VAMP 55

Voltage and frequency protection relay

Publication version: V55/en M/A011

User Manual

Schneider Electric

Trace back information:
Workspace Main version a132
Checked in 2017-02-13
Skribenta version 4.6.323

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1 General

1.1 Legal notice

Copyright

Disclaimer

No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this document. This document is not intended as an instruction manual for untrained persons. This document gives instructions on device installation, commissioning and operation. However, the manual cannot cover all conceivable circumstances or include detailed information on all topics. In the event of questions or specific problems, do not take any action without proper authorization. Contact Schneider Electric and request the necessary information.

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1.2 Safety information and password protection

Important Information

Read these instructions carefully and look at the equipment to become familiar with the device before trying to install, operate, service or maintain it. The following special messages may appear throughout this bulletin or on the equipment to warn of potential hazards or to call attention to information that clarifies or simplifies a procedure.

The addition of either symbol to a “Danger” or “Warning” safety label indicates that an electrical hazard exists which will result in personal injury if the instructions are not followed.

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

⚠ DANGER

DANGER indicates an imminently hazardous situation which, if not avoided, **will result in** death or serious injury.

⚠ WARNING

WARNING indicates a potentially hazardous situation which, if not avoided, **can result in** death or serious injury.

⚠ CAUTION

CAUTION indicates a potentially hazardous situation which, if not avoided, **can result in** minor or moderate injury.

NOTICE

NOTICE is used to address practices not related to physical injury.

User qualification

Electrical equipment should be installed, operated, serviced, and maintained only by trained and qualified personnel. No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this material. A qualified person is one who has skills and knowledge related to the construction, installation, and operation of electrical equipment and has received safety training to recognize and avoid the hazards involved.

Password protection

Use IED's password protection feature in order to protect untrained person interacting this device.

> ⚠ **WARNING**
>
> **WORKING ON ENERGIZED EQUIPMENT**
>
> Do not choose lower Personal Protection Equipment while working on energized equipment.
>
> **Failure to follow these instructions can result in death or serious injury.**

1.3 Relay features

The comprehensive protection functions of the relay make it ideal for utility, industrial, marine and off-shore power distribution applications. The relay features the following protection functions.

Table 1.1: List of protection functions

IEEE/ANSI code	IEC symbol	Function name
24	U/f>, U/f>>	Volts / hertz over excitation protection
25	Δf, ΔU, Δφ	Synchrocheck
27	U<, U<<, U<<<, U<<<<, U<<<<<	Undervoltage protection
27P	U_1<, U_1<<, U_1<<<	Positive sequence undervoltage protection for generator applications
47	U_2>, U_2>>, U_2>>>	Negative sequence overvoltage
50BF	CBFP	Circuit-breaker failure protection
59	U>, U>>, U>>>, U>>>>, U>>>>>	Overvoltage protection
59N	U_0>, U_0>>, U_0>>>	Zero sequence voltage protection
81H/81L	f><, f>><<, f>>><<<	Overfrequency and underfrequency protection
81L	f<, f<<, f<<<	Underfrequency protection
81R	df/dt	Rate of change of frequency (ROCOF) protection
99	Prg1 – 8	Programmable stages

Further the relay includes a disturbance recorder. Arc protection is optionally available.

The relay communicates with other systems using common protocols, such as the Modbus RTU, ModbusTCP, Profibus DP, IEC 60870-5-103, IEC 60870-5-101, IEC 61850, SPA bus, Ethernet / IP and DNP 3.0.

1.3.1 User interface

The relay can be controlled in three ways:

- Locally with the push-buttons on the relay front panel
- Locally using a PC connected to the USB port on the front
- Via remote control over the optional remote control port on the relay rear panel.

1.4 Related documents

Document	**Identification*)**
VAMP Relay Mounting and Commissioning Instructions	VRELAY_MC_xxxx
VAMPSET Setting and Configuration Tool User Manual	VVAMPSET_EN_M_xxxx

**) xxxx = revision number*

Download the latest software and manual at www.schneider-electric.com/vamp-protection or m.vamp.fi.

1.5 Periodical testing

The protection IED, cabling and arc sensors must periodically be tested according to the end-user's safety instructions, national safety instructions or law. Manufacturer recommends functional testing being carried minimum every five (5) years.

It is proposed that the periodic testing is conducted with a secondary injection principle for those protection stages which are used in the IED and its related units.

1.6 EU directive compliance

EMC compliance

CE 2014/30/EU

Compliance with the European Commission's EMC Directive. Product Specific Standards were used to establish conformity:

- EN 60255-26: 2013

Product safety

CE 2014/35/EU

Compliance with the European Commission's Low Voltage Directive. Compliance is demonstrated by reference to generic safety standards:

- EN60255-27:2014

1.7 Abbreviations

ANSI	American National Standards Institute. A standardization organisation.
CB	Circuit breaker
CBFP	Circuit breaker failure protection
cosφ	Active power divided by apparent power = P/S. (See power factor PF). Negative sign indicates reverse power.
CT	Current transformer
CT_{PRI}	Nominal primary value of current transformer
CT_{SEC}	Nominal secondary value of current transformer
Dead band	See hysteresis.
DI	Digital input
DO	Digital output, output relay
Document file	Stores information about the IED settings, events and fault logs.
DSR	Data set ready. An RS232 signal. Input in front panel port of VAMP relays to disable rear panel local port.
DST	Daylight saving time. Adjusting the official local time forward by one hour for summer time.
DTR	Data terminal ready. An RS232 signal. Output and always true (+8 Vdc) in front panel port of VAMP relays.
FFT	Fast Fourier transform. Algorithm to convert time domain signals to frequency domain or to phasors.
FPGA	Field-programmable gate array
HMI	Human-machine interface
Hysteresis	I.e. dead band. Used to avoid oscillation when comparing two near by values.
I_N	Nominal current. Rating of CT primary or secondary.
I_{SET}	Another name for pick up setting value I>
I_{0N}	Nominal current of I_0 input in general

IEC	International Electrotechnical Commission. An international standardization organisation.
IEC-101	Abbreviation for communication protocol defined in standard IEC 60870-5-101
IEC-103	Abbreviation for communication protocol defined in standard IEC 60870-5-103
IED	Intelligent electronic device
IEEE	Institute of Electrical and Electronics Engineers
LAN	Local area network. Ethernet based network for computers and IEDs.
Latching	Output relays and indication LEDs can be latched, which means that they are not released when the control signal is releasing. Releasing of latched devices is done with a separate action.
LCD	Liquid crystal display
LED	Light-emitting diode
Local HMI	IED front panel with display and push-buttons
NTP	Network Time Protocol for LAN and WWW
P	Active power. Unit = [W]
PF	Power factor. The absolute value is equal to cosφ, but the sign is '+' for inductive i.e. lagging current and '-' for capacitive i.e. leading current.
P_M	Nominal power of the prime mover. (Used by reverse/under power protection.)
PT	See VT
pu	Per unit. Depending of the context the per unit refers to any nominal value. For example for overcurrent setting 1 pu = 1 x I_N.
Q	Reactive power. Unit = [var] acc. IEC
RMS	Root mean square
S	Apparent power. Unit = [VA]
SF	IED status inoperative
SNTP	Simple Network Time Protocol for LAN and WWW
TCS	Trip circuit supervision
THD	Total harmonic distortion
U_{0SEC}	Voltage at input U_c at zero ohm ground fault. (Used in voltage measurement mode “2LL+U_0”)
U_A	Voltage input for U_{12} or U_{L1} depending of the voltage measurement mode
U_B	Voltage input for U_{23} or U_{L2} depending of the voltage measurement mode
U_C	Voltage input for U_{31} or U_0 depending of the voltage measurement mode
U_N	Nominal voltage. Rating of VT primary or secondary
UTC	Coordinated Universal Time (used to be called GMT = Greenwich Mean Time)
VAMPSET	Configuration tool for VAMP protection devices
Webset	http configuration interface
VT	Voltage transformer i.e. potential transformer PT
VT_{PRI}	Nominal primary value of voltage transformer
VT_{SEC}	Nominal secondary value of voltage transformer

2 Local panel user interface

2.1 Relay front panel

The figure below shows, as an example, the front panel of the device and the location of the user interface elements used for local control.

1. Navigation push-buttons
2. LED indicators
3. LCD
4. Local port

Navigation push-button function


CANCEL push-button for returning to the previous menu. To return to the first menu item in the main menu, press the button for at least three seconds.


INFO push-button for viewing additional information, for entering the password view and for adjusting the LCD contrast.

programmable function push-button. As default F1 toggles Virtual Input 1 (VI1) On/Off

programmable function push-button. As default F2 toggles Virtual Input 2 (VI2) On/Off

ENTER push-button for activating or confirming a function.


arrow UP navigation push-button for moving up in the menu or increasing a numerical value.


arrow DOWN navigation push-button for moving down in the menu or decreasing a numerical value.


arrow LEFT navigation push-button for moving backwards in a parallel menu or selecting a digit in a numerical value.


arrow RIGHT navigation push-button for moving forwards in a parallel menu or selecting a digit in a numerical value.

LED indicators

The LEDs on the local HMI can be configured in VAMPSET. To customise the LED texts on the local HMI, the texts can be written on a template and then printed on a transparency. The transparencies can be placed to the pockets beside the LEDs.

LED indicator	Meaning	Measure/ Remarks
Power LED lit	The auxiliary power has been switched on	Normal operation state
Status LED lit	Internal fault, operates in parallel with the self supervision output relay	The relay attempts to reboot [REBOOT]. If the error LED remains lit, call for maintenance.
A- H LED lit	Application-related status indicators.	Configurable
F1 / F2 LED lit	Corresponding function key pressed / activated	Depending of function programmed to F1 / F2

Adjusting LCD contrast

1. On the local HMI, push i and OK.
2. Enter the four-digit password and push OK.
3. Push i and adjust the contrast.
   - To increase the contrast, push ∧.
   - To decrease the contrast, push ∨.
4. To return to the main menu, push .

Resetting latched indicators and output relays

All the indicators and output relays can be given a latching function in the configuration.

There are several ways to reset latched indicators and relays:

- From the alarm list, move back to the initial display by pushing for approx. 3s. Then reset the latched indicators and output relays by pushing OK.
- Acknowledge each event in the alarm list one by one by pushing OK equivalent times. Then, in the initial display, reset the latched indicators and output relays by pushing OK.

The latched indicators and relays can also be reset via a remote communication bus or via a digital input configured for that purpose.

2.1.1 Display

The relay is provided with a backlighted 128x64 LCD dot matrix display. The display enables showing 21 characters is one row and eight rows at the same time. The display has two different purposes: one is to show the single line diagram of the relay with the object status, measurement values, identification etc (Figure 2.1). The other purpose is to show the configuration and parameterization values of the relay (Figure 2.2).

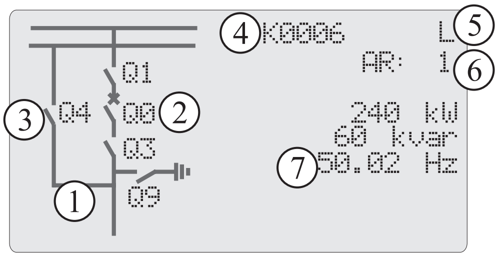


Figure 2.1: Sections of the LCD dot matrix display

1. Freely configurable single-line diagram
2. Controllable objects (max six objects)
3. Object status (max eight objects, including the six controllable objects)
4. Bay identification
5. Local/Remote selection
6. Auto-reclose on/off selection (if applicable)
7. Freely selectable measurement values (max. six values)

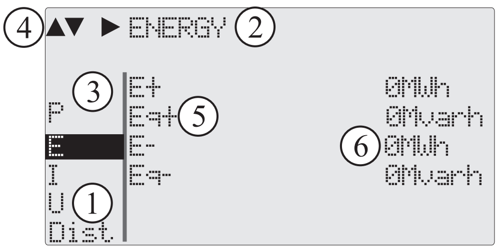


Figure 2.2: Sections of the LCD dot matrix display

1. Main menu column
2. The heading of the active menu
3. The cursor of the main menu
4. Possible navigating directions (push buttons)
5. Measured/setting parameter
6. Measured/set value

Backlight control

Display backlight can be switched on with a digital input, virtual input or virtual output. LOCALPANEL CONF/**Display backlight ctrl** setting is used for selecting trigger input for backlight control. When the selected input activates (rising edge), display backlight is set on for 60 minutes.

2.1.2 Adjusting display contrast

The readability of the LCD varies with the brightness and the temperature of the environment. The contrast of the display can be adjusted via the PC user interface, see Chapter 3 VAMPSET PC software.

2.2 Local panel operations

The front panel can be used to control objects, change the local/ remote status, read the measured values, set parameters, and to configure relay functions. Some parameters, however, can only be set by means of a PC connected to the local communication port. Some parameters are factory-set.

Moving in the menus

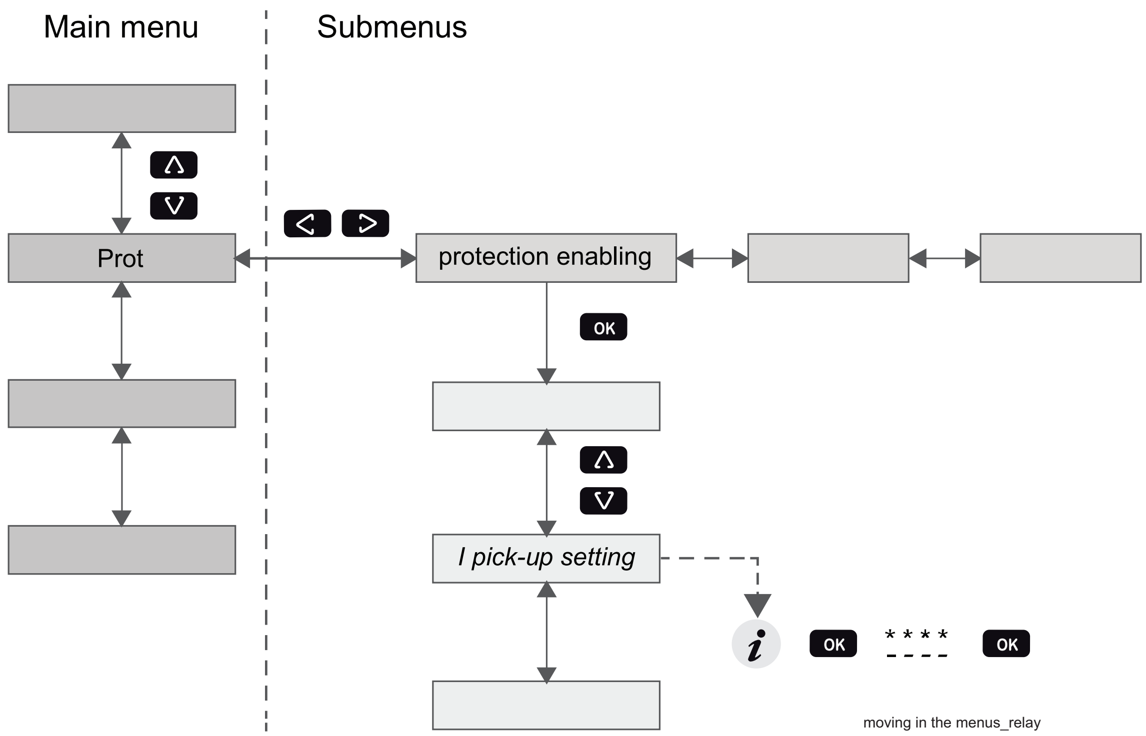


Figure 2.3: Moving in the menus using local HMI

- To move in the main menu, push ∧ or ∨.
- To move in submenus, push > or <.
- To enter a submenu, push OK and use ∨ or ∧ for moving down or up in the menu.
- To edit a parameter value, push *i* and OK.
- To go back to the previous menu, push .
- To go back to the first menu item in the main menu, push for at least three seconds.

NOTE: To enter the parameter edit mode, give the password. When the value is in edit mode, its background is dark.

Main menu

The menu is dependent on the user's configuration and the options according the order code. For example only the enabled protection stages will appear in the menu.

A list of the local main menu

Main menu	Number of menus	Description	ANSI code	Note
	1	Interactive mimic display		1
	5	Double size measurements defined by the user		1
	1	Title screen with device name, time and firmware version.		
U	19	Voltage measurements		
Umax	9	Time stamped min & max of voltages		
Evnt	2	Events		
DR	3	Disturbance recorder		2
Runh	2	Running hour counter. Active time of a selected digital input and time stamps of the latest start and stop.		
TIMR	6	Day and week timers		
DI	5	Digital inputs including virtual inputs		
DO	4	Digital outputs (relays) and output matrix		
ExtAI		External analogue inputs		3
ExDI		External digital inputs		3
ExDO		External digital outputs		3
Prot	18	Protection counters, combined overcurrent status, protection status, protection enabling, and block matrix		
U>	4	1st overvoltage stage	59	4
U>>	3	2nd overvoltage stage	59	4
U>>>	3	3rd overvoltage stage	59	4
Uf>	3	Overexcitation stage volt/hertz	24	4
U1<	4	1st positive sequence undervoltage stage	27P	4
U1<<	4	2nd positive sequence undervoltage stage	27P	4
U0>	4	1st undervoltage stage	27	4
U<	3	2nd undervoltage stage	27	4
U<<	3	3rd undervoltage stage	27	4
U<<<	3	1st residual overvoltage stage	59N	4
U0>>	3	2nd residual overvoltage stage	59N	4
f><	4	1st over/under-frequency stage	81	4
f>><<	4	2nd over/under-frequency stage	81	4
f<	4	1st underfrequency stage	81L	4
f<<	4	2nd underfrequency stage	81L	4
Prg1	3	1st programmable stage	99	4
Prg2	3	2nd programmable stage	99	4

Main menu	Number of menus	Description	ANSI code	Note
Prg3	3	3rd programmable stage	99	4
Prg4	3	4th programmable stage	99	4
Prg5	3	5th programmable stage	99	4
Prg6	3	6th programmable stage	99	4
Prg7	3	7th programmable stage	99	4
Prg8	3	8th programmable stage	99	4
SyC1	5	Synchrocheck 1	25	
CBFP	3	Circuit breaker failure protection	50BF	4
CBWE	5	Circuit breaker wearing supervision		4
AR	15	Auto-reclose	79	
OBJ	11	Object definitions		5
Lgic	2	Status and counters of user’s logic		1
CONF	9	Device setup, scaling etc.		6
Bus	18	Serial port and protocol configuration		7
OPT	1	Option cards		
Diag	9	Device selfdiagnosis		

Notes

1. Configuration is done with VAMPSET

2. Recording files are read with VAMPSET

3. The menu is visible only if protocol "ExternalIO" is selected for one of the serial ports. Serial ports are configured in menu "Bus".

4. The menu is visible only if the stage is enabled.

5. Objects are circuit breakers, disconnectors etc.

6. There are two extra menus, which are visible only if the access level "operator" or "configurator" has been opened with the corresponding password.

7. Detailed protocol configuration is done with VAMPSET.

2.2.1 Menu structure of protection functions

The general structure of all protection function menus is similar although the details do differ from stage to stage. As an example the details of the second overcurrent stage I>> menus are shown below.

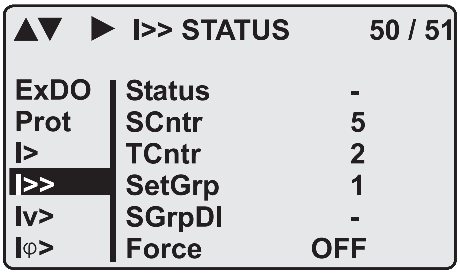


Figure 2.4: First menu of I>> 50/51 stage

This is the status, start and trip counter and setting group menu.

- Status –
  The stage is not detecting any fault at the moment. The stage can also be forced to pick-up or trip is the operating level is "Configurator" and the force flag below is on. Operating levels are explained in Chapter 2.2.4 Operating levels.
- SCntr 5
  The stage has picked-up a fault five times since the last reset or restart. This value can be cleared if the operating level is at least "Operator".
- TCntr 2
  The stage has tripped two times since the last reset or restart. This value can be cleared if the operating level is at least "Operator".
- SetGrp 1
  The active setting group is one. This value can be edited if the operating level is at least "Operator". Setting groups are explained in Chapter 2.2.2 Setting groups
- SGrpDI –
  The setting group is not controlled by any digital input. This value can be edited if the operating level is at least "Configurator".
- Force Off
  The status forcing and output relay forcing is disabled. This force flag status can be set to "On" or back to "Off" if the operating level is at least "Configurator". If no front panel button is pressed within five minutes and there is no VAMPSET communication, the force flag will be set to "Off" position. The forcing is explained in Chapter 2.3.4 Forced control (Force).

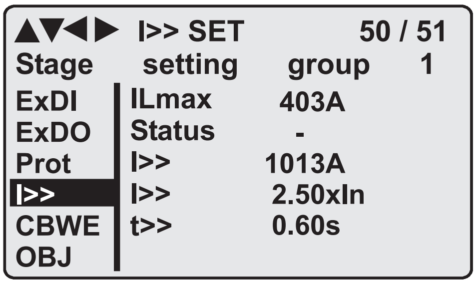


Figure 2.5: Second menu(next on the right) of I>> 50/51 stage

This is the main setting menu.

- Stage setting group 1
  These are the group 1 setting values. The other setting group can be seen by pressing push buttons OK and then > or <. Setting groups are explained in Chapter 2.2.2 Setting groups.
- ILmax 403A
  The maximum of three measured phase currents is at the moment 403 A. This is the value the stage is supervising.
- Status –
  Status of the stage. This is just a copy of the status value in the first menu.
- I>> 1013 A
  The pick-up limit is 1013 A in primary value.
- I>> 2.50 x I_N
  The pick-up limit is 2.50 times the rated current of the generator. This value can be edited if the operating level is at least “Operator”. Operating levels are explained in Chapter 2.2.4 Operating levels.
- t>> 0.60s
  The total operation delay is set to 600 ms. This value can be edited if the operating level is at least “Operator”.

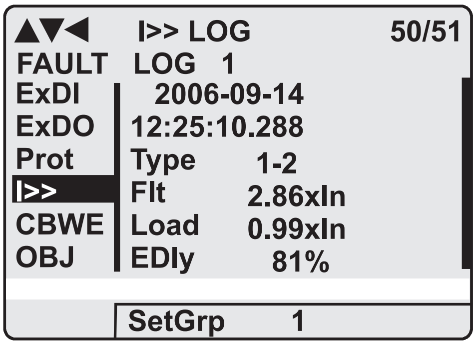


Figure 2.6: Third and last menu (next on the right) of I>> 50/51 stage

This is the menu for registered values by the I>> stage. Fault logs are explained in Chapter 2.2.3 Fault logs.

- FAULT LOG 1
  This is the latest of the eight available logs. You may move between the logs by pressing push buttons OK and then > or <.
- 2006-09-14
  Date of the log.
- 12:25:10.288
  Time of the log.
- Type 1-2
  The overcurrent fault has been detected in phases L1 and L2 (A & B, red & yellow, R/S, u&v).
- Flt 2.86 x I_N
  The fault current has been 2.86 per unit.
- Load 0.99 x I_N
  The average load current before the fault has been 0.99 pu.
- EDly 81%
  The elapsed operation delay has been 81% of the setting 0.60 s = 0.49 s. Any registered elapsed delay less than 100 % means that the stage has not tripped, because the fault duration has been shorter that the delay setting.
- SetGrp 1
  The setting group has been 1. This line can be reached by pressing OK and several times ▽.

2.2.2 Setting groups

Most of the protection functions of the relay have four setting groups. These groups are useful for example when the network topology is changed frequently. The active group can be changed by a digital input, through remote communication or locally by using the local panel.

The active setting group of each protection function can be selected separately. Figure 2.7 shows an example where the changing of the I> setting group is handled with digital input one (SGrpDI). If the digital input is TRUE, the active setting group is group two and correspondingly, the active group is group one, if the digital input is FALSE. If no digital input is selected (SGrpDI = -), the active group can be selected by changing the value of the parameter SetGrp.

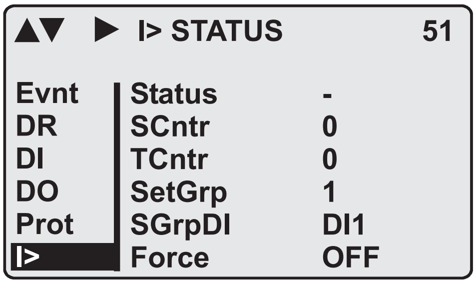


Figure 2.7: Example of protection submenu with setting group parameters

The changing of the setting parameters can be done easily. When the desired submenu has been found (with the arrow keys), press OK to select the submenu. Now the selected setting group is indicated in the down-left corner of the display (See Figure 2.8). Set1 is setting group one and Set2 is setting group two. When the needed changes, to the selected setting group, have been done, press ▷ or ◁ to select another group (◁ is used when the active setting group is 2 and ▷ is used when the active setting group is 1).

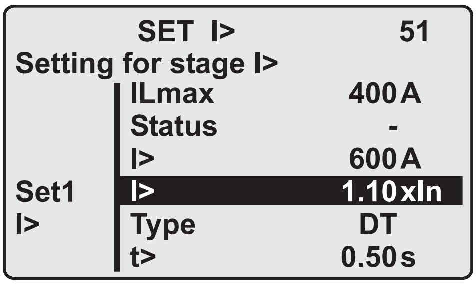


Figure 2.8: Example of I> setting submenu

2.2.3 Fault logs

All the protection functions include fault logs. The fault log of a function can register up to eight different faults with time stamp information, fault values etc. The fault logs are stored in non-volatile memory. Each function has its own logs. The fault logs are not cleared when power is switched off. The user is able to clear all logs using VAMPSET. Each function has its own logs (Figure 2.9).

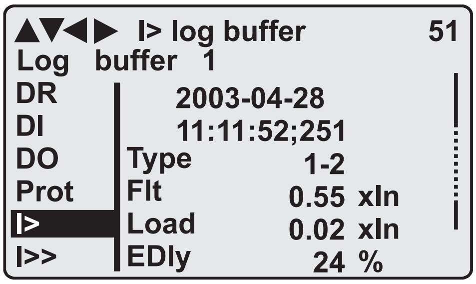


Figure 2.9: Example of fault log

To see the values of, for example, log two, press then OK to select the current log (log one). The current log number is then indicated in the down-left corner of the display (SeeFigure 2.10, Log2 = log two). The log two is selected by pressing ▷ once.

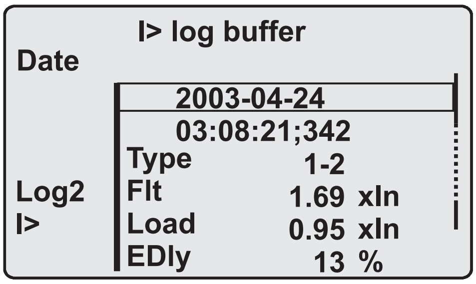


Figure 2.10: Example of selected fault log

2.2.4 Operating levels

The relay has three operating levels: **User level**, **Operator level** and **Configurator level**. The purpose of the access levels is to prevent accidental change of relay configurations, parameters or settings.

USER level

Use:	Possible to read e.g. parameter values, measurements and events
Opening:	Level permanently open
Closing:	Closing not possible

OPERATOR level

Use:	Possible to control objects and to change e.g. the settings of the protection stages
Opening:	Default password is 1
Setting state:	Push OK
Closing:	The level is automatically closed after 10 minutes idle time. Giving the password 9999 can also close the level.

CONFIGURATOR level

Use:	The configurator level is needed during the commissioning of the relay. E.g. the scaling of the voltage and current transformers can be set.
Opening:	Default password is 2
Setting state:	Push OK
Closing:	The level is automatically closed after 10 minutes idle time. Giving the password 9999 can also close the level.

Opening access

1. Push i and OK on the front panel

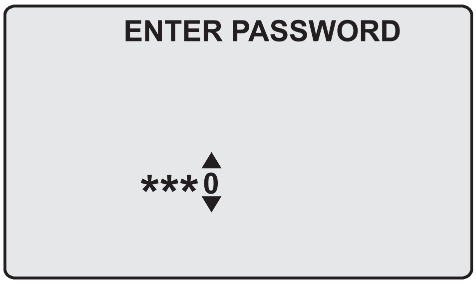


Figure 2.11: Opening the access level

2. Enter the password needed for the desired level: the password can contain four digits. The digits are supplied one by one by first moving to the position of the digit using ▷ and then setting the desired digit value using △.
3. Push OK.

Password handling

The passwords can only be changed using VAMPSET software connected to the USB -port in front of the relay.

It is possible to restore the password(s) in case the password is lost or forgotten. In order to restore the password(s), a relay program is needed. The virtual serial port settings are 38400 bps, 8 data bits, no parity and one stop bit. The bit rate is configurable via the front panel.

Command	Description
get pwd_break	Get the break code (Example: 6569403)
get serno	Get the serial number of the relay (Example: 12345)

Send both the numbers to your nearest Schneider Electric Customer Care Centre and ask for a password break. A device specific break code is sent back to you. That code will be valid for the next two weeks.

Command	Description
set pwd_break=4435876	Restore the factory default passwords (“4435876” is just an example. The actual code should be asked from your nearest Schneider Electric Customer Care Centre.)

Now the passwords are restored to the default values (See Chapter 2.2.4 Operating levels).

2.3 Operating measures

2.3.1 Control functions

The default display of the local panel is a single-line diagram including relay identification, Local/Remote indication, Auto-reclose on/off selection and selected analogue measurement values.

Please note that the operator password must be active in order to be able to control the objects. Please refer to Chapter 2.2.4 Operating levels.

Toggling Local/Remote control

1. Push OK. The previously activated object starts to blink.
2. Select the Local/Remote object (“L” or “R” squared) by using arrow keys.
3. Push OK. The L/R dialog opens. Select “REMOTE” to enable remote control and disable local control. Select “LOCAL” to enable local control and disable remote control.
4. Confirm the setting by pushing OK. The Local/Remote state will change.

Object control

- Using OK and △ / ▽

1. Push OK. The previously activated object starts to blink.
2. Select the object to control by using arrow keys. Please note that only controllable objects can be selected.
3. Push OK. A control dialog opens.
4. Select the “Open” or “Close” command by using the △ or ▽.
5. Confirm the operation by pushing OK. The state of the object changes.

- Using F1 & F2 in object control mode

1. Push F1 or F2. Object assigned to the key starts to blink and a control dialog opens.
2. Confirm the operation by pushing OK.

Toggling virtual inputs

1. Push OK. The previously activated object starts to blink.
2. Select the virtual input object (empty or black square)

3. The dialog opens
4. Select “VIon” to activate the virtual input or select “VIoff” to deactivate the virtual input

2.3.2 Measured data

The measured values can be read from the Meas menu and its submenus. Furthermore, any measurement value in the following table can be displayed on the main view next to the single line diagram. Up to six measurements can be shown.

Value	Menu/Submenu	Description
IL1	MEAS/PHASE CURRENTS	Phase current IL1 [A]
IL2	MEAS/PHASE CURRENTS	Phase current IL2 [A]
IL3	MEAS/PHASE CURRENTS	Phase current IL3 [A]
IL1da	MEAS/PHASE CURRENTS	15 min average for IL1 [A]
IL2da	MEAS/PHASE CURRENTS	15 min average for IL2 [A]
IL3da	MEAS/PHASE CURRENTS	15 min average for IL3 [A]
Io	MEAS /SYMMETRIC CURRENTS	Primary value of zerosequence/ residual current Io [A]
IoC	MEAS /SYMMETRIC CURRENTS	Calculated Io [A]
I1	MEAS /SYMMETRIC CURRENTS	Positive sequence current [A]
I2	MEAS /SYMMETRIC CURRENTS	Negative sequence current [A]
I2/I1	MEAS /SYMMETRIC CURRENTS	Negative sequence current related to positive sequence current (for unbalance protection) [%]
Uo	MEAS/MISCELLANEOUS	Residual voltage Uo [%]
f	MEAS/MISCELLANEOUS	Frequency [Hz]
AngDiag	MEAS/ANGEE DIAGRAM	Phasors
THDIL	MEAS /HARM. DISTORTION	Total harmonic distortion of the mean value of phase currents [%]
THDIL1	MEAS /HARM. DISTORTION	Total harmonic distortion of phase current IL1 [%]
THDIL2	MEAS /HARM. DISTORTION	Total harmonic distortion of phase current IL2 [%]
THDIL3	MEAS /HARM. DISTORTION	Total harmonic distortion of phase current IL3 [%]
IL1har	MEAS/HARMONICS of IL1	Harmonics of phase current IL1 [%]
IL2har	MEAS/HARMONICS of IL2	Harmonics of phase current IL2 [%]
IL3har	MEAS/HARMONICS of IL3	Harmonics of phase current IL3 [%]
IL1 wave	MEAS/IL1 WAVEFORM	Waveform of IL1
IL2 wave	MEAS/IL2 WAVEFORM	Waveform of IL2
IL3 wave	MEAS/IL3 WAVEFORM	Waveform of IL3
IL1 avg	MEAS/IL1 AVERAGE	10 min average of IL1
IL2 avg	MEAS/IL2 AVERAGE	10 min average of IL2
IL3 avg	MEAS/IL3 AVERAGE	10 min average of IL3

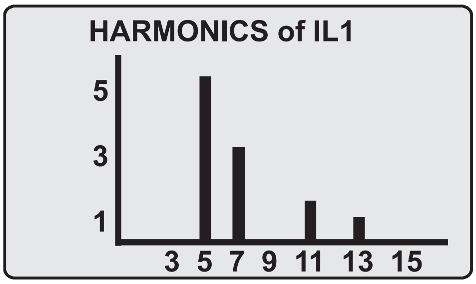


Figure 2.12: Example of harmonics bar display

2.3.3 Reading event register

The event register can be read from the Evnt submenu:

1. Push ▷ once.
2. The EVENT LIST appears. The display contains a list of all the events that have been configured to be included in the event register.

Figure 2.13: Example of an event register

3. Scroll through the event list with the △ and ▽.
4. Exit the event list by pushing ◁.

It is possible to set the order in which the events are sorted. If the “Order” -parameter is set to “New-Old”, then the first event in the EVENT LIST is the most recent event.

2.3.4 Forced control (Force)

In some menus it is possible to switch a function on and off by using a force function. This feature can be used, for instance, for testing a certain function. The force function can be activated as follows:

1. Open access level Configurator.
2. Move to the setting state of the desired function, for example DO (see Chapter 2.4 Configuration and parameter setting).
3. Select the Force function (the background color of the force text is black).

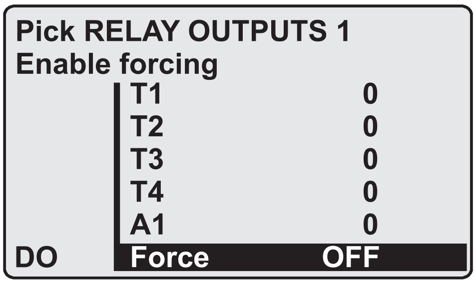


Figure 2.14: Selecting Force function

4. Push OK.
5. Push the △ or ▽ to change the "OFF" text to "ON", that is, to activate the Force function.
6. Push OK to return to the selection list. Choose the signal to be controlled by force with the △ and ▽, for instance the T1 signal.
7. Push OK to confirm the selection. Signal T1 can now be controlled by force.
8. Push the △ or ▽ to change the selection from "0" (not alert) to "1" (alert) or vice versa.
9. Push OK to execute the forced control operation of the selected function, e.g., making the output relay of T1 to pick up.
10. Repeat the steps 7 and 8 to alternate between the on and off state of the function.
11. Repeat the steps 1 – 4 to exit the Force function.
12. Push ⌂ to return to the main menu.

NOTE: All the interlockings and blockings are bypassed when the force control is used.

2.4 Configuration and parameter setting

The minimum procedure to configure a device is

1. Open the access level "Configurator". The default password for configurator access level is 2.
2. Set the rated values in menu [CONF] including at least current transformers, voltage transformers and motor ratings if applicable. Also the date and time settings are in this same main menu.
3. Enable the needed protection functions and disable the rest of the protection functions in main menu [Prot].
4. Set the setting parameter of the enable protection stages according the application.
5. Connect the output relays to the start and trip signals of the enabled protection stages using the output matrix. This can be done in main menu [DO], although the VAMPSET program is recommended for output matrix editing.
6. Configure the needed digital inputs in main menu [DI].
7. Configure blocking and interlockings for protection stages using the block matrix. This can be done in main menu [Prot], although VAMPSET is recommended for block matrix editing.

Some of the parameters can only be changed via the USB-port using the VAMPSET software. Such parameters, (for example passwords, blockings and mimic configuration) are normally set only during commissioning.

Some of the parameters require the restarting of the relay. This restarting is done automatically when necessary. If a parameter change requiresrestarting, the display will show as Figure 2.15

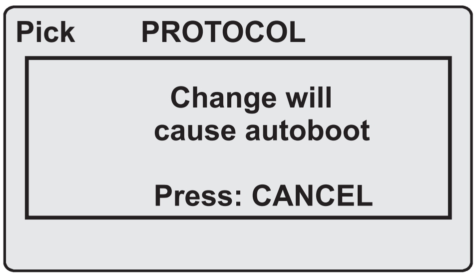


Figure 2.15: Example of auto-reset display

Press to return to the setting view. If a parameter must be changed, press OK again. The parameter can now be set. When the parameter change is confirmed with OK, a [RESTART]- text appears to the top-right corner of the display. This means that auto-resetting is pending. If no key is pressed, the auto-reset will be executed within few seconds.

2.4.1 Parameter setting

1. Move to the setting state of the desired menu (for example CONF/CURRENT SCALING) by pushing OK. The Pick text appears in the upper-left part of the display.
2. Enter the password associated with the configuration level by pushing i and then using the arrow keys and OK (default value is 0002). For more information about the access levels, please refer to Chapter 2.2.3 Fault logs.
3. Scroll through the parameters using the △ and ▽. A parameter can be set if the background color of the line is black. If the parameter cannot be set the parameter is framed.
4. Select the desired parameter (for example Inom) with OK.
5. Use the △ and ▽ keys to change a parameter value. If the value contains more than one digit, use the ▷ and ◁ keys to shift from digit to digit, and the △ and ▽ keys to change the digits.
6. Push OK to accept a new value. If you want to leave the parameter value unchanged, exit the edit state by pushing .

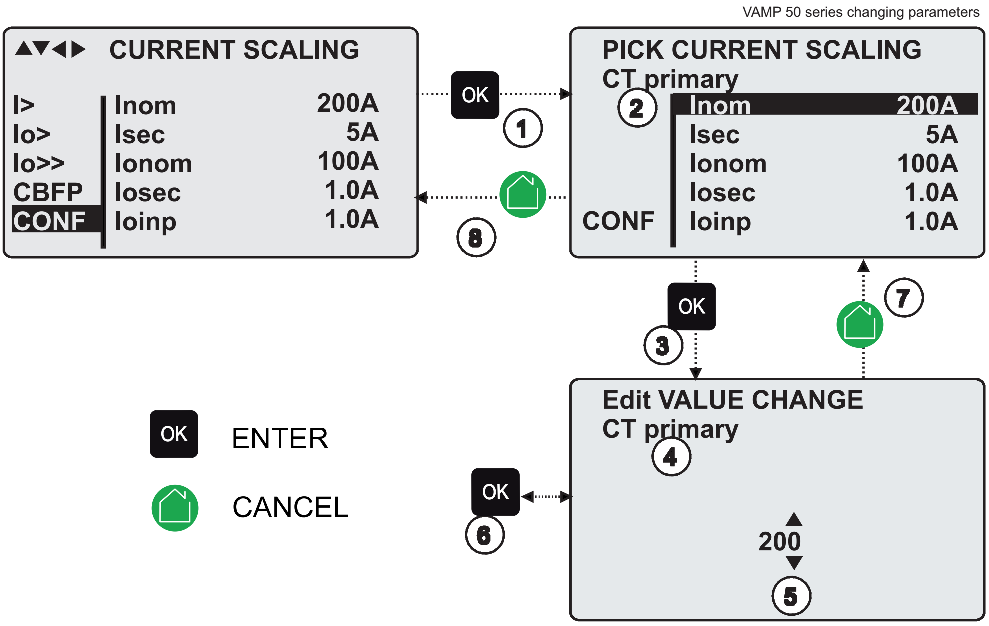


Figure 2.16: Changing parameters

2.4.2 Setting range limits

If the given parameter setting values are out-of-range values, a fault message will be shown when the setting is confirmed with OK. Adjust the setting to be within the allowed range.

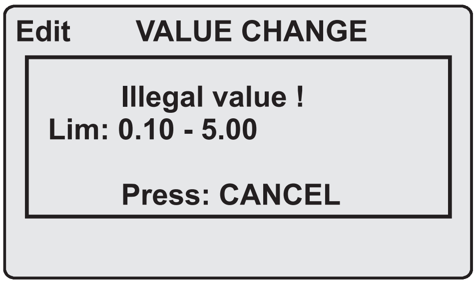


Figure 2.17: Example of a fault message

The allowed setting range is shown in the display in the setting mode. To view the range, push . Push to return to the setting mode.

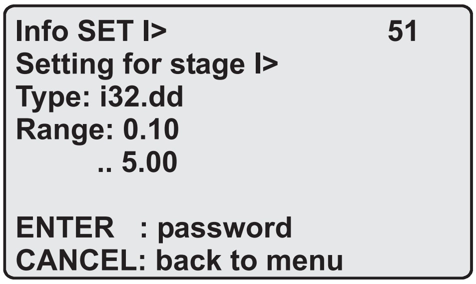


Figure 2.18: Allowed setting ranges show in the display

2.4.3 Disturbance recorder menu DR

Via the submenus of the disturbance recorder menu the following functions and features can be read and set:

Disturbance settings

1. Manual trigger (ManTrg)
2. Status (Status)
3. Clear oldest record (Clear)
4. Clear all records (ClrAll)
5. Recording completion (Stored)
6. Count of ready records (ReadyRec)

Recorder settings

1. Manual trigger (ManTrig)
2. Sample rate (SR)
3. Recording time (Time)
4. Pre trig time (PreTrig)
5. Mximum time (MaxLen)
6. Count of ready records (ReadyRec)

Rec. channels

- Add a link to the recorder (AddCh)
- Clear all links (ClrCh)

Available links

- DO, DI
- f
- Uo
- Uline, Uphase
- U2/U1, U2, U1
- UL3, UL2, UL1
- U31, U23, U12
- fy, U12y

2.4.4 Configuring digital inputs DI

The following functions can be read and set via the submenus of the digital inputs menu:

1. The status of digital inputs (DIGITAL INPUTS 1, 2)
2. Operation counters (DI COUNTERS)
3. Operation delay (DELAYs for DigIn)
4. The polarity of the input signal (INPUT POLARITY). Either normally open (NO) or normally closed (NC) circuit.
5. Event enabling EVENT MASK1

2.4.5 Configuring digital outputs DO

The following functions can be read and set via the submenus of the digital outputs menu:

- The status of the output relays (RELAY OUTPUTS1 and 2)
- The forcing of the output relays (RELAY OUTPUTS1 and 2) (only if Force = ON):
  - Forced control (0 or 1) of the Trip relays
  - Forced control (0 or 1) of the Alarm relays
  - Forced control (0 or 1) of the SF relay
- The configuration of the output signals to the output relays. The configuration of the operation indicators (LED) Alarm and Trip and application specific alarm leds A, B, C, D, E, F, G and H (that is, the output relay matrix).

