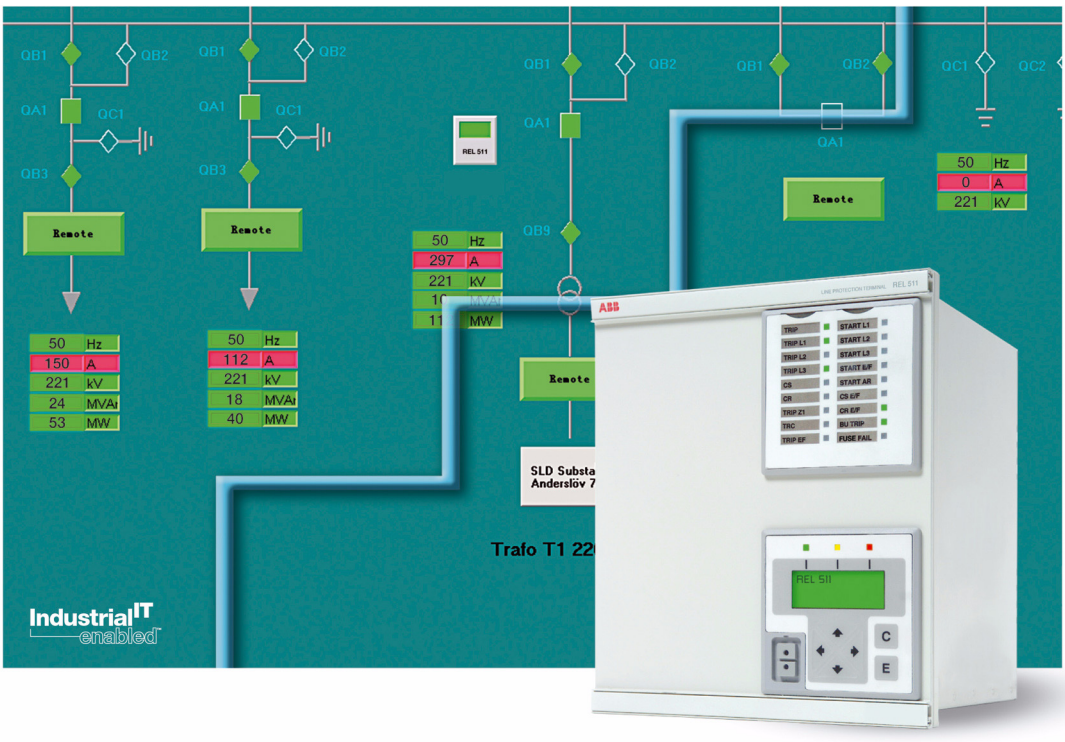
Technical reference manual

Protect^{IT} Line distance protection terminal
REL 511*2.5



Technical reference manual

Line distance protection terminal
REL 511*2.5

About this manual

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Chapter 1 Introduction

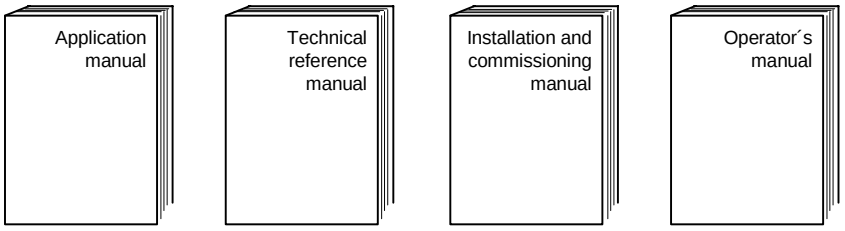
About this chapter

This chapter introduces you to the manual as such.

1 Introduction to the technical reference manual

1.1 About the complete set of manuals for a terminal

The users manual (UM) is a complete set 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 when 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 can be used to find out how to handle disturbances or how to view calculated and measured network data in order to determine the cause 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, energizing and checking of external circuitry, setting and configuration as well as verifying settings and performing a directional test. The chapters and sections are organized in the chronological order (indicated by chapter/section numbers) in which 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.

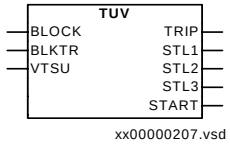


Figure 1: Function block symbol example

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.

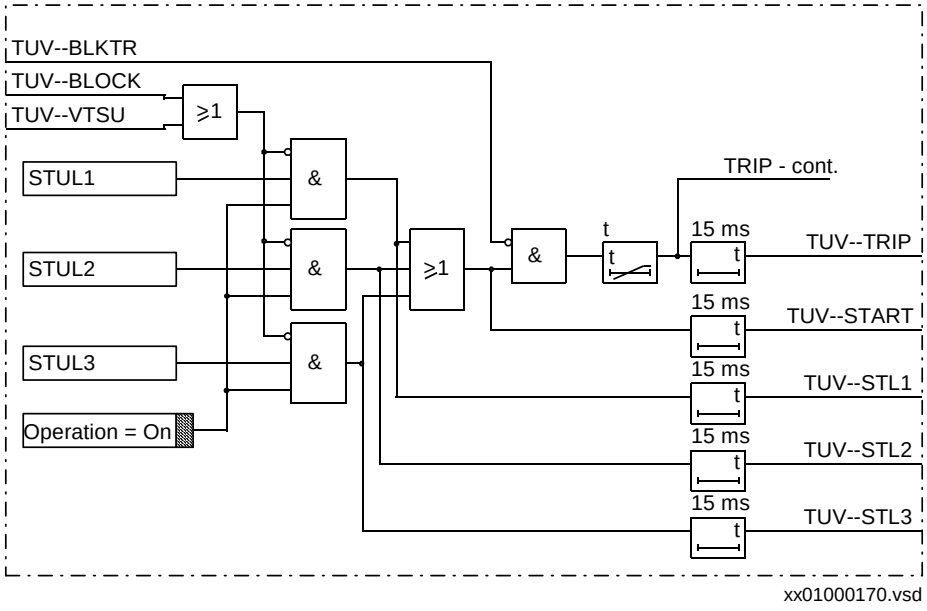


Figure 2: Simplified logic diagram example

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--BLK-TR, 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 set-ting value.The internal signals are usually dedicated to a certain function. They are normally not available for configuration purposes. Examples 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 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	Step	Default	Unit	Description
Operation	Off, On		Off	-	Operating mode for TUV function
UPE<	10-100	1	70	% of U1b	Operate phase voltage
t	0.000-60.000	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 Intended audience

1.3.1 General

This manual addresses system engineers, installation and commissioning personnel, who use technical data during engineering , installation and commissioning, and in normal service.

1.3.2 Requirements

The system engineer must have a thorough knowledge of protection systems, protection equipment, protection functions and the configured functional logics in the protective devices. The installation and commissioning personnel must have a basic knowledge in the handling electronic equipment.

1.4 Related documents

Documents related to REL 511*2.5	Identity number
Operator's manual	1MRK 506 165-UEN
Installation and commissioning manual	1MRK 506 167-UEN
Technical reference manual	1MRK 506 166-UEN
Application manual	1MRK 506 168-UEN
Buyer's guide	1MRK 506 164-BEN

1.5 Revision notes

Revision	Description

1.6 Acronyms and abbreviations

AC	Alternating Current
ACrv2	Setting A for programmable overvoltage IDMT curve, step 2
A/D converter	Analog to Digital converter
ADBS	Amplitude dead-band supervision
AIM	Analog input module
ANSI	American National Standards Institute
ASCT	Auxiliary summation current transformer
ASD	Adaptive Signal Detection
AWG	American Wire Gauge standard
BIM	Binary input module

BLKDEL	Block of delayed fault clearing
BOM	Binary output module
BR	Binary transfer receive over LDCM
BS	British Standard
BSR	Binary Signal Receive (SMT) over LDCM
BST	Binary Signal Transmit (SMT) over LDCM
BT	Binary Transfer Transmit over LDCM
C34.97	
CAN	Controller Area Network. ISO standard (ISO 11898) for serial communication
CAP 531	Configuration and programming tool
CB	Circuit breaker
CBM	Combined backplane module
CCITT	Consultative Committee for International Telegraph and Telephony. A United Nations sponsored standards body within the International Telecommunications Union.
CCS	Current circuit supervision
CEM	Controller area network emulation module
CIM	Communication interface module
CMPPS	Combined Mega Pulses Per Second
CO cycle	Close-Open cycle
Co-directional	Way of transmitting G.703 over a balanced line. Involves two twisted pairs making it possible to transmit information in both directions
Contra-directional	Way of transmitting G.703 over a balanced line. Involves four twisted pairs of with two are used for transmitting data in both directions, and two pairs for transmitting clock signals
CPU	Central Processor Unit
CR	Carrier Receive
CRC	Cyclic Redundancy Check
CRL	POR carrier for WEI logic
CS	Carrier send
CT	Current transformer
CT1L1	Input to be used for transmit CT group 1line L1 in signal matrix tool
CT1L1NAM	Signal name for CT-group 1line L1 in signal matrix tool
CT2L3	Input to be used for transmission of CT-group 2 line L3 to remote end
CT2N	Input to be used for transmission of CT-group 2 neutral N to remote end.
CVT	Capacitive voltage transformer

DAR	Delayed auto-reclosing
db	dead band
DBDL	Dead bus dead line
DBLL	Dead bus live line
DC	Direct Current
DIN-rail	Rail conforming to DIN standard
DIP-switch	Small switch mounted on a printed circuit board
DLLB	Dead line live bus
DSP	Digital signal processor
DTT	Direct transfer trip scheme
EHV network	Extra high voltage network
EIA	Electronic Industries Association
EMC	Electro magnetic compatibility
ENGV1	Enable execution of step one
ENMULT	Current multiplier used when THOL is used for two or more lines
EMI	Electro magnetic interference
ESD	Electrostatic discharge
FOX 20	Modular 20 channel telecommunication system for speech, data and protection signals
FOX 512/515	Access multiplexer
FOX 6Plus	Compact, time-division multiplexer for the transmission of up to seven duplex channels of digital data over optical fibers
FPGA	Field Programmable Gate Array
FRRATED	Rated system frequency
FSMPL	Physical channel number for frequency calculation
G.703	Electrical and functional description for digital lines used by local telephone companies. Can be transported over balanced and unbalanced lines
G.711	Standard for pulse code modulation of analog signals on digital lines
GCM	Communication interface module with carrier of GPS receiver module
GI	General interrogation command
GIS	Gas insulated switchgear.
GOOSE	Generic Object Orientated Substation Event
GPS	Global positioning system
GR	GOOSE Receive (interlock)
HDLC protocol	High level data link control, protocol based on the HDLC standard
HFBR connector type	Fibre connector receiver

HMI	Human-Machine Interface
HSAR	High-Speed Auto-Reclosing
HV	High voltage
HVDC	High voltage direct current
HysAbsFreq	Absolute hysteresis for over and under frequency operation
HysAbsMagn	Absolute hysteresis for signal magnitude in percentage of Ubase
HysRelMagn	Relative hysteresis for signal magnitude
HystAbs	Overexcitation level of absolute hysteresis as a percentage
HystRel	Overexcitation level of relative hysteresis as a percentage
IBIAS	Magnitude of the bias current common to L1, L2 and L3
IDBS	Integrating dead-band supervision
IDMT	Minimum inverse delay time
IDMTtmin	Inverse delay minimum time in seconds
IdMin	Operational restrictive characteristic, section 1 sensitivity, multiple Ibase
IDNSMAG	Magnitude of negative sequence differential current
Idunre	Unrestrained prot. limit multiple of winding1 rated current
ICHARGE	Amount of compensated charging current
IEC	International Electrical Committee
IEC 186A	
IEC 60044-6	IEC Standard, Instrument transformers – Part 6: Requirements for protective current transformers for transient performance
IEC 60870-5-103	Communication standard for protective equipment. A serial master/slave protocol for point-to-point communication
IEEE	Institute of Electrical and Electronics Engineers
IEEE 802.12	A network technology standard that provides 100 Mbits/s on twisted-pair or optical fiber cable
IEEE P1386.1	PCI Mezzanine Card (PMC) standard for local bus modules. References the CMC (IEEE P1386, also known as Common Mezzanine Card) standard for the mechanics and the PCI specifications from the PCI SIG (Special Interest Group) for the electrical
EMF	Electro magnetic force
IED	Intelligent electronic device
I-GIS	Intelligent gas insulated switchgear
IL1RE	Real current component, phase L1
IL1IM	Imaginary current component, phase L1
IminNegSeq	Negative sequence current must be higher than this to be used
INAMPL	Present magnitude of residual current
INSTMAGN	Magnitude of instantaneous value

INSTNAME	Instance name in signal matrix tool
IOM	Binary Input/Output module
IPOSIM	Imaginary part of positive sequence current
IPOSRE	Real component of positve sequence current
IP 20	Enclosure protects against solid foreign objects 12.5mm in diameter and larger but no protection against ingression of liquid according to IEC60529. Equivalent to NEMA type 1.
IP 40	Enclosure protects against solid foreign objects 1.0mm in diameter or larger but no protection against ingression of liquid according to IEC60529.
IP 54	Degrees of protection provided by enclosures (IP code) according to IEC 60529. Dust protected. Protected against splashing water. Equivalent to NEMA type 12.
Ip>block	Block of the function at high phase current in percentage of base
IRVBLK	Block of current reversal function
IRV	Activation of current reversal logic
ITU	International Telecommunications Union
k2	Time multiplier in IDMT mode
kForIEEE	Time multiplier for IEEE inverse type curve
LAN	Local area network
LIB 520	
LCD	Liquid chrystal display
LDCM	Line differential communication module
LDD	Local detection device
LED	Light emitting diode
LNT	LON network tool
LON	Local operating network
MAGN	Magnitude of deadband value
MCB	Miniature circuit breaker
MCM	Mezzanine carrier module
MIM	Milliampere Input Module
MIP	
MPPS	
MPM	Main processing module
MV	Medium voltage
MVB	Multifunction vehicle bus. Standardized serial bus originally developed for use in trains
MVsubEna	Enable substitution

NegSeqROA	Operate angle for internal/external negative sequence fault discriminator.
NSANGLE	Angle between local and remote negative sequence currents
NUMSTEP	Number of steps that shall be activated
NX	
OCO cycle	Open-Close-Open cycle
PCI	Peripheral Component Interconnect
PCM	Pulse code modulation
PISA	Process interface for sensors & actuators
PLD	Programmable Logic Device
PMC	
POTT	Permissive overreach transfer trip
PPS	Precise Positioning System
Process bus	Bus or LAN used at the process level, that is, in near proximity to the measured and/or controlled components
PSM	Power supply module
PST	Parameter setting tool
PT ratio	Potential transformer or voltage transformer ratio
PUTT	Permissive underreach transfer trip
R1A	Source resistance A (near end)
R1B	Source resistance B (far end)
RADSS	Resource Allocation Decision Support System
RASC	Synchrocheck relay, from COMBIFLEX range.
RCA	Functionality characteristic angle
REVAL	Evaluation software
RFPP	Resistance of phase-to-phase faults
RFPE	Resistance of phase-to-earth faults
RISC	Reduced instruction set computer
RMS value	Root mean square value
RS422	A balanced serial interface for the transmission of digital data in point-to-point connections
RS485	Serial link according to EIA standard RS485
RS530	A generic connector specification that can be used to support RS422, V.35 and X.21 and others
RTU	Remote Terminal Unit
RTC	Real Time Clock
SA	Substation Automation

SC	Switch or push-button to close
SCS	Station control system
SLM	Serial communication module. Used for SPA/LON/IEC communication
SMA connector	Sub Miniature version A connector
SMS	Station monitoring system
SPA	Strömberg Protection Acquisition, a serial master/slave protocol for point-to-point communication
SPGGIO	Single Point Gxxxxx Generic Input/Output
SRY	Switch for CB ready condition
ST3UO	RMS voltage at neutral point
STL1	Start signal from phase L1
ST	Switch or push-button to trip
SVC	Static VAr compensation
t1 1Ph	Open time for shot 1, single phase
t1 3PhHS	Open time for shot 1, high speed reclosing three phase
tAutoContWait	Wait period after close command before next shot
tCBCLosedMin	Minimum time that the circuit breaker must be closed before new sequence is permitted
tExtended t1	Open time extended by this value if Extended t1 is true
THL	Thermal Overload Line cable
THOL	Thermal overload
tInhibit	Reset reclosing time for inhibit
tPulse	Pulse length for single command outputs
TP	Logic Pulse Timer
tReporting	Cycle time for reporting of counter value
tRestore	Restore time delay
TCS	Trip circuit supervision
TNC connector	Type of bayonet connector, like BNC connector
TPZ, TPY, TPX, TPS	Current transformer class according to IEC
tReclaim	Duration of the reclaim time
TRIPENHA	Trip by enhanced restrained differential protection
TRIPRES	Trip by restrained differential protection
TRL1	Trip signal from phase 1
truck	Isolator with wheeled mechanism
tSync	Maximum wait time for synchrocheck OK
TTRIP	Estimated time to trip (in minutes)
UBase	Base setting for phase-phase voltage in kilovolts

U/I-PISA	Process interface components that delivers measured voltage and current values
UNom	Nominal voltage in % of UBase for voltage based timer
UPS	Measured signal magnitude (voltage protection)
UTC	Coordinated Universal Time. A coordinated time scale, maintained by the Bureau International des Poids et Mesures (BIPM), which forms the basis of a coordinated dissemination of standard frequencies and time signals
V.36	Same as RS449. A generic connector specification that can be used to support RS422 and others
VDC	Volts Direct Current
WEI	Week-end infeed logic
VT	Voltage transformer
VTSZ	Block of trip from weak-end infeed logic by an open breaker
X1A	Source reactance A (near end)
X1B	Source reactance B (far end)
X1L	Positive sequence line reactance
X.21	A digital signalling interface primarily used for telecom equipment
XLeak	Winding reactance in primary ohms
XOL	Zero sequence line reactance
ZCOM-CACC	Forward overreaching zone used in the communication scheme
ZCOM-CR	Carrier Receive Signal
ZCOM-TRIP	Trip from the communication scheme
ZCOM-LCG	Alarm Signal LIne-check Guard

Chapter 2 General

About this chapter

This chapter describes the terminal in general.

1 Terminal identification rated and base values

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.

Path in local HMI: Configurations/Identifiers

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 local HMI: Configuration/AnalogInputs/General

Table 5: Setting parameters for Analog Inputs - General

Parameter	Range	Default	Unit	Description
CTEarth	In/Out	Out	-	CT earthing location In = bus side Out = line side
fr	50, 60, 16 2/3	50	Hz	System frequency

Path in local HMI: Configuration/AnalogInputs/TrafoinpModule

Table 6: Rated Voltages

Parameter	Range	Default	Unit	Description
Ur *	10.000 - 500.000 Step: 0.001	110.000	V	Rated voltage of transformer module
U1r *	10.000 - 500.000 Step: 0.001	63.509	V	Rated voltage of transformer on input U1
U2r *	10.000 - 500.000 Step: 0.001	63.509	V	Rated voltage of transformer on input U2
U3r*	10.000 - 500.000 Step: 0.001	63.509	V	Rated voltage of transformer on input U3
U4r*	10.000 - 500.000 Step: 0.001	63.509	V	Rated voltage of transformer on input U4
U5r*	10.000 - 500.000 Step: 0.001	63.509	V	Rated voltage of transformer on input U5
*) Setting can be done through the local HMI only. The setting should normally not be changed by the user. The setting is factory preset and depends on the selected transformer input module.				

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

Table 7: Analog Inputs - Voltage

Parameter	Range	Default	Unit	Description
U1b	30.000 - 500.000 Step:0.001	63.509	V	Base voltage of input U1
U1Scale	1.000 - 20000.000 Step: 0.001	2000.000	-	Main voltage transformer ratio, input U1
Name_U1	0 - 13	U1	char	User-defined name of input U1
U2b	30.000 - 500.000 Step: 0.001	63.509	V	Base voltage of input U2
U2Scale	1.000 - 20000.000 Step: 0.001	2000.000	-	Main voltage transformer ratio, input U2
Name_U2	0 - 13	U2	char	User-defined name of input U2
U3b	30.000 - 500.000 Step: 0.001	63.509	V	Base voltage of input U3

Parameter	Range	Default	Unit	Description
U3Scale	1.000 - 20000.000 Step: 0.001	2000.000	-	Main voltage transformer ratio, input U3
Name_U3	0 - 13	U3	char	User-defined name of input U3
U4b	30.000 - 500.000 Step: 0.001	63.509	V	Base voltage of input U4
U4Scale	1.000 - 20000.000 Step: 0.001	2000.000	-	Main voltage transformer ratio, input U4
Name_U4	0 - 13	U4	char	User-defined name of input U4
U5b	30.000 - 500.000 Step: 0.001	63.509	V	Base voltage of input U5
U5Scale	1.000 - 20000.000 Step: 0.001	2000.000	-	Main voltage transformer ratio, input U5
Name_U5	0 - 13	U5	char	User-defined name of input U5

Path in local HMI: Configuration/AnalogInputs/TrafoinpModule

Table 8: Rated Currents

Parameter	Range	Default	Unit	Description
Ir *	0.1000 - 10.0000 Step: 0.0001	1.0000	A	Rated current of transformer module
I1r *	0.1000 - 10.0000 Step: 0.0001	1.0000	A	Rated current of transformer on input I1
I2r *	0.1000 - 10.0000 Step: 0.0001	1.0000	A	Rated current of transformer on input I2
I3r*	0.1000 - 10.0000 Step: 0.0001	1.0000	A	Rated current of transformer on input I3
I4r*	0.1000 - 10.0000 Step: 0.0001	1.0000	A	Rated current of transformer on input I4
I5r*	0.1000 - 10.0000 Step: 0.0001	1.0000	A	Rated current of transformer on input I5
*) Setting can be done through the local HMI only. The setting should normally not be changed by the user. The setting is factory preset and depends on the selected transformer input module.				

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

Table 9: Analog Inputs - Current

Parameter	Range	Default	Unit	Description
I1b	0.1 - 10.0 Step: 0.1	1.0	A	Base current of input I1
I1Scale	1.000 - 40000.000 Step: 0.001	2000.000	-	Main current transformer ratio, input I1
Name_I1	0 - 13	I1	char	User-defined name of input I1
I2b	0.1 - 10.0 Step: 0.1	1.0	A	Base current of input I2
I2Scale	1.000 - 40000.000 Step:0.001	2000.000	-	Main current transformer ratio, input I2
Name_I2	0 - 13	I2	char	User-defined name of input I2
I3b	0.1 - 10.0 Step: 0.1	1.0	A	Base current of input I3
I3Scale	1.000 - 40000.000 Step: 0.001	2000.000	-	Main current transformer ratio, input I3
Name_I3	0 - 13	I3	char	User-defined name of input I3
I4b	0.1 - 10.0 Step: 0.1	1.0	A	Base current of input I4
I4Scale	1.000 - 40000.000 Step: 0.001	2000.000	-	Main current transformer ratio, input I4
Name_I4	0 - 13	I4	char	User-defined name of input I4
I5b	0.1 - 10.0 Step: 0.1	1.0	A	Base current of input I5
I5Scale	1.000 - 40000.000 Step: 0.001	2000.000	-	Main current transformer ratio, input I5
Name_I5	0 - 13	I5	char	User-defined name of input I5

Path in local HMI: Configuration/AnalogInputs/U, I, P, Q, S, f

Table 10: Labels for service values

Parameter	Range	Default	Unit	Description
Name_U	0 - 13	U	Char	Name for analogue input U

Parameter	Range	Default	Unit	Description
Name_I	0 - 13	I	Char	Name for analogue input I
Name_P	0 - 13	P	Char	Name for analogue input P
Name_Q	0 - 13	Q	Char	Name for analogue input Q
Name_S	0 - 13	S	Char	Name for analogue input S
Name_f	0 - 13	f	Char	Name for analogue input f

1.3 Calendar and clock

Table 11: Calendar and clock

Parameter	Range
Built-in calender	With leap years through 2098

2 Technical data

2.1 Case dimensions

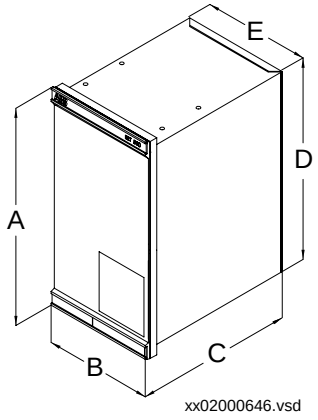


Figure 3: Case without rear cover

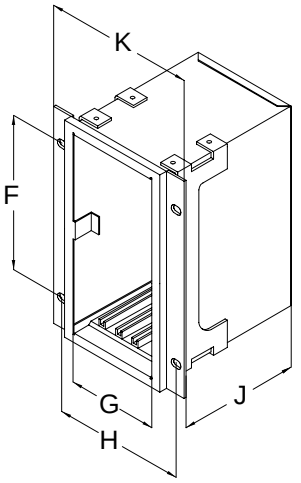


Figure 4: Case without rear cover with 19” rack mounting kit

Case size	A	B	C	D	E	F	G	H	J	K
6U, 1/2 x 19”	265.9	223.7	204.1	252.9	205.7	190.5	203.7	-	186.6	-
The H and K dimensions are defined by the 19” rack mounting kit										(mm)

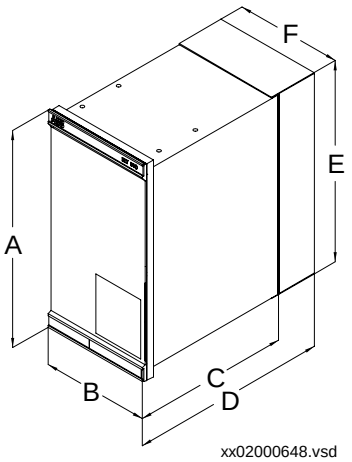


Figure 5: Case with rear cover.

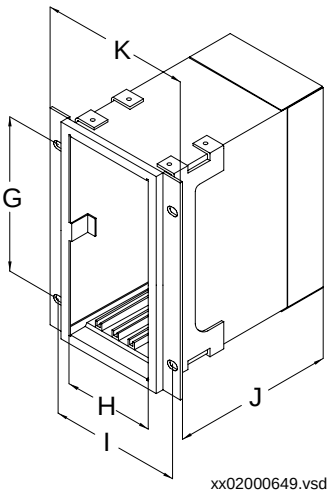


Figure 6: Case with rear cover and 19” rack mounting kit.

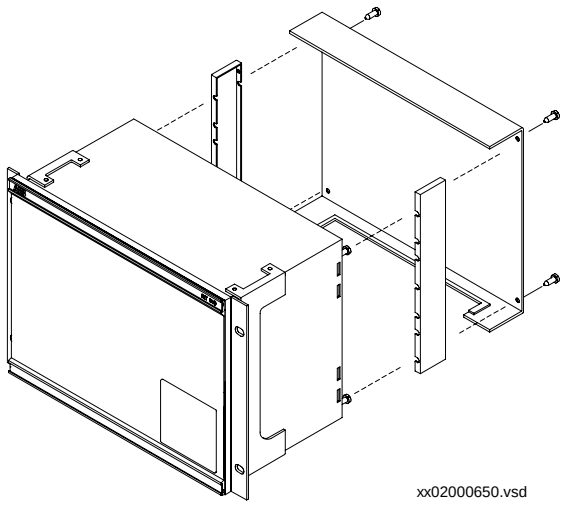
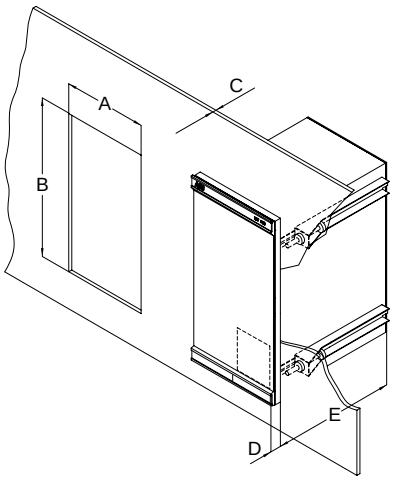


Figure 7: Rear cover case with details.

Case size	A	B	C	D	E	F	G	H	J	K
6U, 1/2 x 19”	265.9	223.7	242.1	252.9	205.7	190.5	203.7	-	186.6	-
6U, 3/4 x 19”	265.9	336	242.1	252.9	318	190.5	316	-	186.6	-
The H and K dimensions are defined by the 19” rack mounting kit. All dimensions are in millimeters.										

Panel cut-outs for REx 500 series, single case

Flush mounting



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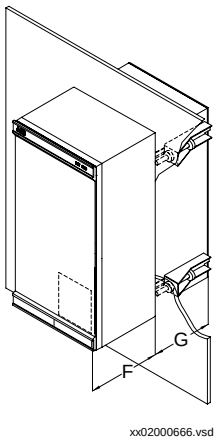
Semi-flush mounting



xx02000666.vsd

Case size	Cut-out dimensions (mm)	
	A+/-1	**B+/-1**
6U, 1/2 x 19”	210.1	254.3
6U, 3/4 x 19”	322.4	254.3

C = 4-10 mm

D = 16.5 mm

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

F = 106.5 mm

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

The flush mounting kit consists of four fasteners (2) with appropriate mounting details (4) and a sealing strip (5) for fastening to the IED (3).

To receive IP54 class protection, an additional sealing (1) must be ordered with the IED. This sealing is factory mounted.

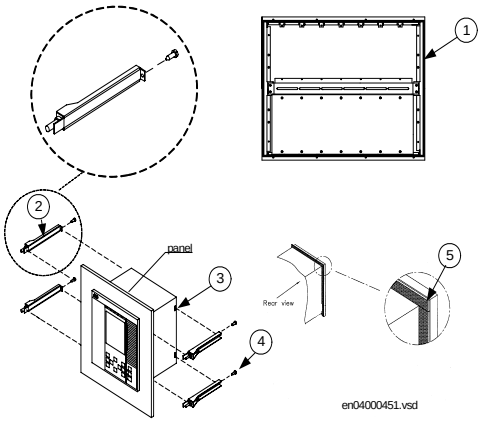
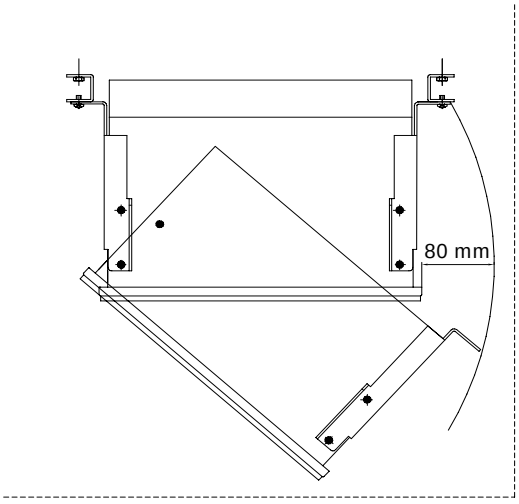


Figure 8: The flush mounting kit

Dimensions, wall mounting



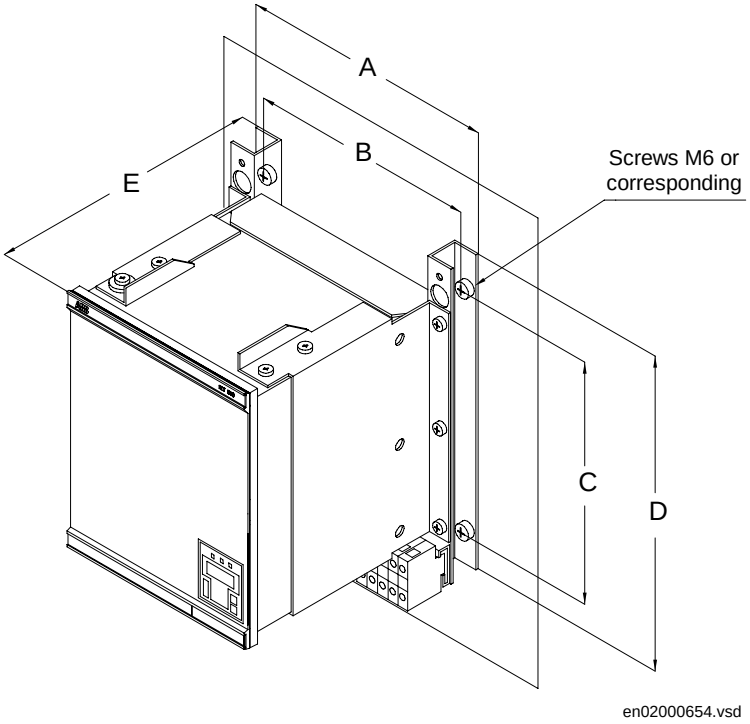


Figure 9: Wall mounting

Case size (mm)	A	B	C	D	E
6U, 1/2 x 19”	292	267.1	272.8	390	247
6U, 3/4 x 19”	404.3	379.4	272.8	390	247

2.2 Weight

Table 12: Weight

Case size	Weight
6U, 1/2 x 19”	≤ 8.5 kg
6U, 3/4 x 19”	≤ 11 kg

2.3 Unit

Table 13: Case

Material	Steel sheet
Front plate	Steel sheet profile with cut-out for HMI and for 18 LED when included
Surface treatment	Aluzink preplated steel
Finish	Light beige (NCS 1704-Y15R)
Degree of protection	Front side: IP40, optional IP54 with sealing strip. Rear side: IP20

2.4 Power consumption

Table 14: Power consumption, basic terminal

Size of terminal	Typical value
1/2 of 19” rack	≤ 18 W
3/4 of 19” rack	≤ 26 W

2.5 Environmental properties

Table 15: Temperature and humidity influence

Parameter	Reference value	Nominal range	Influence
Ambient temperature Operative range	+20 °C -25 °C to +55°C	-10 °C to +55 °C	0.01% / °C
Relative humidity Operative range	10%-90% 0%-95%	10%-90%	-
Storage temperature	-40 °C to +70 °C	-	-

Table 16: Auxiliary DC supply voltage influence on functionality during operation

Dependence on	Within nominal range	Influence
Ripple, in DC auxiliary voltage	Max 12%	0.01% / %
Interrupted auxiliary DC voltage	48-250 V dc ±20%	
Without reset		<50 ms
Correct function		0-∞ s
Restart time		<180 s

Table 17: Frequency influence

Dependence on	Within nominal range	Influence
Frequency dependence	f_r ±10% for 16 2/3 Hz f_r ±10% for 50 Hz f_r ±10% for 60 Hz	±2.0% / Hz
Harmonic frequency dependence (10% content)	2nd, 3rd and 5th harmonic of f_r	±6.0%

Table 18: Electromagnetic compatibility

Test	Type test values	Reference standards
1 MHz burst disturbance	2.5 kV	IEC 60255-22-1, Class III
For short range galvanic modem	2.5kV	IEC 60255-22-1, Class III
For galvanic interface		
• common mode • differential mode	1 kV 0.5 kV	IEC 60255-22-1, Class II IEC 60255-22-1, Class II
Electrostatic discharge		
Direct application	Air 8 kV Contact 6 kV	IEC 60255-22-2, Class III
For short range galvanic modem	Air 8 kV	IEC 60255-22-2, Class III
	Contact 6 kV	
Fast transient disturbance	4 kV	IEC 60255-22-4, Class A
For short range galvanic modem	4 kV	IEC 60255-22-4, Class A
For galvanic interface	1 kV	IEC 60255-22-4, Class B
Surge immunity test	1-2 kV, 1.2/50μs high energy	IEC 60255-22-5
Power frequency immunity test	150-300 V, 50 Hz	IEC 60255-22-7, Class A
Power frequency magnetic field test	1000 A/m, 3s	IEC 61000-4-8, Class V
Radiated electromagnetic field disturbance	10 V/m, 80-1000 MHz	IEC 60255-22-3

Test	Type test values	Reference standards
Radiated electromagnetic field disturbance	10 V/m, 80-1000 MHz, 1.4-2.0 GHz	IEC 61000-4-3, Class III
Radiated electromagnetic field disturbance	35 V/m 26-1000 MHz	IEEE/ANSI C37.90.2
Conducted electromagnetic field disturbance	10 V, 0.15-80 MHz	IEC 60255-22-6
Radiated emission	30-1000 MHz	IEC 60255-25
Conducted emission	0.15-30 MHz	IEC 60255-25

Table 19: Electromagnetic compatibility for RS485 interface

Test	Type test values	Reference standards
1 MHz burst disturbance	1 kV	IEC 60255-22-1, Class II
Electrostatic discharge Direct application	 Air 8 kV Contact 6kV	IEC 60255-22-2, Class III
Fast transient disturbance	1kV	IEC 60255-22-4, Class B
Surge immunity test	1 kV, 1.2/50 μs high energy	IEC 60255-22-5
Power frequency immunity test	150-300 V, 50 Hz	IEC 60255-22-7, Class A
Power frequency magnetic field test	1000 A/m, 3 s	IEC 61000-4-8, Class V
Radiated electromagnetic field disturbance	10 V/m, 80-1000 MHz	IEC 60255-22-3
Radiated electromagnetic field disturbance	10 V/m, 80-1000 MHz, 1.4-2.0 GHz	IEC 61000-4-3, Class III
Radiated electromagnetic field disturbance	35V/m, 26-1000 MHz	IEEE/ANSI C37.90.2
Conducted electromagnetic field disturbance	10 V, 0.15-80 MHz	IEC 60255-22-6
Radiated emission	30-1000 MHz	IEC 60255-25
Conducted emission	0.15-30 MHz	IEC 60255-25

Table 20: Insulation

Test	Type test values	Reference standard
Dielectric test	2.0 kVAC, 1 min.	IEC 60255-5
Impulse voltage test	5 kV, 1.2/50 μs, 0.5 J	
Insulation resistance	>100 MΩ at 500 VDC	

Table 21: CE compliance

Test	According to
Immunity	EN 61000-6-2
Emissivity	EN 61000-6-4
Low voltage directive	EN 50178

Table 22: 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

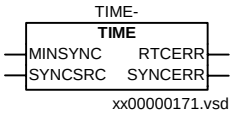
This chapter presents the common functions in the terminal.

1 Real-time clock with external time synchronization (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 SA system possible.

1.2 Function block



1.3 Input and output signals

Table 23: Input signals for the TIME (TIME-) function block

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

Path in local HMI: ServiceReport/Functions/Time

Table 24: Output signals for the TIME (TIME-) function block

Signal	Description
RTCERR	Real time clock error
SYNCERR	Time synchronisation error

1.4 Setting parameters

Path in local HMI: Configuration/Time

Table 25: Setting parameters for the time synchronization source selector function

Parameter	Range	Default	Unit	Description
SYNCSRC	0-5	0	-	Selects the time synchronization source: 0: No source. Internal real time clock is used without fine tuning. 1: LON bus 2: SPA bus 3: IEC 60870-5-103 bus 4: Minute pulse, positive flank 5: Minute pulse, negative flank

1.5 Technical data

Table 26: TIME - Time synchronisation

Function	Accuracy
Time tagging resolution	1 ms
Time tagging error with synchronisation once/60 s	± 1.5 ms
Time tagging error without synchronisation	± 3 ms/min

2 Four parameter setting groups (GRP)

2.1 Application

Use the four sets of settings to optimize the terminals 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

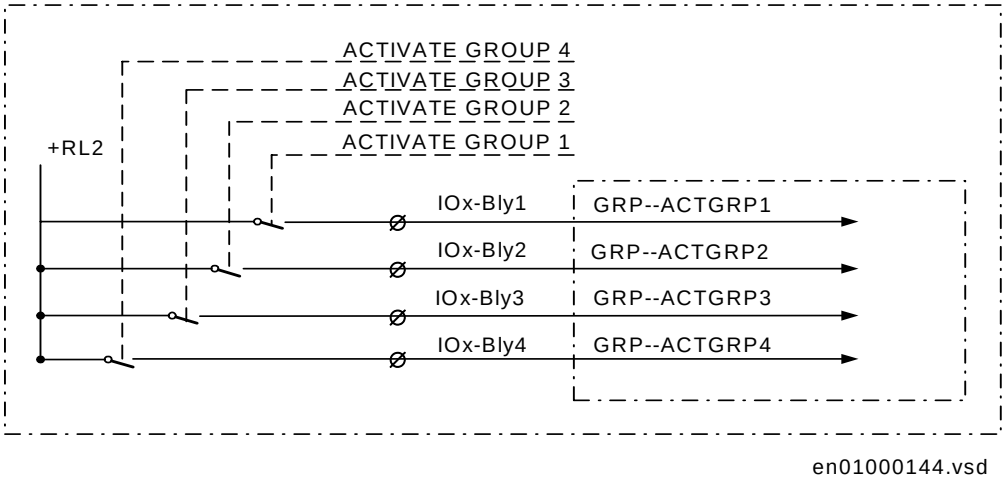
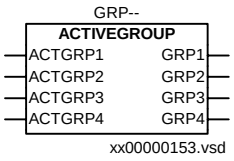


Figure 10: Connection of the function to external circuits

2.3 Function block



2.4 Input and output signals

Table 27: 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

Path in local HMI: ServiceReport/Functions/ActiveGroup/FuncOutputs

Table 28: 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 restriction of HMI (SRH)

Note!

The HMI--BLOCKSET functional input must be configured to the selected binary input before setting the setting restriction function in operation. Carefully read the instructions.

3.1 Application

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

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 local HMI.

3.2 Functionality

The restriction of setting via the local HMI can be activated from the local HMI only. Activating the local HMI setting restriction prevent unauthorized changes of the terminal settings or configuration.

The HMI-BLOCKSET functional input can be configured only to one of the available binary inputs of the terminal. The terminal is delivered with the default configuration HMI--BLOCKSET connected to NONE-NOSIGNAL. The configuration can be made from the local HMI only, see the Installation and comissioning manual.

The function permits remote changes of settings and reconfiguration through the serial communication ports. The restriction of setting from remote can be activated from the local HMI only. Refer to section 2.4.3 "Setting parameters" for SPA communication parameters.

All other functions of the local human-machine communication remain intact. This means that an operator can read disturbance reports, setting values, the configuration of different logic circuits and other available information.

3.3 Logic diagram

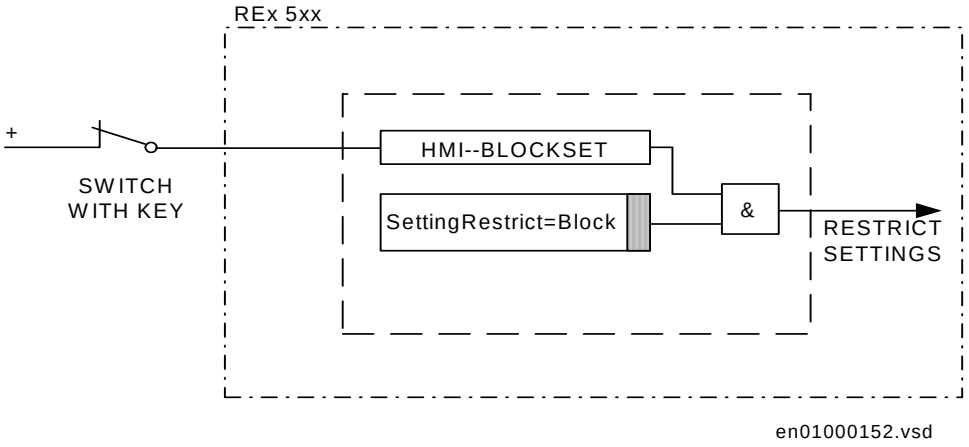


Figure 11: Connection and logic diagram for the BLOCKSET function

3.4 Input and output signals

Table 29: Input signals for the setting restriction of HMI function

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

Path in local HMI: Configuration/LocalHMI/SettingRestrict

Table 30: Setting parameters for the setting restriction of HMI function

Parameter	Range	Default	Unit	Description
SettingRestrict	Open, Block	Open	-	Open: Setting parameters can be changed. Block: Setting parameters can only be changed if the logic state of the BLOCKSET input is zero. **WARNING:** Read the instructions before use.

4 I/O system configurator

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

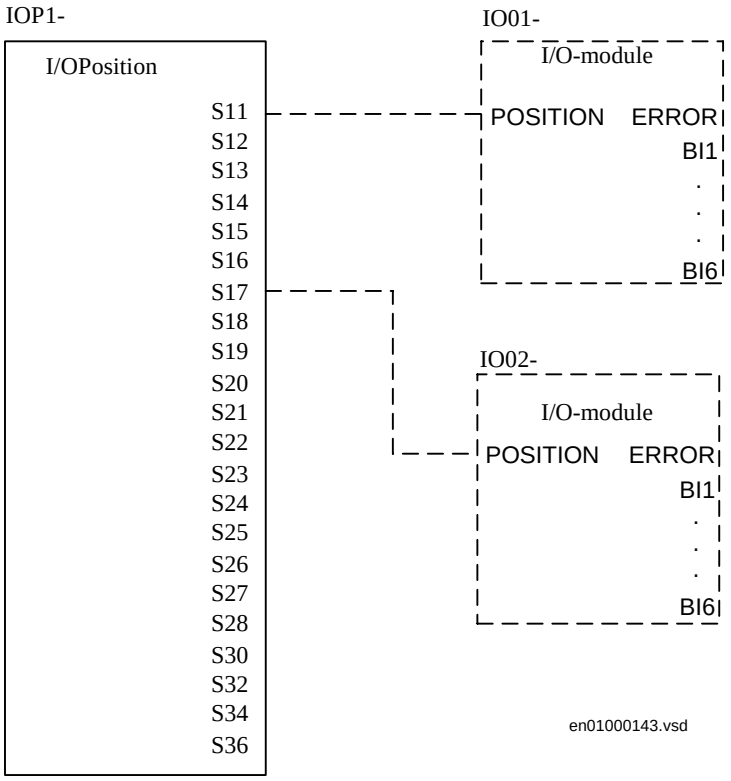
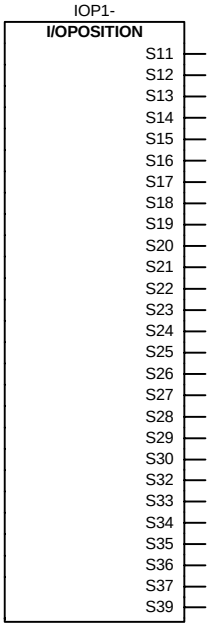


Figure 12: Example of an I/O-configuration in the graphical tool CAP 531 for a REx 5xx with two BIMs.

4.3 Function block



4.4 Input and output signals

Table 31: Output signals for the I/OPOSITION (IOPn-) function block

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

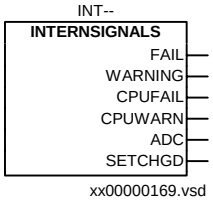
5 Self supervision with internal event recorder (INT)

5.1 Application

Use the local HMI, SMS or SCS 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



5.3 Logic diagram

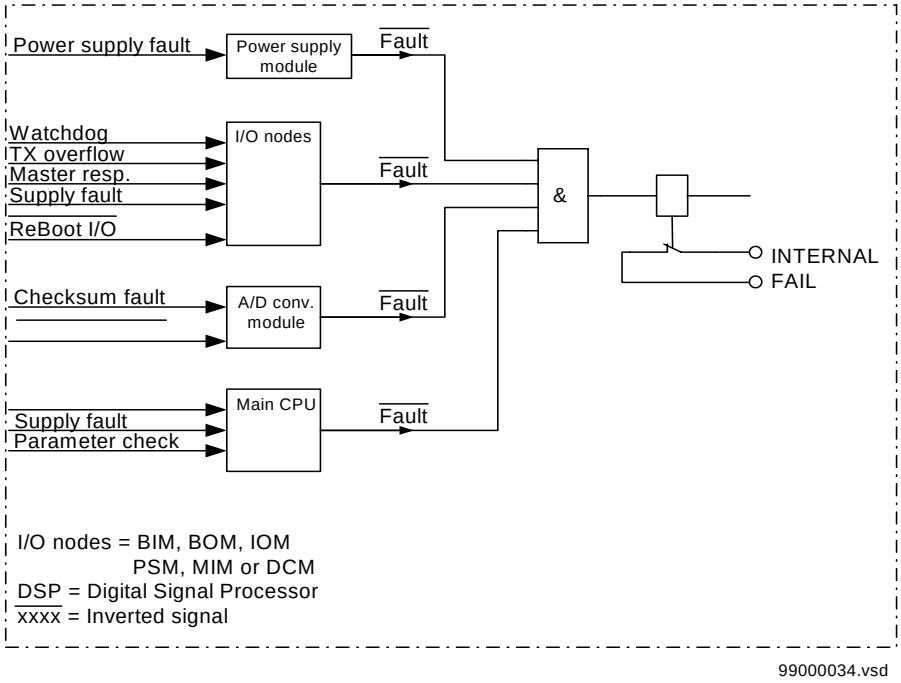


Figure 13: Hardware self-supervision, potential-free alarm contact.

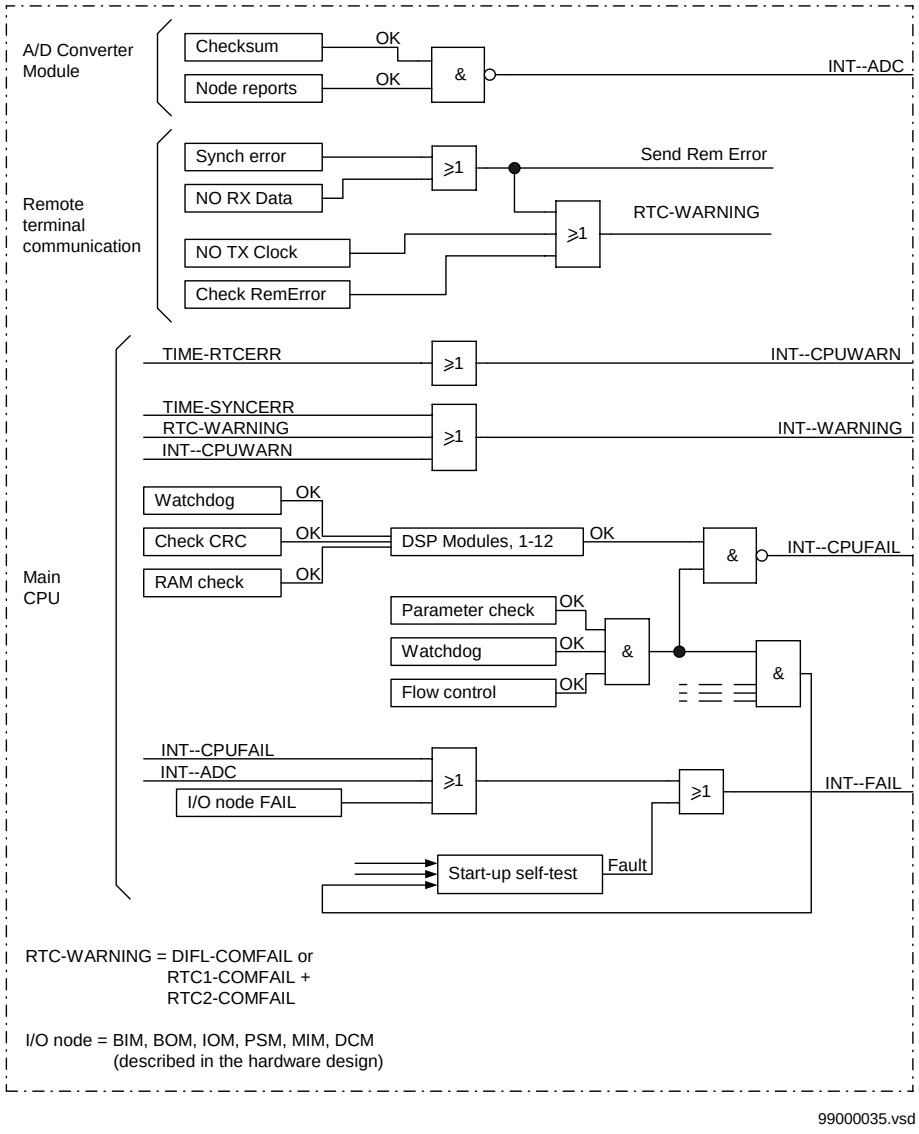


Figure 14: Software self-supervision, function block INTernal signals

5.4 Input and output signals

Path in local HMI: ServiceReport/Functions/InternSignals

Table 32: 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 33: Internal event list

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

6 Configurable logic blocks (CL1)

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.

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.

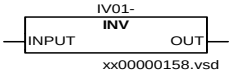


Table 34: Input signals for the INV (IVnn-) function block

Signal	Description
INPUT	Logic INV-Input to INV gate

Path in local HMI: ServiceReport/Functions/INV

Table 35: 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.

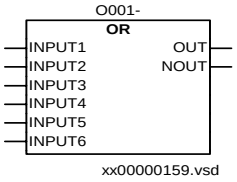


Table 36: Input signals for the OR (Onnn-) function block

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

Path in local HMI: ServiceReport/Functions/OR1n

Table 37: 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.

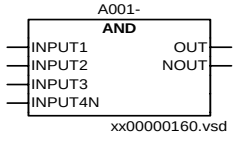


Table 38: Input signals for the AND (Annn-) function block

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

Path in local HMI: ServiceReport/Functions/AND1n

Table 39: 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).

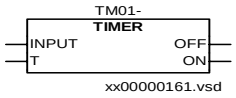


Table 40: Input signals for the TIMER (TMnn-) function block

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

Path in local HMI: ServiceReport/Functions/Timer

Table 41: 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 42: Setting parameters for the Timer (TMnn-) function

Parameter	Range	Default	Unit	Description
T	0.000-60.000 Step: 0.010	0.000	s	Delay for timer nn. Can only be set from CAP configuration tool.

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.

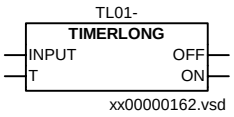


Table 43: Input signals for the TIMERLONG (TLnn-) function block

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

Path in local HMI: ServiceReport/Functions/TimerLong

Table 44: 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 45: Setting parameters for the TimerLong (TLnn-) function

Parameter	Range	Default	Unit	Description
T	0.0-90000.0 Step:0.1	0.0	s	Delay for TLnn function. Can only be set from CAP configuration tool.

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.

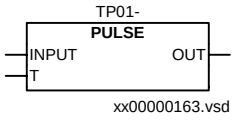


Table 46: Input signals for the TP (TPnn-) function block

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

Path in local HMI: ServiceReport/Functions/Pulsen

Table 47: Output signals for the TP (TPnn-) function block

Signal	Description
OUT	Output from pulse timer

6.7.1 Setting parameters

Table 48: Setting parameters for the Pulse (TPnn-) function

Parameter	Range	Default	Unit	Description
T	0.000-60.000 Step:0.010	0.010	s	Pulse length. Can only be set from CAP configuration tool.

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.

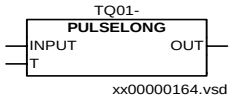


Table 49: Input signals for the PULSELONG (TQnn-) function block

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

Path in local HMI: ServiceReport/Functions/pulseLongn

Table 50: Output signals for the PULSELONG (TQnn-) function block

Signal	Description
OUT	Output from pulse long timer

6.8.1 Setting parameters

Table 51: Setting parameters for the PulseLong (TQnn-) function

Parameter	Range	Default	Unit	Description
T	0.0-90000.0 Step: 0.1	0.0	s	Pulse length. Can only be set from CAP configuration tool.

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.

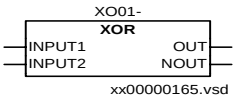


Table 52: Input signals for the XOR (XOnn-) function block

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

Path in local HMI: ServiceReport/Functions/XORn

Table 53: 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.

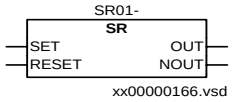


Table 54: Input signals for the SR (SRnn-) function block

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

Path in local HMI: ServiceReport/Functions/SR

Table 55: 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.

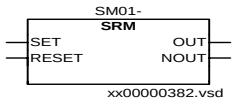


Table 56: Input signals for the SRM (SMnn-) function block

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

Path in local HMI: ServiceReport/Functions/SRWithMem1/FuncOutputs

Table 57: Output signals for the SRM (SMnn-) function block

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

Path in local HMI: Settings/Function/Groupn/SRWithMem1/SRMem01/MemoryFunct

Table 58: 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.

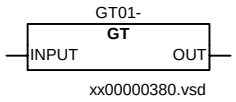


Table 59: Input signals for the GT (GTnn-) function block

Signal	Description
INPUT	Input to gate

Path in local HMI: ServiceReport/Functions/ControlGates1/FuncOutputs

Table 60: Output signals for the GT (GTnn-) function block

Signal	Description
Out	Output from gate

6.12.1 Setting parameters

Path in local HMI: Settings/Functions/Groupn/ContrGates1/Gaten

Table 61: 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. It also has an Operation setting On, Off that controls the operation of the timer.

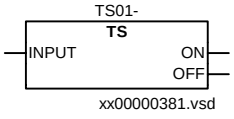


Table 62: Input signals for the TS (TSnn-) function block

Signal	Description
INPUT	Input to timer

Path in local HMI: ServiceReport/Functions/TimerSet1/FuncOutputs

Table 63: 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

Path in local HMI: Settings/Functions/Group1/TimerSet1/TimerSetnn

Table 64: 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 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 does not change any value between input and output.

6.14.1 Function block

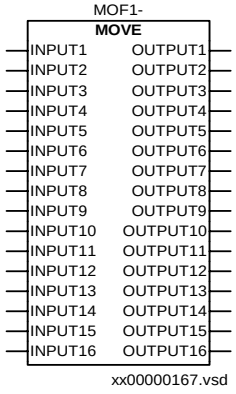


Table 65: Input signals for the MOFx function block

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

Use CAP configuration tool to see status of the output signals.

Table 66: 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 does not change any value between input and output.

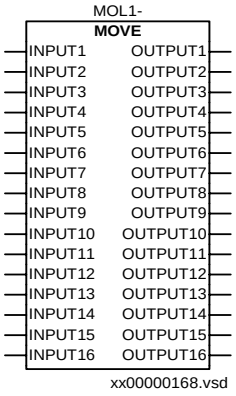


Table 67: Input signals for the MOLx function block

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

Use CAP configuration tool to see status of the output signals.

Table 68: Output signals for the MOLx function block

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

6.16 Technical data

Table 69: CL1 - Configurable blocks as basic

Update rate	Block	Availability
10 ms	AND	30 gates
	OR	60 gates
	INV	20 inverters
	SM	5 flip-flops
	GT	5 gates
	TS	5 timers
200 ms	SR	5 flip-flops
	XOR	39 gates

Table 70: Available timer function blocks as basic

Block	Availability	Setting range	Accuracy
TM	10 timers	0.000-60.000 s in steps of 1 ms	± 0.5% ± 10 ms
TP	10 pulse timers	0.000-60.000 s in steps of 1 ms	± 0.5% ± 10 ms
TL	10 timers	0.0-90000.0 s in steps of 0.1 s	± 0.5% ± 10 ms
TQ	10 puls timers	0.0-90000.0 s in steps of 0.1 s	± 0.5% ± 10 ms

Table 71: CL2 - Additional configurable logic blocks

Update rate	Block	Availability
200 ms	AND	239 gates
	OR	159 gates
	INV	59 inverters
	MOF	3 registers
	MOL	3 registers

Table 72: Additional timer function blocks

Block	Availability	Setting range	Accuracy
TP	40 pulse timers	0.000-60.000 s in steps of 1 ms	± 0.5% ± 10 ms

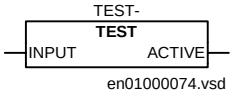
7 Blocking of signals during test (BST)

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 73: Input signals for the Test (TEST-) function block

Signal	Description
INPUT	Sets terminal in test mode when active

Path in local HMI: ServiceReport/Functions/Test

Table 74: Output signals for the Test (TEST-) function block

Signal	Description
ACTIVE	Terminal in test mode

Chapter 4 Line distance

About this chapter

This chapter describes the line impedance functions in the terminal.

1 Distance protection (ZM)

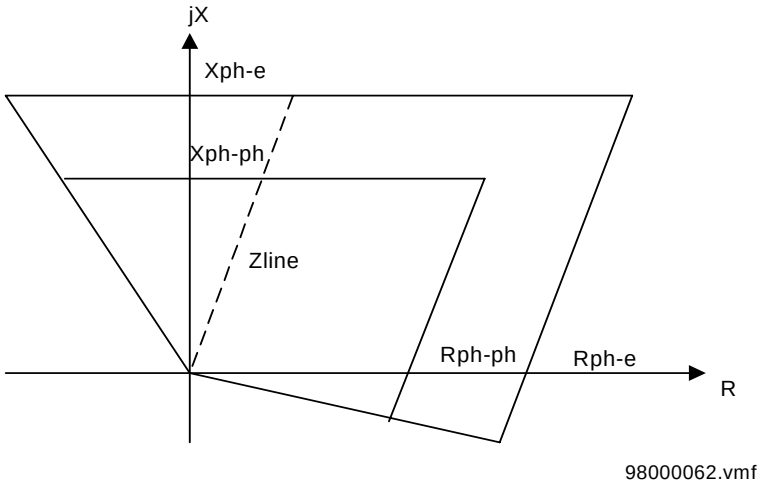
1.1 Application

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 the 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.



Where:

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

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

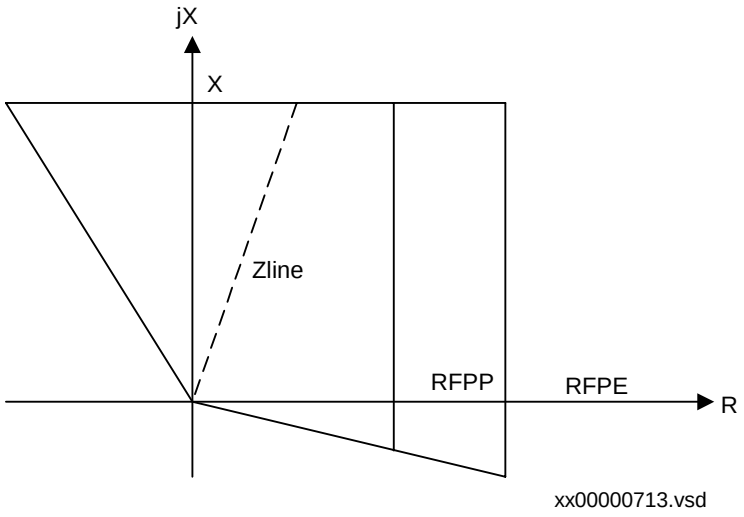
R_{ph-e} = resistive reach for ph-e faults

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

Z_{line} = line impedance

Figure 15: 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 with off-lines and cables.



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 16: 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 one, two and three 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 one to three, but lack the possibility of issuing phase selective output signals.

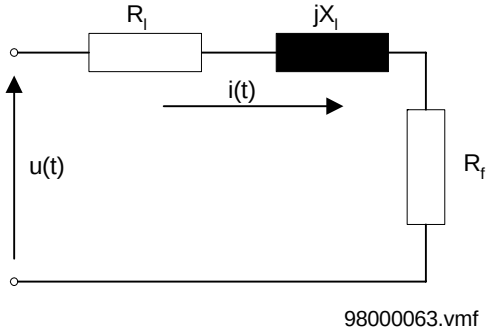
Distance protection zone five has shorter operating time than other zones, but also higher transient overreach. It should generally be used as a check zone together with the SOTF switch onto fault function or as a time delayed zone with time delay set longer than 100ms.

Basic distance protection function is generally suitable for use in non-compensated networks.

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 17.

