VAMP 259

Line manager

Operation and configuration instructions

Technical description

Table of Contents

1. General

This first part (Operation and configuration) of the publication contains general descriptions of the functions as well as operation instructions. It also includes instructions for parameterization and configuration of the relay and instructions for changing settings.

The second part (Technical description) of the publication includes detailed protection function descriptions as well as application examples and technical data sheets.

The Mounting and Commissioning Instructions are published in a separate publication with the code VMMC.EN0xx.

1.1. 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.

List of protection functions

IEEE/ ANSI code	IEC symbol	Function name
Main protection functions		
21	Z<	Short circuit distance protection
21N	Ze<	Earth-Fault distance protection
87	dI>	Line differential protection
85		Pilot signalling
Back-up protection functions		
67	$I_{dir}>$, $I_{dir}>>$, $I_{dir}>>>$, $I_{dir}>>>>$	Directional overcurrent protection
67N	$I_{0\varphi}>$, $I_{0\varphi}>>$	Directional earth fault protection
50/51	3I>, 3I>>, 3I>>>	Non directional overcurrent protection
50N/51N	$I_0>$, $I_0>>$, $I_0>>>$, $I_0>>>>$	Non directional earth fault protection
Supporting functions		
79	0 → 1	Autoreclosing
25	Δf, ΔU, Δφ	Synchrocheck
50ARC/ 50NARC	ArcI>, ArcIO>	Optional arc fault protection
50BF	CBFP	Circuit-breaker failure protection
81R	df/dt	Rate of change of frequency (ROCOF) protection
46R	$I_2/I_1>$	Broken line protection
37	I<	Undercurrent protection
59N	$U_0>$, $U_0>>$	Zero sequence voltage protection
49	T>	Thermal overload protection
59	U>, U>>, U>>>	Overvoltage protection
27	U<, U<<, U<<<	Undervoltage protection
32	P<, P<<	Reverse and underpower protection

IEEE/ ANSI code	IEC symbol	Function name
Supporting functions		
81H/81L	f><, f>><<	Overfrequency and underfrequency protection
81L	f<, f<<	Underfrequency 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 and DNP 3.0.

1.2. 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 serial port on the front panel or on the rear panel of the relay (both cannot be used simultaneously)
- Via remote control over the remote control port on the relay rear panel.

1.3. Operating Safety

The terminals on the rear panel of the relay may carry dangerous voltages, even if the auxiliary voltage is switched off. A live current transformer secondary circuit must not be opened. **Disconnecting a live circuit may cause dangerous voltages!** Any operational measures must be carried out according to national and local handling directives and instructions.

Carefully read through all operation instructions before any operational measures are carried out.

2. Local panel user interface

2.1. Front panel

The figure below shows, as an example, the front panel of VAMP 259 and the location of the user interface elements used for local control.

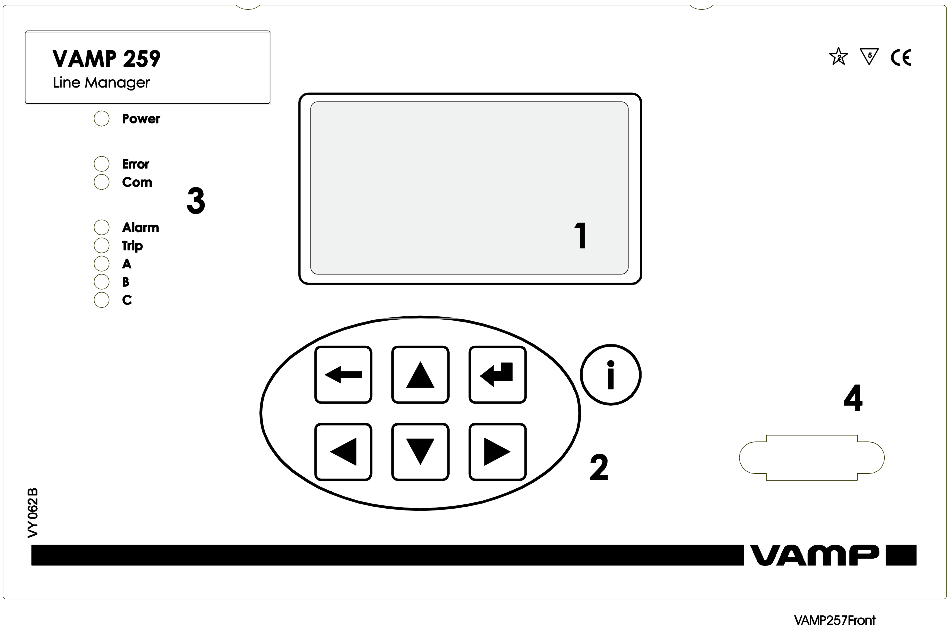


Figure 2.1-1. The front panel of VAMP 259

1. LCD dot matrix display
2. Keypad
3. LED indicators
4. RS 232 serial communication port for PC

2.1.1. Display

The relay is provided with a backlightedt 128x64 LCD dot matrix display. The display enables showing 21 characters in 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 2.1.1-1). The other purpose is to show the configuration and parameterization values of the relay (Figure 2.1.1-2).

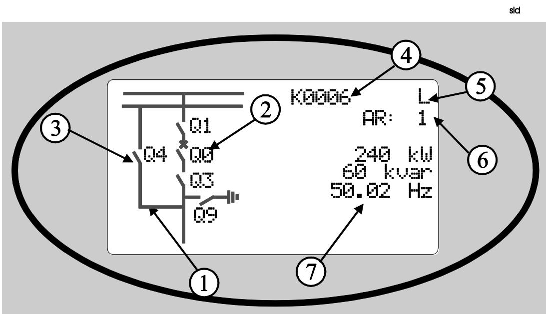


Figure 2.1.1-1 Sections of the LCD dot matrix display

1. Freely configurable single-line diagram
2. Five controllable objects
3. Six object statuses
4. Bay identification
5. Local/Remote selection
6. Auto-reclose on/off selection (if applicable)
7. Freely selectable measurement values (max. six values)

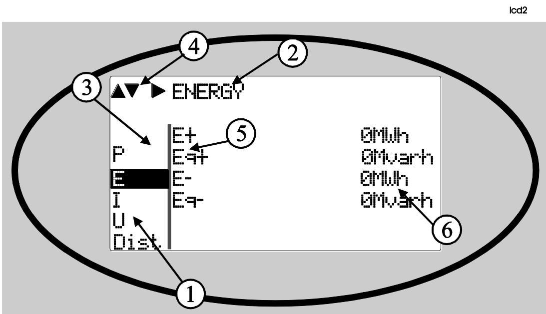


Figure 2.1.1-2 Sections of the LCD dot matrix display

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. Menu navigation and pointers

1. Use the arrow keys UP and DOWN to move up and down in the main menu, that is, on the left-hand side of the display. The active main menu option is indicated with a cursor. The options in the main menu items are abbreviations, e.g. Evnt = events.
2. After any selection, the arrow symbols in the upper left corner of the display show the possible navigating directions (applicable navigation keys) in the menu.
3. The name of the active submenu and a possible ANSI code of the selected function are shown in the upper part of the display, e.g. CURRENTS.
4. Further, each display holds the measured values and units of one or more quantities or parameters, e.g. Ilmax 300A.

2.1.3. Keypad

You can navigate in the menu and set the required parameter values using the keypad and the guidance given in the display. Furthermore, the keypad is used to control objects and switches on the single line diagram display. The keypad is composed of four arrow keys, one cancel key, one enter key and one info key.

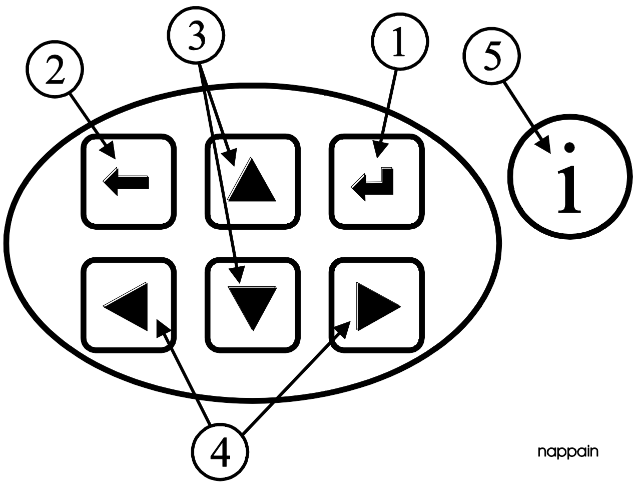


Figure 2.1.3-1 Keys on the keypad

1. Enter and confirmation key (ENTER)
2. Cancel key (CANCEL)
3. Up/Down [Increase/Decrease] arrow keys (UP/DOWN)
4. Keys for selecting submenus [selecting a digit in a numerical value] (LEFT/RIGHT)
5. Additional information key (INFO)

NOTE! The term, which is used for the buttons in this manual, is inside the brackets.

2.1.4. Operation Indicators

The relay is provided with eight LED indicators:

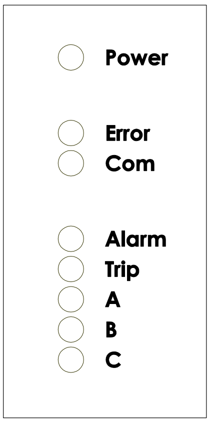


Figure 2.1.4-1. Operation indicators of the relay

LED indicator	Meaning	Measure/ Remarks
Power LED lit	The auxiliary power has been switched on	Normal operation state
Error 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.
Com LED lit or flashing	The serial bus is in use and transferring information	Normal operation state
Alarm LED lit	One or several signals of the output relay matrix have been assigned to output LA and the output has been activated by one of the signals. (For more information about output matrix, please see chapter 2.4.5).	The LED is switched off when the signal that caused output Al to activate, e.g. the START signal, is reset. The resetting depends on the type of configuration, connected or latched.
Trip LED lit	One or several signals of the output relay matrix have been assigned to output Tr, and the output has been activated by one of the signals. (For more information about output relay configuration, please see chapter 2.4.5).	The LED is switched off when the signal that caused output Tr to activate, e.g. the TRIP signal, is reset. The resetting depends on the type of configuration, connected or latched.
A- C LED lit	Application-related status indicators.	Configurable

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 the CANCEL key for approx. 3 s. Then reset the latched indicators and output relays by pushing the ENTER key.
- Acknowledge each event in the alarm list one by one by pushing the ENTER key equivalent times. Then, in the initial display, reset the latched indicators and output relays by pushing the ENTER key.

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

2.1.5. 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**.

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 one of the local communication ports. Some parameters are factory-set.

2.2.1. Navigating in menus

All the menu functions are based on the main menu/submenu structure:

1. Use the arrow keys UP and DOWN to move up and down in the main menu.
2. To move to a submenu, repeatedly push the RIGHT key until the required submenu is shown. Correspondingly, push the LEFT key to return to the main menu.
3. Push the ENTER key to confirm the selected submenu. If there are more than six items in the selected submenu, a black line appears to the right side of the display (Figure 2.2.1-1). It is then possible to scroll down in the submenu.

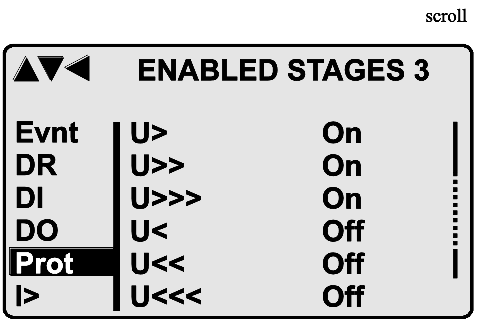


Figure 2.2.1-1. Example of scroll indication

4. Push the CANCEL key to cancel a selection.
5. Pushing the UP or DOWN key in any position of a sub-menu, when it is not selected, brings you directly one step up or down in the main menu.

The active main menu selection is indicated with black back-ground color. The possible navigating directions in the menu are shown in the upper-left corner by means of black triangular symbols.

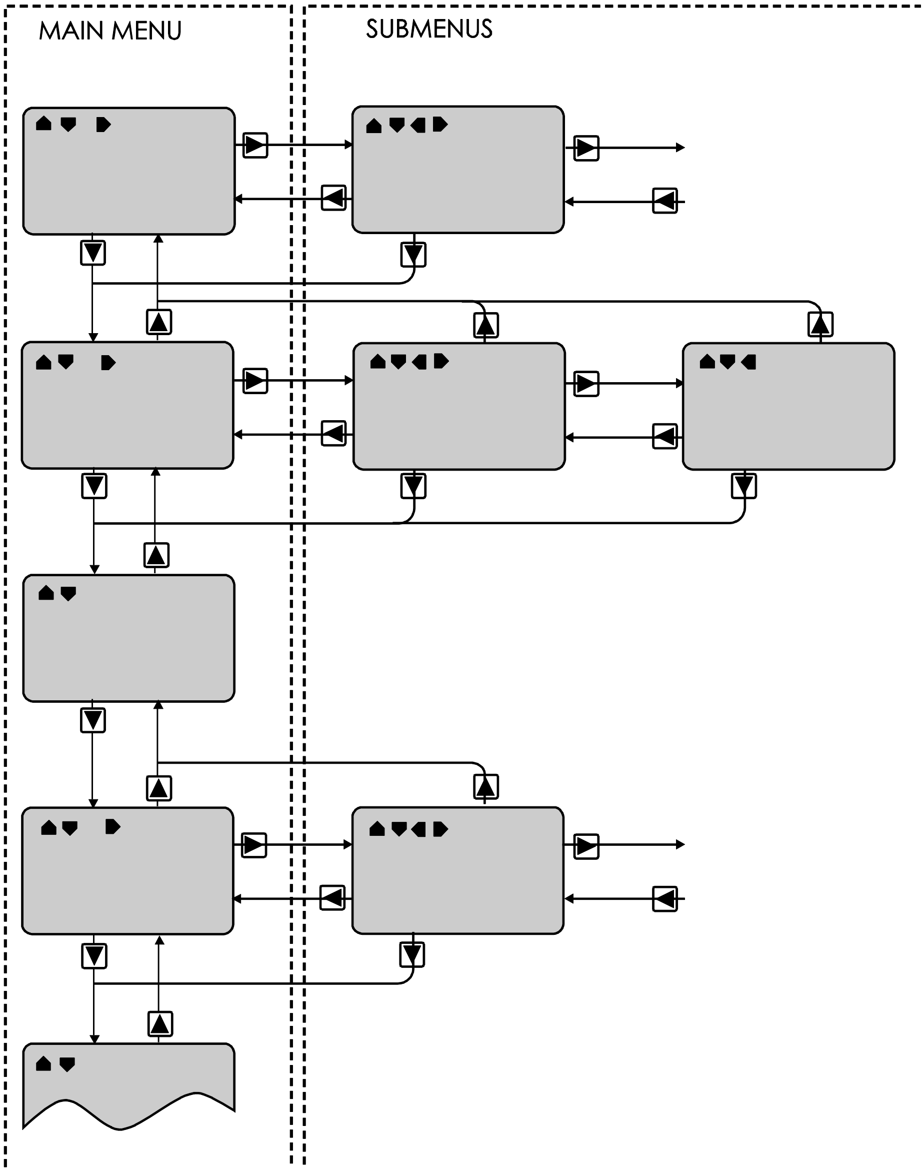


Figure 2.2.1-2. Principles of the menu structure and navigation in the menus

6. Push the INFO key to obtain additional information about any menu item.
7. Push the CANCEL key to revert to the normal display.

Main menu

The general menu structure is shown in Figure 2.2.1-2. 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.		
P	14	Power measurements		
E	4	Energy measurements		
I	13	Current measurements		
U	15	Voltage measurements		
Dema	15	Demand values		
Umax	5	Time stamped min & max of voltages		
Imax	9	Time stamped min & max of currents		
Pmax	5	Time stamped min & max of power and frequency		
Mont	21	Maximum values of the last 31 days and the last twelve months		
Evnt	2	Events		
DR	2	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	3	External analogue inputs		3
ExDI	3	External digital inputs		3
ExDO	3	External digital outputs		3
Prot	27	Protection counters, combined overcurrent status, protection status, protection enabling, cold load and inrush detectionIf2> and block matrix		
DIST	1	Common settings for distance zones (Z1 … Z5)		

Main menu	Number of menus	Description	ANSI code	Note
Z1<	6	Short circuit distance zone 1	21	4
Z2<	6	Short circuit distance zone 2	21	4
Z3<	6	Short circuit distance zone 3	21	4
Z4<	6	Short circuit distance zone 4	21	4
Z5<	6	Short circuit distance zone 5	21	4
Ze1<	6	Earth fault distance zone	21N	4
Ze2<	6	Earth fault distance zone	21N	4
Ze3<	6	Earth fault distance zone	21N	4
Ze4<	6	Earth fault distance zone	21N	4
Ze5<	6	Earth fault distance zone	21N	4
LdI>	4	Line differential stage	87	4
I>	5	1st overcurrent stage	50/51	4
I>>	3	2nd overcurrent stage	50/51	4
I>>>	3	3rd overcurrent stage	50/51	4
Iφ>	6	1st directional overcurrent stage	67	4
Iφ>>	6	2nd directional overcurrent stage	67	4
Iφ>>>	4	3rd directional overcurrent stage	67	4
Iφ>>>>	4	4th directional overcurrent stage	67	4
I<	3	Undercurrent stage	37	4
I2>	3	Current unbalance stage	46	4
T>	3	Thermal overload stage	49	4
Io>	5	1st earth fault stage	50N/51N	4
Io>>	3	2nd earth fault stage	50N/51N	4
Io>>>	3	3rd earth fault stage	50N/51N	4
Io>>>>	3	4th earth fault stage	50N/51N	4
Ioφ>	6	1st directional earth fault stage	67N	4
Ioφ>>	6	2nd directional earth fault stage	67N	4
U>	4	1st overvoltage stage	59	4
U>>	3	2nd overvoltage stage	59	4
U>>>	3	3rd overvoltage stage	59	4
U<	4	1st undervoltage stage	27	4
U<<	3	2nd undervoltage stage	27	4
U<<<	3	3rd undervoltage stage	27	4
Uo>	3	1st residual overvoltage stage	59N	4
Uo>>	3	2nd residual overvoltage stage	59N	4
P<	3	1st reverse and underpower stage	32	4
P<<	3	2nd reverse and underpower stage	32	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

Main menu	Number of menus	Description	ANSI code	Note
f<<	4	2nd underfrequency stage	81L	4
dfdt	3	Rate of change of frequency (ROCOF) stage	81R	4
Prg1	3	1st programmable stage		4
Prg2	3	2nd programmable stage		4
Prg3	3	3rd programmable stage		4
Prg4	3	4th programmable stage		4
Prg5	3	5th programmable stage		4
Prg6	3	6th programmable stage		4
Prg7	3	7th programmable stage		4
Prg8	3	8th programmable stage		4
If2>	3	Second harmonic O/C stage	51F2	4
CBFP	3	Circuit breaker failure protection	50BF	4
CBWE	4	Circuit breaker wearing supervision		4
AR	15	Auto-reclose	79	
CTSV	1	CT supervisor		4
VTSV	1	VT supervisor		4
ArcI>	4	Optional arc protection stage for phase-to-phase faults and delayed light signal.	50ARC	4
ArcIo>	3	Optional arc protection stage for earth faults. Current input = I01	50NARC	4
OBJ	11	Object definitions		5
Lgic	2	Status and counters of user's logic		1
CONF	10+2	Device setup, scaling etc.		6
Bus	13	Serial port and protocol configuration		7
Diag	6	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.. Their position or status can be displayed and controlled in the interactive mimic display.

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.

2.2.2. 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.

First menu of I>> 50/51 stage

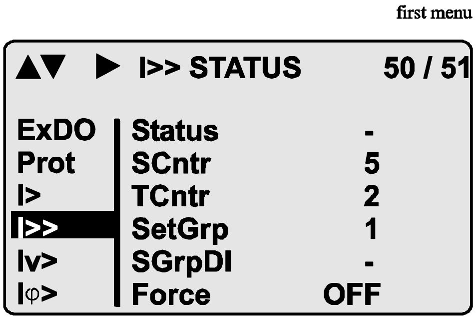


Figure 2.2.2-1 First menu of I>> 50/51 stage

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

- Status –

  The stage is not detecting any fault at the moment. The stage can also be forced to pick-up or trip if the operating level is "Configurator" and the force flag below is on. Operating levels are explained in chapter 2.2.5.

- SCntr 5

  The stage has picked-up a fault five times since the last reset of restart. This value can be cleared if the operating level is at least "Operator".

- TCntr 1

  The stage has tripped two times since the last reset of 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 2.2.3.

- 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.

Second menu of I>> 50/51 stage

second menu

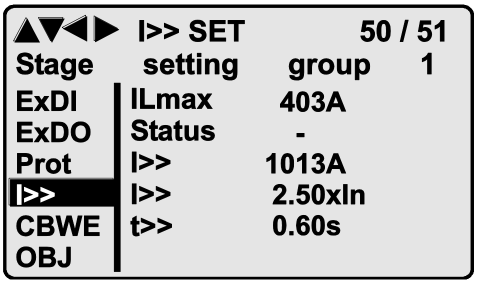


Figure 2.2.2-2. Second menu (next on the right) of I>> 50/51 stage

This is the main setting menu. The content is:

- Stage setting group 1

  These are the group 1 setting values. The other setting group can be seen by pressing push buttons ENTER and then RIGHT or LEFT. Setting groups are explained in chapter 2.2.3.

- ILmax 403A

  The maximum of the 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>> 2.50xIn

  The pick-up limit is 2.50 times the rated current of the CT or motor depending on the application mode in use. This value can be edited if the operating level is at least "Operator". Operating levels are explained in chapter 2.2.5.

- 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".

Third menu of I>> 50/51 stage

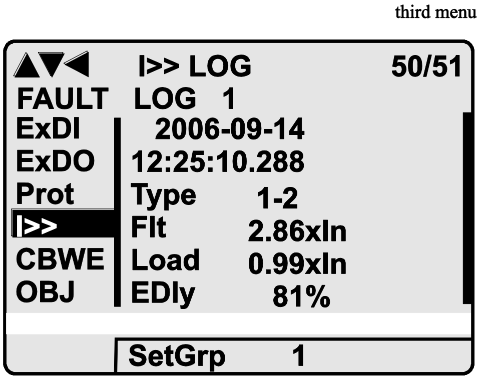


Figure 2.2.2-3. Third and last menu (next on the right) of I>> 50/51 stage

This is the menu for registered values by the I>> stage. Fault logs are explained in chapter 2.2.4.

- FAULT LOG 1

  This is the latest of the eight available logs. You may move between the logs by pressing push buttons ENTER and then RIGHT or LEFT.
- 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 2.86xIn

  The fault current has been 2.86 per unit.
- Load 0.99xIn

  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 than the delay setting.
- SetGrp 1

  The setting group has been 1. This line can be reached by pressing ENTER and several times the DOWN button.

2.2.3. Setting groups

Most of the protection functions of the relay have two 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 2.2.3-1 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.

group1

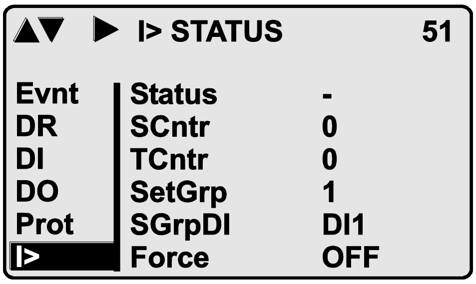


Figure 2.2.3-1. Example of protection submenu with setting group parameters

The changing of the setting parameters can be done easily. When the desired submenu has been found (with the arrow keys), press the ENTER key to select the submenu. Now the selected setting group is indicated in the down-left corner of the display (See Figure 2.2.3-2). Set1 is setting group one and Set2 is setting group two. When the needed changes, to the selected setting group, have been done, press the LEFT or the RIGHT key to select another group (the LEFT key is used when the active setting group is 2 and the RIGHT key is used when the active setting group is 1).

group2

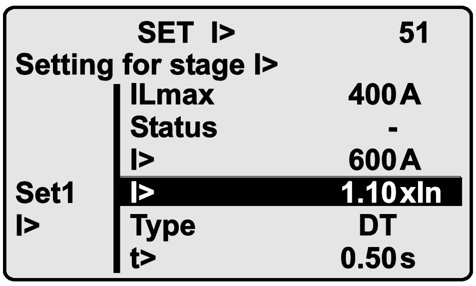


Figure 2.2.3-2. Example of I> setting submenu

2.2.4. 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. 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 (See Figure 2.2.4-1).

log1

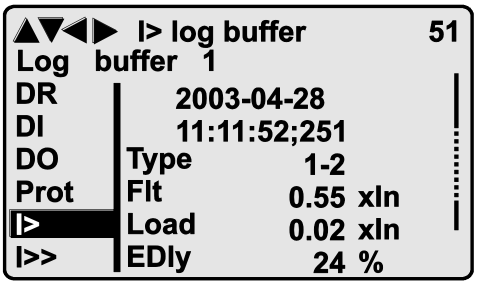


Figure 2.2.4-1. Example of fault log

To see the values of, for example, log two, press the ENTER key to select the current log (log one). The current log number is then indicated in the down-left corner of the display (See Figure 2.2.4-2, Log2 = log two). The log two is selected by pressing the RIGHT key once.

log2

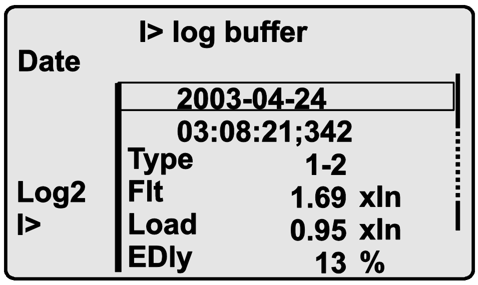


Figure 2.2.4-2. Example of selected fault log

2.2.5. 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 ENTER
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 ENTER
Closing:	The level is automatically closed after 10 minutes idle time. Giving the password 9999 can also close the level.

Opening access

1. Push the INFO key and the ENTER key on the front panel.

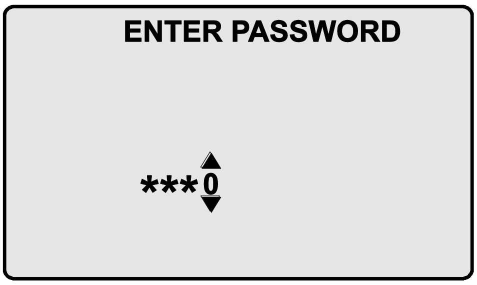


Figure 2.2.5-1. Opening the access level

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 the RIGHT key and then setting the desired digit value using the UP key.
3. Push the ENTER key.

Password handling

The passwords can only be changed using VAMPSET software connected to the local RS-232 port on 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 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 vampsupport@vamp.fi 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 VAMP Ltd.)

Now the passwords are restored to the default values (See chapter 2.2.5).

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 page 22 Opening access.

Toggling Local/Remote control

1. Push the ENTER key. The previously activated object starts to blink.
2. Select the Local/Remote object ("L" or "R" squared) by using the arrow keys.
3. Push the ENTER key. 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 the ENTER key. The Local/Remote state will change.

Object control

1. Push the ENTER key. The previously activated object starts to blink.
2. Select the object to control by using the arrow keys. Please note that only controllable objects can be selected.
3. Push the ENTER key. A control dialog opens.
4. Select the "Open" or "Close" command by using the UP and DOWN arrow keys.
5. Confirm the operation by pushing the ENTER key. The state of the object changes.

Toggling virtual inputs

1. Push the ENTER key. 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 P, E, I and U menus and their 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. Impedance measurements (Z12, Z23, Z31) are located in distance stage displays.

Value	Menu/Submenu	Description
P	P/POWER	Active power [kW]
Q	P/POWER	Reactive power [kvar]
S	P/POWER	Apparent power [kVA]
φ	P/POWER	Active power angle [°]
P.F.	P/POWER	Power factor [ ]
f	P/POWER	Frequency [Hz]
Pda	P/15 MIN POWER	Active power [kW]
Qda	P/15 MIN POWER	Reactive power [kvar]
Sda	P/15 MIN POWER	Apparent power [kVA]
Pfda	P/15 MIN POWER	Power factor [ ]
fda	P/15 MIN POWER	Frequency [Hz]
PL1	P/POWER/PHASE 1	Active power of phase 1 [kW]
PL2	P/POWER/PHASE 1	Active power of phase 2 [kW]
PL3	P/POWER/PHASE 1	Active power of phase 3 [kW]
QL1	P/POWER/PHASE 1	Reactive power of phase 1 [kvar]
QL2	P/POWER/PHASE 1	Reactive power of phase 2 [kvar]
QL3	P/POWER/PHASE 1	Reactive power of phase 3 [kvar]
SL1	P/POWER/PHASE 2	Apparent power of phase 1 [kVA]
SL2	P/POWER/PHASE 2	Apparent power of phase 2 [kVA]
SL3	P/POWER/PHASE 2	Apparent power of phase 3 [kVA]
PF_L1	P/POWER/PHASE 2	Power factor of phase 1 [ ]
PF_L2	P/POWER/PHASE 2	Power factor of phase 2 [ ]
PF_L3	P/POWER/PHASE 2	Power factor of phase 3 [ ]
cos	P/COS & TAN	Cosine phi [ ]
tan	P/COS & TAN	Tangent phi [ ]
cosL1	P/COS & TAN	Cosine phi of phase L1 [ ]
cosL2	P/COS & TAN	Cosine phi of phase L2 [ ]
cosL3	P/COS & TAN	Cosine phi of phase L3 [ ]
Iseq	P/PHASE SEQUENCIES	Actual current phase sequency [OK; Reverse; ??]
Useq	P/PHASE SEQUENCIES	Actual voltage phase sequency [OK; Reverse; ??]
Ioφ	P/PHASE SEQUENCIES	Io/Uo angle [°]
fAdop	P/PHASE SEQUENCIES	Adopted frequency [Hz]
E+	E/ENERGY	Exported energy [MWh]
Eq+	E/ENERGY	Exported reactive energy [Mvar]
E-	E/ENERGY	Imported energy [MWh]
Eq-	E/ENERGY	Imported reactive energy [Mvar]

Value	Menu/Submenu	Description
E+.nn	E/DECIMAL COUNT	Decimals of exported energy [ ]
Eq.nn	E/DECIMAL COUNT	Decimals of reactive energy [ ]
E-.nn	E/DECIMAL COUNT	Decimals of imported energy [ ]
Ewrap	E/DECIMAL COUNT	Energy control
E+	E/E-PULSE SIZES	Pulse size of exported energy [kWh]
Eq+	E/E-PULSE SIZES	Pulse size of exported reactive energy [kvar]
E-	E/E-PULSE SIZES	Pulse size of imported energy [kWh]
Eq-	E/E-PULSE SIZES	Pulse duration of imported reactive energy [ms]
E+	E/E-PULSE DURATION	Pulse duration of exported energy [ms]
Eq+	E/E-PULSE DURATION	Pulse duration of exported reactive energy [ms]
E-	E/E-PULSE DURATION	Pulse duration of imported energy [ms]
Eq-	E/E-PULSE DURATION	Pulse duration of imported reactive energy [ms]
E+	E/E-pulse TEST	Test the exported energy pulse [ ]
Eq+	E/E-pulse TEST	Test the exported reactive energy [ ]
E-	E/E-pulse TEST	Test the imported energy [ ]
Eq-	E/E-pulse TEST	Test the imported reactive energy [ ]
IL1	I/PHASE CURRENTS	Phase current IL1 [A]
IL2	I/PHASE CURRENTS	Phase current IL2 [A]
IL3	I/PHASE CURRENTS	Phase current IL3 [A]
IL1da	I/PHASE CURRENTS	15 min average for IL1 [A]
IL2da	I/PHASE CURRENTS	15 min average for IL2 [A]
IL3da	I/PHASE CURRENTS	15 min average for IL3 [A]
Io	I/SYMMETRIC CURRENTS	Primary value of zerosequence/ residual current Io [A]
IoC	I/SYMMETRIC CURRENTS	Calculated Io [A]
I1	I/SYMMETRIC CURRENTS	Positive sequence current [A]
I2	I/SYMMETRIC CURRENTS	Negative sequence current [A]
I2/I1	I/SYMMETRIC CURRENTS	Negative sequence current related to positive sequence current (for unbalance protection) [%]
THDIL	I/HARM. DISTORTION	Total harmonic distortion of the mean value of phase currents [%]
THDIL1	I/HARM. DISTORTION	Total harmonic distortion of phase current IL1 [%]
THDIL2	I/HARM. DISTORTION	Total harmonic distortion of phase current IL2 [%]
THDIL3	I/HARM. DISTORTION	Total harmonic distortion of phase current IL3 [%]

Value	Menu/Submenu	Description
Diagram	I/HARMONICS of IL1	Harmonics of phase current IL1 [%] (See Figure 2.3.2-1)
Diagram	I/HARMONICS of IL2	Harmonics of phase current IL2 [%] (See Figure 2.3.2-1)
Diagram	I/HARMONICS of IL3	Harmonics of phase current IL3 [%] (See Figure 2.3.2-1)
Uline	U/LINE VOLTAGES	Average value for the three line voltages [V]
U12	U/LINE VOLTAGES	Phase-to-phase voltage U12 [V]
U23	U/LINE VOLTAGES	Phase-to-phase voltage U23 [V]
U31	U/LINE VOLTAGES	Phase-to-phase voltage U31 [V]
UL	U(PHASE VOLTAGES	Average for the three phase voltages [V]
UL1	U/PHASE VOLTAGES	Phase-to-earth voltage UL1 [V]
UL2	U/PHASE VOLTAGES	Phase-to-earth voltage UL2 [V]
UL3	U/PHASE VOLTAGES	Phase-to-earth voltage UL3 [V]
Uo	U/SYMMETRIC VOLTAGES	Residual voltage Uo [%]
U1	U/SYMMETRIC VOLTAGES	Positive sequence voltage [%]
U2	U/SYMMETRIC VOLTAGES	Negative sequence voltage [%]
U2/U1	U/SYMMETRIC VOLTAGES	Negative sequence voltage related to positive sequence voltage [%]
THDU	U/HARM. DISTORTION	Total harmonic distortion of the mean value of voltages [%]
THDUa	U/HARM. DISTORTION	Total harmonic distortion of the voltage input a [%]
THDUb	U/HARM. DISTORTION	Total harmonic distortion of the voltage input b [%]
THDUc	U/HARM. DISTORTION	Total harmonic distortion of the voltage input c [%]
Diagram	U/HARMONICS of Ua	Harmonics of voltage input Ua [%] (See Figure 2.3.2-1)
Diagram	U/HARMONICS of Ub	Harmonics of voltage input Ub [%] (See Figure 2.3.2-1)
Diagram	U/HARMONICS of Uc	Harmonics of voltage input Uc [%] (See Figure 2.3.2-1)
Count	U/VOLT. INTERRUPTS	Voltage interrupts counter [ ]
Prev	U/VOLT. INTERRUPTS	Previous interruption [ ]
Total	U/VOLT. INTERRUPTS	Total duration of voltage interruptions [days, hours]
Prev	U/VOLT. INTERRUPTS	Duration of previous interruption [s]
Status	U/VOLT. INTERRUPTS	Voltage status [LOW; NORMAL]
Z12, Z23, Z31	Z1<, Z2<, Z3<, Z4<, Z5<	Line to line impedance (primary/sec)
Z12angle Z23angle Z31angle	Z1<, Z2<, Z3<, Z4<, Z5<	Impedance angle

harm

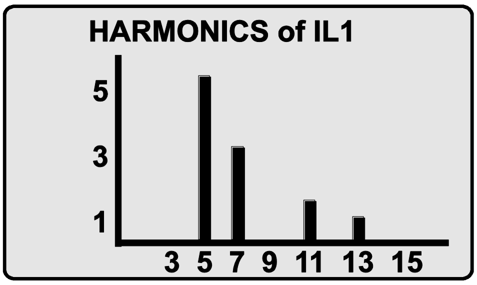


Figure 2.3.2-1. Example of harmonics bar display

2.3.3. Reading event register

The event register can be read from the Evnt submenu:

1. Push the RIGHT key 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.

event_list

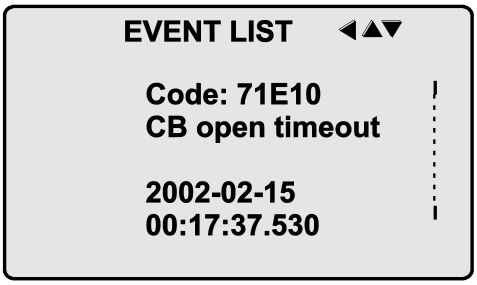


Figure 2.3.3-1. Example of an event register

3. Scroll through the event list with the UP and DOWN keys.
4. Exit the event list by pushing the LEFT key.

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 signal 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. Move to the setting state of the desired function, for example DO (see Chapter 2.4, on page 29).
2. Select the Force function (the background color of the force text is black).

force

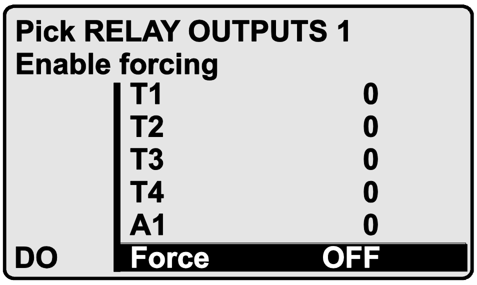


Figure 2.3.4-1. Selecting Force function

3. Push the ENTER key.
4. Push the UP or DOWN key to change the "OFF" text to "ON", that is, to activate the Force function.
5. Push the ENTER key to return to the selection list. Choose the signal to be controlled by force with the UP and DOWN keys, for instance the T1 signal.
6. Push the ENTER key to confirm the selection. Signal T1 can now be controlled by force.
7. Push the UP or DOWN key to change the selection from "0" (not alert) to "1" (alert) or vice versa.
8. Push the ENTER key to execute the forced control operation of the selected function, e.g., making the output relay of T1 to pick up.
9. Repeat the steps 7 and 8 to alternate between the on and off state of the function.
10. Repeat the steps 1...4 to exit the Force function.
11. Push the CANCEL key 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 relay 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 RS-232 serial 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 requires restarting, the display will show as Figure 2.4-1.

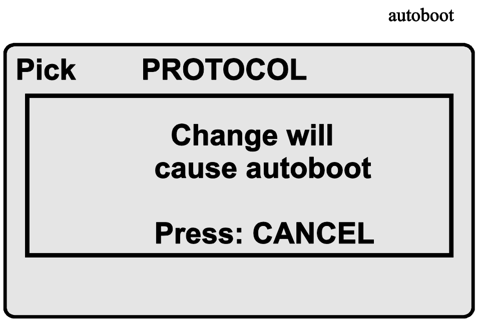


Figure 2.4-1 Example of auto-reset display

Press CANCEL to return to the setting view. If a parameter must be changed, press the ENTER key again. The parameter can now be set. When the parameter change is confirmed with the ENTER key, 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 the ENTER key. The Pick text appears in the upper-left part of the display.
2. Enter the password associated with the configuration level by pushing the INFO key and then using the arrow keys and the ENTER key (default value is 0002). For more information about the access levels, please refer to Chapter 2.2.5.
3. Scroll through the parameters using the UP and DOWN keys. 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 the ENTER key.
5. Use the UP and DOWN keys to change a parameter value. If the value contains more than one digit, use the LEFT and RIGHT keys to shift from digit to digit, and the UP and DOWN keys to change the digits.
6. Push the ENTER key to accept a new value. If you want to leave the parameter value unchanged, exit the edit state by pushing the CANCEL key.

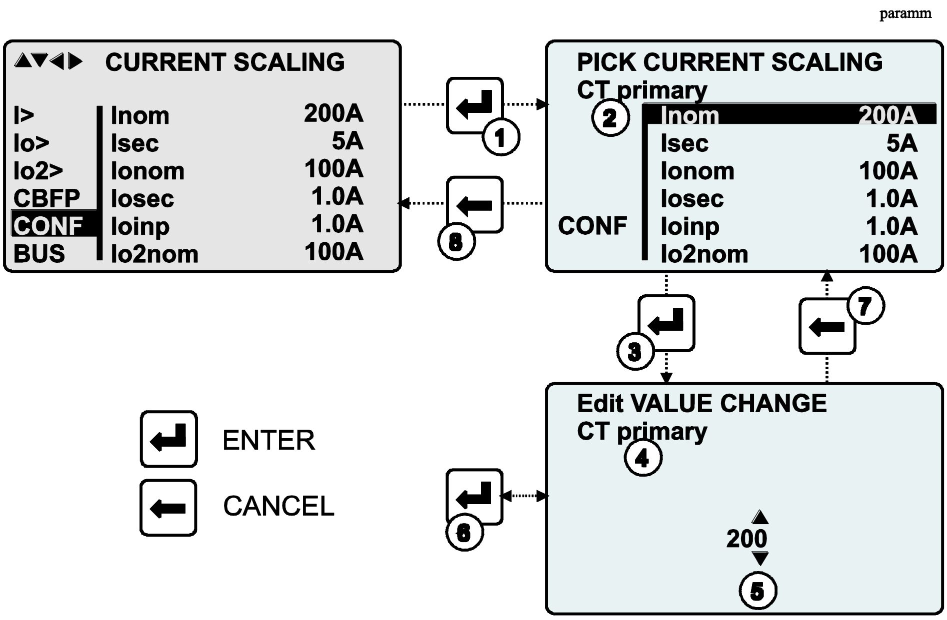


Figure 2.4.1-1.Changing parameters

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 the ENTER key. Adjust the setting to be within the allowed range.

illegal

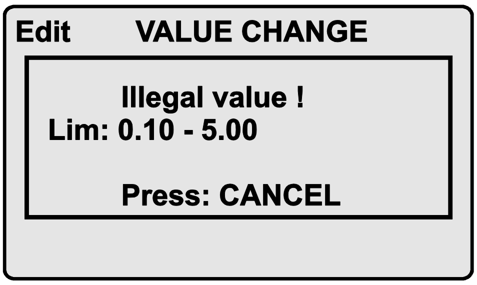


Figure 2.4.2-1 Example of a fault message

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

infoset_I

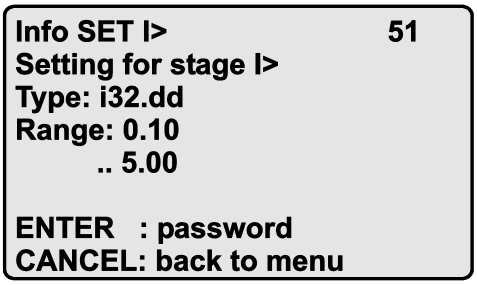


Figure 2.4.2-2. Allowed setting ranges show in the display

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 RECORDER

- Recording mode (Mode)
- Sample rate (Rate)
- Recording time (Time)
- Pre trig time (PreTrig)
- Manual trigger (MnlTrig)
- Count of ready records (ReadyRe)

REC. COUPLING

- Add a link to the recorder (AddLink)
- Clear all links (ClrLnks)

Available links:

- DO, DI
- Uline, Uphase
- IL
- U2/U1, U2, U1
- I2/In, I2/I1, I2, I1, IoCalc
- CosFii
- PF, S, Q, P
- f
- Uo
- UL3, UL2, UL1
- U31, U23, U12
- Io
- IL3, IL2, IL1
- Prms, Qrms, Srms
- Tanfii
- THDIL1, THDIL2, THDIL3
- THDUa, THDUb, THDUc
- IL1RMS, IL2RMS, IL3RMS
- ILmin, ILmax, ULLmin, ULLmax, ULNmin, ULNmax
- fy, fz, U12y, U12z

2.4.4. Configuring digital inputs DI

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

- The status of digital inputs (DIGITAL INPUTS 1-20/24/32)
- Operation counters (DI COUNTERS)
- Operation delay (DELAYs for DigIn)
- The polarity of the input signal (INPUT POLARITY). Either normally open (NO) or normally closed (NC) circuit.
- 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 OUTPUTS 1, 2, 3 and 4)
- The forcing of the output relays (RELAY OUTPUTS 1, 2, 3 and 4) (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 IF 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 and C (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. Protection menu Prot

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

- Reset all the counters (PROTECTION SET/ClAll)
- Read the status of all the protection functions (PROTECT STATUS 1-x)
- Enable and disable protection functions (ENABLED STAGES 1-x)
- 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.

2.4.7. 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 ports X4 and the front panel. The front panel is always using this setting. If SPABUS is selected for the rear panel local port X4, the bit rate is according SPABUS settings.
- Access level [Acc]

LANGUAGE

- List of available languages in the relay

CURRENT SCALING

- Rated phase CT primary current (Inom)
- Rated phase CT secondary current (Isec)
- Rated input of the relay [Iinput]. 5 A or 1 A. This is specified in the order code of the device.
- Rated value of I_0 CT primary current (Ionom)
- Rated value of I_0 CT secondary current (Iosec)
- Rated I_0 input of the relay [Ioinp]. 5 A, 1 A or 0.2 A. This is specified in the order code of the device.

The rated input values are usually equal to the rated secondary value of the CT.

The rated CT secondary may be greater than the rated input but the continuous current must be less than four times the rated input. In compensated, high impedance earthed and isolated networks using cable transformer to measure residual current I_0, it is quite usual to use a relay with 1 A or 0.2 A input although the CT is 5 A or 1A. This increases the measurement accuracy.

The rated CT secondary may also be less than the rated input but the measurement accuracy near zero current will decrease.

MOTOR CURRENTS

- Rated current of the motor

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).
- Scaling for active, reactive and apparent power [Power]. The choices are k for kW, kvar and kVA or M for MW, Mvar and MVA.

DEVICE INFO

- Device type (Type VAMP 2XX)
- 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).

2.4.8. Protocol menu Bus

There are three communication ports in the rear panel. The availability depends on the communication options (see chapter Ordering code in the technical description). In addition there is a connector in the front panel overruling the local port in the rear panel.

REMOTE PORT

- Communication protocol for remote port X5 [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.

LOCAL PORT

This port is disabled, if a cable is connected to the front panel connector.

- Communication protocol for the local port X4 [Protocol]. For VAMPSET use "None" or "SPABUS".
- 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. For VAMPSET and protocol "None" the setting is done in menu CONF/DEVICE SETUP.

PC (LOCAL/SPA BUS)

This is a second menu for local port X4. 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 X4 [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. 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 addres 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 the technical description part of the manual.

EXTERNAL I/O protocol

This is a Modbus master protocol to communicate with the extension I/O modules connected to the extension port. Only one instance of this protocol is possible.

- Bit rate [bit/s]. Default is "9600".
- Parity [Parity]. Default is "Even".

For details see the technical description part of the manual.

SPA BUS

Several instances of this protocol are possible.

- SPABUS addres 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 the technical description part of the manual.

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 the technical description part of the manual.

IEC 103 DISTURBANCE RECORDINGS

For details see the technical description part of the manual.

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].
  When configuring the Profibus master system, the length of these buffers are needed. The size of the both buffers is set indirectly when configuring the data items for Profibus.
- 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 the technical description part of the manual.

DNP3

Only one instance of this protocol is possible.

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

For further details see the technical description part of the manual.

IEC 60870-5-101

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

For further details see the technical description part of the manual.

2.4.9. Single line diagram editing

The single-line diagram is drawn with the VAMPSET software. For more information, please refer to the VAMPSET manual (VMV.EN0xx).

single line diagram

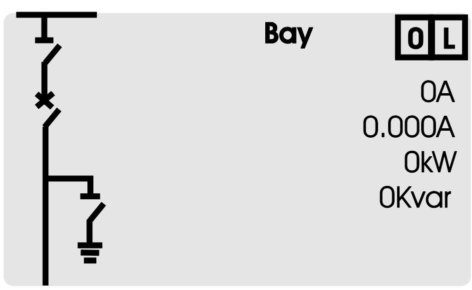


Figure 2.4.9-1. Single line diagram.

2.4.10. 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 (VMV.EN0xx).

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.

Two RS 232 serial ports are available for connecting a local PC with VAMPSET to the relay; one on the front panel and one on the rear panel of the relay. These two serial ports are connected in parallel. However, if the connection cables are connected to both ports, only the port on the front panel will be active. To connect a PC to a serial port, use a connection cable of type VX 003-3.

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

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 www.vamp.fi. For more information about the VAMPSET software, please refer to the user's manual with the code VMV.EN0xx. Also the VAMPSET user's manual is available at our web site.

Table of Contents

1. Introduction

This part of the user manual describes the protection functions, provides application examples and contains technical data.

The numerical VAMP line protection device includes as main protection full scheme distance and line differential protection functions backed up with several standard protection functions needed in protection schemes of medium voltage and sub-transmission overhead lines and cables in utilities, industry, power plants and offshore applications.

Further, the device includes several sophisticated back-up and monitoring functions, such as autoreclosing, synchrocheck, arc (option), trip circuit supervision and circuit breaker monitoring and also communication protocols for various communication solutions including native IEC 61850.

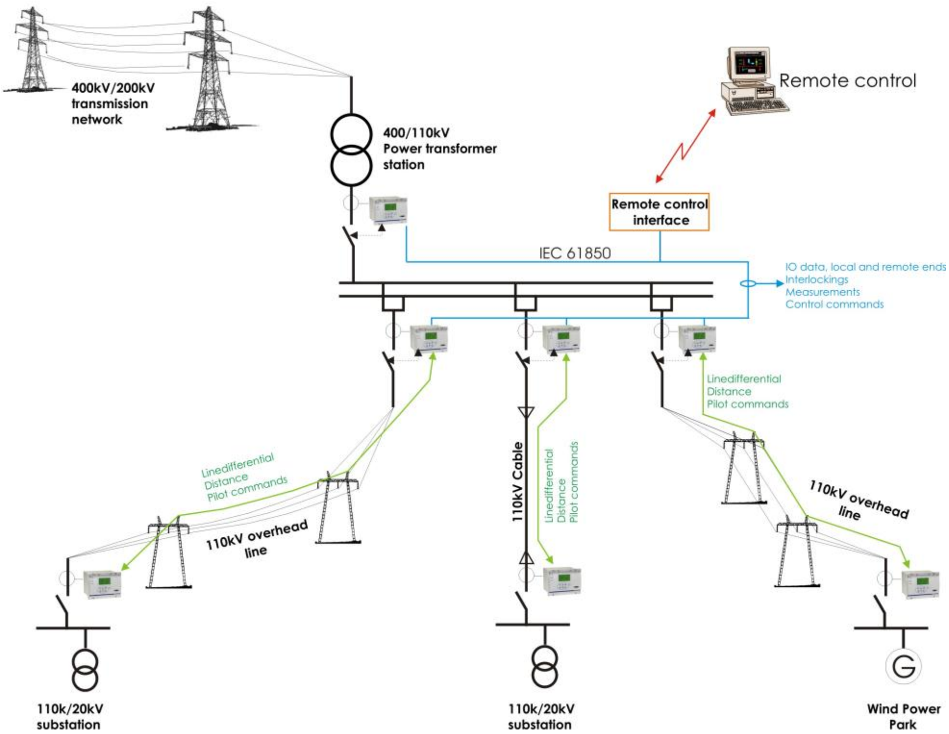


Figure 1-1. Applications of the line protection device

1.1. Main features

- Fully digital signal handling with a powerful 16-bit microprocessor, and high measuring accuracy on all the setting ranges due to an accurate 16-bit A/D conversion technique.
- Wide setting ranges for the protection functions
- Integrated fault location for short circuit faults.
- 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 six objects (e.g. circuit-breakers, disconnectors).
- Status of eight objects (e.g. circuit-breakers, disconnectors, switches).
- Freely configurable 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 a keypad and a local HMI or by means of a PC based VAMPSET user interface.
- All events and indications are in non-volatile memory.
- Easy configuration, parameterisation and reading of information via local HMI, or with a VAMPSET user interface.
- Easy connection to power plant automation system due to a versatile serial connection and several available communication protocols.
- Built-in, self-regulating ac/dc converter for auxiliary power supply from any source within the range from 40 to 265 V_{DC} or V_{AC}. The alternative power supply is for 18 to 36 V_{DC}.
- Built-in disturbance recorder for evaluating all the analogue and digital signals.

1.2. 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 signal (voltage or current) and a sample rate according to the 2^n series, the FFT technique leads to a solution, which can be realized with just 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. Therefore secondary testing of a brand new device should be started with voltage protection functions and voltage injection to let the relay learn the local frequency. However, if this is not possible then the frequency must be parameterised to the device.

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. For example, the function of the unbalanced load protection stage is based on the use of the negative phase sequence component of the current.

Figure 1.2-1 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 1.2-2 shows the heart of the numerical technology. That is the main block diagram for calculated functions.

Figure 1.2-3 shows a principle diagram of a single-phase overvoltage or overcurrent function.

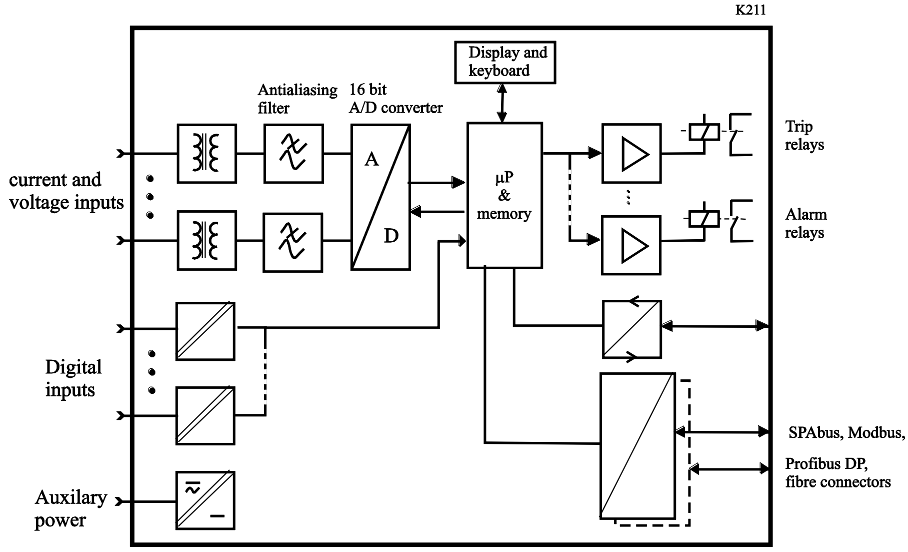


Figure 1.2-1 Principle block diagram of the VAMP hardware

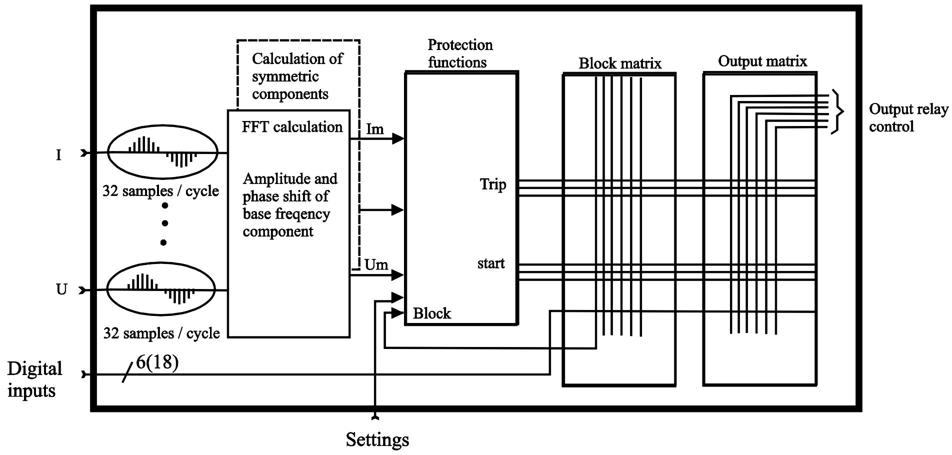


Figure 1.2-2 Block diagram of signal processing and protection software

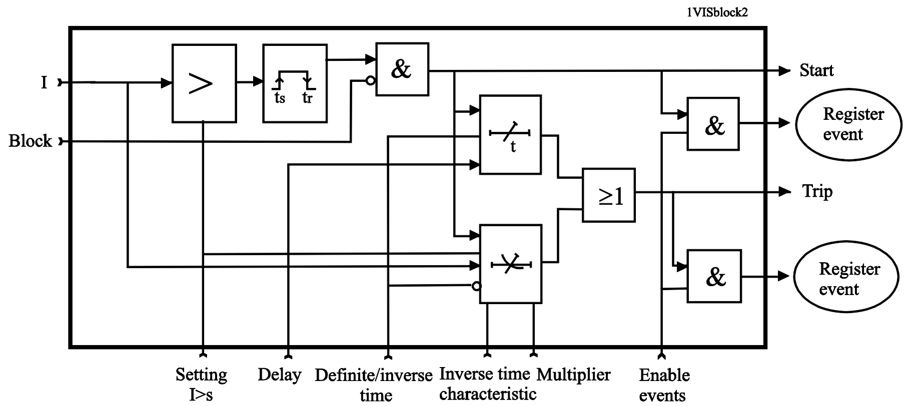


Figure 1.2-3 Block diagram of a basic protection function

2. Protection functions

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

2.1. 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 in the Operation and Configuration instruction.