NOTE: The amount of Trip and Alarm relays depends on the relay type and optional hardware.

2.4.6 Configuring analogue outputs AO (Option)

Via the submenus of the analogue output menu the following functions can be read and set:

Analog output

- Value of AO1 (AO1)
- Forced control of analogue output (Force)

Analog output 1 – 4

- Value linked to the analogue output (Lnk1)
- (See list available links)
- Scaled minimum of linked value (Min)
- Scaled maximum of linked value (Max)
- Scaled minimum of analogue output (AOmin)
- Scaled maximum of analogue output (AOmax)
- Value of analogue output (AO1)

Available links:

- F
- U12, U23, U31
- UL1, UL2, UL3
- Uline, Uphase
- PrgVal
- Uo

2.4.7 Protection menu Prot

The following functions can be read and set via the submenus of the Prot menu:

1. Reset all the counters (PROTECTION SET/ClAll)
2. Read the status of all the protection functions (PROTECT STATUS 1 – x)
3. Enable and disable protection functions (ENABLED STAGES 1 – x)
4. Define the interlockings using block matrix (only with VAMPSET)

Each stage of the protection functions can be disabled or enabled individually in the Prot menu. When a stage is enabled, it will be in operation immediately without a need to reset the relay.

The relay includes several protection functions. However, the processor capacity limits the number of protection functions that can be active at the same time.

2.4.8 Configuration menu CONF

The following functions and features can be read and set via the submenus of the configuration menu:

Device setup

- Bit rate for the command line interface in communication ports and the USB-port in the front panel. The front panel is always using this setting. If SPABUS is selected for the rear panel port, the bit rate is according SPABUS settings.
- Access level [Acc]
- PC access level [PCAcc]

Language

- List of available languages in the relay

Voltage scaling

- Rated VT primary voltage (Uprim)
- Rated VT secondary voltage (Usec)
- Rated U_0 VT secondary voltage (Uosec)
- Voltage measuring mode (Umode)

Units for mimic display

- Unit for voltages (V). The choices are V (volt) or kV (kilovolt).

Device info

- Relay type (Type VAMP 55)
- Serial number (SerN)
- Software version (PrgVer)
- Bootcode version (BootVer)

Date/time setup

- Day, month and year (Date)
- Time of day (Time)
- Date format (Style). The choices are "yyyy-mm-dd", "dd.nn.yyyy" and "mm/dd/yyyy".

Clock synchronisation

- Digital input for minute sync pulse (SyncDI). If any digital input is not used for synchronization, select "-".
- Daylight saving time for NTP synchronization (DST).
- Detected source of synchronization (SyScr).
- Synchronization message counter (MsgCnt).
- Latest synchronization deviation (Dev).

The following parameters are visible only when the access level is higher than "User".

- Offset, i.e. constant error, of the synchronization source (SyOS).
- Auto adjust interval (AAIntv).
- Average drift direction (AvDrft): "Lead" or "lag".
- Average synchronization deviation (FilDev).

SW options

- Application mode, fixed Feeder (ApplMod)
- External led module installed (Ledmodule)
- Mimic display selection (MIMIC)

2.4.9 Protocol menu Bus

There are three optional communication ports in the rear panel. The availability depends on the communication options (see Chapter 14 Order information).

In addition there is a USB-connector in the front panel overruling the local port in the rear panel.

Remote port

- Communication protocol for remote port [Protocol].
- Message counter [Msg#]. This can be used to verify that the device is receiving messages.
- Communication error counter [Errors]
- Communication time-out error counter [Tout].
- Information of bit rate/data bits/parity/stop bits. This value is not directly editable. Editing is done in the appropriate protocol setting menus.

The counters are useful when testing the communication.

PC (Local/SPA-bus)

This is a second menu for local port. The VAMPSET communication status is showed.

- Bytes/size of the transmitter buffer [Tx].
- Message counter [Msg#]. This can be used to verify that the device is receiving messages.
- Communication error counter [Errors]
- Communication time-out error counter [Tout].
- Same information as in the previous menu.

Extension port

- Communication protocol for extension port [Protocol].
- Message counter [Msg#]. This can be used to verify that the device is receiving messages.
- Communication error counter [Errors]
- Communication time-out error counter [Tout].
- Information of bit rate/data bits/parity/stop bits. This value is not directly editable. Editing is done in the appropriate protocol setting menus.

Ethernet port

These parameters are used by the ethernet interface module. For changing the nnn.nnn.nnn.nnn style parameter values, VAMPSET is recommended.

- Ethernet port protocol [Protoc].
- IP Port for protocol [Port]
- IP address [IpAddr].
- Net mask [NetMsk].
- Gateway [Gatew].
- Name server [NameSw].
- Network time protocol (NTP) server [NTPSvr].
- TCP Keep alive interval [KeepAlive]
- MAC address [MAC]
- IP Port for VAMPSET [VS Port]
- Message counter [Msg#]
- Error counter [Errors]
- Timeout counter [Tout]

Modbus

- Modbus address for this slave device [Addr]. This address has to be unique within the system.
- Modbus bit rate [bit/s]. Default is "9600".
- Parity [Parity]. Default is ”Even”.

For details, see Chapter 9.2.2 Modbus TCP and Modbus RTU.

External I/O protocol

External I/O is actually a set of protocols which are designed to be used with the extension I/O modules connected to the extension port. Only one instance of this protocol is possible.

Selectable protocols:

- Modbus: This is a modbus master protocol.
  Bit rate [bit/s]. Default is ”9600”.
  Parity [Parity]. Default is ”Even”.
- RTDInput: This protocol is designed to be used together with VIO 12A RTD input module.
  Bit rate [bit/s]. Default is ”9600”.
  Parity [Parity]. Default is ”Even”.

For details, see Chapter 9.2.8 External I/O (Modbus RTU master).

SPA-bus

Several instances of this protocol are possible.

- SPA-bus address for this device [Addr]. This address has to be unique within the system.
- Bit rate [bit/s]. Default is "9600".
- Event numbering style [Emode]. Default is "Channel".

For details, see Chapter 9.2.4 SPA-bus.

IEC 60870-5-103

Only one instance of this protocol is possible.

- Address for this device [Addr]. This address has to be unique within the system.
- Bit rate [bit/s]. Default is "9600".
- Minimum measurement response interval [MeasInt].
- ASDU6 response time mode [SyncRe].

For details, see Chapter 9.2.5 IEC 60870-5-103.

IEC 103 Disturbance recordings

For details, see Table 9.11.

Profibus

Only one instance of this protocol is possible.

- [Mode]
- Bit rate [bit/s]. Use 2400 bps. This parameter is the bit rate between the main CPU and the Profibus ASIC. The actual Profibus bit rate is automatically set by the Profibus master and can be up to 12 Mbit/s.
- Event numbering style [Emode].
- Size of the Profibus Tx buffer [InBuf].
- Size of the Profibus Rx buffer [OutBuf].
- Address for this slave device [Addr]. This address has to be unique within the system.
- Profibus converter type [Conv]. If the shown type is a dash “-“, either Profibus protocol has not been selected or the device has not restarted after protocol change or there is a communication problem between the main CPU and the Profibus ASIC.

For details, see Chapter 9.2.3 Profibus DP.

DNP3

Only one instance of this protocol is possible.

- Bit rate [bit/s]. Default is "9600".
- [Parity].
- Address for this device [SlvAddr]. This address has to be unique within the system.
- Master's address [MstrAddr].

For details, see Chapter 9.2.6 DNP 3.0.

IEC 60870-5-101

- Bit rate [bit/s]. Default is “9600”.
- [Parity].
- Link layer address for this device [LLAddr].
- ASDU address [ALAddr].

For details, see Chapter 9.2.7 IEC 60870-5-101.

2.4.10 Single line diagram editing

The single-line diagram is drawn with the VAMPSET software. For more information, please refer to the VAMPSET manual (VVAMPSET/EN M/xxxx).

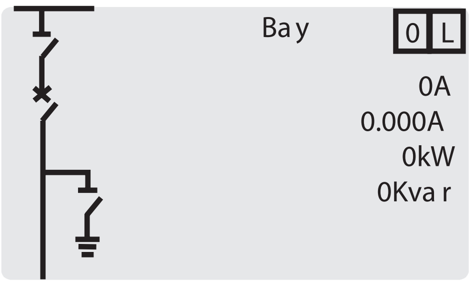


Figure 2.19: Single line diagram

2.4.11 Blocking and Interlocking configuration

The configuration of the blockings and interlockings is done with the VAMPSET software. Any start or trip signal can be used for blocking the operation of any protection stage. Furthermore, the interlocking between objects can be configured in the same blocking matrix of the VAMPSET software. For more information, please refer to the VAMPSET manual (VVAMPSET/EN M/xxxx).

3 VAMPSET PC software

The PC user interface can be used for:

- On-site parameterization of the relay
- Loading relay software from a computer
- Reading measured values, registered values and events to a computer
- Continuous monitoring of all values and events

A USB port is available for connecting a local PC with VAMPSET to the relay. A standard USB-B cable can be used.

The VAMPSET program can also use the TCP/IP LAN connection. Optional hardware is required for Ethernet connection.

There is a free of charge PC program called VAMPSET available for configuration and setting of VAMP relays. Please download the latest VAMPSET.exe from our web page. For more information about the VAMPSET software, please refer to the user's manual with the code VVAMPSET/EN M/xxxx. Also the VAMPSET user's manual is available at our web site.

When the relay is connected to a PC with a USB, a virtual comport will be created. The comport number may vary depending on your computer hardware. In order to check the correct port number, please go to Windows Device Manager: Control Panel->System->Hardware->Device Manager and under Ports (COM&LPT) for "USB Serial Port". The correct comport must be selected from the VAMPSET menu: Settings->Communication Settings. Speed setting can be set up to 187500 bps. Default setting in the relay is 38400 bps which can be manually changed from the front panel of the device.

By default every new relay will create a new comport. To avoid this behavior, the user needs to add a REG_BINARY value called IgnoreHWSerNum04036001 to the Windows registry and set it to 01. The location for this value is HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\UsbFlags\.

3.1 Folder view

In VAMPSET version 2.2.136, a feature called "Folder view" was introduced.

The idea of folder view is to make it easier for the user to work with relay functions inside VAMPSET. When folder view is enabled, VAMPSET gathers similar functions together and places them appropriately under seven different folders (GENERAL,

MEASUREMENTS, INPUTS/OUTPUTS, MATRIX, LOGS and COMMUNICATION). The contents (functions) of the folders depend on the relay type and currently selected application mode.

Folder view can be enabled in VAMPSET via Program Settings dialog (Settings -> Program Settings), see Figure 3.1.

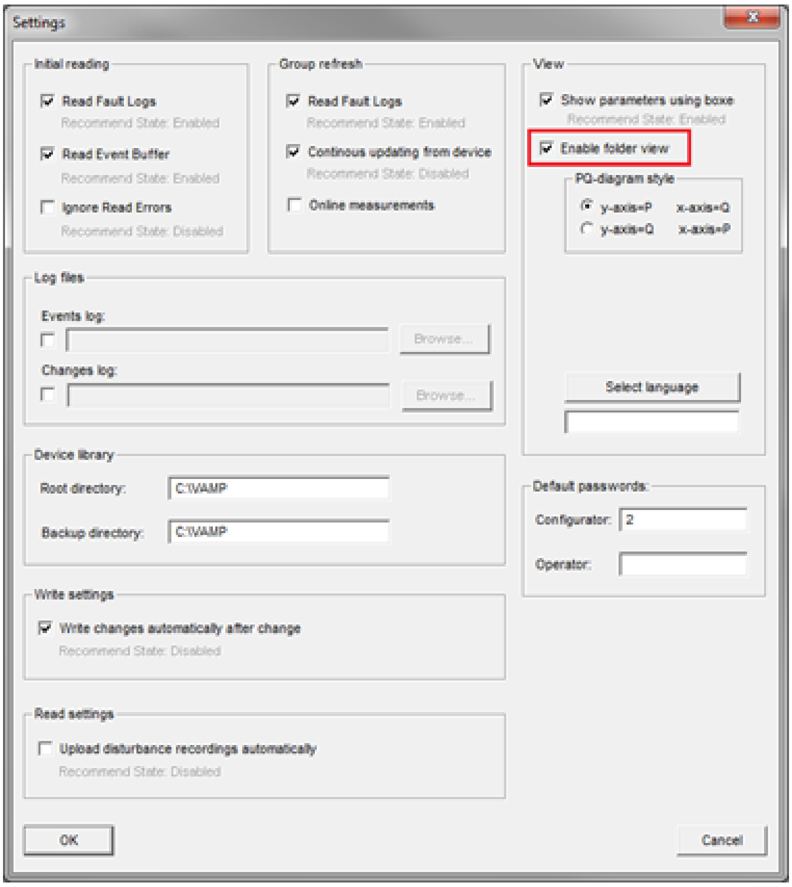


Figure 3.1: Enable folder view setting in Program Settings dialog

NOTE: It is possible to enable/ disable the folder view only when VAMPSET is disconnected from the relay and there is no configuration file opened.

When folder view is enabled, folder buttons become visible in VAMPSET, see Figure 3.2. Currently selected folder appears in bold.

Figure 3.2: Folder view buttons

4 Introduction

The numerical device includes basic voltage and frequency protection functions needed in common applications. Further, the device includes several programmable functions, such as trip circuit supervision and check of synchronism and also communication protocols for various protection and communication applications.

4.1 Main features

- Fully digital signal handling with microprocessor technology, and high measuring accuracy on all the setting ranges due to an accurate A/D conversion technique.
- Set of functions for voltage and frequency based protection of lines, generators and transformers
- The device can be matched to the requirements of the application by disabling the functions that are not needed.
- Flexible control and blocking possibilities due to digital signal control inputs (DI) and outputs (DO).
- Easy adaptability of the device to various substations and alarm systems due to flexible signal-grouping matrix in the device.
- Possibility to control objects (e.g. circuit-breakers, disconnectors) from relay HMI or SCADA/automation system
- Freely configurable large display with six measurement values.
- Freely configurable interlocking schemes with basic logic functions.
- Recording of events and fault values into an event register from which the data can be read via relay HMI or by means of a PC based VAMPSET user interface.
- All events, indications, parameters and waveforms are in non-volatile memory.
- Easy configuration, parameterisation and reading of information via local HMI, or with a VAMPSET user interface.
- Easy connection to various automation systems due to several available communication protocols. Native IEC61850 implementation is available as option.
- Flexible communication option concept available to support different media requirements (serial interfaces, optical fibres, Ethernet etc),
- Built-in, self-regulating ac/dc converter for auxiliary power supply from any source within the range from 40 to 265 Vdc or Vac. The alternative power supply is for 18 to 36 Vdc.

- Built-in disturbance recorder for evaluating all the analogue and digital signals.

4.2 Principles of numerical protection techniques

The device is fully designed using numerical technology. This means that all the signal filtering, protection and control functions are implemented through digital processing.

The numerical technique used in the device is primarily based on an adapted Fast Fourier Transformation (FFT). In FFT the number of calculations (multiplications and additions), which are required to filter out the measuring quantities, remains reasonable.

By using synchronized sampling of the measured analog signals and a sample rate according to the 2^n series, the FFT technique leads to a solution, which can be realized with a 16 bit micro controller, without using a separate DSP (Digital Signal Processor).

The synchronized sampling means an even number of 2^n samples per period (e.g. 32 samples per a period). This means that the frequency must be measured and the number of the samples per period must be controlled accordingly so that the number of the samples per period remains constant if the frequency changes.

VAMP relays have built-in automatical frequency tracking and as an alternative the system frequency can be set manually.

Apart from the FFT calculations, some protection functions also require the symmetrical components to be calculated for obtaining the positive, negative and zero phase sequence components of the measured quantity.

Figure 4.1 shows a principle block diagram of a numerical device. The main components are the energizing inputs, digital input elements, output relays, A/D converters and the micro controller including memory circuits. Further, a device contains a power supply unit and a human-machine interface (HMI).

Figure 4.2 shows the heart of the numerical technology. That is the main block diagram for calculated functions.

Figure 4.3 shows a principle diagram of a single-phase overvoltage function.

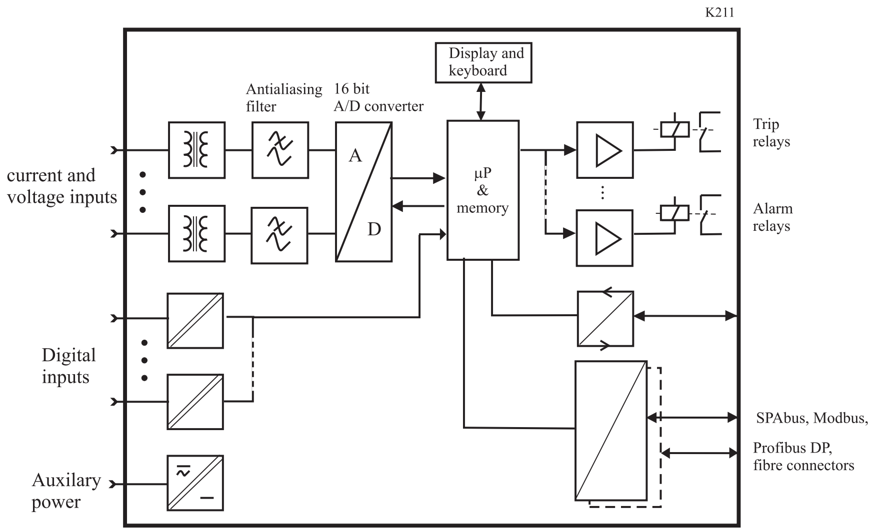


Figure 4.1: Principle block diagram of the VAMP hardware

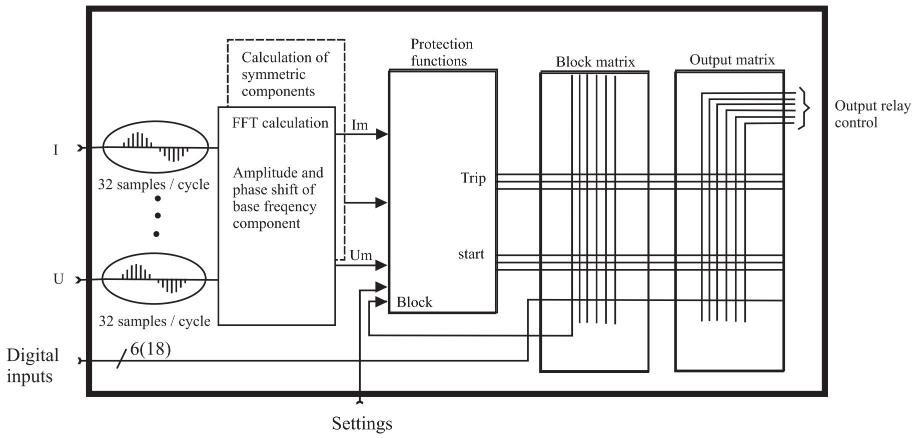


Figure 4.2: Block diagram of signal processing and protection software

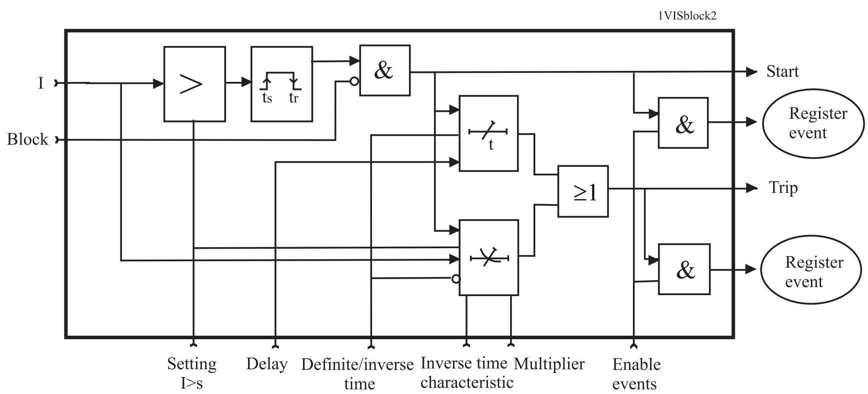


Figure 4.3: Block diagram of a basic protection function

5 Protection functions

Each protection stage can independently be enabled or disabled according to the requirements of the intended application.

5.1 Maximum number of protection stages in one application

The device limits the maximum number of enabled stages to about 30, depending of the type of the stages.

For more information, please see the configuration instructions in Chapter 2.4 Configuration and parameter setting.

5.2 General features of protection stages

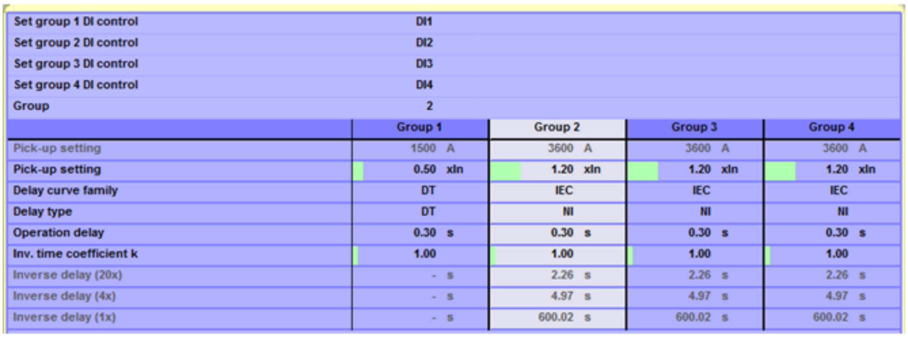
Setting groups

Setting groups are controlled by using digital inputs, function keys or virtual inputs. When none of the assigned input/inputs is/are not active the active setting group is defined by parameter ‘SetGrp no control state’. When controlled input activates the corresponding setting group is activated as well. If multiple inputs are active at the same time the active setting group is defined by ‘SetGrp priority’. By using virtual I/O the active setting group can be controlled using the local panel display, any communication protocol or using the inbuilt programmable logic functions.

Set group 1 DI control	-			
Set group 2 DI control	-			
Set group 3 DI control	-			
Set group 4 DI control	-			
Group	1			
	Group 1	Group 2	Group 3	Group 4
Pick-up setting	480 A	480 A	480 A	480 A
Pick-up setting	1.20 xImot	1.20 xImot	1.20 xImot	1.20 xImot
Delay curve family	IEC	IEC	IEC	IEC
Delay type	NI	NI	NI	NI
Inv. time coefficient k	1.00	1.00	1.00	1.00
Inverse delay (20x)	2.26 s	2.26 s	2.26 s	2.26 s
Inverse delay (4x)	4.97 s	4.97 s	4.97 s	4.97 s
Inverse delay (1x)	600.02 s	600.02 s	600.02 s	600.02 s
	Common settings			
Include harmonics	Off			

Example

Any digital input could be used to control setting groups but in this example DI1, DI2, DI3 and DI4 are chosen to control setting groups 1 to 4. This setting is done with a parameter “Set group x DI control” where x refers to the desired setting group.

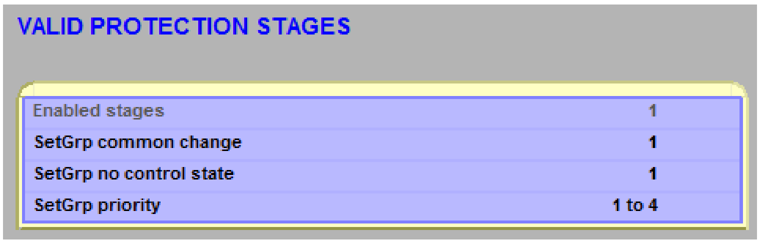


Set group 1 DI control	DI1
Set group 2 DI control	DI2
Set group 3 DI control	DI3
Set group 4 DI control	DI4
Group	2

	Group 1	Group 2	Group 3	Group 4
Pick-up setting	1500 A	3600 A	3600 A	3600 A
Pick-up setting	0.50 xIn	1.20 xIn	1.20 xIn	1.20 xIn
Delay curve family	DT	IEC	IEC	IEC
Delay type	DT	NI	NI	NI
Operation delay	0.30 s	0.30 s	0.30 s	0.30 s
Inv. time coefficient k	1.00	1.00	1.00	1.00
Inverse delay (20x)	- s	2.26 s	2.26 s	2.26 s
Inverse delay (4x)	- s	4.97 s	4.97 s	4.97 s
Inverse delay (1x)	- s	600.02 s	600.02 s	600.02 s

Figure 5.1: DI1, DI2, DI3, DI4 are configured to control Groups 1 to 4 respectively.

“SetGrp priority” is used to give a condition to a situation where two or more digital inputs, controlling setting groups, are active and at a same time . SetGrp priority could have vales “1 to 4” or “4 to 1”.



VALID PROTECTION STAGES

Enabled stages	1
SetGrp common change	1
SetGrp no control state	1
SetGrp priority	1 to 4

Figure 5.2: SetGrp priority setting is located in the Valid Protection stages view.

Assuming that DI2 and DI3 are active at a same time and SetGrp priority is set to “1 to 4” setting group 2 will become active. In case SetGrp priority is reversed i.e. it is set to “4 to 1” setting group 3 would be active.

Forcing start or trip condition for testing

The status of a protection stage can be one of the followings:

- **Ok = ‘-‘**
  The stage is idle and is measuring the analog quantity for the protection. No fault detected.
- **Blocked**
  The stage is detecting a fault but blocked by some reason.
- **Start**
  The stage is counting the operation delay.
- **Trip**
  The stage has tripped and the fault is still on.

The blocking reason may be an active signal via the block matrix from other stages, the programmable logic or any digital input. Some stages also have inbuilt blocking logic. For more details about block matrix, see Chapter 8.6 Blocking matrix.

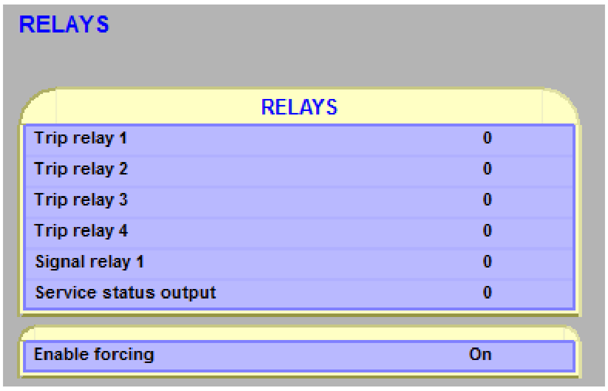
Forcing start or trip condition for testing purposes

There is a "Force flag" parameter which, when activated, allows forcing the status of any protection stage to be "start" or "trip" for a half second. By using this forcing feature any voltage injection to the device is not necessary to check the output matrix configuration, to check the wiring from the output relays to the circuit breaker and also to check that communication protocols are correctly transferring event information to a SCADA system.

After testing the force flag will automatically reset 5-minute after the last local panel push button activity.

The force flag also enables forcing of the output relays.

Force flag can be found in relays menu.



Start and trip signals

Every protection stage has two internal binary output signals: start and trip. The start signal is issued when a fault has been detected. The trip signal is issued after the configured operation delay unless the fault disappears before the end of the delay time.

Output matrix

Using the output matrix the user connects the internal start and trip signals to the output relays and indicators. For more details, see Chapter 8.5 Output matrix.

Blocking

Any protection function, except arc protection, can be blocked with internal and external signals using the block matrix (Chapter 8.6 Blocking matrix). Internal signals are for example logic outputs and start and trip signals from other stages and external signals are for example digital and virtual inputs.

When a protection stage is blocked, it won't pick-up in case of a fault condition is detected. If blocking is activated during the operation delay, the delay counting is frozen until the blocking goes off or the pick-up reason, i.e. the fault condition, disappears. If the stage is already tripping, the blocking has no effect.

Retardation time

Retardation time is the time a protection relay needs to notice, that a fault has been cleared during the operation time delay. This parameter is important when grading the operation time delay settings between relays.

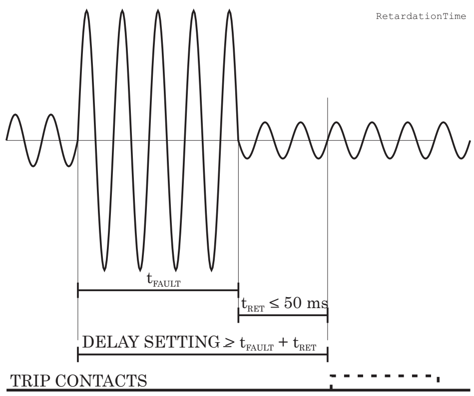


Figure 5.3: Definition for retardation time. If the delay setting would be slightly shorter, an unselective trip might occur (the dash line pulse).

For example when there is a big fault in an outgoing feeder, it might start i.e. pick-up both the incoming and outgoing feeder relay. However the fault must be cleared by the outgoing feeder relay and the incoming feeder relay must not trip. Although the operating delay setting of the incoming feeder is more than at the outgoing feeder, the incoming feeder might still trip, if the operation time difference is not big enough. The difference must be more than the retardation time of the incoming feeder relay plus the operating time of the outgoing feeder circuit breaker.

Figure 5.3 shows an overvoltage fault seen by the incoming feeder, when the outgoing feeder does clear the fault. If the operation delay setting would be slightly shorter or if the fault duration would be slightly longer than in the figure, an unselective trip might happen (the dashed 40 ms pulse in the figure). In VAMP devices the retardation time is less than 50 ms.

Reset time (release time)

Figure 5.4 shows an example of reset time i.e. release delay, when the relay is clearing an overcurrent fault. When the relay's trip contacts are closed the circuit breaker (CB) starts to open. After the CB contacts are open the fault current will still flow through an arc between the opened contacts. The current is finally cut off when the arc extinguishes at the next zero crossing of the current. This is the start moment of the reset delay. After the reset delay the trip contacts and start contact are opened unless latching is configured. The precise reset time depends on the fault size; after a big fault the reset time is longer. The reset time also depends on the specific protection stage.

The maximum reset time for each stage is specified in Chapter 12.3 Protection functions. For most stages it is less than 95 ms.

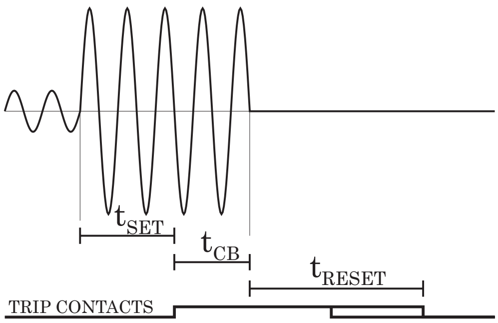


Figure 5.4: Reset time is the time it takes the trip or start relay contacts to open after the fault has been cleared.

Hysteresis or dead band

When comparing a measured value against a pick-up value, some amount of hysteresis is needed to avoid oscillation near equilibrium situation. With zero hysteresis any noise in the measured signal or any noise in the measurement itself would cause unwanted oscillation between fault-on and fault-off situations.

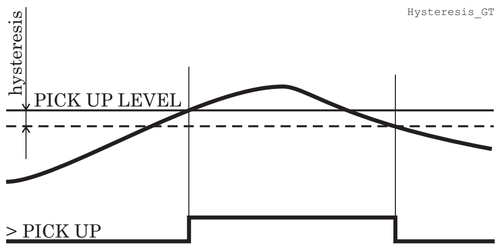


Figure 5.5: Behaviour of a greater than comparator. For example in overvoltage stages the hysteresis (dead band) acts according this figure.

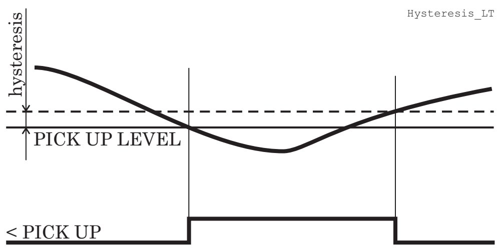


Figure 5.6: Behaviour of a less than comparator. For example in under-voltage and under frequency stages the hysteresis (dead band) acts according this figure.

5.3 Application modes

The application modes available are the feeder protection mode and the motor protection mode. In the feeder protection mode all current dependent protection functions are relative to nominal current I_N derived by CT ratios. The motor protection functions are unavailable in the feeder protection mode. In the motor protection mode all current dependent protection functions are relative to motor's nominal current I_{MOT}. The motor protection mode enables motor protection functions. All functions which are available in the feeder protection mode are also available in the motor protection mode. Default value of the application mode is the feeder protection mode.

The application mode can be changed with VAMPSET software or from CONF menu of the device. Changing the application mode requires configurator password.

5.4 Overvoltage protection U> (59)

The overvoltage function measures the fundamental frequency component of the line-to-line voltages regardless of the voltage measurement mode (Chapter 7.3 Voltage measurement modes). By using line-to-line voltages any phase-to-ground over-voltages during earth faults have no effect. (The earth fault protection functions will take care of earth faults.) Whenever any of these three line-to-line voltages exceeds the user's pick-up setting of a particular stage, this stage picks up and a start signal is issued. If the fault situation remains on longer than the user's operation time delay setting, a trip signal is issued.

In rigidly earthed 4-wire networks with loads between phase and neutral overvoltage protection may be needed for phase-to-ground voltages, too. In such applications the programmable stages can be used. Chapter 5.14 Programmable stages (99)

Five independent stages

There are five separately adjustable stages: U>, U>>, U>>>, U>>>> and U>>>>>. All the stages can be configured for definite time (DT) operation characteristic.

Configurable release delay

The U> stage has a settable release delay, which enables detecting intermittent faults. This means that the time counter of the protection function does not reset immediately after the fault is cleared, but resets after the release delay has elapsed. If the fault appears again before the release delay time has elapsed, the delay counter continues from the previous value. This means that the function will eventually trip if faults are occurring often enough.

Configurable hysteresis

The dead band is 3 % by default. It means that an overvoltage fault is regarded as a fault until the voltage drops below 97 % of the pick up setting. In a sensitive alarm application a smaller hysteresis is needed. For example if the pick up setting is about only 2 % above the normal voltage level, hysteresis must be less than 2 %. Otherwise the stage will not release after fault.

Setting groups

There are four settings groups available for each stage. Switching between setting groups can be controlled by digital inputs, virtual inputs (communication, logic) and manually. See Chapter 5.2 General features of protection stages for more details.

Figure 5.7 shows the functional block diagram of the overvoltage function stages U>, U>> and U>>>.

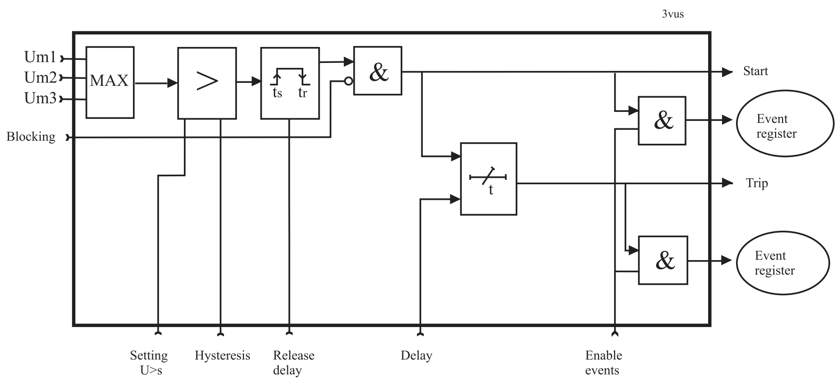


Figure 5.7: Block diagram of the three-phase overvoltage stages U>, U>> and U>>>

Table 5.1: Parameters of the overvoltage stages U>, U>>, U>>>, U>>>>, U>>>>>

Parameter	Value	Unit	Description	Note
Status	- Blocked Start Trip		Current status of the stage	 F F
SCntr			Cumulative start counter	C
TCntr			Cumulative trip counter	C
SetGrp	1, 2, 3, 4		Active setting group	Set
SGrpDI			Digital signal to select the active setting group	Set
	-		None	
	DIx		Digital input	
	VIx		Virtual input	
	LEDx		LED indicator signal	
	VOx		Virtual output	
	Fx		Function key	
Force	Off On		Force flag for status forcing for test purposes. This is a common flag for all stages and output relays, too. Automatically reset by a 5-minute timeout.	Set
Umax		V	The supervised value. Max. of U12, U23 and U31	
U>, U>>, U>>>, U>>>>, U>>>>>		V	Pick-up value scaled to primary value	
U>, U>>, U>>>, U>>>>, U>>>>>		% Un	Pick-up setting relative to U_N	Set
t>, t>>, t>>>, t>>>>, t>>>>>		s	Definite operation time.	Set
RlsDly		s	Release delay (U> stage only)	Set
Hyster	3 (default)	%	Dead band size i.e. hysteresis	Set

Set = An editable parameter (password needed). C = Can be cleared to zero. F = Editable when force flag is on.

For details of setting ranges, see Table 12.17, Table 12.18, Table 12.19.

Recorded values of the latest eight faults

There are detailed information available of the eight latest faults: Time stamp, fault voltage, elapsed delay and setting group.

Table 5.2: Recorded values of the overvoltage stages (8 latest faults) U>, U>>, U>>>, U>>>>, U>>>>>

Parameter	Value	Unit	Description
	yyyy-mm-dd		Time stamp of the recording, date
	hh:mm:ss.ms		Time stamp, time of day
Flt		% Un	Maximum fault voltage
EDly		%	Elapsed time of the operating time setting. 100% = trip
SetGrp	1, 2, 3, 4		Active setting group during fault

5.5 Volts/hertz over-excitation protection U_f> (24)

The saturation of any inductive network components like transformers, inductors, motors and generators, depend on the voltage and frequency. The lower the frequency, the lower is the voltage at which the saturation begins.

The volts/hertz over-excitation protection stage is sensitive to the voltage/frequency ratio instead of voltage only. Figure 5.8 shows the difference between volts/hertz and a standard overvoltage function. The maximum of the three line-to-line voltage is used regardless of the voltage measurement mode (chapter Chapter 7.3 Voltage measurement modes). By using line-to-line voltages any phase-to-ground over-voltages during earth faults have no effect. (The earth fault protection functions will take care of earth faults.)

The used net frequency is automatically adopted according the local network frequency.

Overexcitation protection is needed for generators, which are excitated even during start up and shut down. If such a generator is connected to a unit transformer, also the unit transformer needs volts/hertz over-excitation protection. Another application is sensitive overvoltage protection of modern transformers with no flux density margin in networks with unstable frequency.

Setting groups

There are four settings groups available for each stage. Switching between setting groups can be controlled by digital inputs, virtual inputs (communication, logic) and manually. See Chapter 5.2 General features of protection stages for more details.

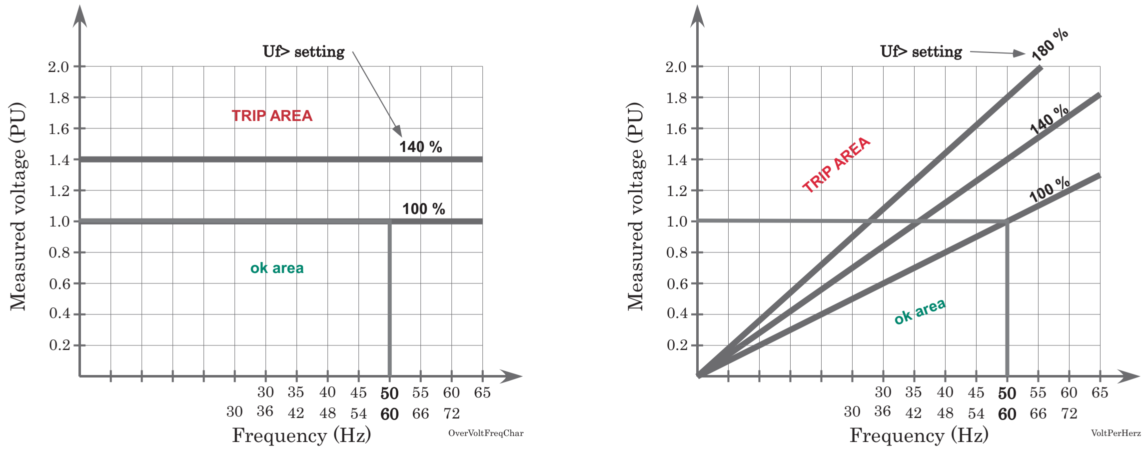


Figure 5.8: This figure shows the difference between volts/hertz and normal overvoltage protection. The volts/hertz characteristics on the left depend on the frequency while the standard overvoltage function on the right is insensitive to frequency. The network frequency, 50 Hz or 60 Hz, is automatically adopted by the relay.

The setting for a certain V/Hz value K can be calculated using the following formala

$$U_{fSET} = K \cdot \frac{f_n}{VT_{SEC}} \cdot 100\%$$

U_{fSET} = setting in per cent

K = secondary volts per hertz sensitivity

f_N = rated network frequency

VT_{SEC} = rated secondary of the voltage transformer

Example:

K = 2.56 VSEC/Hz

f_N = 50 Hz

VT_{SEC} = 110 V

$$U_{fSET} = 2.56 \cdot \frac{50}{110} \cdot 100\% = 116\%$$

Table 5.3: Parameters of the volts/hertz over-excitation stage U_f>, U_f>>

Parameter	Value	Unit	Description	Note
Status	-		Current status of the stage	
	Blocked			
	Start			F
	Trip			F
SCntr			Cumulative start counter	C
TCntr			Cumulative trip counter	C
SetGrp	1, 2, 3, 4		Active setting group	Set
SGrpDI			Digital signal to select the active setting group	Set
	-		None	
	DIx		Digital input	
	VIx		Virtual input	
	LEDx		LED indicator signal	
	VOx		Virtual output	
Force	Off On		Force flag for status forcing for test purposes. This is a common flag for all stages and output relays, too. Automatically reset by a 5-minute timeout.	Set
Umax		V	The supervised value. Max. of U12, U23 and U31	
f		Hz	The supervised frequency value	
U/f		%	Calculated U_{MAX}/f	
Uf>, Uf>>		%	Pick-up setting	Set
t>, t>>		s	Definite operation time.	Set

Set = An editable parameter (password needed). C = Can be cleared to zero. F = Editable when force flag is on.