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



Where:

R_l = line resistance

R_f = fault resistance

X_l = line reactance

ω = $2\pi f$

f = frequency

Figure 17: 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

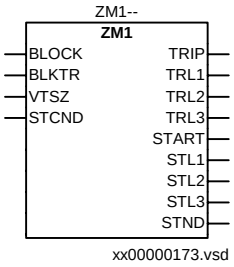


Figure 18: ZM1 function block for single, two and/or three phase tripping

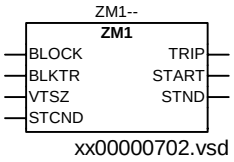


Figure 19: ZM1 function block for three phase tripping

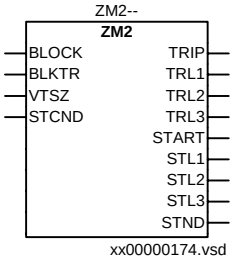


Figure 20: ZM2 function block for single, two and/or three phase tripping

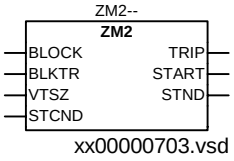


Figure 21: ZM2 function block for three phase tripping

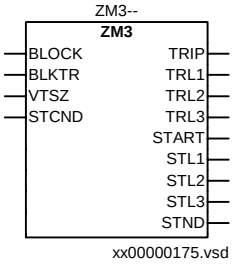


Figure 22: ZM3 function block for single, two and/or three phase tripping

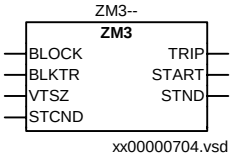


Figure 23: ZM3 function block for three phase tripping

1.4 Function block, zone 4

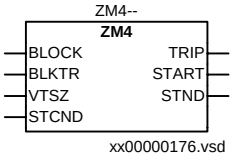


Figure 24: ZM4 function block

1.5 Function block, zone 5

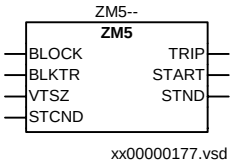


Figure 25: ZM5 function block

1.6 Logic diagram

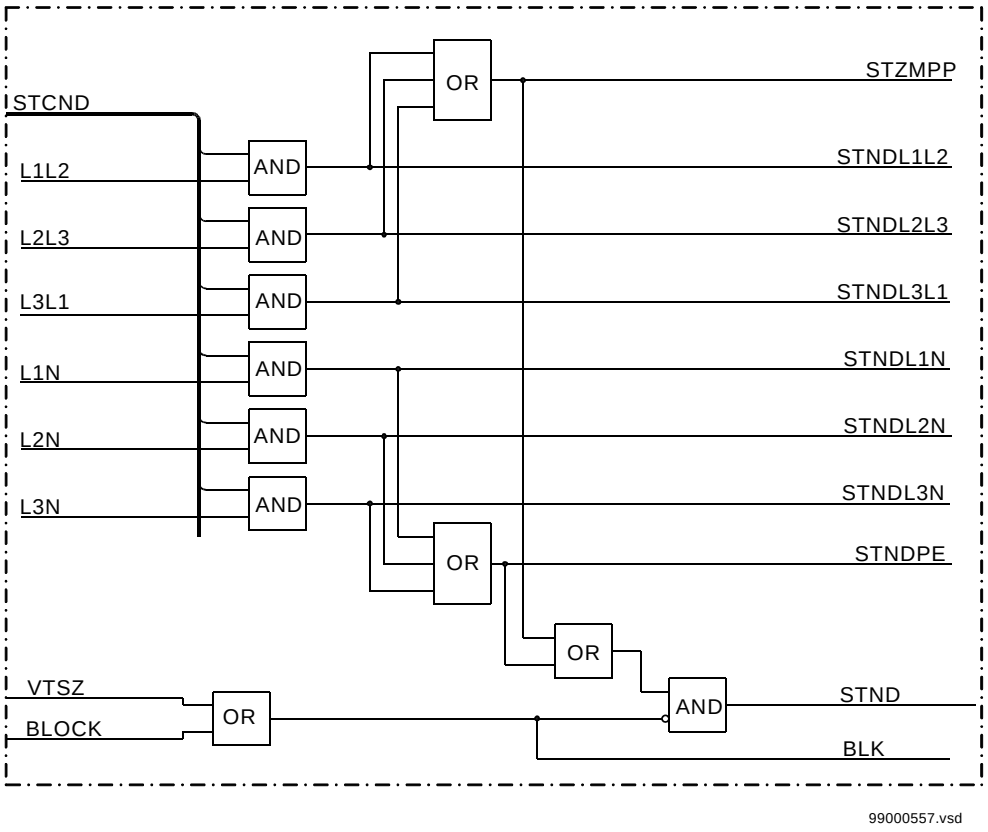


Figure 26: Conditioning by a group functional input signal ZM1--STCND

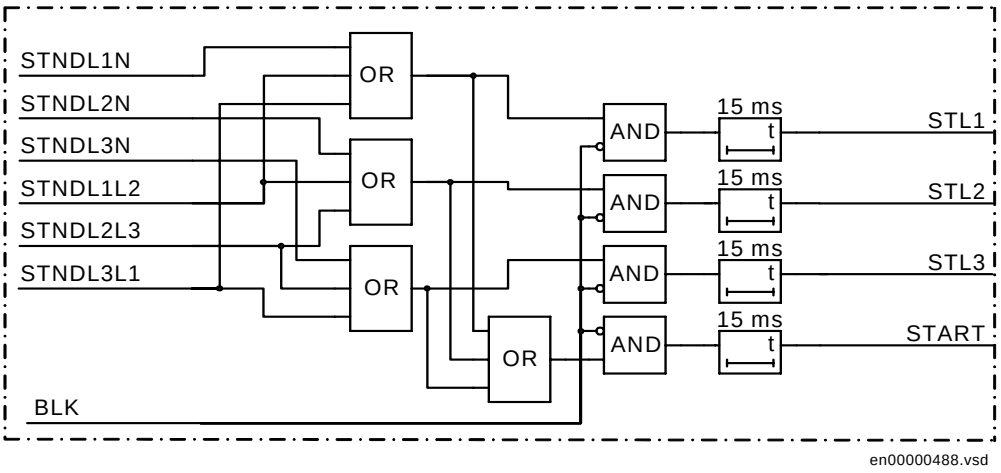


Figure 27: Composition of starting signals in non-directional operating mode

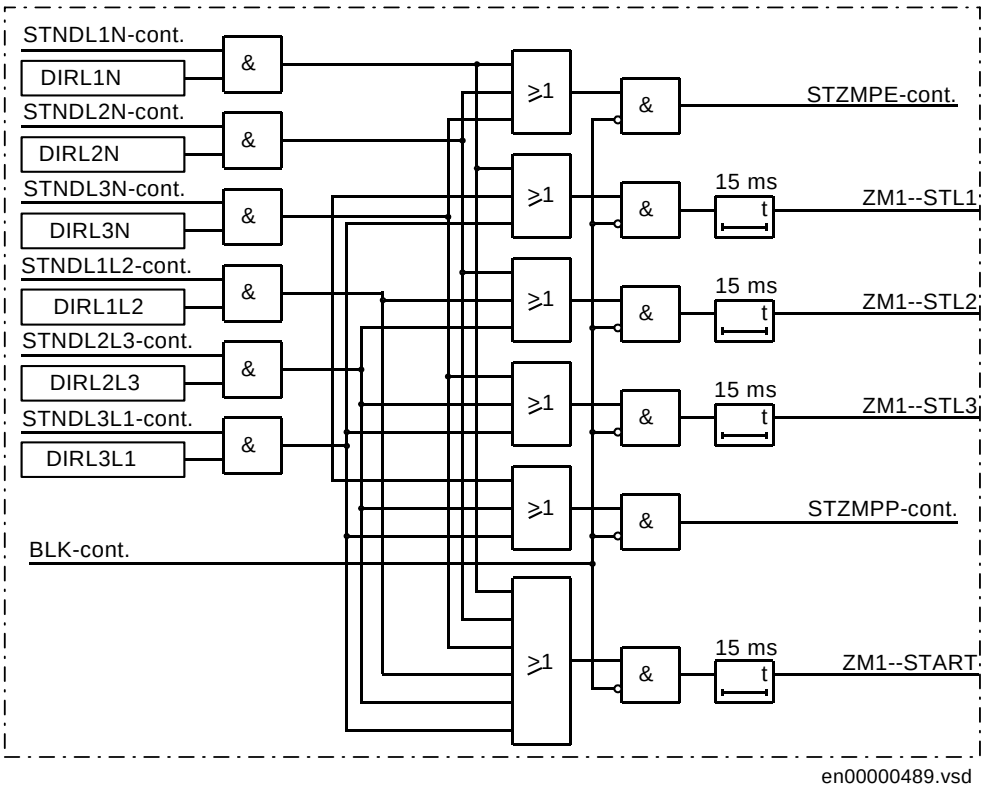


Figure 28: Composition of starting signals in directional operating mode

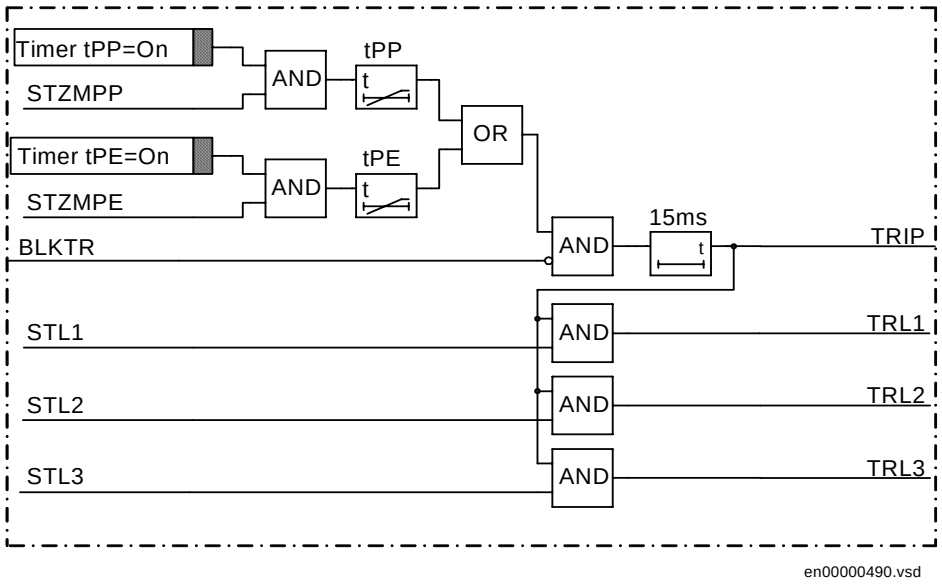


Figure 29: Tripping logic for the distance protection zone one

1.7 Input and output signals, zone 1-3

Table 75: 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

Path in local HMI: ServiceReport/Functions/Impedance/Zonen/FuncOutputs

Table 76: 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 77: 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

Path in local HMI: ServiceReport/Functions/Impedance/Zone4/FuncOutputs

Table 78: 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 79: 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

Path in local HMI: ServiceReport/Functions/Impedance/Zone5/FuncOutputs

Table 80: 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 local HMI: Settings/Functions/Group n/Impedance/General

Table 81: General setting parameters ZM1 - ZM

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

1.11 Setting parameters, zone 1-3

Path in local HMI: Settings/Functions/Groupn/Impedance/Zone1-3

Table 82: General setting parameters for ZM1 - 3 (ZMn--) function

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

Path in local HMI: Settings/Functions/Groupn/Impedance/Zone1-3

Table 83: 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 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 Step: 0.01	ohm/ph	10.00	Positive sequence line resistance included in distance protection zone *n* for Ph-Ph faults
RFPP	0.10-400.00 Step: 0.01	ohm/loop	10.00	Resistive reach of distance protection zone *n* for Ph-Ph faults
Timer t1PP Timer t2PP Timer t3PP	Off, On	-	Off	Operating mode of time delayed trip for the distance protection zone *n* for Ph-Ph faults
t1PP t2PP t3PP	0.000 - 60.000 Step: 0.001	s	0.000	Time delayed trip operation of the distance protection zone *n* for Ph-Ph faults

Path in local HMI: Settings/Functions/Groupn/Impedance/Zone1-3

Table 84: 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 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 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 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 Step: 0.01	ohm/ph	10.00	Zero sequence line resistance included in distance protection zone *n* for Ph-E faults
RFPE	0.10-400.00 Step: 0.01	ohm/loop	10.00	Resistive reach of distance protection zone *n* for Ph-E faults
Timer t1PE Timer t2PE Timer t3PE	Off, On	-	Off	Operating mode of time delayed trip for the distance protection zone *n* for Ph-E faults
t1PE t2PE t3PE	0.000 - 60.000 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 local HMI: Settings/Functions/Groupn/Impedance/Zone4

Table 85: 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 local HMI: Settings/Functions/Groupn/Impedance/Zone4

Table 86: 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 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 Step: 0.01	10.00	ohm/ph	Positive sequence line resistance included in distance protection zone 4 for Ph-Ph faults
RFPP	0.10 - 400.00 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 Step: 0.001	0.000	s	Time delayed trip operation of the distance protection zone 4 for Ph-Ph faults

Path in local HMI: Settings/Functions/Group n/Impedance/Zone4

Table 87: 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 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 Step: 0.01	10.00	ohm/ph	Positive sequence line resistance included in distance protection zone 4 for Ph-E faults

Parameter	Range	Default	Unit	Description
X0PE	0.10 - 1200.00 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 Step:0.01	10.00	ohm/ph	Zero sequence line resistance included in distance protection zone 4 for Ph-E faults
RFPE	0.10 - 400.00 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 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 local HMI: Settings/Functions/Groupn/Impedance/Zone5

Table 88: 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 local HMI: Settings/Functions/Groupn/Impedance/Zone5

Table 89: 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 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 Step: 0.01	10.00	ohm/ph	Positive sequence line resistance included in distance protection zone 5 for Ph-Ph faults
RFPP	0.10 - 400.00 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 Step: 0.001	0.000	s	Time delayed trip operation of the distance protection zone 5 for Ph-Ph faults

Path in local HMI: Settings/Functions/Groupn/Impedance/Zone5

Table 90: 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 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 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 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 Step: 0.01	10.00	ohm/ph	Zero sequence line resistance included in distance protection zone 5 for Ph-E faults
RFPE	0.10 - 400.00 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 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

Path in local HMI: Settings/Functions/Grupn//Impedance/Zonen

Table 91: Simplified settings, ZM1 - ZM

Parameter	Range	Default	Unit	Description
X1	0.10-400.00 Step: 0.01	10.00	ohms/phase	Positive sequence reactance, zone n
R1	0.10-400.00 Step: 0.01	10.00	ohms/phase	Positive sequence resistance, zone n
RFPP	0.10-400.00 Step: 0.01	10.00	ohms/loop	Fault resistance, zone n, phase-to-phase
Timer t1 Timer t2 Timer t3 Timer t4 Timer t5	On/Off	Off	-	Operation trip time delay, zone n. Off= no trip
t1 t2 t3 t4 t5	0.000-60.000 Step: 0.001	0.000	s	Trip time delay, zone n
X0	0.10-1200.00 Step: 0.01	10.00	ohms/phase	Zero sequence reactance, zone n
R0	0.10-1200.00 Step: 0.01	10.00	ohms/phase	Zero sequence resistance, zone n
RFPE	0.10-400.00 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.

Path in local HMI: Settings/Functions/Groupn/Impedance/Direction

Table 92: General setting parameters, ZDIR

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

1.16 Technical data

Table 93: 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 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 degrees and 85 degrees	Voltage range (0.1-1.1) x U_r		+/- 5 %
	Current range (0.5-30) x I_r		
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		
Max dynamic overreach at 85 degrees measured with CVT's 0.5 < SIR < 30			+ 5 %

2 Automatic switch onto fault logic (SOTF)

2.1 Application

The main purpose of the SOTFswitch-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.

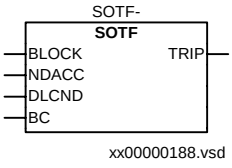
Generally, directional or non-directional overreaching distance or overcurrent protection functions are used as the protection functions to be released for direct tripping during the activated time. When line-side potential transformers are used, the use of non-directional protection zones secures switch-on-to-fault tripping for fault situations where directional information can not be established, for example, due to lack of polarizing voltage. Use of non-directional protection 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 or overcurrent protection functions.

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



2.4 Logic diagram

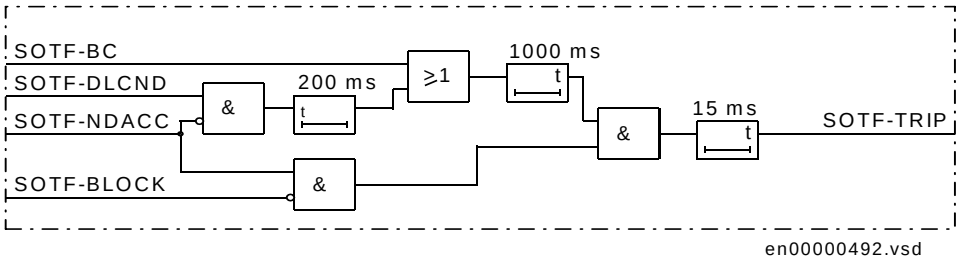


Figure 30: SOTF function - simplified logic diagram

2.5 Input and output signals

Table 94: 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

Path in local HMI: ServiceReport/Functions/Impedance/ SwitchOntoFlt/FuncOutputs

Table 95: Output signals for the SOTF (SOTF-) function block

Signal	Description
TRIP	Trip output

2.6 Setting parameters

Path in local HMI: Settings/Functions/Groupn/Impedance/SwitchOntoFlt

Table 96: 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 97: SOTF - 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

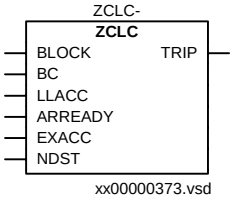
The main purpose of the ZCLC local acceleration logic is to achieve fast fault clearance for faults anywhere on the whole line for those applications where no communication channel is available.

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



3.4 Logic diagram

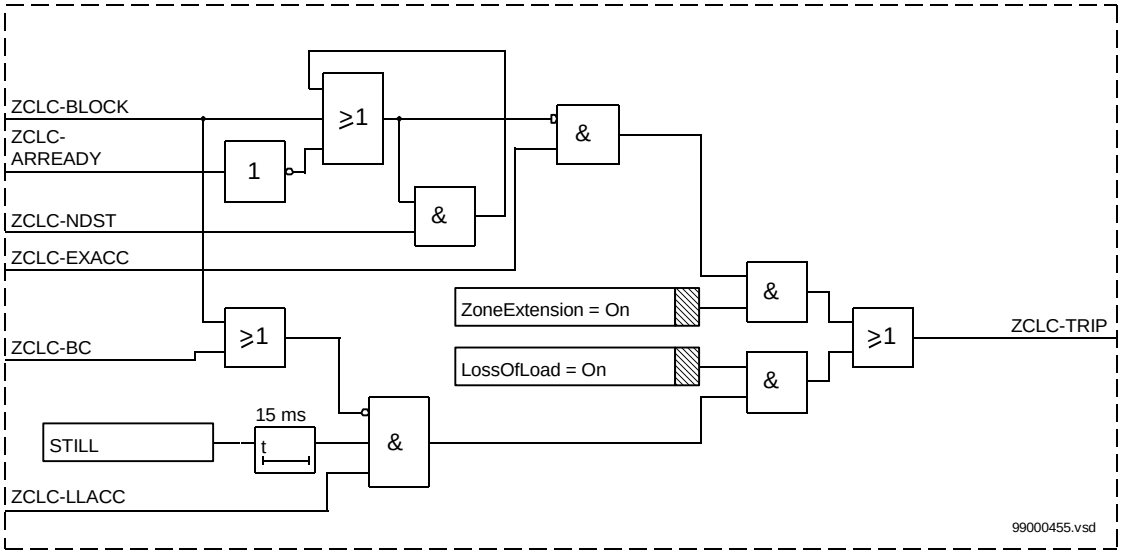


Figure 31: Simplified logic diagram for the local acceleration logic

3.5 Input and output signals

Table 98: 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

Path in local HMI: ServiceReport/Functions/Impedance/ComLocal/FuncOutputs

Table 99: Output signals for the ZCLC (ZCLC-) function block

Signal	Description
TRIP	Trip output

3.6 Setting parameters

Path in local HMI: Settings/Functions/Groupn/Impedance/ComLocal

Table 100: 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 General fault criteria (GFC)

4.1 Application

The GFC general fault criteria function is an independent measuring function. It comprises both impedance and current-based measurement criteria. These can be used separately or at the same time. Its main purpose is to serve as an overall fault detection and phase selection element in all kinds of networks or as an individual underimpedance measuring function. It is not used as a start condition because the distance protection zones utilize full scheme measurement.

For the impedance measurement, the shape of the operating characteristic can be set to prevent operation of the impedance measuring elements for low load impedances, yet at the same time allow coverage of higher fault resistances with remote infeed of fault current. This makes the GFC function especially suited to cases where the fault resistance to be detected exceeds the minimum expected load impedance.

The independent measurement of impedance for each fault loop secures reliable phase selection and correct operation for complex network faults such as simultaneous faults on parallel circuits, evolving faults, etc. Independent reactive reach settings for phase-to-phase and phase-to-ground measurement secure high selectivity in networks with different protective relays used for short-circuit and earth-fault protection.

A possible addition to the GFC function is the optional phase preference logic. Its main purpose is to provide a selective tripping function for cross-country faults in isolated or high impedance-grounded networks.

4.2 Functionality

For the impedance-based phase selection, all six fault loops are measured separately and continuously. The reaches are independently settable in the forward and reverse directions, and for phase-to-phase and phase-to-ground faults. The resistive reaches are also independently settable for phase-to-phase and phase-to-ground faults. Preventing impedance element operation due to low load impedances, but at the same time enabling the GFC function to be as sensitive as possible to faults with high fault resistances, is achieved by the inclusion of a facility that allows the resistive reach to be limited within the load impedance area only.

Checks based on the level of residual current determine which loops, i.e. phase-to-ground 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.

For the current-based phase selection, all three phase currents and the residual current are measured continuously, and compared to set values. Assessment of the type of fault is based on the relationship of the measured currents to the set thresholds.

The GFC starting condition (STCND) output will activate the selected loop of the distance protection measuring zone(s) to which it is connected.

The phase preference logic inhibits tripping for single-phase-to-ground faults in isolated and high impedance-grounded networks. It does this by blocking forward and reverse operation until two earth-faults are detected to be within the non-directional characteristic. For such cross-country faults, the logic initiates tripping of the preferred fault based on the selected phase preference. A number of different phase preference combinations are available for selection.

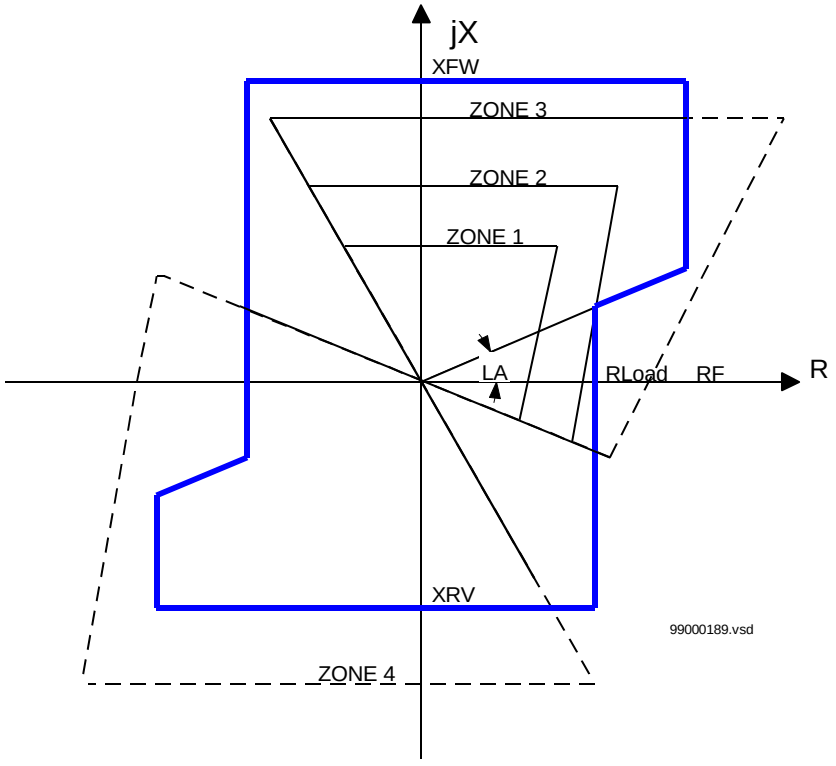
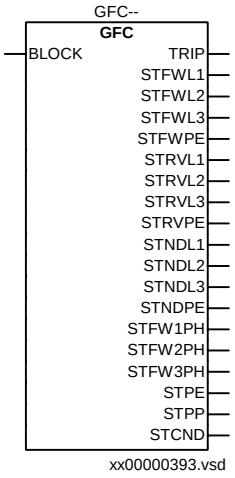


Figure 32: Operating characteristics of the GFC (impedance measuring principle) and zone measuring elements

Figure 32 presents principally a shaped operate characteristic for an impedance based GFC function. Different designations have the following meaning:

- XFW: reactive reach in forward direction
- XRV: reactive reach in reverse direction
- RF: resistive reach within the unlimited area
- RLoad: resistive reach restricted by the minimum load impedance
- LA: expected load impedance angle

4.3 Function block



4.4 Logic diagram

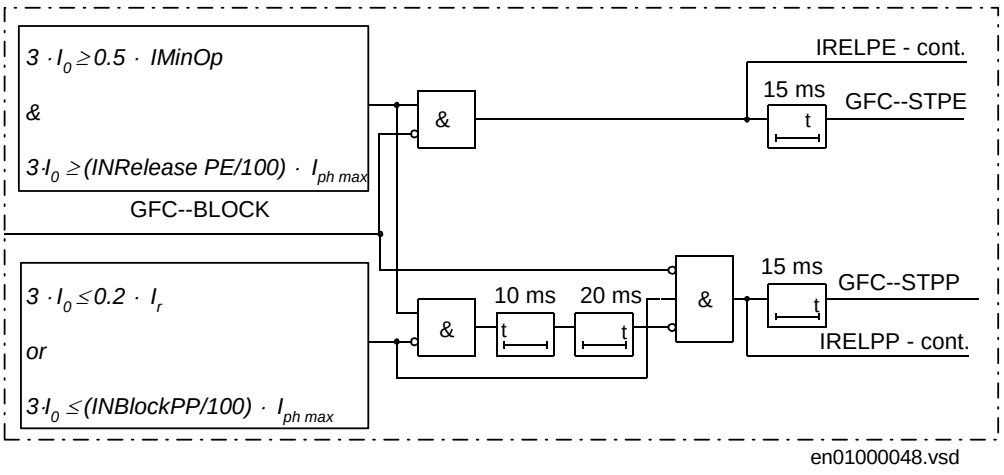


Figure 33: Detection of ph-E and ph-ph fault conditions

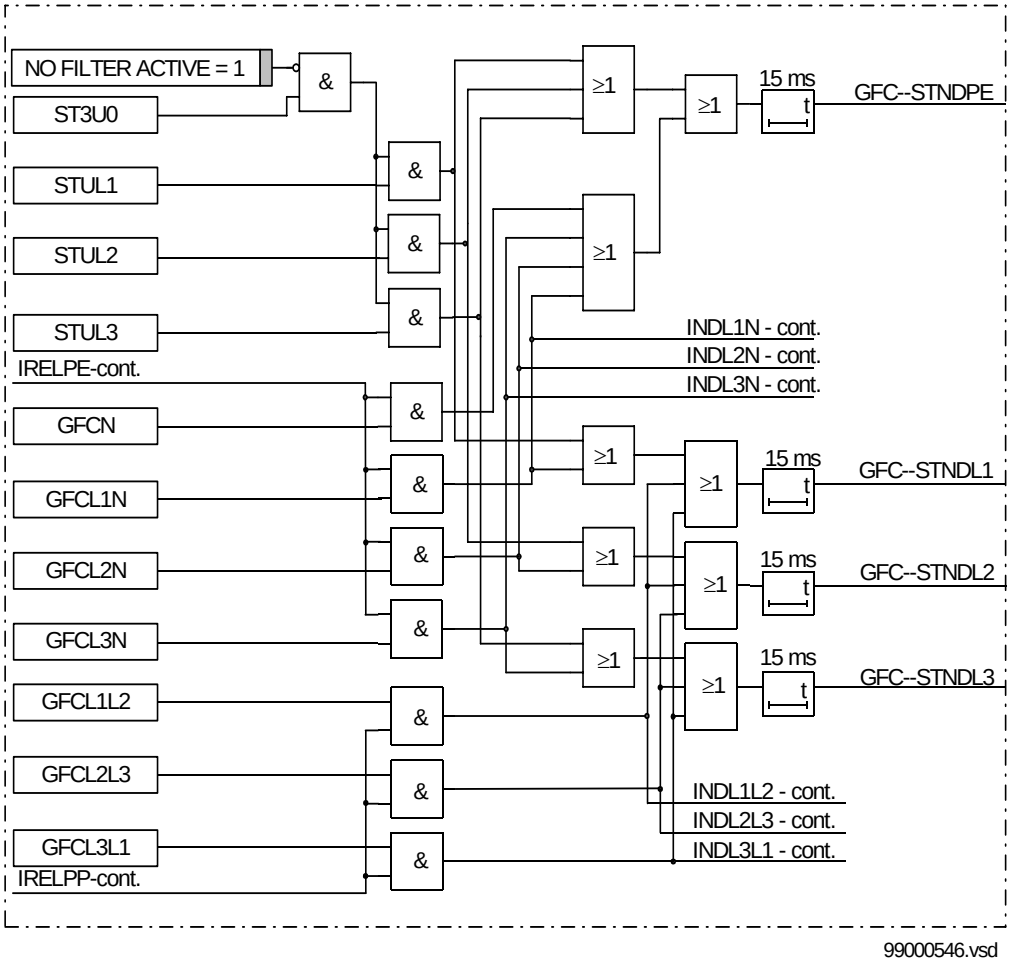


Figure 34: Composition of non-directional GFC signals with phase preference logic

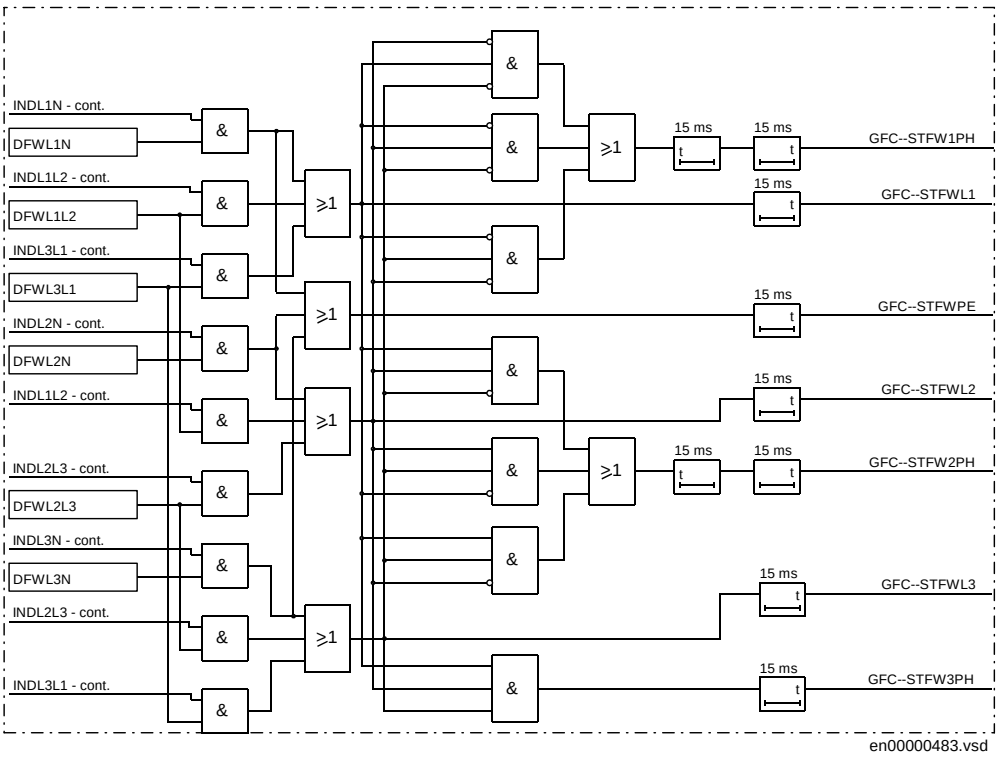


Figure 35: Composition of forward directed GFC signals.

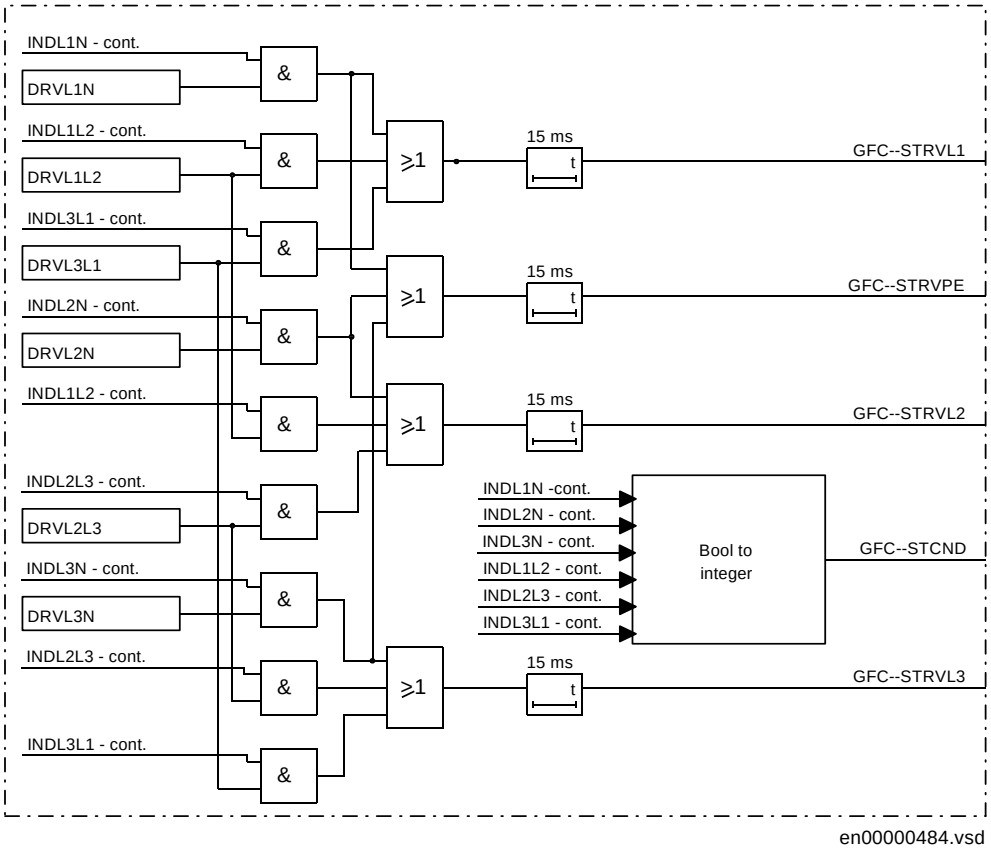


Figure 36: Composition of reverse directed GFC signals and measured impedance related zone starting conditions

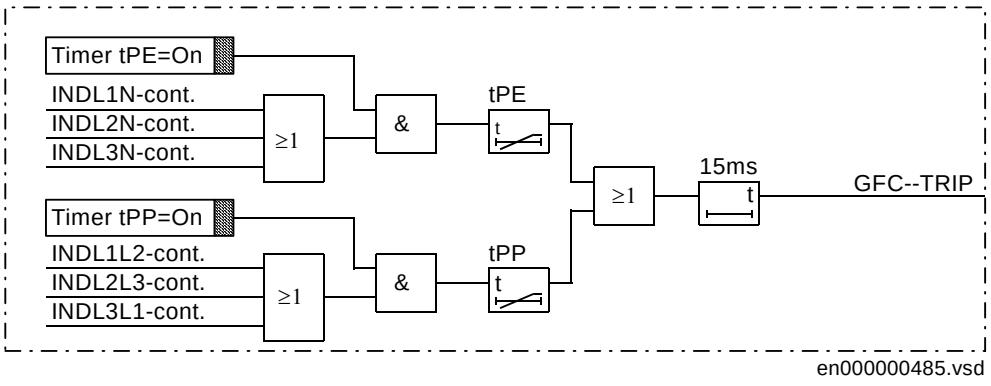


Figure 37: Composition of time-delayed tripping signal

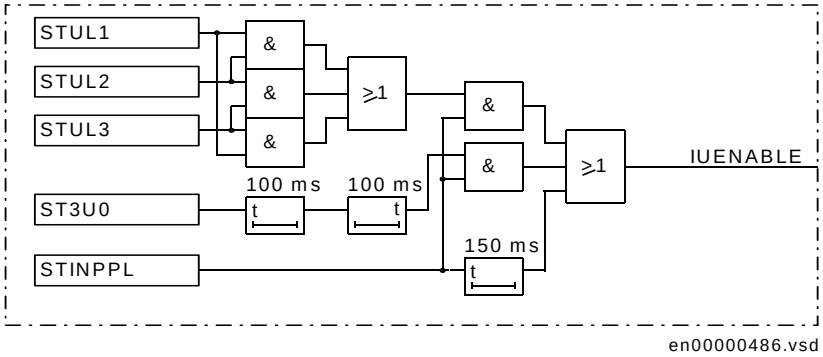


Figure 38: Cross-country fault detection logic

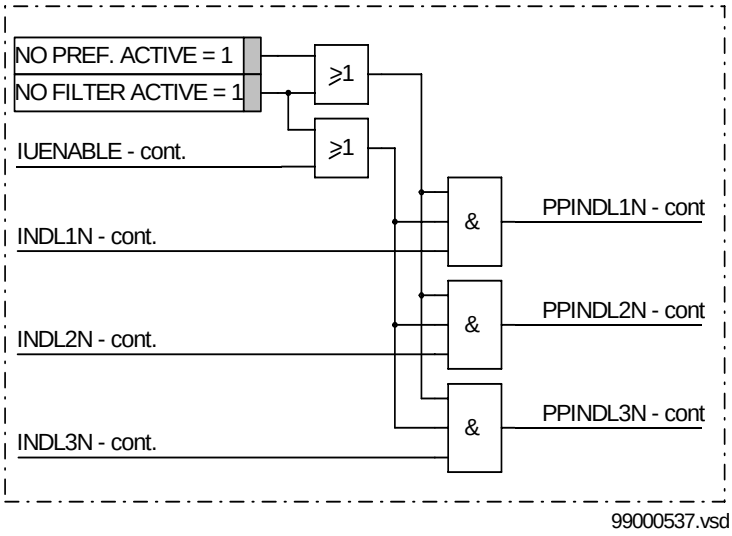


Figure 39: Phase preference logic with no filter setting and no preference setting

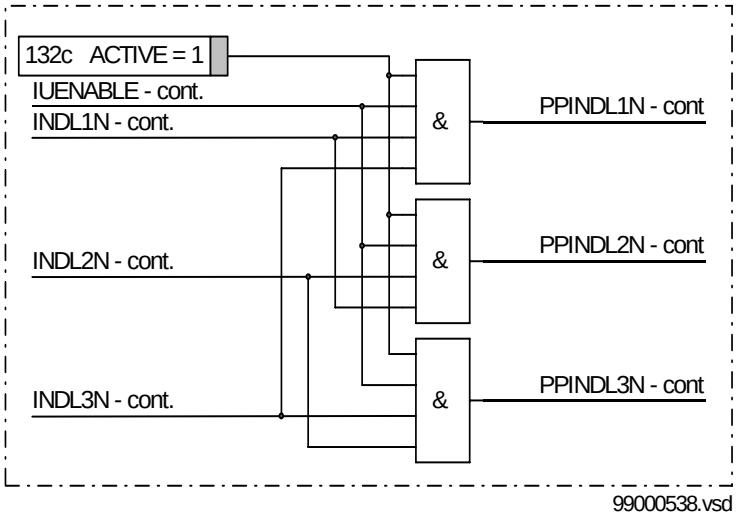


Figure 40: Cyclic phase preference logic with 132c setting active

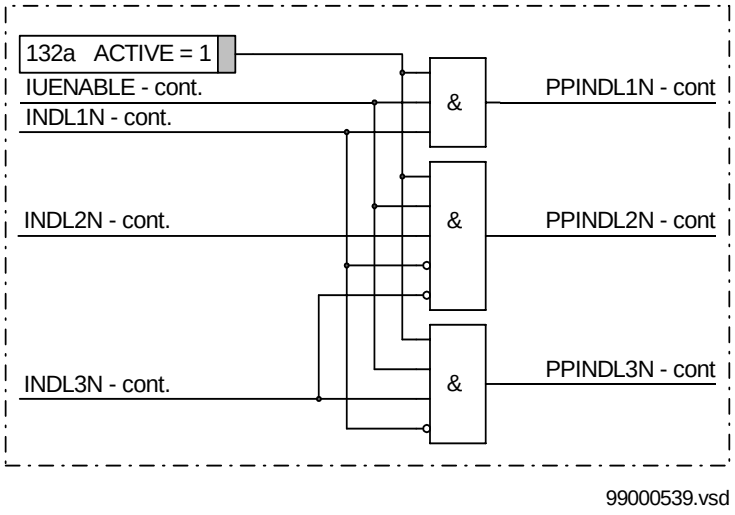


Figure 41: Acyclic phase preference logic with 132a setting active

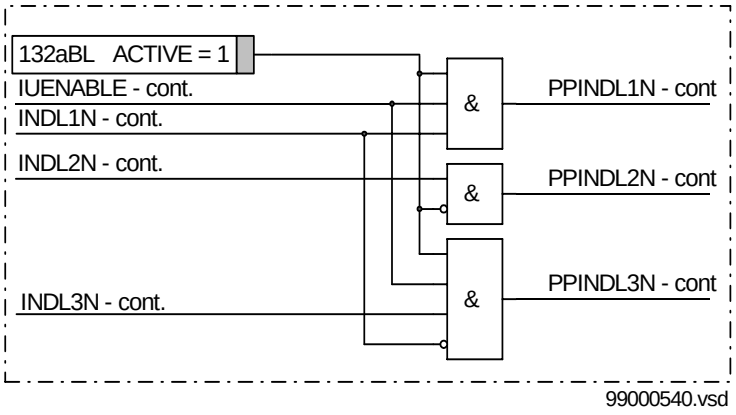


Figure 42: Acyclic phase preference logic with one phase blocked, 132aBL. setting active

4.5 Input and output signals

Table 101: Input signals for the GFC (GFC--) function block

Signal	Description
BLOCK	Block the operation of the GFC measuring elements

Path in local HMI: ServiceReport/Functions/Impedance/GenFltCriteria/FuncOutputs

Table 102: Output signals for the GFC (GFC--) function block

Signal	Description
TRIP	Time delayed trip caused by general fault criteria (GFC)
STFWL1	General fault criteria - forward operation in phase L1
STFWL2	General fault criteria - forward operation in phase L2
STFWL3	General fault criteria - forward operation in phase L3
STFWPE	General fault criteria - forward operation of ph-E loop
STRVL1	General fault criteria - reverse operation in phase L1
STRVL2	General fault criteria - reverse operation in phase L2
STRVL3	General fault criteria - reverse operation in phase L3
STRVPE	General fault criteria - reverse operation of ph-E loop
STNDL1	General fault criteria - non-directional operation in phase L1
STNDL2	General fault criteria - non-directional operation in phase L2
STNDL3	General fault criteria - non-directional operation in phase L3
STNDPE	General fault criteria - non-directional operation of ph-E loop
STFW1PH	General fault criteria - single-phase fault in forward direction

Signal	Description
STFW2PH	General fault criteria - two-phase fault in forward direction
STFW3PH	General fault criteria - three-phase fault in forward direction
STPE	Start the phase-to-earth measuring loops
STPP	Start the phase-to-phase measuring loops
STCND	Release (starting) condition for the external distance protection measuring zones

4.6 Setting parameters

Path in local HMI: Settings/Functions/Groupn/Impedance/GenFltCriteria

Table 103: General setting parameters

Parameter	Range	Default	Unit	Description
Operation	Off/On	Off	-	Operating mode
INReleasePE	10-100 Step: 1	20	% of IphMax	3I0 limit for releasing phase-to-earth measuring loops
INBlockPP	10-100 Step: 1	40	% of IphMax	3I0 limit for blocking phase-to-phase measuring loops
Timer tPP	Off/On	Off	-	Time delayed of trip for phase-to-phase faults enabled or disabled
tPP	0.000-60.000 Step: 0.001	5.000	s	Time delay of trip for phase-to-phase faults
Timer tPE	Off/On	Off	-	Time delay of trip for phase-to-earth faults enabled or disabled
tPE	0.000-60.000 Step:0.001	5.000	s	Time delay of trip for phase-to-earth faults

Path in local HMI: Settings/Functions/Groupn/Impedance/GenFltCriteria

Table 104: Setting parameters for the overcurrent operating mode

Parameter	Range	Default	Unit	Description
Operation I>	Off/On	Off	-	Operation of current based GFC measurement enabled or disabled
IP>	10-400 Step: 1	50	% of I1b	Set operate value for measured phase currents
IN>	10-150 Step: 1	50	% of I4b	Set operate value for measured residual current

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.

Path in local HMI: Settings/Functions/Groupn/Impedance/GenFltCriteria

Table 105: Setting parameters for the underimpedance operating mode (I_r = 1A, divide by 5 for I_r = 5A)

Parameter	Range	Default	Unit	Description
Operation Z<	Off/On	Off	-	Operation of underimpedance based GFC measurement enabled or disabled
ARGLd	5-45 Step: 1	25	degrees	Load angle determining the load impedance area
RLd	0.10-400.00 Step: 0.01	50	ohm/loop	Limitation of resistive reach within the load impedance area
X1RvPP	0.10-400.00 Step: 0.01	50	ohm/phase	Positive sequence reactive reach in reverse direction for phase-to-phase faults
X1FwPP	0.10-400.00 Step: 0.01	50	ohm/phase	Positive sequence reactive reach in forward direction for phase-to-phase faults
RFPP	0.10-400.00 Step: 0.01	50	ohm/loop	Resistive reach (forward and reverse) for phase-to-phase measurement
X1RvPE	0.1-400.00 Step: 0.01	50	ohm/phase	Positive sequence reactive reach in reverse direction for phase-to-earth faults
X1FwPE	0.1-400.00 Step: 0.01	50	ohm/phase	Positive sequence reactive reach in forward direction for phase-to-earth faults
X0FwPE	0.1-1200.00 Step: 0.01	50	ohm/phase	Zero sequence reactance of reach in forward direction for phase-to-earth faults
X0RvPE	0.1-1200.00 Step: 0.01	50	ohm/phase	Zero sequence reactance of reach in reverse direction for phase-to-earth faults
RFPE	0.1-400.00 Step: 0.01	50	ohm/loop	Resistive reach (forward and reverse) for phase-to-earth measurement

Path in local HMI: Settings/Functions/Groupn/Impedance/GenFltCriteria

Table 106: Setting parameters for phase preference logic

Parameter	Range	Default	Unit	Description
PhasePref	NoFilter/NoPref/132c/312c/132a/123a/321a/312a/213a/231a/132aBl/123aBl/321aBl/312aBl/213aBl/231aBl	NoFilter	-	Selection of a phase preference for cross-country faults
IN>	20-200	20	%	Operate value of residual current for cross-country faults
3U0>	30-70	30	%	Operate value of residual voltage for cross-country faults
UPN<	10-100	70	%	Operate value of under voltage non directional phase selection phase-to-earth measurement
UPP<	20-170	70	%	Operate value of under voltage non directional phase selection phase-to-phase measurement
Block1phTrip	Off/On	Off	-	Block of trip for single phase faults enabled or disabled

4.7 Technical data

Table 107: GFC - General fault criteria, impedance and current based

Function			Value
Impedance setting range at I_r = 1A	Reactive reach forward	Positive-sequence reactance	0.1-400 ohm/phase in steps of 0.01 ohm/phase
		Zero-sequence reactance	0.1-1200 ohm/phase in steps of 0.01 ohm /phase
	Reactive reach reverse	Positive-sequence reactance	0.1-400 ohm/phase in steps of 0.01 ohm/phase
		Zero-sequence reactance	0.1-1200 ohm/phase in steps of 0.01 ohm /phase
	Resistive reach (forward & reverse)	For phase - phase faults	0.1-400 ohm/loop in steps of 0.01 ohm/loop
		For phase - earth faults	0.1-400 ohm/loop in steps of 0.01 ohm/loop
		Load encroachment	0.1-400 ohm/loop in steps of 0.01 ohm/loop
		Safety load impedance angle	5-45 degrees in steps of 1 degrees
Overcurrent setting range	Phase currents		10-400% of I1b in steps of 1%
	Residual current		10-150% of I4b in steps of 1%

Function		Value
Timers	For phase-to-phase measuring elements	0.000-60.000 s in steps of 1 ms
	For phase-to-earth measuring elements	0.000-60.000 s in steps of 1 ms
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	
Reset ratio		105% typically

Table 108: GFCppl-zi - Phase preference logic

Parameter		Setting range
Operate residual current, IN>		20-200% of I4b in steps of 1%
Operate residual voltage, 3U0>		30-70% of U1b in steps of 1%
Voltage phase selection	Phase to phase, UPP<	20-170% of U1b in steps of 1%
	Phase to earth, UPN<	10-100% of U1b in steps of 1%
Cyclic tripping phase preference		L1L3L2, L3L1L2
Non-cyclic tripping phase preference		L1L3L2, L1L2L3, L3L2L1, L3L1L2, L2L1L3, L2L3L1
Non-cyclic blocking phase preference		L1L3L2, L1L2L3, L3L2L1, L3L1L2, L2L1L3, L2L3L1

5 Power swing detection (PSD)

5.1 Application

Power swings in 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.

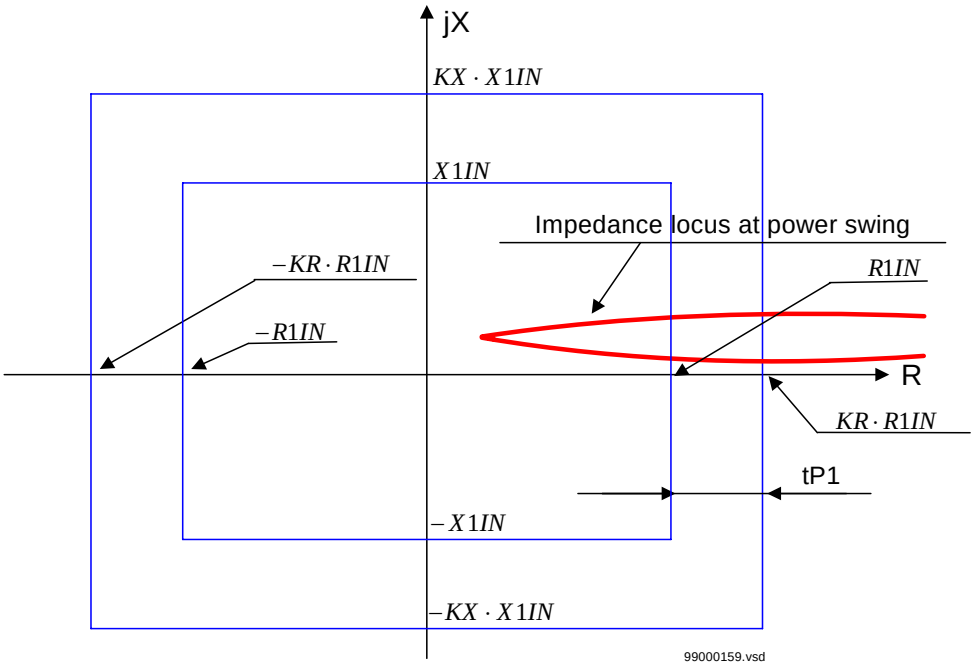
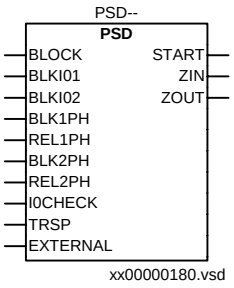


Figure 43: Operating principle and characteristic of the PSD function

5.3 Function block



5.4 Logic diagram

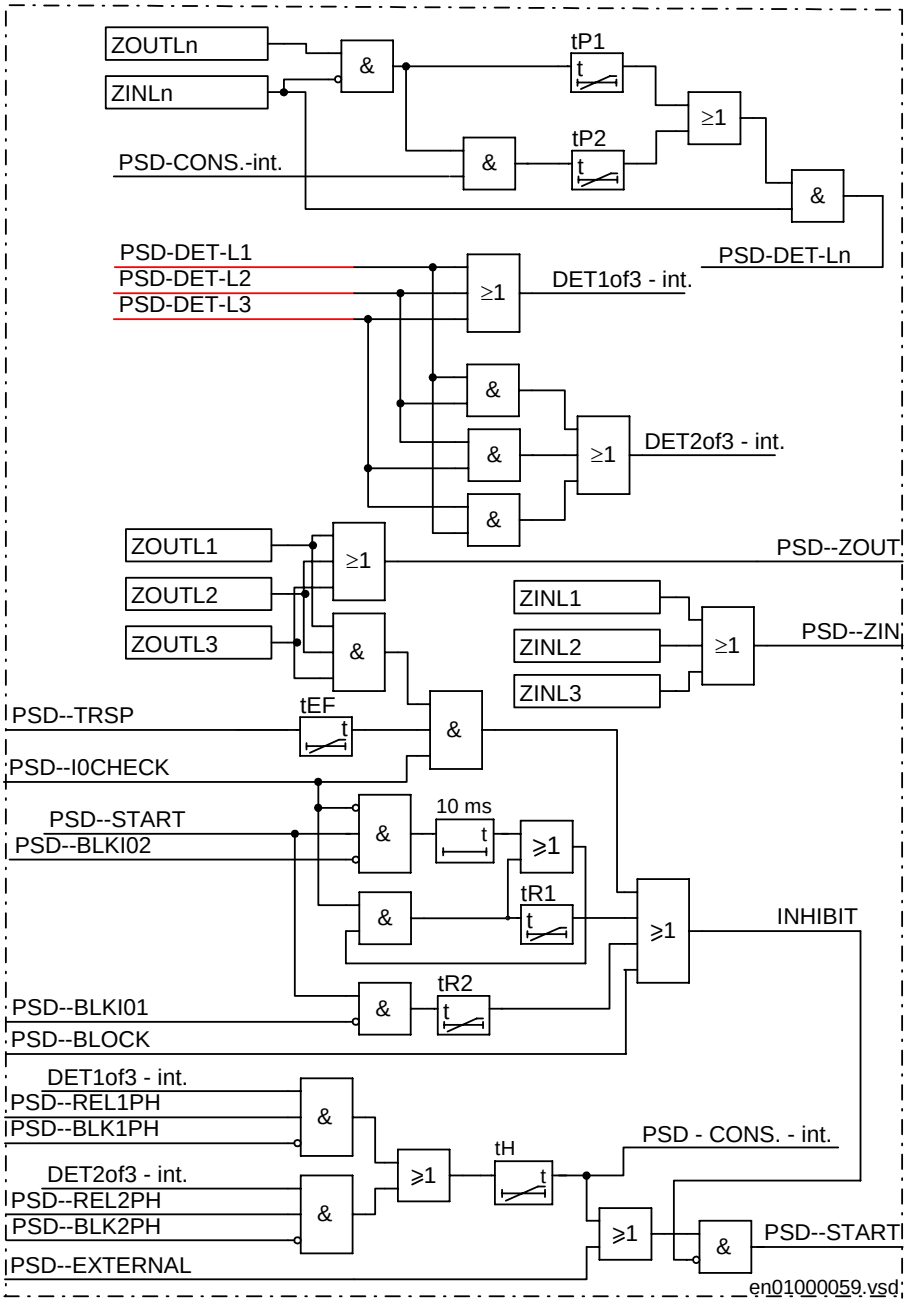


Figure 44: PSD function - block diagram.

5.5 Input and output signals

Table 109: 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

Path in local HMI: ServiceReport/Functions/Impedance/PowerSwingDet/FuncOutputs

Table 110: 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.

Path in local HMI: Settings/Functions/Groupn/Impedance/PowerSwingDet

Table 111: 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 Step: 0.01	30.00	ohm/phase	Positive sequence reactive reach of the inner boundary
R1IN	0.10 - 400.00 Step: 0.01	30.00	ohm/phase	Positive sequence resistive reach of the inner boundary
KX	120 - 200 Step: 1	125	%	Reach multiplication factor for the outer reactive boundary

Parameter	Range	Default	Unit	Description
KR	120 - 200 Step: 1	125	%	Reach multiplication factor for the outer resistive boundary
tP1	0.000 - 60.000 Step: 0.001	0.045	s	Timer for detection of initial power swings
tP2	0.000 - 60.000 Step: 0.001	0.015	s	Timer for detection of subsequent power swings
tW	0.000 - 60.000 Step: 0.001	0.250	s	Waiting timer for activation of tP2 timer
tH	0.000 - 60.000 Step: 0.001	0.500	s	Timer for holding PSD output
tEF	0.000 - 60.000 Step: 0.001	3.000	s	Timer for overcoming single-pole reclosing dead time
tR1	0.000 - 60.000 Step: 0.001	0.300	s	Timer giving delay to blocking of output by the residual current
tR2	0.000 - 60.000 Step: 0.001	2.000	s	Timer giving delay to blocking of output at very slow swings

5.7 Technical data

Table 112: PSD - Power swing detection

Parameter		Setting range	Accuracy
Impedance setting range at I_r =1A (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

Parameter	Setting range	Accuracy
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
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 Radial feeder protection (PAP)

6.1 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.

6.2 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.

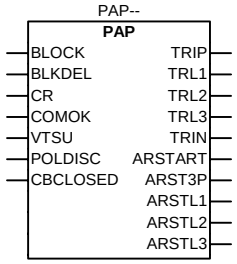
The PAP function has built-in logic for fast tripping as well as time delayed tripping. The voltage-based phase selection is used for both the fast and the delayed tripping. To get fast tripping, scheme communication is required. Delayed tripping does not require scheme communication. It is possible 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.

6.3 Function block



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6.4 Logic diagram, phase selection function

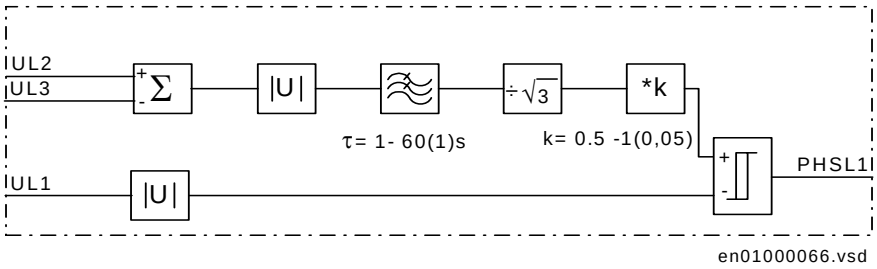


Figure 45: Phase selection function, simplified logic diagram

6.5 Logic diagram, residual current measurement

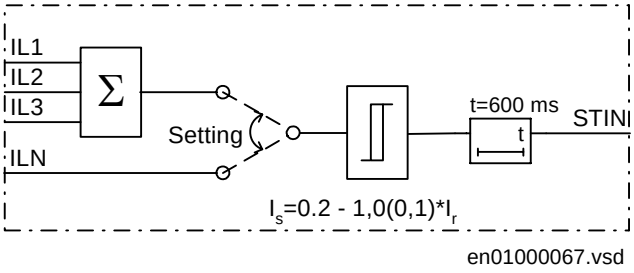


Figure 46: Residual current measurement, simplified logic diagram

6.6 Logic diagram, fast fault clearing

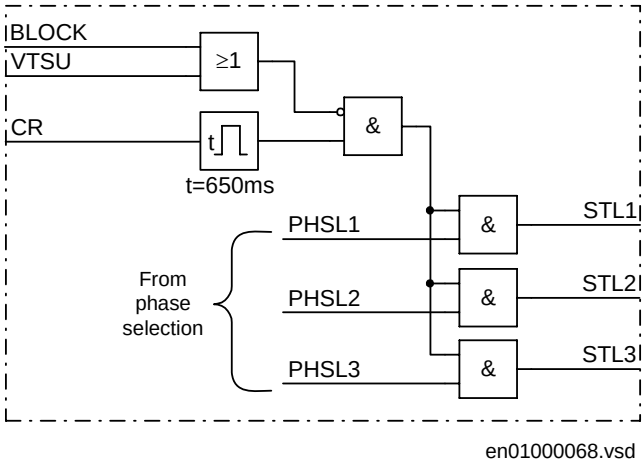


Figure 47: Function for fast fault clearing, simplified logic diagram

6.7 Logic diagram, delayed fault clearing

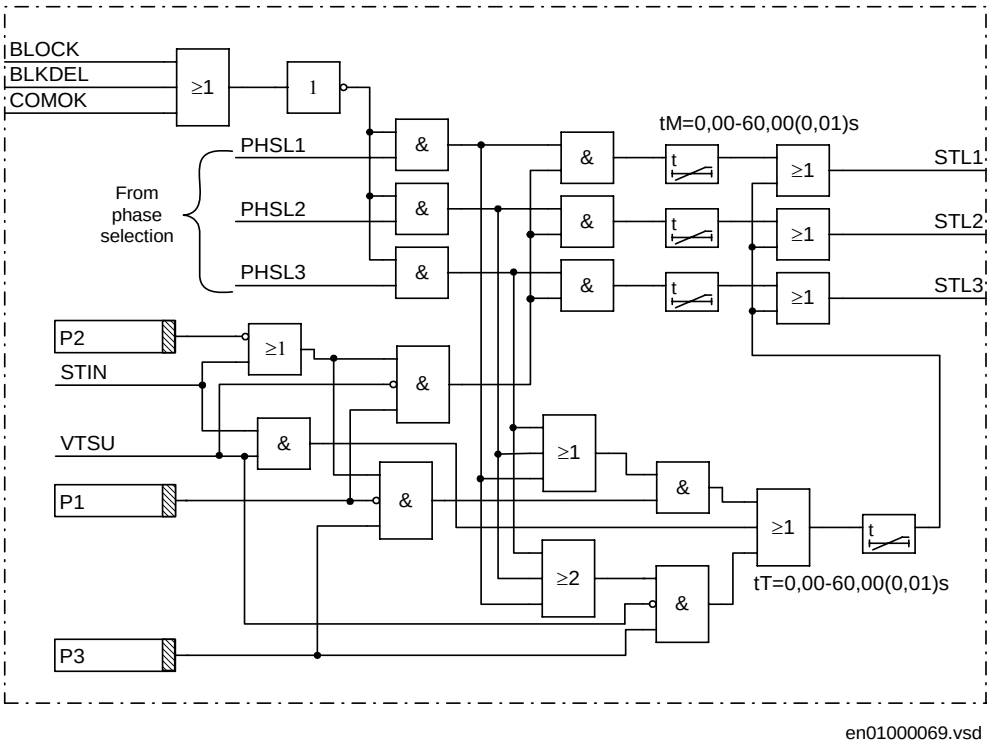


Figure 48: Function for delayed fault clearing, simplified logic diagram

6.8 Logic diagram, residual current detection

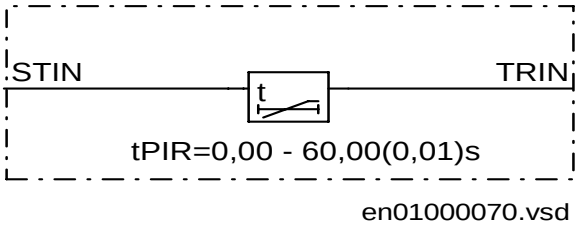


Figure 49: Residual current detection, simplified logic diagram

6.9 Logic diagram, trip and autorecloser start logic

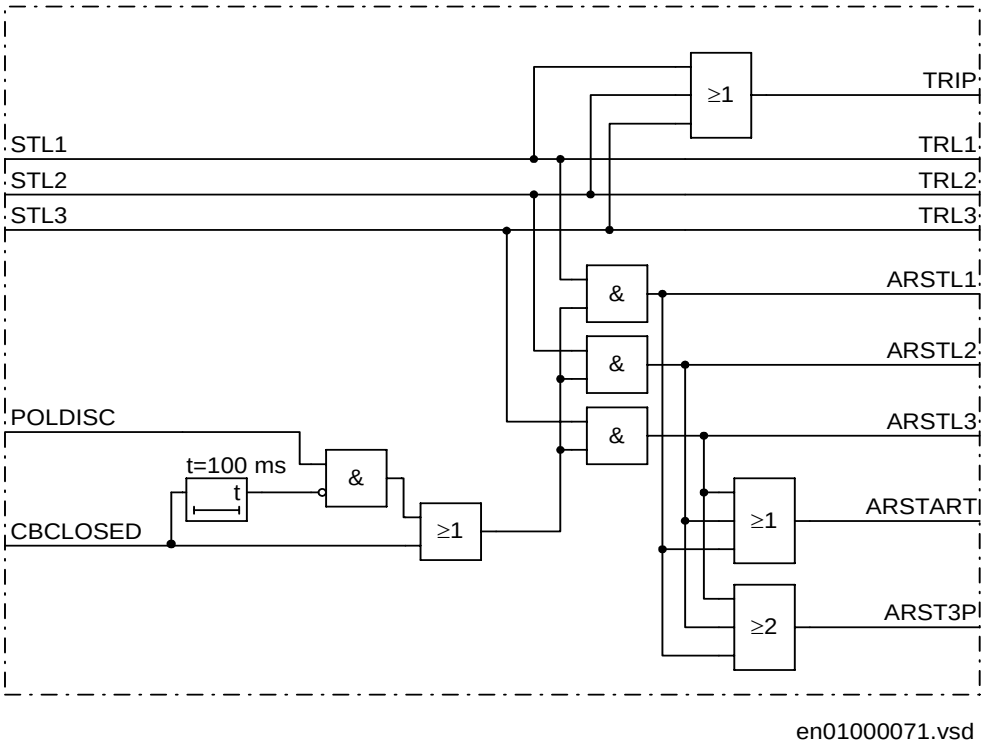


Figure 50: Trip and autorecloser start logic, simplified logic diagram

6.10 Input and output signals

Table 113: 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

Path in local HMI: ServiceReport/Functions/RadialFeederP/FuncOutputs

Table 114: 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

6.11 Setting parameters

Path in local HMI: Settings/Functions/Groupn/RadialFeederP

Table 115: 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 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 Step: 1	5	s	Time constant for reference voltage
IMeasured	I4, I5, I1+I2+I3	I4	-	Residual current signal source
In>	10 - 150 Step: 1	50	% of I1b	Residual current detection level
Del1PhFltTrip	3Ph, 1Ph	3 Ph	-	Delayed trip for single-phase faults
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 Step: 0.01	10.00	s	Time delay for single-pole tripping
tT	0.00 - 60.00 Step: 0.01	10.00	s	Time delay for three-pole tripping
tPIR	0.00 - 60.00 Step: 0.01	10.00	s	Time delay for indication of residual current greater than set threshold

6.12 Technical data

Table 116: PAP - 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 I1b in steps of 1%	±2.5% of I_r at $I \leq I_r$ ±2.5% of I at $I > I_r$
Time delay tM for single-pole tripping	0.000-60.000s in steps of 0.01s	±0.5% ±10 ms
Time delay tT for three-pole tripping	0.000-60.000s in steps of 0.01s	±0.5% ±10 ms
Time delay tPIR for residual current tripping (or indication)	0.000-60.000s in steps of 0.01s	±0.5% ±10 ms

7 Scheme communication logic (ZCOM)

7.1 Application

It is not possible to set an underreaching distance or overcurrent protection 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 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 or overcurrent 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.