2.2. List of protection functions

IEEE/ ANSI code	IEC symbol	Function name
Main protection functions		
21	Z<	Short circuit distance protection
21N	Ze<	Earth-Fault distance protection
87	dI>	Line differential protection
85		Pilot signalling
Back-up protection functions		
67	$I_{dir}>$, $I_{dir}>>$, $I_{dir}>>>$, $I_{dir}>>>>$	Directional overcurrent protection
67N	$I_{0\varphi}>$, $I_{0\varphi}>>$	Directional earth fault protection
50/51	3I>, 3I>>, 3I>>>	Non directional overcurrent protection
50N/51N	$I_0>$, $I_0>>$, $I_0>>>$, $I_0>>>>$	Non directional earth fault protection
Supporting functions		
79	0 → 1	Autoreclosing
25	Δf, ΔU, Δφ	Synchrocheck
50ARC/ 50NARC	ArcI>, ArcIO>	Optional arc fault protection
50BF	CBFP	Circuit-breaker failure protection
81R	df/dt	Rate of change of frequency (ROCOF) protection
46R	$I_2/I_1>$	Broken line protection
37	I<	Undercurrent protection
59N	$U_0>$, $U_0>>$	Zero sequence voltage protection
49	T>	Thermal overload protection
59	U>, U>>, U>>>	Overvoltage protection
27	U<, U<<, U<<<	Undervoltage protection
32	P<, P<<	Reverse and underpower protection
81H/81L	f><, f>><<	Overfrequency and underfrequency protection
81L	f<, f<<	Underfrequency protection
99	Prg1...8	Programmable stages

2.3. General features of protection stages

Setting groups

Most stages have two setting groups. Changing between setting groups can be controlled manually or using any of the digital inputs, virtual inputs, virtual outputs or LED indicator signals. By using virtual I/O the active setting group can be controlled using the local panel mimic display, any communication protocol or using the inbuilt programmable logic functions.

Forcing start or trip condition for testing

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

- Ok = '–' The stage is not detecting any fault.
- 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 example an under frequency stage is blocked if voltage is too low. For more details about block matrix, see chapter 5.5.

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 current or 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 and forcing the optional mA outputs.

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 5.4.

Blocking

Any protection function, except arc protection, can be blocked with internal and external signals using the block matrix (chapter 5.5). 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.

Some protection stages have also inbuilt blocking functions. For example under-frequency protection has inbuilt under-voltage blocking to avoid tripping when the voltage is off.

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.

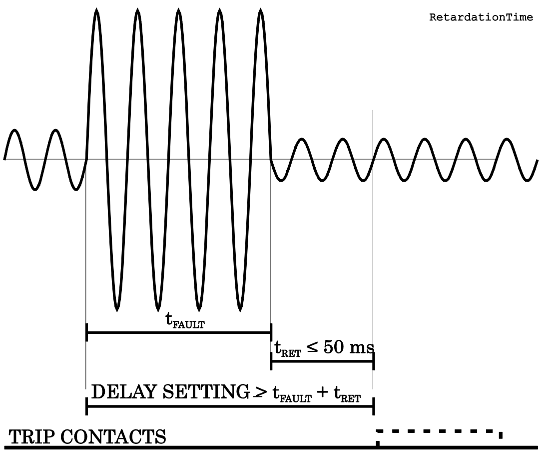


Figure 2.3-1. Definition for retardation time. If the delay setting would be slightly shorter, an unselective trip might occur (the dash line pulse).

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 2.3-1 shows an overcurrent 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 2.3-2 shows an example of reset time i.e. release delay, when the device is clearing an overcurrent fault. When the device'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 reset time varies from fault to fault depending on the fault size. After a big fault the time is longer. The reset time also depends on the specific protection stage. The maximum reset time for each stage is specified in chapter 9.3. For most stages it is less than 95 ms.

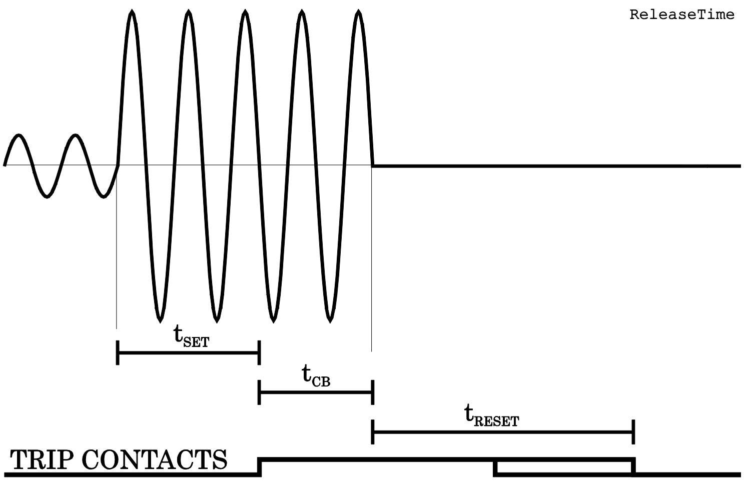


Figure 2.3-2. Reset time is the time it takes the trip or start relay contacts to open after the fault has been cleared.

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.

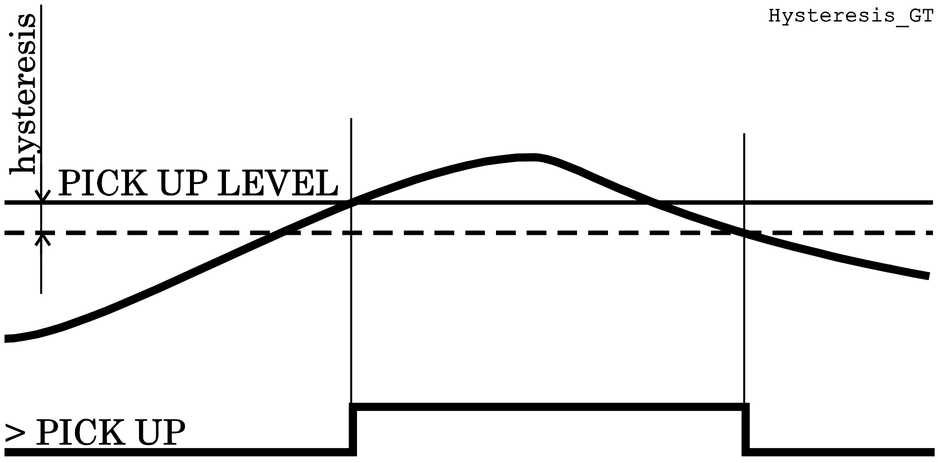


Figure 2.3-3. Behaviour of a greater than comparator. For example in overcurrent and overvoltage stages the hysteresis (dead band) acts according this figure.

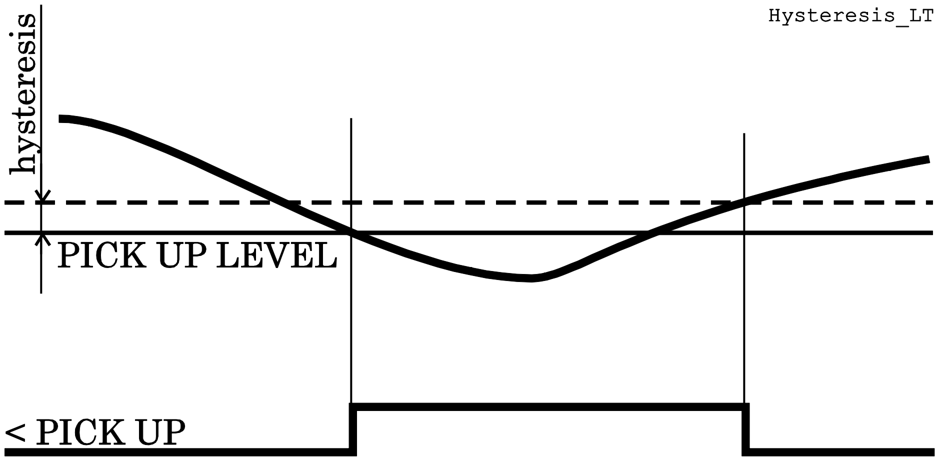


Figure 2.3-4. Behaviour of a less than comparator. For example in under-voltage and under frequency stages the hysteresis (dead band) acts according this figure.

2.4. Distance protection Z<

2.4.1. Short circuit distance protection Z< (21)

The distance protection function calculates the impedance Z = U/I of the short circuit fault loops.

If impedance is inside the tripping zone (normally presented in R-X plane), the distance function operates. In short circuit faults there are 3 possible fault loops. The VAMP distance protection function calculates the impedances of the fault loops continuously and thus separate pick-up conditions are not needed.

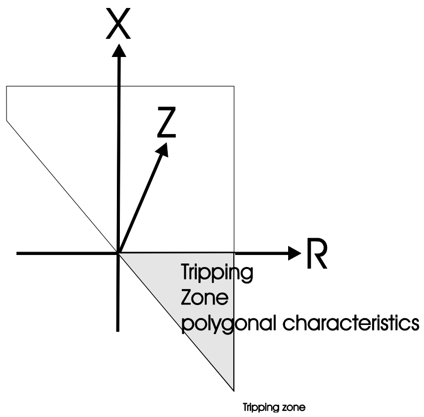


Figure 2.4.1-1 An example of tripping zone. Gray area is the tripping zone, polygonal characteristics.

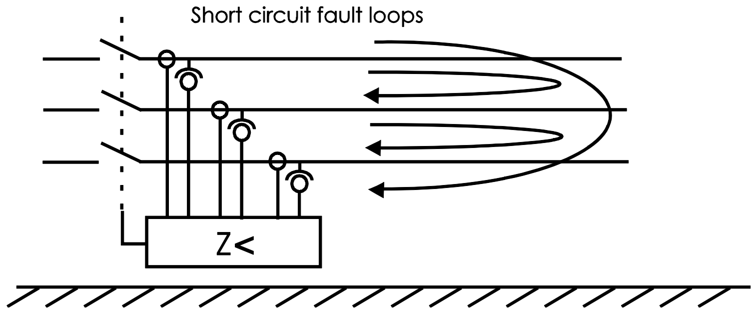


Figure 2.4.1-2 Short circuit fault loops and formulas to calculate the fault impedances.

Zones and characteristics

There are 5 zones (Z1, Z2, Z3, Z4 and Z5) for short circuit protection. These are implemented as protection stages Z1<, Z2<, Z3<, Z4< and Z5<. Z1 extension can be implemented by applying second setting group to cover the extension zone in auto-reclosing.

The distance protection's zones implement a polygonal characteristics as shown in Figure 2.4.1-3.

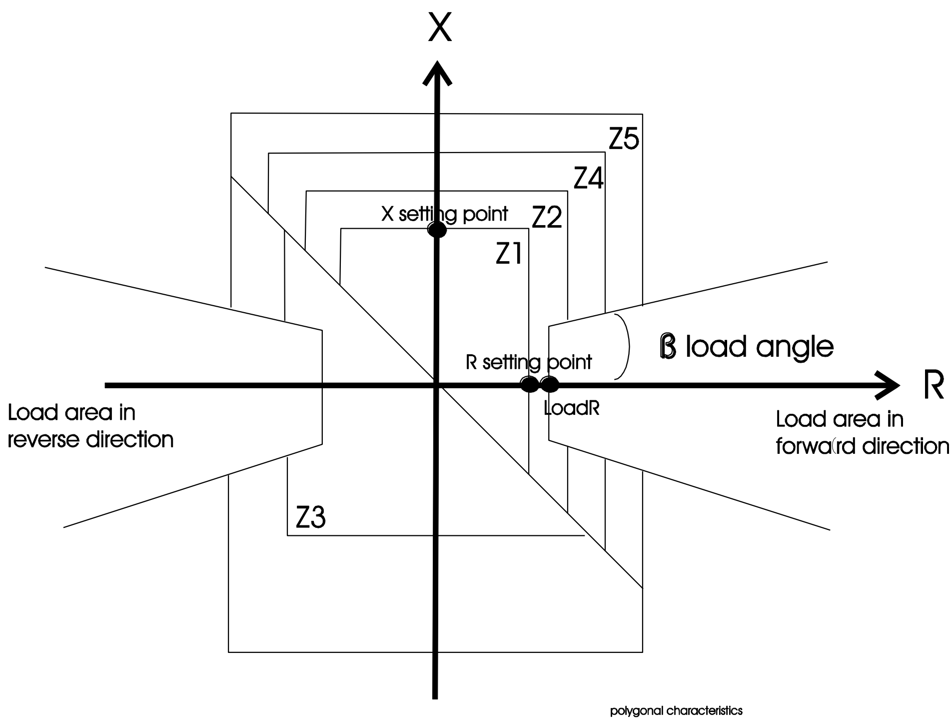


Figure 2.4.1-3 The distance protection polygonal characteristics. In this example zone 3 is in reverse direction and zone 5 is non-directional.

Parameters of the distance protection stage (21) :

Parameter	Value	Unit	Default	Description
X	0.05 .. 250.00	ohm	0.80	X-setting
R	0.05 .. 250.00	ohm	0.80	R-setting
MODE	Reverse/Forward/ Undirectional		Forward	Direction mode
t<	0.04 .. 300.00	S		Operation delay
LOAD BLOCK	No/Yes		Yes	Load block in use
Common parameters for all zones				
LoadAngle	10 .. 40	°	40	Load angle β
LoadR	0.05 .. 250.00	ohm	1.00	Load resistance

X-, R- and Load resistance settings are secondary impedances. Primary values of settings are displayed in VAMPSET and display.

Voltage memory

A 0.5 second cyclic buffer storing the phase-to-earth voltages is used as voltage memory. The stored phase angle information is used as direction reference if all the phase voltages drop below 1% during a fault.

Teleprotection signals

Signalling between two distance protection relays (teleprotection) can be implemented using the normal DI and DO signals of the relay. An external signal transfer system is needed to transfer signals from one relay to another. The signal transfer system has to have an internal signal supervision and fault indication.

The DO output signals can be activated by protection zone's start or trip signals or by the programmable logic functions.

The DI input can be used to block protection zone(s) or it can be used as input into the programmable logic of the device. Different type of permissive tripping conditions such as, permissive under reach (PUTT), permissive over reach (POTT), acceleration or blocking conditions can thus be implemented. The relay's object control can be used to trip the breaker via the "DI for remote open ctr" or "DI for local open ctr" input of the object. Outputs of the relay programmable logic can be connected to "DI for remote open crt" or "DI for local open ctr" inputs via the internal "Virtual output" signals.

2.4.2. Earth-fault distance protection Ze< (21N)

The earth-fault distance protection function calculates the impedance

$$Z_G = \frac{U}{(I + k_0 \times 3 \times I_0)}$$ of the earth-fault fault loops.

$K_0 = (Z_{0L} - Z_{1L}) / (3 \times Z_{1L})$

Z_{0L} = Zero sequence line impedance

Z_{1L} = Positive sequence line impedance

If impedance is inside the tripping zone (normally presented in R-X plane) and set I_0 current is exceeded, the distance function operates. In earth-fault faults there are 3 possible fault loops. The VAMP distance protection function calculates the impedances of the fault loops continuously and thus separate pick-up conditions are not needed.

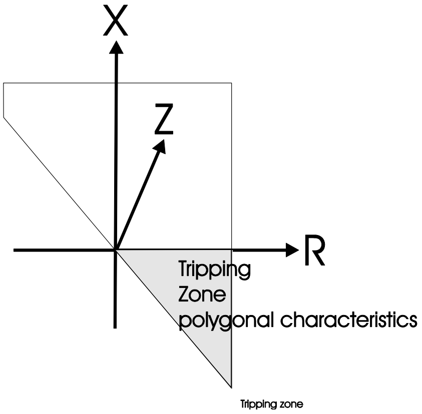


Figure 2.4.2-1 An example of tripping zone. Gray area is the tripping zone, polygonal characteristics.

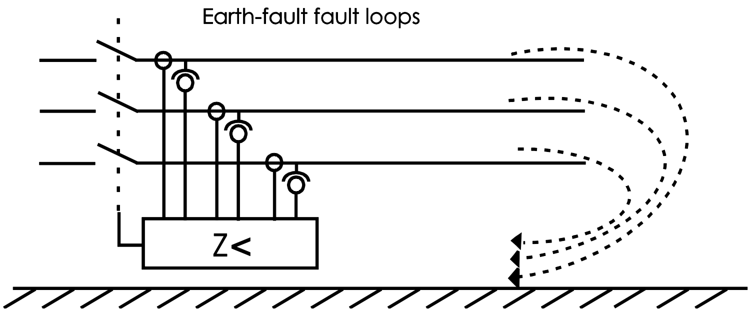


Figure 2.4.2-2 Earth-fault fault loops.

Zones and characteristics

There are 5 zones (Z1e, Z2e, Z3e, Z4e and Z5e) for earth-fault protection. These are implemented as protection stages Z1e<, Z2e<, Z3e<, Z4e< and Z5e<. Z1e extension can be implemented by applying second setting group to cover the extension zone in auto-reclosing.

The distance protection's zones implement a polygonal characteristics as shown in Figure 2.4.2-3.

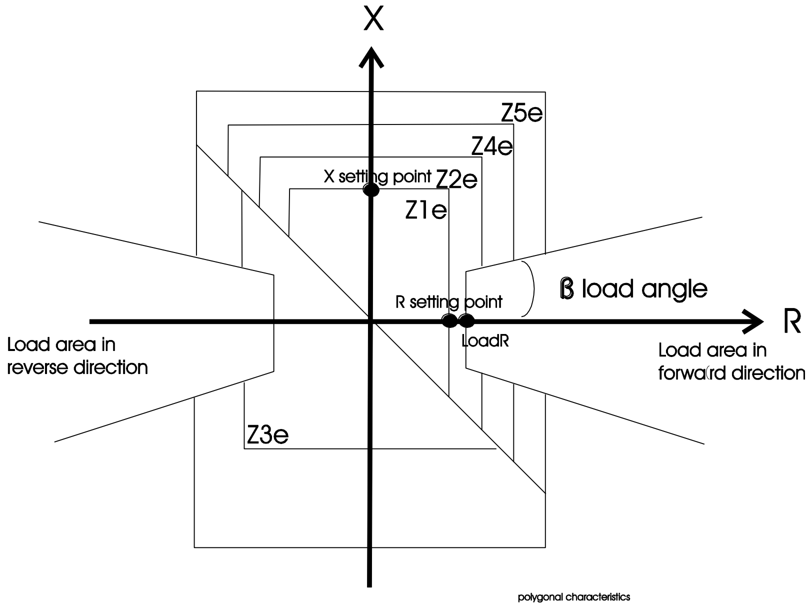


Figure 2.4.2-3 The distance protection polygonal characteristics. In this example zone 3 is in reverse direction and zone 5 is non-directional.

Parameters of the distance protection stage (21N) :

Parameter	Value	Unit	Default	Description
X	0.05 .. 250.00	ohm	0.80	X-setting
R	0.05 .. 250.00	ohm	0.80	R-setting
MODE	Reverse/Forward/ Undirectional		Forward	Direction mode
t<	0.04 .. 300.00	s		Operation delay
LOAD BLOCK	No/Yes		Yes	Load block in use
Io min input	I_0; IoCalc	-	I_0	I_0 input in use for minimum I_0 current
Io min	0.005 .. 8.000 (20.000 for IoCalc)	pu	0.050	Minimum Io current for trip
Common parameters for all zones				
LoadAngle	10 .. 40	°	40	Load angle β
LoadR	0.05 .. 250.00	ohm	1.00	Load resistance
Common parameters for all earth fault zones				
k_0	0.00 .. 10.00		0.00	Earth factor
φ (k_0)	-60 .. 60	°	10	Earth factor angle

X-, R- and Load resistance settings are secondary impedances. Primary values of settings are displayed in VAMPSET and display.

Teleprotection signals

Signalling between two distance protection relays (teleprotection) can be implemented using the normal DI and DO signals of the relay. An external signal transfer system is needed to transfer signals from one relay to another. The signal transfer system has to have an internal signal supervision and fault indication.

The DO output signals can be activated by protection zone's start or trip signals or by the programmable logic functions.

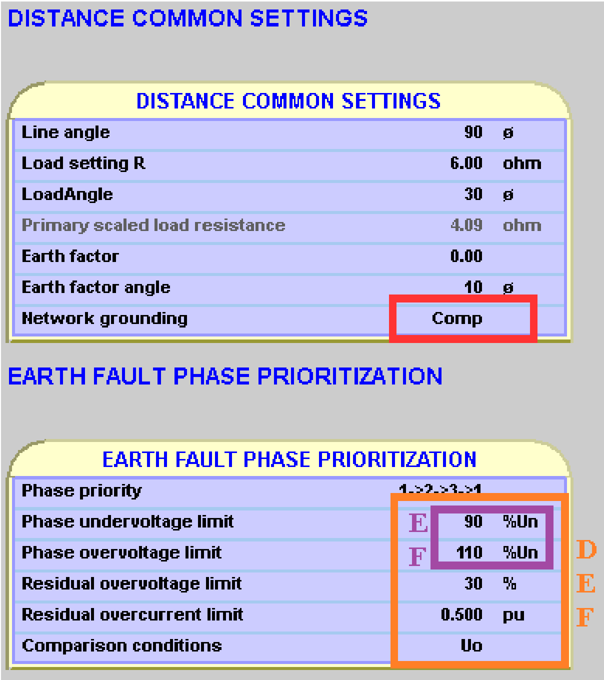
The DI input can be used to block protection zone(s) or it can be used as input into the programmable logic of the device. Different type of permissive tripping conditions such as, permissive under reach (PUTT), permissive over reach (POTT), acceleration or blocking conditions can thus be implemented. The relay's object control can be used to trip the breaker via the "DI for remote open ctr" or "DI for local open ctr" input of the object. Outputs of the relay programmable logic can be connected to "DI for remote open crt" or "DI for local open ctr" inputs via the internal "Virtual output" signals.

2.4.3. Double earth fault

Vamp 259 -line manager is equipped with DEF (Cross country fault) functionality which operates together with distance protection (21). DEF is planned to operate in compensated and isolated meshed network. The single phase to earth -fault in this case does not correspond to a short-circuit cause only a small capacitive or compensated earth-current flows. In mentioned network types system can be operated with the fixed earth-fault for several hours, until the earth fault is located and removed by the isolation of the faulted feeder. The distance protection must not operate during such single-phase earth fault. This can be ensured by using DEF –algorithm.

When small impedance earth fault occur the voltage of the faulty phase will drop and the voltage of the two other phases will increase almost to the amplitude of line to line voltage. Due the raise of phase-earth voltage, on the healthy phases in the entire system, double earth faults may result. The result is similar to two phase short-circuit, however, the short circuit is here from one earth fault location to the other via earth. The second fault may be at any other position in the galvanic connected system, depending on where the weakest point in the insulation is.

The protection strategy usually applied for double-earth faults is aimed at isolating one of the fault locations with the expectation that the second fault location will then extinguish on its own, similar to a single-phase earth-fault, or will be tripped by a hand after successful earth fault searching.

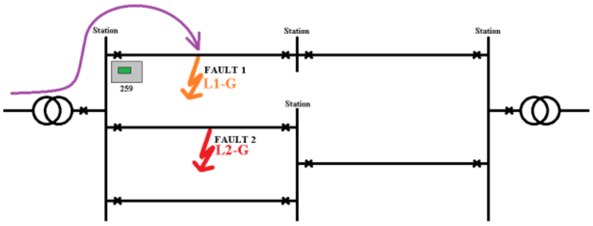


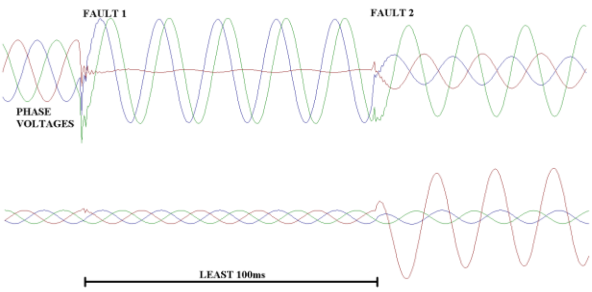
DEF –algorithm in Vamp 259 –relay is enabled together with distance protection Z1e<. Enabling is done by selecting network grounding as "Comp" compensated. When DEF -function is enabled earth fault loop Z1e< is blocked during faults as long as DEF -sequence is fulfilled.

During first earth-fault the fault is recognized due to several terms. One of the phase voltages has to drop below "Phase under-voltage limit". Two of the phase voltages need to increase above "Phase over-voltage limit". Now the relay memorises that in which phase the first earth-fault in the network appeared. In case impedance measurement goes inside the zone Z1e< during voltage drop caused by the first earth-fault the trip will be blocked.

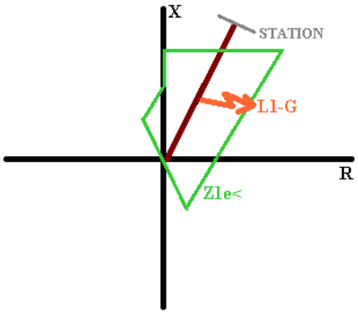
When earth fault turns into double earth fault the fault is recognized as follows. Second faulty phase has to decrease 10% below the healthy phase. Healthy phase still has to stay above the "Phase over-voltage limit". Also certain amount of zero sequence voltage (U0) is required in the final phase. Additionally if comparison condition is selected as U0_I0 also residual current has to exceed the set limit.

Fault L1-G inside zone Z1e<





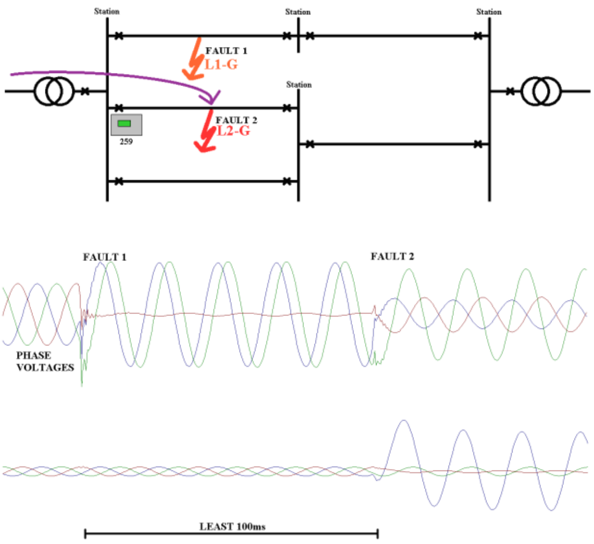
Fault is noticed since one of the voltages in the network area is dropped below the set "Phase under-voltage limit" limit and two other voltages are increasing above the set "Phase over-voltage limit" limit. This phase has to last least 100ms.



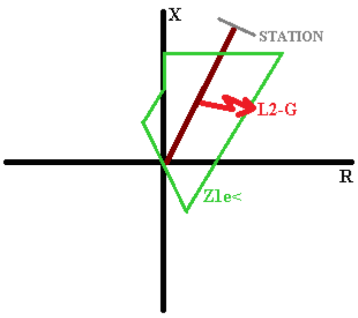
When second fault appears another voltage has to drop at least 10% below the healthy phase". Also set amount of zero sequence voltage has to be exceeded (same applies to residual current if triggering condition U0_I0 is selected).

Selected relay sees the fault 1 (L1-G) inside the zone Z1e<. If phase priority is selected as "1-> 2-> 3" this relay would trip and the same would do to the relay opposite the protected line.

Fault L2-G inside zone Z1e<



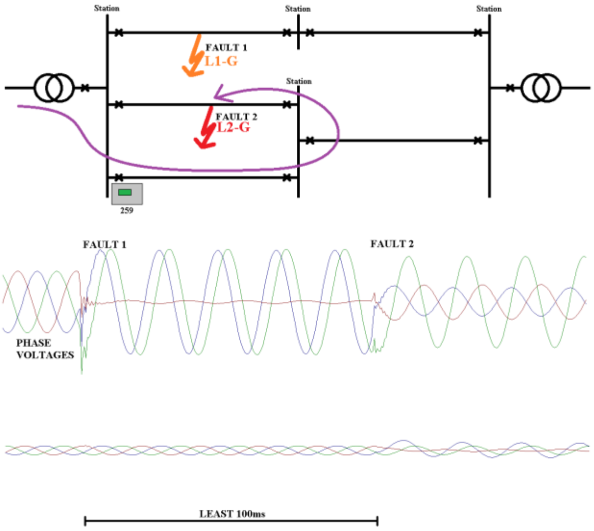
Fault is noticed since one of the voltages in the network area is dropped below the set "Phase under-voltage limit" limit and two other voltages are increasing above the set "Phase over-voltage limit" limit. This phase has to last least 100ms.



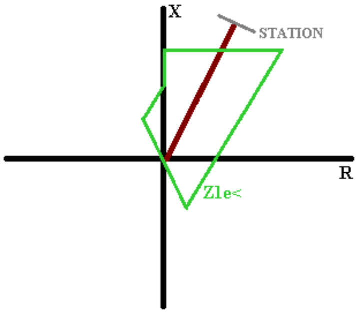
When second fault appears another voltage has to drop at least 10% below the healthy phase". Also set amount of zero sequence voltage has to be exceeded (same applies to residual current if triggering condition U0_I0 is selected).

Selected relay sees the fault 2 (L2-G) inside the zone Z1e<. If phase priority is selected as "1-> 2-> 3" this relay would NOT trip because fault L2-G inside the zone does not have the highest priority at the moment when the double earth-fault occurs.

No fault inside the protected zone Z1e<



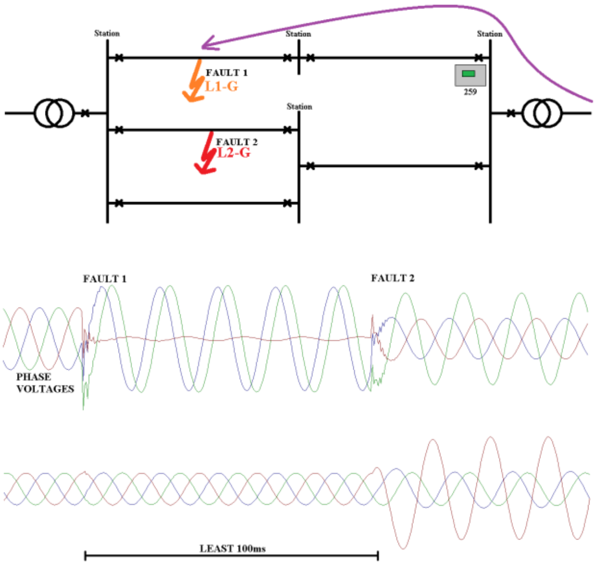
Fault is noticed since one of the voltages in the network area is dropped below the set “Phase under-voltage limit” limit and two other voltages are increasing above the set “Phase over-voltage limit” limit. This phase has to last least 100ms.



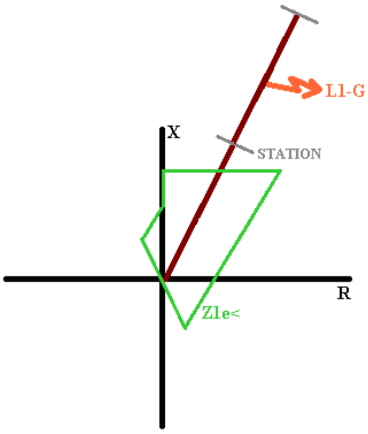
When second fault appears another voltage has to drop at least 10% below the healthy phase”. Also set amount of zero sequence voltage has to be exceeded (same applies to residual current if triggering condition $U_0\_I_0$ is selected).

Selected relay does not see any fault inside the zone Z1e<. There is no reason to trip.

Fault too far away from the protected zone Z1e<



Fault is noticed since one of the voltages in the network area is dropped below the set “Phase under-voltage limit” limit and two other voltages are increasing above the set “Phase over-voltage limit” limit. This phase has to last least 100ms.



When second fault appears another voltage has to drop at least 10% below the healthy phase”. Also set amount of zero sequence voltage has to be exceeded (same applies to residual current if triggering condition U_0_I_0 is selected).

Selected relay sees the fault but outside the zone Z1e< so there is no reason to trip.

Problem situations

Sometimes in certain type of network when fault 1 and 2 both appear in very short distance from the incomer the short circuit distance Z1> protection might disconnect the whole ring. Same would happen even if the DEF –algorithm is not used since short circuit distance protection happens to see the fault inside the zone.

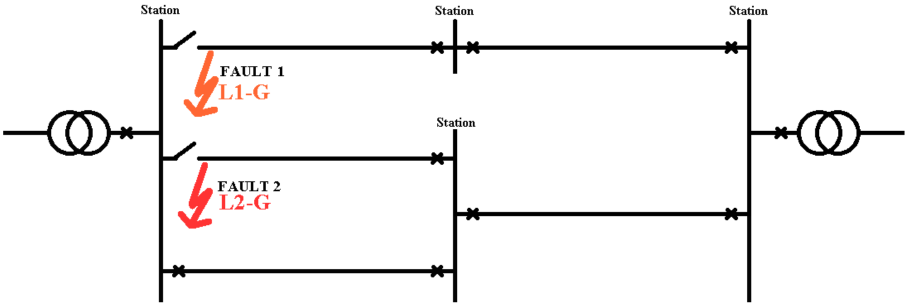


Figure 2.4.3-1 Two earth faults very close to the incomer. SC distance protection Z1> operated

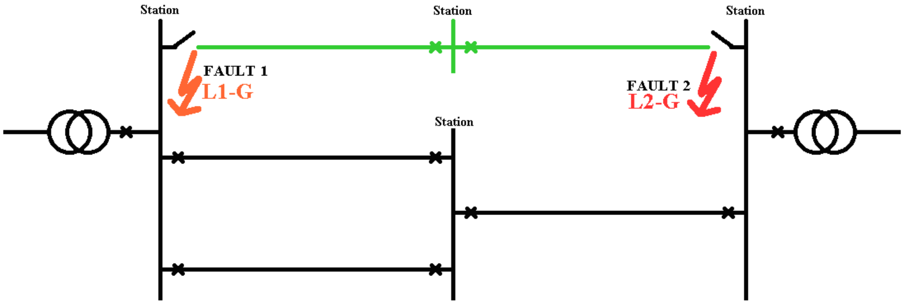
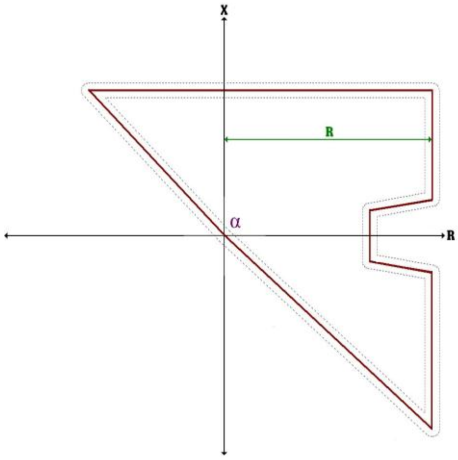


Figure 2.4.3-2 Two earth faults very close to the incomers at different ends of "same" line. Both lines will be separated from the network due the activation of SC-distance stage.

Note! Simple over-current and earth-fault protection is preferred to have as a back-up for "DEF algorithm".

2.4.4. Distance protection applications

The behavior of distance zones



S/C DISTANCE STAGE Z1<   21

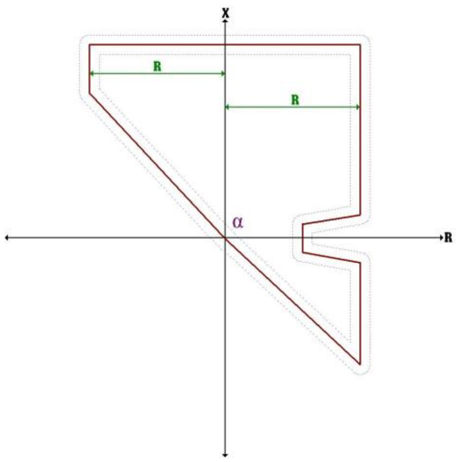
Set group DI control		-
Group		1
	Group 1	
Direction mode	Forward	
Load block in use	Yes	
X setting	7.00	ohm
R setting	10.00	ohm

DISTANCE COMMON SETTINGS

DISTANCE COMMON SETTINGS		
Line angle	90	o
Load setting R	7.00	ohm
LoadAngle	10	o

Characteristic type 1.

In the characteristic type 1 the line angle is set to 90 degrees. The resistive setting R is set above the reactive setting X. Therefore the resistive reach does not reach as far on the second quadrant as on the first quadrant. The load setting R and the angle setting of load block can be found from “distance common settings” menu. These values are being used only if the “Load block in use” is selected as “Yes”. The tolerance of inaccuracy is now taken from the R setting. This is because the R value is greater than the X value. If the allowed inaccuracy is for example 5 % and R setting is 10 Ω the allowed tolerance would be 0.5 Ω.



S/C DISTANCE STAGE Z1<   21

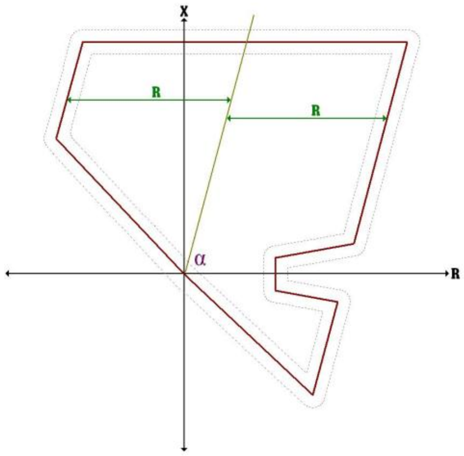
Set group DI control		-
Group		1
	Group 1	
Direction mode	Forward	
Load block in use	Yes	
X setting	10.00	ohm
R setting	7.00	ohm

DISTANCE COMMON SETTINGS

DISTANCE COMMON SETTINGS		
Line angle	90	o
Load setting R	4.00	ohm
LoadAngle	10	o

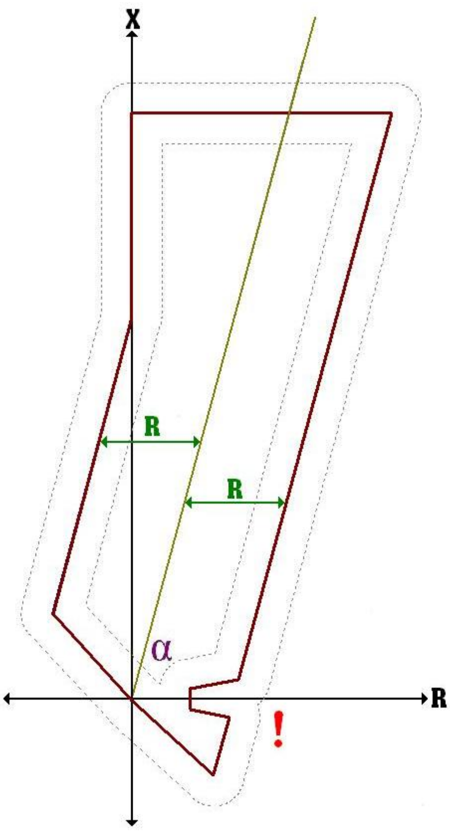
Characteristic type 2.

In the characteristic type 2 the line angle is set to 90 degrees. The reactive setting X is set above the resistive setting R. The resistive reach is equal at the both sides of the line setting. The load setting R and the angle setting of load block can be found from “distance common settings” menu. These values are being used only if the “Load block in use” is selected as “Yes”. The tolerance of inaccuracy is now taken from the X setting. This is because the X value is greater than the R value. If the allowed inaccuracy is for example 5 % and X setting is 10 Ω the allowed tolerance would be 0.5 Ω.



Characteristic type 3.

In the characteristic type 3 the line angle is set to 75 degrees. The reactive setting X is set above the resistive setting R. The resistive reach is equal at the both sides of the line setting. The load setting R and the angle setting of load block can be found from “distance common settings” menu. These values are being used only if the “Load block in use” is selected as “Yes”. The tolerance of inaccuracy is now taken from the X setting. This is because the X value is greater than the R value. If the allowed inaccuracy is for example 5 % and X setting is 10 Ω the allowed tolerance would be 0.5 Ω.



S/C DISTANCE STAGE Z1< 21

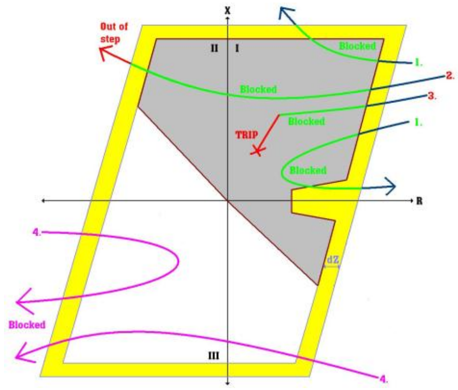
Set group DI control	-
Group	1
	Group 1
Direction mode	Forward
Load block in use	Yes
X setting	40.00 ohm
R setting	7.00 ohm

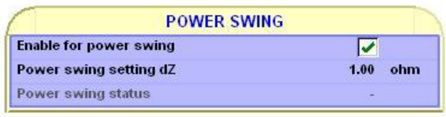
DISTANCE COMMON SETTINGS

DISTANCE COMMON SETTINGS		
Line angle	75	o
Load setting R	4.00	ohm
LoadAngle	10	o

Characteristic type 4.

In the characteristic type 4 the line angle is set to 75 degrees. The reactive setting X is set significantly above the resistive setting R. The resistive reach is equal at the both sides of the line setting until the resistive reach of quadrant II hits the line X. The load setting R and the angle setting of load block can be found from “distance common settings” menu. These values are being used only if the “Load block in use” is selected as “Yes”. The tolerance of inaccuracy is now taken from the X setting. This is because the X value is greater than the R value. If the allowed inaccuracy is for example 5 % and X setting is 40 Ω the allowed tolerance would be 2.0 Ω. Notice that with these settings the load block area is fully covered with the tolerance so all settings are not reasonable.





The behavior of power swing blocking and out of step tripping functions

Power swing is using the setting value “Power swing setting dZ”. Power swing function is enabled when the “Enable for power swing” is active. Depending of the setting “dZ” there is a certain sized area outside the biggest used distance zone. If the dZ is set to 1.0 Ω the “swing area” starts one ohm away from the edge of the biggest zone. The idea of this area is to notice the power swing before it reaches the zone to have enough time to activate the internal blocking. Power swing blocking is used to block desired distance zones by connecting the “power swing” line to the distance zones at the block matrix (see Figure 2.4.4-1).

Power swing blocking is active when the speed of the swing is less than the set value for example 1.0 Ω / 40 ms (40 ms is fixed value). If the speed of the swing exceeds the 1.0 Ω / 40 ms limit there won’t be block and the distance stage trips normally.

Note! Out of step activates at the edge of the power swing area, NOT at the edge of the distance zone. Out of step function can be connected to a tripping signal at the output matrix.

1. Power swing may reach the zone from any direction but only as long as it leaves the zone at the first quadrant it will remain as a power swing. In case that the swing stops in the middle of zone and none of the terms of fault are active the block will remain until the zone is left or fault occurs.
2. Situation starts as a power swing but the swing comes out from the second quadrant. Therefore out of step is activated. When out of step is activated the activation lasts for 0.5 seconds.
3. Fault during the power swing.
4. Basically power swing function is always undirectional. This means quadrants I and III are working similar way regardless the direction mode of distance stage (passing quadrant III with certain speed always activates power swing block). This makes the power swing to function when using reverse or undirectional mode.

Note! The conditions for the power swing blocking to be activated require in addition of the previously mentioned rate of change of impedance (dZ/dt) condition that sequences unbalance (I2/I1) is less than 25% and calculated residual current (IoCalc) is less than 10%. These mentioned parameters I2/I1 and IoCalc are fixed in the relay and can not be set by users.

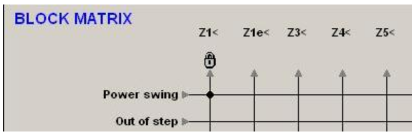


Figure 2.4.4-1 How to use power swing blocking with certain zones.

2.5. Line differential protection LdI> (87)

Line differential protection (LDP) provides high speed clearing for faults occurring at any point on a transmission line.

The line differential protection unit uses voltage measurements to calculate the resistive part of each of the three phase currents. The dedicated communication channel, called pilot channel, is used between two relays to exchange information on resistive phase currents and to determine whether the fault is internal or external to the protected line. In each piloting relay the difference between the corresponding resistive phase currents from this unit and from the remote unit is computed and compared against the configured threshold. In case any of the phases shows the difference in resistive currents greater than the threshold, the relay trips after the configurable operation time.

The measurement and transmission operations in the two piloting relays are not synchronized. Therefore, the communication speed on the pilot channel should be high enough to minimize the impact of fault detection delay asymmetry. The default communication speed is 38400 bps. Using the lower speed may result in longer minimum operation time of the relay.

Serial remote port of the relay is used by line differential protection.

The recommended solution for the pilot channel is the supervised fibre optic wiring. With multimode fibre cables and VSExxx-GG fibre optic modems the communication distance can be up to 1 km. When using single mode fibre cables and third party modems the distance can be up to tens of kilometres.

Using resistive currents for comparison assures good insensitivity to line capacitive charge currents.

The threshold characteristics is biased for CT saturation as presented in Figure 2.5-1 .

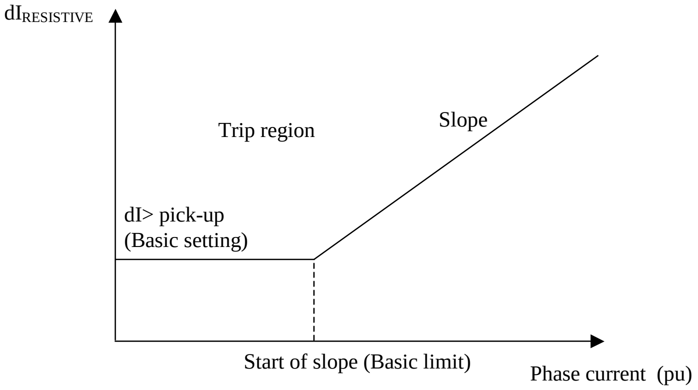


Figure 2.5-1 LDP tripping threshold characteristics

Definite operation time of the LdI> stage can be configured, starting with 60 ms as the minimum value.

When the difference between resistive currents current has been greater than the threshold for at least 60 ms the line differential stage starts to count the operation time according to the configured parameter. If the difference between resistive currents drops below the threshold while counting, the counting to trip is stopped. If the difference between resistive currents remains like this for at least the time defined as the release delay (default 5 ms), the counting is cleared and the relay start is also cleared.

In case of the pilot channel failure the line differential protection is inactive.

LDP Start and Trip signals as well as pilot channel failure status are available as inputs in the output matrix and blocking matrix of the relay.

The pilot channel between two line differential protection relays carries also binary signals in both directions: the status of LDP Start and Trip signals, and the Remote Trip command signal which is an output from the output logic matrix of the sending relay. Remote Trip signal can be processed as an input in the output matrix and blocking matrix of the receiving relay.

Parameters of the line differential protection stage LdI> (87):

	Parameter	Value/unit	Description
Setting values	dI> pick-up	I_n	Basic setting for lower phase currents
	Start of slope	I_n	Phase current limit for applying linear threshold characteristics
	Slope	%	Linear characteristics slope
	Operation delay	[0.050 .. 3.000] / s	Operation time Default 0.050
	CT primary other	[10 .. 20000]	CT ratio of the other unit Default 500
Recorded values	SCntr		Start counter (Start) reading
	TCntr		Trip counter (Trip) reading
	dI> status		Protection state

2.6. Overcurrent stage I> (50/51)

Overcurrent protection is used against short circuit faults and heavy overloads.

The overcurrent function measures the fundamental frequency component of the phase currents. The protection is sensitive for the highest of the three phase currents. Whenever this 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 delay setting, a trip signal is issued.

Three independent stages

There are three separately adjustable overcurrent stages: I>, I>> and I>>>. The first stage I> can be configured for definite time (DT) or inverse time operation characteristic (IDMT). The stages I>> and I>>> have definite time operation characteristic. By using the definite delay type and setting the delay to its minimum, an instantaneous (ANSI 50) operation is obtained.

Figure 2.6-1 shows a functional block diagram of the I> overcurrent stage with definite time and inverse time operation time. Figure 2.6-2 shows a functional block diagram of the I>> and I>>> overcurrent stages with definite time operation delay.

Inverse operation time

Inverse delay means that the operation time depends on the amount the measured current exceeds the pick-up setting. The bigger the fault current is the faster will be the operation. Accomplished inverse delays are available for the I> stage. The inverse delay types are described in chapter 2.24. The device will show the currently used inverse delay curve graph on the local panel display.

Inverse time limitation

The maximum measured secondary current is $50xI_N$. This limits the scope of inverse curves with high pick-up settings. See chapter 2.24 for more information.

Cold load and inrush current handling

See chapter 0.

Setting groups

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

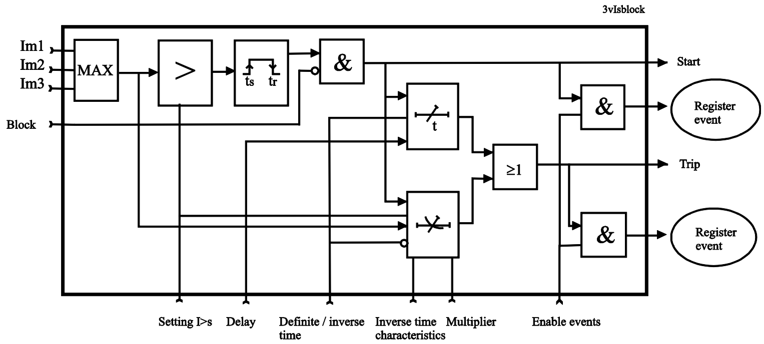


Figure 2.6-1 Block diagram of the three-phase overcurrent stage I>.

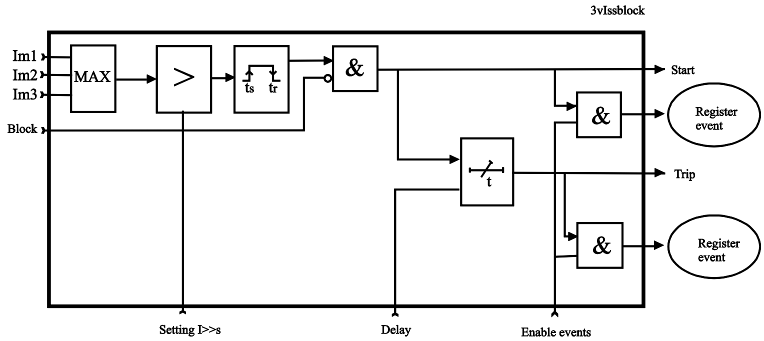


Figure 2.6-2 Block diagram of the three-phase overcurrent stage I>> and I>>>.

Parameters of the overcurrent stage I> (50/51)

Parameter	Value	Unit	Description	Note
Status	- Blocked Start Trip		Current status of the stage	 F F
TripTime		s	Estimated time to trip	
SCntr			Cumulative start counter	Clr
TCntr			Cumulative trip counter	Clr
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. This flag is automatically reset 5 minutes after the last front panel push button pressing.	Set

Parameter	Value	Unit	Description	Note
ILmax		A	The supervised value. Max. of I_{L1}, I_{L2} and I_{L3}	
I>		A	Pick-up value scaled to primary value	
I>		xIn	Pick-up setting	Set
Curve	 DT IEC IEEE IEEE2 RI PrgN		Delay curve family: Definite time Inverse time. See chapter 2.24. Pre 1996	Set
Type	 DT NI VI EI LTI Parameters		Delay type. Definite time Inverse time. See chapter 2.24.	Set
t>		s	Definite operation time (for definite time only)	Set
k>			Inverse delay multiplier (for inverse time only)	Set
Dly20x		s	Delay at 20xIset	
Dly4x		s	Delay at 4xIset	
Dly2x		s	Delay at 2xIset	
Dly1x		s	Delay at 1xIset	
A, B, C, D, E			User's constants for standard equations. Type=Parameters. See chapter 2.24.	Set

For details of setting ranges see chapter 9.3.

Set = An editable parameter (password needed)

C = Can be cleared to zero

F = Editable when force flag is on

Parameters of the overcurrent stages I>>, I>>> (50/51)

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

Parameter	Value	Unit	Description	Note
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
ILmax		A	The supervised value. Max. of I_{L1}, I_{L2} and I_{L3}	
I>>, I>>>		A	Pick-up value scaled to primary value	
I>>, I>>>		xIn	Pick-up setting	Set
t>>, t>>>		s	Definite operation time	Set

For details of setting ranges see chapter 9.3.

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 are detailed information available of the eight latest faults: Time stamp, fault type, fault current, load current before the fault, elapsed delay and setting group.

Recorded values of the overcurrent stages (8 latest faults) I>, I>>, I>>> (50/51)

Parameter	Value	Unit	Description
	yyyy-mm-dd		Time stamp of the recording, date
	hh:mm:ss.ms		Time stamp, time of day
Type	 1-N 2-N 3-N 1-2 2-3 3-1 1-2-3		Fault type Ground fault Ground fault Ground fault Two phase fault Two phase fault Two phase fault Three phase fault
Flt		xIn	Maximum fault current
Load		xIn	1 s average phase currents before the fault
EDly		%	Elapsed time of the operating time setting. 100% = trip
SetGrp	1 2		Active setting group during fault

2.7. Directional overcurrent protection I_{dir}> (67)

Directional overcurrent protection can be used for directional short circuit protection. Typical applications are

- Short circuit protection of two parallel cables or overhead lines in a radial network.
- Short circuit protection of a looped network with single feeding point.
- Short circuit protection of a two-way feeder, which usually supplies loads but is used in special cases as an incoming feeder.
- Directional overcurrent protection in low impedance earthed networks. Please note that in this case the device has to connected to line-to-neutral voltages instead of line-to-line voltages. In other words the voltage measurement mode has to be "3LN" (See chapter 4.7).

The stages are sensitive to the amplitude of the highest fundamental frequency current of the three measured phase currents. The phase angle is based on the phase angle of the three-phase power phasor. For details of power direction see chapter 4.9. A typical characteristic is shown in Figure 2.7-1. The base angle setting is –30°. The stage will pick up, if the tip of the three phase current phasor gets into the grey area.

NOTE! If the maximum possible earth fault current is greater than the used most sensitive directional over current setting, the device has to be connected to the line-to-neutral voltages instead of line-to-line voltages in order to get the right direction for earth faults, too. (For networks having the maximum possible earth fault current less than the over current setting, use 67N, the directional earth fault stages.)

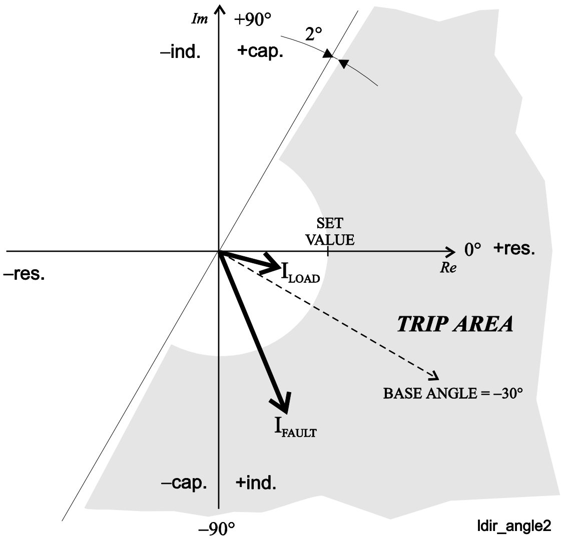


Figure 2.7-1 Example of protection area of the directional overcurrent function.

Two modes are available: directional and non-directional (Figure 2.7-2). In the non-directional mode the stage is acting just like an ordinary overcurrent 50/51 stage.

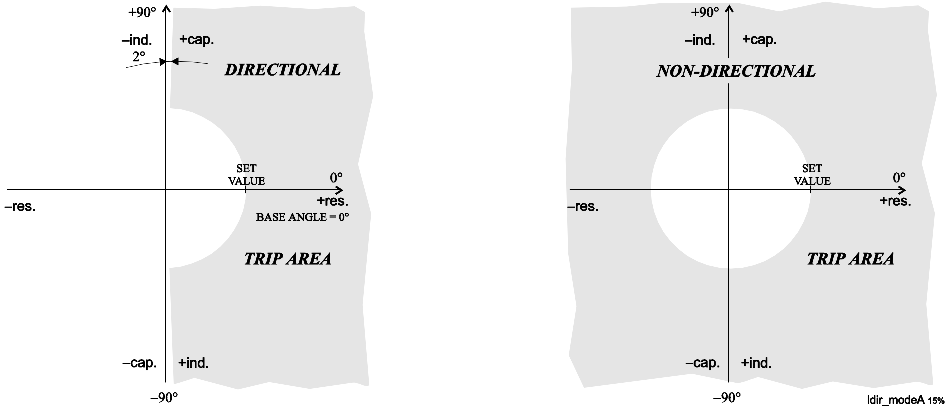


Figure 2.7-2.Difference between directional mode and non-directional mode. The grey area is the trip region.

An example of bi-directional operation characteristic is shown in Figure 2.7-3. The right side stage in this example is the stage Idir> and the left side is Idir>>. The base angle setting of the Idir> is 0° and the base angle of Idir>> is set to –180°.

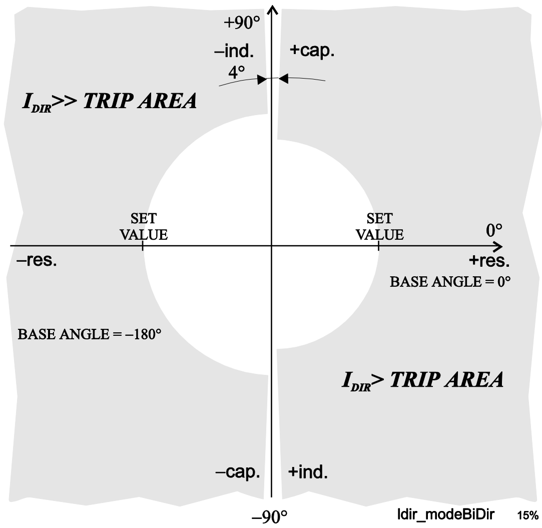


Figure 2.7-3. Bi-directional application with two stages Idir> and Idir>>.

