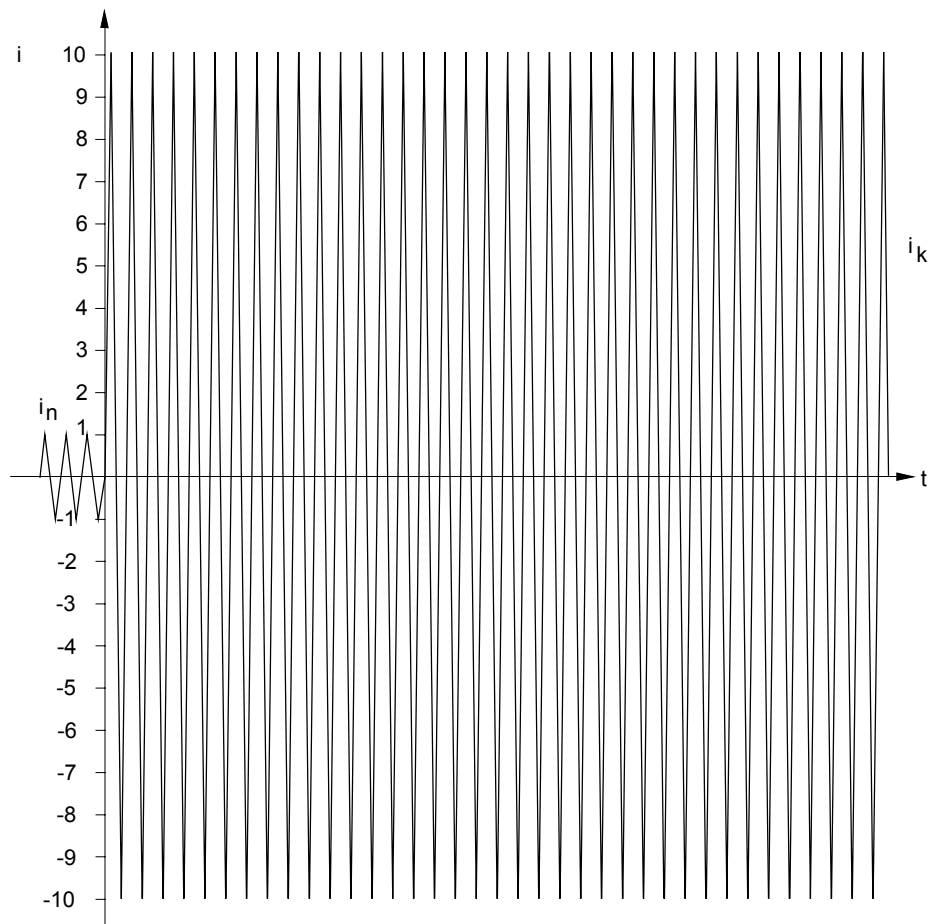
The output of the function is disabled when the ratio  $I_{2h}/I_{1h}$  exceeds 10 % and enabled again when it falls below 8 %.

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).





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Fig. 3.5.3.2 Transformer phase fault current

for  $u_0 = u_{\max}$   
 $x_T = 0.1$

**Typical settings:**

	Transformer	Generator
I-Setting	$1.5 I_N$	Largely determined
Delay	2 s	by plant data

$I_N$  = rated current of the protection



### 3.5.4. ***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
RunOnCPU		CPU1		(Select)	
ParSet4..1		P1		(Select)	
Trip 01-08		00000000			
Trip 09-16		00000000			
Trip 17-24		00000000			
Trip 25-32		00000000			
CurrentInp	CT/VT-Addr.	0			
VoltageInp	CT/VT-Addr.	0			
I-Setting	IN	2.00	0.20	20.00	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	Select	Trip		Trip	
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:****RunOnCPU**

defines the processing unit which runs the function.

**ParSet 4..1**

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

**Trip 01-08**

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

**Trip 09-16**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 17-24**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 25-32**

corresponds to Trip 01-08 (providing tripping unit fitted).

**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.

**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.

**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:

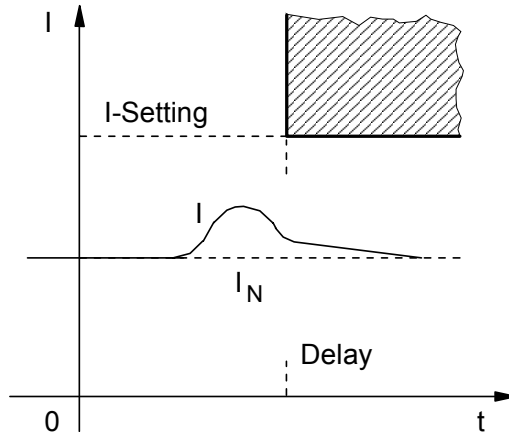
Pick-up current	I-Setting
Characteristic angle	Angle
Delay	Delay
Time allowed for receipt of signal	tWait
Response at the end of the memorised power direction time	MemDirMode
Time during which the memorised direction is valid	MemDuration

### 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. 3.5.4.1 Operating characteristic of the definite time over-current detector

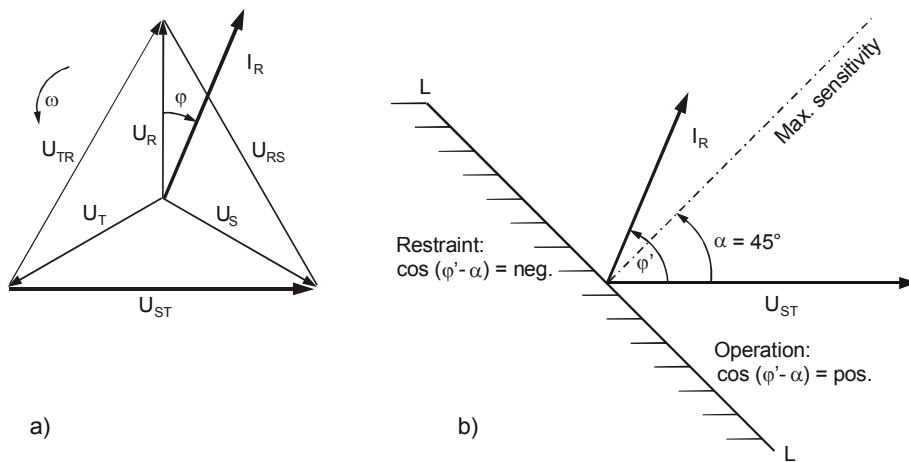
Where the rated c.t. current  $I_{N1}$  differs from the rated current  $I_{GN}$  of the protected unit, compensating the measurement to achieve a match is recommended. This is done by correcting either the reference value of the A/D input or the setting.

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 diagram in Section 12.



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- $\phi'$  = phase-angle between current and voltage (positive angle)
- $\alpha$  = Characteristic angle
- L = Border line between operating and restraint areas

- a) Definition of current and voltage
- b) Operating characteristic

Fig. 3.5.4.2 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 functions takes over after the time set for "Delay" and clears the fault as backup.

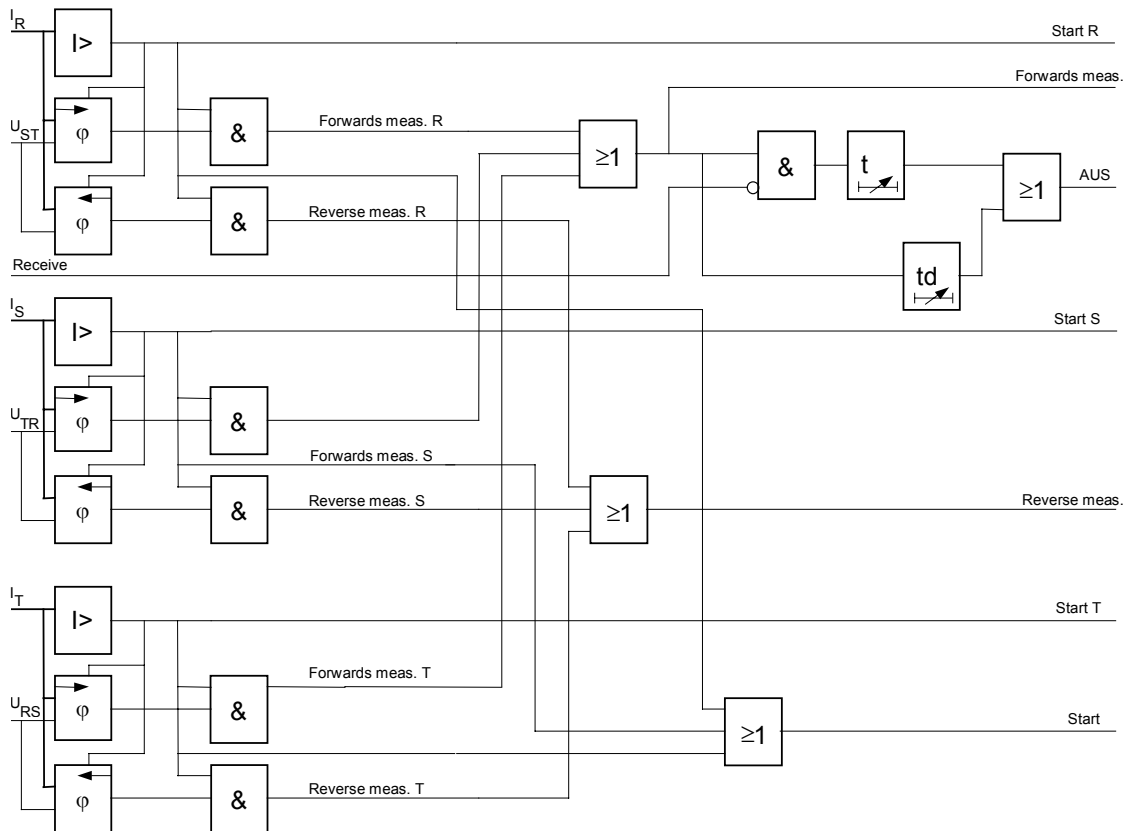


Fig. 3.5.4.3 Block diagram  
 $td$  = "Delay"  
 $t$  = "tWait"

### 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.



### 3.5.5. **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. 3.5.5.1) 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
RunOnCPU		CPU1		(Select)	
ParSet4..1		P1		(Select)	
Trip 01-08		00000000			
Trip 09-16		00000000			
Trip 17-24		00000000			
Trip 25-32		00000000			
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:****RunOnCPU**

defines the processing unit which runs the function.

**ParSet 4..1**

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

**Trip 01-08**

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

**Trip 09-16**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 17-24**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 25-32**

corresponds to Trip 01-08 (providing tripping unit fitted).

**CurrentInp**

defines the c.t. 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.

**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

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

$I_{B1} >$  rated current of prot. unit : 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	

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

Setting

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

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

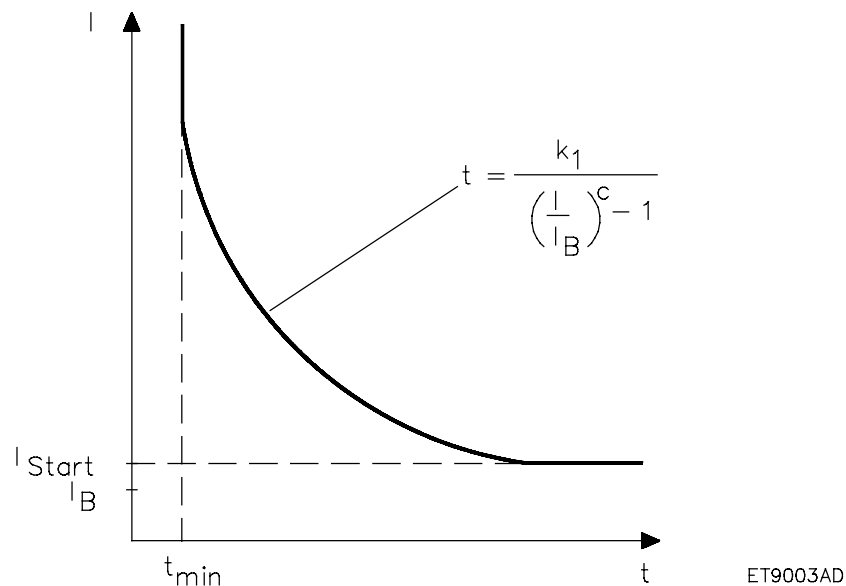


Fig. 3.5.5.1 Operating characteristic of the directional IDMT overcurrent function

### 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

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

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  $k1$ :

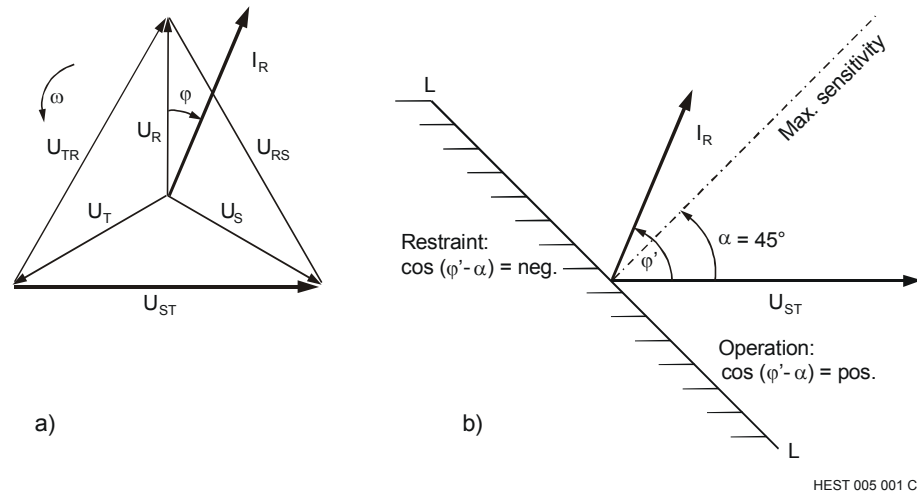
t [s]	k1 [s]
0.5	2.5
1	5
1.5	7.5
2	10
2.5	12.5

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.

## 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 diagram in [Section 4.4.2](#).



$\varphi'$  = phase-angle between current and voltage  
(positive angle)

$\alpha$  = Characteristic angle

L = Border line between operating and restraint areas

a) Definition of current  
and voltage

b) Operating characteristic

Fig. 3.5.5.2 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

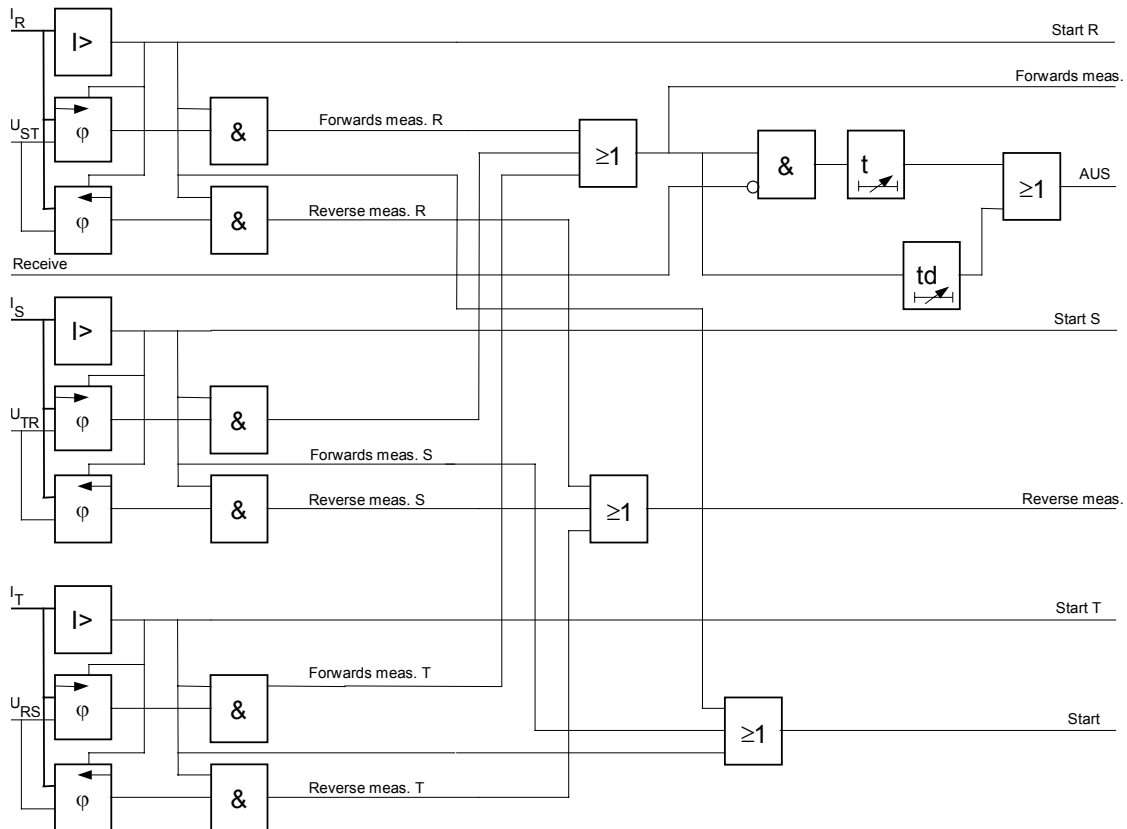


Fig. 3.5.5.3 Block diagram  
td = "Delay"  
t = "tWait"

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.





### 3.5.6. **Peak value overcurrent (Current-Inst)**

#### **A. Application**

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

#### **B. Features**

- processes instantaneous values and 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
RunOnCPU		CPU1	(Select)		
ParSet 4..1		P1	(Select)		
Trip 01-08		00000000			
Trip 09-16		00000000			
Trip 17-24		00000000			
Trip 25-32		00000000			
Delay	s	00.01	0.00	60.00	0.01
I-Setting	IN	04.00	0.1	20	0.1
f-min	Hz	040.0	2	50	1
MaxMin		MAX	(Select)		
NrOfPhases		001	1	3	2
CurrentInp	CT/VT-Addr.	00000			
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr	ER			

**Explanation of parameters:****RunOnCPU**

defines the processing unit which runs the function.

**ParSet 4..1**

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

**Trip 01-08**

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

**Trip 09-16**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 17-24**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 25-32**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Delay**

Time between the function picking up and tripping.

**I-Setting**

Pick-up current setting.

Setting restrictions:

- not  $> 2.5 I_N$  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./v.t. current 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**

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).

**Start**

Output for signalling pick-up  
(signal address).

## E. Setting instructions

### Settings:

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

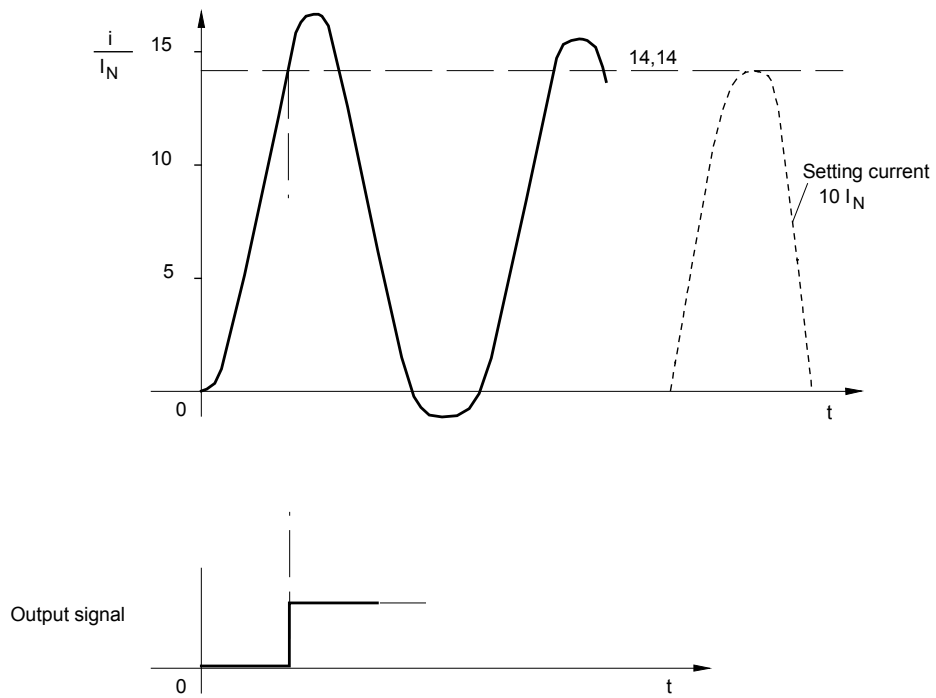
The instantaneous overcurrent function is a high-speed protection, which operates in a wide frequency range. It is intended primarily for two applications.

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. 3.5.6.1). 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.



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Fig. 3.5.6.1 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



### 3.5.7. **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. C.t./v.t. 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<sub>max</sub>-U<sub>min</sub>**

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
RunOnCPU		CPU1	(Select)		
ParSet 4..1		P1	(Select)		
Trip 01-08		00000000			
Trip 09-16		00000000			
Trip 17-24		00000000			
Trip 25-32		00000000			
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	CT/VT-Addr.	00000			
VoltageInp	CT/VT-Addr.	00000			
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr	ER			

**Explanation of parameters:****RunOnCPU**

defines the processing unit which runs the function.

**ParSet 4..1**

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

**Trip 01-08**

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

**Trip 09-16**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 17-24**

corresponds to Trip 01-08 (providing tripping unit fitted).



**Trip 25-32**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Delay**

Time between the function picking up and tripping.

**Current**

Pick-up current setting.

Setting restrictions:

not  $> 2.5 I_N$  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 current 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.

**VoltageInp**

Defines the voltage input channel.

All three-phase voltage I/P's may be selected. A phase-to-phase voltage must be used for measurement. This is derived from the set phase and the (cyclically) lagging phase.

**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).

**Start**

Output for signalling pick-up  
(signal address).

## E. Setting instructions

### Settings:

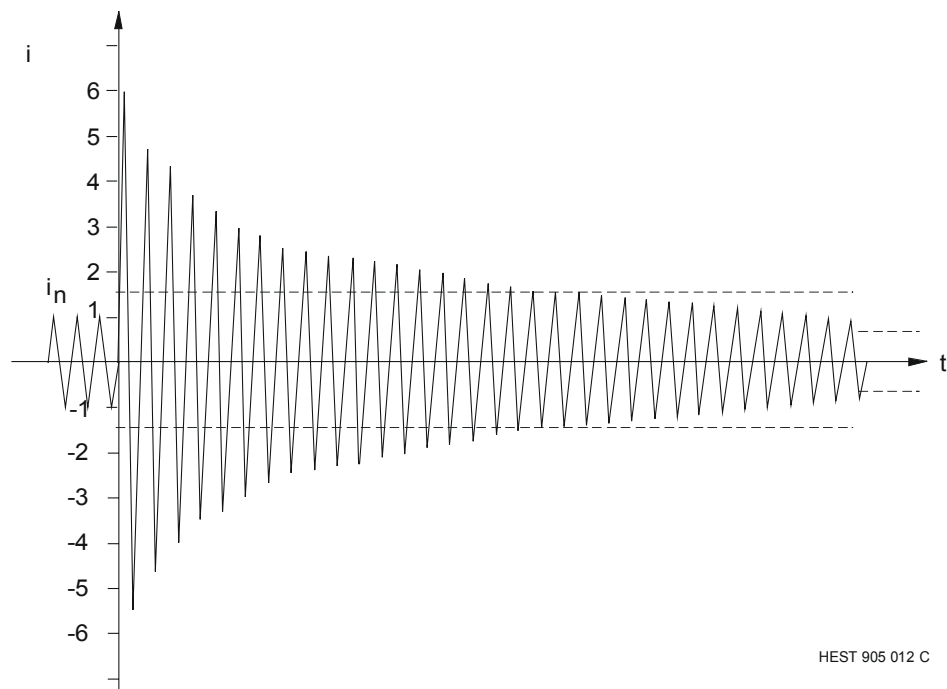
Current pick-up	Current
Delay	Delay
Undervoltage	Hold-Voltage
Reset delay	Hold-Time

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 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. 3.5.7.1).

This function is largely insensitive to DC component and harmonics.



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Fig. 3.5.7.1 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. 3.5.7.2).

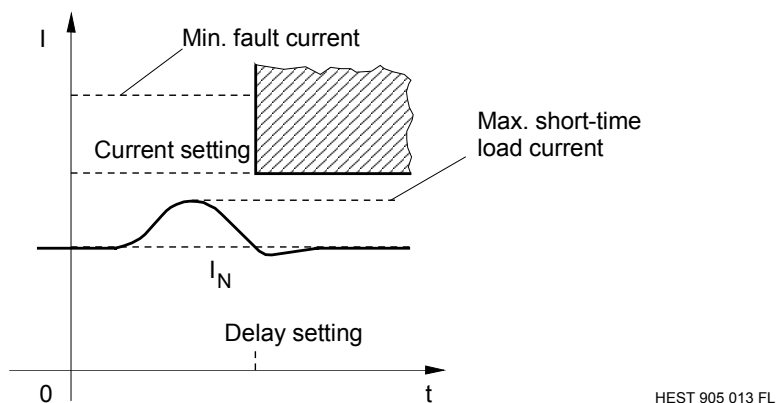


Fig. 3.5.7.2 Operating characteristic of a definite time overcurrent function

$$I_N = \text{rated current of the protection}$$

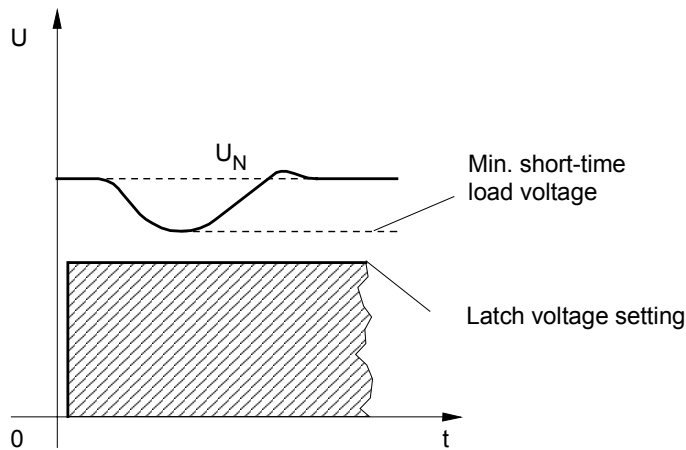
### Delay

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, which can occur during normal load conditions is chosen (Fig. 3.5.7.3).



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Fig. 3.5.7.3 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 1.5  
(referred to the rated  
current of the protection)

Compensated setting:

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

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

Should they differ, the compensated setting would be:

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



### 3.5.8. ***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. 3.5.8.1) according to British Standard 142:
  - c = 0.02 : normal inverse
  - c = 1 : very inverse and long time earth fault
  - c = 2 : extremely inverse.
- RXIDG : logarithmic time characteristic.
- insensitive to DC component
- insensitive to harmonics
- 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
RunOnCPU		CPU1		(Select)	
ParSet4..1		P1		(Select)	
Trip 01-08		00000000			
Trip 09-16		00000000			
Trip 17-24		00000000			
Trip 25-32		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.	00000			
IB-Setting	IN	1.00	0.04	2.50	0.01
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr	ER			

### Explanation of parameters:

#### RunOnCPU

defines the processing unit which runs the function.

#### ParSet 4..1

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

#### Trip 01-08

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

#### Trip 09-16

corresponds to Trip 01-08 (providing tripping unit fitted).



**Trip 17-24**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 25-32**

corresponds to Trip 01-08 (providing tripping unit fitted).

**c-Setting**

Constant determining whether the operating characteristic is inverse or logarithmic (inverse 0.02...2.00, logarithmic RXIDG).

**k1-Setting**

Multiplier.

**I-Start**

Pick-up current at which the characteristic becomes effective.

**t-min**

Definite minimum tripping time.

**NrOfPhases**

defines whether single or three-phase measurement.

**CurrentInp**

defines the c.t. current 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**

Output for signalling tripping.

**Start**

Output for signalling pick-up.

## 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"

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  $I_{B1}$ , 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  $I_B$  to the load current  $I_{B1}$  of the protected unit instead of its rated current enables for

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

$I_{B1} >$  rated current of prot. unit : 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

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

Setting

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

### 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" 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
"logarithmic"	: c = RXIDG

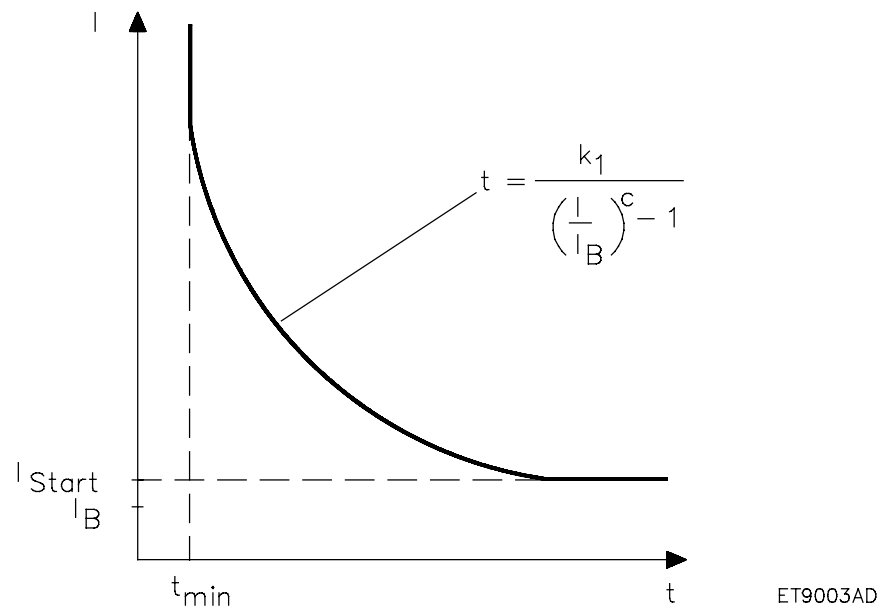


Fig. 3.5.8.1 Operating characteristic of the IDMT overcurrent function according to B.S. 142

The logarithmic characteristic RXIDG is given in Fig. 3.5.8.2.

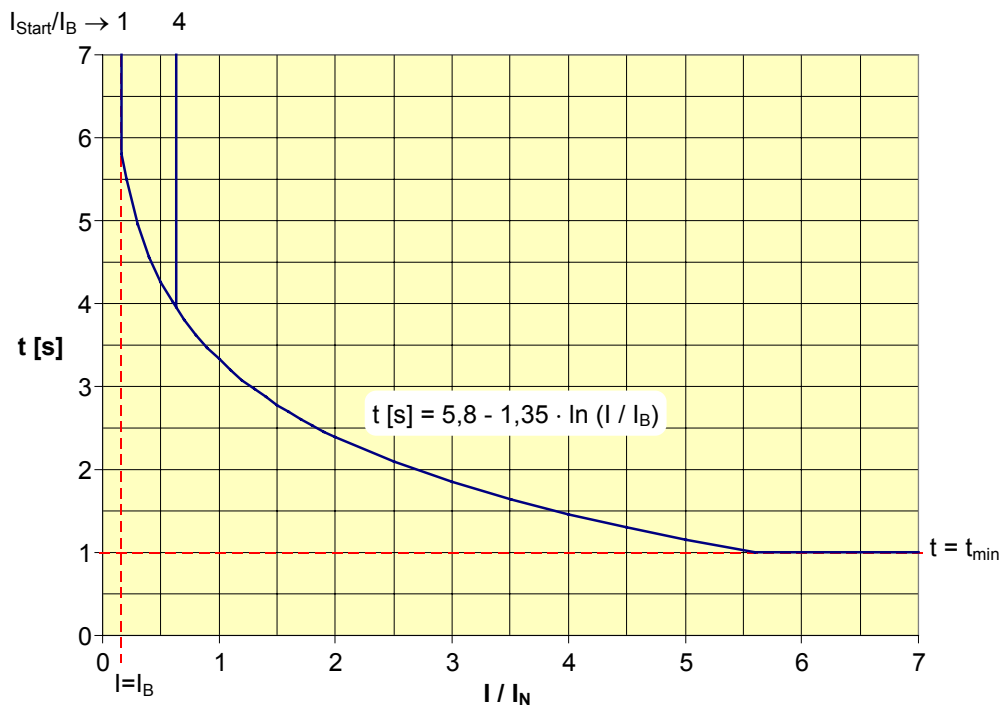


Fig. 3.5.8.2 The RXIDG operating characteristic

### 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 load 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.

The multiplier k1 has no influence on the RXIDG characteristic.

#### 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



### 3.5.9. **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. C.t./v.t. inputs:**

- current

##### **II. Binary inputs:**

- Blocking

##### **III. Binary outputs:**

- pick-up
- tripping

##### **IV. Measurements:**

- proportion of negative-sequence current component

$$I_2 = 1/3 (I_R + a^2 I_S + a I_T).$$

## D. Definite time NPS function settings - NPS-DT

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
RunOnCPU		CPU1		(Select)	
ParSet 4..1		P1		(Select)	
Trip 01-08		00000000			
Trip 09-16		00000000			
Trip 17-24		00000000			
Trip 25-32		00000000			
Delay	s	01.00	0.50	120.0	0.01
I2-Setting	IN	00.20	0.02	0.50	0.01
CurrentInp	CT/VT-Addr.	00000			
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr				

### Explanation of parameters:

#### RunOnCPU

defines the processing unit which runs the function.

#### ParSet 4..1

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

#### Trip 01-08

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

#### Trip 09-16

corresponds to Trip 01-08 (providing tripping unit fitted).

#### Trip 17-24

corresponds to Trip 01-08 (providing tripping unit fitted).

#### Trip 25-32

corresponds to Trip 01-08 (providing tripping unit fitted).



**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 current input channel. All three-phase current I/P's 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→FALSE, T→TRUE, binary input or output of a protection function).

**Trip**

Output for signalling tripping  
(signal address).

**Start**

Output for signalling pick-up  
(signal address).

## E. Setting instructions

### Settings:

Negative-sequence component of stator current Delay	I <sub>2</sub> -Setting 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 the NPS protection.

The asymmetry of the load on a generator is defined in terms of the negative-sequence stator current I<sub>2</sub>, which is therefore the quantity monitored.

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

The maximum continuous NPS current rating I<sub>2∞</sub> is given by the generator manufacturer usually as a percentage of the generator rated current I<sub>GN</sub>.

The alarm stage is normally set to I<sub>2∞</sub> or somewhat lower, e.g.

for I<sub>2∞</sub> = 10 % I<sub>GN</sub>,

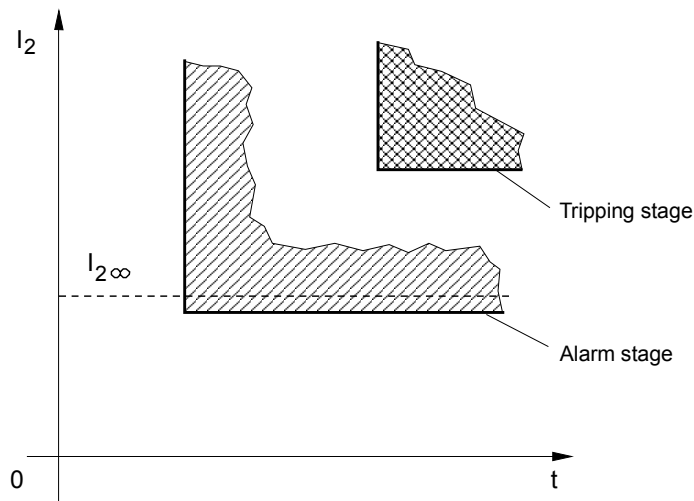
"I<sub>2</sub>-Setting" is set to 8 % I<sub>GN</sub>.

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

I<sub>2</sub>-Setting = 15 % I<sub>GN</sub>

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 temperature rise of the endangered parts of the rotor is relatively slow.

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 recommended for the NPS protection as for other protection functions. 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. Definite time voltage (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
- power system earth fault.

#### **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. C.t./v.t. 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
RunOnCPU		CPU1	(Select)		
ParSet 4..1		P1	(Select)		
Trip 01-08		00000000			
Trip 09-16		00000000			
Trip 17-24		00000000			
Trip 25-32		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	CT/VT-Addr.	00000			
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr	ER			

### Explanation of parameters:

#### RunOnCPU

defines the processing unit which runs the function.

#### ParSet 4..1

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

#### Trip 01-08

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

#### Trip 09-16

corresponds to Trip 01-08 (providing tripping unit fitted).

#### Trip 17-24

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 25-32**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Delay**

time delay between pick-up and tripping.

**V-Setting**

Voltage setting for tripping.

**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. voltage input channel.

All voltage 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**

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).

**Start**

Output for signalling pick-up.  
(signal address).

## 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)

Please note that, although a setting of  $2.0 U_N$  is permitted, the measuring range of the c.t./v.t. input channels is only  $1.3 U_N$  (i.e. 130 V resp. 260 V max.).

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

$$1.4 \frac{U_{GN}}{U_{1N}} = 1.4 \frac{12}{15} = 1.12$$

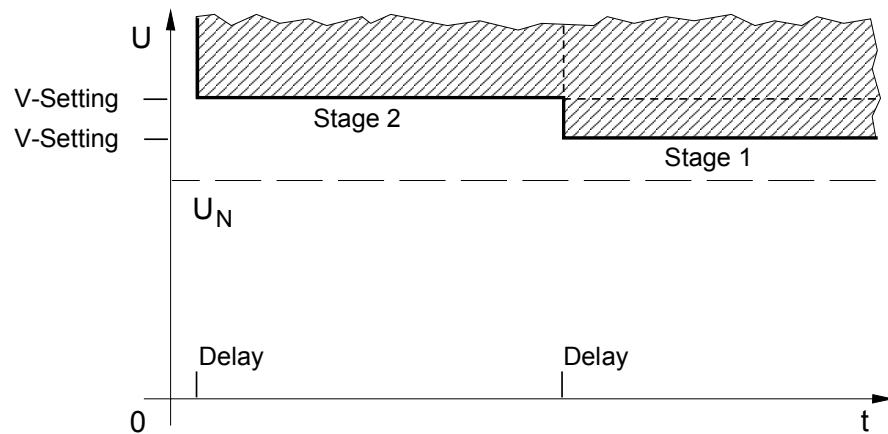
### Over/undervoltage setting (MaxMin)

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.



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Fig. 3.5.10.1 Operating characteristic of the definite time over-voltage function  
 $U_N$  = rated voltage of the protection

#### Typical settings:

##### 1st. Stage

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

##### 2nd. Stage

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

## 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 of generator/transformer units.

### Description

The standard zone of protection of generators of generator/transformer units is 95 % of the length of the stator winding (see Fig. 3.5.10.2). 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 both cases, 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. 3.5.10.2).

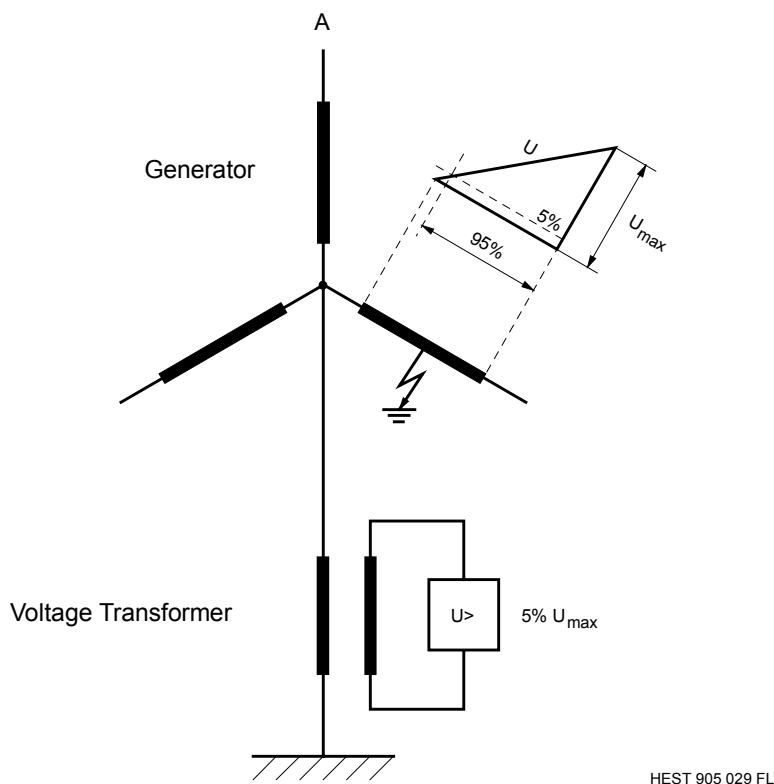
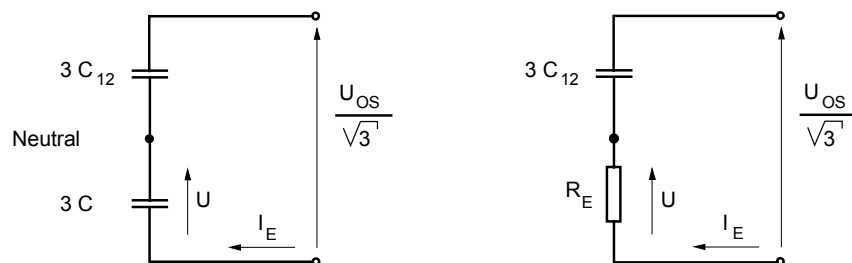


Fig. 3.5.10.2 Stator E/F protection for the generator of a generator/transformer unit

As can be seen from Fig. 3.5.10.2, 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, which determines the potential of the generator star-point (see Fig. 3.5.10.3a). The value of the capacitance  $C$  is usually too low to definitely 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. 3.5.10.4), 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 off-set 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. 3.5.10.3 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 off-set
$U_{OS}$	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, which can be caused by an E/F current, 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

#### 1. Version with grounding resistor and v.t. (see Fig. 3.5.10.4)

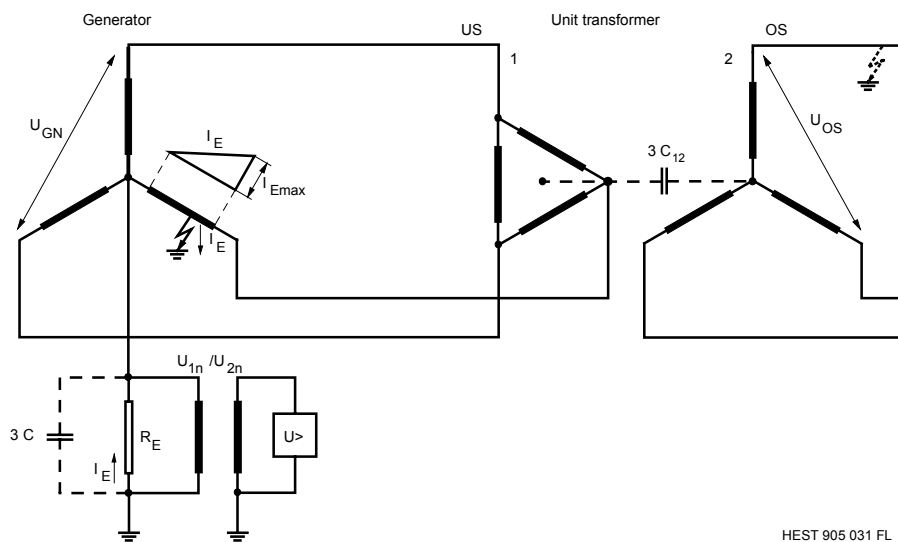


Fig. 3.5.10.4 Stator E/F protection with a grounding resistor at the star-point

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

- the maximum E/F current  $I_E \leq 20$  A
- the off-set 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, which can be produced by 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

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

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

The minimum value of the resistor  $R_{Emin}$ :

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

where  $I_{Emax} \leq 20$  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. 3.5.10.3b:

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

where:

Factor 0.05 - protection sensitivity 5 % (95 % scheme)

Factor 6 - 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  $\Omega$ ;    10 A;    10 s1 v.t.                       $\frac{12000}{\sqrt{3}} / 100 \text{ V}$ ;    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  $\Omega$ ;    2.3 A;    10 s1 v.t.                       $\frac{12000}{\sqrt{3}} / 100 \text{ V}$ ;    single-phase insulation

## 2. Version with grounding transformer (see Fig. 3.5.10.5)

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:

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

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

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

$$I_{2n} = I_e$$

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

The grounding resistor  $R_e$  connected to the secondary is give by

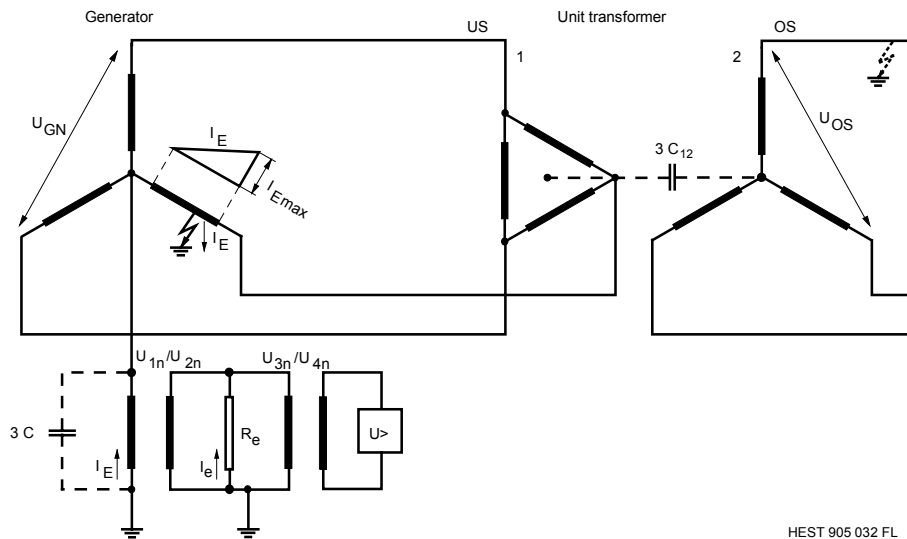
$$R_e = \frac{U_{GN}}{\sqrt{3} I_{E\max}} \left( \frac{U_{2n}}{U_{1n}} \right)^2$$

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

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

Rated power of the grounding transformer:

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



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Fig. 3.5.10.5 Stator E/F protection with a grounding transformer at the star-point

### Example 2

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

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

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

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

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

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

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

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

Specification:

1 grounding transformer 70 kVA; 10 s; 50 Hz

6930/200 V; 10/346 A

1 resistor 0.577  $\Omega$ ; 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.

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

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

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

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

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

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

Specification:

1 grounding transformer	120 kVA;	10 s;	50 Hz
	12000/230 V;	10/522 A	
1 resistor	0.254 $\Omega$ ;	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. 3.5.10.6). In this case, the E/F current is supplied 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.

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

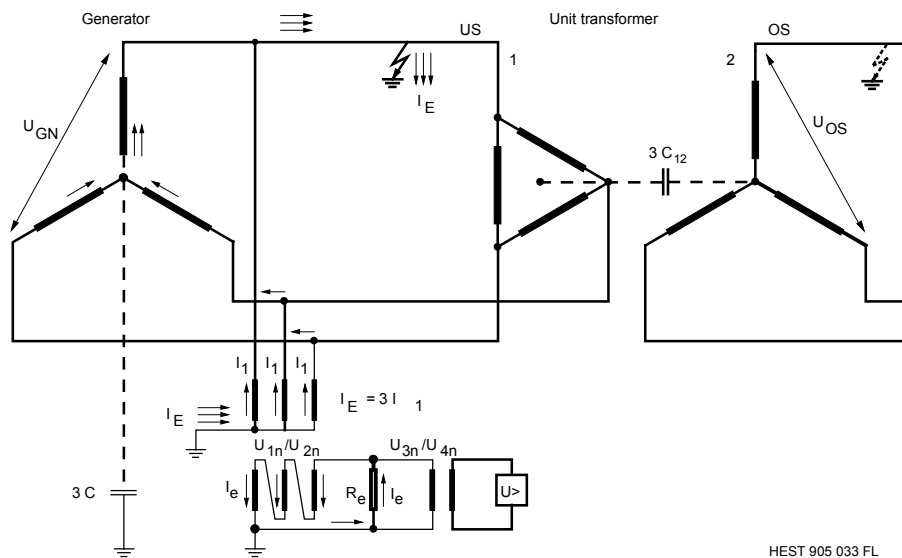


Fig. 3.5.10.6 Stator E/F protection with grounding transformer at the generator terminals

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

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

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 is calculated using

$$R_{e\max} \leq \frac{0.05 U_{GN}}{6\omega C_{12} U_{HV}} \left( \frac{3U_{2n}}{U_{1n}} \right)^2$$

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  $3 U_{2n}$ . 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

$U_{GN} = 12$  kV;  $U_{HV} = 110$  kV;  $C_{12} = 3 \times 10^{-9}$  F;  $\omega = 314$  1/s  
HV system ungrounded.

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

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

$$R_{e\min} \geq \frac{12000}{\sqrt{3} \times 15} \left( \frac{3U_{2n}}{6930} \right)^2 \times 0.7 = 0.60 \times 10^{-4} \times U_{2n}^2$$

$$R_{e\max} \leq \frac{0.05 \times 12}{6 \times 314 \times 3 \times 10^{-9} \times 110} \left( \frac{3U_{2n}}{6930} \right)^2 = 1.81 \times 10^{-4} \times U_{2n}^2$$

Since from this calculation  $R_{e\max}$  is greater than  $R_{e\min}$ , the stability of the protection at the chosen current  $I_{E\max}$  is assured and the value of the resistor  $R_e$  can be determined in relation to  $R_{e\min}$ .

$$I_e = 200$$
 A

$$U_{2n} = 6930 \frac{15}{3 \times 200} = 173$$
 V

It then follows that

$$R_{\text{emin}} \geq 0.60 \times 10^{-4} \times 173^2 = 1.80 \, \Omega$$

$$R_{\text{emax}} \leq 1.81 \times 10^{-4} \times 173^2 = 5.42 \, \Omega$$

$$R_e = 1.80 \, \Omega$$

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  $1.80 \, \Omega$ ; 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 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

$U_{\text{GN}} = 27 \text{ kV}$ ;  $U_{\text{HV}} = 400 \text{ kV}$ ;  $C_{12} = 3 \times 10^{-9} \text{ F}$ ;  $x = 314 \text{ 1/s}$

HV system solidly grounded

$$I_E = 15 \text{ A}$$

$$U_{\text{in}} = \frac{U_{\text{GN}}}{\sqrt{3}} = \frac{27000}{\sqrt{3}} = 15600 \text{ V}$$

$$R_{\text{emin}} \geq \frac{27000}{\sqrt{3} \times 15} \left( \frac{3 U_{2n}}{15600} \right)^2 = 27 \times 10^{-6} \times U_{2n}^2$$

$$R_{e\max} \leq \frac{0.05 \times 27}{6 \times 314 \times 3 \times 10^{-9} \times \frac{400}{6}} \left( \frac{3 U_{2n}}{15600} \right)^2 = 132 \times 10^{-6} \times U_{2n}^2$$

$$I_e = 250 \text{ A (chosen)}$$

$$U_{2n} = 15600 \frac{15}{3 \times 300} = 260 \text{ V}$$

The resistor  $R_e$  is chosen according to  $R_{e\min}$ :

$$R_e = 27 \times 10^{-6} \times 260^2 = 1.825 \Omega$$

$$R_e I_e = 1.825 \times 300 = 547 \text{ V}$$

$$3 U_{2n} = 3 \times 260 = 780 \text{ V}$$

$$S = \sqrt{3} \times 260 \times 300 = 135 \times 10^3 \text{ VA}$$

The specification and the modification of the protection setting is similar to Example 4.

#### Typical settings:

$$\text{V-Setting} \quad 0.05 U_N$$

$$\text{Delay} \quad 0.5 \text{ s}$$

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 off-set 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.

$$\text{V-Setting} = 0.6 U_N$$

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.

## 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 excitation system in use. 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, which 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 $\Omega$ , which is considered as being an E/F. The voltage setting for the scheme is therefore determined during commissioning.

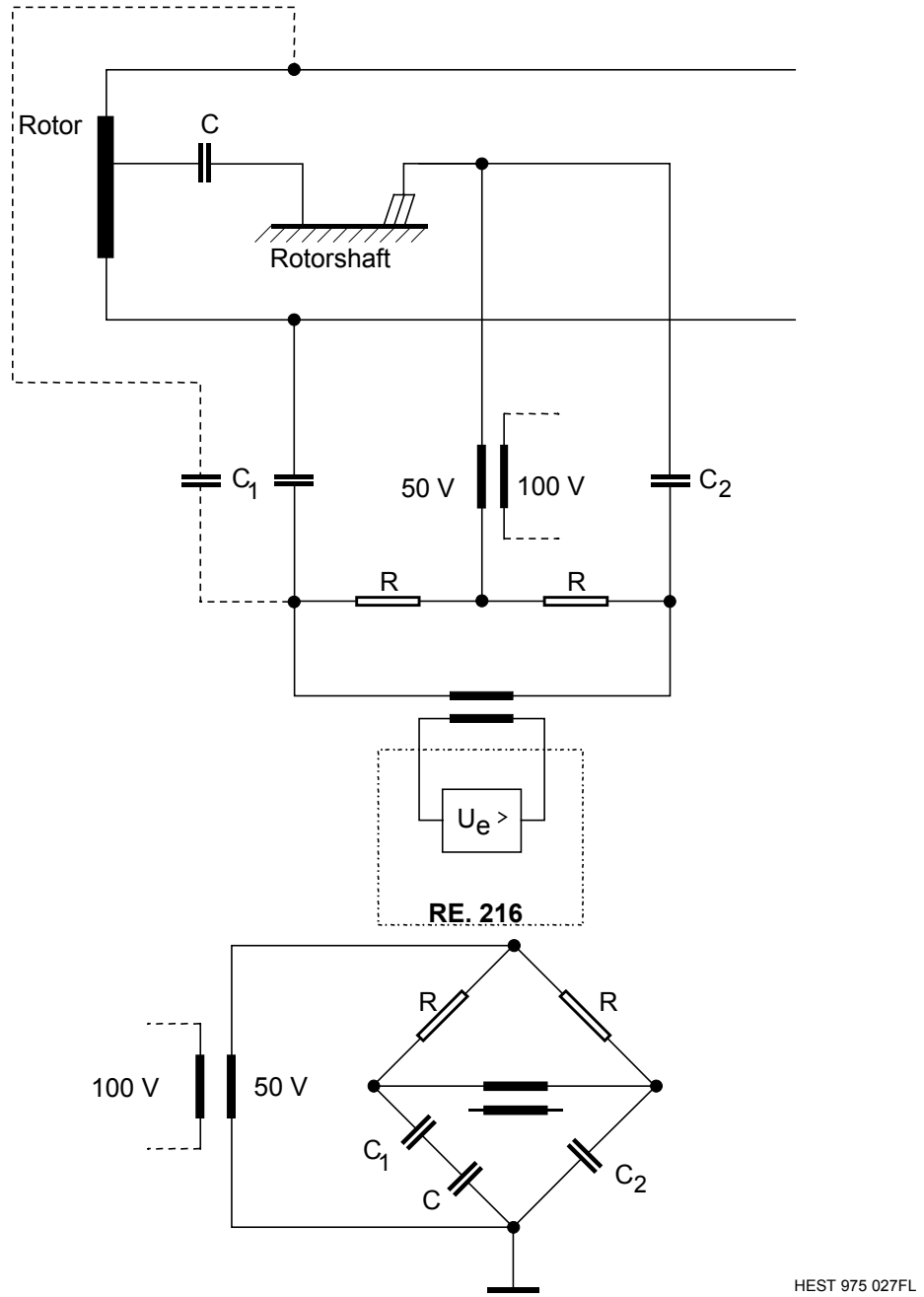


Fig. 3.5.10.7 Rotor E/F protection function  
 $C_1, C_2$  = external coupling capacitances

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**Typical settings:**

V-Setting (for 1 k $\Omega$ )	1 to 3 V
Delay	1 s
MaxMin	MAX



## 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

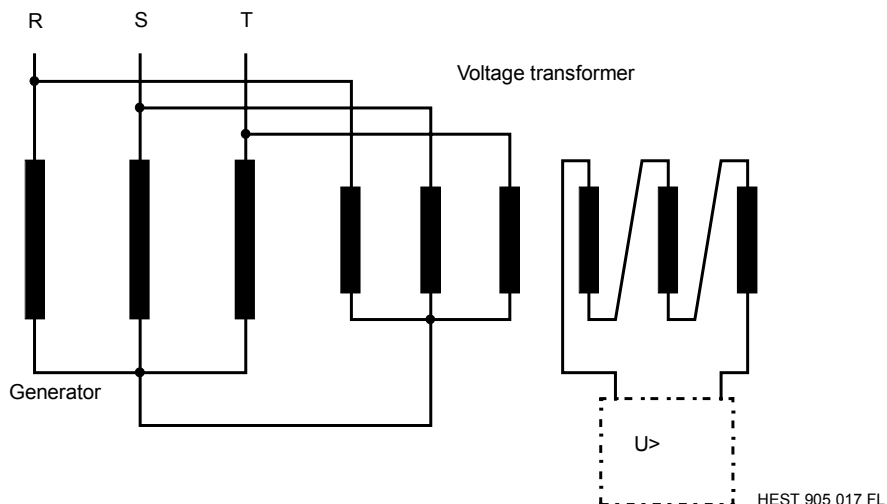


Fig. 3.5.10.8 Interturn protection according to the voltage prin



### **3.5.11. Peak value overvoltage (Voltage-Inst)**

#### **A. Application**

- General voltage monitoring with instantaneous response (over and under)
- Voltage monitoring where insensitivity to frequency is required (over and under).

#### **B. Features**

- processes instantaneous values and 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
RunOnCPU		CPU1		(Select)	
ParSet 4..1		P1		(Select)	
Trip 01-08		00000000			
Trip 09-16		00000000			
Trip 17-24		00000000			
Trip 25-32		00000000			
Delay	s	00.01	0.00	60.00	0.01
V-Setting	UN	1.4	0.01	2	0.01
f-min	Hz	040.0	25	50	1
MaxMin		MAX		(Select)	
NrOfPhases		001	1	3	2
VoltageInp	CT/VT-Addr.	00000			
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr	ER			

### Explanation of parameters:

#### RunOnCPU

defines the processing unit which runs the function.

#### ParSet 4..1

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

#### Trip 01-08

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

#### Trip 09-16

corresponds to Trip 01-08 (providing tripping unit fitted).

#### Trip 17-24

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 25-32**

corresponds to Trip 01-08 (providing tripping unit fitted).

**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. voltage input channel.

All voltage 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**

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)

**Start**

Output for signalling pick-up.

(signal address)

## 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  $f < f_N$ .  
The maximum permissible voltage at  $f = f_N$  is  $2.25 U_N$  and reduces in proportion to  $f/f_N$  at lower frequencies.
- 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 ([Section 3.5.10.](#)), 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 ([Section 3.5.6.](#)) 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.

### Typical settings:

V-Setting	according to application
Delay	according to application
f-min	40 Hz

### 3.5.12. **Balanced voltage (Voltage-Bal)**

#### **A. Application**

Monitoring/comparison of two groups of single or three-phase voltage inputs to prevent incorrect voltage measurement.

#### **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. C.t./v.t. 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
RunOnCPU		CPU1		(Select)	
ParSet 4..1		P1		(Select)	
Trip 01-08		00000000			
Trip 09-16		00000000			
Trip 17-24		00000000			
Trip 25-32		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		003	1	3	2
VoltInpLine1	CT/VT-Addr.	00000			
VoltInpLine2	CT/VT-Addr.	00000			
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr	ER			
Trip-Line1	SignalAddr				
Trip-Line2	SignalAddr				

### Explanation of parameters:

#### RunOnCPU

defines the processing unit which runs the function.

#### ParSet 4..1

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

#### Trip 01-08

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

#### Trip 09-16

corresponds to Trip 01-08 (providing tripping unit fitted).



**Trip 17-24**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 25-32**

corresponds to Trip 01-08 (providing tripping unit fitted).

**V-Unbalance**

Voltage difference setting for tripping.

Value of the 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. 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. 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→FALSE, T→TRUE, binary input or output of a protection function).

**Trip**

Output for signalling tripping  
(signal address).

**Start**

Output for signalling pick-up  
(signal address).

**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).

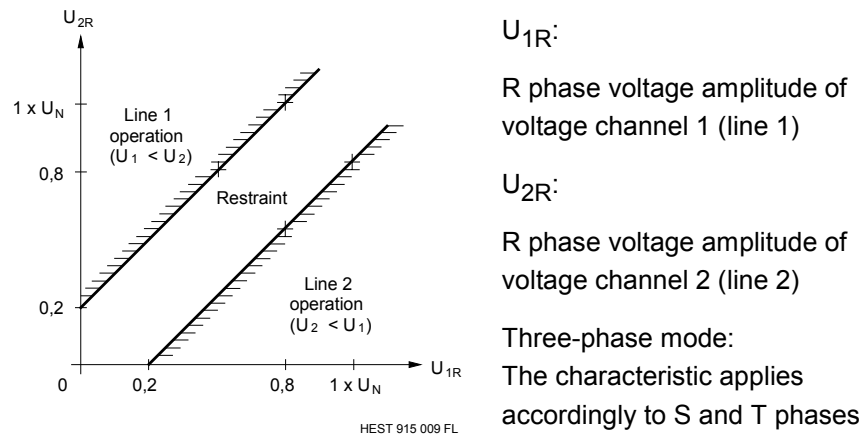


Fig. 3.5.12.1 Operating characteristic of the balanced voltage function (shown for R phase and the setting V-Unbalance =  $0.2 \times U_N$ )

## E. Setting instructions

### Settings:

Max. voltage difference	V-Unbalance
Delay	Delay
Reset delay	t-Reset

The balanced voltage function is intended mainly for preventing incorrect voltage measurement 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) and 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 voltages of similar sources, which 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 groups and by the same input unit. The purpose of this is to limit signal conditioning er

rors 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:

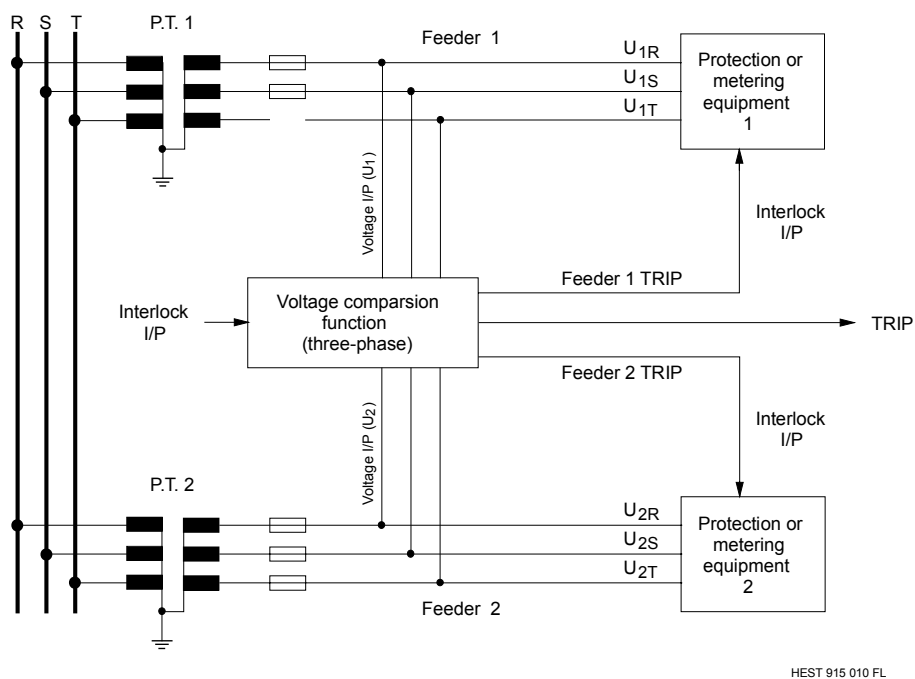


Fig. 3.5.12.2 Three-phase balanced voltage scheme (one measured voltage failed)

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



### 3.5.13. *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. C.t./v.t. 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
RunOnCPU		CPU1	(Select)		
ParSet 4..1		P1	(Select)		
Trip 01-08		00000000			
Trip 09-16		00000000			
Trip 17-24		00000000			
Trip 25-32		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	CT/VT-Addr.	00000			
VoltageInp	CT/VT-Addr.	00000			
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr	ER			

### Explanation of parameters:

#### RunOnCPU

defines the processing unit which runs the function.

#### ParSet 4..1

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

#### Trip 01-08

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

#### Trip 09-16

corresponds to Trip 01-08 (providing tripping unit fitted).

#### Trip 17-24

corresponds to Trip 01-08 (providing tripping unit fitted).



**Trip 25-32**

corresponds to Trip 01-08 (providing tripping unit fitted).

**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 current 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.

**VoltageInp**

defines the voltage input channel.

All voltage I/P's 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→FALSE, T→TRUE, binary input or output of a protection function).

**Trip**

Output for signalling tripping.  
(signal address).

**Start**

Output for signalling pick-up.  
(signal address).

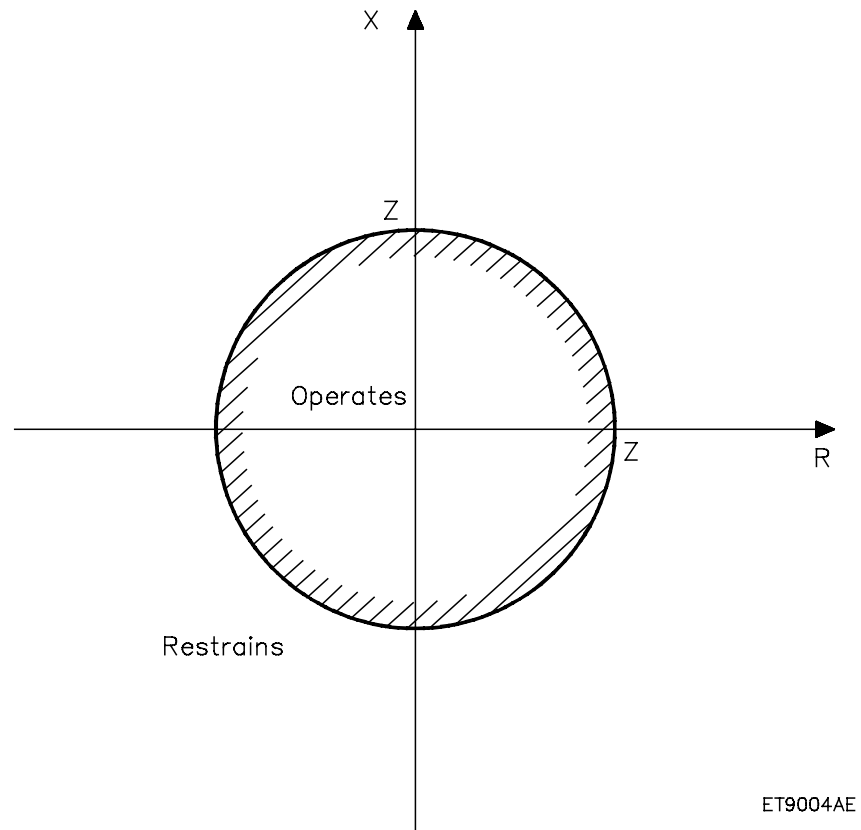


Fig. 3.5.13.1 Operating characteristic of the underimpedance function

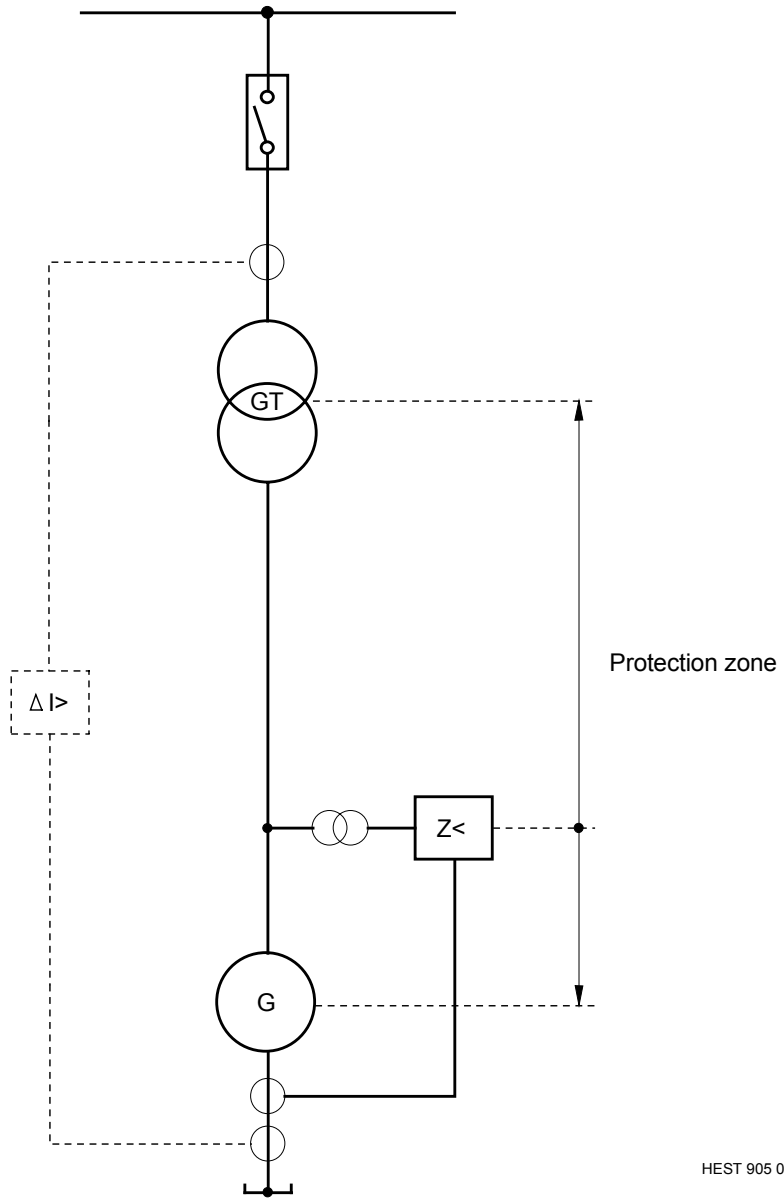
## E. Setting instructions

### 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.



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Fig. 3.5.13.2 Underimpedance protection

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:

$$z_1 = 0.7 x_T \quad [\text{p.u.}]$$

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:

$$K_i = \frac{I_{N1}}{I_{N2}} \qquad K_u = \frac{U_{N1}}{U_{N2}}$$

The impedance to be set on the protection in p.u. is:

$$\text{Z-Setting} = 0.7 x_T \frac{U_{TN}}{I_{TN}} \times \frac{K_i}{K_u} \times \frac{I_N}{U_N} \quad [1; 1; \text{V}; \text{A}]$$

or

$$\text{Z-Setting} = 0.7 x_T \frac{U_{TN}}{I_{TN}} \times \frac{I_{N1}}{I_{N2}} \times \frac{U_{N2}}{U_{N1}} \times \frac{I_N}{U_N} \quad [1; 1; \text{V}; \text{A}]$$

For simple cases where  $U_{TN} = U_{N1}$ ,  $I_{TN} = I_{N1}$ ,  $U_{N2} = U_N$  and  $I_{N2} = I_N$ :

$$\text{Z-Setting} = 0.7 x_T [1; 1]$$

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 price of a zone of protection, which is shorter than that of the differential protection.

**Example:**

Transformer: 500 MVA; 24 kV; 12 kA;  $x_T = 0.1$

C.t's and v.t's: 24000/100 V; 12000/5 A

Protection: 100 V; 5 A

$$K_i = \frac{I_{N1}}{I_{N2}} = \frac{12000}{5} = 2400$$

$$K_u = \frac{U_{N1}}{U_{N2}} = \frac{24000}{100} = 240$$

Settings:

$$Z\text{-Setting} = 0.7 \times x_T \times \frac{U_{TN}}{I_{TN}} \times \frac{K_i}{K_u} \times \frac{I_N}{U_N}$$

$$Z\text{-Setting} = 0.7 \times 0.1 \times \frac{24}{12} \times \frac{2400}{240} \times \frac{5}{100} = 0.07$$

It must not be forgotten that a current of at least  $0.1 I_N$  must flow to enable the underimpedance function.

**Typical settings:**

Z-Setting	0.07
Delay	0.5 s

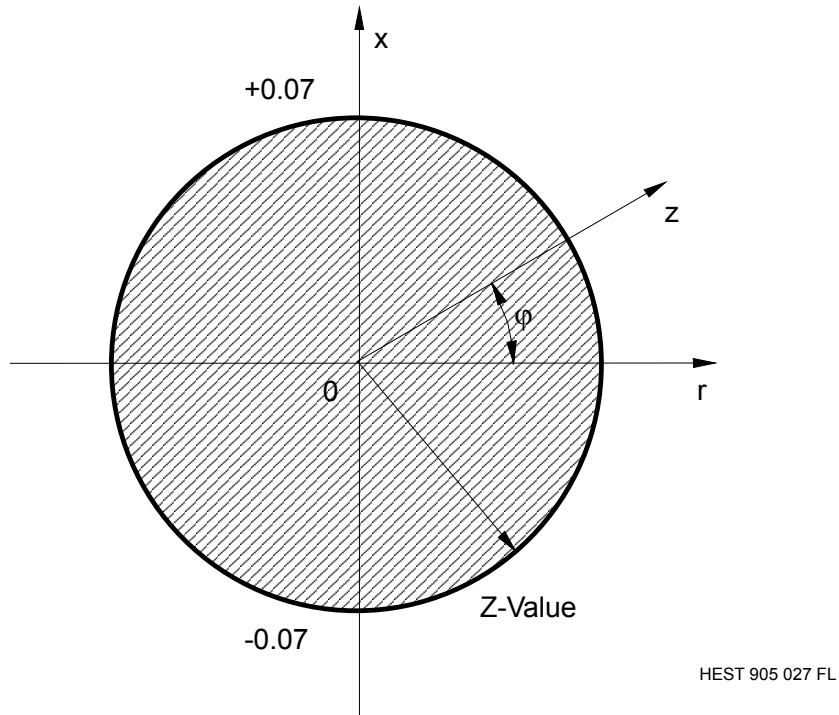


Fig. 3.5.13.3 Operating characteristic of the underimpedance function

Setting: Z-Setting = 0.03





### 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. C.t./v.t. 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
RunOnCPU		CPU1		(Select)	
ParSet 4..1		P1		(Select)	
Trip 01-08		00000000			
Trip 09-16		00000000			
Trip 17-24		00000000			
Trip 25-32		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			
NrOfPhases		001	1	3	1
CurrentInp	CT/VT-Addr.	00000			
VoltageInp	CT/VT-Addr.	00000			
Angle	deg	000	-180	180	5
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr				

### Explanation of parameters:

#### RunOnCPU

defines the processing unit which runs the function.

#### ParSet 4..1

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

#### Trip 01-08

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

#### Trip 09-16

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 17-24**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 25-32**

corresponds to Trip 01-08 (providing tripping unit fitted).

**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 current 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.

**VoltageInp**

defines the voltage input channel.

All voltage I/P's 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.

Voltage and current channels must be sampled by the same 216EA61 unit.

**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→FALSE, T→TRUE, binary input or output of a protection function)

**Trip**

Output for signalling tripping

(signal address)

**Start**

Output for signalling pick-up

(signal address)

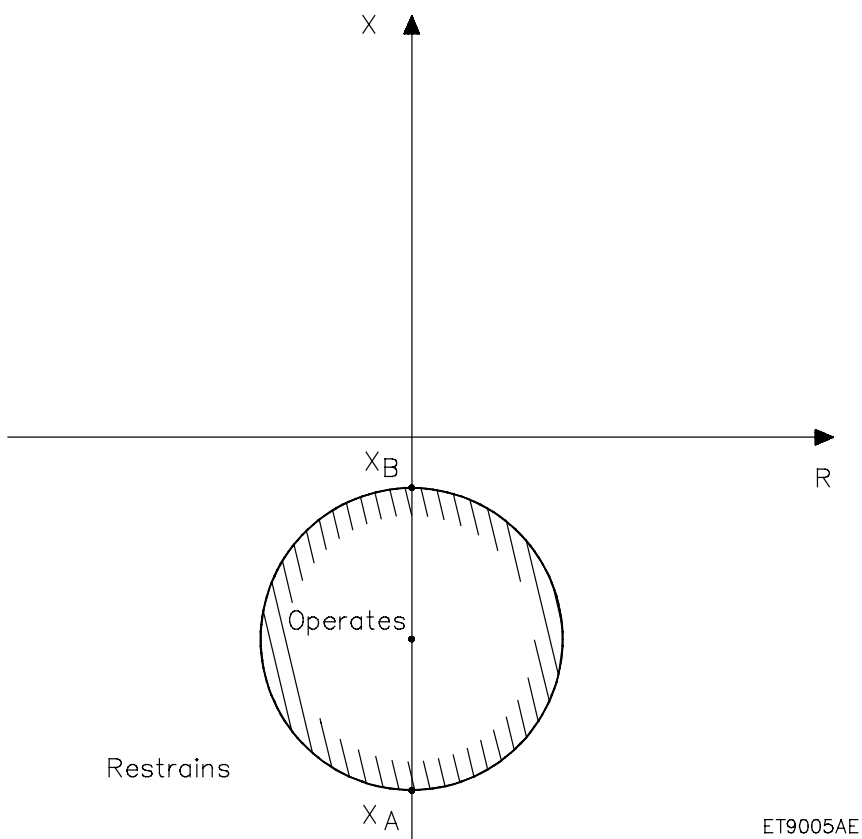


Fig. 3.5.14.1 Operating characteristic of the underreactance function with MaxMin = MIN (default)

## E. Setting instructions

### Settings:

Reactance $X_A$	XA-Setting
Reactance $X_B$	XB-Setting
Phase correction	Angle
Delay	Delay
Integrator	Trip time
	Reset time

### Operating principle of the underreactance function

The underreactance or underexcitation function protects the generator in various 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 fall 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  $\varphi$ . 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, which does not coincide with the stability limit circuit 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.

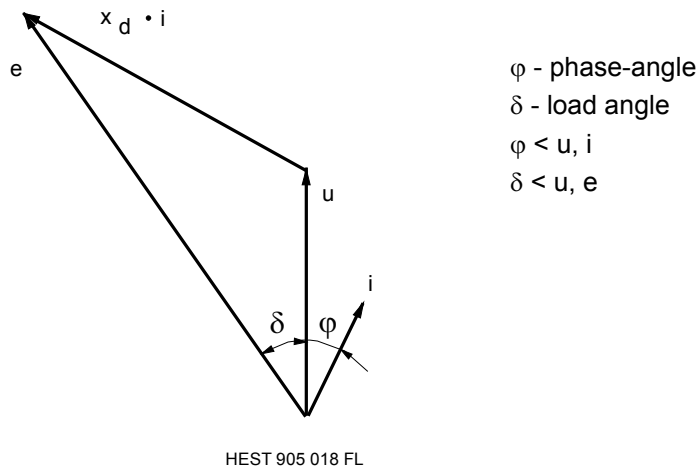
The scheme includes an integrator, which maintains the underexcitation signal in the event of power swings, where the normal time delay would repeatedly reset and prevent tripping from taking place.

**Determining the characteristic of the protection function**

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  $\delta$  is also determined by this angle. 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

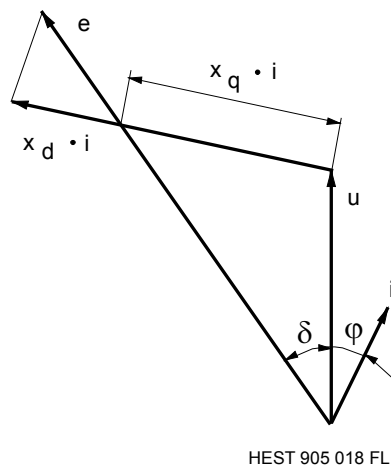


Fig. 3.5.14.2 Vector diagram of an overexcited generator. Voltages, currents and reactances are in p.u.

The reactances  $X_A$  and  $X_B$ , are defined according to the phase-to-phase voltages and calculated for turboalternators as follows:

$$X_A = x_d \times \frac{U_{GN}}{\sqrt{3} I_{GN}} \times \frac{K_i}{K_u} \sqrt{3}$$

$$X_B = \frac{x'_d}{2} \frac{U_{GN}}{\sqrt{3} I_{GN}} \times \frac{K_i}{K_u} \sqrt{3}$$

In the above equation,  $x_q$  is replaced by  $x_d$  for salient pole units.

$$K_i = \frac{I_{N1}}{I_{N2}}$$

$$K_u = \frac{\frac{U_{N1}}{\sqrt{3}}}{\frac{U_{N2}}{\sqrt{3}}} = \frac{U_{N1}}{U_{N2}}$$

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 500 MVA; 24 kV; 12 kA  
 $x_d = 2.0$ ;  $x'_d = 0.25$

$$V.t's \quad K_u = \frac{\frac{U_{N1}}{\sqrt{3}}}{\frac{U_{N2}}{\sqrt{3}}} = \frac{24000}{100} = 240$$

$$C.t's \quad K_i = \frac{12000}{1} = 12000$$

$$X_A = x_d \times \frac{U_{GN}}{\sqrt{3} I_{GN}} \times \frac{K_i}{K_u} \sqrt{3} = 2.0 \times \frac{24000}{\sqrt{3} \cdot 12000} \times \frac{12000}{240} \sqrt{3} = 200.0 \Omega$$

$$X_B = \frac{x'_d}{2} \times \frac{U_{GN}}{\sqrt{3} I_{GN}} \times \frac{K_i}{K_u} \sqrt{3} = \frac{0.25}{2} \times \frac{24000}{\sqrt{3} \cdot 12000} \times \frac{12000}{240} \sqrt{3} = 12.5 \Omega$$

The reactance settings referred to the protection ratings  $U_N$  and  $I_N$  become:

$$X_A \text{ set} = \frac{X_A}{U_N} I_N = -\frac{200}{100} \times 1 = -2.0$$

$$X_B \text{ set} = \frac{X_B}{U_N} I_N = -\frac{12.5}{100} \times 1 = -0.125 = 0.12$$



## 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 correction "Angle"
RS		+30°
ST *)		-90°
TR *)		+150°

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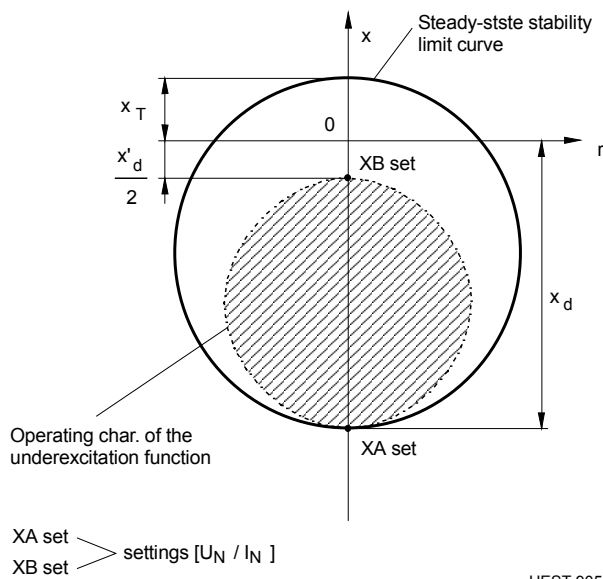
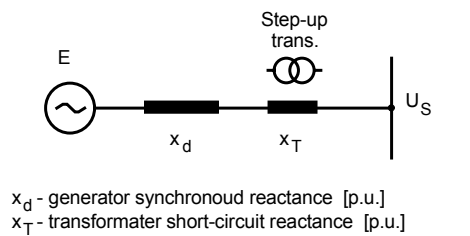
\*) for single-phase measurement

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.

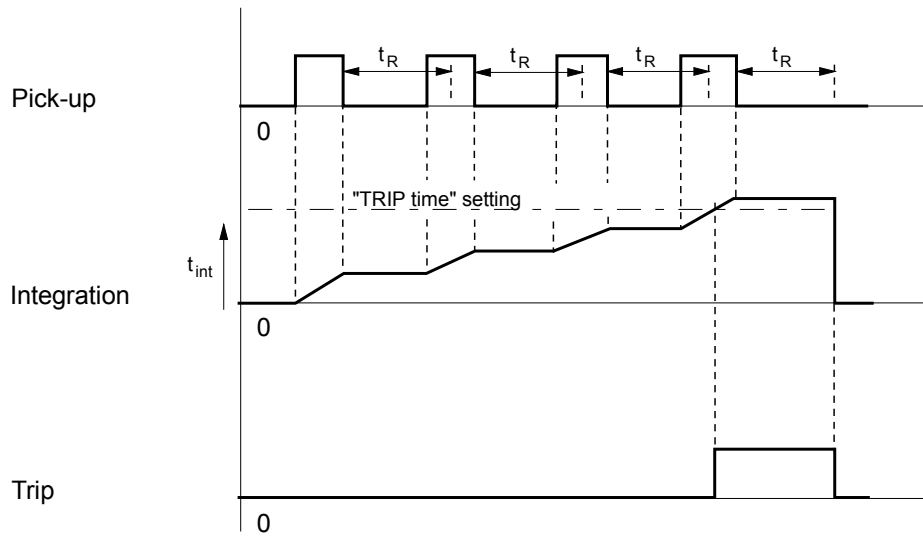
If the c.t. starpoint is earthed secondarily in the direction of the generator starpoint, then an angle of -180° has to be added.

**Typical settings:**

XA-Setting		according to application e.g. -2.0
XB-Setting		according to application e.g. -0.12
Angle	(delta-connected v.t's) (Y-connected v.t's)	+30° 0°
Tripping delay timer		
Delay		2 s
Tripping integrator with		
Trip time		6 s
and with reset delay		
Reset time		3 s



**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:

$$x_d = 2; \quad X_d' = 0,2$$

$$z \leq \frac{1}{2} (2 - 0,1) = 0,95$$

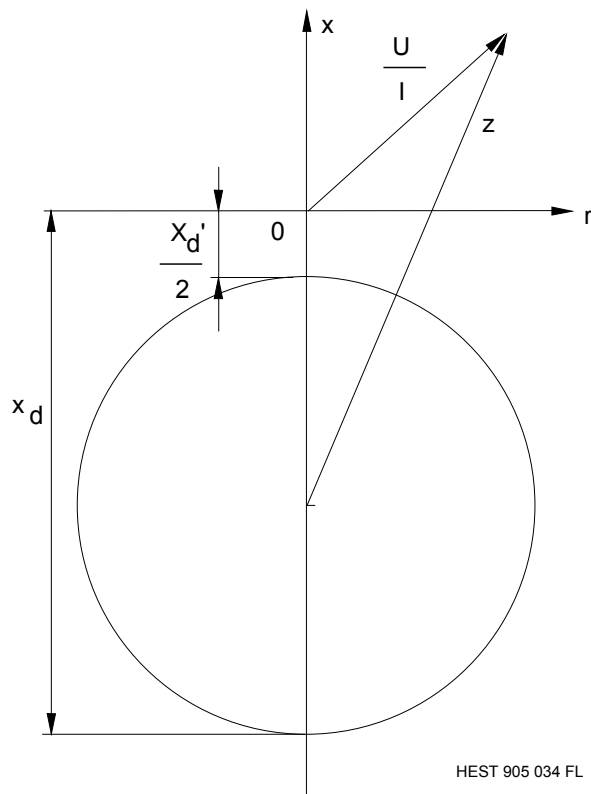


Fig. 3.5.14.5 Display of the impedance measured by the underreactance function

### 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
- wide setting ranges  
(see Fig. 3.5.15.2 to 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
RunOnCPU		CPU1		(Select)	
ParSet 4..1		P1		(Select)	
Trip 01-08		00000000			
Trip 09-16		00000000			
Trip 17-24		00000000			
Trip 25-32		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.	00000			
VoltageInp	CT/VT-Addr.	00000			
PN	UN*IN	1.000	0.500	2.500	0.001
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr				

### Explanation of parameters:

#### RunOnCPU

defines the processing unit which runs the function.

#### ParSet 4..1

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

#### Trip 01-08

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

#### Trip 09-16

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 17-24**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 25-32**

corresponds to Trip 01-08 (providing tripping unit fitted).

**P-Setting**

Power setting for tripping.

Setting restrictions:

Power amplitude not less than:

- $0.005 P_N$  when connected to metering cores
- $0.020 P_N$  when connected to protection cores
- also  $n \times 0.005 P_N$  should the sampling groups for voltage and current be different in the analogue input circuit (to allow for possible errors for  $f \neq f_N$ ;  $n = 1 \dots 3$  according to the spacing of the sampling groups).

Allocation of the c.t./v.t. channels to the sampling groups:

Sampling group	C.t./v.t. channel Nos.
1	1... 6
2	7...12
3	13...18
4	19...24
5	25...30
6	31...36
7	37...42
8	43...48

In view of the required accuracy, the use of metering cores is recommended for settings  $\leq 0.2 P_N$ .

**Angle**

Angle between voltage and current for maximum sensitivity.

$0^\circ$  = active power measurement

$90^\circ$  = 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% – 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 whether over or underpower function.

Settings:

- MIN: overpower
- MAX: 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 analogue 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 selected must be specified. The other phases are derived from the same group.

**VoltageInp**

defines the voltage 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 selected must be specified. The other phases are derived from the same group.

**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**

Output for signalling tripping.  
(signal address)

**Start**

Output for signalling pick-up.  
(signal address)

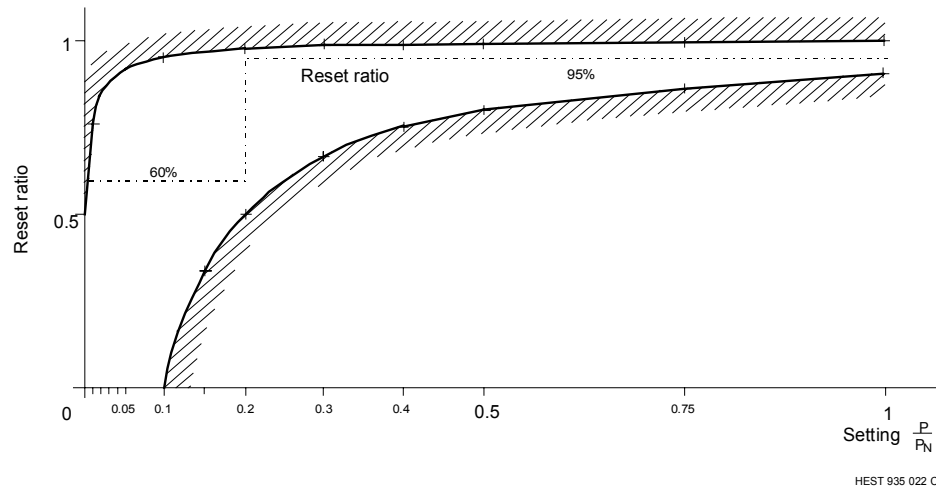


Fig. 3.5.15.1 Permissible reset ratio settings

## 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 Section 4.4.2.

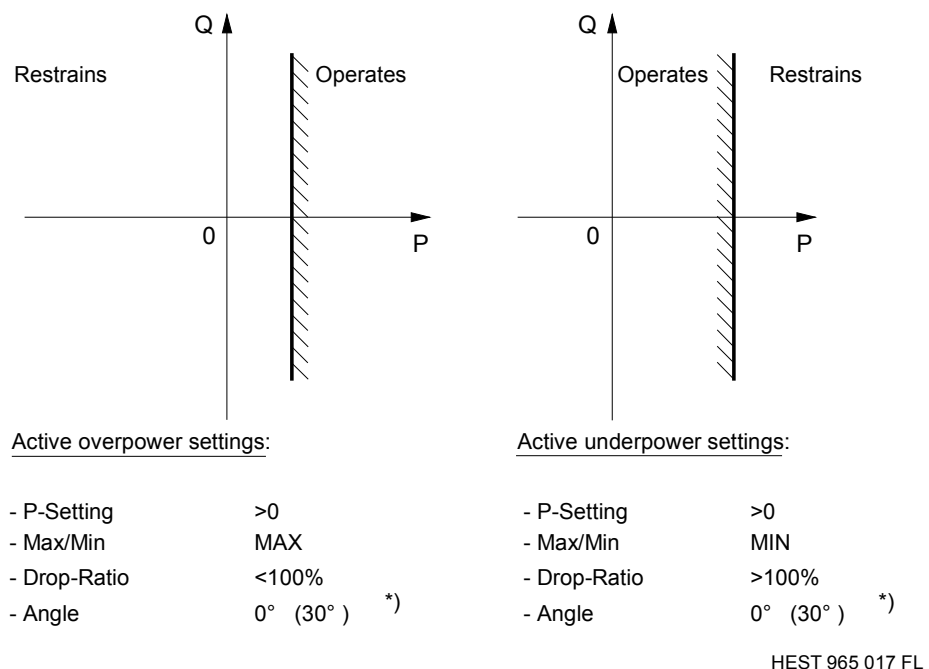
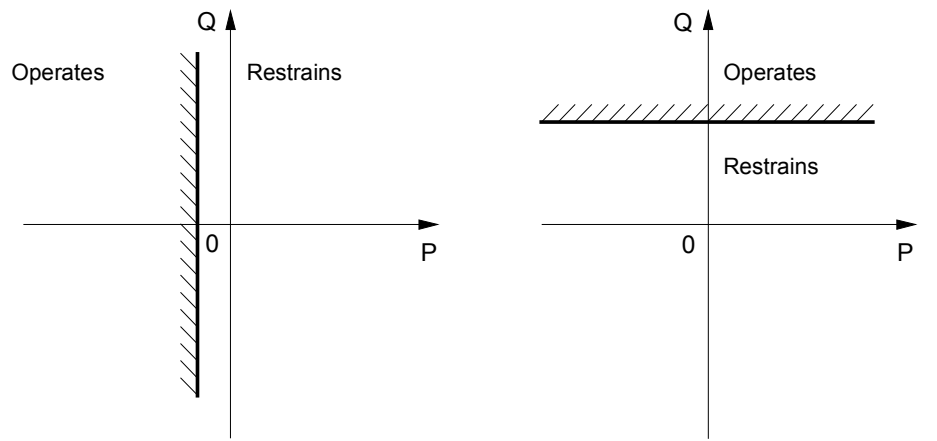


Fig. 3.5.15.2 Power function settings for different applications

\*) 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.

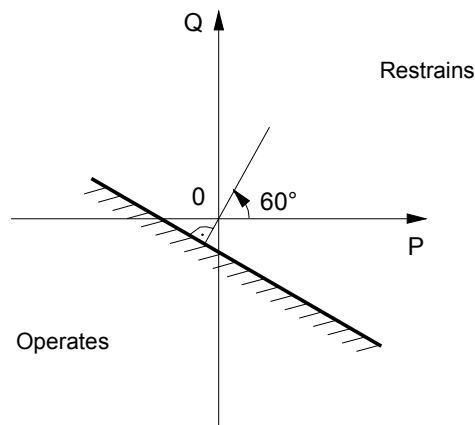


Reserve power settings:

- P-Setting <0
- Max/Min MIN
- Drop-Ratio <100%
- Angle 0° (30° \*)

Reactive overpower settings:

- P-Setting >0
- Max/Min MAX
- Drop-Ratio <100%
- Angle 90° (120° \*)



Directional power settings:

- P-Setting <0
- Max/Min MIN
- Drop-Ratio <100%
- Angle 60° (90° \*)

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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:

$$\text{Reference power } \frac{P_N}{U_N \times I_N} = \frac{P_{GN}}{S_{GN}} = \cos \varphi_{GN} = 0.8$$

$$\text{Reverse power: } \frac{P}{P_N} = 0.005 \frac{U_{GN} \times I_{GN}}{U_{N1} \times I_{N1}} = 0.005 \frac{13.8 \times 4}{14.4 \times 5} = 0.004$$

**Alternative 3: Modification for  $\varphi_{GN}$  and c.t./v.t.. data**

Settings:

Rated power

$$\frac{P_N}{U_N I_N} = \frac{U_{GN} \times I_{GN}}{U_{N1} \times I_{N1}} \cos \varphi_{GN} = \frac{13.8 \times 4}{14.4 \times 5} \times 0.8 = 0.614$$

$$\text{Reverse power } \frac{P}{P_N} = 0.005$$

**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 [Section 4.4.2](#).

The phase compensation also provides facility for changing the direction of measurement or to compensate incorrect v.t. or c.t. polarity.

Function		"Max/Min"	"Drop-Ratio"	Diagram		"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<sub>RS</sub>

## 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  $\cos\phi = 0$  for a total phase error  $\delta$  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.

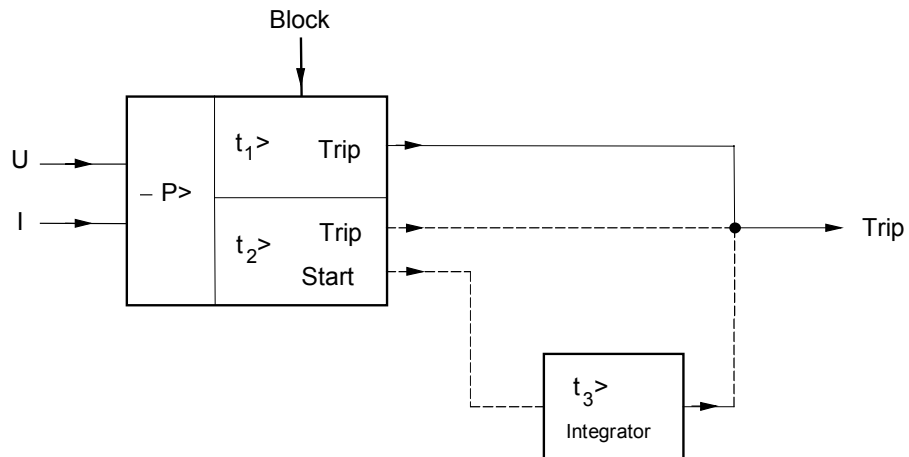
Two reverse power functions are used for prime movers with ratings higher than 30 MW, because of their importance and value.

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. 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. C.t./v.t. 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
RunOnCPU		CPU1		(Select)	
ParSet 4..1		P1		(Select)	
Trip 01-08		00000000			
Trip 09-16		00000000			
Trip 17-24		00000000			
Trip 25-32		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	CT/VT-Addr.	00000			
IB-Setting	IN	1.00	0.50	2.50	0.01
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr	ER			

**Explanation of parameters:****RunOnCPU**

defines the processing unit which runs the function.

**ParSet 4..1**

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

**Trip 01-08**

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

**Trip 09-16**

corresponds to Trip 01-08 (providing tripping unit fitted).

---

\*) k1 Max = 120.00 in versions  $\geq$  V5.2

**Trip 17-24**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 25-32**

corresponds to Trip 01-08 (providing tripping unit fitted).

**k1-Setting**

Multiplier. Operating characteristic constant.

**I-Start**

Enabling current for operating characteristic.

**t-min**

Minimum operating time. Operating characteristic constant.

**tg**

Time duration which the inverse characteristic is active.

Operating characteristic constant.

This may not be greater than 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.

**NrOfPhases**

defines whether single or three-phase measurement.

**CurrentInp**

defines the current input channel.

All current I/P's 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→FALSE, T→TRUE, binary input or output of a protection function)

**Trip**

Output for signalling tripping.  
(signal address)

## Start

Output for signalling pick-up.  
(signal address)

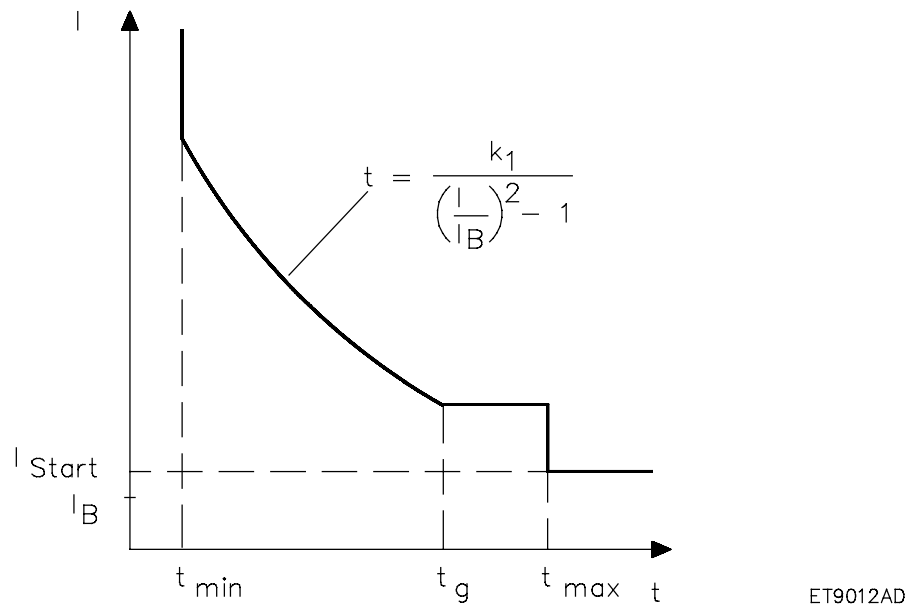


Fig. 3.5.16.1 Operating characteristic of the stator overload function

## E. Setting instructions

### Settings:

Reference current	IB-Setting
Enabling current	I-Start
Multiplier	k1-Setting
Minimum operating time	t-min
Duration of validity for the inverse char.	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 turbogenerators 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  $I_B$  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:

$$I_B = I_{B1} \frac{I_{N2}}{I_{N1}}$$

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

The multiplier  $k_1$  is 41.4 s for units designed according to ASA.

For units with a similar overload capacity:

$$k_1 = \tau \frac{\Delta\vartheta_m - \Delta\vartheta_n}{\Delta\vartheta_n} \quad [\text{s}; \text{s}; \text{K}]$$

where:

- $\tau$  : 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:**

$$\begin{aligned}\tau &= 5 \text{ min or } 300 \text{ s} \\ \Delta\vartheta_m &= 70 \text{ K} \\ \Delta\vartheta_n &= 60 \text{ K} \\ k1 &= 300 \frac{70 - 60}{60} = 50 \text{ s}\end{aligned}$$

**Typical settings:**

IB-Setting	according to protected unit
I-Start	1.1 IB
k1-Setting	41.4 s
t-min	10.0 s
t <sub>g</sub>	120.0 s
t-max	300.0 s
t-Reset	120.0 s



### **3.5.17. 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. C.t./v.t. 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
RunOnCPU		CPU1		(Select)	
ParSet 4..1		P1		(Select)	
Trip 01-08		00000000			
Trip 09-16		00000000			
Trip 17-24		00000000			
Trip 25-32		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	CT/VT-Addr.	00000			
IB set	IN	1.00	0.50	2.50	0.01
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr	ER			

### Explanation of parameters:

#### RunOnCPU

defines the processing unit which runs the function.

#### ParSet 4..1

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

#### Trip 01-08

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

#### Trip 09-16

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 17-24**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 25-32**

corresponds to Trip 01-08 (providing tripping unit fitted).

**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 may not be greater than 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 current input channel.

All current I/P's may be selected.

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

**IB set**

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

**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).

## Start

Output for signalling pick-up.  
(signal address).

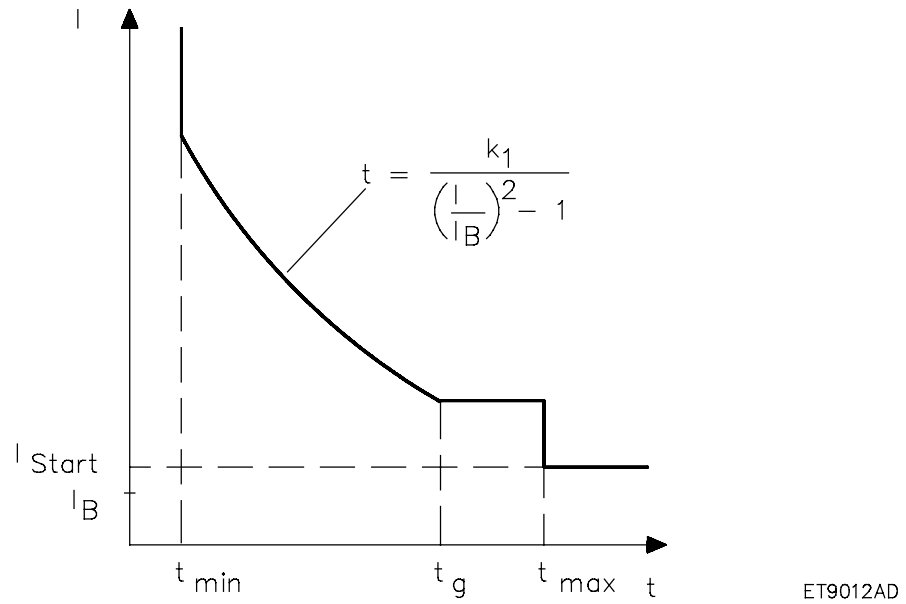


Fig. 3.5.17.1 Operating characteristic of the rotor overload functions

## E. Setting instructions

### Settings:

Reference current	IB set
Enabling current	I-Start
Multiplier	k1-Setting
Minimum operating time	t-min
Duration of validity for the inverse char.	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 turbogenerators 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  $I_{B1}$  of the excitation supply, which is usually the same as the full load excitation 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  $IB/I_N$ ,  $I_N$  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:

- $\tau$  : 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 set	according to protected unit
I-Start	1.1 IB
k1-Setting	33.8 s
t-min	10.0 s
tg	120.0 s
t-max	300.0 s
t-Reset	120.0 s

### 3.5.18. *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 asymmetrical load.

#### B. Features

- inverse time delay according to level of NPS (see Fig. 3.5.18.1)
- wide setting ranges for the operating characteristic parameters
- 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. C.t./v.t. inputs:

- current

##### II. Binary inputs:

- Blocking

##### III. Binary outputs:

- pick-up
- tripping

##### IV. Measurements:

- proportion of negative-sequence current component.

$$I_2 = 1/3 (I_R + a^2 I_S + a I_T)$$

**D. Inverse time NPS function settings - NPS-Inv**

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
RunOnCPU		CPU1		(Select)	
ParSet 4..1		P1		(Select)	
Trip 01-08		00000000			
Trip 09-16		00000000			
Trip 17-24		00000000			
Trip 25-32		00000000			
k1-Setting	s	10.00	5.00	60.00 *)	0.10
k2-Setting	I2/IB	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	CT/VT-Addr.	00000			
IB-Setting	IN	1.00	0.50	2.50	0.01
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr				

**Explanation of parameters:****RunOnCPU**

defines the processing unit which runs the function.

**ParSet 4..1**

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

**Trip 01-08**

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

**Trip 09-16**

corresponds to Trip 01-08 (providing tripping unit fitted).

---

\*) k1 Max = 60.00 in versions  $\geq$  V5.2



**Trip 17-24**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 25-32**

corresponds to Trip 01-08 (providing tripping unit fitted).

**k1-Setting**

Multiplier. Operating characteristic constant.

**k2-Setting**

Continuously permissible NPS ( $I_2/I_B$ ). Operating characteristic constant.

Setting restrictions:

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

not  $< 0.02 I_N/I_B$  when supplied from metering 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 by the machine to cool.

**CurrentInp**

defines the current input channel.

All three-phase current I/P's 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→FALSE, T→TRUE, binary input or output of a protection function).

**Trip**

Output for signalling tripping.  
(signal address).

**Start**

Output for signalling pick-up.  
(signal address).

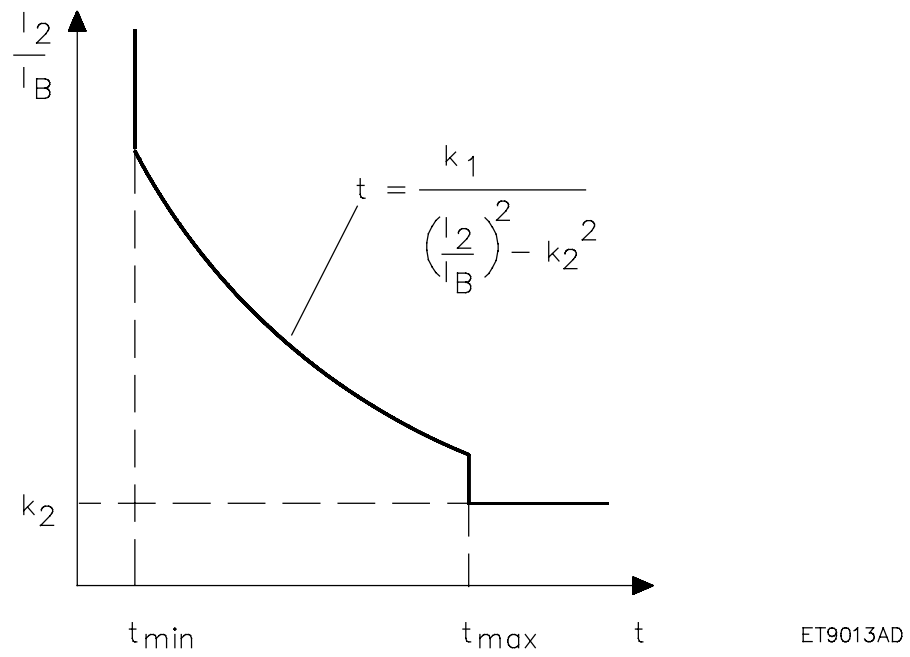


Fig. 3.5.18.1 Operating characteristic of the inverse time NPS function

## 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  $I_B$  for the protection is calculated from the c.t. rated currents  $I_{N1}$  and  $I_{N2}$  as follows:

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

The setting is the ratio  $I_B/I_N$ , 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

### 3.5.19. **Overtemperature (Overtemp)**

#### **A. Application**

Overtemperature protection using a thermal image of the protected unit.

#### **B. Features**

- selectable thermal image for:
  - 1st. order model
  - universal thermal image defined by the impulse response of the thermal system (see Fig. 3.5.19.1)
- alarm and tripping stages
- adjustable initial temperature rise
- extended thermal time constant when stationary
- takes account of temperature coefficient of resistance
- insensitive to d.c. components
- insensitive to harmonics
- single or three-phase measurement
- highest phase value detection in the multi-phase mode
- independent scaling of the impulse response for the universal thermal image (entry of a table)
- 40 temperature rise calculations per thermal time constant (for 1st. order model) or 200 calculations per duration of the impulse response.

#### **C. Inputs and outputs**

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

- current

##### **II. Binary inputs:**

- blocking
- standstill

##### **III. Binary outputs:**

- alarm
- tripping

##### **IV. Measurements:**

- temperature rise
- power dissipation
- current.

**D. Overtemperature function settings - Overtemp**

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
RunOnCPU		CPU1	(Select)		
ParSet 4..1		P1	(Select)		
Trip 01-08		00000000			
Trip 09-16		00000000			
Trip 17-24		00000000			
Trip 25-32		00000000			
Theta-Begin	%	100	000	100	001
Theta-Warn	%	105	050	200	001
Theta-Trip	%	110	050	200	001
Temp.-Coeff.	1/ThetaN	0.00	0.00	1.00	0.01
k-Setting		1	1	9	1
NrOfPhases		1	1	3	2
CurrentInp	CT/VT-Addr.	00000			
IB-Setting	IN	1.00	0.50	2.50	0.01
Stillst.-Inp	BinaryAddr	F			
BlockInp	BinaryAddr	F			
Warning	SignalAddr	ER			
Trip	SignalAddr	ER			
TimeConstant	min	005.0	000.0	500.0	000.1
ResponseTime	min	0000.	0005.	6000.	0001.
h [ 1]		00.00	-00.20	02.00	00.01
h [ 2]		00.00	-00.20	02.00	00.01
h [ 3]		00.00	-00.20	02.00	00.01
.					
.					
.					
h [40]		00.00	-00.20	02.00	00.01

**Explanation of parameters:**

RunOnCPU

defines the processing unit which runs the function.

#### ParSet 4..1

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

#### Trip 01-08

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

#### Trip 09-16

corresponds to Trip 01-08 (providing tripping unit fitted).

#### Trip 17-24

corresponds to Trip 01-08 (providing tripping unit fitted).

#### Trip 25-32

corresponds to Trip 01-08 (providing tripping unit fitted).

#### Theta-Begin

Initial temperature rise.

This is the temperature rise from which the protection starts after it has been initialised, i.e. after switching on or after saving new parameter settings.

A setting of 100 % is recommended for a unit, which is already warm; a setting of 0 % is recommended for a unit starting at room temperature in order to obtain the maximum utilisation during the start-up period.

#### Theta-Warn

temperature at which an alarm is initiated.

#### Theta-Trip

temperature at which a trip is initiated.

#### Temp.-Coeff.

temperature coefficient "a" for taking account of the increased resistance of the conductor due to the temperature rise caused by the flow of current.

The temperature rise is derived from the dissipated power, which is proportional to the resistance R of the conductor:

$$R = R_0 (1 + a \times T).$$

where T is the temperature rise referred to the rated value and  $R_0$  is the resistance at zero temperature rise, i.e. at room temperature.

Normally, a setting of  $a = 0$  models the thermal behaviour sufficiently well.

**k-Setting**

factor for extending the time constant when the unit is stationary.

The unit is assumed to be at a standstill when a logical "1" is being applied to the binary standstill I/P and a low current is being measured at the same time (less than approx.  $0.005 I_N$  in the case of metering c.t. cores or  $0.05 I_N$  in the case of protection c.t. cores).

**NrOfPhases**

defines the number of phases monitored.

**CurrentInp**

defines the current input channel.

All current I/P's may be selected.

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

**IB-Setting**

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

**Stillst.-Inp**

for detecting when the unit is at standstill and switching to a longer time constant for taking account of the slower cooling.  
(binary address)

(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)

**Warning**

Output for signalling an alarm  
(signal address)

**Trip**

Output for signalling tripping  
(signal address)

**TimeConstant**

defines the thermal model for calculating temperature rise.

Settings:

> 0 → 1st. order thermal model for which the thermal time constant has to be entered.

Settings between 0.1 min and 1.0 min are not permitted.

= 0 → Thermal model according to table entered.



**ResponseTime**

Duration of the response impulse.

Only effective for a thermal model described by a table.

Setting restrictions:

not = 0 for a time constant setting = 0

not > 0 for a time constant setting > 0

h [01] ÷ h [40]

define a value of the impulse response of the thermal system.

## E. Setting instructions

### Settings:

Reference current	IB-Setting
Initial temperature rise	Theta enable
Temperature rise for alarm	Theta-Warn
Temperature rise for tripping	Theta-Trip
Temperature coefficient of resistance	Temp.-Coeff.
Extension factor	k-Setting
Thermal time constant	TimeConstant
Duration of impulse response	ResponseTime
Instantaneous value of the impulse response	h[01] to h[40]

The overtemperature protection serves to protect a winding against inadmissible temperature rise due to an overcurrent. It is suitable for machines, transformers and lines. The temperature rise of the winding is derived from the current using a thermal image of the protected unit. In contrast to an overload protection function, the overtemperature function can be used for machines of any rating and thermal capacity. It monitors temperature rise and not the absolute temperature of the winding. Thus neither the ambient temperature nor the efficiency of the cooling system bear any influence on protection.

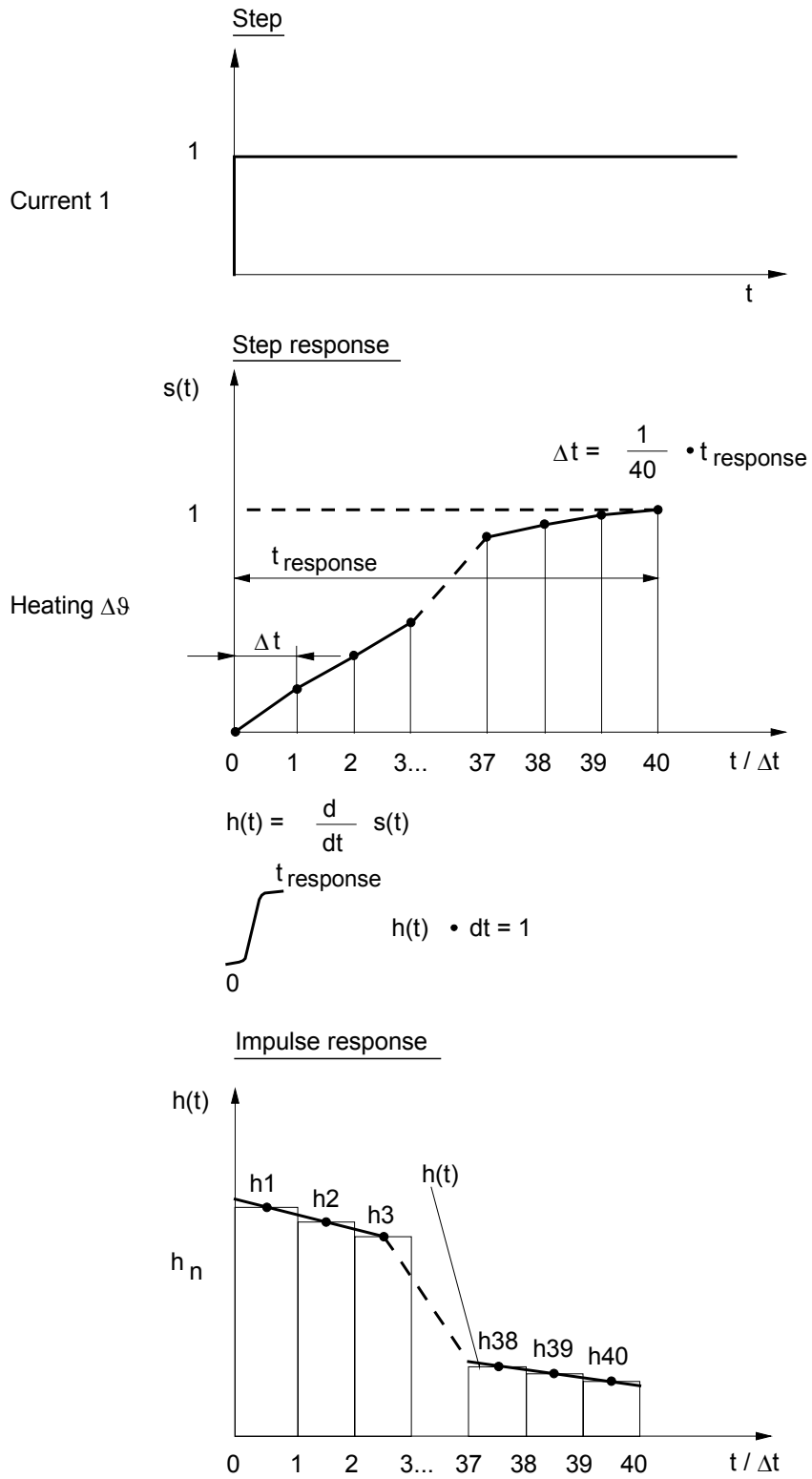
The operation of the overtemperature function is based on a thermal image, which models the temperature rise of the protected winding. When the current changes, the temperature rise changes from an initial value to a final value according to one or more exponential functions. For a transformer, these represent, for example, the thermal behaviour of the cooling water, the oil, the copper of the windings etc. In the case of a motor or a generator, they concern the iron, end windings, windings in the slots etc. One of these functions is always more pronounced than the others, e.g. the transformer oil or motor iron. The overtemperature function utilises two models for constructing the transient temperature rise. The first employs an exponential function and the second "universal" model a universally applicable function (see Fig. 3.5.19.1). The first model is suitable for the case where one exponential function is so predominant, that the others may be either neglected, or approximately taken into account by ad-

justing the thermal time constant. The second model is to be preferred for more complex transient temperature rise functions.

This protection function does not monitor instantaneous values as do most of the others. The temperature rise is determined by integration over a given period, e.g. 1/40 of the thermal time constant.

The overtemperature function determines the temperature rise curve from the following:

- the final temperature rise given by the current
- the rate of temperature rise by virtue of a transient function.



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Fig. 3.5.19.1 Thermal impulse response

It is assumed that the rated current  $I_{GN}$  of the protected unit results in a temperature rise of the winding of 100 %. The protection measures, however, a current  $I_{rel}$  without any compensation for the A/D channel or the base current  $I_B$ .

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

where  $I_{GN}$  is the rated current of the protected generator, motor or power transformer and  $I_{N1}$  and  $I_{N2}$  the c.t. rated currents.

The current referred to the rated current  $I_N$  of the protection is

$$i_{rel} = \frac{I_{rel}}{I_N} \quad \text{or} \quad \frac{I_{GN}}{I_N} \times \frac{I_{N2}}{I_{N1}}$$

The final temperature rise of the winding then becomes

$$\Delta \vartheta_W = \left( \frac{I_{GN}}{I_N} \times \frac{I_{N2}}{I_{N1}} \right)^2 100\%$$

The operating time at a constant current is given by

$$t = \tau \ln \left( \frac{\vartheta_0 [\%] - 100 \times \left( \frac{I}{I_B} \right)^2}{\vartheta [\%] - 100 \times \left( \frac{I}{I_B} \right)^2} \right)$$

where

- $\vartheta_0$  : initial temperature rise
- $\vartheta$  : pick-up temperature rise
- $\tau$  : thermal time constant.

The values given in the submenu 'LIST LOAD VALUES' are the calculated temperature rise, the losses and the current. The first two are mean values over the measurement period ( $= \tau/40$ ). The value shown in the event list is the power at the tripping point.

### Example

Rated current of the protected unit	$I_{GN} = 8000 \text{ A}$
C.t. rated currents	$I_{N1} = 10000 \text{ A}$ $I_{N2} = 5 \text{ A}$
Rated current of the protection	$I_N = 5 \text{ A}$

The final temperature rise determined by the protection at the rated current  $I_{GN}$ :

$$\Delta\vartheta_W = \left( \frac{8,000}{5} \times \frac{5}{10'000} \right)^2 100\% = 64\%$$

The corresponding settings for a temperature rise of 5 % respectively 10 % are:

$$\text{Theta-Warn} = 67\%$$

$$\text{Theta-Trip} = 70\%$$

The protection is usually initialised when the protected unit is still cold, so that the calculation must start at an initial temperature rise of zero and the setting becomes

$$\text{Theta-Begin} = 0 \%$$

providing it is permissible in the case of machines to neglect the temperature rise due to iron and frictional losses.

Taking account of the adjustment of  $I_B$ , the settings become:

$$\text{Base current} \quad \frac{I_B}{I_N} = \frac{I_{GN}}{I_N} \times \frac{I_{N2}}{I_{N1}} = \frac{8,000}{5} \times \frac{5}{10,000} = 0.8$$

Settings for alarm and tripping stages:

$$\text{Theta-Warn} = 105 \%$$

$$\text{Theta-Trip} = 110 \%$$

Neglecting the cooling system, the temperature rise of a winding is given by the square of the current  $I^2$  and the resistance of the winding  $R$ . Since the resistance varies with temperature, the effective temperature rise is influenced by the temperature of the winding. The overtemperature function provides facility for taking account of this influence by setting the factor "Temp.-Coeff.".

The following general equation applies for this influence on temperature

$$R = R_0 (1 + \alpha \times \Delta\vartheta)$$

$$\text{or} \quad R = R_0 (1 + a \times T)$$

where:

- $R_0, R$  resistance of the winding at room temperature or following a temperature rise of  $\Delta\vartheta$
- $\alpha$  temperature factor per degree, usually  $\alpha = 0.004$  for aluminium and copper
- $a$  temperature coefficient at the rated temperature rise  $\Delta\vartheta_N$
- $T$  temperature rise  $\Delta\vartheta$  referred to the rated temperature rise  $\Delta\vartheta_N$

The following applies:

$$\alpha \times \Delta\vartheta = a \times T$$

and then

$$a = \alpha \Delta\vartheta_N \qquad T = \frac{\Delta\vartheta}{\Delta\vartheta_N}$$

### Example

Rated temperature rise  $\Delta\vartheta_N = 60$  K;  $\alpha = 4 \times 10^{-3}$  K<sup>-1</sup>

$$a = \alpha \times \Delta\vartheta_N = 4 \times 10^{-3} \times 60 = 0.24$$

The following must therefore be set:

$$\text{Temp.-Coeff.} = 0.24$$

Transformers have two predominant exponential functions, one determined by the oil, the other by the winding, with the following typical values:

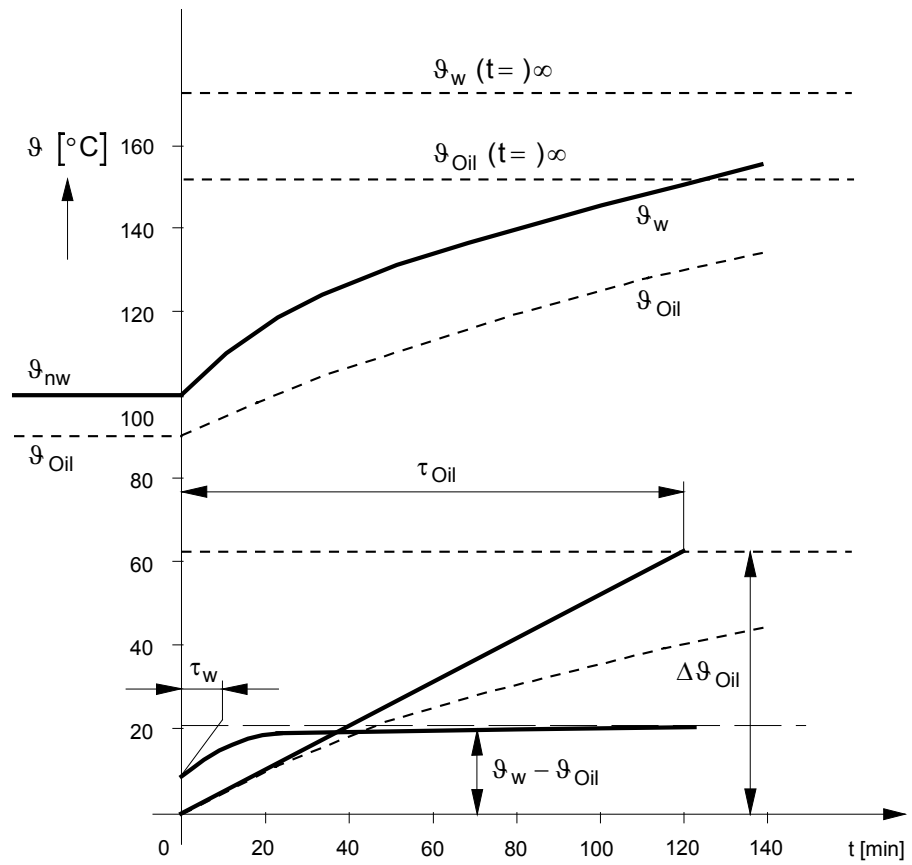
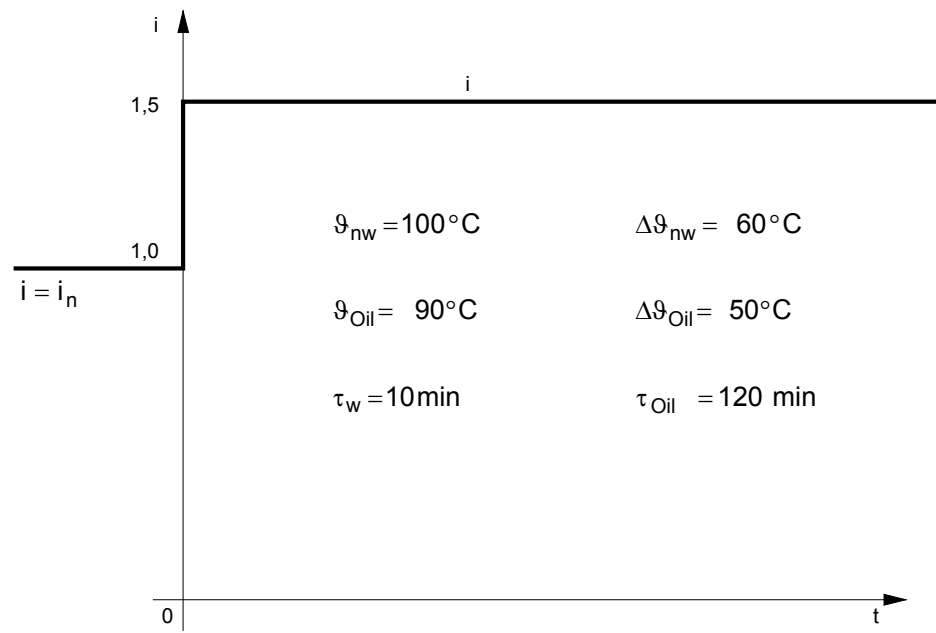
$$\text{oil} \qquad \qquad \qquad : \qquad \Delta\vartheta_{\text{oil}} = 50 \text{ K} \qquad \tau_{\text{oil}} = 120 \text{ min}$$

$$\text{winding} \qquad \qquad \qquad : \qquad \Delta\vartheta_W - \Delta\vartheta_{\text{oil}} = 10 \text{ K} \qquad \tau_W = 10 \text{ min}$$

$$\text{total temperature rise of the winding: } \Delta\vartheta_W = 60 \text{ K}$$

The first model operates with a single exponential function and therefore the composite temperature rise of the winding has to be approximated as closely as possible by adjusting the single curve. This can be seen from [Fig. 3.5.19.2](#). The final temperature rise of the equivalent curve is identical to that of the winding as a whole, i.e.  $\Delta\vartheta_W = 60$  K in the example above. The time constant, however, usually lies between 60 and 80 % of the time constant for the temperature rise of the oil ([see Fig. 3.5.19.3](#)).

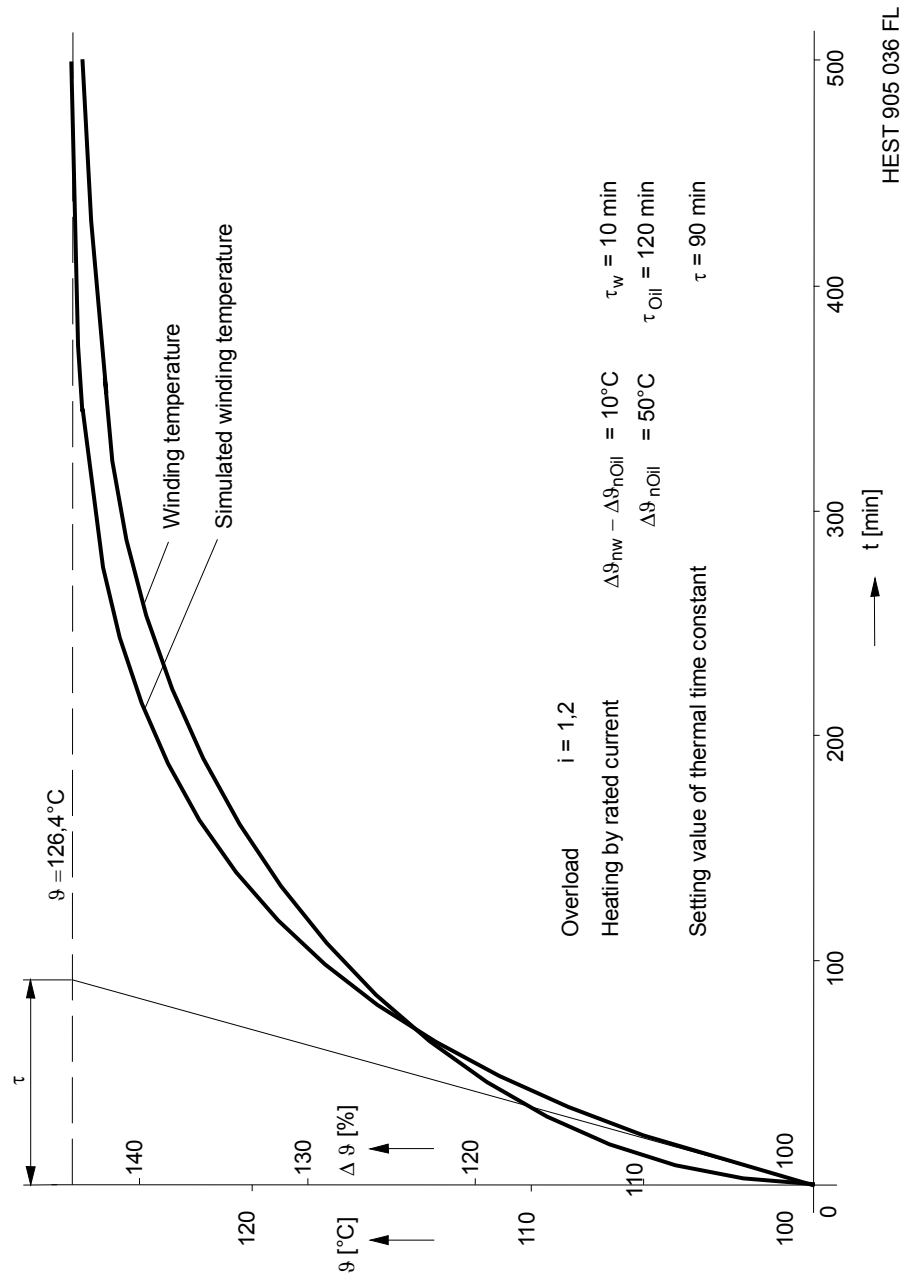
Similar relationships prevail with regard to modelling the temperature rise of generators and motors.



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Fig. 3.5.19.2 Temperature rise of a power transformer winding





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Fig. 3.5.19.3 Comparison of the actual winding temperature with the simulated temperature

When a motor or generator is stationary, there is no forced cooling and the cooling time constant is much longer. The time constant at standstill is defined by the setting of the factor "k". The time constant is switched when the current falls below a given value and the external signal "Stillst.-Inp" is being applied at the same time.

The universal model enables overtemperature to be monitored on the basis of a general function, which describes the temperature rise for a given current change. Fig. 3.5.19.1 shows the response of the general function  $s(t)$  to a step change in the current. The general function  $s(t)$  is divided into 40 sections. The mean values  $h_1, h_2 \dots h_{40}$ , which define the steps of the impulse response, are determined graphically from the derivation of the function  $s(t)$  for the individual sections in relation to time. These instantaneous values of the impulse response are entered as  $h[1]$  to  $h[40]$  when using the universal model. The "ResponseTime", i.e. the duration of the impulse response, must also be entered. Zero must be entered for the thermal time constant "TimeConstant".

The reduced cooling of a motor or generator at standstill is taken into account by extending the impulse response by the factor "k" when an external signal coincides with operation of the low-current monitor.

**Typical settings:**

IB-Setting	according to protected unit
Theta-Begin	0%
Theta-Warn	105%
Theta-Trip	110%
Temp.-Coeff.	0

	1st. order model	Universal model
k-Setting	3 *)	3
TimeConstant	acc. to prot. unit	0.00
ResponseTime	0.	acc. to prot. unit
h[1]	0.0	
h[2]	0.0	
.		
.		
h[40]	0.0	

\*) for motors, otherwise 1.



### **3.5.20. Frequency (Frequency)**

#### **A. Application**

Under and overfrequency protection.

#### **B. Features**

- frequency derived from system voltage
- evaluation of the complex voltage vector
- insensitive to DC components
- 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
- pick-up
- tripping

##### **IV. Measurements:**

- frequency
- voltage.

## D. Frequency function settings - Frequency

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
RunOnCPU		CPU1		(Select)	
ParSet 4..1		P1		(Select)	
Trip 01-08		00000000			
Trip 09-16		00000000			
Trip 17-24		00000000			
Trip 25-32		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.	00000			
Blocked (U<)	SignalAddr				
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr				

### Explanation of parameters:

#### RunOnCPU

defines the processing unit which runs the function.

#### ParSet 4..1

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

#### Trip 01-08

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

#### Trip 09-16

corresponds to Trip 01-08 (providing tripping unit fitted).

#### Trip 17-24

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 25-32**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Frequency**

Frequency setting for tripping.

Setting restrictions:

- not  $\geq f_N$  for underfrequency function
- not  $\leq f_N$  for overfrequency function

**BlockVoltage**

Setting for undervoltage blocking.

(reset ratio approx. 1.05).

**Delay**

time delay between pick-up and tripping.

**MaxMin**

defines operation as overfrequency or underfrequency.

Settings:

- MAX: overfrequency
- MIN: underfrequency

**VoltageInp**

defines the voltage input channel.

All voltage I/P's may be selected.

**Blocked (U<)**

defines the O/P channel for signalling undervoltage blocking.

(signal address).

**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).

**Start**

Output for signalling pick-up.

(signal address).

## E. Setting instructions

Several frequency stages are often required and several single-stage frequency functions are then used.

### Settings:

Frequency	Frequency
Delay	Delay
Undervoltage	BlockVoltage
Over/underfrequency	MaxMin

A frequency function is used to protect synchronous generators and prime mover against variations of speed and also in the underfrequency mode in load shedding schemes.

The frequency function protects:

- synchronous generators against excessive temperature rise due to increased iron and other losses
- synchronous generators and prime movers against damage due to vibration.

Many synchronous machines are subject to severe vibration when operating at speeds other than rated speed.

Vibration is particularly pronounced when underspeeding, but can occur both at under and overspeed. For this reason, a frequency scheme will usually include two stages for alarm and tripping at overspeed and two stages for alarm and tripping at underspeed. A time delay confines the danger of false tripping during transients.

### Typical settings:

#### 1. Generator and prime mover protection

	1st. Stage	2nd. Stage	3rd. Stage	4th. Stage
	Alarm	Tripping	Alarm	Tripping
<b>Frequency (Hz)</b>	51.0	52.0	49.0	48.0
<b>Delay (s)</b>	1.5	3	1.5	3
<b>BlockVoltage</b>	0.6	0.6	0.6	0.6
<b>MaxMin</b>	MAX	MAX	MIN	MIN

Table 3.5.20.1 Typical settings for alarm and tripping



## 2. Load shedding

	<b>1st. Stage</b>	<b>2nd. Stage</b>	<b>3rd. Stage</b>	<b>4th. Stage</b>	<b>5th. Stage</b>
	<b>Alarm</b>	<b>Load shed.</b>	<b>Alarm</b>	<b>Load shed.</b>	<b>Load shed.</b>
<b>Frequency (Hz)</b>	49.8	49.0	48.7	48.8	47.5
<b>Delay (s)</b>	0.5	0.0	0.0	0.0	0.0
<b>BlockVoltage</b>	0.6	0.6	0.6	0.6	0.6
<b>MaxMin</b>	MIN	MIN	MIN	MIN	MIN

Table 3.5.20.2 Typical settings for alarm and load shedding



### **3.5.21. 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
RunOnCPU		CPU1	Select		
ParSet4..1		P1	Select		
Trip 01-08		00000000			
Trip 09-16		00000000			
Trip 17-24		00000000			
Trip 25-32		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:

#### RunOnCPU

defines the processing unit which runs the function.

#### ParSet 4..1

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

#### Trip 01-08

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

#### Trip 09-16

corresponds to Trip 01-08 (providing tripping unit fitted).

#### Trip 17-24

corresponds to Trip 01-08 (providing tripping unit fitted).

#### Trip 25-32

corresponds to Trip 01-08 (providing tripping unit fitted).

**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 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'.

### **3.5.22. 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
RunOnCPU		CPU1		(Select)	
ParSet 4..1		P1		(Select)	
Trip 01-08		00000000			
Trip 09-16		00000000			
Trip 17-24		00000000			
Trip 25-32		00000000			
Delay	s	01.00	0.10	60.00	0.01
VoltageInp	CT/VT-Addr.	00000			
V/f-Setting	UN/fN	01.20	0.20	2.00	0.01
MaxMin		MAX			
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr				

### Explanation of parameters:

#### RunOnCPU

defines the processing unit which runs the function.

#### ParSet 4..1

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

#### Trip 01-08

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

#### Trip 09-16

corresponds to Trip 01-08 (providing tripping unit fitted).

#### Trip 17-24

corresponds to Trip 01-08 (providing tripping unit fitted).

#### Trip 25-32

corresponds to Trip 01-08 (providing tripping unit fitted).



**Delay**

time delay between pick-up and tripping.

**VoltageInp**

defines the voltage input channel.

All voltage I/P's 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→FALSE, T→TRUE, binary input or output of a protection function).

**Trip**

Output for signalling tripping.

(signal address).

**Start**

Output for signalling pick-up.

(signal address).

## 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

### 3.5.23. *Inverse time overfluxing (U/f-Inv)*

#### **A. Application**

Protection of generators and power transformers against excessive flux.

#### **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
- determination of delay by integration
- input of delay table facilitates matching the operating characteristic to a specific machine according to IEEE Guide 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
RunOnCPU		CPU1		(Select)	
ParSet 4..1		P1		(Select)	
Trip 01-08		00000000			
Trip 09-16		00000000			
Trip 17-24		00000000			
Trip 25-32		00000000			
VoltageInp	CT/VT-Addr.	00000			
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	00.400	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:**

RunOnCPU

defines the processing unit which runs the function.

**ParSet 4..1**

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

**Trip 01-08**

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

**Trip 09-16**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 17-24**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 25-32**

corresponds to Trip 01-08 (providing tripping unit fitted).

**VoltageInp**

defines the voltage input channel.  
All voltage I/P's may be selected.

**V/f-Setting**

Setting of the voltage/frequency ratio for enabling the inverse time characteristic, concerning  $UB / f_N$ .

**VB-Setting**

Reference value for compensating differences between the ratings of v.t's and the generator or power 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 limit). This corresponds to the time taken by the generator to cool.

**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)

Start

Output for signalling pick-up.  
(signal address)

## 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  $1.1 U_N/f_N$ .

The limit curve for the maximum magnetic flux (V/f) permissible for electrical machines is defined in

- standards
- data supplied by manufacturers.

The limit curve for Westinghouse machines is given in [Fig. 3.5.23.1](#).

The operating characteristic of the U/f-Inv protection function should be selected to be just below the short-time limit curve for overfluxing. The time limits t-min and t-max must also be set (see [Fig. 3.5.23.2](#)).

It must also be noted that depending on the standard or specification, the units are also designed for a continuous level of overfluxing apart from the short-time level. Typical values for generators would be 100, 105, 107.5 and 110%. The choice of characteristic must also take the continuous level of overfluxing into consideration.

**Typical settings:**

V/f-Setting	1.1 $U_N/f_N$
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 <sup>1)</sup>
t-Reset	60 min

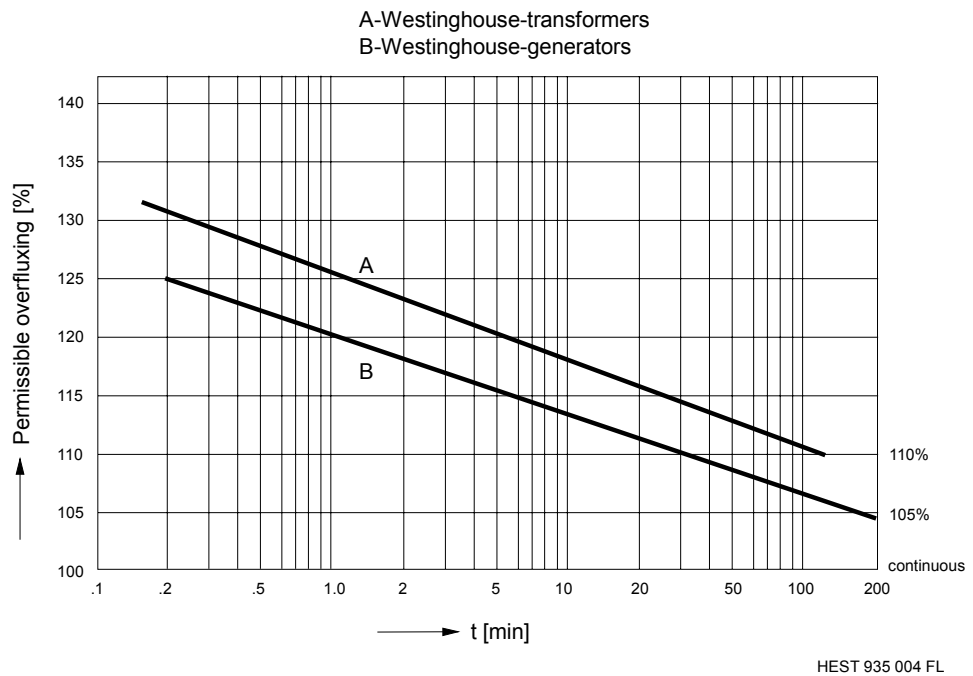


Fig. 3.5.23.1 Permissible overfluxing when off-load

<sup>1)</sup> Refer to Fig. 3.5.23.1 for typical settings for a Westinghouse unit.



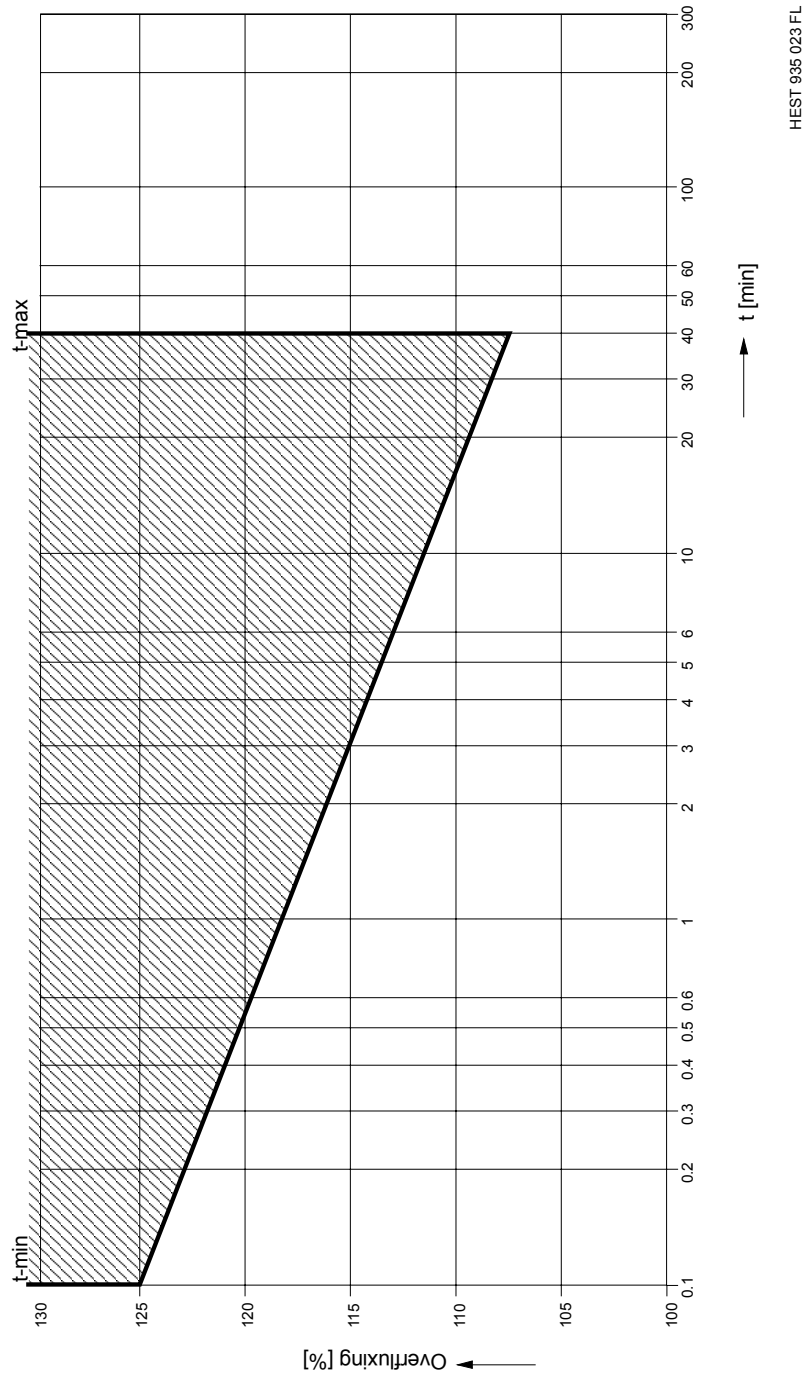


Fig. 3.5.23.2 Operating characteristic for a generator with a permissible continuous voltage in the range  $100 \pm 5 \% U_N$



### 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 displacing 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. This protection in conjunction with the voltage function 'Voltage', which covers 95 % of the winding, achieves 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. In this case the 95 % stator ground fault protection takes over the job of clearing the fault on its own.

#### **B. Features**

- protects the star-point and a part of the stator winding depending on the ground fault current
- displacement of the star-point in relation to ground by injecting a signal generated by the injection unit REX 010
- 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 I/P's)

##### **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 $\Omega$  can be determined and displayed. A display of 29.9 k $\Omega$  or 30 k $\Omega$  indicates a ground fault resistance >29.8 k $\Omega$ . A value of 29.9 k $\Omega$  or 30 k $\Omega$  is displayed when there is no ground fault.

A whole number between 100 and 111 is displayed for the fault code 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 RE. 216 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 the specialist.

MTR":

The value measured for MTR is displayed when the input 'AdjMTRInp' is enabled.

During normal operation, the value entered for MTR on the HMI is displayed.

**REs":**

When the input 'AdjREsInp' is enabled, 123.0 is displayed initially until the resistance has been computed. This can take a maximum of 10 s after which the value measured for REs is displayed.

During normal operation, the value entered for REs on the HMI is displayed.

Normal operation: Neither of the two I/P's 'AdjMTRInp' and 'AdjREsInp' are disabled and injection is taking place.

Note: Only one of the binary I/P's may be enabled at any one time, otherwise an error code is generated for the measurements Rfs, MTR and REs (see table below).

<b>AdjMTRInp</b>	<b>AdjREsInp I/P</b>	
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 I/P disabled

1: binary I/P enabled

**D. Stator ground fault settings - Stator-EFP**

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
RunOnCPU		CPU1	(Select)		
ParSet 4..1		P1	(Select)		
Trip 01-08		000000			
Trip 09-16		000000			
Trip 17-24		000000			
Trip 25-32		000000			
Alarm-Delay	s	0.5	0.20	60.00	0.01
Trip-Delay	s	0.5	0.20	60.00	0.01
RFsAlarmVal	k $\Omega$	10.0	0.1	20.0	0.1
RFsTripVal	k $\Omega$	1.0	0.1	20.0	0.1
REs	k $\Omega$	1.00	0.40	5.00	0.01
REs-2.Starpt	k $\Omega$	1.00	0.90	5.00	0.01
RFs-Adjust	k $\Omega$	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.	00000			
VoltageInpUs	CT/VT-Addr.	00000			
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				

**Explanation of parameters:****RunOnCPU**

defines the processing unit which runs the function.

**ParSet 4..1**

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

**Trip 01-08**

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

**Trip 09-16**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 17-24**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 25-32**

corresponds to Trip 01-08 (providing tripping unit fitted).

**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 greater 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 REs must be 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 when primary system directly grounded.

**NrOfStarpt**

Number of star-points in the zone of protection.

**VoltageInpUi**

defines the voltage I/P channel for the reference voltage.

**VoltageInpUs**

defines the voltage I/P channel for the measured voltage.

**2.StarptInp**

Binary address used as status I/P. 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 'RFs-Setting' for alarm must always be greater than that of 'RFs-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 $\Omega$

delay                    2 s

Tripping stage:

RFs-Setting            500  $\Omega$

delay                    1 s

### Setting procedure:

How accurately Rfs is measured depends on the values entered for REs and MTR. Therefore check the settings and correct them if necessary by connecting resistors between 100  $\Omega$  and 10 k $\Omega$  between the star-point and ground with the generator at a standstill.

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 window for measured values.

Should the values of REs and MTR determined by the adjustment mode differ from their nominal values, the calculated values are the preferred values.

**Determination of 'MTR':**

- Short the star-point to ground (  $R_f = 0 \Omega$  ).
- Set the binary I/P 'AdjMTRInp'.
- On the HMI, open the menu 'Display function measurements' and note the value for 'MTR'. Return to the main 'Editor' menu, select the function 'Stator-EFP' in the sub-menu 'Present prot funcs' and enter and save the value noted for the setting 'MTR'.
- Remove the connection between the star-point and ground.
- Reset the binary I/P 'AdjMTRInp'.

**Determination of 'REs':**

Select the menus and items as for 'Determination of MTR'.

- Set the binary I/P 'AdjREsInp'.
- Enter the approximate value for REs.
- Simulate a ground fault  $R_f$  by connecting a resistor between the star-point and ground:  $8 \text{ k}\Omega < R_f < 12 \text{ k}\Omega$
- On the HMI, open the window 'Edit function settings':  
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.
- Reset the binary I/P 'AdjREsInp'.

**The protection function will only switch back from the determination mode to the normal protection mode when both binary I/P's have been reset.**

Check the settings by connecting resistors of  $100 \Omega$  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 operation of the tripping and alarm triggers is disabled as long as one of the two binary I/P's 'AdjMTRInp' or 'AdjREsInp' is enabled, i.e. the protection will not trip, if the stator circuit is grounded. The two signals 'InterruptInt' and 'InterruptExt', on the other hand, 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  $\leq 5$  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:

$$\text{Condition 2): } R_{Ps} \geq 130 \Omega \text{ and } R_{Ps} \leq 500 \Omega$$

$$\text{Condition 3): } R_{Es} \geq 4.5 \times R_{Ps}$$

$$\text{Condition 4): } R_{Es} \geq 0.7 \text{ k}\Omega \text{ and } R_{Es} \leq 5 \text{ k}\Omega$$

The v.t. must be designed such that for a solid ground fault at the generator terminals, the rated frequency component voltage signal  $U_s = 100 \pm 20 \%$ , i.e. the ratio  $MTR = N_{12}/N_{11}$  must lie within the following range:

Condition 5):

(This isn't a must-condition but it's a recommendation. If Condition 5 isn't fulfilled, there will be no problem).

$$1.2 \times n \geq \frac{N_{12}}{N_{11}} \geq 0.8 \times n \text{ where } n = \frac{U_{Gen}}{\sqrt{3} \times 100 \text{ V}} \times \frac{R_{Es}}{R_{Es} + R_{Ps}}$$

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  $U_{Gen} = 10.5$  kV or 13.5 A for  $U_{Gen} = 27$  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 displacement voltage can also be injected at the secondary of a grounding v.t. with the grounding resistor connected to its secondary winding (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 :

$$\text{Condition 1): } R'_{Es} + R'_{Ps} \geq \frac{U_{Gen}}{\sqrt{3} \times I_{E_{max}}} \times \left( \frac{N_2}{N_1} \right)^2$$

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 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 signal  $U_s = 100 \pm 20 \%$ , i.e. the ratio  $MTR' = N'_{12}/N'_{11}$  must lie within the following range:

Condition 5):

$$1.2 \times n \geq \frac{N'_{12}}{N'_{11}} \geq 0.8 \times n \text{ where } n = \frac{U_{Gen}}{\sqrt{3} \times 100 \text{ V}} \times \frac{N_2}{N_1} \times \frac{R'_{Es}}{R'_{Es} + R'_{Ps}}$$

A v.t.  $\frac{N'_{12}}{N'_{11}} = \frac{U_{Gen}}{\sqrt{3} \times 100 \text{ V}} \times \frac{N_2}{N_1}$  will fulfil Condition 5) in most cases.

The settings for  $R_{Es}$  and MTR must be entered via the HMI, 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.

$R'_{Ps}$ [m $\Omega$ ]	$U_{is}$ [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. Thus inaccuracies due to contact resistance, grounding resistor tolerances etc., are 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 larger, check or measure 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:

$$1.2 \times n \geq \frac{N'_{12}}{N'_{11}} \geq 0.8 \times n = 1.88 \geq 1.732 \geq 1.254 \quad \text{where}$$

$$n = \frac{18 \text{ kV}}{\sqrt{3} \times 100 \text{ V}} \times \frac{1}{60} \times \frac{400 \text{ m}\Omega}{400 \text{ m}\Omega + 42 \text{ m}\Omega} = 1.567$$

**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:

$$R_{Es} = 400 \text{ m}\Omega \times (60)^2 = 1.44 \text{ k}\Omega$$

$$\text{MTR} = \frac{N'_{12}}{N'_{11}} \times \frac{110 \text{ V}}{1.7 \text{ V}} = 112$$

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 switch position being entered via a binary I/P which is TRUE when the switch is closed.
- 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 displacement voltage can also be injected at the secondary of a grounding v.t. connected to the generator terminals with the grounding resistor connected to its secondary winding (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 :

$$\text{Condition 1): } R'_{Es} + R'_{Ps} \geq \frac{U_{Gen}}{\sqrt{3} \times I_{Emax}} \times \left( \frac{3 \times N_2}{N_1} \right)^2$$

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 grounding resistors  $R'_{Es}$  and  $R'_{Ps}$  must fulfil the following conditions:

$$\text{Condition 2): } R'_{Ps} \geq 130 \, \Omega \times \left( \frac{3 \times N_2}{N_1} \right)^2 \text{ and } R'_{Ps} \leq 500 \, \Omega \times \left( \frac{3 \times N_2}{N_1} \right)^2$$

$$\text{Condition 3): } R'_{Es} \geq 4.5 \times R'_{Ps}$$

$$\text{Condition 4): } R'_{Es} \geq 0.7 \, \text{k}\Omega \times \left( \frac{3 \times N_2}{N_1} \right)^2 \text{ and } R'_{Es} \leq 5.0 \, \text{k}\Omega \times \left( \frac{3 \times N_2}{N_1} \right)^2$$

The v.t. must be designed such that for a solid ground fault at the generator terminals, the rated frequency component voltage signal  $U_s = 100 \, \text{V} \pm 20 \, \%$ , i.e. the ratio  $MTR' = N'_{12} / N'_{11}$  must lie within the following range:

Condition 5):

$$1.2 \times n \geq \frac{N'_{12}}{N'_{11}} \geq 0.8 \times n \text{ where } n = \frac{U_{Gen}}{\sqrt{3} \times 100 \, \text{V}} \times \frac{3 \times N_2}{N_1} \times \frac{R'_{Es}}{R'_{Es} + R'_{Ps}}$$

A v.t.  $\frac{N'_{12}}{N'_{11}} = \frac{U_{Gen}}{\sqrt{3} \times 100 \, \text{V}} \times \frac{3 \times N_2}{N_1}$  will fulfil Condition 5) in most

cases.

The settings for  $R_{Es}$  and MTR must be entered via the HMI, 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 24.6 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.

$R'_{Ps}$ [ $\Omega$ ]	$U_{is}$ [V]
> 0.45	6.4
> 1.8	12.8
> 7.2	25.6

Table REX011-2

### Design example:

$$U_{Gen} = 12 \text{ kV}$$

$$\frac{N_1}{N_2} = \frac{\frac{12 \text{ kV}}{\sqrt{3}}}{\frac{600 \text{ V}}{3}}$$

$$\text{Assumed: } I_{E_{max}} \leq 5 \text{ A}$$

Determination of the grounding resistors:

Condition 1:

$$R'_{Es} + R'_{Ps} \geq \frac{12 \text{ kV}}{\sqrt{3} \times 5 \text{ A}} \times \left( \frac{3 \times \frac{600 \text{ V}}{3}}{\frac{12 \text{ kV}}{\sqrt{3}}} \right)^2 = \frac{3 \times (600 \text{ V})^2}{\sqrt{3} \times 5 \text{ A} \times 12 \text{ kV}} = 10.4 \Omega$$

$$\text{Condition 2: } R'_{Ps} \geq 130 \Omega \times \left( \frac{3 \times \frac{600 \text{ V}}{3}}{\frac{12 \text{ kV}}{\sqrt{3}}} \right)^2 = 0.98 \Omega$$

$$\text{Assumed: } R'_{Ps} = 1,0 \Omega$$

$$\text{Condition 3: } R'_{Es} \geq 4.5 \times 1 \Omega = 4.5 \Omega$$

$$\text{Condition 4: } R'_{Es} \geq 700 \Omega \times \left( \frac{3 \times \frac{600 \text{ V}}{3}}{\frac{12 \text{ kV}}{\sqrt{3}}} \right)^2 = 5.25 \Omega$$

In order to fulfil Conditions 1, 3 and 4:  $R'_{Es} = 10.0 \Omega$

Determining the v.t.:

$$\text{Assumed: } \frac{N'_{12}}{N'_{11}} = \frac{12 \text{ kV}}{\sqrt{3} \times 100 \text{ V}} \times \frac{3 \times \frac{600 \text{ V}}{3}}{\frac{12 \text{ kV}}{\sqrt{3}}} = \frac{600 \text{ V}}{100 \text{ V}} = 6.0$$

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:**

$$R'_{Ps} = 1 \Omega$$

$$R'_{Es} = 10 \Omega$$

$$N'_{12}/N'_{11} = 600 \text{ V}/100 \text{ V}$$

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  $U_{is} = 6.4 \text{ V}$ .

