# Technical reference manual

REL 521*2.3

Line distance protection terminal

**About this manual**

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## Manufacturer:

ABB Automation Products AB
Substation Automation Division
SE-721 59 Västerås
Sweden
Tel: +46 (0) 21 34 20 00
Fax: +46 (0) 21 14 69 18
Internet: http://www.abb.se

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# Contents

# Chapter 1 Introduction

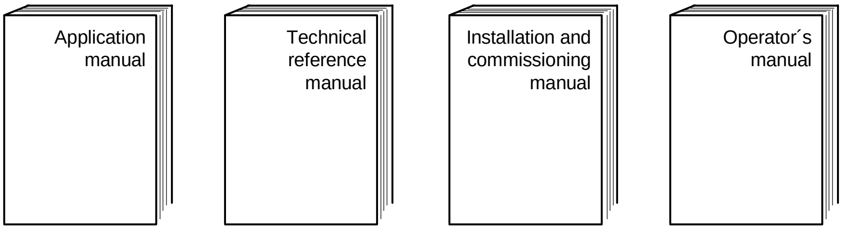
**About this chapter**

This chapter introduces you to the manual as such.

# 1 Introduction to the technical reference manual

## 1.1 About the complete set of manuals to a terminal

The complete package of manuals to a terminal is named users manual (UM). The *Users manual* consists of four different manuals:




**The Application Manual (AM)** contains descriptions, such as application and functionality descriptions as well as setting calculation examples sorted per function. The application manual should be used when designing and engineering the protection terminal to find out where and for what a typical protection function could be used. The manual should also be used when calculating settings and creating configurations.

**The Technical Reference Manual (TRM)** contains technical descriptions, such as function blocks, logic diagrams, input and output signals, setting parameter tables and technical data sorted per function. The technical reference manual should be used as a technical reference during the engineering phase, installation and commissioning phase and during the normal service phase.

**The Operator´s Manual (OM)** contains instructions on how to operate the protection terminal during normal service (after commissioning and before periodic maintenance tests). The operator´s manual could be used to find out how to handle disturbances or how to view calculated and measured network data in order to determine the reason of a fault.

**The Installation and Commissioning Manual (ICM)** contains instructions on how to install and commission the protection terminal. The manual can also be used as a reference if a periodic test is performed. The manual covers procedures for mechanical and electrical installation, energising and checking of external circuitry, setting and configuration as well as verifying settings and performing a directionality test. The chapters and sections are organised in the chronological order (indicated by chapter/section numbers) the protection terminal should be installed and commissioned.

## 1.2 Design of the Technical reference manual (TRM)

The description of each terminal related function follows the same structure (where applicable):

### Application

States the most important reasons for the implementation of a particular protection function.

### Functionality/Design

Presents the general concept of a function.

### Function block

Each function block is imaged by a graphical symbol.

Input signals are always on the left side, and output signals on the right side. Settings are not displayed. A special kind of settings are sometimes available. These are supposed to be connected to constants in the configuration scheme, and are therefore depicted as inputs. Such signals will be found in the signal list but described in the settings table.

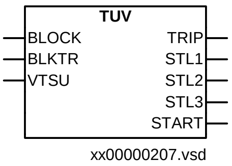



*Figure 1: Function block symbol example*

### Logic diagram

The description of the design is chiefly based on simplified logic diagrams, which use IEC symbols, for the presentation of different functions, conditions etc. The functions are presented as a closed block with the most important internal logic circuits and configurable functional inputs and outputs.

Completely configurable binary inputs/outputs and functional inputs/outputs enable the user to prepare the REx 5xx with his own configuration of different functions, according to application needs and standard practice.

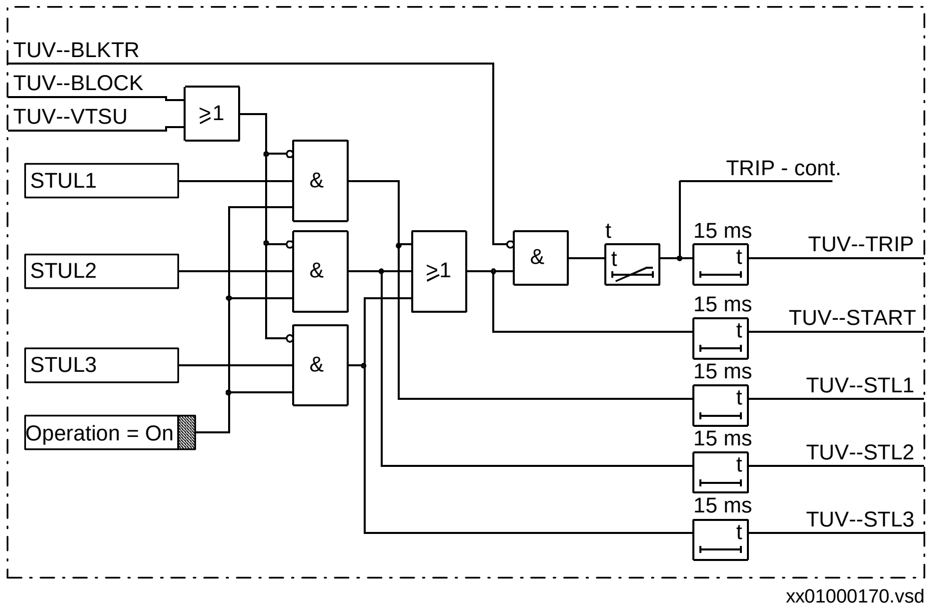



*Figure 2: Function block diagram example*

The names of the configurable logic signals consist of two parts divided by dashes. The first part consists of up to four letters and presents the abbreviated name for the corresponding function. The second part presents the functionality of the particular signal. According to this explanation, the meaning of the signal TUV--BLKTR is as follows.

- The first part of the signal, TUV- represents the adherence to the Time delayed Under-Voltage function.
- The second part of the signal name, BLKTR informs the user that the signal will BLocK the TRip from the under-voltage function, when its value is a logical one (1).

Different binary signals have special symbols with the following significance:

- Signals drawn to the box frame to the left present functional input signals. It is possible to configure them to functional output signals of other functions as well as to binary input terminals of the REx 5xx terminal. Examples are TUV--BLKTR, TUV--BLOCK and TUV--VTSU.Signals in frames with a shaded area on their right side present the logical setting signals. Their values are high (1) only when the corresponding setting parameter is set to the symbolic value specified within the frame. Example is the signal Operation = On. These signals are not configurable. Their logical values correspond automatically to the selected setting value.The internal signals are usually dedicated to a certain function. They are normally not available for configuration purposes. Examples in are signals STUL1, STUL2 and STUL3.The functional output signals, drawn to the box frame to the right, present the logical outputs of functions and are available for configuration purposes. The user can configure them to binary outputs from the terminal or to inputs of different functions. Typical examples in are signals TUV--TRIP, TUV--START etc.

Other internal signals configurated to other function blocks are written on a line with an identity and a cont. reference. An example is the signal TRIP - cont. The signal can be found in the corresponding function with the same identity.

### Input and output signals

The signal lists contain all available input and output signals of the function block, one table for input signals and one for output signals.

**Table 1: Input signals for the TUV (TUV--) function block**

| Signal | Description |
|---|---|
| BLOCK | Block undervoltage function |
| BLKTR | Block of trip from time delayed undervoltage function |
| VTSU | Block from voltage transformer circuit supervision |

**Table 2: Output signals for the TUV (TUV--) function block**

| Signal | Description |
|---|---|
| TRIP | Trip by time delayed undervoltage function |
| STL1 | Start phase undervoltage phase L1 |
| STL2 | Start phase undervoltage phase L2 |
| STL3 | Start phase undervoltage phase L3 |
| START | Start phase undervoltage |

### Setting parameters

The setting parameters table contains all available settings of the function block. If a function consists of more than one block, each block is listed in a separate table.

**Table 3: Setting parameters for the time delayed undervoltage protection TUV (TUV--) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off, On | Off | - | Operating mode for TUV function |
| UPE< | 10-100<br>Step: 1 | 70 | % of U1b | Operate phase voltage |
| t | 0.000-60.000<br>Step: 0.001 | 0.000 | s | Time delay |

### Technical data

The technical data specifies the terminal in general, the functions and the hardware modules.

## 1.3 Related documents

| Documents related to REL 521*2.3 | Identity number |
|---|---|
| Operator’s manual | 1MRK 506 068-UEN |
| Installation and commissioning manual | 1MRK 506 070-UEN |
| Technical reference manual | 1MRK 506 069-UEN |
| Application manual | 1MRK 506 111-UEN |
| Technical overview brochure | 1MRK 506 067-BEN |

# Chapter 2 General

### About this chapter

This chapter describes the terminal in general.

# 1 Terminal identification

## 1.1 General terminal parameters

Use the terminal identifiers to name the individual terminal for identification purposes. Use the terminal reports to check serial numbers of the terminal and installed modules and to check the firmware version.

Identifiers and reports are accessible by using the HMI as well as by SMS or SCS systems.

**Table 4: Set parameters for the general terminal parameters function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Station Name | 0-16 | Station Name | char | Identity name for the station |
| Station No | 0-99999 | 0 | - | Identity number for the station |
| Object Name | 0-16 | Object Name | char | Identity name for the protected object |
| Object No | 0-99999 | 0 | - | Identity number for the protected object |
| Unit Name | 0-16 | Unit Name | char | Identity name for the terminal |
| Unit No | 0-99999 | 0 | - | Identity number for the terminal |

## 1.2 Basic protection parameters

Path in HMI-tree: Configuration/AnalogInputs/General

**Table 5: Setting parameters for analogInputs - General**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| CTEarth | In/Out | Out | - | Direction of CT earthing |
| fr | 50, 60, 16 2/3 | 50 | Hz | System frequency |

Path in HMI-tree: Configuration/AnalogInputs/U1-U5

**Table 6: Analog Inputs - Voltage**

| **Parameter** | **Range** | **Default** | **Unit** | **Description** |
|---|---|---|---|---|
| U1r * | 10.000 - 500.000<br>Step: 0.001 | 63.509 | V | Rated voltage of transformer on input U1 |
| U1b | 30.000 - 500.000<br>Step:0.001 | 63.509 | V | Base voltage of input U1 |
| U1Scale | 1.000 - 20000.000<br>Step: 0.001 | 2000.000 | - | Main voltage transformer ratio, input U1 |
| Name_U1 | 0 - 13 | U1 | char | User-defined name of input U1 |
| U2r * | 10.000 - 500.000<br>Step: 0.001 | 63.509 | V | Rated voltage of transformer on input U2 |
| U2b | 30.000 - 500.000<br>Step: 0.001 | 63.509 | V | Base voltage of input U2 |
| U2Scale | 1.000 - 20000.000<br>Step: 0.001 | 2000.000 | - | Main voltage transformer ratio, input U2 |
| Name_U2 | 0 - 13 | U2 | char | User-defined name of input U2 |
| U3r * | 10.000 - 500.000<br>Step: 0.001 | 63.509 | V | Rated voltage of transformer on input U3 |
| U3b | 30.000 - 500.000<br>Step: 0.001 | 63.509 | V | Base voltage of input U3 |
| U3Scale | 1.000 - 20000.000<br>Step: 0.001 | 2000.000 | - | Main voltage transformer ratio, input U3 |
| Name_U3 | 0 - 13 | U3 | char | User-defined name of input U3 |

| **Parameter** | **Range** | **Default** | **Unit** | **Description** |
|---|---|---|---|---|
| U4r * | 10.000 - 500.000<br>Step: 0.001 | 63.509 | V | Rated voltage of transformer on input U4 |
| U4b | 30.000 - 500.000<br>Step: 0.001 | 63.509 | V | Base voltage of input U4 |
| U4Scale | 1.000 - 20000.000<br>Step: 0.001 | 2000.000 | - | Main voltage transformer ratio, input U4 |
| Name_U4 | 0 - 13 | U4 | char | User-defined name of input U4 |
| U5r * | 10.000 - 500.000<br>Step: 0.001 | 63.509 | V | Rated voltage of transformer on input U5 |
| U5b | 30.000 - 500.000<br>Step: 0.001 | 63.509 | V | Base voltage of input U5 |
| U5Scale | 1.000 - 20000.000<br>Step: 0.001 | 2000.000 | - | Main voltage transformer ratio, input U5 |
| Name_U5 | 0 - 13 | U5 | char | User-defined name of input U5 |
| *) Setting is done through the local HMI only. | | | | |

Path in HMI-tree: Configuration/AnalogInputs/I1-I5

**Table 7: Analog Inputs - Current**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| I1r * | 0.1000 - 10.0000<br>Step: 0.0001 | 1.0000 | A | Rated current of transformer on input I1 |
| I1b | 0.1 - 10.0<br>Step: 0.1 | 1.0 | A | Base current of input I1 |
| I1Scale | 1.000 - 40000.000<br>Step: 0.001 | 2000.000 | - | Main current transformer ratio, input I1 |
| Name_I1 | 0 - 13 | I1 | char | User-defined name of input I1 |
| I2r * | 0.1000 - 10.0000<br>Step: 0.0001 | 1.0000 | A | Rated current of transformer on input I2 |
| I2b | 0.1 - 10.0<br>Step: 0.1 | 1.0 | A | Base current of input I2 |
| I2Scale | 1.000 - 40000.000<br>Step:0.001 | 2000.000 | - | Main current transformer ratio, input I2 |
| Name_I2 | 0 - 13 | I2 | char | User-defined name of input I2 |
| I3r * | 0.1000 - 10.0000<br>Step: 0.0001 | 1.0000 | A | Rated current of transformer on input I3 |
| I3b | 0.1 - 10.0<br>Step: 0.1 | 1.0 | A | Base current of input I3 |
| I3Scale | 1.000 - 40000.000<br>Step: 0.001 | 2000.000 | - | Main current transformer ratio, input I3 |
| Name_I3 | 0 - 13 | I3 | char | User-defined name of input I3 |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| I4r * | 0.1000 - 10.0000<br>Step: 0.0001 | 1.0000 | A | Rated current of transformer on input I4 |
| I4b | 0.1 - 10.0<br>Step: 0.1 | 1.0 | A | Base current of input I4 |
| I4Scale | 1.000 - 40000.000<br>Step: 0.001 | 2000.000 | - | Main current transformer ratio, input I4 |
| Name_I4 | 0 - 13 | I4 | char | User-defined name of input I4 |
| I5r * | 0.1000 - 10.0000<br>Step: 0.0001 | 1.0000 | A | Rated current of transformer on input I5 |
| I5b | 0.1 - 10.0<br>Step: 0.1 | 1.0 | A | Base current of input I5 |
| I5Scale | 1.000 - 40000.000<br>Step: 0.001 | 2000.000 | - | Main current transformer ratio, input I5 |
| Name_I5 | 0 - 13 | I5 | char | User-defined name of input I5 |
| *) Setting is done through the local HMI only | | | | |

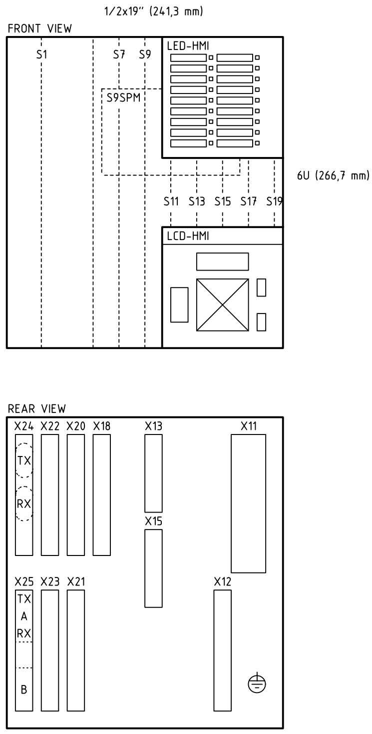
## 1.3 Calendar and clock

**Table 8: Calendar and clock**

| Parameter | Range |
|---|---|
| Built-in calender | 30 years with leap years |

# 2 Technical data

## 2.1 Case dimensions

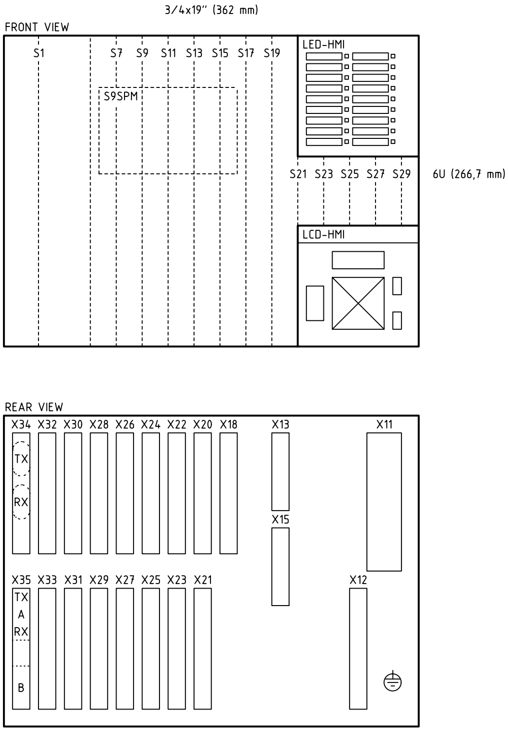



| DESIGNATION CORRESPONDING TO CASING | | |
|---|---|---|
| 1/2x19" | | |
| MODULE | FRONT | REAR |
| TRM 1) | S1 | X11,12 |
| ADM 1) | S7 | - |
| ORM 1) | S7 | - |
| MPM | S9 | X13,15 |
| PSM | S13 | X18 |
| 2) | S15 | X20,21 |
| 2) | S17 | X22,23 |
| 3) | S19 | X24,25 |

TABLE 1

1) OPTION TRM AND ADM OR ORM
2) BIM, BOM, IOM AND/OR MIM
3) BIM, BOM, IOM, MIM OR DCM

*Figure 3: Hardware structure of the 1/2 of full width 19" case*



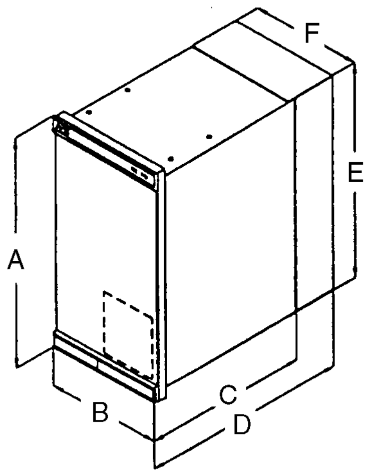

| DESIGNATION CORRESPONDING TO CASING | | |
|---|---|---|
| 3/4x19" | | |
| MODULE | FRONT | REAR |
| TRM 1) | S1 | X11,12 |
| ADM 1) | S7 | - |
| ORM 1) | S7 | - |
| MPM | S9 | X13,15 |
| PSM | S13 | X18 |
| 2) | S15 | X20,21 |
| 2) | S17 | X22,23 |
| 2) | S19 | X24,25 |
| 2) | S21 | X26,27 |
| 2) | S23 | X28,29 |
| 2) | S25 | X30,31 |
| 2) | S27 | X32,33 |
| 3) | S29 | X34,35 |

TABLE 2

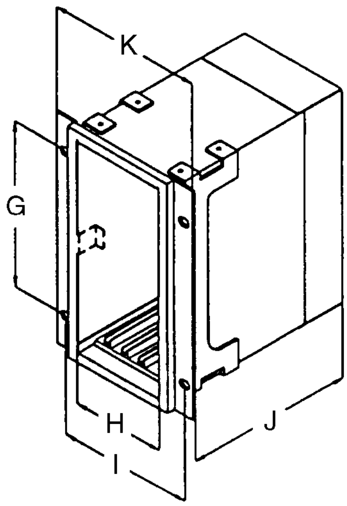
1) OPTION TRM AND ADM OR ORM
2) BIM, BOM, IOM AND/OR MIM
3) BIM, BOM, IOM, MIM OR DCM

*Figure 4: Hardware structure of the 3/4 of full width 19" case*

### Diagrams (Dimensions)




96000309.tif

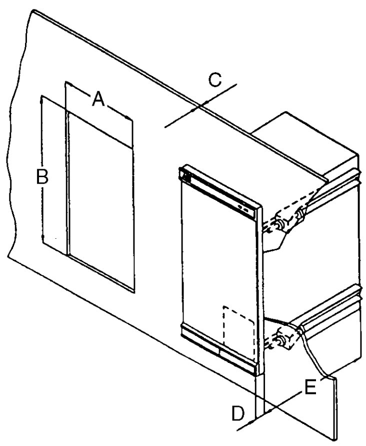



96000310.tif

| Case size | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6U x 1/2 | | 223.7 | | | | 205.7 | | 203.7 | - | | - |
| 6U x 3/4 | 265.9 | 336 | 204.1 | 245.1 | 255.8 | 318 | 190.5 | 316 | - | 227.6 | - |
| 6U x 1/1 | | 448.3 | | | | 430.3 | | 428.3 | 465.1 *) | | 482.6 |
| | | | | | | | *) equal to 19” | | | | (mm) |

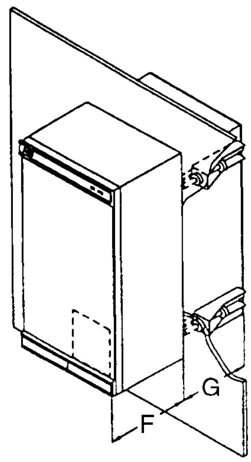
**Panel cut-outs for REx 500 series**

Flush mounting




97000025.tif

Semi-flush mounting




97000026.tif

| Case size | Cut-out dimensions (mm) | |
|---|---|---|
| | **A+/-1** | **B+/-1** |
| 6U x 1/2 | 210.1 | 259.3 |
| 6U x 3/4 | 322.4 | 259.3 |
| 6U x 1/1 | 434.7 | 259.3 |

C = 4-10 mm

D = 16.5 mm

E = 187.6 mm without protection cover, 228.6 mm with protection cover

F = 106.5 mm

G = 97.6 mm without protection cover, 138.6 mm with protection cover

The flush mounting kits are available in three designs, suitable for 1/2, 3/4 or full width terminals and consists of four fasteners (4) with appropriate mounting details and a sealing strip (1) providing IP54 class protection for fastening to the terminal (5). The semiflush mounting kit adds a distance frame (2). An additional sealing strip (3) can be ordered for semiflush mounting to provide IP54 class protection.

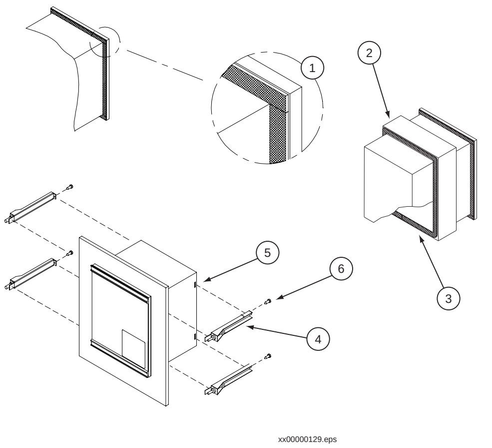
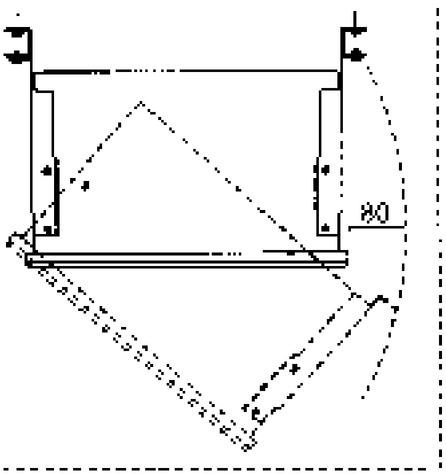
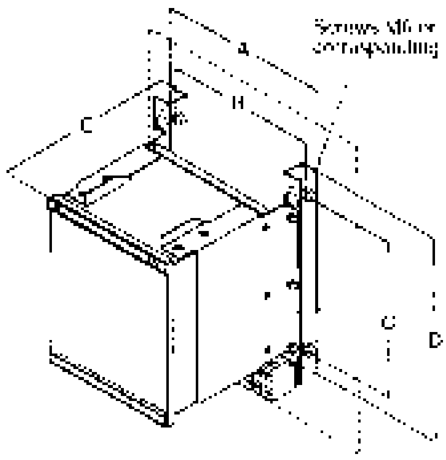



*Figure 5: The flush mounting kit*



| Case size (mm) | A | B | C | D | E |
|---|---|---|---|---|---|
| 6U x 1/2 | 292 | 267.1 | 272.8 | 390 | 247 |
| 6U x 3/4 | 404.3 | 379.4 | | | |
| 6U x 1/1 | 516 | 491.1 | | | |

## 2.2 Weight

**Table 9: Weight**

| Case size | Weight |
|---|---|
| 6U x 1/2 | ≤ 8.5 kg |
| 6U x 3/4 | ≤ 11 kg |
| 6U x 1/1 | ≤ 18 kg |

## 2.3 Unit

**Table 10: Unit**

| | |
|---|---|
| Material | Steel sheet |
| Front plate | Aluminium profile with cut-out for HMI |
| Surface treatment | Aluzink preplated steel |
| Finish | Light beige (NCS 1704-Y15R) |
| Degree of protection | Front side: IP40, IP54 with optional sealing strip Rear side: IP20 |

## 2.4 Environmental properties

**Table 11: Temperature and humidity influence**

| Parameter | Rated value | Nominal range | Influence |
|---|---|---|---|
| Storage temperature | - | -40 °C to +70 °C | - |
| Ambient temperature (during operation) | +20 °C | -5 °C to +55 °C | 0.01%/°C, within nominal range<br>Correct function within operative range |
| Relative humidity | 10%-90% | 10%-90% | - |

**Table 12: Auxiliary DC supply voltage influence on functionality during operation**

<table>
<tr><th colspan="2">Dependence on:</th><th>Within nominal range</th><th>Within operative range</th></tr>
<tr><td colspan="2">Ripple, max 12% or EL</td><td>Negligible</td><td>Correct function</td></tr>
<tr><td rowspan="3">Interrupted auxiliary DC voltage</td><td>Without reset</td><td><50 ms</td><td><50 ms</td></tr>
<tr><td>Correct function</td><td>0-∞ s</td><td>0-∞ s</td></tr>
<tr><td>Restart time</td><td><100 s</td><td><100 s</td></tr>
</table>

**Table 13: Electromagnetic compatibility**

| Test | Type test values | Reference standards |
|---|---|---|
| 1 MHz burst disturbance | 2.5 kV | IEC 60255-22-1, Class III |
| Electrostatic discharge | 8 kV | IEC 60255-22-2, Class III |
| Fast transient disturbance | 4 kV | IEC 60255-22-4, Class IV |
| Radiated electromagnetic field distur-bance | 10 V/m, 25-1000 MHz | IEC 60255-22-3, Class III<br>IEEE/ANSI C37.90.2 |

**Table 14: Insulation**

<table>
<tr><th>Test</th><th>Type test values</th><th>Reference standard</th></tr>
<tr><td>Dielectric test</td><td>2.0 kVAC, 1 min.</td><td rowspan="3">IEC 60255-5</td></tr>
<tr><td>Impulse voltage test</td><td>5 kV, 1.2/50 μs, 0.5 J</td></tr>
<tr><td>Insulation resistance</td><td>>100 MΩ at 500 VDC</td></tr>
</table>

**Table 15: CE compliance**

| Test | According to |
|---|---|
| Immunity | EN 50082-2 |
| Emissivity | EN 50081-2 |
| Low voltage directive | EN 50178 |

**Table 16: Mechanical tests**

| Test | Type test values | Reference standards |
|---|---|---|
| Vibration | Class I | IEC 60255-21-1 |
| Shock and bump | Class I | IEC 60255-21-2 |
| Seismic | Class I | IEC 60255-21-3 |

# Chapter 3 Common functions

**About this chapter**

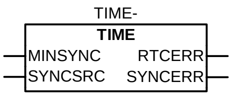
This chapter presents the common functions in the terminal.

# 1 Time synchronisation (TIME)

## 1.1 Application

Use the time synchronization source selector to select a common source of absolute time for the terminal when it is a part of a protection system. This makes comparison of events and disturbance data between all terminals in a system possible.

## 1.2 Function block

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## 1.3 Input and output signals

**Table 17: Input signals for the TIME (TIME-) function block**

| Signal | Description |
|---|---|
| MINSYNC | Minute pulse input |
| SYNCSRC | Synchronization source selector input. See settings for details. |

**Table 18: Output signals for the TIME (TIME-) function block**

| Signal | Description |
|---|---|
| RTCERR | Real time clock error |
| SYNCERR | Time synchronisation error |

## 1.4 Setting parameters

**Table 19: Setting parameters for the time synchronization source selector function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| SYNCSRC | 0-5 | 0 | - | Selects the time synchronization source:<br>0: No source. Internal real time clock is used without fine tuning.<br>1: LON bus<br>2: SPA bus<br>3: IEC 870-5-103 bus<br>4: Minute pulse, positive flank<br>5: Minute pulse, negative flank |

# 2 Setting group selector (GRP)

## 2.1 Application

Use the four sets of settings to optimize the terminal's operation for different system conditions. By creating and switching between fine tuned setting sets, either from the human-machine interface or configurable binary inputs, results in a highly adaptable terminal that can cope with a variety of system scenarios.

## 2.2 Logic diagram

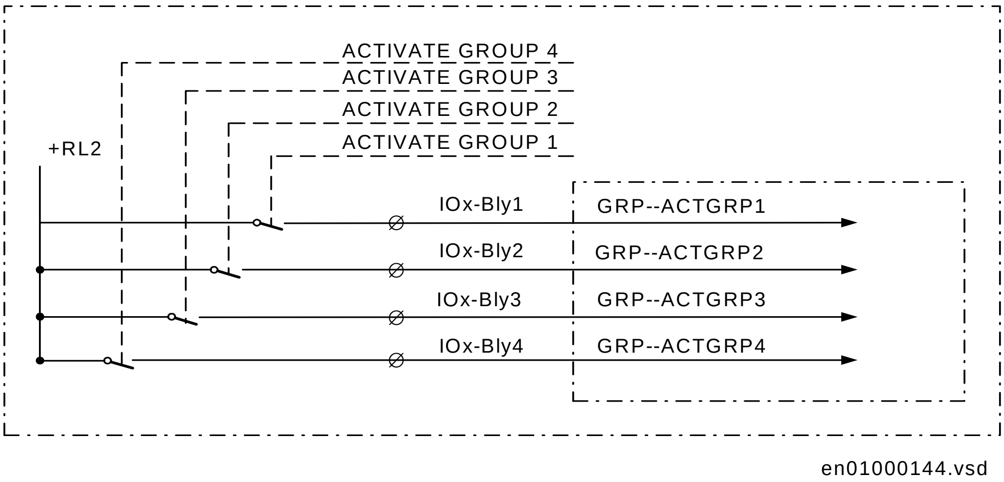
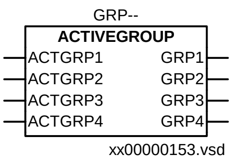



*Figure 6: Connection of the function to external circuits*

## 2.3 Function block



## 2.4 Input and output signals

**Table 20: Input signals for the ACTIVEGROUP (GRP--) function block**

| Signal | Description |
|---|---|
| ACTGRP1 | Selects setting group 1 as active |
| ACTGRP2 | Selects setting group 2 as active |
| ACTGRP3 | Selects setting group 3 as active |
| ACTGRP4 | Selects setting group 4 as active |

**Table 21: Output signals for the ACTIVEGROUP (GRP--) function block**

| Signal | Description |
|---|---|
| GRP1 | Setting group 1 is active |
| GRP2 | Setting group 2 is active |
| GRP3 | Setting group 3 is active |
| GRP4 | Setting group 4 is active |

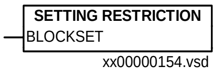
# 3 Setting lockout (HMI)

## 3.1 Application

Unpermitted or uncoordinated changes by unauthorized personnel may cause severe damage to primary and secondary power circuits. Use the setting lockout function to prevent unauthorized setting changes and to control when setting changes are allowed.

By adding a key switch connected to a binary input a simple setting change control circuit can be built simply allowing only authorized keyholders to make setting changes from the built-in HMI.

## 3.2 Function block




## 3.3 Logic diagram

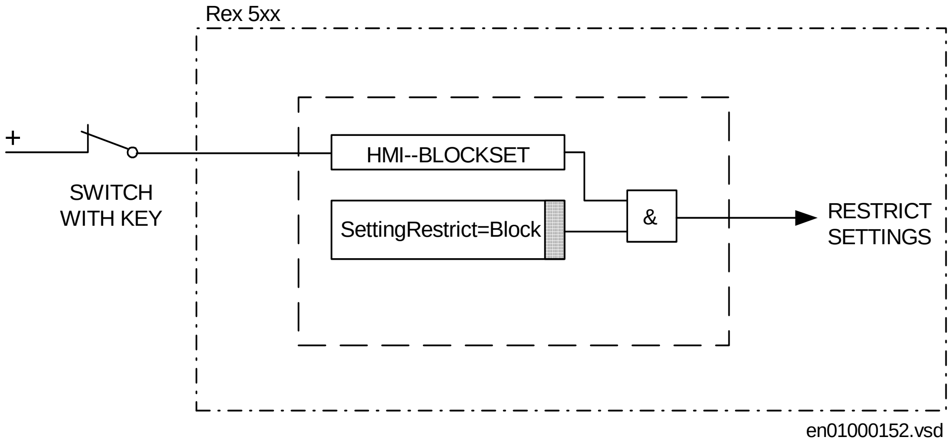



*Figure 7: Connection and logic diagram for the BLOCKSET function*

## 3.4 Input and output signals

**Table 22: Input signals for the SETTING RESTRICTION function block**

| Signal | Description |
|---|---|
| BLOCKSET | Input signal to block setting and/or configuration changes from the local HMI. **WARNING:** Read the instructions before use. Default configuration to NONE-NOSIGNAL. |

## 3.5 Setting parameters

**Table 23: Setting parameters for the setting lockout function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| SettingRestrict | Open, Block | Open | - | Open: Setting parameters can be changed.<br>Block: Setting parameters can only be changed if the logic state of the BLOCKSET input is zero. |

# 4 I/O system configurator (IOP)

## 4.1 Application

The I/O system configurator must be used in order for the terminal's software to recognize added modules and to create internal address mappings between modules and protections and other functions.

## 4.2 Logic diagram

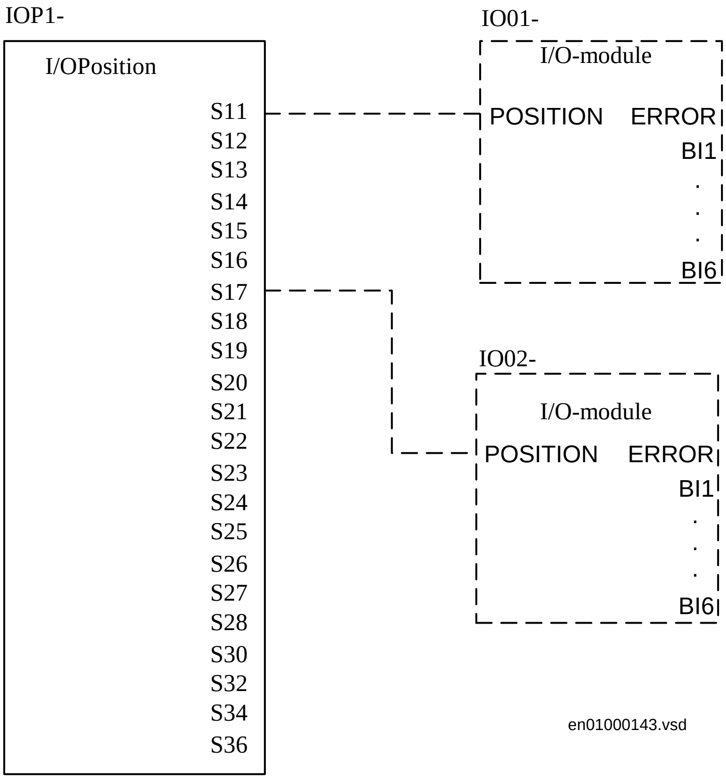
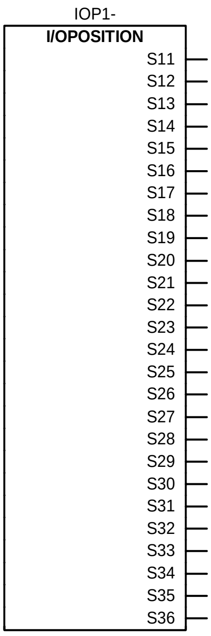



*Figure 8: Example of an I/O-configuration in the graphical tool CAP 531 for a REx 5xx with two BIMs.*

## 4.3 Function block

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## 4.4 Input and output signals

**Table 24: Output signals for the I/OPOSITION (IOPn-) function block**

| Signal | Description |
|---|---|
| Snn | Slot position nn (nn=11-39) |

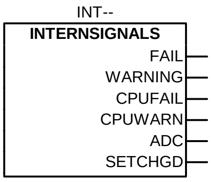
# 5 Self supervision (INT)

## 5.1 Application

Use the local HMI, SMS or SCS system to view the status of the self-supervision function. The self-supervision operates continuously and includes:

- Normal micro-processor watchdog function
- Checking of digitized measuring signals
- Checksum verification of PROM contents and all types of signal communication

## 5.2 Function block

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## 5.3 Logic diagram

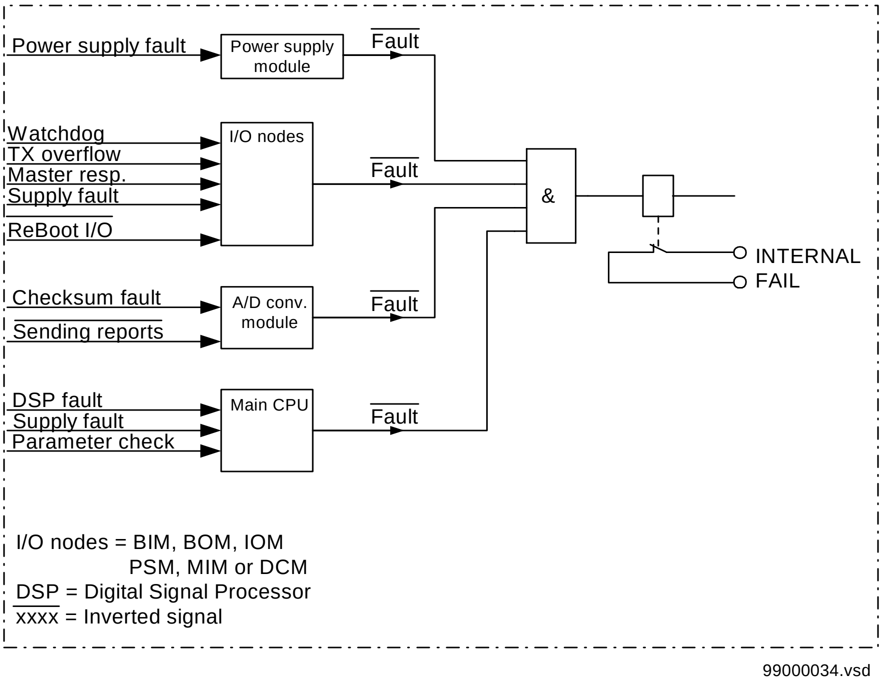



*Figure 9: Hardware self-supervision, potential-free alarm contact.*

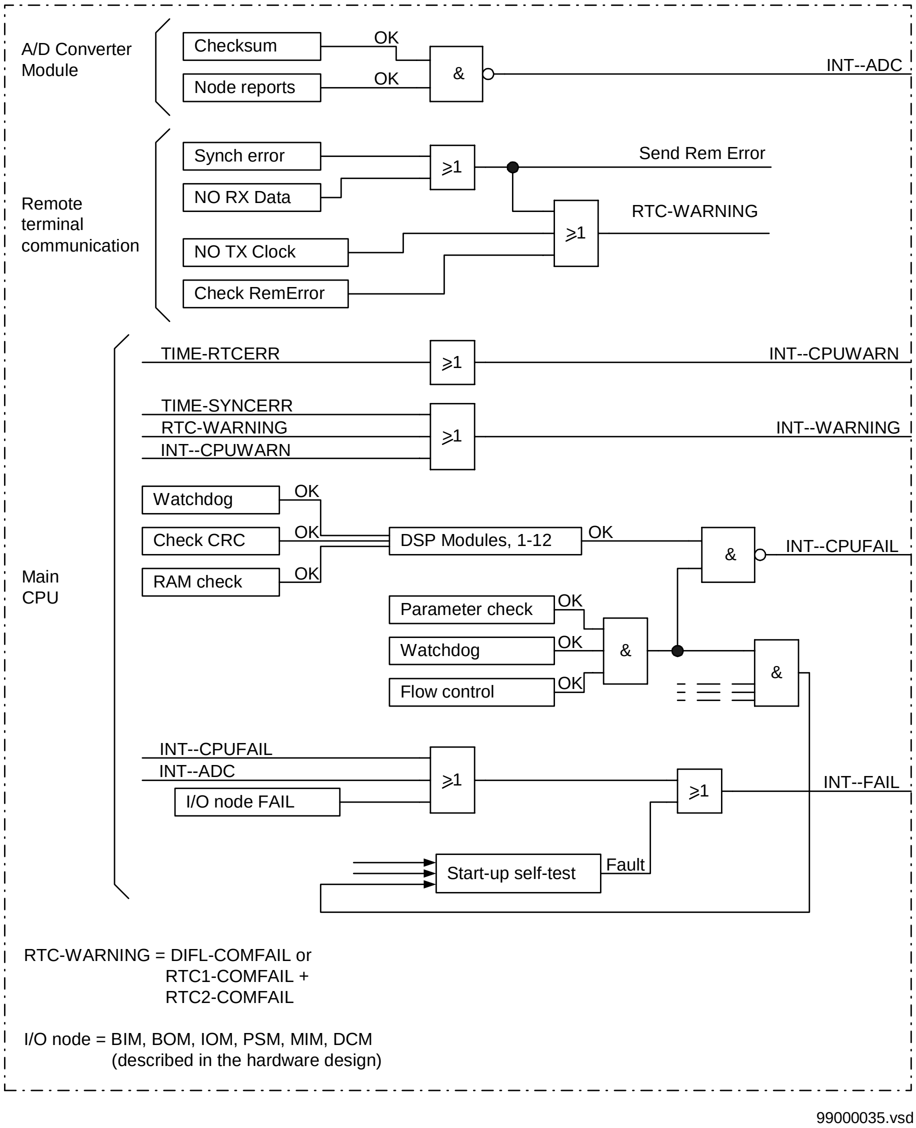



*Figure 10: Software self-supervision, function block INTernal signals*

## 5.4 Input and output signals

**Table 25: Output signals for the INTERNSIGNALS (INT--) function block**

| Signal | Description |
|---|---|
| FAIL | Internal fail status |
| WARNING | Internal warning status |
| CPUFAIL | CPU module fail status |
| CPUWARN | CPU module warning status |
| ADC | A/D-converter error |
| SETCHGD | Setting changed |

## 5.5 Technical data

**Table 26: Internal event list**

| Data | Value |
|---|---|
| Recording manner | Continuous, event controlled |
| List size | 40 events, first in-first out |

# 6 Logic function blocks

## 6.1 Application

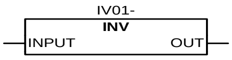
The user can with the available logic function blocks build logic functions and configure the terminal to meet application specific requirements.

Different protection, control, and monitoring functions within the REx 5xx terminals are quite independent as far as their configuration in the terminal is concerned. The user can not change the basic algorithms for different functions. But these functions combined with the logic function blocks can be used to create application specific functionality.

With additional configurable logic means that an extended number of logic circuits are available. Also Move function blocks (MOF, MOL), used for synchronization of boolean signals sent between logics with slow and fast execution, are among the additional configurable logic circuits.

## 6.2 Inverter function block (INV)

The inverter function block INV has one input and one output, where the output is in inverse ratio to the input.



xx00000158.vsd

**Table 27: Input signals for the INV (IVnn-) function block**

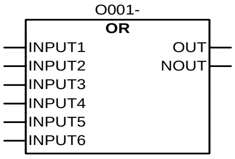
| Signal | Description |
|---|---|
| INPUT | Logic INV-Input to INV gate |

**Table 28: Output signals for the INV (IVnn-) function block**

| Signal | Description |
|---|---|
| Out | Logic INV-Output from INV gate |

## 6.3 OR function block (OR)

The OR function is used to form general combinatory expressions with boolean variables. The OR function block has six inputs and two outputs. One of the outputs is inverted.



xx00000159.vsd

**Table 29: Input signals for the OR (Onnn-) function block**

| Signal | Description |
|---|---|
| INPUT1 | Input 1 to OR gate |
| INPUT2 | Input 2 to OR gate |
| INPUT3 | Input 3 to OR gate |
| INPUT4 | Input 4 to OR gate |
| INPUT5 | Input 5 to OR gate |
| INPUT6 | Input 6 to OR gate |

**Table 30: Output signals for the OR (Onnn-) function block**

| Signal | Description |
|---|---|
| OUT | Output from OR gate |
| NOUT | Inverted output from OR gate |

## 6.4 AND function block (AND)

The AND function is used to form general combinatory expressions with boolean variables.The AND function block has four inputs and two outputs. One of the inputs and one of the outputs are inverted.

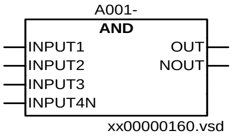



**Table 31: Input signals for the AND (Annn-) function block**

| Signal | Description |
|---|---|
| INPUT1 | Input 1 to AND gate |
| INPUT2 | Input 2 to AND gate |
| INPUT3 | Input 3 to AND gate |
| INPUT4N | Input 4 (inverted) to AND gate |

**Table 32: Output signals for the AND (Annn-) function block**

| Signal | Description |
|---|---|
| OUT | Output from AND gate |
| NOUT | Inverted output from AND gate |

## 6.5 Timer function block (TM)

The function block TM timer has drop-out and pick-up delayed outputs related to the input signal. The timer has a settable time delay (parameter T) between 0.000 and 60.000 s in steps of 0.001 s.

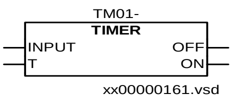



**Table 33: Input signals for the TIMER (TMnn-) function block**

| Signal | Description |
|---|---|
| INPUT | Input to timer |
| T | Time value. See setting parameters |

**Table 34: Output signals for the TIMER (TMnn-) function block**

| Signal | Description |
|---|---|
| OFF | Output from timer, drop-out delayed |
| ON | Output from timer , pick-up delayed |

### 6.5.1 Setting parameters

**Table 35: Setting parameters for the Timer (TMnn-) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| T | 0.000-60.000<br>Step: 0.001 | 0.000 | s | Delay for timer nn |

## 6.6 Timer long function block (TL)

The function block TL timer with extended maximum time delay at pick-up and at drop-out, is identical with the TM timer. The difference is the longer time delay, settable between 0.0 and 90000.0 s in steps of 0.1 s

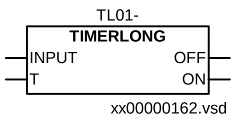



**Table 36: Input signals for the TIMERLONG (TLnn-) function block**

| Signal | Description |
|---|---|
| INPUT | Input to long timer |
| T | Time value. See setting parameters |

**Table 37: Output signals for the TIMERLONG (TLnn-) function block**

| Signal | Description |
|---|---|
| OFF | Output from long timer, drop-out delayed |
| ON | Output from long timer, pick-up delayed |

### 6.6.1 Setting parameters

**Table 38: Setting parameters for the TimerLong (TLnn-) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| T | 0.0-90000.0<br>Step:0.1 | 0.0 | s | Delay for TLnn function |

## 6.7 Pulse timer function block (TP)

The pulse function can be used, for example, for pulse extensions or limiting of operation of outputs. The pulse timer TP has a settable length of a pulse between 0.000 s and 60.000 s in steps of 0.010 s.

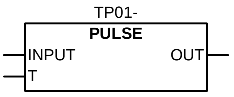


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**Table 39: Input signals for the TP (TPnn-) function block**

| Signal | Description |
|---|---|
| INPUT | Input to pulse timer |
| T | Pulse length. See setting parameters |

**Table 40: Output signals for the TP (TPnn-) function block**

| Signal | Description |
|---|---|
| OUT | Output from pulse timer |

### 6.7.1 Setting parameters

**Table 41: Setting parameters for the Pulse (TPnn-) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| T | 0.000-<br>60.000<br>Step:0.010 | 0.010 | s | Pulse length |

## 6.8 Extended length pulse function block (TQ)

The function block TQ pulse timer with extended maximum pulse length, is identical with the TP pulse timer. The difference is the longer pulse length, settable between 0.0 and 90000.0 s in steps of 0.1 s.

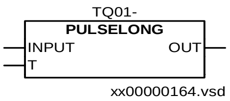


**Table 42: Input signals for the PULSELONG (TQnn-) function block**

| Signal | Description |
|---|---|
| INPUT | Input to pulse long timer |
| T | Pulse length. See setting parameters |

**Table 43: Output signals for the PULSELONG (TQnn-) function block**

| Signal | Description |
|---|---|
| OUT | Output from pulse long timer |

### 6.8.1 Setting parameters

**Table 44: Setting parameters for the PulseLong (TQnn-) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| T | 0.0-90000.0<br>Step: 0.1 | 0.0 | s | Pulse length |

## 6.9 Exclusive OR function block (XO)

The exclusive OR function XOR is used to generate combinatory expressions with boolean variables. The function block XOR has two inputs and two outputs. One of the outputs is inverted. The output signal is 1 if the input signals are different and 0 if they are equal.

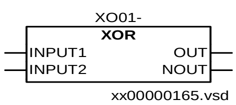

**Table 45: Input signals for the XOR (XOnn-) function block**

| Signal | Description |
|---|---|
| INPUT1 | Input 1 to XOR gate |
| INPUT2 | Input 2 to XOR gate |

**Table 46: Output signals for the XOR (XOnn-) function block**

| Signal | Description |
|---|---|
| OUT | Output from XOR gate |
| NOUT | Inverted output from XOR gate |

## 6.10 Set-reset function block (SR)

The Set-Reset (SR) function is a flip-flop that can set or reset an output from two inputs respectively. Each SR function block has two outputs, where one is inverted.

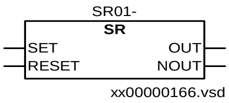


**Table 47: Input signals for the SR (SRnn-) function block**

| Signal | Description |
|---|---|
| SET | Input to SR flip-flop |
| RESET | Input to SR flip-flop |

**Table 48: Output signals for the SR (SRnn-) function block**

| Signal | Description |
|---|---|
| OUT | Output from SR flip-flop |
| NOUT | Inverted output from SR flip-flop |

## 6.11 Set-reset with memory function block (SM)

The Set-Reset function SM is a flip-flop with memory that can set or reset an output from two inputs respectively. Each SM function block has two outputs, where one is inverted. The memory setting controls if the flip-flop after a power interruption will return the state it had before or if it will be reset.

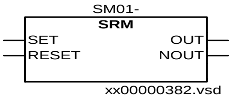


**Table 49: Input signals for the SRM (SMnn-) function block**

| Signal | Description |
|---|---|
| SET | Input to SRM flip-flop |
| RESET | Input to SRM flip-flop |

**Table 50: Output signals for the SRM (SMnn-) function block**

| Signal | Description |
|---|---|
| OUT | Output from SRM flip-flop |
| NOUT | Inverted output from SRM flip-flop |

**Table 51: Setting parameters for the SRM (SMnn-) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Memory | Off/On | Off | - | Operating mode of the memory function |

## 6.12 Controllable gate function block (GT)

The GT function block is used for controlling if a signal should be able to pass from the input to the output or not depending on a setting.

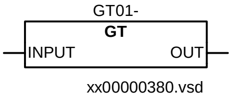

**Table 52: Input signals for the GT (GTnn-) function block**

| **Signal** | **Description** |
|---|---|
| INPUT | Input to gate |

**Table 53: Output signals for the GT (GTnn-) function block**

| **Signal** | **Description** |
|---|---|
| Out | Output from gate |

### 6.12.1 Setting parameters

**Table 54: Setting parameters for the GT (GTnn-) function**

| **Parameter** | **Range** | **Default** | **Unit** | **Description** |
|---|---|---|---|---|
| Operation | Off/On | Off | - | Operating mode for GTn function |

## 6.13 Settable timer function block (TS)

The function block TS timer has outputs for delayed input signal at drop-out and at pick-up. The timer has a settable time delay between 0.00 and 60.00 s in steps of 0.01 s. It also has an Operation setting On, Off that controls the operation of the timer.

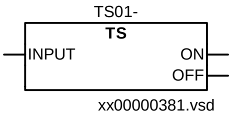


**Table 55: Input signals for the TS (TSnn-) function block**

| **Signal** | **Description** |
|---|---|
| INPUT | Input to timer |

**Table 56: Output signals for the TS (TSnn-) function block**

| **Signal** | **Description** |
|---|---|
| ON | Output from timer, pick-up delayed |
| OFF | Output from timer, drop-out delayed |

### 6.13.1 Setting parameters

**Table 57: Setting parameters for the TS (TSn-) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off/On | Off | - | Operating mode for TSn function |
| T | 0.00-60.00<br>Step: 0.01 | 0.00 | s | Delay for settable timer n |

## 6.14 Move first function block (MOF)

The Move function block MOF is put First in the slow logic and is used for signals coming from fast logic into the slow logic. The MOF function block is only a temporary storage for the signals and do not change any value between input and output.

### 6.14.1 Function block

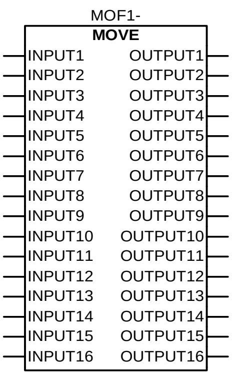


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**Table 58: Input signals for the MOFx function block**

| Signal | Description |
|---|---|
| INPUTn | Input n (n=1-16) to MOFx |

**Table 59: Output signals for the MOFx function block**

| Signal | Description |
|---|---|
| OUTPUTn | Output n (n=1-16) from MOFx |

## 6.15 Move last function block (MOL)

The Move function block MOL is put Last in the slow logic and is used for signals going out from the slow logic to the fast logic. The MOL function block is only a temporary storage for the signals and do not change any value between input and output.

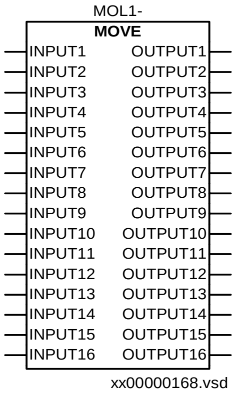



**Table 60: Input signals for the MOLx function block**

| Signal | Description |
|---|---|
| INPUTn | Input n (n=1-16) to MOLx |

**Table 61: Output signals for the MOLx function block**

| Signal | Description |
|---|---|
| OUTPUTn | Output n (n=1-16) from MOLx |

## 6.16 Technical data

**Table 62: Available logic function blocks**

| Update rate | Block | Availability |
|---|---|---|
| 6 ms | AND | 30 gates |
| | OR | 60 gates |
| | INV | 20 inverters |
| | TM | 10 timers |
| | TP | 10 pulse timers |
| | SM | 5 flip-flops |
| | GT | 5 gates |
| | TS | 5 timers |
| 200 ms | TL | 10 timers |
| | TQ | 10 pulse timers |
| | SR | 5 flip-flops |
| | XOR | 39 gates |

**Table 63: Additional logic function blocks**

| Update rate | Block | Availability |
|---|---|---|
| 6 ms | TP | 40 pulse timers |
| 200 ms | AND | 239 gates |
| | OR | 159 gates |
| | INV | 59 inverters |
| | MOF | 3 registers |
| | MOL | 3 registers |

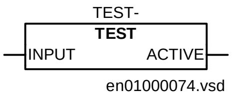
# 7 Blocking of signals during test

## 7.1 Application

The protection and control terminals have a complex configuration with many included functions. To make the testing procedure easier, the terminals include the feature to individually block a single, several or all functions.

This means that it is possible to see when a function is activated or trips. It also enables the user to follow the operation of several related functions to check correct functionality and to check parts of the configuration etc.

## 7.2 Function block




## 7.3 Input and output signals

**Table 64: Input signals for the Test (TEST-) function block**

| Signal | Description |
|---|---|
| INPUT | Sets terminal in test mode when active |

**Table 65: Output signals for the Test (TEST-) function block**

| Signal | Description |
|---|---|
| ACTIVE | Terminal in test mode |

# Chapter 4 Line impedance

**About this chapter**

This chapter describes the line impedance functions in the terminal.

# 1 Distance protection (ZM)

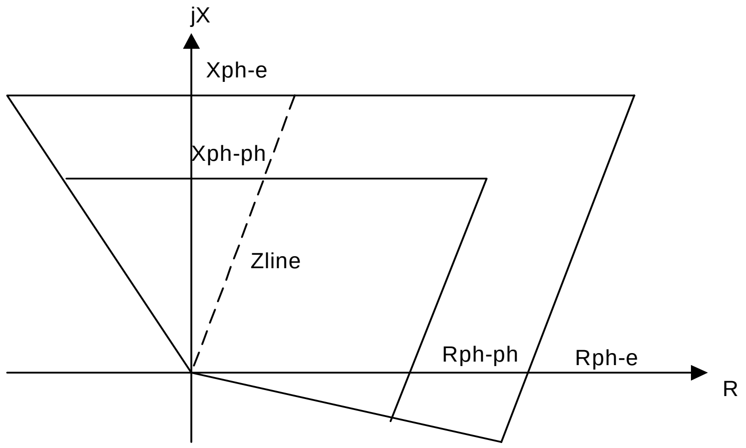
## 1.1 Application

The ZM distance protection function provides fast and reliable protection for overhead lines and power cables in all kinds of power networks. For each independent distance protection zone, full scheme design provides continuous measurement of impedance separately in three independent phase-to-phase measuring loops as well as in three independent phase-to-earth measuring loops.

Phase-to-phase distance protection is suitable as a basic protection function against two- and three-phase faults in all kinds of networks, regardless of the treatment of the neutral point. Independent setting of the reach in the reactive and the resistive direction for each zone separately, makes it possible to create fast and selective short circuit protection in power systems.

Phase-to-earth distance protection serves as basic earth fault protection in networks with directly or low impedance earthed networks. Together with an independent phase preference logic, it also serves as selective protection function at cross-country faults in isolated or resonantly earthed networks.

Independent reactive reach setting for phase-to-phase and for phase-to-earth measurement secures high selectivity in networks with different protective relays used for short-circuit and earth-fault protection.

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Where:

$X_{ph-e}$ = reactive reach for ph-e faults

$X_{ph-ph}$ = reactive reach for ph-ph faults

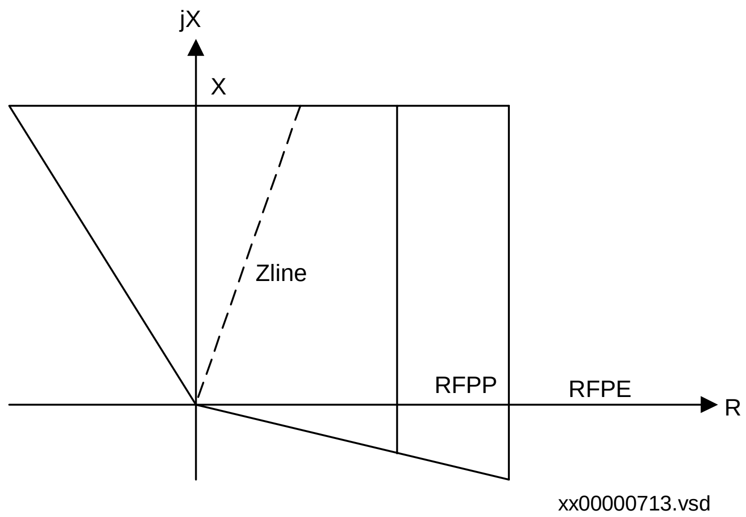
$R_{ph-e}$ = resistive reach for ph-e faults

$R_{ph-ph}$ = resistive reach for ph-ph faults

$Z_{line}$ = line impedance

*Figure 11: Schematic presentation of the operating characteristic for one distance protection zone in forward direction*

Distance protection with simplified setting parameters is available on request. It uses the same algorithm as the basic distance protection function. Simplified setting parameters reduce the complexity of necessary setting procedures and make the operating characteristic automatically more adjusted to the needs in combined networks.



Where:

X = reactive reach for all kinds of faults

RFPP = resistive reach for phase-to-phase faults

RFPE = resistive reach for phase-to-earth faults

$Z_{line}$ = line impedance

*Figure 12: Schematic presentation of the operating characteristic for one distance protection zone in forward direction with simplified setting parameters*

The distance protection zones can operate, independently of each other, in directional (forward or reverse) or non-directional mode. This makes it suitable, together with different communication schemes, for the protection of power lines and cables in complex network configurations, such as double-circuit, parallel lines, multiterminal lines, etc. Zone 1, 2 and 3 can issue phase selective signals, such as start and trip.

The additional distance protection zones four and five have the same basic functionality as zone 1-3, but lack the possibility of issuing phase selective output signals.

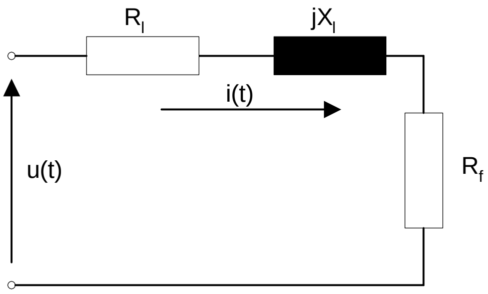
Distance protection zone 5 has shorter operating time than other zones, but also higher transient overreach. It should generally be used as a check zone together with the SOTF switch onto fault function or as a time delayed zone with time delay set longer than 100ms.

Basic distance protection function is generally suitable for use in non-compensated networks. A special addition to the basic functions is available optionally for use on series compensated and adjacent lines where voltage reversals might disturb the correct directional discrimination of a basic distance protection.

## 1.2 Functionality

Separate digital signal processors calculate the impedance as seen for different measuring loops in different distance protection zones. The results are updated each millisecond, separately for all measuring loops and each distance protection zone. Measurement of the impedance for each loop follows the differential equation, which considers complete line replica impedance, as presented schematically in figure 13.

$$u(t) = (R_l + R_f) \cdot i(t) + \frac{X_l}{\omega} \cdot \frac{\Delta i(t)}{\Delta t}$$




Where:

$R_l$ = line resistance

$R_f$ = fault resistance

$X_l$ = line reactance

$\omega$ $2\pi f$

f = frequency

*Figure 13: Schematic presentation of impedance measuring principle.*

Settings of all line parameters, such as positive sequence resistance and reactance as well as zero-sequence resistance and reactance, together with expected fault resistance for phase-to-phase and phase-to-earth faults, are independent for each zone. The operating characteristic is thus automatically adjusted to the line characteristic angle, if the simplified operating characteristic has not been especially requested. The earth-return compensation factor for the earth-fault measurement is calculated automatically by the terminal itself.

Voltage polarization for directional measurement uses continuous calculation and updating of the positive sequence voltage for each measuring loop separately. This secures correct directionality of the protection at different evolving faults within the complex network configurations. A memory retaining the pre-fault positive-sequence voltage secures reliable directional operation at close-up three-phase faults.

The distance protection function blocks are independent of each other for each zone. Each function block comprises a number of different functional inputs and outputs, which are freely configurable to different external functions, logic gates, timers and binary inputs and outputs. This makes it possible to influence the operation of the complete measuring zone or only its tripping function by the operation of fuse-failure function, power swing detection function, etc.

## 1.3 Function block, zone 1- 3

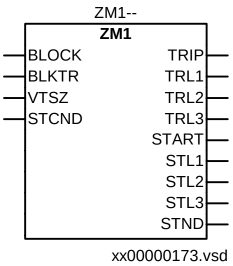



*Figure 14: ZM1 function block for single, two and/or three phase tripping*

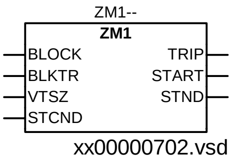



*Figure 15: ZM1 function block for three phase tripping*

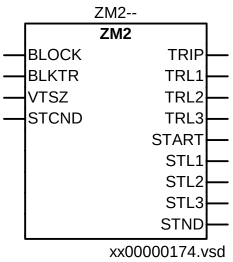



*Figure 16: ZM2 function block for single, two and/or three phase tripping*

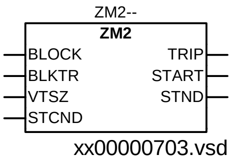



*Figure 17: ZM2 function block for three phase tripping*

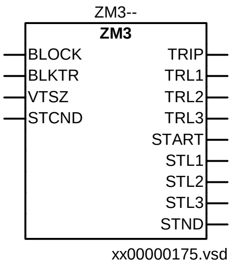



*Figure 18: ZM3 function block for single, two and/or three phase tripping*

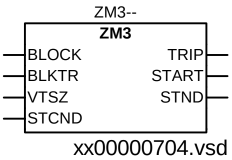



*Figure 19: ZM3 function block for three phase tripping*

## 1.4 Function block, zone 4

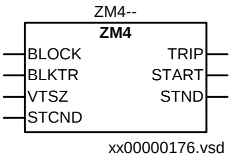



*Figure 20: ZM4 function block*

## 1.5 Function block, zone 5

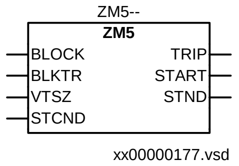



*Figure 21: ZM5 function block*

## 1.6 Logic diagram

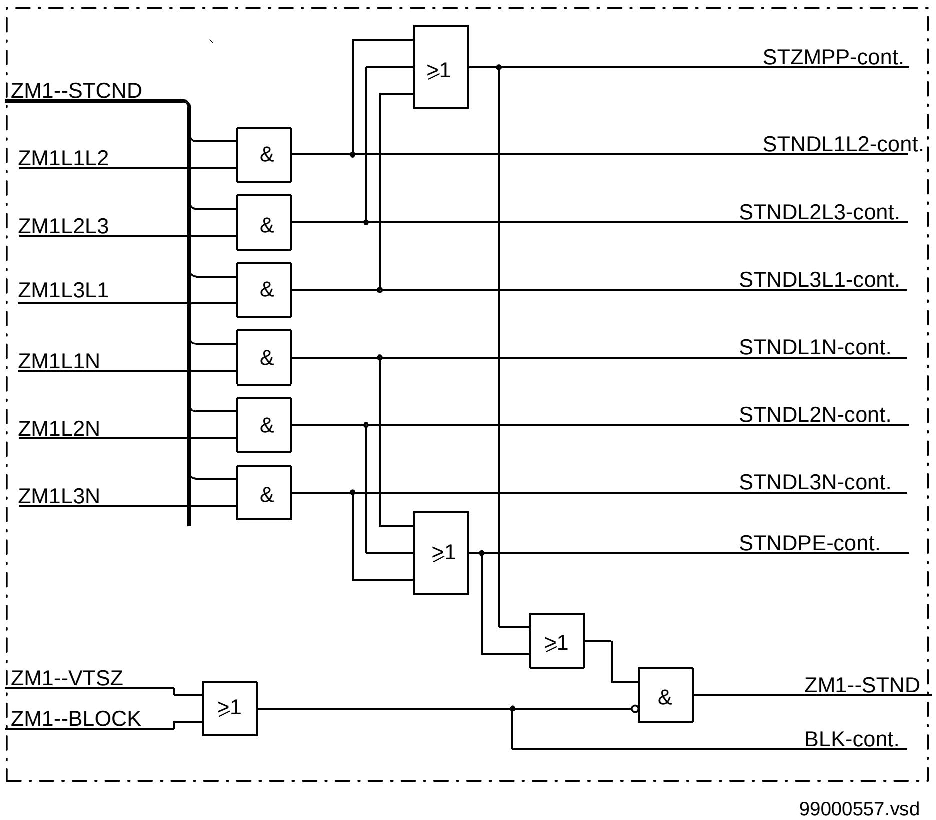



*Figure 22: Conditioning by a group functional input signal ZM1--STCND*

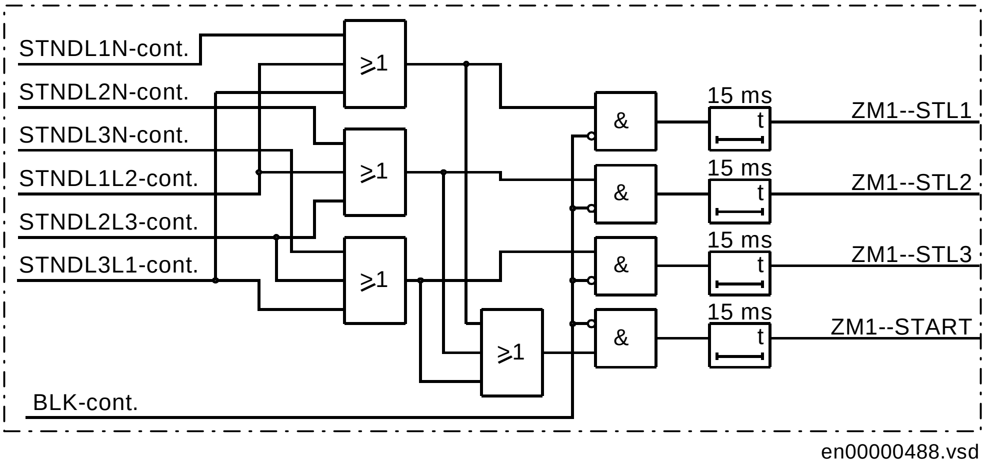



*Figure 23: Composition of starting signals in non-directional operating mode*

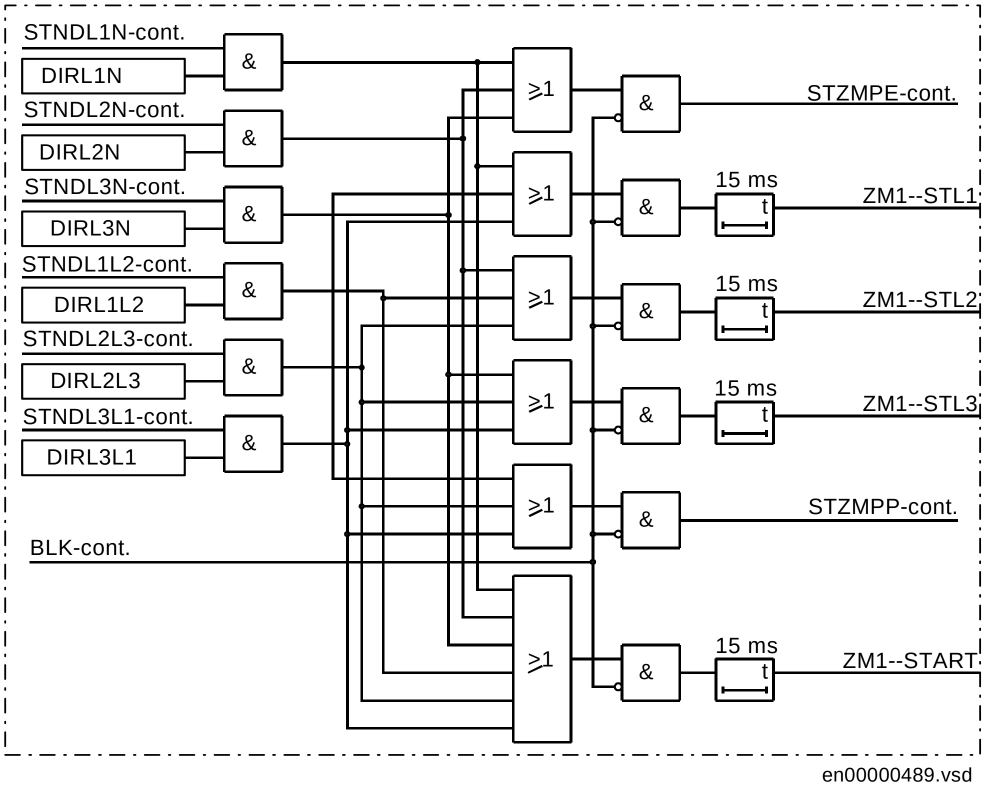



*Figure 24: Composition of starting signals in directional operating mode*

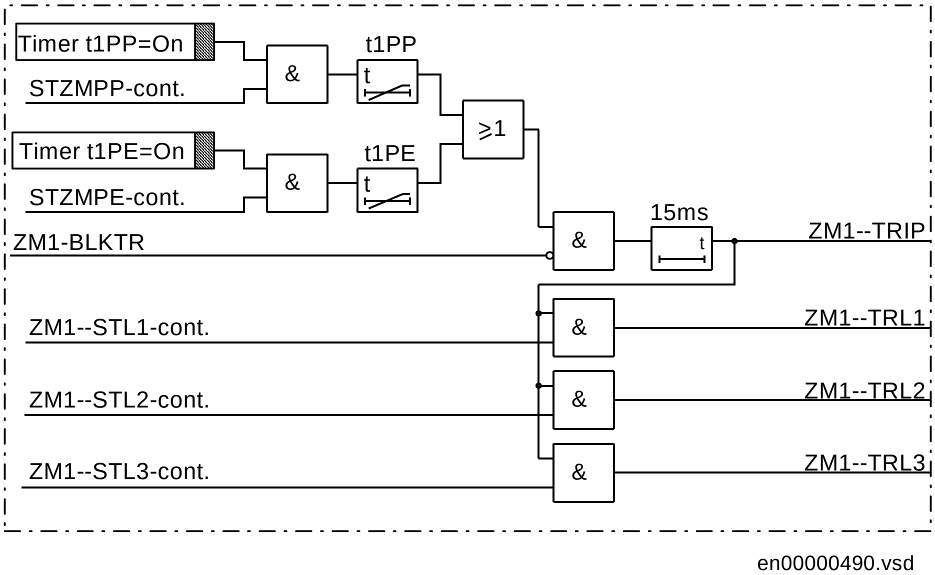



*Figure 25: Tripping logic for the distance protection zone one*

## 1.7 Input and output signals, zone 1-3

**Table 66: Input signals for the ZM1 (ZM1--), ZM2 (ZM2--), ZM3 (ZM3--) function blocks**

| Signal | Description |
|---|---|
| BLOCK | Blocks the operation of distance protection zone n |
| BLKTR | Blocks tripping outputs of distance protection zone n |
| VTSZ | Blocks the operation of distance protection zone n - connected to fuse failure signal FUSE-VTSZ |
| STCND | External starting condition for the operation of the distance protection zone n. Connected to one of the phase selection signals PHS--STCNDI, PHS--STCNDZ or to the general fault criteria signal GFC--STCND |

**Table 67: Output signals for the ZM1 (ZM1--), ZM2 (ZM2--), ZM3 (ZM3--) function blocks**

| Signal | Description |
|---|---|
| TRIP | Trip by distance protection zone n |
| TRL1 | Trip by distance protection zone n in phase L1 (available only with single pole tripping unit) |
| TRL2 | Trip by distance protection zone n in phase L2 (available only with single pole tripping unit) |
| TRL3 | Trip by distance protection zone n in phase L3 (available only with single pole tripping unit) |
| START | Start of (directional) distance protection zone n |
| STL1 | Start of (directional) distance protection zone n in phase L1 (available only with single pole tripping unit) |
| STL2 | Start of (directional) distance protection zone n in phase L2 (available only with single pole tripping unit) |
| STL3 | Start of (directional) distance protection zone n in phase L3 (available only with single pole tripping unit) |
| STND | Non-directional start of distance protection zone n |

## 1.8 Input and output signals, zone 4

**Table 68: Input signals for the ZM4 (ZM4--) function block**

| Signal | Description |
|---|---|
| BLOCK | Blocks the operation of distance protection zone 4 |
| BLKTR | Blocks tripping outputs of distance protection zone 4 |
| VTSZ | Blocks the operation of distance protection zone 4 - connected to fuse failure signal FUSE-VTSZ |
| STCND | External starting condition for the operation of the distance protection zone n. Connected to one of the phase selection signals PHS--STCNDI, PHS--STCNDZ or to the general fault criteria signal GFC--STCND |

**Table 69: Output signals for the ZM4 (ZM4--) function block**

| Signal: | Description: |
|---|---|
| TRIP | Trip by distance protection zone 4 |
| START | Start of directional distance protection zone 4 |
| STND | Start of non-directional distance protection zone 4 |

## 1.9 Input and output signals, zone 5

**Table 70: Input signals for the ZM5 (ZM5--) function block**

| Signal | Description |
|---|---|
| BLOCK | Blocks the operation of distance protection zone 5 |
| BLKTR | Blocks tripping outputs of distance protection zone 5 |
| VTSZ | Blocks the operation of distance protection zone 5 - connected to fuse failure signal FUSE-VTSZ |
| STCND | External starting condition for the operation of the distance protection zone n. Connected to one of the phase selection signals PHS--STCNDI, PHS--STCNDZ or to the general fault criteria signal GFC--STCND |

**Table 71: Output signals for the ZM5 (ZM5--) function block**

| Signal | Description |
|---|---|
| TRIP | Trip by distance protection zone 5 |
| START | Start of directional distance protection zone 5 |
| STND | Start of non-directional distance protection zone 5 |

## 1.10 Setting parameters, general

Setting parameters for the resistive and the reactive reach are presented for the terminals with rated current Ir = 1A. All impedance values should be divided by 5 for the terminals with rated current Ir = 5A.