For details of setting ranges, see Table 12.20.

Recorded values of the latest eight faults

There are detailed information available of the eight latest faults: Time stamp, fault voltage, fault frequency, elapsed delay and setting group.

Table 5.4: Recorded values of the volts/hertz over-excitation stage

Parameter	Value	Unit	Description
	yyyy-mm-dd		Time stamp of the recording, date
	hh:mm:ss.ms		Time stamp, time of day
Flt		%	Fault value V/Hz
U		% Un	Fault voltage
f		Hz	Fault frequency
EDly		%	Elapsed time of the operating time setting. 100% = trip
SetGrp	1, 2, 3, 4		Active setting group during fault

5.6 Undervoltage protection U_1< (27P)

This is a special undervoltage protection for generator applications, where the voltage is measured at the generator side of the generator circuit breaker. There are special self blocking features for starting up and shutting down a generator.

This undervoltage function measures the positive sequence of fundamental frequency component U_1 of the measured voltages (for calculation of U_1, see Chapter 7.4 Symmetric components). By using positive sequence all the three phases are supervised with one value and in case the generator looses connection to the network (loss of mains), the undervoltage situation is detected faster than by using just the minimum of the three line-to-line voltages.

Whenever the positive sequence voltage U_1 drops below the user's pick-up setting of a particular stage, this stage picks up and a start signal is issued. If the fault situation remains on longer than the user's operation time delay setting, a trip signal is issued.

Blocking during VT fuse failure

As all the protection stages the undervoltage function can be blocked with any internal or external signal using the block matrix. For example if the secondary voltage of one of the measuring transformers disappears because of a fuse failure (See VT supervision function in Chapter 6.5 Voltage transformer supervision). The blocking signal can also be a signal from the user's logic (see Chapter 8.8 Logic functions).

Self blocking at very low voltage

The stages will be blocked when the voltage is below a separate low voltage blocking setting. With this setting, LVBlk, both stages are blocked, when the voltage U_1 drops below the given limit. The idea is to avoid purposeless alarms, when the generator is not running. The LVBlk setting is common for both stages. The self blocking can not be disabled.

Initial self blocking

When the voltage U_1 has been below the block limit, the stages will be blocked until the pick-up setting has been reached.

Figure 5.9 shows an example of low voltage self blocking.

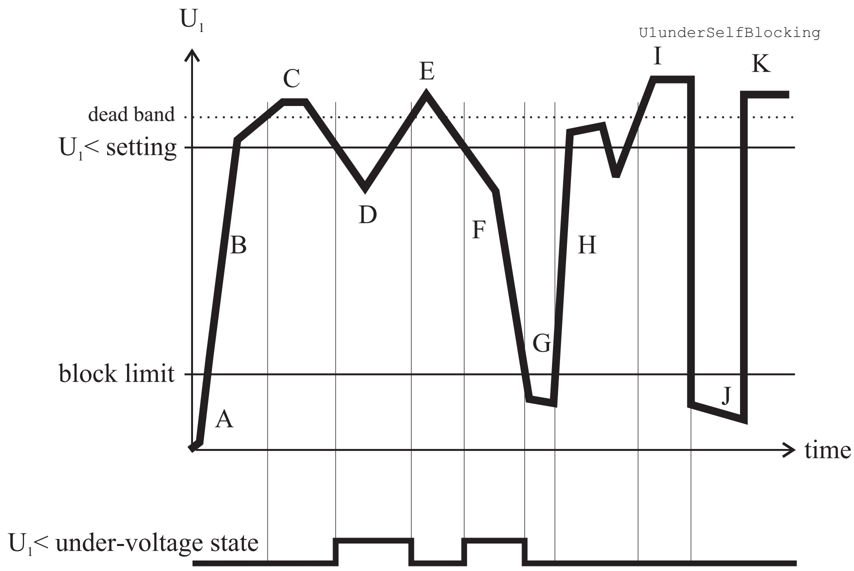


Figure 5.9: Positive sequence under voltage state and block limit.

- A The positive sequence voltage U_1 is below the block limit. This is not regarded as an under voltage situation.
- B The positive sequence voltage U_1 is above the block limit but below the pick-up level. However, this is not regarded as an under voltage situation, because the voltage has never been above the pick-up level since being below the block limit.
- C Voltage is OK, because it is above the pick-up limit.
- D This is an under voltage situation.
- E Voltage is OK.
- F This is an under voltage situation.
- G Voltage is under block limit and this is not regarded as an under voltage situation.
- H Same as B.
- I Voltage is OK.
- J Same as G.
- K Voltage is OK.

Three independent stages

There are three separately adjustable stages: U_1<, U_1<< and U_1<<<. Both stages can be configured for definite time (DT) operation characteristic.

Setting groups

There are four settings groups available for each stage. Switching between setting groups can be controlled by digital inputs, virtual inputs (communication, logic) and manually. See Chapter 5.2 General features of protection stages for more details.

Table 5.5: Parameters of the under voltage stages U_1<, U_1<<, U_1<<<

Parameter	Value	Unit	Description	Note
Status	-		Current status of the stage	F
	Blocked			F
	Start			
	Trip			
SCntr			Cumulative start counter	C
TCntr			Cumulative trip counter	C
SetGrp	1 or 2		Active setting group	Set
SGrpDI			Digital signal to select the active setting group	Set
	-		None	
	DIx		Digital input	
	VIx		Virtual input	
	LEDx		LED indicator signal	
	VOx		Virtual output	
Force	Off On		Force flag for status forcing for test purposes. This is a common flag for all stages and output relays, too. Automatically reset by a 5-minute timeout.	Set
U1		V	The supervised positive sequence voltage in primary volts	
U1		%	The supervised positive sequence voltage of Un/ $\sqrt{3}$	
U1<, U1<<U1<<<		V	Pick-up value scaled to primary value	
U1<, U1<<U1<<<		%	Pick-up setting of Un/ $\sqrt{3}$	Set
t<, t<<t<<<		s	Definite operation time.	Set
LVBlk		% Un	Low limit for self blocking. This is a common setting for both stages.	Set

Set = An editable parameter (password needed). C = Can be cleared to zero. F = Editable when force flag is on.

For details of setting ranges, see Table 12.21.

Recorded values of the latest eight faults

There are detailed information available of the eight latest faults: Time stamp, fault voltage, elapsed delay and setting group.

Table 5.6: Recorded values of the undervoltage stages (8 latest faults)

Parameter	Value	Unit	Description
	yyyy-mm-dd		Time stamp of the recording, date
	hh:mm:ss.ms		Time stamp, time of day
Flt		% Un	Minimum fault voltage
EDly		%	Elapsed time of the operating time setting. 100% = trip
SetGrp	1 2		Active setting group during fault

5.7 Undervoltage protection U< (27)

This is a basic undervoltage protection. The function measures the three line-to-line voltages and whenever the smallest of them drops below the user's pick-up setting of a particular stage, this stage picks up and a start signal is issued. If the fault situation remains on longer than the user's operation time delay setting, a trip signal is issued.

Blocking during VT fuse failure

As all the protection stages the undervoltage function can be blocked with any internal or external signal using the block matrix. For example if the secondary voltage of one of the measuring transformers disappears because of a fuse failure (See VT supervision function in Chapter 6.5 Voltage transformer supervision). The blocking signal can also be a signal from the user's logic (see Chapter 8.8 Logic functions).

Self blocking at very low voltage

The stages can be blocked with a separate low limit setting. With this setting, the particular stage will be blocked, when the biggest of the three line-to-line voltages drops below the given limit. The idea is to avoid purposeless tripping, when voltage is switched off. If the operating time is less than 0.08 s, the blocking level setting should not be less than 15 % to the blocking action to be enough fast. The self blocking can be disabled by setting the low voltage block limit equal to zero.

Figure 5.10 shows an example of low voltage self blocking.

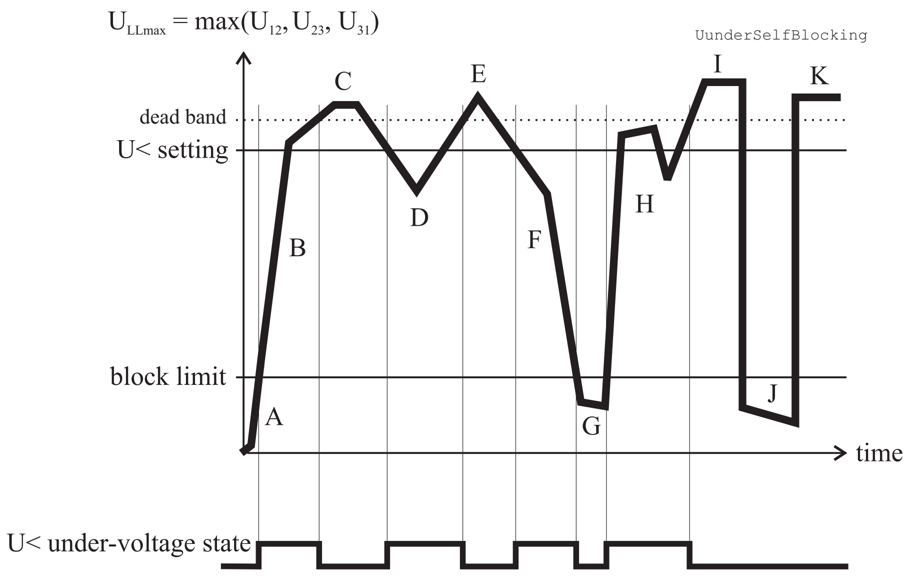


Figure 5.10: Under voltage state and block limit.

A	The maximum of the three line-to-line voltages U_{LLmax} is below the block limit. This is not regarded as an under voltage situation.
B	The voltage U_{LLmin} is above the block limit but below the pick-up level. This is an undervoltage situation.
C	Voltage is OK, because it is above the pick-up limit.
D	This is an under voltage situation.
E	Voltage is OK.
F	This is an under voltage situation.
G	The voltage U_{LLmin} is under block limit and this is not regarded as an under voltage situation.
H	This is an under voltage situation.
I	Voltage is OK.
J	Same as G
K	Voltage is OK.

Five independent stages

There are three separately adjustable stages: U<, U<<, U<<<, U<<<<, U<<<<<. All these stages can be configured for definite time (DT) operation characteristic.

Setting groups

There are four settings groups available for all stages. Switching between setting groups can be controlled by digital inputs, virtual inputs (mimic display, communication, logic) and manually. See Chapter 5.2 General features of protection stages for more details.

Table 5.7: Parameters of the under voltage stages U<, U<<, U<<<, U<<<<, U<<<<<

Parameter	Value	Unit	Description	Note
Status	-		Current status of the stage	
	Blocked			
	Start			F
	Trip			F
SCntr			Cumulative start counter	C
TCntr			Cumulative trip counter	C
SetGrp	1, 2, 3, 4		Active setting group	Set
SGrpDI			Digital signal to select the active setting group	Set
	-		None	
	DIx		Digital input	
	VIx		Virtual input	
	LEDx		LED indicator signal	
	VOx		Virtual output	
	Fx		Function key	
Force	Off On		Force flag for status forcing for test purposes. This is a common flag for all stages and output relays, too. Automatically reset by a 5-minute timeout.	Set
MinU		V	The supervised minimum of line-to-line voltages in primary volts	
U<, U<<, U<<<, U<<<<, U<<<<<		V	Pick-up value scaled to primary value	
U<, U<<, U<<<, U<<<<, U<<<<<		% Un	Pick-up setting	Set
t<, t<<, t<<<, t<<<<, t<<<<<		S	Definite operation time.	Set
LVBlk		% Un	Low limit for self blocking	Set
RlsDly		S	Release delay (U< stage only)	Set
Hyster	Default 3.0 %	%	Dead band setting	Set

Set = An editable parameter (password needed). C = Can be cleared to zero. F = Editable when force flag is on.

For details of setting ranges, see Table 12.22, Table 12.23, Table 12.24.

Recorded values of the latest eight faults

There are detailed information available of the eight latest faults for each of the stages: Time stamp, fault voltage, elapsed delay, voltage before the fault and setting group.

Table 5.8: Recorded values of the undervoltage stages (8 latest faults) U<, U<<, U<<<, U<<<<, U<<<<<

Parameter	Value	Unit	Description
	yyyy-mm-dd		Time stamp of the recording, date
	hh:mm:ss.ms		Time stamp, time of day
Flt		% Un	Minimum fault voltage
EDly		%	Elapsed time of the operating time setting. 100% = trip
PreFlt		% Un	Supervised value before fault, 1 s average value.
SetGrp	1, 2, 3, 4		Active setting group during fault

5.8 Negative sequence overvoltage protection U_2> (47)

This protection stage can be used to detect voltage unbalance and phase reversal situations.

This overvoltage function measures the negative sequence of fundamental frequency component U_2 of the measured voltages (for calculation of U_2, see Chapter 7.4 Symmetric components).

Whenever the negative sequence voltage U_2 raise above the user's pick-up setting of a particular stage, this stage picks up and a start signal is issued. If the fault situation remains on longer than the user's operation time delay setting, a trip signal is issued.

Blocking during VT fuse failure

As all the protection stages, the Negative sequence overvoltage can be blocked with any internal or external signal using the block matrix. For example if the secondary voltage of one of the measuring transformers disappears because of a fuse failure (See VT supervision function in Chapter 6.5 Voltage transformer supervision). The blocking signal can also be a signal from the user's logic (see Chapter 8.8 Logic functions).

Three independent stages

There are three separately adjustable stages: U_2>, U_2>> and U_2>>>. Both stages can be configured for definite time (DT) operation characteristic.

Setting groups

There are two settings groups available for both stages. Switching between setting groups can be controlled by digital inputs, virtual inputs (mimic display, communication, logic) and manually.

Table 5.9: Parameters of the under voltage stages U_2>, U_2>>, U_2>>>

Parameter	Value	Unit	Description	Note
Status	- Blocked Start Trip		Current status of the stage	F F
SCntr			Cumulative start counter	C
TCntr			Cumulative trip counter	C
SetGrp	1 or 2		Active setting group	Set
SGrpDI	 - DIx VIx LEDx VOx		Digital signal to select the active setting group None Digital input Virtual input LED indicator signal Virtual output	Set
Force	Off On		Force flag for status forcing for test purposes. This is a common flag for all stages and output relays, too. Automatically reset by a 5-minute timeout.	Set
U2		%	The supervised negative sequence voltage of Un/ $\sqrt{3}$	
U2>, U2>>, U2>>>		%	Pick-up setting of Un/ $\sqrt{3}$	Set
t<, t<<t<<<		s	Definite operation time.	Set

Set = An editable parameter (password needed). C = Can be cleared to zero. F = Editable when force flag is on.

For details of setting ranges, see Table 12.25.

Recorded values of the latest eight faults

There are detailed information available of the eight latest faults: Time stamp, fault voltage, elapsed delay and setting group.

Table 5.10: Recorded values of the undervoltage stages (8 latest faults)

Parameter	Value	Unit	Description
	yyyy-mm-dd		Time stamp of the recording, date
	hh:mm:ss.ms		Time stamp, time of day
Flt		% Un	Maximun fault voltage
EDly		%	Elapsed time of the operating time setting. 100% = trip
SetGrp	1 2		Active setting group during fault

5.9 Zero sequence voltage protection U_0> (59N)

The zero sequence voltage protection is used as unselective backup for earth faults and also for selective earth fault protections for motors having a unit transformer between the motor and the busbar.

This function is sensitive to the fundamental frequency component of the zero sequence voltage. The attenuation of the third harmonic is more than 60 dB. This is essential, because 3rd harmonics exist between the neutral point and earth also when there is no earth fault.

Whenever the measured value exceeds the user's pick-up setting of a particular stage, this stage picks up and a start signal is issued. If the fault situation remains on longer than the user's operation time delay setting, a trip signal is issued.

Measuring the zero sequence voltage

The zero sequence voltage is either measured with three voltage transformers (e.g. broken delta connection), one voltage transformer between the motor's neutral point and earth or calculated from the measured phase-to-neutral voltages according to the selected voltage measurement mode (see Chapter 7.3 Voltage measurement modes):

- When the voltage measurement mode is 3LN: the zero sequence voltage is calculated from the phase voltages and therefore a separate zero sequence voltage transformer is not needed. The setting values are relative to the configured voltage transformer (VT) voltage/ $\sqrt{3}$.
- When the voltage measurement mode contains "+U_0": The zero sequence voltage is measured with voltage transformer(s) for example using a broken delta connection. The setting values are relative to the VT_0 secondary voltage defined in configuration.

NOTE: The U_0 signal must be connected according the connection diagram (Figure 11.8) in order to get a correct polarization.

Three independent stages

There are three separately adjustable stages: U_0>, U_0>> and U_0>>>. All stages can be configured for definite time (DT) operation characteristic.

The zero sequence voltage function comprises three separately adjustable zero sequence voltage stages (stage U_0>, U_0>> and U_0>>>).

Setting groups

There are four settings groups available for both stages. Switching between setting groups can be controlled by digital inputs, virtual inputs (communication, logic) and manually. See Chapter 5.2 General features of protection stages for more details.

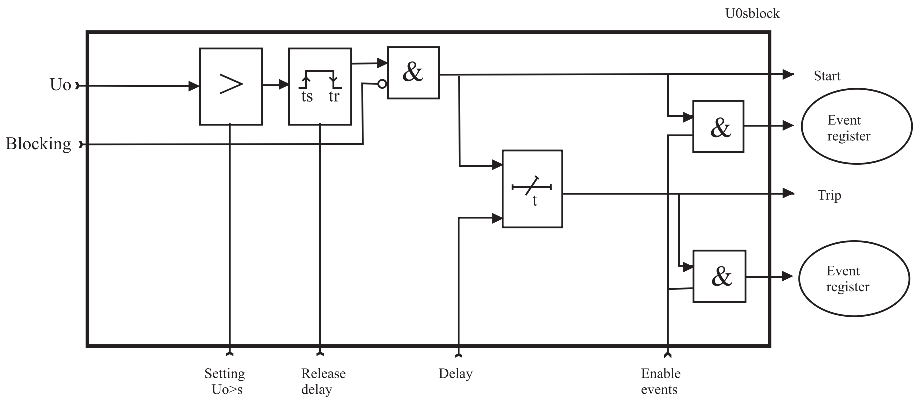


Figure 5.11: Block diagram of the zero sequence voltage stages U_0>, U_0>>, U_0>>>

Table 5.11: Parameters of the residual overvoltage stages U_0>, U_0>>, U_0>>>

Parameter	Value	Unit	Description	Note
Status	-		Current status of the stage	
	Blocked			
	Start			F
	Trip			F
SCntr			Cumulative start counter	C
TCntr			Cumulative trip counter	C
SetGrp	1, 2, 3, 4		Active setting group	Set
SGrpDI			Digital signal to select the active setting group	Set
	-		None	
	DIx		Digital input	
	VIx		Virtual input	
	LEDx		LED indicator signal	
	VOx		Virtual output	
	Fx		Function key	
Force	Off On		Force flag for status forcing for test purposes. This is a common flag for all stages and output relays, too. Automatically reset by a 5-minute timeout.	Set
Uo		%	The supervised value relative to Un/ $\sqrt{3}$	
Uo>, Uo>>, U_0>>>		%	Pick-up value relative to Un/ $\sqrt{3}$	Set
t>, t>>, t>>>		s	Definite operation time.	Set

Set = An editable parameter (password needed). C = Can be cleared to zero. F = Editable when force flag is on.

For details of setting ranges, see Table 12.26, Table 12.27, Table 12.28.

Recorded values of the latest eight faults

There are detailed information available of the eight latest faults: Time stamp, fault voltage, elapsed delay and setting group.

Table 5.12: Recorded values of the residual overvoltage stages U_0>, U_0>>, U_0>>>

Parameter	Value	Unit	Description
	yyyy-mm-dd		Time stamp of the recording, date
	hh:mm:ss.ms		Time stamp, time of day
Flt		%	Fault voltage relative to Un/ $\sqrt{3}$
EDly		%	Elapsed time of the operating time setting. 100% = trip
SetGrp	1, 2, 3, 4		Active setting group during fault

5.10 Frequency Protection f><, f>><< (81)

Frequency protection is used for load sharing, loss of mains detection and as a backup protection for over-speeding.

The frequency function measures the frequency from the two first voltage inputs. At least one of these two inputs must have a voltage connected to be able to measure the frequency. Whenever the frequency crosses the user's pick-up setting of a particular stage, this stage picks up and a start signal is issued. If the fault remains on longer than the operating delay setting, a trip signal is issued. For situations, where no voltage is present an adapted frequency is used. See Chapter 4.2 Principles of numerical protection techniques.

Protection mode for f><, f>><< and f>>><<< stages

These three stages can be configured either for overfrequency or for underfrequency.

Under voltage self blocking of underfrequency stages

The underfrequency stages are blocked when biggest of the three line-to-line voltages is below the low voltage block limit setting. With this common setting, LVBlk, all stages in underfrequency mode are blocked, when the voltage drops below the given limit. The idea is to avoid purposeless alarms, when the voltage is off.

Initial self blocking of underfrequency stages

When the biggest of the three line-to-line voltages has been below the block limit, the under frequency stages will be blocked until the pick-up setting has been reached.

Four independent frequency stages

There are four separately adjustable frequency stages: f><, f>><<, f<, f<<. The two first stages can be configured for either overfrequency or underfrequency usage. So totally four underfrequency stages can be in use simultaneously. Using the programmable stages even more can be implemented (chapter Chapter 5.14 Programmable stages (99)). All the stages have definite operation time delay (DT).

Setting groups

There are four settings groups available for each stage. Switching between setting groups can be controlled by digital inputs, virtual inputs (mimic display, communication, logic) and manually. See Chapter 5.2 General features of protection stages for more details.

Table 5.13: Parameters of the over & underfrequency stages

Parameter	Value	Unit	Description	Note
Status	- Blocked Start Trip		Current status of the stage	 F F
SCntr			Cumulative start counter	C
TCntr			Cumulative trip counter	C
SetGrp	1, 2, 3, 4		Active setting group	Set
SGrpDI			Digital signal to select the active setting group	Set
	-		None	
	DIx		Digital input	
	VIx		Virtual input	
	LEDx		LED indicator signal	
	VOx		Virtual output	
	Fx		Function key	
Force	Off On		Force flag for status forcing for test purposes. This is a common flag for all stages and output relays, too. Automatically reset by a 5-minute timeout.	Set
f		Hz	The supervised value.	
 fX fXX f< f<<		Hz	Pick-up value Over/under stage f><. See row "Mode". Over/under stage f>><<. Under stage f< Under stage f<<	Set
 tX tXX t< t<<		s	Definite operation time. f>< stage f>><< stage f< stage f<< stage	Set
Mode	 > <		Operation mode. (only for f>< and f>><<) Overfrequency mode Underfrequency mode	Set
LVblck		% Un	Low limit for self blocking. This is a common setting for all four stages.	Set

Set = An editable parameter (password needed). C = Can be cleared to zero. F = Editable when force flag is on.

For details of setting ranges, see Table 12.30, Table 12.31.

Recorded values of the latest eight faults

There are detailed information available of the eight latest faults: Time stamp, frequency during fault, elapsed delay and setting group.

Table 5.14: Recorded values of the over & under frequency stages (8 latest faults) f><, f>><<, f<, f<<, f>>><<<<

Parameter	Value	Unit	Description
	yyyy-mm-dd		Time stamp of the recording, date
	hh:mm:ss.ms		Time stamp, time of day
Flt		Hz	Faulty frequency
EDly		%	Elapsed time of the operating time setting. 100% = trip
SetGrp	1, 2, 3, 4		Active setting group during fault

5.11 Rate of change of frequency (ROCOF) (81R)

Rate of change of frequency (ROCOF or df/dt) function is used for fast load shedding, to speed up operation time in over- and under-frequency situations and to detect loss of grid. For example a centralized dedicated load shedding relay can be omitted and replaced with distributed load shedding, if all outgoing feeders are equipped with VAMP devices.

A special application for ROCOF is to detect loss of grid (loss of mains, islanding). The more the remaining load differs from the load before the loss of grid, the better the ROCOF function detects the situation.

Frequency behaviour during load switching

Load switching and fault situations may generate change in frequency. A load drop may increase the frequency and increasing load may decrease the frequency, at least for a while. The frequency may also oscillate after the initial change. After a while the control system of any local generator may drive the frequency back to the original value. However, in case of a heavy short circuit fault or in case the new load exceeds the generating capacity, the average frequency keeps on decreasing.

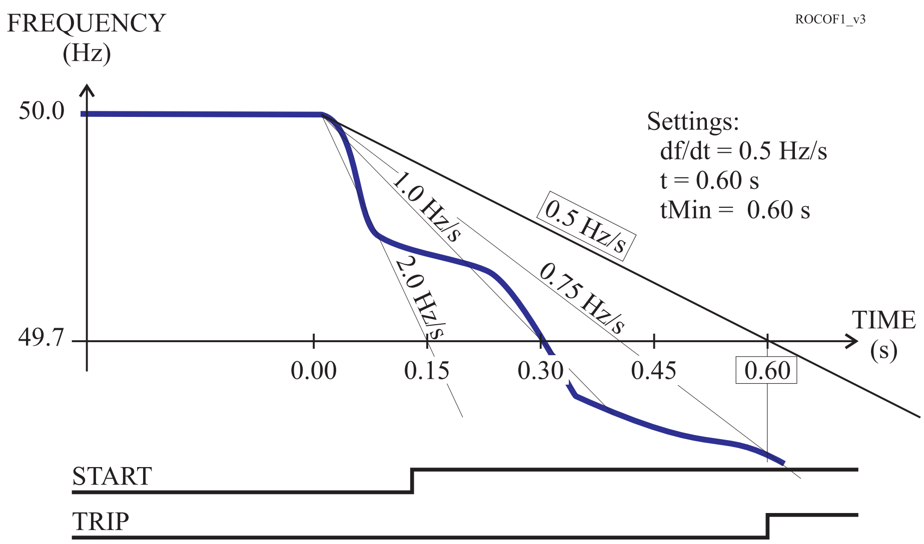


Figure 5.12: An example of definite time df/dt operation time. At 0.6 s, which is the delay setting, the average slope exceeds the setting 0.5 Hz/s and a trip signal is generated.

Setting groups

There are four settings groups available. Switching between setting groups can be controlled by digital inputs, virtual inputs (communication, logic) and manually. See Chapter 5.2 General features of protection stages for more details.

Description of ROCOF implementation

The ROCOF function is sensitive to the absolute average value of the time derivate of the measured frequency |df/dt|. Whenever the measured frequency slope |df/dt| exceeds the setting value for 80 ms time, the ROCOF stage picks up and issues a start signal after an additional 60 ms delay. If the average |df/dt|, since the pick-up moment, still exceeds the setting, when the operation delay time has elapsed, a trip signal is issued. In this definite time mode the second delay parameter "minimum delay, t_{MIN}" must be equal to the operation delay parameter "t".

If the frequency is stable for about 80 ms and the time t has already elapsed without a trip, the stage will release.

ROCOF and frequency over and under stages

One difference between over-/under-frequency and df/dt function is the speed. In many cases a df/dt function can predict an overfrequency or underfrequency situation and is thus faster than a simple overfrequency or underfrequency function. However, in most cases a standard overfrequency and underfrequency stages must be used together with ROCOF to ensure tripping also in case the frequency drift is slower than the slope setting of ROCOF.

Definite operation time characteristics

Figure 5.12 shows an example where the df/dt pick-up value is 0.5 Hz/s and the delay settings are t = 0.60 s and t_{MIN} = 0.60 s. Equal times t = t_{MIN} will give a definite time delay characteristics. Although the frequency slope fluctuates the stage will not release but continues to calculate the average slope since the initial pick-up. At the defined operation time, t = 0.6 s, the average slope is 0.75 Hz/s. This exceeds the setting, and the stage will trip.

At slope settings less than 0.7 Hz/s the fastest possible operation time is limited according the Figure 5.13

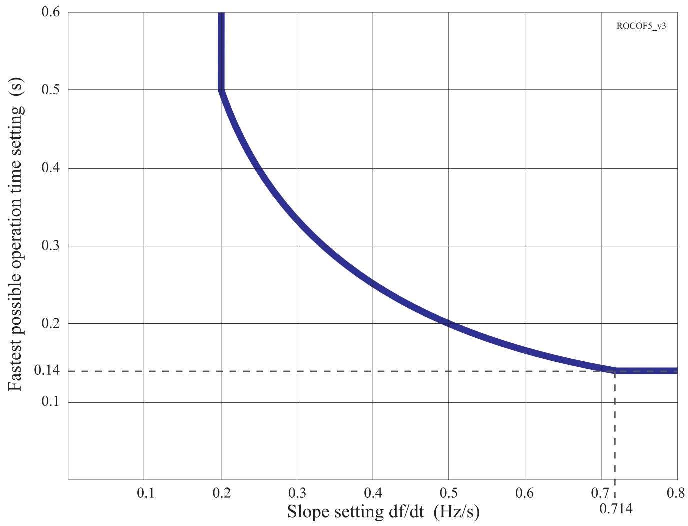


Figure 5.13: At very sensitive slope settings the fastest possible operation time is limited according the figure.

Inverse operation time characteristics

By setting the second delay parameter t_{MIN} smaller than the operational delay t, an inverse type of operation time characteristics is achieved.

Figure 5.15 shows one example, where the frequency behaviour is the same as in the first figure, but the t_{MIN} setting is 0.15 s instead of being equal with t. The operation time depends of the measured average slope according the following equation.

Equation 5.1:

$$t_{TRIP} = \frac{s_{SET} \cdot t_{SET}}{|s|}$$

t_{TRIP} = Resulting operation time (seconds).

s_{SET} = df/dt i.e. slope setting (hertz/seconds).

t_{SET} = Operation time setting t (seconds).

s = Measured average frequency slope (hertz/seconds).

The minimum operating time is always limited by the setting parameter t_{MIN}. In the example of the fastest operation time, 0.15 s, is achieved when the slope is 2 Hz/s or more. The leftmost curve in

Figure 5.14 shows the inverse characteristics with the same settings as in Figure 5.15.

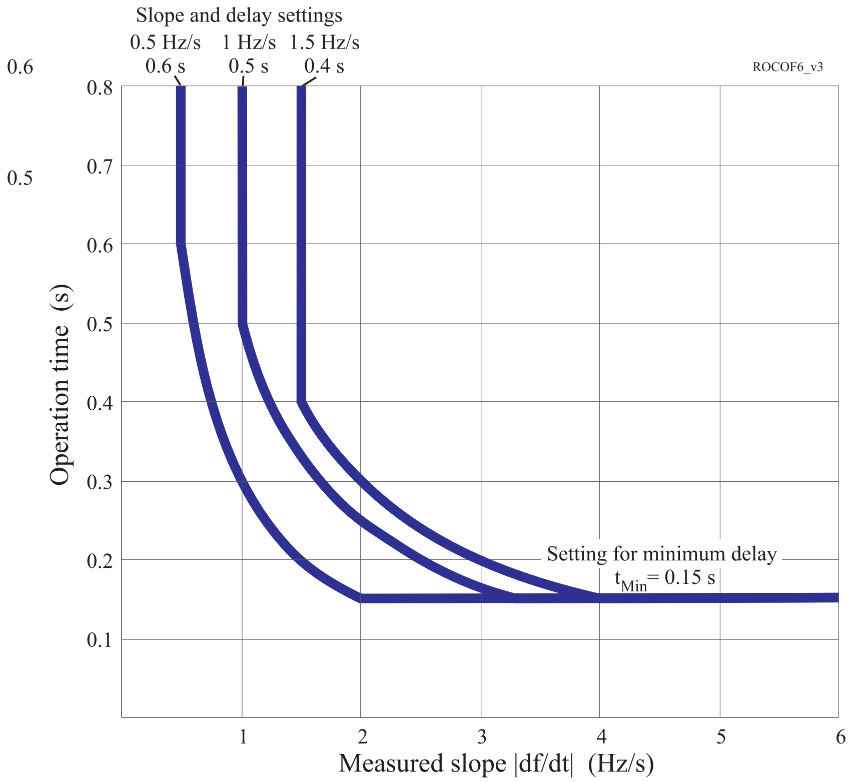


Figure 5.14: Three examples of possible inverse df/dt operation time characteristics. The slope and operation delay settings define the knee points on the left. A common setting for tMin has been used in these three examples. This minimum delay parameter defines the knee point positions on the right.

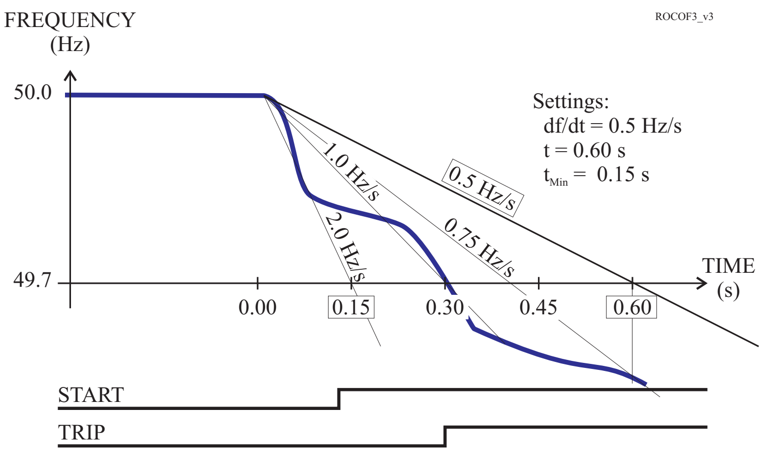


Figure 5.15: An example of inverse df/dt operation time. The time to trip will be 0.3 s, although the setting is 0.6 s, because the average slope 1 Hz/s is steeper than the setting value 0.5 Hz/s.

Table 5.15: Setting parameters of df/dt stage

Parameter	Value	Unit	Default	Description
df/dt	0.2 – 10.0	Hz/s	5.0	df/dt pick-up setting
t>	0.14 – 10.0	s	0.50	df/dt operational delay
tMin>	0.14 – 10.0	s	0.50	df/dt minimum delay
S_On	Enabled; Disabled	-	Enabled	Start on event
S_Off	Enabled; Disabled	-	Enabled	Start off event
T_On	Enabled; Disabled	-	Enabled	Trip on event
T_Off	Enabled; Disabled	-	Enabled	Trip off event

For details of setting ranges, see Table 12.32.

Table 5.16: Measured and recorded values of df/dt stage

	Parameter	Value	Unit	Description
Measured value	f		Hz	Frequency
	df/dt		Hz/s	Frequency rate of change
Recorded values	SCntr		-	Start counter (Start) reading
	TCntr		-	Trip counter (Trip) reading
	Flt		%Hz/s	Max rate of change fault value
	EDly		%	Elapsed time as compared to the set operating time; 100% = tripping

5.12 Synchrocheck (25)

Synchrocheck is a function that will check synchronism in both sides of the opened circuit breaker. The function will monitor voltage amplitude, frequency and phase angle difference between two voltages. The reference for synchrocheck can be phase to ground or phase to phase voltage.

Voltage measuring mode must be selected to enable synchrocheck from the desired reference. Available voltage modes are 3LN/LLy for phase to phase voltage reference and 3LN/LNy for phase to ground reference.

The voltage used for sychrochecking is always phase-to-phase voltage U_{12} or phase to ground voltage U_{L1}.

Table 5.17: Setting parameters of synchrocheck stage SyC1 (25)

Parameter	Values	Unit	Default	Description
Side	U12/U12y;	-	U12/U12z	Voltage selection. The stage 1 has fixed voltages U12/U12y or U12/U1y
CBObj	Obj1	-	Obj1	The selected object for CB control. The synchrocheck closing command will use the closing command of the selected object. **NOTE!** The stage 1 is always using the object 1.

Parameter	Values	Unit	Default	Description
Smode	Async; Sync; Off	-	Sync	Synchrocheck mode. **Off** = only voltage check **Async** = the function checks dU, df and dangle. Furthermore, the frequency slip, df, determines the remaining time for closing. This time must be longer than “CB time”. **Sync mode** = Synchronization is tried to make exactly when angle difference is zero. In this mode df-setting should be enough small (<0.3Hz).
Umode	-, DD, DL, DL/LD, DD/DL/LD	-	-	Voltage check mode: The first letter refers to the reference voltage and the second letter refers to the comparison voltage. **D** means that the side must be “dead” when closing (dead = The voltage below the dead voltage limit setting) **L** means that the side must be “live” when closing (live = The voltage higher than the live voltage limit setting) Example: DL mode for stage 1: The U12 side must be “dead” and the U12y side must be “live”.
Cbtime	0.04 – 0.6	s	0.1	Typical closing time of the circuit-breaker.
Dibypass	Digital inputs	-	-	Bypass input. If the input is active, the function is bypassed.
Bypass	0; 1	-	0	The bypass status. “1” means that the function is bypassed. This parameter can also be used for manual bypass.
CBCtrl	Open;Close	-	-	Circuit-breaker control
ShowInfo	Off; On	-	On	Additional information display about the sychrocheck status to the mimic dispaly.
SGrpDI	Digital inputs	-	-	The input for changing the setting group.
SetGrp	1, 2, 3, 4	-	1	The active setting group.

Table 5.18: Measured and recorded values of synchrocheck stages SyC1 (25)

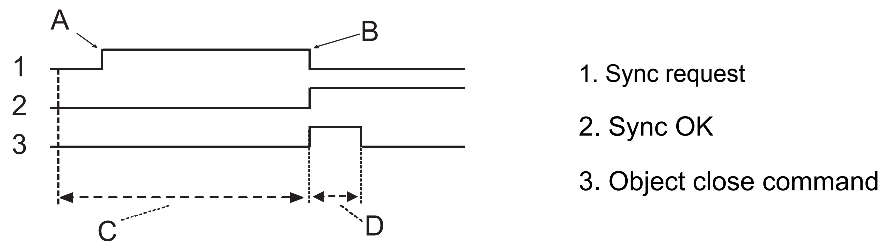
	Parameter	Value	Unit	Description
Measured values	df	-	Hz	Measured frequency difference
	dU	-	% Un / deg	Measured voltage amplitude and phase angle difference
	UState	-	-	Voltage status (e.g. DD)
	SState	-	-	Synchrocheck status
	ReqTime	-	-	Request time status
	f[1)]	-	Hz	Measured frequency (reference side)
	fy[1)]	-	Hz	Measured frequency (comparison side)
	U12[1)]	-	% Un	Measured voltage (reference side)
	U12y[1)]	-	% Un	Measured voltage (comparison side)

	Parameter	Value	Unit	Description
Recorded values	ReqCntr	-	-	Request counter
	SyncCntr	-	-	Synchronising counter
	FailCntr	-	-	Fail counter
	f1)	-	Hz	Recorded frequency (reference side)
	fy1)	-	Hz	Recorded frequency (comparison side)
	U121)	-	% Un	Recorded voltage (reference side)
	U12y1)	-	% Un	Recorded voltage (comparison side)
	dAng	-	Deg	Recorded phase angle difference, when close command is given from the function
	dAngC	-	Deg	Recorded phase angle difference, when the circuit-breaker actually closes.
	EDly	-	%	The elapsed time compared to the set request timeout setting, 100% = timeout

1) Please note that the labels (parameter names) change according to the voltage selection.

For details of setting ranges, see Table 12.33.

The following signals of the stage are available in the output matrix and the logic: “Request”, “OK” and “Fail”. The “request”-signal is active, when a request has received but the breaker is not yet closed. The “OK”-signal is active, when the synchronising conditions are met, or the voltage check criterion is met. The “fail”-signal is activated, if the function fails to close the breaker within the request timeout setting. See below the figure.



A. Object close command gived (minic or bus) actually make only sync request
B. Request going down when "real" object close being requested
C. Synchronizing time if timeout happens, Sync_Fail signal activates Timeout defined in synchrocheck
D. Normal object close operation

Figure 5.16: The principle of the synchrocheck function

Please note that the control pulse of the selected object should be long enough. For example, if the voltages are in opposite direction, the synchronising conditions are met after several seconds.

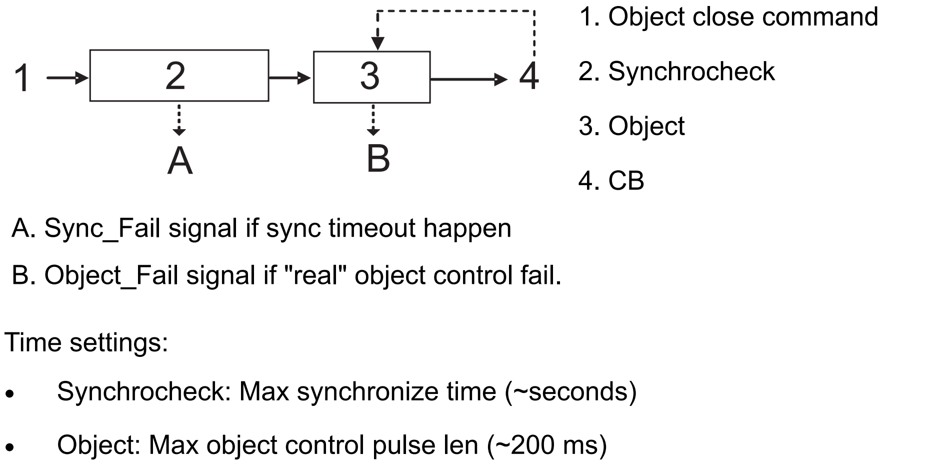


Figure 5.17: The block diagram of the synchrocheck and the controlling object

Please note that the wiring of the secondary circuits of voltage transformers to the device terminal depends on the selected voltage measuring mode.

Table 5.19: Voltage measurement modes for synchrocheck function

Voltage input	Terminals	Signals in mode "3LN+LLy/LNy"
U_a	X1:1-5	U_1
U_b	X1:2-5	U_2
U_c	X1:3-5	U_3
U_d	X1:4-5	U_{12y}/U_{1y}
Number of synchrocheck stages		1
Availability of U_0		No

The following application examples show the correct connection of the voltage inputs. In the Figure 5.18 and Figure 5.19, the applications require only one stage (Voltage measuring modes are "3LN+LLy/LNy ").