When any of the three phase currents exceeds the setting value and – in directional mode – the phase angle including the base angle is within the active ±88° wide sector, the stage picks up and issues a start signal. If this fault situation remains on longer than the delay setting, a trip signal is issued.

Four independent stages

There are four separately adjustable stages available: I_{dir}>, I_{dir}>>, I_{dir}>>> and I_{dir}>>>>.

Inverse operation time

Stages I_{dir}> and I_{dir}>> can be configured for definite time or inverse time characteristic. See chapter 2.24 for details of the available inverse delays. Stages I_{dir}>>> and I_{dir}>>>> have definite time (DT) operation delay. The device will show a scaleable graph of the configured delay on the local panel display.

Inverse time limitation

The maximum measured secondary current is $50xI_N$. This limits the scope of inverse curves with high pick-up settings. See chapter 2.24 for more information.

Cold load and inrush current handling

See chapter 0.

Setting groups

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

Figure 2.7-4 shows the functional block of the Idir> stage.

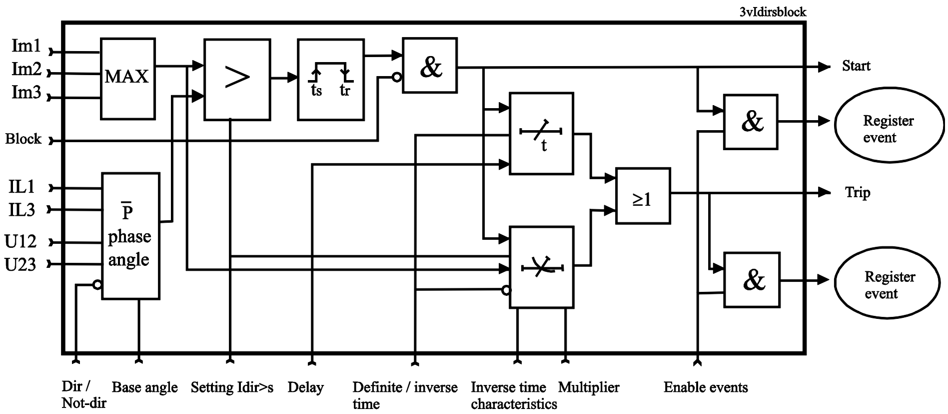


Figure 2.7-4.Block diagram of the three-phase overcurrent stage I_{dir}>

Parameters of the directional overcurrent stages I_{dir}>, I_{dir}>> (67)

Parameter	Value	Unit	Description	Note
Status	- Blocked Start Trip		Current status of the stage	 F F
TripTime		s	Estimated time to trip	
SCntr			Cumulative start counter	Clr
TCntr			Cumulative trip counter	Clr
SetGrp	1 or 2		Active setting group	Set

Parameter	Value	Unit	Description	Note
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
ILmax		A	The supervised value. Max. of I_{L1}, I_{L2} and I_{L3}	
Iφ>, Iφ>>		A	Pick-up value scaled to primary value	
Iφ>, Iφ>>		xIn	Pick-up setting	Set
Curve	 DT IEC IEEE IEEE2 RI PrgN		Delay curve family: Definite time Inverse time. See chapter 2.24.	Set
Type	 DT NI VI EI LTI Parameters		Delay type. Definite time Inverse time. See chapter 2.24.	Set
t>		s	Definite operation time (for definite time only)	Set
k>			Inverse delay multiplier (for inverse time only)	Set
Dly20x		s	Delay at 20xIset	
Dly4x		s	Delay at 4xIset	
Dly2x		s	Delay at 2xIset	
Dly1x		s	Delay at 1xIset	
Mode	Dir Undir		Directional mode (67) Undirectional (50/51)	Set
Offset		°	Angle offset in degrees	Set
φ		°	Measured power angle	
U1		%Un	Measured positive sequence voltage	
A, B, C, D, E			User's constants for standard equations. Type=Parameters. See chapter 2.24.	Set

For details of setting ranges see chapter 9.3.
Set = An editable parameter (password needed)
C = Can be cleared to zero
F = Editable when force flag is on

Parameters of the directional overcurrent stages I_{dir}>>>, I_{dir}>>>> (67)

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
ILmax		A	The supervised value. Max. of I_{L1}, I_{L2} and I_{L3}	
Iφ>>>> Iφ>>>>>		A	Pick-up value scaled to primary value	
Iφ>>>> Iφ>>>>>		xIn	Pick-up setting	Set
t>>> t>>>>		s	Definite operation time (for definite time only)	Set
Mode	Dir Undir		Directional (67) Undirectional (50/51)	Set
Offset		°	Angle offset in degrees	Set
φ		°	Measured power angle	
U1		%Un	Measured positive sequence voltage	

For details of setting ranges see chapter 9.3.
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 are detailed information available of the eight latest faults: Time stamp, fault type, fault current, load current before the fault, elapsed delay and setting group.

Recorded values of the directional overcurrent stages (8 latest faults) I_{dir}>, I_{dir}>>, I_{dir}>>>, I_{dir}>>>> (67)

Parameter	Value	Unit	Description
	yyyy-mm-dd		Time stamp of the recording, date
	hh:mm:ss.ms		Time stamp, time of day
Type			Fault type
	1-N		Ground fault
	2-N		Ground fault
	3-N		Ground fault
	1-2		Two phase fault
	2-3		Two phase fault
	3-1		Two phase fault
	1-2-3		Three phase fault
Flt		xIn	Maximum fault current
Load		xIn	1 s average phase currents before the fault
EDly		%	Elapsed time of the operating time setting. 100% = trip
Angle		°	Fault angle in degrees
U1		xUn	Positive sequence voltage during fault
SetGrp	1 2		Active setting group during fault

2.8. Current unbalance stage I_2> (46)

The purpose of the broken line protection is to detect unbalanced load conditions, for example a broken conductor of a heavy loaded overhead line in case there is no earth fault.

The operation of the unbalanced load function is based on the negative phase sequence component I_2 related to the positive phase sequence component I_1. This is calculated from the phase currents using the method of symmetrical components. The function requires that the measuring inputs are connected correctly so that the rotation direction of the phase currents are as in chapter 8.9. The unbalance protection has definite time operation characteristic.

$K2 = \frac{I_2}{I_1}$, where

$I1 = I_{L1} + aI_{L2} + a^2I_{L3}$
$I2 = I_{L1} + a^2I_{L2} + aI_{L3}$

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

Setting parameters of current unbalanced stage I_2> (46):

Parameter	Value	Unit	Default	Description
I2/I1>	2 … 70	%	20	Setting value, I2/I1
t>	1.0 … 600.0	s	10.0	Definite operating time
Type	DT INV	-	DT	The selection of time characteristics
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

Measured and recorded values of current unbalanced stage I_2> (46):

	Parameter	Value	Unit	Description
Measured value	I2/I1		%	Relative negative sequence component
Recorded values	SCntr			Cumulative start counter
	TCntr			Cumulative start counter
	Flt		%	Maximum I_2/I_1 fault component
	EDly		%	Elapsed time as compared to the set operating time, 100% = tripping

2.9. Undercurrent protection I< (37)

The undercurrent unit measures the fundamental frequency component of the phase currents.

The stage I< can be configured for definite time characteristic.

Parameters of the undercurrent stage I< (37):

	Parameter	Value/unit	Description
Measured value	ILmin	A	Min. value of phase currents I_{L1}…I_{L3} in primary value
Setting values	I<	xIn	Setting value as per times Imot
	t<	S	Operation time [s]
Recorded values	SCntr		Start counter (Start) reading
	TCntr		Trip counter (Trip) reading
	Type	1-N, 2-N 3-N	Fault type/single-phase fault e.g.: 1-N = fault on phase L1
		1-2, 2-3 1-3	Fault type/two-phase fault e.g.: 2-3 = fault between L2 and L3
		1-2-3	Fault type/three-phase fault
	Flt	%	Min. value of fault current as per times Imot
	Load	%	1s mean value of pre-fault currents I_{L1}—I_{L3}
	EDly	%	Elapsed time as compared to the set operate time, 100% = tripping

2.10. Directional earth fault protection $I_{0\varphi}$> (67N)

The directional earth fault protection is used for earth faults in networks where a selective and sensitive earth fault protection is needed and in applications with varying network structure and length.

The device consists of versatile protection functions for earth fault protection in various network types.

The function is sensitive to the fundamental frequency component of the residual current and zero sequence voltage and the phase angle between them. The attenuation of the third harmonic is more than 60 dB. Whenever the size of I_0 and U_0 and the phase angle between I_0 and $-U_0$ fulfils the pick-up criteria, the 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.

Polarization

The negative zero sequence voltage $-U_0$ is used for polarization i.e. the angle reference for I_0. This $-U_0$ voltage is calculated from the phase voltages internally. Since residual voltage is calculated from the phase voltages, therefore any separate zero sequence voltage transformers are not needed. The setting values are relative to the configured voltage transformer (VT) voltage/$\sqrt{3}$.

Modes for different network types

The available modes are:

- ResCap
  This mode consists of two sub modes, Res and Cap. A digital signal can be used to dynamically switch between these two sub modes. This feature can be used with compensated networks, when the Petersen coil is temporarily switched off.

    - Res
      The stage is sensitive to the resistive component of the selected I_0 signal. This mode is used with compensated **networks** (resonant grounding) and **networks earthed with a high resistance.** Compensation is usually done with a Petersen coil between the neutral point of the main transformer and earth. In this context "high resistance" means, that the fault current is limited to be less than the rated phase current. The trip area is a half plane as drawn in Figure 2.10-2. The base angle is usually set to zero degrees.
    - Cap
      The stage is sensitive to the capacitive component of the selected I_0 signal. This mode is used with **unearthed networks.** The trip area is a half plane as drawn in Figure 2.10-2. The base angle is usually set to zero degrees.
- Sector
  This mode is used with **networks earthed with a small resistance.** In this context "small" means, that a fault current may be more than the rated phase currents. The trip area has a shape of a sector as drawn in Figure 2.10-3. The base angle is usually set to zero degrees or slightly on the lagging inductive side (i.e. negative angle).
- Undir
  This mode makes the stage equal to the undirectional stage I_0>. The phase angle and U_0 amplitude setting are discarded. Only the amplitude of the selected I_0 input is supervised.

Input signal selection

Each stage can be connected to supervise any of the following inputs and signals:

- Input I_{01} for all networks other than rigidly earthed.
- Calculated signal I_{0Calc} for rigidly and low impedance earthed networks. $I_{0Calc} = I_{L1} + I_{L2} + I_{L3} = 3I_0$.

Additionally the stage $I_0φ>$ have two more input signal alternatives to measure current peaks to detect short restriking intermittent earth faults:

- I_{01Peak} to measure the peak value of input I_{01}.

Intermittent earth fault detection

Short earth faults make the protection to start (to pick up), but will not cause a trip. (Here a short fault means one cycle or more. For shorter than 1 ms transient type of intermittent earth faults in compensated networks there is a dedicated stage Iot> 67NT.)

When starting happens often enough, such intermittent faults can be cleared using the intermittent time setting. When a new start happens within the set intermittent time, the operation delay counter is not cleared between adjacent faults and finally the stage will trip.

Two independent stages

There are two separately adjustable stages: Iφ> and Iφ>>. Both the stages can be configured for definite time delay (DT) or inverse time delay operation time.

Inverse operation time

Inverse delay means that the operation time depends on the amount the measured current exceeds the pick-up setting. The bigger the fault current is the faster will be the operation. Accomplished inverse delays are available for both stages $I_0φ>$ and $I_0φ>>$. The inverse delay types are described in chapter 2.24. The device will show a scaleable graph of the configured delay on the local panel display.

Inverse time limitation

The maximum measured secondary residual current is $10xI_{0N}$ and maximum measured phase current is $50xI_N$. This limits the scope of inverse curves with high pick-up settings. See chapter 2.24 for more information.

Setting groups

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

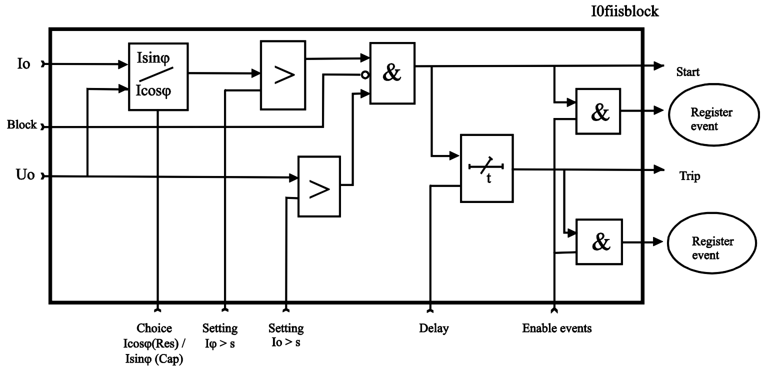


Figure 2.10-1. Block diagram of the directional earth fault stages $I_0\varphi$> and $I_0\varphi$>>

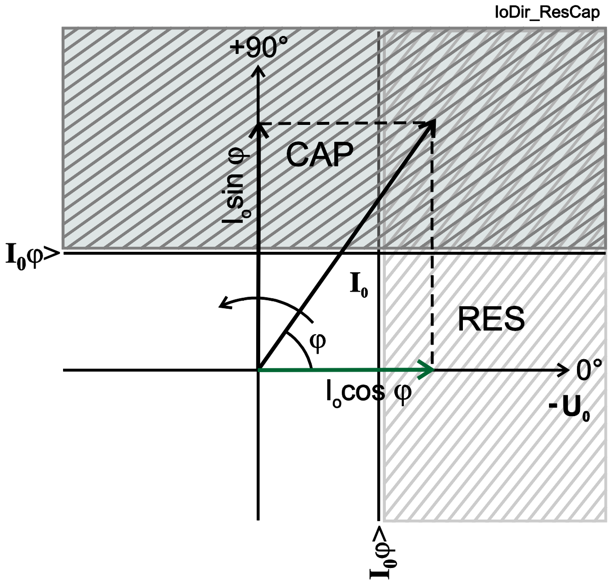


Figure 2.10-2 Operation characteristic of the directional earth fault protection in Res or Cap mode. Res mode can be used with compensated networks and Cap mode is used with ungrounded networks.

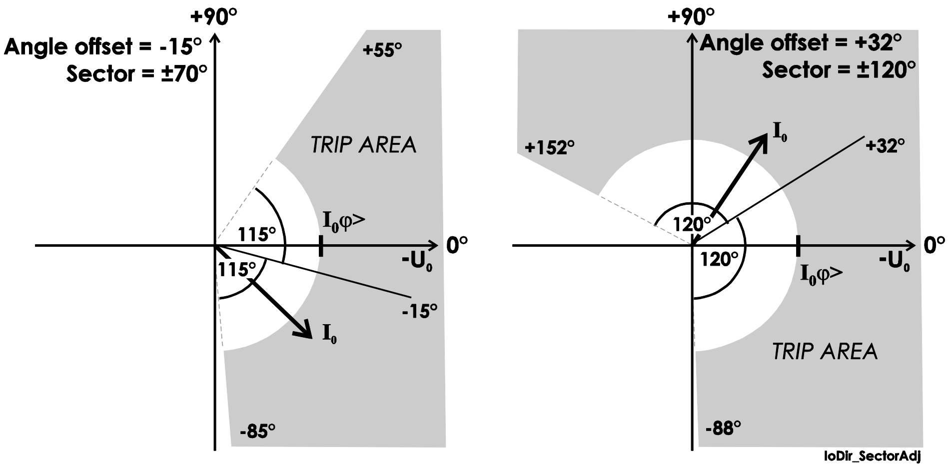


Figure 2.10-3 Two example of operation characteristics of the directional earth fault stages in sector mode. The drawn I_0 phasor in both figures is inside the trip area. The angle offset and half sector size are user's parameters.

Parameters of the directional earth fault stages $I_0\varphi>$, $I_0\varphi>>$ (67N)

Parameter	Value	Unit	Description	Note
Status	- Blocked Start Trip		Current status of the stage	 F F
TripTime		s	Estimated time to trip	
SCntr			Cumulative start counter	Clr
TCntr			Cumulative trip counter	Clr
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
Io IoCalc IoPeak		pu	The supervised value according the parameter "Input" below. ($I_0\varphi>$ only) ($I_0\varphi>$ only)	
IoRes		pu	Resistive part of I_0 (only when "InUse"=Res)	
IoCap		pu	Capacitive part of I_0 (only when "InUse"=Cap)	
Ioφ>		A	Pick-up value scaled to primary value	
Ioφ>		pu	Pick-up setting relative to the parameter "Input" and the corresponding CT value	Set
Uo>		%	Pick-up setting for U_0	Set
Uo		%	Measured U_0	
Curve	 DT IEC IEEE IEEE2 RI PrgN		Delay curve family: Definite time Inverse time. See chapter 2.24.	Set

Parameter	Value	Unit	Description	Note
Type	 DT NI VI EI LTI Parameters		Delay type. Definite time Inverse time. See chapter 2.24.	Set
t>		s	Definite operation time (for definite time only)	Set
k>			Inverse delay multiplier (for inverse time only)	Set
Mode	ResCap Sector Undir		High impedance earthed nets Low impedance earthed nets Undirectional mode	Set
Offset		°	Angle offset (MTA) for RecCap and Sector modes	Set
Sector	Default = 88	±°	Half sector size of the trip area on both sides of the offset angle	Set
ChCtrl	 Res Cap DI1…32 VI1..4		Res/Cap control in mode ResCap Fixed to Resistive characteristic Fixed to Capacitive characteristic Controlled by digital input Controlled by virtual input	Set
InUse	 - Res Cap		Selected submode in mode ResCap. Mode is not ResCap Submode = resistive Submode = capacitive	
Input	I_0 I_{0Calc} I_{0Peak}		X1:7-8. See chapter 8. $I_{L1} + I_{L2} + I_{L3}$ X1:7-8 peak mode ($I_0φ$> only)	Set
Intrmt		s	Intermittent time	Set
Dly20x		s	Delay at 20xIoset	
Dly4x		s	Delay at 4xIoset	
Dly2x		s	Delay at 2xIoset	
Dly1x		s	Delay at 1xIoset	
A, B, C, D, E			User's constants for standard equations. Type=Parameters. See chapter 2.24.	Set

For details of setting ranges see chapter 9.3.

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 earth faults: Time stamp, fault current, elapsed delay and setting group.

Recorded values of the directional earth fault stages (8 latest faults) $I_0\varphi$>, $I_0\varphi$>> (67N)

Parameter	Value	Unit	Description
	yyyy-mm-dd		Time stamp of the recording, date
	hh:mm:ss.ms		Time stamp, time of day
Flt		pu	Maximum earth fault current
EDly		%	Elapsed time of the operating time setting. 100% = trip
Angle	°		Fault angle of I_0. $-U_0 = 0°$
Uo		%	Max. U_0 voltage during the fault
SetGrp	1 2		Active setting group during fault

2.11. Earth fault protection I_0> (50N/51N)

Undirectional earth fault protection is used to detect earth faults in low impedance earthed networks. In high impedance earthed networks, compensated networks and isolated networks undirectional earth fault can be used as back-up protection.

The undirectional earth fault function is sensitive to the fundamental frequency component of the residual current $3I_0$. The attenuation of the third harmonic is more than 60 dB. Whenever this fundamental 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.

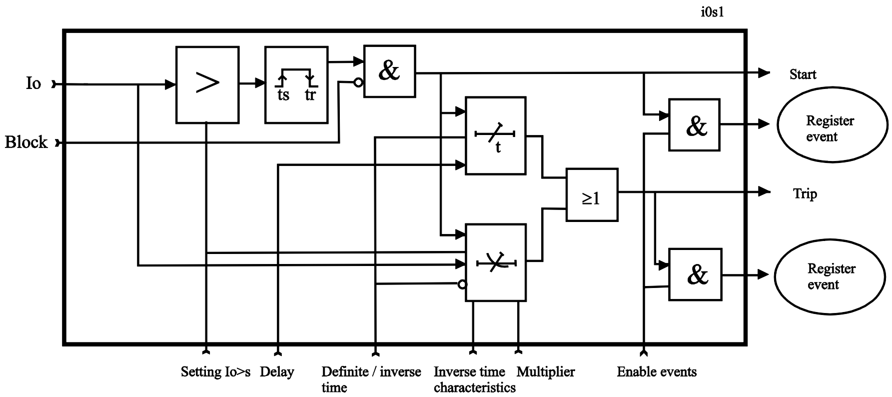


Figure 2.11-1. Block diagram of the earth fault stage I_0>

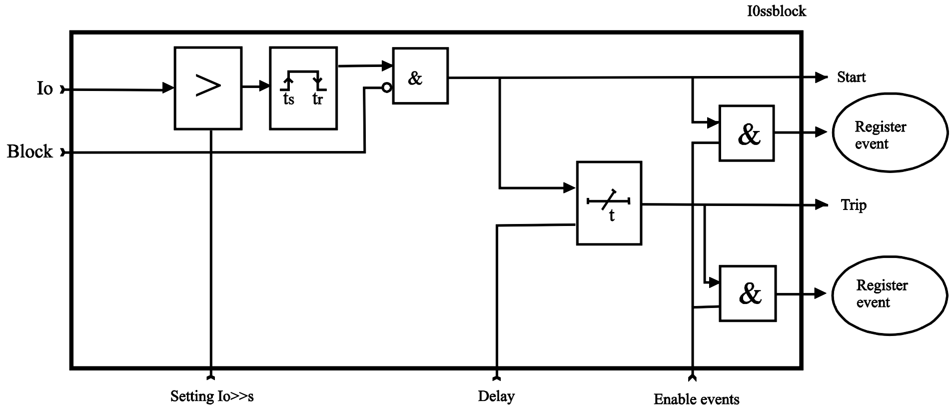


Figure 2.11-2. Block diagram of the earth fault stages I_0>>, I_0>>> and I_0>>>>

Figure 2.11-1 shows a functional block diagram of the I_0> earth overcurrent stage with definite time and inverse time operation time. Figure 2.11-2 shows a functional block diagram of the I_0>>, I_0>>> and I_0>>>> earth fault stages with definite time operation delay.

Input signal selection

Each stage can be connected to supervise any of the following inputs and signals:

- Input I_{01} for all networks other than rigidly earthed.
- From the phase currents calculated signal I_{0Calc} for rigidly and low impedance earthed networks. $I_{0Calc} = I_{L1} + I_{L2} + I_{L3}$.

Additionally the stage I_0> have two more input signal alternatives to measure current peaks to detect a restriking intermittent earth fault:

- I_{01Peak} to measure the peak value of input I_{01}.

Intermittent earth fault detection

Short earth faults make the protection to start (to pick up), but will not cause a trip. (Here a short fault means one cycle or more. For shorter than 1 ms transient type of intermittent earth faults in compensated networks there is a dedicated stage Iot> 67NT.)

When starting happens often enough, such intermittent faults can be cleared using the intermittent time setting. When a new start happens within the set intermittent time, the operation delay counter is not cleared between adjacent faults and finally the stage will trip.

Four or six independent undirectional earth fault overcurrent stages

There are four separately adjustable earth fault stages: I_0>, I_0>>, I_0>>>, and I_0>>>>. The first stage I_0> can be configured for definite time (DT) or inverse time operation characteristic

(IDMT). The other stages have definite time operation characteristic. By using the definite delay type and setting the delay to its minimum, an instantaneous (ANSI 50N) operation is obtained.

Using the directional earth fault stages (chapter 2.10) in undirectional mode, two more stages with inverse operation time delay are available for undirectional earth fault protection.

Inverse operation time (I_0> stage only)

Inverse delay means that the operation time depends on the amount the measured current exceeds the pick-up setting. The bigger the fault current is the faster will be the operation. Accomplished inverse delays are available for the I_0> stage. The inverse delay types are described in chapter 2.24. The device will show a scaleable graph of the configured delay on the local panel display.

Inverse time limitation

The maximum measured secondary residual current is $10xI_{0n}$ and maximum measured phase current is $50xI_n$. This limits the scope of inverse curves with high pick-up settings. See chapter 2.24 for more information.

Setting groups

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

Parameters of the undirectional earth fault stage I_0> (50N/51N)

Parameter	Value	Unit	Description	Note
Status	- Blocked Start Trip		Current status of the stage	 F F
TripTime		s	Estimated time to trip	
SCntr			Cumulative start counter	Clr
TCntr			Cumulative trip counter	Clr
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

Parameter	Value	Unit	Description	Note
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
Io IoCalc IoPeak		pu	The supervised value according the parameter "Input" below.	
Io>		A	Pick-up value scaled to primary value	
Io>		pu	Pick-up setting relative to the parameter "Input" and the corresponding CT value	Set
Curve	 DT IEC IEEE IEEE2 RI PrgN		Delay curve family: Definite time Inverse time. See chapter 2.24.	Set
Type	 DT NI VI EI LTI Parameters		Delay type. Definite time Inverse time. See chapter 2.24.	Set
t>		s	Definite operation time (for definite time only)	Set
k>			Inverse delay multiplier (for inverse time only)	Set
Input	I_0 I_{0Calc} I_{0Peak}		X1:7-8. See chapter 8. $I_{L1} + I_{L2} + I_{L3}$ X1:7-8 peak mode ($I_{0\varphi}$> only)	Set
Intrmt		s	Intermittent time	Set
Dly20x		s	Delay at 20xIoset	
Dly4x		s	Delay at 4xIoset	
Dly2x		s	Delay at 2xIoset	
Dly1x		s	Delay at 1xIoset	
A, B, C, D, E			User's constants for standard equations. Type=Parameters. See chapter 2.24.	Set

For details of seting ranges see chapter 9.3.

Set = An editable parameter (password needed)

C = Can be cleared to zero

F = Editable when force flag is on

Parameters of the undirectional earth fault stages I_0>>, I_0>>>, I_0>>>> (50N/51N)

Parameter	Value	Unit	Description	Note
Status	- Blocked Start Trip		Current status of the stage	 F F
TripTime		s	Estimated time to trip	
SCntr			Cumulative start counter	Clr
TCntr			Cumulative trip counter	Clr
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
Io IoCalc		pu	The supervised value according the parameter “Input” below.	
Io>> Io>>> Io>>>>		A	Pick-up value scaled to primary value	
Io>> Io>>> Io>>>>		pu	Pick-up setting relative to the parameter "Input" and the corresponding CT value	Set
t>		s	Definite operation time (for definite time only)	Set
Input	I_0 I_{0Calc}		X6-7,8,9. See chapter 8. X6-10,11,12 $I_{L1} + I_{L2} + I_{L3}$	 Set

For details of setting ranges see chapter 9.3.

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 earth faults: Time stamp, fault current, elapsed delay and setting group.

Recorded values of the undirectional earth fault stages (8 latest faults) I_0>, I_0>>, I_0>>>, I_0>>>> (50N/51N)

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

2.12. Zero sequence voltage protection U_0> (59N)

The zero sequence voltage protection is used as unselective backup for earth faults.

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 3n 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.

Two independent stages

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

The zero sequence voltage function comprises two separately adjust-table zero sequence voltage stages (stage U_0> and U_0>>).

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.

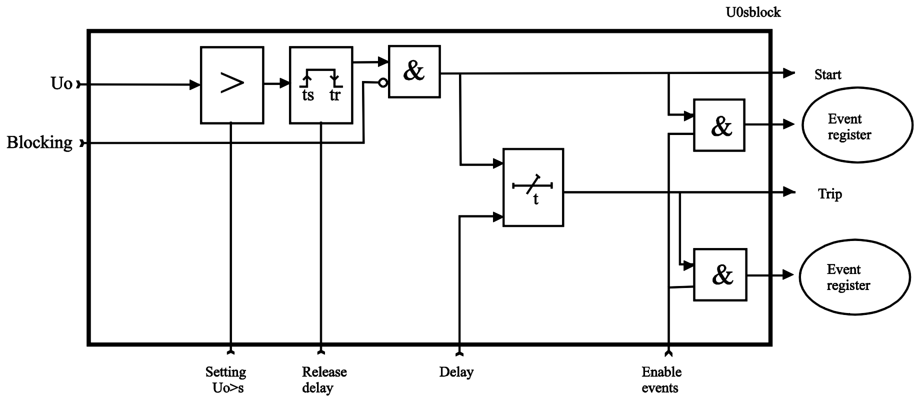


Figure 2.12-1 Block diagram of the zero sequence voltage stages U_0> and U_0>>

Parameters of the residual overvoltage stages U_0>, U_0>> (59N)

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
Uo		%	The supervised value relative to Un/√3	
Uo>, Uo>>		%	Pick-up value relative to Un/√3	Set
t>, t>>		s	Definite operation time	Set

For details of setting ranges see chapter 9.3.

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

Recorded values of the residual overvoltage stages U_0>, U_0>> (59N)

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/√3
EDly		%	Elapsed time of the operating time setting. 100% = trip
SetGrp	1 2		Active setting group during fault

2.13. Thermal overload protection T> (49)

The thermal overload function protects the cables in the feeder mode against excessive heating due to overloading conditions.

Thermal model

The temperature is calculated using rms values of phase currents and a thermal model according IEC 60255-8. The rms values are calculated using harmonic components up to the 15th.

Trip time: $$t = \tau \cdot \ln \frac{I^2 - I_P^{\;2}}{I^2 - a^2}$$

Alarm: $$a = k \cdot k_\Theta \cdot I_{mode} \cdot \sqrt{alarm}$$ (Alarm 60% = 0.6)

Trip: $$a = k \cdot k_\Theta \cdot I_{mode}$$

Release time: $$t = \tau \cdot C_\tau \cdot \ln \frac{I_P^{\;2}}{a^2 - I^2}$$

Trip release: $a = \sqrt{0.95} \times k_\Theta \times I_{mode}$

Start release: $a = \sqrt{0.95} \times k_\Theta \times I_{mode} \times \sqrt{alarm}$ (Alarm 60% = 0.6)

T = Operation time

τ = Thermal time constant tau (Setting value)

ln = Natural logarithm function

I = Measured rms phase current (the max. value of three phase currents)

Ip = Preload current, $I_P = \sqrt{\theta} \times k_\Theta \times I_n$ (If temperature rise is 120%→ $\theta = 1.2$). This parameter is the memory of the algorithm and corresponds to the actual temperature rise.

k = Overload factor (Maximum continuous current), i.e. service factor. (Setting value)

kΘ = Ambient temperature factor (Permitted current due to tamb) Figure 2.13-1.

I_{mode} = The rated current (I_n or I_{mot})

C_τ = Cooling time coefficient (cooling time constant = C_τ x τ)

Heat capacitance, service factor and ambient temperature

The trip level is determined by the maximum allowed continuous current I_{max} corresponding to the 100 % temperature rise Θ_{TRIP} i.e. the heat capacitance of the cable. I_{max} depends of the given service factor k and ambient temperature Θ_{AMB} and settings I_{max40} and I_{max70} according the following equation.

$$I_{max} = k \cdot k_{\Theta} \cdot I_n$$

The value of ambient temperature compensation factor kΘ depends on the ambient temperature Θ_{AMB} and settings I_{max40} and I_{max70}. See Figure 2.13-1. Ambient temperature is not in use when kΘ = 1. This is true when

- I_{max40} is 1.0
- Samb is “n/a” (no ambient temperature sensor)
- TAMB is +40 °C.

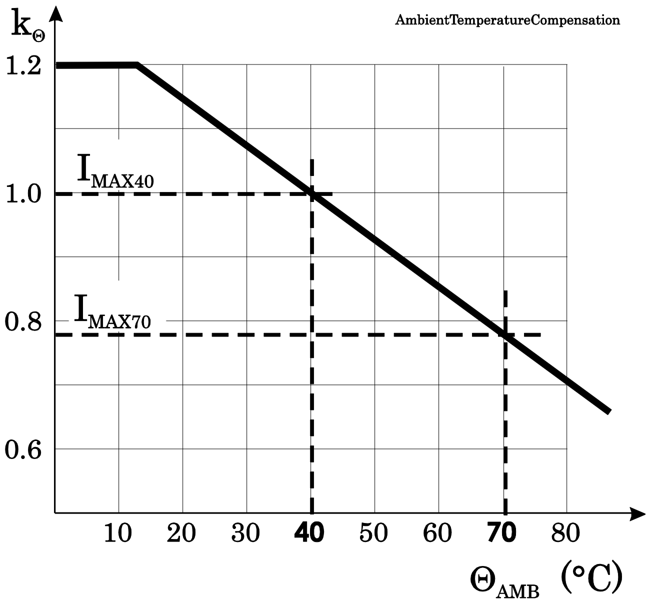


Figure 2.13-1 Ambient temperature correction of the overload stage T>.

Example of a behaviour of the thermal model

Figure 2.13-2 shows an example of the thermal model behaviour. In this example τ = 30 minutes, k = 1.06 and kΘ = 1 and the current has been zero for a long time and thus the initial temperature rise is 0 %. At time = 50 minutes the current changes to 0.85xIn and the temperature rise starts to approach value $(0.85/1.06)^2$ = 64 % according the time constant. At time=300 min, the temperature is about stable, and the current increases to 5 % over the maximum defined by the rated current and the service factor k. The temperature rise starts to approach value 110 %. At about 340 minutes the temperature rise is 100 % and a trip follows.

Initial temperature rise after restart

When the device is switched on, an initial temperature rise of 70 % is used. Depending of the actual current, the calculated temperature rise then starts to approach the final value.

Alarm function

The thermal overload stage is provided with a separately settable alarm function. When the alarm limit is reached the stage activates its start signal.

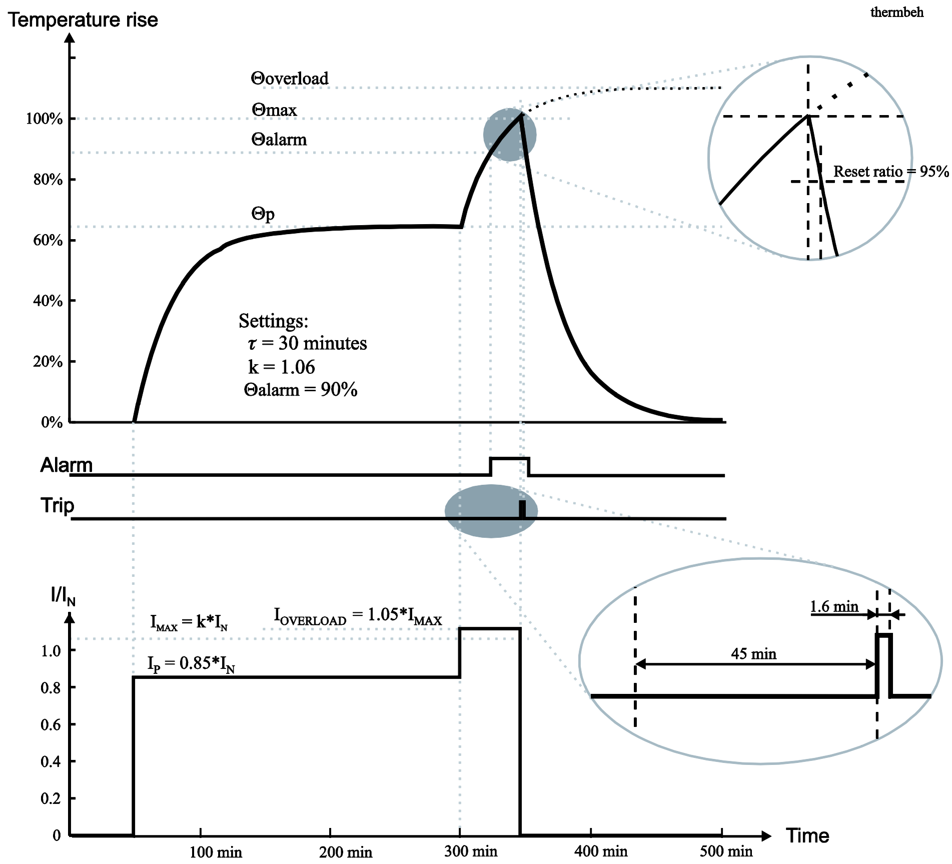


Figure 2.13-2. Example of the thermal model behaviour.

Parameters of the thermal overload stage T> (49)

Parameter	Value	Unit	Description	Note
Status	- Blocked Start Trip		Current status of the stage	 F F
Time	hh:mm:ss		Estimated time to trip	
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
T		%	Calculated temperature rise. Trip limit is 100 %.	F
MaxRMS		Arms	Measured current. Highest of the three phases.	
Imax		A	kxIn. Current corresponding to the 100 % temperature rise.	
k>		xI_n	Allowed overload (service factor)	Set
Alarm		%	Alarm level	Set
tau		min	Thermal time constant	Set
ctau		xtau	Coefficient for cooling time constant. Default = 1.0	Set
kTamb		xI_n	Ambient temperature corrected max. allowed continuous current	
Imax40		$\%I_n$	Allowed load at Tamb +40 °C. Default = 100 %.	Set
Imax70		$\%I_n$	Allowed load at Tamb +70 °C.	Set
Tamb		°C	Ambient temperature. Editable Samb=n/a. Default = +40 °C	Set
Samb	 n/a ExtAI1...16		Sensor for ambient temperature No sensor in use for Tamb External Analogue input 1...16	Set

For details of setting ranges see chapter 9.3.

Set = An editable parameter (password needed)

C = Can be cleared to zero

F = Editable when force flag is on

2.14. 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 4.7). 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. See chapter 2.22.

Three independent stages

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

Figure 2.14-1 shows the functional block diagram of the overvoltage function stages U>, U>> and U>>>.

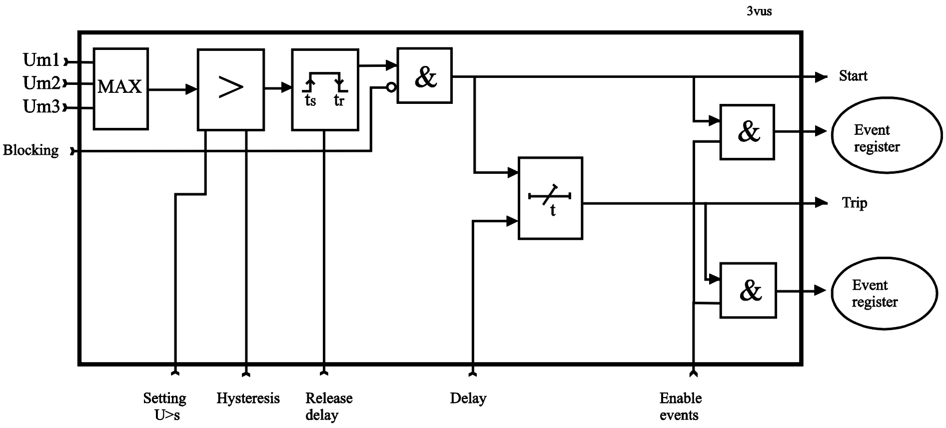


Figure 2.14-1 Block diagram of the three-phase overvoltage stages U>, U>> and U>>>.

Parameters of the overvoltage stages U>, U>>, U>>> (59)

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
Umax		V	The supervised value. Max. of U_{L12}, U_{L23} and U_{L31}	
U>, U>>, U>>>		V	Pick-up value scaled to primary value	
U>, U>>, U>>>		%Un	Pick-up setting relative to U_N	Set
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

For details of setting ranges see chapter 9.3.
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 are detailed information available of the eight latest faults: Time stamp, fault voltage, elapsed delay and setting group.

Recorded values of the overvoltage stages (8 latest faults) U>, U>>, U>>> (59)

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		Active setting group during fault

2.15. 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 3.7). The blocking signal can also be a signal from the user's logic (see chapter 5.8).

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 shows an example of low voltage self blocking.

- 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.

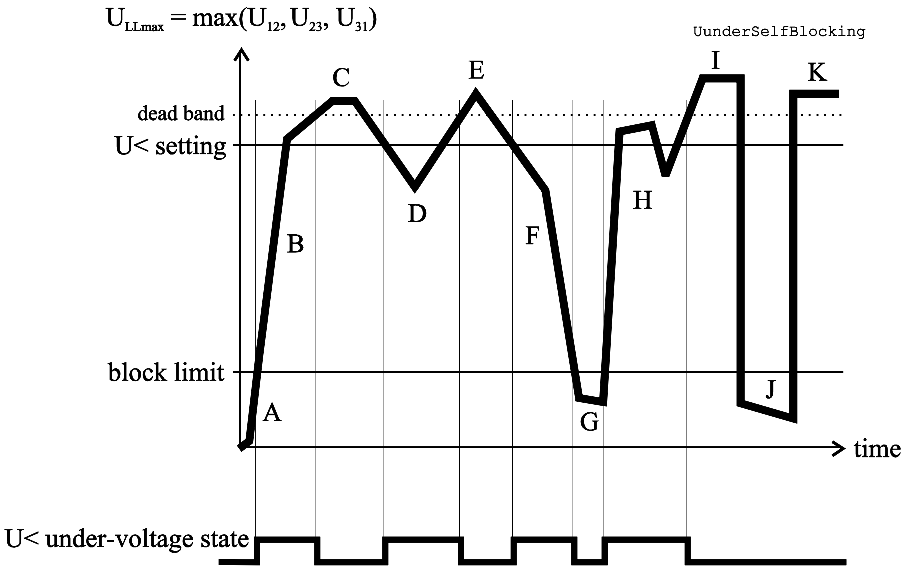


Figure 2.15-1 Under voltage state and block limit.

Three independent stages

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

Setting groups

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

Parameters of the under voltage stages U<, U<<, U<<< (27)

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
MinU		V	The supervised minimum of line-to-line voltages in primary volts	
U<, U<<, U<<<		V	Pick-up value scaled to primary value	
U<, U<<, U<<<		%Un	Pick-up setting	Set
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

For details of setting ranges see chapter 9.3.

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 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.

Recorded values of the undervoltage stages (8 latest faults) U<, U<<, U<<< (27)

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		Active setting group during fault

2.16. Reverse power and underpower protection P< (32)

Reverse power and underpower function is sensitive to active power. For reverse power function the pick-up value is negative. For underpower function a positive pick-up value is used. Whenever the active power goes under the pick-up value, the stage picks up and issues a start signal. If the fault situation stays on longer than the delay setting, a trip signal is issued.

The pick-up setting range is from –200 % to +200 % of the nominal apparent power Sn. The nominal apparent power is determined by the configured voltage and current transformer values.

Equation 2.16-1

$$S_n = VT_{Rated\,Primary} \cdot CT_{Rated\,Primary} \cdot \sqrt{3}$$

There are two identical stages available with independent setting parameters.

Setting parameters of P< and P<< stages:

Parameter	Value	Unit	Default	Description
P<, P<<	-200.0 ... 200.0	%Sn	-4.0 (P<), -20.0(P<<)	P<,P<< pick-up setting
t<	0.3 … 300.0	s	1.0	P<, P<< operational 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

Measured and recorded values of P< and P<< stages:

	Parameter	Value	Unit	Description
Measured value	P		kW	Active power
Recorded values	SCntr		-	Start counter (Start) reading
	TCntr		-	Trip counter (Trip) reading
	Flt		%Sn	Max value of fault
	EDly		%	Elapsed time as compared to the set operating time, 100% = tripping

2.17. Overfrequency and underfrequency Protection f>, f< (81H/81L)

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 situation remains on longer than the user's operation delay setting, a trip signal is issued. For situations, where no voltage is present an adapted frequency is used. See chapter 1.2.

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

These two 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 underfrequency 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 2.22). All the stages have definite operation time delay (DT).

Setting groups

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

Parameters of the over & underfrequency stages f><, f><><, f<, f<< (81H/81L)

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
f		Hz	The supervised value.	
 fX fXX f< f<<		Hz	Pick-up value Over/under stage f><. See 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

For details of setting ranges see chapter 9.3.

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

Recorded values of the over & under frequency stages (8 latest faults) f><, f><><, f<, f<< (81H/81L)

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		Active setting group during fault

2.18. Rate of change of frequency (ROCOF) protection df/dt (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.

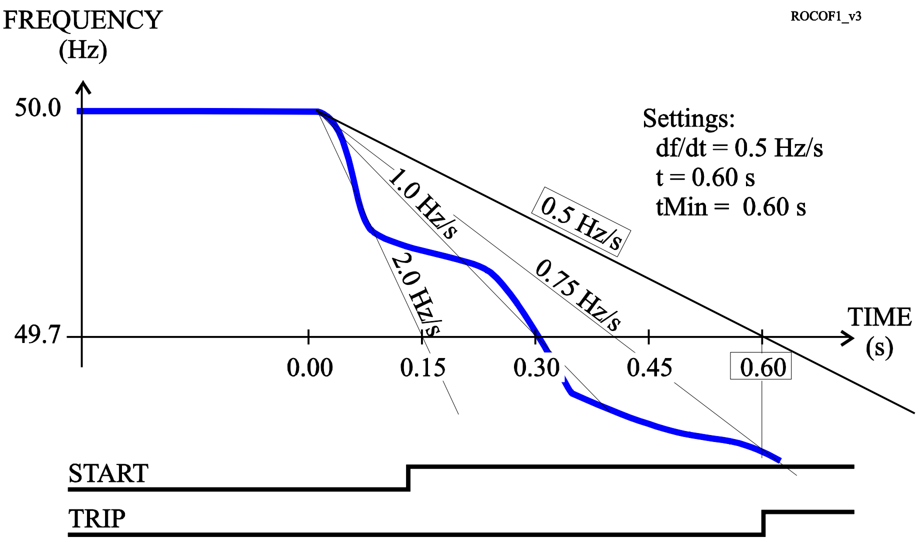


Figure 2.18-1 An example of definite time df/dt operation time. At 0.6 s, which is the delay setting, the average slope exceeds the setting 0.5 Hz/s and a trip signal is generated.

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 2.18-1 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 2.18-2

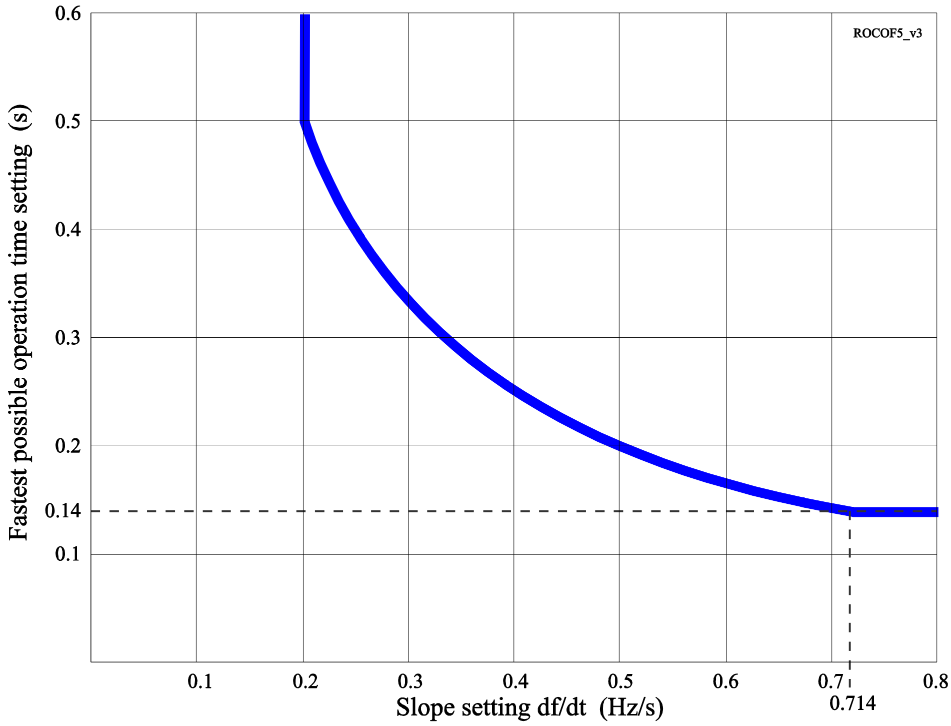


Figure 2.18-2 At very sensitive slope settings the fastest possible operation time is limited according the figure.

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 2.18-3).

Figure 2.18-4 shows an 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 2.18-1

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

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 operation 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 2.18-3 shows the inverse characteristics with the same settings as in Figure 2.18-4.

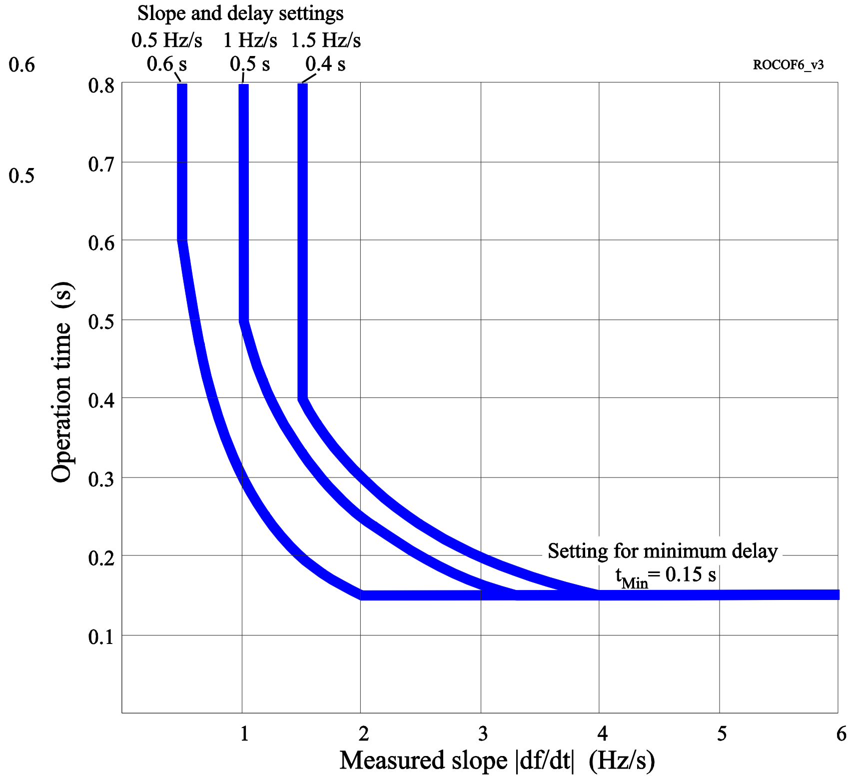


Figure 2.18-3 Three examples of possible inverse df/dt operation time characteristics. The slope and operation delay settings define the knee points on the left. A common setting for t_{Min} has been used in these three examples. This minimum delay parameter defines the knee point positions on the right.

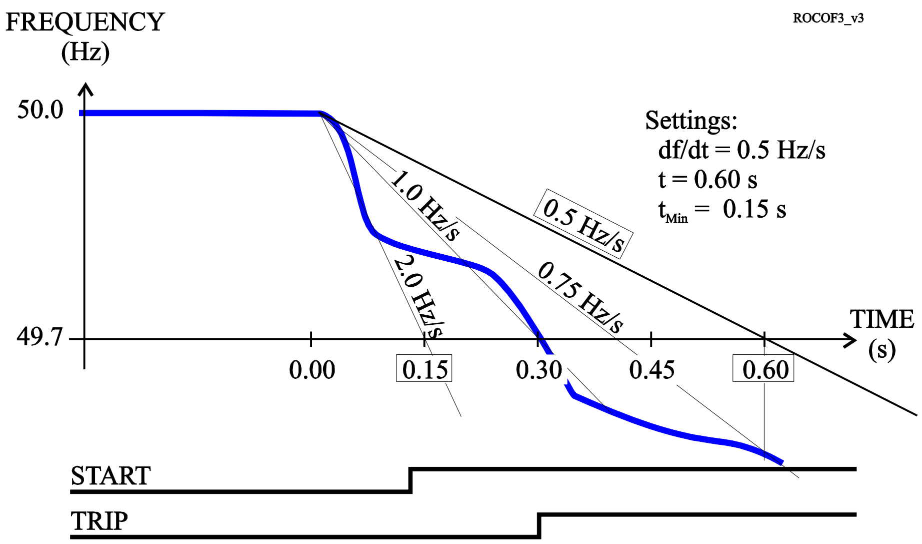


Figure 2.18-4 An example of inverse df/dt operation time. The time to trip will be 0.3 s, although the setting is 0.6 s, because the average slope 1 Hz/s is steeper than the setting value 0.5 Hz/s.

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
t_{Min}>	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

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

2.19. Synchrocheck (25)

The device includes a function that will check synchronism when the circuit-breaker is closed. The function will monitor voltage amplitude, frequency and phase angle difference between two voltages, feeding side and reference. The reference voltage used for sychrochecking is either phase-to-phase voltage U_{12} or phase-to-ground voltage U_{L1}.

Setting parameters of synchrocheck stage SyC1 (25)

Parameter	Values	Unit	Default	Description
Side	UL1/ULLy UL1/ULNy	-	U12/ULLy	Voltage selection. The used voltage reference is selected with voltage measurement mode from the Scaling menu.
CBObj	Obj1	-	Obj1	**NOTE!** The stage is always using the object 1 for syncrocheck.
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 very small (<0.3Hz).

Parameter	Values	Unit	Default	Description
UMode	-, DD, DL, LD, DD/DL, DD/LD, 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.
SGrpDI	Digital inputs	-	-	The input for changing the setting group.
SetGrp	1; 2	-	1	The active setting group.

Measured and recorded values of synchrocheck stage SyC1 (25):

	Parameter	Values	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)
Recorded values	ReqCntr	-	-	Request counter
	SyncCntr	-	-	Synchronising counter
	FailCntr	-	-	Fail counter
	f 1)	-	Hz	Recorded frequency (reference side)
	fy 1)	-	Hz	Recorded frequency (comparison side)
	U12 1)	-	% Un	Recorded voltage (reference side)
	U12y 1)	-	% 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.

The following signals of the both stages 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.

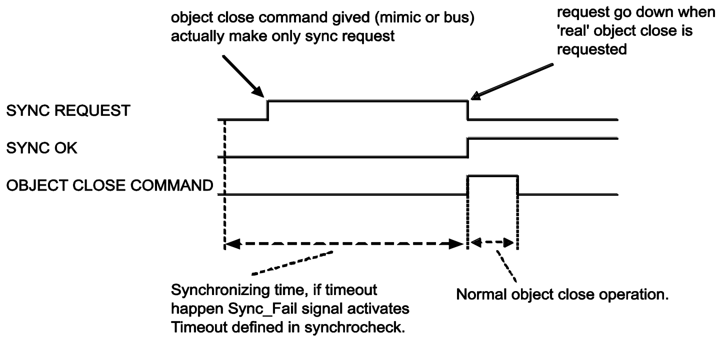


Figure 2.19-1 The principle of the synchrocheck function

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.

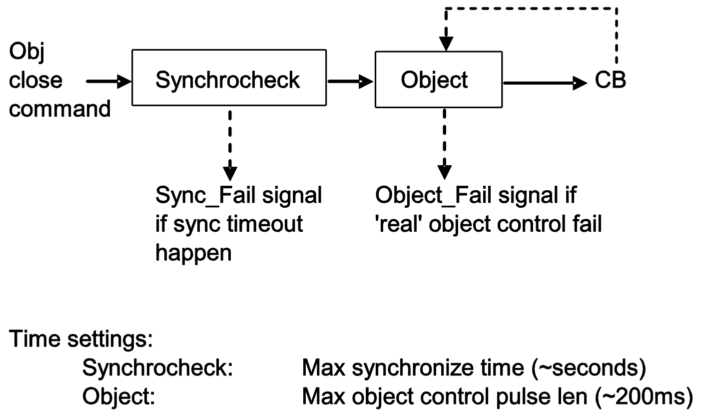


Figure 2.19-2 The block diagram of the synchrocheck and the controlling object

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

Table 2.19-1 Voltage measurement modes for synchrocheck function

Voltage input	Terminals	Signals in mode "3LN/1LLy"	Signals in mode "3LN/1LNy"
U_{L1}	X1:11-12	U_{L1}	U_{L1}
U_{L2}	X1:13-14	U_{L2}	U_{L2}
U_{L3}	X1:15-16	U_{L3}	U_{L3}
U_{Sync}	X1:17-18	U_{L12} (phase to phase sync voltage)	U_{L1} (phase to ground sync voltage)
Number of synchrocheck stages		1	1
Availability of U_0 and directional I_0 stages		Yes	Yes
Power measurement		3-phase power, nonsymmetrical loads	3-phase power, nonsymmetrical loads

2.20. Second harmonic O/C stage I_{f2}>(51F2)

This stage is mainly used to block other stages. The ratio between the second harmonic component and the fundamental frequency component is measured on all the phase currents. When the ratio in any phase exceeds the setting value, the stage gives a start signal. After a settable delay, the stage gives a trip signal.

The start and trip signals can be used for blocking the other stages.

The trip delay is irrelevant if only the start signal is used for blocking.

The trip delay of the stages to be blocked must be more than 60 ms to ensure a proper blocking.

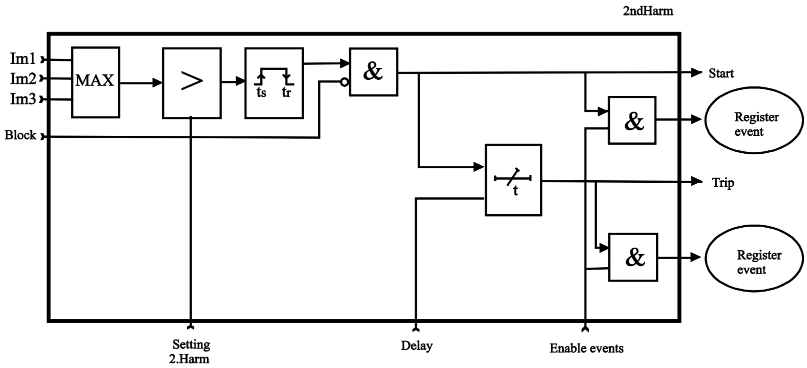


Figure 2.20-1 Block diagram of the second harmonic stage.

