VAMP 265

Transformer, generator and motor differential protection relay

Operation and configuration instructions

Technical description

1. General

This first part (Operation and configuration) of the publication contains general descriptions of the functions, of the differential protection relay 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

VAMP 265 differential protection relay is ideal for transformer, motor, generator and short cable (100) differential protection. The relay features the following protection functions.

List of protection functions

IEEE/ ANSI code	IEC symbol	Function name
50/51	3I>, 3I>>, 3I'>, 3I'>>	Overcurrent protection
87	ΔI>, ΔI>>	Differential overcurrent protection
46	I_2>, I'_2>	Current unbalance protection
49	T>	Thermal overload protection
50N/51N	I_0>, I_0>>, I_0>>>, I_0>>>>	Earth fault protection
50BF	CBFP	Circuit-breaker failure protection
99	Prg1...8	Programmable stages
50ARC 50NARC	ArcI>, ArcI'> ArcI_{01}>, ArcI_{02}>	Optional arc fault protection

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, SPA bus and DNP 3.0, IEC 61850 and IEC 60870-5-101.

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. Relay front panel

The figure below shows, as an example, the front panel of the relay VAMP 265 and the location of the user interface elements used for local control.

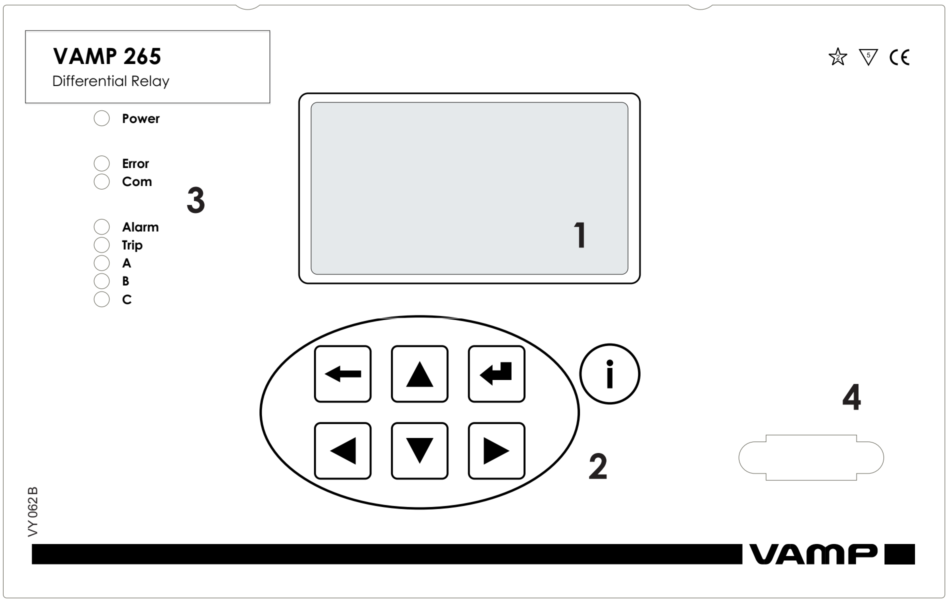


Figure 2.1-1. The front panel of VAMP 265

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).

sld

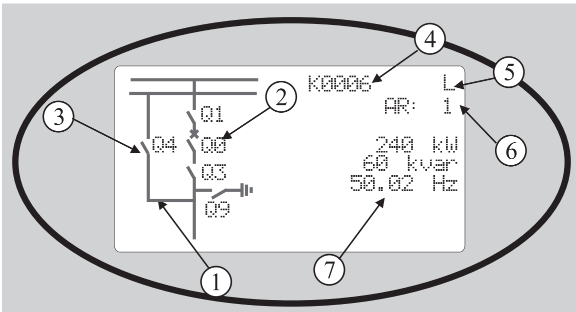


Figure 2.1.1-1 Sections of the LCD dot matrix display

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)

lcd2

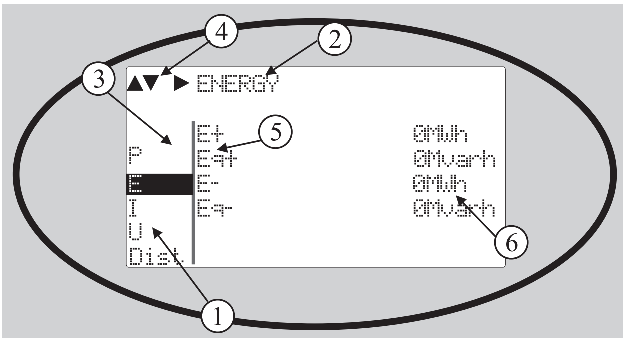


Figure 2.1.1-2 Sections of the LCD dot matrix display

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.

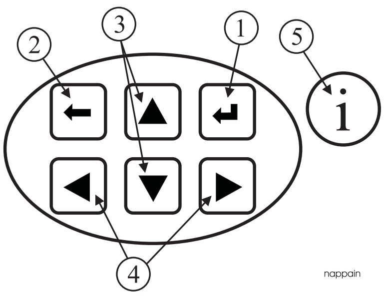


Figure 2.1.3-1 Keys on the keypad

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:

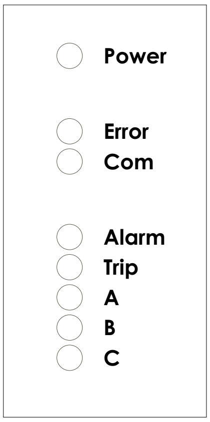


Figure 2.1.4-1. Operation indicators of the relay

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.
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 background color. The possible navigating directions in the menu are shown in the upper-left corner by means of black triangular symbols.

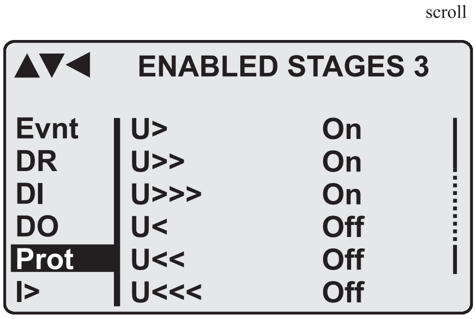


Figure 2.2.1-1. Example of scroll indication

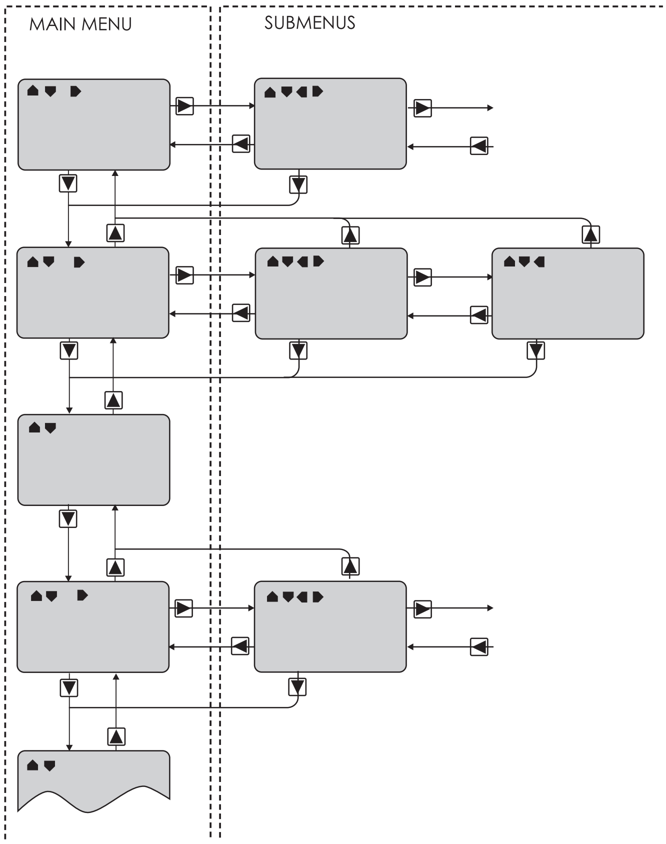


Figure 2.2.1-2. Principles of the menu structure and navigation in the menus

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		
ΔI>	7	1st differential stages		
ΔI>>	5	2nd differential stage		
I>	5	1st overcurrent stage (primary side)	50/51	4
I>>	3	2nd overcurrent stage (primary side)	50/51	4
I'>	5	1st overcurrent stage (secondary side)	50/51	4
I'>>	3	2nd overcurrent stage (secondary side)	50/51	4
I2>	3	Current unbalance stage (primary side)	46	4
I'2>	3	Current unbalance stage (secondary side)	46	4

Main menu	Number of menus	Description	ANSI code	Note
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
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
CBFP	3	Circuit breaker failure protection	50BF	4
CBWE	4	Circuit breaker wearing supervision		4
CTSV	1	CT supervisor		4
CT'SV	1	CT' 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
ArcIo2>	3	Optional arc protection stage for earth faults. Current input = I02	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

first menu

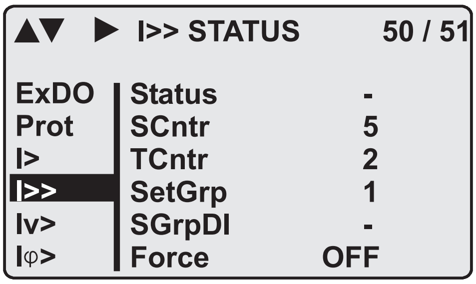


Figure 2.2.2-1 First menu of I>> 50/51 stage

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

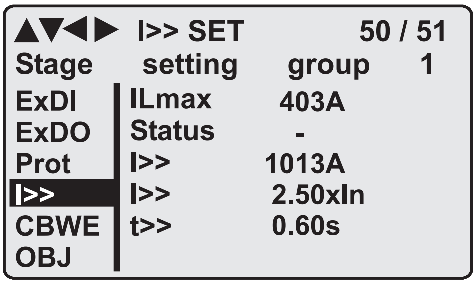


Figure 2.2.2-2. Second menu (next on the right) of I>> 50/51 stage

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 protected object. 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

third menu

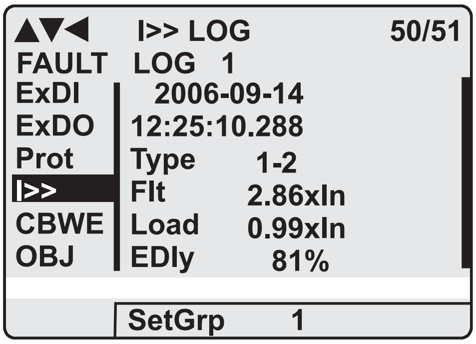


Figure 2.2.2-3. Third and last menu (next on the right) of I>> 50/51 stage

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

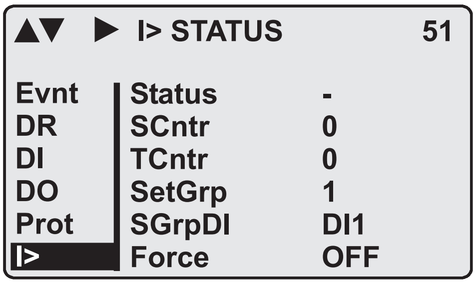


Figure 2.2.3-1. Example of protection submenu with setting group parameters

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

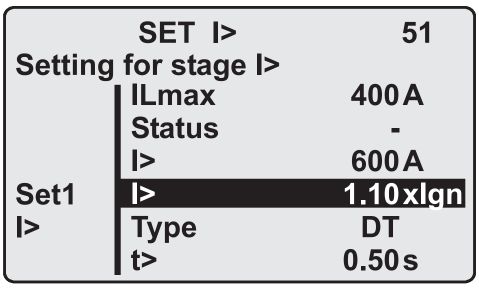


Figure 2.2.3-2. Example of I> setting submenu

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. Each function has its own logs (See Figure 2.2.4-1).

log1

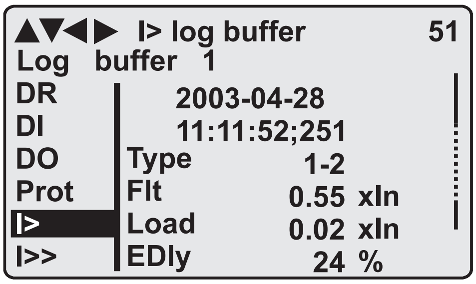


Figure 2.2.4-1. Example of fault log

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

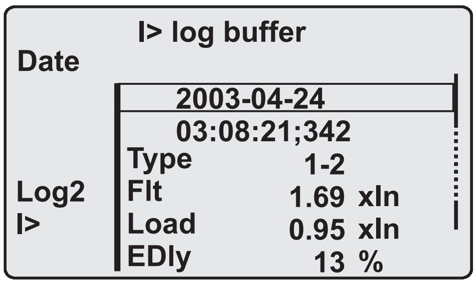


Figure 2.2.4-2. Example of selected fault log

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.

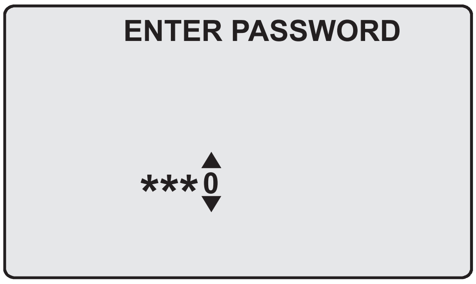


Figure 2.2.5-1. Opening the access level

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 19 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 main 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.

Value	Menu/Submenu	Description
f	P/POWER	Frequency [Hz]
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]
I'L1	I/PHASE CURRENTS	Phase current I'L1 [A]
I'L2	I/PHASE CURRENTS	Phase current I'L2 [A]
I'L3	I/PHASE CURRENTS	Phase current I'L3 [A]
I'L1da	I/PHASE CURRENTS	15 min average for I'L1 [A]
I'L2da	I/PHASE CURRENTS	15 min average for I'L2 [A]
I'L3da	I/PHASE CURRENTS	15 min average for I'L3 [A]
Io	I/SYMMETRIC CURRENTS	Primary value of zerosequence/ residual current Io [A]
Io2	I/SYMMETRIC CURRENTS	Primary value of zero-sequence/residual current Io2 [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) [%]
I'1	I/SYMMETRIC CURRENTS	Positive sequence current [A]
I'2	I/SYMMETRIC CURRENTS	Negative sequence current [A]
I'2/I'1	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 [%]
THDI'L1	I/HARM. DISTORTION	Total harmonic distortion of phase current I'L1 [%]

Value	Menu/Submenu	Description
THDI'L2	I/HARM. DISTORTION	Total harmonic distortion of phase current I'L2 [%]
THDI'L3	I/HARM. DISTORTION	Total harmonic distortion of phase current I'L3 [%]
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)
Diagram	I/HARMONICS of I'L1	Harmonics of phase current I'L1 [%] (see Figure 2.3.2-1)
Diagram	I/HARMONICS of I'L2	Harmonics of phase current I'L2 [%] (see Figure 2.3.2-1)
Diagram	I/HARMONICS of I'L3	Harmonics of phase current I'L3 [%] (see Figure 2.3.2-1)

harm

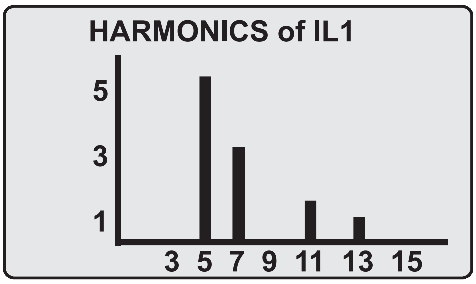


Figure 2.3.2-1. Example of harmonics bar display

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 24).
2. Select the Force function (the background color of the force text is black).

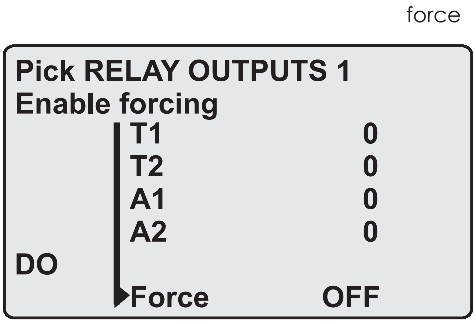


Figure 2.3.4-1. Selecting Force function

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 and a protected transformer rating. 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.

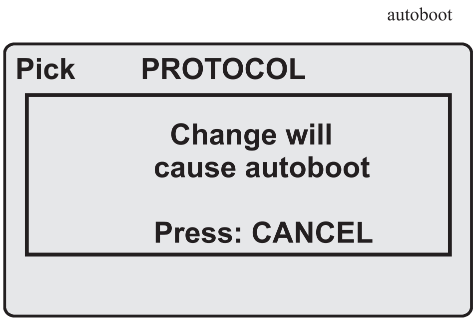


Figure 2.4-1 Example of auto-reset display

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.

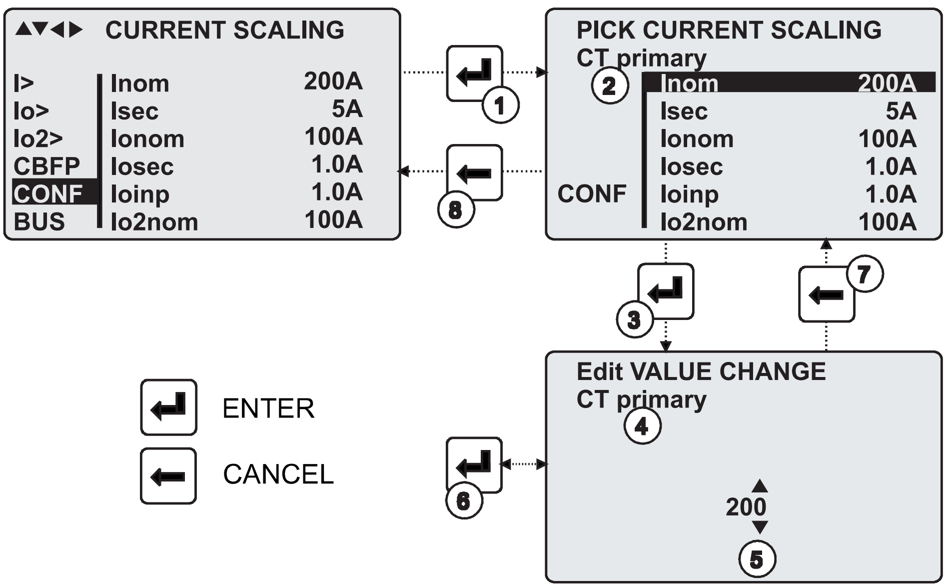


Figure 2.4.1-1.Changing parameters

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

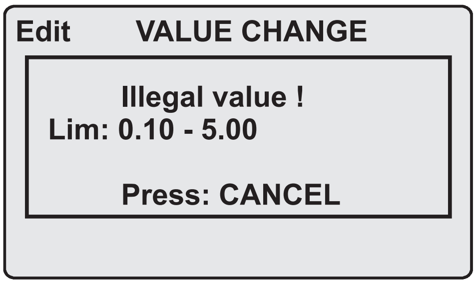


Figure 2.4.2-1 Example of a fault message

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

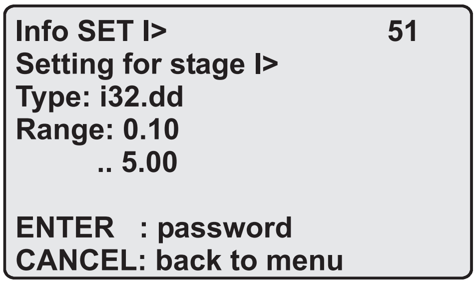


Figure 2.4.2-2. Allowed setting ranges show in the display

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
- IL, I'L
- I2/In, I2/I1, I2, I1, IoCalc, I2/In, I'2/I'1, I'2, I'1, I'oCalc
- f
- Io2, Io1
- IL3, IL2, IL1, I'L3, I'L2, I'L1
- IL1RMS, IL2RMS, IL3RMS
- ILmin, ILmax, I'Lmin, I'Lmax
- ΔIl1, ΔIl2, ΔIl3
- IL1w, IL2w, IL3w, I'L1w, I'L2w, I'L3w

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 1-6)
- 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 OUTPUTS1 and 2)
- The forcing of the output relays (RELAY OUTPUTS1 and 2) (only if Force = ON):
    - Forced control (0 or 1) of the Trip relays
    - Forced control (0 or 1) of the Alarm relays
    - Forced control (0 or 1) of the 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 between signals (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 phase CT' primary current (I'nom)
- Rated phase CT' secondary current (I'sec)
- Rated input of the relay [I'input]. 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 I01 input of the relay [Ioinp]. 5 A or 1 A. This is specified in the order code of the device.
- Rated value of I_{02} CT primary current (Io2nom)
- Rated value of I_{02} CT secondary current (Io2sec)
- Rated I02 input of the relay [Io2inp]. 5A, 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.

TRANSFORMER SETTING

- Rated voltage in IL side (typically high voltage side)
- Rated voltage in I'L side (typically low voltage side)
- Rated power of transformer
- Connection group of transformer
- Zero current compensation in IL side (If transformer is earthed in IL side, this must set as "ON")
- Zero current compensation in I'L side (If transformer is earthed in I'L side, this must set as "ON")
- Connection group of the unit transformer, if any. IEC marking with capital letters Y and D for HV side and small case letters y and d for LV side combined with the dial hour is used. For example Yd11 means a wye-delta transformer where the delta side phase-to-ground voltages are leading 30° the wye side phase-to-ground voltages.

DEVICE INFO

- Relay type (Type VAMP 265)
- 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. In addition there is a connector in the front panel overruling the local port in the rear panel.

REMOTE PORT X5

- 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 X4 (pins 2, 3 and 5)

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 X4 (pins 7, 8 and 5)

- 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.

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.

TCP/IP

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

- IP address [IpAddr].
- Net mask [NetMsk].
- Gateway [Gatew].
- Name server [NameSw].
- Network time protocol (NTP) server [NTPSvr].
- Protocol port for IP [Port]. Default is 502.

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 a few application examples and contains technical data.

Mounting and commissioning instructions are given in a separate mounting and commissioning manual (VMMC.EN0xx).

The numerical VAMP differential protection include all the essential protection functions needed to protect transformers for distribution networks of utilities, industry, power plants and offshore applications as well as motor and generator differential protection. Further, the device includes several programmable functions, such as arc (option), thermal and circuit breaker protection and communication protocols for various protection and communication situations.

The generator, transformer and motor differential protection relay VAMP 265 can be used for selective differential overcurrent, short-circuit protection of generators, transformers and motors in solidly or impedance earthed power systems. The relay can also be used for single, two or three-phase overcurrent and/or sensitive earth fault protection.

The modern technology in association with an extensive self-supervision system and a reliable construction ensures an extremely high availability for the VAMP 265 protection relay

1.1. Main features

The main features of VAMP 265 are

- 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, e.g. the earth fault protection can reach a sensitivity of 0.5%.
- 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 relay to various substations and alarm systems due to flexible signal-grouping matrix in the relay .
- 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.
- Latest 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 ac. The alternative power supply is for 18 to 36 V dc.
- Built-in disturbance recorder for evaluating all the analogue and digital signals.
- Eight (8) programmable stages for alarming or protection purposes

1.2. Principles of numerical protection techniques

The manager is 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 manager is primarily based on an adapted Fast Fourier Transformation (FFT) algorithm. Synchronized sampling of the measured voltage and current signals is used. The sample rate is 32 samples/cycle within the frequency range 45 Hz ... 65 Hz. The frequency is measured from the voltage signals and used to synchronize the sampling rate. 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. The learned frequency is used for sampling rate synchronization when no voltage is present. The local network frequency can also be manually given for the relay.

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 hardware block diagram of the relay. The main components are the current and voltage inputs, digital input elements, output relays, A/D converters and the microcomputer and a power supply unit.

Figure 1.2-2 shows the inputs and outputs of a general protection function. The FFT block is calculating the fundamental frequency phasors and also harmonics used by some protection functions. The block matrix is used for simple interlocking. (More complex interlocking is done with the user's programmable logic.) The output matrix is used to connect the pick-up and trip signals from protection blocks to the output relays and indicators.

Figure 1.2-3 shows a block diagram of a basic overcurrent or overvoltage function with definite and inverse operation time.