Path in HMI-tree: Settings/Functions/Group n/Impedance/General

**Table 72: General setting parameters ZM1 - ZM5**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| IMinOp | 10-30<br>Step: 1 | 20 | % of I1b | Minimum operate current |

## 1.11 Setting parameters, zone 1-3

Path in HMI-tree: Settings/Functions/Group n/Impedance/Zone 1-3

**Table 73: General setting parameters for ZM1 - 3 (ZMn--) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off, Non-Dir, Forward, Reverse | Off | - | Operating mode and directionality for ZMn function |

Path in HMI-tree: Settings/Functions/Group n/Impedance/Zone1-3

**Table 74: Settings for the phase-to-phase measurement ZM1 - 3 (ZMn--) function**

| Parameter | Range | Unit | Default | Description |
|---|---|---|---|---|
| Operation PP | Off, On | - | Off | Operating mode for ZMn function for Ph-Ph faults |
| X1PP | 0.10-400.00<br>Step: 0.01 | ohm/ph | 10.00 | Positive sequence reactive reach of distance protection zone *n* for Ph-Ph faults |
| R1PP | 0.10-400.00<br>Step: 0.01 | ohm/ph | 10.00 | Positive sequence line resistance included in distance protection zone *n* for Ph-Ph faults |

| Parameter | Range | Unit | Default | Description |
|---|---|---|---|---|
| RFPP | 0.10-400.00<br>Step: 0.01 | ohm/ loop | 10.00 | Resistive reach of distance protection zone *n* for Ph-Ph faults |
| Timer t1PP<br>Timer t2PP<br>Timer t3PP | Off, On | - | Off | Operating mode of time delayed trip for the distance protection zone *n* for Ph-Ph faults |
| t1PP<br>t2PP<br>t3PP | 0.000 - 60.000<br>Step: 0.001 | s | 0.000 | Time delayed trip operation of the distance protection zone *n* for Ph-Ph faults |

Path in HMI-tree: Settings/Functions/Group n/Impedance/Zone1-3

**Table 75: Settings for the phase-to-earth measurement ZM1 - 3 (ZMn--) function**

| Parameter | Range | Unit | Default | Description |
|---|---|---|---|---|
| Operation PE | Off, On | - | Off | Operating mode for *ZMn* for Ph-E faults |
| X1PE | 0.10-400.00<br>Step: 0.01 | ohm/ph | 10.00 | Positive sequence reactive reach of distance protection zone *n* for Ph-E faults |
| R1PE | 0.10-400.00<br>Step: 0.01 | ohm/ph | 10.00 | Positive sequence line resistance included in distance protection zone *n* for Ph-E faults |
| X0PE | 0.10-1200.00<br>Step: 0.01 | ohm/ph | 10.00 | Zero sequence line reactance included in distance protection zone *n* for Ph-E faults |
| R0PE | 0.10-1200.00<br>Step: 0.01 | ohm/ph | 10.00 | Zero sequence line resistance included in distance protection zone *n* for Ph-E faults |

| Parameter | Range | Unit | Default | Description |
|---|---|---|---|---|
| RFPE | 0.10-400.00<br>Step: 0.01 | ohm/ loop | 10.00 | Resistive reach of distance protection zone *n* for Ph-E faults |
| Timer t1PE<br>Timer t2PE<br>Timer t3PE | Off, On | - | Off | Operating mode of time delayed trip for the distance protection zone *n* for Ph-E faults |
| t1PE<br>t2PE<br>t3PE | 0.000 - 60.000<br>Step: 0.001 | s | 0.000 | Time delayed trip operation of the distance protection zone *n* for Ph-E faults |

## 1.12 Setting parameters, zone 4

Path in HMI-tree: Settings/Functions/Group n/Impedance/Zone4

**Table 76: General zone setting parameters ZM4 (ZMn--) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off, NoneDir, Forward, Reverse | Off | - | Operating mode and directionality for ZM4 |

Path in HMI-tree: Settings/Functions/Group n/Impedance/Zone4

**Table 77: Settings for the phase-to-phase measurement ZM4 (ZMn--) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation PP | Off, On | Off | - | Operating mode for ZM4 for Ph-Ph faults |
| X1PP | 0.10 - 400.00<br>Step:0.01 | 10.00 | ohm/ph | Positive sequence reactive reach of distance protection zone 4 for Ph-Ph faults |
| R1PP | 0.10 - 400.00<br>Step: 0.01 | 10.00 | ohm/ph | Positive sequence line resistance included in distance protection zone 4 for Ph-Ph faults |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| RFPP | 0.10 - 400.00<br>Step: 0.01 | 10.00 | ohm/loop | Resistive reach of distance protection zone 4 for Ph-Ph faults |
| Timer t4PP | Off, On | On | - | Operating mode of time delayed trip for the distance protection zone 4 for Ph-Ph faults |
| t4PP | 0.000 - 60.000<br>Step: 0.001 | 0.000 | s | Time delayed trip operation of the distance protection zone 4 for Ph-Ph faults |

Path in HMI-tree: Settings/Functions/Group n/Impedance/Zone4

**Table 78: Settings for the phase-to-earth measurement ZM4 (ZMn--) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation PE | Off, On | Off | | Operating mode for ZM4 for Ph-E faults |
| X1PE | 0.10 - 400.00<br>Step: 0.01 | 10.00 | ohm/ph | Positive sequence reactive reach of distance protection zone 4 for Ph-E faults |
| R1PE | 0.10 - 400.00<br>Step: 0.01 | 10.00 | ohm/ph | Positive sequence line resistance included in distance protection zone 4 for Ph-E faults |
| X0PE | 0.10 - 1200.00<br>Step:0.01 | 10.00 | ohm/ph | Zero sequence line reactance included in distance protection zone 4 for Ph-E faults |
| R0PE | 0.10 - 1200.00<br>Step:0.01 | 10.00 | ohm/ph | Zero sequence line resistance included in distance protection zone 4 for Ph-E faults |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| RFPE | 0.10 - 400.00<br>Step: 0.01 | 10.00 | ohm/loop | Resistive reach of distance protection zone 4 for Ph-E faults |
| Timer t4PE | Off, On | On | | Operating mode of time delayed trip for the distance protection zone 4 for Ph-E faults |
| t4PE | 0.000 - 60.000<br>Step: 0.001 | 0.000 | s | Time delayed trip operation of the distance protection zone 4 for Ph-E faults |

## 1.13 Setting parameters, zone 5

Path in HMI-tree: Settings/Functions/Group n/Impedance/Zone5

**Table 79: General setting parameters for ZM5 (ZMn--) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off, NoneDir, Forward, Reverse | Off | - | Operating mode and directionality for ZM5 |

Path in HMI-tree: Settings/Functions/Group n/Impedance/Zone5

**Table 80: Settings for the phase-to-phase measurement ZM5 (ZMn--) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation PP | Off, On | Off | - | Operating mode for ZM5 for Ph-Ph faults |
| X1PP | 0.10 - 400.00<br>Step: 0.01 | 10.00 | ohm/ph | Positive sequence reactive reach of distance protection zone 5 for Ph-Ph faults |
| R1PP | 0.10 - 400.00<br>Step: 0.01 | 10.00 | ohm/ph | Positive sequence line resistance included in distance protection zone 5 for Ph-Ph faults |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| RFPP | 0.10 - 400.00<br>Step: 0.01 | 10.00 | ohm/loop | Resistive reach of distance protection zone 5 for Ph-Ph faults |
| Timer t5PP | Off, On | On | - | Operating mode of time delayed trip for the distance protection zone 5 for Ph-Ph faults |
| t5PP | 0.000 - 60.000<br>Step: 0.001 | 0.000 | s | Time delayed trip operation of the distance protection zone 5 for Ph-Ph faults |

Path in HMI-tree: Settings/Functions/Group n/Impedance/Zone5

**Table 81: Settings for the phase-to-earth measurement ZM5 (ZMn--)**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation PE | Off, On | Off | - | Operating mode for ZM5 for Ph-E faults |
| X1PE | 0.10 - 400.00<br>Step: 0.01 | 10.00 | ohm/ph | Positive sequence reactive reach of distance protection zone 5 for Ph-E faults |
| R1PE | 0.10 - 400.00<br>Step: 0.01 | 10.00 | ohm/ph | Positive sequence line resistance included in distance protection zone 5 for Ph-E faults |
| X0PE | 0.10 - 1200.00<br>Step: 0.01 | 10.00 | ohm/ph | Zero sequence line reactance included in distance protection zone 5 for Ph-E faults |
| R0PE | 0.10 - 1200.00<br>Step: 0.01 | 10.00 | ohm/ph | Zero sequence line resistance included in distance protection zone 5 for Ph-E faults |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| RFPE | 0.10 - 400.00<br>Step: 0.01 | 10.00 | ohm/loop | Resistive reach of distance protection zone 5 for Ph-E faults |
| Timer t5PE | Off, On | On | - | Operating mode of time delayed trip for the distance protection zone 5 for Ph-E faults |
| t5PE | 0.000 - 60.000<br>Step: 0.001 | 0.000 | s | Time delayed trip operation of the distance protection zone 5 for Ph-E faults |

## 1.14 Setting parameters, simplified impedance settings

**Table 82: Simplified settings, ZM1 - ZM5**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| X1 | 0.10-400.00<br>Step: 0.01 | 10.00 | ohms/phase | Positive sequence reactance, zone n |
| R1 | 0.10-400.00<br>Step: 0.01 | 10.00 | ohms/phase | Positive sequence resistance, zone n |
| RFPP | 0.10-400.00<br>Step: 0.01 | 10.00 | ohms/loop | Fault resistance, zone n, phase-to-phase |
| Timer t1<br>Timer t2<br>Timer t3<br>Timer t4<br>Timer t5 | On/Off | Off | - | Operation trip time delay, zone n. Off= no trip |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| t1<br>t2<br>t3<br>t4<br>t5 | 0.000-60.000<br>Step: 0.001 | 0.000 | s | Trip time delay, zone n |
| X0 | 0.10-1200.00<br>Step: 0.01 | 10.00 | ohms/phase | Zero sequence reactance, zone n |
| R0 | 0.10-1200.00<br>Step: 0.01 | 10.00 | ohms/phase | Zero sequence resistance, zone n |
| RFPE | 0.10-400.00<br>Step: 0.01 | 10.00 | ohms/loop | Fault resistance, zone n, phase-to-earth |

## 1.15 Setting parameters, directional measuring element

Setting parameters for the resistive and the reactive reach are presented for the terminals with rated current Ir = 1A. All impedance values should be divided by 5 for the terminals with rated current Ir = 5A.

**Table 83: General setting parameters, ZDIR**

| | | | | |
|---|---|---|---|---|
| ArgDir | 5-45<br>Step:1 | 15 | degrees | Lower angle of forward direction characteristic |
| ArgNegRes | 90-175<br>Step:1 | 115 | degrees | Upper angle of forward direction Characteristic |

## 1.16 Technical data

**Table 84: ZM1, 2, 3, 4, 5 Zone impedance measuring elements**

| **Function** | | | **Value** |
|---|---|---|---|
| Operate time | Typical | | 28 ms |
| | Min and max | | Please refer to the separate isochrone diagrams |
| Min. operate current | | | (10-30) % of I1b in steps of 1 % |
| Resetting ratio | | | Typical 110 % |
| Resetting time | | | Typical 40 ms |
| Output signals start and trip | | Zone 1-3 | Three phase or single phase and/or three phase |
| | | Zone 4, 5 | Three phase start and trip |
| Setting accuracy | | | Included in the measuring accuracy |
| Number of zones | | | 3, 4 or 5, direction selectable |
| Impedance setting range at $I_r$ = 1 A (to be divided by 5 at $I_r$ = 5 A) | Reactive reach | Positive-sequence reactance | (0.10-400.00) Ω/phase in steps of 0.01 Ω |
| | | Zero sequence reactance | (0.10-1200.00) Ω/phase in steps of 0.01 Ω |
| | Resistive reach | Positive-sequence resistance | (0.10-400.00) Ω/phase in steps of 0.01 Ω |
| | | Zero sequence resistance | (0.10-1200.00) Ω/phase in steps of 0.01 Ω |
| | Fault resistance | For phase - phase faults | (0.10-400.00) Ω/loop in steps of 0.01 Ω |
| | | For phase-earth faults | (0.10-400.00) Ω/loop in steps of 0.01 Ω |
| Setting range of timers for impedance zones | | | (0.000-60.000) s in steps of 1 ms |
| Static accuracy at 0° and 85° | Voltage range (0.1-1.1) x $U_r$ | | +/- 5 % |
| | Current range (0.5-30) x $I_r$ | | |
| Static angular accuracy at 0° and 85° | Voltage range (0.1-1,1) x $U_r$ | | +/- 5° |
| | Current range (0.5-30) x $I_r$ | | |
| Max dynamic overreach at 85° measured with CVT's 0.5 < SIR < 30 | | | + 5 % |

# 2 Automatic switch onto fault logic (SOTF)

## 2.1 Application

The main purpose of the SOTF switch-on-to-fault function is to provide high-speed tripping when energizing a power line on to a short-circuit fault on the line.

Automatic initiating of the SOTF function using dead line detection can only be used when the potential transformer is situated on the line-side of the circuit breaker. Initiation using dead line detection is highly recommended for busbar configurations where more than one circuit breaker at one line end can energize the protected line.

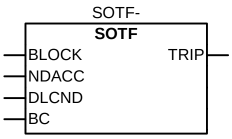
Generally, directional or non-directional overreaching distance protection zones are used as the protection functions to be released for direct tripping during the activated time. When line-side potential transformers are used, the use of non-directional distance zones secures switch-on-to-fault tripping for close-in three-phase short circuits. Use of non-directional distance zones also gives fast fault clearance when energizing a bus from the line with a short-circuit fault on the bus.

## 2.2 Functionality

The SOTF function is a logical function built-up from logical elements. It is a complementary function to the distance protection function.

It is enabled for operation either by the close command to the circuit breaker, by a normally closed auxiliary contact of the circuit breaker, or automatically by the dead line detection. Once enabled, this remains active until one second after the enabling signal has reset. The protection function(s) released for tripping during the activated time can be freely selected from the functions included within the terminal. Pickup of any one of the selected protection functions during the enabled condition will result in an immediate trip output from the SOTF function.

## 2.3 Function block



xx00000188.vsd

## 2.4 Logic diagram

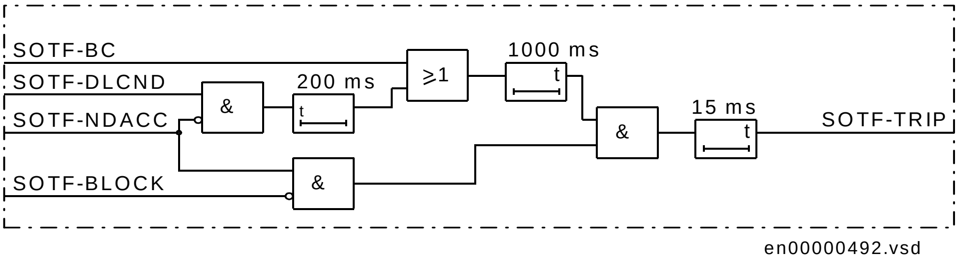



*Figure 26: SOTF function - simplified logic diagram*

## 2.5 Input and output signals

**Table 85: Input signals for the SOTF (SOTF-) function block**

| Signal | Description |
|---|---|
| BLOCK | Blocks function |
| NDACC | Connected to function(s) to be released for immediate tripping when SOTF function is enabled |
| DLCND | Connected to dead line detection function to provide automatic enabling of SOTF function |
| BC | Enabling of SOTF function by circuit breaker close command or normally closed auxiliary contact of the circuit breaker |

**Table 86: Output signals for the SOTF (SOTF-) function block**

| Signal | Description |
|---|---|
| TRIP | Trip output |

## 2.6 Setting parameters

**Table 87: Setting parameters for the automatic switch onto fault logic SOTF (SOTF-) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off / On | Off | - | Operating mode for SOTF function |

## 2.7 Technical data

**Table 88: Automatic switch onto fault function**

| Parameter | Value | Accuracy |
|---|---|---|
| Delay following dead line detection input before SOTF function is automatically enabled | 200 ms | +/-0.5%  +/-10 ms |
| Time period after circuit breaker closure in which SOTF function is active | 1000 ms | +/-0.5%  +/-10 ms |

# 3 Local acceleration logic (ZCLC)

## 3.1 Application

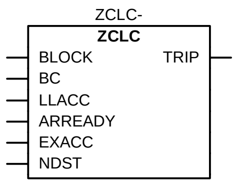
The main purpose of the ZCLC local acceleration logic is to achieve fast fault clearance for faults anywhere on the whole line for those applications where no communication channel is available.

## 3.2 Functionality

The ZCLC function is a complementary function to the distance protection function.

The local acceleration logic can be enabled for operation in two ways. The first way uses an ‘automatic recloser ready’ signal, either from the internal recloser, or an external recloser. The second way uses loss of load detection. When enabled by either method, the local acceleration logic will produce an immediate output on pickup of the function selected to the method of acceleration enabled.

## 3.3 Function block



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## 3.4 Logic diagram

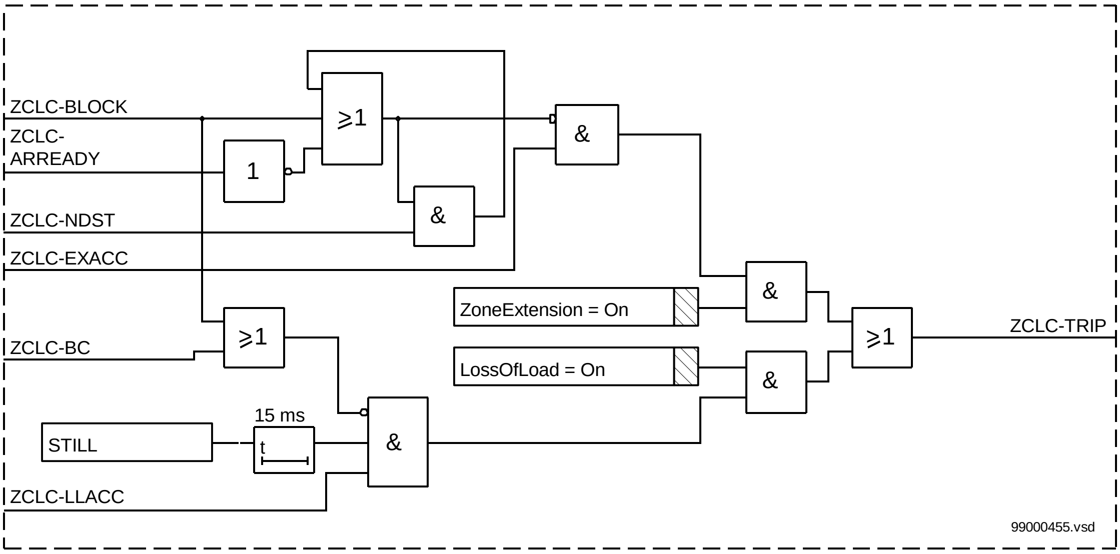



*Figure 27: Simplified logic diagram for the local acceleration logic*

## 3.5 Input and output signals

**Table 89: Input signals for the ZCLC (ZCLC-) function block**

| Signal | Description |
|---|---|
| BLOCK | Blocks function |
| BC | Circuit breaker closed |
| LLACC | Connected to function to be used for tripping at loss of load acceleration |
| ARREADY | Releases function used for zone extension for immediate tripping |
| EXACC | Connected to function to be used for tripping at zone extension |
| NDST | Connected to function to be used to prevent zone extension for its picked-up duration if the release for zone extension is not present when it picks-up |

**Table 90: Output signals for the ZCLC (ZCLC-) function block**

| Signal | Description |
|---|---|
| TRIP | Trip output |

## 3.6 Setting parameters

**Table 91: Setting parameters for the local acceleration logic ZCLC (ZCLC-) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| ZoneExtension | Off / On | Off | - | Operating mode for zone extension logic |
| LossOfLoad | Off / On | Off | - | Operating mode for loss of load acceleration logic |

# 4 Phase selection logic (PHS)

## 4.1 Application

The PHS phase selection logic function is an independent measuring function. It comprises both impedance and current-based measurement criteria. Its main purpose is to augment the phase selectivity of the complete distance protection in networks with long and heavily loaded lines. It is generally intended for use in directly earthed networks, where correct and reliable phase selection for single-phase-to-earth faults, combined with single-pole tripping and automatic reclosing, secures the stability of complete power systems.

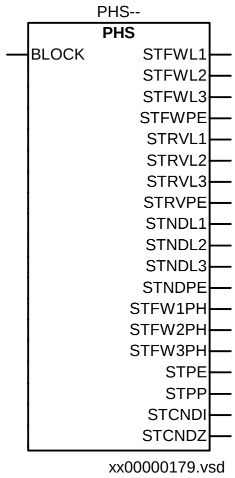
The independent measurement of impedance in all six fault loops secures a high degree of phase selectivity in complex networks. This independent phase selection, combined with directional measurement for each fault loop, also secures selective operation for simultaneous close-in faults on parallel circuits. Independent reactive reach settings for phase-to-phase and phase-to-earth measurement secures high selectivity in networks with different protective relays used for short-circuit and earth-fault protection.

## 4.2 Functionality

For the impedance-based phase selection, all six fault loops are measured separately and continuously. The reactive and resistive reaches are independently settable for phase-to-phase and phase-to-earth faults. Checks based on the level of residual current determine which loops, i.e. phase-to-earth or phase-to-phase, are evaluated. Selection of the faulted phase(s) is determined by which of the selected loops operate. Operation of a loop occurs when the measured impedance within that loop is within the set boundaries of the characteristic. The impedance-based output will activate the selected loop of the distance protection measuring zone(s) to which the impedance-based phase selection output is connected.

The current-based phase selection is based on the same residual current checks as those used to select the phase-to-earth or phase-to-phase loops of the impedance-based phase selection function for evaluation. In this case the current-based output will activate either all the phase-to-earth loops or all the phase-to-phase loops of the distance protection measuring zone(s) to which the current-based phase selection output is configured.

## 4.3 Function block




## 4.4 Logic diagram

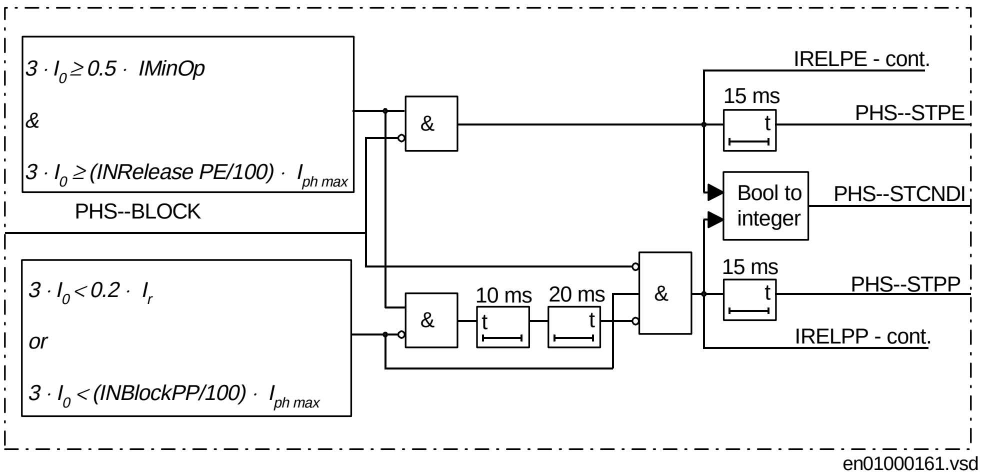



*Figure 28: Ph-Ph and Ph-E operating conditions.*

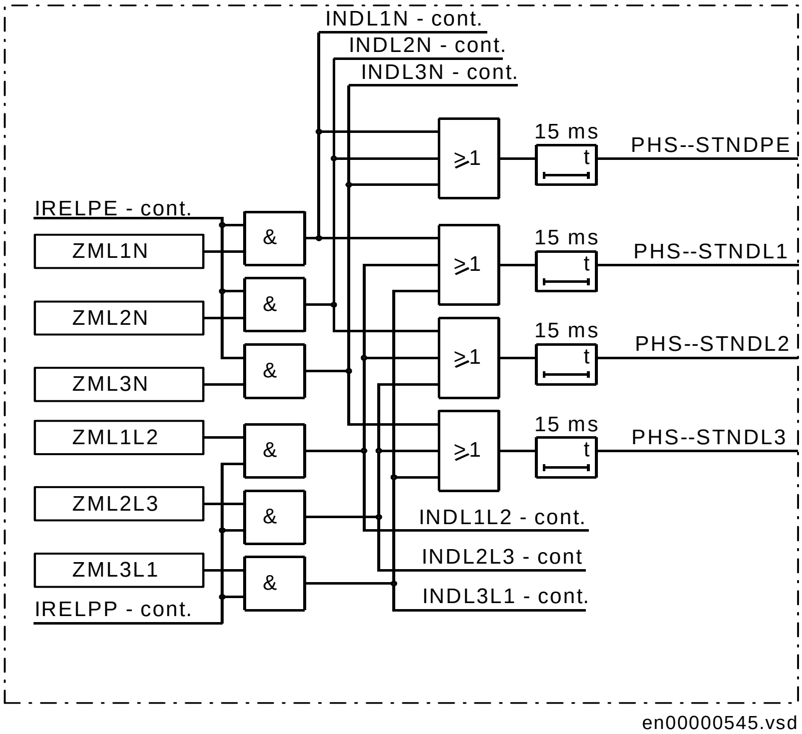



*Figure 29: Composition of reverse directed phase selection signals*

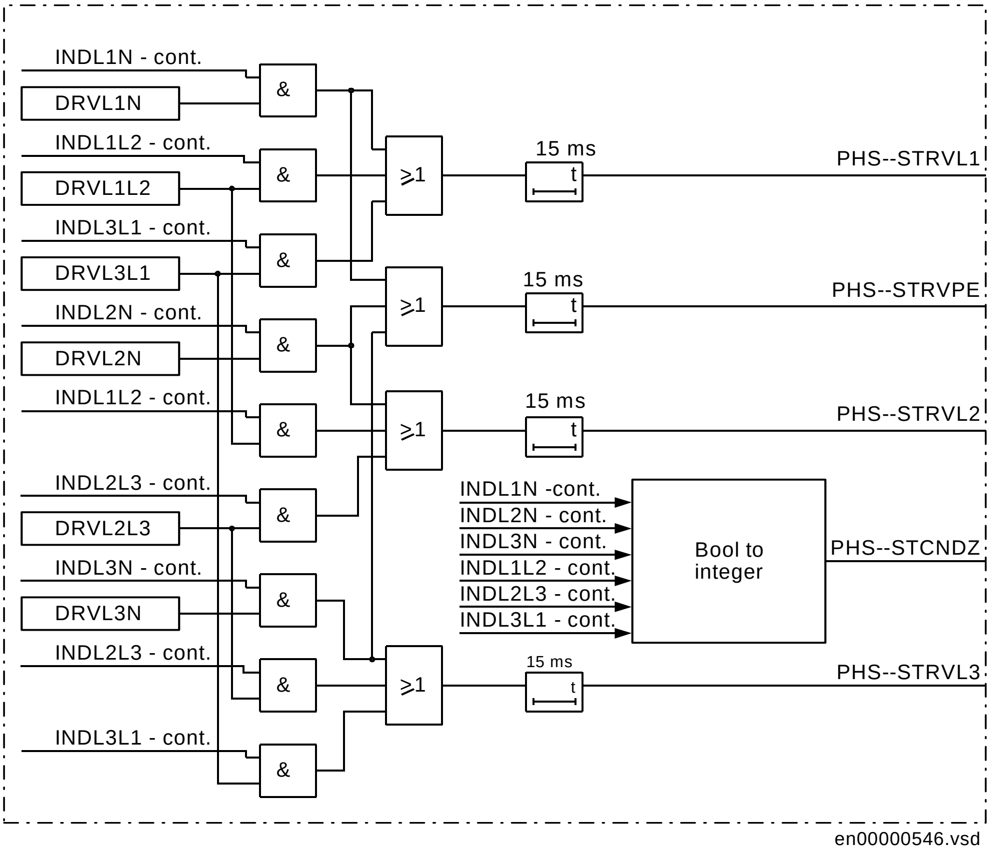



*Figure 30: Composition of undirected phase selection signals*

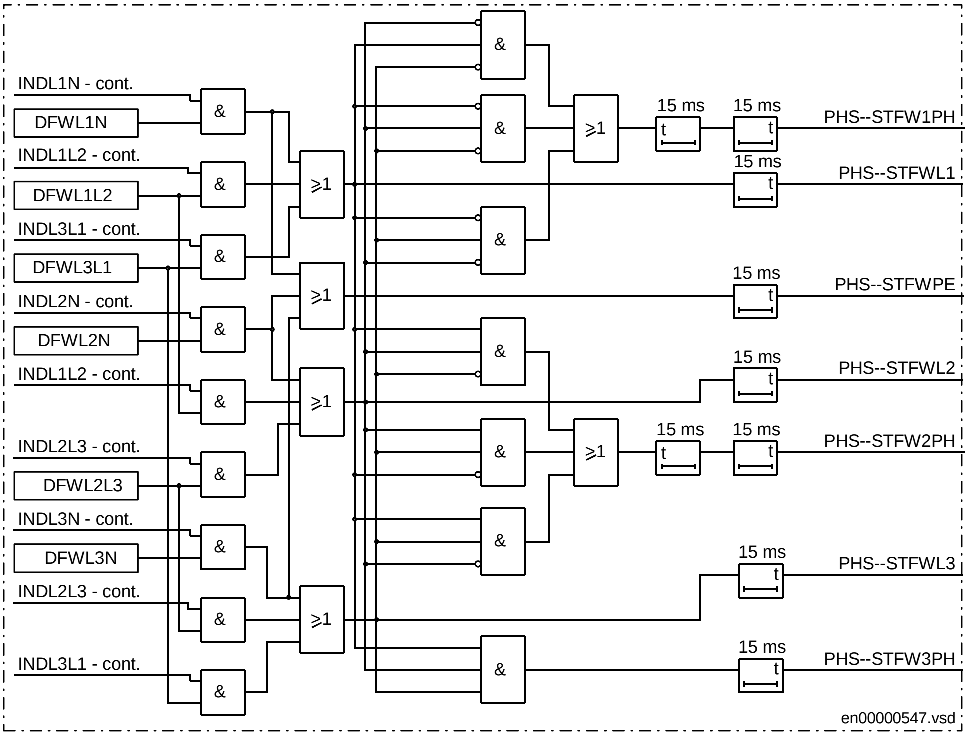



*Figure 31: Composition of forward directed phase selection signals*

## 4.5 Input and output signals

### Table 92: Input signals for the PHS (PHS--) function block

| Signal | Description |
|---|---|
| BLOCK | Block function |

### Table 93: Output signals for the PHS (PHS--) function block

| Signal | Description |
|---|---|
| STFWL1 | Fault detected in phase L1 - forward direction |
| STFWL2 | Fault detected in phase L2 - forward direction |
| STFWL3 | Fault detected in phase L3 - forward direction |
| STFWPE | Earth fault detected in forward direction |
| STRVL1 | Fault detected in phase L1 - reverse direction |

| Signal | Description |
|---|---|
| STRVL2 | Fault detected in phase L2 - reverse direction |
| STRVL3 | Fault detected in phase L3 - reverse direction |
| STRVPE | Earth fault detected in reverse direction |
| STNDL1 | Fault detected in phase L1 |
| STNDL2 | Fault detected in phase L2 |
| STNDL3 | Fault detected in phase L3 |
| STNDPE | Earth fault detected |
| STFW1PH | Single-phase fault detected in forward direction |
| STFW2PH | Two-phase fault detected in forward direction |
| STFW3PH | Three-phase fault detected in forward direction |
| STPE | Start for phase-to-earth measuring elements |
| STPP | Start for phase-to-phase measuring elements |
| STCNDI | Information on current based starting conditions for the operation of zone measuring elements |
| STCNDZ | Information on impedance based starting conditions for the operation of zone measuring elements |

## 4.6 Setting parameters

Setting parameters for the resistive and the reactive reach are given for terminals with rated current Ir = 1A. All values should be divided by 5 for terminals with rated current Ir = 5A.

**Table 94: Setting parameters for the phase selection logic function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off/ On | off | - | Operating mode for PHS function |
| INReleasePE | 10 - 100<br>Step: 1 | 20 | % of IphMax | 3I0 limit for releasing phase-to-earth measuring loops |
| INBlockPP | 10 - 100<br>Step: 1 | 40 | % of IphMax | 3I0 limit for blocking phase-to-phase measuring loops |
| X1PP | 10 - 100<br>Step: 1 | 40 | ohm/ phase | Positive sequence reactive reach for ph-ph loop measurement |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| RFPP | 0.10 - 400.00<br>Step: 0.01 | 40.00 | ohm/ loop | Resistive reach for ph-ph loop measurement |
| X1PE | 0.10 - 400.00<br>Step: 0.01 | 40.00 | ohm/ phase | Positive sequence reactive reach for ph-E loop measurement |
| X0PE | 0.10 - 1200.00<br>Step: 0.01 | 40.00 | ohm/ phase | Zero sequence reactive reach for ph-E loop measurement |
| RFPE | 0.10 - 400.000<br>Step: 0.01 | 40.00 | ohm/ loop | Resistive reach for ph-E loop measurement |

## 4.7 Technical data

**Table 95: Phase selection logic**

| Function | | | Value |
|---|---|---|---|
| Impedance setting range at $I_r$=1 A | Reactive reach | Positive sequence reactance | 0.10-400.00 ohm/phase in steps of 0.01 ohm/phase |
| | | Zero sequence reactance | 0.10-1200.00 ohm/phase in steps of 0.01 ohm/phase |
| | Resistive reach | For phase to phase faults | 0.10-400.00 ohm/loop in steps of 0.01 ohm/loop |
| | | For phase to ground faults | 0.10-400.00 ohm/loop in steps of 0.01 ohm/loop |
| Static angular accuracy at 0 degrees and 85 degrees | Voltage range (0.1-1.1) x $U_r$ | | +/-5 degrees |
| | Current range (0.5-30) x $I_r$ | | |

# 5 Power swing detection (PSD)

## 5.1 Application

Power swings on the system arise due to big changes in load, or changes in power system configuration due to faults and their clearance. Distance protection detects these power swings as variations with time of the measured impedance along a locus in the impedance plane. This locus can enter the operate characteristic of the distance protection and cause its unwanted operation if no preventive measures are taken. The main purpose of the PSD power swing detection function is to detect power swings in power networks and to provide the blocking signal to the distance function to prevent its unwanted operation.

## 5.2 Functionality

The PSD function comprises an inner and an outer quadrilateral measurement characteristic. Its principle of operation is based on the measurement of the time it takes a power swing transient impedance to pass through the impedance area between the outer and the inner characteristics. Power swings are identified by transition times longer than timer settings. The impedance measuring principle is the same as that used for the distance protection zones. The impedance and the transient impedance time are measured in all three phases separately. One-out-of-three or two-out-of-three operating modes can be selected permanently or adaptively according to the specific system operating conditions.

The PSD function detects power swings with a swing period as low as 200 ms (i.e. with a slip frequency as high as 10% of the rated frequency on a 50 Hz basis). It detects swings under normal system operating conditions, as well as during the dead time of a single-pole automatic reclosing cycle. Different timers are used for initial and consecutive swings, securing a high degree of differentiation between power swing and fault conditions.

It is possible to inhibit the power swing detected output on detection of earth fault current. This can be used to release the operation of the distance protection function for earth faults during power swing conditions.

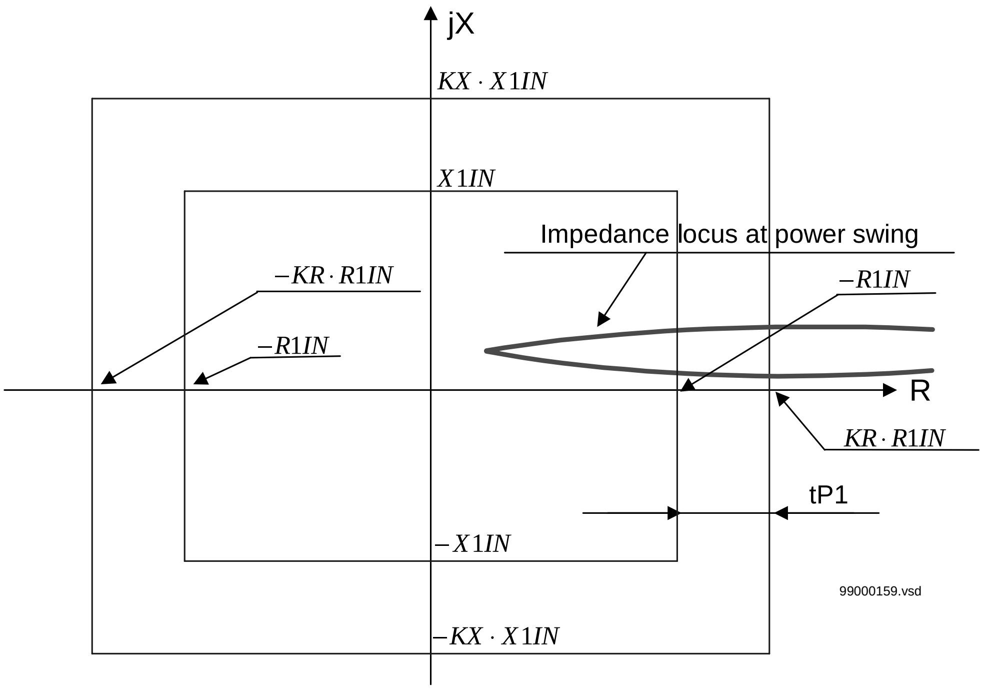
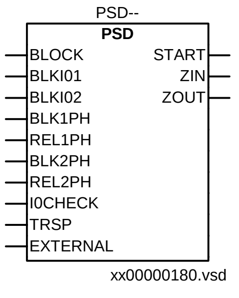



*Figure 32: Operating principle and characteristic of the PSD function*

## 5.3 Function block



## 5.4 Logic diagram

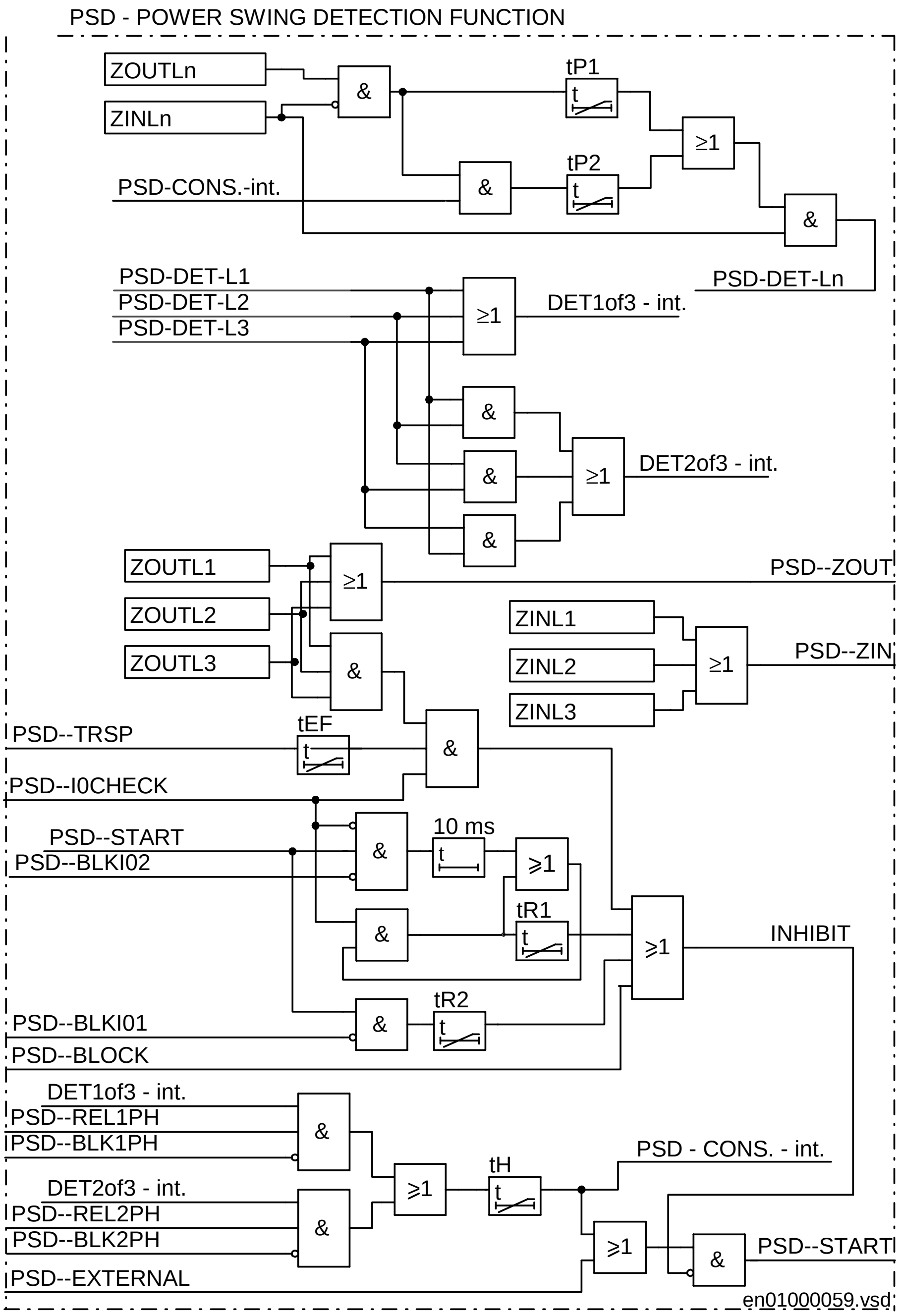



*Figure 33: PSD function - block diagram.*

## 5.5 Input and output signals

**Table 96: Input signals for the PSD (PSD--) function block**

| Signal | Description |
|---|---|
| BLOCK | Blocks the function |
| BLKI01 | Blocks internal inhibit of PSD-START output for slow swing condition |
| BLKI02 | Blocks internal inhibit of PSD-START output for subsequent residual current detection |
| BLK1PH | Blocks one-out-of-three-phase operating mode |
| REL1PH | Releases one-out-of-three-phase operating mode |
| BLK2PH | Blocks two-out-of-three-phase operating mode |
| REL2PH | Releases two-out-of-three-phase operating mode |
| I0CHECK | Residual current ($3I_0$) detection used to inhibit PSD-START output |
| TRSP | Single-pole tripping command issued by tripping function |
| EXTERNAL | Input for external detection of power swing |

**Table 97: Output signals for the PSD (PSD--) function block**

| Signal | Description |
|---|---|
| START | Power swing detected |
| ZIN | Measured impedance within inner impedance boundary |
| ZOUT | Measured impedance within outer impedance boundary |

## 5.6 Setting parameters

Setting values for impedance parameters are given for rated current Ir = 1A. Divide the given values by 5 if the rated current is Ir = 5A.

**Table 98: Setting parameters for the power swing detection PSD (PSD--) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off, On | Off | - | Operating mode for PSD function |
| Detection | Off, On | Off | - | Operating mode for the internal power swing detection (PSD) function |
| X1IN | 0.10 - 400.00<br>Step: 0.01 | 30.00 | ohm/ phase | Positive sequence reactive reach of the inner boundary |
| R1IN | 0.10 - 400.00<br>Step: 0.01 | 30.00 | ohm/ phase | Positive sequence resistive reach of the inner boundary |
| KX | 120 - 200<br>Step: 1 | 125 | % | Reach multiplication factor for the outer reactive boundary |
| KR | 120 - 200<br>Step: 1 | 125 | % | Reach multiplication factor for the outer resistive boundary |
| tP1 | 0.000 - 60.000<br>Step: 0.001 | 0.045 | s | Timer for detection of initial power swings |
| tP2 | 0.000 - 60.000<br>Step: 0.001 | 0.015 | s | Timer for detection of subsequent power swings |
| tW | 0.000 - 60.000<br>Step: 0.001 | 0.250 | s | Waiting timer for activation of tP2 timer |
| tH | 0.000 - 60.000<br>Step: 0.001 | 0.500 | s | Timer for holding PSD output |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| tEF | 0.000 - 60.000<br>Step: 0.001 | 3.000 | s | Timer for overcoming single-pole reclosing dead time |
| tR1 | 0.000 - 60.000<br>Step: 0.001 | 0.300 | s | Timer giving delay to blocking of output by the residual current |
| tR2 | 0.000 - 60.000<br>Step: 0.001 | 2.000 | s | Timer giving delay to blocking of output at very slow swings |

## 5.7 Technical data

**Table 99: Power swing detection**

| Parameter | | Setting range | Accuracy |
|---|---|---|---|
| Impedance setting range at $I_r$ =1A<br>(divide values by 5 for $I_r$ = 5A) | Reactive reach, XIN | 0.10-400.00 ohm/phase in steps of 0.01 ohm/phase | |
| | Resistive reach, RIN | 0.10-400.00 ohm/phase in steps of 0.01ohm/phase | |
| Reach multiplication factor, KX | | 120-200% of XIN in steps of 1% | |
| Reach multiplication factor, KR | | 120-200% of RIN in steps of 1% | |
| Initial PSD timer, tP1 | | 0.000-60.000 s in steps of 1 ms | +/- 0.5 % +/- 10 ms |
| Fast PSD timer, tP2 | | 0.000-60.000 s in steps of 1 ms | +/- 0.5 % +/- 10 ms |
| Hold timer tW for activation of fast PSD timer | | 0.000-60.000 s in steps of 1 ms | +/- 0.5 % +/- 10 ms |
| Hold timer tH for PSD detected | | 0.000-60.000 s in steps of 1 ms | +/- 0.5 % +/- 10 ms |

| Parameter | Setting range | Accuracy |
|---|---|---|
| Timer tEF overcoming 1ph reclosing dead time | 0.000-60.000 s in steps of 1 ms | +/- 0.5 % +/- 10 ms |
| Timer tR1 to time delay block by the residual current | 0.000-60.000 s in steps of 1 ms | +/- 0.5 % +/- 10 ms |
| Timer tR2 to time delay block at very slow swings | 0.000-60.000 s in steps of 1 ms | +/- 0.5 % +/- 10 ms |

# 6 Power-swing logic (PSL)

## 6.1 Application

The main purpose of the PSL power swing logic is to secure selective and reliable operation of the distance protection for both internal and external faults during power swings. It also ensures stable operation of the distance protection for power swings caused by the clearance of external faults, i.e. power swings that begin from within the characteristic of an overreaching zone, and which are therefore not able to be detected by the power swing detection function in the normal way.

## 6.2 Functionality

The PSL is a supplementary function to the power swing detection function. It requires for its operation inputs from the distance protection function, the power swing detection function, etc., and the teleprotection equipment, when available.

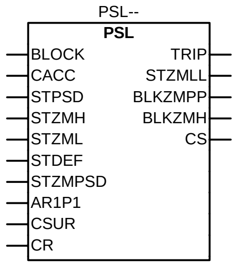
Reliable operation for faults during power swings is achieved by the communication logic within the PSL. For its operation, this function requires inputs from a distance protection zone(s) that are not used for the ordinary distance protection, and therefore that are not blocked by the power swing detection function on detection of a power swing. For this reason it is recommended to include zone 4 and/or zone 5 within the terminal.

The PSL is only activated following detection of a power swing by the power swing detection function.It can operate in both permissive overreaching (one power swing zone required) and permissive underreaching (two power swing zones required) modes. It is possible to use the same communication channels as for the normal scheme communication because the normal distance zones which utilize these channels are blocked during power swings.

For single-line-to-earth faults, an alternative earth fault protection function, e.g. directional earth fault, may be preferred to deal with earth faults during a power swing. It is then possible to block the power swing logic on pickup of this protection, except during the pole open period of a single-pole automatic reclosing cycle.

For power swings caused by external faults measured within the power swing characteristic, stable operation is ensured in these circumstances by automatically replacing the output connections from the normal instantaneous direct tripping distance zone with output connections from the PSL.

## 6.3 Function block




xx00000181.vsd

## 6.4 Logic diagram

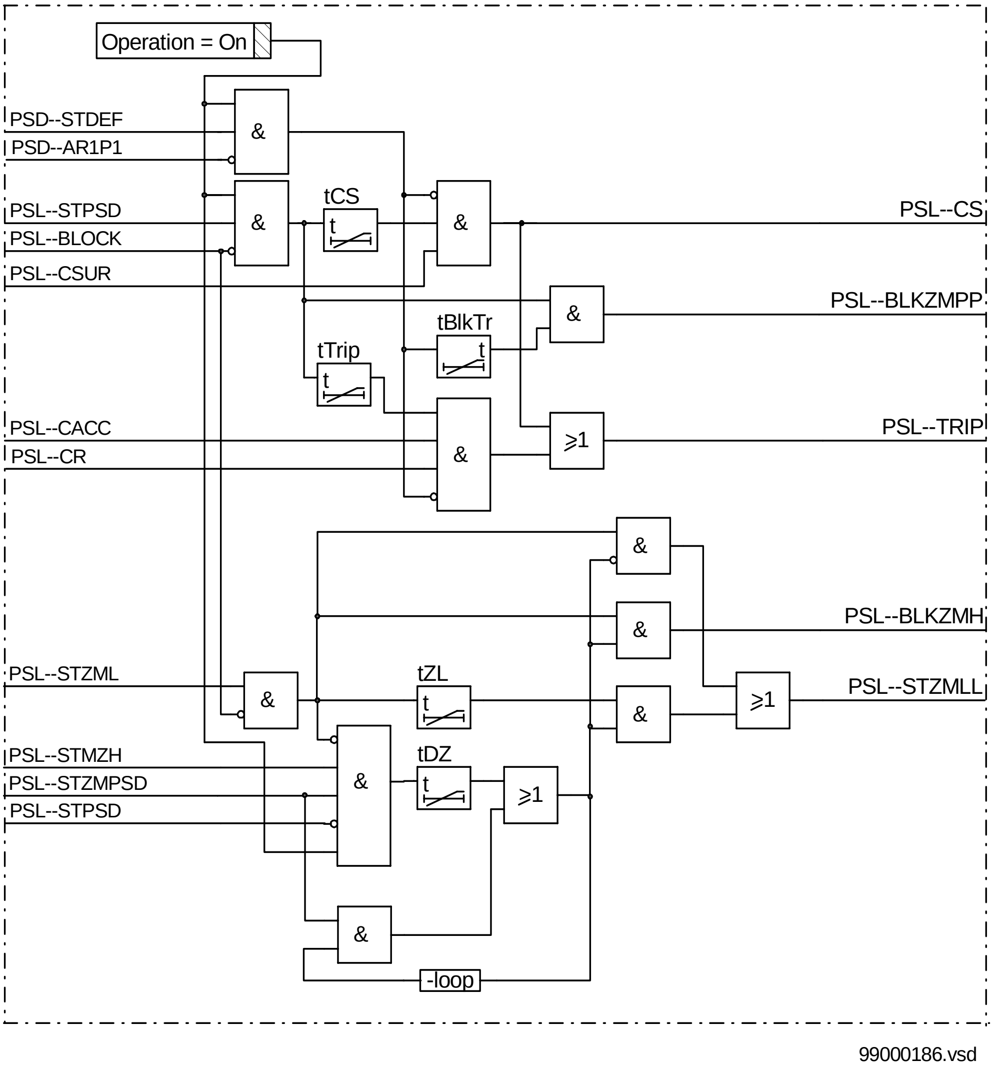



*Figure 34: Power-swing logic - block diagram.*

## 6.5 Input and output signals

**Table 100: Input signals for the PSL (PSL--) function block**

| Signal | Description |
|---|---|
| BLOCK | Blocks function |
| CACC | Operation of the overreaching power swing zone used for permissive tripping on receipt of the carrier signal |
| STPSD | Power swing detected (from power swing detection function) |
| STZMH | First overreaching zone (usually zone 2) |
| STZML | Underreaching zone (usually zone 1) |
| STDEF | Residual OC detected, forward or reverse direction |
| STZMPSD | Outer impedance zone (from power swing detection function) |
| AR1P1 | First single-pole automatic reclosing cycle in progress |
| CSUR | Operation of the underreaching power swing zone used for sending the carrier signal and direct tripping |
| CR | Carrier receive |

**Table 101: Output signals for the PSL (PSL--) function block**

| Signal | Description |
|---|---|
| TRIP | Trip output |
| STZMLL | Output to be used to replace the output from the normal instantaneous underreaching distance zone in the overall terminal logic |
| BLKZMPP | Output to be used to block tripping by either one (or both) of the non-controlled (power swing logic) distance zones |
| BLKZMH | Output to be used to block tripping by the higher controlled (usually zone 2) distance protection zone(s) |
| CS | Carrier send |

## 6.6 Setting parameters

**Table 102: Setting parameters for the power swing logic PSL (PSL--) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off, On | Off | - | Operating mode for PSL function |
| tDZ | 0.000 - 60.000<br>Step: 0.001 | 0.100 | s | Permitted operating time difference between higher and lower zone |
| tZL | 0.000 - 60.000<br>Step: 0.001 | 0.250 | s | Time delay to permitted operation of lower zone with detected difference in operating time |
| tCS | 0.000 - 60.000<br>Step: 0.001 | 0.100 | s | Conditional timer for sending the carrier signal at power swings |
| tTrip | 0.000 - 60.000<br>Step: 0.001 | 0.100 | s | Conditional timer for tripping at power swings |
| tBlkTr | 0.000 - 60.000<br>Step: 0.001 | 0.300 | s | Timer for extending blocking of tripping by the non-controlled zone |

## 6.7 Technical data

**Table 103: Power swing additional logic**

| Parameter | Setting range | Accuracy |
|---|---|---|
| Permitted operate time difference between higher and lower zones, tDZ | 0.000-60.000 s in steps of 1 ms | +/- 0.5 %+/- 10 ms |
| Time delay to permitted operation of lower zone with detected difference in operating time, tZL | 0.000-60.000 s in steps of 1 ms | +/- 0.5 %+/- 10 ms |
| Conditional timer for sending of carrier signal at power swings, tCS | 0.000-60.000 s in steps of 1 ms | +/- 0.5 %+/- 10 ms |
| Conditional timer for tripping at power swings, tTrip | 0.000-60.000 s in steps of 1 ms | +/- 0.5 %+/- 10 ms |
| Timer for extending the blocking of tripping by the non-controlled zone(s), tBlkTr | 0.000-60.000 s in steps of 1 ms | +/- 0.5 %+/- 10 ms |

# 7 Pole slip protection (PSP)

## 7.1 Application

Sudden events in an electrical power system such as large jumps in load, fault occurrence or fault clearance, can cause oscillations referred to as power swings. In a recoverable situation, the power swings will decay and stable operation will be resumed; in a non-recoverable situation, the power swings become so severe that the synchronism is lost, a condition referred to as pole slipping. The main purpose of the PSP pole slip protection is to detect, evaluate, and take the required action for pole slipping occurrences in the power system.

## 7.2 Functionality

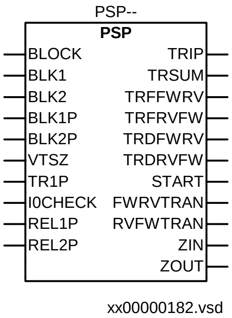
The PSP function comprises an inner and an outer quadrilateral measurement characteristic. It detects oscillations in the power system by measuring the time it takes the transient impedance to pass through the impedance area between the outer and the inner characteristics. Oscillations are identified by transition times longer than timer settings. The impedance measuring principle is the same as that used for the distance protection zones. The impedance and the transient impedance time are measured in all three phases separately. One-out-of-three or two-out-of-three operating modes can be selected permanently or adaptively according to the specific system operating conditions.

Oscillations with an oscillation period as low as 200 ms (i.e. with a slip frequency as high as 10% of the rated frequency on a 50 Hz basis) can be detected for normal system operating conditions, as well as during the dead time of a single-pole automatic reclosing cycle. Different timers are used for initial and consecutive pole slips, securing a high degree of differentiation between oscillation and fault conditions.

It is possible to inhibit the ocsillation detected output on detection of earth fault current. This can be used to release the operation of the distance protection function for earth faults during power oscillation conditions.

The PSP function has two tripping areas. These are located within the operating area, which is located within the inner characteristic. On detecting a new oscillation, the issue of a trip output will depend on the applied settings. These determine the direction of the transition for which tripping is permitted, whether tripping will occur on entry of the measured impedance into a tripping area, or on its exit from the tripping area, and through which tripping area the transition must be measured for tripping to occur. The applied settings also determine the number of pole slips required before the trip output is issued.

## 7.3 Function block




## 7.4 Logic diagram

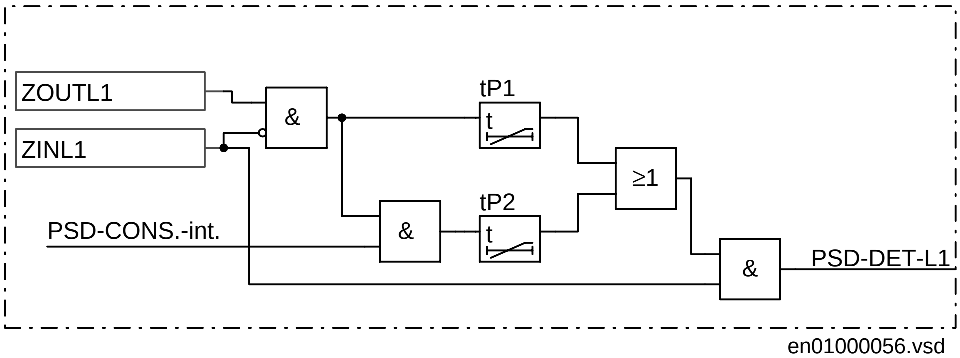



*Figure 35: Detection of oscillation in phase L1*

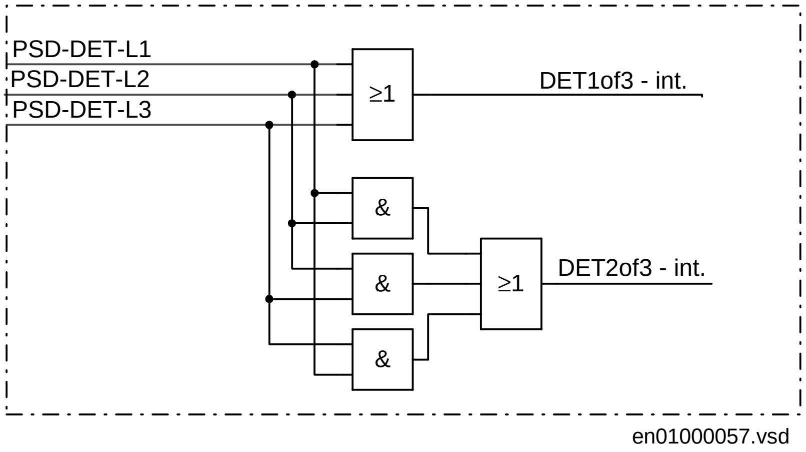



*Figure 36: Simplified logic diagram for “one of three” and “two of three” oscillation detection logic*

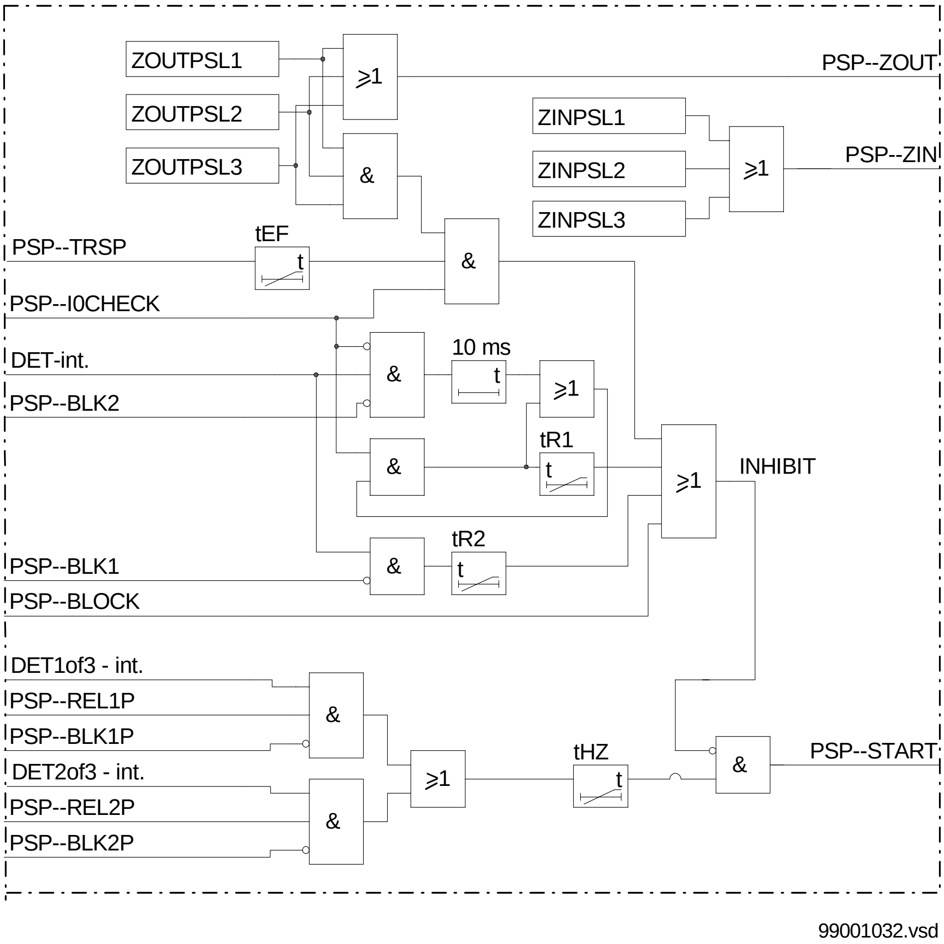



*Figure 37: Simplified logic diagram for cooperation with distance protection function*

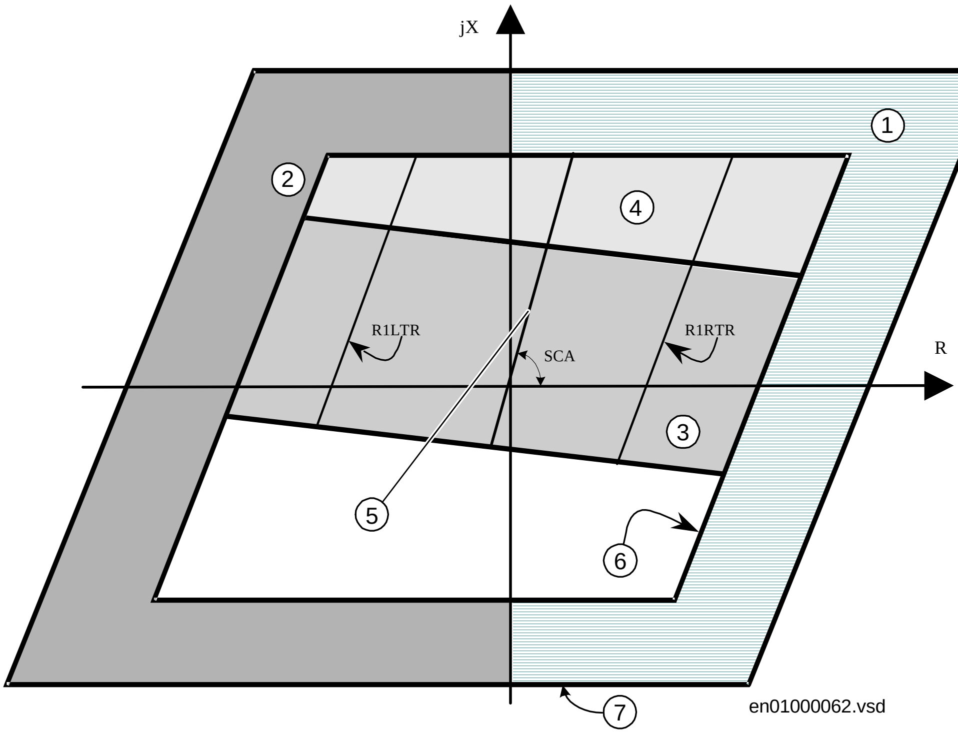



*Figure 38: The impedance operating plane is divided in two detection regions and two trip regions.*

| | |
|---|---|
| 1 | Forward - reverse detection region |
| 2 | Reverse - forward detection region |
| 3 | Fast trip region |
| 4 | Delayed trip region |
| 5 | System impedance |
| 6 | Internal operating boundary |
| 7 | External operating boundary |

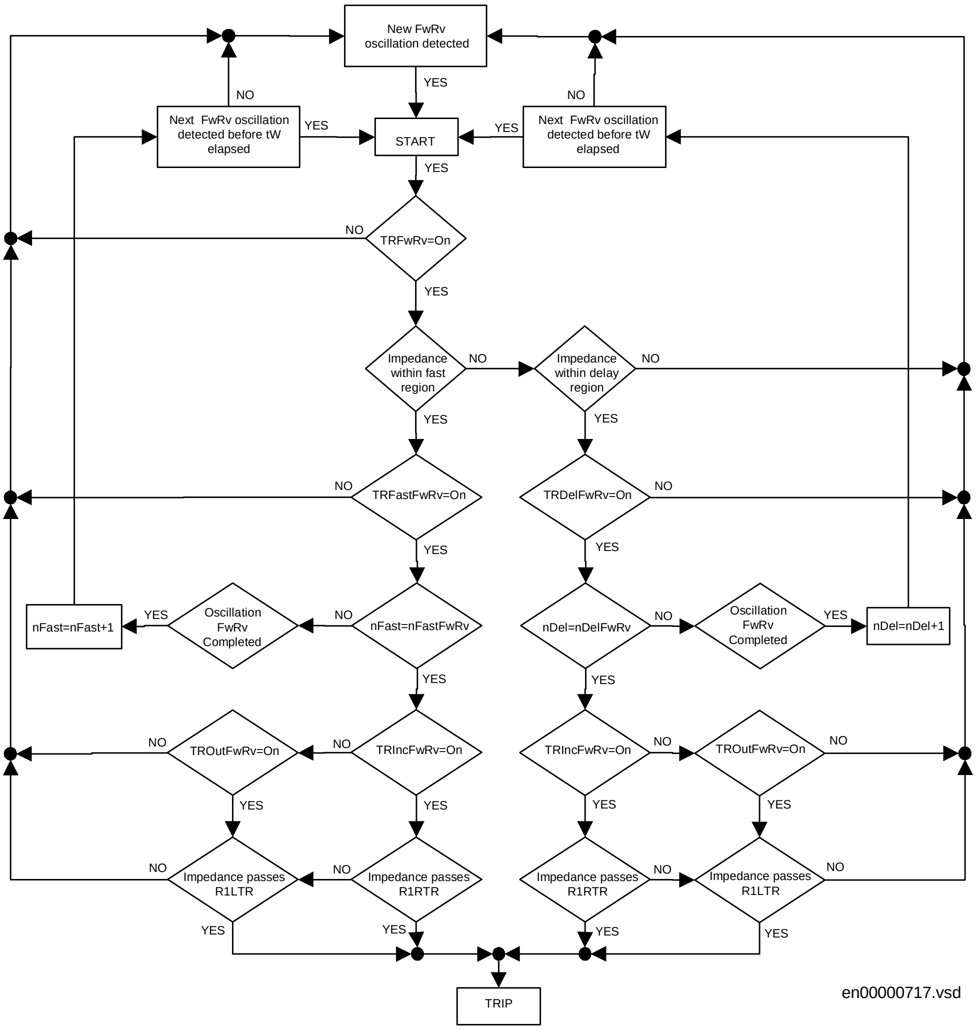



*Figure 39: Flow-chart presenting the operation of the pole slip protection for the forward to reverse transition (FwRv) after the oscillation has been detected.*

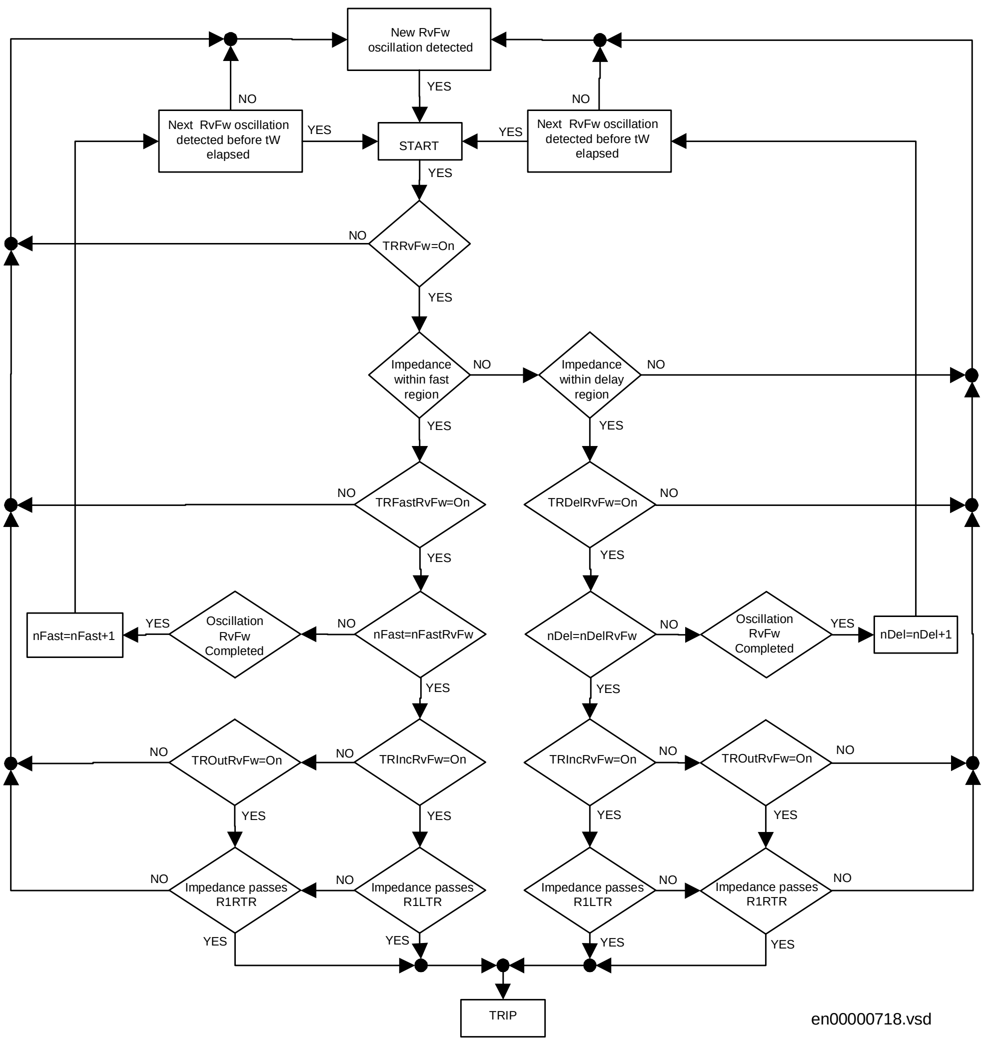



*Figure 40: Flow-chart presenting the operation of the pole slip protection for the reverse to forward transition (RvFw) after the oscillation has been detected.*