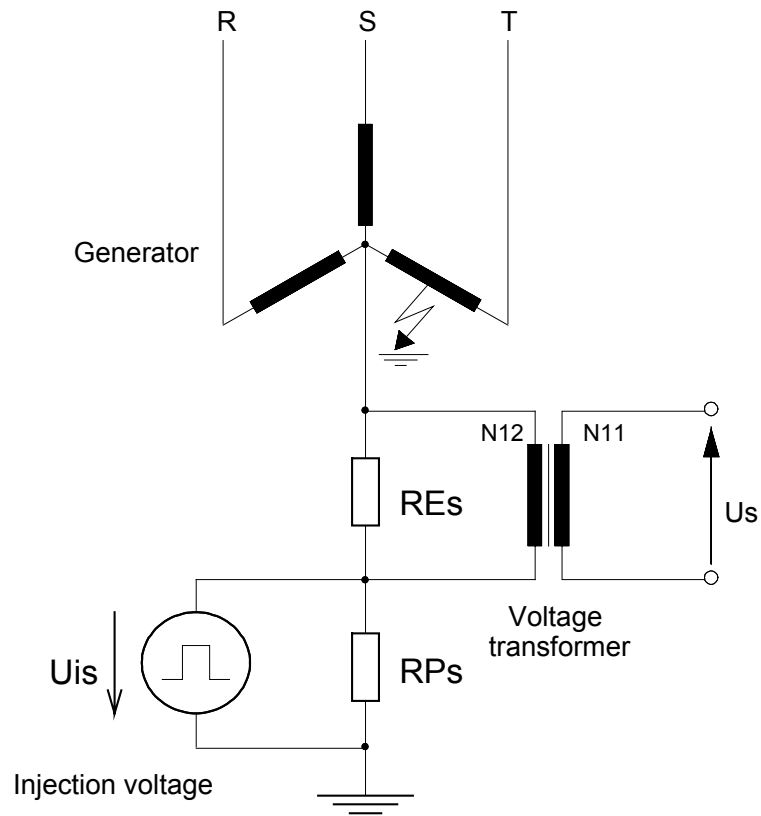


Fig. 3.5.24.1 Stator ground fault protection with primary injection

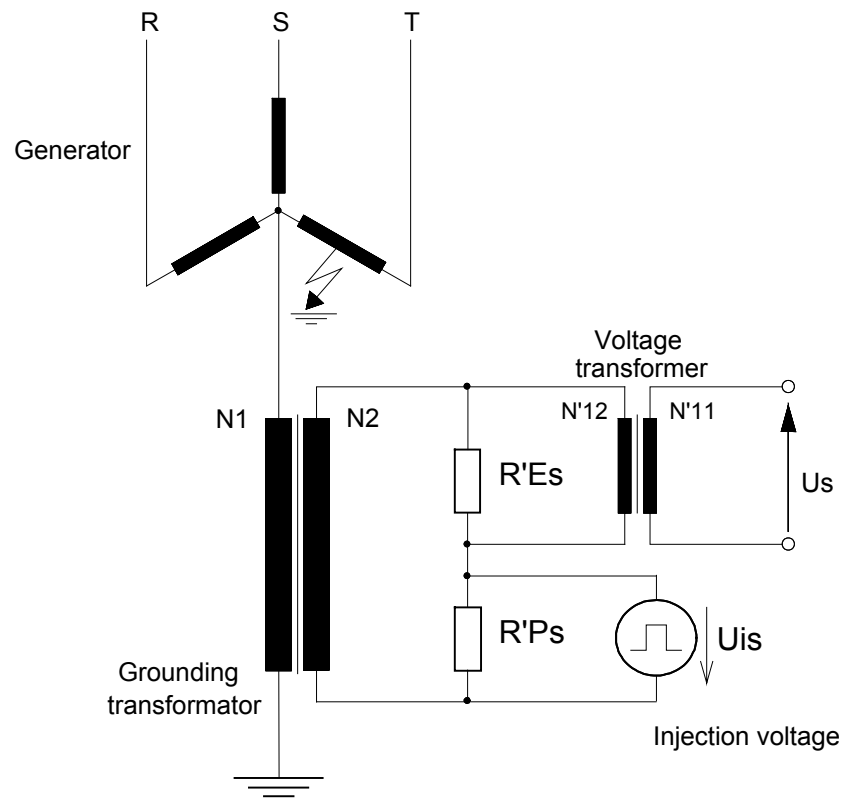


Fig. 3.5.24.2 Stator ground fault protection with secondary injection at the generator star-point

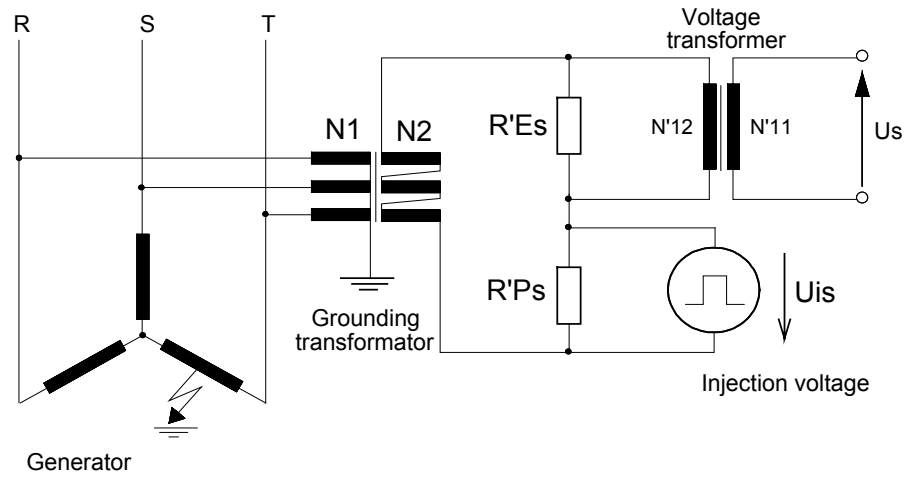


Fig. 3.5.24.3 Wiring diagram for secondary injection of the stator (grounding transformer at the generator terminals)



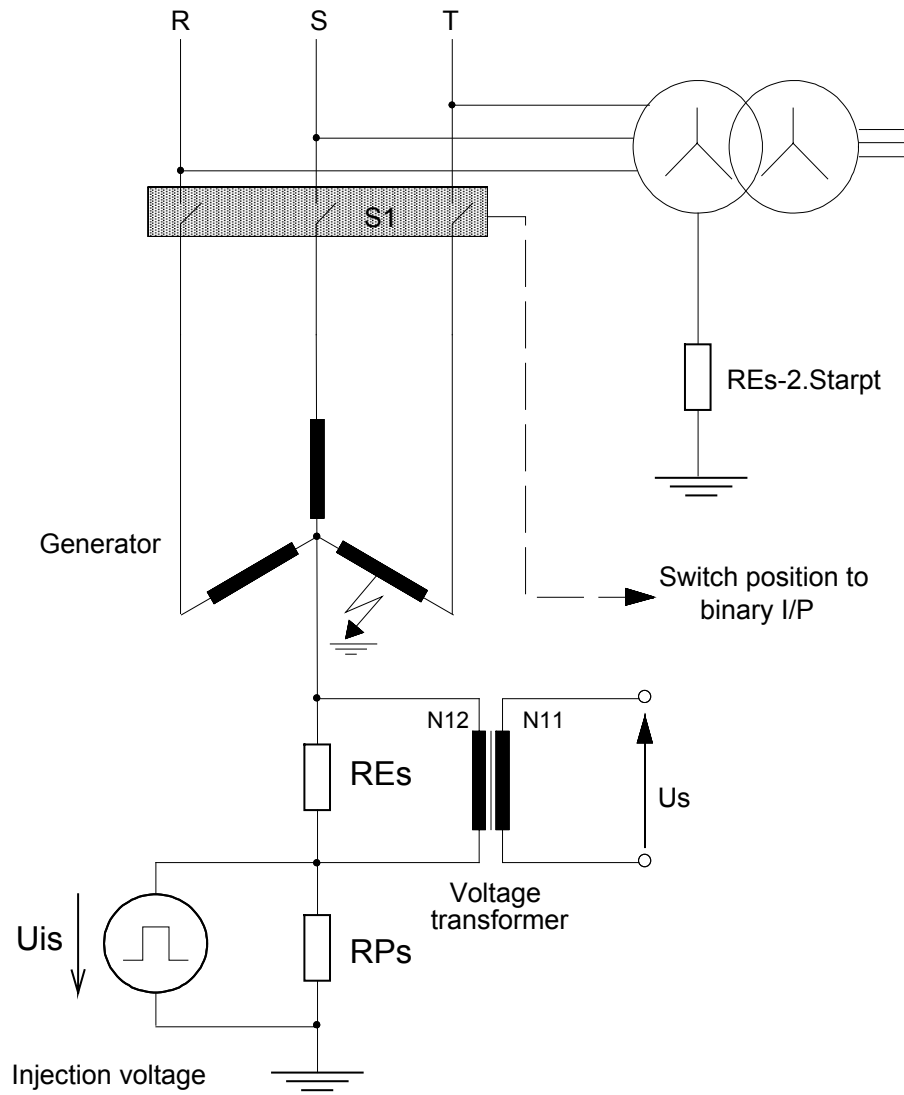


Fig. 3.5.24.4 Stator ground fault protection for installations with two star-points



### 3.5.25. ***Rotor ground fault protection with 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, it 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 I/P's)

##### **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 $\Omega$  can be determined and displayed. A display of 29.9 k $\Omega$  or 30 k $\Omega$  indicates a ground fault resistance >29.8 k $\Omega$ . A value of 29.9 k $\Omega$  or 30 k $\Omega$  is displayed when there is no ground fault.

A whole number between 100 and 111 is displayed for the fault code 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 RE. 216 is incorrectly set.
- **102.0** means external open-circuit.
- **109.0** means that both the binary inputs 'AdjREsInp' 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 specialist.

**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 on the HMI is displayed.

**REr":**

When the input 'AdjRErInp' is enabled, the error code 133.00 is displayed initially until the resistance has been computed. This can take a maximum of 10 s after which 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 HMI is displayed.

**Normal operation:** Neither of the two I/P's 'AdjCoupCInp' and 'AdjRErInp' are disabled and injection is taking place.

**Note:** Only one of the binary I/P's may be enabled at any one time, otherwise an error code is generated for the measurements Rf, C and REr (see table below).

<b>AdjCoupCInp</b>	<b>AdjRErInp</b>	
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 & 109.00 (Rf = 109.0)

0: binary I/P disabled

1: binary I/P enabled

**D. Rotor ground fault settings - Rotor-EFP**

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
RunOnCPU		CPU1	(Select)		
ParSet 4..1		P1	(Select)		
Trip 01-08		000000			
Trip 09-16		000000			
Trip 17-24		000000			
Trip 25-32		000000			
Alarm-Delay	s	0.50	0.00	60.00	0.01
Trip-Delay	s	0.50	0.00	60.00	0.01
RFrAlarmVal	k $\Omega$	10.0	0.1	25.0	0.1
RFrTripVal	k $\Omega$	1.0	0.1	25.0	0.1
REr	k $\Omega$	1.00	0.90	5.00	0.01
Uir	V	50	50	20, 30 or 50	
RFr-Adjust	k $\Omega$	10.0	8.000	12.00	0.01
CouplingCap	$\mu$ F	4.00	2.00	10.00	0.01
VoltageInpUi	CT/VT-Addr.	00000			
VoltageInpUr	CT/VT-Addr.	00000			
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				

**Explanation of parameters:****RunOnCPU**

defines the processing unit which runs the function.

**ParSet 4..1**

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

**Trip 01-08**

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

**Trip 09-16**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 17-24**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip 25-32**

corresponds to Trip 01-08 (providing tripping unit fitted).

**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 greater 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 block Type REX 011.

**RF-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.

**VoltageInUi**

defines the voltage I/P channel for the reference voltage Ui.

**VoltageInUr**

defines the voltage I/P channel for the measured voltage Ur.

**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 an 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.

This signal address has a pick-up and a rest delay of each 5s.

**REr-Adjust**

Output for signalling the binary status of 'AdjRErInp'.  
(signal address)

**CoupC-Adjust**

Output for signalling the binary status of 'AdjCoupCInp'.

**Extern-Block**

Output for signalling that the function is disabled by an external signal.  
(signal address)

**Note:**

If stator and rotor ground fault protection schemes are in use, the same analogue channel  $U_i$  must be selected for both.

## E. Setting instructions

The value of 'R<sub>Fr</sub>- Setting' for alarm must always be greater than that of 'R<sub>Fr</sub>- 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<sub>Er</sub>  
Coupling capacitor C  
'R<sub>Fr</sub>- Setting' for tripping  
'R<sub>Fr</sub>- Setting' for alarm  
Delay for alarm  
Delay for tripping

### Typical settings:

Alarm stage:

R <sub>Fr</sub> - Setting	5 k $\Omega$
delay	2 s

Tripping stage:

R <sub>Fr</sub> - Setting	500 $\Omega$
delay	1 s.

### Setting procedure:

How accurately R<sub>r</sub> is measured depends on the values entered for R<sub>Er</sub> and C. Therefore check the settings and correct them if necessary by connecting resistors between 100  $\Omega$  and 10 k $\Omega$  between the rotor and ground with the generator at a stand still.

The protection function provides a convenient way of setting these two parameters in the software by switching its mode using the input 'AdjR<sub>Er</sub>Inp' or 'AdjCoupCInp'. In this mode, the settings of the parameters 'R<sub>Er</sub>' and 'C' are calculated with the aid of simulated ground fault resistances.

Determination of R<sub>Er</sub>

- Set the binary I/P 'AdjR<sub>Er</sub>Inp'.
- Short-circuit the coupling capacitors.

- Simulate a ground fault  $R_f$  by connecting a resistor to the rotor:  $8 \text{ k}\Omega \leq R_f \leq 12 \text{ k}\Omega$
- On the HMI, open the window 'Edit function settings' and enter and save the value for the simulated ground fault against 'RFR-Adjust' and the nominal value for  $R_{ER}$ .  
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 'Editor' window.
- Remove the short-circuit from across the coupling capacitors and remove the simulated ground fault.
- Reset the binary I/P 'AdjRERInp'.

#### Determination of C

- Set the binary I/P 'AdjCoupCInp'.
- Connect the rotor winding to ground ( $R_f = 0 \Omega$ ).
- Open the 'Editor' menu and enter and save the nominal value of C.  
Open the menu 'Display function measurements' and note the value of  $C_k$ . Enter and save the value noted for the setting of 'AdjCouplingCap' in the 'Editor' window.
- Remove the simulated ground fault from the rotor.
- Reset the binary I/P 'AdjCoupCInp'.

#### Design instructions:

The grounding resistors and coupling capacitors have to fulfil the following conditions:

$$\text{Rotor grounding resistor } R_{pr} : 100 \Omega \leq R_{pr} \leq 500 \Omega$$

$$\text{Rotor grounding resistor } R_{Er} : 900 \Omega \leq R_{Er} \leq 5 \text{ k}\Omega$$

Coupling capacitors

$$C = C_1 + C_2 : 4 \mu\text{F} \leq C \leq 10 \mu\text{F}$$

$$\text{Time constant } \tau = R_{Er} \times C : 3 \text{ ms} \leq \tau \leq 10 \text{ ms}$$

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:**

$$R_{pr} = 200 \, \Omega, P = 15 \, \text{W}$$

$$R_{Er} = 1 \, \text{k}\Omega$$

$$C = 2 \times 2 \, \mu\text{F}, 8 \, \text{kV}$$

$$\tau = 4 \, \text{ms}$$

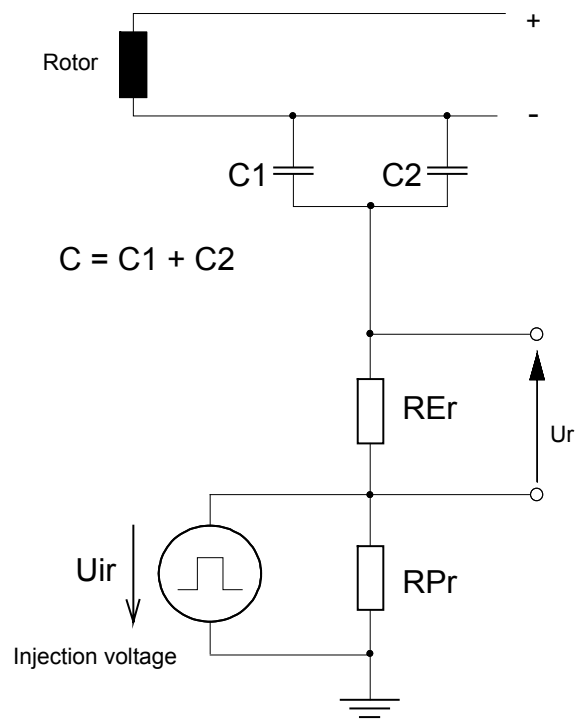


Fig. 3.5.25.1 Injection at one pole of the rotor winding

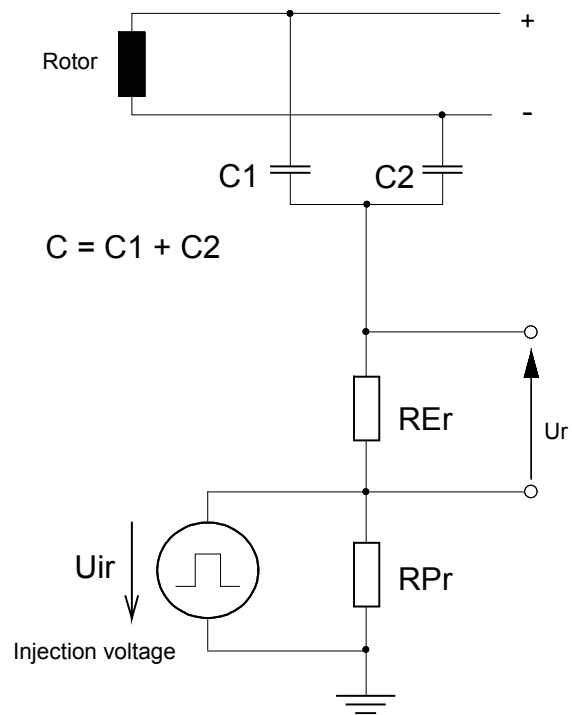


Fig. 3.5.25.2 Injection at both poles of the rotor winding



### 3.5.26. ***Pole slipping (Pole-Slip)***

#### **A. Application**

The pole slipping function detects the condition of a generator which is completely out-of-step with the power system to which it is connected.

#### **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 a local and an external power swing centre
- trips after a set number of slips
- trips within a set rotor angle.

#### **C. Inputs and outputs**

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

- current
- voltage

##### **II. Binary inputs:**

- blocking of the entire function
- blocking for generating (left) directions
- blocking for motoring (right) directions
- external enabling of zone1

##### **III. Binary outputs:**

- alarm before the first slip
- operation for generating (left) slip
- operation for motoring (right) slip
- first operation in zone 1
- first operation in zone 2
- n1th. operation in zone 1 (tripping)
- n2th. 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
RunOnCPU		CPU1	(Select)		
ParSet 4..1		P1	(Select)		
Trip1 01-08		00000000			
Trip1 09-16		00000000			
Trip1 17-24		00000000			
Trip1 25-32		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	CT/VT-Addr.	000000			0,010
VoltageInp	CT/VT-Addr.	000000			
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:****RunOnCPU**

defines the processing unit which runs the function.



**ParSet 4..1**

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

**Trip1 01-08**

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

**Trip1 09-16**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip1 17-24**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip1 25-32**

corresponds to Trip 01-08 (providing tripping unit fitted).

**ZA**

Forwards impedance<sup>1)</sup>. ZA marks the end of zone 2 and is also used for determining phase-angle.

**ZB**

Reverse impedance<sup>1)</sup>. ZB marks the beginning of zone 1 and is also used for determining phase-angle.

**ZC**

Impedance of the zone limit<sup>1)</sup>. ZC is the end of zone 1 between ZB and ZC and the beginning of zone 2 between ZC and ZA.

---

1) As impedance unit 1.000 UN/IN the impedance of 100% is used. If the impedance to be set is known in percent, then it can be applied directly; e.g. 10% is set as 0.100.

The impedance of 1.000 UN/IN, resp. 100% with a current of 1 I<sub>N</sub> corresponds with the rated voltage PH-0 of  $U_N / \sqrt{3}$  in each phase. This corresponds with the positive-sequence impedance of  $U_N / \sqrt{3} / I_N$ :

<b>U<sub>N</sub></b>	<b>I<sub>N</sub></b>	<b>Impedance unit</b>
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.

**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 neutral 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).

**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 current input channel.

**VoltageInp**

defines the voltage 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 when slip is detected 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 I/P '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  $U_{\cos}$  which is 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  $0.92 I_N$
- the voltage  $U_{\cos}$  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 is detected and the rotor angle exceeds the angle set for 'WarnAngle'.

Slipping is detected when

- a change of rotor angle of min. 50 ms is recognized
- the slip line is crossed between  $Z_A$  and  $Z_B$ .

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 n1 slips in zone 1, providing the rotor angle is less than 'TripAngle'.

The 'Trip2' signal is generated after n2 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'.

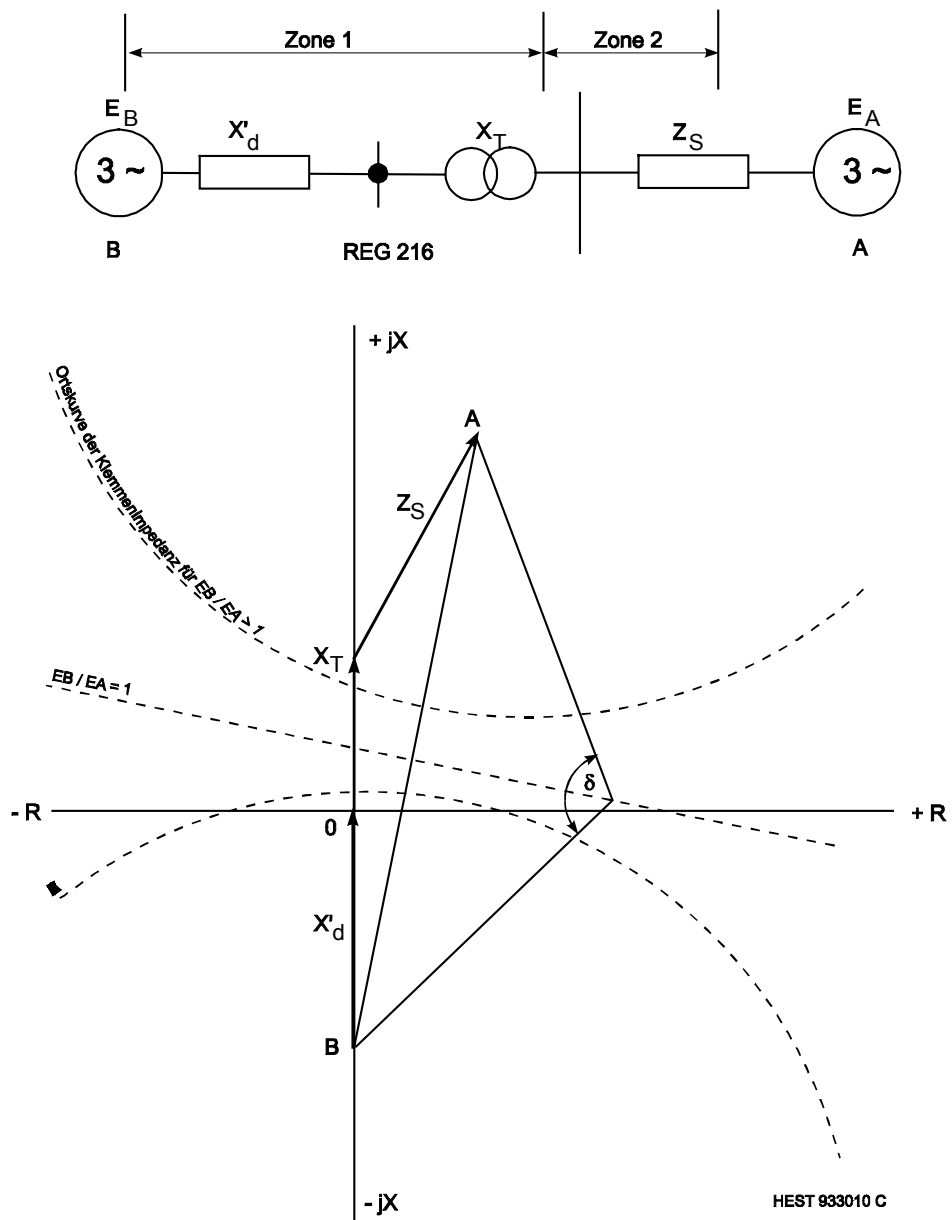


Fig. 3.5.26.1 Locus of the impedance measured at the generator terminals during pole slipping in relation to the power system A

- $X'_d$  : transient reactance of the generator
- $X_T$  : short-circuit reactance of the step-up transformer
- $Z_S$  : 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.

The sampling group of the current angle voltage inputs must also be taken into account. There are no restrictions on Phi providing the **current input number is lower than the voltage input number** and we **urgently recommend** observing this rule when connecting the protection.

In cases where a current input number higher than the voltage input number **cannot be avoided**, the setting range for Phi is:

Current I/P No.	Voltage I/P No.	Phi range
7 - 12	1 - 6	67 - 90°
13 - 18	1 - 6	75 - 90°
13 - 18	7 - 13	67 - 90°
19 - 24	1 - 6	82 - 90°
19 - 24	7 - 12	75 - 90°
19 - 24	13 - 18	67 - 90°

### 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. 4.16](#)

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.

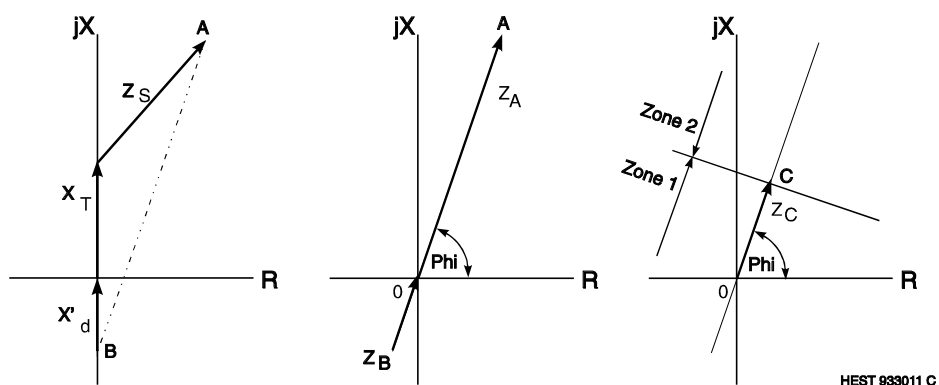


Fig. 3.5.26.2 Determining the settings for  $Z_A$ ,  $Z_B$ ,  $Z_C$ , and  $\Phi$  according to  $X'_d$ ,  $X_T$  and  $Z_S$ .

**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  $0^\circ$  and  $180^\circ$  and determines the rotor angle above which alarm of imminent slipping is given.

With setting of 'WarnAngle' =  $0^\circ$ , 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  $135^\circ$ , for example, by changing the excitation or switching in compensators.

For a setting of 'WarnAngle' =  $180^\circ$ , 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 =  $110^\circ$ .

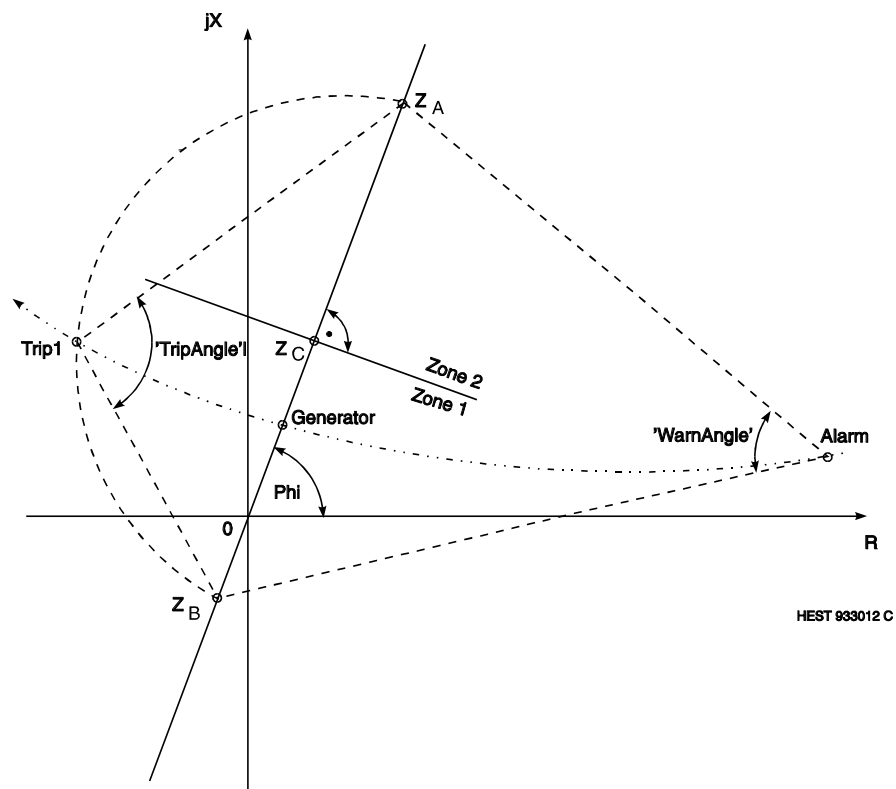


Fig. 3.5.26.3 Example of the operation for  $n_1 = 1$ ,  
WarnAngle =  $53^\circ$  and TripAngle =  $96^\circ$

**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 given.

The setting at which tripping should take place is determined according to an operating point which

- occurs shortly after the last permissible slip
- is favourable for the circuit-breaker (least stress due to re-ignition)

Typical setting: 'TripAngle' = 90°.

**Settings: n1, n2, t-Reset**

The number of slips  $n1$  or  $n2$  which 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. Sensitive earth fault protection for ungrounded systems and systems with Petersen coils (EarthFaultIsol)**

#### **A. Application**

The sensitive E/F protection detects E/F's on overhead lines in radial systems. It is suitable for application in ungrounded systems, systems with Petersen coils and in resistance grounded MV and HV systems. The scheme monitors the neutral voltage and current of the protected line. Depending on the characteristic angle chosen, it responds to either the real or apparent value of the neutral power.

#### **B. Features**

- adjustable characteristic angle
- compensation of c.t. phase errors
- suppression of DC component in voltage and current signals
- suppression of harmonics in voltage and current signals.

#### **C. Inputs and outputs**

##### **I. C.t./v.t. inputs**

- neutral current
- neutral voltage

##### **II. Binary inputs**

- blocking signal

##### **III. Binary outputs**

- tripping signal
- starting signal

##### **IV. Measured variable**

- zero-sequence power.

**D. Sensitive earth fault protection settings - EarthFaultIsol**

Summary of parameters:

Text	Units	Default	Min.	Max.	Step
RunOnCPU		CPU1	(Select)		
ParSet 4..1		P1	(Select)		
Trip1 01-08		00000000			
Trip1 09-16		00000000			
Trip1 17-24		00000000			
Trip1 25-32		00000000			
P-Setting	PN	0.050	0.005	0.100	0.001
Angle	degrees	000.00	-180.00	180.00	0.01
Drop-Ratio	%	60	30	95	1
Delay	s	00.50	00.05	60.00	0.01
Phi-Comp	degrees	0.00	-5.00	5.00	0.01
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 the parameters:****RunOnCPU**

defines the processing unit which runs the function.

**ParSet 4..1**

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

**Trip1 01-08**

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

**Trip1 09-16**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip1 17-24**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip1 25-32**

corresponds to Trip 01-08 (providing tripping unit fitted).

**P-Setting**

Pick-up power setting.

**Angle**

Characteristic angle for the power measurement.

0° = real power forwards

180° = real power backwards

-90° = apparent power forwards

90° = apparent power backwards

All angles between -180° and 180° can be set.

**Drop-Ratio**

Reset ratio of the measuring trigger.

**Delay**

Delay between the protection picking up and the protection tripping. The delay setting also influences the reset time of the function. For  $t > 100$  ms, the protection resets after 50 ms. Resetting is not otherwise intentionally delayed.

**Phi-Comp**

Compensation of c.t. and v.t. phase errors. The setting concerns only the difference between the two errors.

**CurrentInp**

Defines the input channel used for the neutral current. Only single-phase c.t. inputs can be set.

**VoltageInp**

Defines the input channel used for the neutral voltage. Only single-phase v.t. inputs can be set.

**PN**

Rated power given by  $UN \cdot IN$ .

**BlockInp**

Input for blocking the sensitive E/F function.

F: - protection enabled

T: - protection disabled

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

**Trip**

Tripping signal.

**Start**

Starting signal.

## E. Setting instructions

### Settings:

Pick-up power	P-Setting
Characteristic angle	Angle
Reset ratio	Drop-Ratio
Delay	Delay
Phase error compensation	Phi-Comp
Rated power	PN

The value entered for 'P-Setting' is the power at which the function picks up referred to rated power 'PN'. The parameter 'P-Setting' has a setting range of 0.005 to 0.100 in steps of 0.001.

The setting of the parameter 'Angle' determines the characteristic angle of the measurement. Its implications are explained below under "Real power" and "Apparent power".

The desired reset ratio is set as a percentage of the pick-up value using the parameter 'Drop-Ratio'. To ensure that the reset ratio is adequate for low values of 'P-Setting', the following condition is checked:

$$'Drop - Ratio' < 100 - \frac{50}{100 \times 'P - Setting' + 1}$$

An angle to compensate the relative phase errors of c.t's and v.t's can be entered using parameter 'Phi-Comp'. The effective characteristic angle is the sum of the parameters 'Angle' and 'Phi-Comp'.

The setting for the rated power is left at PN = 1.000. The corresponding reference value in the "ANALOGUE CT/VT CHANNELS-AD CHANNEL REF VAL" menu must be adjusted for rated voltages other than 100 V.

### Real power

The real power component (real power component = proportion of real power current x displacement voltage) of the zero-sequence power is monitored to detect E/F's in systems with Petersen coils and high-resistance grounded systems. The neutral component of the current in the healthy phases resulting from their capacitances to ground and the inductive Petersen coil current unite at the fault location and return to the source via the faulted phase.

A power relay is installed at both ends of every line with the exception of stub lines, which only require a relay at the source end. If the E/F current is too low and has to be artificially increased, an overvoltage relay is fitted to detect the displacement voltage and connect a grounding resistor temporarily to the star-point. To avoid any incorrect response of the power relays while this is being done, they are enabled after a short delay. The section of the line with the fault is determined by comparison of the relay directions.

The real power component of the E/F current is determined by the resistive losses of the lines, the Petersen coils and the grounding resistors. A typical value for the charging current of overhead lines is around 2.5 A / 10 kV and 100 km. In the case of cable systems, it can be determined from the cable data. The minimum real power component of the current at the minimum voltage at which the power relay has to operate can be determined according to the above procedure. The power at which it must pick up must be set somewhat lower to allow for phase and ratio errors of the c.t.'s.

The parameter 'Angle' must be set to 0° to measure real power in the forwards direction, respectively 180° to measure real power in the reverse direction.

**Note:**

The connections are made in strict accordance with the ABB wiring diagram.

**Example of how to determine the setting**

Assuming an overhead line system with an E/F current (sum of the three phase currents) of 30 A and a real power current component of 5 A. The core-balance c.t. has a ratio of 125:1. The star-point v.t. has a secondary voltage of 100 V for a solid E/F at the generator/power transformer terminals. Therefore:

$$P_N = 1 \text{ A} \times 100 \text{ V} = 100 \text{ VA.}$$

It is required to detect E/F's down to 50 % of the displacement voltage. The E/F current flows only from one side, so that no division of the current takes place.

The real power component of the current of 5 A results in a secondary current of:

$$I_W = 5 \text{ A} \times 1/125 = 0.04 \text{ A at maximum displacement voltage}$$

$$I_W = 0.04 \text{ A} \times 0.5 = 0.02 \text{ A at 50 % displacement voltage.}$$

The required pick-up power is thus:

$$P = 0.02 \text{ A} \times 50 \text{ V} = 1 \text{ VA}$$

This corresponds to 1 % referred to the rated power  $P_N$  of 100 VA.

A setting of 0.5 %  $P_N$  is possible, but the accuracy of the c.t.'s must be checked before deciding whether such a sensitive setting is permissible. The real power can be increased by adding a grounding resistor.

### **Apparent power**

The apparent power component of the neutral power is monitored to detect E/F's in ungrounded systems. Every feeder is equipped with a relay. During an E/F, the capacitive E/F current of the entire system less that of the faulted line flows into the faulted line. Only the E/F relay of the faulted line indicates power flowing into its line.

The minimum capacitive E/F current available to operate the relays is the total capacitive E/F current of the whole system for the smallest configuration to be expected less that of the faulted line. Of this capacitive current, only the percentage corresponding to the assumed minimum displacement voltage at which the protection is still required to operate may be considered. If there are any double-circuit lines, the division of current between the circuits must also be taken into account.

To allow for the c.t. errors at such low current levels, the pick-up value set on the relay must be less than the product of the minimum current determined above and the minimum voltage.

The parameter 'Angle' must be set to  $-90^\circ$  pick up for E/F's in the forwards direction and  $90^\circ$  for the reverse direction.

### **Note:**

The connections are made in strict accordance with the ABB wiring diagram.



### **Time delay**

The delay required between the picking up of the relay ('Start') and tripping ('Trip') is set by means of parameter 'Delay'. The setting range provided is 0.05 to 60 s in steps of 0.01.

### **C.t./v.t. inputs**

The two c.t. and v.t. input channels 'CurrentInp' (current) and 'VoltageInp' (voltage) have to be configured for the purpose. The current input channel may only be allocated to a single-phase metering (core-balance) c.t. and the voltage channel to a single-phase v.t.

### **Binary inputs and outputs**

The tripping output may be allocated to either a tripping relay or a signalling relay (different parameters) and the starting signal to a signalling relay.

Operation of the sensitive E/F protection can be inhibited by applying a signal to the 'BlockInp' input.



### 3.5.28. ***Sensitive earth fault protection for grounded systems (EarthFltGnd2)***

#### **A. Application**

High-resistance earth faults, which cannot be detected by the distance protection, can still cause appreciable problems in spite of the relatively low fault currents involved.

The sensitive E/F protection function has been included to complement the main line protection function and cover the low E/F current range. The protection processes the zero-sequence components  $3I_0$  and  $3U_0$ .

#### **B. Features**

- DC component filter
- harmonic filter
- directional measurement of zero-sequence components (derived either internally or externally)
- current pick-up enabling level
- reference voltage enabling level
- adjustable characteristic angle
- permissive and blocking transfer tripping schemes
- echo logic for weak infeed and open circuit-breaker
- transient blocking logic for reversal of energy direction.

#### **C. Inputs and outputs**

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

- Voltage
- Current

##### **II. Binary inputs:**

- External blocking
- Receive
- CB closed
- V.t. supervision
- Starting and tripping by the distance function

##### **III. Binary outputs:**

- Pick-up
- Trip
- Fault forwards
- Fault backwards
- Transmit
- Block distance protection receive

**IV. Measurements:**

- Neutral voltage ( $3U_0$ )
- Neutral current ( $3I_0$ )
- Real power component of neutral power ( $3U_0 \cdot 3I_0$ )
- Apparent power component of neutral power
- Fault direction (1 = forwards, -1 = backwards).  
this measured variable only applies when the binary input  
"CB closed" is active)

This function does not transfer any tripping measurements via the IBB.

The measurements in the event list are not generated at the instant of tripping, but when the enabling levels "U-Setting" and "I-Dir are exceeded".

**D. Sensitive E/F protection settings - EarthFltGnd2**

Summary of parameters:

Text	Units	Default	Min.	Max.	Step
RunOnCPU		CPU1	(Select)		
ParSet 4..1		P1	(Select)		
Trip1 01-08		00000000			
Trip1 09-16		00000000			
Trip1 17-24		00000000			
Trip1 25-32		00000000			
VoltageInp	CT/VT-Addr.	0			
CurrentInp	CT/VT-Addr.	0			
CTneutral		Line side	(Select)		
I-Setting	IN	0.100	0.100	1.000	0.01
U-Setting	UN	0.200	0.003	0.100	0.001
Angle	deg	60.0	-90.0	90	5
ComMode		Permissive	(Select)		
SendMode		MeasBwd	(Select)		
1 Channel		off	(Select)		
Echo		off	(Select)		
t Basic	s	0.050	0.000	1.000	0.001
t Wait	s	0.050	0.000	0.500	0.001
tTransBlk	s	0.100	0.000	0.500	0.001
Ext block	BinaryAddr	F			
Receive	BinaryAddr	F			
CB closed	BinaryAddr	T			
VT Superv	BinaryAddr	F			
Ext Start R	BinaryAddr	F			
Ext Start S	BinaryAddr	F			
Ext Start T	BinaryAddr	F			
ExtTrip 3P	BinaryAddr	F			
ExtTrip	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr	ER			
MeasFwd	SignalAddr				
MeasBwd	SignalAddr				
Send	SignalAddr				
Recve Inh	SignalAddr				

**Explanation of parameters:**

RunOnCPU

defines the processing unit which runs the function.

**ParSet 4..1**

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

**Trip1 01-08**

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

**Trip1 09-16**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip1 17-24**

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip1 25-32**

corresponds to Trip 01-08 (providing tripping unit fitted).

**VoltageInp**

I/P channel. All the voltage channels are available for selection. If the neutral voltage is derived from the three phase voltages, the first channel (R phase) of the group of three must be selected.

**CurrentInp**

I/P channel. All the current channels are available for selection. If the neutral current is derived from the three phase currents, the first channel (R phase) of the group of three must be selected.

**CT neutral**

Side of the c.t's on which the star-point is formed (current direction):

- busbar side
- line side.

**I-Setting**

Current pick-up setting.

**U-Setting**

Reference voltage pick-up setting.

**Angle**

Characteristic angle setting.

### ComMode

Kind of transfer tripping scheme:

- permissive
- blocking.

### SendMode

For what system condition a signal is transmitted in an intertripping scheme:

- forwards measurement (only permissive scheme)
- non-directional (only blocking scheme)
- backwards measurement (only blocking scheme).

### 1 Channel

Supplementary logic needed for coordinating E/F and distance protections when using the same communications channel for a permissive scheme.

- off
- on.

### Echo

Echo logic for weak infeed and open CB:

- off                      Echo logic disabled
- Weak                    Echo only for weak infeed
- Bkr                      Echo only when CB open
- Weak & Bkr          Echo for weak infeed or CB open.

### t Basic

Basic time setting.

### t Wait

Time allowed for a blocking signal to be transferred and for the directional comparison to be made.

### tTransBlk

Blocking time after a reversal of fault energy direction (transient blocking).

### Ext block

I/P for an external blocking signal.

F: - enabled

T: - disabled

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

### Receive

PLC receive I/P.

F: - no PLC receive signal

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

**CB closed**

CB position indicator I/P.

F: - function disabled

T: - function enabled

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

**VT Superv**

V.t. supervision I/P.

F: - tripping enabled

T: - tripping disabled

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

**Ext Start R / S / T, Ext Trip 3P, Ext Trip**

I/P's for the distance function signals 'Start R', 'Start S', 'Start T', 'Trip CB 3P' and 'Trip CB' for coordinating operation.

F: - not connected

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

**Trip**

Tripping signal O/P.

**Start**

O/P for signalling that the protection has picked up, i.e. the current has exceeded the enabling setting. (I-Setting)

**MeasFwd**

O/P for signalling a fault in the forwards direction.

**MeasBwd**

O/P for signalling a fault in the backwards direction.

**Send**

PLC transmit signal.

**Recvelnh.**

O/P for preventing the distance function from receiving a PLC signal. (This is only effective when E/F and distance protections use a common PLC channel, i.e. the parameter '1 Channel' is set to 'on' .)



## **E. Setting instructions**

### **3.5.28.1. Coordination with the distance protection**

#### **Directional E/F function as ancillary to the distance function**

Compared with integrated E/F and distance functions, the logic in an independent E/F function needs certain starting and tripping signals generated by the distance function and the E/F protection is blocked in the following situations:

- starting of more than one distance phase
- three-phase tripping
- any trip (single and three-phase), if '1 Channel' is set to 'on'.

#### **Scheme with independent communication channels**

Apart from the added security of redundancy, independent communication channels enable different transfer tripping schemes to be used for E/F and distance protections.

Providing the distance protection can detect a fault, it should trip before the E/F protection picks up. For this reason, the basic operating time 't basic' for the E/F protection must be set longer than the longest response time to be expected of the distance protection.

#### **Scheme with a common communication channel**

Where E/F and distance protections use the same communication channel, the transfer tripping schemes must be either both permissive or both blocking. In the case of permissive schemes, in which the distance protection operates with non-directional criteria at one end for a weak infeed, a supplementary logic must be enabled by appropriately setting the parameter 'Single chan.'.

This supplementary logic interlocks the distance relay's receive signal at the end of the E/F function's basic time or when it picks up in the backwards direction. To this end, the signal 'Recvelnh' is connected to the distance protection input 'ExtBlkHF'. Thus the communication channel is initially available for use by the distance protection and only made available to the E/F protection at the end of the basic time. The basic time setting must allow adequate time for the distance protection to detect and clear a fault if it can.

### **Independent directional E/F protection**

The E/F function can also be applied as a completely independent protection, but only in MV and HV systems.

The coordination of E/F and distance protections in this case is achieved by appropriately setting the parameter 't basic' .

If this time is too short, there is a likelihood that the E/F protection will issue a three-phase trip before the circuit-breaker has opened for faults that have been correctly detected by the distance protection.

The basic time of the E/F protection must therefore be long enough to ensure that the distance protection can trip phase-selectively.

No facility is provided for using the distance relay starters to achieve phase-selective tripping by the directional E/F function.

An independent directional E/F function requires its own communication channel which must be entirely independent of the distance protection.

#### **3.5.28.2. *Choice of operating mode***

It is assumed that the E/F protection settings at both ends of the protected line are the same. This applies especially to the basic time, the blocking time, the transfer tripping scheme in use and options.

### 3.5.28.3. *Choice of transfer tripping scheme*

In the case of a permissive directional comparison scheme, the amount of fault resistance which can be detected reduces towards the remote end of the line, because the enabling current must be exceeded at both ends. Without additional precautions, the use of a permissive scheme would be limited on lines with a weak infeed at one end.

It was possible to eliminate this disadvantage by providing the directional E/F protection with its own echo logic for weak infeeds which can be switched in and out as required.

**Important:**

**Note that the protection only operates in a comparison mode during the comparison time (1 s) and is blocked at the end of this time. The comparison time starts at the end of the basic time.**

On the other hand, a directional comparison scheme using a blocking signal is able to detect high-resistance E/F's along the whole length of the line, because the protection at the strong infeed end is always able to trip although the current at the weak infeed end does not reach the enabling level.

## Permissive directional comparison scheme

In this scheme, each of the protection functions has to receive a signal from the opposite end of line in order to be able to trip. A protection function sends a permissive signal when its current exceeds the enabling level 'I setting', the basic time 't Basic' has expired and the fault detected is in the forwards direction.

Options:

- Echo "Bkr":

Providing this parameter is active, a permissive signal (echo) is sent to the opposite end of the line, if the local circuit-breaker is open and a signal is received. Tripping is thus possible at the infeed end.

The duration of the echo signal is limited to 150 ms.

- Non-directional echo "Weak infeed":

If the directional E/F function at the weak infeed end of a line cannot measure, because the reference voltage is too low or the current does not reach the enabling level, a signal is returned to the opposite end of the line if one is received.

This enables tripping to take place at the end with the stronger infeed.

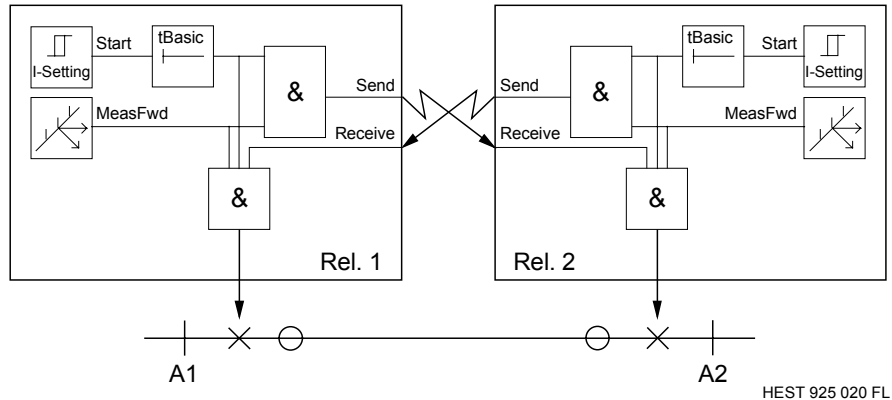


Fig. 3.5.28.1 Principle of a permissive directional comparison scheme

Start : current higher than the enabling level 'I setting' and 't basic' expired

t Basic : basic time

MeasFwd : fault in forwards direction

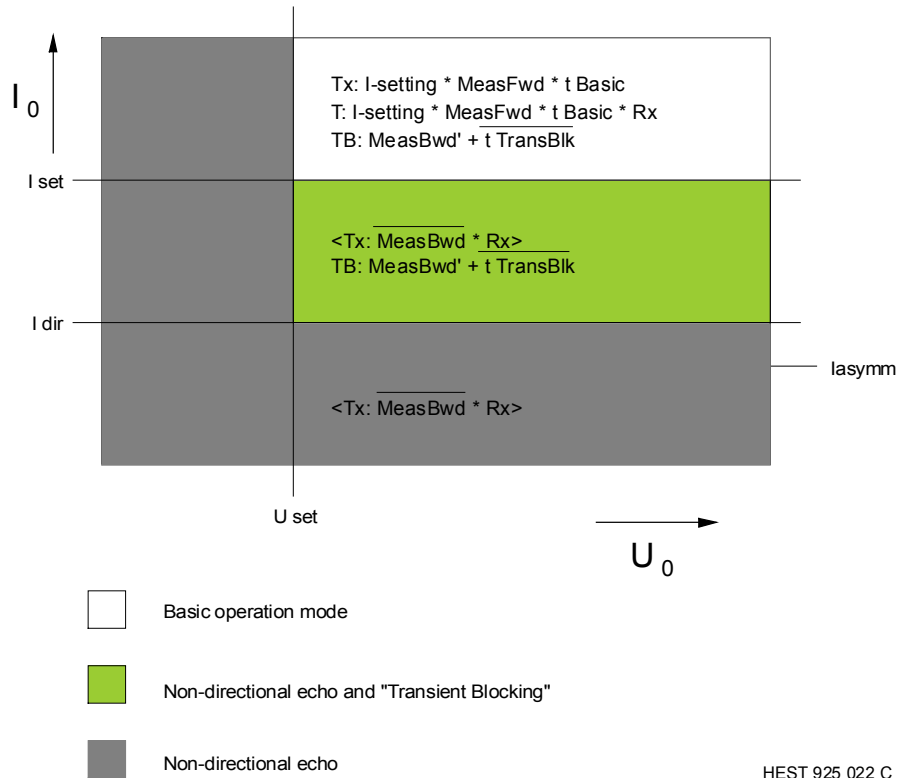


Fig. 3.5.28.2 Operation of a permissive directional comparison scheme

<...>	: optional function
Rx	: receive
MeasFwd	: fault in forwards direction
MeasBwd	: fault in backwards direction including 'Transient blocking'
MeasBwd'	: fault in backwards direction
I dir	: current enable for directional measurement ( $I_{dir} = 0.7 I_{Setting}$ )
I Setting	: current enabling level
lasymm	: asymmetrical currents under normal load conditions
Tx	: send
T	: trip
TB	: transient blocking
t TransBlk	: blocking time
t Basic	: basic time
t Wait	: waiting time
U Setting	: reference voltage

## Blocking directional comparison scheme

Providing the conditions for directional measurement are fulfilled i.e. the current higher than 'I dir' and the voltage higher than its enabling level 'U-Setting', a protection function transmits a blocking signal to the remote station immediately it detects a fault in the backwards direction.

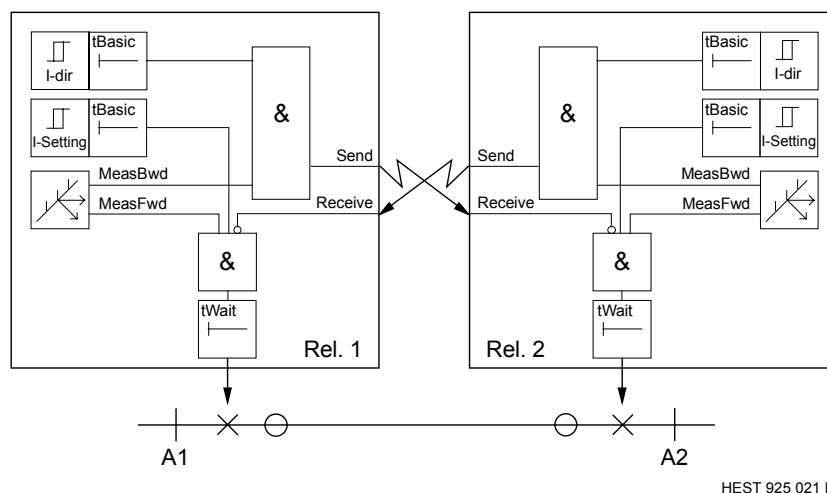
**Note:**  $I_{dir} = 0.7 I\text{-Setting}$

A protection function measuring a fault in the direction of the protected line trips at the end of the adjustable waiting time 't wait', providing a blocking signal is not received beforehand.

### Options:

- SendMode: 'non-directional'

A blocking signal is transmitted in this mode, if the current is higher than 'I dir', the basic time has expired and no fault is detected in the forwards direction (including when  $3U_0 < U\text{-Setting}$ ).



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Fig. 3.5.28.3 Principle of a blocking directional comparison scheme

I-Setting	: current enabling level
I-dir	: current enable for directional measurement ( $I\text{-dir} = 0,7 I\text{-Setting}$ )
t Basic	: basic time
t Wait	: waiting time
MeasFwd	: fault in forwards direction
MeasBwd	: fault in backwards direction

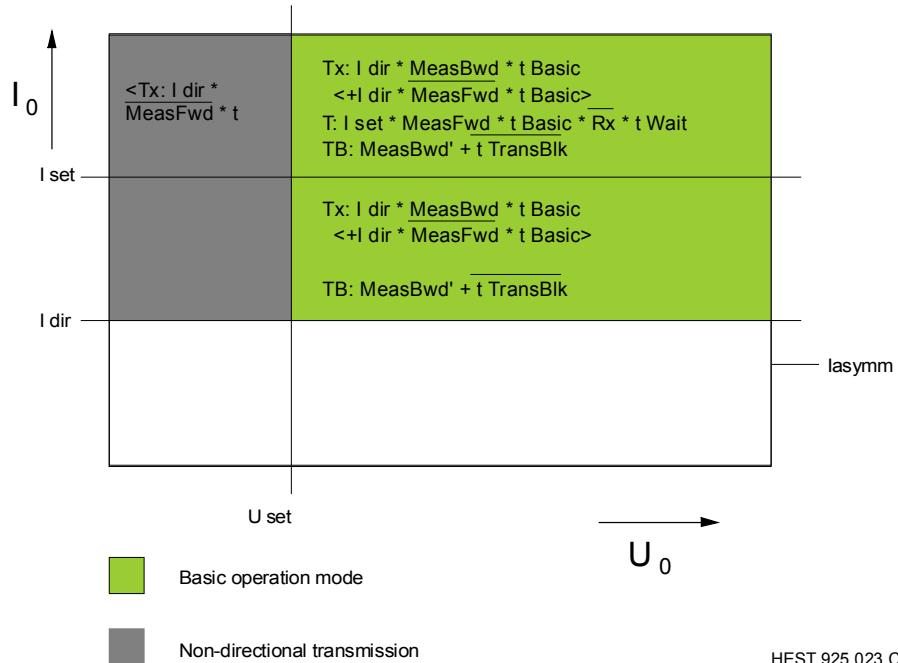


Fig. 3.5.28.4 Operation of a directional comparison blocking scheme (see Fig. 3.5.28.2 for legend)

#### 3.5.28.4. **Setting the enabling pick-up levels**

The setting of the current enabling 'I dir' must take account of the zero-sequence component in normal operation arising from system asymmetries.

The pick-up setting for the voltage enabling signal 'U-Setting' is determined by the level of asymmetries on the secondary side (v.t. tolerances, asymmetrical burdens etc.).

The ability to read voltage and current values on the relay is a useful aid for determining these settings.

For example, if the enabling current setting 'I-Setting' is too low, the pick-up signal lights continuously (current circuit enabled).

Since an E/F causes asymmetrical voltages in the vicinity of the fault, the current flowing via the system capacitances also has a zero-sequence component. A capacitive current of this kind on a long line lies within the setting range of the sensitive E/F protection function.

The pick-up level 'I dir' of the current circuit for the directional measurement has a fixed setting of  $0.7 \times 'I \text{ set}'$  to take account of influences such as c.t. errors and the capacitive charging currents of the line.

The following procedure is recommended for setting the pick-up levels:

- The enabling current for the directional measurement must be set to at least twice the maximum possible asymmetrical current, which can occur in normal operation.

$$I\text{-Setting} = 2.0 \frac{I_{\text{asymm}}}{I_N}$$

- The voltage pick-up must be set to 1.6 times the level of the spurious voltages, which can occur due to asymmetries in the v.t. secondary circuit.

$$U\text{-Setting} = 1.6 \frac{U_{\text{sec.asymm}}}{U_N}$$

where:

U-Setting : setting of the enabling voltage for the directional measurement

$U_{\text{sec.asymm}}$  : voltage component  $3 U_0$  caused by asymmetries in the v.t. secondary circuit (e.g. v.t. errors)

$U_N$  : 100 V or 200 V according to v.t. unit in use

I-Setting : setting of the enabling current

$I_{\text{asymm}}$  : current component  $3I_0$  caused by asymmetrical load currents

$I_N$  : primary c.t. rated current.

### 3.5.28.5. **Setting the characteristic angle 'Angle'**

The line marking the reversal of direction lies at  $+90^\circ$  in relation to the reference voltage.

In order to achieve symmetrical operation of the directional element in spite of this, the characteristic angle should equal that of the source impedance.



**3.5.28.6. Setting the basic time 't basic'**

The basic time is the period between pick-up of the protection and the earliest possible trip.

The operation of the protection function can be coordinated with others on the same line by judiciously setting the basic time.

The basic time is also used to achieve coordination between the E/F function (three-phase tripping) and the distance function (phase-selective tripping).

The E/F protection is delayed to allow time for the distance protection to respond to a fault if it can.

The basic time is normally set to:

- t basic > max. phase-selective trip by the distance protection  
incl. signal transmission time (taking account of  
sequential tripping)
- + CB operating time
- + aux. contact time  
(I/P 'CB position')
- + safety margin.

The sum of these times is usually about 100 to 200 ms.

**3.5.28.7. Circuit-breaker delay**

To avoid operation of the enabling current detector during the transient oscillations, which occur following the closing of the circuit-breaker, it is blocked for 50 ms upon receiving the corresponding signal from the CB.

**3.5.28.8. The comparison time 't comp'**

The comparison time is the time allowed for the directional comparison to be made and is therefore dependent on the type of transfer tripping scheme.

The comparison time has a fixed setting of 1 s.

**3.5.28.9. Setting the waiting time 't wait'**

The waiting time is also started at the end of the basic time, but is only effective in a blocking scheme.

In a blocking scheme, tripping is delayed by the setting of 't wait' to allow time for the protection in the opposite station to decide on the direction of the fault and to transmit a corresponding blocking signal if necessary.

't wait' should be set at least as long as the measuring time (about 30 ms) plus the longest possible signal transmission time.

#### **3.5.28.10. *Setting the transient blocking time 't TransBlk'***

The protection function includes a "transient blocking logic" to prevent any mal-operation during the course of tripping a fault or auto-reclosure on double-circuit lines, when there is a likelihood of the flow of energy reversing direction. The time setting can be selected in a wide range to suit the prevailing conditions.

For example, after a fault has been detected in the backwards direction, a second directional decision in the forwards direction is inhibited for the setting of 't TransBlk' .

The time chosen is determined largely by the time required for the measurement to reset and the transfer tripping scheme in use.

The recommended setting is 60 ms plus the reset time of the communication channel.

#### **3.5.28.11. *Analogue inputs of the function***

Where the zero-sequence components of the voltages and the currents are derived internally, the analogue inputs must be connected precisely as shown in the wiring diagram. The neutral of the c.t.'s in this case is formed on the line side and the parameter 'CT neutral' must be set to 'line side' .

#### **3.5.28.12. *Binary inputs of the function***

##### **Ext. block**

Exciting the 'Ext. block' I/P disables the entire protection function.

##### **Receive**

The signal transmitted by the protection in the opposite station is connected to this I/P.

### **CB position**

The 'CB position' I/P is intended for the position indicator signal from the circuit-breaker and has a fixed pick-up delay of 50 ms. The protection function is only enabled when this signal is received to confirm that the CB is closed. The corresponding auxiliary contacts for the three phases must be connected in series to ensure that the protection does not operate during single-phase reclosure.

The echo logic is enabled 100 ms after the circuit-breaker is opened.

### **VT Supervision**

The 'FuseFail' I/P (v.t. supervision) is needed to block the echo logic. It can be excited either by the 'VTSup' signal from the internal distance protection function or an auxiliary contact on the m.c.b. via a binary I/P.

If this I/P is not needed, it must be set to "F".

### **Ext Start R / S / T, Ext Trip 3P, Ext Trip**

These I/P's are for coordinating operation with the distance protection function. To them are connected the distance function signals 'Start R', 'Start S', 'Start T', 'Trip CB 3P' and 'Trip CB'.

They must be set to "F" if an independent directional E/F scheme is in use.

### **3.5.28.13. Outputs**

#### **Trip**

There are two 'Trip' signals, one for energising the tripping relay via the tripping logic and the other for controlling LED's and signalling contacts.

#### **Start**

An active "Start" O/P signals that the zero-sequence current has exceeded the pick-up setting 'I-Setting' . This signal is only generated providing the function is not blocked.

**MeasFwd**

'MeasFwd' is active when the measuring element detects a fault in the forwards direction, i.e. the settings of 'I dir' and 'U setting' have been exceeded.

**MeasBwd**

'MeasBwd' is active when the measuring element detects a fault in the backwards direction, i.e. the settings of 'I dir' and 'U setting' have been exceeded.

**Send**

The 'Send' O/P is the signal sent to the other end of the line.

**Receive Inhibit**

The 'Recve Inh' signal prevents the distance function from receiving a PLC signal (see [Section 3.5.28.1.](#)). It is only generated when the parameter '1 Channel' is set, the basic time has expired or the E/F protection picks up for a reverse fault.

The signal 'Recve Inh' must be connected to the distance function I/P 'ExtBlkHF'.

### 3.5.29. *Inverse definite minimum time 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. 3.5.29.1):
  - c = 0.02 : normal inverse
  - c = 1 : very inverse and long time earth fault
  - c = 2 : extremely inverse.
  - RXIDG : logarithmic time characteristic
- 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 - IO-Invers

Summary of parameters:

Text	Units	Default	Min.	Max.	Step
RunOnCPU		CPU1	(Select)		
ParSet 4..1		P1	(Select)		
Trip1 01-08		00000000			
Trip1 09-16		00000000			
Trip1 17-24		00000000			
Trip1 25-32		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.	00000			
IB-Setting	I <sub>N</sub>	1.00	0.04	2.50	0.01
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			
Start	SignalAddr	ER			

### Explanation of parameters:

#### RunOnCPU

defines the processing unit which runs the function.

#### ParSet 4..1

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

#### Trip1 01-08

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

#### Trip1 09-16

corresponds to Trip 01-08 (providing tripping unit fitted).

#### Trip1 17-24

corresponds to Trip 01-08 (providing tripping unit fitted).

**Trip1 25-32**

corresponds to Trip 01-08 (providing tripping unit fitted).

**c-Setting**

Determines whether the tripping characteristic is inverse or logarithmic (inverse 0.02...2.00, logarithmic RXIDG).

**k1-Setting**

Multiplier

**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 I/P
- 3 : neutral current derived internally from the three phases.

**CurrentInp**

I/P 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

### Reference current 'IB-Setting'

An IDMT overcurrent function does not have a starting current setting in the same sense as a definite time relay. Instead the position of the characteristic is chosen to be above the load current. This is achieved by setting a reference current  $I_{B1}$  corresponding to the load current of the protected unit. The reference current  $I_B$  determines the relative position of the characteristic. The IDMT function is enabled when the current exceeds the reference current  $I_B$  by a certain amount (setting of 'I-Start'). Setting the reference current  $I_B$  to correspond to the load current  $I_{B1}$  of the protected unit instead of its rated current enables at

- |                                 |   |  |
|---------------------------------|---|--|
| $I_{B1} < \text{rated current}$ | : | greater sensitivity  |
| $I_{B1} > \text{rated current}$ | : | full use to be made of the thermal capability of the protected unit. |

### Example:

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

Reference current setting 'IB-Setting'

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

Setting

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



### 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
"logarithmic"	: c = RXIDG

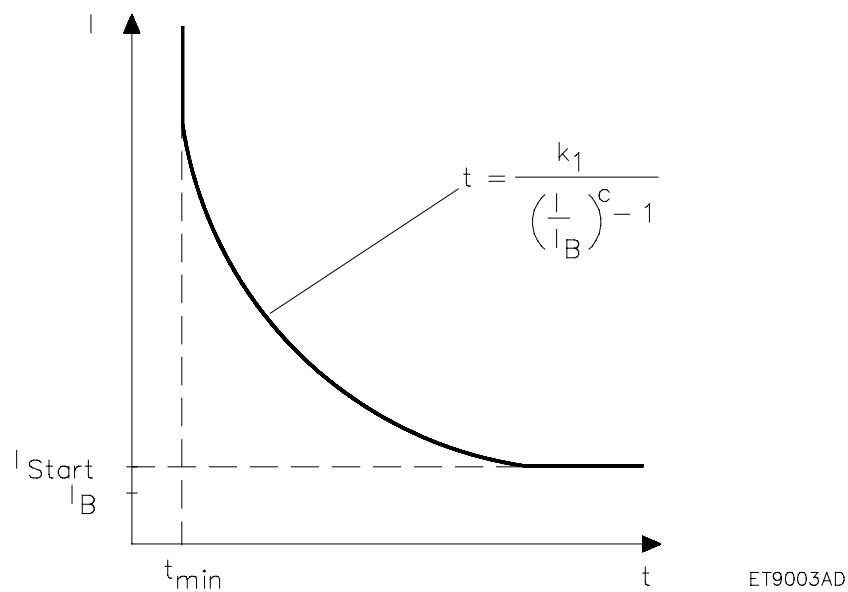


Fig. 3.5.29.1 IDMT tripping characteristic for 'I0-Invers' ( $I = 3 I_0$ ) according to B.S. 142

The logarithmic characteristic RXIDG is shown in Fig. 3.5.29.2.

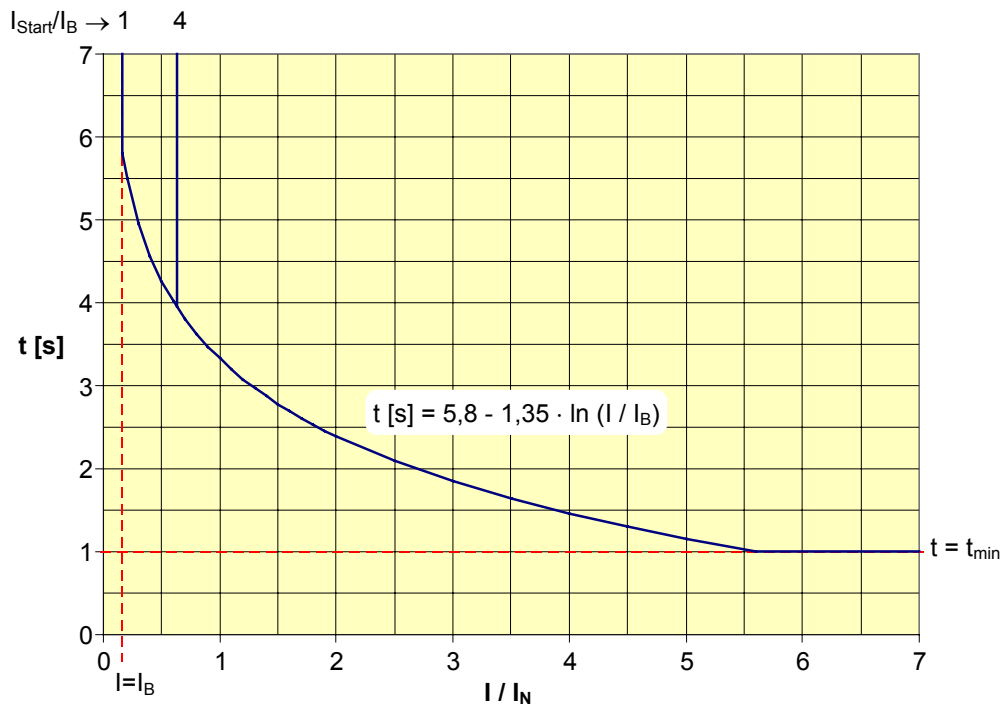


Fig. 3.5.29.2 RXIDG tripping characteristic ( $I = 3 I_0$ )

### 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

$$t = \frac{k1}{\frac{3I_0}{I_B} - 1}$$

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.

The multiplier k1 has no influence on the RXIDG characteristic.

#### **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<sub>min</sub>’ 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 '10-Invers' function has to be blocked for the time that one pole of a circuit-breakers is open if the minimum tripping time 't<sub>min</sub>' 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

### 3.5.30. *HV distance protection function (HV-Distance)*

The HV distance protection is optimised for applications in EHV power systems. The main difference compared with the standard distance protection function is improved phase selection to achieve a better response to evolving faults on parallel circuits.

Refer to the standard distance relay function in [Section 3.5.31](#) for the setting procedure. However, note must be taken of the following differences (the parameters in [Section 3.5.31](#) that do not apply to the HV distance protection or have a different significance are marked):

- The HV distance function is only equipped with underimpedance starters, i.e. the overcurrent starters have been omitted. As a consequence, the parameters “StartMode” and “Istart”, the binary input “ExtUZBlk” and the signals “Start OC” and “Start UZ” do not exist.
- The function is only applicable to solidly grounded systems. Also the “PhaseSelMode” parameter has different settings.
- In addition to the non-directional starter mode available up to the present, the “PhaseSelMode” parameter also permits the direction and reach of the overreach zone to be selected. This is only effective, however, for phase selection in the first time step and has no influence on (non-directional) signals. The “PhaseSelMode” parameter can be set to one of the following:
  - non-directional (default)
  - forwards overreach
- An earth fault detector with negative phase sequence restraint  $I_2$  is now included in addition to the existing restraint using the largest phase current  $I_{max}$ . The settings “Blocked” and “I0 AND U0” are no longer available for the parameter “GndFaultMode”. The settings are therefore (the corresponding earth fault criteria are given on the right,  $I_E = 3 I_0$  being referred to as the neutral current):

I0:  $(I_E > “3I0min”) \text{ AND } (I_E > 0.25 I_{max})$

I0 OR U0:  $(I_E > “3I0min”) \text{ AND } (I_E > 0.25 I_{max})$   
 OR  $(U_E > “3U0min”)$

I0(I2):  $(I_E > \text{"3I0min"}) \text{ AND } (I_E > 0.23 I_2)$

I0(I2) OR U0:  $(I_E > \text{"3I0min"}) \text{ AND } (I_E > 0.23 I_2) \text{ OR } (U_E > \text{"3U0min"})$

- The slope of the measurement characteristic for the first zone is changed from  $7^\circ$  to  $14^\circ$  if the load current exceeds the setting of the new parameter "I Load" and power is flowing from the relay location towards the remote end of the line (over-reaching due to the semaphore effect).  
The setting range for "I Load" is  $0 \dots 2 I_N$  in steps of  $0.01 I_N$  (default setting =  $0.5 I_N$ ), where:

"I Load" =  $0.01 \dots 1.99 I_N$ : Characteristic switches as described above.

"I Load" =  $0 I_N$ : Fixed slope of  $14^\circ$

"I Load" =  $2 I_N$ : Fixed slope of  $7^\circ$

- The setting "BlockZ1" in the "Measurement" sub-menu has been dropped and a binary input "ExtBlock Z1" provided instead.
- In the case of short lines and a large line-to-source impedance ratio, a better response for phase-to-phase faults can be obtained by correcting the phase-angles of  $U_S$  and  $U_T$ . Calibration is performed during commissioning as follows:
  - Inject the same voltage ( $0.5 U_N$ ) into all three phases in parallel.
  - Read the phase error of S and T phases (in relation to R phase) in the "List AD channels".
  - Enter the values of the readings for the parameters "SR Error" and "TR Error" in the sub-menu "Analogue inputs".

### 3.5.31. *Distance protection (Distance)*

#### **A. Application**

Distance protection for the high-speed discriminative protection of long or short overhead lines or cables, double-circuit lines, heavily loaded lines, lines with weak infeeds and what are referred to as “short-zone” lines.

The protection is applicable to solidly or low-resistance grounded systems, systems with Petersen coils or to ungrounded systems.

All kinds of faults are detected including close-in three-phase faults, cross-country faults, evolving faults and high-resistance earth faults.

The protection remains stable in the presence of power swings and reversal of energy direction. Switching onto an existing fault results in instantaneous tripping of the circuit-breaker.

The distance function can also act as back-up protection for the power transformer and neighbouring lines. Most of the logic described in this Section (e.g. the transmission of signals) is not used for these applications.

#### **B. Features**

- overcurrent or underimpedance starters (polygon characteristic)
- 5 distance stages (independently set polygon characteristics)
- definite time overcurrent back-up protection also applicable for protecting short zones (teed section in 1½ breaker schemes ([see Section 4.8.4.](#)))
- V.t. supervision
- power-swing blocking
- tripping logics for:
  - switch-onto-fault protection
  - overreaching zone
  - permissive underreaching transfer tripping (also for weak infeed and communications channel failure)
  - permissive overreaching transfer tripping (also for weak infeed, communications channel failure and reversal of energy direction)
  - blocking scheme (also for reversal of energy direction).

## C. Inputs and outputs

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

- three-phase currents
- three-phase voltages
- neutral current
- neutral current of the parallel circuit

### II. Binary inputs:

- reversal of measuring direction
- distance function blocking
- underimpedance starter blocking
- power-swing blocking
- overcurrent back-up blocking (I O/C)
- dead line
- manual CB close
- zone extension
- isolator open
- communication receive
- communication channel failure
- single-phase auto-reclosure ready
- tripping condition blocking for the switch-onto-fault protection
- incoming PLC blocking signal
- first zone blocking

### III. Binary outputs:

- R+S+T starters
- RST starter
- R starter
- S starter
- T starter
- E starter
- I0 starter
- U0 starter
- I> starter
- Z< starter
- overcurrent back-up starter (I O/C)
- switch-onto-fault starter
- single-phase starter
- CB trip
- RST trip
- R trip
- S trip
- T trip



- three-phase trip
- single-phase trip
- overcurrent back-up trip (I O/C)
- switch-onto-fault trip
- trip with transfer trip signal
- “short-zone” protection trip
- time  $\geq$  2nd. step
- Zone 1 time
- Zone 2 time
- Zone 3 time
- Zone 4 time
- final zone time
- measurement
- overreaching measurement
- forwards measurement
- reverse measurement
- ‘weak infeed’ trip
- distance protection blocked
- delayed distance protection blocked
- power-swing blocking
- v.t. supervision
- delayed v.t. supervision
- communication send
- PLC boost
- memory frequency deviation

#### **IV. Measurements:**

- Impedance loop RE
- Impedance loop SE
- Impedance loop TE
- Impedance loop RS
- Impedance loop ST
- Impedance loop TR

**D. Distance protection function settings - Distance**

Summary of parameters:

Text	Units	Default	Min.	Max.	Step
------	-------	---------	------	------	------

**GENERAL**

RunOnCPU		CPU1	(Select)		
ParSet 4..1		P1	(Select)		
Ref. Length	ohms/phase	01.000	0.01	30.000	0.001
CT Neutral		Busside	(Select)		
EventRecFull		all	(Select)		

**C.T./V.T. INPUTS**

U input	CT/VT-Addr.	0			
I input	CT/VT-Addr.	0			
I0 input	CT/VT-Addr.	0			
I0P input	CT/VT-Addr.	0			

**STARTING (see 'Measurement' for final zone settings)**

1)	StartMode		OC	(Select)		
2)	PhaseSelMode		solid ground	(Select)		
2)	GndFaultMode		I0	(Select)		
1)	Istart	IN	004.00	0.5	10	0.01
	Imin	IN	000.20	0.1	2	0.01
	3I0min	IN	000.20	0.1	2	0.01
	3U0min	UN	000.00	0	2	0.01
	XA	ohms/phase	000.0	0	999	0.1
	XB	ohms/phase	000.0	-999	0	0.1
	RA	ohms/phase	000.0	0	999	0.1
	RB	ohms/phase	000.0	-999	0	0.1
	RLoad	ohms/phase	000.0	0	999	0.1
	AngleLoad	deg	45	0	90	0.1
	Uweak	UN	000.00	0	2	0.01

**MEASUREMENT**

X	(1)	ohms/phase	000.00	-300	300	0.01
R	(1)	ohms/phase	000.00	-300	300	0.01
RR	(1)	ohms/phase	000.00	-300	300	0.01
RRE	(1)	ohms/phase	000.00	-300	300	0.01
k0	(1)	1	001.00	0	8	0.01
K0An	(1)	deg	000.00	-180	90	0.01
Delay	(1)	s	000.000	0	10	0.001

1) Not available on HV distance function.

2) Different settings for the HV distance function.

Text	Units	Default	Min.	Max.	Step
X (2)	ohms/phase	000.00	-300	300	0.01
R (2)	ohms/phase	000.00	-300	300	0.01
RR (2)	ohms/phase	000.00	-300	300	0.01
RRE (2)	ohms/phase	000.00	-300	300	0.01
k0 (2)	1	001.00	0	8	0.01
K0An (2)	deg	000.00	-180	90	0.01
Delay (2)	s	000.00	0	10	0.01
X (3)	ohms/phase	000.00	-300	300	0.01
R (3)	ohms/phase	000.00	-300	300	0.01
RR (3)	ohms/phase	000.00	-300	300	0.01
RRE (3)	ohms/phase	000.00	-300	300	0.01
k0 (3)	1	001.00	0	8	0.01
K0An (3)	deg	000.00	-180	90	0.01
Delay (3)	s	000.00	0	10	0.01
X (4/OR)	ohms/phase	000.00	-300	300	0.01
R (4/OR)	ohms/phase	000.00	-300	300	0.01
RR (4/OR)	ohms/phase	000.00	-300	300	0.01
RRE (4/OR)	ohms/phase	000.00	-300	300	0.01
k0 (4/OR)	1	001.00	0	8	0.01
K0An (4/OR)	deg	000.00	-180	90	0.01
Delay (4/OR)	s	000.00	0	10	0.01
X (BACK)	ohms/phase	000.00	-300	0	0.01
R (BACK)	ohms/phase	000.00	-300	0	0.01
RR (BACK)	ohms/phase	000.00	-300	0	0.01
RRE (BACK)	ohms/phase	000.00	-300	0	0.01
*) Delay (Def)	s	002.00	0	10	0.01
k0m	1	000.00	0	8	0.01
k0mAng	deg	000.00	-90	90	0.01
UminFault	UN	000.05	0.01	2	0.01
MemDirMode		Trip	(Select)		
*) DefDirMode		non-dir	(Select)		
1) BlockZ1		off	(Select)		

\*) These parameters belong to the final zone.

The starter and measurement settings (in columns Min., Max. and Step) have to be divided by 10 for relays with a rated current of 5 A. They do not change for rated currents of 1 A and 2 A.

1) Not available on HV distance function.

Text	Units	Default	Min.	Max.	Step
------	-------	---------	------	------	------

**O/C BACK-UP PROTECTION**

I O/C	IN	000.00	0	10	0.01
Delay O/C	s	005.00	0	10	0.1

**V.T. SUPERVISION**

VTSupMode		off	(Select)		
VTSupBlkDel		off	(Select)		
VTSupDebDel		off	(Select)		
U0min VTSup	UN	000.20	0.01	0.5	0.01
I0min VTSup	IN	000.07	0.01	0.5	0.01
U2min VTSup	UN	000.20	0.01	0.5	0.01
I2min VTSup	IN	000.07	0.01	0.5	0.01

**TRIP SCHEMES**

ComMode		off	(Select)		
TripMode		1Ph trip	(Select)		
SOTFMode		off	(Select)		
SOTF10sec		off	(Select)		
Weak		off	(Select)		
Unblock		off	(Select)		
Echo		off	(Select)		
TransBl		off	(Select)		
t1Block	s	000.04	0	25	0.01
t1TransBl	s	000.05	0	25	0.01
t2TransBl	s	003.00	0	10	0.01
t1EvolFaults	s	003.00	0	10	0.01

**POWER SWING BLOCKING**

tPSblock	s	000.00	0	10	0.01
----------	---	--------	---	----	------

**BINARY INPUTS**

ChgMeasDir	BinaryAddr	F
Ext Blk Dist	BinaryAddr	F
1) ExtUZBlk	BinaryAddr	F
Ext Blk PSB	BinaryAddr	T
Ext Blk O/C	BinaryAddr	F
DeadLine	BinaryAddr	F
Manual Close	BinaryAddr	F
ZExtension	BinaryAddr	F
Isol open	BinaryAddr	F
Com Rec	BinaryAddr	F

---

1) Not available on HV distance function.

Text	Units	Default
Com Fail	BinaryAddr	F
1PolAR	BinaryAddr	T
ExtBlkSOTF	BinaryAddr	F
ExtBlkHF	BinaryAddr	F
ZExtensionAR	BinaryAddr	F
ExtBlock Z1	BinaryAddr	F

**CB COMMANDS**

Trip CB R 01-08	Trip Chan	00000000
Trip CB R 09-16	Trip Chan	00000000
Trip CB R 17-24	Trip Chan	00000000
Trip CB R 25-32	Trip Chan	00000000
Trip CB S 01-08	Trip Chan.	00000000
Trip CB S 09-16	Trip Chan	00000000
Trip CB S 17-24	Trip Chan	00000000
Trip CB S 25-32	Trip Chan	00000000
Trip CB T 01-08	Trip Chan	00000000
Trip CB T 09-16	Trip Chan	00000000
Trip CB T 17-24	Trip Chan	00000000
Trip CB T 25-32	Trip Chan	00000000

**SIGNALLING**

Start R+S+T	SignalAddr	ER
Start RST	SignalAddr	ER
Start RST Aux	SignalAddr	
Start R	SignalAddr	ER
Start R Aux	SignalAddr	
Start S	SignalAddr	ER
Start S Aux	SignalAddr	
Start T	SignalAddr	ER
Start T Aux	SignalAddr	
Start E	SignalAddr	
Start E Aux	SignalAddr	
Start I0	SignalAddr	
Start U0	SignalAddr	ER
1) Start OC	SignalAddr	ER
1) Start UZ	SignalAddr	
Start O/C	SignalAddr	
Start SOTF	SignalAddr	
Start 1ph	SignalAddr	

---

1) Not available on HV distance function.

Text	Units	Default	Min.	Max.	Step
Trip CB	SignalAddr	ER			
Trip RST	SignalAddr				
Trip RST Aux	SignalAddr				
Trip CB R	SignalAddr				
Trip CB S	SignalAddr				
Trip CB T	SignalAddr				
Trip CB 3P	SignalAddr				
Trip CB 1P	SignalAddr				
Trip O/C	SignalAddr	ER			
Trip SOTF	SignalAddr				
Trip Com	SignalAddr				
Trip Stub	SignalAddr				
Delay >=2	SignalAddr				
Delay 1	SignalAddr				
Delay 2	SignalAddr	ER			
Delay 3	SignalAddr	ER			
Delay 4	SignalAddr	ER			
Delay Def	SignalAddr	ER			
Meas Main	SignalAddr				
Meas Oreach	SignalAddr				
Meas Fward	SignalAddr				
Meas Bward	SignalAddr				
Weak Infeed	SignalAddr				
Dist Blocked	SignalAddr				
DelDistBlk	SignalAddr	ER			
Power Swing	SignalAddr	ER			
VTSup	SignalAddr				
VTSup Delay	SignalAddr				
Com Send	SignalAddr	ER			
Com Boost	SignalAddr				
Freq dev	SignalAddr	ER			

**(ADDITIONAL LOGIC)**

BOOL_IN1	BinaryAddr	F			
:	:	:			
BOOL_IN8	BinaryAddr	F			
TIMER_1	ms	0	0	30000	1
:	:	:	:	:	:
TIMER_8	ms	0	0	30000	1
BOOL_OUT1	SignalAddr				
:	:				
BOOL_OUT8	SignalAddr				

## Explanation of parameters:

### GENERAL

#### RunOnCPU

defines the processing unit which runs the function.

#### ParSet 4..1

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

#### Ref. Length (see Section 3.5.31.1.)

Reactance (secondary value) to be used as reference length of the line.

#### CT neutral (see Section 3.5.31.1.)

Side of the c.t.'s on which the star-point is formed (current direction):

busbar side (older BBC diagram)  
line side (standard today).

This parameter only influences the distance function and only the display of the system variables. It does not influence the values of the A/D channels.

#### EventRecFull (see Page 3.5.31-24)

Determination of whether all the distance function events in the event list which have been reset should be displayed:

all  
some.

### C.T./V.T. INPUTS (see wiring diagram in the Appendix)

#### U input

indicates the first of the v.t.inputs assigned to the three phase voltages.

#### I input

indicates the first of the c.t. input assigned to the three phase currents.

#### I0 input

indicates the c.t. input assigned to the neutral current (if fitted and activated). This is used for the external acquisition of the neutral current of the line. If the I0 input is not used, the neutral current is derived from the phase currents.

#### I0P input

indicates the c.t. input assigned to the neutral current of the parallel circuit (if fitted and activated). This is used for the neutral current of the parallel circuit of a double-circuit line.

**Note:**

The c.t. input (IOP) should be wired in the same sense as the neutral current input (I0) (e.g. terminals 9 and 10 correspond to terminals 7 and 8 respectively).

**STARTING** (see Section 3.5.31.2. and 4.8.1.)StartMode <sup>1)</sup>

Definition of the starters used:

- OC - overcurrent
- UZ - underimpedance.

PhaseSelMode <sup>2)</sup>

Phase preference for cross-country faults in systems with Petersen coils and ungrounded systems:

- solidly grounded (no phase preference)
- RTS(R) cyclic
- TRS(T) cyclic
- RTS acyclic
- RST acyclic
- TSR acyclic
- TRS acyclic
- SRT acyclic
- STR acyclic.

GndFaultMode <sup>2)</sup>

Method of detecting ground faults:

- I0
- I0 OR U0
- I0 AND U0.
- Blocked (only phase-to-phase loop measured, e.g. with only two c.t.'s and V connected v.t.'s)

Istart <sup>1)</sup>

Pick-up value of the overcurrent starters.

Imin

Current level for enabling the protection.

3I0min

Current level of the neutral current ( $3I_0$ ) for enabling the protection (ground fault detector).

---

<sup>1)</sup> Not available on HV distance function.

<sup>2)</sup> Different settings for the HV distance function.



**3U0min**

Voltage level of the neutral voltage ( $3U_0$ ) at which the E/F measurement is enabled (ground fault detector).

**XA**

Reactive reach of the impedance characteristic in the tripping direction.

**XB**

Reactive reach of the impedance characteristic in the restraint direction.

**RA**

Resistive reach of the impedance characteristic in the tripping direction.

**RB**

Resistive reach of the impedance characteristic in the restraint direction.

**RLoad**

Resistive reach for avoiding load encroachment.

**AngleLoad**

Limit phase-angle for avoiding load encroachment.

**Uweak**

(Phase) Voltage pick-up value for determining the “weak in-feed” or “dead line” conditions for enabling manually energisation of the line. A setting of zero disables the function.

**MEASUREMENT** (see Section 3.5.31.3. and 4.8.2.)**X (n)**

Pick-up line reactance for Zone (n):

$X < 0$  for the restraint direction

$X = 0$  disables the zone (Zone 1 cannot be disabled).

**R (n)**

Pick-up line resistance for Zone (n); the sign must be the same as for X (n).

**RR (n)**

Resistive reach (incl. arc resistance) of Zone (n) for phase faults; the sign must be the same as for X (n).

- RRE (n)  
Resistive reach (incl. arc resistance) of Zone (n) for E/F's; the sign must be the same as for X (n).
- k0 (n)  
Value of the zero-sequence compensation factor for E/F's in Zone (n);  $\left| (Z_0 - Z_1) / (3 \times Z_1) \right|$ .
- k0Ang (n)  
Phase-angle of the zero-sequence compensation factor for E/F's in Zone (n);  $\text{Arg} \left[ (Z_0 - Z_1) / (3 \times Z_1) \right]$ .
- Delay (n)  
Operating time for Zone (n).
- X (BACK)  
Pick-up line reactance for the reverse zone:  
X = 0 zone disabled.
- R (BACK)  
Pick-up line resistance for the reverse zone.
- RR (BACK)  
Resistive reach for phase faults in the reverse zone.
- RRE (BACK)  
Resistive reach for E/F's in the reverse zone.
- Delay (Def) (see Section 3.5.31.4.)  
Operating time for the final zone (starter reach).
- k0m  
Value of the zero-sequence compensation factor for a parallel circuit (ratio of the mutual impedance to three times the positive-sequence impedance);  $\left| Z_{m0} / (3 \times Z_1) \right|$ . The mutual impedance is not taken into account for a setting of zero.
- k0mAng  
Phase-angle of the zero-sequence compensation factor for a parallel circuit  $\text{Arg} \left[ Z_{m0} / (3 \times Z_1) \right]$ .
- UminFault (see Section 3.5.31.3.2.)  
Minimum voltage at which the fault voltage is used for determining fault direction.

**MemDirMode**

Procedure to be followed after decay of the memory voltage and no voltage is available for measurement:

Protection blocks

Protection trips

Conditional trip: Only trips, if the directions during the present and the preceding times steps are in opposition.

**DefDirMode** (see Section 3.5.31.4.)

Response at the end of the final time step (definitive time):

Non-directional: Trips for faults in both directions.

Forwards: Trips only for faults in the forwards direction.

**Block Z1** <sup>1)</sup>

Zone 1 measurement blocking:

off

on.

**O/C BACK-UP PROTECTION** (see Section 3.5.31.5 and 4.8.4.)**I O/C**

Pick-up value of the definite time back-up overcurrent function.

**Delay O/C**

Time delay for the definite time back-up overcurrent function.

**V.T. SUPERVISION**

(see Section 3.5.31.6 and 4.8.3.)

**VTSupMode**

0 off

1 ZeroSeq  $[U_0 \cdot \bar{I}_0]$

2 NegSeq  $[U_2 \cdot \bar{I}_2]$

3 Zero\*NegSeq  $[(U_0 \cdot \bar{I}_0) + (U_2 \cdot \bar{I}_2)]$

4 Special  $[U_2 \cdot (\bar{I}_0 + \bar{I}_2)]$ .

---

<sup>1)</sup> Not available on HV distance function.

**VTSupBlkDel**

Delayed blocking of the distance function (12 s) for operation of the v.t. supervision.

- off - immediate blocking
- on - delayed blocking.

**VTSupDebDel**

Delay (1 s) for resetting blocking by the v.t. supervision.

- off - immediate reset
- on - delayed reset.

**U0min VTSup**

Pick-up setting of the neutral voltage ( $U_0$ ) for v.t. supervision referred to the rated v.t. voltage  $100/\sqrt{3}$  or  $200/\sqrt{3}$ .

**I0min VTSup**

Pick-up setting of the neutral current ( $I_0$ ) for v.t. supervision.

**U2min VTSup**

Pick-up setting of the negative sequence voltage ( $U_2$ ) for v.t. supervision referred to the rated v.t. voltage  $100/\sqrt{3}$  or  $200/\sqrt{3}$ .

**I2min VTSup**

Pick-up setting of the NPS current ( $I_2$ ) for v.t. supervision.

**TRIP SCHEMES** (see Section 3.5.31.1 and 4.8.5.)**ComMode**

Type of transfer tripping scheme:

- off
- PUTT NONDIR
- PUTT FWD
- PUTT OR2
- POTT
- BLOCK OR.

**TripMode**

Type of tripping (single or three-phase):

- 1PhTrip - single-phase tripping (for single-phase auto-reclosure)
- 3PhTrip - three-phase tripping in all cases
- 3PhTripDel3 - single-phase tripping (for single-phase auto-reclosure) up to the end of 'Delay (3)' then three-phase tripping.

**SOTFMode**

Operating mode of the switch-onto-fault function:

off

non-dir. non-directional underimpedance starting  
(recommended setting)

forward UR2 directional with overreaching (Zone 2, if  
overreaching disabled) and non-directional  
after decay of any memory voltage.

**SOTF10sec**

Enables the 10 s delay for the switch-onto-fault function:

off (t = 200 ms)

on (t = 10 s).

**Weak**

Enables 'Weak infeed' logic for the PUTT or POTT transfer  
tripping modes (Uweak must also be set):

off

on.

**Unblock**

Deblocking logic enable:

off

on (only suitable for PLC).

**Echo**

'Echo' logic enable for the POTT transfer tripping mode:

off

on.

**TransBl**

Enables 'Transient blocking' logic (stabilisation for reversal of  
power direction on double-circuit lines) for the POTT and  
BLOCK OR (overreaching blocking scheme) transfer tripping  
modes:

off

on.

**t1Block**

Time allowed for receiving a blocking signal in the BLOCK  
OR (overreaching blocking scheme) mode.

**t1TransBl**

Time 1 for the TRANSBL (transient blocking) mode. Delay for faults after a fault was detected in the reverse direction.

**t2TransBl**

Time 2 for the TRANSBL (transient blocking) mode. The logic remains enabled for the time t2 after a fault was detected in the reverse direction.

**t1EvolFaults**

Time for discriminating evolving faults (three-phase trip for evolving faults during this time setting).

**POWER-SWING BLOCKING** (see Section 3.5.31.8 and 4.8.6.)**tPSblock**

Maximum time during which the power-swing blocking function is effective. The function is disabled when set to zero.

**BINARY INPUTS** (see Section 3.5.31.10.)**ChgMeasDir**

Input for changing the direction of measurement.

**Ext Blk Dist**

Input for blocking the distance protection function:

- F: - not blocked
- xx: - all binary I/P's (or O/P's of protection functions).

**Ext UZ Blk** <sup>1)</sup>

Input for blocking the underimpedance starters:

- F: - underimpedance starters enabled
- T: - underimpedance starters disabled
- xx: - all binary I/P's (or O/P's of protection functions).

**Ext Blk PSB**

External disable for the power-swing blocking function:

- F: - power-switch blocking enabled
- T: - power-switch blocking disabled
- xx: - all binary I/P's (or O/P's of protection functions).

---

<sup>1)</sup> Not available on HV distance function.

**Ext Blk O/C**

External disable of the back-up overcurrent function

F: - enabled

T: - disabled

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

**DeadLine**

Line de-energised signal (auxiliary contact on the circuit-breaker when the v.t's are on the busbar):

F: - input not used

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

**Manual close**

Circuit-breaker manual close signal:

F: - input not used

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

**ZExtension**

External zone extension control signal:

F: - external zone extension disabled

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

**Isol Open**

Isolator open signal for activating the 'short-zone' logic and protection (T section in 1½ breaker schemes):

F: - disabled

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

**Com Rec**

Input for PLC signal from the remote station:

F: - input not used

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

**Com Fail**

Input for PLC failure signal:

F: - input not used

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

**1PoIAR**

Single-phase trip enable (used in conjunction with the auto-reclosure function):

- F: - three-phase trip only
- T: - single and three-phase trip (depending on type of fault)
- xx: - all binary I/P's (or O/P's of protection functions).

**ExtBlkSOTF**

Input for blocking the tripping condition for the switch-onto-fault logic:

- F: - enabled
- T: - disabled
- xx: - all binary I/P's (or O/P's of protection functions).

Note: The input does not disable the switch-onto-fault starting signal.

**ExtBlkHF**

Input for blocking a received PLC signal (controlled, for example, by a sensitive E/F scheme using the same PLC channel):

- F: - input not used
- xx: - all binary I/P's (or O/P's of protection functions).

**ZExtensionAR**

Input for enabling the overreaching zone by the auto-reclosure function:

- F: - zone extension by the auto-reclosure function disabled
- xx: - all binary I/P's (or O/P's of protection functions).

**ExtBlock Z1**

Input for blocking measurement in the first zone:

- F: - enabled
- T: - disabled
- xx: - all binary I/P's (or O/P's of protection functions).



**CB COMMANDS**

## Trip CB R 01-08

Tripping logic for the R phase pole of the circuit-breaker. This signal is not generated while a blocking signal is being applied with the exception of a trip by the back-up overcurrent protection.

## Trip CB R 09-16

corresponds to Trip 01-08 (providing tripping unit fitted).

## Trip CB R 17-24

corresponds to Trip 01-08 (providing tripping unit fitted).

## Trip CB R 25-32

corresponds to Trip 01-08 (providing tripping unit fitted).

## Trip CB S 01-08

Tripping relay for the S phase pole of the circuit-breaker. This signal is not generated while a blocking signal is being applied with the exception of a trip by the back-up overcurrent protection.

## Trip CB S 09-16

corresponds to Trip 01-08 (providing tripping unit fitted).

## Trip CB S 17-24

corresponds to Trip 01-08 (providing tripping unit fitted).

## Trip CB S 25-32

corresponds to Trip 01-08 (providing tripping unit fitted).

## Trip CB T 01-08

Tripping relay for the T phase pole of the circuit-breaker. This signal is not generated while a blocking signal is being applied with the exception of a trip by the back-up overcurrent protection.

## Trip CB T 09-16

corresponds to Trip 01-08 (providing tripping unit fitted).

## Trip CB T 17-24

corresponds to Trip 01-08 (providing tripping unit fitted).

## Trip CB T 25-32

corresponds to Trip 01-08 (providing tripping unit fitted).

## SIGNALLING

### Start R+S+T

General distance protection starting signal (OR logic for all starting signals excluding 'weak infeed').

### Start RST (StartRSTAux)

General distance protection starting signal (OR logic for all starting signals including 'weak infeed').

### Start R (Start R Aux)

Distance protection R phase starting signal (including 'weak infeed').

### Start S (Start S Aux)

Distance protection S phase starting signal (including 'weak infeed').

### Start T (Start T Aux)

Distance protection T phase starting signal (including 'weak infeed').

### Start E (Start E Aux)

Distance protection E/F starting signal ( $U_0$  or  $I_0$ ). Only generated together with a phase starter.

### Start I0

Neutral current starting signal ( $I_0$ ).

### Start U0

Neutral voltage starting signal ( $U_0$ ).

### Start OC <sup>1)</sup>

Overcurrent starting signal.

### Start UZ <sup>1)</sup>

Underimpedance starting signal.

### Start O/C

Back-up overcurrent pick-up signal.

### Start SOTF

Enabling signal for the switch-onto-fault protection.

### Start 1ph

Indicates that the distance protection was started by a single phase.

---

<sup>1)</sup> Not available on HV distance function.

**Trip CB**

General circuit-breaker tripping signal. This signal is disabled while a blocking signal is being applied with the exception of a trip by the back-up overcurrent protection.

**Trip RST (trip RST Aux)**

General tripping signal. This signal is **not** disabled while a blocking signal is being applied.

**Trip CB R**

Circuit-breaker R phase trip signal.

This signal is disabled while a blocking signal is being applied with the exception of a trip by the back-up overcurrent protection.

**Trip CB S**

Circuit-breaker S phase trip signal.

This signal is disabled while a blocking signal is being applied with the exception of a trip by the back-up overcurrent protection.

**Trip CB T**

Circuit-breaker T phase trip signal.

This signal is disabled while a blocking signal is being applied with the exception of a trip by the back-up overcurrent protection.

**Trip CB 3P**

Three-phase trip signal. This signal is disabled while a blocking signal is being applied with the exception of a trip by the back-up overcurrent protection.

**Trip CB 1P**

Single-phase trip signal. This signal is disabled while a blocking signal is being applied with the exception of a trip by the back-up overcurrent protection.

**Trip O/C**

Back-up overcurrent trip signal.

**Trip SOTF**

Switch-onto-fault trip signal.

**Trip Com**

Signal for tripping either enabled by the receipt of a permissive signal or the non-receipt of a blocking signal. (This signal is disabled while a blocking signal is being applied.)

**Trip Stub**

'Short-zone' protection trip signal.

**Delay >= 2**

Signal for starting in Zone 2 or higher.

**Delay 1**

Signal for starting in Zone 1.

**Delay 2**

Signal for starting in Zone 2.

**Delay 3**

Signal for starting in Zone 3.

**Delay 4**

Signal for starting in Zone 4 (excepting when Zone 4 is being used as an overreaching zone).

**Delay Def**

Signal for starting in the final zone.

**Meas Main**

Measurement by the distance function (Zones 1, 2, 3, 4 or the final zone).

**Meas Oreach**

Measurement in the distance protection overreach zone.

**Meas Fward**

Measurement by the distance protection in the forwards direction.

**Meas Bward**

Measurement by the distance protection in the reverse direction (reverse zone).

**Weak Infeed**

Tripping by the 'weak infeed' function.

**Dist Blocked**

Signal indicating that the distance protection is blocked.

**DelDistBlk**

Signal delayed by 12 s indicating that the distance protection is blocked.

**Power Swing**

Power-swing blocking function picked up.

**VTSup**

V.t. supervision picked up.

**VTSup Delay**

Delayed operation of the v.t. supervision after 12 s.

**Com Send**

Signal generated when a transfer trip signal is transmitted.

**Com Boost**

Signal for boosting PLC transmitting power.

**Freq dev**

Signal indicating a deviation of the memory voltage frequency.

**(ADDITIONAL LOGIC)**

The following settings are only of consequence when a special logic is loaded instead of the standard distance protection logic. Refer to the description of the corresponding logic for their significance.

**BOOL\_IN1, BOOL\_IN2...BOOL\_IN8**

Additional binary inputs for the special distance protection logic.

**TIMER\_1, TIMER\_2...TIMER\_8**

Additional timer settings for the special distance protection logic.

**BOOL\_OUT1, BOOL\_OUT2...BOOL\_OUT8**

Additional signals for the special distance protection logic.

**PROJECT SUBDIR**

The user can determine in which subdirectory the distance protection logic is located. The default name "DISTSTD" applies when the standard distance protection logic located in the MMI directory is used.

The input of a directory is only necessary when a special logic is used instead of the standard one. The procedure in this case is to be found in the description of the logic.

**Behaviour of the signals at the signalling relay outputs and in the event list**

Some of the signalling relay outputs remain excited until the entire distance protection function has reset (i.e. until 'Start R+S+T' resets) and others reset as soon as the particular condition disappears.

The parameter "EventRecFull" (event recorder full) enables a choice to be made, whether all operation and reset events have to be recorded in the event list (essential when the protection is

integrated in a station control system) or whether the less important reset events may be omitted.

The behaviour of the signals can be seen from the following list.

- Output:** H signal latches  
NH signal does not latch.
- Event list:** AR Pick-up (COMES) and reset (GOES) are recorded.  
A Only pick-up (COMES) is recorded providing "EventRecFull" is switched off.

Signal	Output	Event list
Start R+S+T	NH	AR
Start RST	NH	A
Start RSTAux	NH	A
Start R	H	A
Start R Aux	H	A
Start S	H	A
Start S Aux	H	A
Start T	H	A
Start T Aux	H	A
Start E	H	A
Start E Aux	H	A
Start I0	NH	AR
Start U0	NH	AR
Start OC	NH	AR
Start UZ	H	AR
Start O/C	NH	AR
Start SOTF	H	AR
Start 1ph	NH	AR
Trip CB	NH	A
Trip RST	NH	A
Trip RST Aux	NH	A
Trip CB R	NH	AR
Trip CB S	NH	AR
Trip CB T	NH	AR
Trip CB 3P	NH	A
Trip CB 1P	NH	A
Trip O/C	NH	AR
Trip SOTF	NH	A
Trip Com	NH	A
Trip Stub	NH	A
Delay >= 2	NH	A
Delay 1	NH	A

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Delay 2	NH	A
Delay 3	NH	A
Delay 4	NH	A
Delay Def	NH	A
Meas Main	H	A
Meas Oreach	H	AR
Meas Fward	H	AR
Meas Bward	NH	AR
Weak Infeed	NH	AR
Dist Blocked	NH	AR
DelDistBlk	NH	AR
Power Swing	NH	AR
VTSup	NH	AR
VTSup delay	NH	AR
Com Send	NH	AR
Com Boost	NH	A
Freq dev	NH	AR

## E. Setting instructions

### 3.5.31.1. *General*

The first parameter in the sub-menu 'General' is 'Ref length' which is needed to indicate the distance to a fault in the event of a trip, but otherwise bears no influence in the protection function. The parameter gives the reactance of the reference length (in secondary  $\Omega/\text{ph}$  per unit length) and may be defined in km, miles, percent line length etc., i.e.

$$\text{distance} = \frac{X_{\text{meas.}}}{\text{ref. length}}$$

e.g.:

a) In km

$$\begin{aligned} \text{Secondary reactance per km} & \equiv 0.2 \Omega/\text{ph} \\ \text{Ref. length} & = 0.2 \Omega/\text{ph} \end{aligned}$$

b) In percent line length

$$\begin{aligned} \text{Secondary reactance of the line length} & \equiv 25 \Omega/\text{ph} \\ & (1\% \equiv 0.25 \Omega/\text{ph}) \\ \text{Ref. length} & = 0.25 \Omega/\text{ph} \end{aligned}$$

**The setting of the parameter 'CT neutral' depends on whether the star-point of the main c.t's is on the line side or the busbar side. There are thus two possible settings 'Bus side' or 'Line side'. The 'Line side' option is the one to choose, providing the protection is connected according to the wiring diagram in the appendix. This setting only applies to the distance protection function. It does not influence the power direction in all the other functions or the displays of the A/D channels.**



### 3.5.31.2. Starters

(see Section 4.8.1.)

The distance function provides for two methods of starting, i.e. overcurrent or underimpedance. The desired method is selected by appropriately setting the parameter 'StartMode' in the 'STARTERS' sub-menu.

Depending on the setting of the parameter 'DefDirMode', a starter can also trip on its own after the time 'Delay (Def)'. (see Section 3.5.31.4.)

#### 3.5.31.2.1. Overcurrent starters

(see Section 4.8.1.2.)

The overcurrent starters are enabled by selecting 'OC' for the parameter 'StartMode'. The pick-up level of the overcurrent starters is determined by the setting of the parameter 'Istart'. The corresponding setting range is from 0.5 to 10  $I_N$ , in steps of 0.01  $I_N$ . The setting of 'Istart' must be sufficiently above the maximum load current to avoid any risk of mal-operation under normal load conditions. Note that all currents greater than 80% of the highest phase current (and also the enabling current 'Imin') are taken into account by the phase selection function. When determining the maximum load current it must be considered that

- in the case of a double-circuit line, the load current  $I_B$  can briefly reach double its normal value when one circuit is tripped
- E/F's can cause additional balancing currents  $I_A$  in the healthy phases.

It is equally important for an overcurrent starter, which has picked up, to reliably reset at the maximum load current  $I_{Bmax}$ , if for example the fault is tripped by a downstream protection. Taking due account of the reset ratio of 0.95, the lowest permissible setting is given by:

$$(Istart)_{min} > 1.25 \frac{I_{Bmax} + I_A}{0.95 \times I_N}$$

The maximum setting (Istart)max is derived from the minimum fault current  $I_K$  for a fault at the end of the next section of line:

$$(Istart)_{max} < I_{Kmin} / I_N$$

Should the above relationships result in  $(I_{start})_{max}$  being lower than  $(I_{start})_{min}$ , the underimpedance starters must be used instead.

### 3.5.31.2.2. *Underimpedance starters*

(see Section 4.8.1.3. )

The underimpedance starters are enabled by selecting 'UZ' as the 'StartMode' parameter. The following parameters then have to be set:

XA  
XB  
RA  
RB  
RLoad  
AngleLoad.

The characteristic of the underimpedance starters and the corresponding setting parameters can be seen from Fig. 3.5.31.1. The parameters 'RLoad' and 'AngleLoad' define the permissible load area.

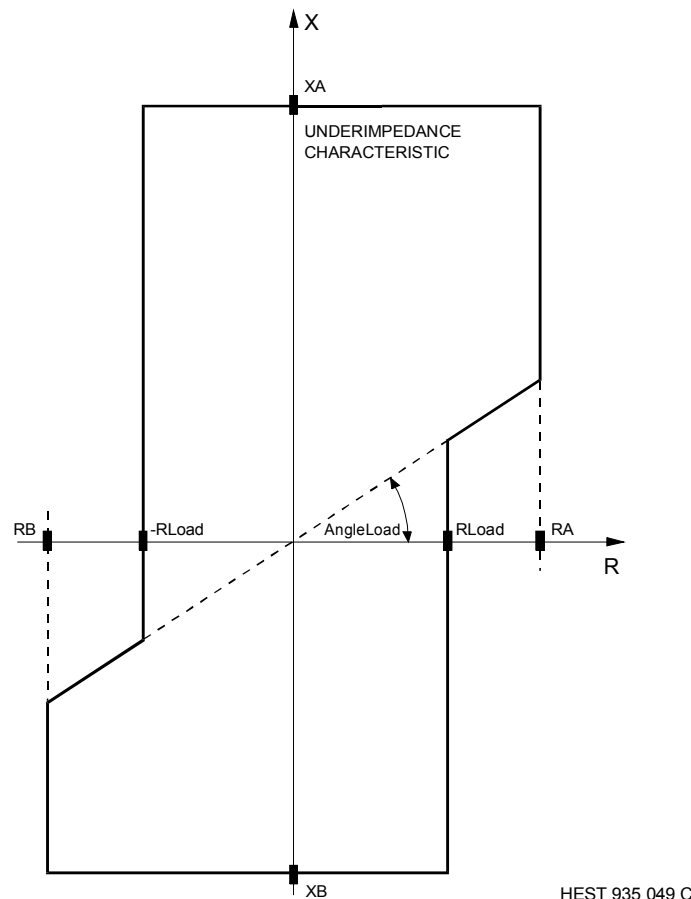


Fig. 3.5.31.1 Underimpedance starting characteristic

Because of the method used to represent impedances by the processor program, the impedance settings should not be set higher than absolutely necessary, otherwise the resolution for low impedances will be reduced.

### Minimum permissible reach of the starters

The starting units must reliably pick-up for a fault towards the end of the next section of line (back-up zone). Should back-up protection of the adjacent section of line not be necessary, the starters must be set to at least 1.3 times the impedance of the protected line. In the case of short lines, fault resistance becomes a factor to be taken into account.

### Maximum permissible reach of the starters

- The setting must take account of the considerable increase in the load current of the healthy circuit of a double-circuit line, when a fault on one circuit is tripped.
- To ensure that the phase selection is correct for single-phase auto-reclosure, the starters in the healthy phases must not pick up for an E/F on one of the phases (in spite of any balancing currents which may occur).

The corresponding limits can be expressed mathematically as follows:

- Solidly grounded systems

$$Z_{\text{set}} \leq \left| \frac{\underline{U}}{2 \times (I_{\text{Bmax}} + I_{\text{A}})} \right| \quad \Omega/\text{ph}$$

- Ungrounded systems or system with Petersen coils

$$Z_{\text{set}} \leq \frac{U_{\text{v}}}{2 \times I_{\text{Bmax}} \times 1,25} \quad \Omega/\text{ph}$$

where:

$Z_{\text{set}}$  maximum value of the impedance, i.e. the maximum value of the expression:

$$\sqrt{XA^2 + RA^2} \quad \text{or} \quad \sqrt{XB^2 + RB^2}$$

$\underline{U}$  lowest phase voltage of the healthy phases for an E/F on one phase ( $\underline{U} = 0.85 \times \text{min. system voltage}$ ). The factor 0.85 takes account of a negligibly small zero sequence source impedance.

$U_v$  lowest phase-to-phase system voltage

1.25 safety factor

2 factor which takes account of the fact that phase currents and not phase-to-phase currents are used.

These requirements are generally fulfilled without difficulty for most applications. Should, however, the first inequality not be satisfied, the right-hand side must be expressed vectorially and compared with the underimpedance starting characteristic in relation to the setting 'RLoad' etc.

The healthy phases must be checked for the case of a single-phase-to-ground fault.

#### 3.5.31.2.3. **Current enable**

Before a phase can take part in phase selection, it must be conducting a current higher than 'Imin'. The recommended setting is  $0.2 I_N$ .

#### 3.5.31.2.4. **E/F detector**

There are three alternative operating modes for the E/F detector, the desired one being chosen by the setting of the parameter 'GndFaultMode'. E/F detection can be based on measurement of the neutral current alone or in combination with the neutral voltage. The fourth possibility is not to measure the ground loop at all, i.e. only the phase-to-phase loop is measured. The following alternatives are available for selection:

blocked (only measures the phase-to-phase loops)

$I_0$

$I_0$  AND  $U_0$

$I_0$  OR  $U_0$ .

The criterion for the highest '3I0min' setting is:

- the E/F detector must pick-up for all E/F's in solidly grounded systems and for all cross-country faults on ungrounded systems or systems with Petersen coils, providing they lie within the reach of the underimpedance starters.

The criteria for the lowest '3I0min' setting are:

- the E/F detector must not pick up for an E/F on ungrounded systems or systems with Petersen coils,
- the E/F detector must not pick up for phase faults, although c.t. errors can cause false neutral currents.

The recommended setting is '3I0min' =  $0.5 I_N$ .

Should it not be possible to find a setting, which satisfies both these conditions, the neutral voltage (3U0min) must be used for measurement in addition to the neutral current.

#### **3.5.31.2.5. Phase preference logic**

(see Section 4.8.1.4.)

The desired phase preference logic for cross-country faults is chosen with the aid of the parameter 'PhaseSelMode'.

In solidly grounded systems, the 'PhaseSelMode' parameter is disabled by setting it to 'solid ground'.

It is essential for all the relays in ungrounded systems and systems with Petersen coils to be set to the same phase preference logic. The logic in use in a system must therefore be known before **one** of the 8 alternative schemes can be selected:

RTS(R) cyclic  
TRS(T) cyclic  
RTS acyclic  
RST acyclic  
TSR acyclic  
TRS acyclic  
SRT acyclic  
STR acyclic.

#### **3.5.31.2.6. Undervoltage starters**

(Uweak)

The undervoltage starters are used in conjunction with the switch-onto-fault function and the transfer tripping schemes POTT and PUTT NONDIR (see Section 3.5.31.7.). The corresponding pick-up value is set in relation to the rated voltage with the aid of the parameter 'Uweak', which has a setting range of 0 to  $2 U_N$  in steps of 0.01.

### 3.5.31.3. *Measuring units*

(see Section 4.8.2.)

All the settings for the impedance measuring zones are to be found in the 'MEASUREMENT' sub-menu.

#### 3.5.31.3.1. *Determining the distance zones*

Before it is possible to determine the reaches of the distance zones, the impedances and phase-angles of the line sections during faults must be known. Typical settings for the various zone reaches along the line are given below:

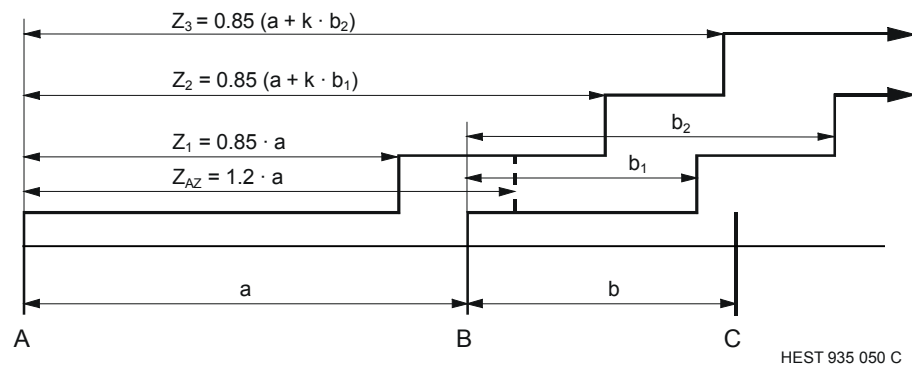


Fig. 3.5.31.2 Typical settings for the reaches of distance relay zones (grading table)

where:

$Z_1, Z_2, Z_3, Z_4$	impedance reach of the various zones [ $\Omega/\text{ph}$ ]
$Z_{OR}$	impedance reach of the overreaching zone [ $\Omega/\text{ph}$ ]
$k \geq 1$	factor to take the apparent increase of line impedance "seen" by a relay due to an intermediate infeed into account
$a, b$	impedance of the corresponding section of line [ $\Omega$ ].

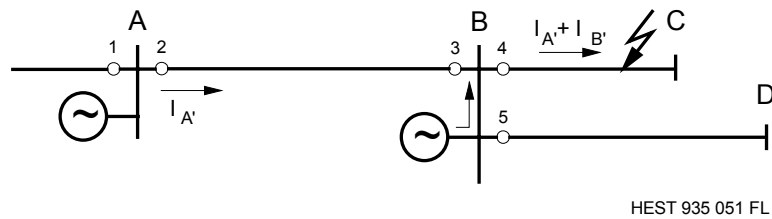


Fig. 3.5.31.3 Example for calculating k. The overreach must be checked for  $k > 1$  when the infeed B is not in operation.

$$k = \frac{I_{A'} + I_{B'}}{I_A} \geq 1$$

where:

$I_{A'}$  maximum fault current possible

$I_{B'}$  minimum fault current possible

1...5 distance relays.

### Calculating the secondary line impedances

The primary values calculated from the grading table for the line impedances have to be converted to secondary values. These are obtained by applying the following relationship:

$$Z_{Ls} = \frac{Z_{LP}}{\left( \frac{K_U}{K_I} \right)} = \frac{Z_{Lp}}{K_Z}$$

where:

$Z_{Lp}$  primary positive-sequence line impedance

$Z_{Ls}$  secondary positive-sequence line impedance

$K_U$  main v.t. ratio

$K_I$  main c.t. ratio

$K_Z$  impedance ratio.

The same applies to the conversion of the resistances and reactances.

The impedance characteristic is defined independently for each of the four distance zones (Zone 4 is used alternatively for the overreaching zone) by the following parameters ( $i = 1$  to 4):

X	(i)
R	(i)
RR	(i)
RRE	(i)
k0	(i)
k0Ang	(i)
Delay	(i).

The reactance and resistance of the line or cable are set in the proper units using the parameters 'R' and 'X' (see Fig. 3.5.31.4).

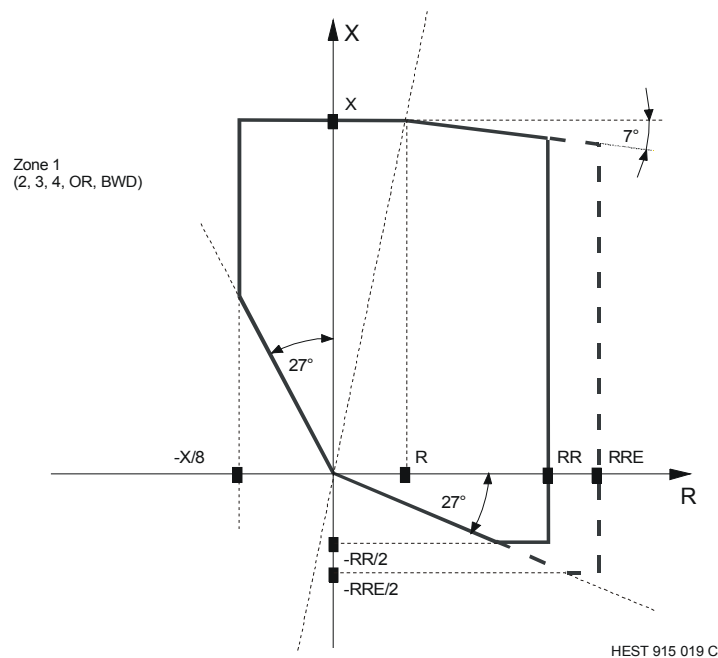


Fig. 3.5.31.4 Distance measurement characteristic

At a rated current of 1 or 2 A, the impedance parameters 'X', 'R', 'RR' and 'RRE' have setting ranges of -300 to +300  $\Omega/\text{ph}$  in steps of 0.01 (-30 to +30  $\Omega/\text{ph}$  in steps of 0.001 for a rated current of 5 A).

A zone is disabled when 'X' is set to zero regardless of the settings of the other parameters. In this case, the other zones are also blocked with the exception of the last one. Zone 1 can only be disabled by the parameter 'Block Z1' or the binary input 'ExtBlock Z1'.

The direction of measurement is reversed for negative values of 'X', 'R', 'RR' and 'RRE'.



## Allowing for fault resistance

Provision is made with parameters 'RRE' and 'RR' for allowing for the fault resistance in an E/F loop and in a phase-to-phase loop. The setting takes the E/F resistance comprising the resistance of the arc and the pylon footing resistance in relation to the line resistance into account.

Typical settings lie in the range  $RR(E)/X = 0.5...3$ .

The arc resistance  $R_B$  can be calculated according to A.R. van C. Warrington as follows:

$$R_B = \frac{28700d}{I^{1.4}}$$

where:

d	length of arc in m
I	current in A
$R_B$	arc resistance in $\Omega$ .

Since the unit is  $\Omega/\text{ph}$ , the fault resistance appears differently in the impedance plane according to the type of fault. Where the value of the fault resistance  $R_F$  is known in  $\Omega$  (see Fig. 3.5.31.5), it has to be entered in the R/X diagram as follows:

- E/F:  $R=R_F/(1+k_0)$
- phase-to-phase fault:  $R=R_F/2$
- three-phase fault:  $R=R_F/\sqrt{3}$ .

It is for this reason that fault resistance is compensated separately for E/F and phase-to-phase loops using the parameters 'RRE' and 'RR'. The parameter 'RR' will generally be set lower than 'RRE', because the phase-to-phase fault resistance is normally very low.

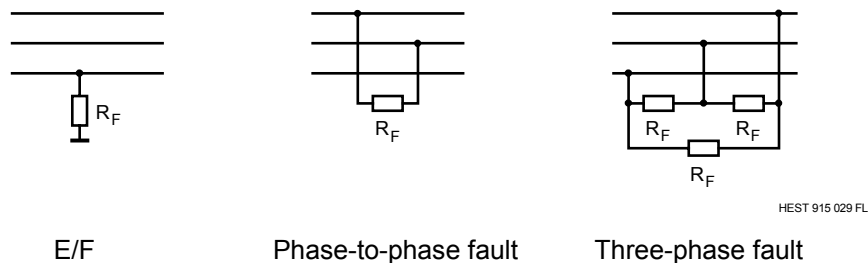


Fig. 3.5.31.5 Fault resistance

### Load current (area)

The load area defined by the underimpedance parameters 'RLoad' and 'AngleLoad' is taken into account by starting and measuring characteristics. It follows from this that the relay can only trip, if the fault impedance measured lies within the underimpedance starting characteristic.

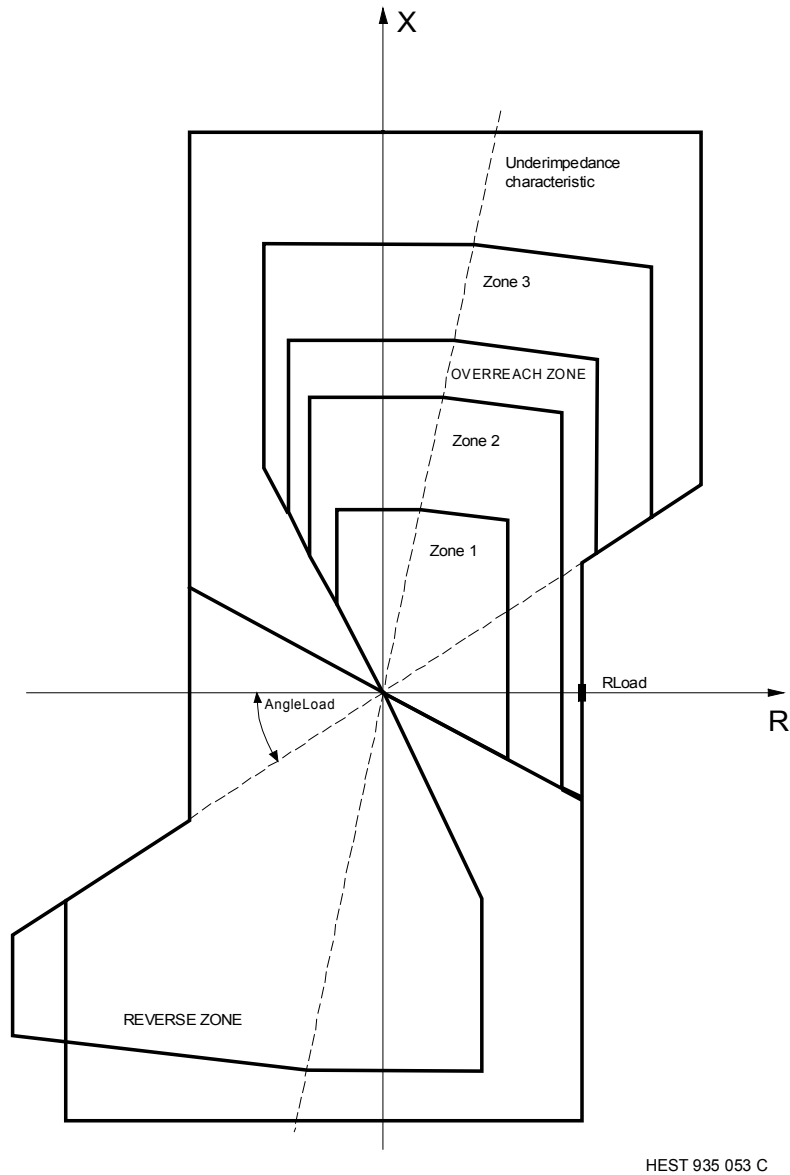


Fig. 3.5.31.6 Relay characteristics

Note that the load impedance area is only formed when the underimpedance starter (UZ) is in operation. It does not exist when starting is provided by the overcurrent starter (OC).

### Zero-sequence compensation of the protected line

The magnitude and phase-angle of the zero-sequence compensation factor are set individually for each zone using parameters 'k0' and k0Ang'. The latter are calculated from the positive-sequence impedance  $Z_L$  and the zero-sequence impedance  $Z_{OL}$  of the line:

$$k_0 = \frac{1}{3} \times \frac{(Z_{OL} - Z_L)}{Z_L}$$

$$|k_0| = 1/3 \times |(Z_{OL} - Z_L) / Z_L|$$

Range: 0 to 8 in steps of 0.01

$$k0Ang = \arctan(X_{OL} - X_L) / (R_{OL} - R_L) - \arctan(X_L / R_L)$$

Range: -180° to +90° in steps of 0.01.

### Zero-sequence compensation for cables

Depending on the type of cable and the application, k0 is set between -10° and -130°. If a complex setting is made for k0, the polygon characteristic is rotated in the R-jX diagram. At k0 angles higher than 20°, a slight setting error causes severe under or overreaching. The setting is often incorrect because

- the cable data are not known exactly
- measured data are only accurate for through faults, but scarcely ever accurate for internal faults

A setting of 0° or -180° (corresponds to negative values) is therefore recommended for k0:

$$k_0 = 1/3 \times |(X_{OL} - X_L) / X_L|$$

$$k0Ang = 0^\circ \quad \text{for } X_{OL} > X_L$$

$$k0Ang = -180^\circ \quad \text{for } X_{OL} < X_L$$

Note that the value of R must be set at least to  $(2 \times R_L + R_{OL}) / 3$  and the desired RRE is increased by  $(2 \times R_L + R_{OL}) / 3$ .

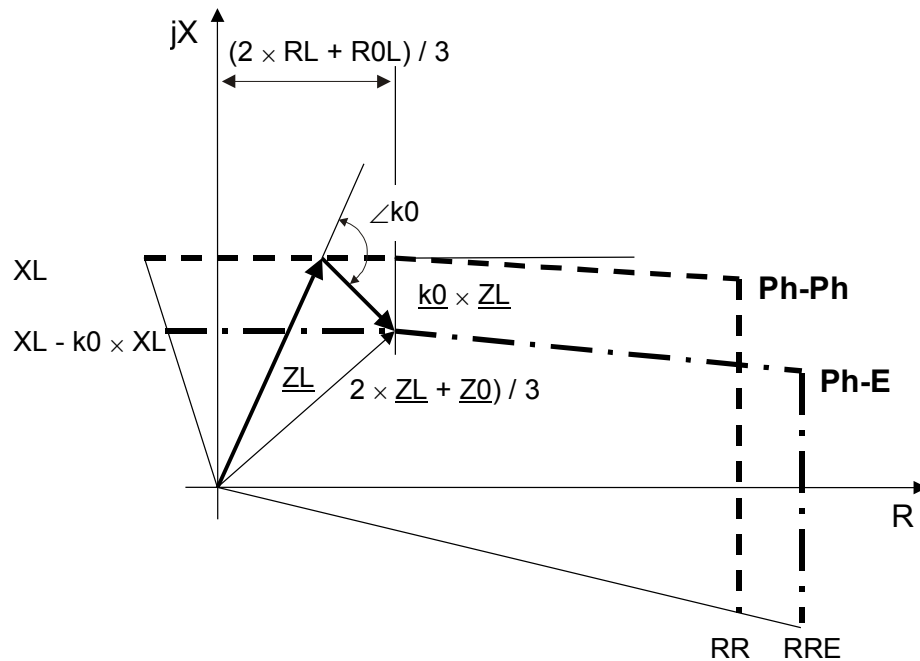


Fig. 3.5.31.7 Relay characteristics

### Zero-sequence compensation of double-circuit lines

The magnitude and phase-angle of the zero-sequence compensation factor for a double-circuit line are set using parameters 'k0m' and 'k0mAng'. This compensation only applies to Zones 1 and 2, the overreaching zone and the reverse zone.

#### 3.5.31.3.2. Directional element

(see Section 4.8.2.4.)

Each distance zone has its own directional measuring element. The voltage used for measurement depends on the amplitude of the fault voltage in relation to the parameter 'UminFault'. The fault voltage is used, providing it is higher than the setting of 'UminFault', and a voltage derived from the healthy voltage and the memory voltage is used when it falls below. The recommended settings are  $0.1 U_N$  for conventional v.t's.

Should correct determination of direction not be possible (reference voltage too low or memory voltage decayed), the setting of the parameter 'MemDirMode' determines whether the protection blocks or trips:

Block	protection blocks all zones (definitive zone only if directional)
-------	--

Trip	protection trips
Cond. trip	Protection blocks unless the instantaneous and preceding zones are in opposite directions, in which case the protection trips.

### 3.5.31.3.3. **Overreaching zone**

(OR)

The settings including the designation '4/OR' ('X (4/OR)' ... delay (4/OR)') can be used either for a fourth measuring zone or a completely independent overreaching zone (but not for both at the same time) by appropriately setting the parameter 'Delay (4/OR)' (see Section 3.5.31.3.5).

In applications requiring a fourth zone, the measuring unit of the second zone is used for overreaching.

An overreaching zone is necessary for the switch-onto-fault and zone extension logics and for overreaching transfer tripping schemes.

### 3.5.31.3.4. **Reverse zone**

(BACK)

A reverse measuring zone is used in a blocking scheme and also the logic for detecting a reversal of fault energy direction. It is set using the parameters 'X (BACK)', 'R (BACK)', 'RR (BACK)' and 'RRE (BACK)' which have setting ranges from 0 to -300  $\Omega/\text{ph}$ .

Note that:

- for underimpedance starting ('UZ'):
 

With the exception of the load discrimination defined by the parameters 'RLoad' and 'AngleLoad', the reverse zone operates independently of the starters.
- for overcurrent starting ('OC'):
 

The reverse zone is only in operation when an overcurrent starter ('Istart') has picked up.
- the binary input ('Ext Blk UZ') blocks operation regardless of the starter mode for the reverse zone.
- Signal output: Meas Bward.
- Measurement of the reverse zone only takes place while the first zone is active, i.e. the 'Meas Bward' signal resets at the latest at the end the second time step.

### 3.5.31.3.5. *Time steps*

(Delay)

The operating time of every activated distance zone (parameter 'X' <> 0) is determined by the parameter 'Delay', which has a setting range of 0 to 10 s in steps of 0.01. The parameter 'Delay (4/OR)' is also associated with a logic, which determines whether it applies to Zone 4 or to the overreaching zone, i.e. if 'Delay (4/OR)' < 'Delay (2)', it applies to the overreaching zone, otherwise to Zone 4.

The set times must satisfy the following relationships:

- Delay (1) < Delay (2) < Delay (3) < Delay (4) < Delay(Def),
- Delay (OR) < Delay (2).

When grading the operating times of several distance relays, the minimum grading time should not be less than the sum of the circuit-breaker operating time plus 150 ms (reset time + operating time of the measuring system + safety margin).

Recommended timer settings:

- Zone 1: normally instantaneous.
- Zone 2: 'Delay (2)' is normally set to the sum of relay and circuit-breaker operating times, arc extinction time, signal transmission time and a tolerance margin, which amounts to about 0.25 to 0.5 s. The tolerance includes an allowance for sequential tripping.
- Zone 3: 'Delay (3)' is set to about 2 x 'Delay (2)'.
- Zone 4: 'Delay (4)' or 'Delay(Def)' is normally set to at least 4 x 'Delay (2)'.

Special cases may require settings, which deviate considerably from the above recommendations.

The time steps of zones 1 to 4 must have settings less than 'Delay(Def)'.

### 3.5.31.4. *Definitive zone*

(Def)

The definitive (or fifth) zone is subject to the same parameters as the underimpedance starters (i.e. XA, XB, RA, RB, RLoad and AngleLoad).

The corresponding time step is defined by the parameter 'Delay (Def)'.

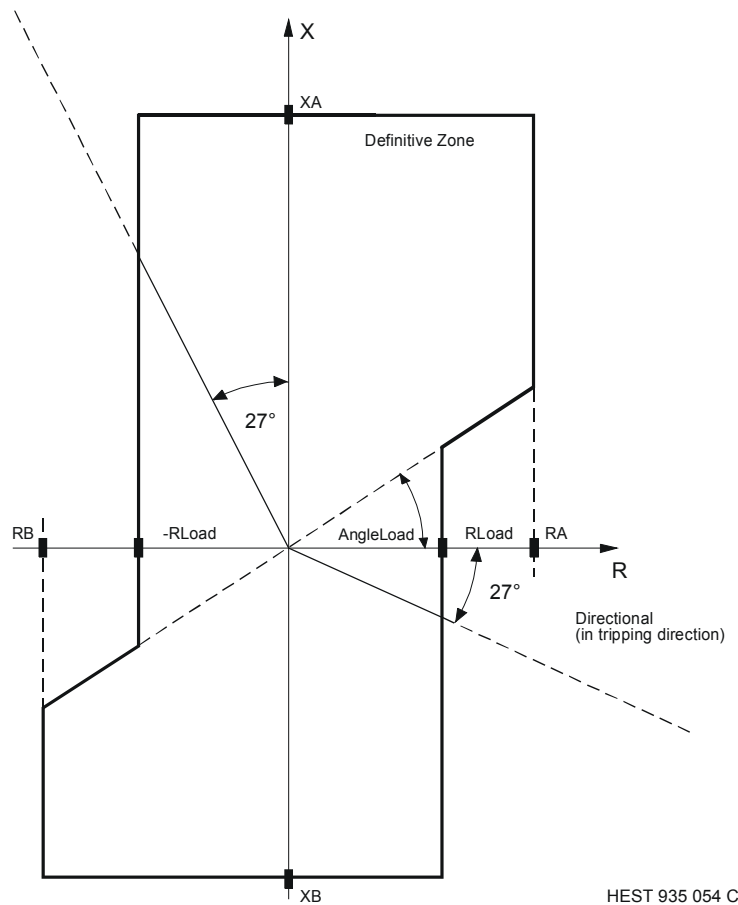


Fig. 3.5.31.8 Definitive zone characteristic

The parameter 'DefDirMode' determines the response at the end of the definitive time. It can be set to be either directional (in tripping direction) or non-directional (see Fig. 3.5.31.8).

Note:

- There is still a definitive zone even using the overcurrent starter (OC), but only with respect to the parameters 'Delay (Def)' and 'DefDirMode'.

### 3.5.31.5. **Back-up overcurrent unit**

(O/C Back-up Protection)

(see Section 4.8.4.)

The settings for the back-up overcurrent unit are made via the sub-menu 'O/C BACK-UP PROTECTION'. The setting of the parameter 'I O/C' determines the pick-up level, which can be chosen in steps of  $0.1 I_N$  between 0 and  $10 I_N$ . The associated time delay is set in steps of 0.1 s between 0 and 10 s by means of the parameter 'Delay O/C'.

The pick-up signal of the overcurrent unit is also used by the STUB protection. If the function is being used for this purpose, i.e. the binary I/P 'Isol open' is at logical '1', the tripping time is fixed at 25 ms.

### 3.5.31.6. **V.t. supervision**

(see Section 4.8.3.)

The parameters for setting the v.t. supervision function are located in the sub-menu 'V.T. SUPERVISION'. One of four different operating modes can be chosen using 'VTSupMode'. The function processes zero and negative-sequence components, which are either used on their own ('ZeroSeq' and 'NegSeq') or combined ('Zero\*NegSeq' and 'Spec').

ZeroSeq	$[U_0 \cdot \bar{I}_0]$
NegSeq	$[U_2 \cdot \bar{I}_2]$
Zero*NegSeq	$[(U_0 \cdot \bar{I}_0) + (U_2 \cdot \bar{I}_2)]$
Spec	$[U_2 \cdot (\overline{I_0 + I_2})]$

The four pick-up values are the settings of the parameters 'U0min VTSup', 'U2min VTSup', 'I0min VTSup' and 'I2min VTSup'. They can be set between 0 and 2 U<sub>N</sub> (or I<sub>N</sub>) in steps of 0.01. The basic settings are 0.2 U<sub>N</sub> for the voltage and 0.07 I<sub>N</sub> for the current.

Only the 'NegSeq' or 'Spec' options are available in ungrounded systems.

Upon operating, the v.t. supervision function is normally required to immediately block the distance protection function (see Section 4.8.5.2.). Provision is made, however, for blocking the distance function after a delay of 12 s by setting the parameter 'VTSupBlkDel'. This parameter is normally set in cases where only the overcurrent starters are in use.



If the v.t. supervision function remains picked up for longer than 12 s, it resets only after a delay (1 s). Should a fault give rise to zero or negative-sequence current components, it resets immediately.

The parameter 'VTSupDebDel' (deblocking) enables the reset delay to be continuously enabled regardless of current.

Recommended setting:

Parameter	Grounded system	Ungrounded system
VTSupDebDel	enabled	disabled

The signal 'VTSup' indicates that the distance function is being blocked by the v.t. supervision and 'VTSupDel' that the 12 s delay is running.

### 3.5.31.7. **Tripping logic**

(see Section 4.8.5.12.)

The parameters for determining the tripping logic are grouped in the sub-menu 'Trip Schemes'.

The various transfer tripping schemes are selected by setting the parameter 'ComMode' (3 x PUTT, POTT and OVERREACHING BLOCKING schemes). The possible settings are given below. The settings for the different schemes only appear after has scheme has been selected.

#### **PUTT NONDIR**

Permissive underreaching transfer tripping (non-directional)

'Weak' - enables the weak infeed logic.

#### **PUTT FWD**

Permissive underreaching transfer tripping (in line direction)

No other parameters.

#### **PUTT OR2**

Permissive underreaching transfer tripping (overreaching zone/Zone 2)

'Unblock' - selects the enabling logic for communications channel failure.

## POTT

Permissive overreaching transfer tripping

- 'Weak' - enables the weak infeed logic.
- 'Unblock' - selects the enabling logic for communications channel failure.
- 'Echo' - enables the echo logic.
- 'TransBI' - enables the logic for reversal of fault energy
- 't1TransBI' - min. holding time for the wrong energy direction signal. This has to be set at least 50 ms longer than the maximum reset time required by the communication channel.
- 't2TransBI' - max. holding time for the wrong energy direction signal. This has to be set at least 0.4 s longer than the dead time setting to make sure that blocking is still effective should an attempt be made to reclose the faulted line.

## BLOCK OR

Blocking scheme

- 'TransBI' - enables the logic for reversal of fault energy
- 't1Block' - time allowed for the receipt of a PLC signal
- 't1TransBI' - min. holding time for the wrong energy direction signal. This has to be set at least 50 ms longer than the maximum signal transmission time.
- 't2TransBI' - max. holding time for the wrong energy direction signal. This has to be set at least 0.4 s longer than the dead time setting to make sure that blocking is still effective should an attempt be made to reclose the faulted line.

## TripMode

Depending on the setting of the parameter 'TripMode', tripping is either phase-selective, controlled by the binary input '1PolAR' (for '1phTrip'), always three-phase (for '3phTrip') or three-phase after the time 'Delay (3)' (for '3phTripDel3').

## SOTF Mode

Access is gained to the switch-onto-fault logic settings by selecting the parameter 'SOTF Mode'. The alternatives presented are whether the switch-onto-fault logic should trip on the basis of the non-directional underimpedance starters or the overreaching zone.

This logic is enabled either by the undervoltage function delayed by 10 s or 200 ms (see Section 3.5.31.2.6) or the binary inputs 'Deadline' and 'Manual close'.

Two signalling outputs 'Start SOTF' and 'Trip SOTF' are associated with the switch-onto-fault logic. 'Start SOTF' is intended for blocking the auto-reclosure function and 'Trip SOTF' signals that tripping took place as a result of the switch-onto-fault logic.

## SOTF 10 sec

The parameter 'SOTF10sec' determines whether the undervoltage function and the binary input 'Deadline' are enabled after 10 s ('on') or after just 200 ms ('off'). 'off' indicates switching onto a fault after fast auto-reclosure (Fast OR). Tripping in this case is thus based on the decisions of the starters alone.

## t1EvolFaults

The setting of the parameter 't1EvolFaults' determines the time during which an evolving fault once detected results in a three-phase trip.

### 3.5.31.8. **Power-swing blocking**

(see Section 4.8.6.)

Only the parameter 'tPSblblock' for the time during which the power-swing blocking signal is maintained has to be set in the 'POWER-SWING BLOCKING' sub-menu. The setting range is 0 to 10 s in steps of 0.01. Tripping is enabled again at the latest at the end of this time.

The power-swing blocking function is disabled when 'tPSblock' is set to zero or a logical '1' is applied to the binary input 'Ext Blk PSB'.

### 3.5.31.9. **Allocation of c.t. and v.t. inputs**

(see Section 5.5.4.1.)

The parameters for allocating c.t. and v.t. channels are grouped in the 'ANALOGUE (CT/VT CHANNELS)' sub-menu.

### 3.5.31.10. **Allocation of binary inputs**

(see Section 5.5.4.4.)

The parameters for allocating binary inputs are grouped in the 'BINARY INPUTS' sub-menu.

All binary inputs can be allocated to external signals or the outputs of other functions.

#### **ChgMeasDir**

Applying a signal to this input reverses the direction of measurement for the entire distance protection function (all zones).

#### **Ext Blk Dist**

This input blocks the entire distance protection function. Blocking is signalled by "Dist blocked" and after 12 s by "DelDistBlk". Only the back-up overcurrent protection (I O/C) then remains active.

#### **Ext UZ Blk**

This input blocks the underimpedance starters, the neutral voltage starter (U0), the measurement for 'Weak' and the reverse measurement. The overcurrent starters (OC) remain in operation.

#### **Ext Blk PSB**

This input blocks the power-swing blocking function.

#### **Ext Blk O/C back-up**

This input blocks the back-up overcurrent protection (O/C Back-up Protection).

#### **Deadline**

The signal applied to this input is needed by the switch-onto-fault logic to indicate to the distance function that the line is without voltage before the circuit-breaker is closed. It is used for the switch-onto-fault logic providing the v.t.'s are on the busbars.

#### **Manual Close**

Prior to manually closing the circuit-breaker, this signal enables the switch-onto-fault logic and blocks the v.t. supervision function.

**ZExtension**

The overreaching logic permits instantaneous tripping within the overreaching zone. It is enabled via the binary input 'Zextension' or 'ZExtensionAR'.

For this purpose, the output 'Zextension' of the auto-reclosure function is connected to the input 'ZExtensionAR'.

**Isol open**

This input is required by the STUB protection to ascertain whether an isolator is open or not (see Section 4.8.5.4.).

**ComRec**

This input is needed for the external signal 'ComRec' (signal received by PLC, optical fibre link or point-to-point radio).

**ComFail**

This input signals to the protection that the PLC channel has failed.

**1PoIAR**

This input permits single-phase tripping to take place and is used in conjunction with single or three-phase auto-reclosure schemes. Refer to the Section 'Auto-reclosure' for the connection to the auto-reclosure function.

**ExtBlkSOTF**

This input is needed in cases where the switch-onto-fault logic is not enabled after an auto-reclosure.

Refer to the Section 'Auto-reclosure' for the connection to the auto-reclosure function.

**ExtBlkHF**

This input blocks the reception of an intertripping signal. It is used for coordinating communication channel signals when in a solidly grounded system, the distance protection and the E/F protection use the same channel. It must be connected to the 'RecBlk' signal of the E/F function.

**ExtBlock Z1**

This input blocks measurement in zone 1.

### **3.5.31.11. Allocation of tripping commands**

(see [Section 5.5.4.3.](#))

The parameters for allocating tripping commands are grouped in the 'CB COMMANDS' sub-menu.

The allocation of the output signals depends on whether single or three-phase tripping has been set (parameter 'TripMode'). In the case of three-phase tripping, the three tripping outputs are allocated to the same auxiliary tripping relay. Single-phase tripping ('TripMode' set to '1PhTrip' or '3PhTripDel3') requires three separate auxiliary tripping relays, i.e. the protection has to be equipped with at least two binary I/O units Type 316DB61/62.

### **3.5.31.12. Signals**

(see [Section 5.5.4.2.](#))

The parameters for allocating binary outputs to auxiliary signalling relays are grouped in the 'SIGNALLING' sub-menu.

Some signalling outputs latch until the entire distance protection function resets (i.e. until 'Start R+S+T' resets, see [Section 3.5.31.](#))

### 3.5.32. **Auto-reclosure (Autoreclosure)**

#### **A. Application**

The function can be configured for single or three-phase auto-reclosure.

The unit can operate in conjunction with any of the three protection functions (distance, longitudinal differential and current) and either an internal or external synchrocheck function.

However, an additional standard FUPLA logic T142 as detailed in the document 1KHF600220 is necessary for single-phase reclosing in 1½ breaker applications.

#### **B. Features**

- up to 4 fast or slow reclosure attempts
- first cycle with up to 4 individually configurable single and/or three-phase reclosure attempts
- independent operating indicators for each reclosure cycle
- wide dead time setting range
- provision to control bypassing of the synchrocheck unit and extending the dead time for the first zone by external signals
- clearly defined response to changing fault conditions during the dead time (evolving faults)
- Logic for 1st. and 2nd. main protection (redundant), duplex and master/follower schemes.

#### **C. Inputs and outputs**

##### **I. C.t./v.t. inputs**

- none

##### **II. Binary inputs**

- |                              |               |    |
|------------------------------|---------------|----|
| • Start                      | (Start)       |    |
| • Redundant start            | (Start 2)     | *) |
| • Redundant start            | (Start 3)     | *) |
| • Three-phase trip           | (Trip CB 3P)  |    |
| • Redundant three-phase trip | (Trip CB2 3P) | *) |
| • Redundant three-phase trip | (Trip CB3 3P) | *) |
| • General trip               | (Trip CB )    |    |
| • Redundant general trip     | (Trip CB2)    | *) |
| • Redundant general trip     | (Trip CB3)    | *) |

---

\*) 2 and 3 denote the I/P's of protection functions 2 and 3 or relays 2 and 3 in a redundant protection scheme (see Fig. 3.5.32.4).

• CB ready for open/close/open cycle	(CB ready)	
• CB2 ready for open/close/open cycle	(CB2 ready)	**)
• CB ready for close/open cycle	(CO Ready)	
• CB2 ready for close/open cycle	(CO Ready 2)	**)
• CB open	(CB open)	
• CB2 open	(CB2 open)	**)
• CB2 preferred circuit-breaker	(CB2 Priority)	**)
• Synchrocheck	(SynchroChck)	
• Synchrocheck 2	(SynchroChck2)	**)
• Dead line	(Dead Line)	
• Dead line 2	(Dead Line2)	**)
• External blocking input	(ExtBlkAR)	
• Conditional blocking input	(CondBkAR)	
• Manual close blocking input	(Manual Close)	
• External synchrocheck bypass	(Ext.SCBypas)	
• External extension of dead time (1st. attempt)	(Extend t1)	
• Delay from master CB	(MasterDel)	
• Block from master CB	(MasterUnsucc)	
• Block reclosure by follower (redundant scheme)	(Inhibit Inp)	
• External 1P-1P selector for 1st. AR	(MD1_EXT_1P_1P)	
• External 1P-3P selector for 1st. AR	(MD1_EXT_1P_3P)	
• External 1P3P-3P selector for 1st. AR	(MD1_EXT_1P3P_3P)	
• External 1P3P-1P3P selector for 1st. AR	(MD1_EX_1P3P_1P3P)	

### III. Binary outputs

• CB close signal	(Close CB)	
• CB2 close signal	(Close CB2)	**)
• Overreach switching signal	(ZExtension)	
• Definitive trip	(Def. Trip)	
• Prepare trip of all three phases	(Trip 3-Pol)	
• Block Follower CB	(BlkFlwr)	
• Delay Follower CB	(DelFlwr)	
• Block for Follower. recloser	(Inhibit Outp)	
• Reclosure function ready	(AR Ready)	
• Reclosure function blocked	(AR Blocked)	
• Reclosure cycle running	(AR in prog.)	
• 1st. single-phase reclosure in progress	(First AR 1P)	
• 1st. three-phase reclosure in progress	(First AR 3P)	
• 2nd. Reclosure in progress	(Second AR)	

---

\*\* ) 2 denotes the I/O's for CB2 in a duplex scheme (see Fig. 3.5.32.7.).



- 3rd. reclosure in progress (Third AR)
- 4th. reclosure in progress (Fourth AR)

#### **IV. Measurements**

- None.

**D. Autoreclosure settings - Autoreclosure**

Summary of parameters:

Text	Units	Default	Min.	Max.	Step
------	-------	---------	------	------	------

**GENERAL**

RunOnCPU		CPU1	(Select)		
ParSet 4..1		P1	(Select)		
1. AR Mode		1P3P-1P3P	(Select)		
2..4. AR Mode		off	(Select)		

**TIMERS**

t Dead1 1P	s	001.20	0,05	300	0.01
t Dead1 3P	s	000.60	0,05	300	0.01
t Dead1 Ext.	s	001.00	0,05	300	0.01
t Dead2	s	001.20	0,05	300	0.01
t Dead3	s	005.00	0,05	300	0.01
t Dead4	s	060.00	0,05	300	0.01
t Oper	s	000.50	0,05	300	0.01
t Inhibit	s	005.00	0,05	300	0.01
t Close	s	000.25	0,05	300	0.01
t Discrim.1P	s	000.60	0.10	300	0.01
t Discrim.3P	s	000.30	0.10	300	0.01
t Timeout	s	001.00	0,05	300	0.01
t AR Block	s	005.00	0,05	300	0.01

**GENERAL BINARY INPUTS**

Start	BinaryAddr	off (F)			
Trip CB 3P	BinaryAddr	off (F)			
Trip CB	BinaryAddr	off (F)			
Start 2	BinaryAddr	off (F)			
Trip CB2 3P	BinaryAddr	off (F)			
Trip CB2	BinaryAddr	off (F)			
Start 3	BinaryAddr	off (F)			
Trip CB3 3P	BinaryAddr	off (F)			
Trip CB3	BinaryAddr	off (F)			
CB Ready	BinaryAddr	off (F)			
CO Ready	BinaryAddr	off (F)			
CB Open	BinaryAddr	off (F)			
Dead line	BinaryAddr	off (F)			
Ext. Blk AR	BinaryAddr	off (F)			
Cond.Blk AR	BinaryAddr	off (F)			
Manual Close	BinaryAddr	off (F)			
Inhibit Inp.	BinaryAddr	off (F)			
Extend t1	BinaryAddr	off (F)			

Text	Units	Default	Min.	Max.	Step
MD1 EXT 1P 1P	BinaryAddr	off (F)			
MD1 EXT 1P 3P	BinaryAddr	off (F)			
MD1 EXT 1P3P 3P	BinaryAddr	off (F)			
MD1 EXT 1P3P 1P3P	BinaryAddr	off (F)			

**CLOSE COMMAND**

Close CB 01-08	Trip Chan	00000000			
Close CB 09-16	Trip Chan	00000000			
Close CB 17-24	Trip Chan	00000000			
Close CB 25-32	Trip Chan	00000000			

**GENERAL SIGNALS**

Close CB	SignalAddr				
Trip 3-Pol	SignalAddr				
Def. Trip	SignalAddr				
AR Ready	SignalAddr				
AR in Prog.	SignalAddr				
AR Blocked	SignalAddr				
First AR 3P	SignalAddr				
First AR 1P	SignalAddr				
Second AR	SignalAddr				
Third AR	SignalAddr				
Fourth AR	SignalAddr				
Inhibit Outp	SignalAddr				

**SYNCHROCHECK**

SCBypas 1P		off	(Select)		
SCBypas 1P3P		off	(Select)		
Ext.SCBypas	BinaryAddr	off (F)			
SynchroChck	BinaryAddr	off (F)			

**ZONE EXTENSION**

ZE Prefault		on	(Select)		
ZE 1. AR		off	(Select)		
ZE 2. AR		off	(Select)		
ZE 3. AR		off	(Select)		
ZE 4. AR		off	(Select)		
ZExtension	SignalAddr				

**MASTER/FOLLOWER LOGIC**

Master mode		off	(Select)		
MasterDelay	BinaryAddr	off (F)			
Mast.noSucc	BinaryAddr	off (F)			

Text	Units	Default	Min.	Max.	Step
------	-------	---------	------	------	------

DelayFlwr.	SignalAddr				
Blk.toFlwr.	SignalAddr				

**DUPLEX LOGIC**

CB2 Ready	BinaryAddr	off (F)			
CO Ready 2	BinaryAddr	off (F)			
CB2 open	BinaryAddr	on (T)			
SynchroChck2	BinaryAddr	off (F)			
Dead line 2	BinaryAddr	off (F)			
Close CB2 01-08	Trip Chan	00000000			
Close CB2 09-16	Trip Chan	00000000			
Close CB2 17-24	Trip Chan	00000000			
Close CB2 25-32	Trip Chan	00000000			
Close CB2	SignalAddr				
CB2 Priority	BinaryAddr	off (F)			

**(ADDITIONAL LOGIC)**

P INPUT1	BinaryAddr	off (F)			
.					
P INPUT16	BinaryAddr	off (F)			
TMSEC Timer1	ms	0	0	30000	1
.					
TMSEC Timer8	ms	0	0	30000	1
P OUTPUT1	SignalAddr				
.					
P OUTPUT8	SignalAddr				

Remarks on the signal designations:

The I/O signals specifically for redundant or duplex schemes include the figure '2', respectively '3' in their designations.

The signals belonging to the basic configuration (1 protection function and 1 auto-reclosure function) do not necessarily include the figure '1' in their designations.

**Explanations of parameters:****GENERAL****RunOnCPU**

defines the processing unit which runs the function

**ParSet 4..1**

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

**1. AR Mode**

Type of first reclosure

- |               |   |
|---------------|---|
| 1. 1P-1P      | single-phase trip and reclosure for earth faults (single-phase dead time), no reclosure for phase faults  |
| 1. 1P-3P      | single-phase trip followed by three phase trip after approx. 20 ms, three-phase reclosure for earth faults (three-phase dead time initiated by single-phase trip), no reclosure for -phase faults |
| 1. 1P3P-3P    | three-phase trip and reclosure for earth and phase faults (three-phase dead time)   |
| 1. 1P3P-1P3P  | single-phase trip and reclosure for earth faults (single-phase dead time), three-phase trip and reclosure for phase faults (three-phase dead time)  |
| Ext.Selection | External selection by the binary inputs MD1_EXT_1P_1P, MD1_EXT_1P_3P, MD1_EXT_1P3P_3P and MD1_EX_1P3P_1P3P.   |

**2..4. AR Mode**

Maximum number of reclosure attempts (all three-phase)

- |      |                                 |
|------|---------------------------------|
| off  | no 2nd., 3rd. or 4th. reclosure |
| 2 AR | 2 reclosures                    |
| 3 AR | 3 reclosures                    |
| 4 AR | 4 reclosures.                   |

**TIMERS****t Dead1 1P**

Dead time for first single-phase reclosure.

**t Dead1 3P**

Dead time for first three-phase reclosure.

**t Dead1 Ext.**

Extension of 1st. dead time for single or three-phase reclosure (effective as long as a logical '1' (pulse or continuous) is applied to the 'Extend t1' I/P before the dead time finishes (falling edge.)

**t Dead2**

2nd. dead time.

**t Dead3**

3rd. dead time.

**t Dead4**

4th. dead time.

**t Oper**

Maximum duration of a fault for which a reclosure attempt is made.

**t Inhibit**

Period (CB recovery time) from the falling edge of the last reclosure attempt during which the autoreclosure function is blocked and after which the function is reset.

In the event of an evolving fault between discrimination and dead times, the period commences at the instant of another trip occurring between the two times.

The reclaim timer is also started if the protection trips after the fault duration time 't Oper' has elapsed.

**t Close**

Duration of CB close signal.

**t Discrim.1P**

Evolving fault discrimination time for single-phase reclosure.

**t Discrim.3P**

Evolving fault discrimination time for three-phase reclosure.

**t Timeout**

Period following the dead time during which the CB close signal has to occur. If it does not, the 'Def. Trip' signal is generated.

**t AR Block**

Time during which reclosure is blocked. 't AR Block' is started by every blocking signal ('Ext.Blk AR', 'Cond.Blk. AR', 'Manual Close', 'Inhibit Inp' and 'MasternoSucc').

**GENERAL BINARY INPUTS****Start \*)**

I/P for signalling the start of a reclosure cycle.

This I/P is connected to the 'General start' signal of a protection function.

---

\*) For the auto-reclosure function to operate correctly, at least the 'Start' and 'Trip CB 3P' inputs must be connected to a protection function or via a binary system I/P to an external protection relay.

**Trip CB 3P \*)**

I/P for the three-phase trip signal.

The three-phase trip from a protection function is connected to this I/P.

**Trip CB**

I/P for the general trip signal

The general trip from a protection function is connected to this I/P.

Set to 'off' ('F' or 'False'), if not needed.

**Start 2**

I/P for the AR start signal.

In redundant protection schemes, the general start signal from the 2nd. protection is connected to this I/P.

Set to 'off' ('F' or 'False'), if not needed.

**Trip CB2 3P**

I/P for the three-phase trip signal.

In redundant protection schemes, the three-phase tripping signal from the 2nd. protection is connected to this I/P.

Set to 'off' ('F' or 'False'), if not needed.

**Trip CB2**

I/P for the general trip signal.

In redundant protection schemes, the general start signal from the 2nd. protection is connected to this I/P.

Set to 'off' ('F' or 'False'), if not needed.

**Start 3**

I/P for the AR start signal.

The general start signal from the 3rd. protection can be connected to this I/P.

Set to 'off' ('F' or 'False'), if not needed.

**Trip CB3 3P**

I/P for the three-phase trip signal.

The three-phase tripping signal from the 3rd. protection can be connected to this I/P.

Set to 'off' ('F' or 'False'), if not needed.

**Trip CB3**

I/P for the general trip signal.

The general start signal from the 3rd. protection can be connected to this I/P.

Set to 'off' ('F' or 'False'), if not needed.

**CB Ready**

I/P excited by a signal from the CB when it is ready (open/close/open).

Set to 'on' ('T' or 'True'), if not needed or not fitted.

I/P logic: 'CB ready' OR 'CB2 ready'

In a duplex scheme, either an active 'CB ready' or 'CB2 ready' I/P enables an auto-reclosure cycle.

Resetting of this input is delayed internally by 100 ms.

**CO Ready**

I/P excited by a signal from the CB when it is ready for a close/open cycle.

Set to 'on' ('T' or 'True') if not needed, not fitted and 'Dead line' or 'ExtSCBypas' not used.

I/P logic for enabling the closing command: ['synchrocheck' AND 'CO Ready'] OR 'Dead line' OR 'ExtSCBypas'].

**CB Open**

I/P excited by a signal from the CB when it is open.

Set to 'off' ('F' or 'False'), if not needed.

To avoid the operation of fast circuit-breakers from being blocked unintentionally, the effect of this input is delayed internally by 100 ms.

**Dead line**

I/P indicating that the line is de-energised ('CB open' input if the v.t.'s are on the busbar side).

Set to 'off' ('F' or 'False'), if not needed.

An active I/P overrides the following logical relationship of the I/P's: 'synchrocheck' AND 'CO Ready'.

**Ext. Blk AR**

I/P for blocking the internal auto-reclosure function.

Even an autoreclosure cycle that is in progress is immediately blocked by a signal applied to this input.

The output signals 'Trip 3 Pol' and 'Def Trip' are generated and a three-phase definitive trip takes place.

Set to 'off' ('F' or 'False'), if not needed.



**Cond. Blk. AR**

I/P for a conditional blocking signal.

Blocking only takes place providing an AR cycle is not in progress.

Set to 'off' ('F' or 'False'), if not needed.

When tripping is by the distance protection SOTF logic or a directional E/F PLC signal, the corresponding signals can be connected to this I/P to prevent auto-reclosure.

**Manual Close**

Blocking I/P excited by the manual CB close signal.

Even an autoreclosure cycle that is in progress is immediately blocked by a signal applied to this input.

Set to 'off' ('F' or 'False'), if not needed.

**Inhibit Inp.**

I/P for blocking the follower reclosure function in a redundant scheme. The follower is blocked from the end of the master closing signal until the end of the reclaim time.

Set to 'off' ('F' or 'False'), if not needed.

**Extend t1**

Input for conditionally extending the dead time (single and three-phase) for the first (fast) reclosure.

Set to 'off' ('F' or 'False'), if not needed.

**MD1\_EXT\_1P\_1P, MD1\_EXT\_1P\_3P, MD1\_EXT\_1P3P\_3P and MD1\_EX\_1P3P\_1P3P**

Inputs for externally selecting the mode for the first reclosure. They are only effective when the parameter '1. AR Mode' is set to 'Ext.Selection'.

Unused inputs must be set to 'off' ('F' or 'False'). If a signal is applied to more than one input, the next mode in the list is the one that is active. The auto-reclosure function is blocked if none of the inputs is used.

**CLOSE COMMAND****Close CB 01-08**

Auxiliary relay O/P for the CB close command.

**Close CB 09-16**

Corresponds to Close CB 01-08 (only if tripping unit fitted).

**Close CB 17-24**

Corresponds to Close CB 01-08 (only if tripping unit fitted).

**Close CB 25-32**

Corresponds to Close CB 01-08 (only if tripping unit fitted).

**GENERAL SIGNALS****Close CB**

CB close signal.

**Trip 3-Pol**

Signal to the distance function so that it can only carry out a three-phase trip.

This signal is inverted and connected to the distance protection I/P '1P AR'.

This signal is active in many situations, but particularly when the AR function is blocked, the CB is not ready for AR, the CB is open, the single-phase discrimination time 't 1P Discrim' finishes or the output signal 'First AR 3P' is active.

It resets at the end of reclaim time.

**Def. Trip**

Signal initiating lock-out tripping of the CB.

This signal is normally active when the protection trips again after the last programmed reclosing shot or trips while the AR function is blocked. The signal resets after a fixed time of 500 ms.

**AR Ready**

Signal indicating that the AR function is ready for a reclosure cycle. This signal is active when the AR function is ON and standing by and also during the closing command.

**AR in Prog.**

Signal indicating that a reclosure cycle is in progress.

This signal is active from the beginning of the dead time until the end of the last reclosure attempt.

**AR Blocked**

Signal indicating that the auto-reclosure relay is blocked.

**First AR 3P**

Signal indicating that the 1st three-phase reclosure attempt is in progress.

**First AR 1P**

Signal indicating that the 1st single-phase reclosure attempt is in progress.

**Second AR**

Signal indicating that the 2nd reclosure attempt is in progress (always three-phase).

**Third AR**

Signal indicating that the 3rd reclosure attempt is in progress (always three-phase).

**Fourth AR**

Signal indicating that the 4th reclosure attempt is in progress (always three-phase).

**Inhibit Outp**

Signal for blocking the follower AR function in a redundant scheme.

This signal is active from the end of the close command from the master AR function to the end of the reclaim time.

**SYNCHROCHECK BYPASS SETTINGS****SCBypas 1P**

Bypass of the synchrocheck and close/open ready signals for the first single-phase reclosure:

- 'on' First single-phase reclosure not enabled by synchrocheck and close/open ready signals (bypass always active).
- 'off' First single-phase reclosure enabled by the synchrocheck and close/open ready signals (bypass inactive).

**SCBypas 1P3P**

Bypass of the synchrocheck and close/open ready signals for the first single or three-phase reclosure:

- 'on' First reclosure not enabled by synchrocheck and close/open ready signals (bypass always active).
- 'off' First reclosure enabled by synchrocheck and close/open ready signals (bypass inactive).