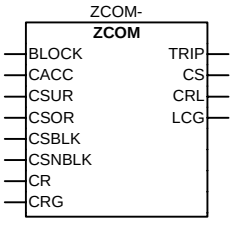
7.2 Functionality

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

7.3 Function block



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7.4 Logic diagram

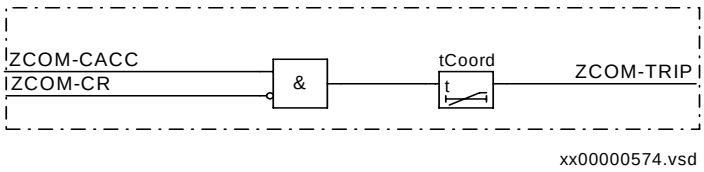


Figure 51: Basic logic for trip carrier in blocking scheme

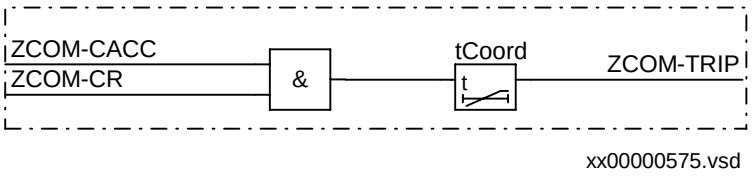


Figure 52: Basic logic for trip carrier in permissive scheme

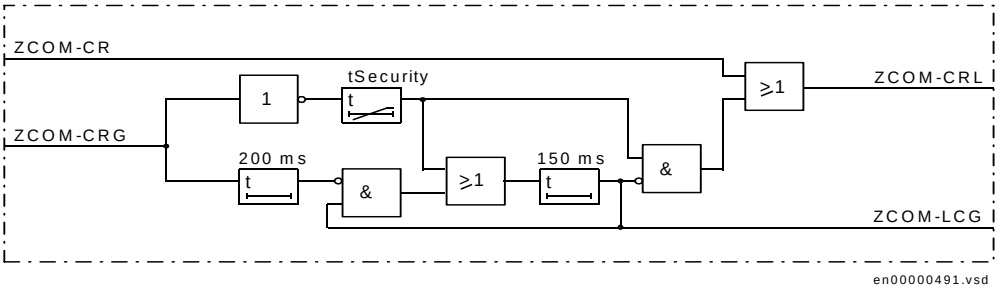


Figure 53: Carrier guard logic with unblock logic

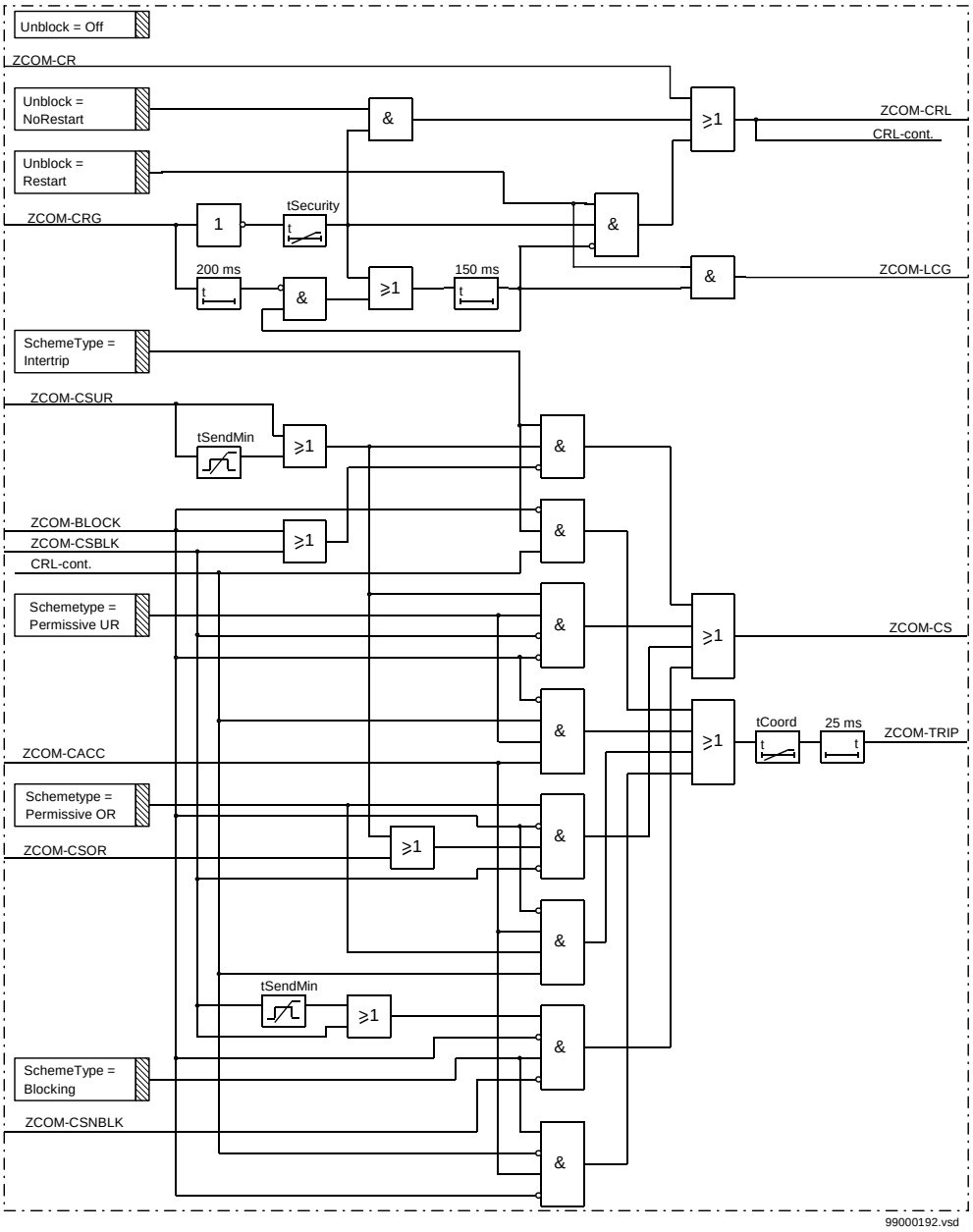


Figure 54: Scheme communication logic for distance or overcurrent protection, simplified logic diagram

7.5 Input and output signals

Table 117: Input signals for ZCOM (ZCOM-) function block

Signal	Description
BLOCK	Blocks the Trip and CS outputs
CACC	Overreaching 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 protection zone to be used for sending a carrier signal in a blocking scheme
CSNBLK	Forward directed protection zone to be used to inhibit sending of a carrier signal in a blocking scheme
CR	Carrier signal received
CRG	Guard signal received

Path in local HMI: ServiceReport/Functions/Impedance/ ZCommunication/FuncOutputs

Table 118: 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

7.6 Setting parameters

Path in local HMI: Settings/Functions/Groupn/Impedance/ZCommunication

Table 119: 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 / PermissiveUR / PermissiveOR / Blocking	Intertrip	-	Operating mode for scheme communication logic
tCoord	0.000 - 60.000 Step: 0.001	0.050	s	Coordination timer
tSendmin	0.000 - 60.000 Step: 0.001	0.100	s	Minimum duration of carrier send signal
Unblock	Off / NoRestart / Restart	Off	-	Operating mode for unblocking logic
tSecurity	0.000 - 60.000 Step: 0.001	0.035	s	Security timer

7.7 Technical data

Table 120: ZCOM - Scheme communication logic for distance or overcurrent protection

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

8 Current reversal and weak-end infeed logic (ZCAL)

8.1 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 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.

Note!

Current reversal and week end infeed logic (ZCAL) and General fault criteria (GFC) including phase preference logic cannot be ordered together.

8.2 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).

8.3 Function block

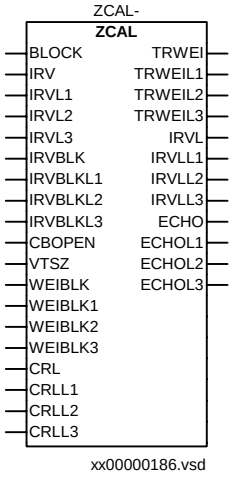


Figure 55: Function block for the ZCAL function, when used together with phase segregated scheme communication logic

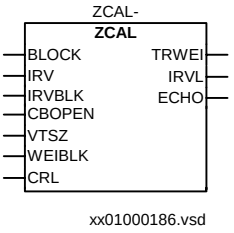


Figure 56: Function block for the ZCAL function, when used together with the three phase scheme communication logic

8.4 Logic diagram

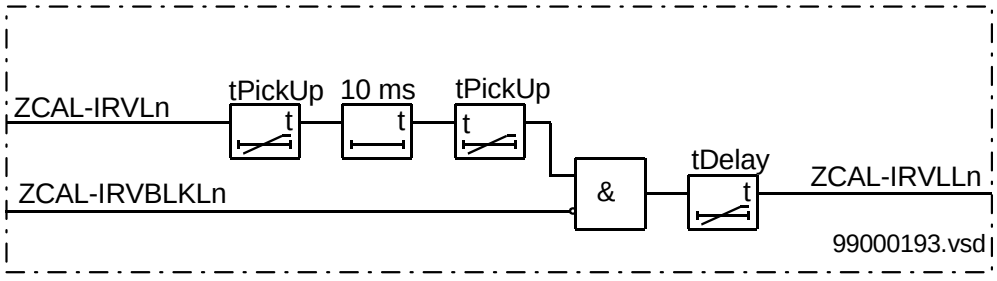


Figure 57: Current reversal logic.

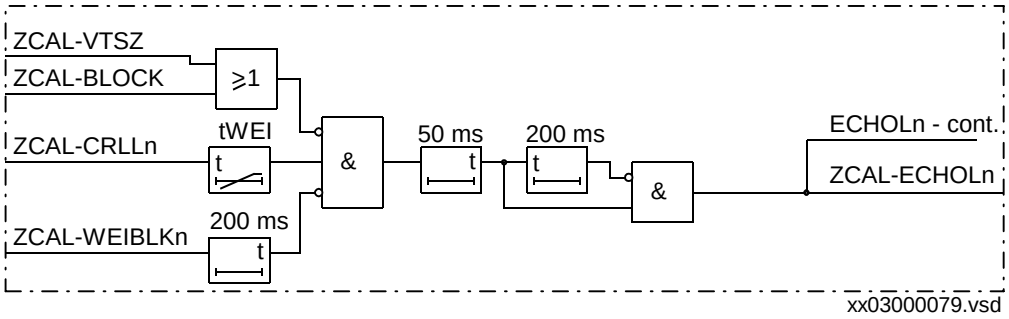


Figure 58: Echo of a received carrier signal by the WEI function.

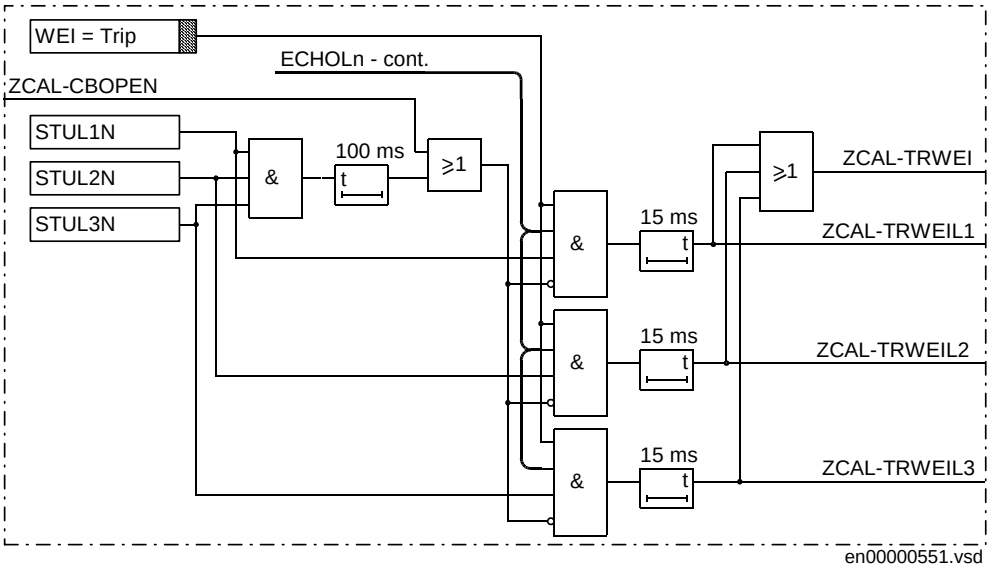


Figure 59: Tripping part of the WEI logic - simplified logic diagram.

8.5 Input and output signals

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

Table 121: 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

Signal	Description
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
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.

Path in local HMI: ServiceReport/Functions/Impedance/ ComlRevWei/FuncOutputs

Table 122: 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

8.6 Setting parameters

Path in local HMI: Settings/Functions/Groupn/Impedance/ComIRevWei

Table 123: 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 Step: 0.001	0.000	s	Pickup time for current reversal function
tDelay	0.000 - 60.000 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 Step: 0.001	0.010	s	Coordination time for the WEI function
UPN<	10 - 100 Step: 1	70	% of U1b	Under voltage detection - ph-N measurement
UPP<	20 - 170 Step: 1	70	% of U1b	Under voltage detection - ph-ph measurement

8.7 Technical data

Table 124: ZCAL - Current reversal and weak end infeed logic

Parameter	Setting range	Accuracy
Pickup time for current reversal, tPickUp	0.000-60.000 s in steps of 0.001s	±0.5% ±10ms
Delay time for current reversal, tDelay	0.000-60.000 s in steps of 0.001s	±0.5% ±10ms
Coordination time for weak end infeed logic, tWEI	0.000-60.000 s in steps of 0.001s	±0.5% ±10ms
Detection level phase to neutral voltage, UPN<	10-100% of U1b	±2.5% of U_r
Detection level phase to phase voltage, UPP<	20-170% of U1b	±2.5% of U_r at $U \leq U_r$ ±2.5% of U at $U > U_r$

Chapter 5 Current

About this chapter

This chapter describes the current protection functions.

1 Instantaneous non-directional 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

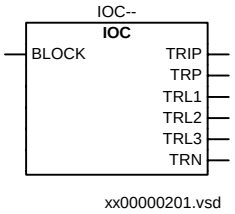


Figure 60: IOC function block phase + N with 1, 2, 3 phase trip

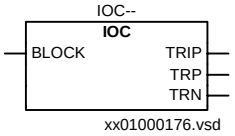


Figure 61: IOC function block, phase + N with 3 phase trip

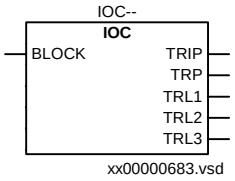


Figure 62: IOC function block phase with 1, 2, 3 phase trip

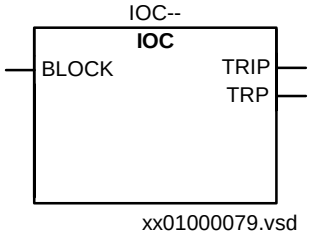


Figure 63: IOC function block, phase with 3 phase trip

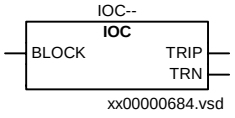


Figure 64: IOC function block, N + 3 phase trip

1.4 Logic diagram

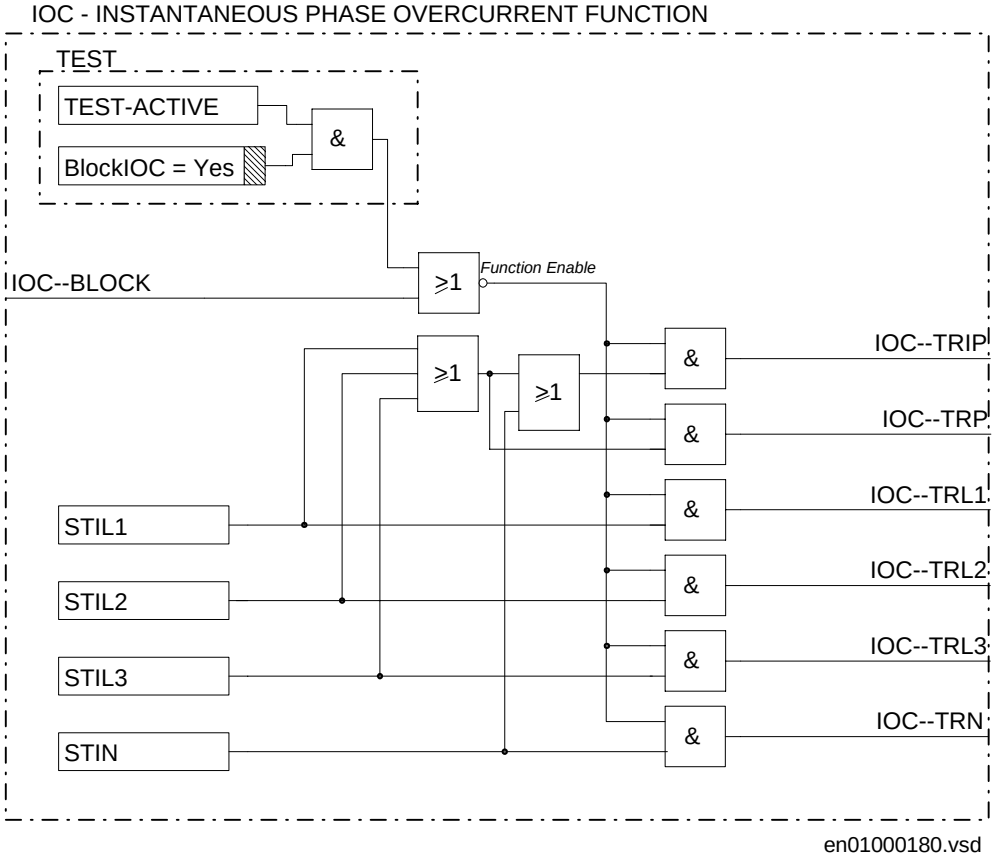


Figure 65: IOC function, logic diagram

1.5 Input and output signals

Table 125: Input signals for the IOC (IOC--) function block

Signal	Description
BLOCK	Block of the instantaneous overcurrent protection function.

Path in local HMI: ServiceReport/Functions/InstantOC/FuncOutputs

Table 126: 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 127: 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 Step: 1	100	% of I1b	Operating phase current
IN>>	50-2000 Step: 1	100	% of I1b	Operating residual current

1.7 Technical data

Table 128: 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 ≤I_r ± 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 ≤ I_r ± 2.5 % of I at I > I_r
Maximum operate time at I > 10 × I_{set}			Max. 15ms	-
Dynamic overreach at τ< 100 ms			-	< 5%

2 Definite time non-directional 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 back-up 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 or as a fault detection for some other protection functions.

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

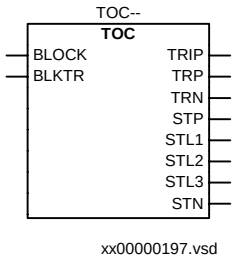


Figure 66: TOC function block, phase + N

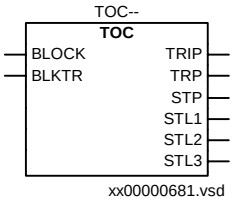


Figure 67: TOC function block, phase

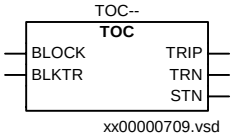


Figure 68: TOC function block, N

2.4 Logic diagram

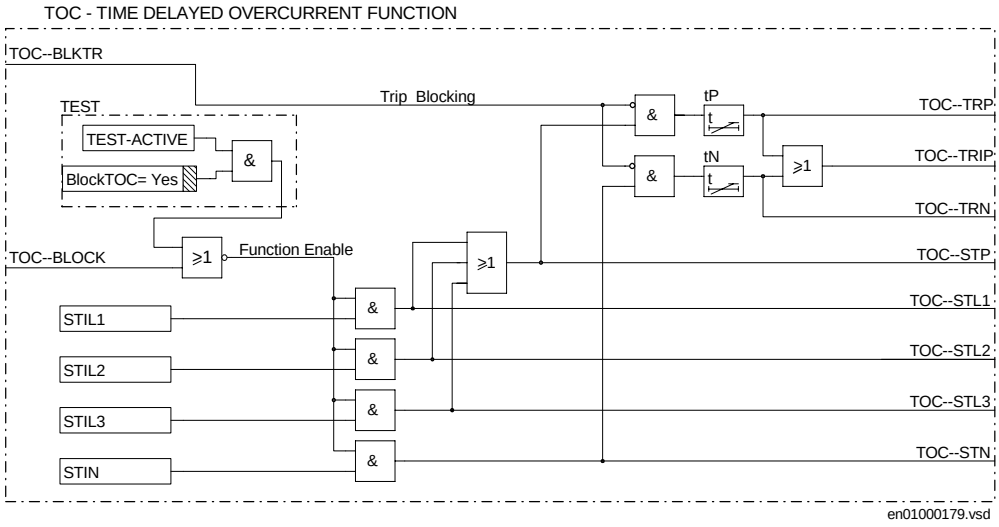


Figure 69: TOC function, logic diagram

2.5 Input and output signals

Table 129: Input signals for the TOC (TOC--) function block

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

Path in local HMI: ServiceReport/Functions/TimeDelayOC/FuncOutputs

Table 130: 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
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 131: 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
IP>	10-400 Step: 1	100	% of I1b	Operating phase overcurrent
tP	0.000-60.000 Step: 0.001	10.000	s	Time delay of phase overcurrent function
IN>	10-150 Step:1	100	% of I4b	Operating residual current
tN	0.000-60.000 Step: 0.001	10.000	s	Time delay of residual overcurrent function

2.7 Technical data

Table 132: TOC - Definite time nondirectional overcurrent protection

Function		Setting range	Accuracy
Operate current	Phase measuring elements, IP>	(10-400) % of I1b 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, IN>	(10-150) % of I4b 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 τ< 100 ms		-	< 5 %

3 Two step time delayed non-directional phase overcurrent protection (TOC2)

3.1 Application

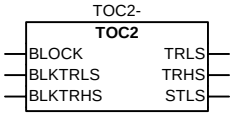
The two current/time stages of overcurrent protection TOC2 improve the possibility to get fast operation for nearby faults by using a high set current stage with short time delay. The low current stage is set with appropriate time delay to get selectivity with the adjacent relays in the system. In networks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



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3.4 Logic diagram

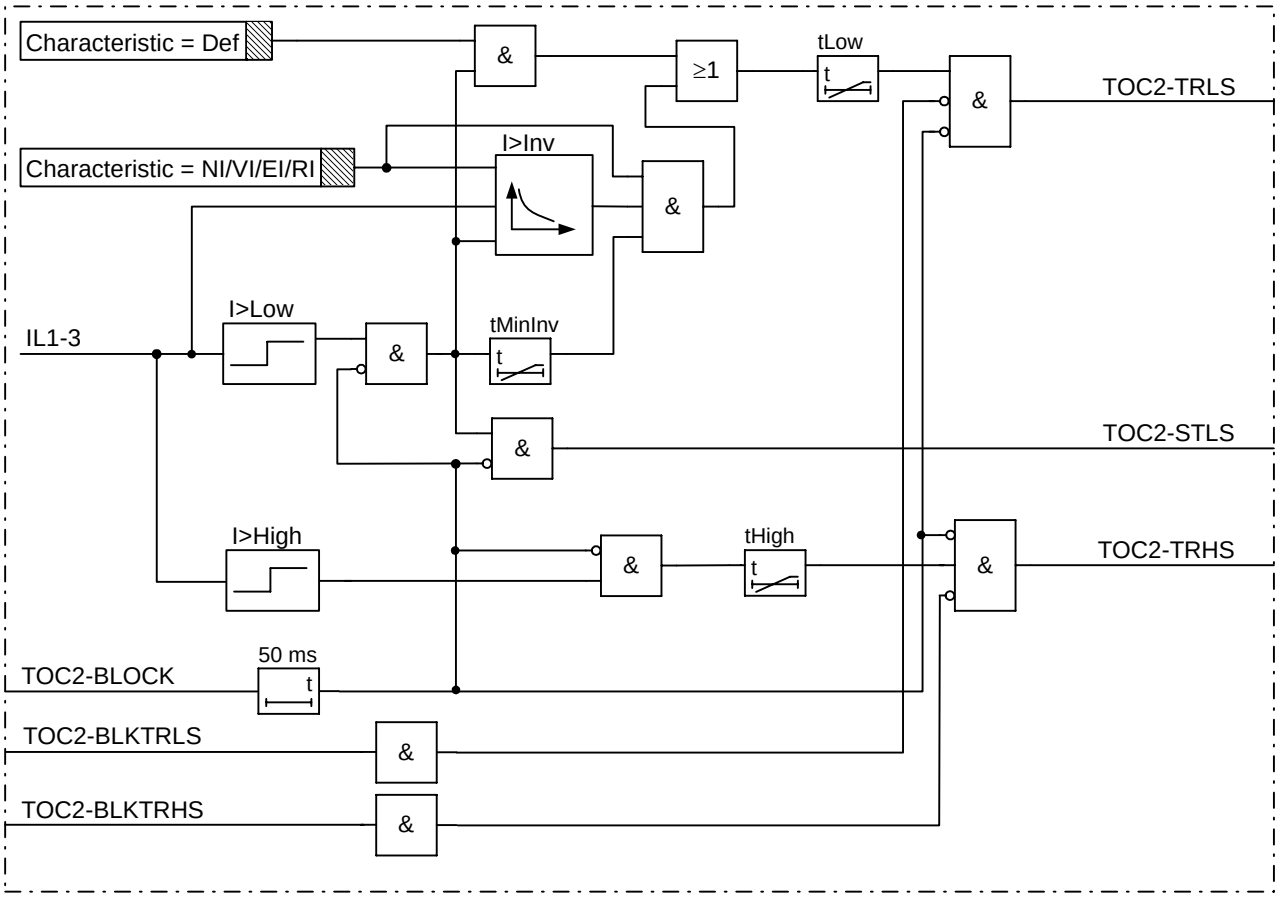


Figure 70: Two step time delayed phase overcurrent protection, simplified logic diagram

3.5 Input and output signals

Path in local HMI: ServiceReport/Functions/TimeDelayOC (RW)/FuncOutputs

Table 133: 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

Path in local HMI: ServiceReport/Functions/TimeDelayOC (RW)/FuncOutputs

Table 134: 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

Path in local HMI-tree: Settings/Functions/Groupn/InvTimeDelayOC

Table 135: 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 Step: 1	10	% of I1b	Base current for low set dependent time delay operation
k	0.05 - 1.10 Step: 0.01	0.05	-	Time multiplier for dependent time delay operation
tMinInv	0.000 - 60.000 Step: 0.001	0.050	s	Minimum operating time for dependent time delay operation
I>Low	5-500 Step: 1	100	% of I1b	Minimum operating current for dependent time delay operation
tLow	0.000 - 60.000 Step: 0.001	1.000	s	Independent time delay for low set TOC2 function
Operation High	Off, On	Off	-	Operating mode of high set TOC2 function
I>High	50-2000 Step: 1	100	% of I1b	Operating current for high set TOC2 function
tHigh	0.000 - 60.000 Step: 0.001	1.000	s	Time delay for high set TOC2 function

3.7 Technical data

Table 136: TOC2 - Two step time delayed non-directional phase overcurrent protection

Function	Setting range	Accuracy
Operate value for low set function I > Low	(5-500) % of I1b in steps of 1%	+/- 2.5% of $I1_r$ at $I \leq I1_r$ +/- 2.5 % of I at $I>I1_r$
Base current for inverse time calculation I > Inv	(5-500) % of I1b in steps of 1%	+/- 2.5 % of $I1_r$ at $I \leq I1_r$ +/- 2.5 % of I at $I> I1_r$
Minimum operate time tMinInv	(0.000-60.000)s in steps of 1 ms	+/- 0.5 % +/- 10 ms
Definite time delay for low set function tLow	(0.000-60.000)s in steps of 1 ms	+/- 0.5 % +/- 10 ms
Operate value of high set function I > High	(50-2000) % of I1b in steps of 1%	+/- 2.5% of $I1_r$ at $I \leq I1_r$ +/- 2.5 % of I at $I>I1_r$
Definite time delay for high set function tHigh	(0.000-60.000) s in steps of 1 ms	+/- 0.5 % +/- 10 ms
Normal inverse characteristic $I = I_{meas}/I_{set}$	$t = \frac{0.14}{I^{0.02} - 1} \cdot k$	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
Dynamic overreach at τ< 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.

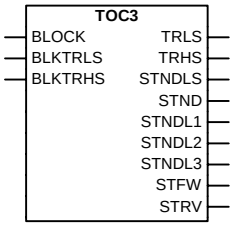
4.2 Functionality

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



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4.4 Logic diagram

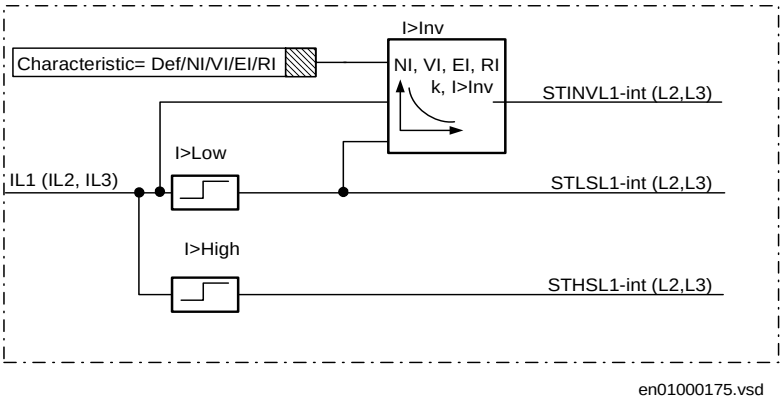


Figure 71: Simplified block diagram for definite and inverse time delayed phase overcurrent function

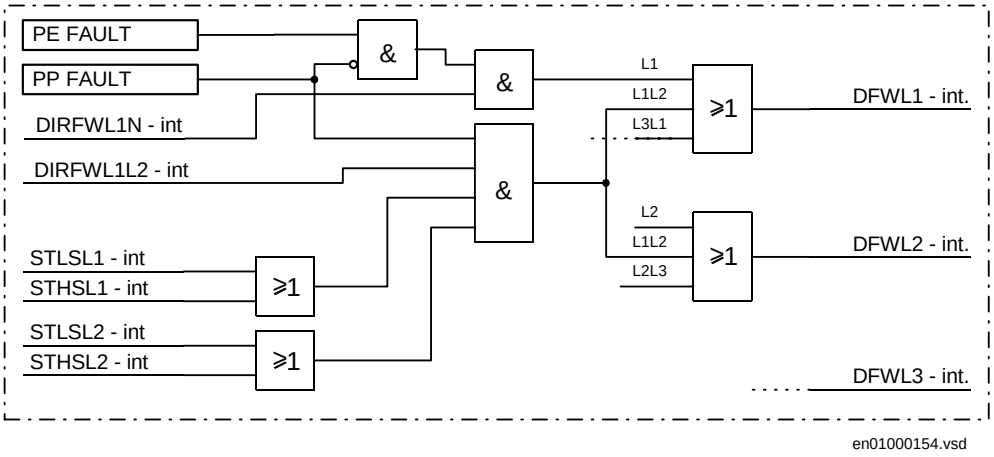


Figure 72: Excerpt from directional phase selection

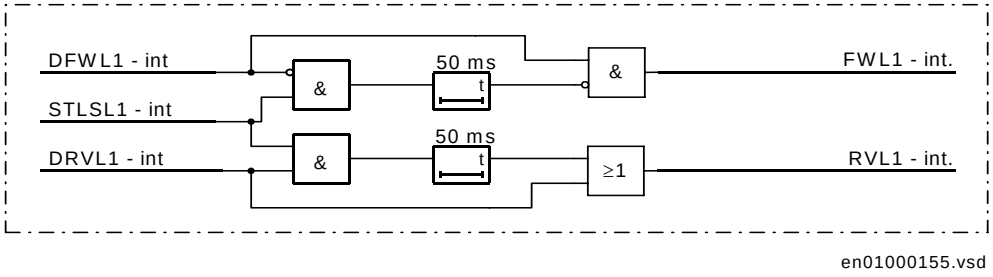


Figure 73: Current reversal logic for one phase and one set step

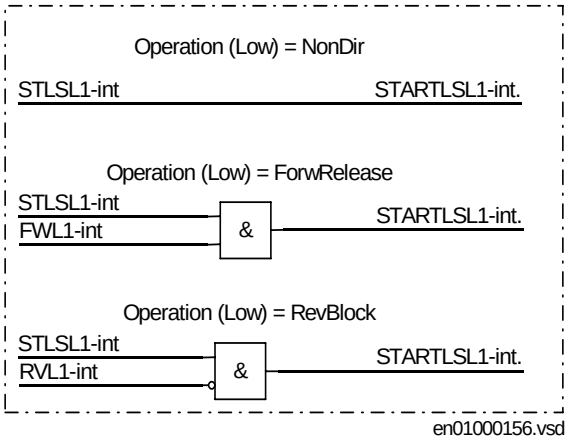


Figure 74: Directional modes of TOC3

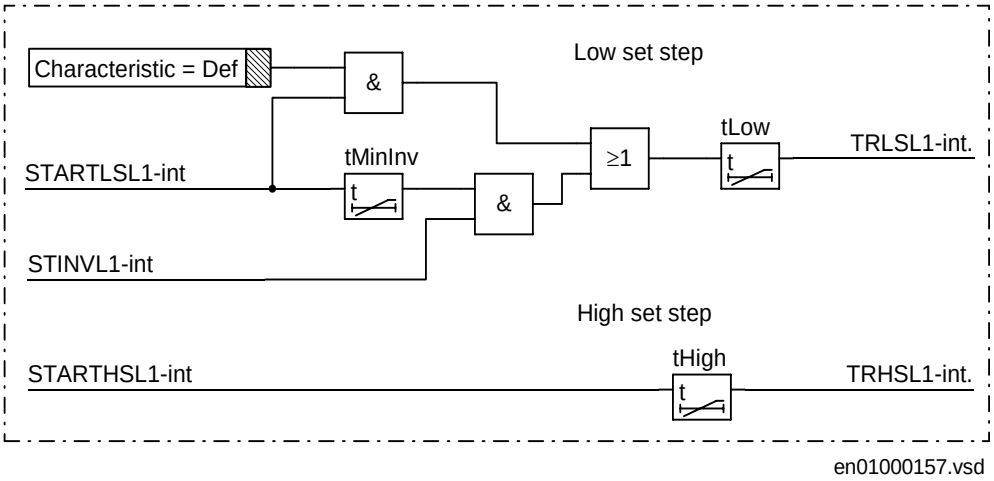


Figure 75: Delayed time operation for low set step and general time delay

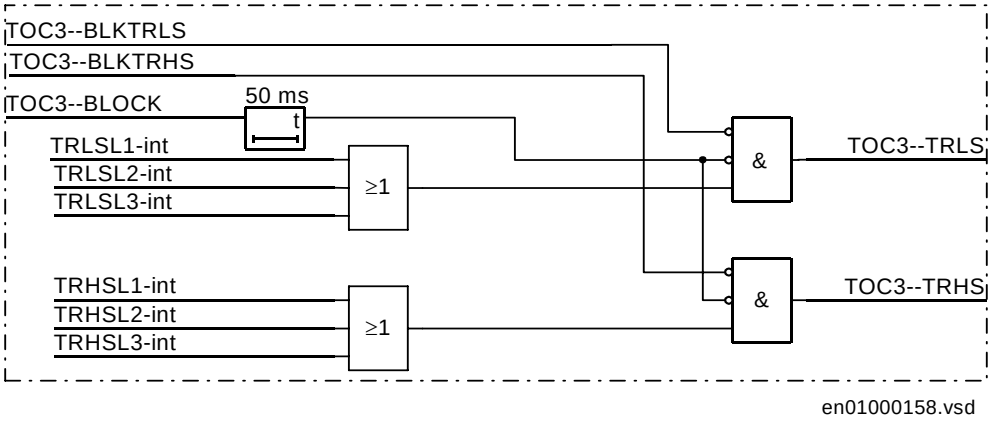


Figure 76: General trip

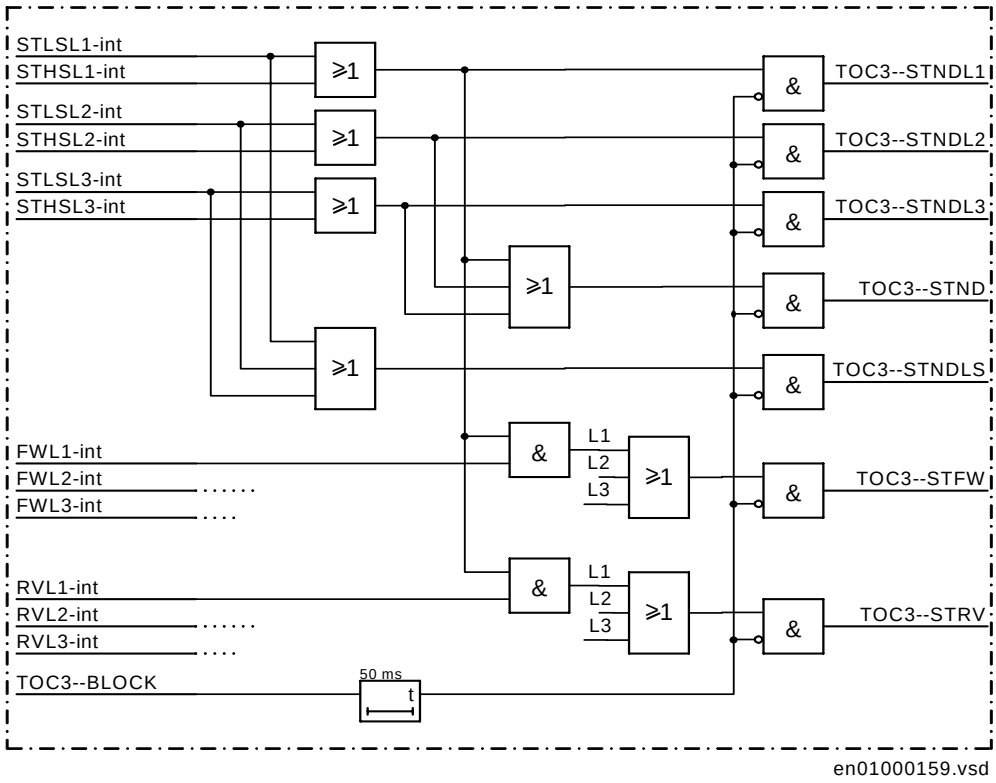


Figure 77: Start signals

4.5 Input and output signals

Table 137: 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

Path in local HMI: ServiceReport/Functions/DirInvTimeDelayOC/FuncOutputs

Table 138: 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

Path in local HMI-tree: Settings/Functions/Groupn/DirInvTDelayOC

Table 139: 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, NonDir, ForwRelease, 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) Step: 1	20	% of I1b	Inverse time base current for low set step
k	0.050 - 1.100 Step: 0.010	0.050		Inverse time multiplier for low set step
tMinInv	0.000 - 60.000 Step: 0.001	0.050	s	Inverse time minimum operating time for low set step
I>Low	20 - 2000 Step: 1	100	% of I1b	Operating current/inverse time min. current low set step
tLow	0.000 - 60.000 Step: 0.001	1.000	s	Independent time delay for lowset

Parameter	Range	Default	Unit	Description
Operation High	Off, NonDir, ForwRelease, RevBlock	Off	-	Operation mode of high set step
I>High	20 - 2000 Step: 1	100	% of I1b	Operating current for high set step
tHigh	0.000 - 60.000 Step: 0.001	1.000	s	Time delay for high set step
ArgDir	5-45 Step: 1	15	degrees	Lower angle of forward direction Characteristic
ArgNegRes	90-175 Step: 1	115	degrees	Upper angle of forward direction Characteristic

4.7 Technical data

Table 140: TOC3 - Two step time delayed directional phase overcurrent protection

Function	Setting range	Accuracy
Operate value of low set function, I>Low	(20-2000)% of I1b in steps of 1%	± 2.5 % of I_r at $I \leq I_r$ ± 2.5 % of I at $I>I_r$
Base current for inverse time calculation, I>Inv	(20-500) % of I1b in steps of 1 %	± 2.5 % of I_r at $I \leq I_r$ ± 2.5 % of I at $I>I_r$
Resetting ratio	-	>95%
Minimum operate time, tMinInv	(0.000-60.000) s in steps of 1 ms	± 0.5 % ±10 ms
Definite time delay for low set function, tLow	(0.000-60.000) s in step of 1ms	± 0.5 % ±10 ms
Operate value of high set function, I>High	(20-2000) % of I1b in steps of 1 %	± 2.5 % of I_r at $I \leq I_r$ ± 2.5 % of I at $I>I_r$
Definite time delay for high set function, tHigh	(0.000-60.000) s 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	± 5 degrees
	Current range (0.5-30) x I_r	

Function	Setting range	Accuracy
Normal inverse characteristic $I = I_{meas}/I_{set}$	$t = \frac{0.14}{I^{0.02} - 1} \cdot k$	IEC 60255-3 class 5 + 60 ms
Very inverse characteristic $I = I_{meas}/I_{set}$	$t = \frac{13.5}{I - 1} \cdot k$	IEC 60255-3 class 7.5 + 60 ms
Extremely inverse characteristic $I = I_{meas}/I_{set}$	$t = \frac{80}{I^2 - 1} \cdot k$	IEC 60255-3 class 7.5 + 60 ms
RI-inverse characteristic $I = I_{meas}/I_{set}$	$t = \frac{1}{0.339 - \frac{0.236}{I}} \cdot k$	IEC 60256-3 class 5 + 60 ms
Dynamic overreach at τ< 100 ms		<5%

5 Time delayed residual overcurrent protection (TEF)

5.1 Application

Use the inverse and definite 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 (definite time delay or some type of inverse 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 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 definite or inverse possibility.

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

The residual overcurrent protection can be set directional. 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

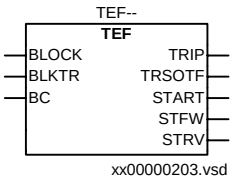


Figure 78: Function block, directional and nondirectional

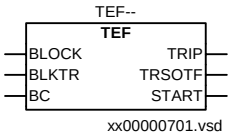


Figure 79: Function block, nondirectional

5.4 Logic diagram

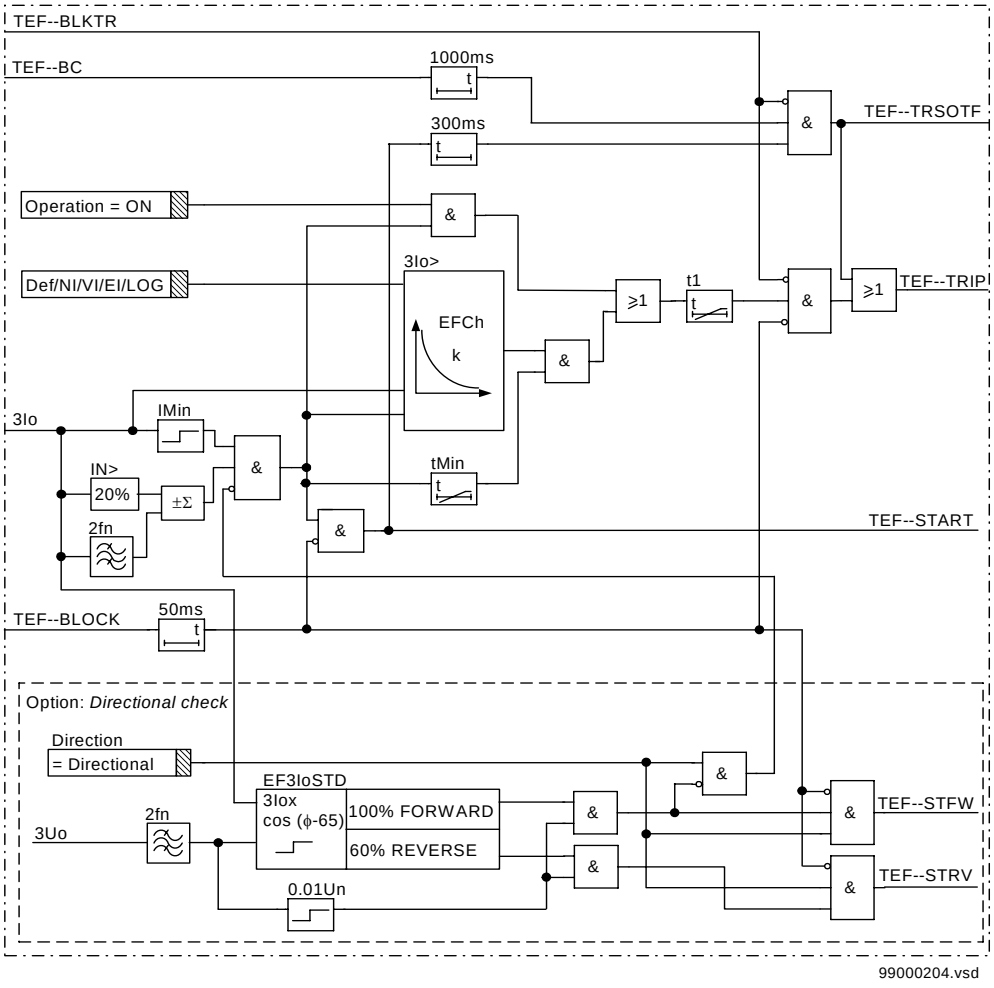


Figure 80: Simplified logic diagram for the residual overcurrent protection

5.5 Input and output signals

Table 141: 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

Path in local HMI: ServiceReport/Functions/EarthFault/TimeDelayEF/FuncOutputs

Table 142: 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

Path in local HMI: Settings/Functions/Groupn/EarthFault/TEF

Table 143: 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 Step: 1	5	% of Inb	Start current for TEF function (I4b or I5b)
IMin	100 - 400 Step: 1	100	% of IN	Minimum operating current
t1	0.000 - 60.000 Step: 0.001	0.000	s	Independent time delay
k	0.05 - 1.10 Step: 0.01	0.05	-	Time multiplier for dependent time delay
tMin	0.000 - 60.000 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, U1+U2+U3	U4	-	Voltage input used for directional earth fault function
IN> Dir	5 - 35 Step: 1	5	% of Inb	Start level for directional operation if selected (I4b or I5b)

5.7 Technical data

Table 144: TEF - Time delayed non-directional residual overcurrent protection

Parameter		Setting range	Accuracy
Start current, definite time or inverse time delay, IN>		5-300% of Ib in steps of 1%	± 5% of set value
Operate value for directional current measurement	Forward I_N at φ=65 degrees	5-35% of Ib in steps of 1%	± 1.5% of I_r
	Reverse	60% of the setting for forward operation	± 1.5% of I_r
Characteristic angles		65 degrees lagging	± 5 degrees at 20 V and I_{set}=35% of I_r
Definite time delay		0.000 - 60.000 s in steps of 1ms	± 0.5 % +/-10 ms
Time multiplier for inverse time delay k		0.05-1.10 in steps of 0.01	According to IEC 60255-3
Normal inverse characteristic $I = I_{meas}/I_{set}$		$t = \frac{0.14}{I^{0.02} - 1} \cdot k$	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		$t = 5.8 - 1.35 \cdot \ln\frac{I}{I_N}$	± 5 % of t at I = (1.3-29) × I_N
Min. operate current for dependent characteristic, IMin		100-400% of IN in steps of 1%	± 5% of I_{set}
Minimum operate time for dependent characteristic, tMin		0.000-60.000 s in steps of 1 ms	± 0.5 % ± 10 ms
Minimum polarising voltage		1 % of U_r	At 50 Hz: 1% of U_r ± 5% At 60 Hz: 1% of U_r -15% to -5%
Reset time		<70 ms	-

6 Four step time delayed directional residual overcurrent protection (EF4)

6.1 Application

In solidly earthed systems the four step residual overcurrent protection can be used in a similar way as a distance protection. As the majority of the faults involve earth connection, the protection will be able to clear most of the faults in these systems. All four steps can be non-directional or directional.

One example of a normal application of the four step residual overcurrent 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 sensitive 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.

Scheme communication logic for residual overcurrent protection (EFC) and Current reversal and weak-end infeed logic for residual overcurrent protection (EFCA) are automatically included in (EF4).

6.2 Functionality

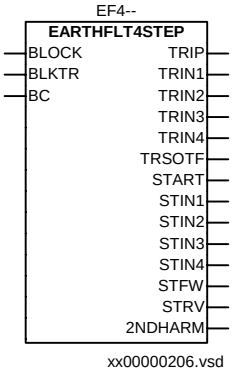
The function operates on the basis of the residual current and voltage measurement. The function has four steps with individual settings (current, delay, directionality, second harmonic restrained etc.). Step 1, 2 and 3 have independent time delay. The time delay for step 4 can be selected between definite or inverse 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 (-3U0) voltage 65ÃÂ° 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.

6.3 Function block



6.4 Logic diagram

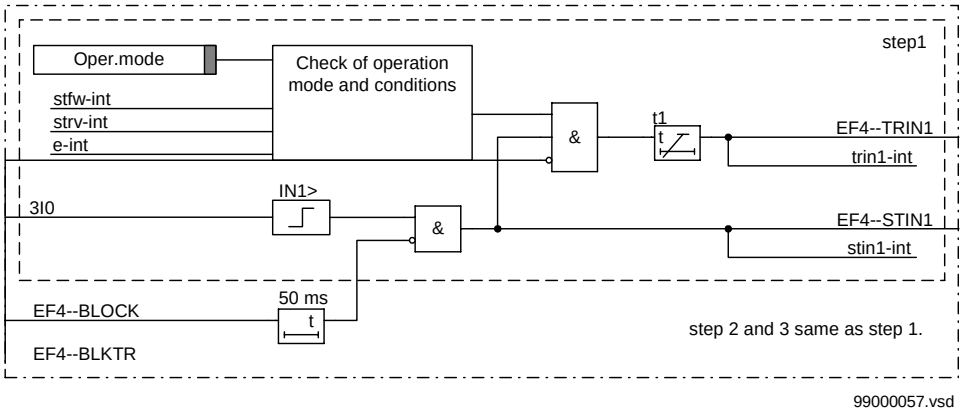


Figure 81: Simplified logic diagram of internal function Step 1. Step 2 and step 3 are designed in the same way.

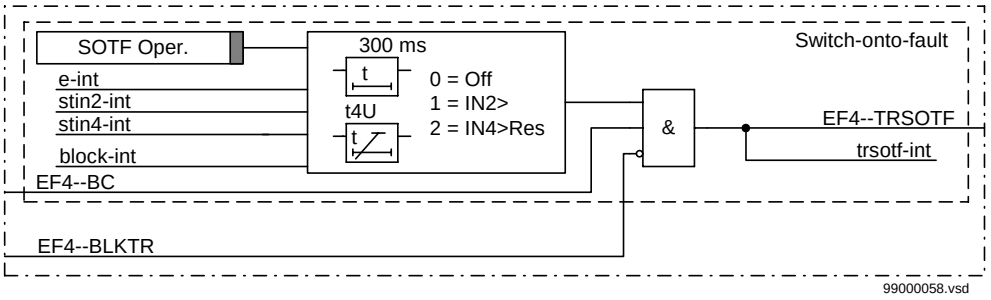


Figure 82: Simplified logic diagram of internal function Switch-onto-fault.

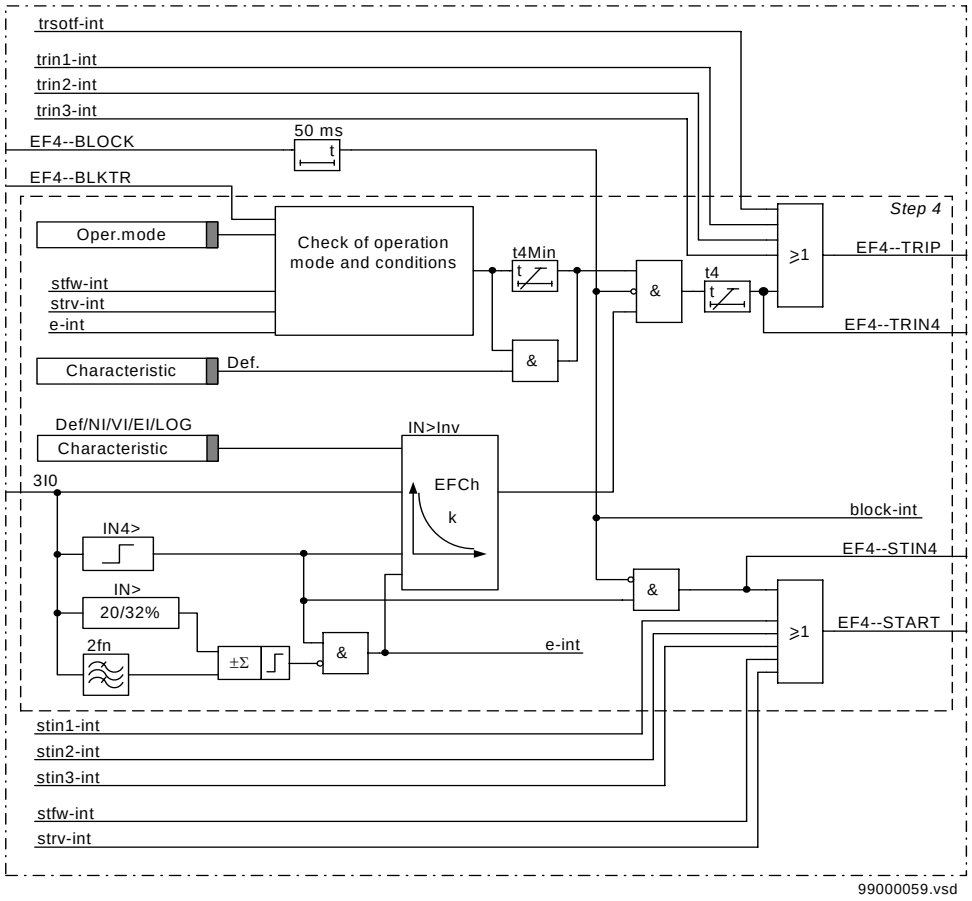


Figure 83: Simplified logic diagram of internal function step 4.

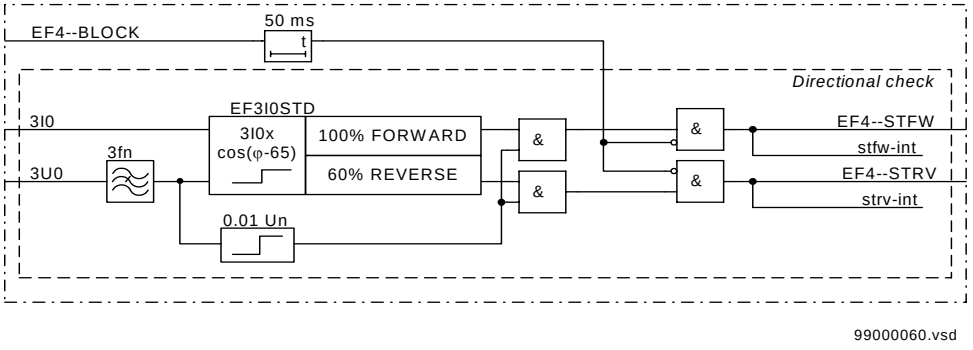


Figure 84: Simplified logic diagram of internal function Directional check.

6.5 Input and output signals

Table 145: 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

Path in local HMI: ServiceReport/Functions/EarthFault/4StepEF/FuncOutputs

Table 146: 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
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

Path in local HMI-tree: Settings/Functions/Groupn/EarthFault/4StepEF

Table 147: 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 NonDirNonRestr ForwRelease Restrained ForwRelRestr RevBlock RevBIRestr	Off		Operating mode of step 1
IN1>	50-2500 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 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 Step: 1	200	% of Ib	Current operate level step 2. Ib is the same as selected for IMeasured above (I4b or I5b)
t2	0.000-60.000 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 Step: 1	100	% of Ib	Current operate level step 3. Ib is the same as selected for IMeasured above (I4b or I5b)
t3	0.000-60.000 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 Step: 0.1	50.0	% of Ib	Inverse time base current. Ib is the same as selected for IMeasured above (I4b or I5b)
k	0.05-1.10 Step: 0.01	0.05		Time multiplier for the dependent time delay characteristic
IN4>	4.0-440.0 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 Step: 0.001	0.000	s	Definite (inverse additional) time delay step 4
t4Min	0.000-60.000 Step: 0.001	0.000	s	Inverse time minimum delay step 4

Parameter	Range	Default	Unit	Description
IN> Dir	5-40 Step: 1	30	% of Ib	Forward direction base current. Ib is the same as selected for IMeasured above (I4b or I5b)
2ndHarmStab	20, 32	20	% of Ib	Second harmonic restrain operation
BlkParTransf	Off, On	Off		Blocking at parallel transformers
SOTF	Off, IN2 >, IN4>, Res	Off		Switch-onto-fault operation mode
t4U	0.000 - 60.000 Step: 0.001	0.000	s	Switch-onto-fault active time

6.7 Technical data

Table 148: EF4 - Four step time delayed directional residual overcurrent protection

Parameter		Setting range	Accuracy
Current level for step 1, IN1>		50 - 2500% of Ib in steps of 1%	± 5 % of I_r at I≤I_r ± 5% of I at I>I_r
Definite time delay for step 1, t1		0.000 - 60.000 s in steps of 1ms	± 0.5 % ±10 ms
Current level for step 2, IN2>		20 - 1500 % of Ib in steps of 1%	± 5 % of I_r at I≤I_r ± 5% of I at I>I_r
Definite time delay for step 2, t2		0.000 - 60.000 s in steps of 1 ms	± 0.5 % ± 10 ms
Current level for step 3, IN3>		20 - 1500 % of Ib in steps of 1%	± 5 % of I_r at I≤I_r ± 5% of I at I>I_r
Definite time delay for step 3, t3		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, IN4>		4 - 440 % of Ib in steps of 0.1%	± 5 % of I_r at I≤I_r ± 5% of I at I>I_r
Definite time delay for step 4 or inverse time additional delay, t4		0.000 - 60.000 s in steps of 1 ms	± 0.5 % ±10 ms
Base current for inverse time delay, IN>Inv		4 - 110% of Ib in steps of 0.1%	± 5 % of I_r at I≤I_r ± 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 I_N at φ= 65°	5-40% of Ib in steps of 1%	± 2.5 % of I_r at I≤I_r ± 2.5% of I at I>I_r
	Reverse	60% of Forward	± 2.5 % of I_r at I≤I_r ± 2.5% of I at I>I_r
Level of harmonic restrain		20% or 32%	± 5%

Parameter	Setting range	Accuracy
Characteristic angle $I = I_{meas}/I_{set}$	65° lagging	± 5° at 20 V and I_{set}= 35 % of I_r
Normal inverse characteristic $I = I_{meas}/I_{set}$	$t = \frac{0.14}{I^{0.02} - 1} \cdot k$	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	$t = 5.8 - 1.35 \cdot \ln\frac{I}{I_N}$	± 5 % of t at I = (1.3-29) × I_N
Switch onto fault active time, t4U	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 φ 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.

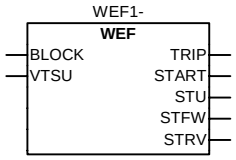
7.2 Functionality

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

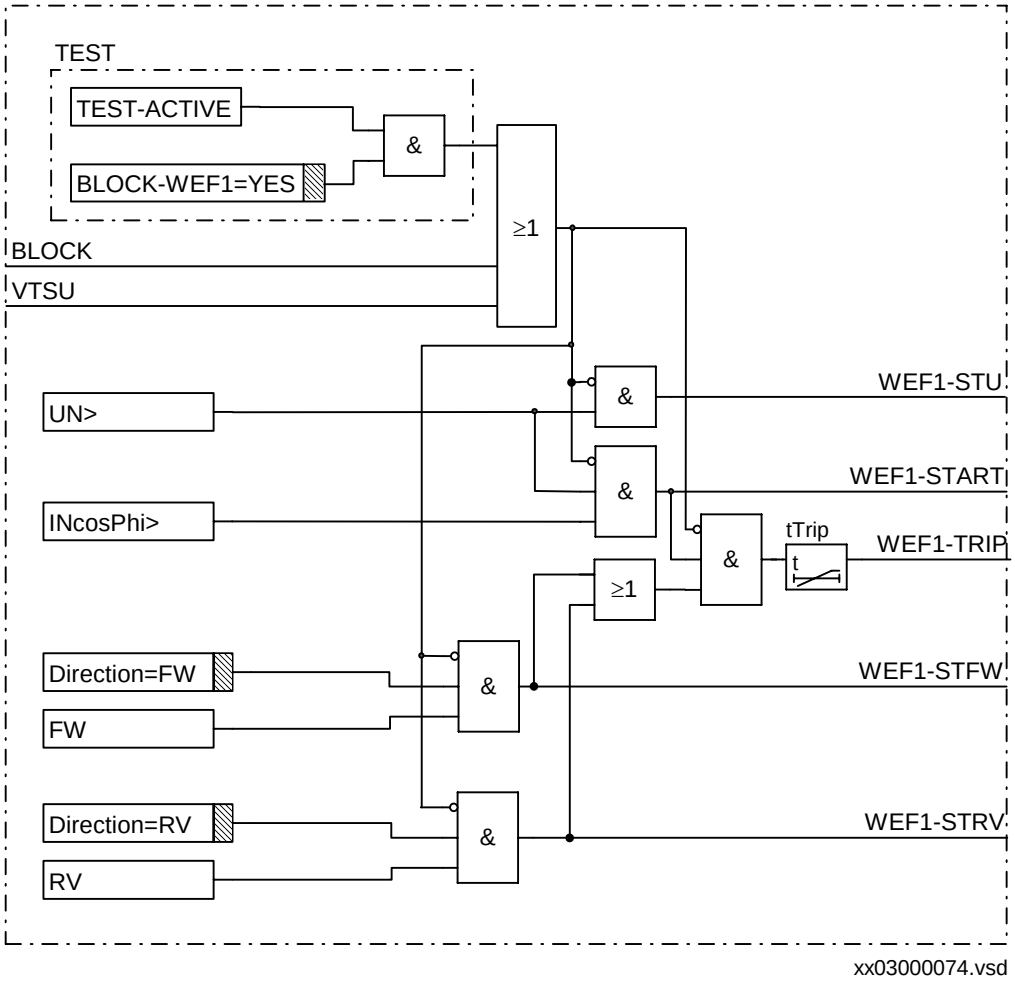


Figure 85: Sensitive directional residual overcurrent protection function, simplified logic diagram

7.5 Input and output signals

Table 149: 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

Path in local HMI: ServiceReport/Functions/EarthFault/WattmetrEF1/FuncOutputs

Table 150: 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

Path in local HMI: Settings/Functions/Groupn/EarthFault/WattmetrEF1

Table 151: Settings for the WEF1 (WEF1-) function

Parameter	Range	Default	Unit	Description
Operation	On / Off	Off		Operation mode for WEF1 function
Direction	For-ward/Reverse	Forward		Direction for trip
INcosPhi>	3.0 - 2000.0 Step: 0.1	10.0	% of Ib	Start current
UN>	5.0 - 70.0 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 Step: 0.1	0.0	degrees	Relay characteristic angle
tTrip	0.000 - 60.000 Step: 0.001	0.000	s	Trip delay

7.7 Technical data

Table 152: WEF1 - Sensitive directional residual overcurrent protection function

Function	Value	Accuracy
Operate current, IN>	(3.0 - 2000.0) % of Ib in steps of 0.1%	± 2.5% of I_r at $I \leq I_r$ ± 2.5% of I at $I > I_r$
Operate voltage, UN>	(5.0 - 70.0) % of Ub in steps of 0.1%	± 2.5% of U_r at $U \leq U_r$ ± 2.5% of U at $U > U_r$
Characteristic Angle	(-90.0 to +90.0) degrees in steps of 0.1 degrees	
Definite time delay, tTrip	(0.000 - 60.000) s in steps of 1 ms	± 0.5% ± 10 ms
Reset ratio	> 90% typically	

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 φ 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.