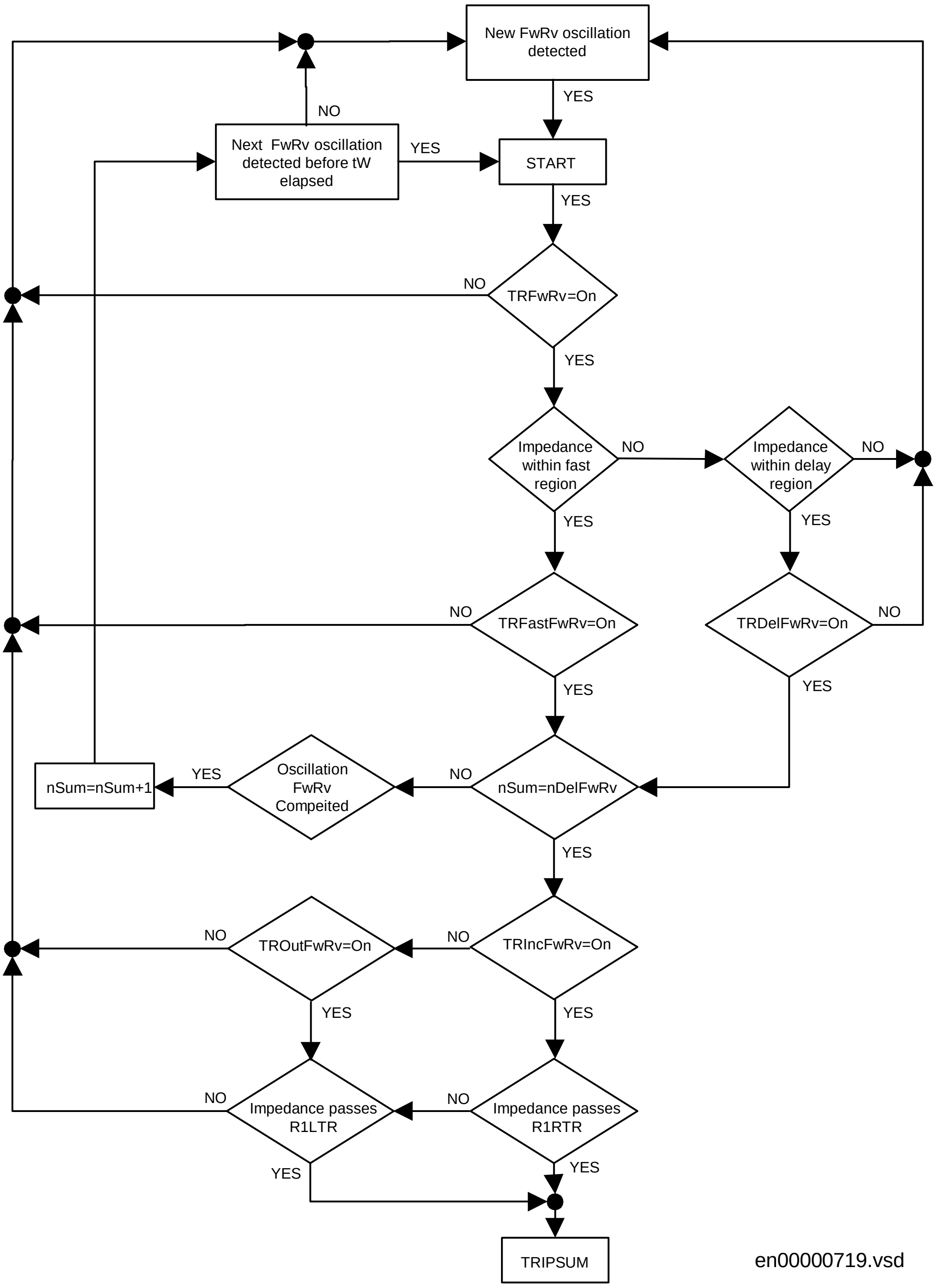



*Figure 41: Flow-chart presenting summation trip (TRIPSUM) of the pole slip protection for the forward to reverse transition (FwRv).*

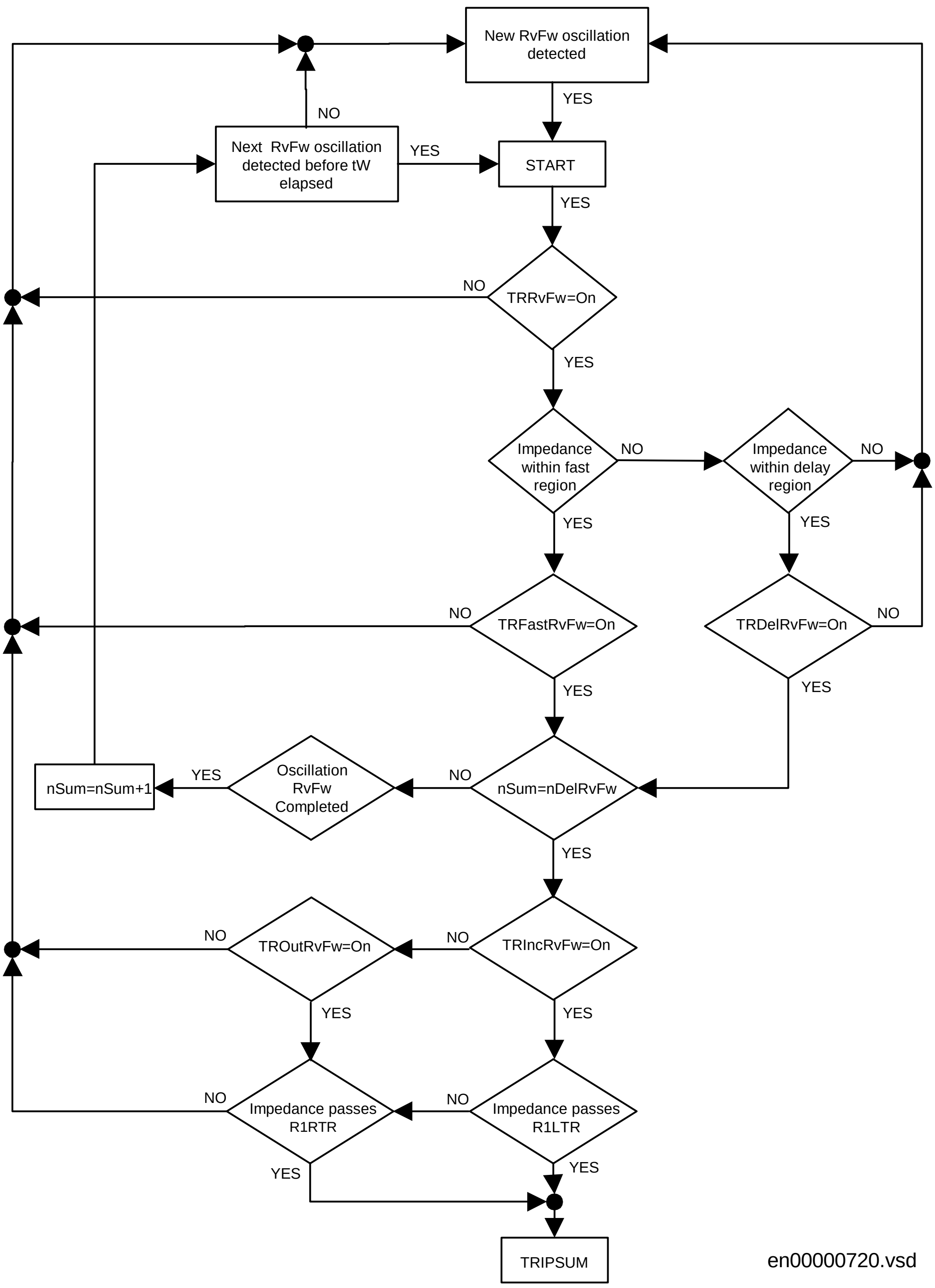



*Figure 42: Flow-chart presenting summation trip (TRIPSUM) of the pole slip protection for the reverse to forward transition (RvFw).*

## 7.5 Input and output signals

**Table 104: Input signals for the PSP (PSP--) function block**

| Signal | Description |
|---|---|
| BLOCK | Blocks function |
| BLK1 | Blocks the inhibit condition controlled by the tR2 timer |
| BLK2 | Blocks the inhibit condition based on residual current detection, unless within tEF timer following 1-pole trip |
| BLK1P | Blocks one-out-of-three phase detection of the oscillation |
| BLK2P | Blocks two-out-of-three phase detection of the oscillation |
| VTSZ | Blocks the operation of the PSP on fuse failure detection |
| TR1P | Starts the tEF timer for 1-pole trip |
| I0CHECK | Residual current detection used to inhibit PSP-START output |
| REL1P | Releases one-out-of-three phase detection of the oscillation |
| REL2P | Releases two-out-of-three phase detection of the oscillation |

**Table 105: Output signals for the PSP (PSP--) function block**

| Signal | Description |
|---|---|
| TRIP | Trip output |
| TRSUM | Delayed trip caused by transitions passing either delayed or fast tripping area |
| TRFFWRV | Fast trip for forward to reverse transition |
| TRFRVFW | Fast trip for reverse to forward transition |
| TRDFWRV | Delayed trip for forward to reverse transition |
| TRDRVFW | Delayed trip for reverse to forward transition |
| START | Oscillation detected |
| FWRVTRAN | Forward to reverse direction transition detected |
| RVFWTRAN | Reverse to forward direction transition detected |
| ZIN | Measured impedance within the inner characteristic boundary |
| ZOUT | Measured impedance within the outer characteristic boundary |

## 7.6 Setting parameters

**Table 106: Setting parameters for the pole slip protection PSP (PSP--) function (reaches given for $I_r$ = 1A, divide by 5 for $I_r$ = 5A)**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | On, Off | Off | - | Operating mode for PSP function |
| R1LEXT | 0.10-400.00<br>Step: 0.01 | 60.00 | ohm/ phase | Resistive reach of the left side external oscillation detection boundary. |
| R1LINT | 0.10-400.00<br>Step: 0.01 | 45.00 | ohm/ phase | Resistive reach of the left side internal oscillation detection boundary. |
| R1RINT | 0.10-400.00<br>Step: 0.01 | 45.00 | ohm/ phase | Resistive reach of the right side internal oscillation detection boundary. |
| R1REXT | 0.10-400.00<br>Step: 0.01 | 60.00 | ohm/ phase | Resistive reach of the right side external oscillation detection boundary. |
| R1LTR | 0.10-400.00<br>Step: 0.01 | 35.00 | ohm/ phase | Resistive reach of the left side tripping characteristic. |
| R1RTR | 0.10-400.00<br>Step: 0.01 | 35.00 | ohm/ phase | Resistive reach of the right side tripping characteristic. |
| X1REXT | 0.10-400.00<br>Step: 0.01 | 60.00 | ohm/ phase | Reactive reach of the external oscillation detection boundary in reverse direction. |
| X1RINT | 0.10-400.00<br>Step: 0.01 | 45.00 | ohm/ phase | Reactive reach of the internal oscillation detection boundary in reverse direction. |
| X1FINT | 0.10-400.00<br>Step: 0.01 | 45.00 | ohm/ phase | Reactive reach of the internal oscillation detection boundary in forward direction. |
| X1FEXT | 0.10-400.00<br>Step: 0.01 | 60.00 | ohm/ phase | Reactive reach of the external oscillation detection boundary in forward direction. |
| SCA | 75.0-90.0<br>Step: 0.1 | 90.0 | degrees | System characteristic angle. |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| X1PSLFw | 0.10-400.00<br>Step: 0.01 | 35.00 | ohm/<br>phase | Positive sequence reactance determining the forward reactive reach of the fast tripping zone. |
| R1PSLFw | 0.10-400.00<br>Step: 0.01 | 1.50 | ohm/<br>phase | Positive sequence resistance determining the forward resistive reach of the fast tripping zone. |
| X1PSLRv | 0.10-400.00<br>Step: 0.01 | 0.10 | ohm/<br>phase | Positive sequence reactance determining the reverse reactive reach of the fast tripping zone. |
| R1PSLRv | 0.10-400.00<br>Step: 0.01 | 0.10 | ohm/<br>phase | Positive sequence resistance determining the reverse resistive reach of the fast tripping zone. |
| tP1 | 0.000-60.000<br>Step: 0.001 | 0.045 | s | Transition time used for the detection of the initial oscillation |
| tP2 | 0.000-60.000<br>Step: 0.001 | 0.015 | s | Transition time used for the detection of subsequent oscillations. |
| tW | 0.000-60.000<br>Step: 0.001 | 0.350 | s | Waiting time to distinguish between new and subsequent oscillations. |
| tEF | 0.000-60.000<br>Step: 0.001 | 3.000 | s | Time window after single pole tripping in which to allow residual current detection to inhibit the output for a detected oscillation. |
| tR1 | 0.000-60.000<br>Step: 0.001 | 0.040 | s | Time delay required to inhibit the oscillation detected output by residual current detection following oscillation detection. |
| tR2 | 0.000-60.000<br>Step: 0.001 | 2.000 | s | Time delay required for the measured impedance to remain within the oscillation detection area before inhibiting the oscillation detected output. |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| tHZ | 0.000-60.000<br>Step: 0.001 | 0.500 | s | Prolongation time of the oscillation detected output. |
| TRFwRv | On, Off | Off | - | Trip for FwRv transitions enabled or disabled. |
| TRIncFwRv | On, Off | Off | - | Trip for FwRv transitions in incoming mode enabled or disabled. |
| TROutFwRv | On, Off | Off | - | Trip for FwRv transitions in outgoing mode enabled or disabled. |
| TRFastFwRv | On, Off | Off | - | Tripping for FwRv transitions in the fast tripping area enabled or disabled. |
| TRDelFwRv | On, Off | Off | - | Tripping for FwRv transitions in the delayed tripping area enabled or disabled. |
| TRRvFw | On, Off | Off | - | Trip for RvFw transitions enabled or disabled. |
| TRIncRvFw | On, Off | Off | - | Trip for RvFw transitions in incoming mode enabled or disabled. |
| TROutRvFw | On, Off | Off | - | Trip for RvFw transitions in outgoing mode enabled or disabled. |
| TRFastRvFw | On, Off | Off | - | Tripping for RvFw transitions in the fast tripping area enabled or disabled. |
| TRDelRvFw | On, Off | Off | - | Tripping for RvFw transitions in the delayed tripping area enabled or disabled. |
| nFastFwRv | 0-10<br>Step: 1 | 0 | slip | Number of slips from forward to reverse direction required to be detected in the fast tripping area to cause the tripping command. |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| nDelFwRv | 0-10<br>Step: 1 | 0 | slip | Number of slips from forward to reverse direction required to be detected in the delayed tripping area to cause the tripping command. |
| nFastRvFw | 0-10<br>Step: 1 | 0 | slip | Number of slips from reverse to forward direction required to be detected in the fast tripping area to cause the tripping command. |
| nDelRvFw | 0-10<br>Step: 1 | 0 | slip | Number of slips from reverse to forward direction required to be detected in the delayed tripping area to cause the tripping command. |

## 7.7 Technical data

**Table 107: Pole slip protection**

| Parameter | Setting range |
|---|---|
| Reactive and resistive reach for all setting parameters at $I_r$=1 A (for $I_r$ = 5 A, divide values by 5) | 0.10-400.00 ohm/phase in steps of 0.01ohm/phase |
| Timers | 0.000-60.000s in steps of 0.001s |
| Counters | 0-10 in steps of 1 |

| Parameter | |
|---|---|
| Reset ratio for impedance measuring elements | 105% typically |

# 8 Radial feeder protection (PAP)

## 8.1 Application

The main purpose of the PAP radial feeder protection function is to provide tripping at the ends of radial feeders with passive load or with weak end infeed. To obtain this tripping, the PAP function must be included within the protection terminal at the load / weak end infeed end.

## 8.2 Functionality

The PAP function performs the phase selection using the measured voltages. Each phase voltage is compared to the opposite phase-phase voltage. A phase is deemed to have a fault if its phase voltage drops below a settable percentage of the opposite phase-phase voltage. The phase-phase voltages include memory. This memory function has a settable time constant.

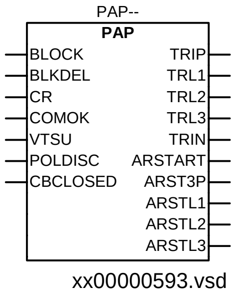
The PAP function has built-in logic for fast tripping as well as time delayed tripping. The voltage-based phase selection is used for both the fast and the delayed tripping. To get fast tripping, scheme communication is required. Delayed tripping does not require scheme communication. It is possible to permit delayed tripping only on failure of the communications channel by blocking the delayed tripping logic with a communications channel healthy input signal.

On receipt of the communications signal, phase selective outputs for fast tripping are given based on the phase(s) in which the phase selection function has operated.

For delayed tripping, the single-pole and three-pole delays are separately and independently settable. Furthermore, it is possible to enable or disable three-pole delayed tripping. It is also possible to select either single-pole delayed tripping or three-pole delayed tripping for single-phase faults. Three-pole delayed tripping for single-phase faults is also dependent on the selection to enable or disable three-pole tripping. For single-phase faults, it is possible to include a residual current check in the tripping logic. Three-pole tripping is always selected for phase selection on more than one phase. Three-phase tripping will also occur if the residual current exceeds the set level during fuse failure for a time longer than the three-pole trip delay time.

The radial feeder protection function also includes logic which provides outputs that are specifically intended for starting the automatic recloser.

## 8.3 Function block




## 8.4 Logic diagram, phase selection function

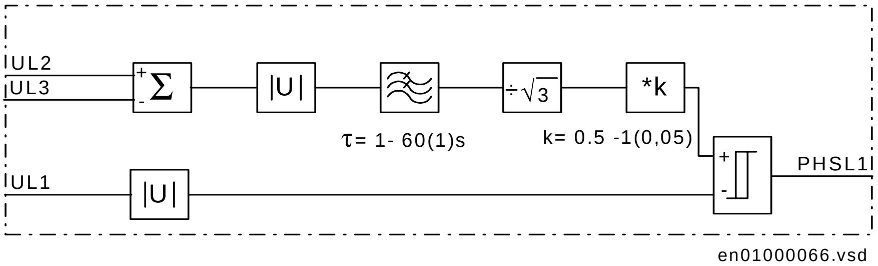



*Figure 43: Phase selection function, simplified logic diagram*

## 8.5 Logic diagram, residual current measurement

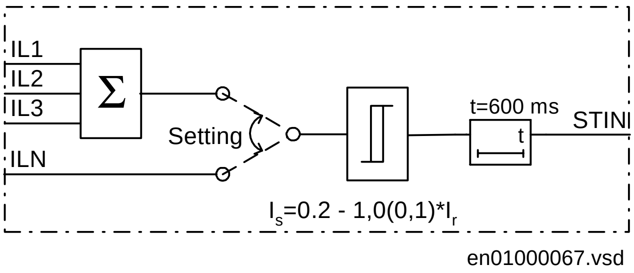



*Figure 44: Residual current measurement, simplified logic diagram*

## 8.6 Logic diagram, fast fault clearing

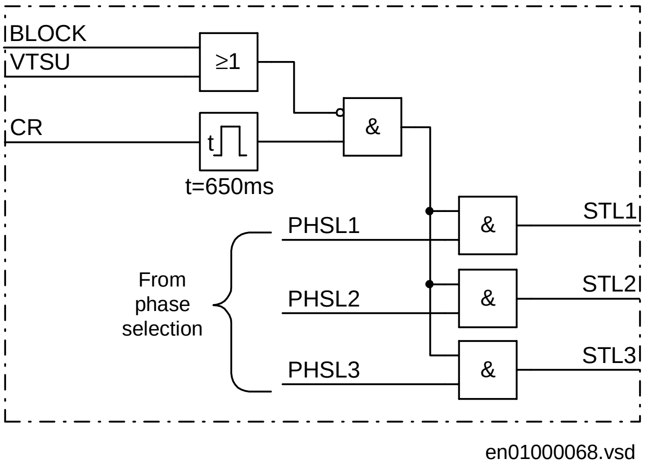



*Figure 45: Function for fast fault clearing, simplified logic diagram*

## 8.7 Logic diagram, delayed fault clearing

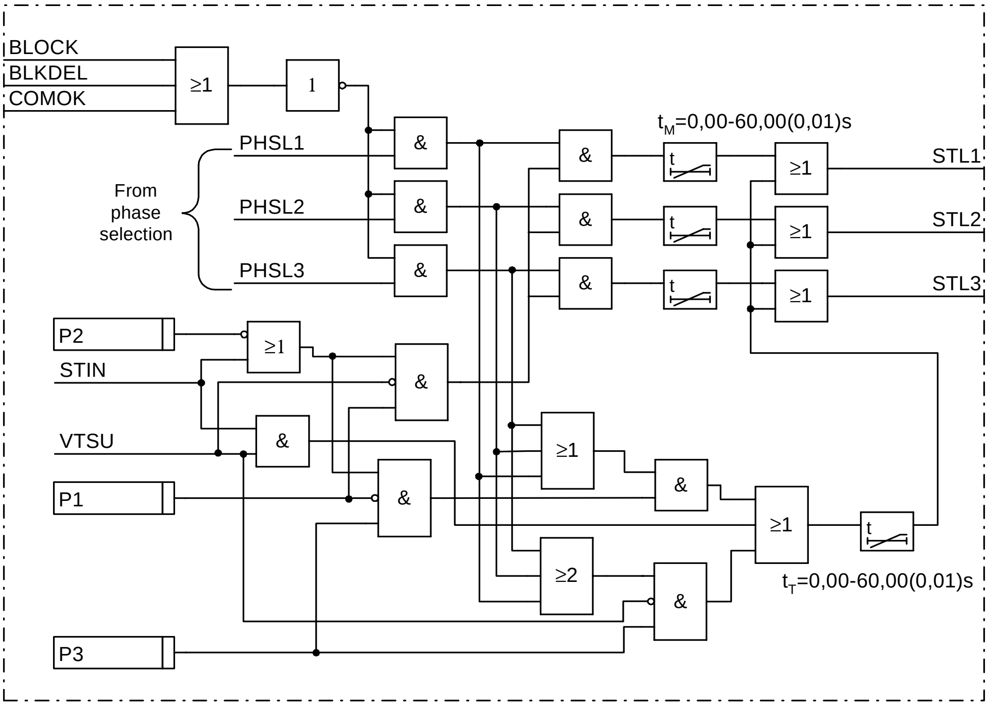



*Figure 46: Function for delayed fault clearing, simplified logic diagram*

## 8.8 Logic diagram, residual current detection

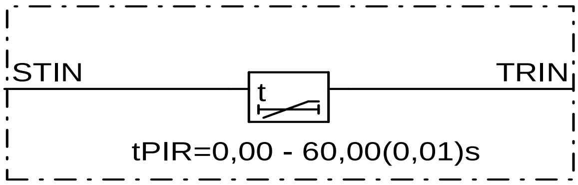



*Figure 47: Residual current detection, simplified logic diagram*

## 8.9 Logic diagram, trip and autorecloser start logic

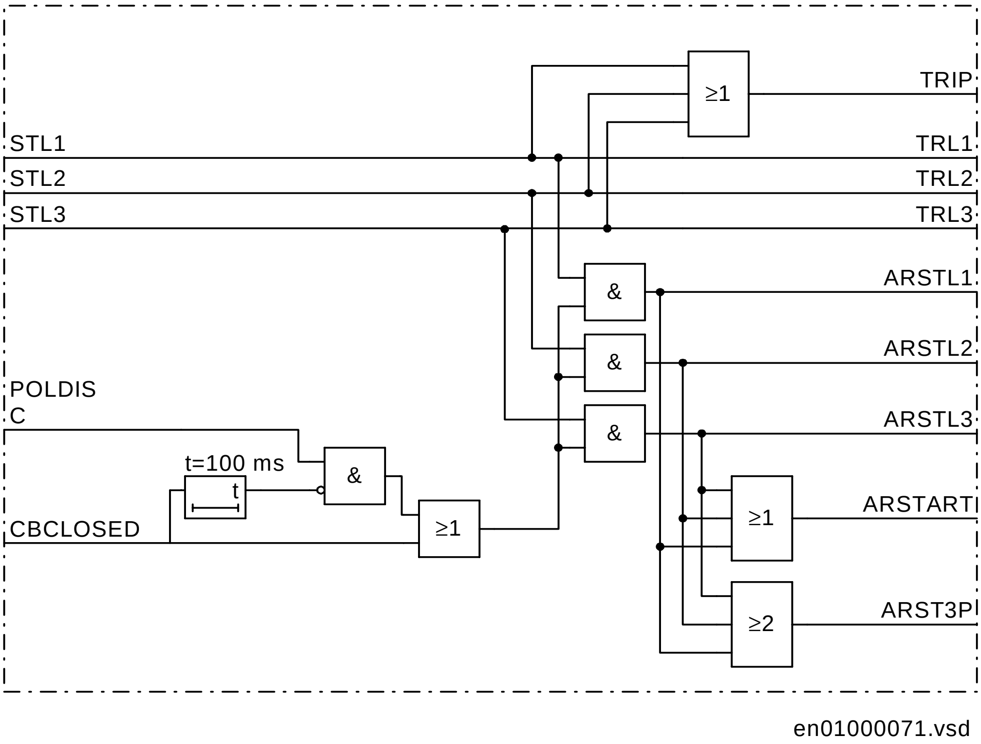



*Figure 48: Trip and autorecloser start logic, simplified logic diagram*

## 8.10 Input and output signals

**Table 108: Input signals for the PAP (PAP--) function block**

| Signal | Description |
|---|---|
| BLOCK | Blocks radial feeder protection |
| BLKDEL | Blocks delayed fault clearing function |
| CR | Communication signal received |
| COMOK | Telecommunications link healthy |
| VTSU | Blocks the operation of the function. Usually connected to FUSE-VTSU. |
| POLDISC | Information on pole discordance |
| CBCLOSED | Information on closed circuit breaker |

**Table 109: Output signals for the PAP (PAP--) function block**

| Signal | Description |
|---|---|
| TRIP | Trip by radial feeder protection |
| TRL1 | Trip in phase L1 |
| TRL2 | Trip in phase L2 |
| TRL3 | Trip in phase L3 |
| TRIN | Trip (or indication) for residual current |
| ARSTART | Start automatic recloser |
| ARST3P | Start automatic recloser three-pole |
| ARSTL1 | Start automatic recloser in phase L1 |
| ARSTL2 | Start automatic recloser in phase L2 |
| ARSTL3 | Start automatic recloser in phase L3 |

## 8.11 Setting parameters

**Table 110: Setting parameters for the radial feeder protection PAP (PAP--) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off, On | Off | - | Operating mode for PAP function |
| OperFast | Off, On | Off | - | Fast fault clearing function |
| U< | 50 - 100<br>Step: 1 | 60 | % of $U_{ref}$ | % with respect to $U_{ref}$ of cross-polarised phase-phase voltage divided by sqrt(3) - used as reference for faulted phase voltage selection |
| Tau | 1 - 60<br>Step: 1 | 5 | s | Time constant for reference voltage |
| IMeasured | I4, I5, I1+I2+I3 | I4 | - | Residual current signal source |
| In> | 10 - 150<br>Step: 1 | 50 | % of I1b | Residual current detection level |
| Del1PhFltTrip | 3Ph, 1Ph | 3 Ph | - | Delayed trip for single-phase faults |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| ResCurrCheck | Off, On | Off | - | Residual current check for delayed trip for single-phase faults enabled or disabled |
| Del3PhTrip | Off, On | Off | - | Delayed three-pole tripping enabled or disabled |
| tM | 0.00 - 60.00<br>Step: 0.01 | 10.00 | s | Time delay for single-pole tripping |
| tT | 0.00 - 60.00<br>Step: 0.01 | 10.00 | s | Time delay for three-pole tripping |
| tPIR | 0.00 - 60.00<br>Step: 0.01 | 10.00 | s | Time delay for indication of residual current greater than set threshold |

## 8.12 Technical data

**Table 111: Radial feeder protection function**

| Parameter | Setting range | Accuracy |
|---|---|---|
| Faulted phase voltage detection level in % of cross-polarised phase-phase voltage divided by sqrt(3) | 50-100% of $U_{ref}$ in steps of 1% | +/- 2.5% of $U_r$ |
| Time constant for reference voltages | 1-60s in steps of 1s | |
| Residual current detection level | 10-150% of $I_r$ in steps of 1% | 2.5% of $I_r$ at $I \le I_r$<br>2.5% of I at $I > I_r$ |
| Time delay tM for single-pole tripping | 0.00-60.00s in steps of 0.01s | +/-0.5% +/-10 ms |
| Time delay tT for three-pole tripping | 0.00-60.00s in steps of 0.01s | +/-0.5% +/-10 ms |
| Time delay tPIR for residual current tripping (or indication) | 0.00-60.00s in steps of 0.01s | +/-0.5% +/-10 ms |

# 9 Scheme communication logic for distance protection functions (ZCOM)

## 9.1 Application

It is not possible to set a underreaching distance protection zone to cover the full length of the line, and at the same time not to overreach for faults beyond the protected line. To avoid overreaching, underreaching distance protection zones must always reach short of the remote end of the line by some safety margin of 15-20%. The main purpose of the ZCOM scheme communication logic is to supplement the distance protection function such that fast clearance of faults is also achieved at the line end for which the faults are on the part of the line not covered by its underreaching zone. To accomplish this, one communication channel, capable of transmitting an on/off signal, is required in each direction.

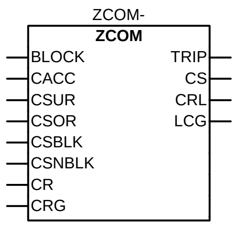
## 9.2 Functionality

The ZCOM function is a logical function built-up from logical elements. It is a supplementary function to the distance protection, requiring for its operation inputs from the distance protection and the teleprotection equipment.

The type of communication-aided scheme to be used can be selected by way of the settings. The ability to select which distance protection zone is assigned to which input of the ZCOM logic makes this logic able to support practically any scheme communication requirements regardless of their basic operating principle. The outputs to initiate tripping and sending of the teleprotection signal are given in accordance with the type of communication-aided scheme selected and the distance protection zone(s) which have operated.

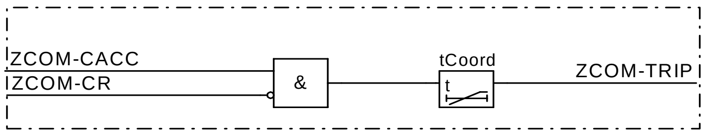
When power line carrier communication channels are used, unblocking logic is provided which uses the loss of guard signal. This logic compensates for the lack of dependability due to the transmission of the command signal over the faulted line.

## 9.3 Function block



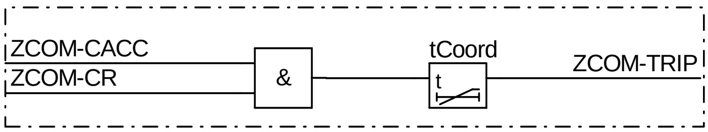

xx00000184.vsd

## 9.4 Logic diagram




xx00000574.vsd

*Figure 49: Basic logic for trip carrier in blocking scheme*




xx00000575.vsd

*Figure 50: Basic logic for trip carrier in permissive scheme*

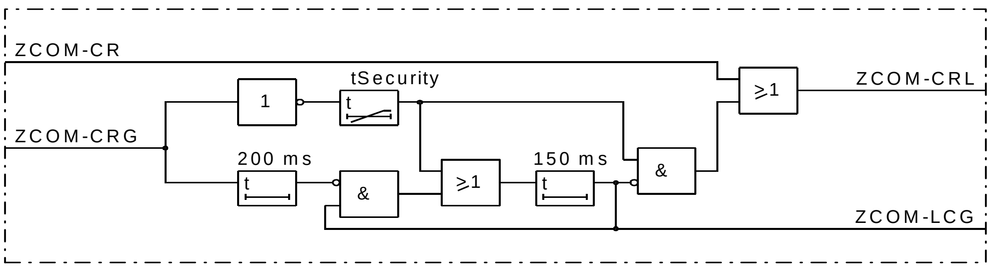



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*Figure 51: Carrier guard logic with unblock logic*

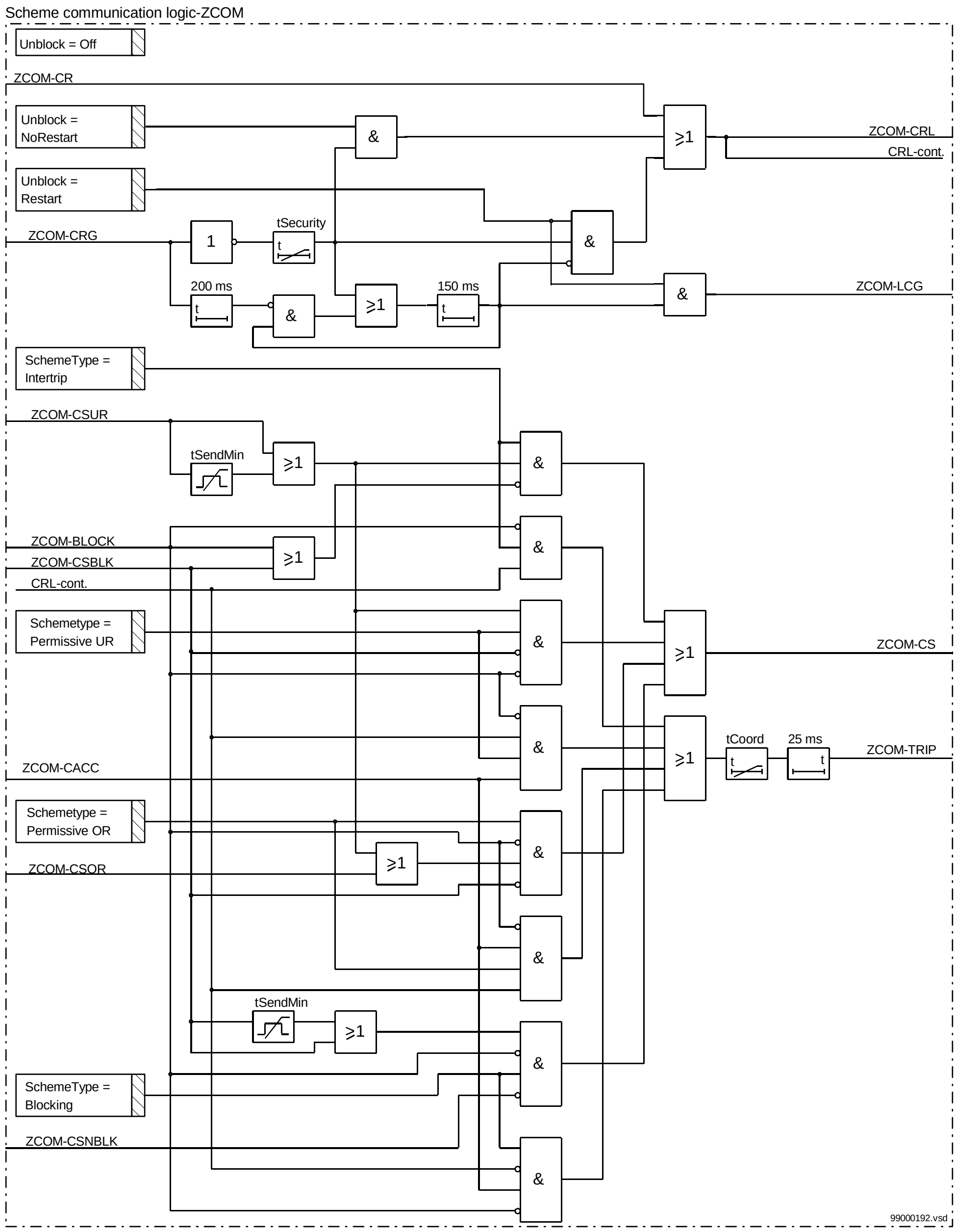



*Figure 52: Scheme communication logic for distance protection, simplified logic diagram*

## 9.5 Input and output signals

**Table 112: Input signals for ZCOM (ZCOM-) function block**

| Signal | Description |
|---|---|
| BLOCK | Blocks the Trip and CS outputs |
| CACC | Overreaching distance protection zone to be used as the local criterion for permissive tripping on receipt of the carrier signal |
| CSUR | Underreaching function(s) to be used for sending a carrier signal |
| CSOR | Overreaching function(s) to be used for sending a carrier signal |
| CSBLK | Reverse directed distance protection zone to be used for sending a carrier signal in a blocking scheme |
| CSNBLK | Forward directed distance protection zone to be used to inhibit sending of a carrier signal in a blocking scheme |
| CR | Carrier signal received |
| CRG | Guard signal received |

**Table 113: Output signals for ZCOM (ZCOM-) function block**

| Signal | Description |
|---|---|
| TRIP | Trip output |
| CS | Carrier send |
| CRL | Carrier signal received |
| LCG | Loss of carrier guard signal |

## 9.6 Setting parameters

**Table 114: Setting parameters for the scheme communication logic ZCOM (ZCOM-) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off /On | Off | - | Operating mode for ZCOM function |
| SchemeType | Intertrip / Permis-siveUR / Permissi-veOR / Blocking | Intertrip | - | Operating mode for scheme com-munication logic |
| tCoord | 0.000 - 60.000<br>Step: 0.001 | 0.050 | s | Coordination timer |
| tSendmin | 0.000 - 60.000<br>Step: 0.001 | 0.100 | s | Minimum duration of carrier send signal |
| Unblock | Off / NoRe-start / Restart | Off | - | Operating mode for unblocking logic |
| tSecurity | 0.000 - 60.000<br>Step: 0.001 | 0.035 | s | Security timer |

## 9.7 Technical data

**Table 115: Scheme communication logic for distance protection (ZCOM)**

| Parameter | Setting range | Accuracy |
|---|---|---|
| Coordination timer, tCoord | 0.000-60.000 s in steps of 1 ms | +/-0.5% +/-10ms |
| Minimum send time, tSendMin | 0.000-60.000 s in steps of 1 ms | +/-0.5% +/-10ms |
| Security timer, tSec | 0.000-60.000 s in steps of 1 ms | +/-0.5% +/-10ms |

# 10 Current reversal and WEI logic for distance protection (ZCAL)

## 10.1 Application

In interconnected systems, for parallel line applications, the direction of flow of the fault current on the healthy line can change when the circuit breakers on the faulty line open to clear the fault. This can lead to unwanted operation of the distance protection on the healthy line when permissive overreach schemes are used. The main purpose of the ZCAL current reversal logic is to prevent such unwanted operations for this phenomenon.

If the infeed of fault current at the local end for faults on the protected line is too low to operate the measuring elements, no trip output will be issued at the local end and no teleprotection signal will be sent to the remote end. This can lead to time delayed tripping at the remote strong infeed end. The main purpose of the ZCAL weak end infeed logic is to enhance the operation of permissive communication schemes and to avoid sequential tripping when, for a fault on the line, the initial infeed of fault current from one end is too weak to operate the measuring elements.

## 10.2 Functionality

The ZCAL function block provides the current reversal and weak end infeed logic functions that supplement the standard scheme communication logic, or the phase segregated scheme communication logic.

On detection of a current reversal, the current reversal logic provides an output to block the sending of the teleprotection signal to the remote end, and to block the permissive tripping at the local end. This blocking condition is maintained long enough to ensure that no unwanted operation will occur as a result of the current reversal.

On verification of a weak end infeed condition, the weak end infeed logic provides an output for sending the received teleprotection signal back to the remote sending end, and other output(s) for tripping. For terminals equipped for single-, two-, and three-pole tripping, outputs for the faulted phase(s) are provided. Undervoltage detectors are used to select the faulted phase (s).

## 10.3 Function block

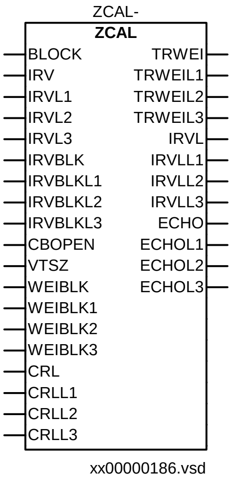



*Figure 53: Function block for the ZCAL function, when used together with phase segregated scheme communication logic*

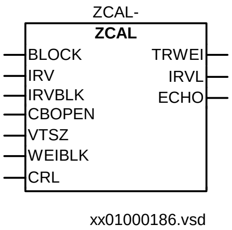



*Figure 54: Function block for the ZCAL function, when used together with the three phase scheme communication logic*

## 10.4 Logic diagram

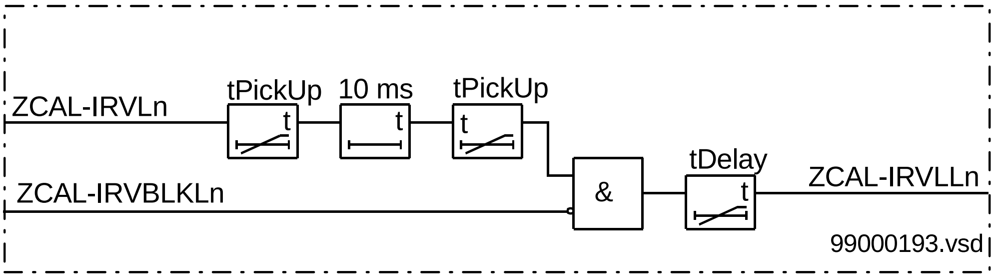



*Figure 55: Current reversal logic.*

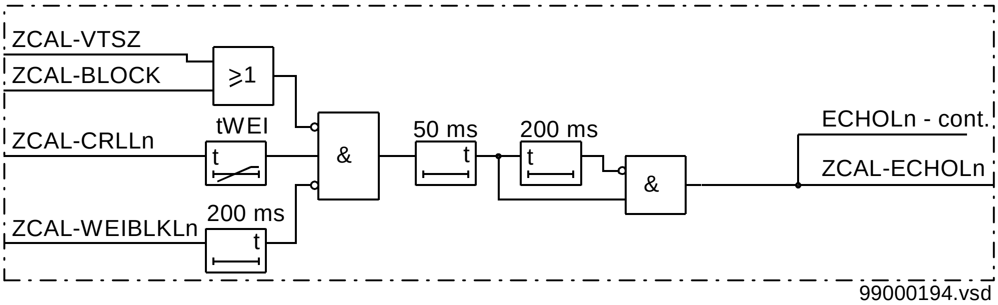



*Figure 56: Echo of a received carrier signal by the WEI function.*

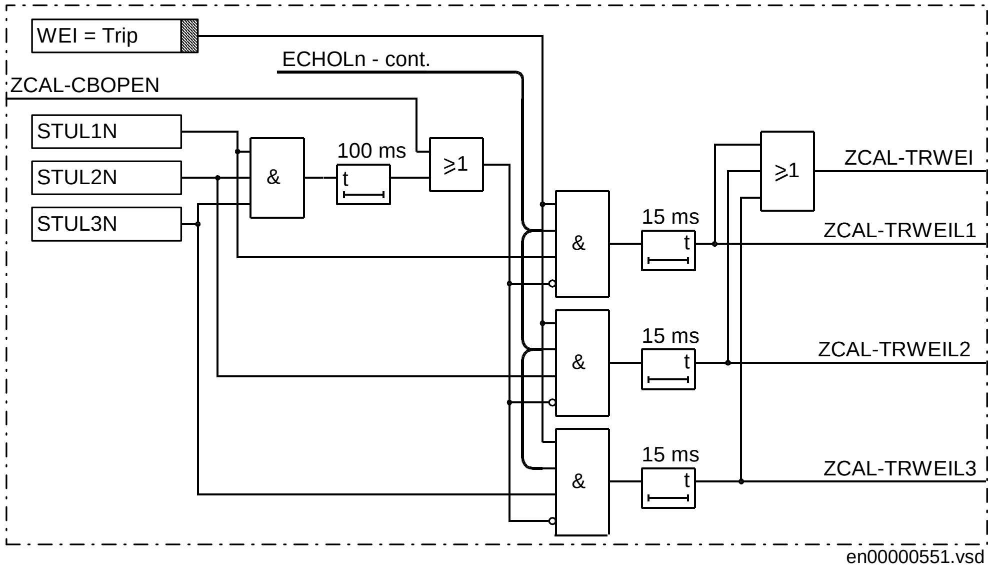



*Figure 57: Tripping part of the WEI logic - simplified logic diagram.*

## 10.5 Input and output signals

**Note:** Some signals may not be present depending on the ordered options.

**Table 116: Input signals for the ZCAL (ZCAL-) function block**

| Signal | Description |
|---|---|
| BLOCK | Blocks function |
| IRV | Activates current reversal logic |
| IRVL1 | Activates current reversal logic in phase L1 |
| IRVL2 | Activates current reversal logic in phase L2 |
| IRVL3 | Activates current reversal logic in phase L3 |
| IRVBLK | Blocks current reversal logic |
| IRVBLKL1 | Blocks current reversal logic in phase L1 |
| IRVBLKL2 | Blocks current reversal logic in phase L2 |
| IRVBLKL3 | Blocks current reversal logic in phase L3 |
| CBOPEN | Blocks trip from weak end infeed logic |
| VTSZ | Blocks weak end infeed logic on fuse failure detection |

| Signal | Description |
|---|---|
| WEIBLK | Blocks weak end infeed logic |
| WEIBLK1 | Blocks weak end infeed logic in phase L1 |
| WEIBLK2 | Blocks weak end infeed logic in phase L2 |
| WEIBLK3 | Blocks weak end infeed logic in phase L3 |
| CRL | Carrier received |
| CRLL1 | Carrier received in phase L1 |
| CRLL2 | Carrier received in phase L2 |
| CRLL3 | Carrier received in phase L3 |

**Note:** Some signals may not be present depending on the ordered options.

**Table 117: Output signals for the ZCAL (ZCAL-) function block**

| Signal | Description |
|---|---|
| TRWEI | Weak end infeed logic trip output |
| TRWEIL1 | Weak end infeed logic trip output in phase L1 |
| TRWEIL2 | Weak end infeed logic trip output in phase L2 |
| TRWEIL3 | Weak end infeed logic trip output in phase L3 |
| IRVL | Output from current reversal logic |
| IRVLL1 | Output from current reversal logic in phase L1 |
| IRVLL2 | Output from current reversal logic in phase L2 |
| IRVLL3 | Output from current reversal logic in phase L3 |
| ECHO | Carrier send (echo) by weak end infeed logic |
| ECHOL1 | Carrier send (echo) by weak end infeed logic in phase L1 |
| ECHOL2 | Carrier send (echo) by weak end infeed logic in phase L2 |
| ECHOL3 | Carrier send (echo) by weak end infeed logic in phase L3 |

## 10.6 Setting parameters

**Table 118: Setting parameters for the current reversal and weak end infeed logic ZCAL (ZCAL-) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| CurrRev | Off / On | Off | - | Operating mode for the ZCAL function |
| tPickUp | 0.000 - 60.000<br>Step: 0.001 | 0.000 | s | Pickup time for current reversal function |
| tDelay | 0.000 - 60.000<br>Step: 0.001 | 0.100 | s | Output hold time for current reversal function |
| WEI | Off / Trip / Echo | Off | - | Operating mode for the WEI function |
| tWEI | 0.000 - 60.000<br>Step: 0.001 | 0.010 | s | Coordination time for the WEI function |
| UPN< | 10 - 100<br>Step: 1 | 70 | % of U1b | Under voltage detection - ph-N measurement |
| UPP< | 20 - 170<br>Step: 1 | 70 | % of U1b | Under voltage detection - ph-ph measurement |

## 10.7 Technical data

**Table 119: Current reversal and weak end infeed logic**

| Parameter | Setting range | Accuracy |
|---|---|---|
| Pickup time for current reversal logic | 0.000-60.000 s in steps of 0.001s | +/-0.5% +/-10ms |
| Delay time for reset of current reversal output | 0.000-60.000 s in steps of 0.001s | +/-0.5% +/-10ms |

| Parameter | Setting range | Accuracy |
|---|---|---|
| Coordination time delaying receipt of carrier receive signal into weak end infeed logic | 0.000-60.000 s in steps of 0.001s | +/-0.5% +/-10ms |
| Detection level phase to neutral voltage | 10-100% of U1b | +/-5% of $U_b$ |
| Detection level phase to phase voltage | 20-170% of U1b | +/-5% of $U_b$ for U<=$U_b$<br>+/-5% of $U_b$ for U>=$U_b$ |

# Chapter 5 Current

**About this chapter**

This chapter describes the current protection functions

# 1 Instantaneous overcurrent protection (IOC)

## 1.1 Application

Different system conditions, such as source impedance and the position of the faults on long transmission lines influence the fault currents to a great extent. An instantaneous phase overcurrent protection with short operate time and low transient overreach of the measuring elements can be used to clear close-in faults on long power lines, where short fault clearing time is extremely important to maintain system stability.

The instantaneous residual overcurrent protection can be used in a number of applications. Below some examples of applications are given.

- Fast back-up earth fault protection for faults close to the line end.
- Enables fast fault clearance for close in earth faults even if the distance protection or the directional residual current protection is blocked from the fuse supervision function

## 1.2 Functionality

The current measuring element continuously measures the current in all three phases and compares it to the set operate value IP>>. A filter ensures immunity to disturbances and dc components and minimizes the transient overreach. If any phase current is above the set value IP>>, the phase overcurrent trip signal TRP is activated. Separate trip signal for the actual phase(s) is also activated. The input signal BLOCK blocks all functions in the current function block.

The current measuring element continuously measures the residual current and compares it to the set operate value IN>>. A filter ensures immunity to disturbances and dc components and minimizes the transient overreach. If the residual current is above the set value IN>>, the residual overcurrent trip signal TRN is activated. The general trip signal TRIP is activated as well. The input signal BLOCK blocks the complete function.

## 1.3 Function block

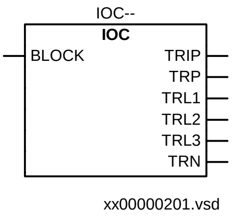



*Figure 58: IOC function block phase + N with 1, 2, 3 phase trip*

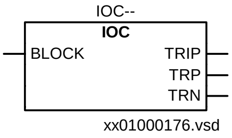



*Figure 59: IOC function block, phase + N with 3 phase trip*

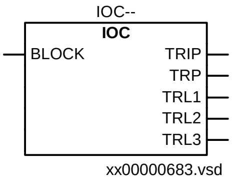



*Figure 60: IOC function block phase with 1, 2, 3 phase trip*

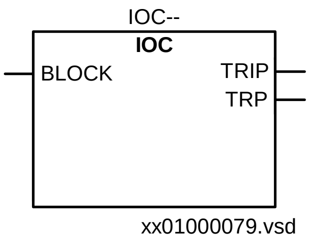



*Figure 61: IOC function block, phase with 3 phase trip*

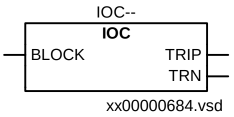



*Figure 62: IOC function block, N + 3 phase trip*

## 1.4 Logic diagram

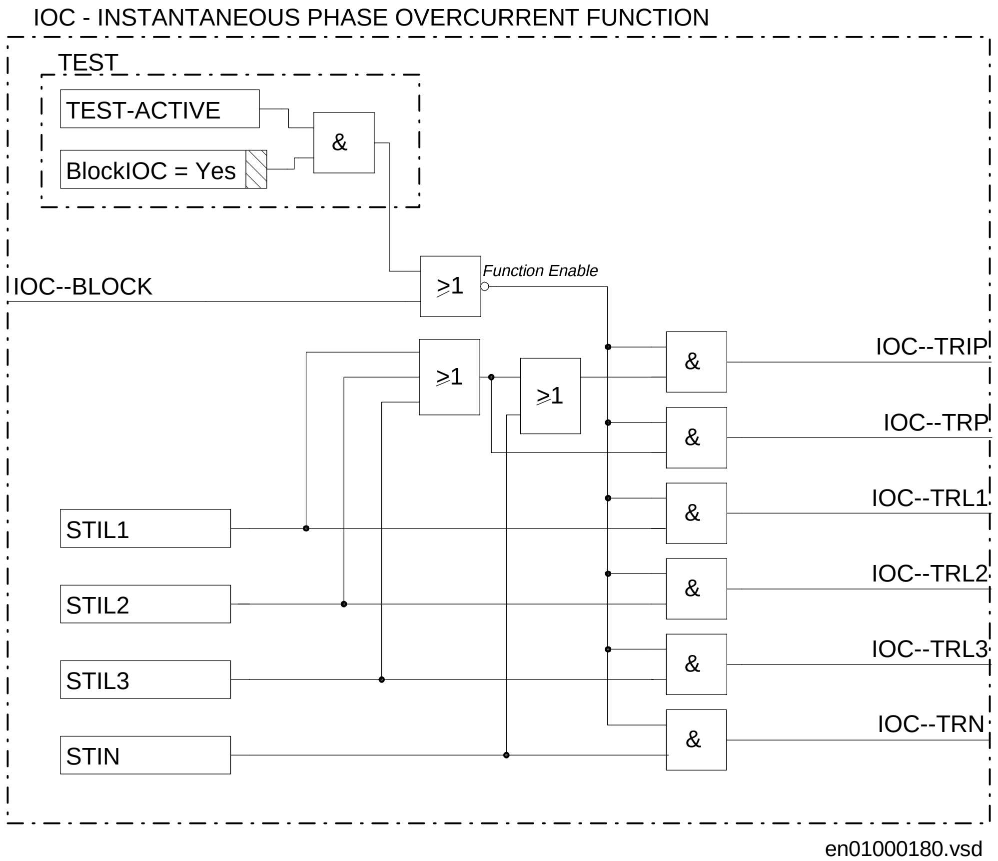



*Figure 63: IOC function, logic diagram*

## 1.5 Input and output signals

**Table 120: Input signals for the IOC (IOC--) function block**

| Signal | Description |
|---|---|
| BLOCK | Block of the instantaneous overcurrent protection function. |

**Table 121: Output signals for the IOC (IOC--) function block**

| Signal | Description |
|---|---|
| TRIP | Trip by instantaneous overcurrent function. |
| TRP | Trip by instantaneous phase overcurrent function when included |
| TRL1 | Trip by instantaneous overcurrent function, phase L1 when single pole tripping is included |
| TRL2 | Trip by instantaneous overcurrent function, phase L2 when single pole tripping is included |
| TRL3 | Trip by instantaneous overcurrent function, phase L3 when single pole tripping is included |
| TRN | Trip by the instantaneous residual overcurrent function when included |

## 1.6 Setting parameters

Path in local HMI: Settings/Functions/Group*n*/InstantOC (where *n*=1-4)

**Table 122: Setting parameters for the instantaneous phase and residual overcurrent protection IOC (IOC--) (non-dir.) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off, On | Off | - | Operating mode for the IOC function |
| IP>> | 50-2000<br>Step: 1 | 100 | % of I1b | Operating phase current |
| IN>> | 50-2000<br>Step: 1 | 100 | % of I1b | Operating residual current |

## 1.7 Technical data

**Table 123: IOC - Instantaneous overcurrent protection**

| **Function** | | **Setting range** | **Operate time** | **Accuracy** |
|---|---|---|---|---|
| Operate current I>> | Phase measuring elements | (50-2000)% of I1b In steps of 1% | - | +/- 2.5 % of $I_r$ at $I \leq I_r$<br>+/- 2.5 % of I at $I > I_r$ |
| | Residual measuring elements | (50-2000)% of I1b In steps of 1% | - | +/- 2.5 % of $I_r$ at $I \leq I_r$<br>+/- 2.5 % of I at $I > I_r$ |
| Operate time at $I > 10 \times I_{set}$ | | | Max 15ms | - |
| Dynamic overreach at $\tau$< 100 ms | | | - | < 5% |

# 2 Time delayed overcurrent protection (TOC)

## 2.1 Application

The time delayed overcurrent protection, TOC, operates at different system conditions for currents exceeding the preset value and which remains high for longer than the delay time set on the corresponding timer. The function can also be used for supervision and fault detector for some other protection functions, to increase the security of a complete protection system. It can serve as a reserve function for the line distance protection, if activated under fuse failure conditions which has disabled the operation of the line distance protection.

The time delayed residual overcurrent protection is intended to be used in solidly and low resistance earthed systems. The time delayed residual overcurrent protection is suitable as back-up protection for phase to earth faults, normally tripped by operation of the distance protection. The protection function can also serve as protection for high resistive phase to earth faults.

## 2.2 Functionality

The current measuring element continuously measures the current in all three phases and compares it to the set operate value IP>. A filter ensures immunity to disturbances and dc components and minimizes the transient overreach. If the current in any of the three phases is above the set value IP>, a common start signal STP and a start signal for the actual phase(s) are activated. The timer tP is activated and the phase overcurrent trip signal TRP is activated after set time. The general trip signal TRIP is activated as well.

The input signal BLOCK blocks the function. The input signal BLKTR blocks both trip signals TRP and TRIP.

The residual current measuring element continuously measures the residual current and compares it with the set operate value IN>. A filter ensures immunity to disturbances and dc components and minimizes the transient overreach. If the measured current is above the set value IN>, a start signal STN is activated. The timer tN is activated and the residual overcurrent trip signal TRN is activated after set time. The general trip signal TRIP is activated as well. The input signal BLOCK blocks the function. The input signal BLKTR blocks both trip signals TRN and TRIP.

## 2.3 Function block

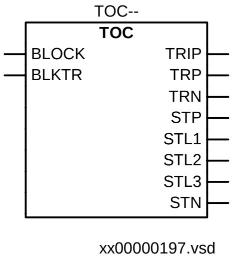



*Figure 64: TOC function block, phase + N*

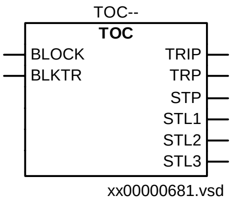



*Figure 65: TOC function block, phase*

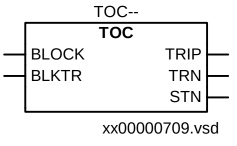



*Figure 66: TOC function block, N*

## 2.4 Logic diagram

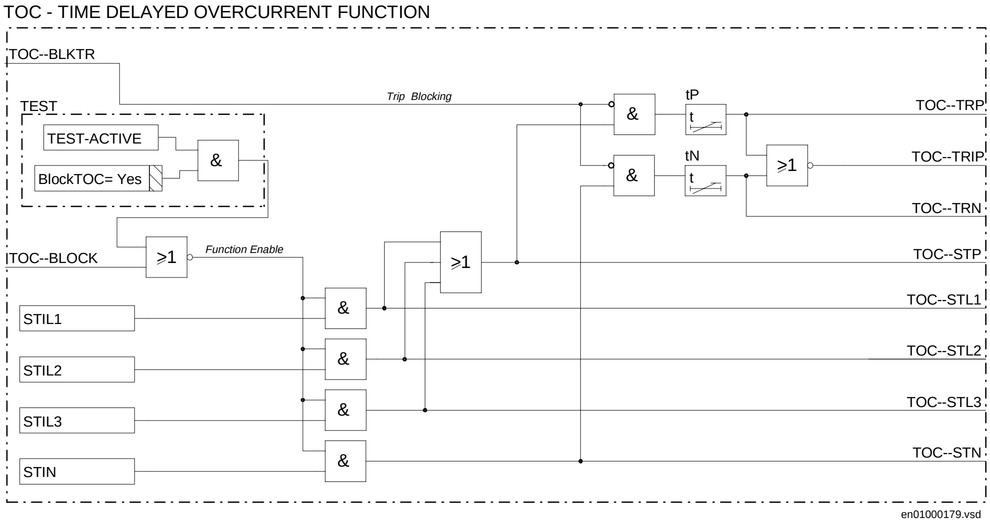



*Figure 67: TOC function, logic diagram*

## 2.5 Input and output signals

### Table 124: Input signals for the TOC (TOC--) function block

| Signal | Description |
|---|---|
| BLOCK | Block of the overcurrent function. |
| BLKTR | Block of trip from the overcurrent function |

### Table 125: Output signals for the TOC (TOC--) function block

| Signal | Description |
|---|---|
| TRIP | Trip by time delayed overcurrent function. |
| TRP | Trip by time delayed phase overcurrent function when included |
| TRN | Trip by the time delayed residual overcurrent function when included |
| STP | Start of phase overcurrent function when included |
| STL1 | Start phase overcurrent, phase L1 when phase overcurrent function included |

| Signal | Description |
|---|---|
| STL2 | Start phase overcurrent, phase L2 when phase overcurrent function included |
| STL3 | Start phase overcurrent, phase L3 when phase overcurrent function included |
| STN | Start of the time delayed residual overcurrent function when included |

## 2.6 Setting parameters

Path in local HMI: Settings/Functions/Group*n*/TimeDelayOC (where *n*=1-4)

**Table 126: Setting parameters for the time delayed phase and residual overcurrent protection TOC (TOC--) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off, On | Off | - | Operating mode for TOC function |
| IN> | 10-150<br>Step: 1 | 100 | % of I4b | Operating residual current |
| tP | 0.000-60.000<br>Step: 0.001 | 10.000 | s | Time delay of phase overcurrent function |
| IN> | 10-150<br>Step: 1 | 100 | % of I4b | Operating residual current |
| tN | 0.000-60.000<br>Step: 0.001 | 10.000 | s | Time delay of residual overcurrent function |

## 2.7 Technical data

**Table 127: TOC - Time delayed overcurrent protection**

| Function | | Setting range | Accuracy |
|---|---|---|---|
| Operate current I> | Phase measuring elements | (10-400) % of $I1_b$ in steps of 1 % | +/- 2.5 % of $I_r$ at $I \leq I_r$ |
| | | | +/- 2.5 % of I at $I > I_r$ |
| | Residual measuring elements | (10-150) % of $I4_b$ in steps of 1 % | +/- 2.5 % of $I_r$ at $I \leq I_r$ |
| | | | +/- 2.5 % of I at $I > I_r$ |
| Time delay | Phase measuring elements | (0.000-60.000) s in steps of 1 ms | +/- 0.5 % of t +/- 10 ms |
| | Residual measuring elements | (0.000-60.000) s in steps of 1 ms | +/- 0.5 % of t +/- 10 ms |
| Dynamic overreach at $\tau$< 100 ms | | - | < 5 % |

# 3 Two step time delayed phase overcurrent protection (TOC2)

## 3.1 Application

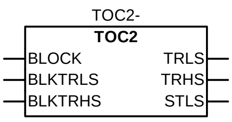
The two current/time stages of overcurrent protection TOC2 improve the possibility to get fast operation for nearby faults by using a high set current stage with short time delay. The low current stage is set with appropriate time delay to get selectivity with the adjacent relays in the system. In networks with inverse time delayed relays, selectivity is generally best obtained by using the same type of inverse time characteristic for all overcurrent relays.

## 3.2 Functionality

The current measuring element continuously measures the current in all three phases and compares it to the set operate value for the two current stages. A filter ensures immunity to disturbances and DC components and minimizes the transient overreach. If the current in any of the three phases is above the set value I>Low, the start signal for the low current stage is activated. With setting Characteristic = Def, the timer tLow is activated and the trip signal TRLS is activated after set time. If inverse time delay is selected, the timer tMinInv starts when the current is above the set value I>Low. If the current also is above the set value I>Inv, the inverse time evaluation starts. When both time circuits operate, the definite time circuit tLow is activated and the trip signal TRLS is activated after the additional time tLow. If the current is above the set value I>High, the timer tHigh is activated and the trip signal TRHS is activated after set time.

The input signal BLOCK blocks all functions. Each current stage can also be individually blocked.

## 3.3 Function block




xx00000679.vsd

## 3.4 Logic diagram

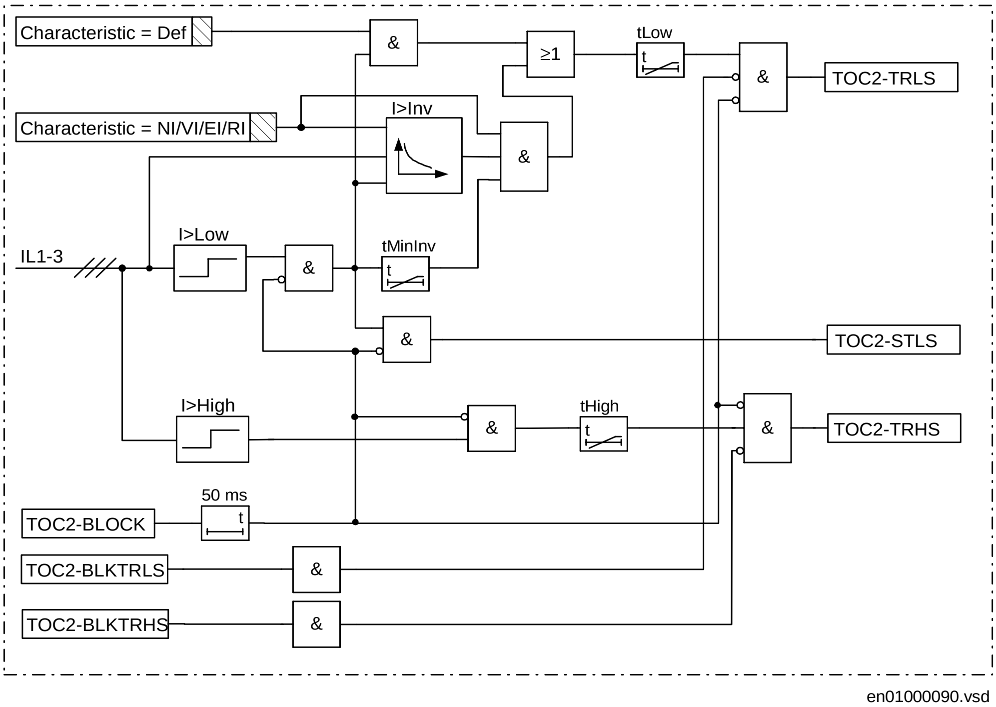



*Figure 68: Two step time delayed phase overcurrent protection, simplified logic diagram*

## 3.5 Input and output signals

**Table 128: Input signals for the TOC2 (TOC2-) function block**

| Signal | Description |
|---|---|
| BLOCK | Blocks the operation of both time delayed overcurrent stages. |
| BLKTRLS | Blocks the trip from the definite or inverse time delayed low current stage. |
| BLKTRHS | Blocks the trip from the definite time delayed high set current stage |

**Table 129: Output signals for the TOC2 (TOC2-) two-step overcurrent function**

| Signal | Description |
|---|---|
| TRLS | Trip from the definite or inverse time delayed low set current stage |
| TRHS | Trip from the definite time delayed high set current stage |
| STLS | Start of the low set current stage |

## 3.6 Setting parameters

**Table 130: Setting parameters for the two step time delayed phase overcurrent protection TOC2 (TOC2-) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off, On | Off | - | Operating mode for TOC2 function |
| Operation Low | Off, On | On | - | Operating mode of low set TOC2 function |
| Characteristic | Def, NI, VI, EI, RI | Def | - | Time delay characteristic for low set TOC2 function |
| I>Inv | 5 - 500<br>Step: 1 | 10 | % of I1b | Base current for low set dependent time delay operation |
| k | 0.05 - 1.10<br>Step: 0.01 | 0.05 | - | Time multiplier for dependent time delay operation |
| tMinInv | 0.000 - 60.000<br>Step: 0.001 | 0.050 | s | Minimum operating time for dependent time delay operation |
| I>Low | 5-500<br>Step: 1 | 100 | % of I1b | Minimum operating current for dependent time delay operation |
| tLow | 0.000 - 60.000<br>Step: 0.001 | 1.000 | s | Independent time delay for low set TOC2 function |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation High | Off, On | Off | - | Operating mode of high set TOC2 function |
| I>High | 50-2000<br>Step: 1 | 100 | % of I1b | Operating current for high set TOC2 function |
| tHigh | 0.000 - 60.000<br>Step: 0.001 | 1.000 | s | Time delay for high set TOC2 function |

## 3.7 Technical data

**Table 131: TOC2 - Two step time delayed overcurrent protection**

| Function | Setting range | Accuracy |
|---|---|---|
| Operate value for low set function | (5-500)% of I1b in steps of 1% | +/- 2.5% of $I1_r$ at<br>$I <= I1_r$<br>+/- 2.5 % of I at $I>I1_r$ |
| Base current for inverse time calculation | (5-500) % of I1b in steps of 1 % | +/- 2.5 % of $I1_r$ at<br>$I <= I1_r$<br>+/- 2.5 % of I at $I> I1_r$ |
| Minimum operate time | (0.000-60.000)s in steps of 1 ms | +/- 0.5 % +/- 10 ms |
| Definite time delay for low set function | (0.000-60.000)s in step of 1ms | +/- 0.5 % +/- 10 ms |
| Operate value of high set function | (50-2000)% of I1b in steps of 1 % | +/- 2.5% of $I1_r$ at<br>$I <= I1_r$<br>+/- 2.5 % of I at $I>I1_r$ |
| Definite time delay for high set function | (0.000-60.000) s in steps of 1 ms | +/- 0.5 % +/- 10 ms |
| Normal inverse characteristic<br>$I = I_{meas}/I_{set}$ | $t = \frac{0.14}{I^{0.02} - 1} \cdot k$ | IEC 60255-3 class 5+/- 60 ms |

| **Function** | **Setting range** | **Accuracy** |
|---|---|---|
| Very inverse characteristic | $t = \frac{13.5}{I-1} \cdot k$ | IEC 60255-3 class 7.5+/- 60 ms |
| Extremely inverse characteristic | $t = \frac{80}{I^2 - 1} \cdot k$ | IEC 60255-3 class 7.5+/- 60 ms |
| Dynamic overreach at t< 100 ms | | <5% |

# 4 Two step time delayed directional phase overcurrent protection (TOC3)

## 4.1 Application

The two current/time stages of the TOC3 overcurrent protection, both with optional directional (Forward release or Reverse block) or non-directional function, improve the possibility to obtain selective function of the overcurrent protection relative other relays even in meshed networks. It must be realized, however, that the setting of a phase overcurrent protection system in a meshed network can be very complicated and a large number of fault current calculations are needed. In some cases, it is not possible to obtain selectivity even when using directional overcurrent protection. In such cases it is suggested to use line differential protection or distance protection function.

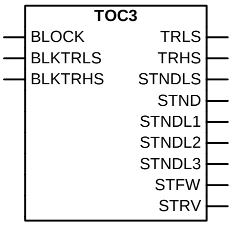
## 4.2 Functionality

The current measuring element continuously measures the current in all three phases and compares it to the set operate value for the two current stages. A filter ensures immunity to disturbances and dc components and minimizes the transient overreach. If the current in any of the three phases is above the set value I>Low, the start signal for the low current stage is activated. With setting Characteristic = Def, the timer tLow is activated and the trip signal TRLS is activated after set time. If inverse time delay is selected, the timer tMinInv starts when the current is above the set value I>Low. If the current also is above the set value I>Inv, the inverse time evaluation starts. When both time circuits operate, the definite time circuit tLow is activated and the trip signal TRLS is activated after set time.

If the current is above the set value I>High, the timer tHigh is activated and the trip signal TRHS is activated after set time.The low and the high set current stages can individually be set directional or non-directional. Directional information is calculated from positive sequence polarization voltages and the phase currents. The polarization voltage contains memory voltage to ensure directional function at close-in three-phase faults. The directional element relay characteristic angle (RCA) and operate angle are settable in wide ranges.

The input signal BLOCK blocks all functions. Trip from each current stage can also be individually blocked.