**Ext.SCBypas**

Bypasses the 'synchroChck' and 'CO Ready' signals.

Set to 'off' ('F' or 'False'), if not needed.

I/P logic for enabling the close command: [( 'synchrocheck' AND 'CO Ready') OR 'Dead line' OR 'Ext.SCBypas'].

I/P logic for enabling the close command: [( 'synchroChk2' AND 'CO Ready 2') OR 'Dead line' OR 'Ext.SCBypas'].

**SynchroChck**

I/P for a signal from a synchrocheck relay.

Set to 'on' ('T' or 'True'), if not needed, not fitted and 'Dead line' or 'ExtSCBypas' not used.

I/P logic: [( 'synchrocheck' AND 'CO Ready') OR 'Dead line' OR 'Ext.SCBypas'].

**ZONE EXTENSION**

To achieve the functions described below, the 'ZExtension' signal must be connected to the distance protection function ([see Section 3.5.32.2.](#)).

This signal can be used to initiate fast tripping in schemes including overcurrent functions ([see Section 3.5.32.3.](#)).

**ZE Prefault**

Distance relay reach setting before the first fault:

'on'	overreaching ('ZExtension' signal active)
'off'	underreaching ('ZExtension' signal inactive).

**ZE 1. AR**

Distance relay reach after the 1st. reclosure attempt:

'on'	overreaching ('ZExtension' signal active)
'off'	underreaching ('ZExtension' signal inactive).

**ZE 2. AR**

Distance relay's reach after the 2nd. reclosure attempt:

'on'	overreaching ('ZExtension' signal active)
'off'	underreaching ('ZExtension' signal inactive).

**ZE 3. AR**

Distance relay's reach after the 3rd. reclosure attempt:

'on'	overreaching ('ZExtension' signal active)
'off'	underreaching ('ZExtension' signal inactive).

#### ZE 4. AR

Distance relay's reach after the 4th. reclosure attempt:  
'on'       overreaching ('ZExtension' signal active)  
'off'       underreaching ('ZExtension' signal inactive).

#### ZExtension

Signal to the distance function to switch it to overreach or enable an overcurrent function with a short delay.

### MASTER/FOLLOWER LOGIC

#### Master Mode

(for 1½ breaker and redundant schemes)

Selection of an auto-reclosure function to be "Master":

'on'       Master O/P signals transmitted.  
'off'       Master O/P's blocked.

#### MasterDelay

I/P for a signal delaying the closing command from the follower reclosure function.

This signal picks up when the dead time of the master reclosure function starts and is reset either by a new trip after the last reclosure of the cycle or at the end of the wait time following successful reclosure by the master.

Set to 'off' ('F' or 'False'), if not needed.

#### Mast.noSucc

I/P for a blocking signal from the master CB.

This signal is triggered by the rising edge of the 'Def.Trip' output from the master reclosure function and resets after a fixed time of 500 ms.

Set to 'off' ('F' or 'False'), if not needed.

#### DelayFlwr.

Signal to delay the follower CB for as long as the master circuit-breaker has not completed its auto-reclosure cycle.

The signal picks up at the start of master AR dead time and is reset either by the rising edge of the 'Def.Trip' output or the falling edge of the 'Close CB' output after the time 'tClose'.

#### Blk.toFlwr

Signal to block the follower CB as long as reclosure of the master CB is unsuccessful.

The excursion of this signal is the same as for the 'Def.Trip' output.

## DUPLEX LOGIC

### CB2 Ready

I/P excited by a signal from CB2 when it is ready (open/close/open).

Set to 'off' ('F' or 'False'), if not needed or not fitted.

I/P logic: 'CB ready' OR 'CB2 ready'

In a duplex scheme, the auto-reclosure cycle is enabled either by an active 'CB ready' or 'CB2 ready' I/P.

Resetting of this input is delayed internally by 100 ms.

### CO Ready 2

I/P excited by a signal from CB2 when it is ready for a close/open operation.

Set to 'on' ('T' or 'True'), if not needed, not fitted and 'Dead line 2' is not used.

I/P logic for enabling the close command: [( 'synchrocheck2' AND 'CO Ready 2') OR 'Dead line 2' OR 'ExtSCBypas'].

### CB2 open

I/P excited by a signal from CB2 when it is open.

Set to 'on' ('T' or 'True'), if not needed. Observe the information given for the duplex logic in a duplex scheme ([see Section 3.5.32.5](#)).

### SynchroChck2

I/P for a signal from a synchrocheck function belonging to CB2.

Set to 'on' ('T' or 'True'), if not needed, not fitted and 'Dead line 2' or 'ExtSCBypas' not used.

I/P logic for enabling the close command: [( 'synchrocheck2' AND 'CO Ready 2') OR 'Dead line 2' OR 'ExtSCBypas'].

### Dead line 2

I/P indicating that line 2 is de-energised (CB2 open and v.t's 2 on the busbar side).

Set to 'off' ('F' or 'False'), if not needed.

An active I/P overrides the following logical relationship of the I/P's: 'synchrocheck 2' AND 'CO Ready 2'.

**Close CB2 01-08**

Tripping relay O/P for the CB2 close command.

**Close CB2 09-16**

Corresponds to Close CB 01-08 (only if tripping unit fitted).

**Close CB2 17-24**

Corresponds to Close CB 01-08 (only if tripping unit fitted).

**Close CB2 25-32**

Corresponds to Close CB 01-08 (only if tripping unit fitted).

**Close CB2**

Auxiliary relay O/P for the CB2 close signal.

**CB2 Priority**

Input for determining the preferred circuit-breaker:

'off' ('F' or 'False')	CB1 is preferred circuit-breaker
'on' ('T' or 'True')	CB2 is preferred circuit-breaker.

If both circuit-breakers are closed before a fault, only the preferred circuit-breaker performs the entire auto-reclosure cycle. The other circuit-breaker closes either after successful auto-reclosure or when the close command to the preferred circuit-breaker is not enabled (missing 'CO Ready' or 'Synchrocheck').

**(ADDITIONAL LOGIC)**

The following settings are only of consequence if a special auto-reclosure logic is installed. In this case, consult the associated description for the significance of the various settings.

**BOOL\_IN1, BOOL\_IN2...BOOL\_IN16**

Additional binary input for a special auto-reclosure logic.

**TIMER\_1, TIMER\_2...TIMER\_8**

Additional timer settings for a special auto-reclosure logic.

**BOOL\_OUT1, BOOL\_OUT2...BOOL\_OUT8**

Additional signals for a special auto-reclosure logic.

## **PROJECT DIRECTORY**

The user can choose the subdirectory in which to store the auto-reclosure logic. The default name "AURESTD" applies when using the standard logic in the MMI directory.

It is necessary to change the name and path when using a special logic. In this case, consult the associated description for the procedure.



## E. Setting instructions

### 3.5.32.1. *General*

The auto-reclosure function can perform from 1 to 4 auto-reclosure attempts. The first attempt can be either single or three-phase while the subsequent attempts are always three-phase. The type and number are determined by the parameters '1. AR Mode' (4 different modes for the 1st. reclosure cycle) and '2..4 AR Mode'.

The function can operate in conjunction with either an external distance protection relay or other internal protection functions.

It can also operate in a scheme comprising two or more protection functions (see Sections 3.5.32.2. to 3.5.32.5.).

### 3.5.32.2. *Connections between auto-reclosure and distance functions*

The auto-reclosure function determines from the states of the input signals 'start', 'Trip CB' and 'Trip CB 3P', whether the distance protection has picked up and whether it has performed a single or a three-phase trip. Only the 'Trip CB' signal is generated for a single-phase trip, whereas both the 'Trip CB' and 'Trip CB 3P' signals are generated for a three-phase trip.

The external distance relay or internal distance function decides whether single or three-phase tripping should take place.

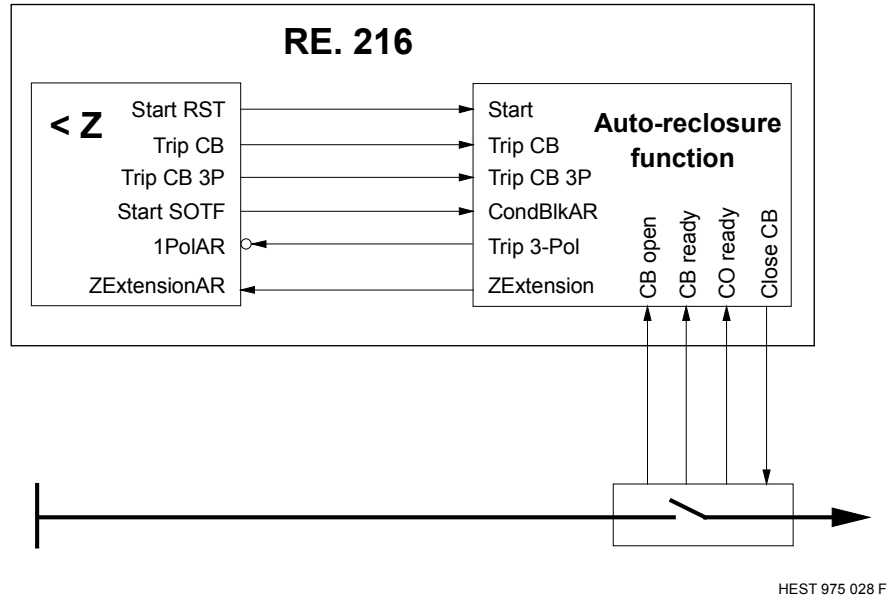
The auto-reclosure function can send two signals to the distance protection. The 'Trip 3-Pol' signal informs the distance protection whether it should perform a single or a three-phase trip. The 'ZExtension' signal switches the distance protection's overreaching zone on and off.

When setting the parameters, attention should be paid to the order of the functions. For runtime reasons, the distance function should be configured before the auto-reclosure function.

Where the SOTF logic is not required to operate during auto-reclosure, connect the 'AR in prog.' Signal to the 'ExtBlkSOTF' binary I/P of the distance function. The 'SOTF 10 s' timer in the distance function's SOTF logic is normally activated for dead times <10 s and in this case the above connection is not necessary.

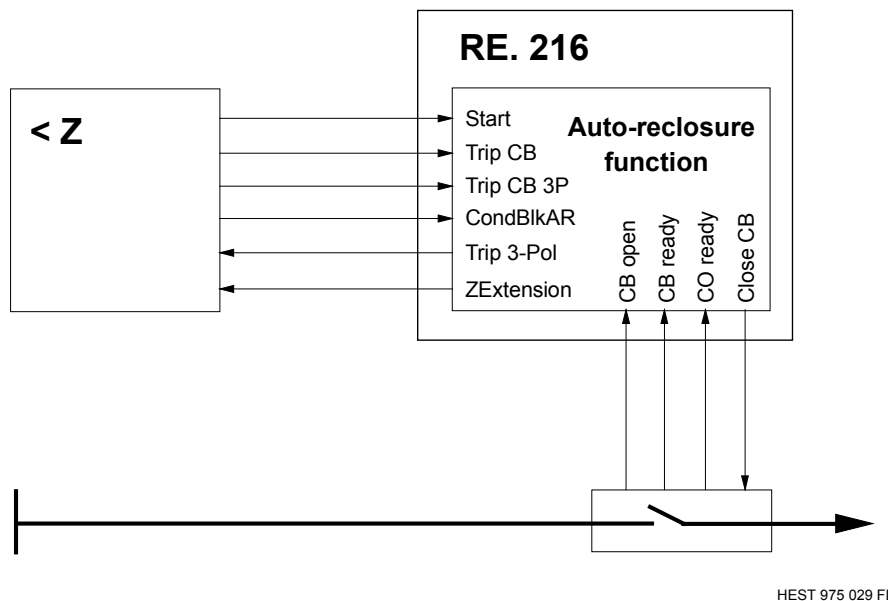
If the SOTF logic initiates tripping, an auto-reclosure cycle can be inhibited by connecting the 'start SOTF' from the distance function to the 'CondBlkAR' I/P of the auto-reclosure function.

The exchange of signals in the various schemes (one distance and one auto-reclosure function, and several protection functions and one reclosure function) can be seen from Fig. 3.5.32.1, Fig. 3.5.32.2 and Fig. 3.5.32.5.



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Fig. 3.5.32.1 Distance and auto-reclosure functions in the same unit



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Fig. 3.5.32.2 Distance protection and auto-reclosure functions in different units

### 3.5.32.3. **Connections between auto-reclosure and overcurrent or differential functions**

When setting the parameters, attention should be paid to the order of the functions. For run-time reasons, the overcurrent function should be configured before the auto-reclosure function.

To prevent the discrimination timer from operating, connect the overcurrent 'Trip' signal to the two inputs 'Start' and 'Trip CB 3P' of the auto-reclosure function.

The time 't Close' must be set longer than the maximum operating time of the activated (graded) overcurrent functions to prevent the reclaim time from blocking the AR function in the event of a permanent fault:

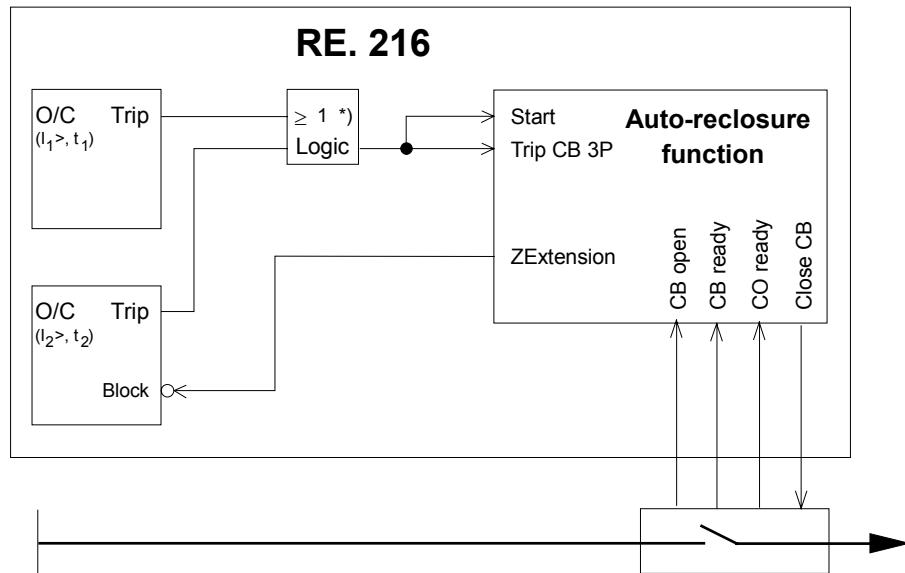
$$t_{\text{Close from AR function}} > t_{\text{max. overcurrent time delay}}$$

In cases where the zone extension signal is used in conjunction with overcurrent functions (see zone extension settings), the terms 'overreach' and 'underreach' have the following meanings:

'overreach': enabling of an overcurrent function having a short (non-graded) time delay.

'underreach' : enabling of an overcurrent function having a long (graded) time delay.

The exchange of signals in conjunction with O/C functions is shown in [Fig. 3.5.32.3](#).



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Fig. 3.5.32.3 Overcurrent and auto-reclosure functions in the same unit

where:

- $t_1$  standard delay (0.5 ... 1.5 s)
- $t_2$  short delay (0.02 ... 0.2 s)
- $I_1 >$ ,  $I_2 >$  pick-up value 'I set' for 'Trip'.

<sup>\*)</sup> The 'Trip' signal from the second current function may be connected to the inputs 'Start 2' and 'Trip CB2 3P' instead of to the logic function.

#### **3.5.32.4. Redundant schemes**

Provision is made for coordinating the operation of two protection functions and one or two auto-reclosure functions per line terminal (see Fig. 3.5.32.4 and Fig. 3.5.32.5).

A master/follower logic has to be used to avoid any time-race problems due to differing timer tolerances.

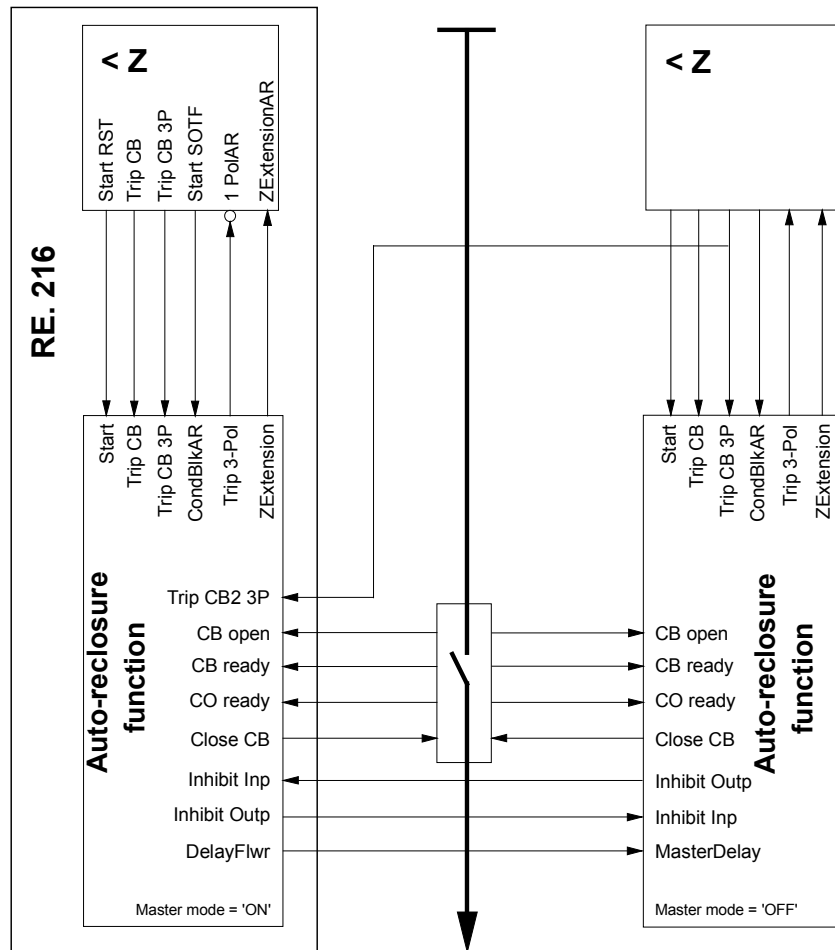
A redundant scheme assumes first and second main protection schemes each with its own reclosure function. The operation of the reclosure functions therefore has to be coordinated by configuring one as 'master' and the other as 'follower'. If the master AR starts first, it delays the operation of the follower AR until it has either achieved successful reclosure or otherwise.

If the follower AR is enabled first, its dead time starts to run, but should the master start during the follow's dead time, operation of the follower reclosure function is suspended and the master takes over and performs its reclosure cycle.

The follower is on "hot standby" and only takes over, if the master AR or its protection function fails to operate.

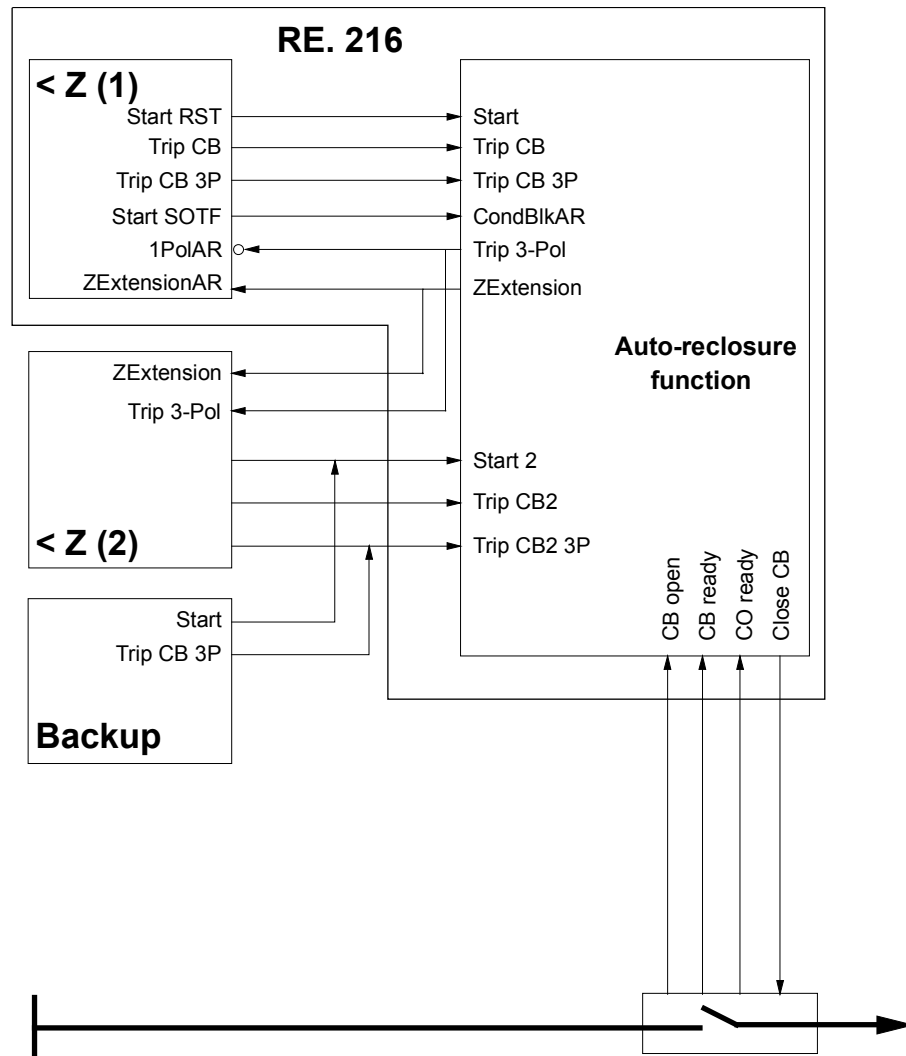
The signal from a faulty contact like 'CO Ready' to the master recloser, however, would result in a 'Def.Trip' output after the time 't Timeout' and this would also block the Follower AR.

In the circuit of Fig. 3.5.32.4, the master and follower functions can also be the other way round by appropriately configuring the system software.



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Fig. 3.5.32.4 Redundant scheme (first and second main < Z and auto-reclosure functions) with master/follower logic



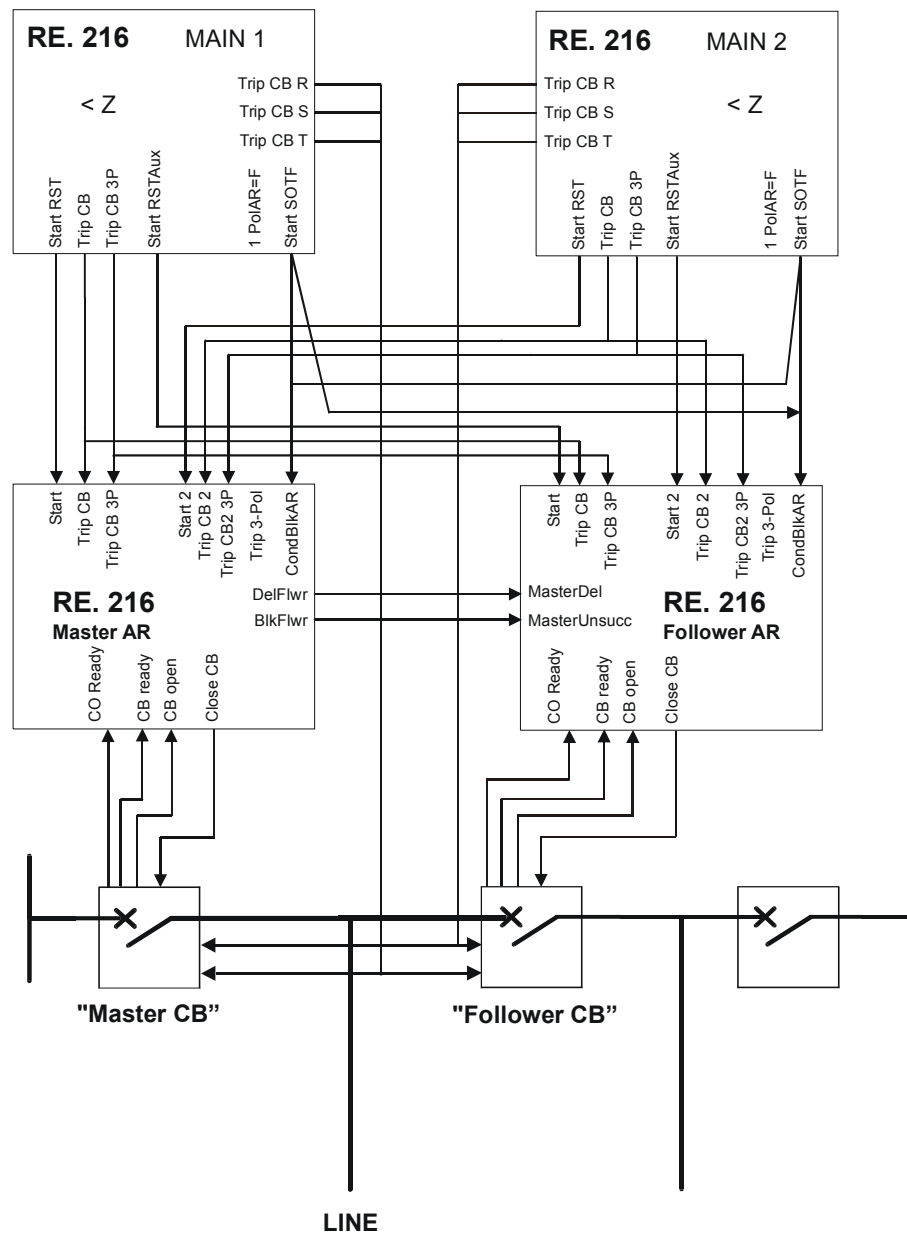
HEST 975 032 FL

Fig. 3.5.32.5 Several protection functions and a common auto-reclosure unit

### 3.5.32.5. Master/follower logic

Provision is made for a master/follower logic in 1½ breaker schemes with two line protections per line and an auto-reclosure function per circuit-breaker.

One of the reclosure functions is assigned the role of master by appropriately setting the parameter 'Master mode'. After a successful reclosure, the master AR then enables the follower AR, respectively its CB (the connections are as given in Fig. 3.5.32.6 for a three-phase trip and reclosure for all types of faults).



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Fig. 3.5.32.6 Earth and phase fault master/follower scheme for AR mode 1P3P-3P

Note: A second line on the diameter (1½ breaker scheme) requires additional connections and logic.



### **Follower CB delay 'DelayFlwr'**

The master reclosure function sends an active 'DelFlwr' signal to the 'MasterDelay' I/P of the follower to delay its 'Close CB' command to the follower CB until the master reclosure function issues the 'Close CB' command, which is followed by a wait time of 300 ms as a precaution to allow time for a successful reclosure. If the reclosure is unsuccessful, the output remains high until the signal 'Def.Trip' is activated (the 'DelayFlwr' signal resets and 'Blk to Flwr' signal is generated).

Should this signal reset before the end of the follower dead time, the close command to the follower CB is issued at the end of the dead time.

### **Blocking reclosure by the follower 'Blk.toFlwr'**

The master reclosure function sends an active 'Blk.toFlwr' signal to the follower 'Mast.noSucc' I/P to block reclosure by the follower, if the reclosure attempt by the master was unsuccessful as indicated by the generation of its 'Def.Trip' output.

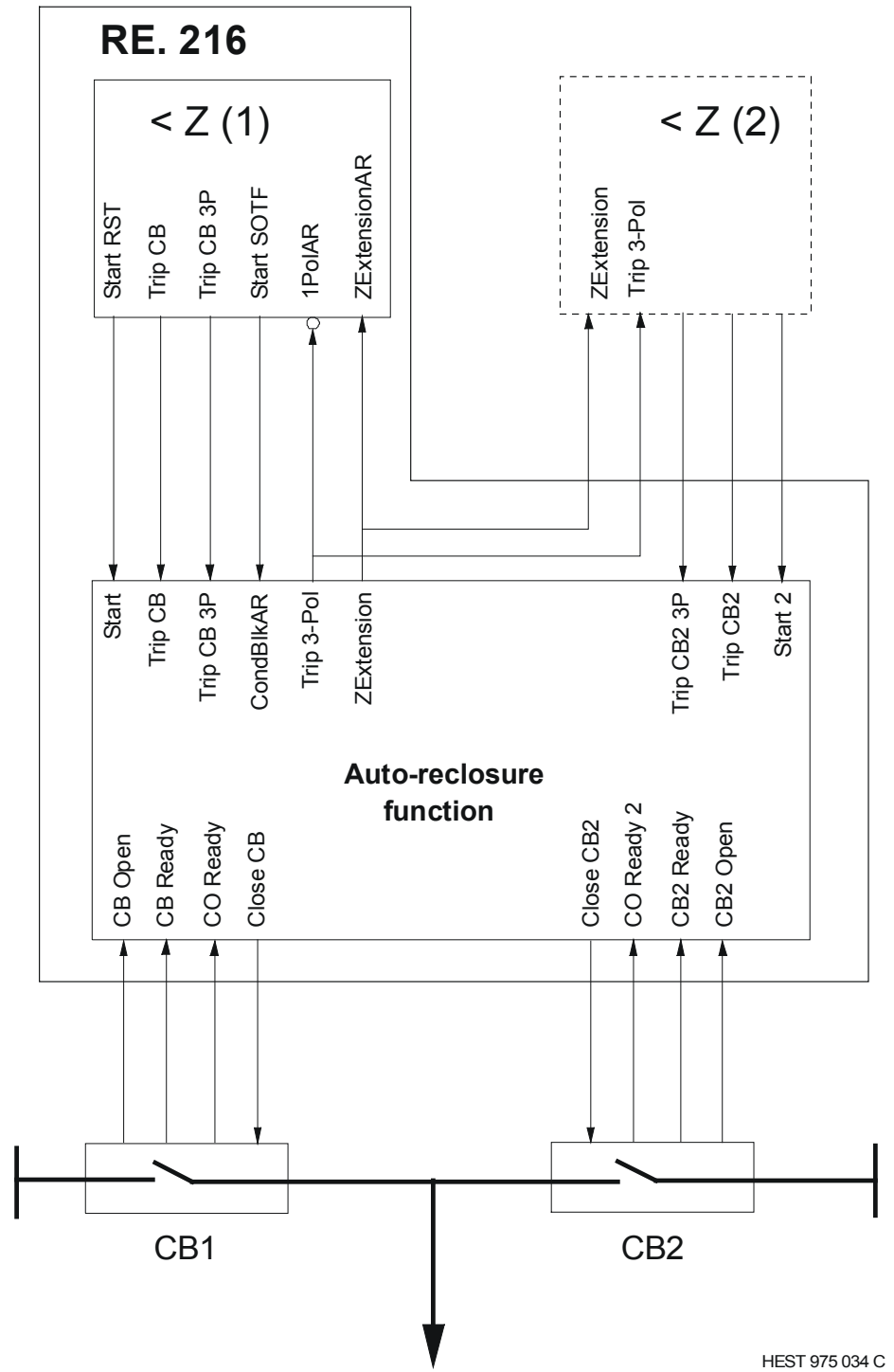
#### **3.5.32.6. Duplex logic**

A duplex logic for a line with two circuit-breakers is also included (see Fig. 3.5.32.7).

Observe the following in connection with a duplex scheme:

Note: One of the breakers has to be set to low priority.

- For the scheme to operate correctly, the corresponding CB signals must be connected to the 'CB open' and 'CB2 open' inputs for the duplex logic (setting to 'off' disables the duplex logic). Follow the procedure below, if separate 'CB ready' and 'CB open' signals are not available from the circuit-breakers:
  - Connect the two circuit-breaker signalling contacts 'CB ready' (air-pressure or spring charging) and 'CB closed' in series. For this, 't Close' must be set longer than the maximum spring charging time to suppress the definitive trip signal in the case of a successful reclosure.
  - Assign the combined signals to the corresponding 'CB ready' inputs.
  - Assign the same signals but inverted to the corresponding 'CB open' inputs.



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Fig. 3.5.32.7 Duplex scheme (< Z can be redundant)

### 3.5.32.7. **Timers**

The timers have setting ranges extending up to 300 s in steps of 10 ms.

The purpose of each of the timers is described below.

#### **Dead times 't Dead1 1P' to 't Dead 4'**

Provided the trip signal is issued before 't Oper' elapses, the dead time is the period between the tripping signal ('Trip CB') and the close signal ('Close CB').

The required dead time must be entered separately for each re-closure cycle. This necessitates setting the following parameters: 't Dead1 1P', 't Dead1 3P', 't Dead 2', 't Dead 3' and 't Dead 4'.

Provision is made for externally switching the dead times 't Dead1 1P' and 't Dead1 3P' for the first (fast) reclosure attempt to a second setting. The corresponding additional time period can be set with the aid of the parameter 't Dead 1 Ext' and activated via the binary I/P 'Extend t1'.

The 2nd., 3rd. and 4th. reclosure attempts are always three-phase.

#### **Extended dead time 't Dead 1 Ext'**

This time provides facility for extending the dead time (e.g. should the communications channel be defective or for a redundant scheme with 2 auto-reclosure functions). The extended dead time is enabled by the binary input 'Extend t1'.

#### **Maximum fault duration for a reclosure attempt 't Oper'**

If a fault has persisted for some time, the probability of a successful reclosure reduces. The likelihood of the power system becoming unstable is also greater for an unsuccessful auto-reclosure attempt following a fault which has persisted for a long period. It is for these reasons that the time after the inception of a fault during which reclosure can be initiated is limited. The fault duration is set using parameter 't Oper'.

The timer for the fault duration is started by the pick-up signal from the protection function (Start). Faults resulting in tripping after 't Oper' are locked out ('Def. Trip') and reclosure does not take place.

Should the fault duration time expire before the protection trips, auto-reclosure is blocked and the reclaim time is started.

Example:

Time 'T Oper' < 'Delay(2)' of the distance function means that auto-reclosure only takes place for faults in the first distance zone ('Delay(1)').

This function is not required for schemes that only use current functions. The binary inputs 'Start' and 'Trip CB 3P' are connected together (see Section 3.5.32.3.).

### **Reclaim time 't inhibit'**

The purpose of the inhibit time is among other things to permit the circuit-breaker to recover its full voltage withstand. To this end, it disables the auto-reclosure function for the time set for parameter 't inhibit' after one of the following events:

- the last reclosing attempt
- a definitive trip resulting from a protection trip after the fault duration time 't Oper'
- a recurring trip between discrimination time and dead time (evolving fault, see O/P signal 'Def. Trip').

### **Close signal duration 't Close'**

The maximum duration of the circuit-breaker close signal (command O/P 'Close CB') is determined by the parameter 't Close'. Any tripping signal which occurs during this time overrides the close signal. A second, third or fourth reclosure attempt can only take place, if the next trip occurs within the time 't Close'.

### **Discrimination times 't 1P discrim.' and 't 3P discrim.'**

The discrimination time determines the procedure in the event of a different kind of fault occurring during the dead time (evolving fault), i.e. one of the other two phases also picks up or the tripping signal resets and picks up again. The discrimination time is started together with the dead time. Should a tripping signal recur due to an evolving fault between the expiry of the discrimination time and before the end of the dead time, the reclaim timer is started and a definitive trip ('Def. Trip') initiated. The dead time is also discontinued and the signal 'AR in prog.' reset.

If the first fault was initially an earth fault and evolves during the time 't Dead1 1P', but before the end of the discrimination time 't Discrim 1P', the dead time 't Dead1 3P' is started and three-phase reclosure takes place.

The discrimination time 't Discrim 3P' is also needed for 2 or 1½ breaker schemes, where each circuit-breaker has its own auto-reclosure function.

A typical setting for the parameters 't Discrim 1P' or 't Discrim 3P' for single and three-phase reclosure is 50 % of the shortest dead time.

The minimum permissible setting for the discrimination time is:

$$100 \text{ ms} + \text{CB time}$$

Note:

The time 't1EvolFaults' during which a subsequent fault has to be detected (evolving or unsuccessful reclosure) is a distance function setting.

The distance protection parameter 't1EvolFaults' enables the time to be set during which a subsequent fault (evolving or unsuccessful reclosure) results in a three-phase trip, i.e. every second trip by the distance protection function trips all three phases. The auto-reclosure function also signals the switchover to three-phase tripping by exciting the signal 'Trip 3-Pol' at the end of the fault discrimination time 't Discrim. 1P'.

It is advisable to set the time 't1EvolFaults' longer than the auto-reclosure dead time 't Dead1 1P'.

### **'t Timeout'**

The parameter 't Timeout' determines the period after the dead time within which the close signal must be issued, otherwise a 'Def.Trip' is generated and no further reclosure attempt is made. Before a close command is issued at the end of every dead time, the logic [( 'synchroChck' AND 'CO ready') OR 'Dead Line' OR 'ExtSCBypas')] is checked and the command only enabled providing all the criteria are correct within the setting of 't Timeout'.

### **Blocking time 't AR Block'**

The auto-reclosure function can be enabled or disabled by the following binary I/P signals:

- ExtBlkAR - also blocks during the reclosure cycle
- Manual close - also blocks during the reclosure cycle
- Inhibit Inp - also blocks during the reclosure cycle
- CB Ready - blocks excepting during the reclosure cycle

- CB2 Ready - blocks excepting during the reclosure cycle \*)
- CO Ready - blocks at the end of the reclosure cycle after expiry of the time 't time-out'
- CO Ready 2 - blocks at the end of the reclosure cycle after expiry of the time 't time-out' \*)
- Mast.noSucc - blocks the follower CB after an unsuccessful reclosure attempt by the master
- CondBlkAR - blocks excepting during the reclosure cycle.

Should a 'CondBlkAR' signal occur during a reclosure cycle (i.e. the 'AR in prog.' signal is active), it only becomes effective from the end of the current reclosure cycle and providing it is still active.

A reclosure cycle remains blocked for the duration of the set blocking time 't AR Block' after the last binary I/P has been enabled. Blocking also takes place during initialisation of the protection relay when its auxiliary supply is switched on or the parameter settings are being loaded.

---

\*) 2 denotes the I/O's for CB2 in a duplex scheme (see Fig. 3.5.32.7.).

### 3.5.32.8. *External binary inputs*

#### **Starting and tripping signals from the protection function: 'Start' ('Start 2', 'Start 3'), 'Trip CB' and 'Trip CB 3P' ( 'Trip CB2', 'Trip CB3', 'Trip CB2 3P', 'Trip CB3 3P')**

In order to control the auto-reclosure function, it is necessary to configure the three I/P signals 'Trip CB' (general trip), 'Trip CB 3P' (three-phase trip) and 'Start'. The normal procedure to achieve this is to select the protection signals via the sub-menu 'OUTPUT FROM FUNCTION'. Since the auto-reclosure function is completely independent, signals from other functions may also be selected.

In a 1st. and 2nd. main (redundant) protection scheme with one auto-reclosure relay (see [Section 3.5.32.4.](#)), the I/P signals 'Trip CB2', 'Trip CB2 3P' and 'Start 2' must also be connected to the second protection function.

#### **Circuit-breaker ready signals: 'CB ready' and 'CO Ready' ( 'CB2 ready' and 'CO Ready 2')**

The I/P's for the parameters 'CO Ready' and 'CB ready' (or 'CO Ready 2' and 'CB2 ready' in a duplex scheme) must be connected to the circuit-breakers in order to signal that they are ready to perform a complete reclosure cycle. In cases where one of the I/P's is not used, it must be set to 'TRUE'.

An active 'CB ready' signal informs the auto-reclosure function that reclosure is permissible (i.e. sufficient energy is available for a full open/close/open cycle).

Once a reclosure cycle has started, this signal is ignored (because the pressure varies during a reclosure cycle of an air-blast breaker).

Resetting of this signal is internally delayed by 100 ms.

The 'CO Ready' signal (close-open cycle can be carried out) is only effective during a reclosure cycle, i.e. during the dead time. Should there be insufficient energy to open the circuit-breaker again following closure, the close signal is disabled and a 'Def. Trip' (definitive trip) is generated.

This I/P is only used in conjunction with circuit-breakers, which provide the corresponding information (C-O query), e.g. spring-charged and air-blast circuit-breakers with two switching energy levels.

### **Circuit-breaker open 'CB open' ('CB2 open')**

It is also necessary to include the initial status of the circuit-breakers to prevent one from receiving a close signal, which was already open before the fault occurred.

The binary I/P 'CB open' (and 'CB2 open' in a duplex scheme) is thus provided to determine the initial status of a circuit-breaker.

The pick-up of these signals is delayed by 100 ms to prevent any unwanted blocking of fast circuit-breakers.

A circuit-breaker which was already open before the 'Start' signal was received ('CB open' at logical '1') is not closed by the auto-reclosure function.

Where a circuit-breaker does not provide the necessary information ('CB open' signal), the I/P must be permanently set to 'off' ('F' or 'False'). Providing the scheme is also not a duplex scheme (i.e. only one CB), the binary I/P 'CB2 open' must also be permanently set to 'on' ('T' or 'True').

Accordingly, these are the default settings for 'CB open' and 'CB2 open'.

The auto-reclosure function can then operate with a single circuit-breaker without a 'CB open' signal and no superfluous close signal is generated for the non-existing CB2.

### **De-energised line 'Dead Line' ('Dead Line 2') with checking of synchronism 'synchroChck' ('synchroChck2')**

Before the 'Close CB' (or 'Close CB2') instruction can be issued, either the 'Dead line' or the 'synchroChck' I/P (or 'Dead line 2' or 'synchroChck2' in a duplex scheme) must be at logical '1'.

Logic: [( 'synchroChck' AND 'CO ready') OR 'Dead Line' OR 'ExtSCBypas']

Logic: [( 'synchroChck2' AND 'CO ready 2') OR 'Dead Line 2' OR 'ExtSCBypas']

### **External blocking 'ExtBlkAR' and 'CondBlkAR'**

The reclosure function is always blocked by an active 'ExtBlkAR' I/P.

An active 'CondBlkAR' I/P will only block the function, providing a reclosure cycle is not running (i.e. the 'AR in prog.' signal is at logical '0').

The 'Cond.Blk AR' signal is needed to prevent a reclosure cycle, when no reclosure is wanted for a first trip that occurs during 't Oper'. This is the case, for example, for trips by the switch-onto-fault (SOTF) protection or by a directional E/F protection via PLC.



To prevent the SOFT from initiating auto-reclosure, the distance protection 'SOFT start' signal must be connected to the 'CondBlkAR' input.

### **'Manual close'**

The reclosure function is immediately blocked (for the blocking time 't AR Block') by a 'Manual close' signal. This signal is also needed for the overreaching logic to switch the 'ZExtension' signal to 'on'.

### **External synchrocheck bypass signal 'ExtSCBypas'**

This I/P provides facility for bypassing the 'synchroChck' and 'CO Ready' (or SynchroChck2' and 'CO Ready 2' for CB2) enabling I/P's.

It is only active for the first fast three-phase or single-phase reclosure attempt.

### **External extension of the dead time 'Extend t1'**

A logical '1' at the 'Extend t1' I/P extends the dead times 't Dead1 1P' and 't Dead1 3P' by the setting 't Dead1 Ext' for the first (fast) reclosure attempt. This could be necessary, for example, in the event of a communication channel failure or in a redundant scheme.

## **3.5.32.9. Close CB and signalling outputs**

The most important auto-reclosure output is the 'Close CB' command which must be assigned to a heavy-duty auxiliary O/P relay. This and 14 other heavy-duty and signalling O/P's are provided.

This signal picks up when the closing command is issued and resets at the end of the time 't Close' or earlier if there is a tripping occurs upon reclosing.

### **Status of the auto-reclosure function ('AR Ready' and 'AR Blocked')**

The signal 'AR Ready' is generated when the auto-reclosure function is ready to perform a reclosure cycle and the signal 'AR Blocked' when it is blocked.

The 'AR Ready' signal is active providing a reclosure cycle is not blocked (no 'AR Blocked' signal) and a dead time is not running.

The 'AR Ready' signal is active during a reclose command for purposes of enabling the synchrocheck function (see Fig. 3 in the synchrocheck function section).

### Auto-reclosure cycle in progress

There are six signals which show that a reclosure cycle is running and what stage has been reached:

'AR in prog.'	reclosure cycle in progress
'First AR 1P'	first single-phase reclosure attempt
'First AR 3P'	first three-phase reclosure attempt
'second AR'	second reclosure attempt
'Third AR'	third reclosure attempt
'Fourth AR'	fourth reclosure attempt.

The signal 'AR in prog' picks up at the start of the dead time and is reset by the falling edge of the last reclose command.

### Circuit-breaker closing signals 'Close CB' and 'Close CB2'

The CB closing command is normally assigned to a heavy-duty auxiliary O/P relay by correspondingly configuring the parameter 'Close CB' (also 'Close CB2' in a duplex scheme). It is also possible to assign the same signal to a signalling O/P under the same parameter name.

A trip subsequent to a close command during the time 't Close' + 300 ms switches the dead time step (second, third and fourth AR) or initiates a lock-out trip (depending on the setting). A close command is reset immediately after a trip.

### Definitive trip 'Def. Trip'

The 'Def. Trip' signal indicates that the circuit-breaker will remain tripped and no further reclosure attempts will be made. The following conditions can cause a definitive trip:

- All reclosure attempts were unsuccessful.
- A starting or tripping signal was generated after the discrimination time and before dead time.
- Tripping takes place while a reclosure cycle is blocked (either via the blocking I/P or by the reclaim time).
- The 'synchroChck' (or 'Dead line') and/or 'CO Ready' I/P's were not enabled during 't Timeout' due to lack of synchronism.
- The 'CB open' signal is still active 300 ms after the close signal has reset (i.e. the CB has not responded to the close signal).
- The trip signal that followed the start signal occurred after the fault duration time 't Oper'.
- Tripping occurred for a phase fault and the mode selected for the first reclosure cycle is 1P-1P or 1P-3P.

### **Perform three-phase trip 'Trip 3-Pol'**

The 'Trip 3-Pol' O/P instructs the line protection to trip all three phases.

The signal can be externally or internally connected.

This signal is generated automatically, if reclosure is blocked, 'CB Ready' is inactive, the CB is open, the single-phase discrimination time 't1P Discrim' has elapsed or the signal 'First AR 3P' is active.

### **Zone extension 'ZExtension'**

The setting of the auto-reclosure parameter 'ZE Prefault' determines the pre-fault reach of the distance protection when the auto-reclosure function is inactive (before the first fault), i.e. setting 'ZE Prefault' to 'on' activates the output signal 'ZExtension' which then switches the distance function to overreach.

The parameters 'ZE 1. AR reach' to 'ZE 4. AR reach' provide facility for individually switching the reach for each reclosure attempt. Setting one of these parameters to 'on' means that the 'ZExtension' O/P is at logical '1' and the distance relay is switched to overreach either before fault occurrence or for the following reclosure attempt, otherwise the distance relay is set to underreach.

With the exception of its first change of state when providing 'ZEPrefault' is set to 'ON' it resets together with the signal 'Trip CB' or 'Trip CB 3P', this signal picks up and resets together with the 'Close CB' signal.

The distance relay is switched to overreaching for a 'Manual close'.

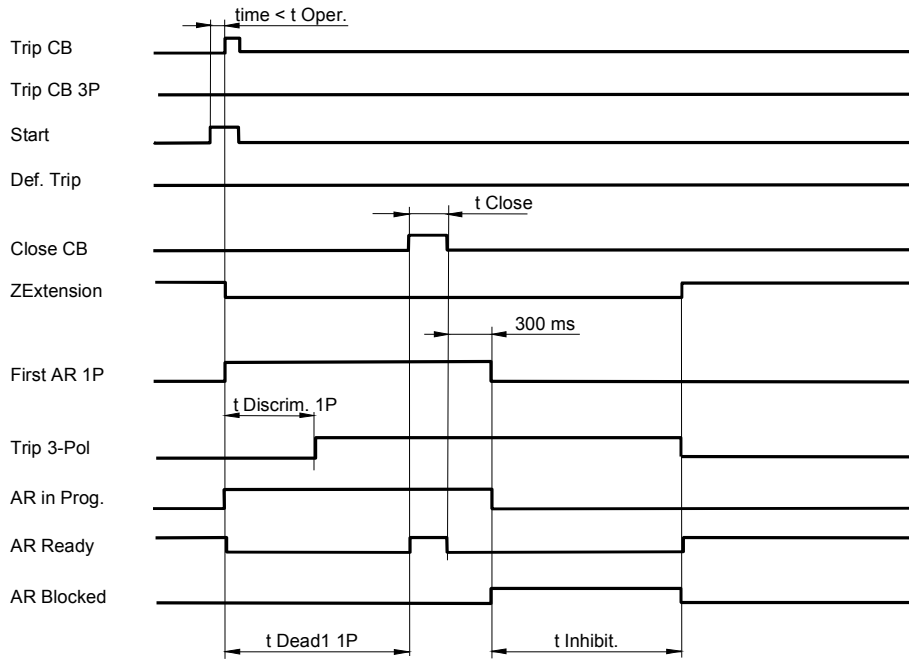
It is switched to underreaching when the auto-reclosure function is blocked.

Note also that the 'ZExtension' signal is connected to the binary input 'ZEMode AR' of the zone extension logic in the distance protection function.

#### **3.5.32.10. *Timing diagrams***

The time relationship between the various signals during operation of the auto-reclosure function can be seen from [Fig. 3.5.32.8](#) to [Fig. 3.5.32.16](#).

**Successful AR**



**Unsuccessful AR**

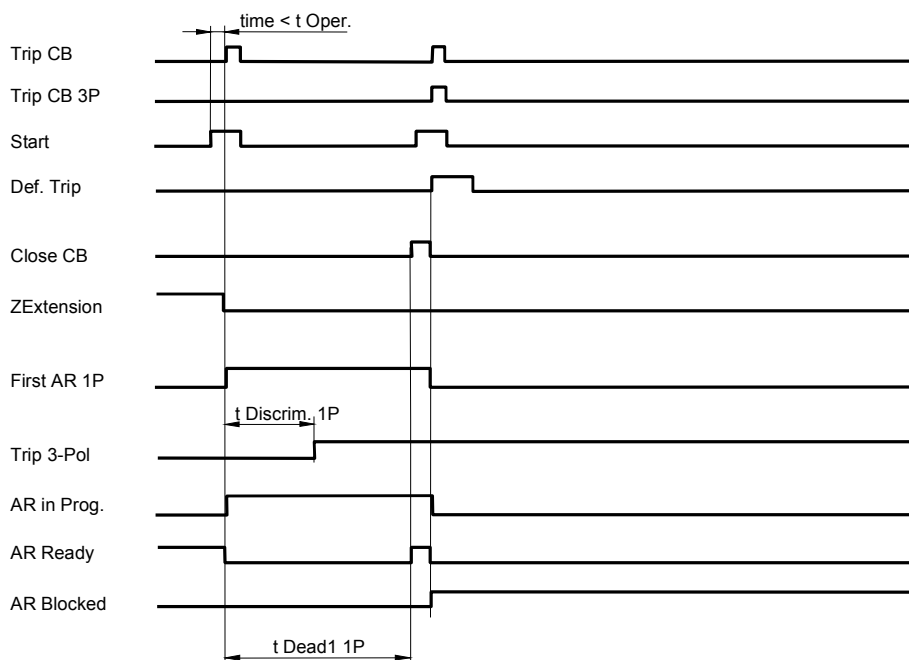


Fig. 3.5.32.8 Timing diagram for a single or double busbar arrangement with 1 distance and 1 AR function. Response for an earth fault.

Settings:

- '1. AR Mode' = '1P-1P' or '1P3P-1P3P',
- '2..4. AR Mode' = 'off', 'ZE Prefault' = 'on',
- 'ZE 1. AR' = 'off'.

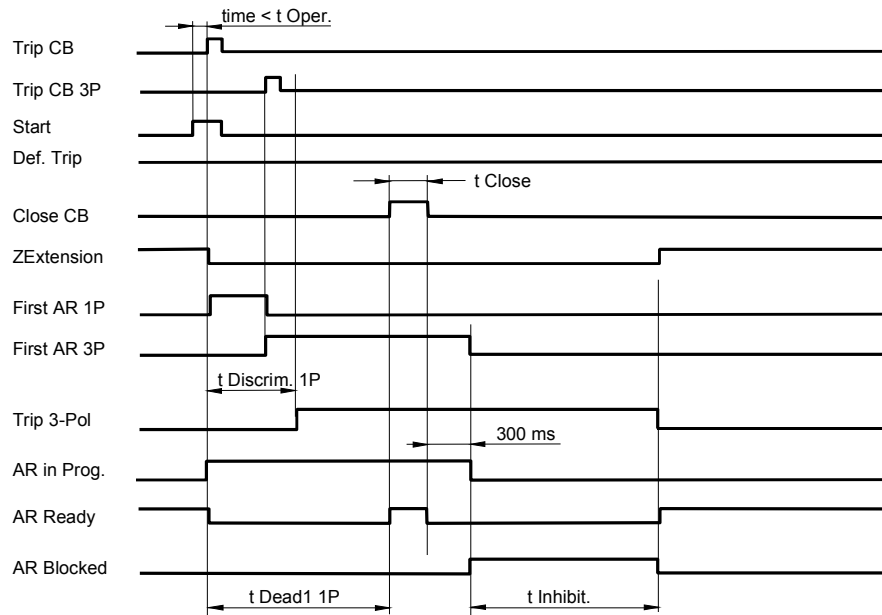
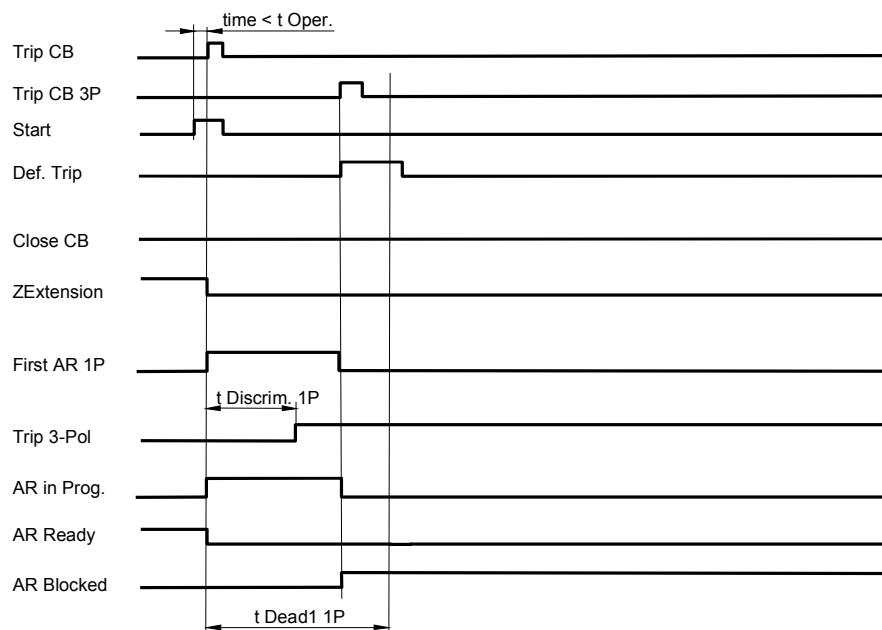
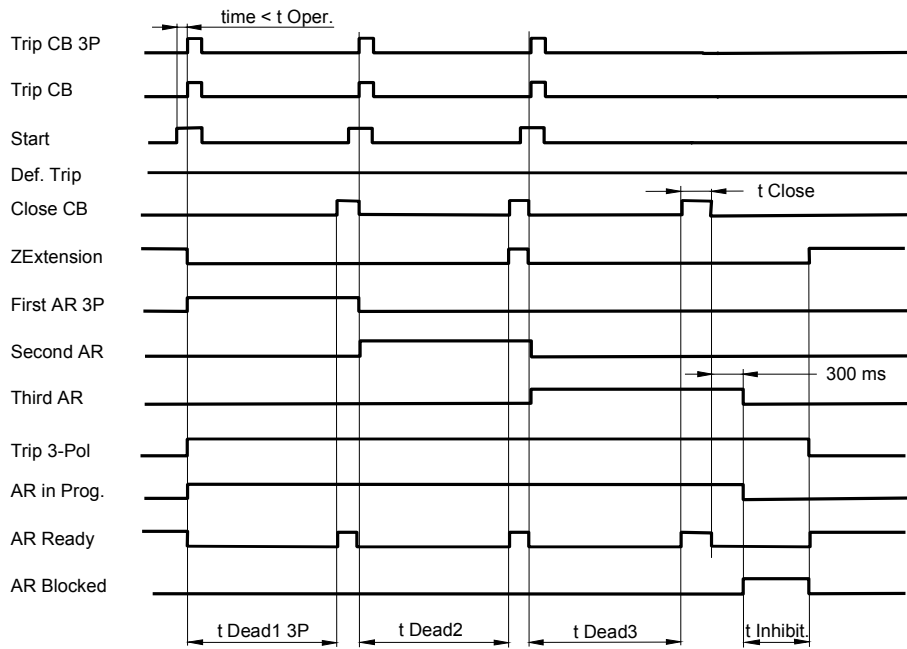
**Successful AR (evolving fault during 't Discrim1P')****Unsuccessful AR (evolving fault within 't Dead1 1P', but after 't Discrim1P')**

Fig. 3.5.32.9 Timing diagram for a single or double busbar arrangement with 1 distance and 1 AR function. Response for an earth fault which evolves.

Settings:

'1. AR Mode' = '1P3P-1P3P', '2..4. AR Mode' = 'off',  
'ZE Prefault' = 'on', 'ZE 1. AR' = 'off'.

**Successful AR**



**Unsuccessful AR**

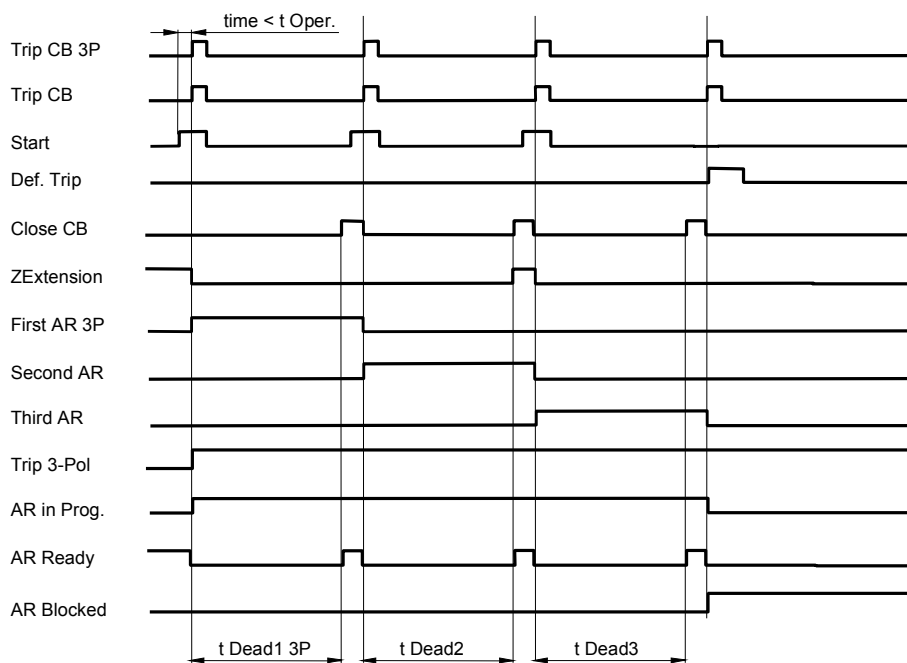
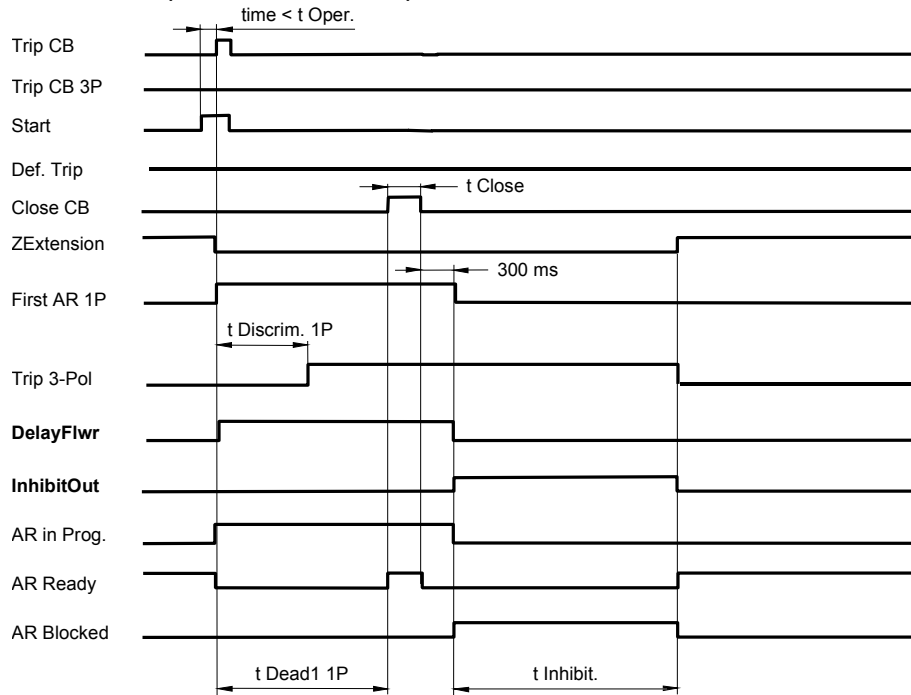


Fig. 3.5.32.10 Timing diagram for a single or double busbar arrangement with 1 distance and 1 AR function. Response for multiple phase faults.

Settings:

- '1. AR Mode' = '1P3P-1P3P', '2..4. AR Mode' = 3,
- 'ZE Prefault' = 'on', 'ZE 1. AR' = 'off',
- 'ZE 2. AR' = 'on' and 'ZE 3. AR' = 'off'.

**Master AR (Master Mode = "ON")**



**Follower AR (Master Mode = "OFF", AR on "hot standby")**

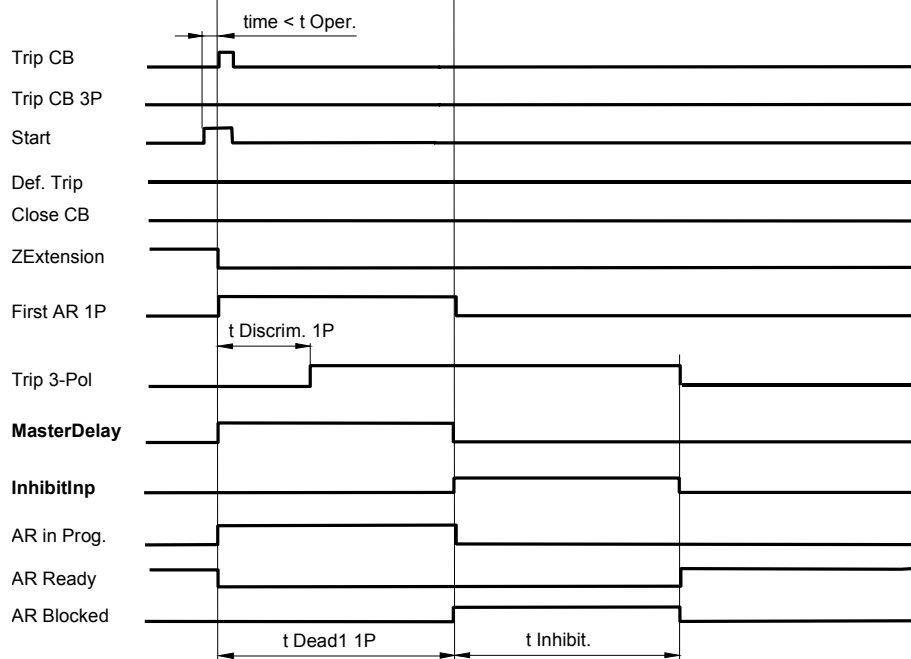
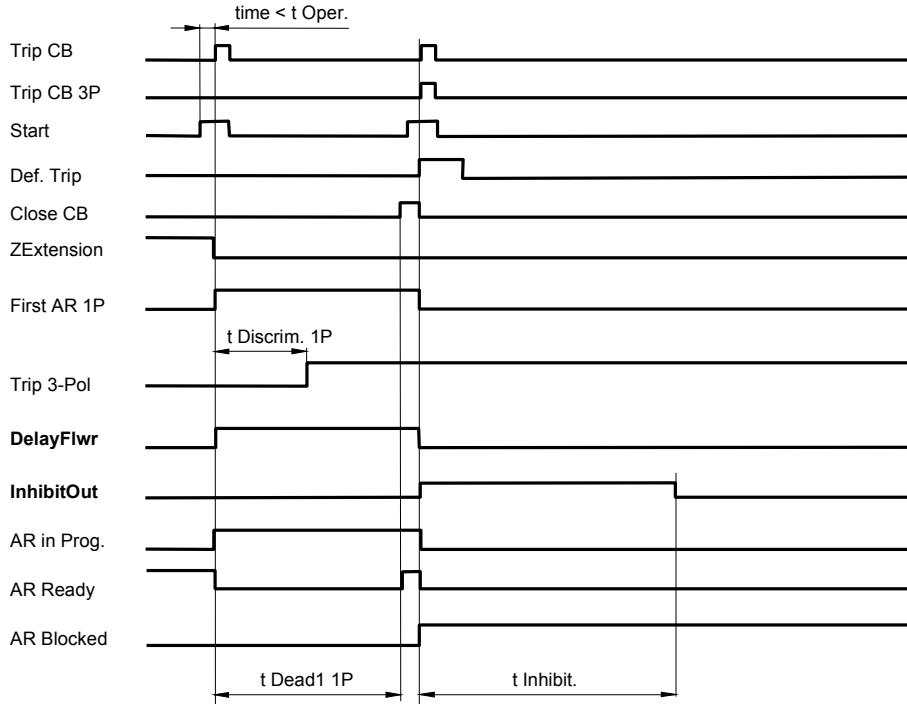


Fig. 3.5.32.11 Timing diagram for redundant scheme with 2 AR's. Response for 1 successful reclosure.

Settings:

'1. AR Mode' = '1P3P-1P3P', '2..4. AR Mode' = 'off',  
'ZE Prefault' = 'on' and 'ZE 1. AR' = 'off'.

**Master AR (Master Mode = "ON")**



**Follower AR (Master Mode = "OFF", AR on "hot standby")**

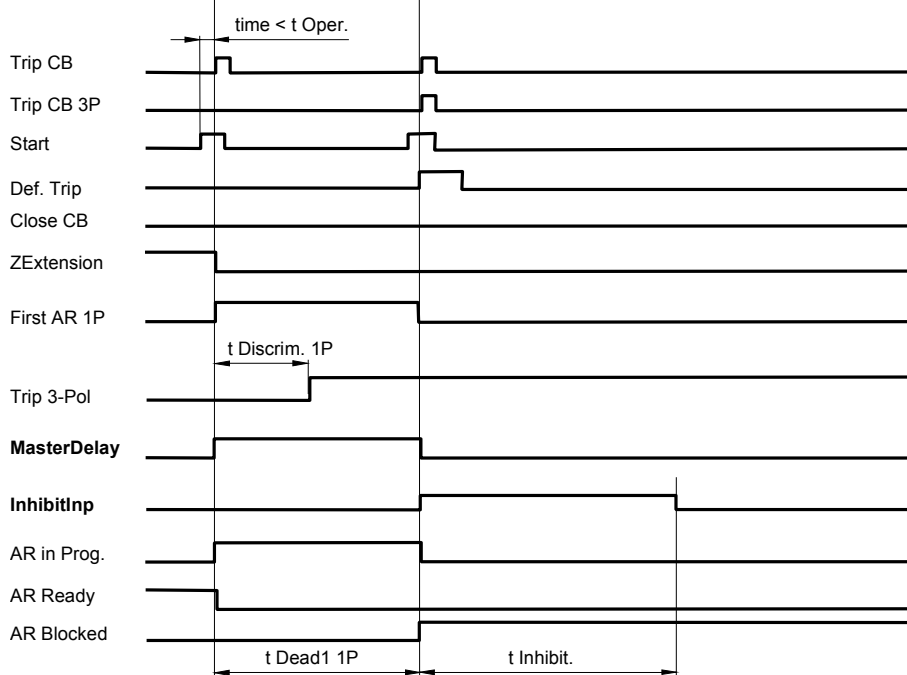


Fig. 3.5.32.12 Timing diagram for redundant scheme with 2 AR's. Response for 1 unsuccessful reclosure.

Settings:

'1. AR Mode' = '1P3P-1P3P', '2..4. AR Mode' = 'off',  
'ZE Prefault' = 'on' and 'ZE 1. AR' = 'off'.



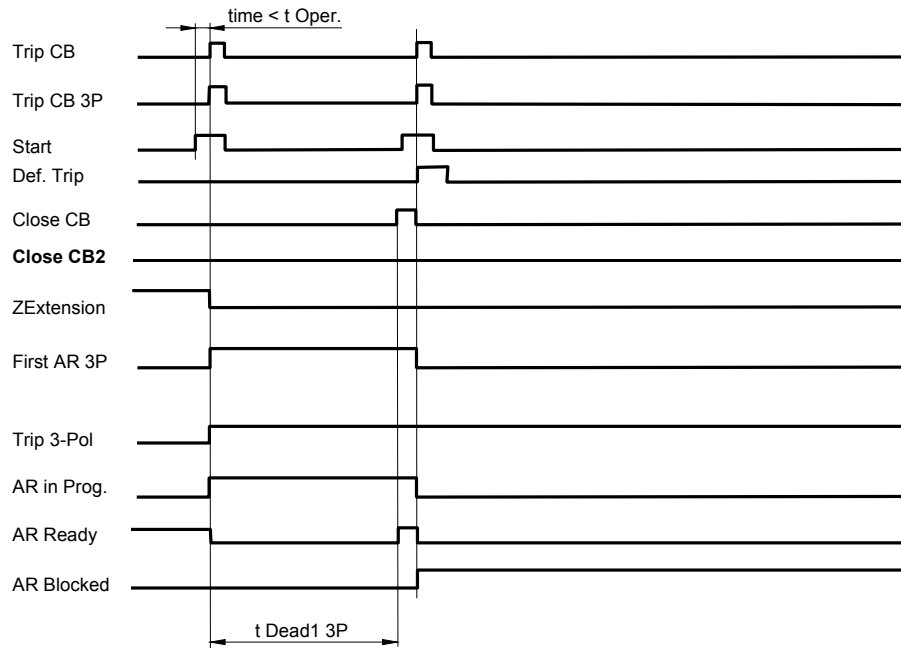
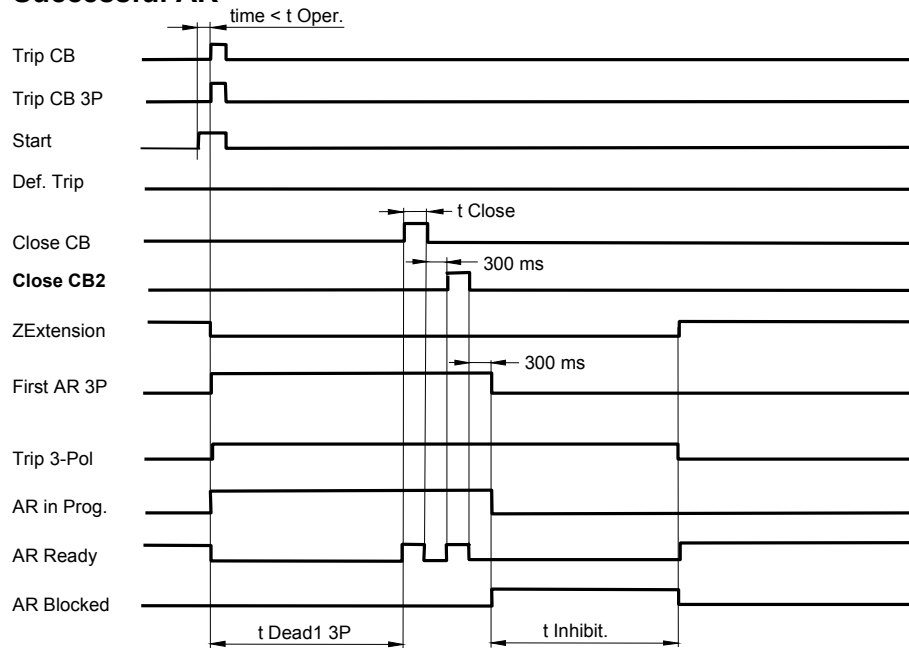
**Unsuccessful AR****Successful AR**

Fig. 3.5.32.13 Timing diagram for duplex scheme.  
Response for a multiple phase fault.

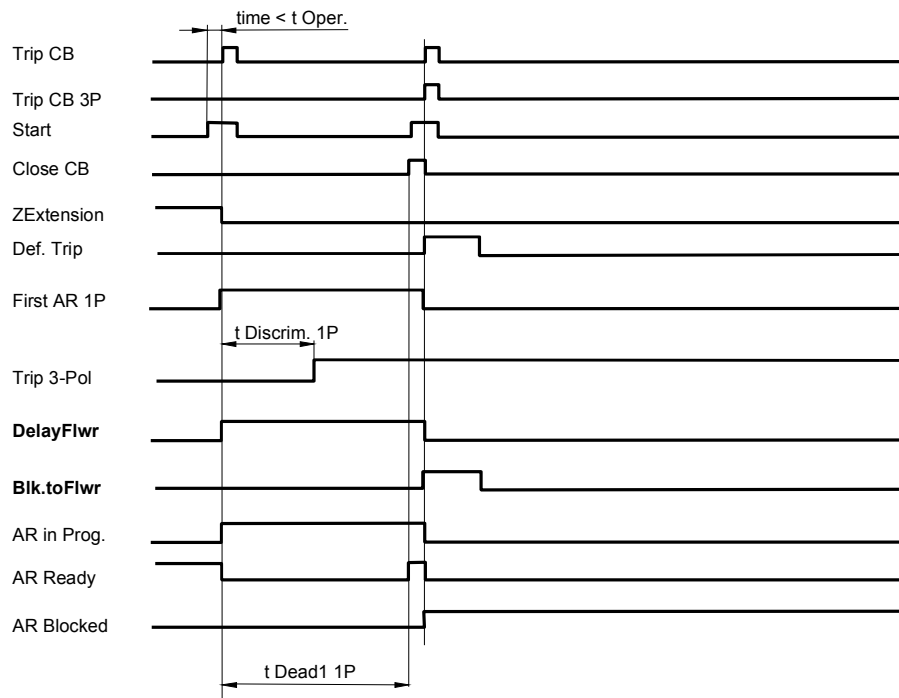
Settings:

'1. AR Mode' = '1P3P-1P3P', '2..4. AR Mode' = 'off',

'ZE Prefault' = 'on', 'ZE 1. AR' = 'off'

and 'CB2 Priority' = 'off'.

**Master AR (Master Mode = "ON", CB on bus side)**



**Follower AR (Master Mode = "OFF", Centre CB)**

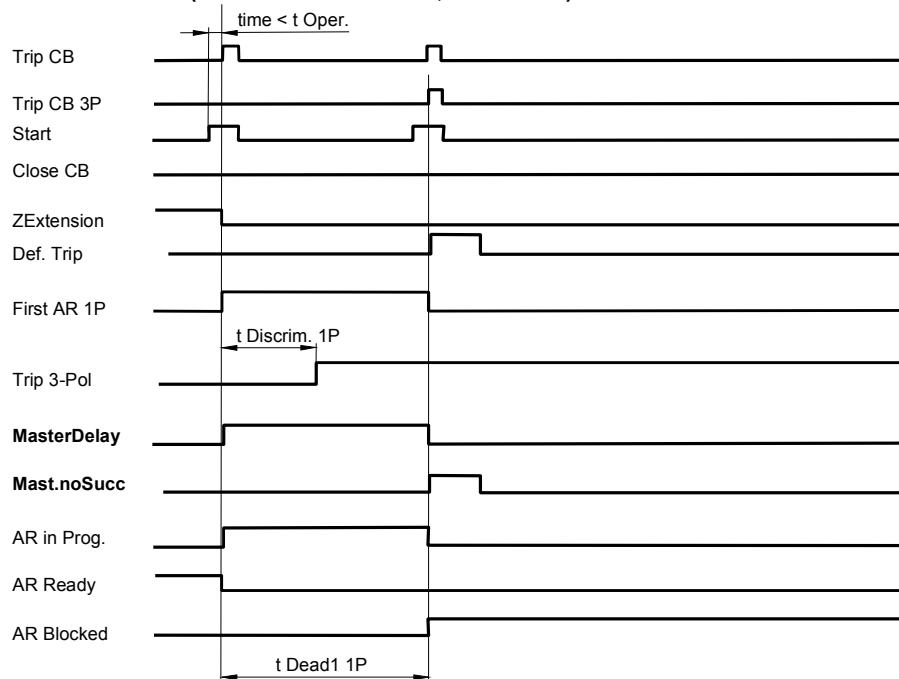


Fig. 3.5.32.14 Timing diagram for a 1½ breaker scheme. Response for an unsuccessful reclosure.

Settings:

- '1. AR Mode' = '1P3P-1P3P' or '1P-1P',
- '2.4. AR Mode' = 'off', 'ZE Prefault' = 'on' and 'ZE 1. AR' = 'off'.

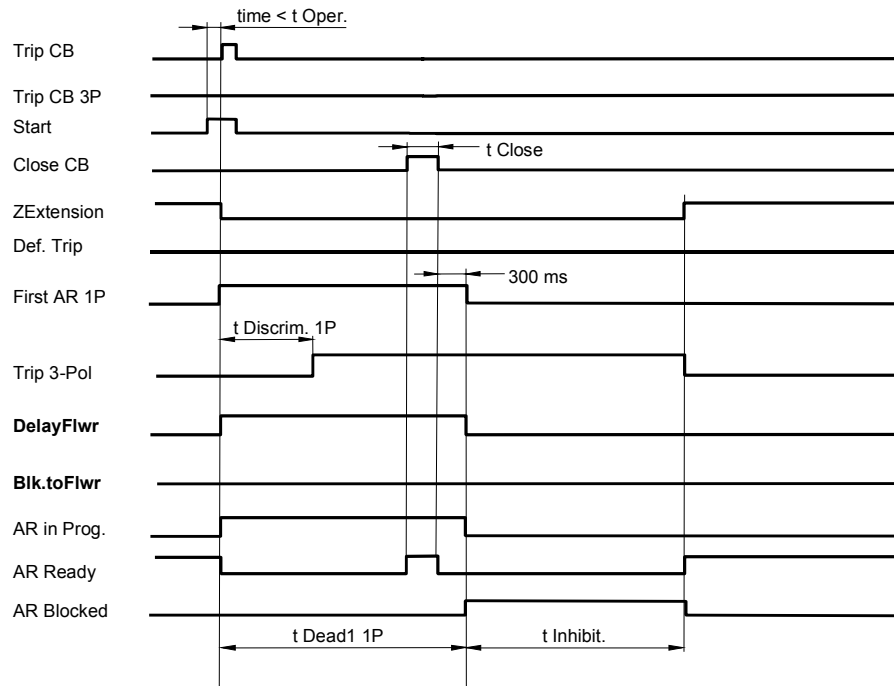
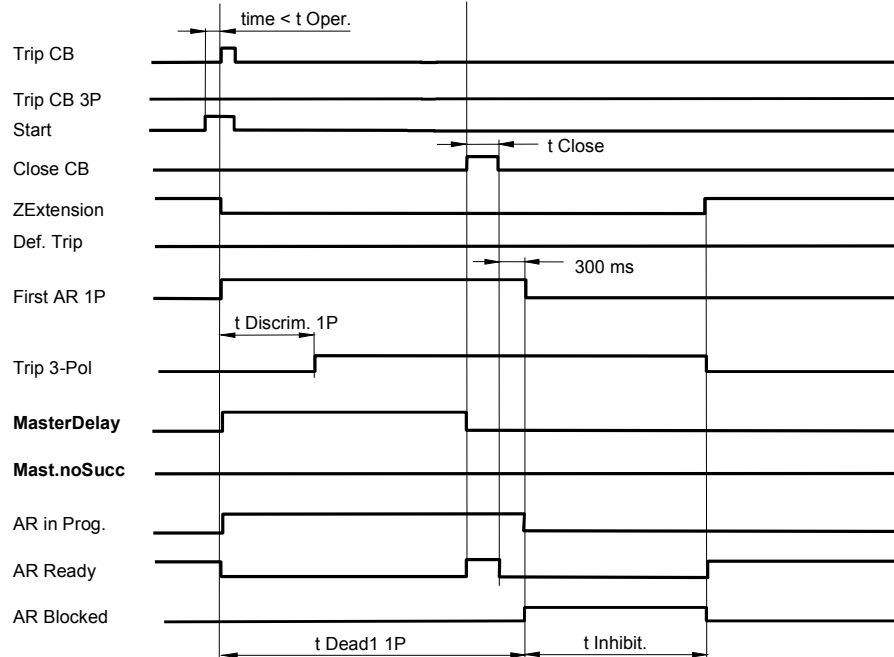
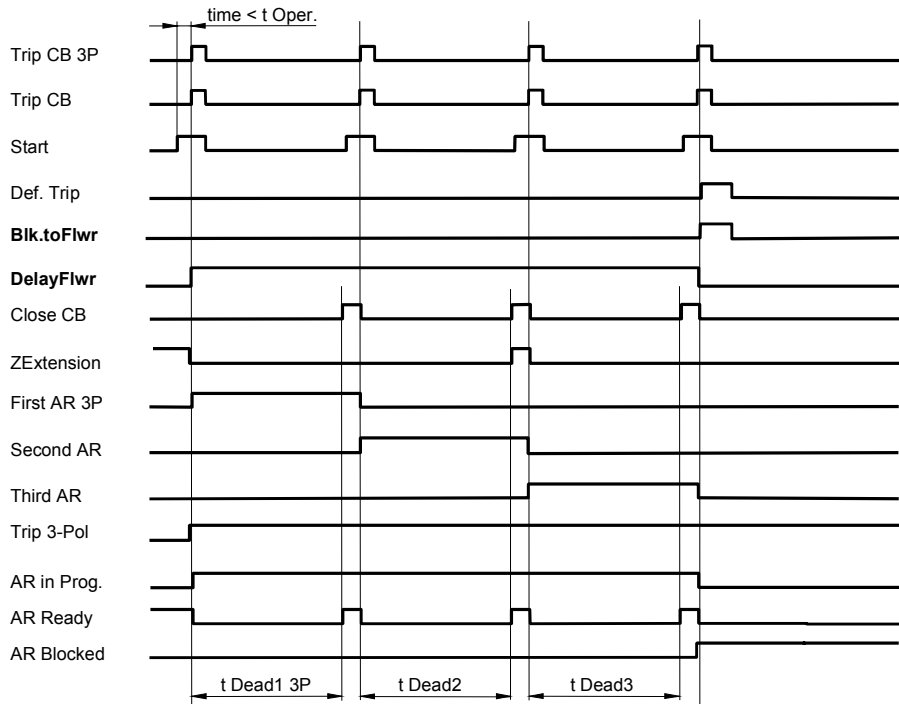
**Master AR (Master Mode = "ON", CB on bus side)****Follower AR (Master Mode = "OFF", Centre CB)**

Fig. 3.5.32.15 Timing diagram for a 1½ breaker scheme.  
Response for a successful reclosure.

Settings:

'1. AR Mode' = '1P3P-1P3P' or '1P-1P',  
'2..4. AR Mode' = 'off', 'ZE Prefault' = 'on'  
und 'ZE 1. AR' = 'off'.

**Master AR (Master Mode = "ON", CB on bus side)**



**Follower AR (Master Mode = "OFF", Centre CB)**

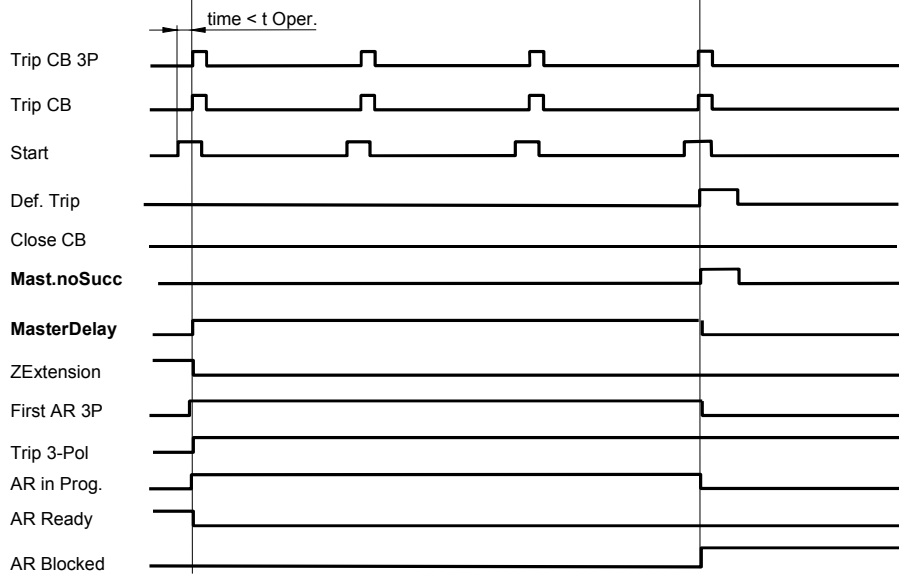


Fig. 3.5.32.16 Timing diagram for 1½ breaker scheme.  
Response for an unsuccessful multiple reclosure.

Settings:

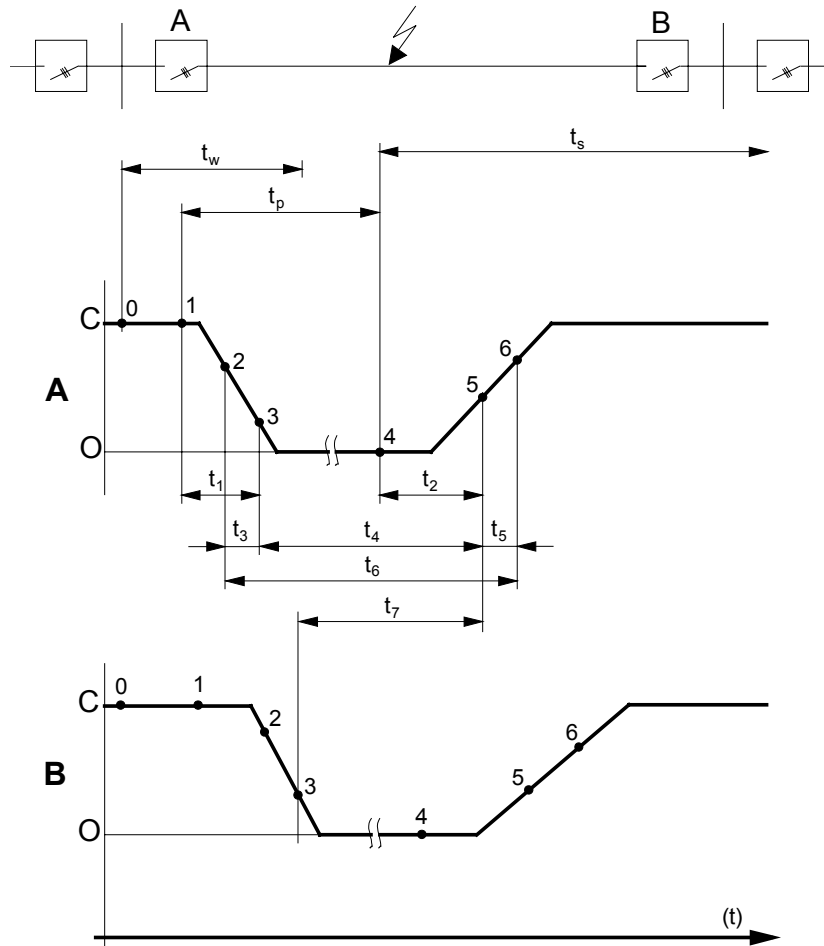
- '1. AR Mode' = '1P3P-1P3P';
- '2..4. AR Mode' = 'off';
- 'ZE Prefault' = 'on';
- 'ZE 1. AR' = 'off';
- 'ZE 2. AR' = 'on' and 'ZE 3. AR' = 'off'.

### **3.5.32.11. Checking the dead times**

When commissioning the auto-reclosure function, it is not sufficient to check the combined operation of protection function, auto-reclosure function and circuit-breaker, the resulting dead times must also be determined.

Since the dead time settings do not correspond to the effective total dead times, especially in a scheme with two circuit-breakers (see Fig. 3.5.32.17), the period during which the circuit-breaker is actually open must be measured. This entails adjusting the dead time until the measured breaker time minus arcing and pre-ignition times and the inevitable CB tolerances result in an adequate composite dead time.

Providing the circuit-breakers at both ends of the line are of the same type and thus permit the same tolerances to be assumed at both ends, the same dead time  $t_p$  can be set in the two terminal stations. Where this is not the case, the tripping and closing times of the two circuit-breakers must also be measured in addition to the dead times. The dead times set for the two auto-reclosure functions must then ensure that a sufficiently long "overlapping" dead time exists to enable the circuit-breakers to deionise.



HEST 925 035 FL

A: circuit-breaker 1

B: circuit-breaker 2

C: "closed" position

O: "open" position

0: start

1: 'trip' signal

2: contacts part

3: current interrupted

4: 'close' signal

5: current flows again

6: contacts make

$t_1$ : tripping time

$t_2$ : reclosing time

$t_3$ : arc extinction time

$t_4$ : dead time

$t_5$ : pre-ignition time

$t_6$ : duration of interruption

$t_7$ : resulting dead time

$t_p$ : dead time

$t_s$ : inhibit time

$t_w$ : fault duration

Fig. 3.5.32.17 Resulting composite dead time

(Source: "Guidelines for auto-reclosure in electrical power systems" published by the German Association of Power Utilities VDEW)

### 3.5.33. **Breaker failure protection (BreakerFailure)**

#### **A. Application**

- Redundant tripping schemes (RED <sup>1)</sup>)
- Repeated tripping attempts (BFP <sup>2)</sup>)
- Backup tripping (BFP)
- End fault protection (EFP <sup>3)</sup>)
- Unconditional tripping (UT <sup>4)</sup>).
- 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 Blocking 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
<b>CB Commands</b>					
TRIP t1 01-08		B00000000			
TRIP t1 09-16		B00000000			
TRIP t1 17-24		B00000000			
TRIP t1 25-32		B00000000			
TRIP t1 L1 01-08		B00000000			
TRIP t1 L1 09-16		B00000000			
TRIP t1 L1 17-24		B00000000			
TRIP t1 L1 25-32		B00000000			
TRIP t1 L2 01-08		B00000000			
TRIP t1 L2 09-16		B00000000			
TRIP t1 L2 17-24		B00000000			
TRIP t1 L2 25-32		B00000000			
TRIP t1 L3 01-08		B00000000			
TRIP t1 L3 09-16		B00000000			
TRIP t1 L3 17-24		B00000000			
TRIP t1 L3 25-32		B00000000			
TRIP t2 01-08		B00000000			
TRIP t2 09-16		B00000000			
TRIP t2 17-24		B00000000			
TRIP t2 25-32		B00000000			
REMOTE TRIP 01-08		B00000000			
REMOTE TRIP 09-16		B00000000			
REMOTE TRIP 17-24		B00000000			
REMOTE TRIP 25-32		B00000000			
RED TRIP L1 01-08		B00000000			
RED TRIP L1 09-16		B00000000			
RED TRIP L1 17-24		B00000000			
RED TRIP L1 25-32		B00000000			
RED TRIP L2 01-08		B00000000			
RED TRIP L2 09-16		B00000000			
RED TRIP L2 17-24		B00000000			
RED TRIP L2 25-32		B00000000			

Text	Unit	Default	Min.	Max.	Step
RED TRIP L3 01-08		B00000000			
RED TRIP L3 09-16		B00000000			
RED TRIP L3 17-24		B00000000			
RED TRIP L3 25-32		B00000000			
EFP REM TRIP 01-08		B00000000			
EFP REM TRIP 09-16		B00000000			
EFP REM TRIP 17-24		B00000000			
EFP REM TRIP 25-32		B00000000			
EFP BUS TRIP 01-08		B00000000			
EFP BUS TRIP 09-16		B00000000			
EFP BUS TRIP 17-24		B00000000			
EFP BUS TRIP 25-32		B00000000			

#### General parameters

RunOnCPU	CPU1		(Select)		
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 01-08

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' after the first time step t1.

#### TRIP t1 09-16

Corresponds to TRIP 01-08 (providing tripping unit fitted).

**TRIP t1 17-24**

Corresponds to TRIP 01-08 (providing tripping unit fitted).

**TRIP t1 25-32**

Corresponds to TRIP 01-08 (providing tripping unit fitted).

**TRIP t1 L1, L2 or L3 01-08**

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 t1 L1, L2 or L3 09-16**

Corresponds to TRIP 01-08 (providing tripping unit fitted).

**TRIP t1 L1, L2 or L3 17-24**

Corresponds to TRIP 01-08 (providing tripping unit fitted).

**TRIP t1 L1, L2 or L3 25-32**

Corresponds to TRIP 01-08 (providing tripping unit fitted).

**TRIP t2 01-08**

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.

**TRIP t2 09-16**

Corresponds to TRIP 01-08 (providing tripping unit fitted).

**TRIP t2 17-24**

Corresponds to TRIP 01-08 (providing tripping unit fitted).

**TRIP t2 25-32**

Corresponds to TRIP 01-08 (providing tripping unit fitted).

**REMOTE TRIP 01-08**

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

**REMOTE TRIP 09-16**

Corresponds to TRIP 01-08 (providing tripping unit fitted).

**REMOTE TRIP 17-24**

Corresponds to TRIP 01-08 (providing tripping unit fitted).

**REMOTE TRIP 25-32**

Corresponds to TRIP 01-08 (providing tripping unit fitted).

**RED TRIP L1, L2 or L3 01-08**

defines the tripping channel activated by the function's tripping outputs RED TRIP L1, L2 or L3 (matrix tripping logic).

**RED TRIP L1, L2 or L3 09-16**

Corresponds to TRIP 01-08 (providing tripping unit fitted).

**RED TRIP L1, L2 or L3 17-24**

Corresponds to TRIP 01-08 (providing tripping unit fitted).

**RED TRIP L1, L2 or L3 25-32**

Corresponds to TRIP 01-08 (providing tripping unit fitted).

**EFP REM TRIP 01-08**

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

**EFP REM TRIP 09-16**

Corresponds to TRIP 01-08 (providing tripping unit fitted).

**EFP REM TRIP 17-24**

Corresponds to TRIP 01-08 (providing tripping unit fitted).

**EFP REM TRIP 25-32**

Corresponds to TRIP 01-08 (providing tripping unit fitted).

**EFP BUS TRIP 01-08**

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

**EFP BUS TRIP 09-16**

Corresponds to TRIP 01-08 (providing tripping unit fitted).

**EFP BUS TRIP 17-24**

Corresponds to TRIP 01-08 (providing tripping unit fitted).

**EFP BUS TRIP 25-32**

Corresponds to TRIP 01-08 (providing tripping unit fitted).

**RunOnCPU**

defines the processing unit which runs the function.

**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 tripping 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 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. 3.5.33.1 shows a typical timing diagram for clearing a fault.

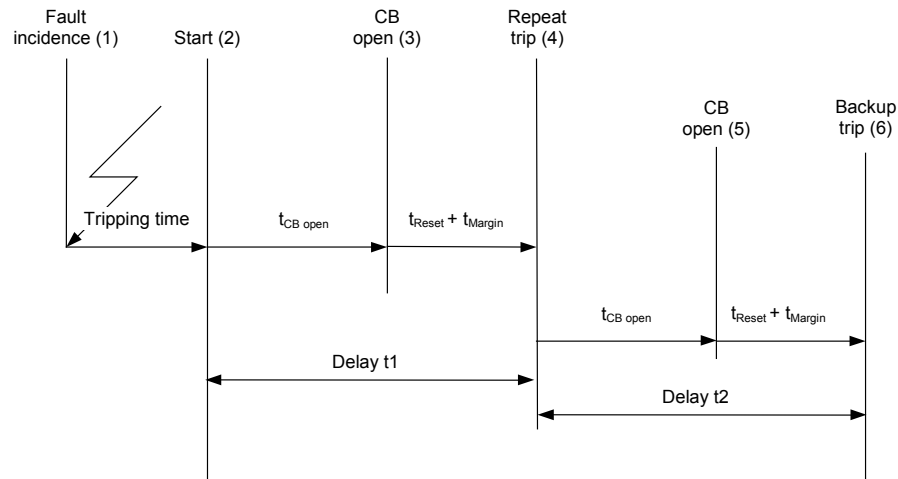


Fig. 3.5.33.1 Operation of the BFP/UT timers t1 and t2

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  $t_{\text{Reset}}$  plus a safety margin  $t_{\text{Margin}}$ , 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. 3.5.33.1, 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  $t_{\text{Reset}}$  plus a safety margin  $t_{\text{Margin}}$ , 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  $t_{\text{Reset}}$  plus a safety margin  $t_{\text{Margin}}$  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

$t_{\text{Reset}}$     Reset time of the current criterion <sup>1)</sup>

$t_{\text{Margin}}$     Allowance for variations in normal fault clearing times <sup>2)</sup>

---

<sup>1)</sup> see reset time of the current detector  $t_{\text{Reset}}$

<sup>2)</sup> see safety margin  $t_{\text{Margin}}$

## Tripping delay tEFP

The setting for tEFP can be seen from Fig. 3.5.33.2 which shows a typical timing diagram for tripping a fault.

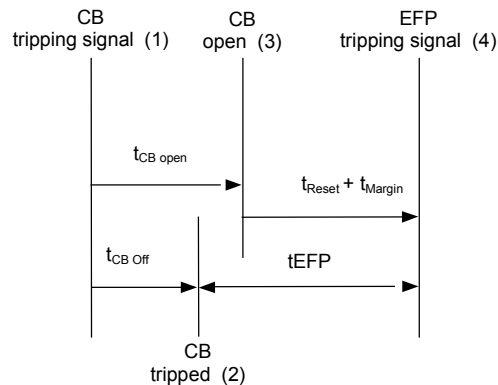


Fig. 3.5.33.2 Timing diagram for an end zone fault

- (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<sub>CB open</sub> CB opening time including arc extinction time

t<sub>CB Off</sub> CB opening time of the CB auxiliary contact (Signal „CB open“)

t<sub>Reset</sub> Reset time of the current detector <sup>3)</sup>

t<sub>Margin</sub> Allowance for variations in normal fault clearing time <sup>4)</sup>

<sup>3)</sup> see reset time of the current detector t<sub>Reset</sub>

<sup>4)</sup> see Margin time t<sub>Margin</sub>

**Reset time of the current detector  $t_{\text{Reset}}$** 

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  $t_{\text{Margin}}$** 

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. Other functions**

#### **3.6.1. 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**

- binary I/P channel assignable to
  - binary I/P signals
  - 2 protection function tripping signals (trips)
- All I/P channels 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:**

- binary value (I/P 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	Unit	Default	Min.	Max.	Step
RunOnCPU		CPU1		(Select)	
ParSet 4..1		P1		(Select)	
Trip 01-08		00000000			
Trip 09-16		00000000			
Trip 17-24		00000000			
Trip 25-32		00000000			
Trip-Delay	s	001.00	000.00	300.00	0.01
Reset-Delay	s	001.00	000.00	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:

#### RunOnCPU

defines the processing unit which runs the function.

#### ParSet 4..1

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

#### Trip 01-08

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

#### Trip 09-16

corresponds to Trip 01-08 (providing tripping unit fitted).

#### Trip 17-24

corresponds to Trip 01-08 (providing tripping unit fitted).

#### Trip 25-32

corresponds to Trip 01-08 (providing tripping unit fitted).

**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.
- 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.

**BinaryInp**

Definition of the binary I/P.

(binary address)

(F→FALSE, T→TRUE, binary I/P or the O/P of a protection function).

**BlockInp**

Binary address of the blocking I/P.

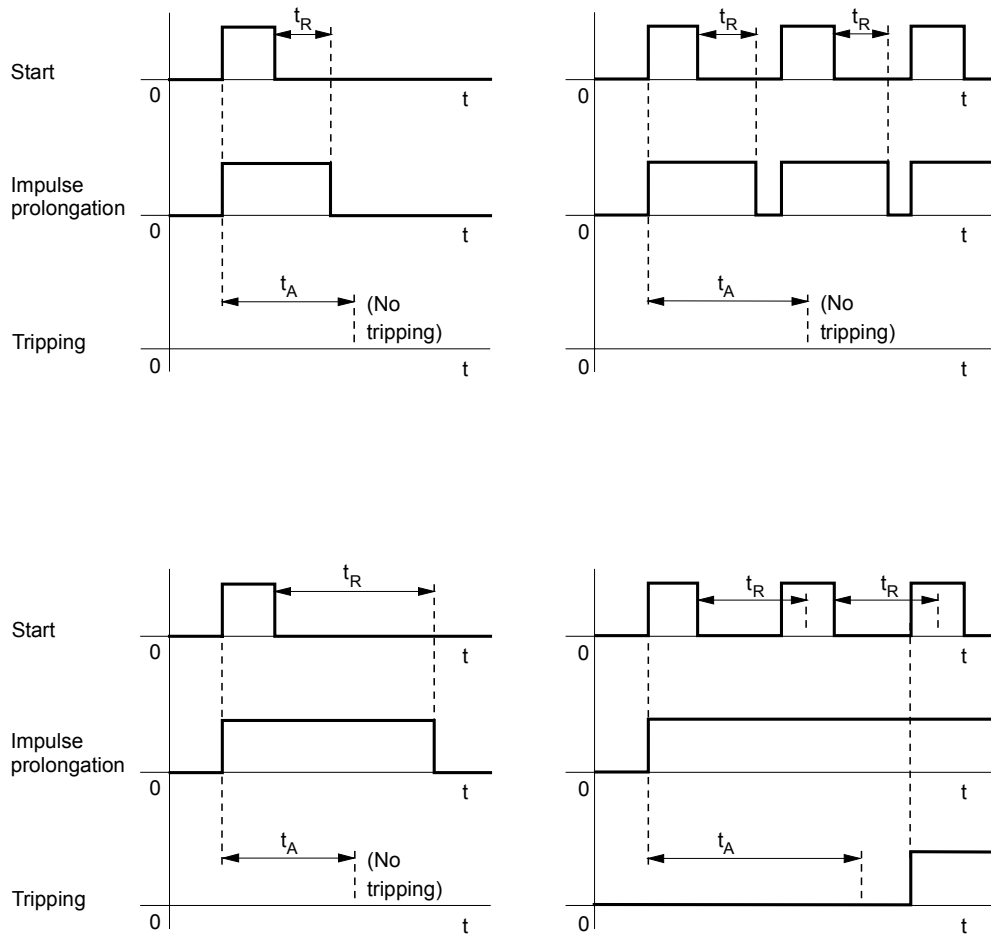
(F→FALSE, T→TRUE, binary I/P or the O/P of a protection function).

**Trip**

Output for signalling tripping.  
(signal address).

**Start**

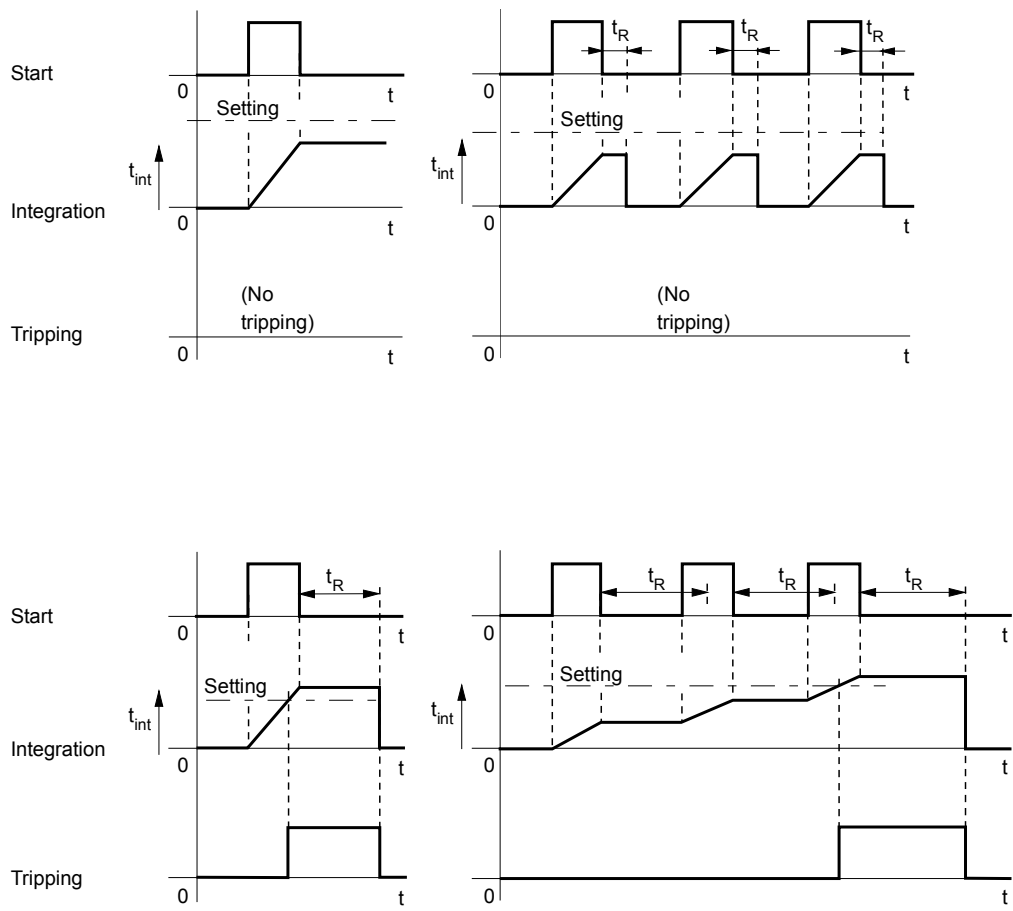
Output for signalling pick-up.  
(signal address).



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Note: There is only a trip if starting also persists within  $t_R$   
 $t_A$  tripping time ("Trip-Delay")  
 $t_R$  reset time ("Reset-Delay")

Fig. 3.6.1.1 Operation of the "Delay" function without integration



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$t_{int}$       integrated time for tripping  
 $t_R$         reset time ("Reset-Delay")  
 Setting    "Trip-Delay"

Fig. 3.6.1.2 Operation of the "Delay" function with integration



### 3.6.2. **Counter (Count)**

#### **A. Application**

- General purpose counter, for example, for counting the output impulses of the loss-of-excitation or reverse power functions
- extension of short I/P signals (pulse prolongation).

#### **B. Features**

- binary I/P channel assignable to
  - binary I/P signals
  - 2 protection function tripping signals (trips)
- All I/P channels can be inverted.

#### **C. Inputs and outputs**

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

- none

##### **II. Binary inputs:**

- binary value (I/P signal)
- blocking

##### **III. Binary outputs:**

- pick-up
- tripping

##### **IV. Measurements:**

- current count.

## D. Counter function settings - Count

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
RunOnCPU		CPU1		(Select)	
ParSet 4..1		P1		(Select)	
Trip 01-08		00000000			
Trip 09-16		00000000			
Trip 17-24		00000000			
Trip 25-32		00000000			
Set count		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:

#### RunOnCPU

defines the processing unit which runs the function.

#### ParSet 4..1

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

#### Trip 01-08

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

#### Trip 09-16

corresponds to Trip 01-08 (providing tripping unit fitted).

#### Trip 17-24

corresponds to Trip 01-08 (providing tripping unit fitted).

#### Trip 25-32

corresponds to Trip 01-08 (providing tripping unit fitted).



**Set count**

No. of impulses counted for operation.

**O/P time**

Duration of the tripping signal after the input signal disappears.

**Reset-Delay**

Time required to reset after the input signal disappears, if tripping does not take place.

**BinaryInp**

Definition of the binary I/P.

(binary address)

(F→FALSE, T→TRUE, binary I/P or the O/P of a protection function).

**BlockInp**

Binary address of the blocking I/P.

(F→FALSE, T→TRUE, binary I/P or the O/P of a protection function).

**Trip**

Output for signalling tripping.

(signal address).

**Start**

Output for signalling pick-up.

(signal address).



### 3.6.3. **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
  - O/P signals (trips) of protection functions
- 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".
    - After it has picked up, the function's O/P does not reset until a logical "1" is applied to either the blocking I/P or one of the reset I/P's.
- 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 binary values (I/P signals)
- blocking

##### **III. Binary O/P's:**

- tripping

##### **IV. Measurements:**

- none

## D. Logic function settings - Logic

Summary of parameters:

Text	Unit	Default	Min.	Max.	Set
RunOnCPU		CPU1		(Select)	
ParSet 4..1		P1		(Select)	
Trip 01-08		00000000			
Trip 09-16		00000000			
Trip 17-24		00000000			
Trip 25-32		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:

#### RunOnCPU

defines the processing unit which runs the function.

#### ParSet 4..1

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

#### Trip 01-08

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

#### Trip 09-16

corresponds to Trip 01-08 (providing tripping unit fitted).

#### Trip 17-24

corresponds to Trip 01-08 (providing tripping unit fitted).

#### Trip 25-32

corresponds to Trip 01-08 (providing tripping unit fitted).

### 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 (3 and 4) and 2 reset I/P's (1 and 2). 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.  
(signal address).

### BlockInp

Binary address of the blocking I/P.  
(F→FALSE, T→TRUE, binary I/P or the O/P of a protection function)  
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)

Binary I/P No. 1.  
(binary address)  
(F→FALSE, T→TRUE, binary I/P or the O/P of a protection function).

### BinInp2 (R2)

Binary I/P No. 2.  
(binary address)  
(F→FALSE, T→TRUE, binary I/P or the O/P of a protection function).

### BinInp3 (S1)

Binary I/P No. 3.  
(binary address)  
(F→FALSE, T→TRUE, binary I/P or the O/P of a protection function).

**BinInp4 (S2)**

Binary I/P No. 4.

(binary address)

(F→FALSE, T→TRUE, binary I/P or the O/P of a protection function).

### 3.6.4. **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 SF<sub>6</sub> 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 object bus 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**

Eight FUPLA functions can be configured. The total maximum size of FUPLA code for all the functions is 128kB. The FUPLA function cannot be copied. The function plan programming tool CAP316 is described in the publication CH-ES 83-60.10 E.

The control function depends on the particular application for which it is specifically created using FUPLA. 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.

## **C. Inputs and outputs**

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

- Constants, measured protection variables, IBB data inputs and sampled values

### **II. Analogue outputs:**

- Measured variable outputs

### **III. Binary inputs:**

- IBB blocked, binary input for blocking the IBB
- 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.



### 3.6.4.1. 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.

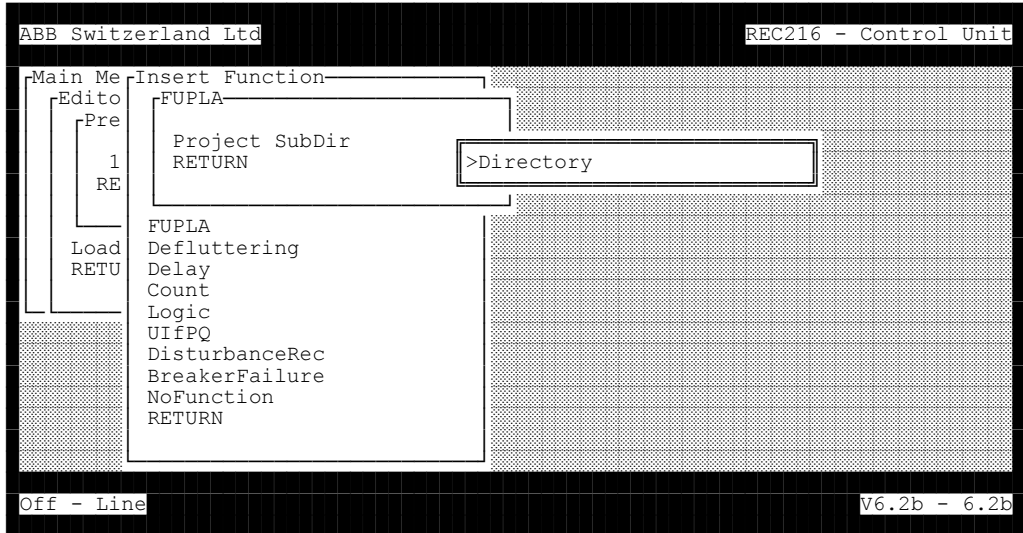
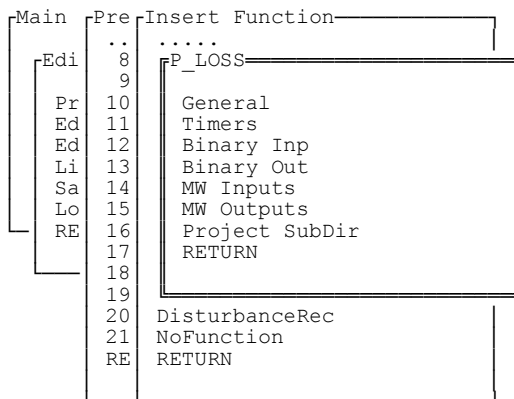


Fig. 3.6.4.1 Entering the FUPLA directory

The individual parameters can then be entered.



**3.6.4.1.1. General**

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
RunOnCPU		CPU1		(Select)	
ParSet 4..1		P1		(Select)	
RepetitRate		low	low	high	1
Cycl. time ho	ms	20	0	1000	1
Blocking	BinaryAddr	F			

**Explanation of parameters:****RunOnCPU**

defines the processing unit which runs the function.

**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 ho**

Determines the interval between FUPLA starts.

**Blocking**

(F → FALSE, T → TRUE, system binary input, protection function binary output or input from IBB).

This blocks FUPLA.

### 3.6.4.1.2. *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 IBB**

Observe the factors ms (TON), 10 ms (TONS), 1 s (TONL).

### 3.6.4.1.3. *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: 786 inputs in 24 groups of 32 signals each.

### 3.6.4.1.4. *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
- Inputs to the IBB: 786 inputs in 24 groups of 32 signals each.

### 3.6.4.1.5. *Measured variable inputs*

Measured variable 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.
- Analogue channels.

### 3.6.4.1.6. *Measured variable outputs*

Measured variable outputs can be connected to the following sinks:

- Measurements Nos. 1...64.

### 3.6.4.1.7. *Flow chart for measured variable inputs and outputs*

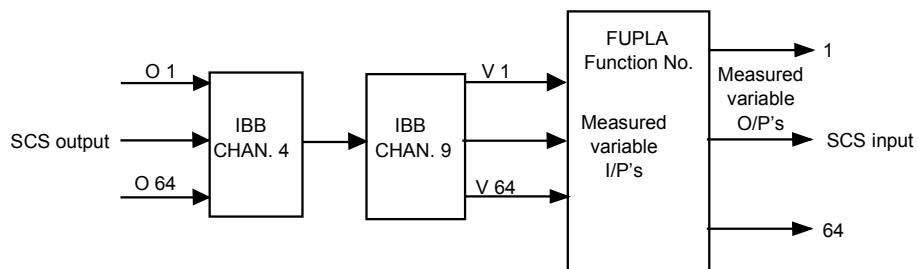


Fig. 3.6.4.2 Flow chart for measured variable inputs and outputs

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.

### 3.6.4.2. 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.

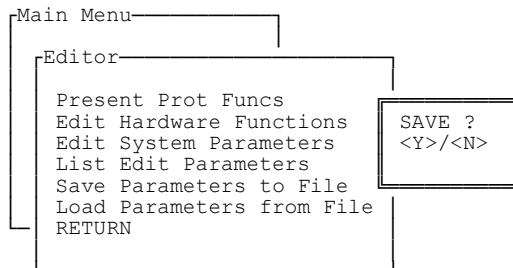


Fig. 3.6.4.3 Editor, Save ?



### 3.6.5. **Measurement function (UIfPQ)**

#### **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 ... 1.1) fN
- frequency of voltage measured unless voltage too low, in which case current is measured; if both are too low, the display is 0.000 Hz
- at least 1 measurement per second
- insensitive to DC components in voltage and current
- insensitive to harmonics in voltage and current
- provision for compensation of circuit 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 - (UifPQ)

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
RunOnCPU		CPU1		(Select)	
ParSet 4..1		P1		(Select)	
CurrentInp	CT/VT-Addr	00000			
Angle	deg	000.0	-180.0	180.0	0.1
VoltageInp	CT/VT-Addr	0			
PN	UN*IN	1.000	0.200	2.500	0.001
Voltage mode		phase-to-ground		(Select)	

### Explanation of parameters

#### RunOnCPU

defines the processing unit which runs the function.

#### ParSet 4..1

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

#### CurrentInp

Analogue current I/P channel.

All current I/P's 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**

Reference value for the power being measured.

This enables the amplitude of the power being measured to be adjusted, e.g. to take account of the rated power factor.

**Voltage mode**

Definition of the method of voltage measurement and therefore also the calculation of power. Settings:

- phase-to-ground The voltage of the selected voltage I/P is measured directly.
- phase-to-phase 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 analogue input channels must be set such that, when the rated values are applied to the I/P's, 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 apply to all phases.

- "Angle" setting for phase error compensation  
The parameter "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  $-180^\circ$

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 4.4.2](#).

- Reference value for the power "PN"  
In most cases it will be possible to retain the default reference setting of 1.000. Fine adjustment may be necessary, however, to achieve the best possible accuracy, because the errors of the voltage and current reference values are superimposed on each other.

The settings of the parameters "Angle" and "PN" must be checked using a correspondingly accurate instrument as follows:

- a) Inject purely real power at rated voltage and rated current.
- b) The real power measured must be as close as possible to 1.000, or vary symmetrically about this value.  
→ Adjust the value of "PN" as necessary.
- c) The apparent power measured must be as close as possible to 0.000, or vary symmetrically about this value.  
→ Adjust the value of "Angle" as necessary.



### 3.6.6. **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 small 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
- residual current (optional)

##### **II. Binary inputs:**

- blocking

##### **III. Binary outputs:**

- tripping

##### **IV. Measurements:**

- residual current amplitude.

## D. Current plausibility function settings - Check-I3ph

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
RunOnCPU		CPU1		(Select)	
ParSet 4..1		P1		(Select)	
Trip 01-08		00000000			
Trip 09-16		00000000			
Trip 17-24		00000000			
Trip 25-32		00000000			
I-Setting	IN	0.20	0.05	1.00	0.1
Delay	s	10.0	0.1	60.0	0.1
CT-Compens		01.00	-2.00	+2.00	0.01
CurrentInp	CT/VT-Addr	00000			
SumInp	CT/VT-Addr	00000			
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			

### Explanation of parameters:

#### RunOnCPU

defines the processing unit which runs the function.

#### ParSet 4..1

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

#### Trip 01-08

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

#### Trip 09-16

corresponds to Trip 01-08 (providing tripping unit fitted).

#### Trip 17-24

corresponds to Trip 01-08 (providing tripping unit fitted).

#### Trip 25-32

corresponds to Trip 01-08 (providing tripping unit fitted).

**I-Setting**

Current setting for tripping.

**Delay**

Time between start signal at the I/P and the tripping signal at the O/P.

Setting restriction:

$\text{not } \leq 1 \text{ s for current settings } < 0.2 I_N$ .

**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 I/P 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**

Binary address of the blocking I/P.

(F→FALSE, T→TRUE, binary I/P or the O/P of a protection function).

**Trip**

O/P for signalling tripping.

(signal address).

**Note:**

If the phase sequence is wrong, tripping will take place regardless of the pick-up setting (I-Setting).





### 3.6.7. *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 small voltages (below  $0.4 \times U_N$  phase-to-phase voltages)
- insensitive to DC components
- insensitive to harmonics.

Evaluation of the phase voltages is only possible in the case of Y connected I/P transformers, otherwise the residual component cannot be detected.

#### **C. Inputs and outputs**

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

- phase voltages
- residual voltage (optional)

##### **II. Binary inputs:**

- Blocking

##### **III. Binary outputs:**

- tripping

##### **IV. Measurements:**

- residual voltage amplitude.

## D. Voltage plausibility function settings - Check-U3ph

Summary of parameters:

Text	Unit	Default	Min.	Max.	Step
RunOnCPU		CPU1		(Select)	
ParSet 4..1		P1		(Select)	
Trip 01-08		00000000			
Trip 09-16		00000000			
Trip 17-24		00000000			
Trip 25-32		00000000			
V-Setting	UN	0.20	0.05	1.20	0.1
Delay	s	10.0	0.1	60.0	0.1
VT-Compens		+1.00	-2.00	+2.00	0.01
VoltageInp	CT/VT-Addr	00000			
SumInp	CT/VT-Addr	00000			
BlockInp	BinaryAddr	F			
Trip	SignalAddr	ER			

### Explanation of parameters:

#### RunOnCPU

defines the processing unit which runs the function.

#### ParSet 4..1

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

#### Trip 01-08

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

#### Trip 09-16

corresponds to Trip 01-08 (providing tripping unit fitted).

#### Trip 17-24

corresponds to Trip 01-08 (providing tripping unit fitted).

#### Trip 25-32

corresponds to Trip 01-08 (providing tripping unit fitted).

**V-Setting**

Voltage setting for tripping.

**Delay**

Time between start signal at the I/P and the tripping signal at the O/P.

Setting restriction:

$\text{not } \leq 1 \text{ s for voltage settings } < 0.2 U_N.$

**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 I/P's 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 voltage input channel. Any of the single-phase voltage I/P's may be selected.

**BlockInp**

Binary address of the blocking I/P.

(F→FALSE, T→TRUE, binary I/P or the O/P of a protection function).

**Trip**

O/P for signalling tripping.  
(signal address).

**Note:**

If the phase sequence is wrong, tripping will take place regardless of the pick-up setting (V-Setting).



### 3.6.8. ***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**

- record of up to 12 c.t. and v.t. inputs
- record of up to 12 measured function variables
- 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 on the first analogue input unit 216EA61

##### **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
RunOnCPU		CPU1		(Select)	
ParSet 4..1		P1		(Select)	
StationNr		01	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	0			
.		0			
.		0			
MWAImp 12	MeasVar	0			
MWAScale1	Factor	1	1	1000	1
.		1			
.		1			
MWAScale12	Factor	1			

**Explanation of parameters:****RunOnCPU**

defines the processing unit which runs the function.  
Only CPU1 is admitted.

**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 analogue 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 OR gates for the triggering conditions are coupled and one of the triggering conditions is fulfilled, subsequent trigger conditions have no further influence and are not recorded. In this status, operating the disturbance recorder reset is registered as a record.

### 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**

Definition of the c.t. and v.t. I/P's to be recorded. The setting is the number of the I/P.

It is not essential for the numbers of the c.t. and v.t. inputs 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 “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 12 analogue and 8 binary signals to be recorded within a maximum of approx. 3 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 predefined 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 function variables can be transferred back to the RE. 216 device using the conversion program INTERFAC and test set XS92a (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 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  $\pm 16535$ . 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  $t_{\text{rec}}$ : max. recording time

n: No. of events recorded

a: No. of analogue channels recorded

b: No. 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 XS92a).

**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**

\*\*\*\*\*

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 an analogue 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 RE. 216

15 V:	TR = 5.082	in V
100 V:	TR = 33.88	in V
200 V:	TR = 67.76	in V
	TR = 0.3388	times UN

## Current channels RE. 216

Protection:	1 A:	TR = 8.981	in A
	2 A:	TR = 17.96	in A
	5 A:	TR = 44.9	in A
		TR = 8.981	times IN
Metering:	1 A:	TR = 0.601	in A
	2 A:	TR = 1.202	in A
	5 A:	TR = 3.005	in A
		TR = 0.601	times IN

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 (HMI) was started when saving the RE. 316 settings.

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.

### 3.6.9. **Synchrocheck function (SynchroCheck)**

#### **A. Application**

Checking the synchronisation criteria (amplitudes, phase-shift and frequency difference) of two electrical systems and, providing the corresponding limits are satisfied, enabling them to be connected in parallel.

#### **B. Features**

- Monitoring synchronism:  
Single-phase voltage measurement.  
Comparison of the voltages (dU), phase-shift (dPh) and frequencies (df) of two voltage vectors. Calculation of the corresponding differences between the voltage vectors in the complex plane.  
Evaluation of the fundamental frequency components of the voltage signals (after filtering of harmonic and DC components).
- Monitoring voltage:  
Single or three-phase voltage measurement.  
Evaluation of instantaneous values (non-digitally filtered analogue signals) resulting in a large permissible frequency range. Detection of the largest and smallest of the three phase voltages in the case of three-phase measurement.  
No filtering of harmonics or DC component.
- Choice of phase for the voltage I/P's on busbar and line sides (for amplitude and phase-angle adjustment).
- Additional voltage I/P (for use in double busbar stations) with provision for remote switchover.
- Provision for remote selection of the operating mode.

#### **C. Inputs and outputs**

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

- Voltages (2 or 3 single or three-phase I/P's for 'ul/P bus1', 'ul/P bus2' and 'ul/P line').

##### **II. Binary inputs:**

- 2 I/P's for enabling the synchrocheck function ('ReleaseInp1' and 'ReleaseInp2')
- 3 I/P's for interlocking the synchrocheck O/P's ('BlkO/PBus1', 'BlkO/PBus2' and 'BlkO/PLine')



**D. Synchrocheck function settings - SyncChk**

Summary of parameters:

Text	Units	Default	Min.	Max.	Step
RunOnCPU		CPU1		(Select)	
ParSet 4..1		P1		(Select)	
PermitToClos	Trip Chan	00000000			
maxVoltDif	UN	0.20	0.05	0.40	0.05
maxPhaseDif	deg	10.0	05.0	80.0	05.0
maxFreqDif	Hz	0.20	0.05	0.40	0.05
minVoltage	UN	0.70	0.60	1.00	0.05
maxVoltage	UN	0.30	0.10	1.00	0.05
Operat.-Mode		SynChck only		(Select)	
supervisTime	s	0.20	0.05	5.00	0.05
t-Reset	s	0.05	0.00	1.00	0.05
uBusInp-Ph		1ph R-S		(Select)	
uBusInput1	CT/VT-Addr	0			
uBusInput2	CT/VT-Addr	0			
uLineInp-Ph		3ph Y		(Select)	
uLineInput	CT/VT-Addr	0			
uBus1Activ	BinaryAddr	T			
uBus2Activ	BinaryAddr	F			
ReleaseInp1	BinaryAddr	T			
ReleaseInp2	BinaryAddr	F			
BkTrigBus1	BinaryAddr	F			
BkTrigBus2	BinaryAddr	F			
BkTrigLine	BinaryAddr	F			
OverridSync	BinaryAddr	F			
OpModelnp1	BinaryAddr	F			
OpModelnp2	BinaryAddr	F			
PermitToClos	SignalAddr	ER			
Start	SignalAddr				
SyncBlockd	SignalAddr				
TrigBlockd	SignalAddr				
SyncOverrid	SignalAddr				
AmplDifOk	SignalAddr				
PhaseDifOk	SignalAddr				
FreqDifOk	SignalAddr				
LiveBus	SignalAddr				
DeadBus	SignalAddr				
LiveLine	SignalAddr				
DeadLine	SignalAddr				

**Explanation of parameters:****RunOnCPU**

defines the processing unit which runs the function.

**ParSet 4..1**

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

**PermitToClos**

O/P channel at which the CB close signal is available (matrix logic).

**maxVoltDif**

Max. permissible voltage difference  $dU$  between the phases used for checking synchronism.

**maxPhaseDif**

Max. permissible phase-shift  $dPh$  between the voltages of the phases used for checking synchronism.

**maxFreqDif**

Max. permissible difference of frequency  $df$  between the phases used for checking synchronism.

**minVoltage**

Voltage level for discriminating between busbar and line being live (lowest phase voltage in the case of three-phase measurement).

**maxVoltage**

Voltage level for discriminating between busbar and line being dead (highest phase voltage in the case of three-phase measurement).

**Operat.-Mode**

Possible synchrocheck function operating modes:

- “Only SyncChk”: Synchrocheck  
[Synchrocheck conditions fulfilled AND  
(bus live AND line live)]
- “BusD & LineL”: Synchrocheck OR  
(bus dead AND line live)
- “BusL & LineD”: Synchrocheck OR  
(bus live AND line dead)
- “BusD LineD”: Synchrocheck OR  
(bus dead AND line live) OR  
(bus live AND line dead)

- “BusD & LineD”: Synchrocheck OR  
(bus live AND line dead)

#### supervisTime

Definition of the period between the function picking up and it issuing the CB close enable ('PermitToClos').

All the conditions for synchronism must remain fulfilled during this time, otherwise the function is reset.

#### t-Reset

Reset time following the non-fulfilment of one or more synchronism conditions

#### uBusInp-Ph

Choice of phase I/P on the busbar side.

Possible settings:

1 ph RS, ST or TR; 1 ph RE, SE or TE; 3 ph Y; 3 ph  $\Delta$

The chosen phase must agree with the voltage I/P channel selected (i.e. 'uBusInput1' and, if selected, 'uBusInput2').

#### uBusInput1

Designation of the 1st. voltage I/P channel on the busbar side. This must agree with the chosen phase ('uBusInp-Ph').

In the case of a three-phase connection ('uBusInp-Ph' = '3 ph Y' or '3 ph phase-to-phase'), the first channel (R phase) of a three-phase group must be chosen.

#### uBusInput2

Designation of the 2nd. voltage I/P channel (if applicable) on the busbar side. This must agree with the chosen phase ('uBusInp-Ph').

In the case of a three-phase connection ('uBusInp-Ph' = '3 ph Y' or '3 ph phase-to-phase'), the first channel (R phase) of a three-phase group must be chosen.

If a second I/P is not configured, the function takes only in account the 1st. voltage I/P channel ('uBusInput1').

#### uLineInp-Ph

Choice of phase I/P on the line side.

Possible settings:

1 ph RS, ST or TR; 1 ph RE, SE or TE; 3 ph Y; 3 ph

The chosen phase must agree with the voltage I/P channel selected (i.e. 'uLineInput').

**uLineInp**

Designation of the voltage I/P channel on the line side. This must agree with the chosen phase ('uLineInp-Ph'). In the case of a three-phase connection ('uLineInp-Ph' = '3 ph Y' or '3 ph phase-to-phase'), the first channel (R phase) of a three-phase group must be chosen.

**uBus1Activ, uBus2Activ**

Binary I/P's for switching between voltage I/P channels by an remote signal in the case of double busbars (mimic busbar). This I/P's are only active providing the second busbar I/P channel has been configured ('uBusInput2').

F: - I/P disabled

T: - I/P enabled

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

'uBus1Activ'	'uBus2Activ'	Selected voltage I/P
(T) TRUE	(F) FALSE	'uBusInput1'
(F) FALSE	(T) TRUE	'uBusInput2'
Other conditions:		The previous voltage I/P remains active.

**ReleaseInp1, ReleaseInp2**

Binary I/P's for enabling the synchrocheck function. The I/P's are connected internally to an OR gate so that at least one must be set to "TRUE" (T) or appropriately controlled by an remote signal. If both I/P's are set to "FALSE" (F), the functions routine (synchronism algorithm) does not run.

These I/P's are used where the synchrocheck function is only needed at certain times (e.g. in auto-reclosure schemes).

F: - synchrocheck function disabled

T: - synchrocheck function enabled

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

**BlkSynchBus1, BlkSynchBus2, BlkSynchLine**

Binary I/P's for interlocking the enabling signals at the O/P of the synchrocheck function.

These would be typically controlled by fuse failure equipment (m.c.b's) monitoring the v.t. circuits.



- Parts of the function effected by the blocking I/P's:  
Assuming that both busbar I/P channels have been configured (double busbars), the active blocking I/P's depend on the statuses of the binary I/P's 'uBus1Activ' and 'uBus2Activ':

'uBus1Activ'	'uBus2Activ'	Active blocking I/P's
(T) TRUE	(F) FALSE	'BlckTrigBus1' and 'BlckTrigLine'
(F) FALSE	(T) TRUE	'BlckTrigBus2' and 'BlckTrigLine'
Other conditions		The previous blocking I/P's remain active

- Assuming that only the first busbar I/P channel has been configured, all the blocking I/P's are active regardless of the statuses of the binary I/P's 'uBus1Activ' and 'uBus2Activ'.

The active blocking I/P's are connected internally to an OR gate and the CB close enabling O/P's are blocked, if one of them is set to "TRUE" (T).

F: - Blocking I/P inactive

T: - Blocking I/P active

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

#### OverridSync

Binary I/P for bypassing the synchrocheck function. This causes an enabling signal to be issued regardless of whether the synchronism conditions are fulfilled or not. It overrides the function's blocking and other enabling I/P's.

F: - I/P disabled

T: - I/P enabled (The synchrocheck O/P 'PermitToClos' is continuously active.)

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

#### OpModelnp1, OpModelnp2

I/P's for remotely selecting the operating mode:

F: - I/P disabled

T: - I/P continuously enabled

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

<b>'I/P1 mode'</b>	<b>'I/P2 mode'</b>	<b>Synchrocheck mode</b>
(F) FALSE	(F) FALSE	Mode specified in the control program ('Operat.-Mode')
(F) FALSE	(T) TRUE	Synchrocheck OR (bus dead AND line live)
(T) TRUE	(F) FALSE	Synchrocheck OR (bus live AND line dead)
(T) TRUE	(T) TRUE	Synchrocheck OR (bus dead AND line live) OR (bus live AND line dead)

#### PermitToClos

Signal indicating that the synchrocheck function is enabling closure of the circuit-breaker. It is generated at the end of the measuring period ('supervisTime') and remains active for as long as the synchronism conditions are fulfilled, or until a blocking signal is received, or the synchrocheck function re-sets.

(signal address)

#### Start

Signal generated at the instant the conditions for synchronism are fulfilled for the first time.

(signal address)

#### SyncBlockd

The synchrocheck function is disabled (both the I/P's 'SynchEnable1' and 'SynchEnable2' are set to "FALSE" (F)) and the synchrocheck algorithm is discontinued.

(signal address)

#### TrigBlockd

The CB close enabling O/P's are blocked (one or more blocking I/P's are at logical '1'), but the synchrocheck algorithm continues to run.

(signal address)

#### SyncOverrid

Signal indicating that the synchrocheck function is being bypassed, so that a CB close enabling signal is being generated ('PermitToClos) regardless of whether the synchronism conditions are fulfilled or not.

(signal address)

**AmplDifOk**

Signal indicating that the voltage difference  $dU$  between the phases used for checking synchronism has fallen below the value of the parameter 'maxVoltDif'.

(signal address)

**PhaseDifOk**

Signal indicating that the phase-shift  $dPh$  between the phases used for checking synchronism has fallen below the value of the parameter 'maxPhaseDif'.

(signal address)

**FreqDifOk**

Signal indicating that the difference of frequency  $df$  between the phases used for checking synchronism has fallen below the value of the parameter 'maxFreqDif'.

(signal address)

**LiveBus**

Signal indicating that the busbar is energised.

( $U > \text{'minVoltage'}$ )

(signal address)

**DeadBus**

Signal indicating that the busbar is de-energised.

( $U < \text{'maxVoltage'}$ )

(signal address)

**LiveLine**

Signal indicating that the line is energised.

( $U > \text{'minVoltage'}$ )

(signal address)

**DeadLine**

Signal indicating that the line is de-energised.

( $U < \text{'maxVoltage'}$ )

(signal address)

## E. Setting instructions

### 3.6.9.1. *General*

It is only permissible to connect two energised parts of a power system, if the difference between the amplitudes of their voltages, the phase-shift between their voltages and the frequency difference are within acceptable limits.

The purpose of the synchrocheck function is to determine these three parameters and decide whether it is permissible to connect the systems in parallel.

The function thus issues an enable signal ('PermitToClos'), providing the voltages of the two systems are higher than the set minimum voltage ('minVoltage') and

- the difference between the voltage amplitudes  $dU$
- the phase-shift  $dPh$
- the difference between the frequencies  $df$

do not exceed the limits set for the parameters 'Volt. diff', 'maxPhaseDif' and 'maxFreqDif' for the adjustable time 'supervisTime'.

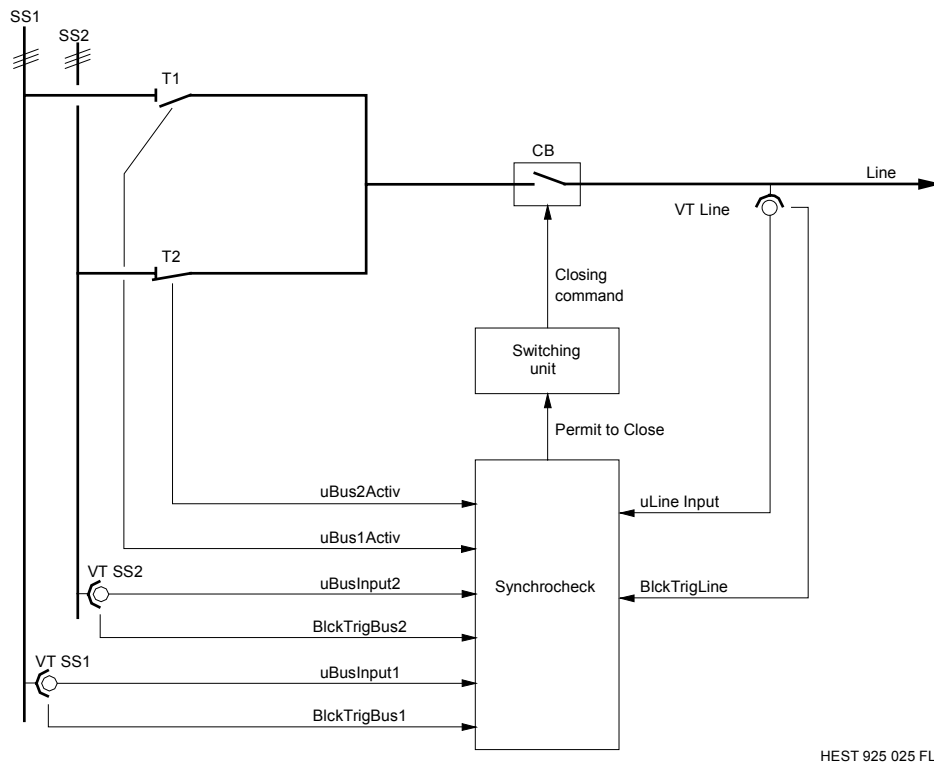
According to the operating mode ('Operat.-Mode') selected, the function also permits de-energised parts of a power system such as a feeder to be coupled.

Provision is also made for switching between voltage I/P's belonging to the busbars of a double busbar station by appropriately controlling two binary I/P's ('uBus1Activ' and 'uBus2Activ'). Note that the function can only check the synchronism of two voltages at any one time, that of one of the busbars and that of the line.

The synchrocheck function is therefore used mainly

- to connect infeeds in parallel and to connect outgoing feeders to the system
- to interconnect two synchronous or asynchronous parts of a power system
- in auto-reclosure schemes
- as a safety check when carrying out manual switching operations.

**Note:** The expressions in brackets are the names of the corresponding setting parameters. Refer also to Section D.

**Application example: Feeder connected to double busbars**

HEST 925 025 FL

Fig. 3.6.9.1 Principle of synchrocheck scheme for determining the instant when it is permissible to connect a feeder to the power system. (The voltages of busbar "SS2" and the line are monitored.)

SS1, SS2	: busbar 1, busbar 2
VT SS1, VT SS2, VT Line	: v.t.'s on busbar 1, busbar 2 and line
T1, T2	: isolators
CB	: circuit-breaker
uBusInput1, uBusInput2	: voltage I/P channels on the busbar side
uLineInput	: voltage I/P channel on the line side

BlckTrigBus1, BlckTrigBus2, BISyncLine	:	I/P's for blocking the synchro-check function by the v.t. fuse failure equipment.
uBus1Activ, uBus2Activ	:	Binary I/P's for switching between the analogue busbar voltage I/P's in accordance with the configuration of the isolators (mimic busbar).

### 3.6.9.2. **Settings**

maxVoltage difference dU	maxVoltDif
Max. phase-shift dPh	maxPhaseDif
Max. frequency difference df	maxFreqDif
Minimum voltage level for monitoring (determination of whether plant is energised)	minVoltage
Maximum voltage level for monitoring (determination of whether plant is de-energised)	maxVoltage
Choice of operating mode	Operat.-Mode
Measuring period (delay before issuing enable)	supervisTime
Reset delay	t-Reset
Choice of phase for monitoring on the busbar side	uBusInp-Ph
Choice of phase for monitoring on the line side	uLineInp-Ph

#### **Monitoring the conditions for synchronism ('maxVoltDif', 'maxPhaseDif' and 'maxFreqDif')**

The determination of voltage difference, phase-shift and frequency difference is performed for just one of the phases of the three-phase system. For this purpose, the c.t. and v.t. values are first filtered by a digital Fourier bandpass filter (to obtain the fundamentals) and then the orthogonal components 'U bus' and 'U line' are derived.

The phase-shift dPh between the voltages and the difference between their amplitudes dU are calculated from the corresponding vector diagram in the complex plane.

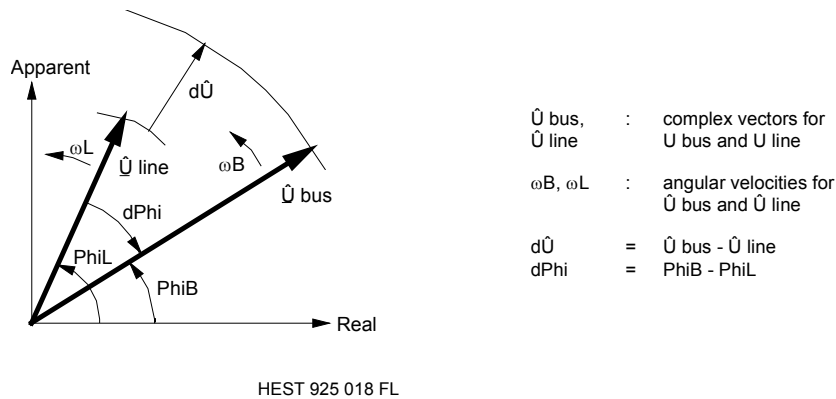


Fig. 3.6.9.2 Monitoring the conditions for synchronism

The frequency difference  $df$  is obtained by determining the rate at which the phase-shift between the voltage vectors varies:

$$df \approx \frac{d}{dT}(d\Phi) \approx (\omega_B - \omega_L)$$

The conditions for synchronism are fulfilled, providing the values of the resulting variables are within the limits set for 'maxVoltDif', 'maxPhaseDif' and 'maxFreqDif'.

#### Typical values:

maxVoltDif 0.2 UN

maxPhaseDif 10°

maxFreqDif 50 mHz - for connecting largely synchronous parts of a stable closely meshed system or where high demands with regard to synchronism have to be fulfilled.

100 mHz - in auto-reclosure schemes with long dead times (e.g. three-phase slow reclosure) or for auto-reclosure of short transmission lines.

200 mHz - in auto-reclosure schemes with short dead times, but where high slip frequencies are to be expected.

**Note:**

The setting of the synchronism measuring period ('supervisTime') must be chosen to correspond to the settings for the maximum phase-shift and maximum frequency difference.

**Monitoring the voltage in two power systems ('minVoltage', 'maxVoltage')**

The determination of voltage amplitude can be either based on monitoring a single phase or all three phases depending on how the particular c.t. and v.t. input is configured. If the three phases are included, then the highest voltage of the three is detected for the maximum limit, respectively the lowest of the three for the minimum limit.

In order to be able to monitor the voltages in a wide frequency range, instantaneous values are measured (instead of digitally filtered c.t. and v.t. voltages).

The voltage detectors may be used to determine whether a system is de-energised or whether it is energised:

- A system is considered to be "de-energised", if its voltage (highest of the three phases in the case of three-phase measurement) falls below the setting of the parameter 'maxVoltage'.
- A system is considered to be "energised", if its voltage (lowest of the three phases in the case of three-phase measurement) exceeds the setting of the parameter 'minVoltage'.

On no account will an enable signal permitting closure of the circuit-breaker be issued, should the voltage lie between the limits of 'maxVoltage' and 'minVoltage'.

**Typical values:**

minVoltage	0.70 UN
maxVoltage	0.30 UN



## Choosing the operating mode of the synchrocheck function ('Operat.-Mode')

Basically, an enable signal will always be issued, if the conditions for synchronism ('dU', 'dPh' and 'df') are fulfilled for the prescribed period and both systems, i.e. busbar and line, are energised (voltage > 'minVoltage').

In cases where closure of the circuit-breaker should also be enabled when one system is de-energised, e.g. connection of a radial feeder, this can be achieved by appropriately setting the parameter 'Operat.-Mode':

Operat.-Mode	Closure enabled when:
"SyncChk only"	Synchronism conditions fulfilled AND (busbar > 'minVoltage' AND line > 'minVoltage')
"BusD & LineL"	"Only SyncChk" OR (busbar < 'maxVoltage' AND line > 'minVoltage')
"BusL & LineD"	"Only SyncChk" OR (busbar > 'minVoltage' AND line < 'maxVoltage')
"BusD   LineD"	"Only SyncChk" OR (busbar < 'maxVoltage' AND line > 'minVoltage') OR (busbar > 'minVoltage' AND line < 'maxVoltage')
"BusD & LineD"	"Only SyncChk" OR (busbar < 'maxVoltage' AND line < 'maxVoltage')

- **Remote mode selection:**

Four of the five operating modes can be selected by external signals applied to two of the function's binary I/P's ('OpModeInp1' and 'OpModeInp2').

Binary I/P signals		Operat.-Mode (see above)	
'OpModeInp1'	'OpModeInp2'	"Operat.-Mode set in the control program" ('Operat.-Mode')	
(F) FALSE	(F) FALSE		
(F) FALSE	(T) TRUE		"BusD & LineL"
(T) TRUE	(F) FALSE		"BusL & LineD"
(T) TRUE	(T) TRUE		"BusD   LineD"

### Choice of phase for the voltage I/P on the busbar and line sides ('uBusInp-Ph', 'uLineInp-Ph')

The phase voltage ('uBusInp-Ph', 'uLineInp-Ph') to be used for determining synchronism can be entered separately for busbar and line I/P's (to facilitate individual adjustment of phase-angle and amplitude).

All single and three-phase voltages are available for setting (1ph RS, ST or TR; 1ph RE, SE or TE; 3ph Y; 3ph Δ), but the ones chosen must agree with the setting for the corresponding I/P channels (see Section D "Synchrocheck function settings"). Where both busbar I/P's are in use, the definition of the phase ('uBusInp-Ph') applies to both busbars.

#### Notes:

- A phase-to-phase measurement is to be preferred for a single-phase voltage measurement.  
If a single-phase I/P has to be chosen on both sides, the same phase should be used wherever possible.
- If a three-phase 'Y' connection is selected, phase-to-phase voltages are formed internally. This reduces the harmonic content and enables the function to continue to be used in ungrounded systems, which are required to remain in service with a single earth fault.

- According to the setting for 'uBusInp-Ph' and 'uLineInp-Ph', either a just one phase or all three phases are monitored. Whether or not the conditions for synchronism ('dU', 'dPh' and 'df') are fulfilled is determined on the basis of a single phase, whereby the following apply:
  - Where three phases are monitored on busbar and line sides, the phase-to-phase potential  $U_{RS}$  is the one extracted for further processing.
  - Should a three-phase measurement be defined on one side and a single-phase on the other, then the single-phase voltage set for the single-phase I/P is used on both sides.

**The measuring period ('supervisTime'), reset time ('t-Reset') and the operating time of the function and also the dead time of any auto-reclosure function**

- **Measuring period ('supervisTime'):**

This adjustable delay time, which is initiated at the end of the pick-up time, is the period during which all the conditions for synchronism must be continuously fulfilled to permit closure of the circuit-breaker. The timer is reset should one of the parameters move out of the permissible range.

Providing they all remain within their preset ranges, the enable signal ('PermitToClos') is issued at the end of the measuring period.

Especially in auto-reclosure applications, it is of advantage to set the measuring period ('supervisTime') in relation to the settings for 'Phase diff.' and 'maxFreqDif'. It also provides facility for allowing for the operating time of the circuit-breaker:

$$'t \text{ meas. per.}' [s] \leq \frac{2x(\text{'Phase - shift'}) [^\circ]}{(\text{'Frequ. diff.}') [Hz] \times 360} - (t_v + t_s) [s]$$

where:

$t_s$ : circuit-breaker operating time

**Typical range:** 0 ... 100 ms.

$t_v$ : time required by the function to pick up  
(response by the function to transient phenomena in the input voltage and timer tolerances):

- typically 60... 80 ms for values of 'supervisTime' < 200 ms
- typically 80... 100 ms for values of 'supervisTime' ≥ 200 ms

The above setting for the measuring period ensures that for a constant frequency difference  $df$  within the setting of 'maxFreqDif', the phase-shift  $dPh$  will still be inside the set permissible angular range (- 'maxPhaseDif' to + 'maxPhaseDif') at the end of the time 'supervisTime'.

### Typical values:

For a phase-shift setting ('maxPhaseDif') of 10:

'maxFreqDif'	'supervisTime'
200 mHz	100... 200 ms
100 mHz	250... 450 ms
50 mHz	600...1000 ms

- **Minimum operating time of the function:**

The minimum operating time achieved by the function, i.e. the shortest possible time between the instant the synchronism conditions are fulfilled for the first time and the generation of the signal enabling the circuit-breaker to be closed ('PermitToClos'), is given by the sum of the measuring time setting ('supervisTime') and the pick-up response time  $t_v$  of the function.

Min. operating time = ('supervisTime') +  $t_v$

- **Auto-reclosure dead time:**

In an auto-reclosure scheme, the dead time set for the auto-reclosure function must be at least as long as the minimum operating time of the synchrocheck function given above in order to permit the synchrocheck function to issue an enable signal ('PermitToClos') within the dead time:

dead time  $\geq$  min. operating time = ('supervisTime') +  $t_v$

- **Reset time ('t-Reset'):**

From the instant that one or more of the synchronism conditions are no longer fulfilled, the enabling signal O/P ('PermitToClos') and the pick-up signal reset after the time set for 't-Reset'.

This ensures the a CB closing signal can be maintained for a certain minimum time.

**Typical value:**

t-Reset 50 ms.

**Note:**

- Where high slip frequencies are to be expected, 't-Reset' must be short enough to prevent the phase-shift from exceeding the set permissible range of phase-angles (- 'maxPhaseDif' to + 'maxPhaseDif') during the reset time.

**3.6.9.3. Binary inputs of the function****Inputs for switching between analogue busbar inputs ('uBus1Activ', 'uBus2Activ')**

Where the two busbar I/P's ('Bus I/P1' and 'Bus I/P2') have been configured for a double busbar installation, the measurement can be switched from one busbar to the other by signals corresponding to the isolator positions applied to the I/P's 'uBus1Activ' and 'uBus2Activ':

'uBus1Activ' 'uBus2Activ'	Analogue I/P's for synchronisation
(T) TRUE (F) FALSE	'uBusInput1' and 'uLineInput'
(F) FALSE (T) TRUE	'uBusInput2' and 'uLineInput'

Other combinations of the states of these two I/P's do not result in any switching of the analogue I/P channels and the prevailing situation is maintained.

**Notes:**

- The function (timer, all measuring elements and the associated O/P's) is automatically reset when busbar I/P's are switched. This procedure takes about **60 ms** (internal response times). The function then begins to evaluate the new busbar voltage and from this instant onwards the generation of an enable signal ('PermitToClos') relating to the new system configuration is possible.
- The two binary I/P's 'uBus1Activ' and 'uBus2Activ' are inactivated in configurations in which only one busbar I/P ('uBusInput1') is defined.

### Blocking inputs for preventing the synchrocheck function from issuing an enable signal ('BlckTrigBus1', 'BlckTrigBus2', 'BlckTrigLine')

These are assigned to the corresponding voltage I/P's and used mainly when the v.t. circuit can be interrupted by fuse-failure equipment (miniature circuit-breakers). In such cases, the blocking I/P's are connected to auxiliary contacts on the fuse-failure equipment. This precaution eliminates any risk of the synchrocheck function permitting the closure of a circuit-breaker onto a line it considers to be de-energised, which in reality is under voltage.

Functionality of the blocking I/P's:

- Both busbar voltage I/P's have been configured:

Which of the blocking I/P's is enabled depends on which of the busbar I/P's 'uBus1Activ' and 'uBus2Activ' is active, i.e. on which voltage I/P is active:

'uBus1Activ'	'uBus2Activ'	Active blocking I/P's
(T) TRUE	(F) FALSE	'BlckTrigBus1' and 'BlckTrigLine'
(F) FALSE	(T) TRUE	'BlckTrigBus2' and 'BlckTrigLine'

Other combinations of the states of these two I/P's do not influence the blocking I/P's and the prevailing situation is maintained.

- If only one busbar voltage I/P is configured, all the blocking I/P's ('BlksyncBus1', 'BlksyncBus2' and 'BlckTrigLine') are enabled regardless of the states of the binary I/P's 'uBus1Activ' and 'uBus2Activ'.

The active blocking I/P's are connected to an OR function so that a logical '1' from any one of them causes all the measuring elements and the associated O/P's ('Start', 'AmplDifOk', 'PhaseDifOk', 'FreqDifOk', 'LiveBus', 'LiveLine', 'DeadBus' and 'DeadLine') and also the enabling O/P ('PermitToClos') to reset. The algorithm of the synchrocheck function, however, continues to run.

### Inputs for enabling the synchrocheck function ('ReleasInp1', 'ReleasInp2')

Since the synchrocheck function is only required during the relevant switching operations and auto-reclosure cycles, it may be blocked at all other times to save processor time. The binary I/P's 'ReleasInp1' and 'ReleasInp2' are used for this purpose.

Internally they are the I/P's of an OR gate, so that at least one must be active before the synchrocheck program will run.

If neither of the two enabling signals is at logical '1', processing of the algorithm ceases. All the function's measuring element O/P's also reset immediately and any circuit-breaker close enabling signal ('PermitToClos') resets after the time set for 't-Reset'.

Conditional enabling of the synchrocheck function is especially recommended, where it has to operate in conjunction with other functions in the same unit such as distance protection, which are critical from the operating time point of view, so as not to adversely influence their tripping times.

### **Input for bypassing the synchrocheck function ('OverridSync')**

A signal applied to this binary I/P causes a 'PermitToClos' signal to be generated immediately regardless of whether the conditions for synchronism are fulfilled or not.

This I/P overrides all other blocking or enabling I/P's.

### **Inputs for remotely selecting the operating mode ('OpModeInp1', 'OpModeInp2')**

I/P's for remotely selecting the operating mode:

<b>'I/P1 mode'</b>	<b>'I/P2 mode'</b>	<b>Synchrocheck mode</b>
(F) FALSE	(F) FALSE	Mode specified in the control program ('Operat.-Mode')
(F) FALSE	(T) TRUE	Synchrocheck OR (bus dead AND line live)
(T) TRUE	(F) FALSE	Synchrocheck OR (bus live AND line dead)
(T) TRUE	(T) TRUE	Synchrocheck OR (bus dead AND line live) OR (bus live AND line dead)





### **3.6.10. Flutter detector (Defluttering)**

#### **A. Application**

Suppresses superfluous event records due to pulsating of binary signals.

#### **B. Features**

- binary inputs assignable to
  - binary input signals
  - protection function output signals (trips)
  - all inputs can be inverted
  - adjustable gate time and permissible signal changes
- two outputs assigned to every input:
  - signal indicating that the input is pulsating (switches too often during the gate time)
  - image of the input status.

#### **C. Inputs and outputs**

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

- none

##### **II. Binary inputs:**

- binary signal levels (input signal)

##### **III. Binary outputs:**

- input pulsating
- input status

##### **IV. Measurements:**

- none.

## D. Flutter detector function settings - Defluttering

Summary of parameters:

Text	Units	Default	Min.	Max.	Step
RunOnCPU		CPU1		(Select)	
ParSet 4..1		P1		(Select)	
SupervisTime	s	1.0	0.1	60.0	0.1
NrOfChanges		2	2	100	1
BinInp 1	BinaryAddr	F			
BinInp 2	BinaryAddr	F			
BinInp 3	BinaryAddr	F			
BinInp 4	BinaryAddr	F			
StateOfInp 1	SignalAddr	ER			
StateOfInp 2	SignalAddr	ER			
StateOfInp 3	SignalAddr	ER			
StateOfInp 4	SignalAddr	ER			
FlutterMess1	SignalAddr	ER			
FlutterMess2	SignalAddr	ER			
FlutterMess3	SignalAddr	ER			
FlutterMess4	SignalAddr	ER			

### Explanation of parameters:

#### RunOnCPU

defines the processing unit which runs the function.

#### ParSet 4..1

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

#### SupervisTime

Gate time for monitoring the number of input impulses.

#### NrOfChanges

Defines the maximum number of impulses permissible during the gate time. If the counted number of impulses is greater than this number, then the input is recognized as fluttering.

#### BinInp 1

Binary input No. 1

F: - not used

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

**BinInp 2**

Binary input No. 2

F: - not used

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

**BinInp 3**

Binary input No. 3

F: - not used

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

**BinInp 4**

Binary input No. 4

F: - not used

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

**StateOfInput 1**

Indicates the status of input No. 1

**StateOfInput 2**

Indicates the status of input No. 2

**StateOfInput 3**

Indicates the status of input No. 3

**StateOfInput 4**

Indicates the status of input No. 4

**FlutterMess1**

Indicates the flutter state of input No. 1

**FlutterMess2**

Indicates the flutter state of input No. 2

**FlutterMess3**

Indicates the flutter state of input No. 3

**FlutterMess4**

Indicates the flutter state of input No. 4

## E. Setting instructions

### General:

An input signal counts as fluttering when it changes its state more than the permissible number of times (NrOfChanges) during the set gate time (SupervisTime). Subsequent changes of the input concerned are not recorded as events. The input remains effective, however, for protection functions. This situation persists until fewer impulses than the permissible number are counted during the gate time.

### Settings:

Gate time	SupervisTime
Permissible number of impulses	NrOfChanges

The function continuously counts the number of signal changes made by the inputs selected during the gate time. All the counters are reset to zero at the end of the set gate time. Should the number of impulses, a binary signal produces at the input, exceed the maximum permissible number set for the input during the gate time, the input is tagged as pulsating (fluttering) and the corresponding output signal is set. This status does not change as long as the number of impulses remains higher than the permissible number. Only when the number of impulses counted during the preceding gate time falls below the maximum permissible number is the 'fluttering' status terminated and the corresponding output signal reset.

To prevent the flutter detector itself from fluttering when the number of impulses being counted during the gate time is precisely the number set, the number of impulses for resetting is ten percent lower than the maximum permissible number, respectively at least one impulse less if the setting for the maximum permissible number of impulses is less than ten.

Note that the beginning and end of the gate time is not indicated externally. Thus a sequence of impulses may be higher than the permissible number for a short time, but is not detected as fluttering because it started in one gate time and finished in the next.

**Typical settings:**

SupervisTime	10 s
NrOfChanges	20



### **3.6.11. 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
RunOnCPU		CPU1	(Select)		
ParSet 4..1		P1	(Select)		
VoltageInp	CT/VT-Addr	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	(none)	1.0000	0.0001	1.0000	0.0001
Cnt1New	SignalAddr				
t2-Interval	Select	15 min			
PulseInp2	BinaryAddr	F			
Reset2	BinaryAddr	F			
ScaleFact2	(none)	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./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 inputs 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:  $-180^\circ$  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 c.t. and v.t. 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 according to the connections in [Section 4.4.2](#).

- 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".

### 3.6.11.1. *Impulse counter inputs*

The impulses counted are normally generated by a measuring or metering device (see Fig. 3.6.11.1).

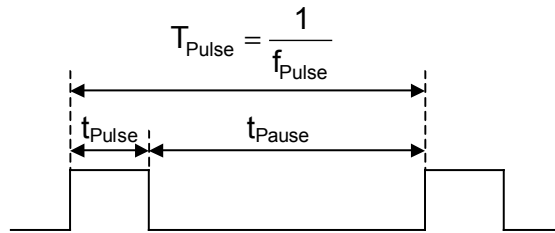


Fig. 3.6.11.1 Impulse counter input signal

The maximum impulse repetition rate is 25 Hz (see Fig. 3.6.11.1). Thus the minimum time between the positive-going edges of two input impulses is  $T_{\text{Puls, min}} = \frac{1}{25} \text{ Hz} = 40 \text{ ms}$ .

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.:

$$t_{\text{Pulse, min}} = \frac{1}{1+3} \times T_{\text{Pulse, min}} = \frac{1}{4} \times T_{\text{Pulse, min}} = 10 \text{ ms}.$$

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).

**3.6.11.2. Impulse counter operation**

Fig. 3.6.11.2 shows the principles of impulse counter operation.

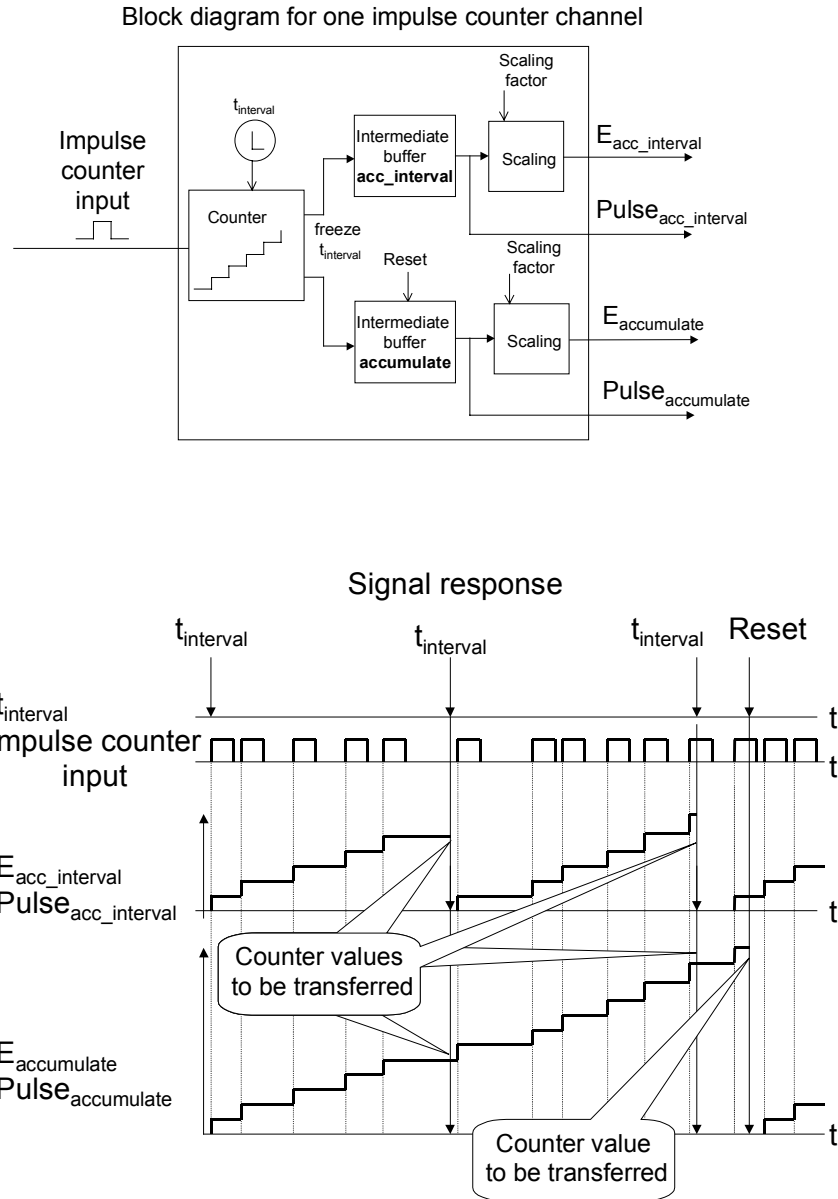


Fig. 3.6.11.2 Block diagram for one impulse counter channel and signal response

**3.6.11.3. 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.  $2 \times 10^9$ . 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.