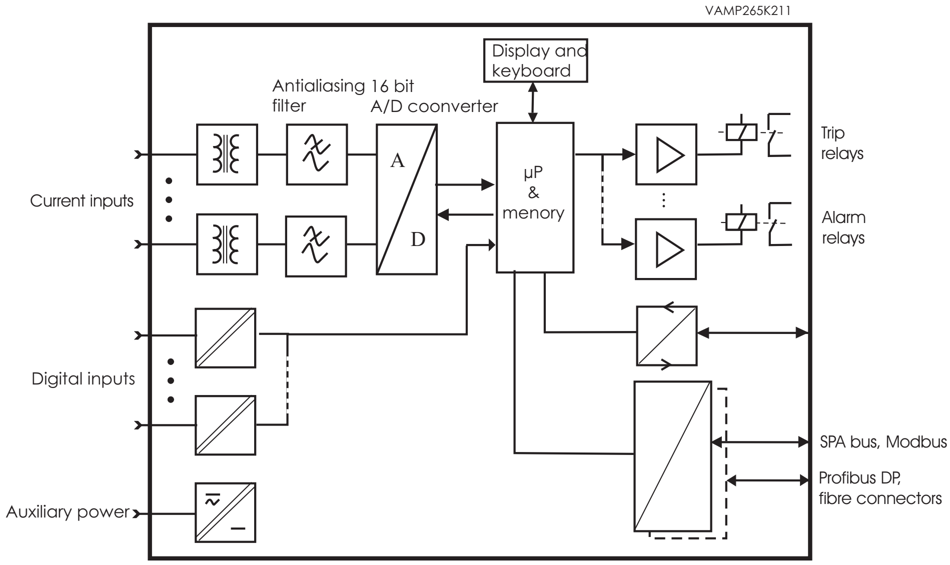


Figure 1.2-1. Principle block diagram of the VAMP 265 hardware.

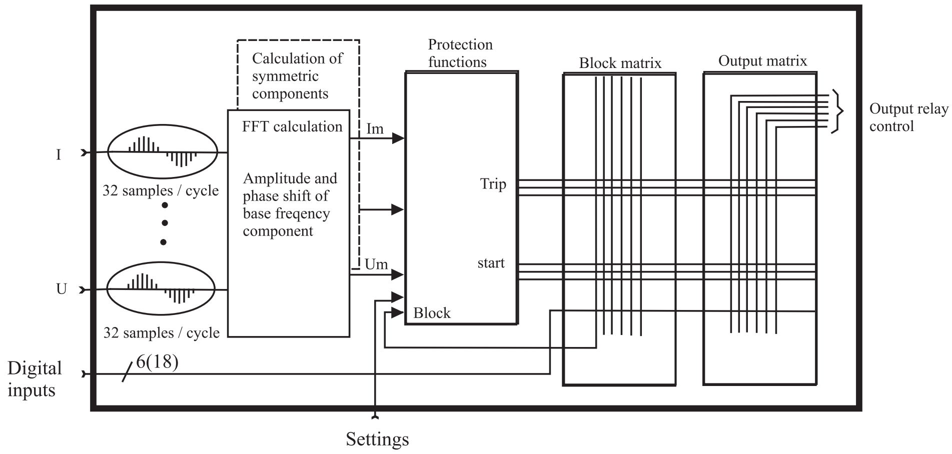


Figure 1.2-2. Block diagram of signal processing and protection software.

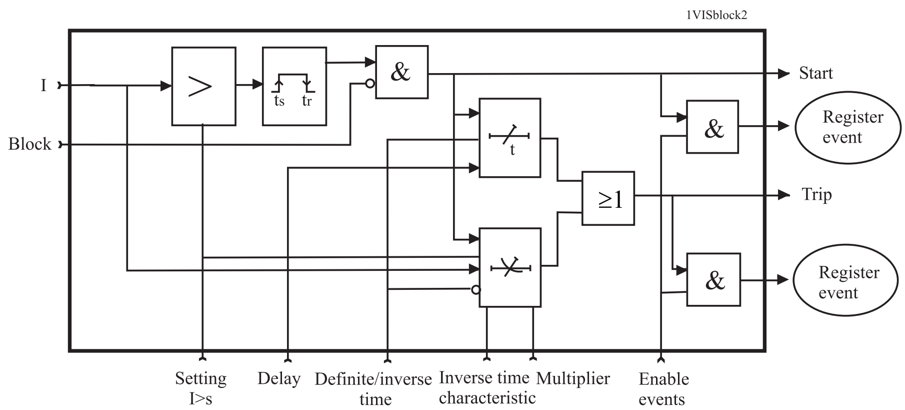


Figure 1.2-3. Block diagram of a basic protection function.

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 first part of this manual.

2.2. List of protection functions

IEEE/ ANSI code	IEC symbol	Function name
50/51	3I>, 3I>>, 3I'>, 3I'>>	Overcurrent protection
87	ΔI>, ΔI>>	Differential overcurrent protection
46	$I_2>$, $I'_2>$	Current unbalance protection
49	T>	Thermal overload protection
50N/51N	$I_0>$, $I_0>>$, $I_0>>>$, $I_0>>>>$	Earth fault protection
50BF	CBFP	Circuit-breaker failure protection
99	Prg1...8	Programmable stages
50ARC 50NARC	ArcI>, ArcI'> ArcI_{01}>, ArcI_{02}>	Optional arc fault protection

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 relay 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.

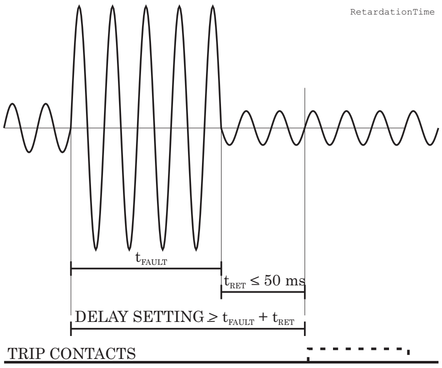


Figure 2.3-1. Definition for retardation time. If the delay setting would be slightly shorter, an unselective trip might occur (the dash line pulse).

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 relays 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 relay is clearing an overcurrent fault. When the relay's trip contacts are closed the circuit breaker (CB) starts to open. After the CB contacts are open the fault current will still flow through an arc between the opened contacts. The current is finally cut off when the arc extinguishes at the next zero crossing of the current. This is the start moment of the reset delay. After the reset delay the trip contacts and start contact are opened unless latching is configured. The 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.

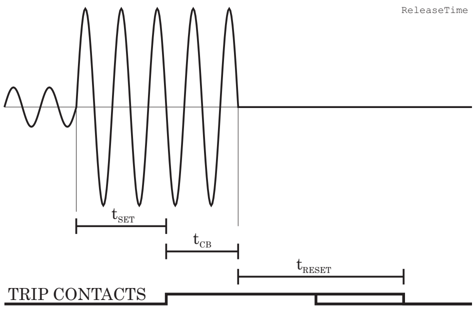


Figure 2.3-2. Reset time is the time it takes the trip or start relay contacts to open after the fault has been cleared.

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.

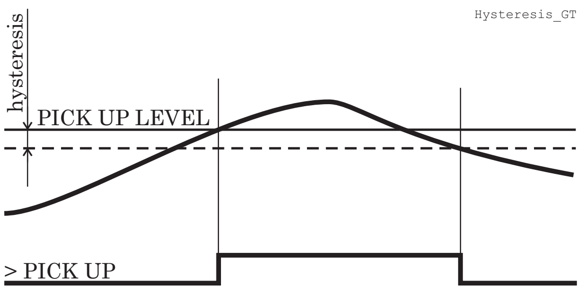


Figure 2.3-3. Behaviour of a greater than comparator. For example in overcurrent and overvoltage stages the hysteresis (dead band) acts according this figure.

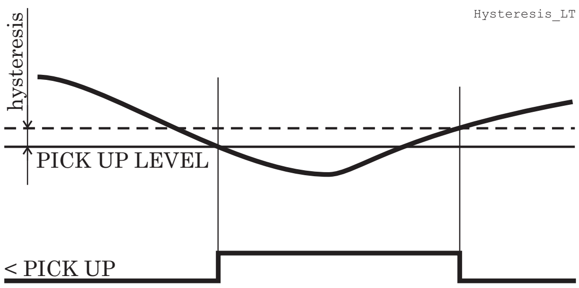


Figure 2.3-4. Behaviour of a less than comparator. For example in under-voltage and under frequency stages the hysteresis (dead band) acts according this figure.

2.4. Differential overcurrent protection ΔI> (87)

The differential overcurrent protection comprises two separately adjustable stages, stage ΔI> and stage ΔI>>.

The differential protection is based on winding currents difference between IL and I'L side. In transformer applications the current calculation depends on transformer connection group. E.g. in Yy0 connection measured currents are also winding currents, see Figure 2.4-1. In generator applications the connection group is always Yy0 and measured currents are also winding currents.

WindingCurrent1

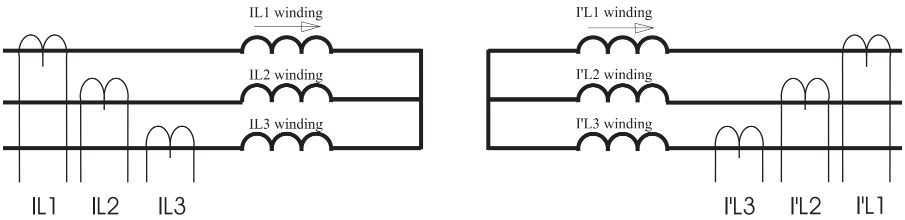


Figure 2.4-1 Winding currents in connection group Yy0.

In the second example if transformer IL side is connected to open delta, e.g. Dy11, then winding currents are calculated in delta side (IL side), see Figure 2.4-2.

WindingCurrent2

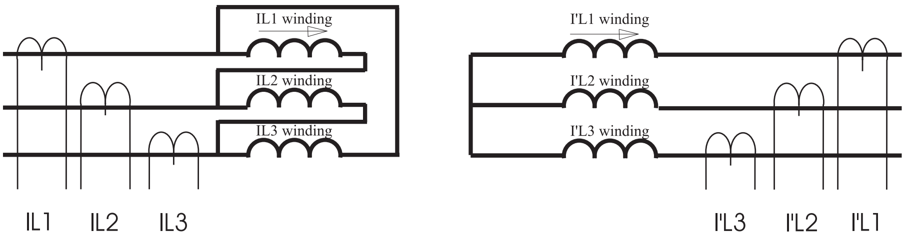


Figure 2.4-2 Winding currents in connection group Dy11.

Equation 1: Winding current calculation in delta side, Dy11 connection

$$\overline{I_{L1W}} = \left(\overline{I_{L1}} - \overline{I_{L2}}\right)/3$$
$$\overline{I_{L2W}} = \left(\overline{I_{L2}} - \overline{I_{L3}}\right)/3$$
$$\overline{I_{L3W}} = \left(\overline{I_{L3}} - \overline{I_{L1}}\right)/3$$

Equation 2: Winding currents in star side, Dy11 connection

$$\overline{I'_{L1W}} = \overline{I'_{L1}}$$
$$\overline{I'_{L2W}} = \overline{I'_{L2}}$$
$$\overline{I'_{L3W}} = \overline{I'_{L3}}$$

Equation 3: Bias current

$$I_b = \frac{\left|\overline{I}_W\right| + \left|\overline{I}'_W\right|}{2}$$

Equation 4: Differential current

$$I_d = \left|\overline{I}_W + \overline{I}'_W\right|$$

Bias current calculation is only used in protection stage ΔI>. Bias current describes the average current flow in transformer. Bias and differential currents are calculated individually for each phase.

If transformer is earthed, e.g. connection group Dyn11, then zero current must be compensated before differential and bias current calculation. Zero current compensation can be selected individually for IL and I'L side.

Table 2.4-1 describe connection group and zero current compensation for different connection groups. If protection area is only generator then connection group setting is always Yy0, see Table 2.4-2. Also the settings of Un and U'n are set to be the same, e.g. generator nominal voltage.

Table 2.4-1 Zero current compensation in transformer applications

Transformator Connection group	Relay setting ConnGrp	Io cmps	I'o cmps
YNy0	Yy0	ON	OFF
YNyn0	Yy0	ON	ON
Yy0	Yy0	OFF	OFF
Yyn0	Yy0	OFF	ON
YNy6	Yy6	ON	OFF
YNyn6	Yy6	ON	ON
Yy6	Yy6	OFF	OFF
Yyn6	Yy6	OFF	ON
Yd1	Yd1	OFF	OFF
YNd1	Yd1	ON	OFF
Yd5	Yd5	OFF	OFF
YNd5	Yd5	ON	OFF
Yd7	Yd7	OFF	OFF
YNd7	Yd7	ON	OFF
Yd11	Yd11	OFF	OFF
YNd11	Yd11	ON	OFF
Dy1	Dy1	OFF	OFF
Dyn1	Dy1	OFF	ON
Dy5	Dy5	OFF	OFF
Dyn5	Dy5	OFF	ON
Dy7	Dy7	OFF	OFF
Dyn7	Dy7	OFF	ON
Dy11	Dy11	OFF	OFF
Dyn11	Dy11	OFF	ON

Table 2.4-2 Zero current compensation in generator applications

Genarator only	Relay setting ConnGrp	Io cmps	I'o cmps
None earthing	Yy0	OFF	OFF

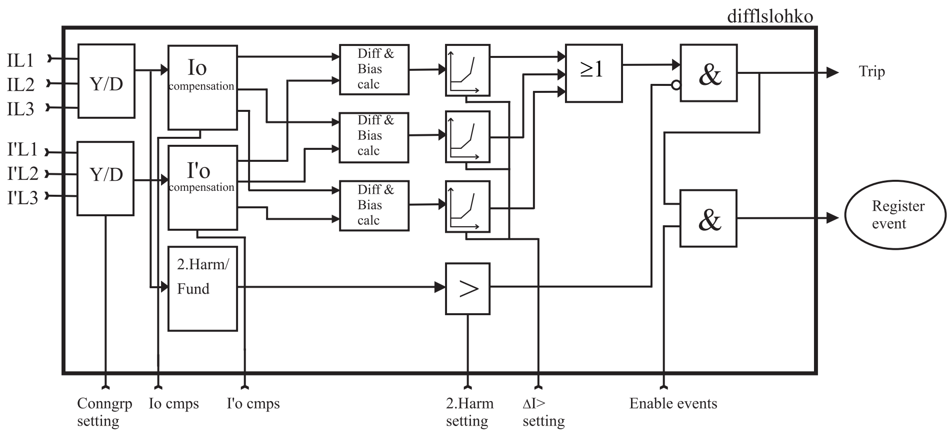


Figure 2.4-3 Block diagram of the differential overcurrent stage ΔI>.

The stage ΔI> can be configured to operate as shown in Figure 2.4-4. This dual slope characteristic allows more differential current at higher currents before tripping.

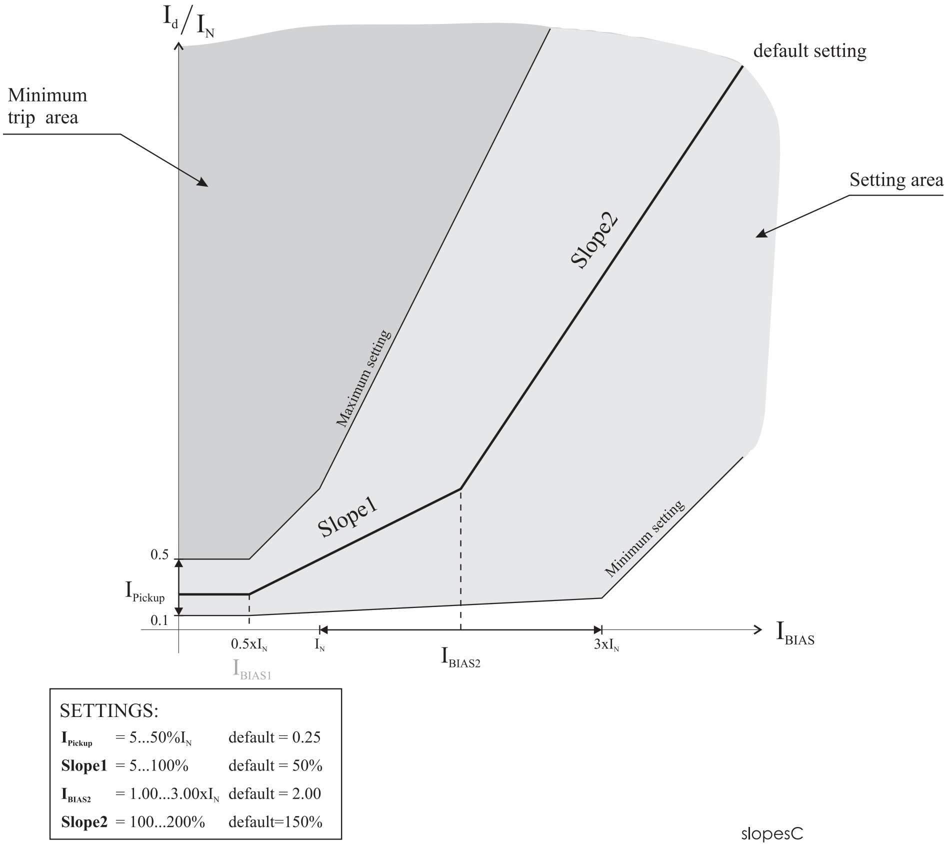


Figure 2.4-4 Example of differential overcurrent characteristics.

The stage also includes second harmonics blocking. The second harmonic is calculated from winding currents. Harmonic ratio is:

$100 \text{ x } I_{f2\_Winding} / I_{f1\_Winding}$ [%].

Fast differential overcurrent stage ΔI>> does not include slope characteristics and second harmonics blocking.

Parameters of the differential overcurrent stages:

ΔI> (87)

	Parameter	Value/unit	
Measured values (1	ΔL1 ΔL2 ΔL3	xIn	Current difference value
Setting values (2	ΔI>	%In	Setting value
	Slope1	%	Slope 1 setting
	Ibias2	xIn	Bias current start of slope 2
	Slope2	%	Slope 2 setting
	Harm2>	On/Off	2. harmonic blocking enable/disable
	Harm2>	%	2. harmonic block limit

Recorded values	Parameter	Value/unit	
	TCntr		Cumulative trip counter
	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
	ΔFlt	xIn	Max. value of fault differential current as compared to I_n
	Bias	xIn	Value of bias current of faulted phase as compared to I_n
	Load	xIn	1 s mean value of pre-fault phase currents IL1…IL3

1) Measurement ranges are described in section 9.1.1.

2) Setting ranges are described in section 9.3.1.

ΔI>> (87)

	Parameter	Value/unit	
Measured values	ΔL1 ΔL2 ΔL3	xIn	Current difference value
Setting values	ΔI>>	xIn	Setting value
Recorded values	TCntr		Cumulative trip counter
	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
	ΔFlt	xIn	Max. value of fault differential current as compared to I_n
	Load	xIn	1 s mean value of pre-fault phase currents IL1…IL3

2.5. Overcurrent protection 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.

Two independent stages

There are two separately adjustable overcurrent stages: I>, I>> I'>and I'>>. The first stage I> can be configured for definite time (DT) or inverse time operation characteristic (IDMT). The stage I>> has 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 2.5-1 shows a functional block diagram of the I> overcurrent stage with definite time and inverse time operation time. Figure 2.5-2 shows a functional block diagram of the I>> overcurrent stage 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 2.12. The relay 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 2.12 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.

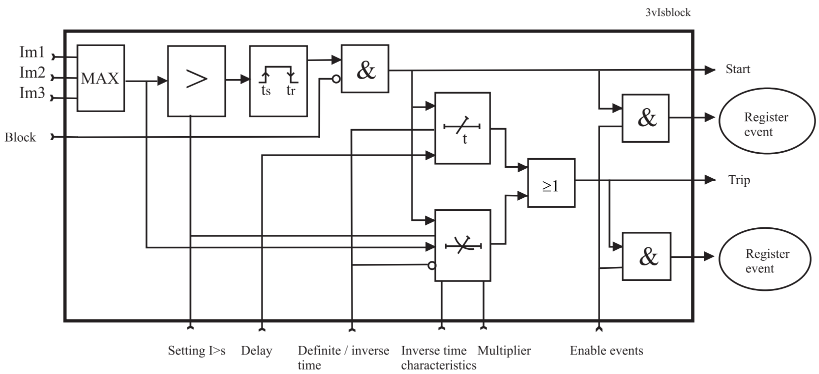


Figure 2.5-1 Block diagram of the three-phase overcurrent stage I>.

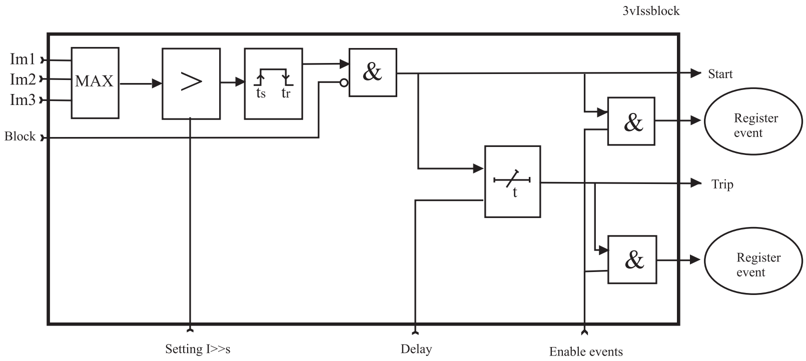


Figure 2.5-2 Block diagram of the three-phase overcurrent stage I>> and I>>>.

Parameters of the overcurrent stage I> and 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
ILmax		A	The supervised value. Max. of IL1, IL2 and IL3	
I>		A	Pick-up value scaled to primary value	
I>		xIgn	Pick-up setting	Set
Curve	 DT IEC IEEE IEEE2 RI PrgN		Delay curve family: Definite time Inverse time. See chapter 2.12. Pre 1996	Set

Parameter	Value	Unit	Description	Note
Type	 DT NI VI EI LTI Parameters		Delay type. Definite time Inverse time. See chapter 2.12.	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 2.12.	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
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 IL1, IL2 and IL3	
I>>, I>>>		A	Pick-up value scaled to primary value	

Parameter	Value	Unit	Description	Note
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			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		xIgn	Maximum fault current
Load		xIgn	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

2.6. Current unbalance protection I_2>, I'_2> (46)

The current unbalance stage protects against unbalanced phase currents and single phasing. The protection is based on the negative sequence current.

Both definite time and inverse time characteristics are available. The inverse delay is based on Equation 2.6-1. Only the base frequency components of the phase currents are used to calculate the negative sequence value I_2.

Inverse delay

The inverse delay is based on the following equation.

Equation 2.6-1

$$t = \frac{K_1}{\left(\frac{I_2}{I_N}\right)^2 - K_2^2}$$, where

t	=	Operation time
K_1	=	Delay multiplier
I_2	=	Measured and calculated negative sequence phase current of fundamental frequency.
I_N	=	Rated current
K_2	=	Pick-up setting $I_2>$ in pu. The maximum allowed degree of unbalance.

Example:

K_1	=	15 s
I_2	=	22.9 % = 0.229 xI_N
K_2	=	5 % = 0.05 xI_N

$$t = \frac{15}{\left(\frac{0.229}{1}\right)^2 - 0.05^2} = 300.4$$

The operation time in this example will be five minutes.

More stages (definite time delay only)

If more than one definite time delay stages are needed for current unbalance protection, the freely programmable stages can be used (chapter 2.11).

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.

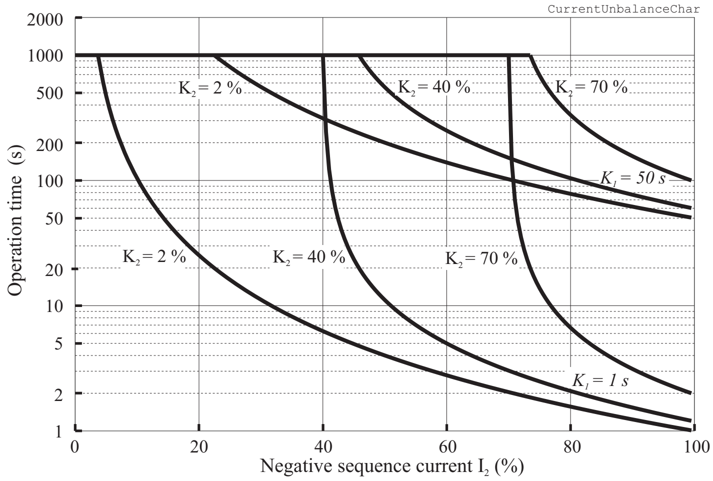


Figure 2.6-1. Inverse operation delay of current unbalance stage I_2>. The longest delay is limited to 1000 seconds (=16min 40s).