Setting parameters of second harmonic blocking 2.Ha(51F2):

Parameter	Value	Unit	Default	Description
If2>	10…100	%	10	Setting value If2/Ifund
t_f2	0.05…300.0	s	0.05	Definite operating time
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

Measured and recorded values of second harmonic blocking 2.Ha(51F2):

	Parameter	Value	Unit	Description
Measured values	IL1H2.		%	2. harmonic of IL1, proportional to the fundamental value of IL1
	IL2H2.		%	2. harmonic of IL2
	IL3H2.		%	2. harmonic of IL3
Recorded values	Flt		%	The max. fault value
	EDly		%	Elapsed time as compared to the set operating time; 100% = tripping

2.21. 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 5.4 for details about the output matrix and the trip relays.

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

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
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	 1 - 14		The supervised output relay*). Relay T1 – T14 (depending on the orderinf code)	Set
t>		s	Definite operation time.	Set

For details of setting ranges see chapter 9.3.

Set = An editable parameter (password needed)

C = Can be cleared to zero

F = Editable when force flag is on

*) This setting is used by the circuit breaker condition monitoring, too. See chapter 3.8.

Recorded values of the latest eight faults

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

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

2.22. Programmable stages (99)

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

The following parameters are available:

- **Priority**
  If operation times less than 60 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.
- **Link**
  The name of the supervised signal (see table below).
- **Cmp**
  Compare mode. ‘>’ for over or ‘<’ for under comparison.
- **Pick-up**
  Limit of the stage. The available setting range and the unit depend on the selected signal.
- **T**
  Definite time operation delay
- **Hyster**
  Dead band (hysteresis)
- **NoCmp**
  Only used with compare mode under (‘<’). This is the limit to start the comparison. Signal values under NoCmp are not regarded as fault.

Table 2.22-1 Available signals to be supervised by the programmable stages

I_{L1}, I_{L2}, I_{L3}	Phase currents
I_0	Residual current input I_0
U_{L12}, U_{L23}, U_{L31}	Line-to-line voltages
U_{L1}, U_{L2}, U_{L3}	Phase-to-ground voltages
U_0	Zero-sequence voltage
f	Frequency
P	Active power
Q	Reactive power
S	Apparent power
Cos Fii	Cosine φ
I_{0Calc}	Phasor sum $\underline{I}_{L1} + \underline{I}_{L2} + \underline{I}_{L3}$
I1	Positive sequence current
I2	Negative sequence current
I2/I1	Relative negative sequence current
I2/In	Negative sequence current in pu
U1	Positive sequence voltage
U2	Negative sequence voltage
U2/U1	Relative negative sequence voltage
IL	Average $(I_{L1} + I_{L2} + I_{L3})/3$
Uphase (U_{LN})	Average $(U_{L1} + U_{L2} + U_{L3})/3$
Uline (U_{LL})	Average $(U_{L12} + U_{L23} + U_{L31})/3$
TanFii	Tangent φ [=tan(arccosφ)]
Prms	Active power rms value
Qrms	Reactive power rms value
Srms	Apparent powre rms value
$THDI_{L1}$	Total harmonic distortion of I_{L1}
$THDI_{L2}$	Total harmonic distortion of I_{L2}
$THDI_{L3}$	Total harmonic distortion of I_{L3}
$THDU_{L1}$	Total harmonic distortion of input U_{L1}
$THDU_{L2}$	Total harmonic distortion of input U_{L2}
$THDU_{L3}$	Total harmonic distortion of input U_{L3}
fy	Frequency behind circuit breaker
fz	Frequency behind 2nd circuit breaker
I_{L1}rms	I_{L1} RMS for average sampling
I_{L2}rms	I_{L2} RMS for average sampling
I_{L3}rms	I_{L3} RMS for average sampling
U_{L12}y	Voltage behind circuit breaker
U_{L12}z	Voltage behind 2nd circuit breaker
ILmin, ILmax	Minimum and maximum of phase currents
ULLmin, ULLmax	Minimum and maximum of line voltages
ULNmin, ULNmax	Minimum and maximum of phase voltages

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

There are two identical stages available with independent setting parameters.

Parameters of the programmable stages PrgN (99)

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
Link	(Table 2.22-1)		Name for the supervised signal	Set
(Table 2.22-1)			Value of the supervised signal	
Cmp	 > <		Mode of comparison Over protection Under protection	Set
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.

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		Active setting group during fault

2.23. Arc fault protection (50ARC/50NARC)-optional

NOTE! This protection function needs optional hardware in slot X6. More details of the hardware can be found in chapters 8.4 and 9.1.8).

Arc protection is used for fast arc protection. The function is based on simultaneous light and current measurement. Special arc sensors are used to measure the light of an arc.

Three stages for arc faults

There are three separate stages for the various current inputs:

- ArcI> for phase-to-phase arc faults. Current inputs I_{L1}, I_{L2}, I_{L3} are used.
- ArcI_0> for phase-to-earth arc faults. Current input I_{01} is used.

Light channel selection

The light information source to the stages can be selected from the following list.

- – No sensor selected. The stage will not work.
- S1 Light sensor S1.
- S2 Light sensor S2.
- S1/S2 Either one of the light sensors S1 or S2.
- BI Binary input of the arc card. 48 Vdc.
- S1/BI Light sensor S1 or the binary input.
- S2/BI Light sensor S2 or the binary input.
- S1/S2/BI Light sensor S1 or S2 or the binary input.

Binary input

The binary input (BI) on the arc option card (see chapter 8.4) can be used to get the light indication from another relay to build selective arc protection systems. The BI signal can also be connected to any of the output relays, BO, indicators etc. offered by the output matrix (See chapter 5.4). BI is a dry input for 48 Vdc signal from binary outputs of other VAMP devices or dedicated arc protection devices by VAMP.

Binary output

The binary output (BO) on the arc option card (see chapters 8.4 and 8.5) can be used to give the light indication signal or any other signal or signals to another relay's binary input to build selective arc protection systems. Selection of the BO connected signal(s) is done with the output matrix (See chapter 5.4). BO is an internally wetted 48 Vdc signal for BI of other VAMP devices or dedicated arc protection devices by VAMP.

Delayed light indication signal

Relay output matrix has a delayed light indication output signal (Delayed Arc L>) available for building selective arc protection systems. Any light source combination and a delay can be configured starting from 0.01 s to 0.15 s. The resulting signal is available in the output matrix to be connected to BO, output relays etc.

Pick up scaling

The per unit (pu) values for pick up setting are based on the current transformer values.

ArcI>: 1 pu = $1xI_n$ = rated phase current CT value

ArcI$_0$>: 1 pu = $1xI_{0n}$ = rated residual current CT value for input I_{01}.

Parameters of arc protection stages ArcI>, ArcI$_0$>(50ARC/50NARC)

Parameter	Value	Unit	Description	Note
Status	- Start Trip		Current status of the stage Light detected according ArcIn Light and overcurrent detected	 F F
LCntr			Cumulative light indication counter. S1, S2 or BI.	C
SCntr			Cumulative light indication counter for the selected inputs according parameter ArcIn	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
 ILmax I$_0$			Value of the supervised signal Stage ArcI> Stage ArcI$_0$>	
ArcI> ArcIo>		pu pu	Pick up setting xI$_n$ Pick up setting xI$_{0n}$	Set
ArcIn	– S1 S2 S1/S2 BI S1/BI S2/BI S1/S2/BI		No sensor selected Sensor 1 at terminals X6:4-5 Sensor 2 at terminals X6:6-7 Sensor in terminals 1 and 2 Terminals X6:1-3 for BI Sensor 1 and BI in use Sensor 2 and BI in use Sensor 1, 2 and BI in use	Set
Delayed light signal output				
Ldly		s	Delay for delayed light output signal	Set
LdlyCn	– S1 S2 S1/S2 BI S1/BI S2/BI S1/S2/BI		No sensor selected Sensor 1 at terminals X6:4-5 Sensor 2 at terminals X6:6-7 Sensor in terminals 1 and 2 Terminals X6:1-3 for BI Sensor 1 and BI in use Sensor 2 and BI in use Sensor 1, 2 and BI in use	Set

For details of setting ranges see chapter 9.3.

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 are detailed information available of the eight latest faults: Time stamp, fault type, fault value, load current before the fault and elapsed delay.

Recorded values of the arc protection stages ArcI>, ArcI$_{01}$A, ArcI$_{02}$> (50ARC/50NARC)

Parameter	Value	Unit	Description
	yyyy-mm-dd		Time stamp of the recording, date
	hh:mm:ss.ms		Time stamp, time of day
Type		pu	Fault type value. Only for ArcI> stage.
Flt		pu	Fault value
Load		pu	Pre fault current. Only for ArcI> stage.
Edly		%	Elapsed time of the operating time setting. 100% = trip

2.24. Inverse time operation

The inverse time operation - i.e. inverse delay minimum time (IDMT) type of operation - is available for several protection functions. The common principle, formulae and graphic representations of the available inverse delay types are described in this chapter.

Inverse delay means that the operation time depends on the measured real time process values during a fault. For example with an overcurrent stage using inverse delay a bigger a fault current gives faster operation. The alternative to inverse delay is definite delay. With definite delay a preset time is used and the operation time does not depend on the size of a fault.

Stage specific inverse delay

Some protection functions have their own specific type of inverse delay. Details of these dedicated inverse delays are described with the appropriate protection function.

Operation modes

There are three operation modes to use the inverse time characteristics:

- Standard delays
Using standard delay characteristics by selecting a curve family (IEC, IEEE, IEEE2, RI) and a delay type (Normal inverse, Very inverse etc). See chapter 2.24.1.

- Standard delay formulae with free parameters
Selecting a curve family (IEC, IEEE, IEEE2) and defining one's own parameters for the selected delay formula. This mode is activated by setting delay type to ‘Parameters’, and then editing the delay function parameters A ... E. See chapter 2.24.2.

- Fully programmable inverse delay characteristics
Building the characteristics by setting 16 [current, time] points. The relay interpolates the values between given points with 2nd degree polynomials. This mode is activated by setting curve family to ‘PrgN''. There are maximum three different programmable curves available at the same time. Each programmed curve can be used by any number of protection stages. See chapter 2.24.3.

Local panel graph

The device will show a graph of the currently used inverse delay on the local panel display. Up and down keys can be used for zooming. Also the delays at $20xI_{SET}$, $4xI_{SET}$ and $2xI_{SET}$ are shown.

Inverse time setting error signal

If there are any errors in the inverse delay configuration the appropriate protection stage will use definite time delay.

There is a signal 'Setting Error' available in output matrix, which indicates three different situations:

1. Settings are currently changed with VAMPSET or local panel, and there is temporarily an illegal combination of curve/delay/points. For example if previous settings were IEC/NI and then curve family is changed to IEEE, the setting error will active, because there is no NI type available for IEEE curves. After changing valid delay type for IEEE mode (for example MI), the 'Setting Error' signal will release.
2. There are errors in formula parameters A…E, and the device is not able to build the delay curve
3. There are errors in the programmable curve configuration and the device is not able to interpolate values between the given points.

Limitation

The maximum measured secondary phase current is $50xI_n$ and the maximum directly measured earth fault current is $10xI_{0n}$. The full scope of inverse delay curves goes up to 20 times the setting. At high setting the maximum measurement capability limits the scope of inverse curves according the following table.

Table 2.24-1

Current input	Maximum measured **secondary** current	Maximum **secondary scaled setting** enabling inverse delay times up to full 20x setting
I_{L1}, I_{L2}, I_{L3} and I_{0Calc}	250 A	12.5 A
I_{0n} = 5 A *)	50 A	2.5 A
I_{0n} = 1 A *)	10 A	0.5 A
I_{0n}= 0.2 A *)	2 A	0.1 A

*) The availableI_{0n} values depend on the order code. VAMP 259 has 5 A, 1 A or 0.2 A residual current inputs available. Desired input needs to be specified when ordering the relay.

Example of limitations

CT = 750/5

Application mode is Feeder

CT_0 = 100/1 (cable CT is used for residual current)

The cable CT is connected to a 1 A terminals of the available I_0 inputs.

For overcurrent stage I> the table above gives 12.5 A. Thus the maximum setting for I> stage giving full inverse delay range is 12.5 A / 5 A = 2.5 xI_n = 1875 $A_{Primary}$.

For earth fault stage I_0> the table above gives 0.5 A. Thus the maximum setting for I_0> stage giving full inverse delay range is 0.5 A / 1 A = 0.5 xI_{0n} = 50 $A_{Primary}$.

2.24.1. Standard inverse delays IEC, IEEE, IEEE2, RI

The available standard inverse delays are divided in four categories IEC, IEEE, IEEE2 and RI called delay curve families. Each category of family contains a set of different delay types according the following table.

Inverse time setting error signal

The inverse time setting error signal will be activated, if the delay category is changed and the old delay type doesn't exist in the new category. See Table 2.24-1 for more details.

Limitations

The minimum definite time delay start latest, when the measured value is twenty times the setting. However, there are limitations at high setting values due to the measurement range. See Table 2.24.1-1 for more details.

Table 2.24.1-1 Available standard delay families and the available delay types within each family.

Delay type		Curve family				
		DT	IEC	IEEE	IEEE2	RI
DT	Definite time	X				
NI1	Normal inverse		X		X	
VI	Very inverse		X	X	X	
EI	Extremely inverse		X	X	X	
LTI	Long time inverse		X	X		
LTEI	Long time extremely inverse			X		
LTVI	Long time very inverse			X		
MI	Moderately inverse			X	X	
STI	Short time inverse			X		
STEI	Short time extremely inverse			X		
RI	Old ASEA type					X
RXIDG	Old ASEA type					X

IEC inverse time operation

The operation time depends on the measured value and other parameters according Equation 2.24.1-1. Actually this equation can only be used to draw graphs or when the measured value I is constant during the fault. A modified version is implemented in the device for real time usage.

Equation 2.24.1-1

$$t = \frac{k\,A}{\left(\frac{I}{I_{pickup}}\right)^{B} - 1}$$

t	=	Operation delay in seconds
k	=	User's multiplier
I	=	Measured value
Ipickup	=	User's pick up setting
A, B	=	Constants parameters according Table 2.24.1-1.

There are three different delay types according IEC 60255-3, Normal inverse (NI), Extremely inverse (EI), Very inverse (VI) and a VI extension. Additional there is a de facto standard Long time inverse (LTI).

Table 2.24.1-2 Constants for IEC inverse delay equation

Delay type		Parameter A	Parameter B
NI	Normal inverse	0.14	0.02
EI	Extremely inverse	80	2
VI	Very inverse	13.5	1
LTI	Long time inverse	120	1

Example for Delay type "Normal inverse (NI) ":

k = 0.50

I = 4 pu (constant current)

I_{pickup} = 2 pu

A = 0.14

B = 0.02

$$t = \frac{0.50 \cdot 0.14}{\left(\frac{4}{2}\right)^{0.02} - 1} = 5.0$$

The operation time in this example will be 5 seconds. The same result can be read from Figure 2.24.1-1.

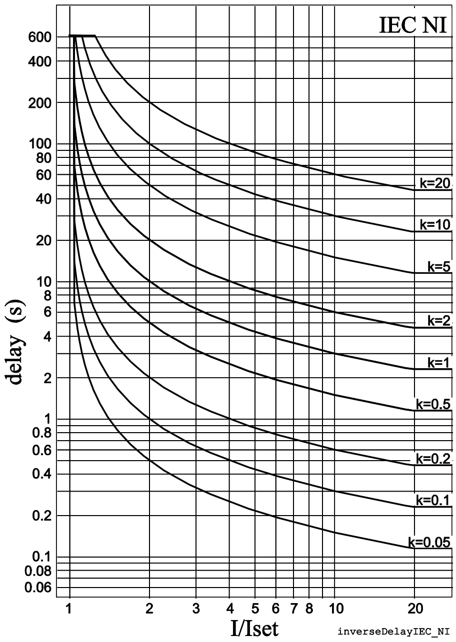


Figure 2.24.1-1 IEC normal inverse delay.

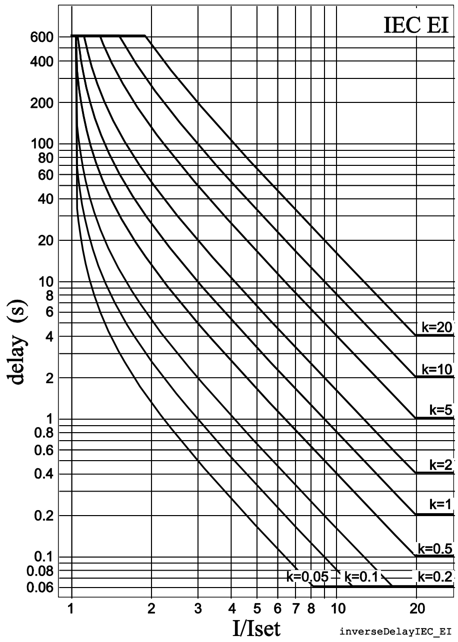


Figure 2.24.1-2 IEC extremely inverse delay.

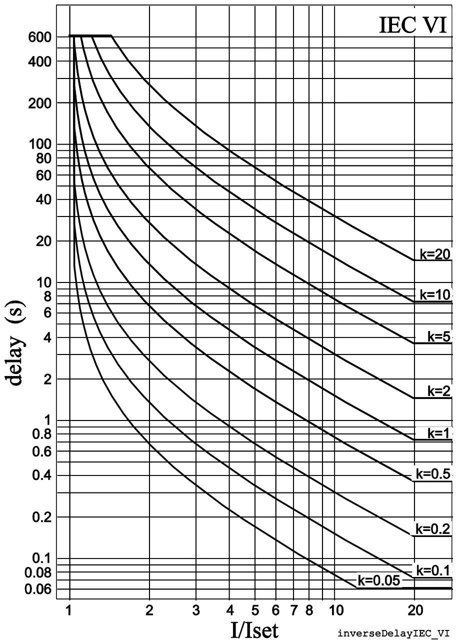


Figure 2.24.1-3 IEC very inverse delay.

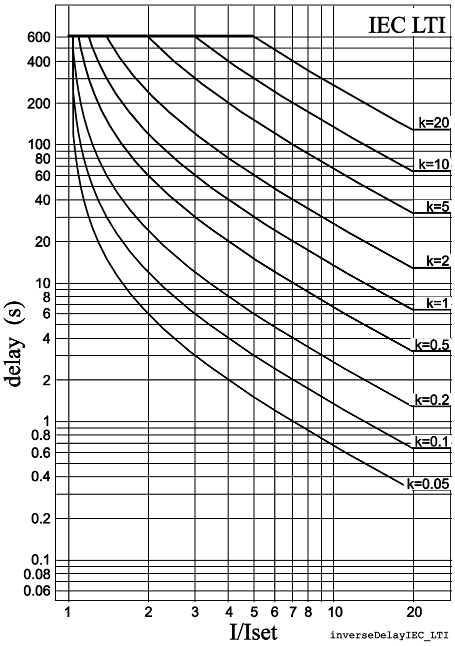


Figure 2.24.1-4 IEC long time inverse delay.

IEEE/ANSI inverse time operation

There are three different delay types according IEEE Std C37.112-1996 (MI, VI, EI) and many de facto versions according Table 2.24.1-3. The IEEE standard defines inverse delay for both trip and release operations. However, in the VAMP device only the trip time is inverse according the standard but the release time is constant.

The operation delay depends on the measured value and other parameters according Equation 2.24.1-2. Actually this equation can only be used to draw graphs or when the measured value I is constant during the fault. A modified version is implemented in the device for real time usage.

Equation 2.24.1-2

$$t = k\left[\frac{A}{\left(\frac{I}{I_{pickup}}\right)^{C} - 1} + B\right]$$

t	=	Operation delay in seconds
k	=	User's multiplier
I	=	Measured value
I_{pickup}	=	User's pick up setting
A,B,C	=	Constant parameter according Table 2.24.1-3.

Table 2.24.1-3 Constants for IEEE/ANSI inverse delay equation

Delay type		Parameter		
		A	B	C
LTI	Long time inverse	0.086	0.185	0.02
LTVI	Long time very inverse	28.55	0.712	2
LTEI	Long time extremely inverse	64.07	0.250	2
MI	Moderately inverse	0.0515	0.1140	0.02
VI	Very inverse	19.61	0.491	2
EI	Extremely inverse	28.2	0.1217	2
STI	Short time inverse	0.16758	0.11858	0.02
STEI	Short time extremely inverse	1.281	0.005	2

Example for Delay type "Moderately inverse (MI)":

$k = 0.50$

$I = 4$ pu

$I_{pickup} = 2$ pu

$A = 0.0515$

$B = 0.114$

$C = 0.02$

$$t = 0.50 \cdot \left[\frac{0.0515}{\left(\frac{4}{2}\right)^{0.02} - 1} + 0.1140 \right] = 1.9$$

The operation time in this example will be 1.9 seconds. The same result can be read from Figure 2.24.1-8.

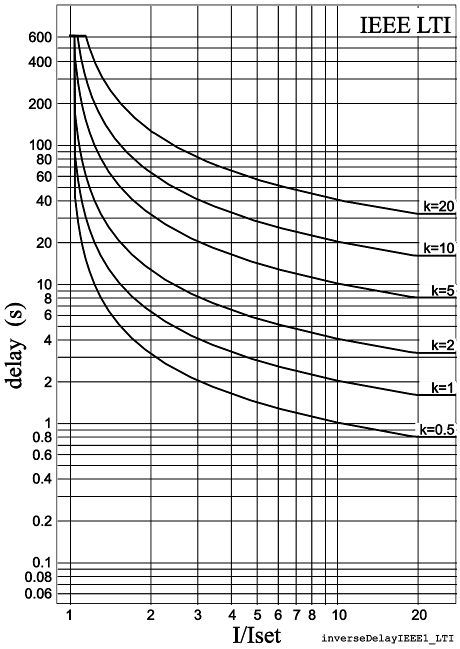


Figure 2.24.1-5 ANSI/IEEE long time inverse delay

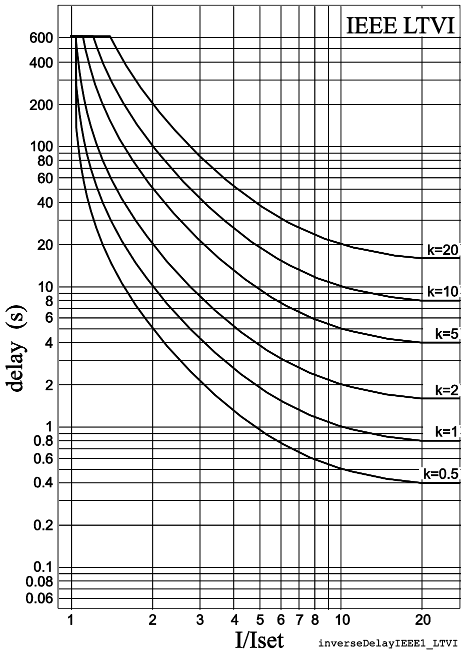


Figure 2.24.1-6 ANSI/IEEE long time very inverse delay

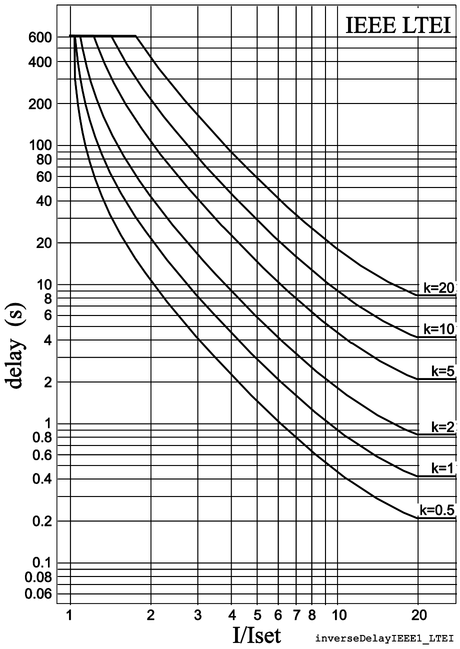


Figure 2.24.1-7 ANSI/IEEE long time extremely inverse delay

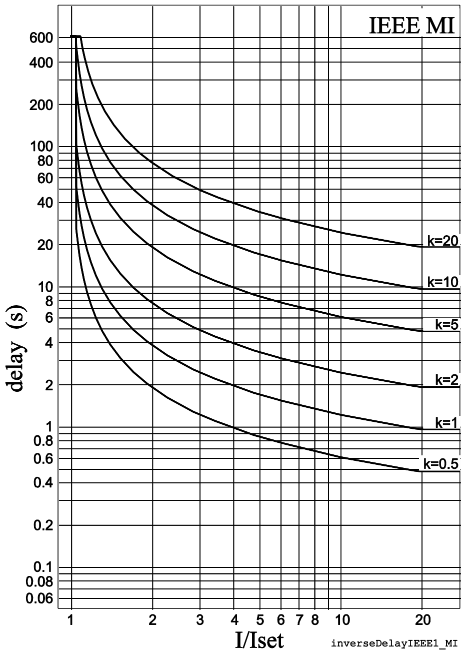


Figure 2.24.1-8 ANSI/IEEE moderately inverse delay

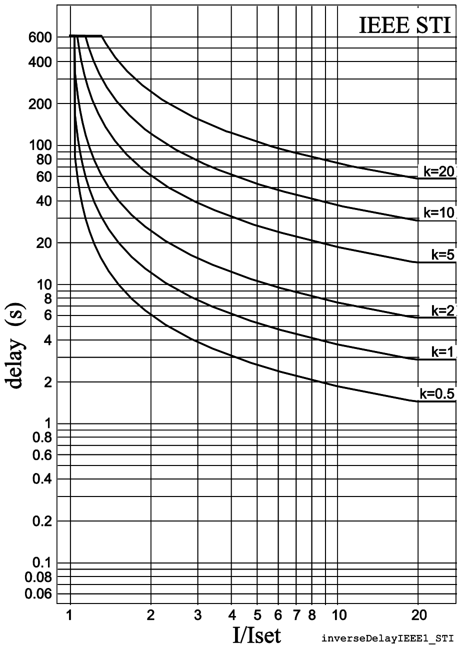


Figure 2.24.1-9 ANSI/IEEE short time inverse delay

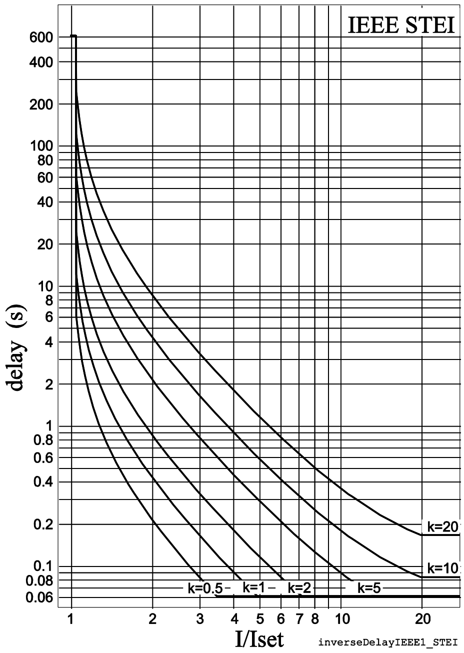


Figure 2.24.1-10 ANSI/IEEE short time extremely inverse delay

IEEE2 inverse time operation

Before the year 1996 and ANSI standard C37.112 microprocessor relays were using equations approximating the behaviour of various induction disc type relays. A quite popular approximation is Equation 2.24.1-3, which in VAMP devices is called IEEE2. Another name could be IAC, because the old General Electric IAC relays have been modeled using the same equation.

There are four different delay types according Table 2.24.1-4. The old electromechanical induction disc relays have inverse delay for both trip and release operations. However, in VAMP devices only the trip time is inverse the release time being constant.

The operation delay depends on the measured value and other parameters according

Equation 2.24.1-3. Actually this equation can only be used to draw graphs or when the measured value I is constant during the fault. A modified version is implemented in the device for real time usage.

Equation 2.24.1-3

$$t = k\left[A + \frac{B}{\left(\frac{I}{I_{pickup}} - C\right)} + \frac{D}{\left(\frac{I}{I_{pickup}} - C\right)^2} + \frac{E}{\left(\frac{I}{I_{pickup}} - C\right)^3}\right]$$

t = Operation delay in seconds

k = User's multiplier

I = Measured value

I_{pickup} = User's pick up setting

A,B,C,D,E = Constant parameter according Table 2.24.1-4.

Table 2.24.1-4 Constants for IEEE2 inverse delay equation

Delay type		Parameter				
		A	B	C	D	E
MI	Moderately inverse	0.1735	0.6791	0.8	-0.08	0.1271
NI	Normally inverse	0.0274	2.2614	0.3	-.1899	9.1272
VI	Very inverse	0.0615	0.7989	0.34	-0.284	4.0505
EI	Extremely inverse	0.0399	0.2294	0.5	3.0094	0.7222

Example for Delay type "Moderately inverse (MI)":

k	=	0.50
I	=	4 pu
I_{pickup}	=	2 pu
A	=	0.1735
B	=	0.6791
C	=	0.8
D	=	-0.08
E	=	0.127

$$t = 0.5 \cdot \left[0.1735 + \frac{0.6791}{\left(\frac{4}{2} - 0.8\right)} + \frac{-0.08}{\left(\frac{4}{2} - 0.8\right)^2} + \frac{0.127}{\left(\frac{4}{2} - 0.8\right)^3} \right] = 0.38$$

The operation time in this example will be 0.38 seconds. The same result can be read from Figure 2.24.1-11.

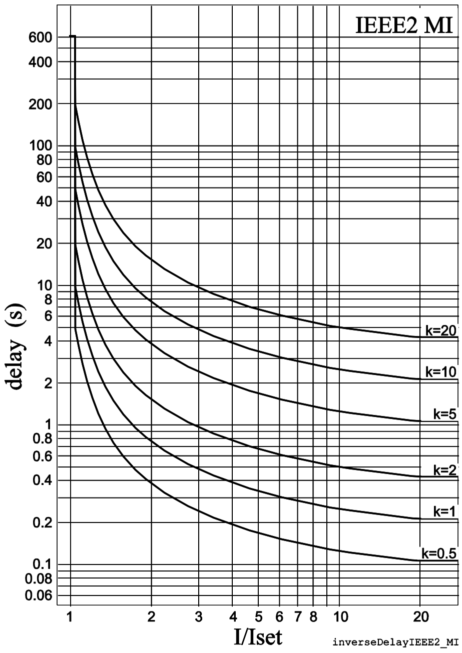


Figure 2.24.1-11 IEEE2 moderately inverse delay

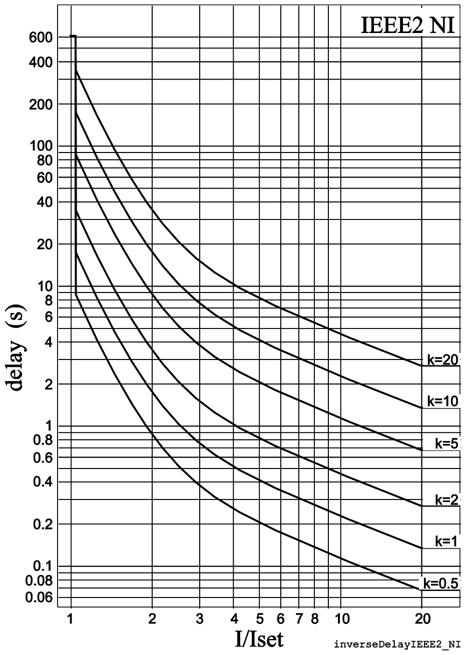


Figure 2.24.1-12 IEEE2 normal inverse delay

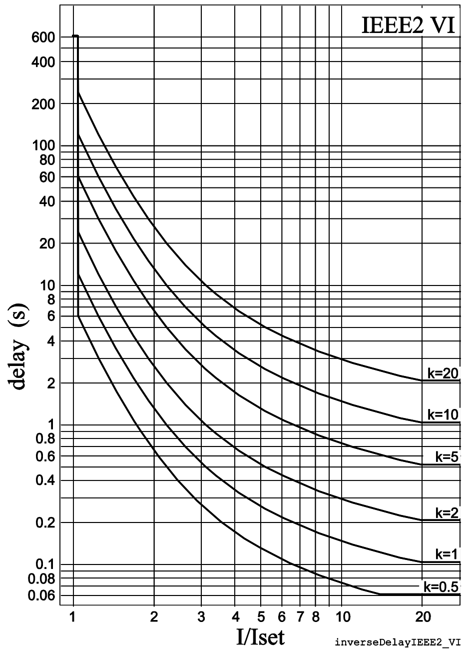


Figure 2.24.1-13 IEEE2 very inverse delay

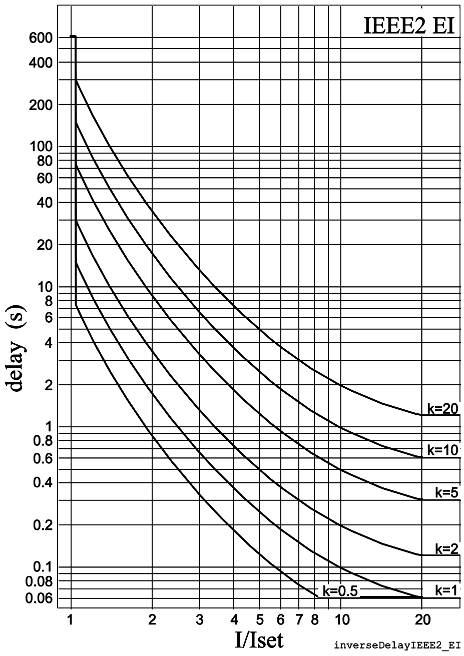


Figure 2.24.1-14 IEEE2 extremely inverse delay

RI and RXIDG type inverse time operation

These two inverse delay types have their origin in old ASEA (nowadays ABB) earth fault relays.

The operation delay of types RI and RXIDG depends on the measured value and other parameters according Equation 2.24.1-4 and Equation 2.24.1-5. Actually these equations can only be used to draw graphs or when the measured value I is constant during the fault. Modified versions are implemented in the device for real time usage.

Equation 2.24.1-4. RI

$$t_{RI} = \frac{k}{0.339 - \dfrac{0.236}{\left(\dfrac{I}{I_{pickup}}\right)}}$$

Equation 2.24.1-5 RXIDG

$$t_{RXIDG} = 5.8 - 1.35 \ln \frac{I}{k\, I_{pickup}}$$

t	=	Operation delay in seconds
k	=	User's multiplier
I	=	Measured value
I_{pickup}	=	User's pick up setting

Example for Delay type RI :

k = 0.50

I = 4 pu

I_{pickup} = 2 pu

$$t_{RI} = \frac{0.5}{0.339 - \frac{0.236}{\left(\frac{4}{2}\right)}} = 2.3$$

The operation time in this example will be 2.3 seconds. The same result can be read from Figure 2.24.1-15.

Example for Delay type RXIDG:

k = 0.50

I = 4 pu

I_{pickup} = 2 pu

$$t_{RXIDG} = 5.8 - 1.35 \ln \frac{4}{0.5 \cdot 2} = 3.9$$

The operation time in this example will be 3.9 seconds. The same result can be read from Figure 2.24.1-16.

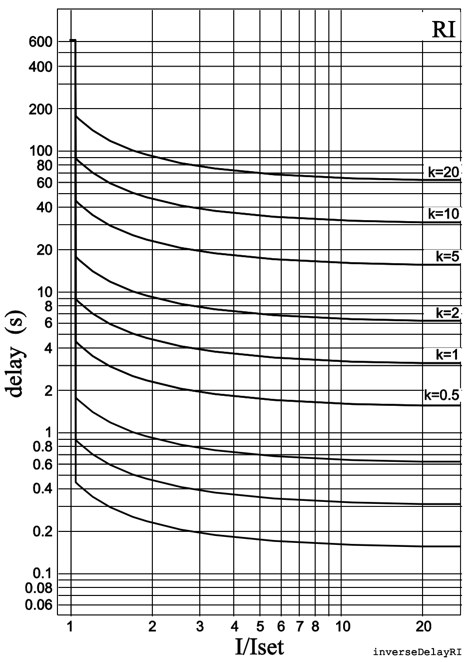


Figure 2.24.1-15 Inverse delay of type RI.

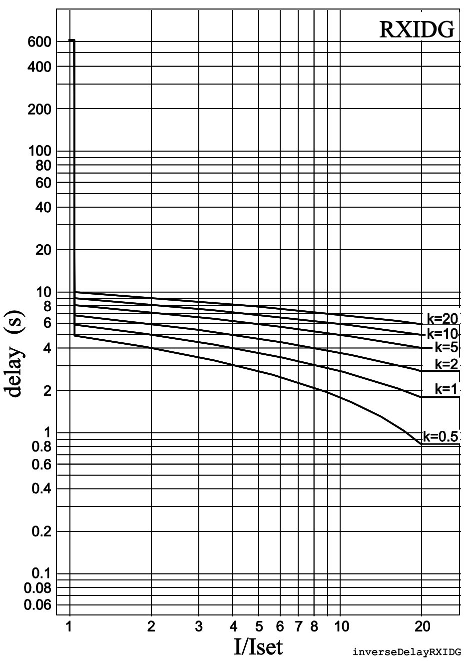


Figure 2.24.1-16 Inverse delay of type RXIDG.

2.24.2. Free parametrisation using IEC, IEEE and IEEE2 equations

This mode is activated by setting delay type to 'Parameters', and then editing the delay function constants, i.e. the parameters A ... E. The idea is to use the standard equations with one's own constants instead of the standardized constants as in the previous chapter.

Example for GE-IAC51 delay type inverse:

k	=	0.50
I	=	4 pu
I_{pickup}	=	2 pu
A	=	0.2078
B	=	0.8630
C	=	0.8000
D	=	–0.4180
E	=	0.1947

$$t = 0.5 \cdot \left[0.2078 + \frac{0.8630}{\left(\frac{4}{2} - 0.8\right)} + \frac{-0.4180}{\left(\frac{4}{2} - 0.8\right)^2} + \frac{0.1947}{\left(\frac{4}{2} - 0.8\right)^3} \right] = 0.37$$

The operation time in this example will be 0.37 seconds.

The resulting time/current characteristic of this example matches quite well with the characteristic of the old electromechanical IAC51 induction disc relay.

Inverse time setting error signal

The inverse time setting error signal will become active, if interpolation with the given parameters is not possible. See chapter 2.24 for more details.

Limitations

The minimum definite time delay start latest, when the measured value is twenty times the setting. However, there are limitations at high setting values due to the measurement range. See chapter 2.24 for more details.

2.24.3. Programmable inverse time curves

Only with VAMPSET, requires rebooting.

The [current, time] curve points are programmed using VAMPSET PC program. There are some rules for defining the curve points:

- configuration must begin from the topmost row
- row order must be as follows: the smallest current (longest operation time) on the top and the largest current (shortest operation time) on the bottom
- all unused rows (on the bottom) should be filled with [1.00 0.00s]

Here is an example configuration of curve points:

Point	Current $I/I_{pick\text{-}up}$	Operation delay
1	1.00	10.00 s
2	2.00	6.50 s
3	5.00	4.00 s
4	10.00	3.00 s
5	20.00	2.00 s
6	40.00	1.00 s
7	1.00	0.00 s
8	1.00	0.00 s
9	1.00	0.00 s
10	1.00	0.00 s
11	1.00	0.00 s
12	1.00	0.00 s
13	1.00	0.00 s
14	1.00	0.00 s
15	1.00	0.00 s
16	1.00	0.00 s

Inverse time setting error signal

The inverse time setting error signal will be activated, if interpolation with the given points fails. See chapter 2.24 for more details.

Limitations

The minimum definite time delay start latest, when the measured value is twenty times the setting. However, there are limitations at high setting values due to the measurement range. See chapter 2.24 for more details.

3. Supporting functions

3.1. 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. The event codes are listed in a separate document Modbus_Profibus_Spabus_event.pdf.

As an example of information included with a typical event an overvoltage trip event of the first 59 stage U> is shown in the following table.

EVENT	Description	Local panel	Communication protocols
Code: 1E2	Channel 30, event 2	Yes	Yes
I> trip on	Event text	Yes	No
2.7 x In	Fault value	Yes	No
2007-01-31	Date	Yes	Yes
08:35:13.413	Time	Yes	Yes
Type: $U_{L12,L23,L31}$	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 VAMSET the events can be stored to a file especially in case the device 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 error, the latest event can be reread any number of times using an other 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 in all v.10.xx softwares. Modification can be done in "Local panel conf" –menu. Alarm 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 10 ms or 20 ms resolution. The absolute accuracy of all time stamps depends on the time synchronizing of the relay. See chapter 3.10 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, the event buffer will eventually overflow. On the local screen this is indicated with string "OVF" after the event code.

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	PU Pri	Scaling of event fault value Per unit scaling Primary scaling	Set
Display Alarms	On Off	Alarm pop-up display is enabled No alarm 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 3.10)	
hh:mm:ss.nnn		Time	

3.2. Disturbance recorder

The disturbance recorder can be used to record all the measured signals, that is, currents, voltages 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 means that also 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 is also 12 (limited in waveform recording). The 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.

Disturbance recorder parameters

Parameter	Value	Unit	Description	Note
Mode	 Saturated Overflow		Behaviour in memory full situation: No more recordings are accepted The oldest recorder will be overwritten	Set
SR	 32/cycle 16/cycle 8/cycle 1/10ms 1/20ms 1/200ms 1/1s 1/5s 1/10s 1/15s 1/30s 1/1min		Sample rate Waveform Waveform Waveform One cycle value *) One cycle value **) Average Average Average Average Average Average Average	Set
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	 – Run Trig FULL		Status of recording Not active Waiting a triggering Recording 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
	I_{L1}, I_{L2}, I_{L3}		Phase current	
	I_0		Measured residual current	
	U_{L12}, U_{L23}, U_{L31}		Line-to-line voltage	
	U_{L1}, U_{L2}, U_{L3}		Phase-to-neutral voltage	
	U_0		Zero sequence voltage	
	f		Frequency	
	P, Q, S		Active, reactive, apparent power	
	P.F.		Power factor	
	CosFii		$\cos\varphi$	
	IoCalc		Phasor sum Io = $(\underline{I}_{L1}+\underline{I}_{L2}+\underline{I}_{L3})/3$	
	I1		Positive sequence current	
	I2		Negative sequence current	
	I2/I1		Relative current unbalance	
	I2/In		Current unbalance to nominal ratio	
	U1		Positive sequence voltage	
	U2		Negative sequence voltage	
	U2/U1		Relative voltage unbalance	
	IL		Average $(I_{L1} + I_{L2} + I_{L3})/3$	
	Uphase		Average $(U_{L1} + U_{L2} + U_{L3})/3$	
	Uline		Average $(U_{L12} + U_{L23} + U_{L31})/3$	
	DO		Digital outputs	
	DI		Digital inputs	
	TanFii		$\tan\varphi$	
	$THDI_{L1}$		Total harmonic distortion of I_{L1}	
	$THDI_{L2}$		Total harmonic distortion of I_{L2}	
	$THDI_{L3}$		Total harmonic distortion of I_{L3}	
	THDUa		Total harmonic distortion of input Ua	
	THDUb		Total harmonic distortion of input Ub	
	THDUc		Total harmonic distortion of input Uc	
	DI_2		Digital inputs 21-32	
	Prms		Active power rms value	
	Qrms		Reactive power rms value	
	Srms		Apparent power rms value	

Parameter	Value	Unit	Description	Note
	fy		Frequency behind circuit breaker	
	fz		Frequency behind 2nd circuit breaker	
	U_{LN}y		Voltage behind circuit breaker, phase to ground	
	U_{LL}y		Voltage behind circuit breaker, phase to phase	
	I_{L1}RMS		I_{L1} RMS for average sampling	
	I_{L2}RMS		I_{L2} RMS for average sampling	
	I_{L3}RMS		I_{L3} RMS for average sampling	
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.

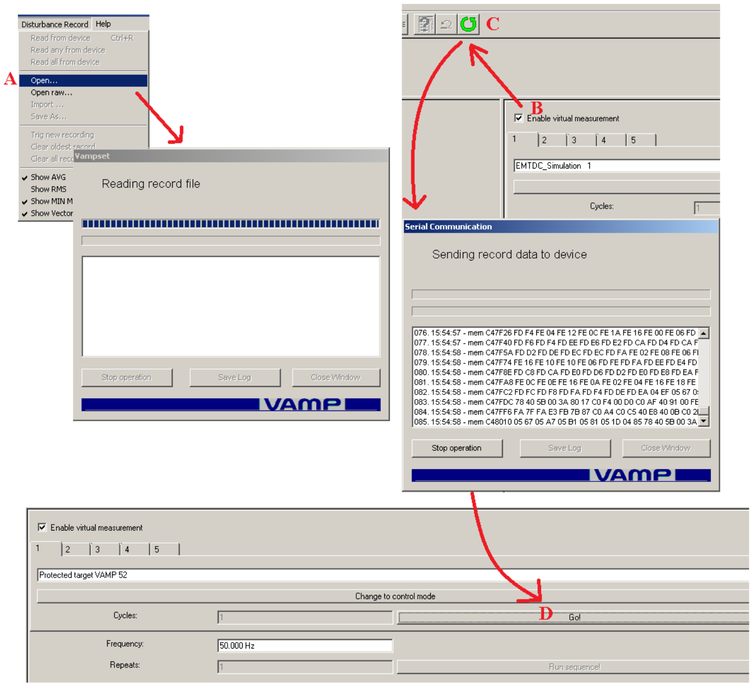
**) This is the fundamental frequency rms value of one cycle updated every 20 ms.

Running virtual comtrade files with VAMP relays

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 relay’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 φs when 50 Hz is used). The channel names have to correspond to the channel names in Vamp relays: IL1, IL2, IL3, Io1, Io2, U12, U23, UL1, UL2, UL3 and Uo.

3.3. Cold load pick-up and inrush current detection

Cold load pick-up

A situation is regarded as cold load when all the three phase currents have been less than a given idle value and then at least one of the currents exceeds a given pick-up level within 80 ms. In such case the cold load detection signal is activated for a given time. This signal is available for output matrix and blocking matrix. Using virtual outputs of the output matrix setting group control is possible.

Application for cold load detection

Right after closing a circuit breaker a given amount of overload can be allowed for a given limited time to take care of concurrent thermostat controlled loads. Cold load pick-up function does this for example by selecting a more coarse setting group for over-current stage(s). It is also possible to use the cold load detection signal to block any set of protection stages for a given time.

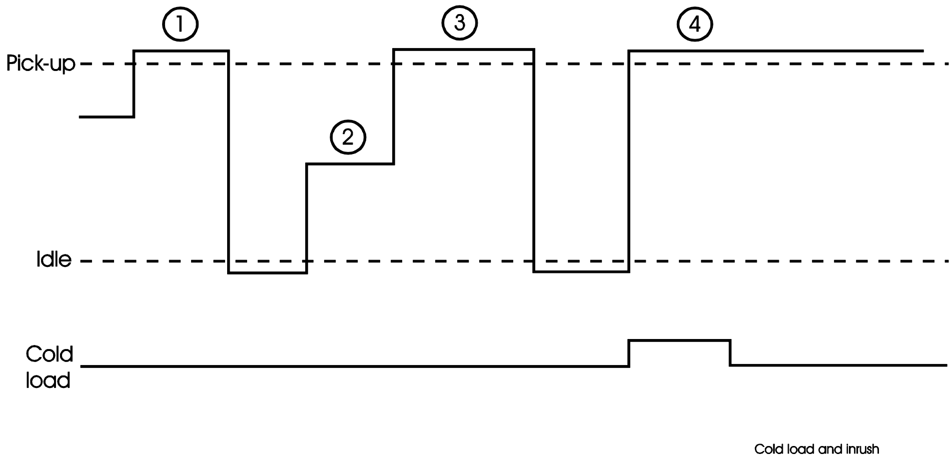
Inrush current detection

Inrush current detection is quite similar with the cold load detection but it does also include a condition for second harmonic relative content of the currents. When all phase currents have been less than a given idle value and then at least one of them exceeds a given pick-up level within 80 ms and the ratio 2nd harmonic ratio to fundamental frequency, I_{f2}/I_{f1}, of at least one phase exceeds the given setting, the inrush detection signal is activated. This signal is available for output matrix and blocking matrix. Using virtual outputs of the output matrix setting group control is possible.

By setting the Pickupf2 parameter for I_{f2}/I_{f1} to zero, the inrush signal will behave equally with the cold load pick-up signal.

Application for inrush current detection

The inrush current of transformers usually exceeds the pick-up setting of sensitive overcurrent stages and contains a lot of even harmonics. Right after closing a circuit breaker the pick-up and tripping of sensitive overcurrent stages can be avoided by selecting a more coarse setting group for the appropriate over-current stage with inrush detect signal. It is also possible to use the detection signal to block any set of protection stages for a given time.



① No activation because the current has not been under the set I_{dle} current.

② Current dropped under the I_{dle} current level but now it stays between the I_{dle} current and the pick-up current for over 80ms.

③ No activation because the phase two lasted longer than 80ms.

④ Now we have a cold load activation which lasts as long as the operation time was set or as long as the current stays above the pick-up setting.

Figure 3.3-1 Functionality of cold load / inrush current feature.

Parameters of the cold load & inrush detection function

Parameter	Value	Unit	Description	Note
ColdLd	- Start Trip		Status of cold load detection: Cold load situation is active Timeout	
Inrush	- Start Trip		Status of inrush detection: Inrush is detected Timeout	
ILmax		A	The supervised value. Max. of I_{L1}, I_{L2} and I_{L3}	
Pickup		A	Primary scaled pick-up value	
Idle		A	Primary scaled upper limit for idle current	
MaxTime		s		Set
Idle		xIn	Current limit setting for idle situation	Set
Pickup		xIn	Pick-up setting for minimum start current	Set
	80	ms	Maximum transition time for start recognition	
Pickupf2		%	Pick-up value for relative amount of 2[nd] harmonic, I_{f2}/I_{f1}	Set

Set = An editable parameter (password needed)

3.4. 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”.

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

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

	Parameter	Value	Unit	Description
Sag/ swell logs 1…4	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

3.5. 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 3.5-1).

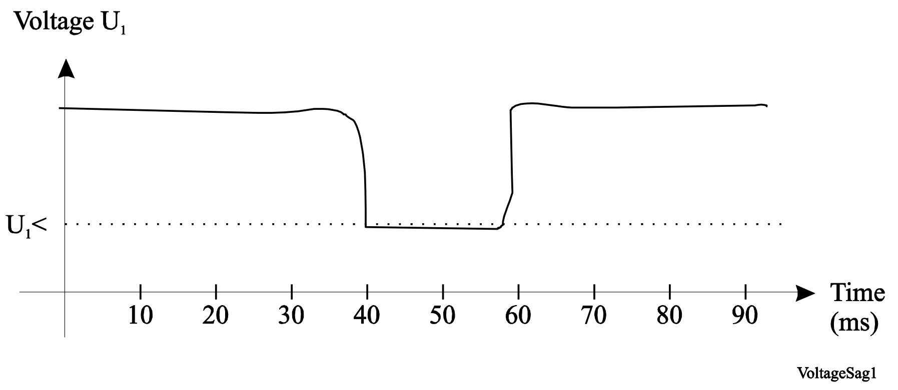


Figure 3.5-1. A short voltage interruption which is probably not recognized

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 3.5-2).

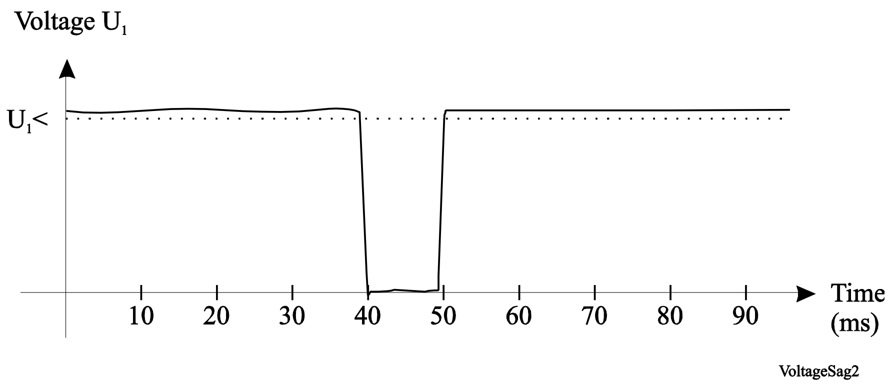


Figure 3.5-2 A short voltage interrupt that will be recognized

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

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

3.6. Current transformer supervision

The device supervise the external wiring between the device terminals and current transformers (CT) and the CT them selves. Furthermore, this is a safety function as well, since an open secondary of a CT, causes dangerous voltages.

The CT supervisor function measures phase currents. If one of the three phase currents drops below I_{MIN}< setting, while another phase current is exceeding the I_{max}> setting, the function will issue an alarm after the operation delay has elapsed.

Setting parameters of CT supervisor CTSV ( ):

Parameter	Value	Unit	Default	Description
Imax>	0.0 … 10.0	xIn	2.0	Upper setting for CT supervisor
Imin<	0.0 … 10.0	xIn	0.2	Lower setting for CT supervisor
t>	0.02 … 600.0	s	0.10	Operation delay
CT on	On; Off	-	On	CT supervisor on event
CT off	On; Off	-	On	CT supervisor off event

Measured and recorded values of CT supervisor CTSV ( ):

	Parameter	Value	Unit	Description
Measured value	ILmax		A	Maximum of phase currents
	ILmin		A	Minimum of phase currents
Display	Imax>, Imin<		A	Setting values as primary values
Recorded Values	Date		-	Date of CT supervision alarm
	Time		-	Time of CT supervision alarm
	Imax		A	Maximum phase current
	Imin		A	Minimum phase current

3.7. 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 currentI_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.

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
VT off	On; Off	-	On	VT supervisor off event

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

3.8. Circuit breaker condition monitoring

The device has a condition monitoring function that supervises the wearing of the circuit-breaker. The condition monitoring can give alarm for the need of CB maintenance well before the CB condition is critical.

The CB wear function measures the breaking current of each CB pole separately and then estimates the wearing of the CB accordingly the permissible cycle diagram. The breaking current is registered when the trip relay supervised by the circuit breaker failure protection (CBFP) is activated. (See chapter 2.20 for CBFP and the setting parameter "CBrelay".)

Breaker curve and its approximation

The permissible cycle diagram is usually available in the documentation of the CB manufacturer (Figure 3.8-1). The diagram specifies the permissible number of cycles for every level of the breaking current. This diagram is parameterised to the condition monitoring function with maximum eight [current, cycles] points. See Table 3.8-1. If less than eight points needed, the unused points are set to [I_{BIG}, 1], where I_{BIG} is more than the maximum breaking capacity.

If the CB wearing characteristics or part of it is a straight line on a log/log graph, the two end points are enough to define that part of the characteristics. This is because the device is using logarithmic interpolation for any current values falling in between the given current points 2...8.

The points 4...8 are not needed for the CB in Figure 3.8-1. Thus they are set to 100 kA and one operation in the table to be discarded by the algorithm.

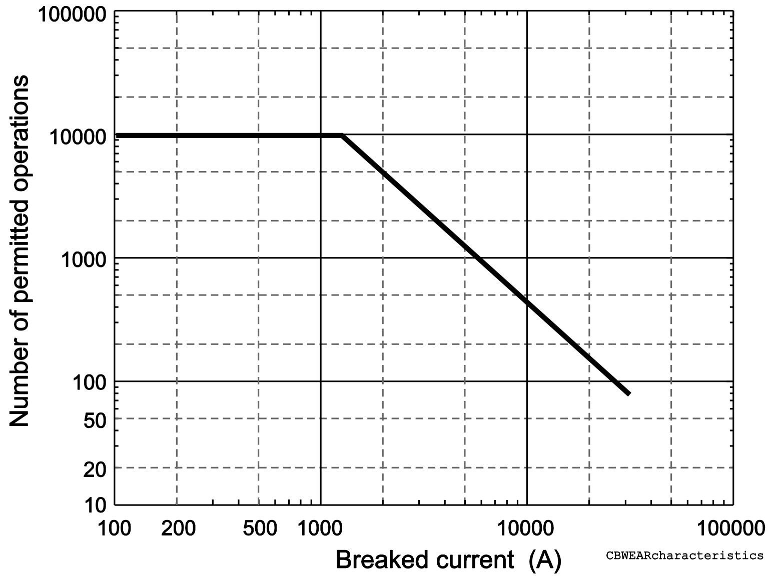


Figure 3.8-1. An example of a circuit breaker wearing characteristic graph.

Table 3.8-1. An example of circuit breaker wearing characteristics in a table format. The value are taken from the figure above. The table is edited with VAMPSET under menu "BREAKER CURVE".

Point	Interrupted current (kA)	Number of permitted operations
1	0 (mechanical age)	10000
2	1.25 (rated current)	10000
3	31.0 (maximum breaking current)	80
4	100	1
5	100	1
6	100	1
7	100	1
8	100	1

Setting alarm points

There are two alarm points available having two setting parameters each.