#### 3.6.11.4. *Interval processing*

The interval starts at a full hour plus an even multiple of  $t_{\text{interval}}$  and is synchronised to a full minute by the internal RE..16 clock. Assuming  $t_{\text{interval}}$  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  $t_{\text{interval}}$  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, i.e. written to the measurement data array, 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. 3.6.11.3.

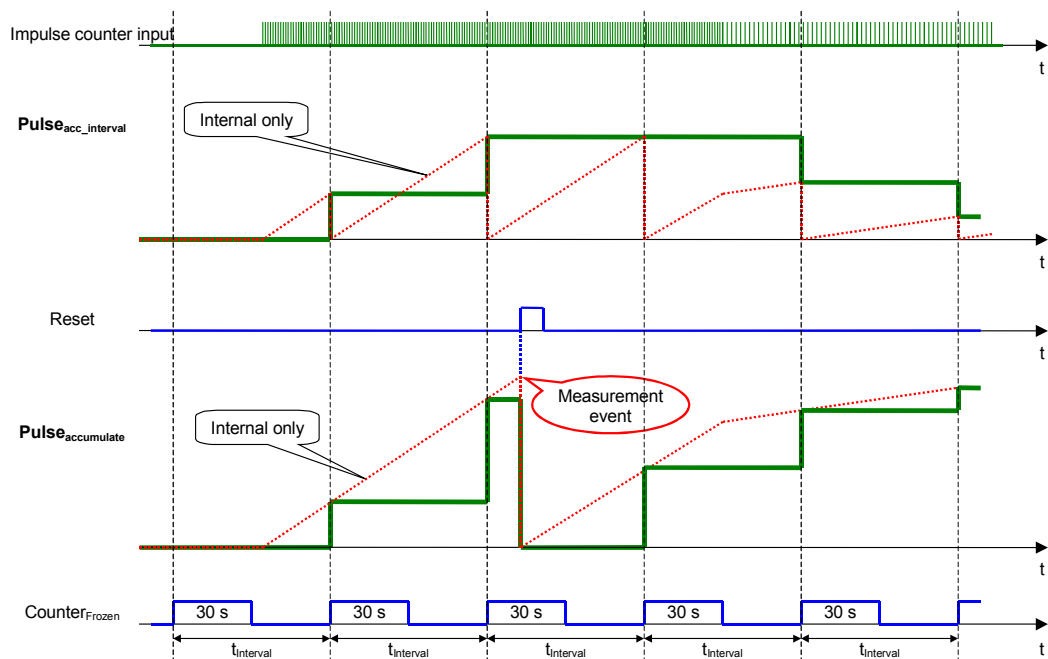


Fig. 3.6.11.3 Interval processing



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## 4. DESCRIPTION OF FUNCTION AND APPLICATION

### 4.1. *Summary*

Both analogue and binary I/P signals pass through a signal conditioning stage before being processed by the main processor: Analogue signals go through the chain comprising the input transformer, shunt, low-pass filter (anti-alias filter), amplifier, sampling (sample and hold), multiplexer and A/D converter. As digital signals they are then separated by digital filters into real and apparent components before entering the main processor. The binary signals are isolated by opto-couplers in the input circuits and are evaluated by the main processor. Only now are the protection algorithms and the logic functions processed in the main processor.

A delay function and a logic function are also included. The delay function enables a time to be defined between pick-up (I/P of the function) and its operation. A setting is also provided for the reset time. The logic function provides an AND, OR or RS gate for combining different O/P signals (of functions and binary I/P's).

The distance protection function is equipped with overcurrent or underimpedance starters. In ungrounded systems, all the usual cyclic and acyclic phase preference schemes are available. The residual (neutral) current and/or residual (zero-sequence) voltage are monitored to detect earth faults.

The first distance zone, the overreaching zone and the reverse zone measure simultaneously. All of the distance zones have wide setting ranges and can be set completely independently of each other, also with respect to whether they measure in the forwards or reverse direction. There are three directional distance zones and a fourth, which can be either directional or non-directional as demanded by the application. The overreaching and reverse zones are for use in transfer tripping schemes with signal transmission between the units at the two ends of a line. The operating characteristics are polygons with the reactance borders slightly inclined to give an ideal tripping area. For close three-phase faults with very low voltages, the use of a reference voltage comprising a healthy voltage and the voltage of a memory feature ensures a reliable directional decision.

Compensation of the mutual zero-sequence impedance of parallel circuits can be achieved by appropriate selection of the zero-sequence impedance factor ( $k_0$ ) or the residual current of the parallel circuit using  $k_{0m}$ .

A v.t. supervision feature (fuse failure) is already incorporated. Its measurement can be based on either the zero-sequence component ( $U_0$  · not  $I_0$ ) and/or the negative-sequence component ( $U_2$  · not  $I_2$ ). The latter is of special advantage in ungrounded systems or systems with poor grounding.

An independent back-up overcurrent function becomes a short-zone protection, as soon as the line isolator is opened. Tripping of the overcurrent back-up protection is uninfluenced by any signal, which may be blocking the distance protection (e.g. v.t. supervision or power swing blocking).

The power swing blocking function monitors the variation of the quantity  $U \cdot \cos \varphi$ . This method of detecting power swings is entirely independent of the characteristic and location of the distance protection. Power swings with frequencies between 0.2 and 8 Hz are detected.

The sensitive E/F protection for ungrounded systems and systems with Petersen coils measures both in the forwards and reverse directions. A characteristic angle of  $90^\circ$  ( $U_0 \cdot I_0 \cdot \sin \varphi$ ) is chosen for ungrounded systems and one of  $0^\circ$  ( $U_0 \cdot I_0 \cdot \cos \varphi$ ) for systems with Petersen coils.

An logic, which can be freely programmed with the aid of FUPLA (function block programming language), provides convenient facility for achieving special circuits needed for specific applications.

The auto-reclosure function enables up to four three-phase reclosure cycles to be carried out, each with independently set dead time for fast or slow auto-reclosure.

Where necessary, a large variety of supplementary protection and logic functions is contained in the RE. 216 and RE. 316\*4 function software libraries.

The distance protection logic gives the user access for blocking or enabling purposes to a wide range of functions, including for example the kind of transfer tripping scheme, switch-onto-fault logic, zone extension logic, v.t. supervision logic and whether the protection should trip just the phase concerned or all three phases for an E/F.

The memory of the event recorder function has sufficient capacity for up to 256 binary signals and their relative time tags.

The memory of the disturbance recorder registers 12 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 MODURES 216 function software library, which can provide other protection functions such as restricted earth fault protection or standstill protection.

## **4.2. Protection functions**

### **4.2.1. High-impedance**

#### **4.2.1.1. General**

In a high-impedance scheme, the measuring 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 compensator reactors
- restricted E/F protection for 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 compensator reactors and earth faults on power transformers, which are grounded via an impedance. In some instances solidly grounded transformer can also be protected.

Either an overcurrent function with a series resistor or an overvoltage function can be used in a high-impedance scheme. The application of an overcurrent function in a high-impedance scheme is illustrated by a restricted earth fault protection (R.E.F) in the following Section.

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 are.

##### **4.2.1.2.2. 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, the high fault level results in a high c.t. flux and the probability of it saturating is then also high.

The influence of through faults on the circulating current circuit is limited, especially if the connections between the c.t. cores can be kept short. It is for this reason, that phase faults are neglected when designing a scheme for a solidly grounded system. Phase faults have to be taken into consideration, 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 the c.t.'s 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  $\Delta U_a$ .

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 <a href="#">Fig. 4.3</a>
$\Delta U_a, \Delta U_i$	voltage drop across the circulating current circuit for external, respectively internal faults.
$U_k$	knee-point voltages of the c.t.'s
$\hat{U}$	peak value of voltage
$I$	current setting
$R_S$	stabilising resistor
$I_F$	highest primary fault current (AC component) for an internal E/F.

Equations:

$$\Delta U_a = (R_2 + 2 R_L) I_2$$

$$U_k \geq 2 \Delta U_a$$

$$I = 0.25 I_{2N} \quad (\text{solidly grounded star-point})$$

$$I = 0.10 I_{2N} \quad (\text{impedance grounded star-point})$$

$$R_S \geq \frac{\Delta U_a}{I}$$

$$\Delta U_i = R_S I_2 \quad (I_2 \text{ is given by } I_F)$$

$$U_{\max} = 2\sqrt{2} U_k (\Delta U_i - U_k)$$

**4.2.1.2.3. Example**

Determination of the stabilising resistor:

C.t's 1000/1 A

$R_2 = 5 \Omega$

$$R_L = \frac{100 \text{ m}}{50 \times 4 \text{ mm}^2} = 0.5 \Omega$$

(c.t. leads 100 m long with a specific conductance of  $50 \Omega^{-1} \text{ m/mm}^2$  and a gauge of  $4 \text{ mm}^2$ )

Maximum earth fault through current:

$I_E = 10\,000 \text{ A (r.m.s)}$

This would be the current for an E/F on the HV system for the following data:

$x_d'' = x_2 = 0.2$  ;  $x_T = x_{T0} = 0.1$  ;  $x_{\text{sys}} = x_{\text{sys } 0} = 0.01$

$$I_2 = 10\,000 \frac{1}{1000} = 10 \text{ A (r.m.s)}$$

$\Delta U_a = (5 + 2 \times 0.5) \times 10 = 60 \text{ V (r.m.s)}$

$U_k \geq 2 \Delta U_a = 120 \text{ V (r.m.s)}$

Chosen

$U_k = 200 \text{ V (r.m.s)}$

Settings for a solidly grounded system:

$I = 0.25 I_N = 0.25 \text{ A (r.m.s)}$

(The setting  $I = 0.1 I_N$  is usually chosen for a impedance grounded system.)

Stabilising resistor

$$R_S \geq \frac{\Delta U}{I} = \frac{60}{0.25} = 240 \Omega$$

Chosen  $R_S = 300 \Omega$

Check of the overvoltage at maximum fault current.

$$I_F = \frac{3 \times I_{1N}}{2 X_{\text{Netz}} + X_{\text{Netz0}}} = \frac{3 \times 1000}{0,02 + 0,01} = 100,000 \text{ A (r.m.s)}$$

$$I_2 = 100,000 \frac{1}{1000} = 100 \text{ A (r.m.s)}$$

$$\Delta U_i = R_S I_2 = 300 \times 100 = 30,000 \text{ V (r.m.s)}$$

$$\hat{U} = 2\sqrt{2} \sqrt{U_k(\Delta U_i - U_k)}$$

$$\hat{U} = 2\sqrt{2} \sqrt{200(30,000 - 200)} = 6\,905 \text{ V}$$

Since this value exceeds the permissible maximum of 2000 V peak, a non-linear resistor must be connected across the circulating current circuit to limit the voltage. Shorting contacts may also be necessary.

The maximum spill current flowing in the relay branch for an internal fault is

$$\hat{I} = \frac{\hat{U}}{R_S} = \frac{6\,905}{300} = 23 \text{ A}$$

This current peak is visible in [Fig. 4.4](#). A non-linear resistor, e.g. Metrosil Type 600 A/S1/256, can be used to limit the peak voltage. According to the characteristic shown in [Fig. 4.5](#), the peak current flowing through the resistor is 20 A at 900 V. Since the current through a linear resistor of 300 Ω at 900 V is 3 A, the total current is 23 A.

For a knee-point voltage of 200 V, the current through the non-linear resistor during an internal fault is only 0.09 A, so that it bears no appreciable influence on the pick-up value.

1. C.t specification:

Rated currents	1000/1 A
Winding resistance	$R_2 \leq 5 \Omega$
Knee-point voltage	$U_k = 200 \text{ V}$
Magnetising current	$I_{2m} \leq 2\% I_{2N}$
	i.e. $I_{2m} \leq 0.02 \text{ A at } U_2 = 60 \text{ V}$

Wherever possible the secondary windings should be evenly distributed along the core.

Wherever possible the c.t's should not have any winding correction according to British Standard 3938, Class X.

## 2. Stabilising resistor specification:

1 piece      300  $\Omega$ ;    0.5 A;    10 s

## 3. Non-linear resistor specification:

1 piece      Metrosil Type 600 A/S1/256.

Setting value of the function "Current":

I-setting      0.25  $I_N$ 

Delay          0.02 s

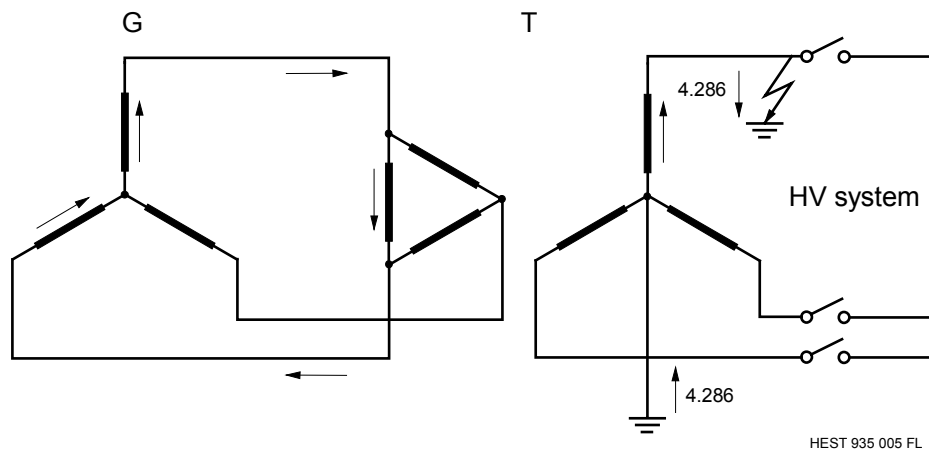


Fig. 4.1      E/F on the HV system supplied by the generator

$$x_d'' = x_2 = 0.2 ; \quad x_T = x_{T0} = 0.1$$

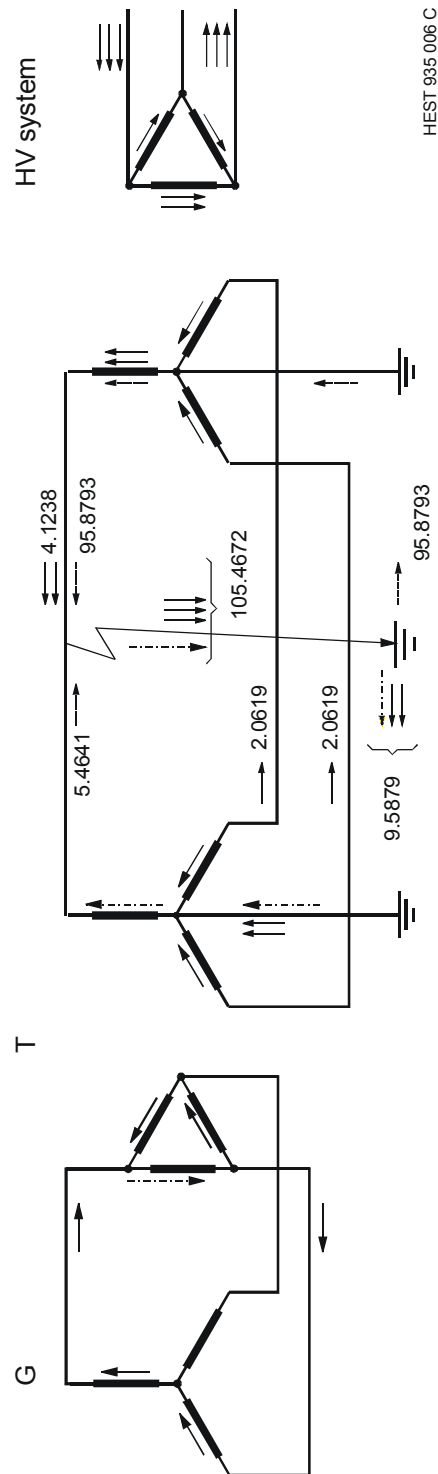
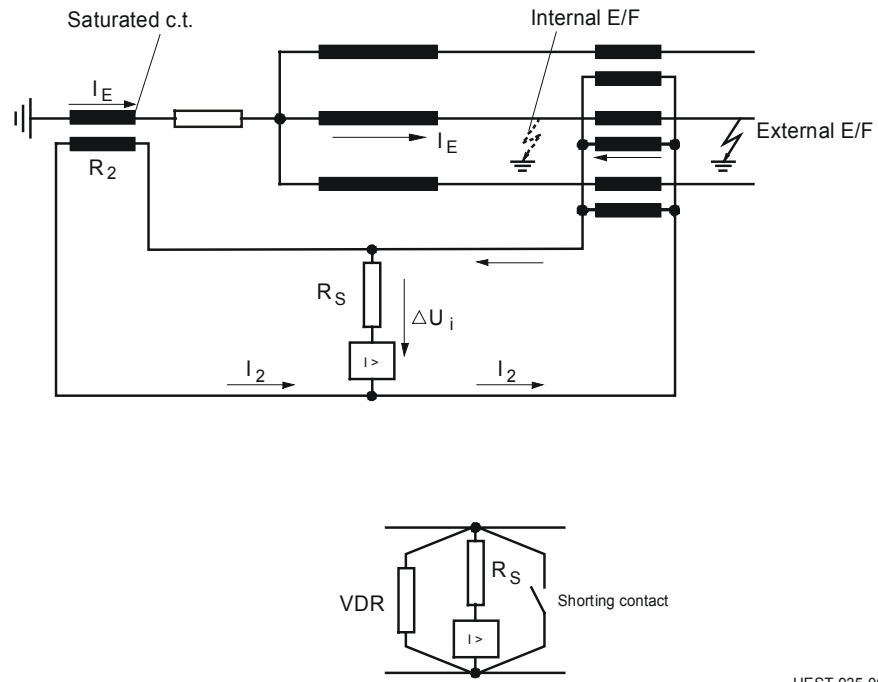


Fig. 4.2

E/F on the HV system supplied by the generator and the HV system

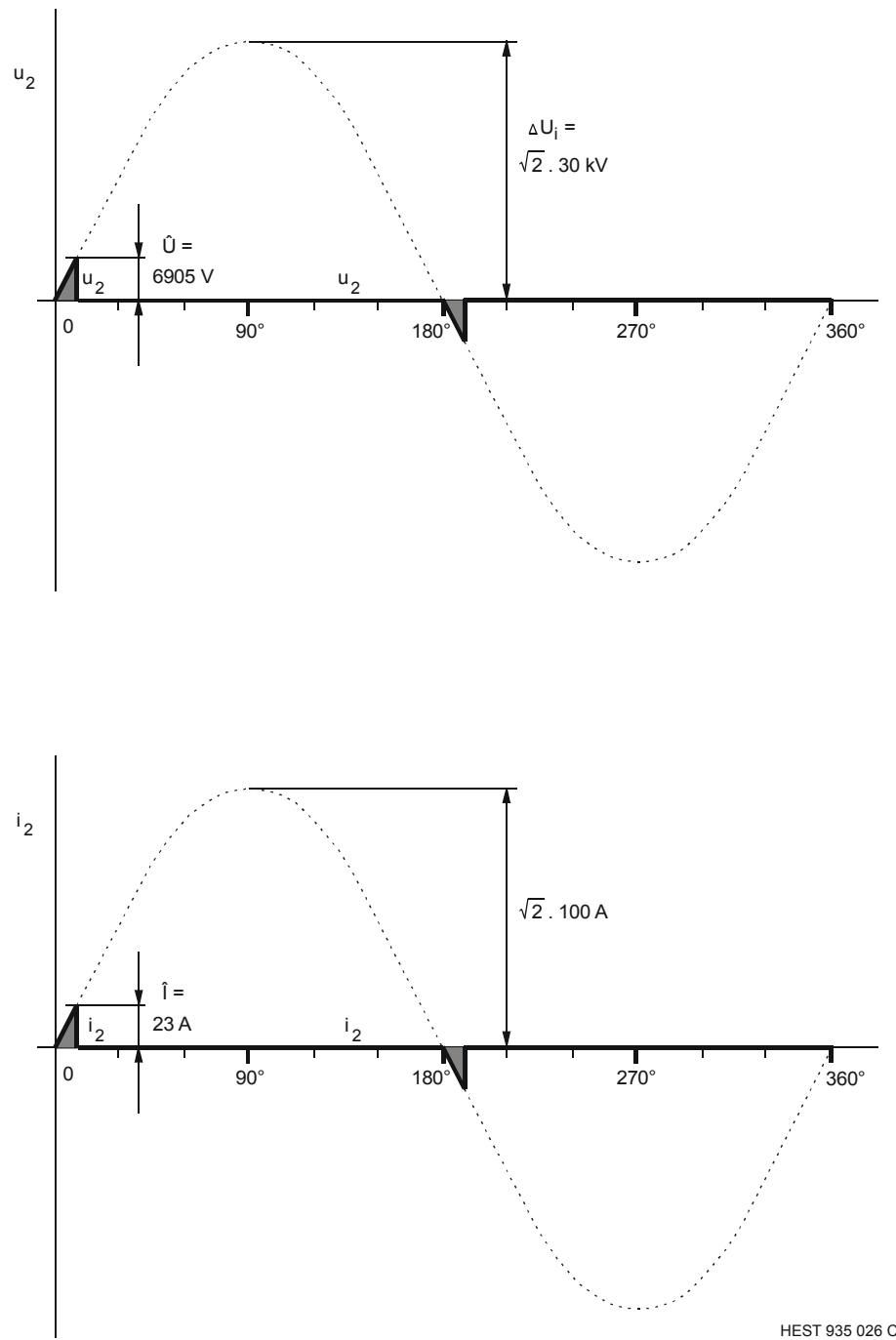
$$x_d'' = x_2 = 0.2 ; x_T = x_{T0} = 0.1 ;$$

$$x_{sys} = x_{sys 0} = 0.01$$



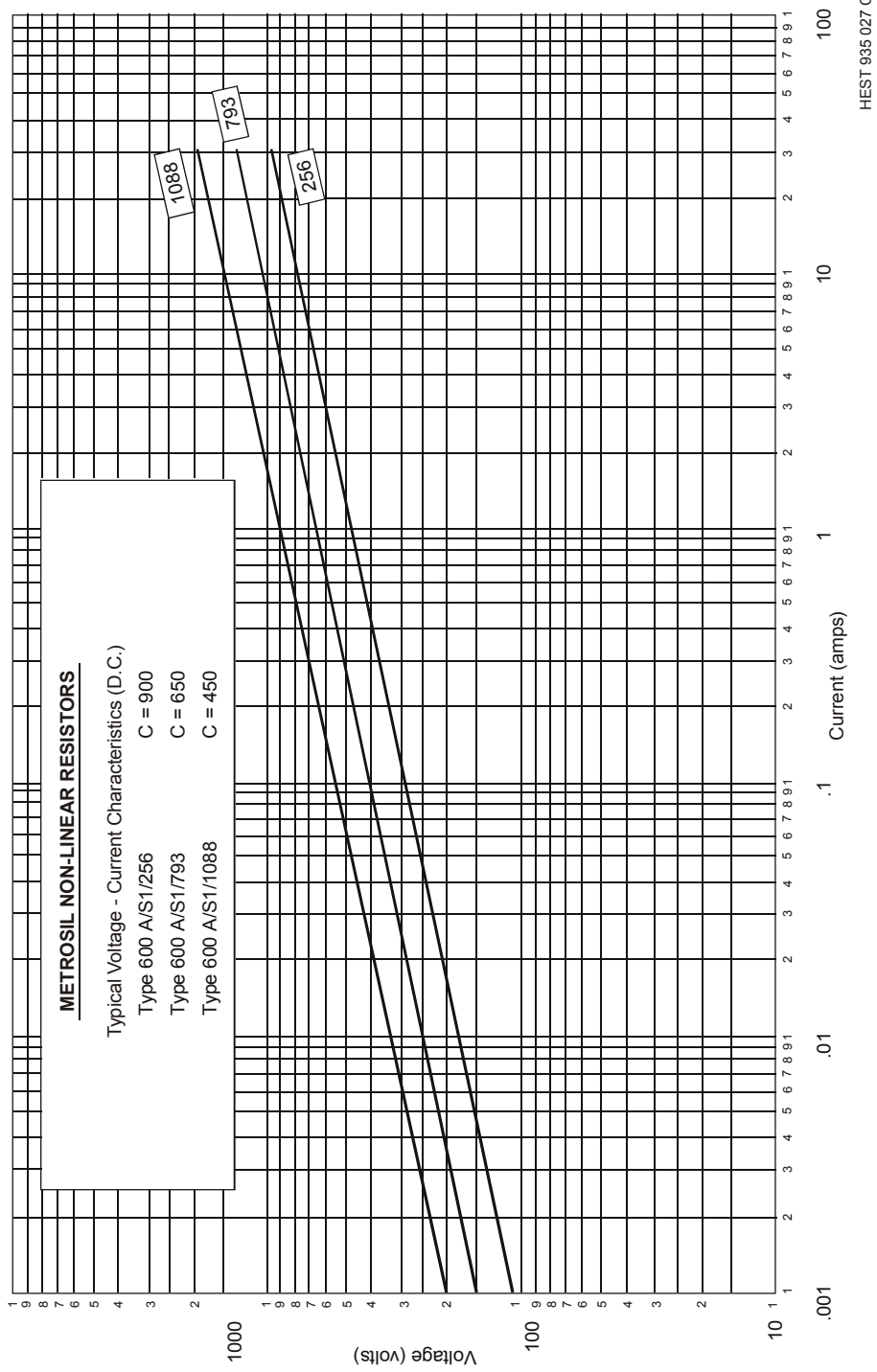
HEST 935 007 C

Fig. 4.3 Restricted E/F protection of a Y-connected transformer winding



HEST 935 026 C

Fig. 4.4 Voltage and current of the relay branch of a circulating current circuit during and internal fault



HEST 935 027 C

Fig. 4.5 Non-linear METROSIL resistors



## **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 at standstill, 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, if the unit is suddenly connected to the system in these circumstances. 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 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. 4.6](#). The computing requirement is 23 %.

Similarly, the overcurrent function can be enabled by an auxiliary contact on the circuit-breaker.

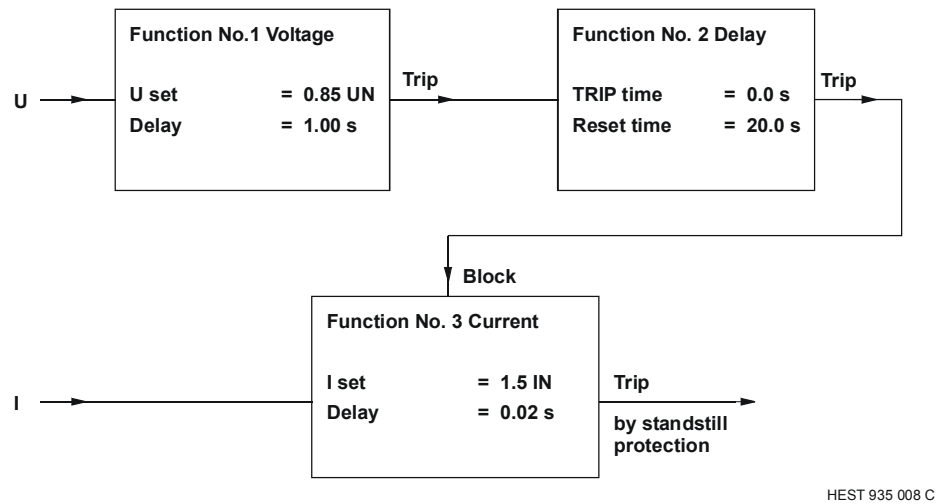


Fig. 4.6 Block diagram of a standstill protection scheme using an overcurrent function

### 4.2.3. Rotor earth fault protection

#### 4.2.3.1. Application

The use of a “Voltage” protection function in combination with an ancillary unit Type YWX111-11 or YWX111-21 enables earth faults on the rotor windings of synchronous alternators and motors to be detected.

The protection scheme is coupled via capacitors (d.c. isolation) to the positive and negative poles of the excitation circuit and to the shaft ground. The YWX111-11/-21 ancillary unit, the coupling capacitors and the normal ground (shaft) capacitance of the rotor winding form a balanced bridge in normal operation. An earth fault represents a leakage resistance across the capacitance of the rotor winding to ground (shaft) and disturbs the balance of the bridge. The voltage difference occurring across the bridge is applied to an I/P v.t. of the RE. 216 and causes the corresponding voltage function to trip.

#### Design

The ancillary unit Type YWX111-11/-21 is in a casing for surface mounting having dimensions of 183 x 113 x 81 mm.

#### 4.2.3.2. **Determining the settings**

Since it is not possible to set the value of leakage resistance directly in ohms, a voltage (U set) proportional to a given leakage resistance has to be set on the RE. 216 together with a time delay t [s]. A typical setting range for the leakage resistance R would be 0 to 5000  $\Omega$ :

- U set = 0.5...3 V
- t = 0.5...5 s

R: leakage resistance between the rotor winding and ground (shaft)

U set: voltage setting

t: operating time for the E/F protection.

##### 4.2.3.2.1. **Data required**

No special data are required in order to determine the protection settings. The latter are in any event difficult to calculate and are therefore normally determined by measurement.

##### 4.2.3.2.2. **Recommended settings for $R_f$ or U set and t**

In principle any value can be set within the setting ranges for the pick-up value  $R_f$  and the time delay t.

The setting of the voltage function should not be too sensitive to avoid mal-operation of RE. 216 during fast regulation of load changes. This is especially important where the protection trips the field switch and shuts the unit down.

##### **Recommended settings:**

- 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 voltage across the bridge is low for a high leakage resistance and high for a low leakage resistance.

#### **4.2.3.3. Functional check**

Where it is considered necessary to check the function of the protection prior to installation or connection to the machine, the procedure is given in [Section 4.2.3.5.1.](#), or alternatively the circuit of [Fig. 4.9](#) can be simulated and the protection checked according to the procedure given in [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 installed as closely as possible to the RE. 216 equipment (same panel or cubicle) to minimise the risk of interference.

On the other hand, the coupling capacitors  $C_K$  should not be installed in the protection equipment room, but as closely as possible to the protected unit. The cables to the rotor winding must be suitable for the insulation level of the rotor circuit as determined by the excitation voltage.

##### **4.2.3.4.2. Checking the wiring**

The strict conformity of all connections with the wiring diagram must be checked.

Check that the auxiliary supplies available in the plant 100 V AC or 220 V AC agree with those on the rating plate of the YWX111-11/-21.

##### **YWX111-11/-21 connections**

The auxiliary supply of 100 V AC or 220 V AC can be obtained from a voltage divider within the plant or from one of the generator v.t.'s. In the case of the compact version of the RE. 216, the auxiliary a.c. supply can be taken from the input terminals of the input transformer unit used for measuring the generator voltage.

Since double ground connections can cause problems, it may be necessary to disconnect the YWX111-11/-21 ground connection at terminal 3 within the cubicle (shaft ground).

##### **4.2.3.4.3. Wiring for a two-stage scheme**

A two-stage scheme requires two "Voltage" protection functions and one YWX111-11/-21 ancillary unit.

The stages are used normally as follows:

- Stage 1: “Alarm”
- Stage 2: “Trip”

The scheme must be wired according to [Fig. 4.12](#).

#### **4.2.3.4.4. *Wiring for an excitation system with shaft-mounted diodes***

In the case of excitation systems with shaft-mounted rectifier diodes, the protection has only a single-pole connection to the rotor winding via an auxiliary slip-ring.

The two capacitors  $C_{K1}$  and  $C_{K2}$  are connected in parallel to either the positive or negative terminal of the rotor winding. If both alternatives are possible (several slip-rings), the connection of capacitors  $C_{K1}$  and  $C_{K2}$  to the minus pole is to be preferred.

The remaining connections must conform to [Fig. 4.10](#) to [Fig. 4.12](#).

#### **4.2.3.4.5. *Protection for units with shaft filter***

If a “shaft filter” is connected in the rotor supply to prevent currents from flowing which damage the bearings, the sensitivity of the protection will be reduced.

In order to reach an acceptable sensitivity in such plants, the value of R9 in the ancillary unit Type YWX111-11/-21 can be increased.

##### **YWX 111-11/-21**

- Standard:  $R_9 = 120 \Omega$   
(normal sensitivity)
- Units with a shaft filter:  $R_9 = 1 \text{ k}\Omega$   
(increased sensitivity)

Refer to [Fig. 4.14](#) for the location of the resistor R9.

#### **4.2.3.5. *Commissioning***

The commissioning procedure is given in [Sections 4.2.3.5.1](#) to [4.2.3.5.4](#). The tripping circuits of the RE. 216 must be interrupted while carrying out commissioning.

#### 4.2.3.5.1. Checks prior to commissioning

- Check the wiring according to [Section 4.2.3.4.](#)
- Check that the ancillary unit Type YWX111-11/-21 is connected to the correct auxiliary supply of either 100 V AC or 220 V AC.

Check that the shaft earthing brush assembly is in proper working order.

#### 4.2.3.5.2. Adjusting the ancillary unit Type YWX111-11/-21

The bridge which includes the YWX111-11/-21 must be balanced with the protection connected to the protected unit by inserting a corresponding value for the capacitor  $C_X$ .

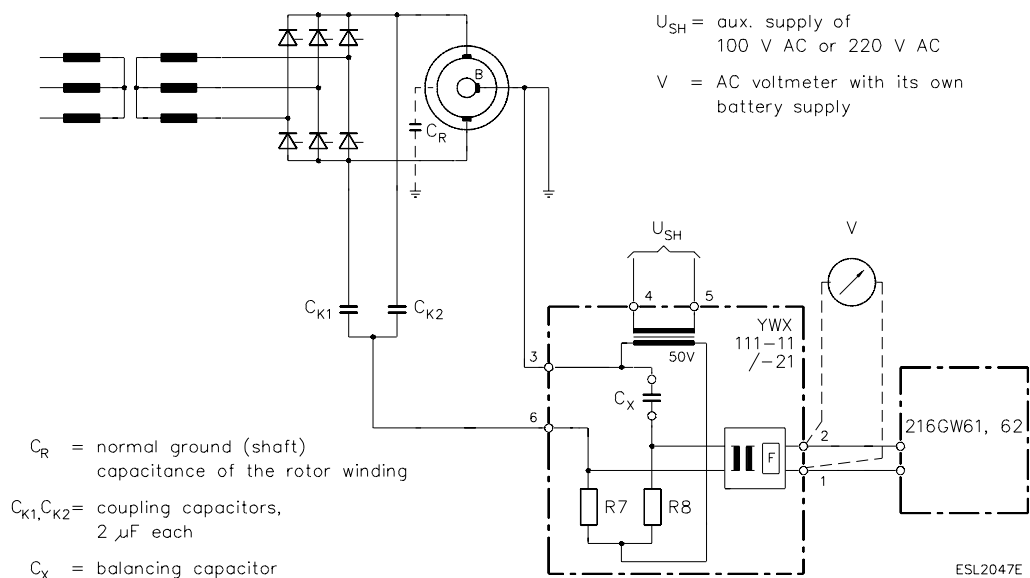


Fig. 4.7 Adjustment of the ancillary unit YWX111-11/-21

Balancing capacitor  $C_X$ : Polyester condenser,  $\geq 400$  V

Adjustment may be carried out with the machine stationary.

**Procedure:**

- Interrupt the tripping circuits from the RE. 216.
- Connect an AC voltmeter to terminals 1 and 2 of YWX111-11/-21.
- Connect a capacitor decade in place of  $C_X$ .
- Close the field switch.
- Switch on the auxiliary supply  $U_{SH}$ .
- Vary the capacitor decade in place of  $C_X$  until the output voltage at terminals 1 and 2 of YWX111-11/-21 becomes a minimum; normally  $\leq 50 \text{ mV}_{r.m.s.}$

**Note:** It is possible that  $50 \text{ mV}_{r.m.s.}$  will not be reached by schemes with increased sensitivity of the YWX111-11/-21 ( $R_9 = 1 \text{ k}\Omega$ ) for excitation systems with shaft filters.

- Solder in a combination of fixed capacitors for  $C_X$  corresponding to the value set on the capacitor decade.

**Theoretical value of  $C_X$** 

a) Circuit according to Fig. 4.10 (or Fig. 4.7):

$$C_X = \frac{(C_{K1} + C_{K2}) \times C_R}{C_{K1} + C_{K2} + C_R}$$

b) Circuit according to Fig. 4.11:

$$C_X = \frac{3C_K \times (3C_S + C_R)}{3C_K + 3C_S + C_R}$$

**4.2.3.5.3. Measuring the voltage values**

The values of the voltage across the bridge measured at the YWX 111 in relation to leakage resistance are determined by simulation using a variable resistor (e.g. resistance decade) and the circuit according to Fig. 4.8.

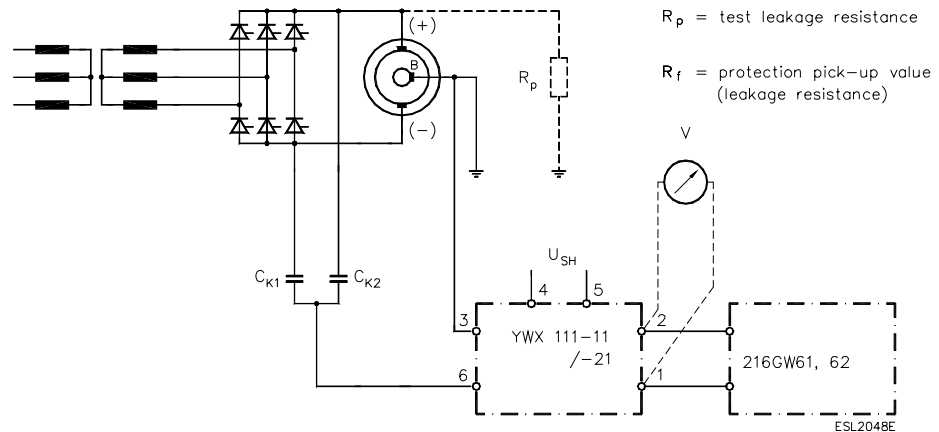


Fig. 4.8 Circuit for measuring bridge voltage in relation to leakage resistance

Leakage resistance  $R_p$ :

- 0  $\Omega$ , solid earth fault
- 2000  $\Omega$ ,  $\geq 2.5$  W
- 5000  $\Omega$ ,  $\geq 2.5$  W

Measurement may be carried out with the machine stationary.

#### Procedure:

- Interrupt the tripping circuits from the RE. 216.
- Connect resistors for  $R_p = 5000 \Omega$ , 2000  $\Omega$  and  $R_p = 0 \Omega$  to the positive pole of the excitation circuit.
- Close the field switch.
- Switch on the auxiliary supply  $U_{SH}$ .
- Measure the voltage across the bridge corresponding to the different values of resistance.
- Set the voltages measured at the two resistances of 2000 and 5000  $\Omega$  on the RE. 216. They should lie between 0.5 and 3 V.
- Repeat the procedure with the resistors  $R_p = 5000 \Omega$ , 2000  $\Omega$  and  $R_p = 0 \Omega$  connected to the negative pole of the excitation circuit.



#### 4.2.3.5.4. Test with the plant in operation

The purpose of the test is to confirm the correct operation of the RE. 216 and the ancillary unit in practical operation. This is done by simulating a rotor earth fault by inserting a leakage resistor. The protection must pick up and trip at the prescribed values of leakage resistance.

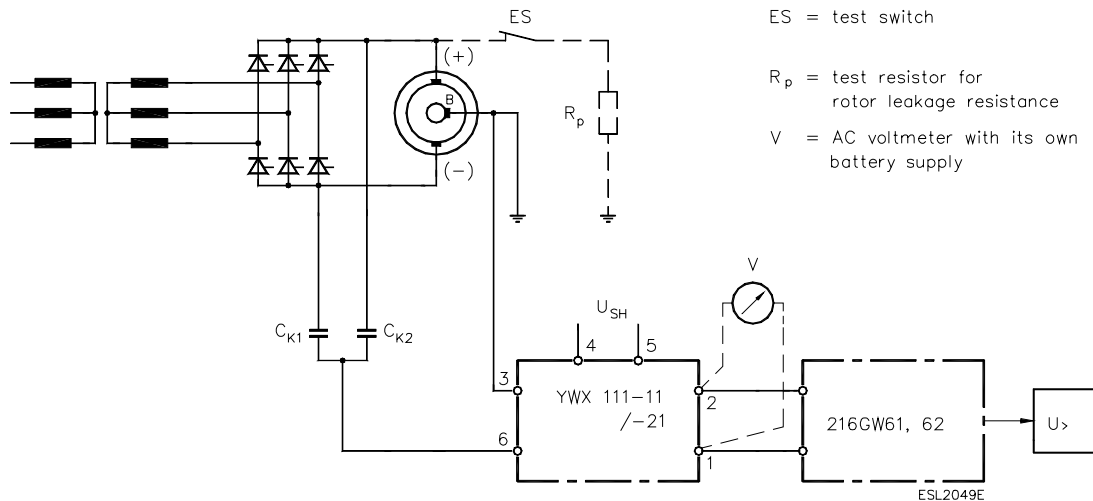


Fig. 4.9 Testing operation of the protection with the plant in operation

Test resistor  $R_p$ : 1000  $\Omega$ ,  $\geq 10$  W, rated voltage according to IEC recommendations (for the different excitation voltages).

#### Procedure:

- Test conditions: Machine running at rated speed, on load and excited. Test switch open.
- Interrupt the tripping circuits.
- Set the RE. 216 to the voltage measured in [Section 4.2.3.5.3](#).
- Close the test switch ES.
- Reduce the value set for “U set” in steps until the protection trips.

**Caution:** The tripping signal has a time delay.

- Repeat the above procedure with the test resistor  $R_p$  connected to the negative pole of the excitation circuit.

- Measure and record the output voltage at terminals 1 and 2 of YWX111-11/-21 during the test.
- Open the test switch ES and make the tripping circuits at the conclusion of the test.

### Checking the adjustment of YWX111-11/-21

With the machine excited and on load, measure the voltage across the bridge at terminals 1 and 2 of YWX111-11/-21. In normal operation (ES open), the voltage measured should be  $\leq 150 \text{ mV}_{\text{r.m.s.}}$ . If this voltage is exceeded,

- check the contact resistance of the connecting brushes (see [Section 4.2.3.6.](#))
- repeat and optimise the adjustment of YWX111-11/-21 according to [Section 4.2.3.5.2.](#)

**Note:** It is possible that  $140 \text{ mV}_{\text{r.m.s.}}$  will not be reached by schemes with increased sensitivity of the YWX111-11/-21 ( $R_9 = 1 \text{ k}\Omega$ ) for excitation systems with shaft filters.

## 4.2.3.6. *Operation and maintenance*

### 4.2.3.6.1. *Possible causes of failures*

Should the protection mal-operate during normal operation of the plant, the possible causes are the following:

- The shaft earthing brushes are not making proper contact (see [Section 4.2.3.6.2.](#)).
- The ancillary unit Type YWX111-11/-21 is not properly adjusted (see [Sections 4.2.3.5.2. and 4.2.3.5.4.](#)).
- An additional ground is connected to terminal 3 of YWX111-11/-21 resulting in a double earth loop (see [Section 4.2.3.4.2.](#)).
- The setting for the protection is too sensitive (the pick-up 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. It should, however, be checked regularly as is the case with all safety devices. This can take place according to the procedure given in [Section 4.2.3.5](#).

The shaft grounding brush must be checked frequently and, where necessary, cleaned and the spring pressure adjusted. The contact resistance of the brush must be as low as possible and above all constant.

#### **4.2.3.7. Fault-finding**

Fault-finding is limited to using the test procedures described in [Section 4.2.3.5](#) to determine whether the protection is functioning correctly. Faulty devices must be returned to the nearest ABB office or agent or to ABB, Baden, Switzerland.

#### **4.2.3.8. Accessories and spares**

When ordering accessories or spares always state the type designation and serial number of the protection device for which they are intended. Where several devices of the same type are installed in a plant, the procurement of a spare unit is recommended.

Spares must be stored in a clean dry room at moderate temperatures. It is recommended that spare units be tested at the same time as routine testing is being carried out on those in operation.

#### **4.2.3.9. Appendices**

[Fig. 4.10](#) Wiring diagram of the relay RE. 216 and ancillary unit Type YWX111-11/-21 - Connection to the d.c. part of the excitation circuit

[Fig. 4.11](#) Wiring diagram of the relay RE. 216 and ancillary unit Type YWX111-11/-21 - Connection to the a.c. part of the excitation circuit

[Fig. 4.12](#) Wiring diagram of a two-stage scheme

[Fig. 4.13](#) Block diagram and terminals of the ancillary unit Type YWX111-11/-21

[Fig. 4.14](#) Component side of the PCB in the ancillary unit Type YWX111-11/-21

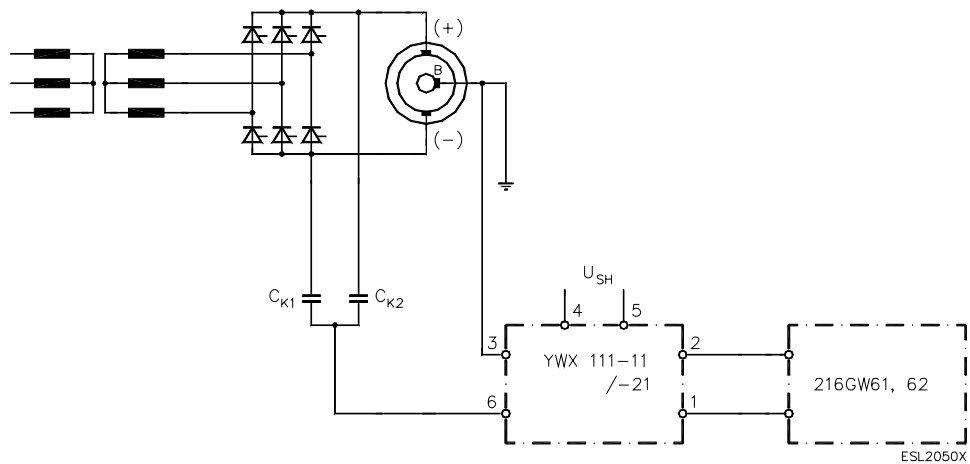


Fig. 4.10 Wiring diagram of the relay RE. 216 and ancillary unit Type YWX111-11/-21  
Connection to the d.c. part of the excitation circuit

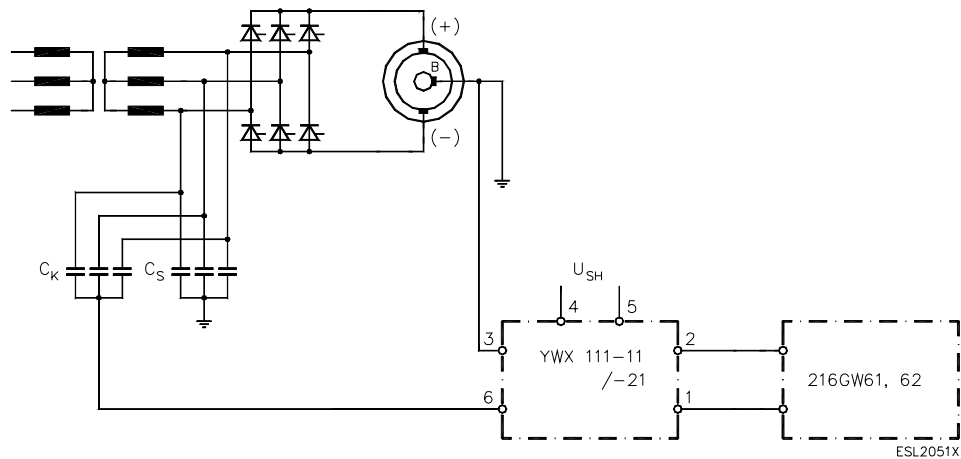


Fig. 4.11 Wiring diagram of the relay RE. 216 and ancillary unit Type YWX111-11/-21  
Connection to the a.c. part of the excitation circuit

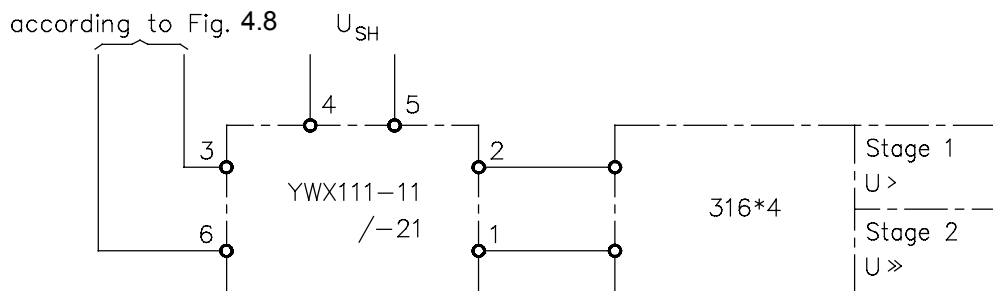
$C_{K1}, C_{K2}$ : coupling capacitors;  $2 \times 2 \mu\text{F}$ , 8...20 kV, 0.55 A

$C_K$ : coupling capacitors;  $3 \times 0.5 \mu\text{F}$ , 8...20 kV, 0.55 A

$C_S$ : snubber capacitors for thyristor excitation

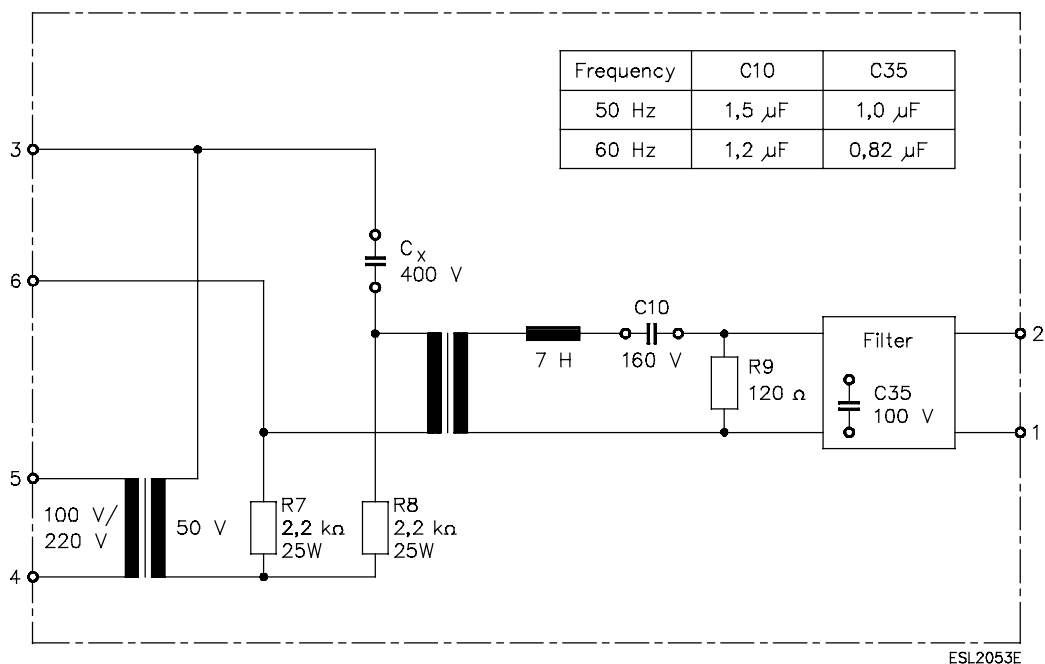
$U_{SH}$ : auxiliary supply; 100 V or 220 V, 50/60 Hz

B: shaft grounding brush



ESL2092E

Fig. 4.12 Wiring diagram of a two-stage scheme



ESL2053E

Fig. 4.13 Block diagram and terminals of the ancillary unit Type YWX111-11/-21

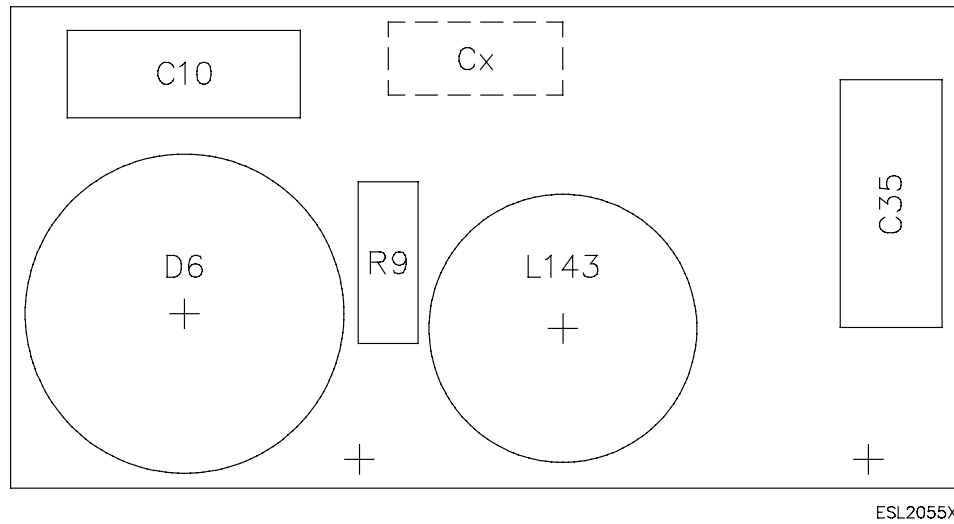


Fig. 4.14 Component side of the PCB in the ancillary unit  
 Type YWX111-11/-21  
 (derived from HESG 437 807)

### 4.3. Signalling channels

It is advisable to make a list of all the signals when engineering an RE. 216 scheme. Table 4.1 shows an example of a suitable list for all the signalling channels and Table 4.2 when using a matrix tripping logic.

216DB61 unit located at division 14					216AB61 unit, division 12			
Inputs		Outputs			Outputs			
216GE61			216GA62		216GA61			
CHI	Ext. trip/ Blocking	Signal	CH	Trip	CH	Signal	CH	Signal
01			01		01	No system failure	02	System ready
02			02		03		04	
03			03		05		06	
04			04		07		08	
05			05		09		10	
06			06		11		12	
07			07		13		14	
08			08		15		16	
09			216NG6.		17		18	
10			Division 1		19		20	
11				Signal	21		22	
12			K 100	24 V failure	23		24	
13			216NG6.		25		26	
14			Division 19 *)		27		28	
15				Signal	29		30	
16			K 100	24 V failure	31		32	

\*) if fitted

HES 925 014 C

Table 4.1 Example of a signal list for the signalling channel I/P's and O/P's of the cubicle version of the RE. 216

Inputs		Outputs							
216GE61		216GA62							
CHI	External trip	01	02	03	04	05	06	07	08
01									
02									
03									
04									
05									
06									
07									
08									
09									
10									
Tripping channels									

HES 925 015 C

Table 4.2 Example of a signal list when using a matrix tripping logic on 216GA62



#### **4.4. C.t and v.t. connections**

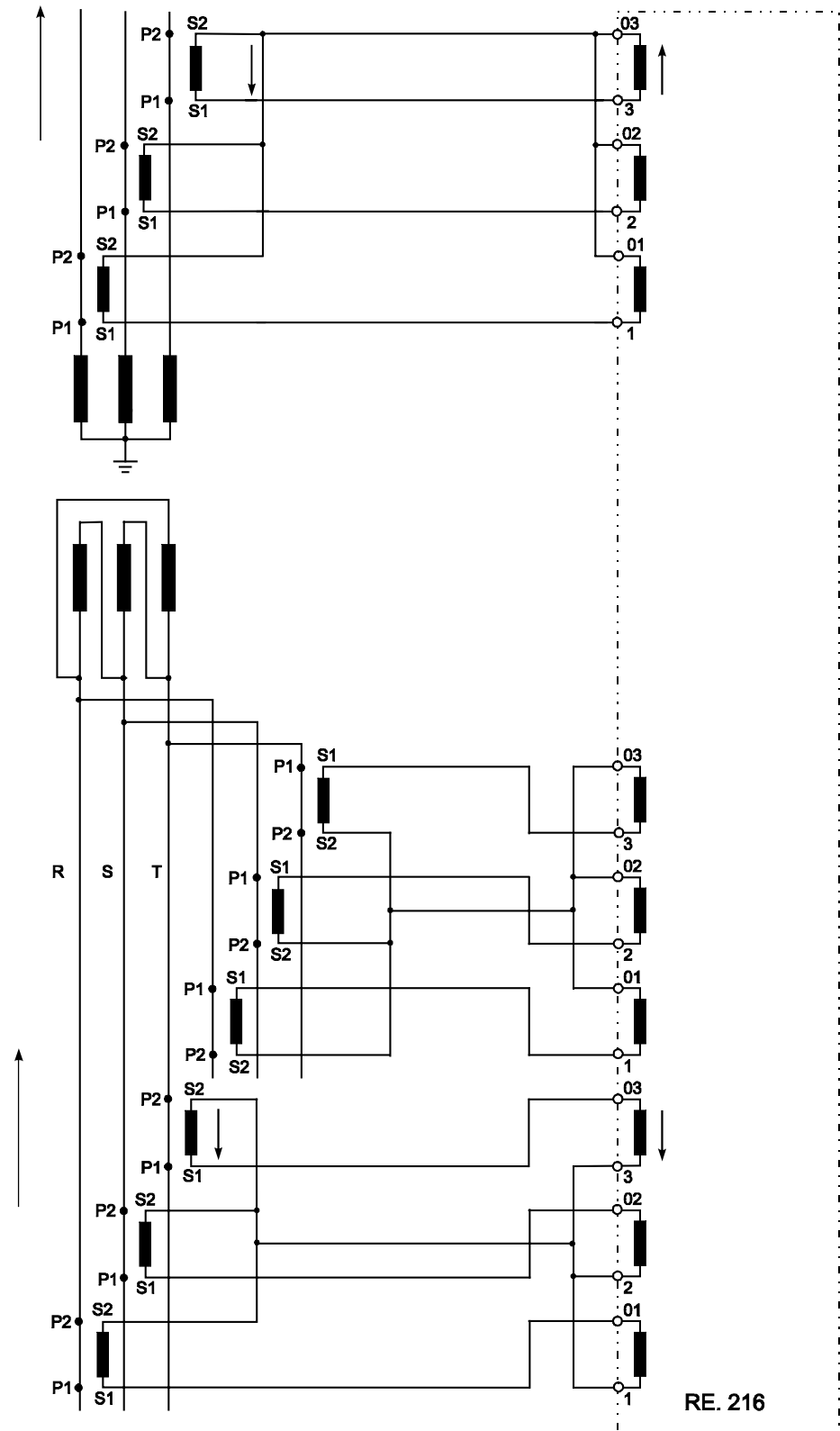
The correct polarity of the instrument transformers is essential in differential and directional functions schemes.

##### **4.4.1. Differential protection**

In the case of differential protection, the c.t.'s must be connected such that for a through-current, i.e. as during normal load conditions or an external fault, the currents flowing through the RE. 216 are in opposition thus producing zero differential current (see example of [Fig. 4.15](#)).

##### **4.4.2. Directional power**

Providing the c.t.'s and v.t.'s are connected as shown in [Fig. 4.16](#) for directional protection functions ('DirCurrentDT', 'DirCurrentInv', 'MinReactance', 'Power', 'Pole-Slip', 'UlfPQ' and 'MeasureModule'), the directional data give in Section 3 applies, i.e. power transferred to the power system is assumed to be positive and power consumed from the power system (reverse power) to be negative. With the c.t. and v.t. circuit shown in [Fig. 4.16](#), the setting for the reverse power function is entered as a negative quantity.



HEST 975001 C

Fig. 4.15 Wiring diagram for the differential protection of a step-up transformer

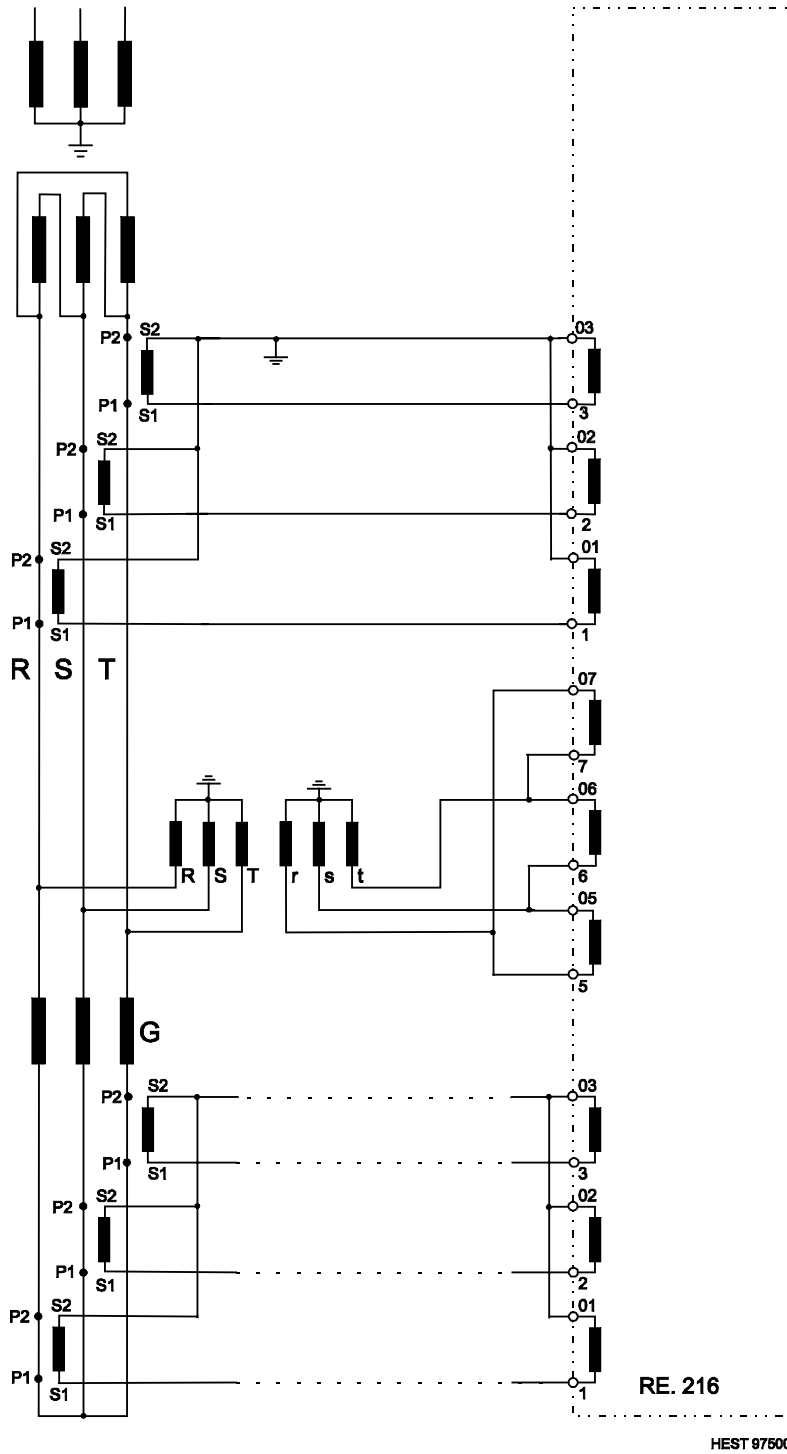


Fig. 4.16 Example of a wiring diagram for a directional protection function ('DirCurrentDT', 'DirCurrentInv', 'MinReactance', 'Power', 'Pole-Slip', 'UifPQ' and 'MeasureModule')

Allocation of phases:

Current: phase A  
 Voltage: phases A, B

## **4.5. Application of the underreactance protection function**

### **4.5.1. 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.  $\delta = 70^\circ$ .

### **4.5.2. Out-of-step conditions**

The stability limit of a turbo-alternator with or without step-up transformer is illustrated in Fig. 4.17, at the upper left 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. 4.17) 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. 4.17) which is applicable whether the generator is connected to a step-up transformer or directly to a busbar.

### **4.5.3. 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  $X_q$  on the stability limit
- salient pole machines.

A load angle of  $\delta < 90^\circ$  represents an off-set circle in the impedance diagram (see Fig. 4.18 left). The centre of the circle lies on a straight line which is displaced from the R axis by the angle  $\delta$ . The circle is the locus of the operating points with the load angle  $\delta$ . The corresponding characteristic in the power diagram is a straight line with a slope of  $\delta$ .

The value of the load angle  $\delta$  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. 4.18](#)  $X_B$  can also be positive or negative and represented in an impedance diagram 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  $\delta$  and the same  $X_A$  setting (see [Fig. 4.17](#)).

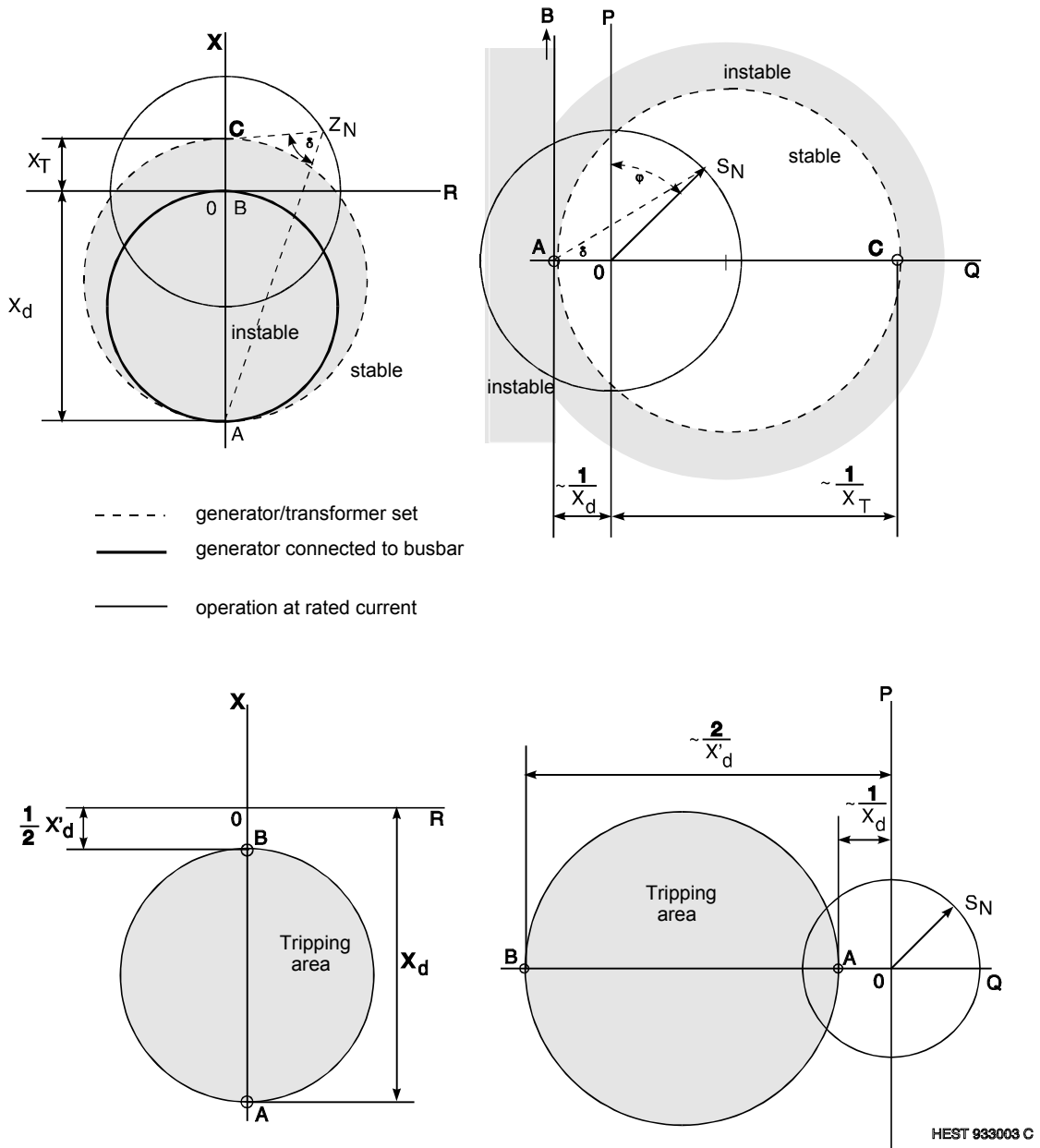
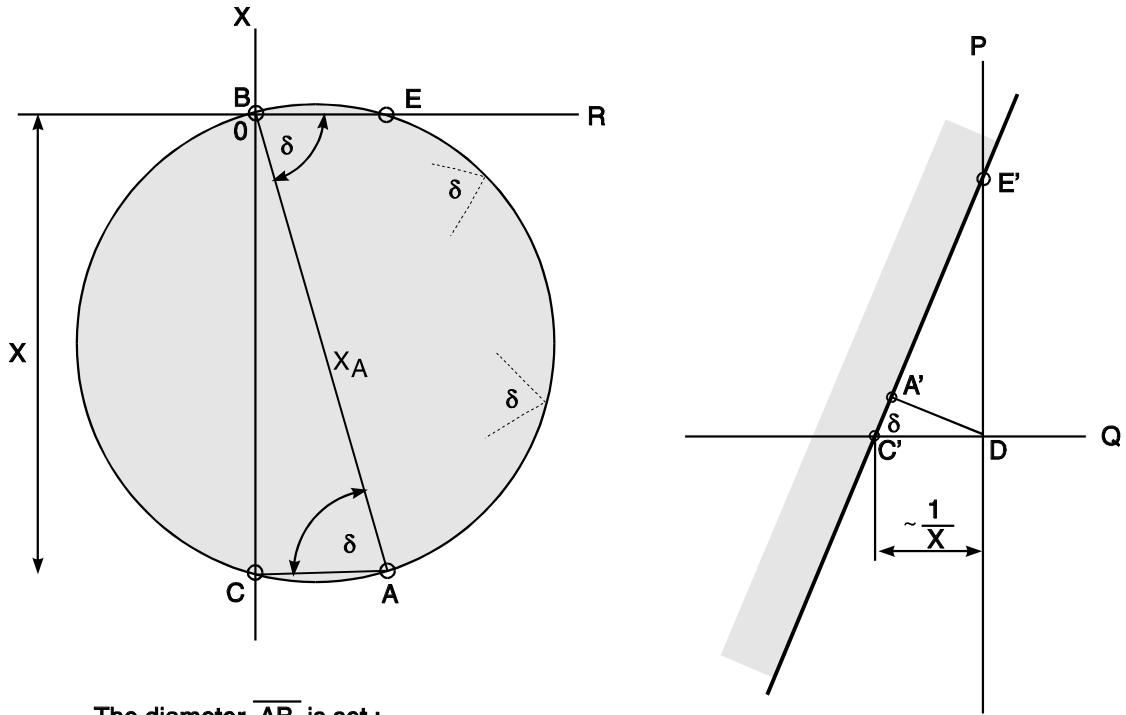


Fig. 4.17 Stability limit of a generator/transformer set and the characteristic of the 'Minreactance' protection function

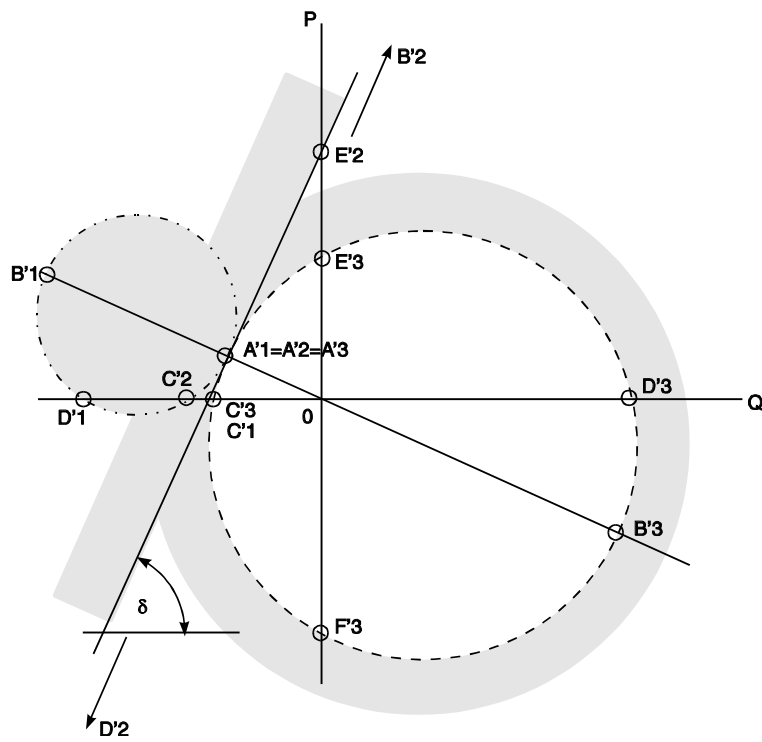
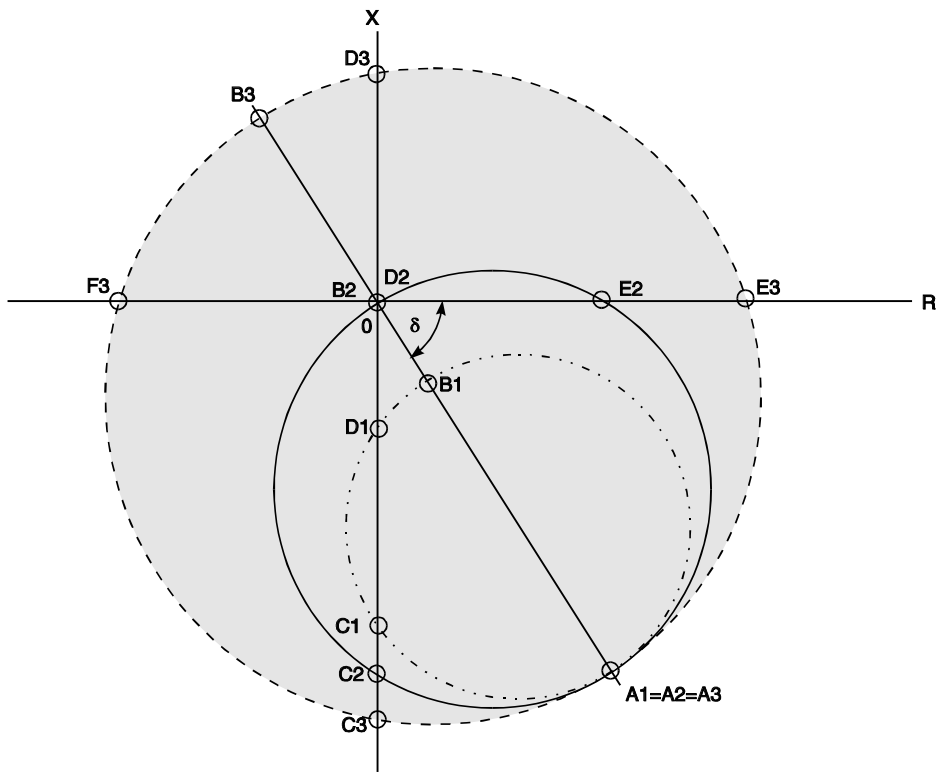


The diameter  $\overline{AB}$  is set :

$$X_A = \frac{X}{\sin \delta}$$

HEST 933004 C

Fig. 4.18 Locus of the load angle  $\delta < 90^\circ$



HEST 933005 C

Fig. 4.19 Operating characteristic for different settings of 'XB-Setting' and a load angle  $\delta < 90^\circ$



#### **4.6. 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 by either three single-phase v.t.'s or a three-phase v.t. In either case the secondaries are connected as a broken delta across which a resistor ( $R_e$ ) is briefly switched after a ground fault has been detected. The grounding transformers or transformer are connected to the busbars and are continuously under voltage. 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 that comprises:

- grounding transformer
- ferroresonance damping resistor  $R_p$
- switched grounding resistor  $R_e$
- neutral voltage detector for switching in the resistor automatically
- contactor
- interposing v.t.

The second part comprises the power function and a either a core-balance or three bushing c.t.'s to measure the zero-sequence current. This arrangement discriminatively locates the ground fault after the real power component has been added.

##### **4.6.1. 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,  $t_1 = 0.1$  s
- T2 prevents “pumping” when the grounding resistor  $R_e$  is switched in and out of circuit,  $t_2 = 1$  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 voltage neutral can be caused by:

a) in normal operation by

- asymmetrical capacitances between the phases and ground
- a third harmonic component

b) under abnormal conditions by

- switching transients
- power system faults inside and outside the zone of protection.

To avoid any risk of mal-operation of the ground fault detector, a setting must be chosen that is safely above the voltage offset that can occur in normal operation.

Under conditions of power system instability, the offset can be increased by the power system capacitances oscillating the v.t. inductances (ferroresonance).

The risk of mal-operation of the ground fault detector due to switching transients can be minimised or even eliminated by adding a resistor  $R_p$  and introducing a delay. The positive effect of this depends on how low the resistor  $R_p$  may be. A low value increases the current and thus the power rating of the resistor and the v.t.'s or the grounding transformer.

**4.6.2. 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.

**4.6.3. 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.

**4.6.4. 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 80 kVA for 10 s. At 6.66 A, this arrangement can be used up to a rated generator voltage of 12 kV, respectively at 5 A up to 16 kV and 4 A up to 20 kV.
- a three-phase dry v.t. permits a current of 6.66 A up to 12 kV.

Apart from the advantage of a higher overload rating, a three-phase grounding also has a negligible voltage drop.

The recommended rated voltages and currents for a ground fault current of 20 A (6.66 A per phase) are:

Voltage transformer			Short-time sec. rating
$U_{1N}$ [V]	$U_{2N}$ [V]	S [kVA]	[A] for 10 s
$\frac{10500}{\sqrt{3}}$	167	70	240

#### 4.6.5. **Ferroresonance damping resistor $R_p$**

Should the ground fault detector pick up for a ground fault on the busbar, it gives alarm but the fault is not tripped. The resistor  $R_p$  must therefore be rated for continuous operation. A resistor rated for 1 or 2 A is frequently used, which while being satisfactory for most v.t.'s, only has a limited damping effect on transient voltages. In the case of the v.t. in the example, the v.t. output power varies for a constant current of 2 A between 577 and 831 VA.

Should it be considered necessary to limit the risk of mal-operation still further, the resistor  $R_p$  can be designed for the maximum permissible continuous rating of the v.t. This is usually in the range 5 to 10 % of the permissible 10 s rating. If the v.t. is also used for metering purposes, it must be borne in mind that both voltage and phase errors are higher at the maximum continuous rating.

#### 4.6.6. **Grounding resistor $R_e$**

The grounding resistor must be rated for 10 s. A voltage drop of 20 % has to be allowed when using a v.t. The recommended value of the resistor  $R_e$  for a ground fault current of 20 A at a rated voltage of  $U_N = 10.5$  kV is:

$U_N$	$U_{\text{broken } \Delta}$	$R_p$		$R_e$	$I_2$
[V]	[V]	[ $\Omega$ ]	[A]	V.t.	[A] 10 s
10500	500	250	2	1.7 $\Omega$	240

#### 4.6.7. **Contactors**

The contactor switches both ends of the grounding resistor  $R_e$ .

**4.6.8. Residual current c.t.**

Alternative I:

1 core-balance c.t. 100/1 A, rated burden 2.5  $\Omega$ .

Alternative II:

3 bushing c.t.'s, .../5 A - 33/1 A, rated burden 1.5  $\Omega$ .

The above burdens apply for c.t. leads of 2 x 100 m with a gauge of 4 mm<sup>2</sup>.

**4.6.9. Required RE. 216 functions**

The following RE. 216 functions are required for a discriminative ground fault scheme:

- 1 100 V voltage I/P
- 1 metering current I/P
- 1 to 4 tripping channels  
depending on the number of circuit-breaker tripping coils and whether redundancy is required or not
- 1 signalling channel "Ground fault"
- 2 signalling I/P's

The start-up scheme requires:

- 1 100 V voltage I/P
- 1 or 2 tripping channels for the excitation switch
- 1 signalling channel "Start-up ground fault"
- 1 signalling I/P "Generator CB closed"

**4.6.10. 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 RE. 216. 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 RE. 216 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  $U_{RN} = 100$  V and  $I_{RN} = 1$  A.

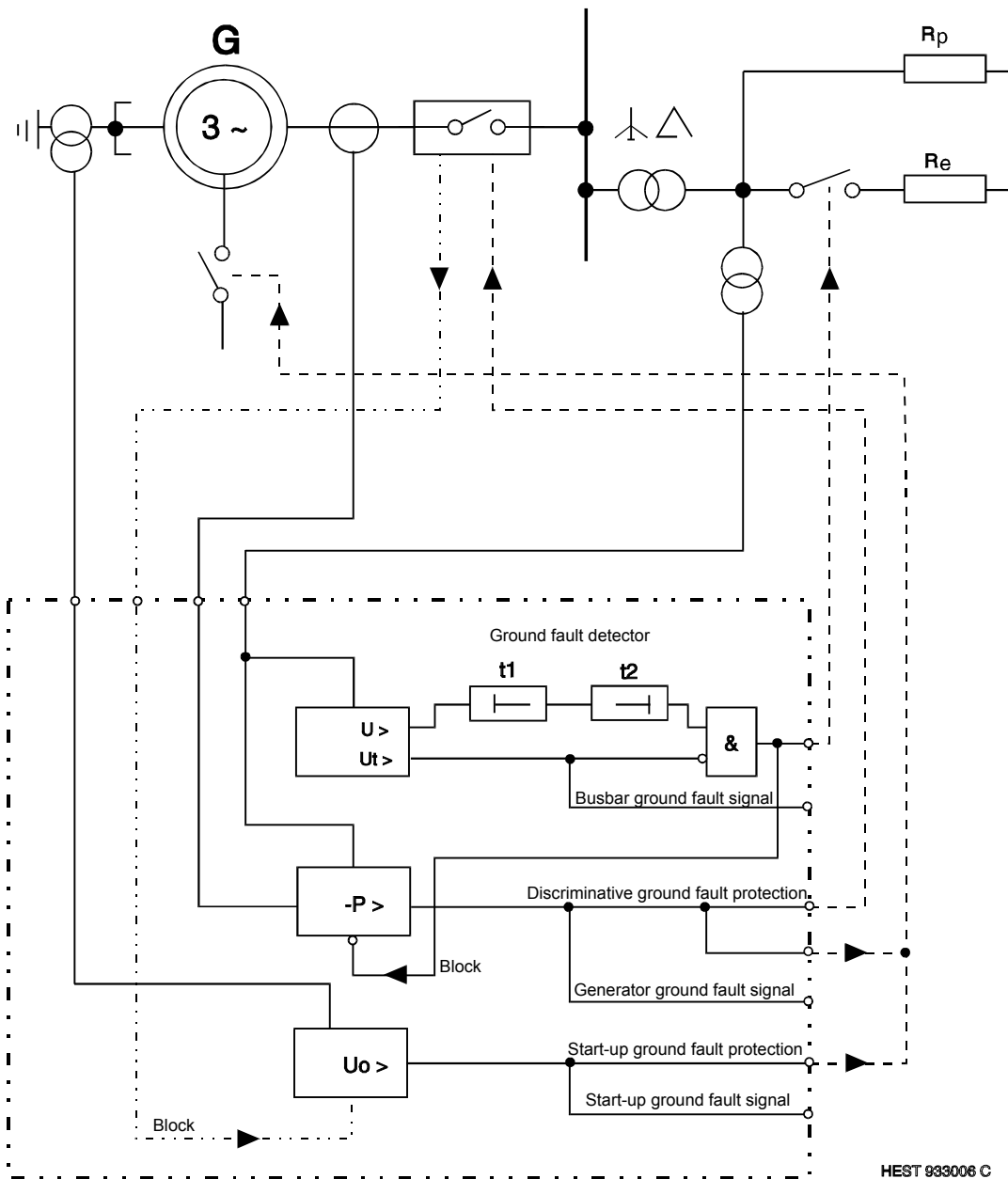


Fig. 4.20 Discriminative ground fault and start-up schemes for a generator feeder

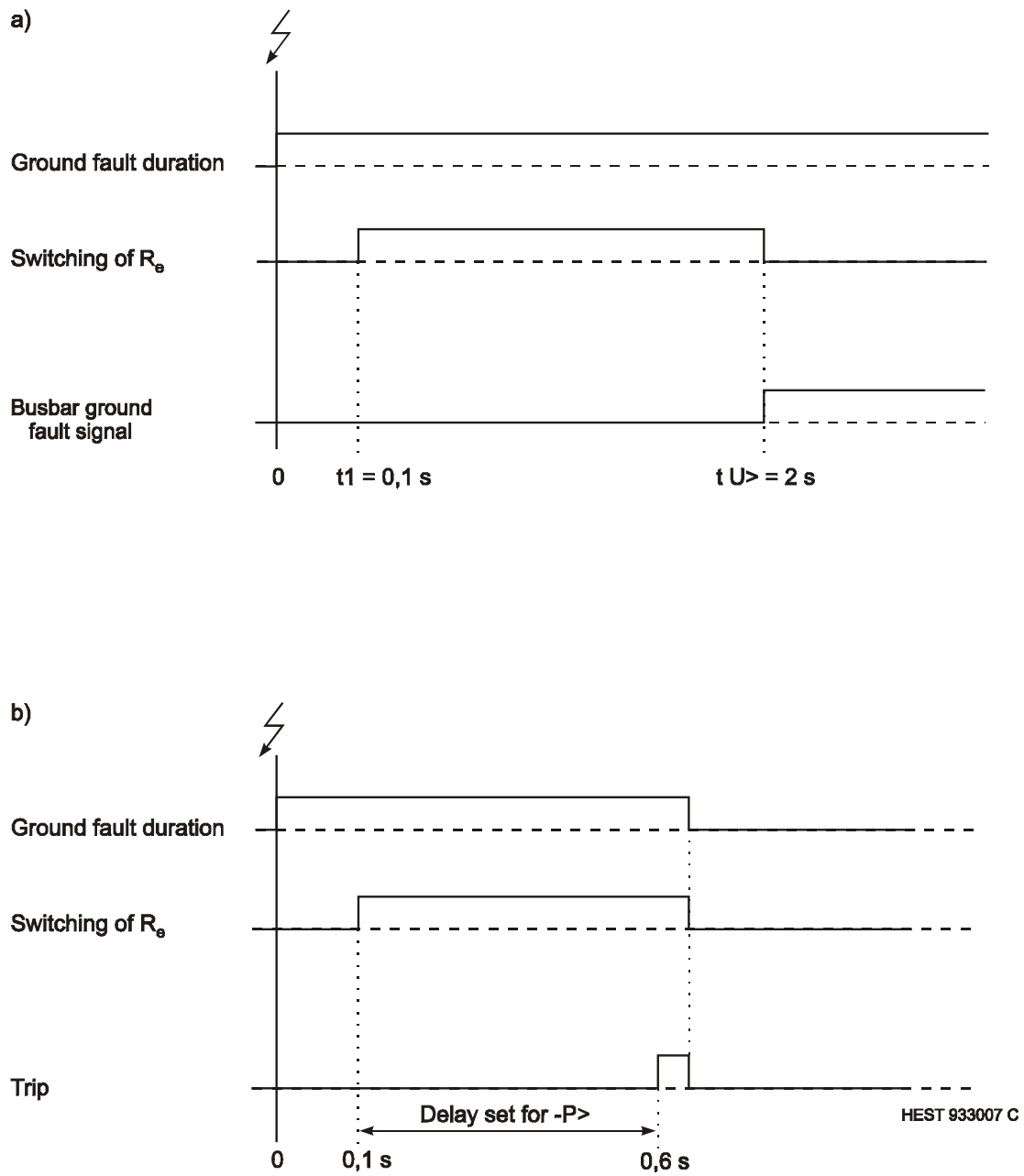
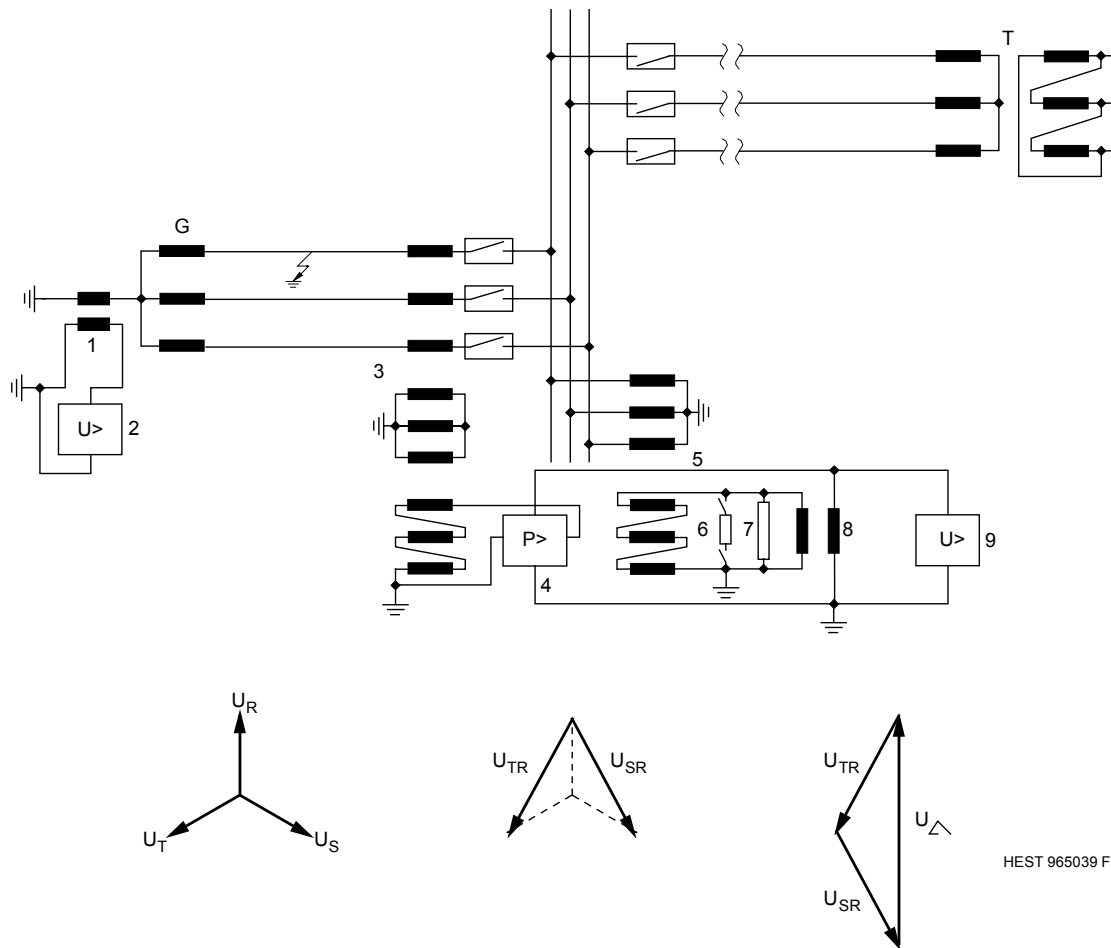


Fig. 4.21 Operation of the ground fault protection for a fault

- a) on the busbar
- b) on a feeder



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where:

- 1 v.t. at the generator neutral
- 2 start-up protection voltage relay
- 3 3 neutral c.t.'s for measuring the ground fault current
- 4 power relay for the generator ground fault protection scheme
- 5 grounding transformer
- 6 ground resistor  $R_e$  for the generator ground fault protection scheme
- 7 transient voltage damping resistor  $R_p$
- 8 intermediate v.t.
- 9 voltage relay for the busbar ground fault protection

Fig. 4.22 Three-phase circuit diagram of the protection and associated vector diagram



#### **4.7. 100% stator and rotor ground fault protection**

##### **Stator ground fault protection**

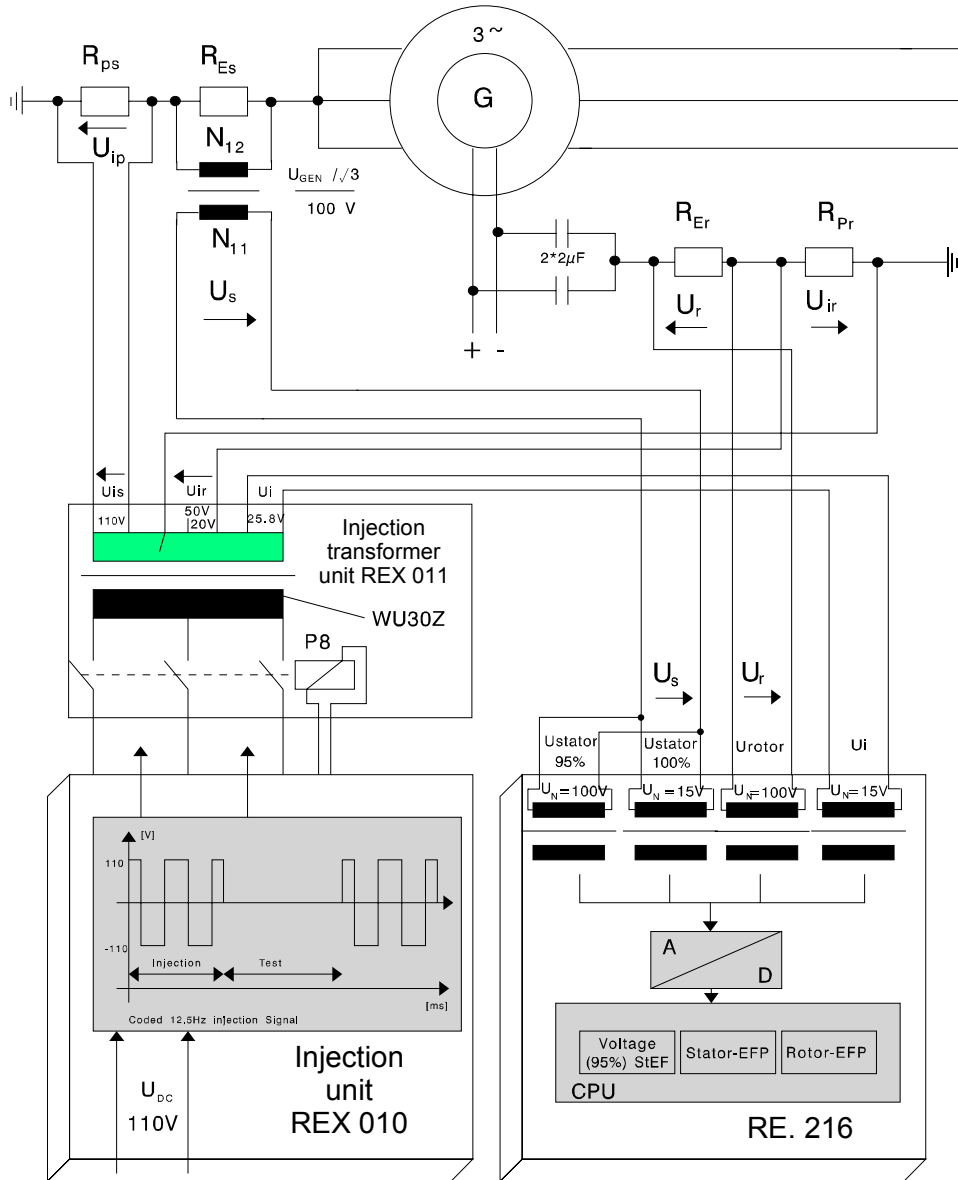
The ground fault protection of the entire stator winding comprises a 95 % scheme and a 100 % scheme (see Fig. 4.23). The zones of the two schemes overlap in the stator windings. Ground faults in the region of the generator terminals are detected primarily by the 95 % stator ground fault scheme. Ground faults near the star-point, on the other hand, can only be detected by the 100 % stator ground fault scheme.

The RE. 216 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 displace the star-point voltage. 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 block REX 011. The scheme measures the ground fault leakage resistance.



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Fig. 4.23 100% stator and rotor ground fault protection

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 $\Omega$  for alarm and 500  $\Omega$  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 to the whole stator winding.

### **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 off-set 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 block Type REX 011 as are used for the stator ground fault scheme.

## 4.8. *Distance protection*

### 4.8.1. *Starters*

#### 4.8.1.1. *Operation of the starters*

The RE.216 is equipped with either overcurrent or underimpedance starters. The setting of the parameter "StartMode" determines which of the two is in operation.

**A starter must pick up at least twice** before its signal is processed (for phase selection, starting timers, signalling etc.). Should a starter pick up only sporadically, only the backwards measuring system and ancillary functions such as displaying measurements etc. are enabled.

Starting signals do not reset unless all the starters have reset.

#### 4.8.1.2. *Overcurrent starters ( $I>$ )*

The variables at the I/P's of the overcurrent starters are the phase currents  $I_R$ ,  $I_S$  and  $I_T$  and the residual current  $I_E$  ( $3I_0$ ), respectively the neutral voltage  $U_E$  ( $3U_0$ ). Initially, a logic determines  $I_{max}$ , i.e. the highest of the three phase currents  $I_R$ ,  $I_S$  and  $I_T$ . If the value of  $I_{max}$  exceeds the setting of the parameter "Istart" (overcurrent starters), each of the phase currents  $I_{ph}$  is checked to determine whether it exceeds the setting of the parameter "Imin" (current enable) and also 80 % of  $I_{max}$ . In the case of the residual current, the corresponding values are the setting of the parameter "3I0min" and 25 % of  $I_{max}$ .

In the case of the ground current  $I_E$ , it is checked whether it exceeds the setting of the parameter "3I0min" and also 25 % of  $I_{max}$ . Depending on the setting of the parameter "Earth fault detector" (I0, I0 AND U0, I0 OR U0), it is checked at the same time whether the residual voltage has exceeded the setting of the parameter "3U0min" (neutral voltage enable).

The logic signals R, S, T and E are accordingly changed from logical "0" to logical "1" or remain at logical "0". The kind of fault and the phases involved are thus determined, information which is needed for

- phase selection (determination of the loop to be measured)
- signalling the kind of fault (signalling relays, LED's etc.)
- enabling signals for single or three-phase tripping
- starting the timers for the measuring zones.

The starting signals R, S, T and E do not reset until measurement has taken place and the impedances of all six loops lie outside the back-up impedance zone. (If only the overcurrent starters are in operation, there is no underimpedance starting characteristic and relay response is determined by the setting of the overcurrent starter "Istart".)

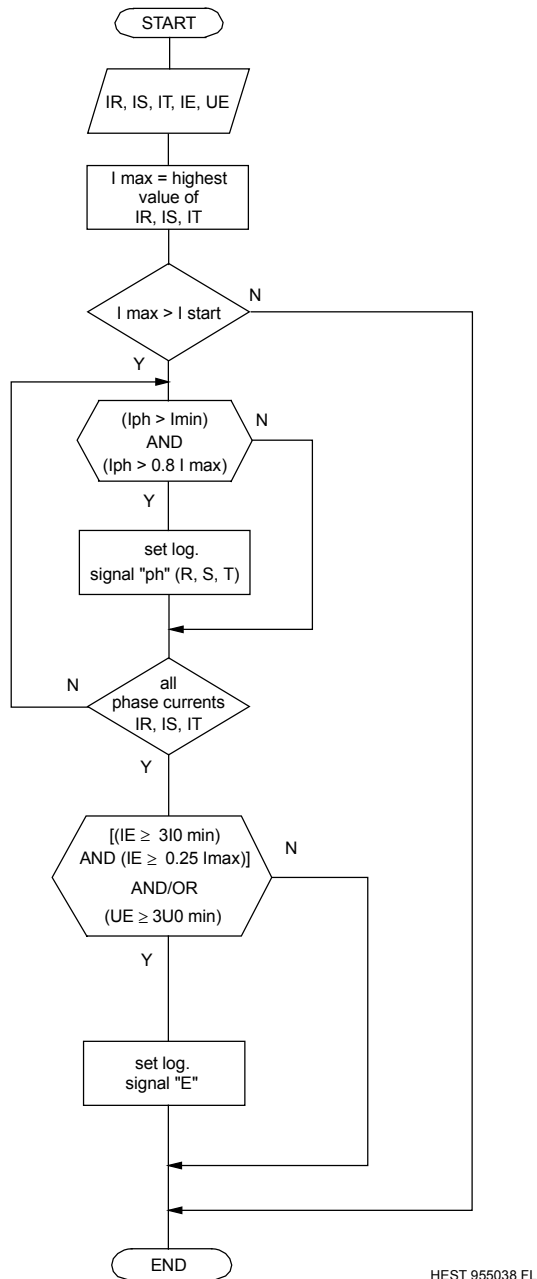
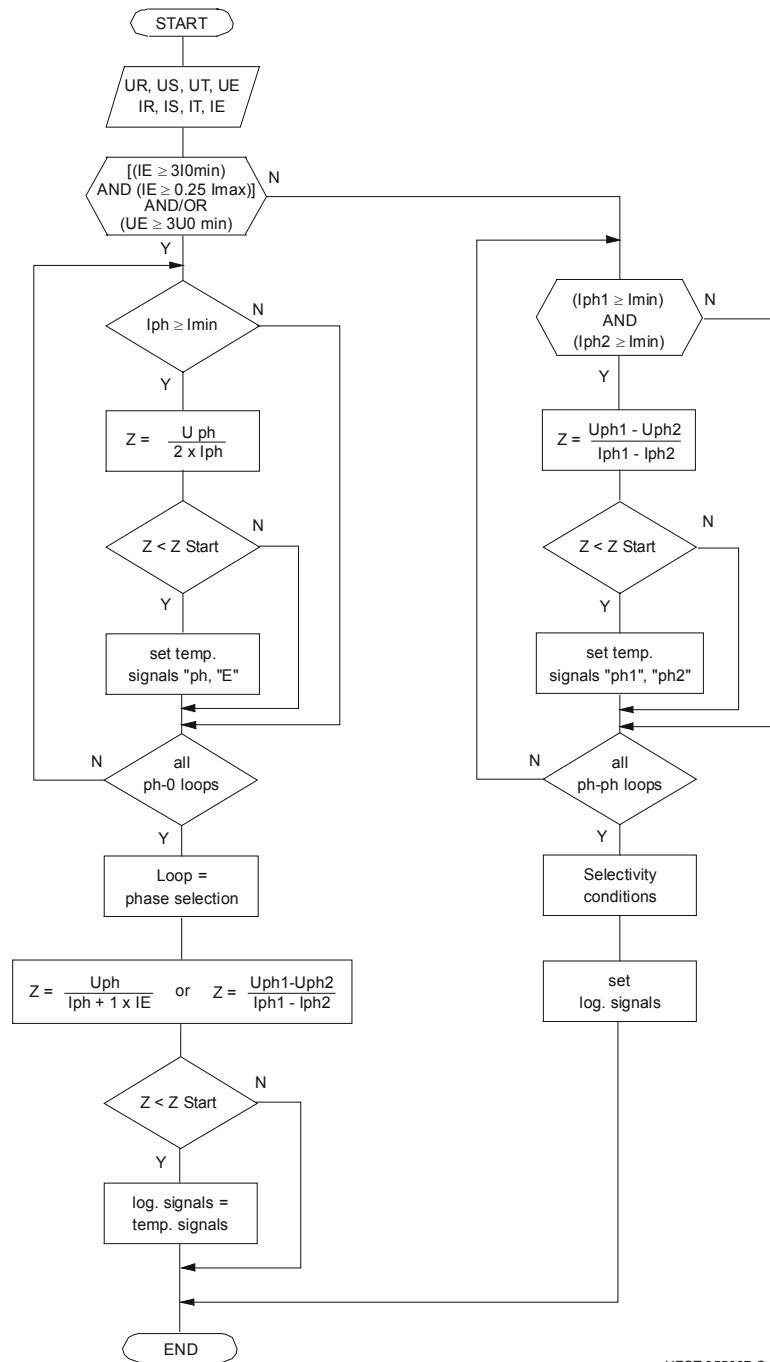


Fig. 4.24 Overcurrent starters (I>)

**4.8.1.3. Underimpedance starters (Z<) up to the first pick-up**

The variables at the I/P's of the underimpedance starters are the phase currents  $I_R$ ,  $I_S$  and  $I_T$  and the residual current  $I_E$  ( $3I_0$ ) and the phase-to-neutral voltages  $U_R$ ,  $U_S$ ,  $U_T$  and the neutral voltage  $U_E$  ( $3U_0$ ).



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Fig. 4.25 Underimpedance starters

Depending on the setting of the parameter “Earth fault detector” (I<sub>0</sub>, I<sub>0</sub> AND U<sub>0</sub>, I<sub>0</sub> OR U<sub>0</sub>), the function determines initially whether one or both of the E/F criteria is fulfilled, i.e. whether the residual current I<sub>E</sub> exceeds the setting of the parameter “3I<sub>0min</sub>” and/or the residual voltage U<sub>E</sub> the setting of the parameter “3U<sub>0min</sub>”. Should this be the case, the three phase-to-ground loops are measured first, otherwise just the three phase-to-phase loops.

**The three phase-to-ground loops are processed as follows:**

If I<sub>ph</sub> (I<sub>R</sub>, I<sub>S</sub> or I<sub>T</sub>) is greater than “I<sub>min</sub>”, the corresponding loops are enabled and the loop impedances calculated as follows:

$$Z_R = \frac{U_R}{2I_R} \quad (\text{uncompensated})$$

$$Z_S = \frac{U_S}{2I_S} \quad (\text{uncompensated})$$

$$Z_T = \frac{U_T}{2I_T} \quad (\text{uncompensated})$$

All uncompensated impedances Z<sub>R</sub>, Z<sub>S</sub> and Z<sub>T</sub> are compared with the starting characteristic and temporarily set the logical signals ‘Ph’ and ‘E’ (no display). An impedance loop is selected (see Section 4.8.1.4) on the basis of these signals (loop = selected phase).

If the loop is a **phase-to-neutral** one, the impedance is **compensated by k<sub>0</sub> = 1** for calculation:

$$Z_{Ph-0} = \frac{U_{Ph-0}}{I_{Ph-0} + k_0 \cdot I_E} \quad \text{e.g.} \quad Z_R = \frac{U_R}{I_R + k_0 \cdot I_E}$$

If the loop is a **phase-to-phase** one, the impedance is calculated using phase-to-phase quantities:

$$Z_{Ph-Ph} = \frac{U_{Ph-Ph}}{I_{Ph-Ph}} \quad \text{e.g.} \quad Z_{RS} = \frac{U_R - U_S}{I_R - I_S}$$

If the impedance (Z) calculated for the loop determined by the phase selection logic lies within the underimpedance starting characteristic (Z<sub>start</sub>), the loop is used for measurement.

The logical signals are needed for

- signalling the kind of fault (signalling relays, LED's etc.)
- enabling signals for tripping
- starting the timers for the measuring zones.

**The three phase-to-phase loops are processed as follows:**

Providing  $I_{ph1}$  and  $I_{ph2}$  ( $I_R$  and  $I_S$ ,  $I_S$  and  $I_T$ , or  $I_T$  and  $I_R$ ) are higher than " $I_{min}$ ", the corresponding loops are enabled and the impedances are calculated as follows:

$$Z_{RS} = \frac{U_R - U_S}{I_R - I_S}$$

$$Z_{ST} = \frac{U_S - U_T}{I_S - I_T}$$

$$Z_{TR} = \frac{U_T - U_R}{I_T - I_R}$$

Comparison of the three starting impedances eliminates the healthy loops (discrimination condition).

If just one of the loop impedances lies within the underimpedance starting characteristic ( $Z_{start}$ ), only the signals (R and S), or (S and T), or (T and R) would be set to logical "1".

If more than one of the loop impedances lie within the underimpedance starting characteristic, the signals R and S and T are set to logical "1". The kind of fault is thus determined, information which is needed for

- phase selection (determination of the loop to be measured)
- signalling the kind of fault (remote signalling relays, frontplate LED's etc.)
- enabling signals for single or three-phase tripping
- starting the timers for the measuring zones.



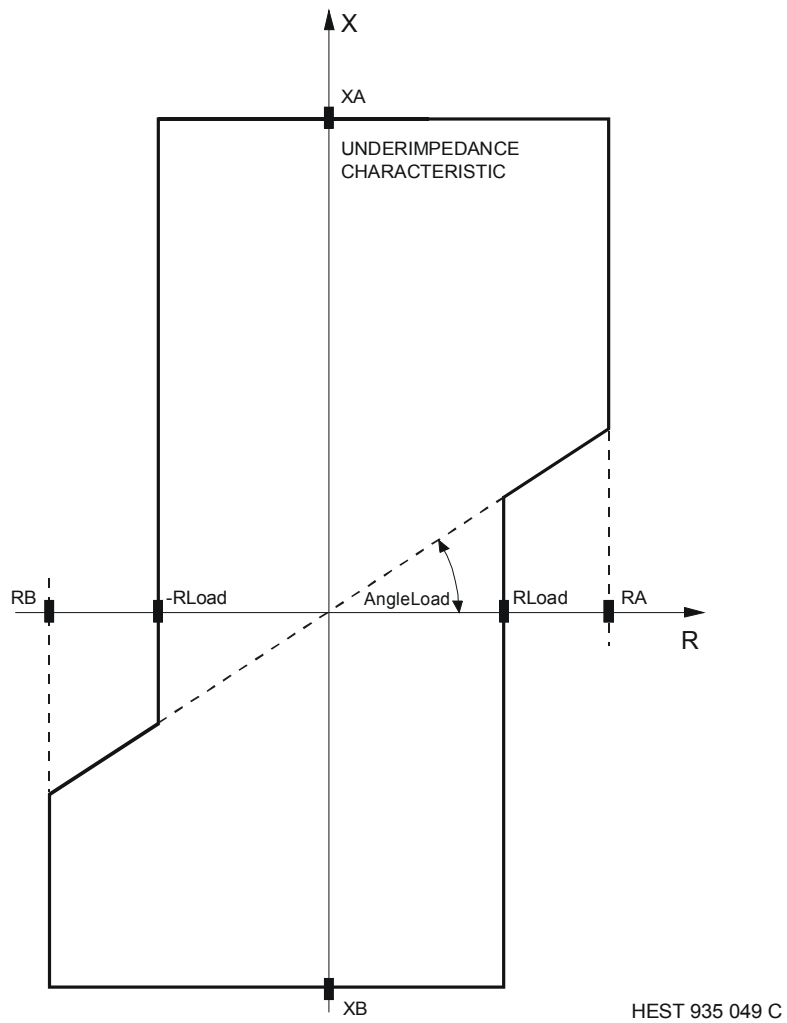
**Underimpedance starting and definitive zone characteristic**

Fig. 4.26 Underimpedance starting and definitive zone characteristic

#### 4.8.1.4. Phase selection

The phase selection logic determines the loop

- for the underimpedance starting measurement when an ground fault has been detected
- to be measured in the first period (max. 20 ms) after starting
- to be measured during the time the function is in the picked-up state when a ground fault has been detected on an ungrounded system or system with Petersen coils (phase selection  $\neq$  solidly grounded).

In a solidly grounded system (parameter "PhaseSelMode" set to "solid gr."), the loop to be measured is determined according to the following table:

	Starters	Loop measured
E/F	R,E	RE
E/F	S,E	SE
E/F	T,E	TE
Phase-to-phase fault	R,S	RS
Phase-to-phase fault	S,T	ST
Phase-to-phase fault	T,R	TR
Phase-to-phase-to-ground fault	R,S,E	RS
Phase-to-phase-to-ground fault	S,T,E	ST
Phase-to-phase-to-ground fault	T,R,E	TR
Three-phase fault	R,S,T	TR (RS) (ST)

In a solidly grounded system, both phases involved in a phase-to-phase-to-ground fault have to be tripped, which is not the case in ungrounded systems or a systems with Petersen coils. The phase-to-phase loops are measured.

In ungrounded systems or a systems with Petersen coils (parameter "PhaseSelMode" set to cyclic/acyclic phase selection), the loop to be measured is determined according to the following table:

	Starters	Loop measured
Phase-to-phase fault	R,S	RS
Phase-to-phase fault	S,T	ST
Phase-to-phase fault	T,R	TR
Three-phase fault	R,S,T	TR (RS) (ST)
Cross-country fault *)	R,S,E	} according to phase selection logic
Cross-country fault *)	S,T,E	
Cross-country fault *)	T,R,E	

\*) two E/F's at different locations

In ungrounded systems or systems with Petersen coils, it is usual for only one E/F of the two involved in a cross-country fault to be tripped, so that as much of the system remains in operation as possible.

This is achieved by arranging for all the distance relays on the system to measure the same E/F loop and this is the purpose of the phase selection function.

The logic of the phase selection function provides a choice of the following sequences:

Starters	Fault loop measure in relation to "PhaseSelMode"							
	RTSR cycl.	TRST cycl.	RTS acycl.	RST acycl.	TSR acycl.	TRS acycl.	SRT acycl.	STR acycl.
R, S, E	SE	RE	RE	RE	SE	RE	SE	SE
S, T, E	TE	SE	TE	SE	TE	TE	SE	SE
T, R, E	RE	TE	RE	RE	TE	TE	RE	TE

RTSR cyclic (R before T, T before S, S before R) means, for example, that for a cross-country fault T-R-E, R phase (the R-E loop) is measured rather than T phase, for a cross-country fault S-T-E, T phase (the T-E loop) rather than S phase and for a cross-country fault R-S-E, S phase (the S-E loop) rather than R phase.

RTS acyclic (R before T before S) means, for example, that for a cross-country fault T-R-E, R phase (the R-E loop) is measured rather than T phase, for a cross-country fault S-T-E, T phase (the T-E loop) rather than S phase and for a cross-country fault R-S-E, R phase (the R-E loop) rather than S phase.

## 4.8.2. *Measuring units*

### 4.8.2.1. *Operation of the measuring units*

The distance measurement of a fault is enabled after one of the two starting functions, overcurrent or underimpedance, has picked up twice.

Initially the fault loop determined by the phase selection function is measured. This is called **processing period I** and lasts until a trip signal is generated in the first zone or a maximum of one period of the power system frequency.

At the latest after one period of the power system frequency, all six impedance loops are measured. This is called **processing period II**, during which the three phase-to-ground loops and the three phase-to-phase loops are measured alternately.

Comparison of the results of the six measurements eliminates those impedance loops, which are not involved in the fault (discrimination conditions).

The timer started by the starting units controls the comparison of the measured impedances with the polygon characteristic.

#### 4.8.2.2. *Measurement during processing period I*

Processing period I lasts from the instant a starter picks up until the first tripping signal is generated, but is restricted to a maximum of one period of the power system frequency. The input signals are the phase currents  $I_R$ ,  $I_S$ ,  $I_T$ , the residual current  $I_E$  ( $3I_0$ ), the residual current of any parallel circuit  $I_{Em}$  ( $3I_{0m}$ ), the neutral current  $I_{Em}$  of any parallel circuit of a double-circuit line ( $3I_{0m}$ ) and the three phase-to-ground voltages  $U_R$ ,  $U_S$  and  $U_T$ , which have been sampled, analogue and digitally filtered and broken down into their component vectors.

If the overcurrent starters are in operation and have picked up, the phase selection function is performed and the loop to be measured determined. Should this not be the case, the loop determined by the underimpedance starters is measured.

**The impedance of a phase-to-ground loop**, e.g. R-E is calculated using the equation:

$$Z_R = \frac{U_R}{I_R + k_0 \cdot I_E + k_{0m} \cdot I_{Em}} \quad (\text{compensated})$$

$k_0$  zero-sequence compensation factor for  $Z_0$   
 $k_0 = (Z_0 - Z_1) / 3Z_1$

$k_{0m}$  zero-sequence compensation factor for the mutual impedance  $Z_{0m}$  of double-circuit line  
 $k_{0m} = Z_{0m} / 3Z_1$

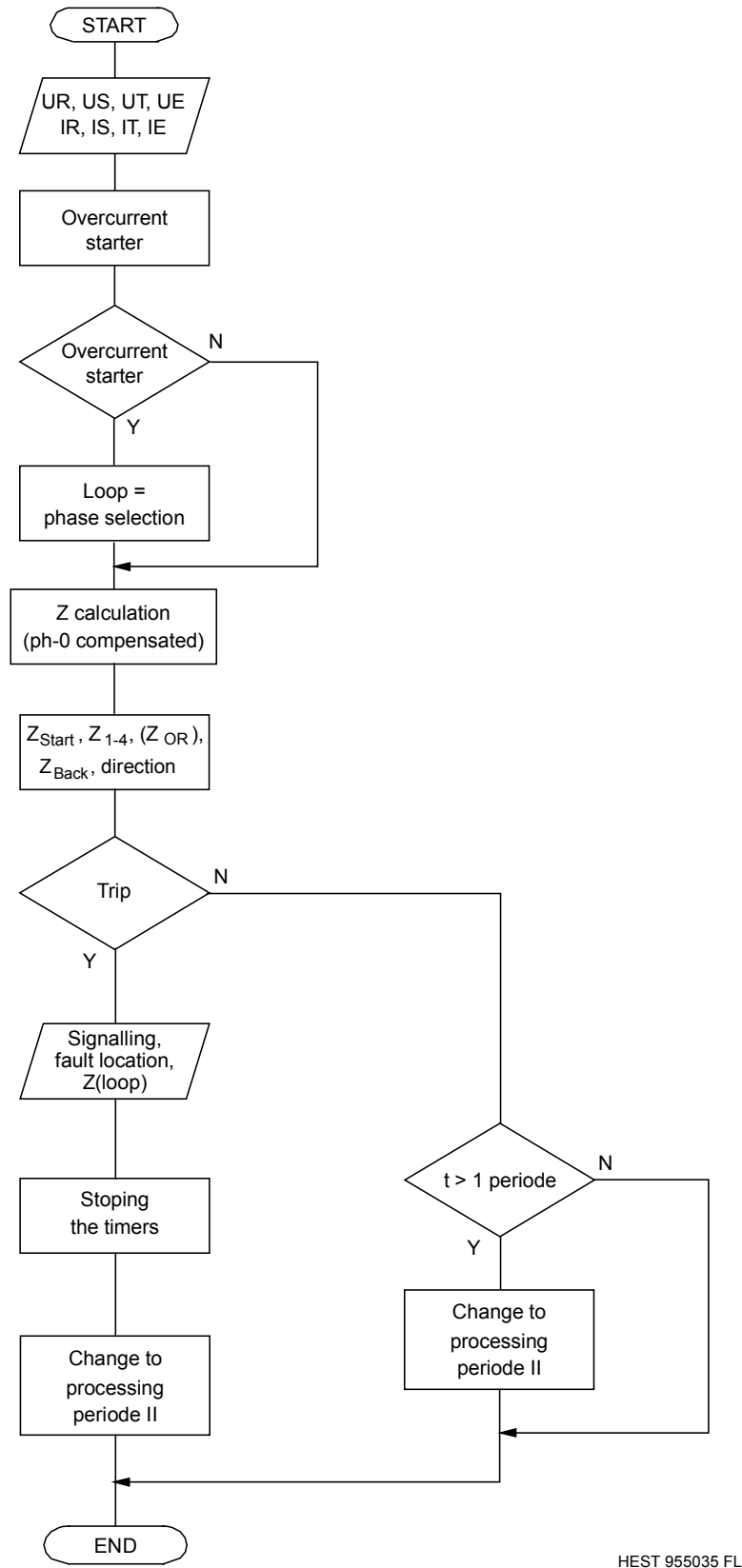
The mutual zero-sequence impedance of a double-circuit line ( $k_{0m} \cdot I_{Em}$ ) is only compensated for the 1st., 2nd. and overreaching zones, and in the latter two cases, only if their direction of measurement is the same as that of the 1st. zone. In this respect, a reverse measuring zone is treated in the same manner as an overreaching zone.

The mutual zero-sequence impedance ( $k_{0m} \cdot I_{Em}$ ) is not compensated, should  $I_{Em}$  exceed  $1.25 \cdot I_E$  or the direction of  $I_{Em}$  not be the same as that of  $I_E$ . This prevents a "healthy" parallel circuit from being adversely influenced by a fault relatively close to the relay location of the faulted circuit.

Assuming a fault between R and S, **the impedance of the phase-to-phase loop** is calculated using the equation:

$$Z_{RS} = \frac{U_R - U_S}{I_R - I_S}$$

It is determined almost simultaneously, whether the impedance measured lies within the characteristic and whether it is in the direction of the 1st. zone and overreaching zone, or in the direction of the reverse measuring zone. The corresponding tripping and other signals are processed by the system logic. **Tripping of the circuit-breaker, however, only takes place after a measuring unit has operated twice.**



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Fig. 4.27 Processing period I

### 4.8.2.3. *Measurement during processing period II*

Processing period II commences after the first tripping signal or at the latest one period of the system frequency after a starter picks up. The variables measured are the same as those already processed during processing period I.

Only in the case of a cross-country fault in an ungrounded system or system with Petersen coils is measurement restricted during processing period II to just the impedance loop determined by the phase selection logic.

Otherwise all the phase-to-ground and phase-to-phase impedance loops are continuously processed in sequence, providing the enabling and ground fault criteria are fulfilled.

The equations used to calculate the loop impedances are the same as those in the preceding Section.

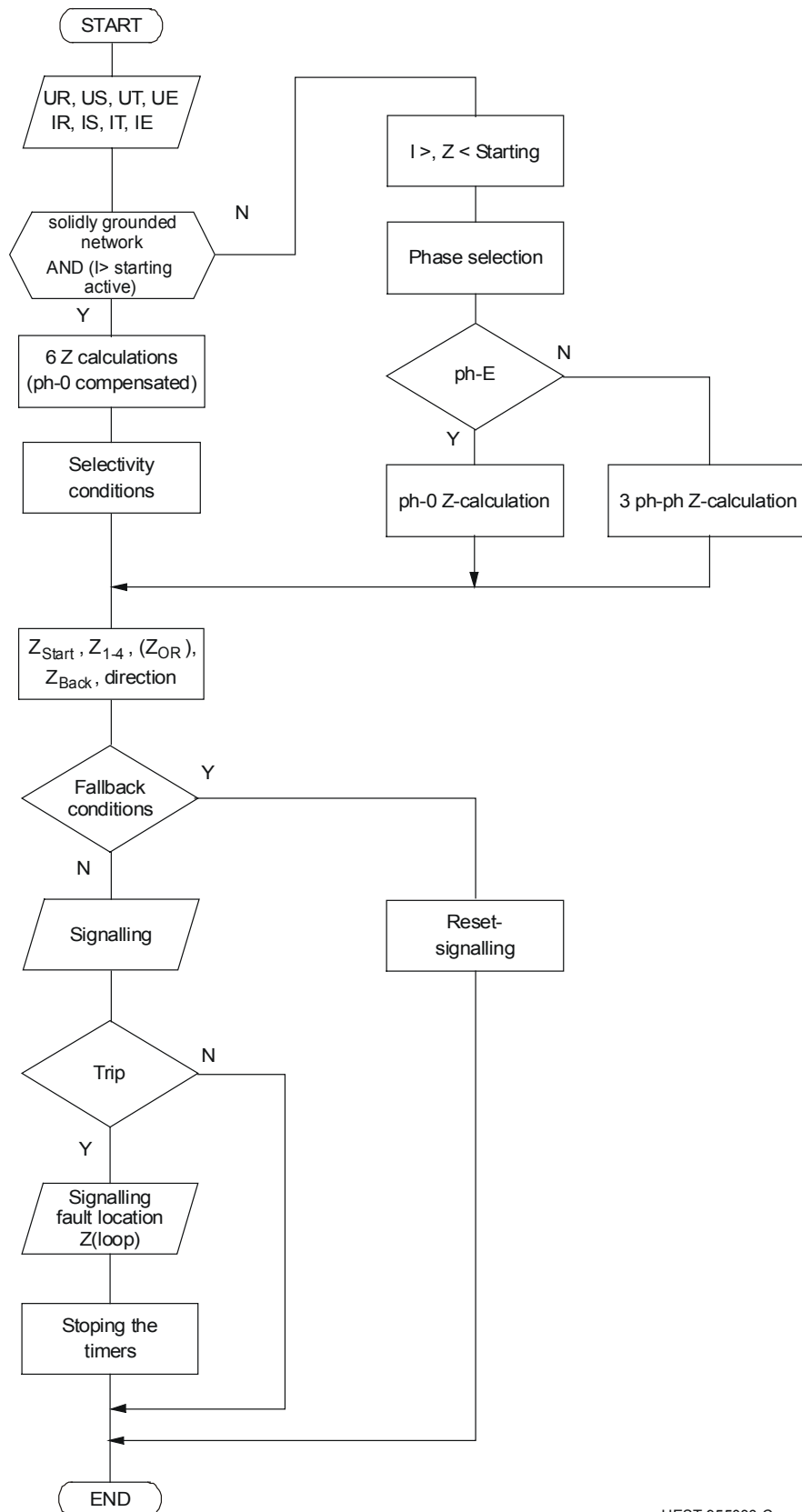
It is then determined whether the impedance measured lies within the characteristic and whether it is in the direction of the zone being measured. The overreaching zone and reverse measuring zone are evaluated as part of the measurement of the 1st. zone. The corresponding tripping and other signals are processed by the system logic. **Tripping of the circuit-breaker, however, only takes place after a measuring unit has operated twice.**

#### **Displaying impedance and fault distance**

The impedance and fault distance only appear in the even list after a further measurement has tripped unless

- the measuring loop, i.e. the phase selection, has changed
- the impedance is measured to be outside the characteristic
- tripping was initiated by the reverse measuring zone, the overreaching zone or the switch-onto-fault (SOTF) logic.

In the above cases, the impedance and fault distance stored by the preceding measurement (which produced tripping) is displayed.



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Fig. 4.28 Processing period II



#### 4.8.2.4. *Directional decision*

Before deciding the direction of a fault, the fault voltage (used as reference voltage) is checked to determine whether it is higher than the setting of the parameter “UminFault” (minimum fault voltage). Providing this is the case, the phase-angle of the impedance, i.e. between fault current and voltage, is determined:

$$\arg Z = \arg \frac{U}{I}$$

$$\arg Z = \arg U - \arg I$$

where

arg: argument of the complex number (angle)

U: fault voltage

$$U = U_R \quad (\text{phase-to-ground loop, e.g. R-E})$$

$$U = U_R - U_S \quad (\text{phase-to-phase loop, e.g. R-S})$$

I: fault current

$$I = I_R + I_E \cdot k_0 + I_{Em} \cdot k_{0m} \quad (\text{phase-to-ground loop, e.g. R-E})$$

$$I = I_R - I_S \quad (\text{phase-to-phase loop, e.g. R-S})$$

arg Z must lie within the following limits for the fault to be designated a “forwards fault”:

$$- 27^\circ < \arg Z < + 117^\circ$$

arg Z must lie within the following limits for the fault to be designated a “reverse fault”:

$$+ 153^\circ < \arg Z < - 63^\circ$$

Z is the impedance measured by the protection, which corresponds to the line impedance  $Z_L$ . By using the fault voltage as reference voltage for determining direction, the measurement is independent of source impedance (see following [Section 4.8.2.5](#) “Construction of the measuring characteristic”).

If the fault voltage is less than the setting of the parameter “UminFault” (minimum fault voltage), the impedance is determined from the fault current and a separate reference voltage:

$$\arg Z_{\text{ref}} = \arg \frac{U_{\text{ref}}}{I} = \arg U_{\text{ref}} - \arg I$$

where

arg: argument of the complex number (angle)

$U_{\text{ref}}$ : reference voltage

$$U_{\text{ref}} = (U_S - U_T) \cdot \sqrt{2} \quad (\text{phase-to-ground loop, e.g. R-E})$$

$$U_{\text{ref}} = (U_R - U_T) + 1/8 \cdot (U_{\text{Rmem}} - U_{\text{Tmem}}) \quad (\text{phase-to-phase loop, e.g. R-S})$$

$I$ : fault current

$$I = I_R + I_E \cdot k_0 + I_{\text{Em}} \cdot k_{0m} \quad (\text{phase-to-ground loop, e.g. R-E})$$

$$I = I_R - I_S \quad (\text{phase-to-phase loop, e.g. R-S})$$

The reference voltage  $U_{\text{ref}}$  is derived from the phase voltages not involved in the fault. In the case of a phase-to-phase loop, the reference voltage also includes a proportion of the memory voltage  $U_{\text{mem}}$ . The duration of the memory voltage is limited to between 5 and 15 periods of the power system frequency, depending on the discrepancy between the measured frequency and the rated power system frequency, i.e. the memory voltage is used for 15 periods at rated system frequency and for a proportionally reduced number of periods as the frequency deviates from rated power system frequency.

As long as the reference voltage  $U_{\text{ref}}$  is greater than 0.5% of rated voltage, it is used to determine fault direction:

In this case, a “forwards fault” satisfies the condition:

$$-90^\circ < \arg Z_{\text{ref}} < +90^\circ$$

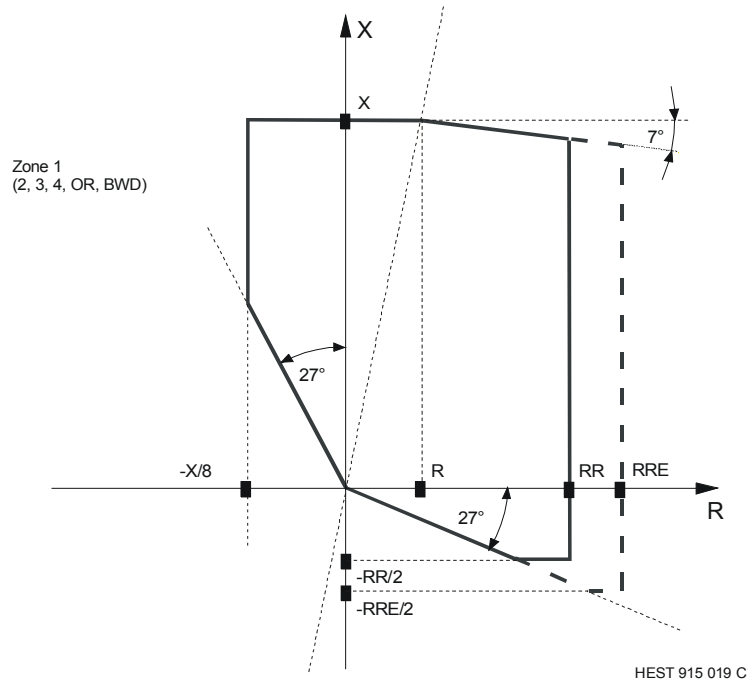
A “reverse fault” satisfies the condition:

$$+90^\circ < \arg Z_{\text{ref}} < -90^\circ$$

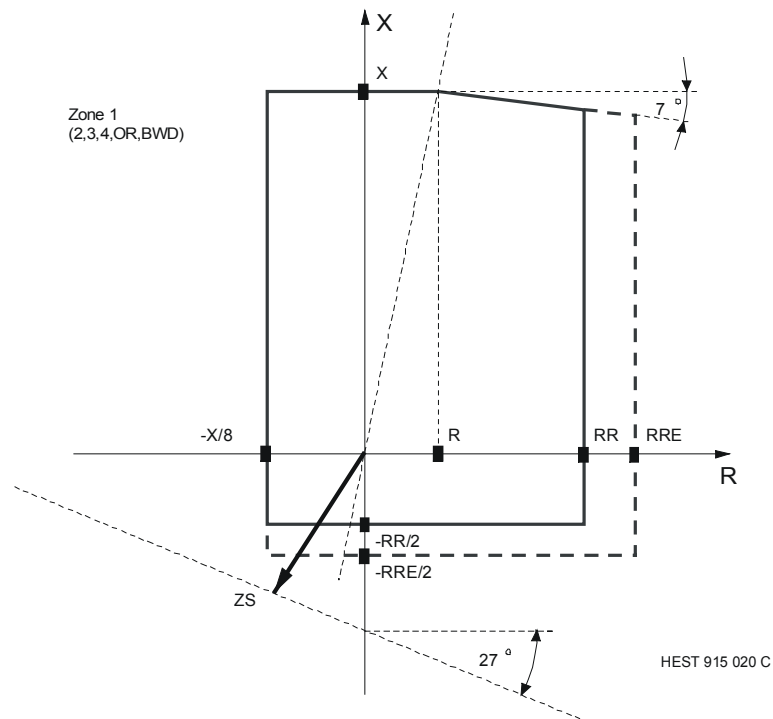
$Z_{\text{ref}}$  is the impedance measured by the protection, which contains a component of the source impedance  $Z_S$  in addition to the line impedance  $Z_L$ . The operating characteristic has to be mathematically transformed in order to make the influence of the source impedance visible (see following [Section 4.8.2.5.](#), “Construction of the measuring characteristic”).

If the reference voltage is less than 0.5% of rated voltage, direction is not taken into account for the phase-to-ground loop and tripping is blocked. In the case of the phase-to-phase loops, tripping is either enabled or blocked, depending on the setting of the parameter “MemDirMode”.

**4.8.2.5. Construction of the measuring characteristic**



**Fig. 4.29** Measuring characteristic using the fault voltage as reference



**Fig. 4.30** Measuring characteristic using a healthy voltage as reference

**4.8.3. V.t. supervision**

The purpose of the v.t. supervision function is to monitor the v.t. leads with respect to asymmetrical short-circuits and open-circuits. An m.c.b. can be included for three-phase v.t. short-circuits and arranged to block the protection via a separate optocoupler I/P.

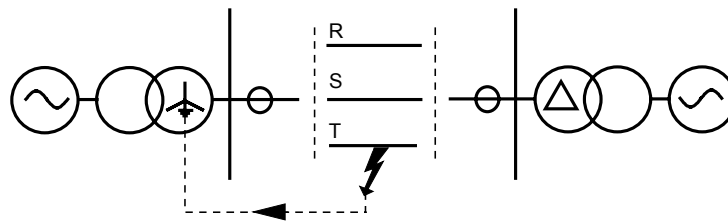
The I/P variables monitored by the v.t. supervision function are the three voltages  $U_R, U_S,$  and  $U_T$  and the three currents  $I_R, I_S, I_T$ . The zero-sequence ( $U_0, I_0$ ) and negative-sequence ( $U_2, I_2$ ) components are calculated for both the three-phase voltage and three-phase current systems.

$$3U_0 = U_R + U_S + U_T$$

$$3U_2 = U_R + U_S \cdot a^2 + U_T \cdot a \quad a = -0.5 + j\sqrt{\frac{3}{2}} = 1 \angle 120^\circ$$

$$3I_0 = I_R + I_S + I_T$$

$$3I_2 = I_R + I_S \cdot a^2 + I_T \cdot a$$

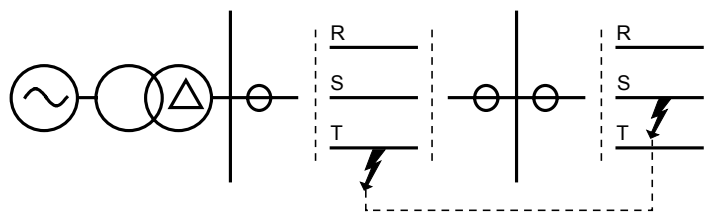


$$\begin{matrix} 3I_0 > 0 & I_2 > 0 \\ 3U_0 > 0 & U_2 > 0 \end{matrix}$$

$U_0$  and not  $I_0$

$$\begin{matrix} 3I_0 = 0 & I_2 > 0 \\ 3U_0 > 0 & U_2 > 0 \end{matrix}$$

$U_2$  and not  $I_2$



$$\begin{matrix} 3I_0 > 0 & I_2 > 0 \\ 3U_0 > 0 & U_2 > 0 \end{matrix}$$

$U_2$  and not  $I_2$

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Fig. 4.31 V.t. supervision

The measurement has to be performed using the negative-sequence component, whenever there is no source of residual current behind the relay, i.e. no grounded transformer neutrals. The parameter "VTSupMode" (operating mode) must be set accordingly.

The zero and/or negative-sequence components of currents and voltages are compared with the settings of the parameters "U0min VTSup" [U0\_VTSUP], "I0min VTSup" [I0\_VTSUP], "U2min VTSup" [U2\_VTSUP] and "I2min VTSup" [I2\_VTSUP] and the associated binary signals  $U_0$ ,  $U_2$ ,  $I_0$  and  $I_2$  are then set to logical "1" or left at logical "0".

The signals  $U_0$  and  $U_2$  are delayed by 5 ms as a precaution against incorrect blocking as a result of discrepancies between the operating times of the three circuit-breaker poles.

Depending on the operating mode selected, one of the following four conditions is monitored:

$U_0 \cdot \text{not } I_0$	residual voltage, but no residual current
$U_2 \cdot \text{not } I_2$	NPS voltage, but no NPS current
$(U_0 \cdot \text{not } I_0) + (U_2 \cdot \text{not } I_2)$	condition 1 or 2
$U_2 \cdot \text{not } (I_0 + I_2)$	NPS voltage, but neither residual current nor NPS current.

Blocking by the v.t. supervision function is delayed for 12 s following manual closing of the circuit-breaker, an external blocking signal (m.c.b. via an opto-coupler I/P), a transfer tripping signal from the opposite station or the generation of a local tripping signal.

Should  $U_0$  (or  $U_2$ ) and  $I_0$  (or  $I_2$ ) pick-up during this delay, operation of the v.t. supervision function remains blocked until  $U_0$  (or  $U_2$ ) resets. This measure prevents unwanted blocking during single-phase auto-reclosure.

The signal generated by the v.t. supervision function 'VTSup-Mode' instantly blocks the distance protection function. Resetting the parameter 'VTSupMode' [VTSUP\_BLKDEL] enables the distance function to be blocked after delay of 12 s.

From 12 s after the v.t. supervision circuit has picked up, resetting of blocking is delayed by 1 s. Standard m.c.b.'s can therefore be used, providing their main contacts do not close before their auxiliary contacts.

Blocking by the v.t. supervision circuit resets the instant a fault with zero and negative-sequence components occurs.  
 The parameter 'VTSupDebDel' [VTSUP\_DEBDEL] (deblocking) provides facility for setting the 1 s reset delay permanently regardless of current.

The blocking signal issued by the v.t. supervision function does not influence the back-up overcurrent function.

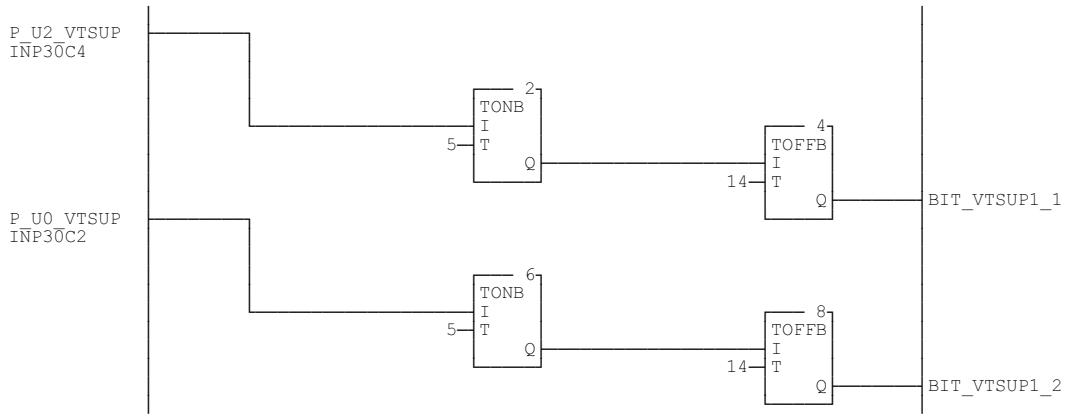


Fig. 4.32 Segment: VTSUP1

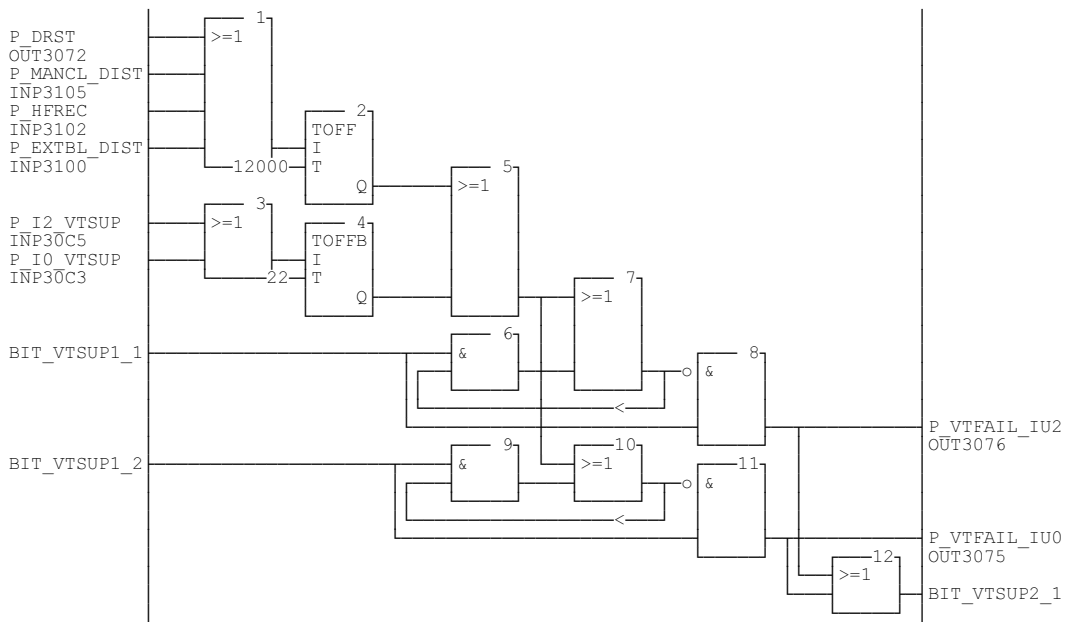


Fig. 4.33 Segment: VTSUP2

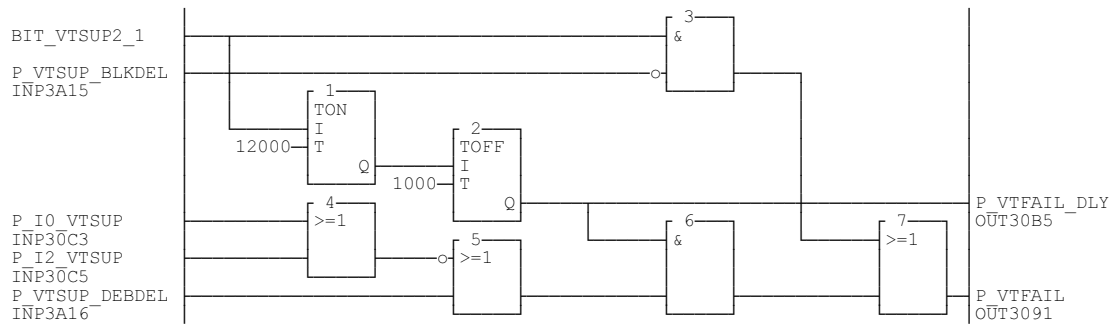


Fig. 4.34 Segment: VTSUP3

#### 4.8.4. Back-up overcurrent function O/C

The distance protection function includes a definite time overcurrent unit as back-up protection. A starting signal “Start O/C” is set to logical “1”, when one or more of the currents  $I_R$ ,  $I_S$ , and  $I_T$  exceed the setting of the parameter “I O/C”. Following the adjustable time delay “O/C delay”, the tripping signal “Trip O/C” is set to logical “1” and applied to the system logic.

Blocking signals generated by the distance, underimpedance starting, power swing blocking or v.t. supervision functions do not influence the back-up overcurrent function.

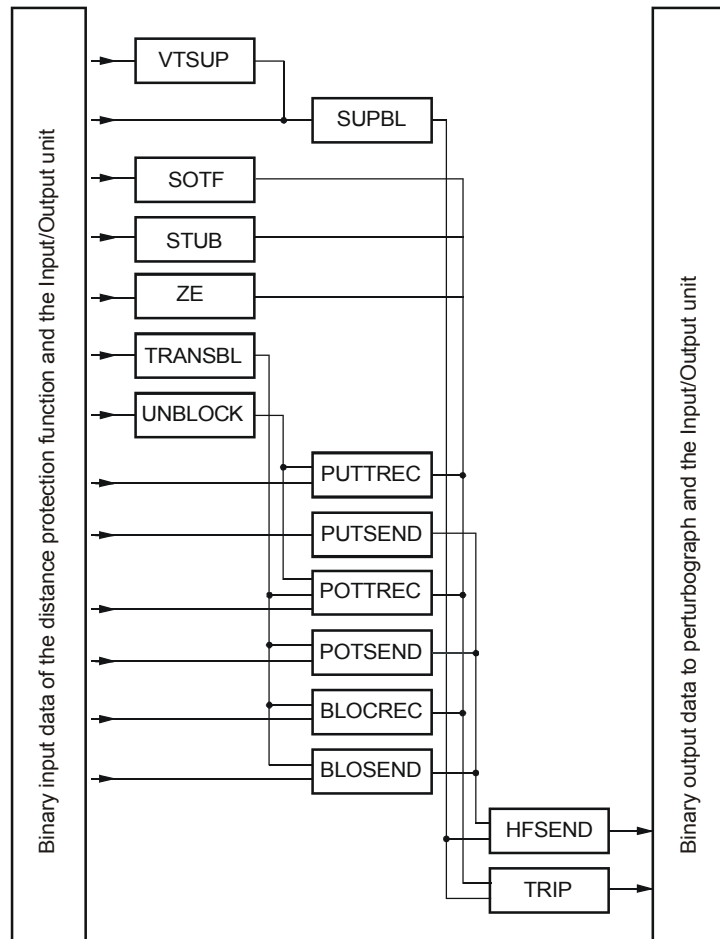
The back-up overcurrent function is independent of the distance protection starters and, since it does not have to perform any phase selection, can therefore have a more sensitive setting.

#### 4.8.5. System logic

##### 4.8.5.1. Structure of the system logic

The system logic processes the binary I/P signals from external plant (opto-coupler I/P's) and all the binary signals of the distance protection function.

The system logic is programmed using FUPLA (function block programming language) and is divided into what are referred to as segments, which are processed with a higher priority than, for example, the auto-reclosure function.



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Fig. 4.35 System logic in the distance protection function

The O/P's of the system logic are binary signals for controlling a fault recorder, LED signals and auxiliary tripping and signalling relays.

#### 4.8.5.2. **Enabling and blocking logic (SUPBL)**

The logic of the v.t. supervision function (segment VTSUP) has already been described in the relevant Section. The segment SUPBL coordinates all the external blocking signals distance protection [EXTBL\_DIST] (opto-coupler I/P's), the power swing blocking function [PS\_BLOCK] and the v.t. supervision function [VT\_BLOCK] and blocks all the distance protection functions [DISTBL] with the exception of the back-up overcurrent function.



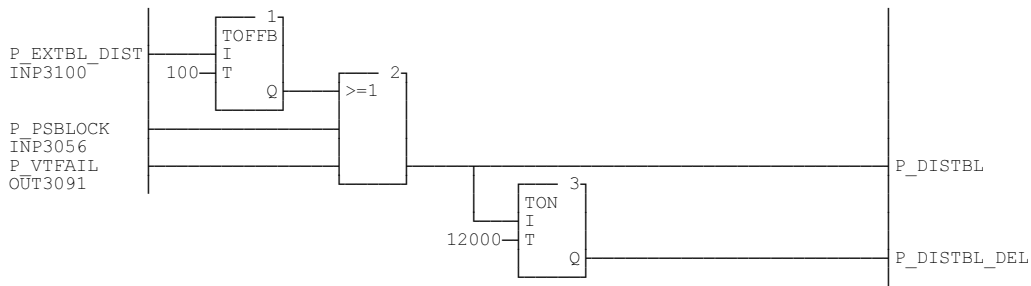


Fig. 4.36 Segment: SUPBL

#### 4.8.5.3. Switch-onto-fault logic (SOTF)

When a circuit-breaker is closed onto and existing three-phase fault (e.g. forgotten earthing clamps), a three-phase trip is immediately initiated.

The fault detectors in this case are the non-directional starters (overcurrent or underimpedance units) or optionally the overreaching zone, but this is only used in the following special cases:

- power transformer with high inrush currents at the remote end of the line. In such cases fault detection involving the distance measuring units is safer.
- close faults with complete voltage collapse may possibly not otherwise be detected, in which case the parameter “MemDirMode” has to be set to “Trip”.

The switch-onto-fault logic can be activated and the switch-onto-fault signal [SOTF] set to logical “1” in one of three ways:

- 1) by an auxiliary contact of the CB control switch when closing the CB (opto-coupler I/P “Manual close” [MANCL\_DIST])
- 2) by an auxiliary contact of the CB when opening the CB (opto-coupler I/P “Dead line” [DEADLINE])
- 3) by prolonged undervoltage (‘U weak’) on all three phases and no current enable which corresponds to a dead line [UWEAK\_R,S,T].

Alternative 2) is used, if the v.t.’s are connected to the busbars and alternative 1) is not possible. The criteria of alternatives 2) and 3) may only be recognised after either 200 ms or 10 s [SOTF\_10S] (setting), depending on whether the switch-onto-fault logic is required to operate after auto-reclosure (200 ms) or

not (10 s). For dead times longer than 10 s (autoreclosure function) there is the possibility of using the blocking input ‘Ext Blk SOTF’. This is a binary I/P which is interlocked by [P\_SOTF\_INIT] via an AND gate (see Section 3.5.32.2).

Combining undervoltage and a missing current enable signal [CREL\_R, S, T] as in alternative 3) prevents mal-operation of the logic after 200 ms, respectively 10 s, in cases of system faults with low fault current contribution, which are detected in the higher distance zones.

Resetting of the signal “SOTF” [START\_SOTF] is delayed by 1 s, i.e. every distance protection start within a time of 1 s after one of the three switch-onto-fault criteria was fulfilled gives rise to three-phase tripping [SOTF] of the circuit-breaker.

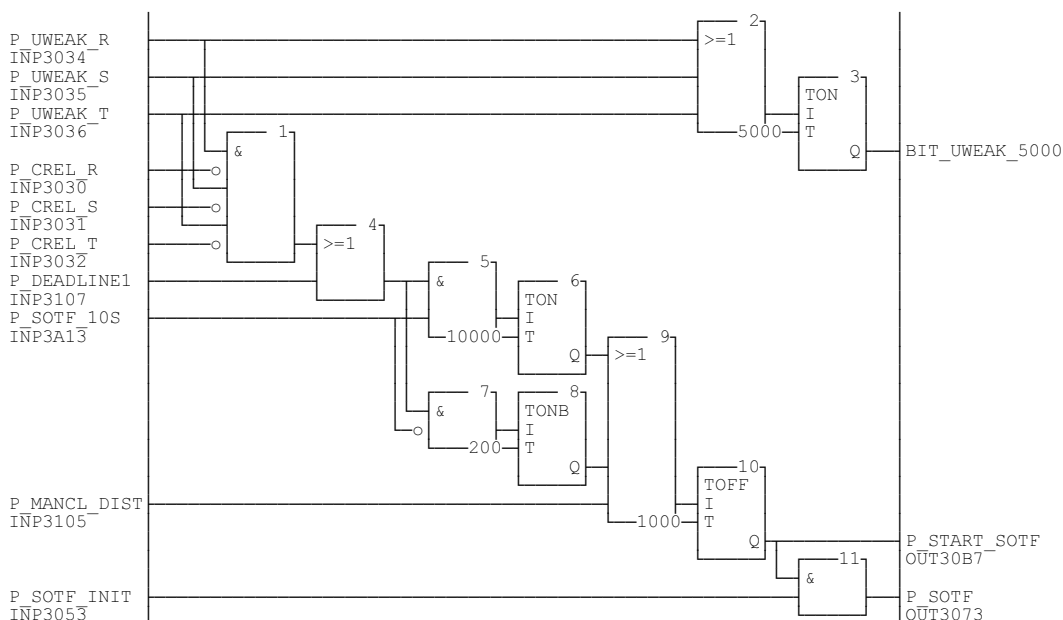


Fig. 4.37 Segment: SOTF

**4.8.5.4. Short-zone logic (STUB)**

In 1½ breaker schemes, the short zone between the two circuit-breakers and the line isolator can be protected by the back-up overcurrent function by permitting its instantaneous pick-up signal [OC\_RST] to trip the circuit-breakers [TRIP\_STUB] after 25 ms whenever the line isolator is open (signal applied to the opto-coupler I/P “Isol open”).

This arrangement is only necessary, if the v.t.'s are installed on the line side of the isolator and the c.t.'s are in the bars between the circuit-breakers.

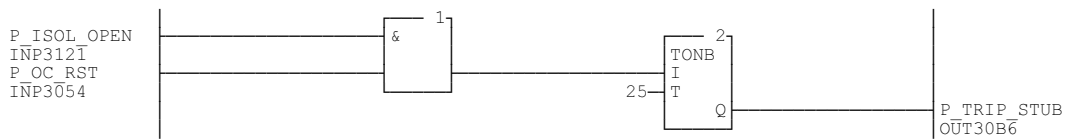


Fig. 4.38 Segment: STUB

#### 4.8.5.5. Zone extension logic (ZE)

This logic enables the reach of the distance measurement to be switched from the underreaching first zone to overreaching [BIT\_TRIP\_ZE] under the control of a signal from another function or an external signal.

Such a signal can originate, for example, from the internal auto-reclosure function (binary input “ZExtensionAR” [AR\_ZE]) or from an opto-coupler input (binary input “ZExtension” [ZE\_FOR\_DIST]).

The internal auto-reclosure function issues an overreach signal [AR\_ZE] when all the auto-reclosure conditions are fulfilled.

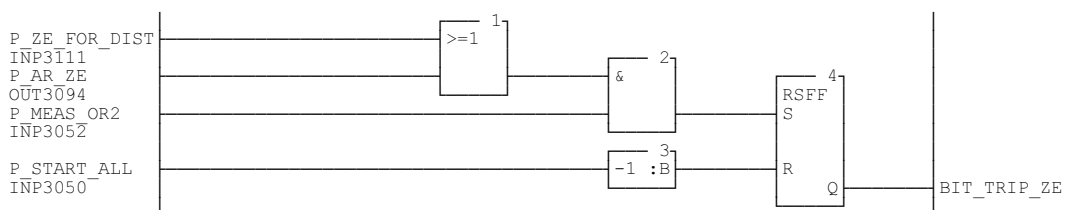


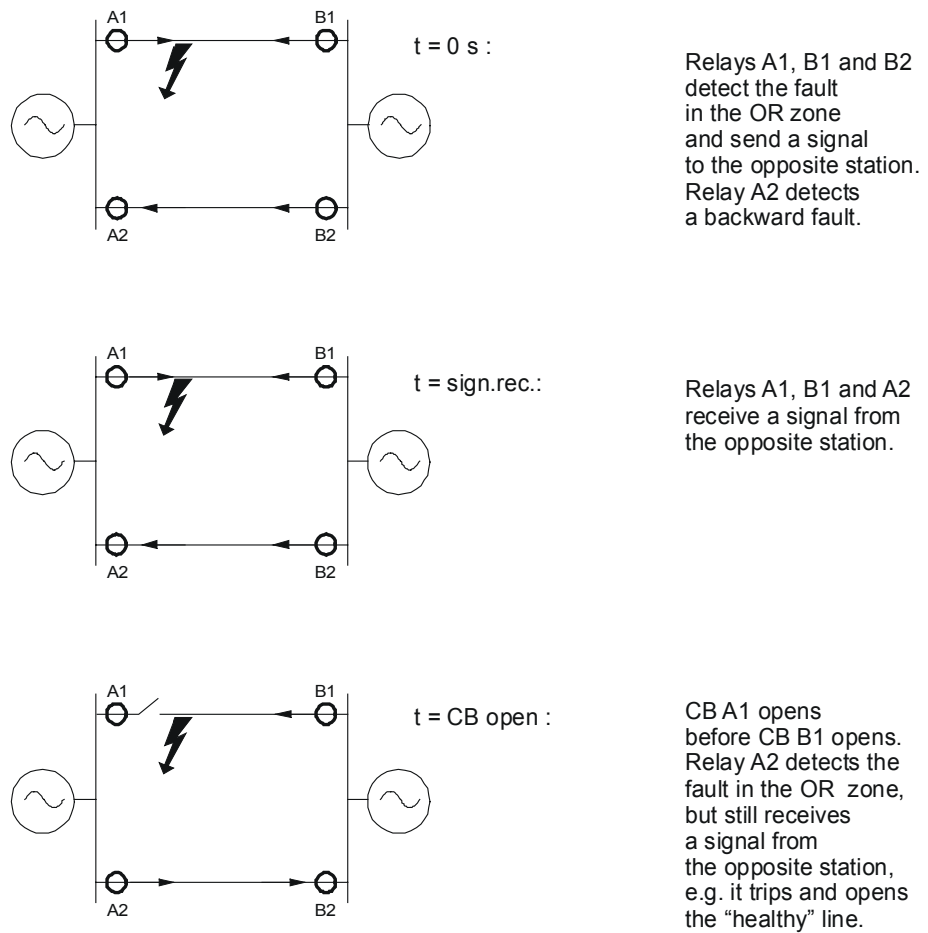
Fig. 4.39 Segment: ZE

#### 4.8.5.6. Transient blocking logic (Transbl)

This logic is only used in conjunction with a permissive overreaching transfer tripping scheme (POTT) or an overreaching blocking scheme (BLOCK OR) on double-circuit lines with infeeds from both ends and a high mutual zero-sequence impedance (both circuits on the same pylons). A blocking scheme does not require this logic, providing the waiting time is set sufficiently long.

The logic solves the following problem:

The problem (with POTT)

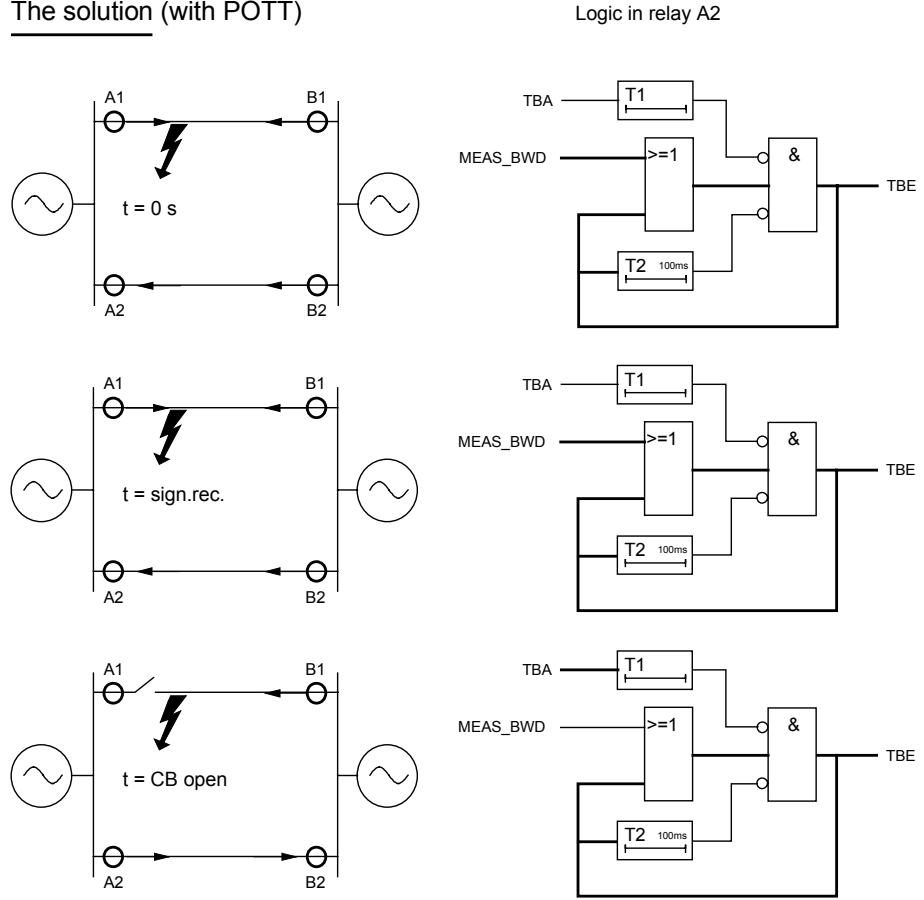


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Fig. 4.40 Transient blocking

The operation of the logic is as follows:

The solution (with POTT)



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Fig. 4.41 Transient blocking

The critical relay A2 cannot trip, because the reverse measurement signal [MEAS\_BWD] is maintained for at least T1 (parameter "t1TransBI") and resets at the latest after T2 (parameter "t2TransBI"). The purpose of T2 is to ensure that blocking is maintained should auto-reclosure of the faulted circuit take place.

T1 allows time for the incorrect signal "Com Rx" to reset. Its setting is thus given by the reset time of relay B2 and the reset time of the communication channel. The receiver signal must not be prolonged.

Tripping takes place instantaneously, if the tripping condition TBA is still fulfilled after the time T1.

Tripping always causes the logic to be reset, after which it remains inactive for 100 ms. The faulted circuit will therefore be immediately tripped, for example, in the case of an unsuccessful auto-reclosure attempt.

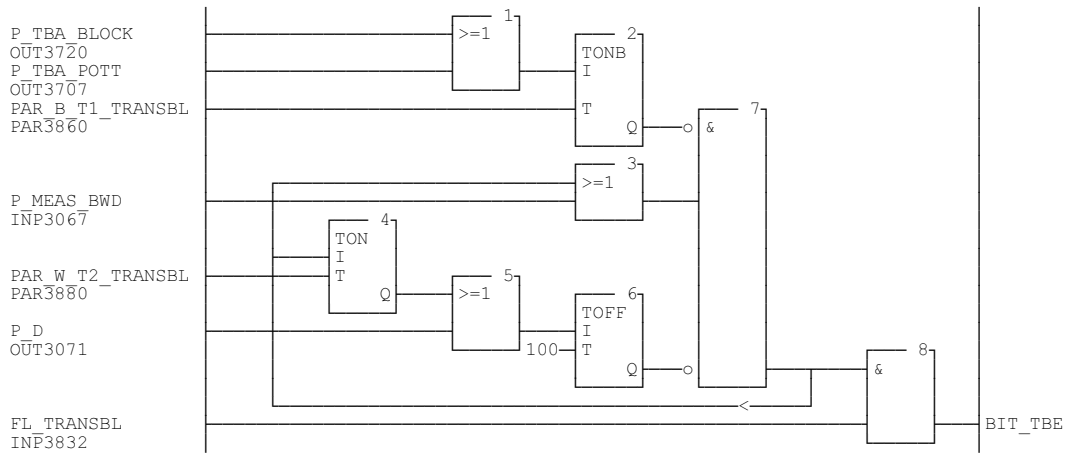


Fig. 4.42 Segment: TRANSBL

#### 4.8.5.7. **Communication channel failure (Deblock)**

This logic is only used in conjunction with a permissive under-reaching transfer tripping scheme (PUTT OR2) or a permissive overreaching transfer tripping scheme (POTT).

The logic causes the communication channel failure signal from the communication equipment (opto-coupler I/P 'Com Fail') to be interpreted for 100 ms as a receive signal. This enables tripping [BIT\_UNBL] to take place in PUTT OR2 or POTT schemes in cases where the PLC receive signal is attenuated by the primary system fault on the line.