Parameters of the current unbalance stage I_2>, I'_2> (46)

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
I2/In		%In	The supervised value.	
I2>		%In	Pick-up setting	Set
t>		s	Definite operation time (Type=DT)	Set
Type	DT INV		Definite time Inverse time (Equation)	Set
K1		s	Delay multiplier (Type =INV)	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 faults: Time stamp, unbalance current, elapsed delay and setting group.

Recorded values of the current unbalance stage (8 latest faults) I_2>, I'_2> (46)

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

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

Undirectional earth fault protection is used for 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.

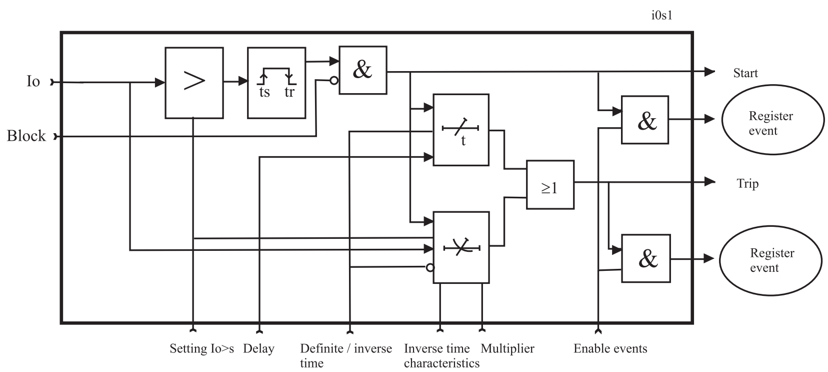


Figure 2.7-1. Block diagram of the earth fault stage I_0>

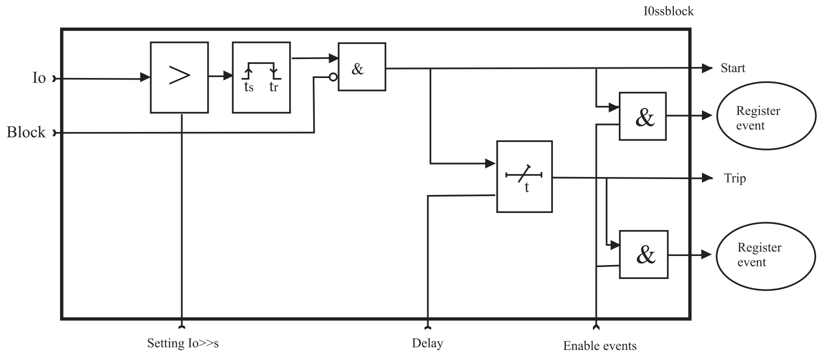


Figure 2.7-2. Block diagram of the earth fault stages I_0>>, I_0>>> and I_0>>>>

Figure 2.7-1 shows a functional block diagram of the I_0> earth overcurrent stage with definite time and inverse time operation time. Figure 2.7-2 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.
- Input I_{02} for all networks other than rigidly earthed.
- Calculated signal I_{0Calc} for rigidly and low impedance earthed networks. $I_{0Calc} = I_{L1} + I_{L2} + I_{L3}$.
- 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}.
- I_{02Peak} to measure the peak value of input I_{02}.

Intermittent earth fault detection

Short earth faults make the protection to start (pick up), but will not cause trip. 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. By using input signals I_{01Peak} or I_{02Peak} a single one-millisecond current peak is enough to start the stage and increase the delay counter by 20 ms. For example if the operating time is 120 ms, and the time between two peaks does not exceed the intermittent time setting, the sixth peak will cause a trip.

Four 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.

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 2.12. The relay 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 2.12 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 Io2 IoCalc IoPeak Io2Peak I'oCalc		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 2.12.	Set
Type	 DT NI VI EI LTI Parameters		Delay type. Definite time Inverse time. See chapter 2.12.	Set
t>		s	Definite operation time (for definite time only)	Set
k>			Inverse delay multiplier (for inverse time only)	Set
Input	Io1 Io2 IoCalc Io1Peak Io2Peak I'oCalc		X1-7&8. See chapter 8 X1-9&10 IL1 + IL2 + IL3 X1-7&8 peak mode X1-9&10 peak mode I'L1 + I'L2 + I'L3	Set
Intrmt		s	Intermittent time	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 2.12.	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 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 Io2 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	Io1 Io2 IoCalc I'oCalc		X1-7&8. See chapter 8 X1-9&10 IL1 + IL2 + IL3 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

2.8. Thermal overload protection T> (49)

The thermal overload function protects the transformer against excessive temperatures.

Thermal model

The temperature is calculated using rms values of phase currents and a thermal model according IEC 60255-8. The rms values is 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: $$a = k \cdot k\Theta \cdot I_{mode} \cdot alarm$$ (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: $$a = \sqrt{0.95} \times k \times I_n$$

Start release: $$a = \sqrt{0.95} \times k \times I_n \times alarm$$ (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, $I_P = \sqrt{\theta} \times k \times I_n$ (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). See Figure 2.8-1

I_{MODE} = The rated current (I_N or I_{MOT})

C_τ = Relay cooling time constant (Setting value)

Time constant for cooling situation

If the transformer's fan is stopped, the cooling will be slower than with an active fan. Therefore there is a coefficient cτ for thermal constant available to be used as cooling time constant, when current is less than $0.3xI_N$.

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 transformer. 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 2.8-1. Ambient temperature is not in use when kΘ = 1. This is true when

- IMAX40 is 1.0
- Samb is “n/a” (no ambient temperature sensor)
- TAMB is +40 °C.

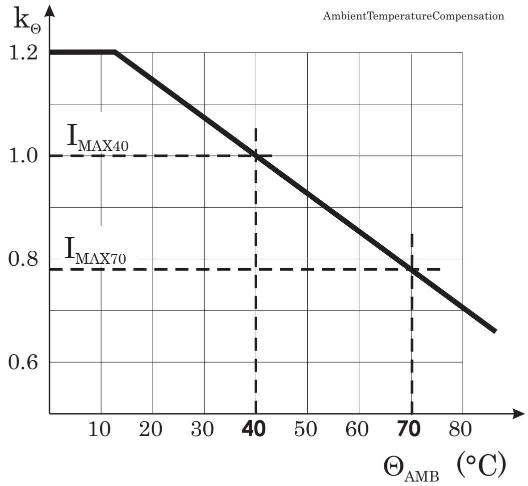


Figure 2.8-1 Ambient temperature correction of the overload stage T>.

Example of a behaviour of the thermal model

Figure 2.8-1 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 0.85xI_N 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 relay 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.

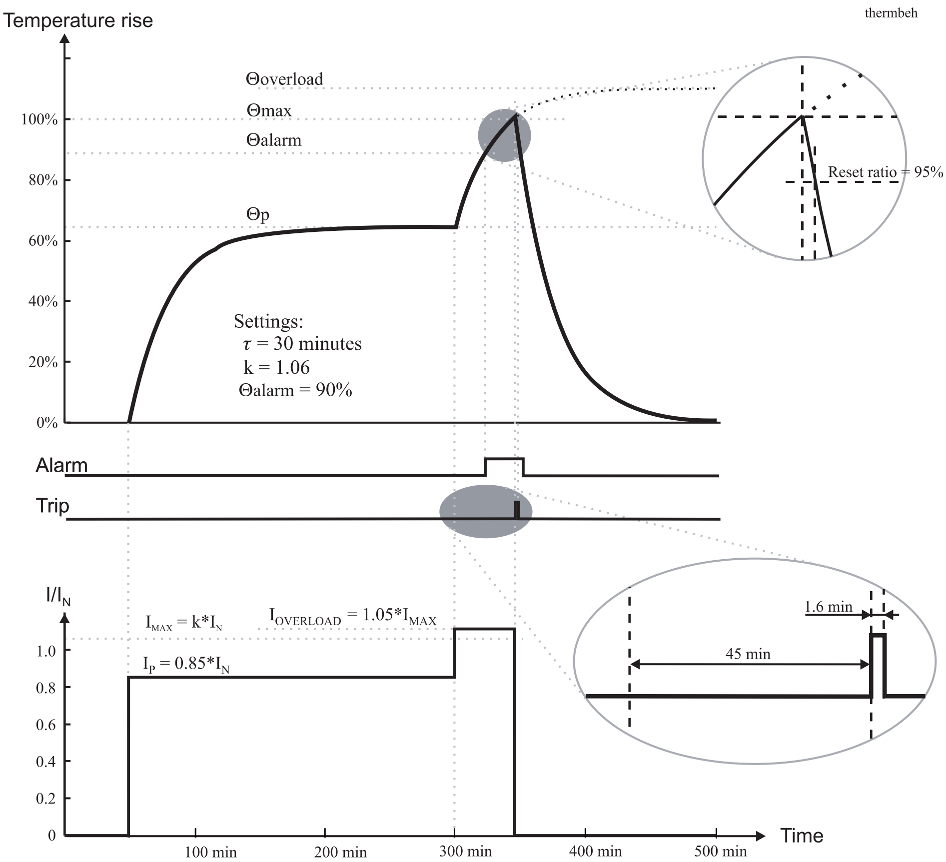


Figure 2.8-1. Example of the thermal model behaviour.

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	kxIgn. Current corresponding to the 100 % temperature rise.	
k>		xIn	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		xIn	Ambient temperature corrected max. allowed continuous current	
Imax40		%In	Allowed load at Tamb +40 °C. Default = 100 %.	Set
Imax70		%In	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

2.9. 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 relay 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 relay. 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 2		The supervised output relay*). Relay T1 Relay T2	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 3.4.

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

2.10. 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 IL1, IL2, IL3 are used.
- ArcI'> for phase-to-phase arc faults. Current inputs I'L1, I'L2, I'L3 are used.
- ArcI_{01}> for phase-to-earth arc faults. Current input I_{01} is used.
- ArcI_{02}> for phase-to-earth arc faults. Current input I_{02} 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 relays 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 relays or dedicated arc protection devices by VAMP.

Delayed light indication signal

There is a delayed light indication output signal available for building selective arc protection systems. Any light source combination and a delay can be configured. 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'>: 1 pu = 1xI'_N = rated phase current CT value

ArcI_{01}>: 1 pu = 1xI_{01N} = rated residual current CT value for input I_{01}.

ArcI_{02}>: 1 pu = 1xI_{02N} = rated residual current CT value for input I_{02}.

Parameters of arc protection stages ArcI>, ArcI'>, ArcI_{01}A, ArcI_{02}> (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

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
 ILmax I'Lmax Io1 Io2			Value of the supervised signal Stage ArcI> Stage ArcI'> Stage ArcI$_{01}$> Stage ArcI$_{02}$>	
ArcI> ArcI'> ArcIo1> ArcIo2>		pu pu pu pu	Pick up setting xI$_N$ Pick up setting xI'$_N$ Pick up setting xI$_{01N}$ Pick up setting xI$_{02N}$	Set
ArcIn	 – S1 S2 S1/S2 BI S1/BI S2/BI S1/S2/BI		Light indication source selection No sensor selected Sensor 1 at terminals X6:4-5 Sensor 2 at terminals X6:6-7 Terminals X6:1-3	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		Light indication source selection No sensor selected Sensor 1 at terminals X6:4-5 Sensor 2 at terminals X6:6-7 Terminals X6:1-3	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'>, 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

2.11. 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.

Available signals to be supervised by the programmable stages

Alarm stages link signals	Task interval
IL1 – IL3, IL1W-IL3W, I'L1W-I'L3W, IL, I'L Io, Io2, Iocalc, I'oCalc, I1, I2, I2/I1, I2/In, I'1, I'2, I'2/I'1, I'2/In, dIL1, dIL2, dIL3 THDIL1, THDIL2, THDIL3	100ms

Eight independent stages

The relay 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	(See table above)		Name for the supervised signal	Set
(See table above)			Value of the supervised signal	
Cmp	 > <		Mode of comparison Over protection Under protection	Set

Parameter	Value	Unit	Description	Note
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 are 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

2.12. 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 2.12.1.
- **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 2.12.2.
- **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 2.12.3.

Local panel graph

The relay 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.

- There are errors in formula parameters A…E, and the device is not able to build the delay curve
- 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 phase current is $50xI_N$ and the maximum directly measured earth fault current is $5xI_{0N}$. This limits the scope of inverse curves when the setting is more than $2.5xI_N$ (overcurrent stages and earth fault stages using I_{0Calc} input) or $0.25xI_{01N}$ (earth fault stages using I_{01} input or I_{02} input). The I_N and I_{01N} and I_{02N} depend on the order code (See chapter 12). The table below gives the limit values in secondary amperes.

Example of limitation

CT = 750/5

I_N = 577 A

CT_0 = 100/1 (a cable CT for I_0)

Secondary scaled I_{GNsec} is now 3.85 A

For 5 A CT secondaries and 1 A residual current inputs VAMP relay VAMP 265-5D7AAA is used. It has 5 A phase current inputs and 1 A residual inputs.

For overcurrent stage I> the table below gives 12.5 A. Thus the maximum setting for I> stage giving full inverse delay range is 12.5 A / 3.85 A = 3.25 xI_{GN}.

For earth fault stage I_0> and input I_{01} the table below gives 0.25 A. Thus the maximum setting for I_0> stage giving full inverse delay range is 0.25 A / 1 A = 0.25 pu. This equals a 25 A primary earth fault current.

When using input signal I_{0Calc} the corresponding setting is 12.5 A / 1 A = 12.5 pu. This equals a 9375 A of primary earth fault current.

	RATED INPUT				Maximum **secondary scaled setting** enabling inverse delay times up to 20x setting			
Order code	**I_L**	**I'_L**	**I_{01}**	**I_{02}**	**I_{L1}, I_{L2}, I_{L3} & I_{0Calc}**	**I'_{L1}, I'_{L2}, I'_{L3} & I'_{0Calc}**	**I_{01}**	**I_{02}**
VAMP 265-1_	1	1			2.5 A	2.5 A		
VAMP 265-3_	1	5			2.5 A	12.5 A		
VAMP 265-4_	5	1			12.5 A	2.5 A		
VAMP 265-5_	5	5			12.5 A	12.5 A		
VAMP 265-_A			5	5			1.25 A	1.25 A
VAMP 265-_B			5	1			1.25 A	0.25 A
VAMP 265-_C			1	5			0.25 A	1.25 A
VAMP 265-_D			1	1			0.25 A	0.25 A

2.12.1. 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 chapter 2.12 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 2.12 for more details.

Table 2.12.1-1 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 2.12.1-1. 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 relay for real time usage.

Equation 2.12.1-1

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

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

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

Table 2.12.1-2 Constants for IEC inverse delay equation

Delay type		Parameter	
		A	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 2.12.1-1 .

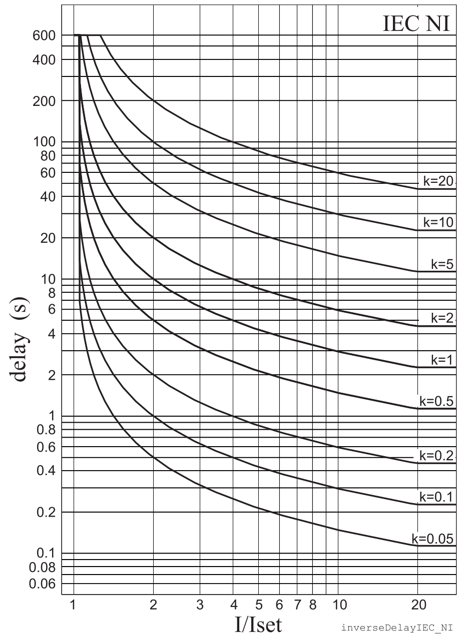


Figure 2.12.1-1 IEC normal inverse delay.

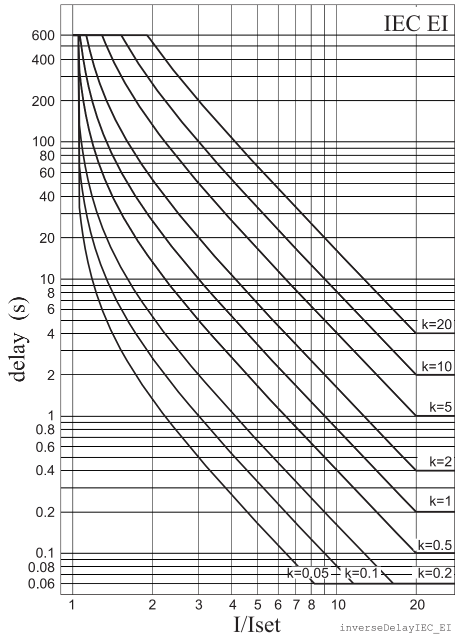


Figure 2.12.1-2 IEC extremely inverse delay.

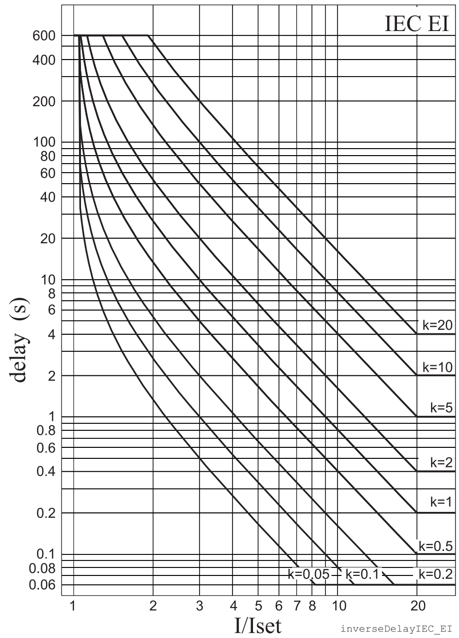


Figure 2.12.1-3 IEC very inverse delay.

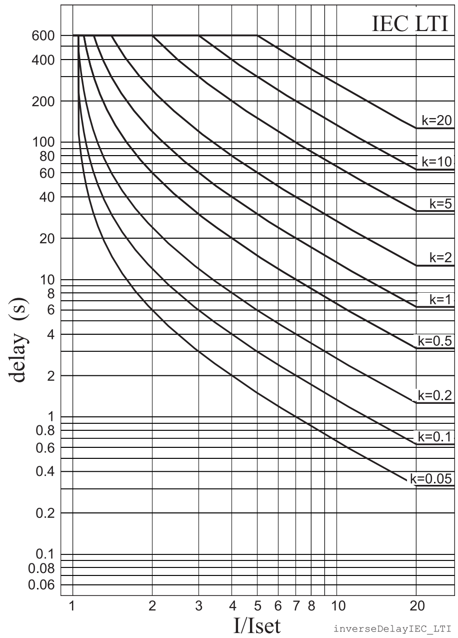


Figure 2.12.1-4 IEC long time inverse delay.

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 2.12.1-3. The IEEE standard defines inverse delay for both trip and release operations. However, in the VAMP relay 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 2.12.1-1. 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 relay for real time usage.

Equation 2.12.1-1

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

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 2.12.1-3.

Table 2.12.1-3 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 2.12.1-8.

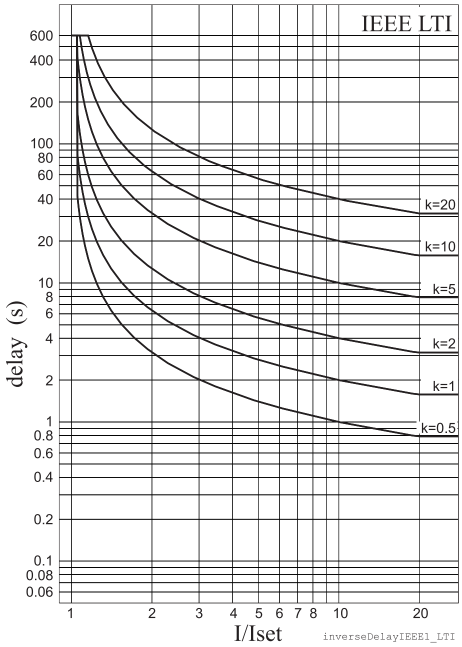


Figure 2.12.1-5 ANSI/IEEE long time inverse delay

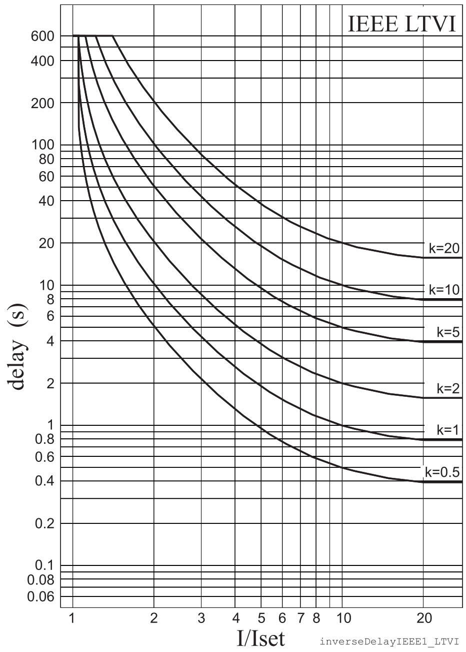


Figure 2.12.1-6 ANSI/IEEE long time very inverse delay

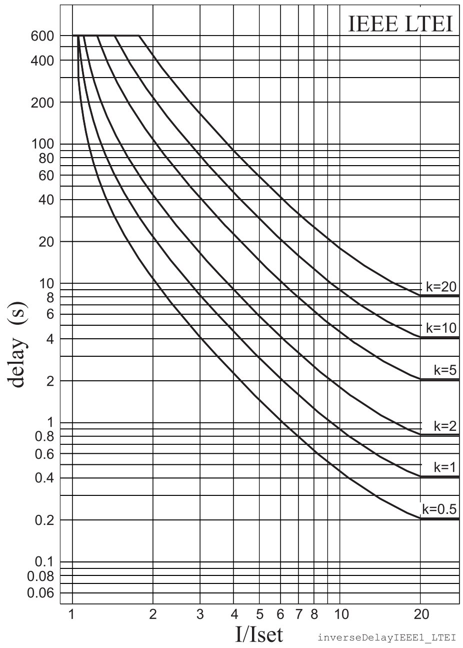


Figure 2.12.1-7 ANSI/IEEE long time extremely inverse delay

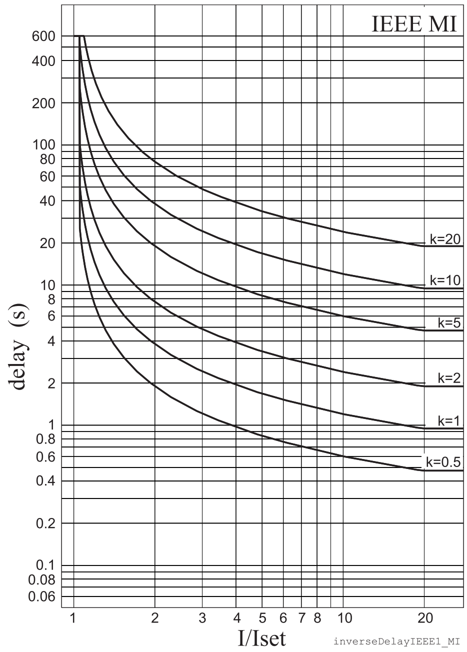


Figure 2.12.1-8 ANSI/IEEE moderately inverse delay

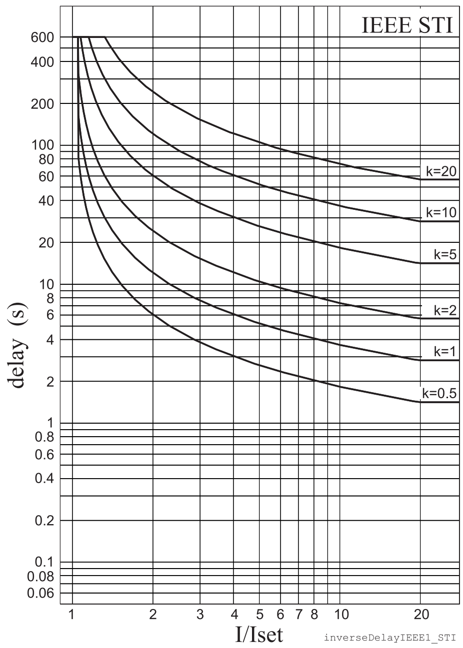


Figure 2.12.1-9 ANSI/IEEE short time inverse delay

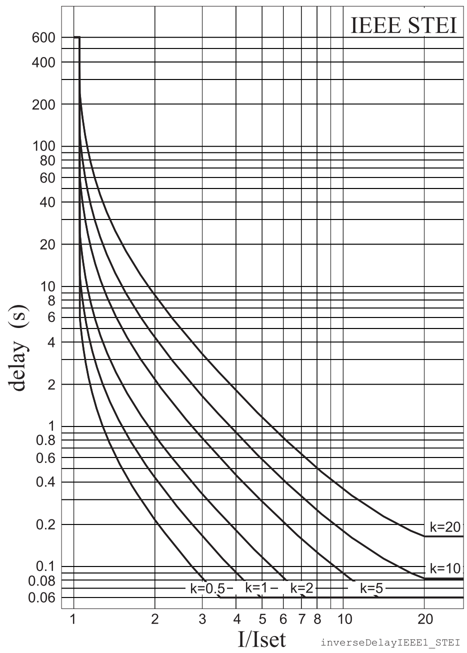


Figure 2.12.1-10 ANSI/IEEE short time extremely inverse delay

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 2.12.1-2, which in VAMP device 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 2.12.1-1. The old electromechanical induction disc relays have inverse delay for both trip and release operations. However, in VAMP device only the trip time is inverse the release time being constant.