- Current.
  The first alarm can be set for example to nominal current of the CB or any application typical current. The second alarm can be set for example according a typical fault current.
- Operations left alarm limit
  An alarm is activated when there are less operation left at the given current level than this limit.

Any actual interrupted current will be logarithmically weighted for the two given alarm current levels and the number of operations left at the alarm points is decreased accordingly. When the "operations left" i.e. the number of remaining operations, goes under the given alarm limit, an alarm signal is issued to the output matrix. Also an event is generated depending on the event enabling.

Clearing "operations left" counters

After the breaker curve table is filled and the alarm currents are defined, the wearing function can be initialised by clearing the decreasing operation counters with parameter "Clear" (Clear oper. left cntrs). After clearing the device will show the maximum allowed operations for the defined alarm current levels.

Operation counters to monitor the wearing

The operations left can be read from the counters "A_{L1}Ln" (Alarm 1) and "A_{L2}Ln" (Alarm2). There are three values for both alarms, one for each phase. The smallest of three is supervised by the two alarm functions.

Logarithmic interpolation

The permitted number of operations for currents in between the defined points are logarithmically interpolated using equation

Equation 3.8-1

$$C = \frac{a}{I^n}$$, where

C = permitted operations

I = interrupted current

a = constant according Equation 3.8-2

n = constant according Equation 3.8-3

Equation 3.8-2

$$n = \frac{\ln \frac{C_k}{C_{k+1}}}{\ln \frac{I_{k+1}}{I_k}}$$

Equation 3.8-3

$$a = C_k I_k^2$$

ln = natural logarithm function

C_k = permitted operations. k = row 2...7 in Table 3.8-1.

I_k = corresponding current. k = row 2...7 in Table 3.8-1.

C_{k+1} = permitted operations. k = row 2...7 in Table 3.8-1.

I_{k+1} = corresponding current. k = row 2...7 in Table 3.8-1.

Example of the logarithmic interpolation

Alarm 2 current is set to 6 kA. What is the maximum number of operations according Table 3.8-1.

The current 6 kA lies between points 2 and 3 in the table. That gives value for the index k. Using

k = 2

C_k = 10000

C_{k+1} = 80

I_{k+1} = 31 kA

I_k = 1.25 kA

and the Equation 3.8-2 and Equation 3.8-3, the device calculates

$$n = \frac{\ln \frac{10000}{80}}{\ln \frac{31000}{1250}} = 1.5038$$

$$a = 10000 \cdot 1250^{1.5038} = 454 \cdot 10^6$$

Using Equation 3.8-1 the device gets the number of permitted operations for current 6 kA.

$$C = \frac{454 \cdot 10^6}{6000^{1.5038}} = 945$$

Thus the maximum number of current breaking at 6 kA is 945. This can be verified with the original breaker curve in Figure 3.8-1. Indeed, the figure shows that at 6 kA the operation count is between 900 and 1000. A useful alarm level for operation-left, could be in this case for example 50 being about five per cent of the maximum.

Example of operation counter decrementing when the CB is breaking a current

Alarm2 is set to 6 kA. CBFP is supervising trip relay T1 and trip signal of an overcurrent stage detecting a two phase fault is connected to this trip relay T1. The interrupted phase currents are 12.5 kA, 12.5 kA and 1.5 kA. How much are Alarm2 counters decremented ?

Using Equation 3.8-1 and values n and a from the previous example, the device gets the number of permitted operation at 10 kA.

$$C_{10kA} = \frac{454 \cdot 10^6}{12500^{1.5038}} = 313$$

At alarm level 2, 6 kA, the corresponding number of operations is calculated according

Equation 3.8-4

$$\Delta = \frac{C_{AlarmMax}}{C}$$

$$\Delta_{L1} = \Delta_{L2} = \frac{945}{313} = 3$$

Thus Alarm2 counters for phases $L1$ and $L2$ are decremented by 3. In phase $L1$ the currents is less than the alarm limit current 6 kA. For such currents the decrement is one.

$$\Delta_{L3} = 1$$

Local panel parameters of CBWEAR function

Parameter	Value	Unit	Description	Set
CBWEAR STATUS				
 A_{L1L1} A_{L1L2} A_{L1L3} A_{L2L1} A_{L2L2} A_{L2L3}			Operations left for - Alarm 1, phase L1 - Alarm 1, phase L2 - Alarm 1, phase L3 - Alarm 2, phase L1 - Alarm 2, phase L2 - Alarm 2, phase L3	
Latest trip				
Date time			Time stamp of the latest trip operation	
I_{L1} I_{L2} I_{L3}		A A A	Broken current of phase L1 Broken current of phase L2 Broken current of phase L3	
CBWEAR SET				
Alarm1				
Current	0.00 – 100.00	kA	Alarm1 current level	Set
Cycles	100000 – 1		Alarm1 limit for operations left	Set
Alarm2				
Current	0.00 – 100.00	kA	Alarm2 current level	Set
Cycles	100000 – 1		Alarm2 limit for operations left	Set
CBWEAR SET2				
A_{L1}On	On Off		'Alarm1 on' event enabling	Set
A_{L1}Off	On Off		'Alarm1 off' event enabling	Set
A_{L2}On	On Off		'Alarm2 on' event enabling	Set
A_{L2}Off	On Off		'Alarm2 off' event enabling	Set
Clear	– Clear		Clearing of cycle counters	Set

Set = An editable parameter (password needed)

The breaker curve table is edited with VAMPSET.

3.9. Energy pulse outputs

The device can be configured to send a pulse whenever certain amount of energy has been imported or exported. The principle is presented in Figure 3.9-1. Each time the energy level reaches the pulse size, an output relay is activated and it will stay active as long as defined by a pulse duration setting.

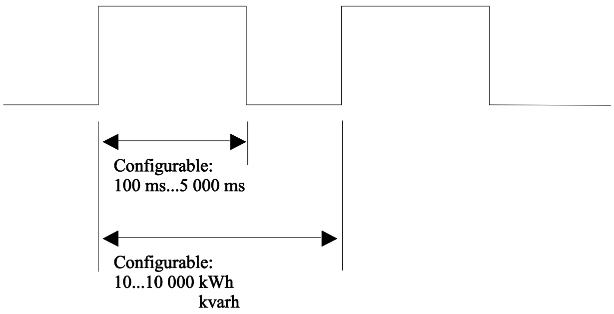


Figure 3.9-1. Principle of energy pulses

The device has four energy pulse outputs. The output channels are:

- Active exported energy
- Reactive exported energy
- Active imported energy
- Reactive imported energy

Each channel can be connected to any combination of the output relays using output matrix. The parameters for the energy pulses can be found in the E menu under the submenus E-PULSE SIZES and E-PULSE DURATION.

Energy pulse output parameters

	Parameter	Value	Unit	Description
E-PULSE SIZES	E+	10 … 10 000	kWh	Pulse size of active exported energy
	Eq+	10 … 10 000	kvarh	Pulse size of reactive exported energy
	E-	10 … 10 000	kWh	Pulse size of active imported energy
	Eq-	10 … 10 000	kvarh	Pulse size of reactive imported energy
E-PULSE DURATION	E+	100 … 5000	ms	Pulse length of active exported energy
	Eq+	100 … 5000	ms	Pulse length of reactive exported energy
	E-	100 … 5000	ms	Pulse length of active imported energy
	Eq-	100 … 5000	ms	Pulse length of reactive imported energy

Scaling examples

Example 1.

Average active exported power is 250 MW.

Peak active exported power is 400 MW.

Pulse size is 250 kWh.

The average pulse frequency will be 250/0.250 = 1000 pulses/h.

The peak pulse frequency will be 400/0.250 = 1600 pulses/h.

Set pulse length to 3600/1600 – 0.2 = 2.0 s or less.

The lifetime of the mechanical output relay will be $50x10^6/1000$ h = 6 a.

This is not a practical scaling example unless an output relay lifetime of about six years is accepted.

Example 2.

Average active exported power is 100 MW.

Peak active exported power is 800 MW.

Pulse size is 400 kWh.

The average pulse frequency will be 100/0.400 = 250 pulses/h.

The peak pulse frequency will be 800/0.400 = 2000 pulses/h.

Set pulse length to 3600/2000 – 0.2 = 1.6 s or less.

The lifetime of the mechanical output relay will be $50x10^6/250$ h = 23 a.

Example 3.

Average active exported power is 20 MW.

Peak active exported power is 70 MW.

Pulse size is 60 kWh.

The average pulse frequency will be 25/0.060 = 416.7 pulses/h.

The peak pulse frequency will be 70/0.060 = 1166.7 pulses/h.

Set pulse length to 3600/1167 – 0.2 = 2.8 s or less.

The lifetime of the mechanical output relay will be $50x10^6/417$ h = 14 a.

Example 4.

Average active exported power is 1900 kW.

Peak active exported power is 50 MW.

Pulse size is 10 kWh.

The average pulse frequency will be 1900/10 = 190 pulses/h.

The peak pulse frequency will be 50000/10 = 5000 pulses/h.

Set pulse length to 3600/5000 – 0.2 = 0.5 s or less.

The lifetime of the mechanical output relay will be $50x10^6/190$ h = 30 a.

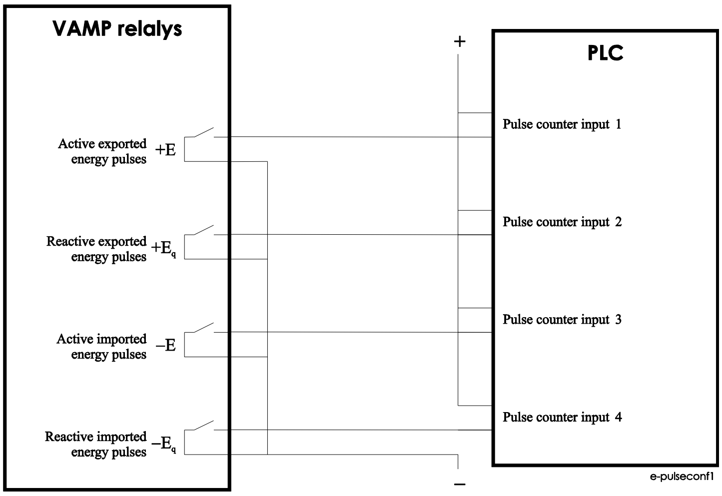


Figure 3.9-2. Application example of wiring the energy pulse outputs to a PLC having common plus and using an external wetting voltage

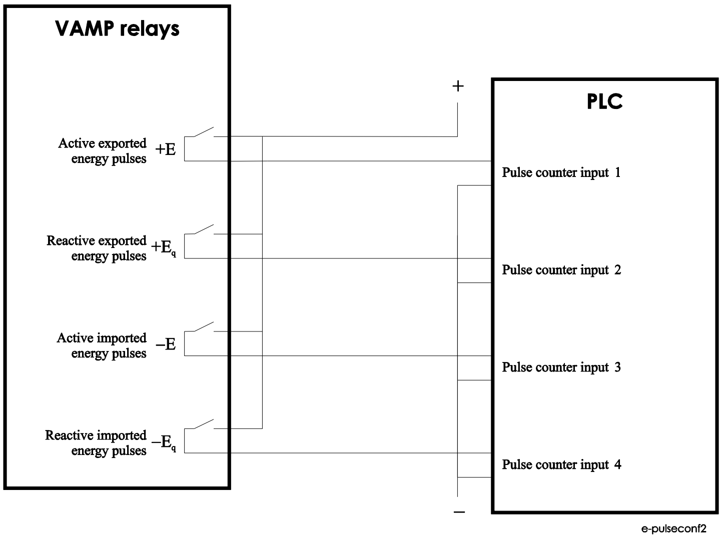


Figure 3.9-3. Application example of wiring the energy pulse outputs to a PLC having common minus and using an external wetting voltage

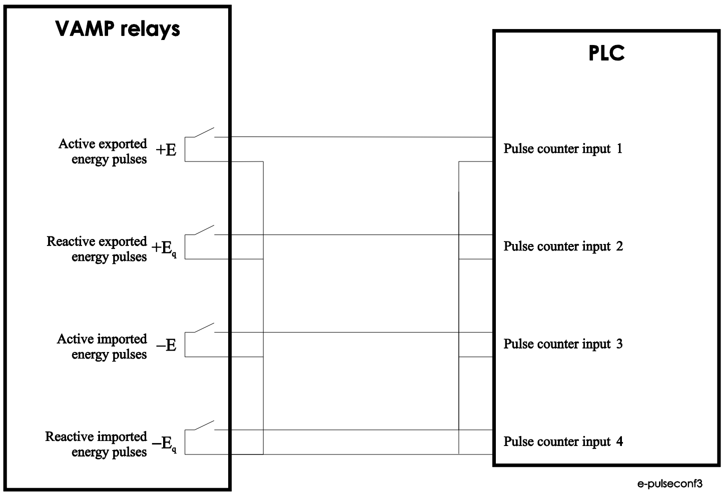


Figure 3.9-4. Application example of wiring the energy pulse outputs to a PLC having common minus and an internal wetting voltage.

3.10. System clock and synchronization

The internal clock of the device 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.

Adapting auto adjust

During tens of hours of synchronizing the device will learn its average error 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 error 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 device'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 device'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

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

$$AvDrft = Lead$$

NOTE! **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.**

System clock parameters

Parameter	Value	Unit	Description	Note
Date			Current date	Set
Time			Current time	Set
Style	 y–d–m d.m.y m/d/y		Date format Year-Month-Day Day.Month.Year Month/Day/Year	Set
SyncDI	 – DI1 ... DI6		The digital input used for clock synchronisation. DI not used for synchronizing Minute pulse input	***)
TZone	–12.00 ... +14.00 *)		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	 Internal DI SNTP SpaBus ModBus ProfibusDP IEC-103 IEC-101 DNP3		Clock synchronisation source No sync recognized since 200 s Digital input Protocol sync Protocol sync Protocol sync Protocol sync Protocol sync Protocol sync	
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 error in the synchronizing source.	Set
AAIntv	±10000	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).

*) Astronomically a range –11 ... +12 h would be enough, but for political and geographical reasons a larger range is needed.

**) If external synchoronization 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.

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.

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 errors 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.

3.11. Running hour counter

This function calculates the total active time of the selected digital input, virtual I/O or output matrix output signal. The resolution is ten seconds.

Running hour counter parameters

Parameter	Value	Unit	Description	Note
Runh	0 ... 876000	h	Total active time, hours Note: The label text "Runh" can be edited with VAMPSET.	(Set)
Runs	0 ... 3599	s	Total active time, seconds	(Set)
Starts	0 ... 65535		Activation counter	(Set)
Status	Stop Run		Current status of the selected digital signal	
DI	 - DI1…DI32, VI1...VI4, LedAl, LedTr, LedA, LedB, LedC, LedDR VO1...VO6		Select the supervised signal None Physical inputs Virtual inputs Output matrix out signal Al Output matrix out signal Tr Output matrix out signal LA Output matrix out signal LB Output matrix out signal LC Output matrix out signal DR Virtual outputs	Set
Started at			Date and time of the last activation	
Stopped at			Date and time of the last inactivation	

Set = An editable parameter (password needed).

(Set) = An informative value which can be edited as well.

3.12. Timers

The VAMP protection platform includes four settable timers that can be used together with the user's programmable logic or to control setting groups and other applications that require actions based on calendar time. Each timer has its own settings. The selected on-time and off-time is set and then the activation of the timer can be set to be as daily or according the day of week (See the setting parameters for details). The timer outputs are available for logic functions and for the block and output matrix.

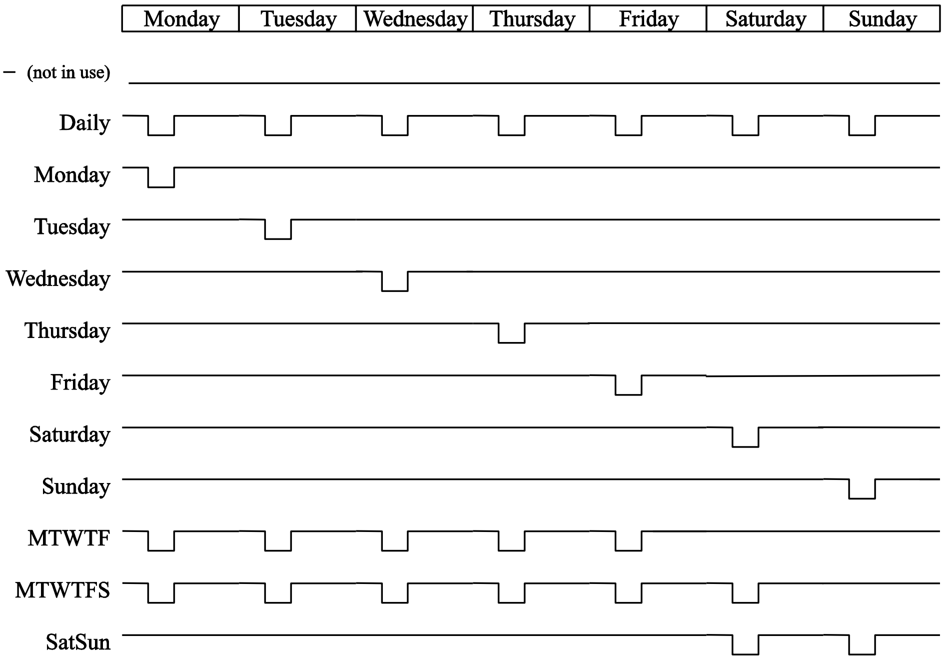


Figure 3.12-1. Timer output sequence in different modes.

The user can force any timer, which is in use, on or off. The forcing is done by writing a new status value. No forcing flag is needed as in forcing i.e. the output relays.

The forced time is valid until the next forcing or until the next reversing timed act from the timer itself.

The status of each timer is stored in non-volatile memory when the auxiliary power is switched off. At start up, the status of each timer is recovered.

Setting parameters of timers

Parameter	Value	Description
TimerN		Timer status
	–	Not in use
	0	Output is inactive
	1	Output is active
On	hh:mm:ss	Activation time of the timer
Off	hh:mm:ss	De-activation time of the timer
Mode		For each four timers there are 12 different modes available:
	–	The timer is off and not running. The output is off i.e. 0 all the time.
	Daily	The timer switches on and off once every day.
	Monday	The timer switches on and off every Monday.
	Tuesday	The timer switches on and off every Tuesday.
	Wednesday	The timer switches on and off every Wednesday.
	Thursday	The timer switches on and off every Thursday.
	Friday	The timer switches on and off every Friday.
	Saturday	The timer switches on and off every Saturday.
	Sunday	The timer switches on and off every Sunday.
	MTWTF	The timer switches on and off every day except Saturdays and Sundays
	MTWTFS	The timer switches on and off every day except Sundays.
	SatSun	The timer switches on and off every Saturday and Sunday.

3.13. Combined overcurrent status

This function is collecting faults, fault types and registered fault currents of all enabled overcurrent stages.

Line fault parameters

Parameter	Value	Unit	Description	Note
IFltLas		xIn	Current of the latest overcurrent fault	(Set)
LINE ALARM				
Alr_{L1} Alr_{L2} Alr_{L3}	 0 1		Start (=alarm) status for each phase. 0=No start since alarm ClrDly 1=Start is on	
OCs	 0 1		Combined overcurrent start status. $Alr_{L1}=Alr_{L2}=Alr_{L3}=0$ $Alr_{L1}=1$ or$Alr_{L2}=1$ or $Alr_{L3}=1$	
LxAlarm	 On Off		'On' Event enabling for $Alr_{L1...3}$ Events are enabled Events are disabled	Set
LxAlarmOff	 On Off		'Off' Event enabling for $Alr_{L1...3}$ Events are enabled Events are disabled	Set
OCAlarm	 On Off		'On' Event enabling for combined o/c starts Events are enabled Events are disabled	Set
OCAlarmOff	 On Off		'Off' Event enabling for combined o/c starts Events are enabled Events are disabled	Set
IncFltEvnt	 On Off		Disabling several start and trip events of the same fault Several events are enabled *) Several events of an increasing fault is disabled **)	Set
ClrDly	0 ... 65535	s	Duration for active alarm status Alr_{L1}, Alr2, Alr_{L3} and OCs	Set

Parameter	Value	Unit	Description	Note
LINE FAULT				
Flt_{L1} Flt_{L2} Flt_{L3}	 0 1		Fault (=trip) status for each phase. 0=No fault since fault ClrDly 1=Fault is on	
OCt	 0 1		Combined overcurrent trip status. Flt_{L1}=Flt_{L2}=Flt_{L3}=0 Flt_{L1}=1 orFlt_{L2}=1 or Flt_{L3}=1	
LxTrip	 On Off		'On' Event enabling for $Flt_{L1...3}$ Events are enabled Events are disabled	Set
LxTripOff	 On Off		'Off' Event enabling for $Flt_{L1...3}$ Events are enabled Events are disabled	Set
OCTrip	 On Off		'On' Event enabling for combined o/c trips Events are enabled Events are disabled	Set
OCTripOff	 On Off		'Off' Event enabling for combined o/c starts Events are enabled Events are disabled	Set
IncFltEvnt	 On Off		Disabling several events of the same fault Several events are enabled *) Several events of an increasing fault is disabled **)	Set
ClrDly	0 ... 65535	s	Duration for active alarm status Flt_{L1}, Flt2, Flt_{L3} and OCt	Set

Set = An editable parameter (password needed)

*) Used with IEC 60870-105-103 communication protocol. The alarm screen will show the latest if it's the biggest registered fault current, too. Not used with Spabus, because Spabus masters usually don't like to have unpaired On/Off events.

**) Used with SPA-bus protocol, because most SPA-bus masters do need an off-event for each corresponding on-event.

3.14. Self supervision

The functions of the micro controller and the associated circuitry, as well as the program execution are supervised by means of a separate watchdog circuit. Besides supervising the device, the watchdog circuit attempts to restart the micro controller in a fault situation. If the restarting fails, the watchdog issues a self-supervision alarm indicating a permanent internal fault.

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 device disappear, an alarm is automatically given because the internal fault (IF) output relay functions on a working current principle. This means that the IF relay is energized when the auxiliary supply is on and no internal fault is detected.

3.14.1. Diagnostics

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

Fatal errors

If fatal error has been detected, the device releases IF relay contact and error led is set on. Local panel will also display an error message about the detected fault. Fatal error state is entered when the device is not able to handle protections.

Runtime errors

When self-diagnostic function detects a fault, **Selfdiag Alarm** matrix signal is set and an event (E56) is generated. In case the error was only temporary, an off event is generated (E57). Self diagnostic error can be reset via local panel interface.

Error registers

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

Register	Bit	Code	Description
SelfDiag1	0 (LSB)	T1	Output relay fault
	1	T2	
	2	T3	
	3	T4	
	4	A1	
	5	A2	
	6	A3	
	7	A4	
	8	A5	
	10	T5	
	11	T6	
	12	T7	
	13	T8	
SelfDiag3	0 (LSB)	DAC	mA-output fault
	1	STACK	OS: stack fault
	2	MemChk	OS: memory fault
	3	BGTask	OS: background task timeout
	4	DI	Digital input fault (DI1, DI2)
	5		
	6	Arc	Arc card fault
	7	SecPulse	Hardware error
	8	RangeChk	DB: Setting outside range
	9	CPULoad	OS: overload
	10	+24V	Internal voltage fault
	11	-15V	
	12	ITemp	Internal temperature too high
	13	ADChk1	A/D converter error
	14	ADChk2	A/D converter error
	15 (MSB)	E2prom	E2prom error
SelfDiag4	0 (LSB)	+12V	Internal voltage fault
	1	ComBuff	BUS: buffer error

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

3.15. Short circuit fault location

The device includes a stand-alone fault location algorithm. The algorithm can locate a short circuit in radial operated networks. The fault location is given as in reactance (ohms) and kilometres. Fault value can then be exported, for example, with event to a DMS (Distribution Management System). The system can then localize the fault. If a DMS is not available, the distance to the fault is displayed as kilometres, as well as a reactance value. However, the distance value is valid only if the line reactance is set correctly. Furthermore, the line should be homogenous, that is, the wire type of the line should be the same for the whole length. If there are several wire types on the same line, an average line reactance value can be used to get an approximate distance value to the fault (examples of line reactance values: Overhead wire Sparrow: 0.408 ohms/km and Raven: 0.378 ohms/km).

The fault location is normally used in the incoming bay of the substation. Therefore, the fault location is obtained for the whole network with just one device. This is very cost-effective upgrade of an existing system.

The algorithm functions in the following order:

1. The needed measurements (phase currents and voltages) are continuously available.
2. The fault distance calculation can be triggered in two ways: by opening a feeder circuit-breaker due to a fault and sudden increase in phase currents (ΔI + DI). Other option is to use only the sudden increase in the phase currents (ΔI).
3. Phase currents and voltages are registered in three stages: before the fault, during the fault and after the faulty feeder circuit-breaker was opened.
4. The fault distance quantities are calculated.
5. Two phases with the biggest fault current are selected.
6. The load currents are compensated.
7. The faulty line length reactance is calculated.

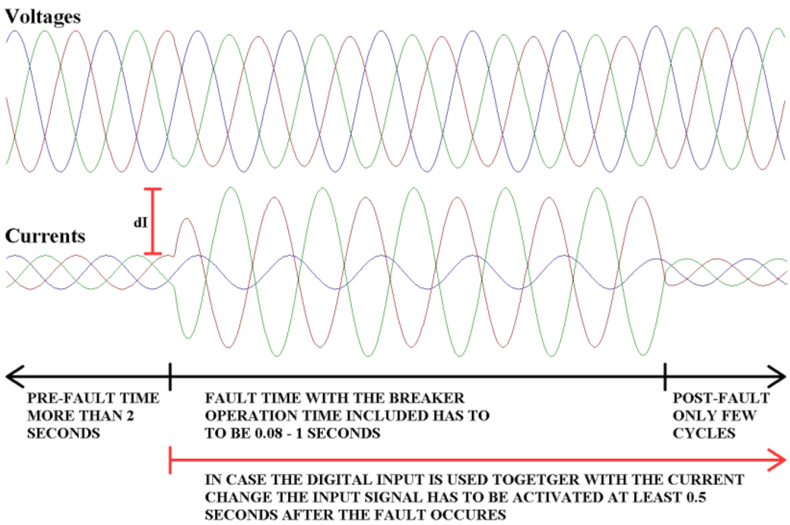
Setting parameters of fault location Dist:

Parameter	Value	Unit	Default	Description
Trig	dI; DI1 … DI20	-	-	Trigger mode (dI= triggering based on sudden increase of phase current)
Line reactance	0.010 … 10.000	Ohms/km	0.378	Line reactance of the line. This is used only to convert the fault reactance to kilometres.
dItrig	5 … 300	% Imode	20	Trig current (sudden increase of phase current)
Event	Disabled; Enabled	-	Enabled	Event mask

Measured and recorded values of fault location Dist:

	Parameter	Value	Unit	Description
Measured values/ recorded values	Distance		km	Distance to the fault
	Xfault		ohm	Fault reactance
	Date		-	Fault date
	Time		-	Fault time
	Time		ms	Fault time
	Cntr		-	Number of faults
	Pre		A	Pre-fault current (=load current)
	Fault		A	Current during the fault
	Post		A	Post-fault current
	Udrop		%Un	Voltage dip during the fault
	Durati		s	Fault duration
	Xfault		ohm	Fault reactance

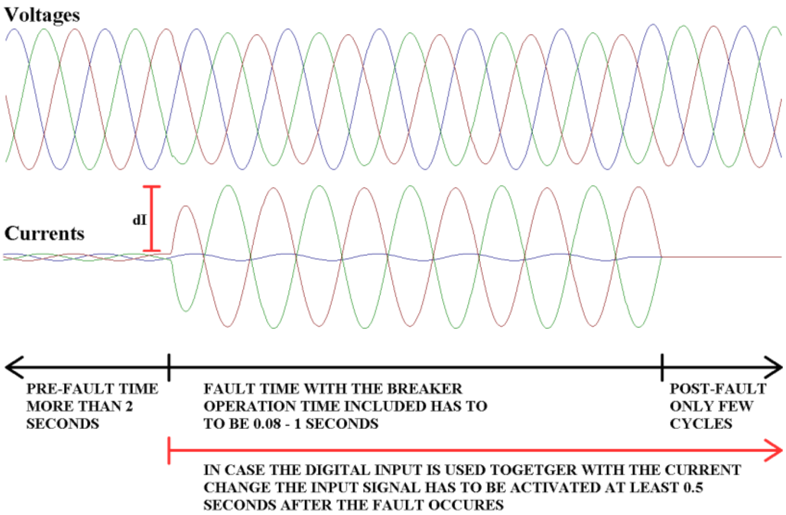
Below is presented an application example where the fault location algorithm is used at the incomer side. Notice following things while commissioning the relay:

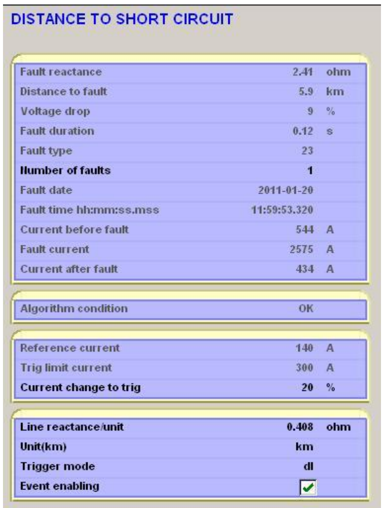


DISTANCE TO SHORT CIRCUIT

Fault reactance	2.49	ohm
Distance to fault	6.1	km
Voltage drop	9	%
Fault duration	0.12	s
Fault type	23	
Number of faults	**1**	
Fault date	2011-01-20	
Fault time hh:mm:ss.mss	11:16:44.600	
Current before fault	111	A
Fault current	2285	A
Current after fault	0	A
Algorithm condition	OK	
Reference current	0	A
Trig limit current	300	A
Current change to trig	**20**	%
Line reactance/unit	**0.408**	ohm
Unit(km)	**km**	
Trigger mode	**dI**	
Event enabling	☑	

Below is presented an application example where the fault location algorithm is used at the feeder side. Notice following things while commissioning the relay:




DISTANCE TO SHORT CIRCUIT

Fault reactance	2.41	ohm
Distance to fault	5.9	km
Voltage drop	9	%
Fault duration	0.12	s
Fault type	23	
Number of faults	1	
Fault date	2011-01-20	
Fault time hh:mm:ss.mss	11:59:53.320	
Current before fault	544	A
Fault current	2575	A
Current after fault	434	A
Algorithm condition	OK	
Reference current	140	A
Trig limit current	300	A
Current change to trig	20	%
Line reactance/unit	0.408	ohm
Unit(km)	km	
Trigger mode	dI	
Event enabling	✓	

3.16. Earth-fault location

The device includes a sophisticated stand-alone earth-fault location algorithm. The algorithm can locate an earth-fault accurately in radically operated compensated earthed networks.

The function can locate a fault only if the fault resistance is low, say less than 50 ohms. The fault location is given in reactance value. This value can then be exported, for example, with event to a DMS (Distribution Management System). The system can then localize the fault and display it on a map.

The fault location must be used in the incoming bay of the substation. Therefore, the fault location is obtained for the whole network with just one device. This is very cost-effective upgrade of an existing system.

Please note also that the earth-fault location function requires a change during an earth-fault. This change is done by switching the secondary resistor of the compensation coil on or off. The fault should be allowed to be on at least 200 ms, of which 100 ms without the resistor. The resistor change can be done by using the logic functionality of the device.

The reactance value is converted to distance in the DMS. The following formula is used:

$$s = \frac{3 * X}{Xo + X_1 + X_2}$$

Where,

s = distance in km

X = reactance calculated by the device

X_0 = zero sequence reactance per kilometre of the line

X_1 = positive sequence reactance per kilometre of the line

X_2 = negative sequence reactance per kilometre of the line

The algorithm functions in the following order:

1. The needed measurements (phase currents and voltages) are continuously available.
2. The fault distance calculation can be triggered in two ways: by switching ON or OFF the secondary resistor (that is, by using a digital input) or the calculation can be triggered if there is a change in earth fault or negative sequence current
3. The fault phase is identified by that the voltage of the faulted phase is decreased at least by half.
4. The fault distance is calculated by dividing the change of the voltage by the change of the negative sequence current.
5. Only the imaginary part is used, so then the reactance is solved.

Setting parameters of earth-fault location EFDi:

Parameter	Value	Unit	Default	Description
EFMode	Normal; Reverse	-	Normal	Normal: The resistor is switched ON during a fault. Reverse: The resistor is switched OFF during a fault
TrigIn	I_0;I2;DI1	-	I_0	Triggering input: I_0: earth fault current will trig the function. I2: negative phase sequence current will trig the function DI1: the function is triggered by activating the digital input 1
U_0Trig	1 … 80	% Uon	20	Trig level for U_0
Itrig	10 … 800	% In	80	Trig level for current
Event	On: Off	-	On	Event mask

Measured and recorded values of earth-fault location EFDi:

	Parameter	Value	Unit	Description
Measured values/ recorded values	Fault ph			Fault phase information
	X		ohm	Fault reactance
	Date		-	Fault date
	Time		-	Fault time
	Time		ms	Fault time
	Count		-	Number of faults

4. Measurement functions

All the direct measurements are based on fundamental frequency values. (The exceptions are frequency and instantaneous current for arc protection.) The figure shows a current waveform and the corresponding fundamental frequency component, second harmonic and rms value in a special case, when the current deviates significantly from a pure sine wave.

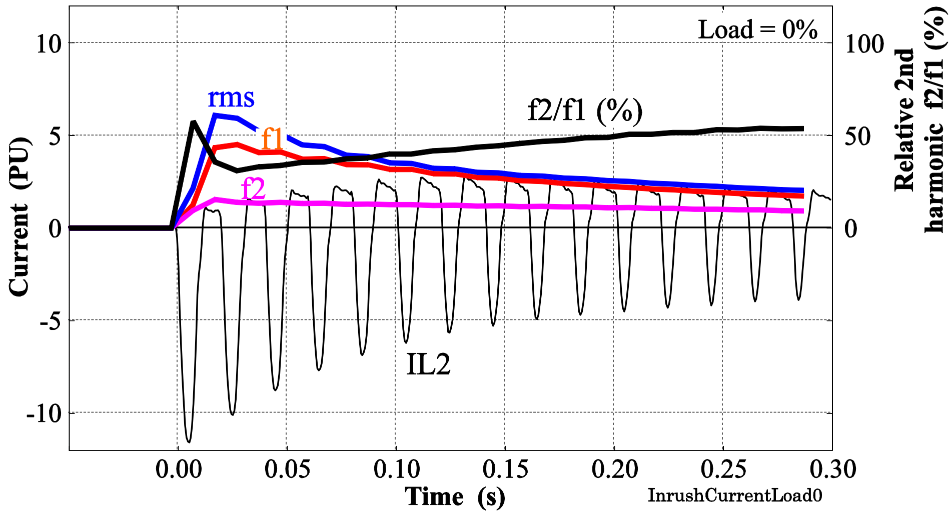


Figure 4-1 Example of various current values of a transformer inrush current.

4.1. Measurement accuracy

Measurement accuracy Phase current inputs I_{L1}, I_{L2}, I_{L3}

Measuring range		25mA – 250 A
Inaccuracy	I ≤ 7.5 A	0.5 % of value or 15 mA
	I > 7.5 A	3 % of value

The specified frequency range is 45 Hz – 65 Hz.

Voltage inputs U_A, U_B, U_C

The usage of voltage inputs depends on the configuration parameter "voltage measurement mode". For example, U_c is the zero sequence voltage input U_0 if the mode "1LL+U_0/LLy" is selected.

Measuring range	0 – 160 V
Inaccuracy	0.5 % or 0.3 V

The specified frequency range is 45 Hz – 65 Hz.

Residual current input I_0

The rated input I_n is 5A, 1 A or 0.2 A. It is specified in the order code of the device.

Measuring range		0 – 10 xI_n
Inaccuracy	I ≤ 1.5 xI_n	0.3 % of value or 0.2 % of I_n
	I > 1.5 xI_n	3 % of value

The specified frequency range is 45 Hz – 65 Hz.

Frequency

Measuring range	16 Hz – 75 Hz
Inaccuracy	10 mHz

Power measurements P, Q, S

Inaccuracy	|PF|> 0.5	1 % of value or 3 VA_{SEC}

The specified frequency range is 45 Hz – 65 Hz.

Power factor

Inaccuracy	|PF| >0.5	0.02 unit

The specified frequency range is 45 Hz – 65 Hz.

Energy counters E+, Eq+, E-, Eq-

Inaccuracy	|PF| > 0.5	1 % of value or 3 $Wh_{secondary}$/1 h

The specified frequency range is 45 Hz – 65 Hz.

THD and harmonics

Inaccuracy	I, U > 0.1 PU	2 % units
Update rate		Once a second

The specified frequency range is 45 Hz – 65 Hz.

4.2. RMS values

RMS currents

The device calculates the RMS value of each phase current. The minimum and the maximum of RMS values are recorded and stored (see chapter 4.5).

$$I_{rms} = \sqrt{I_{f1}^{2} + I_{f2}^{2} + \ldots + I_{f15}^{2}}$$

RMS voltages

The device calculates the RMS value of each voltage input. The minimum and the maximum of RMS values are recorded and stored (see chapter 4.5).

$$U_{rms} = \sqrt{U_{f1}^{2} + U_{f2}^{2} + \ldots + U_{f15}^{2}}$$

4.3. Harmonics and Total Harmonic Distortion (THD)

The device calculates the THDs as percentage of the base frequency for currents and voltages.

The device calculates the harmonics from the 2nd to the 15th of phase currents and voltages. (The 17th harmonic component will also be shown partly in the value of the 15th harmonic component. This is due to the nature of digital sampling.)

The harmonic distortion is calculated using equation

$$THD = \frac{\sqrt{\sum_{i=2}^{15} h_i^2}}{h_1}$$, where

h_1 = Fundamental value

$h_{2...15}$ = Harmonics

Example

h_1 = 100 A

h_3 = 10 A

h_7 = 3 A

h_{11} = 8 A

$$THD = \frac{\sqrt{10^2 + 3^2 + 8^2}}{100} = 13.2\%$$

For reference the RMS value is:

$$RMS = \sqrt{100^2 + 10^2 + 3^2 + 8^2} = 100.9A$$

Another way to calculate THD is to use the RMS value as reference instead of the fundamental frequency value. In the example above the result would then be 13.0 %.

4.4. Demand values

The device calculates average i.e. demand values of phase currents I_{L1}, I_{L2}, I_{L3} and power values S, P and Q. The demand time is configurable from 10 minutes to 30 minutes with parameter "Demand time".

Demand value parameters

Parameter	Value	Unit	Description	Set
Time	10 ... 30	min	Demand time (averaging time)	Set
Fundamental frequency values				
I_{L1}da		A	Demand of phase current I_{L1}	
I_{L2}da		A	Demand of phase current I_{L2}	
I_{L3}da		A	Demand of phase current I_{L3}	
Pda		kW	Demand of active power P	
PFda			Demand of power factor PF	
Qda		kvar	Demand of reactive power Q	
Sda		kVA	Demand of apparent power S	
RMS values				
I_{L1}da		A	Demand of phase current I_{L1}	
I_{L2}da		A	Demand of phase current I_{L2}	
I_{L3}da		A	Demand of phase current I_{L3}	

4.5. 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
I_{L1}, I_{L2}, I_{L3}	Phase current (fundamental frequency value)
I_{L1}RMS, I_{L2}RMS, I_{L3}RMS	Phase current, rms value
I_0	Residual current
U_{L12}, U_{L23}, U_{L31}	Line-to-line voltage
U_0	Zero sequence voltage
f	Frequency
P, Q, S	Active, reactive, apparent power
I_{L1}da, I_{L2}da, I_{L3}da	Demand values of phase currents
I_{L1}da, I_{L2}da, I_{L3}da (rms value)	Demand values of phase currents, rms values
PFda	Power factor demand value

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

Parameters

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

4.6. Maximum values of the last 31 days and twelve months

Some maximum and minimum values of the last 31 days and the last twelve months are stored in the non-volatile memory of the device. Corresponding time stamps are stored for the last 31 days. The registered values are listed in the following table.

Measurement	Max	Min	Description
I_{L1}, I_{L2}, I_{L3}	X		Phase current (fundamental frequency value)
I_0	X		Residual current
S	X		Apparent power
P	X	X	Active power
Q	X	X	Reactive power

The value can be a one cycle value or an average according parameter "Timebase".

Parameters of the day and month registers

Parameter	Value	Description	Set
Timebase		Parameter to select the type of the registered values.	S
	20 ms	Collect min & max of one cycle values *)	
	200 ms	Collect min & max of 200 ms average values	
	1 s	Collect min & max of 1 s average values	
	1 min	Collect min & max of 1 minute average values	
	demand	Collect min & max of demand values (see chapter 4.4)	
ResetDays		Reset the 31 day registers	S
ResetMon		Reset the 12 month registers	S

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

4.7. Voltage measurement mode

Line manager relay is always used in the three line to ground voltages measurement mode. The configuration parameter "Voltage measurement mode" must be set according the used connection for the synchrocheck stage. If synchrocheck is not used in the application this selection has no effect.

The available modes are:

- "3LN/LLy"

The synchrocheck voltage transformer is connected to line-to-line voltages U_{L12}.

- "3LN/LNy "

The synchrocheck voltage transformer is connected to line-to-line voltages U_{L12}.

4.8. Power calculation

The equations used for power calculations are described in this chapter.

Following equation is used for power calculation.

$\overline{S} = \overline{U}_{L1} \cdot \overline{I}_{L1}^{*} + \overline{U}_{L2} \cdot \overline{I}_{L2}^{*} + \overline{U}_{L3} \cdot \overline{I}_{L3}^{*}$, where

$\overline{S}$	=	Three phase power phasor
$\overline{U}_{L1}$	=	Measured voltage phasor corresponding the fundamental frequency voltage of phase L1.
$\overline{I}_{L1}^{*}$	=	Complex conjugate of the measured phase L1 fundamental frequency current phasor.
$\overline{U}_{L2}$	=	Measured voltage phasor corresponding the fundamental frequency voltage of phase L2.
$\overline{I}_{L2}^{*}$	=	Complex conjugate of the measured phase L2 fundamental frequency current phasor.
$\overline{U}_{L3}$	=	Measured voltage phasor corresponding the fundamental frequency voltage of phase L3.
$\overline{I}_{L3}^{*}$	=	Complex conjugate of the measured phase L3 fundamental frequency current phasor.

Apparent power, active power and reactive power are calculated as follows

$$S = \left| \overline{S} \right|$$

$$P = real(\overline{S})$$

$$Q = imag(\overline{S})$$

$$\cos\varphi = \frac{P}{S}$$

4.9. Direction of power and current

Figure 4.9-1 shows the concept of three phase current direction and sign of cosφ and power factor PF. Figure 4.9-2 shows the same concepts, but on a PQ-power plane.

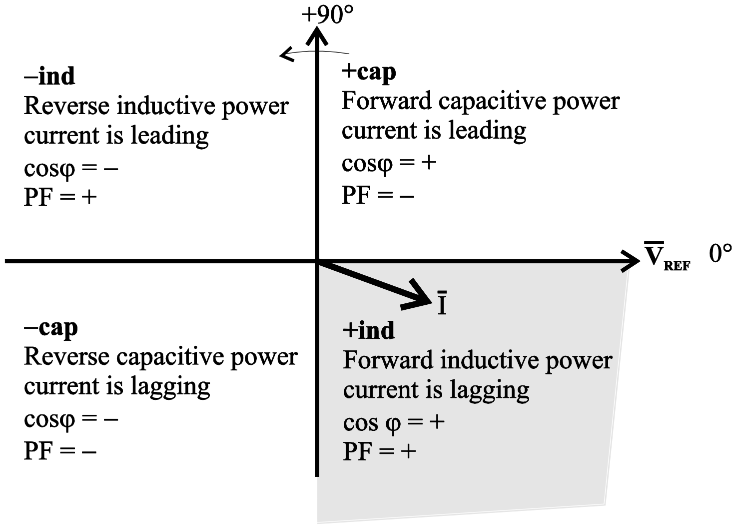


Figure 4.9-1 Quadrants of voltage/current phasor plane

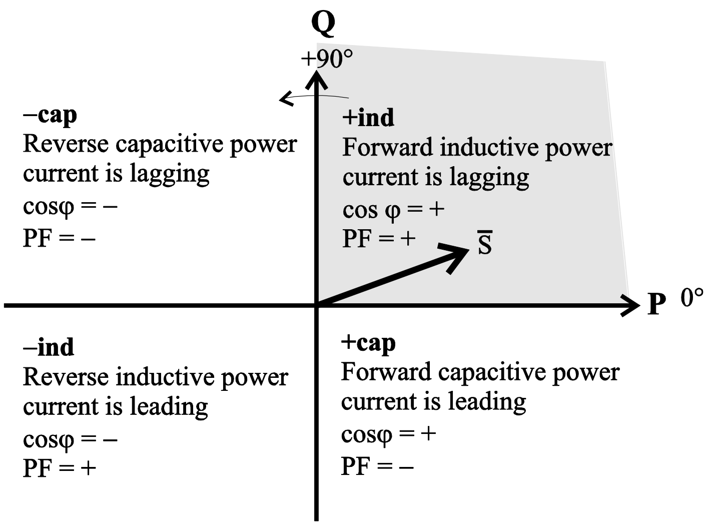


Figure 4.9-2 Quadrants of power plane

Table of power quadrants

Power quadrant	Current related to voltage	Power direction	cosφ	Power factor PF
+ inductive	Lagging	Forward	+	+
+ capacitive	Leading	Forward	+	–
– inductive	Leading	Reverse	–	+
– capacitive	Lagging	Reverse	–	–

4.10. 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:

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

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

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

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

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

$\underline{U}$ = phasor of phase $_{L1}$
(phase current or line-to-neutral voltage)

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

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

NOTE! The zero sequence or residual measurement signals connected to the device are $-U_0$ and $3I_0$. However, usually the name "I_0" is used instead of the correct name "$3I_0$"

Example 1, single phase injection

U_N = 100 V

Injection:

U_{L1} = U_{L12} = 100 V

U_{L2} = U_{L23} = 0

$$\begin{bmatrix} \underline{U}_1 \\ \underline{U}_2 \end{bmatrix} = \frac{1}{3}\begin{bmatrix} 1 & -\underline{a}^2 \\ 1 & -\underline{a} \end{bmatrix}\begin{bmatrix} 100\angle 0^\circ \\ 0 \end{bmatrix} = \frac{1}{3}\begin{bmatrix} 100\angle 0^\circ \\ 100\angle 0^\circ \end{bmatrix} = \begin{bmatrix} 33 \\ 33 \end{bmatrix}$$

U_1 = 33 %

U_2 = 33 %

U_2/U_1 = 100 %

When using a single phase test device, the relative unbalance U_2/U_1 will always be 100 %.

Example 2, two phase injection with adjustable phase angle

U_N = 100 V

Injection:

U_{L1} = U_{L1} = 100/√3 V ∠0° = 57.7 V ∠0°

U_{L2} = U_{L2} = 100/√3 V ∠–120° = 57.7 V ∠–120°

U_{L3} = U_{L3} = 0 V

This is actually identical case with example 2 because the resulting line-to-line voltages $U_{L12} = U_{L1} - U_{L2}$ = 100 V ∠30° and $U_{L23} = U_{L2} - U_{L3} = U_{L2}$ = 100/√3 V∠–120° are the same as in example 2. The only difference is a +30° phase angle difference, but without any absolute angle reference this phase angle difference is not seen by the device.

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

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

U_0 = 19.2 %

U_1 = 38.5 %

U_2 = 19.2 %

U_2/U_1 = 50 %

Figure 4.10-1 shows a graphical solution. The input values have been scaled with √3/100 to make the calculation easier.

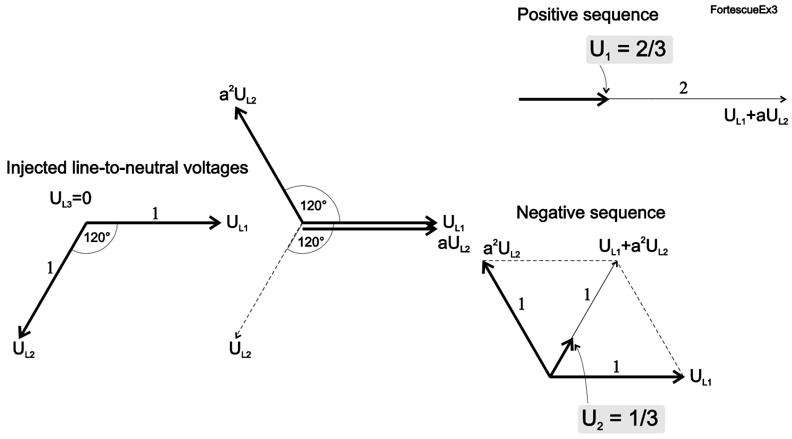


Figure 4.10-1 Example of symmetric component calculation using line-to-neutral voltages.

Unscaling the geometric results gives

U_1 = 100/√3 x 2/3 = 38.5 %

U_2 = 100√3 x 1/3 = 19.2 %

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

4.11. Primary, secondary and per unit scaling

Many measurement values are shown as primary values although the device 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 CT, VT ratios in the "Scaling" of the relay.

Following scaling equations seen in the sub chapters are useful when doing secondary testing.

4.11.1. Current scaling

NOTE! The rated value of the device's current input, 5 A, 1A or 0.2 A, does not have any effect in the scaling equations, but it defines the measurement range and the maximum allowed continuous current. See chapter 9.1.1 for details.

Primary and secondary scaling

	Current scaling
secondary ⇒ primary	$I_{PRI} = I_{SEC} \cdot \frac{CT_{PRI}}{CT_{SEC}}$
primary ⇒ secondary	$I_{SEC} = I_{PRI} \cdot \frac{CT_{SEC}}{CT_{PRI}}$

For residual currents to input I_{01} use the corresponding CT_{PRI} and CT_{SEC} values. For earth fault stages using I_{0Calc} signals use the phase current CT values for CT_{PRI} and CT_{SEC}.

Example 1: Secondary to primary.

CT = 500/5

Current to the device's input is 4 A.

⇒ Primary current is I_{PRI} = 4x500/5 = 400 A

Example 2: Primary to secondary.

CT = 500/5

The device displays I_{PRI} = 400 A

⇒ Injected current is I_{SEC} = 400x5/500 = 4 A

Per unit [pu] scaling

For phase currents excluding ArcI> stage
1 pu = 1xI_n = 100 %, where
I_n is the rated current according to the mode (see chapter 10).

For residual currents and ArcI> stage
1 pu = 1xCT_{SEC} for secondary side and
1 pu = 1xCT_{PRI} for primary side.

	Phase current scaling for phase currents, ArcI> stage and residual current ($3I_0$)
secondary ⇒ per unit	$I_{PU} = \frac{I_{SEC}}{CT_{SEC}}$
per unit ⇒ secondary	$I_{SEC} = I_{PU} \cdot CT_{SEC}$

Example 1: Secondary to per unit for feeder mode and ArcI>.

CT = 750/5

Current injected to the device's inputs is 7 A.

⇒ Per unit current is
I_{PU} = 7/5 = 1.4 pu = 140 %

Example 2: Per unit to secondary for feeder mode and ArcI>.

CT = 750/5

The device setting is 2 pu = 200 %.

⇒ Secondary current is
I_{SEC} = 2x5 = 10 A

Example 3: Secondary to per unit for residual current.

Input is I_{01}.

CT_0 = 50/1

Current injected to the device's input is 30 mA.

⇒ Per unit current is
I_{PU} = 0.03/1 = 0.03 pu = 3 %

Example 4: Per unit to secondary for residual current.

Input is I_{01}

CT_0 = 50/1

The device setting is 0.03 pu = 3 %.

⇒ Secondary current is
I_{SEC} = 0.03x1 = 30 mA

Example 5: Secondary to per unit for residual current.

Input is I_{0Calc}.

CT = 750/5

Currents injected to the device's I_{L1} input is 0.5 A.
$I_{L2} = I_{L3} = 0$.
⇒ Per unit current is
$I_{PU} = 0.5/5 = 0.1$ pu = 10 %

Example 6: Per unit to secondary for residual current.

Input is I_{0Calc}.

CT = 750/5

The device setting is 0.1 pu = 10 %.

⇒ If $I_{L2} = I_{L3} = 0$, then secondary current to I_{L1} is
$I_{SEC} = 0.1x5 = 0.5$ A

4.11.2. 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	$U_{SEC} = \frac{U_{PRI}}{\sqrt{3}} \cdot \frac{VT_{SEC}}{VT_{PRI}}$

Example 1: Secondary to primary.
VT = 12000/110

Three phase symmetric voltages connected to the device's inputs Ua, Ub and Uc are 57.7 V.
⇒ Primary voltage is $U_{PRI} = \sqrt{3}x58x12000/110 = 10902$ V

Example 2: Primary to secondary.

VT = 12000/110

The device displays $U_{L12} = U_{L23} = U_{L31} = 10910$ V.
⇒ Symmetric secondary voltages at Ua, U_b and U_c are
$U_{SEC} = 10910/\sqrt{3}x110/12000 = 57.7$ V4

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	$U_{SEC} = U_{PU} \cdot \frac{VT_{SEC}}{\sqrt{3}} \cdot \frac{U_N}{VT_{PRI}}$

Example 1: 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} = √3x63.5/110x12000/11000 = 1.00 pu = 1.00xU_N = 100 %

Example 2: Per unit to secondary.

VT = 12000/110

U_N = 11000 V

The device 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} = 1.00x110/√3x11000/12000 = 58.2 V

Per unit [pu] scaling of zero sequence voltage

secondary ⇒ per unit	$U_{PU} = \frac{U_{SEC}}{U_{0SEC}}$	$U_{PU} = \frac{1}{VT_{SEC}} \cdot \frac{\left\|\bar{U}_a + \bar{U}_b + \bar{U}_c\right\|_{SEC}}{\sqrt{3}}$
per unit ⇒ secondary	$U_{SEC} = U_{PU} \cdot U_{0SEC}$	$\left\|\bar{U}_a + \bar{U}_b + \bar{U}_c\right\|_{SEC} = \sqrt{3} \cdot U_{PU} \cdot VT_{SEC}$

Example 1: 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} = ($\underline{38.1}$+$\underline{0}$+$\underline{0}$)/(√3x110) = 0.20 pu = 20 %

Example 2: 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} = √3x0.2x110 = 38.1 V

5. Control functions

5.1. 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 output matrix for more details.

NOTE! If the device has the mA option, it is equipped with only three alarm relays from A1 to A3.

The difference between trip contacts and alarm contacts is the DC breaking capacity. See chapters 9.1.4 and 0 for details. The contacts are SPST normal open type (NO), except alarm relays A1, A2 and A3, which have change over contacts (SPDT).

Parameters of output relays

Parameter	Value	Unit	Description	Note
T1 ...T14	0 1		Status of trip output relay (The actual number of relays depends on the ordering code)	F
A1 ... A5	0 1		Status of alarm output relay	F
IF	0 1		Status of the internal fault indication relay	F
Force	On Off		Force flag for output relay forcing for test purposes. This is a common flag for all output relays and protection stage status, too. Any forced relay(s) and this flag are automatically reset by a 5-minute timeout.	Set
REMOTE PULSES				
A1 ... A5	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...14 or ”Alarm relay n”, n=1...5	Set

Set = An editable parameter (password needed)

F = Editable when “Enable forcing” is activated from the “Relays” menu

5.2. Digital inputs

There are 1-32 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.

The contacts connected to digital inputs DI1 … DI6 must be dry (potential free). These inputs use the common internal 48 Vdc wetting voltage from terminal X3:1, only.

NOTE! These digital inputs must not be connected parallel with inputs of an another 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.

Parameters of digital inputs

Parameter	Value	Unit	Description	Set
DI1 ... DIn	0 1		Status of digital input (The actual number of digital inputs depends on the ordering code)	
DI COUNTERS				
DI1 ... DIn	0 ... 65535		Cumulative active edge counter (The actual number of digital inputs depends on the ordering code)	(Set)
DELAYS FOR DIGITAL INPUTS				
DI1 ... DIn	0.00 ... 60.00	s	Definite delay for both on and off transitions (The actual number of digital inputs depends on the ordering code)	Set
CONFIGURATION DI1 ... DI32				
Inverted	no yes		For normal open contacts (NO). Active edge is 0⇒1 For normal closed contacts (NC) Active edge is 1⇒0	Set
Alarm display	no yes		No pop-up display Alarm pop-up display is activated at active DI edge	Set
On event	On Off		Active edge event enabled Active edge event disabled	Set
Off event	On Off		Inactive edge event enabled Inactive edge event disabled	Set
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...32	Set
Description	String of max. 32 characters		Long name for DIs. Default is "Digital input n", n=1...32	Set

Set = An editable parameter (password needed)

Summary of digital inputs:

DI	Terminal	Operating voltage	Availability
←	X3:1	48VDC supply for DI1…6	Always available
1	X3:2	Internal 48VDC	
2	X3:3		
3	X3:4		
4	X3:5		
5	X3:6		
6	X3:7		
7	X7:1	External 18…265 VDC 50…250 VAC	
8	X7:2		
9	X7:3		
10	X7:4		
11	X7:5		
12	X7:6		
→	X7:7	Common for DI7…12	
13	X7:8	External 18…265 VDC 50…250 VAC	
14	X7:9		
15	X7:10		
16	X7:11		
17	X7:12		
18	X7:13		
→	X7:14	Common for DI13…17	
19	X6:1…2	External 18…265 VDC 50…250 VAC	ARC card with 2 DIs
20	X6:3…4		
21	X8:1	External 18…265 VDC 50…250 VAC	Additional I/O (X8)
22	X8:2		
→	X8:3	Common for D21…22	
23	X8:4	External 18…265 VDC 50…250 VAC	
24	X8:5		
→	X8:6	Common for D23…24	
25	X8:7	External 18…265 VDC 50…250 VAC	
26	X8:8		
→	X8:9	Common for D25…26	
27	X8:10	External 18…265 VDC 50…250 VAC	
28	X8:11		
→	X8:12	Common for D27…28	
29	X8:19...20	External 18…265 VDC 50…250 VAC	If T5 not in use
30	X8:17...18		If T6 not in use
31	X8:15...16		If T7 not in use
32	X8:13...14		If T8 not in use

Common input	Input group	Wetting voltage	
		On	Off
X7:7	X7: 1-6 (DI 7-12)	≥18 V dc or ≥50 Vac	≤10 V dc or ≤5 V ac
X7:14	X7: 8-13 (DI 13-18)	≥18 V dc or ≥50 Vac	≤10 V dc or ≤5 V ac
X8:3	X8: 1-2 (DI 21-22)	≥18 V dc or ≥50 Vac	≤10 V dc or ≤5 V ac
X8:6	X8: 4-5 (DI 23-24)	≥18 V dc or ≥50 Vac	≤10 V dc or ≤5 V ac
X8:9	X8: 7-8 (DI 25-26)	≥18 V dc or ≥50 Vac	≤10 V dc or ≤5 V ac
X8:12	X8: 10-11 (DI 27-28)	≥18 V dc or ≥50 Vac	≤10 V dc or ≤5 V ac

For input group X8: 13-20 (DI 29-32), it is possible to use different control voltages individually.