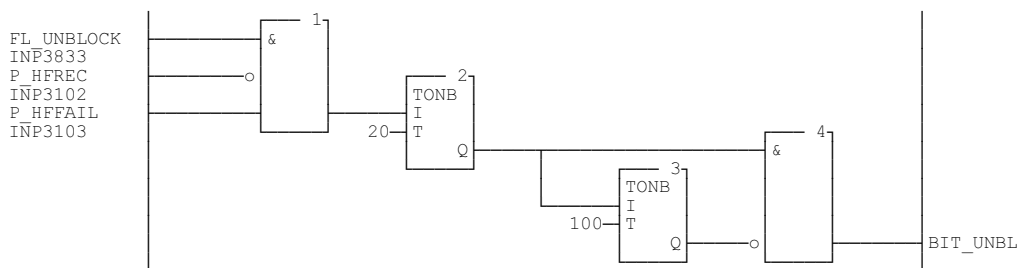


Fig. 4.43 Segment: DEBLOCK

#### 4.8.5.8. **Permissive underreaching transfer tripping (PUTT)**

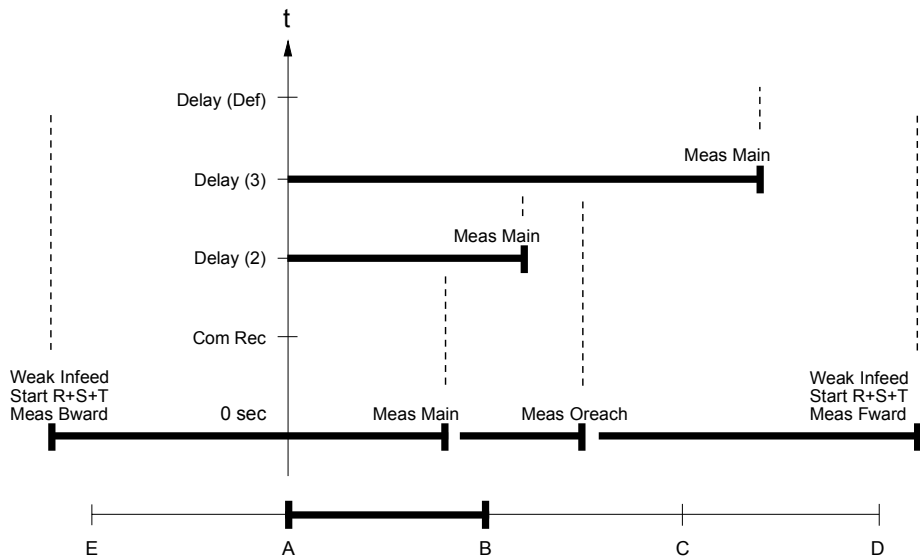
The PUTT logic is divided into a receive logic (segment PUTTREC) and a transmit logic (segment PUTTSEND).

The O/P signals from the receive logic (PUTTREC) are transferred to the transmit logic, while taking account of any weak in-feed (Weak) [UWEAK\_R, S, T] and short-term enable signals due to communication channel failure (Deblock) [BIT\_UNBL].

The tripping criterion is thus available for evaluation in conjunction with the underimpedance starting characteristic (PUTT NONDIR) [PUTT\_NONDIR], the starting characteristic in the forwards direction (PUTT FWD) [PUTT\_FWD] or the overreaching zone, respectively the 2nd. distance zone (PUTT OR2) [PUTT\_OR2].

The O/P signals from the transmit logic (PUTTSEND) are passed on to the common transmit logic for PUTT, POTT and BLOCK OR schemes.

The tripping (Trip) [TRIP\_PUTT] and transmit (Tx) criteria [SEND\_PUTT] can be seen from the following diagram.



t = Delay (1)	Trip	= Meas Main
= 0 sec :	Send	= Meas Main
t = Com Rec :	Trip (PUTT NONDIR)	= Com Rec * (Start R+S+T + Weak)
	Trip (PUTT FWD)	= Com Rec * Meas Fward
	Trip (PUTT OR2)	= (Com Rec + Unblock) * Meas Oreach
	Send	= Meas Main
t = Delay (2) :	Trip	= Meas Main
	Send	= Meas Main
t = Delay (3) :	Trip	= Meas Main
	Send	= "0"
t = Delay (Def) :	Trip	= Start R+S+T (dir/nondir)
	Send	= "0"

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Fig. 4.44 PUTT NONDIR, PUTT FWD, PUTT OR2



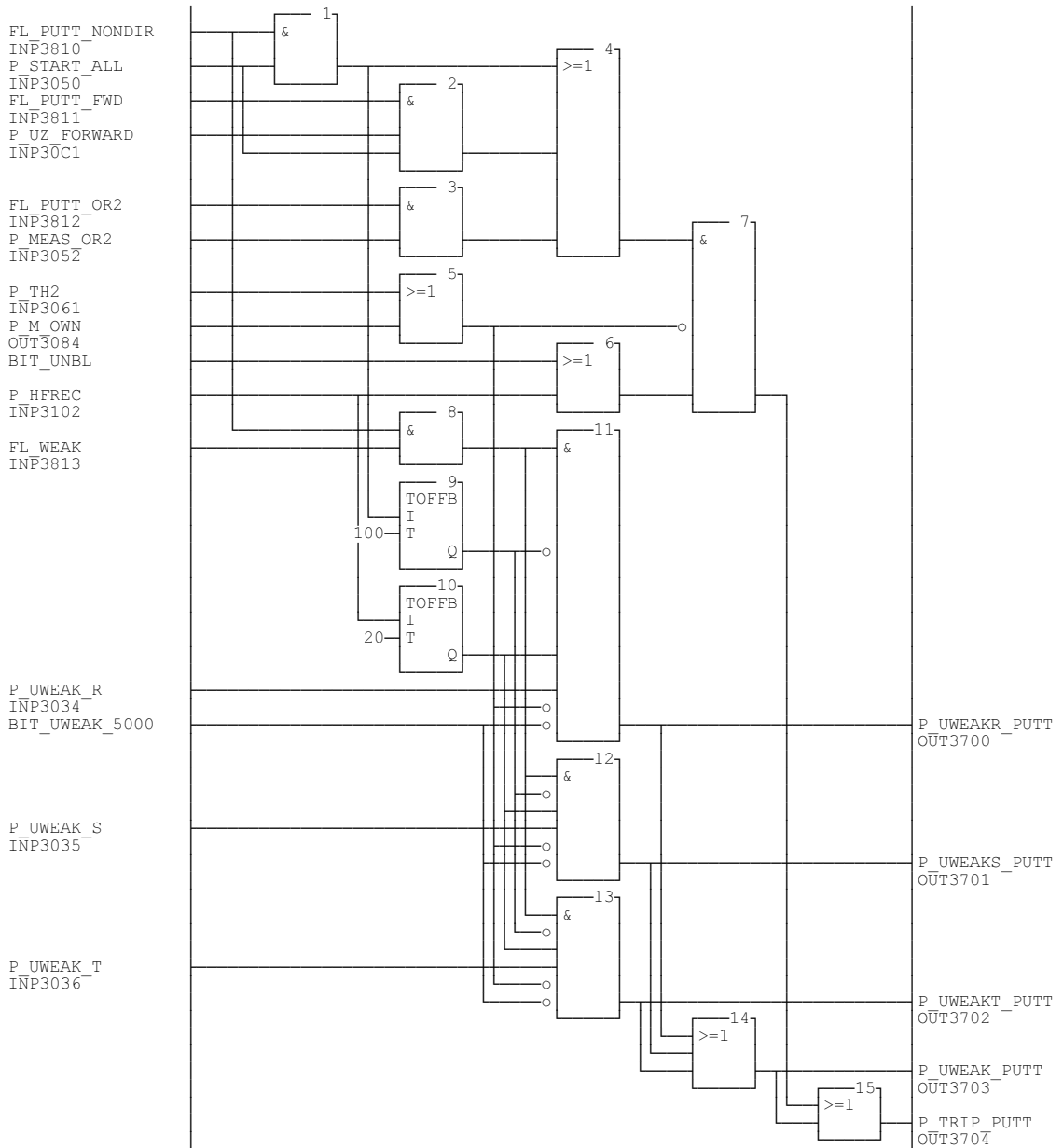


Fig. 4.45 Segment: PUTTREC

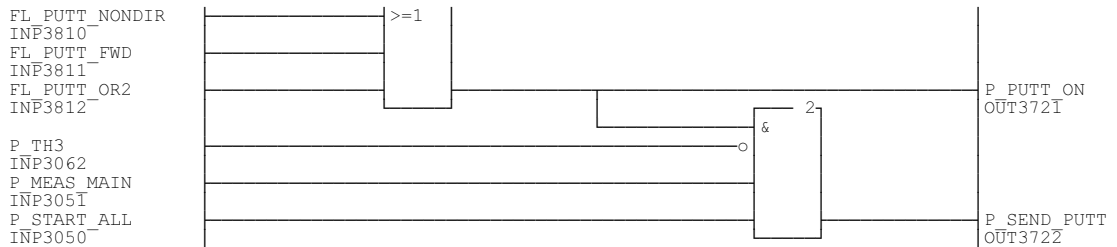


Fig. 4.46 Segment: PUTSEND

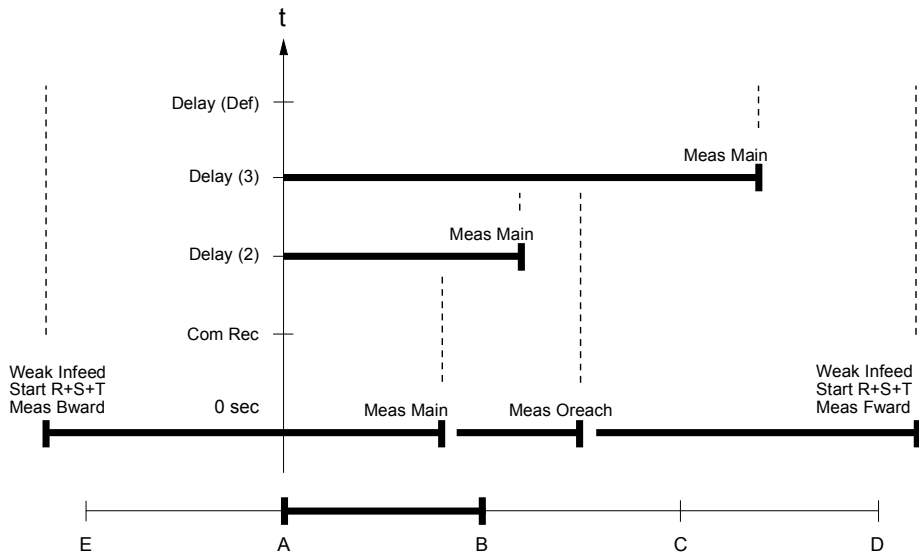
**4.8.5.9. Permissive overreaching transfer tripping (POTT)**

The POTT logic is divided into a receive logic (segment POTTREC) and a transmit logic (segment POTSEND).

The O/P signals from the receive logic (POTTREC) are transferred to the transmit logic, while taking account of any weak infeed (Weak) [UWEAK\_R, S, T], short-term enable signals due to communication channel failure (Deblock) [BIT\_UNBL] and transient blocking (Transbl) [BIT\_TBE].

The O/P signals from the transmit logic (POTTSEND) are passed on to the common transmit logic for PUTT, POTT and BLOCK OR schemes, while taking account of the signal returned from the remote end of the line in the case of a weak infeed (Echo).

The tripping (Trip) [TRIP\_POTT] and transmit (Tx) criteria [SEND-POTT] can be seen from the following diagram.



t = Delay (1)	Trip	= Meas Main
= 0 sec :	Send	= Meas Oreach * notTransbl
t = Com Rec :	Trip	= (Com Rec + Unblock) * Meas Oreach * notTransbl
	Trip Weak	= Com Rec * Weak * notMeas Bward * notMeas Oreach
	Send	= Meas Oreach * notTransbl
	Send Echo	= Com Rec * notMeas Bward
t = Delay (2) :	Trip	= Meas Main
	Send	= "0"
t = Delay (3) :	Trip	= Meas Main
	Send	= "0"
t = Delay (Def) :	Trip	= Start R+S+T (dir/nondir)
	Send	= "0"

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Fig. 4.47 POTT

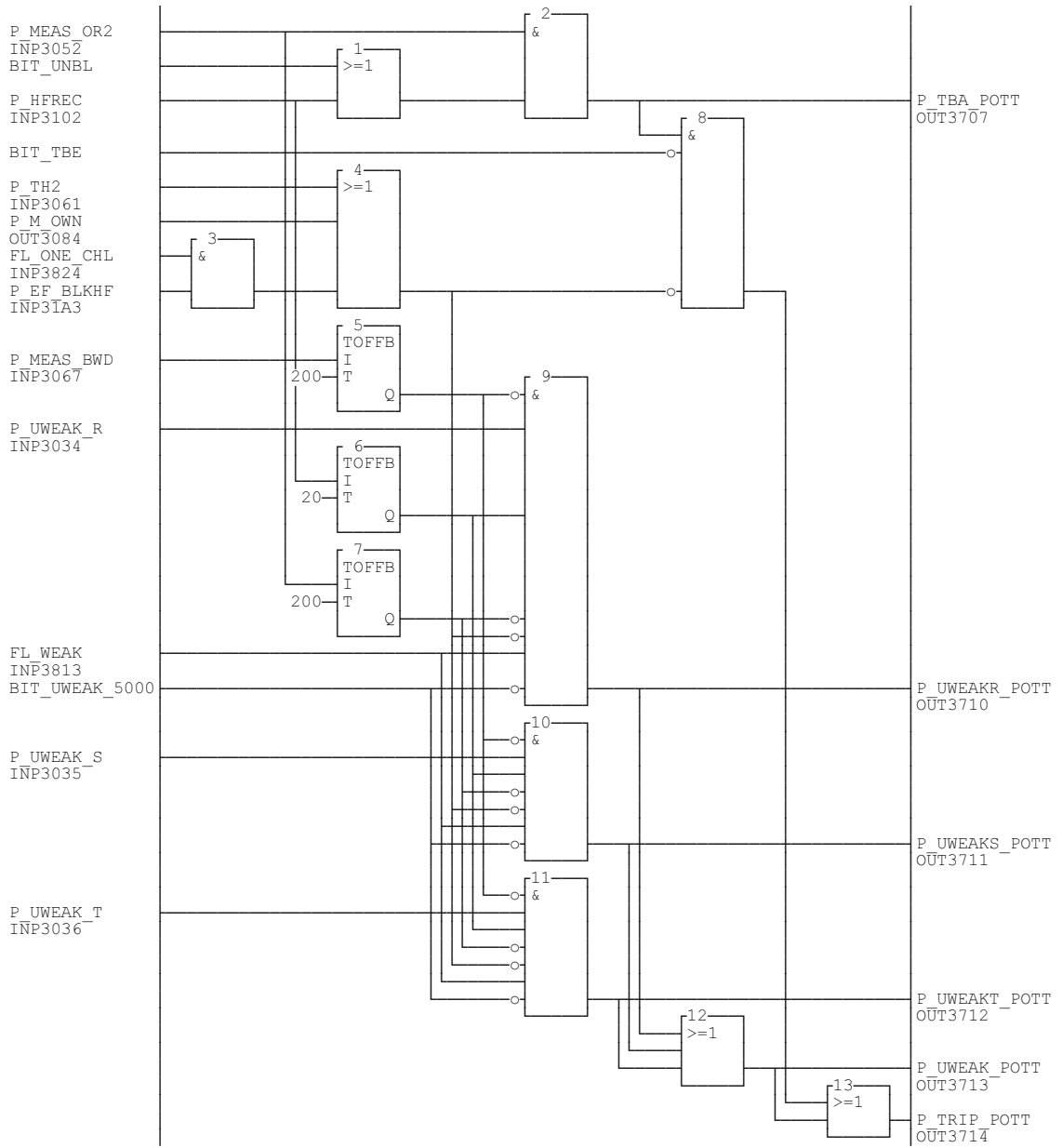


Fig. 4.48 Segment: POTTREC

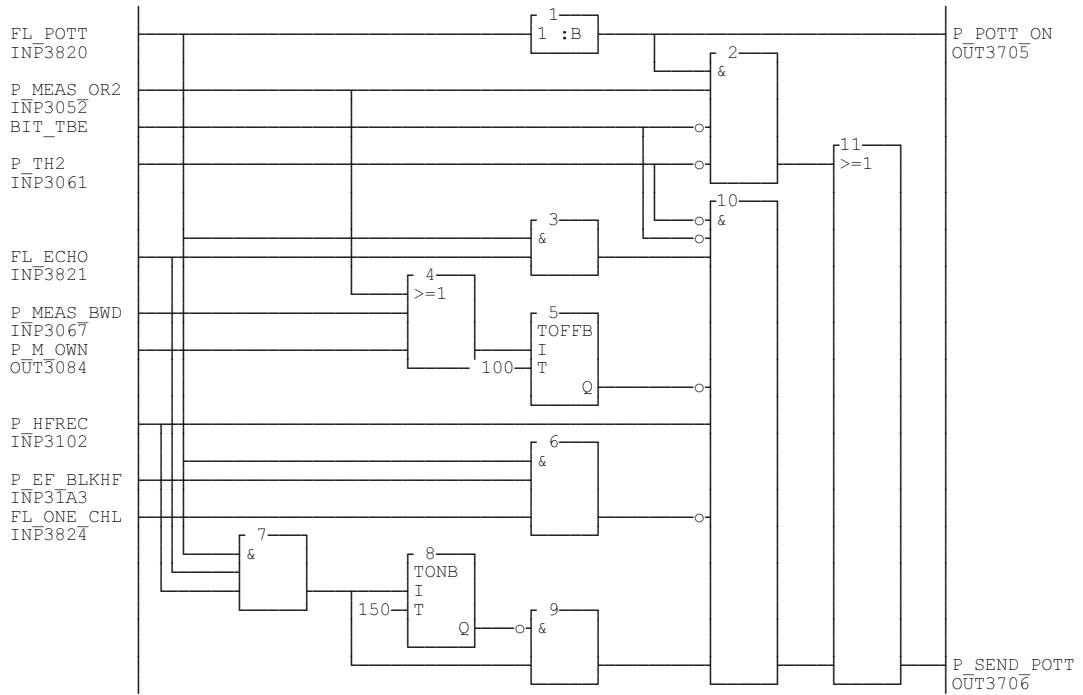


Fig. 4.49 Segment: POTSEND

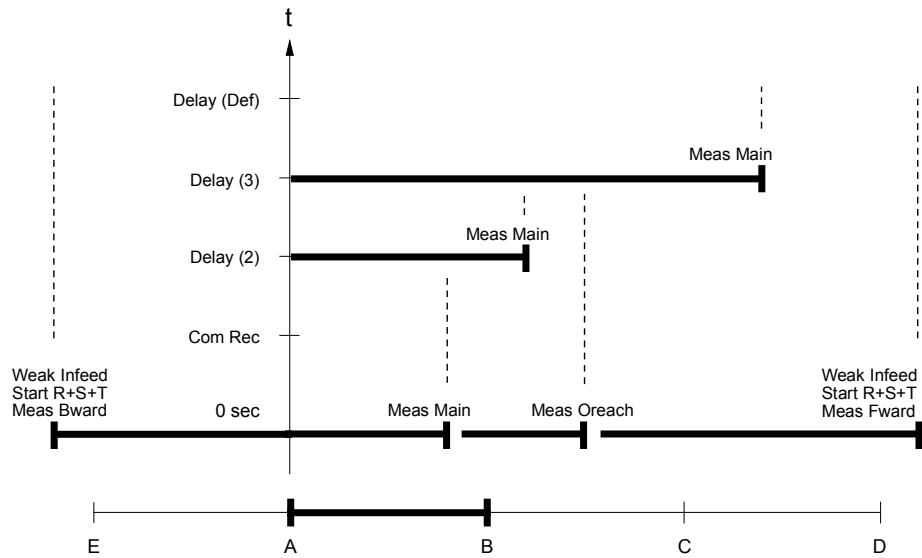
**4.8.5.10. Overreaching blocking scheme (BLOCK OR)**

The BLOCK OR logic is divided into a receive logic (segment BLOCREC) and a transmit logic (segment BLOSEND).

The O/P signals from the receive logic (BLOCREC) are transferred to the transmit logic, while taking account of any transient blocking due to reversal of energy direction (Transbl).

The O/P signals from the transmit logic are passed on to the common transmit logic for PUTT, POTT and BLOCK OR schemes.

The tripping (Trip) and transmit (Tx) criteria can be seen from the following diagram.



t = Delay (1) :	Trip	= Meas Main
= 0 sec :	Send	= Meas Bward
t = t1Block :	Trip	= Meas Oreach * notComRec * notTransbl
	Send	= Meas Bward + Transbl
t = Delay (2) :	Trip	= Meas Main
	Send	= "0"
t = Delay (3) :	Trip	= Meas Main
	Send	= "0"
t = Delay (Def) :	Trip	= Start R+S+T (dir/nondir)
	Send	= "0"

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Fig. 4.50 BLOCK OR

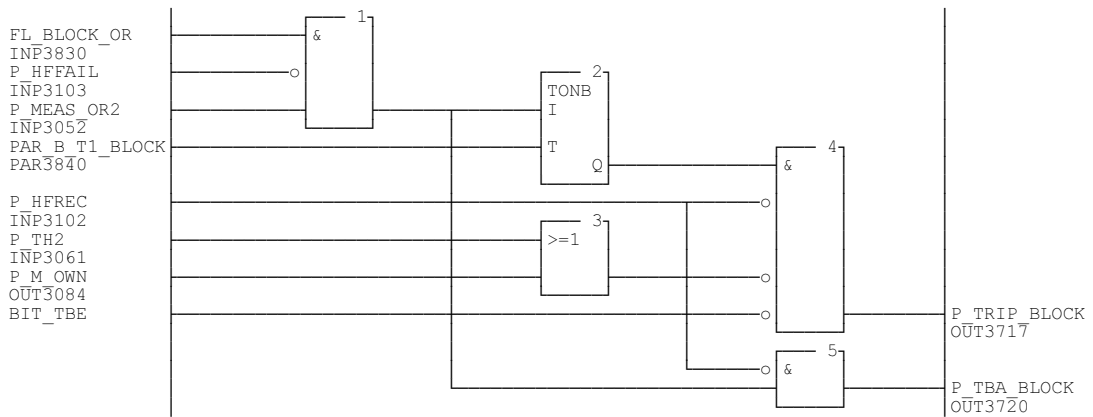


Fig. 4.51 Segment: BLOCREC

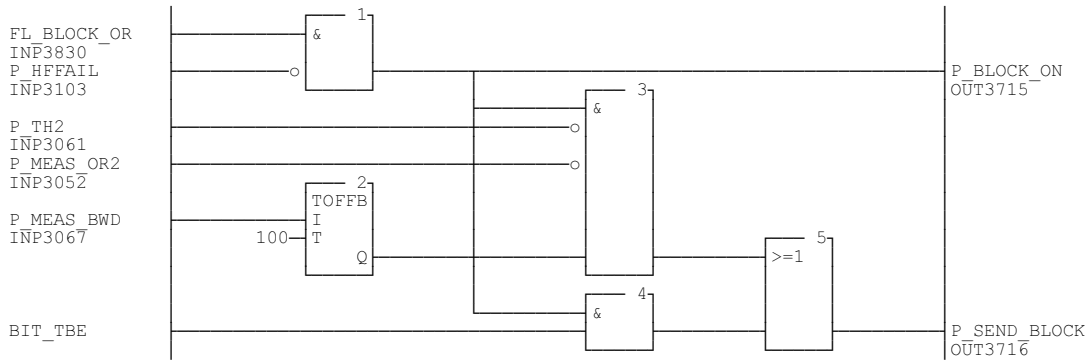


Fig. 4.52 Segment: BLOSEND

**4.8.5.11. PLC transmit logic (HFSEND)**

The task of the transmit logic is to boost (Com Boost) the PLC transmitter and transmit a signal (signalling relay O/P “Com Send”) [HFSEND] to the opposite end of the line (signalling relay O/P “Com Boost”) [HFBOOST].

General rules are:

The underreaching zone transmits the signal in a permissive underreaching transfer tripping scheme (PUTT).

The overreaching zone transmits the signal in a permissive overreaching transfer tripping scheme (POTT).

The reverse measuring zone transmits the blocking signal in an overreaching blocking scheme (BLOCK OR).

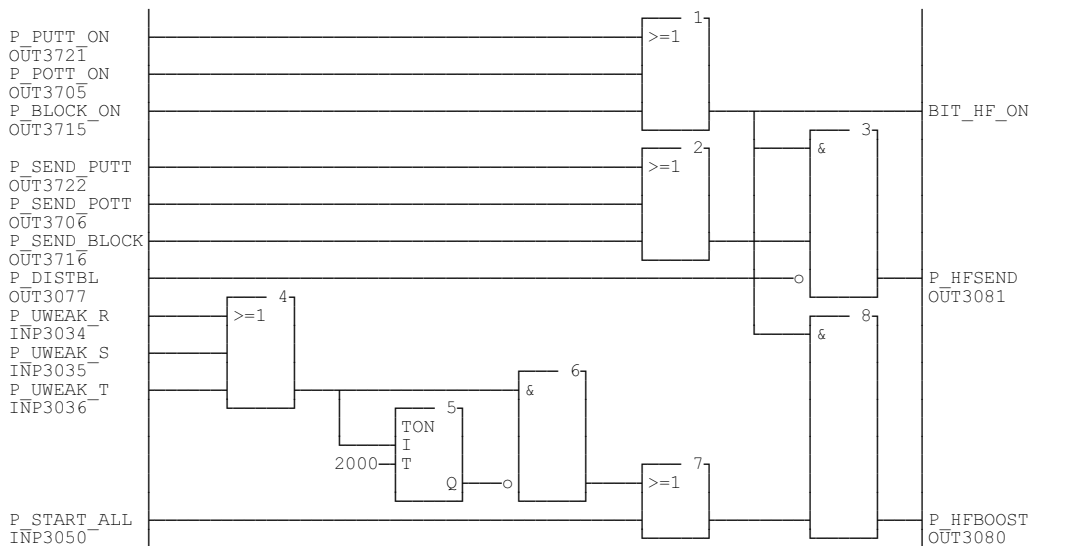


Fig. 4.53 Segment: HFSEND

#### 4.8.5.12. *Tripping logic*

The main purpose of the tripping logic is coordination of single and three-phase tripping of the circuit-breaker (heavy-duty tripping relay O/P's). It also provides additional starting and tripping signals.

Single, respectively three-phase tripping is initiated when at least the following conditions are simultaneously fulfilled:

- starter picked up, i.e. underimpedance start or overcurrent start or undervoltage start (Weak) [UWEAK\_R, S, T] from the POTT or PUTT receive logic
- trip by the relays own measuring unit or by the back-up overcurrent unit or by the short-zone logic or by the switch-onto-fault logic or by the zone extension logic or from the PUTT, POTT or BLOCK OR receive logic.
- no blocking signal is being generated by the enable and blocking logic. (This signal cannot block tripping by the back-up overcurrent unit or short-zone logic.)

Only single-phase tripping will take place when:

- the parameter "3PhTripMode" is set to "1PhTrip"
- the starter of just one phase has picked up
- none of the conditions for three-phase tripping is fulfilled.

Any one of the following conditions will result in three-phase tripping:

- The parameter "3PhTripMode" is set to "Trip CB 3P".
- The starters of more than one phase have picked up.
- The auto-reclosure function has instructed the distance function to trip all three-phases.
- Either the back-up overcurrent function or the short-zone logic has tripped.
- operation of the switch-onto-fault logic
- A second trip occurs (e.g. evolving fault) during, for example, the auto-reclosure dead time.
- The parameter "3PhTripMode" is set to "Trip CB 3P/Delay 3" and the zone 3 time has expired (auto-reclosure in the 2nd. zone as well).

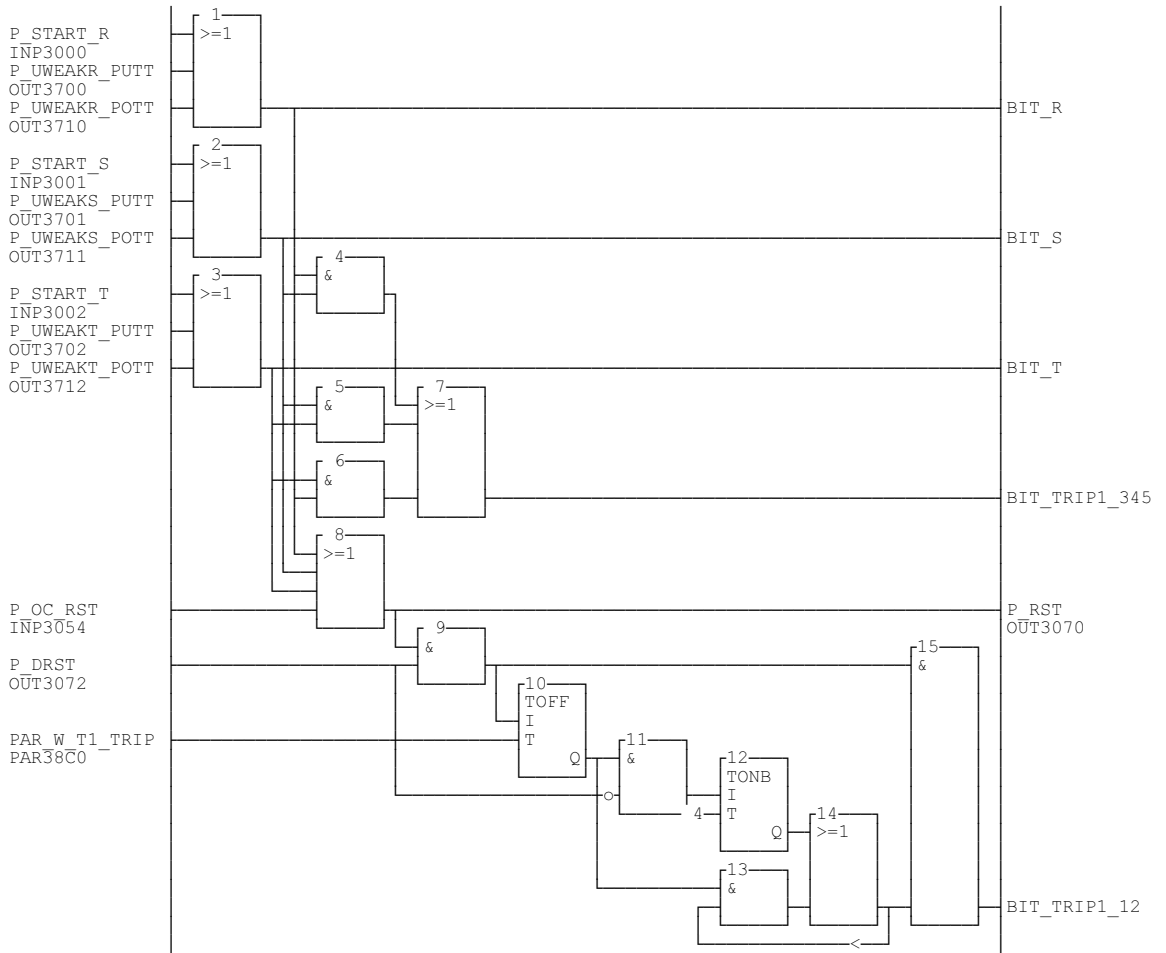


Fig. 4.54 Segment: TRIP1

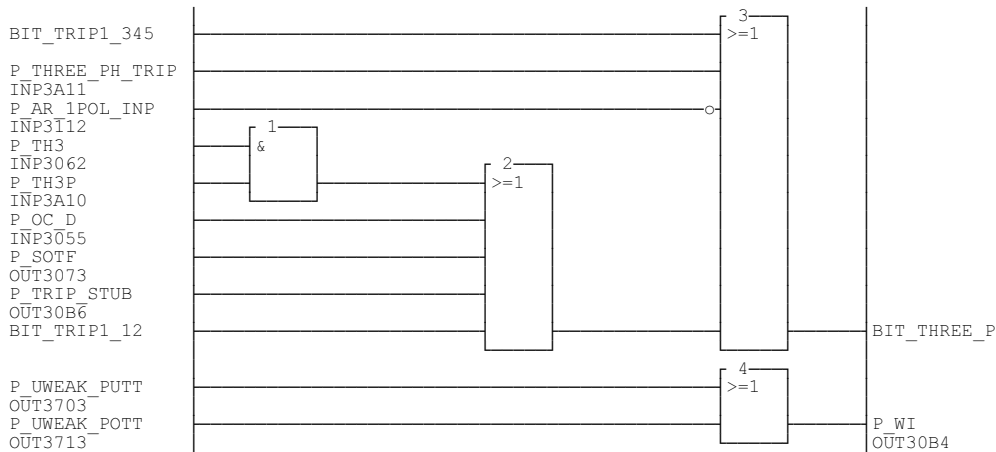


Fig. 4.55 Segment: TRIP2



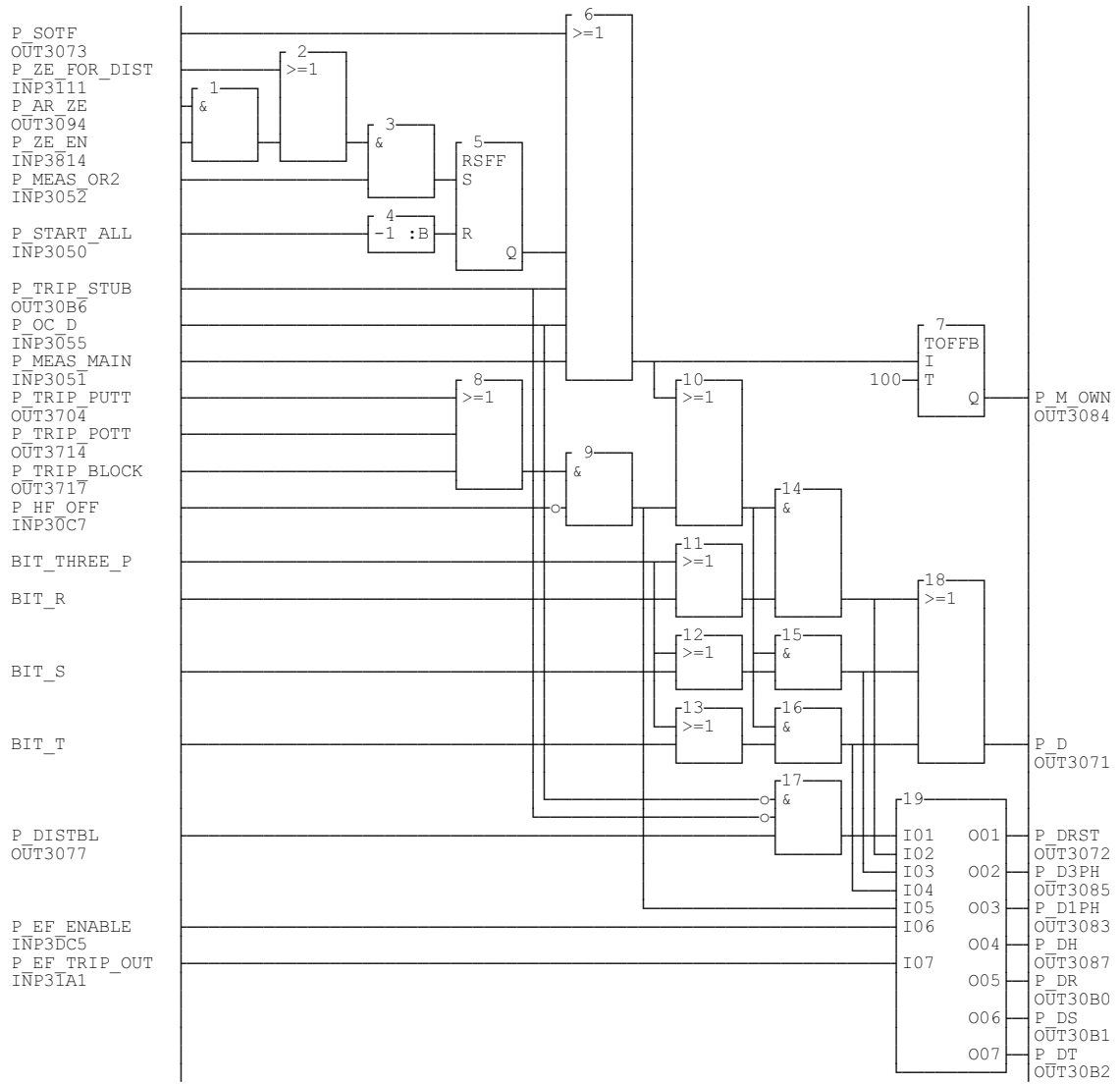


Fig. 4.56 Segment: TRIP3

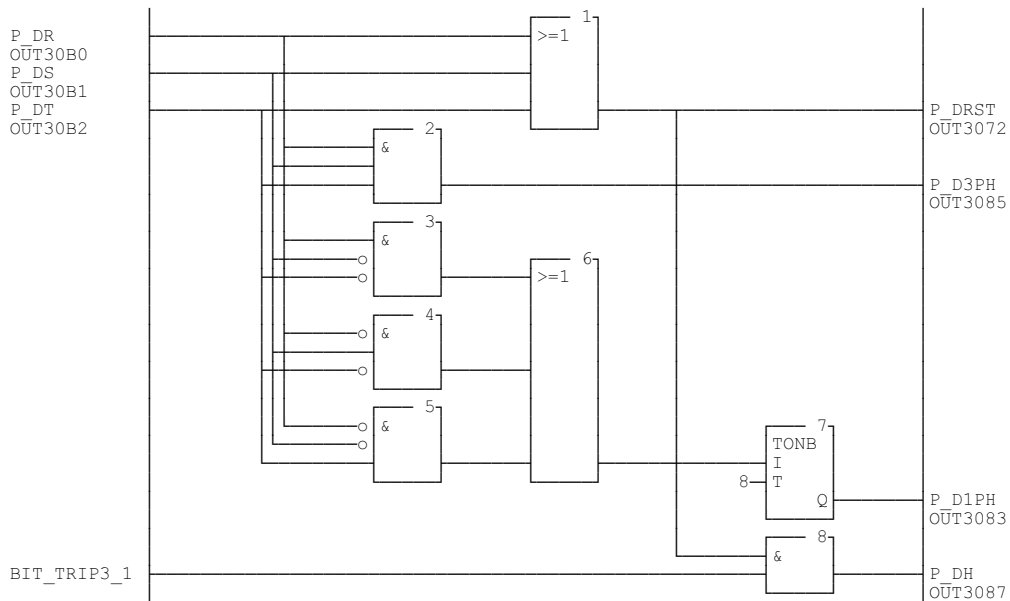
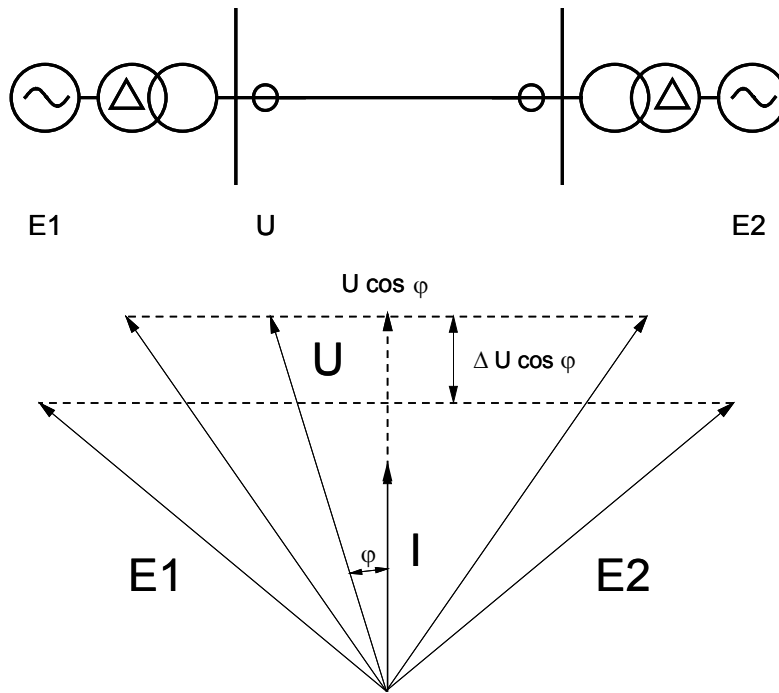


Fig. 4.57 Segment: TRIP4

#### 4.8.6. Power swing blocking (PSB)

The purpose of the power swing blocking function is to prevent unwanted tripping of the distance protection function in response to power system instability with oscillatory fluctuations of power (power swings) or loss of synchronism (out-of-step). The power swing blocking function does not influence the operation of the back-up overcurrent function.

When power swings occur, the electrical parameters of the system vary at a slower or faster rate in relation to the angle  $\delta$  between the voltage vectors of the energy sources in different parts of the system. In the case of a fault on the other hand, step changes of these parameters take place. The parameters, which regardless of location are subject to appreciable variation in the general region around phase opposition ( $\delta = 180^\circ$ ), are the resistance  $R$  and the voltage component  $U \cdot \cos \varphi$ . The value of  $\varphi$  corresponds to the angle between phase voltage and current.



Independent of: -Relay location  
 -Relay characteristics  
 -Relay settings

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Fig. 4.58 Power swing blocking

The voltage and current input variables are passed on to the evaluation system. The criterion for pick-up of the power swing blocking function is the continuous variation of  $(U \cdot \cos \varphi)$ , which corresponds to the variation of real power in relation to current amplitude ( $P = I \cdot U \cdot \cos \varphi$ ). The value of  $(U \cdot \cos \varphi)$  is determined after every zero-crossing of the current. A blocking signal is generated, as soon as a repetitive variation of the value of  $(U \cdot \cos \varphi)$  is detected, i.e. a variation must be detected at least three times to count as a power swing.

Two periods are needed to detect the faster power swings up to a frequency of 8 Hz. The power swing blocking function does not pick up during a fault, because the variation of  $(U \cdot \cos \varphi)$  in relation to time only occurs once and at a much higher rate than the function's operating range.

Slow swings are evaluated over five periods by a second system. At its lowest operating limit, this system detects a frequency of 0.2 Hz.

Together the two systems cover a range from 0.2 to 8 Hz and no setting is required during commissioning.

The blocking signal "PSB" is maintained for as long as the distance protection function is in the picked-up state. The power swing blocking function is only effective for the symmetrical three-phase condition and cannot block the distance function for asymmetrical faults (E/F's and phase-to-phase faults).

A blocking signal is not issued, if the zero-crossings of the current signal occur at relatively irregular intervals, because considerable differences between the zero-crossing intervals are a clear indication of a fault on the power system. Phase jumps in the current wave form occur at the incidence of a fault, as a consequence of incorrect switching and when c.t. saturation takes place. Since the currents during power swings are sinusoidal and do not contain a DC component, it is permissible to assume that the problem of c.t. saturation does not arise. Zero-crossings resulting from the slip are in any event excluded by the current enable setting of  $I_{\min}$ .

**4.8.7. Signal designations and abbreviations**

FUPLA name	MMC name	Signal description	INT	PAR	CPU	OPT	OUT
3P		Preparation of a three-phase trip	x				
AR_1POL-INP	1P recl.	Single-phase reclosure by the auto-reclosure function				x	
AR_ZE	ZExtensionAR	Sig. from recl. function to switch distance function to overreach				x	
BLOCK_ON		Overreaching blocking scheme selected	x				
BLOCK_OR	BLOCK OR	Overreaching blocking scheme		x			
CREL_E	Start I0	Residual current enable, I0 criterion			x		x
CREL_R		R phase current enable			x		
CREL_S		S phase current enable			x		
CREL_T		T phase current enable			x		
D	Trip RST	General trip signal before blocking gate from R, S or T phases					x
D_RELEASE		Any trip before phase selection	x				
D1PH	Trip CB 1P	Single-phase trip signal before blocking gate					x
D3PH	Trip CB 3P	Three-phase trip signal before blocking gate					x
DEADLINE1	Dead line	Line isolator open; used when v.t.'s on the busbars.				x	
DH	Trip Com	Trip via the communication channel					x
DISTBL	Dist blocked	Tripping blocked					x
DISTBL_OFF	NoDistBlk	HW_RDY missing therefore no RELAY_RDY		x			
DR	Trip CB R	Trip signal to R phase of CB					x
DRST	Trip CB	General trip from R, S or T phase					x
DS	Trip CB S	Trip signal to S phase of CB					x
DT	Trip CB T	Trip signal to T phase of CB					x
ECHO	Echo	Transmission of an echo sig. in a POTT scheme		x			
EXTBL_DIST	Ext blk dist	Distance function blocked by external signal				x	
EXTBL_PSB	Ext blk PSB	Power swing blocking blocked by external signal				x	
HF_ON		A transfer tripping mode is selected.	x				
HFBOOST	Com boost	Signal to boost PLC power ready for transmission					x
HFFAIL	Com fail	PLC channel failure				x	
HFREC	Com Rx	Signal received by PLC				x	
HFREC_EF		(unused)	x				
HFSEND	Com Tx	PLC signal transmitted					x
HW_RDY		Hardware standing by			x		
I0_VTSUP		V.t. supervision I0> setting exceeded.			x		
I2_VTSUP		V.t. supervision I2> setting exceeded.			x		
ISOL_OPEN	Isol open	Line isolator open (only in conjunction with short-zone logic)				x	
M_OWN		Relays own measurement, no transfer tripping involved.					x
MANCL_DIST	Manual close	Signal from CB manual control switch				x	
MEAS_BWD	Meas Bward	Fault in the reverse direction			x		x
MEAS_MAIN	Meas main	Fault in zone 1, 2, 3, 4 or <Z (dir./non-dir.) acc. to sig. delay			x		x
MEAS_OR2	Meas Oreach	Fault in the overreach zone or zone 2			x		x

FUPLA name	VDU name	Signal description	INT	PAR	CPU	OPT	OUT
OC_D	Trip O/C	General O/C trip			x		x
OC_RST	Start O/C	General O/C start			x		x
ONE_CHL		(not used)	x				
POTT	POTT	Permissive overreaching transfer tripping		x			
POTT_ON		POTT scheme selected	x				
PSBLOCK	Power swing	Power swing function blocking signal			x		x
PUTT_FWD	PUTT FWD	PUTT for forwards only		x			
PUTT_NONDIR	PUTT NONDIR	PUTT for the entire underimpedance characteristic		x			
PUTT_ON		A PUTT scheme is selected	x				
PUTT_OR2	PUTT OR2	PUTT only for overreach zone or zone 2		x			
R		Starting or Uweak phase selection sig. for R phase	x				
RELAY_RDY	Relay ready	Relay standing by.					x
RST	Start RST	General start with Uweak active					x
S		Starting or Uweak phase selection sig. for S phase	x				
SEND_BLOCK		Tx signal from BLOCK OR scheme	x				
SEND_POTT		Tx signal from POTT scheme	x				
SEND_PUTT		Tx signal from PUTT scheme	x				
SOTF	Trip SOTF	Switch-onto-fault condition fulfilled					x
SOTF_10S	SOTF10sec	Switch-onto-fault condition fulfilled (after 10 s)		x			
SOTF_INIT		Switch-onto-fault start			x		
ST1	Delay 1	Zone 1 time delay running			x		x
ST1FWD		Zone 1 set for forwards measurement			x		
ST2	Delay 2	Zone 2 time delay running			x		x
ST2FWD		Zone 2 set for forwards measurement			x		
ST3	Delay 3	Zone 3 time delay running			x		x
ST3FWD		Zone 3 set for forwards measurement			x		
ST4	Delay 4	Zone 4 time delay running			x		x
ST4FWD		Zone 4 set for forwards measurement			x		
START_ALL	Start R+S+T	General start with Uweak inactive			x		x
START_E	Start E	General E/F start with I0 and/or U0			x		x
START_OC	Start OC	Overcurrent start			x		x
START_R	Start R	General start by R phase with Uweak inactive			x		x
START_S	Start S	General start by S phase with Uweak inactive			x		x
START_T	Start T	General start by T phase with Uweak inactive			x		x
START_U0	Start U0	Residual voltage start, U0 criterion			x		x
START_UZ	Start UZ	Underimpedance start			x		x
STDEF	Delay def	Lock-out timer running			x		x
STOR		Overreach zone selected, i.e. T4<T2			x		x

FUPLA name	VDU name	Signal description	INT	PAR	CPU	OPT	OUT
T		Starting or Uweak phase selection sig. for T phase	x				
T1_BLOCK	t1Block	Waiting time for HFREC, default 40 ms		x			
T1_TRANSBL	t1TransBl	Timer for monitoring the TBA signal, default 50 ms		x			
T1_TRIP	t1EvolFaults	Timer for detecting evolving faults, default 3000 ms		x			
T2_TRANSBL	t2TransBl	Max. duration of the TBE signal, default 3000 ms		x			
TBA_BLOCK		BLOCK OR tripping condition fulfilled.					x
TBA_POTT		POTT tripping condition fulfilled.					x
TBE		Transient blocking logic selected.	x				
TH1	Delay >=2	End of zone 1 time			x		
TH2		End of zone 2 time			x		x
TH3	3PhTripDel3	End of zone 3 time			x		
TH3P		Three-phase trip after TH3		x			
TH4		End of zone 4 time			x		
THDEF		End of lock-out time			x		
THREE_PH_TRIP	3ph trip	Always 3 phases tripped.		x			
TRANSBL	TransBl	Transient blocking logic		x			
TRIP_BLOCK		Tripping signal from BLOCK OR scheme	x				
TRIP_POTT		Tripping signal from POTT scheme	x				
TRIP_PUTT		Tripping signal from POTT scheme	x				
TRIP_STUB	Trip Stub	Tripping by short-zone logic					x
TRIP_ZE		Tripping by zone extension logic	x				
U0_VTSUP		U0> setting exceeded.			x		
U2_VTSUP		U2> setting exceeded.			x		
UNBL	Unblock	Deblocking selected.	x				
UNBLOCK		PLC channel failure		x			
UWEAK_POTT		"General Uweak condition fulfilled" from POTT	x				
UWEAK_PUTT		"General Uweak condition fulfilled" from PUTT	x				
UWEAK_R		Weak infeed in R phase			x		
UWEAK_S		Weak infeed in S phase			x		
UWEAK_T		Weak infeed in T phase			x		
UWEAKR_POTT		"Uweak condition fulfilled in R phase" from POTT	x				
UWEAKR_PUTT		"Uweak condition fulfilled in R phase" from PUTT	x				
UWEAKS_POTT		"Uweak condition fulfilled in S phase" from POTT	x				
UWEAKS_PUTT		"Uweak condition fulfilled in S phase" from PUTT	x				
UWEAKT_POTT		"Uweak condition fulfilled in T phase" from POTT	x				
UWEAKT_PUTT		"Uweak condition fulfilled in T phase" from PUTT	x				
UZ_FORWARD	Meas. Fward	Fault in forwards direction			x		x
VT_FAIL	VTSup	V.t supervision operated.					x
VTFAIL_DLY	VTSup Delay	Delayed VT_FAIL signal					x
VTFAIL_IU0		V.t supervision using zero-sequence component	x				
VTFAIL_IU2		V.t supervision using negative-sequence component	x				

FUPLA name	VDU name	Signal description	INT	PAR	CPU	OPT	OUT
WEAK	Weak	POTT/PUTT phase selection by weak infeed logic		x			
WI	Weak Infeed	Weak infeed condition fulfilled.					x
ZE_FOR_DIST	ZExtension	Signal switching distance function to overreach				x	

INT: internal signal connecting two FUPLA segments

P\_.....

BIT\_..... (not contained in the above table)

PAR: Parameter or mode which can be set.

PAR\_B\_..... (short-time element, TONB: delayed pick-up,

TOFFB: delayed

reset)

PAR\_W\_.....(long-time element, TON: delayed pick-up, TOFF: delayed

reset)

FL\_..... (Flag, Mode)

CPU: Main processor signal

P\_.....

OPT: Opto-coupler input

P\_.....

OUT: Signal output which can be assigned to an output relay, LED, event recorder or disturbance recorder

P\_.....

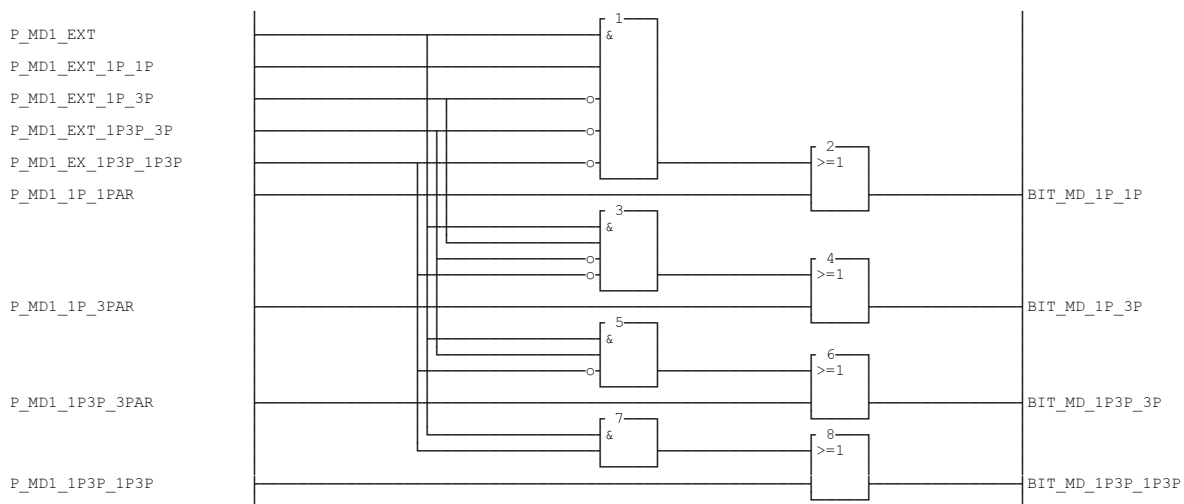


**4.9. Auto-reclosure**

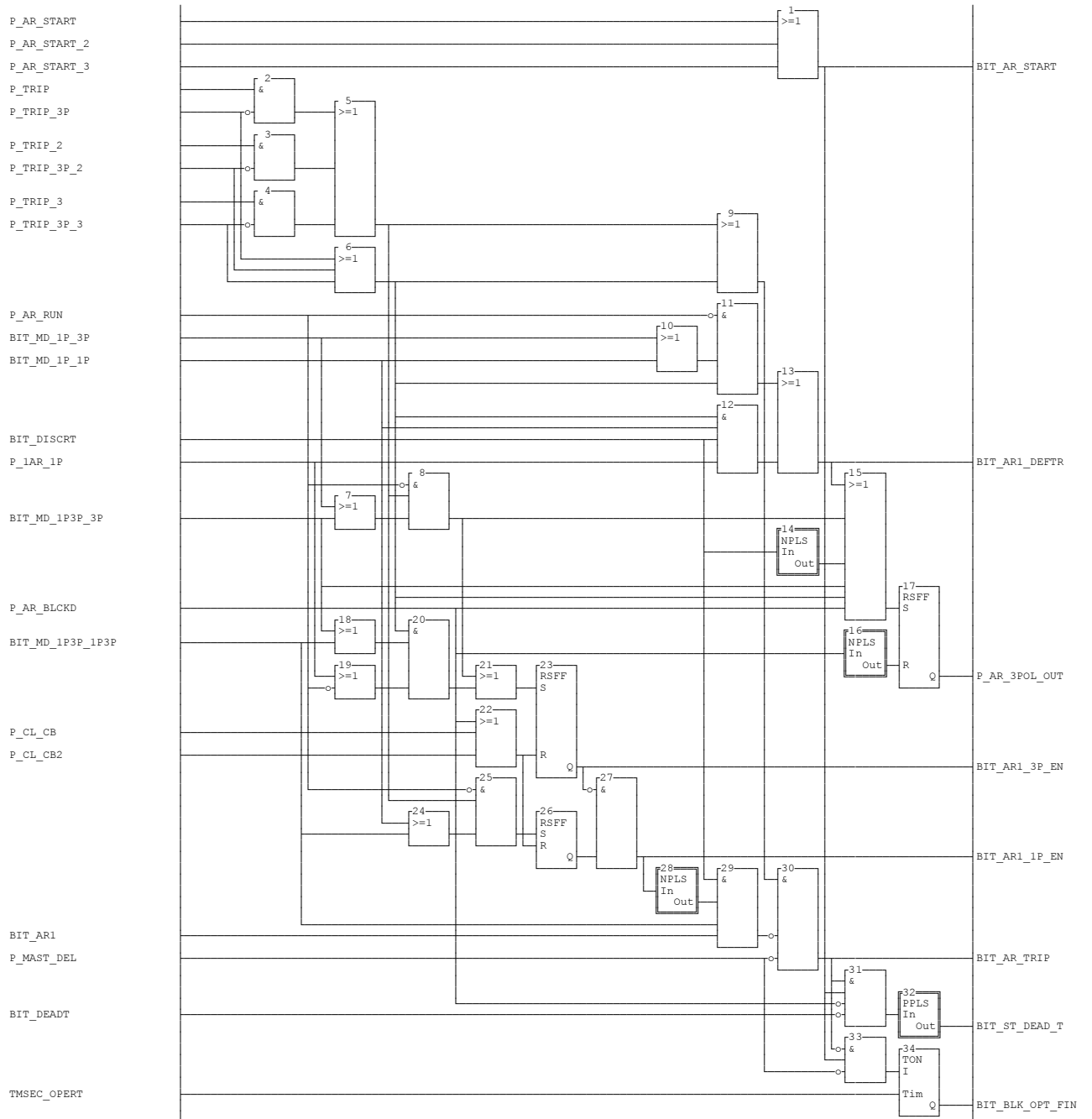
**4.9.1. Logic segments**

The auto-reclosure logic comprises the several FUPLA segments, the block diagrams of which are shown below.

The relationship between the inputs and outputs and the designations used for the HMI is given in [Section 4.9.2.](#)



**Fig. 4.59** MODE\_1AR segment:  
Selection of the mode for the first auto-reclosure cycle



**Fig. 4.60** ARTRIP segment:  
Starting and tripping inputs, determination of the auto-reclosure mode, AR initiation and fault duration time

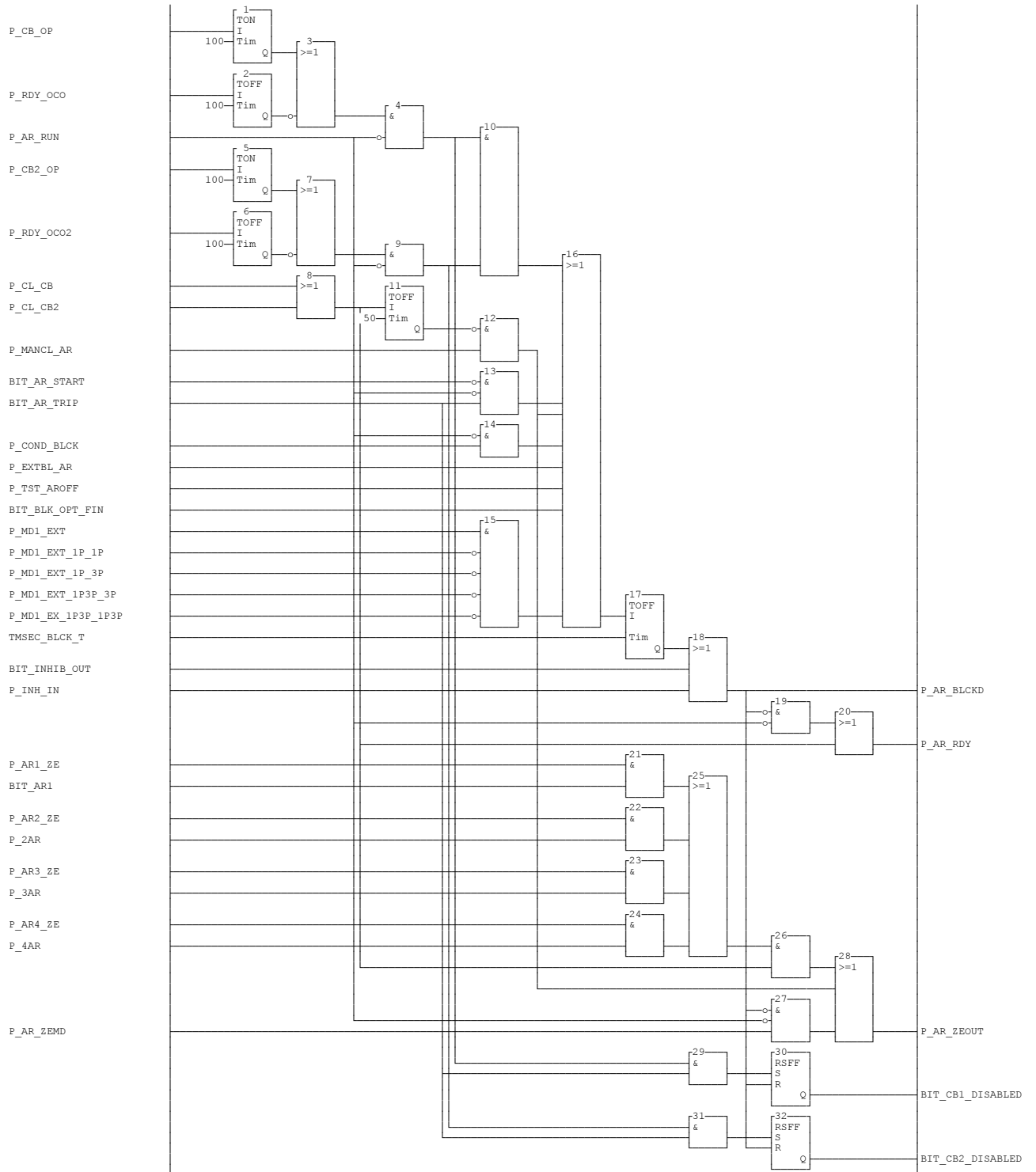


Fig. 4.61 BLOCK segment:  
Blocking and zone extension logic

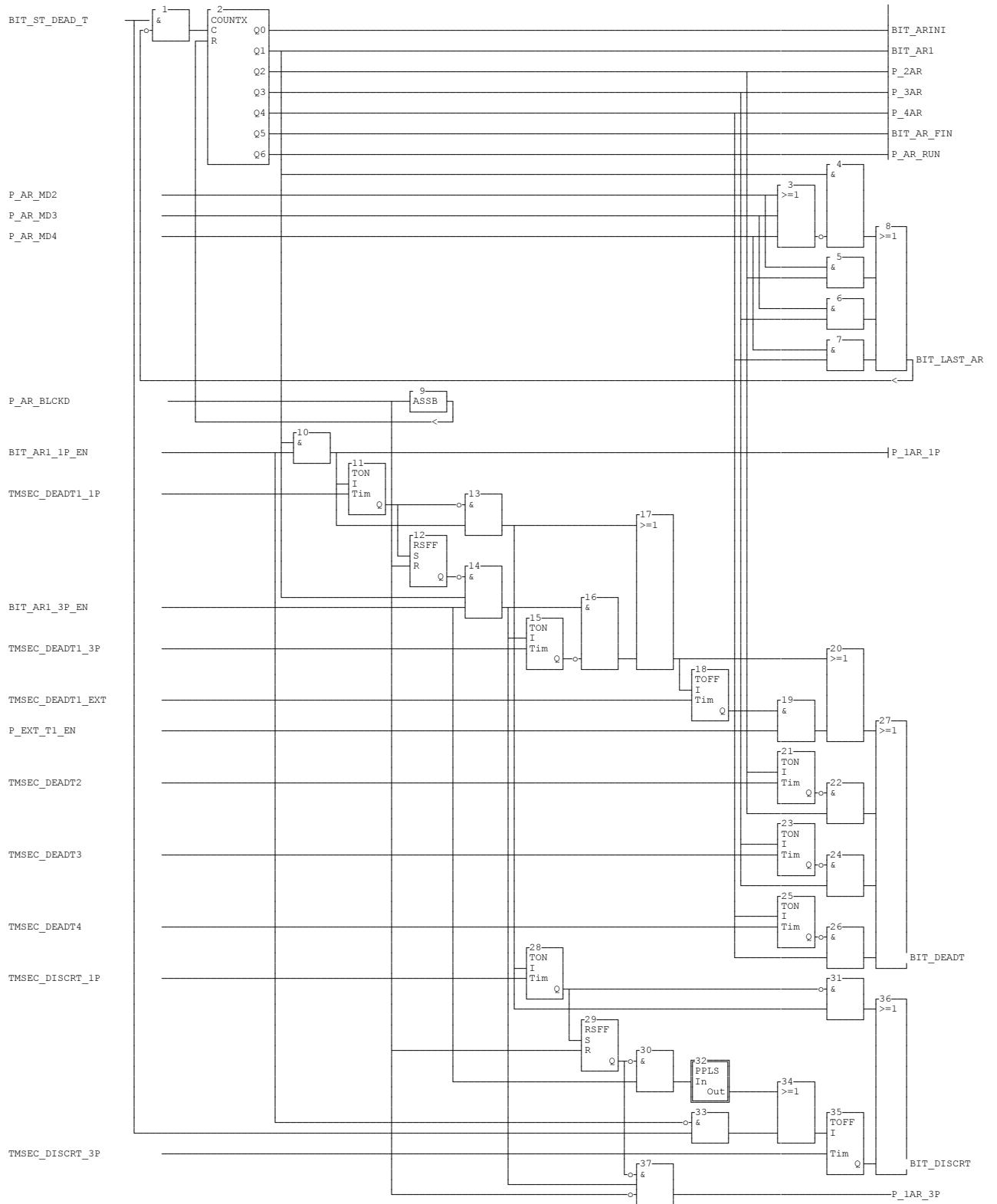


Fig. 4.62 ARCOUNT segment:  
Auto-reclosure attempt counter

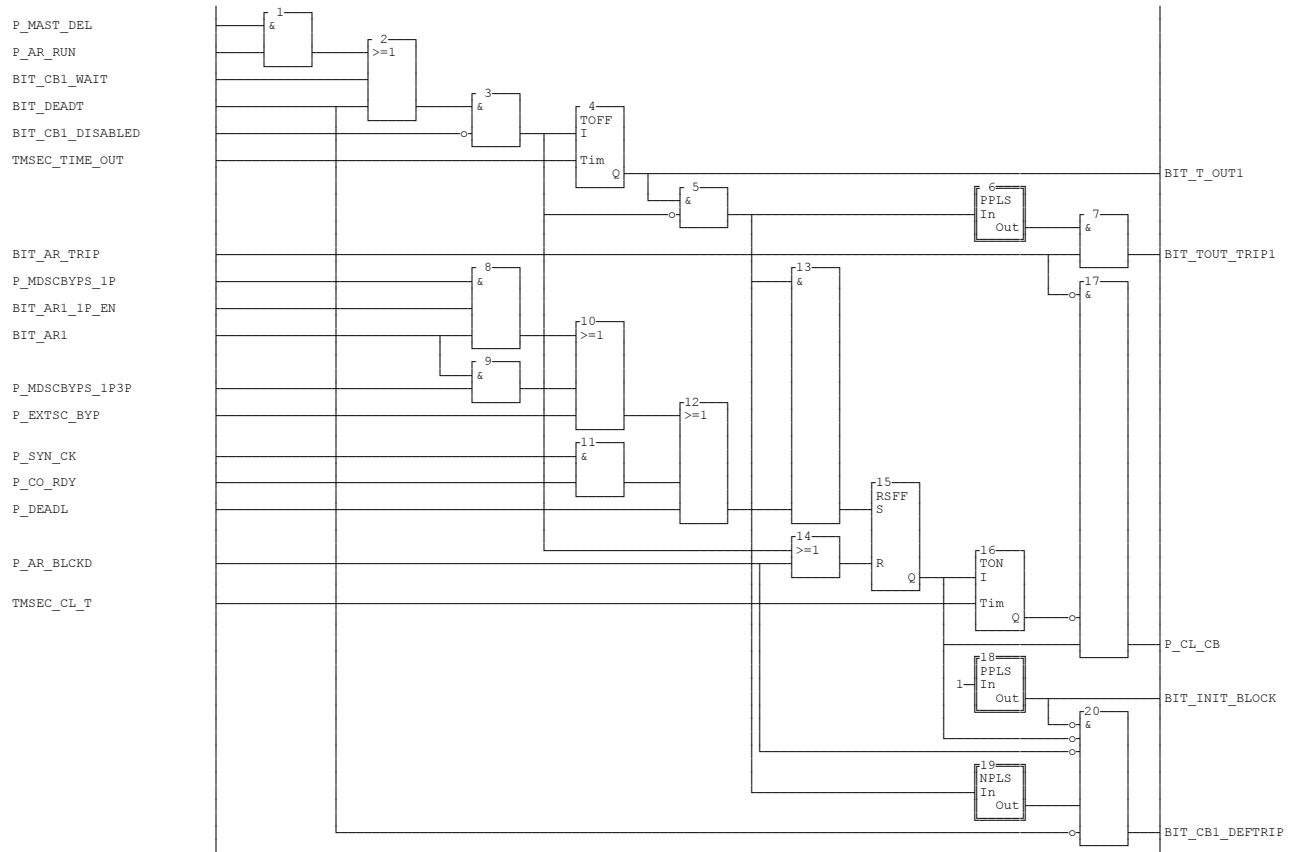


Fig. 4.63 CLOSE1 segment:  
Close signal for the first circuit-breaker

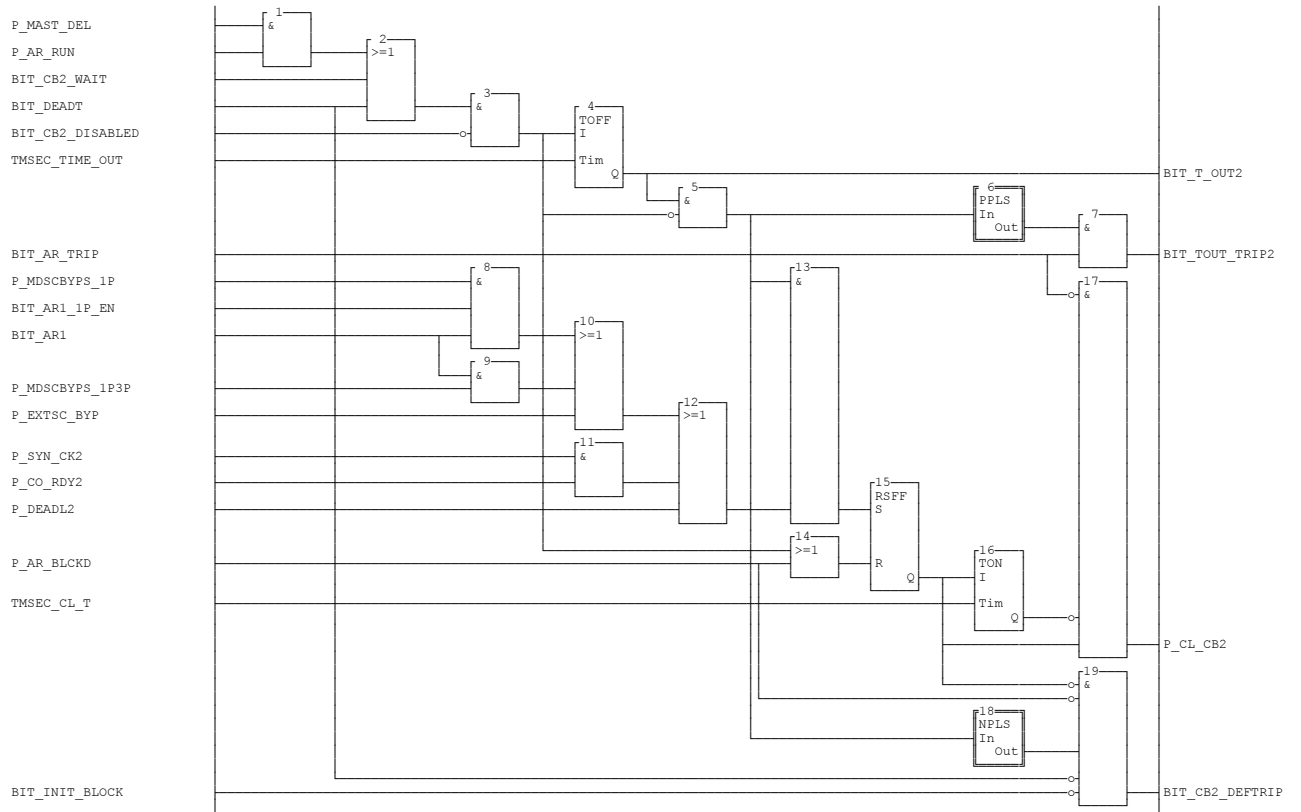


Fig. 4.64 CLOSE2 segment:  
Close signal for the second circuit-breaker

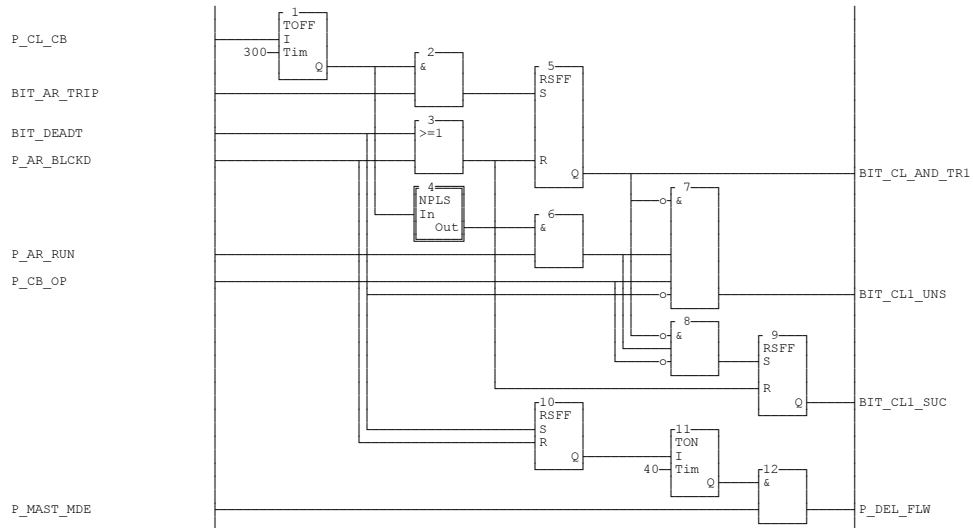


Fig. 4.65 SUCCES1 segment:  
Close supervision for the first circuit-breaker

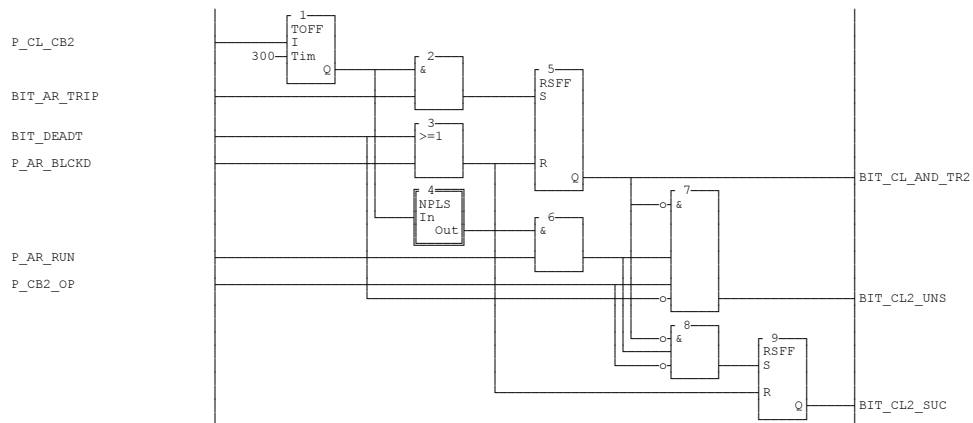


Fig. 4.66 SUCCES2 segment:  
Close supervision for the second circuit-breaker

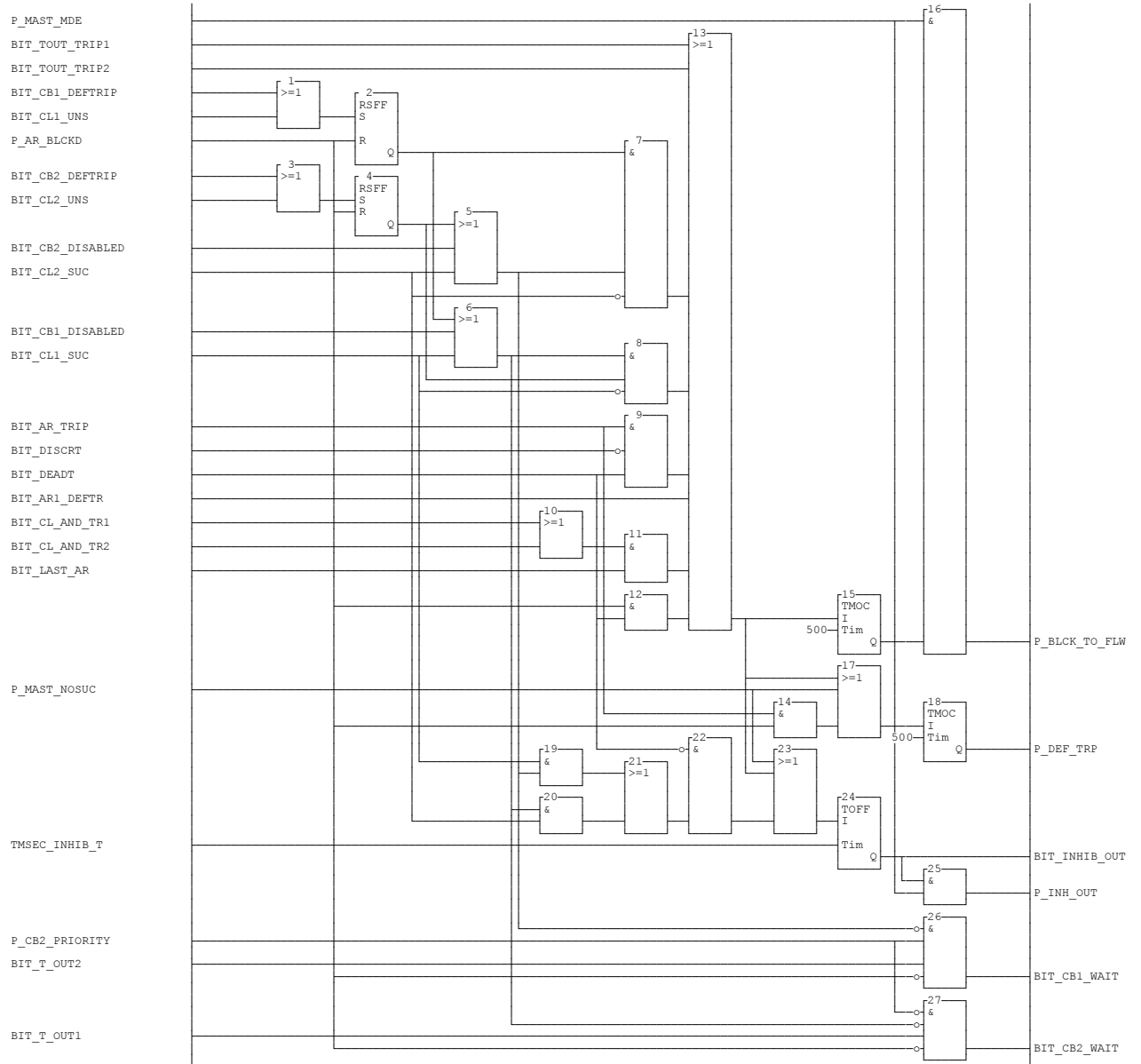


Fig. 4.67 DEFTRIP segment:  
Master/follower and duplex logic and definitive TRIP signal



### 4.9.2. **Signal designations**

The relationship between the designations of the FUPLA input and output signals and the parameter designations used in the HMI can be seen from the following tables. The tables do not show the connections between the various segments.

#### **Timer settings**

<b>FUPLA signal name</b>	<b>HMI designation</b>	<b>HMI setting</b>
TMSEC_BLK_T	t AR Block	0.05 ... 300
TMSEC_CL_T	t Close	0.05 ... 300
TMSEC_DEADT1_1P	t Dead1 1P	0.05 ... 300
TMSEC_DEADT1_3P	t Dead1 3P	0.05 ... 300
TMSEC_DEADT1_EXT	t Dead1 Ext	0.05 ... 300
TMSEC_DEADT2	t Dead2	0.05 ... 300
TMSEC_DEADT3	t Dead3	0.05 ... 300
TMSEC_DEADT4	t Dead4	0.05 ... 300
TMSEC_DISCRT_1P	t Discrim. 1P	0.10 ... 300
TMSEC_DISCRT_3P	t Discrim. 3P	0.10 ... 300
TMSEC_INHIB_T	t Inhibit	0.05 ... 300
TMSEC_OPERT	t Oper	0.05 ... 300
TMSEC_TIME_OUT	t Timeout	0.05 ... 300

#### **Binary inputs**

<b>FUPLA signal name</b>	<b>HMI designation</b>	<b>HMI setting</b>
P_AR_MD2	2..4WE Modus	2 AR
P_AR_MD3	2..4WE Modus	3 AR
P_AR_MD4	2..4WE Modus	4 AR
P_AR_START	Start	-
P_AR_START_2	Start 2	-
P_AR_START_3	Start 3	-
P_AR_ZEMD	ZE Prefault	On
P_AR1_ZE	ZE 1. AR	On
P_AR2_ZE	ZE 2. AR	On

FUPLA signal name	HMI designation	HMI setting
P_AR3_ZE	ZE 3. AR	On
P_AR4_ZE	ZE 4. AR	On
P_CB_OP	CB Open	-
P_CB2_OP	CB2 Open	-
P_CB2_PRIORITY	CB2 Priority	-
P_CO_RDY	CO Ready	-
P_CO_RDY2	CO Ready 2	-
P_COND_BLCK	Cond.Blk AR	-
P_DEADL	Dead line	-
P_DEADL2	Dead line 2	-
P_EXT_T1_EN	Extend t1	-
P_EXTBL_AR	Ext. Blk. AR	-
P_EXTSC_BYP	Ext.SCBypas	-
P_INH_IN	Inhibit Inp.	-
P_MANCL_AR	Manual Close	-
P_MAST_DEL	MasterDelay	-
P_MAST_MDE	Master mode	On
P_MAST_NOSUC	Mast.noSucc	-
P_MD1_1P_1PAR	1. AR Mode	1. 1P-1P
P_MD1_1P_3PAR	1. AR Mode	1. 1P-3P
P_MD1_1P3P_3PAR	1. AR Mode	1. 1P3P-3P
P_MD1_1P3P_1P3P	1. AR Mode	1. 1P3P-1P3P
P_MD1_EXT	1. AR Mode	Ext. selection
P_MD1_EXT_1P_1P	MD1_EXT_1P_1P	-
P_MD1_EXT_1P_3P	MD1_EXT_1P_3P	-
P_MD1_EXT_1P3P_3P	MD1_EXT_1P3P_3P	-
P_MD1_EX_1P3P_1P3P	MD1_EX_1P3P_1P3P	-
P_MDSCBYP_1P	SCBypas 1P	-
P_MDSCBYP_1P3P	SCBypas1P3P	-
P_RDY_OCO	CB Ready	-
P_RDY_OCO2	CB2 Ready	-

FUPLA signal name	HMI designation	HMI setting
P_SYN_CHK	SynchroChck	-
P_SYN_CHK2	SynchroChck2	-
P_TRIP	Trip CB	-
P_TRIP_2	Trip CB2	-
P_TRIP_3	Trip CB3	-
P_TRIP_3P	Trip CB 3P	-
P_TRIP_3P_2	Trip CB2 3P	-
P_TRIP_3P_3	Trip CB3 3P	-

### Signal outputs

FUPLA signal name	HMI designation
P_1AR_1P	First AR 1P
P_1AR_3P	First AR 3P
P_2AR	Second AR
P_3AR	Third AR
P_4AR	Fourth AR
P_AR_3POL_OUT	Trip 3-Pol.
P_AR_BLKCD	AR Blocked
P_AR_RDY	AR Ready
P_AR_RUN	AR in Prog
P_AR_ZEOUT	ZExtension.
P_BLK_TO_FLW	Blk.toFlwr.
P_CL_CB	Close CB
P_CL_CB2	Close CB2
P_DEF_TRP	Def. Trip
P_DEL_FLW	DelayFlwr.
P_INH_OUT	Inhibit Outp

## **4.10. Breaker failure protection**

### **4.10.1. 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.

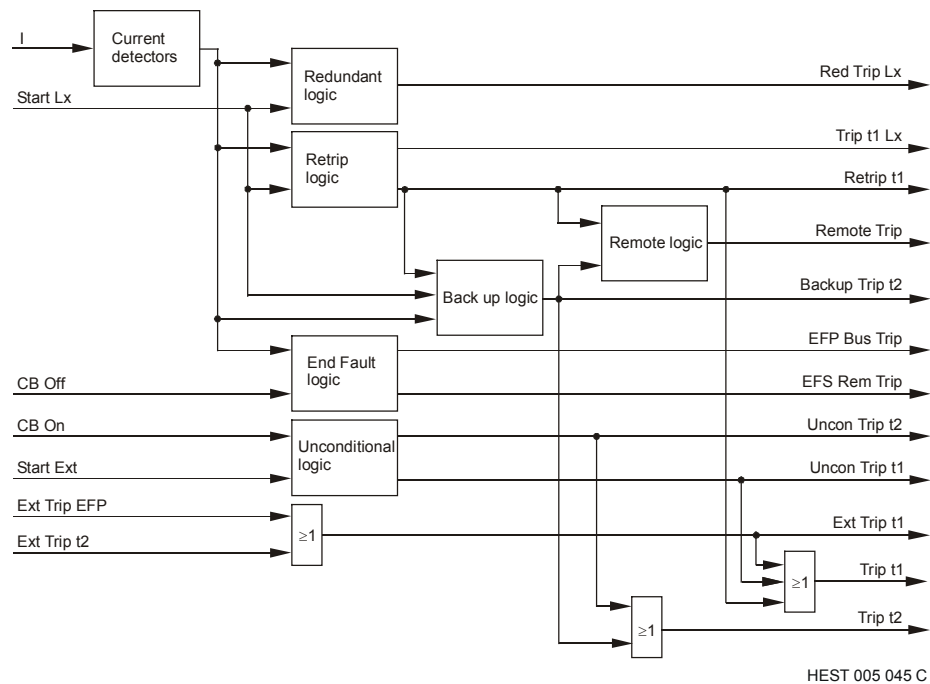


Fig. 4.68 Block diagram

#### 4.10.2. *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.

#### 4.10.3. *'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.

**4.10.4. '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.

**4.10.5. '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.

**4.10.6. '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.

**4.10.7. '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.

#### **4.10.8. '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.

#### **4.10.9. '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. 216 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. 216 runs in the protected mode. The minimum requirements for the PC are 16MB of RAM, 12MB free hard disc space and an operating system MS Windows 3.x, Windows 95, Windows NT4.0 or higher. A 486 series processor or higher is recommended.

The HMI can communicate with the RE. 216 at a baud rate of 9600 Baud. A problem can be encountered with some PC's if the memory manager EMM386 is active. This can be alleviated either by reducing the baud rate or disabling the EMM386 memory manager.

The baud rate for the HMI is determined by a parameter in the configuration file 're.cfg', e.g. for 9600 Baud, the setting must be 'BAUD XX=BAUD96'. The configuration file 're.cfg' can be edited using an ASCII editor such as DOS editor.

The simplest way of temporarily disabling the EMM386 memory manager is to enter REM (for 'remark') at the beginning of the corresponding line in the 'config.sys' file and restarting the PC:

```
REM DEVICE=.....\EMM386.....
```

### **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.

There is an installation program on the discs to simplify the installation of the HMI software.

#### **Installation on a hard disc**

1. Insert the first disc into drive A.
2. Start the installation program by entering:  
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 queries concerning language, drive, directory and COM port.

## HMI configuration

Before the operator program can be executed, the device driver "ansi.sys" must be loaded. The following changes are made to the configuration files of the respective operating system:

### DOS, Windows 3.x:

In C:\CONFIG.SYS:  
device=c:\dos\ansi.sys.

### Windows 95:

In C:\CONFIG.W40:  
device=c:\win95\command\ansi.sys

### Windows NT 4.0:

In C:\WINNT\SYSTEM32\CONFIG.NT:  
device=%SystemRoot%\system32\ansi.sys

## 5.2.3. *Starting and shutting down the operator program*

Click on the icon created during installation to start the operator program.

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 RE. 216. The choice of relay type and the main configuration parameters can be entered or edited by selecting the menu item 'Edit hardware functions'.

### Note:

If the system is required to operate on-line, e.g. to exchange data between the PC and the RE. 216, 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 RS-232 connector on the front of the RE. 216. The protection must be in operation, i.e. the green stand-by LED must be lit or flashing.

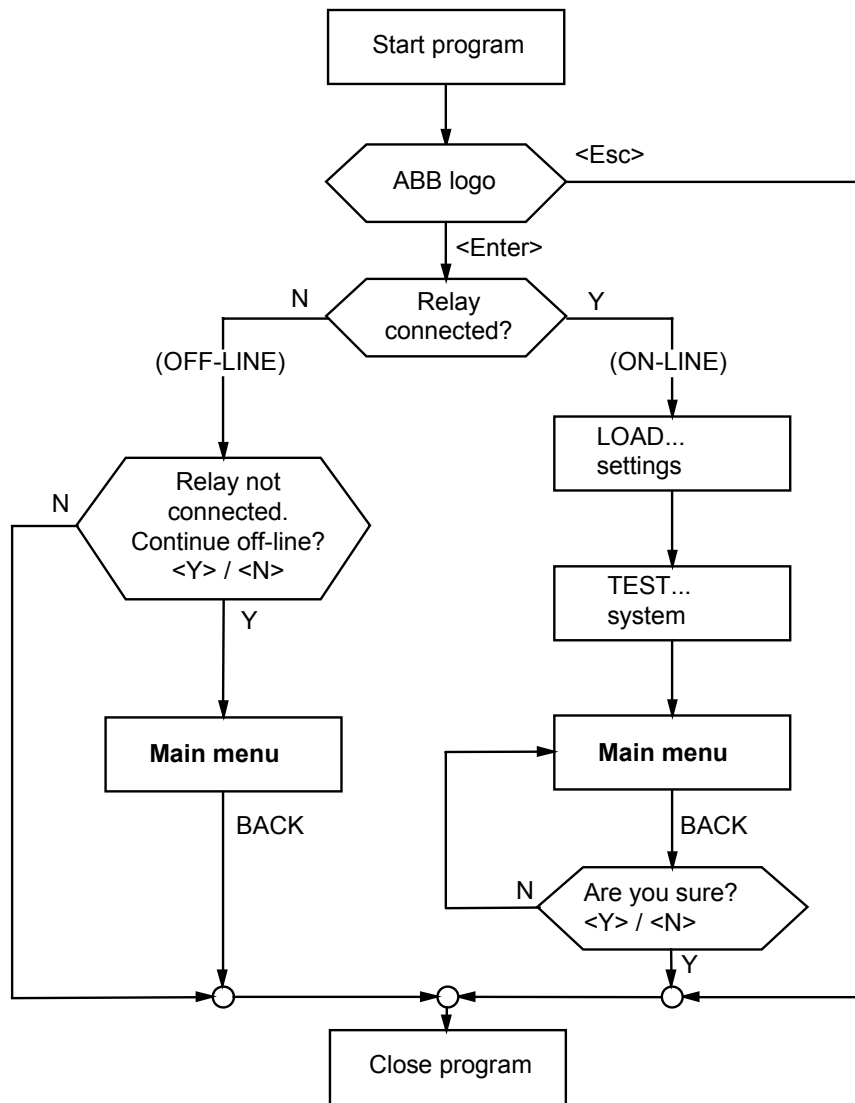


Fig. 5.1 Flow chart of the operator program start-up and shut-down sequence

### 5.3. **Operation**

#### 5.3.1. **General**

The operator program 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. 216:  
"On-line" or "Off-line".
- Interface baud rate:  
"4800 bps", "9600 bps" or " 9600 bps".
- Active protocol for communication with the station automation system (SCS):  
"SCS:SPA", "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. Measurement values 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 configuration of the scheme can be saved in text files for implementation in an SCS substation automation system.
8. RETURN closes the operator program.

All the above options are available when the PC is connected on-line, but only 1, 6 and 7 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.

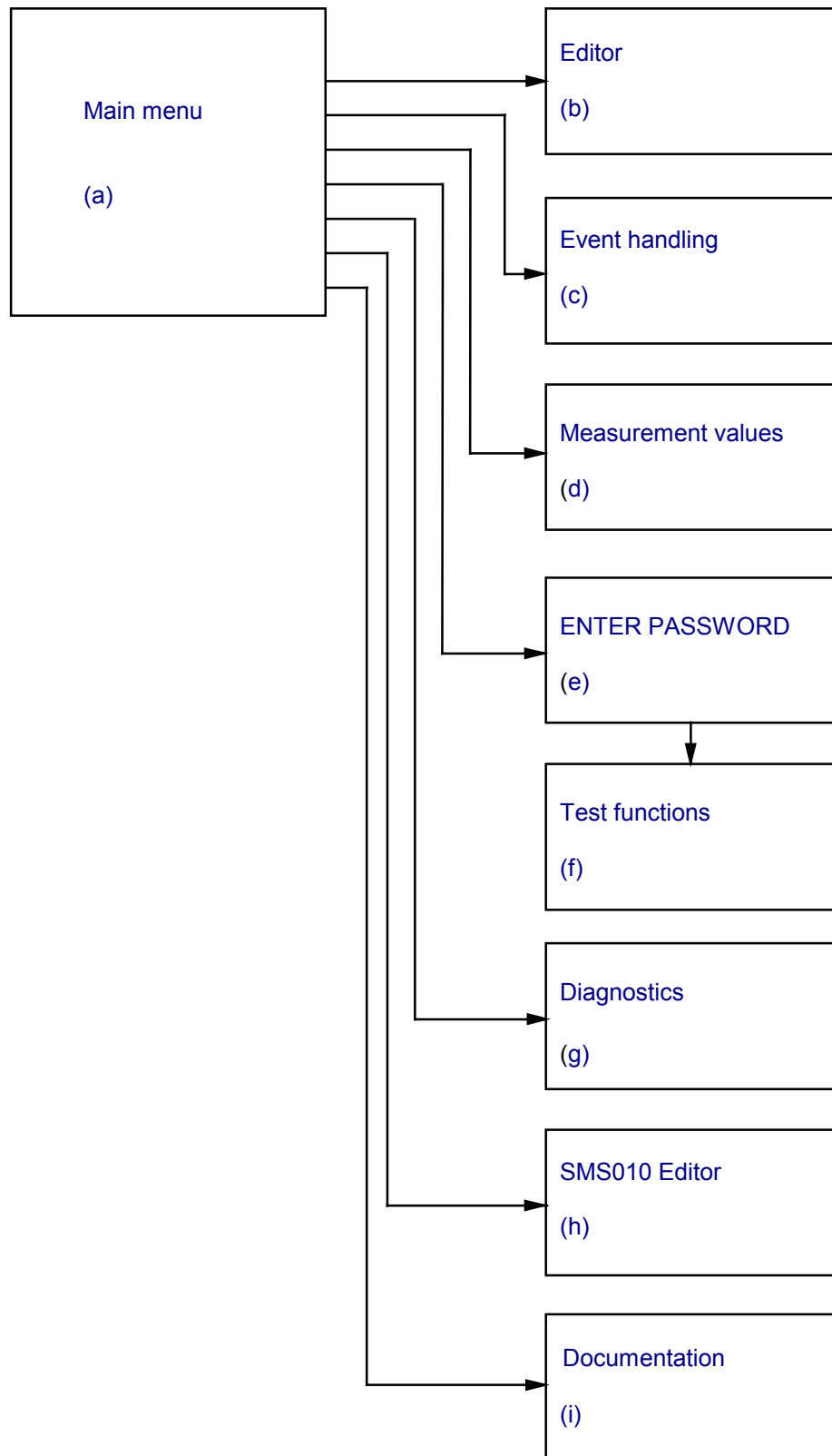


Fig. 5.2 Main and sub-menu structure  
(see displays a to i on the following pages)

```
ABB Switzerland Ltd      Example      REG216 Generator Terminal
Main Menu
Editor
Event Handling
Measurement Values
Test Functions
Diagnostics
SMS010-Editor
Documentation
RETURN
On-line  9600 bps  SCS:SPA      V6.2b \ V6.2b
```

Fig. 5.2 a Main menu

```
ABB Switzerland Ltd      Example      REG216 Generator Terminal
Main Menu
Editor
Present Prot Funcs
Edit Hardware Functions
Edit System Parameters
List Edit Parameters
Save Parameters to File
Load Parameters from File
RETURN
On - Line  9600 bps  SCS:SPA      V6.2b - V6.2b
```

Fig. 5.2 b Editor  
(see Section 5.5)

```
ABB Switzerland Ltd      Example      REG216 Generator Terminal
-----
Main Menu
├── Event Handling
│   ├── Display current Events
│   ├── List Event List
│   ├── Clear Event List
│   ├── Disturbance Recorder
│   └── RETURN
└──
-----
On - Line 9600 bps  SCS:SPA      V6.2b \ V6.2b
```

Fig. 5.2 c Event handling  
(see Section 5.6)

```
ABB Switzerland Ltd      Example      REG216 Generator Terminal
-----
Main Measurement Values
├── Ed Display AD(CT/VT) Channels
├── Ev Display Function Measurements
├── Me Display Binary Inputs
├── Te Display Signal Outputs
├── Di Display Trip Outputs
├── SM Display LED Outputs
├── Do Display Analogue Inputs
├── RE Display Analogue Outputs
├── Display RBI Status
├── Display RBO Status
├── Display ITL_I Status
├── Display ITL_O Status
├── Display SCS_O Status
├── Display FUPLA Signals
└── RETURN
-----
On - Line 9600 bps  SCS:SPA      V6.2b \ V6.2b
```

Fig. 5.2 d Measurement processing  
(see Section 5.7)

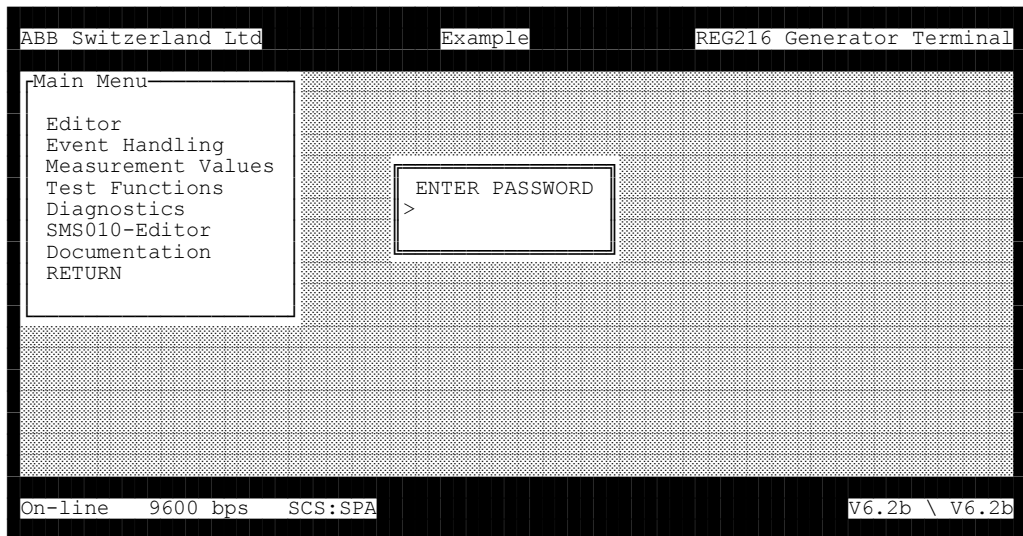
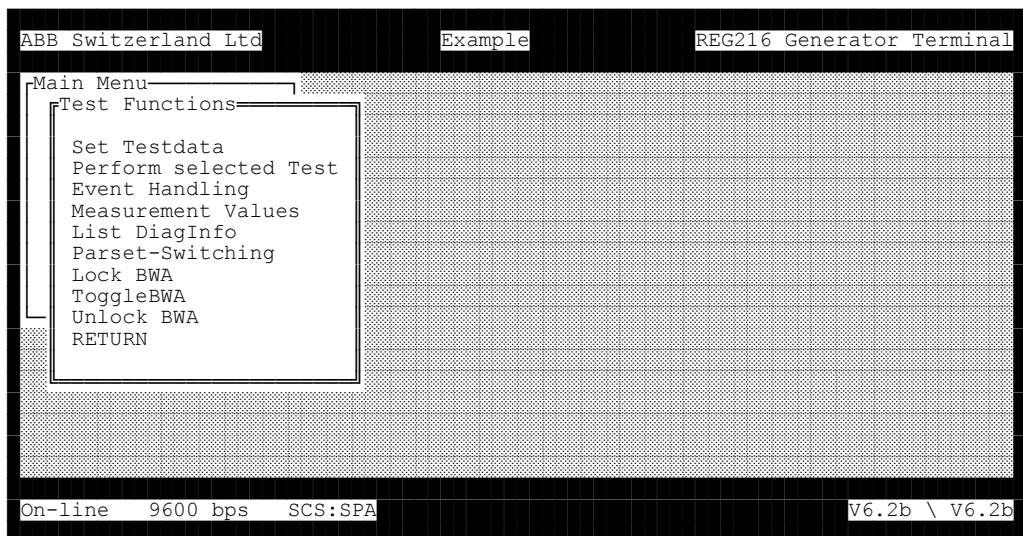


Fig. 5.2 e ENTER PASSWORD

Fig. 5.2 f Test functions  
(see Section 5.9)

```
ABB Switzerland Ltd      Example      REG216 Generator Terminal
Main Menu
Diagnostics
List DiagInfo
Get Hex Dump
Clear Hex Dump
IBB-Information
RIO-Information
Reset SCS-Inputdata
Load SCS-Masks
RETURN
On-line  9600 bps  SCS:LON      V6.2b \ V6.2b
```

Fig. 5.2 g      Diagnostics  
(see Section 5.9)

```
ABB Switzerland Ltd      Example      REG216 Generator Terminal
Main Menu
SMS010-Editor
Edit EVENT.DSC
Edit LOGGING.DSC
Create new DSC-Files
RETURN
RETURN
On-line  9600 bps  SCS:SPA      V6.2b \ V6.2b
```

Fig. 5.2 h      SMS010 editor  
(see Section 5.13)

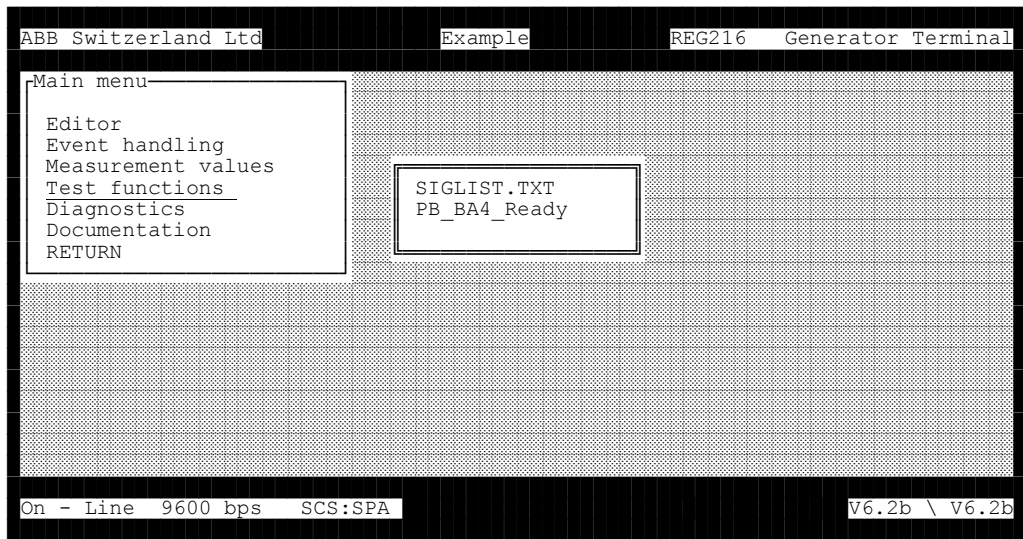


Fig. 5.2 i      Documentation  
(see Section 5.10)



## 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 IBB 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.

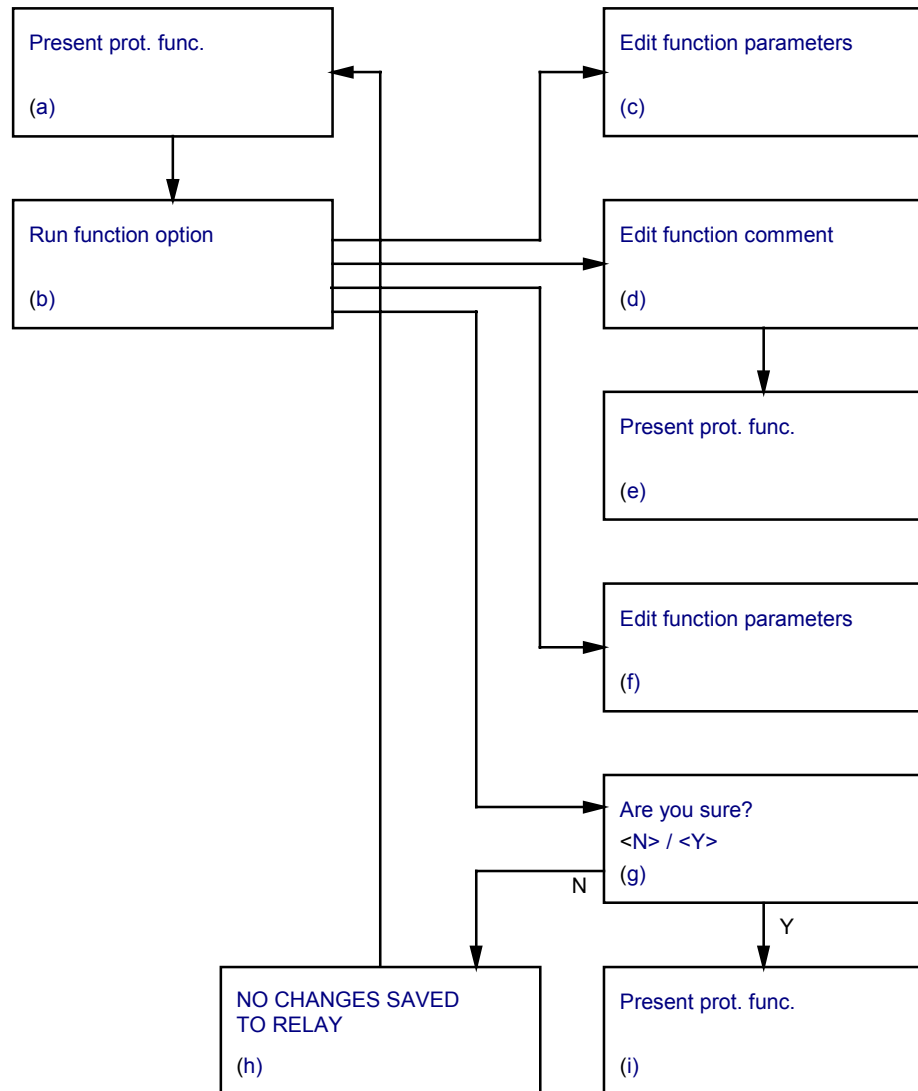


Fig. 5.3 Editing an active protection function  
(see displays a to i on the following pages)

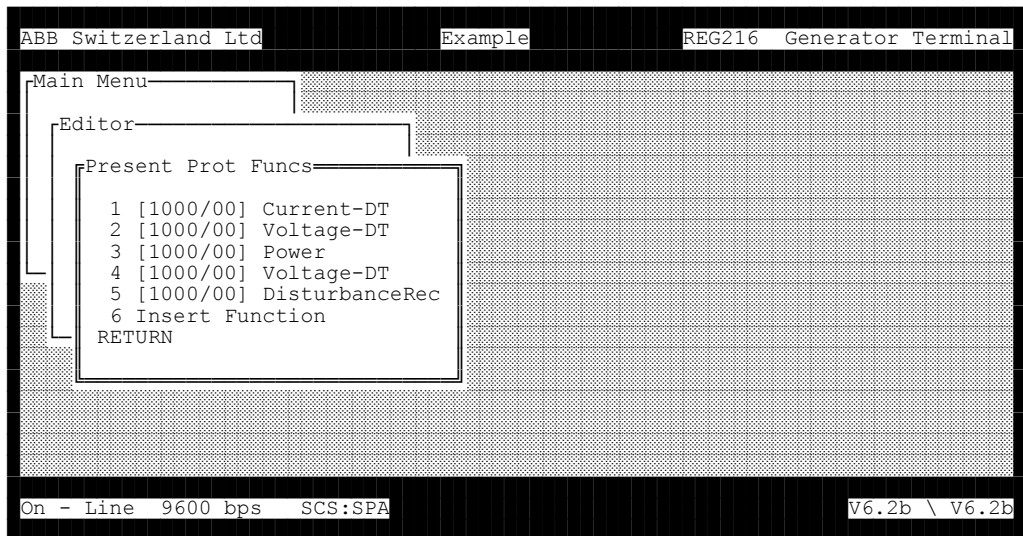


Fig. 5.3 a Present prot. funcs.

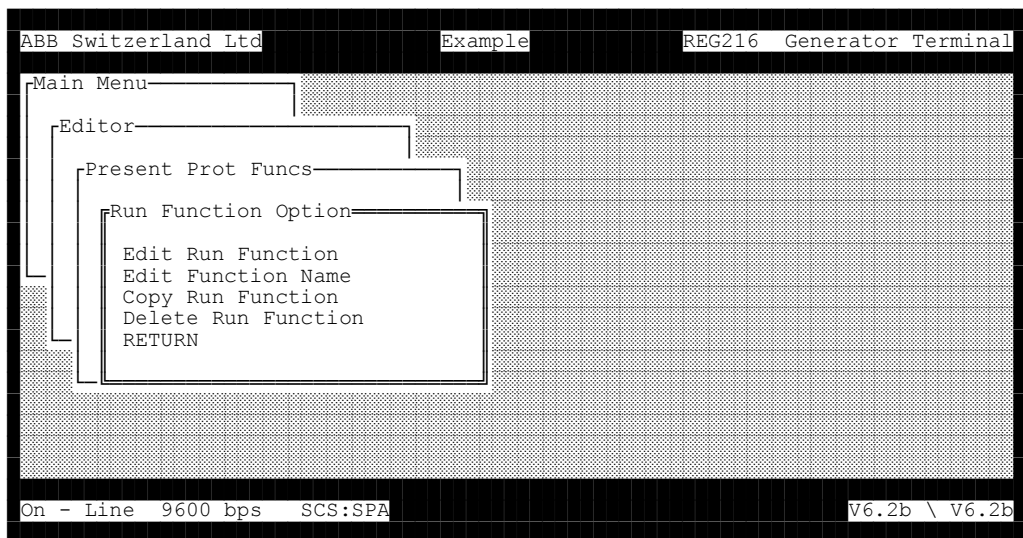


Fig. 5.3 b Run function option

### 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](#).

```

ABB Switzerland Ltd      Example      REG216 Generator Terminal
Edit Function Parameters
Func Nr 1 - Current-DT      * *
ParSet4..1      P1      Select
Trip      B10000000
Delay      01.00      s
I-Setting      02.00      IN
MaxMin      MAX (1ph)      Select
NrOfPhases      003
CurrentInp      1      AnalogAddr
BlockInp      F      BinaryAddr
Trip      ER      SignalAddr
Start      ER      SignalAddr
RETURN/ENTER
On - Line 9600 bps SCS:SPA      V6.2b \ V6.2b

```

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.

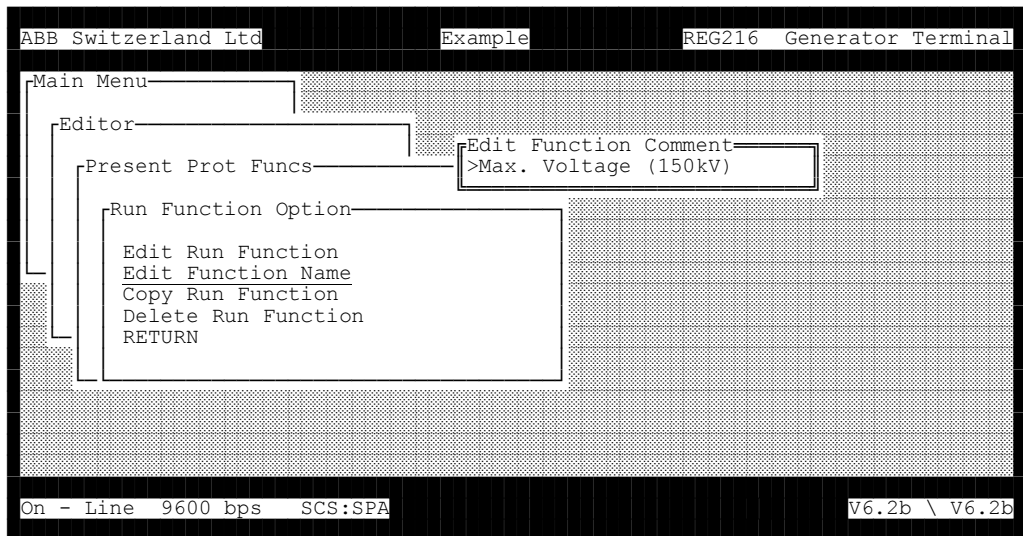


Fig. 5.3 d Edit function comment

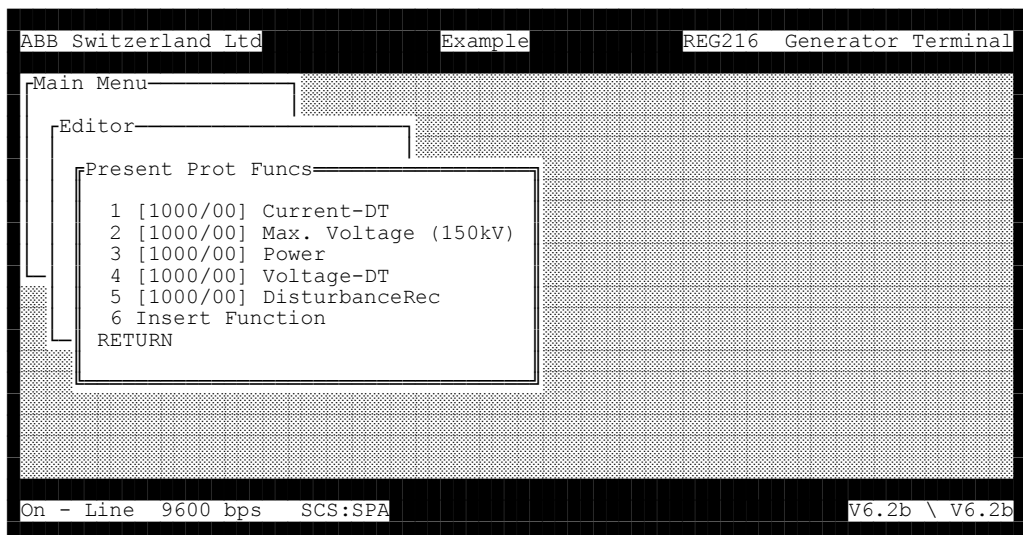


Fig. 5.3 e Present prot. funcs.

### 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 Fig. 5.3 c and f). 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:

$$P1 \leq pO \leq \quad \text{and} \quad pO < pK \leq P4$$

where

pO = parameter set number of the original function

pK = parameter set number of the copied function.

```

ABB Switzerland Ltd      Example      REG216  Generator Terminal
-----
Edit Function Parameters
-----
Func Nr 6 - Current-DT      * *
ParSet4..1                  Select
Delay                       01.00      s
I-Setting                   02.00      IN
MaxMin                      MAX (1ph)  Select
NrOfPhases                  003
BlockInp                    F          BinaryAddr
RETURN/ENTER
-----
On - Line  9600 bps  SCS:SPA      v6.2b \ v6.2b

```

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.

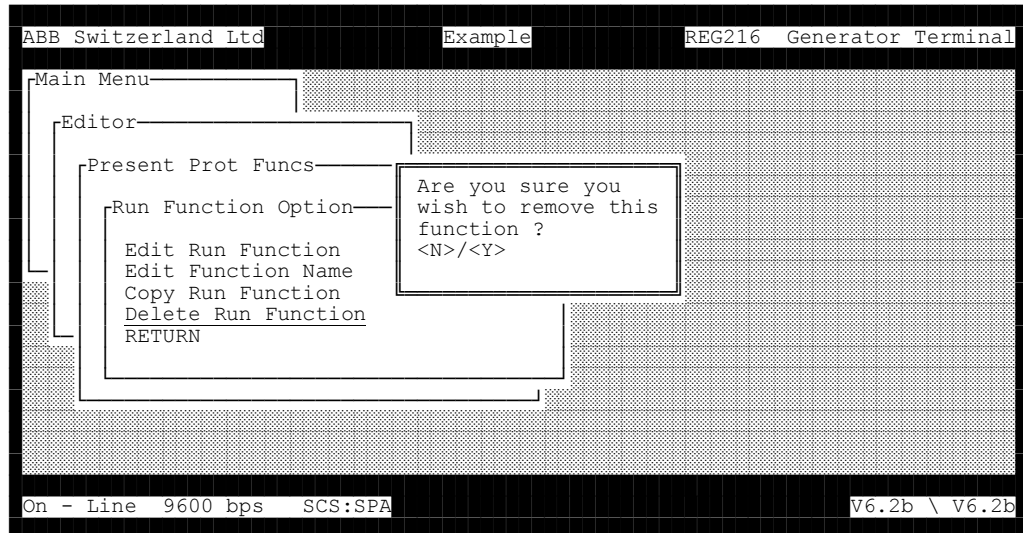


Fig. 5.3 g Are you sure?

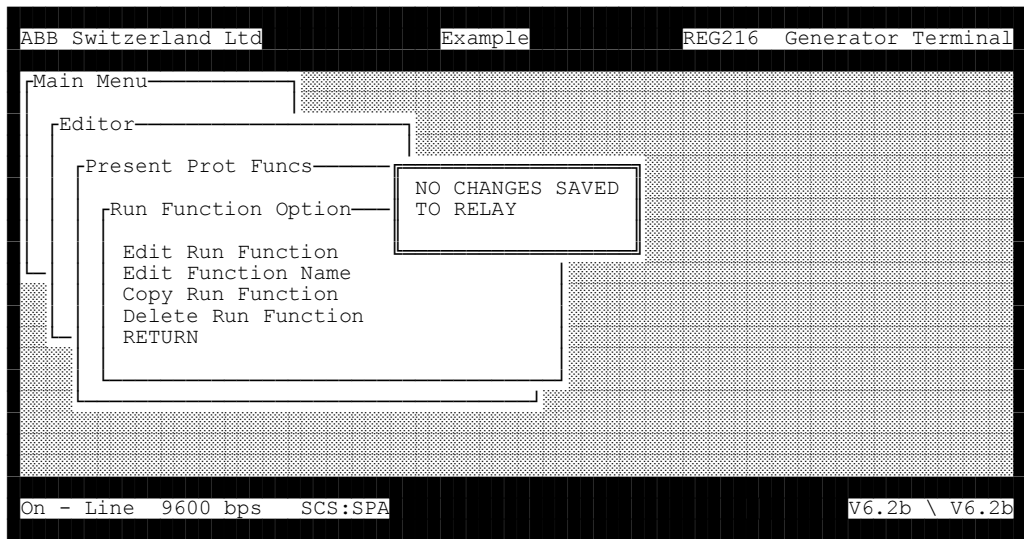


Fig. 5.3 h NO CHANGES SAVED TO RELAY

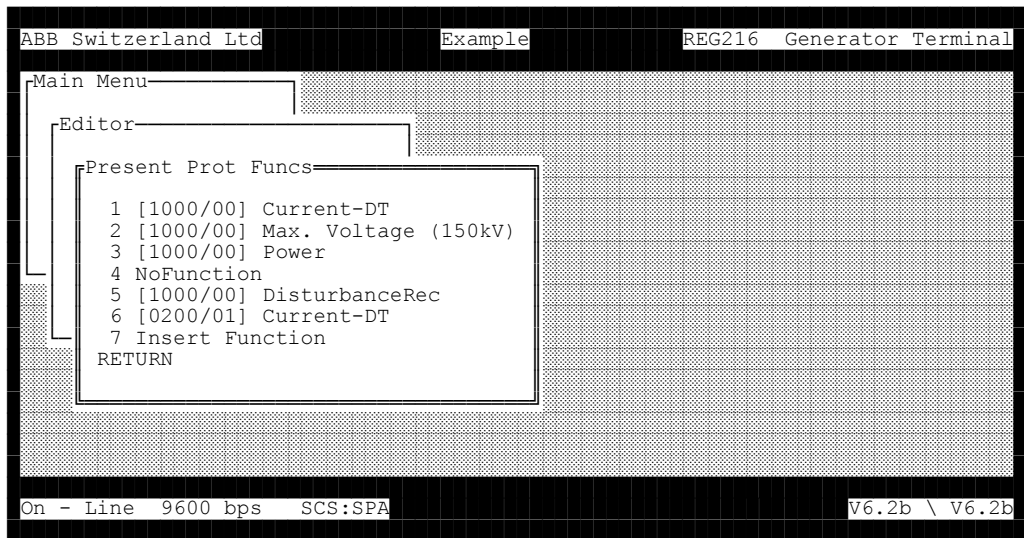


Fig. 5.3 i Present prot. funcs.



### 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:**

```

ABB Switzerland Ltd      Example      REG216 Generator Terminal
Edit Function Parameters
Func Nr 2 - Voltage-DT      * Max. Voltage (150kV) *
ParSet4..1                  P1                      Select
Trip                        B10300000
Delay                        02.00                   s
V-Setting                    1.200                   UN
MaxMin                       MAX (1ph)               Select
NrOfPhases                   001
VoltageInp                    6                      AnalogAddr
BlockInp                      f 1 Trip                BinaryAddr
Trip                          S104 L003 M1307 ER      SignalAddr
Start                          S103 ER                 SignalAddr
RETURN/ENTER
On - Line 9600 bps      SCS:SPA      V6.2b \ V6.2b
  
```

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:

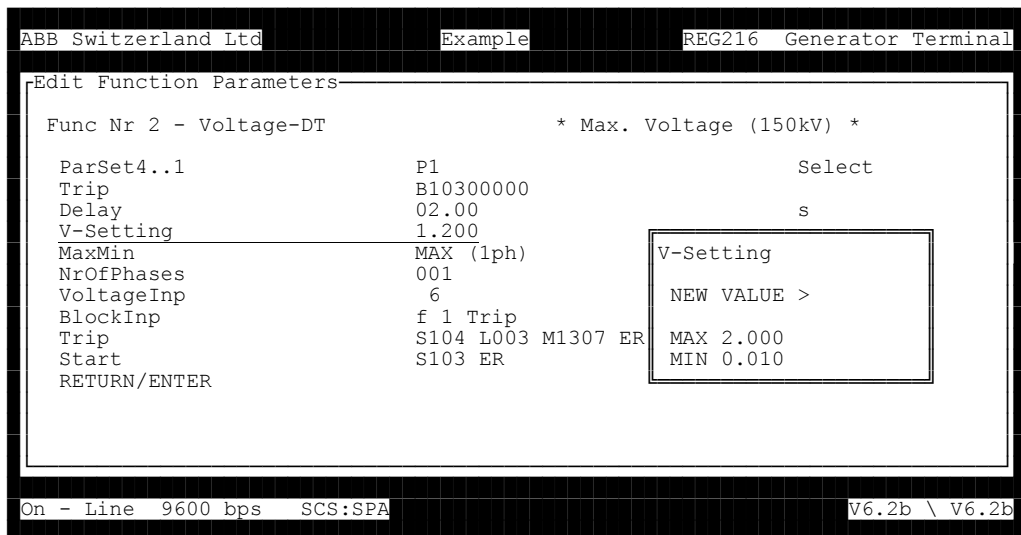


Fig. 5.5 Window for entering numerical settings

**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>

```

**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 “>”.

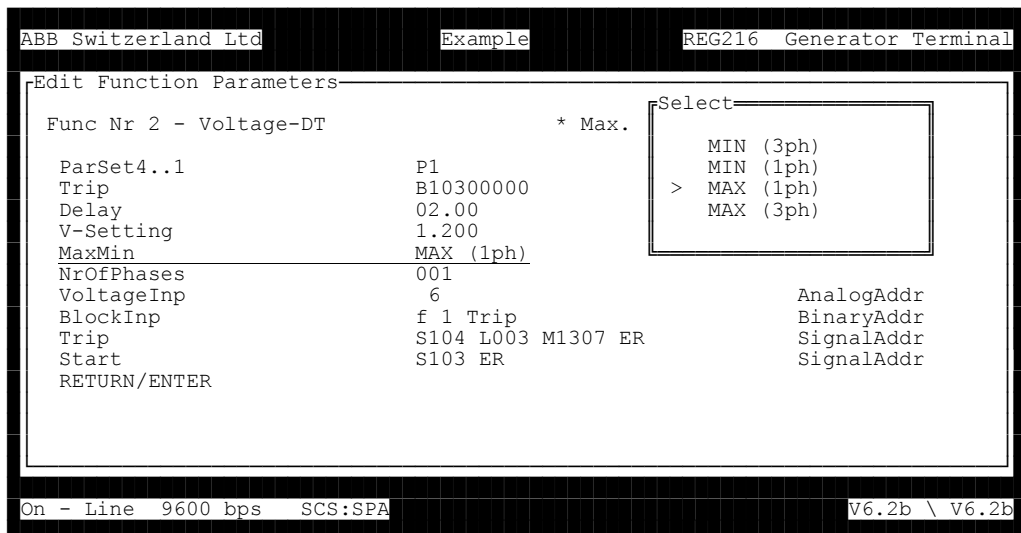


Fig. 5.6 Option selection window

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 a 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 bleep 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 to the “A-D Input Channels” selection window:

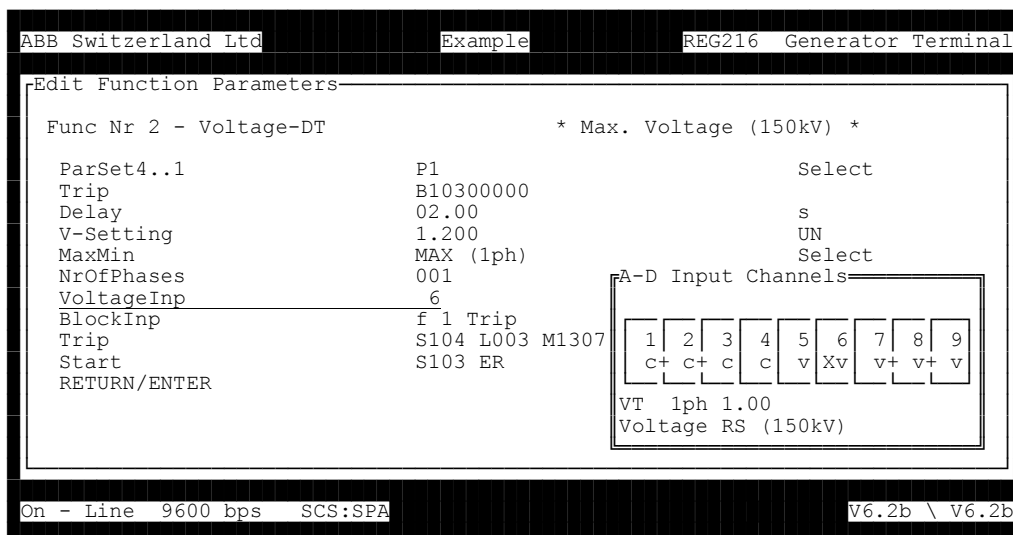


Fig. 5.7 “A-D Input Channels” selection window

The nine boxes representing the available c.t. and v.t. channels in the selection window 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 has been 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, physical outputs (signalling relays and RBO), a station automation output (SCS) and the interlocking logic (ITL). The bleep sounds if an attempt is made to use more than two physical outputs.

```

ABB Switzerland Ltd      Example      REG216 Generator Terminal
-----
Edit Function Parameters
Func Nr 2 - Voltage-DT      * Max. Voltage (150kV) *
ParSet4..1
Trip
Delay
V-Setting
MaxMin
NrOfPhases
VoltageInp
BlockInp
Trip
Start
RETURN/ENTER

Select Binary Output
Signal relays
Event recording
Signal to SCS
Signal to RBO
Signal to ITL
RETURN

Select
UN
Select
AnalogAddr
BinaryAddr
SignalAddr
SignalAddr

On - Line 9600 bps  SCS:SPA      V6.2b \ V6.2b

```

Fig. 5.8 Setting signalling channels

## 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.

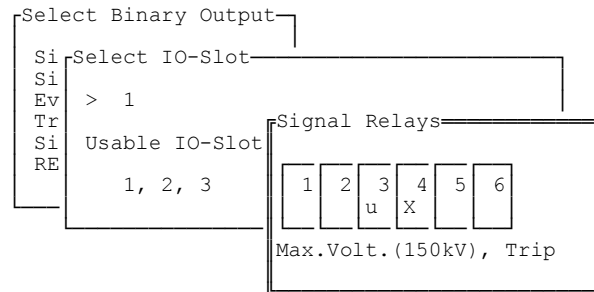


Fig. 5.9 “Signal relays” selection window

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. S1204) are indicated in the parameter value column of the “Edit function parameters” window.

Sxyy: x = plug-in unit number  
yy = channel number (1...32).

## Event recording

The flag which determines whether a signal is recorded as an event is set in the “Event recording” window:

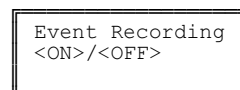


Fig. 5.10 Setting and resetting the event recording flag

“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.**

**Tripping relays**

Tripping relays can be used for signalling purposes. 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. C1401) are indicated in the parameter value column of the “Edit function parameters” window.

Cxyy:   x   = plug-in unit number  
          yy  = channel number (1...8)

**Signal to SCS**

Before a signal can be assigned to the SCS, the respective group (1 to 24) must be selected in the “Select SCS group” window. SCS groups 1c...24c are used to transfer short signals to the MVB interbay bus (signal capturing).

The “Signals to SCS” selection window then appears.



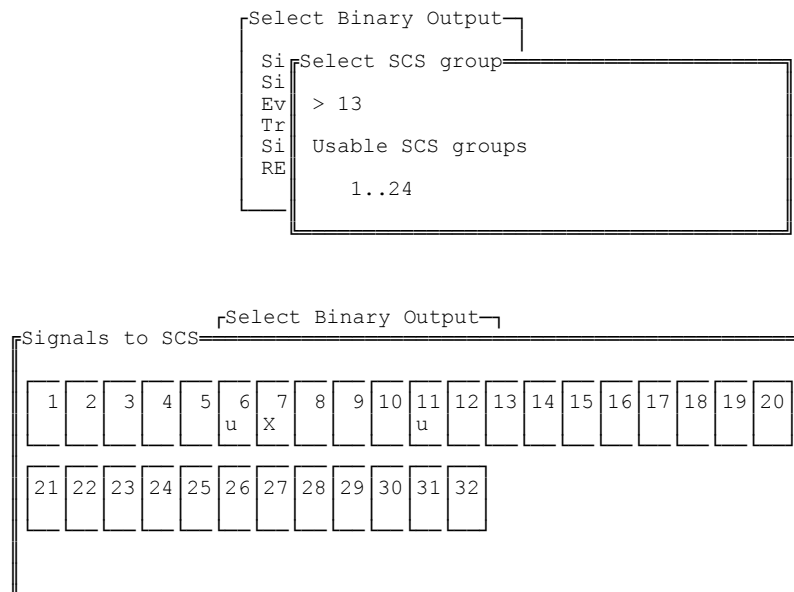


Fig. 5.11 “Select SCS group” and “Signals to SCS” selection windows

The boxes 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. M1307) is indicated in the parameter value column of the “Edit function parameters” window.

Mxxy: xx = IBB group number (1...24)  
 yy = data node within a group (1...32).

### Signal to RBO (remote binary output)

Before a signal can be assigned to a RBO, the respective group (1 to 80) must be selected in the “Select RBO No.” window.

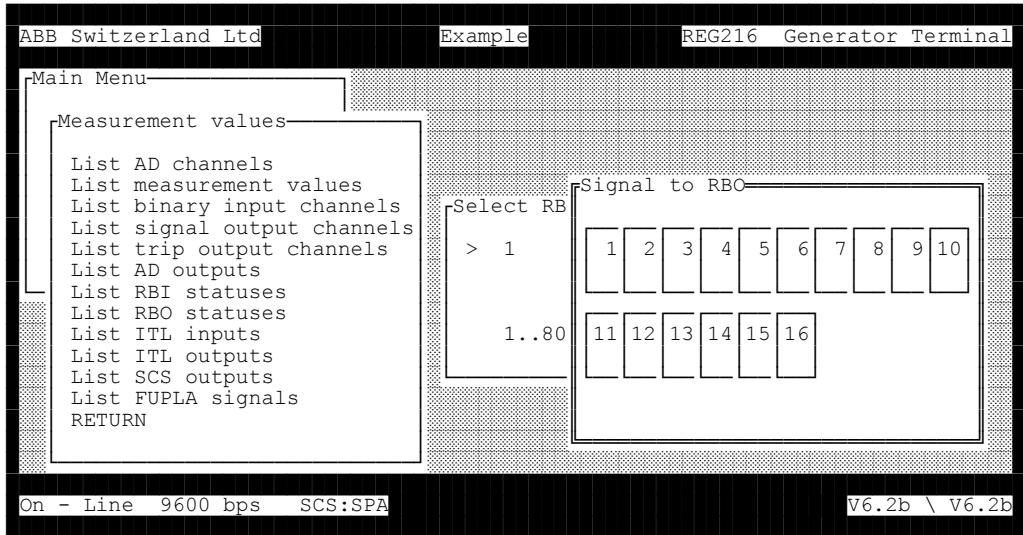


Fig. 5.12 “Select RBO group” and “Signal to RBO” selection windows

The assignment to an RBO (e.g. R101) is indicated in the parameter value column in the “Edit function parameters” window:

Ryyxx: y = RBO group number (1...80)  
 xx = RBO within a group (1...16).

**Signal to ITL (interlocking)**

Before a signal can be assigned to ITL, the respective group (1 to 3) must be selected in the “Select ITL group” window.

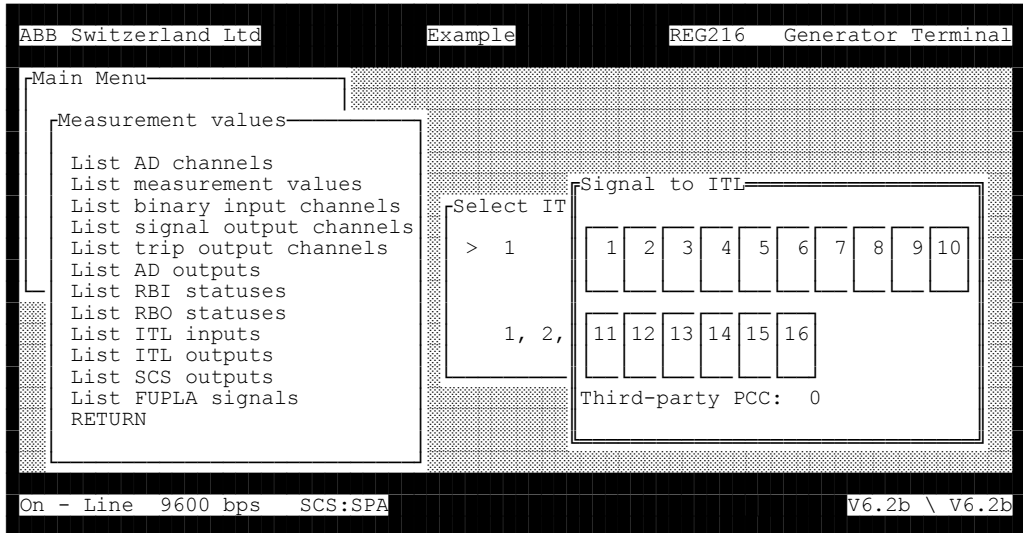


Fig. 5.13 “Select ITL group” and “Signal to ITL” selection windows

The ITL assignment (e.g. I101) is indicated in the parameter value column in the “Edit function parameters” window:

Ryyxx: y = ITL group number (1...3)  
 xx = ITL 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:

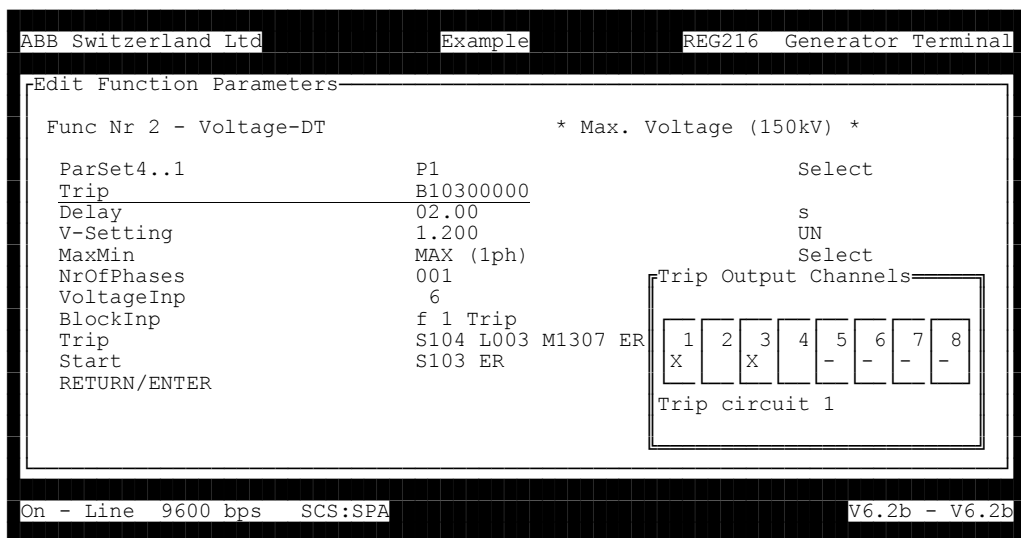


Fig. 5.14 “Trip output channel” selection window

The boxes 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.

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:**

Generally the protection function TRIP signal will only set the common 'General TRIP' signal, if it is assigned to a tripping logic ) and configured to be recorded as an event (ER)..

The distance function is an exception because it always initiates a general trip alarm.

**5.5.4.4. Binary channels**

Binary inputs of functions can either be switched permanently on or off or be connected to a system binary input, a binary output of another function, an SCS input, an RBI (remote binary input) or an ITL (interlocking) data input. The corresponding setting is made in the "Select binary input" window:

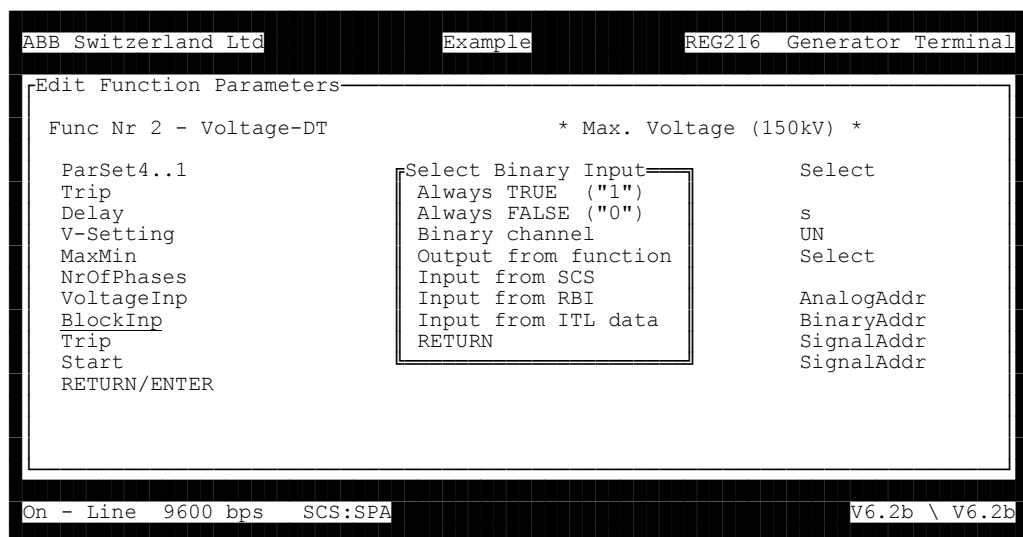


Fig. 5.15 "Select binary input" window

**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. The respective I/O unit is selected first and then the “Binary input channels” selection window opens:

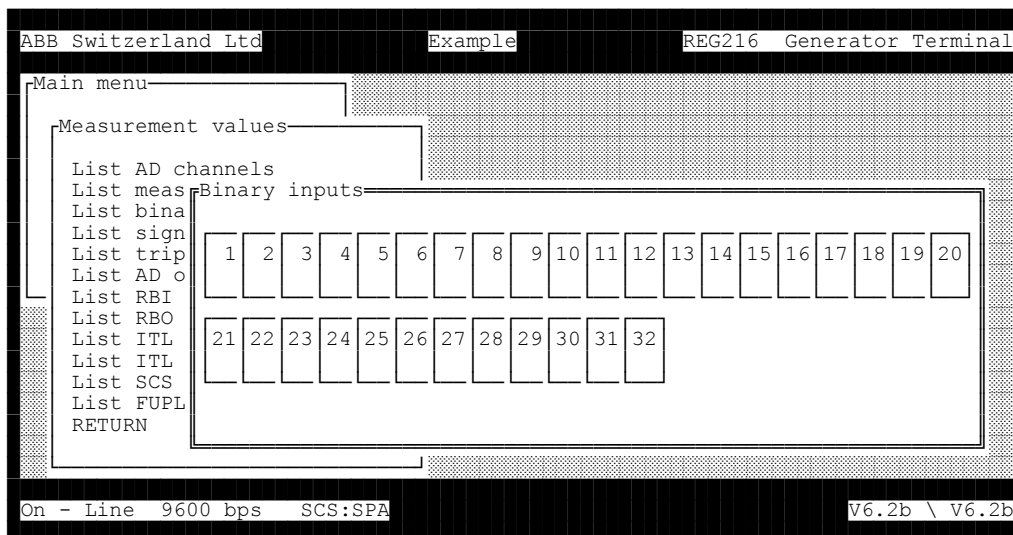


Fig. 5.16 “Binary input channels” selection window

The boxes representing the binary input channels in the selection window are designated as follows:

Top: 1...32 : 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. -1501) 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

zz = channel number (1...32).

**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:

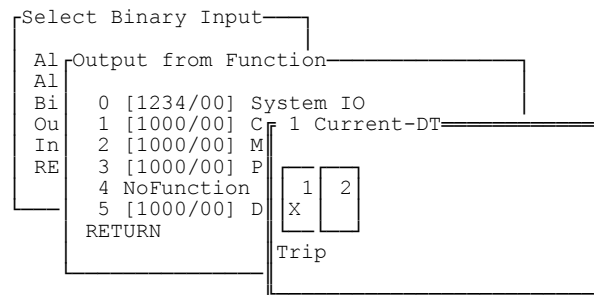


Fig. 5.17 “Output from function” selection window

The boxes in the selection window are designated as follows:

Top: 1...47 : 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 function number and signal name of the selected output and a minus sign if it is inverted (e.g. -f 1 OFF) are indicated in the parameter value column of the “Edit function parameters” window.

xfy z: x = non-inverted () or inverted (-) input

y = function number

z = signal name.

## Input from SCS

Every function input can be assigned either inverted or non-inverted to an SCS input. The respective group (1 to 24) is first selected in the “Select SCS group” window and then the “Inputs from SCS” selection window opens:

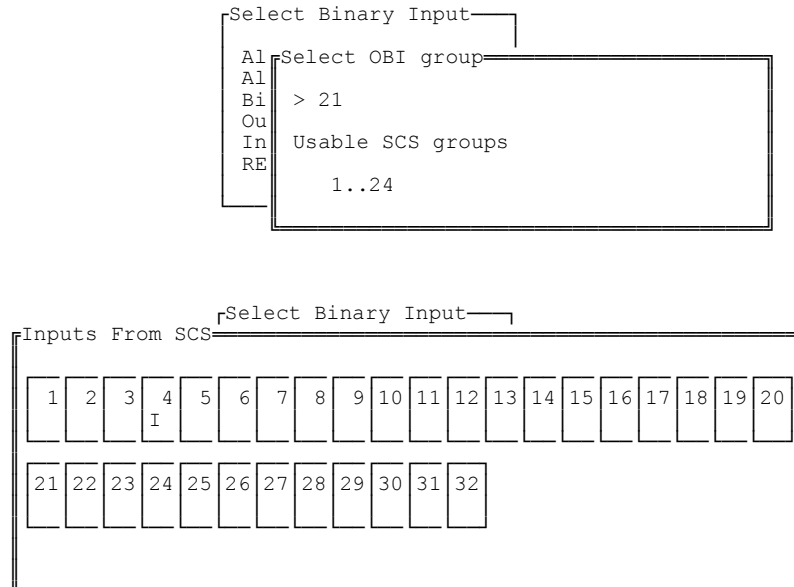


Fig. 5.18 “Select SCS group” and “Inputs from SCS” selection windows

The boxes 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. -m2104) is indicated in the parameter value column of the “Edit function parameters” window.

- xmyzz: x = non-inverted ( ) or inverted (-) input
- yy = SCS group number (1...24)
- zz = data node within the group (1...32).

## Input from RBI (remote binary input)

Every function input can be assigned either inverted or non-inverted to an RBI input. The respective group (1 to 80) is first

selected in the “Select RBI group” window and then the “Inputs from RBI” selection window opens:

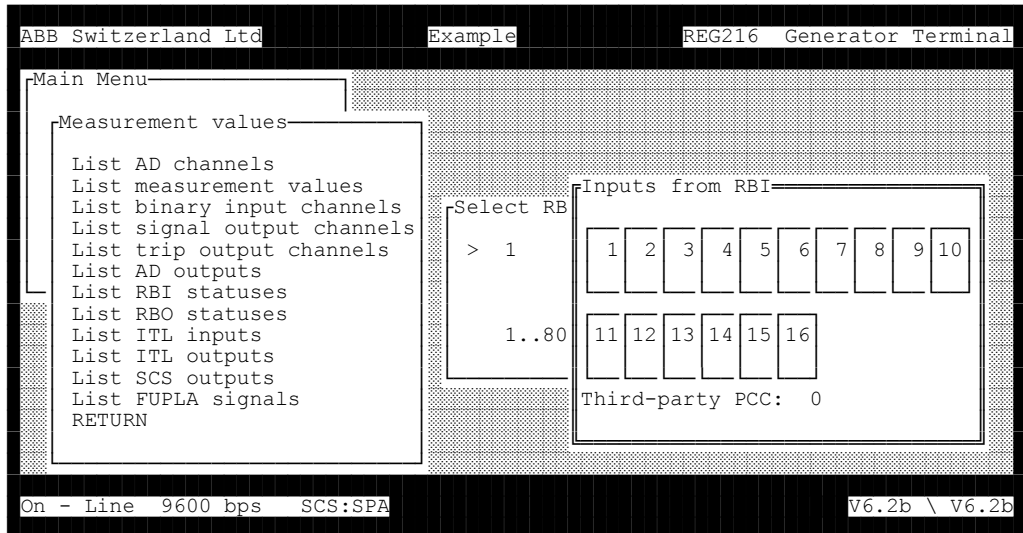


Fig. 5.19 “Select RBI group” and “Inputs from RBI” selection windows

### Input from ITL (interlocking data)

Every function input can be assigned either inverted or non-inverted to an ITL input. The respective group (1 to 64) is first selected in the “Select ITL No.” window and then the “Inputs from ITL data” selection window opens:

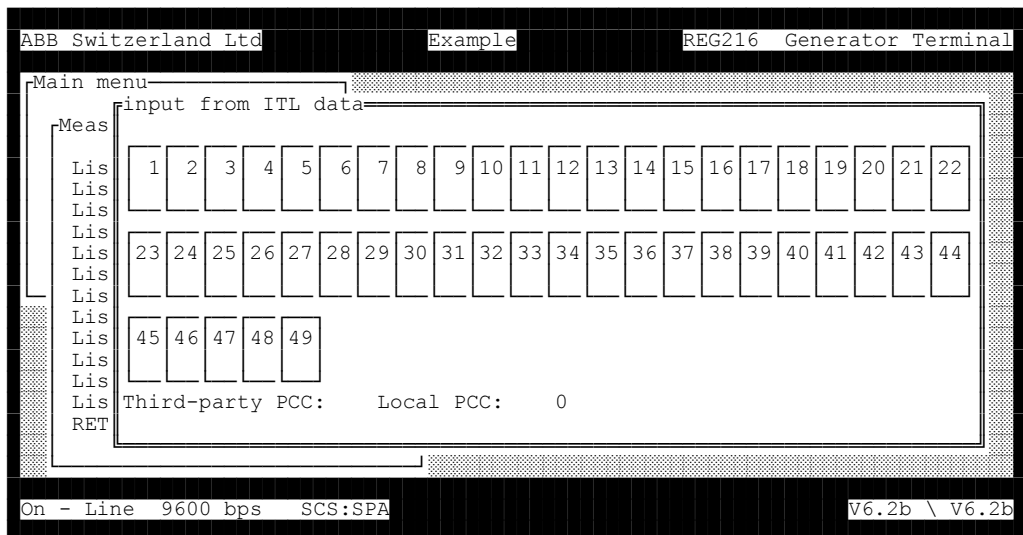


Fig. 5.20 “Select ITL group” and “Inputs from ITL” selection windows



### 5.5.5. **Editing hardware functions**

The hardware functions include all the hardware device settings. The menu structure can be seen from Fig. 5.21:

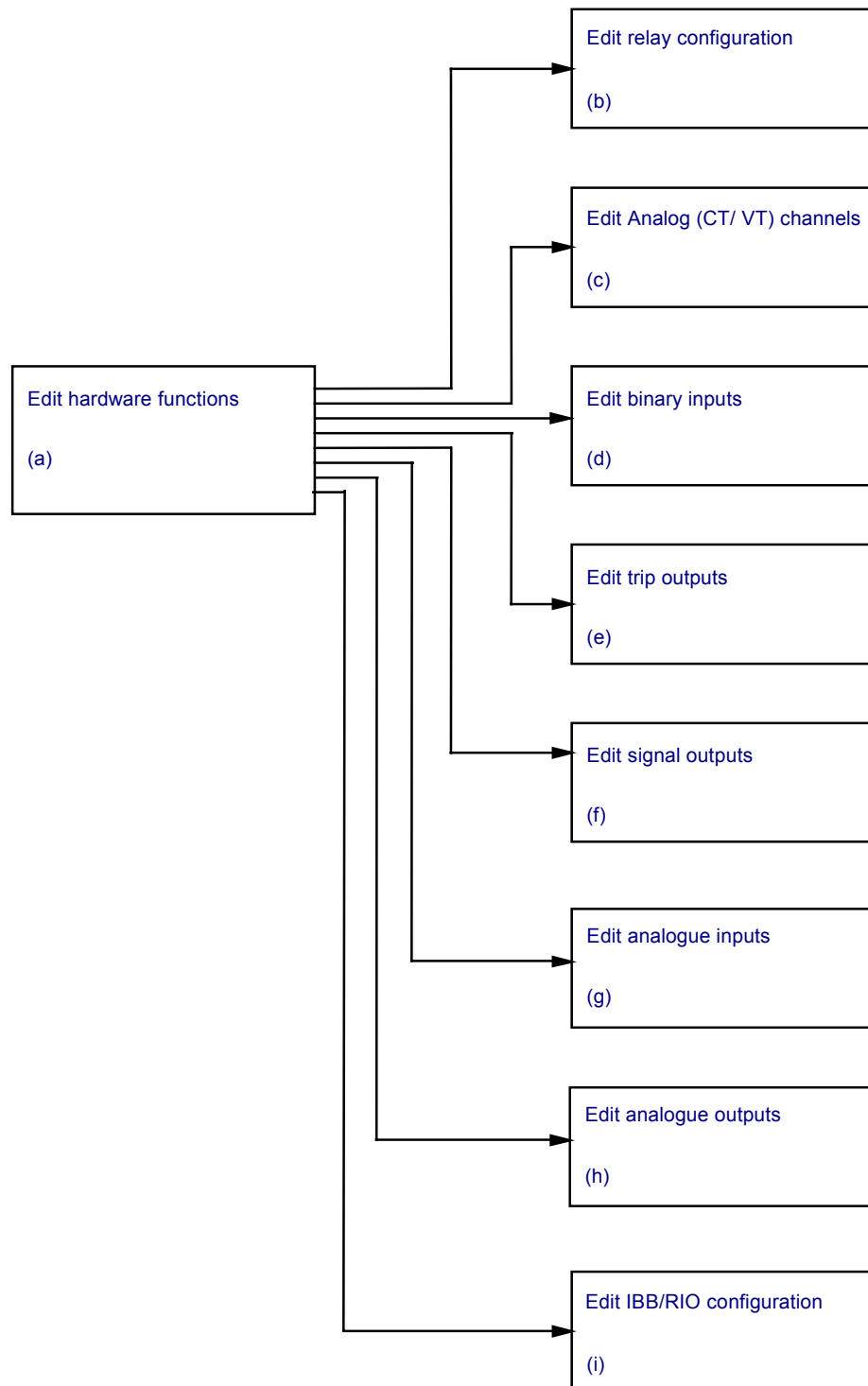


Fig. 5.21 Editing hardware functions  
(see displays a to i on the following pages)

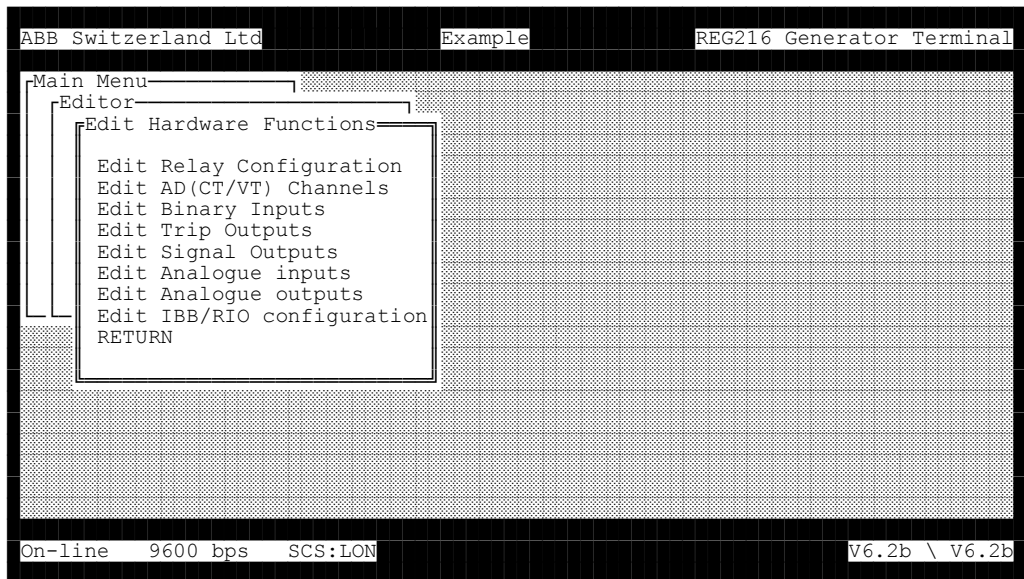


Fig. 5.21 a Edit hardware functions

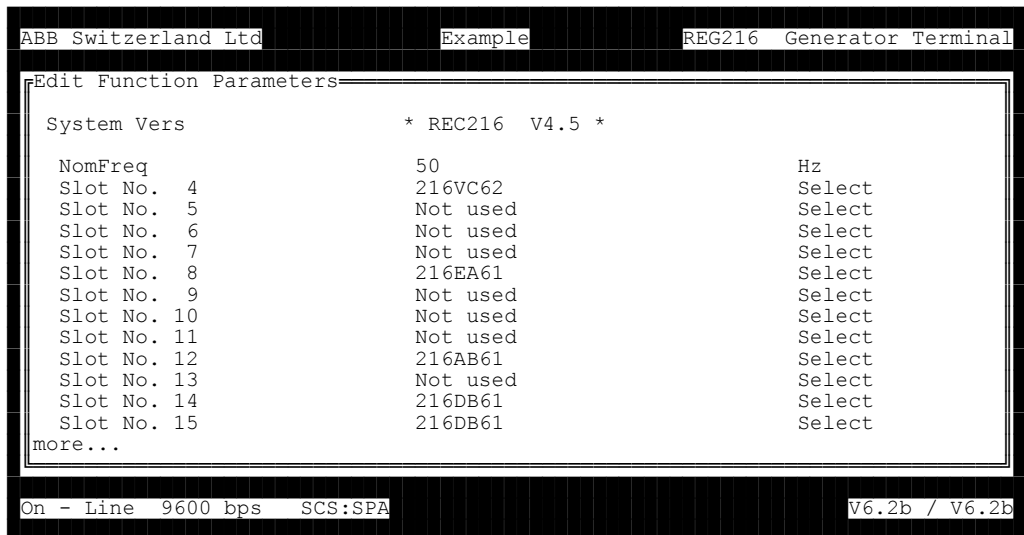


Fig. 5.21 b Edit function settings and relay configuration

```
ABB Switzerland Ltd      Example      REG216 Generator Terminal
Main Menu
Editor
  Edit Hardware Functions
    Edit Analog (CT/VT) Channels
      Edit AD Channel Type
      Edit AD Nominal Value
      Edit AD Prim /Sec Ratio
      Edit AD Channel Ref Val
      Edit AD Channel comment
      RETURN
On-line  9600 bps  SCS:LON      V6.2b \ V6.2b
```

Fig. 5.21 c Edit Analog (CT/VT) channels

```
ABB Switzerland Ltd      Example      REC216 Generator Terminal
Main Menu
Editor
  Edit Hardware Functions
    Edit Binary Inputs
      Edit Enable / Eventmask
      Edit Comment
      Edit DoubleIndication
      RETURN
On - Line 9600 bps  SCS:SPA      V6.2b \ V6.2b
```

Fig. 5.21 d Edit binary inputs

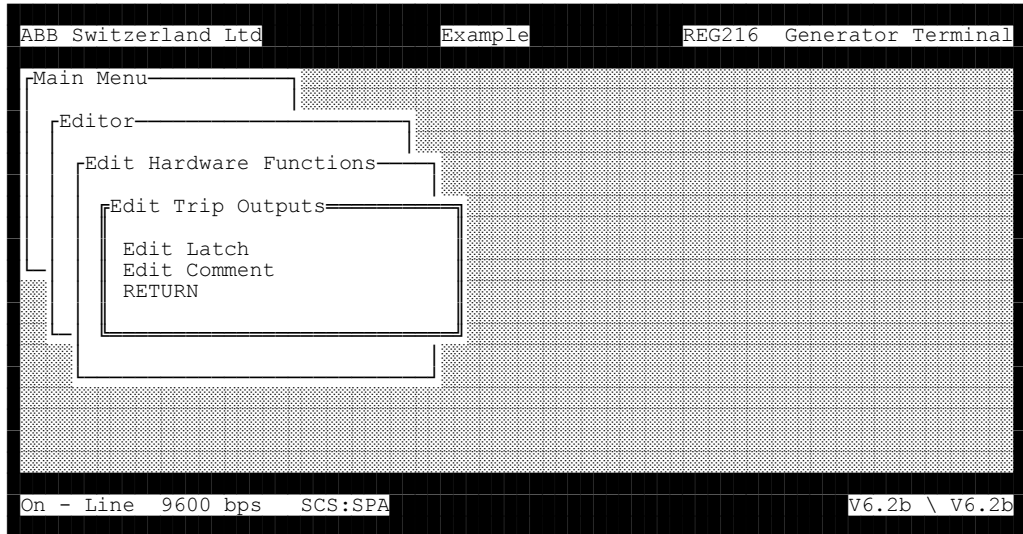


Fig. 5.21 e Edit trip outputs

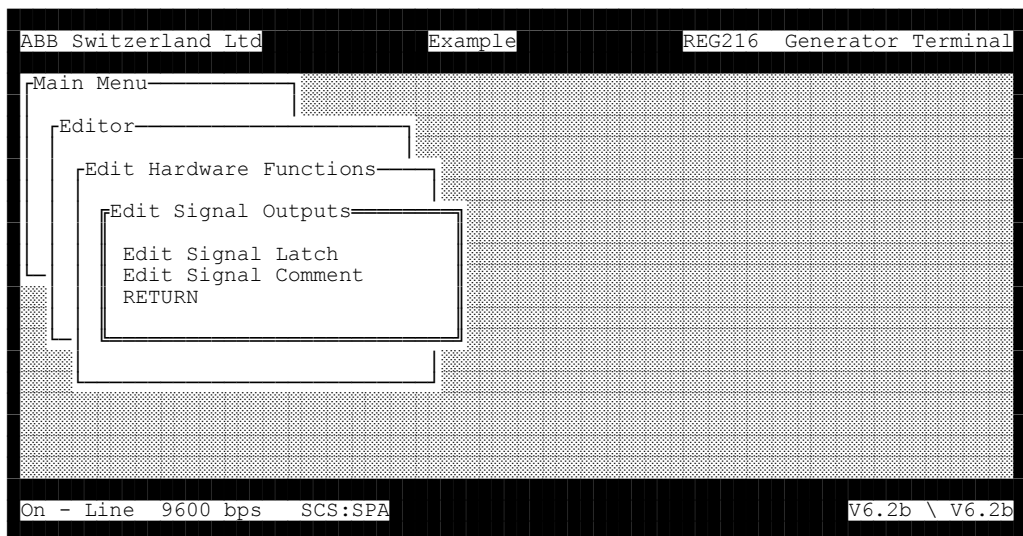


Fig. 5.21 f Edit signal outputs

```
ABB Switzerland Ltd      Example      REG216 Generator Terminal
┌Main Menu──────────┐
│Editor──────────┐
│┌Edit Hardware Functions──┐
││┌Analogue Inputs──┐
│││Edit Input Type
│││Edit Channel Parameters
│││RETURN
││└──────────┘
││┌Edit Analogue Outputs
│││IBB/RIO - Function
│││RETURN
││└──────────┘
│└──────────┘
└──────────┘
On-line 9600 bps  SCS:LON      V6.2b \ V6.2b
```

Fig. 5.21 g Edit Analogue Inputs