## 4.3 Function block




## 4.4 Logic diagram

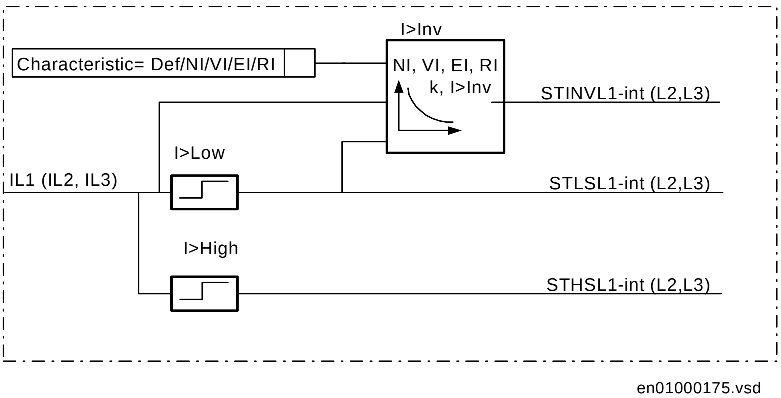



*Figure 69: Simplified block diagram for definite and inverse time delayed phase overcurrent function*

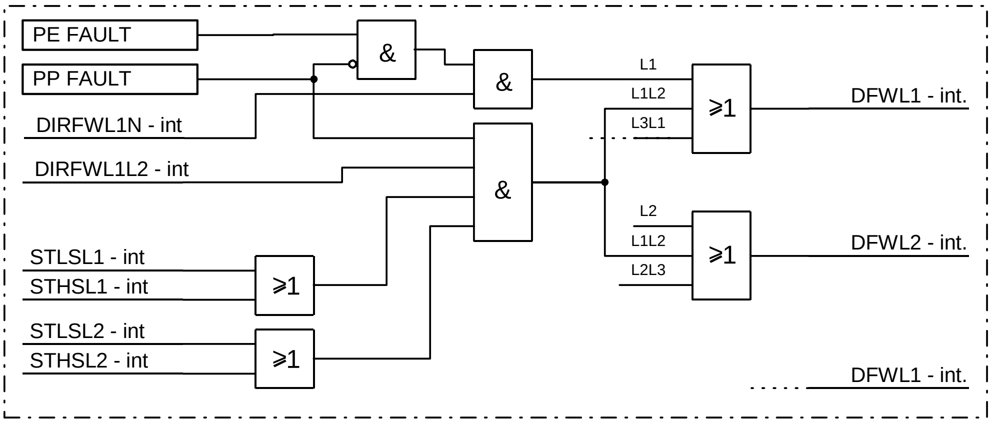



*Figure 70: Excerpt from directional phase selection*

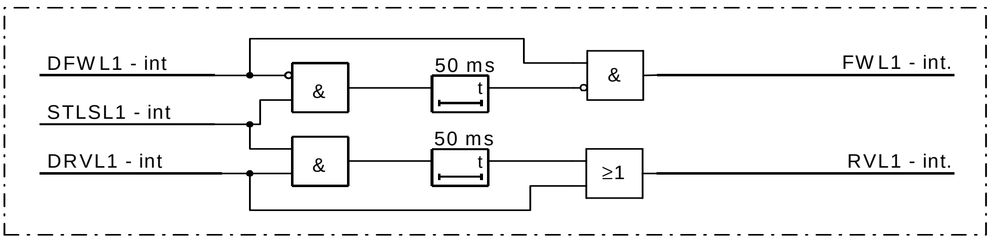



*Figure 71: Current reversal logic for one phase and one set step*

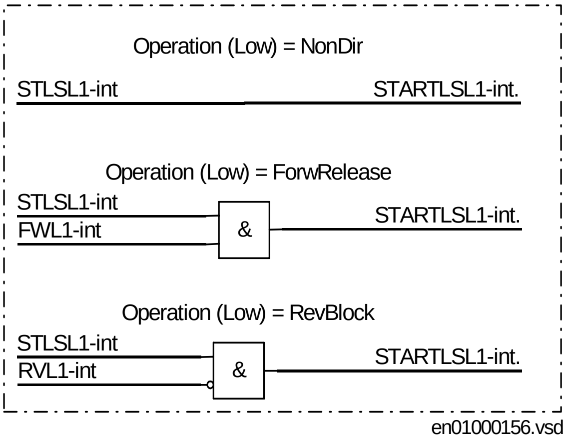



*Figure 72: Directional modes of TOC3*

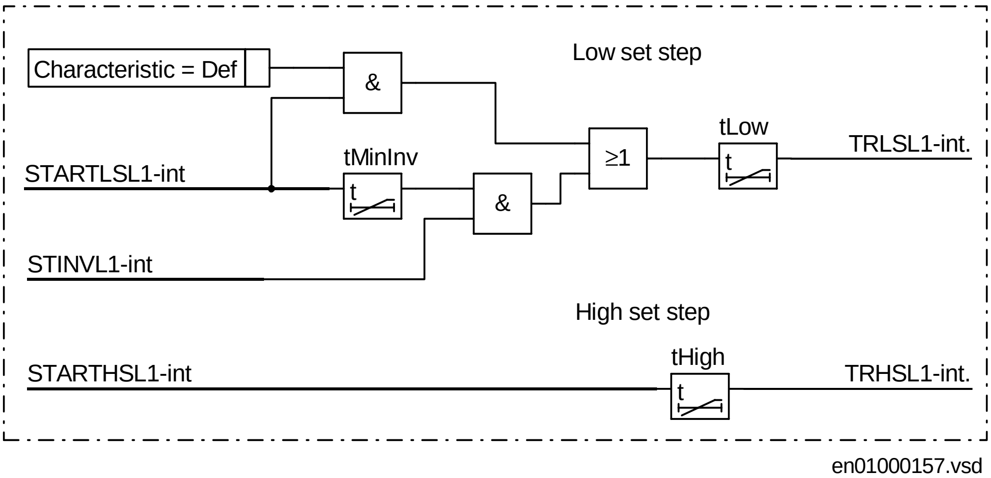



*Figure 73: Delayed time operation for low set step and general time delay*

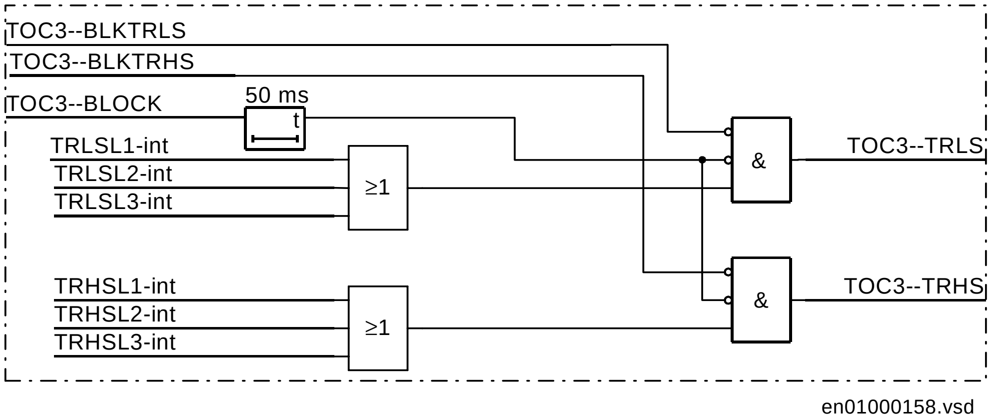



*Figure 74: General trip*

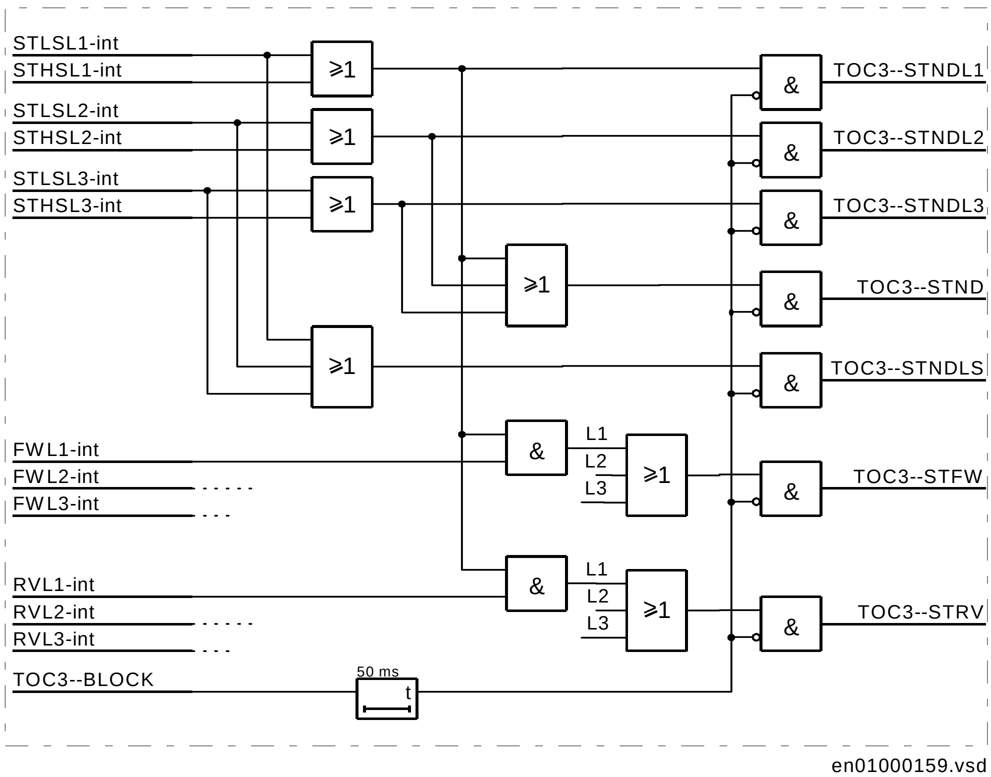



*Figure 75: Start signals*

## 4.5 Input and output signals

**Table 132: Input signals for the TOC3 (TOC3-) function block**

| Signal | Description |
|---|---|
| BLOCK | Blocks the time delayed overcurrent function |
| BLKTRLS | Block the trip from the definite or inverse time delayed low current stage |
| BLKTRHS | Blocks the trip from the definite time delayed high current stage |

**Table 133: Output signals for the TOC3 (TOC3-) function block**

| Signal | Description |
|---|---|
| TRLS | Trip from the definite or inverse time delayed low current stage |
| TRHS | Trip from the definite time delayed high current stage |
| STNDLS | Non directional start for the low current stage |
| STND | General non directional start |
| STNDL1 | General non directional start, phase L1 |
| STNDL2 | General non directional start, phase L2 |
| STNDL3 | General non directional start, phase L3 |
| STFW | Operation of the forward directional element |
| STRV | Operation of the reverse directional element |

## 4.6 Setting parameters

**Table 134: Setting parameters for the directional inverse time phase overcurrent protection TOC3 (TOC3-) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | On/Off | Off | | Operating mode for TOC3 function |
| Operation Low | Off, Non-Dir, For-wRelease, RevBlock | Off | - | Operation mode of low set step |
| Characteristic | Def, NI, VI, EI, RI | Def | - | Time characteristic for low set step |
| I>Inv | (20 - 500)<br>Step: 1 | 20 | % of I1b | Inverse time base current for low set step |
| k | 0.050 - 1.100<br>Step: 0.010 | 0.050 | | Inverse time multiplier for low set step |
| tMinInv | 0.000 - 60.000<br>Step: 0.001 | 0.050 | s | Inverse time minimum operating time for low set step |
| I>Low | 20 - 2000<br>Step: 1 | 100 | % of I1b | Operating current/inverse time min. current low set step |
| tLow | 0.000 - 60.000<br>Step: 0.001 | 1.000 | s | Independent time delay for lowset |
| Operation High | Off, Non-Dir, For-wRelease, RevBlock | Off | - | Operation mode of high set step |
| I>High | 20 - 2000<br>Step: 1 | 100 | % of I1b | Operating current for high set step |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| tHigh | 0.000 - 60.000<br>Step: 0.001 | 1.000 | s | Time delay for high set step |
| ArgDir | 5-45<br>Step: 1 | 15 | degrees | Lower angle of forward direction Characteristic |
| ArgNegRes | 90-175<br>Step: 1 | 115 | degrees | Upper angle of forward direction Characteristic |

## 4.7 Technical data

**Table 135: TOC3-Two step directional overcurrent protection**

| Function | Setting range | Accuracy |
|---|---|---|
| Operate value of low set function | (20-2000)% of I1b in steps of 1% | +/- 2.5 % of $I_r$ at<br>$I \leq I_r$<br>+/- 2.5 % of I at $I>I_r$ |
| Base current for inverse time calculation | (20-500) % of I1b in steps of 1 % | +/- 2.5 % of $I_r$ at<br>$I \leq I_r$<br>+/- 2.5 % of I at $I>I_r$ |
| Minimum operate time | (0.000-60.000) s in steps of 1 ms | +/- 0.5 % +/- 10 ms |
| Definite time delay for low set function | (0.000-60.000) s in step of 1ms | +/- 0.5 % +/- 10 ms |
| Operate value of high set function | (20-2000) % of I1b in steps of 1 % | +/- 2.5 % of $I_r$ at<br>$I \leq I_r$<br>+/- 2.5 % of I at $I>I_r$ |
| Definite time delay for high set function | (0.000-60.000) in steps of 1 ms | +/- 0.5 % +/- 10 ms |
| Static angular accuracy at 0 degrees and 85 degrees | Voltage range (0.1-1.1) x $U_r$<br>Current range (0.5-30) x $I_r$ | +/- 5 degrees |
| Normal inverse characteristic<br>$I = I_{meas}/I_{set}$ | $t = \frac{0.14}{I^{0.02} - 1} \cdot k$ | IEC 60255-3 class 5 +/- 60 ms |

| Function | Setting range | Accuracy |
|---|---|---|
| Very inverse characteristic | $t = \frac{13.5}{I-1} \cdot k$ | IEC 60255-3 class 7.5 +/-60 ms |
| Extremely inverse characteristic | $t = \frac{80}{I^2 - 1} \cdot k$ | IEC 60255-3 class 7.5 +/-60 ms |
| Dynamic overreach at t< 100 ms | | <5% |

# 5 Definite and inverse time-delayed residual overcurrent protection (TEF)

## 5.1 Application

Use the dependent and independent time delayed residual overcurrent functions in solidly earthed systems to get a sensitive and fast fault clearance of phase to earth faults.

The nondirectional protection can be used when high sensitivity for earth fault protection is required. It offers also a very fast back-up earth fault protection for the part of a transmission line, closest to the substation with the protection.

The nondirectional residual overcurrent protection can be given a relatively low current pick-up setting. Thus the protection will be sensitive, in order to detect high resistive phase to earth faults.

The directional residual overcurrent protection can be used in a number of applications:

1. Main protection for phase to earth faults on the radial lines in solidly earthed systems. Selectivity is achieved by using time delayed function according to practices in the system (independent time delay or some type of dependent time characteristic).
2. Main protection for phase to earth faults on lines in a meshed solidly earthed system. The directional function can be used in an permissive overreach communication scheme or a blocking scheme. In this application the directional residual overcurrent function is used together with the communication logic for residual overcurrent protection.
3. Back-up protection for phase to earth faults for lines in solidly earthed systems. By using the directional residual protection as back-up function, the back-up fault clearance time can be kept relatively short together with the maintained selectivity.
4. Etc.

## 5.2 Functionality

The residual overcurrent protection (TEF) measures the residual current of the protected line. This current is compared to the current settings of the function. If the residual current is larger than the setting value a trip signal will be sent to the output after a set delay time. The time delay can be selected between the independent or dependent possibility.

In order to avoid unwanted trip for transformer inrush currents, the function is blocked if the second harmonic of the residual current is larger than 20% of the measured residual current.

As an option the residual overcurrent protection can have directional function. The residual voltage is used as a polarizing quantity. This voltage is either derived as the vectorial sum of inputs U1+U2+U3 or as the input U4. The fault is defined to be in the forward direction if the residual current component in the characteristic angle 65° (residual current lagging the reference voltage, -3U0), is larger than the set operating current in forward direction. The same kind of measurement is performed also in the reverse direction.

## 5.3 Function block

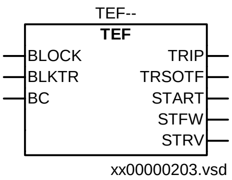



*Figure 76: Function block, directional and nondirectional*

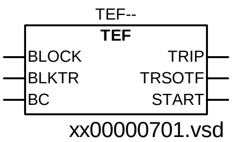



*Figure 77: Function block, nondirectional*

## 5.4 Logic diagram

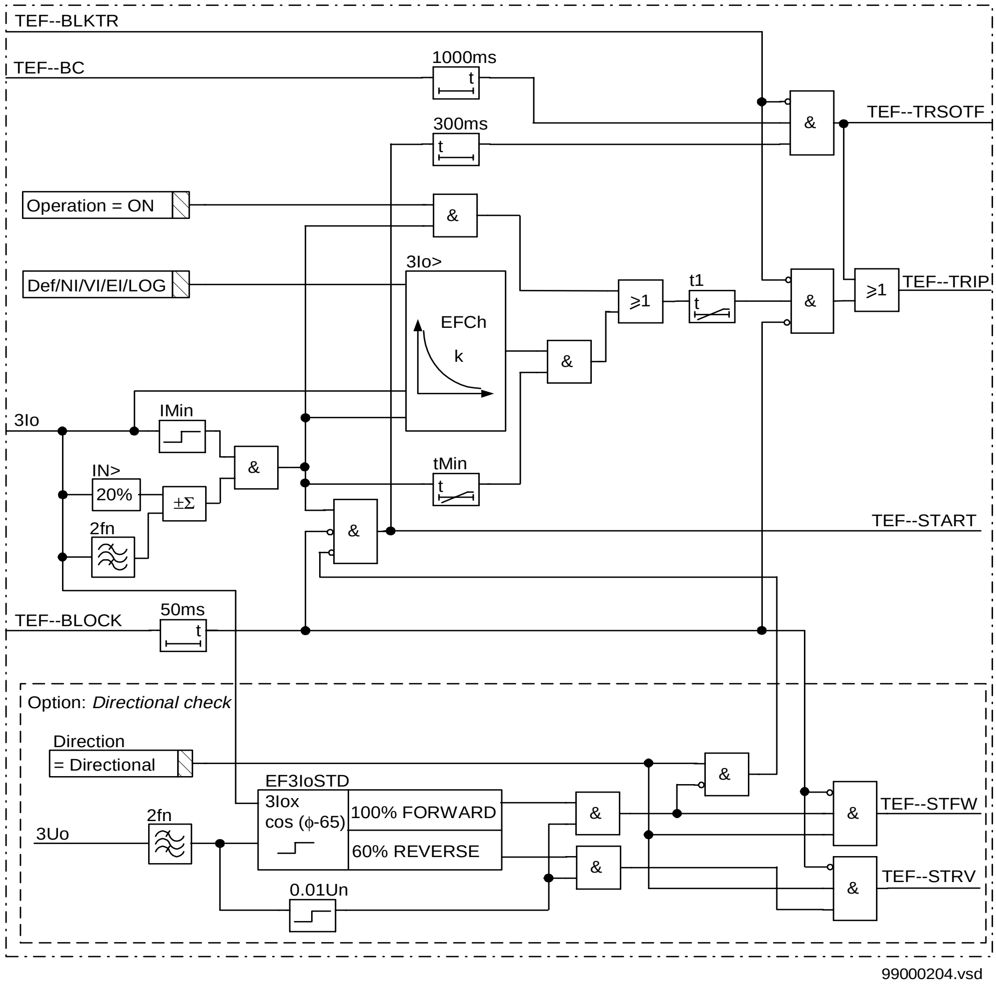



*Figure 78: Simplified logic diagram for the residual overcurrent protection*

## 5.5 Input and output signals

**Table 136: Input signals for the TEF (TEF--) function block**

| Signal | Description |
|---|---|
| BLOCK | Block of function |
| BLKTR | Block of trip |
| BC | Information on breaker position, or on breaker closing command |

**Table 137: Output signals for the TEF (TEF--) function block**

| Signal | Description |
|---|---|
| TRIP | Trip by TEF |
| TRSOTF | Trip by earth fault switch onto fault function |
| START | Non directional start |
| STFW | Forward directional start |
| STRV | Reverse directional start |

## 5.6 Setting parameters

**Table 138: Settings for the TEF (TEF--) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off, On | Off | - | Operating mode for TEF function |
| IMeasured | I4, I5 | I4 | - | Current signal used for earth fault function |
| Characteristic | Def, NI, VI, EI, LOG | Def | - | Time delay characteristic for TEF protection |
| IN> | 5 - 300<br>Step: 1 | 5 | % of Inb | Start current for TEF function (I4b or I5b) |
| IMin | 100 - 400<br>Step: 1 | 100 | % of IN | Minimum operating current |
| t1 | 0.000 - 60.000<br>Step: 0.001 | 0.000 | s | Independent time delay |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| k | 0.05 - 1.10<br>Step: 0.01 | 0.05 | - | Time multiplier for dependent time delay |
| tMin | 0.000 - 60.000<br>Step: 0.001 | 0.050 | s | Min. operating time for dependent time delay function |
| Direction | NonDir, Directional | NonDir | - | Selection of directional or non directional mode |
| UMeasured | U4,<br>U+U2+U3 | U4 | - | Voltage input used for directional earth fault function |
| IN> Dir | 5 - 35<br>Step: 1 | 5 | % of Inb | Start level for directional operation if selected (I4b or I5b) |

## 5.7 Technical data

**Table 139: Independent and dependent time delayed residual protection function**

| Parameter | | Setting range | Accuracy |
|---|---|---|---|
| Start current, definite time or inverse time delay $3I_0$ | | 5-300% of $I_r$ in steps of 1% | +/-5% of set value |
| Operate value for directional current measurement | Forward $3I_0$ at $\varphi$=65 degrees | 5-35% of $I_r$ in steps of 1% | +/-1.5% of $I_r$ |
| | Reverse | 60% of the setting for forward operation | +/-1.5% of $I_r$ |
| Definite time delay | | 0.000 - 60.000 s in steps of 1ms | +/- 0.5 % +/-10 ms |
| Normal inverse characteristic<br>$I = I_{meas}/I_{set}$ | | $t = \frac{0.14}{I^{0.02} - 1} \cdot k$ | IEC 60255-3 class 5 +/- 60 ms |
| Very inverse characteristic | | $t = \frac{13.5}{I-1} \cdot k$ | IEC 60255-3 class 7.5 +/- 60 ms |
| Extremely inverse characteristic | | $t = \frac{80}{I^2 - 1} \cdot k$ | IEC 60255-3 class 7.5 +/- 60 ms |
| Min. operate current for dependent characteristic | | 100-400% of $3I_0$ in steps of 1% | +/-5% of $I_{set}$ |

| **Parameter** | **Setting range** | **Accuracy** |
|---|---|---|
| Minimum operate time | 0.000-60.000 s in step of 1 ms | +/- 0.5 % +/-10 ms |
| Characteristic angles | 65 degrees lagging | +/-5 degrees at 20 V and $I_{set}$=35% of $I_r$ |
| Logarithmic characteristic | $t = 5.8\text{-}1.35 \cdot \ln I$ | +/- 5 % of t at $I = (1.3\text{-}29) \times 3I_0$ |
| Minimum polarising voltage | 1 % of $U_r$ | At 50 Hz: 1% of $U_r$ +/-5%<br>At 60 Hz: 1% of $U_r$ -15% to -5% |
| Reset time | <70 ms | - |

# 6 Four step residual overcurrent protection (EF4)

## 6.1 Application

Use the four step earth fault overcurrent protection in solidly earthed systems in a similar way as a distance protection. As the majority of faults involve earth connection, the protection will be able to clear most of the faults in solidly grounded systems.

The normal application of the four step earth fault current protection can be described as follows: The instantaneous and directional step 1 will normally cover most of the line. The rest of the line is covered by the directional and delayed step 2. Step 2 will also detect and trip earth faults on the remote busbar. The directional step 3 has a longer time delay and will act as a selective protection for earth faults with some degree of fault resistance. The non-directional step 4 has the longest delay. This step will detect and clear high resistive earth faults as well as the majority of series faults.

The four step residual overcurrent protection can also be used together with the communication logic for residual overcurrent protection, in order to realize blocking or permissive overreaching communication schemes.

## 6.2 Functionality

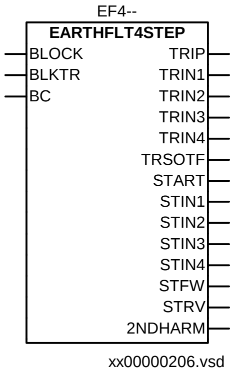
The function operates on the basis of the residual current and voltage measurement. The function has four steps with individual settings (current, delay, etc.). Step 1, 2 and 3 have independent time delay. The time delay for step 4 can be selected between independent or dependent mode of operation.

For each step the current is compared to the set current of the step. Further the following quantities are checked to be used as release or blocking of function from the steps:

- Direction, forward or reverse direction to the fault. The residual current component lagging the reference (-3.U0) voltage 65° is derived. If this current component is larger than the directional current setting, forward direction is detected.
- The second harmonic of the residual current is derived. If this current is larger than 20/32 % of the total residual current, a signal is given that can be used for blocking of the steps.

If the conditions for function is fulfilled for a step, a trip signal is given after the set time delay. For step 1, 2 and 3 independent time delay is used. For step 4 independent or dependent time delay can be used.

## 6.3 Function block




## 6.4 Logic diagram

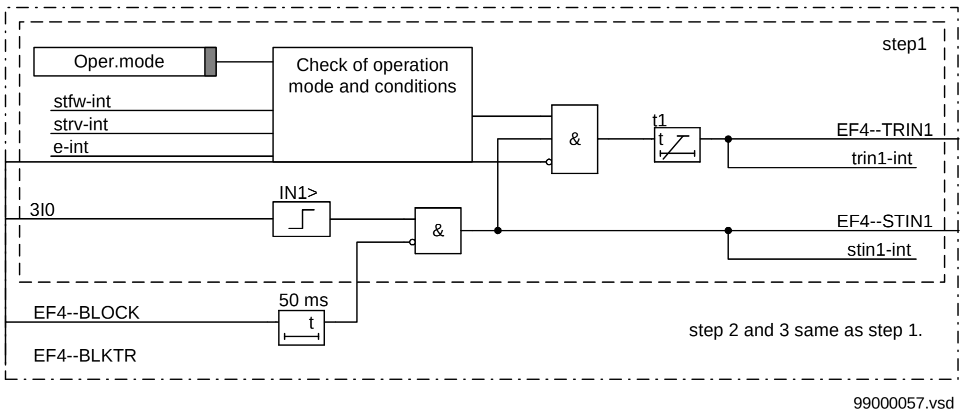



*Figure 79: Simplified logic diagram of internal function Step 1. Step 2 and step 3 are designed in the same way.*

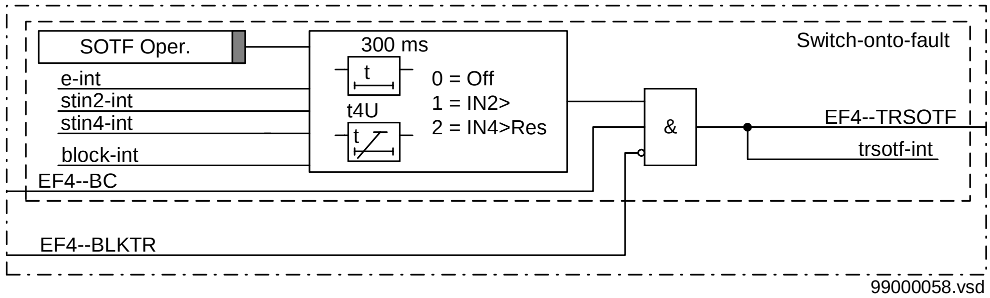



*Figure 80: Simplified logic diagram of internal function Switch-onto-fault.*

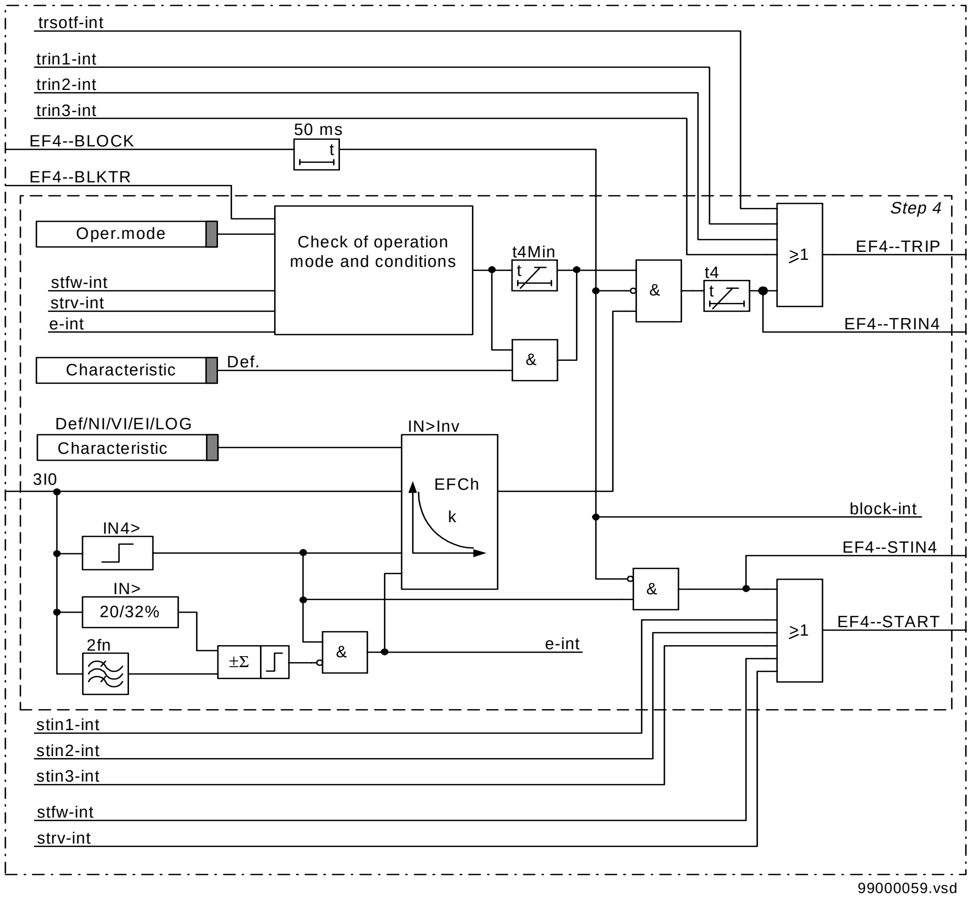



*Figure 81: Simplified logic diagram of internal function step 4.*

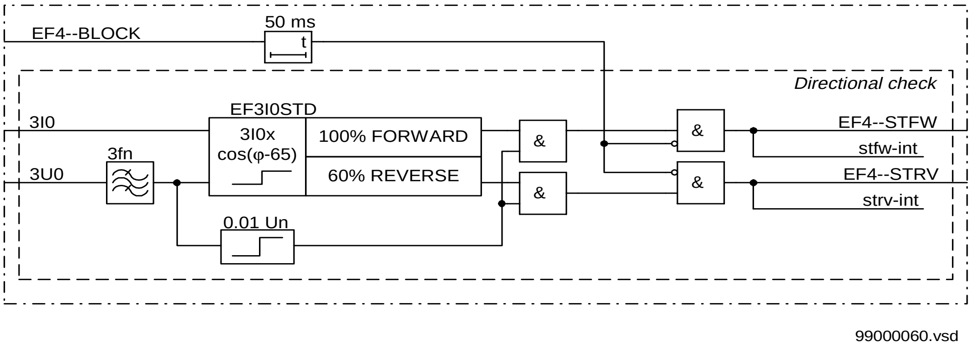



*Figure 82: Simplified logic diagram of internal function Directional check.*

## 6.5 Input and output signals

**Table 140: Input signals for the four step residual overcurrent protection (EF4--) function block**

| Signal | Description |
|---|---|
| BLOCK | Block of earth-fault function |
| BLKTR | Block of trip from earth-fault function |
| BC | Breaker close command |

**Table 141: Output signals for the four step residual overcurrent protection EF4 (EF4--) function block**

| Signal | Description |
|---|---|
| TRIP | Trip |
| TRIN1 | Trip by step 1 |
| TRIN2 | Trip by step 2 |
| TRIN3 | Trip by step 3 |
| TRIN4 | Trip by step 4 |
| TRSOTF | Trip by earth fault switch onto fault function |
| START | Start function |
| STIN1 | Start step 1 |
| STIN2 | Start step 2 |

| Signal | Description |
|---|---|
| STIN3 | Start step 3 |
| STIN4 | Start step 4 |
| STFW | Forward directional start |
| STRV | Reverse directional start |
| 2NDHARM | 2nd harmonic detection operate |

## 6.6 Setting parameters

**Table 142: Setting parameters for the four step residual overcurrent protection EF4 (EF4--) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off, On | Off | | Operating mode for EF4 function |
| IMeasured | I4, I5 | I4 | | Current input used for measurement |
| UMeasured | U4, U1+U2+U3 | U4 | | Voltage input used for measurement |
| Step1 | Off<br>NonDirNonRestr<br>ForwRelease<br>Restrained<br>ForwRelRestr<br>RevBlock<br>RevBIRestr | Off | | Operating mode of step 1 |
| IN1> | 50-2500<br>Step: 1 | 500 | % of Ib | Current operate level step 1. Ib is the same as selected for IMeasured above (I4b or I5b) |
| t1 | 0.000-60.000<br>Step: 0.001 | 0.000 | s | Independent time delay step 1 |
| Step2 | Same as for step 1 | Off | | Operation mode of step 2 |
| IN2> | 20-1500<br>Step: 1 | 200 | % | Current operate level step 2. Ib is the same as selected for IMeasured above (I4b or I5b) |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| t2 | 0.000-60.000<br>Step: 0.001 | 0.000 | s | Definite time delay step 2 |
| Step3 | Same as for step 1 | Off | | Operation mode for step 3 |
| IN3> | 20-1500<br>Step: 1 | 100 | % of Ib | Current operate level step 3. Ib is the same as selected for IMea-sured above (I4b or I5b) |
| t3 | 0.000-60.000<br>Step: 0.001 | 0.000 | s | Definite time delay step 3 |
| Step4 | Same as for step 1 | Off | | Operation mode for step 4 |
| Characteristic | Def, NI, VI, EI, LOG | Def | | Time delay operation step 4 |
| IN>Inv | 4.0-110.0<br>Step: 0.1 | 50.0 | % of Ib | Inverse time base current. Ib is the same as selected for IMea-sured above (I4b or I5b) |
| k | 0.05-1.10<br>Step: 0.01 | 0.05 | | Time multiplier for the dependent time delay characteristic |
| IN4> | 4.0-440.0<br>Step: 0.1 | 100.0 | % of Ib | Operate current/inverse time min current step 4. Ib is the same as selected for IMeasured above (I4b or I5b) |
| t4 | 0.000-60.000<br>Step: 0.001 | 0.000 | s | Definite (inverse additional) time delay step 4 |
| t4Min | 0.000-60.000<br>Step: 0.001 | 0.000 | s | Inverse time minimum delay step 4 |
| IN> Dir | 5-40<br>Step: 1 | 30 | % of Ib | Forward direction base current. Ib is the same as selected for IMea-sured above (I4b or I5b) |
| 2ndHarmStab | 20, 32 | 20 | % | Second harmonic restrain opera-tion |
| BlkParTransf | Off, On | Off | | Blocking at parallel transformers |
| SOTF | Off, IN2 >, IN4>, Res | Off | | Switch-onto-fault operation mode |
| t4U | 0.000 - 60.000<br>Step: 0.001 | 0.000 | s | Switch-onto-fault active time |

## 6.7 Technical data

**Table 143: EF4-Four step earth fault overcurrent protection**

| Parameter | | Setting range | Accuracy |
|---|---|---|---|
| Current level for step 1 | | 50 - 2500% of Ib in steps of 1% | +/- 5 % of $I_r$ at $I \leq I_r$<br>+/- 5% of I at $I > I_r$ |
| Definite time delay for step 1 | | 0.000 - 60.000 s in steps of 1ms | +/- 0.5 % +/- 10 ms |
| Current level for step 2 | | 20 - 1500 % of Ib in steps of 1% | +/- 5 % of $I_r$ at $I \leq I_r$<br>+/- 5% of I at $I > I_r$ |
| Definite time delay for step 2 | | 0.000 - 60.000 s in steps of 1 ms | +/- 0.5 % +/- 10 ms |
| Current level for step 3 | | 20 - 1500 % of Ib in steps of 1% | +/- 5 % of $I_r$ at $I \leq I_r$<br>+/- 5% of I at $I > I_r$ |
| Definite time delay for step 3 | | 0.000 - 60.000 s in steps of 1 ms | +/- 0.5 % +/- 10 ms |
| Current level for step 4 definite time delay or minimum operate current for inverse time delay | | 4 - 440 % of Ib in steps of 0.1% | +/- 5 % of $I_r$ at $I \leq I_r$<br>+/- 5% of I at $I > I_r$ |
| Definite time delay for step 4 or inverse time additional delay | | 0.000 - 60.000 s in steps of 1 ms | +/- 0.5 % +/- 10 ms |
| Base current for inverse time delay | | 4 - 110% of Ib in steps of 1% | +/- 5 % of $I_r$ at $I \leq I_r$<br>+/- 5% of I at $I > I_r$ |
| Time multiplier for inverse time delay | | 0.05 - 1.10 in steps of 0.01 | - |
| Inverse time minimum delay step 4 | | 0.000 - 60.000 s in steps of 1 ms | +/- 0.5 % +/- 10 ms |
| Operate value for directional current measurement | Forward $3I_0$ at $\varphi$= 65° | 5-40% of Ib in steps of 1% | +/- 2.5 % of $I_r$ at $I \leq I_r$<br>+/- 2.5% of I at $I > I_r$ |
| | Reverse | 60% of Forward | +/- 2.5 % of $I_r$ at $I \leq I_r$<br>+/- 2.5% of I at $I > I_r$ |
| Level of harmonic restrain | | 20% or 32% | +/- 5% |
| Characteristic angle<br>$I = I_{meas}/I_{set}$ | | 65° lagging | +/- 5° at 20 V and $I_{set}$= 35 % of $I_r$ |

| **Parameter** | **Setting range** | **Accuracy** |
|---|---|---|
| Normal inverse characteristic<br>$I = I_{meas}/I_{set}$ | $t = \frac{0.14}{I^{0.02} - 1} \cdot k$ | IEC 60255-3 class 5 +/- 60 ms |
| Very inverse characteristic | $t = \frac{13.5}{I-1} \cdot k$ | IEC 60255-3 class 7.5 +/- 60 ms |
| Extremely inverse characteristic | $t = \frac{80}{I^2 - 1} \cdot k$ | IEC 60255-3 class 7.5 +/- 60 ms |
| Logarithmic characteristic | $t = 5.8\text{-}1.35 \cdot \ln I$ | +/- 5 % of t at I = (1.3-29) $\times 3I_0$ |
| Switch onto fault active time | 0.000 - 60.000 s in steps of 1 ms | +/- 0.5 % +/-10 ms |

# 7 Sensitive directional residual overcurrent protection (WEF1)

## 7.1 Application

In isolated networks or in networks with high impedance earthing, the phase to earth fault current is significantly smaller than the short circuit currents. In addition to this, the magnitude of the fault current is almost independent on the fault location in the network.

The protection uses the residual current component $3I_0 \cos\varphi$, where $\varphi$ is the angle between the residual current and the reference voltage, compensated with a characteristic angle. The characteristic angle is chosen to -90° in an isolated system. The characteristic angle is chosen to 0° in compensated systems.

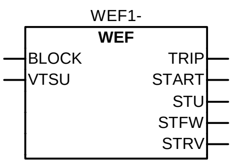
## 7.2 Functionality

The function measures the residual current and voltage. The angle between the residual voltage and residual current (angle between 3I0 and -3U0 i.e U0 is 180 degrees adjusted) is calculated. This angle is used in two functions namely first to determine if the fault is in forward or reverse direction, and secondly to calculate the residual current component in the characteristic angle direction.

The residual current component in the characteristic angle direction is compared with the set operating value. If this current component is larger than the setting this is one criterion for function of the protection. The residual voltage is compared to a set operating value. If the measured voltage is larger than the setting this is another criterion for the operation of the protection. If both the criteria are fulfilled and the set time delay has elapsed, the function will give a trip signal.

Due to the demands on accuracy and sensitivity for this function, special current input transformers must be used.

## 7.3 Function block



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## 7.4 Logic diagram

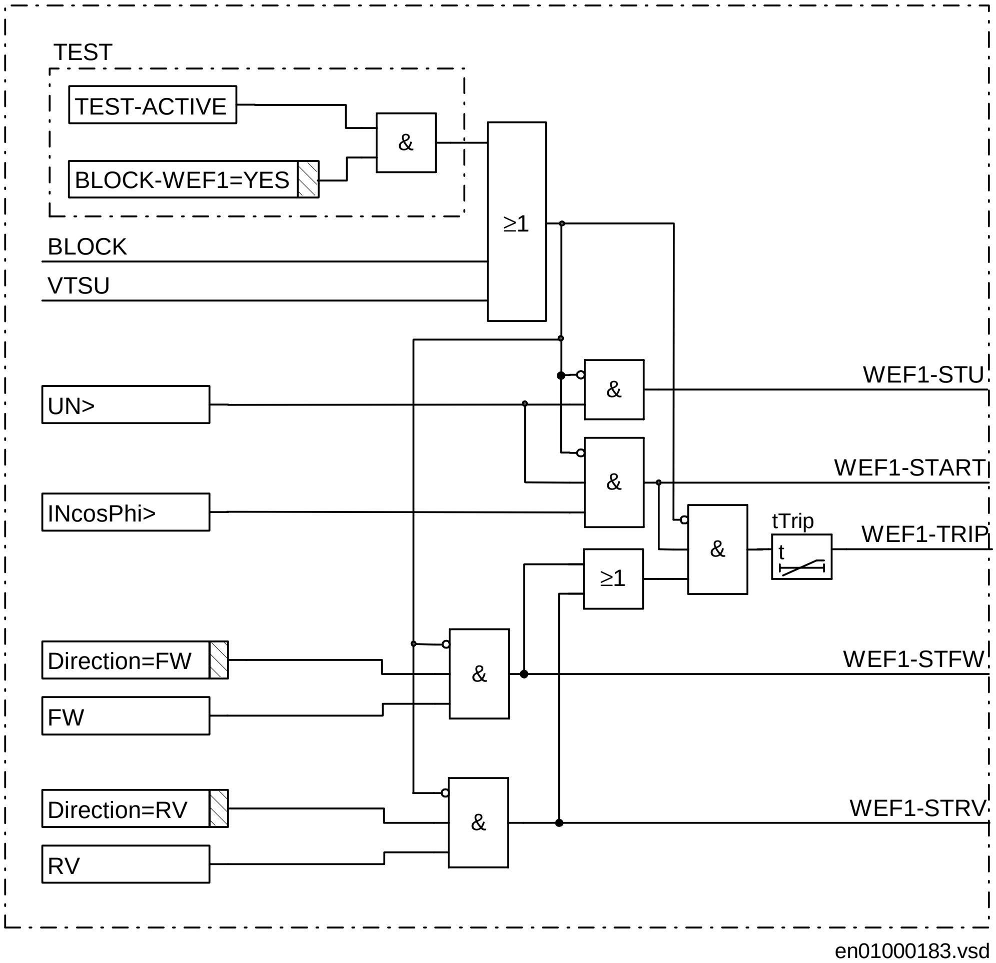



*Figure 83: Sensitive directional residual overcurrent protection function, simplified logic diagram*

## 7.5 Input and output signals

**Table 144: Input signals for the sensitive directional residual overcurrent protection (WEF1-) function**

| Signal | Description |
|---|---|
| BLOCK | Block the function |
| VTSU | Block the function by voltage circuit supervision |

**Table 145: Output signals for the sensitive directional residual overcurrent WEF1 (WEF1-) protection function**

| Signal | Description |
|---|---|
| TRIP | Trip output |
| START | Non directional start, $3U_0 > U_{set}$ and $3I_0 \cos \varphi > I_{set}$ |
| STU | Start $3U_0 > U_{set}$ |
| STFW | Forward direction start |
| STRV | Reverse direction start |

## 7.6 Setting parameters

**Table 146: Settings for the WEF1 (WEF1-) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | On / Off | Off | | Operation mode for WEF1 function |
| Direction | Forward/ Reverse | Forward | | Direction for trip |
| INcosPhi> | 3.0 - 2000.0<br>Step: 0.1 | 10.0 | % of Ib | Start current |
| UN> | 5.0 - 70.0<br>Step: 0.1 | 30.0 | % of Ub | Start voltage |
| IMeasured | I4, I5 | I4 | | Current signal used for the earth fault function |
| UMeasured | U4, U1+U2+U3 | U4 | | Voltage signal used for the earth fault function |
| RCA | -90.0 - 90.0<br>Step: 0.1 | 0.0 | degrees | Relay characteristic angle |
| tTrip | 0.000 - 60.000<br>Step: 0.001 | 0.000 | s | Trip delay |

## 7.7 Technical data

**Table 147: Sensitive directional residual overcurrent protection function, WEF1**

| Function | Setting range | Accuracy |
|---|---|---|
| Operate current | (3.0 - 2000.0 ) % of Ib in steps of 0.1% | +/-2.5% of $I_r$ at $I \leq I_r$<br>+/-2.5% of I at $I > I_r$ |
| Operate voltage | (5.0 - 70.0) % of Ub in steps of 0.1% | +/-2.5% of $U_r$ at $U \leq U_r$<br>+/-2.5% of U at $U > U_r$ |
| Characteristic Angle | (-90.0 - +90.0) degrees in steps of 0.1 degrees | |
| Independent time delay | (0.000 - 60.000) s in steps of 1 ms | +/-0.5% +/- 10 ms |

# 8 Sensitive directional residual power protection (WEF2)

## 8.1 Application

In isolated networks or in networks with high impedance earthing, the phase to earth fault current is significantly smaller than the short circuit currents. In addition to this, the magnitude of the fault current is almost independent on the fault location in the network.

The protection uses the residual power component $3U_0 .3I_0.\cos\varphi$, where $\varphi$ is the angle between the residual current and the reference voltage, compensated with a characteristic angle. The characteristic angle is chosen to -90° in an isolated system. The characteristic angle is chosen to 0° in compensated systems.

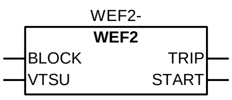
## 8.2 Functionality

The function measures the residual current and voltage. The angle between the residual voltage and residual current is calculated. This angle is used in two functions namely first to determine if the fault is in forward or reverse direction, and secondly to calculate the residual power component in the characteristic angle direction.

The residual voltage ($U_0$) is compared to a setting value. The residual current ($I_0$) is compared to a setting value. The residual power component in the characteristic angle direction ($S_N$) is compared to a power reference setting. If the power is larger than the setting this is one criterion for function of the protection. The voltage and current measurement are two other criteria that must be fulfilled for function. The information on power is the input to a dependent time delay function. The function will give a trip signal when all three criteria for function are fulfilled and the time delay has elapsed.

Due to the demands on accuracy and sensitivity for this function, special current input circuits must be used.

## 8.3 Function block




xx00000559.vsd

## 8.4 Logic diagram

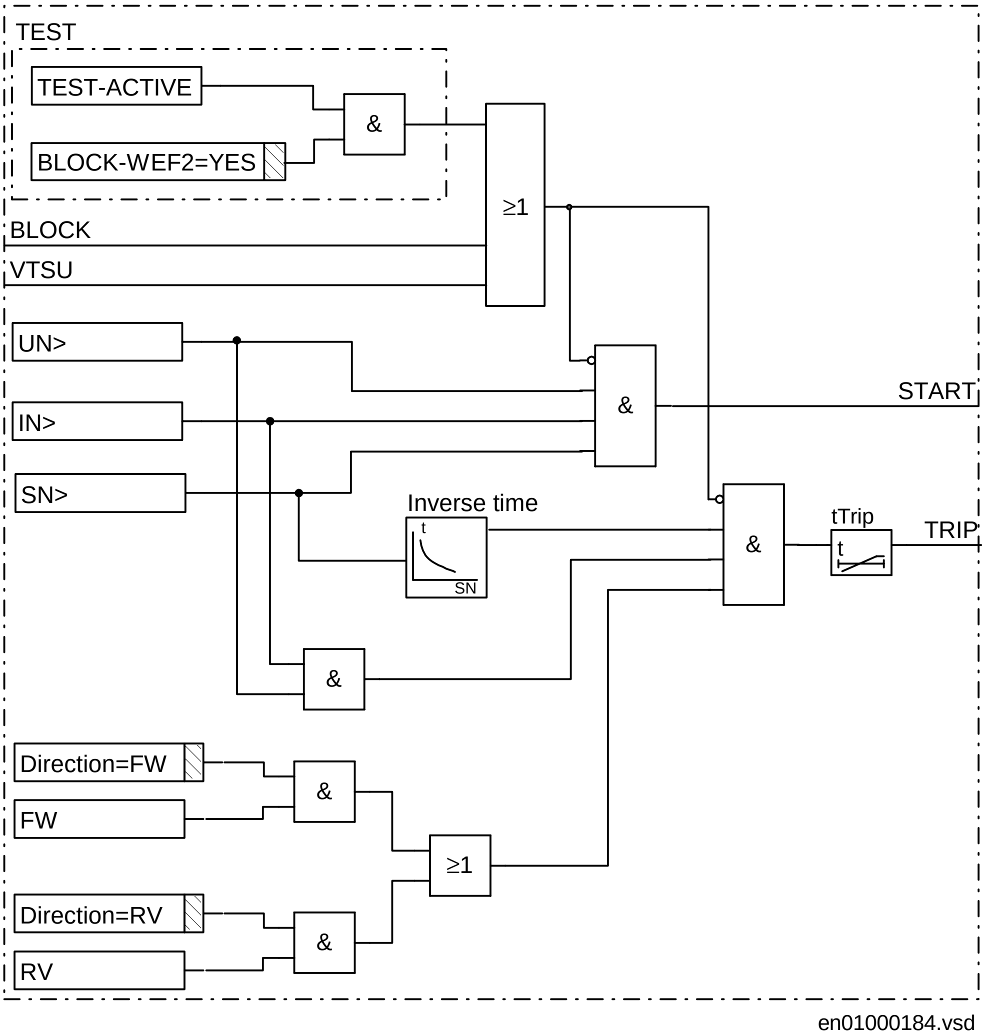



*Figure 84: Sensitive directional residual power protection function, simplified logic diagram*

## 8.5 Input and output signals

**Table 148: Input signals for the sensitive directional residual power protection (WEF2-) function block**

| Signal | Description |
|---|---|
| BLOCK | Block function |
| VTSU | Block function by voltage circuit supervision |

**Table 149: Output signals for the sensitive directional residual power protection WEF2 (WEF2-) function block**

| Signal | Description |
|---|---|
| TRIP | Trip output |
| START | Start for voltage, current and power |

## 8.6 Setting parameters

**Table 150: Settings for the WEF2 (WEF2-) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | On / Off | Off | | Operation mode for WEF2 function |
| Direction | Forward/ Reverse | Forward | | Direction for trip |
| RCA | -90.0 - 90.0 Step: 0.1 | 0.0 | degrees | Relay characteristic angle |
| SN> | 0.3 - 100.0 Step: 0.1 | 1.0 | % of Sb | Start real power |
| IN> | 5.0 - 400.0 Step: 0.1 | 10.0 | % of Ib | Start current |
| UN> | 1.0 - 70.0 Step: 0.1 | 5.0 | % of Ub | Start voltage |
| Sref | 5.0 - 50.0 Step: 0.1 | 15.0 | % of Sb | Reference power |
| k | 0.02 - 2.00 Step: 0.01 | 1.00 | | Time multiplier |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| tTrip | 0.000 - 60.000<br>Step: 0.001 | 0.000 | s | Independent trip delay |
| IMeasured | I4, I5 | I4 | | Current input used for the earth fault function |
| UMeasured | U4, U1+U2+U3 | U4 | | Voltage input used for the earth fault function |

## 8.7 Technical data

**Table 151: Sensitive directional residual power protection function, WEF2**

| Function | Setting range | Accuracy |
|---|---|---|
| Operate current | (5.0 - 400.0) % of $I_b$ in steps of 0.1% | +/-2.5% of $I_r$ at $I \leq I_r$<br>+/-2.5% of I at $I > I_r$ |
| Operate voltage | (1.0-70.0) % of $U_b$ in steps of 0.1% | +/-2.5% of $U_r$ at $U \leq U_r$<br>+/-2.5% of U at $U > U_r$ |
| Characteristic angle | (-90.0 -90.0) degrees in steps of 0.1 degrees | |
| Independent time delay | (0.000-60.000) s in steps of 1 ms | +/-0.5% +/- 10 ms |
| Inverse characteristic<br>$T_i = \frac{k \cdot S_{ref}}{S_{measured}}$ | k = (0.0-2.0) in steps of 0.01<br>Sref = (5.0 - 50.0) % of Sb in steps of 0.1% | IEC 60255-3 class 5 +/- 60 ms |

# 9 Scheme communication logic for residual overcurrent protection (EFC)

## 9.1 Application

The EFC directional comparison function contains logic for blocking overreaching and permissive overreaching schemes. The function is applicable together with TEF time delayed directional residual overcurrent protection in order to decrease the total operate time of a complete scheme.

One communication channel, which can transmit an on / off signal, is required in each direction. It is recommended to use the complementary additional communication logic EFCA, if the weak infeed and/or current reversal conditions are expected together with permissive overreaching scheme.

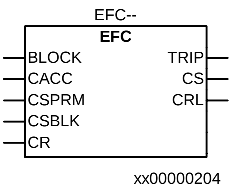
## 9.2 Functionality

The communication logic for residual overcurrent protection contains logics for blocking overreach and permissive overreach schemes.

In the blocking scheme a signal is sent to the remote end of the line if the directional element, in the directional residual overcurrent protection (sending end), detects the fault in the reverse direction. If no blocking signal is received and the directional element, in the directional residual overcurrent protection (receiving end), detects the fault in the forward direction, a trip signal will be sent after a settable time delay.

In the permissive overreach scheme a signal is sent to the remote end of the line if the directional element, in the directional residual overcurrent protection (sending end), detects the fault in the forward direction. If an acceleration signal is received and the directional element, in the directional residual overcurrent protection (receiving end), detects the fault in the forward direction, a trip signal will be sent, normally with no time delay. In case of risk for fault current reversal or weak end infeed, the additional logic for this should be used.

## 9.3 Function block



## 9.4 Logic diagram

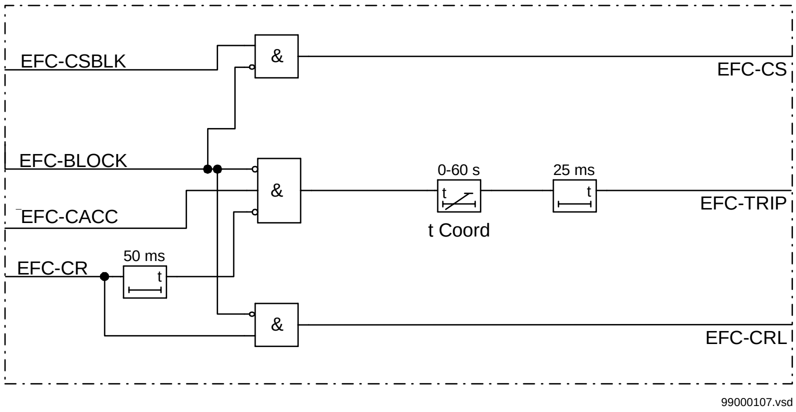



*Figure 85: Simplified logic diagram, Scheme type = blocking*

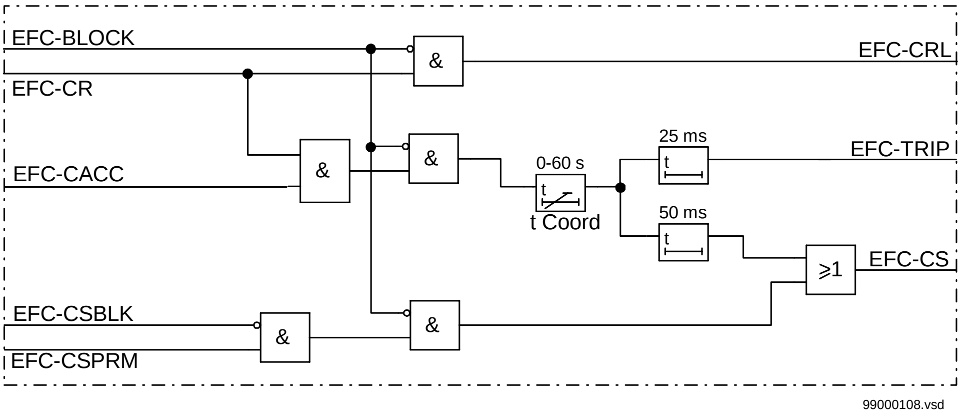



*Figure 86: Simplified logic diagram, Scheme type = permissive*

## 9.5 Input and output signals

**Table 152: Input signals for the EFC (EFC--) function block**

| Signal | Description |
|---|---|
| BLOCK | Block function |
| CACC | Permits the operation when high |

| Signal | Description |
|---|---|
| CSPRM | Initiates sending of carrier signal in permissive scheme |
| CSBLK | Initiates sending of carrier signal in blocking scheme |
| CR | Information on received carrier signal |

**Table 153: Output signals for the EFC (EFC--) function block**

| Signal | Description |
|---|---|
| TRIP | Trip by communication scheme logic |
| CS | Carrier send by communication scheme logic |
| CRL | Carrier receive by the communication scheme logic |

## 9.6 Setting parameters

**Table 154: Setting parameters for the scheme communication logic EFC (EFC--) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off, On | Off | - | Operating mode for EFC function |
| SchemeType | Permissive, Blocking | Permissive | - | Scheme type, mode of operation |
| tCoord | 0.000-60.000<br>Step: 0.001 | 0.050 | s | Communication scheme coordination time |

## 9.7 Technical data

**Table 155: Scheme communication logic for residual overcurrent protection (EFC)**

| Parameter | Setting range | Accuracy |
|---|---|---|
| Coordination timer | 0.000-60.000 s in steps of 1 ms | +/-0.5% +/-10 ms |

# 10 Current reversal and weak end infeed logic for residual overcurrent protection (EFCA)

## 10.1 Application

The EFCA additional communication logic is a supplement to the EFC scheme communication logic for the residual overcurrent protection.

To achieve fast fault clearing for all earth faults on the line, the TEF earth-fault protection function can be supported with logic, that uses communication channels. REx 5xx terminals have for this reason available additions to scheme communication logic.

If parallel lines are connected to common busbars at both terminals, overreaching permissive communication schemes can trip unselectively due to fault current reversal. This unwanted tripping affects the healthy line when a fault is cleared on the other line. This lack of security can result in a total loss of interconnection between the two buses.To avoid this type of disturbance, a fault current-reversal logic (transient blocking logic) can be used.

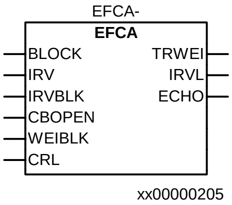
Permissive communication schemes for residual overcurrent protection, can basically operate only when the protection in the remote terminal can detect the fault. The detection requires a sufficient minimum residual fault current, out from this terminal. The fault current can be too low due to an opened breaker or high positive and/or zero sequence source impedance behind this terminal. To overcome these conditions, weak end infeed (WEI) echo logic is used.

## 10.2 Design

The reverse directed signal from the directional residual overcurrent function, starts the operation of a current reversal logic. The output signal, from the logic, will be activated, if the fault has been detected in reverse direction for more than the tPickUp time set on the corresponding timers. The tDelay timer delays the reset of the output signal. The signal blocks the operation of the overreach permissive scheme for residual current, and thus prevents unwanted operation due to fault current reversal.

The weak end infeed logic uses normally a forward and reverse signal from the directional residual overcurrent function. The weak end infeed logic echoes back the received permissive signal, if none of the directional measuring elements have been activated during the last 200 ms. Further, it can be set to give signal to trip the breaker if the echo conditions are fulfilled and the residual voltage is above the set operate value for $3U_0$>.

## 10.3 Function block




## 10.4 Logic diagram

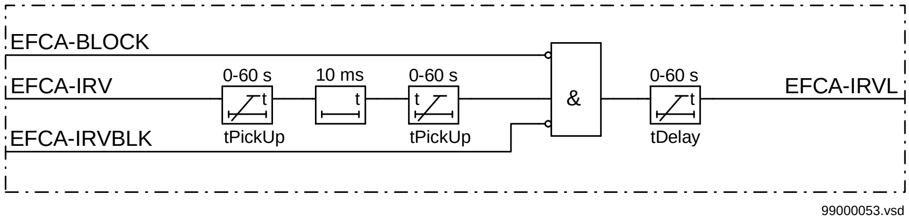



*Figure 87: Simplified logic diagram, current reversal logic*

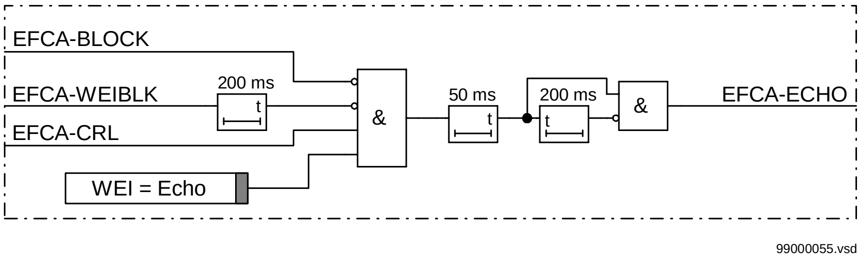



*Figure 88: Simplified logic diagram, weak end infeed - Echo logic*

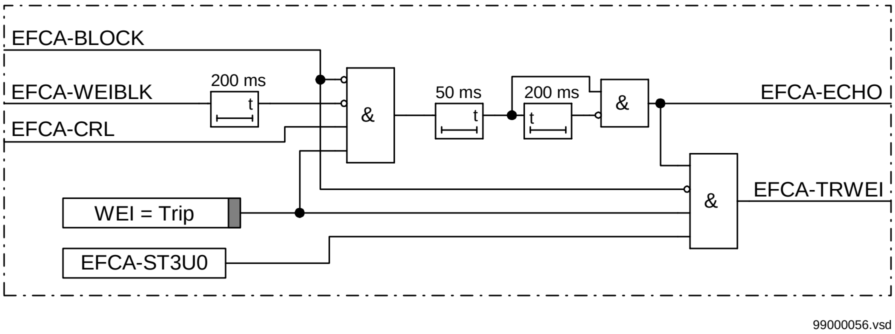



*Figure 89: Simplified logic diagram, weak end infeed - Trip logic*

## 10.5 Input and output signals

**Table 156: Input signals for the EFCA (EFCA-) function block**

| Signal | Description |
|---|---|
| BLOCK | Blocking of function |
| IRV | Activation of current reversal logic |
| IRVBLK | Blocking of current reversal logic |
| WEIBLK | Blocking of weak end infeed logic |
| CRL | Carrier received for weak end infeed logic |

**Table 157: Output signals for the EFCA (EFCA-) function block**

| Signal | Description |
|---|---|
| TRWEI | Trip by weak end infeed logic |
| IRVL | Operation of current reversal logic |
| ECHO | Carrier send by weak end infeed logic |

## 10.6 Setting parameters

**Table 158: Setting parameters for the current reversal and weak end infeed logic for residual overcurrent protection EFCA (EFCA-) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| CurrRev | Off, On | Off | - | Operating mode for current reversal logic |
| tPickUp | 0.000-60.000<br>Step: 0.001 | 0.000 | s | Current reversal pickup timer |
| tDelay | 0.000-60.000<br>Step: 0.001 | 0.100 | s | Current reversal delay timer |
| WEI | Off, Trip, Echo | Off | - | Operating mode of weak end infeed logic |
| U> | 5-70<br>Step: 1 | 25 | % of U1b | Operate phase voltage for WEI trip |

## 10.7 Technical data

**Table 159: Current reversal and weak end infeed logic for residual overcurrent protection (EFCA)**

| Parameter | Setting range | Accuracy |
|---|---|---|
| Operate voltage for WEI trip | 5-70 % of U1b in steps of 1% | +/-5% of $U_r$ |
| Current reversal pickup timer | 0.000-60.000 s in steps of 1 ms | +/-0.5% +/-10 ms |
| Current reversal delay timer | 0.000-60.000 s in steps of 1 ms | +/-0.5% +/-10 ms |

# 11 Thermal overload protection (THOL)

## 11.1 Application

Load currents that exceed the permissible continuous value may cause damage to the conductors and isolation due to overheating. The permissible load current will vary with the ambient temperature.

The THOL thermal overcurrent function supervises the phase currents and provides a reliable protection against damage caused by excessive currents. The temperature compensation gives a reliable thermal protection even when the ambient temperature varies largely.

## 11.2 Functionality

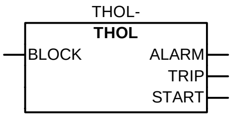
The final temperature rise of an object relative the ambient temperature is proportional to the square of the current. The rate of temperature rise is determined by the magnitude of the current and the thermal time constant of the object. The same time constant determines the rate of temperature decrease when the current is decreased.

The thermal overload function uses the highest phase current. The temperature change is continuously calculated and added to the figure for the temperature stored in the thermal memory. When temperature compensation is used, the ambient temperature is added to the calculated temperature rise. If no compensation is used, $20^{o}$ C is added as a fixed value. The calculated temperature of the object is then compared to the set values for alarm and trip.

The information on the ambient temperature is received via a transducer input 0 - 10 mA or 4 - 20 mA.

The output signal THOL--TRIP has a duration of 50 ms. The output signal THOL--START remains activated as long as the calculated temperature is higher than the set trip value minus a settable temperature difference TdReset (hysteresis). The output signal THOL--ALARM has a fixed hysteresis of $5^{o}$ C.

## 11.3 Function block

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## 11.4 Logic diagram

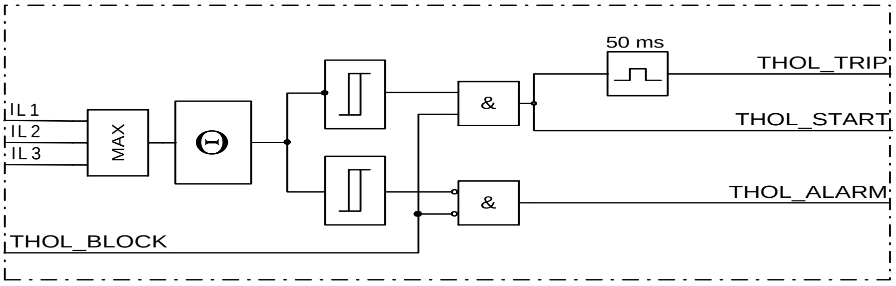



*Figure 90: Thermal overload protection, simplified logic diagram*

## 11.5 Input and output signals

**Table 160: Input signals for the THOL (THOL-) function block**

| Signal | Description |
|---|---|
| BLOCK | Block of the thermal overload function |

**Table 161: Output signals for the THOL (THOL-) function block**

| Signal | Description |
|---|---|
| ALARM | Alarm signal from the thermal overload function |
| TRIP | Trip signal from the thermal overload function (pulse) |
| START | Start signal which is reset when the temperature drops below the resetting level |

## 11.6 Setting parameters

**Table 162: Settings for the thermal overload protection THOL (THOL-) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off,<br>NonComp, Comp | Off | - | Operating mode for THOL function |
| IBase | 10-200<br>Step: 1 | 100 | % of I1b | Base current |
| TBase | 0-100<br>Step: 1 | 50 | °C | Temperature rise at base current |
| tau | 1-62<br>Step: 1 | 30 | min | Thermal time constant |
| TAlarm | 50-150<br>Step: 1 | 80 | °C | Alarm level |
| TTrip | 50-150<br>Step: 1 | 100 | °C | Trip level |
| TdReset | 5-30<br>Step: 1 | 10 | °C | Trip hystereses |

**Table 163: Settings for thermal overload protection (THOL), mA input**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| MI11-I_Max | -25.00-25.00<br>Step: 0.01 | 20.00 | mA | Max current of transducer to Input 1 |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| MI11-I_Min | -25.00-25.00<br>Step: 0.01 | 4.00 | mA | Min current of transducer to Input 1 |
| MI11-I_MaxValue | -1000.00-1000.00<br>Step: 0.01 | 20.00 | °C | Max primary value corr. to I_Max, Input 1 |
| MI11-I_MinValue | -1000.00-1000.00<br>Step: 0.01 | 4.00 | °C | Min primary value corr. to I_Min, Input 1 |

## 11.7 Technical data

**Table 164: Thermal overload protection-Settings via HMI, SMS or PST**

| Function | Setting range | Accuracy |
|---|---|---|
| Mode of operation | Off / NonComp / Comp<br>( Function blocked/No temp. compensation/Temp. comp.) | |
| Basic current<br>IBase | (10 - 200 ) % of I1b in steps of 1 % | +/- 2.5% of $I_r$ |
| Temperature rise at IBase<br>TBase | (0 - 100) °C in steps of 1 °C | +/- 1°C |
| Time constant<br>tau | (1 - 62) min in steps of 1 min | +/- 1 min |
| Alarm temperature<br>TAlarm | (50 - 150) °C in steps of 1°C | |
| Trip temperature<br>TTrip | (50 - 150) °C in steps of 1 °C | |
| Temp. difference for reset of trip<br>TdReset | (5 - 30) °C in steps of 1°C | |

**Table 165: Thermal overload protection mA input - Settings only via SMS or PST**

| Function | Setting range | Accuracy |
|---|---|---|
| Upper value for mA input<br>MI11-1_Max | -25.00 - 25.00 mA in steps of 0.01 mA | +/- 0.5% of set value |
| Lower value for mA input<br>MI11-I_Min | -25.00 - 25.00 mA in steps of 0.01 mA | +/- 0.5% of set value |
| Temp. corresponding to the MI11-1_Max setting<br>MI11-MaxValue | -1000 - 1000 °C in steps of 1 °C | +/- 1% of set value +/- 1°C |
| Temp. corresponding to the MI11-1_Min setting<br>MI11-MinValue | -1000 - 1000° C in steps of 1 °C | +/- 1% of set value +/- 1°C |

# 12 Stub protection (STUB)

## 12.1 Application

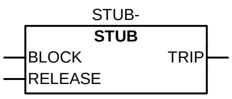
The stub protection operates for faults in the parts of 1 1/2 and ring bus station configurations, which cannot be protected by the distance protection function if the line isolators are opened. The use of the function can be extended to various other purposes, when a three phase overcurrent protection can operate only under special external conditions.

## 12.2 Design

The function operates as a three phase instantaneous overcurrent protection. The function is released when the line disconnector is open; a normally closed auxiliary contact of the line disconnector has to be connected to the STUB-RELEASE functional input by configuration.

The operating level of the overcurrent protection is settable over a wide range.

## 12.3 Function block

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## 12.4 Logic diagram

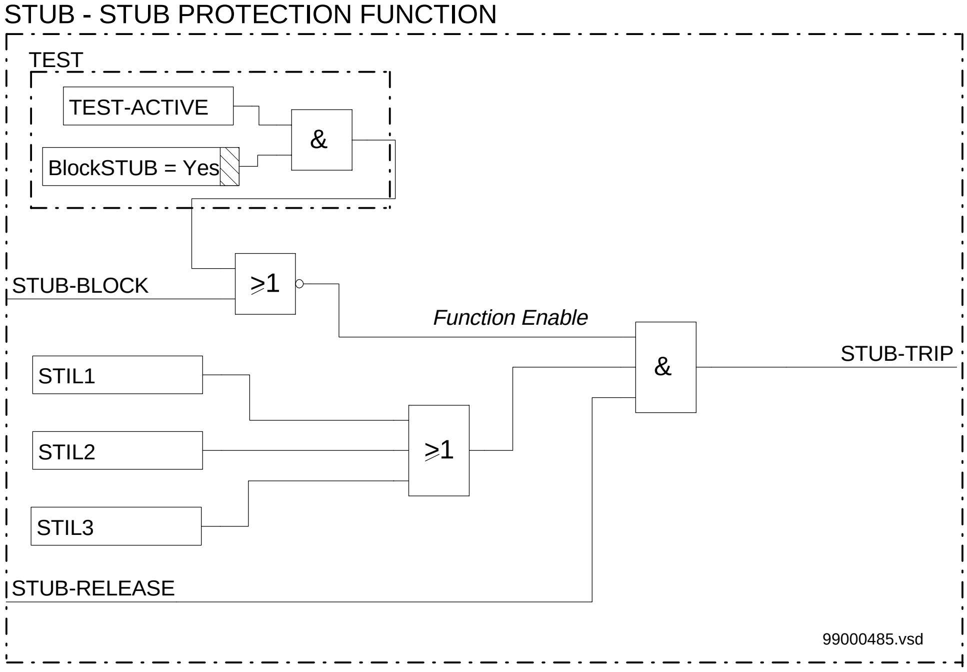



*Figure 91: Simplified logic diagram of stub protection.*

## 12.5 Input and output signals

**Table 166: Input signals for the STUB (STUB-) function block**

| Signal | Description |
|---|---|
| BLOCK | Block of stub protection |
| RELEASE | Release of stub protection |

**Table 167: Output signals for the STUB (STUB-) function block**

| Signal | Description |
|---|---|
| TRIP | Trip by stub protection |

## 12.6 Setting parameters

**Table 168: Setting parameters for the stub protection STUB (STUB-) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off, On | Off | - | Operating mode for STUB function |
| IP> | 20 - 300<br>Step: 1 | 100 | % of I1b | Operating phase current |

## 12.7 Technical data

**Table 169: STUB - Stub protection**

| Function | Setting range | Accuracy |
|---|---|---|
| Operate current I> | (20-300) % of $I_r$ | +/- 2.5 % of $I_r$ at $I \leq I_r$ |
| | | +/- 2.5 % of I at $I > I_r$ |

# 13 Breaker failure protection (BFP)

## 13.1 Application

In many protection applications local redundancy is used. One part of the fault clearance system is however never duplicated, namely the circuit breaker. Therefor a breaker failure protection can be used.

The breaker failure protection is initiated by trip signals from different protection functions within or outside the protection terminal. When a trip signal is sent to the breaker failure protection first, with no or a very short delay, a re-trip signal can be sent to the protected breaker. If fault current is flowing through the breaker still after a setting time a back-up trip signal is sent to the adjacent breakers. This will ensure fault clearance also if the circuit breaker is out of order.

## 13.2 Design

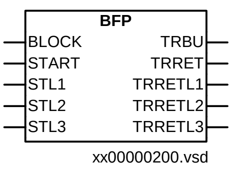
The breaker failure protection function is initiated by the trip commands from protection functions placed either inside the same terminal or externally, by connection to appropriate binary inputs. Three separate functional inputs are available for single-phase starting. A dedicated input is available also for three-phase starting.

The operate value of the phase segregated current measuring elements is settable within a wide range. Three independent timers t2 are available for phase segregated breaker failure detection.

An additional timer t1 for retrip command is available. Dedicated setting allows to enable or disable the retrip or to perform it by current check or not. Retrip to the faulty circuit breaker can be issued single phase or three phase.

Special adaptive algorithm (ASD), together with RMS measurement, allow a fast resetting time of the current measuring elements. The current measurement is stabilised against transients which can cause unwanted operation with saturated current transformers.