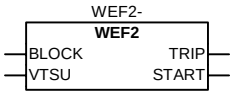
8.2 Functionality

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 ($3U_0$) is compared with a setting value. The residual current ($3I_0$) 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



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8.4 Logic diagram

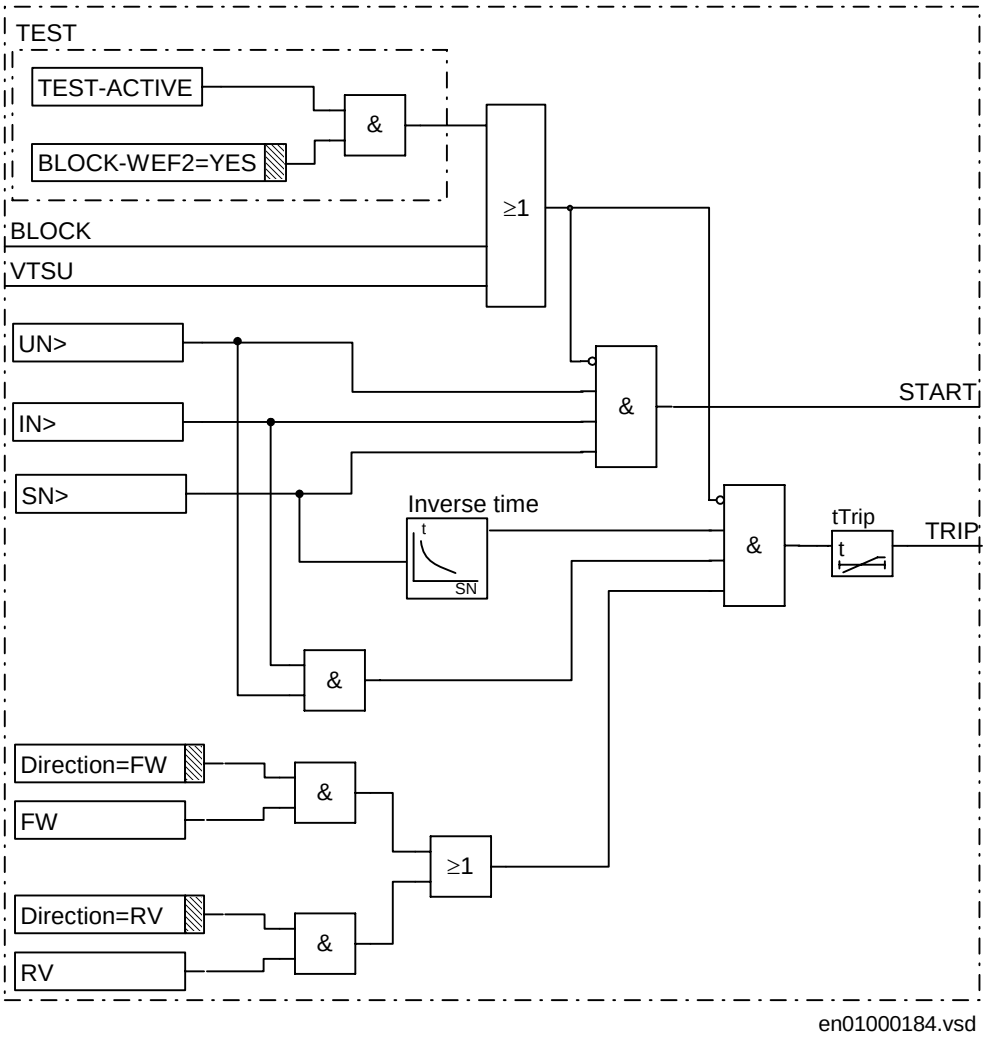


Figure 86: Sensitive directional residual power protection function, simplified logic diagram

8.5 Input and output signals

Table 153: Input signals for the sensitive directional residual power protection (WEF2-) function block

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

Path in local HMI: ServiceReport/Functions/EarthFault/WattmetrEF2/FuncOutputs

Table 154: 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

Path in local HMI: Settings/Functions/Groupn/EarthFault/WattmetrEF2

Table 155: Settings for the WEF2 (WEF2-) function

Parameter	Range	Default	Unit	Description
Operation	On / Off	Off		Operation mode for WEF2 function
Direction	For-ward/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
tTrip	0.000 - 60.000 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 156: WEF2 - Sensitive directional residual power protection function

Function	Value	Accuracy
Operate current, IN>	(5.0 - 400.0) % of I_b in steps of 0.1%	± 2.5% of I_r at $I \leq I_r$ ± 2.5% of I at $I > I_r$
Operate voltage, UN>	(1.0-70.0) % of U_b in steps of 0.1%	± 2.5% of U_r at $U \leq U_r$ ± 2.5% of U at $U > U_r$
Characteristic angle	(-90.0 to +90.0) degrees in steps of 0.1 degrees	
Definite time delay, tTrip	(0.000-60.000) s in steps of 1 ms	± 0.5% ± 10 ms
Inverse characteristic $T_i = k \frac{S_{ref}}{S_{measured}}$	k = (0.0-2.0) in steps of 0.01 Sref = (5.0 - 50.0) % of Sb in steps of 0.1%	IEC 60255-3 class 5 ± 60 ms
Reset ratio	> 90% typically	

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 a 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.

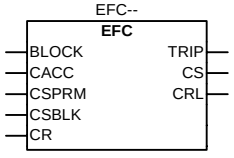
9.2 Functionality

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, an additional logic can be used to take care of this.

9.3 Function block



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9.4 Logic diagram

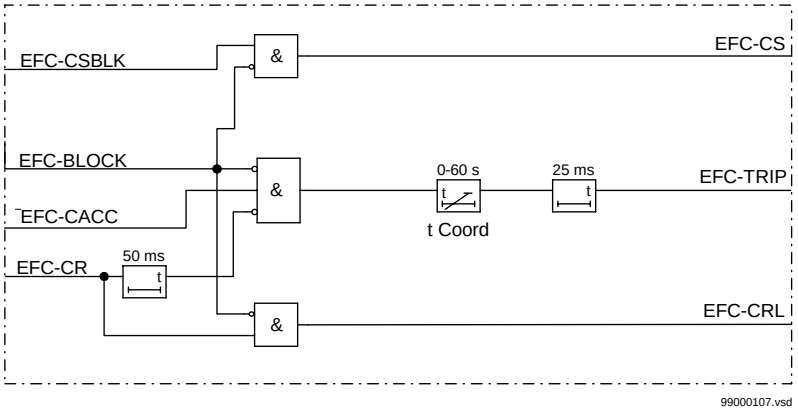


Figure 87: Simplified logic diagram, Scheme type = blocking

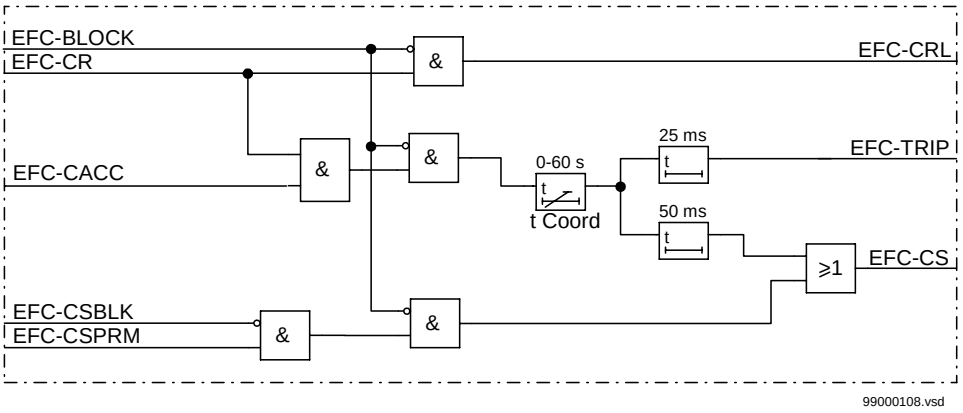


Figure 88: Simplified logic diagram, Scheme type = permissive

9.5 Input and output signals

Table 157: Input signals for the EFC (EFC--) function block

Signal	Description
BLOCK	Block function
CACC	Permits the operation when high
CSPRM	Initiates sending of carrier signal in permissive scheme
CSBLK	Initiates sending of carrier signal in blocking scheme
CR	Information on received carrier signal

Path in local HMI: ServiceReport/Functions/EarthFault/EFCom/FuncOutputs

Table 158: 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

Path in local HMI: Settings/Functions/Groupn/EarthFault/EFCom

Table 159: 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 Step: 0.001	0.050	s	Communication scheme coordination time

9.7 Technical data

Table 160: EFC - Scheme communication logic for residual overcurrent protection

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 directional 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.

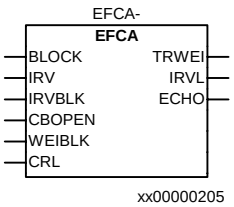
Permissive communication schemes for residual overcurrent protection, can basically operate only when the protection in the remote terminal can detect the fault. The detection requires a sufficient minimum residual fault current, out from this terminal. The fault current can be too low due to an opened 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

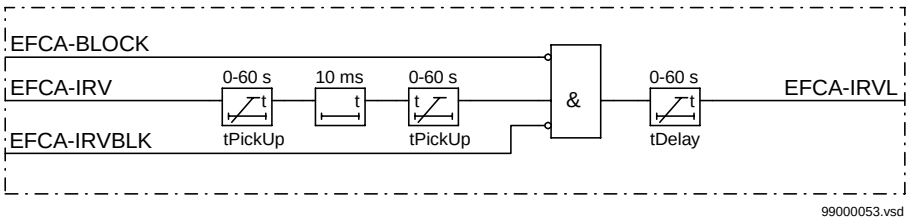


Figure 89: Simplified logic diagram, current reversal logic

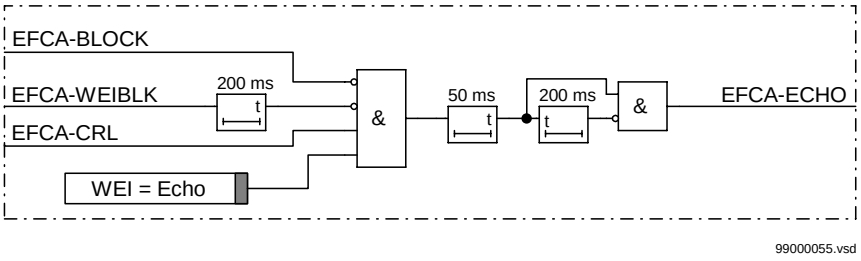


Figure 90: Simplified logic diagram, weak end infeed - Echo logic

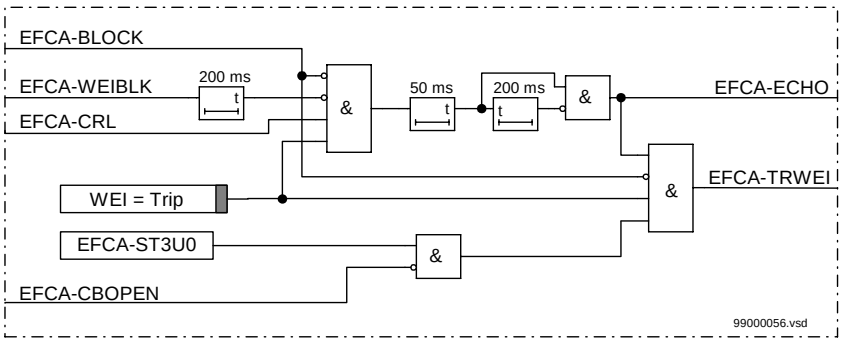


Figure 91: Simplified logic diagram, weak end infeed - Trip logic

10.5 Input and output signals

Table 161: 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
CBOPEN	Blocking of trip when breaker is open

Path in local HMI: ServiceReport/Functions/EarthFault/ComIRevWeiEF/FuncOutputs

Table 162: 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

Path in local HMI: Settings/Functions/Groupn/EarthFault/ComIRevWeiEF

Table 163: 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 Step: 0.001	0.000	s	Current reversal pickup timer
tDelay	0.000-60.000 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 Step: 1	25	% of U1b	Operate phase voltage for WEI trip

10.7 Technical data

Table 164: EFCA - Current reversal and weak end infeed logic for residual overcurrent protection

Parameter	Setting range	Accuracy
Operate voltage for WEI trip, U>	5-70 % of U1b in steps of 1%	± 5% of set value
Current reversal pickup timer, tPickUp	0.000-60.000 s in steps of 1 ms	± 0.5% ± 10 ms
Current reversal delay timer, tDelay	0.000-60.000 s in steps of 1 ms	± 0.5% ± 10 ms

11 Thermal phase 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 has large variations.

11.2 Functionality

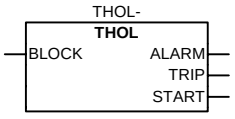
The final temperature rise of an object relative the ambient temperature is proportional to the square of the current. The rate of temperature rise is determined by the magnitude of the current and the thermal time constant of the object. The same time constant determines the rate of temperature decrease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

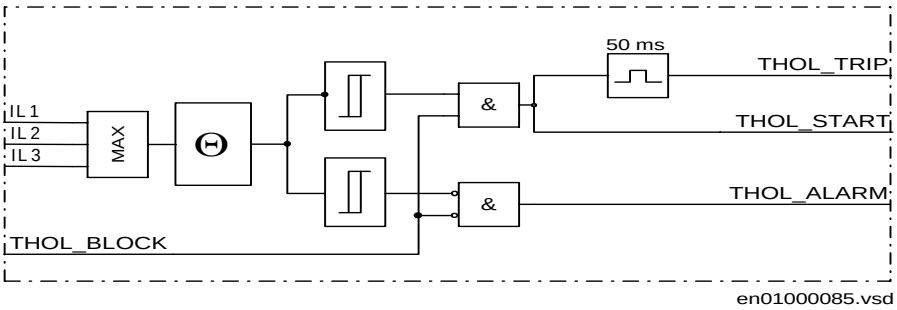


Figure 92: Thermal overload protection, simplified logic diagram

11.5 Input and output signals

Table 165: Input signals for the THOL (THOL-) function block

Signal	Description
BLOCK	Block of the thermal overload function

Path in local HMI: ServiceReport/Functions/ThermOverLoad/FuncOutputs

Table 166: 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

Path in local HMI: Settings/Functions/Groupn/ThermOverLoad

Table 167: Settings for the thermal overload protection THOL (THOL-) function

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

Table 168: Settings for thermal overload protection (THOL), mA input

Parameter	Range	Default	Unit	Description
MI11-I_Max	-25.00-25.00 Step: 0.01	20.00	mA	Max current of transducer to Input 1 Can only be set from PST
MI11-I_Min	-25.00-25.00 Step: 0.01	4.00	mA	Min current of transducer to Input 1 Can only be set from PST
MI11-I_MaxValue	-1000.00-1000.00 Step: 0.01	20.00	ÃÂ°C	Max primary value corr. to I_Max, Input 1 Can only be set from PST
MI11-I_MinValue	-1000.00-1000.00 Step: 0.01	4.00	ÃÂ°C	Min primary value corr. to I_Min, Input 1 Can only be set from PST

11.7 Technical data

Table 169: THOL - Thermal phase overload protection

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

Table 170: Thermal overload protection mA input

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

12 Breaker failure protection (BFP)

12.1 Application

In many protection applications local redundancy is used. One part of the fault clearance system is however never duplicated, namely the circuit breaker. Therefore 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.

12.2 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. A dedicated input is available for general starting.

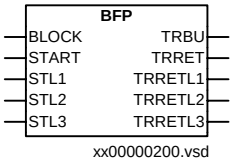
Three separate functional inputs are also available for single-phase starting

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.

12.3 Function block



12.4 Logic diagram

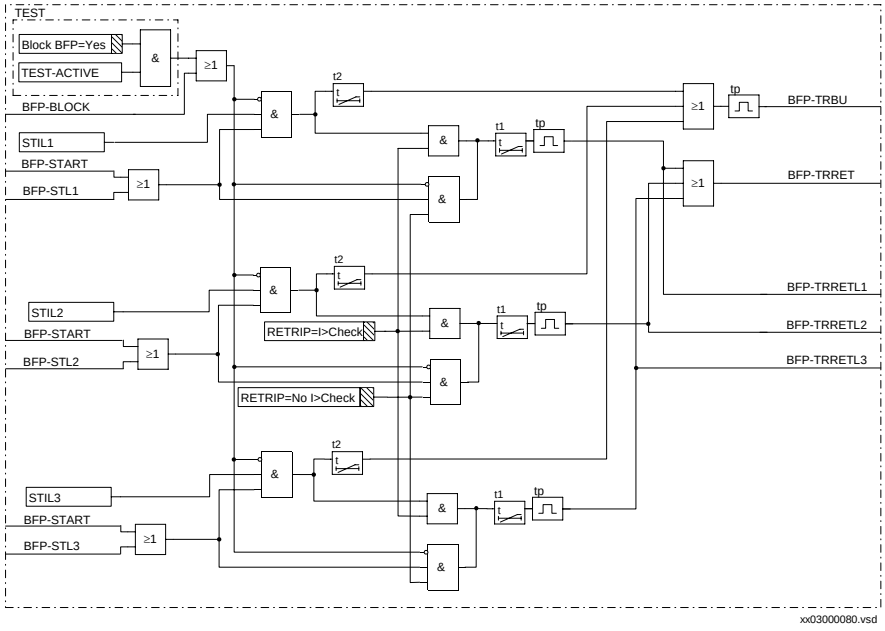


Figure 93: Logic diagram for breaker failure protection

12.5 Input and output signals

Table 171: 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

Path in local HMI: ServiceReport/Functions/BreakerFailure/FuncOutputs

Table 172: Output signals for the breaker failure protection (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

12.6 Setting parameters

Path in local HMI: Settings/Functions/Groupn/BreakerFailure

Table 173: 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 Step: 1	100	% of I1b	Operating phase current
t2	0.000-60.000 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 Step: 0.001	0.050	s	Delay timer for retrip

12.7 Technical data

Table 174: BFP - Breaker failure protection

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

Parameter	Value
Trip operate time	Max 18 ms
Operate time for current detection	Max 10 ms

Chapter 6 Voltage

About this chapter

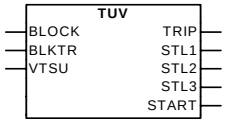
This chapter describes the voltage protection functions.

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



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1.3 Logic diagram

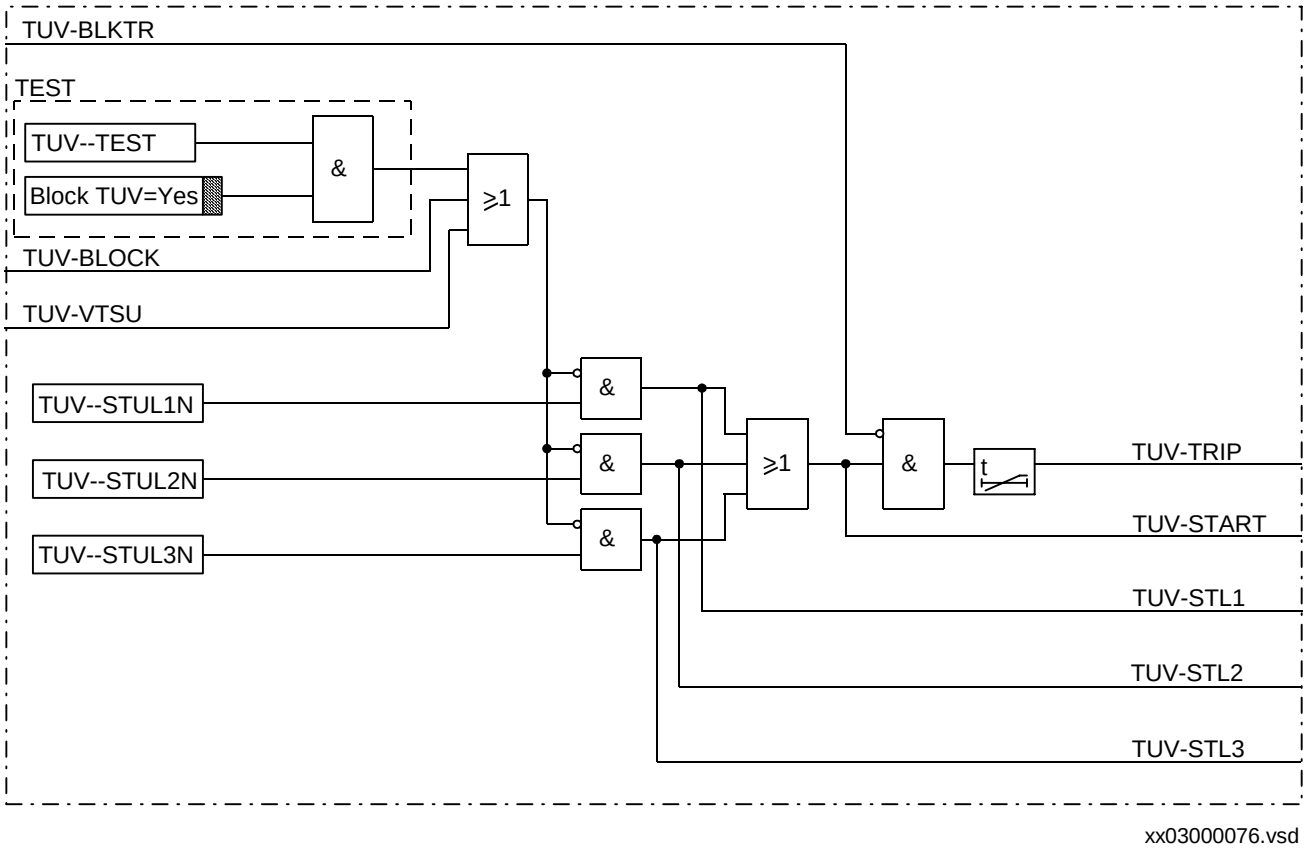


Figure 94: Undervoltage protection - simplified logic diagram

1.4 Input and output signals

Table 175: 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

Path in local HMI: ServiceReport/Functions/TimeDelayUV/FuncOutputs

Table 176: 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

Path in local HMI: Settings/Functions/Groupn/TimeDelayUV

Table 177: 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 Step: 1	70	% of U1b	Operate phase voltage
t	0.000-60.000 Step: 0.001	0.000	s	Time delay

1.6 Technical data

Table 178: TUV - Time delayed undervoltage protection

Function	Setting range	Accuracy
Operate voltage, UPE<	(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

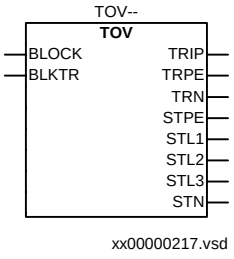
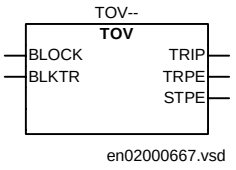


Figure 95: TOV function block, phase and residual overvoltage



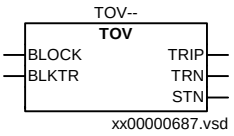


Figure 96: TOV function block residual overvoltage

2.4 Logic diagram

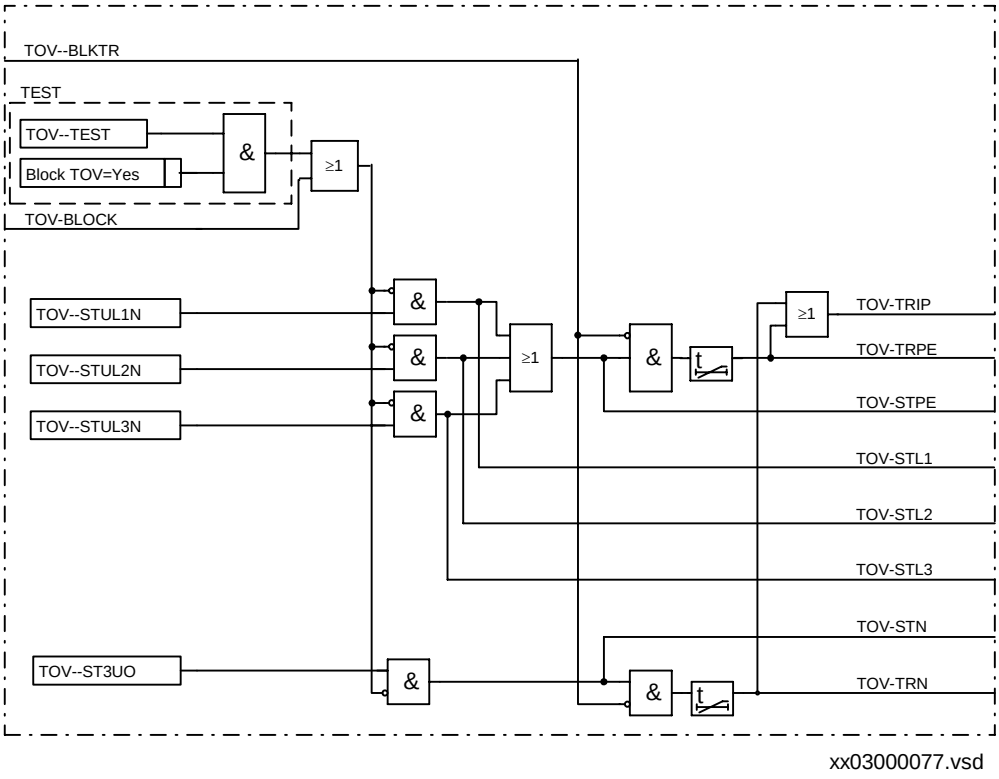


Figure 97: TOV, logic diagram

2.5 Input and output signals

Table 179: 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

Path in local HMI: ServiceReport/Functions/TimeDelayOV/FuncOutputs

Table 180: 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
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

Path in local HMI: Settings/Functions/Groupn/TimeDelayOV

Table 181: 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 Step: 1	120	% of U1b	Operate value for the phase overvoltage function
t	0.000-60.000 Step: 0.001	0.000	s	Time delay of the phase overvoltage function
3U0>	5-100 Step: 1	30	% of U1b	Operate value for the neutral overvoltage function
t	0.000-60.000 Step: 0.001	0.000	s	Time delay of the neutral overvoltage function

2.7 Technical data

Table 182: TOV - Time delayed overvoltage protection

Function		Setting range	Accuracy
Operate voltage U>	Phase measuring elements	(50-170)% of U1b in steps of 1%	± 2.5 % of U_r at $U \leq U_r$ ± 2.5 % of U at $U > U_r$
Time delay	Phase measuring elements	(0.000-60.000) s in steps of 1ms	± 0.5 % ± 10 ms
Operate voltage U>	Residual measuring elements	(5-100)% of U1b in steps of 1%	± 2.5 % of U_r at $U \leq U_r$ ± 2.5 % of U at $U > U_r$
Time delay	Residual measuring elements	(0.000-60.000) s in steps of 1ms	± 0.5 % ± 10 ms

Chapter 7 Power system supervision

About this chapter

This chapter describes the power system supervision functions.

1 Broken conductor check (BRC)

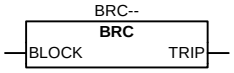
1.1 Application

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

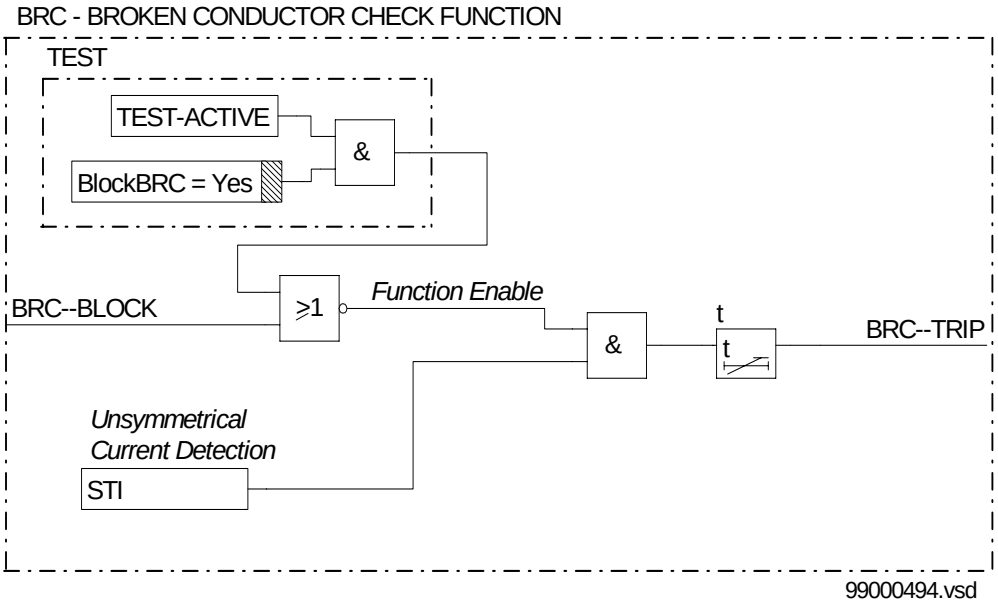


Figure 98: Simplified logic diagram of broken conductor check function

1.5 Input and output signals

Table 183: Input signals for the BRC (BRC--) function block

Signal	Description
BLOCK	Block of BRC function

Path in local HMI: ServiceReport/Functions/BrokenConduct/FuncOutputs

Table 184: Output signals for BRC (BRC--) function block

Signal	Description
TRIP	Trip by BRC function

1.6 Setting parameters

Path in local HMI: Settings/Functions/Groupn/BrokenConduct

Table 185: 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 Step: 1	10	% of I1b	Operating phase current
t	0.000-60.000 Step: 0.001	20.000	s	Time delay before giving output for which detected broken conductor conditions must persist

1.7 Technical data

Table 186: BRC - Broken conductor check

Parameter	Setting range	Accuracy
Minimum level of highest phase current for operation, IP>	10-100% of I1b in steps of 1%	± 2.5% of I_r
Output time delay, t	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.

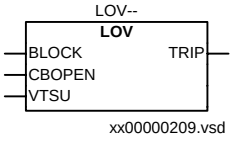
2.2 Functionality

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



2.4 Logic diagram

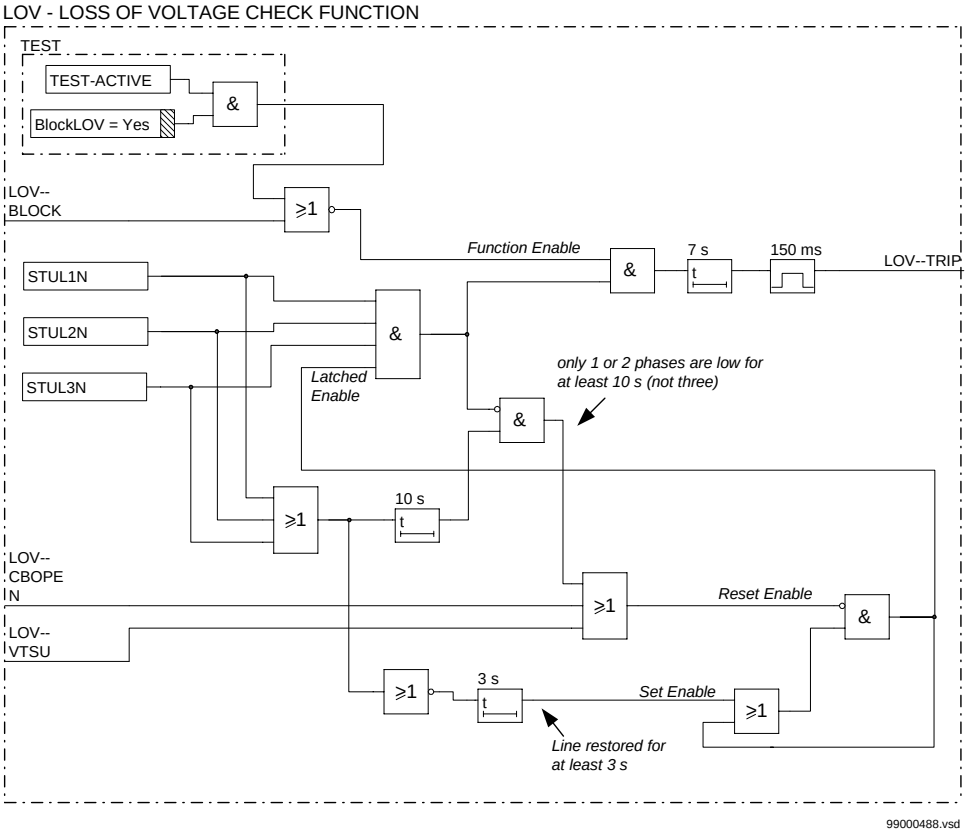


Figure 99: Simplified logic diagram of loss of voltage check protection function

2.5 Input and output signals

Table 187: 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

Path in local HMI: ServiceReport/Functions/LossOfVoltage/FuncOutputs

Table 188: Output signals for the LOV (LOV--) function block

Signal	Description
TRIP	Trip by loss of voltage check

2.6 Setting parameters

Path in local HMI: Settings/Function/Groupn/LossOfVoltage

Table 189: 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 Step: 1	70	% of U1b	Operating phase voltage

2.7 Technical data

Table 190: LOV - Loss of voltage check

Parameter	Setting range	Accuracy
Operate voltage, UPE<	10-100% of U1b in steps of 1%	± 2.5% of U_r

3 Overload supervision (OVLD)

3.1 Application

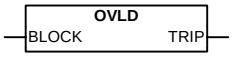
The overload protection, OVLD, prevents excessive loading of power transformers, lines and cables.

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



xx00000210.vsd

3.4 Logic diagram

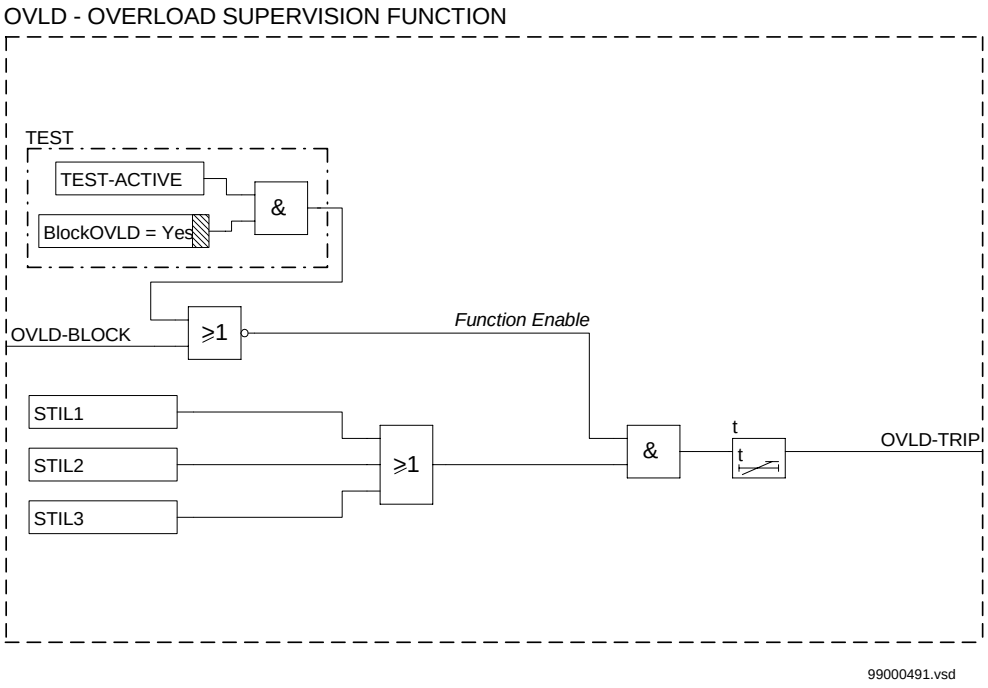


Figure 100: Simplified logic diagram of overload supervision function

3.5 Input and output signals

Table 191: Input signals for the OVLD (OVLD-) function block

Signal	Description
BLOCK	Block of overload supervision function

Path in local HMI: ServiceReport/Functions/OverLoad/FuncOutputs

Table 192: Output signals for the OVLD (OVLD-) function block

Signal	Description
TRIP	Trip by overload supervision function

3.6 Setting parameters

Path in local HMI: Settings/Functions/Groupn/OverLoad

Table 193: 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 Step: 0.1	20.0	s	Time delay

3.7 Technical data

Table 194: OVLD - Overload supervision function

Parameter	Setting range	Accuracy
Operate current, IP>	20-300% of I1b in steps of 1%	± 2.5% of I_r at $I \leq I_r$ ± 2.5% of I at $I > I_r$
Time delay, t	0.0-90000.0 s in steps of 0.1 s	± 0.5% ± 10 ms

4 Dead line detection (DLD)

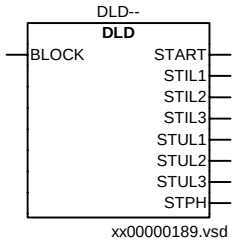
4.1 Application

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

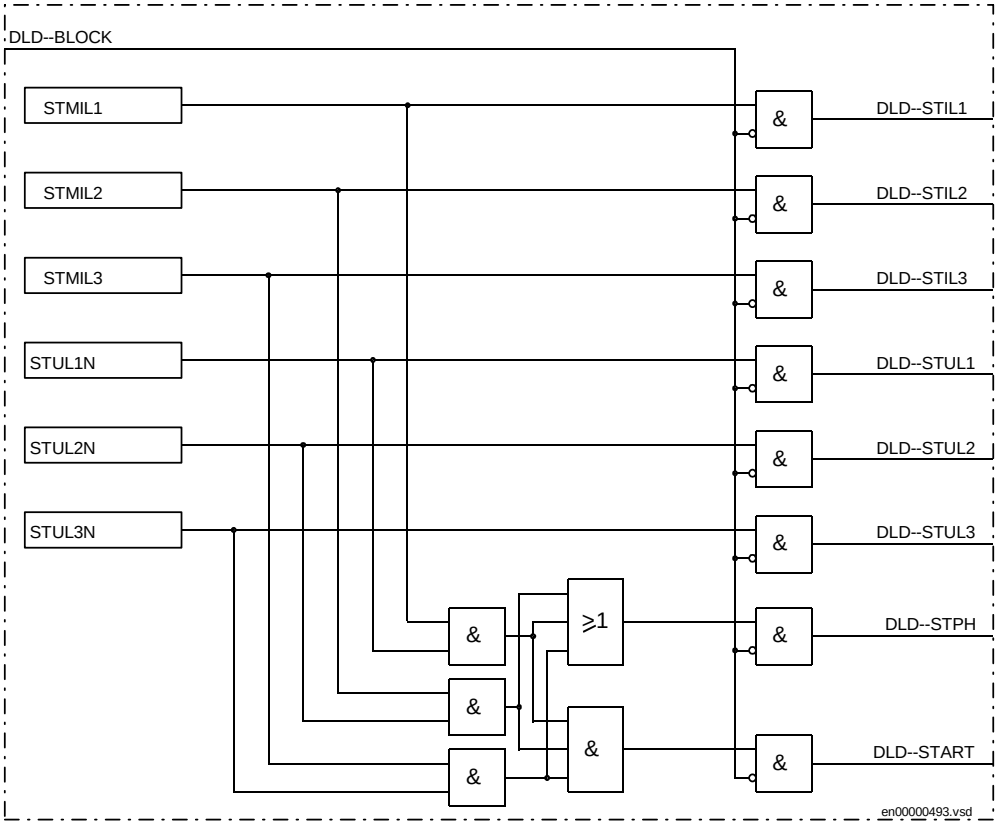


Figure 101: DLD - simplified logic diagram of a function

4.5 Input and output signals

Table 195: Input signals for the DLD (DLD--) function block

Signal	Description
BLOCK	Block of dead line detection

Path in local HMI: ServiceReport/Functions/DeadLineDet/FuncOutputs

Table 196: 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

Path in local HMI: Settings/Functions/Groupn/DeadLineDet

Table 197: 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 Step: 1	70	% of U1b	Operating phase voltage (undervoltage function)
IP<	5 - 100 Step: 1	20	% of I1b	Operating phase current (undercurrent function)

4.7 Technical data

Table 198: DLD - Dead line detection

Function		Setting range	Accuracy
Automatic check of dead line condition	Operate phase current, IP<	(5-100) % of I1b in steps of 1%	± 2.5 % of I_r
	Operate phase voltage, U<	(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, current based (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.

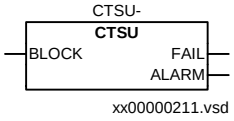
The signal can be configured to block different protection functions or initiate an alarm.

1.2 Functionality

The function compares the zero sequences currents, from the protection current transformer core, with a reference zero sequence current, from another current transformer core. For example from a measuring core.

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

1.3 Function block



1.4 Logic diagram

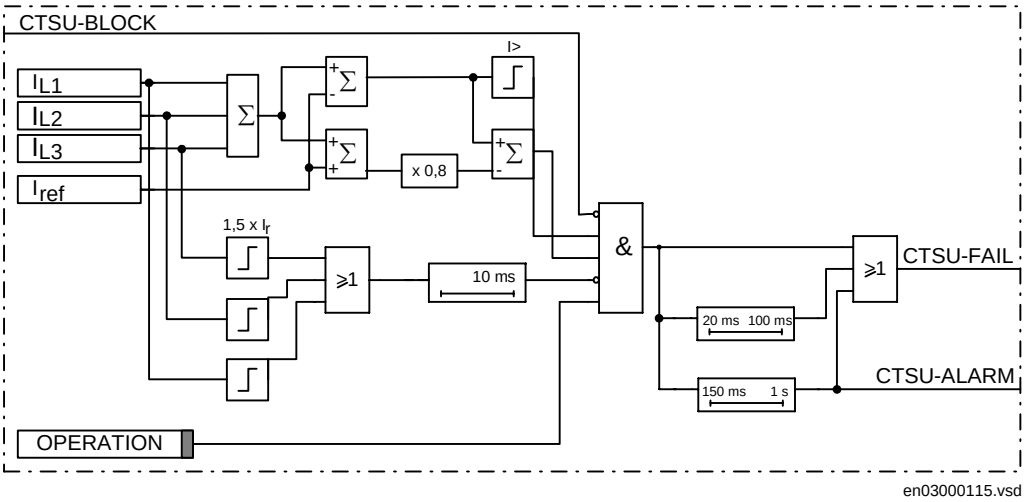


Figure 102: Simplified logic diagram for the current circuit supervision

1.5 Input and output signals

Table 199: Input signals for the CTSU (CTSU-) function block

Signal	Description
BLOCK	Block function

Path in local HMI: ServiceReport/Functions/CTSupervision/FuncOutputs

Table 200: Output signals for the CTSU (CTSU-) function block

Signal	Description
FAIL	Current circuit failure
ALARM	Alarm for current circuit failure

1.6 Setting parameters

Path in local HMI: Settings/Functions/Groupn/CTSupervision

Table 201: 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 Step: 1	20	% of I1b	Minimum operate phase current

1.7 Technical data

Table 202: CTSU - Current circuit supervision, current based

Function	Setting range	Accuracy
Operate current, IMinOp	5-100% of I1b in steps of 1%	± 5.0% 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.

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

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 di/dt and du/dt 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

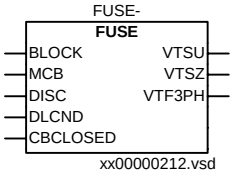


Figure 103: Function block, FUSE function including DU/Dt based

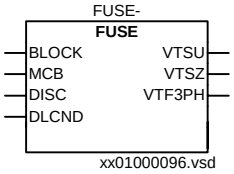


Figure 104: Function block, negative sequence

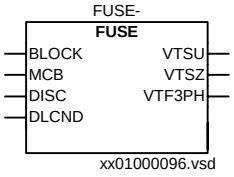


Figure 105: Function block, zero sequence

2.4 Logic diagram

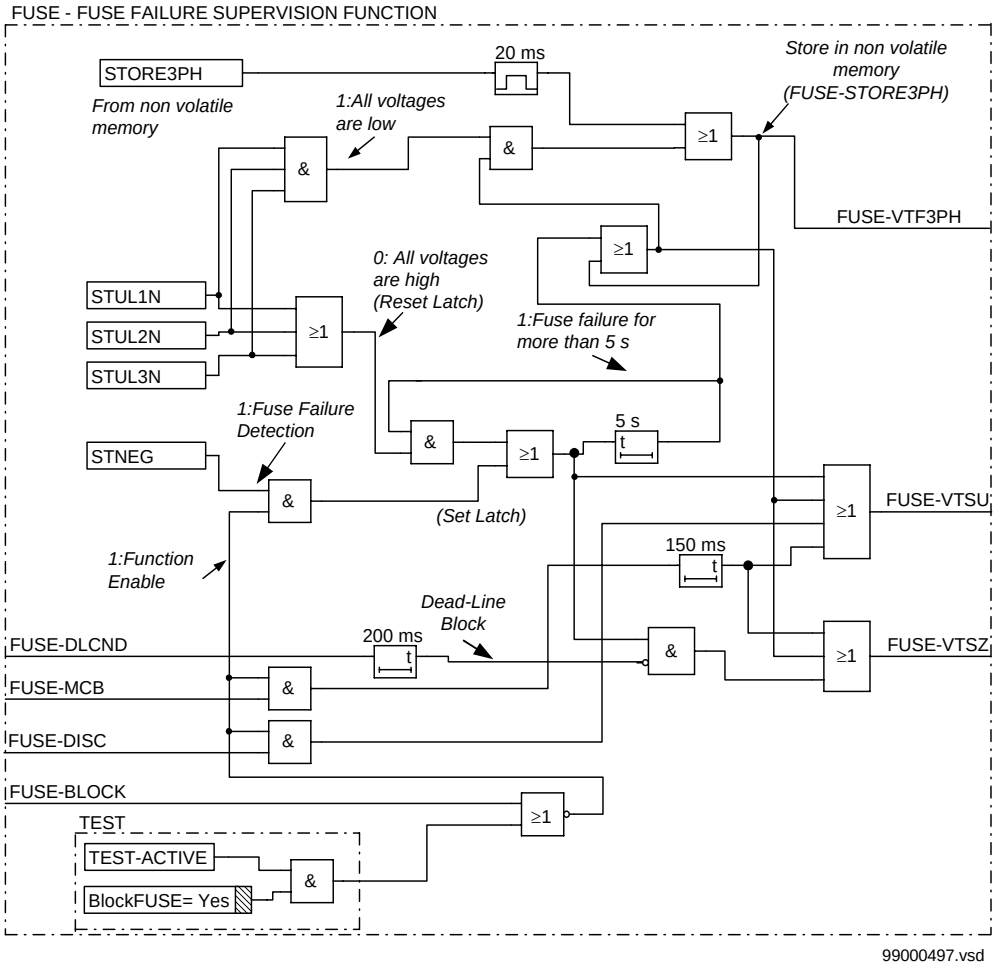


Figure 106: Simplified logic diagram for fuse failure supervision function, negative sequence.

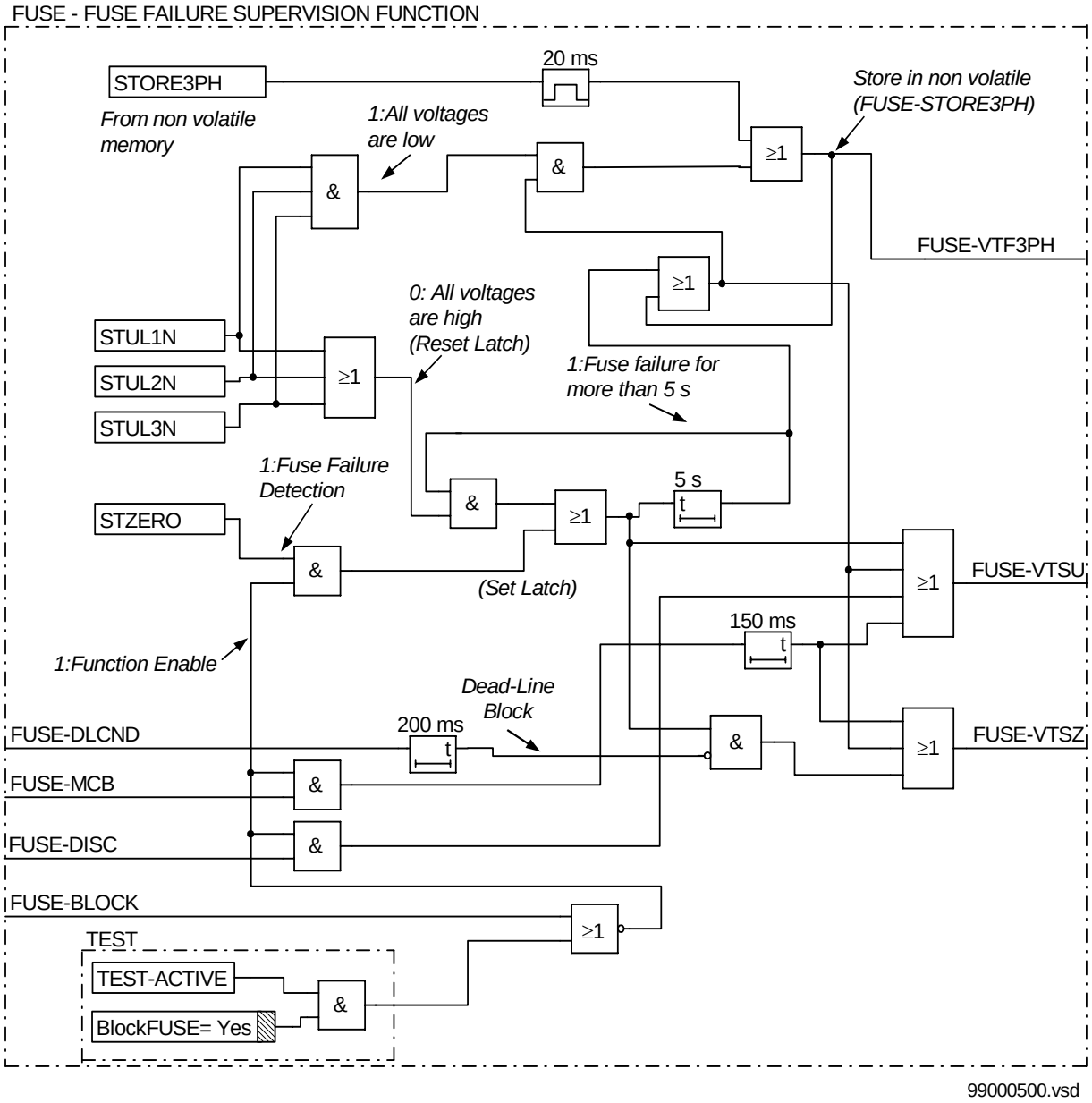


Figure 107: Simplified logic diagram for fuse failure supervision function, zero sequence

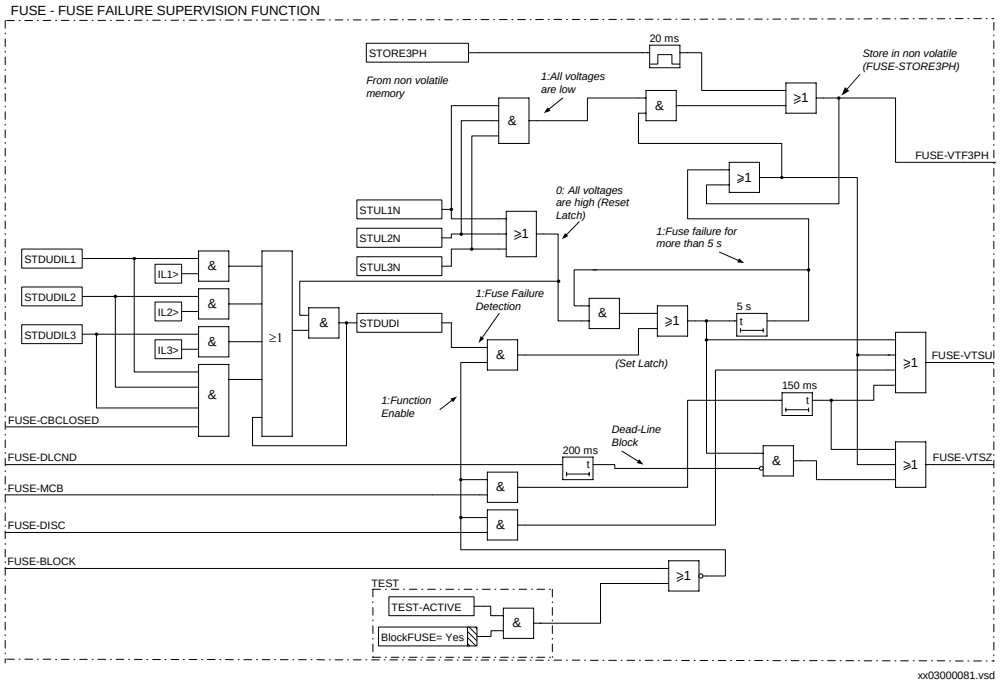


Figure 108: Simplified logic diagram for fuse failure supervision function, du/dt based

2.5 Input and output signals

Table 203: 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

Path in local HMI: ServiceReport/Functions/FuseFailure/FuncOutputs

Table 204: 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

Path in local HMI: Settings/Functions/Groupn/FuseFailure

Table 205: 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 Step: 1	10	% of U1b	Operating zero sequence voltage
3I0<	10-50 Step: 1	10	% of I1b	Operating zero sequence current

Path in local HMI-tree: Settings/Functions/Groupn/FuseFailure

Table 206: Setting parameters for the fuse failure supervision FUSE (FUSE-) function

Parameter	Range	Default	Unit	Description
NegativeSeq	Off, On	Off	-	Operating mode for FUSE function
3U2>	10-50 Step: 1	10	% of U1b	Operating negative sequence voltage
3I2<	10-50 Step: 1	10	% of I1b	Operating negative sequence current

Path in local HMI-tree: Settings/Functions/Groupn/FuseFailure

Table 207: Setting parameters for the fuse failure supervision FUSE (FUSE-) function, du/dt, di/dt based

Parameter	Range	Default	Unit	Description
dUdI	Off, On	Off	-	Operating mode for FUSE function
I>	10-50 Step: 1	10	% of I1b	Operate phase current level
DU>	50-90 Step: 1	80	% of U1b	Operate voltage change level
DI<	10-50 Step: 1	10	% of I1b	Operate current change level

Note!

Parameter dUdI is only possible to change in the local HMI.

2.7 Technical data

Table 208: FUSEzs - Fuse failure supervision, zero sequence

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 209: FUSEns - Fuse failure supervision function, negative sequence

Function		Setting range	Accuracy
Negative-sequence quantities:	Operate voltage $3U_2>$	(10 - 50)% of U1b in steps of 1%	± 2.5 % of U_r
	Operate current $3I_2>$	(10 - 50)% of I1b in steps of 1%	± 2.5 % of I_r

Table 210: FUSEdb - Fuse failure supervision, du/dt and di/dt based

Function	Setting range	Accuracy
Operate voltage change level, DU>	(50-90)% of U1b in steps of 1%	± 2.5% of Ur
Operate current change level, DI<	(10-50)% of I1b in steps of 1%	± 2.5% of Ir

3 Voltage transformer supervision (TCT)

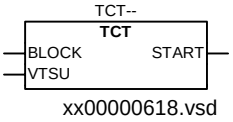
3.1 Application

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

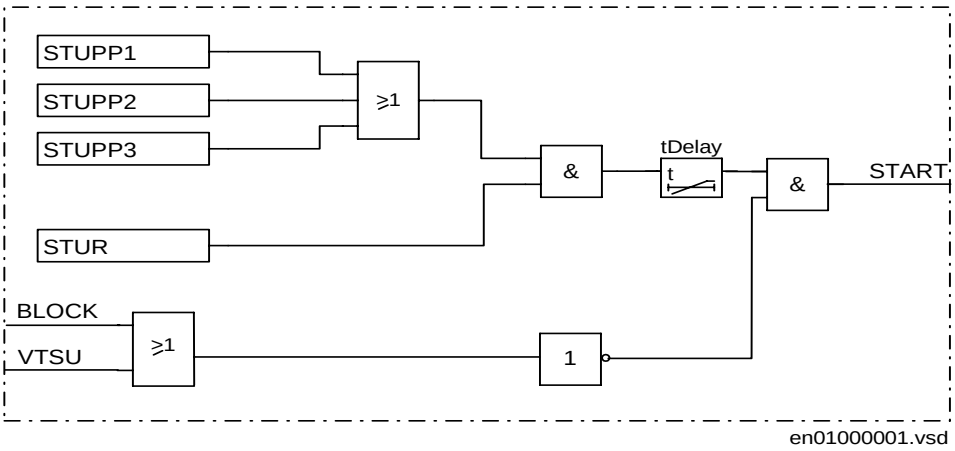


Figure 109: Simplified logic diagram, TCT function

3.5 Input and output signals

Table 211: 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

Path in local HMI: ServiceReport/Functions/VoltageTransfS/FuncOutputs

Table 212: Output signals for the TCT (TCT--) function block

Signal	Description
START	Start by voltage transformer supervision

3.6 Setting parameters

Path in local HMI-tree: Settings/Functions/Groupn/VoltageTransfS

Table 213: 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 Step: 0.1	10.0	% of Ub	Residual overvoltage limit
tDelay	0.000-300.000 Step. 0.001	3.000	s	Time delayed operation for start signal

3.7 Technical data

Table 214: TCT - Voltage transformer supervision

Parameter	Setting range	Accuracy
Residual overvoltage limit, UN>	1.0-80.0% of Ub 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 and energizing check (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 synchronizing 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.

The synchronizing 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 synchronizing 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.

1.2.1 Single breaker

For single 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 disconnection.

1.3 Function block

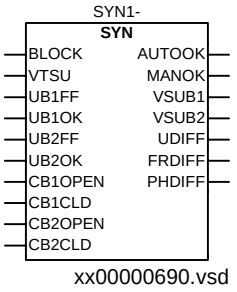


Figure 110: Function block for single CB

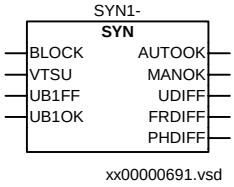


Figure 111: Function block for double CB

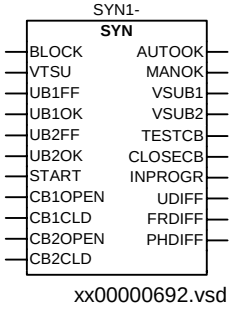


Figure 112: Function block for single CB with phasing

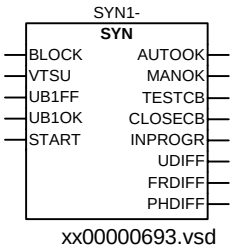


Figure 113: Function block for double CB with phasing

1.4 Logic diagram

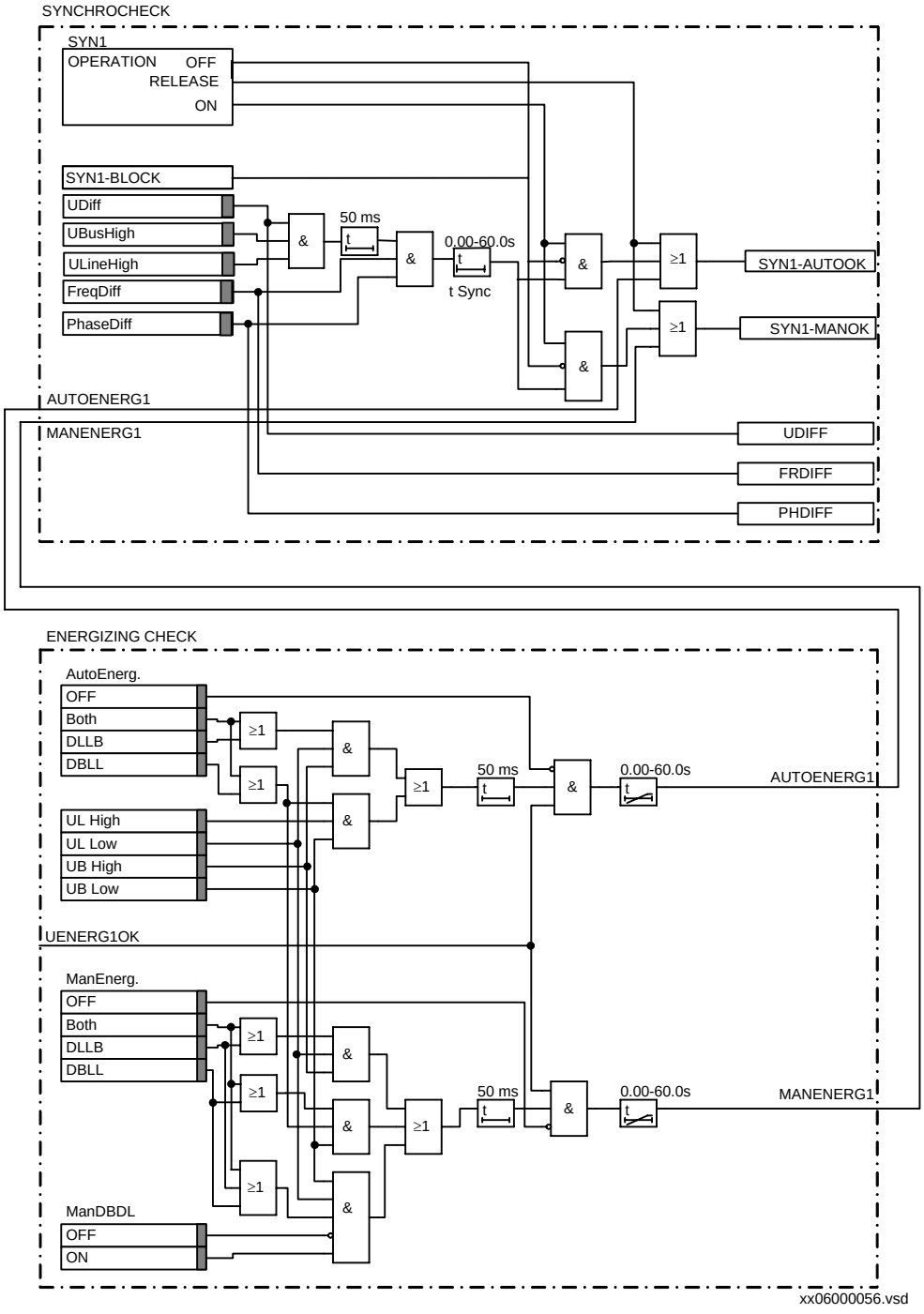


Figure 114: Simplified logic diagram, synchrocheck and energizing check, The internal signal

UENERG1OK refers to the voltage selection logic.