```
ABB Switzerland Ltd      Example      REG216 Generator Terminal
┌Main Menu──────────┐
│Editor──────────┐
│┌Edit Hardware Functions──┐
││┌Analog Outputs──┐
│││Edit Output Types (RIO)
│││Edit Channel Parameters
│││Edit AC61 Parameters
│││RETURN
││└──────────┘
││┌Edit IBB/RIO Configuration
│││RETURN
││└──────────┘
│└──────────┘
└──────────┘
On - Line 9600 bps  SCS:LON      V6.2b \ V6.2b
```

Fig. 5.21 h Edit analogue outputs

Refer to the Operating Instructions 1MRB520192-Uen for the distributed input/output system RIO580 for the various submenus and the parameters for configuring the analogue inputs and outputs. Please refer to [Section 3.4.5.](#) for the significance of the configuration parameters for the 216AC61 analogue outputs.

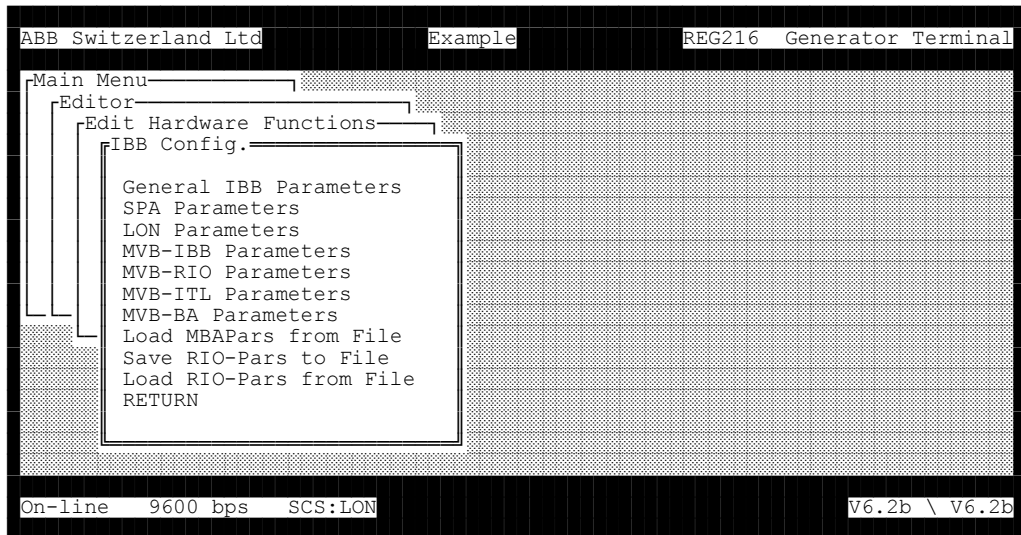


Fig. 5.21 i Edit IBB Configuration

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.

### 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.

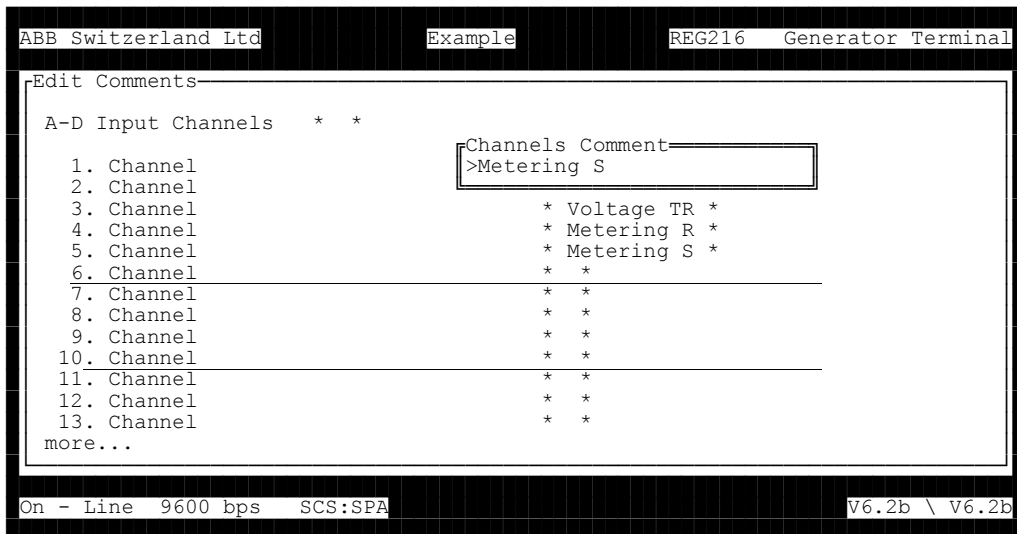


Fig. 5.22 Editing the comments of analogue channels  
Press <Enter> to open the data input window for editing channel comments.

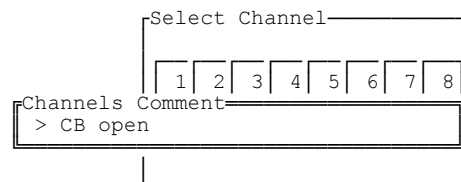
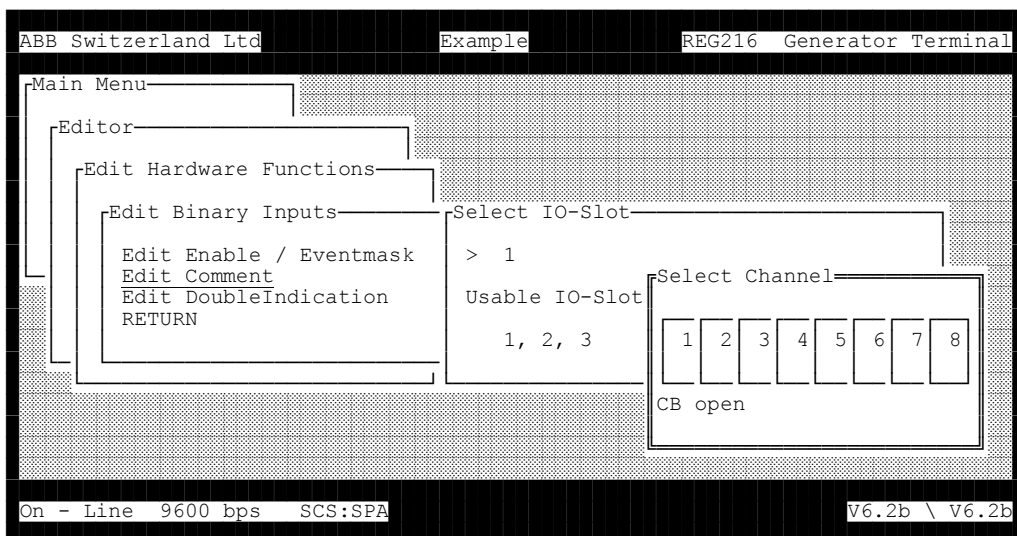


Fig. 5.23 Editing comments for binary, tripping and signalling channels

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 <Insert>.

### **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:**  
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.  
Reference range: 0.5...2.0

### **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 <Insert> 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).



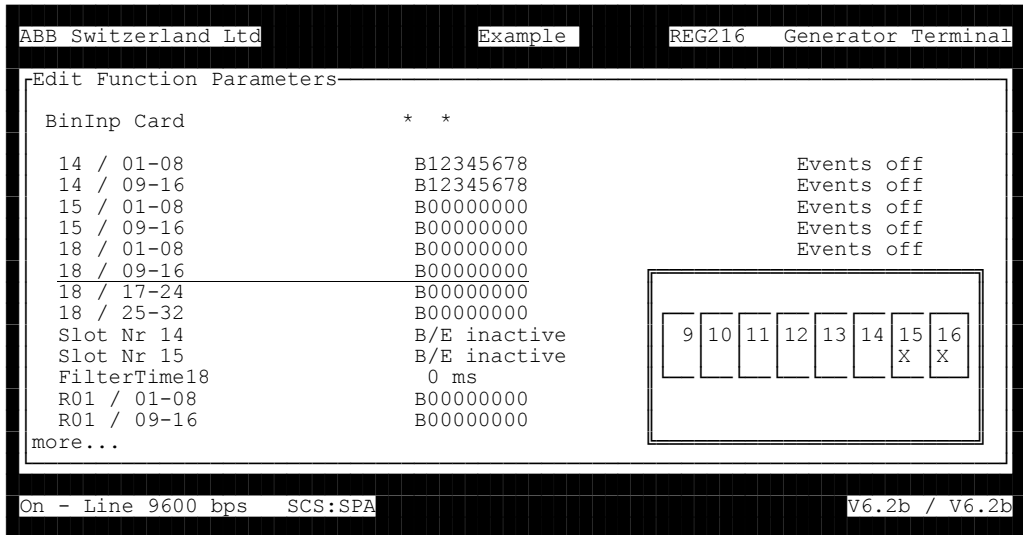


Fig. 5.24 Changing the event masking settings

**Edit double indication signals**

Two consecutive binary inputs can be configured as a 'duplicate signal'.

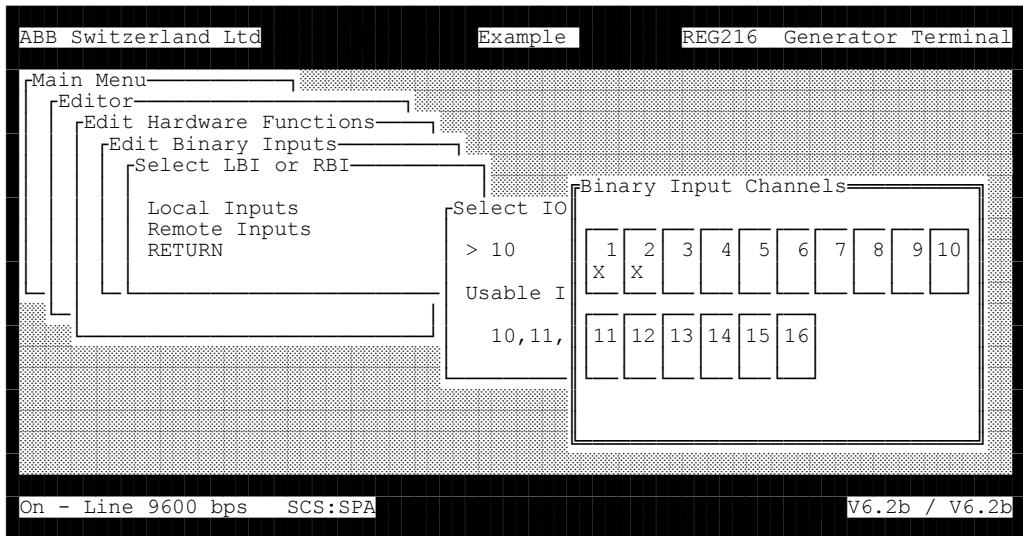


Fig. 5.25 Edit double indication signals

### Tripping and signalling channel latching

Every 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.

#### 5.5.6. *Editing system functions*

System functions include all the settings common to all functions. The menu structure can be seen from Fig. 5.26.

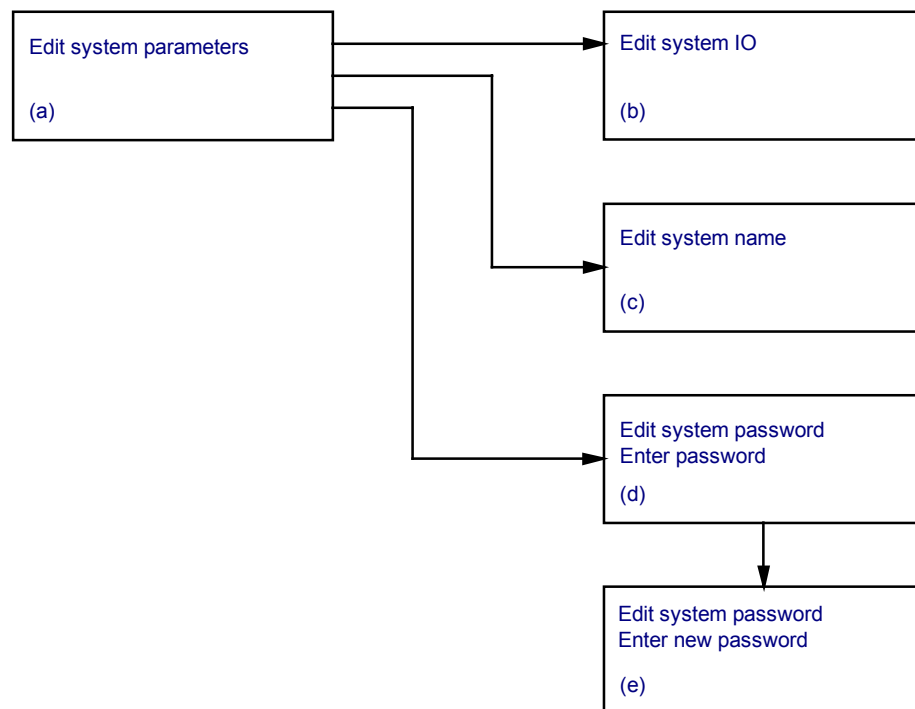


Fig. 5.26 Editing system functions  
(see displays a to e on the following pages)

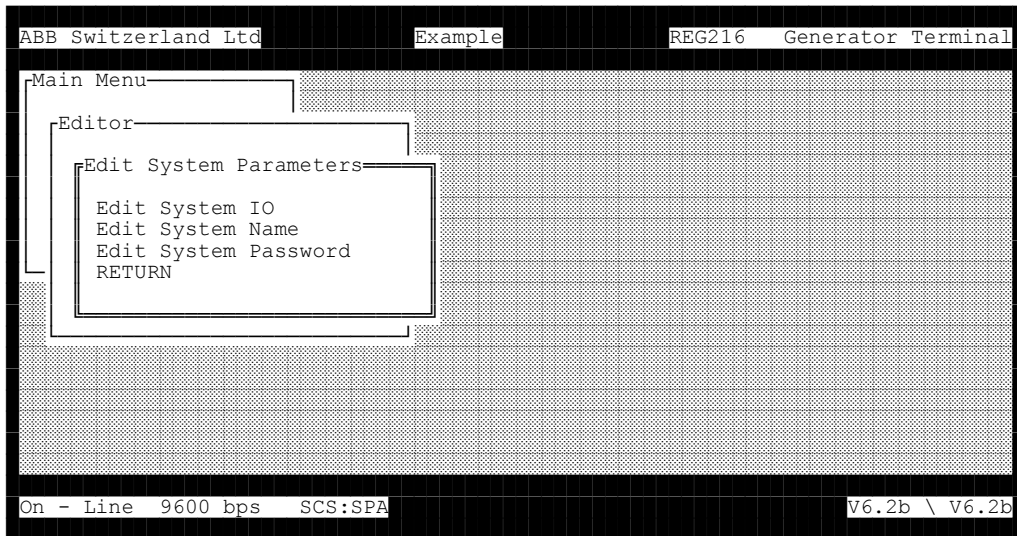


Fig. 5.26 a Edit system parameters



Fig. 5.26 b Edit function parameters

System settings concern those independent of functions, binary inputs and signals.

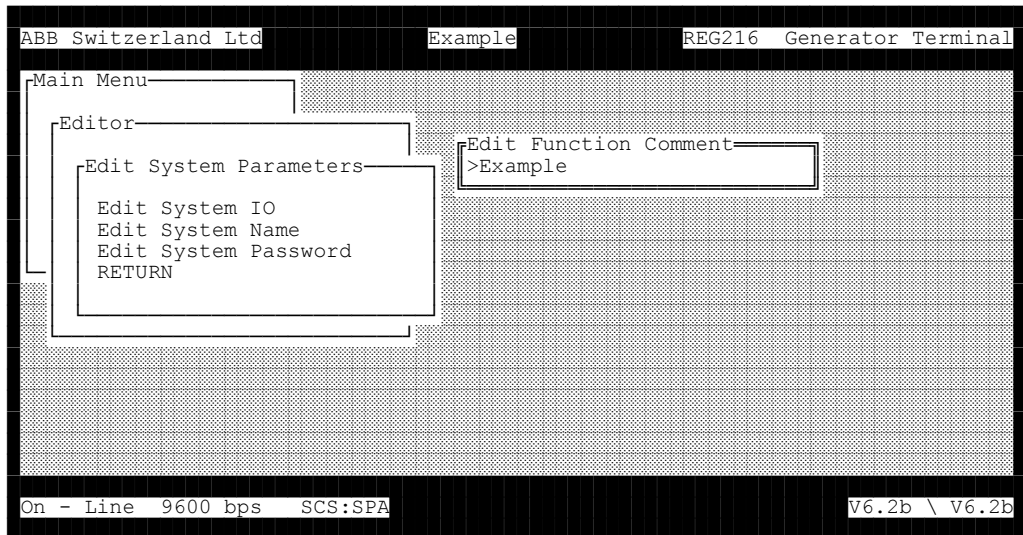


Fig. 5.26 c Edit system name

A name of up to 25 characters can be entered for every device which then appears in the header of the HMI window.

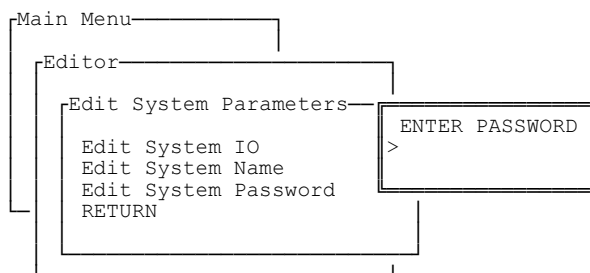


Fig. 5.26 d Edit system password, entering the old password

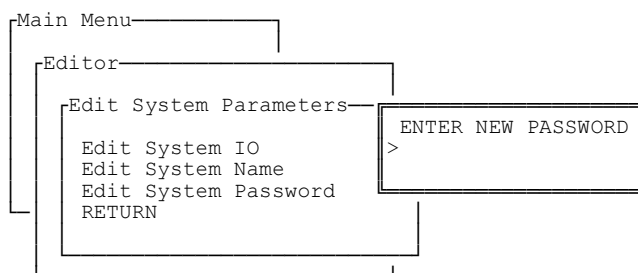


Fig. 5.26 e Edit system password, entering the new password

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>.

A password that has disappeared can be replaced by entering SYSMAN for 'Enter 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. 5.27.

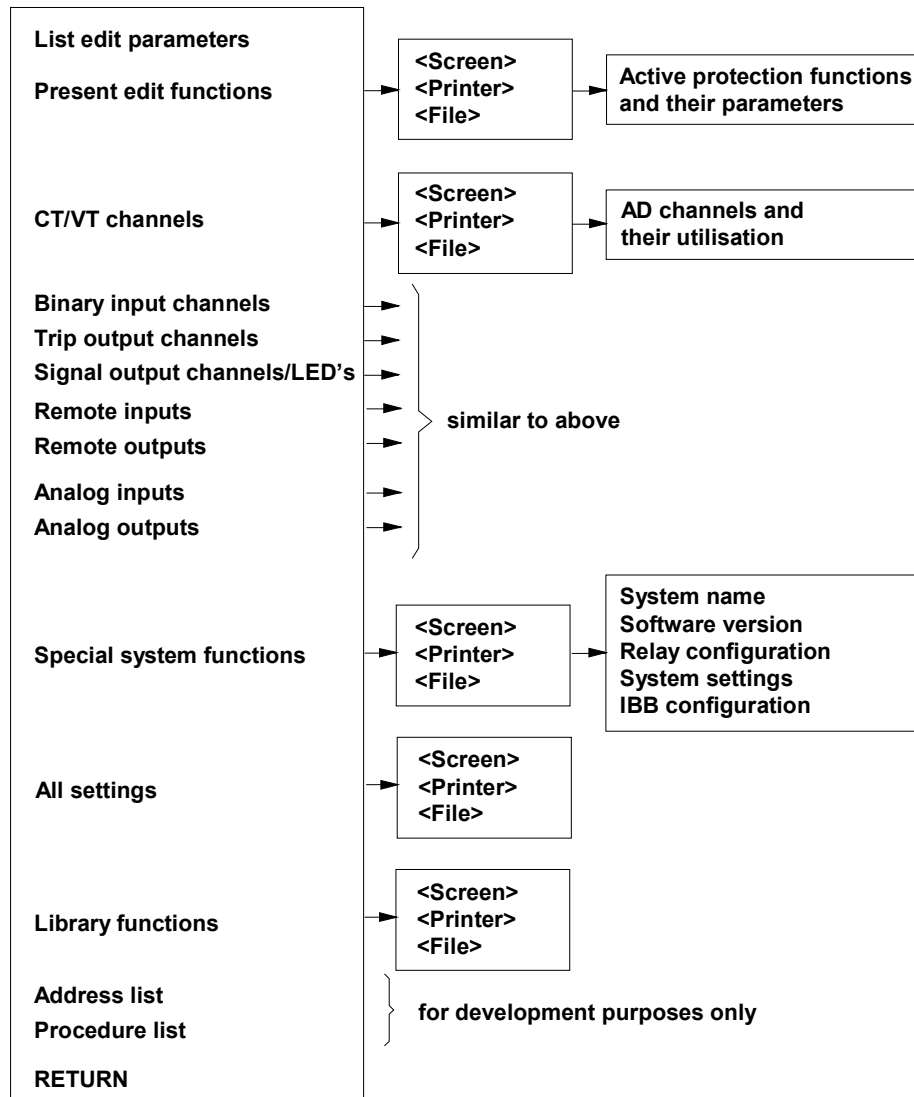


Fig. 5.27 Listing relay settings

5.5.8. Saving the contents of the editor

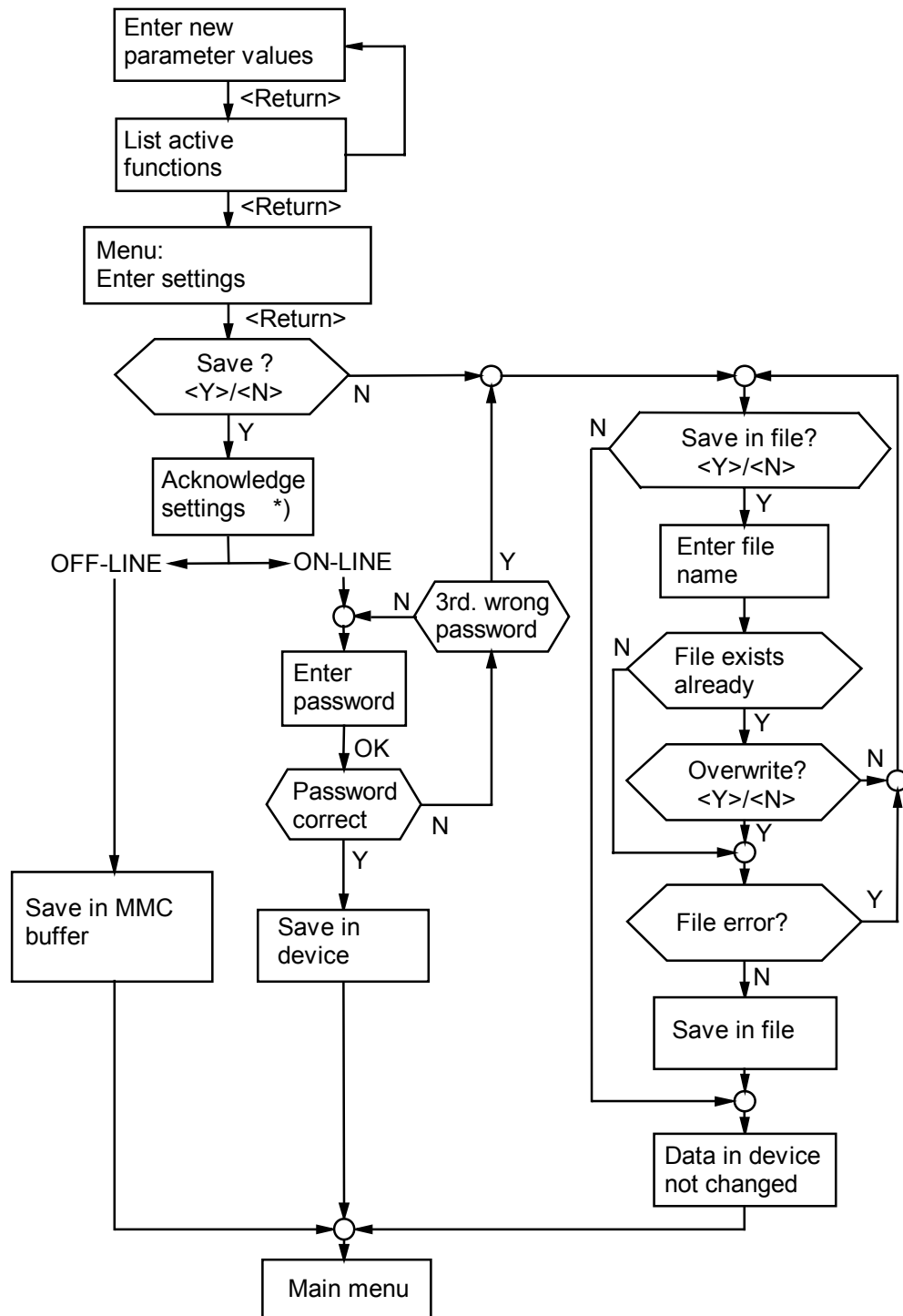


Fig. 5.28 Flow chart for saving the contents of the editor

\*) 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. 5.28](#).

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 settings in a file"
- repeatedly selecting "RETURN" as illustrated in [Fig. 5.28](#).

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. Should <ENTER> be pressed instead of entering a file name, existing files of the form \*.set in the current directory are displayed and the desired one can be selected using <↓> and pressing <ENTER>. If a file conforming to name entered is found or an existing file is selected, 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**

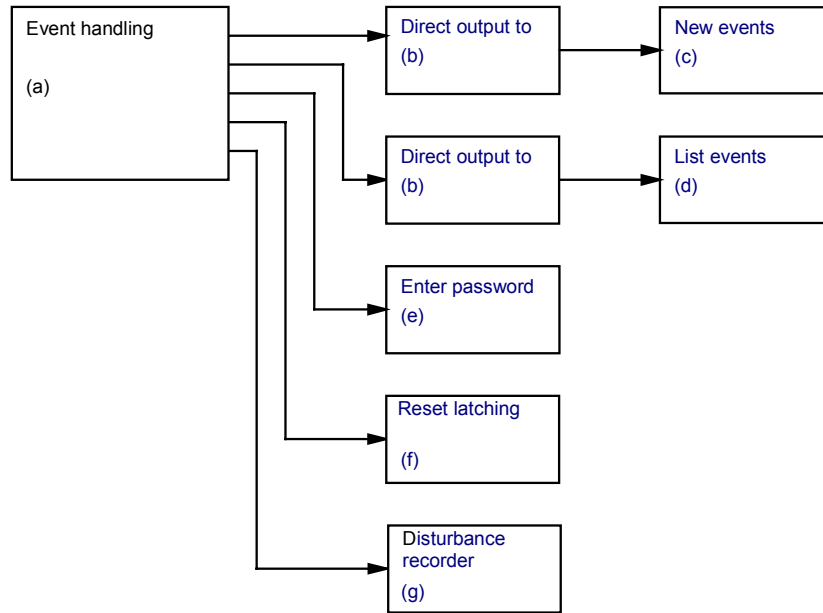


Fig. 5.29 Event handling  
(see displays a to g on the following pages)

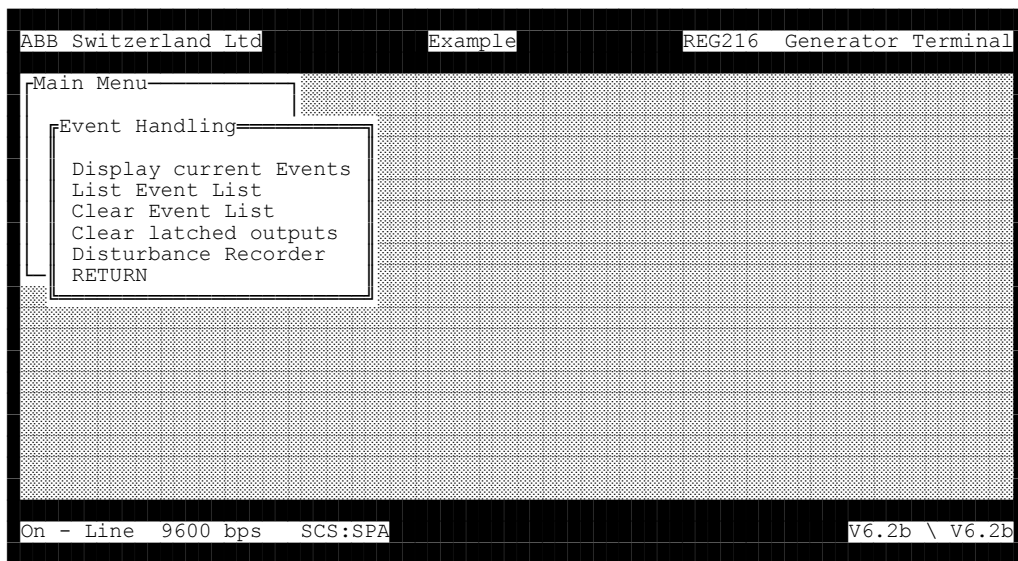


Fig. 5.29 a Event handling

Events can be viewed in two different ways as determined by the two sub-menus “Display new events” and “List events”.



## 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.

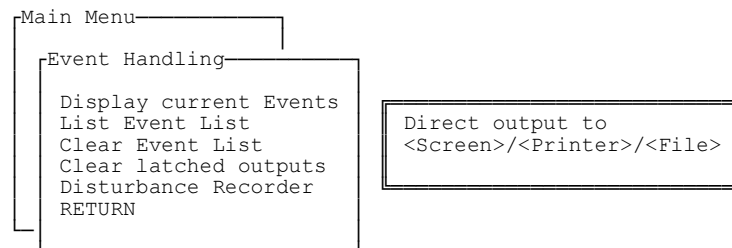


Fig. 5.29 b Direct output to

ABB Switzerland Ltd		Example		REG216 Generator Terminal	
30	2002-04-19 12:36;56.951			GenStart	ON
31	2002-04-19 12:36;56.951	1	Current-DT	Start	ON
32	2002-04-19 12:36;56.955	5	DisturbanceR	BinOutput	ON
33	2002-04-19 12:36;57.055	5	DisturbanceR	BinOutput	OFF
34	2002-04-19 12:36;57.951			GenTrip	ON
35	2002-04-19 12:36;57.951	1	Current-DT	Trip	ON
36	2002-04-19 12:36;57.951	1	Current-DT		2.983 IN
37	2002-04-19 12:36;58.031	1	Current-DT	Trip	OFF
38	2002-04-19 12:36;58.031			GenTrip	OFF
39	2002-04-19 12:36;58.031	1	Current-DT	Start	OFF
40	2002-04-19 12:36;58.031			GenStart	OFF

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

Fig. 5.29 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           REG216 Generator Terminal
-----
0 2002-04-19 12:32;50.048           GenStart      ON
1 D: 00000 00:00;00.000 1 Current-DT  Start         ON
2 D: 00000 00:00;00.001 5 DisturbanceR BinOutput     ON
3 D: 00000 00:00;00.101 5 DisturbanceR BinOutput     OFF
4 D: 00000 00:00;01.000           GenTrip       ON
5 D: 00000 00:00;01.000 1 Current-DT  Trip          ON
6 D: 00000 00:00;01.000 1 Current-DT           5.000 IN
7 D: 00000 00:00;03.751 1 Current-DT  Trip          OFF
8 D: 00000 00:00;03.751           GenTrip       OFF
9 D: 00000 00:00;03.751 1 Current-DT  Start         OFF
10 2002-04-19 12:32;53.801           GenStart      OFF
11 2002-04-19 12:32;54.276 Protection stopped
12 2002-04-19 12:32;54.696           ParSet1       ON
13 2002-04-19 12:32;54.703 Protection restarted
14 2002-04-19 12:32;54.890           MMI is on     ON
15 2002-04-19 12:33;50.885           GenStart      ON
16 D: 00000 00:00;00.000 1 Current-DT  Start         ON
-----
On - Line 9600 bps  SCS:SPA           V6.2b \ V6.2b

```

Fig. 5.29 d Event list

## Deleting events

Providing a valid password is entered, the event list can be deleted as follows.

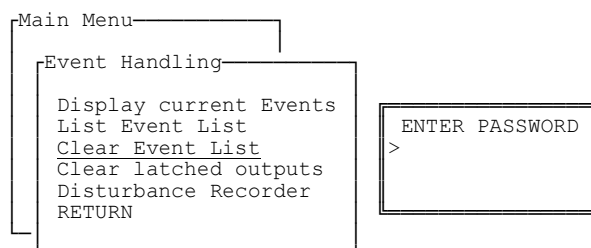


Fig. 5.29 e Enter password

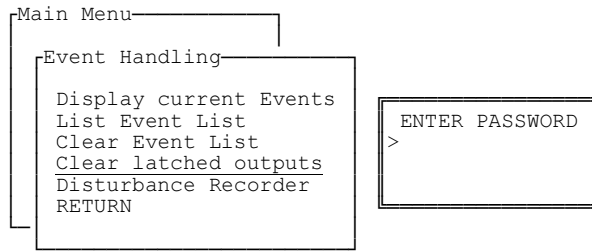


Fig. 5.29 f Enter password

### Disturbance recorder

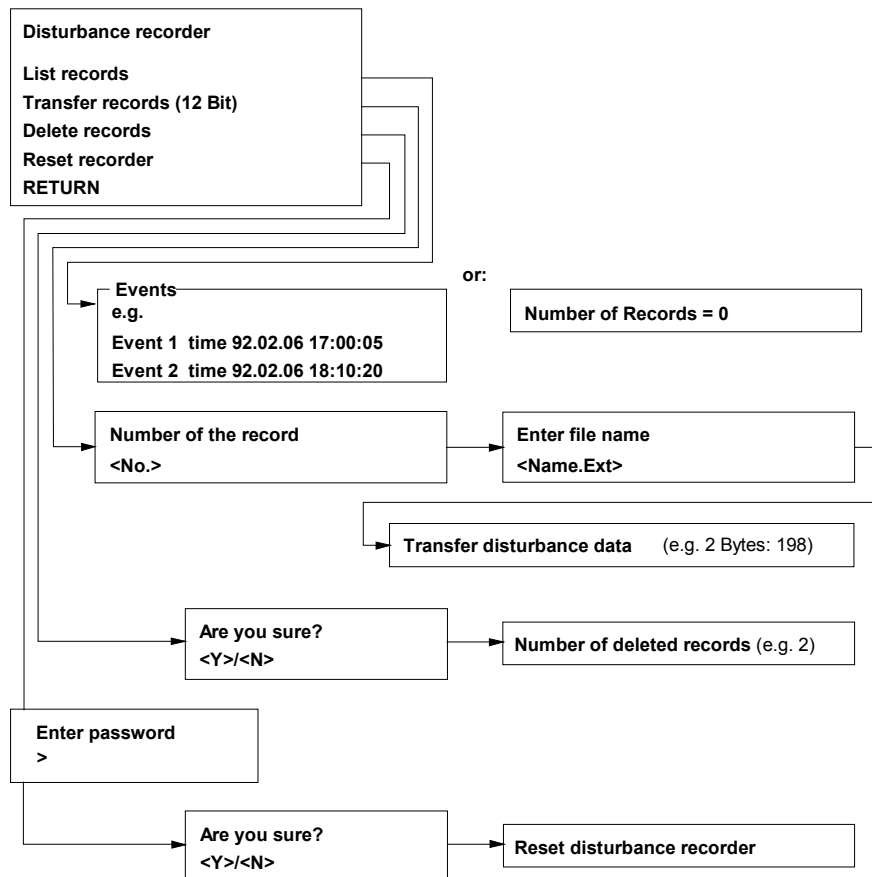


Fig. 5.29 g Operation of the disturbance recorder

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*

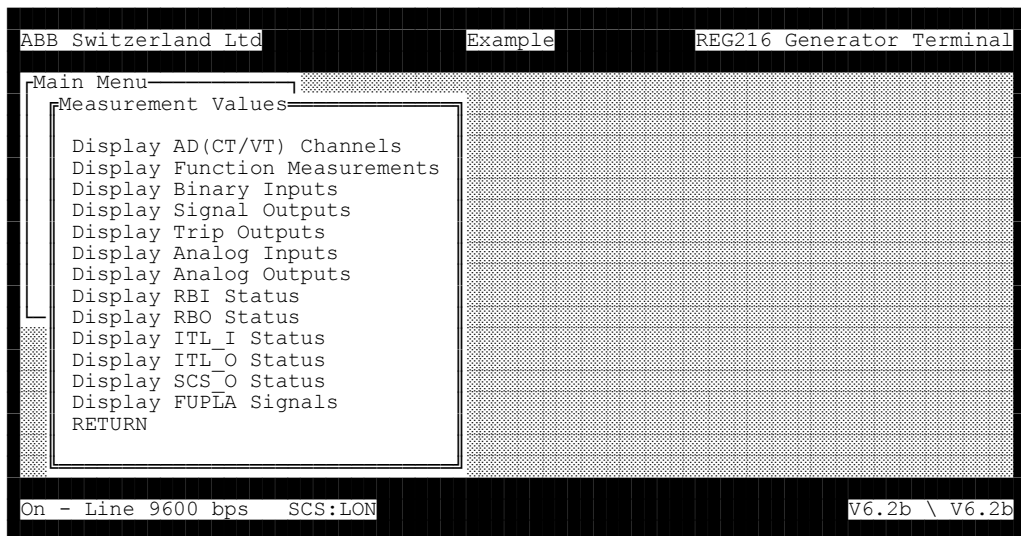


Fig. 5.30 Measurement values

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*

9 analogue I/P's can be viewed at the same time:

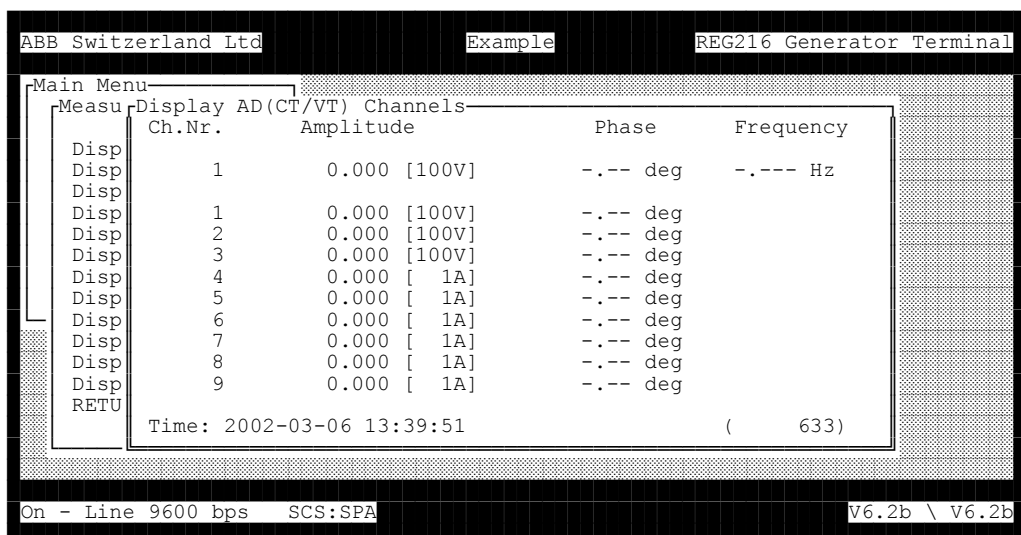


Fig. 5.31 Display AD(CT/VT) Channels

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. Once the reference channel has been entered, the first channel to be displayed can also be entered and all the AD channels can be viewed in groups of nine.

### 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
- flatter detection
- logic
- disturbance recorder.

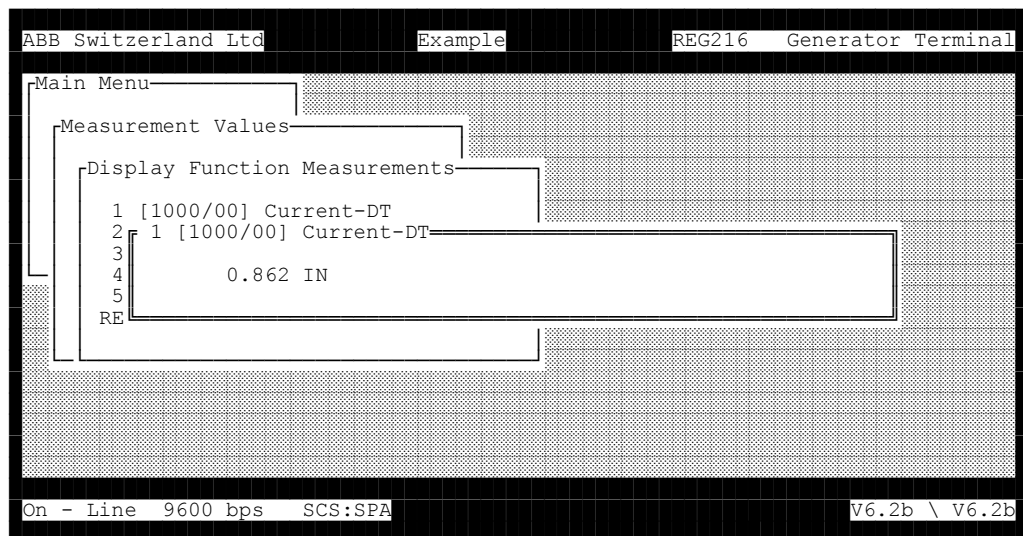


Fig. 5.32 Display function measurements (load values)

### 5.7.3. **Displaying binary inputs, RBI, signalling relays, RBO or tripping relays**

The inputs or outputs are displayed upon entering the number of the corresponding plug-in unit. Active inputs and outputs are indicated by an "X".

```

ABB Switzerland Ltd          EXAMPLE          REG216 Generator Terminal
-----
Main Menu
Measurement Values
Display AD Channels
Display F Binary Input Channels
Display B
Display S
Display T
Display A
Display R
Display R
Display I
Display I
Display S
Display F
RETURN
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
21 22 23 24 25 26 27 28 29 30 31 32
-----
On - Line 9600 bps   SCS:SPA          V6.2b \ V6.2b

```

Fig. 5.33 Display binary inputs

### 5.7.4. **Displaying analogue inputs and outputs**

Enter the device number to view the associated inputs or outputs.

```

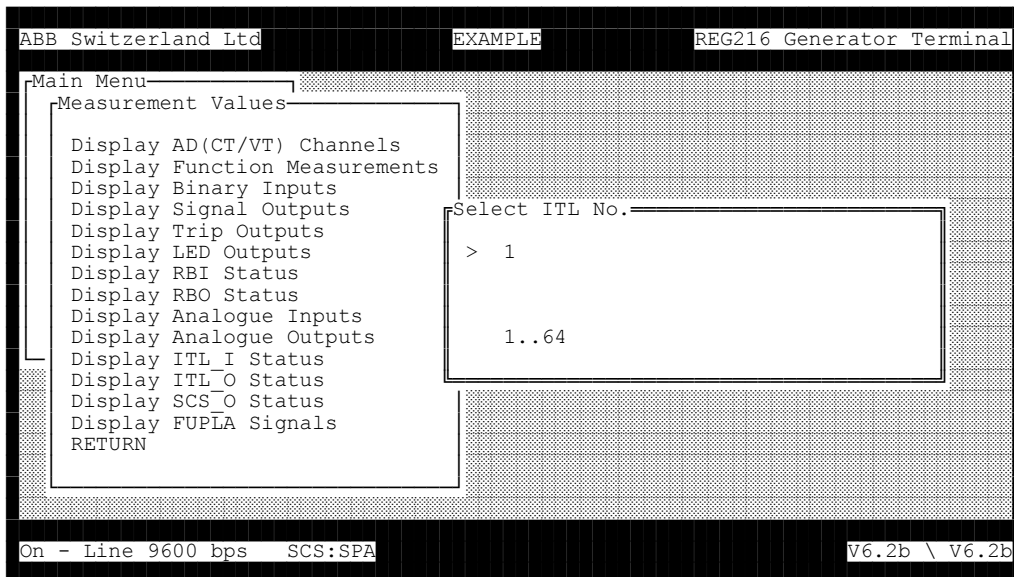
ABB Switzerland Ltd          Example          REG216 Generator Terminal
-----
Main Menu
Measurement Values
Display AD(CT/VT) Channels
Display Function Measurements
Display Binary Inputs
Display Signal Analog Inputs
Display Trip Ou
Display Analog
Display Analog      Slot 1
Display RBI Sta    12.711 mA
Display RBO Sta    -15.314 mA
Display ITL_I S    3.592 V
Display ITL_O S    138.52 °C
Display SCS_O S
Display FUPLA S
RETURN
-----
On - Line 9600 bps   SCS:LON          V6.2b \ V6.2b

```

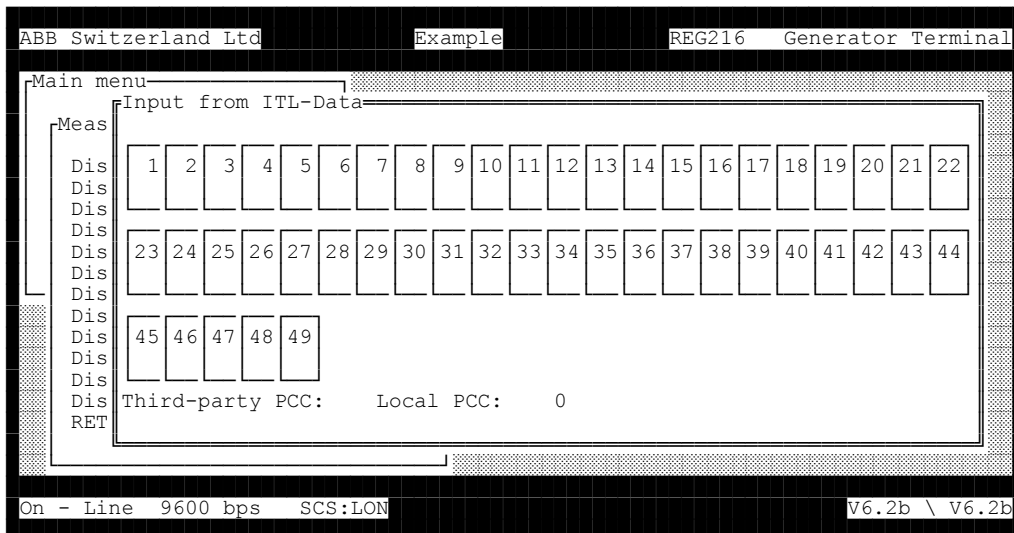
Fig. 5.34 Display analogue inputs

**5.7.5. Displaying ITL inputs and outputs**

The ITL inputs are displayed in 64 blocks of 48 inputs. The clock impulse of the local and other PC card are also included.



**Fig. 5.35** Select ITL No.



**Fig. 5.36** ITL data input



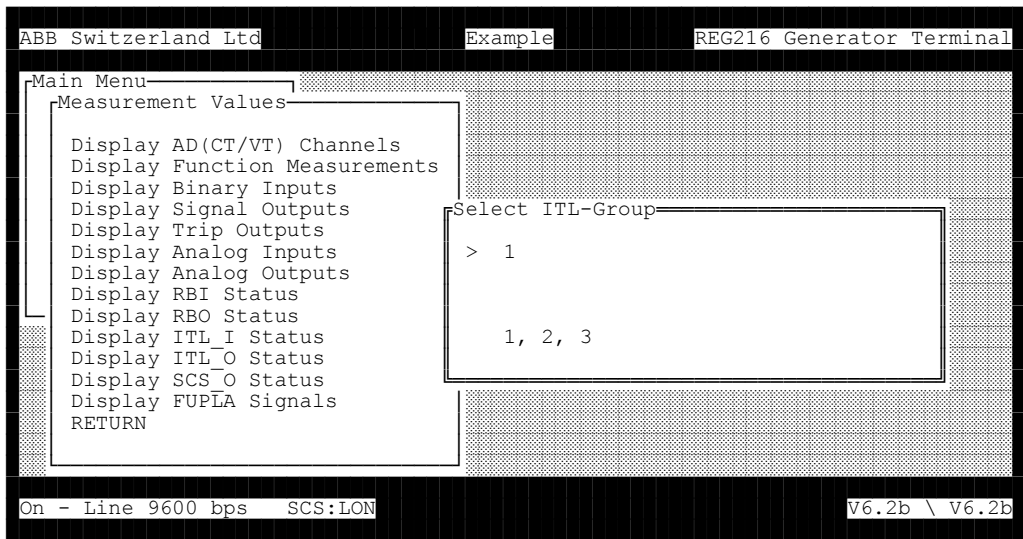


Fig. 5.37 Select ITL out group

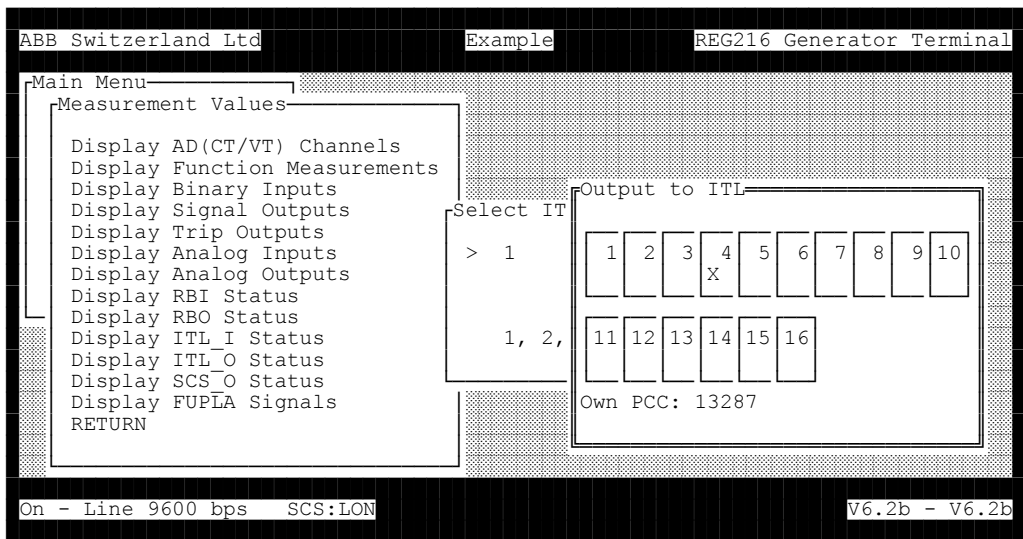


Fig. 5.38 Signal to ITL

Active inputs or outputs are marked with an "X".

**5.7.6. Displaying SCS outputs**

The SCS outputs are displayed in 3 blocks of 8 times 32 signals. Press <↑>, respectively <↓> to switch between the blocks. The number of the block (1...3) being displayed is shown at the top left of the window.

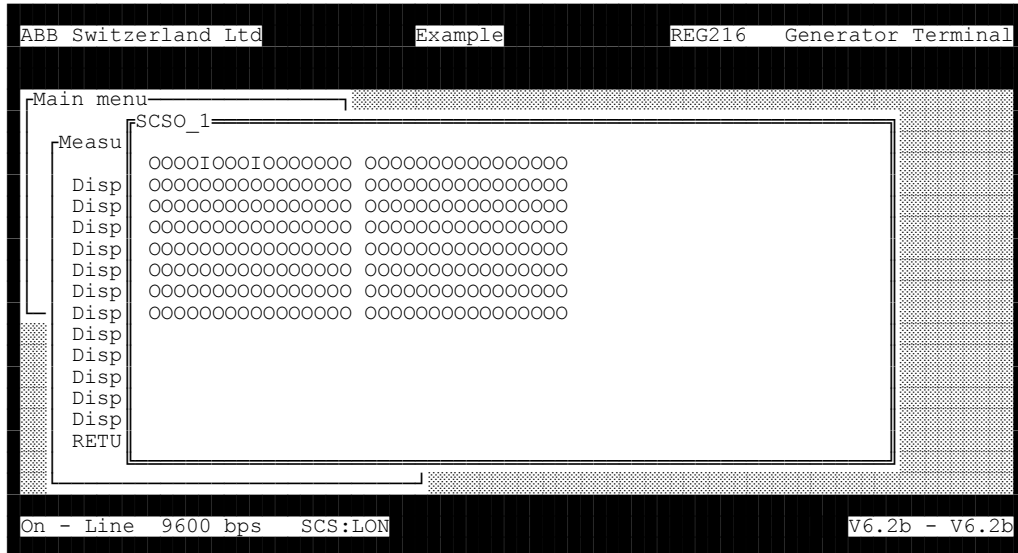


Fig. 5.39 SCS output window

Active inputs or outputs are marked with an "I".

## 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.  
Information is similarly included on the statuses of all the FUPLA logics together with the names of the active ones.
- “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.
- “Delete password”  
Deletes the current password.
- “Reset SCS input data”  
The SCS input data are deleted after entering a password.
- “Load SCS masks”  
Loads an ASCII file with the SCS event masks.

## 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 reactivated.

The procedure for using the test functions can be seen from the following figures.

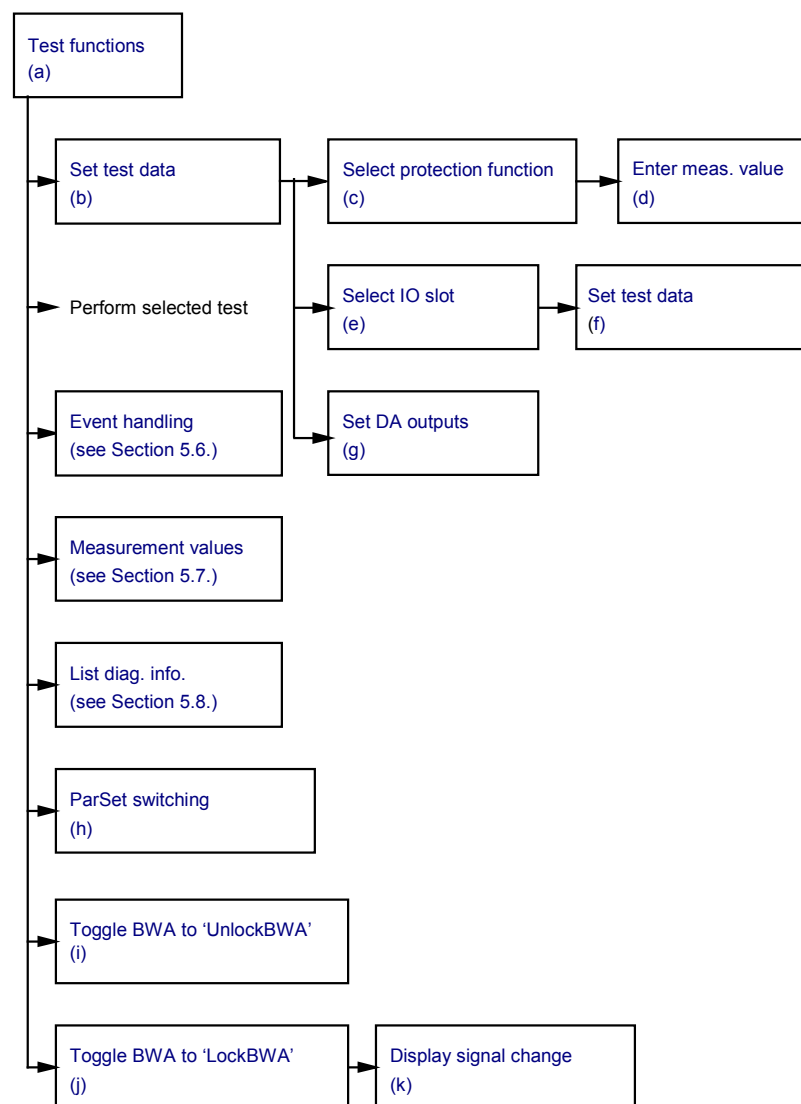


Fig. 5.40 Test functions  
(see displays a to k on the following pages)

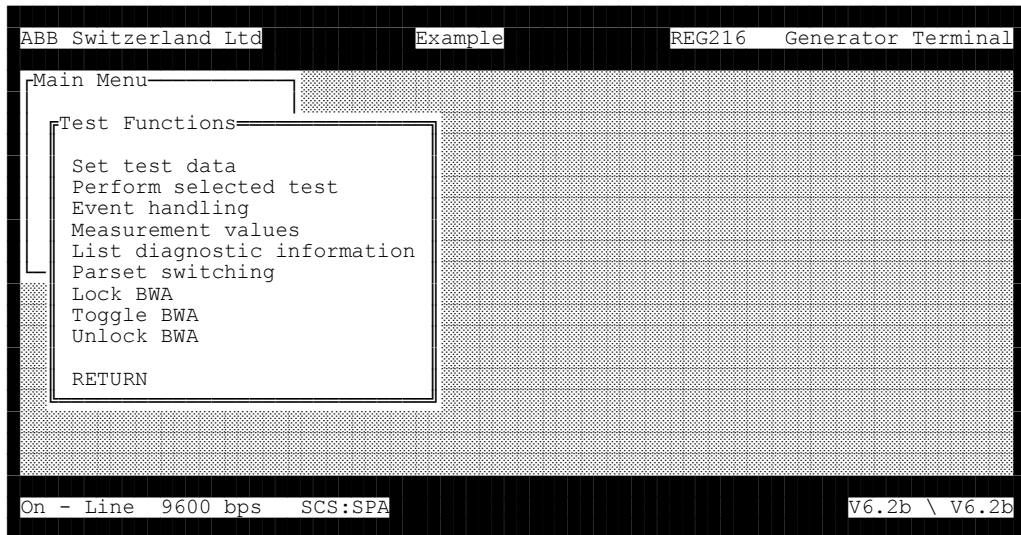


Fig. 5.40 a Test functions

### Set test data

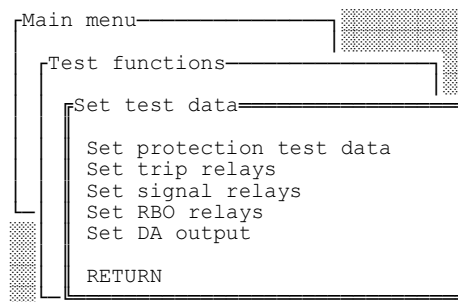


Fig. 5.40 b Set test data

#### 1. Testing the protection functions:

A protection function is selected for testing (using <Insert>) 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
- EarthFitGnd2
- Remote binary
- FUPLA
- VDEW6
- Flatter 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.

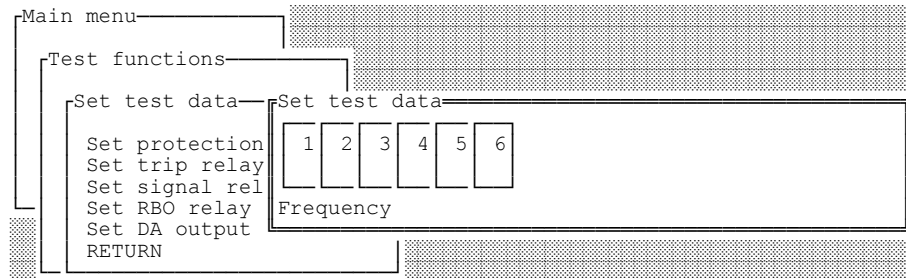


Fig. 5.40 c Select protection function

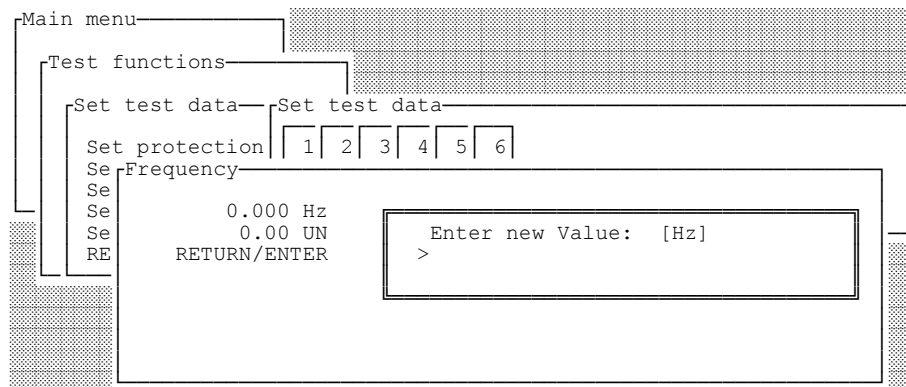


Fig. 5.40 d Enter measurement value

## 2. Testing the tripping relays, signalling relays or RBO relays:

After entering the slot number and RBO number, one or several tripping channels may be selected for testing (by pressing <Ins>). Upon executing the command, the corresponding tripping relays or signalling relays of the channels concerned are energised.

It is only possible to set tripping commands, signals or RBO relays of one input/output unit at a time and the signals must be of the same type, e.g. signalling and tripping relays.

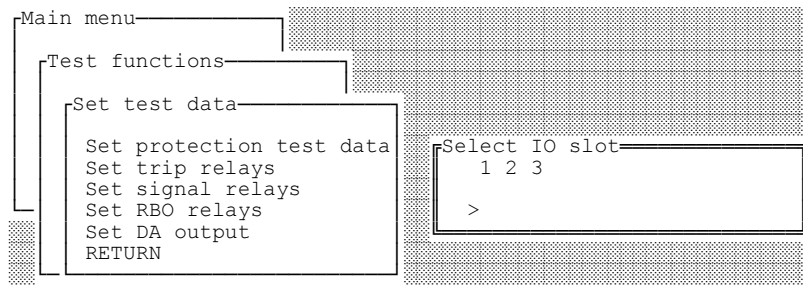


Fig. 5.40 e Select IO slot

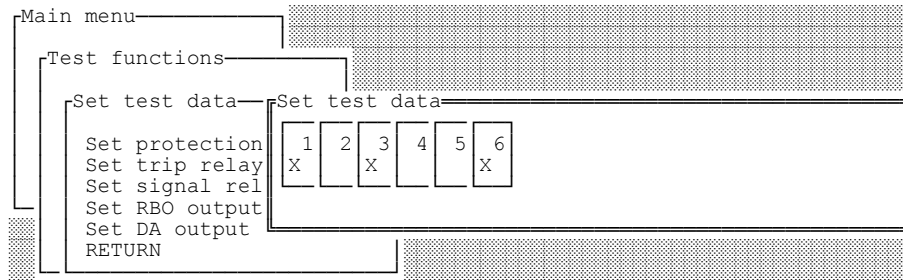


Fig. 5.40 f Set test data

3. Setting the analogue outputs at 216AC61:

After selecting the slot No., an output value between 0...20.47 mA can be entered.

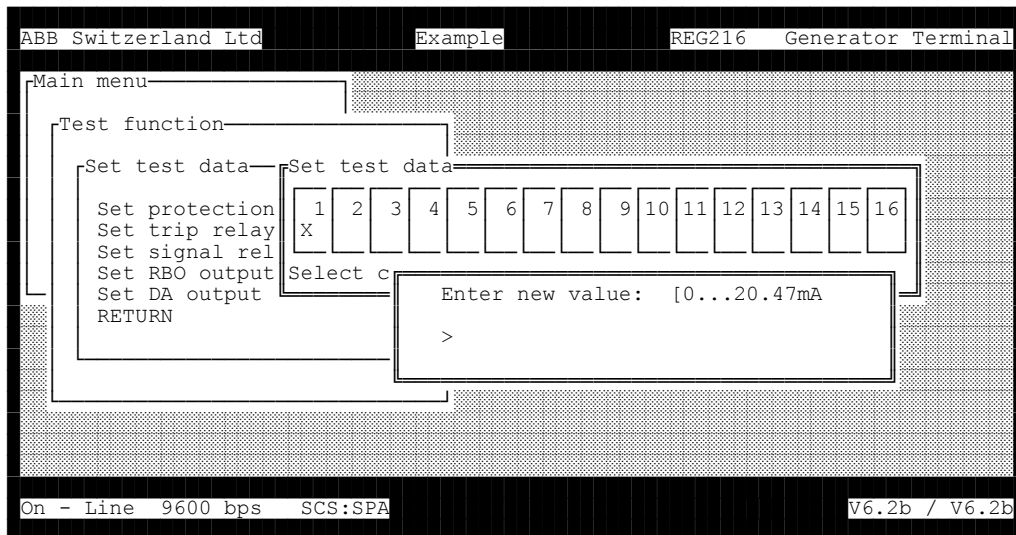


Fig. 5.40 g Set analogue outputs

#### 4. Setting of decentral analogue outputs (RIO580).

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.

#### 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.

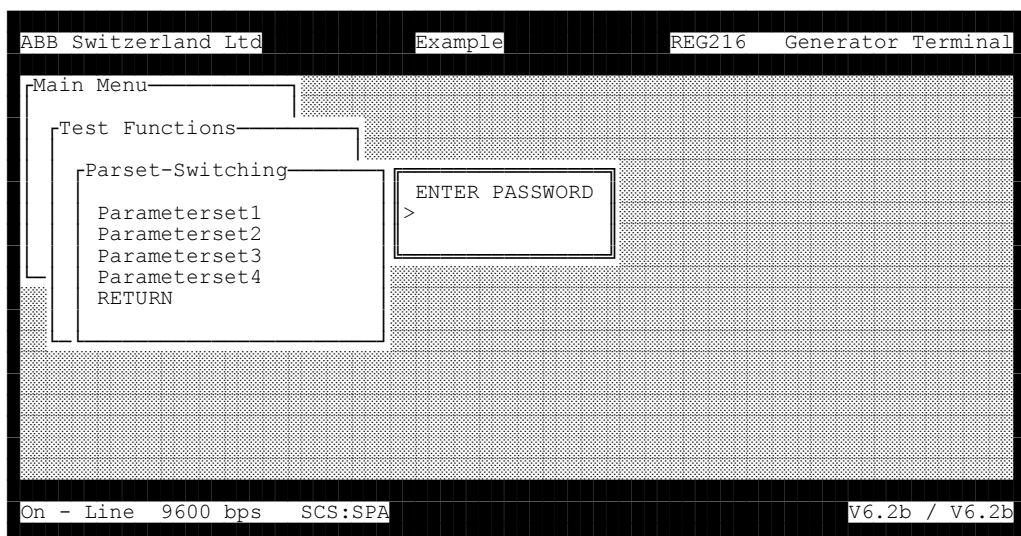


Fig. 5.40 h Parset switching



## Lock, toggle and unlockBWA

BWA is the section of memory where the statuses of the binary outputs (signalling and tripping relays etc.) of the functions are stored. The status of every binary output can be switched with the aid of 'Toggle BWA'. The respective binary output is selected using 'BWA index' and the indices of the various binary outputs are contained in the file Siglist.txt that is created by the 'Documentation' function.

'Lock BWA' prevents the statuses of the binary outputs from changing while testing is in progress. The 'Lock BWA' status is indicated by the fact that the test function window moves to the right. The locked status is cancelled by clicking on 'Unlock BWA' or by simply quitting the test function.

The new status is displayed as soon as the desired BWA index has been entered and <ENTER> pressed.

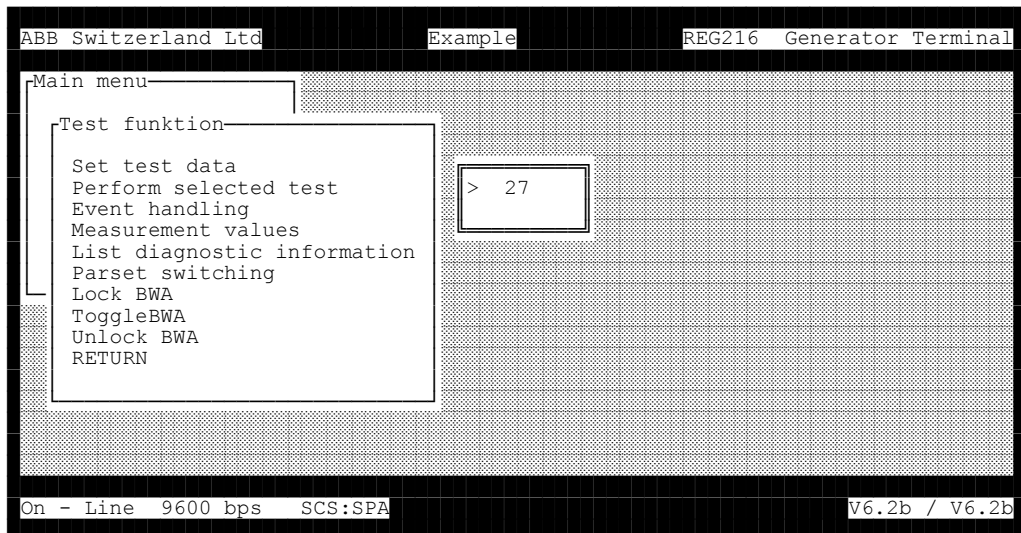


Fig. 5.40 i BWA in the unlocked status

```

ABB Switzerland Ltd      Example      REG216 Generator Terminal
-----
Main menu
Editor
Event handling
Measurement values
Test functions
Diagnostics
Documentation
RETURN

> 27

BWA_locked
Test functions
Set test data
Perform selected test
Event handling
Measurement values
List diagnostic information
Parset switching
Lock BWA
ToggleBWA
Unlock BWA
RETURN

On - Line 9600 bps  SCS:SPA      V6.2b / V6.2b

```

Fig. 5.40 j BWA in the locked status

```

ABB Switzerland Ltd      Example      REG216 Generator Terminal
-----
Main menu
Editor
Event handling
Measurement values
Test functions
Diagnostics
Documentation
RETURN

FALSE -> TRUE

BWA_locked
Test functions
Set test data
Perform selected test
Event handling
Measurement values
List diagnostic information
Parset switching
Lock BWA
ToggleBWA
Unlock BWA
RETURN

On - Line 9600 bps  SCS:SPA      V6.2b / V6.2b

```

Fig. 5.40 k Displaying changes in signal status

Extract from the file Siglist.txt:

For example, 'Toggle BWA' switches the 'TRIP' signal with the BWA index 27 on and off.

---

FunctionName	FuncType	SignalStdName	BWAIndex	SigType
System IO	34	GeneralTRIP	3	SI
System IO	34	GeneralStart	5	SI
Logic	31	BinOut	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. 216 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**

Switching between the four sets of parameters can be accomplished by

- a) applying signals to binary I/P's (opto-couplers)
- b) a signal from the station control 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 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.

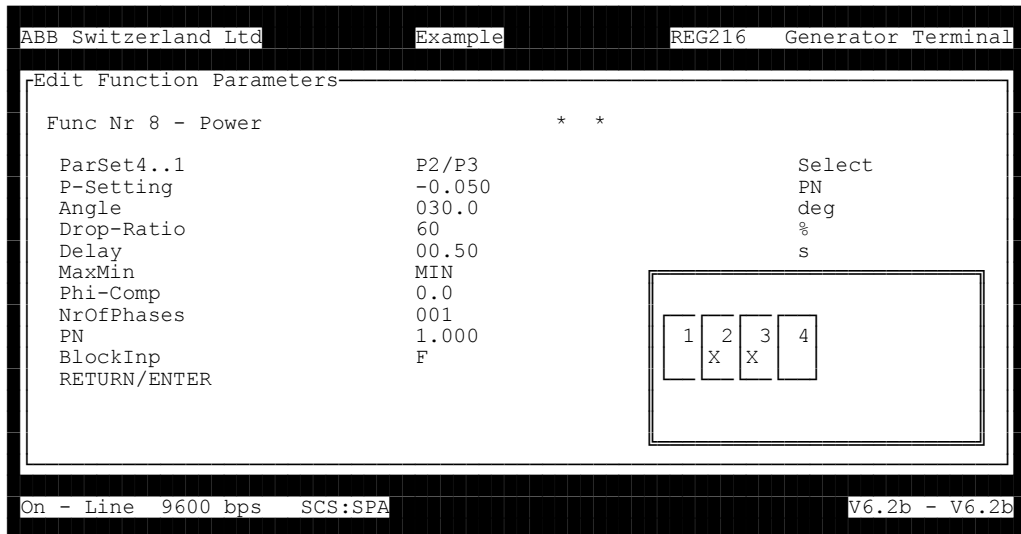


Fig. 5.41 Assigning sets of parameters

### 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:

$$\text{RULE: } P1 \leq pO \leq P4 \leftrightarrow pO < pK \leq P4$$

$pO$  = 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*

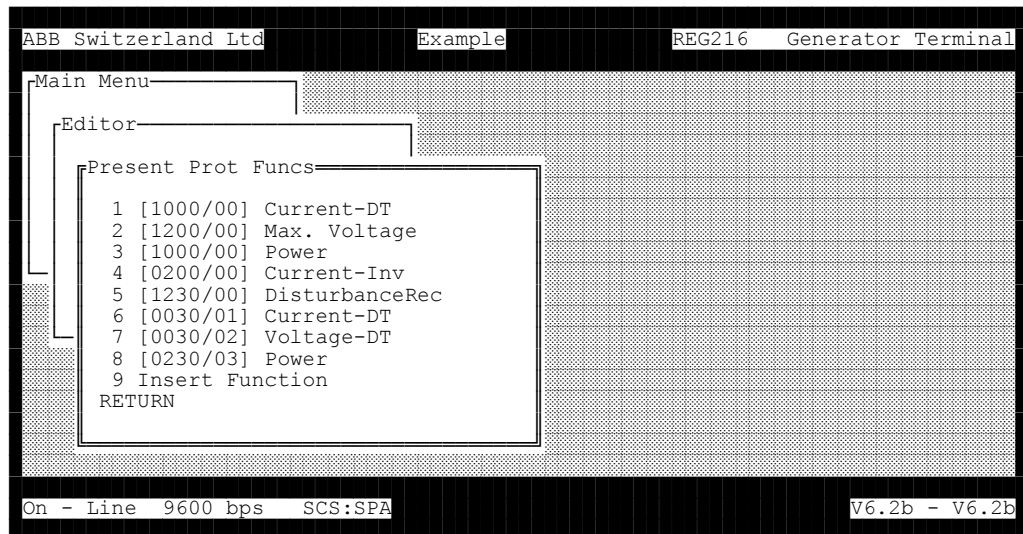


Fig. 5.42 Presentation by the HMI of the protection functions

The list of functions and their settings are presented as follows:

A [B/C] D (e.g. 1 [1000/00] current)

- 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.



## **5.12. Remote HMI**

### **5.12.1. Summary**

Version V4.5 of the firmware provides facility for controlling RE. 216 devices grouped according to stations. All the HMI functions are available. User access of the remote HMI to such functions as 'Setfile', 'Download', 'Test function', 'Time synchronisation' and 'SPA communication' can be restricted.

We do not recommend downloading the FUPLA code via a modem link as it will not run 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 a 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 remote 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.

The initialisation string for the remote modem is as follows:

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  
no result codes        Q1

Save modem settings:    AT&W0.

### 5.12.3. *Remote HMI shell*

The HMI shell runs under Windows 3.xx, Windows 95 and windows NT 4.x. The procedure for entering the data necessary to configure the stations and the units in them is menu controlled. The HMI is started in a DOS window.

#### 5.12.3.1. *Installation*

Insert installation disc No. 1 in the drive and start the installation be selecting 'Run' in the 'File' menu.

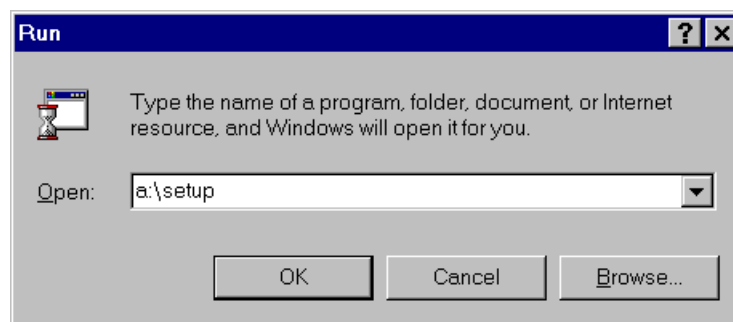


Fig. 5.43 Starting the installation procedure

#### 5.12.3.2. *Configuring a new station*

Start the remote HMI shell and then select 'New station' in the 'File' menu to open the dialogue for entering the station name.

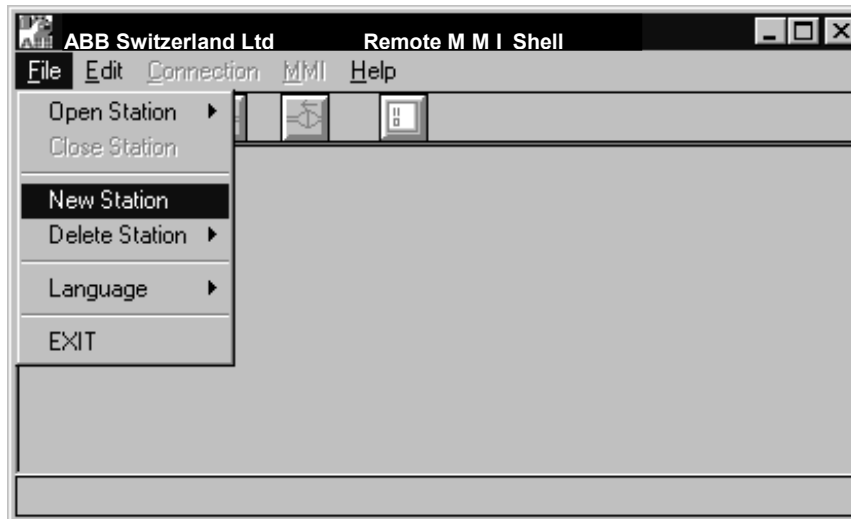


Fig. 5.44 Configuring a new station

Enter the station name (max. 8 characters) and click on OK to confirm it.

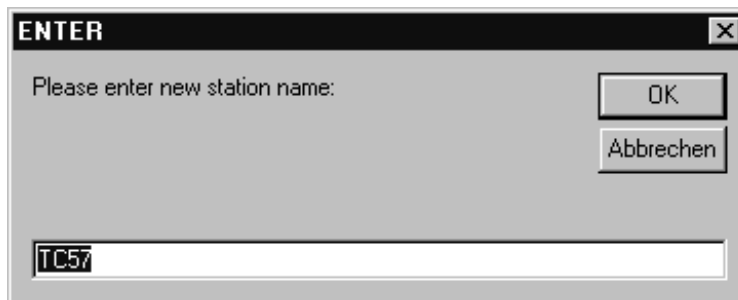


Fig. 5.45 Dialogue for entering the station name

Now open the 'Edit' menu and select 'Edit station' and then the new station from the list. The dialogue for configuring the station appears.

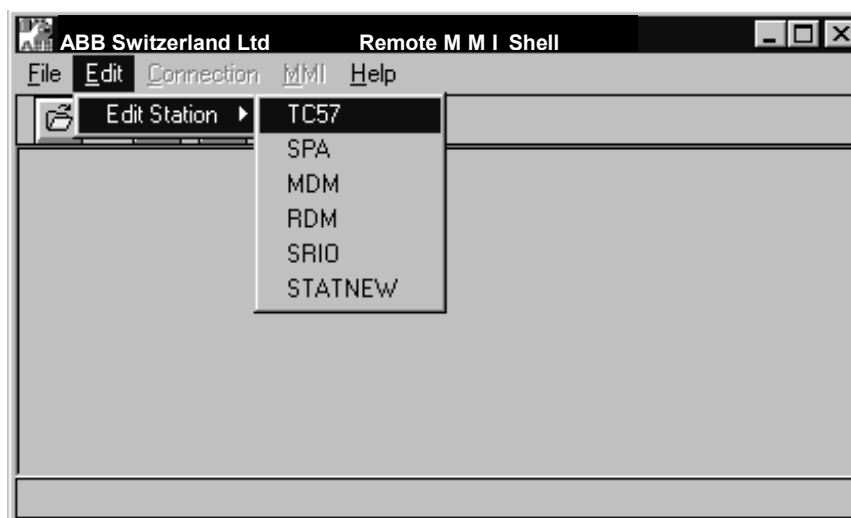


Fig. 5.46 Opening the dialogue to configure a new station

The dialogue provides facility for editing the files 'Station.cfg' and 'HMIShell.mnu'.

The following parameters are set in the file 'Station.cfg':

- COMT: Communication parameter,  
 TC = communication via the frontplate interface  
 SPA = communication via the SPA-BUS interface  
 MDM = communication via a modem and SPA-BUS interface  
 SRIO = communication directly via the SRIO  
 RDM = communication via a modem and SRIO.
- BAUD: Baud rate
- TNR: Station telephone number (T...tone dialling,  
 P...impulse dialling)
- MPAR: Modem initialisation parameter. The default parameter can be accepted in most cases.

Click on 'SAVE' to store the new parameter settings.

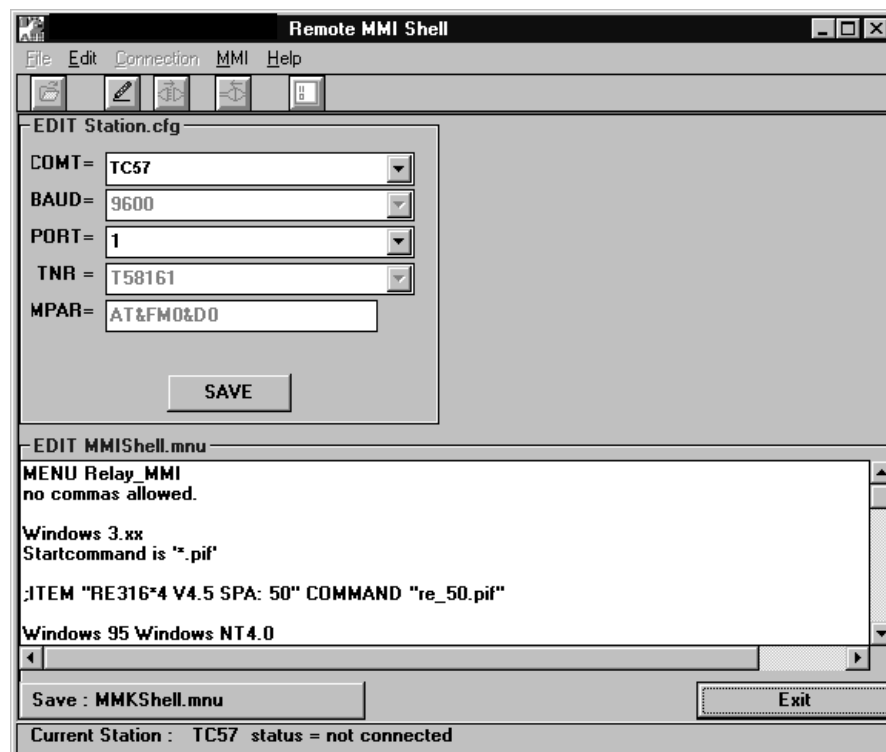


Fig. 5.47 Dialogue for configuring a station

An entry has to be made in the file 'HMIShell.mnu' for every unit in the station. The entry varies according to the version of Windows in use.

Windows 3.xx:

ITEM "Text" COMMAND "Filename.pif".

The first text in inverted commas appears in the 'HMI' menu. Windows 3.xx uses \*.pif files that contain the initialisation data of the respective DOS programs. The PIF editor starts automatically when the file 'HMShell.mnu' is saved.

The following entries have to be made:

Program file name: Path to the HMI file pcgc91.exe, e.g. C:\HMI\PCGC91

Program title: Name of the window running the HMI.

Program parameters: Replace 'Default' by the desired name for the file \*.cfg.

Save the file \*.pif when you have finished editing it.

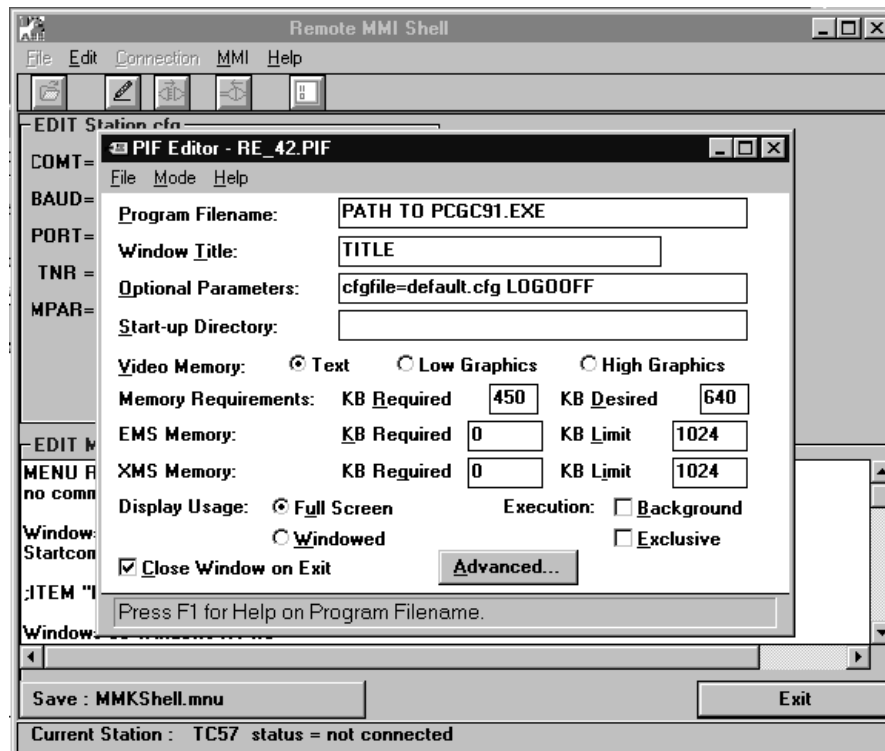


Fig. 5.48 PIF editor dialogue

Entries in the file 'HMIShell.mnu' for Windows 95 and Windows NT:

ITEM "Text" COMMAND "Path to HMI\PCGC91  
CFGFILE=NAME.CFG LOGOOFF"

When the file 'HMIShell.mnu' is saved, the file 'NAME.CFG' is created and can be edited by clicking on 'Edit NAME.CFG' in the 'HMI' menu:

RETYP	Type of unit
LANG	HMI language
COLOR	RGB = colour monitor
EVEDATA	Directory containing the HMI disturbance recorder data. This directory is created automatically if it does not already exist.
SLVE	SPA slave address
BAUD	Only applies to TC57 communications parameter and is set to 9600 or 19200 Baud.

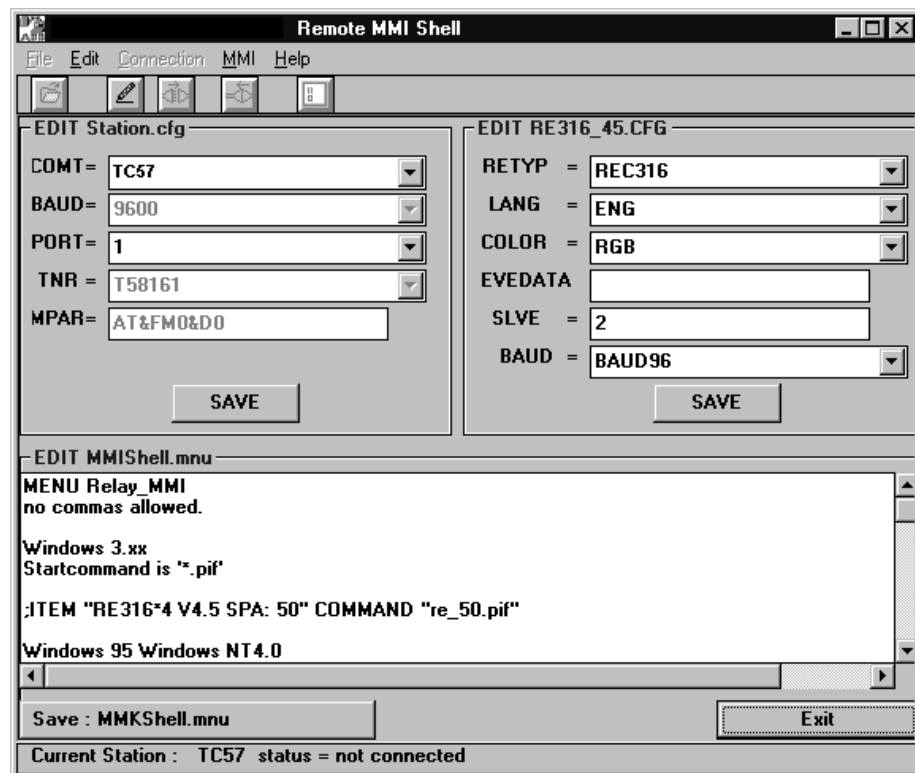


Fig. 5.49 Editing \*.cfg files

Click on 'Exit' to leave the edit mode.

### 5.12.3.3. *Establishing communication with the station*

Select 'Open station' from the 'File' menu and then the desired station from the list.

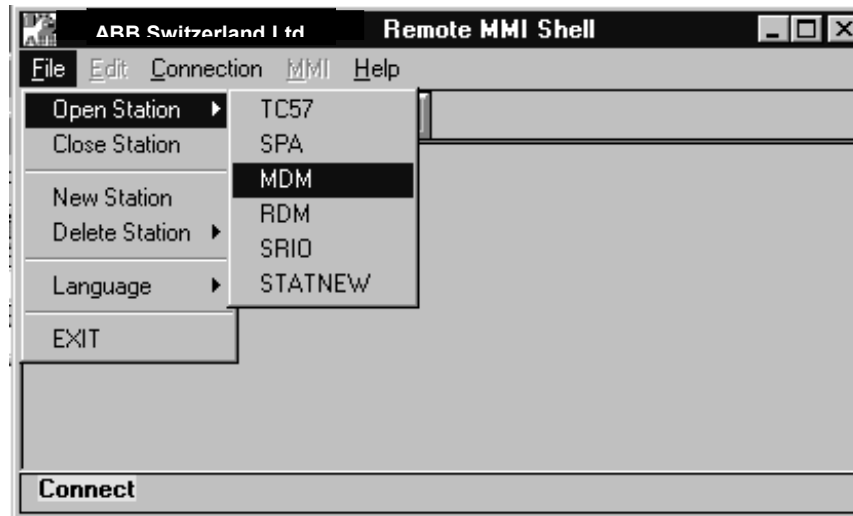


Fig. 5.50 Establishing communication with a station

The communication parameter determine whether the HMI is started directly or via the modem after communication has been established.

Communication is established via the modem for the communication parameters RDM and MDM. The 'HMI' menu is inactive (grey) until the communication link operating. Click on 'Connection' and 'Connect' to open the script window in which the exchanges between the modem and the remote HMI shell are logged.

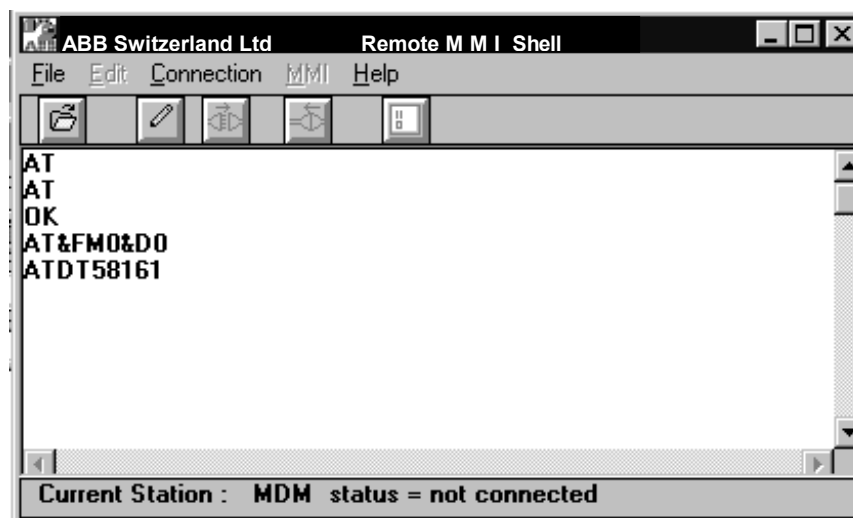


Fig. 5.51 Script window

The following appears providing the link is established within the time-out set on the modem:



Fig. 5.52 'Connect' confirmation

After clicking on 'OK', the script window closes and the 'HMI' menu is active.

Now open the 'HMI' menu and select the desired HMI.

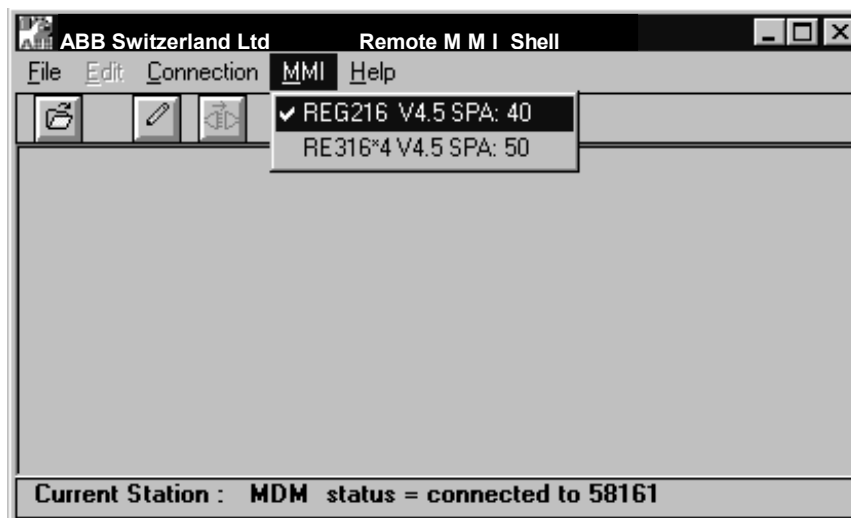


Fig. 5.53 Selecting the desired HMI

Select 'Connection' and 'Interrupt' to break the communication link.

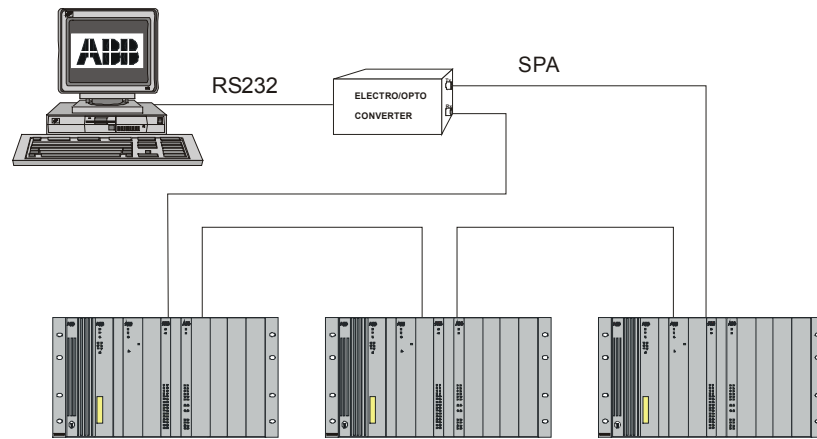
#### **5.12.4. *Configuring a remote HMI for operation via the SPA-BUS interface***

##### **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.





HEST005052 C

Fig. 5.54 Remote HMI connected directly to the 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.

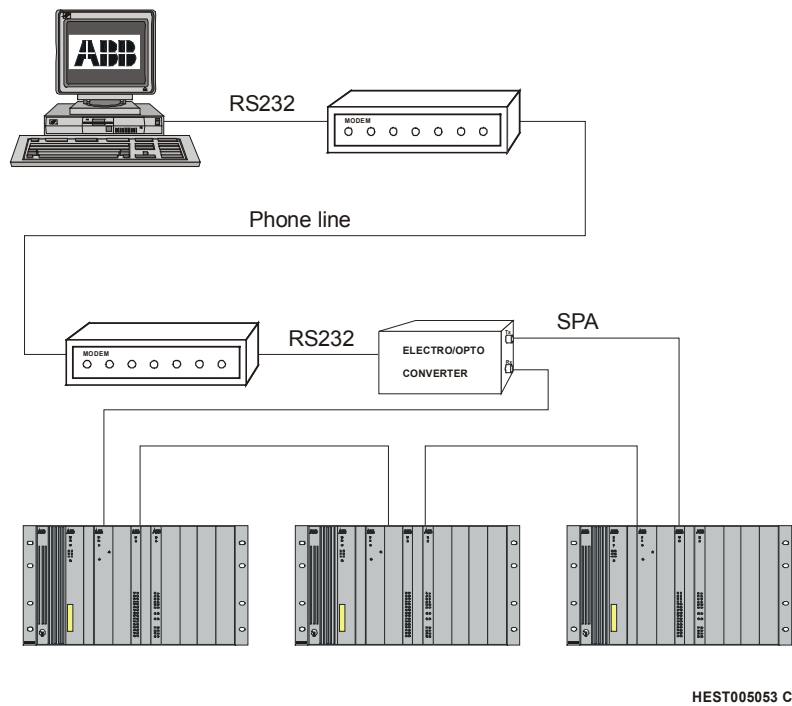


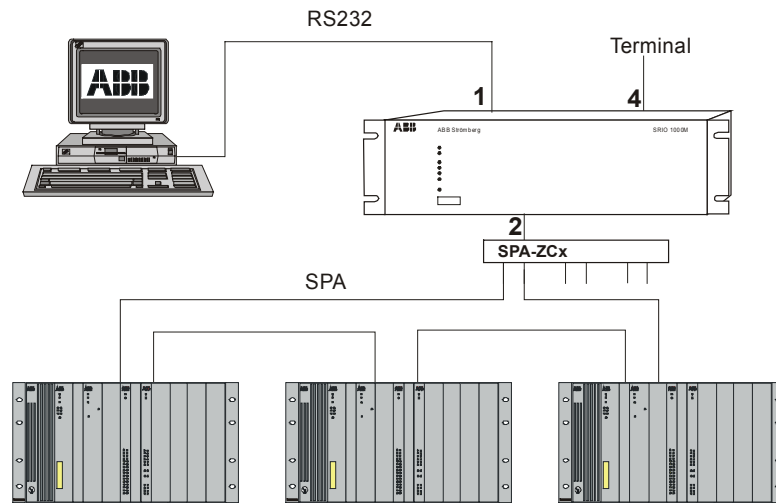
Fig. 5.55 Remote HMI connected to the electro-optical converter via a modem

### 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.



HEST005054 C

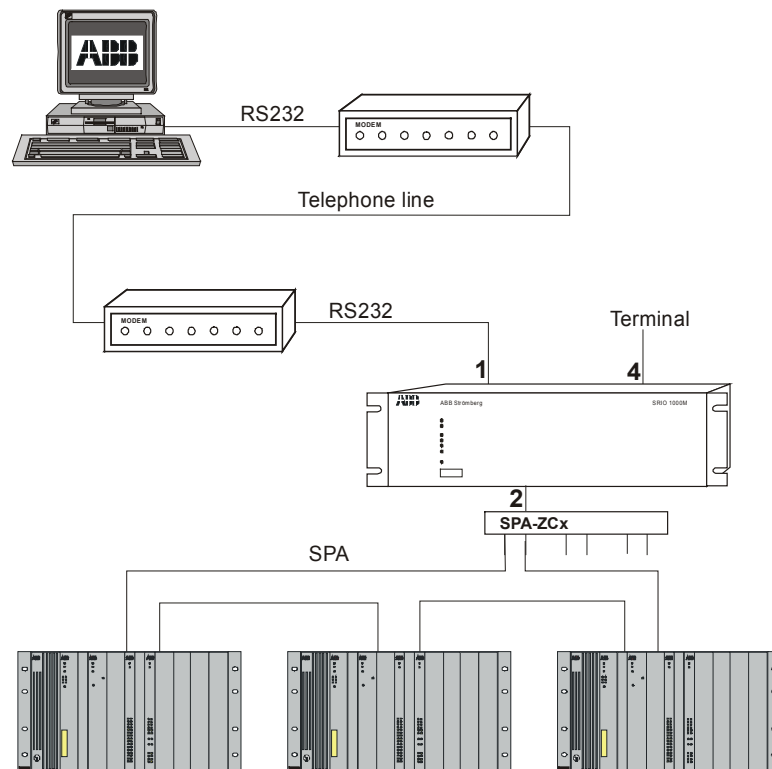
Fig. 5.56 Remote HMI connected directly to the SRIO

**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.



HEST005055 C

Fig. 5.57 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 'SCS functions', the following menu items are accessible for COMT=TC57:

RemoteHMI	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 dialogue 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.

Access by the remote HMI to the menu item 'Read password' in the 'Diagnosis' menu is always disabled.

### 5.12.7. **Control via an SPA-BUS, SRIO or a modem**

After the program starts, the slave control window opens and a check is made that the unit is ready.

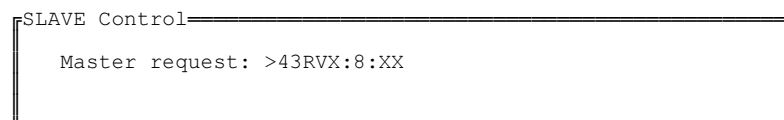


Fig. 5.58 Master request

When the selected device is ready, it replies by returning its type.

```
slave Control
Master request: >43RVX:8:XX
Slave response: <43D:REG316:1C
```

Fig. 5.59 Slave response

Providing the response is correct, the HMI start window opens.

```
SLAVE Control
Master request: >43RVX:8:XX
Slave response : ERROR
```

Fig. 5.60 ERROR

If a valid response is not received within 15 seconds, the message 'ERROR' is displayed and the program offers the off-line mode after a further 5 seconds.

#### 5.12.7.1. **HMI start-up**

The exchange of data via a modem, SRIO etc., is appreciably slower than the direct connection to the interface on the front of the units. For this reason, a file called ReXX.dat is created every time data are changed and saved together with the unit ID so that the data of all the units do not have to be read every time the HMI is started. XX is the unit's SPA address. When the HMI is started, it reads the units ID and searches for an ReXX.dat with the corresponding ID in the current directory. Providing a valid file is found, not all the remaining data in the unit are read. The HMI uses the information in the ReXX.dat file and this considerably shortens the time needed to establish communication.

Since the unit data are not normally saved via the remote HMI, the ReXX.dat files are not automatically available, but have to be copied to the station's directory after all the devices have been finally configured.

The main menu appears as soon as all the unit data are available.

The main menu now includes the item 'SPAComm'.

### 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.

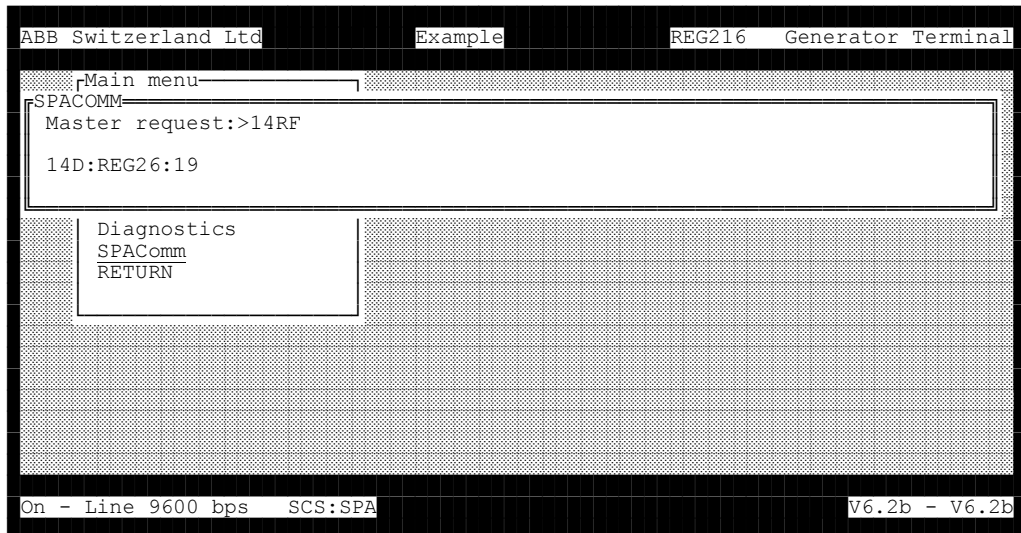


Fig. 5.61 The SPAComm window

Enter a command by pressing <ENTER> and entering 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' and '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	Zero mode
4	10	Terminal mode

BUS setup:

Set-up	BUS 1	BUS 2	BUS 4
Baud	9600	9600	9600
Parity	2	2	0
Stop bit	1	1	1
CTS	1	0	0
DCD	1	0	0
Aut. lf	1	0	1
Time-out	60000	3000	0
Resend	0	3	0

ANSI\_SUP must be set to 'half-duplex'. The remaining ANSI\_SETUP parameters are of no consequence.

After saving the new bus modes (STORE F), the computer 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. SMS010

### 5.13.1. 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\_216#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 Rec216.CNF, Rec216.DEF and Rec216.SUP are copied to the directory \SMS010\Base\Modules\REC216.
- The file devices in directory \SMS010\Base\Modules are updated.



## 5.13.2. SMS010 Editor

### 5.13.2.1. Main menu

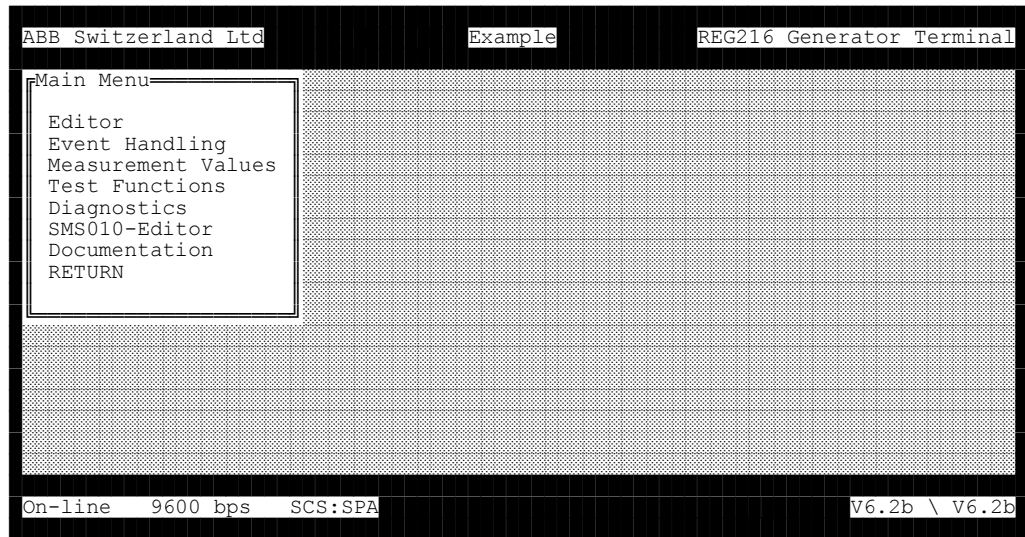


Fig. 5.62 Main menu

The menu item 'SMS010 editor' is added to the main menu when installing SMS010.

### 5.13.3. Sub-menu 'SMS010 editor'

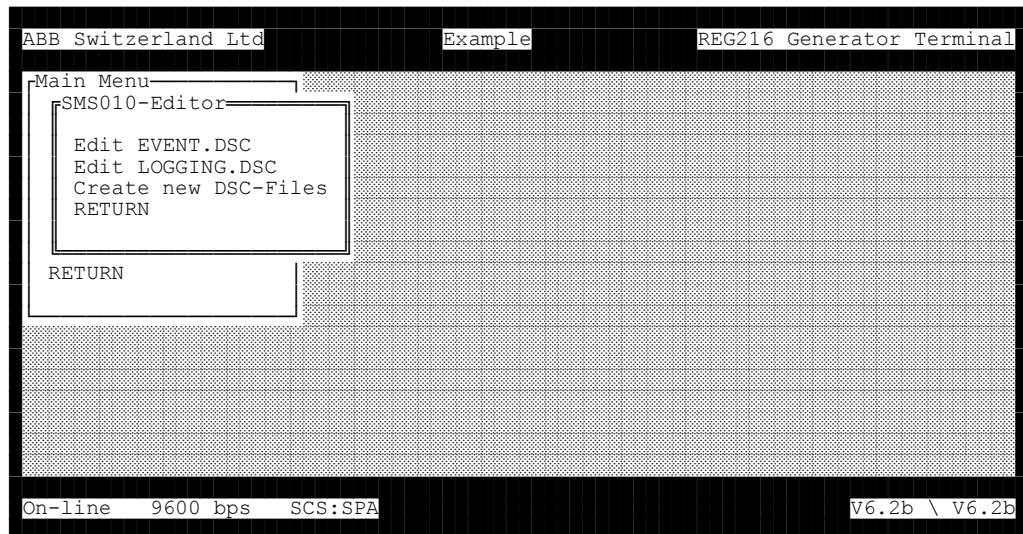


Fig. 5.63 SMS010 editor

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.)

### 5.13.4. Descriptions of the various menu items

#### 5.13.4.1. Menu item 'Edit Event. Dsc' for processing Event.DSC

```

ABB Switzerland Ltd      Example      REG216 Generator Terminal
-----
SMS Edit
Relay address = 45      CHANNEL = 21      Page 19 of 28
                        45.021 Frequency
Code Description      ON/OFF      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. 5.64 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.

### 5.13.4.2. Menu item 'Edit Logging. Dsc' for processing Logging.DSC

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

Page 1 of 2

On-line 9600 bps SCS:SPA V6.2b \ V6.2b

Fig. 5.65 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.

**5.13.4.3. 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:

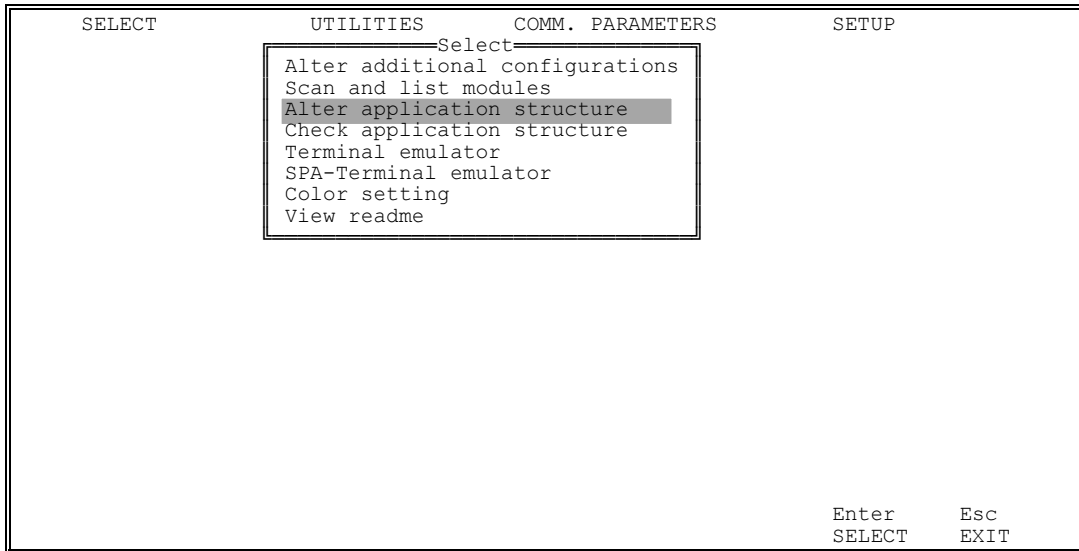
- Event.DSC ⇒ event handling file for 'Reporting'
- Logging.DSC ⇒ logging window file for 'Reporting'
- Channel.DSC ⇒ file with the function designations
- Functyp.DSC ⇒ required for updating files.

### 5.13.5. **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.

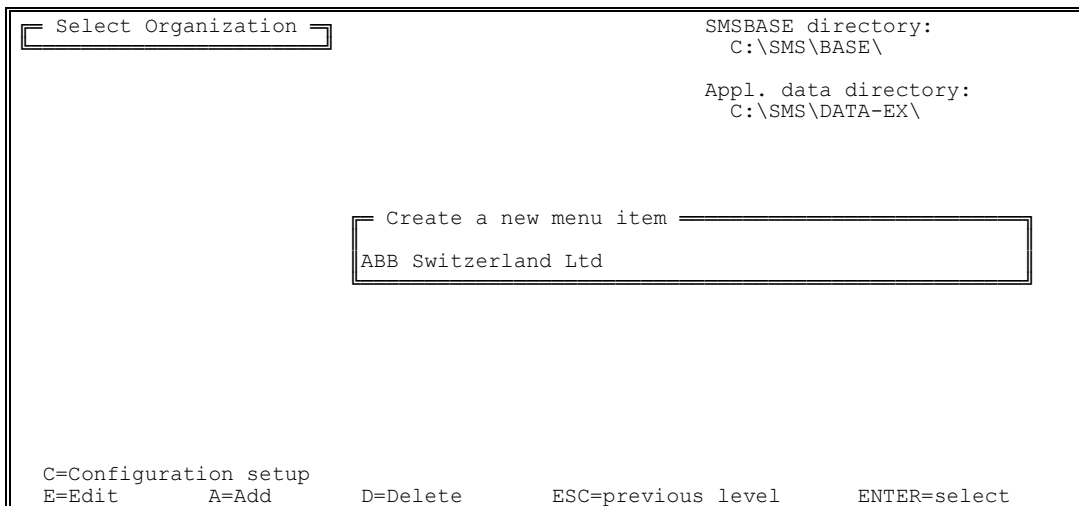
#### 5.13.5.1. **Creating the application structure**

- 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 Sw Select Station	SMSBASE directory: C:\SMS\BASE\  Appl. data directory: C:\SMS\DATA-EX\  Create a new menu item ABB Baden
Organiz: ABB Switzerland 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 Sw Select Station ABB Ba Select Object/Bay	SMSBASE directory: C:\SMS\BASE\  Appl. data directory: C:\SMS\DATA-EX\  Create a new menu item UTATP-2 REC316 45
Organiz: ABB Switzerland 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 Sw Select Station [
  ABB Ba Select Object/Bay [
    UTATP-2 REC316 45
  ]
]
]
SMSBASE directory:
C:\SMS\BASE\

Appl. data directory:
C:\SMS\DATA-EX\

Edit communication parameters
-----
Phone no:      161707          161707
Connection:    Direct         Direct
Serial port:   COM1           COM1
Protocol:      SPA            SRIO
Baud rate:     9600           9600
Parity:        EVEN          EVEN
Data bits:     7              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 Sw Select Station [
  ABB Ba Select Object/Bay [
    UTATP-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 Switzerland Ltd
Station:  ABB Baden
Obj/Bay:  UTATP-2 REC316 45

C=Create communication parameters
SPACE=next value          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  [
ABB Sw [ Select Station [
      [ ABB Ba [ Select Object/Bay [
            [ UTATP- [ Select Unit [a directory:
                  [ REC31 [ Select Module/Part of Unit [
                        [ REC316 REC316 Control & Protection Terminal

Organiz:   ABB switzerland Ltd
Station:   ABB Baden
Obj/Bay:   UTATP-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  [
ABB Sw [ Select Station [
      [ ABB Ba [ Select Object/Bay [
            [ UTATP- [ 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 Switzerland Ltd
Station:   ABB Baden
Obj/Bay:   UTATP-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.

### 5.13.5.2. Updating the Spin.CNF file

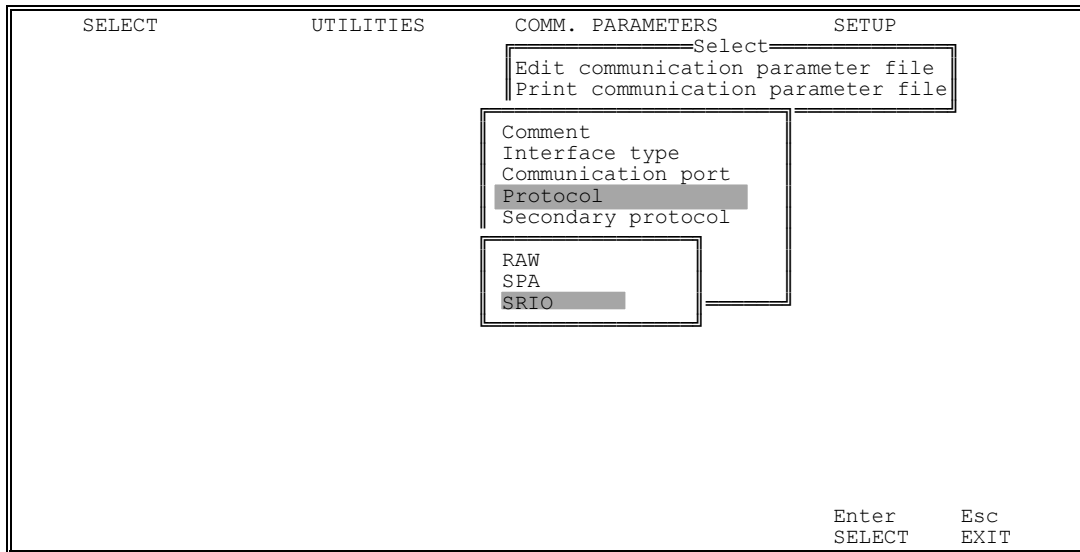
- Select *Edit communication parameter file* from the *Comm parameters* menu.

SELECT	UTILITIES	COMM. PARAMETERS	SETUP
		Select Edit communication parameter file Print communication parameter file	
			Enter      Esc SELECT    EXIT

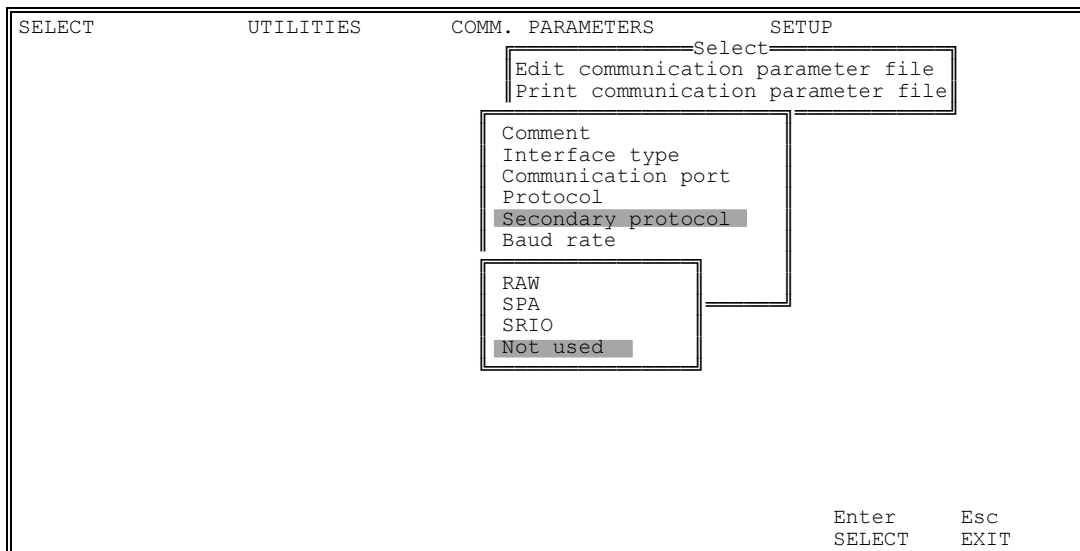
- Select the desired station and respond with 'Yes' to the question '*Continue with this file?*'.

SELECT	UTILITIES	COMM. PARAMETERS	SETUP
		Select Edit communication parameter file Print communication parameter file	
Organiz ABB Switzerland	Station ABB Baden	Obj/Bay Unit	
			Enter      Esc SELECT    EXIT

- Select 'SRIO' from the *Protocol* sub-menu.



- Select **NOT USED** from the *Secondary protocol* sub-menu



- All other settings can be left at their default values.

Note that all the above settings must agree with the SRIO settings (Syspar 4).

### 5.13.5.3. 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'.

```

Select Organization
ABB Sw Select Station
      ABB Ba Select Object/Bay
            UTATP-2 REC316 45
            UTATP-2 REC316 94

SMSBASE directory:
C:\SMS\BASE\

Appl. data directory:
C:\SMS\DATA-EX\

Create a new menu item
Report NTP

Organiz:   ABB Switzerland Ltd
Station:   ABB Baden

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.

```

Select Organization
ABB Sw Select Station
      ABB Ba Select Objec
            UTATP- Select
            UTATP- Select
            Report UTATP

A Manual Entry
MODEM
OTHER
REC316
REPORT STATION

SMSBASE directory:
C:\SMS\BASE\

Appl. data directory:
C:\SMS\DATA-EX\

Organiz:   ABB Switzerland Ltd
Station:   ABB Baden
Obj/Bay:   Report UTATP

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 Sw Select Station
      ABB Ba Select Object/Bay
            UTATP- Select Unit
            UTATP REPOR 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 Switzerland Ltd
Station: ABB Baden
Obj/Bay: Report UTATP
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.**

**5.13.5.4. 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.

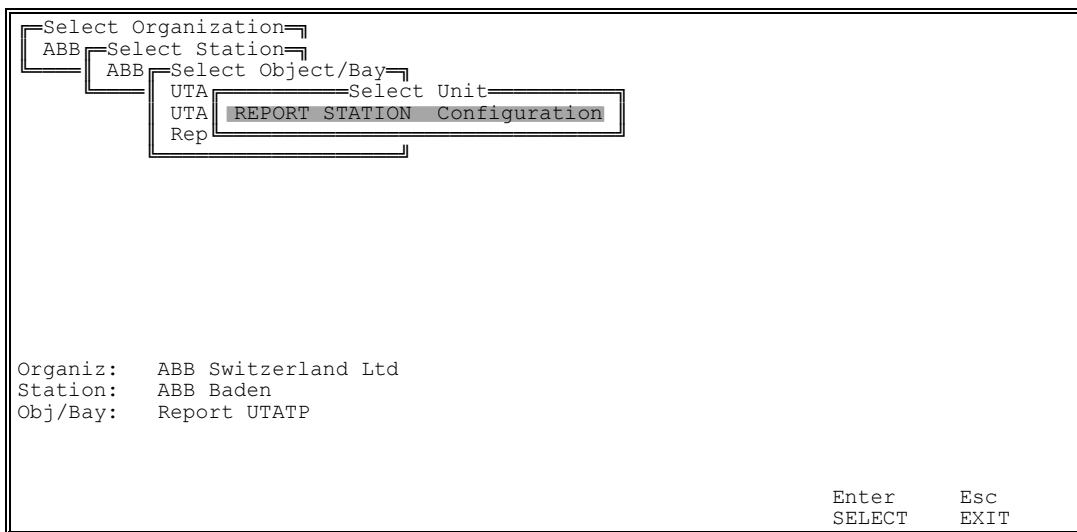
```

Select Organization
ABB Select Station
      ABB Select Object/Bay
            UTATP-2 REC316 45
            UTATP_2 REC316 94
            Report UTATP

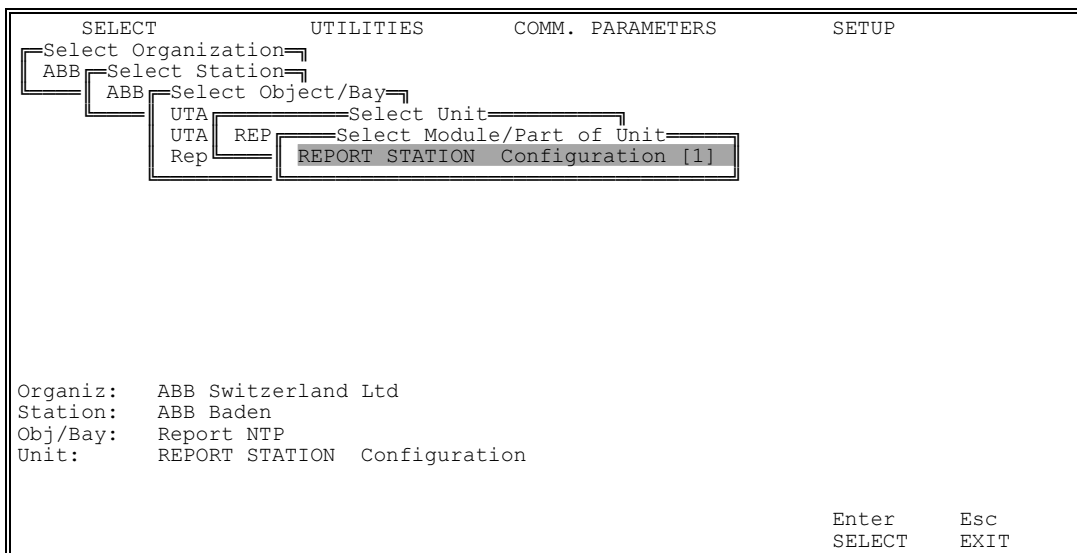
Organiz: ABB Switzerland Ltd
Station: ABB Baden

F3          F5          Enter  Esc
MODEM      PASSWORD  SELECT EXIT
    
```

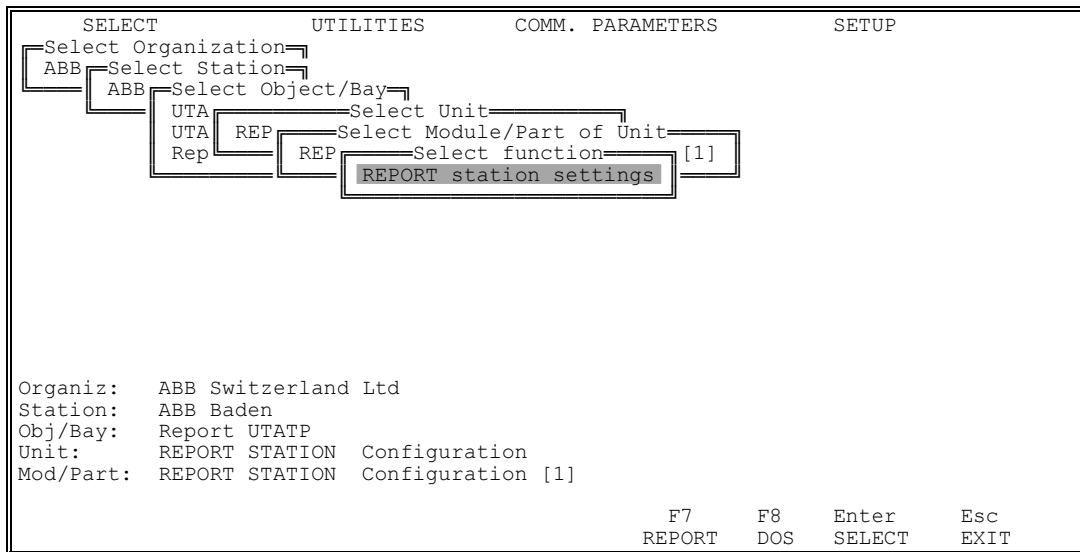
- Select Report station configuration in the Select unit window (Level 4).



- Select Report station configuration in the Select module/part of unit window (Level 5).



- Select the menu item *Select function* and then *Report station settings (Level 6)*.



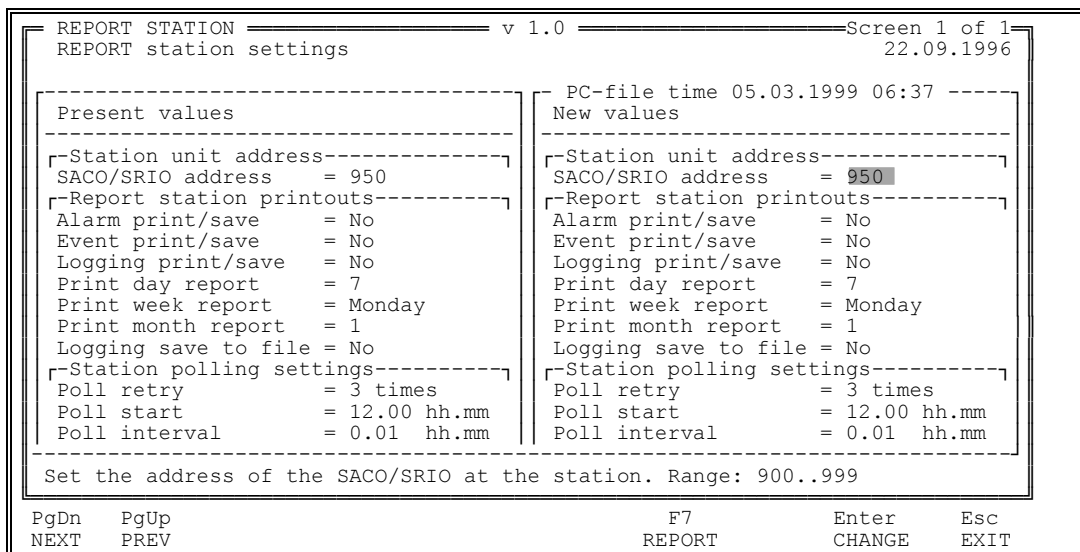
```

SELECT      UTILITIES      COMM. PARAMETERS      SETUP
├──Select Organization──
│   ├──ABB──Select Station──
│   │   ├──ABB──Select Object/Bay──
│   │   │   ├──UTA──Select Unit──
│   │   │   │   ├──UTA──Select Module/Part of Unit──
│   │   │   │   │   ├──Rep──Select function── [1]
│   │   │   │   │   │   └──REPORT station settings
└──Organiz:  ABB Switzerland Ltd
    Station:  ABB Baden
    Obj/Bay:  Report UTATP
    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 22.09.1996

-----
Present values                   PC-file time 05.03.1999 06:37 -----
New values
-----
[-Station unit address-----] [-Station unit address-----]
SACO/SRIO address   = 950      SACO/SRIO address   = 950
[-Report station printouts-----] [-Report station printouts-----]
Alarm print/save   = No        Alarm print/save   = No
Event print/save   = No        Event print/save   = No
Logging print/save = No        Logging print/save = No
Print day report   = 7         Print day report   = 7
Print week report  = Monday    Print week report  = Monday
Print month report = 1         Print month report = 1
Logging save to file = No      Logging save to file = No
[-Station polling settings-----] [-Station polling settings-----]
Poll retry         = 3 times    Poll retry         = 3 times
Poll start        = 12.00 hh.mm Poll start        = 12.00 hh.mm
Poll interval     = 0.01 hh.mm Poll interval     = 0.01 hh.mm
-----

Set the address of the SACO/SRIO at the station. Range: 900..999

PgDn  PgUp      F7      Enter      Esc
NEXT  PREV     REPORT   CHANGE     EXIT

```

Refer to the Section 'Reporting' in the SMS010 manual for further information.



September 97

## 6. SELF-MONITORING AND DIAGNOSIS

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## 6. SELF-MONITORING AND DIAGNOSIS

### 6.1. *Self-monitoring and diagnosis*

The RE. 216 system is equipped with self-monitoring and diagnostic functions, which operate continuously and instantly block the protection functions should a defect occur and the correct operation of the protection be in question.

A defect is signalled on the frontplate of the device and remotely by the general alarm signalling relay. The program records the disturbance in the event list.

The status of the system and the individual units and the event list can be viewed using the diagnostic function on the control unit (PC).

#### 6.1.1. *Self-monitoring*

Each unit has its own self-monitoring function, which signals the status of the unit to the system via its device status register.

The principal signals transmitted by the function are:

<b>GNB</b> :	unit not ready
<b>SSG</b> :	general device alarm
<b>SSS</b> :	general system alarm.

A defect is also signalled to the other units connected to the bus by the "SML" or "CK" bus lines and on the frontplate of the unit concerned by the alarm LED "AL".

A defective unit sets the general alarm bus line "SML" (i.e. applies a logical "1"). In normal operation, the bus line "CK" oscillates at the clock frequency of the B448C bus. A defective unit disables this signal (i.e. connects the line to logical "0").

#### **Legend for the following tables:**

1 : logical "1" or LED lit  
0 : logical "0" or LED extinguished  
- : no influence.

**6.1.1.1. Auxiliary supply units 216NG61, 216NG62 and 216NG63**

Status	Signal via:		
	UIN	UOUT	CK
Normal operation "ON"	1	1	-
O/P voltage failure	1	0	0
I/P voltage failure	0	0	0

**6.1.1.2. Processor unit 216VC62A**

Status	Signal via:			
	Status	CK	SML	AL
Normal operation	-	-	-	0
24 V supply failure	-	0	-	0
Internal 5 V supply failure	SSG	0	1	1
Internal clock failure	SSG	0	1	1
RAM or ROM failure	SSG	-	1	1
B448C bus failure	SSS	-	-	0
"PASSIVE" connector inserted	GNB	-	-	0

**Device status register:**

Symbol	Function	Weighting
GNB	Unit not ready (passive pin inserted)	0002 Hex
EEPROM	FUPLA code not valid	0005 Hex
STG	Incorrect device configuration	0004 Hex
SSG	General alarm for device failure	0010 Hex
SSS	General alarm for system failure	0020 Hex
BBOE	Warm start following bus time-out	0040 Hex
SWTO	Warm start following watchdog time-out	0080 Hex
RAM	RAM error	0100 Hex
ROM	ROM error	0200 Hex
BERI	B448C bus failure	1000 Hex
ARBG	MBIC failure	2000 Hex
PER	Failure of a peripheral device - failure of the auxiliary supply for the O/P module of a 216AB61 - warm start of an other unit	4000 Hex
SML	SML line active	8000 Hex

**6.1.1.3. Analogue input unit 216EA61**

Status	Signal via:				
	Status	CK	SML	AL	RUN
Normal operation	-	-	-	0	1
24 V supply failure	-	0	-	0	0
Internal 5 V supply failure	SSG	0	1	1	0
Internal clock failure	SSG	0	1	1	0
RAM, ROM error	SSG	-	1	1	0
Defective analogue section	SSG	-	1	1	0
B448C bus failure	SSS	-	-	0	-
"PASSIVE" connector inserted	GNB	-	-	0	0

**Device status register:**

Symbol	Function	Weighting
GNB	Device not ready (passive pin inserted)	0002 Hex
STG	A/D converter disabled	0004 Hex
SSG	General alarm for device failure	0010 Hex
SSS	General alarm for B448C bus failure	0020 Hex
BBO	Warm start following bus time-out	0040 Hex
SWTO	Warm start following watchdog time-out	0080 Hex
RAM	RAM error	0100 Hex
ROM	ROM error	0200 Hex
VREF	Reference voltage out of tolerance	0400 Hex
ASE	Analogue section supply failure	0800 Hex
BERI	B448C bus failure	1000 Hex
ARBG	Arbitration error (Not all analogue data can be transferred via the bus.)	2000 Hex
PER	Redispatch interrupt	4000 Hex
SML	SML line active	8000 Hex

**6.1.1.4. Binary input unit 216EB61**

Status	Signal via:			
	Status	CK	SML	AL
Normal operation	-	-	-	0
24 V supply failure	-	0	-	0
Internal 5 V supply failure	SSG	0	1	1
Internal clock failure	SSG	0	1	1
RAM, ROM error	SSG	-	1	1
B448C bus failure	SSG	-	1	1
"PASSIVE" connector inserted	GNB	-	-	0

**Device status register:**

Symbol	Function	Weighting
GNB	Device not ready (passive pin inserted)	0002 Hex
STG	Incorrect device configuration, event signal disabled	0004 Hex
SSG	General alarm for device failure	0010 Hex
SSS	General alarm for B448C bus failure	0020 Hex
BBOE	Warm start following bus time-out	0040 Hex
SWTO	Warm start following watchdog time-out	0080 Hex
RAM	RAM error	0100 Hex
ROM	ROM error	0200 Hex
BERI	B448C bus failure	1000 Hex
ARBG	Synapsen 2 error: Synapse 2 from the analogue I/P unit 216EA61 is missing	2000 Hex

**6.1.1.5. Binary input and output unit 216DB61**

Status	Signal via:		
	Status	SML	AL
Normal operation	-	-	0
Internal 5 V supply failure	-	1	1
Defective O/P channel driver	SSG, FA0	1	1
Tripping relay module supply failure	SSG, FA1	1	1
Data transmission error for a received tripping signal	SSG, FA2	1	1
I/P module UP supply failure	SSG, UP	1	1
Device not initialised	GNB	1	1

**Device status register:**

Symbol	Function	Weighting
GNB	Device not ready	0002 Hex
SSG	General alarm for device failure	0010 Hex
FA0	Tripping channel driver failure	--
FA1	Tripping relay module supply failure	--
FA2	Data transmission error for a received tripping signal	--
FK0..7	Channel No. definition (1..8) for signals FA0..FA2	--
ZS	Time-out operated (A tripping signal was not transmitted twice.)	--
BL1	An FA0 signal has set the blocking flip-flop for group 1 (channels 1, 3, 5, 7).	--
BL2	An FA0 signal has set the blocking flip-flop for group 2 (channels 2, 4, 6, 8).	--
UP	I/P module supply failure	--
DISB	The functions ENABLE 1/2 and BLOCK 1/2 are not in operation (see <a href="#">Section 2.5.6.</a> )	--

**6.1.1.6. Binary output unit 216AB61**

Status	Signal via:				
	Status	SML	AL	CHO01 <sup>*)</sup>	CHO02 <sup>*)</sup>
Normal operation	-	-	0	1	1
Redundant 24 V supply failure (on the B448C bus)	-	1	1	0	-
Internal 5 V supply failure	-	1	1	0	-
UP supply failure	UP	-	0	-	-
"PASSIVE" - Connector inserted	GNB	-	1	0	0
Device not initialised	GNB	1	1	0	0
System alarm functions <sup>*)</sup> :					
"SML" bus line active	-	-	-	0	-
"CK" bus line blocked	-	-	1	0	0

**Device status register:**

Symbol	Function	Weighting
GNB	Device not ready (passive pin inserted)	0002 Hex
UP	O/P module supply failure	--
S	Special function for channels CHO01 and CHO02 active	--

---

<sup>\*)</sup> only of significance if a special function is active.

**6.1.1.7. Analogue/binary output unit 216AC61**

Status	Signal via:				
	Status	SML	AL	CHO01 <sup>*)</sup>	CHO02 <sup>*)</sup>
Normal operation	-	-	0	1	1
Redundant 24 V supply failure (on the B448C bus)	-	1	1	0	-
Internal 5 V supply failure	-	1	1	0	-
UP supply failure	UP	-	0	-	-
Internal ± 15 V supply failure	-	1	1	0	-
"PASSIVE" - Connector inserted	GNB	-	1	0	0
Device not initialised	GNB	1	1	0	0
System alarm functions <sup>*)</sup> :					
"SML" bus line active	-	-	-	0	-
"CK" bus line blocked	-	-	1	0	0

**Device status register:**

Symbol	Function	Weighting
GNB	Device not ready (passive pin inserted)	0002 Hex
UP	O/P module supply failure	--
S	Special function for channels CHO01 and CHO02 active	--

---

<sup>\*)</sup> Only of consequence, if special function active.



### 6.1.2. **Self-diagnosis**

In addition to continuous hardware self-monitoring, a diagnostics routine runs on the 216VC62A processing unit which performs the following functions:

- cyclic testing of its own memories (RAM, EPROM, EEPROM).
- monitoring the correct running of the program (watchdog).  
The operation of the microprocessor is monitored by a watchdog, which is basically a timer. The program must reset the watchdog at least once every 50 ms. If the program does not run correctly (run-time error) the timer goes the full time and resets the processor. The diagnostic system reports a warm start.
- initialisation and checking that the actual configuration of all the devices connected to the B448C bus agrees with the set hardware configuration.
- evaluation of all the disturbance signals from all the units, setting the status of the protection system and blocking of the protection functions if necessary.
- entry in the event list.

The status of the protection system can be determined with the aid of the control unit's (PC) diagnostic function (see [Section 5.9.](#)) and can assume one of the four following states:

No error:	Normal operation
Urgent error:	A unit is defective or passive. The protection is partially operational (underfunction). The SML line is set.
Fatal error:	The system is blocked. The SML line is set.

Every change in the status of the device gives rise to an entry in the event list. The same list can also be viewed and printed using the HMI (PC).

The diagnostic function can make the following entries in the event list:

<b>Signal</b>	<b>Significance</b>
Cold system start	Signal generated upon switching on the auxiliary supply.
Warm system start	The system has been reinitialised due to a software or hardware error (watchdog).
Diagnostics: System status ...	The status of the system has changed as indicated by the message.
Diagnostics: Device ...	An error has been detected in the device indicated. Refer to <a href="#">Section 6.1.1.</a> for the significance.
A/D error	A 216EA61 analogue I/P unit has detected an error and initiated a warm system start.
Software error	A software (run-time) error has reinitialised the system. Further information can be obtained via the control unit (menus: "Diagnostics" → "Read run-time error data"). Refer also to <a href="#">Section 6.3.1.</a>
Bus error	A data transfer error was detected on the B448C parallel bus and a warm system start initiated.
Program stop	The protection program was stopped, for example, for changing parameter settings or because a fatal error was discovered.
Program start	The protection program was initialised, for example, after switching the system on or after parameters have been reset.

There now follow some examples of event lists:

a) Entries after switching on the auxiliary supply:

0	00:00:00.000	Cold system start
1	00:00:00.000	Diagnostics: Unit 216VC62A No.1: No error
2	00:00:00.000	Diagnostics: Unit 216VC62A No.2: No error
3	00:00:00.000	Diagnostics: Unit 216DB61 No.1: No error
4	00:00:00.000	Diagnostics: Unit 216DB61 No.2: No error
5	00:00:00.000	Diagnostics: Unit 216AB61 No.1: No error
6	00:00:00.000	Diagnostics: Unit 216AB61 No.2: No error
7	00:00:00.000	Diagnostics: Unit 216AB61 No.3: No error
8	00:00:00.000	Diagnostics: Unit 216EB61 No.1: No error
9	00:00:00.000	Diagnostics: Unit 216EB61 No.2: No error
10	00:00:00.000	Diagnostics: Unit 216EB61 No.3: No error
11	00:00:00.000	Diagnostics: Unit 216EB61 No.4: No error
12	00:00:00.000	Diagnostics: Unit 216EB61 No.5: No error
13	00:00:00.000	Diagnostics: Unit 216AC61 No.1: No error
14	00:00:00.000	Diagnostics: System status: No error
15	00:00:00.826	ParSet1 ON
16	00:00:0.828	Reinitialisation
17	00:00:00.830	BinI/P No.9/ 6 ON
		BinI/P No.9/ 7 ON
		BinI/P No.9/ 8 ON
		BinI/P No.9/ 9 ON
18	1994-11-05 10:41:00.360	HMI active ON

The date and time are only added and synchronised after the control unit (PC) has been connected.

b) Entries following connection of the control unit (PC) and after binary I/P No. 1 has been switched on and then off again:

14	1990-07-29 05:28:28.758	BinI/P No. 1 ON
15	1990-07-29 05:28:29.111	BinI/P No. 1 OFF

c) Entries when the passive pin is inserted on the 216AB61 unit:

20	1990-07-29 05:32:51.021	Diagnostics: Unit 216AB61 No.2: GNB (0002H)
21	1990-07-29 05:32:51.021	Diagnostics: System status: Urgent error

The number in brackets at the end of the status line indicates the contents of the device status register for the unit concerned. It can be decoded with the aid of the weighting data (see Section 6.1.1.).

For example, entry No. 22: Unit 216VC62A No.4: SSS (8020H)

```

8000H : SML   SML bus line active
+ 0020H : SSS   General system alarm
-----
8020H
=====

```

d) Entries when the passive pin is withdrawn:

```

26 1990-07-29 05:32:55.158 Diagnostic: Unit 216AB61 No.2: No error
27 1990-07-29 05:32:55.158 Diagnostics: System status: Non-urgent error

```

e) Entries after switching on the auxiliary supply, if the device configuration is incorrect:

1	00:00:00.000	Diagnostics: Unit 216VC62A No.1: No error
2	00:00:00.000	Diagnostics: Unit 216VC62A No.2: No error
3	00:00:00.000	Diagnostics: Unit 216DB61 No.1: No error
4	00:00:00.000	Diagnostics: Unit 216DB61 No.2: No error
5	00:00:00.000	Diagnostics: Unit 216AB61 No.1: No error
6	00:00:00.000	Diagnostics: Unit 216AB61 No.2: No error
7	00:00:00.000	Diagnostics: Unit 216AB61 No.3: No error
8	00:00:00.000	Diagnostics: Unit 216EB61 No.1: No error
9	00:00:00.000	Diagnostics: Unit 216EB61 No.2: No error
10	00:00:00.000	Diagnostics: Unit 216EB61 No.3: No error
11	00:00:00.000	Diagnostics: Unit 216EB61 No.4: No error
12	00:00:00.000	Diagnostics: Unit 216AC61 No.1: No error
13	00:00:00.000	Diagnostics: System status: No error
14	00:00:00.636	Diagnostics: Unit 216VC62A No.2: SSS (0024H)
15	00:00:00.741	Diagnostics: System status: Urgent error
16	00:00:00.721	Diagnostics: Unit 216VC62A No.1: (0004H)
17	00:00:00.741	Diagnostics: Unit 216VC62A No.1: SSS (0024H)

Event messages Nos. 11..13 indicate the device status SSS (0024H).

This means:

```
0004H : STG  Incorrect device configuration
+ 0020H : SSS  General system alarm
-----
0024H
=====
```

The above entries can have the following causes:

- The units are not inserted at the positions defined in the device settings.
- The plug-in jumpers on the 216DB61 binary I/P and tripping units are not at the locations defined in the device settings (see [Section 2.5.6.](#)).

The parameter settings can be changed by selecting the following sequence of menus:

- “Editor”
  - “Edit hardware functions”
    - “Edit binary channels”
      - “Enable/block”
- The plug-in jumpers on the 216AB61 binary O/P units are not at their correct locations (see [Section 2.5.4.](#)).

## 6.2. *Signals during normal operation*

The green LED's on the front of all the units should be lit during normal operation and the red LED's should not.

The yellow LED's on the I/P and O/P units indicate the statuses of the associated channels.

Channels CH001 and CH002 on the **first** 216AB61 or 216AC61 binary O/P unit are especially important, because they are used for monitoring the entire system:

CH001: System ready

The following errors can reset this channel to logical "0":

- The protection program is not running.
- The diagnostic function sets the status to "Fatal error" or "Urgent error".
- The device configuration does not agree with the hardware configuration defined in the program.
- The EEPROM does not contain any valid protection parameters.
- The FUPLA function has been configured, however the FUPLA code is invalid or not loaded.

CH002 : No system error

This line is set by the diagnostics routine during initialisation and remains active until a device failure blocks the "CK" bus line. In this case CH001 is also set to log. 0; the system does not run (see [Section 6.1.1.](#)).

The yellow LED's on the 216VC62a processing unit(s) respond as follows to the various operating statuses:

System status	LED L1	LED L2
No error	0	0
Urgent error	1	0
Fatal error	1	1

Communication	LED L3	LED L4
transmit	1	0
receive	0	1

Communication with the control and setting PC

LED 5 lights briefly when a LON wink telegram is received.

LED 6 lights while executing a write operation to the program flash memory.

LED "MST" lights whenever the corresponding unit accesses the B448C bus in a master role.

LED "AL" indicates that the unit to which it belongs is defective.

In the event of a disturbance signal (CH001 and CH002 off), it can be determined whether the protection is running by observing the display of the cycling time in the "Display analogue channels window.

A display of (0) means that the protection is not running.

The protection then **has to be reset** using the resetting pin.

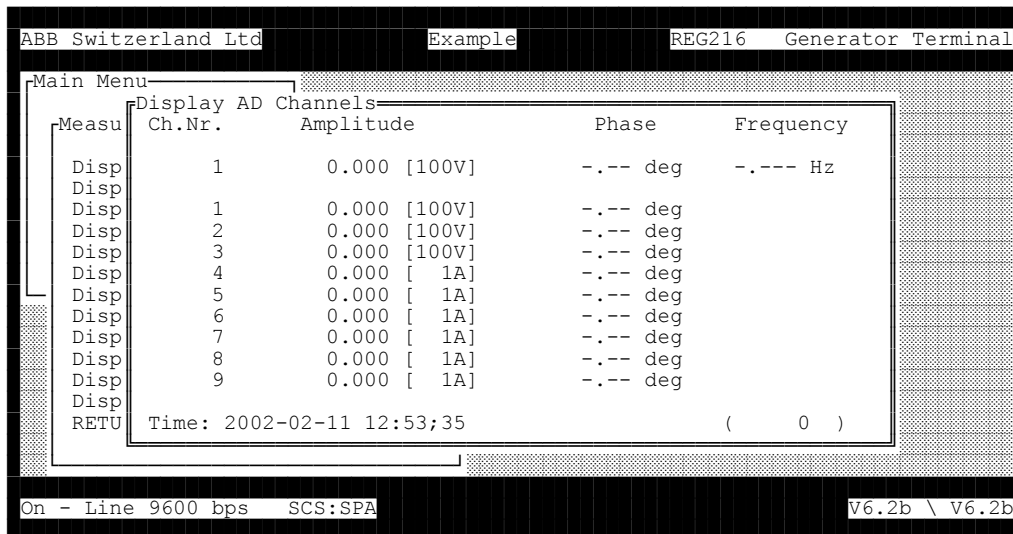


Fig. 6.1 Cycling time display

### 6.3. *Display functions*

#### 6.3.1. *Diagnosis*

The diagnostic data of the various units can be viewed by selecting the menus “Diagnostics” → “List unit statuses”.

The following example shows the diagnostic data generated when the passive pin is inserted on the 216EA61 unit.

#### **RE. 216 protection system: Diagnostics**

SYSTEM - REC216 V4.5 10-09-1997 11:06

List status report

SYSTEM - REC216 V4.5 10-09-1997 11:06

Diagnosis M216

216EA61 No.1 Slot No. 8

Status : Error detected

Hardware configuration invalid

Device not ready

Firmware Version : 3.02

216VC62A No.1 Slot No. 4

Status : No error

HW No.: 000000FE8CD3/06D0/23

Protection stop

Software = 00:00;00.000

Setting = 00:00;00.000

FUPLA status: None loaded

216DB61 No.1 Slot No. 14

Status : No error

ENABLE/BLOCK is not active

216DB61 No.2 Slot No.15

Status : No error

ENABLE/BLOCK is not active

216AB61 No.1 Slot No. 12

Status : No error

Special function is active.

216AB61 No.2 Slot No. 17

Status : No error

Special function is not active



216EB61 No.1 Slot No. 18

Status : Error detected

STG: Event recording is not active

Firmware Version: V4.50

216AC61 No.1 Slot No. 20

Status : No error

Special function is not active

216AC61 No.2 Slot No. 21

Status : No error

Special function is not active

Unit : 216AB61 No.1 Slot No. 11

Status : No error

Note: Special function is not active

Unit : 216AB61 No.2 Slot No. 18

Status : No error

Note: Special function is not active

Unit : 216AB61 No.3 Slot No. 19

Status : No error

Note: Special function is not active

Unit : 216EB61 No.1 Slot No. 12

Status : Error detected

STG: Event recording is not active

Firmware version: V3.20

Unit : 216EB61 No.2 Slot No. 13

Status : Error detected

STG: Event recording is not active

Firmware version: V3.20

Unit : 216EB61 No.3 Slot No. 14

Status : Error detected

STG: Event recording is not active

Firmware version: V3.20

Unit : 216EB61 No.4 Slot No. 15

Status : Error detected

STG: Event recording is not active

Firmware version: V3.20

Unit : 216EB61 No.5 Slot No. 17

Status : Error detected

STG: Event recording is not active

Firmware version: V3.20

Unit : 216AC61 No.1 Slot No. 21

Status : No error

Note: Special function is not active

The following information can be viewed by selecting “Read run-time error data” from the “Diagnostics” menu should the system signal a warm start.

### Diagnostic dump