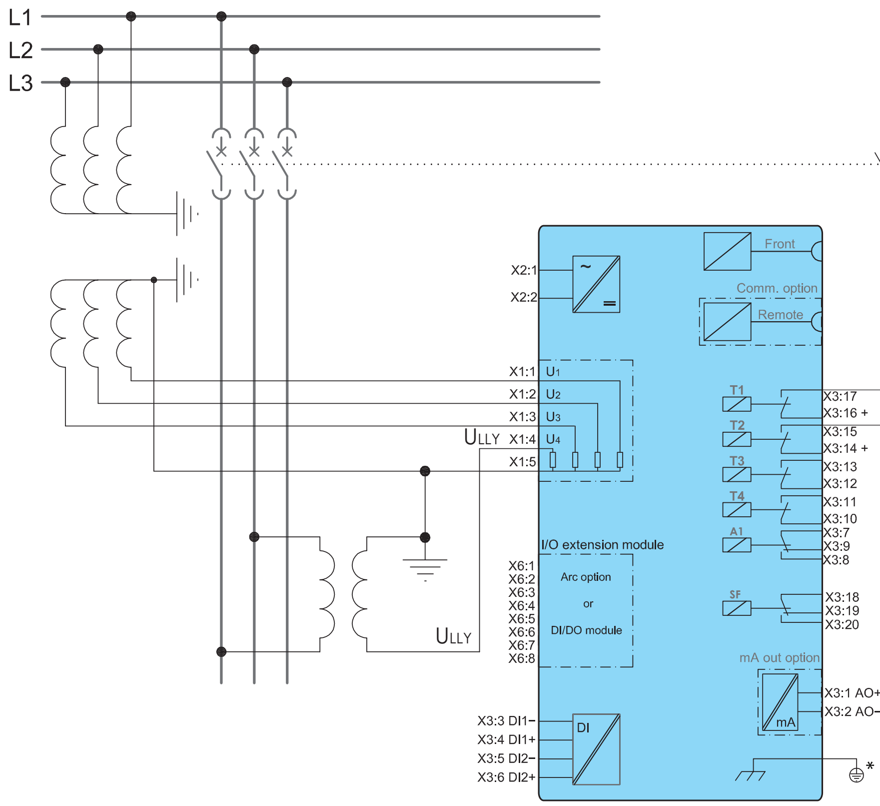


Figure 5.18: One synchrocheck stage with "3LN+LLy"-mode.

*** Voltage measurement of the 50 series relays should be at the same potential with the grounding of the relay. Normally this happens "automatically" on field but pay attention when doing tests with the relay.**

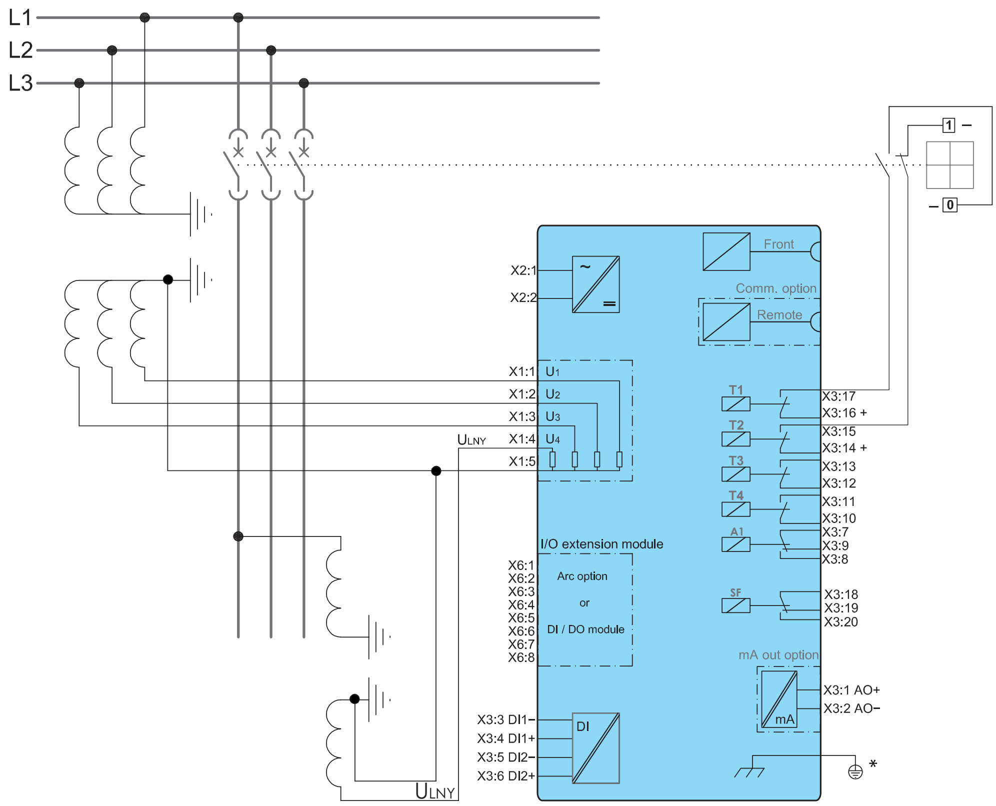


Figure 5.19: One synchrocheck stage with “3LN+LNy”-mode.

*** Voltage measurement of the 50 series relays should be at the same potential with the grounding of the relay. Normally this happens “automatically” on field but pay attention when doing tests with the relay.**

5.13 Circuit breaker failure protection CBFP (50BF)

The circuit breaker failure protection can be used to trip any upstream circuit breaker (CB), if the fault has not disappeared within a given time after the initial trip command. A different output contact of the device must be used for this backup trip.

The operation of the circuit-breaker failure protection (CBFP) is based on the supervision of the signal to the selected trip relay and the time the fault remains on after the trip command.

If this time is longer than the operating time of the CBFP stage, the CBFP stage activates another output relay, which will remain activated until the primary trip relay resets.

The CBFP stage is supervising all the protection stages using the same selected trip relay, since it supervises the control signal of this device. See Chapter 8.5 Output matrix

Table 5.20: Parameters of the circuit breaker failure stage CBFP (50BF)

Parameter	Value	Unit	Description	Note
Status	-		Current status of the stage	
	Blocked			
	Start			F
	Trip			F
SCntr			Cumulative start counter	C
TCntr			Cumulative trip counter	C
Force	Off On		Force flag for status forcing for test purposes. This is a common flag for all stages and output relays, too. Automatically reset by a 5-minute timeout.	Set
Cbrelay			The supervised output relay.	Set
	1 – 14		Relay T1 – T14 (depending on the orderinf code)	
t>		s	Definite operation time.	Set

Set = An editable parameter (password needed). C = Can be cleared to zero. F = Editable when force flag is on.

For details of setting ranges, see Table 12.29.

Recorded values of the latest eight faults

There are detailed information available of the eight latest faults: Time stamp and elapsed delay.

Table 5.21: Recorded values of the circuit breaker failure stage (8 latest faults) CBFP (50BF)

Parameter	Value	Unit	Description
	yyyy-mm-dd		Time stamp of the recording, date
	hh:mm:ss.ms		Time stamp, time of day
EDly		%	Elapsed time of the operating time setting. 100% = trip

5.14 Programmable stages (99)

For special applications the user can built own protection stages by selecting the supervised signal and the comparison mode.

The following parameters are available:

- **Priority**
  If operation times less than 80 milliseconds are needed select 10 ms. For operation times under one second 20 ms is recommended. For longer operation times and THD signals 100 ms is recommended.
- **Coupling A**
  The name of the supervised signal in “>” and “<” modes (see table below). Also the name of the supervised signal 1 in “Diff” and “AbsDiff” modes.
- **Coupling B**
  The name of the supervised signal 2 in “Diff” and “AbsDiff” modes.
- **Compare condition**
  Compare mode. ‘>’ for over or ‘<’ for under comparison, “Diff” and “AbsDiff” for comparing Coupling A and Coupling B.
- **Pick-up**
  Limit of the stage. The available setting range and the unit depend on the selected signal.
- **Operation delay**
  Definite time operation delay
- **Hysteresis**
  Dead band (hysteresis)
- **No Compare limit for mode <**
  Only used with compare mode under (‘<’). This is the limit to start the comparison. Signal values under NoCmp are not regarded as fault.

Table 5.22: Available signals to be supervised by the programmable stages

U12, U23, U31	Line-to-line voltages
UL1, UL2, UL3	Phase-to-ground voltages
Uo	Zero sequence voltage
f	Frequency
THDUa	Total harmonic distortion of input U_A
THDUb	Total harmonic distortion of input U_B
THDUc	Total harmonic distortion of input U_C
fy	Frequency behind circuit breaker
U12y	Voltage behind circuit breaker
U12z	Voltage behind 2nd circuit breaker
ULLmin, ULLmax	Minimum and maximum of line voltages
ULNmin, ULNmax	Minimum and maximum of phase voltages
VAI1, VAI2, VAI3, VAI4, VAI5	Virtual analog inputs 1, 2, 3, 4, 5 (GOOSE)

Eight independent stages

The device has eight independent programmable stages. Each programmable stage can be enabled or disabled to fit the intended application.

Setting groups

There are four settings groups available. Switching between setting groups can be controlled by digital inputs, virtual inputs (mimic display, communication, logic) and manually.

There are four identical stages available with independent setting parameters.

See Chapter 5.2 General features of protection stages for more details.

Table 5.23: Parameters of the programmable stages PrgN (99)

Parameter	Value	Unit	Description	Note
Status	-		Current status of the stage	
	Blocked			
	Start			F
	Trip			F
SCntr			Cumulative start counter	C
TCntr			Cumulative trip counter	C
SetGrp	1, 2, 3, 4		Active setting group	Set

Parameter	**Value**	**Unit**	**Description**	**Note**
SGrpDI			Digital signal to select the active setting group	Set
	-		None	
	DIx		Digital input	
	VIx		Virtual input	
	LEDx		LED indicator signal	
	VOx		Virtual output	
	Fx		Function key	
Force	Off On		Force flag for status forcing for test purposes. This is a common flag for all stages and output relays, too. Automatically reset by a 5-minute timeout.	Set
Link	See Table 5.22		Name for the supervised signal	Set
See Table 5.22			Value of the supervised signal	
Cmp			Mode of comparison	Set
	>		Over protection	
	<		Under protection	
	Diff		Difference	
	AbsDiff		Absolut difference	
Pickup			Pick up value scaled to primary level	
Pickup		pu	Pick up setting in pu	Set
t		s	Definite operation time.	Set
Hyster		%	Dead band setting	Set
NoCmp		pu	Minimum value to start under comparison. (Mode='<')	Set

Set = An editable parameter (password needed). C = Can be cleared to zero. F = Editable when force flag is on.

Recorded values of the latest eight faults

There is detailed information available of the eight latest faults: Time stamp, fault value and elapsed delay.

Table 5.24: Recorded values of the programmable stages PrgN (99)

Parameter	**Value**	**Unit**	**Description**
	yyyy-mm-dd		Time stamp of the recording, date
	hh:mm:ss.ms		Time stamp, time of day
Flt		pu	Fault value
EDly		%	Elapsed time of the operating time setting. 100% = trip
SetGrp	1, 2, 3, 4		Active setting group during fault

6 Supporting functions

6.1 Event log

Event log is a buffer of event codes and time stamps including date and time. For example each start-on, start-off, trip-on or trip-off of any protection stage has a unique event number code. Such a code and the corresponding time stamp is called an event.

As an example of information included with a typical event a programmable stage trip event is shown in the following table.

EVENT	Description	Local panel	Communication protocols
Code: 30E2	Channel 30, event 2	Yes	Yes
U> trip on	Event text	Yes	No
120 %Un	Fault value	Yes	No
2007-01-31	Date	Yes	Yes
08:35:13.413	Time	Yes	Yes
Type: 1-N, 2-N, 3-N	Fault type	Yes	No

Events are the major data for a SCADA system. SCADA systems are reading events using any of the available communication protocols. Event log can also be scanned using the front panel or using VAMPSET. With VAMPSET the events can be stored to a file especially in case the relay is not connected to any SCADA system.

Only the latest event can be read when using communication protocols or VAMPSET. Every reading increments the internal read pointer to the event buffer. (In case of communication interruptions, the latest event can be reread any number of times using another parameter.) On the local panel scanning the event buffer back and forth is possible.

Event enabling/masking

In case of an uninteresting event, it can be masked, which prevents the particular event(s) to be written in the event buffer. As a default there is room for 200 latest events in the buffer. Event buffer size can be modified from 50 to 2000.

Modification can be done in “Local panel conf” –menu.

Indication screen (popup screen) can also be enabled in this same menu when VAMPSET –setting tool is used. The oldest one will be overwritten, when a new event does occur. The shown resolution of a time stamp is one millisecond, but the actual resolution depends of the particular function creating the event. For example most protection stages create events with 5ms, 10 ms or 20 ms resolution. The absolute accuracy of all time stamps depends on the time synchronizing of the relay. See Chapter 6.6 System clock and synchronization for system clock synchronizing.

Event buffer overflow

The normal procedure is to poll events from the device all the time. If this is not done then the event buffer could reach its limits. In such case the oldest event is deleted and the newest displayed with OVF code in HMI.

Table 6.1: Setting parameters for events

Parameter	Value	Description	Note
Count		Number of events	
ClrEn	- Clear	Clear event buffer	Set
Order	Old-New New-Old	Order of the event buffer for local display	Set
FVSca		Scaling of event fault value	Set
	PU	Per unit scaling	
	Pri	Primary scaling	
Display Alarms	On Off	Indication dispaly is enabled No indication display	Set
FORMAT OF EVENTS ON THE LOCAL DISPLAY			
Code: CHENN		CH = event channel, NN=event code	
Event description		Event channel and code in plain text	
yyyy-mm-dd		Date (for available date formats, see Chapter 6.6 System clock and synchronization)	
hh:mm:ss.nnn		Time	

6.2 Disturbance recorder

The disturbance recorder can be used to record all the measured signals, that is, currents, voltage and the status information of digital inputs (DI) and digital outputs (DO).

The digital inputs include also the arc protection signals S1, S2, BI and BO, if the optional arc protection is available.

Triggering the recorder

The recorder can be triggered by any start or trip signal from any protection stage or by a digital input. The triggering signal is selected in the output matrix (vertical signal DR). The recording can also be triggered manually. All recordings are time stamped.

Reading recordings

The recordings can be uploaded, viewed and analysed with the VAMPSET program. The recording is in COMTRADE format. This also means that other programs can be used to view and analyse the recordings made by the relay.

For more details, please see a separate VAMPSET manual.

Number of channels

At the maximum, there can be 12 recordings, and the maximum selection of channels in one recording 12 (limited in wave form) and digital inputs reserve one channel (includes all the inputs). Also the digital outputs reserve one channel (includes all the outputs). If digital inputs and outputs are recorded, there will be still 10 channels left for analogue waveforms.

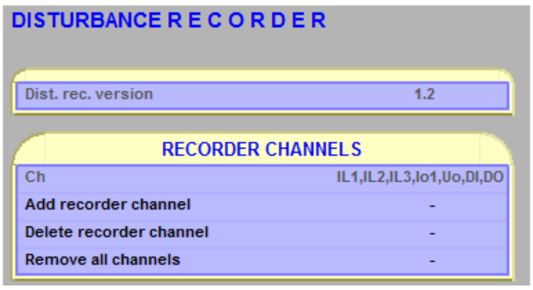


Table 6.2: Disturbance recorder waveform

Channel	Description	Available for waveform		
		Voltage measurement mode		
		3LN+U_0	3LN+LNy	3LN+LLy
U12	Line-to-line voltage	-	-	-
U23	Line-to-line voltage	-	-	-
U31	Line-to-line voltage	-	-	-
UL1	Phase-to-neutral voltage	Yes	Yes	Yes
UL2	Phase-to-neutral voltage	Yes	Yes	Yes
UL3	Phase-to-neutral voltage	Yes	Yes	Yes
Uo	Zero sequence voltage	Yes	-	-
f	Frequency	-	-	-
U1	Positive sequence voltage	-	-	-
U2	Negative sequence voltage	-	-	-
U2/U1	Relative voltage unbalance	-	-	-
IL	Average (IL1 + IL2 + IL3)/3	-	-	-
Uphase	Average (UL1 + UL2 + UL3) / 3	-	-	-
Uline	Average (U12 + U23 + U31) / 3	-	-	-
DO	Digital outputs	Yes	Yes	Yes
DI	Digital inputs	Yes	Yes	Yes
THDUa	Total harmonic distortion of Ua	-	-	-
THDUb	Total harmonic distortion of Ub	-	-	-
THDUc	Total harmonic distortion of Uc	-	-	-
fy	Frequency behind circuit breaker	-	-	-
U12y	Voltage behind circuit breaker	-	-	Yes
ULLmin	Minimum of line voltages	-	-	-
ULLmax	Maximum of line voltages	-	-	-
ULNmin	Minimum of phase voltages	-	-	-
ULNmax	Maximum of phase voltages	-	-	-

Table 6.3: Disturbance recorder parameters

Parameter	Value	Unit	Description	Note
Mode			Behavior in memory full situation:	Set
	Saturated		No more recordings are accepted	
	Overflow		The oldest recorder will be overwritten	
SR			Sample rate	Set
	32/cycle		Waveform	
	16/cycle		Waveform	
	8/cycle		Waveform	
	1/10ms		One cycle value *)	
	1/20ms		One cycle value **)	
	1/200ms		Average	
	1/1s		Average	
	1/5s		Average	
	1/10s		Average	
	1/15s		Average	
	1/30s		Average	
	1/1min		Average	
Time		s	Recording length	Set
PreTrig		%	Amount of recording data before the trig moment	Set
MaxLen		s	Maximum time setting. This value depends on sample rate, number and type of the selected channels and the configured recording length.	
Status			Status of recording	
	-		Not active	
	Run		Waiting a triggering	
	Trig		Recording	
	FULL		Memory is full in saturated mode	
ManTrig	-, Trig		Manual triggering	Set
ReadyRec	n/m		n = Available recordings / m = maximum number of recordings The value of 'm' depends on sample rate, number and type of the selected channels and the configured recording length.	

Parameter	Value	Unit	Description	Note
AddCh			Add one channel. Maximum simultaneous number of channels is 12.	Set
	Uo		Zero sequence voltage	
	f		Frequency	
	U1		Positive sequence voltage	
	U2		Negateive sequence voltage	
	U2/U1		Relative negative sequence voltage	
	IL		Average (IL1 + IL2 + IL3) / 3	
	Uphase		Average phase voltage	
	Uline		Average line-to-lines voltages	
	DI, DO		Digital inputs, Digital outputs	
	THDUa, THDUb, THDUc		Total harmonic distortion of Ua, Ub or Uc	
	fy		Frequency behind circuit breaker	
	fz		Frequency behind 2nd circuit breaker	
	U12y		Voltage behind circuit breaker	
	Starts		Protection stage start signals	
	Trips		Protection stage trip signals	
AddCh	ULLmin		Minimum of line voltages	Set
	ULLmax		Maximum of line voltages	
	ULNmin		Minimum of phase voltages	
	ULNmax		Maximum of phase voltages	
Delete recorder channel			Delete selected channel	
ClrCh	-, Clear		Remove all channels	Set
(Ch)			List of selected channels	

Set = An editable parameter (password needed).

*) This is the fundamental frequency rms value of one cycle updated every 10 ms.

**) This is the fundamental frequency rms value of one cycle updated every 20 ms.

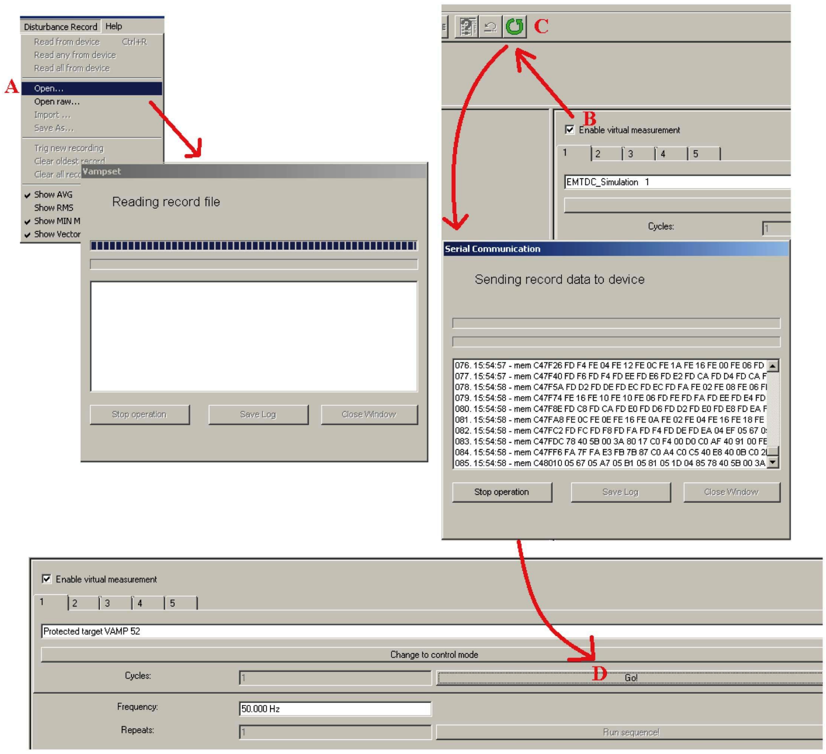
For details of setting ranges, see Table 12.35.

6.2.1 Running virtual comtrade files

Virtual comtrade files can be run with VAMP relays with the v.10.74 software or a later version. Relay behaviour can be analysed by playing the recorder data over and over again in the relay memory.

Steps of opening the VAMPSET setting tool:

1. Go to “Disturbance record” and select Open… (A).
2. Select the comtrade file from you hard disc or equivalent. VAMPSET is now ready to read the recording.
3. The virtual measurement has to be enabled (B) in order to send record data to the relay (C).
4. Sending the file to the device’s memory takes a few seconds. Initiate playback of the file by pressing the Go! button (D). The “Change to control mode” button takes you back to the virtual measurement.



NOTE: The sample rate of the comtrade file has to be 32/cycle (625 micro seconds when 50 Hz is used). The channel names have to correspond to the channel names in VAMP relays: I_{L1}, I_{L2}, I_{L3}, I_0, U_{12}, U_{23}, U_{L1}, U_{L2}, U_{L3} and U_0.

6.3 Voltage sags and swells

The power quality of electrical networks has become increasingly important. The sophisticated loads (e.g. computers etc.) require uninterruptible supply of “clean” electricity. VAMP protection platform provides many power quality functions that can be used to evaluate, monitor and alarm on the basis of the quality. One of the most important power quality functions are voltage sag and swell monitoring.

VAMP provides separate monitoring logs for sags and swells. The voltage log is trigged, if any voltage input either goes under the sag limit (U<) or exceeds the swell limit (U>). There are four registers for both sags and swells in the fault log. Each register will have start time, phase information, duration, minimum, average, maximum voltage values of each sag and swell event. Furthermore, there are total number of sags and swells counters as well as total timers for sags and swells.

The voltage power quality functions are located under the submenu “U”.

Table 6.4: Setting parameters of sags and swells monitoring

Parameter	Value	Unit	Default	Description
U>	20 – 150	%	110	Setting value of swell limit
U<	10 – 120	%	90	Setting value of sag limit
Delay	0.04 – 1.00	s	0.06	Delay for sag and swell detection
SagOn	On; Off	-	On	Sag on event
SagOff	On; Off	-	On	Sag off event
SwelOn	On; Off	-	On	Swell on event
SwelOf	On; Off	-	On	Swell off event

Table 6.5: Recorded values of sags and swells monitoring

	Parameter	Value	Unit	Description
Recorded values	Count		-	Cumulative sag counter
	Total		-	Cumulative sag time counter
	Count		-	Cumulative swell counter
	Total		-	Cumulative swell time counter
Sag / swell logs 1 – 4	Date		-	Date of the sag/swell
	Time		-	Time stamp of the sag/swell
	Type		-	Voltage inputs that had the sag/swell
	Time		s	Duration of the sag/swell
	Min1		% Un	Minimum voltage value during the sag/swell in the input 1
	Min2		% Un	Minimum voltage value during the sag/swell in the input 2
	Min3		% Un	Minimum voltage value during the sag/swell in the input 3
	Ave1		% Un	Average voltage value during the sag/swell in the input 1
	Ave2		% Un	Average voltage value during the sag/swell in the input 2
	Ave3		% Un	Average voltage value during the sag/swell in the input 3
	Max1		% Un	Maximum voltage value during the sag/swell in the input 1
	Max2		% Un	Maximum voltage value during the sag/swell in the input 2
	Max3		% Un	Maximum voltage value during the sag/swell in the input 3

For details of setting ranges, see Table 12.37.

6.4 Voltage interruptions

The device includes a simple function to detect voltage interruptions. The function calculates the number of voltage interruptions and the total time of the voltage-off time within a given calendar period. The period is based on the real time clock of the device. The available periods are:

- 8 hours, 00:00 – 08:00, 08:00 – 16:00, 16:00 – 24:00
- one day, 00:00 – 24:00
- one week, Monday 00:00 – Sunday 24:00
- one month, the first day 00:00 – the last day 24:00
- one year, 1st January 00:00 – 31st December 24:00

After each period, the number of interruptions and the total interruption time are stored as previous values. The interruption counter and the total time are cleared for a new period. The old previous values are overwritten.

The voltage interruption is based on the value of the positive sequence voltage U_1 and a user given limit value. Whenever the measured U_1 goes below the limit, the interruption counter is increased, and the total time counter starts increasing.

Shortest recognized interruption time is 40 ms. If the voltage-off time is shorter it may be recognized depending on the relative depth of the voltage dip.

If the voltage has been significantly over the limit U_1< and then there is a small and short under-swing, it will not be recognized (Figure 6.1).

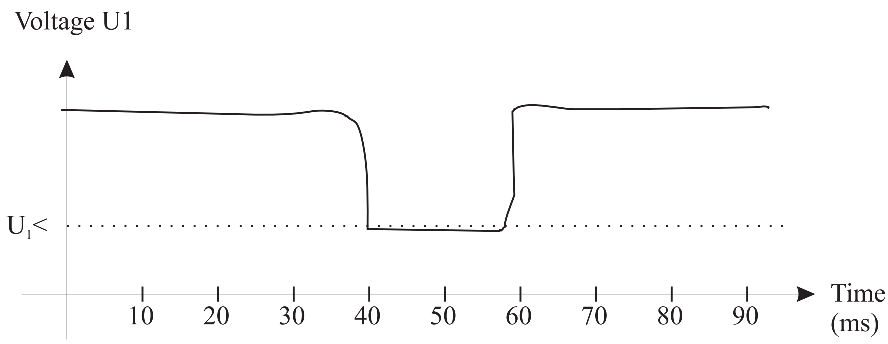


Figure 6.1: A short voltage interruption which is probably not recognized

On the other hand, if the limit U_1< is high and the voltage has been near this limit, and then there is a short but very deep dip, it will be recognized (Figure 6.2).

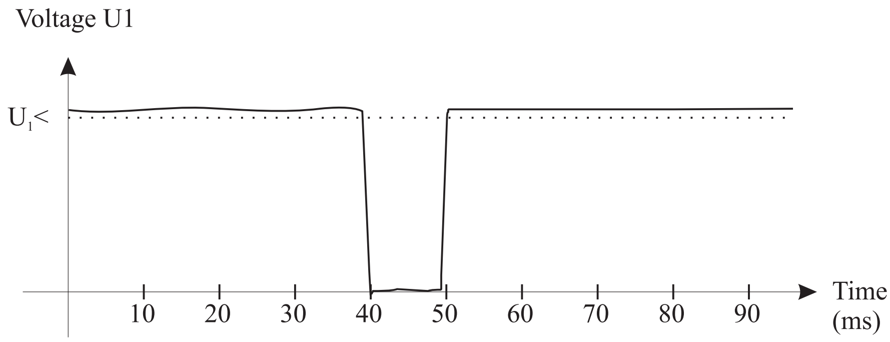


Figure 6.2: A short voltage interrupt that will be recognized

Table 6.6: Setting parameters of the voltage sag measurement function:

Parameter	Value	Unit	Default	Description
U1<	10.0 – 120.0	%	64	Setting value
Period	8h Day Week Month	-	Month	Length of the observation period
Date		-	-	Date
Time		-	-	Time

Table 6.7: Measured and recorded values of voltage sag measurement function:

	Parameter	Value	Unit	Description
Measured value	Voltage	LOW; OK	-	Current voltage status
	U1		%	Measured positive sequence voltage
Recorded values	Count		-	Number of voltage sags during the current observation period
	Prev		-	Number of voltage sags during the previous observation period
	Total		s	Total (summed) time of voltage sags during the current observation period
	Prev		s	Total (summed) time of voltage sags during the previous observation period

For details of setting ranges, see Table 12.38.

6.5 Voltage transformer supervision

The device supervises the VTs and VT wiring between the device terminals and the VTs. If there is a fuse in the voltage transformer circuitry, the blown fuse prevents or distorts the voltage measurement. Therefore, an alarm should be issued. Furthermore, in some applications, protection functions using voltage signals, should be blocked to avoid false tripping.

The VT supervisor function measures the three phase voltages and currents. The negative sequence voltage U_2 and the negative sequence current I_2 are calculated. If U_2 exceed the U_2> setting and at the same time, I_2 is less than the I_2< setting, the function will issue an alarm after the operation delay has elapsed.

Table 6.8: Setting parameters of VT supervisor VTSV ( )

Parameter	Value	Unit	Default	Description
U2>	0.0 – 200.0	% Un	34.6	Upper setting for VT supervisor
I2<	0.0 – 200.0	% In	100.0	Lower setting for VT supervisor
t>	0.02 – 600.0	s	0.10	Operation delay
VT on	On; Off	-	On	VT supervisor on event

Parameter	Value	Unit	Default	Description
VT off	On; Off	-	On	VT supervisor off event

Table 6.9: Measured and recorded values of VT supervisor VTSV ( )

	Parameter	Value	Unit	Description
Measured value	U2		% Un	Measured negative sequence voltage
	I2		% In	Measured negative sequence current
Recorded Values	Date		-	Date of VT supervision alarm
	Time		-	Time of VT supervision alarm
	U2		% Un	Recorded negative sequence voltage
	I2		% In	Recorded negative sequence current

For details of setting ranges, see Table 12.36.

6.6 System clock and synchronization

The internal clock of the relay is used to time stamp events and disturbance recordings.

The system clock should be externally synchronised to get comparable event time stamps for all the relays in the system.

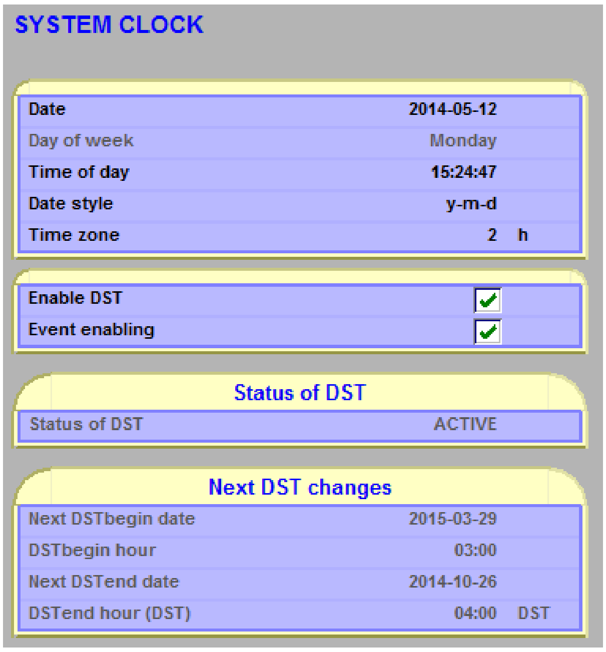
The synchronizing is based on the difference of the internal time and the synchronising message or pulse. This deviation is filtered and the internal time is corrected softly towards a zero deviation.

Time zone offsets

Time zone offset (or bias) can be provided to adjust the local time for IED. The Offset can be set as a Positive (+) or Negative (-) value within a range of -15.00 to +15.00 hours and a resolution of 0.01/h. Basically quarter hour resolution is enough.

Daylight saving time (DST)

IED provides automatic daylight saving adjustments when configured. A daylight savings time (summer time) adjustment can be configured separately and in addition to a time zone offset.

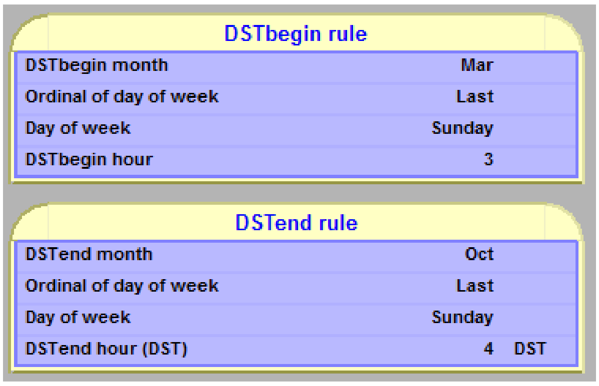


Daylight time standards vary widely throughout the world. Traditional daylight/summer time is configured as one (1) hour positive bias. The new US/Canada DST standard, adopted in the spring of 2007 is: one (1) hour positive bias, starting at 2:00am on the second Sunday in March, and ending at 2:00am on the first Sunday in November. In the European Union, daylight change times are defined relative to the UTC time of day instead of local time of day (as in U.S.) European customers, please carefully find out local country rules for DST.

The daylight saving rules for Finland are the IED defaults (24-hour clock):

- Daylight saving time start: Last Sunday of March at 03.00

- Daylight saving time end: Last Sunday of October at 04.00



To ensure proper hands-free year-around operation, automatic daylight time adjustments must be configured using the “Enable DST” and not with the time zone offset option.

Adapting auto adjust

During tens of hours of synchronizing the device will learn its average deviation and starts to make small corrections by itself. The target is that when the next synchronizing message is received, the deviation is already near zero. Parameters "AAIntv" and "AvDrft" will show the adapted correction time interval of this ±1 ms auto-adjust function.

Time drift correction without external sync

If any external synchronizing source is not available and the system clock has a known steady drift, it is possible to roughly correct the clock deviation by editing the parameters "AAIntv" and "AvDrft". The following equation can be used if the previous "AAIntv" value has been zero.

$$AAIntv = \frac{604.8}{DriftInOneWeek}$$

If the auto-adjust interval "AAIntv" has not been zero, but further trimming is still needed, the following equation can be used to calculate a new auto-adjust interval.

$$AAIntv_{NEW} = \frac{1}{\frac{1}{AAIntv_{PREVIOUS}} + \frac{DriftInOneWeek}{604.8}}$$

The term *DriftInOneWeek*/604.8 may be replaced with the relative drift multiplied by 1000, if some other period than one week has been used. For example if the drift has been 37 seconds in 14 days, the relative drift is 37*1000/(14*24*3600) = 0.0306 ms/s.

Example 1

If there has been no external sync and the relay's clock is leading sixty-one seconds a week and the parameter AAIntv has been zero, the parameters are set as

$$AvDrft = Lead$$

$$AAIntv = \frac{604.8}{61} = 9.9s$$

With these parameter values the system clock corrects itself with –1 ms every 9.9 seconds which equals –61.091 s/week.

Example 2

If there is no external sync and the relay's clock has been lagging five seconds in nine days and the AAIntv has been 9.9 s, leading, then the parameters are set as

$$AAIntv_{NEW} = \frac{1}{\frac{1}{9.9} - \frac{5000}{9 \cdot 24 \cdot 3600}} = 10.6$$

$$AvDrft = Lead$$

When the internal time is roughly correct – deviation is less than four seconds – any synchronizing or auto-adjust will never turn the clock backwards. Instead, in case the clock is leading, it is softly slowed down to maintain causality.

Table 6.10: System clock parameters

Parameter	Value	Unit	Description	Note
Date			Current date	Set
Time			Current time	Set
Style			Date format	Set
	y-d-m		Year-Month-Day	
	d.m.y		Day.Month.Year	
	m/d/y		Month/Day/Year	
SyncDI	-		DI not used for synchronizing	***)
	DI1, DI2		Minute pulse input	
TZone	-15.00 – +15.00 *)		UTC time zone for SNTP synchronization. Note: This is a decimal number. For example for state of Nepal the time zone 5:45 is given as 5.75	Set
DST	No; Yes		Daylight saving time for SNTP	Set
SySrc			Clock synchronisation source	
	Internal		No sync recognized since 200s	
	DI		Digital input	
	SNTP		Protocol sync	
	SpaBus		Protocol sync	
	ModBus		Protocol sync	
	ModBus TCP		Protocol sync	
	ProfibusDP		Protocol sync	
	IEC101		Protocol sync	
	IEC103		Protocol sync	
	DNP3		Protocol sync	
	IRIG-B003		IRIG timecode B003 ****)	
MsgCnt	0 – 65535, 0 – etc.		The number of received synchronisation messages or pulses	
Dev	±32767	ms	Latest time deviation between the system clock and the received synchronization	
SyOS	±10000.000	s	Synchronisation correction for any constant deviation in the synchronizing source	Set
AAIntv	±1000	s	Adapted auto adjust interval for 1 ms correction	Set**)
AvDrft	Lead; Lag		Adapted average clock drift sign	Set**)
FilDev	±125	ms	Filtered synchronisation deviation	

Set = An editable parameter (password needed).

*) A range of -11 h – +12 h would cover the whole Earth but because the International Date Line does not follow the 180° meridian, a more wide range is needed.

**) If external synchronization is used this parameter will be set automatically.

***) Set the DI delay to its minimum and the polarity such that the leading edge is the synchronizing edge.

****) Relay needs to be equipped with suitable hardware option module to receive IRIG-B clock synchronization signal. (Chapter 14 Order information).

Synchronisation with DI

Clock can be synchronized by reading minute pulses from digital inputs, virtual inputs or virtual outputs. Sync source is selected with **SyncDI** setting. When rising edge is detected from the selected input, system clock is adjusted to the nearest minute. Length of digital input pulse should be at least 50 ms. Delay of the selected digital input should be set to zero.

Synchronisation correction

If the sync source has a known offset delay, it can be compensated with **SyOS** setting. This is useful for compensating hardware delays or transfer delays of communication protocols. A positive value will compensate a lagging external sync and communication delays. A negative value will compensate any leading offset of the external synch source.

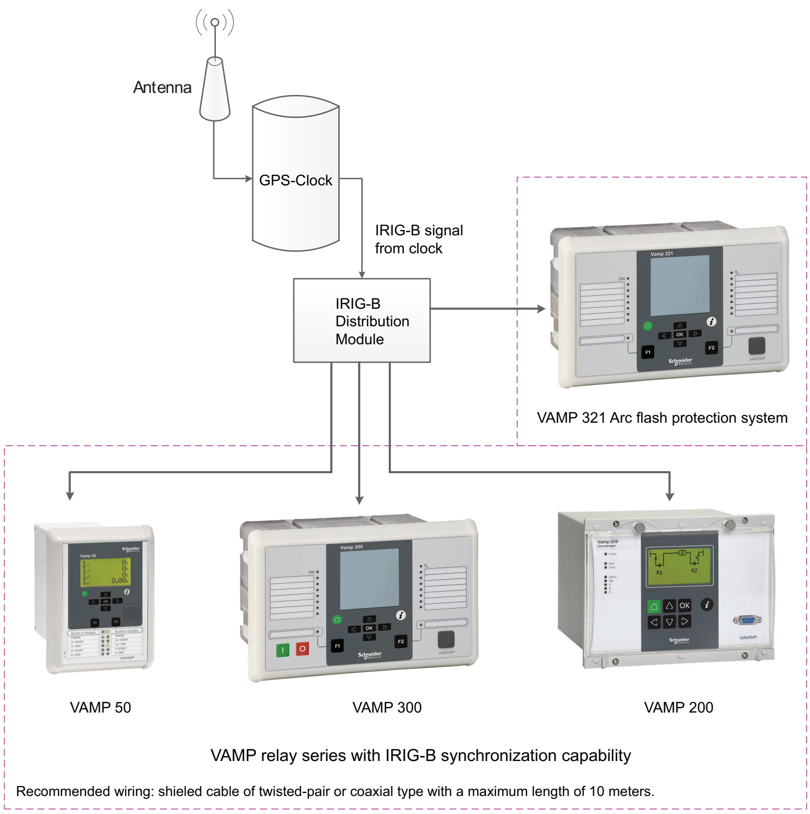
Sync source

When the device receives new sync message, the sync source display is updated. If no new sync messages are received within next 1.5 minutes, the device will change to internal sync mode.

Sync source: IRIG-B003

IRIG-B003 synchronization is supported with a dedicated communication option with either a two-pole or two pins in a D9 rear connector (See Chapter 14 Order information).

IRIG-B003 input clock signal voltage level is TLL. The input clock signal originated in the GPS receiver must be taken to multiple relays trough an IRIG-B distribution module. This module acts as a centralized unit for a point-to-multiple point connection. Note: Daisy chain connection of IRIG-B signal inputs in multiple relays must be avoided.



The recommended cable must be shielded and either of coaxial or twisted pair type. Its length should not exceed a maximum of 10 meters.

Deviation

The time deviation means how much system clock time differs from sync source time. Time deviation is calculated after receiving new sync message. The filtered deviation means how much the system clock was really adjusted. Filtering takes care of small deviation in sync messages.

Auto-lag/lead

The device synchronizes to the sync source, meaning it starts automatically leading or lagging to stay in perfect sync with the master. The learning process takes few days.

6.7 Self-supervision

The functions of the microcontroller and the associated circuitry, as well as the program execution are supervised by means of a separate watchdog circuit. Besides supervising the relay, the watchdog circuit attempts to restart the micro controller in an inoperable situation. If the micro controller does not resart, the watchdog issues a self-supervision signal indicating a permanent internal condition.

When the watchdog circuit detects a permanent fault, it always blocks any control of other output relays (except for the self-supervision output relay). In addition, the internal supply voltages are supervised. Should the auxiliary supply of the IED disappear, an indication is automatically given because the IED status inoperative (SF) output relay functions on a working current principle. This means that the SF relay is energized when the auxiliary supply is on and the arc flash protection is healthy.

6.7.1 Diagnostics

The device runs self-diagnostic tests for hardware and software in boot sequence and also performs runtime checking.

Permanent inoperative state

If permanent inoperative state has been detected, the device releases SF relay contact and status LED is set on. Local panel will also display a detected fault message. Permanet inoperative state is entered when the device is not able to handle main functions.

Temporal inoperative state

When self-diagnostic function detects a temporal inoperative state, Selfdiag matrix signal is set and an event (E56) is generated. In case the inoperative state was only temporary, an off event is generated (E57). Self diagnostic state can be reset via local HMI.

Diagnostic registers

There are four 16-bit diagnostic registers which are readable through remote protocols. The following table shows the meaning of each diagnostic register and their bits.