The digital input signals can also be used as blocking signals and control signals for the output relays.

5.3. Virtual inputs and outputs

There are four virtual inputs and six virtual outputs. The four 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.

Parameters of virtual inputs

Parameter	Value	Unit	Description	Set
VI1 ... VI4	0 1		Status of virtual input	
Events	On Off		Event enabling	Set

Parameter	Value	Unit	Description	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 relay

s, 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.

5.4. 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, front panel indicators, virtual outputs etc.

There are two LED indicators named "Alarm" and "Trip" on the front panel. Furthermore there are three general purpose LED indicators – "A", "B" and "C" – available for customer-specific indications. In addition, the triggering of the disturbance recorder (DR) and virtual outputs are configurable in the output matrix. See an example in Figure 5.4-1.

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.

There is a common "release latched" signal to release all the latched relays. This release signal resets all the latched output relays and indicators. The reset signal can be given via a digital input, via a keypad or through communication. Any digital input can be used for resetting. The selection of the input is done with the VAMPSET software under the menu "Release output matrix latches". Under the same menu, the "Release latches" parameter can be used for resetting.

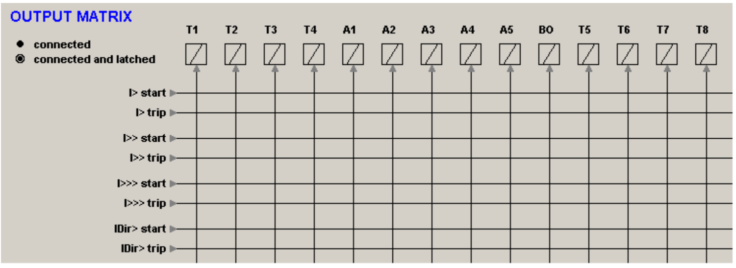


Figure 5.4-1 Output matrix.

5.5. 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 DIn (see chapter order code), 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 5.5-1 an active blocking is indicated with a black dot (•) in the crossing point of a blocking signal and the signal to be blocked.

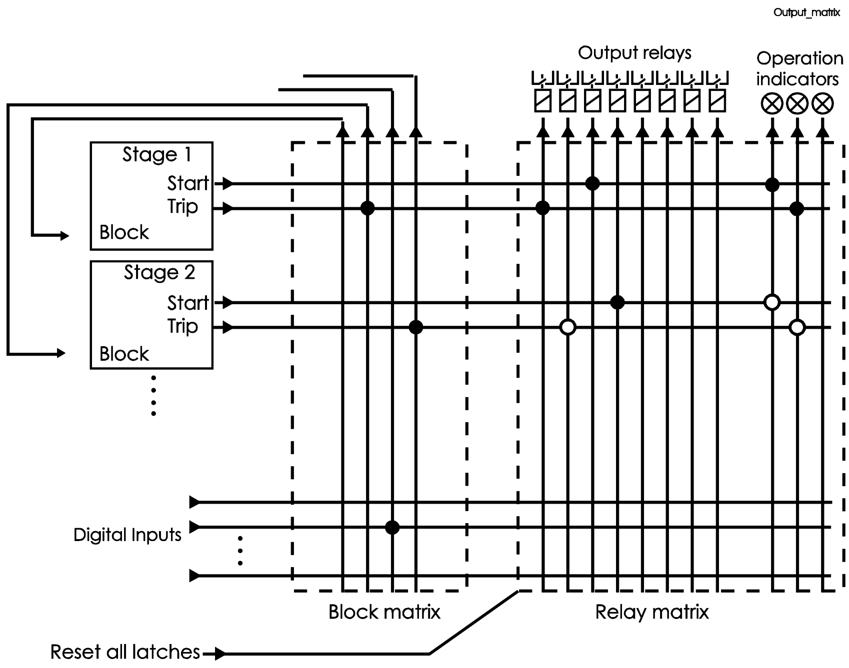


Figure 5.5-1 Blocking matrix and output matrix

5.6. Controllable objects

The device allows controlling of six objects, that is, circuit-breakers, disconnectors and earthing switches. Controlling can be done by "select-execute" or "direct control" principle.

The 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:

- o through the local HMI
- o through a remote communication
- o through a digital input.

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 fails.

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 fails 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.

Output signals of controllable objects

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

Each read-only 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
Object timeout	0.02 … 600 s	Timeout for state changes

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

Controlling with DI (firmware version >= 5.53)

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 control	In remote state
DI for remote close control	
DI for local open control	In local state
DI for local close control	

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.

5.6.1. 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.

5.7. Auto-reclose function (79)

The auto-reclose (AR) matrix in the following Figure 5.7-1 describes the start and trip signals forwarded to the auto-reclose function.

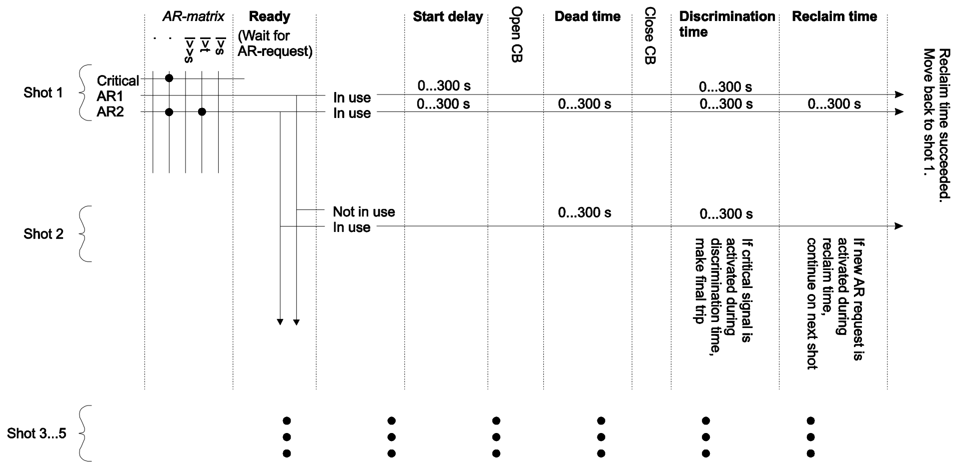


Figure 5.7-1 Auto-reclose matrix

The AR matrix above defines which signals (the start and trip signals from protection stages or digital input) are forwarded to the auto-reclose function. In the AR function, the AR signals can be configured to initiate the reclose sequence. Each shot from 1 to 5 has its own enabled/disabled flag. If more than one AR signal activates at the same time, AR1 has highest priority and AR2 the lowest. Each AR signal has an independent start delay for the shot 1. If a higher priority AR signal activates during the start delay, the start delay setting will be changed to that of the highest priority AR signal.

After the start delay the circuit-breaker (CB) will be opened if it is closed. When the CB opens, a dead time timer is started. Each shot from 1 to 5 has its own dead time setting.

After the dead time the CB will be closed and a discrimination time timer is started. Each shot from 1 to 5 has its own discrimination time setting. If a critical signal is activated during the discrimination time, the AR function makes a final trip. The CB will then open and the AR sequence is locked. Closing the CB manually clears the “locked” state.

After the discrimination time has elapsed, the reclaim time timer starts. If any AR signal is activated during the reclaim time or the discrimination time, the AR function moves to the next shot. The reclaim time setting is common for every shot.

If the reclaim time runs out, the auto-reclose sequence is successfully executed and the AR function moves to ready -state and waits for a new AR request in shot 1.

A trip signal from the protection stage can be used as a backup. Configure the start signal of the protection stage to initiate the AR function. If something fails in the AR function, the trip signal of the protection stage will open the CB. The delay setting for the protection stage should be longer than the AR start delay and discrimination time.

If a critical signal is used to interrupt an AR sequence, the discrimination time setting should be long enough for the critical stage, usually at least 100 ms.

Manual closing

When CB is closed manually with the local panel, remote bus, digital inputs etc, AR will function as follows:

Firmware version	Functioning
>= 5.31	Reclaim-state is activated. Within the reclaim time all AR requests are ignored. It is up to protection stages to take care of tripping. Trip signals of protection stages must be connected to a trip relay in the output matrix.
< 5.31	Reclaim-state is activated. Within the reclaim time any AR request (1...4) will cause final tripping.

Manual opening

Manual CB open command during AR sequence will stop the sequence and leaves the CB open.

Reclaim time setting

Firmware version	Settings
>= 5.53	**Use shot specific reclaim time : No** Reclaim time setting defines reclaim time between different shots during sequence and also reclaim time after manual closing. AR works exactly like in older firmwares.
	Use shot specific reclaim time : Yes Reclaim time setting defines reclaim time only for manual control. Reclaim time between different shots is defined by shot specific reclaim time settings.
< 5.53	Reclaim time setting defines reclaim time between different shots during sequence and also reclaim time after manual closing.

Support for 2 circuit breakers (firmware version >= 5.31)

AR function can be configured to handle 2 controllable objects. Object 1 is always used as CB1 and any other controllable object can be used as CB2. The object selection for CB2 is made with **Breaker 2 object** setting. Switching between the two objects is done with a digital input, virtual input or virtual output. AR controls CB2 when the input defined by **Input for selecting CB2** setting is active. Control is changed to another object only if the current object is not close.

Blocking of AR shots (firmware version >= 5.57)

Each AR shot can be blocked with a digital input, virtual input or virtual output. Blocking input is selected with **Block** setting. When selected input is active the shot is blocked. A blocked shot is treated like it doesn't exist and AR sequence will jump over it. If the last shot in use is blocked, any AR request during reclaiming of the previous shot will cause final tripping.

Starting AR sequence (firmware version >= 5.1)

Each AR request has own separate starting delay counter. The one which starting delay has elapsed first will be selected. If more than one delay elapses at the same time, an AR request of the highest priority is selected. AR1 has the highest priority and AR4 has the lowest priority. First shot is selected according to the AR request. Next AR opens the CB and starts counting dead time.

Starting AR sequence (firmware version < 5.1)

If more than one AR requests are active, a request of the highest priority is selected. AR1 has the highest priority and AR4 has the lowest priority. After the start delay of shot 1 has elapsed, AR opens the CB and starts counting dead time.

Starting sequence at shot 2…5 & skipping of AR shots (firmware version >= 5.1)

Each AR request line can be enabled to any combination of the 5 shots. For example making a sequence of **Shot 2** and **Shot 4** for AR request 1 is done by enabling AR1 only for those two shots.

NOTE: If AR sequence is started at shot 2...5 the starting delay is taken from the discrimination time setting of the previous shot. For example if Shot 3 is the first shot for AR2, the starting delay for this sequence is defined by Discrimination time of Shot 2 for AR2.

For older firmware versions (< 5.1) starting at other shot than shot 1 or skipping shots is not possible. AR request lines must be enabled to consecutive shots starting from shot 1. If AR sequence is not yet started, an AR request which is not enabled for shot 1 will cause final tripping. During sequence run an AR request which is not enabled for the next shot will cause final tripping.

Critical AR request

Critical AR request stops the AR sequence and cause final tripping. Critical request is ignored when AR sequence is not running and also when AR is reclaiming.

Critical request acceptance depends on the firmware version:

Firmware version	Critical signal is accepted during
>= 5.31	Dead time and discrimination time
< 5.31	Discrimination time only

Shot active matrix signals (firmware version >= 5.53)

When starting delay has elapsed, active signal of the first shot is set. If successful reclosing is executed at the end of the shot, the active signal will be reset after reclaim time. If reclosing was not successful or new fault appears during reclaim time, the active of the current shot is reset and active signal of the next shot is set (if there are any shots left before final trip).

AR running matrix signal

This signal indicates dead time. The signal is set after controlling CB open. When dead time ends, the signal is reset and CB is controlled close.

Final trip matrix signals

There are 5 final trip signals in the matrix, one for each AR request (1…4 and critical). When final trip is generated, one of these signals is set according to the AR request which caused the final tripping. The final trip signal will stay active for 0.5 seconds and then resets automatically.

DI to block AR setting

This setting is useful with an external synchro-check device. This setting only affects re-closing the CB. Re-closing can be blocked with a digital input, virtual input or virtual output. When the blocking input is active, CB won't be closed until the blocking input becomes inactive again. When blocking becomes inactive the CB will be controlled close immediately.

AR info for mimic display setting (firmware version >= 4.95)

When AR info is enabled, the local panel mimic display shows small info box during AR sequence.

Setting parameters of AR function:

Parameter	Value	Unit	Default	Description
ARena	ARon; ARoff	-	ARon	Enabling/disabling the autoreclose
Block	None, any digital input, virtual input or virtual output	-	-	The digital input for block information. This can be used, for example, for Synchrocheck.
AR_DI	None, any digital input, virtual input or virtual output	-	-	The digital input for toggling the ARena parameter
AR2grp	ARon; ARoff	-	ARon	Enabling/disabling the autoreclose for group 2
ReclT	0.02 … 300.00	s	10.00	Reclaim time setting. This is common for all the shots.
ARreq	On; Off	-	Off	AR request event
ShotS	On; Off	-	Off	AR shot start event
ARlock	On; Off	-	Off	AR locked event
CritAr	On; Off	-	Off	AR critical signal event
ARrun	On; Off	-	Off	AR running event
FinTrp	On; Off	-	Off	AR final trip event
ReqEnd	On; Off	-	Off	AR end of request event
ShtEnd	On; Off	-	Off	AR end of shot event
CriEnd	On; Off	-	Off	AR end of critical signal event
ARUnl	On; Off	-	Off	AR release event
ARStop	On; Off	-	Off	AR stopped event
FTrEnd	On; Off	-	Off	AR final trip ready event
ARon	On; Off	-	Off	AR enabled event
ARoff	On; Off	-	Off	AR disabled event
CRITri	On; Off	-	On	AR critical final trip on event
AR1Tri	On; Off	-	On	AR AR1 final trip on event
AR2Tri	On; Off	-	On	AR AR2 final trip on event
CRITri	On; Off	-	On	AR critical final trip off event
AR1Tri	On; Off	-	On	AR AR1 final trip off event
AR2Tri	On; Off	-	On	AR AR2 final trip off event
Shot settings				
DeadT	0.02 … 300.00	s	5.00	The dead time setting for this shot. This is a common setting for all the AR lines in this shot
AR1	On; Off	-	Off	Indicates if this AR signal starts this shot
AR2	On; Off	-	Off	Indicates if this AR signal starts this shot
Start1	0.02 … 300.00	s	0.02	AR1 Start delay setting for this shot

Start2	0.02 … 300.00	s	0.02	AR2 Start delay setting for this shot
Discr1	0.02 … 300.00	s	0.02	AR1 Discrimination time setting for this shot
Discr2	0.02 … 300.00	s	0.02	AR2 Discrimination time setting for this shot

Measured and recorded values of AR function:

	Parameter	Value	Unit	Description
Measured or recorded values	Obj1	UNDEFINED; OPEN; CLOSE; OPEN_REQUEST; CLOSE_REQUEST; READY; NOT_READY; INFO_NOT_AVAILABLE; FAIL	-	Object 1 state
	Status	INIT; RECLAIM_TIME; READY; WAIT_CB_OPEN; WAIT_CB_CLOSE; DISCRIMINATION_TIME; LOCKED; FINAL_TRIP; CB_FAIL; INHIBIT	-	AR-function state
	Shot#	1…5	-	The currently running shot
	ReclT	RECLAIMTIME; STARTTIME; DEADTIME; DISCRIMINATIONTIME	-	The currently running time (or last executed)
	SCntr		-	Total start counter
	Fail		-	The counter for failed AR shots
	Shot1 *		-	Shot1 start counter
	Shot2 *		-	Shot2 start counter
	Shot3 *		-	Shot3 start counter
	Shot4 *		-	Shot4 start counter
	Shot5 *		-	Shot5 start counter

*) There are 5 counters available for each one of the two AR signals.

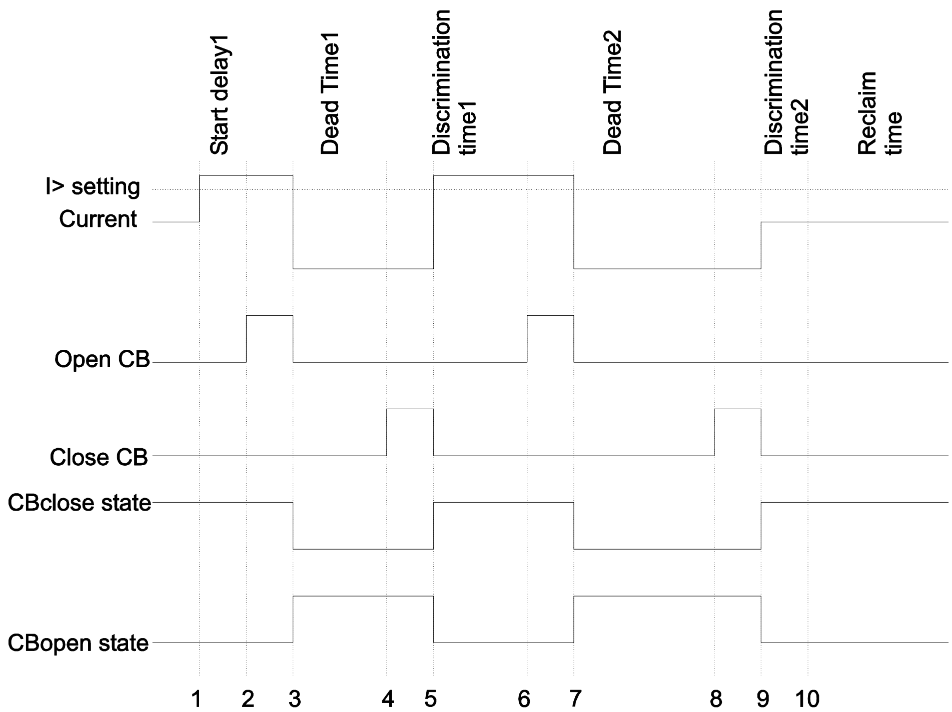


Figure 5.7-2 Example sequence of two shots. After shot 2 the fault is cleared.

1. Current exceeds the I> setting; the start delay from shot 1 starts.
2. After the start delay, an OpenCB relay output closes.
3. A CB opens. The dead time from shot 1 starts, and the OpenCB relay output opens.
4. The dead time from shot 1 runs out; a CloseCB output relay closes.
5. The CB closes. The CloseCB output relay opens, and the discrimination time from shot 1 starts. The current is still over the I> setting.
6. The discrimination time from the shot 1 runs out; the OpenCB relay output closes.
7. The CB opens. The dead time from shot 2 starts, and the OpenCB relay output opens.
8. The dead time from shot 2 runs out; the CloseCB output relay closes.
9. The CB closes. The CloseCB output relay opens, and the discrimination time from shot 2 starts. The current is now under I> setting.
10. Reclaim time starts. After the reclaim time the AR sequence is successfully executed. The AR function moves to wait for a new AR request in shot 1.

5.8. Logic functions

The device supports customer-defined programmable logic for boolean 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

Maximum number of outputs is 20. Maximum number of input gates is 31. An input gate can include any number of inputs.

For detailed information, please refer to the VAMPSET manual (VMV.EN0xx).

6. Communication

6.1. Communication ports

The device has three communication ports as standard.

A fourth port, Ethernet, is available as an option. When this option is chosen, it will take over communication option 2 slot.

There can be up to three communication ports in the rear panel. The front panel RS-232 port will shut off the local port on the rear panel when a VX003 cable is inserted. See Figure 6.1-1 and chapter 8.

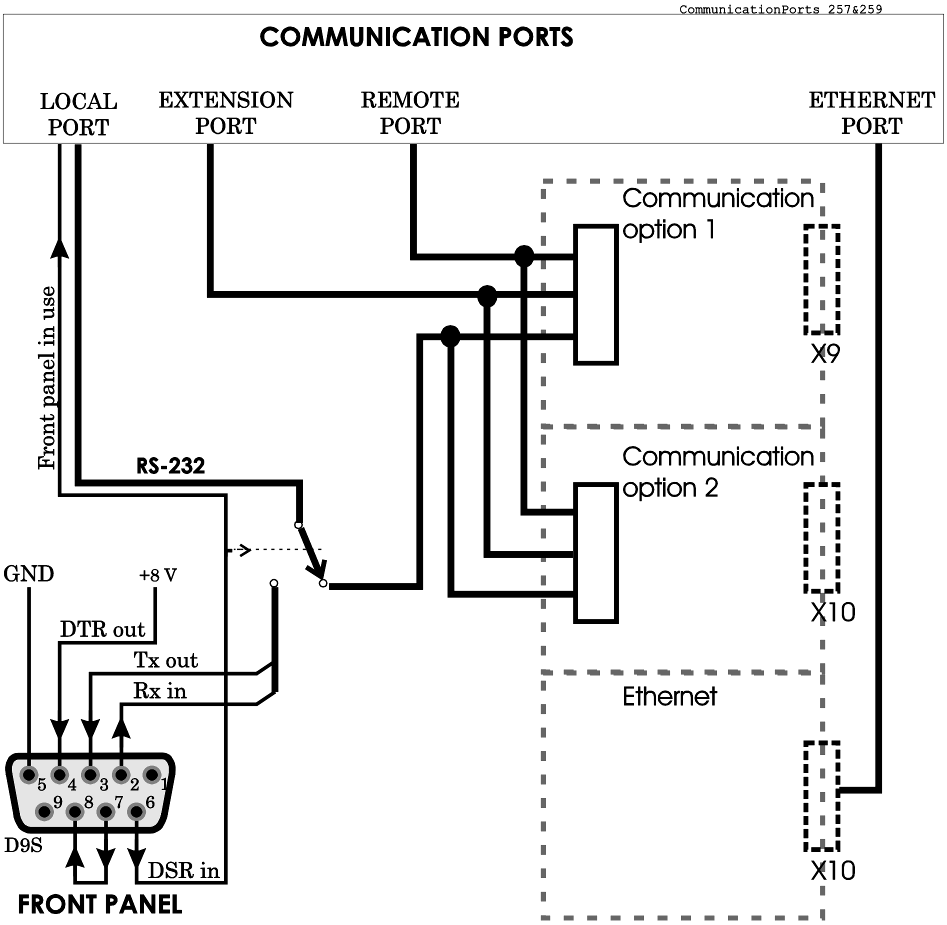


Figure 6.1-1. Communication ports and connectors. The type of connectors X9 or X10 depends on the type of the communication option (see chapter 8).

6.1.1. Local port

The local port may have two connectors:

- On the front panel
- On the rear panel (See chapter 8)

Only one can be used at a time.

NOTE! The local port functionality may be available via connector X9 or X10 depending on the type of communication modules and DIP switch settings (see chapter 8).

NOTE! When the VX003 cable is inserted to the front panel connector it activates the front panel port and disables the rear panel local port by connecting the DTR pin 6 and DSR pin 4 together. See Figure 6.1-1.

Protocol for the local port

The front panel 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 with the default 38400/8N1. While the front panel connector is in use, the rear panel local port is disabled. 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 RS-232, but the connector type depends on the option module type.

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
			Display of actual communication parameters.	1)
	speed/DPS		speed = bit/s	
			D = number of data bits	
	Default = 38400/8N1 for VAMPSET		P = parity: none, even, odd	
			S = number of stop bits	
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.

6.1.2. Remote port X9

Physical interface

The physical interface of this port depends of the communication letter in the order code. See Figure 6.1-1, chapter 8, chapter 12 and the table below. The TTL interface is for external converters and converter cables only. It is not suitable for direct connection to distances more than one meter.

Table 6.1.2-1 Physical interface and connector types of remote port X5 with various options. TTL (A) is the default.

Order Code	Communication interface	Connector type
A	TTL (for external converters only)	D9S
B	Plastic fibre interface	HFBR-0500
C	Not available	
D	RS-485 (isolated)	screw crimp
E	Glass fibre interface (62.5/125 μm)	SMA
F	Plastic Rx/glass (62.5/125 μm) Tx fibre interface	HFBR-0500/SMA
G	Glass (62.5/125 μm) Rx/plastic fibre interface	SMA/HFBR-0500

Parameters

Parameter	Value	Unit	Description	Note
Protocol	 None SPA-bus ProfibusDP ModbusSla ModbusTCPs IEC-103 ExternalIO DNP3		Protocol selection for remote port - SPA-bus (slave) Profibus DB (slave) Modbus RTU slave Modbus TCP slave IEC-60870-5-103 (slave) Modbus RTU master for external I/O-modules DNP 3.0	Set
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		Display of current communication parameters. speed = bit/s D = number of data bits P = parity: none, even, odd S = number of stop bits	1)
Debug	 No Binary ASCII		Echo to local port No echo For binary protocols For SPA-bus protocol	Set

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.

6.1.3. Extension port

This is a RS-485 port for external I/O devices. The physical interface of this port depends on the type of communication modules. The port is located in the rear panel connector X9 or X10. See Figure 6.1-1 and chapter 8.

Parameters

Parameter	Value	Unit	Description	Note
Protocol			Protocol selection for the 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
			Display of actual communication parameters.	1)
	speed/DPS		speed = bit/s	
			D = number of data bits	
	Default = 38400/8N1 for VAMPSET		P = parity: none, even, odd	
			S = number of stop bits	

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.

6.1.4. Ethernet port

IEC61850 and Modbus TCP uses Ethernet communication. Also VAMPSET, SPA-bus and DNP 3.0 communication can be directed via TCP/IP.

Parameters

Parameter	Value	Unit	Description	Set
Protoc			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	
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
VS Port	nn		IP port for Vampset	Set
KeepAlive	nn		TCP keepalive interval	Set
MAC	nnnnnnnnnnnn		MAC address	
Msg#	nnn		Message counter	
Errors	nnn		Error counter	
Tout	nnn		Timeout counter	

Set = An editable parameter (password needed)

6.2. Communication protocols

This 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)

6.2.1. PC communication

PC communication is using a VAMP specified command line interface. The VAMPSET program can communicate using the local RS-232 port or using 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 interface configuration see chapter 6.1.4.

6.2.2. 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. A separate document "Modbus Parameters.pdf" is also available.

The Modbus communication is activated usually for remote port via a menu selection with parameter "Protocol". See chapter 6.1.

For ethernet interface configuration see chapter 6.1.4.

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
Parameter	Value	Unit	Description	Note
Parity	None Even Odd		Parity for Modbus RTU	Set

Set = An editable parameter (password needed)

6.2.3. Profibus DP

The Profibus DP protocol is widely used in industry. An external VPA 3CG 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 more it is not possible to read continuously only one single data item. At least two data items must be read in turn to get updated data from the device.

There is a separate manual for VPA 3CG with the code VMVPA.ENXX available for the continuous mode and request mode.

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 6.1.

Parameters

Parameter	Value	Unit	Description	Note
Mode	 Cont Reqst		Profile selection Continuous mode Request mode	Set
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	 Channel (Limit60) (NoLimit)		Event numbering style. Use this for new installations. (The other modes are for compatibility with old systems.)	(Set)
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	 – VE		Converter type No converter recognized Converter type "VE" is recognized	 4)

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 length 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) If the value is "–", 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.

6.2.4. 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.

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	Channel (Limit60) (NoLimit)		Event numbering style. Use this for new installations. (The other modes are for compatibility with old systems.)	(Set)

Set = An editable parameter (password needed)

6.2.5. 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"-principle. The IEC functionality includes the following 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.

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)

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)

6.2.6. DNP 3.0

The device 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”.

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.

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)

6.2.7. 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” document.

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)

6.2.8. External I/O (Modbus RTU master)

External Modbus I/O devices can be connected to the device using this protocol. (See chapter 8.6.2 for more information).

6.2.9. IEC 61850

The relay supports communication using IEC 61850 protocol with native implementation. IEC 61850 protocol is available with the optional inbuilt Ethernet port. The protocol can be used to read / write static data from the relay or to receive events and to receive / send GOOSE messages to other relays.

IEC 61850 serve 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
- Supported control model: direct with normal 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" on our website.

IEC 61850 main config parameters

Parameter	Value	Unit	Description	Set
Port	0 - 64000		IP protocol port	Set
Check upper addresses	Yes / No		If the checkbox 'Check upper addresses' is checked the below parameters are also checked and used for addressing when the client is communicating to the device, by default this is disabled.	Set
.			The below parameters are ACSE association parameters described in the standard part 61850-8-1	
AP ID	nnn.nnn.nnn.nnn		ACSE AP title value	Set
AE Qualifier	0 – 64000		ACSE AE qualifier	
P Selector	0 – 4200000000		Presentation selector	
S Selector	0 – 64000		Session selector	
T Selector	0 – 64000		Transport selector	
IED Name	String		Identifcation of the device. Each device must have unique name.	
Delete dynamic datasets	command		Send command to clear all dynamic datasets	

6.2.10. EtherNet/IP

The relay 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 relay using request / response communication or via cyclic messages transporting data assigned to assemblies (sets of data).

EtherNet/IP main features:

- Static data model: 2 standard objects (Overload and Control Supervisor), 2 private objects (one for digital data and one for analog data) and 4 configuration objects for protection functions configuration
- Two configurable assemblies (one producing and one consuming) with the maximum capacity of 128 bytes each EDS file that can be fed to any client supporting EDS files: can be generated at any time, all changes to EtherNet/IP configuration (see configuration parameters in table below) or to assemblies' content require generating of the new EDS file.
- Three types of communications are supported: UCMM (one time request / response), Class 3 connection (cyclic request / response) and Class 1 connection (cyclic IO messages containing assemblies' data)

EtherNet/IP implementation on VAMP relay serves as a server and is not capable of initiating communication

7. Applications

The following examples illustrate VAMP 259 functions in most common applications.

7.1. Subtransmission line protection

In this application example VAMP 259 line managers are used in subtransmission application. Protected line is 110 kV and the length of the line is 40 km. In this example the line is protected with line differential and distance functions.

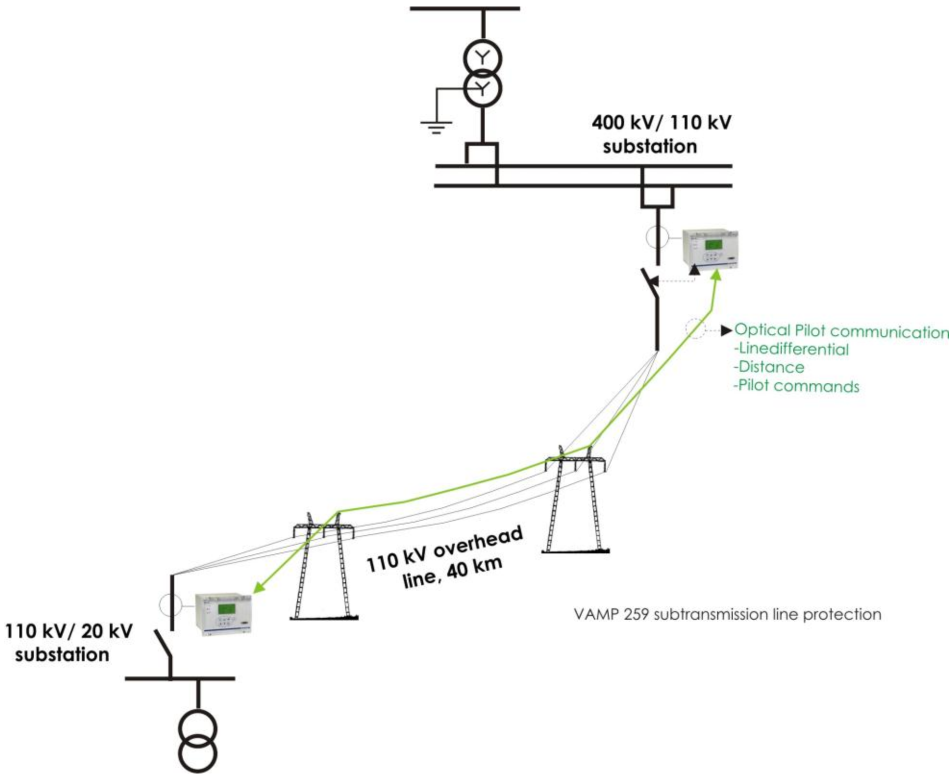


Figure 7.1-1 VAMP Line protection devices used in subtransmission line protection

In between of the two line managers is used optical communication link which is carried along the power lines in the overhead line towers. Relays communicate with each other in 5 ms cycles in which time the measurement data is transferred and processed in each of the line ends.

7.2. Distributed generation application

In this application example VAMP 259 line managers are used in medium voltage application. Protected line is 20 kV and in the line is connected distributed generation. In this example the line is protected with line differential and distance functions. Transfer trip is used for anti-islanding of the DG pover plant.

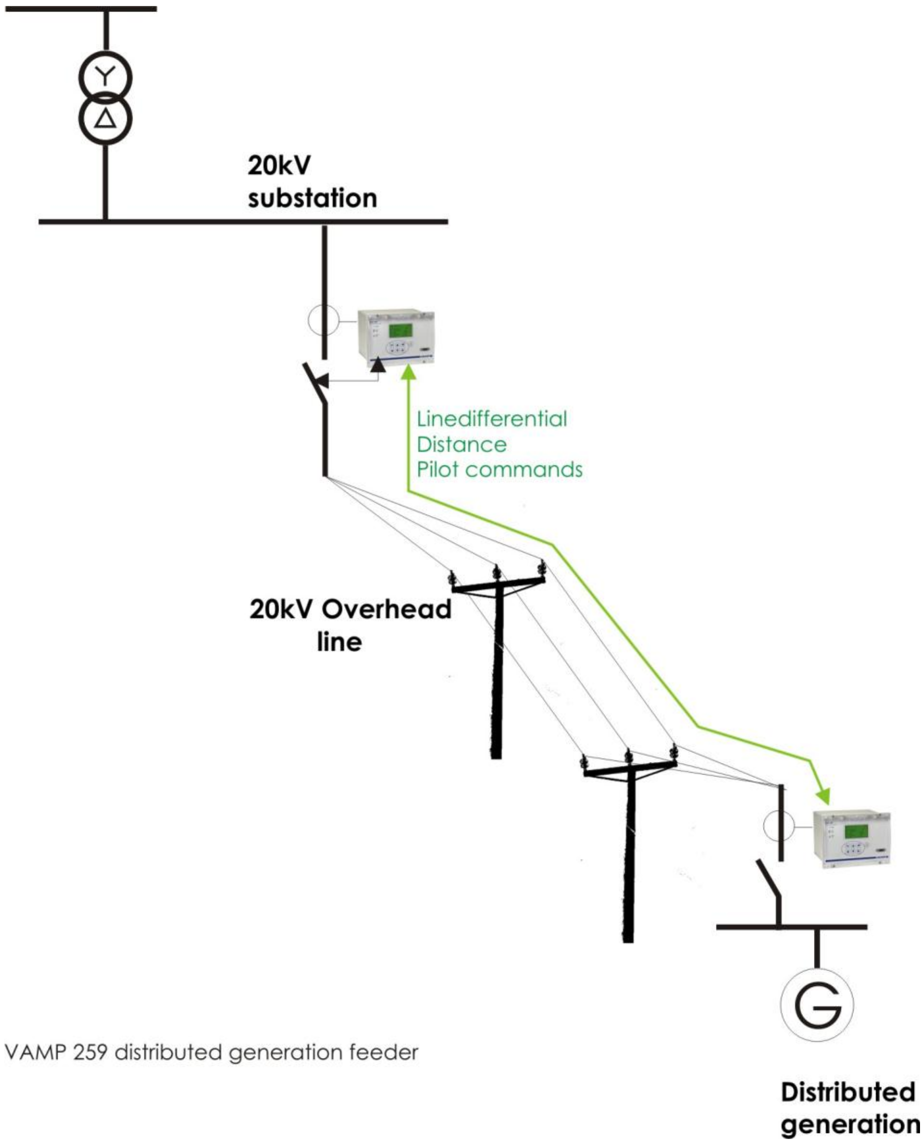


Figure 7.2-1 VAMP Line protection devices used in distributed generation feeder.

By using the transfer tripping command in the line managers distributed generation can be disconnected simultaneously when the feeder relay is about to initiate autoreclosing.

7.3. Medium voltage ring network protection

With distance and linedifferential protection relays the protected area of each relay can be set up specifically thus giving optimal solutions into ring network protection. Also the power generation in the protected areas does not cause troubles in the protection scheme and the operating times of the set zones. All of the fault situations can be cleared with minimum operating time.

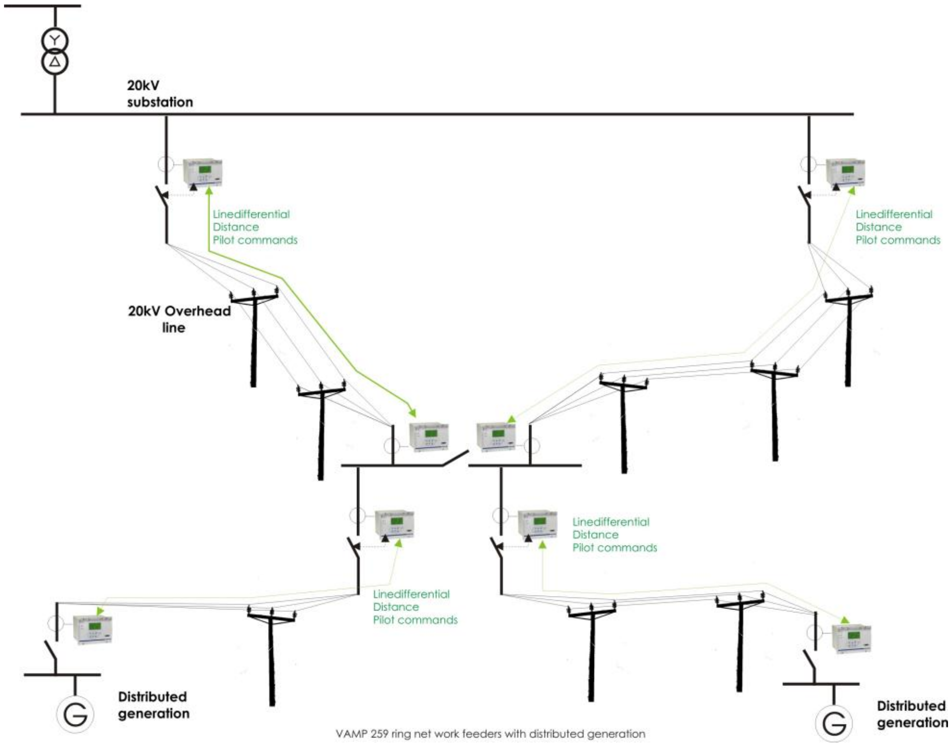


Figure 7.3-1 VAMP Line protection devices used in ring network feeders with distributed generation.

By using distance and linedifferential relays the back-up protection in the ring network can also be set to very fast and precise operation.

7.4. 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.

The digital inputs of the device can be used for trip circuit monitoring. The dry digital inputs are most suitable for trip circuit supervision. The first six digital inputs of VAMP 200 series relays are not dry and an auxiliary miniature relay is needed, if these inputs are used for trip circuit supervision.

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

The optimum digital inputs for trip circuit supervision are inputs DI29 …DI32, which are internally wired in parallel within trip relays T5 … T8. These inputs are not sharing the common terminal with others inputs.

7.4.1. Internal parallel digital inputs

In VAMP 259-3C7 and VAMP 259-3C8, the output relays T5 (DI29), T6(DI30), T7(DI31) and T8(DI32) have internal, parallel digital inputs available for trip circuit supervision.

7.4.2. 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 7.4.2-1).
- 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.
- When using the dry digital inputs DI7..., using the other inputs of the same group, sharing a common terminal, is limited.
- When using the wet digital inputs DI1 ... DI6, an auxiliary relay is needed.

Using any of the dry digital inputs DI7 ...

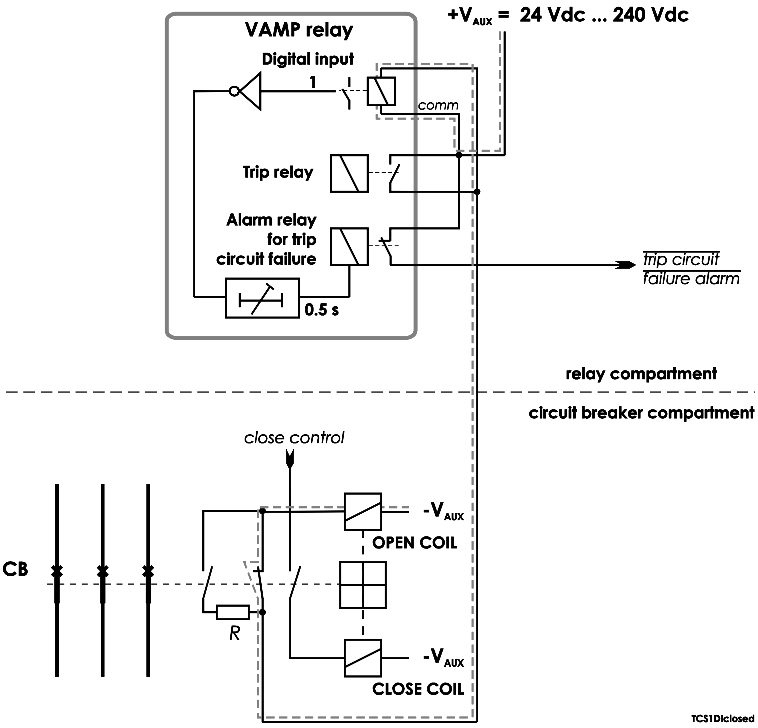


Figure 7.4.2-1 Trip circuit supervision using a single dry digital input and an external resistor R. The circuit-breaker is in the closed position. The supervised circuitry in this CB position is double-lined. The digital input is in active state when the trip circuit is complete. This is applicable for dry inputs DI7...DI20.

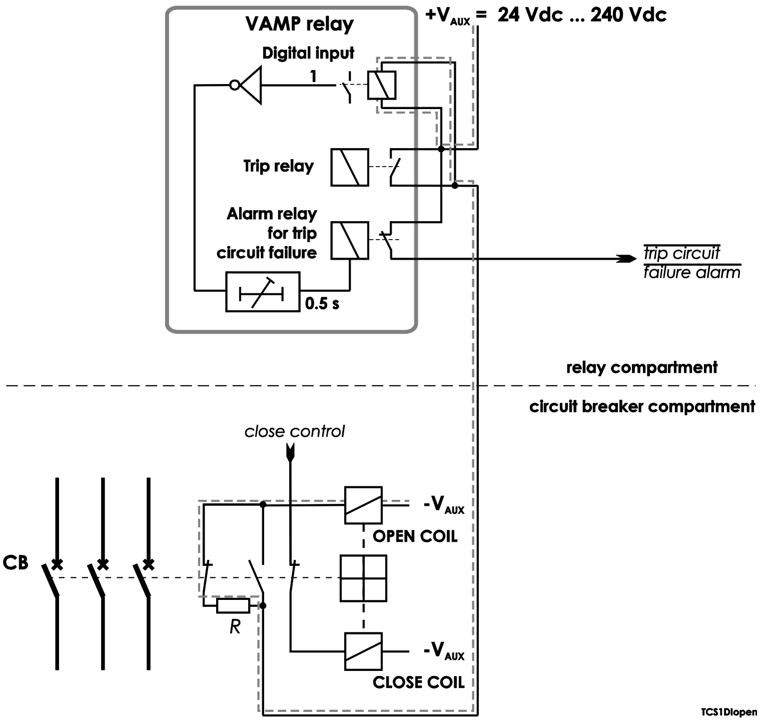
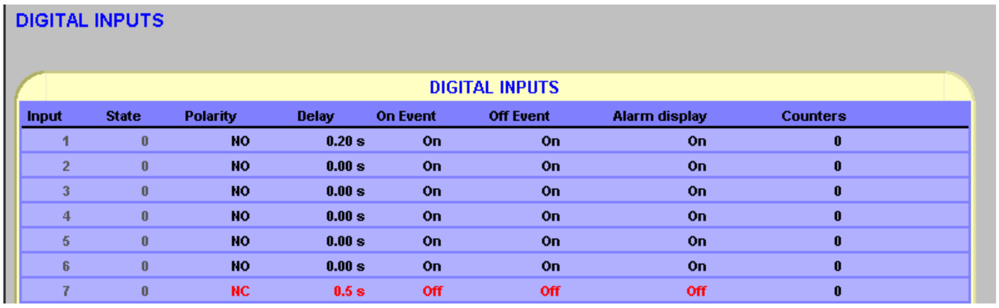


Figure 7.4.2-2 Trip circuit supervision using a single dry digital input, when the circuit breaker is in open position.

Note: If for example DI7 is used for trip circuit supervision, the usage of DI8 ... DI14 is limited to the same circuitry sharing the V_{aux} in the common terminal.



DIGITAL INPUTS

DIGITAL INPUTS

Input	State	Polarity	Delay	On Event	Off Event	Alarm display	Counters
1	0	NO	0.20 s	On	On	On	0
2	0	NO	0.00 s	On	On	On	0
3	0	NO	0.00 s	On	On	On	0
4	0	NO	0.00 s	On	On	On	0
5	0	NO	0.00 s	On	On	On	0
6	0	NO	0.00 s	On	On	On	0
7	0	NC	0.5 s	Off	Off	Off	0

Figure 7.4.2-3 An example of digital input DI7 configuration for trip circuit supervision with one dry digital input.

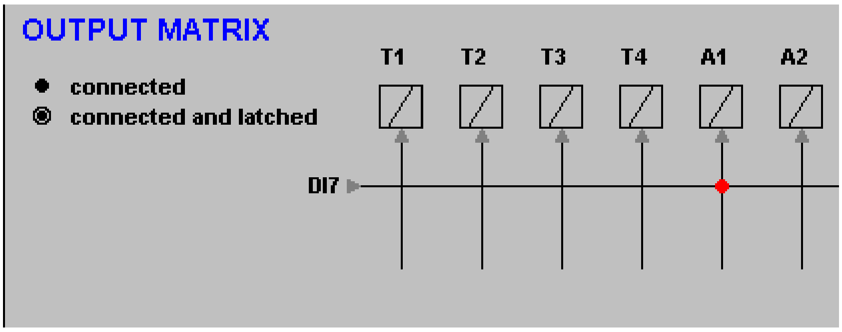


Figure 7.4.2-4 An example of output matrix configuration for trip circuit supervision with one dry digital input.

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 = 242 Ω.

The external resistance value is calculated using Equation 7.4.2-1

Equation 7.4.2-1

$$R = \frac{U_{\min} - U_{DI} - I_{DI} \cdot R_{coil}}{I_{DI}}$$

R = (88 – 18 – 0.003*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 7.4.2-2 and Equation 7.4.2-3. The Equation 7.4.2-2 is for the CB open situation including a 100 % safety margin to limit the maximum temperature of the resistor.

Equation 7.4.2-2

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

P = 2*0.003^2x22000 = 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 7.4.2-3) for this short time.

Equation 7.4.2-3

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

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.

Using any of the non-dry digital inputs DI1...DI6

In this scheme an auxiliary relay is needed to connect the wet digital input to the trip circuit (Figure 7.4.2-5). The rated coil voltage of the auxiliary relay is selected according the rated auxiliary voltage used in the trip circuit. The operating voltage range of the relay should be as wide as possible to cover the tolerance of the auxiliary voltage.

In this application using the other wet inputs for other purposes is not limited unlike, when using the dry inputs.

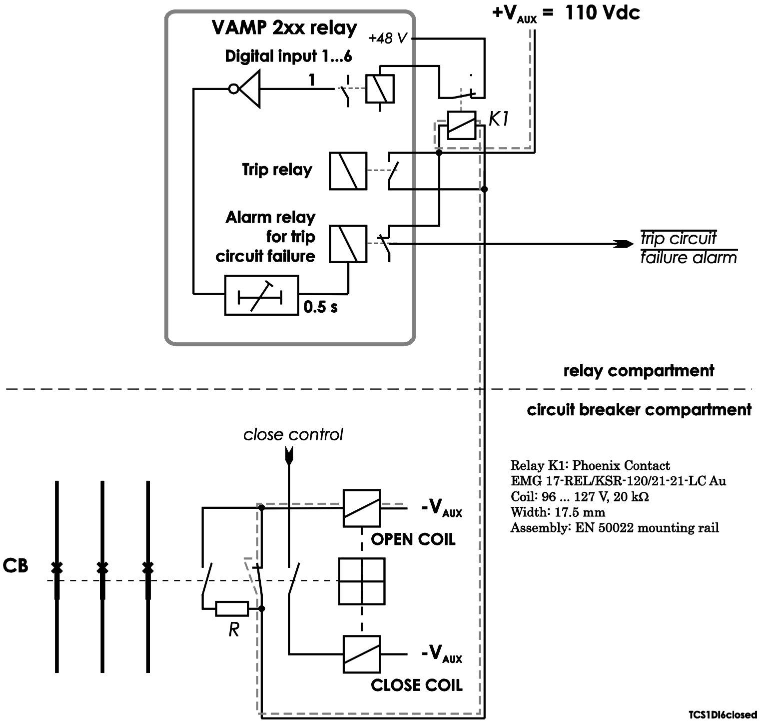


Figure 7.4.2-5 Trip circuit supervision using one of the VAMP 200 series internally wetted digital input (DI1...DI6) and auxiliary relay K1 and an external resistor R. The circuit-breaker is in the closed position. The supervised circuitry in this CB position is double-lined. The digital input is in active state when the trip circuit is complete.

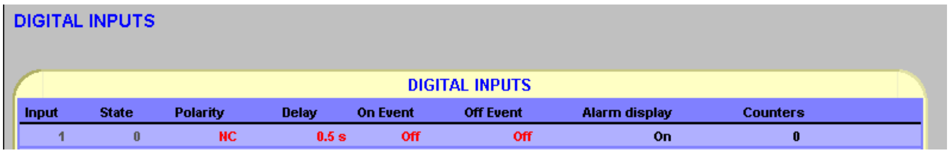


Figure 7.4.2-6 An example of digital input DI1 configuration for trip circuit supervision with one wet digital input.

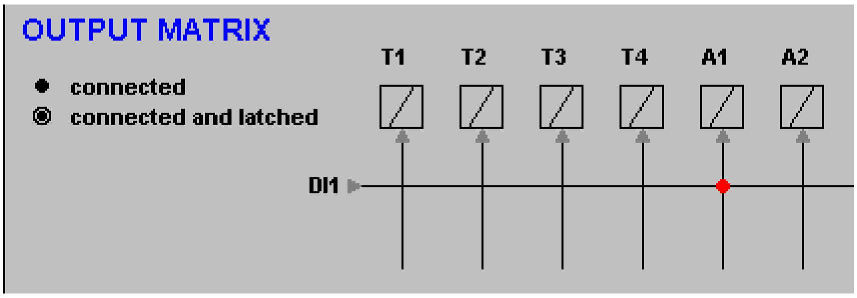


Figure 7.4.2-7 An example of output matrix configuration for trip circuit supervision with one wet digital input.

Example of dimensioning the external resistor R:

U_{aux} = 110 Vdc –5 % + 10%

Auxiliary voltage with tolerance. Short time voltage dips more than 5 % are not critical from the trip circuit supervision point of view.

Relay type for the K1 auxiliary relay:

Phoenix Contact 2941455

EMG 17-REL/KSR-120/21-21-LC Au

U_{K1} = 120 Vac/dc –20 % + 10%

Coil voltage of the auxiliary relay K1

I_{K1} = 6 mA

Nominal coil current of the auxiliary relay K1

P_{CBcoil} = 50 W

Rated power of the open coil of the circuit breaker.

$U_{min} = U_{aux} - 5\ \% = 104.5$ V

$U_{max} = U_{aux} + 10\ \% = 121$ V

$U_{K1min} = U_{K1} - 10\ \% = 96$ V

$R_{K1coil} = U_{K1}/I_{K1} = 20\ k\Omega$.

$I_{K1min} = U_{K1min}/R_{K1coil} = 4.8$ mA

$I_{K1max} = U_{K1max}/R_{K1coil} = 6.1$ mA

$R_{CBcoil} = U^2_{aux}/P = 242\ \Omega$.

The external resistance value is calculated using Equation 7.4.2-4.

Equation 7.4.2-4

$$R = \frac{U_{\min} - U_{K1\min}}{I_{K1\min}} - R_{coil}$$

R = (104.5 – 96)/0.0048 - 242 = 1529 Ω

By selecting the next smaller standard size we get **1.5 kΩ**.

The power rating for the external resistor is calculated using Equation 7.4.2-5. This equation includes a 100 % safety margin to limit the maximum temperature of the resistor, because modern resistors are extremely hot at their rated maximum power.

Equation 7.4.2-5

$$P = 2 \cdot I_{K1\max}^{2} \cdot R$$

P = 2*0.0061^2x1500 = 0.11 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 7.4.2-3) for this short time.

P = 121^2/1500 = 9.8 W

A **1 W** resistor should be selected to withstand this short time peak power. However, if the trip relay can be closed for longer time than a few seconds, a 20 W resistor should be used.

7.4.3. 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.
- 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.
- 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 7.4.3-1 is not possible in most applications. Using the other digital inputs in the same group as the lower DI in the Figure 7.4.3-1 is limited, because the whole group will be tied to the auxiliary voltage V_{aux}.

Note: In many applications the optimum digital inputs for trip circuit supervision are the optional inputs DI19 and DI20 because they don't share their terminals with any other digital inputs.

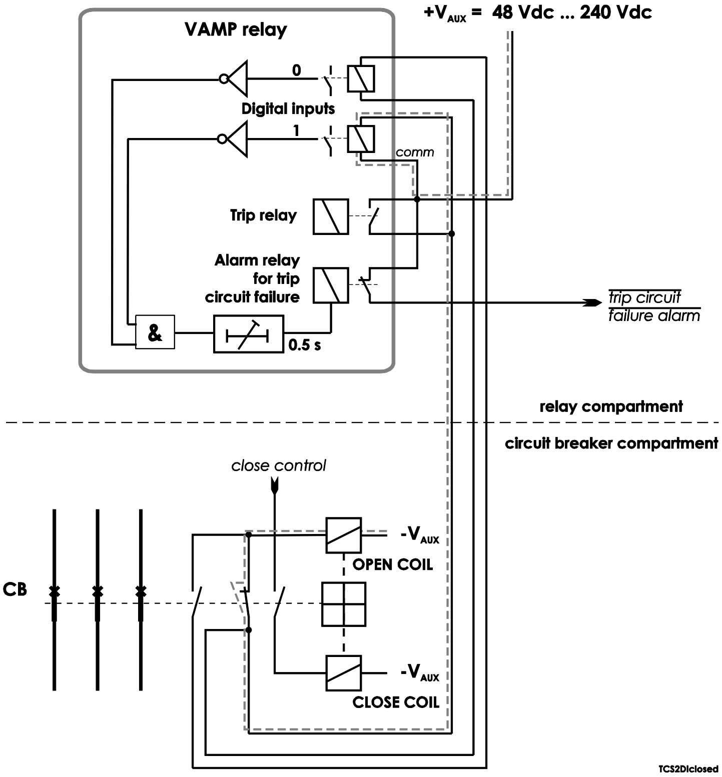


Figure 7.4.3-1 Trip circuit supervision with two dry digital inputs. The CB is closed. The supervised circuitry in this CB position is double-lined. The digital input is in active state when the trip circuit is complete. This is applicable for dry inputs DI7...D20 only.