```
2000:0000    0000  Error code = no error occurred
2000:0002    0000  Code segment = 0000H
2000:0004    0000  Module name = Module not found
2000:0006    0000  Program counter = 0000H
2000:0008    0000
2000:000A    0000
2000:000C    0000
2000:000E    0000  EEPROM: 0000000000000101
2000:0010    0000
2000:0012    0000
2000:0014    0000
2000:0016    0000
2000:0018    0000
2000:001A    0000
2000:001C    0000
2000:001E    00C5
```

If a program run-time error was the reason for the warm start, this information enables the source code instruction to be located at which the error occurred.

After viewing the information, the list can be deleted in the protection by selecting “Delete HEX dump” from the “Diagnostics” menu .

The list is deleted when a new set of settings is saved.

### 6.3.2. *Displaying measurements*

The menu “Measurement handling” provides facility for viewing the following variables:

- r.m.s value, phase-angle and frequency for the primary system variable connected to each analogue channel

Example:

Analogue I/P channel

Channel No.	Amplitude	Phase-angle	Frequency
1	1.000 UN	0.00 deg	50.000 Hz

- the most important measurements by the individual protection functions

Example:

Gen. diff.

0.52 IN (spill current in the relay circuit,  
IN = transformer rated current)

- binary I/P's and O/P's
- O/P signals.

Note on the display of measurements by the protection functions:

The underreactance function describes an impedance vector which starts at the centre of the circular characteristic. This vector and the impedance measured at the generator terminals form a triangle as shown in [Fig. 6.2](#). The function picks up when the displayed impedance is equal to or less than the radius of the circle:

$$z \leq \frac{1}{2} \left( x_d - \frac{x'_d}{2} \right)$$

**Example:**

$$x_d = 2; \quad x'_d = 0.2$$

$$z \leq \frac{1}{2}(2 - 0.1) = 0.95$$

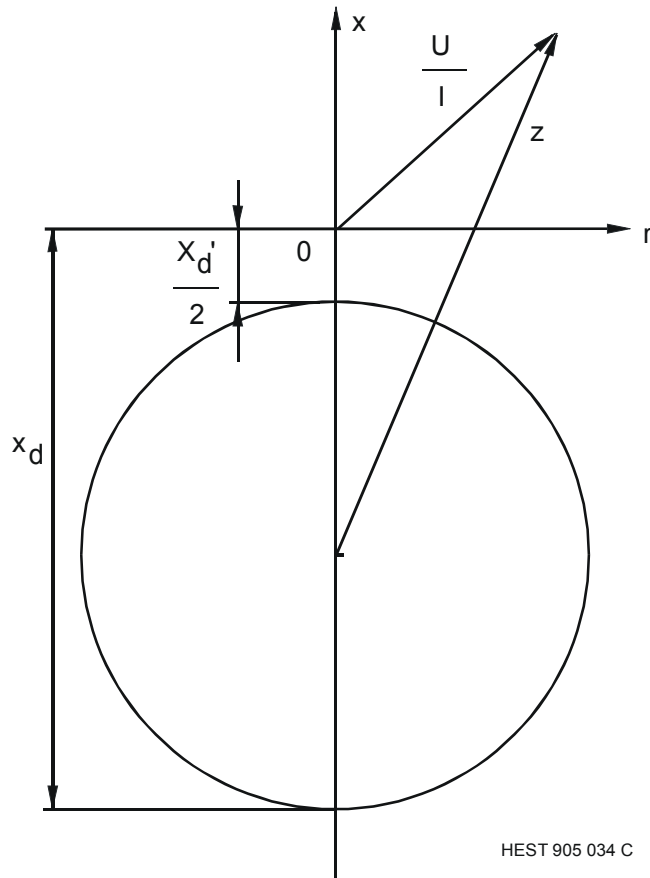


Fig. 6.2 Value displayed for the underreactance protection function

August 2000

## 7. INSTALLATION AND MAINTENANCE

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## **7. INSTALLATION AND MAINTENANCE**

### **7.1. *Checks upon receipt***

#### **7.1.1. *Unpacking and 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 transport damage be found, the last carrier must be informed immediately and be held responsible in writing. Also inform your nearest ABB office or agent and ABB Switzerland Ltd., Department NAP-1, CH-5401 Baden, Switzerland.

If the cubicle is not to be installed immediately, it should be put in a suitable room in its original packing together with the other components (see Section 7.1.2.) until they can all be put into permanent storage. Where the packing has been damaged, check the desiccant and replace if necessary. Finally, re-weld the plastic foil.

#### **7.1.2. *Transport and storage***

The crates with the protection cubicle and the separate units have transport frames, which enable them to be off-loaded and moved on site using fork lift trucks, rolling gear and cranes. After unpacking, the cubicle may only be lifted by the lugs fitted to the top of the cubicle frame.

The cubicle should only be moved in a vertical position and tipping should be avoided as far as possible. If absolutely necessary, single cubicles may be laid horizontally on their sides for short periods, e.g. to pass through doorways. Care should be taken when doing this to support the cubicle over a large area.

The equipment may never be stored in the open. The protection cubicle and the separate units must be stored in a suitably closed dry room, which is not subject to extremes of temperature.

The packing is gauged for a given maximum storage period. The packing must be opened at the end of this period and at least the desiccant must be checked and replaced if necessary. Special long-term packing includes humidity indicators, which can be inspected without opening the packing.

Consult the general ABB instructions for further details regarding transport and storage.

## **7.2. Accessories**

A PC is necessary during commissioning and for setting the system. The user may supply the PC himself, providing it fulfils certain minimum requirements.

### **7.2.1. Minimum PC requirements**

The PC used for commissioning and setting must satisfy at least the following:

- Windows 3.1x, Windows 95 or Windows NT4.0 operating system
- 164 MByte RAM
- 1 floppy drive (3½", 1.44 MB) and a hard disc with at least 12 MByte of free space
- 1 serial interface (RS-232).
- 1 parallel interface (Centronics)

### **7.2.2. Printer**

The printer connected to the PC must be fitted with a parallel interface (Centronics).

### **7.2.3. Interfaces**

The 216VC62a has a 25 pin connector on the frontplate for the serial interface RS-423A, CCIT V.10. Data transfer takes place via a unbalanced cable at a data transfer rate between 1200 and 19200 Baud. The signal level for the 216VC62a is approx.  $\pm 4.5$  V.

The PC interface (RS-232C) is initialised and appropriately set to communicate with the RE. 216 by the software.

### **7.2.4. Connecting cables 216VE61, 216VC62a ↔ PC**

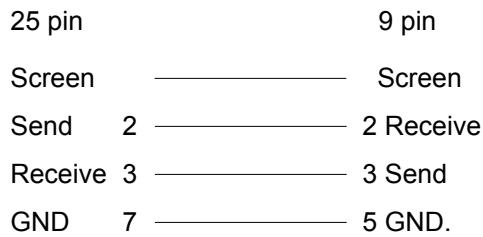
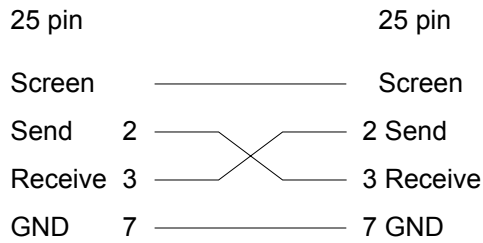
Optical fibre cables must be used for these connections (e.g. Type YX 216-1, see Data Sheet).

A copper cable may be used in laboratory conditions.



Pin connections:

1. 216VC62a ↔ PC



### 7.3. Spares

When ordering spares, state the name, type designation and the function in the protection system for which it is intended. Stocking spare units is recommended, if there are several units of the same type in a plant.

The remarks in [Section 7.1.2.](#) also apply to storing spares. Testing the spares at the same time as carrying out routine testing of units in operation is recommended. This should include connecting them to the auxiliary supply and allowing them to run for a quarter of an hour.

#### **7.4. Maintenance**

Because of the self-testing and monitoring features included, RE. 216 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 control program.
- Test the external circuits using the test functions provided by the control program (see [Section 5.9.](#)).

The wet electrolytic capacitors have a life of >20 years. This assumes a mean ambient temperature around the casing of 40° C. The life is doubled, respectively halved for each 10° C of difference.

## **7.5. Installation and wiring**

### **7.5.1. Place of installation and ambient conditions**

When choosing the place of installation, ensure that there is sufficient space in front of the cubicle. It must be possible to fully open the door and the hinged frame without difficulty.

All work on and in the cubicle such as installation, wiring, testing, repairs etc., can be carried out from the front. Access to the rear of the cubicle is not absolutely essential, but can be an added convenience, e.g. when working on the I/O assemblies, which otherwise have to be dismantled from the front.

The place of installation must also conform to the ambient conditions given in the technical data according to Data Sheet "REG 216 - Generator protection" (see [Section 8](#)).

The location should not be exposed to excessive air pollution such as dust, aggressive substances etc. Severe vibration, extreme changes of temperature, high levels of humidity and strong induced magnetic fields should be avoided as far as possible.

### **7.5.2. Carrying out installation and wiring**

The instructions and drawings forming part of the specific set of plant diagrams must be observed when installing the cubicle. Further installation details are given in the general ABB descriptions.

[Section 2.3.](#), the [Figures 12.18](#) and [12.22](#) and the dimensioned drawings in the data sheet must be observed when installing the compact version of the RE. 216.

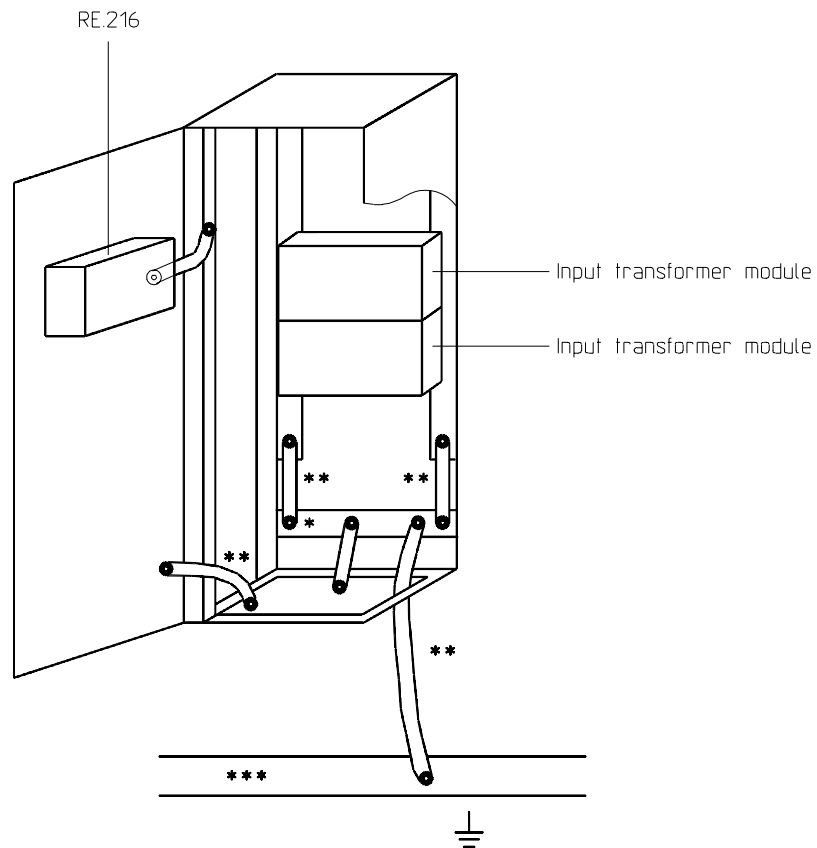
Attention must be paid that the external DC and AC cabling is run sufficiently far apart to minimise the influence of the heavy current circuits on the control circuits. The DC and AC wiring within the cubicle is clearly segregated.

### **7.5.2.1. *Grounding the racks and input transformer modules***

#### **Installation in a cubicle**

The following units are connected to the ground rail by copper braiding:

- racks and hinged frames  
(minimum width of copper braiding: 2 cm / short as possible)
- hinged frame via floor plate  
(minimum width of copper braiding: 3 cm)
- two side plates to the rear plate of the cubicle on which the input transformer modules are mounted  
(minimum width of copper braiding: 3 cm)



EG065

- non-insulated connection
- \* ground rail
- \*\* braided copper with the same effective gauge as the ground rail
- \*\*\* plant ground

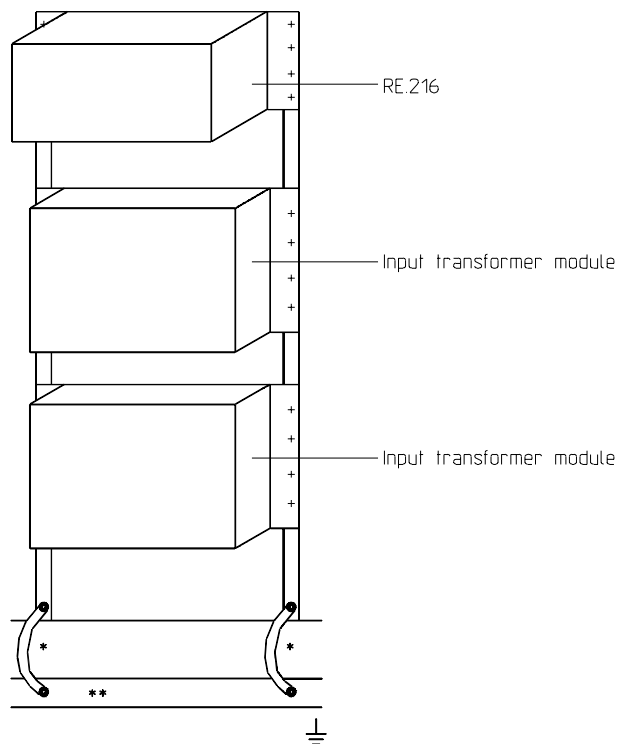
Fig. 7.1 Installation in a cubicle

**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.

### 7.5.2.2. *Grounding the assemblies and input transformer modules (compact version)*

#### Mounting on a rack

Where the assemblies and input transformer modules are mounted in a rack, the surfaces of all units must make good contact with the frame of the rack which must be properly grounded. All connecting surfaces must be free of paint etc., otherwise the casing must be connected directly to the plant ground by copper braiding (at least 2 cm wide).



EG066

- non-insulated connection
- \* copper braiding (minimum width 3 cm)
- \*\* plant ground

Fig. 7.2 Mounting in a rack

### **7.5.3. *Inserting the units in the equipment rack***

#### **Handling the electronic modules**

A large part of the electronic elements consist of CMOS modules. These are very sensitive with respect to electric and magnetic fields as well as electric discharges. Therefore care must be taken to avoid touching the modules, resp. the soldered joints.

The electronic plug-in units should only be grasped at the metallic parts (front plate, draw-out handle, etc.). Prior to this, the person handling the parts must be discharged electrostatically by touching grounded metal.

The plug-in units may only be placed on antistatic surfaces (mat).

The plug-in units may only be plugged into (resp. removed from) the equipment racks with the auxiliary supply switched off.

All the plug-in electronic units must be inserted in the racks and at the locations in the hinged frame specified in the set of specific plant diagrams. Where there are several units of the same type, the numbering on the units must also be observed.

Check that all the units are correctly and fully inserted and then secure them in place in the rack by tightening the screws at the top and bottom front edges.

Fit the electronic units of the compact version as instructed in [Section 2.3](#).

### **7.5.4. *Commissioning tests***

A complete test of the generator protection on site is divided essentially into two parts:

- I) basic functional test of the RE. 216
- II) tests in operation with the generator.

#### **I) Basic functional test of the RE. 216**

For the protection scheme as a whole to operate correctly, it is not enough for just the RE. 216 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.

All the points that have to be checked during commissioning can be seen from the check list in the Appendix in [Section 12](#).

The correct operation of the RE. 216 itself is determined by the following tests:

- secondary injection of every current and voltage input
- activating and deactivating every binary input (auxiliary relay or opto-coupler)
- energising and de-energising every auxiliary tripping and signalling relay
- simulation of logic functions (respectively delays and counters) controlled by external signals
- checking the settings (as 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 all analogue inputs at their rated values (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/de-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

The Appendix in [Section 12](#) includes a test report.



## II) Tests in operation with the generator

These tests determine whether the pick-up settings for the various schemes are correct.

The event list provided by RE. 216 serves in this case as a test report and also includes the primary current and/or voltage values at the instant of every event.

Current tests:

The current functions are tested by installing a three-phase fault (either upstream and/or downstream of the step-up transformer).

Specific protection functions:

- For the differential protection, the c.t. secondary windings are shorted at the isolating terminals and the loop to the protection opened phase by phase.
- The NPS function can be tested by exchanging two phases at the input.
- The underimpedance function can be tested by installing a fault downstream of the step-up transformer. In this case the value of impedance measured must correspond to the short-circuit impedance of the transformer.

Voltage tests:

The protection functions requiring voltage are tested with the generator running off-load.

Specific protection functions:

- The frequency functions are checked by varying the generator speed.
- The earth fault protection is tested by installing an earth fault at the corresponding location on the primary system and slowly increasing the excitation from zero.

Tests with the generator synchronised and connected to the power system:

The general power function is tested by varying the generator power through the corresponding pick-up setting. The reverse power function is checked by closing, for example, the main steam valve and allowing the unit to motor.

The generator excitation can be reduced to test the underreactance function, providing this is permissible, otherwise either the phase-angle setting can be temporarily changed by 180° or the corresponding current connections could be reversed at isolating terminals, if fitted. Both these methods enable the underexcitation function to be tested with the generator excited.

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 current and voltage circuits are interrupted, respectively short-circuited. This menu is also used for periodically checking the protection.

## 7.6. ***Fault-finding***

The diagnostic function on the control unit (PC) is a valuable tool for finding faults on the RE. 216 protection system.

Where an error message points to an internal defect, the corresponding unit must be replaced.

### **Caution:**

**The electronic units may only be inserted into, or withdrawn from the equipment rack when the auxiliary supply is switched off!**

If the failure of an auxiliary supply is being signalled, check the fuses in the corresponding circuits.

The following points should be checked, should there be no voltage at the output of a 216NG6. unit:

a) Is the green LED "U<sub>IN</sub>" lit?

If not, check whether the voltage at the input is available and within the permissible range?

b) Does the green LED "U<sub>OUT</sub>" light when the switch on the front is in position "1"?

If not, disconnect the supply circuits connected to the output and withdraw the units connected to the bus.

Should the output voltage now be correct, the defective circuit can be located by reconnecting the output circuits one after the other. Should, however, the voltage not recover when all the output circuits are isolated, the unit must be replaced.

Should none of these measures enable the fault to be located and cleared, consult the nearest ABB office or agent, or contact ABB Switzerland Ltd., Baden, Switzerland directly. Detailed information on the signals generated by the fault condition are an invaluable help in locating the cause of a problem quickly.

## **7.7. Maintenance**

### **7.7.1. General**

Because of the self-testing and monitoring features included, RE. 216 requires neither special maintenance nor periodic testing.

### **7.7.2. 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 control program (PC).
- Test the external circuits using the test functions provided by the control program ([see Section 7.5.](#)).

It is not normally necessary to check the pick-up values.

## **7.8. Firmware updates**

By updating the firmware and possibly the hardware, new functions or expanded functions can be implemented.

The firmware version is displayed in the bottom right-hand corner of the screen when the HMI is operating on-line. (The first number is the HMI version and the second the version of the firmware installed in the unit.)

The HMI software is compatible with the firmware in the unit when the first digit after the decimal point in the version numbers is the same.

It is not necessary to dismantle the unit to update the firmware, because the program is stored in a writeable non-volatile memory (flash EPROM).

A firmware update should always be carried out by ABB personnel. Nevertheless, the procedure is described below to facilitate updating should properly qualified personnel (full familiarity with PC's) and the new software be available.

### **7.8.1. Setting data**

A backup has to be made of the settings in the unit using the HMI (menu item 'Save parameters to file' in the 'Editor' menu). Close the HMI after doing so.

### **7.8.2. Deleting the old settings and program and downloading the new program**

During this procedure only one processing unit 216VC62 may be installed.

The following files needed to update the firmware are in the HMI directory after installation:

- spa216.h26, spa216n.h26, mvb216.h26, mvb216n.h26, lon216.h26 and lon216n.h26. This is the software for the various communication protocols.
- spa216.bat, spa216n.bat, lon216.bat, lon216n.bat, mvb216.bat and mvb216n.bat. The batch file corresponding to the communications protocol in use is needed to load the software into the processor unit 216VC62a.

The units are updated by running the corresponding batch file. To this end, select the HMI directory using the file manager in the case of Windows 3.1 or 3.11, or Explorer in the case of

Windows 95 or NT 4.0 and double click on the respective batch file. Before the HMI starts, a dialogue appears with the query 'Are you sure? <Y>/<N>' as a safety precaution. If you select 'N', the normal HMI is started; if you select 'Y', a further dialogue with the query 'LED 6 ON? <Y>/<N>'. Respond with 'Y' as soon as LED 6 on 216VC62a lights. A dialogue then appears with the query 'LED 6 OFF? <Y>/<N>'. LED 6 lights for about fifteen to twenty seconds while the old software in the 216VC62a is being deleted. Respond with 'Y' as soon as LED 6 goes out.

The download then starts automatically and transfers the file '\*.h26' to the unit. This operation takes about 5 to 6 minutes and progress is indicated by numbered lines of dots.

33 .....

The new program starts automatically in the unit after downloading and the time stamp in the \*.h26 file is saved in the unit's memory.

Do not make any entries at the PC keyboard throughout this entire procedure to avoid it from being interrupted.

### **7.8.3. *Problems while downloading the new software***

The occurrence of errors while downloading and saving new software can never be entirely excluded (e.g. power supply failure during data transfer). Should something of this kind occur, you can attempt to transfer the program file by running the same batch file again. If the unit does not respond to a call by the HMI, attempt to reinitialise the unit using the reset pin and then to download the program file.

Should this procedure prove unsuccessful, the contents of the program memory in the main processor unit have to be deleted as follows:

Switch off the auxiliary supply and withdraw the main processor unit 216VC62a. Insert the two jumpers X602 and X603 and reinsert the unit. Switch on the auxiliary supply, after which LED 6 lights for about 20 seconds. Switch off the auxiliary supply again after LED 6 has gone out and withdraw the unit and remove the two jumpers X602 and X603. Reinsert the main processor unit and repeat the download procedure as before.

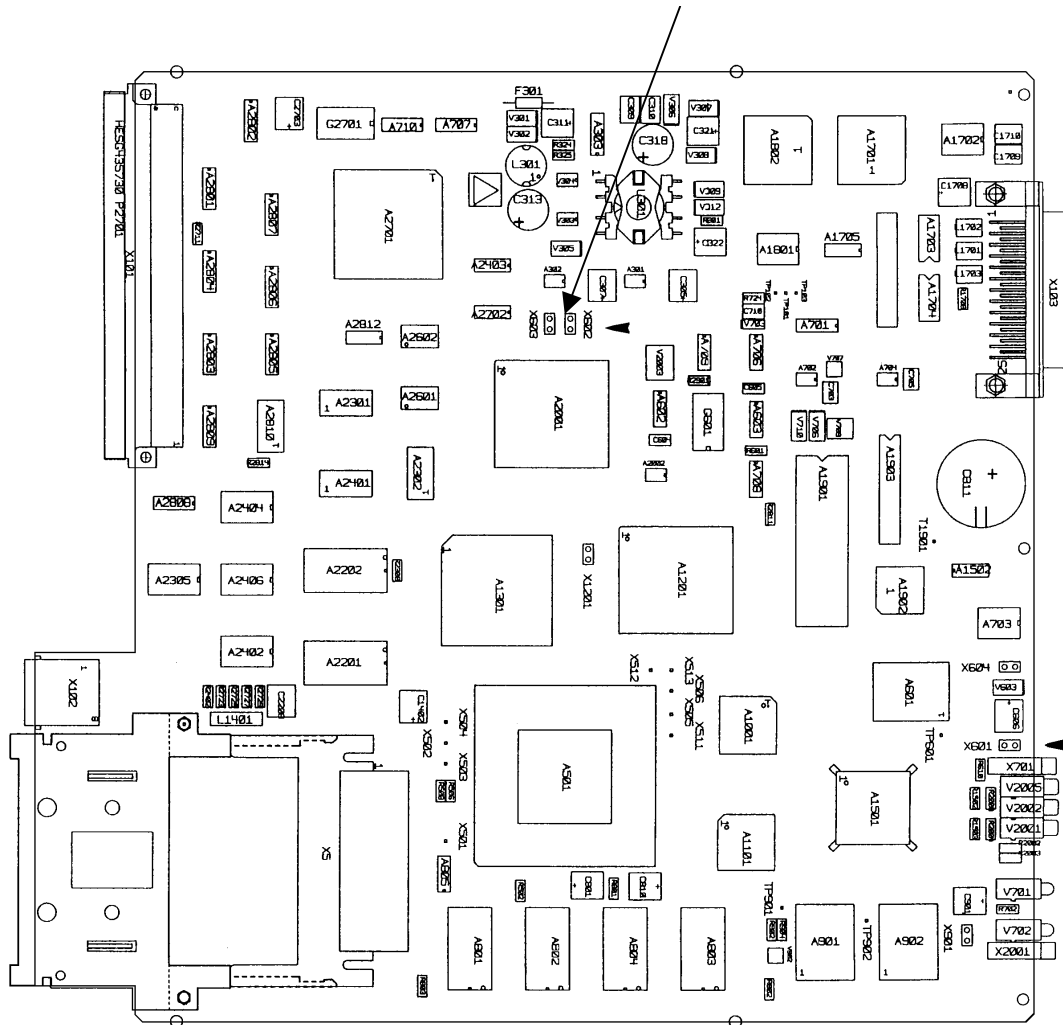


Fig. 7.3 Main processor unit 216VC62a with the jumpers X602 and X603

## 7.9. **Replacing hardware**

**Hardware units (PCB's) may only be replaced by suitably trained personnel. It is essential that the standard basic precautions to prevent electrostatic discharge be strictly observed.**

It may be necessary to upload the existing settings from the relay or download new settings to it afterwards and this assumes familiarity with the operator program (HMI).

It follows from the purpose for which the devices and equipment are used that if they are not correctly handled, mal-operation or damage can result (either to the devices themselves or to items of plant), e.g.:

- false tripping of primary system plant
- destruction of modules etc.

The following precautions should be taken to avoid electrostatic discharge:

- Before touching the modules, discharge your body by touching the station ground (cubicle).
- Only hold the modules at the edges and do not touch contacts or components.
- Only store or transport modules in their original packing.

### **Tools required**

Philips No. 0 screwdriver (normal No. 1 screwdriver for older versions)

### **Procedure**

Follow the check list when replacing hardware units (PCB's) (see [Section 7.9.1.](#)). The check list is primarily intended for replacing defective units by one of the same type.

Where changing a module involves updating the software, check with ABB Switzerland Ltd., to confirm compatibility etc.



**7.9.1. Check list for replacing hardware units**

	Unnecessary Not fitted	Finished
Upload and save any existing settings in the relay (always the case when replacing 216VC62a)	<input type="checkbox"/>	<input type="checkbox"/>
Upload and print the diagnostic and event lists	<input type="checkbox"/>	<input type="checkbox"/>
Switch off the supply (both supplies where redundant supplies installed). This has to be done externally when replacing a power supply unit.		<input type="checkbox"/>
Unscrew the securing screw and withdraw the PCB.		<input type="checkbox"/>
Compare the jumper positions on original and replacement PCB's in the case of 216AB61 (XJ1) and/or 216DB61 (BR1).	<input type="checkbox"/>	<input type="checkbox"/>
Compare the software of original and replacement.		<input type="checkbox"/>
Insert the replacement PCB and tighten the securing screw.		<input type="checkbox"/>
Switch on the auxiliary supply.		<input type="checkbox"/>
Download the settings previously saved to the relay (always necessary when replacing 216VC62a; FUPLA may also have to be downloaded).	<input type="checkbox"/>	<input type="checkbox"/>
Check the proper function of the relay (e.g. open the "List AD channels" menu and check the currents and voltages; further checks are necessary for some PCB's, e.g. alarms, trips and binary inputs in the case of 216DB61).		<input type="checkbox"/>

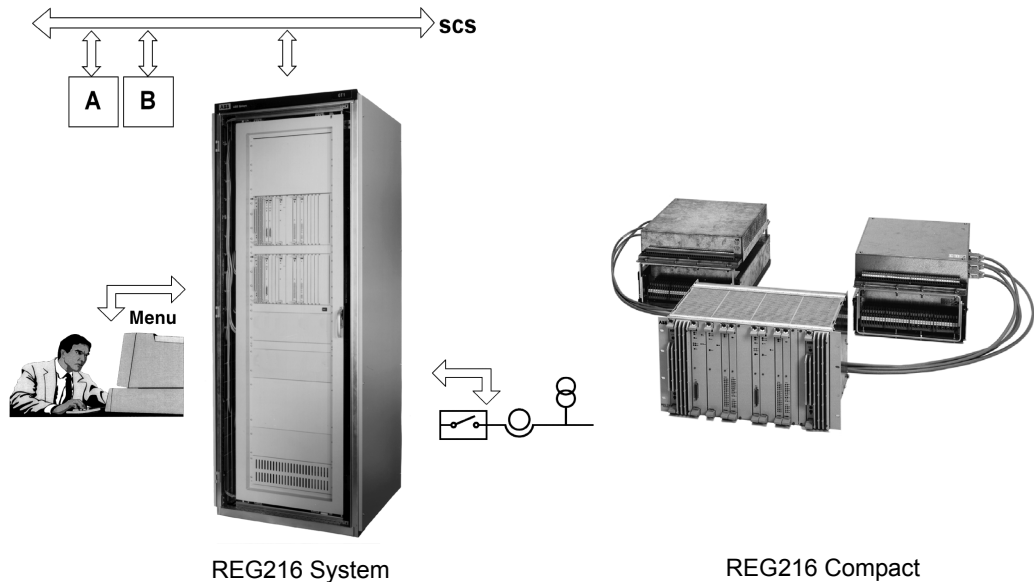


July 2002

## **8. TECHNICAL DATA**

Data Sheet REG 216 .....1MRB520004-Ben  
Demands on measuring transformers.....CH-ES 30-32.20 E





REG216 System

REG216 Compact

### Features

- Modular hardware
- Selectable protection functions
- Multitude of applications
- Menu-assisted setting with PC
- Fully numerical signal processing
- Continuous self-monitoring of hardware
- Cyclical testing routines mostly performed by the software
- Setting of parameters and recording of the settings by PC
- Display of measured values
- Display of event, their acknowledgment and printout
- Disturbance recording
- Self-documentation
- Long-term stability
- Communication and coordination with station control
- Two design versions available; extended version or compact version (with or without cubicle)

### Application

The REG216/REG216 Compact system is intended for the protection of generators and block transformers.

The modular hardware and software design allows an extremely flexible installation. Simplicity of adaption to the size of the primary system and the desired protection schemes are achieved through the combination of a software library and hardware modules. Economic solutions can thus be achieved in the full range of applications for which it is intended.

The REG216 software system offers a library of protective functions. Functions suitable for generator and transformer protection are listed in the table below.

Different degrees of redundancy can be selected. Availability and reliability of the protection can be chosen to suit the application by duplicating e.g. auxiliary supply units of the whole system.

Standard interfaces make REG216/REG216 Compact compatible with different process control systems. 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:	ANSI code	Description
Generator differential Power transformer differential	87 G 87 T	three-phase three-phase for 2- and 3-winding transformers
Definite time overcurrent (undercurrent)	51	definite time delay, for phase and earth-fault, over- and undercurrent
Overcurrent or undercurrent with peak value evaluation	50	instantaneous operation or with definite time delay, value evaluation wide frequency range, over- and undercurrent
Restricted earth fault	87 N	overcurrent operation with definite time delay*
Voltage-controlled overcurrent	51-27	operation restrained by undervoltage
Inverse time overcurrent	51	inverse current dependent time delay, for phase and earth fault
Directional definite time overcurrent	67	definite time tripping
Directional inverse time overcurrent	67	inverse time tripping
Negative phase sequence current	46	negative phase sequence current with definite time delay or inverse time delay with thermal replica
Definite time overvoltage (undervoltage)	59 27 64	definite time delay, over- and undervoltage Applicable also for - stator E/F (95%) (59 G/N) - rotor E/F (64 R) **
100% stator and rotor earth fault protection	64 S 64 R	- intertium fault protection based on the displacement principle calculation of the earth fault resistance. in addition the units REX010 and REX011 are required
Underimpedance	21	circular characteristics centered at origin of impedance plane
Minimum reactance	40	circular characteristics for loss of excitation protection
Pole slip protection	78	detecting loss of synchronism of a generator as against the network
High-voltage distance protection	21 Z<HV	6-system high-voltage protection
Distance protection	21 Z<	distance protection with overcurrent or underimpedance starting
Power	32	any characteristic angle, over and underpower for: - active power - reactive power - reverse power protection - minimum forward power
Overload	49	thermal replica with operating characteristic according to ASA-C50.13*** for: - standard stator current (49 S) - rotor current (49 R)
Negative phase sequence current	46	evaluation of negative phase sequence of currents inverse time delay; with terminal replica
Overtemperature	49	thermal protection with precise thermal replica
Frequency	81	evaluation of voltage input
Rate-of-change of frequency	81	df/dt
Overexcitation	24	voltage/frequency protection definite time delay or inverse time delay
Voltage balance	60	monitoring/comparing two groups of single- or three-phase voltage
Voltage peak value evaluation	59,27	instantaneous operation with definite time delay
Synchro check	25	supervision of phase angle frequency and voltage level of two systems
Logical functions		AND, OR, flip-flop, time delay, counter

\* with external hardware: stabilizing resistor, voltage-dependent resistor

\*\* with external hardware: measuring bridge YWX111-..., coupling condensers

\*\*\*ASA = American Standard Association

Aside from these typical generator protection functions the entire library of the RE.316\*4 platform is also available (e.g. distance protection, autoreclosure, I<sub>0</sub> inverse, etc.). For more details see manual of REG216.

### Protection functions

All protection functions required for the stand-alone protection of generators, power transformers and feeders are available. The system therefore replaces several relays of a conventional protection scheme for such power system equipment. The table on page 2 gives a survey of the most significant protection functions.

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

- Allocation of processing units
- Input channel or channels
- Pick-up setting
- Time delay
- Definition of the operating characteristic
- 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 internally combined logically:

- The tripping outputs of each protection function can be assigned to channels of the tripping auxiliary relay assembly in a manner corresponding to a matrix.

- The pick-up and tripping signals can be assigned to the channels of the signalling auxiliary relay assembly.
- Provision is available for blocking each protection function with a digital signal (e.g. digital inputs or by using 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.

### Remote in- and outputs (RIO580)

Using the process bus type MVB, remote in- and output units 500RIO11 can be connected to the REG216/REG216 Compact terminals. The input and output channels can be extended to a large number by using the 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 REG216/REG216 Compact 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.

## Construction

### Hardware

There are two different versions available: REG216 and REG216 Compact. The REG216 equipment comprises two main assemblies which are physically separated from each other and linked by standard prefabricated screened cables:

- Interfaces to the primary system (CT's, PT's and auxiliary relays), which provide dc isolation and a barrier to electromagnetic interference.

- Parallel bus and associated electronic units (e.g. analogue inputs and data processors/ for signal conditioning and processing

The complete protection scheme comprises relatively few hardware modules allowing subsequent expansion of electronic units and the interfaces. 21 units of rack space is available per equipment frame.

Construction (cont'd)

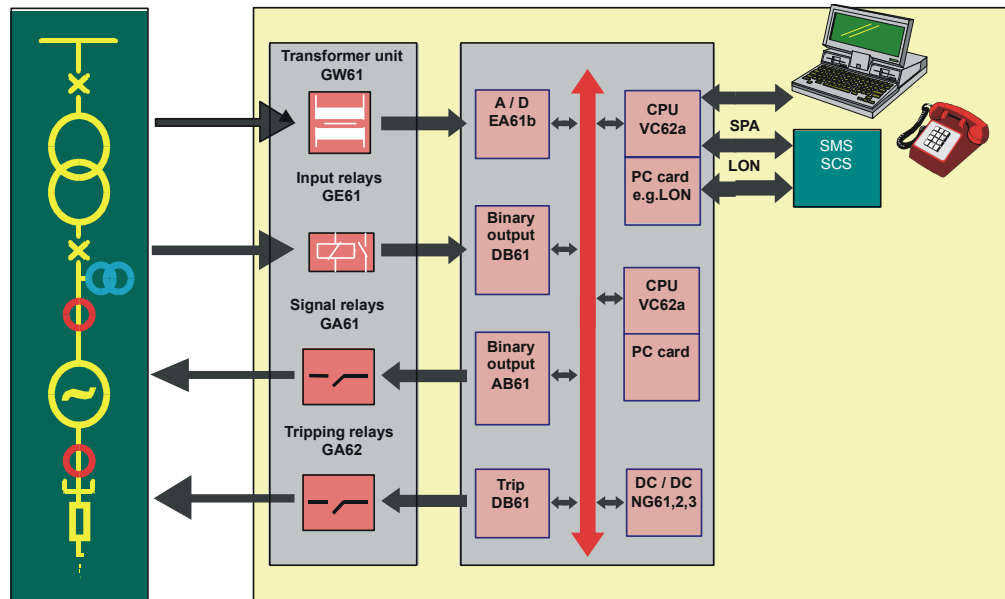


Fig. 1 Configuration of the REG216 protection system

Excellent electromagnetic compatibility has been achieved through careful attention to physical separation of the interfaces from the signal processing units

All hardware can be accommodated in one cubicle, which provides a further screen against induced interference and affords physical protection against dust, etc.

REG216 C is a standard compact rack version, available in 7 versions, with a limited number of I/O's but equipped with the same SW library as the REG216 system.

Other protection relays for functions which are not part of the REG216/REG216 Compact system may be installed in the cubicle and correspondingly interwired with REG216/REG216 Compact.

**Interfaces to the primary system**

The following modular assemblies provide interfacing of REG216 to the power system.

**Input transformer assembly 216GW61**

This assembly adjusts the signal levels and provides isolation between the primary system CT and PT circuits and the electronic circuits of the protection. One type of PT and

two types of CT's are available, to meet different accuracy and dynamic performance requirements.

Space is available for up to 12 transformers, which are selected to suit the application. Up to four assemblies can be used, i.e. 48 inputs.

**Input auxiliary relay assembly 216GE61**

Up to 16 auxiliary relays can be accommodated, providing complete potential separation of digital input signals.

**Output auxiliary relay assembly 216GA61**

Up to 16 auxiliary relays can be accommodated providing complete potential separation of digital output signals (two contacts per signal).

**Tripping auxiliary relay assembly 216GA62**

Up to eight powerful, potential-free tripping contacts and circuits, which provide high-speed operation (surge circuit) with reduced consumption after operation (economy circuit) are provided.

Facilities for different trip circuit supervision arrangements in conjunction with the output unit 216DB61 and the input auxiliary relay assembly 216GE61 are also provided.



The tripping auxiliary relay assembly can be optionally fitted with a tripping logic diode matrix to enable direct coupling of external signals. REG216 can also read and process external signals via digital inputs.

#### Auxiliary relay and optocoupler assembly 216GD61a

This assembly is used in the compact version REG216. It provides eight tripping relays, each with two powerful, potential-free tripping contacts (with surge circuits), 16 auxiliary relays and 16 optocoupler input circuits. Max. four assemblies can be provided.

#### Parallel bus and electronic units

The electronic units are of plug-in design and accommodated in an equipment rack with the standard dimension 19", 6U (1U = 44,45 mm). An equipment rack of this kind is divided into 21 standard divisions. The exchange of data via the parallel bus B448C is controlled and monitored by all units available.

The protection system is based on a data bus with digital signal processing for most functions; signal conditioning, analogue and digital inputs, A/D conversion, processing and signal output.

The components of the system are:

- Static plug-in units, which exchange data via a powerful parallel bus.
- Interfaces to the process (primary system, station equipment), which are isolated from the digital processing unit.

#### Equipment rack 216MB66/216MB68 and parallel bus B448C

The main features of the parallel bus B448C are:

- Specification based on IEEE P 896 (future bus).
- Time multiplexing of addresses and data (16 bit).
- Asynchronous data transmission with handshake.
- Integrity checking of each data exchange.
- Up to 32 master units having equal status, actively accessing the bus.
- Common internal 24V auxiliary supply for all electronic units; redundant 24V are possible.

#### Processing unit 216VC62a

- 32 bit processor type 80486DX-2
- Application software on Flash EPROM
- Operating data on RAM
- Settings on non-volatile Flash EPROM
- Potential-free RS-423 interface for PC operation
- Connection to the station control with transmission of messages
- Time clock synchronizing for time-tagging of events
- Non-volatile event and disturbance memory (gold capacitor buffered)
- Space requirement: two rack divisions

#### Analogue Input unit 216EA61b

- 24 inputs sampled simultaneously in groups of six
- Sampling frequency 600 (720) Hz for a power frequency of 50 (60) Hz
- Space requirement: two rack divisions

#### Digital output unit 216AB61

- 32 outputs for controlling the relays of the output auxiliary relay assembly
- Short-circuit proof
- Front plate LED's for indication of activated relays
- Space requirement: one rack division

#### Binary and analog output unit 216AC61

- 16 binary outputs for controlling of the output auxiliary relay assembly
  - Short-circuit proof
  - Front plate LED's for marking activated relays
- 8 analog outputs (0 to 20 mA without galvanic separation)
- Front space requirements: one rack division

#### Binary input unit 216EB61

- 32 binary inputs used to connect ON or OFF signals to the REG216 protection system from input relay assembly
- Time-tagging with a resolution of 1 ms
- Front plate LED's marking activated relays
- Front space requirements: one rack division

Construction (cont'd)

**Tripping output unit 216DB61**

- 8 outputs for two-pole control of auxiliary tripping relays
- Monitored output amplifiers
- 16 digital inputs for the signals from the input auxiliary relay assembly (two each can be used to externally enable and block tripping respectively)
- Activated outputs and inputs indicated by LED's
- Front space requirements: one rack division

**Auxiliary dc supply unit 216NG61, 216NG62 and 216NG63**

- Versions for 36 to 312 V dc input
- Outputs 24V dc, 150 W
- Short-circuit and overload-proof outputs
- Parallel connection to increase rating
- Parallel connection for redundancy (2 outputs)
- Space requirement: 3 rack divisions

All the REG216 protection functions operate with sampled primary system voltages and currents. The sampling rate of the analogue input units is 12 times per period at rated power system frequency with a dynamic range of 15 bits.

All further signal processing takes place digitally. The protection functions are therefore universally applicable, highly accurate and have excellent long-time stability.

Dc components and harmonic contents are efficiently suppressed by digital filters to avoid disturbance. The tripping logic for the internal protection functions (earlier a diode matrix), is software-controlled in REG216/REG216 Compact.

**Setting and control**

The protection system is set and controlled using a personal computer connected to it via a serial interface.

Operation of the console is menu-assisted and permits:

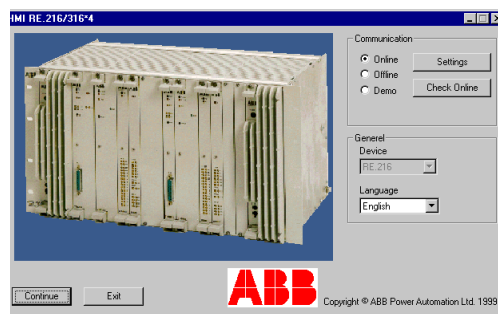
- Setting of parameters and recording of the settings
- Display of measured values
- Display of events, their acknowledgment and printout
- Disturbance recording.

**Windows HMI**

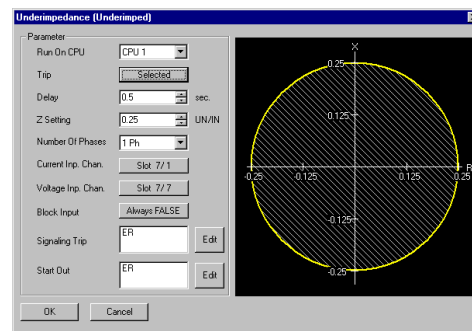
A new Windows-based setting tool CAP2/316 is available since the Firmware version V5.2. This Software runs only under the following operating systems:

- WINDOWS NT 4.0
- WINDOWS 2000

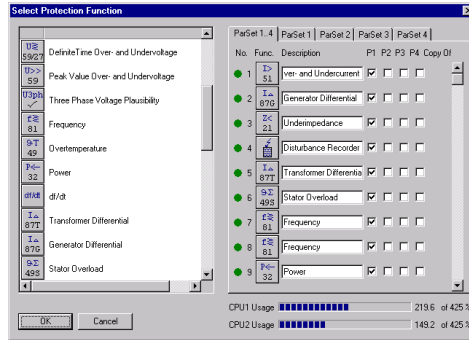
The perfect tool for engineering, testing, commissioning and maintenance personnel can be used for ON-LINE or OFF-LINE programming.



For each protection function a visible tripping characteristic is displayed depending on the setting values, e.g. the underimpedance function shown below.



There is a library with all protection functions necessary for generator and transformer protection. Easy activation of a protective function by “drag & drop” technology.



### Self-monitoring and testing facilities

The self-monitoring and testing routine philosophy of the REG216/REG216 Compact can be divided into following sections:

- Self-monitoring
- Parameter viewing facilities
- Injection testing with separate test equipment.

#### Self-monitoring

The self-monitoring and testing routine philosophy is quite different from conventional testing techniques. Whilst the previous practice in protection was to maintain availability through comprehensive periodic testing, REG216/REG216 Compact does this continuously by taking full advantage of digital and data bus technology.

The self-monitoring functions have two elements:

- Continuous self-monitoring by hardware
- Cyclically executed testing routines, mainly by software.

### Testing

#### Viewing protection measurements

One feature of the REG216/REG216 Compact is the provision to view various operating measurements. This together with the self-monitoring functions replaces the pe-

riodic injection testing necessary with conventional protection equipment. The following data can be viewed:

- The system values as measured by all protection functions. The corresponding functions do not have to have picked up for this purpose.
- Analogue inputs. The amplitudes, frequency and phase relationships of all the analogue inputs can be viewed without jeopardizing the operation of the protection functions.
- Digital input and output signals. The status of each signal can be viewed.

Apart from the self-monitoring routines, the fact that the measurement data can be viewed all the way from the input transformers to the digital signals also confirms the correct functioning of the digital processors and the data bus.

#### Using software HMI „Test functions“

The desired protective function may be selected from the list of available active functions. The test operation is based on simulated numerical values. One or more channels may be selected for testing the tripping or signalling outputs. The test function is mainly used for commissioning purposes when the system is out of service.

#### Redundancy

Hardware and software redundancy is adapted to the functional requirements. Two independent groups of protection functions are accommodated in either two separate hardware racks (REG216) or in only one rack (REG216 C), but with two completely independent hardware groups.

#### Injection testing

A 100% test of system can be carried out by injecting test voltages and currents using, for example, a test set type XS92b or FREJA. Provision is made for injection testing with a test set at the terminals of the input transformer assembly 216GW61/216GW62. The terminals enable primary system PT circuits to be interrupted and CT's to be short-circuited.

Technical data

Table 1: Input circuit

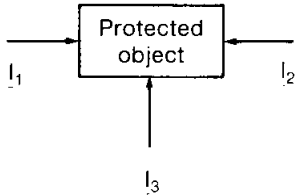
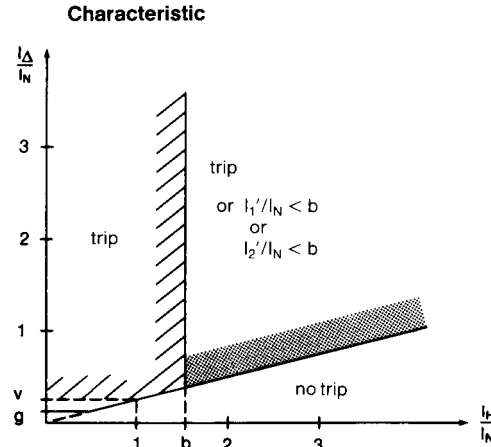
Rated current $I_N$	1 A, 2 A or 5 A
Rated voltage $U_N$	100 V or 200 V
Rated frequency $f_N$	50/60 Hz
Thermal ratings: continuous for 10 s for 1 s surge (half-cycle)	4 x $I_N$ 30 x $I_N$ 100 x $I_N$ 250 x $I_N$ (peak)
Burden of the current inputs Burden of the voltage inputs	<0.2 VA/input at $I_N$ <0.4 VA/input at $U_N$
Input signals REG216 REG216 Compact	24 to 220 V AC or 24 to 250 V DC 20 to 30 V DC, 36 to 75 V DC or 82 to 312 V DC

Table 2: Generator differential (87G)

Features:	
<ul style="list-style-type: none"> <li>• Three-phase function</li> <li>• Current-adaptive characteristic</li> <li>• High stability for external faults and current transformer saturation</li> </ul>	
Settings:	
g-setting (basic sensitivity)	0.1 to 0.5 $I_N$ in steps of 0.05 $I_N$
v-setting (slope)	0.25; 0.5
Max. trip time - for $I_{\Delta} > 2 I_N$ - for $I_{\Delta} \leq 2 I_N$	$\leq 30$ ms $\leq 50$ ms
Accuracy of pick-up value of g	$\pm 5\%$ $I_N$ (at $f_N$ )

Table 3: Transformer differential (87T)

Features:	
<ul style="list-style-type: none"> <li>• For two- and three-winding transformers</li> <li>• Three-phase function</li> <li>• Current-adaptive characteristic</li> <li>• High stability for external faults and current transformer saturation</li> <li>• No auxiliary transformers necessary because of vector group and CT ratio compensation</li> <li>• Inrush restraint using 2nd harmonic</li> </ul>	
Settings:	
g-setting	0.1 to 0.5 $I_N$ in steps of 0.1 $I_N$
v-setting	0.25, 0.5
b-setting	1.25 to 5 in steps of 0.25
Max. trip time (protected transformer loaded) - for $I_{\Delta} > 2 I_N$ - for $I_{\Delta} \leq 2 I_N$	$\leq 30$ ms $\leq 50$ ms

Accuracy of pick-up value	$\pm 5\% I_N$ (at $f_N$ )
Reset conditions	$I_{\Delta} < 0.8$ g-setting
Differential protection definitions:	
 <p> <math>I_{\Delta} =  I_1 + I_2 + I_3 </math>  <math>I_H = \sqrt{I_1' \cdot I_2' \cdot \cos \alpha}</math>                      0 for <math>\cos \alpha \geq 0</math>                      for <math>\cos \alpha &lt; 0</math>  <math>\alpha = \arg(I_1'; -I_2')</math>                      2-winding: <math>I_1' = I_1, I_2' = I_2</math>                      3-winding: <math>I_1' = \text{MAX}(I_1, I_2, I_3)</math>  <math>I_2' = I_1 + I_2 + I_3 - I_1'</math> </p>	
 <p>Fig. 2 Differential protection characteristic</p>	

**Table 4: Definite time current function (51DT)**

<ul style="list-style-type: none"> <li>• Over and undercurrent detection.</li> <li>• Single or three-phase measurement with detection of the highest, respectively lowest phase current.</li> <li>• 2nd. harmonic restraint for high inrush currents.</li> </ul>	
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 undercurrent	>94 % (for max. function) <106 % (for min. function)
Max. operating time without intentional delay	60 ms
Inrush restraint pick-up setting reset ratio	optional 0.1 $I_{2h}/I_{1h}$ 0.8

Technical data (cont'd)

**Table 5: Instantaneous overcurrent (50)**

Features:	
<ul style="list-style-type: none"> <li>• Maximum or minimum function (over- and undercurrent)</li> <li>• Single- or three-phase measurements</li> <li>• Wide frequency range (0.04 to 1.2 <math>f_N</math>)</li> <li>• Peak value evaluation</li> </ul>	
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 $f_N$ )	$\leq 30$ ms (for max. function) $\leq 60$ ms (for min. function)

**Table 6: Voltage-controlled overcurrent (51-27)**

Features:	
<ul style="list-style-type: none"> <li>• Maximum current value memorized after start</li> <li>• Reset of function after voltage return or after trip</li> <li>• Single- or three-phase measurement for current</li> <li>• Positive-sequence voltage evaluation</li> </ul>	
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	>93%
Starting time	$\leq 80$ ms

**Table 7: Inverse time-overcurrent function (51)**

<ul style="list-style-type: none"> <li>• Single or three-phase measurement with detection of the highest phase current</li> <li>• Stable response to transients</li> </ul>	
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 earth fault	$c = 1$
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	1 to 4 $I_B$ in steps of 0.01 $I_B$
Min. time setting	0 to 10 s in steps of 0.1 s
$k_1$ setting	0.01 to 200 s in steps of 0.01 s
Accuracy classes for the operating time according to BritishStandard 142 RXIDG characteristic	E 5.0 $\pm 4\%$ (1 - $1/80 I_B$ )
Reset ratio	>94%

**Table 8: Directional definite time overcurrent protection (67)**

<ul style="list-style-type: none"> <li>• Directional overcurrent protection with detection of the power direction</li> <li>• Backup protection for distance protection scheme</li> </ul>	
<ul style="list-style-type: none"> <li>• Three-phase measurement</li> <li>• Suppression of DC- and high-frequency components</li> <li>• Definite time characteristic</li> <li>• Voltage memory feature for close faults</li> </ul>	
Settings:	
Current	0.02 to 20 I <sub>N</sub> in steps of 0.01 I <sub>N</sub>
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 <sub>N</sub> )	±5% or ±0.02 I <sub>N</sub>
Reset ratio	>94%
Accuracy of angle measurement (at 0.94 to 1.06 f <sub>N</sub> )	±5°
Voltage input range	0.005 to 2 U <sub>N</sub>
Voltage memory range	<0.005 U <sub>N</sub>
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 9: Directional inverse time overcurrent function (67)**

<ul style="list-style-type: none"> <li>• Directional overcurrent protection with detection of the power direction</li> <li>• Backup protection for distance protection scheme</li> </ul>	
<ul style="list-style-type: none"> <li>• Three-phase measurement</li> <li>• Suppression of DC- and high-frequency components</li> <li>• Inverse time characteristic</li> <li>• Voltage memory feature for close faults</li> </ul>	
Settings:	
Current I <sub>Start</sub>	1...4 I <sub>B</sub> in steps of 0.01 I <sub>B</sub>
Angle	-180°...+180° in steps of 15°
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 earth fault	c = 1
k <sub>1</sub> -setting	0.01 to 200 s in steps of 0.01 s
t-min	0 to 10 s in steps of 0.1 s
IB-value	0.04 to 2.5 I <sub>N</sub> in steps of 0.01 I <sub>N</sub>
tWait	0.02 s to 20 s in steps of 0.01 s

Technical data (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 10: Negative phase sequence current (46)**

Features:	
<ul style="list-style-type: none"> <li>• Protection against unbalanced load</li> <li>• Definite time delay</li> <li>• Three-phase measurement</li> </ul>	
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	
$I_2 \geq 0.2 I_N$	$>94\%$
$I_2 < 0.2 I_N$	$>90\%$
Starting time	$\leq 80$ ms

**Table 11: Definite time overvoltage (27, 59)**

Features:	
<ul style="list-style-type: none"> <li>• Maximum or minimum function</li> <li>• Single- or three-phase measurement</li> <li>• Highest or lowest phase value evaluation for three-phase function</li> <li>• Also applicable as</li> <li>• Stator earth fault (95%)(59G/N)</li> <li>• Rotor earth fault* (64R)</li> <li>• Interturn fault</li> </ul>	
Settings:	
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 pick-up value (at $f_N$ )	$\pm 2\%$ or $\pm 0.005 U_N$
Reset ratio	$>96\%$ (for max. function) $<104\%$ (for min. function)
Response time without delay	$\leq 60$ ms

\*requires ext. hardware: measuring bridge YWX111-... and coupling condensers.



**Table 12: Instantaneous overvoltage protection function (59, 27) with peak value evaluation**

Features:	
<ul style="list-style-type: none"> <li>• Evaluation of instantaneous values, therefore extremely fast and frequency-independent on a wide scale</li> <li>• Storing of the highest instantaneous value after start</li> <li>• No suppression of d. c. components</li> <li>• No suppression of harmonics</li> <li>• 1- or 3phase</li> <li>• Maximum value detection for multi-phase functions</li> <li>• Variable lower limiting frequency <math>f_{min}</math></li> </ul>	
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 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)

**Table 13: Distance protection (21)**

All values of settings referred to the secondaries, every zone can be set independently of the others, 4 independent files for sets of settings.	
Impedance measurement	-300 to 300 $\Omega/ph$ in steps of 0.01 $\Omega/ph$ ( $I_N = 1 A$ or 2 A) -30 to 30 $\Omega/ph$ in steps of 0.001 $\Omega/ph$ ( $I_N = 5 A$ )
Zero-sequence current compensation	0 to 8 in steps of 0.01, -180° to +90° in steps of 1°
Mutual impedance for parallel circuit lines	0 to 8 in steps of 0.01, -90° to +90° in steps of 1°
Time step setting range	0 to 10 s in steps of 0.01 s
Underimpedance starters	-999 to 999 $\Omega/ph$ in steps of 0.1 $\Omega/ph$ ( $I_N = 1 A$ or 2 A) -99.9 to 99.9 $\Omega/ph$ in steps of 0.01 $\Omega/ph$ ( $I_N = 5 A$ )
Overcurrent starters	0.5 to 10 $I_N$ in steps of 0.01 $I_N$
Min. operating current	0.1 to 2 $I_N$ in steps of 0.01 $I_N$
Back-up overcurrent	0 to 10 $I_N$ in steps of 0.01 $I_N$
Neutral current criterion	0.1 to 2 $I_N$ in steps of 0.01 $I_N$
Neutral voltage criterion	0 to 2 $U_N$ in steps of 0.01 $U_N$
Low voltage criterion for detecting, for example, a weak infeed	0 to 2 $U_N$ in steps of 0.01 $U_N$
V.t. supervision NPS/neutral voltage criterion NPS/neutral current criterion	0.01 to 0.5 $U_N$ in steps of 0.01 $U_N$ 0.01 to 0.5 $I_N$ in steps of 0.01 $I_N$
Accuracy (applicable for current time constants between 40 and 150 ms) amplitude error phase error Supplementary error for - frequency fluctuations of $\pm 10$ - 10 % third harmonic - 10 % fifth harmonic	$\pm 5\%$ for $U/U_N > 0.1$ $\pm 2^\circ$ for $U/U_N > 0.1$ $\pm 5\%$ $\pm 10\%$ $\pm 10\%$
Minimum operating time (incl. tripping relay):	21 ms
Typical operating time (incl. tripping relay): Basic distance protection function With ancillary functions activated	30 ms +8 ms
Typical reset time	45 ms

Technical data (cont'd)

Table 14: Underimpedance (21)

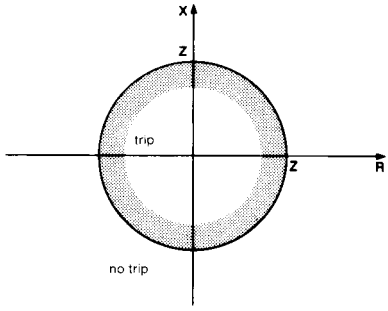
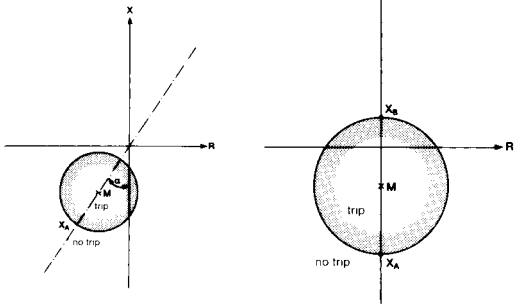
<p>Features:</p> <ul style="list-style-type: none"> <li>• Detection of two- and three-phase short circuits (back-up protection)</li> <li>• Single- or three-phase measurement</li> <li>• Circular characteristic centered at origin of R-X diagram</li> <li>• Lowest phase value evaluation for three-phase measurement</li> </ul>	
	
<p>Fig. 3 Underimpedance protection function characteristics</p>	
<p>Settings:</p>	
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	<107%
Starting time	<80 ms (at $f_N$ )

Table 15: Minimum reactance (40)

<p>Features:</p> <ul style="list-style-type: none"> <li>• Detection of loss-of-excitation failure of synchronous machines</li> <li>• Single- or three-phase measurement</li> <li>• Out-of-step detection with additional time delay or count logic</li> <li>• Circular characteristic</li> <li>• Tripping possible inside or outside the circle</li> </ul>	
	
<p>Fig. 4 Minimum reactance protection function characteristics</p>	
<p>Settings:</p>	
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	-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	≤80 ms

**Table 16: Power (32)**

Features:	
<ul style="list-style-type: none"> <li>• Applicable for             <ul style="list-style-type: none"> <li>– Active power protection</li> <li>– Reverse power protection</li> <li>– Reactive power protection</li> </ul> </li> <li>• Maximum and minimum function</li> <li>• Single- or two- or three-phase measurement</li> <li>• Adjustable compensation angle for input transformer errors</li> </ul>	
Settings:	
Power	-0.1 to 1.2 P <sub>N</sub> in steps of 0.005 P <sub>N</sub>
Minimum setting:	- 0.005 P <sub>N</sub> (with measuring CT) - 0.02 P <sub>N</sub> (with protection CT)
Angle	-180° to +180° in steps of 5°
Delay	0.05 to 60s in steps of 0.01 s
Compensation angle	-5° to +5° in steps of 0.1°
Nominal power P <sub>N</sub>	0.5 to 2.5 U <sub>N</sub> • I <sub>N</sub> in steps of 0.001 U <sub>N</sub> • I <sub>N</sub>
Reset ratio	30% to 170% in steps of 1%
Accuracy	±10% of setting or 2% U <sub>N</sub> • I <sub>N</sub> (for protection c.t.'s) ±3% of setting or 0.5% U <sub>N</sub> • I <sub>N</sub> (for core-balance c.t.'s)
Max. operating time without intentional delay	70 ms

**Table 17: Stator overload (49S)**

Features:
<ul style="list-style-type: none"> <li>• Single- or three-phase measurement</li> <li>• Operating characteristics according to ASA-C50.13</li> <li>• Highest phase value for three-phase measurement</li> <li>• Wide time multiplier setting.</li> </ul>

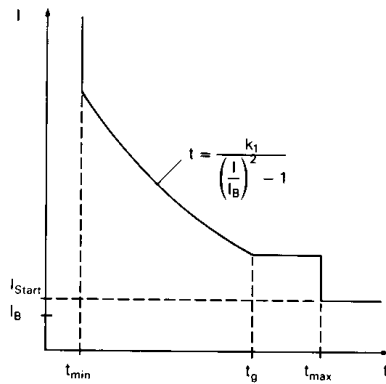


Fig. 5 Stator overload protection function characteristics

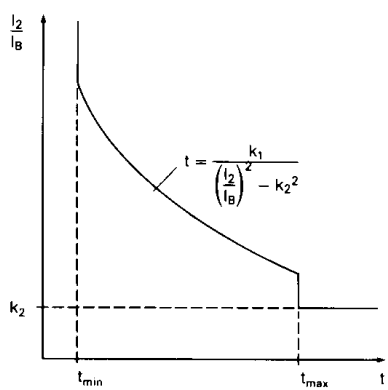
Settings:	
Base current (I <sub>B</sub> )	0.5 to 2.5 I <sub>N</sub> in steps of 0.01 I <sub>N</sub>
Time multiplier k <sub>1</sub>	1 to 50 s in steps of 0.1 s
Pick-up current (I <sub>start</sub> )	1.0 to 1.6 I <sub>B</sub> in steps of 0.01 I <sub>B</sub>
t <sub>min</sub>	1 to 120 s in steps of 0.1 s
t <sub>g</sub>	10 to 2000 s in steps of 10 s
t <sub>max</sub>	100 to 2000 s in steps of 10 s
t <sub>reset</sub>	10 to 2000 s in steps of 10 s
Accuracy of current measurement	±5% (at f <sub>N</sub> ), ± 2% (at f <sub>N</sub> ) with measuring transformer
Starting time	≤80 ms

Technical data (cont'd)

**Table 18: Rotor overload (49R)**

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

**Table 19: Inverse time negative phase sequence current (46)**

Features:	
<ul style="list-style-type: none"> <li>• Protection against unbalanced load</li> <li>• Inverse time delay</li> <li>• Three-phase measurement</li> </ul>	
	
Fig. 6 Inverse time negative phase sequence current protection function characteristics	
Settings:	
Base current ( $I_B$ )	0.5 to 2.5 $I_N$ in steps of 0.01 $I_N$
Time multiplier $k_1$	5 to 30 s in steps of 0.1 s
Factor $k_2$ (pick-up)	0.02 to 0.20 in steps of 0.01
$t_{min}$	1 to 120 s in steps of 0.1 s
$t_{max}$	500 to 2000 s in steps of 1 s
$t_{reset}$	5 to 2000 s in steps of 1 s
Accuracy of NPS current ( $I_2$ ) measurement	+2% (at $f_N$ ) with measuring transformers
Starting time	≤80 ms

**Table 20: Overtemperature (49)**

Features:	
<ul style="list-style-type: none"> <li>• Thermal replica for system of first order or general thermal system response</li> <li>• Single- or three-phase current measurement</li> <li>• Highest phase value for three-phase measurement</li> </ul>	
Settings:	
Base current $I_B$	0.5 to 2.5 $I_N$ in steps of 0.01 $I_N$
Warning stage	50 to 200% $\vartheta_N$ in steps of 1% $\vartheta_N$
Tripping stage	50 to 200% $\vartheta_N$ in steps of 1% $\vartheta_N$
Thermal time constant	0.0 to 500 min in steps of 0.1 min
Accuracy of current measurement	±2% (at $f_N$ ) with measuring transformers
Accuracy of the thermal image	±5%

**Table 21: Frequency (81)**

Features:	
<ul style="list-style-type: none"> <li>• Maximum or minimum function (over-, underfrequency)</li> <li>• Minimum voltage blocking</li> </ul>	
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	$\pm 30$ mHz (at $U_N$ and $f_N$ )
Reset ratio	<106%
Starting time	<135 ms

**Table 22: Rate-of-change of frequency df/dt (81)**

Features:	
<ul style="list-style-type: none"> <li>• combined pick-up with frequency criterion possible</li> <li>• blocking by undervoltage</li> </ul>	
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 $f_N$ )	$\pm 0.1$ Hz/s
Accuracy of frequency (at 0.9 to 1.05 $f_N$ )	$\pm 30$ mHz
Reset ratio df/dt	95% for max. function 105% for min. function

**Table 23: Overexcitation (24)**

Features:	
<ul style="list-style-type: none"> <li>• U/f measurement</li> <li>• Minimum voltage blocking</li> </ul>	
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 $\pm 0.01 U_N/f_N$
Reset ratio	>97% (max.), < 103% (min.)
Starting time	$\leq 120$ ms

Technical data (cont'd)

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

Features:	
<ul style="list-style-type: none"> <li>• Single-phase measurement</li> <li>• inverse time delay</li> <li>• According to IEEE Guide C37.91-1985, setting made by help of table settings</li> </ul>	
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

**Table 25: 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

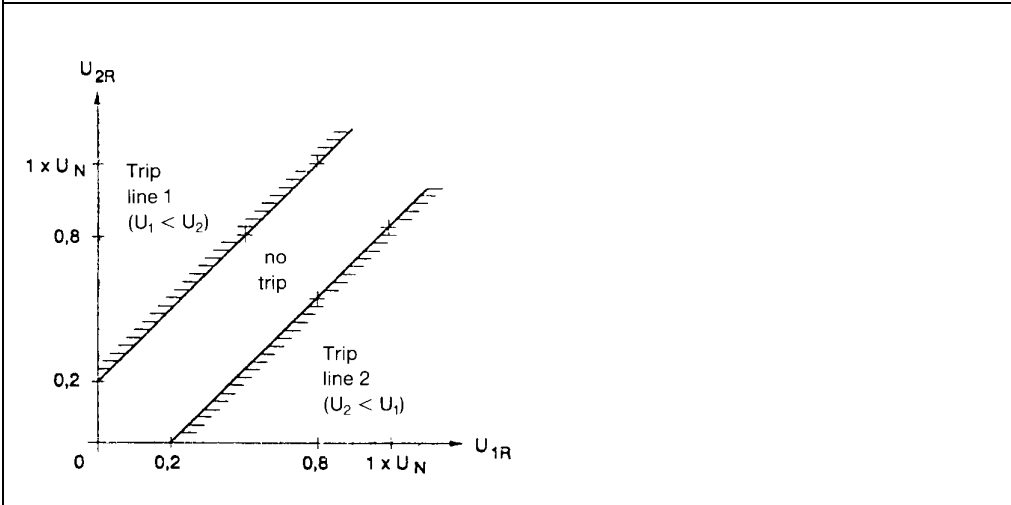


Fig. 7 Tripping characteristic Voltage comparison (shown for the phases R and the setting value volt. diff. =  $0.2 \cdot U_N$ )

Settings:	
Voltage difference	0.1 to $0.5 U_N$ in steps of $0.05 U_N$
Trip delay	0.00 to 1.0 s in steps of 0.01 s
Reset delay	0.1 to 2.0 s in steps of 0.01 s
Numbers of phases	1 or 3
Maximum tripping time without delay	$\leq 50$ ms
$U_{1R}$ : $U_{2R}$ :	phase R voltage amplitude voltage channel 1 (line 1) phase R voltage amplitude voltage channel 2 (line 2)
For 3-phase function: the characteristic is valid accordingly for the phases S and T	

Technical data (cont'd)

**Table 26: Dead machine protection (51, 27)**

<p>Features:</p> <ul style="list-style-type: none"> <li>• Quick separation from network at accidental energization of generator (e.g. at standstill or on turning gear)</li> <li>• Instant overcurrent measurement</li> <li>• Voltage-controlled overcurrent function e.g. blocked at voltage values <math>&gt; 0.85 U_N</math></li> </ul> <p>This function does not exist in the library, it must be combined from the voltage current and time function</p>	
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 27: 100% Stator earth fault protection (64S)**

<p>Features:</p> <ul style="list-style-type: none"> <li>• Protection of the entire stator winding, including star points, even at standstill. Works also for most of the operating conditions.</li> <li>• Also suitable when 2 earthings (groundings) are in the protection zone</li> <li>• Continuous supervision of the insulation level of the stator</li> <li>• Based on the earth (ground) voltage displacement principle and calculation of the earth (ground) fault resistance</li> <li>• Alarm and tripping values are entered, resp. measured and displayed in <math>k\Omega</math></li> </ul> <ul style="list-style-type: none"> <li>• Type of earthings (groundings): <ul style="list-style-type: none"> <li>- star point earthing with resistors (requires REX011)</li> <li>- star point earthing with grounding transformer (requires REX011-1)</li> <li>- earthing transformers on generator terminals (requires REX011-2)</li> </ul> </li> </ul>	
Settings:	
Alarm stage	100 $\Omega$ to 20 $k\Omega$
Delay	0.2 s to 60 s
Tripping stage	100 $\Omega$ to 20 $k\Omega$
Delay	0.2 s to 60 s
$R_{ES}$	400 $\Omega$ to 5 $k\Omega$
Number of star points	2
$R_{ES-2}$ starpoint	900 $\Omega$ to 30 $k\Omega$
Reset ratio	110% for setting values of $\leq 10 k\Omega$ 120% for setting values of $> 10 k\Omega$
Accuracy	0.1 $k\Omega$ to 10 $k\Omega$ : $< \pm 10\%$ 0 to 100 $\Omega$ , 10 $k\Omega$ to 20 $k\Omega$ : $< \pm 20\%$
Starting time	1.5 s
Functional requirements:	
- max. earthing current	$I_0 < 20 A$ (recommended $I_0 = 5A$ )
- stator earthing capacity	0.5 $\mu F$ to 6 $\mu F$
- stator earthing resistance $R_{PS}$	130 $\Omega$ to 500 $\Omega$
- stator earthing resistance $R_{ES}$	700 $\Omega$ to 5 $k\Omega$ ( $\geq 4.5 \times R_{PS}$ )
(All values are based on the starpoint side)	
<p>The actual earthing resistances <math>R_{ES} + R_{PS}</math> 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.</p>	



**Table 28: Rotor earth fault protection (64R)**

Features:	
<ul style="list-style-type: none"> <li>• Continuous supervision of the insulation level and calculation of the earthing (grounding) resistance</li> <li>• Alarm and tripping values are entered resp. measured and displayed in <math>k\Omega</math></li> </ul>	
Settings:	
Alarm stage	100 $\Omega$ to 25 $k\Omega$
Delay	0.2 s to 60 s
Tripping stage	100 $\Omega$ to 25 $k\Omega$
Delay	0.2 s to 60 s
$R_{ER}$	900 $\Omega$ to 5 $k\Omega$
Coupling capacity	2 $\mu F$ to 10 $\mu F$
Reset ratio	110%
Accuracy	0.1 $k\Omega$ to 10 $k\Omega$ $<\pm 10\%$ 0 to 100 $\Omega$ , 10 $k\Omega$ to 25 $k\Omega$ $<\pm 20\%$
Starting time	1.5 s
Functional requirements:	
- total rotor earthing capacity	200 nF to 1 $\mu F$
- rotor earthing resistance $R_{PR}$	100 $\Omega$ to 500 $\Omega$
- rotor earthing resistance $R_{ER}$	900 $\Omega$ to 5 $k\Omega$
- coupling capacity	4 $\mu F$ to 10 $\mu F$
- time constant	$T = R_{ER} \times C = 3$ to 10 ms
<p>The actual earthing resistance <math>R_{ER} + R_{PR}</math> 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 capacities.</p>	

Technical data (cont'd)

Table 29: Pole slip protection (78)

<p>Features:</p> <ul style="list-style-type: none"> <li>Recording the pole wheel movements from 0.2 Hz to 8 Hz</li> <li>Differentiation of the pendulum center inside or outside of the generator-transformer block zone by two independent tripping stages</li> <li>Adjustable warning angle for pole wheel movements</li> <li>Number of slips adjustable before tripping</li> </ul>	
<p>Fig. 8 Characteristic of the function</p>	
<p>Settings:</p>	
ZA (system impedance)	0 to 5.0 $U_N/I_N$
ZB (generator impedance)	-5.0 to 0 $U_N/I_N$
ZC (impedance step 1)	0 to 5.0 $U_N/I_N$
Phi	60° to 270°
warning angle	0° to 180°
tripping angle	0° to 180°
n1	0 to 20
n2	0 to 20
t-reset	0.5 s to 25 s

Table 30: Synchrocheck (25)

<p>Features:</p> <ul style="list-style-type: none"> <li>Supervision of synchronism. Single-phase measurement. The differences of the amplitudes, phase angles and frequencies of two voltage-vectors are checked</li> <li>Voltage supervision: Single- or three-phase voltage measurement. Evaluation of instantaneous values and therefore a large frequency range. Detection of maximum and minimum values in case of three-phase input</li> <li>Phase-selection of the voltage-inputs</li> <li>External switch over to another voltage input is possible (for double busbar systems)</li> <li>External selection of the mode</li> </ul>	
<p>Settings:</p>	
Max. voltage diff.	0.05 to 0.4 $U_N$ in steps of 0.05 $U_N$
Max. phase diff.	5 to 80 deg. in steps of 5.0 deg.
Max. frequency diff.	0.05 to 0.4 Hz in steps of 0.05 Hz
Min. voltage	0.6 to 1 $U_N$ in steps of 0.05 $U_N$
Max. voltage	0.1 to 1 $U_N$ in steps of 0.05 $U_N$
Supervision time	0.05 to 5 s in steps of 0.05 s
Reset time	0 to 1 s in steps of 0.05 s

**Table 31: Metering function UIfPQ**

<ul style="list-style-type: none"> <li>• Single-phase measurement of voltage, current, frequency, real power and apparent power</li> <li>• Choice of measuring phase-to-ground or phase-to phase voltages</li> <li>• Suppression of DC components and harmonics in current and voltage</li> <li>• Compensation of phase errors in main and input c.t.'s and v.t.'s</li> </ul>	
Settings:	
Phase-angle	-180° to +180° in steps of 0.1°
Reference value of the power $S_N$	0.2 to 2.5 $S_N$ in steps of 0.001 $S_N$

Refer to Table 33 for accuracy.

**Table 32: Three-phase measuring module**

<ul style="list-style-type: none"> <li>• Three-phase measurement of voltage (star or delta), current, frequency, real and apparent power and power factor.</li> <li>• Two independent impulse counter inputs for calculation of interval and accumulated energy.</li> <li>• The impulse counters can be used independently and may also be disabled.</li> <li>• This function may be configured four times.</li> </ul>	
Settings:	
Angle	-180° to +180° in steps of 0.1°
Reference value for power	0.2 to 2.5 $S_N$ in steps of 0.001 $S_N$
t1-Interval	1 min., 2 min., 5 min., 10 min., 15 min., 20 min., 30 min., 60 min. or 120 min.
Scale factor of power	0.0001 to 1
Max. impulse frequency	25 Hz
Min. impulse duration	10 ms
Accuracy of time interval	±100 ms

See Table 33 for accuracy

**Table 33: Accuracy of the metering function UIfPQ and three-phase measuring module (including input voltage and input current c.t.)**

Input variable	Accuracy		Conditions
	Core balance c.t.s with error compensation	Protection c.t.s without error compensation	
Voltage	±0.5% $U_N$	±1% $U_N$	0.2 to 1.2 $U_N$ $f = f_N$
Current	±0.5% $I_N$	±2% $I_N$	0.2 to 1.2 $I_N$ $f = f_N$
Real power	±0.5% $S_N$	±3% $S_N$	0.2 to 1.2 $S_N$ 0.2 to 1.2 $U_N$ 0.2 to 1.2 $I_N$ $f = f_N$
Apparent power	±0.5% $S_N$	±3% $S_N$	
Power factor	±0.01	±0.03	$S = S_N, f = f_N$
Frequency	±0.1% $f_N$	±0.1% $f_N$	0.9 to 1.1 $f_N$ 0.8 to 1.2 $U_N$

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

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

Technical data (cont'd)

**Table 34: Breaker-failure protection (50BF)**

<b>Features</b> <ul style="list-style-type: none"> <li>• Individual phase current recognition</li> <li>• Single or three-phase operation</li> <li>• External blocking input</li> <li>• Two independent time steps</li> <li>• Remote tripping adjustable simultaneously with retripping or backup tripping</li> <li>• Possibility of segregated activating/deactivating each trip (Redundant trip, retrip, backup trip and remote trip).</li> </ul>	
<b>Settings</b>	
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
Number of phases	1 or 3
Accuracy of pick-up current (at $f_N$ )	±15%
Reset ratio of current measurement	>85%
Reset time (for power system time constants up to 300 ms and short-circuit currents up to $40 \cdot I_N$ )	$\leq 28$ ms (with main c.t.s TPX) $\leq 28$ ms (with main c.t.s TPY and current setting $\geq 1.2 I_N$ ) $\leq 38$ ms (with main c.t.s TPY and current setting $\geq 0.4 I_N$ )

**Table 35: Disturbance recorder**

<ul style="list-style-type: none"> <li>• Max. 12 c.t./v.t. channels</li> <li>• Max. 16 binary channels</li> <li>• Max. 12 analogue channels of internal measurement values</li> <li>• 12 samples per period (sampling frequency 600 or 720 Hz at a rated frequency of 50/60 Hz)</li> <li>• Available recording time for 9 c.t./v.t.- and 8 binary signals approximately 5 s</li> <li>• Recording initiated by any binary signal, e.g. the general trip signal.</li> </ul>	
Data format	EVE
Dynamic range	$70 \times I_N, 2.2 \times U_N$
Resolution	12 bits
<b>Settings:</b>	
Recording periods	
Pre-event	40...400 ms in steps of 20 ms
Event	100...3000 ms in steps of 50 ms
Post-event	40...400 ms in steps of 20 ms

**Table 36: Logic functions**

Delay function: - Adjustable trip delay and drop delay - Two time integration modes - Input invertible	0 to 300 s in steps of 0.01 s
Counting function: - Adjustable trip counting threshold and drop delay - Input invertible	1 to 100 in steps of 1
AND function - Maximum of four inputs - All inputs invertible - Trip with additional delay or counting function	
OR-function - Maximum of four inputs - All inputs invertible - Trip with additional delay or counting function	
FLIP-FLOP function - Two set- and two reset inputs - All inputs invertible - Trip with additional delay or counting function	

**Table 37: Configuration and Settings**

Locally via the comm. port on the front-plate using an IBM AT or compatible PC
User interface program in English, German, French or Spanish on a disc (3½"/1.44 MByte or 5¼"/1.2 MByte)

**Table 38: Remote communication**

RS232C interface Data transfer rate Protocol Electrical/optical converter (optional)	9600 Bit/s SPA or IEC 60870-5-103 216BM61b
PC-Card interface Number	2 plug-in sockets for type 3 cards (for 2 processing units 216VC62a)
PC-Cards (optional) interbay bus protocol process bus protocol (interbay and process bus can be used concurrently) LON bus Data transfer rate IEC 61375 bus Data transfer rate	LON or MVB (part of IEC 61375) MVB (part of IEC 61375)  PC-Card with fibre-optical port, ST connectors 1.25 MBit/s PC-Card with redundant fibre-optical port, ST connectors 1.5 Mbit/s
Event memory Capacity Time marker resolution	256 events 1 ms
Time deviation without remote synchronization	<10 s per day
Engineering interface	integrated software interface for signal engineering with SigTOOL

Technical data (cont'd)

**Table 39: Contact data**

Tripping:	
Max. operating voltage	250 V <sub>AC</sub> or V <sub>DC</sub>
Make and carry for 0.5 s	30 A <sub>AC</sub> or A <sub>DC</sub>
Continuous current	10 A <sub>AC</sub> or A <sub>DC</sub>
Making power	2500 VA
Rupture current with two contacts in series and L/R = 40 ms at U ≤ 50 V <sub>DC</sub> at U ≤ 120 V <sub>DC</sub> at U ≤ 250 V <sub>DC</sub>	5 A 1 A 0,3 A
Signalling stand by No. of contacts (216GA61) No. of contacts (216GD61)	2 break contacts per signalling channel 1 make contact per signalling channel 4 signalling channels with 1 break contact
Max. operating voltage	250V <sub>AC</sub> or V <sub>DC</sub>
Make and carry for 0.5 s	10 A <sub>AC</sub> or A <sub>DC</sub>
Continuous current	5 A <sub>AC</sub> or A <sub>DC</sub>
Making power	1250 VA <sub>AC</sub> 60 W <sub>DC</sub>

**Table 40: Auxiliary supply**

Max. installed rating per cubicle	400W
Supply interruption bridging time at min input voltage and full load at rated input voltage and 70% load	>10 ms >50 ms

**Table 41: General data**

Temperature range operation storage	-10° C to +55° C -40° C to +85° C	EN 60255-6 (1994), IEC 60255-6 (1988)
Humidity	93%, 40° C, 4 days	IEC 60068-2-3 (1969)
Seismic test	5 g, 30 s, 1 to 33 Hz (1 octave/min)	IEC 60255-21-3 (1995), IEEE 344 (1987)
Leakage resistance	>100 MΩ, 500 V DC	EN 60255-5 (2001), IEC 60255-5 (2000)
Insulation test	2 kV, 50 Hz, 1 min 1 kV across open contacts	EN 60255-5 (2001), IEC 60255-5 (2000), EN 60950 (1995)
Surge voltage test	5 kV, 1.2/50 μs	EN 60255-5 (2001), IEC 60255-5 (2000) *
1 MHz burst disturbance test	1.0/2.5 kV, Cl. 3; 1MHz, 400 Hz rep.freq.	IEC 60255-22-1 (1988), ANSI/IEEE C37.90.1 (1989)
Fast transient test	2/4 kV, Cl. 4	EN 61000-4-4 (1995), IEC 61000-4-4 (1995)

Electrostatic discharge test (ESD)	6/8 kV (10 shots), Cl. 3	EN 61000-4-2 (1996), IEC 61000-4-2 (2001)
Immunity to magnetic interference at power system frequencies	300 A/m; 1000 A/m; 50/60 Hz	EN 61000-4-8 (1993), IEC 61000-4-8 (1993)
Radio frequency interference test (RFI)	<ul style="list-style-type: none"> <li>• 0.15-80 MHz, 80% amplitude modulated 10 V, Cl. 3</li> <li>• 80-1000 MHz, 80% amplitude modulated 10 V/m, Cl. 3</li> <li>• 900 MHz, puls modulated 10 V/m, Cl. 3</li> </ul>	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 42: Mechanical design**

Terminals CT and PT circuits	10 mm <sup>2</sup> , Type Phoenix URTK/S
tripping and signalling circuits	4 mm <sup>2</sup> , Type Phoenix UKK5-MT KD-P/P (GKOS for 216GD61)
aux. dc supply and remaining aux. circuits	10 mm <sup>2</sup> , Type Phoenix UK4 (GKOS for 216GD61)
Cubicle wiring CT and PT circuits	directly mounted terminals
aux. dc supply	1.50 mm <sup>2</sup>
tripping and signalling circuits	0.5 mm <sup>2</sup>
standard pre-made cables	0.25 mm <sup>2</sup>
Cubicle design	ABB Type RESP (see Data Sheet 1MRB520115-Ben)
Cubicle dimensions (w x d x h)	800 x 800 x 2200 mm
Total weight (with all aux. relays and units inserted)	200 to 400 kg

## Ordering

In order to configure the generator protection system type REG216 the ABB-engineering group needs the information from the Questionnaire 1MRB520026-Ken.

When ordering the compact version the following has to be stated:

- Rated current
- Rated voltage
- Optocoupler voltage
- Quantity of different units (electronic part) and interfaces

- 1) 216GW62 Input transformer assembly
- 2) 216GD61 Interface unit consisting of:
  - 8 tripping relays
  - 16 signalling relays
  - 16 optocouplers
  - 3 cables 216IK61

**NOTE:**

The compact version in addition requires configuration and final testing, which is normally **not included**. For customizing the compact version, please contact an ABB sales representative.

**Table 43: Subcodes**

Subcode	Explanation	Description	Remarks for ordering
A- A0 A1 A2 A5	none 1A 2A 5A	rated current	for protection transf.
B- B0 B1 B2 B5	none 1A 2A 5A	rated current	for measurement transf.
U- U0 U1 U2	none 100 V AC 200 V AC	rated voltage	
K-/L- K01 L01	6 CT's (3ph 1 MT (1ph 2 VT (1ph 3 VT (3ph delta	Code A-) Code B-) Code U-) Code U-)	VT,CT and MT arrangement of transformer unit
K02 L02	6 CT's (3ph 3 MT's (3ph 3 VT's (3ph delta	Code A-) Code B-) Code U-)	Typ 216GW62 Explanation: CT= Protection transformer VT= Voltage transformer MT= Measurement transformer
K03 L03	6 CT's (3ph 3 VT's (3ph delta 3 VT's (3ph delta	Code A-) Code U-) Code U-)	
K04 L04	6 CT's (3ph 1 CT (1ph 1Mt (1ph 1 VT (1ph 3 VT (3ph delta	Code A-) Code A-) Code B-) Code U-) Code U-)	The variants M2,M3, M6 and M7 consisting of two units GW62. The first is specified with code Kx- and the second with code Lx-
K05 L05	9 CT's (3ph 1 MT (1ph 2 VT's (1ph	Code A-) Code B-) Code U-)	
K06 L06	9 CT's (3ph 3 VT's (3ph delta	Code A-) Code U-)	
K07 L07	12 CT's (3ph	Code A-)	
K08 L08	9 CT's (3ph 3 MT's (3ph	Code A-) Code B-)	



K09 L09	3 CT's (3ph 3 MT's (3ph 3 VT's (3ph delta 2 VT's (1ph 1 MT (1ph	Code A-) Code B-) Code U-) Code U-) Code B-)	
K10 L10	6 CT's (3ph 3 VT's (3ph delta 3 VT's (1ph	Code A-) Code U-) Code U-)	
K11 L11	9 CT's (3ph 3 VT's (3ph star	Code A-) Code U-)	
K12 L12	3 CT's (3ph 3 VT's (3ph delta 1 VT (1ph 1 MT (1ph 1 VT (1ph 3 VT's (spez.	Code A-) Code U-) Code U-) Code B-) Code U-) Code U-)	95% Stator earth fault protection 100% Stator- + rotor earth fault protection
K13 L13	6 CT's (3ph 3 VT's (3ph delta 1 VT (1ph 2 VT's (spez.	Code A-) Code U-) Code U-) Code U-)	95% Stator earth fault protection 100% Stator earth fault protection
M- M1	1*rack 216MB66 consisting of 1*NG6x, 1*EA61b, 1*AB61, 1*DB61 1*GW62 1*GD61a	Code K- Code I-	
M2	1*rack 216MB66 consisting of 1*NG6x, 1*EA61b, 1*AB61, 2*DB61 2*GW62 2*GD61a	Code K- / L- Code I-/J-	
M3	1*rack 216MB66 consisting of 1*NG6x, 1*EA61b, 1*AB61, 1*DB61 2*GW62 1*GD61a	Code K- / L- Code I-/J-	
M4	1*rack 216MB66 consisting of 1*NG6x, 1*EA61b, 1*AB61, 2*DB61 1*GW62 2*GD61a	Code K- Code I-/J-	
M5	1*rack 216MB68 consisting of 1*NG6x, 1*EA61b, 1*AB61, 1*DB61 per group 1*GW62 2*GD61a	Code K- Code I-/J-	
M6	1*rack 216MB68 consisting of 1*NG6x, 1*EA61b, 1*AB61, 1*DB61 per group 2*GW62 2*GD61a	Code K- / L- Code I-/J-	
M7	1*rack 216MB68 consisting of 1*NG6x, 1*EA61b, 1*AB61, 2*DB61 per group 2*GW62 4*GD61a	Code K- / L- Code I-/J-	

The above mentioned devices are included in the code Mx.  
The number and types of CPU's must be specified by code

G- G1 G2 G4	165...312 V DC 82.....156 V DC 36.....75 V DC	1.DC/DC-con- verter supply voltage	
H- H1 H2 H4	165...312 V DC 82.....156 V DC 36.....75 V DC	2.DC/DC-con- verter supply voltage	for variant M1-M4 an optional 2. redund- ant DC/DC-converter can be used
I- I0 I1 I2 I3	none 82...312 V DC 36...75 V DC 20....30 V DC	Binary input/output unit GD61a optocoupler input voltage	

**Ordering (cont'd)**

S-	S1	SPA protocol	(Interbay bus)	
	S2			
	S3	LON protocol		
	S4	MVB protocol		
T-	T0	none	(216VC62a includes gold capacitor, no battery) (T-code for new CPU not necessary)	
	T6	Lithium-battery		
V-	V5	216VC62a	425%	1.CPU Communication and Dist.recorder included
W-	W5	216VC62a	425%	Communication and Dist.recorder included
R-	R0	none	Reset unit	
	R1	available		

**Table 44: Accessories**

<b>PCC card interface</b>					
Type	Protocol	Connector	Optical fibre*	Gauge **	ID No
For interbay bus:					
PCCLON2 SET	LON	ST (bajonet)	G/G	62,5/125	HESG 448766R0001
500PCC02	MVB	ST (bajonet)	G/G	62,5/125	HESG 448735R0231
For process bus:					
500PCC02	MVB	ST (bajonet)	G/G	62,5/125	HESG 448735R0232
<b>RS232C interbay bus interface</b>					
Type	Protocol	Connector	Optical fibre*	Gauge **	Order No.
216BM61b	SPA	ST (bajonet)	G/G	62,5/125	HESG448267R1021
* receiver Rx / transmitter Tx, G = glass, P = plastic			**optical fibre conductor gauge in $\mu\text{m}$		
<b>Human machine interface</b>					
Type	Description		Order No.		
CAP2/316	Installation CD	German/English	1MRB260030M0001		
** Unless expressly specified the latest version is supplied.					
<b>Optical fibre PC connecting cable</b>					
Type	Order No.		Type/ID No.		
YX216a-1 (4 m)	7433 1640-AA		HESG448522R1		
YX216a-1 (10 m)	7433 1640-BA		HESG448522R2		
YX216a-1 (30 m)	7433 1640-CA		HESG448522R3		
<b>Disturbance recorder evaluation program</b>					
Type, description	Order No.		Type/ID No.		
REVAL English	3½"-Disk	1MRK000078-A			
REVAL German	3½"-Disk	1MRK000078-D			
WINEVE	English/German		Basic version		
WINEVE	English/German		Full version		

### Ordering (cont'd)

#### Variant M1 (single system)

Standard configuration:

- 1\*216NG6x Code G
- 1\*216VC62a
- 1\*216EA61b
- 1\*216AB61
- 1\*216DB61
- 12 Input transformers (1\*216GW62) Code K
- 8 Tripping relays (1\*216GD61a)
- 16 Signalling relays (1\*216GD61a)
- 16 Binary inputs (1\*216GD61a) Code I

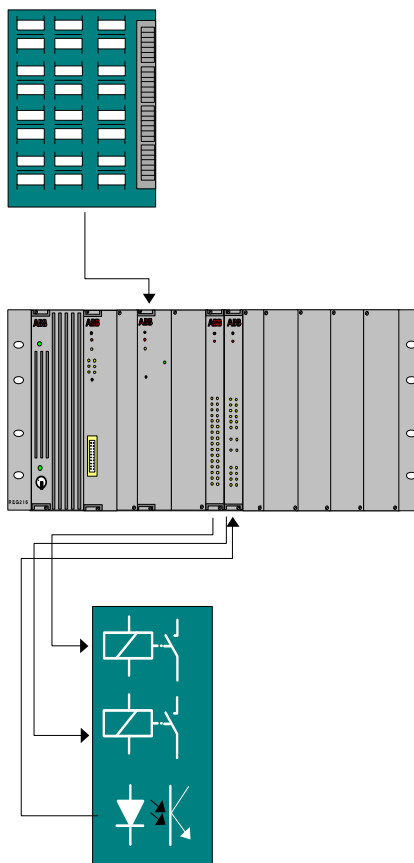
#### Option:

- additional CPU type 216VC62a
- 2. DC/DC-converter (for redundant power supply)

#### Ordering example for Racks with CPU-type 216VC62a

HESG 324510 M1

Code: M1K\*A\*B\*U\*G\*H\*I\*V5W\*S\*R\* P\*3



## Variant M2 (single system)

Standard configuration:

- 1\*216NG6x Code G
- 1\*216VC62a
- 1\*216EA61b
- 1\*216AB61
- 2\*216DB61
- 24 Input transformers (2\*216GW62) Code K / L
- 16 Tripping relays (2\*216GD61a)
- 32 Signalling relays (2\*216GD61a)
- 32 Binary inputs (2\*216GD61a) Code I

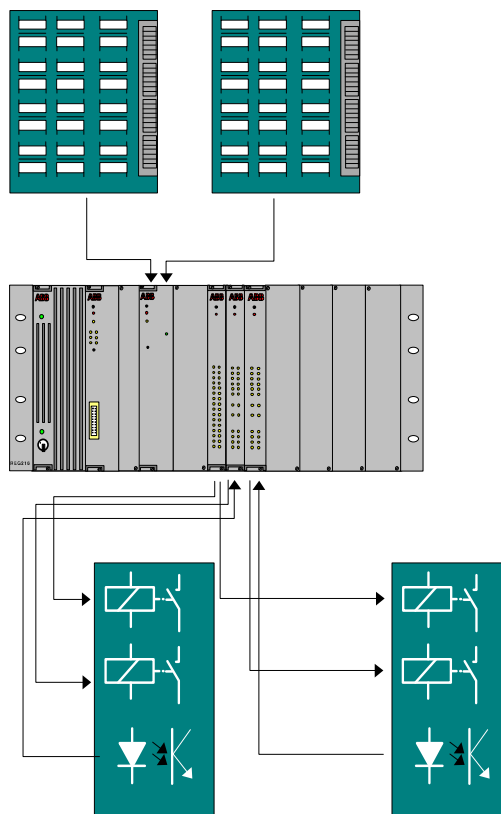
### Option:

- additional CPU type 216VC62a
- 2. DC/DC-converter (for redundant power supply)

### Ordering example for Racks with CPU-type 216VC62a

HESG 324510 M1

Code: M2K\*L\*A\*B\*U\*G\*H\*I\*V5W\*S\*R\*P\*3



## Ordering (cont'd)

### Variant M3 (single System)

Standard configuration:

- 1\*216NG6x Code G
- 1\*216VC62a
- 1\*216EA61b
- 1\*216AB61
- 1\*216DB61
- 24 Input transformers (2\*216GW62) Code K / L
- 8 Tripping relays (1\*216GD61a)
- 16 Signalling relays (1\*216GD61a)
- 16 Binary inputs (1\*216GD61a) Code I

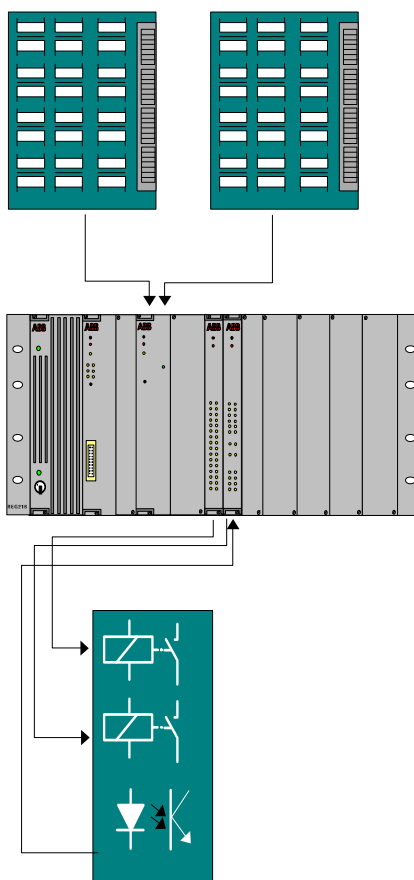
### Option:

- additional CPU type 216VC62a
- 2. DC/DC-converter (for redundant power supply)

### Ordering example for Racks with CPU-type 216VC62a

HESG 324510 M1

Code: M3K\*L\*A\*B\*U\*G\*H\*I\*V5W\*S\*R\*P\*3



**Variant M4 (single System)**

Standard configuration:

- 1\*216NG6x Code G
- 1\*216VC62a
- 1\*216EA61b
- 1\*216AB61
- 2\*216DB61
- 12 Input transformers (1\*216GW62) Code K
- 16 Tripping relays (2\*216GD61a)
- 32 Signalling relays (2\*216GD61a)
- 32 Binary inputs (2\*216GD61a) Code I

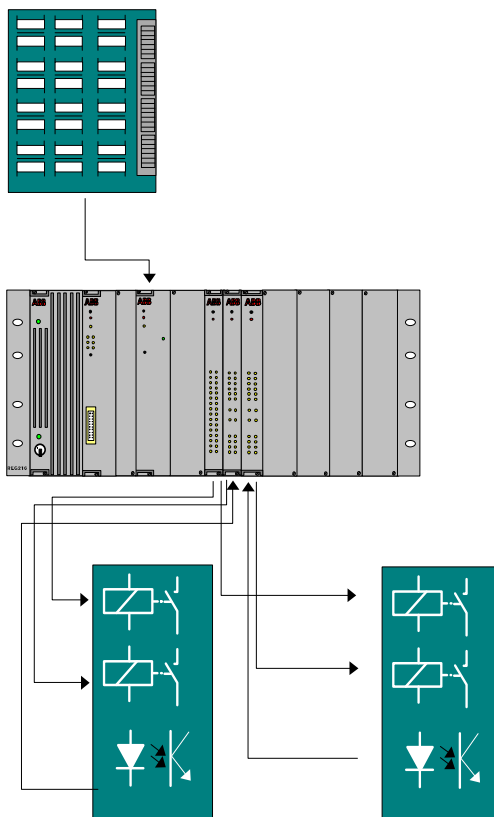
**Option:**

- additional CPU type 216VC62a
- 2. DC/DC-converter (for redundant power supply)

**Ordering example for Racks with CPU-type 216VC62a**

HESG 324510 M1

Code: M4K\*A\*B\*U\*G\*H\*I\*V5W\*S\*R\* P\*3



### Ordering (cont'd)

#### Variant M5 (redundant System)

Standard configuration:

- 1\*216NG6x (per group) Code G
- 1\*216VC62a (per group)
- 1\*216EA61b (per group)
- 1\*216AB61 (per group)
- 1\*216DB61 (per group)
- 12 Input transformers (1\*216GW62) Code K / L
- 8 Tripping relays (1\*216GD61a) (per group)
- 16 Signalling relays (1\*216GD61a) (per group)
- 16 Binary inputs (1\*216GD61a) (per group)

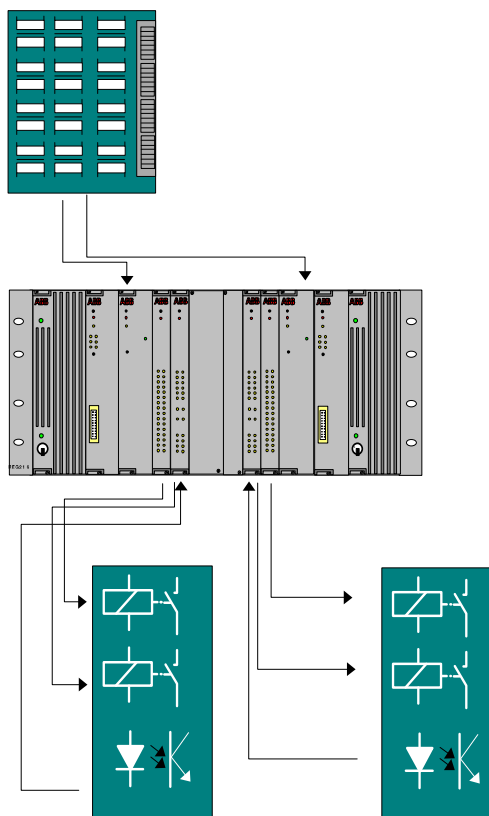
#### Option:

- none

#### Ordering example for Racks with CPU-type 216VC62a

HESG 324510 M1

Code: M5K\*A\*B\*U\*G\*H0 I\*V5W5S\*R\* P\*3





## Variant M6 (redundant system)

Standard configuration:

- 1\*216NG6x (per group) Code G
- 1\*216VC62a (per group)
- 1\*216EA61b (per group)
- 1\*216AB61 (per group)
- 1\*216DB61 (per group)
- 24 Input transformers (2\*216GW62) Code K / L
- 8 Tripping relays (1\*216GD61a) (per group)
- 16 Signalling relays (1\*216GD61a) (per group)
- 16 Binary inputs (1\*216GD61a) (per group)

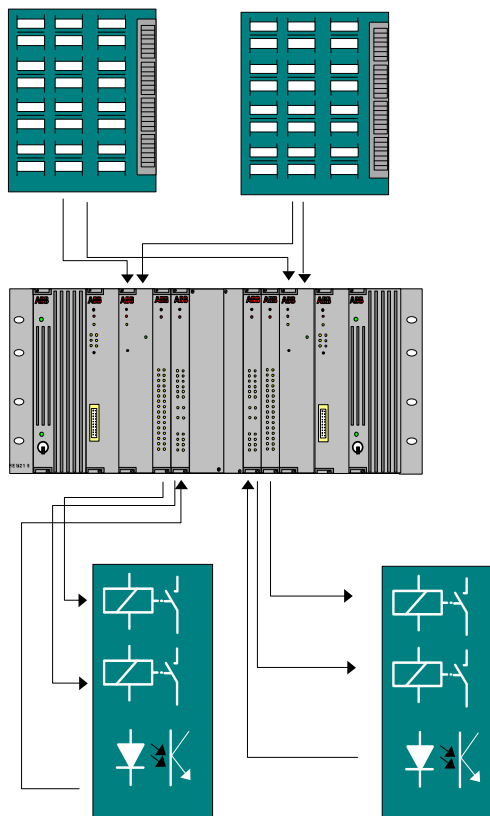
### Option:

- none

### Ordering example for Racks with CPU-type 216VC62a

HESG 324510 M1

Code: M6K\*L\*A\*B\*U\*G\*H0 I\*V5W5S\*R\*P\*3



**Ordering (cont'd)**

**Variant M7 (redundant System)**

Standard configuration:

- 1\*216NG6x (per group) Code G
- 1\*216VC62a (per group)
- 1\*216EA61b (per group)
- 1\*216AB61 (per group)
- 2\*216DB61 (per group)
- 24 Input transformers (2\*216GW62) Code K / L
- 16 Tripping relays (2\*216GD61a) (per group)
- 32 Signalling relays (2\*216GD61a) (per group)
- 32 Binary inputs (2\*216GD61a) (per group)

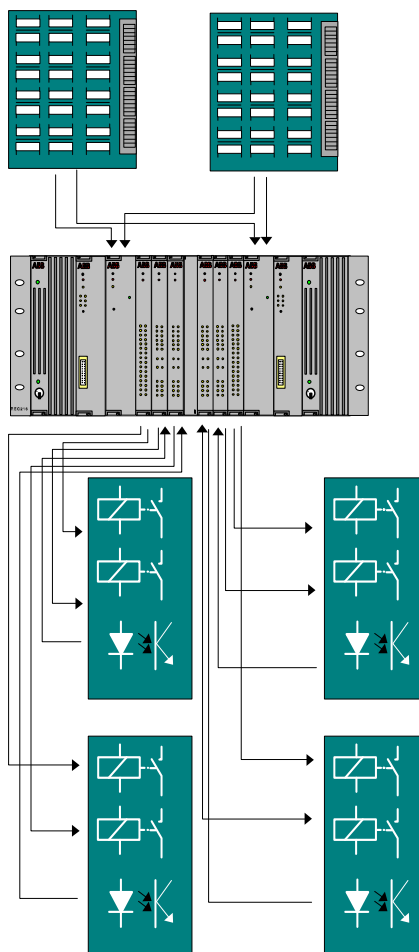
**Option:**

- none

**Ordering example for Racks with CPU-type 216VC62a**

HESG 324510 M1

Code: M7K\*L\*A\*B\*U\*G\*H0 I\*V5W5S\*R\*P\*3



**Accessories (optional)**

These may also be obtained elsewhere, however correct operation of the overall system is crucial and the following details must be considered.

**Personal computer**

Various PC's having a RS232 and working with the operating systems Windows NT 4.0 or Windows 2000 can be used.

This PC type can also be used in the future in the probable event that the software functions increase (graphic display, etc.). Following requirements should be met:

- 64 MByte RAM
- 1 CD-ROM drive
- 1 Hard disk minimum 500 MB
- 1 serial interface (RS 232 C)
- 2nd serial interface as option

**Sample specification**

Numerical protection equipment used for generator and block-transformer protection.

It will be a stand-alone system but closely involved in the process. Parameters, signals, measured values as well as remote parameter regulation commands, will be exchanged via appropriate interfaces and a serial communications channel to central process control equipment.

The system will be supported by a software library of diverse protection functions. A menu-driven HMI (human machine interface) will allow users to activate functions which are provided in the protection function library.

The entire protective system will consist of a relatively small number of hardware components. This applies not only to the electronic units, but also to the process interfaces, such as current and voltage inputs as well as the numbers of signal and tripping relays.

This flexibility resulting from the modular hardware will enable the equipment configuration to be easily adapted for installations of different sizes and the desired scope of protection.

The system will permit various degrees of redundancy. The user can specify the desired configuration

- duplicating power supply unit

- duplicating the whole system

Additional benefits considered are wide setting ranges, excellent long-term stability and few setting steps. The numerical system should offer a library of the available protective functions. These functions will then be selected by the user by the simple assignment of parameters.

All protection functions should operate from sampled primary system voltages and currents. The sampling rate of the analogue input units should be 12 times per period at rated power system frequency with a dynamic range of 15 bit.

The man-machine-communication should be performed easily using only a few push-button commands on a personal computer (PC) via a serial RS 232 interface. No prior knowledge of programming should be necessary. For all functions the user is guided with the aid of screen menus and windows. All different languages for texts could be supplied. Any text change is accommodated easily.

All the hardware components should be packaged in a single cabinet. This cubicle can also accommodate other protection relays with external functions, for example, 100% stator earth fault protection, Buchholz relay or some thermal sensors.

**References**

Cubicles for Electronic Installations  
Operating Instructions REG216 (printed)  
Operating Instructions REG216 (CD)  
Questionnaire REG216  
Reference List REG216

1MRB520115-Ben  
1 MDU02005-EN  
1MRB260030M0001  
1MRB520026-Ken  
1MRB520011-Ren



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**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 5P 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.

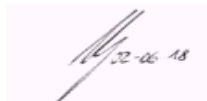
**Conditions for the CT requirements**

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.

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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 ( $0^\circ$ ). Investigations have proved that 95% of the faults in the network will occur when the voltage is between  $40^\circ$  and  $90^\circ$ .

#### 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 IK, ( 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).

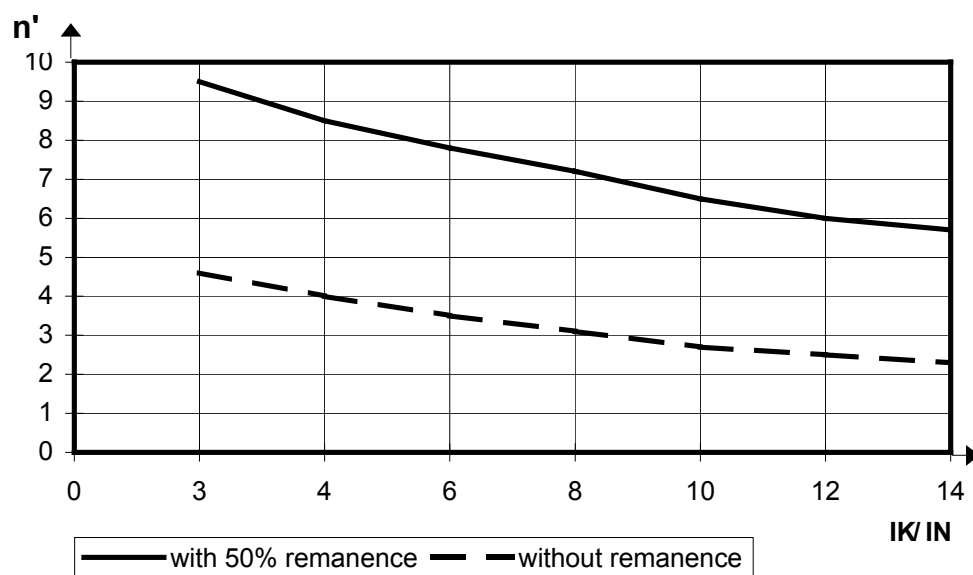


Figure 1: Overcurrent factors



March 2001

## 9. INTERBAY BUS (IBB) INTERFACE

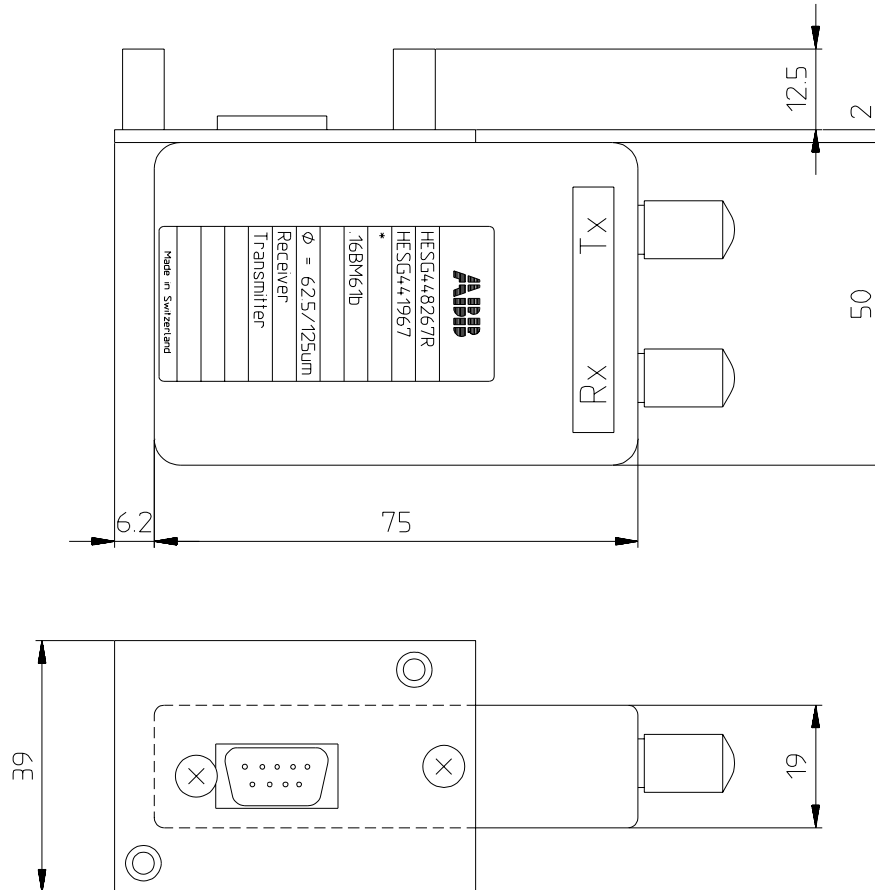
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## 9. Interbay bus (IBB) interface

### 9.1. Connection to a station automation system

An electro-optical converter Type 316BM61b is plugged onto the rear of the protection to convert the electrical RS232 signals from the 216VC62a or 316VC61b into optical signals.



g448308

Fig. 9.1 Electro-optical converter Type 316BM61b

RS232 interface:

Pin 2:	Rx
Pin 3:	Tx
Pin 4:	+12V
Pin 5:	0V
Pin 9:	-12V

Optical cable connections:

Optical fibre cables with bayonet connectors (ST) are used for the SPA bus (62.5 µm 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.

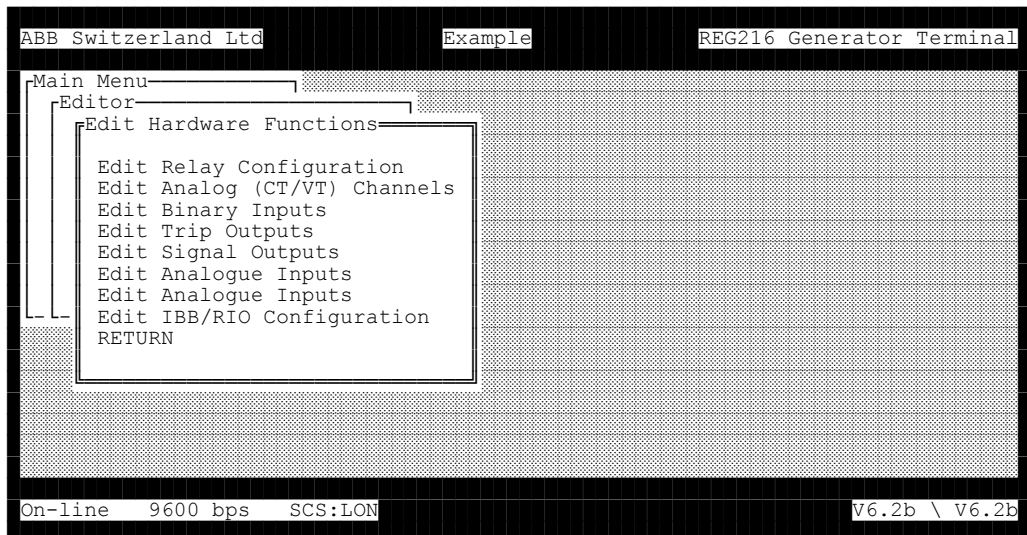


Fig. 9.2 Opening the “IBB/RIO configuration” window

The following parameters can be set for the IBB/RIO function (see Fig. 9.3):

```

ABB Switzerland Ltd      Example      REG216 Generator Terminal
Main Menu
  Editor
    Edit Hardware Functions
      IBB Config.
        General IBB Parameters
        SPA Parameters
        LON Parameters
        MVB-IBB Parameters
        MVB-RIO Parameters
        MVB-ITL Parameters
        MVB-BA Parameters
        Load MBAPars from File
        Save RIO-Pars to File
        Load RIO-Pars from File
        RETURN
  
```

On-line 9600 bps SCS:LON V6.2b \ V6.2b

Fig. 9.3 IBB/RIO 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.