Register	Bit	Code	Description
SelfDiag1	0 (LSB)	T1	Potential output relay problem
	1	T2	
	2	T3	
	3	T4	
	4	A1	
SelfDiag3	0 (LSB)	DAC	Potential mA-output problem
	1	STACK	Potential stack problem
	2	MemChk	Potential memory problem
	3	BGTask	Potential background task timeout
	4	DI	Potential input problem (Remove DI1, DI2)
	5		
	6	Arc	Potential arc card problem
	7	SecPulse	Potential hardware problem
	8	RangeChk	DB: Setting outside range
	9	CPULoad	Overload
	10	+24V	Potential internal voltage problem
	11	-15V	
	12	ITemp	Internal temperature too high
	13	ADChk1	Potential A/D converter problem
	14	ADChk2	Potential A/D converter problem
	15 (MSB)	E2prom	Potential E2prom problem
SelfDiag4	1	ComBuff	Potential BUS: buffer problem
	2	OrderCode	Potential order code problem

The code is displayed in self diagnostic events and on the diagnostic menu on local panel and VAMPSET.

7 Measurement functions

All the direct measurements are based on fundamental frequency values. The exception is frequency. Most protection functions are also based on the fundamental frequency values.

The figure shows a current waveform and the corresponding fundamental frequency component f1, second harmonic f2 and rms value in a special case, when the current deviates significantly from a pure sine wave.

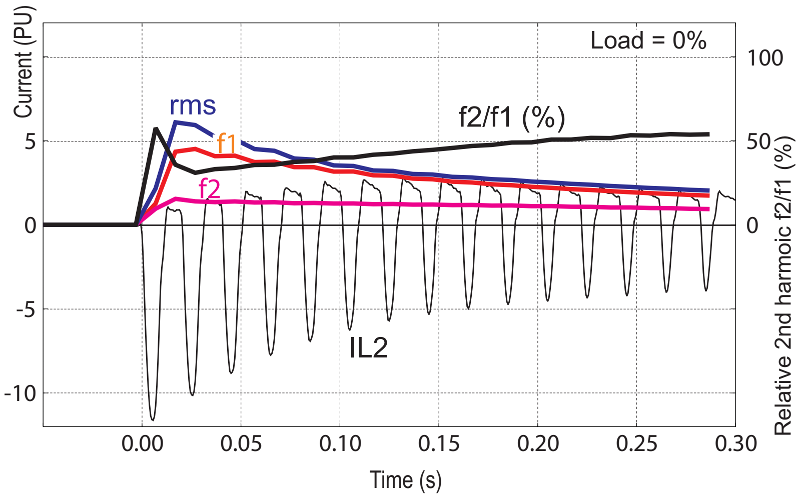


Figure 7.1: Example of various current values of a transformer inrush current

7.1 Measurement accuracy

Table 7.1: Frequency

Measuring range	16 Hz – 75 Hz
Inaccuracy	±10 mHz
The frequency is measured from current signals.	

Table 7.2: Voltage inputs U_A, U_B, U_C, U_D

Measuring range L- N	0 – 300 V (LL measurement 0 – 520 V)
Inaccuracy	0.5 % or 0.3 V
The usage of voltage inputs depends on the configuration parameter “voltage measurement mode”. For example, Ud is the zero sequence voltage input U_0 if the mode “3LL + U_0” is selected. The specified frequency range is 45 Hz – 65 Hz.	

7.2 Minimum and maximum values

Minimum and maximum values are registered with time stamps since the latest manual clearing or since the device has been restarted. The available registered min & max values are listed in the following table.

Min & Max measurement	Description
U12, U23, U31	Line-to-line voltage
Uo	Zero sequence voltage
f	Frequency

The clearing parameter "ClrMax" is common for all these values.

Table 7.3: Parameters

Parameter	Value	Description	Set
ClrMax	- Clear	Reset all minimum and maximum values	Set

Set = An editable parameter (password needed).

7.3 Voltage measurement modes

Depending on the application and available voltage transformers, the relay can be connected either to line-to-line voltages or phase-to-ground voltages. The configuration parameter "Voltage measurement mode" must be set according the used connection.

- “3LN+LLy/LNy”
  This mode is used with the synchrocheck function. See Table 5.18.
- “3LN+Uo”
  The device is connected to line-to-netural voltages U_{L1} - U_{L3} and to zero sequence voltage U_0. The phase-to-phase voltages are calculated. See Figure 11.8

The overvoltage protection is always based on the line-to-line voltage regardless of the measurement mode.

7.4 Symmetric components

In a three phase system, the voltage or current phasors may be divided in symmetric components according C. L. Fortescue (1918). The symmetric components are:

- Positive sequence 1
- Negative sequence 2
- Zero sequence 0

Symmetric components are calculated according the following equations:

$$\begin{bmatrix} \underline{S}_0 \\ \underline{S}_1 \\ \underline{S}_2 \end{bmatrix} = \frac{1}{3} \begin{bmatrix} 1 & 1 & 1 \\ 1 & \underline{a} & \underline{a}^2 \\ 1 & \underline{a}^2 & \underline{a} \end{bmatrix} \begin{bmatrix} \underline{U} \\ \underline{V} \\ \underline{W} \end{bmatrix}$$

$\underline{S}_0$ = zero sequence component

$\underline{S}_1$ = positive sequence component

$\underline{S}_2$ = negative sequence component

$\underline{a} = 1\angle 120° = -\frac{1}{2} + j\frac{\sqrt{3}}{2}$, a phasor rotating constant

$\underline{U}$ = phasor of phase L1 (phase current)

$\underline{V}$ = phasor of phase L2

$\underline{W}$ = phasor of phase L3

Example: two phase injection with adjustable phase angle

U_N = 100 V

Voltage measurement mode is "3LN".

Injection:

$U_A = U_{L1} = 100/\sqrt{3}$ V $\angle 0°$ = 57.7 V $\angle 0°$

$U_B = U_{L2} = 100/\sqrt{3}$ V $\angle$-120° = 57.7 V $\angle$-120°

$U_C = U_{L3}$ = 0 V

$$\begin{bmatrix} \underline{U}_0 \\ \underline{U}_1 \\ \underline{U}_2 \end{bmatrix} = \frac{1}{3} \begin{bmatrix} 1 & 1 & 1 \\ 1 & \underline{a} & \underline{a}^2 \\ 1 & \underline{a}^2 & \underline{a} \end{bmatrix} \begin{bmatrix} \frac{100}{\sqrt{3}} \angle 0° \\ \frac{100}{\sqrt{3}} \angle -120° \\ 0 \end{bmatrix} = \frac{1}{3\sqrt{3}} \begin{bmatrix} 100\angle 0° + 100\angle -120° \\ 100\angle 0° + 100\angle 0° \\ 100\angle 0° + 100\angle +120° \end{bmatrix} =$$

$$= \frac{1}{3\sqrt{3}} \begin{bmatrix} 100\angle -60° \\ 200\angle 0° \\ 100\angle 60° \end{bmatrix} = \begin{bmatrix} 19.2\angle -60° \\ 38.5\angle 0° \\ 19.2\angle +60° \end{bmatrix}$$

U_0 = 19.2 %

U_1 = 38.5 %

U_2 = 19.2 %

U_2/U_1 = 50 %

Figure 7.2 shows a graphical solution. The input values have been scaled with $\sqrt{3}$/100 to make the calculation easier.

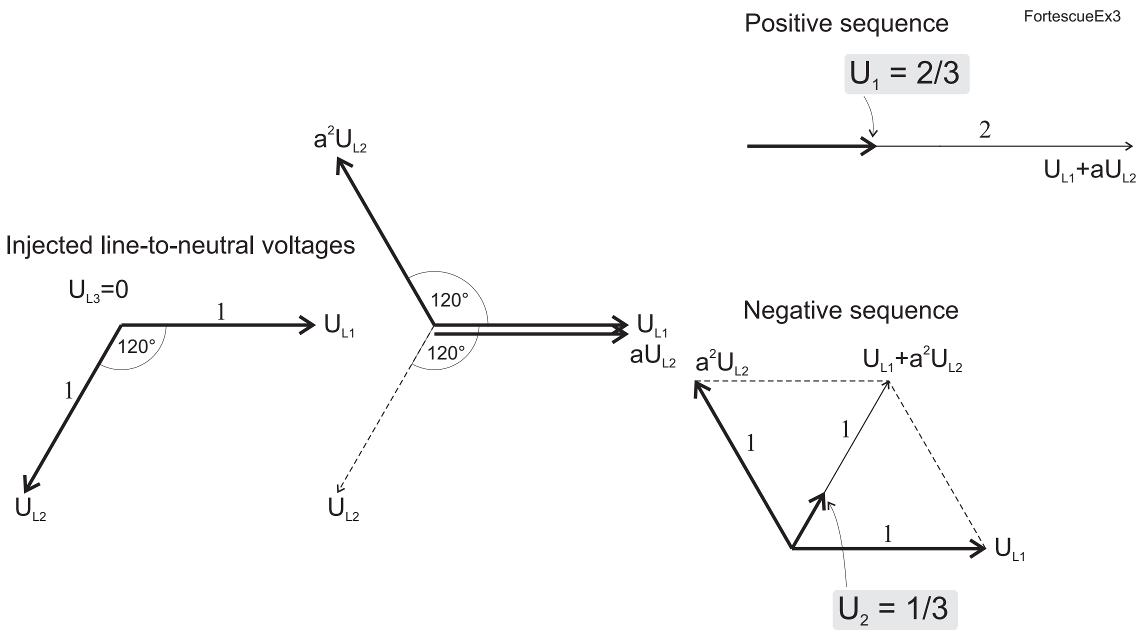


Figure 7.2: Example of symmetric component calculation using line-to-neutral voltages.

Unscaling the geometric results gives

U_1 = 100/$\sqrt{3}$ x 2/3 = 38.5 %

U_2 = 100/$\sqrt{3}$ x 1/3 = 19.2 %

U_2/U_1 = 1/3:2/3 = 50 %

7.5 Primary secondary and per unit scaling

Many measurement values are shown as primary values although the relay is connected to secondary signals. Some measurement values are shown as relative values - per unit or per cent. Almost all pick-up setting values are using relative scaling.

The scaling is done using the given VT. The following scaling equations are useful when doing secondary testing.

7.5.1 Voltage scaling

Primary/secondary scaling of line-to-line voltages

secondary → primary	$U_{PRI} = \sqrt{3} \cdot U_{SEC} \cdot \frac{VT_{PRI}}{VT_{SEC}}$
primary → secondary	$U_{SEC} = \frac{U_{PRI}}{\sqrt{3}} \cdot \frac{VT_{SEC}}{VT_{PRI}}$

Examples:

1. **Secondary to primary**

   VT = 12000 / 110

   Voltage connected to the device's input U_A or U_B is 100 V.

   Primary voltage is U_{PRI} = 100 x 12000 / 110 = 10909 V.

2. **Secondary to primary**

   VT = 12000 / 110

   Three phase symmetric voltages connected to the device's inputs U_A, U_B and U_C are 57.7 V.

   Primary voltage is U_{PRI} = $\sqrt{3}$ x 58 x 12000 / 110 = 10902 V

3. **Primary to secondary**

   VT = 12000 / 110

   The relay displays U_{PRI} = 10910 V.

   Secondary voltage is U_{SEC} = 10910 x 110 / 12000 = 100 V

4. **Primary to secondary**

   VT = 12000 / 110

   The relay displays $U_{12} = U_{23} = U_{31}$ = 10910 V.

   Symmetric secondary voltages at U_A, U_B and U_C are U_{SEC} = 10910 / $\sqrt{3}$ x 110 / 12000 = 57.7 V.

Per unit [pu] scaling of line-to-line voltages

One per unit = 1 pu = 1xU_N = 100 %, where U_N = rated voltage of the VT.

secondary → per unit	$U_{PU} = \sqrt{3} \cdot \frac{U_{SEC}}{VT_{SEC}} \cdot \frac{VT_{PRI}}{U_N}$
per unit → secondary	$U_{SEC} = U_{PU} \cdot \frac{VT_{SEC}}{\sqrt{3}} \cdot \frac{U_N}{VT_{PRI}}$

Examples:

1. **Secondary to per unit.**

   VT = 12000 / 110,

   Voltage connected to the device's input U_A or U_B is 110 V.

   Per unit voltage is U_{PU} = 110 / 110 = 1.00 pu = 1.00 x U_N = 100 %

2. **Secondary to per unit.**

   VT = 12000 / 110,

   Three symmetric phase-to-neutral voltages connected to the device's inputs U_A, U_B and U_C are 63.5 V

   Per unit voltage is U_{PU} = $\sqrt{3}$ x 63.5 / 110 x 12000 / 11000 = 1.00 pu = 1.00 x U_N = 100 %

3. **Per unit to secondary.**

   VT = 12000/110, U_N = 11000 V

   The relay displays 1.00 pu = 100 %.

   Secondary voltage is U_{SEC} = 1.00 x 110 x 11000 / 12000 = 100.8 V

4. **Per unit to secondary.**

   VT = 12000 / 110, U_N = 11000 V

   The relay displays 1.00 pu = 100 %.

   Three symmetric phase-to-neutral voltages connected to the device 's inputs U_A, U_B and U_C are

   U_{SEC} = 1.00 x 110 / $\sqrt{3}$ x 11000 / 12000 = 58.2 V

Per unit [pu] scaling of zero sequence voltage

secondary -> per unit	$U_{PU} = \frac{1}{VT_{SEC}} \cdot \frac{\left\| \overline{U}_a + \overline{U}_b + \overline{U}_c \right\|_{SEC}}{\sqrt{3}}$
per unit -> secondary	$\left\| \overline{U}_a + \overline{U}_b + \overline{U}_c \right\|_{SEC} = \sqrt{3} \cdot U_{PU} \cdot VT_{SEC}$

Examples:

1. **Secondary to per unit.**

   U_{0SEC} = 110 V (This is a configuration value corresponding to U_0 at full ground fault.)

   Voltage connected to the device's input U_C is 22 V.

   Per unit voltage is U_{PU} = 22 / 110 = 0.20 pu = 20 %

2. **Secondary to per unit.** .

   VT = 12000 / 110

   Voltage connected to the device's input U_A is 38.1 V, while

   $U_A = U_B = 0$.

   Per unit voltage is U_{PU} = (<u>38.1</u> + <u>0</u> + <u>0</u>) / ($\sqrt{3}$ x 110) = 0.20 pu = 20 %

3. **Per unit to secondary.**

   U_{0SEC} = 110 V (This is a configuration value corresponding to U_0 at full earth fault.)

   The device displays U_0 = 20 %.

   Secondary voltage at input U_C is U_{SEC} = 0.20 x 110 = 22 V

4. **Per unit to secondary.**

   VT = 12000/110

   The device displays U_0 = 20 %.

   If $U_B = U_C = 0$, then secondary voltages at U_A is U_{SEC} = $\sqrt{3}$ x 0.2 x 110 = 38.1 V

7.6 Analogue output (option)

A device with the mA option has one configurable analogue output. The resolution of the analogue output is 10 bits resulting current steps less than 25 µA. The output current range is configurable allowing e.g. the following ranges: 0 – 20 mA and 4 – 20 mA. More exotic ranges like 0 – 5 mA or 10 – 2 mA can be configured freely as long as the boundary values are within 0 – 20 mA.

Available couplings to the analog output:

- f
- U12, U23, U31
- UL1, UL2, UL3
- Uo

7.6.1 mA scaling example

Example of configuration of scaling the transducer (mA) output.

Example of mA scaling for Uline

Coupling = Uline

Scaled minimum = 0 V

Scaled maximum = 15000 V

Analogue output minimum value = 4 mA

Analogue output maximum value = 20 mA

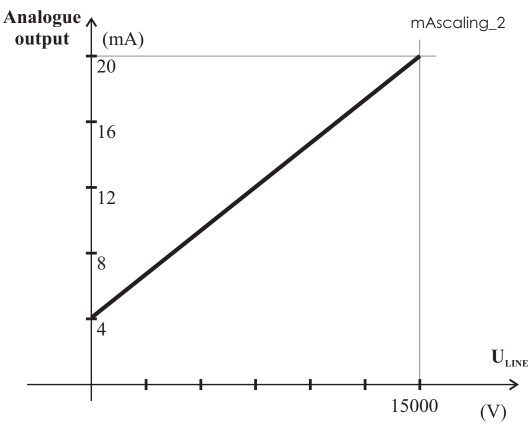


Figure 7.3: The average of the line-to-line voltages. At 0 V the transducer ouput is 4 mA, at 15000 V the output is 20 mA

8 Control functions

8.1 Output relays

The output relays are also called digital outputs. Any internal signal can be connected to the output relays using output matrix. An output relay can be configured as latched or non-latched. See Chapter 8.5 Output matrix for more details.

The difference between trip contacts and signal contacts is the DC breaking capacity. See Table 12.4 and Table 12.5 for details. The contacts are SPST normal open type (NO), except signal relay A1 which has change over contact (SPDT).

Table 8.1: Parameters of output relays

Parameter	Value	Unit	Description	Note
T1 – T4	0 1		Status of trip output relay	F
A1	0 1		Status of alarm output relay	F
SF	0 1		Status of the SF relay In VAMPSET, it is called as "Service status output"	F
Force	On Off		Force flag for output relay forcing for test purposes. This is a common flag for all output relays and detection stage status, too. Any forced relay(s) and this flag are automatically reset by a 5-minute timeout.	Set
REMOTE PULSES				
A1, T3, T4	0.00 – 99.98 or 99.99	s	Pulse length for direct output relay control via communications protocols. 99.99 s = Infinite. Release by writing "0" to the direct control parameter	Set
NAMES for OUTPUT RELAYS (editable with VAMPSET only)				
Description	String of max. 32 characters		Names for DO on VAMPSET screens. Default is "Trip relay n", n=1 – 4 or "Signal relay n", n=1	Set

F = Editable when force flag is on. Set = An editable parameter (password needed).

8.2 Digital inputs

There are two (2) digital inputs available for control purposes.

The polarity – normal open (NO) / normal closed (NC) – and a delay can be configured according the application. The signals are available for the output matrix, block matrix, user's programmable logic etc.

Selection in order code	Threshold voltage
1	24 V dc / 110 V ac
2	110 V dc / 220 V ac
3	220 V dc

The digital inputs need an external control voltage (ac or dc). The voltage nominal activation level can be selected in Chapter 14 Order information.

When 110 or 220 V ac voltage is used to activate the digital Inputs, the AC mode should be selected as shown in Figure 8.1

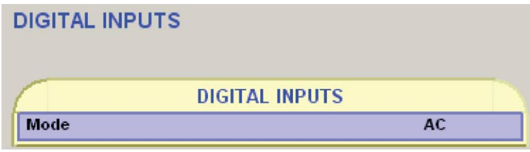


Figure 8.1: AC mode selection in VAMPSET

These inputs are ideal for transferring the status information of switching devices into the device.

Label and description texts can be edited with VAMPSET according the application. Labels are the short parameter names used on the local panel and descriptions are the longer names used by VAMPSET.

Table 8.2: Parameters of digital inputs

Parameter	Value	Unit	Description	Note
DI1, DI2	0; 1		Status of digital input	
DI COUNTERS				
DI1, DI2	0 – 65535		Cumulative active edge counter	(Set)
DELAYS FOR DIGITAL INPUTS				
DI1, DI2	0.00 – 60.00	s	Definite delay for both on and off transitions	Set
CONFIGURATION DI1 – DI6				
Inverted	no		For normal open contacts (NO). Active edge is 0 -> 1	Set
	yes		For normal closed contacts (NC). Active edge is 1 -> 0	
Indication display	no		No pop-up display	Set
	yes		Indication display is activated at active DI edge	
On event	On		Active edge event enabled	Set
	Off		Active edge event disabled	
Off event	On		Inactive edge event enabled	Set
	Off		Inactive edge event disabled	
NAMES for DIGITAL INPUTS (editable with VAMPSET only)				
Label	String of max. 10 characters		Short name for DIs on the local display. Default is "DIn", n = 1 – 2	Set
Description	String of max. 32 characters		Long name for DIs. Default is "Digital input n", n = 1 – 2	Set

Set = An editable parameter (password needed).

8.3 Virtual inputs and outputs

There are virtual inputs and virtual outputs, which can in many places be used like their hardware equivalents, execpt that they are only located in the memory of the device. The virtual inputs acts like normal digital inputs. The state of the virtual input can be changed from display, communication bus and from VAMPSET. For example setting groups can be changed using virtual inputs.

Table 8.3: Parameters of virtual inputs

Parameter	Value	Unit	Description	Note
VI1 – VI4	0; 1		Status of virtual input	
Events	On; Off		Event enabling	Set
NAMES for VIRTUAL INPUTS (editable with VAMPSET only)				
Label	String of max. 10 characters		Short name for VIs on the local display Default is "VIn", n = 1 – 4	Set
Description	String of max. 32 characters		Long name for VIs. Default is "Virtual input n", n = 1 – 4	Set

Set = An editable parameter (password needed).

The six virtual outputs do act like output relays, but there are no physical contacts. Virtual outputs are shown in the output matrix and the block matrix. Virtual outputs can be used with the user's programmable logic and to change the active setting group etc.

8.4 Function keys / F1 & F2

There are two independent function keys, F1 and F2, available in the device front panel. As default, these keys are programmed to toggle VI1 and VI2. It is possible to change F1 & F2 to toggle other VIs or to act as object control.

8.5 Output matrix

By means of the output matrix, the output signals of the various protection stages, digital inputs, logic outputs and other internal signals can be connected to the output relays, virtual outputs, etc.

There are eight general purpose LED indicators – "A", "B", "C", "D", "E", "F", "G" and "H" – available for customer-specific indications on the front panel.

Furthermore there are two LED indicators specified for keys F1 and F2. In addition, the triggering of the disturbance recorder (DR) and virtual outputs are configurable in the output matrix.

See an example in Figure 8.2.

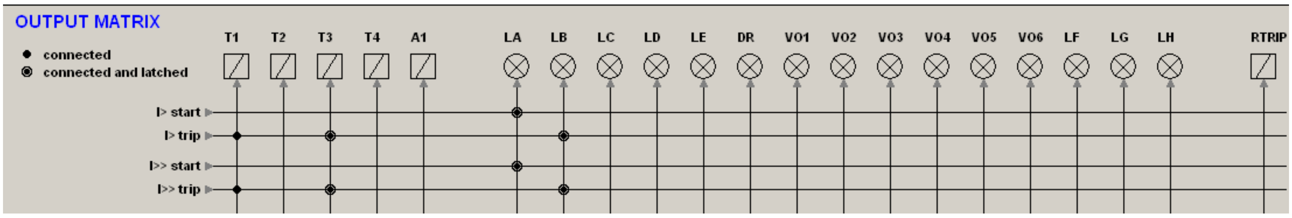


Figure 8.2: Output matrix

An output relay or indicator LED can be configured as latched or non-latched. A non-latched relay follows the controlling signal. A latched relay remains activated although the controlling signal releases.

“Auto LED release” function is designed to indicate only the latest event. When Auto LED release is enabled “old” latched LED’s will release latch when new event occurs. This way only the latest event LED’s are active. “ Auto LED release enable time” sets the time delay after the event deactivation latched LED is interpret as “old”. See an example in Figure 8.3.

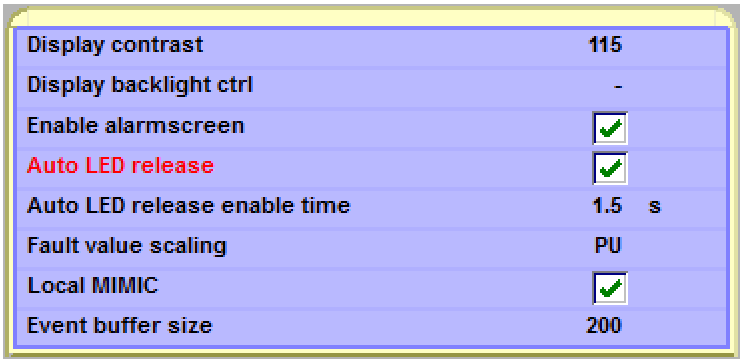


Figure 8.3: Local panel configuration menu

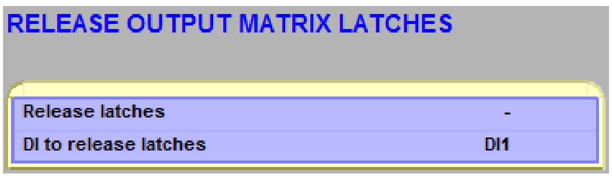


Figure 8.4: Release output matrix latches

There is a common "release all latches" signal to release all the latched relays. This release signal resets all the latched output relays and indicators with CPU and FPGA control. The reset signal can be given via a digital input, via HMI or through communication. The selection of the input is done with the VAMPSET software under the menu "Release output matrix latches". See an example in Figure 8.4.

NOTE: "Release all latches" signal clears and resets FPGA controlled latches.

8.6 Blocking matrix

By means of a blocking matrix, the operation of any protection stage can be blocked. The blocking signal can originate from the digital inputs DI1 to DI2, or it can be a start or trip signal from a protection stage or an output signal from the user's programmable logic. In the block matrix Figure 8.5 an active blocking is indicated with a black dot (•) in the crossing point of a blocking signal and the signal to be blocked.

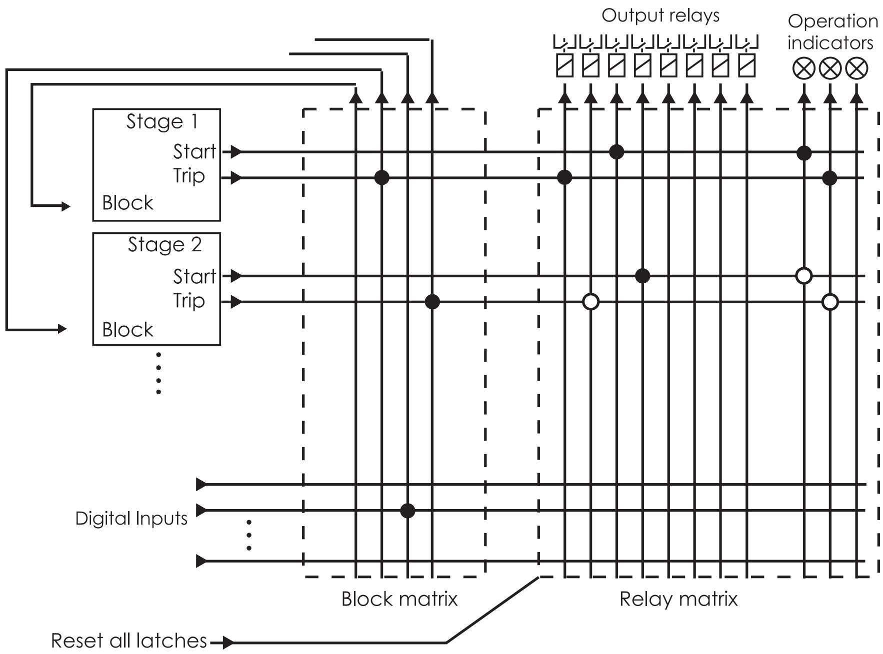


Figure 8.5: Blocking matrix and output matrix

8.7 Controllable objects

The object block matrix and logic functions can be used to configure interlocking for a safe controlling before the output pulse is issued. The objects 1 – 6 are controllable while the objects 7 – 8 are only able to show the status.

Controlling is possible by the following ways:

- through the local HMI
- through a remote communication
- through a digital input
- through the function key

The connection of an object to specific output relays is done via an output matrix (object 1 – 6 open output, object 1 – 6 close output). There is also an output signal "Object failed", which is activated if the control of an object is not completed.

Object states

Each object has the following states:

Setting	Value	Description
Object state	Undefined (00)	Actual state of the object
	Open	
	Close	
	Undefined (11)	

Basic settings for controllable objects

Each controllable object has the following settings:

Setting	Value	Description
DI for 'obj open'	None, any digital input, virtual input or virtual output	Open information
DI for 'obj close'		Close information
DI for 'obj ready'		Ready information
Max ctrl pulse length	0.02 – 600 s	Pulse length for open and close commands
Completion timeout	0.02 – 600 s	Timeout of ready indication
Object control	Open/Close	Direct object control

If changing states takes longer than the time defined by "Max ctrl pulse length" setting, object is inoperative and "Object failure" matrix signal is set. Also undefined-event is generated. "Completion timeout" is only used for the ready indication. If "DI for 'obj ready'" is not set, completion timeout has no meaning.

Each controllable object has 2 control signals in matrix:

Output signal	Description
Object x Open	Open control signal for the object
Object x Close	Close control signal for the object

These signals send control pulse when an object is controlled by digital input, remote bus, auto-reclose etc.

Settings for read-only objects

Setting	Value	Description
DI for ‘obj open’	None, any digital input, virtual input or virtual output	Open information
DI for ‘obj close’		Close information
Object timeout	0.02 – 600 s	Timeout for state changes

If changing states takes longer than the time defined by “Object timeout” setting, and “Object failure” matrix signal is set. Also undefined-event is generated.

8.7.1 Controlling with DI

Objects can be controlled with digital input, virtual input or virtual output. There are four settings for each controllable object:

Setting	Active
DI for remote open / close control	In remote state
DI for local open / close control	In local state

If the device is in local control state, the remote control inputs are ignored and vice versa. Object is controlled when a rising edge is detected from the selected input. Length of digital input pulse should be at least 60 ms.

8.7.2 Local/Remote selection

In Local mode, the output relays can be controlled via a local HMI, but they cannot be controlled via a remote serial communication interface.

In Remote mode, the output relays cannot be controlled via a local HMI, but they can be controlled via a remote serial communication interface.

The selection of the Local/Remote mode is done by using a local HMI, or via one selectable digital input. The digital input is normally used to change a whole station to a local or remote mode. The selection of the L/R digital input is done in the “Objects” menu of the VAMPSET software.

NOTE: A password is not required for a remote control operation.

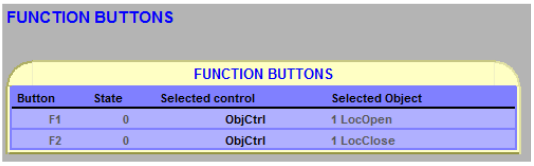
8.7.3 Controlling with F1 & F2

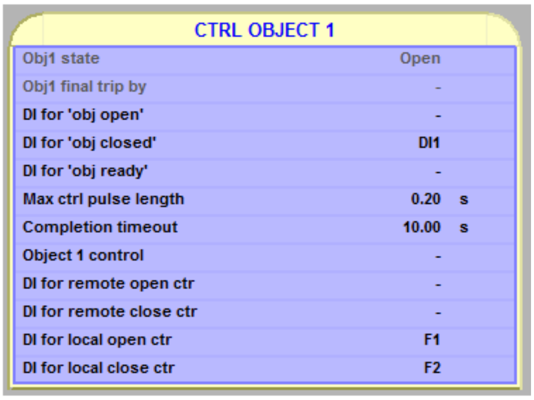
Objects can be controlled with F1 & F2.

As default these keys are programmed to toggle F1 and F2. It is possible to configure F1 & F2 to toggle VI1 – VI4 or act as object control. Selection of the F1 and F2 function is made with the VAMPSET software under the FUNCTION BUTTONS menu.

Table 8.4: Parameters of F1, F2

Parameter	Value	Unit	Description	Set
F1 – F2 VI1 – VI4	0		Function key toggles Virtual input 1 – 4 and Function button 1 – 2 between on (1) and off (0)	Set
ObjCtrl PrgFncs	1		When Object conrol in chosen F1 and F2 can be linked in OBJECTS to desired objects close/open command.	





Selected object and control is shown in VAMPSET software under the menu ”FUNCTION BUTTONS”. If no object with local control is selected ’-’ is shown. If multiple local controls are selected for one key ’?’ is shown.

8.8 Logic functions

The device supports customer-defined programmable logic for signals. The logic is designed by using the VAMPSET setting tool and downloaded to the device. Functions available are:

- AND
- OR
- XOR
- NOT
- COUNTERs
- RS & D flip-flops

Logic is made with VAMPSET setting tool. Consumed memory is dynamically shown on the configuration view in percentage. The first value indicates amount of used inputs, second amount of gates and third values shows amount of outputs consumed.

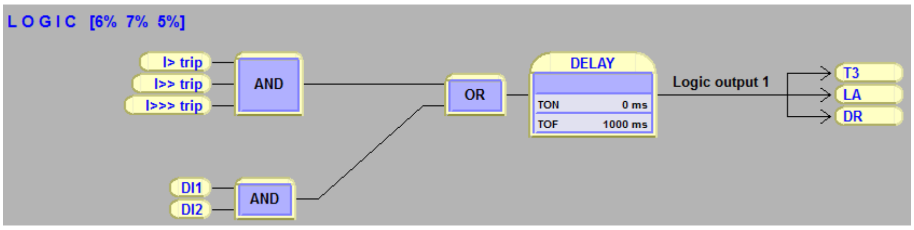


Figure 8.6: Logic can be found and modified in “logic” menu in VAMPSET setting tool

Percentages show used memory amount.

Inputs/Logical functions/Outputs- used. None of these is not allowed to exceed 100%. See guide below to learn basics of logic creation:

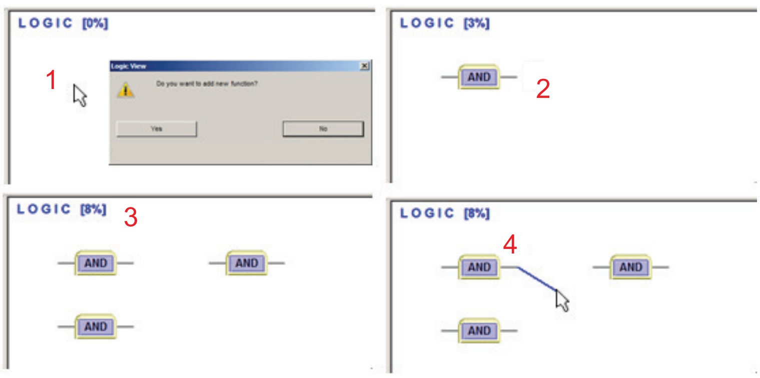


Figure 8.7: How to create logical nodes.

1. Press empty area to add a logic gate, confirm new function by pressing “Yes”.
2. Logic function is always "AND" -gate as a default.
3. While logic increases the capacity is increasing as well.
4. To joint logic functions, go on top of the output line of gate and hold down mouse left -> make the connection to other logic functions input.

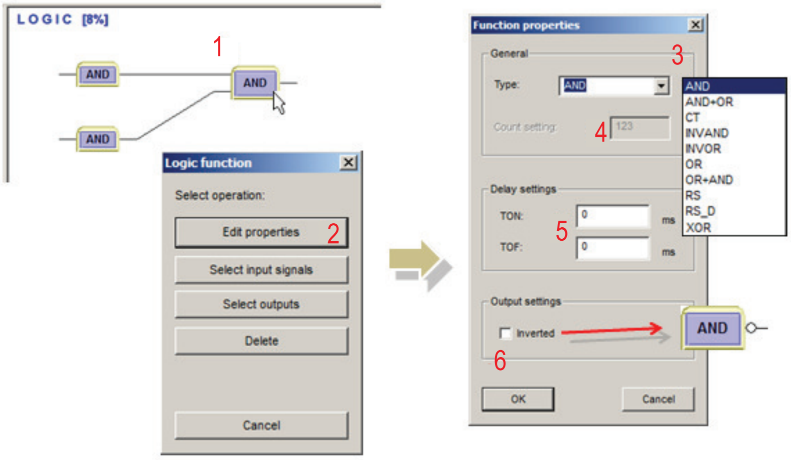


Figure 8.8: Logic creation

1. Left click on top of any logic function to activate the “Select operation” view.
2. Edit properties button opens the “Function properties” window.
3. Generally it is possible to choose the type of logic function between and/or/counter/swing -gate.
4. When counter is selected, count setting may be set here.
5. Separate delay setting for logic activation and dis-activation.
6. Possible to invert the output of logic. Inverted logic output is marked with circle.

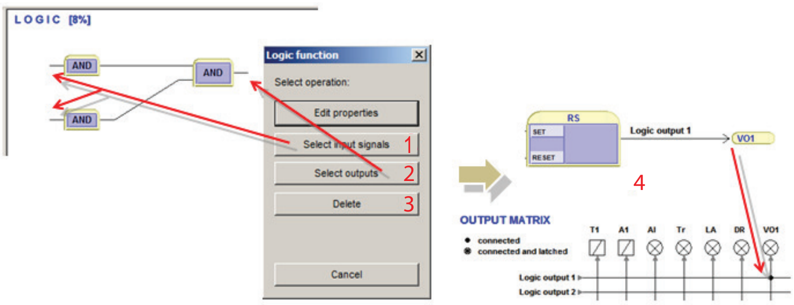


Figure 8.9: Logic creation

1. Select input signals can be done by pressing the following button or by clicking mouse left on top of the logic input line.
2. Select outputs can be done by pressing the following button or by clicking mouse left on top of the logic output line.
3. This deletes the logic function.
4. When logic is created and settings are written to the IED the unit requires a restart. After restarting the logic output is automatically assigned in output matrix as well.

NOTE: Whenever writing new logic to the IED the unit has to be restarted.

9 Communication and protocols

9.1 Communication ports

The relay has one communication port. See Figure 9.1.

There is also one optional communication module slot in the rear panel.

CommunicationPorts50

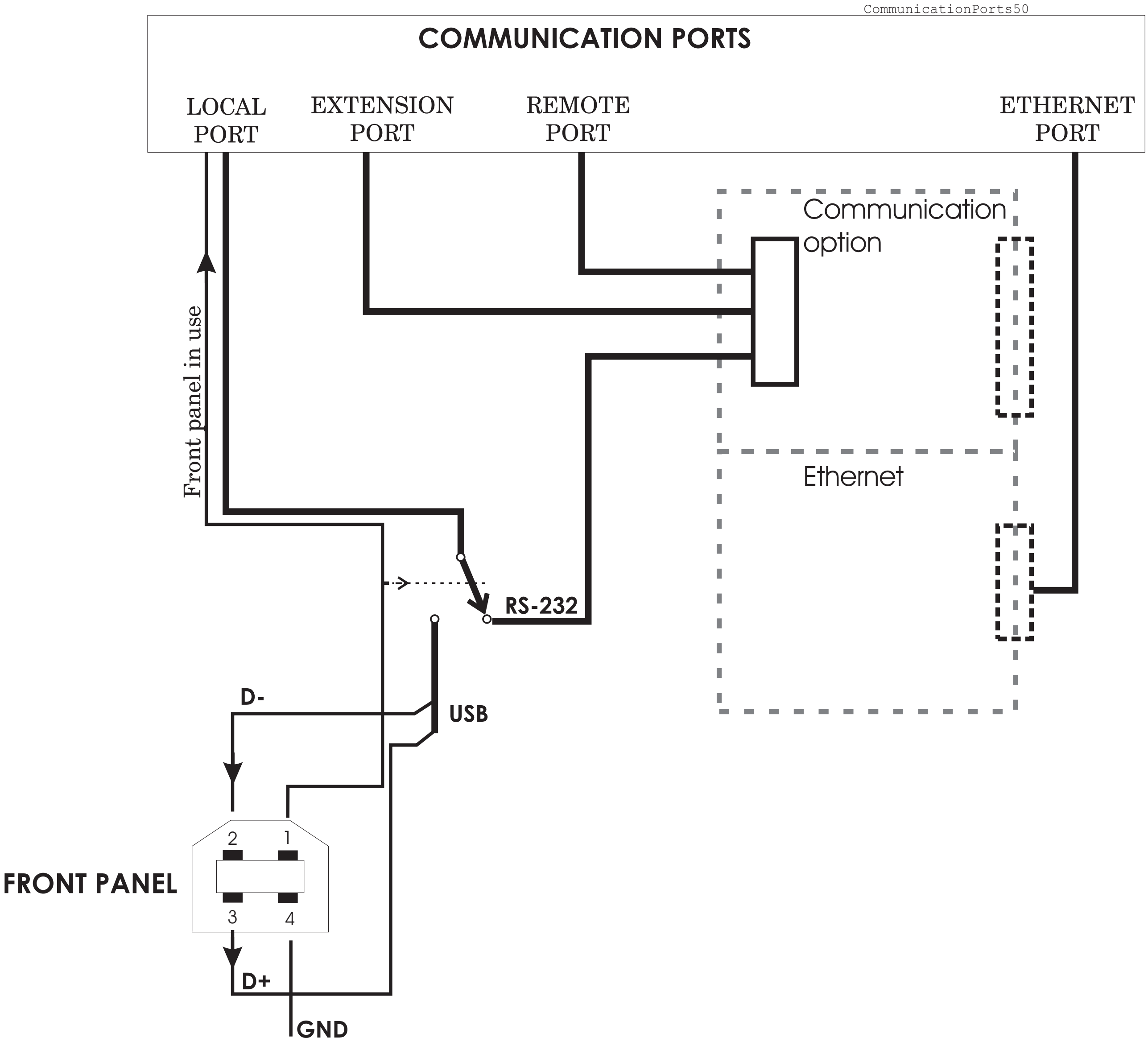


Figure 9.1: Communication ports and connectors. The DSR signal from the front panel port selects the active connector for the RS232 local port.

9.1.1 Local port (Front panel)

The relay has a USB-connector in the front panel

Protocol for the USB port

The front panel USB port is always using the command line protocol for VAMPSET regardless of the selected protocol for the rear panel local port.

If other than “None” protocol is selected for the rear panel local port, the front panel connector, when activated, is still using the plain command line interface with the original speed, parity etc. For example if the rear panel local port is used for remote VAMPSET communication using SPA-bus default 9600/7E1, it is possible to temporarily connect a PC with VAMPSET to the front panel connector.

Connecting a cable between the PC and the relay will create a virtual com-port. The default settings for the relay are 38400/8N1. The communication parameter display on the local display will show the active parameter values for the local port.

Physical interface

The physical interface of this port is USB.