## 13.3 Function block



## 13.4 Logic diagram

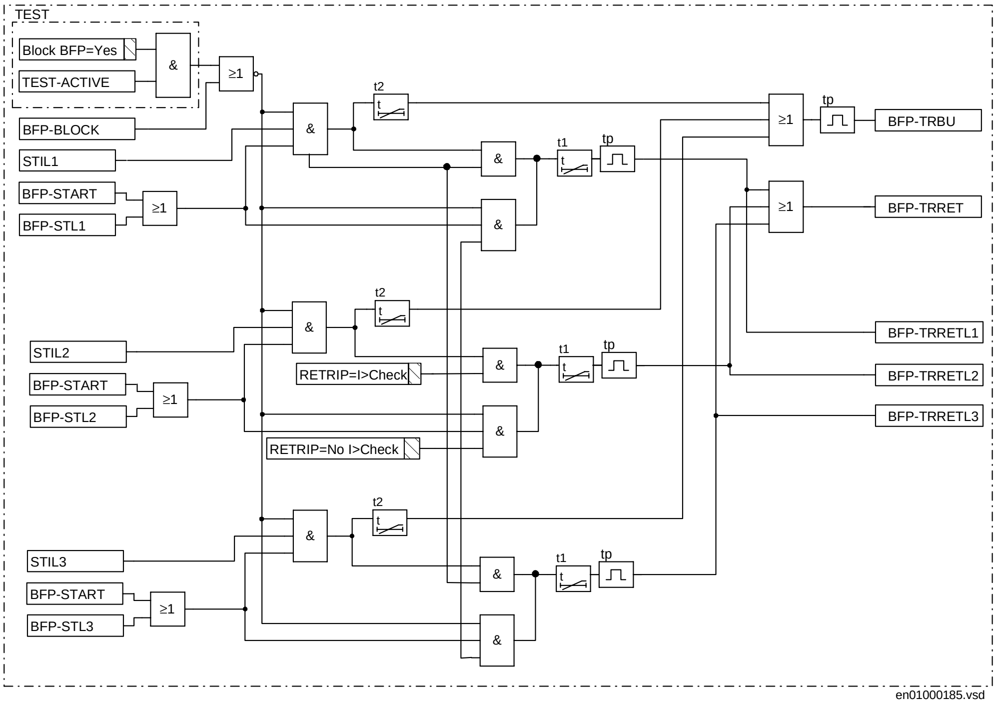



*Figure 92: Breaker-failure protection, logic diagram*

## 13.5 Input and output signals

**Table 170: Input signals for the breaker failure protection (BFP--) function block**

| Signal | Description |
|---|---|
| BLOCK | Block function |
| START | Start function |
| STL1 | Start phase L1 |
| STL2 | Start phase L2 |
| STL3 | Start phase L3 |

**Table 171: Output signals for the breaker failure protection BFP (BFP--) function block**

| Signal | Description |
|---|---|
| TRBU | Backup trip |
| TRRET | Retrip |
| TRRETL1 | Retrip by phase L1 |
| TRRETL2 | Retrip by phase L2 |
| TRRETL3 | Retrip by phase L3 |

## 13.6 Setting parameters

**Table 172: Setting parameters for the breaker failure protection BFP (BFP--) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off, On | Off | | Operating mode for BFP function |
| IP> | 5-200<br>Step: 1 | 100 | % of I1b | Operating phase current |
| t2 | 0.000-60.000<br>Step: 0.001 | 0.200 | s | Delay timer for backup trip |
| RetripType | Retrip Off, I> Check, No I> Check | Retrip Off | | Operating mode of retrip logic |
| t1 | 0.000-60.000<br>Step: 0.001 | 0.050 | s | Delay timer for retrip |

## 13.7 Technical data

**Table 173: Breaker failure protection**

| Parameter | Setting range | Accuracy |
|---|---|---|
| Operate current (one measuring element per phase) | 5-200% of I1b in steps of 1% | +/-2.5% of $I_r$ at $I \leq I_r$<br>+/-2.5% of I at $I > I_r$ |
| Retrip time delay t1 | 0.000-60.000 s in steps of 1 ms | +/-0.5% of setting +/-10 ms |
| Back-up trip time delay t2 | 0.000-60.000 s in steps of 1 ms | +/-0.5% of setting +/-10 ms |

| Parameter | Value |
|---|---|
| Trip operate time | Max 18 ms |
| Reset time | Max 10 ms |

# 14 Unbalance protection for capacitor banks (TOCC)

## 14.1 Application

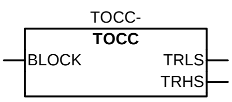
Capacitor banks are made up of individual units which are series and parallel connected. Each unit is made up of several series and parallel connected elements. If one element is short-circuited or disconnected by internal fuses, the load on the remaining elements increases.The unbalance protection is connected to a current transformer which measures the current flowing between two normally balanced parts of the capacitor bank. Under normal conditions, no current flows in the interconnection. A low set current stage gives alarm when elements are damaged and current flows in the interconnection. The trip stage is set to disconnect the bank before healthy elements become overloaded and damaged.

## 14.2 Functionality

The current measuring element continuously measures the unbalance current and compares it to the set operate value for the two current stages. A filter ensures immunity to disturbances and harmonic currents.The output relay for the low current (alarm) stage operates if the current becomes higher than the set operate value ILow during a time exceeding the set time delay tLow. If the current becomes higher than the set operate value IHigh during a time exceeding the set time delay tHigh, the output relay for the high current stage operates.

The input signal BLOCK blocks both the low set and the high set functions.

## 14.3 Function block

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## 14.4 Logic diagram

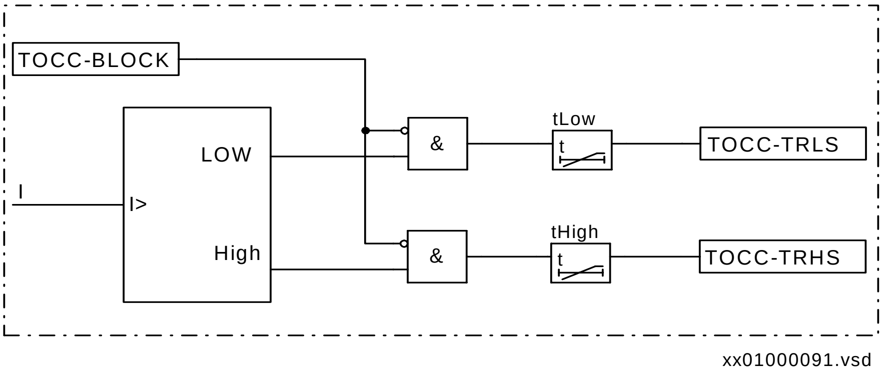



*Figure 93: Unbalance protection for capacitor banks, simplified logic diagram*

## 14.5 Input and output signals

**Table 174: Input signals for the TOCC (TOCC-) function block**

| Signal | Description |
|---|---|
| BLOCK | Blocks the unbalance protection function |

**Table 175: Output signals for the TOCC (TOCC-) function block**

| Signal | Description |
|---|---|
| TRLS | Alarm from the low set current stage |
| TRHS | Trip from the high set current stage |

## 14.6 Setting parameters

**Table 176: Setting parameters for the TOCC (TOCC-) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation Low | On/Off | Off | - | Operating mode of the low set current function |
| I>Low | 2-100<br>Step: 1 | 30 | % of I5b | Operate value of the low set current function |
| tLow | 0.000-60.000<br>Step: 0.001 | 5.000 | s | Time delay of the low set current function |
| Operation High | On/Off | Off | - | Operating mode of the high set current function |
| I>High | 2-100<br>Step: 1 | 30 | % of I5b | Operate value of the high set current function |
| tHigh | 0.000-60.000<br>Step: 0.001 | 5.000 | s | Time delay of the high set current function |

## 14.7 Technical data

**Table 177: TOCC- Unbalance protection**

| Function | Setting range | Accuracy |
|---|---|---|
| Operate current of low set stage I>Low | (2-100) % of I5b in steps of 1% | +/- 5 % of $I_r$ |
| Time delay tLow of current stage I>Low | (0.000-60.000) s in steps of 1ms | +/- 0.5 % of t +/- 10 ms |
| Operate current of high set stage I>High | (2-200) % of I5b in steps of 1% | +/- 5 % of $I_r$ |
| Time delay tHigh of current stage I>High | (0.000-60.000) s in steps of 1ms | +/- 0.5 % of t +/- 10 ms |

# Chapter 6 Voltage

**About this chapter**

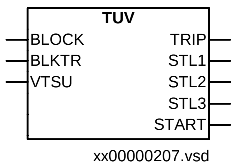
This chapter describes the voltage protection functions.

# 1 Time delayed undervoltage protection (TUV)

## 1.1 Application

The time delayed undervoltage protection function, TUV, is applicable in all situations, where reliable detection of low phase voltages is necessary. The function can also be used as a supervision and fault detection function for some other protection functions, to increase the security of a complete protection system.

## 1.2 Function block




## 1.3 Logic diagram

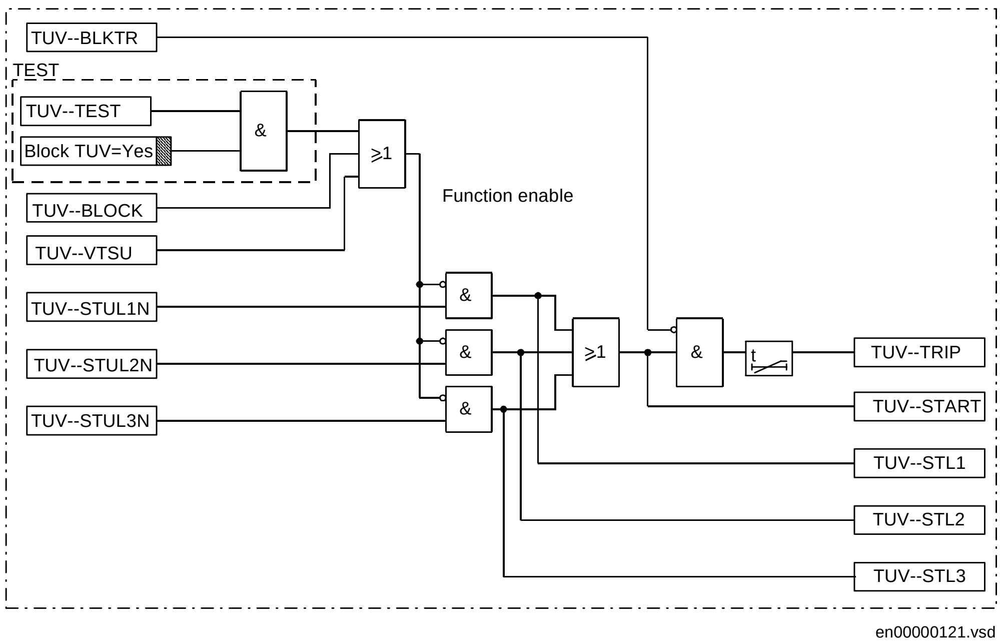



*Figure 94: Undervoltage protection - simplified logic diagram*

## 1.4 Input and output signals

**Table 178: Input signals for the TUV (TUV--) function block**

| Signal | Description |
|---|---|
| BLOCK | Block undervoltage function |
| BLKTR | Block of trip from time delayed undervoltage function |
| VTSU | Block from voltage transformer circuit supervision |

**Table 179: Output signals for the TUV (TUV--) function block**

| Signal | Description |
|---|---|
| TRIP | Trip by time delayed undervoltage function |
| STL1 | Start phase undervoltage phase L1 |
| STL2 | Start phase undervoltage phase L2 |
| STL3 | Start phase undervoltage phase L3 |
| START | Start phase undervoltage |

## 1.5 Setting parameters

**Table 180: Setting parameters for the time delayed undervoltage protection TUV (TUV--) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off, On | Off | - | Operating mode for TUV function |
| UPE< | 10-100<br>Step: 1 | 70 | % of U1b | Operate phase voltage |
| t | 0.000-60.000<br>Step: 0.001 | 0.000 | s | Time delay |

## 1.6 Technical data

**Table 181: TUV - Time delayed undervoltage protection**

| Function | Setting range | Accuracy |
|---|---|---|
| Operate voltage U< | (10-100) % of U1b in steps of 1% | +/- 2.5 % of $U_r$ |
| Time delay | (0.000-60.000) s in steps of 1ms | +/- 0.5 % +/- 10 ms |

# 2 Time delayed overvoltage protection (TOV)

## 2.1 Application

The time delayed phase overvoltage protection is used to protect the electrical equipment and its insulation against overvoltage by measuring three phase voltages. In this way, it prevents the damage to the exposed primary and secondary equipment in the power systems.

The residual overvoltage protection function is mainly used in distribution networks, mainly as a backup protection for the residual overcurrent protection in the line feeders, to secure the disconnection of earth-faults.

## 2.2 Functionality

The phase overvoltage protection function continuously measures the three phase voltages and initiates the corresponding output signals if the measured phase voltages exceed the preset value (starting) and remain high longer than the time delay setting on the timers (trip). This function also detects the phases which caused the operation.

The residual overvoltage protection function calculates the residual voltage (3U0) from the measuring three phase voltages and initiates the corresponding output signals if the residual voltage is larger than the preset value (starting) and remains high longer than the time delay setting (trip).

## 2.3 Function block

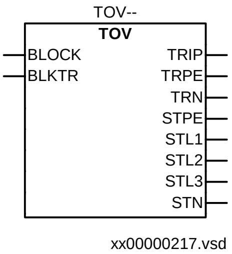



*Figure 95: TOV function block, phase and residual overvoltage*

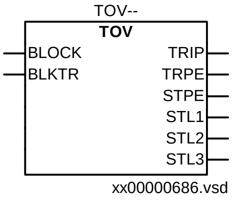



*Figure 96: TOV function block phase overvoltage*

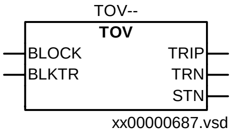



*Figure 97: TOV function block residual overvoltage*

## 2.4 Logic diagram

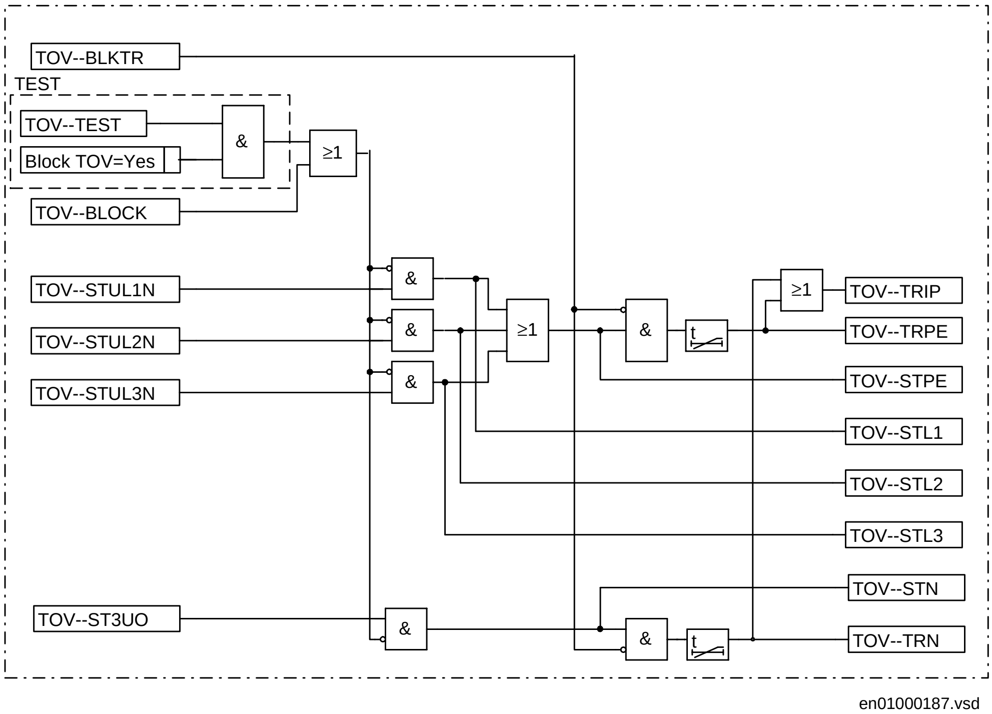



*Figure 98: TOV, logic diagram*

## 2.5 Input and output signals

**Table 182: Input signals for the TOV (TOV--) function block**

| Signal | Description |
|---|---|
| BLOCK | Block of time delayed overvoltage function |
| BLKTR | Block of trip output from time delayed overvoltage function |

**Table 183: Output signals for the time delayed overvoltage protection TOV (TOV--) function**

| Signal | Description |
|---|---|
| TRIP | General trip output from TOV function block |
| TRPE | Trip by phase overvoltage function |
| TRN | Trip by residual overvoltage function |

| Signal | Description |
|---|---|
| STPE | Start phase overvoltage function |
| STL1 | Start phase overvoltage phase L1 |
| STL2 | Start phase overvoltage phase L2 |
| STL3 | Start phase overvoltage phase L3 |
| STN | Start by residual overvoltage function |

## 2.6 Setting parameters

**Table 184: Setting parameters for time delayed overvoltage TOV (TOV--) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off, On | Off | - | Operating mode for TOV function |
| UPE> | 50-200<br>Step: 1 | 120 | % of U1b | Operate value for the phase over-voltage function |
| t | 0.000-60.000<br>Step: 0.001 | 0.000 | s | Time delay of the phase overvoltage function |
| 3U0> | 5-100<br>Step: 1 | 30 | % of U1b | Operate value for the neutral over-voltage function |
| t | 0.000-60.000<br>Step: 0.001 | 0.000 | s | Time delay of the neutral overvolt-age function |

## 2.7 Technical data

**Table 185: TOV - Time delayed overvoltage protection**

| Function | | Setting range | Accuracy |
|---|---|---|---|
| Operate voltage U> | Phase measuring elements | (50-200)% of U1b in steps of 1% | +/- 2.5 % of $U_r$ at U ≤ $U_r$<br>+/- 2.5 % of $U_r$ at U> ≤ $U_r$ |
| Time delay | Phase measuring elements | (0.000-60.000) s in steps of 1ms | +/- 0.5 % +/- 10 ms |
| Operate voltage 3U0> | Residual measur-ing elements | (5-100)% of U1b in steps of 1% | +/- 2.5 % of $U_r$ at U ≤ $U_r$<br>+/- 2.5 % of U at U> $U_r$ |
| Time delay | Residual measur-ing elements | (0.000-60.000) s in steps of 1ms | +/- 0.5 % +/- 10 ms |

# 3 Intercircuit bridging protection (TOVI)

## 3.1 Application

If a conductor in the 50 Hz system comes into contact with the conductor of a 16 2/3 Hz system with higher nominal voltage, the 16 2/3 Hz voltage must quickly be disconnected to avoid damage on the power transformer and other components in the 50 Hz system.

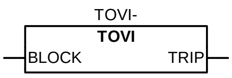
The protection is connected to measure the phase-to-ground voltage of the 50 Hz conductor. The operate voltage must, with margin, be set higher than the 16 2/3 Hz voltage normally induced in the 50 Hz circuit.

## 3.2 Functionality

The voltage measuring element continuously measures the 16 2/3 Hz voltage component and compares it to the set operate value U>. A filter ensures immunity to disturbances and harmonic voltages and reduces the influence of the 50 Hz voltage component with a factor > 10.The output trip relay operates if the voltage becomes higher than the set operate value U> under a time exceeding the set definite time delay t.

The input signal BLOCK blocks the function.

## 3.3 Function block

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## 3.4 Logic diagram

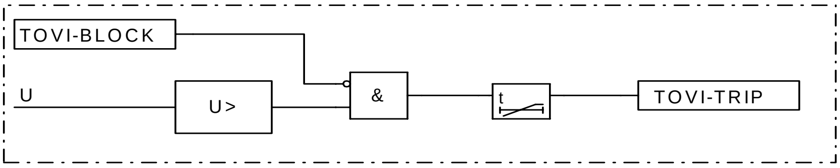


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*Figure 99: Intercircuit bridging protection function, simplified logic diagram*

## 3.5 Input and output signals

**Table 186: Input signals for the TOVI (TOVI--) intercircuit bridging protection**

| Signal | Description |
|---|---|
| BLOCK | Blocks the intercircuit bridging protection function |

**Table 187: Output signals for the TOVI (TOVI-) inter circuit bridging protection**

| Signal | Description |
|---|---|
| TRIP | Trip from the inter circuit bridging protection function |

## 3.6 Setting parameters

**Table 188: Setting parameters, intercircuit bridging protection TOVI (TOVI-) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | On/Off | Off | - | Operating mode for TOVI function |
| U> | (10-170)<br>Step: 1 | 40 | % of U4b | Operate voltage for the intercircuit bridging protection function |
| t | 0.000-60.000<br>Step: 0.001 | 5.000 | s | Delay of trip signal |

## 3.7 Technical data

**Table 189: TOVI - Intercircuit bridging protection**

| Function | Setting range | Accuracy |
|---|---|---|
| Operate voltage U> | (10-170) % of Ub in steps of 1% | +/- 2.5 % of $U_r$ at U <= $U_r$<br>+/- 2.5 % of U at U > $U_r$ |
| Time delay t | (0.000-60.000) s in steps of 1ms | +/- 0.5 % of t +/- 10 ms |

# Chapter 7 Power system supervision

**About this chapter**

This chapter describes the power system supervision functions.

# 1 Broken conductor check (BRC)

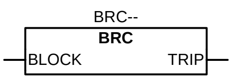
## 1.1 Application

The main purpose of the BRC broken conductor check function is the detection of broken conductors on protected power lines and cables (series faults). It is also able to detect interruptions in the secondary current circuits.

## 1.2 Functionality

The BRC function detects a broken conductor condition by detecting the non symmetry between currents in the three phases. It does this by measuring the difference between the maximum and minimum phase currents, i.e. it compares the magnitude of the minimum current with that of the maximum current, and gives an output if the minimum current is less than 80% of the maximum current for a set time interval. At the same time, the highest current must be higher than a set percentage of the terminal rated current.

## 1.3 Function block

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## 1.4 Logic diagram

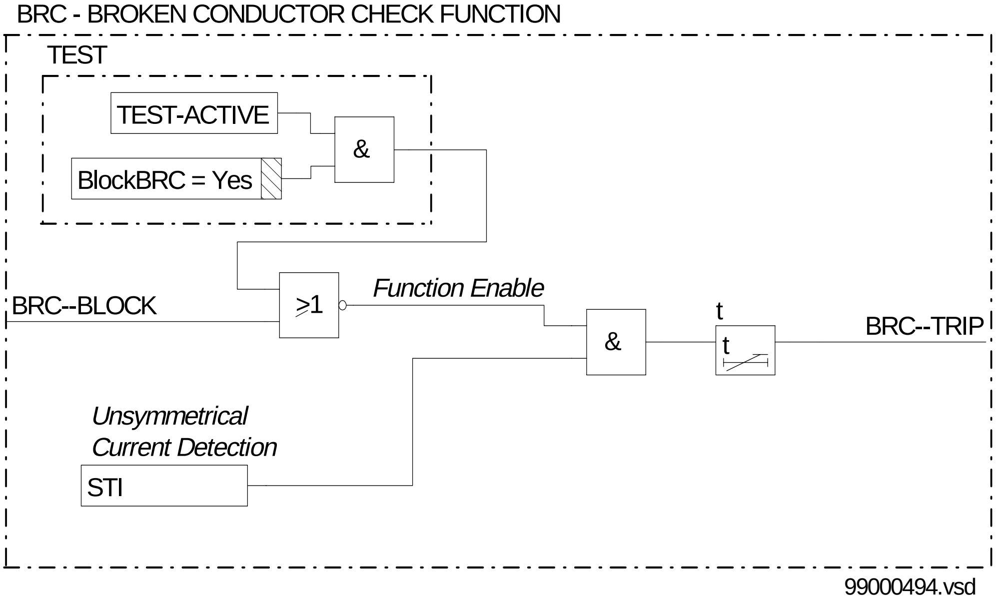



*Figure 100: Simplified logic diagram of broken conductor check function*

## 1.5 Input and output signals

**Table 190: Input signals for the BRC (BRC--) function block**

| Signal | Description |
|---|---|
| BLOCK | Block of BRC function |

**Table 191: Output signals for BRC (BRC--) function block**

| Signal | Description |
|---|---|
| TRIP | Trip by BRC function |

## 1.6 Setting parameters

**Table 192: Setting parameters for the broken conductor check BRC (BRC--) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off, On | Off | - | Broken conductor function |
| IP> | 10-100<br>Step: 1 | 10 | % of I1b | Operating phase current |
| t | 0.000-60.000<br>Step: 0.001 | 20.000 | s | Time delay before giving output for which detected broken conductor conditions must persist |

## 1.7 Technical data

**Table 193: Broken conductor check**

| Parameter | Setting range | Accuracy |
|---|---|---|
| Minimum level of highest phase current for operation | 10-100% of I1b in steps of 1% | +/-2.5% of $I_r$ |
| Output time delay | 0.000-60.000 s in steps of 0.001s | +/-0.5% +/-10ms |

# 2 Loss of voltage check (LOV)

## 2.1 Application

The loss of voltage detection, LOV, is suitable for use in networks with an automatic restoration function. The LOV function issues a three-pole trip command to the circuit breaker, if all three phase voltages fall below the set value for a time longer than 7 seconds, and the circuit breaker remains closed.

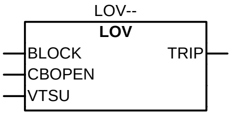
## 2.2 Functionality

The operation of LOV function is based on line voltage measurement. The function is provided with a logic, which automatically recognises if the line was restored for at least three seconds before starting the seven seconds timer. Additionally, the function is automatically blocked if only one or two phase voltages have been detected low for more than 10 seconds. The LOV function operates again only if the line has been fully energised.

Operation of LOV function is also inhibited by fuse failure and open circuit breaker information signals, by their connection to dedicated inputs of the function block.

The operation of the function is supervised by the fuse-failure function and the information about the closed position of the associated circuit breaker.

## 2.3 Function block

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## 2.4 Logic diagram

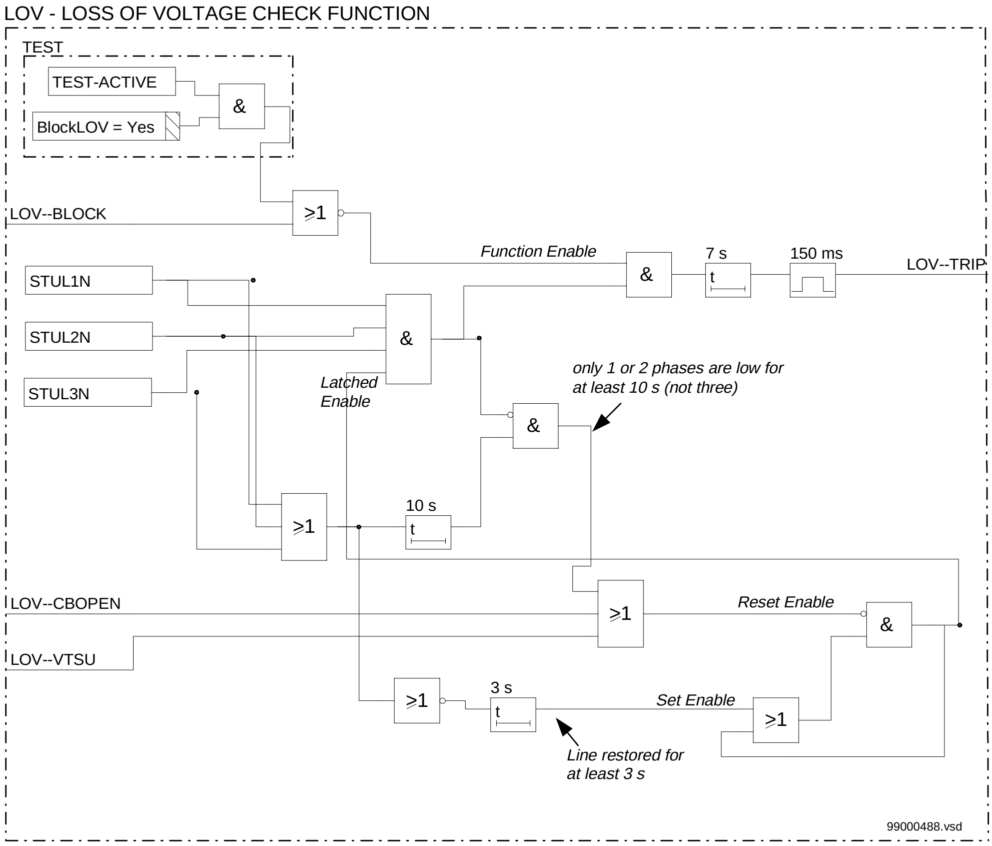



*Figure 101: Simplified logic diagram of loss of voltage check protection function*

## 2.5 Input and output signals

### Table 194: Input signals for the LOV (LOV--) function block

| Signal | Description |
|---|---|
| BLOCK | Block of loss of voltage check |
| CBOPEN | Circuit breaker open |
| VTSU | Block of loss of voltage check from voltage circuit supervision |

**Table 195: Output signals for the LOV (LOV--) function block**

| Signal | Description |
| --- | --- |
| TRIP | Trip by loss of voltage check |

## 2.6 Setting parameters

**Table 196: Setting parameters for the loss of voltage check LOV (LOV--) function**

| Parameter | Range | Default | Unit | Description |
| --- | --- | --- | --- | --- |
| Operation | Off, On | Off | - | Operating mode for LOV function |
| UPE< | 10-100<br>Step: 1 | 70 | % of U1b | Operating phase voltage |

## 2.7 Technical data

**Table 197: Loss of voltage check**

| Parameter | Setting range | Accuracy |
| --- | --- | --- |
| Operate voltage, U< | 10-100% of U1b in steps of 1% | +/-2.5% of $U_r$ |

# 3 Overload supervision (OVLD)

## 3.1 Application

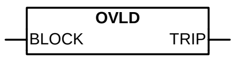
The overload protection, OVLD, prevents excessive loading of power transformers, lines and cables

Alternative application is the detection of primary current transformer overload, as they usually can withstand a very small current beyond the rated value

## 3.2 Functionality

The function continuously measures the three phase currents flowing through the terminal. If any of the three currents is beyond the preset overcurrent threshold for a time longer than the preset value, a trip signal is activated.

## 3.3 Function block



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## 3.4 Logic diagram

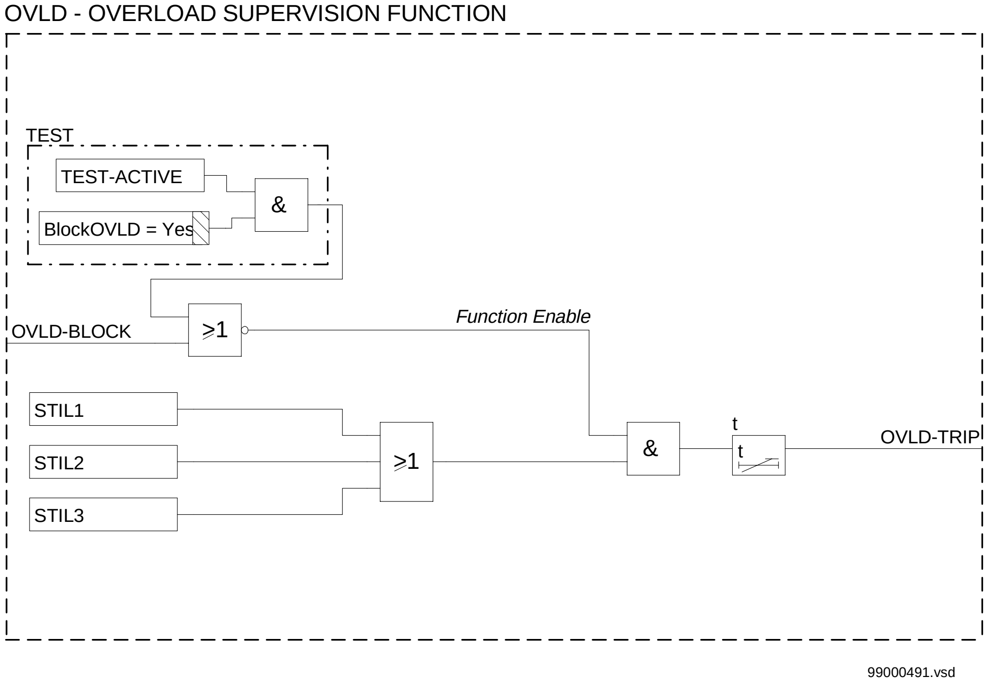



*Figure 102: Simplified logic diagram of overload supervision function*

## 3.5 Input and output signals

**Table 198: Input signals for the OVLD (OVLD-) function block**

| Signal | Description |
|---|---|
| BLOCK | Block of overload supervision function |

**Table 199: Output signals for the OVLD (OVLD-) function block**

| Signal | Description |
|---|---|
| TRIP | Trip by overload supervision function |

## 3.6 Setting parameters

**Table 200: Setting parameters for the overload supervision OVLD (OVLD-) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off, On | Off | - | Operating mode for OVLD function |
| IP> | 20-300 | 100 | % of I1b | Operating phase current |
| t | 0.0-90000.0<br>Step: 0.1 | 20.0 | s | Time delay |

## 3.7 Technical data

**Table 201: Overload supervision function**

| Parameter | Setting range | Accuracy |
|---|---|---|
| Operate current I> | 20-300% of I1b in steps of 1% | +/-2.5% of $I_r$ at $I \leq I_r$<br>+/-2.5% of I at $I > I_r$ |
| Time delay | 0.0-90000.0 s<br>Step: 0.1 | +/-0.5% +/- 10 ms |

# 4 Dead line detection (DLD)

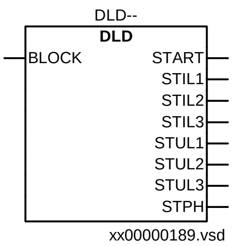
## 4.1 Application

The main purpose of the dead line detection is to provide different protection, control and monitoring functions with the status of the line, i.e whether or not it is connected to the rest of the power system

## 4.2 Functionality

The dead line detection function continuously measures all three phase currents and phase voltages of a protected power line. The line is declared as dead (not energized) if all three measured currents and voltages fall below the preset values for more than 200 ms.

## 4.3 Function block



## 4.4 Logic diagram

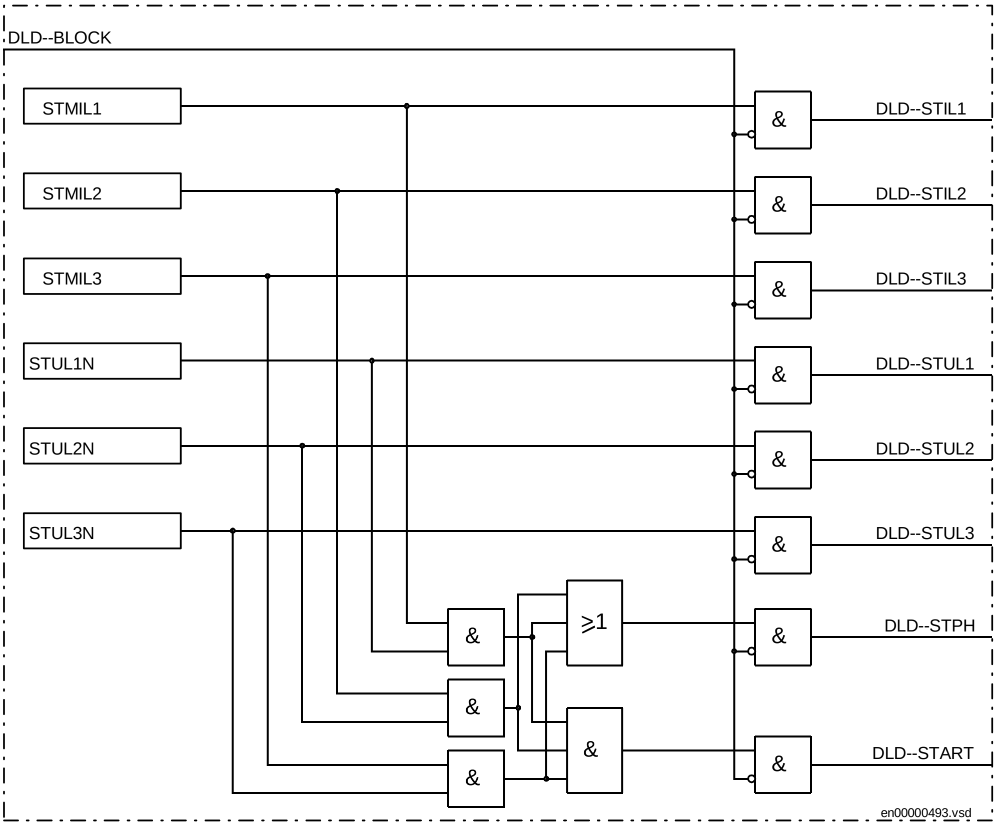



*Figure 103: DLD - simplified logic diagram of a function*

## 4.5 Input and output signals

**Table 202: Input signals for the DLD (DLD--) function block**

| Signal | Description |
|---|---|
| BLOCK | Block of dead line detection |

**Table 203: Output signals for the DLD (DLD--) function block**

| Signal | Description |
|---|---|
| START | Dead line condition detected in all three phases |
| STIL1 | Current below set value phase L1 |
| STIL2 | Current below set value phase L2 |
| STIL3 | Current below set value phase L3 |
| STUL1 | Voltage below set value phase L1 |
| STUL2 | Voltage below set value phase L2 |
| STUL3 | Voltage below set value phase L3 |
| STPH | Dead phase condition detected in at least one phase |

## 4.6 Setting parameters

**Table 204: Setting parameters for the dead line detection DLD (DLD--) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off / On | Off | - | Operating mode for DLD function |
| U< | 10 - 100<br>Step: 1 | 70 | % of U1b | Operating phase voltage (undervoltage function) |
| IP< | 5 - 100<br>Step: 1 | 20 | % of I1b | Operating phase current (undercurrent function) |

## 4.7 Technical data

**Table 205: DLD - Dead line detection**

| Function | | Setting range | Accuracy |
|---|---|---|---|
| Automatic check of dead line condition | Operate phase current | (5-100) % of I1b in steps of 1% | +/- 2.5 % of $I_r$ |
| | Operate phase voltage | (10-100) % of U1b in steps of 1% | +/- 2.5 % of $U_r$ |

# Chapter 8 Secondary system supervision

**About this chapter**

This chapter describes the secondary system supervision functions

# 1 Current circuit supervision (CTSU)

## 1.1 Application

Faulty information about current flows in a protected element might influence the security (line differential protection) or dependability (line distance protection) of a complete protection system.

The main purpose of the current circuit supervision function is to detect different faults in the current secondary circuits and influence the operation of corresponding main protection functions.

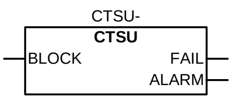
The signal can be configured to block different protection functions or initiate an alarm.

## 1.2 Functionality

The function compares the sum of the three phase currents from one current transformer core with a reference zero sequence current from another current transformer core.

The function issues an output signal when the difference is greater than the set value.

## 1.3 Function block



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## 1.4 Logic diagram

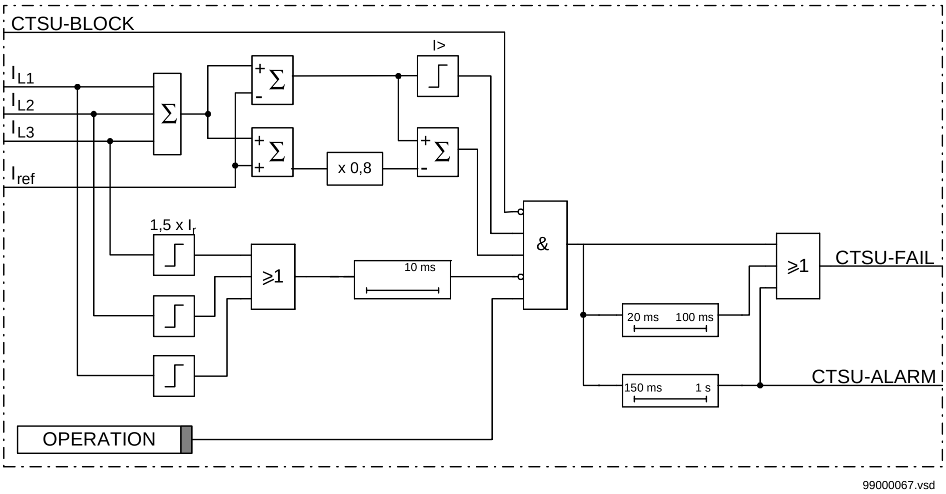



*Figure 104: Simplified logic diagram for the current circuit supervision*

## 1.5 Input and output signals

**Table 206: Input signals for the CTSU (CTSU-) function block**

| **Signal** | **Description** |
|---|---|
| BLOCK | Block function |

**Table 207: Output signals for the CTSU (CTSU-) function block**

| **Signal** | **Description** |
|---|---|
| FAIL | Current circuit failure |
| ALARM | Alarm for current circuit failure |

## 1.6 Setting parameters

**Table 208: Setting parameters for the current circuit supervision CTSU (CTSU-) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off, On | Off | - | Operating mode for CTSU function |
| IMinOp | 5-100<br>Step: 1 | 20 | % of I1b | Minimum operate phase current |

## 1.7 Technical data

**Table 209: Current circuit supervision**

| Function | Setting range | Accuracy |
|---|---|---|
| Operate current I> | 5-100% of I1b in steps of 1% | +/-2.5% of $I_r$ |

# 2 Fuse failure supervision (FUSE)

## 2.1 Application

The fuse failure supervision function, FUSE, continuously supervises the ac voltage circuits between the voltage instrument transformers and the terminal. Different output signals can be used to block, in case of faults in the ac voltage secondary circuits, the operation of the distance protection and other voltage-dependent functions, such as the synchro-check function, undervoltage protection, etc.

Different measurement principles are available for the fuse failure supervision function.

The FUSE function based on zero sequence measurement principle, is recommended in directly or low impedance earthed systems.

A criterion based on delta current and delta voltage measurements can be added to the FUSE function in order to detect a three phase fuse failure, which in practice is more associated with voltage transformer switching during station operations.

## 2.2 Functionality

The FUSE function based on the zero sequence measurement principle continuously measures the zero sequence current and voltage in all three phases. It operates if the measured zero sequence voltage increases over preset operating value, and if the measured zero sequence current remains below the preset operating value.

The delta current and delta voltage algorithm, detects a fuse failure if a sufficient negative change in voltage amplitude without a sufficient change in current amplitude is detected in each phase separately. This check is performed if the circuit breaker is closed. Information about the circuit breaker position is brought to the function input CBCLOSED through a binary input of the terminal.

Three output signals are available. The first depends directly on the voltage and current measurement. The second depends on the operation of the dead line detection function, to prevent unwanted operation of the distance protection if the line has been deenergised and energised under fuse failure conditions. The third depends on the loss of all three measured voltages. A special function input serves the connection to the auxiliary contact of a miniature circuit breaker, MCB (if used), to secure correct operation of the function on simultaneous interruption of all three measured phase voltages also when the additional delta current and delta voltage algorithm is not present in the function block.

## 2.3 Function block

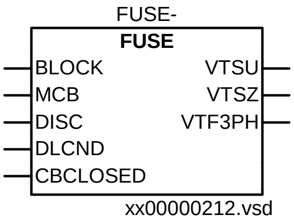



*Figure 105: Function block, FUSE function including DU/Dt based*

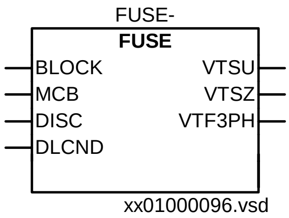



*Figure 106: Function block, negative sequence, zero sequence*

## 2.4 Logic diagram

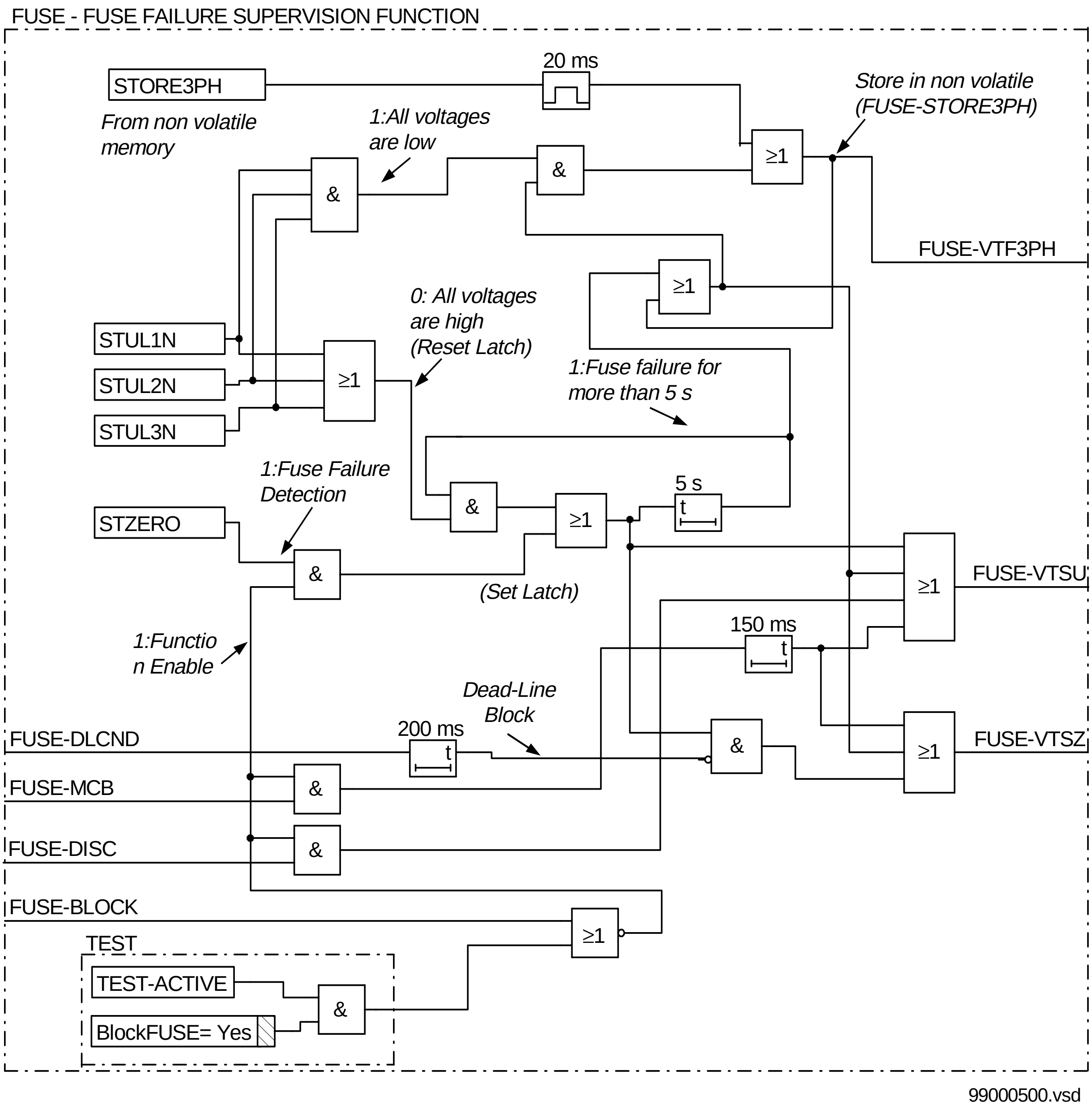



*Figure 107: Simplified logic diagram for fuse failure supervision function, zero sequence*

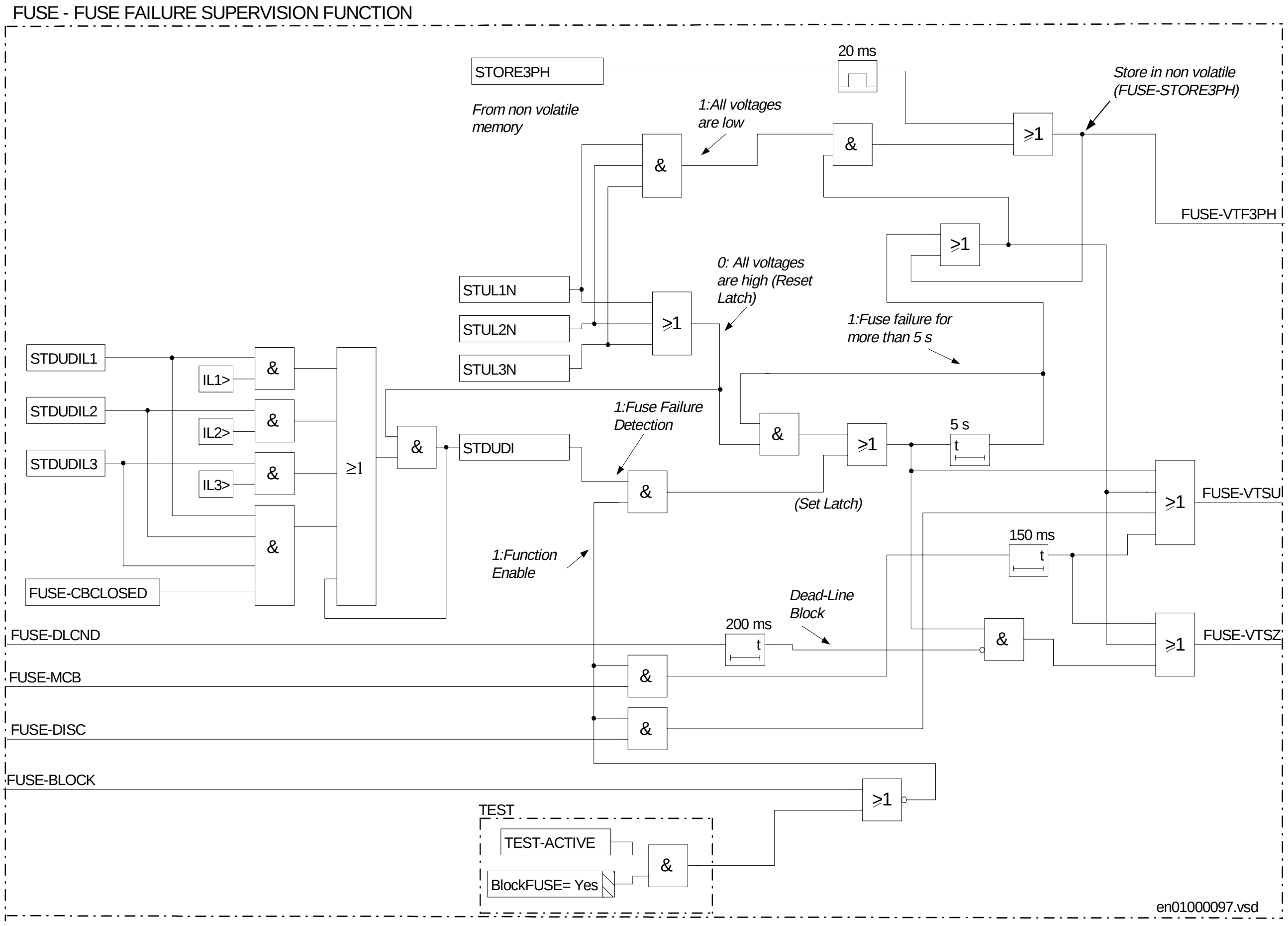



*Figure 108: Simplified logic diagram for fuse failure supervision function, du/dt based*

## 2.5 Input and output signals

### Table 210: Input signals for the FUSE (FUSE-) function block

| Signal | Description |
|---|---|
| BLOCK | Block of fuse failure function |
| MCB | Operation of MCB |
| DISC | Line disconnector position |
| DLCND | Dead line condition |
| CBCLOSED | Circuit breaker closed information |

**Table 211: Output signals for the FUSE (FUSE-) function block**

| Signal | Description |
|---|---|
| VTSU | Block for voltage measuring functions |
| VTSZ | Block for impedance measuring functions |
| VTF3PH | Detection of 3-phase fuse failure |

## 2.6 Setting parameters

**Table 212: Setting parameters for the fuse failure supervision FUSE (FUSE-) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| ZeroSeq | Off, On | Off | - | Operating mode for FUSE function |
| 3U0> | 10-50<br>Step: 1 | 10 | % of U1b | Operating zero sequence voltage |
| 3I0< | 10-50<br>Step: 1 | 10 | % of I1b | Operating zero sequence current |

**Table 213: Setting parameters for the fuse failure supervision FUSE (FUSE-) function, du/dt, di/dt based**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| I> | 10-50<br>Step: 1 | 10 | % of I1b | Operate phase current level |
| DU> | 50-90<br>Step: 1 | 80 | % of U1b | Operate voltage change level |
| DI< | 10-50<br>Step: 1 | 10 | % of I1b | Operate current change level |

## 2.7 Technical data

**Table 214: FUSE - Fuse failure supervision function**

| Function | | Setting range | Accuracy |
|---|---|---|---|
| Zero-sequence quantities: | Operate voltage $3U_0$ | (10-50)% of U1b in steps of 1% | +/- 2.5 % of $U_r$ |
| | Operate current $3I_0$ | (10-50)% of I1b in steps of 1% | +/- 2.5 % of $I_r$ |

**Table 215: Fuse failure supervision function**

| Function | Setting range | Accuracy |
|---|---|---|
| Operate voltage change level | (50-90)% of U1b in steps of 1% | +/-2.5% of Ur |
| Operate current change level | (10-50)% of I1b in steps of 1% | +/- 2.5% of Ir |

# 3 Voltage transformer supervision (TCT)

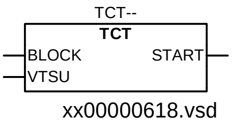
## 3.1 Application

The main purpose of the voltage transformer supervision function is to indicate failure in the measuring voltage from a capacitive voltage transformer.

## 3.2 Functionality

The voltage transformer supervision function checks all of the three phase-phase voltages and the residual voltage. If the residual voltage exceeds the setpoint value and any of the phase-phase voltages is higher than 80% of the rated phase-phase voltage the output is activated after a settable time delay.

## 3.3 Function block




## 3.4 Logic diagram

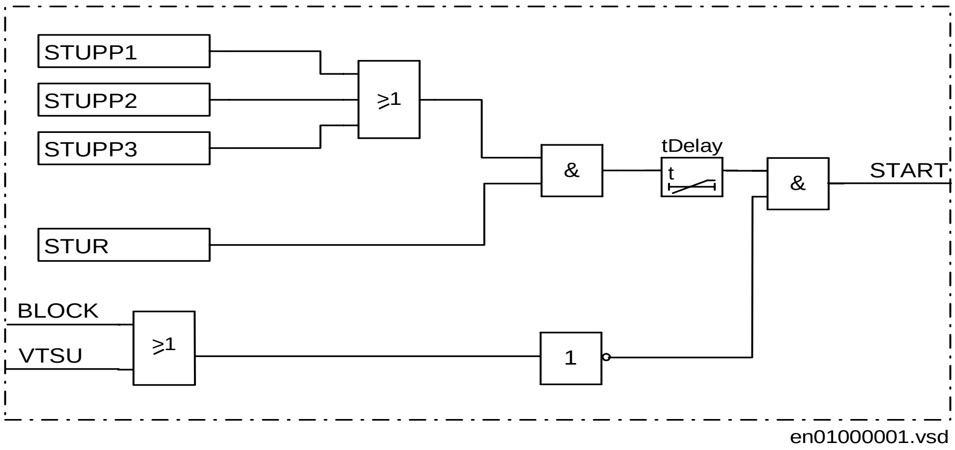



*Figure 109: Simplified logic diagram, TCT function*

## 3.5 Input and output signals

**Table 216: Input signals for the TCT (TCT--) function block**

| Signal | Description |
|---|---|
| BLOCK | Block of voltage transformer supervision |
| VTSU | Block of voltage transformer supervision from voltage circuit supervision |

**Table 217: Output signals for the TCT (TCT--) function block**

| Signal | Description |
|---|---|
| START | Start by voltage transformer supervision |

## 3.6 Setting parameters

**Table 218: Settings for the voltage transformer supervision TCT (TCT--) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | On/Off | Off | - | Operating mode for TCT function |
| UN> | 1.0-80.0<br>Step: 0.1 | 10.0 | % of U1b | Residual overvoltage limit |
| tDelay | 0.000-300.000<br>Step. 0.001 | 3.000 | s | Time delayed operation for start signal |

## 3.7 Technical data

**Table 219: Voltage transformer supervision**

| Parameter | Setting range | Accuracy |
|---|---|---|
| Residual overvoltage limit, UN> | 1.0-80.0% of U1b in steps of 0.1% | +/- 2.5% of $U_r$ |
| Time delayed operation for start signal, tDelay | 0.000-300.000 s in steps of 1 ms | +/- 0.5% +/- 10 ms |

# Chapter 9  Control

**About this chapter**

This chapter describes the control functions

# 1 Synchrocheck (SYN)

## 1.1 Application

The main purpose of the synchrocheck function is to provide controlled closing of circuit breakers in interconnected networks.

The main purpose of the energizing check function is to facilitate the controlled reconnection of a disconnected line or bus to, respectively, an energized bus or line.

The main purpose of the phasing function is to provide controlled closing of circuit breakers when two asynchronous systems are going to be connected. It is used for slip frequencies that are larger than those for synchrocheck.

**Note:**

The phasing function is only available together with the synchrocheck and energizing check functions.

To meet the different application arrangements, a number of identical SYN function blocks may be provided within a single terminal. The number of these function blocks that may be included within any given terminal depends on the type of terminal. Therefore, the specific circuit breaker arrangements that can be catered for, or the number of bays of a specific arrangement that can be catered for, depends on the type of terminal.

## 1.2 Functionality

The synchrocheck function measures the conditions across the circuit breaker and compares them to set limits. The output is only given when all measured conditions are simultaneously within their set limits.

The energizing check function measures the bus and line voltages and compares them to both high and low threshold detectors. The output is only given when the actual measured conditions match the set conditions.

The phasing function measures the conditions across the circuit breaker, and also determines the angle change during the closing delay of the circuit breaker from the measured slip frequency. The output is only given when all measured conditions are simultaneously within their set limits. The issue of the output is timed to give closure at the optimal time.

For single circuit breaker and 1 1/2 circuit breaker arrangements, the SYN function blocks have the capability to make the necessary voltage selection. For single circuit breaker arrangements, selection of the correct voltage is made using auxiliary contacts of the bus disconnectors. For 1 1/2 circuit breaker arrangements, correct voltage selection is made using auxiliary contacts of the bus disconnectors as well as the circuit breakers (as well as binary output signals from the other terminals in the same diameter for 1 1/2 circuit breaker applications with a separate terminal per circuit breaker).

## 1.3 Function block

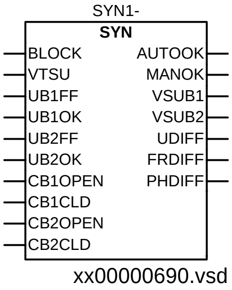



*Figure 110: Function block for single CB*

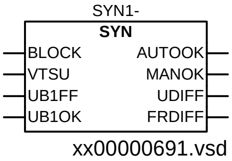



*Figure 111: Function block for double CB*

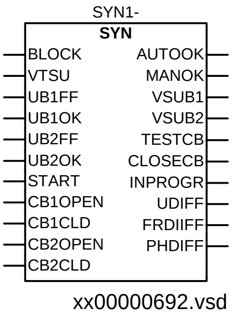



*Figure 112: Function block for single CB with phasing*

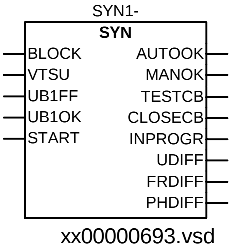



*Figure 113: Function block for double CB with phasing*

## 1.4 Logic diagram

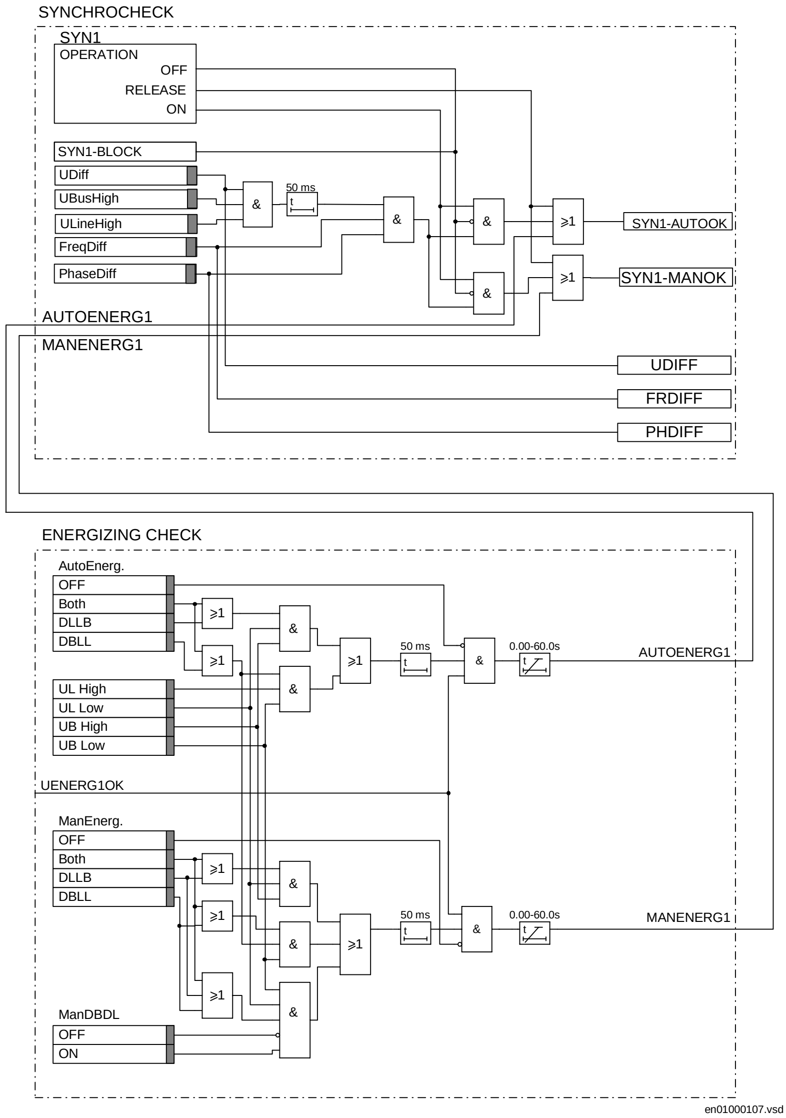



*Figure 114: SYN, simplified logic diagram, synchrocheck and energizing check, The internal signal UENERG1OK refers to the voltage selection logic.*

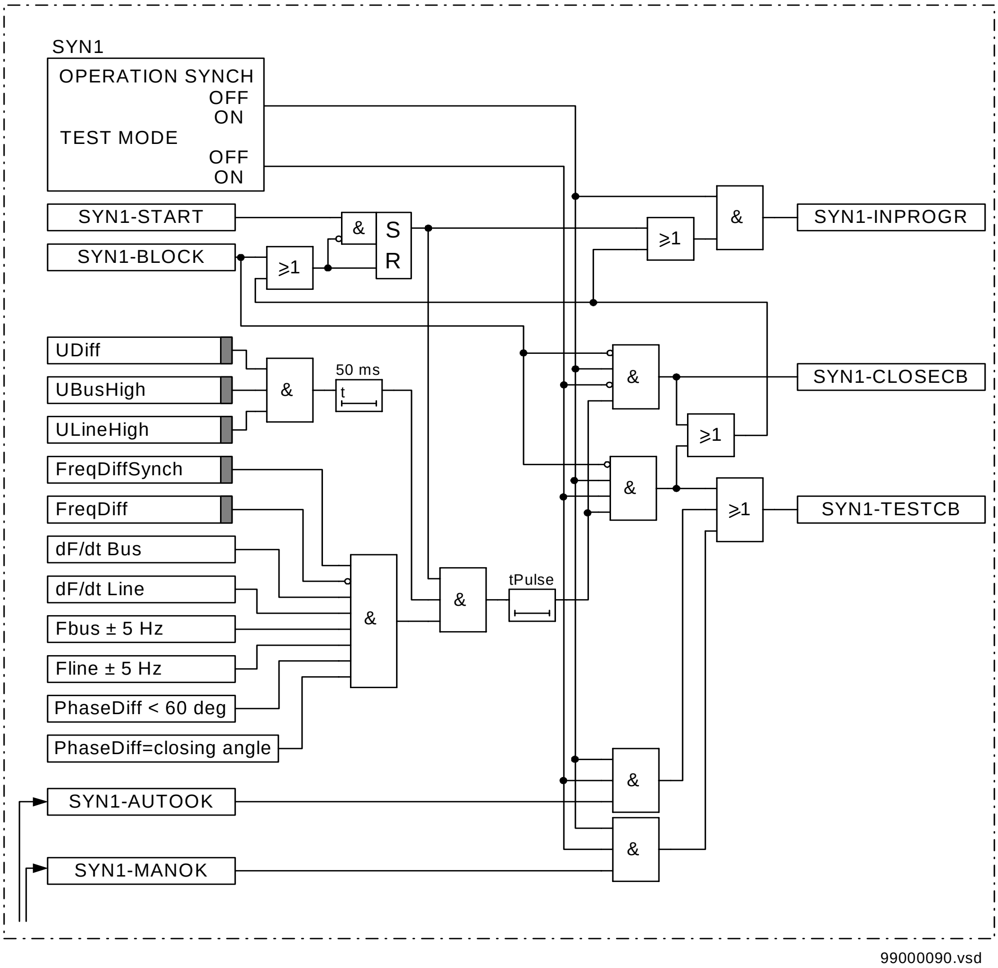



*Figure 115: SYN, phasing, simplified logic diagram. The input signals SYN1-AUTOOK and SYN1-MANOK derive from the synchrocheck and energizing logic*

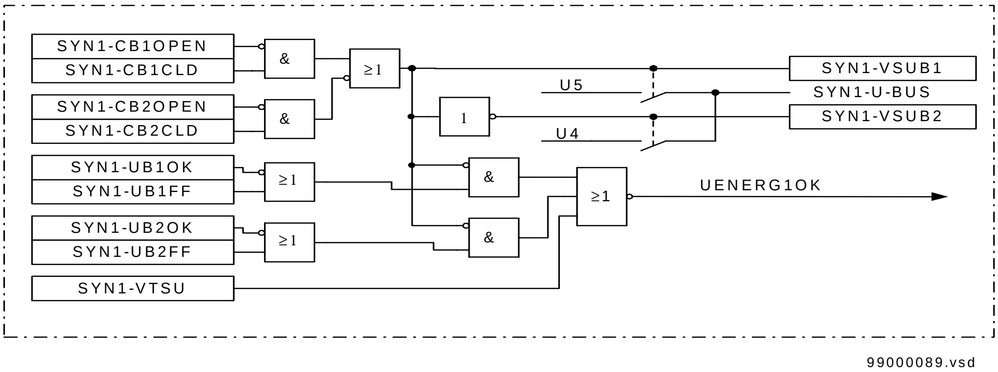



*Figure 116: SYN, simplified voltage selection logic in a double bus, single breaker arrangement*

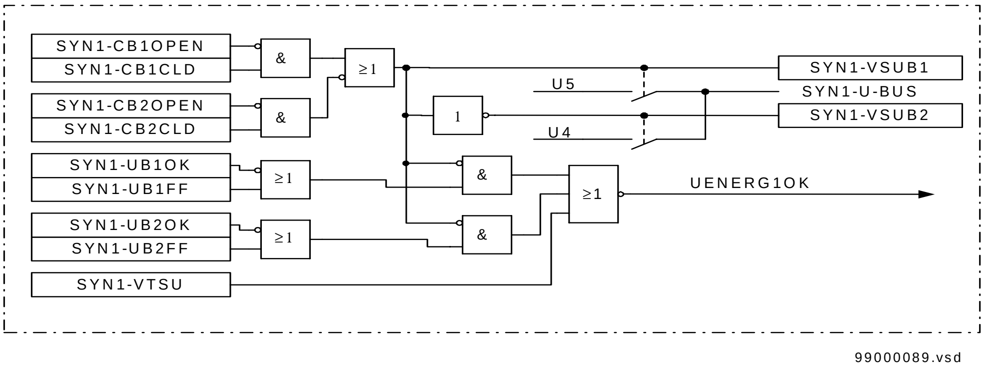



*Figure 117: SYN, simplified voltage selection logic in a double bus, single breaker arrangement.*

## 1.5 Input and output signals

**Table 220: Input signals for the SYN (SYN--) function block for single circuit breaker**

| Signal | Description |
|---|---|
| BLOCK | Blocks function |
| VTSU | Fuse failure supervision, line voltage |
| UB1FF | Fuse failure, bus 1 |
| UB1OK | Fuse healthy, bus 1 |

| Signal | Description |
|---|---|
| UB2FF | Fuse failure, bus 2 |
| UB2OK | Fuse healthy, bus 2 |
| CB1OPEN | Circuit breaker section 1 open |
| CB1CLD | Circuit breaker section 1 closed |
| CB2OPEN | Circuit breaker section 2 open |
| CB2CLD | Circuit breaker section 2 closed |

**Table 221: Output signals for the SYN (SYN--) function block for single circuit breaker**

| Signal | Description |
|---|---|
| AUTOOK | Synchrocheck / energizing check OK for automatic reclosing |
| MANOK | Synchrocheck / energizing check OK for manual closing |
| VSUB1 | Voltage selection from bus 1 |
| VSUB2 | Voltage selection from bus 2 |
| UDIFF | Difference in voltage is less than the set difference limit |
| FRDIFF | Difference in frequency is less than the set difference limit |
| PHDIFF | Difference in phase angle is less than the set difference limit |

**Table 222: Input signals for the SYN (SYN--) function block for double circuit breakers**

| Signal | Description |
|---|---|
| BLOCK | Blocks function |
| VTSU | Fuse failure supervision, line voltage |
| UB1FF | Fuse failure, bus 1 |
| UB1OK | Fuse healthy, bus 1 |

**Table 223: Output signals for the SYN (SYN--) function block for double circuit breakers**

| Signal | Description |
|---|---|
| AUTOOK | Synchrocheck / energizing check OK for automatic reclosing |
| MANOK | Synchrocheck / energizing check OK for manual closing |
| UDIFF | Difference in voltage is less than the set difference limit |
| FRDIFF | Difference in frequency is less than the set difference limit |
| PHDIFF | Difference in phase angle is less than the set difference limit |

**Table 224: Input signals for the SYN (SYN--) function block for single circuit breaker**

| Signal | Description |
|---|---|
| BLOCK | Blocks function |
| VTSU | Fuse failure supervision, line voltage |
| UB1FF | Fuse failure, bus 1 |
| UB1OK | Fuse healthy, bus 1 |
| UB2FF | Fuse failure, bus 2 |
| UB2OK | Fuse healthy, bus 2 |
| START | Start phasing function |
| CB1OPEN | Circuit breaker section 1 open |
| CB1CLD | Circuit breaker section 1 closed |
| CB2OPEN | Circuit breaker section 2 open |
| CB2CLD | Circuit breaker section 2 closed |

**Table 225: Output signals for the SYN (SYN--) function block for single circuit breaker**

| Signal | Description |
|---|---|
| AUTOOK | Synchrocheck / energizing check OK for automatic reclosing |
| MANOK | Synchrocheck / energizing check OK for manual closing |
| VSUB1 | Voltage selection from bus 1 |
| VSUB2 | Voltage selection from bus 2 |

| Signal | Description |
|---|---|
| TESTCB | Circuit breaker close output in test mode |
| CLOSECB | Circuit breaker close output |
| INPROGR | Phasing operation in progress |
| UDIFF | Difference in voltage is less than the set difference limit |
| FRDIFF | Difference in frequency is less than the set difference limit |
| PHDIFF | Difference in phase angle is less than the set difference limit |

**Table 226: Input signals for the SYN (SYN--) function block for double circuit breaker**

| Signal | Description |
|---|---|
| BLOCK | Blocks function |
| VTSU | Fuse failure supervision, line voltage |
| UB1FF | Fuse failure, bus 1 |
| UB1OK | Fuse healthy, bus 1 |
| START | Start phasing function |

**Table 227: Output signals for the SYN (SYN--) function block for double circuit breaker**

| Signal | Description |
|---|---|
| AUTOOK | Synchrocheck / energizing check OK for automatic reclosing |
| MANOK | Synchrocheck / energizing check OK for manual closing |
| TESTCB | Circuit breaker close output in test mode |
| CLOSECB | Circuit breaker close output |
| INPROGR | Phasing operation in progress |
| UDIFF | Difference in voltage is less than the set difference limit |
| FRDIFF | Difference in frequency is less than the set difference limit |
| PHDIFF | Difference in phase angle is less than the set difference limit |

## 1.6 Setting parameters

**Table 228: Setting parameters for the SYN (SYN--) function block for single circuit breaker**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off, Release, On | Off | - | Operating mode for SYN function |
| InputPhase | L1, L2, L3, L1-L2, L2-L3, L3-L1 | L1 | - | Selected input voltage |
| UMeasure | Ph/N, Ph/Ph | Ph/N | - | Selected input voltage Ph/N or Ph/Ph |
| PhaseShift | 0-360<br>Step: 1 | 0 | degrees | Phase shift between U-bus and U-line |
| URatio | 0.20-5.00<br>Step: 0.01 | 1.00 | - | Voltage ratio between U-bus and U-line |
| USelection | SingleBus, DbleBus | SingleBus | - | Bus arrangement for voltage selection |
| AutoEnerg | Off, DLLB, DBLL, Both | Off | - | Permitted energizing conditions for automatic reclosing |
| ManEnerg | Off, DLLB, DBLL, Both | Off | - | Permitted energizing conditions for manual closing |
| ManDBDL | Off, On | Off | - | Select On/Off for manual closing |
| UHigh | 50-120<br>Step: 1 | 80 | % of Ub | High voltage limit |
| ULow | 10-100<br>Step: 1 | 40 | % of Ub | Low voltage limit |
| FreqDiff | 0.05-0.30<br>Step: 0.01 | 0.20 | Hz | Frequency difference limit |
| PhaseDiff | 5-75<br>Step: 1 | 20 | degrees | Phase difference limit |
| UDiff | 5-50<br>Step: 1 | 20 | % of Ub | Voltage difference limit |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| tAutoEnerg | 0.000-60.000<br>Step: 0.001 | 0.100 | s | Time delay from fulfillment of all conditions to issue of energizing release signal for automatic reclosing |
| tManEnerg | 0.000-60.000<br>Step: 0.001 | 0.100 | s | Time delay from fulfillment of all conditions to issue of energizing release signal for manual closing |
| VTConnection | Line, Bus | Line | - | Voltage transformer connection side |
| tSync | 0.000-60.000<br>Step: 0.001 | 0 | s | Synchrocheck operation delay time |

**Table 229: Setting parameters for the SYN (SYN--) function block for double circuit breakers**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off, Release, On | Off | - | Operating mode for SYN function |
| InputPhase | L1, L2, L3, L1-L2, L2-L3, L3-L1 | L1 | - | Selected input voltage |
| UMeasure | Ph/N, Ph/Ph | Ph/N | - | Selected input voltage Ph/N or Ph/Ph |
| PhaseShift | 0-360<br>Step: 1 | 0 | degrees | Phase shift between U-bus and U-line |
| URatio | 0.20-5.00<br>Step: 0.01 | 1.00 | - | Voltage ratio between U-bus and U-line |
| AutoEnerg | Off, DLLB, DBLL, Both | Off | - | Permitted energizing conditions for automatic reclosing |
| ManEnerg | Off, DLLB, DBLL, Both | Off | - | Permitted energizing conditions for manual closing |
| ManDBDL | Off, On | Off | - | Select On/Off for manual closing |
| UHigh | 50-120<br>Step: 1 | 80 | % of Ub | High voltage limit |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| ULow | 10-100<br>Step: 1 | 40 | % of Ub | Low voltage limit |
| FreqDiff | 0.05-0.30<br>Step: 0.01 | 0.20 | Hz | Frequency difference limit |
| PhaseDiff | 5-75<br>Step: 1 | 20 | degrees | Phase difference limit |
| VTConnection | Line, Bus | Line | - | Voltage transformer connection side |
| tSync | 0.000-60.000<br>Step: 0.001 | 0 | s | Synchrocheck operation delay time |
| UDiff | 5-50<br>Step: 1 | 20 | % of Ub | Voltage difference limit |
| tAutoEnerg | 0.000-60.000<br>Step: 0.001 | 0.100 | s | Time delay from fulfillment of all conditions to issue of energizing release signal for automatic reclosing |
| tManEnerg | 0.000-60.000<br>Step: 0.001 | 0.100 | s | Time delay from fulfillment of all conditions to issue of energizing release signal for manual closing |

**Table 230: Setting parameters for the SYN (SYN--) function block for single circuit breaker with phasing**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off, Release, On | Off | - | Operating mode for SYN function |
| InputPhase | L1, L2, L3, L1-L2, L2-L3, L3-L1 | L1 | - | Selected input voltage |
| PhaseShift | 0-360<br>Step: 1 | 0 | degrees | Phase shift between U-bus and U-line |
| URatio | 0.20-5.00<br>Step: 0.01 | 1.00 | - | Voltage ratio between U-bus and U-line |

| **Parameter** | **Range** | **Default** | **Unit** | **Description** |
|---|---|---|---|---|
| USelection | SingleBus, DbleBus | SingleBus | - | Bus arrangement for voltage selection |
| AutoEnerg | Off, DLLB, DBLL, Both | Off | - | Permitted energizing conditions for automatic reclosing |
| ManEnerg | Off, DLLB, DBLL, Both | Off | - | Permitted energizing conditions for manual closing |
| ManDBDL | Off, On | Off | - | Select On/Off for manual closing |
| UHigh | 50-120<br>Step: 1 | 80 | % of Ub | High voltage limit |
| ULow | 10-100<br>Step: 1 | 40 | % of Ub | Low voltage limit |
| FreqDiff | 0.05-0.30<br>Step: 0.01 | 0.20 | Hz | Frequency difference limit |
| PhaseDiff | 5-75<br>Step: 1 | 20 | degrees | Phase difference limit |
| UDiff | 5-50<br>Step: 1 | 20 | % of Ub | Voltage difference limit |
| tAutoEnerg | 0.000-60.000<br>Step: 0.001 | 0.100 | s | Time delay from fulfillment of all conditions to issue of energizing release signal for automatic reclosing |
| tManEnerg | 0.000-60.000<br>Step: 0.001 | 0.100 | s | Time delay from fulfillment of all conditions to issue of energizing release signal for manual closing |
| Operation-Synch | Off, On | Off | - | Phasing function Off/On |
| ShortPulse | Off, On | Off | - | Short pulse Off/On |
| FreqDiffSynch | 0.05-0.50<br>Step: 0.01 | 0.30 | Hz | Frequency difference limit for phasing |
| tPulse | 0.000-60.000<br>Step: 0.001 | 0.200 | s | Breaker closing pulse duration |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| tBreaker | 0.02-0.50<br>Step: 0.01 | 0.20 | s | Closing time of the breaker |
| VTConnection | Line, Bus | Line | - | Voltage transformer connection side |
| tSync | 0.000-60.000<br>Step: 0.001 | 0 | s | Synchrocheck operation delay time |

**Table 231: Setting parameters for the SYN (SYN--) function block for double circuit breaker with phasing**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off, Release, On | Off | - | Operating mode for SYN function |
| InputPhase | L1, L2, L3, L1-L2, L2-L3, L3-L1 | L1 | - | Selected input voltage |
| PhaseShift | 0-360<br>Step: 1 | 0 | degrees | Phase shift between U-bus and U-line |
| URatio | 0.20-5.00<br>Step: 0.01 | 1.00 | - | Voltage ratio between U-bus and U-line |
| AutoEnerg | Off, DLLB, DBLL, Both | Off | - | Permitted energizing conditions for automatic reclosing |
| ManEnerg | Off, DLLB, DBLL, Both | Off | - | Permitted energizing conditions for manual closing |
| ManDBDL | Off, On | Off | - | Select On/Off for manual closing |
| UHigh | 50-120<br>Step: 1 | 80 | % of Ub | High voltage limit |
| ULow | 10-100<br>Step: 1 | 40 | % of Ub | Low voltage limit |
| FreqDiff | 0.05-0.30<br>Step: 0.01 | 0.20 | Hz | Frequency difference limit |

| **Parameter** | **Range** | **Default** | **Unit** | **Description** |
|---|---|---|---|---|
| PhaseDiff | 5-75<br>Step: 1 | 20 | degrees | Phase difference limit |
| UDiff | 5-50<br>Step: 1 | 20 | % of Ub | Voltage difference limit |
| tAutoEnerg | 0.000-60.000<br>Step: 0.001 | 0.100 | s | Time delay from fulfillment of all conditions to issue of energizing release signal for automatic reclosing |
| tManEnerg | 0.000-60.000<br>Step: 0.001 | 0.100 | s | Time delay from fulfillment of all conditions to issue of energizing release signal for manual closing |
| Operation-Synch | Off, On | Off | - | Phasing function Off/On |
| ShortPulse | Off, On | Off | - | Short pulse Off/On |
| FreqDiffSynch | 0.05-0.50<br>Step: 0.01 | 0.30 | Hz | Frequency difference limit for phasing |
| tPulse | 0.000-60.000<br>Step: 0.001 | 0.200 | s | Breaker closing pulse duration |
| tBreaker | 0.02-0.50<br>Step: 0.01 | 0.20 | s | Closing time of the breaker |
| VTConnection | Line, Bus | Line | - | Voltage transformer connection side |
| tSync | 0.000-60.000<br>Step: 0.001 | 0 | s | Synchrocheck operation delay time |

## 1.7 Technical data

**Table 232: Synchrocheck and energizing check**

| Function | Setting range | Accuracy |
|---|---|---|
| Synchrocheck: | | |
| Frequency difference limit | 50-300 mHz in steps of 10 mHz | ≤20 mHz |
| Voltage difference limit | 5-50% of $U_b$ in steps of 1% | +/-2.5% of $U_r$ |
| Phase difference limit | 5-75 degrees in steps of 1 degrees | +/-2 degrees |
| Energizing check: | | |
| Voltage level high | 50-120% of $U_b$ in steps of 1% | +/-2.5% of $U_r$ |
| Voltage level low | 10-100% of $U_b$ in steps of 1% | +/-2.5% of $U_r$ |
| Energizing period, automatic reclosing | 0-60 s in steps of 1 ms | +/-0.5% +/-10 ms |
| Energizing period, manual closing | 0-60 s in steps of 1 ms | +/-0.5% +/- 10 ms |
| Phase shift $\varphi_{line}$ - $\varphi_{bus}$ | 0-360 degrees in steps of 5 degrees | |
| Voltage ratio $U_{bus}/U_{line}$ | 0.20-5.00 in steps of 0.01 | |

| Parameter | Value |
|---|---|
| Synchrocheck: | |
| Bus voltage frequency range limit | +/-5 Hz from $f_r$ |
| Minimum Operating time | 190 ms typically |
| Energizing check: | |
| Minimum Operating time | 90 ms typically |

**Table 233: Phasing check option (specific parameters)**

| Parameter | Setting range | Accuracy |
|---|---|---|
| Frequency difference limit | 50-500 mHz in steps of 10 mHz | ≤20 mHz |
| Circuit breaker closing pulse duration | 0.000-60.000 s in steps of 1 ms | +/-0.5% +/-10 ms |
| Circuit breaker closing time | 0.000-60.000 s in steps of 1 ms | +/-0.5% +/-10 ms |

| Parameter | Value |
|---|---|
| Bus / line voltage frequency range limit | +/-5 Hz from $f_r$ |
| Bus / line voltage frequency rate of change limit | <0.21 Hz/s |

# 2 Automatic reclosing function (AR)

## 2.1 Application

The majority of power line faults are transient in nature, i.e. they do not recur when the line is re-energized following disconnection. The main purpose of the AR automatic reclosing function is to automatically return power lines to service following their disconnection for fault conditions.