The operation delay depends on the measured value and other parameters according Equation 2.12.1-2. 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 relay for real time usage.

Equation 2.12.1-2

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

t = Operation delay in seconds
k = User's multiplier
I = Measured value
I_{pickup} = User's pick up setting
A,B,C,D = Constant parameter according Table 2.12.1-1.

Table 2.12.1-1 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 2.12.1-11.

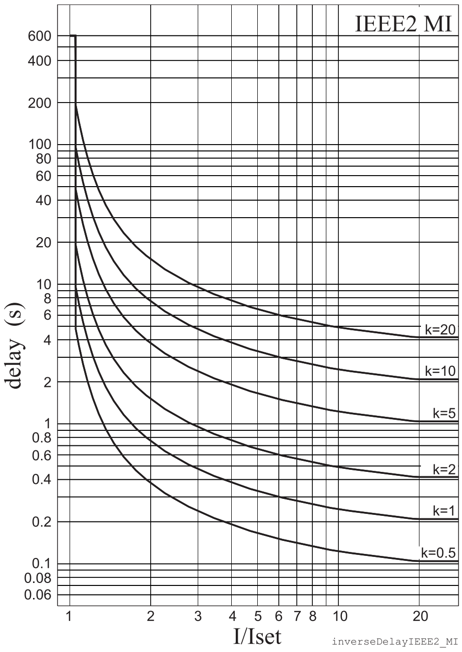


Figure 2.12.1-11 IEEE2 moderately inverse delay

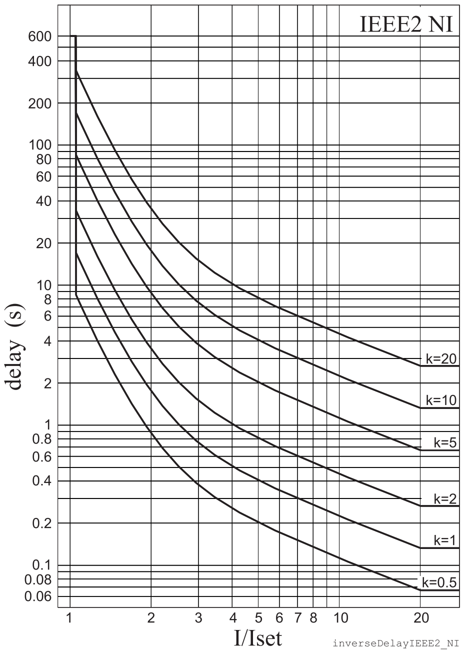


Figure 2.12.1-12 IEEE2 normal inverse delay

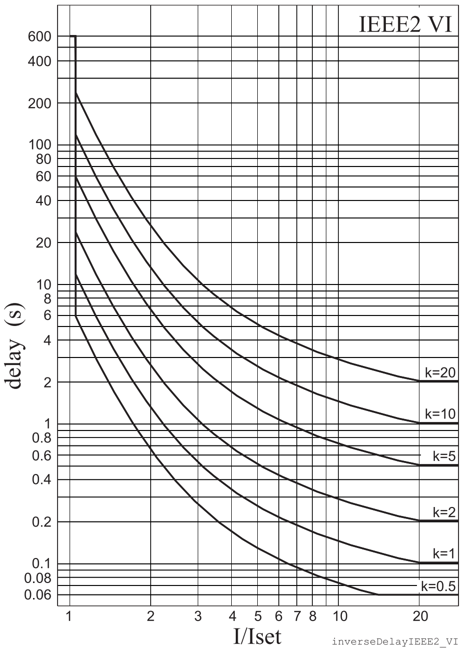


Figure 2.12.1-13 IEEE2 very inverse delay

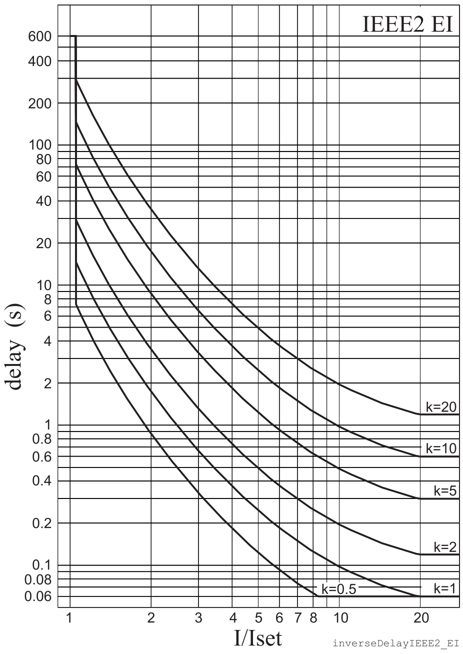


Figure 2.12.1-14 IEEE2 extremely inverse delay

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 2.12.1-3 and Equation 2.12.1-4. 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 relay for real time usage.

Equation 2.12.1-3. RI

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

Equation 2.12.1-4 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 2.12.1-15.

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 2.12.1-16.

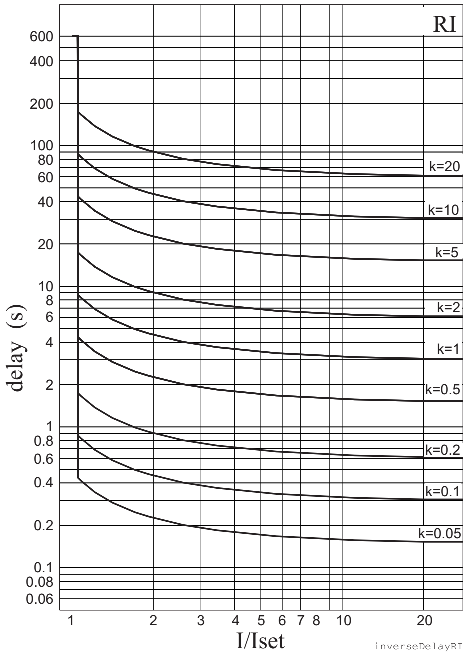


Figure 2.12.1-15 Inverse delay of type RI.

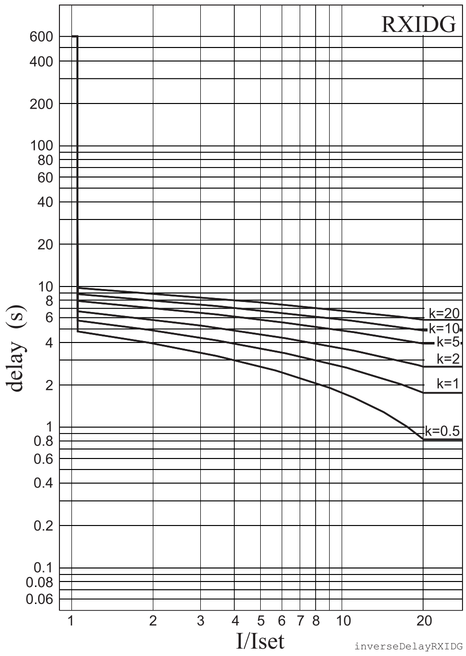


Figure 2.12.1-16 Inverse delay of type RXIDG.

2.12.2. 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 2.12 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 2.12 for more details.

2.12.3. 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 line
- line 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 lines (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 2.12 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 2.12 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 VAMP2xx_Events.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: 30E2	Channel 30, event 2	Yes	Yes
U> trip on	Event text	Yes	No
112.0 %Ugn	Fault value	Yes	No
2007-01-31	Date	Yes	Yes
08:35:13.413	Time	Yes	Yes
Type: U12,23,31	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 relay is not connected to any SCADA system.

Only the latest event can be read when using communication protocols or VAMPSET. Every reading increments the internal read pointer to the event buffer. (In case of communication 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.

There are room for 50 latest events in the event buffer. 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 3.5 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 3.5)	
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.

Available channels

The following channels i.e. signals can be linked to a disturbance recorder:

Channel	Description	Available for waveform
IL1, IL2, IL3	Phase current	Yes
I'L1, I'L2, I'L3	Phase current	Yes
Io1, Io2	Measured residual current	Yes
f	Frequency	–
IoCalc	Phasor sum Io = (IL1+IL2+IL3)/3	–
I'oCalc	Phasor sum Io = (I'L1+I'L2+I'L3)/3	–
I1, I'1	Positive sequence current	–
I2, I'2	Negative sequence current	–
I2/I1, I'2/I'1	Relative current unbalance	–
I2/In, I'2/I'n	Current unbalance [xI_{GN}]	–
IL	Average (IL1 + IL2 + IL3)/3	–
I'L	Average (I'L1 + I'L2 + I'L3)/3	–
DO	Digital outputs	Yes
DI	Digital inputs	Yes
THDIL1	Total harmonic distortion of IL1	–
THDI'L1	Total harmonic distortion of I'L1	–
THDIL2	Total harmonic distortion of IL2	–
THDI'L2	Total harmonic distortion of I'L2	–
THDIL3	Total harmonic distortion of IL3	–
THDI'L3	Total harmonic distortion of I'L3	–
IL1RMS	IL1 RMS for average sampling	–
IL2RMS	IL2 RMS for average sampling	–
IL3RMS	IL3 RMS for average sampling	–
ILmin		
I'Lmin		
ILmax		
I'Lmax		
ΔIL1,ΔIL2,ΔIL3		
IL1w,IL2w,IL3w		
I'L1w,I'L2w,I'L3w		

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.	

AddCh	IL1, IL2, IL3 I'L1, I'L2, I'L3 Io1, Io2 f IoCalc I1, I2, I2/I1 I2/In, IoCalc I'1, I'2, I'2/I'1 I'2/I'n, I'oCalc IL, I'L DO, DI THDIL1 THDIL2 THDIL3 IL1RMS IL2RMS IL3RMS ILmin, ILmax I'Lmin I'Lmax ΔIL1, ΔIL2, ΔIL3 IL1w, IL2w, IL3w I'L1w, I'L2w, I'L3w		Add one channel. Maximum simultaneous number of channels is 12.	Set
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.

3.3. Current transformer supervision

The relay supervise the external wiring between the relay 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, 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, 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

3.4. Circuit breaker condition monitoring

The relay 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 2.9 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 3.4-1). 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 3.4-1. 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 relay 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 3.4-1. Thus they are set to 100 kA and one operation in the table to be discarded by the algorithm.

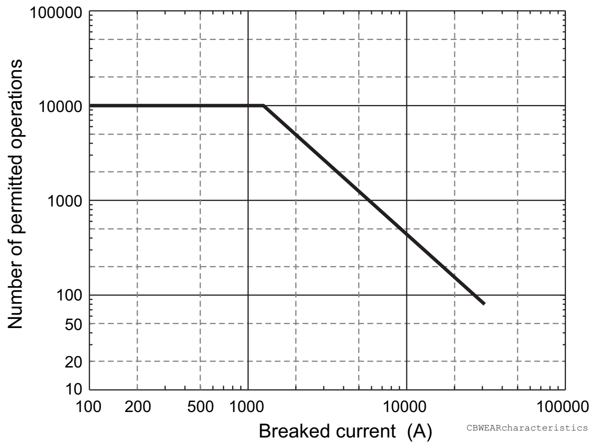


Figure 3.4-1. An example of a circuit breaker wearing characteristic graph.

Table 3.4-1. 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 relay 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 "Al1Ln" (Alarm 1) and "Al2Ln" (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 3.4-1

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

C = permitted operations

I = interrupted current

a = constant according Equation 3.4-2

n = constant according Equation 3.4-3

Equation 3.4-2

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

Equation 3.4-3

$$a = C_k I_k^2$$

ln	= natural logarithm function		
C_k	= permitted operations.	k = row 2...7 in Table 3.4-1.
I_k	= corresponding current.	k = row 2...7 in Table 3.4-1.
C_{k+1}	= permitted operations.	k = row 2...7 in Table 3.4-1.
I_{k+1}	= corresponding current.	k = row 2...7 in Table 3.4-1.

Example of the logarithmic interpolation

Alarm 2 current is set to 6 kA. What is the maximum number of operations according Table 3.4-1.

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 3.4-2 and Equation 3.4-3, the relay 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 3.4-1 the relay 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 3.4-1. 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 3.4-1 and values n and a from the previous example, the relay 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 3.4-1

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

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

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				
 Al1L1 Al1L2 Al1L3 Al2L1 Al2L2 Al2L3			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	
IL1 IL2 IL3		A A A	Broken current of phase L1 Broken current of phase L2 Broken current of phase L3	

Parameter	Value	Unit	Description	Set
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				
Al1On	On Off		'Alarm1 on' event enabling	Set
Al1Off	On Off		'Alarm1 off' event enabling	Set
Al2On	On Off		'Alarm2 on' event enabling	Set
Al2Off	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.

3.5. System clock and synchronization

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

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

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

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 relay's clock is leading sixty-one seconds a week and the parameter AAIntv has been zero, the parameters are set as

$$AvDrft = Lead$$

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

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

Example 2.

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

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

$$AvDrft = Lead$$

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 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. 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.	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.

3.6. 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)
	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 ...DI6, 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.

3.7. 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.

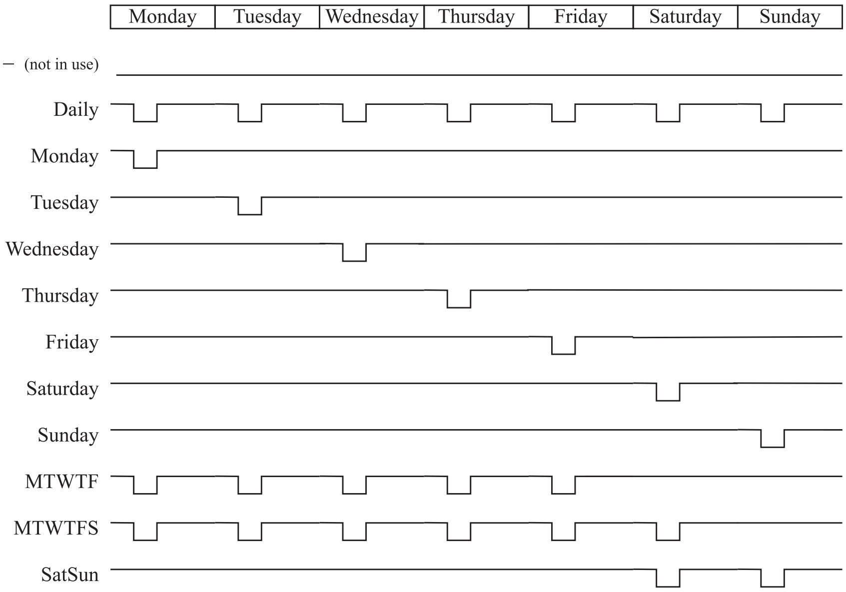


Figure 3.7-1. Timer output sequence in different modes.

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	 – 0 1	Timer status Not in use Output is inactive Output is active
On	hh:mm:ss	Activation time of the timer
Off	hh:mm:ss	De-activation time of the timer
Mode	 – Daily Monday Tuesday Wednesday Thursday Friday Saturday Sunday MTWTF MTWTFS SatSun	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. The timer switches on and off once every day. The timer switches on and off every Monday. The timer switches on and off every Tuesday. The timer switches on and off every Wednesday. The timer switches on and off every Thursday. The timer switches on and off every Friday. The timer switches on and off every Saturday. The timer switches on and off every Sunday. The timer switches on and off every day except Saturdays and Sundays The timer switches on and off every day except Sundays. The timer switches on and off every Saturday and Sunday.

3.8. 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		xI_N	Current of the latest overcurrent fault	(Set)
LINE ALARM				
AlrL1 AlrL2 AlrL3	 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. AlrL1=AlrL2=AlrL3=0 AlrL1=1 orAlrL2=1 or AlrL3=1	

Parameter	Value	Unit	Description	Note
LxAlarm	 On Off		'On' Event enabling for AlrL1…3 Events are enabled Events are disabled	Set
LxAlarmOff	 On Off		'Off' Event enabling for AlrL1…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 AlrL1, Alr2, AlrL3 and Ocs	Set
LINE FAULT				
FltL1 FltL2 FltL3	 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. FltL1=FltL2=FltL3=0 FltL1=1 orFltL2=1 or FltL3=1	
LxTrip	 On Off		'On' Event enabling for FltL1…3 Events are enabled Events are disabled	Set
LxTripOff	 On Off		'Off' Event enabling for FltL1…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

Parameter	Value	Unit	Description	Note
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 FltL1, Flt2, FltL3 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.

3.9. 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 relay, 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 relay 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.

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.

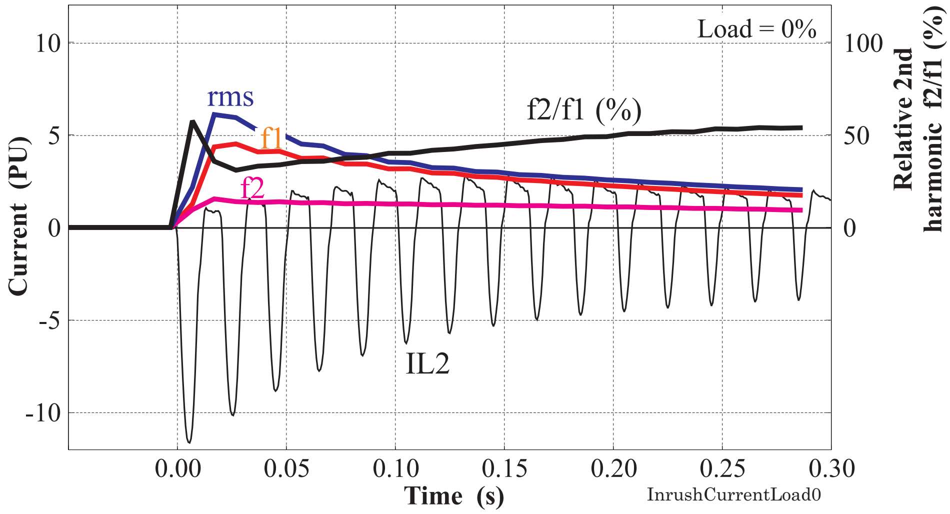


Figure 4-1 Example of various current values of a transformer inrush current.

4.1. Measurement accuracy

Phase current inputs I_{L1}, I_{L2}, I_{L3}, I'_{L1}, I'_{L2}, I'_{L3}

Measuring range		0 – 250 A (5A) 0 – 50 A (1A)
Inaccuracy	I ≤ 7.5 A	0.5 % of value or 15 mA
	I > 7.5 A	3 % of value

The rated input I_N is 5A or 1A. It is specified in the order code of the relay.
The specified frequency range is 45 Hz – 65 Hz.

Residual current inputs I_{01}, I_{02}

Measuring range		0 – 5 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.
The rated input I_n is 5A or 1A. This must be specified when ordering the relay.

Frequency

Measuring range	16 Hz – 75 Hz
Inaccuracy	10 mHz

In VAMP 265 frequency is measured from current signals.

THD and harmonics

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

The specified frequency range is 45 Hz – 65 Hz.

4.2. 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 %.

4.3. RMS values

RMS currents

Relay calculates the RMS value of each phase current. The minimum and the maximum of RMS values are recorded and stored.

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

4.4. Demand values

The relay calculates average i.e. demand values of phase currents I_{L1}, I_{L2}, I_{L3}. 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				
IL1da		A	Demand of phase current IL1	
IL2da		A	Demand of phase current IL2	
IL3da		A	Demand of phase current IL3	
RMS values				
IL1da		A	Demand of phase current IL1	
IL2da		A	Demand of phase current IL2	
IL3da		A	Demand of phase current IL3	

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
IL1, IL2, IL3	Phase current (fundamental frequency value)
IL1RMS, IL2RMS, IL3RMS	Phase current, rms value
Io1, Io2	Residual current
f	Frequency
IL1da, IL2da, IL3da	Demand values of phase currents
IL1da, IL2da, IL3da (rms value)	Demand values of phase currents, rms values

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 relay. Corresponding time stamps are stored for the last 31 days. The registered values are listed in the following table.

Measurement	Max	Min	Description
IL1, IL2, IL3	X		Phase current (fundamental frequency value)
Io1, Io2	X		Residual current

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	 20 ms 200 ms 1 s 1 min demand	Parameter to select the type of the registered values. Collect min & max of one cycle values *) Collect min & max of 200 ms average values Collect min & max of 1 s average values Collect min & max of 1 minute average values Collect min & max of demand values (see chapter 4.4)	S
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. Primary, secondary and per unit scaling

Many measurement values are shown as primary values although the relay is connected to secondary signals. Some measurement values are shown as relative values - per unit or per cent. Almost all pick-up setting values are using relative scaling. The scaling is done using the given CT and transformer / generator name plate values.

The following scaling equations are useful when doing secondary testing.

4.7.1. Current scaling

NOTE! The rated value of the relay's current input, 5 A and 1A , 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 inputs I_{01} or I_{02} 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 relay's input is 4 A.

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

Example 2: Primary to secondary.

CT = 500/5

The relay 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 of the transformer.

The rated current for high voltage side (HV) and low voltages side (LV) are calculated by the device itself using Equation 4.7.1-1.

Equation 4.7.1-1

$$I_N = \frac{S_N}{\sqrt{3} \cdot U_N}$$

Where

I_N	=	The rated current 1 pu.
S_N	=	Rated apparent power of the protected device
U_N	=	Rated line-to-line voltage of the protected device

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

	Phase current scaling excluding ArcI> stage	**Residual current ($3I_0$) scaling and phase current scaling for ArcI> stage**
secondary ⇒ per unit	$I_{PU} = \frac{I_{SEC} \cdot CT_{PRI}}{CT_{SEC} \cdot I_N}$	$I_{PU} = \frac{I_{SEC}}{CT_{SEC}}$
per unit ⇒ secondary	$I_{SEC} = I_{PU} \cdot CT_{SEC} \cdot \frac{I_N}{CT_{PRI}}$	$I_{SEC} = I_{PU} \cdot CT_{SEC}$

Example 1: Secondary to per unit and percent for phase currents excluding ArcI>.

CT_{PRI} = 150/1
CT_{SEC} = 800/5
S_N = 25 MVA
U_N = 110 kV
U'_N = 21 kV

Current injected to the relay's primary side input is 175 mA and 859 mA for the secondary side input.