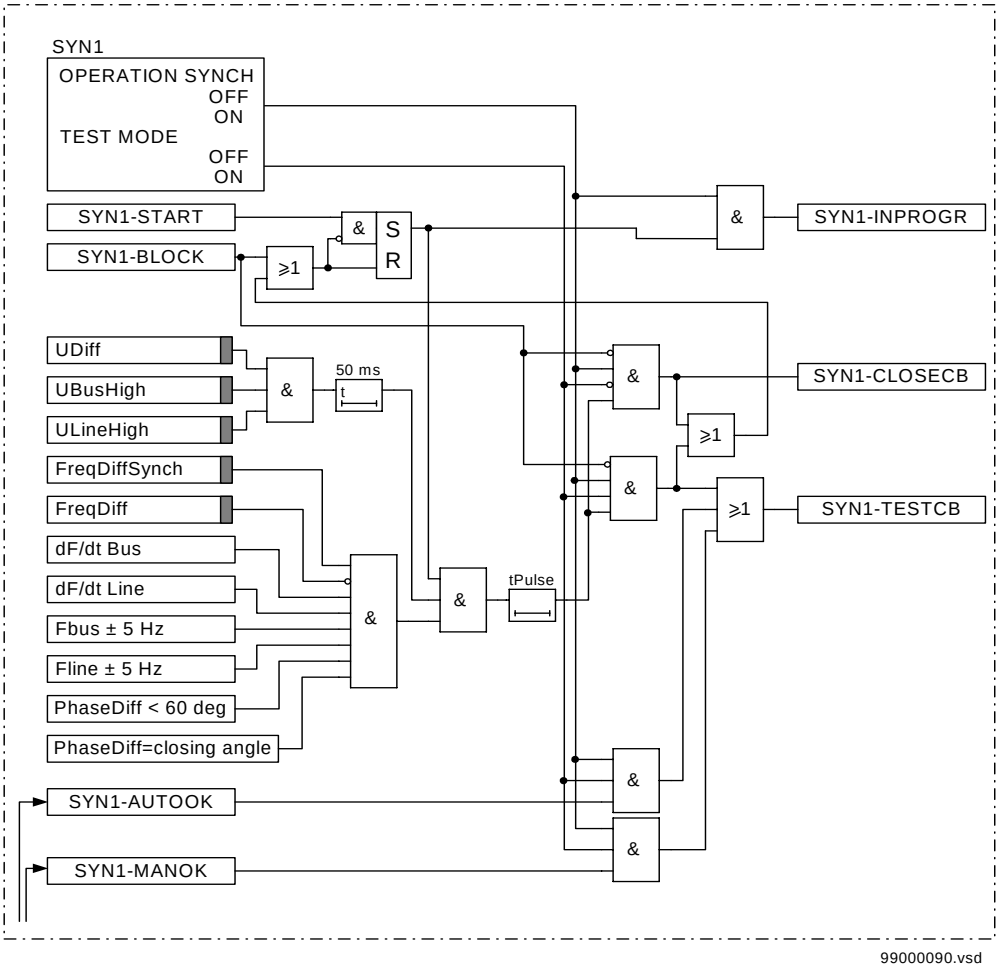


Figure 115: SYN, phasing, simplified logic diagram. The input signals SYN1-AUTOOK and SYN1-MANOK derive from the synchrocheck and energizing logic

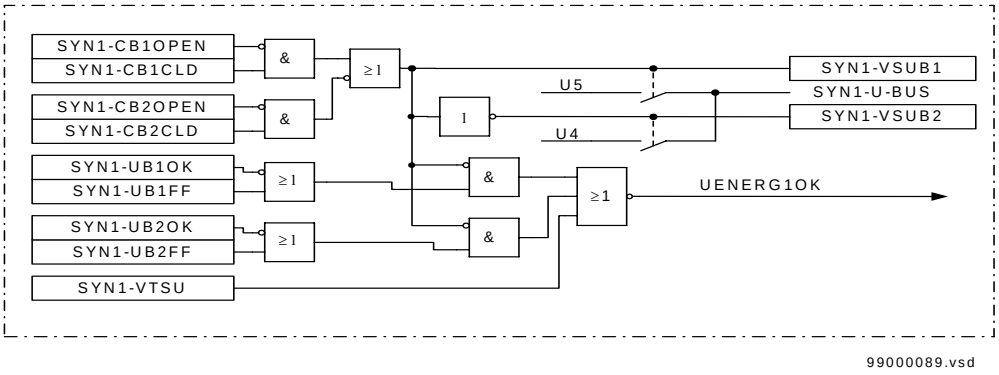


Figure 116: SYN, simplified voltage selection logic in a double bus, single breaker arrangement

1.5 Input and output signals

Table 215: 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
CB1OPEN	Circuit breaker section 1 open
CB1CLD	Circuit breaker section 1 closed
CB2OPEN	Circuit breaker section 2 open
CB2CLD	Circuit breaker section 2 closed

Path in local HMI: ServiceReport/Functions/SynchroCheckn/FuncOutputs

Table 216: 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

Signal	Description
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 217: 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

Path in local HMI: ServiceReport/Functions/SynchroCheckn/FuncOutputs

Table 218: 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 219: Input signals for the SYN (SYN--) function block for single circuit breaker with phasing

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

Path in local HMI: ServiceReport/Functions/SynchroCheckn/FuncOutputs

Table 220: Output signals for the SYN (SYN--) function block for single circuit breaker with phasing

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
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 221: Input signals for the SYN (SYN--) function block for double circuit breaker with phasing

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

Path in local HMI: ServiceReport/Functions/SynchroCheckn/FuncOutputs

Table 222: Output signals for the SYN (SYN--) function block for double circuit breaker with phasing

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

Path in local HMI: Settings/Functions/Groupn/SynchroCheck 1-4

Table 223: 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 Step: 1	0	degrees	Phase shift between U-bus and U-line
URatio	0.20-5.00 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 Step: 1	80	% of Ub	High voltage limit
ULow	10-100 Step: 1	40	% of Ub	Low voltage limit
FreqDiff	0.05-0.30 Step: 0.01	0.20	Hz	Frequency difference limit
PhaseDiff	5-75 Step: 1	20	degrees	Phase difference limit
UDiff	5-50 Step: 1	20	% of Ub	Voltage difference limit
tAutoEnerg	0.000-60.000 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 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 for the three-phase voltage
tSync	0.000-60.000 Step: 0.001	0	s	Synchrocheck operation delay time

Path in local HMI: Settings/Functions/Groupn/SynchroCheckn

Table 224: 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 Step: 1	0	degrees	Phase shift between U-bus and U-line
URatio	0.20-5.00 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 Step: 1	80	% of Ub	High voltage limit
ULow	10-100 Step: 1	40	% of Ub	Low voltage limit
FreqDiff	0.05-0.30 Step: 0.01	0.20	Hz	Frequency difference limit
PhaseDiff	5-75 Step: 1	20	degrees	Phase difference limit
tSync	0.000-60.000 Step: 0.001	0	s	Synchrocheck operation delay time
UDiff	5-50 Step: 1	20	% of Ub	Voltage difference limit
tAutoEnerg	0.000-60.000 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 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 for the three-phase voltage

Path in local HMI-tree: Settings/Functions/Groupn/SynchroCheckn

Table 225: 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 Step: 1	0	degrees	Phase shift between U-bus and U-line
URatio	0.20-5.00 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 Step: 1	80	% of Ub	High voltage limit
ULow	10-100 Step: 1	40	% of Ub	Low voltage limit
FreqDiff	0.05-0.30 Step: 0.01	0.20	Hz	Frequency difference limit
PhaseDiff	5-75 Step: 1	20	degrees	Phase difference limit
UDiff	5-50 Step: 1	20	% of Ub	Voltage difference limit
tAutoEnerg	0.000-60.000 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 Step: 0.001	0.100	s	Time delay from fulfillment of all conditions to issue of energizing release signal for manual closing
OperationSynch	Off, On	Off	-	Phasing function Off/On
ShortPulse	Off, On	Off	-	Short pulse Off/On
FreqDiffSynch	0.05-0.50 Step: 0.01	0.30	Hz	Frequency difference limit for phasing

Parameter	Range	Default	Unit	Description
tPulse	0.000-60.000 Step: 0.001	0.200	s	Breaker closing pulse duration
tBreaker	0.02-0.50 Step: 0.01	0.20	s	Closing time of the breaker
VTConnection	Line, Bus	Line	-	Voltage transformer connection side for the three-phase voltage
tSync	0.000-60.000 Step: 0.001	0	s	Synchrocheck operation delay time
FreqDiffBlock	Off, On	Off	-	On enables the phasing function even if the frequency difference is lower than set value of FreqDiff

Path in local HMI-tree: Settings/Functions/Groupn/SynchroCheckn

Table 226: 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 Step: 1	0	degrees	Phase shift between U-bus and U-line
URatio	0.20-5.00 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 Step: 1	80	% of Ub	High voltage limit
ULow	10-100 Step: 1	40	% of Ub	Low voltage limit
FreqDiff	0.05-0.30 Step: 0.01	0.20	Hz	Frequency difference limit
PhaseDiff	5-75 Step: 1	20	degrees	Phase difference limit
UDiff	5-50 Step: 1	20	% of Ub	Voltage difference limit
tAutoEnerg	0.000-60.000 Step: 0.001	0.100	s	Time delay from fulfillment of all conditions to issue of energizing release signal for automatic reclosing

Parameter	Range	Default	Unit	Description
tManEnerg	0.000-60.000 Step: 0.001	0.100	s	Time delay from fulfillment of all conditions to issue of energizing release signal for manual closing
OperationSynch	Off, On	Off	-	Phasing function Off/On
ShortPulse	Off, On	Off	-	Short pulse Off/On
FreqDiffSynch	0.05-0.50 Step: 0.01	0.30	Hz	Frequency difference limit for phasing
tPulse	0.000-60.000 Step: 0.001	0.200	s	Breaker closing pulse duration
tBreaker	0.02-0.50 Step: 0.01	0.20	s	Closing time of the breaker
tSync	0.000-60.000 Step: 0.001	0	s	Synchrocheck operation delay time
FreqDiffBlock	Off, On	Off	-	On enables the phasing function even if the frequency difference is lower than set value of FreqDiff

1.7 Technical data

Table 227: SYN - Synchrocheck and energizing check

Function	Setting range	Accuracy
Synchrocheck:		
Frequency difference limit, FreqDiff	50-300 mHz in steps of 10 mHz	≤20 mHz
Voltage difference limit, UDiff	5-50% of U1b in steps of 1%	± 2.5% of U_r
Phase difference limit, PhaseDiff	5-75 degrees in steps of 1 degree	± 2 degrees
Energizing check:		
Voltage level high, UHigh	70-100% of U1b in steps of 1%	± 2.5% of U_r
Voltage level low, ULow	10-80% of U1b in steps of 1%	± 2.5% of U_r
Energizing period, automatic reclosing, tAutoEnerg	0.000-60.000 s in steps of 1 ms	± 0.5% ± 10 ms
Energizing period, manual closing, tManEnerg	0.000-60.000 s in steps of 1 ms	± 0.5% ± 10 ms
Phase shift φ_{line} - φ_{bus}	0-360 degrees in steps of 1 degree	
Voltage ratio U_{bus}/U_{line}	0.20-5.00 in steps of 0.01	

Table 228: Synchrocheck and energizing check, general

Parameter	Value
Synchrocheck:	
Bus voltage frequency range limit	± 5 Hz from f_r
Operate time	190 ms typically
Energizing check:	
Operate time	80 ms typically

Table 229: SYN - Synchro-check with synchronizing and energizing-check

Parameter	Setting range	Accuracy
Frequency difference limit, FreqDiff-Synch	50-500 mHz in steps of 10 mHz	≤20 mHz
Breaker closing pulse duration, tPulse	0.000-60.000 s in steps of 1 ms	± 0.5% ± 10 ms
Breaker closing time, tBreaker	0.02-0.50 s in steps of 0.01 s	± 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 Autorecloser (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. The binary input signals can be 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

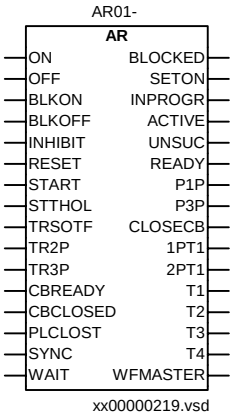


Figure 117: AR Function block: Single, two and/or three phase

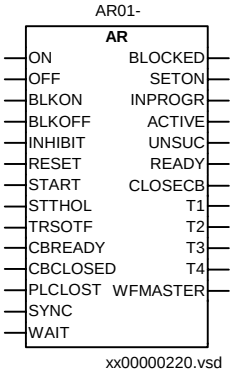


Figure 118: AR Function block: Three phase

2.4 Logic diagram

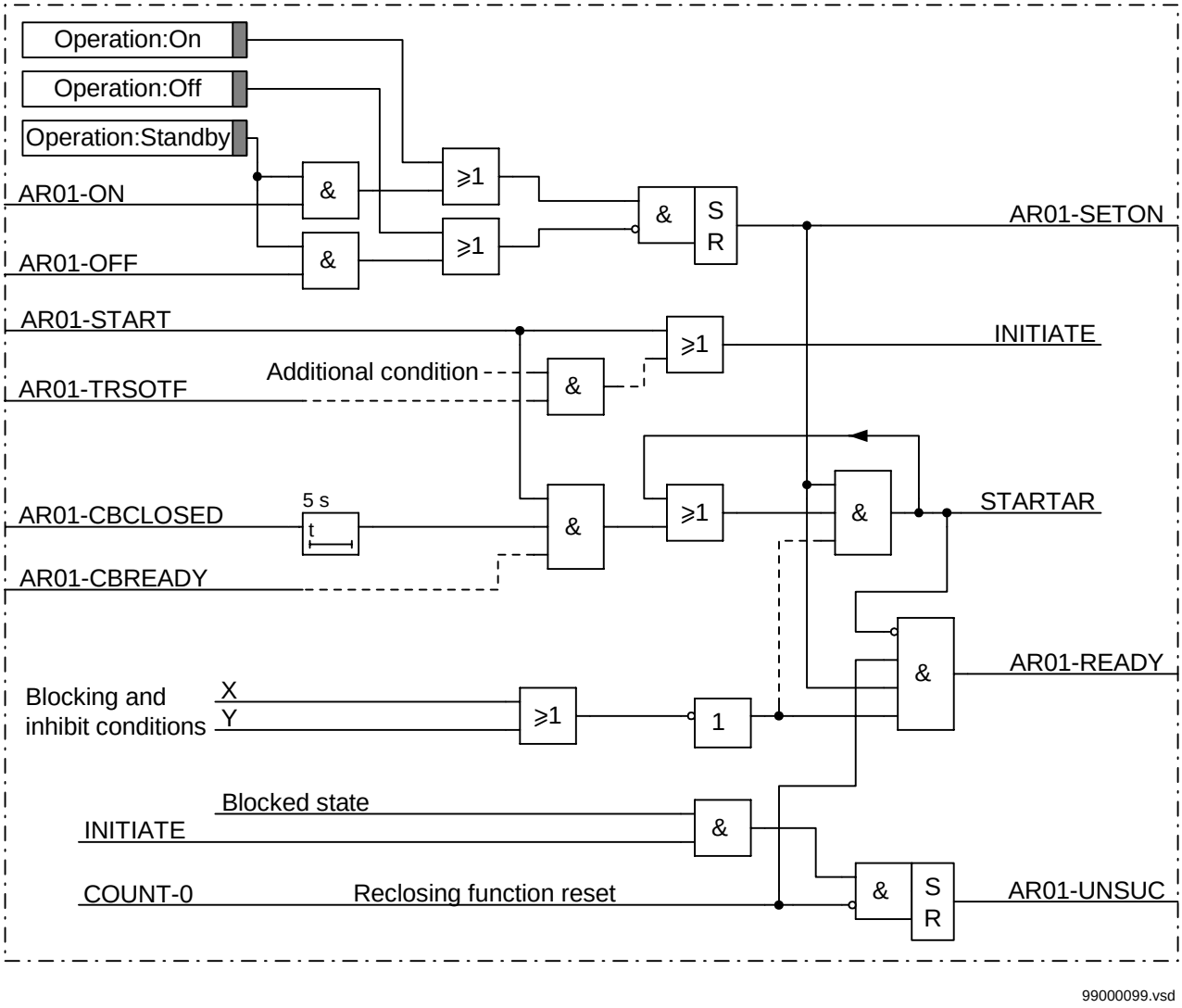


Figure 119: Auto-reclosing on/off control and start

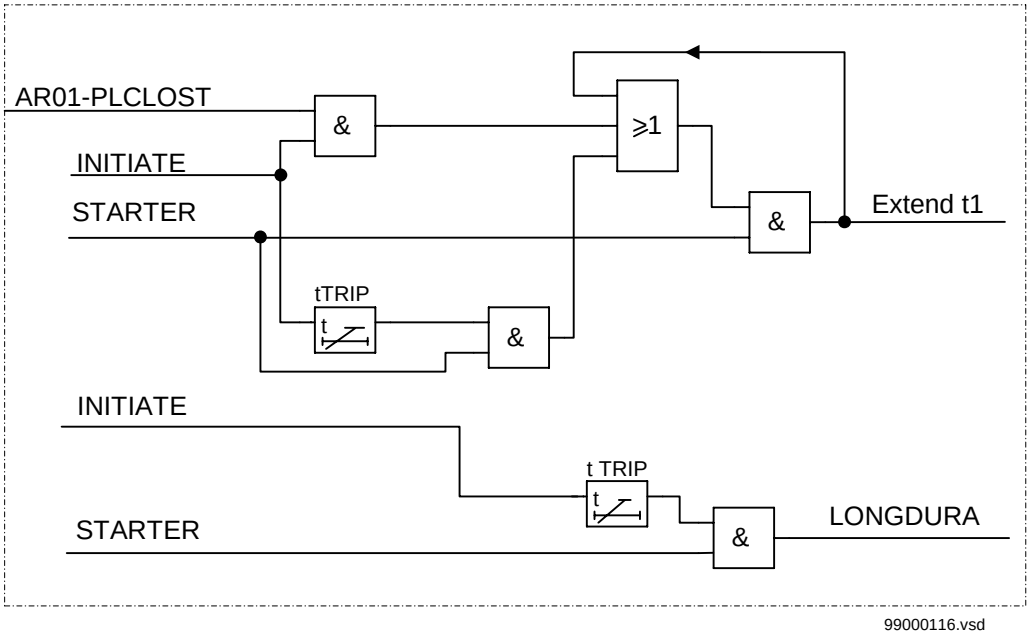


Figure 120: Control of extended AR open time, shot 1

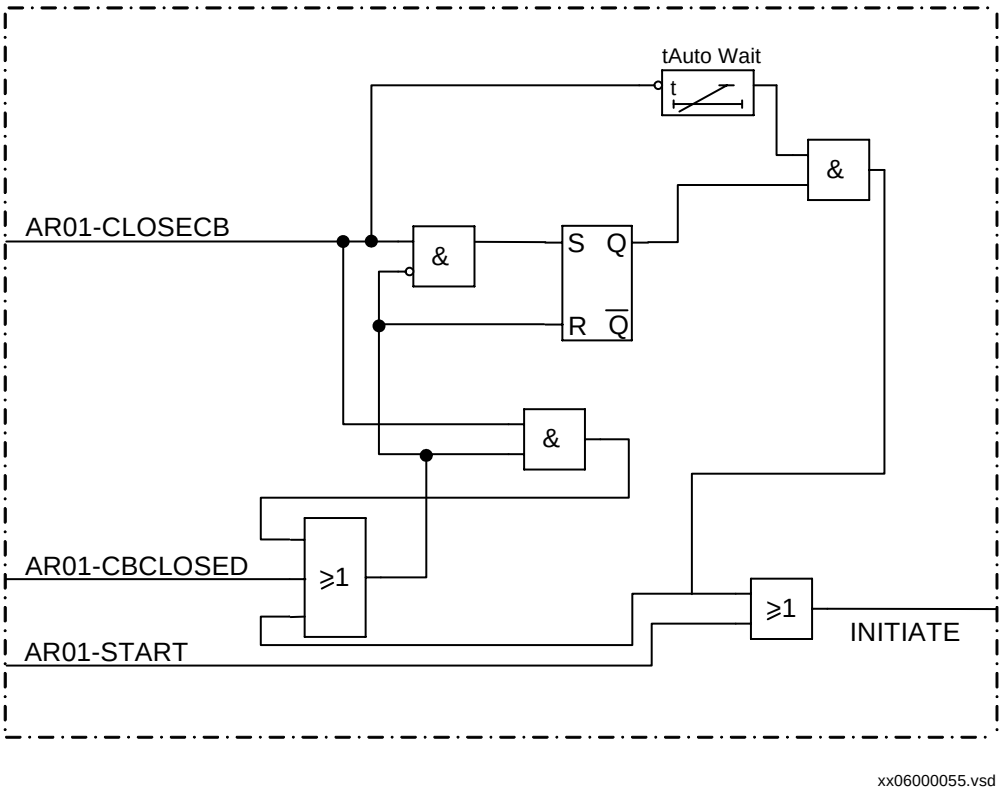


Figure 121: Automatic proceeding of shot 2 to 4

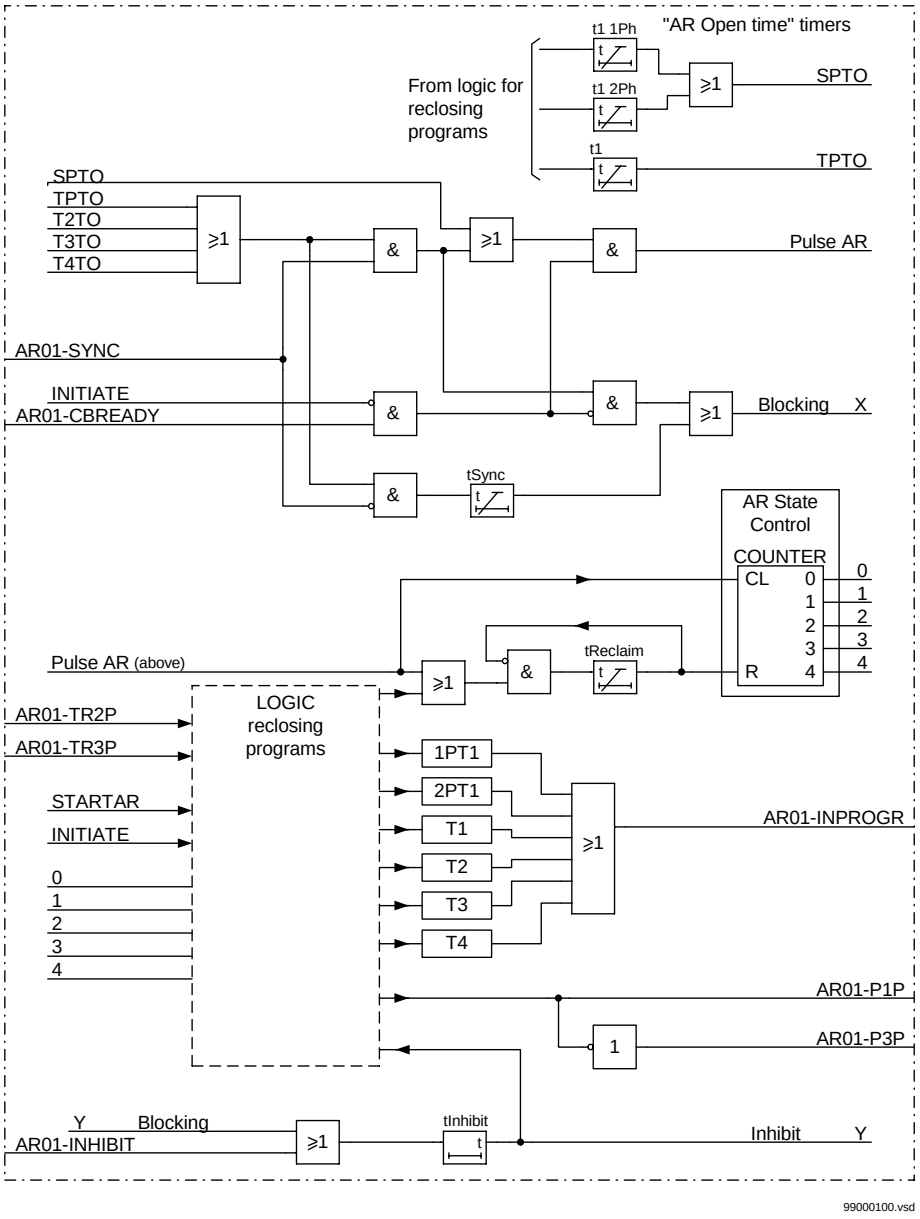


Figure 122: Reclosing checks and "Reclaim" and "Inhibit" timers

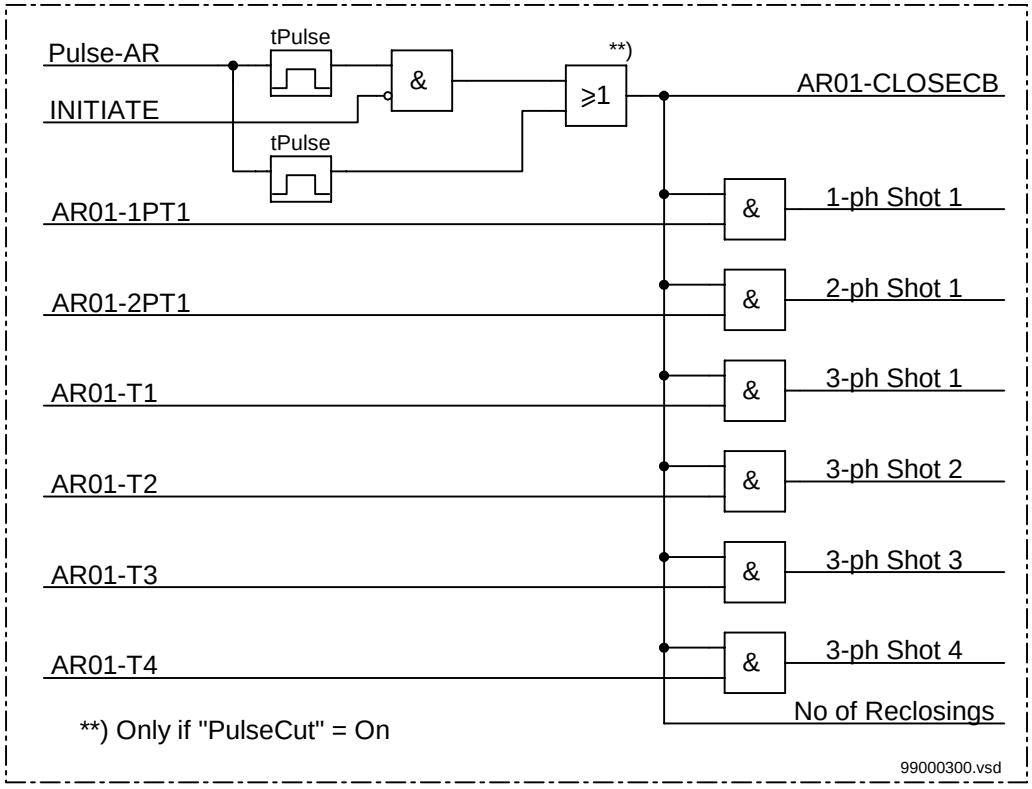


Figure 123: Pulsing of close command and driving of operation counters

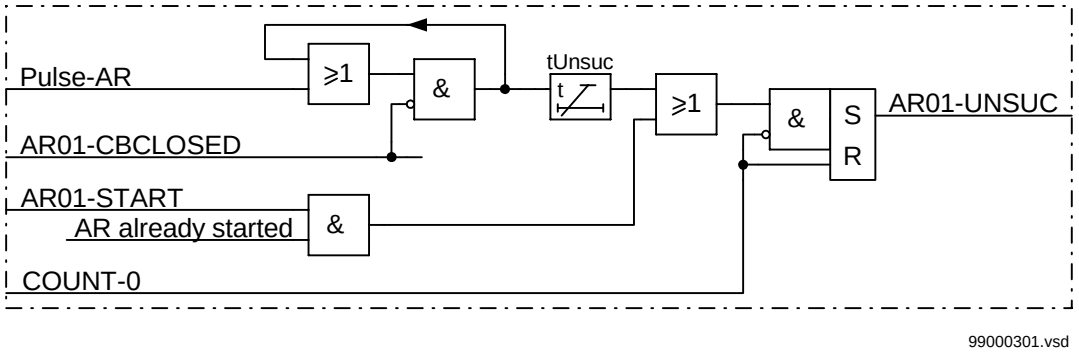


Figure 124: Issuing of the AR01-UNSUC signal

2.5 Input and output signals

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

Table 230: 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.

Path in local HMI: ServiceReport/Functions/AutoRecloser/AutoReclosern/FuncOutputs

Table 231: 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
P3P	Prepare three-pole trip
CLOSECB	Close command to circuit breaker
1PT1	Single-pole reclosing in progress
2PT1	Two-pole reclosing in progress

Signal	Description
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

2.5.1 Autorecloser counter values

Table 232: Autorecloser counter values AR (AR---)

Viewed data (default labels used, data is example values)	Counter value
1ph-Shot1= nnn	Recorded number of first single pole reclosing attempts
2ph-Shot1= nnn	Recorded number of first two pole reclosing attempts
3ph-Shot1= nnn	Recorded number of first three-pole reclosing attempts
3ph-Shot2= nnn	Recorded number of second three-pole reclosing attempts
3ph-Shot3= nnn	Recorded number of third three-pole reclosing attempts
3ph-Shot4= nnn	Recorded number of fourth three-pole reclosing attempts
NoOfReclosings= nnn	Recorded number of all reclosing attempts

2.6 Setting parameters

Path in local HMI: Settings/Functions/Group1/Autorecloser/Autorecloser1

Table 233: Setting parameters for the automatic reclosing AR (AR---) function

Parameter	Range	Default	Unit	Description
Operation	Off, Stand-by, On	Off	-	Operating mode for AR function
NoOfReclosing	1-4	1	-	Maximum number of reclosing attempts
FirstShot	3 ph, 1/2/3 ph, 1/2 ph, 1 ph+1*2 ph, 1/2+1*3 ph, 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 Step: 0.001	1.000	s	Dead time for first single-phase automatic reclosing shot
t1 2Ph	0.000-60.000 Step: 0.001	1.000	s	Dead time for first two-phase automatic reclosing shot
t1	0.000-60.000 Step: 0.001	1.000	s	Dead time for first three-phase automatic reclosing shot
t2	0.0-90000.0 Step: 0.1	30.0	s	Dead time for second automatic reclosing shot
t3	0.0-90000.0 Step: 0.1	30.0	s	Dead time for third automatic reclosing shot
t4	0.0-90000.0 Step: 0.1	30.0	s	Dead time for fourth automatic reclosing shot
tSync	0.0-90000.0 Step: 0.1	2.0	s	Maximum wait time for sync
tPulse	0.000-60.000 Step: 0.001	0.200	s	Circuit breaker closing pulse length
CutPulse	Off, On	Off	-	Shorten closing pulse at a new trip
tReclaim	0.0-90000.0 Step: 0.1	60.0	s	Reclaim time
tInhibit	0.000-60.000 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 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	0.0-90000.0 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

Parameter	Range	Default	Unit	Description
BlockUnsuc	Off, On	Off	-	Block automatic reclosing function for unsuccessful reclosing
tAutoWait	0.000-60.000 Step: 0.001	2.000	s	Maximum wait time between shots
UnsucMode	NoCBCheck, CBCheck	NOCBCheck	-	CB Check enabled or disabled for unsuccessful mode
tUnsuc	0.0-90000.0 Step: 0.1	30.0	s	CB Check time before unsuccessful
tCBClosed	0.000-60.000 Step: 0.001	5.000	s	The time a breaker must be closed before AR becomes ready for a reclosing cycle

2.7 Technical data

Table 234: AR - Autorecloser

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	0.0-90000.0 s in steps of 0.1 s	± 0.5% ± 10 ms
shot 3 - t3 3ph	0.0-90000.0 s in steps of 0.1 s	± 0.5% ± 10 ms
shot 4 - t4 3ph	0.0-90000.0 s in steps of 0.1 s	± 0.5% ± 10 ms
Autorecloser maximum wait time for sync, tSync	0.0-90000.0 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
Reclaim time, tReclaim	0.0-90000.0 s in steps of 0.1 s	± 0.5% ± 10 ms
Inhibit 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	0.0-90000.0 s in steps of 0.1 s	± 0.5% ± 10 ms
Maximum wait time between shots, tAutoWait	0.000-60.000 s in steps of 1 ms	± 0.5% ± 10 ms
Time delay before indicating reclosing unsuccessful, tUnsuc	0.0-90000.0 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 235: AR - Autorecloser

Parameter	Value
Reclosing shots	1-4
Programs	Three pole trip: 1 Single, two and three pole trip: 6
Number of autoreclosers	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, 16 signals (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

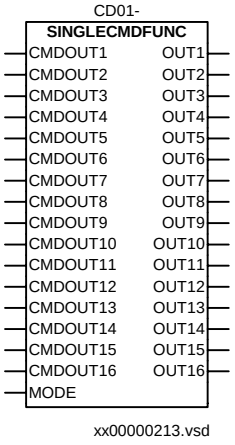
The single command function consists of a function block CD for 16 binary output signals.

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



3.4 Input and output signals

Table 236: 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

Path in local HMI: ServiceReport/Functions/CDnn

Table 237: Output signals for the command control CD (CDnn-) function

Signal	Description
OUTy	Command output y (y=1-16)

3.5 Setting parameters

Table 238: Setting parameters for the command control CD (CDnn-) function

Parameter	Range	Default	Unit	Description
CMDOUTy	User def. string	CDnn-CMD-OUTy	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.

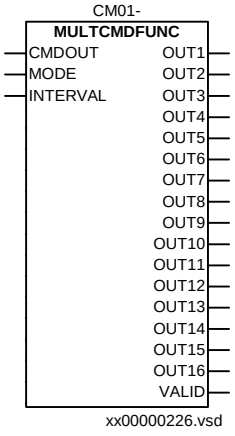
The output signals can be of the types Off, Steady, or Pulse. The setting is done on the MODE input, common for the whole block, from the CAP 531 configuration tool.

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 239: 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

Use CAP configuration tool to see status of the output signals.

Table 240: 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

Use CAP configuration tool to see status of the parameter settings.

Table 241: Setting parameters for the command (CMnn-) functions

Parameter	Range	Default	Unit	Description
CMDOUT	User def. string	CMnn-CMD-OUT	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	0.000-60.000 Step: 1ms	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 Tripping 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 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

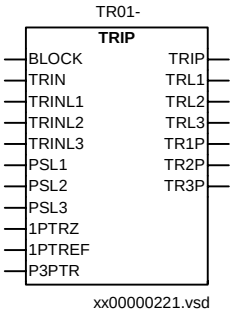


Figure 125: TR function block: Single, two and/or three phase tripping logic

1.4 Logic diagram

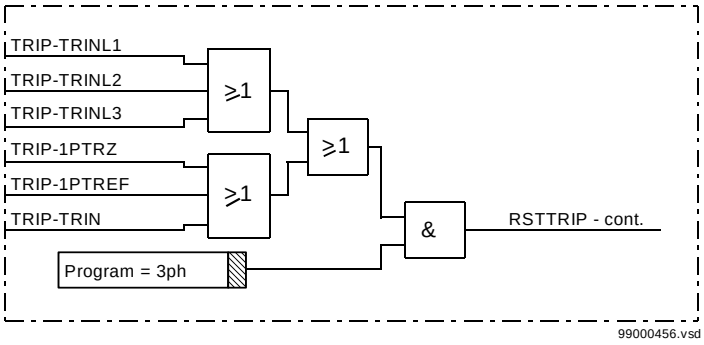


Figure 126: Three-phase front logic - simplified logic diagram

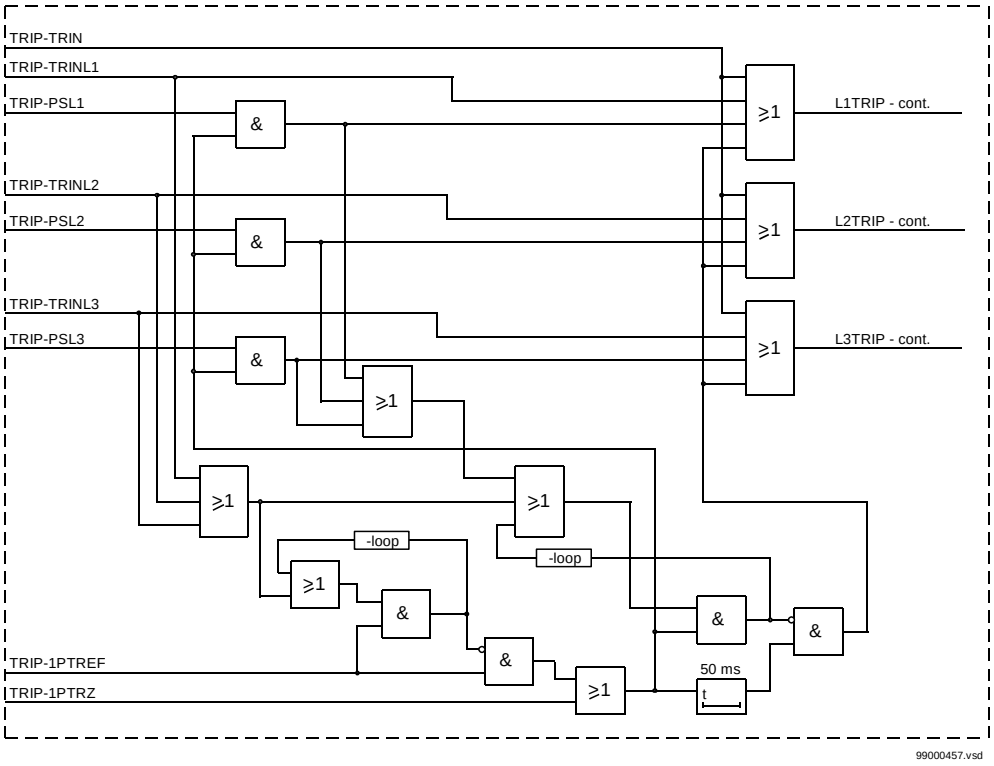


Figure 127: Phase segregated front logic

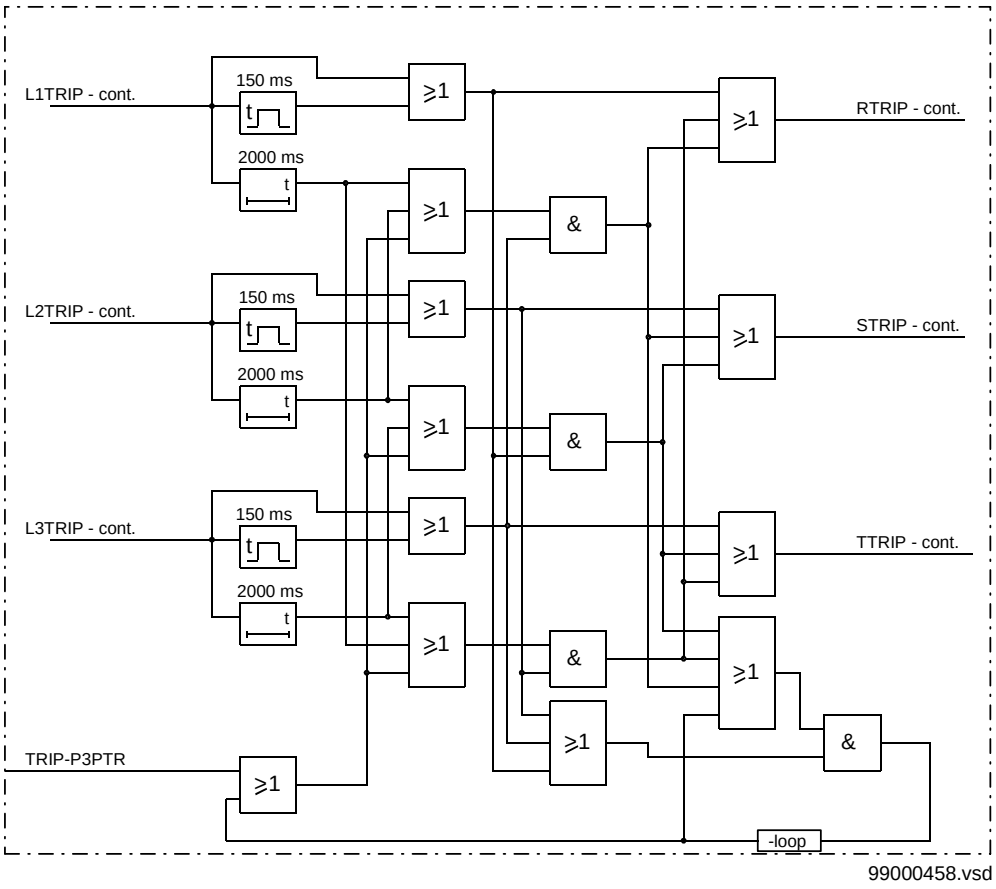


Figure 128: Additional logic for the 1ph/3ph operating mode

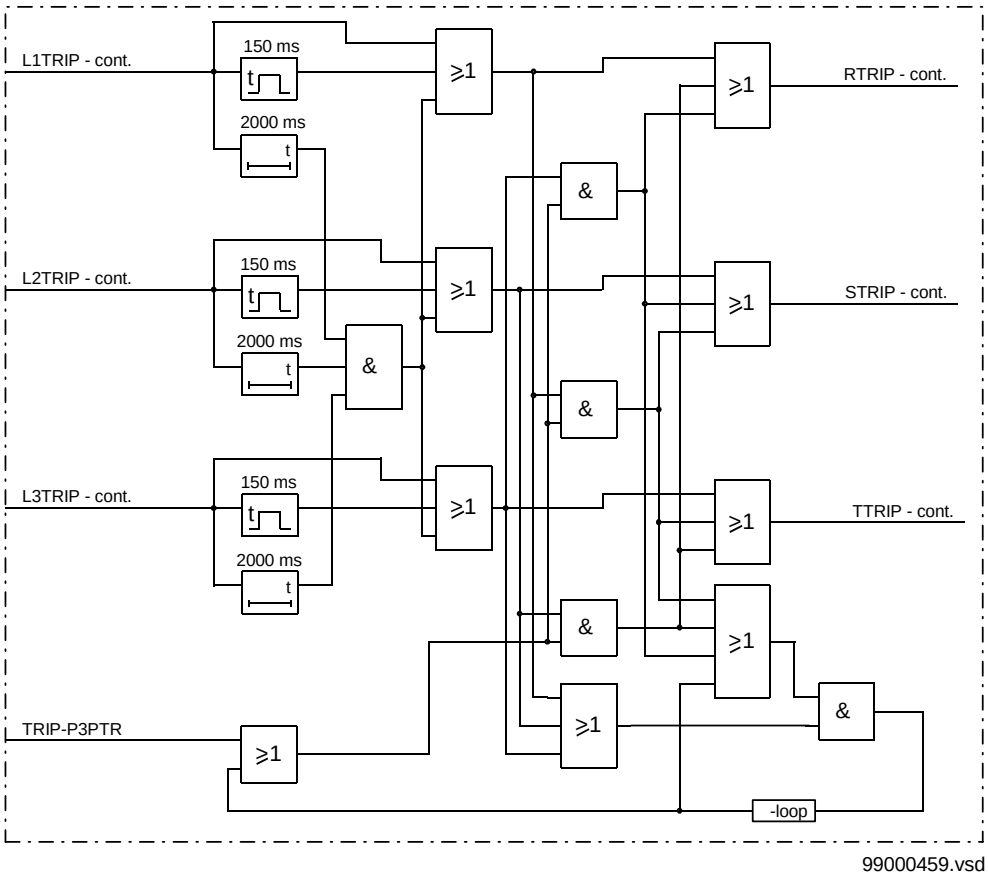


Figure 129: Additional logic for the 1ph/2ph/3ph operating mode

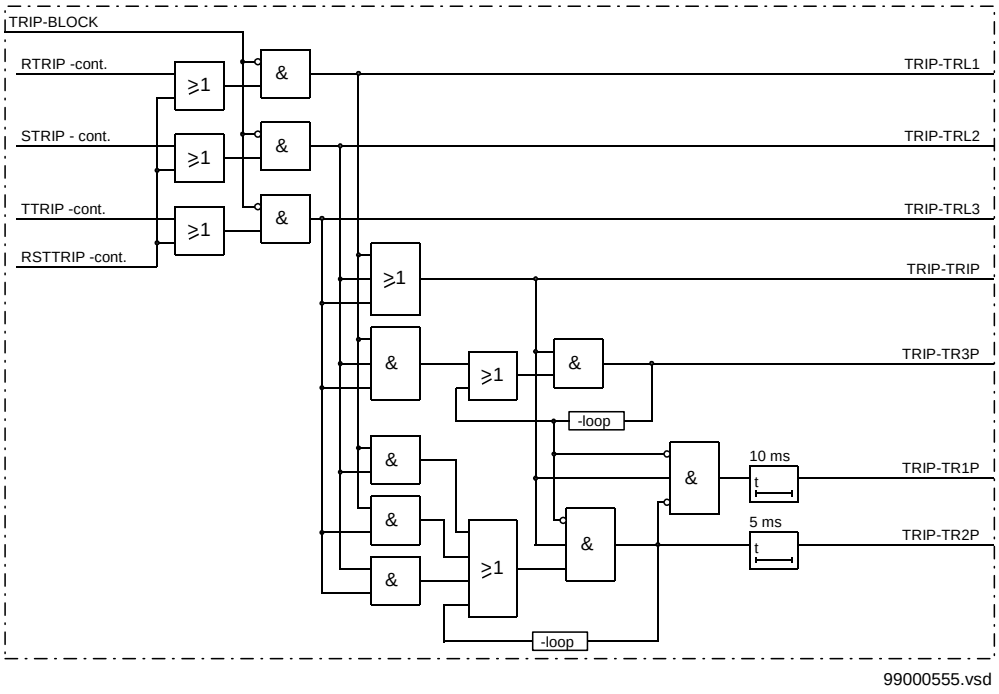


Figure 130: Final tripping circuits

1.5 Input and output signals

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

Table 242: Input signals for the TR (TRnn-) function block

Signal	Description
BLOCK	Block trip logic
TRIN	Trip all 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
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.

Path in local HMI: ServiceReport/Functions/TRn/FuncOutputs

Table 243: 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

Path in local HMI: Settings/Functions/Groupn/TRn

Table 244: 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 Step. 0.001	0.150	s	Minimum duration of trip time

1.7 Technical data

Table 245: TR - Tripping logic

Parameter	Value	Accuracy
Setting for the minimum trip pulse length, tTripMin	0.000 - 60.000 s in steps of 1 ms	± 0.5% ± 10 ms

2 Pole discordance logic (PDc)

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, PDc, is based on checking the position of the breaker auxiliary contacts, see figure 131.

Figure 131: Pole discordance external detection logic.

2.3 Function block

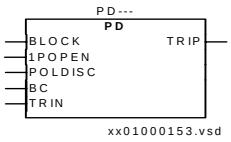


Figure 132: PD function block, contact based

2.4 Logic diagram

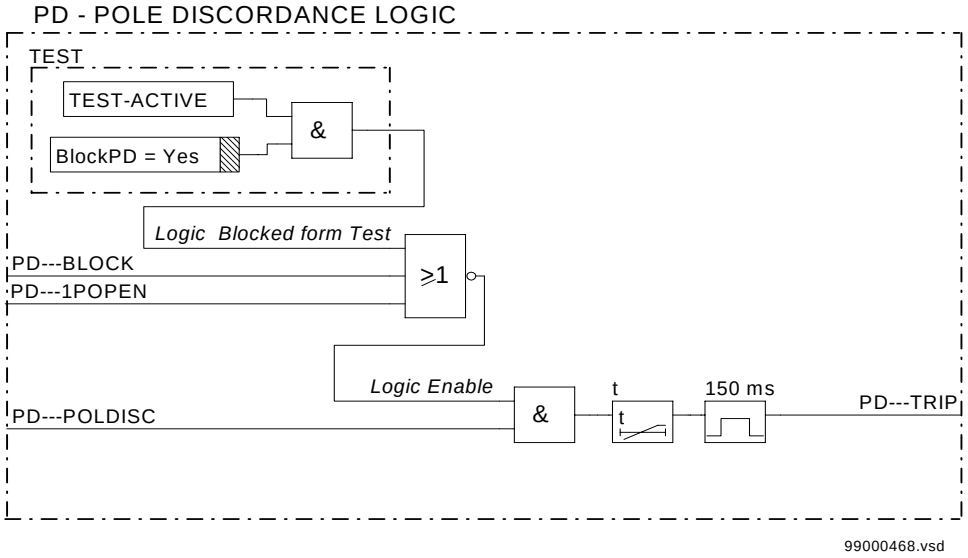


Figure 133: Simplified logic diagram of pole discordance logic, contact based

2.5 Input and output signals

Table 246: Input signals for the PDc (PD---) function block

Signal	Description
BLOCK	Block of pole discordance function
1POPEN	One or two phase AR in progress
POLDISC	Pole discordance signal from the circuit breaker

Path in local HMI: ServiceReport/Functions/PoleDiscord/FuncOutputs

Table 247: Output signals for the PDc (PD---) function block

Signal	Description
TRIP	Trip by pole discordance function

2.6 Setting parameters

Path in local HMI-tree: Settings/Functions/Groupn/PoleDiscord

Table 248: Setting parameters Pole discordance protection PD (PD---) function

Parameter	Range	Default	Unit	Description
Operation	Off, On	Off	-	Pole discordance protection On/Off
t	0.000-60.000 Step: 0.001	0.500	s	Delay timer

2.7 Technical data

Table 249: PDc - Pole discordance logic, contact 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

3 High speed binary output logic (HSBO)

3.1 Application

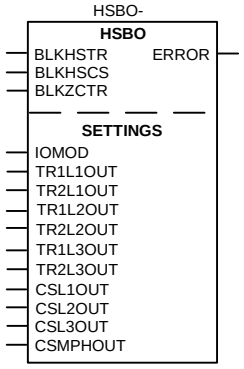
The time taken for signals to be transferred from binary inputs to protection functions, and from protection functions to binary outputs contributes to the overall tripping time. The main purpose of the HSBO high speed binary output logic is to minimize overall tripping times by establishing the critical 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



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3.4 Logic diagram

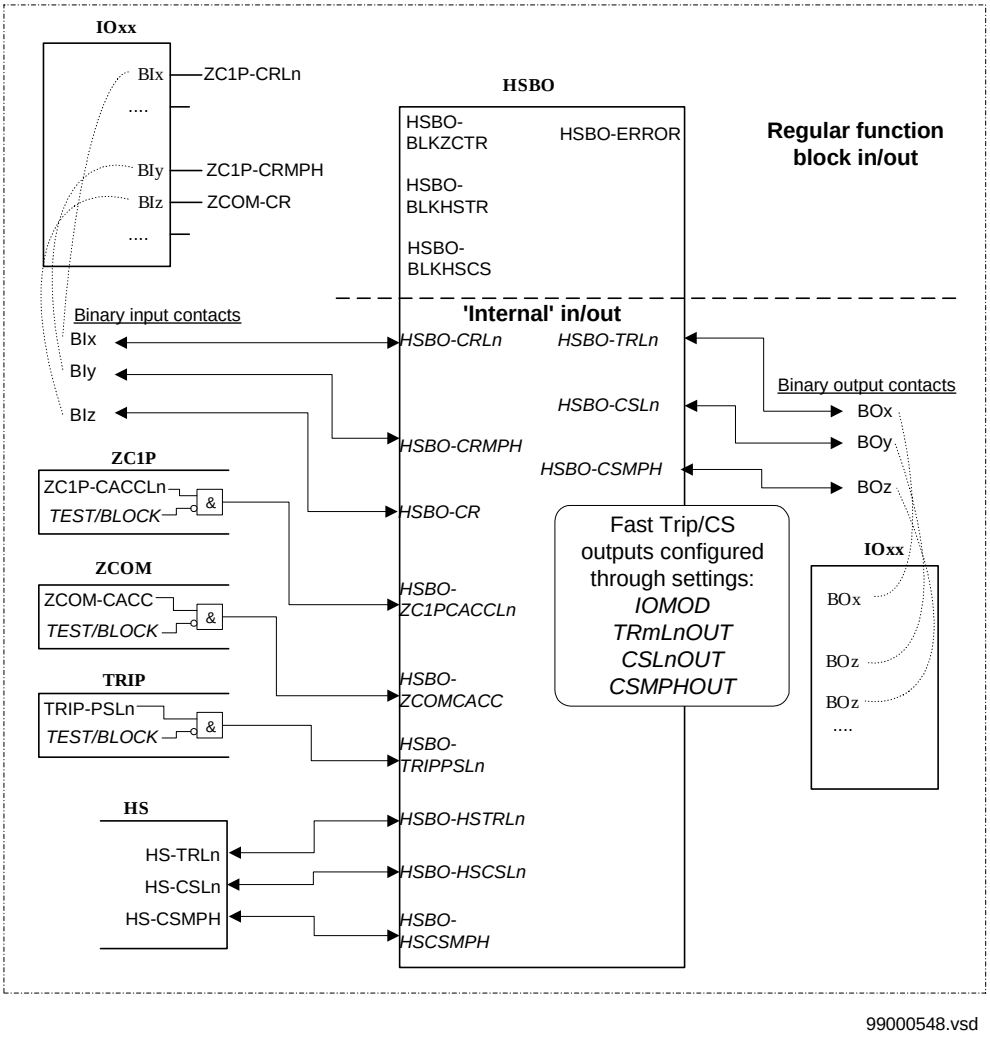


Figure 134: High speed binary output, simplified logic diagram

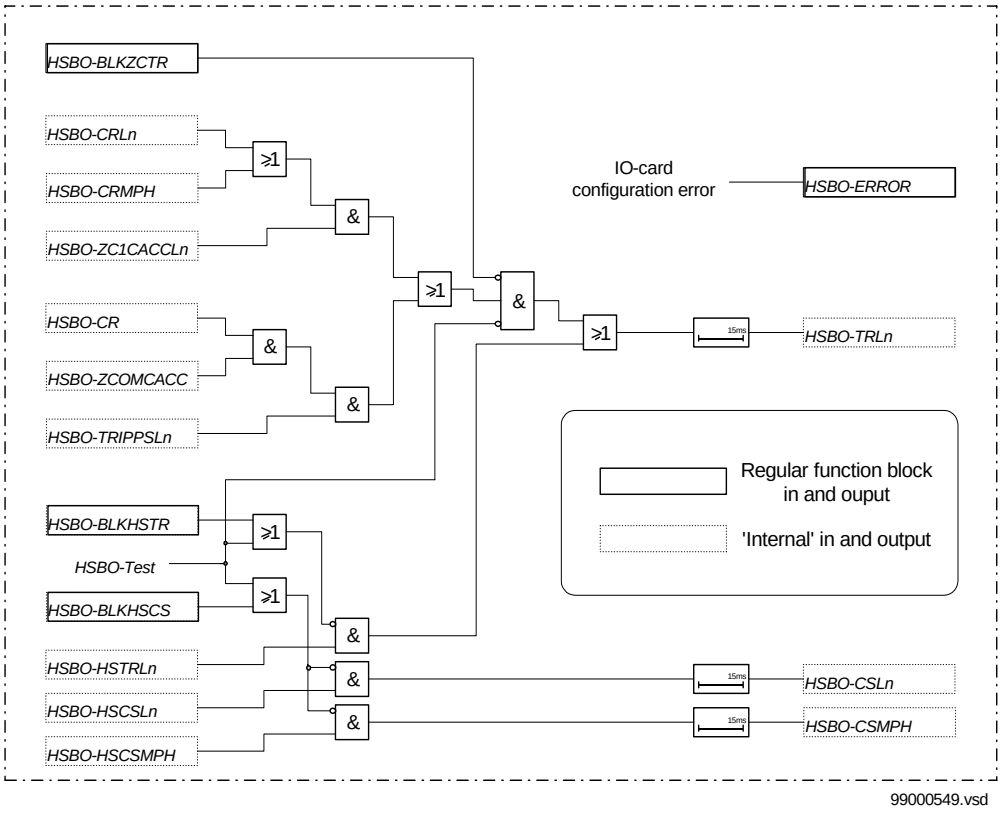


Figure 135: Simplified logic diagram of the HSBO function logic.

3.5 Input and output signals

Table 250: 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

Path in local HMI: ServiceReport/Functions/Impedance/HighSpeedBo/FuncOutputs

Table 251: 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 252: Setting parameters for the high speed binary output logic HSBO (HSBO-) 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 540 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 540 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 540 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 540 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 540 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 540 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 540 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 540 configuration tool.
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 540 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 540 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 540 configuration tool.

4 Communication channel test logic (CCHT)

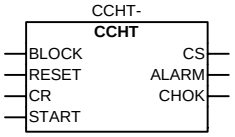
4.1 Application

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.

4.2 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.

4.3 Function block



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4.4 Logic diagram

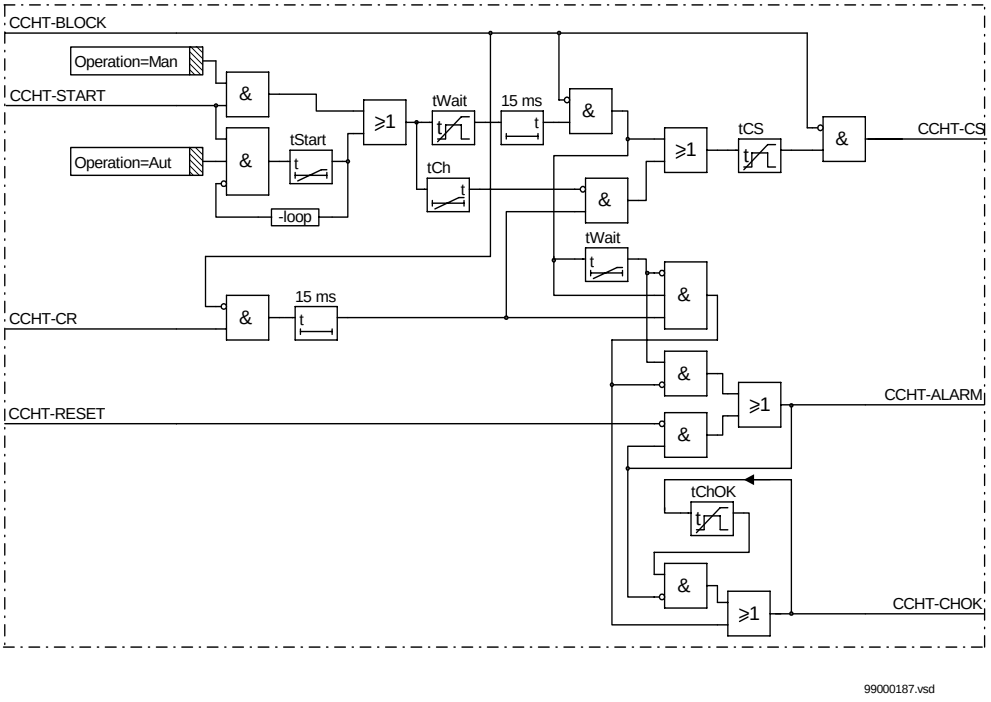


Figure 136: Simplified logic diagram for the CCHT function

4.5 Input and output signals

Table 253: 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

Path in local HMI: ServiceReport/Functions/ComChanTest/FuncOutputs

Table 254: Output signals for the CCHT (CCHT-) function block

Signal	Description
CS	Send carrier signal (test external function)
ALARM	Test failed
CHOK	Test OK

4.6 Setting parameters

Path in local HMI: Settings/Functions/Groupn/ComChanTest

Table 255: 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 ManualMode	AutoMode	-	Operating mode for start of test
tStart	0.0 - 90000.0 Step: 0.1	86400.0	s	Time interval between automatic starts of channel testing
tWait	0.0 - 90000.0 Step: 0.1	0.1	s	Time interval allowed for successful return of channel test signal
tCh	0.0 - 90000.0 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 Step: 0.1	0.1	s	Duration of channel test output signal
tChOK	0.0 - 90000.0 Step: 0.1	60.0	s	Duration of channel OK output signal
tInh	0.0 - 90000.0 Step: 0.1	0.2	s	Duration of block extension following reset of Block input signal

4.7 Technical data

Table 256: CCHT - Communication channel test logic

Parameter	Setting range	Accuracy
Time interval between automatic starts of testing cycle, tStart	0.0-90000.0 s in steps of 0.1 s	± 0.5% ± 10 ms
Time interval available for test of the external function to be registered as successful, tWait	0.0-90000.0 s in steps of 0.1 s	± 0.5% ± 10 ms
Minimum time interval required before repeated test of the external function, tCh	0.0-90000.0 s in steps of 0.1 s	± 0.5% ± 10 ms
Duration of CS output signal, tCS	0.0-90000.0 s in steps of 0.1 s	± 0.5% ± 10 ms
Duration of CHOK output signal, tChOK	0.0-90000.0 s in steps of 0.1 s	± 0.5% ± 10 ms
Duration of inhibit condition extension after the BLOCK input signal resets, tInh	0.0-90000.0 s in steps of 0.1 s	± 0.5% ± 10 ms

5 Binary signal transfer to remote end (RTC12)

5.1 General

In this function, there are two function blocks, RTC1-, and RTC2-. They are identical in all aspects.

5.2 Application

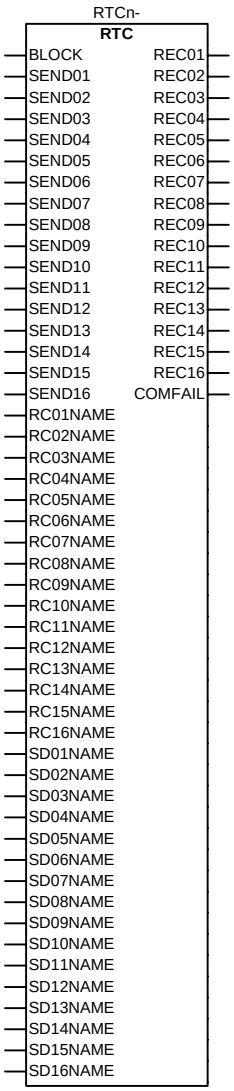
The main purpose of the RTC binary signal transfer to remote end function is the exchange of communication scheme related signals, trip signals and/or other binary signals between opposite ends of the line.

5.3 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.

5.4 Function block



5.5 Input and output signals

Table 257: 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
RCyy Name Where yy=01-16	Remote terminal communication n, Name for Input yy Set from CAP 540
SDyy Name Where yy=01-16	Remote terminal communication n, Name for Input yy Set from CAP 540

Path in local HMI: ServiceReport/I/O/RemTermComn/Funcoutputs

Table 258: 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

5.6 Setting parameters

Path in local HMI: Settings/DisturbReport/BinarySignals

Table 259: Setting parameters for the binary signal transfer to remote end logic, RTCn, where n = 1, 2

Parameter	Range	Default	Unit	Description
RCyyNAME Where yy = 01-16	0-13	RTCn- RECyy	Char	Remote Terminal Communication n, Name for Output yy Set from CAP 540
SDyyNAME Where yy =01-16	0-13	RTCn-SENDyy	Char	Remote Terminal Communication n, Name for Input yy Set from CAP 540

6 Event function (EV)

6.1 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.

6.2 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.

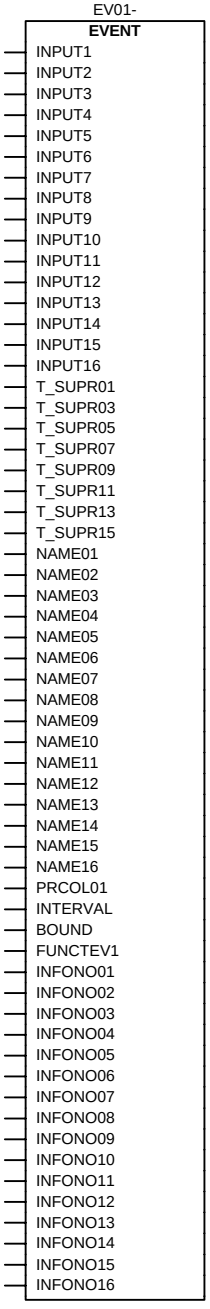
Each event function block has 16 connectables corresponding to 16 inputs INPUT1 to INPUT16. Every input can be given a name with up to 19 characters from the CAP 540 configuration tool.

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.

6.3 Function block



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6.4 Input and output signals

Table 260: 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. 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.

6.5 Setting parameters

Table 261: 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 540 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 540 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 540 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 540 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 540 configuration tool.

Parameter	Range	Default	Unit	Description
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 540 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 540 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 540 configuration tool.
NAMEy	0-16	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 540 configuration tool.
PrCoInn	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 540 configuration tool.
PrCoInn	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 540 configuration tool.
INTERVAL	0 - 60 Step: 1	0	s	Cyclic sending of data. Can only be set from CAP 540 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 540 configuration tool.
FuncTEVnn	0-255 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 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 midpos.	No events	-	Event mask for input y, y=01-16. Can only be set from PST.

7 Event counter (CN)

7.1 Application

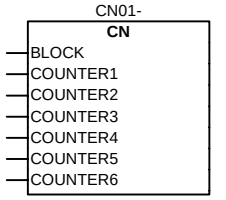
The function consists of six counters which are used for storing the number of times each counter has been activated. It is also provided with a common blocking function for all six counters, to be used for example at testing. Every counter can separately be set on or off by a parameter setting.

7.2 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.

7.3 Function block



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7.4 Input and output signals

Table 262: 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
COUNTER4	Input for counter 4
COUNTER5	Input for counter 5
COUNTER6	Input for counter 6

7.5 Setting parameters

Path in local HMI: Settings/Functions/Groupn/Counters/Countern

Table 263: 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
Counter n Name	0-13	Counter n	Char	Name for counter n Can only be set from PST

7.6 Technical data

Table 264: CN - Event counter

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 Disturbance report (DRP)

1.1 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.

1.1.1 Requirement of trig condition for disturbance report

Disturbance reports, setting and internal events in REx 5xx are stored in a non volatile flash memory. Flash memories are used in many embedded solutions for storing information due to high reliability, high storage capacity, short storage time and small size.

In REx 5xx there is a potential failure problem, caused by too many write operations to the flash memory.

Our experience shows that after storing more than fifty thousand disturbances, settings or internal events the flash memory exceeds its storing capacity and the component is finally defected.

When the failure occurs there is no risk of unwanted operation of the protection terminal due to the self-supervision function that detects the failure. The terminal will give a signal for internal fail and go into blocking mode.

The above limitation on the storage capacity of the flash memory gives the following recommendation for the disturbance report trig condition:

- Cyclic trig condition more often then once/day not recommended.
- Minute pulse input is not used as a trig condition.
- Total number of stored disturbance reports shall not exceed fifty thousand.

1.2 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.

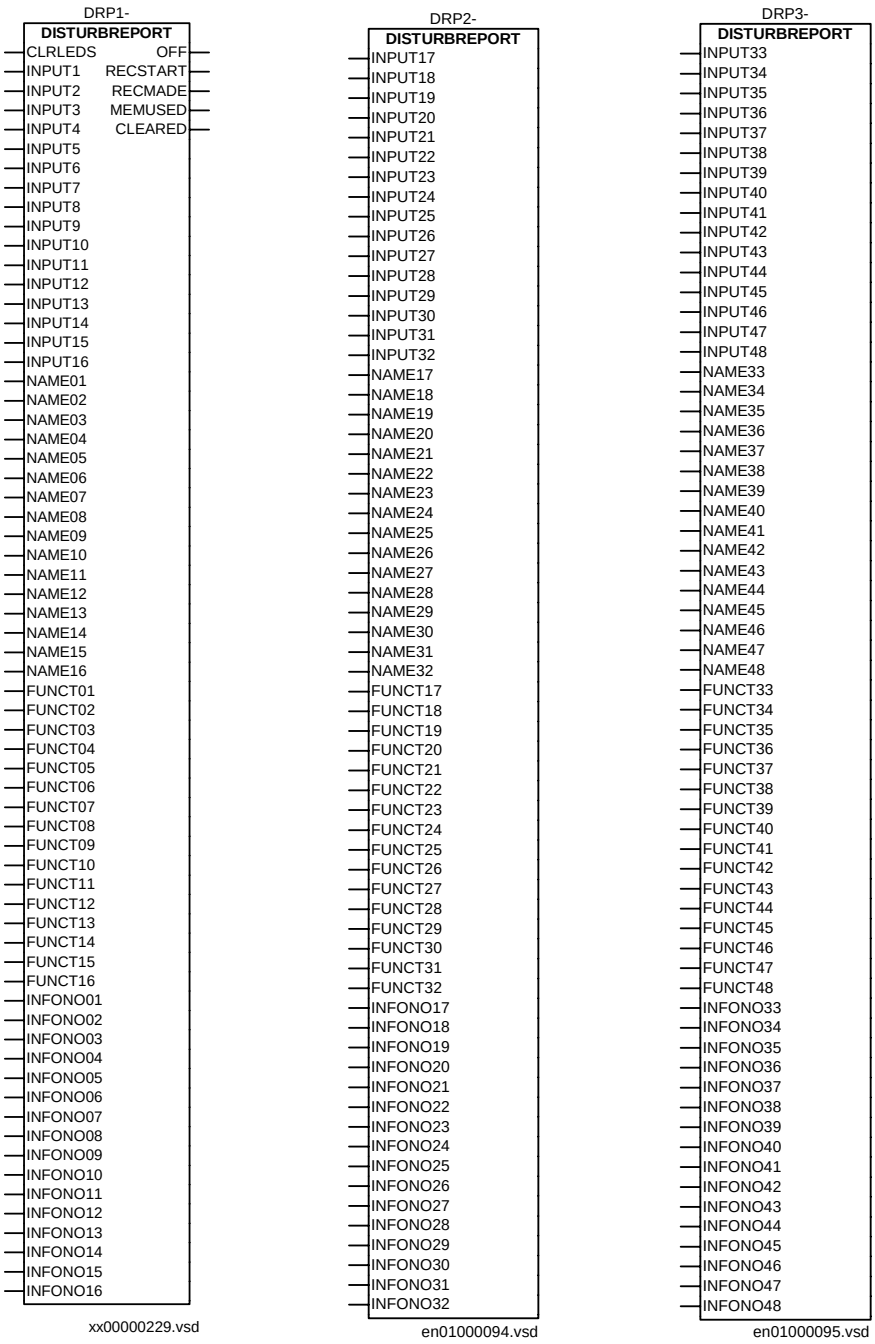
The collection is started by a trigger. Any binary input signal or function block output signal can be used as a trigger. The analog signals can also be set to trigger the data collection. Both over levels and under levels are available. The trigger is common for all subsystems, hence it activates them 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)

1.3 Function block



1.4 Input and output signals

Table 265: 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)

Path in local HMI: ServiceReport/Functions/DisturbReport

Table 266: 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

1.5 Setting parameters

Path in local HMI: Settings/DisturbReport/Operation

Table 267: 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 post-fault recording is allowed (on) or not (off).