Table 9.1: Parameters

Parameter	Value	Unit	Description	Note
Protocol			Protocol selection for the rear panel local port.	Set
	None		Command line interface for VAMPSET	
	SpaBus		SPA-bus (slave)	
	ProfibusDP		Profibus DB (slave)	
	ModbusSla		Modbus RTU slave	
	ModbusTCPs		Modbus TCP slave	
	IEC-103		IEC-60870-5-103 (slave)	
	ExternalIO		Modbus RTU master for external I/O-modules	
	DNP3		DNP 3.0	
Msg#	$0 – 2^{32}-1$		Message counter since the device has restarted or since last clearing	Clr
Errors	$0 – 2^{16}-1$		Protocol errors since the device has restarted or since last clearing	Clr
Tout	$0 – 2^{16}-1$		Timeout errors since the device has restarted or since last clearing	Clr
	speed/DPS Default = 38400/8N1 for VAMPSET		Display of actual communication parameters. Speed = bit/s D = number of data bits P = parity: none, even, odd S = number of stop bits	1)
VAMPSET communication (Direct or SPA-bus embedded command line interface)				
Tx	bytes/size		Unsent bytes in transmitter buffer/size of the buffer	
Msg#	$0 – 2^{32}-1$		Message counter since the device has restarted or since last clearing	Clr
Errors	$0 – 2^{16}-1$		Errors since the device has restarted or since last clearing	Clr
Tout	$0 – 2^{16}-1$		Timeout errors since the device has restarted or since last clearing	Clr

Set = An editable parameter (password needed). Clr = Clearing to zero is possible.

1) The communication parameters are set in the protocol specific menus. For the local port command line interface the parameters are set in configuration menu.

9.1.2 Remote port

Table 9.2: Parameters

Parameter	Value	Unit	Description	Note
Protocol			Protocol selection for remote port	Set
	None		-	
	SPA-bus		SPA-bus slave	
	ProfibusDP		Profibus DB slave	
	ModbusSla		Modbus RTU slave	
	ModbusTCPs		Modbus TCP slave	
	IEC-103		IEC-60870-5-103 slave	
	ExternalIO		Modbus RTU master for external I/O-modules	
	DNP3		DNP 3.0	
Msg#	$0 – 2^{32}-1$		Message counter since the device has restarted or since last clearing	Clr
Errors	$0 – 2^{16}-1$		Protocol errors since the device has restarted or since last clearing	Clr
Tout	$0 – 2^{16}-1$		Timeout errors since the device has restarted or since last clearing	Clr
			Display of current communication parameters.	1)
	speed/DPS		Speed = bit/s D = number of data bits P = parity: none, even, odd S = number of stop bits	
Debug			Echo to local port	Set
	No		No echo	
	Binary		For binary protocols	
	ASCII		For SPA-bus protocol	

Set = An editable parameter (password needed). Clr = Clearing to zero is possible.

1) The communication parameters are set in the protocol specific menus. For the local port command line interface the parameters are set in configuration menu.

9.1.3 Extension port

Table 9.3: Parameters

Parameter	Value	Unit	Description	Note
Protocol			Protocol selection for extension port	Set
	None		Command line interface for VAMPSET	
	SPA-bus		SPA-bus slave	
	ProfibusDP		Profibus DB slave	
	ModbusSla		Modbus RTU slave	
	ModbusTCPs		Modbus TCP slave	
	IEC-103		IEC-60870-5-103 slave	
	ExternalIO		Modbus RTU master for external I/O-modules	
	DNP3		DNP 3.0	
Msg#	$0 – 2^{32}-1$		Message counter since the device has restarted or since last clearing	Clr
Errors	$0 – 2^{16}-1$		Protocol errors since the device has restarted or since last clearing	Clr
Tout	$0 – 2^{16}-1$		Timeout errors since the device has restarted or since last clearing	Clr
	speed/DPS Default = 38400/8N1 for VAMPSET		Display of current communication parameters. Speed = bit/s D = number of data bits P = parity: none, even, odd S = number of stop bits	1)

Set = An editable parameter (password needed). Clr = Clearing to zero is possible.

1) The communication parameters are set in the protocol specific menus. For the local port command line interface the parameters are set in configuration menu.

9.1.4 Ethernet port

TCP port 1st INST and TCP port 2nd INST are ports for ethernet communication protocols. Ethernet communication protocols can be selected to these ports when such hardware option is installed. The parameters for these ports are set via local HMI or with VAMPSET in menus TCP port 1st INST and TCP port 2nd INST. Two different protocols can be used simultaneously on one physical interface (both protocols use the same IP address and MAC address but different IP port).

Protocol configuration menu contains address and other related information for the ethernet port. TCP port 1st and 2nd instance include selection for the protocol, IP port settings and message/error/timeout counters. More information about the protocol configuration menu on table below.

Table 9.4: Main configuration parameters (local display), inbuilt Ethernet port

Parameter	Value	Unit	Description	Note
Protocol			Protocol selection for the extension port	Set
	None		Command line interface for VAMPSET	
	ModbusTCPs		Modbus TCP slave	
	IEC-101		IEC-101	
	IEC 61850		IEC-61850 protocol	
	EtherNet/IP		Ethernet/IP protocol	
	DNP3		DNP/TCP	
Port	nnn		Ip port for protocol, default 102	Set
IpAddr	n.n.n.n		Internet protocol address (set with VAMPSET)	Set
NetMsk	n.n.n.n		Net mask (set with VAMPSET)	Set
Gatew	default = 0.0.0.0		Gateway IP address (set with VAMPSET)	Set
NTPSvr	n.n.n.n		Network time protocol server (set with VAMPSET) 0.0.0.0 = no SNTP	Set
KeepAlive	nn		TCP keepalive interval	Set 1)
FTP server	on/off		Enable FTP server	Set
FTP speed	4 Kb/s (default)		Maximum transmission speed for FTP	Set
FTP password	? (user) config (configurator)		FTP password	Set
MAC address	001ADnnnnnnn		MAC address	
VS Port	nn 23 (default)		IP port for Vampset	Set
Msg#	nnn		Message counter	
Errors	nnn		Error counter	
Tout	nnn		Timeout counter	
EthSffEn	on/off		Sniffer port enable	Set
SniffPort	Port2		Sniffer port	

Set = An editable parameter (password needed)

1) KeepAlive: The KeepAlive parameter sets in seconds the time between two keepalive packets are sent from the IED. The setting range for this parameter is between zero (0) and 20 seconds; with the exception that zero (0) means actually 120 seconds (2 minutes). A keep alive's packet purpose is for the VAMP IED to send a probe packet to a connected client for checking the status of the TCP-connection when no other packet is being sent e.g. client does not poll data from the IED. If the keepalive packet is not acknowledged, the IED will close the TCP connection. Connection must be resumed on the client side.

Table 9.5: TCP PORT 1st INST

Parameter	Value	Unit	Description	Note
Protocol			Protocol selection for the extension port.	Set
	None		Command line interface for VAMPSET	
	ModbusTCPs		Modbus TCP slave	
	IEC 61850		IEC-61850 protocol	
	EtherNet/IP		Ethernet/IP protocol	
	DNP3		DNP/TCP	
Port	nnn		Ip port for protocol, default 502	Set
Msg#	nnn		Message counter	
Errors	nnn		Error counter	
Tout	nnn		Timeout counter	

Table 9.6: CP PORT 2nd INST

Parameter	Value	Unit	Description	Note
Ethernet port protocol			Protocol selection for the extension port.	Set
(TCP PORT 2nd INST)	None		Command line interface for VAMPSET	
	ModbusTCPs		Modbus TCP slave	
	IEC 61850		IEC-61850 protocol	
	EtherNet/IP		Ethernet/IP protocol	
	DNP3		DNP/TCP	
Port	nnn		Ip port for protocol, default 502	Set
Msg#	nnn		Message counter	
Errors	nnn		Error counter	
Tout	nnn		Timeout counter	

Set = An editable parameter (password needed).

9.2 Communication protocols

The protocols enable the transfer of the following type of data:

- events
- status information
- measurements
- control commands.
- clock synchronizing
- Settings (SPA-bus and embedded SPA-bus only)

9.2.1 PC communication

PC communication is using a VAMP specified command line interface. The VAMPSET program can communicate using the local USB-port or using optional Ethernet interface.

It is also possible to select SPA-bus protocol for the local port and configure the VAMPSET to embed the command line interface inside SPA-bus messages.

For Ethernet configuration, see Chapter 9.1.4 Ethernet port.

9.2.2 Modbus TCP and Modbus RTU

These Modbus protocols are often used in power plants and in industrial applications. The difference between these two protocols is the media. Modbus TCP uses Ethernet and Modbus RTU uses asynchronous communication (RS-485, optic fibre, RS-232).

VAMPSET will show the list of all available data items for Modbus.

The Modbus communication is activated usually for remote port via a menu selection with parameter "Protocol". See Figure 9.1.

For Ethernet interface configuration, see Chapter 9.1.4 Ethernet port.

Table 9.7: Parameters

Parameter	Value	Unit	Description	Note
Addr	1 – 247		Modbus address for the device. Broadcast address 0 can be used for clock synchronizing. Modbus TCP uses also the TCP port settings.	Set
bit/s	1200 2400 4800 9600 19200	bps	Communication speed for Modbus RTU	Set
Parity	None Even Odd		Parity for Modbus RTU	Set

Set = An editable parameter (password needed)

9.2.3 Profibus DP

The Profibus DP protocol is widely used in industry. For the protocol to be used in the VAMP50-series, an internal optioncard or VPA 3CG external communication module is required.

Device profile "continuous mode"

In this mode, the device is sending a configured set of data parameters continuously to the Profibus DP master. The benefit of this mode is the speed and easy access to the data in the Profibus master. The drawback is the maximum buffer size of 128 bytes, which limits the number of data items transferred to the master. Some PLCs have their own limitation for the Profibus buffer size, which may further limit the number of transferred data items.

Device profile "Request mode"

Using the request mode it is possible to read all the available data from the VAMP device and still use only a very short buffer for Profibus data transfer. The drawback is the slower overall speed of the data transfer and the need of increased data processing at the Profibus master as every data item must be separately requested by the master.

NOTE: In request mode, it is not possible to read continuously only one single data item. At least two different data items must be read in turn to get updated data from the device.

There is a separate manual for VPA 3CG (VVPA3CG/EN M/xxxx) for the continuous mode and request mode. The manual is available to download from our website.

Available data

VAMPSET will show the list of all available data items for both modes. A separate document “Profibus parameters.pdf” is also available.

The Profibus DP communication is activated usually for remote port via a menu selection with parameter "Protocol". See Chapter 9.1 Communication ports.

Table 9.8: Parameters

Parameter	Value	Unit	Description	Note
Mode			Profile selection	Set
	Cont		Continuous mode	
	Reqst		Request mode	
bit/s	2400	bps	Communication speed from the main CPU to the Profibus converter. (The actual Profibus bit rate is automatically set by the Profibus master and can be up to 12 Mbit/s.)	
Emode			Event numbering style.	(Set)
	Channel		Use this for new installations.	
	(Limit60) (NoLimit)		(The other modes are for compatibility with old systems.)	
InBuf		bytes	Size of Profibus master's Rx buffer. (data to the master)	1. 3.
OutBuf		bytes	Size of Profibus master's Tx buffer. (data from the master)	2. 3.
Addr	1 – 247		This address has to be unique within the Profibus network system.	Set
Conv			Forcing flag for converter selection	4. 5. 8.
	VE		"VE" converter	
	HMS		"HMS" converter	
Conv			Recognized converter type	6. 7. 8.
	-		“-” Converter not found	
	VE		“VE” converter found	
	HMS		“HMS” converter found	

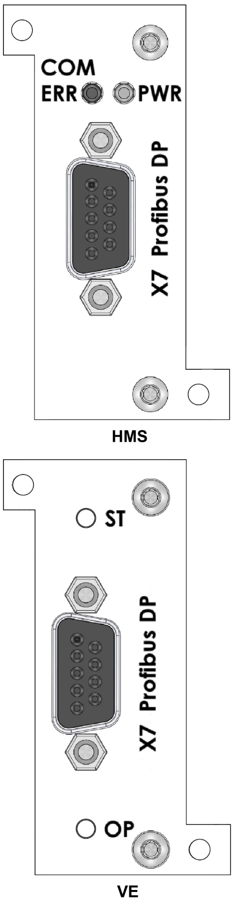


Figure 9.2: Profibus option-card profiles for VAMP50-Series

Set = An editable parameter (password needed)

Clr = Clearing to zero is possible

1. In continuous mode the size depends of the biggest configured data offset of a data item to be send to the master. In request mode the size is 8 bytes.
2. In continuous mode the size depends of the biggest configured data offset of a data to be read from the master. In request mode the size is 8 bytes.
3. When configuring the Profibus master system, the lengths of these buffers are needed. The device calculates the lengths according the Profibus data and profile configuration and the values define the in/out module to be configured for the Profibus master.
4. Forcing flag for converter-type recognition. Typically, this flag is set at the factory; users are only required to use this flag when either a new internal option-card or VPA external communication module are installed.
   - If an internal option-card option card is used, the possible converter types are HMS and VE.
   - If the VPA external communication module is used, the only possible converter type is VE.
5. Internal option-card with “VE” converter is supported from software version 10.115 and later.
6. If the converter type has as value "−" (converter not found), the possible reasons are:
   - The wrong forcing flag was used for converter recognition
   - There is a communication problem between the main CPU and the Profibus ASIC.
7. Each converter type requires an specific gsd-file for installation, for an VE converter, the gsd-file named VPA_00F7.gsd is needed whereas for the HMS converter, the HMS_1002.gsd is required. These files are available from the website.
8. Users can recognize which of the converters is available in the delivered internal option-card by observing the profile of the card’s back plate.

9.2.4 SPA-bus

The device has full support for the SPA-bus protocol including reading and writing the setting values. Also reading of multiple consecutive status data bits, measurement values or setting values with one message is supported.

Several simultaneous instances of this protocol, using different physical ports, are possible, but the events can be read by one single instance only.

There is a separate document “Spabus parameters.pdf” of SPA-bus data items available.

Table 9.9: Parameters

Parameter	Value	Unit	Description	Note
Addr	1 – 899		SPA-bus address. Must be unique in the system.	Set
bit/s	1200 2400 4800 9600 (default) 19200	bps	Communication speed	Set
Emode			Event numbering style.	(Set)
	Channel		Use this for new installations.	
	(Limit60) (NoLimit)		(The other modes are for compatibility with old systems.)	

Set = An editable parameter (password needed)

9.2.5 IEC 60870-5-103

The IEC standard 60870-5-103 "*Companion standard for the informative interface of protection equipment*" provides standardized communication interface to a primary system (master system).

The unbalanced transmission mode of the protocol is used, and the device functions as a secondary station (slave) in the communication. Data is transferred to the primary system using "data acquisition by polling"-principl

The IEC functionality includes application functions:

- station initialization
- general interrogation
- clock synchronization and
- command transmission.

It is not possible to transfer parameter data or disturbance recordings via the IEC 103 protocol interface.

The following ASDU (Application Service Data Unit) types will be used in communication from the device:

- ASDU 1: time tagged message
- ASDU 3: Measurands I
- ASDU 5: Identification message
- ASDU 6: Time synchronization and
- ASDU 8: Termination of general interrogation.

The device will accept:

- ASDU 6: Time synchronization
- ASDU 7: Initiation of general interrogation and
- ASDU 20: General command.

The data in a message frame is identified by:

- type identification
- function type and
- information number.

These are fixed for data items in the compatible range of the protocol, for example, the trip of I> function is identified by: type identification = 1, function type = 160 and information number = 90. "Private range" function types are used for such data items, which are not defined by the standard (e.g. the status of the digital inputs and the control of the objects).

The function type and information number used in private range messages is configurable. This enables flexible interfacing to different master systems.

For more information on IEC 60870-5-103 in VAMP devices refer to the "IEC103 Interoperability List" document.

Table 9.10: Parameters

Parameter	Value	Unit	Description	Note
Addr	1 – 254		An unique address within the system	Set
bit/s	9600 19200	bps	Communication speed	Set
MeasInt	200 – 10000	ms	Minimum measurement response interval	Set
SyncRe	Sync Sync+Proc Msg Msg+Proc		ASDU6 response time mode	Set

Set = An editable parameter (password needed)

Table 9.11: Parameters for disturbance record reading

Parameter	Value	Unit	Description	Note
ASDU23	On Off		Enable record info message	Set
Smpls/msg	1 – 25		Record samples in one message	Set
Timeout	10 – 10000	s	Record reading timeout	Set
Fault			Fault identifier number for IEC-103. Starts + trips of all stages.	
TagPos			Position of read pointer	
Chn			Active channel	
ChnPos			Channel read position	
Fault numbering				
Faults			Total number of faults	
GridFlts			Fault burst identifier number	
Grid			Time window to classify faults together to the same burst.	Set

Set = An editable parameter (password needed)

9.2.6 DNP 3.0

The relay supports communication using DNP 3.0 protocol. The following DNP 3.0 data types are supported:

- binary input
- binary input change
- double-bit input
- binary output
- analog input
- counters

Additional information can be obtained from the “DNP 3.0 Device Profile Document” and “DNP 3.0 Parameters.pdf”. DNP 3.0 communication is activated via menu selection. RS-485 interface is often used but also RS-232 and fibre optic interfaces are possible.

Table 9.12: Parameters

Parameter	Value	Unit	Description	Set
bit/s	4800 9600 (default) 19200 38400	bps	Communication speed	Set
Parity	None (default) Even Odd		Parity	Set
SlvAddr	1 – 65519		An unique address for the device within the system	Set
MstrAddr	1 – 65519 255 = default		Address of master	Set
LLTout	0 – 65535	ms	Link layer confirmation timeout	Set
LLRetry	1 – 255 1 = default		Link layer retry count	Set
APLTout	0 – 65535 5000 = default	ms	Application layer confirmation timeout	Set
CnfMode	EvOnly (default); All		Application layer confirmation mode	Set
DBISup	No (default); Yes		Double-bit input support	Set
SyncMode	0 – 65535	s	Clock synchronization request interval. 0 = only at boot	Set

Set = An editable parameter (password needed)

9.2.7 IEC 60870-5-101

The IEC 60870-5-101 standard is derived from the IEC 60870-5 protocol standard definition. In VAMP devices, IEC 60870-5-101 communication protocol is available via menu selection. The VAMP unit works as a controlled outstation (slave) unit in unbalanced mode.

Supported application functions include process data transmission, event transmission, command transmission, general interrogation, clock synchronization, transmission of integrated totals, and acquisition of transmission delay.

For more information on IEC 60870-5-101 in VAMP devices, refer to the “IEC 101 Profile checklist & datalist.pdf” document.

Table 9.13: Parameters

Parameter	Value	Unit	Description	Note
bit/s	1200 2400 4800 9600	bps	Bitrate used for serial communication.	Set
Parity	None Even Odd		Parity used for serial communication	Set
LLAddr	1 – 65534		Link layer address	Set
LLAddrSize	1 – 2	Bytes	Size of Link layer address	Set
ALAddr	1 – 65534		ASDU address	Set
ALAddrSize	1 – 2	Bytes	Size of ASDU address	Set
IOAddrSize	2 – 3	Bytes	Information object address size. (3-octet addresses are created from 2-octet addresses by adding MSB with value 0.)	Set
COTsize	1	Bytes	Cause of transmission size	
TTFormat	Short Full		The parameter determines time tag format: 3-octet time tag or 7-octet time tag.	Set
MeasFormat	Scaled Normalized		The parameter determines measurement data format: normalized value or scaled value.	Set
DbandEna	No Yes		Dead-band calculation enable flag	Set
DbandCy	100 – 10000	ms	Dead-band calculation interval	Set

Set = An editable parameter (password needed)

9.2.8 External I/O (Modbus RTU master)

External Modbus I/O devices can be connected to the relay using this protocol. (See Chapter 11.6.1 Third-party external input / output modules module for more information).

9.2.9 IEC 61850

IEC 61850 protocol is available with the optional communication module. IEC 61850 protocol can be used to read / write static data from the relay to receive events and to receive / send GOOSE messages to other relays.

IEC 61850 server interface is capable of

- Configurable data model: selection of logical nodes corresponding to active application functions
- Configurable pre-defined data sets
- Supported dynamic data sets created by clients
- Supported reporting function with buffered and unbuffered Report Control Blocks
- Sending analogue values over GOOSE
- Supported control modes:
  - direct with normal security
  - direct with enhanced security
  - select before operation with normal security
  - select before operation with enhanced security
- Supported horizontal communication with GOOSE: configurable GOOSE publisher data sets, configurable filters for GOOSE subscriber inputs, GOOSE inputs available in the application logic matrix

Additional information can be obtained from the separate documents “IEC 61850 conformance statement.pdf”, “IEC 61850 Protocol data.pdf” and “Configuration of IEC 61850 interface.pdf”.

9.2.10 EtherNet/IP

The device supports communication using EtherNet/IP protocol which is a part of CIP (Common Industrial Protocol) family. EtherNet/IP protocol is available with the optional inbuilt Ethernet port. The protocol can be used to read / write data from the device using request / response communication or via cyclic messages transporting data assigned to assemblies (sets of data).

For more detailed information and parameter lists for EtherNet/IP, refer to a separate application note “Application Note EtherNet/IP.pdf”.

For the complete data model of EtherNet/IP, refer to the document “Application Note DeviceNet and EtherNetIP Data Model.pdf”.

9.2.11 FTP server

The FTP server is available on VAMP IEDs equipped with an inbuilt or optional Ethernet card.

The server enables downloading of the following files from an IED:

- Disturbance recordings.
- The MasterICD and MasterICDEd2 files.

The MasterICD and MasterICDEd2 files are VAMP-specific reference files that can be used for offline IEC61850 configuration.

The inbuilt FTP client in Microsoft Windows or any other compatible FTP client may be used to download files from the device.

Parameter	Value	Unit	Description	Note
Enable FTP server	Yes No		Enable or disable the FTP server.	Set
FTP password	Max 33 characters		Required to access the FTP server with an FTP client. Default is “config”. The user name is always “vamp”.	Set
FTP max speed	1 – 10	KB/s	The maximum speed at which the FTP server will transfer data.	Set

9.2.12 DeviceNet

The device supports communication using DeviceNet protocol which is a part of CIP (Common Industrial Protocol) family. DeviceNet protocol is available with the optional external VSE009 module. The protocol can be used to read / write data from the device using request / response communication or via cyclic messages transporting data assigned to assemblies (sets of data).

For more detailed information about DeviceNet, refer to a separate application note “Application Note DeviceNet.pdf”.

For the complete data model of DeviceNet, refer to the document “Application Note DeviceNet and EtherNetIP Data Model.pdf”.

10 Application

The following chapters illustrate the functions of the voltage and frequency protection relays in different protection applications.

The device can be used for protection in distribution systems, on transformers and for generators. Additionally it can be used for sychrocheck or fast load shedding (e.g. loss of mains).

The relays provide circuit-breaker control functionality, additional primary switching devices (earthing switches and disconnector switches) can also be controlled from the relay HMI or the control or SCADA/automation system. Programmable logic functionality is also implemented in the relay for various applications e.g interlockings schemes. For details about the functionality in the relays, see Table 1.1.

10.1 Trip circuit supervision

Trip circuit supervision is used to ensure that the wiring from the protective device to a circuit-breaker is in order. This circuit is unused most of the time, but when a protection device detects a fault in the network, it is too late to notice that the circuit-breaker cannot be tripped because of a broken trip circuitry.

Also the closing circuit can be supervised, using the same principle.

10.1.1 Trip circuit supervision with one digital input

The benefits of this scheme is that only one digital inputs is needed and no extra wiring from the relay to the circuit breaker (CB) is needed. Also supervising a 24 Vdc trip circuit is possible.

The drawback is that an external resistor is needed to supervise the trip circuit on both CB positions. If supervising during the closed position only is enough, the resistor is not needed.

- The digital input is connected parallel with the trip contacts (Figure 10.1).
- The digital input is configured as Normal Closed (NC).
- The digital input delay is configured longer than maximum fault time to inhibit any superfluous trip circuit fault alarm when the trip contact is closed.
- The digital input is connected to a relay in the output matrix giving out any trip circuit alarm.
- The trip relay should be configured as non-latched. Otherwise, a superfluous trip circuit fault alarm will follow after the trip contact operates, and the relay remains closed because of latching.
- By utilizing an auxiliary contact of the CB for the external resistor, also the auxiliary contact in the trip circuit can be supervised.

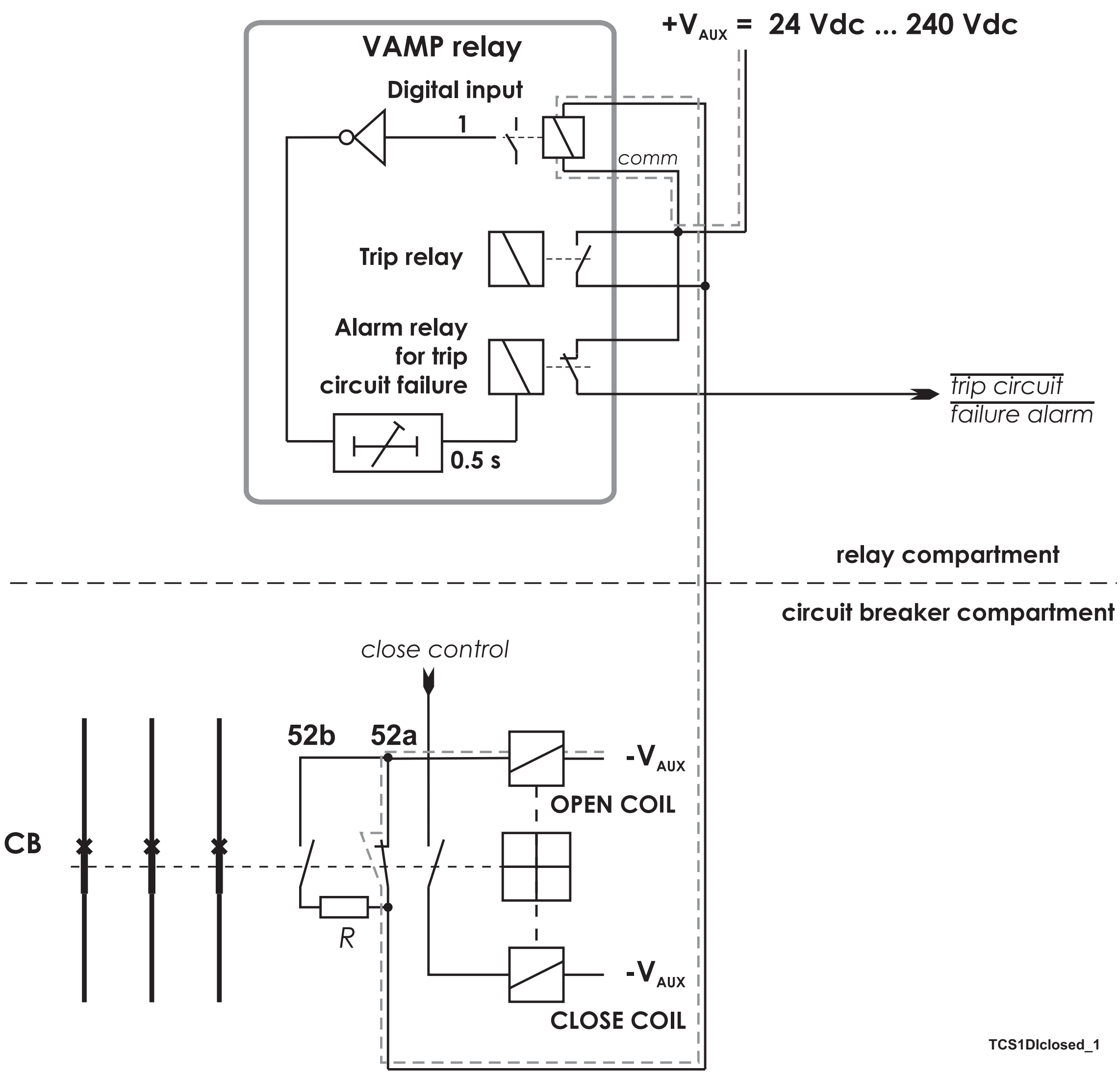


Figure 10.1: Trip circuit supervision using a single digital input and an external resistor R. The circuit-breaker is in the closed position. The supervised circuitry in this CB position is double-lined. The digital input is in active state when the trip circuit is complete.

NOTE: The need for the external resistor R depends on the application and circuit breaker manufacturer's specifications.

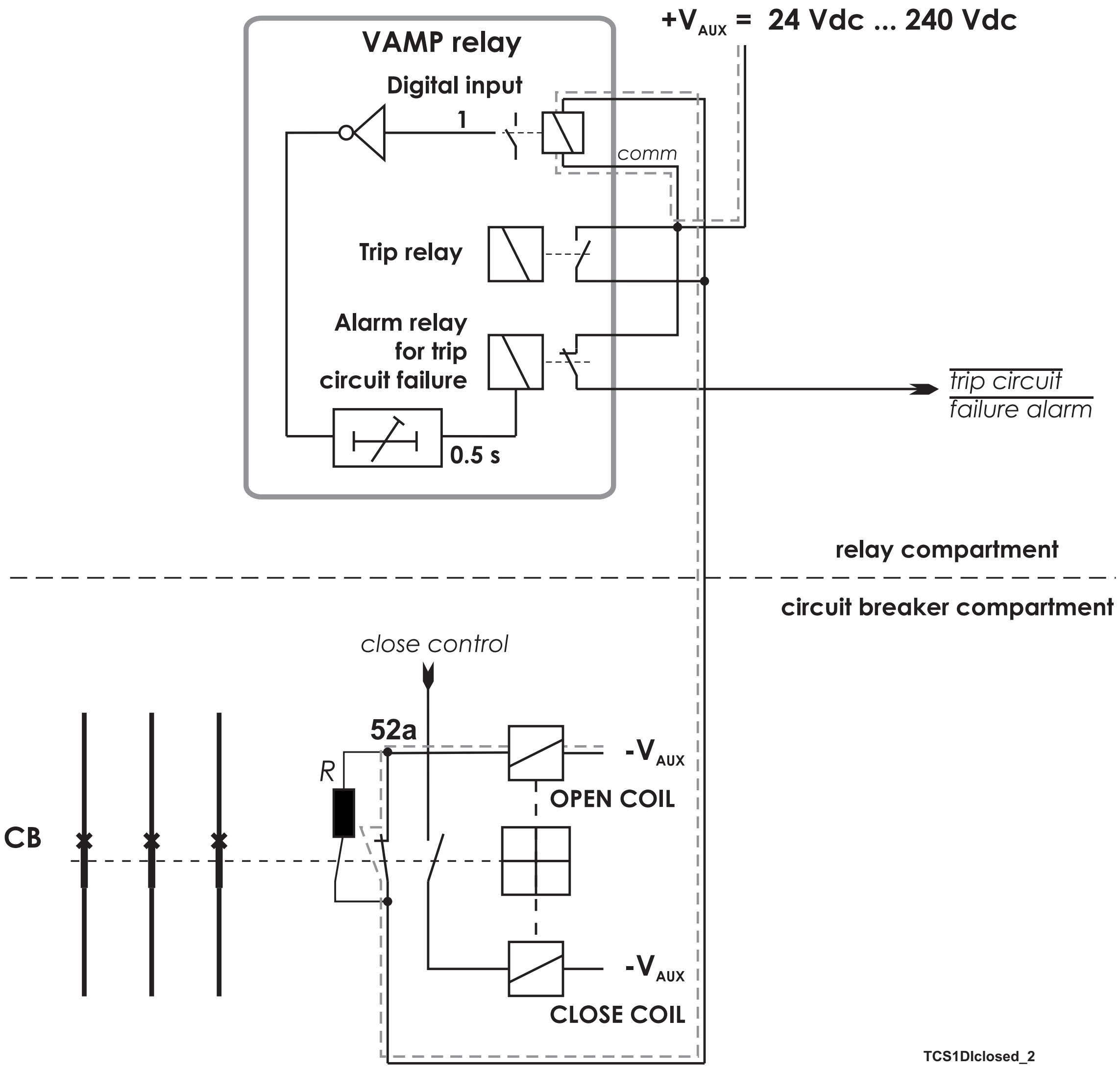


Figure 10.2: Alternative connection without using circuit breaker 52b auxiliary contacts. Trip circuit supervision using a single digital input and an external resistor R. The circuit-breaker is in the closed position. The supervised circuitry in this CB position is double-lined. The digital input is in active state when the trip circuit is complete.

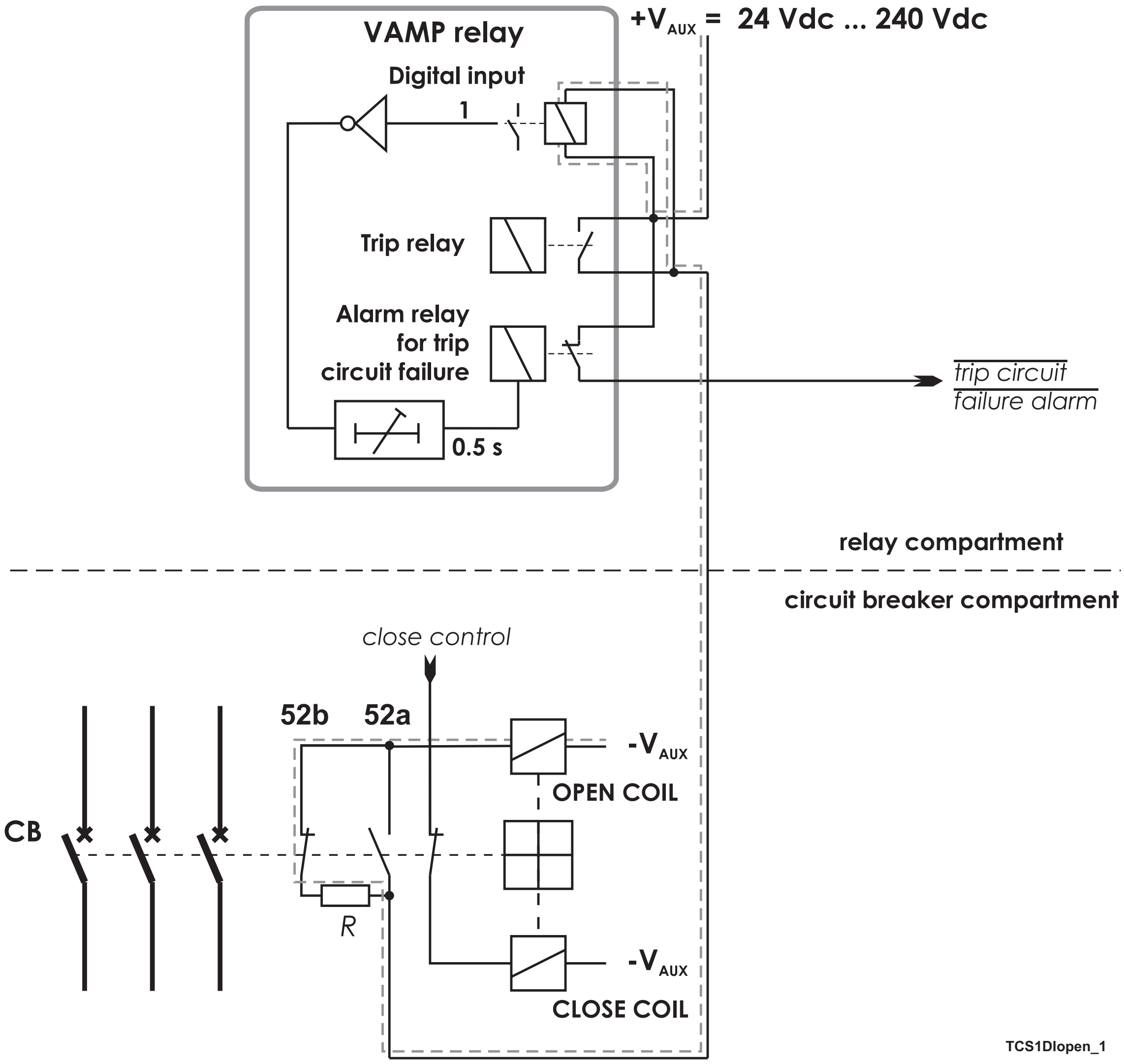


Figure 10.3: Trip circuit supervision using a single digital input, when the circuit breaker is in open position.

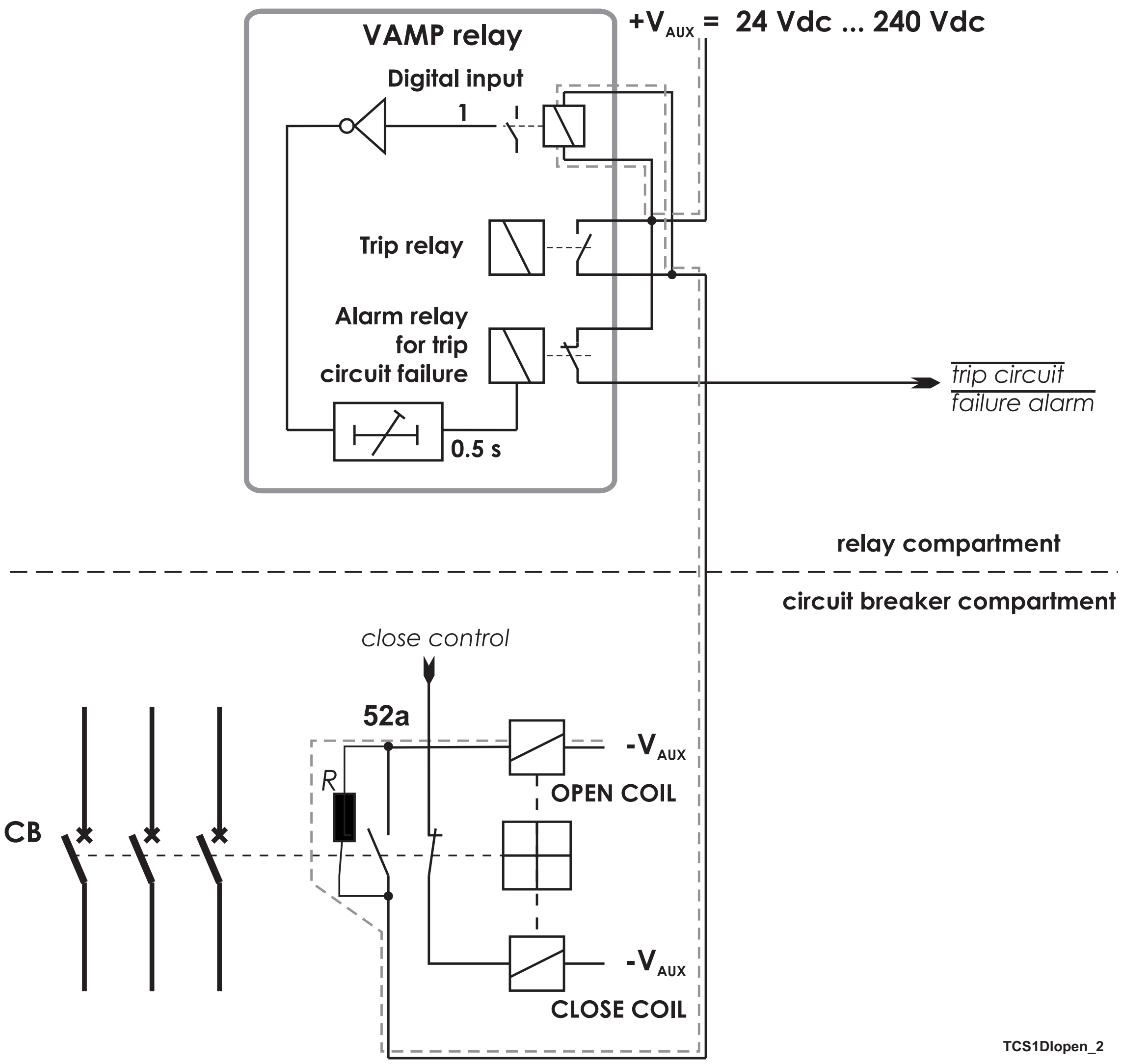
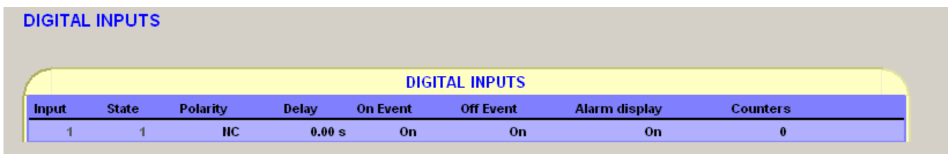


Figure 10.4: Alternative connection without using circuit breaker 52b auxiliary contacts. Trip circuit supervision using a single digital input, when the circuit breaker is in open position.



DIGITAL INPUTS

DIGITAL INPUTS

Input	State	Polarity	Delay	On Event	Off Event	Alarm display	Counters
1	1	NC	0.00 s	On	On	On	0

Figure 10.5: An example of digital input DI1 configuration for trip circuit supervision with one digital input.

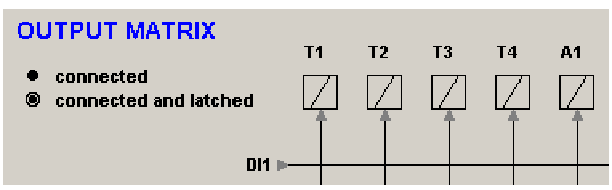


Figure 10.6: An example of output matrix configuration for trip circuit supervision with one digital input.

Example of dimensioning the external resistor R:

U_{AUX} =	110 Vdc - 20 % + 10%, Auxiliary voltage with tolerance
U_{DI} =	18 Vdc, Threshold voltage of the digital input
I_{DI} =	3 mA, Typical current needed to activate the digital input including a 1 mA safety margin.
P_{COIL} =	50 W, Rated power of the open coil of the circuit breaker. If this value is not known, 0 Ω can be used for the R_{COIL}.
U_{MIN} =	U_{AUX} - 20 % = 88 V
U_{MAX} =	U_{AUX} + 10 % = 121 V
R_{COIL} =	U^2_{AUX} / P_{COIL} = 242 Ω.

The external resistance value is calculated using Equation 10.1.

Equation 10.1:

$$R = \frac{U_{MIN} - U_{DI} - I_{DI} \cdot R_{Coil}}{I_{DI}}$$

R = (88 – 18 – 0.003 x 242)/0.003 = 23.1 kΩ

(In practice the coil resistance has no effect.)

By selecting the next smaller standard size we get **22 kΩ**.

The power rating for the external resistor is estimated using Equation 10.2 and Equation 10.3. The Equation 10.2 is for the CB open situation including a 100 % safety margin to limit the maximum temperature of the resistor.

Equation 10.2:

$$P = 2 \cdot I_{DI}^2 \cdot R$$

P = 2 x 0.003^2 x 22000 = 0.40 W

Select the next bigger standard size, for example **0.5 W**.

When the trip contacts are still closed and the CB is already open, the resistor has to withstand much higher power (Equation 10.3) for this short time.

Equation 10.3:

$$P = \frac{U_{MAX}^2}{R}$$

P = 121^2 / 22000 = 0.67 W

A 0.5 W resistor will be enough for this short time peak power, too. However, if the trip relay is closed for longer time than a few seconds, a 1 W resistor should be used.