The rated current on HV and LV side will be
I_N = 25 MVA/(√3 x 110 kV) = 131.2 A
I'_N = 25 MVA/(√3 x 21 kV) = 687.3 A

⇒ Per unit currents are
I_{PU} = 0.175x150/(1x131.2) = 0.20 pu = 20 %xI_N (HV side)
I'_{PU} = 0.859x800/(5x687.3) = 0.20 pu = 20 % (LV side)

Example 2: Secondary to per unit for ArcI>.

CT = 750/5

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

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

Example 3: Per unit and percent to secondary for phase currents excluding ArcI>.

CT_{PRI} = 150/1
CT_{SEC} = 800/5
S_N = 25 MVA
U_N = 110 kV
U'_N = 21 kV
The relay setting is 0.20 pu = 20 %xI_N.
The rated current on HV and LV side will be same as in example 1.
⇒ The corresponding secondary currents are
I_{SEC} = 0.20xI_N = 0.20x131.2x1/150 = 175 mA (HV side)
I'_{SEC} = 0.20xI'_N = 0.20x687.3x5/800 = 859 mA (LV side)

Example 4: Per unit to secondary for ArcI>.

CT = 750/5

The relay setting is 2 pu = 200 %.

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

Example 5: Secondary to per unit for residual current.

Input is I_{01} or I_{02}.

CT_0 = 50/1

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

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

Example 6: Per unit to secondary for residual current.

Input is I_{01} or I_{02}.

CT_0 = 50/1

The relay setting is 0.03 pu = 3 %.

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

Example 7: Secondary to per unit for residual current.

Input is I_{0Calc}.

CT = 750/5

Currents injected to the relay'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 8: Per unit to secondary for residual current.

Input is I_{0Calc}.

CT = 750/5

The relay 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

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 VAMP 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 9.1.5 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, T2	0 1		Status of trip output relay	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", "Alarm relay n",	Set

Set = An editable parameter (password needed)

F = Editable when force flag is on

5.2. Digital inputs

There are 6 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.

Common input	Input group	Wetting voltage	
		On	Off
X7:7	X7: 1-6 (DI 7-12)	≥18 V_{DC} or ≥50 V_{AC}	≤10 V_{DC} or ≤5 V_{AC}

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 ... DI6	0 1		Status of digital input	
DI COUNTERS				
DI1 ... DI6	0 ... 65535		Cumulative active edge counter	(Set)
DELAYS FOR DIGITAL INPUTS				
DI1 ... DI6	0.00 ... 60.00	s	Definite delay for both on and off transitions	Set
CONFIGURATION DI1 ... DI6				
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

Parameter	Value	Unit	Description	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...6	Set
Description	String of max. 32 characters		Long name for DIs. Default is "Digital input n", n=1...6	Set

Set = An editable parameter (password needed)

Summary of digital inputs:

DI	Terminal	Operating voltage	Availability
←	X3:1	48V$_{DC}$ supply for DI1…6	VAMP 265
1	X3:2	Internal 48V$_{DC}$	
2	X3:3		
3	X3:4		
4	X3:5		
5	X3:6		
6	X3:7		
19	X6:1…2	External 18…265 V$_{DC}$ 50…250 V$_{AC}$	ARC card with 2 DIs

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
NAMES for VIRTUAL INPUTS (editable with VAMPSET only)				
Label	String of max. 10 characters		Short name for VIs on the local display Default is "VIn", n=1...4	Set
Description	String of max. 32 characters		Long name for VIs. Default is "Virtual input n", n=1...4	Set

Set = An editable parameter (password needed)

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

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.

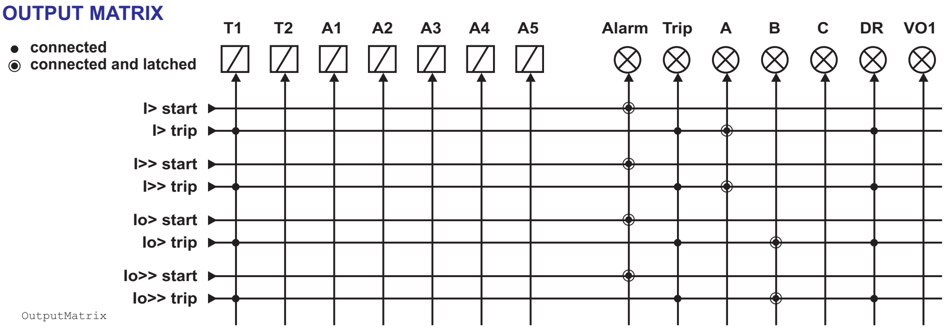


Figure 5.4-1 Output matrix.

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 DI6, 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.

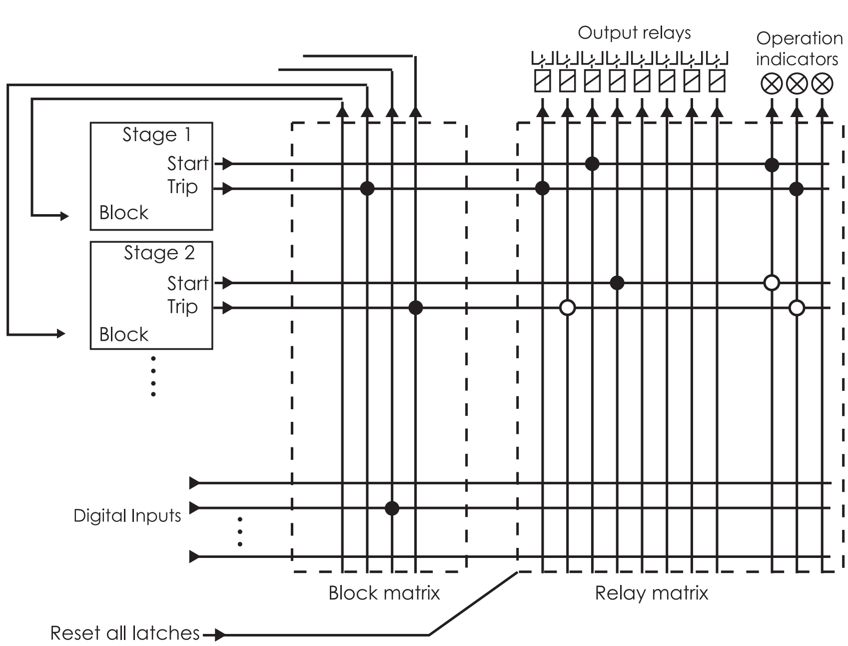


Figure 5.5-1 Blocking matrix and output matrix

5.6. Controllable objects

The relay 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:

- through the local HMI
- through a remote communication
- 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 1-65 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. Logic functions

The relay supports customer-defined programmable logic for boolean signals. The logic is designed by using the VAMPSET setting tool and downloaded to the relay. 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 relay has three communication ports as standard. A fourth port, Ethernet, is available as option. See Figure 6.1-1.

There are three communication ports in the rear panel. The Ethernet port is optional. The X4 connector includes two ports: local port and extension port. The front panel RS-232 port will shut off the local port on the rear panel when a VX003 cable is inserted.

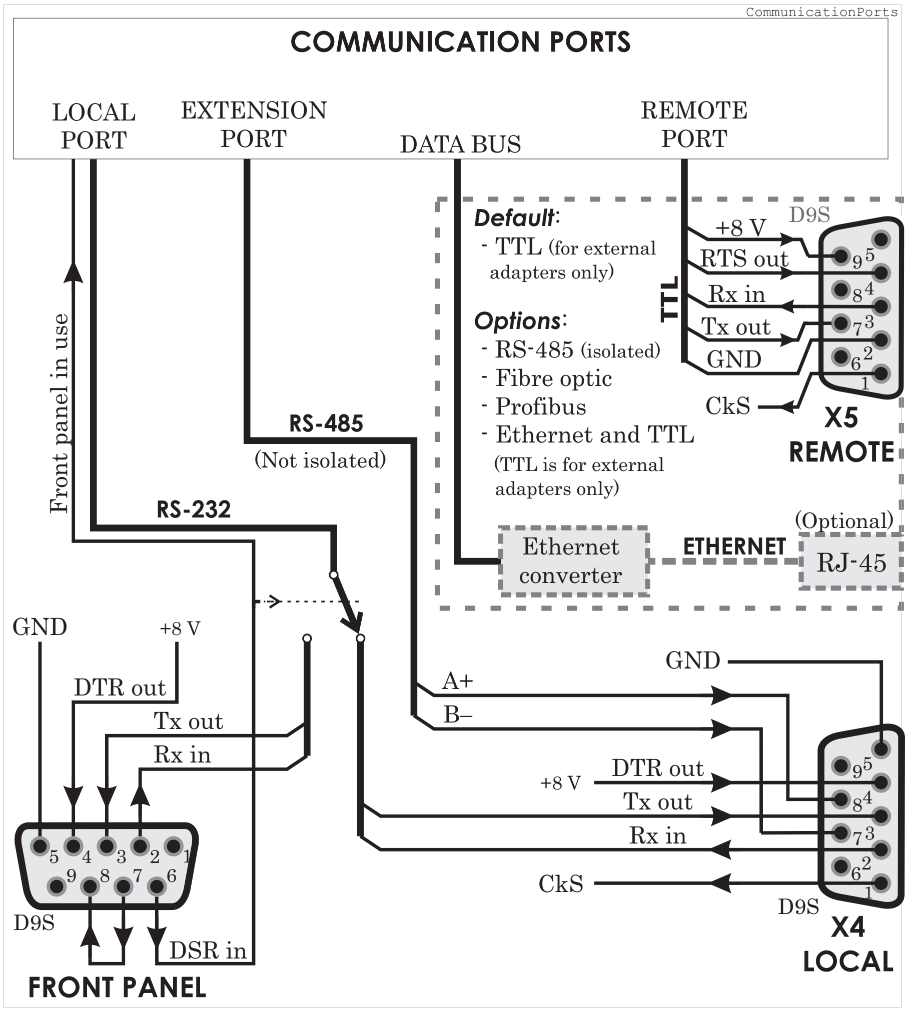


Figure 6.1-1. Communication ports and connectors. By default the X5 is a D9S type connector with TTL interface. The DSR signal from the front panel port selects the active connector for the RS232 local port.

By default the remote port has a TTL interface. It can only be used together with external converters or converting cables. Inbuilt options for RS-485, fibre optic (plastic/plastic, plastic/glass, glass/plastic or glass/glass), Profibus and Ethernet are available.

6.1.1. Local port X4

The local port has two connectors:

- On the front panel
- X4 the rear panel (D9S pins 2, 3 and 5)

Only one can be used at a time.

NOTE! The extension port is locating in the same X4 connector.

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.

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 X5

Physical interface

The physical interface of this port depends of the communication letter in the order code. See Figure 6.1-1, 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	Profibus interface	D9S
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
H	Ethernet interface and TTL (for external converters only)	RJ-45 and D9S

Parameters

Parameter	Value	Unit	Description	Note
Protocol			Protocol selection for remote port	Set
	None		-	
	SPA-bus		SPA-bus (slave)	
	ProfibusDP		Profibus DB (slave)	
	ModbusSla		Modbus RTU slave	
	ModbusTCPs		Modbus TCP slave	
	IEC-103		IEC-60870-5-103 (slave)	
	ExternalIO		Modbus RTU master for external I/O-modules	
	DNP3		DNP 3.0	
Msg#	0 ... $2^{32}-1$		Message counter since the device has restarted or since last clearing	Clr
Errors	0 ... $2^{16}-1$		Protocol errors since the device has restarted or since last clearing	Clr
Tout	0 ... $2^{16}-1$		Timeout errors since the device has restarted or since last clearing	Clr
			Display of current communication parameters.	1)
	speed/DPS		speed = bit/s	

			D = number of data bits P = parity: none, even, odd S = number of stop bits	
Debug	 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 X4

This is a non-isolated RS-485 port for external I/O devices. The port is located in the same rear panel D9S connector X4 as the local port, but pins (7, 8, 5) are used instead of the standard RS-232 pins (2, 3, 5) used by the local port. See Figure 6.1-1.

Parameters

Parameter	Value	Unit	Description	Note
Protocol	 None SPA-bus ProfibusDP ModbusSla ModbusTCPs IEC-103 ExternalIO DNP3		Protocol selection for the extension port. Command line interface for VAMPSET 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 Default = 38400/8N1 for VAMPSET		Display of actual communication parameters. speed = bit/s D = number of data bits P = parity: none, even, odd S = number of stop bits	1)

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. Optional inbuilt ethernet port

This is an optional inbuilt Ethernet port for VAMPSET and Modbus TCP and other communication protocols using TCP/IP. See Figure 6.1-1.

The IP address, net mask, gateway, name server and NTP server are common with the internal ethernet port setting in chapter 6.2.7.

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)	
	ModbusTCPs		Modbus TCP slave	
	IEC-103		IEC-60870-5-103 (slave)	
	ExternalIO		Modbus RTU master for external I/O-modules	
	DNP3		DNP 3.0	
Port	Default = 502		TCP/IP port.	Set
IpAddr	n.n.n.n		IP address. (Use VAMPSET to edit.)	Set
NetMsk	n.n.n.n		Net mask (Use VAMPSET to edit.)	Set
Gatew	n.n.n.n		Gateway (Use VAMPSET to edit.)	Set
NTPSvr	n.n.n.n		IP address for network time protocol (NTPS) server. (Use VAMPSET to edit.)	Set
VSport	Default=23		VAMPSET port for IP	Set
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

6.1.5. Optional 61850 interface

With this option the relay has two communication connectors in the rear panel : RJ-45 connector (61850 interface, Ethernet 10/100-Base T) and a 6 pin connector (Extension port).

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 TCP/IP and 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 TCP/IP configuration see chapter 6.2.7.

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_SWx.xx 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 TCP/IP configuration see chapter 6.2.7.

Parameters

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

Set = An editable parameter (password needed)

6.2.3. Profibus DP

The Profibus DP protocol is widely used in industry. An external VPA 3CG or an internal Profibus module (see the order code in chapter 12.) 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 document ProfiBusDPdeviceProfilesOf-VAMPdevices.pdf available of 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_SWx.xx.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 manager 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_SWx.xx.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.

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 relay supports communication using DNP 3.0 protocol.

The following DNP 3.0 data types are supported:

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

Additional information can be obtained from the DNP3_Parameters_SWx.xx.pdf.

DNP 3.0 communication is activated via menu selection. RS-485 interface is often used but also RS-232 and fibre optic interfaces are possible.

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 Profile checklist 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. TCP/IP

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

The IP address, net mask, gateway, name server and NTP server are common with the internal ethernet port setting in chapter 6.1.4.

Parameters

Parameter	Value	Unit	Description	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
NameSv	default = 0.0.0.0		Name server (set with VAMPSET)	Set
NTPSvr	n.n.n.n		Network time protocol server (set with VAMPSET) 0.0.0.0 = no SNTP	Set
Port	502 = default		Port 502 is reserved for Modbus TCP	Set

Set = An editable parameter (password needed)

6.2.9. External I/O (Modbus RTU master)

External Modbus I/O devices can be connected to the relay using this protocol. (See chapter External input / output module for more information).

6.2.10. IEC 61850

IEC 61850 protocol is available with the optional 61850 interface. The protocol can be configured to transfer the same information which is available with the IEC 103 protocol. Configuration is described in document “IEC 61850 communication VAMP relays/VSE 006, Configuration instructions”. When IEC 61850 is used the Remote port protocol of the relay is set to IEC-103.

7. Applications

7.1. Restricted earth fault protection

Restricted earth fault (REF) protection is a sensitive way to protect a zone between two measuring points against earth faults. See Figure 7.1-1.

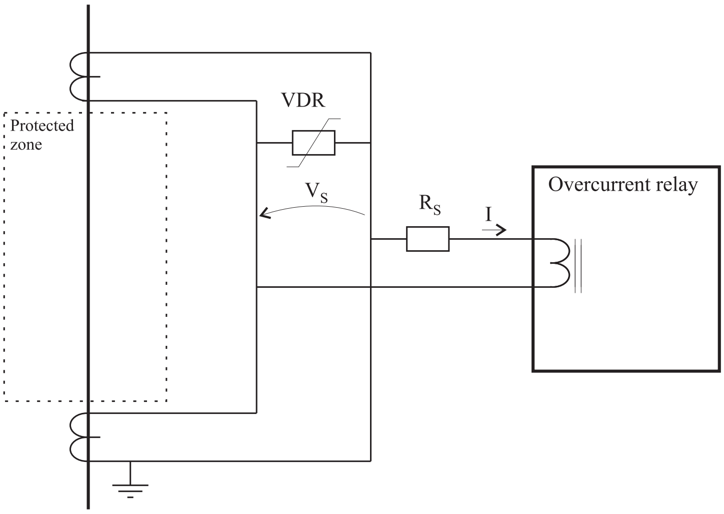


Figure 7.1-1 Principle of restricted earth fault protection. The CT secondaries are wired to cancel each other's currents during through faults and to drive all to the relay when the fault is inside the protected zone. (Saturation of the CTs makes the situation a little more complicated than that.) The stabilizing resistor Rs guarantees that the relay will not trip during a through fault. The VDR is used to protect the CTs and the wiring by limiting the voltage Vs during heavy inside faults.

When there is a fault outside the protected zone the CT secondaries will cancel each other's currents. This is partly true even if both or only one of the CTs saturates, because the impedance of a saturated CT secondary will collapse to near zero. The non-zero wiring impedance and CT impedance will however cause a voltage V_S, but the resistor R_S will prevent the relay from tripping. RS is called the stabilizing resistor.

During an inside fault the secondary currents of the two CTs have no other way to go than the relay. The relay will trip when the current $I = V_S/R_S$ exceeds the setting I_S of the relay. The voltage dependent resistor (VDR, varistor, METROSIL) is used to protect the CTs and wiring by limiting the voltage V_S during heavy inside faults.

The resistance of the secondary loop connecting the CTs together should be as low as possible.

7.2. Restricted earth fault protection for a transformer with neutral connection

Figure 7.2-1 shows and example where three phase current CTs are connected parallel with each other and then in series with the CT in the neutral point.

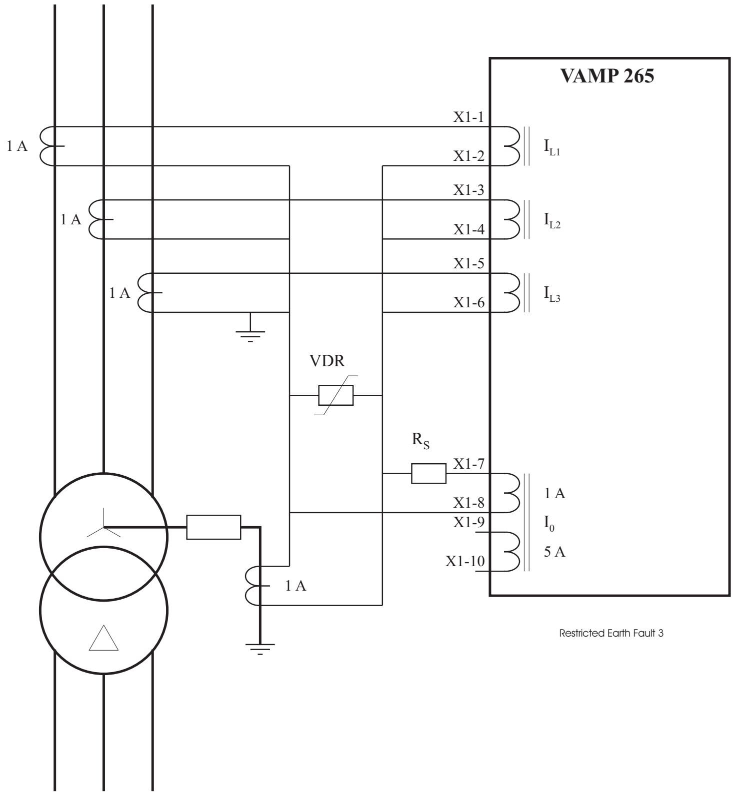


Figure 7.2-1 Overcurrent and restricted earth fault protection of transformer's wye winding. All the CTs have the same ratio and the nominal secondary current is 1 A. In through fault the residual secondary currents of phase CTs and the neutral CT cancel each other and in inside fault the two residual secondary currents are summed up and forced to flow through the I_0 input of the relay and the voltage limiting VDR.

7.2.1. CT Requirements

Any difference between the CTs will give a misleading residual current signal to the relay. Especially during heavy through faults (i.e. the fault is outside the protected zone) the dissimilar saturation of the CTs should not yield to a REF trip. On the other hand a very high fault current causing an unselective earth fault start or trip is not a fatal error.

Class X CT

In restricted earth fault protection the high and low side CTs should give similar responses even for high over currents.

Class X CTs will fulfil this requirement. Their performance is defined in terms of a knee-point voltage (V_{KP}), the magnetizing current at the knee point voltage and the resistance of the secondary winding at +75 °C.

Knee point voltage (V_{KP}) is the secondary voltage at which a 50 % increase of primary current is needed to increase the secondary voltage by 10 %.

7.3. Calculating the stabilizing resistance R_S, VDR value and actual sensitivity

7.3.1. Value of stabilizing resistor R_S

The voltage V_S (Figure 7.1-1) is:

Equation 7.3.1-1

$$V_S = I_{MAXT} \frac{CT_{SEC}}{CT_{PRIM}} R_{CT} + R_W$$

I_{MAXT}	=	Maximum through fault current not to cause an REF trip[1]
CT_{SEC}	=	Nominal secondary current of the CT
CT_{PRI}	=	Nominal primary current of the CT
R_{CT}	=	Resistance of CT secondary.
R_W	=	Total resistance of wiring, connections etc.

The CT should be of class X (see chapter 7.2.1) and the knee point voltage should be twice the calculated V_S.

[1] Selecting a low value helps to achieve more sensitivity and helps to avoid the usage of a voltage limiting VDR. An unselective earth fault pick-up/trip is not always a problem if a fast overcurrent stage will clear the fault anyway.

The stabilizing resistor R_S is calculated as:

Equation 7.3.1-2

$$R_S = \frac{V_S}{I_{Set}}$$

I_{Set} = Setting value of the relay as secondary value.

7.3.2. Voltage limitation

During heavy inside faults the voltage in the secondary circuit may rise to several kilovolts depending on the fault currents, CT properties and the stabilizing resistor R_S. If the secondary voltage would exceed 2 kV it should be limited using a voltage dependent resistor (VDR).

The peak voltage according a linear CT model is:

Equation 7.3.2-1

$$V_p = I_{MAXF} \frac{CT_{SEC}}{CT_{PRIM}} B_{CT} + R_W + R_S$$

I_{MAXF}	=	Maximum fault current when the fault is inside the protected zone
CT_{SEC}	=	Nominal secondary current of the CT
CT_{PRI}	=	Nominal primary current of the CT
R_{CT}	=	Resistance of CT secondary.
R_W	=	Total resistance of wiring, connections, relay input etc.
R_S	=	Stabilizing resistor according Equation 7.3.1-2.

The peak voltage of a saturating CT can be approximated using P. Mathews' formula:

Equation 7.3.2-2

$$V_{sp} = 2\sqrt{2V_{KP}V_P - V_{KP}}$$

V_{KP}	=	Knee point voltage of the CT. The secondary voltage at which a 50 % increase of primary current is needed to increase the secondary voltage by 10%.
V_P	=	Peak voltage according linear model of a CT

This approximating formula does not hold for an open circuit condition and is inaccurate for very high burden resistances.

7.3.3. Actual operating sensitivity

The differential scheme will multiply the fault current by two thus increasing the sensitivity from the actual setting. The quiescent current of the possible VDR will decrease the sensitivity from the actual setting value.

7.3.4. Example

CT	=	2000/1	V_{KP} = 100 V
I_{MAXT}	=	16 kA = 8 x I_N	
I_{REF}	=	5 % = 50 mA	Setting value scaled to secondary level
R_{CT}	=	6 Ω	
R_W	=	0.4 Ω	
I_{MAXF}	=	25 kA	

Maximum secondary voltage during a through fault (Equation 7.3.1-1):

$$V_S = 16000 \frac{1}{2000} 6 + 0.4 - 51.2\ \text{V}$$

Conclusion: The knee point voltage of 100 V is acceptable being about twice the V_S..