Path in local HMI:Settings/DisturbReport/SequenceNo

Table 268: Parameters for sequence number

Parameter	Range	Default	Unit	Description
SequenceNo	0-255 Step: 1	0	-	Allows for manual setting of the sequence number of the next disturbance.

Path in local HMI: Settings/DisturbReport/RecordingTimes

Table 269: Parameters for recording time

Parameter	Range	Default	Unit	Description
tPre	0.05-0.30 Step: 0.01	0.10	s	Prefault recording time
tPost	0.1-5.0 Step: 0.1	0.5	s	Postfault recording time
tLim	0.5-6.0 Step: 0.1	1.0	s	Fault recording time limit

Path in local HMI: Settings/DisturbReport/BinarySignals/Inputn

Table 270: 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. (*n*=1-48)

Path in local HMI: Settings/DisturbReport/AnalogSignals/Un

Table 271: 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 Step: 1	90	% of Unb	Undervoltage trigger level in per cent of signal.
>TrigLevel	0-200 Step: 1	110	% of Unb	Overvoltage trigger level in per cent of signal.
<TrigOperation	Off, On	Off	-	Determines if the analog signal's under-voltage trigger condition should be used (on) or not (off)
>TrigOperation	Off, On	Off	-	Determines if the analog signal's over-voltage trigger condition should be used (on) or not (off)

Path in local HMI: Settings/DisturbReport/AnalogSignals/In

Table 272: 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 Step: 1	50	% of Inb	Undercurrent trigger level in per cent of signal.
>TrigLevel	0-5000 Step: 1	200	% of Inb	Overcurrent trigger level in per cent of signal.
<TrigOperation	Off, On	Off	-	Determines if the analog signal's under-current trigger condition should be used (on) or not (off)
>TrigOperation	Off, On	Off	-	Determines if the analog signal's overcur-rent trigger condition should be used (on) or not (off)

Table 273: Disturbance report settings

Operation	DisturbSum-mary	Then the results are...
Off	Off	• Disturbances are not stored. • LED information is not displayed on the HMI and not stored. • No disturbance summary is scrolled on the HMI.
Off	On	• Disturbances are not stored. • LED information (yellow - start, red - trip) are displayed on the local HMI but not stored in the terminal. • Disturbance summary is scrolled automatically on the local HMI for the two latest recorded disturbances, until cleared. • The information is not stored in the terminal.
On	On or Off	• The disturbance report works as in normal mode. • 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. • The disturbance summary is scrolled automatically on the local HMI for the two latest recorded disturbances, until cleared. • All disturbance data that is stored during test mode remains in the ter-minal when changing back to normal mode.

1.6 Technical data

Table 274: DRP - Disturbance report setting performance

Data	Setting range
Pre-fault time, tPre	50-300 ms in steps of 10 ms
Post-fault time, tPost	100-5000 ms in steps of 100 ms
Limit time, tLim	500-6000 ms in steps of 100 ms
Number of recorded disturbances	Max. 10

2 Indications

2.1 Application

Use the indications list to view the state of binary signals during the fault. All binary input signals to the disturbance report function are listed.

2.2 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 blocks, (DRP1, DRP2, DRP3).
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.

3 Disturbance recorder (DR)

3.1 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.

3.2 Functionality

The disturbance recorder records both analog and binary signal information and up to ten disturbances can be recorded.

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.

3.3 Technical data

Table 275: DR - 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 276: DR - 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		(0.01-2.00) 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 offset	(0.01-110.00) × I_r
		With full DC offset	(0.01-60.00) × 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

4 Event recorder (ER)

4.1 Application

Use the event recorder to obtain a list of binary signal events that occurred during the disturbance.

4.2 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 and up to ten disturbances can be recorded. 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.

4.3 Technical data

Table 277: ER - Event recorder

Function		Value
Event buffering capacity	Max. number of events/disturbance report	150
	Max. number of disturbance reports	10

5 Fault locator (FLOC)

5.1 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.

5.2 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.

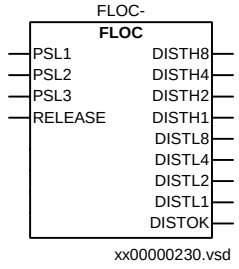
In case of double circuit lines, the influence of the zero-sequence mutual impedance Zm0 is compensated for by considering the residual current on the parallel line.

The function indicates the distance to the fault as a percentage of the line length, in kilometers or miles as selected.

Possibility to make recalculations with changed parameter settings exists.

Information on the last ten disturbances is stored.

5.3 Function block



5.4 Input and output signals

Table 278: 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

Path in local HMI: ServiceReport/Functions/FaultLocator/FuncOutputs

Table 279: 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

5.5 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.

Path in local HMI: Settings/Functions/Groupn/Linereference

Table 280: 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 Step: 0.01	40.00	-	Line length value in present length unit
X1	0.001 - 1500.000 Step: 0.001	12.000	ohm/phase	Positive sequence line reactance
R1	0.001 - 1500.000 Step: 0.001	2.000	ohm/phase	Positive sequence line resistance
X0	0.001 - 1500.000 Step: 0.001	48.000	ohm/phase	Zero sequence line reactance
R0	0.001 - 1500.000 Step: 0.001	8.000	ohm/phase	Zero sequence line resistance
X1SA	0.001 - 1500.000 Step: 0.001	12.000	ohm/phase	Positive sequence source reactance, near end
R1SA	0.001 - 1500.000 Step: 0.001	2.000	ohm/phase	Positive sequence source resistance, near end
X1SB	0.001 - 1500.000 Step: 0.001	12.000	ohm/phase	Positive sequence source reactance, far end
R1SB	0.001 - 1500.000 Step: 0.001	2.000	ohm/phase	Positive sequence source resistance, far end
Xm0	0.001 - 1500.000 Step: 0.001	0.000	ohm/phase	Mutual reactance from parallel line
Rm0	0.001 - 1500.000 Step: 0.001	0.000	ohm/phase	Mutual resistance from parallel line

5.6 Technical data

Table 281: FLOC - Fault locator

Function			Setting range	Accuracy
Distance to fault locator	Reach for I_r =1 A	Resistive direction	(0 - 1500) ohm/phase	± 2.5 % (typical)
		Reactive direction	(0 - 1500) ohm/phase	± 2.5 % (typical)
	Phase selection		According to input signals	

6 Trip value recorder (TVR)

6.1 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.

6.2 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.

7 Supervision of AC input quantities (DA)

7.1 Application

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.

7.2 Functionality

Alarm limits can be set and used as triggers, e.g. 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), i.e. Transformer Input Module (TRM).

7.3 Function block

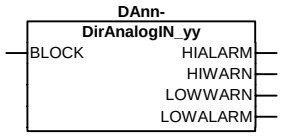


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Table 282: AC monitoring function block types

Instance name (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

Instance name (DAnn-)	Function block name	Description
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

7.4 Input and output signals

Table 283: Input signals for the AC monitoring (DAnn-) function block

Signal	Description
BLOCK	Block updating of value for measured quantity

Use CAP configuration tool to se status of the output signals.

Table 284: 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

7.5 Setting parameters

The PST, Parameter Setting Tool, must be used to set the parameters.

Table 285: 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 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 Step: 0.1	220.0	kV	High Alarm level for U1 - U5
HiWarn	0.0-1999.9 Step: 0.1	210.0	kV	High Warning level for U1 - U5
LowWarn	0.0-1999.9 Step: 0.1	170.0	kV	Low Warning level for U1 - U5
LowAlarm	0.0-1999.9 Step. 0.1	160.0	kV	Low Alarm level for U1 - U5
RepInt	0-3600 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 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 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 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)

Parameter	Range	Default	Unit	Description
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 Step: 1	900	A	High Alarm level for I1 - I5
HiWarn	0-99999 Step: 1	800	A	High Warning level for I1 - I5
LowWarn	0-99999 Step: 1	200	A	Low Warning level for I1 - I5
LowAlarm	0-99999 Step: 1	100	A	Low Alarm level for I1 - I5
RepInt	0-3600 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 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 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 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)
HiAlarm	0.0-1999.9 Step: 0.1	220.0	kV	High Alarm level for U
HiWarn	0.0-1999.9 Step: 0.1	210.0	kV	High Warning level for U
LowWarn	0.0-1999.9 Step: 0.1	170.0	kV	Low Warning level for U
LowAlarm	0.0-1999.9 Step: 0.1	160.0	kV	Low Alarm level for U

Parameter	Range	Default	Unit	Description
RepInt	0-3600 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 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 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 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)
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 Step: 1	900	A	High Alarm level for I
HiWarn	0-99999 Step: 1	800	A	High Warning level for I
LowWarn	0-99999 Step: 1	200	A	Low Warning level for I
LowAlarm	0-99999 Step: 1	100	A	Low Alarm level for I
RepInt	0-3600 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 Step: 1	50	A	Amplitude dead band for I
EnIDeadB	Off, On	Off	-	Enable integrating dead band supervision for I
IDeadB	0-99999 Step: 1	10000	A	Integrating dead band for I
EnDeadBP	Off, On	Off	-	Enable periodic dead band reporting I

Parameter	Range	Default	Unit	Description
				Active power measuring channel P: DA13-
Operation	Off, On	Off	-	Operating mode for DAnn function
Hysteres	0.0-9999.9 Step. 0.1	5.0	MW	Alarm hysteresis for P
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 Step: 0.1	300.0	MW	High Alarm level for P
HiWarn	0.0-9999.9 Step: 0.1	200.0	MW	High Warning level for P
LowWarn	0.0-9999.9 Step: 0.1	80.0	MW	Low Warning level for P
LowAlarm	0.0-9999.9 Step: 0.1	50.0	MW	Low Alarm level for P
RepInt	0-3600 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 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 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
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)

Parameter	Range	Default	Unit	Description
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-
Operation	Off, On	Off	-	Operating mode for DAnn function
Hysteres	0.0-99.9 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 Step: 0.1	55.0	Hz	High Alarm level for f
HiWarn	0.0-99.9 Step: 0.1	53.0	Hz	High Warning level for f
LowWarn	0.0-99.9 Step: 0.1	47.0	Hz	Low Warning level for f
LowAlarm	0.0-99.9 Step: 0.1	45.0	Hz	Low Alarm level for f

Parameter	Range	Default	Unit	Description
RepInt	0-3600 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 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 Step: 0.1	5	Hz	Integrating dead band for f
EnDeadBP	Off, On	Off	-	Enable periodic dead band reporting f
				Apparent power measuring channel S: DA16-
Operation	Off, On	Off	-	Operating mode for DAnn function
Hysteres	0.0-9999.9 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 Step: 0.1	300.0	MVA	High Alarm level for S
HiWarn	0.0-9999.9 Step: 0.1	200.0	MVA	High Warning level for S
LowWarn	0.0-9999.9 Step: 0.1	80.0	MVA	Low Warning level for S
LowAlarm	0.0-9999.9 Step: 0.1	50.0	MVA	Low Alarm level for S
RepInt	0-3600 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 Step: 0.1	1.0	MVA	Amplitude dead band for S
EnIDeadB	Off, On	Off	-	Enable integrating dead band supervision for S
IDeadB	0.0-9999.9 Step: 0.1	10.0	MVA	Integrating dead band for S

Parameter	Range	Default	Unit	Description
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
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

Parameter	Range	Default	Unit	Description
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

7.6 Technical data

Table 286: Mean values (AC-monitoring)

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≤ U_r ± 2.5% of U, at U> U_r
Current (RMS)	(0.2 - 4) x I_r	± 2.5% of I_r, at I≤ I_r ± 2.5% of I, at I> I_r
Active power*)	at |cos φ| ≥ 0.9	± 5.0%
Reactive power*)	at |cos φ| ≤ 0.8	± 7.5%
*) Measured at U_r and 20% of I_r		

8 Increased accuracy of AC input quantities (IMA)

8.1 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.

8.2 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.

8.3 Technical data

Table 287: IMA - Increased accuracy of AC input quantities

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 ± 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 ± 0.25% of I, at I> I_r
Active power	0.8 x U_r < U < 1.2 x U_r 0.2 x I_r < I < 2 x I_r	± 0.5% of S_r at S ≤S_r ± 0.5% of S at S > S_r
Reactive power	0.8 x U_r < U < 1.2 x U_r 0.2 x I_r < I < 2 x I_r	± 0.5% of S_r at S ≤S_r ± 0.5% of S at S >S_r

9 Supervision of mA input quantities (MI)

9.1 Application

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 various parameters such as frequency, temperature and DC battery voltage.

9.2 Functionality

Alarm limits can be set and used as triggers, e.g. 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 mA Input Module (MIM).

9.3 Function block

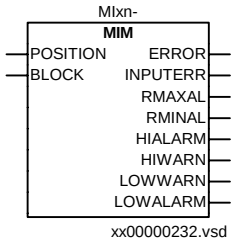


Figure 137: A MIM module (mA input module) has six input channels. Each channel has a function block, MIxn-, where x=(1-6) is the number of the MIM module, and n=(1-6) is the number of the channel.

9.4 Input and output signals

Table 288: Input signals for the MIM (MIxn-) function block

Signal	Description
POSITION	I/O module slot position connector. Only present in first function block for each present input module.
BLOCK	Block value updating

Path in local HMI: ServiceReport/Functions/MInn-Error

Use CAP configuration tool to see status of output signals: INPUTERR-RMINAL

Table 289: Output signals for the MIM (MIxn-) function block

Signal	Description
ERROR	Module fail. Only present in first function 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

9.5 Setting parameters

9.5.1 Setting table for a generic mA input module MIM

The PST, Parameter Settings Tool, must be used to set the parameters

Table 290: Module parameter

Parameter	Range	Default	Unit	Description
SampRate	5-255 Step: 1	5	Hz	Sampling Rate for mA Input Module x

The PST, Parameter Settings Tool, must be used to set the parameters

Table 291: 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*
Hysteres	0.0-20.0 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 Step: 0.01	20.00	mA	Max current of transducer to Input *n*

Parameter	Range	Default	Unit	Description
I_Min	-25.00-25.00 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 Step: 0.01	19.00	mA	High Alarm level for Input *n*
HiWarn	-25.00-25.00 Step: 0.01	18.00	mA	High Warning level for Input *n*
LowWarn	-25.00-25.00 Step: 0.01	6.00	mA	Low warning level for Input *n*
LowAlarm	-25.00-25.00 Step: 0.01	5.00	mA	Low Alarm level for Input *n*
RepInt	0-3600 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 Step: 0.01	1.00	mA	Amplitude dead band for Input *n*
EnIDeadB	Off, On	Off	-	Enable integrating dead band supervision for Input *n*
IDeadB	0.00-1000.00 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 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 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

9.6 Technical data

Table 292: MIM - mA measuring function

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, I_Max	(-25.00 to +25.00) mA in steps of 0.01	
Min current of transducer to input, I_Min	(-25.00 to +25.00) mA in steps of 0.01	
High alarm level for input, HiAlarm	(-25.00 to +25.00) mA in steps of 0.01	
High warning level for input, HiWarn	(-25.00 to +25.00) mA in steps of 0.01	
Low warning level for input, LowWarn	(-25.00 to +25.00) mA in steps of 0.01	
Low alarm level for input, Low-Alarm	(-25.00 to +25.00) mA in steps of 0.01	
Alarm hysteresis for input, Hys-teresis	(0-20) mA in steps of 1	
Amplitude dead band for input, DeadBand	(0-20) mA in steps of 1	
Integrating dead band for input, IDeadB	(0.00-1000.00) mA in steps of 0.01	

Chapter 12 Metering

About this chapter

This chapter describes the metering functions.

1 Pulse counter logic for metering (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.

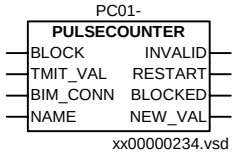
1.2 Design

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 293: 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 294: 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 295: 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 analog events from pulse counter nn. Can only be set from PST.

1.6 Technical data

Table 296: PC - Pulse counter logic 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 System protection and control functions

About this chapter

This chapter describes the system protection and control functions

1 Pole slip protection (PSP)

1.1 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.

1.2 Functionality

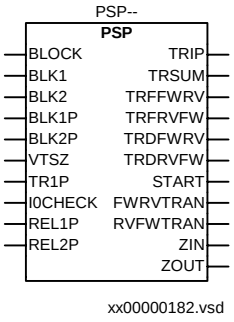
The PSP function comprises an inner and an outer quadrilateral measurement characteristic. It detects oscillations in the power system by measuring the time it takes the transient impedance to pass through the impedance area between the outer and the inner characteristics. Oscillations are identified 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 detection of a new oscillation, the activation 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.

1.3 Function block



1.4 Logic diagram

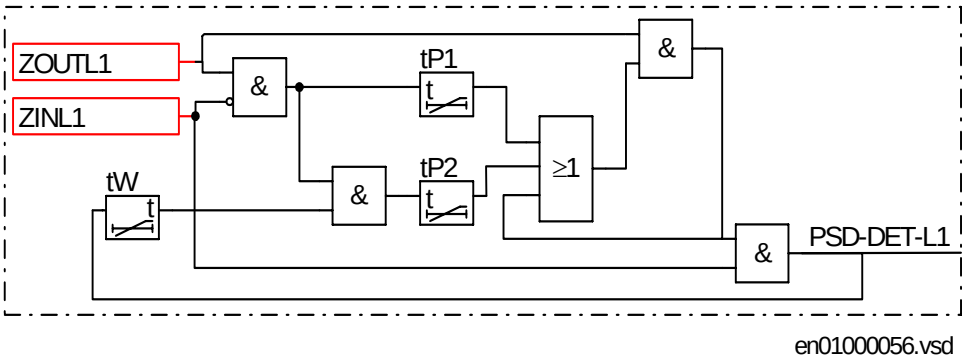


Figure 138: Detection of oscillation in phase L1

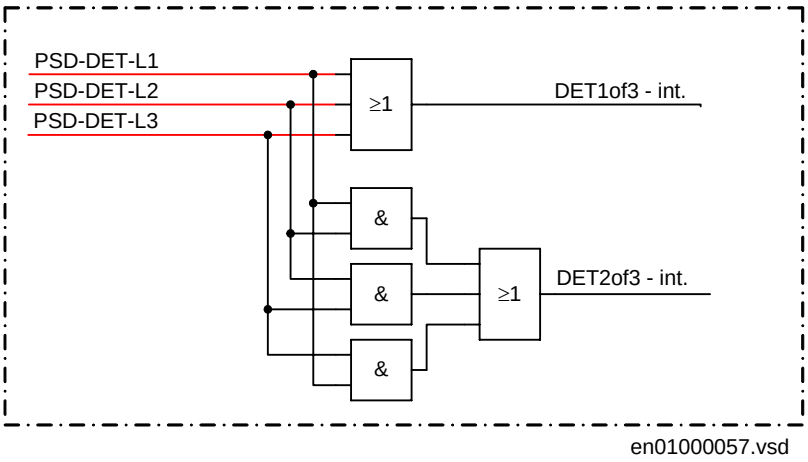


Figure 139: Simplified logic diagram for "one of three" and "two of three" oscillation detection logic

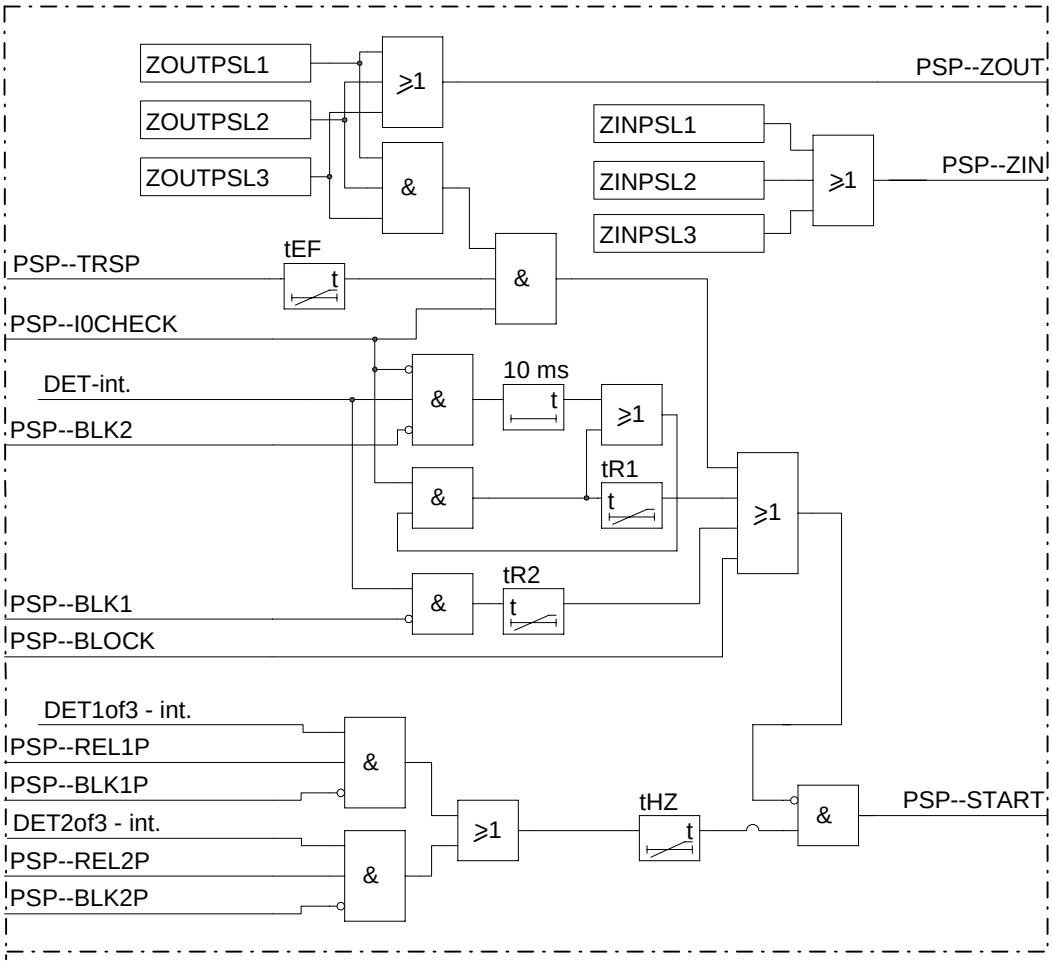
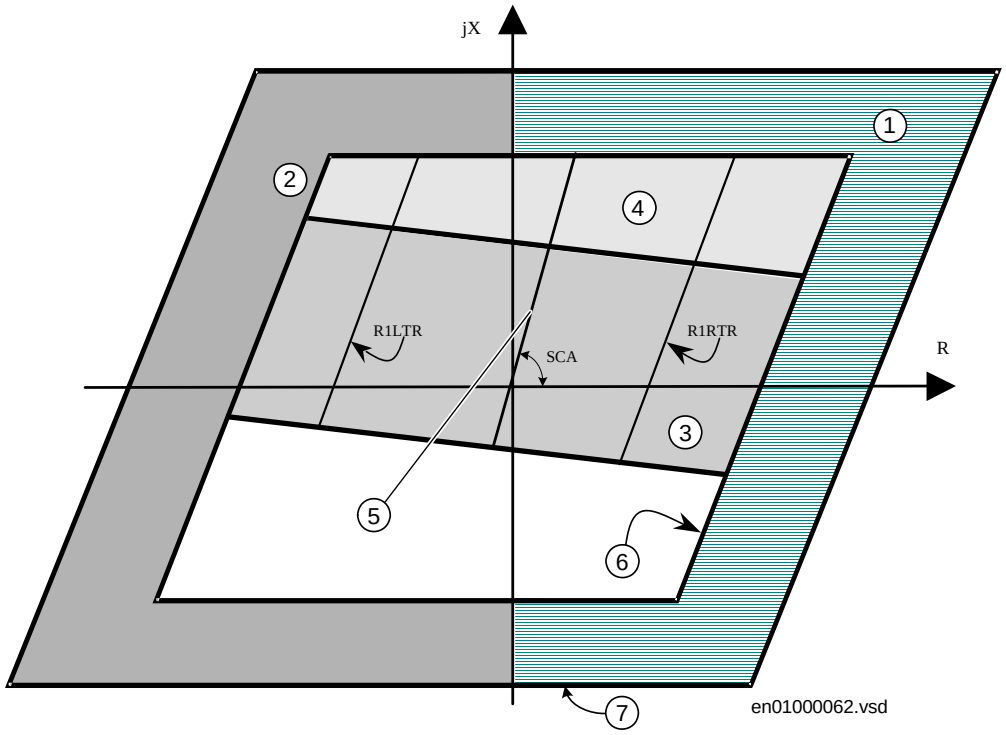


Figure 140: Simplified logic diagram for cooperation with distance protection function



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 141: The impedance operating plane is divided in two detection regions and two trip regions.

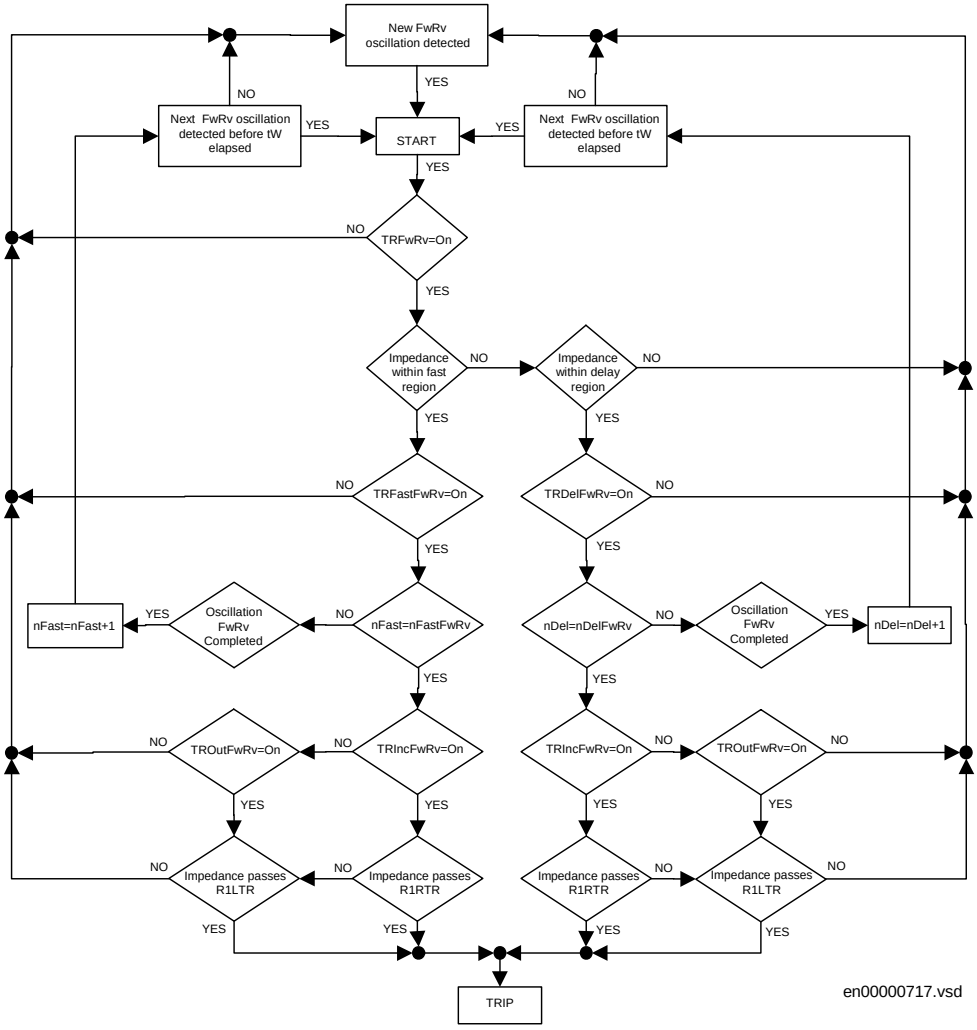


Figure 142: Flow-chart presenting the operation of the pole slip protection for the forward to reverse transition (FwRv) after the oscillation has been detected.

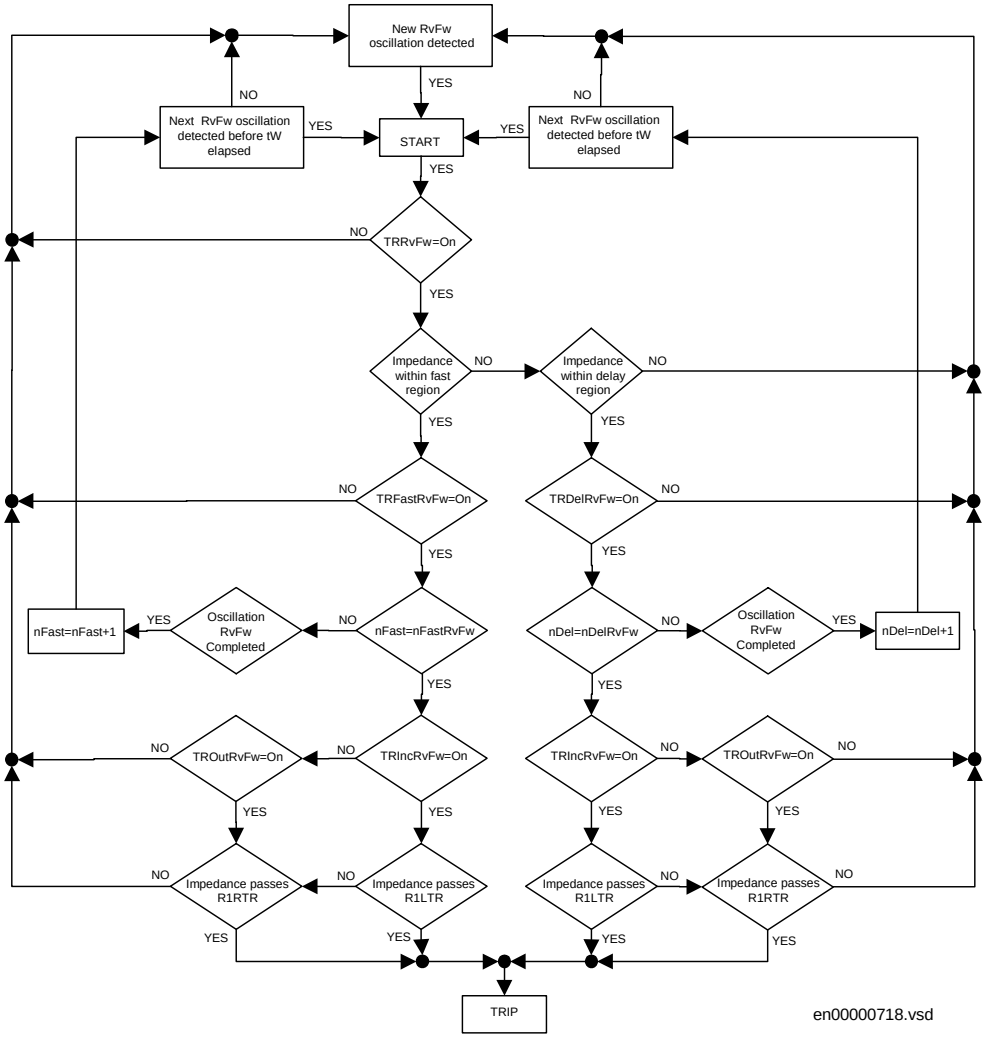


Figure 143: Flow-chart presenting the operation of the pole slip protection for the reverse to forward transition (RvFw) after the oscillation has been detected.

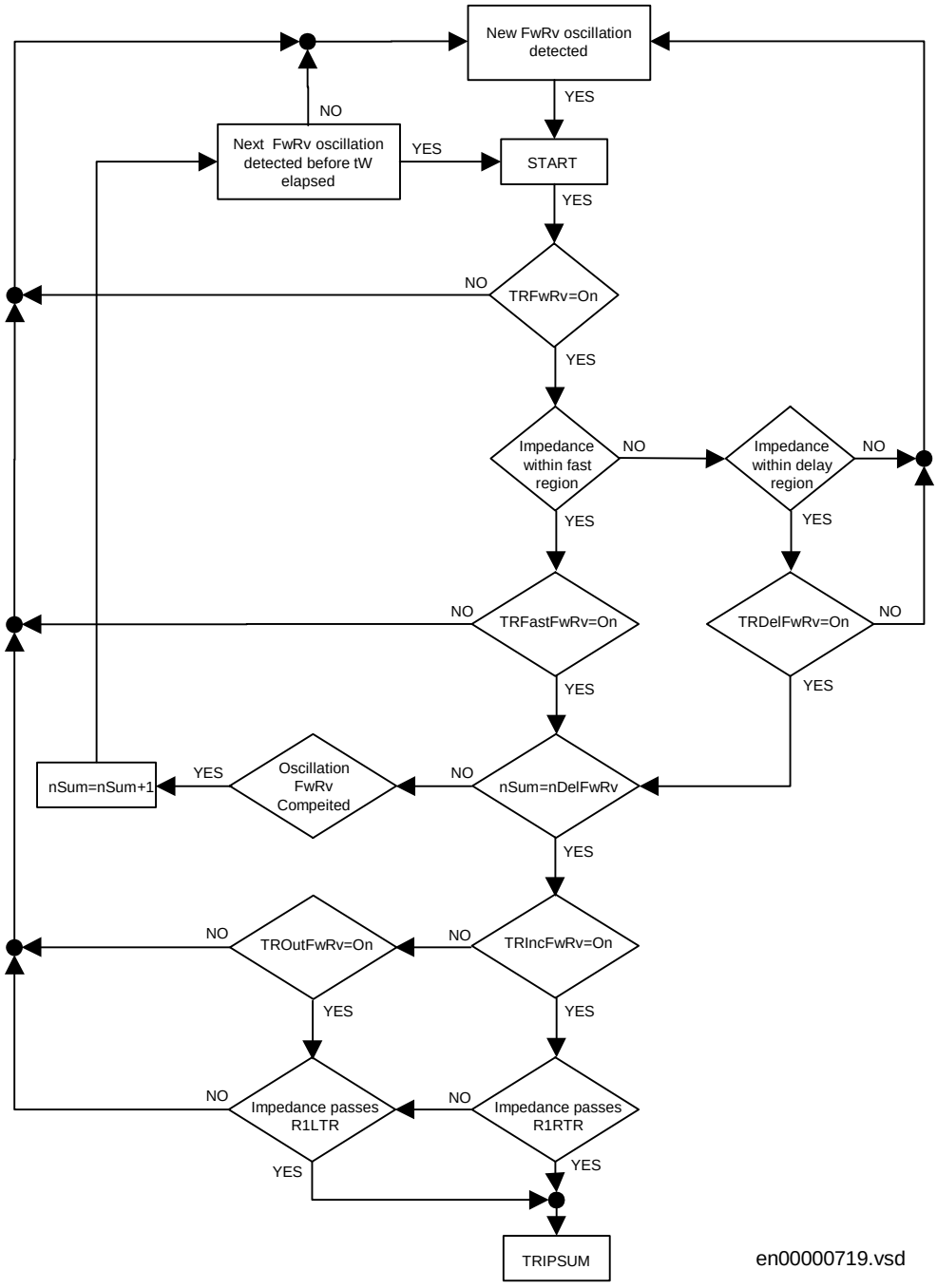


Figure 144: Flow-chart presenting summation trip (TRIPSUM) of the pole slip protection for the forward to reverse transition (FwRv).

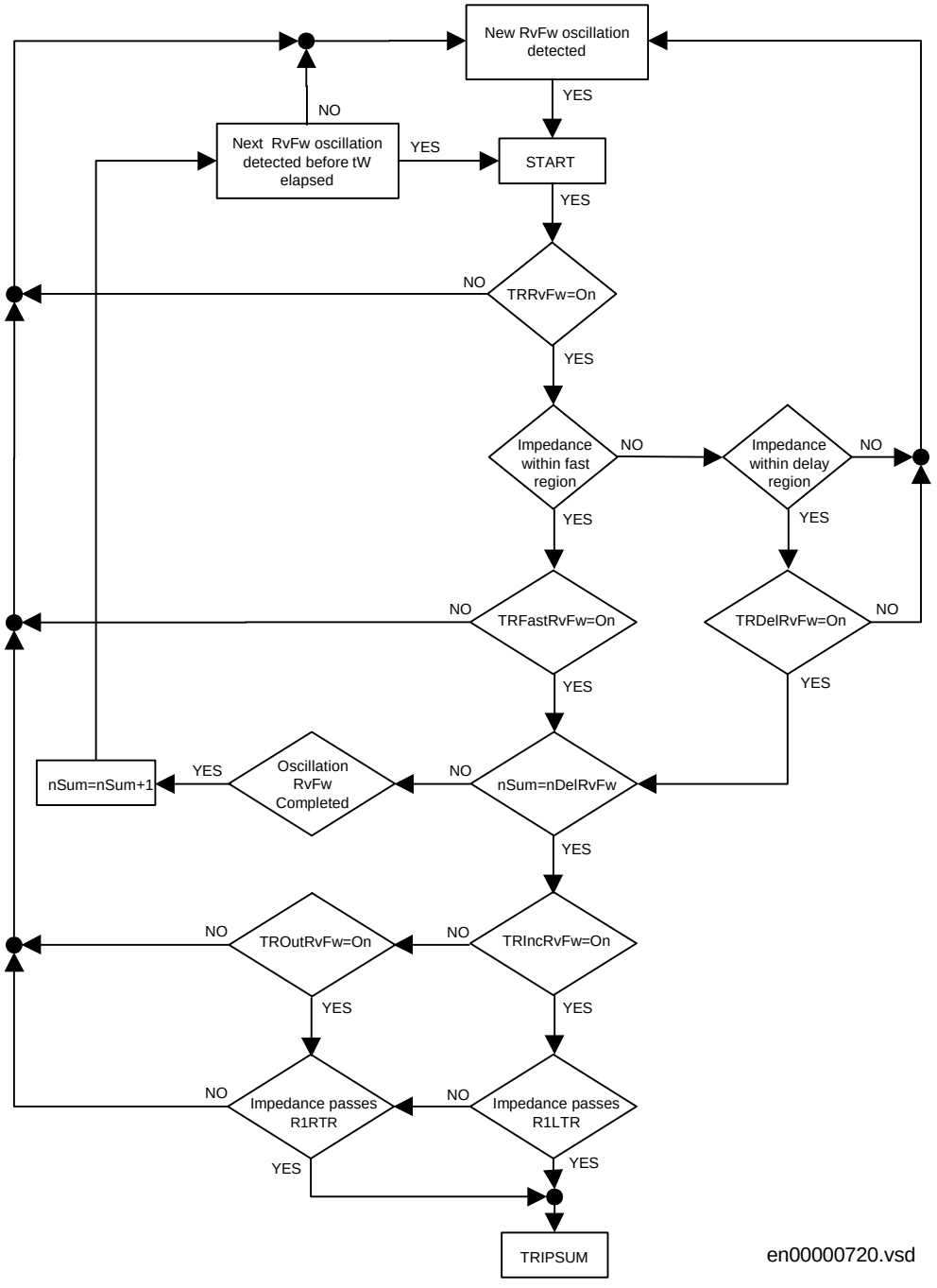


Figure 145: Flow-chart presenting summation trip (TRIPSUM) of the pole slip protection for the reverse to forward transition (RvFw).

1.5 Input and output signals

Table 297: 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

Path in local HMI: ServiceReport/Functions/Impedance/PoleSlipProt/FuncOutputs

Table 298: 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

1.6 Setting parameters

Path in local HMI-tree: Settings/Functions/Groupn/Impedance/PowerSlipProt

Table 299: 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 Step: 0.01	60.00	ohm/phase	Resistive reach of the left side external oscillation detection boundary.
R1LINT	0.10-400.00 Step: 0.01	45.00	ohm/phase	Resistive reach of the left side internal oscillation detection boundary.
R1RINT	0.10-400.00 Step: 0.01	45.00	ohm/phase	Resistive reach of the right side internal oscillation detection boundary.
R1REXT	0.10-400.00 Step: 0.01	60.00	ohm/phase	Resistive reach of the right side external oscillation detection boundary.
R1LTR	0.10-400.00 Step: 0.01	35.00	ohm/phase	Resistive reach of the left side tripping characteristic.
R1RTR	0.10-400.00 Step: 0.01	35.00	ohm/phase	Resistive reach of the right side tripping characteristic.
X1REXT	0.10-400.00 Step: 0.01	60.00	ohm/phase	Reactive reach of the external oscillation detection boundary in reverse direction.
X1RINT	0.10-400.00 Step: 0.01	45.00	ohm/phase	Reactive reach of the internal oscillation detection boundary in reverse direction.
X1FINT	0.10-400.00 Step: 0.01	45.00	ohm/phase	Reactive reach of the internal oscillation detection boundary in forward direction.
X1FEXT	0.10-400.00 Step: 0.01	60.00	ohm/phase	Reactive reach of the external oscillation detection boundary in forward direction.
SCA	75.0-90.0 Step: 0.1	90.0	degrees	System characteristic angle.
X1PSLFw	0.10-400.00 Step: 0.01	35.00	ohm/phase	Positive sequence reactance determining the forward reactive reach of the fast tripping zone.
R1PSLFw	0.10-400.00 Step: 0.01	1.50	ohm/phase	Positive sequence resistance determining the forward resistive reach of the fast tripping zone.
X1PSLRv	0.10-400.00 Step: 0.01	0.10	ohm/phase	Positive sequence reactance determining the reverse reactive reach of the fast tripping zone.
R1PSLRv	0.10-400.00 Step: 0.01	0.10	ohm/phase	Positive sequence resistance determining the reverse resistive reach of the fast tripping zone.
tP1	0.000-60.000 Step: 0.001	0.045	s	Transition time used for the detection of the initial oscillation
tP2	0.000-60.000 Step: 0.001	0.015	s	Transition time used for the detection of subsequent oscillations.
tW	0.000-60.000 Step: 0.001	0.350	s	Waiting time to distinguish between new and subsequent oscillations.

Parameter	Range	Default	Unit	Description
tEF	0.000-60.000 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 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 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.
tHZ	0.000-60.000 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.

Parameter	Range	Default	Unit	Description
TRDelRvFw	On, Off	Off	-	Tripping for RvFw transitions in the delayed tripping area enabled or disabled.
nFastFwRv	0-10 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.
nDelFwRv	0-10 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 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 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.

1.7 Technical data

Table 300: PSP - Pole slip protection function

Function	Value
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
Reset ratio	105% typically

2 Low active power protection (LAPP)

2.1 Application

The low active power protection function (LAPP) can be used wherever a “low active power” signal is needed. The main application is as a local criterion to increase security when transfer trips are used.

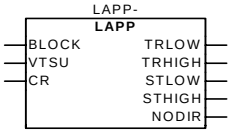
In many power systems transfer trips are used, i.e. a trip criterion in one substation will be transferred to an adjacent substation via some sort of communication system. For such solutions there is always a risk that a false transfer trip signal is generated in the communication system and causes an unwanted trip. In order to prevent such a scenario a local criterion can be added in the substation where the trip is intended to take place. Such a local criterion could be low active power on a line, which, in a correct sequence, is disconnected in the remote end.

2.2 Functionality

The low active power function measures the active power separately in each phase. It also determines whether the power flow is towards or from the relay point as long as the measured current and voltage are higher than the minimum operating values. The operation becomes automatically non-directional, if the measured current decreases under the minimum value and the measured voltage remains higher.

Two operating levels are setable independent of each other regarding their operating values, directionality and time delay. It is possible to use their start and trip signals within the configuration of the terminal.

2.3 Function block



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2.4 Logic diagram

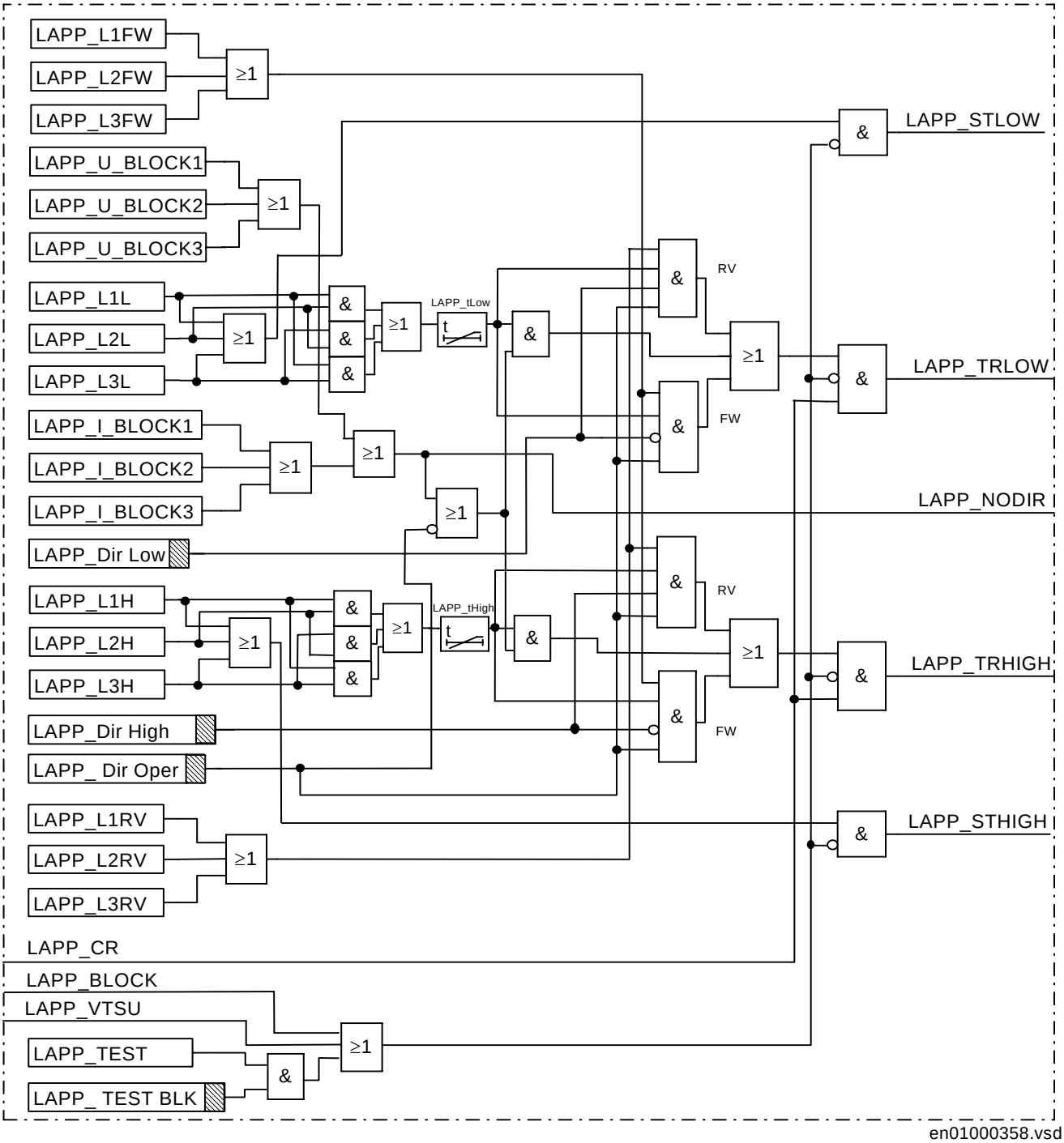


Figure 146: LAPP logic

2.5 Input and output signals

Table 301: Input signals for LAPP (LAPP-) function block

Signal	Description
BLOCK	Block of low active power protection
VTSU	Block of LAPP function by voltage circuit supervision
CR	Received signal from communication channel logic

Path in local HMI: ServiceReport/Functions/SystemProtec/LowActivePP/FuncOutputs

Table 302: Output signals for LAPP (LAPP-) function block

Signal	Description
TRLOW	Low-set trip by low active power protection
TRHIGH	High-set trip by low active power protection
STLOW	Low-set start by low active power protection
STHIGH	High-set start by low active power protection

2.6 Setting parameters

Path in local HMI-tree: Settings/Functions/SystemProtec/LowActivePP

Table 303: Setting parameters for the low active power protection function

Parameter	Range	Default	Unit	Description
Operation	On/Off	Off	-	Operation low active power protection function, Off/On
DirOper	On/Off	Off	-	Directional operation of low active power protection
DirLow	Forward / Reverse	Forward	-	Direction of low active power protection, low-set
DirHigh	Forward / Reverse	Forward	-	Direction of low active power protection, high-set
PLow<	3.0 - 100.00 Step: 0.1	10.0	% of S_b	Low-set limit of low active power
PHigh<	3.0 - 100.0 Step: 0.1	20.0	% of S_b	High-set limit of low active power
tLow	0.000 - 60.000 Step: 0.001	0.000	s	Time delayed operation of low-set step
tHigh	0.000 - 60.000 Step: 0.001	0.000	s	Time delayed operation of high-set step

2.7 Technical data

Table 304: LAPP - Low active power protection function

Function	Setting range	Accuracy
Power function P<	(3.0 - 100.0) % of S_b in steps of 0.1 %	± 5 % of S_r
Time delay	(0.000 - 60.000) s in steps of 1 ms	± 0.5 % ± 10 ms
Minimum operating current for directional measurement: 5% of I_r		
Minimum operating voltage for directional measurement: 10% of U_r		

3 Low active and reactive power protection (LARP)

3.1 Application

The combined low active and reactive power protection function (LARP) can be used wherever a “low reactive power” signal is needed. The main application is as a local criterion to increase security when transfer trips are used. The design gives the user a possibility to increase the sensitivity for high levels of active power. The tripping criterion is a function of the set value and the actual active power according to:

$$Q_{trip} = Q_{set} + \alpha \cdot |P|$$

(Equation 1)

where:
$0 \leq \alpha \leq 1$

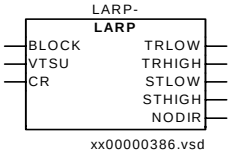
In many power systems transfer trips are used, i.e. a trip criterion in one substation will be transferred to an adjacent substation via some sort of communication system. For such solutions there is always a risk that a false transfer trip signal is generated in the communication system and causes an unwanted trip. In order to prevent such a scenario a local criterion can be added in the substation where the trip is intended to take place. Such a local criterion could be low reactive power on a line, which, in a correct sequence, is disconnected in the remote end.

3.2 Functionality

The low active and reactive power function measures the active and the reactive power separately in each phase. It also determines whether the power flow is towards or from the relay point as long as the measured current and voltage are higher than the minimum operating values. The operation becomes automatically nondirectional, if the measured current decreases under the minimum value and the measured voltage remains higher.

Two operating levels are settable independent of each other regarding their operating values, directionality and time delay. It is possible to use their start and trip signals within the configuration of a terminal.

3.3 Function block



3.4 Logic diagram

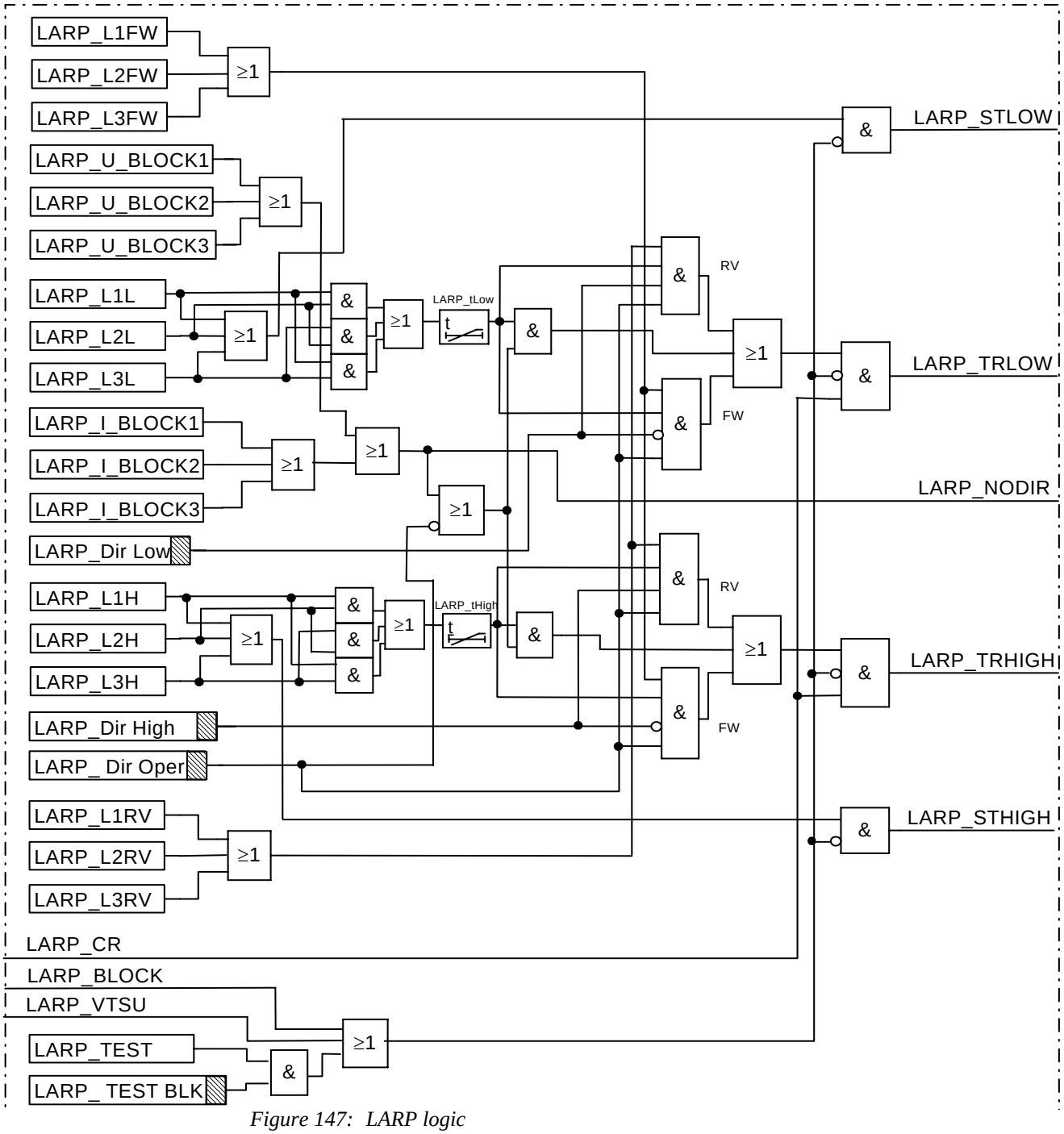


Figure 147: LARP logic

3.5 Input and output signals

Table 305: Input signals for the LARP (LARP-) function block

Signal	Description
BLOCK	Block of combined low active and reactive power P
VTSU	Block of LARP function by voltage circuit supervision
CR	Received signal from communication channel logic

Path in local HMI: ServiceReport/Functions/SystemProtec/LowActiveRP/FuncOutputs

Table 306: Output signals for the LARP (LARP-) function block

Signal	Description
TRLOW	Low-set trip by combined low active and reactive power P
TRHIGH	High-set trip by combined low active and reactive power P
STLOW	Low-set start by combined low active and reactive power P
STHIGH	High-set start by combined low active and reactive power P

3.6 Setting parameters

Path in local HMI-tree: Settings/Functions/SystemProtec/LowActivRP

Table 307: Setting parameters for the low active and reactive power protection

Parameter	Range	Default	Unit	Description
Operation	On/Off	Off	-	Operation combined low active and reactive power protection function, Off/On
DirOper	On/Off	Off	-	Direction operation of combined low active and reactive power protection
DirLow	Forward / Reverse	Forward	-	Direction of combined low active and reactive power protection , low-set
DirLow	Forward / Reverse	Forward	-	Direction of combined low active and reactive power protection , high-set
QLow<	3.0 - 100.0 Step: 0.1	10.0	% of S_b	Low-set limit of reactive power
QHigh<	3.0 - 100.0 Step: 0.1	20.0	% of S_b	High-set limit of reactive power

Parameter	Range	Default	Unit	Description
QLow<	3.0-100.0 Step: 0.1	10.0	% of S_b	Low-set limit of reactive power
QHigh<	3.0-100.0 Step: 0.1	20.0	% of S_b	High-set limit of reactive power
k	0.0 - 45.0 Step: 0.1	0.0	deg	Declination angle of operating characteristic
tLow	0.000 - 60.000 Step: 0.001	0.000	s	Time delayed operation of low-set step
tHigh	0.000 - 60.000 Step: 0.001	0.000	s	Time delayed operation of high-set step

3.7 Technical data

Table 308: LARP - Low active and reactive power protection function

Function	Setting range	Accuracy
Power function Q<	(3.0 - 100.0) % of S_b in steps of 0.1 %	± 5 % of S_r
Time delay	(0.000 - 60.000) s in steps of 1 ms	± 0.5 % ± 10 ms
Minimum operating current for directional measurement: 5% of I_r		
Minimum operating voltage for directional measurement: 10% of U_r		

4 High active power protection (HAPP)

4.1 Application

The high active power protection function (HAPP) can be used wherever a high active power signal is needed.

There are a number of applications for the high active power protection, wherever active power flow has to be limited or certain actions have to be taken when the active power exceeds specific values.

One example is to arm system protection schemes based on high active power transfer. Suppose that the transmission corridor, in figure 148, can transfer 500 MW on each line. With all four lines in operation, the generation shedding system, triggered by line trip, has to be armed at a transfer of 1500 MW. If one line is tripped, or out of service, and the transmission exceeds 1000 MW, the generation shedding has to be armed.

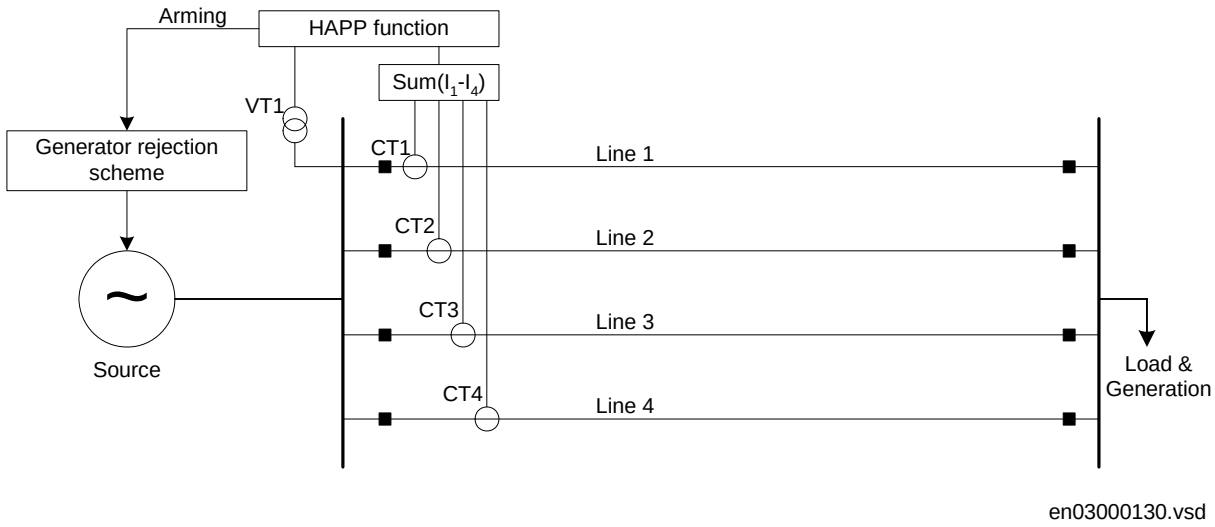


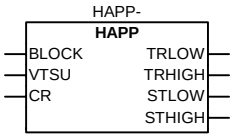
Figure 148: Generation shedding system armed by high active power.

4.2 Functionality

The high active power function measures the active power separately in each phase. It also determines whether the power flow is towards or from the relay point as long as the measured current and voltage are higher than the minimum operating values.

Two operating levels are setable independent of each other regarding their operating values, directionality and time delay. It is possible to use their start and trip signals within the configuration of the terminal.

4.3 Function block



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4.4 Logic diagram

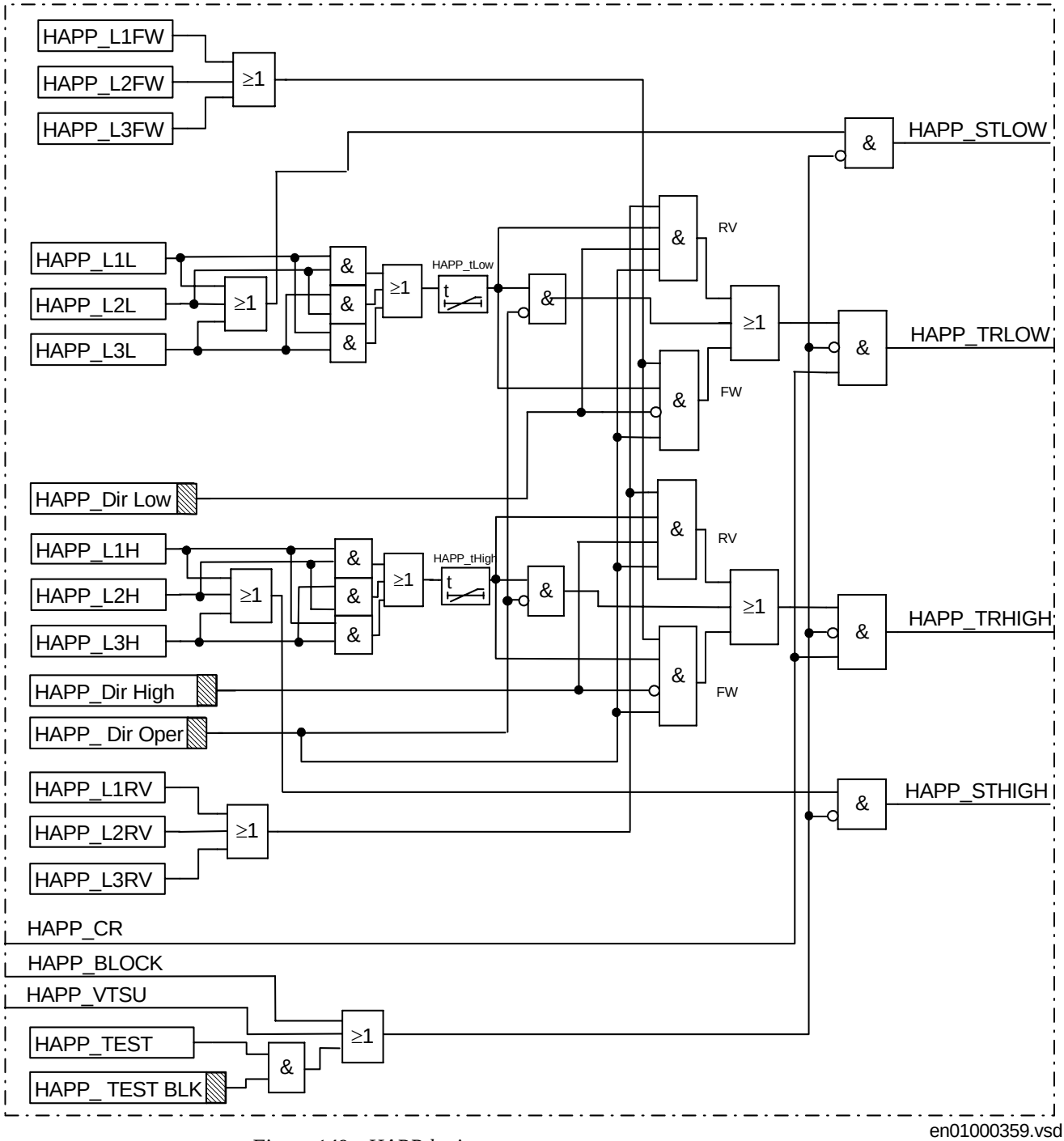


Figure 149: HAPP logic

4.5 Input and output signals

Table 309: Input signals for the HAPP (HAPP-) function block

Signal	Description
BLOCK	Block of high active power protection
VTSU	Block of high active P by voltage circuit supervision
CR	Received signal from communication channel logic

Path in local HMI: ServiceReport/Functions/SystemProtec/HighActivePP/FuncOutputs

Table 310: Output signals for the HAPP (HAPP-) function block

Signal	Description
TRLOW	Low-set trip by high active power protection
TRHIGH	High-set trip by high active power protection
STLOW	Low-set start by high active power protection
STHIGH	High-set start by high active power protection

4.6 Setting parameters

Path in the local HMI-tree: Settings/Functions/SystemProtec/HighActivePP

Table 311: Settings for the HAPP (HAPP-) function block

Parameter	Range	Default	Unit	Description
Operation	On/Off	Off	-	Operation high active power protection function, Off/On
DirOper	On/Off	Off	-	Direction operation of high active power protection
DirLow	Forward / Reverse	Forward	-	Direction of high active power protection, low-set
DirHigh	Forward / Reverse	Forward	-	Direction of high active power protection, high-set
Plow>	3.0 - 200.0 Step: 0.1	110.0	% of S_b	Low-set limit of high active power
PHigh>	3.0 -200.0 Step: 0.1	120.0	% of S_b	High-set limit of high active power
tLow	0.000 - 60.000 Step: 0.001	0.000	s	Time delayed operation of low-set step
tHigh	0.000 - 60.000 Step: 0.001	0.000	s	Time delayed operation of high-set step

4.7 Technical data

Table 312: HAPP - High active power protection function

Function	Value	Accuracy
Power function P>	(3.0 - 200.0) % of S_b in steps of 0.1 %	± 5 % of S_r
Time delay	(0.000 - 60.000) s in steps of 1 ms	± 0.5 % ± 10 ms
Minimum operating current for directional measurement: 5% of I_r		
Minimum operating voltage for directional measurement: 10% of U_r		
Reset ratio	> 90% typically	

5 High active and reactive power protection (HARP)

5.1 Application

The combined high active and reactive power protection function (HARP) can be used wherever a “high reactive power” signal is needed. The design gives the user a possibility to increase the sensitivity for high levels of active power. The tripping criterion is a function of the set value and the actual active power according to:

$$Q_{trip} = Q_{set} + \alpha \cdot |P|$$

(Equation 2)

where:
$0 \leq \alpha \leq 1$

Typically, high reactive power output from generators, connected to transmission grids, is used as an important signal in system protection schemes to counteract voltage instability.