```

ABB Switzerland Ltd      Example      REG216 Generator Terminal
Edit Function Parameters
  IBB Config.          * *
  Slave/NodeAddr      2
  IBB_RunOnCPU        CPU1          Select
  RIO_RunOnCPU        CPU2          Select
  TouchScreen/SMS     not active    Select
  Read Distr.Data     by IBB        Select
  IBB-MW 1
  IBB-MW 2
  IBB-MW 3
  IBB-MW 4
  IBB-MW 5
  IBB-MW 6
  IBB-MW 7
  IBB-MW 8
  more...
  
```

On-line 9600 bps SCS:SPA V6.2b \ V6.2b

Fig. 9.4 General IBB parameters

## Slave/Nodes

Range 1...255. These must be set to the correct SPA bus address.

## Touchscreen/SMS

This setting determines whether the connection to a touch screen or SMS is enabled or not.

- inactive Connection disabled (default)
- active Connection enabled

Note that this parameter does not apply to the SPA and IEC60870-5-103 bus versions and is ineffective.

The LON and MVB interbay bus versions have an SPA interface in addition to the interbay bus interface, to which either a touch screen or an SMS can be connected. The 'Touchscreen/SMS' parameter should only be set to 'active' when the corresponding device is connected to the SPA interface Parameter, because it slightly increases the response time of the LON or MVB bus interface. The IBB must run on CPU 1 and the MVB process bus on CPU 2, as shown in [Fig. 9.4](#).

## Read Distr.Data

This parameter determines which system is permitted to read disturbance recorder data.

- By IBB Disturbance recorder data are read by the interbay bus (SCS).
- By SMS Disturbance recorder data are read by the SMS.

Disturbance recorder data can always be read by the HMI regardless of the setting.

Note that this parameter does not apply to the SPA and IEC870-5-103 bus versions and is ineffective.

## 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).

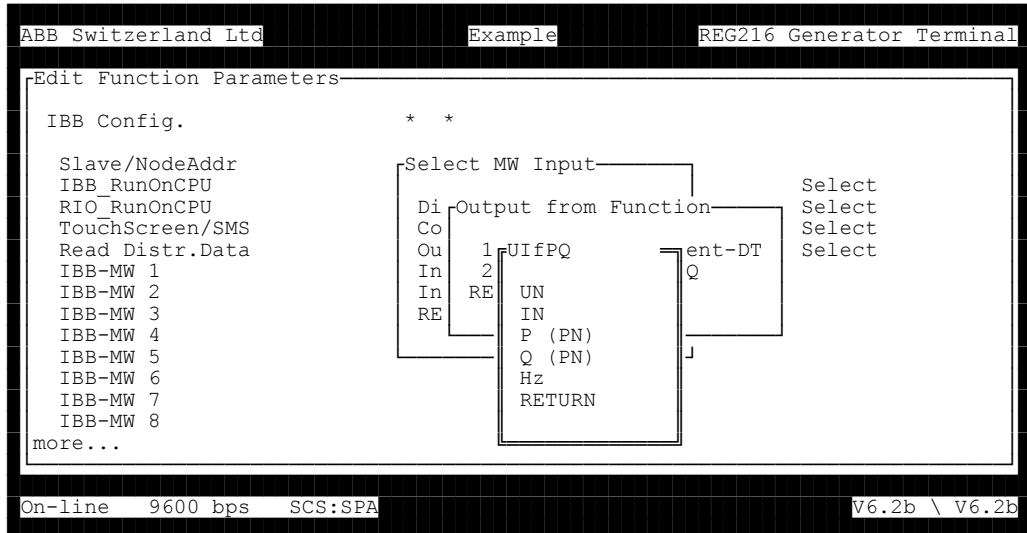


Fig. 9.5 Connecting an IBB measured variable

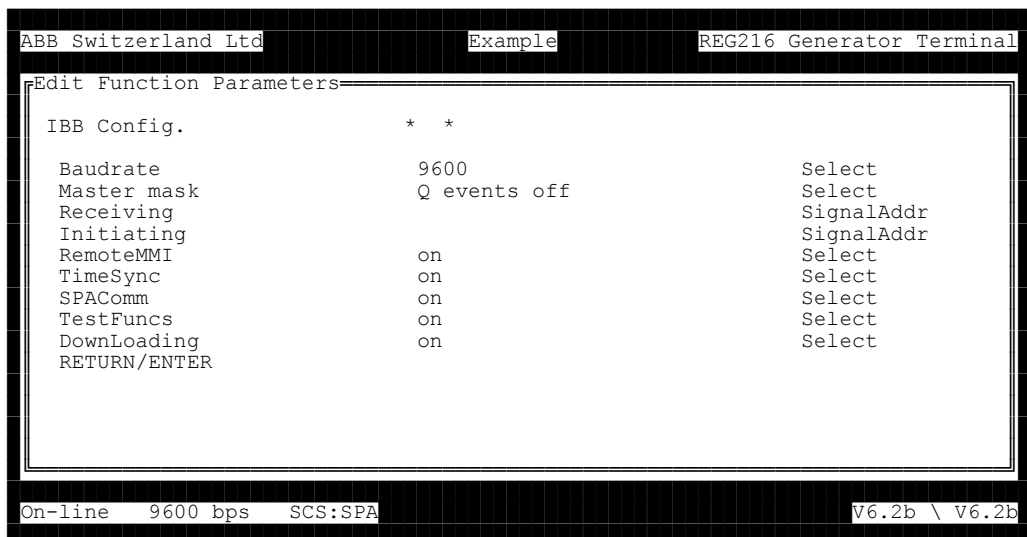


Fig. 9.6 SPA parameters

The parameters must be set as follows:

## Baud rate

Default 9600 for SPA bus. Do not change.

## MasterMask

- Bit masks  
The bit masks set for every function via the SPA bus apply to 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  
This setting is for use while testing and during coHMIssioning if events should not be transmitted to the control room.
- Receiving  
Indicates that valid SPA telegrams have been received.
- Initialising  
Indicates that the device is being initialised.

‘Receiving’ and ‘Initialising’ can be connected to the following sinks:

signalling relays  
event handling  
Signal to SCS  
Signal to RBO  
Signal to ITL

The following parameters determine the access rights of the remote HMI and can only be configured on the local HMI (see [Section 5.11.](#)):

- RemoteHMI           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 downloading of a ‘setfile’ from the remote HMI.
- Load code           on / off  
Enables or disables the test function on 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 in channel 0 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 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	216VC62a	
V104	R	VC software version		
V110	R, W	Master event mask	1 Q events masked	0 Bit masks 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	REC216	REG216
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 and time format: YY-MM-DD hh.mm;ss.sss

**9.6.2. Channel 0, event list**

<b>Event No.</b>	<b>Cause</b>	<b>Event mask</b>	<b>Enable code</b>
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**

<b>Event No.</b>	<b>Cause</b>	<b>Event mask</b>	<b>Enable code</b>
1E11	AD fault CPU No. 1	V155	1
1E12	AD fault CPU No. 2	V155	2
1E21	SW fault CPU No. 1	V155	16
1E22	SW fault CPU No. 2	V155	32
1E31	Bus fault CPU No. 1	V155	256
1E32	Bus fault CPU No. 2	V155	512
1E41	Supply fault CPU No. 1	V155	4096
1E42	Supply fault CPU No. 2	V155	8192



**9.6.4. Channel 4, event list**

Event No.	Cause	Event mask	Enable code
4E1	EA61 failure	V155	1
4E2	EA61 OK	V155	2
4E3	VE61 failure	V155	4
4E4	VE61 OK	V155	8
4E5	DB61 failure	V155	16
4E6	DB61 OK	V155	32
4E7	AB61 failure	V155	64
4E8	AB61 OK	V155	128
4E9	VC61 failure	V155	256
4E10	VC61 OK	V155	512
4E11	EB61 failure	V155	1024
4E12	EB61 OK	V155	2048
4E13	AC61 failure	V155	4096
4E14	AC61 OK	V155	8192

**9.6.5. Channel 4 analogue input**

IBB channel 4 provides 64 data points as FUPLA analogue inputs. 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,

integer = real × 100.

Input format:            nnn.mm.

FFFFH

Data point number:    O1...O64

**9.6.6. Binary input signals**

The significance of the events, for standard as well as for double signals, is explained in [Section 9.6.12](#).

Channel	Inputs	Events	Slot
101	I1 - I16	E1 - E32	6
102	I1 - I16	E1 - E32	7
103	I1 - I16	E1 - E32	8
104	I1 - I16	E1 - E32	9
105	I1 - I32	E1 - E64	10
106	I1 - I32	E1 - E64	11
107	I1 - I32	E1 - E64	12
108	I1 - I32	E1 - E64	13
109	I1 - I32	E1 - E64	14
110	I1 - I32	E1 - E64	15
111	I1 - I32	E1 - E64	16
112	I1 - I32	E1 - E64	17
113	I1 - I32	E1 - E64	18
114	I1 - I32	E1 - E64	19
115	I1 - I32	E1 - E64	20
116	I1 - I31	E1 - E62	21

**9.6.7. 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

Channel	Inputs	Group	No.
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

#### 9.6.8. *Binary output signals*

Channel	Outputs	Events	Slot
101	O1 - O16	None	6
102	O1 - O16	None	7
103	O1 - O16	None	8
104	O1 - O16	None	9
105	O1 - O32	None	10
106	O1 - O32	None	11
107	O1 - O32	None	12
108	O1 - O32	None	13
109	O1 - O32	None	14
110	O1 - O32	None	15
111	O1 - O32	None	16
112	O1 - O32	None	17
113	O1 - O32	None	18
114	O1 - O32	None	19
115	O1 - O32	None	20
116	O1 - O31	None	21

**9.6.9. Tripping signals**

<b>Channel</b>	<b>Outputs</b>	<b>Events</b>	<b>Slot</b>
101	M1 - M16	None	6
102	M1 - M16	None	7
103	M1 - M16	None	8
104	M1 - M16	None	9
105	M1 - M32	None	10
106	M1 - M32	None	11
107	M1 - M32	None	12
108	M1 - M32	None	13
109	M1 - M32	None	14
110	M1 - M32	None	15
111	M1 - M32	None	16
112	M1 - M32	None	17
113	M1 - M32	None	18
114	M1 - M32	None	19
115	M1 - M32	None	20
116	M1 - M31	None	21

**9.6.10. 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

**9.6.11. 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	16348
	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

<b>Output</b>	<b>Event</b>	<b>Event No.</b>	<b>Mask</b>	<b>Enable code</b>
O31	On	61	V158	4096
	Off	62	V158	8192
O32	On	63	V158	16348
	Off	64	V158	327680



**9.6.12. Binary input event masks**

Input	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
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

Input	Event	Event No.	Mask	Enable code
I16	On	E31	V156	16384
	Off	E32	V156	32768
I17	On	E33	V157	1
	Off	E34	V157	2
I18	On	E35	V157	4
	Off	E36	V157	8
I19	On	E37	V157	16
	Off	E38	V157	32
I20	On	E39	V157	64
	Off	E40	V157	128
I21	On	E41	V157	256
	Off	E42	V157	512
I22	On	E43	V157	1024
	Off	E44	V157	2048
I23	On	E45	V157	4096
	Off	E46	V157	8192
I24	On	E47	V157	16348
	Off	E48	V157	32768
I25	On	E49	V158	1
	Off	E50	V158	2
I26	On	E51	V158	4
	Off	E52	V158	8
I27	On	E53	V158	16
	Off	E54	V158	32
I28	On	E55	V158	64
	Off	E56	V158	128
I29	On	E57	V158	256
	Off	E58	V158	512
I30	On	E59	V158	1024
	Off	E60	V158	2048

Input	Event	Event No.	Mask	Enable code
I31	On	E61	V158	4096
	Off	E62	V158	8192
I32	On	E63	V158	16348
	Off	E64	V158	327680

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

**9.6.13. Hardware****35**

RE. 216 unit addresses and codes

Address	Access	Slot No.
1S1	R	4
1S2	R	5
1S3	R	6
1S4	R	7
1S5	R	8
1S6	R	9
1S7	R	10
1S8	R	11
1S9	R	12
1S10	R	13
1S11	R	14
1S12	R	15
1S13	R	16
1S14	R	17
1S15	R	18
1S16	R	19
1S17	R	20
1S18	R	21

Module type	Code
Not used	0
216EA61	1
216VE61	2
216DB61	3
216AB61	4
216VC61	5
216EB61	6
216AC61	7
216VE61b	8
216VC61b	9
216VC62a	10

**9.6.14. Channel 8 system I/O's 34****Event list**

Event No.	Cause	Event mask	Enable code	Status
8E1	GenTrip Set	V155	1	811
8E2	Dito Reset	V155	2	811
8E3	GenStart Set	V155	4	812
8E4	Dito Reset	V155	8	812
8E5	Test active Set	V155	16	813
8E6	Dito Reset	V155	32	813
8E11	ParSet1 Set	V155	1024	816
8E12	Dito Reset	V155	2048	816
8E13	ParSet2 Set	V155	4096	817
8E14	Dito Reset	V155	8192	817
8E15	ParSet3 Set	V155	16384	818
8E16	Dito Reset	V155	32768	818
8E17	ParSet4 Set	V155	1	819
8E18	Dito Reset	V155	2	819
8E19	HMI is on Set	V156	4	8110
8E20	Dito Reset	V156	8	8110
8E25	MVB_PB_WARN Set	V156	256	8113
8E26	Dito Reset	V156	512	8113
8E27	MVB_PB_CRASH Set	V156	1024	8114
8E28	Dito Reset	V156	2048	8114
8E29	PB_BA1_Ready Set	V156	4096	8115
8E30	Dito Reset	V156	8192	8115
8E31	PB_BA2_Ready Set	V156	16384	8116
8E32	Dito Reset	V156	32768	8116
8E33	PB_BA3_Ready Set	V157	1	8117
8E34	Dito Reset	V157	2	8117
8E35	PB_BA4_Ready Set	V157	4	8118
8E36	Dito Reset	V157	8	8118

**9.6.15. IBB I/O 43****Event list**

Event No.	Cause	Event mask	Enable code
9E1	Received Set	V155	1
9E2	Dito Reset	V155	2
9E3	Initialisation Set	V155	4
9E4	Dito Reset	V155	8
9E5	BlckPsDatSig Set	V155	16
9E6	Dito Reset	V155	32

**Measured variables**

Function 9 (IBB I/O) makes measured variables available the number and significance of which depend on the device configuration. The number of measured variables is limited to 64.

Address	Access	Text	Format
9V1	R	IBBMW 1	Longinteger
9Vn	R	IBBMW 2	Longinteger
9V64	R	IBBMW 3	Longinteger

**9.6.16. Current-DT 2****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		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	Dito Reset	V155	2	
14E3	Start Set	V155	4	14I2
14E4	Dito Reset	V155	8	

**9.6.17. Current 3****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		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	Dito Reset	V155	2	
14E3	Start Set	V155	4	14I2
14E4	Dito Reset	V155	8	



**9.6.18. Diff-Transf 4****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		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				

Address	Access	Text	Unit	Default	Min.	Max.	Step
		z1	13				
		z2	14				
		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				
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	Dito Reset	V155	2	
14E3	Trip-R Set	V155	4	14I2
14E4	Dito Reset	V155	8	
14E5	Trip-S Set	V155	16	14I3
14E6	Dito Reset	V155	32	
14E7	Trip-T Set	V155	64	14I4
14E8	Dito Reset	V155	128	
14E9	Inrush Set	V155	256	14I5
14E10	Dito Reset	V155	512	
14E11	Stabil. Set	V155	1024	14I6
14E12	Dito Reset	V155	2048	

**9.6.19. Underimped 5****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		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	Dito Reset	V155	2	
14E3	Start Set	V155	4	14I2
14E4	Dito Reset	V155	8	

**9.6.20. MinReactance 6****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		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	Degree	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	Dito Reset	V155	2	
14E3	Start Set	V155	4	14I2
14E4	Dito Reset	V155	8	

**9.6.21. NPS-DT 7****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		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	Dito Reset	V155	2	
14E3	Start Set	V155	4	14I2
14E4	Dito Reset	V155	8	

**9.6.22. NPS-Inv 11****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		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	Dito Reset	V155	2	
14E3	Start Set	V155	4	14I2
14E4	Dito Reset	V155	8	

**9.6.23. Voltage 12****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		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	Dito Reset	V155	2	
14E3	Start Set	V155	4	14I2
14E4	Dito Reset	V155	8	



**9.6.24. Current-Inv 13****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		00000000B			
14S9	R	c-Setting	<Select>	1.00	0	2	1
		0.02	0				
		1.00	1				
		2.00	2				
		RxDIG					
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	0.04	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	V155	1	14I1
14E2	Dito	V155	2	
14E3	Start	V155	4	14I2
14E4	Dito	V155	8	

**9.6.25. OLoad-Stator 14****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		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	V155	1	14I1
14E2	Dito	V155	2	
14E3	Start	V155	4	14I2
14E4	Dito	V155	8	

**9.6.26. OLoad-Rotor 15****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		00000000B			
14S9	R	k1-Setting	s	033.8	1.0	120.0	0.1
14S10	R	l-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	Dito Reset	V155	2	
14E3	Start Set	V155	4	14I2
14E4	Dito Reset	V155	8	

**9.6.27. Power 18****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		00000000B			
14S9	R	P-Setting	PN	-0.050	-0.100	1.200	0.005
14S10	R	Angle	Degree	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.	Degree	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	Dito Reset	V155	2	
14E3	Start Set	V155	4	14I2
14E4	Dito Reset	V155	8	

**9.6.28. I<sub>max</sub>-U<sub>min</sub> 20****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		00000000B			
14S9	R	Delay	s	01.00	0.5	60.00	0.01
14S10	R	Current	IN	02.00	0.5	20	0.1
14S11	R	Hold-	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	Dito Reset	V155	2	
14E3	Start Set	V155	4	14I2
14E4	Dito Reset	V155	8	

**9.6.29. Delay 22****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		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	V155	1	14I1
14E2	Dito	V155	2	
14E3	Start	V155	4	14I2
14E4	Dito	V155	8	

**9.6.30. Diff-Gen 23****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		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	Dito Reset	V155	2	
14E3	Trip-S Set	V155	4	14I2
14E4	Dito Reset	V155	8	
14E5	Trip-T Set	V155	16	14I3
14E6	Dito Reset	V155	32	
14E7	Trip Set	V155	64	14I4
14E8	Dito Reset	V155	128	

**9.6.31. 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
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S9	R	X (1)	$\Omega$ /ph	000.00	-300	300	0.01
14S10	R	R (1)	$\Omega$ /ph	000.00	-300	300	0.01
14S11	R	RR (1)	$\Omega$ /ph	000.00	-300	300	0.01
14S12	R	RRE (1)	$\Omega$ /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)	$\Omega$ /ph	000.00	-300	300	0.01
14S17	R	R (2)	$\Omega$ /ph	000.00	-300	300	0.01
14S18	R	RR (2)	$\Omega$ /ph	000.00	-300	300	0.01
14S19	R	RRE (2)	$\Omega$ /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)	$\Omega$ /ph	000.00	-300	300	0.01
14S24	R	R (3)	$\Omega$ /ph	000.00	-300	300	0.01
14S25	R	RR (3)	$\Omega$ /ph	000.00	-300	300	0.01
14S26	R	RRE (3)	$\Omega$ /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>	I>	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	$\Omega$ /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	$\Omega$ /ph	000.0	0	999	0.1
14S57	R	XB	$\Omega$ /ph	000.0	-999	0	0.1
14S58	R	RA	$\Omega$ /ph	000.0	0	999	0.1
14S59	R	RB	$\Omega$ /ph	000.0	-999	0	0.1
14S60	R	RLoad	$\Omega$ /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				
15S27	R	TIMER_1	ms	0	0	30000	1
15S28	R	TIMER_2	ms	0	0	30000	1
15S29	R	TIMER_3	ms	0	0	30000	1
15S30	R	TIMER_4	ms	0	0	30000	1
15S31	R	TIMER_5	ms	0	0	30000	1
15S32	R	TIMER_6	ms	0	0	30000	1
15S33	R	TIMER_7	ms	0	0	30000	1
15S34	R	TIMER_8	ms	0	0	30000	1
14S35	R	TRIP CB R 01-08		00000000B			
14S36	R	TRIP CB R 09-16		00000000B			

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S37	R	TRIP CB R 17-24		00000000B			
14S38	R	TRIP CB R 25-32		00000000B			
14S39	R	TRIP CB S 01-08		00000000B			
14S40	R	TRIP CB S 09-16		00000000B			
14S41	R	TRIP CB S 17-24		00000000B			
14S42	R	TRIP CB S 25-32		00000000B			
14S43	R	TRIP CB T 01-08		00000000B			
14S44	R	TRIP CB T 09-16		00000000B			
14S45	R	TRIP CB T 17-24		00000000B			
14S46	R	TRIP CB T 25-32		00000000B			

### 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	Dito Reset	V155	2	
14E3	Start U0 Set	V155	4	14I2
14E4	Dito Reset	V155	8	
14E5	Meas Oreach Set	V155	16	14I3
14E6	Dito Reset	V155	32	
14E7	Trip O/C Set	V155	64	14I4
14E8	Dito Reset	V155	128	
14E9	Power Swing Set	V155	256	14I5
14E10	Dito Reset	V155	512	
14E11	Trip CB R Set	V155	1024	14I6
14E12	Dito Reset	V155	2048	
14E13	Trip CB S Set	V155	4096	14I7
14E14	Dito Reset	V155	8192	
14E15	Trip CB T Set	V155	16384	14I8
14E16	Dito Reset	V155	32768	
14E17	Trip SOFT Set	V156	1	14I9
14E18	Dito Reset	V156	2	
14E19	Start O/C Set	V156	4	14I10
14E20	Dito Reset	V156	8	
14E21	Meas Main Set	V156	16	14I11
14E22	Dito Reset	V156	32	
14E23	Trip CB Set	V156	64	14I12
14E24	Dito Reset	V156	128	
14E25	Start R+S+T Set	V156	256	14I13
14E26	Dito Reset	V156	512	
14E27	Com Send Set	V156	1024	14I14
14E28	Dito Reset	V156	2048	
14E29	Dist Blocked Set	V156	4096	14I15
14E30	Dito Reset	V156	8192	

Event No.	Cause	Event mask	Enable code	Status
14E31	FreqDev Set	V156	16384	14I16
14E32	Dito Reset	V156	32768	
14E33	Start R Set	V157	1	14I17
14E34	Dito Reset	V157	2	
14E35	Start S Set	V157	4	14I18
14E36	Dito Reset	V157	8	
14E37	Start T Set	V157	16	14I19
14E38	Dito Reset	V157	32	
14E39	Start E Set	V157	64	14I20
14E40	Dito Reset	V157	128	
14E41	Start I> Set	V157	256	14I21
14E42	Dito Reset	V157	512	
14E43	Start Z< Set	V157	1024	14I22
14E44	Dito Reset	V157	2048	
14E45	Delay 2 Set	V157	4096	14I23
14E46	Dito Reset	V157	8192	
14E47	Delay 3 Set	V157	16384	14I24
14E48	Dito Reset	V157	32768	
14E49	Delay 4 Set	V158	1	14I25
14E50	Dito Reset	V158	2	
14E51	Delay Def Set	V158	4	14I26
14E52	Dito Reset	V158	8	
14E53	Start RST Set	V158	16	14I27
14E54	Dito Reset	V158	32	
14E55	Weak infeed Set	V158	64	14I28
14E56	Dito Reset	V158	128	
14E57	Meas Bward Set	V158	256	14I29
14E58	Dito Reset	V158	512	
14E59	Trip CB 3P Set	V158	1024	14I30
14E60	Dito Reset	V158	2048	
14E61	Trip CB 1P Set	V158	4096	14I31
14E62	Dito Reset	V158	8192	

Event No.	Cause	Event mask	Enable code	Status
15E1	Trip RST Set	V155	1	15I1
15E2	Dito Reset	V155	2	
15E3	Trip Com Set	V155	4	15I2
15E4	Dito Reset	V155	8	
15E5	Delay 1 Set	V155	16	15I3
15E6	Dito Reset	V155	32	
15E7	Com Boost Set	V155	64	15I4
15E8	Dito Reset	V155	128	
15E9	Trip Stub Set	V155	256	15I5
15E10	Dito Reset	V155	512	
15E11	VTSup Set	V155	1024	15I6
15E12	Dito Reset	V155	2048	
15E13	VTSup Delay Set	V155	4096	15I7
15E14	Dito Reset	V155	8192	
15E15	Start R Aux Set	V155	16384	15I8
15E16	Dito Reset	V155	32768	
15E17	Start S Aux Set	V156	1	15I9
15E18	Dito Reset	V156	2	
15E19	Start T Aux Set	V156	4	15I10
15E20	Dito Reset	V156	8	
15E21	Start E Aux Set	V156	16	15I11
15E22	Dito Reset	V156	32	
15E23	Start RST Aux Set	V156	64	15I12
15E24	Dito Reset	V156	128	
15E25	Trip RST Aux Set	V156	256	15I13
15E26	Dito Reset	V156	512	
15E27	Start SOFT Set	V156	1024	15I14
15E28	Dito Reset	V156	2048	
15E29	Delay >= 2 Set	V156	4096	15I15
15E30	Dito Reset	V156	8192	



Event No.	Cause	Event mask	Enable code	Status
15E31	Meas Fward Set	V156	16384	15I16
15E32	Dito Reset	V156	32768	
15E33	BOOL_OUT1 Set	V157	1	15I17
15E34	Dito Reset	V157	2	
15E35	BOOL_OUT2 Set	V157	4	15I18
15E36	Dito Reset	V157	8	
15E37	BOOL_OUT3 Set	V157	16	15I19
15E38	Dito Reset	V157	32	
15E39	BOOL_OUT4 Set	V157	64	15I20
15E40	Dito Reset	V157	128	
15E41	BOOL_OUT5 Set	V157	256	15I21
15E42	Dito Reset	V157	512	
15E43	BOOL_OUT6 Set	V157	1024	15I22
15E44	Dito Reset	V157	2048	
15E45	BOOL_OUT7 Set	V157	4095	15I23
15E46	Dito Reset	V157	8192	
15E47	BOOL_OUT8 Set	V157	16384	15I24
15E48	Dito Reset	V157	32768	
15E49	Start 1ph Set	V158	1	15I25
15E50	Dito Reset	V158	2	
15E51	DelDistBlock Set	V158	4	15I26
15E52	Dito Reset	V158	8	

**9.6.32. Frequency 25****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		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	Dito Reset	V155	2	
14E3	Trip Set	V155	4	14I2
14E4	Dito Reset	V155	8	
14E5	Start Set	V155	16	14I3
14E6	Dito Reset	V155	32	

**9.6.33. Overexcitat 26****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		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	Dito Reset	V155	2	
14E3	Start Set	V155	4	14I2
14E4	Dito Reset	V155	8	

**9.6.34. Count 27****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		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	Dito Reset	V155	2	
14E3	Start Set	V155	4	14I2
14E4	Dito Reset	V155	8	

**9.6.35. Overtemp. 28****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		00000000B			
14S9	R	Theta-Begin	%	100	000	100	001
14S10	R	Theta-Warn	%	105	050	200	001
14S11	R	Theta-Trip	%	110	050	200	001
14S12	R	Temp.-coeff.	1/ThetaN	0.00	0.00	1.00	0.01
14S13	R	k-Wert		1	1	9	1
14S14	R	NrOfPhases		1	1	3	2
14S15	R	TimeConstant	min	005.0	000.0	500.0	000.1
14S16	R	ResponseTime	min	0000.	0005.	6000.	0001.
14S17	R	h [ 1]		00.00	-00.20	02.00	00.01
14S18	R	h [ 2]		00.00	-00.20	02.00	00.01
14S19	R	h [ 3]		00.00	-00.20	02.00	00.01
14S20	R	h [ 4]		00.00	-00.20	02.00	00.01
14S21	R	h [ 5]		00.00	-00.20	02.00	00.01
14S22	R	h [ 6]		00.00	-00.20	02.00	00.01
14S23	R	h [ 7]		00.00	-00.20	02.00	00.01
14S24	R	h [ 8]		00.00	-00.20	02.00	00.01

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S25	R	h [ 9]		00.00	-00.20	02.00	00.01
14S26	R	h [10]		00.00	-00.20	02.00	00.01
14S27	R	h [11]		00.00	-00.20	02.00	00.01
14S28	R	h [12]		00.00	-00.20	02.00	00.01
14S29	R	h [13]		00.00	-00.20	02.00	00.01
14S30	R	h [14]		00.00	-00.20	02.00	00.01
14S31	R	h [15]		00.00	-00.20	02.00	00.01
14S32	R	h [16]		00.00	-00.20	02.00	00.01
14S33	R	h [17]		00.00	-00.20	02.00	00.01
14S34	R	h [18]		00.00	-00.20	02.00	00.01
14S35	R	h [19]		00.00	-00.20	02.00	00.01
14S36	R	h [20]		00.00	-00.20	02.00	00.01
14S37	R	h [21]		00.00	-00.20	02.00	00.01
14S38	R	h [22]		00.00	-00.20	02.00	00.01
14S39	R	h [23]		00.00	-00.20	02.00	00.01
14S40	R	h [24]		00.00	-00.20	02.00	00.01
14S41	R	h [25]		00.00	-00.20	02.00	00.01
14S42	R	h [26]		00.00	-00.20	02.00	00.01
14S43	R	h [27]		00.00	-00.20	02.00	00.01
14S44	R	h [28]		00.00	-00.20	02.00	00.01
14S45	R	h [29]		00.00	-00.20	02.00	00.01
14S46	R	h [30]		00.00	-00.20	02.00	00.01
14S47	R	h [31]		00.00	-00.20	02.00	00.01
14S48	R	h [32]		00.00	-00.20	02.00	00.01
14S49	R	h [33]		00.00	-00.20	02.00	00.01
14S50	R	h [34]		00.00	-00.20	02.00	00.01

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S51	R	h [35]		00.00	-00.20	02.00	00.01
14S52	R	h [36]		00.00	-00.20	02.00	00.01
14S53	R	h [37]		00.00	-00.20	02.00	00.01
14S54	R	h [38]		00.00	-00.20	02.00	00.01
14S55	R	h [39]		00.00	-00.20	02.00	00.01
14S56	R	h [40]		00.00	-00.20	02.00	00.01
14S57	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	Dito Reset	V155	2	
14E3	Trip Set	V155	4	14I2
14E4	Dito Reset	V155	8	

**9.6.36. Check-I3ph 29****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		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	Dito Reset	V155	2	



**9.6.37. Check-U3ph 30****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		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	Dito Reset	V155	2	

**9.6.38. Logic 31****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		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	V155	1	1411
14E2	Dito	V155	2	

**9.6.39. Disturbance Rec 32****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
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
		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				

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S18	R	BinInp 4	<Select>	No trig	0	2	1
		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				

Address	Access	Text	Unit	Default	Min.	Max.	Step
		Inv. Trigger	2				
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	V155	1	1411
14E2	Dito	V155	2	
14E3	Mem full	V155	4	1412
14E4	Dito	V155	8	

**9.6.40. Voltage-Inst 36****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		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	Dito Reset	V155	2	
14E3	Start Set	V155	4	1412
14E4	Dito Reset	V155	8	

**9.6.41. Autoreclosure 38****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
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				

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S15	R	ZE 3. AR	<Select>	off	0	1	1
		off	0				
		on	1				
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



Address	Access	Text	Unit	Default	Min.	Max.	Step
14S39	R	TMSEC_Timer8	ms	0	0	30000	1
14S40	R	CB Close 01-08		00000000B			
14S41	R	CB Close 09-16		00000000B			
14S42	R	CB Close 17-24		00000000B			
14S43	R	CB Close 25-32		00000000B			
14S44	R	CB2 Close 01-08		00000000B			
14S45	R	CB2 Close 09-16		00000000B			
14S46	R	CB2 Close 17-24		00000000B			
14S47	R	CB2 Close 25-32		00000000B			

### Event list

Event No.	Cause	Event mask	Enable code	Status
14E1	CB Close Set	V155	1	14I1
14E2	Dito Reset	V155	2	
14E3	CB2 Close Set	V155	4	14I2
14E4	Dito Reset	V155	8	
14E5	Trip 3-Pol Set	V155	16	14I3
14E6	Dito Reset	V155	32	
14E7	ZExtension Set	V155	64	14I4
14E8	Dito Reset	V155	128	
14E9	Def. Trip Set	V155	256	14I5
14E10	Dito Reset	V155	512	
14E11	Delay Flwr. Set	V155	1024	14I6
14E12	Dito Reset	V155	2048	
14E13	Blk. to Flwr Set	V155	4096	14I7
14E14	Dito Reset	V155	8192	
14E15	Inhibit Outp Set	V155	16384	14I8
14E16	Dito Reset	V155	32768	
14E17	AR Ready Set	V156	1	14I9
14E18	Dito Reset	V156	2	
14E19	AR Blocked Set	V156	4	14I10
14E20	Dito Reset	V156	8	

Event No.	Cause	Event mask	Enable code	Status
14E21	AR in Prog Set	V156	16	14I11
14E22	Dito Reset	V156	32	
14E23	First AR 1P Set	V156	64	14I12
14E24	Dito Reset	V156	128	
14E25	First AR 3P Set	V156	256	14I13
14E26	Dito Reset	V156	512	
14E27	Second AR Set	V156	1024	14I14
14E28	Dito Reset	V156	2048	
14E29	Third AR Set	V156	4096	14I15
14E30	Dito Reset	V156	8192	
14E31	Fourth AR Set	V156	16384	14I16
14E32	Dito Reset	V156	32768	
14E33	P_OUTPUT1 Set	V157	1	14I17
14E34	Dito Reset	V157	2	
14E35	P_OUTPUT2 Set	V157	4	14I18
14E36	Dito Reset	V157	8	
14E37	P_OUTPUT3 Set	V157	16	14I19
14E38	Dito Reset	V157	32	
14E39	P_OUTPUT4 Set	V157	64	14I20
14E40	Dito Reset	V157	128	
14E41	P_OUTPUT5 Set	V157	256	14I21
14E42	Dito Reset	V157	512	
14E43	P_OUTPUT6 Set	V157	1024	14I22
14E44	Dito Reset	V157	2048	
14E45	P_OUTPUT7 Set	V157	4096	14I23
14E46	Dito Reset	V157	8192	
14E47	P_OUTPUT8 Set	V157	16384	14I24
14E48	Dito Reset	V157	32768	

**9.6.42. EarthFaultsol 40****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		00000000B			
14S9	R	P-Setting	PN	0.050	0.005	0.100	0.001
14S10	R	Angle	Degree	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.	Degree	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	Dito Reset	V155	2	
14E3	Start Set	V155	4	14I2
14E4	Dito Reset	V155	8	

**9.6.43. Voltage-Bal 41****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		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**

<b>Event No.</b>	<b>Cause</b>	<b>Event mask</b>	<b>Enable code</b>	<b>Status</b>
14E1	Trip Set	V155	1	14I1
14E2	Dito Reset	V155	2	
14E3	Start Set	V155	4	14I2
14E4	Dito Reset	V155	8	
14E5	Trip-Line1 Set	V155	16	14I3
14E6	Dito Reset	V155	32	
14E7	Trip-Line2 Set	V155	64	14I1
14E8	Dito Reset	V155	28	

**9.6.44. U/f-Inv 47****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		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	Dito Reset	V155	2	
14E3	Start Set	V155	4	14I2
14E4	Dito Reset	V155	8	

**9.6.45. UifPQ 48****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S9	R	Angle	Degree	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



**9.6.46. SynchroCheck 49****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		00000000B			
14S9	R	maxVoltDif	UN	0.20	0.05	0.40	0.05
14S10	R	maxPhaseDif	Degree	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	Degree (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	Degree (dPhi)	2
14Q3	R	Hz ( df )	2

**Event list**

Event No.	Cause	Event mask	Enable code	Status
4E1	PermitToClos Set	V155	1	14I1
14E2	Dito Reset	V155	2	
14E3	Start Set	V155	4	14I2
14E4	Dito Reset	V155	8	
14E5	SyncBlockd Set	V155	16	14I3
14E6	Dito Reset	V155	32	
14E7	TrigBlockd Set	V155	64	14I4
14E8	Dito Reset	V155	128	
14E9	SyncOverrid Set	V155	256	14I5
14E10	Dito Reset	V155	512	
14E11	AmplDifOK Set	V155	1024	14I6
14E12	Dito Reset	V155	2048	
14E13	PhaseDifOK Set	V155	4096	14I7
14E14	Dito Reset	V155	8192	
14E15	FreqDifOK Set	V155	16384	14I8
14E16	Dito Reset	V155	32768	
14E17	LiveBus Set	V156	1	14I9
14E18	Dito Reset	V156	2	
14E19	DeadBus Set	V156	4	14I10
14E20	Dito Reset	V156	8	
14E21	LiveLine Set	V156	16	14I11
14E22	Dito Reset	V156	32	
14E23	DeadLine Set	V156	64	14I12
14E24	Dito Reset	V156	128	

**9.6.47. Rotor-EFP****51****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		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	Dito Reset	V155	2	
14E3	Start Trip Set	V155	4	14I2
14E4	Dito Reset	V155	8	
14E5	Alarm Set	V155	16	14I3
14E6	Dito Reset	V155	32	
14E7	Start Alarm Set	V155	64	14I4
14E8	Dito Reset	V155	128	
14E9	InterruptInt Set	V155	256	14I5
14E10	Dito Reset	V155	512	
14E11	InterruptExt Set	V155	1024	14I6
14E12	Dito Reset	V155	2048	
14E13	Rer-Adjust Set	V155	4096	14I7
14E14	Dito Reset	V155	8192	
14E15	CoupC-Adjust SetSet	V155	16384	14I8
14E16	Dito Reset	V155	32768	
14E17	Extern-Block Set	V156	1	14I9
14E18	Dito Reset	V156	2	

**9.6.48. Stator-EFP****52****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		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	MTR	1
14V3	R	REs" (kOhm)	2

**Tripping levels**

Address	Access	Text	Dec.
14Q1	R	Rfs (kOhm)	1
14Q2	R	MTR	1
14Q3	R	REs" (kOhm)	2

**Event list**

Event No.	Cause	Event mask	Enable code	Status
14E1	Trip Set	V155	1	14I1
14E2	Dito Reset	V155	2	
14E3	Start Trip Set	V155	4	14I2
14E4	Dito Reset	V155	8	
14E5	Alarm Set	V155	16	14I3
14E6	Dito Reset	V155	32	
14E7	Start Alarm Set	V155	64	14I4
14E8	Dito Reset	V155	128	
14E9	InterruptInt Set	V155	256	14I5
14E10	Dito Reset	V155	512	
14E11	InterruptExt Set	V155	1024	14I6
14E12	Dito Reset	V155	2048	
14E13	2.Starpt Set	V155	4096	14I7
14E14	Dito Reset	V155	8192	
14E15	MTR-Adjust Set	V155	16384	14I8
14E16	Dito Reset	V155	32768	
14E17	Res-Adjust Set	V156	1	14I9
14E18	Dito Reset	V156	2	
14E19	Extern-Block Set	V156	4	14I10
14E20	Dito Reset	V156	8	

**9.6.49. 10-Invers****53****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		00000000B			
14S9	R	c-Setting	<Select>	1.00	0	2	1
		0.02	0				
		1.00	1				
		2.00	2				
		RxIDG					
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	0.04	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	Dito Reset	V155	2	
14E3	Start Set	V155	4	14I2
14E4	Dito Reset	V155	8	



**9.6.50. Pole-Slip 55****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU1	1	2	1
		CPU1	1				
		CPU2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip1 01-08		00000000B			
14S6	R	Trip1 09-16		00000000B			
14S7	R	Trip1 17-24		00000000B			
14S8	R	Trip1 25-32		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	Degree	090	60	270	1
14S13	R	WarnAngle	Degree	000	0	180	1
14S14	R	TripAngle	Degree	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**

<b>Event No.</b>	<b>Cause</b>	<b>Event mask</b>	<b>Enable code</b>	<b>Status</b>
14E1	Warning Set	V155	1	14I1
14E2	Dito Reset	V155	2	
14E3	Generator SetSet	V155	4	14I2
14E4	Dito Reset	V155	8	
14E5	Motor Set	V155	16	14I3
14E6	Dito Reset	V155	32	
14E7	Zone1 Set	V155	64	14I4
14E8	Dito Reset	V155	128	
14E9	Zone2 Set	V155	256	14I5
14E10	Dito Reset	V155	512	
14E11	Trip1 Set	V155	1024	14I6
14E12	Dito Reset	V155	2048	
14E13	Trip2 Set	V155	4096	14I7
14E14	Dito Reset	V155	8192	

**9.6.51. EarthFltGnd2 58****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		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	1411
14E2	Dito Reset	V155	2	
14E3	Start Set	V155	4	1412
14E4	Dito Reset	V155	8	
14E5	MeasFwd Set	V155	16	1413
14E6	Dito Reset	V155	32	
14E7	MeasBwd Set	V155	64	1414
14E8	Dito Reset	V155	128	
14E9	Senden Set	V155	256	1415
14E10	Dito Reset	V155	512	
14E11	Recve Inh Set	V155	1024	1416
14E12	Dito Reset	V155	2048	

**9.6.52. FUPLA 59****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
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
14Vn	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.

**9.6.53. Defluttering 60****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
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	State of Input1 Set	V155	1	1411
14E2	Dito Reset	V155	2	
14E3	State of Input2 Set	V155	4	1413
14E4	Dito Reset	V155	8	
14E5	State of Input3 Set	V155	16	1415
14E6	Dito Reset	V155	32	
14E7	State of Input4 Set	V155	64	1417
14E8	Dito Reset	V155	128	
14E9	FlutterMess1 Set	V155	256	1412
14E10	Dito Reset	V155	1024	
14E11	FlutterMess2 Set	V155	512	1414
14E12	Dito Reset	V155	2048	
14E13	FlutterMess3 Set	V155	4096	1416
14E14	Dito Reset	V155	8192	
14E15	FlutterMess4 Set	V155	16384	1418
14E16	Dito Reset	V155	32768	

**9.6.54. 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)	$\Omega/\text{ph}$	000.00	-300	300	0.01
14S10	R	R (1)	$\Omega/\text{ph}$	000.00	-300	300	0.01
14S11	R	RR (1)	$\Omega/\text{ph}$	000.00	-300	300	
14S12	R	RRE (1)	$\Omega/\text{ph}$	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)	$\Omega/\text{ph}$	000.00	-300	300	0.01
14S17	R	R (2)	$\Omega/\text{ph}$	000.00	-300	300	0.01
14S18	R	RR (2)	$\Omega/\text{ph}$	000.00	-300	300	0.01
14S19	R	RRE (2)	$\Omega/\text{ph}$	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)	$\Omega/\text{ph}$	000.00	-300	300	0.01
14S24	R	R (3)	$\Omega/\text{ph}$	000.00	-300	300	0.01
14S25	R	RR (3)	$\Omega/\text{ph}$	000.00	-300	300	0.01
14S26	R	RRE (3)	$\Omega/\text{ph}$	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)	$\Omega$ /ph	000.00	-300	300	0.01
14S31	R	R (4/OR)	$\Omega$ /ph	000.00	-300	300	0.01
14S32	R	RR (4/OR)	$\Omega$ /ph	000.00	-300	300	0.01
14S33	R	RRE (4/OR)	$\Omega$ /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)	$\Omega$ /ph	000.00	-300	0	0.01
14S38	R	R (BACK)	$\Omega$ /ph	000.00	-300	0	0.01
14S39	R	RR (BACK)	$\Omega$ /ph	000.00	-300	0	0.01
14S40	R	RRE (BACK)	$\Omega$ /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	$\Omega$ /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	3I0min	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**

<b>Address</b>	<b>Access</b>	<b>Text</b>	<b>Dec.</b>
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**

<b>Address</b>	<b>Access</b>	<b>Text</b>	<b>Dec.</b>
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	Dito	Reset	V155	2	
14E3	Start U0	Set	V155	4	14I2
14E4	Dito	Reset	V155	8	
14E5	Meas Oreach	Set	V155	16	14I3
14E6	Dito	Reset	V155	32	
14E7	Trip O/C	Set	V155	64	14I4
14E8	Dito	Reset	V155	128	
14E9	Power Swing	Set	V155	256	14I5
14E10	Dito	Reset	V155	512	
14E11	Trip CB R	Set	V155	1024	14I6
14E12	Dito	Reset	V155	2048	
14E13	Trip CB S	Set	V155	4096	14I7
14E14	Dito	Reset	V155	8192	
14E15	Trip CB T	Set	V155	16384	14I8
14E16	Dito	Reset	V155	32768	
14E17	Trip SOFT	Set	V156	1	14I9
14E18	Dito	Reset	V156	2	
14E19	Start O/C	Set	V156	4	14I10
14E20	Dito	Reset	V156	8	
14E21	Meas Main	Set	V156	16	14I11
14E22	Dito	Reset	V156	32	
14E23	Trip CB	Set	V156	64	14I12
14E24	Dito	Reset	V156	128	
14E25	Start R+S+T	Set	V156	256	14I13
14E26	Dito	Reset	V156	512	
14E27	Com Send	Set	V156	1024	14I14
14E28	Dito	Reset	V156	2048	
14E29	Dist Blocked	Set	V156	4096	14I15
14E30	Dito	Reset	V156	8192	

Event No.	Cause	Event mask	Enable code	Status
14E31	FreqDev Set	V156	16384	14I16
14E32	Dito Reset	V156	32768	
14E33	Start R Set	V157	1	14I17
14E34	Dito Reset	V157	2	
14E35	Start S Set	V157	4	14I18
14E36	Dito Reset	V157	8	
14E37	Start T Set	V157	16	14I19
14E38	Dito Reset	V157	32	
14E39	Start E Set	V157	64	14I20
14E40	Dito Reset	V157	128	
14E41	Delay 2 Set	V157	256	14I21
14E42	Dito Reset	V157	512	
14E43	Delay 3 Set	V157	1024	14I22
14E44	Dito Reset	V157	2048	
14E45	Delay 4 Set	V157	4096	14I23
14E46	Dito Reset	V157	8192	
14E47	Delay Def Set	V157	16384	14I24
14E48	Dito Reset	V157	32768	
14E49	Start RST Set	V158	1	14I25
14E50	Dito Reset	V158	2	
14E51	Weak Set	V158	4	14I26
14E52	Dito Reset	V158	8	
14E53	Meas Bward Set	V158	16	14I27
14E54	Dito Reset	V158	32	
14E55	Trip CB 3P Set	V158	64	14I28
14E56	Dito Reset	V158	128	
14E57	Trip CB 1P Set	V158	256	14I29
14E58	Dito Reset	V158	512	
14E59	Trip RST Set	V158	1024	14I30
14E60	Dito Reset	V158	2048	

Event No.	Cause		Event mask	Enable code	Status
14E61	Trip Com	Set	V158	4096	14I31
14E62	Dito	Reset	V158	8192	
15E1	Delay 1	Set	V155	1	15I1
15E2	Dito	Reset	V155	2	
15E3	Com Boost	Set	V155	4	15I2
15E4	Dito	Reset	V155	8	
15E5	Trip Stub	Set	V155	16	15I3
15E6	Dito	Reset	V155	32	
15E7	VTSup	Set	V155	64	15I4
15E8	Dito	Reset	V155	128	
15E9	VTSup Delay	Set	V155	256	15I5
15E10	Dito	Reset	V155	512	
15E11	Start R Aux	Set	V155	1024	15I6
15E12	Dito	Reset	V155	2048	
15E13	Start S Aux	Set	V155	4096	15I7
15E14	Dito	Reset	V155	8192	
15E15	Start T Aux	Set	V155	16384	15I8
15E16	Dito	Reset	V155	32768	
15E17	Start E Aux	Set	V156	1	15I9
15E18	Dito	Reset	V156	2	
15E19	Start RST Aux	Set	V156	4	15I10
15E20	Dito	Reset	V156	8	
15E21	Trip RST Aux	Set	V156	16	15I11
15E22	Dito	Reset	V156	32	
15E23	Start SOFT	Set	V156	64	15I12
15E24	Dito	Reset	V156	128	
15E25	Delay >= 2	Set	V156	256	15I13
15E26	Dito	Reset	V156	512	
15E27	Meas Fward	Set	V156	1024	15I14
15E28	Dito	Reset	V156	2048	

Event No.	Cause		Event mask	Enable code	Status
15E29	BOOL_OUT1	Set	V156	4096	15I15
15E30	Dito	Reset	V156	8192	
15E31	BOOL_OUT2	Set	V156	16384	15I16
15E32	Dito	Reset	V156	32768	
15E33	BOOL_OUT3	Set	V157	1	15I17
15E34	Dito	Reset	V157	2	
15E35	BOOL_OUT4	Set	V157	4	15I18
15E36	Dito	Reset	V157	8	
15E37	BOOL_OUT5	Set	V157	16	15I19
15E38	Dito	Reset	V157	32	
15E39	BOOL_OUT6	Set	V157	64	15I20
15E40	Dito	Reset	V157	128	
15E41	BOOL_OUT7	Set	V157	256	15I21
15E42	Dito	Reset	V157	512	
15E43	BOOL_OUT8	Set	V157	1024	15I22
15E44	Dito	Reset	V157	2048	
15E45	Start 1ph	Set	V157	4096	15I23
15E46	Dito	Reset	V157	8192	
15E47	DelDistBlock	Set	V157	16384	15I24
15E48	Dito	Reset	V157	32768	



**9.6.55. df/dt 69****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		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
14Q2	R	Hz	3

**Event list**

Event No.	Cause	Event mask	Enable code	Status
14E1	Blocked (U<) Set	V155	1	14I1
14E2	Dito Reset	V155	2	
14E3	Trip Set	V155	4	14I2
14E4	Dito Reset	V155	8	

**9.6.56. DirCurrentDT 70****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		00000000B			
14S9	R	I-Setting	IN	2.00	0.20	20.00	0.01
14S10	R	Angle	Degree	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	MemDir Mode	<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 <sub>R</sub> , U <sub>ST</sub> )	3
14Q5	R	PN (I <sub>S</sub> , U <sub>TR</sub> )	3
14Q6	R	PN (I <sub>T</sub> , U <sub>RS</sub> )	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	Dito Reset	V155	2	
14E3	Start Set	V155	4	14I2
14E4	Dito Reset	V155	8	
14E5	Start R Set	V155	16	14I3
14E6	Dito Reset	V155	32	
14E7	Start S Set	V155	64	14I4
14E8	Dito Reset	V155	128	
14E9	Start T Set	V155	256	14I5
14E10	Dito Reset	V155	512	
14E11	MeasFwd Set	V155	1024	14I6
14E12	Dito Reset	V155	2048	
14E13	MeasBwd Set	V155	4096	14I7
14E14	Dito Reset	V155	8192	

**9.6.57. DirCurrentInv 71****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	Trip 01-08		00000000B			
14S6	R	Trip 09-16		00000000B			
14S7	R	Trip 17-24		00000000B			
14S8	R	Trip 25-32		00000000B			
14S9	R	I-Start	IB	1.10	1.00	4.00	0.01
14S10	R	Angle	Degree	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 <sub>R</sub> , U <sub>ST</sub> )	3
14V5	R	PN (I <sub>S</sub> , U <sub>TR</sub> )	3
14V6	R	PN (I <sub>T</sub> , U <sub>RS</sub> )	3

Address	Access	Text	Dec.
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 <sub>R</sub> , U <sub>ST</sub> )	3
14Q5	R	PN (I <sub>S</sub> , U <sub>TR</sub> )	3
14Q6	R	PN (I <sub>T</sub> , U <sub>RS</sub> )	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	Dito Reset	V155	2	
14E3	Start Set	V155	4	14I2
14E4	Dito Reset	V155	8	
14E5	Start R Set	V155	16	14I3
14E6	Dito Reset	V155	32	
14E7	Start S Set	V155	64	14I4
14E8	Dito Reset	V155	128	
14E9	Start T Set	V155	256	14I5
14E10	Dito Reset	V155	512	
14E11	MeasFwd Set	V155	1024	14I6
14E12	Dito Reset	V155	2048	
14E13	MeasBwd Set	V155	4096	14I7
14E14	Dito Reset	V155	8192	

**9.6.58. BreakerFailure 72****Basic channel No.: 14****Summary of parameters:**

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S2	R	RunOnCPU	<Select>	CPU 1	1	2	1
		CPU 1	1				
		CPU 2	2				
14S4	R	ParSet4..1	<Select>	P1	00000010B	00011110B	
14S5	R	23105 TRIP t1 01-08		00000000B			
14S6	R	23105 TRIP t1 09-16		00000000B			
14S7	R	23105 TRIP t1 17-24		00000000B			
14S8	R	23105 TRIP t1 25-32		00000000B			
14S9	R	23110 TRIP t1 L1 01-08		00000000B			
14S10	R	23110 TRIP t1 L1 09-16		00000000B			
14S11	R	23110 TRIP t1 L1 17-24		00000000B			
14S12	R	23110 TRIP t1 L1 25-32		00000000B			
14S13	R	23115 TRIP t1 L2 01-08		00000000B			
14S14	R	23115 TRIP t1 L2 09-16		00000000B			
14S15	R	23115 TRIP t1 L2 17-24		00000000B			
14S16	R	23115 TRIP t1 L2 25-32		00000000B			
14S17	R	23120 TRIP t1 L3 01-08		00000000B			
14S18	R	23120 TRIP t1 L3 09-16		00000000B			
14S19	R	23120 TRIP t1 L3 17-24		00000000B			
14S20	R	23120 TRIP t1 L3 25-32		00000000B			
14S21	R	23125 TRIP t2 01-08		00000000B			
14S22	R	23125 TRIP t2 09-16		00000000B			
14S23	R	23125 TRIP t2 17-24		00000000B			
14S24	R	23125 TRIP t2 25-32		00000000B			
14S25	R	23130 REMOTE TRIP		00000000B			
14S26	R	23130 REMOTE TRIP		00000000B			
14S27	R	23130 REMOTE TRIP		00000000B			
14S28	R	23130 REMOTE TRIP		00000000B			
14S29	R	23135 RED TRIP L1 01-08		00000000B			
14S30	R	23135 RED TRIP L1 09-16		00000000B			
14S31	R	23135 RED TRIP L1 17-24		00000000B			
14S32	R	23135 RED TRIP L1 25-32		00000000B			

Address	Access	Text	Unit	Default	Min.	Max.	Step
14S33	R	23140 RED TRIP L2 01-08		00000000B			
14S34	R	23140 RED TRIP L2 09-16		00000000B			
14S35	R	23140 RED TRIP L2 17-24		00000000B			
14S36	R	23140 RED TRIP L2 25-32		00000000B			
14S37	R	23145 RED TRIP L3 01-08		00000000B			
14S38	R	23145 RED TRIP L3 09-16		00000000B			
14S39	R	23145 RED TRIP L3 17-24		00000000B			
14S40	R	23145 RED TRIP L3 25-32		00000000B			
14S41	R	23150 EFP REM TRIP 01-08		00000000B			
14S42	R	23150 EFP REM TRIP 09-16		00000000B			
14S43	R	23150 EFP REM TRIP 17-24		00000000B			
14S44	R	23150 EFP REM TRIP 25-32		00000000B			
14S45	R	23155 EFP BUS TRIP 01-08		00000000B			
14S46	R	23155 EFP BUS TRIP 09-16		00000000B			
14S47	R	23155 EFP BUS TRIP 17-24		00000000B			
14S48	R	23155 EFP BUS TRIP 25-32		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 Puls 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	Rem Trip active	<Select>	on	0	1	1
		off	0				
		on	1				
14S59	R	EFP active	<Select>	on	0	1	1
		off	0				
		on	1				

Address	Access	Text	Unit	Default	Min.	Max.	Step
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	Cause	Event	Enable	Status
14E1	23305 Trip t1 Set	V155	1	14I1
14E2	Dito Reset	V155	2	
14E3	23315 Trip t1 L1 Set	V155	4	14I2
14E4	Dito Reset	V155	8	
14E5	23320 Trip t1 L2 Set	V155	16	14I3
14E6	Dito Reset	V155	32	
14E7	23325 Trip t1 L3 Set	V155	64	14I4
14E8	Dito Reset	V155	128	
14E9	23310 Trip t2 Set	V155	256	14I5
14E10	Dito Reset	V155	512	
14E11	23340 Remote Trip Set	V155	1024	14I6
14E12	Dito Reset	V155	2048	
14E13	23345 Red Trip L1 Set	V155	4096	14I7
14E14	Dito Reset	V155	8192	
14E15	23350 Red Trip L2 Set	V155	16384	14I8
14E16	Dito Reset	V155	32768	
14E17	23355 Red Trip L3 Set	V156	1	14I9
14E18	Dito Reset	V156	2	
14E19	23375 EFP Rem Trip Set	V156	4	14I10
14E20	Dito Reset	V156	8	
14E21	23370 EFP Bus Trip Set	V156	16	14I11
14E22	Dito Reset	V156	32	



<b>Event</b>	<b>Cause</b>	<b>Event</b>	<b>Enable</b>	<b>Status</b>
14E23	23330 Retrip t1 Set	V156	64	14I12
14E24	Dito Reset	V156	128	
14E25	23360 Uncon Trip t1 Set	V156	256	14I13
14E26	Dito Reset	V156	512	
14E27	23380 Ext Trip t1 Set	V156	1024	14I14
14E28	Dito Reset	V156	2048	
14E29	23335 Backup Trip t2 Set	V156	4096	14I15
14E30	Dito Reset	V156	8192	
14E29	23365 Uncon Trip t2 Set	V156	16384	14I16
14E30	Dito Reset	V156	32768	

**9.6.59. 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* $\sqrt{3}$	1.000	0.200	2.500	0.001
14S10	R	AngleComp	Deg	0.000	-180	180	0.1
14S11	R	t1-Interval	Select	15 min			
		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	(none)	1.0000	0.0001	1.0000	0.0001
14S13	R	t2-Interval	Select	15 min			
		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	(none)	1.0000	0.0001	1.0000	0.0001

**Measured variables**

<b>Address</b>	<b>Access</b>	<b>Text</b>	<b>Dec.</b>
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**

<b>Address</b>	<b>Access</b>	<b>Text</b>	<b>Dec.</b>
14Q16	R	E1Acc	3
14Q17	R	P1Acc	0
14Q20	R	E2Acc	3
14Q21	R	P2Acc	0

**Event list**

<b>Event No.</b>	<b>Cause</b>	<b>Event mask</b>	<b>Enable code</b>	<b>Status</b>
14E1	Cnt1New Set	V155	1	14I1
14E2	Dito Reset	V155	2	
14E3	Cnt2New Set	V155	4	14I2
14E4	Dito Reset	V155	8	

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## **10. Supplementary information**

### **10.1. *Changes in Version 5.1a in relation to Version 4.5***

LON level 2 is released with and without 216EA61.

Remote HMI, with remote parameterization, Windows Shell.

216EB61 Firmware: V5.1a

When using V5.1a on the 216VC62, V5.1a has to be used on 216EB61 as well.

### **10.2. *Changes in Version 5.1b in relation to Version 5.1a***

#### **10.2.1. *'MinReactance' function***

The 'MinReactance' function can now be connected to Y-connected v.t's.

### **10.3. *Changes in Version 5.1c in relation to Version 5.1b***

#### **10.3.1. *Year 2000 compatibility***

From version V5.1c onwards, all the devices are entirely year 2000 compatible.

#### **10.3.2. *Remote input/output system RIO580***

The remote I/O system is supported from Version 5.1c onwards. RIO580 includes distributed I/O units that are connected to the RE.216 via an MVB process bus and an MVB PC card. Further details are to be found in Data Sheet 1MRB520176-Ben and Operating Instructions 1MRB520192-Uen.

**10.4. Changes in Version 5.2 in relation to Version 5.1c****10.4.1. Rate-of-change of frequency protection  $df/dt$** 

A  $df/dt$  function has been added to the function block library.

**10.4.2. 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 or SMS.

**10.4.3. MVB Process bus**

MVB process bus including RIO580 is released.

**10.4.4. MVB Interbay bus**

MVB interbay bus (MVB-IBB) is not released, V5.1c has to be used for MVB-IBB applications.

**10.5. Changes in Version 6.0 in relation to Version 5.2(a)****10.5.1. 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.

**10.5.2. Breaker failure protection 'BreakerFailure'**

A 'BreakerFailure' function has been added to the function block library.

**10.5.3. Distance, HV-Distance, Autoreclosure**

The functions Distance, HV-Distance, Autoreclosure have been added to the function block library, but have not been released.

**10.6. Changes in Version Version 6.1 in relation to Version 6.0****10.6.1. Analogue input/output unit 500AXM11**

Versions from V6.1 onwards support the analogue input/output unit 500AXM11 of the distributed input/output system RIO580.

**10.6.2. '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.

**10.6.3. 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.

**10.6.4. 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.



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## CHECKLIST GENERATOR PROTECTION

## TEST SHEET

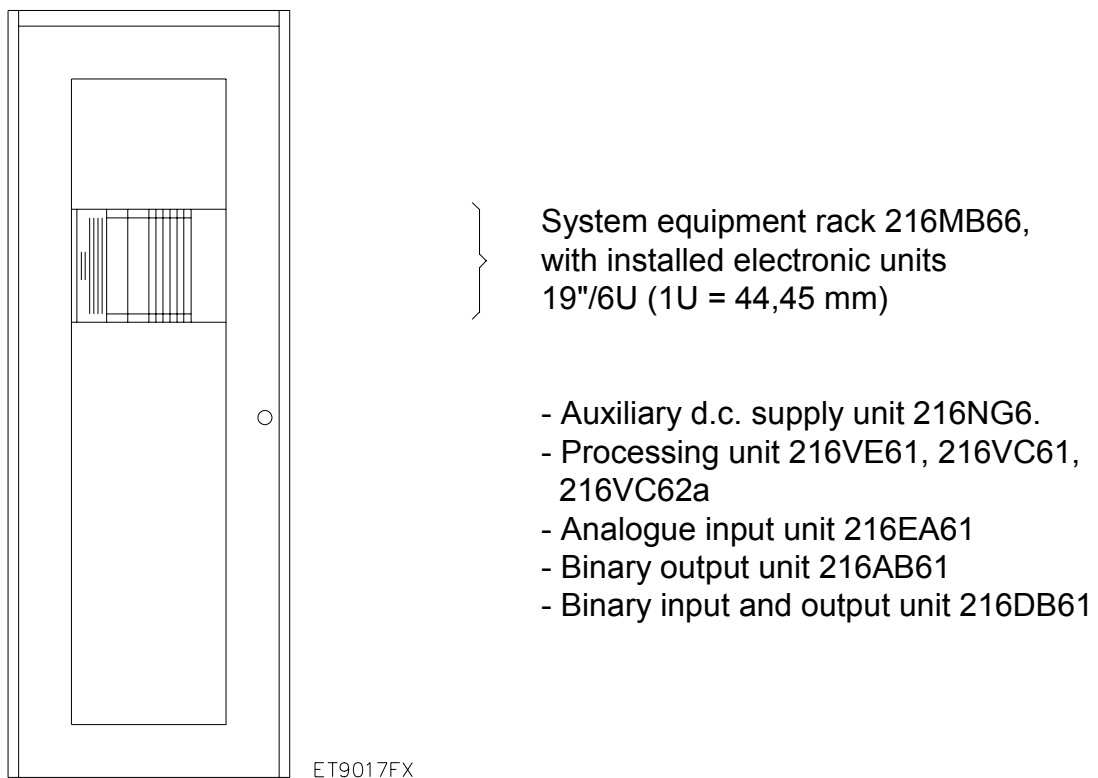


Fig. 12.1 REG 216 protection cubicle; front view

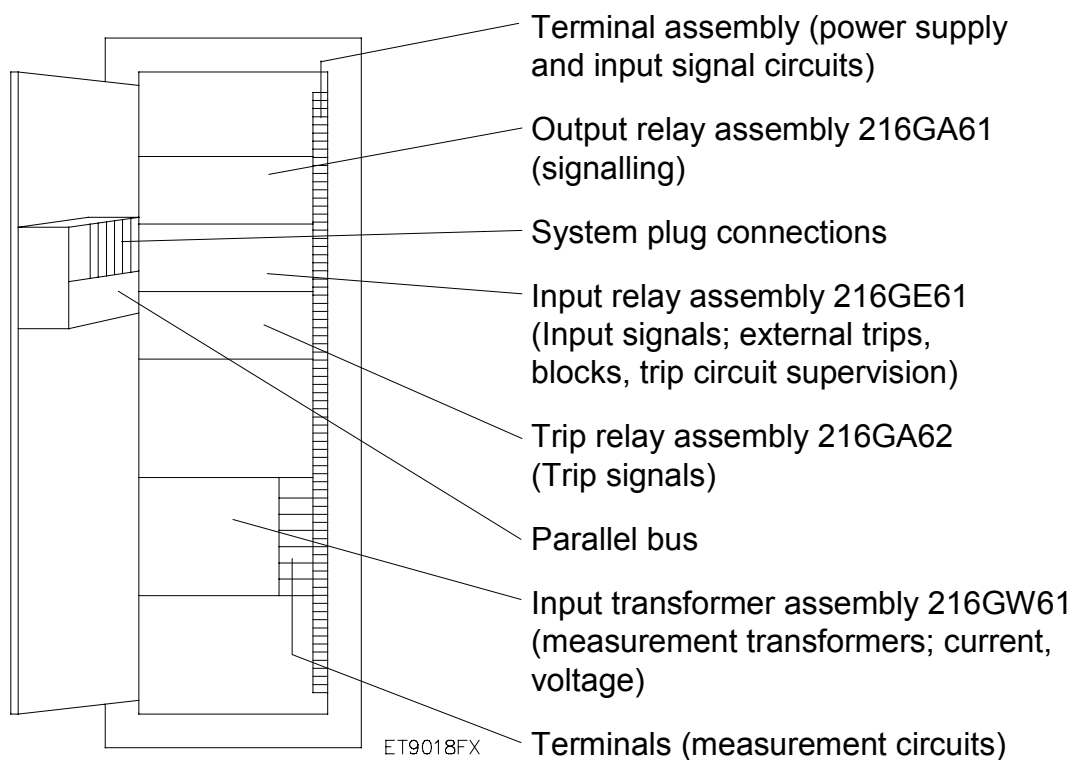


Fig. 12.2 REG 216 protection cubicle; inside view

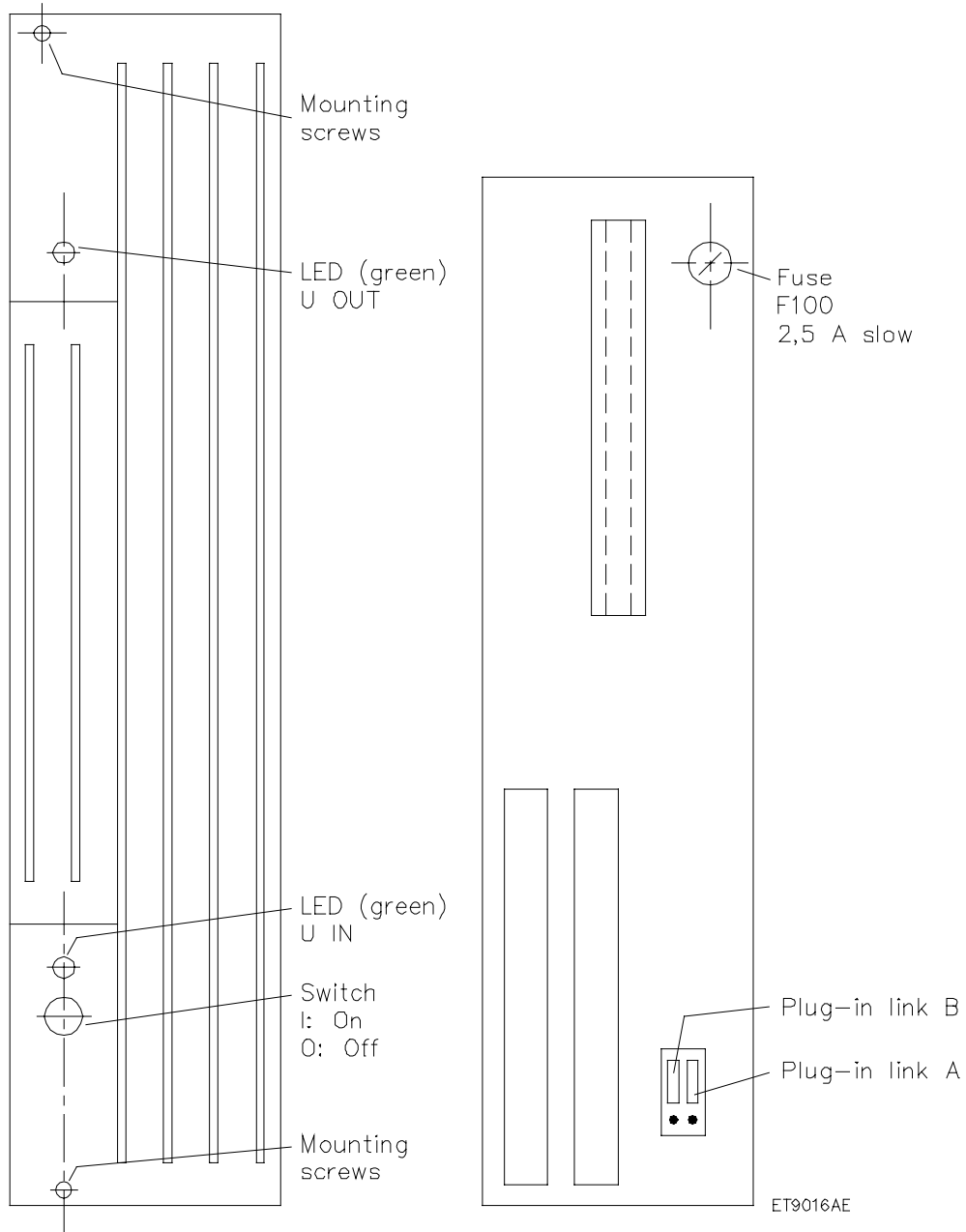


Fig. 12.3 Auxiliary d.c. supply unit 216NG6.;front view

Fig. 12.4 Auxiliary d.c. supply unit 216NG6.; rear view

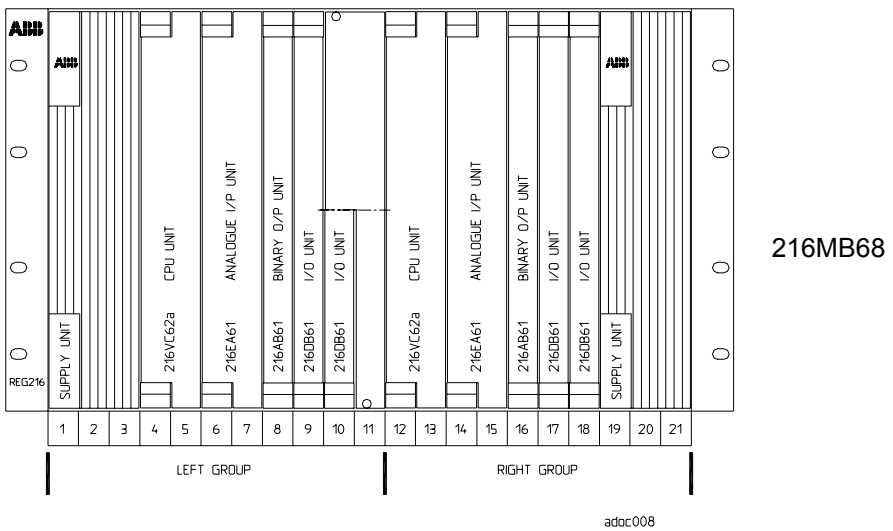
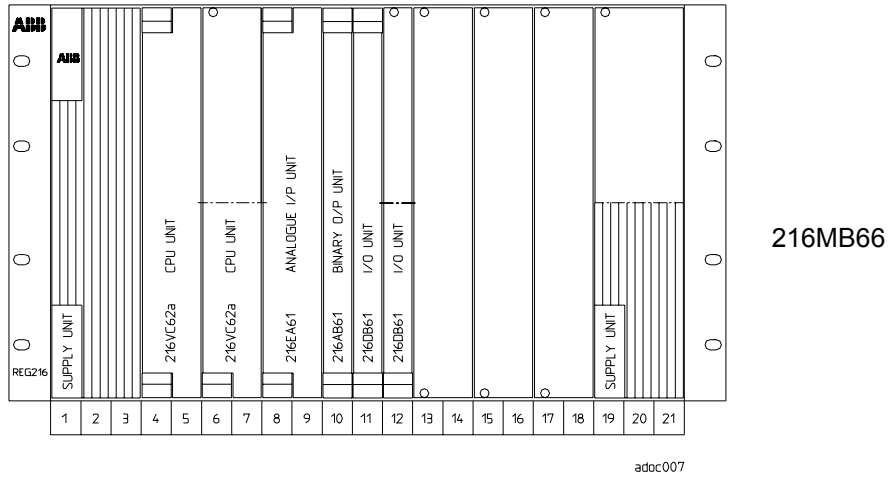


Fig. 12.5 System equipment rack 216MB66/216MB68; front view

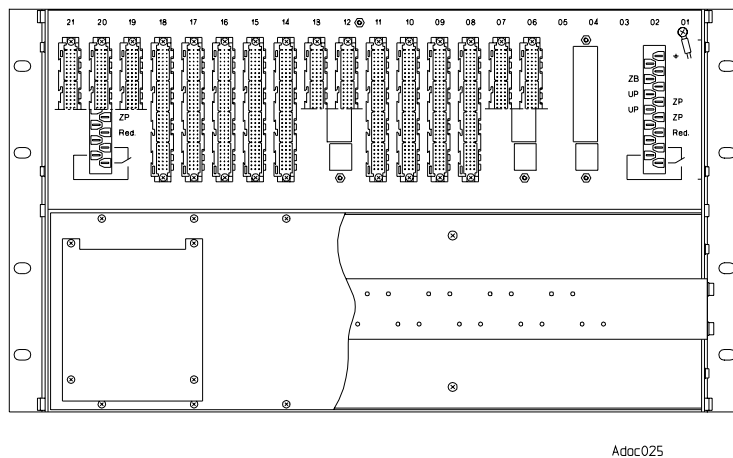


Fig. 12.6 System equipment rack 216MB66/216MB68; rear view

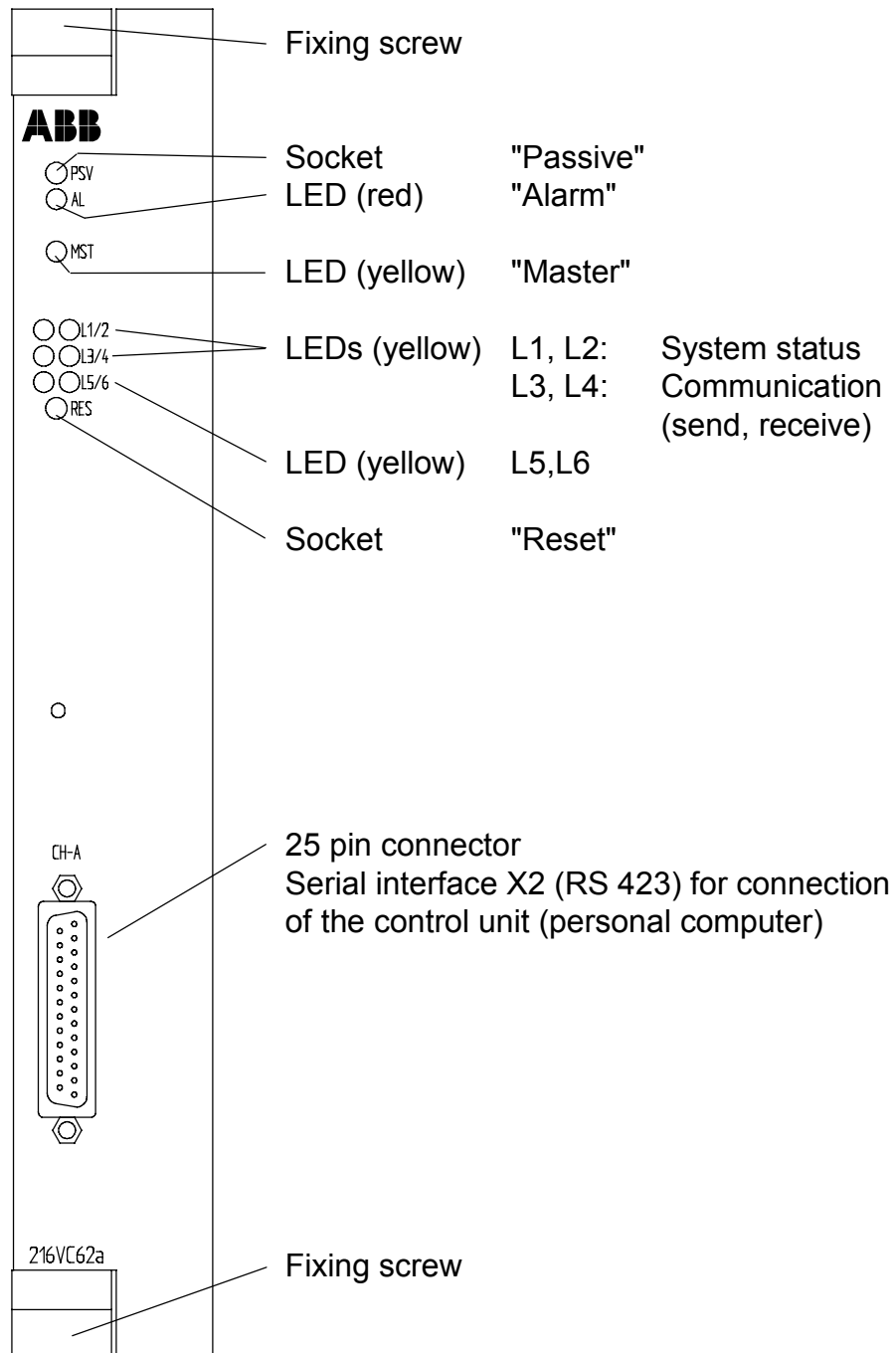


Fig. 12.7 Processing unit 216VC62a; front view

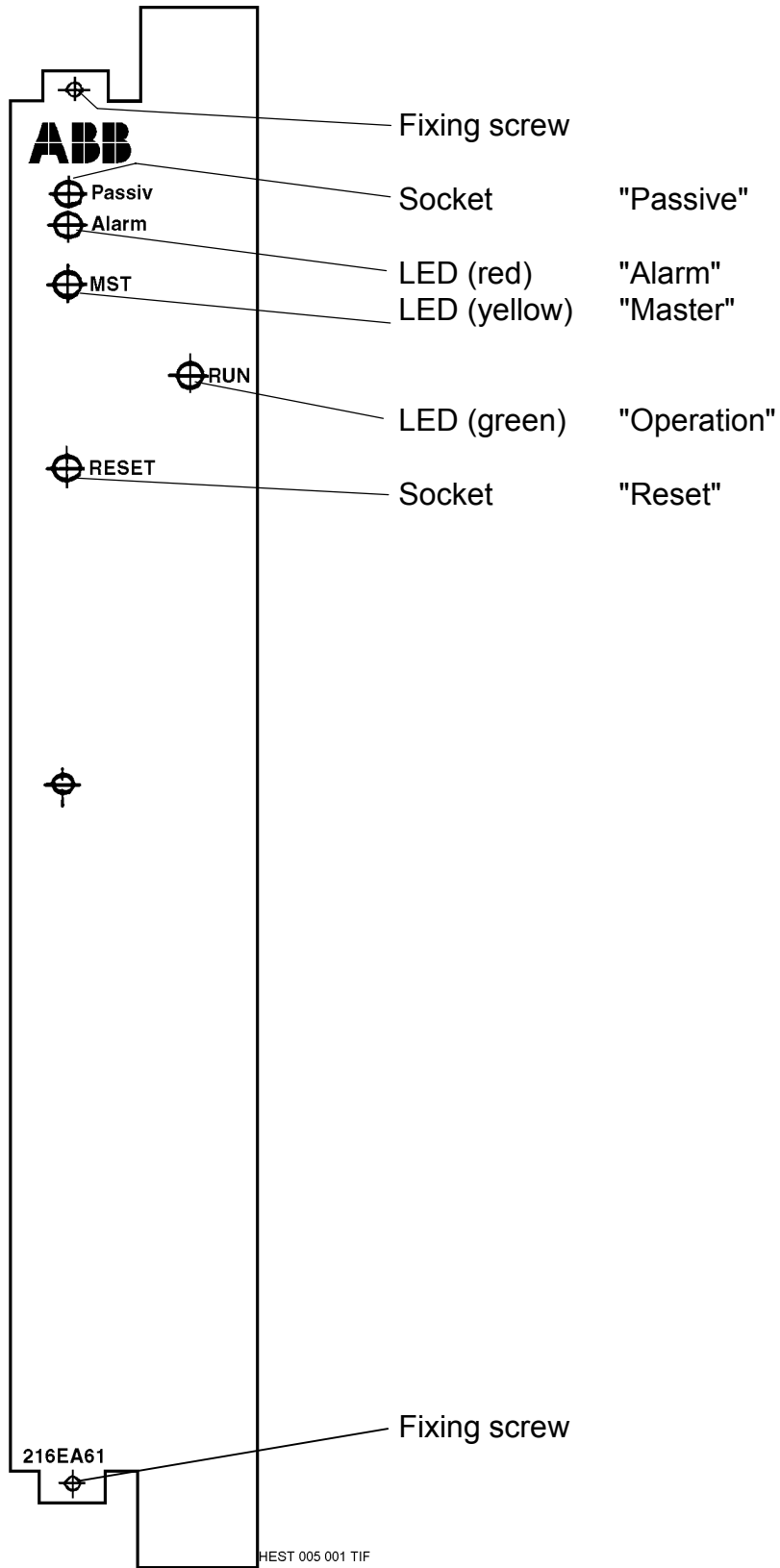


Fig. 12.8 Analogue input unit 216EA61; front view (corresponds to HESG 324 096)

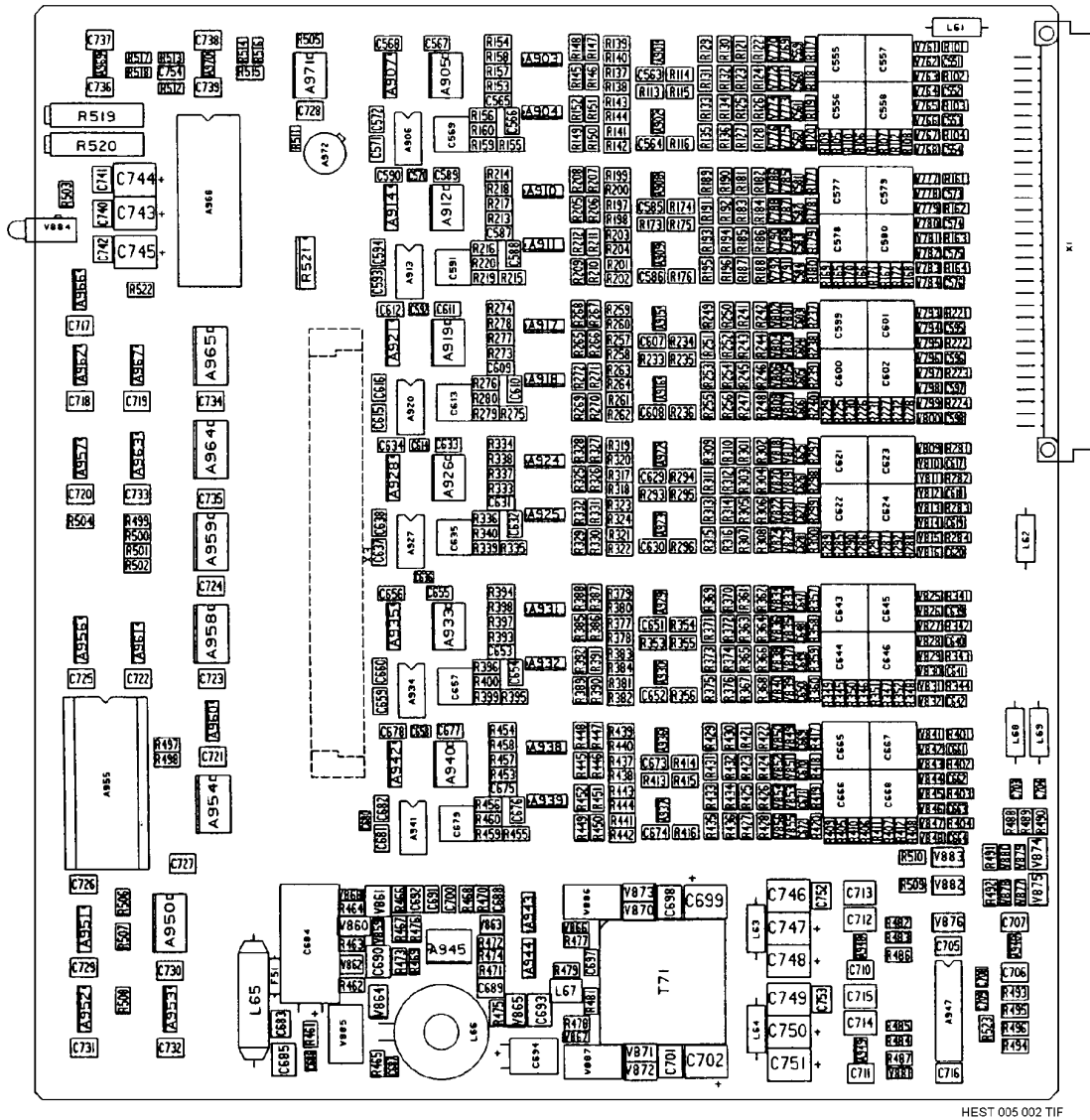


Fig. 12.9 Analogue input unit 216EA61; component side of the PCB (corresponds to HESG 324 015)



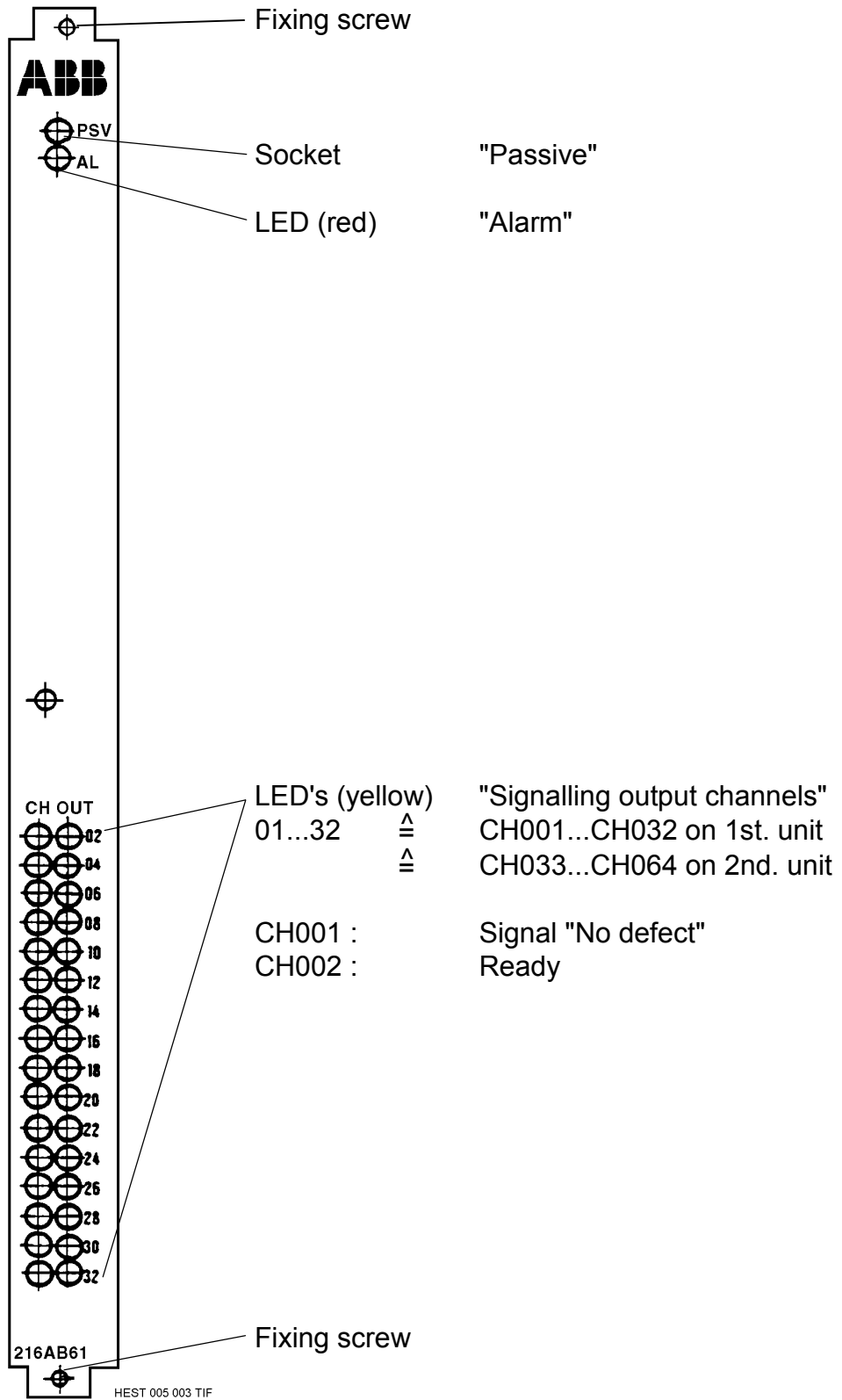
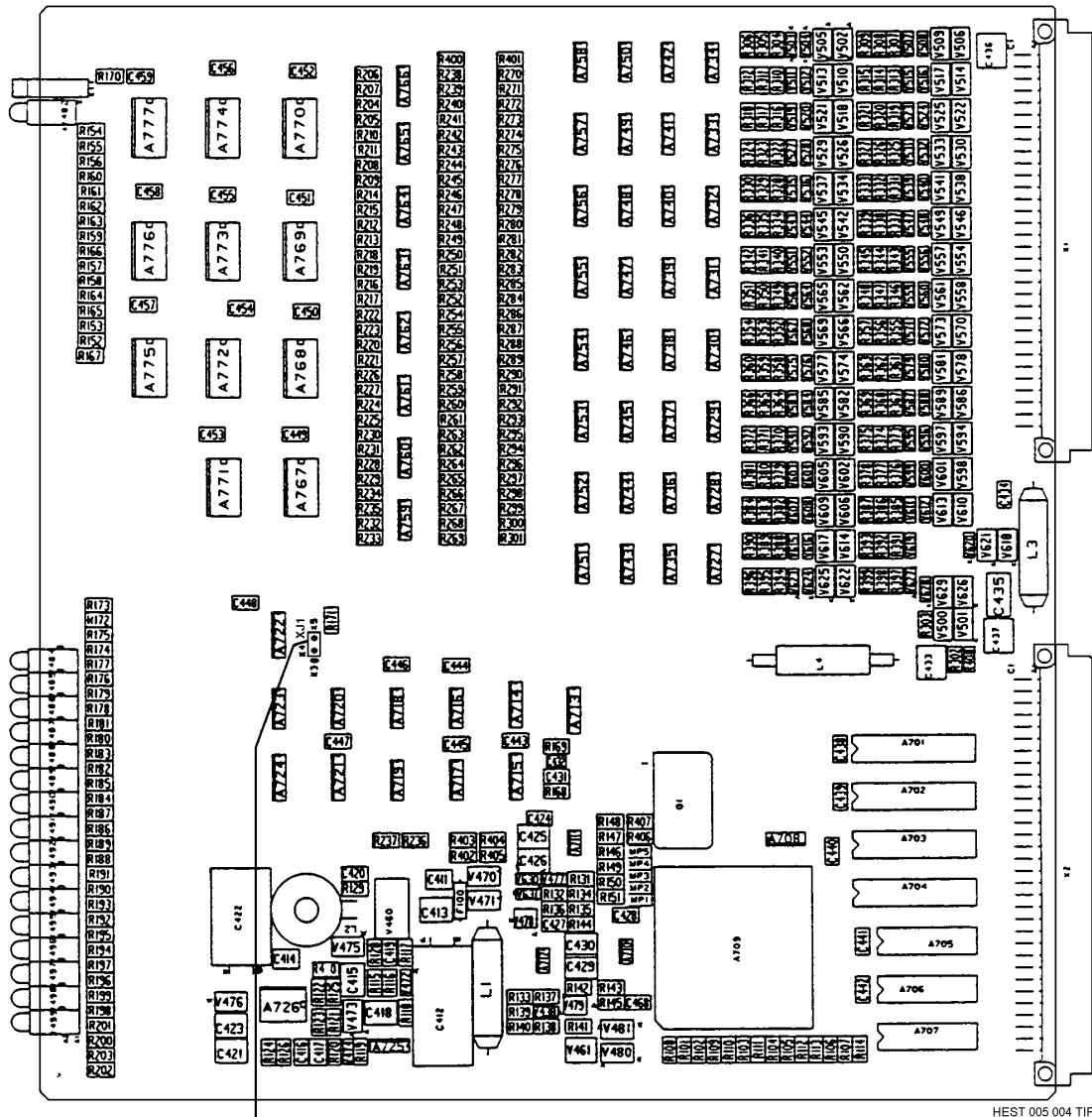


Fig. 12.10 Binary output unit 216AB61; front view (corresponds to HESG 324 031)



HESG 005 004 TIF

Plug-in jumper XJ1

Position X4-X5 : defect and ready signals (CH001, 002) in operation

Position X3-X4 : defect and ready signals (CH001, 002) not in operation

Fig. 12.11 Binary output unit 216AB61; component side of the PCB (corresponds to HESG 324 013)

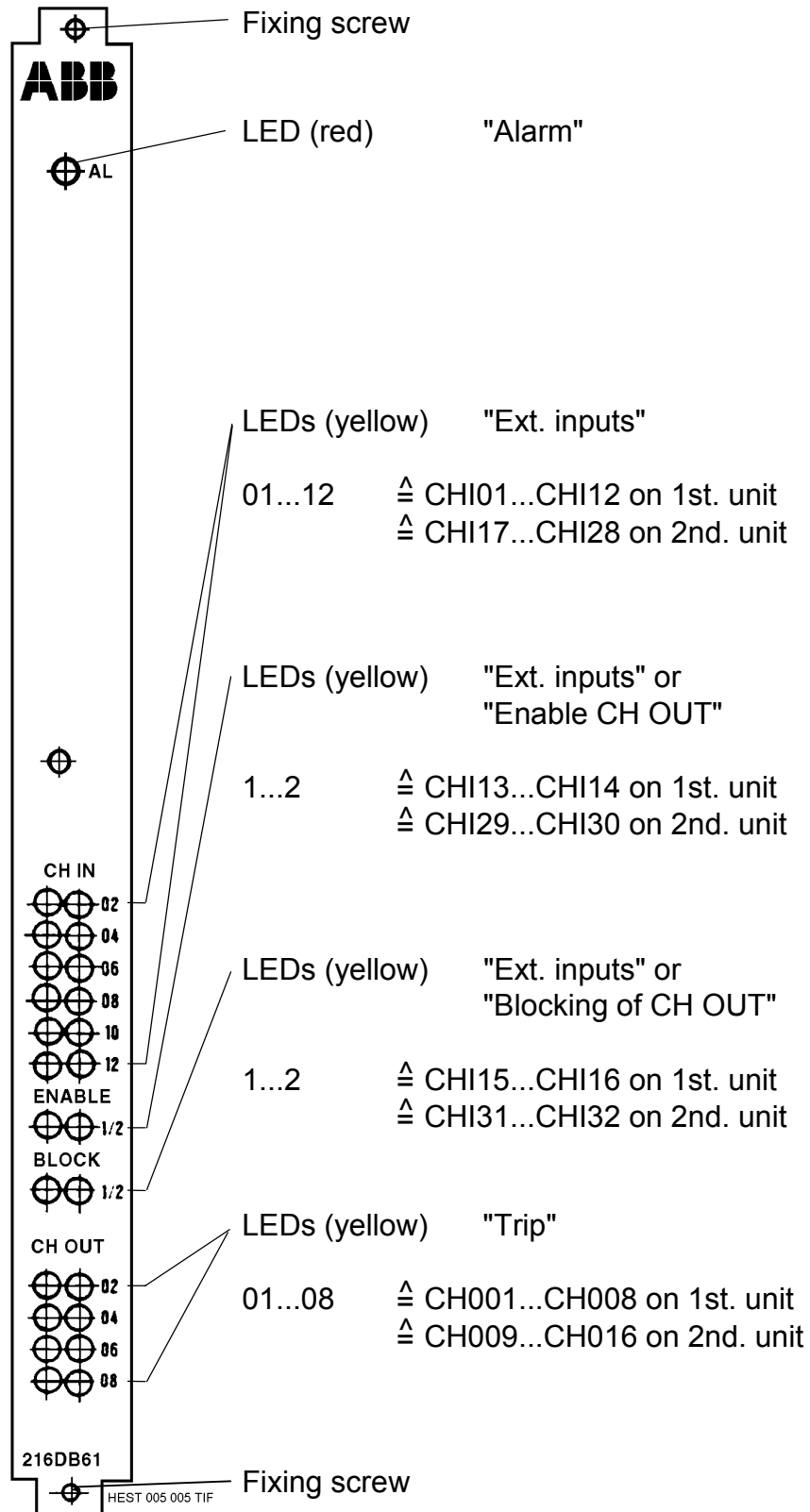


Fig. 12.12 Binary input and output unit 216DB61; front view (corresponds to HESG 324 098)

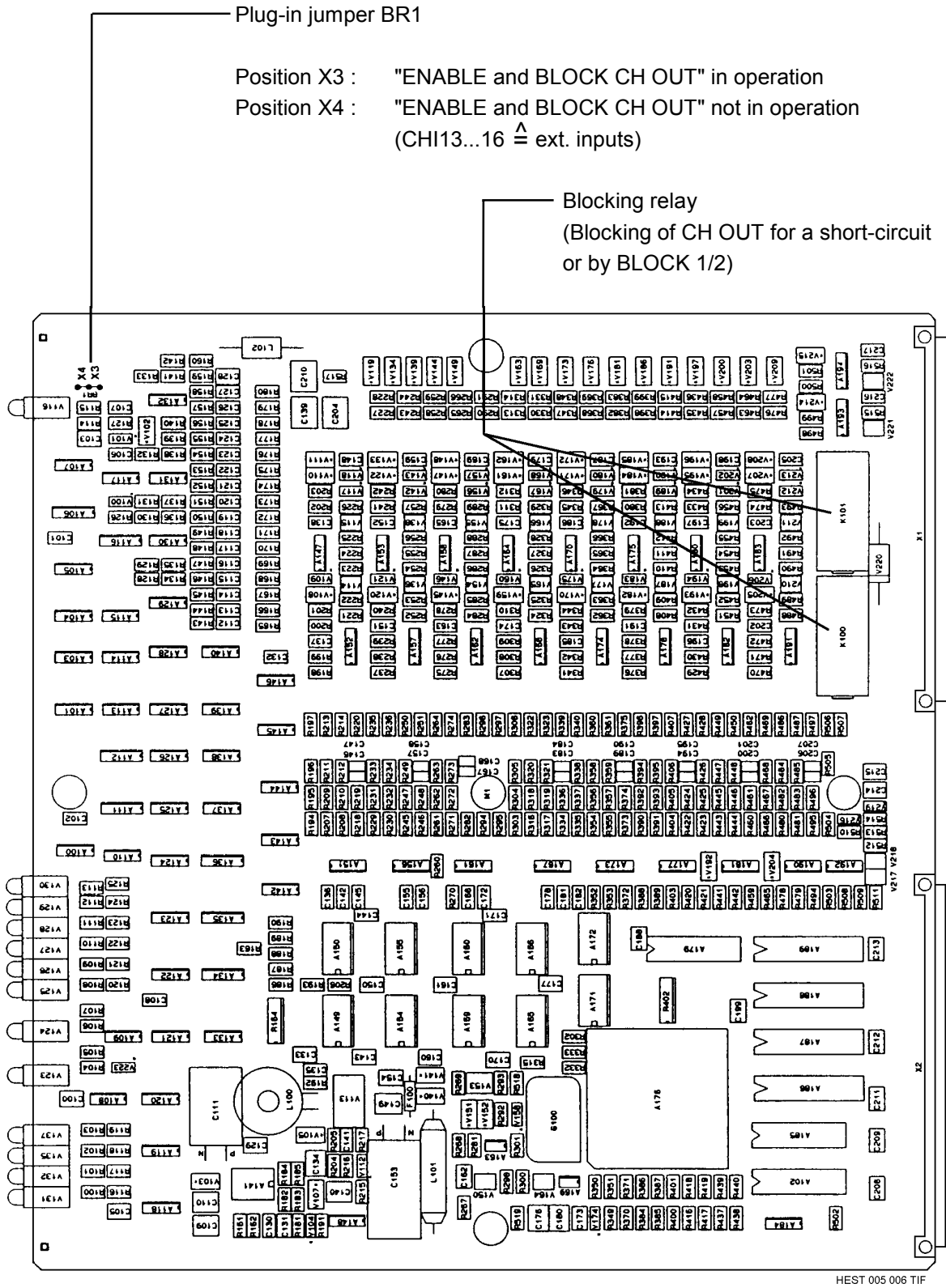
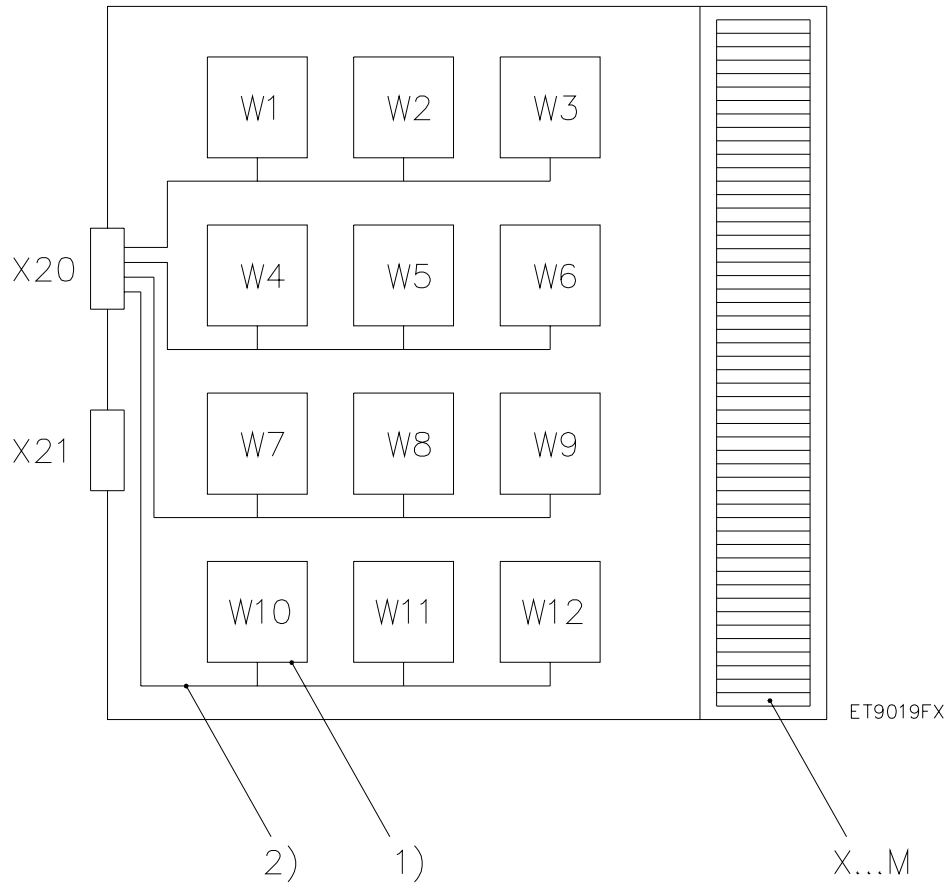


Fig. 12.13 Binary input and output unit 216DB61; component side of the PCB (corresponds to HESG 324 063)



W1...W12 : c.t's or v.t's)

X20, X21 : 25 pin connector

X...M : measuring circuit terminals

1) : 2 pin connector

2) : wiring according to Table 12.1

Fig. 12.14 Input transformer module 216GW61; front view

Input transformer module 216GW61				Connected to channels CH.. on the 216EA61 units			
W..	Connector 2 pin	Connector;X20,X 25 pin	Wire colour	1st unit		2nd unit	
				a	b	a	b
1	1.1	1	br	1	13	25	37
	1.2	14	nat				
2	2.1	2	rd	2	14	26	38
	2.2	15	nat				
3	3.1	3	or	3	15	27	39
	3.2	16	nat				
4	4.1	4	ye	4	16	28	40
	4.2	17	nat				
5	5.1	5	gn	5	17	29	41
	5.2	18	nat				
6	6.1	6	bl	6	18	30	42
	6.2	19	nat				
7	7.1	7	vl	7	19	31	43
	7.2	20	nat				
8	8.1	8	gr	8	20	32	44
	8.2	21	nat				
9	9.1	9	wh	9	21	33	45
	9.2	22	nat				
10	10.1	10	bk	10	22	34	46
	10.2	23	nat				
11	11.1	11	br	11	23	35	47
	11.2	24	nat				
12	12.1	12	rd	12	24	36	48
	12.2	25	nat				

a : Connector (upper)

b : Connector (lower)

Colour code:

br : brown

bl : blue

nat : natural

vl : violet

rd : red

gr : grey

or : orange

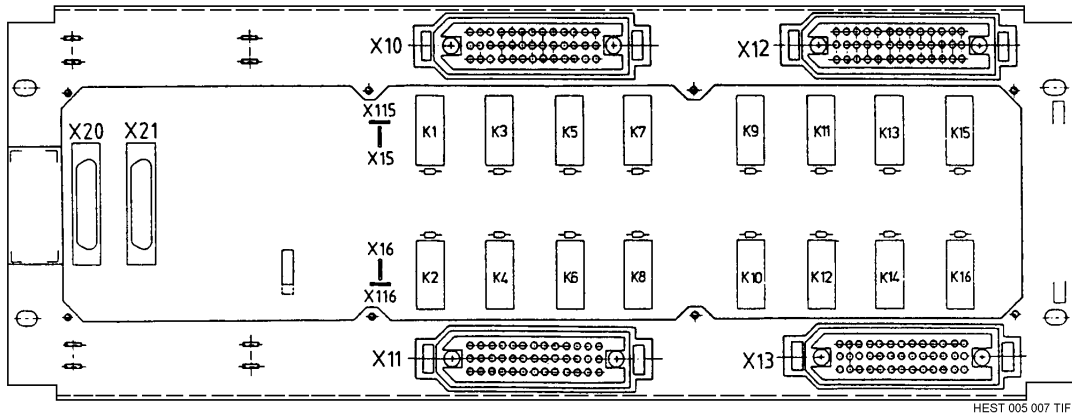
wh : white

ye : yellow

bk : black

gn : green

Table 12.1 Wiring for 216GW61 and c.t. and v.t. assignment on 216EA61



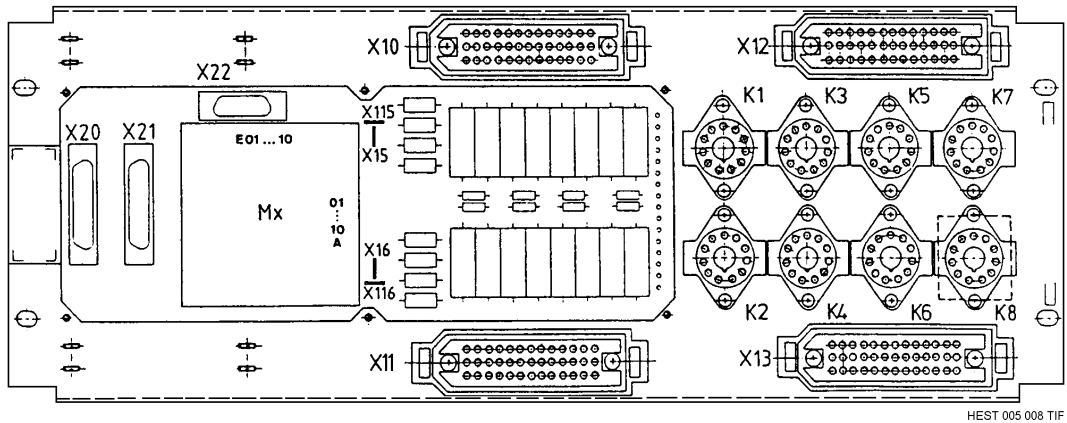
- K1...K16 : signalling relays 24 V DC
- X20, X21 : standard cables for controlling K1...K16
- X15, X115 : UP auxiliary supply connections (24 V DC)
- X16, X116
- X10...X13 : cable connectors for the wiring to the signalling contacts and terminals

Fig. 12.15 Output relay module 216GA61; front view

Wiring variants – signalling contacts K1...K16			
A1	A6	A2	A4

ET9020AE

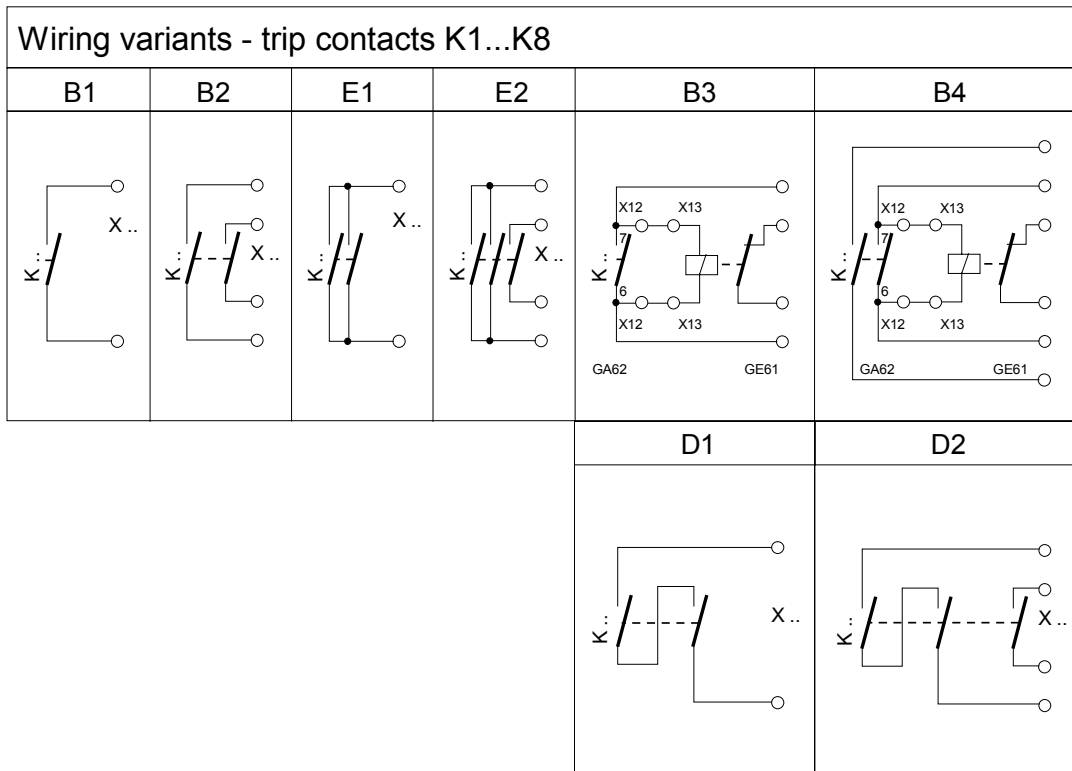
Table 12.2 216GA61; signalling contact versions



- K1...K8 : tripping relays 12 V DC
- X20, X21 : standard cables for controlling K1...K8
- X15, X115 : UP auxiliary supply connections (24 V DC)  
X16, X116
- X10...X13 : cable connectors for the wiring to the tripping contacts and terminals
- X22 : standard cables for controlling K1...K8 via Mx
- Mx : diode matrix (tripping logic) 10 x 10 for direct tripping  
E : inputs, A : outputs

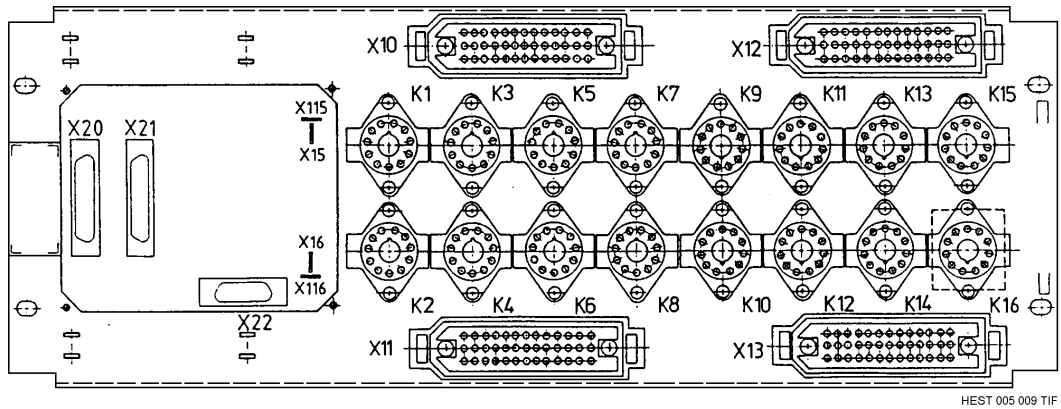
Fig. 12.16 Tripping relay module 216GA62; front view





HEST 925 013 FL

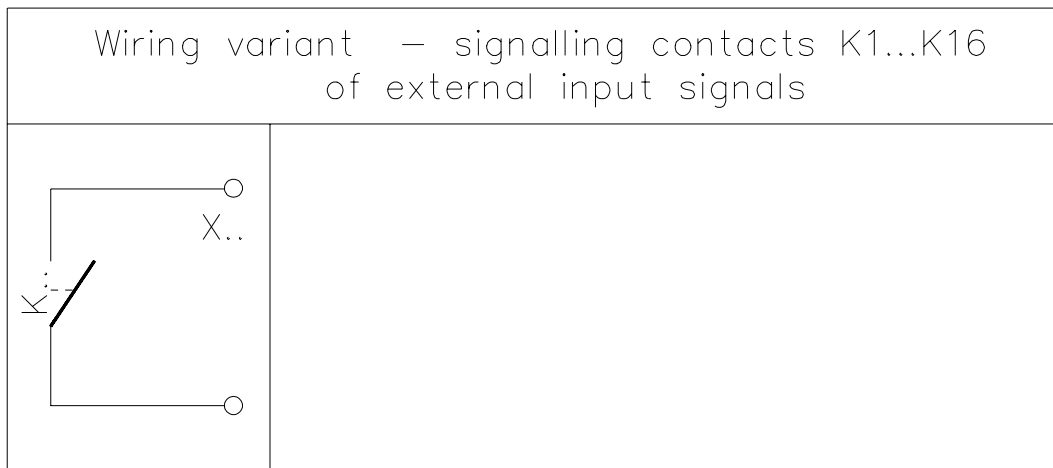
Table 12.3 216GA62; tripping contact versions  
(with trip circuit supervision by 216GE61)



HEST 005 009 TIF

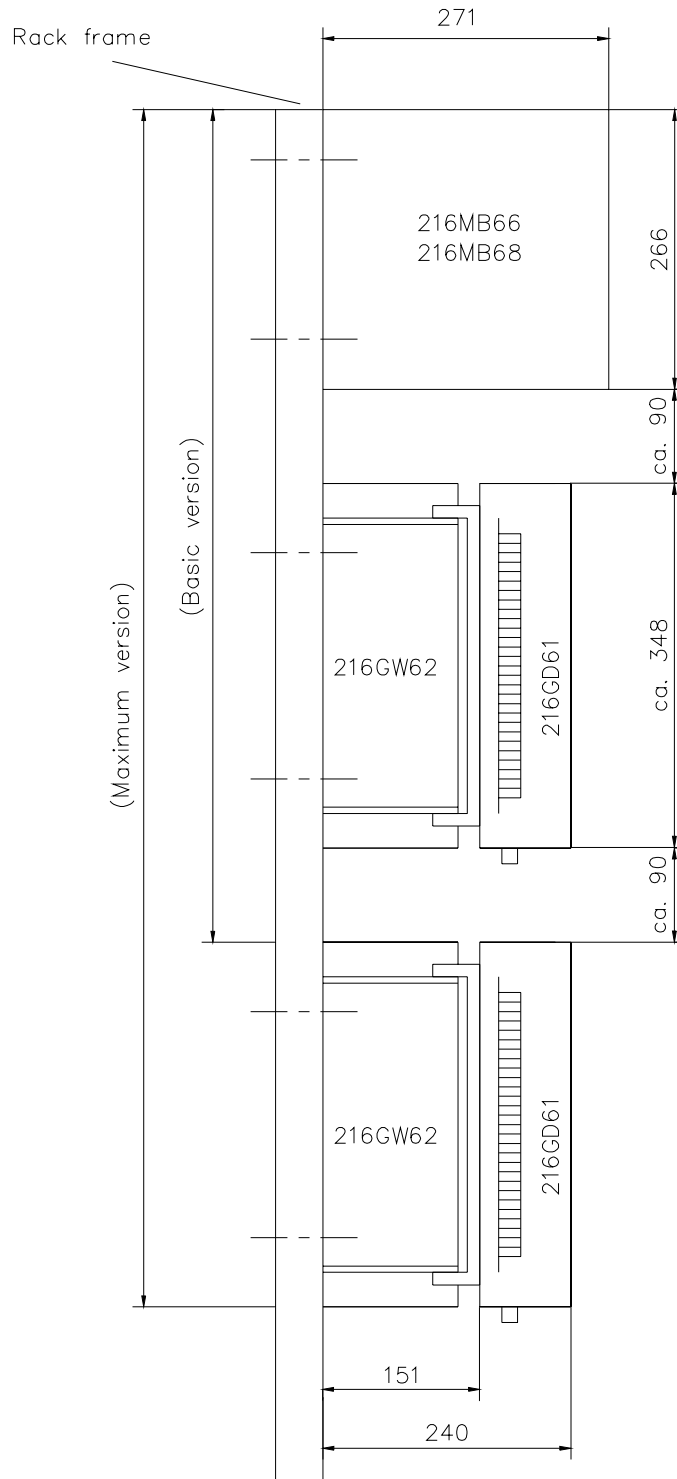
- K1...K16 : auxiliary relays for external input signals  
rated coil voltage = external aux. supply
- X20, X21 : standard cables for control of 216DB61 by  
K1...K16
- X15, X115 : UP auxiliary supply connections (24 V DC)
- X16, X116
- X10...X13 : cable connectors for the wiring to the  
external auxiliary supply and terminals
- X22 : standard cables for controlling 216GA62

Fig. 12.17 Input relay module 216GE61; front view



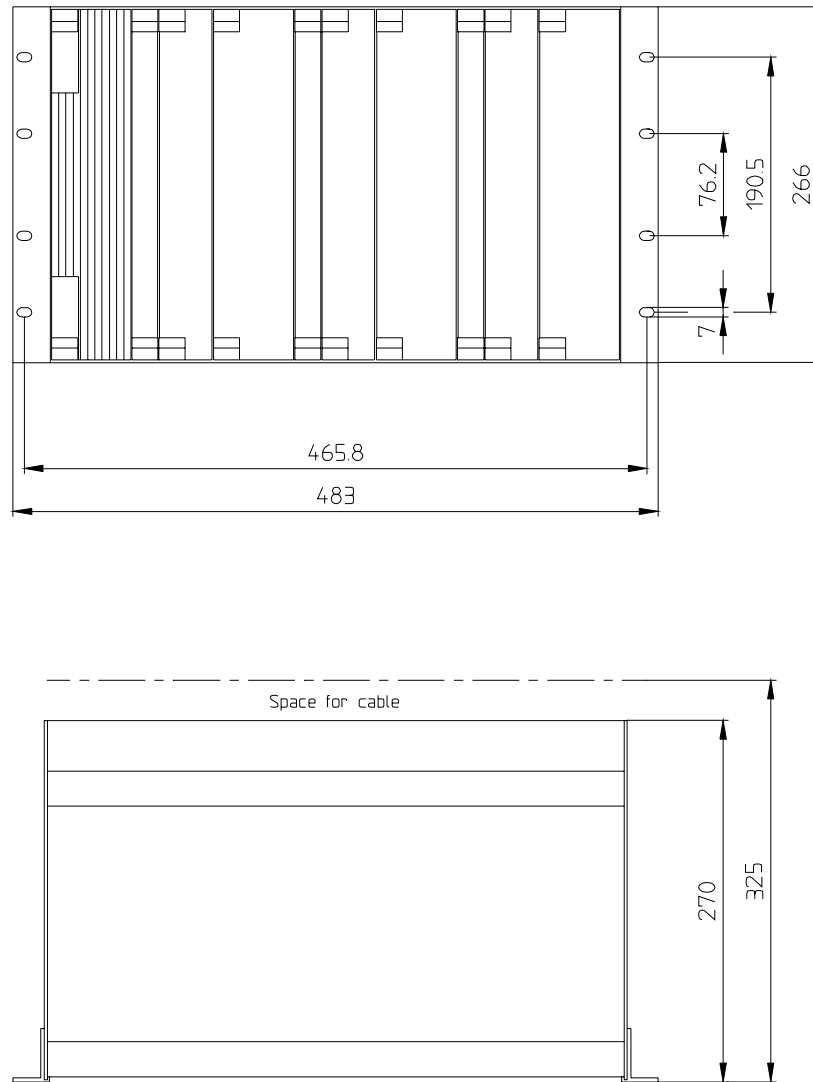
ET9022AE

Table 12.4 216GE61; signalling contact wiring



EG004E

Fig. 12.18 Compact version; dimensioned drawing and assembly drawing (corresponds to HESG 441 791)



adoc001

Fig. 12.19 Dimensioned drawing 216MB6  
(corresponds to HESG 448 456)

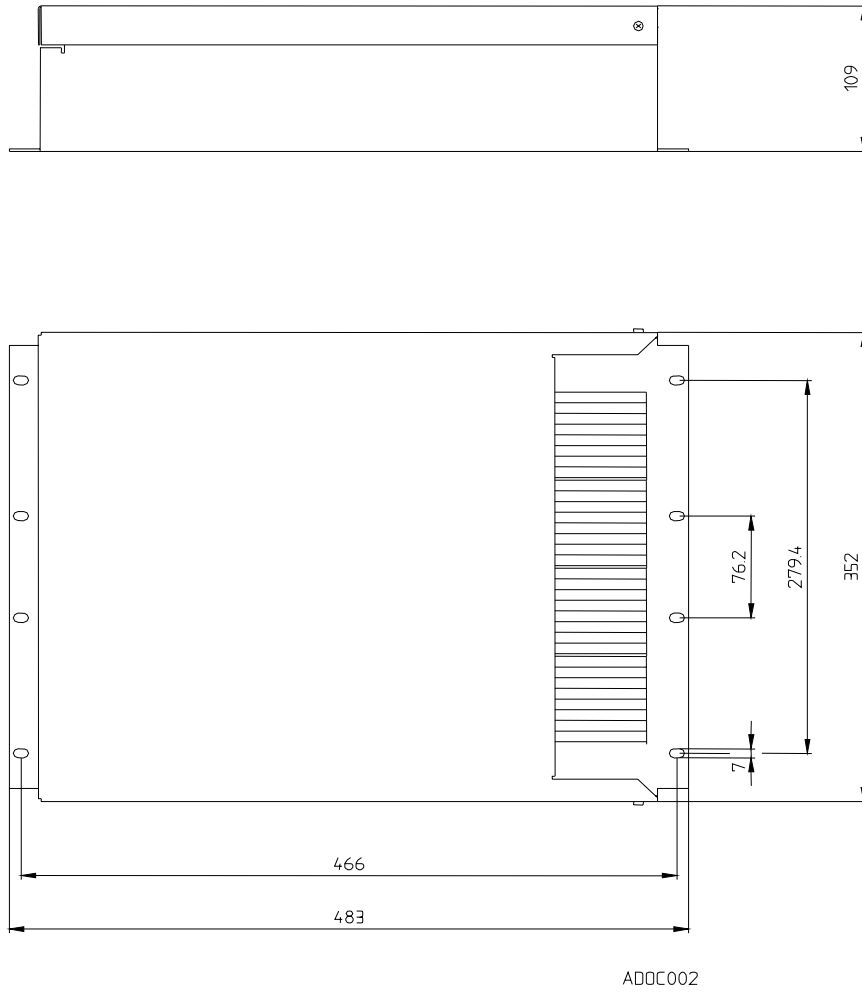


Fig. 12.20 Dimensioned drawing 216GW62  
(corresponds to HESG 448 457)

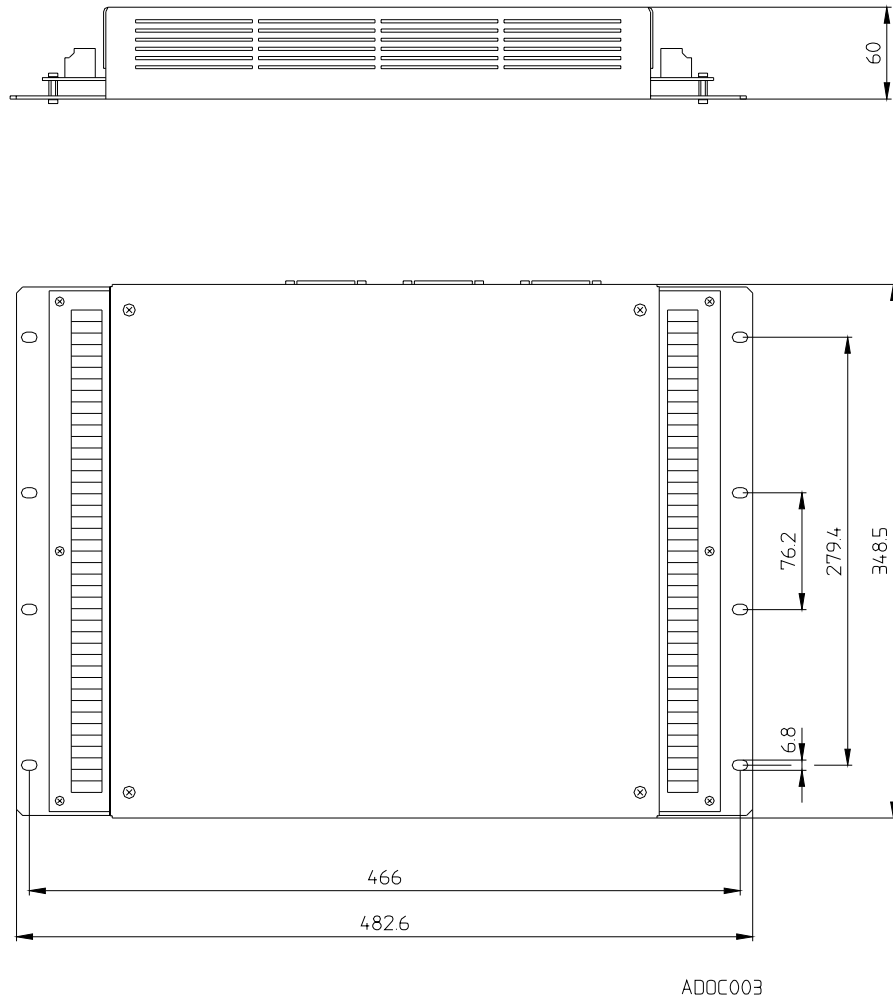


Fig. 12.21 Dimensioned drawing 216GD61  
(corresponds to HESG 448 458)

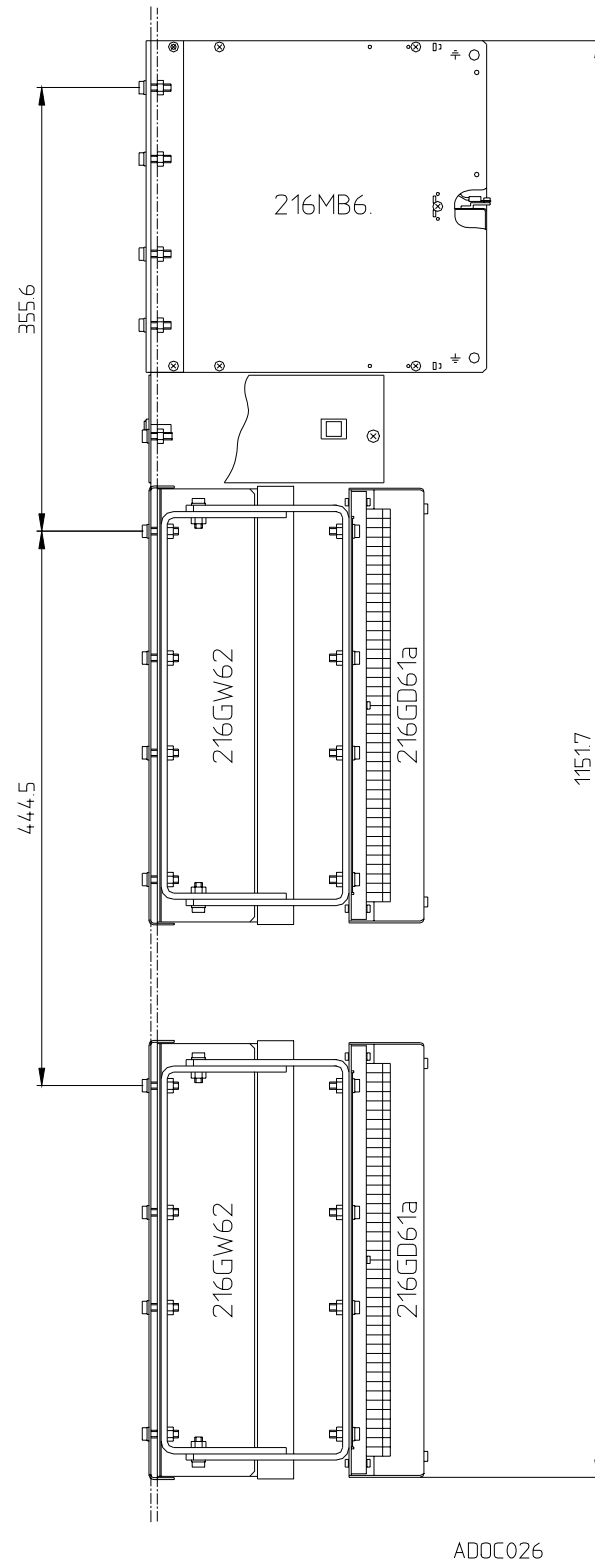
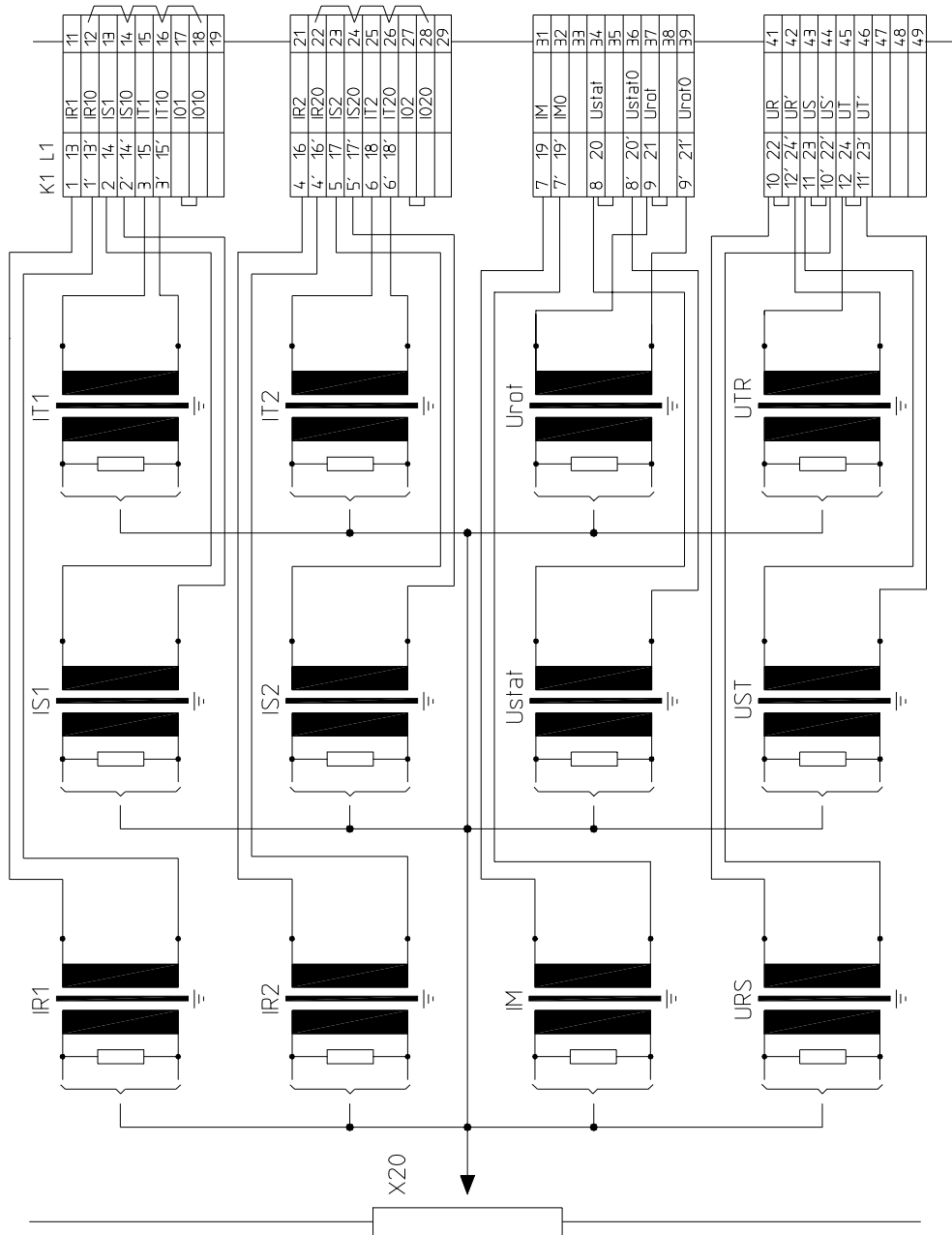


Fig. 12.22 Compact version; side view  
(corresponds to HESG 441 791)



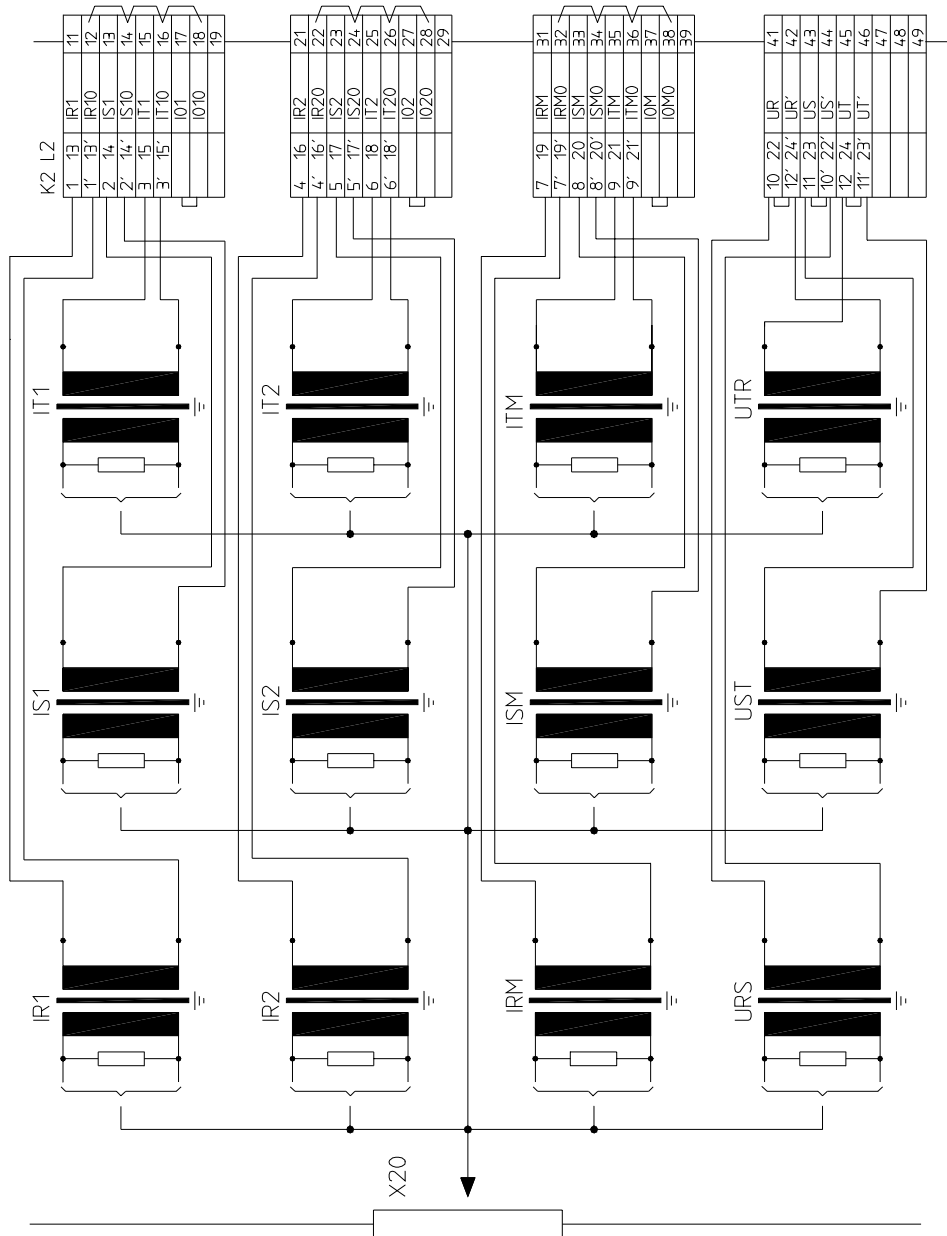
Transformer :  
 I = 1-2-5A/0,471V    IM = 1-2-5A/7,07V    U = 100-200V/12,6V

K1/L1

HESG 4417891

Fig. 12.23 Compact version; input transformer module 216GW62; block diagram and terminals (corresponds to HESG 441 789)





Transformer :

I = 1-2-5A/0,471V    IM = 1-2-5A/7,07V    U = 100-200V/12,6V

K2/L2

HESG 4417892

Fig. 12.24 Compact version; input transformer module 216GW62; block diagram and terminals (corresponds to HESG 441 789)

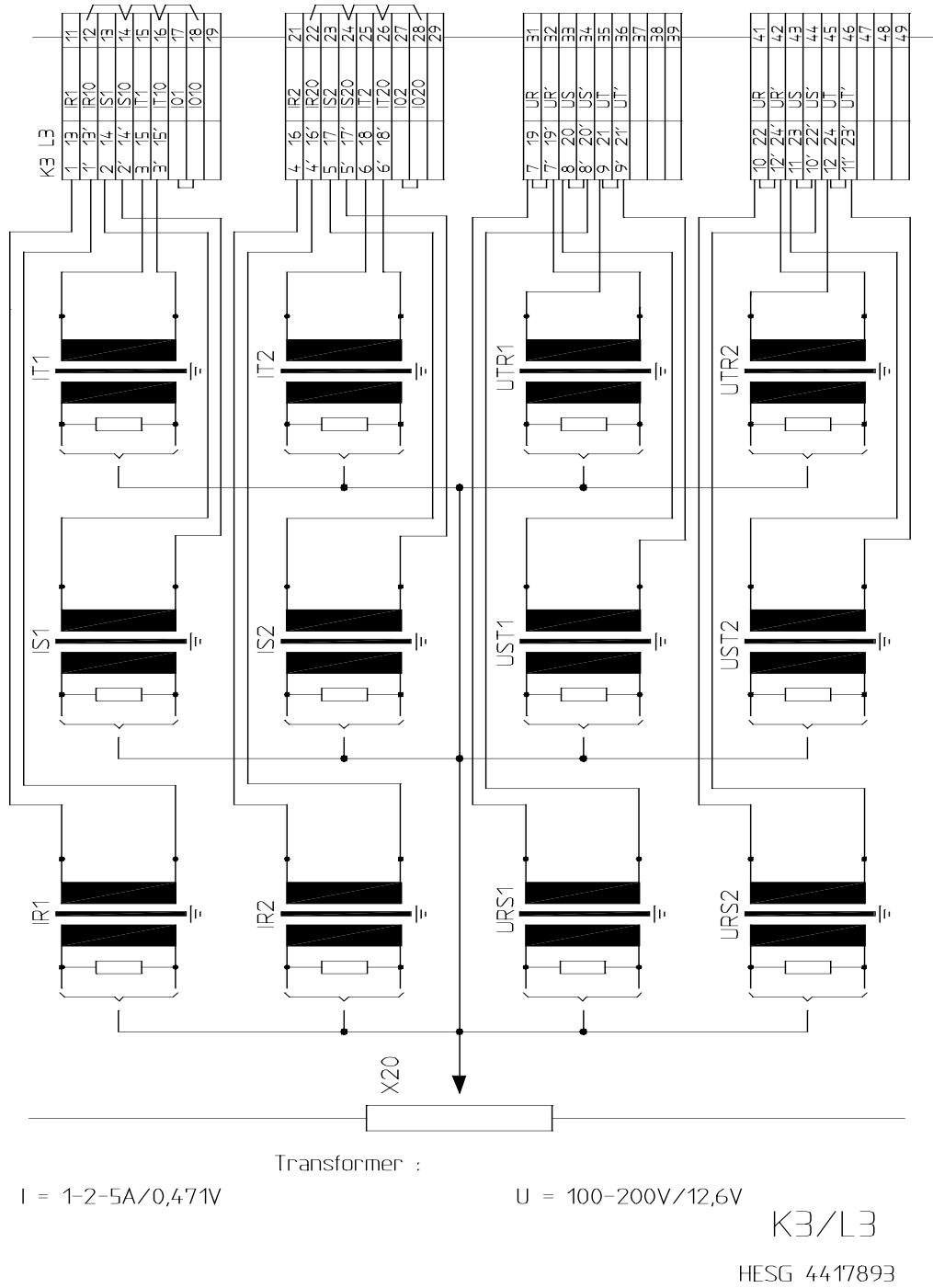
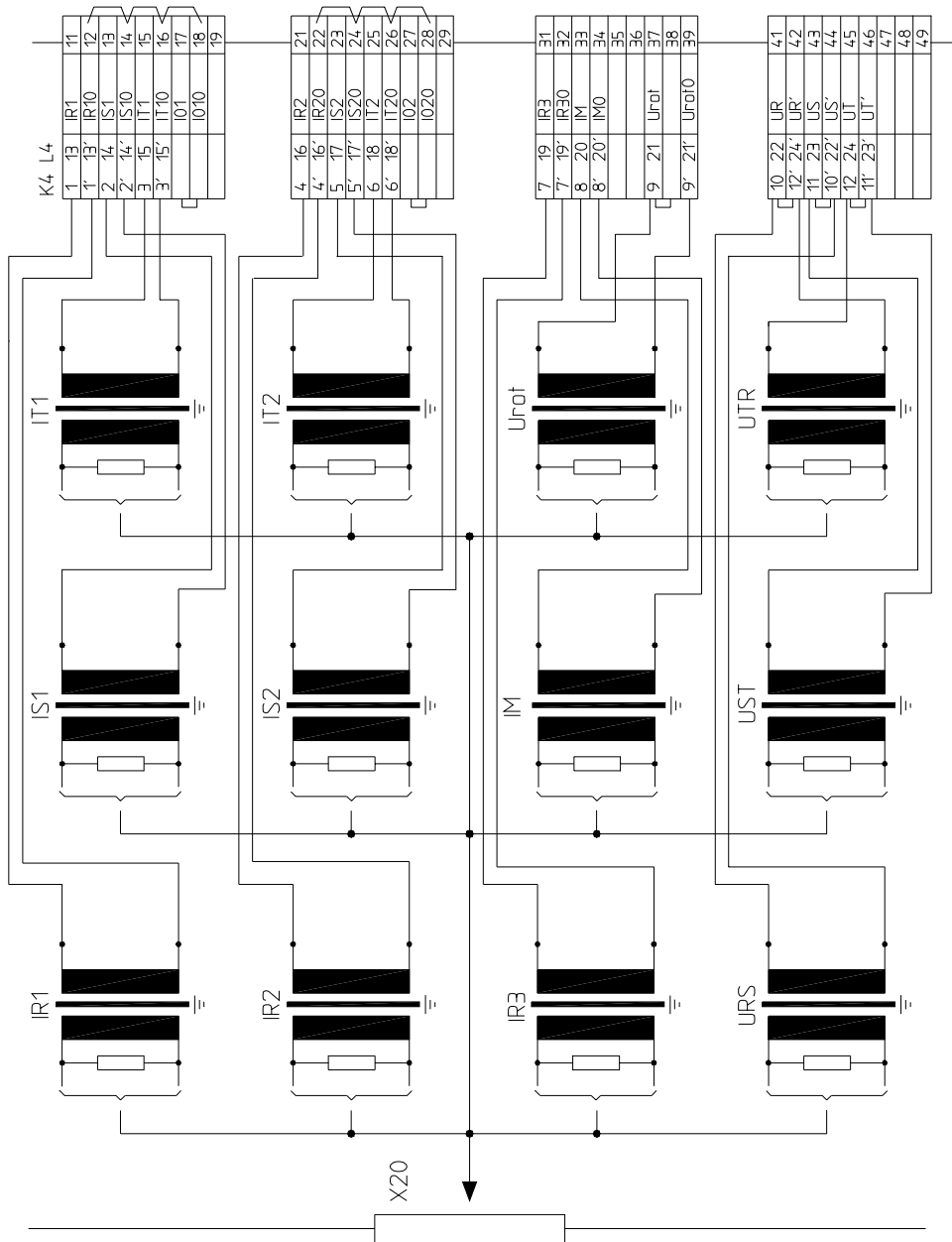


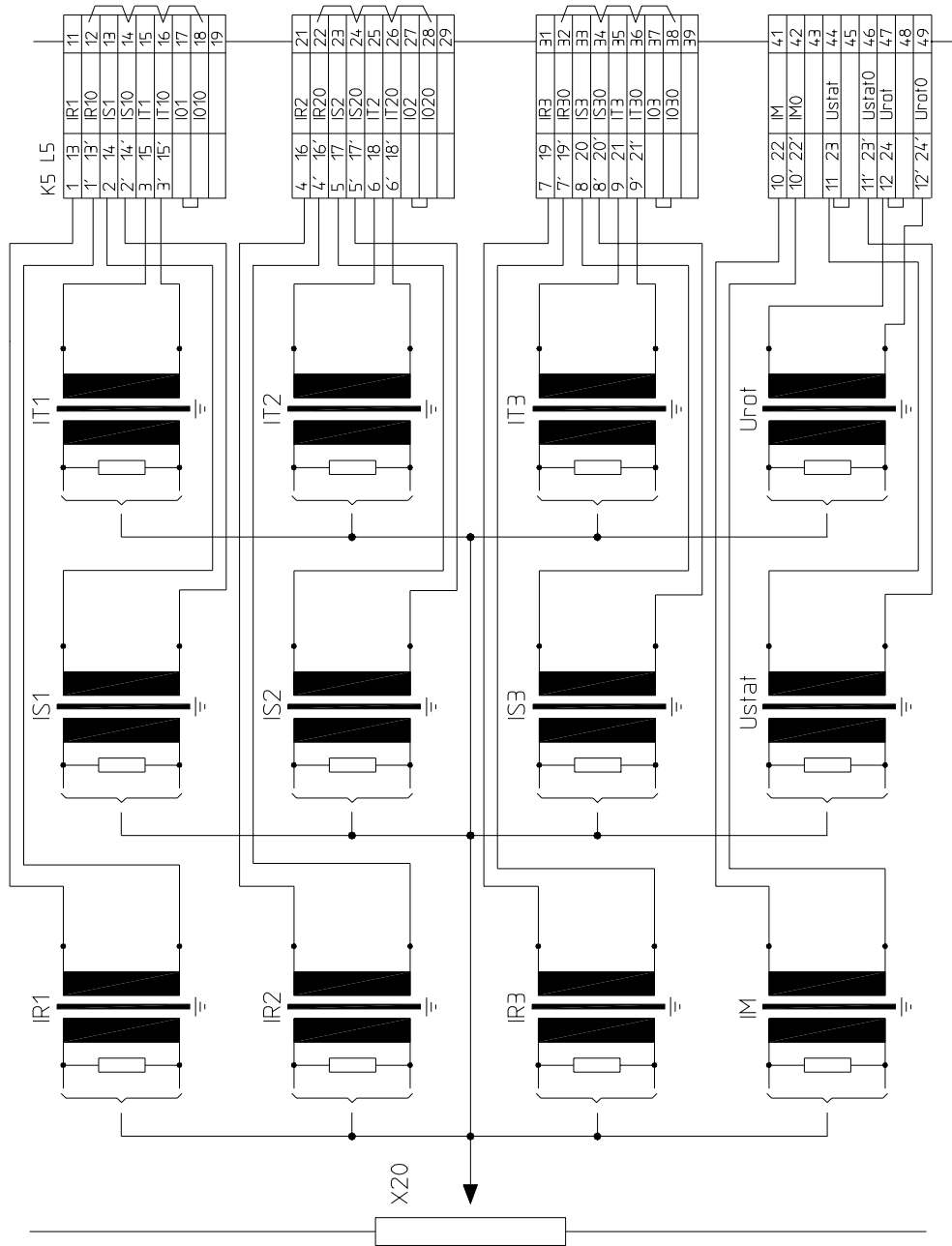
Fig. 12.25 Compact version; input transformer module 216GW62; block diagram and terminals (corresponds to HESG 441 789)



Transformer :  
 I = 1-2-5A/0,471V    IM = 1-2-5A/7,07V    U = 100-200V/12,6V

K4/L4  
 HESG 4417894

Fig. 12.26 Compact version; input transformer module 216GW62; block diagram and terminals (corresponds to HESG 441 789)



Transformer :

I = 1-2-5A/0,471V

IM = 1-2-5A/7,07V

U = 100-200V/12,6V

K5/L5

HESG 4417895

Fig. 12.27 Compact version; input transformer module 216GW62; block diagram and terminals (corresponds to HESG 441 789)

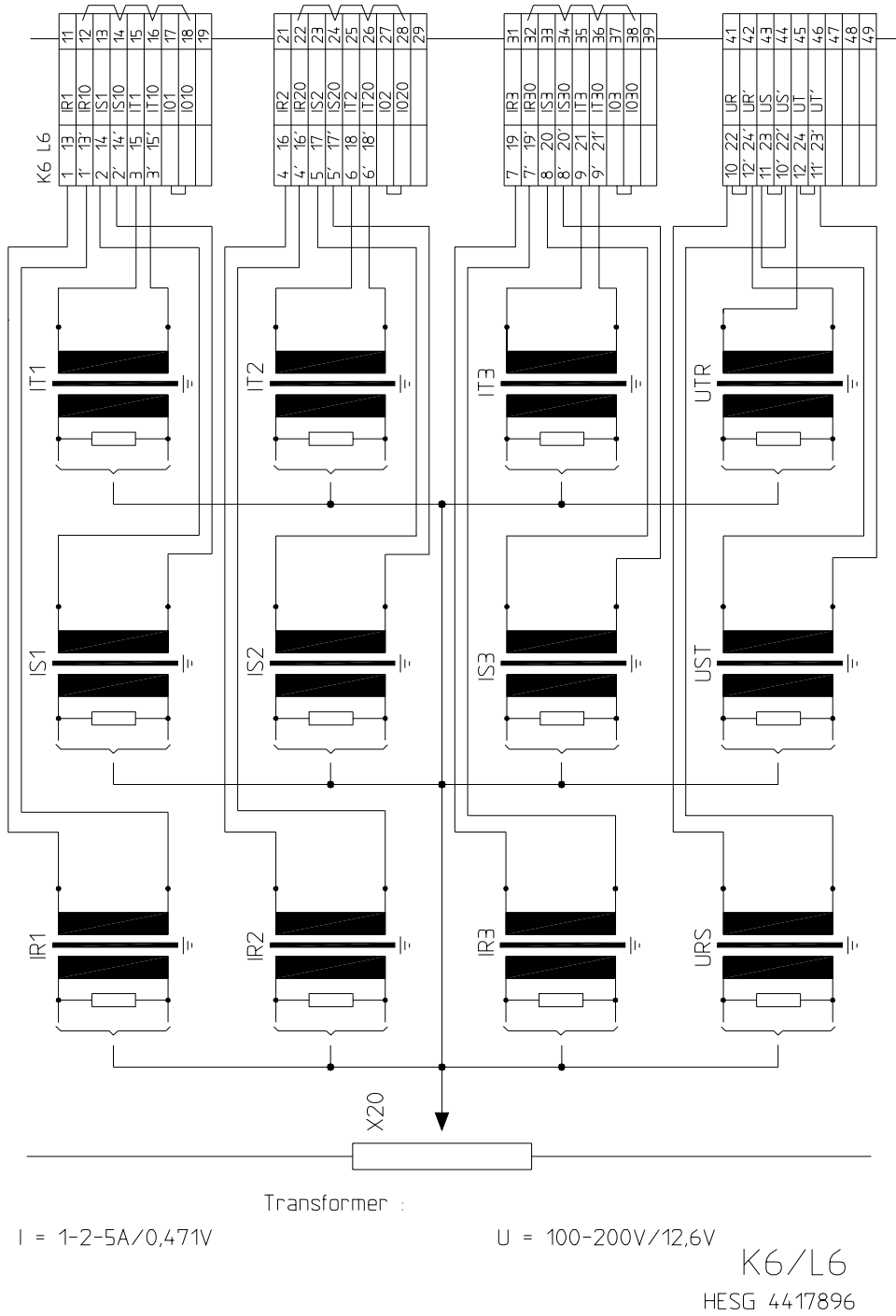


Fig. 12.28 Compact version; input transformer module 216GW62; block diagram and terminals (corresponds to HESG 441 789)

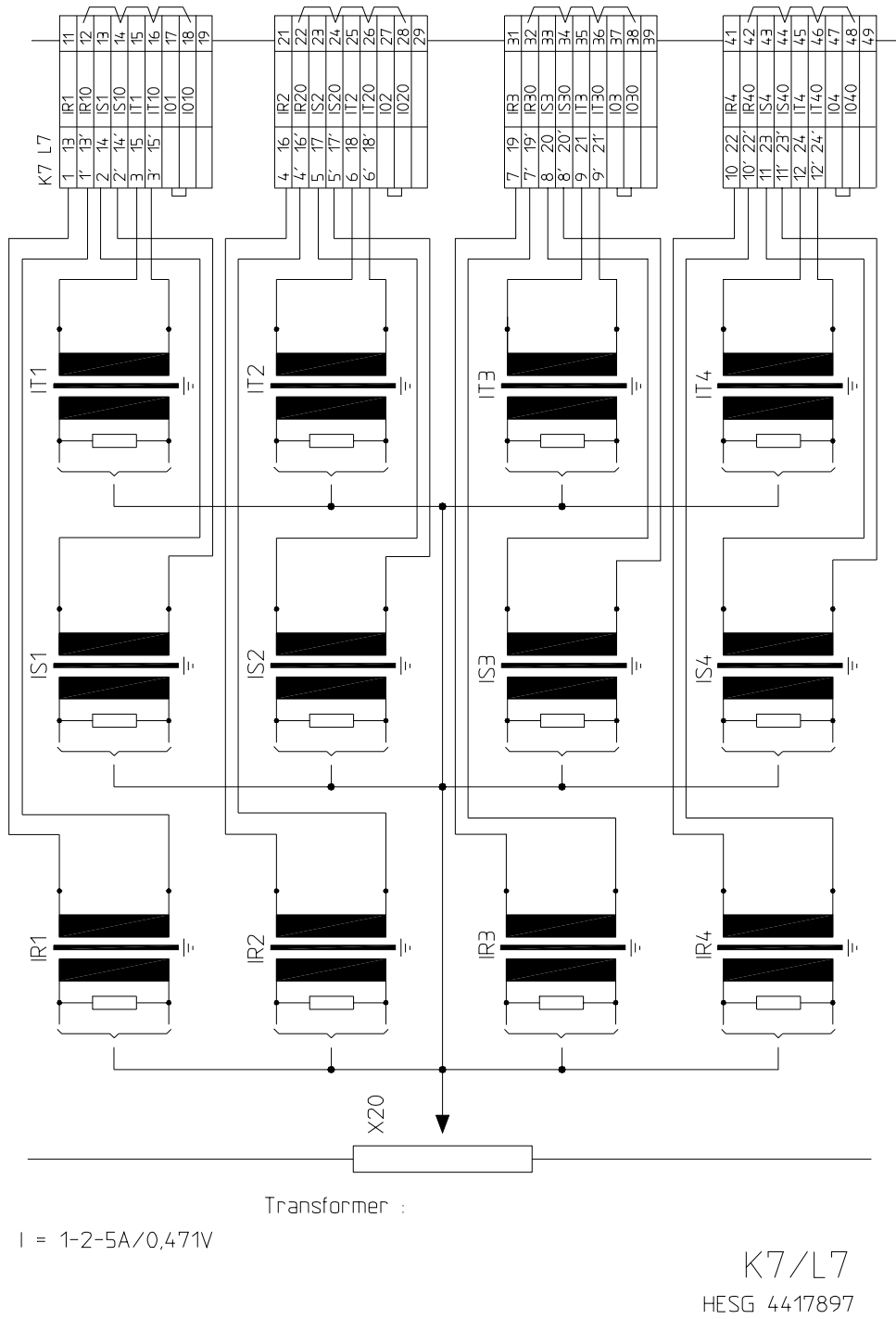


Fig. 12.29 Compact version; input transformer module 216GW62; block diagram and terminals (corresponds to HESG 441 789)

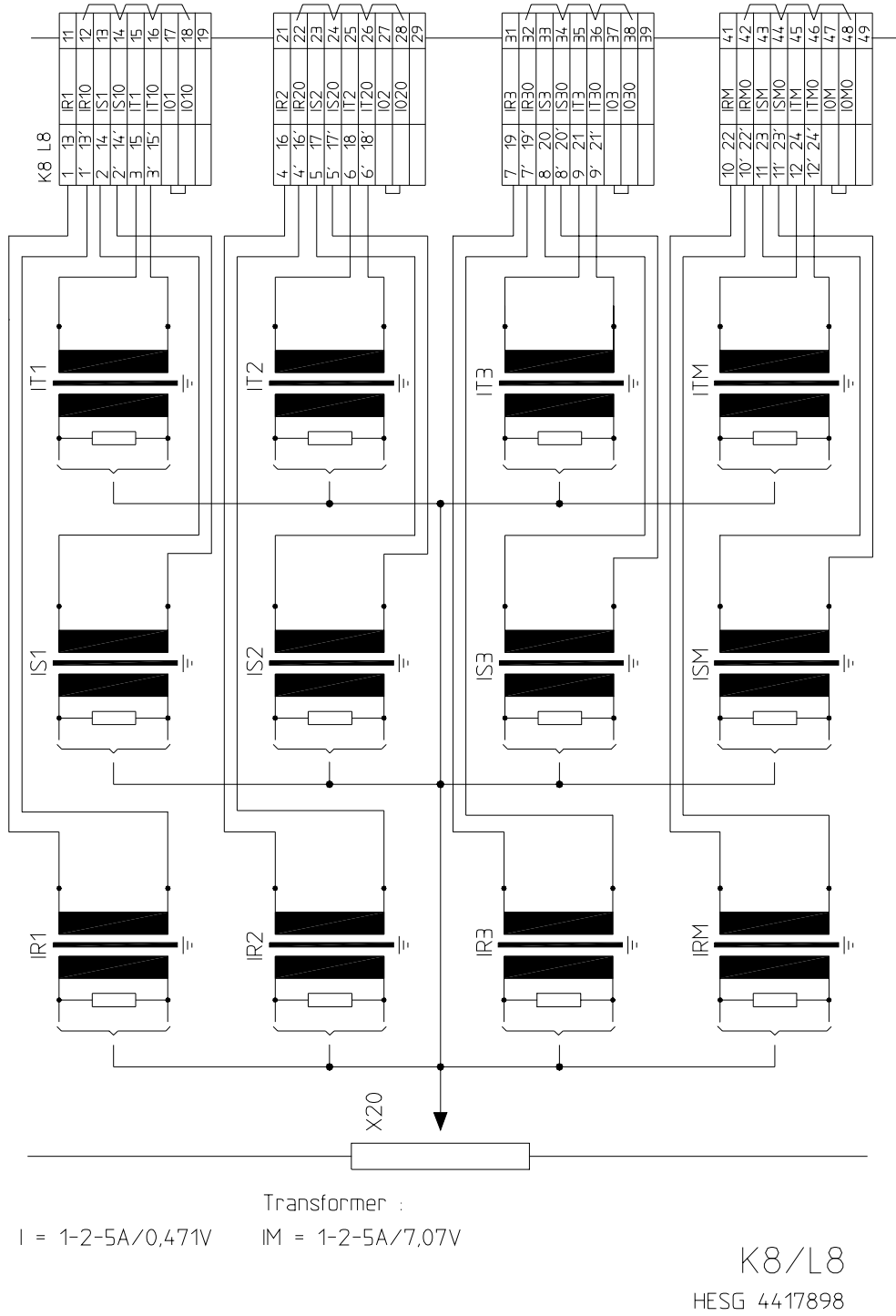
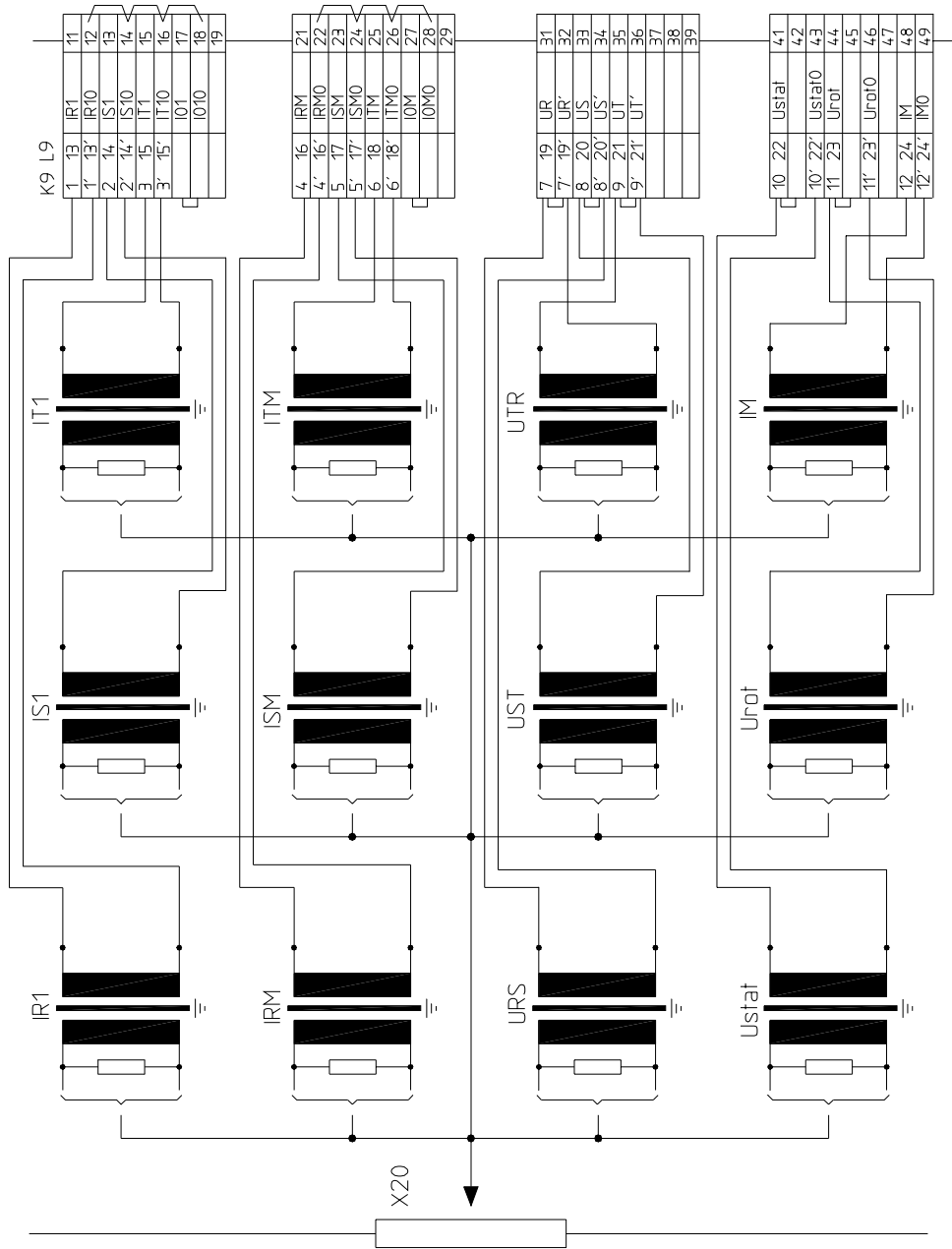


Fig. 12.30 Compact version; input transformer module 216GW62; block diagram and terminals (corresponds to HESG 441 789)



Transformer :  
 I = 1-2-5A/0,471V    IM = 1-2-5A/7,07V    U = 100-200V/12,6V    K9/L9  
 HESG 4417899

Fig. 12.31 Compact version; input transformer module 216GW62; block diagram and terminals (corresponds to HESG 441 789)



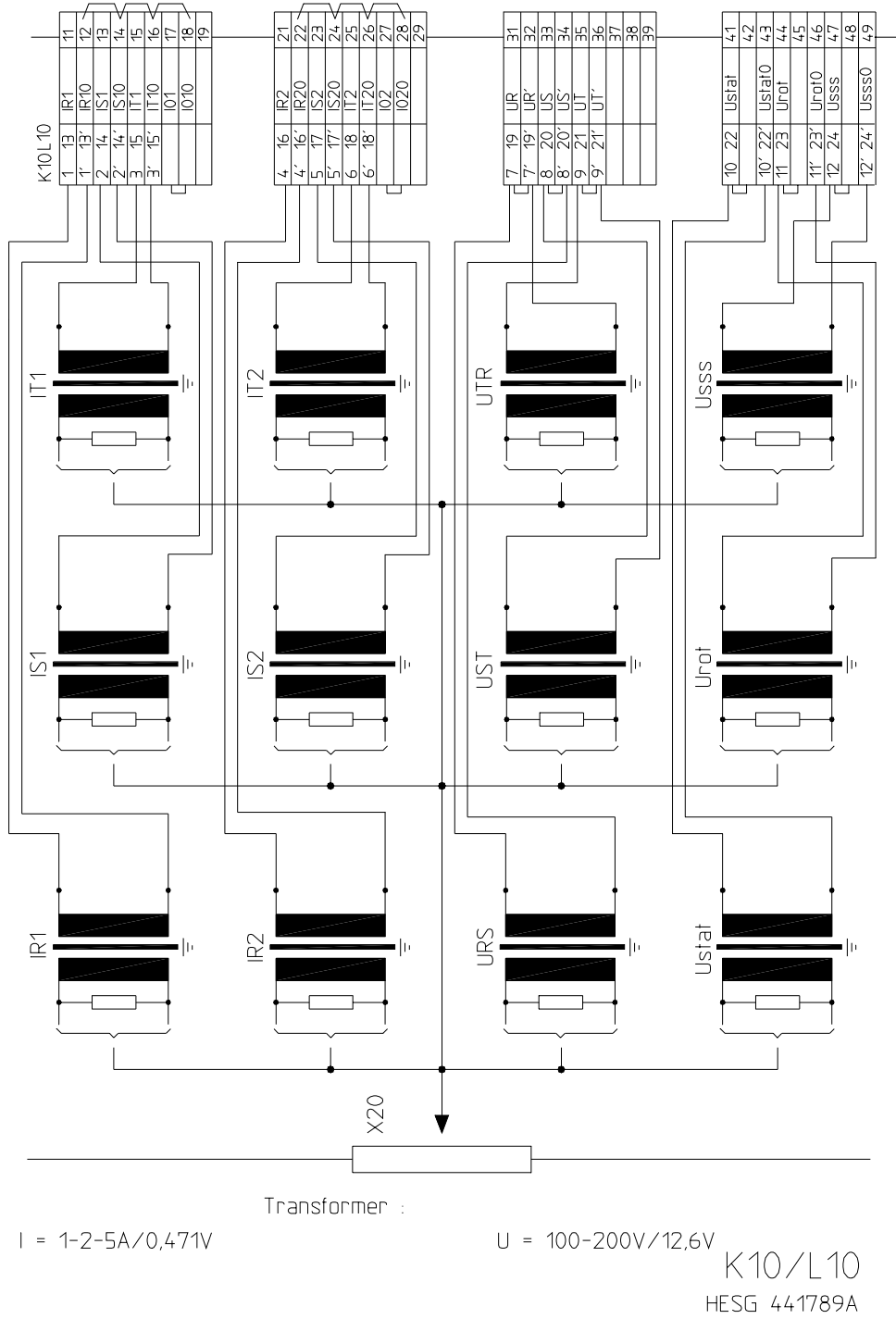


Fig. 12.32 Compact version; input transformer module 216GW62; block diagram and terminals (corresponds to HESG 441 789)

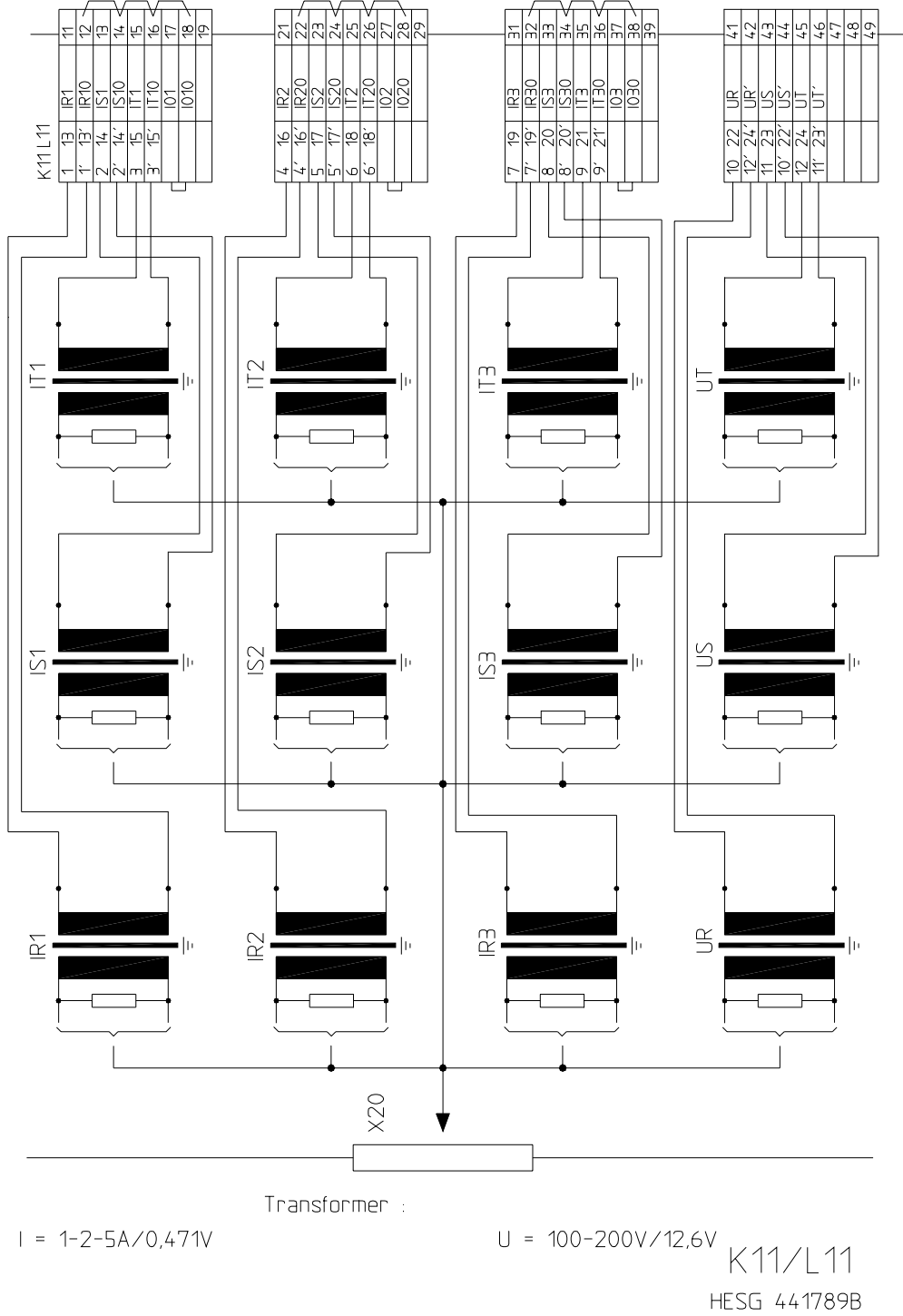


Fig. 12.33 Compact version; input transformer module 216GW62; block diagram and terminals (corresponds to HESG 441 789)

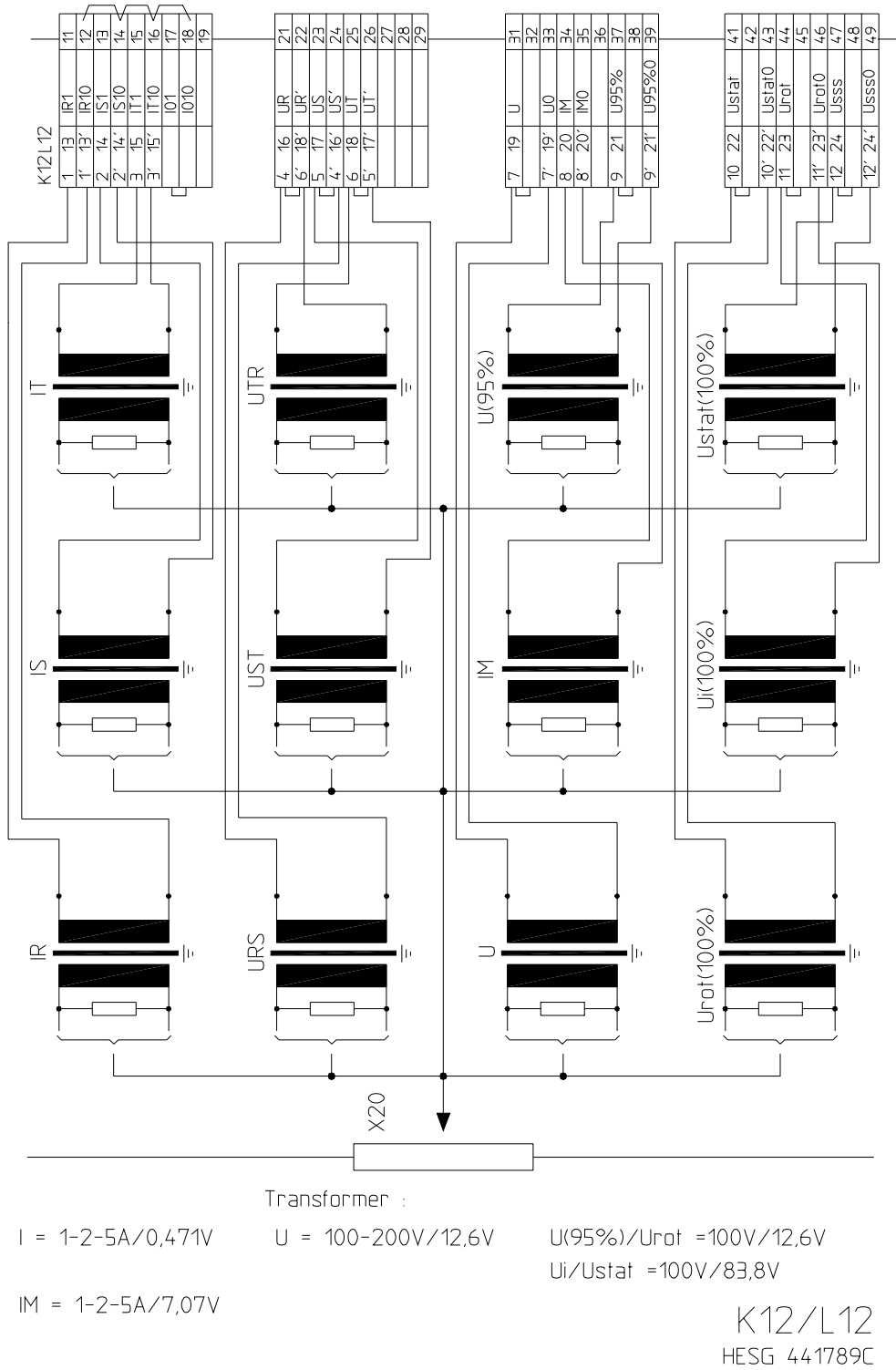


Fig. 12.34 Compact version; input transformer module 216GW62; block diagram and terminals (corresponds to HESG 441 789)

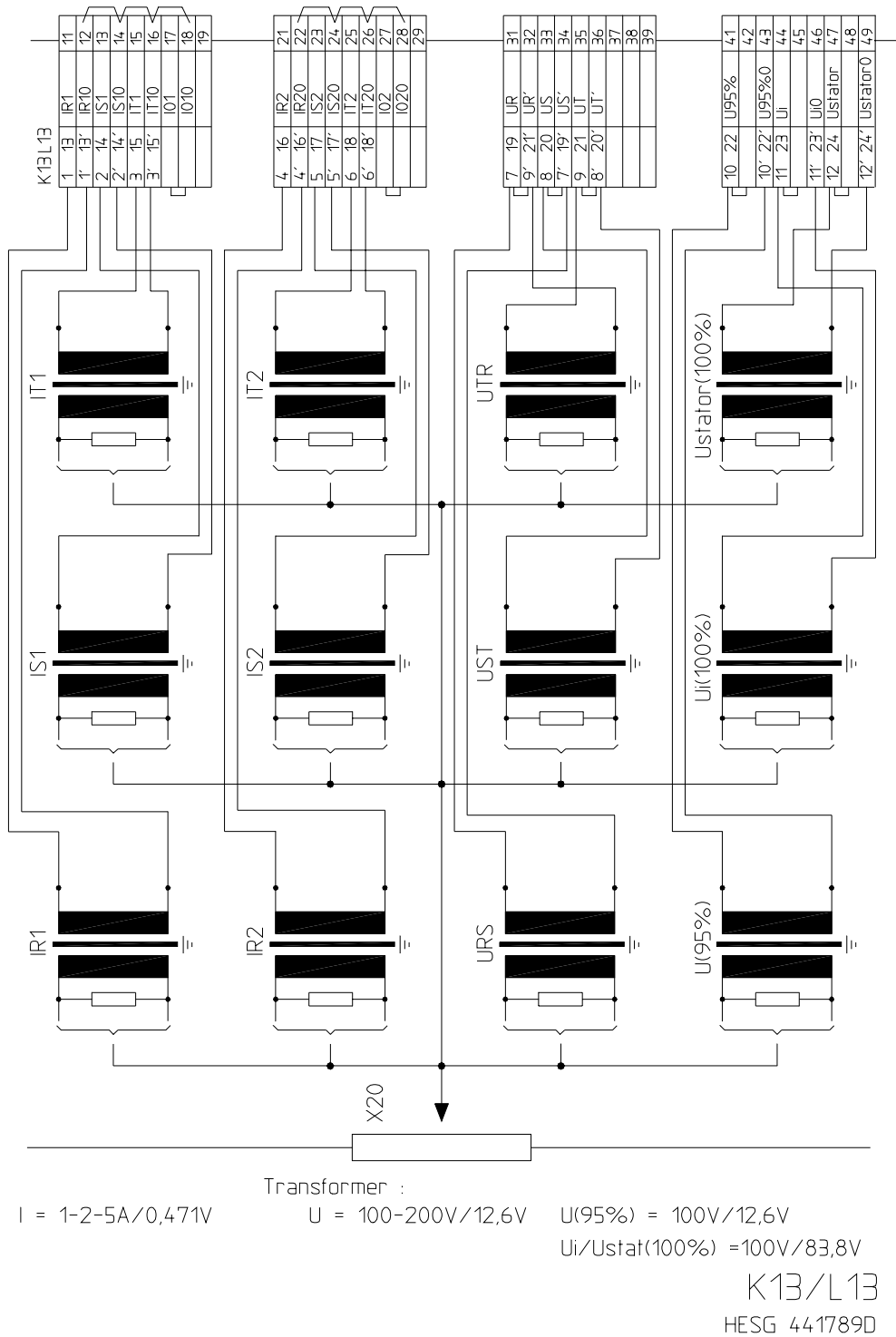
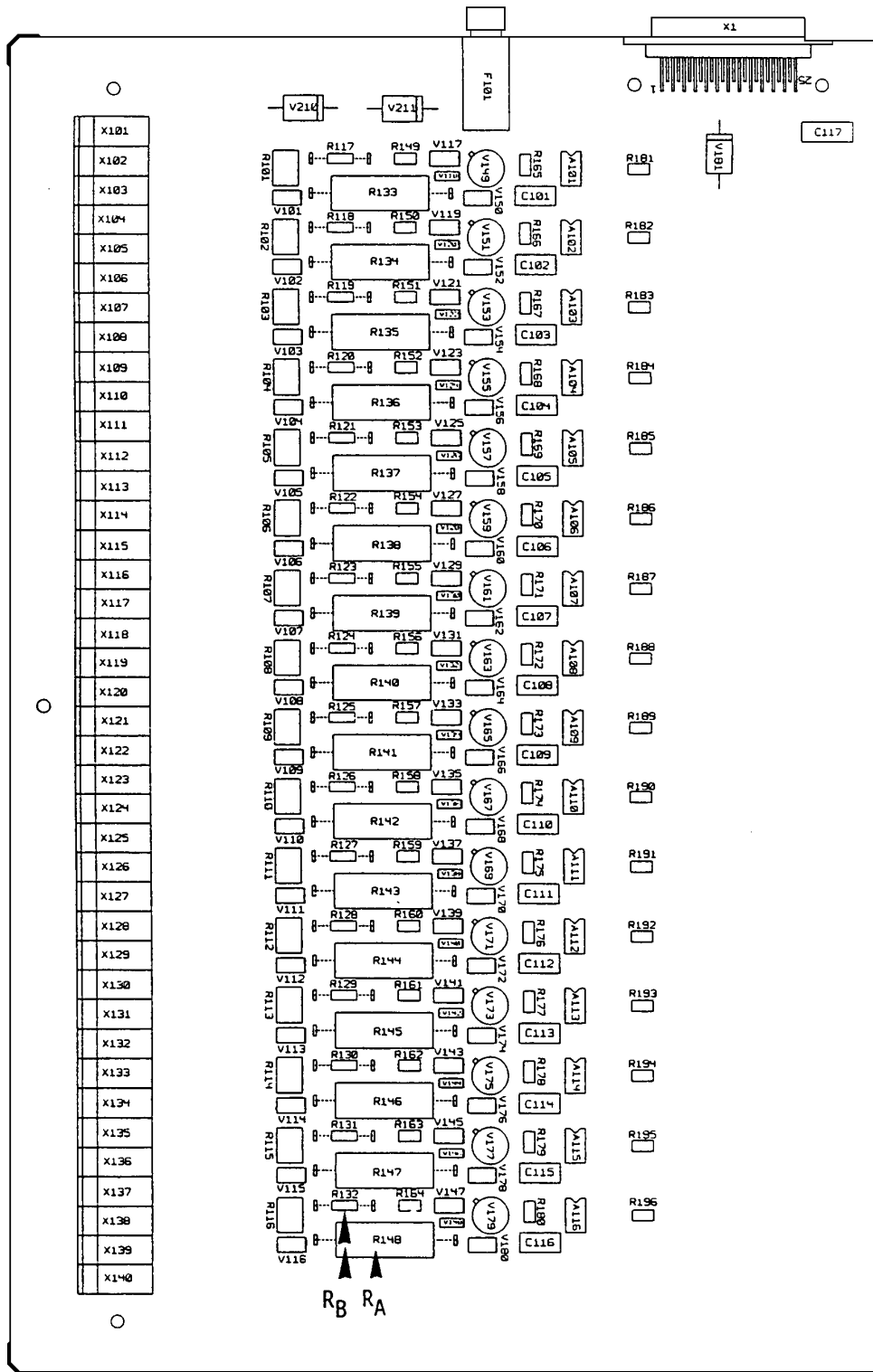
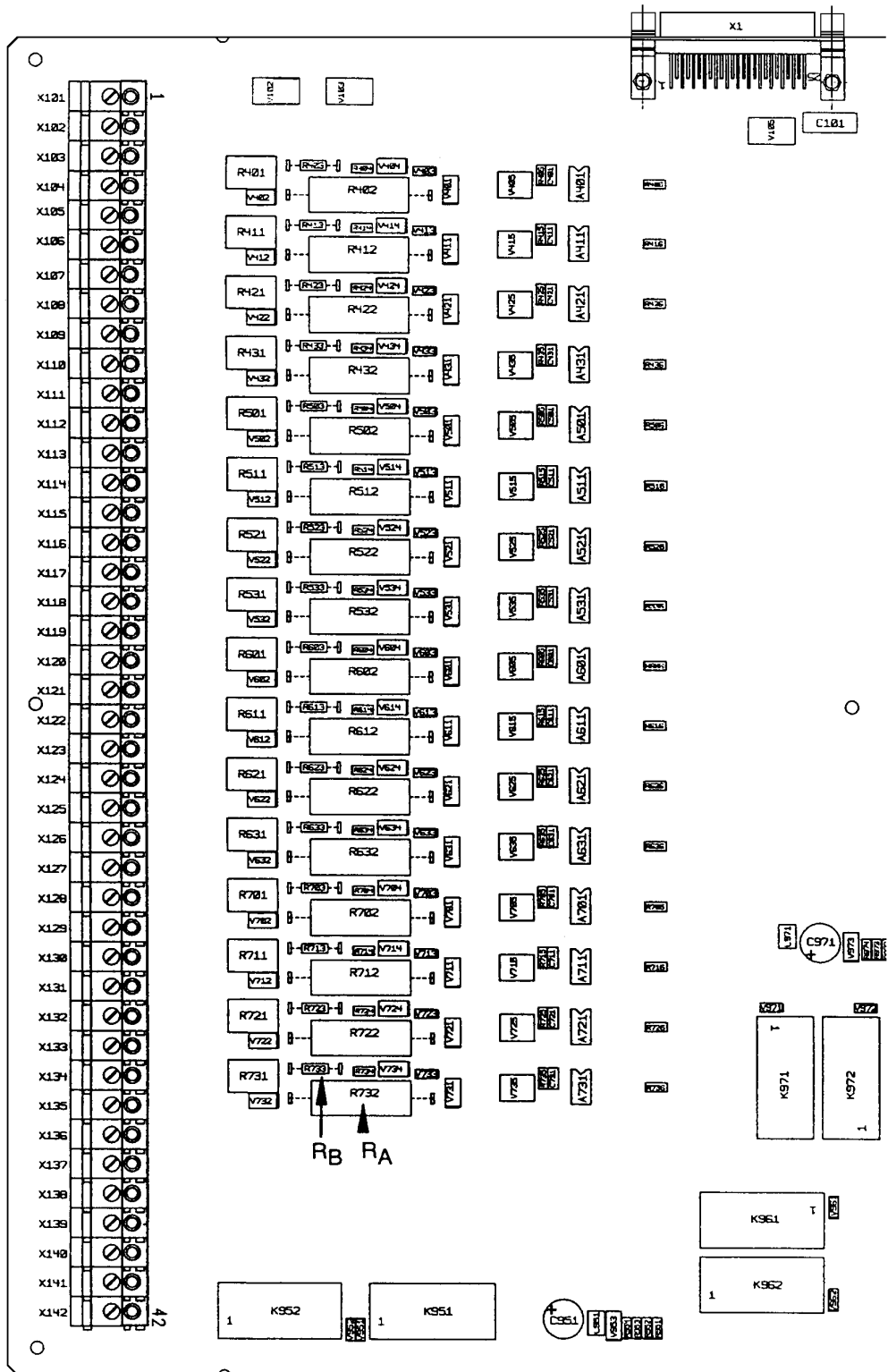


Fig. 12.35 Compact version; input transformer module 216GW62; block diagram and terminals (corresponds to HESG 441 789)



HESG 005 010 TIF

Fig. 12.36 Compact version; relay and opto-coupler module 216GD61; PCB with components (extract of HESG 216 939)



HESG 005 011 TIF

Fig. 12.37 Compact version; relay and opto-coupler module 216GD61a; PCB with components (extract of HESG 216 939)

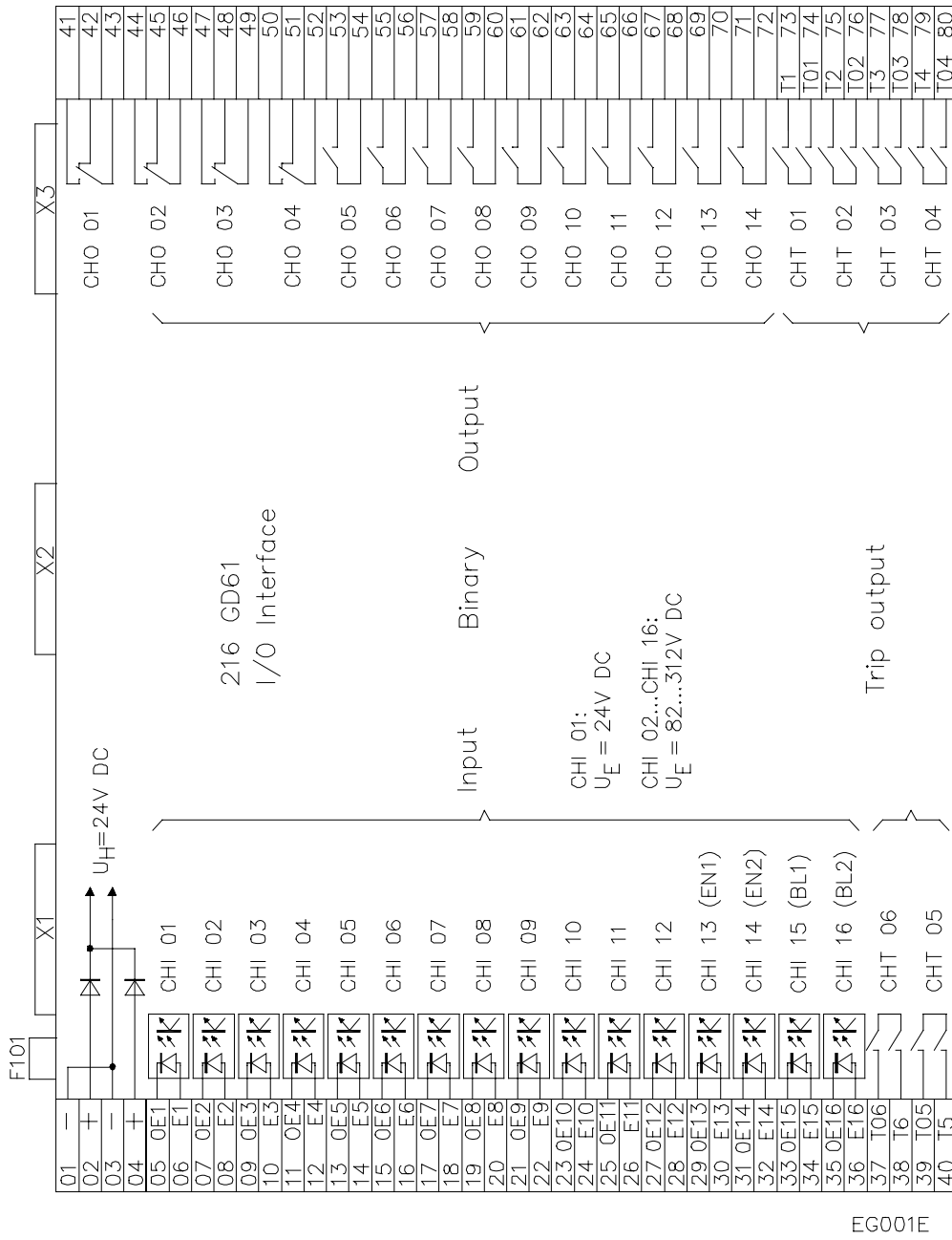
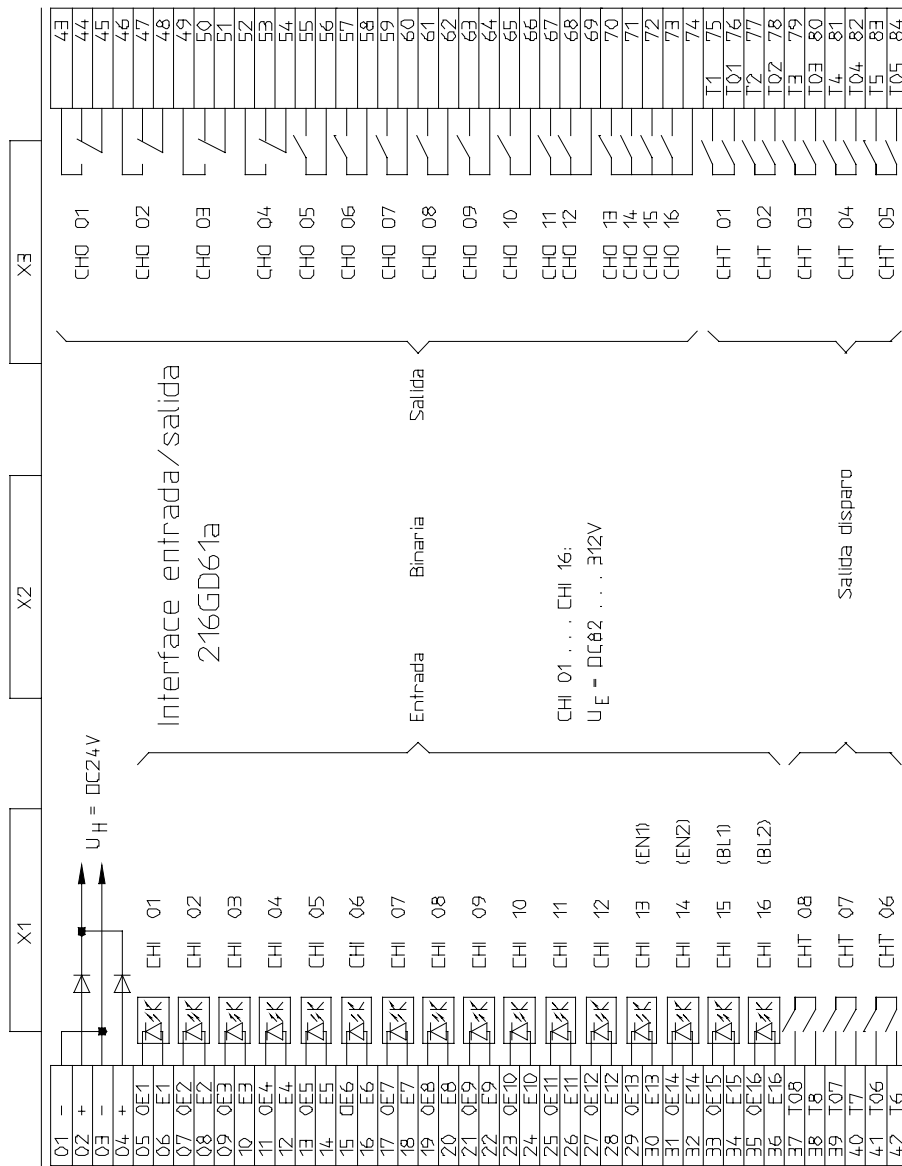


Fig. 12.38 Compact version; relay and opto-coupler module 216GD61; block diagram and terminals (corresponds to HESG 441 788)



adoc009

Fig. 12.39 Compact version; relay and opto-coupler module 216GD61a; block diagram and terminals (corresponds to HESG 441 788)



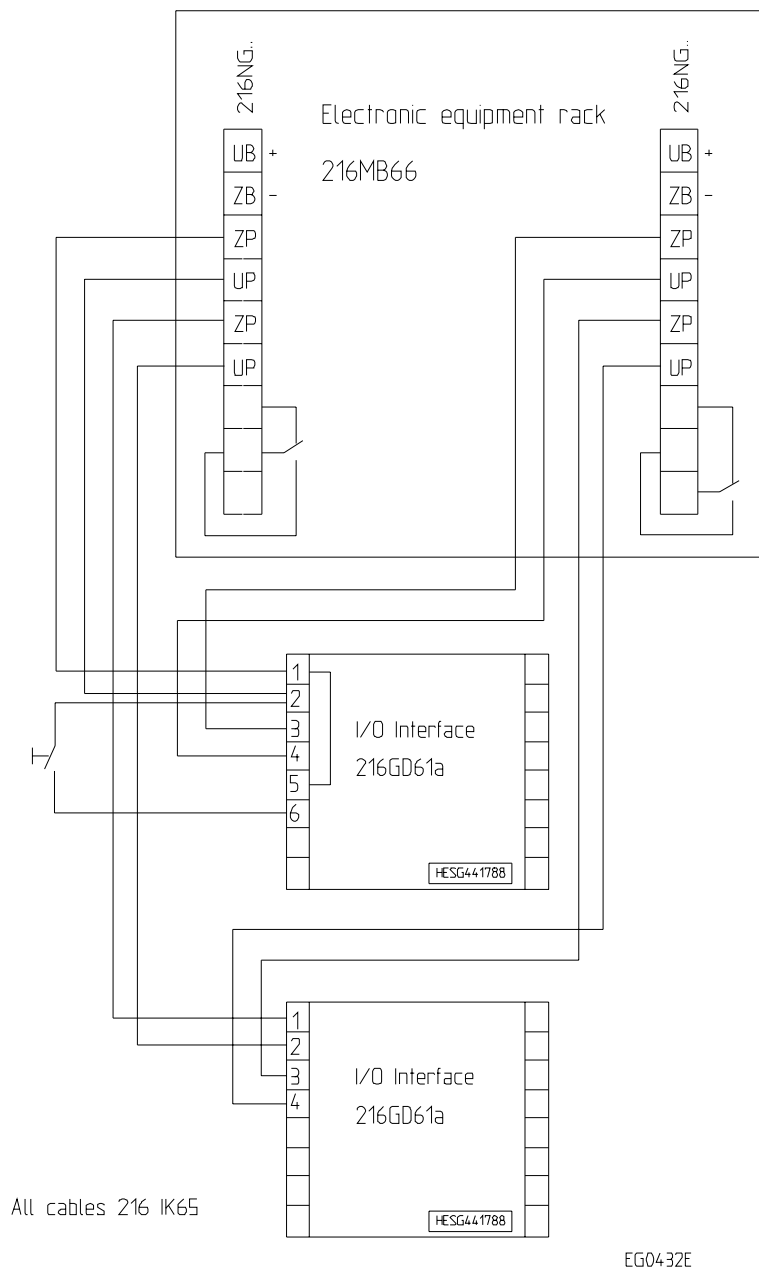


Fig. 12.40 Compact version; auxiliary supply wiring (corresponds to HESG 441 790)

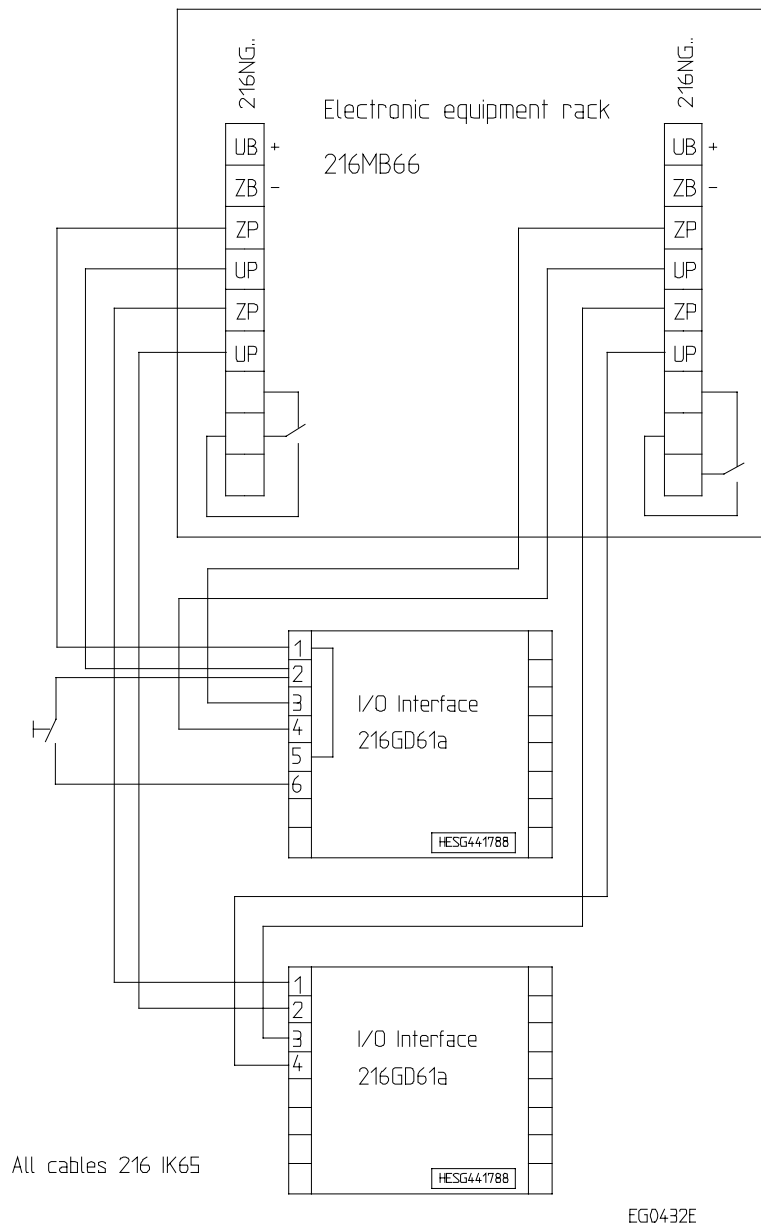


Fig. 12.41 Compact version; auxiliary supply wiring with 216GD61a, single system (corresponds to HESG 441 941)

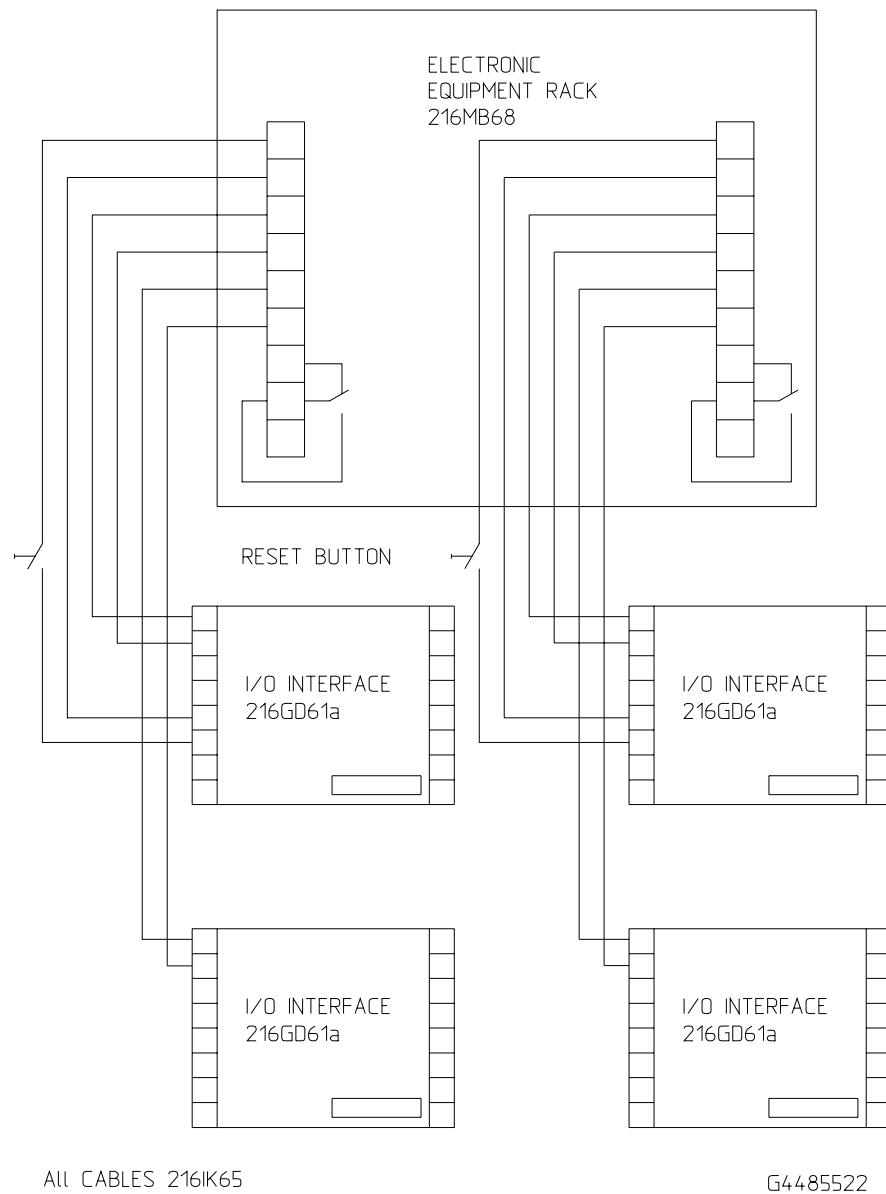


Fig. 12.42 Compact version; auxiliary supply wiring with 216GD61a, redundant system (corresponds to HESG 448 552)

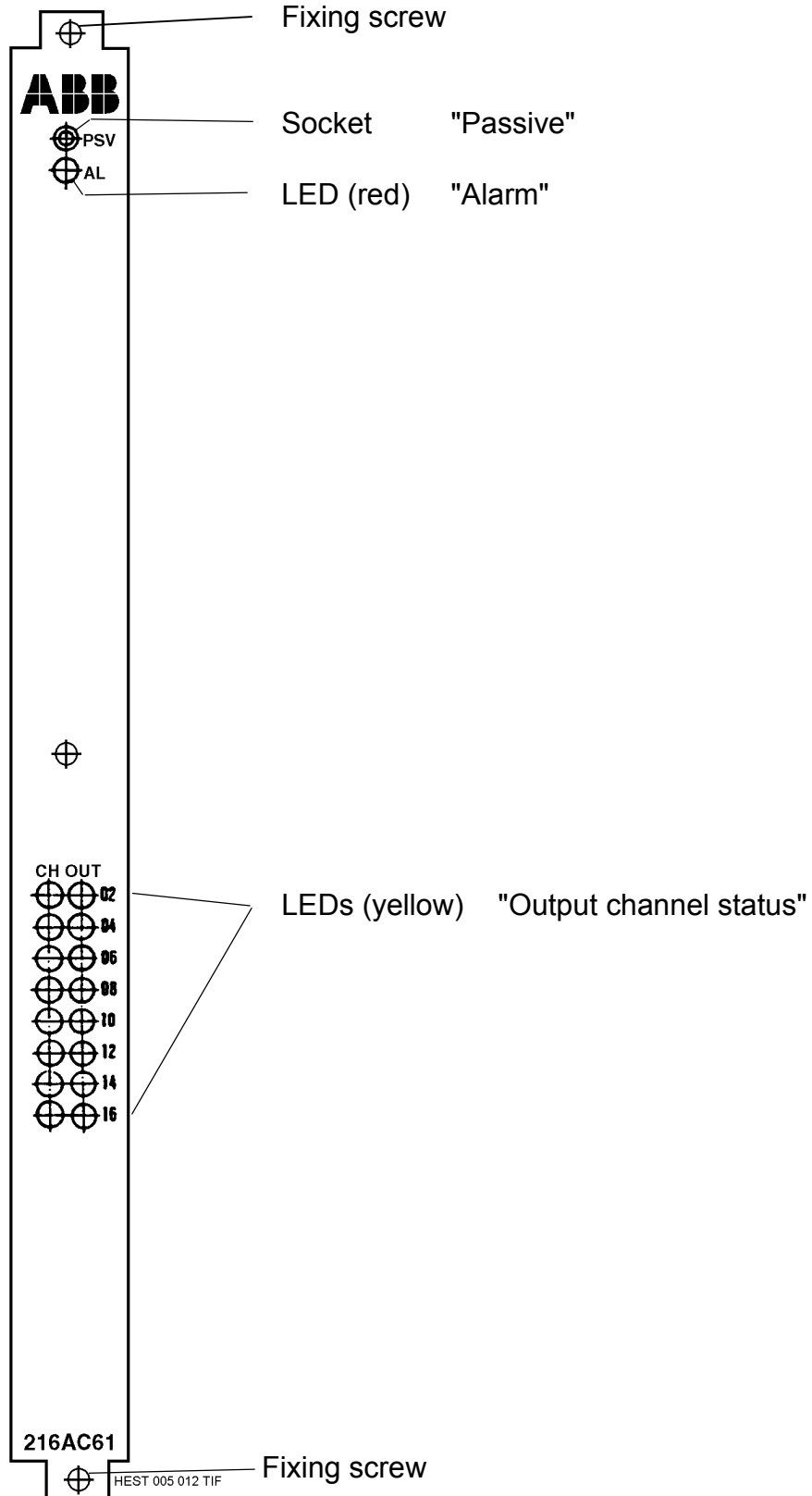
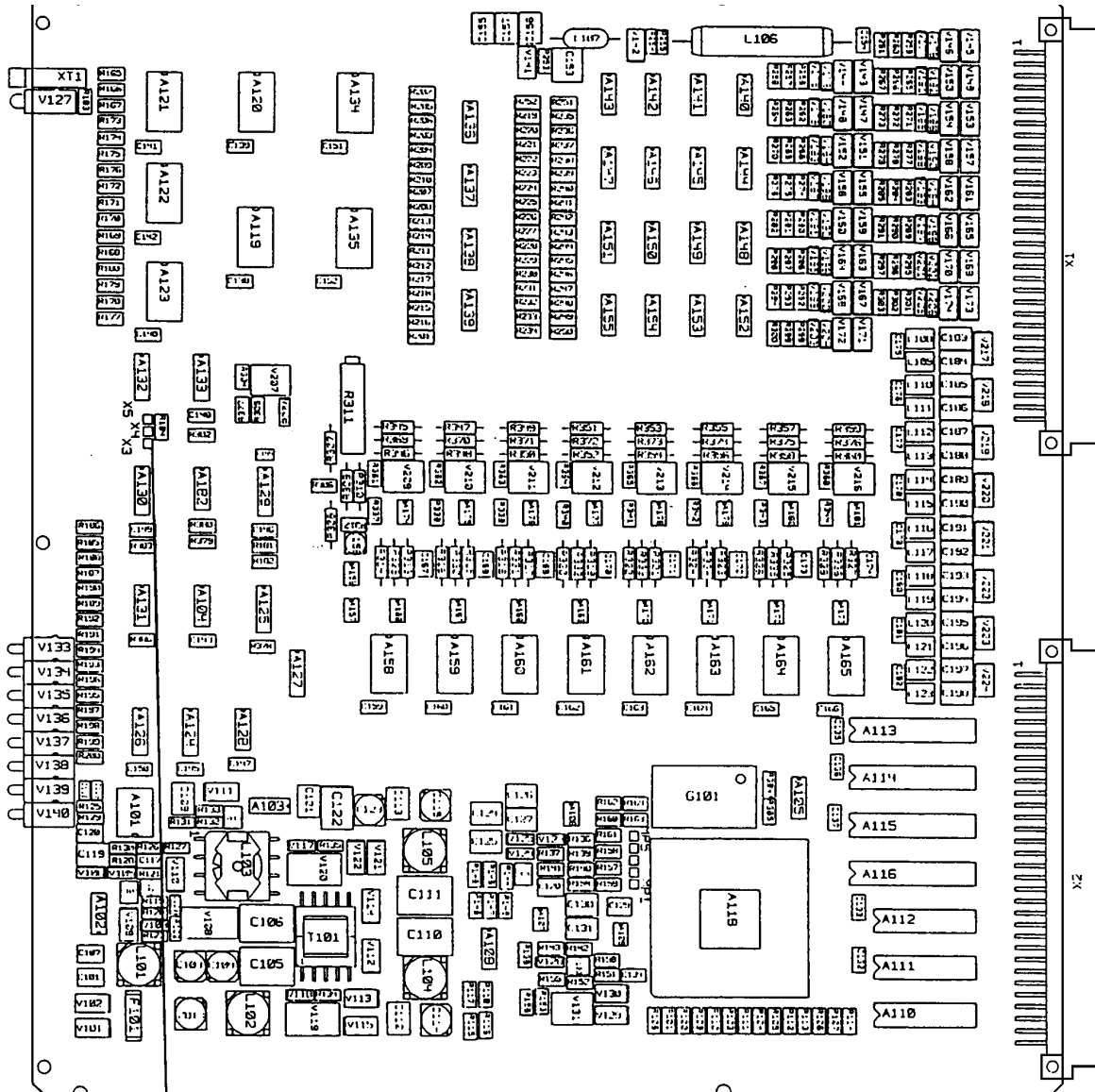


Fig. 12.43 Analogue/binary output unit 216AC61; front view (corresponds to HESG 324 317)



HESG 005 013 TIF

Plug-in jumper XJ1

Position X4-X5 : defect and ready (CH001, 002) in operation  
 Position X3-X4 : defect and ready (CH001, 002) not in operation

Fig. 12.44 Analogue/binary output unit 216AC61; component side of the PCB (corresponds to HESG 324 315)

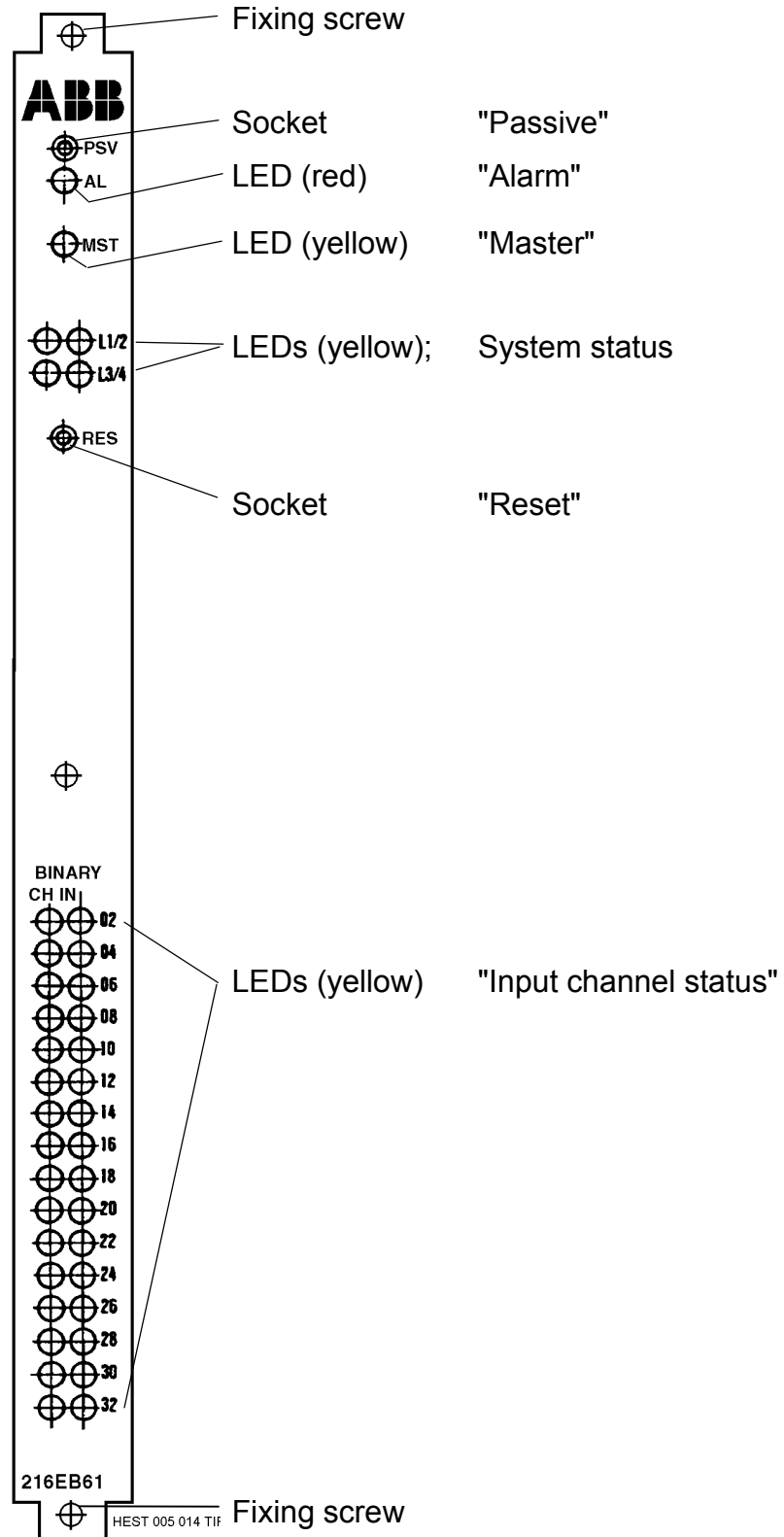
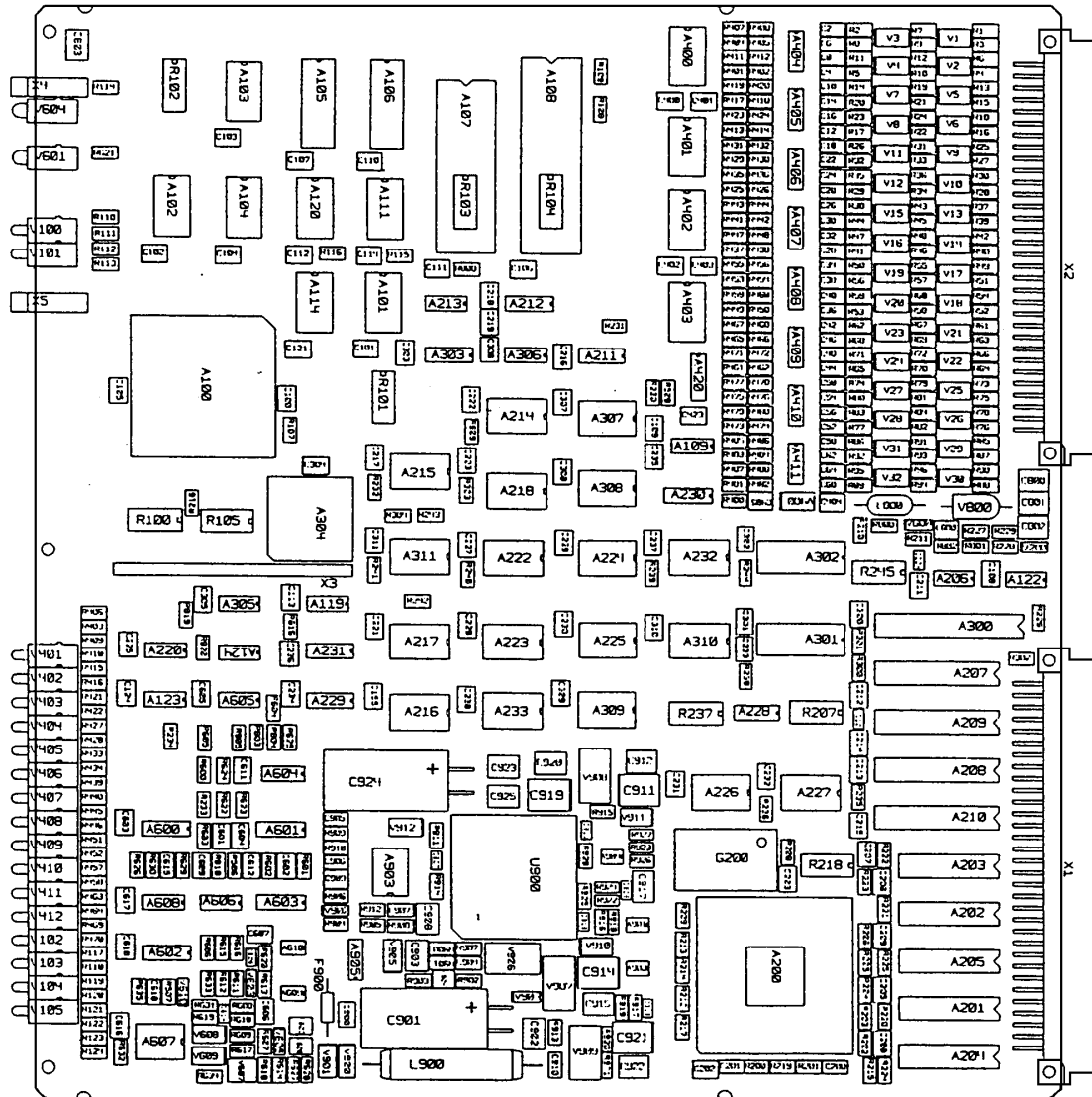


Fig. 12.45 Binary input unit 216EB61; front view (corresponds to HESG 324 298)



HESG 005 015 TIF

Fig. 12.46 Binary input unit 216EB61;  
component side of the PCB (corresponds to HESG 324 295)







# CHECKLIST GENERATOR PROTECTION

STATION: \_\_\_\_\_

UNIT: \_\_\_\_\_

94-04

## KIND OF CHECK

## REMARKS

Type of protection	_____
Cubicle/relay number	_____
Visual check for transport damage	_____
Visual check of external wiring	_____
Check of cubicle grounding	_____
Check of supply voltage (DC/AC)	_____
Check of settings (calculated by .....)	_____
Check of C.T. circuits	_____
Check of P.T. circuits	_____
Check by internal test function	_____
Check by test set, type .....	_____
Check of input signals	_____
Check of signalisation/alarms	_____
Starting breaker failure protection	_____
Check of tripping circuits	_____
Primary tests	_____
Final check	_____

Date:

Signature:

Client

Date:

Signature:







## Notification Form for Errors in this Document

Dear User,

We constantly endeavour to improve the quality of our **technical publications** and would like to hear your suggestions and comments. Would you therefore please fill in this questionnaire and return it to the address given below.

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Utility Automation  
Betreuung Dokumentation, UTA-BD1  
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CH-5401 Baden  
Telefax +41 58 585 28 00

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**Concerns publication:** 1MDU02005-EN (RE.216 V6.3)

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Do you find the publication readily understandable and logically structured? Can you make any suggestions to improve it?

Is the information sufficient for the purpose of the publication? If not, what is missing and where should it be included?

Name

Date

Company

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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  
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Betreuung Software, Abt. UTASS  
Bruggerstrasse 71a  
CH-5401 Baden  
Telefax +41 58 585 35 82  
e-mail: SA-LEC-Support@ch.abb.com

---

Unit/	<input type="checkbox"/> REL 316*4	SW Version:	<input type="checkbox"/> HMI	SW Version:
System:	<input type="checkbox"/> RET 316*4	SW Version:	<input type="checkbox"/> others:	SW Version:
	<input type="checkbox"/> RE.216	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:  
Answered by:

Date:  
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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