Serial resistance for the relay input (Equation 7.3.1-2):

$$R_S = \frac{51.2}{0.05} = 1024\ \Omega \approx 1000\ \Omega$$

Maximum peak voltage during inside fault using a linear model for CT (Equation 7.3.2-1):

$$V_p = 25000 \frac{1}{2000} (6 + 0.4 + 1000) = 12.6\ \text{kV}$$

Approximation of peak voltage during inside fault using a non-linear model for a saturating CT (Equation 7.3.2-2):

$$V_{sp} = 2\sqrt{2 \cdot 100(12600 - 100)} = 3.2\ \text{kV}$$

This is a too high value and a VDR must be used to reduce the voltage below 3 kV.

A zinc oxide varistor (i.e. VDR, METROSIL) of 1 kV will limit the voltage. Using a 400 J model allows two 20 VA CTs feeding ten times their nominal power during one second before the energy capacity of the varistor is exceeded.

7.4. Current Transformer Selection

Iron core current transformers (CT) are accurate in amplitude and phase when used near their nominal values. At very low and at very high currents they are far from ideal. For over-current and differential protection, the actual performance of CTs at high currents must be checked to ensure correct function of the protection relay.

7.4.1. CT classification according IEC 60044-1, 1996

CT model

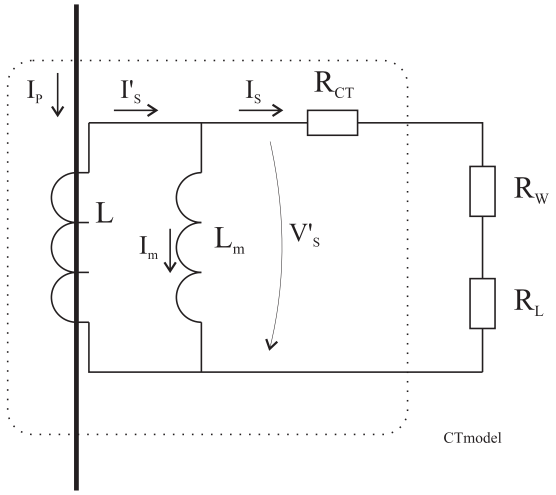


Figure 7.4.1-1 A CT equivalent circuit. L_m is the saturable magnetisation inductance, L is secondary of an ideal current transformer, R_{CT} is resistance of the CT secondary winding, R_W is resistance of wiring and R_L is the burden i.e. the protection relay.

Composite error ε_C

Composite error is the difference between the ideal secondary current and the actual secondary current under steady-state conditions. It includes amplitude and phase errors and also the effects of any possible harmonics in the exciting current.

Equation 7.4.1-1

$$\varepsilon_C = \frac{\sqrt{\frac{1}{T}\int_0^T (K_N i_S - i_P)^2 dt}}{I_P} \cdot 100\%$$

T	=	Cycle time
K_N	=	Rated transformation ratio $I_{NPrimary}/I_{Nsecondary}$
i_S	=	Instantaneous secondary current
i_P	=	Instantaneous primary current
I_P	=	Rms value of primary current

NOTE: All current based protection functions of VAMP relays, except arc protection, thermal protection and 2nd harmonic blocking functions, are using the fundamental frequency component of the measured current. The IEC formula includes an RMS value of the current. That is why the composite error defined by IEC 60044-1 is not ideal for VAMP relays. However the difference is not big enough to prevent rough estimation.

Standard accuracy classes

At rated frequency and with rated burden connected, the amplitude error, phase error and composite error of a CT shall not exceed the values given in the following table.

Accuracy class	Amplitude error at rated primary current (%)	Phase displacement at rated primary current (°)	Composite error ε_C at rated accuracy limit primary current (%)
5P	±1	±1	5
10P	±3	-	10

Marking:

The accuracy class of a CT is written after the rated power.
E.g. 10 VA **5P**10, 15 VA **10P**10, 30 VA **5P**20

Accuracy limit current I_{AL}

Current transformers for protection must retain a reasonable accuracy up to the largest relevant fault current. Rated accuracy limit current is the value of primary current up to which the CT will comply with the requirements for composite error ε_C.

Accuracy limit factor k_{ALF}

The ratio of the accuracy limit current to the rated primary current.

Equation 7.4.1-2

$$K_{ALF} = \frac{I_{AL}}{I_N}$$

The standard accuracy limit factors are 5, 10, 15, 20 and 30.

Marking:

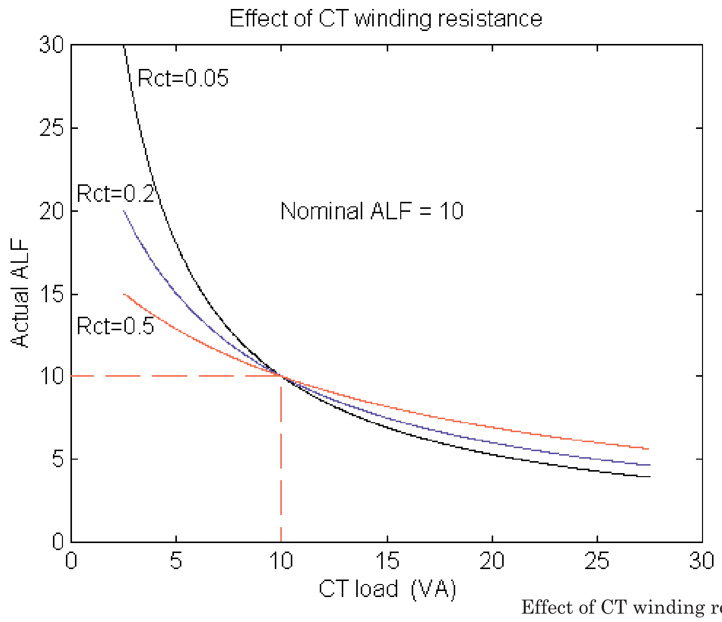
Accuracy limit factor is written after the accuracy class.
E.g. 10 VA 5P**10**, 15 VA 10P**10**, 30 VA 5P**20**.

The actual accuracy limit factor k_A depends on the actual burden.

Equation 7.4.1-3.

$$k_A = k_{ALF} \frac{|S_i + S_N|}{|S_i + S_A|}$$

k_{ALF}	=	Accuracy limit factor at rated current and rated burden
S_i	=	Internal secondary burden. (Winding resistance R_{CT} in Figure 7.4.1-1)
S_N	=	Rated burden
S_A	=	Actual burden including wiring and the load.



Effect of CT winding resistance

Figure 7.4.1-2 This figure of Equation 7.4.1-3 shows that it is essential to know the winding resistance R_{CT} of the CT if the load is much less than the nominal. A 10 VA 5P10 CT with 25% load gives actual ALF values from 15..30 when the winding resistance varies from 0.5 Ω to 0.05 Ω.

7.4.2. CT Requirement for Protection

When the through current equals and exceeds $k_A x I_N$ there may be enough secondary differential current to trip a relay although there is no in zone fault. This is because the CTs are unique and they do not behave equally when approaching saturation.
To avoid false trips caused by heavy through faults the actual accuracy limit factor k_A of the CTs should exceed the relative setting I_{SET} of the non-stabilized differential stage.

Equation 7.4.2-1

$$k_A > c \cdot I_{SET} \cdot \frac{I_{NTra}}{I_{NCT}}$$

c	=	Safety factor
I_{SET}	=	Relative setting of the non-stabilized differential current stage
I_{NTra}	=	Rated current of the transformer (primary side or secondary side)
I_{NCT}	=	Rated primary current of the CT (primary side or secondary side)

Using slightly smaller safety factor than indicated in the table will increase the setting inaccuracy.

Protection application	Safety factor c
Overcurrent	2
Earth-fault, cable transformer	3
Earth-fault overcurrent, sum of three phase currents [2]	6
Transformer differential, Δ-winding or unearthed Y-winding	3
Transformer differential, earthed Y-winding	4
Generator differential	3

Formula to solve needed CT power SN

By replacing the complex power terms with corresponding resistances in Equation 7.4.1-3 we get,

Equation 7.4.2-2

$$k_A = k_{ALF} \frac{R_{CT} + R_N}{R_{CT} + R_W + R_L}$$

where the nominal burden resistance is

$$R_N = \frac{S_N}{I_{NCT\sec}^2}$$

R_{CT}	=	Winding resistance (See Figure 7.4.1-1)
R_W	=	Wiring resistance (from CT to the relay and back)
R_L	=	Resistance of the protection relay input
S_N	=	Nominal burden of the CT
I_{NCTsec}	=	Nominal secondary current of the CT

By solving S_N and substituting k_A according Equation 7.4.2-2 , we get

Equation 7.4.2-3

$$S_N > \left[\frac{cI_{SET} I_{NTra}}{k_{ALF} I_{NCT}} (R_{CT} + R_W + R_L) - R_{CT} \right] I_{NCT\sec}^2$$

[2] Sensitive earth-fault current settings, < 5% x I_N, should be avoided in this configuration because a set of three CTs are not exactly similar and will produce some secondary residual current even though there is no residual current in the primary side.

Example 1

Transformer:

16 MVA YNd11 Z_k = 10%
110 kV / 21 kV (84 A / 440 A)

CT's on HW side:

100/5 5P10
Winding resistance R_{CT} = 0.07 Ω

(RCT depends on the CT type, INCT and power rating. Let's say that the selected CT type, 100 A and an initial guess of 15 VA yields to 0.07 Ω.)
Safety factor c = 4.

(Transformer differential, earthed Y.)

CTs on LV side:

500/5 5P10

(Max. Short circuit curent is 4400 A = 8.8 x 500 A)
Winding resistance R_{CT} = 0.28 Ω

(RCT depends on the CT type, INCT and power rating. Let's say that the selected CT type, 500 A and an initial guess of 15 VA yields to 0.28 Ω.)
Safety factor c = 3.

(Transformer differential, Δ.)

Differential current setting of the non-stabilized stage ΔI>>:
I_{SET} = 9 x I_N

R_L	=	0.008 Ω Typical burden of a VAMP relay current input.
R_{WHV}	=	0.138 Ω Wiring impedance of high voltage side. (2x16 m, 4 mm²)
R_{WLV}	=	0.086 Ω Wiring impedance of low voltage side. (2x10 m, 4 mm²)

The needed CT power on HV side will be

$$S_N > \left[\frac{4 \cdot 9 \cdot 84}{10 \cdot 100} \cdot (0.07 + 0.138 + 0.008) - 0.07 \right] \cdot 5^2 = 14.6 \text{ VA}$$

⇒ 15 VA is a good choice for HV side.

And on the LV side

$$S_N > \left[\frac{3 \cdot 9 \cdot 440}{10 \cdot 500} \cdot (0.28 + 0.086 + 0.008) - 0.28 \right] \cdot 5^2 = 15.2 \text{ VA}$$

⇒ 15 VA is a good choice for LV side.

7.5. Protection of a Dyn11 transformer

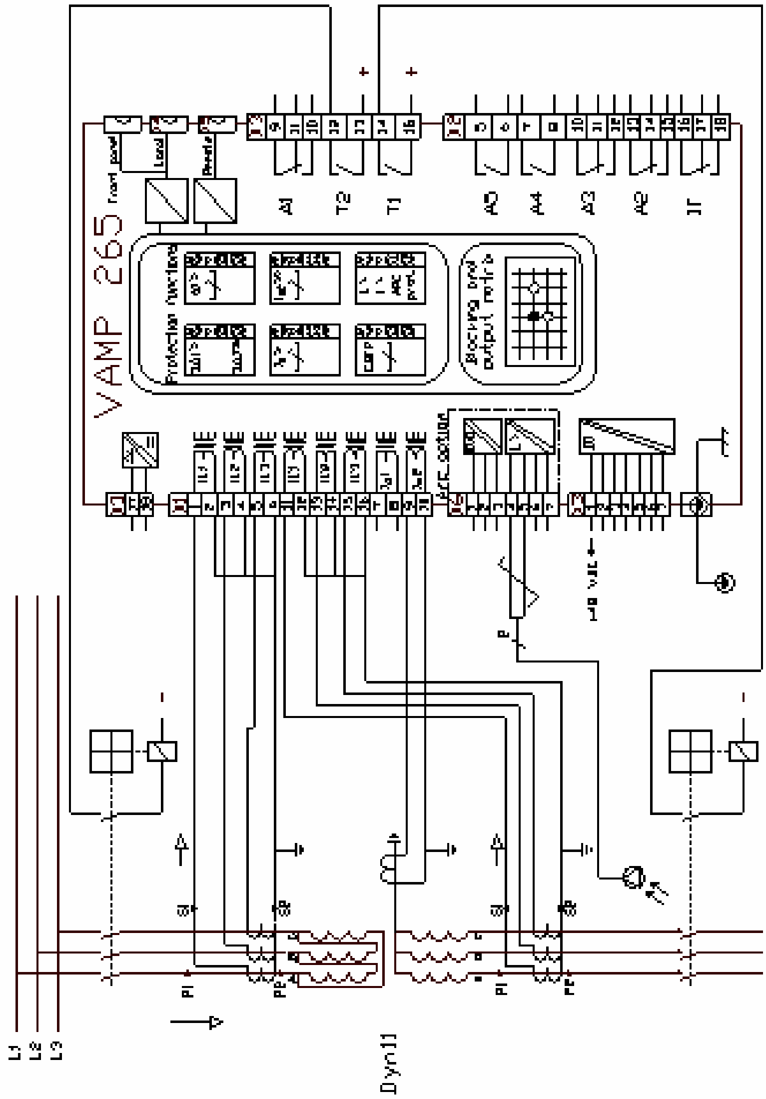


Figure 7.5-1 Differential protection of a Dyn11 transformer using VAMP 265. Primary and secondary current transformers are connected according to subtractive polarity.

Settings:

ConnGrp	Dy11
IoCmps	OFF
I'oCmps	ON
Un	High side voltage
U'n	Low side voltage

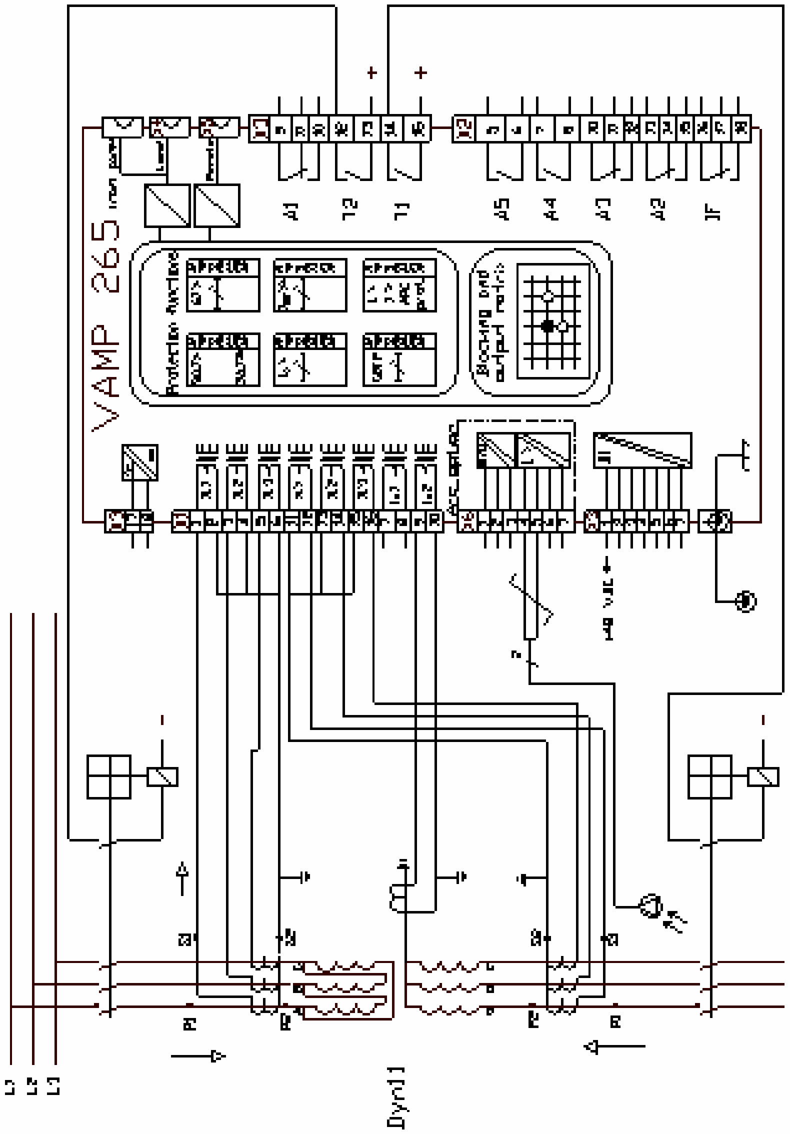


Figure 7.5-2 Differential protection of a Dyn11 transformer using VAMP 265. Primary and secondary current transformers are connected according to additive polarity.

Settings:

ConnGrp	Dy11
IoCmps	OFF
I'oCmps	ON
Un	High side voltage
U'n	Low side voltage

7.6. Protection of a YNd11 transformer

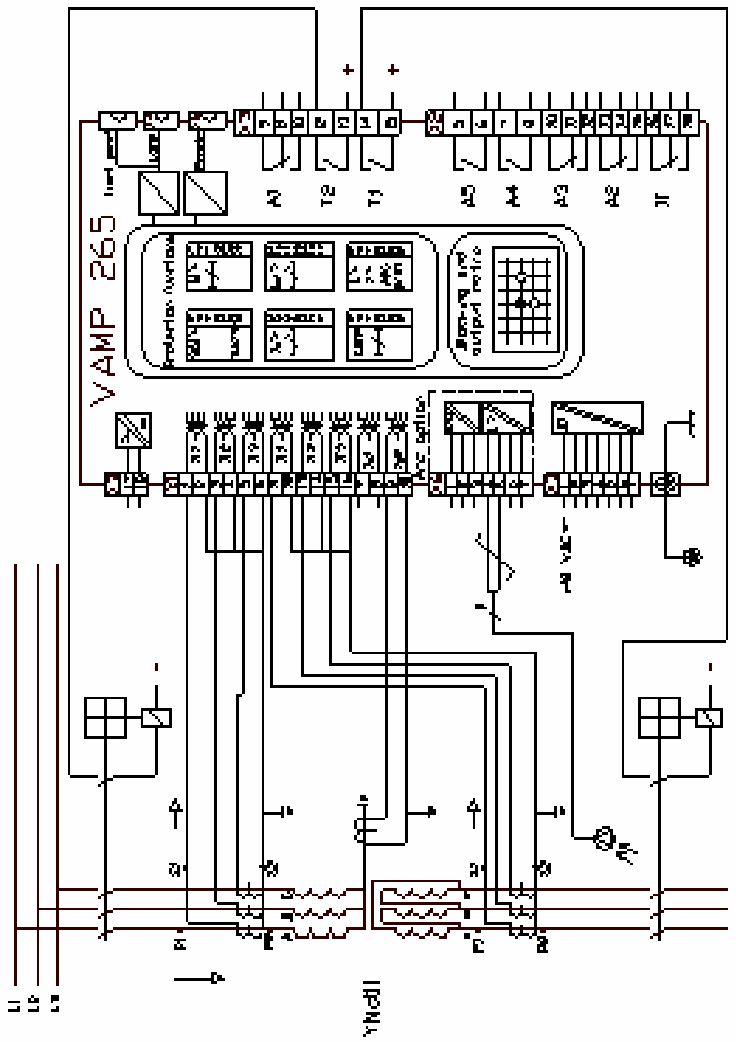


Figure 7.6-1 Differential protection of a YNd11 transformer using VAMP 265.

Settings:

ConnGrp	Yd11
IoCmps	ON
I'oCmps	OFF
Un	High side voltage
U'n	Low side voltage

7.7. Protection of generator and block transformer

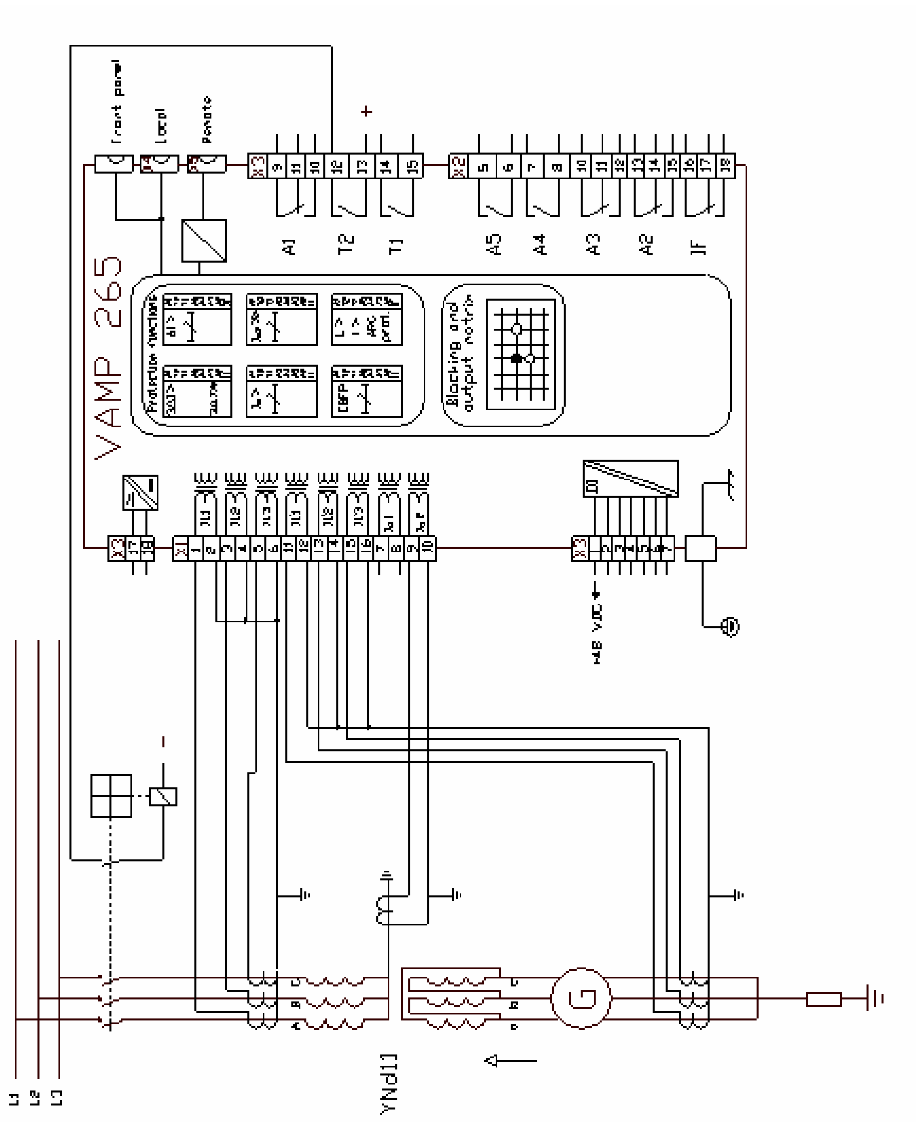


Figure 7.7-1 Differential protection of a YNd11 transformer and generator using VAMP 265.