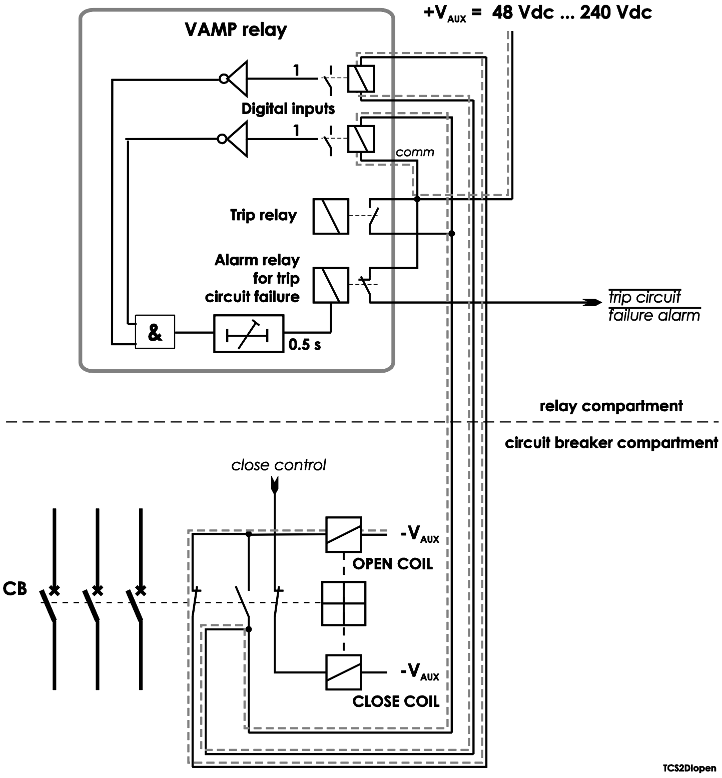
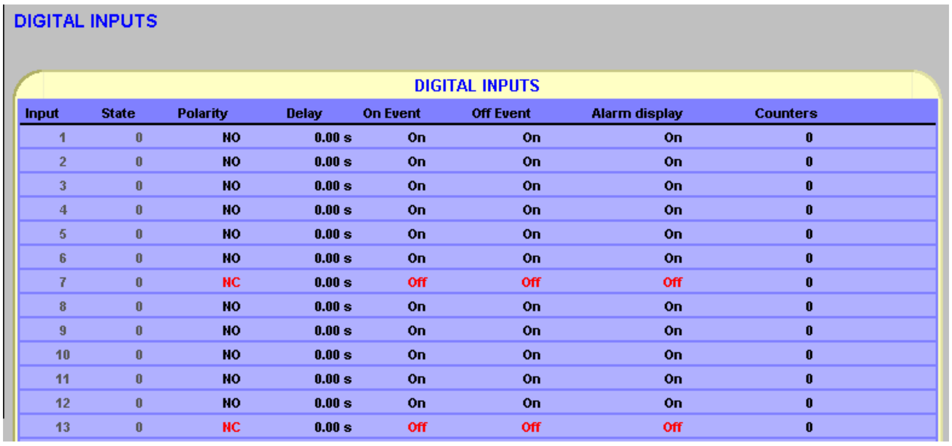


Figure 7.4.3-2 Trip circuit supervision with two dry digital inputs. The CB is in the open position. The two digital inputs are now in series.

Note: If for example DI13 and DI7 are used as the upper and lower digital inputs in the Figure 7.4.3-2, the usage of DI8 ... DI14 is limited to the same circuitry sharing the Vaux in the common terminal and the DI14 ... DI18 cannot be used, because they share the same common terminal with DI13.



Input	State	Polarity	Delay	On Event	Off Event	Alarm display	Counters
1	0	NO	0.00 s	On	On	On	0
2	0	NO	0.00 s	On	On	On	0
3	0	NO	0.00 s	On	On	On	0
4	0	NO	0.00 s	On	On	On	0
5	0	NO	0.00 s	On	On	On	0
6	0	NO	0.00 s	On	On	On	0
7	0	NC	0.00 s	Off	Off	Off	0
8	0	NO	0.00 s	On	On	On	0
9	0	NO	0.00 s	On	On	On	0
10	0	NO	0.00 s	On	On	On	0
11	0	NO	0.00 s	On	On	On	0
12	0	NO	0.00 s	On	On	On	0
13	0	NC	0.00 s	Off	Off	Off	0

Figure 7.4.3-3 An example of digital input configuration for trip circuit supervision with two dry digital inputs DI7 and DI13.

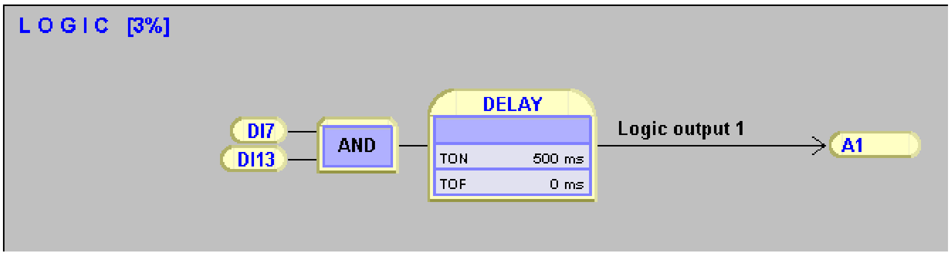


Figure 7.4.3-4 An example of logic configuration for trip circuit supervision with two dry digital inputs DI7 and DI13.

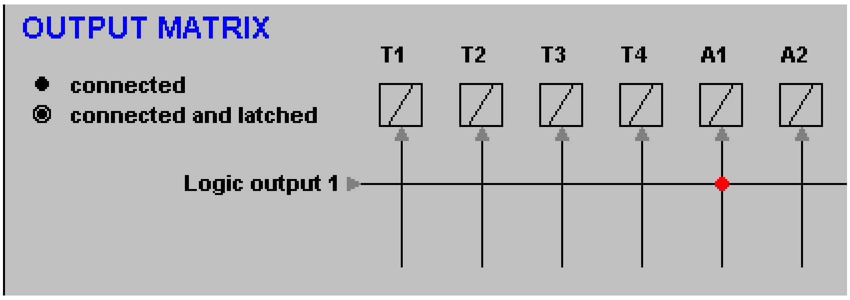


Figure 7.4.3-5 An example of output matrix configuration for trip circuit supervision with two dry digital inputs.

8. Connections

8.1. Rear panel view

VAMP 259 is connected to the protected object through the following measuring and control connections:

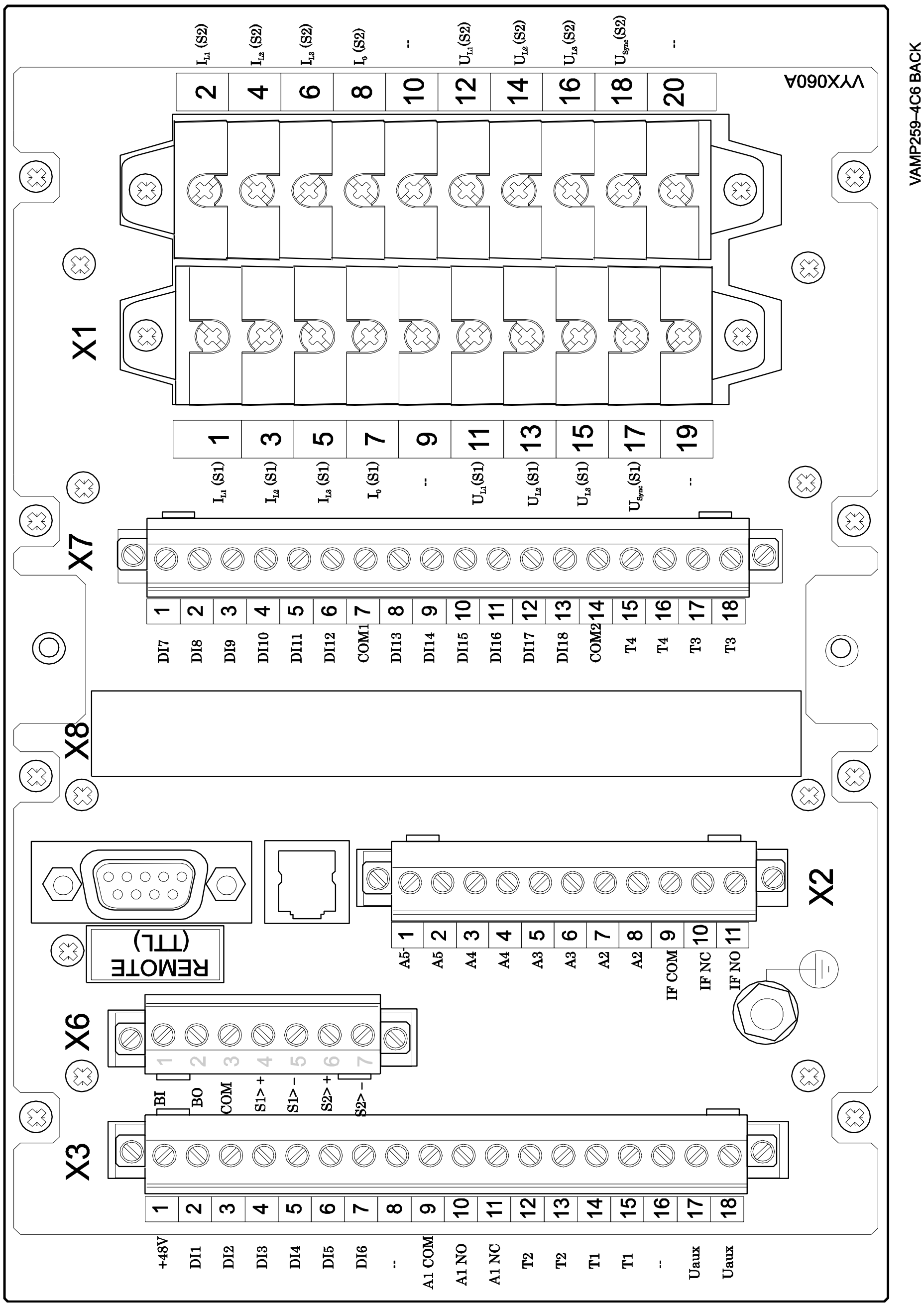


Figure 8.1-1 Connection on the rear panel of the VAMP 259-4C6

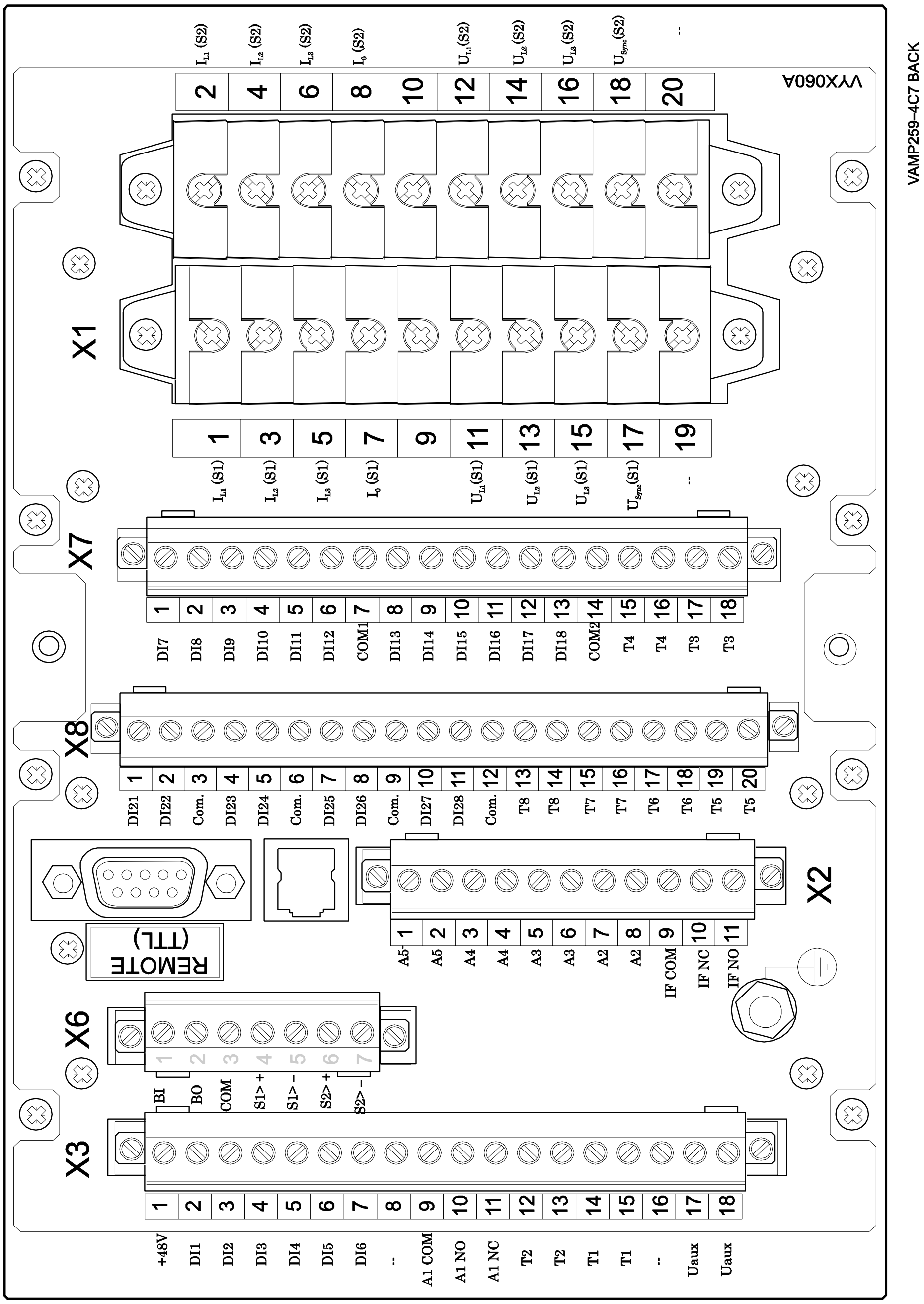


Figure 8.1-2 Connection on the rear panel of the VAMP 259-4C7

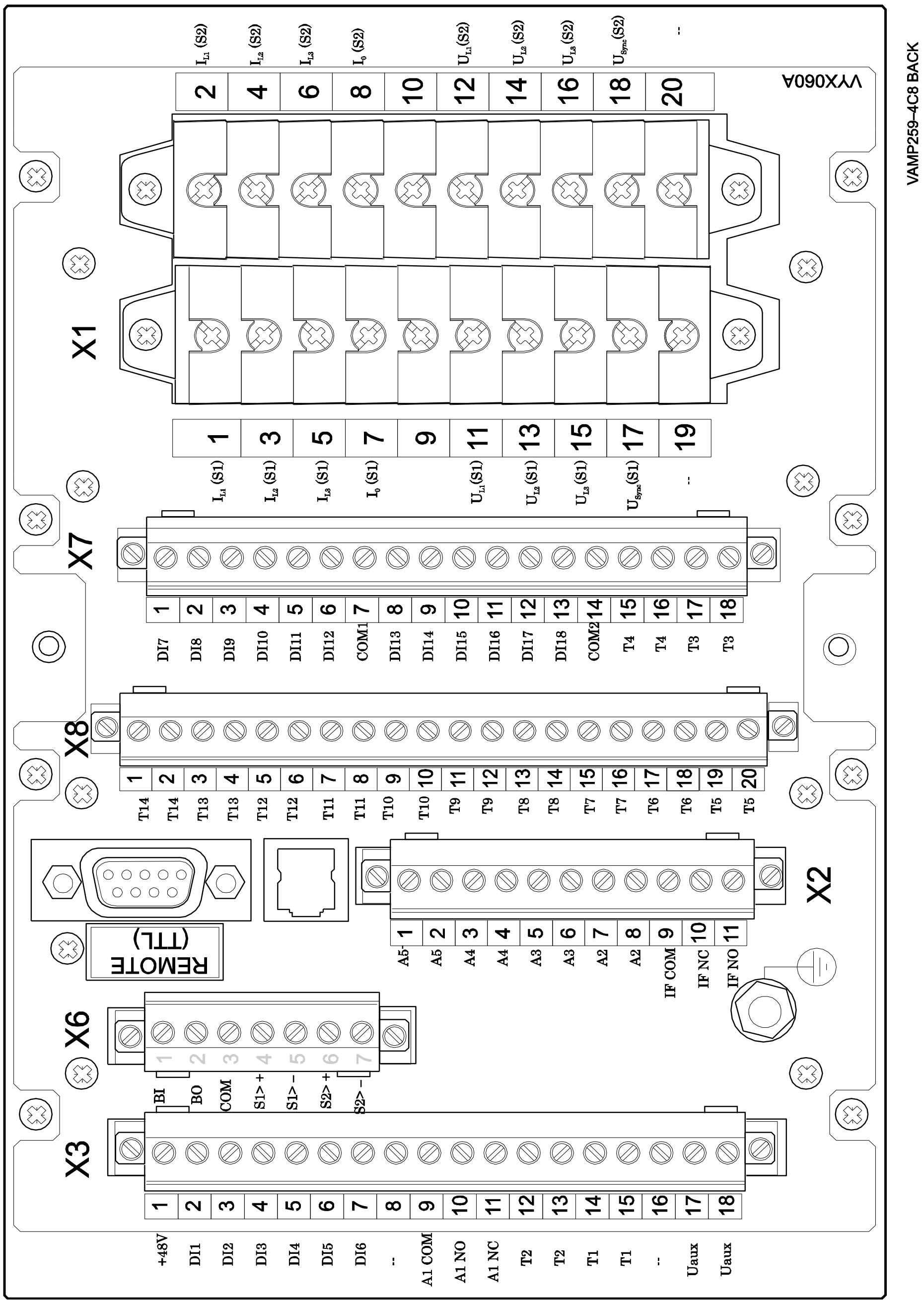
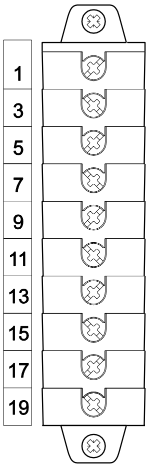


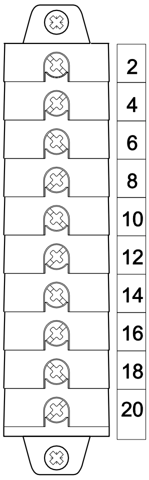
Figure 8.1-3 Connection on the rear panel of the VAMP 259-4C8

Terminal X1 left side



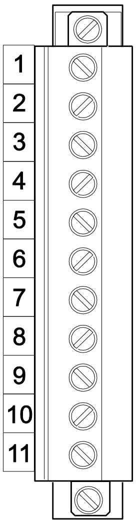
No:	Symbol	Description
1	I_{L1}(S1)	Phase current $_{L1}$ (S1)
3	I_{L2}(S1)	Phase current $_{L2}$ (S1)
5	I_{L3}(S1)	Phase current $_{L3}$ (S1)
7	I_0 (S1)	Residual current I_0 (S1)
9	--	--
11	U_{L1} (S1)	Phase to ground voltage U_{L1} (S1)
13	U_{L2} (S1)	Phase to ground voltage U_{L2} (S1)
15	U_{L3} (S1)	Phase to ground voltage U_{L3} (S1)
17	USync (S1)	Synchrocheck voltage input (S1)
19	--	--

Terminal X1 right side



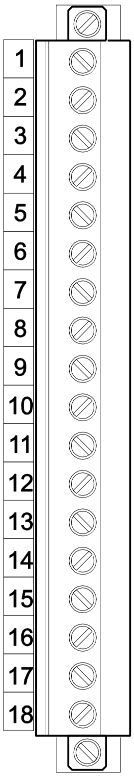
No:	Symbol	Description
2	I_{L1}(S2)	Phase current $_{L1}$ (S2)
4	I_{L2}(S2)	Phase current $_{L2}$ (S2)
6	I_{L3}(S2)	Phase current $_{L3}$ (S2)
8	I_0 (S2)	Residual current I_0 (S2)
10	--	--
12	U_{L1} (S2)	Phase to ground voltage U_{L1} (S2)
14	U_{L2} (S2)	Phase to ground voltage U_{L2} (S2)
16	U_{L3} (S2)	Phase to ground voltage U_{L3} (S2)
18	Usync (S2)	Synchrocheck voltage input (S2)
20	--	--

Terminal X2



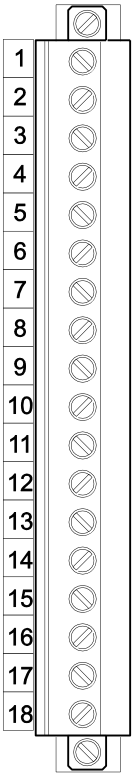
No:	Symbol	Description
1	A5	Alarm relay 5
2	A5	Alarm relay 5
3	A4	Alarm relay 4
4	A4	Alarm relay 4
5	A3	Alarm relay 3
6	A3	Alarm relay 3
7	A2	Alarm relay 2
8	A2	Alarm relay 2
9	IF COM	Internal fault relay, common connector
10	IF NC	Internal fault relay, normal closed connector
11	IF NO	Internal fault relay, normal open connector

Terminal X3



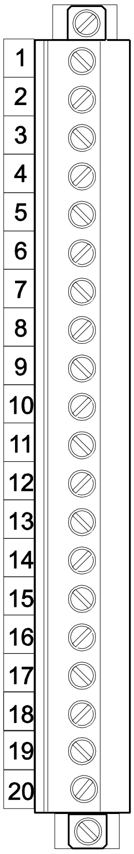
No:	Symbol	Description
1	+48V	Internal control voltage for digital inputs 1 – 6
2	DI1	Digital input 1
3	DI2	Digital input 2
4	DI3	Digital input 3
5	DI4	Digital input 4
6	DI5	Digital input 5
7	DI6	Digital input 6
8	--	--
9	A1 COM	Alarm relay 1, common connector
10	A1 NO	Alarm relay 1, normal open connector
11	A1 NC	Alarm relay 1, normal closed connector
12	T2	Trip relay 2
13	T2	Trip relay 2
14	T1	Trip relay 1
15	T1	Trip relay 1
16	--	--
17	Uaux	Auxiliary voltage
18	Uaux	Auxiliary voltage

Terminal X7



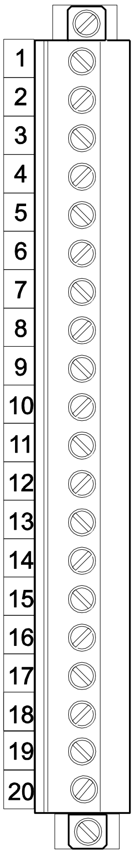
No:	Symbol	Description
1	DI7	Digital input 7
2	DI8	Digital input 8
3	DI9	Digital input 9
4	DI10	Digital input 10
5	DI11	Digital input 11
6	DI12	Digital input 12
7	COM1	Common potential of digital inputs 7 – 12
8	DI13	Digital input 13
9	DI14	Digital input 14
10	DI15	Digital input 15
11	DI16	Digital input 16
12	D117	Digital input 17
13	DI18	Digital input 18
14	COM2	Common potential of digital inputs 13 – 18
15	T4	Trip relay 4
16	T4	Trip relay 4
17	T3	Trip relay 3
18	T3	Trip relay 3

Terminal X8 (VAMP 259-3C7)



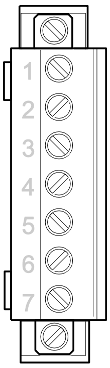
No:	Symbol	Description
1	DI21	Digital input 21
2	DI22	Digital input 22
3	COM1	Common potential of digital inputs 21-22
4	DI23	Digital input 23
5	DI24	Digital input 24
6	COM2	Common potential of digital inputs 23-24
7	DI25	Digital input 25
8	DI26	Digital input 26
9	COM3	Common potential of digital inputs 25-26
10	DI27	Digital input 27
11	DI28	Digital input 28
12	COM4	Common potential of digital inputs 27-28
13	T8	Trip relay 8/ Digital input 32
14	T8	Trip relay 8/ Digital input 32
15	T7	Trip relay 7/ Digital input 31
16	T7	Trip relay 7/ Digital input 31
17	T6	Trip relay 6/ Digital input 30
18	T6	Trip relay 6/ Digital input 30
19	T5	Trip relay 5/ Digital input 29
20	T5	Trip relay 5/ Digital input 29

Terminal X8 (VAMP 259-3C8)



No:	Symbol	Description
1	T14	Trip relay 14/
2	T14	Trip relay 14/
3	T13	Trip relay 13/
4	T13	Trip relay 13/
5	T21	Trip relay 12/
6	T12	Trip relay 12/
7	T11	Trip relay 11/
8	T11	Trip relay 11/
9	T10	Trip relay 10/
10	T10	Trip relay 10/
11	T9	Trip relay 9/
12	T9	Trip relay 9/
13	T8	Trip relay 8/ Digital input 32
14	T8	Trip relay 8/ Digital input 32
15	T7	Trip relay 7/ Digital input 31
16	T7	Trip relay 7/ Digital input 31
17	T6	Trip relay 6/ Digital input 30
18	T6	Trip relay 6/ Digital input 30
19	T5	Trip relay 5/ Digital input 29
20	T5	Trip relay 5/ Digital input 29

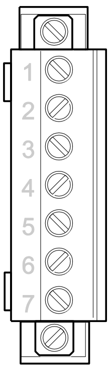
Terminal X6



No:	Symbol	Description
1	BI	External arc light input
2	BO	Arc light output
3	COM	Common connector of arc light I/O
4	S1>+	Arc sensor 1, positive connector *
5	S1>–	Arc sensor 1, negative connector *
6	S2>+	Arc sensor 2, positive connector *
7	S2>–	Arc sensor 2, negative connector *

*) Arc sensor itself is polarity free

Terminal X6 with DI19/DI20 option



No:	Symbol	Description
1	DI19	Digital input 19
2	DI19	Digital input 19
3	DI20	Digital input 20
4	DI20	Digital input 20
5	--	--
6	S1>+	Arc sensor 1, positive connector *
7	S1>–	Arc sensor 1, negative connector *

*) Arc sensor itself is polarity free

8.2. Auxiliary voltage

The external auxiliary voltage U_{aux} (standard 40…265 V ac/dc or optional 18…36 Vdc) for the terminal is connected to the terminals X3: 17-18.

NOTE! When optional 18…36 Vdc power module is used the polarity is as follows:

X3:17 positive, X3:18 negative.

8.3. Serial communication connection

The device can be equipped with two optional communication interfaces:

Option 1: inbuilt Ethernet ST-fiber interface or option module 1

Option 2: inbuilt **Ethernet RJ-45 interface** or option module 2

The physical location of the communication options is at the back of the relay. The option modules can be installed at the site, but the inbuilt Ethernet modules are installed at the factory (see chapter 12 for more information).

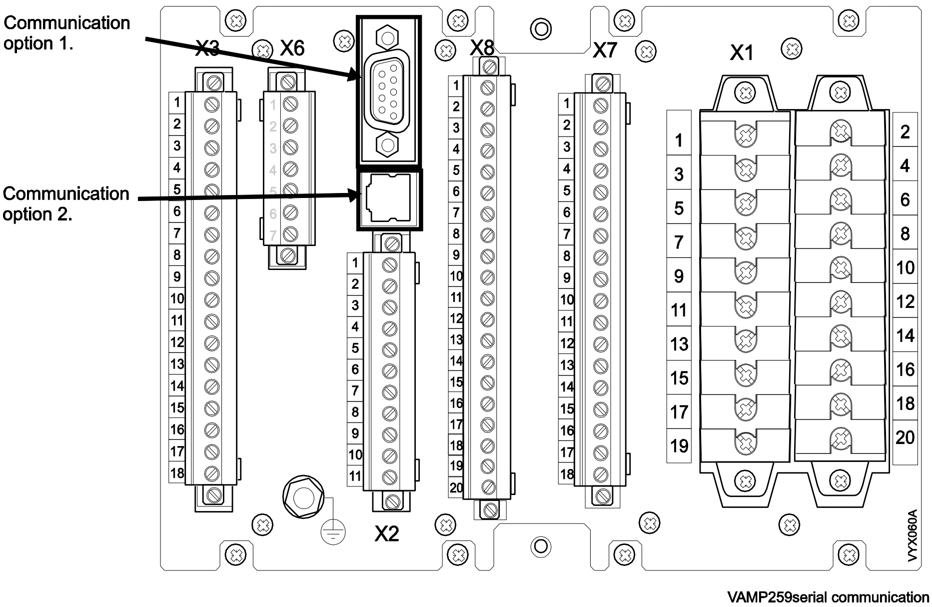


Figure 8.3-1 Example of VAMP259 back panel serial communication connection

The internal connection in both communication modules is identical (see Figure 8.3-2). The transmit and receive lines of all the three "logical communication ports" REMOTE, LOCAL and EXTENSION port are available for both modules (RS-232 signal levels). Depending on the module type one or more of these ports are physically available at the external connector.

The communication modules convert the RS-232 signal levels to some other levels e.g. TTL, RS-485 or fibre-optics. The modules may also contain intelligence to make protocol conversion on software level.

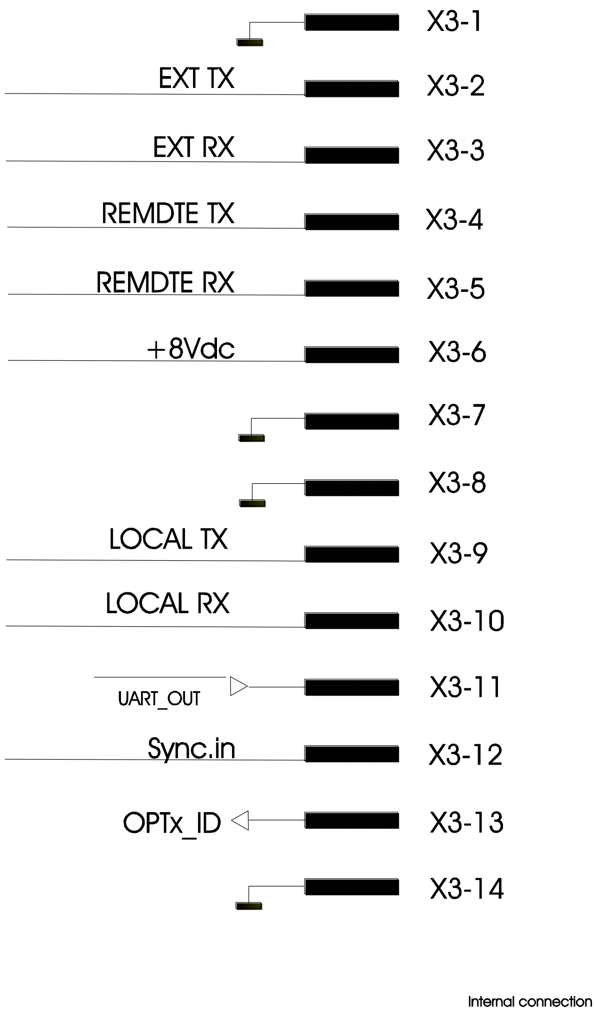


Figure 8.3-2 Internal connection to communication modules

The internal connection of the communication modules contain the RX/TX signals from the communication ports, general output (UART_OUT), clock sync/general input (Sync.in) and OPTx_ID for module detection.

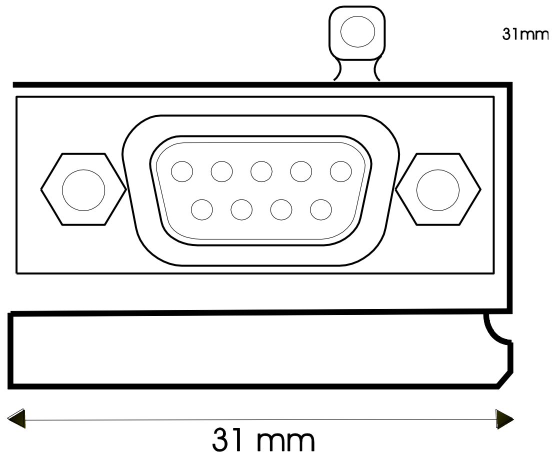


Figure 8.3-3 Communication module with a height of 31mm

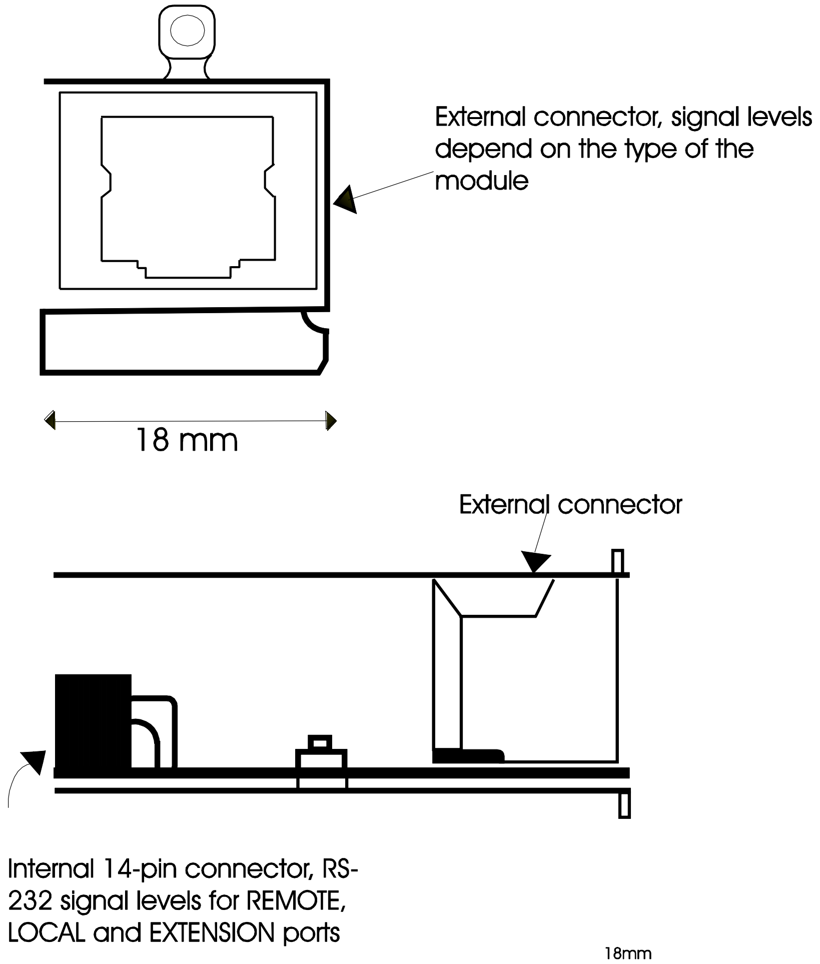


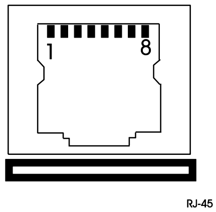
Figure 8.3-4 Communication module with a height of 18mm

The device has a 31mm high "slot" for Communication option 1 and 18mm high "slot" for Communication option 2. The option modules are either 31mm or 18mm high, the 18mm modules can be used either in the 31mm or 18mm slot.

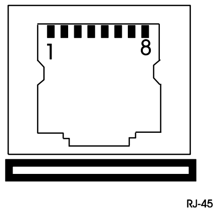
8.3.1. Pin assignments of communication options

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

Optional inbuilt Ethernet / 61850 interfaces (for software version 10.0 onwards):

Type	Communication ports	Signal levels	Connector	Pin usage
Ethernet 	TCP port	Ethernet	RJ-45 connector 	1=Transmit+ 2=Transmit – 3=Receive+ 4=Reserved 5=Reserved 6=Receive- 7=Reserved 8=Reserved
Ethernet	TCP port	Fiber ethernet	ST connectors	

18 mm high modules:

Type	Communication ports	Signal levels	Connector	Pin usage
VCM 232	REMOTE, LOCAL and EXTENSION	RS-232	RJ-45 connector 	1= LOC TX 2= EXT TX 3= +8V 4= GND 5= REM TX 6= REM RX 7= LOC RX 8= EXT RX
VCM 485-2	REMOTE, LOCAL or EXTENSION port selectable with a dip switch	RS-485 (2-wire connection)	3-pole screw connector	1= - 2= + 3= GND

32 mm high modules:

Type	Communication ports	Signal levels	Connector	Pin usage
VCM TTL	REMOTE LOCAL EXTENSION	REMOTE: TTL or RS-232 selectable with a dip switch LOCAL: RS-232 EXTENSION: RS-232	D- connector	1= EXT TX 2= REM TX 3= REM RX 4= SYNC IN 5= LOC TX 6= LOC RX 7= GND 8= EXT RX 9= +8V
VCM 485-4	REMOTE, LOCAL or EXTENSION port selectable with a dip switch	RS-485 (2- or 4-wire connection)	5- pole screw connector	1= GND 2= T+ 3= T- 4= R+ 5= R-
VCM fiber PP	REMOTE or LOCAL selectable with a dip switch.	Light, switch for echo/ no-echo and light/ no-light selection	Snap-in connector	
VCM fiber GG	REMOTE or LOCAL selectable with a dip switch.	Light, switch for echo/ no-echo and light/ no-light selection	ST connector	
VCM fiber PG	REMOTE or LOCAL selectable with a dip switch.	Light, switch for echo/ no-echo and light/ no-light selection	Snap-in & ST connectors	
VCM fiber GP	REMOTE or LOCAL selectable with a dip switch.	Light, switch for echo/ no-echo and light/ no-light selection	ST & Snap-in connectors	

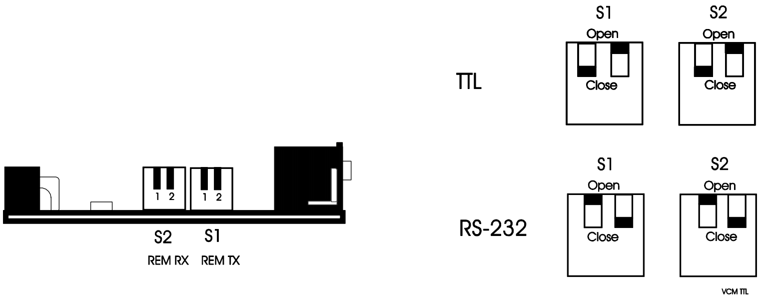


Figure 8.3.1-1 VCM TTL– module's dip-switches

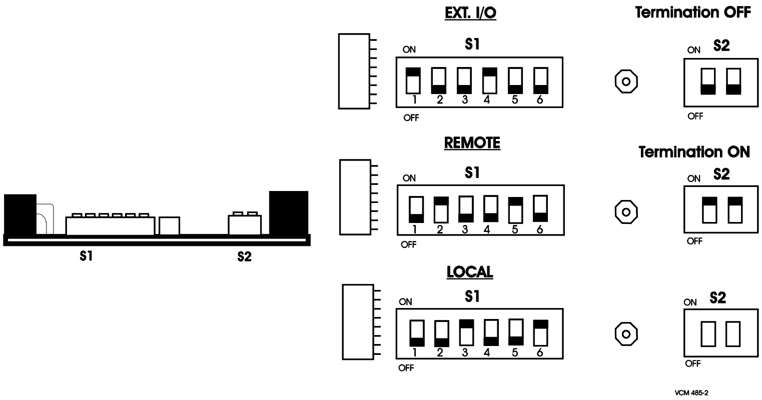


Figure 8.3.1-2 VCM 485-2– module's dip-switches

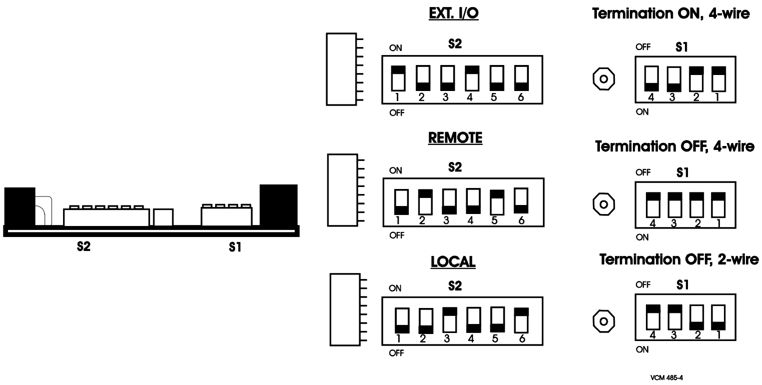


Figure 8.3.1-3 VCM 485-4– module's dip-switches

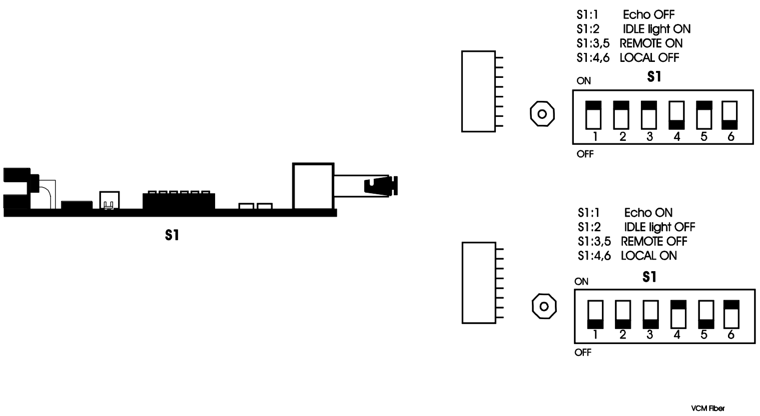


Figure 8.3.1-4 VCM Fiber– module's dip-switches

NOTE! Profibus will be supported by the external VPA 3CG module. This is connected with a VX007-F3 cable to VCM TTL module (VCM TTL dip-switch must be set to TTL).

8.3.2. Front panel connector

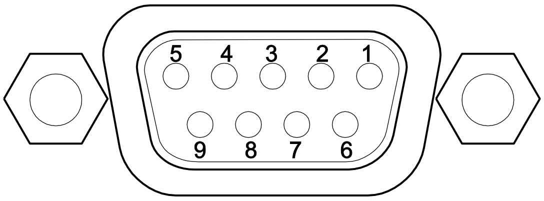


Figure 8.3.2-1 Pin numbering of the front panel D9S connector

Pin	RS232 signal
1	Not connected
2	Rx in
3	Tx out
4	DTR out (+8 V)
5	GND
6	DSR in (activates this port and disables the X4 RS232 port)
7	RTS in (Internally connected to pin 8)
8	CTS out (Internally connected to pin 7)
9	No connected

NOTE! DSR must be connected to DTR to activate the front panel connector and disable the rear panel X4 RS232 port. (The other port in the same X4 connector will not be disabled.)

8.4. Optional two channel arc protection card

NOTE! When this option card is installed, the parameter "Arc card type" has value "2Arc+BI/O". Please check the ordering code in chapter 12.

NOTE! If the slot X6 is already occupied with the DI19/DI20 digital input card, this option is not available, but there is still one arc sensor channel available. See chapter 8.5.

The optional arc protection card includes two arc sensor channels. The arc sensors are connected to terminals X6: 4-5 and 6-7.

The arc information can be transmitted and/or received through digital input and output channels. This is a 48 V dc signal.

Connections:

X6: 1	Binary input (BI)
X6: 2	Binary output (BO)
X6: 3	Common for BI and BO.
X6: 4-5	Sensor 1
X6: 6-7	Sensor 2

The binary output of the arc option card may be activated by the arc sensors or by any available signal in the output matrix. The binary output can be connected to an arc binary input of another VAMP protection device.

8.5. Optional digital I/O card (DI19/DI20)

NOTE! When this option card is installed, the parameter "Arc card type" has value "Arc+2DI". With DI19/DI20 option only one arc sensor channel is available. Please check the ordering code in chapter 12.

NOTE! If the slot X6 is already occupied with the two channel arc sensor card (chapter 8.4), this option is not available.

The DI19/DI20 option enables two more digital inputs. These inputs are useful in applications where the contact signals are not potential free. For example trip circuit supervision is such application. The inputs are connected to terminals X6:1 – X6:2 and X6:3 – X6:4.

Connections:

X6:1	DI19+
X6:2	DI19-
X6:3	DI20+
X6:4	DI20-
X6:5	NC
X6:6	L+
X6:7	L-

8.6. External I/O extension modules

8.6.1. External LED module VAM 16D

The optional external VAM 16D led module provides 16 extra led-indicators in external casing. Module is connected to the serial port of the device's front panel. Please refer the User manual VAM 16 D, VM16D.ENxxx for details.

8.6.2. External input / output module

The device supports an optional external input/output modules sed to extend the number of digital inputs and outputs. Also modules for analogue inputs and outputs are available. 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 IO modules. This port is found in the LOCAL connector of the device backplane and IO devices should be connected to the port with VSE003 adapter.

NOTE! If ExternalIO protocol is not selected to any communication port, VAMPSET doesn't display the menus required for configuring the IO devices. After changing EXTENSION port protocol to ExternalIO, restart the device and read all settings with VAMPSET.

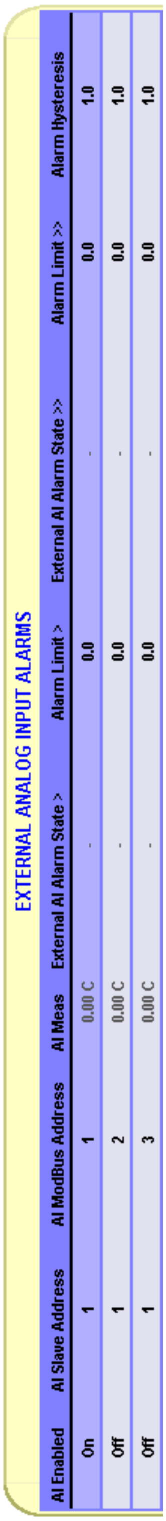
External analog inputs configuration (VAMPSET only)

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	Point 2
		Y1	Scaled value	Point 1
		X1	Modbus value	Point 1
-32000…32000		Off set	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



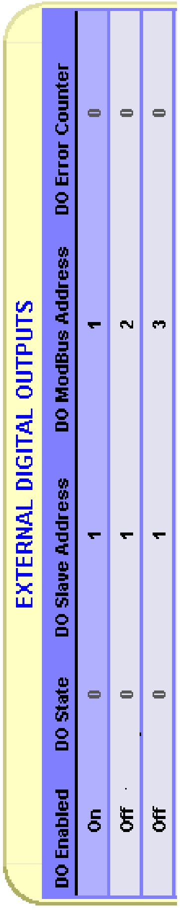
Range	Description	
0…10000	Hysteresis for alarm limits	
-21x107… …21x107	Alarm >>	Limit setting
- / Alarm		Active state
-21x107… …21x107	Alarm >	Limit setting
- / Alarm		Active state
	Active value	
1…9999	Modbus register for the measurement	
1…247	Modbus address of the I/O device	
On / Off	Enabling for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

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

External digital inputs configuration (VAMPSET only)

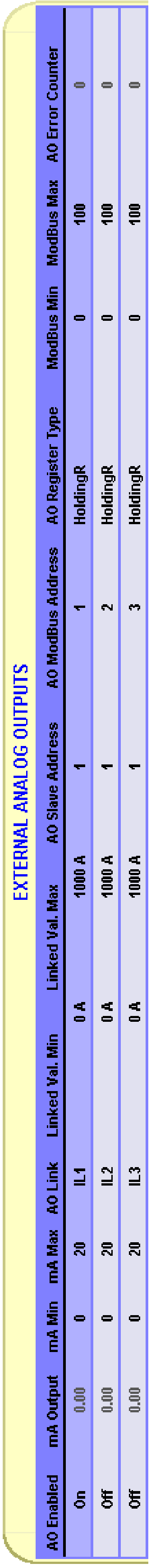
Range	Description
	Communication read errors
1…16	Bit number of Modbus register value
CoilS, InputS, InputR or HoldingR	Modbus register type
1…9999	Modbus register for the measurement
1…247	Modbus address of the I/O device
0 / 1	Active state
On / Off	Enabling for measurement

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
On / Off	Enabling for measurement

External analog outputs configuration (VAMPSET only)

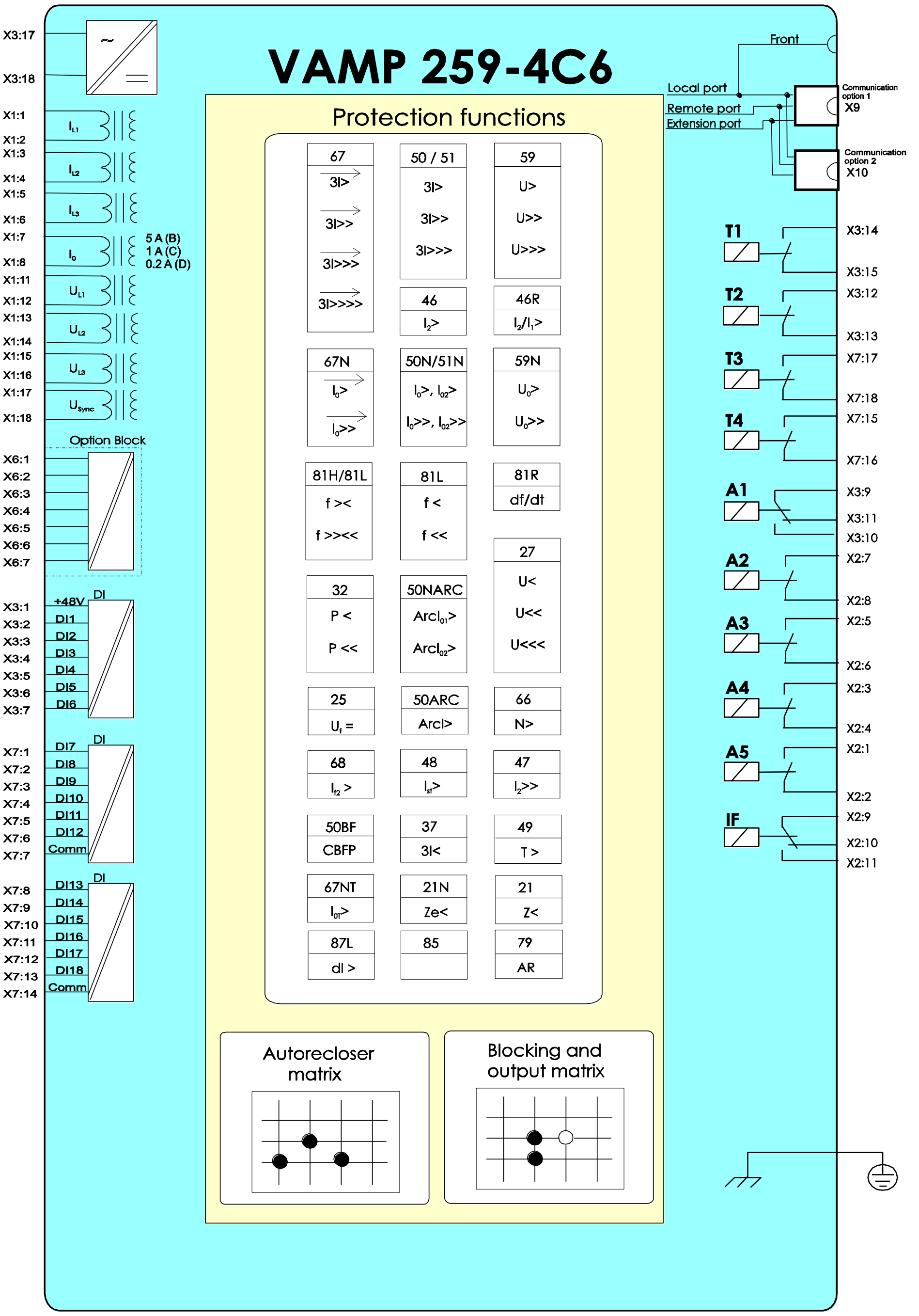

EXTERNAL ANALOG OUTPUTS

AO Enabled	mA Output	mA Min	mA Max	AO Link	Linked Val. Min	Linked Val. Max	AO Slave Address	AO ModBus Address	AO Register Type	ModBus Min	ModBus Max	AO Error Counter
On	0.00	0	20	IL1	0 A	1000 A	1	1	HoldingR	0	100	0
Off	0.00	0	20	IL2	0 A	1000 A	1	2	HoldingR	0	100	0
Off	0.00	0	20	IL3	0 A	1000 A	1	3	HoldingR	0	100	0

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, -21…+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

8.7. Block diagrams

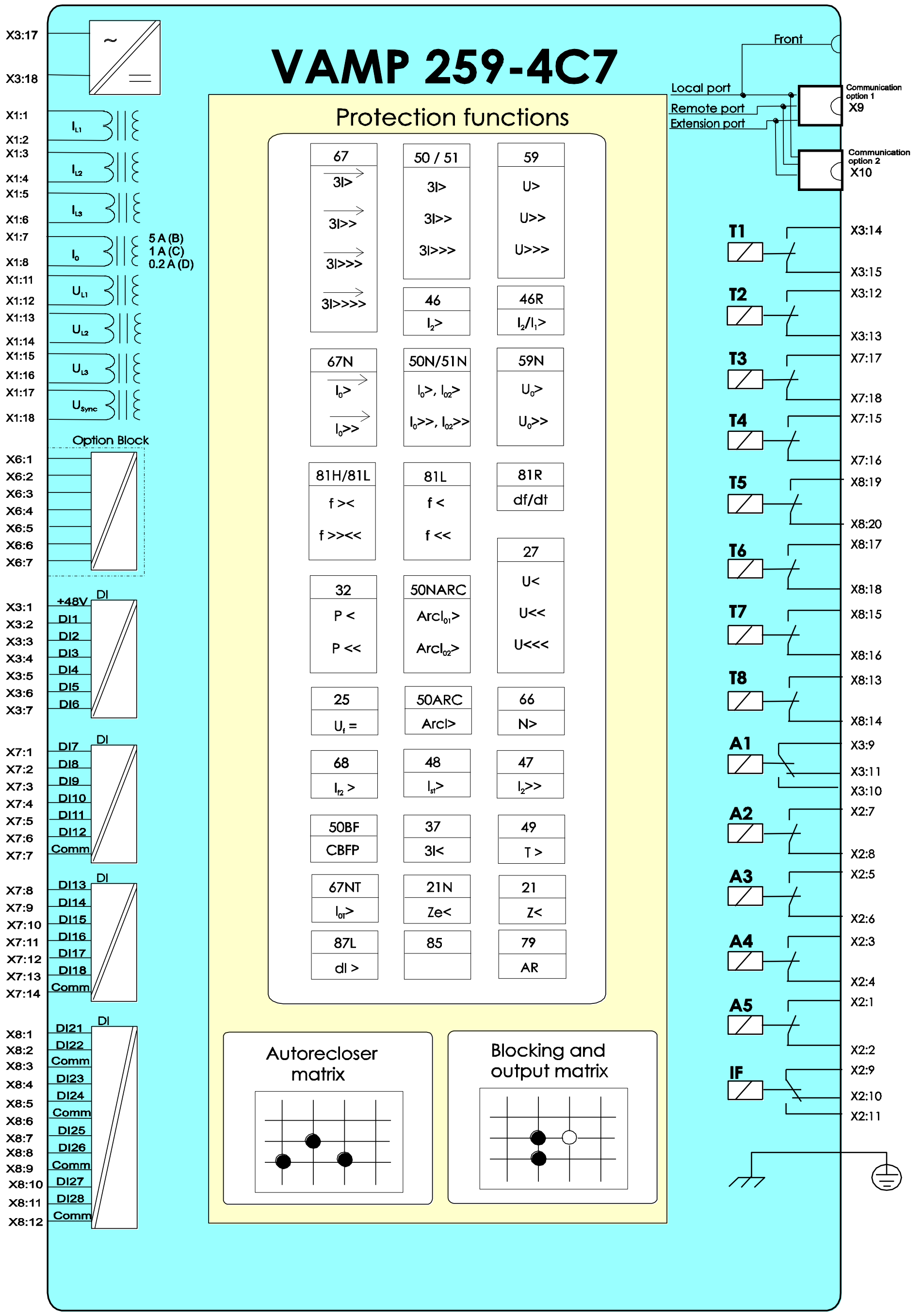
8.7.1. VAMP 259-4C6



VAMP259-4C6blockDiagram

Figure 8.7.1-1 Block diagram of VAMP 259-4C6.