10.1.2 Trip circuit supervision with two digital inputs

The benefits of this scheme is that no external resistor is needed.

The drawbacks are, that two digital inputs from two separate groups are needed and two extra wires from the relay to the CB compartment is needed. Additionally the minimum allowed auxiliary voltage is 48 Vdc, which is more than twice the threshold voltage of the dry digital input, because when the CB is in open position, the two digital inputs are in series.

- The first digital input is connected parallel with the auxiliary contact of the open coil of the circuit breaker.
- Another auxiliary contact is connected in series with the circuitry of the first digital input. This makes it possible to supervise also the auxiliary contact in the trip circuit.
- The second digital input is connected in parallel with the trip contacts.
- Both inputs are configured as normal closed (NC).
- The user’s programmable logic is used to combine the digital input signals with an AND port. The delay is configured longer than maximum fault time to inhibit any superfluous trip circuit fault alarm when the trip contact is closed.
- The output from the logic is connected to a relay in the output matrix giving out any trip circuit alarm.
- Both digital inputs must have their own common potential. Using the other digital inputs in the same group as the upper DI in the Figure 10.7 is not possible in most applications. Using the other digital inputs in the same group as the lower DI in the Figure 10.7 is limited, because the whole group will be tied to the auxiliary voltage V_{AUX}.

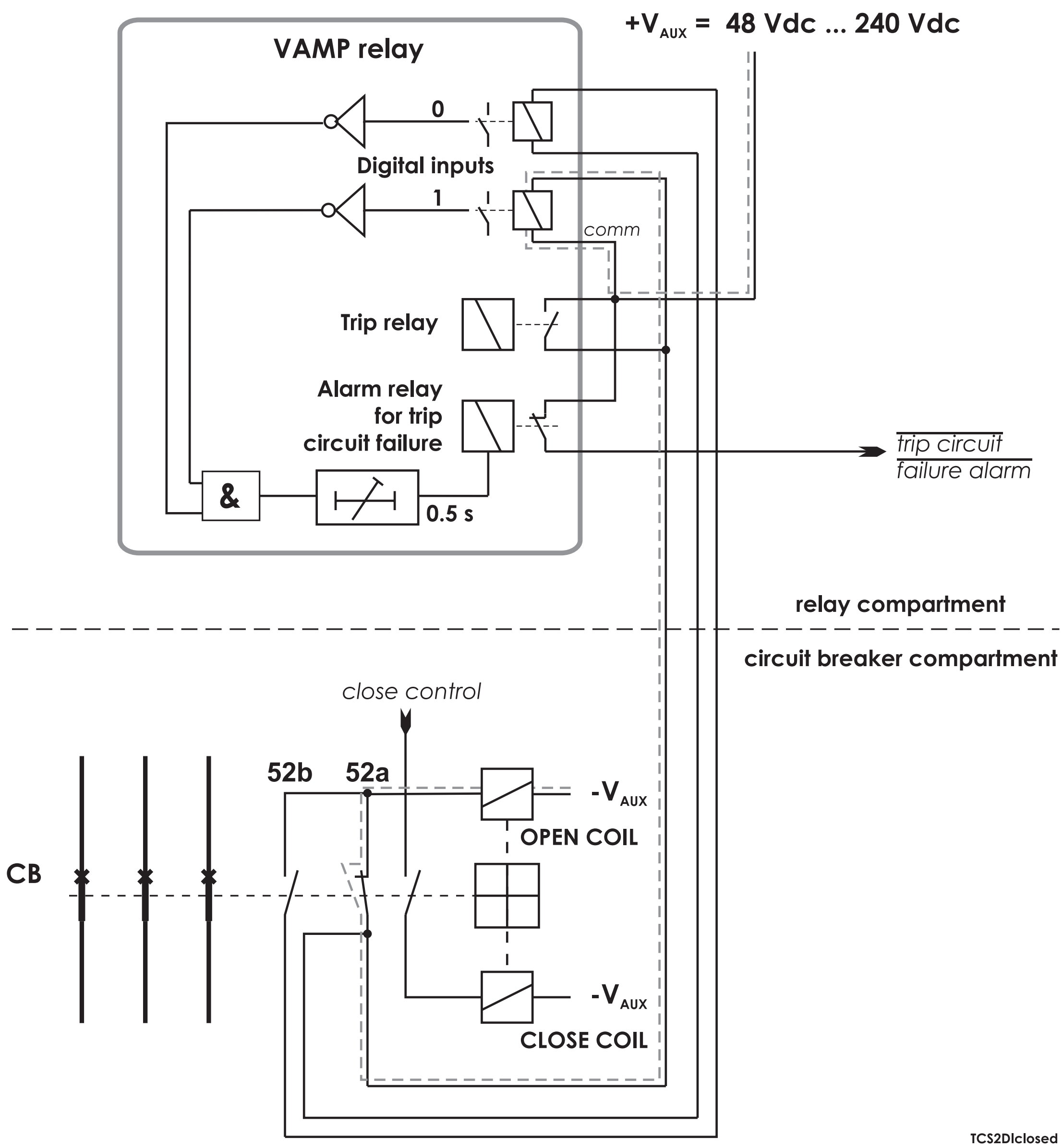


Figure 10.7: Trip circuit supervision with two digital inputs. The CB is closed. The supervised circuitry in this CB position is double-lined. The digital input is in active state when the trip circuit is complete.

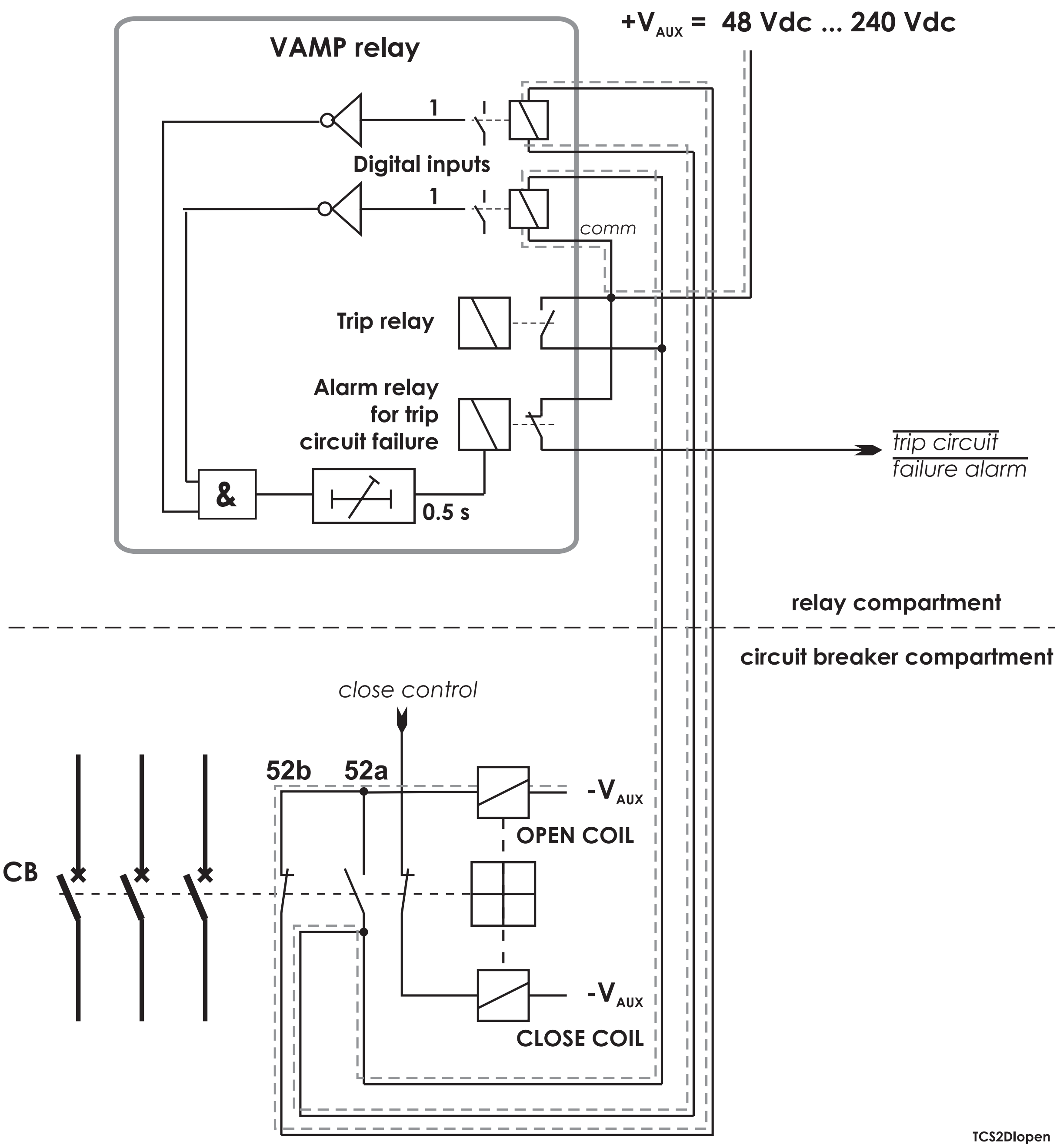
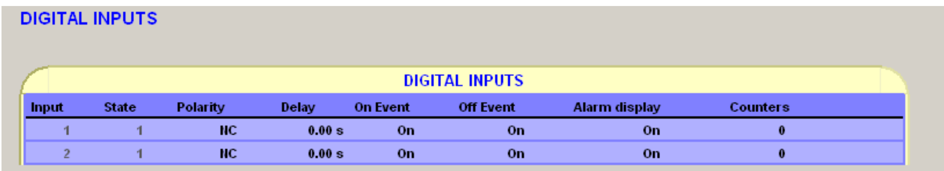


Figure 10.8: Trip circuit supervision with two digital inputs. The CB is in the open position. The two digital inputs are now in series.



DIGITAL INPUTS

DIGITAL INPUTS

Input	State	Polarity	Delay	On Event	Off Event	Alarm display	Counters
1	1	NC	0.00 s	On	On	On	0
2	1	NC	0.00 s	On	On	On	0

Figure 10.9: An example of digital input configuration for trip circuit supervision with two dry digital inputs DI1 and DI2.

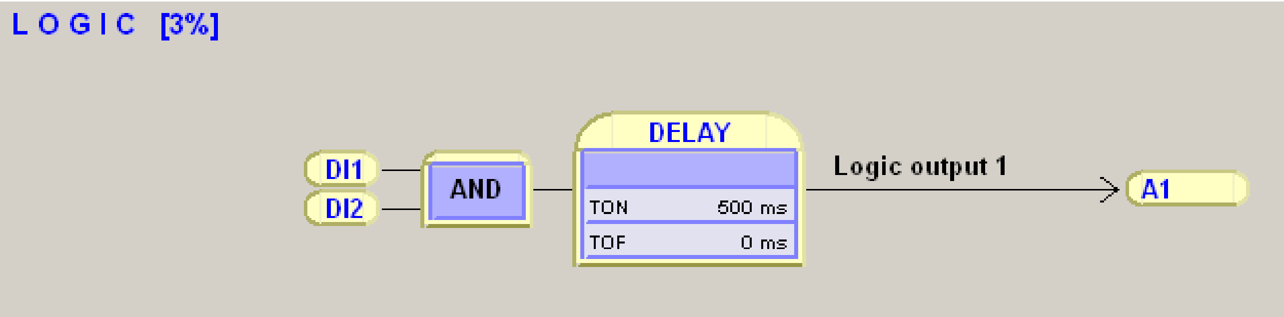


Figure 10.10: An example of logic configuration for trip circuit supervision with two dry digital inputs DI1 and DI2.

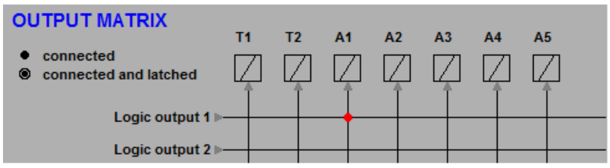


Figure 10.11: An example of output matrix configuration for trip circuit supervision with two digital inputs.

11 Connections

11.1 Rear panel

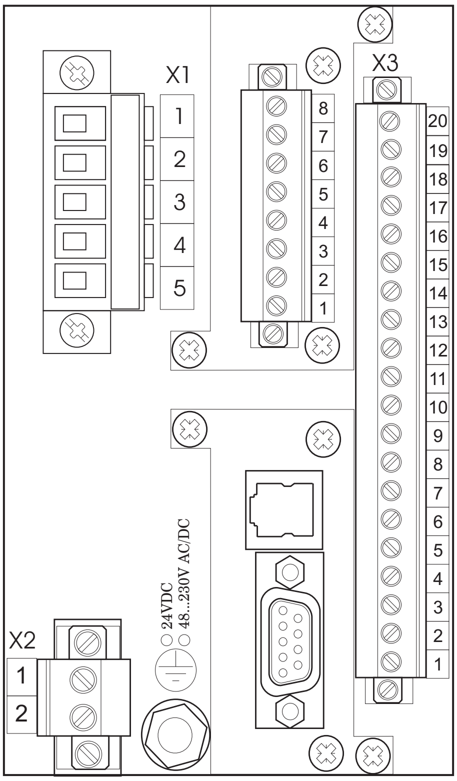
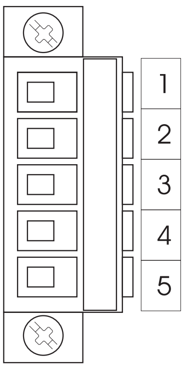


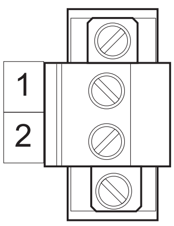
Figure 11.1: Connections on the rear panel

Terminal X1



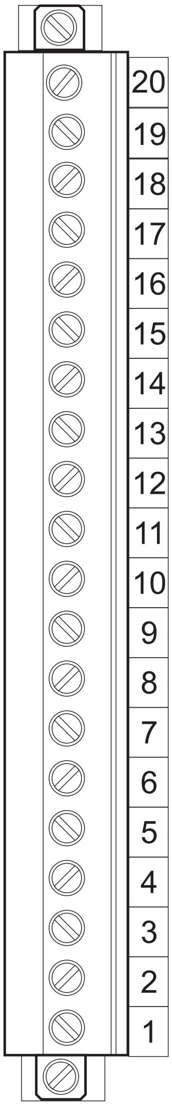
No	Symbol	Description
1	Ua	Voltage input 1
2	Ub	Voltage input 2
3	Uc	Voltage input 3
4	Ud	Voltage input 4
5	Neutral	Neutral

Terminal X2



No	Symbol	Description
1	U_{AUX}	Auxiliary voltage
2	U_{AUX}	Auxiliary voltage

Terminal X3



No	Symbol	Description
20	SF NO	Internal fault relay, common connector
19	SF NC	Internal fault relay, normal open connector
18	SF COM	Internal fault relay, normal closed connector
17	T1	Trip relay 1
16	T1	Trip relay 1
15	T2	Trip relay 2
14	T2	Trip relay 2
13	T3	Trip relay 3
12	T3	Trip relay 3
11	T4	Trip relay 4
10	T4	Trip relay 4
9	A1 NC	Alarm relay 1, common connector
8	A1 NO	Alarm relay 1, normal open connector
7	A1 COM	Alarm relay 1, normal closed connector
6	DI2 +	Digital inputs
5	DI2 -	Digital inputs
4	DI1 +	Digital inputs
3	DI1 -	Digital inputs
2	mA out -	Analogue output
1	mA out +	Analogue output

11.2 Auxiliary voltage

The external auxiliary voltage U_{AUX} (40 – 265 V ac or V dc, or optionally 18 – 36V dc) for the relay is connected to the pins X2: 1 – 2.

NOTE: When optional 18 – 36 Vdc power module is used the polarity is as follows: X2:1 positive (+), X2:2 negative (-).

11.3 Output relays

The relay is equipped with 5 configurable output relays, and a separate output relay for the self-supervision system.

- Trip relays T1 – T4 (terminals X3: 10-17)
- Alarm relay A1 (terminals X3: 7-9)
- Self-supervision system output relay IF (terminals X3: 18-20)

11.4 Serial communication connection

The device can be equipped with optional communication module. The physical location of the module is the lower option card slot at the back of the relay. The modules can be installed in the field (when power is first turned off).

There are three “logical communication ports” available in the relay: REMOTE, LOCAL and EXTENSION. Depending on the module type one or more of these ports are physically available at the external connectors.

11.4.1 Front panel USB connector

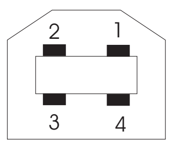


Figure 11.2: Pin numbering of the front panel USB type B connector

Pin	Signal name
1	VBUS
2	D-
3	D+
4	GND
Shell	Shield

11.4.2 Pin assignments of the optional communication interface cards

The communication card types and their pin assignments are introduced in the following table.

Type	Order code, Name	Communication ports	Signal levels	Connectors	Pin usage
VCM 232	CA RS-232 interface	REMOTE EXTENSION	RS-232 RS-232	D-connector	2 = TX_REM 3 = RX_REM 5 = TX_EXT 6 = RX_EXT 7 = GND 9 = +12V
VCM 232+ET	HA Ethernet interface	Ethernet	Ethernet 10Mbps	RJ-45	1=Transmit+ 2=Transmit- 3=Receive+ 4=Reserved 5=Reserved 6=Receive- 7=Reserved 8=Reserved
VCM 232+I6	KA IEC 61850 inter-face	Ethernet	Ethernet 10Mbps	RJ-45	
VCM 232+00	LA RS-232 interface	REMOTE	RS-232	D-connector	2 = TX_REM 3 = RX_REM 7 = GND 9 = +12V
VCM 232+IR	LB RS-232 interface with timesyn-cronisation input	CLOCK SYNC (IRIG-B)	TTL	2-pole screw con-nector	1= Data 2= GND
VCM 232+FI	LC RS-232 interface with RTD fiber op-tic interface	EXTENSION RTD protocol must be selected for the port	Light	Snap-in connector	
VCM 232+ET2	LD RS-232 interface with Ethernet inter-face	Ethernet	Ethernet 10Mbps	RJ-45	1=Transmit+ 2=Transmit- 3=Receive+ 4=Reserved 5=Reserved 6=Receive- 7=Reserved 8=Reserved
VCM 232+I62	LE RS-232 interface with IEC 61850 in-terface	Ethernet	Ethernet 10Mbps	RJ-45	

Type	Order code, Name	Communication ports	Signal levels	Connectors	Pin usage
VCM 232+LC	LF RS-232 interface with Ethernet fibre interface	Ethernet	Light 100Mbps	LC-connector	TX=Lower LC-connector RX=Upper LC-connector
VCM 232+L6	LG RS-232 interface with IEC 61850 Ethernet fibre interface	Ethernet	Light 100Mbps	LC-connector	
VCM 485+00	BA RS-484 interface	REMOTE	RS-485 (2-wire)	3-pole screw connector	1= - 2= + 3= GND
VCM 485+IR	BB RS-485 interface with timesyncronisation input	CLOCK SYNC (IRIG-B)	TTL	2-pole screw connector	1= Data 2= GND
VCM 485+FI	BC RS-485 interface with RTD fiber optic interface BC	EXTENSION RTD protocol must be selected for the port	Light	Snap-in connector	
VCM 485+ET	BD RS-485 interface with Ethernet interface	Ethernet	Ethernet 10Mbps	RJ-45	1=Transmit+ 2=Transmit- 3=Receive+ 4=Reserved 5=Reserved 6=Receive- 7=Reserved 8=Reserved
VCM 485+I6	BE RS-485 interface with IEC 61850 Ethernet fibre interface	Ethernet	Ethernet 10Mbps	RJ-45	
VCM 485+LC	BF RS-485 interface with Ethernet fibre interface	Ethernet	Light 100Mbps	LC-connector	TX=Lower LC-connector RX=Upper LC-connector
VCM 485+L6	BG RS-485 interface with IEC 61850 Ethernet fibre interface	Ethernet	Light 100Mbps	LC-connector	

Type	Order code, Name	Communication ports	Signal levels	Connectors	Pin usage
VCM FI PP	DA Plastic/Plastic fibre interface	REMOTE	Light	P/P fiber	TX=Lower fiber connector RX=Upper fiber connector
VCM FI GG	EA Glass/Glass fibre interface	REMOTE	Light	G/G fiber	
VCM FI PG	FA Plastic/Glass fibre interface	REMOTE	Light	P/G fiber	
VCM FI GP	GA Glass/Plastic fibre interface	REMOTE	Light	G/P fiber	
VCM PB	PA Profibus interface	REMOTE	Profibus DP/RS-485	D-connector	3=RXD/TXD+/P 5= GND 6=+5V 8= RXD/TXD-/N
VCM ET2xST	RA Double ethernet fibre interface with IEC 61850	Ethernet	Light 100Mbps	ST-connector	ST-connector from top: -X8 Ethernet 1 Rx -X8 Ethernet 1 Tx -X7 Ethernet 2 Rx -X7 Ethernet 2 Tx
VCM ET2xRJ	SA Double ethernet interface with IEC 61850	Ethernet	Ethernet 100Mbps	RJ-45	1=Transmit+ 2=Transmit- 3=Receive+ 4=Reserved 5=Reserved 6=Receive- 7=Reserved 8=Reserved

11.5 Input/output card B = 4 x DI + 1 x DI/DO

The digital input/output option “B = 4 x DI + 1 x DI/DO" enables four more digital inputs and one optional digital input / output contact. This card enables use of digital inputs DI3 – DI7. In case DI7 is not used as digital input then it can be used as additional output T5, but not simultaneously.

NOTE: Pay special attention when using DI7 (terminals numbers X6:1 – X6:2) as digital input use. Never configure, operate or control T5 output if DI7 is used as an imput. Should the control of T5 happen the output contact will short-circuit DI7 and will lead to equipment damage and loss of data.

For this block information, please see Figure 11.5.

When this option card is installed to slot X6, the CARD INFO view indicates value “4DI + 1DO” for parameter “I/O card” in HMI and VAMPSET. In case arc sensor card is chosen for slot X6 then this I/O card cannot be used.

Digital inputs of the device can operate in three different voltage areas. It is also possible to select whether ac or dc –voltage is used. Digital input threshold of the device is selected in the ordering code when the relay(s) are being ordered.

When 110 or 220 V ac voltage is used to activate the digital Inputs, the AC mode should be selected as shown in the screenshot below:

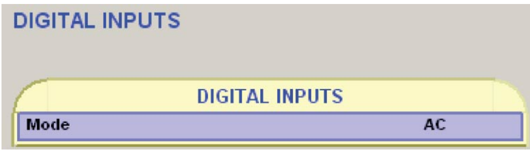


Figure 11.3: AC mode selection in VAMPSET

11.6 External option modules

11.6.1 Third-party external input / output modules

The device supports also external input / output modules used to extend the number of digital/analog inputs and outputs.

The following types of devices are supported:

- Analog input modules (RTD)
- Analog output modules (mA-output)
- Binary input/output modules

EXTENSION port is primarily designed for I/O modules. The relay must have a communication option card with EXTENSION port. Depending of the option card I/O devices may require an adapter to be able to connect to the port (i.e. VSE004).

NOTE: If External I/O protocol is not selected to any communication port, VAMPSET doesn't display the menus required for configuring the I/O devices. After changing EXTENSION port protocol to External I/O, restart the relay and read all settings with VAMPSET.

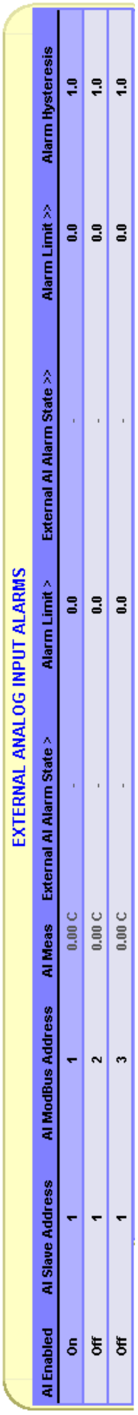
External analog inputs configuration (VAMPSET only)

EXTERNAL ANALOG INPUTS

AI Enabled	AI Meas	AI Unit	AI Slave Address	AI ModBus Address	AI Register Type	AI Offset	x1	y1	x2	y2	AI Error Counter
On	0.00 C	C	1	1	HoldingR	0	0	0	1	1	0
Off	0.00 C	C	1	2	HoldingR	0	0	0	1	1	0
Off	0.00 C	C	1	3	HoldingR	0	0	0	1	1	0

Range	Description			
	Communication read errors			
X: -32000 – 32000 Y: -1000 – 1000	Scaling	**Y2**	Scaled value	Point 2
		X2	Modbus value	
		Y1	Scaled value	Point 1
		X1	Modbus value	
-32000 – 32000		**Offset**	Subtracted from Modbus value, before running XY scaling	
InputR or HoldingR	Modbus register type			
1 – 9999	Modbus register for the measurement			
1 – 247	Modbus address of the I/O device			
C, F, K, mA, Ohm or V/A	Unit selection			
	Active value			
On / Off	Enabling for measurement			

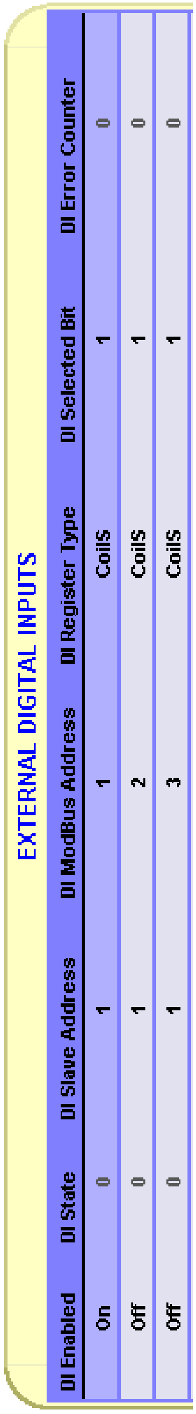
Alarms for external analog inputs



Range	Description	
0 – 10000	Hysteresis for alarm limits	
-21x107 – +21x107	**Alarm >>**	Limit setting
- / Alarm		Active state
-21x107 – +21x107	**Alarm >**	Limit setting
- / Alarm		Active state
	Active value	
1 – 9999	Modbus register for the measurement	
1 – 247	Modbus address of the I/O device	
On / Off	Enabling for measurement	

Analog input alarms have also matrix signals, “Ext. Aix Alarm1” and “Ext. Aix Alarm2”.

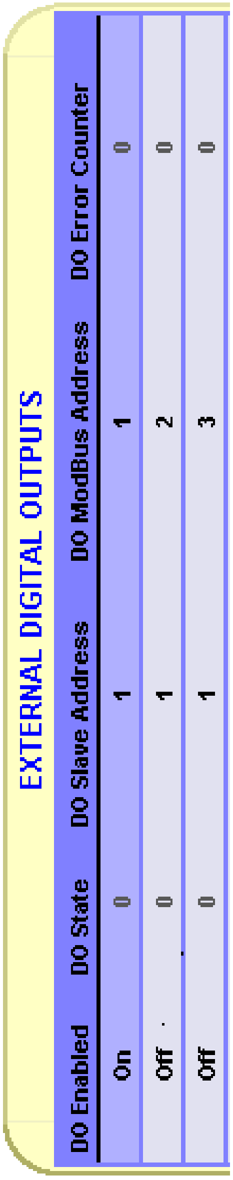
External digital inputs configuration (VAMPSET only)


EXTERNAL DIGITAL INPUTS

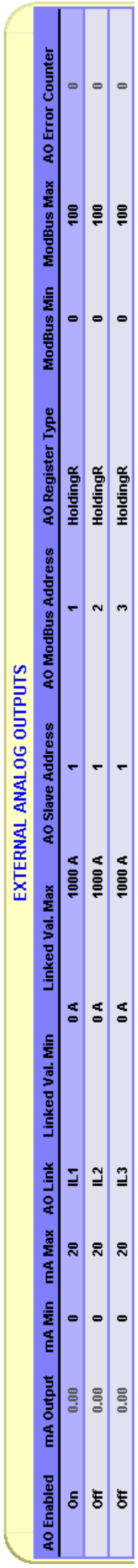
DI Enabled	DI State	DI Slave Address	DI ModBus Address	DI Register Type	DI Selected Bit	DI Error Counter
On	0	1	1	CoilS	1	0
Off	0	1	2	CoilS	1	0
Off	0	1	3	CoilS	1	0

Range	Description
	Communication read errors
1 – 16	Bit number of Modbus register value
CoilS, InputS, InputR or HoldingR	Modbus register type
1 – 9999	Modbus register for the measurement
1 – 247	Modbus address of the I/O device
0 / 1	Active state
On / Off	Enabling for measurement

External digital outputs configuration (VAMPSET only)

	Range	Description
		Communication errors
	1 – 9999	Modbus register for the measurement
	1 – 247	Modbus address of the I/O device
	0 / 1	Output state
		Enabling for measurement

External analog outputs configuration (VAMPSET only)



Range	Description
	Communication errors
-32768 – +32767 (0 – 65535)	Modbus value corresponding Linked Val. Max
	Modbus value corresponding Linked Val. Min
InputR or HoldingR	Modbus register type
1 – 9999	Modbus register for the output
1 – 247	Modbus address of the I/O device
0 – 42x108, -21x108 – +21x108	Maximum limit for lined value, corresponding to “Modbus Max”
	Minimum limit for lined value, corresponding to “Modbus Min”
	Link selection
-21x107 – +21x107	Minimum & maximum output values
	Active value
On / Off	Enabling for measurement

11.7 Block optional diagram

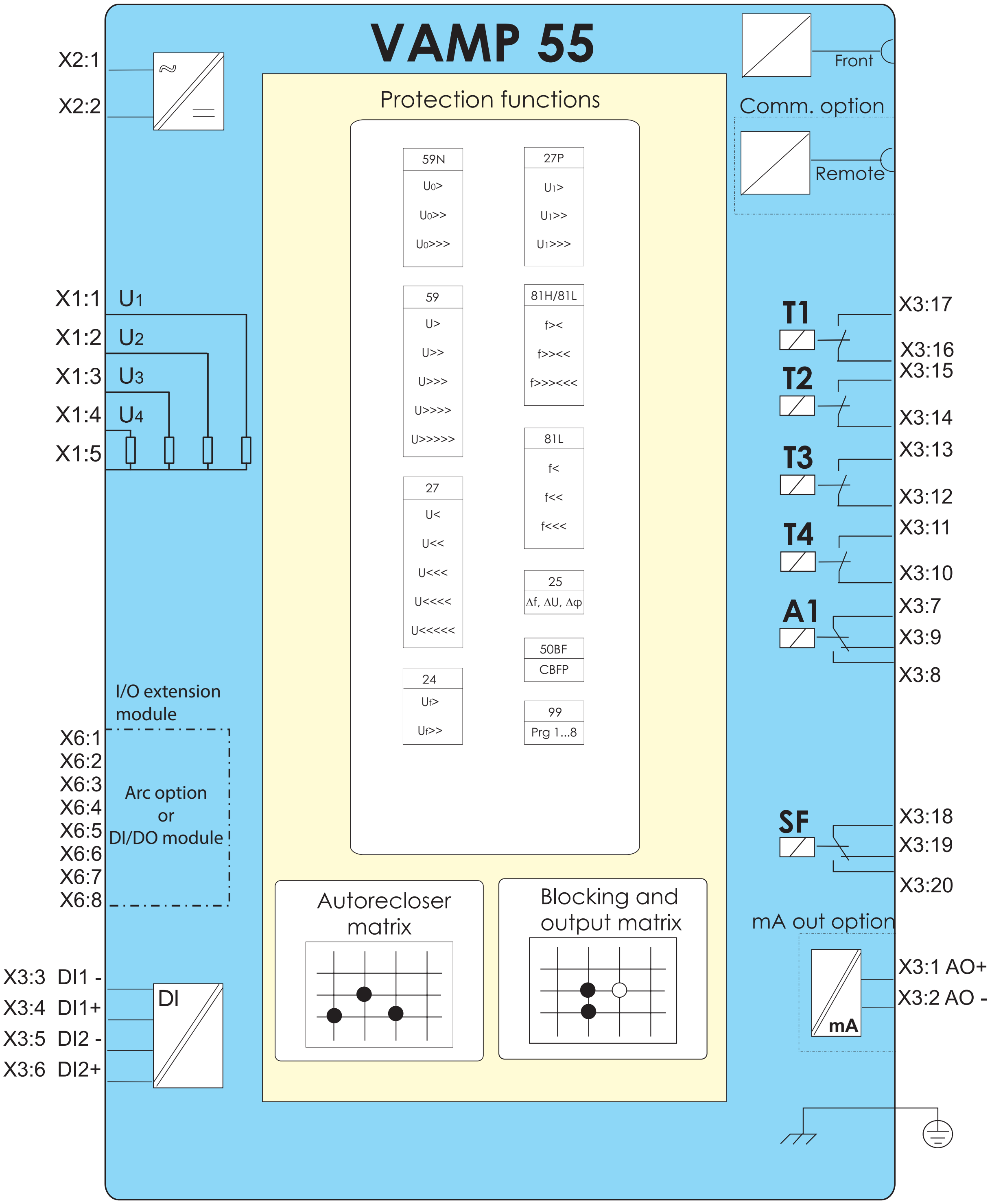


Figure 11.4: Bolck diagram of voltage and frequency protection relay VAMP 55

11.8 Block diagrams of optional modules

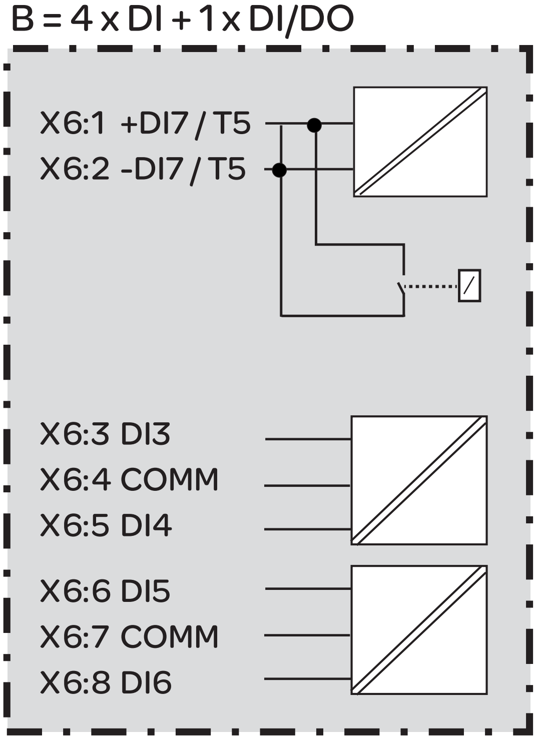


Figure 11.5: Block diagram of optional module “B = Digital I/O; 4 x DI + 1 x DI/DO”

11.9 Connection examples

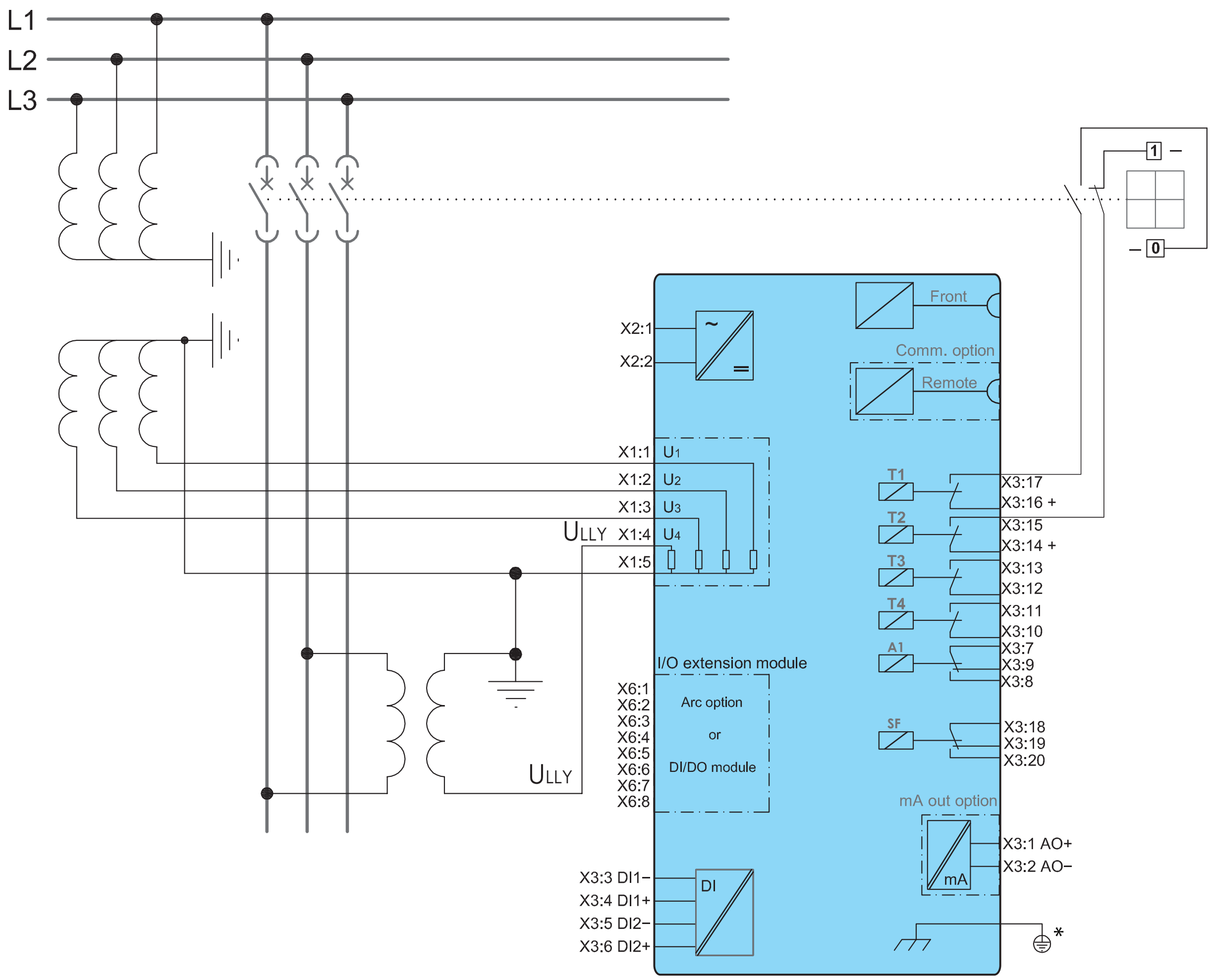


Figure 11.6: One synchrocheck stage with "3LN+LLy"-mode.

*** Voltage measurement of the 50-series relays should be at the same potential with the grounding of the relay. Normally this happens "automatically" on field but pay attention when doing tests with the relay.**

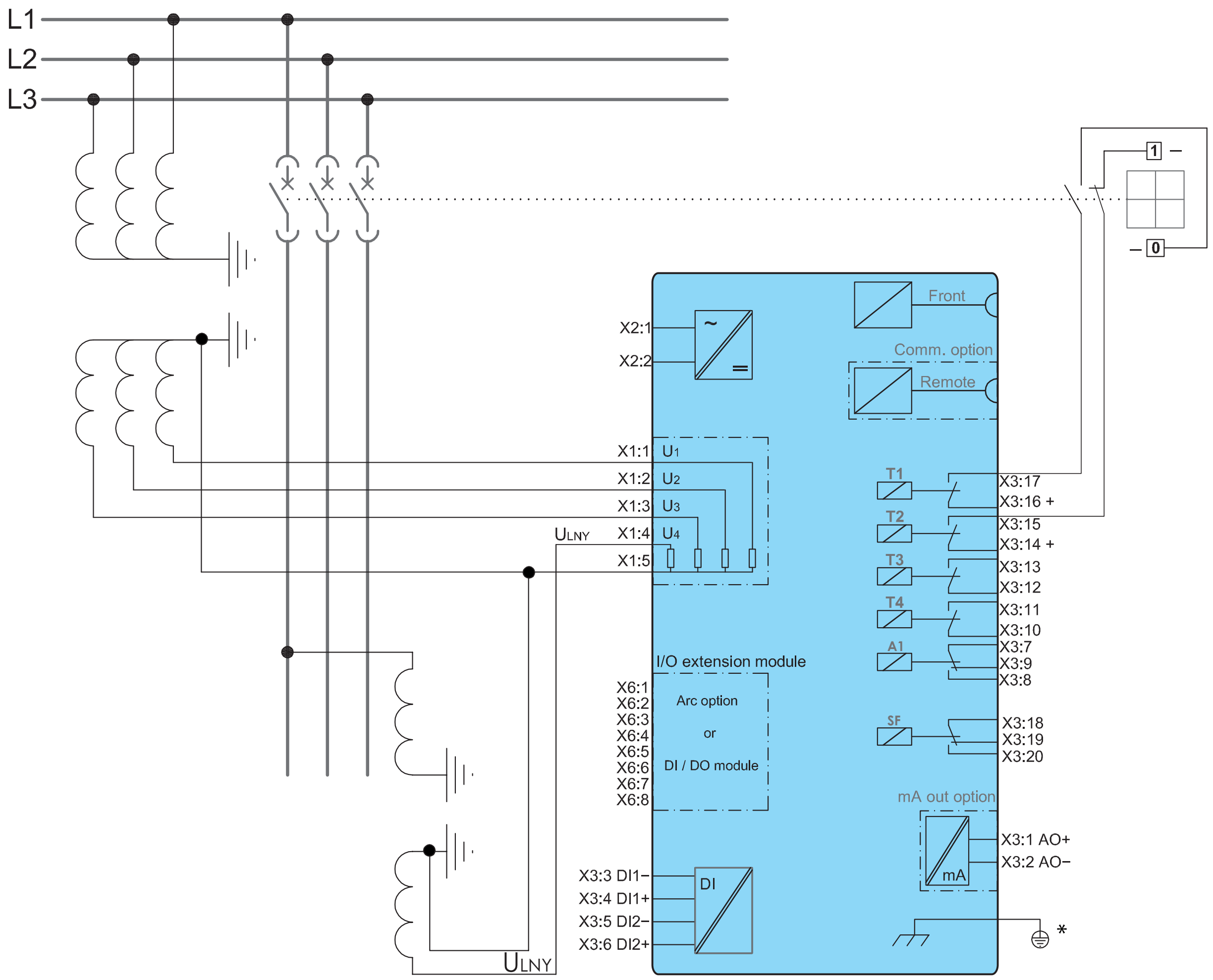


Figure 11.7: One synchrocheck stage with “3LN+LNy”-mode.