Settings:

ConnGrp	Yd11
IoCmps	ON
I'oCmps	OFF
Un	High side voltage
U'n	Low side voltage

7.8. Application example of differential protection using VAMP 265

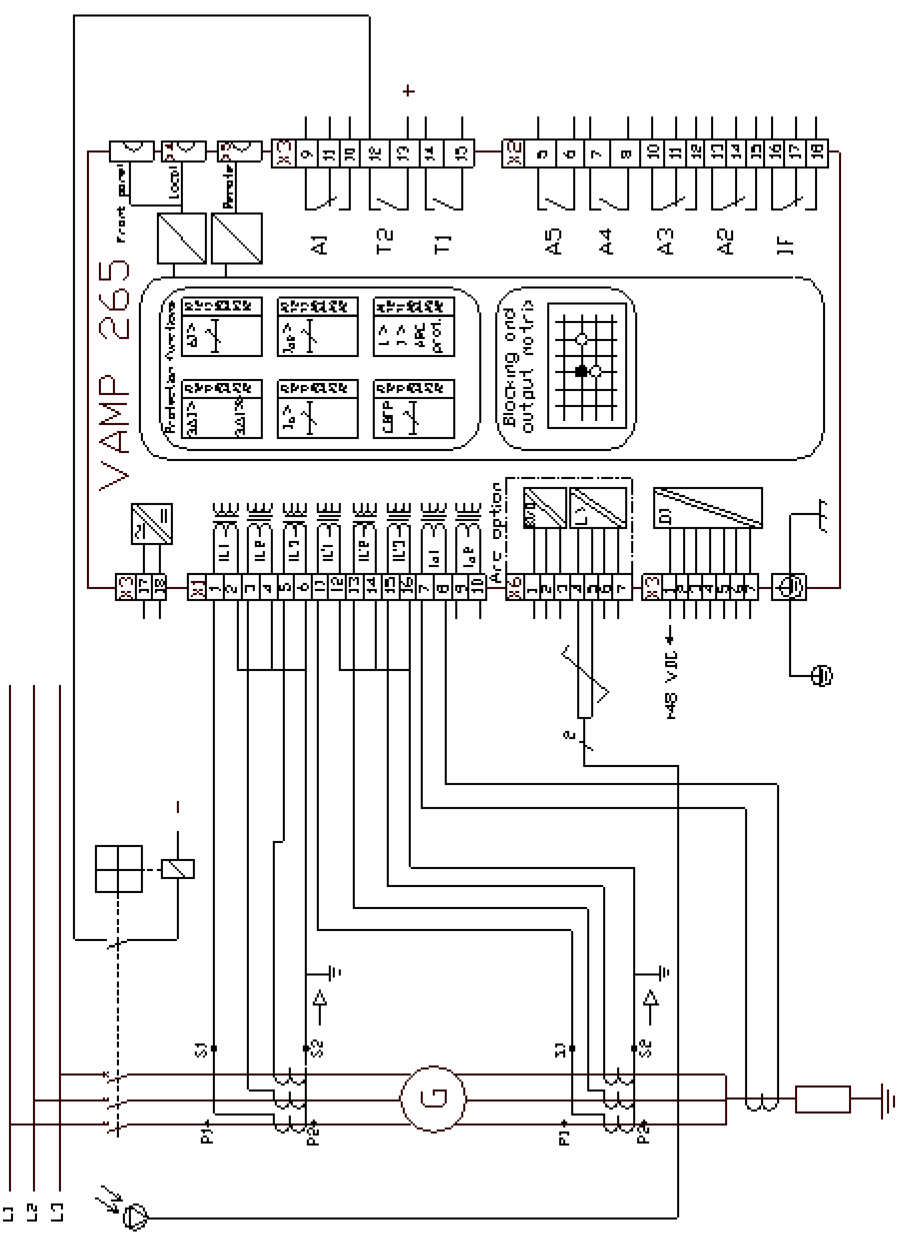


Figure 7.8-1 Differential protection of a generator using VAMP 265.

Settings:

ConnGrp	Yy0
IoCmps	OFF
I'oCmps	OFF
Un	Generator nominal voltage
U'n	Generator nominal voltage

7.9. Trip Circuit Supervision

Trip circuit supervision is used to ensure that the wiring from the protective relay to the circuit breaker is in order. This circuit is most of the time unused, but when the protection relay 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.

A digital input of the relay can be used for trip circuit monitoring.

- The digital input is connected to an auxiliary miniature relay, which is connected parallel with the trip contacts.
- A resistor module enables supervision also when the circuit breaker is open. The module consists of a resistor for 110 V dc and is connected according the auxiliary voltage.
- 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 trip relay should be configured as non-latched. Otherwise a superfluous trip circuit fault alarm will follow after the trip contact operates and remains closed because of latching.

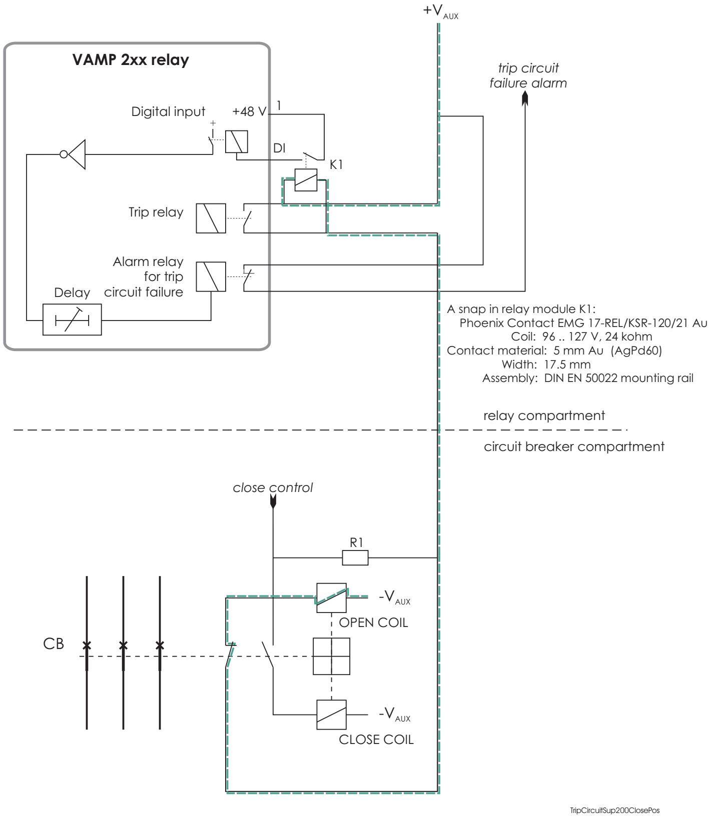


Figure 7.9-1. Trip circuit supervision when the circuit-breaker is closed. The supervised circuitry in this CB position is double-lined. The digital input is in active state.

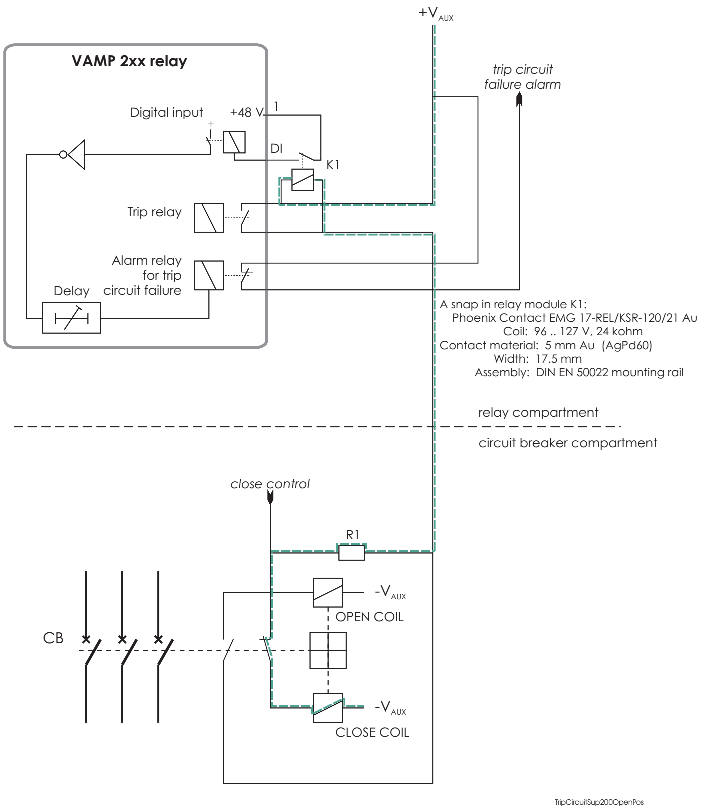


Figure 7.9-2. Trip circuit supervision when the circuit-breaker is open. The supervised circuitry in this CB position is doubled-lined.

8. Connections

8.1. Rear panel view

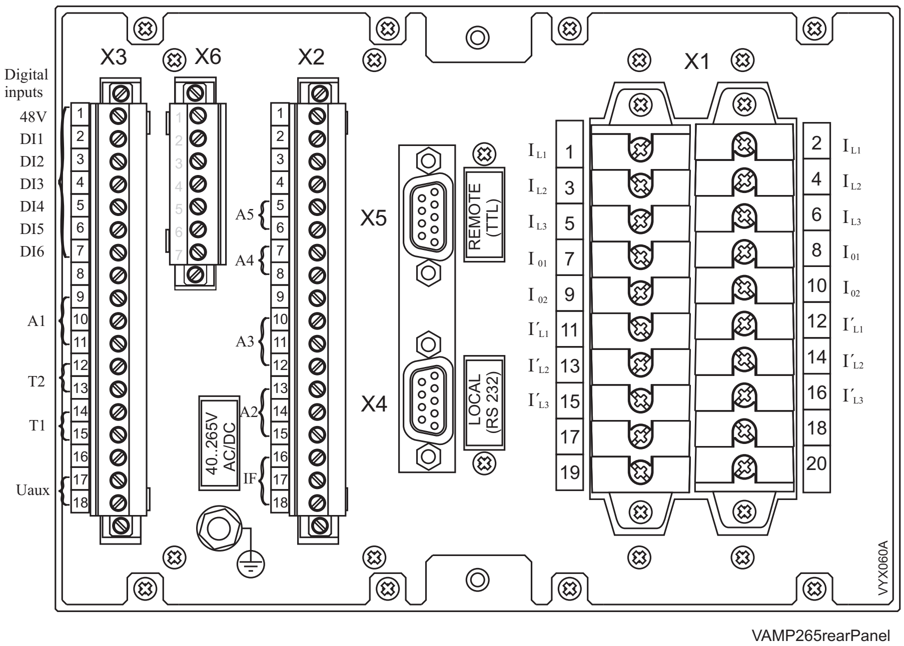
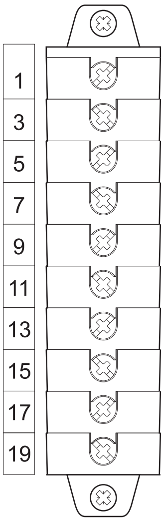


Figure 8.1-1 Connections on the rear panel of the relay.

The generator, transformer and motor differential protection relay is connected to the protected object through the following measuring and control connections, Figure 8.1-1:

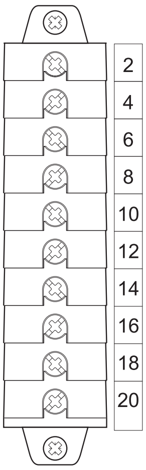
- Phase currents I_{L1}, I_{L2} and I_{L3} (terminals X1: 1-6)
- Phase currents I'_{L1}, I'_{L2} and I'_{L3} (terminals X1: 11-16)
- Earth fault current I_{01} (terminals X1: 7-8)
- Earth fault current I_{02} (terminals X1: 9-10)

Terminal X1 left side



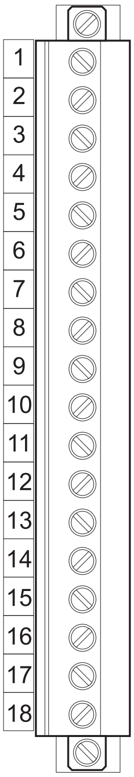
No:	Symbol	Description
1	IL1	Phase current IL1 (S1), high voltage side
3	IL2	Phase current IL2 (S1), high voltage side
5	IL3	Phase current IL3 (S1), high voltage side
7	Io1	Residual current Io1 (S1)
9	Io2	Residual current Io2 (S1)
11	I'L1	Phase current I'L1 (S1), low voltage side
13	I'L2	Phase current I'L2 (S1), low voltage side
15	I'L3	Phase current I'L3 (S1), low voltage side
17	--	--
19	--	--

Terminal X1 right side



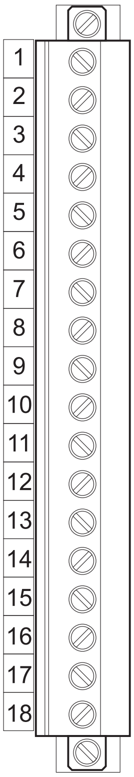
No:	Symbol	Description
2	IL1	Phase current L1 (S2), high voltage side
4	IL2	Phase current L2 (S2), high voltage side
6	IL3	Phase current L3 (S2), high voltage side
8	Io1	Residual current Io1 (S2)
10	Io2	Residual current Io2 (S2)
12	I'L1	Phase current I'L1 (S2), low voltage side
14	I'L2	Phase current I'L2 (S2), low voltage side
16	I'L3	Phase current I'L3 (S2), low voltage side
18	--	--
20	--	--

Terminal X2 without the analogue output



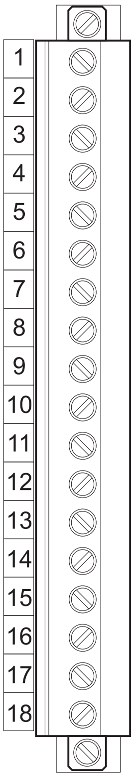
No:	Symbol	Description
1	--	--
2	--	--
3	--	--
4	--	--
5	A5	Alarm relay 5
6	A5	Alarm relay 5
7	A4	Alarm relay 4
8	A4	Alarm relay 4
9	--	--
10	A3 COM	Alarm relay 3, common connector
11	A3 NC	Alarm relay 3, normal closed connector
12	A3 NO	Alarm relay 3, normal open connector
13	A2 COM	Alarm relay 2, common connector
14	A2 NC	Alarm relay 2, normal closed connector
15	A2 NO	Alarm relay 2, normal open connector
16	IF COM	Internal fault relay, common connector
17	IF NC	Internal fault relay, normal closed connector
18	IF NO	Internal fault relay, normal open connector

Terminal X2 with the analogue output



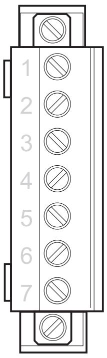
No:	Symbol	Description
1	AO1+	Analogue output 1, common positive connector
2	AO1–	Analogue output 1, negative connector
3	AO2+	Analogue output 2, common positive connector
4	AO2–	Analogue output 2, negative connector
5	AO3+	Analogue output 3, common positive connector
6	AO3–	Analogue output 3, negative connector
7	AO4+	Analogue output 4, common positive connector
8	AO4–	Analogue output 4, negative connector
9	--	--
10	A3 COM	Alarm relay 3, common connector
11	A3 NC	Alarm relay 3, normal closed connector
12	A3 NO	Alarm relay 3, normal open connector
13	A2 COM	Alarm relay 2, common connector
14	A2 NC	Alarm relay 2, normal closed connector
15	A2 NO	Alarm relay 2, normal open connector
16	IF COM	Internal fault relay, common connector
17	IF NC	Internal fault relay, normal closed connector
18	IF NO	Internal fault relay, normal open connector

Terminal X3



No:	Symbol	Description
1	+48V	Internal wetting 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

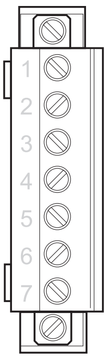
Terminal X6



No:	Symbol	Description
1	BI	External arc light input
2	BO	Arc output
3	COM	Common for BI and BO
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 or dc) for the terminal is connected to the terminals X3: 17-18.

NOTE! Polarity of the auxiliary voltage U_{aux} (24 V ac, option B) :

– = X3: 17 and + = X3: 18

8.3. Serial communication connectors

The pin assignments of communication connectors including internal communication converters are presented in the following figures and tables.

8.3.1. Front panel connector

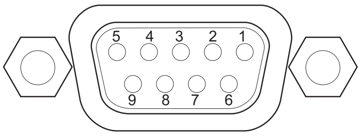


Figure 8.3.1-1 Pin numbering of the front panel D9S connector

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.)

8.3.2. Rear panel connector X5 (REMOTE)

The X5 remote port communication connector options are shown in Figure 8.3.2-1. The connector types are listed in **Table 6.1.2-1**.

Without any internal options, X5 is a TTL port for external converters. Some external converters (VSE) are attached directly to the rear panel and X5. Some other types (VEA, VPA) need various TTL/RS-232 converter cables. The available accessories are listed in chapter 12 order information.

2&4-wire galvanically isolated RS-485 (Figure 8.3.2-2), Internal options for fibre optic (Figure 8.3.2-3), and Profibus (Figure 8.3.2-4) are available. See chapter 12 order information.

Port (REMOTE)	Pin/ Terminal	TTL (Default)	RS-485 (Option)	Profibus DP (Option)
X5	1	reserved	Signal Ground	
X5	2	Tx out /TTL	Receiver –	
X5	3	Rx in /TTL	Receiver +	RxD/TxD +/P
X5	4	RTS out /TTL	Transmitter –	RTS
X5	5		Transmitter +	GND
X5	6			+5V
X5	7	GND		
X5	8			RxD/TxD -/N
X5	9	+8V out		

NOTE! In the VAMP relays RS485 interfaces a positive voltage from Tx+ to Tx– or Rx+ to Rx– does correspond to the bit value "1". In X5 connector the optional RS485 is galvanically isolated.

NOTE! In 2-wire mode the receiver and transmitter are internally connected in parallel. See a table below.

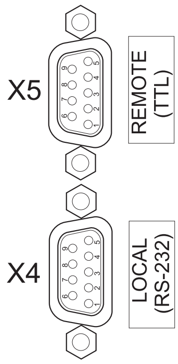


Figure 8.3.2-1 Pin numbering of the rear communication ports, REMOTE TTL

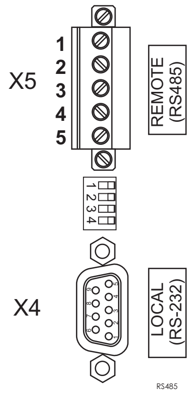


Figure 8.3.2-2 Pin numbering of the rear communication ports, REMOTE RS-485.

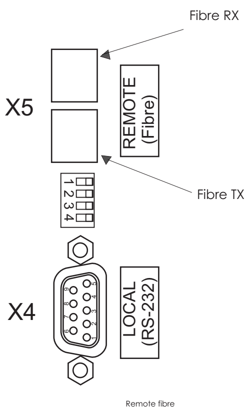


Figure 8.3.2-3 Picture of rear communication port, REMOTE FIBRE.

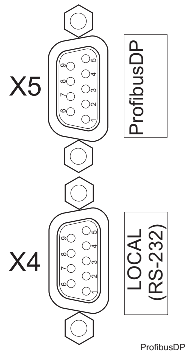


Figure 8.3.2-4 Pin numbering of the rear communication ports, Profibus DP.

8.3.3. X4 rear panel connector (local RS232 and extension RS485 ports)

Rear panel port (LOCAL)	Pin	Signal
X4	1	No connection
X4	2	Rx in, RS232 local
X4	3	Tx out, RS232 local
X4	4	DTR out (+8 V)
X4	5	GND
X4	6	No connection
X4	7	B– RS485 extension port
X4	8	A+ RS485 extension port
X4	9	No connection

NOTE! In the VAMP relays a positive RS485 voltage from A+ to B– corresponds to bit value "1". In X4 connector the RS485 extension port is not galvanically isolated.

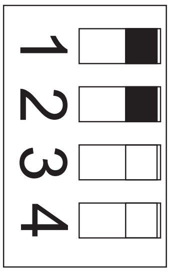


Figure 8.3.3-1 Dip switches in RS-485 and optic fibre options.

Dip switch number	Switch position	Function RS-485	Function Fibre optics
1	Left	2 wire connection	Echo off
1	Right	4 wire connection	Echo on
2	Left	2 wire connection	Light on in idle state
2	Right	4 wire connection	Light off in idle state
3	Left	Termination On	Not applicable
3	Right	Termination Off	Not applicable
4	Left	Termination On	Not applicable
4	Right	Termination Off	Not applicable

NOTE! The internal 2-wire RS485 port in X4 connector is not galvanically isolated.

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 relay or manager.

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:

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 relays front panel. Please refer the User manual VAM 16 D, VM16D.ENxxx for details.

8.6.2. External input / output module

The relay supports an optional external input/output modules used 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 relay 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 relay and read all settings with VAMPSET.

External analog inputs configuration (VAMPSET only)

EXTERNAL ANALOG INPUTS

	AI Enabled	AI Meas	AI Unit	AI Slave Address	AI ModBus Address	AI Register Type	AI Offset	x1	y1	x2	y2	AI Error Counter
	On	0.00 C	C	1	1	HoldingR	0	0	0	1	1	0
	Off	0.00 C	C	1	2	HoldingR	0	0	0	1	1	0
	Off	0.00 C	C	1	3	HoldingR	0	0	0	1	1	0
Range	On / Off		C, F, K, or V/A	1…247	1…9999	InputR or HoldingR	-32000…32000	X: -32000…32000 Y: -1000…1000				
Description	Enabling for measurement	Active value	Unit selection	Modbus address of the IO device	Modbus register for the measurement	Modbus register type	offset: Subtracted from Modbus value, before running XY scaling	X1: Modbus value (Point 1)	Y1: Scaled value (Point 1)	X2: Modbus value (Point 2)	Y2: Scaled value (Point 2)	Communication read errors

Scaling:

X1	Modbus value	Point 1
Y1	Scaled value	Point 1
X2	Modbus value	Point 2
Y2	Scaled value	Point 2
offset	Subtracted from Modbus value, before running XY scaling	

Alarms for external analog inputs

EXTERNAL ANALOG INPUT ALARMS

	AI Enabled	AI Slave Address	AI ModBus Address	AI Meas	External AI Alarm State >	Alarm Limit >	External AI Alarm State >>	Alarm Limit >>	Alarm Hysteresis
	On	1	1	0.00 C	-	0.0	-	0.0	1.0
	Off	1	2	0.00 C	-	0.0	-	0.0	1.0
	Off	1	3	0.00 C	-	0.0	-	0.0	1.0
Range	On / Off	1…247	1…9999		- / Alarm	-21x107… …21x107	- / Alarm	-21x107… …21x107	0…10000
Description	Enabling for measurement	Modbus address of the IO device	Modbus register for the measurement	Active value	Alarm >: Active state	Alarm >: Limit setting	Alarm >>: Active state	Alarm >>: Limit setting	Hysteresis for alarm limits

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

External digital inputs configuration (VAMPSET only)

EXTERNAL DIGITAL INPUTS

	DI Enabled	DI State	DI Slave Address	DI ModBus Address	DI Register Type	DI Selected Bit	DI Error Counter
	On	0	1	1	CoilS	1	0
	Off	0	1	2	CoilS	1	0
	Off	0	1	3	CoilS	1	0
Range	On / Off	0 / 1	1...247	1...9999	CoilS, InputS, InputR or HoldingR	1...16	
Description	Enabling for input	Active state	Modbus address of the IO device	Modbus register for the measurement	Modbus register type	Bit number of Modbus register value	Communication read errors

External digital outputs configuration (VAMPSET only)

EXTERNAL DIGITAL OUTPUTS

	DO Enabled	DO State	DO Slave Address	DO ModBus Address	DO Error Counter
	On	0	1	1	0
	Off	0	1	2	0
	Off	0	1	3	0
Range	On / Off	0 / 1	1...247	1...9999	
Description	Enabling for output	Output state	Modbus address of the IO device	Modbus register for the measurement	Communication errors