To meet the different single, double or 1 and 1/2 circuit breaker arrangements, one, two, three, or six identical AR function blocks may be provided within a single terminal. The actual number of these function blocks that may be included within any given terminal depends on the type of terminal. Therefore, the specific circuit breaker arrangements that can be catered for, or the number of bays of a specific arrangement that can be catered for, depends on the type of terminal.

Especially at higher voltages, the majority of line faults are single-phase-to-earth. Faults involving all three phases are rare. The main purpose of the single- and two-pole automatic reclosing function, operating in conjunction with a single- and two-pole tripping capability, is to limit the effect to the system of faults involving less than all three phases. This is particularly valuable for maintaining system stability in systems with limited meshing or parallel routing.

## 2.2 Functionality

The AR function is a logical function built up from logical elements. It operates in conjunction with the trip output signals from the line protection functions, the OK to close output signals from the synchrocheck and energizing check function, and binary input signals (for circuit breaker position/status, or from other external protection functions).

The AR function has a priority selection capability that enables reclosing coordination for double and 1 and 1/2 circuit breaker arrangements. Reclosing of the circuit breakers will take place sequentially. No reclosing of the second circuit breaker will occur if reclosure of the first was unsuccessful due to reclosure on to a persistent fault.

Of the six reclosing programs, one provides for three-pole reclosing only, while the others provide for single- and two-pole reclosing as well. For the latter, only the first shot may be single- or two-pole. All subsequent shots up to the maximum number will be three-pole. For some of the programs, depending on the initial trip, no shot, or only one shot, will be permitted irrespective of the number of shots selected.

## 2.3 Function block

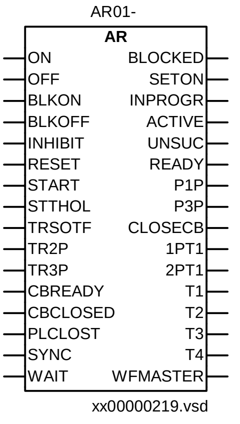



*Figure 118: AR Function block: Single, two and/or three phase*

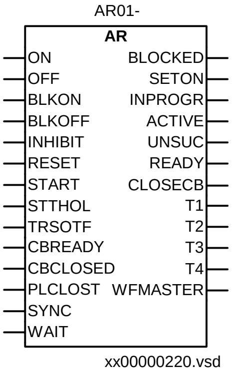



*Figure 119: AR Function block: Three phase*

## 2.4 Input and output signals

**Note:** Some signals may not be present depending on the ordered options.

**Table 234: Input signals for the AR (ARnn-) function block**

| Signal | Description |
|---|---|
| ON | Enables automatic reclosing operation |
| OFF | Disables automatic reclosing operation |
| BLKON | Sets automatic recloser to blocked state |
| BLKOFF | Releases automatic recloser from blocked state |
| INHIBIT | Inhibits automatic reclosing cycle |
| RESET | Resets automatic recloser |
| START | Starts automatic reclosing cycle |
| STTHOL | Blocks automatic reclosing from thermal overload protection |
| TRSOFT | Provides for start of automatic reclosing cycle from switch-on-to-fault |
| TR2P | Information on two-pole trip from trip function |
| TR3P | Information on three-pole trip from trip function |
| CBREADY | Circuit breaker ready for operation |
| CBCLOSED | Circuit breaker closed |
| PLCLOST | Permissive communication channel out of service |
| SYNC | OK to close from synchronizing / energizing function |
| WAIT | Wait from Master for sequential reclosing |

**Note:** Some signals may not be present depending on the ordered options.

**Table 235: Output signals for the AR (ARnn-) function block**

| Signal | Description |
|---|---|
| BLOCKED | Automatic recloser in blocked state |
| SETON | Automatic recloser switched on |
| INPROGR | Automatic reclosing attempt in progress |
| ACTIVE | Automatic reclosing cycle in progress |
| UNSUC | Automatic reclosing unsuccessful |
| READY | Automatic recloser prepared for reclosing cycle |
| P1P | Permit single-pole trip |

| Signal | Description |
|---|---|
| P3P | Prepare three-pole trip |
| CLOSECB | Close command to circuit breaker |
| 1PT1 | Single-pole reclosing in progress |
| 2PT1 | Two-pole reclosing in progress |
| T1 | Three-pole reclosing, shot 1 in progress |
| T2 | Three-pole reclosing, shot 2 in progress |
| T3 | Three-pole reclosing, shot 3 in progress |
| T4 | Three-pole reclosing, shot 4 in progress |
| WFMASTER | Wait from Master for sequential reclosing |

### 2.4.1 Autorecloser counter values

**Table 236: Autorecloser counter values AR (AR---)**

| Viewed data (default labels used, data is example values) | Counter value |
|---|---|
| 1ph-Shot1=<br>nnn | Recorded number of first single pole reclosing attempts |
| 3ph-Shot1=<br>nnn | Recorded number of first three-pole reclosing attempts |
| 3ph-Shot2=<br>nnn | Recorded number of second three-pole reclosing attempts |
| 3ph-Shot3=<br>nnn | Recorded number of third three-pole reclosing attempts |
| 3ph-Shot4=<br>nnn | Recorded number of fourth three-pole reclosing attempts |
| NoOfReclosings=<br>nnn | Recorded number of all reclosing attempts |

## 2.5 Setting parameters

**Table 237: Setting parameters for the automatic reclosing AR (AR---) function**

| **Parameter** | **Range** | **Default** | **Unit** | **Description** |
|---|---|---|---|---|
| Operation | Off,<br>Stand-by,<br>On | Off | - | Operating mode for AR function |
| NoOfReclosing | 1-4 | 1 | - | Maximum number of reclosing attempts |
| FirstShot | 3 ph,<br>1/2/3 ph,<br>1/2 ph,<br>1 ph+1*2 ph,<br>1/2+1*3 ph,<br>1 ph+1*2/3 ph | 3 ph | - | Selection of reclosing program |
| Extended t1 | Off, On | Off | - | Extended dead time for loss of permissive channel |
| t1 1Ph | 0.000-60.000<br>Step: 0.001 | 1.000 | s | Dead time for first single-phase automatic reclosing shot |
| t1 2Ph | 0.000-60.000<br>Step: 0.001 | 1.000 | s | Dead time for first two-phase automatic reclosing shot |
| t1 | 0.000-60.000<br>Step: 0.001 | 1.000 | s | Dead time for first three-phase automatic reclosing shot |
| t2 | 0.0-9000.0<br>Step: 0.1 | 30.0 | s | Dead time for second automatic reclosing shot |
| t3 | 0.0-9000.0<br>Step: 0.1 | 30.0 | s | Dead time for third automatic reclosing shot |
| t4 | 0.0-9000.0<br>Step: 0.1 | 30.0 | s | Dead time for fourth automatic reclosing shot |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| tSync | 0.0-9000.0<br>Step: 0.1 | 2.0 | s | Maximum wait time for sync |
| tPulse | 0.000-60.000<br>Step: 0.001 | 0.200 | s | Circuit breaker closing pulse length |
| CutPulse | Off, On | Off | - | Shorten closing pulse at a new trip |
| tReclaim | 0.0-9000.0<br>Step: 0.1 | 60.0 | s | Reclaim time |
| tInhibit | 0.000-60.000<br>Step: 0.001 | 5.000 | s | Inhibit reset time |
| CB Ready | CO, OCO | CO | - | Select type of circuit breaker ready signal |
| tTrip | 0.000-60.000<br>Step: 0.001 | 1.000 | s | Detection time for long trip duration to block automatic reclosing |
| Priority | None, Low, High | None | - | Priority selection (Master/Slave) (when reclosing multiple circuit breakers) |
| tWaitForMaster | 0.0-9000.0<br>Step: 0.1 | 60.0 | s | Maximum wait time for Master |
| AutoCont | Off, On | Off | - | Continue with next reclosing attempt if breaker does not close |
| BlockUnsuc | Off, On | Off | - | Block automatic reclosing function for unsuccessful reclosing |
| tAutoWait | 0.000-60.000<br>Step: 0.001 | 2.000 | s | Maximum wait time between shots |
| UnsucMode | NoCB-Check, CBCheck | NOCB-Check | - | CB Check enabled or disabled for unsuccessful mode |
| tUnsuc | 0.0-9000.0<br>Step: 0.1 | 30 | s | CB Check time before unsuccessful |

## 2.6 Technical data

**Table 238: Automatic reclosing function**

| Parameter | Setting range | Accuracy |
|---|---|---|
| Automatic reclosing open time: | | |
| shot 1 - t1 1ph | 0.000-60.000 s in steps of 1 ms | +/- 0.5% +/- 10 ms |
| shot 1 - t1 2ph | 0.000-60.000 s in steps of 1 ms | +/- 0.5% +/- 10 ms |
| shot 1 - t1 3ph | 0.000-60.000 s in steps of 1 ms | +/- 0.5% +/- 10 ms |
| shot 2 - t2 3ph | 0-9000 s in steps of 0.1 s | +/- 0.5% +/- 10 ms |
| shot 3 - t3 3ph | 0-9000 s in steps of 0.1 s | +/- 0.5% +/- 10 ms |
| shot 4 - t4 3ph | 0-9000 s in steps of 0.1 s | +/- 0.5% +/- 10 ms |
| Maximum wait time for OK to close from synchronizing function tSync | 0-9000 s in steps of 0.1 s | +/- 0.5% +/- 10 ms |
| Duration of close pulse to circuit breaker tPulse | 0.000-60.000 s in steps of 1 ms | +/- 0.5% +/- 10 ms |
| Duration of reclaim time tReclaim | 0-9000 s in steps of 0.1 s | +/- 0.5% +/- 10 ms |
| Inhibit reclosing reset time tInhibit | 0.000-60.000 s in steps of 1 ms | +/- 0.5% +/- 10 ms |
| Maximum trip pulse duration tTrip (longer trip pulse durations will either extend the dead time or interrupt the reclosing sequence) | 0.000-60.000 s in steps of 1 ms | +/- 0.5% +/- 10 ms |
| Maximum wait time for release from Master tWaitForMaster | 0-9000 s in steps of 0.1 s | +/- 0.5% +/- 10 ms |
| Wait time following close command before continuing with further reclosing attempts without new start signal if circuit breaker does not close tAutoWait | 0.000-60.000 s in steps of 1 ms | +/- 0.5% +/- 10 ms |
| Time delay before indicating reclosing unsuccessful tUnsuc | 0-9000 s in steps of 0.1 s | +/- 0.5% +/- 10 ms |
| Time CB must be closed before AR becomes ready for a reclosing cycle tCBClosed | 0.000-60.000 s in steps of 1 ms | +/- 0.5% +/- 10 ms |

**Table 239: Automatic reclosing function**

| Parameter | Value |
|---|---|
| Reclosing shots | 1-4 |
| Programs | Three pole trip: 1<br>Single, two and three pole trip: 6 |
| Number of instances | Up to six depending on terminal type (different terminal types support different CB arrangements and numbers of bays) |
| Breaker closed before start | 5 s |

# 3 Single command (CD)

## 3.1 Application

The terminals may be provided with a function to receive signals either from a substation automation system (SMS and/or SCS) or from the local human-machine interface, HMI. That receiving function block has 16 outputs that can be used, for example, to control high voltage apparatuses in switchyards. For local control functions, the local HMI can also be used. Together with the configuration logic circuits, the user can govern pulses or steady output signals for control purposes within the terminal or via binary outputs.

## 3.2 Functionality

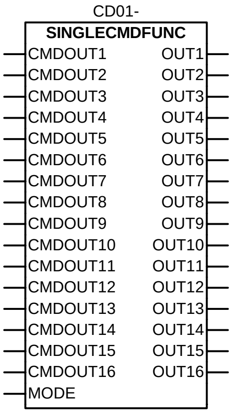
The single command function consists of a function block CD for 16 binary output signals.

The output signals can be of the types Off, Steady, or Pulse. The setting is done on the MODE input, common for the whole block, from the CAP 531 configuration tool.

The outputs can be individually controlled from the operator station, remote-control gateway, or from the local HMI. Each output signal can be given a name with a maximum of 13 characters from the CAP 531 configuration tool.

The output signals, here OUT1 to OUT16, are then available for configuration to built-in functions or via the configuration logic circuits to the binary outputs of the terminal.

## 3.3 Function block




xx00000213.vsd

## 3.4 Input and output signals

**Table 240: Input signals for the command control (CDnn-) function**

| Signal | Description |
|---|---|
| CMDOUTy | User defined name for output y (y=1-16) of function block CDnn. String length up to 13 characters. |
| MODE | Operation mode, 0: Off, 1: Not pulsed (steady). 2: Pulsed |

**Table 241: Output signals for the command control CD (CDnn-) function**

| Signal | Description |
|---|---|
| OUTy | Command output y (y=1-16) |

## 3.5 Setting parameters

**Table 242: Setting parameters for the command control CD (CDnn-) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| CMDOUTy | User def. string | CDnn-CMDOUTy | String | User defined name for output y (y=1-16) of function block CDnn. String length up to 13 characters, all characters available on the HMI can be used. Can only be set from the CAP 531 configuration tool. |
| MODE | 0, 1, 2 | 0 | - | Operation mode, 0: Off, 1: Not pulsed (steady). 2: Pulsed. Can only be set from the CAP 531 configuration tool. |

# 4 Multiple command (CM)

## 4.1 Application

The terminals may be provided with a function to receive signals either from a substation automation system or from other terminals via the interbay bus. That receiving function block has 16 outputs that can be used, together with the configuration logic circuits, for control purposes within the terminal or via binary outputs. When it is used to communicate with other terminals, these terminals must have a corresponding event function block to send the information.

## 4.2 Functionality

One multiple command function block CM01 with fast execution time also named *Binary signal interbay communication, high speed* and/or 79 multiple command function blocks CM02-CM80 with slower execution time are available in the REx 5xx terminals as options.

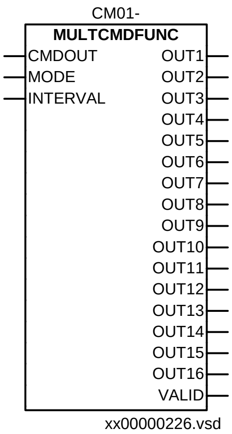
The output signals can be of the types Off, Steady, or Pulse. The setting is done on the MODE input, common for the whole block, from the CAP 531 configuration tool.

The multiple command function block has 16 outputs combined in one block, which can be controlled from the operator station or from other terminals. One common name for the block, with a maximum of 19 characters, is set from the configuration tool CAP 531.

The output signals, here OUT1 to OUT16, are then available for configuration to built-in functions or via the configuration logic circuits to the binary outputs of the terminal.

The command function also has a supervision function, which sets the output VALID to 0 if the block did not receive data within a configured INTERVAL time.

## 4.3 Function block




## 4.4 Input and output signals

**Table 243: Input signals for the command (CMnn-) functions**

| Signal | Description |
|---|---|
| CMDOUT | User defined common name for all outputs of function block CMnn. String length up to 19 characters. |
| INTERVAL | Time interval for supervision of received data |
| MODE | Operation mode. 0: Off, 1: Not pulsed (steady), 2: Pulsed |

**Table 244: Output signals for the command (CMnn-) functions**

| Signal | Description |
|---|---|
| OUTy | Command output y (y=1-16) |
| VALID | Received data. 0: invalid, 1: valid |

## 4.5 Setting parameters

**Table 245: Setting parameters for the command (CMnn-) functions**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| CMDOUT | User def. string | CMnn-CMDOUT | String | User defined common name for all outputs of function block CMnn (nn=01-80). String length up to 19 characters. Can only be set from CAP 531 configuration tool |
| INTERVAL | 0-60<br>Step: 1 | 0 | s | Time interval for supervision of received data. Can only be set from CAP 531 configuration tool |
| MODE | 0, 1, 2 | 0 | - | Operation mode. 0: Off, 1: Not pulsed (steady), 2: Pulsed. Can only be set from CAP 531 configuration tool |

# Chapter 10 Logic

**About this chapter**

This chapter describes the logic functions.

# 1 Trip logic (TR)

## 1.1 Application

The main purpose of the TR trip logic function is to serve as a single node through which all tripping for the entire terminal is routed.

The main purpose of the single- and two-pole extension to the basic three-pole tripping function is to cater for applications where, for reasons of system stability, single-pole tripping is required for single-phase faults, and/or two-pole tripping is required for two-phase faults, e.g. on double circuit parallel lines.

To meet the different single, double, 1 and 1/2 or other multiple circuit breaker arrangements, one or more identical TR function blocks may be provided within a single terminal. The actual number of these TR function blocks that may be included within any given terminal depends on the type of terminal. Therefore, the specific circuit breaker arrangements that can be catered for, or the number of bays of a specific arrangement that can be catered for, depends on the type of terminal.

## 1.2 Functionality

The minimum duration of a trip output signal from the TR function is settable.

The three-pole TR function has a single input through which all trip output signals from the protection functions within the terminal, or from external protection functions via one or more of the terminal’s binary inputs, are routed. It has a single trip output for connection to one or more of the terminal’s binary outputs, as well as to other functions within the terminal requiring this signal.

The expanded TR function for single- and two-pole tripping has additional phase segregated inputs for this, as well as inputs for faulted phase selection. The latter inputs enable single- and two-pole tripping for those functions which do not have their own phase selection capability, and therefore which have just a single trip output and not phase segregated trip outputs for routing through the phase segregated trip inputs of the expanded TR function. The expanded TR function has two inputs for these functions, one for impedance tripping (e.g. carrier-aided tripping commands from the scheme communication logic), and one for earth fault tripping (e.g. tripping output from a residual overcurrent protection). Additional logic secures a three-pole final trip command for these protection functions in the absence of the required phase selection signals.

The expanded TR function has three trip outputs, one per phase, for connection to one or more of the terminal’s binary outputs, as well as to other functions within the terminal requiring these signals.

The expanded TR function is equipped with logic which secures correct operation for evolving faults as well as for reclosing on to persistent faults. A special input is also provided which disables single- and two-pole tripping, forcing all tripping to be three-pole.

## 1.3 Function block

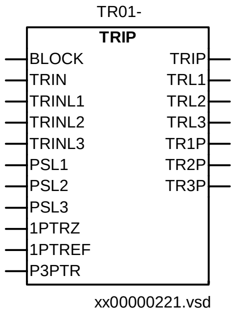



*Figure 120: TR function block: Single, two and/or three phase tripping logic*

## 1.4 Logic diagram

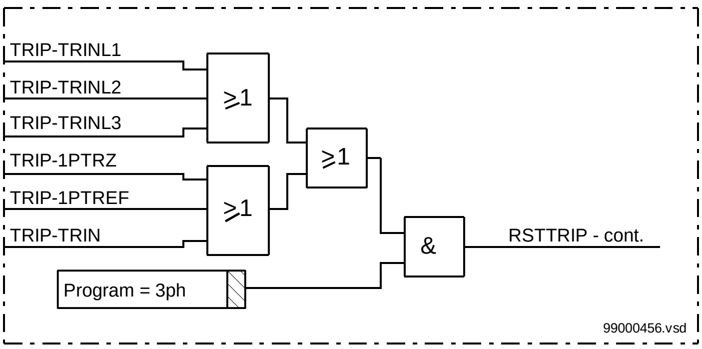



*Figure 121: Three-phase front logic - simplified logic diagram*

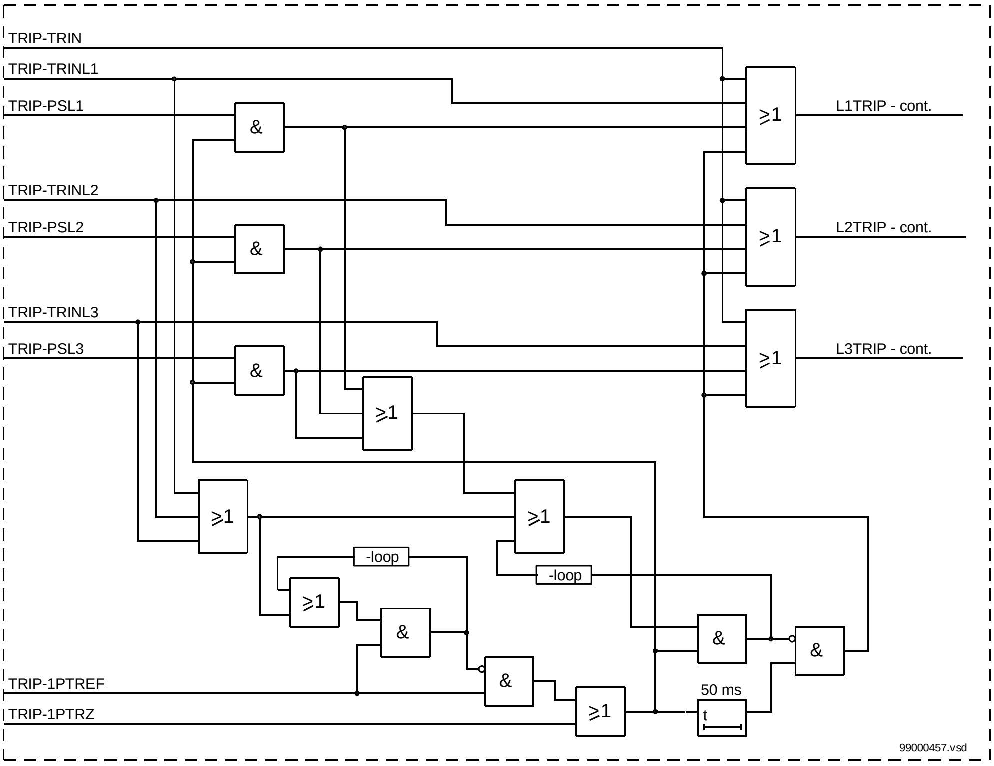



*Figure 122: Phase segregated front logic*

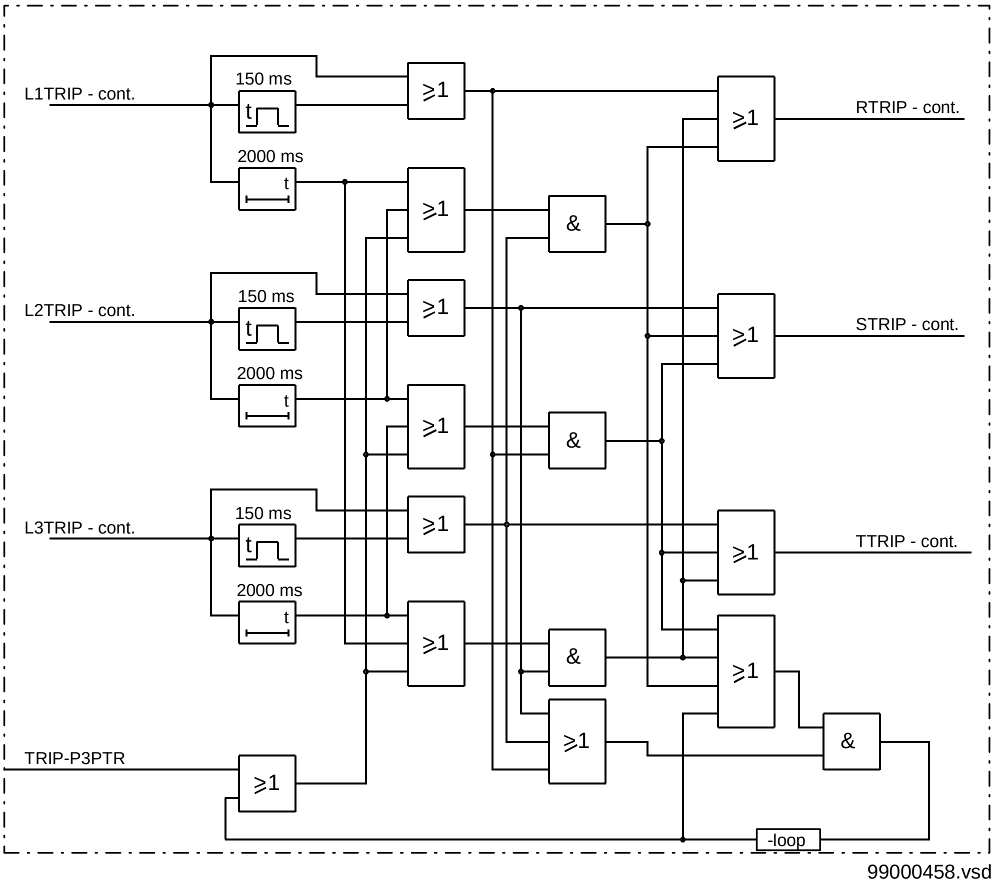



*Figure 123: Additional logic for the 1ph/3ph operating mode*

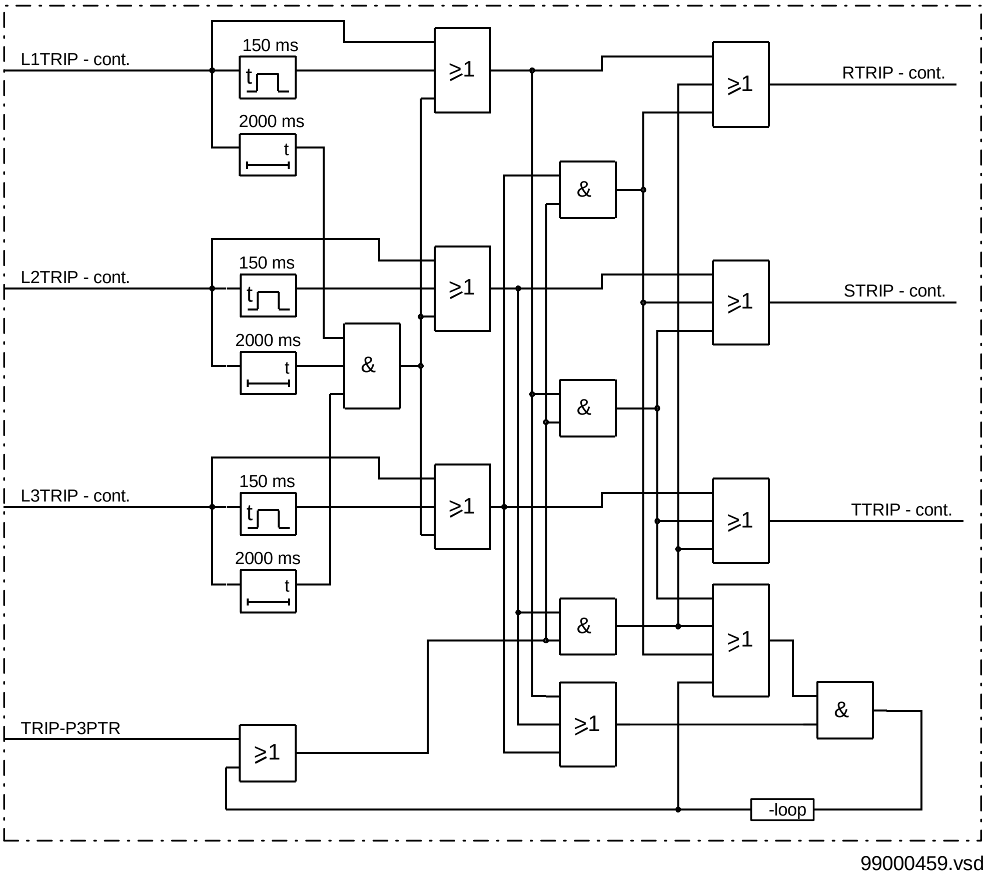



*Figure 124: Additional logic for the 1ph/2ph/3ph operating mode*

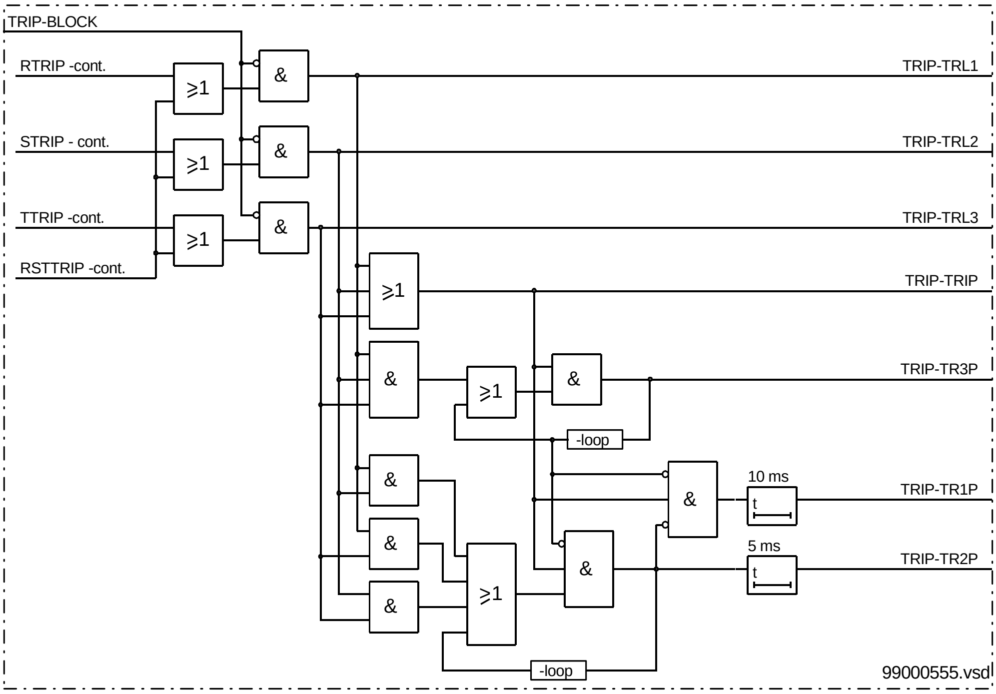



*Figure 125: Final tripping circuits*

## 1.5 Input and output signals

**Note**: Some signals may not be present depending on the ordered option.

**Table 246: Input signals for the TR (TRnn-) function block**

| Signal | Description |
|---|---|
| BLOCK | Block trip logic |
| TRIN | Trip all three phases |
| TRINL1 | Trip phase L1 |
| TRINL2 | Trip phase L2 |
| TRINL3 | Trip phase L3 |
| PSL1 | Phase selection in phase L1 |
| PSL2 | Phase selection in phase L2 |
| PSL3 | Phase selection in phase L3 |

| Signal | Description |
|---|---|
| 1PTRZ | Impedance trip without own phase selection capability |
| 1PTREF | Earth fault trip without phase selection capability |
| P3PTR | Prepare all tripping to be three phase |

**Note**: Some signals may not be present depending on the ordered option.

**Table 247: Output signals for the TR (TRnn-) function block**

| Signal | Description |
|---|---|
| TRIP | General trip output signal |
| TRL1 | Trip output signal in phase L1 |
| TRL2 | Trip output signal in phase L2 |
| TRL3 | Trip output signal in phase L3 |
| TR1P | Tripping single-pole |
| TR2P | Tripping two-pole |
| TR3P | Tripping three-pole |

## 1.6 Setting parameters

**Table 248: Setting parameters for the trip logic TR (TR---) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off / On | Off | - | Operating mode for TR function |
| Program | 3ph, 1/3ph, 1/2/3ph | 3ph | - | Operating mode for trip logic |
| tTripMin | 0.000-60.000<br>Step. 0.001 | 0.150 | s | Minimum duration of trip time |

## 1.7 Technical data

**Table 249: Trip logic**

| Parameter | Value | Accuracy |
|---|---|---|
| Setting for the minimum trip pulse length, tTripMin | 0.000 - 60.000 s in steps of 0.001 s | +/-0.5% +/-10 ms |

# 2 Pole discordance protection (PD)

## 2.1 Application

Breaker pole position discordance can occur on the operation of a breaker with independent operating gears for the three poles. The reason may be an interruption in the closing or trip coil circuit, or a mechanical failure resulting in a stuck breaker pole. A pole discordance can be tolerated for a limited time, for instance during a single-phase trip-reclose cycle. The pole discordance function detects a breaker pole discordancy not generated by auto-reclose cycle and issues a trip signal for the circuit breaker.

## 2.2 Functionality

The operation of the pole discordance logic, PD, is based on checking the position of the breaker auxiliary contacts. Three parallel normally open contacts in series with three normally closed contacts in parallel of the respective breaker poles form a condition of pole discordance, connected to a binary input dedicated for the purpose.

## 2.3 Function block

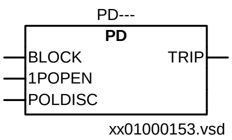



*Figure 126: PD function block, contact based*

## 2.4 Logic diagram

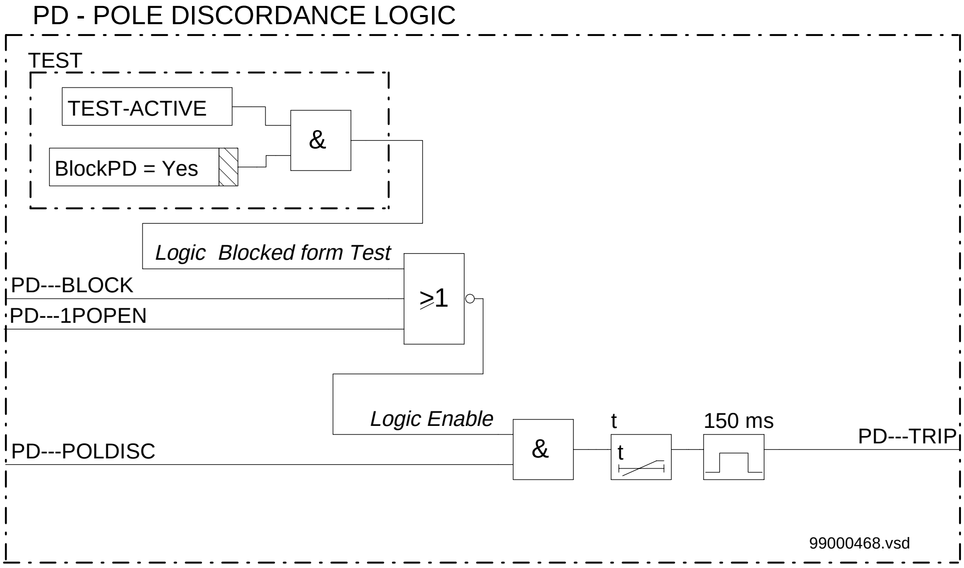



*Figure 127: Simplified logic diagram of pole discordance logic, contact based*

## 2.5 Input and output signals

**Table 250: Input signals for the PD (PD---) function block**

| Signal | Description |
|---|---|
| BLOCK | Block of pole discordance function |
| 1POPEN | One phase open |
| BC | Breaker closing |
| TRIN | Activate from external trip |
| POLDISC | Pole discordance signal from the circuit breaker |

**Table 251: Output signals for the PD (PD---) function block**

| Signal | Description |
|---|---|
| TRIP | Trip by pole discordance function |

## 2.6 Technical data

**Table 252: PD - Pole discordance, contact and current based**

| Function | Setting range | Accuracy |
|---|---|---|
| Auxiliary-contact-based function - time delay | (0.000-60.000) s in steps of 1 ms | +/- 0.5% +/- 10 ms |
| Operate current | 10% of I1b | +/- 2.5 % of $I_r$ |
| Time delay | (0.000-60.000) s in steps of 1 ms | +/- 0.5 % +/- 10 ms |

# 3 High speed binary output logic (HSBO)

## 3.1 Application

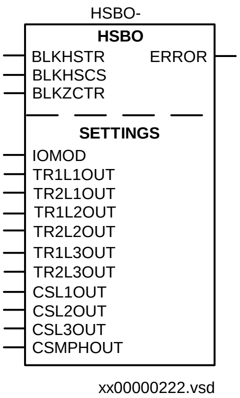
The time taken for signals to be transferred from binary inputs to protection functions, and from protection functions to binary outputs contributes to the overall tripping time. The main purpose of the HSBO high speed binary output logic is to minimize overall tripping times by establishing the critical connections to/from the binary outputs/inputs in a more direct way than with the regular I/O connections.

## 3.2 Functionality

The outputs from the HSBO logic utilize 'fast' connections to initiate binary outputs. The inputs to the HSBO logic utilize the same 'fast' connections. Input connections to the logic are derived from binary inputs, from outputs of the high speed distance protection, and from inputs to the regular trip logic and scheme communication logic. The HSBO scheme communication logic runs in parallel with the regular scheme communication logic.

The 'fast' connections to and from the HSBO logic comprise so called hard connections in software. This configuration is made internally and cannot be altered. The only exceptions are the connections to the binary outputs where limited configuration is possible, and required, on the part of the user.

## 3.3 Function block



## 3.4 Logic diagram

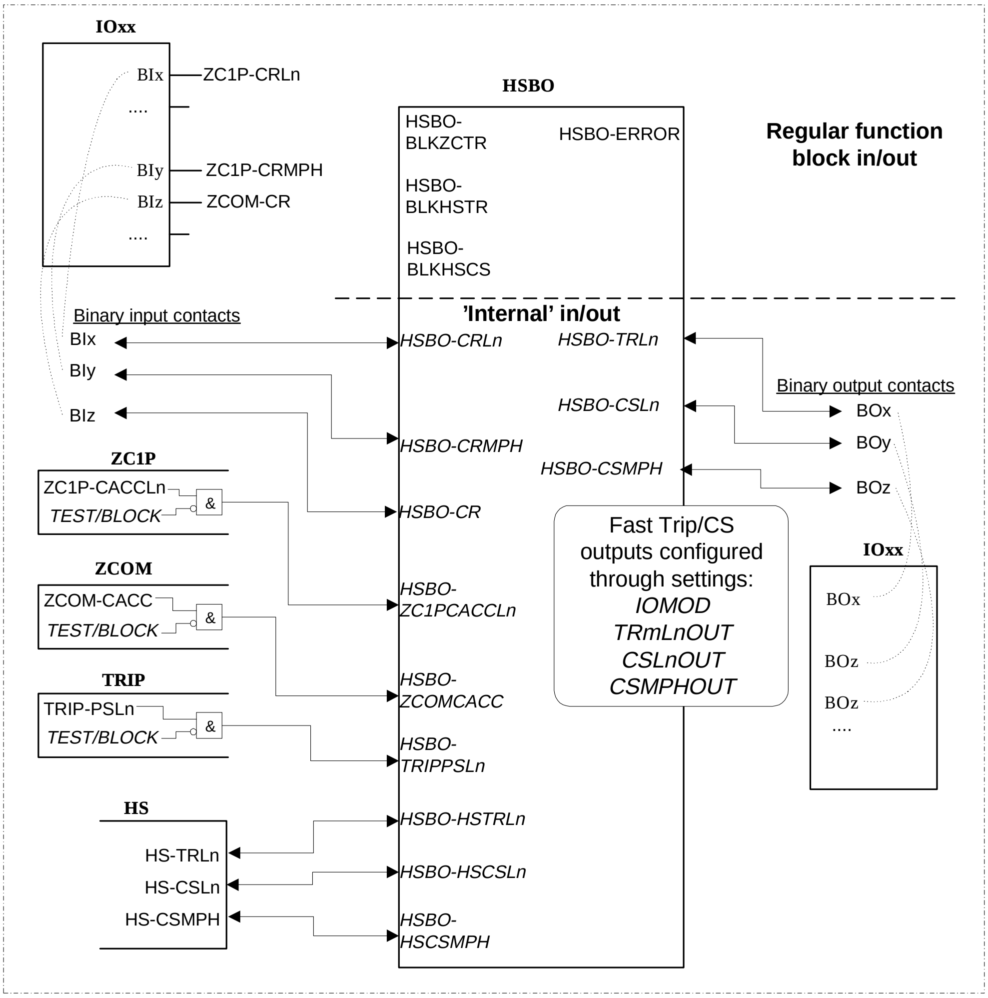



*Figure 128: High speed binary output, simplified logic diagram*

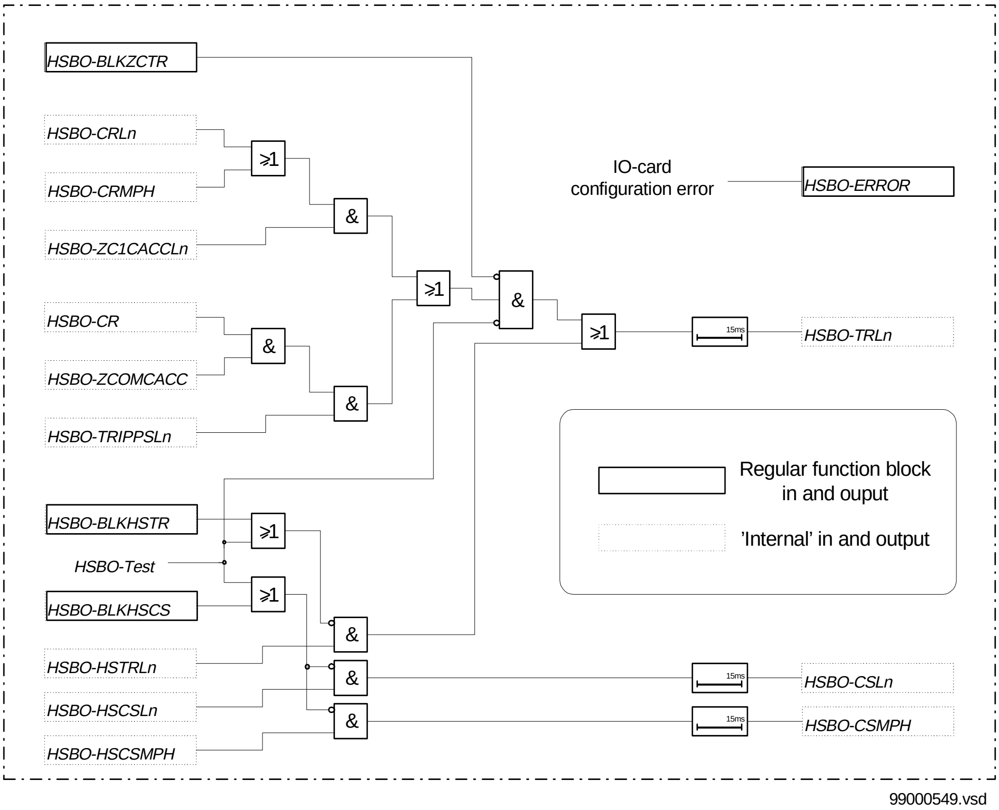



*Figure 129: Simplified logic diagram of the HSBO function logic.*

## 3.5 Input and output signals

### Table 253: Input signals for the HSBO (HSBO-) function block

| **Signal:** | **Description:** |
|---|---|
| BLKHSTR | Blocks high speed trip |
| BLKHSCS | Blocks high speed carrier send |
| BLKZCTR | Blocks high speed scheme communication impedance trip |

### Table 254: Output signals for the HSBO (HSBO-) function block

| **Signal:** | **Description:** |
|---|---|
| ERROR | Error output if configuration of ‘fast’ outputs does not correspond to actual hardware |

## 3.6 Setting parameters

**Table 255: Setting parameters for the high speed binary output logic HSBO (HS-BO-) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| IOMOD | 0-13 | 0 | - | I/O module number for the fast output trip contacts. Can only be set from the CAP 535 configuration tool. |
| TR1L1OUT | 0-24 | 0 | - | Fast trip phase L1 output contact on I/O module according to IOMOD setting. Can only be set from the CAP 535 configuration tool. |
| TR2L1OUT | 0-24 | 0 | - | Fast trip phase L1 output contact on I/O module according to IOMOD setting. Can only be set from the CAP 535 configuration tool. |
| TR1L2OUT | 0-24 | 0 | - | Fast trip phase L2 output contact on I/O module according to IOMOD setting. Can only be set from the CAP 535 configuration tool. |
| TR2L2OUT | 0-24 | 0 | - | Fast trip phase L2 output contact on I/O module according to IOMOD setting. Can only be set from the CAP 535 configuration tool. |
| TR1L3OUT | 0-24 | 0 | - | Fast trip phase L3 output contact on I/O module according to IOMOD setting. Can only be set from the CAP 535 configuration tool. |
| TR2L3OUT | 0-24 | 0 | - | Fast trip phase L3 output contact on I/O module according to IOMOD setting. Can only be set from the CAP 535 configuration tool. |
| CSL1OUT | 0-24 | 0 | - | Carrier send phase L1 output contact on I/O module according to IOMOD setting. Can only be set from the CAP 535 configuration tool. |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| CSL2OUT | 0-24 | 0 | - | Carrier send phase L2 output contact on I/O module according to IOMOD setting. Can only be set from the CAP 535 configuration tool. |
| CSL3OUT | 0-24 | 0 | - | Carrier send phase L3 output contact on I/O module according to IOMOD setting. Can only be set from the CAP 535 configuration tool. |
| CSMPHOUT | 0-24 | 0 | - | Carrier send multiple phase output contact on I/O module according to IOMOD setting. Can only be set from the CAP 535 configuration tool. |

# 4 Communication channel logic (CCHL)

## 4.1 Application

Many applications utilize the transmission of On/Off type signals from one end of the protected line to the other to obtain enhanced performance from the protection schemes. For those functions that utilize the receipt of a channel signal to execute a direct output without further conditional checks, security of the received signal is of paramount importance, as the erroneous receipt of a channel signal would have severe consequences. The main purpose of the CCHL communication channel logic is to allow applications requiring high security to use two separate channels for the one function. The CCHL logic receives inputs from both channels, and provides consolidated output signals for use by the applicable function(s).

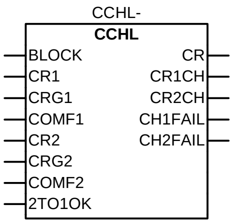
## 4.2 Functionality

The CCHL logic gets channel received, channel guard received, and channel failed signals from both communication channels. The unblocking logic is not incorporated in the logic for the receipt of both channels. To get this output, the actual signals for both channels must be simultaneously received. The logic for the receipt of one-channel-out-of-two is enabled by way of an input signal. Furthermore, the one-channel-out-of-two output can only be given if one of the communications channels has failed, as this logic is supervised by the failure of either channel. When selected, the unblocking logic is incorporated within this one-out-of-two logic.

The CCHL logic incorporates a number of security timers to make absolutely sure that no erroneous outputs are given for spurious channel received signals.

The CCHL logic also provides, for each channel, a communications channel failed output.

## 4.3 Function block



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## 4.4 Logic diagram

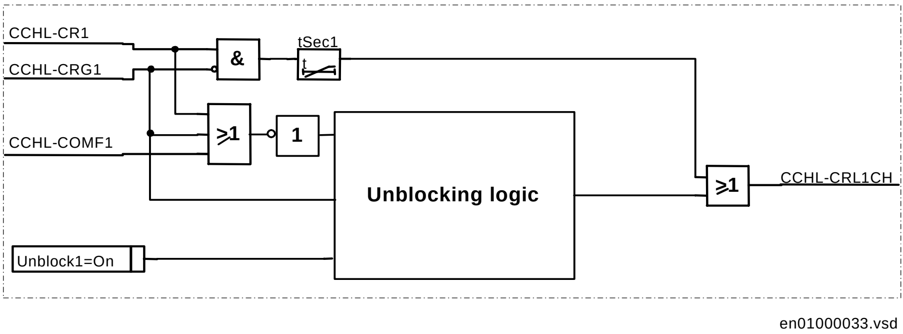



*Figure 130: Communication channel logic 1*

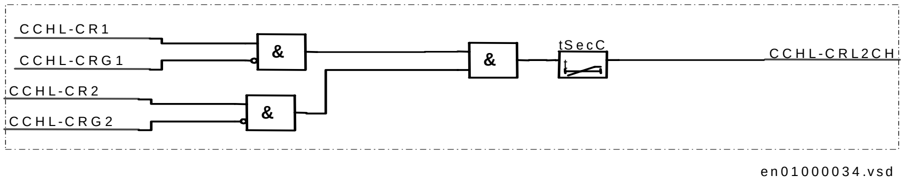



*Figure 131: Combination of two communication channels*

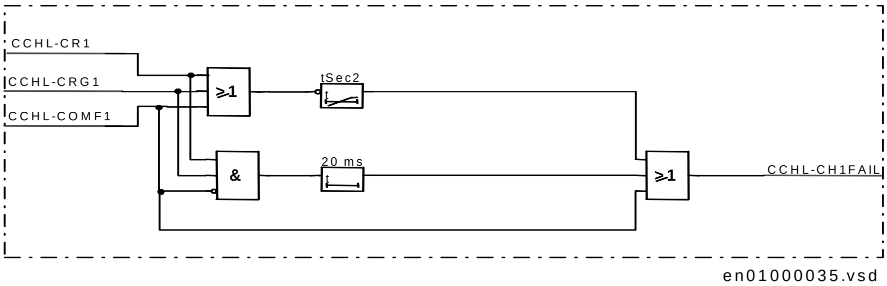



*Figure 132: Communication channel fail logic*

## 4.5 Input and output signals

**Table 256: Input signals for the CCHL (CCHL-) function block**

| Signal | Description |
|---|---|
| BLOCK | Blocks function |
| CR1 | Receive carrier signal channel 1 |
| CRG1 | Receive carrier guard signal channel 1 |
| COMF1 | Communications failure channel 1 |
| CR2 | Receive carrier signal channel 2 |
| CRG2 | Receive carrier guard signal channel 2 |
| COMF2 | Communications failure channel 2 |
| 2TO1OK | Permits one-out-of-two output |

**Table 257: Output signals for the CCHL (CCHL-) function block**

| Signal | Description |
|---|---|
| CR | Carrier signal received (one-out-of-two, or two-out-of-two) |
| CR1CH | Carrier signal received by only one communications channel (one-out-of-two) |
| CR2CH | Carrier signal received by both communications channels (two-out-of-two) |
| CH1FAIL | Communications channel 1 failed |
| CH2FAIL | Communications channel 2 failed |

## 4.6 Setting parameters

**Table 258: Setting parameters for the communication channel logic CCHL (CCHL-) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off, On | Off | - | Operating mode for CCHL function |
| Unblock1 | Off, On | Off | - | Unblocking logic for communication channel 1 enabled or disabled |
| Unblock2 | Off, On | Off | - | Unblocking logic for communication channel 2 enabled or disabled |

| **Parameter** | **Range** | **Default** | **Unit** | **Description** |
|---|---|---|---|---|
| tsecC | 0.000 - 60.000<br>Step: 0.001 | 0.000 | s | Time for which the signals from both channels must be simultaneously received before the output is given |
| tSec1 | 0.000 - 60.000<br>Step: 0.001 | 0.000 | s | Security time to ensure definite, and not spurious, receipt of the channel signal |
| tSec2 | 0.000 - 60.000<br>Step: 0.001 | 0.050 | s | Security time following loss of guard signal before activation of the unblocking logic |
| tReSt | 0.000 - 60.000<br>Step: 0.001 | 0.200 | s | Time period for which the carrier guard signal must have returned before another carrier received signal from the unblocking logic can be given on loss of the guard signal |
| tSig | 0.000 - 60.000<br>Step: 0.001 | 0.050 | s | Duration of received signal from the unblocking logic |

## 4.7 Technical data

**Table 259: Communication channel logic**

| Parameter | Setting range | Accuracy |
|---|---|---|
| Time delay before triggering two-out-of-two output for which both signals must be simultaneously received tSecC | 0.000-60.000s in steps of 0.001s | +/-0.5% +/-10ms |
| Time delay before triggering one-out-of-two output for which received signal must be present without guard signal tSec1 | 0.000-60.000s in steps of 0.001s | +/-0.5% +/-10ms |
| Security time delay following loss of guard signal before initiating received signal from unblocking logic tSec2 | 0.000-60.000s in steps of 0.001s | +/-0.5% +/-10ms |
| Time delay giving duration of received signal from unblocking logic tSig | 0.000-60.000s in steps of 0.001s | +/-0.5% +/-10ms |
| Time delay for which guard signal must have returned before new start of unblocking logic may occur tReSt | 0.000-60.000s in steps of 0.001s | +/-0.5% +/-10ms |

# 5 Communication channel test logic (CCHT)

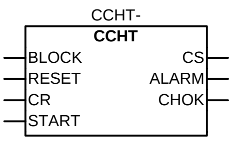
## 5.1 Application

Many secondary system applications require testing of different functions with confirmed information about the result of the test. The main purpose of the CCHT communication channel test logic is to perform testing of communication channels (power line carrier) in applications where continuous monitoring by some other means is not possible due to technical or economic reasons, and to indicate the result of the test.

## 5.2 Functionality

Starting of a communications channel test may be performed manually (by means of an external pushbutton) or automatically (by means of an included timer). When started, the CCHT logic initiates the sending of an impulse (carrier send signal) to the remote end. This action starts the operation of the applicable external functions. On receipt of the sent signal at the remote end terminal, a return signal is immediately sent back to the initiating end by the identical CCHT logic function within that terminal. The initiating end waits for this returned signal. It reports a successful or an unsuccessful response to the initiated test based on the receipt or not of this signal. An input is provided through which it is possible to abort the test by means of an external signal.

## 5.3 Function block

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## 5.4 Logic diagram

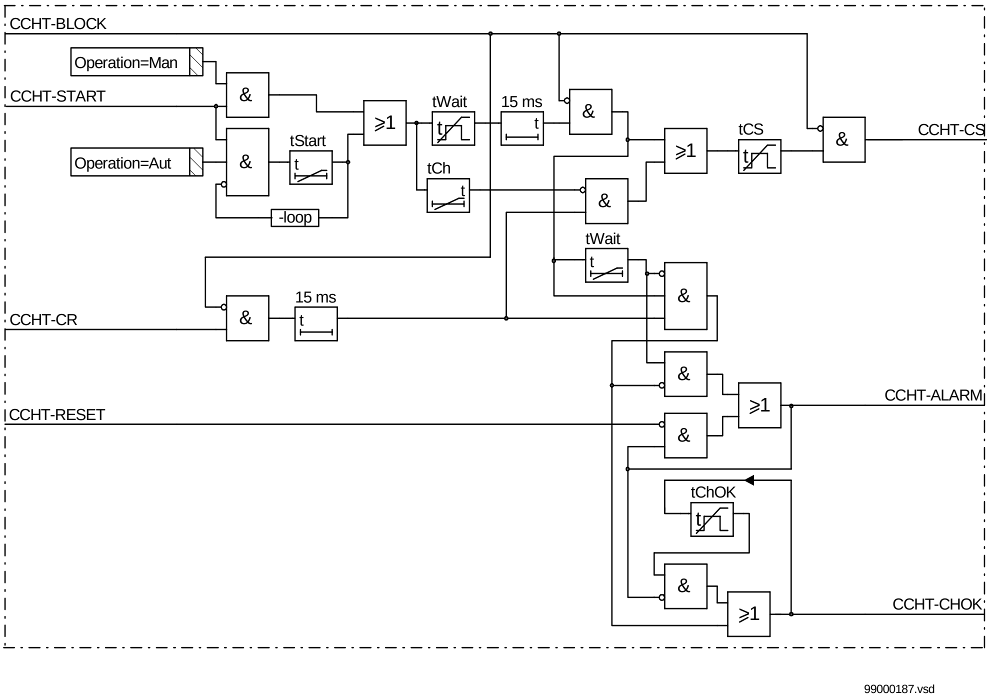



*Figure 133: Simplified logic diagram for the CCHT function*

## 5.5 Input and output signals

**Table 260: Input signals for the logic CCHT (CCHT-) function block**

| Signal | Description |
|---|---|
| BLOCK | Blocks function |
| RESET | Resets alarm |
| CR | Return carrier signal received (external test completed) |
| START | Starts test |

**Table 261: Output signals for the CCHT (CCHT-) function block**

| Signal | Description |
|---|---|
| CS | Send carrier signal (test external function) |
| ALARM | Test failed |
| CHOK | Test OK |

## 5.6 Setting parameters

**Table 262: Setting parameters for the communication channel test logic CCHT (CCHT-) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off, On | Off | - | Operating mode for CCHT function |
| StartMode | AutoMode<br>ManualM-ode | AutoMode | - | Operating mode for start of test |
| tStart | 0.0 - 90000.0<br>Step: 0.1 | 86400.0 | s | Time interval between automatic starts of channel testing |
| tWait | 0.0 - 90000.0<br>Step: 0.1 | 0.1 | s | Time interval allowed for successful return of channel test signal |
| tCh | 0.0 - 90000.0<br>Step: 0.1 | 0.5 | s | Time interval following start of test during which no received signal will be returned |
| tCS | 0.0 - 90000.0<br>Step: 0.1 | 0.1 | s | Duration of channel test output sig-nal |
| tChOK | 0.0 - 90000.0<br>Step: 0.1 | 60.0 | s | Duration of channel OK output sig-nal |
| tInh | 0.0 - 90000.0<br>Step: 0.1 | 0.2 | s | Duration of block extension following reset of Block input signal |

## 5.7 Technical data

**Table 263: Communication channel test logic**

| Parameter | Setting range | Accuracy |
|---|---|---|
| tStart Time interval between automatic starts of testing cycle | 0.0-90000.0 s in steps of 0.1 s | +/-0.5% +/-10 ms |
| tWait Time interval available for test of the external function to be registered as successful | 0.0-90000.0 s in steps of 0.1 s | +/-0.5% +/-10 ms |
| tCh Minimum time interval required before repeated test of the external function | 0.0-90000.0 s in steps of 0.1 s | +/-0.5% +/-10 ms |
| tCS Duration of CS output signal | 0.0-90000.0 s in steps of 0.1 s | +/-0.5% +/-10 ms |
| tChOK Duration of CHOK output signal | 0.0-90000.0 s in steps of 0.1 s | +/-0.5% +/-10 ms |
| tInh Duration of inhibit condition extension after the BLOCK input signal resets | 0.0-90000.0 s in steps of 0.1 s | +/-0.5% +/-10 ms |

# 6 Binary signal transfer to remote end (RTC)

## 6.1 General

In this function, there are two function blocks, RTC1-, and RTC2-. They are identical in all aspects.

## 6.2 Application

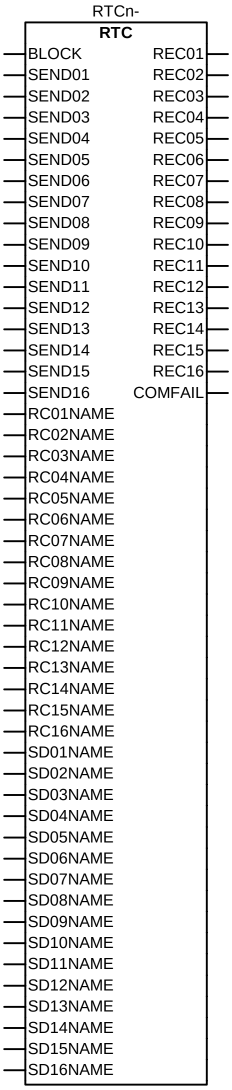
The main purpose of the RTC binary signal transfer to remote end function is the exchange of communication scheme related signals, trip signals and/or other binary signals between opposite ends of the line.

## 6.3 Functionality

The RTC function comprises two identical function blocks, each able to handle up to 16 inputs and 16 outputs, giving a total of 32 signals that can be transmitted in each direction.

The updated status of the selected binary signals is packaged within a data message which is sent once every computation loop.

## 6.4 Function block

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## 6.5 Input and output signals

**Table 264: Input signals for the binary signal transfer to remote end function RTCn where n = 1.2**

| Signal | Description |
|---|---|
| BLOCK | Blocks sending signals to remote end, no effect on received signals from remote end |
| SEND01-SEND16 | Binary signals to be sent to remote terminal, inputs 01-16 |

**Table 265: Output signals for the binary signal transfer to remote end function RTCn where n = 1.2**

| Signal | Description |
|---|---|
| REC01-REC16 | Binary signals received from remote terminal, outputs 01-16 |
| COMFAIL | Communication failure |

## 6.6 Setting parameters

**Table 266: Setting parameters for the binary signal transfer to remote end logic, RTCn, where n = 1, 2**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| RCyyNAME<br>Where yy = 01-16 | 0-13 | RTCn-RECyy | - | Remote Terminal Communication n, Name for Output yy<br>Set from CAP 535 |
| SDyyNAME<br>Where yy =01-16 | 0-13 | RTCn-SENDyy | - | Remote Terminal Communication n, Name for Input yy<br>Set from CAP 535 |

# 7 Serial communication

## 7.1 Application, common

One or two optional optical serial interfaces, one with LON protocol and the other with SPA or IEC 60870-5-103 protocol, for remote communication, enables the terminal to be part of a Substation Control System (SCS) and/or Substation Monitoring System (SMS). These interfaces are located at the rear of the terminal. The two interfaces can be configured independent of each other, each with different functionalities regarding monitoring and setting of the functions in the terminal.

An optical network can be used within the Substation Control System. This enables communication with the terminal through the LON bus from the operator’s workplace, from the control center and also from other terminals.

The second bus is used for SMS. It can include different numerical relays/terminals with remote communication possibilities. Connection to a personal computer (PC) can be made directly (if the PC is located in the substation) or by telephone modem through a telephone network with CCITT characteristics.

## 7.2 Design, common

The hardware needed for applying LON communication depends on the application, but one very central unit needed is the LON Star Coupler and optic fibres connecting the star coupler to the terminals. To communicate with the terminals from a Personal Computer (PC), the SMS 510 software or/and the application library LIB 520 together with MicroSCADA is needed.

When communicating with a PC, using the rear SPA/IEC port, the only hardware needed for a station monitoring system is optical fibres and opto/electrical converter for the PC. Remote communication over the telephone network also requires a telephone modem. The software needed in the PC when using SPA, either locally or remotely, is SMS 510 or/and CAP 535.

SPA communication is applied when using the front communication port, but for this purpose, no special serial communication function is required in the terminal. Only the software in the PC and a special cable for front connection is needed.

The IEC 60870-5-103 protocol implementation in REx 5xx consists of these functions:

- Event handling
- Report of analog service values (measurements)
- Fault location
- Command handling
  - Autorecloser ON/OFF
  - Teleprotection ON/OFF
  - Protection ON/OFF
  - LED reset
  - Characteristics 1 - 4 (Setting groups)
- File transfer (disturbance files)
- Time synchronization

The events created in the terminal available for the IEC protocol are based on the event function blocks EV01 - EV06 and disturbance function blocks DRP1 - DRP3. The commands are represented in a dedicated function block ICOM. This block has output signals according to the IEC protocol for all commands.

# 8 Serial communication, SPA (SPA-bus V 2.4 protocol)

## 8.1 Application

This communication bus is mainly used for SMS. It can include different numerical relays/terminals with remote communication possibilities. Connection to a personal computer (PC) can be made directly (if the PC is located in the substation) or by telephone modem through a telephone network with CCITT characteristics.

## 8.2 Design

When communicating with a PC, using the rear SPA port, the only hardware needed for a station monitoring system is optical fibres and opto/electrical converter for the PC. Remote communication over the telephone network also requires a telephone modem. The software needed in the PC when using SPA, either locally or remotely, is SMS 510 or/and CAP 535.

SPA communication is applied when using the front communication port, but for this purpose, no special serial communication function is required in the terminal. Only the software in the PC and a special cable for front connection is needed.

## 8.3 Setting parameters

**Table 267: Setting parameters for SPA communication, rear comm. port**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| SlaveNo | (1 - 899) | 30 | - | SPA-bus identification number |
| BaudRate | 300, 1200, 2400, 4800, 9600, 19200, 38400 | 9600 | Baud | Communication speed |
| RemoteChActgrp | Open, Block | Open | - | Open = Access right to change between active groups (both rear ports) |
| RemoteChSet | Open, Block | Open | - | Open = Access right to change any parameter (both rear ports) |

**Table 268: Setting parameters for SPA communication, front comm. port**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| SlaveNo | (1 - 899) | 30 | - | SPA-bus identification number |
| BaudRate | 300, 1200, 2400, 4800, 9600 | 9600 | Baud | Communication speed |

## 8.4 Technical data

**Table 269: Serial communication (SPA)**

| Function | Value |
|---|---|
| Protocol | SPA |
| Communication speed | 300, 1200, 2400, 4800, 9600, 19200 or 38400 bit/s |
| Slave number | 1 to 899 |
| Remote change of active group allowed | yes/no |
| Remote change of settings allowed | yes/no |
| Connectors and optical fibres | glass or plastic |

# 9 Serial communication, IEC (IEC 60870-5-103 protocol)

## 9.1 Application

This communication protocol is mainly used when a protection terminal communicates with a third party control system. This system must have a program that can interpret the IEC 60870-5-103 communication messages.

## 9.2 Design

As an alternative to the SPA communication the same port can be used for the IEC communication. The IEC 60870-5-103 protocol implementation in REx 5xx consists of these functions:

- Event handling
- Report of analog service values (measurements)
- Fault location
- Command handling
  - Autorecloser ON/OFF
  - Teleprotection ON/OFF
  - Protection ON/OFF
  - LED reset
  - Characteristics 1 - 4 (Setting groups)
- File transfer (disturbance files)
- Time synchronization

The events created in the terminal available for the IEC protocol are based on the event function blocks EV01 - EV06 and disturbance function blocks DRP1 - DRP3. The commands are represented in a dedicated function block ICOM. This block has output signals according to the IEC protocol for all commands.

## 9.3 IEC 60870-5-103 information types

The tables below specifies the information types supported by the REx 5xx products with the communication protocol IEC 60870-5-103 implemented.

To support the information, corresponding functions must be included in the protection terminal.

There are no representation for the following parts:

- Generating events for test mode
- Cause of transmission: Info no 11, Local operation

EIA RS-485 is not supported. Glass or plastic fibre should be used. BFOC/2.5 is the recommended interface to use (BFOC/2.5 is the same as ST connectors). ST connectors are used with the optical power as specified in standard.