5.2 Functionality

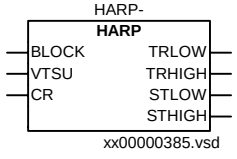
The high active and reactive power function measures the active and the reactive power separately in each phase. It also determines whether the power flow is towards or from the relay point as long as the measured current and voltage are higher than the minimum operating values.

The operational characteristic is according to:

Q>Qset+tan(k)*abs(P).

Two operating levels are settable independent of each other regarding their operating values, directionality and time delay. It is possible to use their start and trip signals within the configuration of a terminal.

5.3 Function block



5.4 Logic diagram

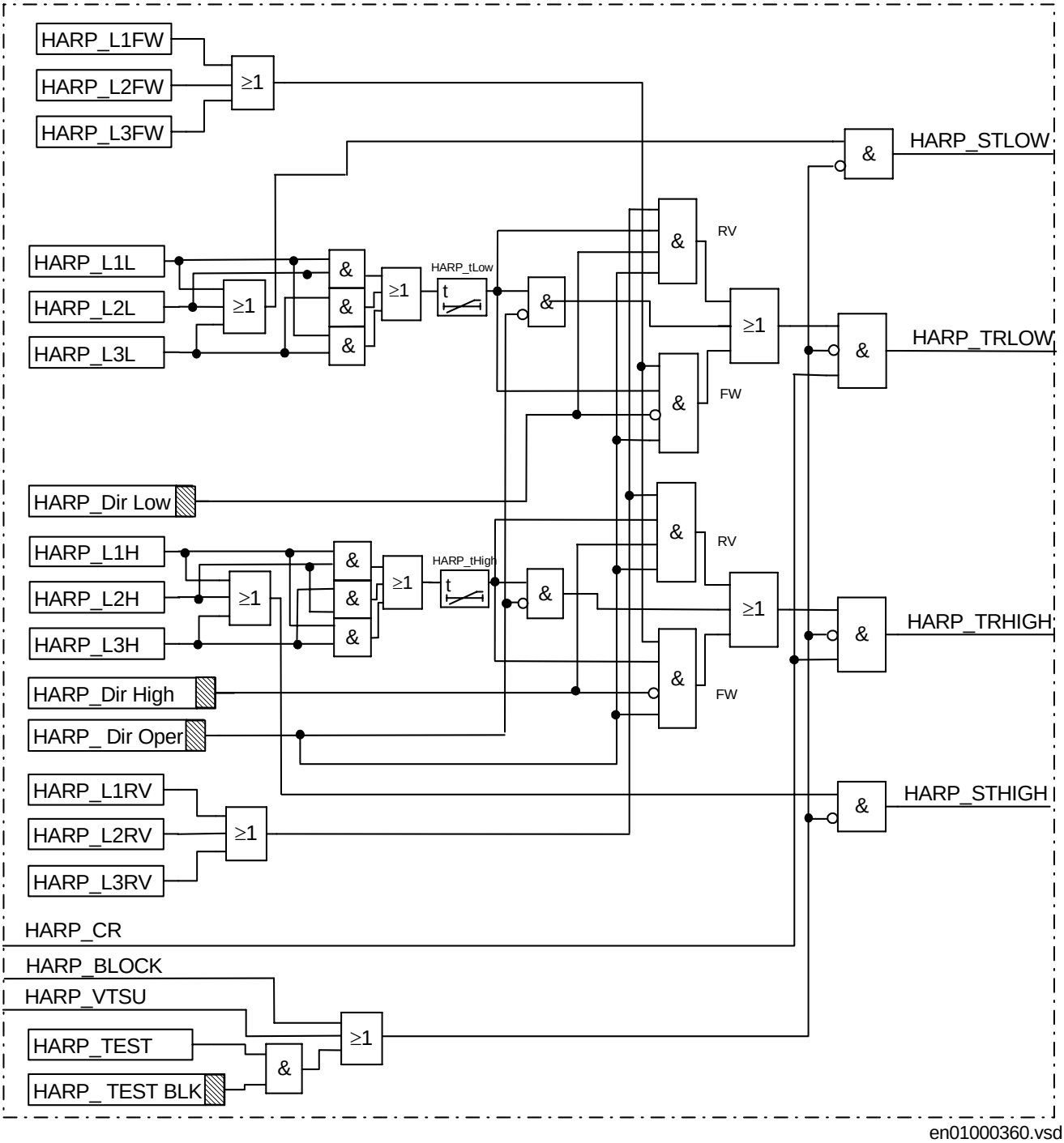


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Figure 150: HARP logic

5.5 Input and output signals

Table 313: Input signals for the HARP (HARP-) function block

Signal	Description
BLOCK	Block of combined high active and reactive power protection
VTSU	Block of HARP function by voltage circuit supervision
CR	Received signal from communication channel logic

5.6 Setting parameters

Path in local HMI-tree: Settings/Functions/SystemProtec/HIghActivRP

Table 314: Settings for the high active and reactive power protection function

Parameter	Range	Default	Unit	Description
Operation	On/Off		-	Operation combined high active and reactive power protection function, Off/On
DirOper	On/Off	Off	-	Direction of operation of combined high active and reactive power protection
DirLow	Forward / Reverse	Forward	-	Direction of combined high reactive and active power protection, low-set
DirHigh	Forward / Reverse	Forward	-	Direction of combined high reactive and active power protection, high-set
QLow>	3.0 - 200.0 Step: 0.1	110.0	% of S_b	Low-set limit of reacive power
QHigh>	3.0 - 200.0 Step: 0.1	120.0	% of S_b	High-set limit of reactive power
QLow	3.0-200.0 Step: 0.1	110.0	% of S_b	Low-set limit of reactive power
k	0.0 - 45.0 Step: 0.1	0.0	deg	Declination angle of operationg characteristic
tLow	0.000 - 60.000 Step: 0.001	0.000	s	Time delayed operation of low-set step
tHigh	0.000 - 60.000 Step: 0.001	0.000	s	Time delayed operation of high-set step

5.7 Technical data

Table 315: HARP - High active and reactive power protection function

Function	Value	Accuracy
Power function Q>	(3.0 - 200.0) % of S_b in steps of 0.1 %	± 5 % of S_r
Time delay	(0.000 - 60.000) s in steps of 1 ms	± 0.5 % ± 10 ms
Minimum operating current for directional measurement: 5% of I_r		
Minimum operating voltage for directional measurement: 10% of U_r		
Reset ratio	> 90%	

6 Sudden change in phase current protection function (SCC1)

6.1 Application

The sudden change in current protection function (SCC1) can be used wherever a sudden change in current can be used to improve the overall functionality of the protection system. The main application is as a local criterion to increase security when transfer trips are used.

In many power systems transfer trips are used, i.e. a trip criterion in one substation will be transferred to an adjacent substation via some sort of communication system. For such solutions there is always a risk that a false transfer trip signal is generated in the communication system and causes an unwanted trip. In order to prevent such a scenario a local criterion can be added in the substation where the trip is intended to take place. Such a local criterion could be a sudden change in current on a line, which, in a correct sequence, is disconnected in the remote end.

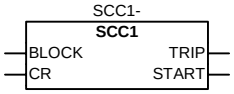
6.2 Functionality

The amplitude of the difference between the magnitudes of two consecutive cycles is derived by means of the fourier coefficients of the fundamental signal.

The integration time is one power system cycle.

The change in current is compared to a setting value to create the start and, after a time delay, the trip signal.

6.3 Function block



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6.4 Logic diagram

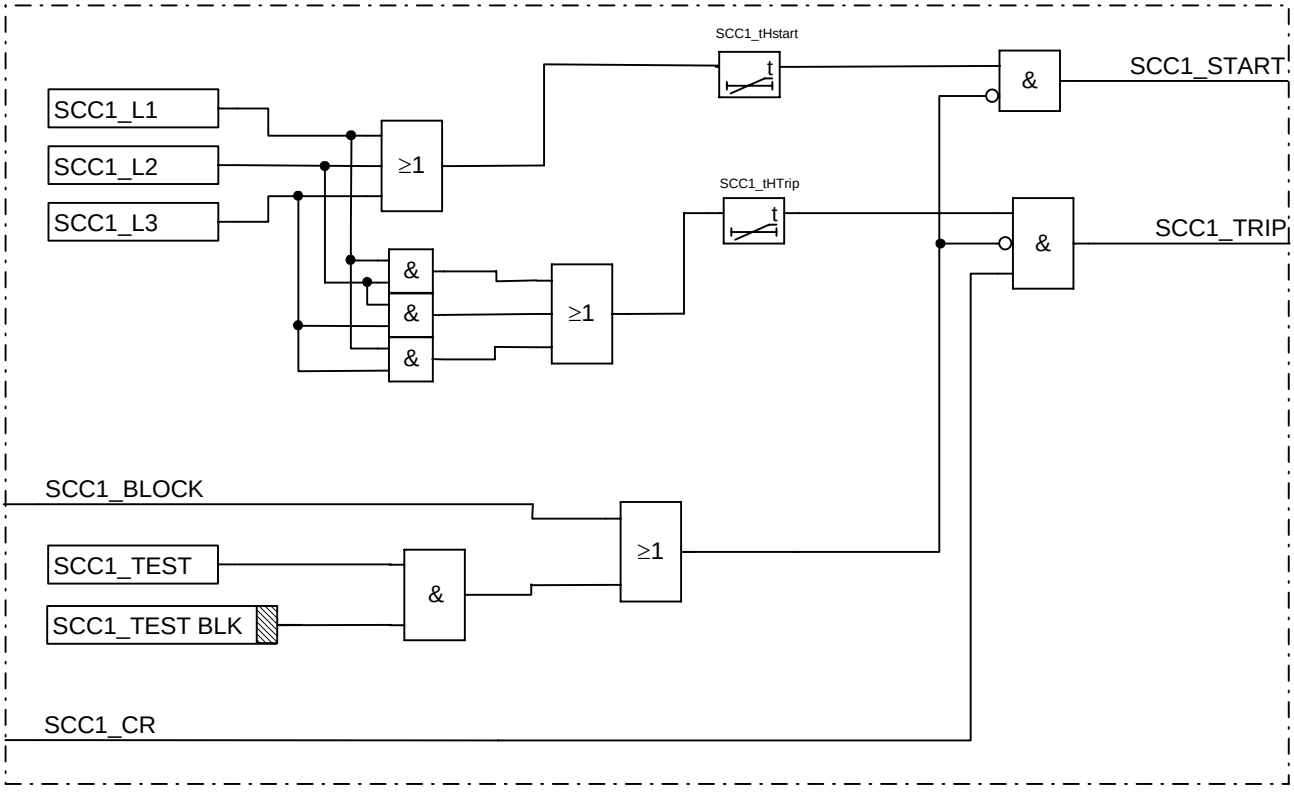


Figure 151: SCC1 logic

6.5 Input and output signals

Table 316: Input signals for the SCC1 (SCC1-) function block

Signal	Description
BLOCK	Block of sudden change in current
CR	Received signal from communication channel logic

Path in local HMI: ServiceReport/Functions/SystemProtec/SuddenChangeC/FuncOutputs

Table 317: Output signals for the SCC1 (SCC1-) function block

Signal	Description
TRIP	Trip by sudden change in function
START	Start by sudden change in current

6.6 Setting parameters

Path in local HMI-tree: Settings/Functions/SystemProtec/SuddenChangeC

Table 318: Settings for the sudden change in phase current protection SCC1 (SCCn-) function

Parameter	Range	Default	Unit	Description
Operation	On/Off	Off	-	Operation sudden change in current function, Off/On
DIL>	20 - 100.0 Step: 0.1	30.0	% of I_b	Change in current limit
tHStart	0.000 - 60.000 Step: 0.001	0.000	s	Hold timer for start signal
tHTrip	0.000 - 60.000 Step: 0.001	0.000	s	Hold timer for trip signal

6.7 Technical data

Table 319: SCC1 - Sudden change in phase current function

Parameter	Setting range	Accuracy
Change in current per power system cycle, DIL>	20.0-100.0% of Ib in steps of 0.1%	± 5.0 % of I_r
Time delay for start signal, tHStart	0.000-60.000 s in steps of 1 ms	± 0.5 % ± 10 ms
Time delay for trip signal, tHTrip	0.000-60.000 s in steps of 1 ms	± 0.5 % ± 10 ms

7 Sudden change in residual current protection function (SCRC)

7.1 Application

The sudden change in residual current protection function (SCRC) can be used wherever a sudden change in residual current can be used to improve the overall functionality of the protection system. The main application is as a local criterion to increase security when transfer trips are used.

Whenever an earth-fault occurs, or a circuit-breaker get stuck in one phase, a residual current appears, that can be used to increase the security of transfer trip arrangements.

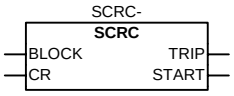
7.2 Functionality

The amplitude of the difference between the magnitudes of two consecutive cycles is derived by means of the fourier coefficients of the fundamental signal.

The integration time is one power system cycle.

The change in residual current is compared to a setting value to create the start and, after a time delay, the trip signal.

7.3 Function block



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7.4 Logic diagram

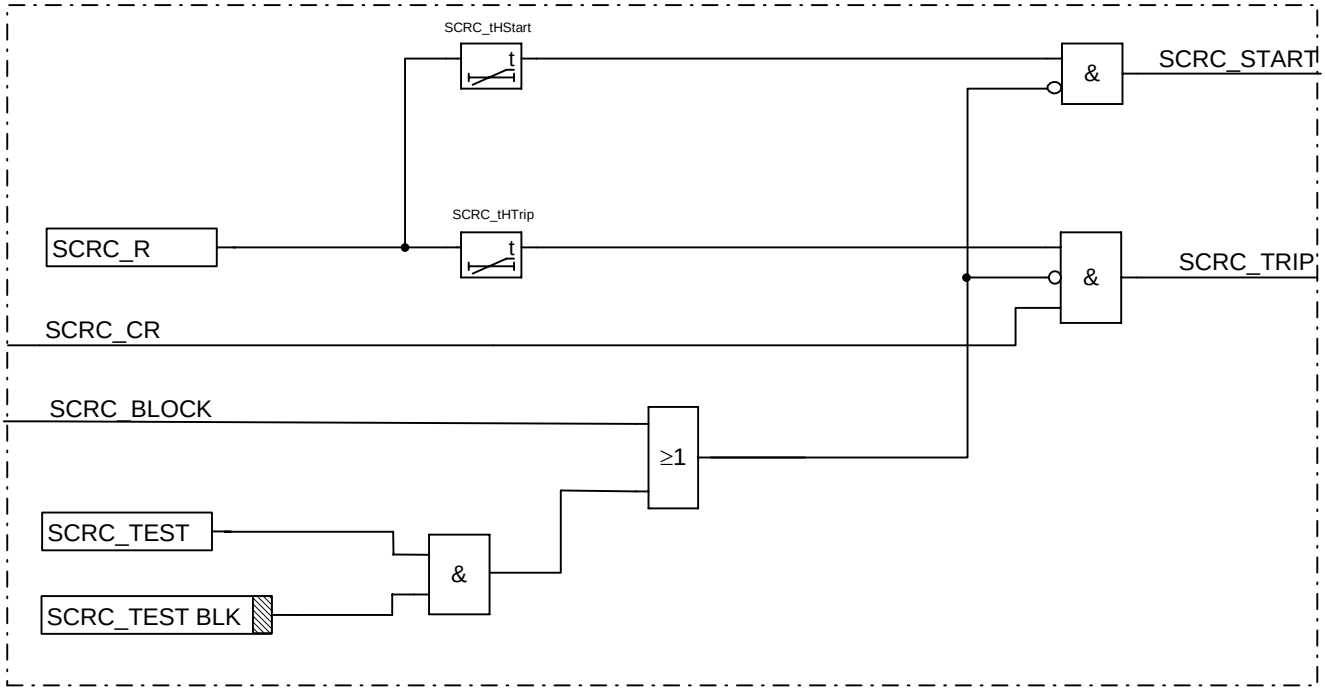


Figure 152: SCRC logic

7.5 Input and output signals

Table 320: Input signals for the SCRC (SCRC-) function block

Signal	Description
BLOCK	Block of sudden change in residual current
CR	Received signal from communication channel logic

Path in local HMI: ServiceReport/Functions/SystemProtec/SuddenChangeRC/FuncOutputs

Table 321: Output signals for the SCRC (SCRC-) function block

Signal	Description
TRIP	Trip by sudden change in residual current
START	Start by sudden change in residual current

7.6 Setting parameters

Path in local HMI-tree: Settings/Functions/SystemProtec/SuddenChangeRC

Table 322: Settings for the sudden change in residual protection SCRC (SCRC-) function

Parameter	Range	Default	Unit	Description
Operation	On/Off	Off	-	Operation sudden change in residual current function, Off/On
DIN>	20.0 - 100.0 Step: 0.1	30.0	% of I_b	Change in residual current limit
tHStart	0.000 - 60.000 Step: 0.001	0.000	s	Hold timer for start signal
tHTrip	0.000 - 60.000 Step: 0.001	0.000	s	Hold timer for trip signal
IMeasured	I4, I5 Step: I5	I4	-	Current signal used in function

7.7 Technical data

Table 323: SCRC - Sudden change in residual current protection function

Function	Setting range	Accuracy
Change in residual current per power system cycle, DIN>	20.0-100.0% of Ib in steps of 0.1%	± 5.0% of I_r
Time delay for start signal, tHStart	0.000-60.000 s in steps of 1 ms	± 0.5 % ± 10 ms
Time delay for trip signal, tHTrip	0.000-60.000 s in steps of 1 ms	+± 0.5 % ± 10 ms

8 Sudden change in voltage protection function (SCV)

8.1 Application

The sudden change in voltage protection function (SCV) can be used wherever a sudden change in voltage can be used to improve the overall functionality of the protection system.

One application is as a local criterion to increase security when transfer trips are used. Another application is to recognize network topology changes that cause sudden changes in voltage. Also faults, tap-changer operations, shunt device switching, etc., cause sudden changes in voltage that can be captured by the SCV function.

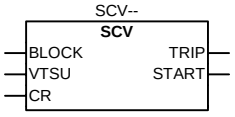
8.2 Functionality

The amplitude of the difference between the magnitudes of two consecutive cycles is derived by means of the fourier coefficients of the fundamental signal.

The integration time is one power system cycle.

The change in voltage is compared to a setting value to create a start signal and, after a time delay, a trip signal.

8.3 Function block



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8.4 Logic diagram

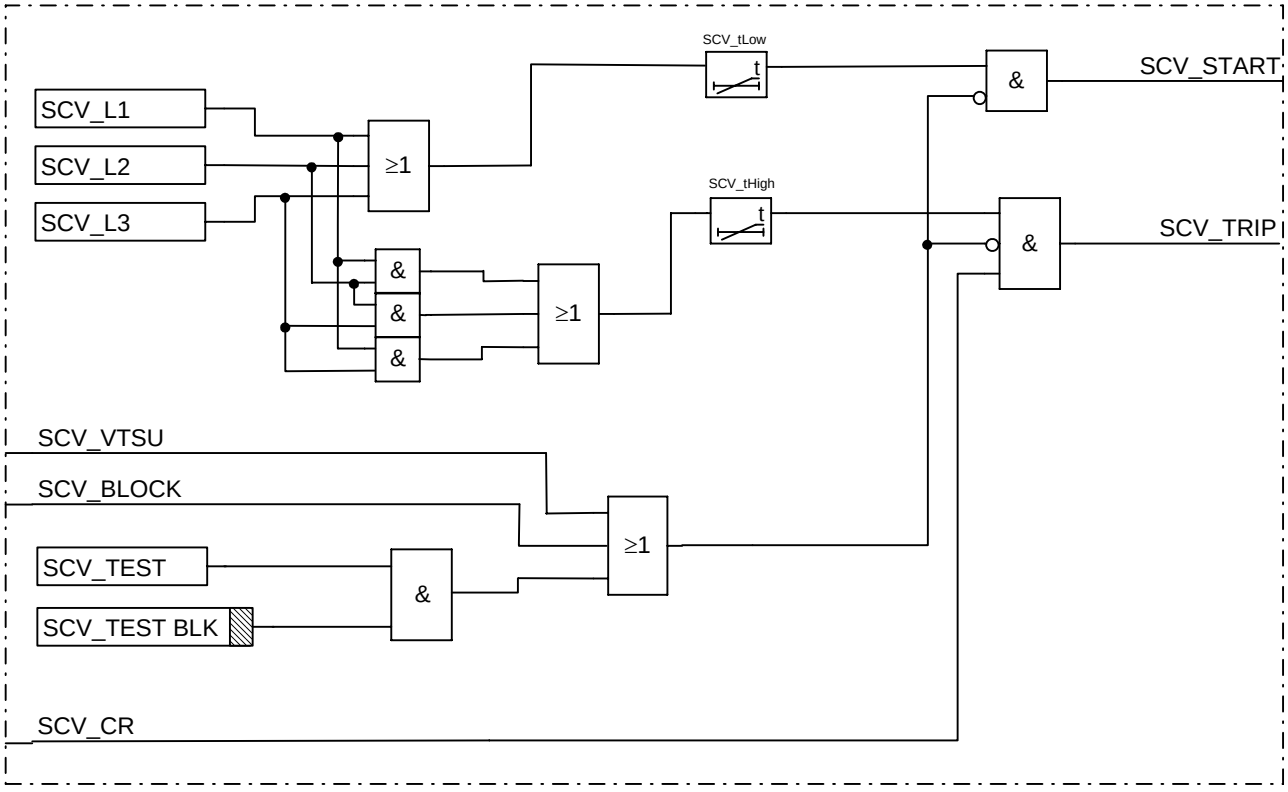


Figure 153: SCV logic

8.5 Input and output signals

Table 324: Input signals for the SCV (SCV--) function block

Signal	Description
BLOCK	Block of sudden change in voltage
VTSU	Block of sudden change in V by voltage circuit supervision
CR	Received signal from communication channel logic

Path in local HMI: ServiceReport/Functions/SystemProtec/SuddenChangeV/FuncOutputs

Table 325: Output signals for the SCV (SCV--) function block

Signal	Description
TRIP	Trip by sudden change in voltage
START	Start by sudden change in voltage

8.6 Setting parameters

Path in local HMI-tree: Settings/Functions/SystemsProtec/SuddenChangeV

Table 326: Settings for the sudden change in voltage protection SCV (SCV--)

Parameter	Range	Default	Unit	Description
Operation	On/Off	Off	-	Operation sudden change in voltage function, Off/On
DUL>	5.0 - 100.0 Step:0.1	20.0	% of U_b	Change in voltage limit
tHStart	0.000 - 60.000 Step: 0.001	0.000	s	Hold timer for start signal
tHTrip	0.000 - 60.000 Step: 0.001	0.000	s	Hold timer for trip signal

8.7 Technical data

Table 327: SCV - Sudden change in voltage protection function

Function	Setting range	Accuracy
Change in voltage per power system cycle, DUL>	5.0-100.0% of Ub in steps of 0.1%	± 0.5 % of U_r
Time delay for start signal, tHStart	0.000-60.000 s in steps of 1 ms	± 0.5 % ± 10 ms
Time delay for trip signal, tHTrip	0.000-60.000 s in steps of 1 ms	± 0.5 % ± 10 ms

9 Overvoltage protection (OVP)

9.1 Application

The overvoltage protection function (OVP) can be used wherever a "high voltage" signal is needed. The function can be used for applications where a high voltage is the result of an event that has to be indicated, or actions to reduce the time with high voltage levels are required.

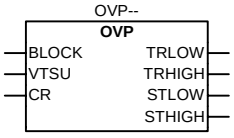
One application example is to take actions to quickly reduce high voltage levels by switching out shunt capacitors or switching in shunt reactors, in case of a long transmission connected in one end only.

9.2 Functionality

The overvoltage protection function (OVP) measures all three phase voltages on a protected power line. The measured voltage signals are extensively filtered, to secure high accuracy of the measurement. Each of two independent voltage measuring stages has its own, independently settable time delay.

The resetting ratio of the function is settable, to adjust the operation as much as possible to the expected system overvoltage conditions. This expecially when the big shunt reactors are used in the network to control the system overvoltages.

9.3 Function block



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9.4 Logic diagram

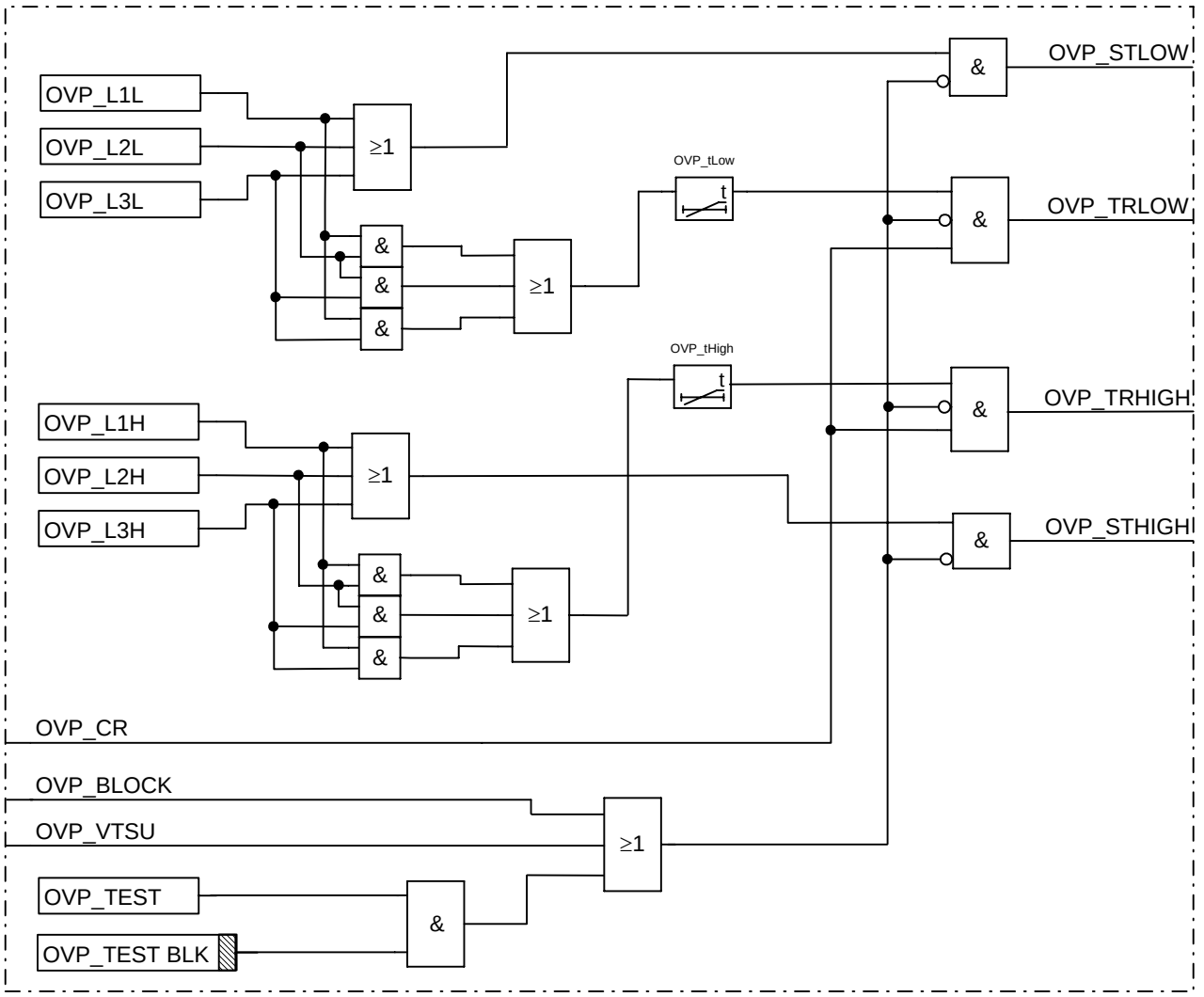


Figure 154: OVP logic

9.5 Input and output signals

Table 328: Input signals for the OVP (OVP--) function block

Signal	Description
BLOCK	Block of overvoltage protection
VTSU	Block of overvoltage protection by voltage circuit supervision
CR	Received signal from communication channel logic

Path in local HMI: ServiceReport/Functions/SystemProtec/OverVoltageP/FuncOutputs

Table 329: Output signals for the OVP (OVP--) function block

Signal	Description
TRLOW	Low-set trip by overvoltage protection
TRHIGH	High-set trip by overvoltage protection
STLOW	Low-set start by overvoltage protection
STHIGH	High-set start by overvoltage protection

9.6 Setting parameters

Path in local HMI-tree: Settings/Functions/SystemProtec/OverVoltageP

Table 330: Settings for the accurate overvoltage protection OVP (OVP--) function

Parameter	Range	Default	Unit	Description
Operation	On/Off	Off	-	Operation overvoltage protection function, Off/on
ULLow>	80.0 - 150.0 Step: 0.1	110.0	% of U_b	Low-set step of overvoltage limit
ULHigh>	80.0 - 150.0 Step: 0.1	120.0	% of U_b	High-set step of overvoltage limit
tLow	0.000 - 60.000 Step: 0.001	0.000	s	Time delayed operation of low-set step
tHigh	0.000 - 60.000 Step: 0.001	0.000	s	Time delayed operation of high-set step
Hysteresis	94.0 - 99.0 Step: 0.1	96.0	%	Reset ratio of low and high-set step

9.7 Technical data

Table 331: OVP - Accurate overvoltage protection function

Function	Setting range	Accuracy
Low-set operating value, ULLow>	80.0-150.0% of Ub in steps of 0.1%	± 2.5 % of U_r
High-set operating value, ULHigh>	80.0-150.0% of Ub in steps of 0.1%	± 2.5 % of U_r
Time delayed operation of low-set step, tLow	0.000-60.000 s in steps of 1 ms	± 0.5 % ± 10 ms
Time delayed operation of high-set step, tHigh	0.000-60.000 s in steps of 1 ms	± 0.5 % ± 10 ms

10 Accurate undercurrent protection function (UCP)

10.1 Application

The undercurrent protection function (UCP) can be used whenever a "low current" signal is needed. The main application is as a local criterion to increase security when transfer trips are used.

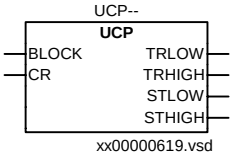
In many power systems transfer trips are used, i.e. a trip criterion in one substation will be transferred to an adjacent substation via some sort of communication system. For such solutions there is always a risk that a false transfer trip signal is generated in the communication system and causes an unwanted trip. In order to prevent such a scenario a local criterion can be added in the substation where the trip is intended to take place. Such a local criterion could be low current on a line, which, in a correct sequence, is disconnected in the remote end.

10.2 Functionality

When any phase current decreases under the setpoint value, a start signal is issued.

When a start signal is activated and the carrier received signal is true, a trip signal is issued after a settable time delay.

10.3 Function block



10.4 Logic diagram

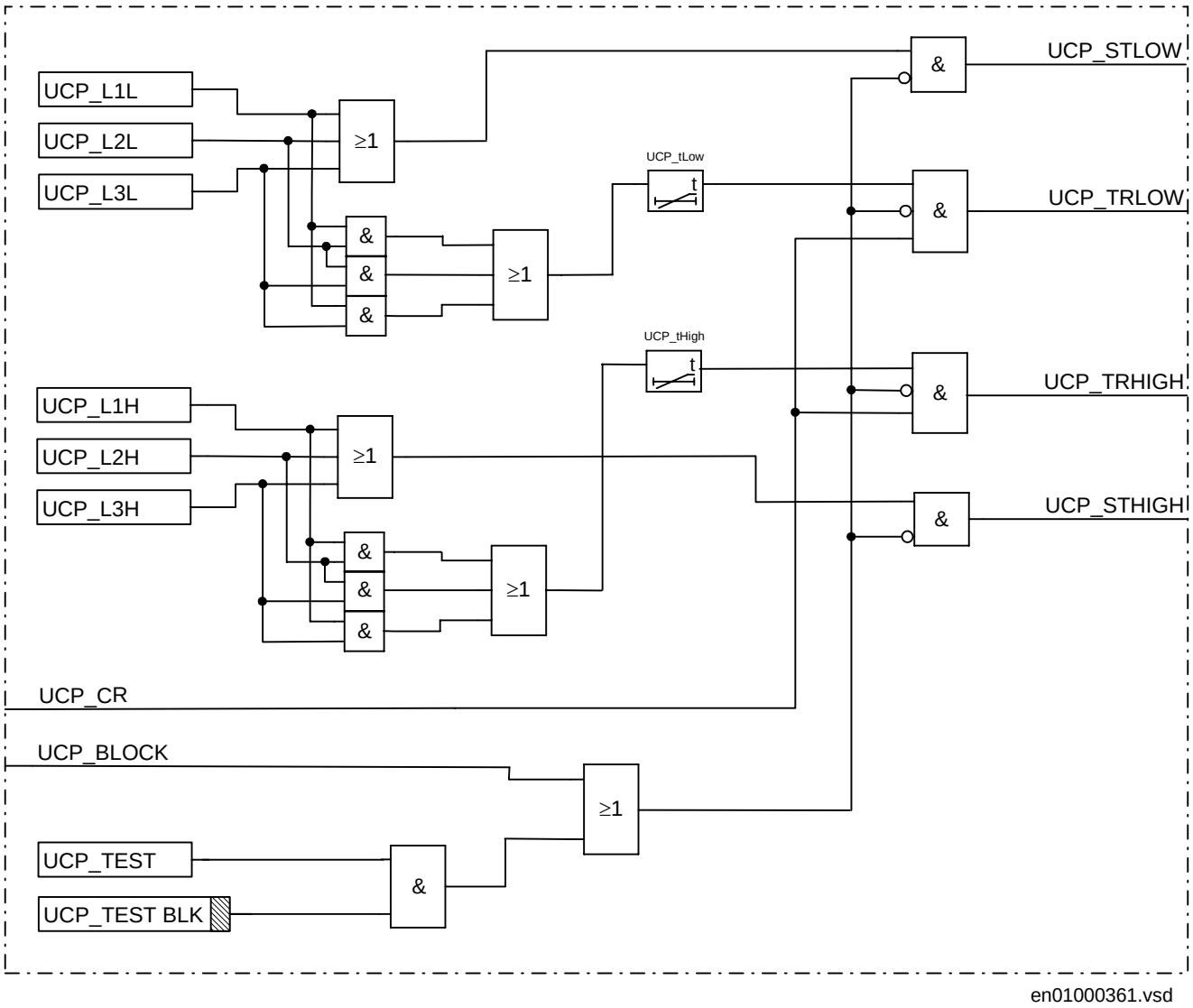


Figure 155: UCP logic

10.5 Input and output signals

Table 332: Input signals for the UCP (UCP--) function block

Signal	Description
BLOCK	Block of undercurrent protection
CR	Received signal from communication channel logic

Path in local HMI: ServiceReport/Functions/SystemProtec/UnderCurrentP/FuncOutputs

Table 333: Output signals for the UCP (UCP--) function block

Signal	Description
TRLOW	Low-set trip by undercurrent protection
TRHIGH	High-set trip by undercurrent protection
STLOW	Low-set start by undercurrent protection
STHIGH	High-set start by undercurrent protection

10.6 Setting parameters

Path in local HMI-tree: Settings/Functions/SystemProtec/UnderCurrentP

Table 334: Settings for the accurate undercurrent protection UCP (UCP--) function

Parameter	Range	Default	Unit	Description
Operation	On/Off	Off	-	Operation undercurrent protection function, Off/On
ILLow<	5.0 - 100.0 Step: 0.1	20.0	% of I_b	Low-set step of undercurrent limit
ILHigh<	5.0 - 100.0 Step: 0.1	30.0	% of I_b	High-set step of undercurret limit
tLow	0.000 - 60.000 Step: 0.001	0.000	s	Time delayed operation of low-set step
tHigh	0.000 - 60 000 Step: 0.001	0.000	s	Time delayed operation of high-set step

10.7 Technical data

Table 335: UCP - Undercurrent protection function

Function	Setting range	Accuracy
Low-set step of undercurrent limit, ILLow<	5.0-100.0% of Ib in steps of 0.1%	± 2.5 % of I_r
High-set step of undercurrent limit, ILHigh<	5.0-100.0% of Ib in steps of 0.1%	± 2.5 % of I_r
Time delayed operation of low-set step, tLow	0.000-60.000 s in steps of 1 ms	± 0.5 % ± 10 ms
Time delayed operation of high-set step, tHigh	0.000-60.000 s in steps of 1 ms	± 0.5 % ± 10 ms
Reset ratio	> 106% typically	

11 Phase overcurrent protection (OCP)

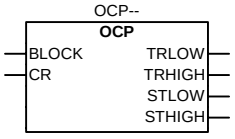
11.1 Application

The overcurrent protection function (OCP) can be used wherever a "high current" signal is needed. There is a number of applications for the high current protection, wherever current has to be limited, or certain actions have to be taken when the current exceeds specific values.

11.2 Functionality

The amplitude of the phase currents are calculated by means Fourier filtering. When any of the phase currents are larger than the setting values for the high-set step or the low-set step, the corresponding start signal will be activated. At the same time the corresponding timer will be started. After the timer for the step has elapsed and there is a CR signal, a trip signal will be activated.

11.3 Function block



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11.4 Logic diagram

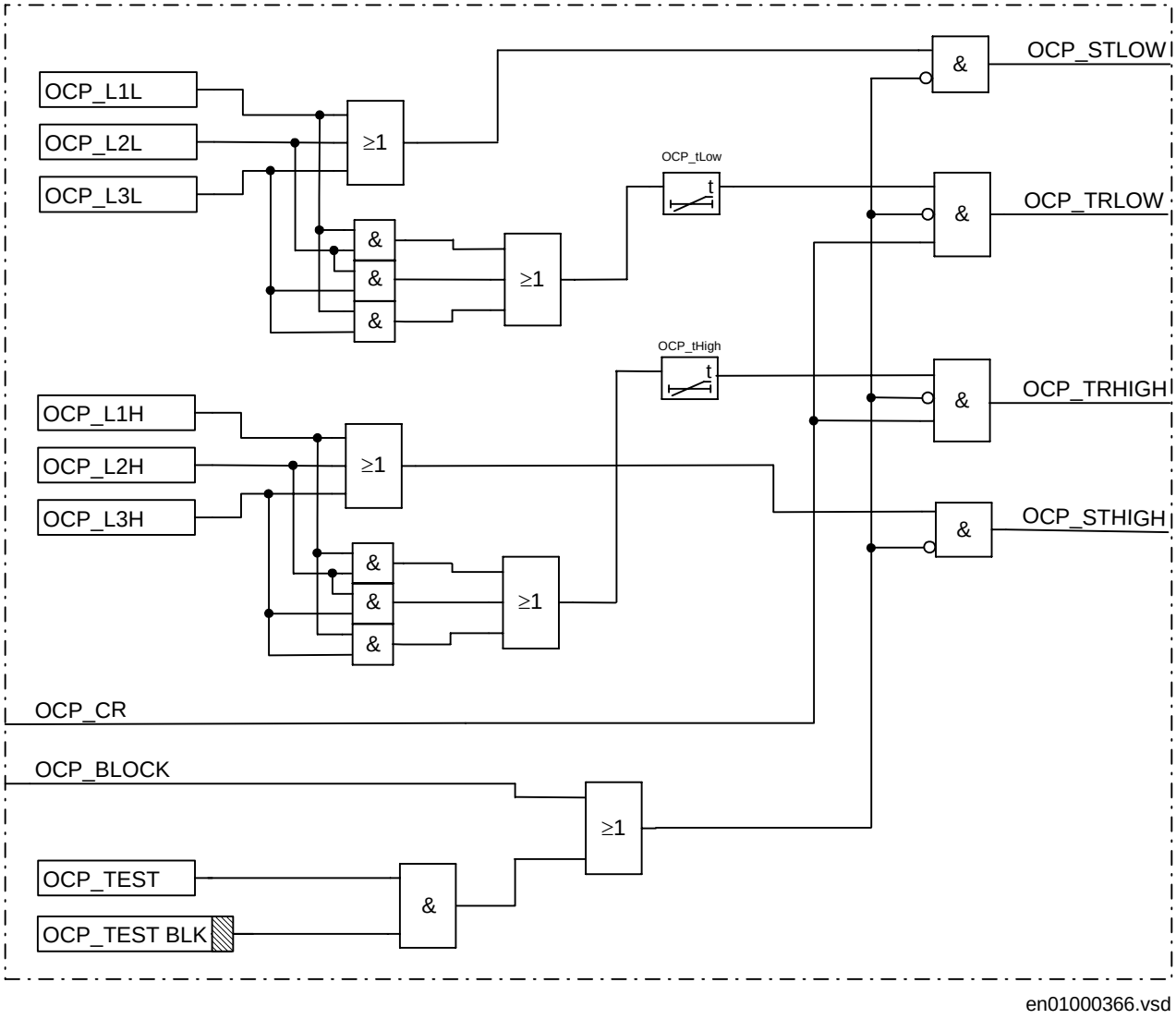


Figure 156: OCP logic

11.5 Input and output

Table 336: Input signals for phase overcurrent protection (OCP--) function

Signal	Description
BLOCK	Block of overcurrent protection
CR	Received signal from communication channel logic

11.6 Setting parameters

Path in local HMI-tree: Settings/Functions/SystemProtec/OverCurrentP

Table 337: Settings for the phase overcurrent protection OCP (OCP--) function

Parameter	Range	Default	Unit	Description
Operation	On/Off	Off	-	Operation overcurrent protection function, Off/On
ILLow>	5.0 - 200.0 Step: 0.1	120.0	% of I_b	Low-set step of overcurrent limit
ILHigh>	5.0 - 200.0 Step: 0.1	130.0	% of I_b	High set step of overcurrent limit
tLow	0.000 - 60.000 Step: 0.001	0.000	s	Time delayed operation of low-set step
tHigh	0.000 - 60.000 Step: 0.001	0.000	s	Time delayed operation of hig-set step

11.7 Technical data

Table 338: OCP - Overcurrent protection function

Function	Value	Accuracy
Low-set operating value, ILLow>	5.0-200.0% of Ib in steps of 0.1%	± 5.0 % of I_r
High-set operating value, ILHigh>	5.0-200.0% of Ib in steps of 0.1%	± 5.0 % of I_r
Time delay of low-set step, tLow	0.000-60.000 s in steps of 1 ms	± 0.5 % ± 10 ms
Time delay of high-set step, tHigh	0.000-60.000 s in steps of 1 ms	± 0.5 % ± 10 ms
Reset ratio	> 94% typically	

12 Residual overcurrent protection (ROCP)

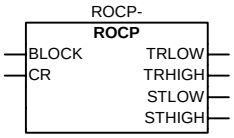
12.1 Application

The residual overcurrent protection function (ROCP) can be used wherever a high residual current signal is needed. There is a number of applications for the high residual current protection, most of them related to earth faults in low impedance earthed systems. One example is to use the residual overcurrent protection as a simple earth fault protection, as a back-up for the primary earth fault protection included in the line distance protection.

12.2 Functionality

The amplitude of the residual current is calculated by means Fourier filtering. When the residual current is larger than the setting value for the high-set step or the low set step, the corresponding start signal will be activated. At the same time the corresponding timer will be started. After the timer for the step has elapsed and there is a CR signal, a trip signal will be activated.

12.3 Function block



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12.4 Logic diagram

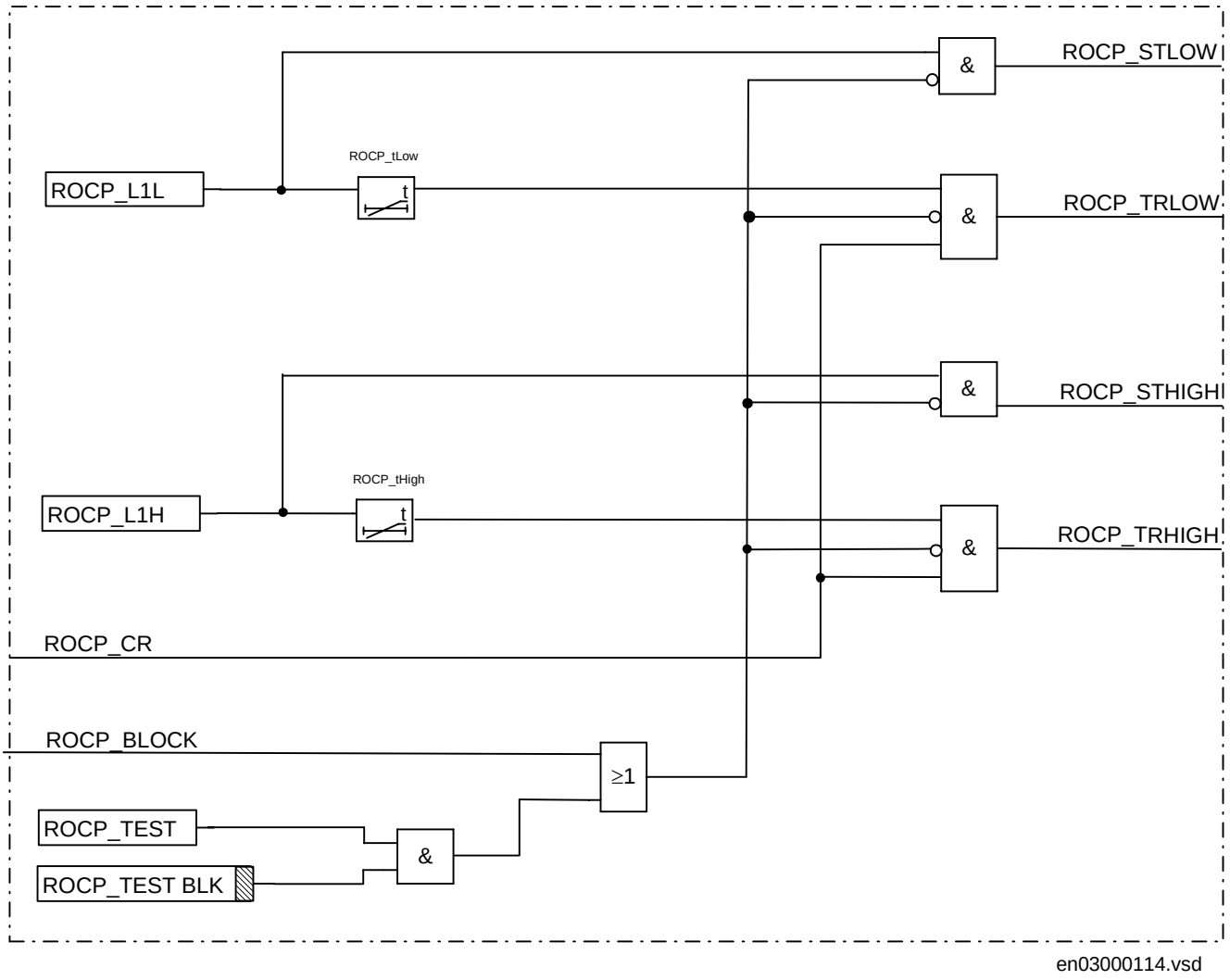


Figure 157: ROCP logic

12.5 Input and output signals

Table 339: Input signals for the ROCP (ROCP-) function block

Signal	Description
BLOCK	Block of residual overcurrent protection
CR	Received signal from communication channel logic

Path in local HMI: ServiceReport/Functions/SystemProtec/ResidOverCP/FuncOutputs

Table 340: Output signals for the ROCP (ROCP-) function block

Signal	Description
TRLOW	Low-set trip by residual overcurrent protection
TRHIGH	High-set trip by residual overcurrent protection
STLOW	Low-set start by residual overcurrent protection
STHIGH	High-set start by residual overcurrent protection

12.6 Setting parameters

Path in local HMI-tree: Settings/Functions/SystemsProtec/.....

Table 341: Settings for the residual overcurrent protection ROCP (ROCP--) function

Parameter	Range	Default	Unit	Description
Operation	On/Off	Off	-	Operation residual overcurrent protection function, Off/On
INLow>	5.0 - 100.0 Step: 0.1	20.0	% of I_b	Residual overcurrent limit
INHigh>	5.0 - 100.0 Step: 0.1	30.0	% of I_b	Residual overcurrent limit
tLow	0.000 - 60.000 Step: 0.001	0.000	s	Time delayed operation of low-set step
tHigh	0.000 - 60.000 Step: 0.001	0.000	s	Time delayed operation of high-set step
IMeasured	I4, I5	I4	-	Current signal used in function

12.7 Tecnical data

Table 342: ROCP - Residual overcurrent protection function

Function	Setting range	Accuracy
Residual overcurrent low-set limit, INLow>	5.0-100.0% of Ib in steps of 0.1%	± 2.5 % of I_r
Residual overcurrent high-set limit, INHigh>	5.0-100.0% of Ib in steps of 0.1%	± 2.5 % of I_r
Time delayed operation of low-set step, tLow	0.000-60.000 s in steps of 1 ms	± 0.5 % ± 10 ms
Time delayed operation of high-set step, tHigh	0.000-60.000 s in steps of 1 ms	± 0.5 % ± 10 ms
Reset ratio	> 95% typically	

Chapter 14 Data communication

About this chapter

This chapter describes the data communication and the associated hardware.

1 Remote end data communication

1.1 Application

The remote terminal communication modules can be used either for differential line protection applications or for binary signal transfer of up to 32 signals in both directions between, for example, distance protections. The following hardware modules are available:

- V35/36 contra-directional and co-directional
- X.21
- RS530/422 contra-directional and co-directional
- G.703
- Short-range galvanic module
- Fibre optical communication module
- Short-range fibre optical module

1.2 Setting parameters

Path in local HMI-tree: Configuration/TerminalCom/RemTermCom

Table 343: Setting parameters for remote terminal communication

Parameter	Range	Default	Unit	Description
TerminalNo	0-255 Step: 1	0	-	Select number for this terminal
RemoteTermNo	0-255 Step: 1	0	-	Select number for remote terminal
CommSync	Master, Slave	Master	-	Select Master or Slave for communication synchronisation
BitRate	56 kb/s, 64kb/s	56 kb/s		Select bitrate for Codir communication
OptoPower	Low, High	Low	-	Select High or Low opto power
Format	2.0, 2.2/2.3	2.2/2.3	-	Line differential telegram format

1.3 Fibre optical module

1.3.1 Application

The fibre optical communication module DCM-FOM can be used both with multi-mode and single-mode fibres.The communication distance can typically be 40-60 km for single mode fibre and typically 15-20 km for multi-mode fibre, and even further with high quality fibre. This interface can also be used for direct connection with communication equipment of type FOX 512/515 from ABB.

1.3.2 Technical data

Table 344: DCM-FOM - Fibre optical communication module

Optical interface		
Type of fibre	Graded-index multimode 50/125μm or 62,5/125μm	Single mode 9/125 μm
Wave length	1300 nm	1300 nm
Optical transmitter injected power	LED -17 dBm	LED -22 dBm
Optical receiver sensitivity	PIN diode -38 dBm	PIN diode -38 dBm
Optical budget	21 dB	16 dB
Transmission distance	typical 15-20 km [a)]	typical 40-60 km [a)]
Optical connector	Type FC-PC	Type FC-PC
Protocol	ABB specific	ABB specific
Data transmission	Synchronous, full duplex	Synchronous, full duplex
Transmission rate	64 kbit/s	64 kbit/s
Clock source	Internal or derived from received signal	Internal or derived from received signal
[a)] depending on optical budget calculation, see example in Application manual for REC 561		

1.4 Galvanic interface

1.4.1 Application

The galvanic data communication modules according to V35/36 DCM-V36 contra, DCM-V36 co, X.21 DCM-X21, RS530/422 DCM-RS 530 contra, DCM-RS 530 co can be used for galvanic short range communication covering distances up to 100 m in low noise environments. Only contra-directional operation is recommended for best system performance. These modules are designed for 64 kbit/s operation but can also be used at 56 kbit/s.

1.4.2 Technical data

Table 345: DCM - 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
RS 530/RS422 Co-directional (on request)	EIA	D-sub 25 pins

Interface type	**According to standard**	**Connector type**
RS 530/RS422 Contra-directional	EIA	D-sub 25 pins
G.703 Co-directional	ITU (CCITT)	Screw
Function	**Value**	
Data transmission	synchronous, full duplex	
Transmission type	56 or 64 kbit/s	
	For G703 only 64 kbit/s	

1.5 Short range galvanic module

1.5.1 Application

The short-range galvanic module DCM-SGM can be used for communication over galvanic pilot wires and can operate over distances of up to 3 km depending on pilot wire cable. Twisted-pair or double-shielded cable is recommended.

1.5.2 Technical data

Table 346: DCM-SGM - Short-range galvanic module

Data transmission	Synchronous, full duplex
Transmission rate	64 kbit/s (256 kBaud; code transparent)
Clock source	Internal or derived from received signal
Range	< 3 km
Line interface	Balanced symmetrical three-state current loop (4 wires)
Connector	5-pin connector with screw connection
Insulation	2,5 kV 1 min. Opto couplers and insulating DC/DC-converter
	15 kV with additional insulating transformer

1.6 Short range fibre optical module

1.6.1 Application

The short-range fibre optical module DCM-SFOM can only be used with multi-mode fibre.The communication distance is normally 3 to 5 km. This module can also be used for direct connection to optical/electrical communication converters of type 21-15xx and 21-16xx from FIBERDATA

Physically the DCM module is inserted in slot position S19 for 1/2 19” rack.

Physically the DCM module is inserted in slot position S29 for 3/4 19” rack.

1.6.2 Technical data

Table 347: DCM-SFOM - Short-range fibre optical module

Data transmission	Synchronous, full duplex
Transmission rate	64 kbit/s
Clock source	Internal or derived from received signal
Optical fibre	Graded-index multimode 50/125μm or 62,5/125μm
Wave length	850 nm
Optical connectors	ST
Optical budget	15 dB
Transmission distance	typically 3-5 km [a)]
Protocol	FIBERDATA specific
Optical connector	Type ST
[a)] depending on optical budget calculation, see example in Application manual for REC 561	

1.7 Co-directional G. 703 galvanic interface

1.7.1 Application

The galvanic data communication module DCM-G.703 according to G.703 is not recommended 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.

1.8 Carrier module

1.8.1 Application

Use the carrier module with the appropriate galvanic or optical communication submodule for short range communication of binary signals. Use the optical communication module (DCM-SFOM) when connecting a FIBERDATA 21-15X or FIBERDATA 21-16X optical-to-electric modem. The 21-15X model supports V.35 and V.36 standards, and the 21-16X model X.21 or G.703 standards.

1.8.2 Design

The carrier module is used to connect a communication sub-module to the platform. It adds the CAN-communication and the interface to the rest of the platform. By this the capability to transfer binary signals between for example two distance protection units is added.

The following three types of sub-modules can be added to the carrier module:

- Short range galvanic communication module (DCM-SGM)
- Short range optical communication module (DCM-SFOM)
- G.703 communication module (DCM-G.703)

The carrier module senses the type of sub-module via one of the two connectors.

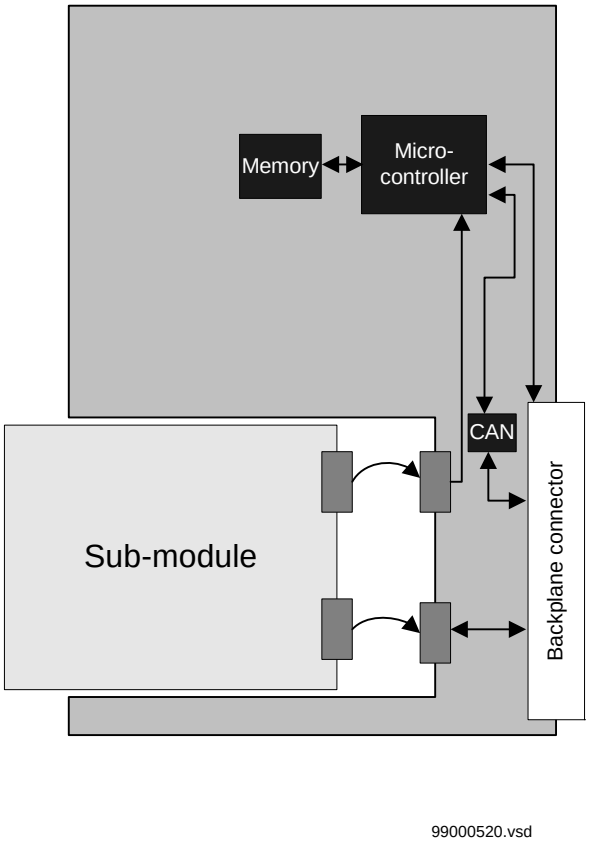


Figure 158: Block diagram for the carrier module.

2 Serial communication

2.1 Application, common

One or two optional serial interfaces with LON protocol, SPA protocol 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. For more information, please refer to Table 348: "Serial communication protocols - possible combinations of interface and connectors".

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.

2.2 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.

The communciation alternatives available are shown in table 348.

Table 348: Serial communication protocols - possible combinations of interface and connectors

	Alt. 1	Alt. 2	Alt. 3
X13	SPA/IEC fibre optic	SPA/IEC RS485	SPA fibre optic
X15	LON fibre optic	LON fibre optic	IEC fibre optic

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 or a RS485 network according to EIA Standard RS-485. 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 540.

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.

2.3 Setting parameters

Path in local HMI: Configuration/TerminalCom/SPA-IEC-LON

Table 349: Setting parameter for selection of communication protocols for rear ports

Parameter	Range	Default	Unit	Description
Port	SPA-LON, IEC-LON, SPA-IEC	SPA-LON	-	Communication protocol alternatives for the rear communication ports

2.4 Serial communication, SPA

2.4.1 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 ITU (former CCITT) characteristics.

2.4.2 Design

When communicating with a PC, using the rear SPA port, the only hardware needed for a station monitoring system is:

- Optical fibres
- Opto/electrical converter for the PC
- PC

or

- An RS485 network installation according to EIA
- PC

Remote communication over the telephone network also requires a telephone modem.

The software needed in the PC, either local or remote, is CAP 540.

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.

2.4.3 Setting parameters

Path in local HMI: Configuration/TerminalCom/SPACom/Rear

Table 350: 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
ActGrpRestrict	Open, Block	Open	-	Open = Access right to change between active groups
SettingRestrict	Open, Block	Open	-	Open = Access right to change any parameter

Path in local HMI:Configuration/TerminalCom/SPACom/Front

Table 351: 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

2.4.4 Technical data

Table 352: Serial communication (SPA), rear communication port

Function	Value
Protocol	SPA
Communication speed	300, 1200, 2400, 4800, 9600, 19200 or 38400 Bd
Slave number	1 to 899
Remote change of active group allowed	yes/no
Remote change of settings allowed	yes/no

Table 353: Serial communication (RS485)

Function	Value
Protocol	SPA/IEC 60870-5-103
Communication speed	9600 Bd

Table 354: Serial communication (SPA) via front

Function	Value
Protocol	SPA
Communication speed for the terminals	300, 1200, 2400, 4800, 9600 Bd
Slave number	1 to 899
Change of active group allowed	Yes
Change of settings allowed	Yes

2.5 Serial communication, IEC (IEC 60870-5-103 protocol)

2.5.1 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.

2.5.2 Design

The IEC protocol may be used alternatively on a fibre optic or on an RS485 network. The fibre optic network is point to point only, while the RS485 network may be used by multiple terminals in a multidrop configuration.

Note!

The RS485 network shall be terminated properly according to the standard, either in the relay terminal, by choosing the terminated RS485 interface, or externally as described in "Informative excerpt from EIA Standard RS485" in the Installation and commissioning manual.

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.

2.5.3 IEC 60870-5-103

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

Glass or plastic fibre should be used for the optical ports. BFOC2.5 is the recommended interface to use (BFOC2.5 is the same as ST connectors). ST connectors are used with the optical power as specified in standard, please see the Installation and commissioning manual.

For the galvanic interface RS485, use terminated network according to EIA Standard RS-485. The modem contact for the cable is Phoenix MSTB2.5/6-ST-5.08 1757051.

For more information please see the IEC standard IEC 60870-5-103.

Table 355: 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 I>> (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 group	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 356: 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 357: 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

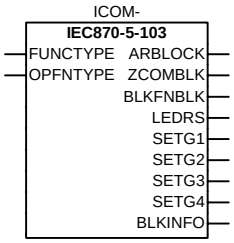
Table 358: Interoperability, physical layer

	Supported
Electrical Interface	
EIA RS485	NoYes
number of loads	No4
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 BFOC2, 5	Yes

Table 359: 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 II	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 transmission	Yes
Selection of basic application functions		
	Test mode	No
	Blocking of monitoring direction	Yes
	Disturbance data	Yes
	Private data	No
	Generic services	No

2.5.4 Function block



2.5.5 Input and output signals

Table 360: Input signals for the IEC (ICOM-) function block

Signal	Description
FUNCTYPE	Main function type for terminal
OPFNTYPE	Main function type operation for terminal

Path in local HMI: ServiceReport/Functions/IEC103Command

Table 361: 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.

2.5.6 Setting parameters

Table 362: Setting parameters for the IEC (ICOM-) function block

Parameter	Range	Default	Unit	Description
FuncType	0-255	0	-	Main function type for terminal Set from CAP 540
OpFnType	Off, On	Off	-	Main function type operation for terminal Set from CAP 540

Path in local HMI: Configuration/TerminalCOM/IECCom/Commands/ARBlock

Table 363: Setting parameters for controlling autorecloser command

Parameter	Range	Default	Unit	Parameter description
Operation	On, Off	Off	-	Operation mode of autorecloser command. On=Blocked, Off=Released

Path in local HMI: Configuration/TerminalCom/IECCom/Commands/ZCommBlock

Table 364: Configuration/TerminalCom/IECCom/Commands/ZCommBlock

Parameter	Range	Default	Unit	Parameter description
Operation	On, Off	Off	-	Operation mode of protection command. On=Blocked, Off=Released

Path in local HMI: Configuration/TerminalCom/IECCom/Commands/LEDReset

Table 365: Setting parameter for controlling the LED reset command

Parameter	Range	Default	Unit	Parameter description
Operation	On, Off	Off	-	Operation mode of LED reset command. On=Blocked, Off=Released

Path in local HMI: Configuration/TerminalCom/IECCom/Commands/SettingGrpn where n=1-4

Table 366: Setting parameter for controlling the active setting group n command. n=1-4

Parameter	Range	Default	Unit	Parameter description
Operation	On, Off	Off	-	Operation mode of active setting group command. On=Blocked, Off=Released

Path in local HMI: Configuration/TerminalCom/IECCom/Measurands

Table 367: Setting parameter for measurand type

Parameter	Range	Default	Unit	Parameter description
MeasurandType	3.1, 3.2, 3.3, 3,4, 9	3.1	-	Measurand types according to the standard

Path in local HMI: Configuration/TerminalCom/IECCom/FunctionType

Table 368: Setting parameters for main function types

Parameter	Range	Default	Unit	Parameter description
Operation	On, Off	Off	-	
MainFuncType	1-255		-	Main function types according to the standard

Path in local HMI: Configuration/TerminalCom/IECCom/Communication

Table 369: Setting parameters for IEC communication

Parameter	Range	Default	Unit	Parameter description
SlaveNo	0-255	30	-	Slave number
BaudRate	9600, 19200	19200	Baud	Communication speed

Path in local HMI: Configuration/TerminalCom/IECCom/BlockOfInfoCmd

Table 370: IEC command

Command	Command description
BlockOfInfoCmd	Command with status and confirmation. Controls information sent to the master.