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

8.7. Block diagrams

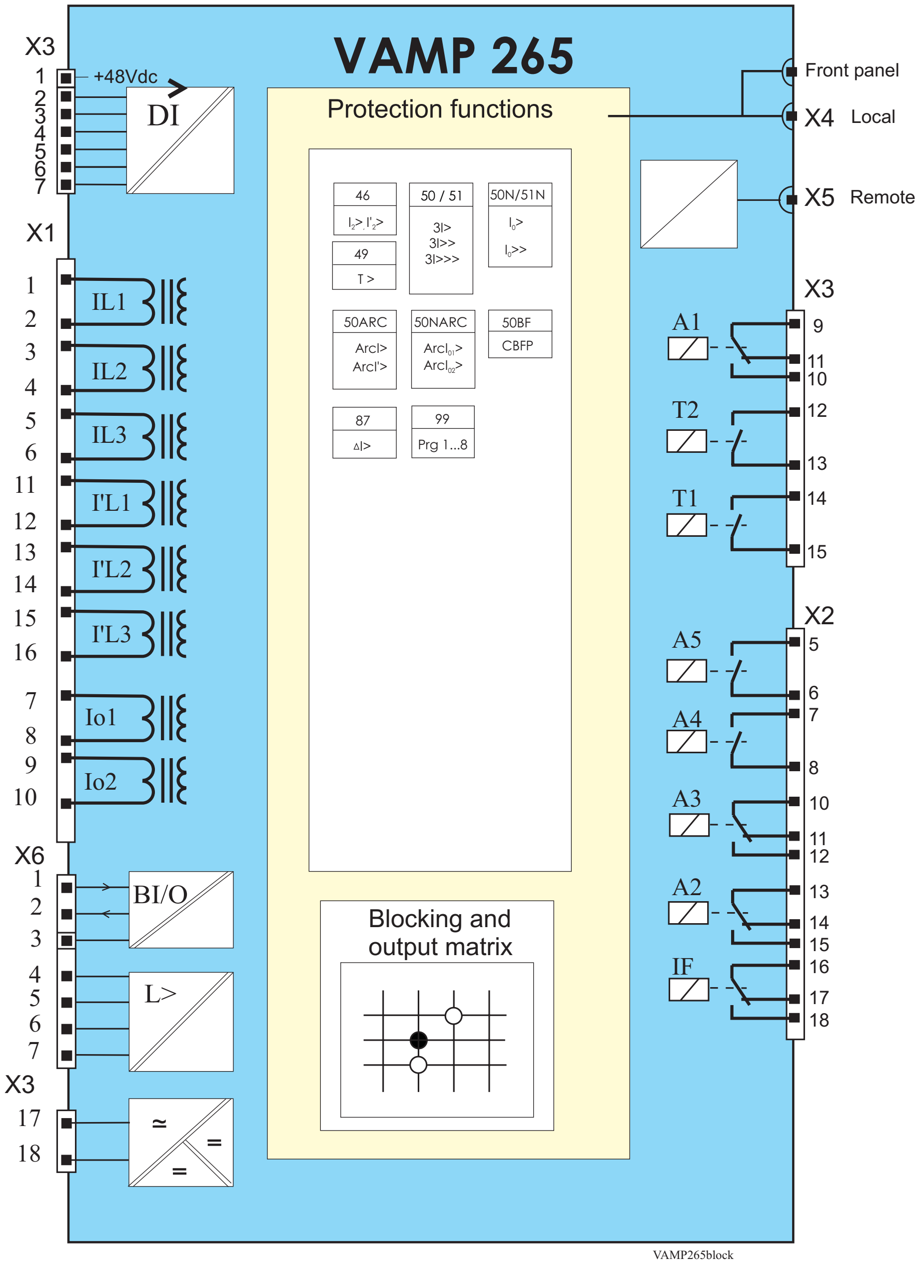


Figure 8.7-1 Block diagram of VAMP 265

8.8. Block diagrams of option modules

8.8.1. Optional arc protection

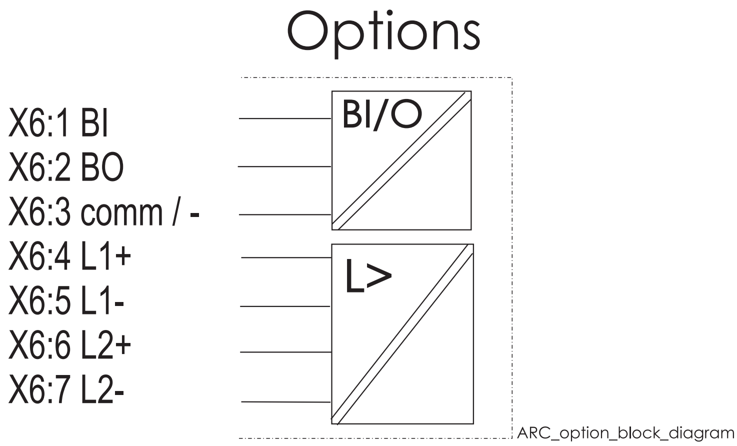


Figure 8.8.1-1 Block diagram of optional arc protection module.

8.8.2. Optional DI19/DI20

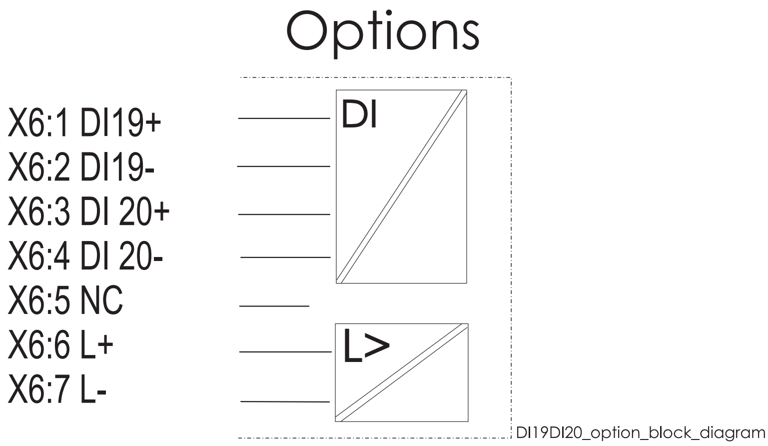


Figure 8.8.2-1 Block diagram of optional DI19/DI20 module with one arc channel.

8.9. Connection examples

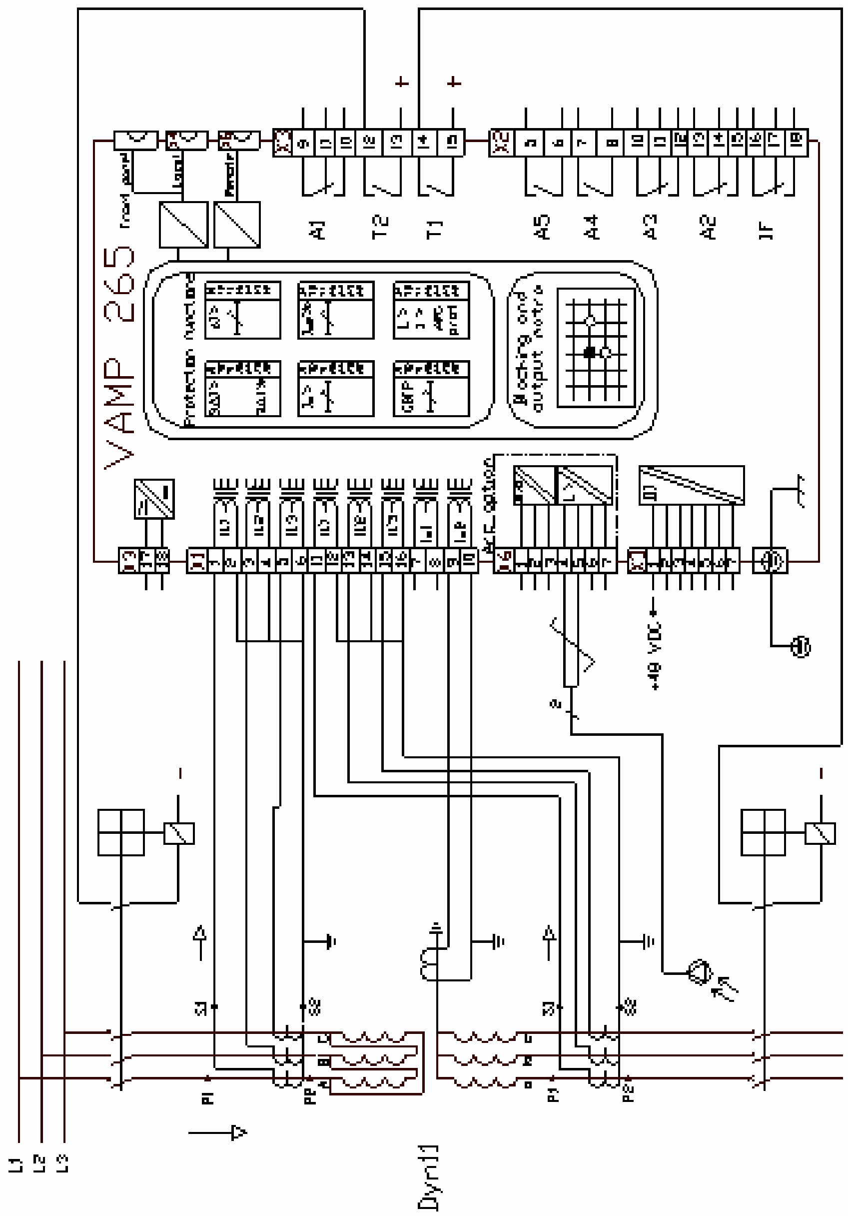


Figure 8.9-1 Connection example of VAMP 265.

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
Rated phase current - Current measuring range - Thermal withstand - Burden	1 A (configurable for CT secondaries 1 – 10 A) 0…50 A 20 A (continuously) 100 A (for 10 s) 500 A (for 1 s) < 0.1 VA
Rated residual current (optional) - Current measuring range - Thermal withstand - Burden	5 A (configurable for CT secondaries 1 – 10 A) 0…25 A 20 A (continuously) 100 A (for 10 s) 500 A (for 1 s) < 0.2 VA
Rated residual current - Current measuring range - Thermal withstand - Burden	1 A (configurable for CT secondaries 0.1 – 10 A) 0…5 A 4 A (continuously) 20 A (for 10 s) 100 A (for 1 s) < 0.1 VA
Rated frequency f_n - Frequency measuring range	45 – 65 Hz 16 – 75 Hz
Terminal block: - Solid or stranded wire	Maximum wire dimension: 4 mm^2 (10-12 AWG)

9.1.2. Auxiliary voltage

	Type A (standard)	Type B (option)
Rated voltage Uaux	40 - 265 V ac/dc 110/120/220/240 V ac 48/60/110/125/220 V dc	18...36 V dc 24 V dc
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	Max. wire dimension: 2.5 mm^2 (13-14 AWG)	

9.1.3. Digital inputs

Number of inputs	6
Operation time	0.00 – 60.00 s (step 0.01 s)
Polarity	NO (normal open) or NC (normal closed)
Inaccuracy: - Operate time	 ±1% or ±10 ms
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	Max. wire dimension: 2.5 mm² (13-14 AWG)

9.1.4. Trip contacts

Number of contacts	2 making contacts
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, AC	2 000 VA
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, 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
Breaking capacity, AC	2 000 VA
Contact material	AgNi 0.15 goldplated
Terminal Block: - Phoenix MVSTBW or equivalent	Max. 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
Data transfer rate	1200 - 38 400 kb/s

9.1.7. Remote control connection

Number of ports	1 on rear panel
Electrical connection	TTL (standard) RS 485 (option) RS 232 (option) Plastic fibre connection (option) Glass fibre connection (option) Ethernet 10 Base-T (option, external module)
Data transfer rate	1 200 - 19 200 kb/s
Protocols	Modbus, RTU master Modbus, RTU slave Spabus, slave IEC 60870-5-103 Profibus DP (option) Modbus TCP (option, external module)

9.1.8. 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 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. Differential protection

Differential overcurrent stage ΔI> (87)

Setting range	5 - 50 % I_n
Bias current for start of slope 1	0.50 x I_n
Slope 1	5 - 100 %
Bias current for start of slope 2	1.00 - 3.00 x I_n
Slope 2	100 - 200 %
Second harmonic blocking	5 - 30 %, or disable
Reset time Reset ratio	< 60 ms 0.95
Inaccuracy: - Starting - Operating time (I_d > 1.2 x I_{set}) - Operating time (I_d > 3 x I_{set})	 ±3% of set value or ±0.5% of rated value < 60 ms < 50 ms

Differential overcurrent stage ΔI>> (87)

Setting range	5.0 - 40.0 x I_n
Reset time Reset ratio	< 60 ms 0.95
Inaccuracy: - Starting - Operating time	 ±3% of set value or ±0.5% of rated value < 40 ms

9.3.2. Non-directional current protection

Overcurrent stage I>, I'> (50/51)

Pick-up current	0.10 – 5.00 x I_{mode}
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 ±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 I_{mode} (I>>)
Definite time function: - Operating time	 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 ±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)

Setting range:	0.1 – 2.40 x I_{mot} or I_N (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_{mot} (step 1)
Max. overload at +70 °C	50 – 100 %I_{mot} (step 1)
Ambient temperature	-55 – 125 °C (step 1°)
Resetting ratio (Start & trip)	0.95
Accuracy:	
- operating time	±5% or ±1 s

Unbalance stage I_2>, I'_2> (46)

Setting range:	2 – 70% (step 1%)
Definite time characteristic:	
- operating time	1.0 – 600.0s s (step 0.1)
Inverse time characteristic:	
- 1 characteristic curve	Inv
- time multiplier K_1	1 – 50 s (step 1)
- Upper limit for inverse time	1 000 s
Start time	Typically 300 ms
Reset time	<450 ms
Reset ratio	0.95
Inaccuracy:	
- Starting	±3% of the set value or 0.5% of the rated value
- Operate time	±5% or ±150 ms

Earth fault stage I_0> (50N/51N)

Input signal	I_0 (input X1-7 & 8) I_{02} (input X1-9 & 10) I_{0Calc} (= $I_{L1}+I_{L2}+I_{L3}$)
Setting range I_0>	0.005 … 8.00 When I_0 or I_{02} 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_{02} (input X1-9 & 10) I_{0Calc} (= $I_{L1}+I_{L2}+I_{L3}$)
Setting range I_0>>	0.01 … 8.00 When I_0 or I_{02} 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.

9.3.3. Circuit-breaker failure protection

Circuit-breaker failure protection CBFP (50BF)

Relay to be supervised	T1-T12
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.

9.3.4. 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 relay is provided with the optional arc protection card.

Arc protection stage ArcI> (50AR), 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
- BO operating time	<3 ms
Reset time	<95 ms
Reset time (Delayed ARC L)	<120 ms
Reset time (BO)	<80 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$_0$> (50AR), 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
- BO operating time	<3 ms
Reset time	<95 ms
Reset time (Delayed ARC L)	<120 ms
Reset time (BO)	<80 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$_{02}$> (50AR), 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
- BO operating time	<3 ms
Reset time	<95 ms
Reset time (Delayed ARC L)	<120 ms
Reset time (BO)	<80 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. 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)

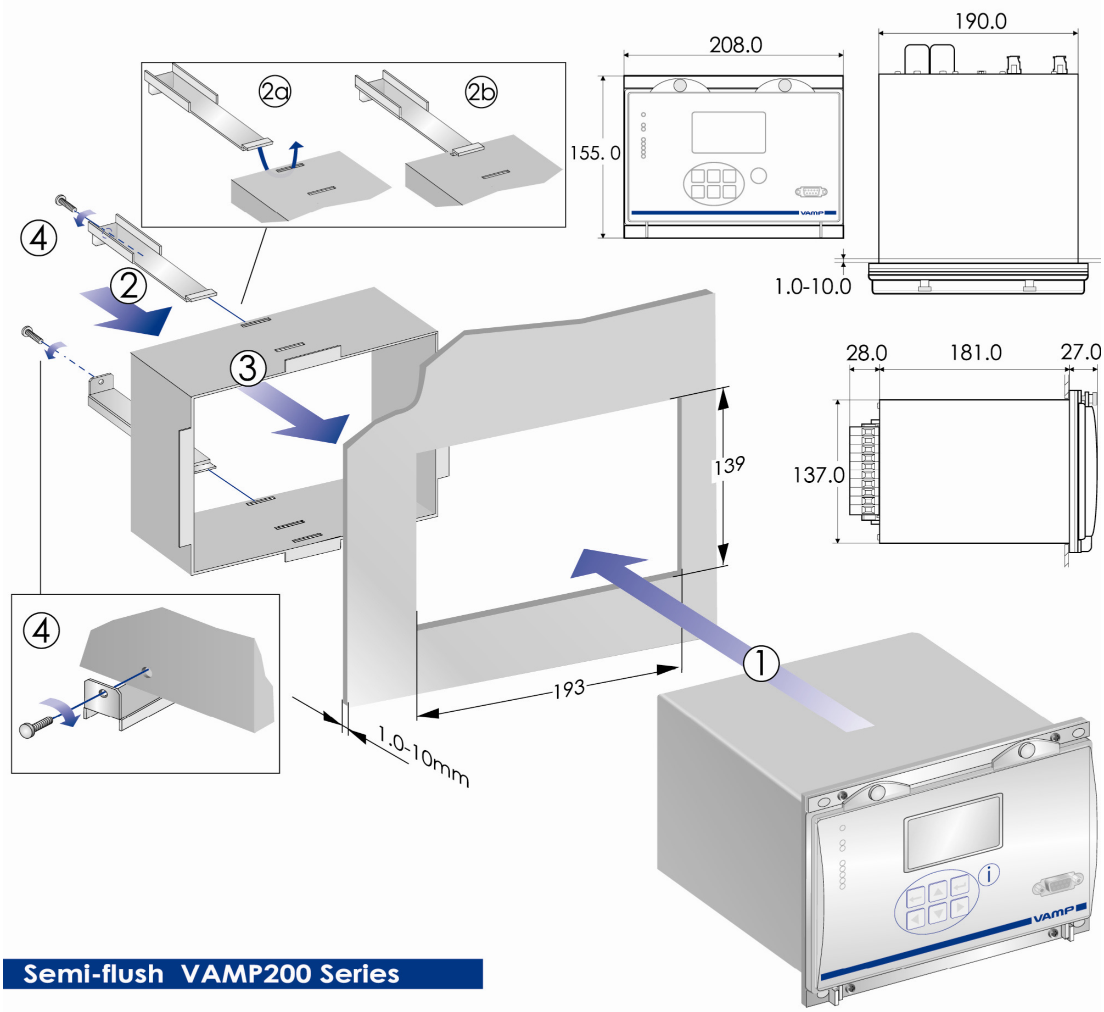
Mode of recording:	Saturated / Overflow
Sample rate:	
- Waveform recording	32/cycle, 16/cycle, 8/cycle
- Trend curve recording	10, 20, 200 ms
	1, 5, 10, 15, 30 s
	1 min
Recording time (one record)	0.1 s – 12 000 min
	(must be shorter than MAX time)
Pre-trigger rate	0 – 100%
Number of selected channels	0 – 12

10. Abbreviations and symbols

ANSI	American National Standards Institute. A standardization organisation.
CB	Circuit breaker
CBFP	Circuit breaker failure protection
cosφ	Active power divided by apparent power = P/S. (See power factor PF). Negative sign indicates reverse power.
CT	Current transformer
CT_{PRI}	Nominal primary value of current transformer
CT_{SEC}	Nominal secondary value of current transformer
Dead band	See hysteresis.
DI	Digital input
DO	Digital output, output relay
DSR	Data set ready. An RS232 signal. Input in front panel port of VAMP relays to disable rear panel local port.
DST	Daylight saving time. Adjusting the official local time forward by one hour for summer time.
DTR	Data terminal ready. An RS232 signal. Output and always true (+8 Vdc) in front panel port of VAMP relays.
FFT	Fast Fourier transform. Algorithm to convert time domain signals to frequency domain or to phasors.
Hysteresis	I.e. dead band. Used to avoid oscillation when comparing two near by values.
I_{01N}	Nominal current of the I_{01} input of the relay
I_{02N}	Nominal current of the I_{02} input of the relay
I_{0N}	Nominal current of I_0 input in general
I_N	Nominal current. Rating of CT primary or secondary.
IEC	International Electrotechnical Commission. An international standardization organisation.
IEEE	Institute of Electrical and Electronics Engineers
IEC-103	Abbreviation for communication protocol defined in standard IEC 60870-5-103
LAN	Local area network. Ethernet based network for computers and relays.
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
pu	Per unit. Depending of the context the per unit refers to any nominal value. For example for overcurrent setting 1 pu = $1xI_{GN}$.
RMS	Root mean square
SNTP	Simple Network Time Protocol for LAN and WWW
TCS	Trip circuit supervision
THD	Total harmonic distortion
UTC	Coordinated Universal Time (used to be called GMT = Greenwich Mean Time)
WWW	World wide web ≈ internet

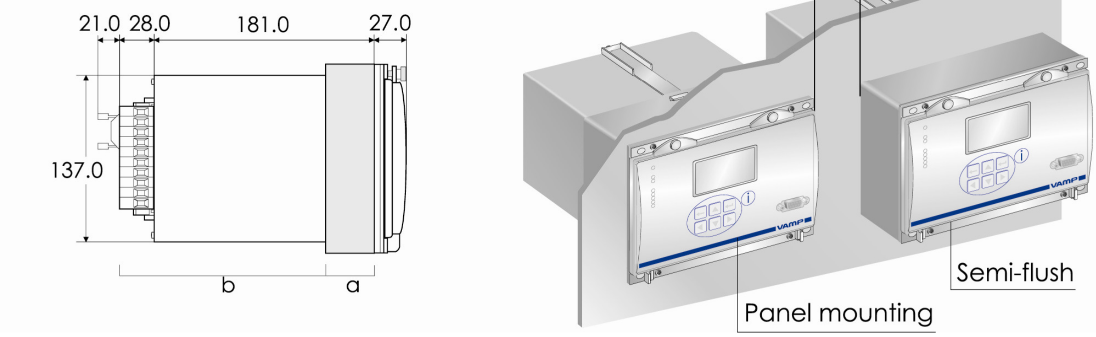
11. Construction

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 the ordering code:

VAMP 265 ORDERING CODE

VAMP 265 - □□ 7 □□□

Nominal current, HV & LV side [A]
1 = 1A & 1A
3 = 1A & 5A
4 = 5A & 1A
5 = 5A & 5A

Nominal earth-fault currents Io & I'o [A]
A = 5A & 5A
B = 5A & 1A
C = 1A & 5A
D = 1A & 1A

Frequency [Hz]
7 = 50/60Hz

Supply voltage [V]
A = 40.. 265Vac/dc
B = 18.. 36Vdc
C = 40.. 265Vac/dc + ARC Protection
D = 18.. 36Vdc + ARC Protection

Optional hardware
A = None
B = Plastic/Plastic fibre interface
C = Profibus Interface
D = RS485 Interface
E = Glass/Glass Optic Interface
F = Plastic/Glass Optic Interface
G = Glass/Plastic Optic Interface
H = Ethernet interface
K = 61850 interface

Optional software **(See Firmware revision history)**
A = Version 2 firmware **(For OLD porjects)**
C = Standard firmware

Accessories :

Order Code	Explanation	Note
VEA 3 CG	External Ethernet Interface Module	VAMP Ltd
VPA 3 CG	Profibus Interface Module	VAMP Ltd
VSE001	Fiber optic Interface Module	VAMP Ltd
VSE002	RS485 Interface Module	VAMP Ltd
VX003-3	Programming Cable (VAMPSet, VEA 3 CG+200serie)	Cable length 3m
VX004-M3	TTL/RS232 Converter Cable (for PLC, VEA3CG+200serie)	Cable length 3m
VX007-F3	TTL/RS232 Converter Cable (for VPA 3 CG or VMA 3 CG)	Cable length 3m
VX015-3	TTL/RS232 Converter Cable (for 100serie+VEA3CG)	Cable length 3m
VX008-4	TTL/RS232 Converter Cable (for Modem MD42, ILPH, ..)	Cable length 4m
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

13. Revision history

13.1. Manual revision history

VM265.EN007	Firmware version 3
VM265.EN008	Firmware version 6 with several new features.

13.2. Firmware revision history

3.66 Non-volatile value storage (E^2PROM) updated.

3.68 Info-display v. spontaneous alarm-display conflict updated.

6.11 A major update. Older versions of VAMPSET parameter files are not compatible and must NOT be used! Numerous new features has been added:

- several new protection stages
- two setting groups for protection stages
- temperature measurement and supervising using external Modbus modules
- digital I/O extension using external Modbus modules.
- user's programmable logic
- user configurable interactive mimic display
- language support (Latin alphabet)
- IEC 60870-5-103, DNP 3.0 communication protocols
- Supported for internal Ethernet adaptor (See Communication interface “H” in Chapter Order information

14. Reference information

Documentation:

Mounting and Commissioning Instructions VMMC.EN0xx
VAMPSET User's Manual VMV.EN0xx

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