For more information please see the IEC standard IEC 60870-5-103.

**Table 270: Information numbers in monitoring direction**

| Info no | Message | Supported |
|---|---|---|
| 2 | Reset FCB | Yes |
| 3 | Reset CU | Yes |
| 4 | Start/restart | Yes |
| 5 | Power on | No |
| | | |
| 16 | Autorecloser active | Yes |
| 17 | Teleprotection active | Yes |
| 18 | Protection active | Yes |
| 19 | LED reset | Yes |
| 20 | Information blocking | Yes |
| 21 | Test mode | No |
| 22 | Local parameter setting | No |
| 23 | Characteristic 1 | Yes |
| 24 | Characteristic 2 | Yes |
| 25 | Characteristic 3 | Yes |
| 26 | Characteristic 4 | Yes |
| 27 | Auxiliary input 1 | Yes |
| 28 | Auxiliary input 2 | Yes |
| 29 | Auxiliary input 3 | Yes |
| 30 | Auxiliary input 4 | Yes |

| | | |
|---|---|---|
| | | |
| 32 | Measurand supervision I | Yes |
| 33 | Measurand supervision V | Yes |
| 35 | Phase sequence supervision | No |
| 36 | Trip circuit supervision | Yes |
| 37 | I>> backup operation | Yes |
| 38 | VT fusefailure | Yes |
| 39 | Teleprotection disturbed | Yes |
| 46 | Teleprotection disturbed | Yes |
| 47 | Group alarm | Yes |
| | | |
| 48 | Earth fault L1 | Yes |
| 49 | Earth fault L2 | Yes |
| 50 | Earth fault L3 | Yes |
| 51 | Earth fault forward, e.g. line | Yes |
| 52 | Earth fault reverse, e.g. bus bar | Yes |
| 64 | Start/pickup L1 | Yes |
| 65 | Start/pickup L2 | Yes |
| 66 | Start/pickup L3 | Yes |
| 67 | Start/pickup N | Yes |
| 68 | General trip | Yes |
| 69 | Trip L1 | Yes |
| 70 | Trip L2 | Yes |
| 71 | Trip L3 | Yes |
| 72 | Trip 1>> (back up operation) | Yes |
| 73 | Fault location X in Ohm | Yes |
| 74 | Fault forward/line | Yes |
| 75 | Fault reverse/busbar | Yes |
| 76 | Teleprotection signal transmitted | Yes |
| 77 | Teleprotection signal received | Yes |

| | | |
|---|---|---|
| 78 | Zone 1 | Yes |
| 79 | Zone 2 | Yes |
| 80 | Zone 3 | Yes |
| 81 | Zone 4 | Yes |
| 82 | Zone 5 | Yes |
| 83 | Zone 6 | Yes |
| 84 | General start/pickup | Yes |
| 85 | Breaker failure | Yes |
| 86 | Trip measuring system L1 | No |
| 87 | Trip measuring system L2 | No |
| 88 | Trip measuring system L2 | No |
| 89 | Trip measuring system E | No |
| 90 | Trip I> | Yes |
| 91 | Trip I>> | Yes |
| 92 | Trip IN> | Yes |
| 93 | Trip IN>> | Yes |
| 128 | CB “on" by AR | Yes |
| 129 | CB "on” by long-time AR | Yes |
| 130 | AR blocked | Yes |
| 144 | Measurand I | Yes |
| 145 | Measurands I,V | Yes |
| 147 | Measurands IN, VEN | Yes |
| 148 | Measurands IL1,2,3,VL123,P,Q,f | Yes |
| 240 | Read headings of all defined groups | No |
| 241 | Read values of all entries of one gro up | No |
| 243 | Read directory of a single entry | No |
| 244 | Read value of a single entry | No |
| 245 | End of general interrogation generic data | No |
| 249 | Write entry with confirmation | No |
| 250 | Write entry with execution | No |

**Table 271: Information numbers in Control direction**

| Info no | Message | Supported |
|---|---|---|
| 16 | Autorecloser on/off | Yes |
| 17 | Teleprotection on/off | Yes |
| 18 | Protection on/off | Yes |
| 19 | LED reset | Yes |
| 23 | Characteristic 1 | Yes |
| 24 | Characteristic 2 | Yes |
| 25 | Characteristic 3 | Yes |
| 26 | Characteristic 4 | Yes |
| 240 | Read headings of all defined groups | No |
| 241 | Read values of all entries of one group | No |
| 243 | Read directory of a single entry | No |
| 244 | Read value of a single entry | No |
| 245 | General interrogation on generic data | No |
| 248 | Write entry | No |
| 249 | Write entry with confirmation | No |
| 250 | Write entry with execution | No |
| 251 | Write entry abort | No |

**Table 272: Measurands**

| Measurand | Rated value | |
|---|---|---|
| | 1.2 | 2.4 |
| Current L1 | | Yes |
| Current L2 | | Yes |
| Current L3 | | Yes |
| Voltage L1-E | | Yes |
| Voltage L2-E | | Yes |
| Voltage L3-E | | Yes |

| | | |
|---|---|---|
| Voltage L1 -L2 | | Yes |
| Active power P | | Yes |
| Reactive power Q | | Yes |

**Table 273: Interoperability, physical layer**

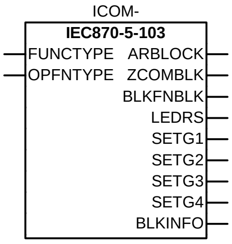
| | **Supported** |
|---|---|
| Electrical Interface | |
| EIA RS-485 | No |
| number of loads | No |
| Optical Interface | |
| glass fibre | Yes |
| plastic | Yes |
| Transmission Speed | |
| 9600 bit/s | Yes |
| 19200 bit/s | Yes |
| Link Layer | |
| DFC-bit used | Yes |
| Connectors | |
| connector F-SMA | No |
| connector BFOC/2, 5 | Yes |

**Table 274: Interoperability, application layer**

| | | **Supported** |
|---|---|---|
| Selection of standard ASDUs in monitoring direction | | |
| ASDU | | |
| 1 | Time-tagged message | Yes |
| 2 | Time-tagged message with rel. time | Yes |
| 3 | Measurands I | Yes |
| 4 | Time-taggedmeasurands with rel.time | Yes |
| 5 | Identification | Yes |

| | | |
|---|---|---|
| 6 | Time synchronization | Yes |
| 8 | End of general interrogation | Yes |
| 9 | Measurands ll | Yes |
| 10 | Generic data | No |
| 11 | Generic identification | No |
| 23 | List of recorded disturbances | Yes |
| 26 | Ready for transm. of disturbance data | Yes |
| 27 | Ready for transm.of a channel | Yes |
| 28 | Ready for transm. of tags | Yes |
| 29 | Transmission of tags | Yes |
| 30 | Transmission of disturbance data | Yes |
| 31 | End of transmission | Yes |
| Selection of standard ASDUs in control direction | | |
| ASDU | | |
| 6 | Time synchronization | Yes |
| 7 | General interrogation | Yes |
| 10 | Generic data | No |
| 20 | General command | Yes |
| 21 | Generic command | No |
| 24 | Order for disturbance data transmission | Yes |
| 25 | Acknowledgement for distance data transmis-sion | Yes |
| Selection of basic application functions | | |
| | Test mode | No |
| | Blocking of monitoring direction | Yes |
| | Disturbance data | Yes |
| | Private data | No |
| | Generic services | No |

## 9.4 Function block

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## 9.5 Input and output signals

**Table 275: Input signals for the IEC (ICOM-) function block**

| Signal | Description |
|---|---|
| FUNCTYPE | Main function type for terminal |
| OPFNTYPE | Main function type operation for terminal |

**Table 276: Output signals for the IEC (ICOM-) function block**

| Signal | Description |
|---|---|
| ARBLOCK | Command used for switching autorecloser on/off. |
| ZCOMBLK | Command used for switching teleprotection on/off. |
| BLKFNBLK | Command used for switching protection on/off. |
| LEDRS | Command used for resetting the LEDs. |
| SETG1 | Command used for activation of setting group 1. |
| SETG2 | Command used for activation of setting group 2. |
| SETG3 | Command used for activation of setting group 3. |
| SETG4 | Command used for activation of setting group 4. |
| BLKINFO | Output activated when all information sent to master is blocked. |

## 9.6 Setting parameters

**Table 277: Setting parameters for the IEC (ICOM-) function block**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| FuncType | 0-255 | 0 | - | Main function type for terminal<br>Set from CAP 535 |
| OpFnType | Off, On | Off | - | Main function type operation for terminal<br>Set from CAP 535 |

## 9.7 Technical data

**Table 278: Serial communication (IEC 60870-5-103)**

| Function | Value |
|---|---|
| Protocol | IEC 60870-5-103 |
| Communication speed | 9600, 19200 bit/s |
| Connectors and optical fibres | glass or plastic |

# 10 Serial communication, LON

## 10.1 Application

An optical network can be used within the Substation Automation system. This enables communication with the terminal through the LON bus from the operator's workplace, from the control center and also from other terminals.

## 10.2 Design

An optical serial interface with LON protocol enables the terminal to be part of a Substation Control System (SCS) and/or Substation Monitoring System (SMS). This interface is located at the rear of the terminal. The hardware needed for applying LON communication depends on the application, but one very central unit needed is the LON Star Coupler and optic fibres connecting the star coupler to the terminals. To communicate with the terminals from a Personal Computer (PC), the SMS 510, CAP 535 software or/and the application library LIB 520 together with MicroSCADA is needed.

## 10.3 Technical data

**Table 279: Serial communication (LON)**

| Function | Value |
|---|---|
| Protocol | LON |
| Communication speed | 1.25 Mbit/s |
| Connectors and optical fibres | glass or plastic |

# 11 Event function (EV)

## 11.1 Application

When using a Substation Automation system, events can be spontaneously sent or polled from the terminal to the station level. These events are created from any available signal in the terminal that is connected to the event function block. The event function block can also handle double indication, that is normally used to indicate positions of high-voltage apparatuses. With this event function block, data also can be sent to other terminals over the interbay bus.

## 11.2 Design

As basic, 12 event function blocks EV01-EV12 running with a fast cyclicity, are available in REx 5xx. When the function Apparatus control is used in the terminal, additional 32 event function blocks EV13-EV44, running with a slower cyclicity, are available.

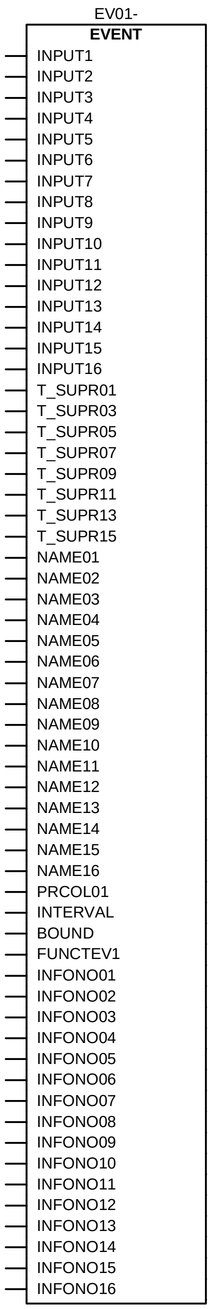
Each event function block has 16 connectables corresponding to 16 inputs INPUT1 to INPUT16. Every input can be given a name with up to 19 characters from the CAP 535 configuration tool.

The inputs can be used as individual events or can be defined as double indication events.

The inputs can be set individually, from the Parameter Setting Tool (PST) under the Mask-Event function, to create an event at pick-up, drop-out or at both pick-up and drop-out of the signal.

The event function blocks EV01-EV06 have inputs for information numbers and function type, which are used to define the events according to the communication standard IEC 60870-5-103.

## 11.3 Function block

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## 11.4 Input and output signals

**Table 280: Input signals for the EVENT (EVnn-) function block**

| Signal | Description |
|---|---|
| INPUTy | Event input y, y=1-16 |
| NAMEy | User name of signal connected to input y, y=01-16. String length up to 19 characters. |
| T_SUPR01 | Suppression time for event inputs 1and 2 |
| T_SUPR03 | Suppression time for event inputs 3 and 4 |
| T_SUPR05 | Suppression time for event inputs 5 and 6 |
| T_SUPR07 | Suppression time for event inputs 7 and 8 |
| T_SUPR09 | Suppression time for event inputs 9 and 10 |
| T_SUPR11 | Suppression time for event inputs 11 and 12 |
| T_SUPR13 | Suppression time for event inputs 13 and 14 |
| T_SUPR15 | Suppression time for event inputs 15 and 16 |
| PrColnn | Protocol for event block nn (nn=01-06). 0: Not used, 1: SPA, 2: LON, 3: SPA+LON, 4:  IEC, 5: IEC+SPA, 6: IEC+LON, 7: IEC+LON+SPA.<br>Protocol for event block nn (nn=07-44). 0: Not used, 1: SPA, 2: LON, 3: SPA+LON |
| INTERVAL | Time setting for cyclic sending of data |
| BOUND | Input signals connected to other terminals on the network, 0: not connected, 1: connected |
| FuncTEVnn | Function type for event block nn (nn=01-06), used for IEC protocol communication. Only present in blocks EV01-EV06. |
| InfoNoy | Information number for event input y, y=01-16. Used for IEC protocol communication. Only present in blocks EV01-EV06. |

## 11.5 Setting parameters

**Table 281: Setting parameters for the EVENT (EVnn-) function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| T_SUPR01 | 0.000-60.000 Step: 0.001 | 0.000 | s | Suppression time for event input 1 and 3. Can only be set using the CAP 535 configuration tool. |
| T_SUPR03 | 0.000-60.000 Step: 0.001 | 0.000 | s | Suppression time for event input 3 and 4. Can only be set using the CAP 535 configuration tool. |
| T_SUPR05 | 0.000-60.000 Step: 0.001 | 0.000 | s | Suppression time for event input 5 and 6. Can only be set using the CAP 535 configuration tool. |
| T_SUPR07 | 0.000-60.000 Step: 0.001 | 0.000 | s | Suppression time for event input 7 and 8. Can only be set using the CAP 535 configuration tool. |
| T_SUPR09 | 0.000-60.000 Step: 0.001 | 0.000 | s | Suppression time for event input 9 and 10. Can only be set using the CAP 535 configuration tool. |
| T_SUPR11 | 0.000-60.000 Step: 0.001 | 0.000 | s | Suppression time for event input 11 and 12. Can only be set using the CAP 535 configuration tool. |
| T_SUPR13 | 0.000-60.000 Step: 0.001 | 0.000 | s | Suppression time for event input 13 and 14. Can only be set using the CAP 535 configuration tool. |
| T_SUPR15 | 0.000-60.000 Step: 0.001 | 0.000 | s | Suppression time for event input 15 and 16. Can only be set using the CAP 535 configuration tool. |
| NAMEy | 0-19 | EVnn-INPUTy | Char | User name of signal connected to input y, y=01-16. String length up to 19 characters. Can only be set using the CAP 535 configuration tool. |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| PrColnn | 0-7 | 0 | - | Protocol for event block nn (nn=01-06). 0: Not used, 1: SPA, 2: LON, 3: SPA+LON, 4: IEC, 5: IEC+SPA, 6: IEC+LON, 7: IEC+LON+SPA. Range valid only for blocks EV01-EV06. Can only be set from CAP 535 configuration tool. |
| PrColnn | 0-3 | 0 | - | Protocol for event block nn (nn=07-44). 0: Not used, 1: SPA, 2: LON, 3: SPA+LON Range valid only for blocks EV07-EV44. Can only be set from CAP 535 configuration tool. |
| INTERVAL | 0 - 60<br>Step: 1 | 0 | s | Cyclic sending of data. Can only be set from CAP 535 configuration tool. |
| BOUND | 0, 1 | 0 | - | Event connected to other terminals on the network, 0: not connected, 1: connected. Can only be set from CAP 535 configuration tool. |
| FuncTEVnn | 0-255<br>Step: 1 | 0 | - | Function type for event block nn (nn=01-06), used for IEC protocol communication. Only present in blocks EV01-EV06. |
| InfoNoy | 0-255<br>Step: 1 | 0 | - | Information number for event input y, y=01-16. Used for IEC protocol communication. Only present in blocks EV01-EV06. |
| EventMasky | No events, OnSet, OnReset, OnChange, Double Ind., Double Ind. with mid-pos. | No events | - | Event mask for input y, y=01-16. Can only be set from PST. |

# 12 Event counter (CN)

## 12.1 Application

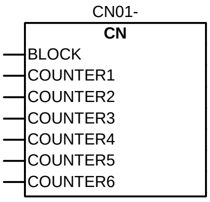
The function consists of six counters which are used for storing the number of times each counter has been activated. It is also provided with a common blocking function for all six counters, to be used for example at testing. Every counter can separately be set on or off by a parameter setting.

## 12.2 Design

The function block has six inputs for increasing the counter values for each of the six counters respectively. The content of the counters are stepped one step for each positive edge of the input respectively.

The function block also has an input BLOCK. At activation of this input all six counters are blocked.

## 12.3 Function block

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## 12.4 Input and output signals

**Table 282: Input signals for the CN01 function block**

| Signal | Description |
|---|---|
| BLOCK | Blocking of counters |
| COUNTER1 | Input for counter 1 |
| COUNTER2 | Input for counter 2 |
| COUNTER3 | Input for counter 3 |

| Signal | Description |
|---|---|
| COUNTER4 | Input for counter 4 |
| COUNTER5 | Input for counter 5 |
| COUNTER6 | Input for counter 6 |

## 12.5 Setting parameters

**Table 283: Setting parameters for the CN01 function block**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Counter1 | Off, On | Off | | Counter 1 |
| Counter2 | Off, On | Off | | Counter 2 |
| Counter3 | Off, On | Off | | Counter 3 |
| Counter4 | Off, On | Off | | Counter 4 |
| Counter5 | Off, On | Off | | Counter 5 |
| Counter6 | Off, On | Off | | Counter 6 |

## 12.6 Technical data

**Table 284: Technical data**

| Function | Value |
|---|---|
| Counter value | 0-10000 |
| Max. count up speed | 10 pulses/s |

# Chapter 11 Monitoring

**About this chapter**

This chapter describes the monitoring functions

# 1 LED indication function (HL, HLED)

## 1.1 Application

Each LED indication can be set individually to operate in six different sequences; two as follow type and four as latch type. Two of the latching types are intended to be used as a protection indication system, either in collecting or re-starting mode, with reset functionality. The other two are intended to be used as a signaling system in collecting mode with an acknowledgment functionality.

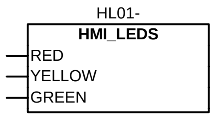
## 1.2 Design

The LED indication function consists of one common function block named HLED and one function block for each LED named HL01, HL02,..., HL18.

The color of the LEDs can be selected in the function block to red, yellow or green individually. The input signal for an indication has separate inputs for each color. If more than one color is used at the same time, the following priority order is valid; red, yellow and green, with red as highest priority.

The information on the LEDs is stored at loss of the auxiliary power for the terminal, so that the latest LED picture appears immediately after the terminal has restarted succesfully.

## 1.3 Function block



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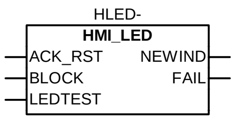

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## 1.4 Input and output signals

**Table 285: Input signals for the HMI_LEDs (HLnn-) function block**

| Signal | Description |
|---|---|
| RED | Signal input for indication with red color. |
| YELLOW | Signal input for indication with yellow color. |
| GREEN | Signal input for indication with green color. |

**Table 286: Input signals for the HMI_LED (HLED-) function block**

| Signal | Description |
|---|---|
| ACK-RST | Input to acknowledge/reset the indications on the LED-unit. To be used for external acknowledgement/reset. |
| BLOCK | Input to block the operation of the LED-unit. To be used for external blocking. |
| LEDTEST | Input for external LED test. Common for the whole LED-unit. |

**Table 287: Output signals for the HMI_LED (HLED-) function block**

| Signal | Description |
|---|---|
| NEWIND | Output that gives a pulse each time a new signal on any of the indication inputs occurs. |
| FAIL | Indication for overflow in HMI-LED buffer. |

## 1.5 Setting parameters

**Table 288: Setting parameters for the LED indication function**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | On, Off | On | - | Operation for the LED-function. |
| tRestart | 0.0 - 90000.0<br>Step: 0.1 | 5.0 | s | Defines the disturbance length after the last active signal has been reset or reached its tMax. Applicable only in mode LatchedReset-S. |
| tMax | 0.0 - 90000.0<br>Step: 0.1 | 5.0 | s | The maximum time an indication is allowed to affect the definition of a disturbance. Applicable only in mode LatchedReset-S. |
| SeqTypeLEDx | Follow-S,<br>Follow-F,<br>LatchedAck-F-S, LatchedAck-S-F, LatchedColl-S, LatchedReset-S | Follow-S | - | Sequence type for the indication in LED x (x = 1-18). S = Steady and F = Flashing light. |

# 2 Disturbance report (DRP)

## 2.1 Application

Use the disturbance report to provide the network operator with proper information about disturbances in the primary network. The function comprises several subfunctions enabling different types of users to access relevant information in a structured way.

Select appropriate binary signals to trigger the red HMI LED to indicate trips or other important alerts.

## 2.2 Functionality

The disturbance report collects data from each subsystem for up to ten disturbances. The data is stored in nonvolatile memory, used as a cyclic buffer, always storing the latest occurring disturbances. Data is collected during an adjustable time frame, the collection window. This window allows for data collection before, during and after the fault.

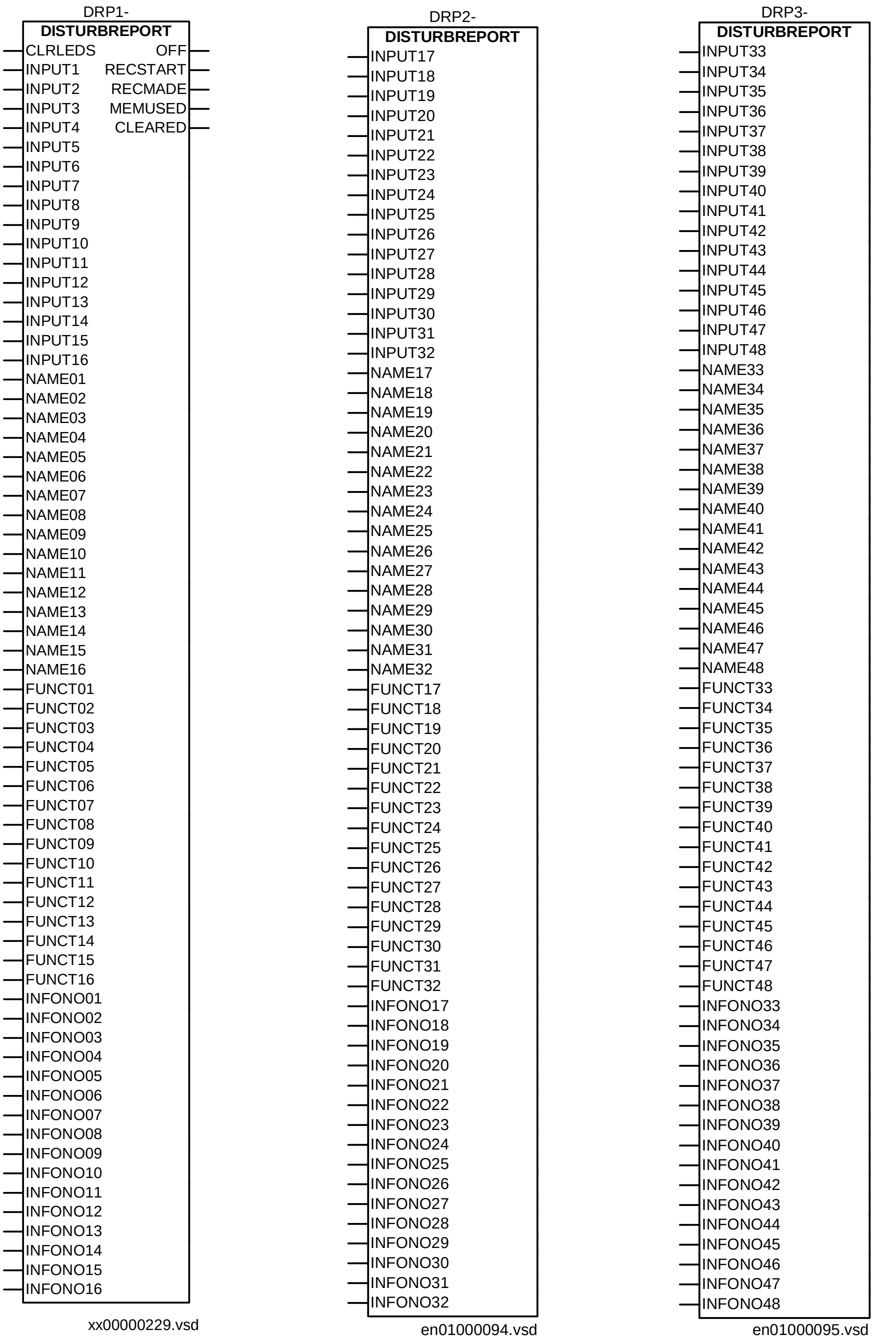
The collection is started by a trigger. Any binary input signal or function block output signal can be used as a trigger. The analog signals can also be set to trigger the data collection. Both over levels and under levels are available. The trigger is common for all subsystems, hence it activates them all simultaneously.

A triggered report cycle is indicated by the yellow HMI LED, which will be lit. Binary signals may also be used to activate the red HMI LED for additional alerting of fault conditions. A disturbance report summary can be viewed on the local HMI.

Disturbance overview is a summary of all the stored disturbances. The overview is available only on a front-connected PC or via the Station Monitoring System (SMS). The overview contains:

- Disturbance index
- Date and time
- Trip signals
- Trig signal that activated the recording
- Distance to fault (requires Fault locator)
- Fault loop selected by the Fault locator (requires Fault locator)

## 2.3 Function block



## 2.4 Input and output signals

**Table 289: Input signals for the DISTURBREPORT (DRPn-) function blocks**

| Signal | Description |
|---|---|
| CLRLEDS | Clear HMI LEDs (only DRP1) |
| INPUT1 - INPUT48 | Select binary signal to be recorded as signal no. xx were xx=1 - 48. |
| NAME01-48 | Signal name set by user, 13 char., for disturbance presentation |
| FuncT01-48 | Function type, set by user ( for IEC ) |
| InfoNo01-48 | Information number, set by user ( for IEC ) |

**Table 290: Output signals for the DISTURBREPORT (DRP1-) function block**

| Signal | Description |
|---|---|
| OFF | Disturbance Report function turned off |
| RECSTART | Disturbance recording started |
| RECMADE | Disturbance recording made |
| MEMUSED | More than 80% of recording memory used |
| CLEARED | All disturbances in Disturbance Report cleared |

## 2.5 Setting parameters

**Table 291: Parameters for disturbance report**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off, On | On | - | Determines if disturbances are recorded (on) or not (off). |
| PostRetrig | Off, On | Off | - | Determines if retriggering during the postfault recording is allowed (on) or not (off). |

**Table 292: Parameters for sequence number**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| SequenceNo | 0-255<br>Step: 1 | 0 | - | Allows for manual setting of the sequence number of the next disturbance. |

**Table 293: Parameters for recording time**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| tPre | 0.05-0.30<br>Step: 0.01 | 0.10 | s | Prefault recording time |
| tPost | 0.1-5.0<br>Step: 0.1 | 0.5 | s | Postfault recording time |
| tLim | 0.5-6.0<br>Step: 0.1 | 1.0 | s | Fault recording time limit |

**Table 294: Parameters for reporting of binary signals**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| TrigOperation | Off, On | Off | - | Determines if the signal should trigger disturbance recording |
| TrigLevel | Trig on 1, Trig on 0 | Trig on 1 | - | Selects the trigger signal transition. |
| IndicationMask | Hide, Show | Hide | - | Determines if the signal should be included in the HMI indications list |
| SetLed | Off, On | Off | - | Determines if the signal should activate the red HMI LED |
| NAME | 1 - 13 | Input *n* | Char | Signal name used in disturbance report and indications. Can only be set from the configuration tool.<br>(*n*=1-48) |

**Table 295: Voltage parameters for disturbance recorder**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off, On | On | - | Determines if the analog signal is to be recorded (on) or not (off). |
| <TrigLevel | 0-110<br>Step: 1 | 90 | % of Unb | Undervoltage trigger level in per cent of signal. |
| >TrigLevel | 0-200<br>Step: 1 | 110 | % of Unb | Overvoltage trigger level in per cent of signal. |
| <TrigOperation | Off, On | Off | - | Determines if the analog signal’s undervoltage trigger condition should be used (on) or not (off) |
| >TrigOperation | Off, On | Off | - | Determines if the analog signal’s overvoltage trigger condition should be used (on) or not (off) |

**Table 296: Current parameters for disturbance recorder**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off, On | On | - | Determines if the analog signal is to be recorded (on) or not (off). |
| <TrigLevel | 0-200<br>Step: 1 | 50 | % of Inb | Undercurrent trigger level in per cent of signal. |
| >TrigLevel | 0-5000<br>Step: 1 | 200 | % of Inb | Overcurrent trigger level in per cent of signal. |
| <TrigOperation | Off, On | Off | - | Determines if the analog signal’s undercurrent trigger condition should be used (on) or not (off) |
| >TrigOperation | Off, On | Off | - | Determines if the analog signal’s overcurrent trigger condition should be used (on) or not (off) |

**Table 297: Disturbance report settings**

| Operation | Disturb-Summary | Then the results are... |
|---|---|---|
| Off | Off | • Disturbances are not stored.<br>• LED information is not displayed on the HMI and not stored.<br>• No disturbance summary is scrolled on the HMI. |
| Off | On | • Disturbances are not stored.<br>• LED information (yellow - start, red - trip) are displayed on the local HMI but not stored in the terminal.<br>• Disturbance summary is scrolled automatically on the local HMI for the two latest recorded disturbances, until cleared.<br>• The information is not stored in the terminal. |
| On | On or Off | • The disturbance report works as in normal mode.<br>• Disturbances are stored. Data can be read from the local HMI, a front-connected PC, or SMS.- LED information (yellow - start, red - trip) is stored.<br>• The disturbance summary is scrolled automatically on the local HMI for the two latest recorded disturbances, until cleared.<br>• All disturbance data that is stored during test mode remains in the terminal when changing back to normal mode. |

## 2.6 Technical data

**Table 298: Disturbance report setting performance**

| Data | Setting range |
|---|---|
| Pre-fault time | 50-300 ms in steps of 10 ms |
| Post-fault time | 100-5000 ms in steps of 100 ms |
| Limit time | 500-6000 ms in steps of 100 ms |
| Number of recorded disturbances | Max. 10 |

# 3 Indications

## 3.1 Application

Use the indications list to view the state of binary signals during the fault. All binary input signals to the distance report function are listed.

## 3.2 Functionality

The indications list tracks zero-to-one changes of binary signals during the fault period of the collection window. This means that constant logic zero, constant logic one or state changes from logic one to logic zero will not be visible in the indications list. Signals are not time tagged. In order to be listed in the indications list the:

1. signal must be connected to the DRP function block.
2. setting parameter, IndicationMask, for the input must be set to Show.

Output signals of other function blocks of the configuration will be listed by the signal name listed in the corresponding signal list. Binary input signals are listed by the name defined in the configuration.

The indications can be viewed on the local HMI and via SMS.

# 4 Disturbance recorder

## 4.1 Application

Use the disturbance recorder to record analog and binary signals during fault conditions in order to analyze disturbances. The analysis may include fault severity, fault duration and protection performance. Replay the recorded data in a test set to verify protection performance.

## 4.2 Functionality

The disturbance recorder records both analog and binary signal information.

Analog and digital signals can be used as triggers. A trigger signal does not need to be recorded.

A trigger is generated when the analog signal moves under and/or over set limit values. The trig level is compared to the signal's average peak-to-peak value, making the function insensible to DC offset. The trig condition must occur during at least one full period, that is, 20 ms for a 50 Hz network.

The recorder continuously records data in a cyclic buffer capable of storing the amount of data generated during the set pre-fault time of the collection window. When triggered, the pre-fault data is saved and the data for the fault and post-fault parts of the collection window is recorded.

The RAM area for temporary storage of recorded data is divided into subareas, one for each recording. The size of a subarea depends on the set recording times. There is sufficient memory for four consecutive recordings with a maximum number of analog channels recorded and with maximum time settings. Should no subarea be free at a new disturbance, the oldest recording is overwritten.

When a recording is completed, the post recording process:

- merges the data for analog channels with corresponding data for binary signals stored in an event buffer
- compresses the data without loosing any data accuracy
- stores the compressed data in a non-volatile memory

The disturbance recordings can be viewed via SMS or SCS.

## 4.3 Technical data

**Table 299: Disturbance recorder setting performance**

| Function | Setting range |
|---|---|
| Overcurrent triggering | 0-5000% of Inb in steps of 1% |
| Undercurrent triggering | 0-200% of Inb in steps of 1% |
| Overvoltage triggering | 0-200% of Unb in steps of 1% at 100 V sec. |
| Undervoltage triggering | 0-110% of Unb in steps of 1% |

**Table 300: Disturbance recorder performance**

| Data | | | Value |
|---|---|---|---|
| Number of binary signals | | | 48 |
| Number of analog signals | | | 10 |
| Sampling rate | | | 2 kHz |
| Recording bandwidth | | | 5-250 Hz |
| Total recording time with ten analog and 48 binary signals recorded. (The amount of harmonics can affect the maximum storage time) | | | 40 s typically |
| Voltage channels | Dynamic range | | (0.01-2.0) x $U_r$ at 100/200 V sec. |
| | Resolution | | 0.1% of $U_r$ |
| | Accuracy at rated frequency | $U \leq U_r$ | 2.5% of $U_r$ |
| | | $U > U_r$ | 2.5% of U |
| Current channels | Dynamic range | Without DC off-set | (0.01-110) $\times$ $I_r$ |
| | | With full DC off-set | (0.01-60) $\times$ $I_r$ |
| | Resolution | | 0.5 % of $I_r$ |
| | Accuracy at rated frequency | $I \leq I_r$ | +/-2.5 % of $I_r$ |
| | | $I > I_r$ | +/-2.5 % of I |

# 5 Event recorder

## 5.1 Application

Use the event recorder to obtain a list of binary signal events that occurred during the disturbance.

## 5.2 Design

When a trigger condition for the disturbance report is activated, the event recorder collects time tagged events from the 48 binary signals that are connected to disturbance report and lists the changes in status in chronological order. Each list can contain up to 150 time tagged events that can come from both internal logic signals and binary input channels. Events are recorded during the total recording time which depends on the set recording times and the actual fault time.

Events can be viewed via SMS and SCS.

## 5.3 Technical data

**Table 301: Event recorder**

| Function | | Value |
|---|---|---|
| Event buffering capacity | Max. number of events/disturbance report | 150 |
| | Max. number of disturbance reports | 10 |

# 6 Fault locator (FLOC)

## 6.1 Application

An accurate fault locator is an essential complement to the line protection. The fault locator provides distance to fault together with information about the measuring loop that has been used in the calculation.

Reliable information on fault location reduces the outage time and minimises the need for patrolling.

The function has limitations for applications with series compensated lines.

## 6.2 Functionality

The fault locator can be started by any internal or external binary signal. Pre-fault and fault phasors of currents and voltages, that were filtered from disturbance data stored into digital sample buffers, are then used for the distance to fault calculation. The phase selective signals from the built-in protection functions provide the necessary information for the selection of the loop to be used for the calculation. It is also possible to use the external phase selection information.

For the distance to fault calculation, a line modelling algorithm that takes into account the sources at both ends of the line, is used. In this way, the influence of the load current, the infeed from the remote end and the fault resistance, can be compensated for, resulting in a highly accurate calculation.

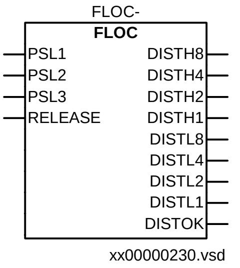
In case of double circuit lines, the influence of the zero-sequence mutual impedance Zm0 is compensated for by considering the residual current on the parallel line.

The function indicates the distance to the fault as a percentage of the line length, in kilometers or miles as selected. The SPA address 61V13 also contains the latest distance to fault.

Possibility to make recalculations with changed parameter settings exists.

Information on the last ten disturbances is stored.

## 6.3 Function block




## 6.4 Input and output signals

**Table 302: Input signals for the FLOC (FLOC-) function block**

| Signal | Description |
|---|---|
| PSL1 | Fault locator phase selection information - phase L1 |
| PSL2 | Fault locator phase selection information - phase L2 |
| PSL3 | Fault locator phase selection information - phase L3 |
| RELEASE | Starts the operation of the fault location function |

**Table 303: Output signals for the FLOC (FLOC-) function block**

| Signal | Description |
|---|---|
| DISTH8 | Fault locator BCD (Binary Coded Decimal) H8, most significant digit, bit 4 |
| DISTH4 | Fault locator BCD H4, most significant digit, bit 3 |
| DISTH2 | Fault locator BCD H2, most significant digit, bit 2 |
| DISTH1 | Fault locator BCD H1, most significant digit, bit 1 |
| DISTL8 | Fault locator BCD L8, least significant digit, bit 4 |
| DISTL4 | Fault locator BCD L4, least significant digit, bit 3 |
| DISTL2 | Fault locator BCD L2, least significant digit, bit 2 |
| DISTL1 | Fault locator BCD L1, least significant digit, bit 1 |
| DISTOK | Fault locator distance Ok |

## 6.5 Setting parameters

Setting parameters for the resistive and reactive reach are presented for the terminals with rated current Ir= 1A. All impedance values should be divided by 5 for the terminals with rated current Ir= 5 A.

**Table 304: Settings for the fault locator FLOC (FLOC-) function (Line reference)**

| Parameter | Range | Default | Unit | Parameter description |
|---|---|---|---|---|
| Length unit | km, mile | km | km, mile | Line length unit in km or mile |
| Line length | 0.00 - 10000.00<br>Step: 0.01 | 40.00 | - | Line length value in present length unit |
| X1 | 0.001 - 1500.000<br>Step: 0.001 | 12.000 | ohm/phase | Positive sequence line reactance |
| R1 | 0.001 - 1500.000<br>Step: 0.001 | 2.000 | ohm/phase | Positive sequence line resistance |
| X0 | 0.001 - 1500.000<br>Step: 0.001 | 48.000 | ohm/phase | Zero sequence line reactance |
| R0 | 0.001 - 1500.000<br>Step: 0.001 | 8.000 | ohm/phase | Zero sequence line resistance |
| X1SA | 0.001 - 1500.000<br>Step: 0.001 | 12.000 | ohm/phase | Positive sequence source reactance, near end |
| R1SA | 0.001 - 1500.000<br>Step: 0.001 | 2.000 | ohm/phase | Positive sequence source resistance, near end |
| X1SB | 0.001 - 1500.000<br>Step: 0.001 | 12.000 | ohm/phase | Positive sequence source reactance, far end |

| Parameter | Range | Default | Unit | Parameter description |
|---|---|---|---|---|
| R1SB | 0.001 - 1500.000<br>Step: 0.001 | 2.000 | ohm/phase | Positive sequence source resistance, far end |
| Xm0 | 0.001 - 1500.000<br>Step: 0.001 | 0.000 | ohm/phase | Mutual reactance from parallel line |
| Rm0 | 0.001 - 1500.000<br>Step: 0.001 | 0.000 | ohm/phase | Mutual resistance from parallel line |

## 6.6 Technical data

**Table 305: FLOC - Fault locator**

<table>
<tr><th colspan="3">Function</th><th>Setting range</th><th>Accuracy</th></tr>
<tr><td rowspan="3">Distance to fault locator</td><td rowspan="2">Reach for $I_r$ =1 A</td><td>Resistive direction</td><td>(0 - 1500) ohm/ phase</td><td rowspan="3">+/- 2.5 % (typical)</td></tr>
<tr><td>Reactive direction</td><td>(0 - 1500) ohm/ phase</td></tr>
<tr><td colspan="2">Phase selection</td><td>According to input signals</td></tr>
</table>

# 7 Trip value recorder

## 7.1 Application

Use the trip value recorder to record fault and prefault phasor values of voltages and currents to  be used in detailed analysis of the severity of the fault and the phases that are involved. The recorded values can also be used to simulate the fault with a test set.

## 7.2 Design

Pre-fault and fault phasors of currents and voltages are filtered from disturbance data stored in digital sample buffers.

When the disturbance report function is triggered, the function looks for non-periodic change in the analog channels. Once the fault interception is found, the function calculates the pre-fault RMS values during one period starting 1,5 period before the fault interception. The fault values are calculated starting a few samples after the fault interception and uses samples during 1/2 - 2 periods depending on the waveform.

If no error sample is found the trigger sample is used as the start sample for the calculations. The estimation is based on samples one period before the trigger sample. In this case the calculated values are used both as pre-fault and fault values.

The recording can be viewed on the local HMI or via SMS.

# 8 Monitoring of AC analogue measurements

## 8.1 Application

Alarm limits can be set and used as triggers, i.e. to generate trip signals. The software functions to support presentation of measured values are always present in the terminal. In order to retrieve actual values, however, the terminal must be equipped with the appropriate hardware measuring module(s).

Use the AC monitoring function to provide three phase or single phase values of voltage and current. At three phase measurement, the values of apparent power, active power, reactive power, frequency and the RMS voltage and current for each phase are calculated. Also the average values of currents and voltages are calculated.

## 8.2 Functionality

The AC monitoring function provides three phase or single phase values of voltage and current. At three phase measurement, the values of active power, reactive power, apparent power, frequency and the RMS voltage and current for each phase can be calculated. Alarm limits can be set and used as triggers, i.e. to generate trip signals.

The software functions to support presentation of measured values are always present in the terminal. In order to retrieve actual values, however, the terminal must be equipped with the appropriate hardware measuring module(s).

## 8.3 Function block

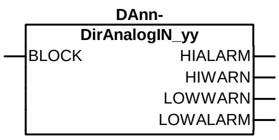



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**Table 306: AC monitoring function block types**

| Instance name<br>( DAnn- ) | Function block name | Description |
|---|---|---|
| DA01- | DirAnalogIn_U1 | Input voltage U1 |
| DA02- | DirAnalogIn_U2 | Input voltage U2 |
| DA03- | DirAnalogIn_U3 | Input voltage U3 |
| DA04- | DirAnalogIn_U4 | Input voltage U4 |
| DA05- | DirAnalogIn_U5 | Input voltage U5 |
| DA06- | DirAnalogIn_I1 | Input current I1 |
| DA07- | DirAnalogIn_I2 | Input current I2 |
| DA08- | DirAnalogIn_I3 | Input current I3 |
| DA09- | DirAnalogIn_I4 | Input current I4 |
| DA10- | DirAnalogIn_I5 | Input current I5 |
| DA11- | DirAnalogIn_U | Mean value U of the three phase to phase voltages calculated from U1, U2 and U3 |
| DA12- | DirAnalogIn_I | Mean value I of the three currents I1,I2 and I3 |
| DA13- | DirAnalogIn_P | Three phase active power P measured by the first three voltage and current inputs |
| DA14- | DirAnalogIn_Q | Three phase reactive power Q measured by the first three voltage and current inputs |
| DA15- | DirAnalogIn_f | Mean value of frequency f as measured by the voltage inputs U1, U2 and U3 |
| DA16- | DirAnalogIn_S | Three phase apparent power S measured by the first three voltage and current inputs |

## 8.4 Input and output signals

**Table 307: Input signals for the AC monitoring (DAnn-) function block**

| Signal | Description |
|---|---|
| BLOCK | Block updating of value for measured quantity |

**Table 308: Output signals for the AC monitoring (DAnn-) function block**

| Signal | Description |
|---|---|
| HIALARM | High Alarm for measured quantity |
| HIWARN | High Warning for measured quantity |
| LOWWARN | Low Warning for measured quantity |
| LOWALARM | Low Alarm for measured quantity |

## 8.5 Setting parameters

**Table 309: Setting parameters for the AC monitoring (DAnn-) function block**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| | | | | **For each voltage input channels U1 - U5: DA01--DA05** |
| Operation | Off, On | Off | - | Operating mode for DAnn function |
| Hysteres | 0.0-1999.9<br>Step: 0.1 | 5.0 | kV | Alarm hysteres for U1 - U5 |
| EnAlRem | Off, On | On | - | Immediate event when an alarm is disabled for U1 - U5 (produces an immediate event at reset of any alarm monitoring element, when On) |
| EnAlarms | Off, On | On | - | Set to ’On’ to activate alarm supervision for U1 - U5 (produces an immediate event at operation of any alarm monitoring element, when On) |
| HiAlarm | 0.0-1999.9<br>Step: 0.1 | 220.0 | kV | High Alarm level for U1 - U5 |
| HiWarn | 0.0-1999.9<br>Step: 0.1 | 210.0 | kV | High Warning level for U1 - U5 |
| LowWarn | 0.0-1999.9<br>Step: 0.1 | 170.0 | kV | Low Warning level for U1 - U5 |
| LowAlarm | 0.0-1999.9<br>Step. 0.1 | 160.0 | kV | Low Alarm level for U1 - U5 |

| **Parameter** | **Range** | **Default** | **Unit** | **Description** |
|---|---|---|---|---|
| RepInt | 0-3600<br>Step: 1 | 0 | s | Time between reports for U1 - U5 in seconds. Zero = Off (duration of time interval between two reports at periodic reporting function. Setting to 0 disables the periodic reporting) |
| EnDeadB | Off, On | Off | - | Enable amplitude dead band supervision for U1 - U5 |
| DeadBand | 0.0-1999.9<br>Step: 0.1 | 5.0 | kV | Amplitude dead band for U1 - U5 |
| EnIDeadB | Off, On | Off | - | Enable integrating dead band supervision for U1 - U5 |
| IDeadB | 0.0-1999.9<br>Step: 0.1 | 10.0 | kV | Integrating dead band for U1 - U5 |
| EnDeadBP | Off, On | Off | - | Enable periodic dead band reporting U1 - U5 |
| | | | | |
| | | | | **For each current input channels I1 - I5: DA06 - DA10** |
| Operation | Off, On | Off | - | Operating mode for DAnn function |
| Hysteres | 0-99999<br>Step: 1 | 50 | A | Alarm hysteresis for I1 - I5 |
| EnAlRem | Off, On | On | - | Immediate event when an alarm is disabled for I1 - I5 (produces an immediate event at reset of any alarm monitoring element, when On) |
| EnAlarms | Off, On | Off | - | Set to 'On' to activate alarm supervision for I1 - I5 (produces an immediate event at operation of any alarm monitoring element, when On) |
| HiAlarm | 0-99999<br>Step: 1 | 900 | A | High Alarm level for I1 - I5 |
| HiWarn | 0-99999<br>Step: 1 | 800 | A | High Warning level for I1 - I5 |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| LowWarn | 0-99999<br>Step: 1 | 200 | A | Low Warning level for I1 - I5 |
| LowAlarm | 0-99999<br>Step: 1 | 100 | A | Low Alarm level for I1 - I5 |
| RepInt | 0-3600<br>Step: 1 | 0 | s | Time between reports for I1 - I5 in seconds. Zero = Off (duration of time interval between two reports at periodic reporting function. Setting to 0 disables the periodic reporting) |
| EnDeadB | Off, On | Off | - | Enable amplitude dead band supervision for I1 - I5 |
| DeadBand | 0-99999<br>Step: 1 | 50 | A | Amplitude dead band for I1 - I5 |
| EnIDeadB | Off, On | Off | - | Enable integrating dead band supervision for I1 - I5 |
| IDeadB | 0-99999<br>Step: 1 | 10000 | A | Integrating dead band for I1 - I5 |
| EnDeadBP | Off, On | Off | - | Enable periodic dead band reporting I1 - I5 |
| | | | | |
| | | | | **Mean phase-to-phase voltage measuring channel U: DA11-** |
| Operation | Off, On | Off | - | Operating mode for DAnn function |
| Hysteres | 0.0-1999.9<br>Step: 0.1 | 5.0 | kV | Alarm hysteresis for U |
| EnAlRem | Off, On | On | - | Immediate event when an alarm is disabled for U (produces an immediate event at reset of any alarm monitoring element, when On) |
| EnAlarms | Off, On | On | - | Set to ’On’ to activate alarm supervision for U (produces an immediate event at operation of any alarm monitoring element, when On) |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| HiAlarm | 0.0-1999.9<br>Step: 0.1 | 220.0 | kV | High Alarm level for U |
| HiWarn | 0.0-1999.9<br>Step: 0.1 | 210.0 | kV | High Warning level for U |
| LowWarn | 0.0-1999.9<br>Step: 0.1 | 170.0 | kV | Low Warning level for U |
| LowAlarm | 0.0-1999.9<br>Step: 0.1 | 160.0 | kV | Low Alarm level for U |
| RepInt | 0-3600<br>Step: 1 | 0 | s | Time between reports for U in seconds. Zero = Off (duration of time interval between two reports at periodic reporting function. Setting to 0 disables the periodic reporting |
| EnDeadB | Off, On | Off | - | Enable amplitude dead band supervision for U |
| DeadBand | 0.0-1999.9<br>Step: 0.1 | 5.0 | kV | Amplitude dead band for U |
| EnIDeadB | Off, On | Off | - | Enable integrating dead band supervision for U |
| IDeadB | 0.0-1999.9<br>Step: 0.1 | 10.0 | kV | Integrating dead band for U |
| EnDeadBP | Off, On | Off | - | Enable periodic dead band reporting U |
| | | | | |
| | | | | **Mean current measuring channel I**: **DA12-** |
| Operation | Off, On | Off | - | Operating mode for DAnn function |
| Hysteres | 0-99999<br>Step: 1 | 50 | A | Alarm hysteresis for I |
| EnAlRem | Off, On | On | - | Immediate event when an alarm is disabled for I (produces an immediate event at reset of any alarm monitoring element, when On) |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| EnAlarms | Off, On | Off | - | Set to 'On' to activate alarm supervision for I (produces an immediate event at operation of any alarm monitoring element, when On) |
| HiAlarm | 0-99999<br>Step: 1 | 900 | A | High Alarm level for I |
| HiWarn | 0-99999<br>Step: 1 | 800 | A | High Warning level for I |
| LowWarn | 0-99999<br>Step: 1 | 200 | A | Low Warning level for I |
| LowAlarm | 0-99999<br>Step: 1 | 100 | A | Low Alarm level for I |
| RepInt | 0-3600<br>Step: 1 | 0 | s | Time between reports for I in seconds. Zero = Off (duration of time interval between two reports at periodic reporting function. Setting to 0 disables the periodic reporting) |
| EnDeadB | Off, On | Off | - | Enable amplitude dead band supervision for I |
| DeadBand | 0-99999<br>Step: 1 | 50 | A | Amplitude dead band for I |
| EnIDeadB | Off, On | Off | - | Enable integrating dead band supervision for I |
| IDeadB | 0-99999<br>Step: 1 | 10000 | A | Integrating dead band for I |
| EnDeadBP | Off, On | Off | - | Enable periodic dead band reporting I |
| | | | | |
| | | | | **Active power measuring channel P: DA13-** |
| Operation | Off, On | Off | - | Operating mode for DAnn function |
| Hysteres | 0.0-9999.9<br>Step. 0.1 | 5.0 | MW | Alarm hysteresis for P |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| EnAlRem | Off, On | On | - | Immediate event when an alarm is disabled for P (produces an immediate event at reset of any alarm monitoring element, when On) |
| EnAlarms | Off, On | Off | - | Set to 'On' to activate alarm supervision for P (produces an immediate event at operation of any alarm monitoring element, when On) |
| HiAlarm | 0.0-9999.9<br>Step: 0.1 | 300.0 | MW | High Alarm level for P |
| HiWarn | 0.0-9999.9<br>Step: 0.1 | 200.0 | MW | High Warning level for P |
| LowWarn | 0.0-9999.9<br>Step: 0.1 | 80.0 | MW | Low Warning level for P |
| LowAlarm | 0.0-9999.9<br>Step: 0.1 | 50.0 | MW | Low Alarm level for P |
| RepInt | 0-3600<br>Step: 1 | 0 | s | Time between reports for P in seconds. Zero = Off (duration of time interval between two reports at periodic reporting function. Setting to 0 disables the periodic reporting) |
| EnDeadB | Off, On | Off | - | Enable amplitude dead band supervision for P |
| DeadBand | 0.0-9999.9<br>Step: 0.1 | 1.0 | MW | Amplitude dead band for P |
| EnIDeadB | Off, On | Off | - | Enable integrating dead band supervision for P |
| IDeadB | 0.0-9999.9<br>Step: 0.1 | 10.0 | MW | Integrating dead band for P |
| EnDeadBP | Off, On | Off | - | Enable periodic dead band reporting P |
| | | | | |
| | | | | **Reactive power measuring channel Q: DA14-** |
| Operation | Off, On | Off | - | Operating mode for DAnn function |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Hysteres | 0.0-9999.9 Step: 0.1 | 5.0 | Mvar | Alarm hysteresis for Q |
| EnAlRem | Off, On | On | - | Immediate event when an alarm is disabled for Q (produces an immediate event at reset of any alarm monitoring element, when On) |
| EnAlarms | Off, On | Off | - | Set to ’On’ to activate alarm supervision for Q (produces an immediate event at operation of any alarm monitoring element, when On) |
| HiAlarm | 0.0-9999.9 Step: 0.1 | 300.0 | Mvar | High Alarm level for Q |
| HiWarn | 0.0-9999.9 Step: 0.1 | 200.0 | Mvar | High Warning level for Q |
| LowWarn | 0.0-9999.9 Step: 0.1 | 80.0 | Mvar | Low Warning level for Q |
| LowAlarm | 0.0-9999.9 Step: 0.1 | 50.0 | Mvar | Low Alarm level for Q |
| RepInt | 0-3600 Step: 1 | 0 | s | Time between reports for Q in seconds. Zero = Off (duration of time interval between two reports at periodic reporting function. Setting to 0 disables the periodic reporting) |
| EnDeadB | Off, On | Off | - | Enable amplitude dead band supervision for Q |
| DeadBand | 0.0-9999.9 Step: 0.1 | 1.0 | Mvar | Amplitude dead band for Q |
| EnIDeadB | Off, On | Off | - | Enable integrating dead band supervision for Q |
| IDeadB | 0.0-9999.9 Step: 0.1 | 10.0 | Mvar | Integrating dead band for Q |
| EnDeadBP | Off, On | Off | - | Enable periodic dead band reporting Q |
| | | | | **Frequency measuring channel f: DA15-** |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Operation | Off, On | Off | - | Operating mode for DAnn function |
| Hysteres | 0.0-99.9<br>Step: 0.1 | 1.0 | Hz | Alarm hysteresis for f |
| EnAlRem | Off, On | On | - | Immediate event when an alarm is disabled for f (produces an immediate event at reset of any alarm monitoring element, when On) |
| EnAlarms | Off, On | Off | - | Set to 'On' to activate alarm supervision for f (produces an immediate event at operation of any alarm monitoring element, when On) |
| HiAlarm | 0.0-99.9<br>Step: 0.1 | 55.0 | Hz | High Alarm level for f |
| HiWarn | 0.0-99.9<br>Step: 0.1 | 53.0 | Hz | High Warning level for f |
| LowWarn | 0.0-99.9<br>Step: 0.1 | 47.0 | Hz | Low Warning level for f |
| LowAlarm | 0.0-99.9<br>Step: 0.1 | 45.0 | Hz | Low Alarm level for f |
| RepInt | 0-3600<br>Step: 1 | 0 | s | Time between reports for f in seconds. Zero = Off (duration of time interval between two reports at periodic reporting function. Setting to 0 disables the periodic reporting) |
| EnDeadB | Off, On | Off | - | Enable amplitude dead band supervision for f |
| DeadBand | 0.0-99.9<br>Step: 0.1 | 1.0 | Hz | Amplitude dead band for f |
| EnIDeadB | Off, On | Off | | Enable integrating dead band supervision for f |
| IDeadB | 0.0-99.9<br>Step: 0.1 | 5 | Hz | Integrating dead band for f |
| EnDeadBP | Off, On | Off | - | Enable periodic dead band reporting f |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| | | | | |
| | | | | **Apparent power measuring channel S: DA16-** |
| Operation | Off, On | Off | - | Operating mode for DAnn function |
| Hysteres | 0.0-9999.9<br>Step: 0.1 | 5.0 | MVA | Alarm hysteresis for S |
| EnAlRem | Off, On | On | - | Immediate event when an alarm is disabled for S (produces an immediate event at reset of any alarm monitoring element, when On) |
| EnAlarms | Off, On | Off | - | Set to 'On' to activate alarm supervision for S (produces an immediate event at operation of any alarm monitoring element, when On) |
| HiAlarm | 0.0-9999.9<br>Step: 0.1 | 300.0 | MVA | High Alarm level for S |
| HiWarn | 0.0-9999.9<br>Step: 0.1 | 200.0 | MVA | High Warning level for S |
| LowWarn | 0.0-9999.9<br>Step: 0.1 | 80.0 | MVA | Low Warning level for S |
| LowAlarm | 0.0-9999.9<br>Step: 0.1 | 50.0 | MVA | Low Alarm level for S |
| RepInt | 0-3600<br>Step: 1 | 0 | s | Time between reports for S in seconds. Zero = Off (duration of time interval between two reports at periodic reporting function. Setting to 0 disables the periodic reporting) |
| EnDeadB | Off, On | Off | - | Enable amplitude dead band supervision for S |
| DeadBand | 0.0-9999.9<br>Step: 0.1 | 1.0 | MVA | Amplitude dead band for S |
| EnIDeadB | Off, On | Off | - | Enable integrating dead band supervision for S |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| IDeadB | 0.0-9999.9<br>Step: 0.1 | 10.0 | MVA | Integrating dead band for S |
| EnDeadBP | Off, On | Off | - | Enable periodic dead band reporting S |
| | | | | |
| | | | | **Reporting of events to the station control system (SCS) through LON port**: |
| EventMask U1 | No Events, Report Events | No Events | - | Enables (Report Events) or disables (No Events) the reporting of events from channel DA01 to the SCS |
| EventMask U2 | No Events, Report Events | No Events | - | Enables (Report Events) or disables (No Events) the reporting of events from channel DA02 to the SCS |
| EventMask U3 | No Events, Report Events | No Events | - | Enables (Report Events) or disables (No Events) the reporting of events from channel DA03 to the SCS |
| EventMask U4 | No Events, Report Events | No Events | - | Enables (Report Events) or disables (No Events) the reporting of events from channel DA04 to the SCS |
| EventMask U5 | No Events, Report Events | No Events | - | Enables (Report Events) or disables (No Events) the reporting of events from channel DA05 to the SCS |
| EventMask I1 | No Events, Report Events | No Events | - | Enables (Report Events) or disables (No Events) the reporting of events from channel DA06 to the SCS |
| EventMask I2 | No Events, Report Events | No Events | - | Enables (Report Events) or disables (No Events) the reporting of events from channel DA07 to the SCS |
| EventMask I3 | No Events, Report Events | No Events | - | Enables (Report Events) or disables (No Events) the reporting of events from channel DA08 to the SCS |
| EventMask I4 | No Events, Report Events | No Events | - | Enables (Report Events) or disables (No Events) the reporting of events from channel DA09 to the SCS |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| EventMask I5 | No Events, Report Events | No Events | - | Enables (Report Events) or disables (No Events) the reporting of events from channel DA10 to the SCS |
| EventMask U | No Events, Report Events | No Events | - | Enables (Report Events) or disables (No Events) the reporting of events from channel DA11 to the SCS |
| EventMask I | No Events, Report Events | No Events | - | Enables (Report Events) or disables (No Events) the reporting of events from channel DA12 to the SCS |
| EventMask P | No Events, Report Events | No Events | - | Enables (Report Events) or disables (No Events) the reporting of events from channel DA13 to the SCS |
| EventMask Q | No Events, Report Events | No Events | - | Enables (Report Events) or disables (No Events) the reporting of events from channel DA14 to the SCS |
| EventMask f | No Events, Report Events | No Events | - | Enables (Report Events) or disables (No Events) the reporting of events from channel DA15 to the SCS |
| EventMask S | No Events, Report Events | No Events | - | Enables (Report Events) or disables (No Events) the reporting of events from channel DA16 to the SCS |

## 8.6 Technical data

**Table 310: Mean values**

| Function | Nominal range | Accuracy |
|---|---|---|
| Frequency | (0.95 - 1.05) x $f_r$ | +/- 0.2 Hz |
| Voltage (RMS) Ph-Ph | (0.1 - 1.5) x $U_r$ | +/- 2.5% of $U_r$, at $U \leq U_r$<br>+/- 2.5% of U, at $U > U_r$ |
| Current (RMS) | (0.2 - 4) x $I_r$ | +/- 2.5% of $I_r$, at $I \leq I_r$<br>+/- 2.5% of I, at $I > I_r$ |
| Active power*) | at $\lvert\cos \varphi\rvert \geq 0.9$ | +/- 5% |
| Reactive power*) | at $\lvert\cos \varphi\rvert \leq 0.8$ | +/- 7.5% |
| *) Measured at $U_r$ and 20% of $I_r$ | | |

# 9 Monitoring of DC analogue measurements

## 9.1 Application

Alarm limits can be set and used as triggers, i.e. to generate trip signals. The software functions to support presentation of measured values are always present in the terminal. In order to retrieve actual values, however, the terminal must be equipped with the appropriate hardware measuring module(s).

Use the DC monitoring function to measure and process signals from different measuring transducers. Many devices used in process control uses low currents, usually in the range 4-20 mA or 0-20 mA to represent low frequency, near dc signals. The terminal can be equipped with analogue inputs for such signals, function blocks MI11-MI66, in the mA range.

## 9.2 Function block

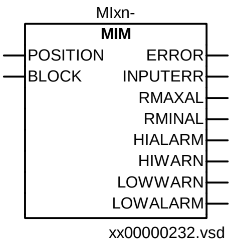



*Figure 134: A MIM module (mA input module) has six input channels. Each channel has a function block, MIxn-, where x=(1-6) is the number of the MIM module, and n=(1-6) is the number of the channel.*

## 9.3 Input and output signals

**Table 311: Input signals for the MIM (MIxn-) function block**

| Signal | Description |
|---|---|
| POSITION | I/O module slot position connector. Only present in first instance of block for each present input module. |
| BLOCK | Block value updating |

**Table 312: Output signals for the MIM (MIxn-) function block**

| Signal | Description |
|---|---|
| ERROR | Module fail. Only present in first instance of block for each present input module. |
| INPUTERR | Input error |
| RMAXAL | Upper range limit reached |
| HIALARM | Input high alarm limit reached |
| HIWARN | Input high warning limit reached |
| LOWWARN | Input low warning limit reached |
| LOWALARM | Input low alarm limit reached |
| RMINAL | Lower range limit reached |

## 9.4 Setting parameters

### Setting table for a generic mA input module MIM

**Table 313: Module parameter**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| SampRate | 5-255<br>Step: 1 | 5 | Hz | Sampling Rate for mA Input Module x |

**Table 314: Input n, where n = 1 - 6**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| Name | 0-13 | MIx*n* -Value | Char | User defined name for input *n* in module x. String length up to 13 characters, all characters available on the HMI can be used |
| Operation | Off, On | Off | - | Input *n* |
| Calib | Off, On | On | - | Set to ’On’ to use production calibration for Input *n* |
| ChSign | Off, On | Off | - | Set to ’On’ if sign of Input *n* shall be changed |
| Unit | 0-5 | Unit *n* | Char | State a 5 character unit name for Input *n* |

| **Parameter** | **Range** | **Default** | **Unit** | **Description** |
|---|---|---|---|---|
| Hysteres | 0.0-20.0<br>Step: 0.1 | 1.0 | mA | Alarm hysteresis for Input *n* |
| EnAlRem | Off, On | Off | - | Immediate event when an alarm is removed for Input *n* |
| I_Max | -25.00-25.00<br>Step: 0.01 | 20.00 | mA | Max current of transducer to Input *n* |
| I_Min | -25.00-25.00<br>Step: 0.01 | 4.00 | mA | Min current of transducer to Input *n* |
| EnAlarm | Off, On | Off | - | Set to 'On' to activate alarm supervision for Input *n* |
| HiAlarm | -25.00-25.00<br>Step: 0.01 | 19.00 | mA | High Alarm level for Input *n* |
| HiWarn | -25.00-25.00<br>Step: 0.01 | 18.00 | mA | High Warning level for Input *n* |
| LowWarn | -25.00-25.00<br>Step: 0.01 | 6.00 | mA | Low warning level for Input *n* |
| LowAlarm | -25.00-25.00<br>Step: 0.01 | 5.00 | mA | Low Alarm level for Input *n* |
| RepInt | 0-3600<br>Step: 1 | 0 | s | Time between reports for Input *n* |
| EnDeadB | Off, On | Off | - | Enable amplitude dead band supervision for Input *n* |
| DeadBand | 0.00-20.00<br>Step: 0.01 | 1.00 | mA | Amplitude dead band for Input *n* |
| EnIDeadB | Off, On | Off | - | Enable integrating dead band supervision for Input *n* |

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| IDeadB | 0.00-1000.00<br>Step: 0.01 | 2.00 | mA | Integrating dead band for Input *n* |
| EnDeadBP | Off, On | Off | - | Enable periodic dead band reporting Input *n* |
| MaxValue | -1000.00-1000.00<br>Step: 0.01 | 20.00 | - | Max primary value corr. to I_Max, Input *n*. It determines the maximum value of the measuring transducer primary measuring quantity, which corresponds to the maximum permitted input current I_Max |
| MinValue | -1000.00-1000.00<br>Step: 0.01 | 4.00 | - | Min primary value corr. to I_Min, Input 1. It determines the minimum value of the measuring transducer primary measuring quantity, which corresponds to the minimum permitted input current I_Min |

## 9.5 Technical data

**Table 315: mA measuring function ( MIM )**

| Function | Setting range | Accuracy |
|---|---|---|
| mA measuring function | +/- 5, +/- 10, +/- 20 mA 0-5, 0-10, 0-20, 4-20 mA | +/- 0.1 % of set value +/-0.005 mA |
| Max current of transducer to input | (-25.00 to +25.00) mA in steps of 0.01 | |
| Min current of transducer to input | (-25.00 to +25.00) mA in steps of 0.01 | |
| High alarm level for input | (-25.00 to +25.00) mA in steps of 0.01 | |
| High warning level for input | (-25.00 to +25.00) mA in steps of 0.01 | |
| Low warning level for input | (-25.00 to +25.00) mA in steps of 0.01 | |
| Low alarm level for input | (-25.00 to +25.00) mA in steps of 0.01 | |
| Alarm hysteresis for input | (0-20) mA in steps of 1 | |
| Amplitude dead band for input | (0-20) mA in steps of 1 | |
| Integrating dead band for input | (0.00-1000.00) mA in steps of 0.01 | |

# 10 Increased measuring accuracy

## 10.1 Application

Select the increased accuracy option to increase the measuring accuracy of analog input channels, thus also increasing the accuracy of calculated quantities such as frequency, active and reactive power.

## 10.2 Functionality

The increased accuracy is reached by a factory calibration of the hardware. Calibration factors are stored in the terminal. If the transformer input module, A/D conversion module or the main processing module is replaced, the terminal must be factory calibrated again to retain the increased accuracy.

## 10.3 Technical data

**Table 316: Mean values with increased accuracy**

| Function | Nominal range | Accuracy |
|---|---|---|
| Frequency | (0.95 - 1.05) x $f_r$ | +/- 0.2 Hz |
| Voltage (RMS) Ph-Ph | (0.8 - 1.2) x $U_r$ | +/- 0.25% of $U_r$, at U<= $U_r$<br>+/- 0.25% of U, at U> $U_r$ |
| Current (RMS) | (0.2 - 2) x $I_r$ | +/- 0.25% of $I_r$, at I<= $I_r$<br>+/- 0.25% of I, at I> $I_r$ |
| Active power | 0.8 x $U_r$ < U < 1.2 x $U_r$<br>0.2 x $I_r$ < I < 2 x $I_r$<br>Active power, \|cosφ\|>= 0.9 | +/- 0.5% of $P_r$ at P <= $P_r$ *),<br>+/- 0.5% of P at P > $P_r$ *), |
| *) $P_r$: Active power at U = $U_r$ , I = Ir and \|cosφ\|= 1 | | |

# Chapter 12 Metering

**About this chapter**

This chapter describes the metering functions

# 1 Pulse counter logic (PC)

## 1.1 Application

The pulse counter logic function counts externally generated binary pulses, for instance pulses coming from an external energy meter, for calculation of energy consumption values. The pulses are captured by the binary input module and then read by the pulse counter function. The number of pulses in the counter is then reported via LON to the station control system or read via SPA from the station monitoring system as a service value.

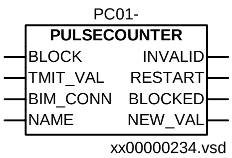
## 1.2 Design

Up to 12 inputs located on binary input modules can be used for counting of pulses with a frequency of up to 40 Hz. The registration of pulses is done for positive transitions (0 to 1) on any of the 16 binary input channels on the input module.

Pulse counter values are read from the operator workplace with predefined cyclicity without reset. The integration time period can be set in the range from 30 seconds to 60 minutes and is synchronized with absolute system time.

The counter value is a 32-bit, signed integer with a range 0...+2147483647. The reported value over the communication bus contains Identity, Value, Time and Pulse Counter Quality.

## 1.3 Function block



## 1.4 Input and output signals

**Table 317: Input signals for the PC (PCnn-) function block**

| Signal | Description |
|---|---|
| BLOCK | Block acquisition |
| TMIT_VAL | Asynchronous reading. Pulsing of this input makes an additional reading of the pulse input. Value is read at TMIT_VAL positive flank. |
| BIM_CONN | Binary input module connection used for pulse acquisition |
| NAME | User defined name. String length up to 19 characters. |

**Table 318: Output signals for the PC (PCnn-) function block**

| Signal | Description |
|---|---|
| INVALID | Set when used BIM fails or has wrong configuration |
| RESTART | Set if counter value does not comprise a full integration cycle for read report |
| BLOCKED | Set when BLOCK input is set or when the used BIM is inoperative |
| NEW_VAL | New value exists. Set if counter value has changed since last read report |

## 1.5 Setting parameters

**Table 319: Setting parameters for the pulse counter (PCnn-) functions**

| Parameter | Range | Default | Unit | Description |
|---|---|---|---|---|
| NAME | 0-19 | PCnn-NAME | Char | User defined name for pulse counter nn (nn = 01-12). String length up to 19 characters. Can only be set using the CAP 531 configuration tool. |
| Operation | Off, On | Off | - | Operating mode for PC function. Can only be set from PST. |
| CycleTime | 30 s, 1 min, 1min 30 s, 2 min, 2 min 30 s, 3 min, 4 min, 5 min, 6 min, 7 min30s, 10 min, 12min, 15 min, 20 min, 30 min, 60 min | 15min | - | Reporting of counter value cycle time in minutes and seconds. Can only be set from PST. |
| EventMasknn | No events, Report events | No events | - | Mask for analogue events from pulse counter nn. Can only be set from PST. |

## 1.6 Technical data

**Table 320: Pulse counter for metering**

| Function | Setting range | Accuracy |
|---|---|---|
| Input frequency | See Binary Input Module (BIM) | - |
| Cycle time for pulse counter | 30 s, 1 min, 1 min 30 s, 2 min, 2 min 30 s, 3 min, 4 min, 5 min, 6 min, 7 min 30s, 10 min, 12 min, 15 min, 20 min, 30 min, 60 min | +/- 0,1% of set value |

# Chapter 13 Hardware modules

**About this chapter**

This chapter describes the different hardware modules.

# 1 Modules

**Table 321: Basic, always included, modules**

| Module | Description |
|---|---|
| Combined backplane module (CBM) | Carries all internal signals between modules in a terminal. The size of the module depends on the size of the case. |
| Power supply module (PSM) | Available in two different versions, each including a regulated DC/DC converter that supplies auxiliary voltage to all static circuits.<br>• For case size 1/2x19" and 3/4x19" a version with four binary inputs and four binary outputs are used. An internal fail alarm output is also available.<br>• For case size 1/1x19" a version without binary I/O:s and increased output power is used. An internal fail alarm output is available. |
| Main processing module (MPM) | Module for overall application control. All information is processed or passed through this module, such as configuration, settings and communication. |
| Human machine interface (LCD-HMI) | The module consist of LED:s, a LCD, push buttons and an optical connector for a front connected PC |

**Table 322: Application specific modules**

| Module | Description |
|---|---|
| Signal processing module (SPM) | Module for protection algorithm processing. Carries up to 12 digital signal processors, performing all measuring functions. |
| Milliampere input module (MIM) | Analog input module with 6 independent, galvanically separated channels. |
| Binary input module (BIM) | Module with 16 optically isolated binary inputs |

| **Module** | **Description** |
|---|---|
| Binary output module (BOM) | Module with 24 single outputs or 12 double-pole command outputs including supervision function |
| Binary I/O module (IOM) | Module with 8 optically isolated binary inputs, 10 outputs and 2 fast signalling outputs. |
| Data communication modules (DCMs) | Modules used for digital communication between remote ends. |
| Transformer input module (TRM) | Used for galvanic separation of voltage and/or current process signals and the internal circuitry. |
| A/D conversion module (ADM) | Used for analog to digital conversion of analog process signals galvanically separated by the TRM. |
| Optical receiver module (ORM) | Used to interface process signals from optical instrument transformers. |
| Serial communication module (SCM) | Used for SPA/LON/IEC communication |
| LED module (LED-HMI) | Module with 18 user configurable LEDs for indication purposes |

# 2 Transformer input module (TRM)

## 2.1 Design

A transformer input module can have up to 10 input transformers. The actual number depends on the type of terminal. Terminals including only current measuring functions only have current inputs. Fully equipped the transformer module consists of:

- Five voltage transformers that cover a rated range from 100 to 125 V or 220 V.
- Five current transformers with rated current 1 A or 5 A.