2.5.7 Technical data

Table 371: Serial communication (IEC 60870-5-103)

Function	Value
Protocol	IEC 60870-5-103
Communication speed	9600, 19200 Bd

Table 372: Serial communication (RS485)

Function	Value
Protocol	SPA/IEC 60870-5-103
Communication speed	9600 Bd

2.6 Serial communication, LON

2.6.1 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.

2.6.2 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, software or/and the application library LIB 520 together with MicroSCADA is needed.

2.6.3 Setting parameters

Path in local HMI: Configuration/TerminalCom/LONCom/NodeInfo/AddressInfo

These parameters can only be set with the LNT, LON Network Tool. They can be viewed in the local HMI.

Table 373: Setting parameters for the LON communication

Parameter	Range	Default	Unit	Parameter description
DomainID	0	0	-	Domain identification number
SubnetID	0 - 255 Step: 1	0	-	Subnet identification number
NodeID	0 - 127 Step: 1	0	-	Node identification number

Path in local HMI: Configuration/TerminalCom/LONCom/NodeInfo

These parameters can only be set with the LNT, LON Network Tool. They can be viewed in the local HMI.

Table 374: LON node information parameters

Parameter	Range	Default	Unit	Parameter description
NeuronID	0 - 12	Not loaded	-	Neuron hardware identification number in hexadecimal code
Location	0 - 6	No value	-	Location of the node

Path in local HMI: Configuration/TerminalCom/LONCom/SessionTimers

Table 375: Setting parameters for the session timers

Parameter	Range	Default	Unit	Parameter description
SessionTmo	1-60	20	s	Session timeout. Only to be changed after recommendation from ABB.
RetryTmo	100-10000	2000	ms	Retransmission timeout.Only to be changed after recommendation from ABB.
IdleAckCycle	1-30	5	s	Keep active ack.Only to be changed after recommendation from ABB.
BusyAckTmo	100-5000	300	ms	Wait before sending ack.Only to be changed after recommendation from ABB.
ErrNackCycle	100-10000	500	ms	Cyclic sending of nack. Only to be changed after recommendation from ABB.

Path in local HMI: Configuration/TerminalCom/LONCom

Table 376: LON commands

Command	Command description
ServicePinMsg	Command with confirmation. Transfers the node adress to the LON network tool.
LONDefault	Command with confirmation. Resets the LON communication in the terminal.

2.6.4 Technical data

Table 377: LON - Serial Communication

Function	Value
Protocol	LON
Communication speed	1.25 Mbit/s

2.7 Serial communication modules (SCM)

2.7.1 Design, SPA/IEC

The serial communication module for SPA/IEC is placed in a slot at the rear of the main processing module. One of the following conection options is available for serial communication:

- two plastic fibre cables; (Rx, Tx) or
- two glass fibre cables; (Rx, Tx) or
- galvanic RS485

The type of connection is chosen when ordering the terminal.

The fibre optic SPA/IEC port can be connected point-to-point, in a loop, or with a star coupler. The incoming optical fibre is connected to the Rx receiver input and the outgoing optical fibre to the Tx transmitter output. The module is identified with a number on the label on the module.

The electrical RS485 can be connected in multidrop with maximum 4 terminals.

Note!

Pay special attention to the instructions concerning the handling, connection, etc. of the optical fibre cables.

2.7.2 Design, LON

The serial communication module for LON is placed in a slot at the rear of the Main processing module. One of the following options is available for serial communication:

- two plastic fibre cables; (Rx, Tx) or
- two glass fibre cables; (Rx, Tx)

The type of connection is chosen when ordering the terminal.

The incoming optical fibre is connected to the Rx receiver input and the outgoing optical fibre to the Tx transmitter output. The module is identified with a number on the label on the module.

Note!

Pay special attention to the instructions concerning the handling, connection, etc. of the optical fibre cables.

2.7.3 Technical data

Table 378: Optical fibre connection requirements for SPA/IEC

	Glass fibre	**Plastic fibre**
Cable connector	ST connector	HFBR, Snap-in connector
Fibre diameter	62.5/125 μm 50/125 μm	1 mm
Max. cable length	1000 m	25 m

Table 379: RS485 connection requirements for SPA/IEC

Cable connector	Phoenix, MSTB 2.5/6-ST-5.08 1757051
Cable dimension	SSTP according to EIA Standard RS485
Max. cable length	100 m

Table 380: LON - Optical fibre connection requirements for LON bus

	Glass fibre	**Plastic fibre**
Cable connector	ST-connector	HFBR, Snap-in connector
Fibre diameter	62.5/125 μm 50/125 μm	1 mm
Max. cable length	1000 m	25 m

Chapter 15 Hardware modules

About this chapter

This chapter describes the different hardware modules.

1 Modules

Table 381: Basic, always included, modules

Module	Description
Backplane module (BPM)	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)	Including a regulated DC/DC converter that supplies auxiliary voltage to all static circuits. • For case size 1/2x19" and 3/4x19" a version with four binary inputs and four binary outputs used. An internal fail alarm output is also 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. Carries up to 12 digital signal processors, performing all measuring functions.
Human machine interface (LCD-HMI)	The module consist of LED:s, a LCD, push buttons and an optical connector for a front connected PC
Signal processing module (SPM)	Module for protection algorithm processing. Carries up to 12 digital signal processors, performing all measuring functions.

Table 382: Application specific modules

Module	Description
Milliampere input module (MIM)	Analog input module with 6 independent, galvanically separated channels.
Binary input module (BIM)	Module with 16 optically isolated binary inputs
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 to remote terminal.
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.
Serial communication module (SCM)	Used for SPA/LON/IEC communication
LED module (LED-HMI)	Module with 18 user configurable LEDs for indication purposes

2 A/D module (ADM)

2.1 Design

The inputs of the A/D-conversion module (ADM) are 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 low-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.

3 Transformer module (TRM)

3.1 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
- Five current transformers

The inputs are mainly used for:

- 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.
- 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.

3.2 Technical data

Table 383: TRM - Energizing quantities, rated values and limits

Quantity	Rated value	Nominal range
Current	I_r = 1 or 5 A	(0.2-30) × I_r
	I_r=0.1, 0.5, 1 or 5 A for I_5	
Operative range	(0.004-100) x I_r	
Permissive overload	4 × I_r cont.	
	100 × 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	
Ac voltage for the terminal	U_r = 110 V **)	100/110/115/120 V
	U_r = 220 V **)	200/220/230/240 V
Operative range	(0.001-1.5) x U_r	

Quantity	Rated value	Nominal range
Permissive overload	2.3 × U_r phase-earth, cont. 3.0 x U_r phase-earth, for 1 s	
Burden	< 0.2 VA at U_r	
Frequency	f_r = 50/60 Hz	+/-10%
*) max. 350 A for 1 s when COMBITEST test switch is included. **) The rated voltage of each individual voltage input U1 to U5 is $U_r/\sqrt{3}$		

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, and increase the disturbance immunity during normal protection operate times. This is achieved with a high peak in-rush 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 384: BIM, IOM, PSM - 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 +/-20%	48/60 VDC +/-20%	110/125 VDC +/-20%	220/250 VDC +/-20%
Power dissipation (max.)	0.05 W/input	0.1 W/input	0.2 W/input	0.4 W/input
*) Only available for BIM				

Table 385: BOM, IOM, PSM - 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

Function or quantity		**Trip and Signal relays**	**Fast signal relays**
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
Power consumption for each output relay		≤ 0.15 W	

Table 386: Power consumption

Module	**Power consumption**
Binary input/output module (IOM)	≤ 1.0 W
Binary input module (BIM)	≤ 0.5 W
Binary output module (BOM)	≤ 1.0 W

5 Binary input module (BIM)

5.1 Application

The binary input module has 16 optically isolated inputs and 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

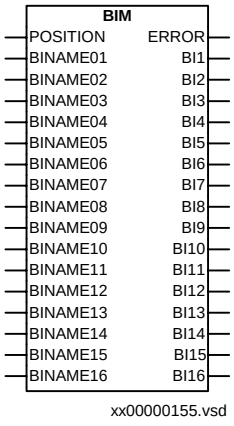


Figure 159: Binary input module

5.4 Input and output signals

Table 387: Input signals for binary input module BIM

Signal	Description
POSITION	I/O module slot position
BINAME01-BINAME16	Input name string settings

Path in local HMI: ServiceReport/IO/Slotnn-BIMn/FuncOutputs

Table 388: Output signals for binary input module BIM

Signal	Description
ERROR	Binary module fail
BI1-BI16	Binary input data

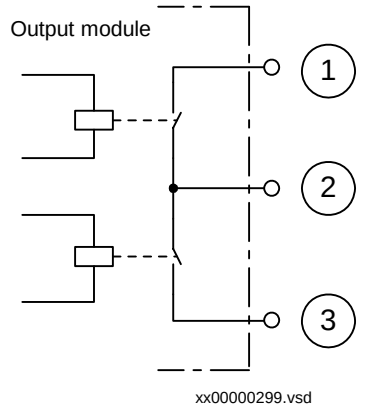
6 Binary output module (BOM)

6.1 Application

The binary output module has 24 independent output relays and is used for trip output or any signalling purpose.

6.2 Design

The binary output module (BOM) has 24 software supervised output relays. Two relays share a common power source input. This should be considered when connecting the wiring to the connection terminal on the back of the IED.



1	Output connection from relay 1
2	Ootput signal power source connection
3	Output connection from relay 2

Figure 160: Relay pair example

6.3 Function block

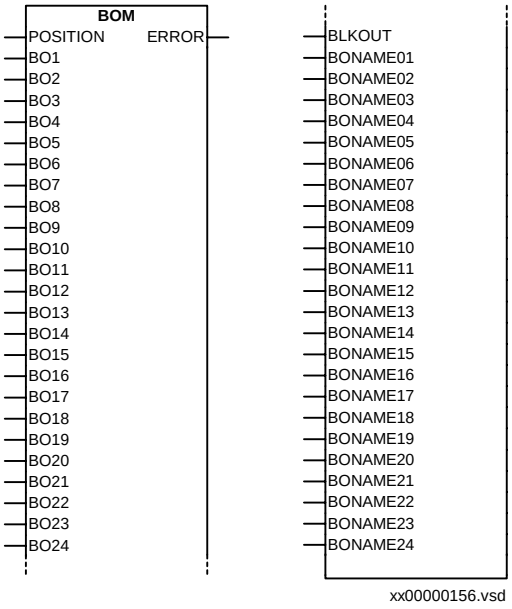


Figure 161: Binary output module

6.4 Input and output signals

Table 389: 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

Path in local HMI: ServiceReport/I/O/Slotnn-BOMn/FuncOutputs

Table 390: Output signals for binary output module BOM

Signal	Description
ERROR	Binary module fail

7 I/O module (IOM)

7.1 Application

The binary input/output module is used when only a few input and output channels are needed. The ten standard 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. Eight optically isolated binary inputs cater for required binary input information.

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.

Note!

The making capacity of the reed relays are limited.

7.3 Function block

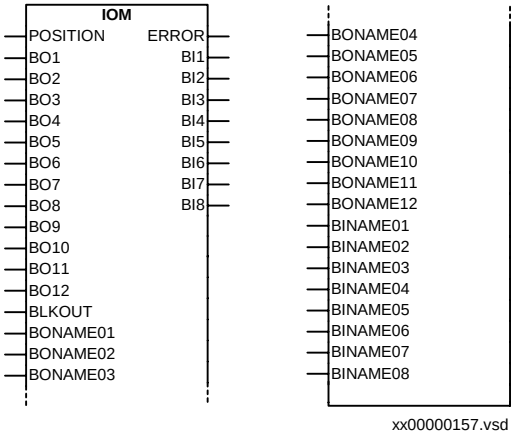


Figure 162: I/O module

7.4 Input and output signals

Table 391: 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

Path in local HMI: ServiceReport/I/O/slotnn-IOMn/FuncOutputs

Table 392: 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 analog measurements.

8.4 Technical data

Table 393: MIM - 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	-

Table 394: MIM - Temperature dependence

Dependence on	Within nominal range	Influence
Ambient temperature, mA-input ± 20 mA	-10°C to +55°C	0.02% / °C

9 Power supply module (PSM)

9.1 Application

The 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 power supply module, PSM, has four optically isolated binary inputs and four output relays.

9.3 Function block

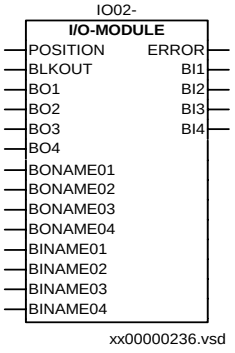


Figure 163: Binary I/O on the power supply module PSM

9.4 Input and output signals

Table 395: 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
BO1-BO4	Binary output data
BONAME01-BONAME04	Output name string settings
BINAME01-BINAME04	Input name string settings

Path in local HMI: ServiceReport/I/O/slotnn-PSMn/FuncOutputs

Table 396: 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 397: PSM - Power Supply Module

Quantity	Rated value	Nominal range
Auxiliary dc voltage	EL = (48 - 250) V	± 20%

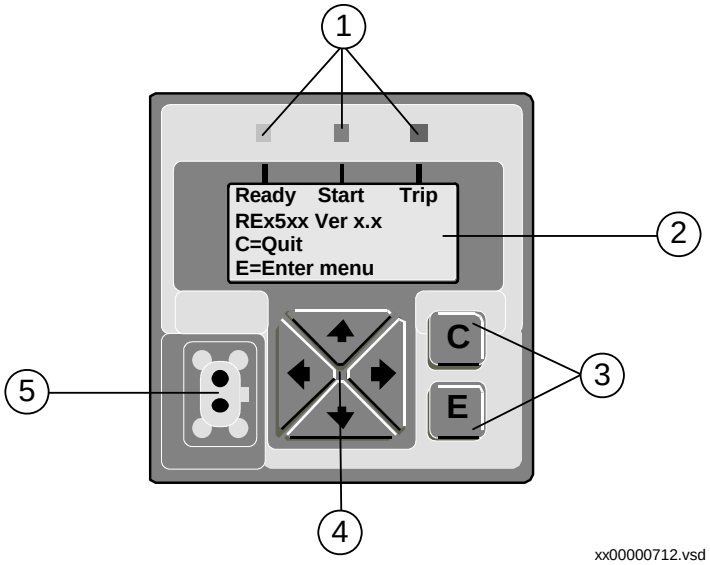
10 Local LCD human machine interface (LCD-HMI)

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.

10.2 Design



1. Status indication LEDs
2. LCD display
3. *Cancel* and *Enter* buttons
4. Navigation buttons
5. Optical connector

Figure 164: The LCD-HMI module

The number of buttons used on the HMI module is reduced to a minimum to allow a communication as simple as possible for the user. The buttons normally have more than one function, depending on actual dialogue.

11 18 LED indication module (LED-HMI)

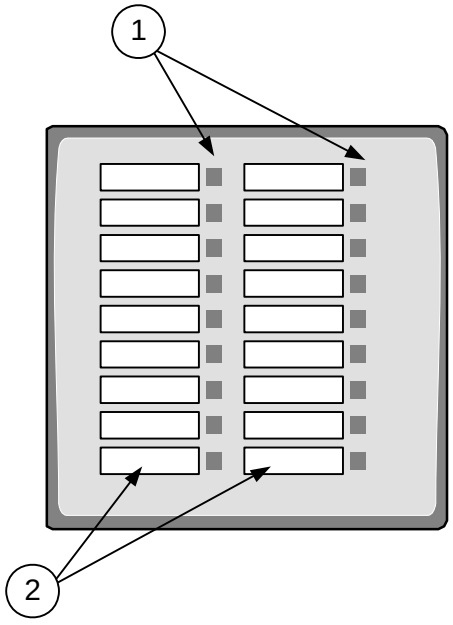
11.1 Application

The LED indication module is an option for the 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.

11.2 Functionality

The 18 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.

See LED indication function (HL, HLED) for details on application and functionality.



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1	Three-color LEDs
2	Descriptive label, user exchangeable

Figure 165: The 18 LED indication module (LED-HMI)

11.3 LED indication function (HL,HLED)

11.3.1 Application

Each LED indication on the HMI LED module 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. See Application manual for more detailed information.

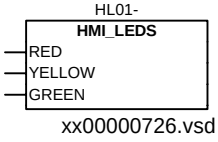
11.3.2 Design

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.

11.3.3 Function block



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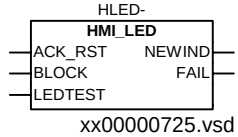


xx00000725.vsd

11.3.4 Input and output signals

Table 398: 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 399: 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.

Path in local HMI: ServiceReport/Functions/HMI LED

Table 400: 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.

11.3.5 Setting parameters

Path in local HMI: Settings/Functions/Groupn/HMI LED

Table 401: 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 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 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, Follow-F, LatchedAck-F-S, LatchedAck-S-F, LatchedColl-S, LatchedReset-S	Follow-S	-	Sequence type for the indication in LED n(n = 1-18). S = Steady and F = Flashing light.

12 Serial communication modules (SCM)

12.1 SPA/IEC

Refer to chapter Data communication.

12.2 LON

Refer to chapter Data communication.

13 Data communication modules (DCM)

For more informaton about the data communication modules, refer to the previous chapter 14 "Data communication".

Note!

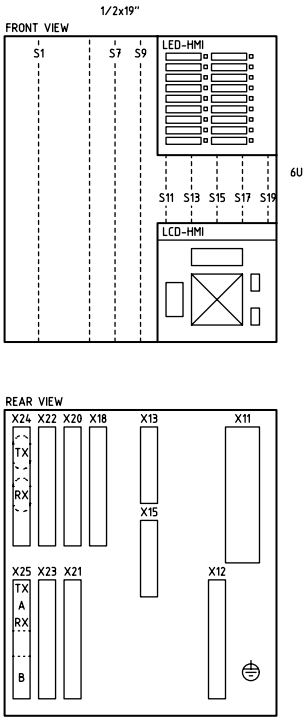
Instructions how to configure the digital communication modules, see Chapter Configuring the digital communication modules in the Installation and commissioning manual for each product.

Chapter 16 Diagrams

This chapter contains the terminal diagrams for the terminal.

1 Terminal diagrams

1.1 Terminal diagram, Rex5xx



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

TABLE 1

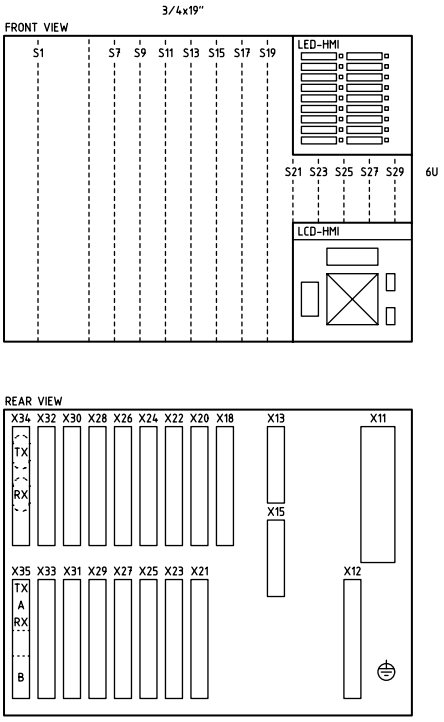
1) OPTION TRM AND ADM

2) BIM, BOM, IOM AND/OR MIM

3) BIM, BOM, IOM, MIM OR DCM

en03000143.eps

Figure 166: 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	-
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

2) BIM, BOM, IOM AND/OR MIM

3) BIM, BOM, IOM, MIM OR DCM

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Figure 167: Hardware structure of the 3/4 of full width 19” case

1.2 Terminal diagram, Rex5xx

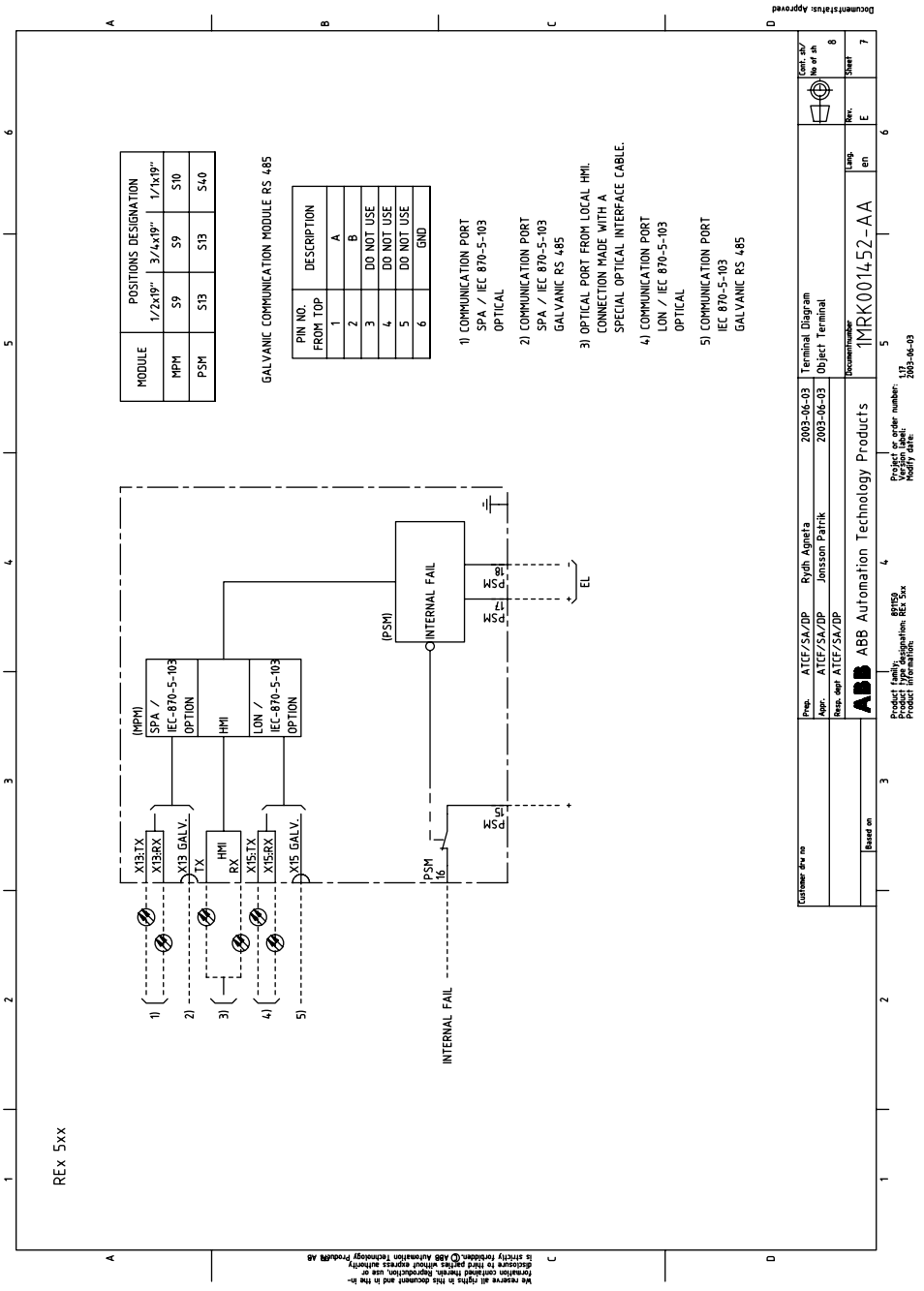

Figure 168: REx 5xx

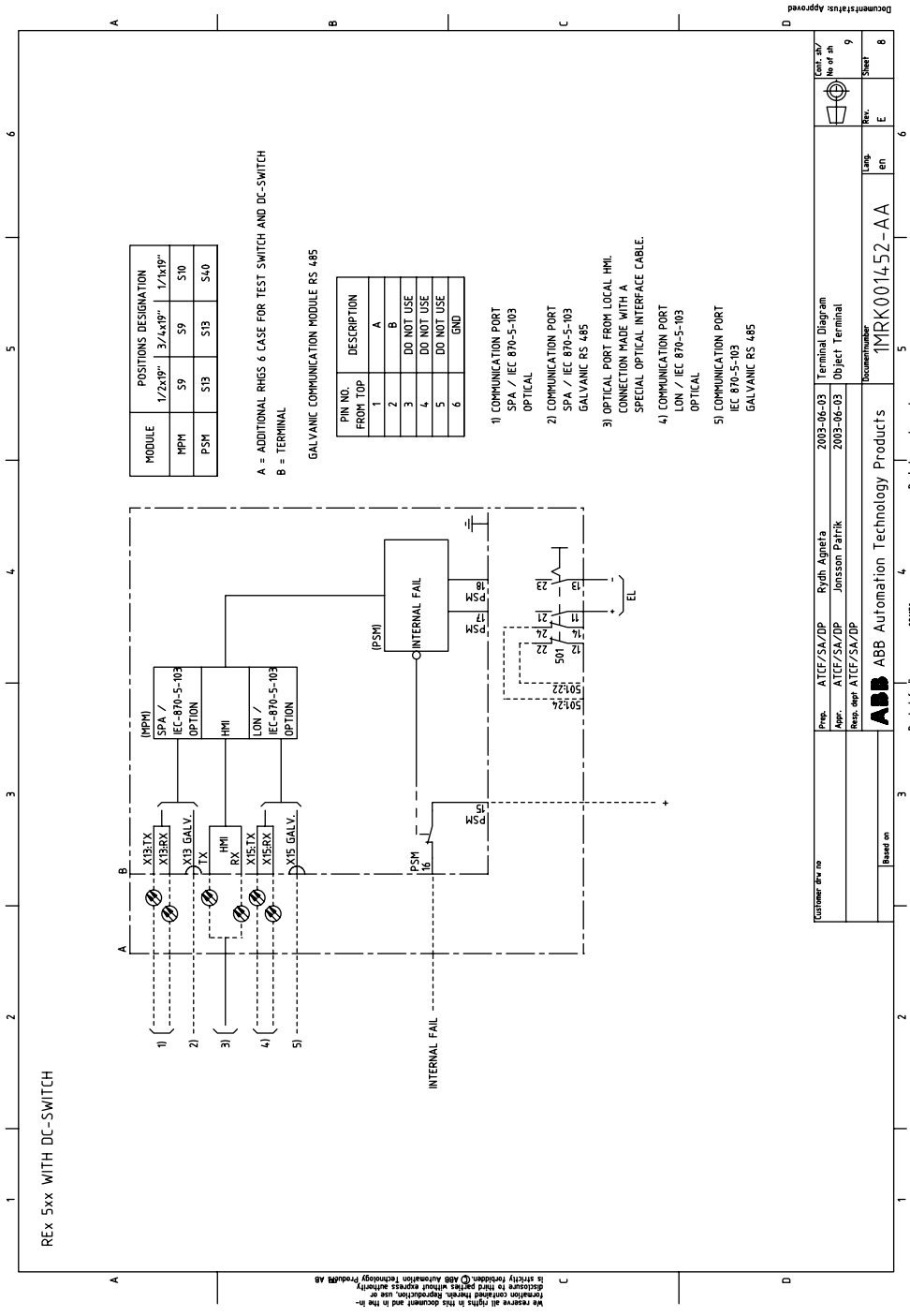

Figure 169: REx 5xx with DC-switch

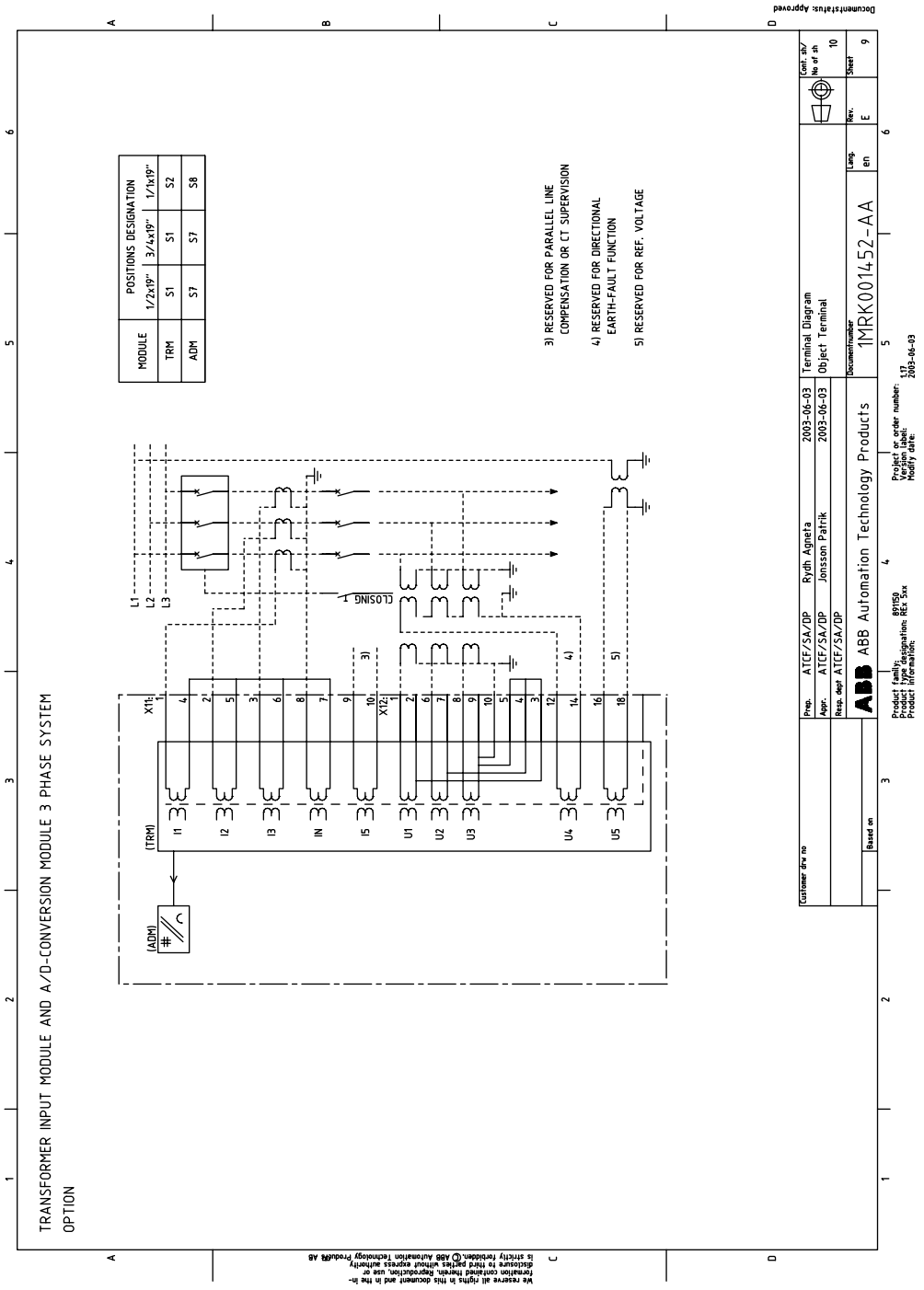

Figure 170: REx 5xx, transformer input module and A/D conversion module 3 phase system option

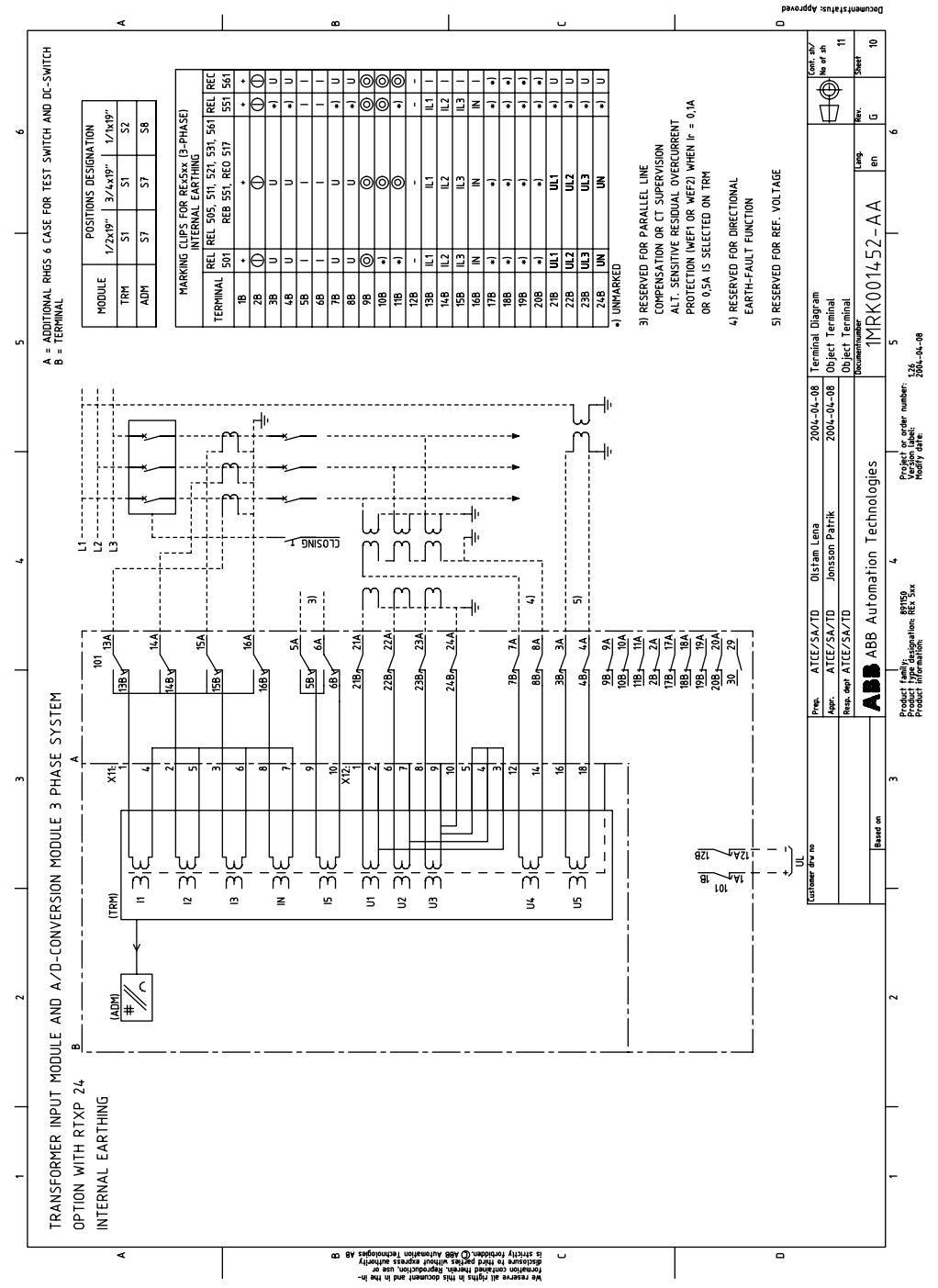

Figure 171: REx 5xx, transformer input module and A/D conversion module 3 phase system option with RTXP 24, internal earthing

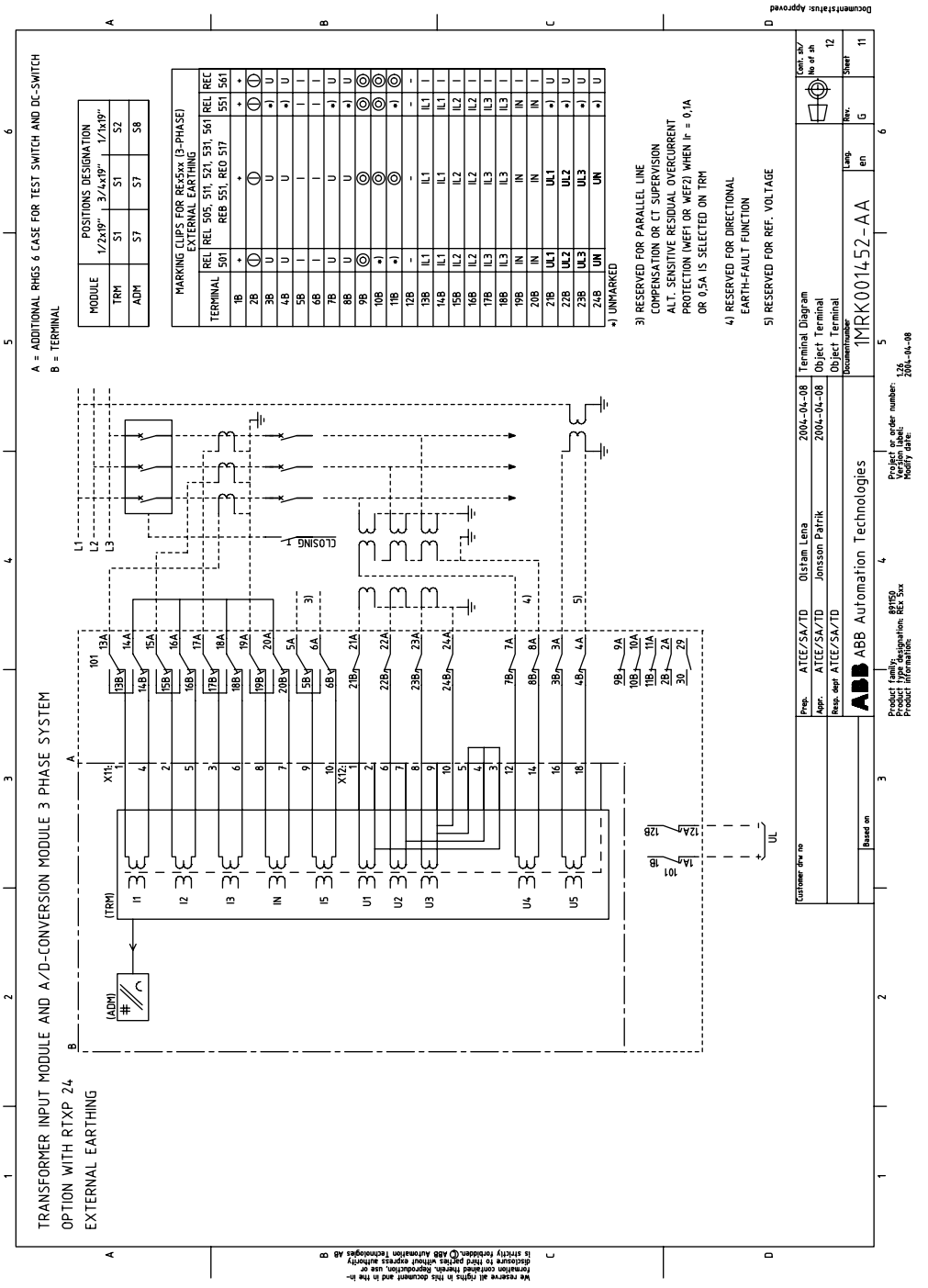

Figure 172: REx 5xx, transformer input module and A/D conversion module 3 phase system option with RTXP 24, external earthing

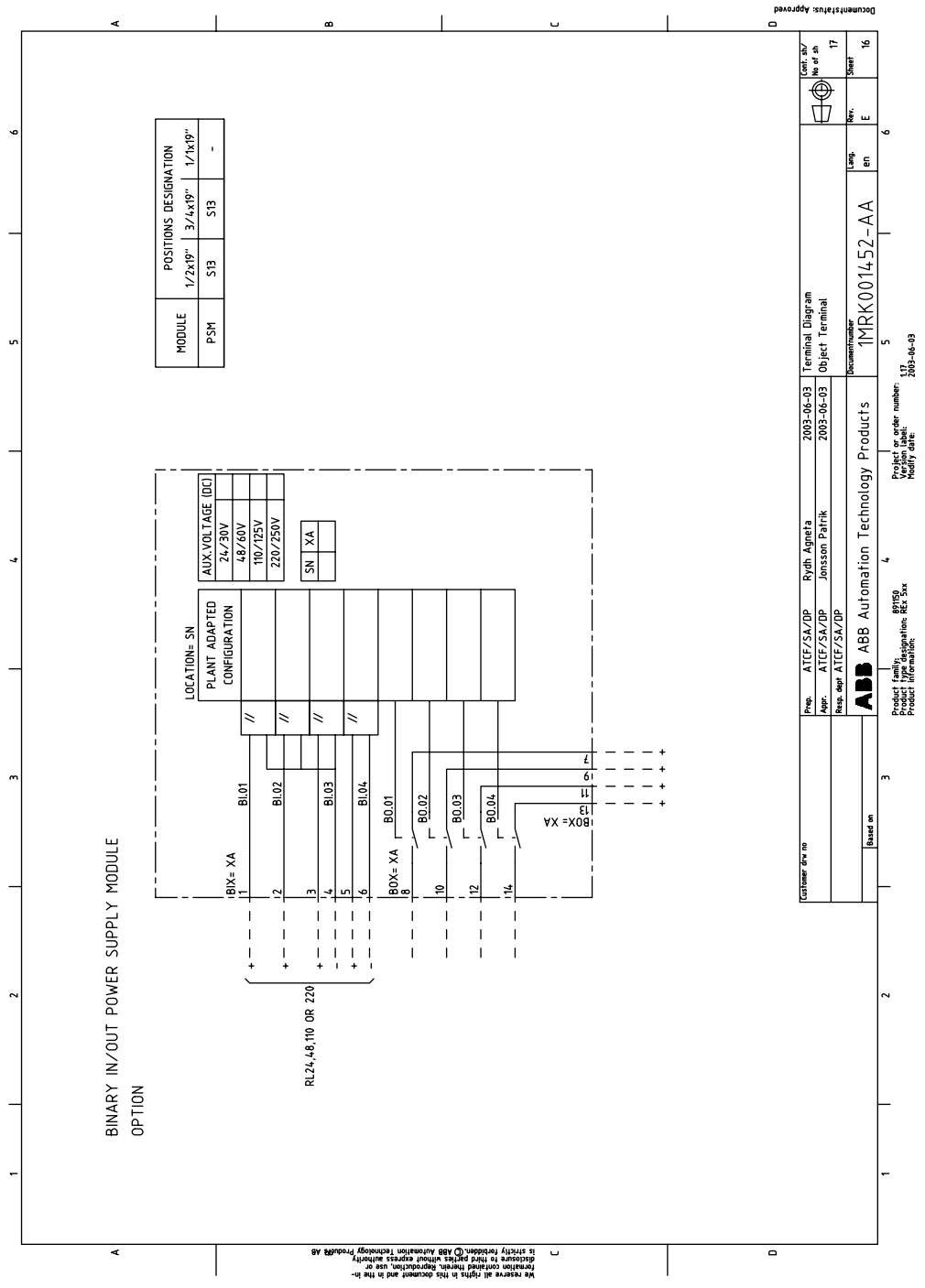

Figure 173: REx 5xx, binary in/out power supply module option

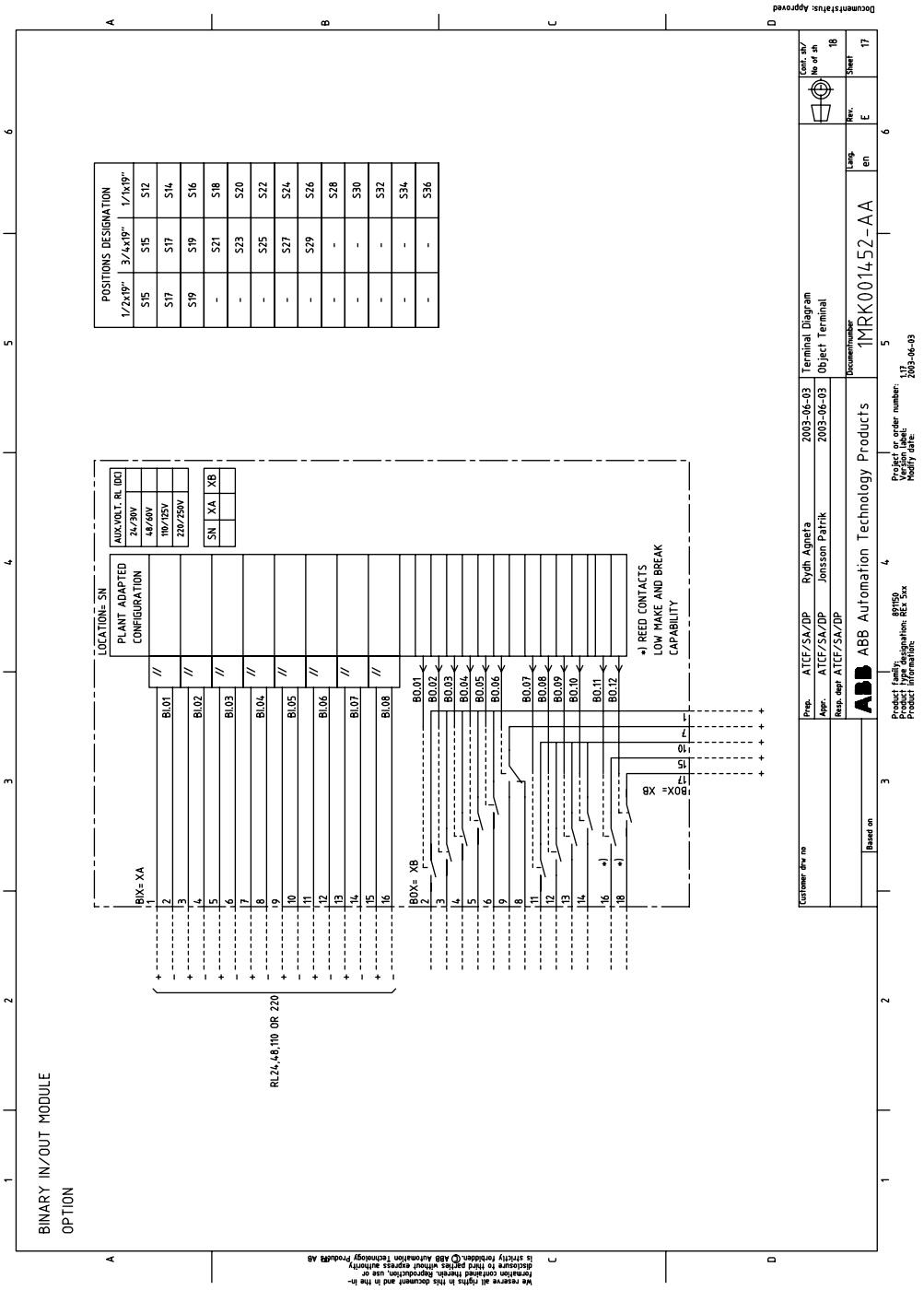

Figure 174: REx 5xx, binary in/out module option

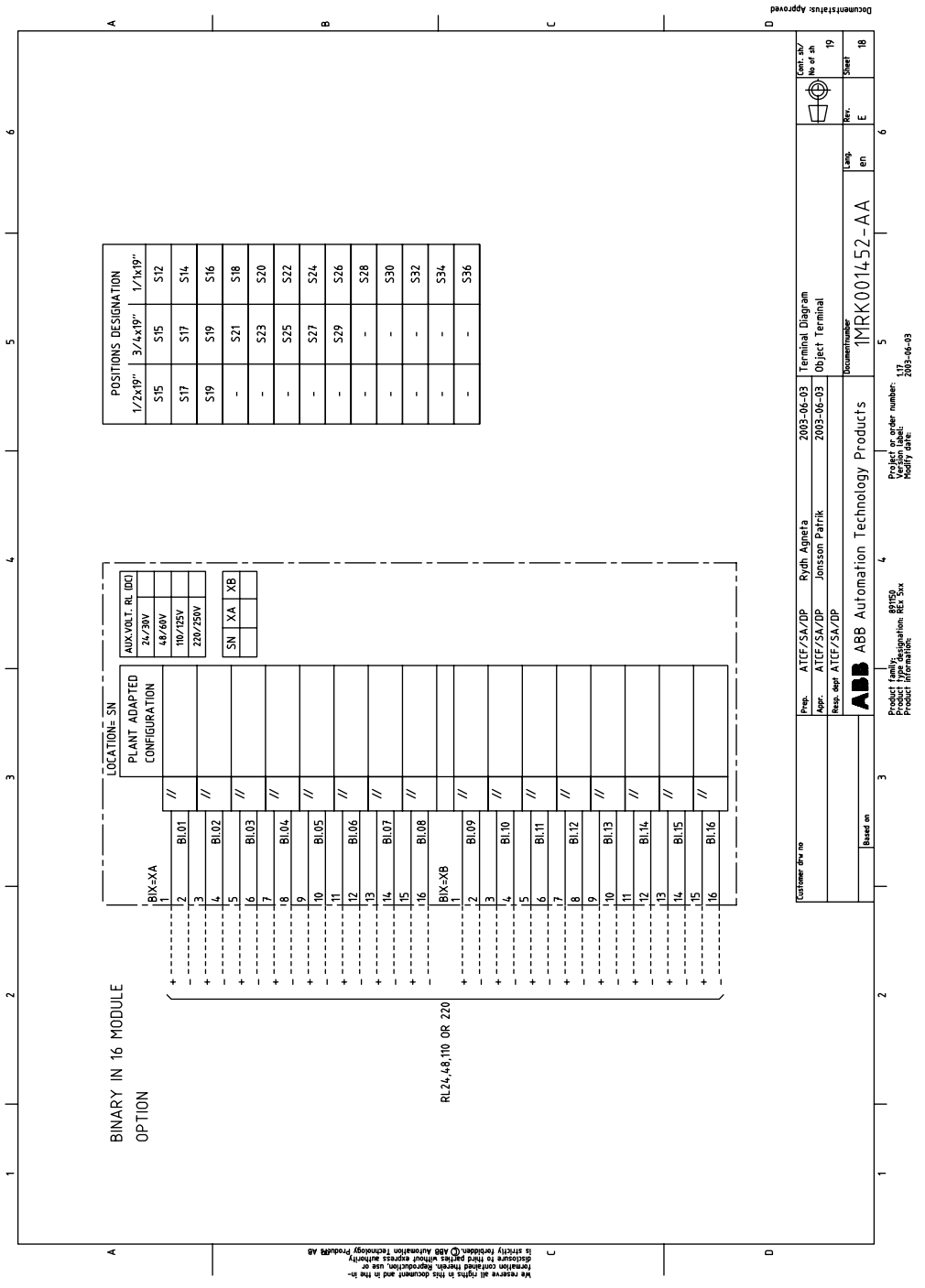

Figure 175: REx 5xx, binary in 16 module option

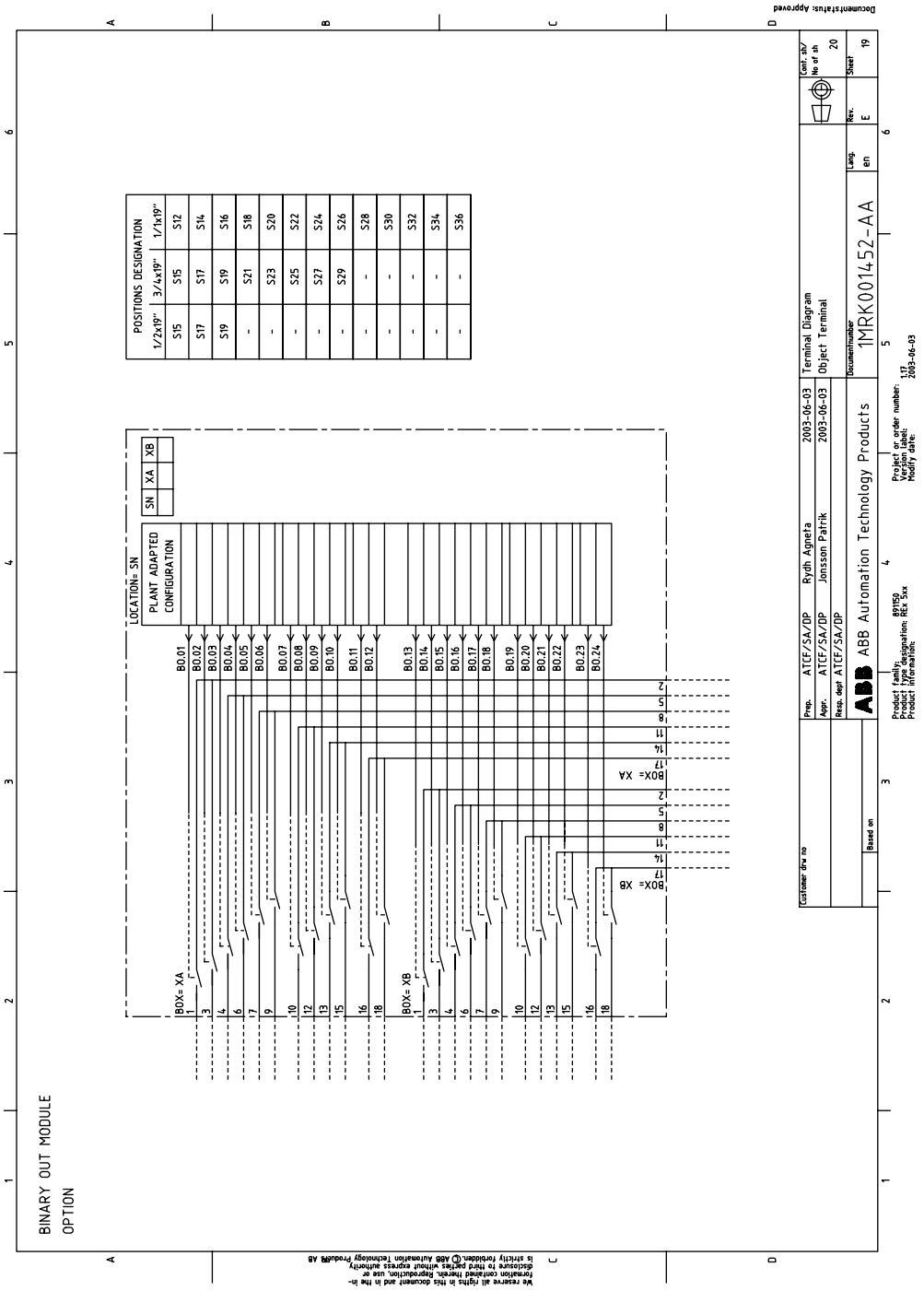

Figure 176: REx 5xx, binary out module option

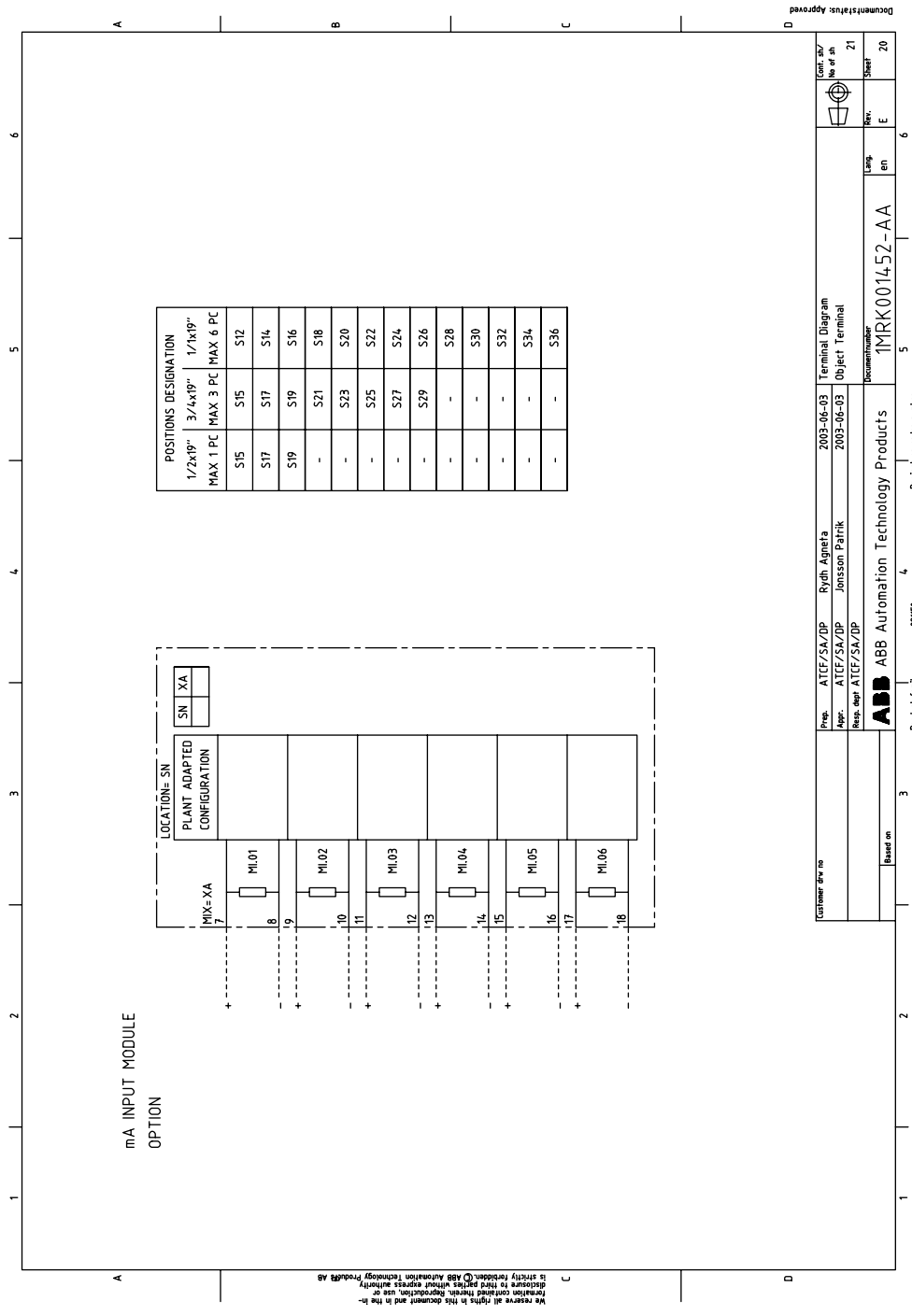

Figure 177: REx 5xx, mA input module option

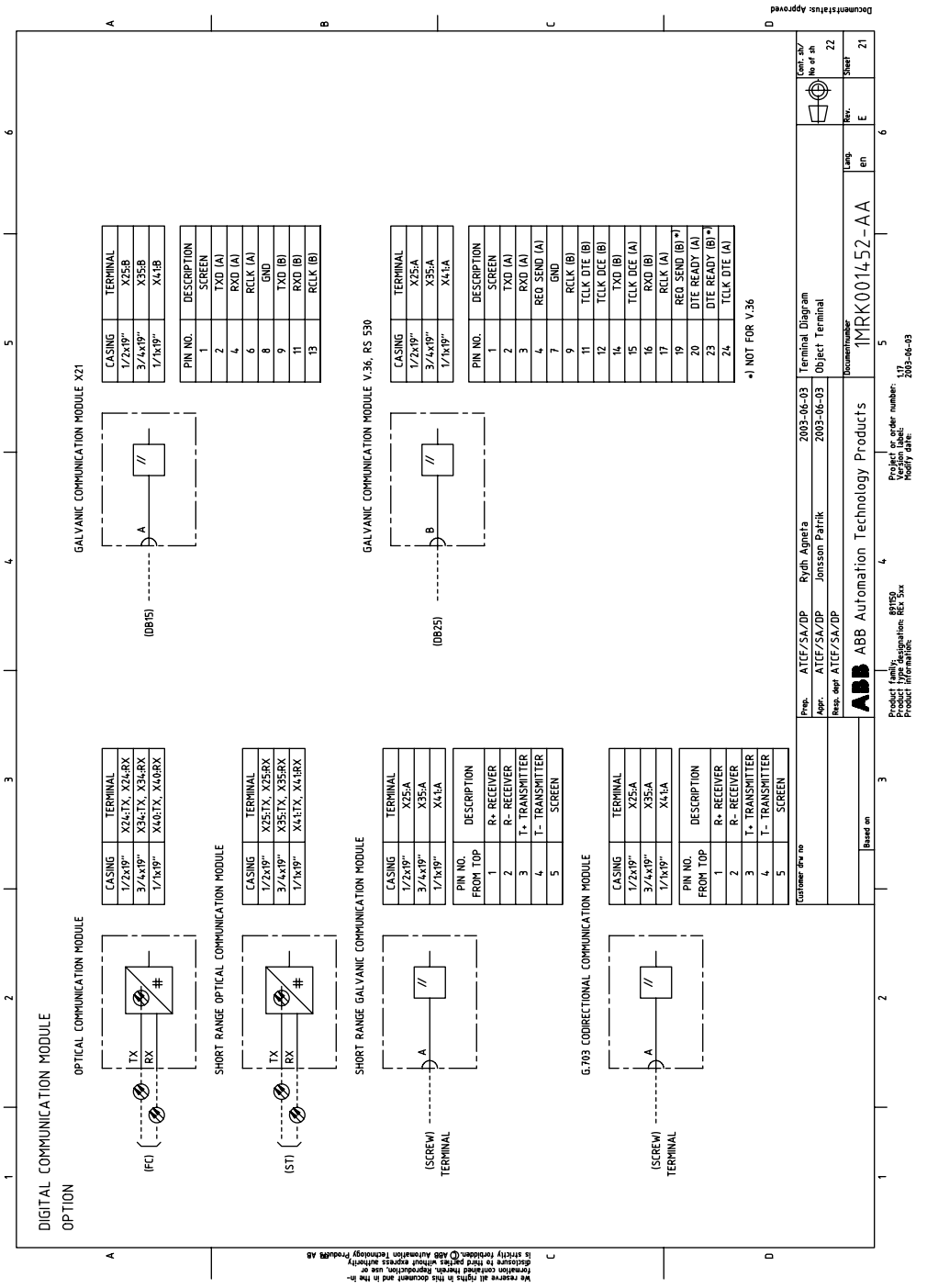

Figure 178: REx 5xx, digital communication module option

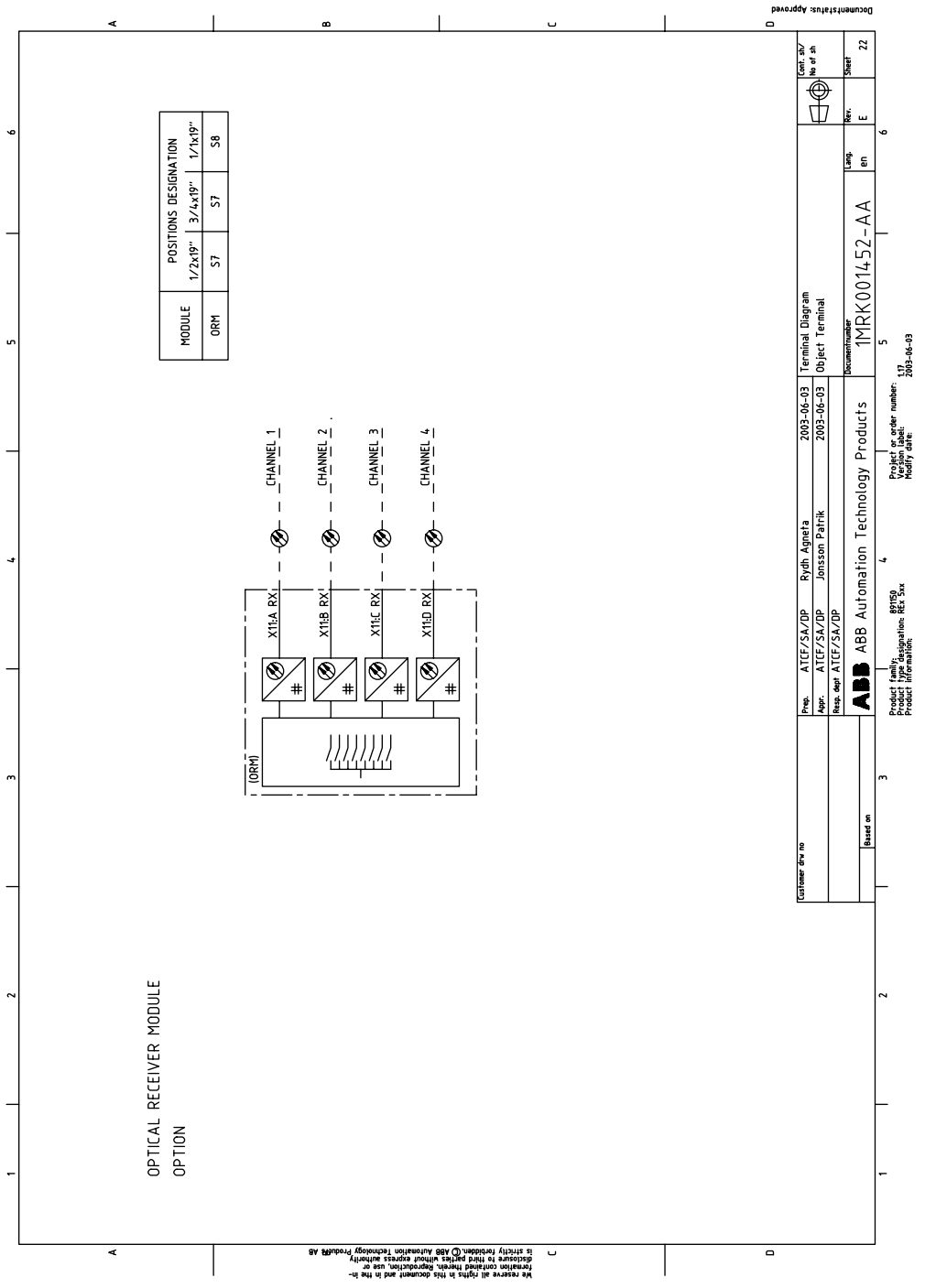

Figure 179: REx 5xx, optical receiver module option

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