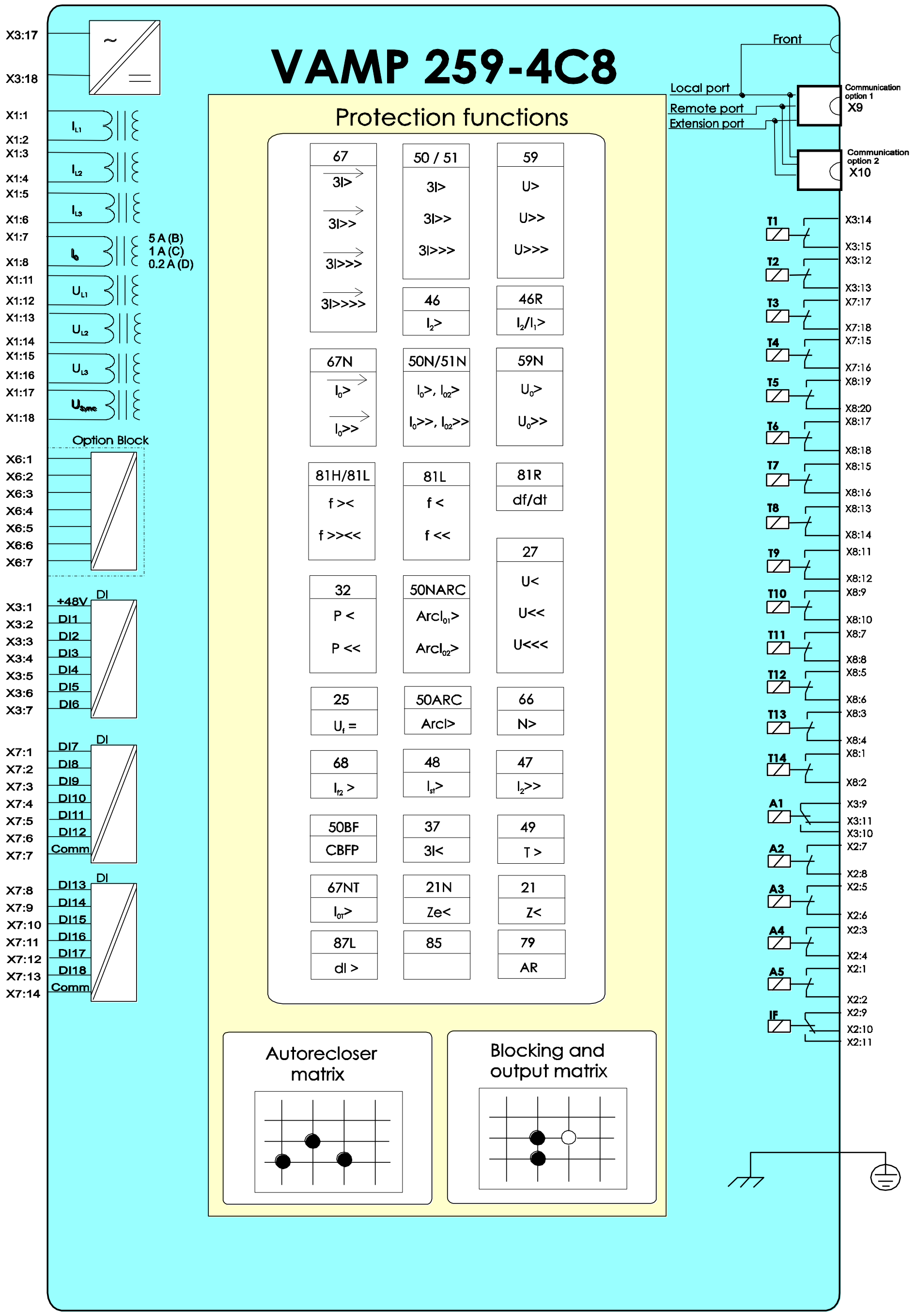
8.7.2. VAMP 259-4C7



VAMP259-4C7blockDiagram

Figure 8.7.2-1 Block diagram of VAMP 259-4C7

8.7.3. VAMP 259-4C8



VAMP259-4C8blockDiagram

Figure 8.7.3-1 Block diagram of VAMP 259-4C8

8.8. Block diagrams of option modules

8.8.1. Optional arc protection

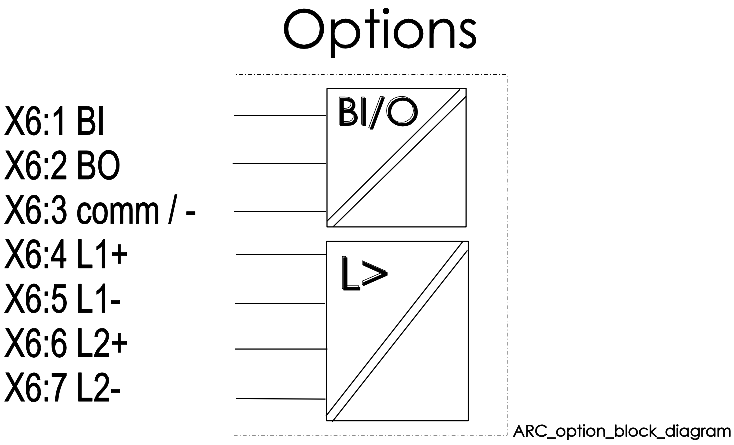


Figure 8.8.1-1 Block diagram of optional arc protection module.

8.8.2. Optional DI19/DI20

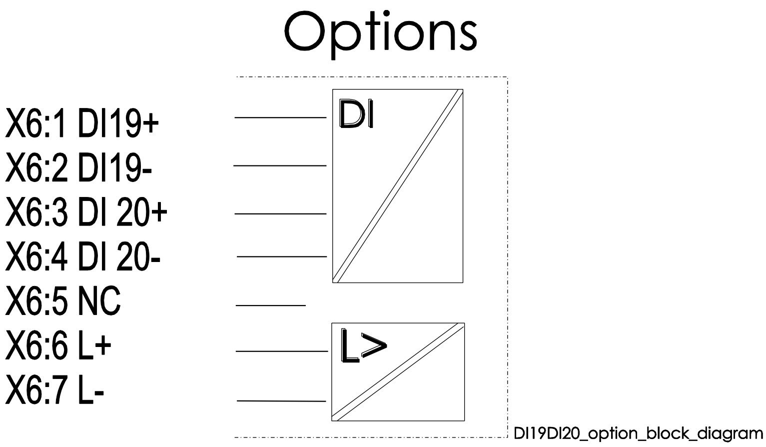


Figure 8.8.2-1 Block diagram of optional DI19/DI20 module with one arc channel.

8.9. Connection examples

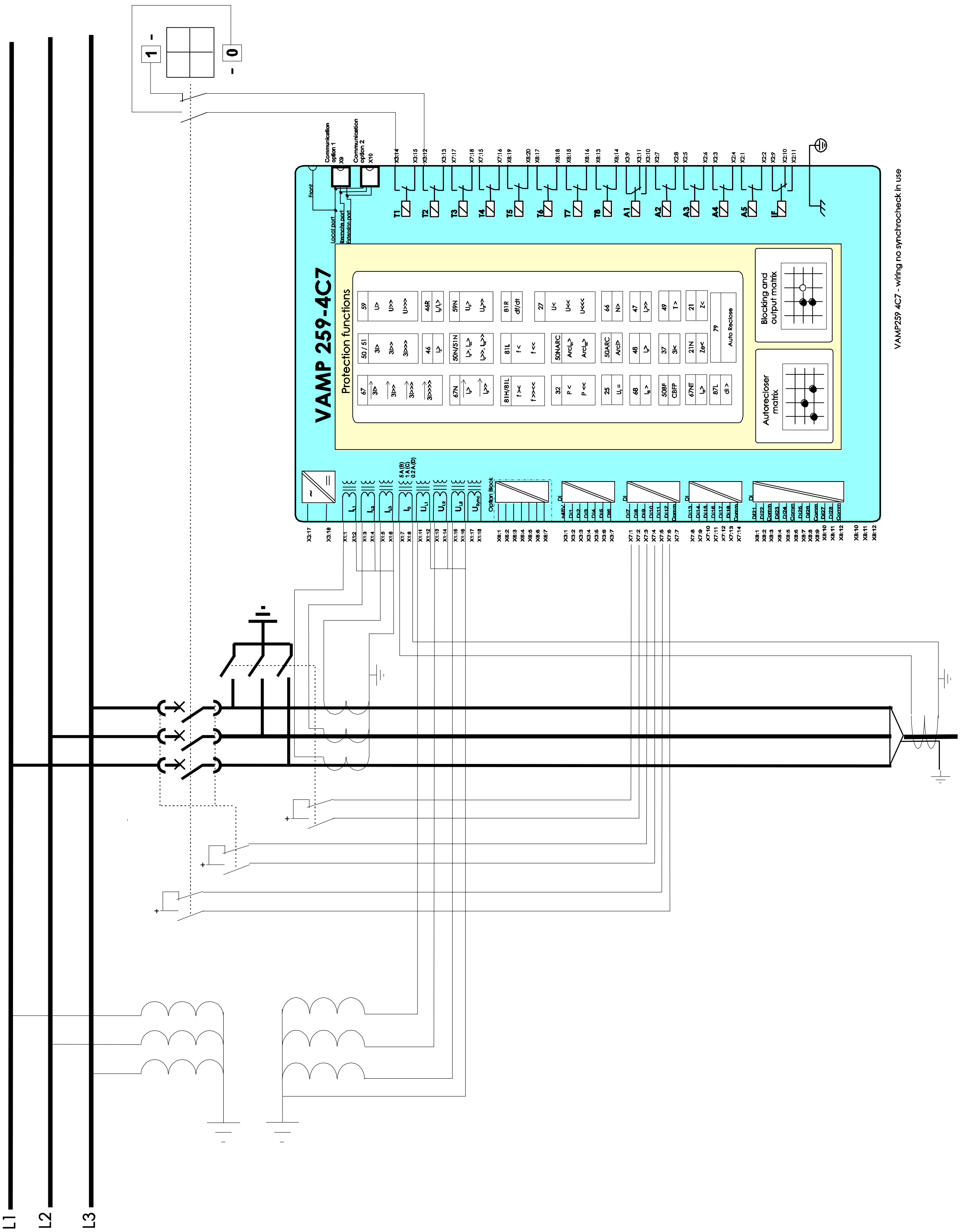


Figure 8.9-1 Connection example of VAMP 259-3C7 without a synchrocheck function in use. The voltage measurement mode is set to "3LN".

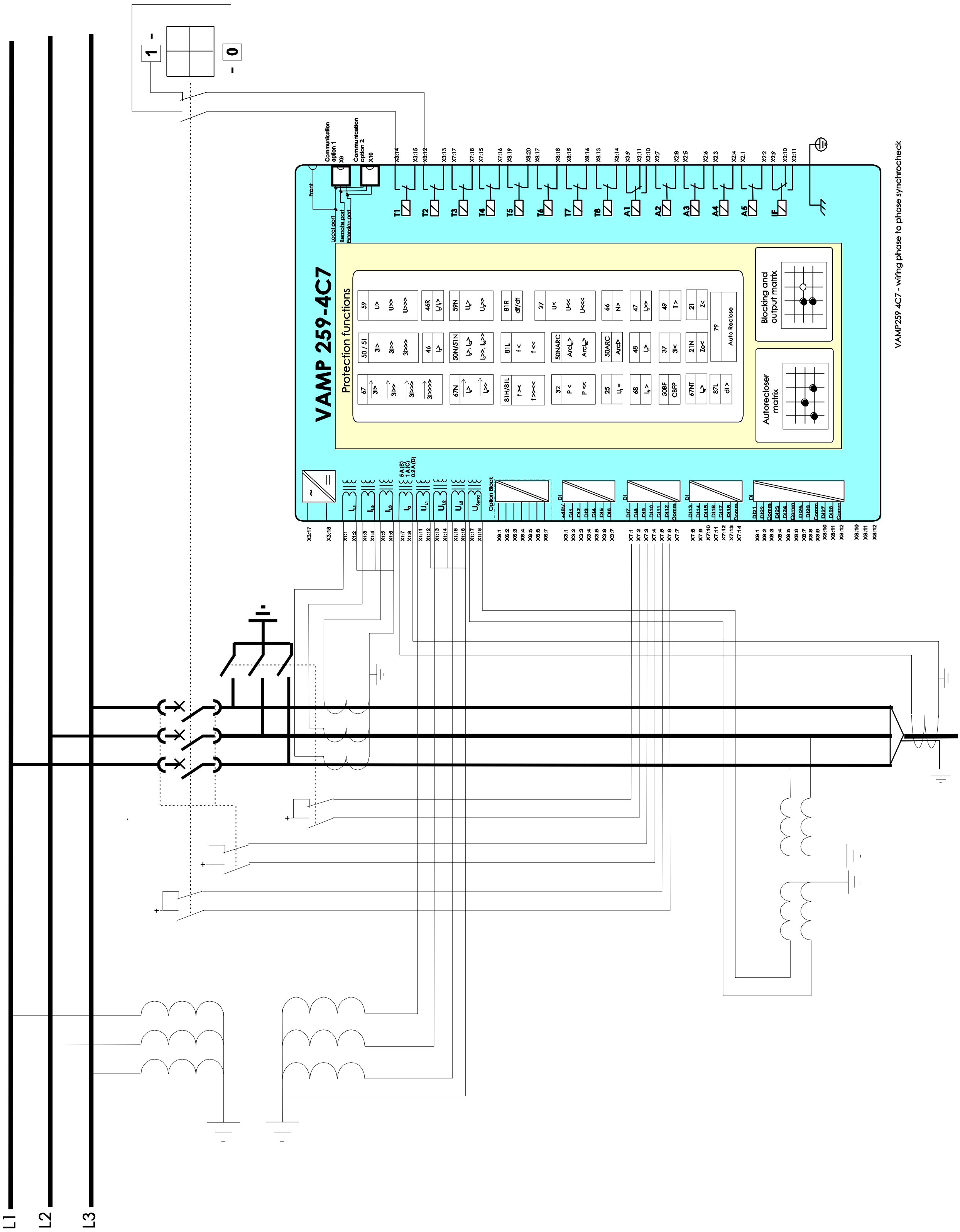


Figure 8.9-2 Connection example of VAMP 259-4C7 with a synchrocheck function from phase to phase voltage. The voltage measurement mode is set to "3LN/LLy".

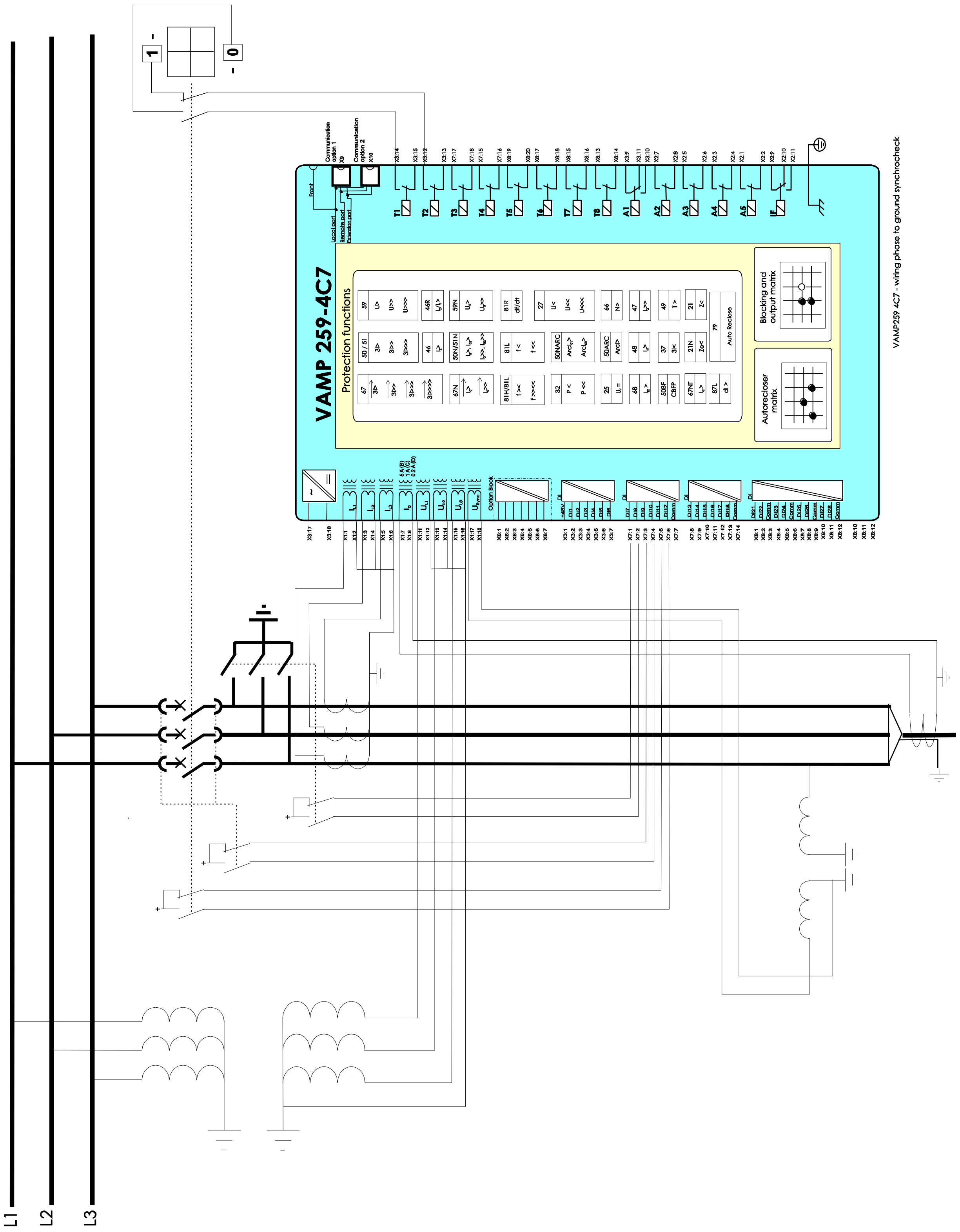


Figure 8.9-3 Connection example of VAMP 259-4C7 with a synchrocheck function from phase to ground voltage. The voltage measurement mode is set to "3LN/LNy".

9. Technical data

9.1. Connections

9.1.1. Measuring circuitry

Rated phase current - Current measuring range - Thermal withstand - Burden	5 A (configurable for CT secondaries 1 – 10 A) 0…250 A 20 A (continuously) 100 A (for 10 s) 500 A (for 1 s) < 0.2 VA
I_0 input option B **(see Order information)** Rated residual current (optional) - Current measuring range - Thermal withstand - Burden	 5 A (configurable for CT secondaries 1 – 10 A) 0…50 A 20 A (continuously) 100 A (for 10 s) 500 A (for 1 s) < 0.2 VA
I_0 input option C **(see Order information)** Rated residual current - Current measuring range - Thermal withstand - Burden	 1 A (configurable for CT secondaries 0.1 – 10.0 A) 0…10 A 4 A (continuously) 20 A (for 10 s) 100 A (for 1 s) < 0.1 VA
I_0 input option D **(see Order information)** Rated residual current (optional) - Current measuring range - Thermal withstand - Burden	 0.2 A (configurable for CT secondaries 0.1 – 10.0 A) 0…2 A 0.8 A (continuously) 4 A (for 10 s) 20 A (for 1 s) < 0.1 VA
Rated voltage U_n - Voltage measuring range - Continuous voltage withstand - Burden	100 V (configurable for VT secondaries 50 – 120 V) 0 – 160 V (100 V/110 V) 250 V < 0.5V A
Rated frequency f_n	45 – 65 Hz
Terminal block: - Solid or stranded wire	Maximum wire dimension: 4 mm² (10-12 AWG)

9.1.2. Auxiliary voltage

	Type A	Type B
Voltage range U_{aux}	40 - 265 V ac/dc	18...36 Vdc Note! Polarity. X3:17= positive (+) X3:18= negative (-)
Start-up peak (DC) 110V 220V	 15A with time constant of 1ms 25A with time constant of 1ms	
Power consumption Max. permitted interruption time	< 7 W (normal conditions) < 15 W (output relays activated) >50 ms (110 V dc)	
Terminal block: - Phoenix MVSTBW or equivalent	Maximum wire dimension: 2.5 mm² (13-14 AWG)	

9.1.3. Digital inputs

Internal operating voltage

Number of inputs	6
Internal operating voltage	48 V dc
Current drain when active (max.)	approx. 20 mA
Current drain, average value	< 1 mA
Terminal block: - Phoenix MVSTBW or equivalent	Maximum wire dimension: 2.5 mm² (13-14 AWG)

External operating voltage

Number of inputs	12/24/16 (depends on the ordering code)
external operating voltage	18 V…265 V dc
Current drain	approx. 2 mA
Terminal block: - Phoenix MVSTBW or equivalent	Maximum wire dimension: 2.5 mm² (13-14 AWG)

9.1.4. Trip contacts

Number of contacts	4/8/14 (depends on the ordering code)
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: at 110 V dc: at 220 V dc	 5 A 3 A 1 A
Contact material	AgNi 90/10
Terminal block: - Phoenix MVSTBW or equivalent	Maximum wire dimension: 2.5 mm² (13-14 AWG)

9.1.5. Alarm contacts

Number of contacts:	3 change-over contacts (relays A1, A2 and A3) 2 making contacts (relays A4 and A5) 1 change-over contact (IF relay)	
Rated voltage	250 V ac/dc	
Max. make current, 4s at duty cycle 10%	15 A	
Continuous carry	5 A	
Breaking capacity, AC	2 000 VA	
Breaking capacity, DC (L/R=40ms) at 48 V dc: at 110 V dc: at 220 V dc	 1,3 A 0,4 A 0,2 A	
Contact material	AgNi 0.15 gold plated	AgNi 90 / 10
Terminal block - Phoenix MVSTBW or equivalent	Maximum wire dimension 2.5 mm² (13-14 AWG)	

9.1.6. Local serial communication port

Number of ports	1 on front and 1 on rear panel
Electrical connection	RS 232 in the front RS 2320 with VCM-TTL (standard) RS-485 with VCM 485-2 or VCM 485-4 Plastic fibre with VCM-fibre (option) Glass fibre with VCM-fibre (option)
Data transfer rate	2 400 – 38 400 kb/s

9.1.7. Remote control connection

Number of ports	1 on rear panel
Electrical connection	TTL with VCM TTL (standard) RS 485 with VCM 485 – 4 (option) RS 232 with VCM TTL (standard) Plastic fibre connection with VCM fiber (option) Glass fibre connection with VCM fiber (option)
Data transfer rate	1 200 – 19 200 kb/s
Protocols	ModBus, RTU master ModBus' RTU slave SpaBus, slave IEC 60870-5-103 IEC 61870-5-101 ProfiBus DP (option, with external module) DNP 3.0

9.1.8. Ethernet connection

Number of ports	1
Electrical connection	Ethernet RJ-45 (Ethernet 10-Base-T)
Protocols	VAMPSET Modbus TCP IEC 61850
Data transfer rate	10 Mb/s

9.1.9. Arc protection interface (option)

Number of arc sensor inputs Sensor type to be connected Operating voltage level Current drain, when active Current drain range	2 VA 1 DA 12 V dc > 11.9 mA 1.3…31 mA (**NOTE!** If the drain is outside the range, either sensor or the wiring is defected)
Number of binary inputs Operating voltage level	1 (optically isolated) +48 V dc
Number of binary outputs Operating voltage level	1 (transistor controlled) +48 V dc

NOTE! Maximally three arc binary inputs can be connected to one arc binary output without an external amplifier.

9.2. Tests and environmental conditions

9.2.1. Disturbance tests

Emission (EN 50081-1) - Conducted (EN 55022B) - Emitted (CISPR 11)	 0.15 - 30 MHz 30 - 1 000 MHz
Immunity (EN 50082-2) - Static discharge (ESD) - Fast transients (EFT) - Surge - Conducted HF field - Emitted HF field - GSM test	 EN 61000-4-2, class III 6 kV contact discharge 8 kV air discharge EN 61000-4-4, class III 2 kV, 5/50 ns, 5 kHz, +/- EN 61000-4-5, class III 2 kV, 1.2/50 µs, common mode 1 kV, 1.2/50 µs, differential mode EN 61000-4-6 0.15 - 80 MHz, 10 V/m EN 61000-4-3 80 - 1000 MHz, 10 V/m ENV 50204 900 MHz, 10 V/m, pulse modulated

9.2.2. Test voltages

Insulation test voltage (IEC 60255-5) Class III	2 kV, 50 Hz, 1 min
Surge voltage (IEC 60255-5) Class III	5 kV, 1.2/50 µs, 0.5 J

9.2.3. Mechanical tests

Vibration (IEC 60255-21-1) Class I	10...60 Hz, amplitude ±0.035 mm 60...150 Hz, acceleration 0.5g sweep rate 1 octave/min 20 periods in X-, Y- and Z axis direction
Shock (IEC 60255-21-1) Class I	half sine, acceleration 5 g, duration 11 ms 3 shocks in X-, Y- and Z axis direction

9.2.4. Environmental conditions

Operating temperature	-10 to +55 °C
Transport and storage temperature	-40 to +70 °C
Relative humidity	< 75% (1 year, average value) < 90% (30 days per year, no condensation permitted)

9.2.5. Casing

Degree of protection (IEC 60529)	IP20
Dimensions (W x H x D)	208 x 155 x 225 mm
Material	1 mm steel plate
Weight	4.2 kg
Colour code	RAL 7032 (Casing) / RAL 7035 (Back plate)

9.2.6. Package

Dimensions (W x H x D)	215 x 160 x 275 mm
Weight (Terminal, Package and Manual)	5.2 kg

9.3. Protection stages

9.3.1. Non-directional current protection

Overcurrent stage I> (50/51)

Pick-up current	0.10 – 5.00 x In
Definite time function: - Operating time	DT 0.08**) – 300.00 s (step 0.02 s)
IDMT function: - Delay curve family - Curve type - Time multiplier k	 (DT), IEC, IEEE, RI Prg EI, VI, NI, LTI, MI…depends on the family *) 0.05 – 20.0, except 0.50 – 20.0 for RXIDG, IEEE and IEEE2
Start time Reset time Retardation time Reset ratio	Typically 60 ms <95 ms <50 ms 0.97
Transient over-reach, any τ	<10 %
Inaccuracy: - Starting - Operating time at definite time function - Operating time at IDMT function	 ±3% of the set value or 5 mA secondary ±1% or ±30 ms ±5% or at least ±30 ms **)

*) 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.

Overcurrent stages I>> and I>>> (50/51)

Pick-up current	0.10 – 20.00 x In (I>>) 0.10 – 40.00 x In (I>>>)
Definite time function: - Operating time - I>> - I>>>	 DT 0.04**) – 1800.00 s (step 0.01 s) 0.04**) – 300.00 s (step 0.01 s)
Start time Reset time Retardation time Reset ratio	Typically 60 ms <95 ms <50 ms 0.97
Transient over-reach, any τ	<10 %
Inaccuracy: - Starting - Operation time	 ±3% of the set value or 5 mA secondary ±1% or ±25 ms

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

Thermal overload stage T> (49)

Overload factor:	0.1 – 2.40 x In (step 0.01)
Alarm setting range:	60 – 99 % (step 1%)
Time constant Tau:	2 – 180 min (step 1)
Cooling time coefficient:	1.0 – 10.0 xTau (step 0.1)
Max. overload at +40 °C	70 – 120 %I_n(step 1)
Max. overload at +70 °C	50 – 100 %I_n(step 1)
Ambient temperature	-55 – 125 °C (step 1°)
Resetting ratio (Start & trip)	0.95
Accuracy:	
- operating time	±5% or ±1 s

NOTE! Stage is blocked when motor has been running for 2 seconds.

Secondary current has to be > 1A in all phases.

Undercurrent protection stage I< (37)

Current setting range:	20 – 70 %In (step 1%)
Definite time characteristic:	
- operating time	0.3 – 300.0s s (step 0.1)
Block limit:	15 % (fixed)
Starting time	Typically 200 ms
Resetting time	<450 ms
Resetting ratio	1.05
Accuracy:	
- starting	±2% of set value or ±0.5% of the rated value
- operating time	±1% or ±150 ms

NOTE! Stage Blocking is functional when all phase currents are below the block limit.

Current unbalance stage $I_2>$ (46)

Settings: - Setting range $I_2/ I_1>$	 2 – 70 %
Definite time function: - Operating time	 1.0 – 600.0 s (step 0.1 s)
Start time Reset time Reset ratio	Typically 200 ms <450 ms 0.95
Inaccuracy: - Starting - Operate time	 ±1%-unit ±5% or ±200 ms

Earth fault stage $I_0>$ (50N/51N)

Input signal	I_0 (input X1-7 & 8) I_{0Calc} (= $I_{L1}+I_{L2}+I_{L3}$)
Setting range $I_0>$	0.005 … 8.00 When I_0 0.05 … 20.0 When I_{0Calc}
Definite time function: - Operating time	DT 0.08**) – 300.00 s (step 0.02 s)
IDMT function: - Delay curve family - Curve type - Time multiplier k	 (DT), IEC, IEEE, RI Prg EI, VI, NI, LTI, MI…depends on the family *) 0.05 - 20.0, except 0.50 – 20.0 for RXIDG, IEEE and IEEE2
Start time Reset time Reset ratio	Typically 60 ms <95 ms 0.95
Inaccuracy: - Starting - Starting (Peak mode) - Operating time at definite time function - Operating time at IDMT function.	 ±2% of the set value or ±0.3% of the rated value ±5% of the set value or ±2% of the rated value (Sine wave <65 Hz) ±1% or ±30 ms ±5% or at least ±30 ms **)

*) 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.

Earth fault stages $I_0>>$, $I_0>>>$, $I_0>>>>$ (50N/51N)

Input signal	I_0 (input X1-7 & 8) I_{0Calc} (= $I_{L1}+I_{L2}+I_{L3}$)
Setting range $I_0>>$	0.01 … 8.00 When I_0 0.05 … 20.0 When I_{0Calc}
Definite time function: - Operating time	 0.08**) – 300.00 s (step 0.02 s)
Start time Reset time Reset ratio	Typically 60 ms <95 ms 0.95
Inaccuracy: - Starting - Starting (Peak mode) - Operate time	 ±2% of the set value or ±0.3% of the rated value ±5% of the set value or ±2% of the rated value (Sine wave <65 Hz) ±1% or ±30 ms

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

Short circuit distance stages Z1-Z5 (21)

Pick-up setting range X	0.05 – 250 Ω
Pick-up setting range R	0.05 – 250 Ω
Definite time function:	
- Setting range Reset time Retardation time Reset ratio	0.05*) – 300.00 s (step 0.01 s) <65 ms <50 ms 1.05
Inaccuracy: - Starting (when U > 1V and I > 0.5 A + UxI > 10 VA) - Operating time at definite time function	 Typically ±5% of X (R if R > X) or 10 mΩ 1% or ±25 ms

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

Earth-fault distance stages Z1e-Z5e (21N)

Pick-up setting range X	0.05 – 250 Ω
Pick-up setting range R	0.05 – 250 Ω
Definite time function: - Setting range	 0.05*) – 300.00 s (step 0.01 s)
Start Io current setting range Start Io current input Reset time Retardation time Reset ratio	0.01 - 8.00 x I_{0n} 0.05 … 20.0 When I_{0Calc} I_0 (input X1-7 & 8) I_{0Calc} (= $I_{L1}+I_{L2}+I_{L3}$) <65 ms <50 ms 1.05
Inaccuracy: - Starting (when U > 1V and I > 0.5 A + UxI > 10 VA) - Operating time at definite time function	 Typically ±5% of X (R if R > X) or 10 mΩ 1% or ±25 ms

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

Distance common settings (21 and 21N)

Line angle	60 – 90°
Load block: Pick-up setting range R Load angle	 0.05 – 250 Ω 10 - 40°
Earth factor: Setting range Earth factor angle	 0.00 – 10.00 -60 - 60°
Power swing: dZ	 1.0 – 50.00
Inaccuracy: Starting	 ±0.2 Ω of set value (when setting is 1.0 -5.0)

NOTE! All distance zones are using angle memory when voltage of all phase is dropped below 0.5 V. Angle memory is active for maximym of 500 ms. So if the tripping time of zones is more than 0.5 s, there won't be trip. Direction checkin of angle memory function is based on U1.

9.3.2. Directional current protection

Directional overcurrent stages I_{dir}> and I_{dir}>> (67)

Pick-up current	0.10 - 4.00 x I_n
Mode	Directional/non-directional
Minimum voltage for the direction solving	0.1 $V_{Secondary}$
Base angle setting range	-180° to + 179°
Operation angle	±88°
Definite time function: - Operating time	DT 0.06**) – 300.00 s (step 0.02 s)
IDMT function: - Delay curve family - Curve type - Time multiplier k	 (DT), IEC, IEEE, RI Prg EI, VI, NI, LTI, MI…depends on the family *) 0.05 - 20.0, except 0.50 – 20.0 for RXIDG, IEEE and IEEE2
Start time Reset time Retardation time Reset ratio Reset ratio (angle)	Typically 60 ms <95 ms <50 ms 0.95 2°
Transient over-reach, any τ	<10 %
Inaccuracy: - Starting (rated value IN= 1 – 5A) - Angle - Operate time at definite time function - Operate time at IDMT function	 ±3% of the set value or ±0.5% of the rated value ±2° U>5 V ±30° U=0.1 – 5.0 V ±1% or ±30 ms ±5% or at least ±30 ms **)

*) 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.

Directional overcurrent stages I_{dir}>>> and I_{dir}>>>> (67)

Pick-up current	0.10 – 20.0 x I_n
Mode	Directional/non-directional
Minimum voltage for the direction solving	0.1 V
Base angle setting range	-180° to + 179°
Operation angle	±88°
Definite time function: - Operating time	DT 0.06**) – 300.00 s (step 0.02 s)
Start time Reset time Retardation time Reset ratio Reset ratio (angle)	Typically 60 ms <95 ms <50 ms 0.95 2°
Transient over-reach, any τ	<10 %
Inaccuracy: - Starting (rated value IN= 1 .. 5A) - Angle - Operate time at definite time function	 ±3% of the set value or ±0.5% of the rated value ±2° U>5 V ±30° U>0.1 – 5.0 V ±1% or ±30 ms

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

Directional earth fault stages $I_0\varphi$>, $I_0\varphi$>> (67N)

Pick-up current	0.005 - 8.00 x I_{0n} 0.05 … 20.0 When I_{0Calc}
Start voltage	1 – 50 %U_{0n}
Input signal	I_0 (input X1-7 & 8) I_{0Calc} (= I_{L1}+I_{L2}+I_{L3})
Mode	Non-directional/Sector/ResCap
Base angle setting range	-180° to + 179°
Operation angle	±88° (10° - 170°)
Definite time function: - Operating time	 0.10**) – 300.00 s (step 0.02 s)
IDMT function: - Delay curve family - Curve type - Time multiplier k	 (DT), IEC, IEEE, RI Prg EI, VI, NI, LTI, MI…depends on the family *) 0.05 – 20.0, except 0.50 – 20.0 for RXIDG, IEEE and IEEE2
Start time Reset time Reset ratio Reset ratio (angle)	Typically 60 ms <95 ms 0.95 2°
Inaccuracy: - Starting Uo&Io (rated value In= 1 .. 5A) - Starting Uo&Io (Peak Mode when, rated value Io_n= 1 .. 10A) - Starting U_0&I_0 (I_{0Calc}) - Angle - Operate time at definite time function - Operate time at IDMT function	 ±3% of the set value or ±0.3% of the rated value ±5% of the set value or ±2% of the rated value (Sine wave <65 Hz) ±3% of the set value or ±0.5% of the rated value ±2° (when U> 1V and I_0 > 5% of I_{0N} else ±20° ±1% or ±30 ms ±5% or at least ±30 ms **)

*) 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.

9.3.3. Voltage protection

Overvoltage stages U>, U>> and U>>> (59)

Overvoltage setting range: Definite time characteristic: - operating time Starting time Resetting time U> Resetting time U>>, U>>> Retardation time Reset ratio Inaccuracy: - starting - operate time	50 - 150 %U_n for U>, U>> **) 50 - 160 % U_n for U>>> **) 0.08*) - 300.00 s (step 0.02) (U>, U>>) 0.06*) - 300.00 s (step 0.02) (U>>>) Typically 60 ms 0.06 - 300.00 s (step 0.02) <95 ms <50 ms 0.99 – 0.800 (0.1 – 20.0 %, step 0.1 %) ±3% of the set value **) ±1% or ±30 ms

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

**) The measurement range is up to 160 V. This limits the maximum usable setting when rated VT secondary is more than 100 V.

Undervoltage stages U<, U<< and U<<< (27)

Setting range	20 – 120%xU_n
Definite time function: - Operating time U< - Operating time U<< and U<<<	 0.08 *) – 300.00 s (step 0.02 s) 0.06 *) – 300.00 s (step 0.02 s)
Undervoltage blocking	0 – 80% x U_n
Start time	Typically 60 ms
Reset time for U< Reset time for U<< and U<<< Retardation time Reset ratio (hysteresis) Reset ratio (Block limit)	0.06 – 300.00 s (step 0.02 s) <95 ms <50 ms 1.001 – 1.200 (0.1 – 20.0 %, step 0.1 %) 0.5 V or 1.03 (3 %)
Inaccuracy: - starting - blocking - time	 ±3% of set value ±3% of set value or ±0.5 V ±1% or ±30 ms

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

Zero sequence voltage stages U_0> and U_0>> (59N)

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

9.3.4. Frequency protection

Overfrequency and underfrequency protection stages f>< and 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
Low voltage blocking	10 – 100 %Un *)
Definite time function:	
-operating time	0.10**) – 300.0 s (step 0.02 s)
Starting time	<100 ms
Reset time	<120 ms
Reset ratio (f> and f>>)	0.998
Reset ratio (f< and f<<)	1.002
Reset ratio (LV block)	Instant (no hysteresis)
Inaccuracy:	
- starting	±20 mHz
- starting (LV block)	3% of the set value or ±0.5 V
- operating time	±1% or ±30 ms

*) Suitable frequency area for low voltage blocking is 45 - 65 Hz. Low voltage blocking is checking the maximum of line to line voltages.

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

NOTE! f< 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 visit above the set limit.

Underfrequency stages f< and f<<

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 %Un *)
Definite time function:	
-operating time	0.10**) - 300.0 s (step 0.02 s)
Undervoltage blocking	2 – 100 %
Starting time	<100 ms
Reset time	<120 ms
Reset ratio	1.002
Reset ratio (LV block)	Instant (no hysteresis)
Inaccuracy:	
- starting	±20 mHz
- starting (LV block)	3% of the set value or ±0.5 V
- operating time	±1% or ±30 ms

*) Suitable frequency area for low voltage blocking is 45 - 65 Hz. Low voltage blocking is checking the maximum of line to line voltages.

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

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)
Starting time	Typically 140 ms
Reset time	t>
Inaccuracy:	
- starting	10% of set value or ±0.1 Hz/s
- operating time(overshoot ≥ 0.2 Hz/s)	±35 ms, when area is 0.2 – 1.0 Hz/s

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

NOTE! ROCOF stage is using same low voltage blocking with frequency stages.

9.3.5. Power protection

Reverse power and under-power stages P<, P<< (32)

Pick-up setting range	–200.0 ... +200.0 %Pm
Definite time function: - Operating time	 0.3 – 300.0 s
Start time Reset time Reset ratio	Typically 200 ms <500 ms 1.05
Inaccuracy: - Starting - Operating time at definite time function	 ±3 % of set value or ±0.5 % of rated value ±1 % or ±150 ms

NOTE! When pick-up setting is +1 … +200% an internal block will be activated if max. voltage of all phases drops below 5% of rated.

9.3.6. Synchrocheck function

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 deg
Request timeout	0.1 – 600.0 s
Stage operation range	46.0 - 64.0 Hz
Reset ratio (U)	0.97
Inaccuracy:	
- voltage	±3 % U_n
- frequency	±20 mHz
- phase angle	±2° when Δf < 0.2 Hz, else ±5°
- operating time	±1% or ±30 ms

NOTE! When “sync” mode is used, Δf should be less < 0.2 Hz.

9.3.7. Second harmonic function

2. Harmonic stage (51F2)

Settings: - Setting range 2.Harmonic - Operating time	 10 – 100 % 0.05 – 300.00 s (step 0.01 s)
Inaccuracy: - Starting	 ±1%- unit

NOTE! The amplitude of second harmonic content has to be at least 2% of the nominal of CT. If the moninal current is 5 A, the 100 Hz component needs to exceed 100 mA.

9.3.8. Circuit-breaker failure protection

Circuit-breaker failure protection CBFP (50BF)

Relay to be supervised	T1-T14 (depending the ordering code)
Definite time function - Operating time	 0.1** – 10.0 s (step 0.1 s)
Reset time	<95 ms
Inaccuracy - Operating time	 ±20 ms

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

9.3.9. Arc fault protection stages (option)

The operation of the arc protection depends on the setting value of the ArcI>, $ArcI_0$> and $ArcI_{02}$> current limits. The arc current limits cannot be set, unless the device is provided with the optional arc protection card.

Arc protection stage ArcI> (50ARC), option

Setting range	0.5 - 10.0 x I_n
Arc sensor connection	S1, S2, S1/S2, BI, S1/BI, S2/BI, S1/S2/BI
- Operating time (Light only)	13 ms
- Operating time (4xIset + light)	17ms
- Operating time (BIN)	10 ms
- Operating time (Delayed Arc L>)	0.01 – 0.15 s
- BO operating time	<3 ms
Reset time	<95 ms
Reset time (Delayed ARC L)	<120 ms
Reset time (BO)	<85 ms
Reset ratio	0.90
Inaccuracy:	
- Starting	10% of the set value
- Operating time	±5 ms
- Delayed ARC light	±10 ms

Arc protection stage $ArcI_0$> (50NARC), option

Setting range	0.5 - 10.0 x I_n
Arc sensor connection	S1, S2, S1/S2, BI, S1/BI, S2/BI, S1/S2/BI
- Operating time (Light only)	13 ms
- Operating time (4xIset + light)	17ms
- Operating time (BIN)	10 ms
- Operating time (Delayed Arc L>)	0.01 – 0.15 s
- BO operating time	<3 ms
Reset time	<95 ms
Reset time (Delayed ARC L)	<120 ms
Reset time (BO)	<85 ms
Reset ratio	0.90
Inaccuracy:	
- Starting	10% of the set value
- Operating time	±5 ms
- Delayed ARC light	±10 ms

9.4. Supporting functions

9.4.1. Inrush current detection (68)

Settings: - Setting range 2.Harmonic - Operating time	 10 – 100 % 0.05** – 300.00 s (step 0.01 s)

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

9.4.2. Disturbance recorder (DR)

The operation of disturbance recorder depends on the following settings. The recording time and the number of records depend on the time setting and the number of selected channels.

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
	(must be shorter than MAX time)
Pre-trigger rate	0 – 100%
Number of selected channels	0 – 12

9.4.3. Transformer supervision

Current transformer supervision

Pick-up current	0.00 – 10.00 x In
Definite time function: - Operating time	DT 0.06 – 600.00 s (step 0.02 s)
Reset time Reset ratio Imax> Reset ratio Imin<	<60 ms 0.97 1.03
Inaccuracy: - Activation - Operating time at definite time function	 ±3% of the set value ±1% or ±30 ms

Voltage transformer supervision

Pick-up setting U2>	0.0 – 200.0 %
Pick-up setting I2<	0.0 – 200.0 %
Definite time function: - Operating time	DT 0.06 – 600.00 s (step 0.02 s)
Reset time Reset ratio	<60 ms 3% of the pick-up value
Inaccuracy: - Activation U2> - Activation I2< - Operating time at definite time function	 ±1%-unit ±1%-unit ±1% or ±30 ms

9.4.4. Voltage sag & swell

Voltage sag limit	10 – 120 %
Voltage swell limit	20 – 150 %
Definite time function: - Operating time	DT 0.08 – 1.00 s (step 0.02 s)
Low voltage blocking Reset time Reset ration: - Sag - Swell Block limit	0 – 50 % <60 ms 1.03 0.97 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.

9.4.5. Voltage interruptions

Voltage low limit (U1)	10 – 120 %
Definite time function: - Operating time	DT <60 ms (Fixed)
Reset time Reset ratio:	<60 ms 1.03
Inaccuracy: - Activation	 3% of the set value

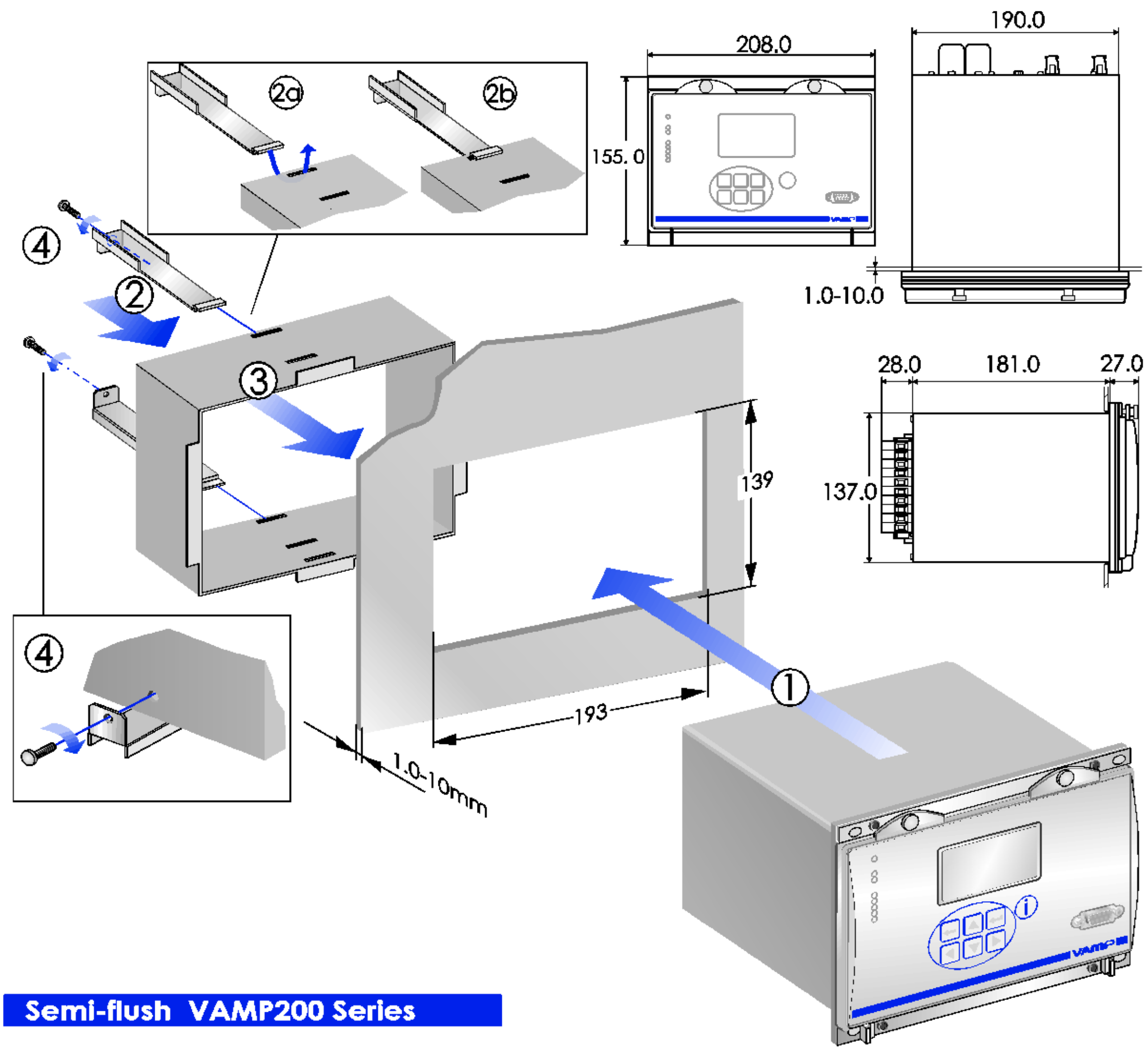
10. Abbreviations and symbols

ANSI	American National Standards Institute. A standardization organisation.
CB	Circuit breaker
CBFP	Circuit breaker failure protection
$\cos\varphi$	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
DSR	Data set ready. An RS232 signal. Input in front panel port of VAMP devices 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 devices.
FFT	Fast Fourier transform. Algorithm to convert time domain signals to frequency domain or to phasors.
Hysteresis	I.e. dead band. Used to avoid oscillation when comparing two near by values.
I_{set}	Another name for pick up setting value I>
I_{0set}	Another name for pick up setting value I_0>
I_{01n}	Nominal current of the I_{01} input of the device
I_{0n}	Nominal current of I_0 input in general
In	Nominal current. Rating of CT primary or secondary.
IEC	International Electrotechnical Commission. An international standardization organisation.
IEEE	Institute of Electrical and Electronics Engineers
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
LAN	Local area network. Ethernet based network for computers and devices.
Latching	Output relays and indication LEDs can be latched, which means that they are not released when the control signal is releasing. Releasing of lathed devices is done with a separate action.
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 = 1xIN.
Q	Reactive power. Unit = [var] acc. IEC
RMS	Root mean square
S	Apparent power. Unit = [VA]
SNTP	Simple Network Time Protocol for LAN and WWW
TCS	Trip circuit supervision
THD	Total harmonic distortion
I_{L1}	Current input for I_{L1}
I_{L2}	Current input for I_{L2}
I_{L3}	Current input for I_{L3}
U_{L1}	Voltage input for U_{L1}
U_{L2}	Voltage input for U_{L2}
U_{L3}	Voltage input for U_{L3}
U_{Sync}	Voltage input for synchronizing voltage. Depending on the voltage input mode can be phase to ground or phase to phase voltage
U_{L12}	Calculated phase to phase voltage U_{L12}
U_{L23}	Calculated phase to phase voltage U_{L23}
U_{L31}	Calculated phase to phase voltage U_{L31}
VT	Voltage transformer i.e. potential transformer PT
VT_{pri}	Nominal primary value of voltage transformer
VT_{sec}	Nominal secondary value of voltage transformer
WWW	World wide web ≈ internet

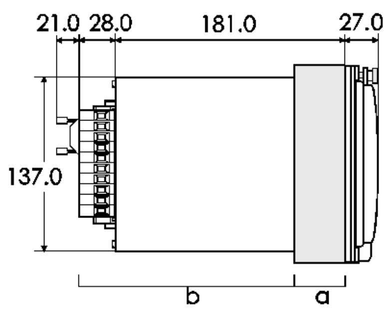
11. Constructions

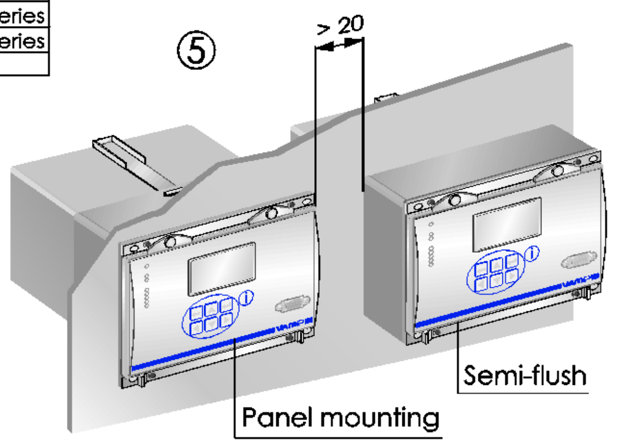
Panel mounting VAMP200 Series



Semi-flush VAMP200 Series

	a mm	b mm	Fixing bracket
VYX076	40	169	Standard for 200 series
VYX077	60	149	Standard for 200 series
VYX233	100	109	2 x VYX199





12. Order information

When ordering, please state:

- Type designation: VAMP 259
- Quantity:
- Options (see respective ordering code):

VAMP LINE MANAGER ORDER CODES

VAMP 259 - 4 □□□□□

DI7-18 nominal activation voltage
4 = Standard (24 Vdc)

Nominal earth-fault current Io1 [A]
B = 5A
C = 1A
D = 0.2A

Additional I/O (X8 terminal)
6 = None
7 = 8 standard inputs, 4 TCS Hybrid inputs/outputs
8 = 10 outputs
9 = 8 standard inputs and 4 outputs

Supply voltage [V]
A = 40.. 265Vac/dc
B = 18.. 36Vdc
C = 40.. 265Vac/dc + ARC Protection
D = 18.. 36Vdc + ARC Protection
E = 40.. 265Vac/dc + DI19, DI20 Optional
F = 18.. 36Vdc + DI19, DI20 Optional

Optional hardware (communication port 1)
A = TTL/RS-232 (VCM TTL)
B = Plastic/Plastic serial fibre interface (VCM FIBRE PP)
C = N/A
D = RS 485 interface (4-wire, VCM 485-4)
E = Glass/Glass serial fibre interface (VCM FIBRE GG)
F = Rx Plastic/Tx Glass serial fibre interface (VCM FIBRE PG)
G = Rx Glass/Tx Plastic serial fibre interface (VCM FIBRE GP)
I = RS 232 with RJ-45 connector (VCM 232)
M = ST 100Mbps ethernet fibre interface with IEC 61850
N = RTD interface (Glass fibre, VCM RTD)

Optional hardware (communication port 2)
A = None
C = RS 232 with RJ-45 connector (VCM 232)
D = RS-485 interface (2-wire, VCM 485-2)
L = RJ-45 10Mbps ethernet interface(1
M = RJ-45 10Mbps ethernet interface with IEC 61850(1
N = RTD interface (Glass fibre, VCM RTD)

Note:
(1 NOT possible to order in combination with the following optional communication module 1: (M) ST 100Mbps ethernet fibre interface with IEC 61850
(1 NOT yet selectable

Accessories :

Order Code	Explanation	Note
VEA3CGi	External ethernet interface module	
VPA3CG	Profibus interface module	
VSE001	Fiber optic Interface Module	
VSE002	RS485 Interface Module	
VX003-3	RS232 programming cable (Vampset, VEA 3CGi)	Cable length 3m
VX004-M3	TTL/RS232 converter cable (PLC, VEA 3CGi)	Cable length 3m
VX007-F3	TTL/RS232 converter cable (VPA 3CG)	Cable length 3m
VX048	RS232 (COM1=A) converter cable for MOXA TCF-90 (remote port)	Cable length 3m
VX055	RJ45 (COM1=I or COM2=C) converter cable for MOXA TCF-90	Cable length 3m
VX056	RJ45 (COM1=I or COM2=C) converter cable for MOXA TCF-142-S-ST	Cable length 3m
3P0142	MOXA TCF-90	
3P022	MOXA TCF-142-S-ST	
VA 1 DA-6	Arc Sensor	Cable length 6m
VYX076	Raising Frame for 200-serie	Height 40mm
VYX077	Raising Frame for 200-serie	Height 60mm

Available option-cards possible to be ordered separately:

Order Code	Explanation	Note
VCM TCP	RJ45 10Mbps ethernet interface	Not inbuilt
VCM 485-4	RS 485 interface (4 wire)	
VCM 485-2	RS 485 interface (2 wire)	
VCM FIBRE PP	Serial fibre interface (Plastic/Plastic)	
VCM FIBRE GG	Serial fibre interface (Glass/Glass)	
VCM FIBRE PG	Serial fibre interface (Plastic/Glass)	
VCM FIBRE GP	Serial fibre interface (Glass/Plastic)	
VCM 232	RS 232 with RJ45 connector	
VCM RTD	RTD interface (Glass fibre)	
VCM TTL	TTL/RS-232 interface	

13. Revision history

Manual revision history

VM259.EN001	First version of VAMP 259 manual.
	From this version onwards, the manual also applies to VAMP 257.
VM259.EN002	Renamed Broken conductor protection to Broken line protection
	Intermittent transient earth fault protection function added
	Adjustments in technical data
VM259.EN003	The operation time for voltage interruptions changes to < 60 ms fixed.
	New text and pictures of Trip circuit supervision added.
	Earth-fault distance protection Ze< (21N)
	Added.
	VAMP 257 / 259 order codes are modified to support inbuilt Ethernet and IEC 61850.
	Line differential protection LdI > (87) added.
VM259.EN004	From this version onwards, the manual does not applied to VAMP 257 anymore.
VM259.EN005	Second harmonic O/C stage added.
	Distance protection application added.
VM259.EN006	Arc flash protection delayed light indication signal and technical data were amended.
	Description of running virtual comtrade files with VAMP relays added in chapter Disturbance recorder.
VM259.EN007	Double earth fault added.

Firmware revision history

5.46	Programmable inverse delay curves added.
5.56	Month max values added. Number of virtual outputs increased to 6. Number of logic outputs increased to 20. Auto-reclose updated (reclaim time setting and active signal for each shot).
5.68	DNP 3.0 protocol added. Extended self diagnostics. Inrush & cold load detection added (fast block operation). Running hour calculation added. Display backlight controlling with DI. Support for analog output modules added to External I/O protocol. Auto-reclose updated(blocking of shots)
5.75	Adjustable hysteresis for U>>, U>>>, U<<, U<<<. I_{02}> & I_{02}>> renamed as I_0>>> & I_0>>>>. Increased setting range for T> Voltage measurement mode description modified
6.6	IEC60870-5-101 (unbalanced) added. Auto detection added for External I/O (optional). VCM 61850 module detection added **NOTE!** Require VAMPSET (2.1.2) or newer version. Old files cannot be used with 6.x firmware.
6.12	IEC60870-5-101 (unbalanced) updated. Increased I_{0dir}> setting range
6.23	Nonvolatile fault logs. Updates for I/O cards.
6.28	Transient intermittent earth fault stage I_{0int}>.
6.43	RMS mode added to I>. Short sircuit distance improvements. Max op. time extended to 7200s for programmable delay curves.
10.9	New CPU card with optional inbuilt Ethernet interface and 61850 protocol, distance protection and line differential protection.
10.17	Digital input sync supports DCF-77 timecode. Support for SNTP version 4.
10.19	VIO12 RTD module support added.
10.26	VCM RTD option module support added. IEC 61850 updates including GOOSE added. UTF-8 support for local HMI panel (Russian) added.

10.38	IEC 61850 updates added. UTF-8 support for local HMI panel (Russian) added. RTD Inputs- Quick Setup support added EthernetIP added. DeviceNet improvements. Improvements added to DNP3.0,IEC 60870-5-101 protocols. DI AC mode added.
10.45	Power swing blocking and out of step tripping functions added. Line angle (degrees) setting added for the tripping zones.
10.46	NVRAM event buffer size is user parameter.
10.48	Support for HMS Profibus solution. IRIG-B003. Better code address checking.
10.49	Polarity added for relays. Read/write MAC address to/from EEPROM with new chip. IEC61850: DI counters are reported via deadband calculation.
10.51	SC fault distance added to IEC103 map
10.56	Uo setting grange of IoDir stages changed from 1...20% to 1...50%.
10.58	DbEF: final version. New features in IEC 61850 added. Outputs vef files with suomi & russian language packets.
10.68	Default font sizes changed. Io>> minimum delay setting changed to 0.05s with 0.01s step. Popup window added for language packet init. EF items: EFDX, EFDFph, EFctr and EFDFltDist added to IEC103.
10.69	Ethernet/IP and DeviceNet identity info changes.
10.74	Double earth fault blocking first version added. I> and I_0> - I_0>>>> -stages with faster operation time. Harmonic driver to 10ms priority. I0CALC driver to 10ms priority. Logic outputs to GOOSE.

14. Reference information

Documentation:

Mounting and Commissioning Instructions VMMC.EN0xx
VAMPSET User's Manual VMV.EN0xx

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