*** Voltage measurement of the 50-series relays should be at the same potential with the grounding of the relay. Normally this happens “automatically” on field but pay attention when doing tests with the relay.**

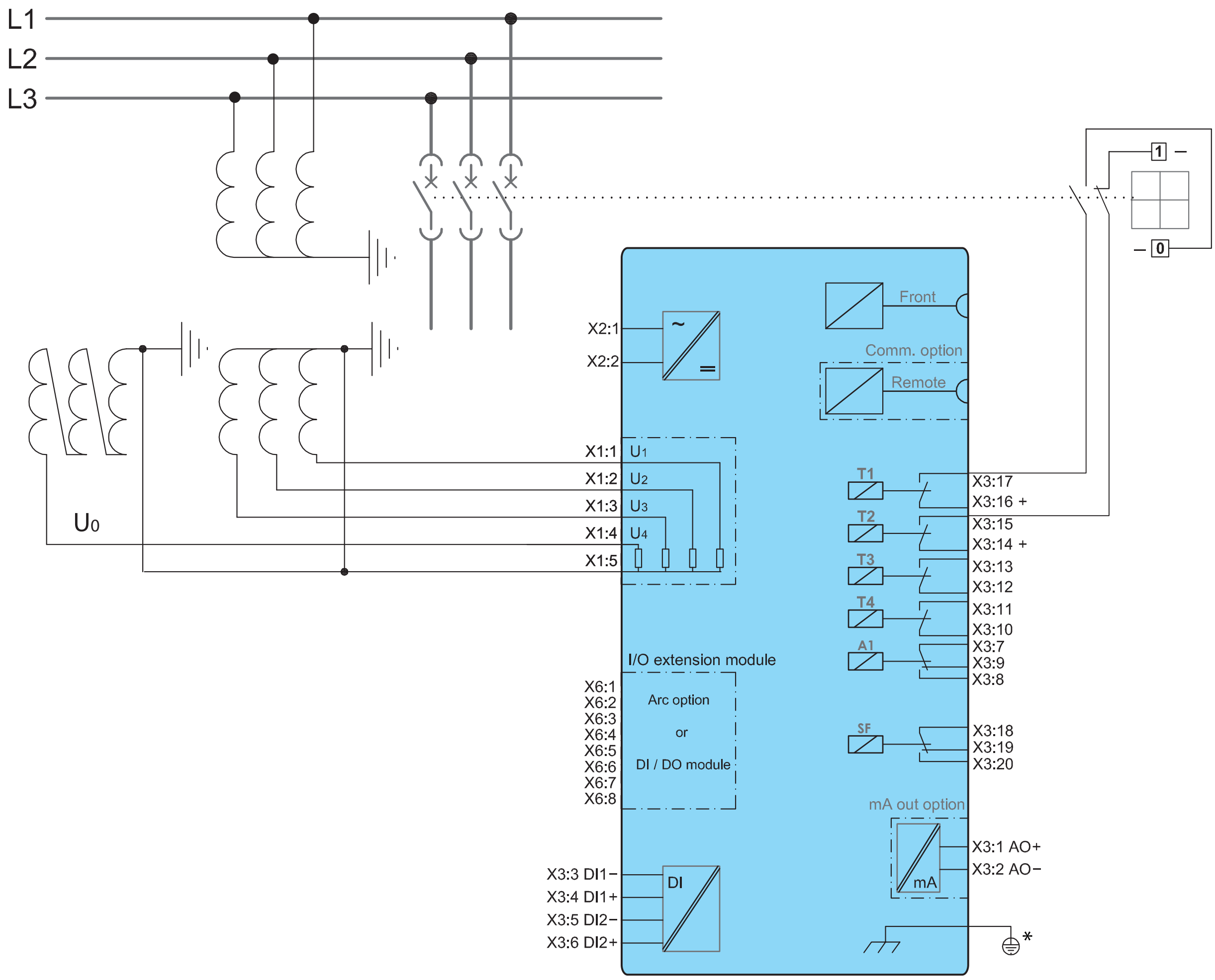


Figure 11.8: Three phase voltages and open delta connection with “3LN+U_0“ mode.

*** Voltage measurement of the 50-series relays should be at the same potential with the grounding of the relay. Normally this happens “automatically” on field but pay attention when doing tests with the relay.**

12 Technical data

12.1 Connections

Table 12.1: Measuring circuits

Rated voltage U_N	230 V_{LN} (configurable for VT secondaries 50 – 400 V)
- Voltage measuring range	0 – 300 V
- Continuous voltage withstand	250 V
- Burden	< 0.5 VA
Rated frequency f_N	45 – 65 Hz
Terminal block: - Solid or stranded wire	Maximum wire dimension: 4 mm^2 (10 – 12 AWG)

Table 12.2: Auxiliary voltage

	Type A (standard)	Type B (option)
Rated voltage U_{AUX}	40 – 265 V ac/dc	18 – 36 V dc **Note! Polarity** X2:1= positive (+) X2:2= negative (-)
Start-up peak (DC) 24 V (Type B) 110 V (Type A) 220 V (Type A)	 25 A with time constant of 1000 µs 15 A with time constant of 500 µs 25 A with time constant of 750 µs	
Power consumption Max. permitted interruption time	< 15 W (normal conditions) < 25 W (output relays activated) < 50 ms (110 V dc)	
Terminal block: - Phoenix MVSTBW or equivalent	Maximum wire dimension: 2.5 mm^2 (13 – 14 AWG)	

Table 12.3: Digital inputs internal operating voltage

Number of inputs	2
Voltage withstand	265 V ac/dc
External operating voltage, threshold	1: 24 – 230 V ac/dc (max. 265 V ac/dc) 2: 110 – 230 V ac/dc (max. 265 V ac/dc) 3: 220 – 230 V ac/dc (max. 265 V ac/dc)
Typical switching threshold	1: 12 V dc 2: 75 V dc 3: 155 V dc
Current drain	approx. 3 mA
Activation time dc/ac	< 11 ms / < 15 ms
Reset time dc/ac	< 11 ms / < 15 ms
Terminal block: - MSTB2.5 – 5.08	Maximum wire dimension: 2.5 mm^2 (13 – 14 AWG)

NOTE: set dc/ac mode according to the used voltage in VAMPSET.

Table 12.4: Trip contact, Tx

Number of contacts	4 making contacts (relays T1, T2, T3, T4)
Rated voltage	250 V ac/dc
Continuous carry	5 A
Make and carry, 0.5 s Make and carry, 3s	30 A 15 A
Breaking capacity, DC (L/R=40ms)	
at 48 V dc:	1.15 A
at 110 V dc:	0.5 A
at 220 V dc:	0.25 A
Contact material	AgNi 90/10
Terminal block: - MSTB2.5 - 5.08	Wire dimension: Maximum 2.5 mm^2 (13 – 14 AWG) Minimum 1.5 mm^2 (15 – 16 AWG)

Table 12.5: Signal contacts

Number of contacts:	2 change-over contacts (relays A1 and SF)
Rated voltage	250 V ac/dc
Continuous carry	5 A
Breaking capacity, DC (L/R=40ms)	
at 48 V dc:	1 A
at 110 V dc:	0.3 A
at 220 V dc:	0.15 A
Contact material	AgNi 0.15 gold plated
Terminal block - MSTB2.5 - 5.08	Wire dimension Maximum 2.5 mm^2 (13 – 14 AWG) Minimum 1.5 mm^2 (15 – 16 AWG)

Table 12.6: Local serial communication port

Number of ports	1 on front
Electrical connection	USB
Data transfer rate	2 400 – 187 500 kb/s

Table 12.7: Remote control connection (option)

Number of ports	1 option slot on rear panel
Electrical connection	RS 485 RS 232 Plastic fibre connection Glass fibre connection Ethernet 10 Base-T
Protocols	Modbus, RTU master Modbus, RTU slave SPA-bus, slave IEC 60870-5-103 Profibus DP (external module) IEC 60870-5-101 IEC 60870-5-101 TCP DNP 3.0 DNP 3.0 TCP IEC 61850 Ethernet IP

Table 12.8: Analogue output connection (option)

Number of analogue mA output channels	1
Maximum output current	1 – 20 mA, step 1 mA
Minimum output current	0 – 19 mA, step 1 mA
Exception output current	0 – 20.50 mA, step 25 μA
Resolution	10 bit
Current step	< 25 μA
Inaccuracy	±80 μA
Response time - normal mode - fast mode	 < 400 ms < 50 ms
Burden	< 600 Ω

Table 12.9: Ethernet fiber interface

Type	Multimode
Connector	LC for single FO Ethernet ST for double FO Ethernet
Physical layer	100 Base-Fx
Maximum cable distance	2 km
Optical wavelength	1300 nm
Cable core / cladding size	50/125 or 62.5/125 μm

12.2 Test and environmental conditions

Table 12.10: Disturbance tests

Test	Standard & Test class / level	Test value
Emission	EN 61000-6-4 / IEC 60255-26	
- Conducted	EN 55011, Class A / IEC 60255-25	0.01 – 30 MHz
- Emitted	EN 55011, Class A / IEC 60255-25 / CISPR 11	30 – 1000 MHz
Immunity	EN 61000-6-2 / IEC 60255-26	
- 1Mhz damped oscillatory wave	IEC 60255-22-1	±2.5kVp CM, ±1.0kVp DM
- Static discharge (ESD)	EN 61000-4-2 Level 4 / IEC 60255-22-2 Class 4	±8 kV contact, ±15 kV air
- Emitted HF field	EN 61000-4-3 Level 3 / IEC 60255-22-3	80 - 2700 MHz, 10 V/m
- Fast transients (EFT)	EN 61000-4-4 Level 4 / 3 / IEC 60255-22-4 Class A	4 kV / Signal ports 2.0 kV , 5/50 ns, 5 kHz
- Surge	EN 61000-4-5 Level 3 / IEC 60255-22-5	±2 kV, 1.2/50 µs, CM ±1 kV, 1.2/50 µs, DM
- Conducted HF field	EN 61000-4-6 Level 3 / IEC 60255-22-6	0.15 - 80 MHz, 10 Vemf
- Power-frequency magnetic field	EN 61000-4-8	300A/m (continuous), 1000A/m 1-3s
- Pulse magnetic field	EN 61000-4-9 Level 5	1000A/m, 1.2/50 µs
- Voltage dips	EN 61000-4-29 / IEC 60255-11	30%/1s, 60%/0.1s, 100%/0.01s
- Voltage short interruptions	EN 61000-4-11	30%/10ms, 100%/10ms, 60%/100ms, 95%/5000ms
- Voltage alternative component	EN 61000-4-17 / IEC 60255-11	12% of operating voltage (DC) / 10min

Table 12.11: Electrical safety tests

Test	Standard & Test class / level	Test value
- Impulse voltage withstand	EN 60255-5, Class III	5 kV, 1.2/50 ms, 0.5 J 1 kV, 1.2/50 ms, 0.5 J Communication
- Dielectric test	EN 60255-5, Class III	2 kV, 50 Hz 0.5 kV, 50 Hz Communication
- Insulation resistance	EN 60255-5	
- Protective bonding resistance	EN 60255-27	
- Power supply burden	IEC 60255-1	

Table 12.12: Mechanical tests

Test	Standard & Test class / level	Test value
Device in operation		
- Vibrations	IEC 60255-21-1, Class II / IEC 60068-2-6, Fc	1Gn, 10Hz – 150 HZ
- Shocks	IEC 60255-21-2, Class II / IEC 60068-2-27, Ea	10Gn/11ms
Device de-energized		
- Vibrations	IEC 60255-21-1, Class II / IEC 60068-2-6, Fc	2Gn, 10Hz – 150 HZ
- Shocks	IEC 60255-21-2, Class II / IEC 60068-2-27, Ea	30Gn/11ms
- Bump	IEC 60255-21-2, Class II / IEC 60068-2-27, Ea	20Gn/16ms

Table 12.13: Environmental tests

Test	Standard & Test class / level	Test value
Device in operation		
- Dry heat	EN / IEC 60068-2-2, Bd	65°C (149°F)
- Cold	EN / IEC 60068-2-1, Ad	-40°C (-40°F)
- Damp heat, cyclic	EN / IEC 60068-2-30, Db	• From 25°C (77°F) to 55°C (131°F) • From 93% RH to 98% RH • Testing duration: 6 days
- Damp heat, static	EN / IEC 60068-2-78, Cab	• 40°C (104°F) • 93% RH • Testing duration: 10 days
Flowing mixed gas corrosion test, method 2	IEC 60068-2-60, Ke	25°C (77°F), 75% RH, 10 ppb H_2S, 200 ppb NO_2, 10 ppb CL_2
Flowing mixed gas corrosion test, method 4	IEC 60068-2-60, Ke	25°C (77°F), 75% RH, 10 ppb H_2S, 200 ppb NO_2, 10 ppb CL_2, 200 ppb SO_2
Device in storage		
- Dry heat	EN / IEC 60068-2-2, Bb	75°C (167°F)
- Cold	EN / IEC 60068-2-1, Ab	-40°C (-40°F)

Table 12.14: Environmental conditions

Ambient temperature, in-service	-40 – 65°C (-40 – 149°F)
Ambient temperature, storage	-40 – 70°C (-40 – 158°F)
Relative air humidity	< 95%, no condensation allowed
Maximum operating altitude	2000 m (6561.68 ft)

Table 12.15: Casing

Degree of protection (IEC 60529)	IP54 front panel, IP 20 rear panel
Dimensions (w x h x d):	130 x 170 x 210 mm / 5.12 x 6.69 x 8.27 in
Material	1 mm (0.039 in) steel plate
Weight	2.0 kg (4.415 lb)
Colour code	RAL 7032 (Casing) / RAL 7035 (Back plate)

Table 12.16: Package

Dimensions (W x H x D)	230 x 215 x 175 mm / 9.06 x 8.46 x 6.89 in
Weight (Terminal, Package and Manual)	3.0 kg (6.623 lb)

12.3 Protection functions

*) EI = Extremely Inverse, NI = Normal Inverse, VI = Very Inverse, LTI = Long Time Inverse, MI= Moderately Inverse

**) This is the instantaneous time i.e. the minimum total operational time including the fault detection time and operation time of the trip contacts.

12.3.1 Voltage protection

Table 12.17: Overvoltage stage U> (59)

Pick-up value	50 – 150 %U_N (step 1%)
Definite time characteristic: - Operating time	 0.08** – 300.00 s (step 0.02)
Hysteresis	0.99 – 0.800 (0.1 – 20.0 %, step 0.1 %)
Start time	Typically 60 ms
Release delay	0.06 – 300.00 s (step 0.02)
Reset time	<95 ms
Retardation time	< 50 ms
Inaccuracy: - Starting - operate time	 ±3% of the set value ±1% or ±30 ms

Table 12.18: Overvoltage stage U>> (59)

Pick-up value	50 – 150 %U_N (step 1%)
Definite time characteristic: - Operating time	 0.06** – 300.00 s (step 0.02)
Hysteresis	0.99 – 0.800 (0.1 – 20.0 %, step 0.1 %)
Start time	Typically 60 ms
Reset time	<95 ms
Retardation time	< 50 ms
Inaccuracy: - Starting - operate time	 ±3% of the set value ±1% or ±30 ms

Table 12.19: Overvoltage stages U>>>> and U>>>>> (59)

Pick-up value	50 – 160 %U_N (step 1%)
Definite time characteristic: - Operating time	 0.04 – 300.00 s (step 0.01)
Hysteresis	0.99 – 0.800 (0.1 – 20.0 %, step 0.1 %)
Start time	Typically 30 ms
Reset time	<95 ms
Retardation time	< 50 ms
Inaccuracy: - Starting - operate time	 ±3% of the set value ±1% or ±25 ms

Table 12.20: Volts/hertz over-excitation protection U_f>, U_f>> (24)

Pick-up setting range	100 – 200 %
Operating time	0.3 – 300.0 s
Start time	Typically 200 ms
Reset time	< 450 ms
Reset ratio:	0.995
Inaccuracy:	
- Starting	U < 0.5 % unit f < 0.05 Hz
- Operating time at definite time function	±1 % or ±150 ms

Table 12.21: Positive sequence undervoltage stages U_1<, U_1<<, U_1<<< (27P)

Pick-up value	20 – 120% x U_N
Definite time function: - Operating time	 0.08**) – 300.00 s
Undervoltage blocking	2 – 100% x U_N (common for both stages)
Start time	Typically 60 ms
Reset time	<95 ms
Retardation time	< 50 ms
Reset ratio:	1.05
Inaccuracy: - Starting - Operating time	 1% unit ±1% or ±30 ms

NOTE: To make the relay trip after low voltage blocking, the positive sequence voltage has to go above the pick-up setting.

Table 12.22: Undervoltage stage U< (27)

Pick-up value	20 – 120 %U_N (step 1%)
Definite time characteristic: - Operating time	 0.08** – 300.00 s (step 0.02)
Hysteresis	1.001 – 1.200 (0.1 – 20.0 %, step 0.1 %)
Self-blocking value of the undervoltage	0 – 80 %U_N
Start time	Typically 60 ms
Release delay	0.06 – 300.00 s (step 0.02 s)
Reset time	<95 ms
Retardation time	< 50 ms
Reset ratio (Block limit)	0.5 V or 1.03 (3 %)
Reset ratio:	1.03 (depends on the hysteresis setting)
Inaccuracy: - Starting - blocking - operate time	 ±3% of the set value ±3% of set value or ±0.5 V ±1% or ±30 ms

Table 12.23: Undervoltage stage U<< (27)

Pick-up value	20 – 120 %U_N (step 1%)
Definite time characteristic: - Operating time	 0.06** – 300.00 s (step 0.02)
Hysteresis	1.001 – 1.200 (0.1 – 20.0 %, step 0.1 %)
Self-blocking value of the undervoltage	0 – 80 %U_N
Start time	Typically 60 ms
Reset time	<95 ms
Retardation time	< 50 ms
Reset ratio (Block limit)	0.5 V or 1.03 (3 %)
Reset ratio:	1.03 (depends on the hysteresis setting)
Inaccuracy: - Starting - blocking - operate time	 ±3% of the set value ±3% of set value or ±0.5 V ±1% or ±30 ms

Table 12.24: Undervoltage stages U<<<, U<<<<, U<<<<< (27)

Pick-up value	20 – 120 %U_N (step 1%)
Definite time characteristic: - Operating time	 0.04 – 300.00 s (step 0.01)
Hysteresis	1.001 – 1.200 (0.1 – 20.0 %, step 0.1 %)
Self-blocking value of the undervoltage	0 - 80 %U_N
Start time	Typically 30 ms
Reset time	<95 ms
Retardation time	< 50 ms
Reset ratio (Block limit)	0.5 V or 1.03 (3 %)
Reset ratio:	1.03 (depends on the hysteresis setting)
Inaccuracy: - Starting - blocking - operate time	 ±3% of the set value ±3% of set value or ±0.5 V ±1% or ±25 ms

Table 12.25: Positive sequence undervoltage stages U_2>, U_2>>, U_2>>> (47)

Setting range Definite time function:	 20 – 120% x U_N
- Operating time	0.08 **) – 300.00 s
Start time	Typically 60 ms
Reset time	<95 ms
Retardation time	< 50 ms
Reset ratio:	0.95
Inaccuracy: - Starting - Operating time	 0.5% unit ±1% or ±30 ms

NOTE: To make the relay trip after low voltage blocking, the positive sequence voltage has to go above the pick-up setting.

Table 12.26: Zero sequence voltage stage U_0> (59N)

Pick-up value	1 – 60 %U_{0N} (step 1%)
Definite time function: - Operating time	 0.3 – 300.0 s (step 0.1 s)
Start time	Typically 200 ms
Reset time	< 450 ms
Reset ratio:	0.97
Inaccuracy:	
- Starting	±2% of the set value or ±0.3% of the rated value
- Starting UoCalc (3LN mode)	±1 V
- Operate time	±1 % or ±150 ms

Table 12.27: Zero sequence voltage stage U_0>> (59N)

Pick-up value	1 – 60 %U_{0N} (step 1%)
Definite time function: - Operating time	 0.08 – 300.0 s (step 0.02 s)
Start time	Typically 60 ms
Reset time	<95 ms
Reset ratio:	0.97
Inaccuracy:	
- Starting	±2% of the set value or ±0.3% of the rated value
- Starting U_{0Calc} (3LN mode)	±1 V
- Operate time	±1% or ±30 ms

Table 12.28: Zero sequence voltage stage U_0>>> (59N)

Pick-up value	1 – 60 %U_{0N}
Definite time function: - Operating time	 0.04 – 300.0 s (step 0.01 s)
Start time	Typically 30 ms
Reset time	<95 ms
Reset ratio:	0.97
Inaccuracy:	
- Starting	±2% of the set value or ±0.3% of the rated value
- Starting U_{0Calc} (3LN mode)	±1 V
- Operate time	±1% or ±25 ms

12.3.2 Circuit-breaker failure protection CBFP (50BF)

Table 12.29: Circuit-breaker failure protection CBFP (50BF)

Relay to be supervised	T1 or T2
Definite time function: - Operating time	 0.1** – 10.0 s (step 0.1 s)
Reset time	<95 ms
Inaccuracy - Operating time	 ±20 ms

12.3.3 Frequency protection

Table 12.30: Overfrequency and underfrequency stages f><, f>><<, f>>><<< (81H/81L)

Frequency measuring area	16.0 – 75.0 Hz
Current and voltage meas. range	45.0 – 65.0 Hz
Frequency stage setting range	40.0 – 70.0 Hz (step 0.01)
Low voltage blocking	10 – 100 %U_N
Definite time function: - Operating time	 0.10** – 300.0 s (step 0.02 s)
Start time	< 100 ms
Reset time	<120 ms
Reset ratio (f>, f>> and f>>>)	0.998
Reset ratio (f<, f<< and f<<<)	1.002
Reset ratio (LV block)	Instant (no hysteresis)
Inaccuracy: - Starting - starting (LV block) - Operating time	 ±20 mHz 3% of the set value or ±0.5 V ±1% or ±30 ms

NOTE: If device restarts for some reason there will be no trip even if the frequency is below the set limit during the start up (Start and trip is blocked). To cancel this block, frequency has to rise above the set limit.

Table 12.31: Underfrequency stages f<, f<<, f<<< (81)

Frequency measuring area	16.0 – 75.0 Hz
Current and voltage meas. range	45.0 – 65.0 Hz
Frequency stage setting range	40.0 – 64.0 Hz
Low voltage blocking	10 – 100 %U_N
Definite time function: - Operating time	 0.10** – 300.0 s (step 0.02 s)
Undervoltage blocking	2 – 100 %
Start time	< 100 ms
Reset time	<120 ms
Reset ratio:	1.002
Reset ratio (LV block)	Instant (no hysteresis)
Inaccuracy: - Starting - starting (LV block) - Operating time	 ±20 mHz 3% of the set value or ±0.5 V ±1% or ±30 ms

Table 12.32: Rate of change of frequency (ROCOF) stage df/dt> (81R)

Pick-up setting df/dt	0.2 – 10.0 Hz/s (step 0.1 Hz/s)
Definite time delay (t> and t_{Min}> are equal): - operating time t>	 0.14** – 10.00 s (step 0.02 s)
Inverse time delay (t> is more than t_{Min}>): - minimum operating time t_{Min}>	 0.14** – 10.00 s (step 0.02 s)
Start time	Typically 140 ms
Reset time	150 ms
Retardation time	< 90 ms
Reset ratio:	1
Inaccuracy: - Starting - operating time(overshoot ≥ 0.2 Hz/s)	 10% of set value or ±0.1 Hz/s ±35 ms, when area is 0.2 – 1.0 Hz/s

NOTE: ROCOF stage is using the same low voltage blocking limit as the frequency stages.

12.3.4 Synchrocheck function

Table 12.33: Synchrocheck function Δf, ΔU, Δφ (25)

Sync mode	Off; Async; Sync;
Voltage check mode	DD; DL; LD; DD/DL; DD/LD; DL/LD; DD/DL/LD
CB closing time	0.04 – 0.6 s
U_{DEAD} limit setting	10 – 120 %U_N
U_{LIVE} limit setting	10 – 120 %U_N
Frequency difference	0.01 – 1.00 Hz
Voltage difference	1 – 60 %U_N
Phase angle difference	2° – 90°
Request timeout	0.1 – 600.0 s
Stage operation range	46.0 – 64.0 Hz
Reset ratio (U)	0.97
Inaccuracy: - voltage - frequency - phase angle - Operating time	 ±3 %U_N ±20 mHz ±2° (when Δf < 0.2 Hz, else ±5°) ±1% or ±30 ms

NOTE: When “sync” mode is used, Δf should be less < 0.2 Hz.

12.3.5 Digital input / output card (option)

Table 12.34: Digital input / output card (option)

Number of digital inputs	4 (5)
External operating voltage	Voltage selectable in order code (same as DI nominal voltage for the relay): 1: 24 dc/ac (max 265 V)* 2: 110 dc/ac (max 265 V)* 3: 220 dc/ac (max 265 V)*
Current drain, when active	Approx. 3 mA
Number of digital outputs	(1)
Voltage withstand Continuous carry Make and carry 0.5 s Make and carry 3 s	265 V dc/ac 5 A 30 A 15 A
Breaking capacity. DC (L/R = 40 ms) at 48 V dc: at 110 V dc: at 220 V dc:	 1.0 A 0.44 A 0.22 A
Terminal block Phoenix MVSTBW or equivalent	Maximum wire dimension: 2.5 mm2 (13 – 14 awg)

* set dc/ac mode according to the used voltage in VAMPSET.

NOTE: Approximately 2 mA of current is going trough the T5 (X6:1 & X6:2) circuit even when used as a digital output. This has to be noticed when T5 is used with certain type of applications (if 2 mA is enough to control for example a breaker).

When DI/DO-option cards are ordered separately the threshold has to be modified manually on field according the description in the manual (see Chapter 11.5 Input/output card B = 4 x DI + 1 x DI/DO).

12.4 Supporting functions

Table 12.35: Disturbance recorder (DR)

Mode of recording	Saturated / Overflow
Sample rate:	
- Waveform recording	32/cycle, 16/cycle, 8/cycle
- Trend curve recording	10, 20, 200 ms 1, 5, 10, 15, 30 s 1 min
Recording time (one record)	0.1 s – 12 000 min (According recorder setting)
Pre-trigger rate	0 – 100%
Number of selected channels	0 – 12

The recording time and the number of records depend on the time setting and the number of selected channels.

Table 12.36: Voltage transformer supervision

$U_2>$ setting $I_2<$ setting	0.0 – 200.0 % (step 0.1%) 0.0 – 200.0 % (step 0.1%)
Definite time function: - Operating time	DT 0.04 – 600.00 (step 0.02s)
Reset time	< 60 ms
Reset ratio:	3% of the pick-up value
Inaccuracy: - Activation $U_2>$ - Activation $I_2<$ - Operating time at definite time function	 ±1% - unit ±1% - unit ±1% or ±30 ms

Table 12.37: Voltage sag & swell

Voltage sag limit	10 – 120 %U_N (step 1%)
Voltage swell limit	20 – 150 %U_N (step 1%)
Definite time function: - Operating time	DT 0.08 – 1.00 s (step 0.02 s)
Low voltage blocking	0 – 50 %
Reset time	< 60 ms
Reset ration: - Sag - Swell	 1.03 0.97
Block limit	0.5 V or 1.03 (3 %)
Inaccuracy: - Activation - Activation (block limit) - Operating time at definite time function	 ±0.5 V or 3% of the set value ±5% of the set value ±1% or ±30 ms

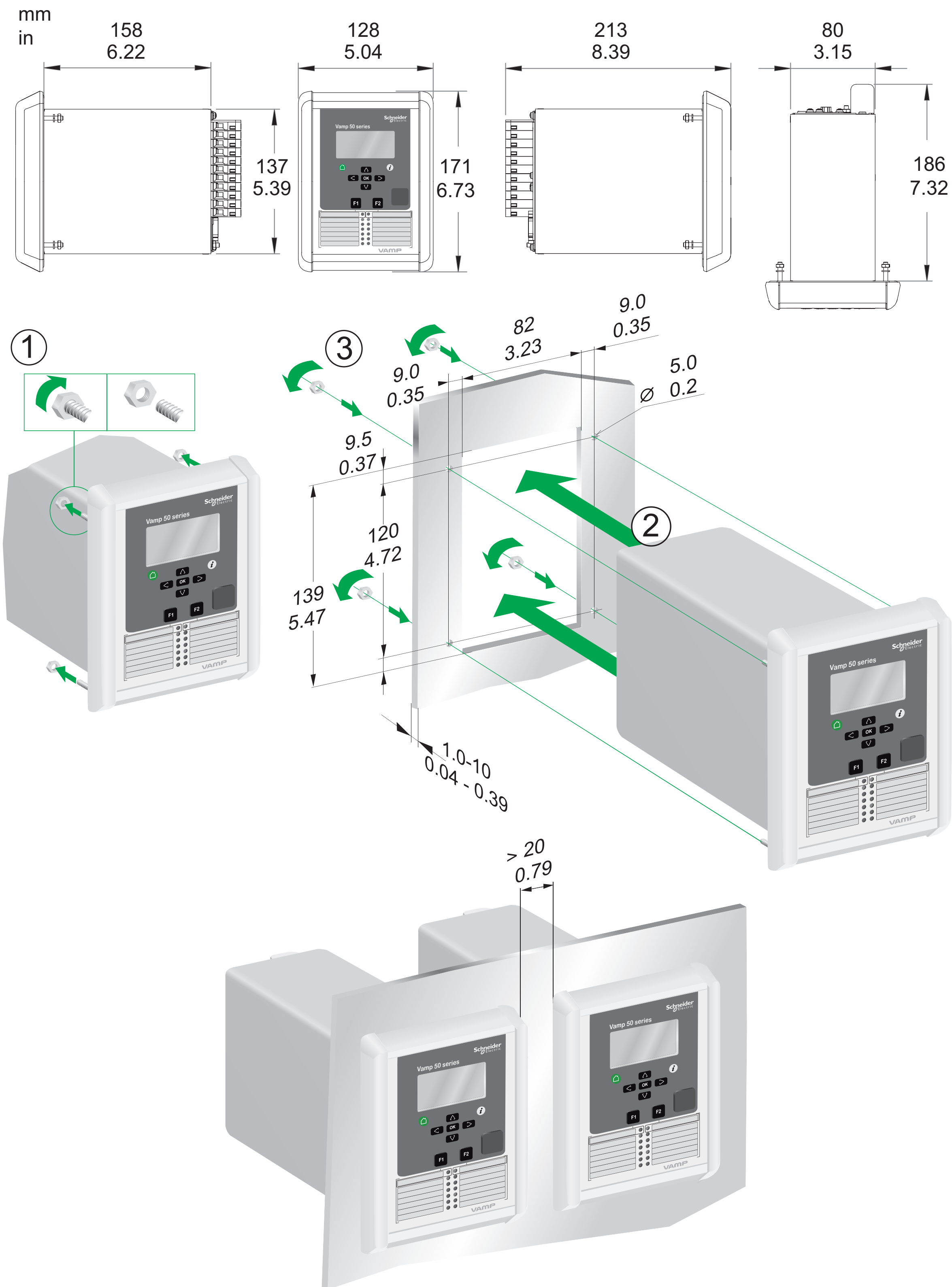
If one of the phase voltages is below sag limit and above block limit but another phase voltage drops below block limit, blocking is disabled.

Table 12.38: Voltage interruptions

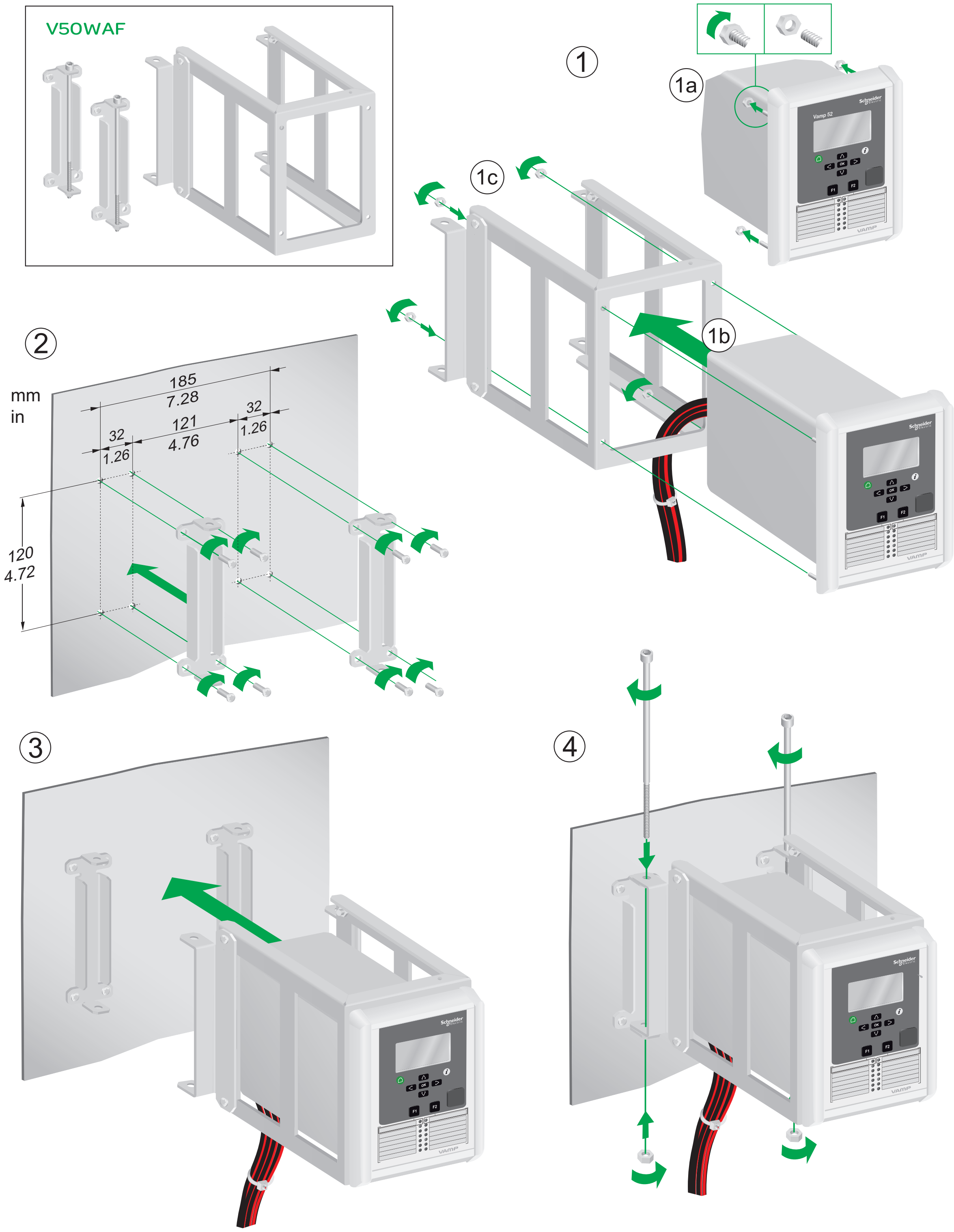
Voltage low limit (U_1)	10 – 120 %U_N (step 1%)
Definite time function: - Operating time	DT <60 ms (Fixed)
Reset time	< 60 ms
Reset ratio:	1.03
Inaccuracy: - Activation	 3% of the set value

13 Mounting

PANEL MOUNTING VAMP 50 SERIES



VAMP 50 SERIES (DEFAULT SIZE) WALL MOUNTING FRAME TYPE V50WAF



14 Order information

When ordering, please state:

- Type designation:
- Quantity:
- Options (see respective ordering code):

V55 - □ x □□□□□□ - **Voltage and Frequency Protection Relay**

Relay type
= Default

Nominal voltage [V]
4 = 50...400Vac

None

Nominal Supply Voltage [V]
A = Power A 48 - 230 V (40.. 265Vac/dc)
B = Power B 24 V (18.. 36Vdc)

mA output option
A = None
B = mA output

DI nominal activation voltage
1 = 24 Vdc / 110 Vac
2 = 110 Vdc / 220Vac
3 = 220 Vdc

Optional I/O extension modules
A = None
B = 4xDI + 1xDI/DO

Optional communication module 1
A = None
D = Plastic/Plastic serial fibre interface
E = Glass/Glass serial fibre interface
F = Rx Plastic/Tx Glass serial fibre interface
G = Rx Glass/Tx Plastic serial fibre interface
K = RJ-45 10Mbps ethernet interface and RS-232
P = Profibus interface
R = 2 x ST 100Mbps ethernet fibre interface inc. IEC 61850 (*
S = 2 x RJ-45 100Mbps ethernet interface inc. IEC 61850
B = RS 485 interface (2-wire) with option for module 2
L = RS-232 remote port inteface and support for module 2
M = RS-232 remote port interface with IRIG B and extension port and support for module 2

Optional communication module 2
A = None
B = IRIG-B time syncronisation input (**
C = RTD interface (Glass fibre) (**
E = RJ-45 10Mbps ethernet interface inc. IEC 61850 (**
G = LC 100Mbps ethernet fibre interface inc. IEC 61850 (**

Note:
(* Supply voltage has to be 110 Vac/dc or more
(** Option available only with communication module 1: B, L and M

Accessories

Order code	Description	Note
VX052-3	USB programming cable (VAMPSET)	Cable length 3m
VX054-3	Interface cable to VPA 3 CG (Profibus module) for RS 232	Cable length 3m
VX044	Interface cable to VIO 12 (RTD module)	Cable length 2 m
VSE001PP	Fibre optic Interface Module (plastic - plastic)	Max. distance 30 m
VSE001GG	Fibre optic Interface Module (glass - glass)	Max. distance 1 km
VSE001GP	Fibre optic Interface Module (glass - plastic)	Max. distance 1 km / 30 m
VSE001PG	Fibre optic Interface Module (plastic - glass)	Max. distance 30 m / 1 km
VSE002	RS485 Interface Module	
VPA3CG	External Profibus module	To be used when ethernet and profibus communication needed. Always use connection cable type VX054-3 and separate 12 V dc Auxuliary power supply to feed energy to VPA3CG. Read more in VPA3CG User's manual.
VX054-3	Interface cable to VPA 3 CG (Profibus module) for RS 232	Cable length 3m
VIO 12 AA	RTD Module, 12pcs RTD inputs, Optical Tx Communication (24-230 Vac/dc)	
VIO 12 AB	RTD Module, 12pcs RTD inputs, RS 485 Communication (24-230 Vac/dc)	
VIO 12 AC	RTD/mA Module, 12pcs RTD inputs, PTC, mA inputs/outputs, RS232, RS485 and Optical Tx/Rx Communication (24 Vdc)	
VIO 12 AD	RTD/mA Module, 12pcs RTD inputs, PTC, mA inputs/outputs, RS232, RS485 and Optical Tx/Rx Communication (48-230 Vac/dc)	
V50WAF	V50 wall assembly frame	

15 Firmware revision

10.52	First revision for the product
10.58	Two voltagemodes added: 2LL+Uo/LNy and 2LL+Uo/LLy New features in IEC 61850 added Outputs vef files with suomi & Russian language packets
10.65	3LN+Uo mode added Ucommon (fundamental component) subtracted from other channels U_f>, U1< and U1<< protection stages added
10.67	100 Mbps option card support
10.68	Default font sizes changed Popup window added for language packet init
10.74	I> and I_0> - I_0>>>> -stages with faster operation time
10.87	Maximum rated power increased to 400000 kVA from 200000 kVA Support for two instances of TCP protocols on Ethernet port Virtual output events added Ethernet/IP: mapping extensions (ExtDOs, ExtAOs and ExtAIs alarms) “get/set” added to communication ports’ protocol lists VTZsecondary VTysecondary added to scaling menu Phasor diagrams added for synchrocheck
10.97	Autoreclose: • when two CB's are used and both closed, AR is blocked • start counter is not increased after manual CB close 5th harmonic blocking stage added
10.106	GOOSE supervision signals added Automatic LED latch release added Disturbance recorder full event added Motor load current in per cent
10.108	Use of recorder memory in percents added Various additions to IEC 61850
10.116	IP and other TCP parameters are able to change without reboot Logic output numbering is not changed when changes are made in the logic **NOTE! Vampset version 2.2.97 required**
10.118	Enable sending of analog data in GOOSE message Day light saving (DST) rules added for system clock HMI changes: • Order of the first displays changed, 1.measurement, 2. mimic, 3. title • timeout does not apply if the first 3 displays are active

10.123	Stages renamed: • I_{f2}> = MAGNETISING INRUSH 68F2 • I_{f5}> = OVER EXCITATION 68F5 • P< = DIRECTIONAL POWER 32 • P<< = DIRECTIONAL POWER 32
10.127	Harmonic and waveform displays have real input channel names, not U_A - U_D IEC 101 over Ethernet ModbusTCPs and ModbusSlv can be used simultaneously
10.141	61850 File Transfer added Difference of 2 signals compare mode in programmable stage added U2> negative sequence unbalance stage added FTP passive mode added Second CB object to syncrocheck added BackUp SNTP server added "WEBSET" web server added
10.144	Possible to remove linked channels from disturbance recorder one by one UDP mode for IEC 101 over Ethernet
10.175	Support to larger flash memory Goose messages can include quality attributes Object names editable Programmable stage f measurement removed Relay name can be 10 characters long I>: Pick-up limit setting minimum value changed from 0.10 to 0.05 Number of setting groups increased from 2 to 4 When accept zero delay enabled, stages' definite operation delay can be set to 0 GOOSE operation speed improvement
10.176	Added: IEC-61850: Multiple MAC addresses for GOOSE subscriber DI for loc/rem & DI for AR enable fixed: if digital input changes states when aux power is down, the change is now detected on next boot. U_{0RMS} scaled to phase voltage
20.101	Optional parameter to set zero delay for definite time protection stage Io>>>>> with 30ms operation time

20.103	IEC-61850: Multiple MAC addresses for GOOSE subscriber N> & T> Estimated time to allow restart' added to MeasList (available in MIMIC and Local panel measurement displays) U_{0RMS} scaled to phase voltage SerNo label and description changed to VID DeviceID label and description changed to s/n IEC61850: Group switch LNs for Group 3/4 added IEC61850: General trip information (all stages) in PTRC LN IEC61850: Ethernet communication channels have LNs to indicate link down Support for info field in logic Function buttons, digital inputs and logic outputs' descriptions can be renamed. Renamed descriptions appear also in logic.
20.104	Support for user configurable self diagnostic Common set group information now available in MIMIC

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Publication version: V55/en M/A011

Publishing: Schneider Electric
02/2017