The inputs are mainly used for:

- Three phase currents
- Residual current of the protected line
- Residual current of the parallel circuit (if any) for compensation of the effect of the zero sequence mutual impedance on the fault locator measurement or residual current of the protected line but from a parallel core used for CT circuit supervision function or independent earth fault function.
- Three phase voltages
- Open delta voltage for the protected line (for an optional directional earth-fault protection)
- Phase voltage for an optional synchronism and energizing check.

## 2.2 Technical data

**Table 323: Energising quantities, rated values and limits**

| Quantity | Rated value | Nominal range |
|---|---|---|
| Current | $I_r$ = 1 or 5 A | $(0.2\text{-}30) \times I_r$ , |
| | $I_r$ = 0.1, 0.5, 1 or 5 A for $I_5$ | $(0.2\text{-}15) \times I_r$ for line differential function |
| Operation range | $(0.004\text{-}100) \times I_r$ | |
| Permissive overload | $4 \times I_r$ cont. | |
| | $100 \times I_r$ for 1 s $^{*)}$ | |
| Burden | < 0.25 VA at $I_r$=1 or 5 A | |
| | < 0.02 VA at $I_r$=0.1 or 0.5 A | |

| **Quantity** | **Rated value** | **Nominal range** |
|---|---|---|
| Ac voltage Ph-Ph | $U_r$ = 100/110/115/120 V | (80-120) % of $U_r$ |
| | $U_r$ = 200/220/230/240 V | |
| Operation range | (0.001-1.5) x $U_r$ | |
| Permissive overload | 1.5 × $U_r$ cont. | |
| | 2.5 × $U_r$ for 1 s | |
| Burden | < 0.2 VA at $U_r$ | |
| Frequency | $f_r$ = 50/60 Hz | +/- 5 % |
| *) max. 350 A for 1 s when COMBITEST test switch is included | | |

# 3 A/D-conversion module (ADM)

## 3.1 Design

The inputs of the A/D-conversion module (ADM) is fed with voltage and current signals from the transformer module. The current signals are adapted to the electronic voltage level with shunts. To gain dynamic range for the current inputs, two shunts with separate A/D channels are used for each input current. By that a 16-bit dynamic range is obtained with a 12 bits A/D converter.

The input signals passes an anti aliasing filter with a cut-off frequency of 500 Hz.

Each input signal (5 voltages and 5 currents) is sampled with a sampling frequency of 2 kHz.

The A/D-converted signals are band-pass filtered with a cut-off frequency of 250 Hz and down-sampled to 1 kHz in a digital signal processor (DSP) before transmitted to the main processing module.

# 4 Binary I/O capabilities

## 4.1 Application

Input channels with high EMI immunity can be used as binary input signals to any function. Signals can also be used in disturbance or event recording. This enables extensive monitoring and evaluation of the operation of the terminal and associated electrical circuits.

## 4.2 Design

Inputs are designed to allow oxide burn-off from connected contacts. This is achieved with a high peak inrush current while having a low steady-state current. Inputs are debounced by software.

Well defined input high and input low voltages ensures normal operation at battery supply earth faults.

The voltage level of the inputs is selected when ordering.

I/O events are time stamped locally on each module for minimum time deviance and stored by the event recorder if present.

## 4.3 Technical data

**Table 324: Binary inputs**

| **Inputs** | **RL24** | **RL48** | **RL110** | **RL220** |
|---|---|---|---|---|
| Binary inputs | BIM: 16, IOM: 8, PSM: 4 | | | |
| Debounce frequency | 5 Hz (BIM), 1 Hz (IOM) | | | |
| Oscillating signal discriminator.* | Blocking and release settable between 1-40 Hz | | | |
| Binary input voltage RL | 24/30 VDC<br>+/-20% | 48/60 VDC<br>+/-20% | 110/125 VDC<br>+/-20% | 220/250 VDC<br>+/-20% |
| Power consumption (max.) | 0.05 W/input | 0.1 W/input | 0.2 W/input | 0.4 W/input |
| *) Only available for BIM | | | | |

**Table 325: Binary outputs**

| **Function or quantity** | | **Trip and Signal relays** | **Fast signal relays** |
|---|---|---|---|
| Binary outputs | | BOM: 24, IOM: 10, PSM: 4 | IOM: 2 |
| Max system voltage | | 250 V AC, DC | 250 V AC, DC |
| Test voltage across open contact, 1 min | | 1000 V rms | 800 V DC |
| Current carrying capacity | Continuous | 8 A | 8 A |
| | 1 s | 10 A | 10 A |
| Making capacity at inductive load with L/R>10 ms | 0.2 s | 30 A | 0.4 A |
| | 1.0 s | 10 A | 0.4 A |
| Breaking capacity for AC, cos φ>0.4 | | 250 V/8.0 A | 250 V/8.0 A |
| Breaking capacity for DC with L/R<40ms | | 48 V/1 A | 48 V/1 A |
| | | 110 V/0.4 A | 110 V/0.4 A |
| | | 220 V/0.2 A | 220 V/0.2 A |
| | | 250 V/0.15 A | 250 V/0.15 A |
| Maximum capacitive load | | - | 10 nF |

# 5 Binary input module (BIM)

## 5.1 Application

Use the binary input module, BIM, when a large amount of input channels is needed. The BIM is available in two versions, one standard and one with enhanced pulse counting inputs to be used with the pulse counter function.

## 5.2 Design

The binary input module, BIM, has 16 optically isolated binary inputs.

A signal discriminator detects and blocks oscillating signals. When blocked, a hysteresis function may be set to release the input at a chosen frequency, making it possible to use the input for pulse counting. The blocking frequency may also be set.

## 5.3 Function block

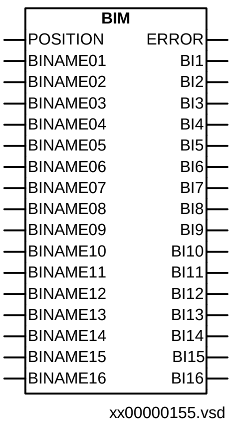



*Figure 135: Binary input module*

## 5.4 Input and output signals

**Table 326: Input signals for binary input module BIM**

| Signal | Description |
|---|---|
| POSITION | I/O module slot position |
| BINAME01-BINAME16 | Input name string settings |

**Table 327: Output signals for binary input module BIM**

| Signal | Description |
|---|---|
| ERROR | Binary module fail |
| BI1-BI16 | Binary input data |

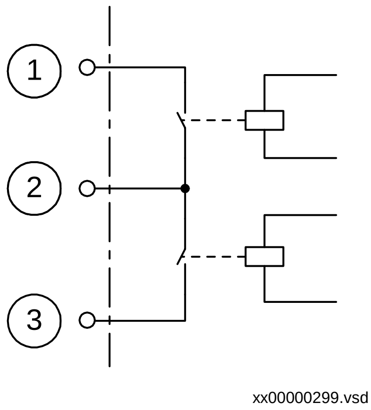
# 6 Binary output module (BOM)

## 6.1 Application

Use the binary output module, BOM, for trip output or any signalling purpose when a large amount of outputs is needed.

## 6.2 Design

The binary output module, BOM, has 24 software supervised output relays, pairwise connected to be used as single-output channels with a common or as command output channels.




| | |
|---|---|
| 1 | Output connection from relay 1 |
| 2 | Common input connection |
| 3 | Output connection from relay 2 |

*Figure 136: Relay pair example*

## 6.3 Function block

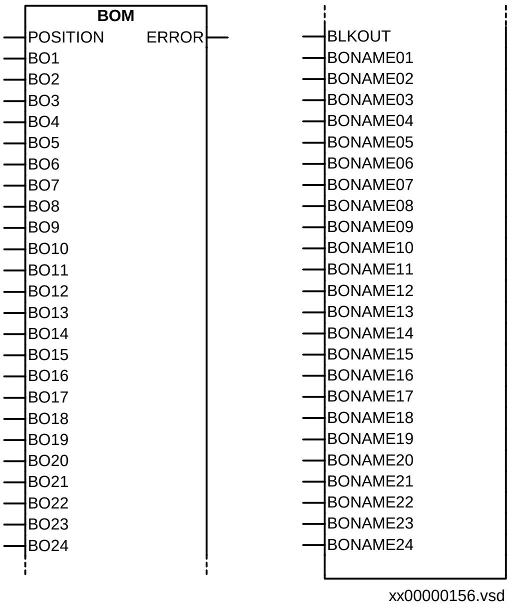



*Figure 137: Binary output module*

## 6.4 Input and output signals

**Table 328: Input signals for binary output module BOM**

| Signal | Description |
|---|---|
| POSITION | I/O module slot position |
| BO1-BO24 | Binary output data |
| BLKOUT | Block output signals |
| BONAME01-BONAME24 | Output name string settings |

**Table 329: Output signals for binary output module BOM**

| Signal | Description |
|---|---|
| ERROR | Binary module fail |

# 7 I/O module (IOM)

## 7.1 Application

Use the binary I/O module, IOM, when few input and output channels is needed. The ten output channels are used for trip output or any signalling purpose. The two high speed signal output channels are used for applications where short operating time is essential, for example time synchronization.

## 7.2 Design

The binary I/O module, IOM, has eight optically isolated inputs and ten output relays. One of the outputs has a change-over contact. The nine remaining output contacts are connected in two groups. One group has five contacts with a common and the other group has four contacts with a common, to be used as single-output channels.

The binary I/O module also has two high speed output channels where a reed relay is connected in parallel to the standard output relay.

## 7.3 Function block

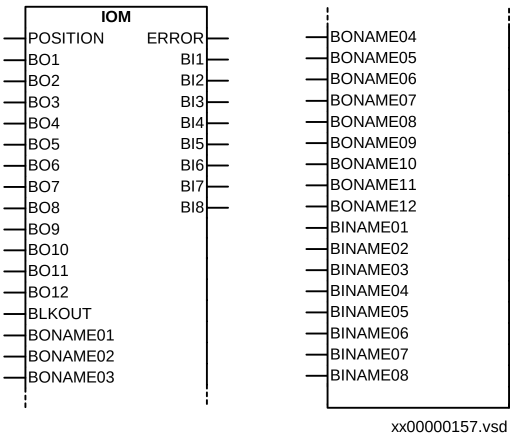



*Figure 138: I/O module*

## 7.4 Input and output signals

**Table 330: Input signals for I/O module IOM**

| Signal | Description |
|---|---|
| POSITION | I/O module slot position |
| BO1-BO12 | Binary output data |
| BLKOUT | Block output signals |
| BONAME01-BONAME12 | Output name string settings |
| BINAME01-BINAME08 | Input name string settings |

**Table 331: Output signals for I/O module IOM**

| Signal | Description |
|---|---|
| ERROR | Binary module fail |
| BI1-BI8 | Binary input data |

# 8 mA input module (MIM)

## 8.1 Application

Use the milliampere input module, MIM, to interface transducer signals in the +/- 20 mA range from for example temperature and pressure transducers.

## 8.2 Design

The milliampere input module has six input channels, each with a separate protection and filter circuit, A/D converter and optically isolated connection to the backplane.

The digital filter circuits have individually programmable cut-off frequencies, and all parameters for filtering and calibration are stored in a nonvolatile memory on the module. The calibration circuitry monitors the module temperature and commences an automatical calibration procedure if the temperature drift increase outside the allowed range. The module uses the serial CAN bus for backplane communication.

Signal events are time stamped locally for minimum time deviance and stored by the event recorder if present.

## 8.3 Function block

See Monitoring / Monitoring of DC analogue measurements.

## 8.4 Technical data

**Table 332: Energizing quantities, rated values and limits**

| Quantity | | | Rated value | Nominal range |
|---|---|---|---|---|
| mA input module | input range | | +/- 20 mA | - |
| | input resistance | | $R_{in}$ = 194 ohm | - |
| | power consumption | each mA-module | ≤ 4 W | - |
| | | each mA-input | ≤ 0.1 W | - |

# 9 Power supply module (PSM)

## 9.1 Application

The 20 W power supply module, PSM, with built in binary I/O is used in 1/2 and 3/4 of full width 19” units. It has four optically isolated binary inputs and five binary outputs, out of which one binary output is dedicated for internal fail.

## 9.2 Design

The power supply modules contain a built-in, self-regulated DC/DC converter that provides full isolation between the terminal and the battery system.

The 20 W power supply module, PSM, has four optically isolated inputs and four output relays.

## 9.3 Function block

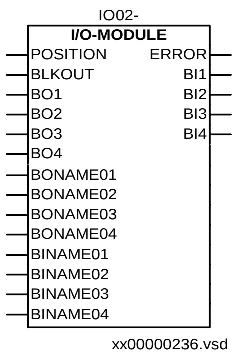



*Figure 139: Binary I/O on the power supply module PSM*

## 9.4 Input and output signals

**Table 333: Input signals for the I/O-module (IO02-) function block (I/O on PSM)**

| Signal | Description |
|---|---|
| POSITION | I/O module slot position connector |
| BLKOUT | Block output signals |

| Signal | Description |
|---|---|
| BO01-BO04 | Binary output data |
| BONAME01-BONAME04 | Output name string settings |
| BINAME01-BINAME04 | Input name string settings |

**Table 334: Output signals for the I/O-module (IO02-) function block (I/O on PSM)**

| Signal | Description |
|---|---|
| ERROR | I/O-module fail |
| BI1-BI4 | Binary input data |

## 9.5 Technical data

**Table 335: PSM 20/30 W**

| Quantity | Rated value | Nominal range |
|---|---|---|
| Auxiliary dc voltage | EL = (48 - 250) V | +/- 20% |

# 10 Human-machine-interface modules (HMI)

## 10.1 Application

The human machine interface is used to monitor and in certain aspects affect the way the product operates. The configuration designer can add functions for alerting in case of important events that needs special attention from you as an operator.

Use the terminals built-in communication functionality to establish SMS communication with a PC with suitable software tool. Connect the PC to the optical connector on the local HMI with the special front communication cable including an opto-electrical converter for disturbance free and safe communication.

The LED indication module is an additional feature for the REx 5xx terminals for protection and control and consists totally of 18 LEDs (Light Emitting Diodes). The main purpose is to present on site an immediate visual information such as protection indications or alarm signals. It is located on the front of the protection and control terminals.

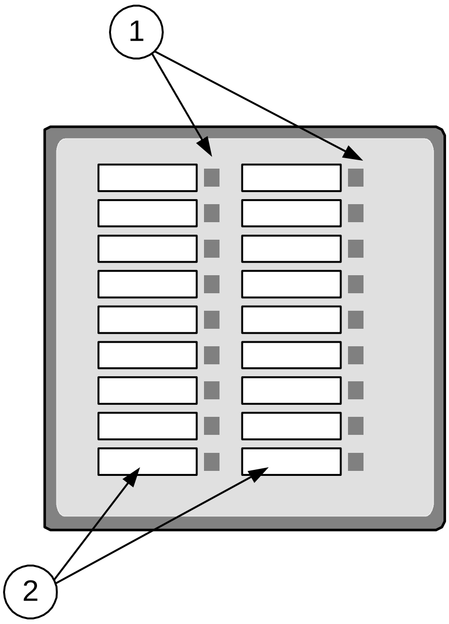
## 10.2 Design

The human-machine interface consists of:

- the human-machine interface (HMI) module.
- the LED module.

*Figure 140: The figure shows the LED (upper) and the HMI (lower).*

The LED indication module is equipped with 18 LEDs, which can light or flash in either red, yellow or green color. A description text can be added for each of the LEDs.




| | |
|---|---|
| 1 | Three-color LEDs |
| 2 | Descriptive label, user exchangeable |

*Figure 141: The LED module*

## 10.3 Function block

See Monitoring/LED indication function.

## 10.4 Technical data

**Table 336: SMS communication via front**

| Function | Value |
|---|---|
| Protocol | SPA |
| Communication speed | 300, 1200, 2400, 4800, 9600 Baud |
| Slave number | 1 to 899 |
| Remote change of active group allowed | Yes |
| Remote change of settings allowed | Yes |

# 11 Optical receiver module (ORM)

## 11.1 Application

The optical receiver module (ORM) is used to interface signals from optical instrument transformers (OITP) to the terminal. The ORM module can replace the conventional analog input modules. Either 50 or 60 Hz signals is handled by the module. Only one of the frequencies must be selected and used for all inputs.

## 11.2 Design

The optical receiver module has four optical input channels that handles data from optical instrument transformers (OITP). It converts the OITP data to a format used in the terminal. The received data is processed in different ways depending on the setting of the eight pole dip-switch of the module.

## 11.3 Logic diagram

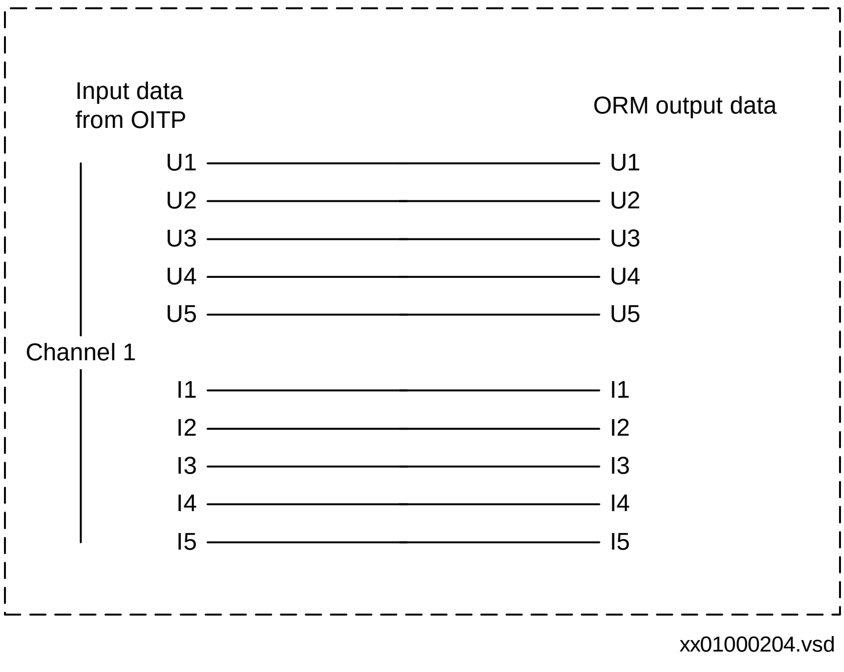



*Figure 142: Straight connection*

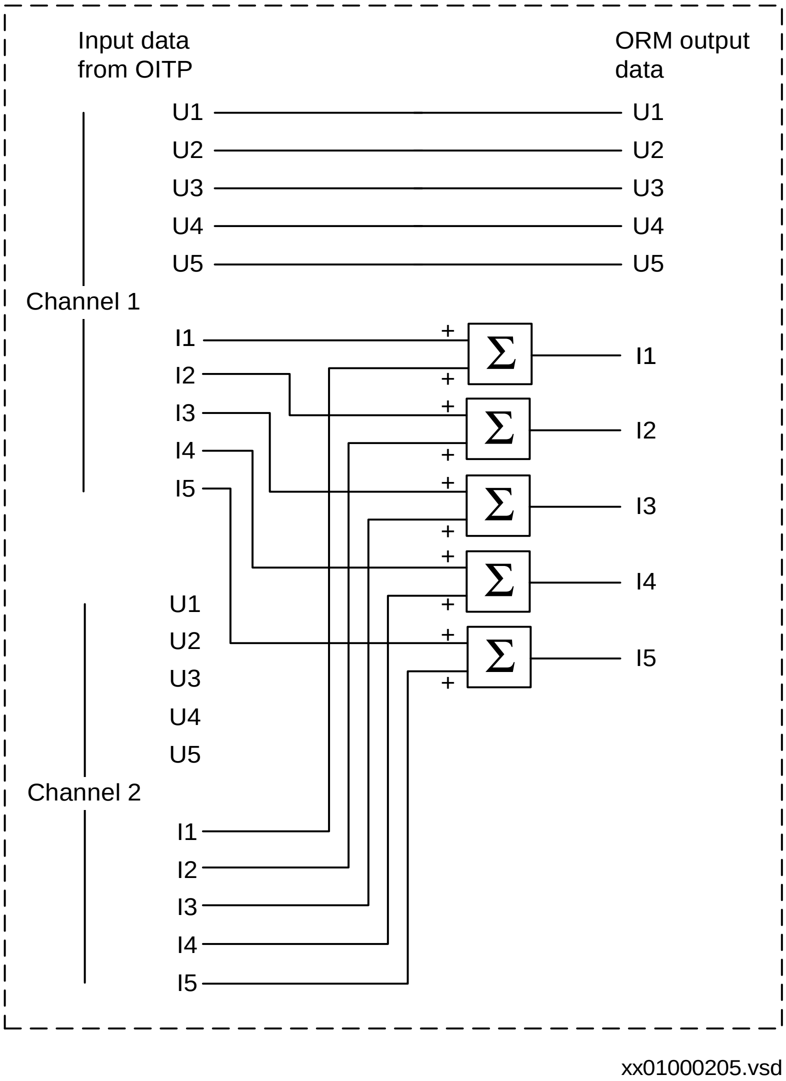



*Figure 143: Line terminal connection*

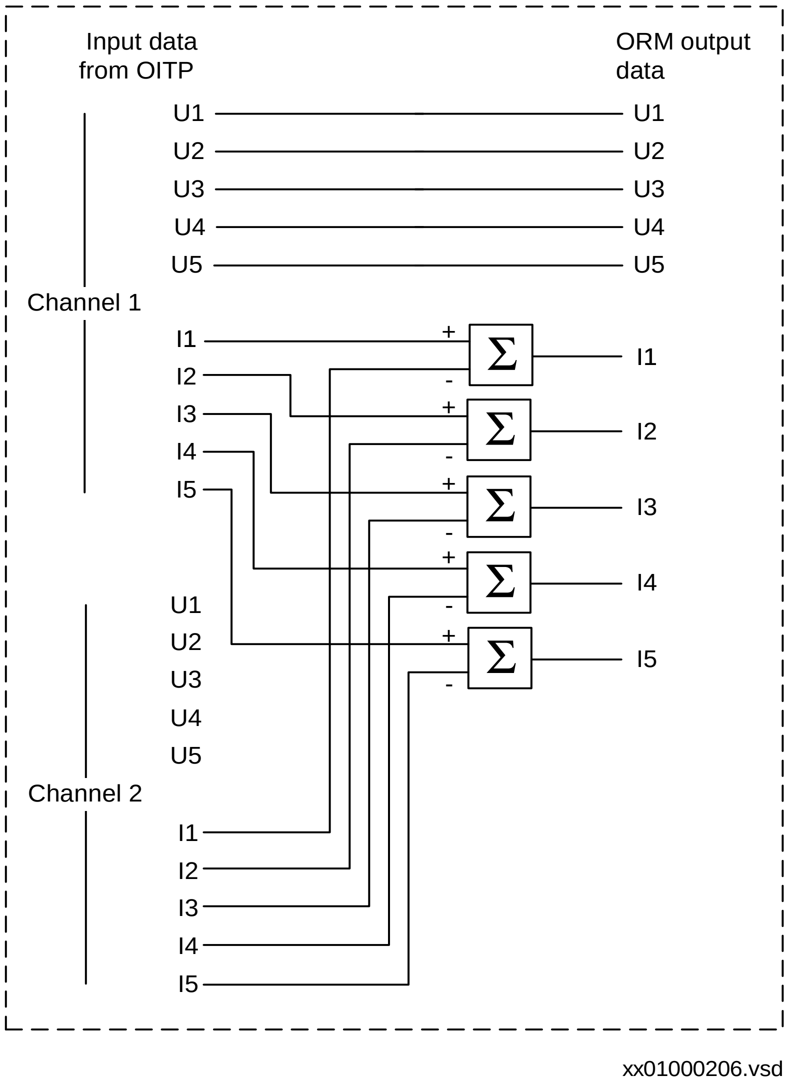



*Figure 144: Line terminal connection, reversed current direction channel 2*

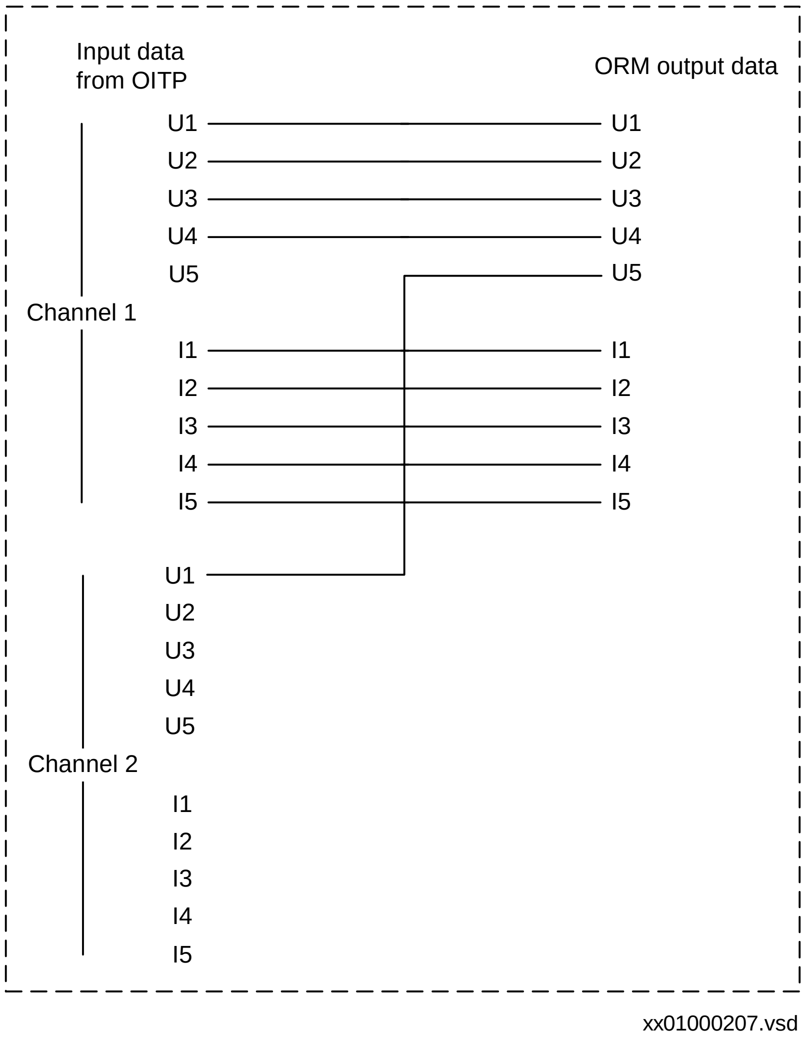



*Figure 145: Signal selection for synchro check functions*

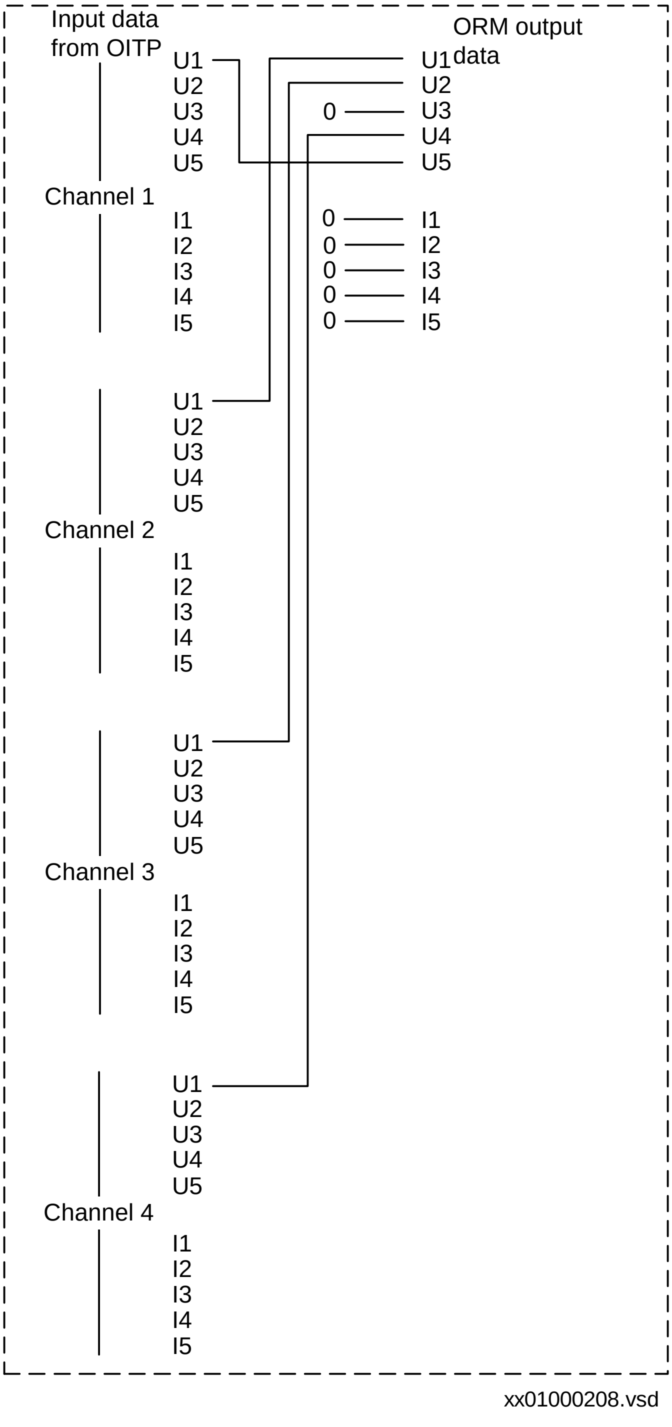



*Figure 146: Signal selection for control terminal functions*

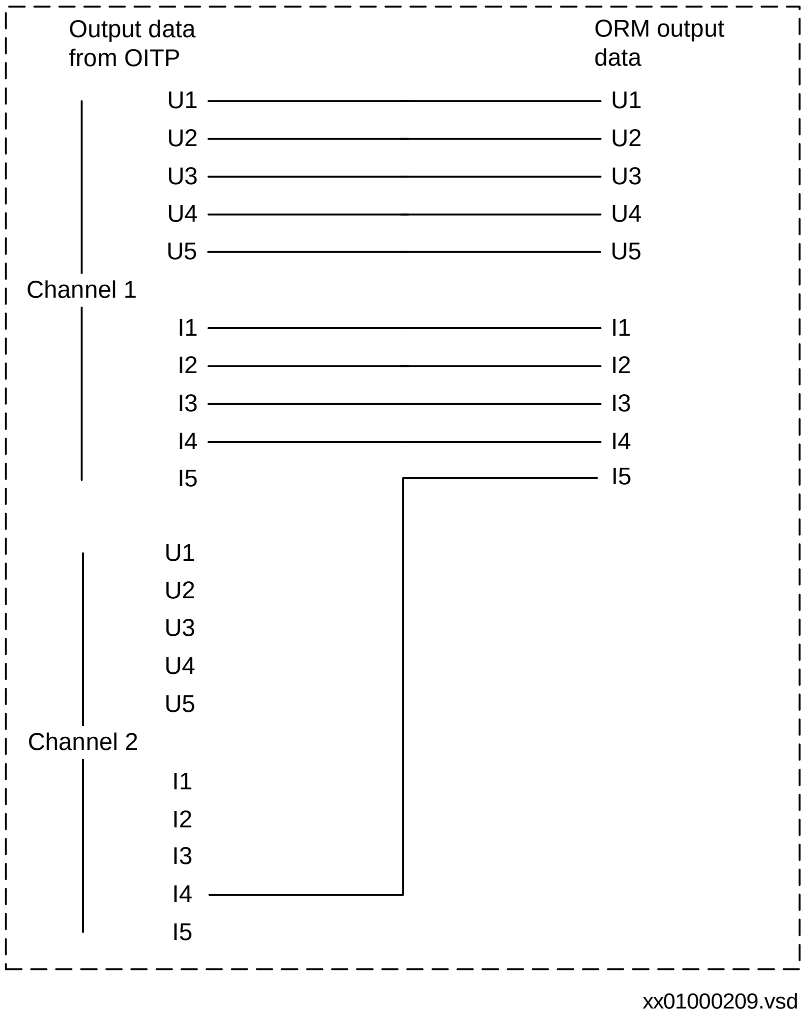



*Figure 147: Signal selection for fault locator or CTCF functions*

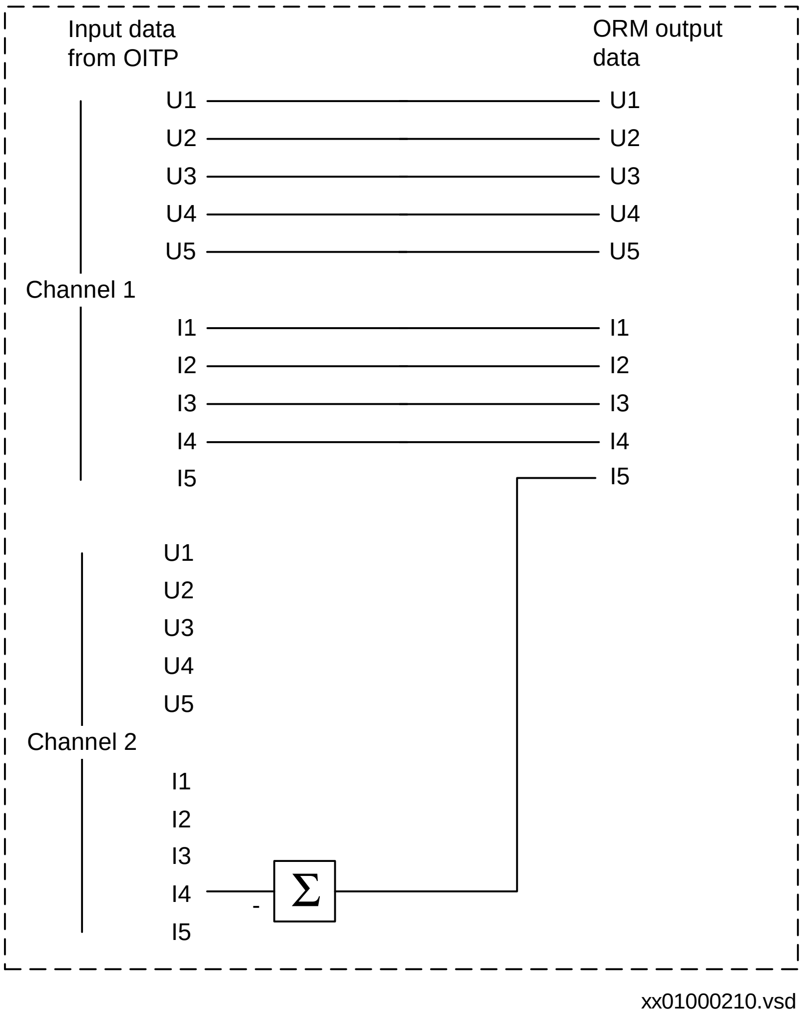



*Figure 148: Signal selection for fault locator or CTCF functions, reversed current direction channel 2*

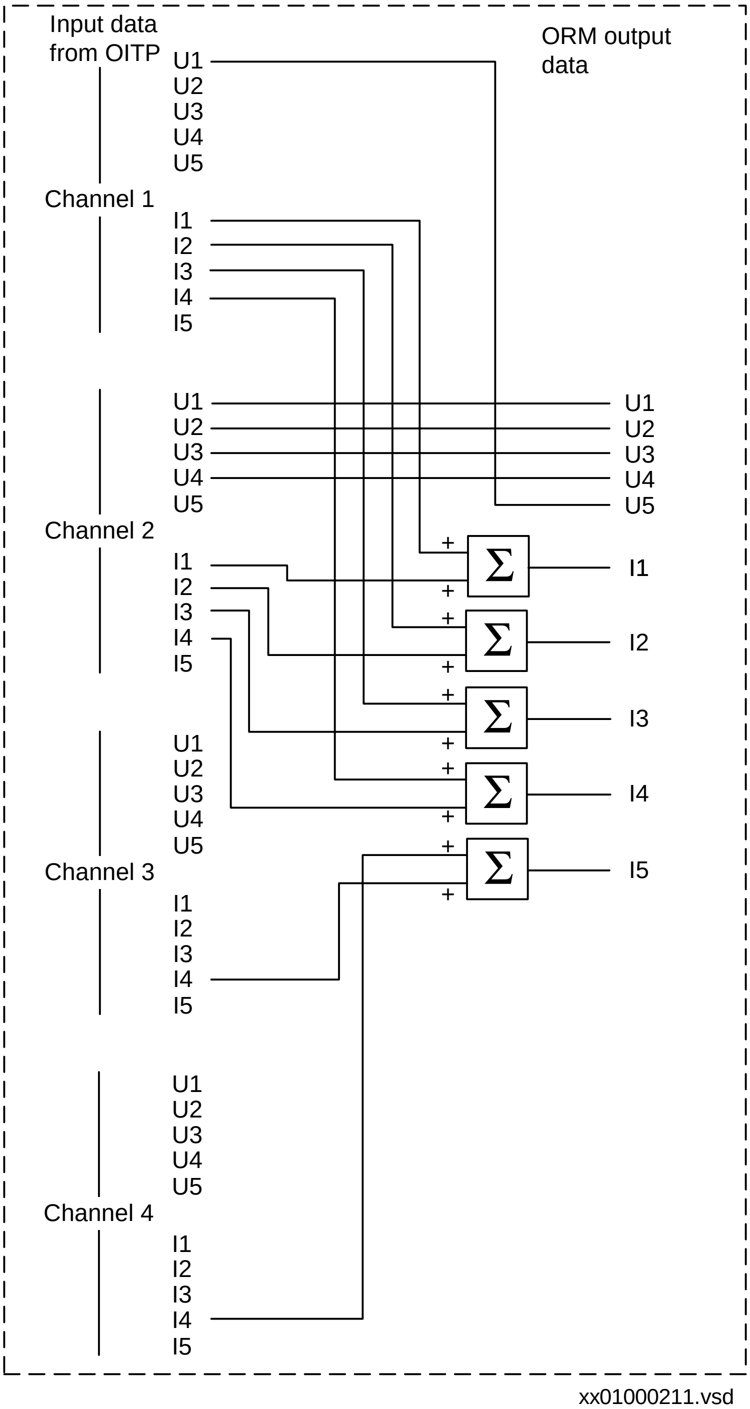



*Figure 149: Signal selection for 1 1/2 breaker switchgear*

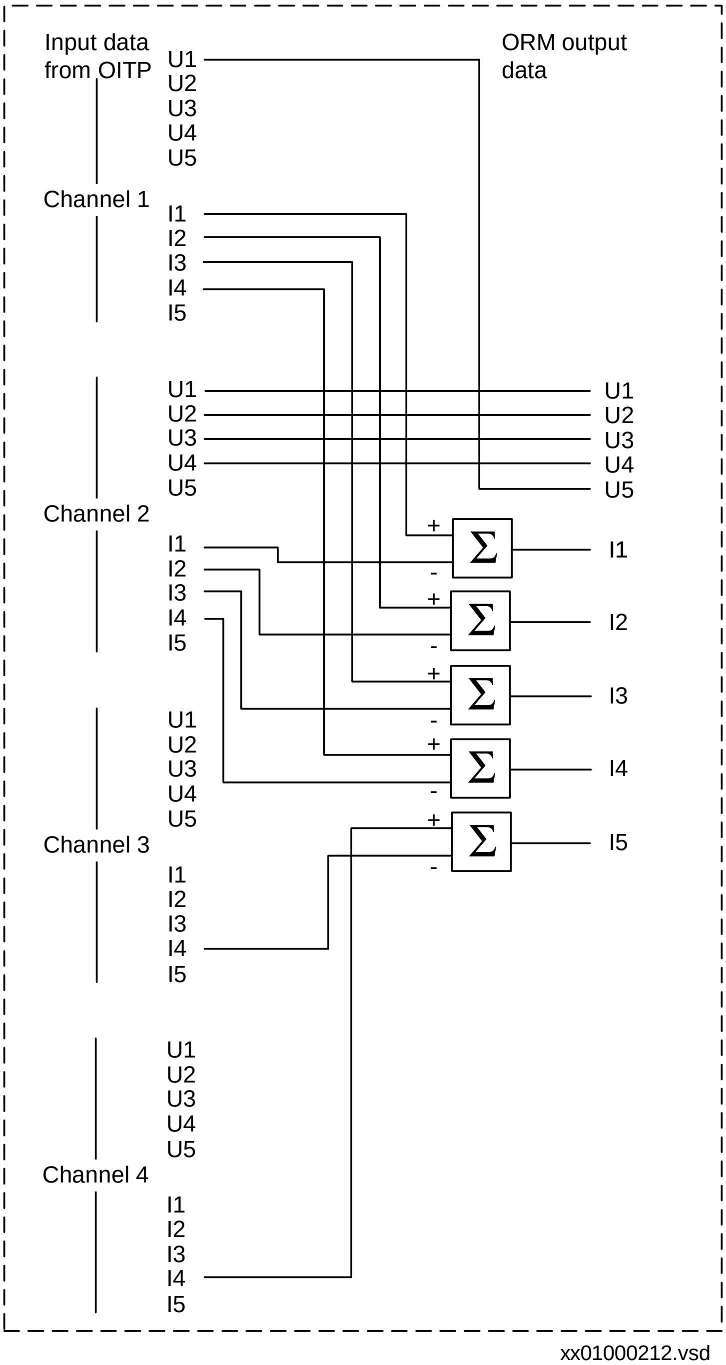



*Figure 150: Signal selection for 1 1/2 breaker switchgear, reversed current direction channel 2 and channel 3*

## 11.4 Setting parameters

**Table 337: Settings for applications supported by ORM module**

| 8-pole DIP | | | | | | | | Application | Frequency | Reverse direction, Current input |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | | | |
| x | x | x | x | x | x | | x | Straight connection | 50 Hz | - |
| | x | x | x | x | x | | x | Line terminal connection | | - |
| | x | x | x | x | x | | | Line terminal connection | | Channel 2 |
| x | | x | x | x | x | | x | Synchro check functions | | - |
| x | x | | x | x | x | | x | Control terminal functions | | - |
| | x | | x | x | x | | x | Fault locator or CTCF function | | - |
| | x | | x | x | x | | | Fault locator or CTCF function | | Channel 2 |
| x | | | x | x | x | | x | 1 1/2 breaker switchgear | | - |
| x | | | x | x | x | | | 1 1/2 breaker switchgear | | Channel 2 and 3 |
| | | | | | | | | | | |
| x | x | x | x | x | x | x | x | Straight connection | 60 Hz | - |
| | x | x | x | x | x | x | x | Line terminal connection | | - |
| | x | x | x | x | x | x | | Line terminal connection | | Channel 2 |
| x | | x | x | x | x | x | x | Synchro check functions | | - |
| x | x | | x | x | x | x | x | Control terminal functions | | - |
| | x | | x | x | x | x | x | Fault locator or CTCF function | | - |
| | x | | x | x | x | x | | Fault locator or CTCF function | | Channel 2 |
| x | | | x | x | x | x | x | 1 1/2 breaker switchgear | | - |
| x | | | x | x | x | x | | 1 1/2 breaker switchgear | | Channel 2 and 3 |
| x= DIP On | | | | | | | | | | |

## 11.5 Technical data

**Table 338: Optical receiver module, ORM**

| Function | Type |
|---|---|
| Optical connector | Type ST |

# 12 Serial communication modules (SCM)

## 12.1 Design, SPA/IEC

The serial communication module for SPA/IEC is placed in a slot at the rear part of the Main processing module. The serial communication module can have connectors for two plastic fibre cables or two glass fibre cables. The incoming optical fibre is connected to the RX receiver input, and the outgoing optical fibre to the TX transmitter output. When the fibre optic cables are laid out, pay special attention to the instructions concerning the handling, connection, etc. of the optical fibres. The module is identified with a number on the label on the module.

## 12.2 Design, LON

The serial communication module for LON is placed in a slot at the rear part of the Main processing module. The serial communication module can have connectors for two plastic fibre cables or two glass fibre cables. The incoming optical fibre is connected to the RX receiver input, and the outgoing optical fibre to the TX transmitter output. When the fibre optic cables are laid out, pay special attention to the instructions concerning the handling, connection, etc. of the optical fibres. The module is identified with a number on the label on the module.

## 12.3 Technical data

**Table 339: SPA/IEC optical fibre connector**

| Communication | Fibre connection |
|---|---|
| SPA/IEC | Plastic, snap-in |
| | ST, glass, bayonet |

**Table 340: LON optical fibre connector**

| Communication | Fibre connection |
|---|---|
| LON | Plastic, snap-in |
| | ST, glass, bayonet |

# 13 Data communication modules

## 13.1 Application

The remote terminal communication modules are used both for differential line protection applications and for binary signal to remote end, for example for distance protections. The following hardware modules are available:

- V.36
- X.21
- RS530
- G.703
- Short-range galvanic module
- Fibre optical communication module
- Short-range fibre optical module

The galvanic data communication modules according to V.36, X.21 and RS530 can be used for galvanic short range communication covering distances up to 100 m in low noise environment. Only contra-directional operation is recommended in order to get best system performance.These modules are designed for 64 kbit/s operation but can also be used at 56 kbit/s.

The galvanic data communication module according to G.703 is not recomended for distances above 10 m. Special attention must be paid to avoid problems due to noise interference. This module is designed only for 64 kbit/s operation.

The short-range galvanic module can be used for communication over galvanic pilot wires and can operate up to distances between 0,5 and 4 km depending on pilot wire cable. Twisted-pair, double-screened cable is recommended.

The fibre optical communication module can be used both with multi-mode and single-mode fibres.The communication distance can typically be up to 30 km for single mode fibre, with high quality fibres even longer. This interface can also be used for direct connection to communication equipment of type FOX from ABB.

The short-range fibre optical module can only be used with multi-mode fibre .The communication distance can normally be up to 5 km. This module can also be used for direct connection to communication equipments of type 21-15xx and 21-16xx from FIBER-DATA

## 13.2 Technical data

**Table 341: Galvanic data communication module**

| Interface type | According to standard | Connector type |
|---|---|---|
| V.36/V11 Co-directional (on request) | ITU (CCITT) | D-sub 25 pins |
| V.36/V11 Contra-directional | ITU (CCITT) | D-sub 25 pins |
| X.21/X27 | ITU (CCITT) | D-sub 15 pins |
| RS530/RS422 Co-directional (on request) | EIA | D-sub 25 pins |
| RS530/RS422 Contra-directional | EIA | D-sub 25 pins |
| G.703 Co-directional | ITU (CCITT) | Screw |

**Table 342: Short-range galvanic module**

| | |
|---|---|
| Range | max 4 km |
| Line interface | Balanced symmetrical three-state current loop (4 wires) |
| Connector | 5-pin divisible connector with screw connection |
| Insulation | 2,5 kV 1 min. Opto couplers and insulating DC/DC-converter |
| | 15 kV with additional insulating transformer |

**Table 343: Fibre optical communication module**

| Optical interface | | |
|---|---|---|
| Type of fibre | Graded-index multimode 50/125mm or 62,5/125mm | Single mode 9/125 mm |
| Wave length | 1300 nm | 1300 nm |
| Optical transmitter<br>injected power | LED<br>-17 dBm | LED<br>-22 dBm |
| Optical receiver<br>sensitivity | PIN diode<br>-38 dBm | PIN diode<br>-38 dBm |
| Optical budget | 21 dB | 16 dB |
| Transmission distance | typical 20 km | typical 30 km |
| Optical connector | Type FC-PC | Type FC-PC |
| Protocol | ABB FOX specific | ABB FOX specific |

**Table 344: Short-range fibre optical module**

| | |
|---|---|
| Optical fibre | Graded-index multimode 50/125mm or 62,5/125mm |
| Wave length | 850 nm |
| Optical connectors | ST |
| Optical budget | 15 dB |
| Transmission distance | max 5 km |
| Protocol | FIBERDATA specific |

# Chapter 14 Diagrams

This chapter contains the terminal diagrams for the terminal.

# 1 Terminal diagrams

## 1.1 Terminal diagram, Rex5xx

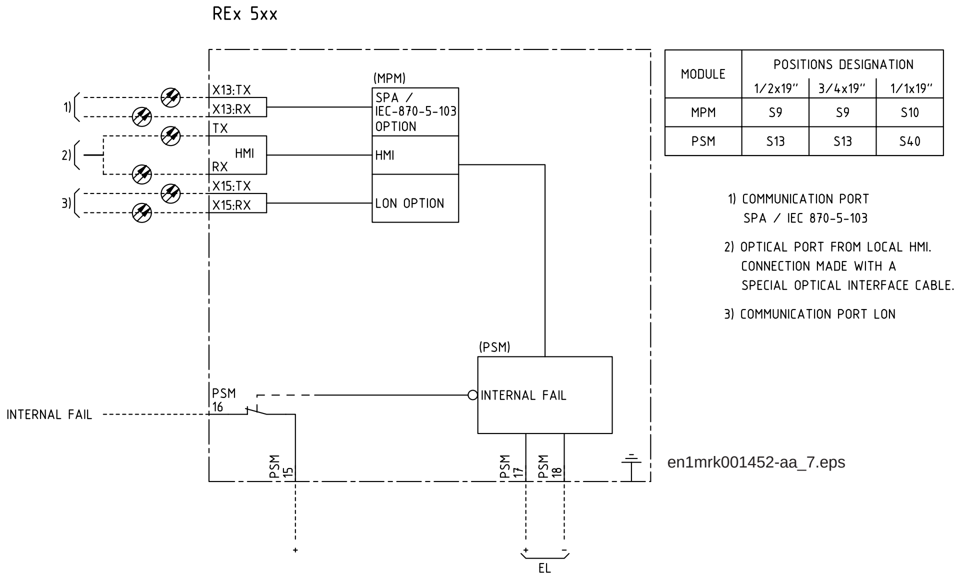



*Figure 151: REx 5xx*

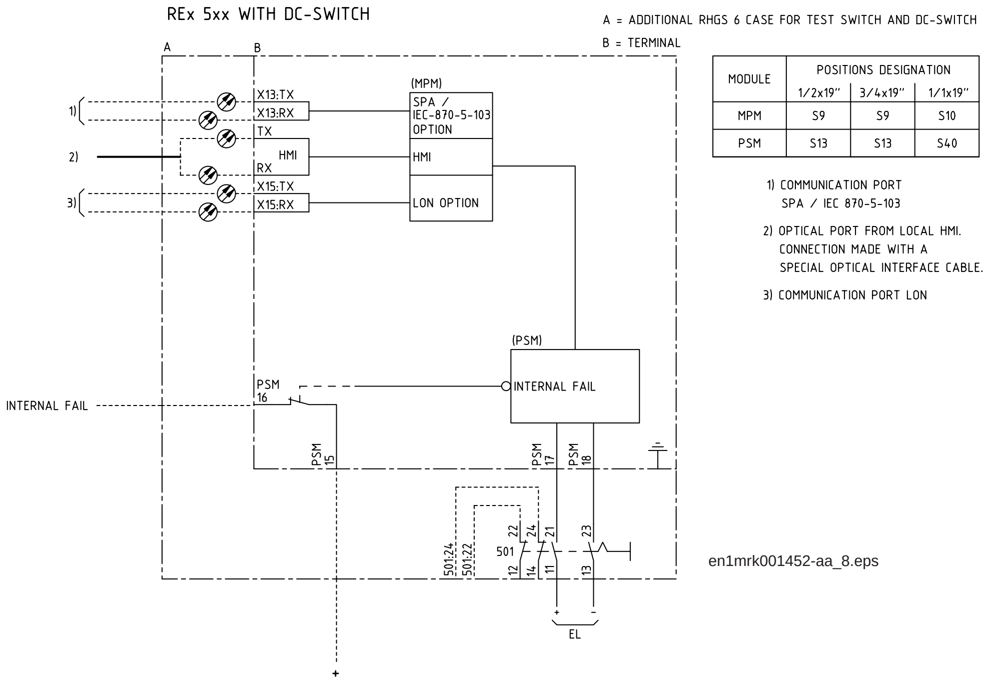



*Figure 152: REx 5xx with DC-switch*

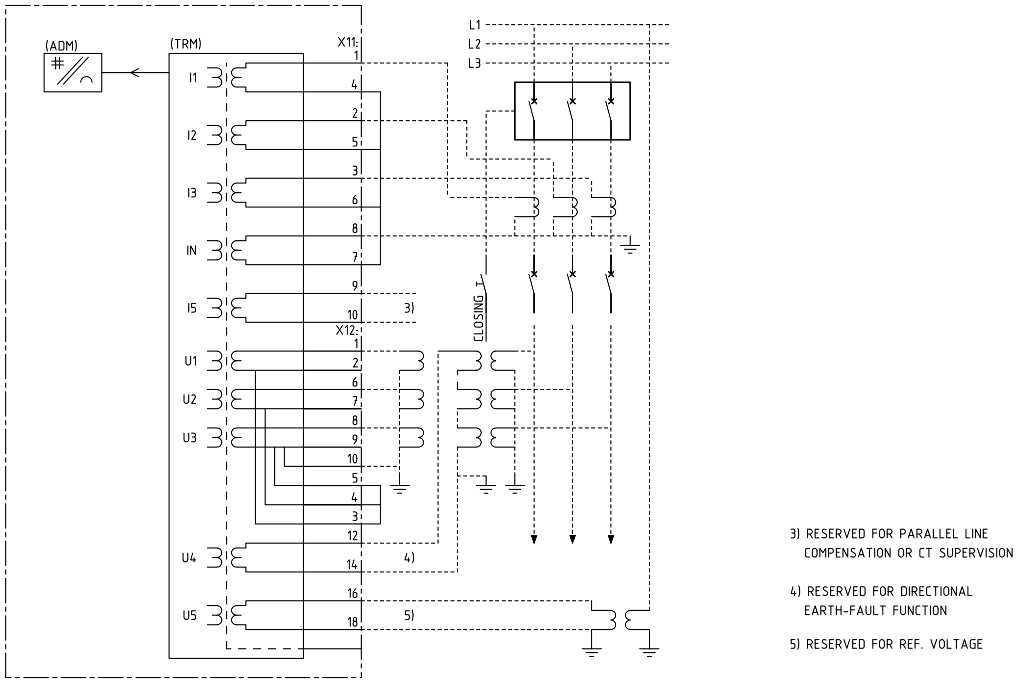



*Figure 153: REx 5xx, transformer input module and A/D conversion module 3 phase system option*

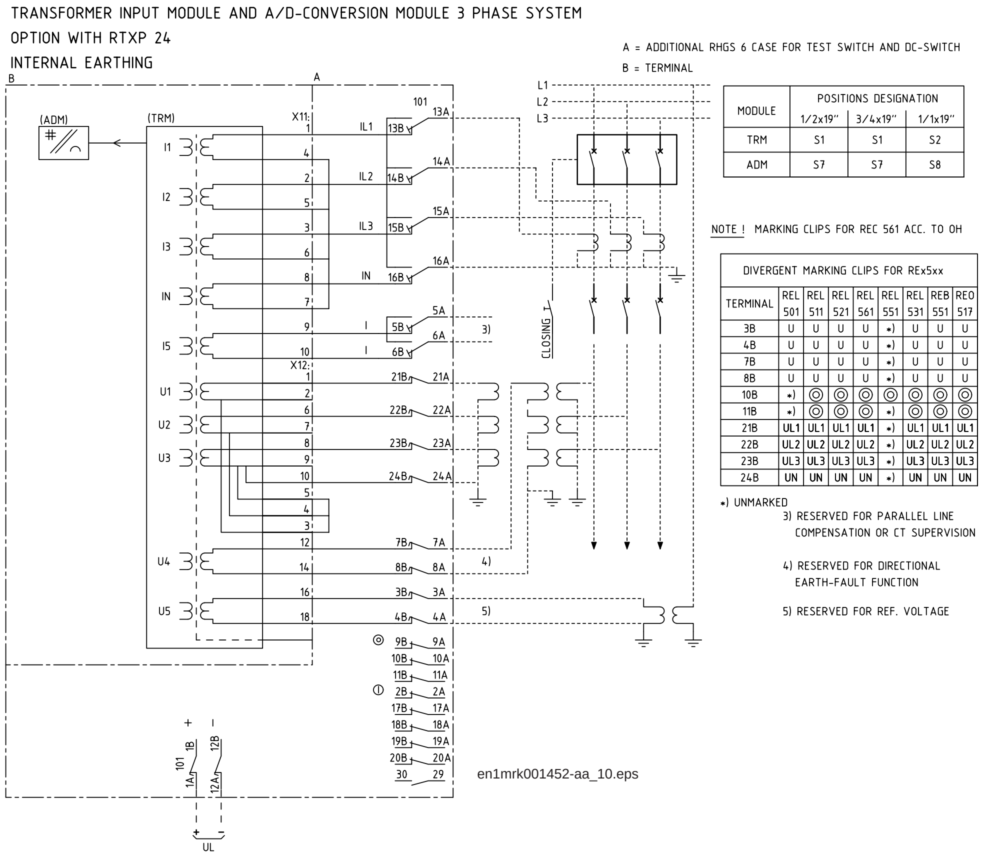
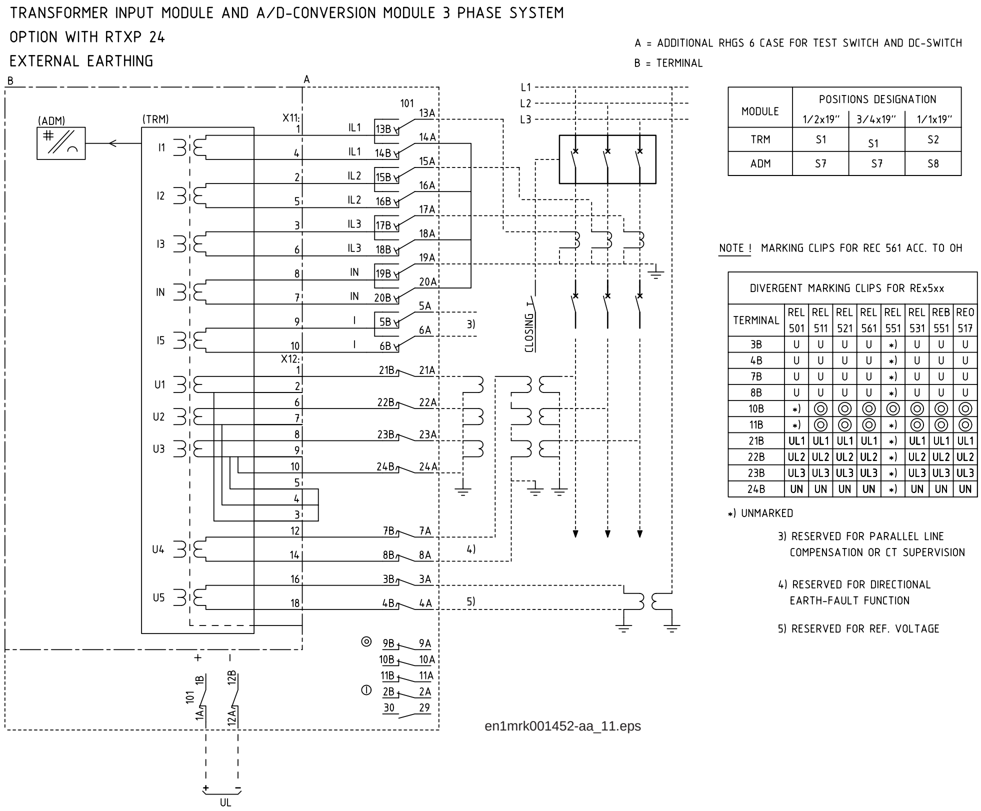


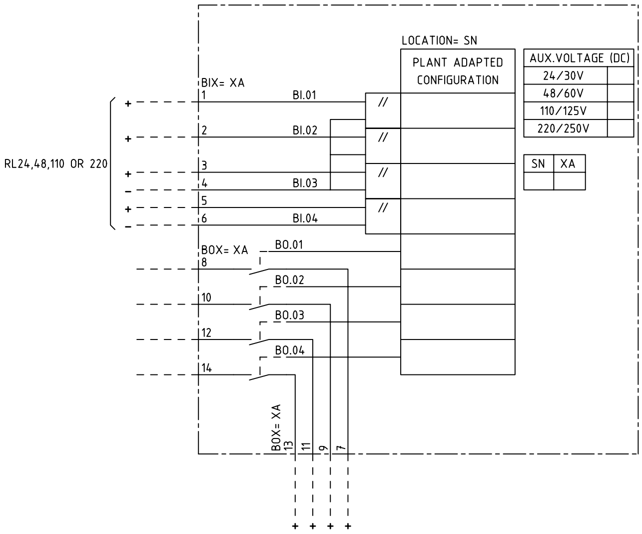

*Figure 154: REx 5xx, transformer input module and A/D conversion module 3 phase system option with RTXP 24, internal earthing*




| MODULE | POSITIONS DESIGNATION | | |
|---|---|---|---|
| | 1/2x19" | 3/4x19" | 1/1x19" |
| TRM | S1 | S1 | S2 |
| ADM | S7 | S7 | S8 |

| DIVERGENT MARKING CLIPS FOR REx5xx | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| TERMINAL | REL 501 | REL 511 | REL 521 | REL 561 | REL 551 | REL 531 | REB 551 | REO 517 |
| 3B | U | U | U | U | *) | U | U | U |
| 4B | U | U | U | U | *) | U | U | U |
| 7B | U | U | U | U | *) | U | U | U |
| 8B | U | U | U | U | *) | U | U | U |
| 10B | *) | ◎ | ◎ | ◎ | ◎ | ◎ | ◎ | ◎ |
| 11B | *) | ◎ | ◎ | ◎ | *) | ◎ | ◎ | ◎ |
| 21B | UL1 | UL1 | UL1 | UL1 | *) | UL1 | UL1 | UL1 |
| 22B | UL2 | UL2 | UL2 | UL2 | *) | UL2 | UL2 | UL2 |
| 23B | UL3 | UL3 | UL3 | UL3 | *) | UL3 | UL3 | UL3 |
| 24B | UN | UN | UN | UN | *) | UN | UN | UN |

*Figure 155: REx 5xx, transformer input module and A/D conversion module 3 phase system option with RTXP 24, external earthing*




| MODULE | POSITIONS DESIGNATION | | |
|---|---|---|---|
| | 1/2x19" | 3/4x19" | 1/1x19" |
| PSM | S13 | S13 | - |

*Figure 156: REx 5xx, binary in/out power supply module option*

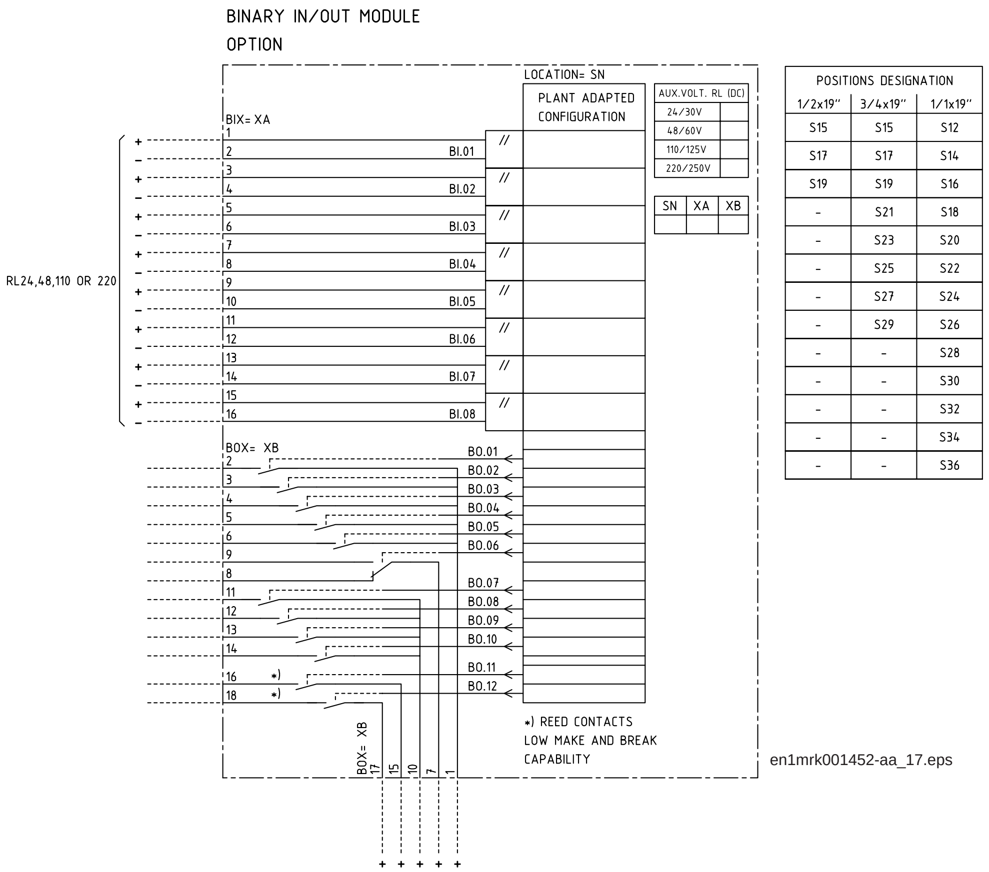



*Figure 157: REx 5xx, binary in/out module option*

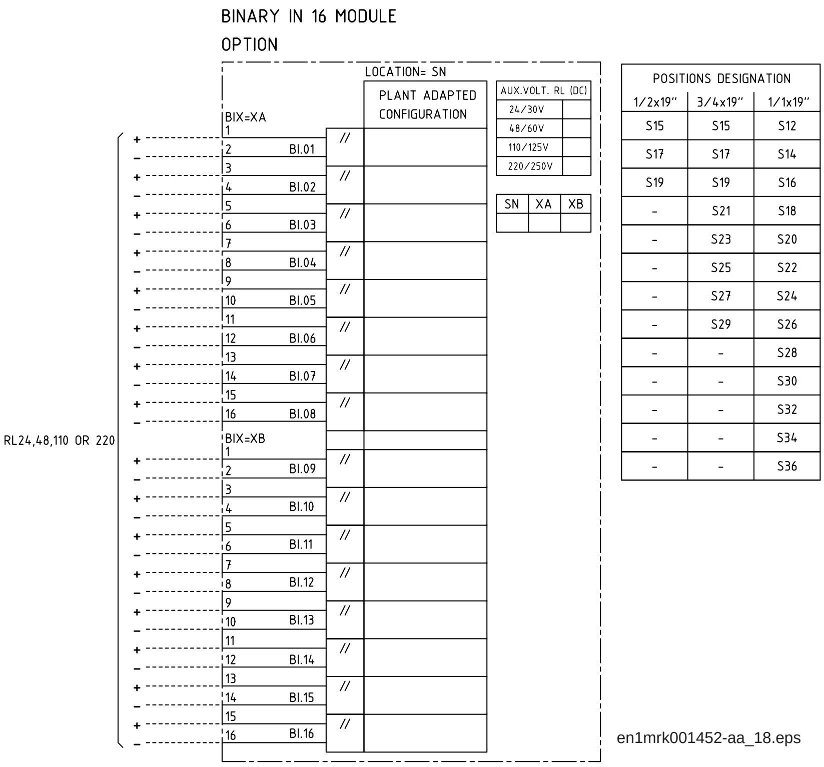



*Figure 158: REx 5xx, binary in 16 module option*

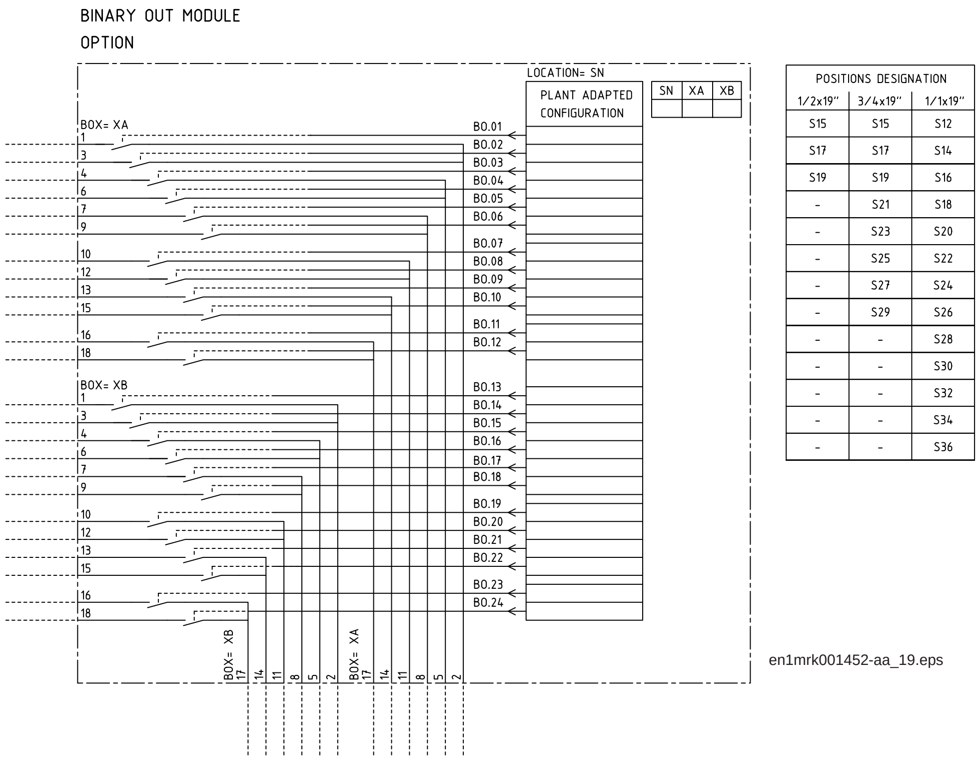



*Figure 159: REx 5xx, binary out module option*

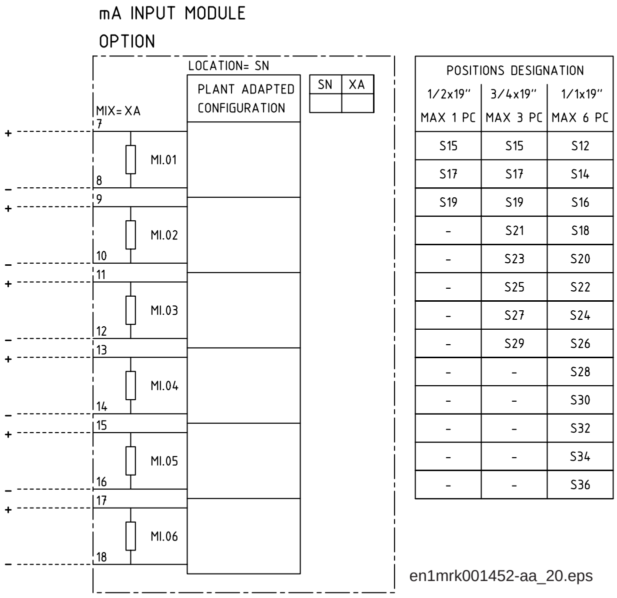



*Figure 160: REx 5xx, mA input module option*

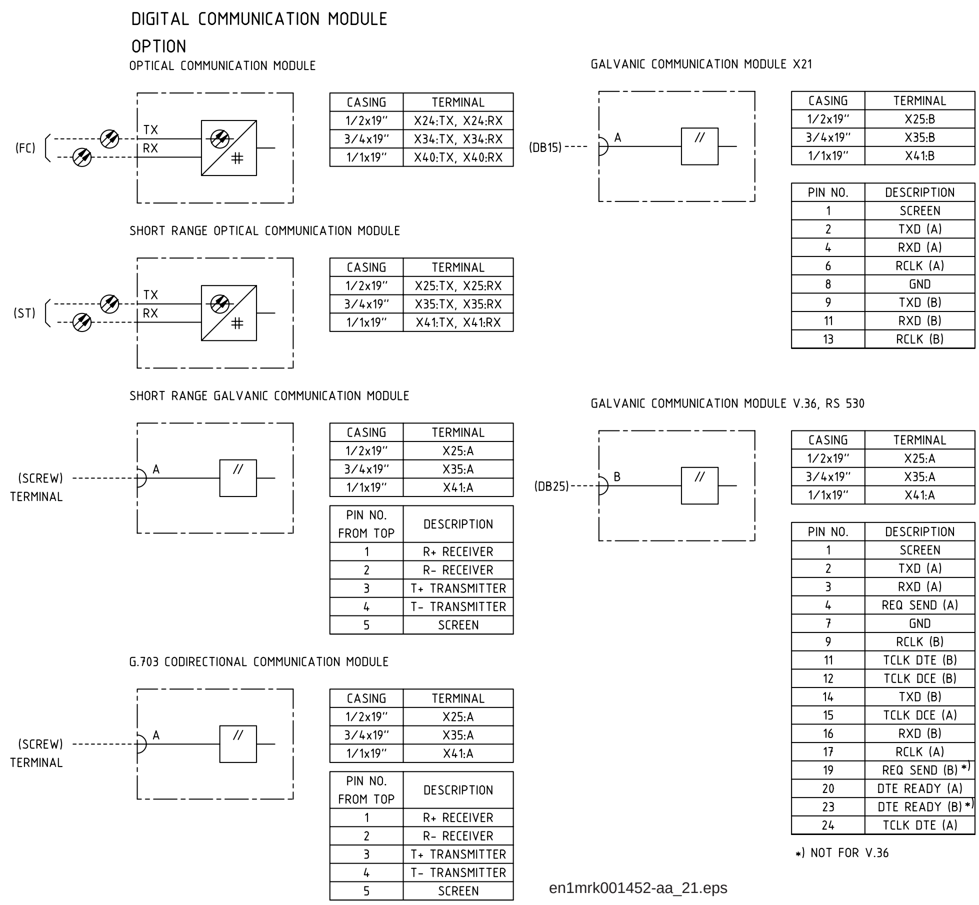



*Figure 161: REx 5xx, digital communication module option*

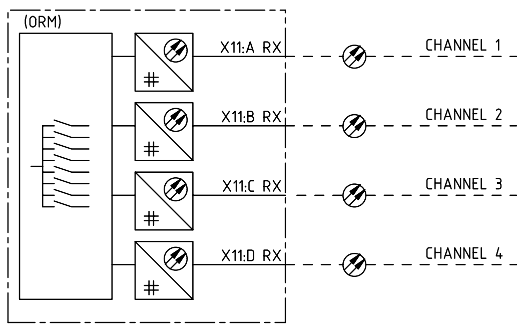



*Figure 162: REx 5xx, optical receiver module option*