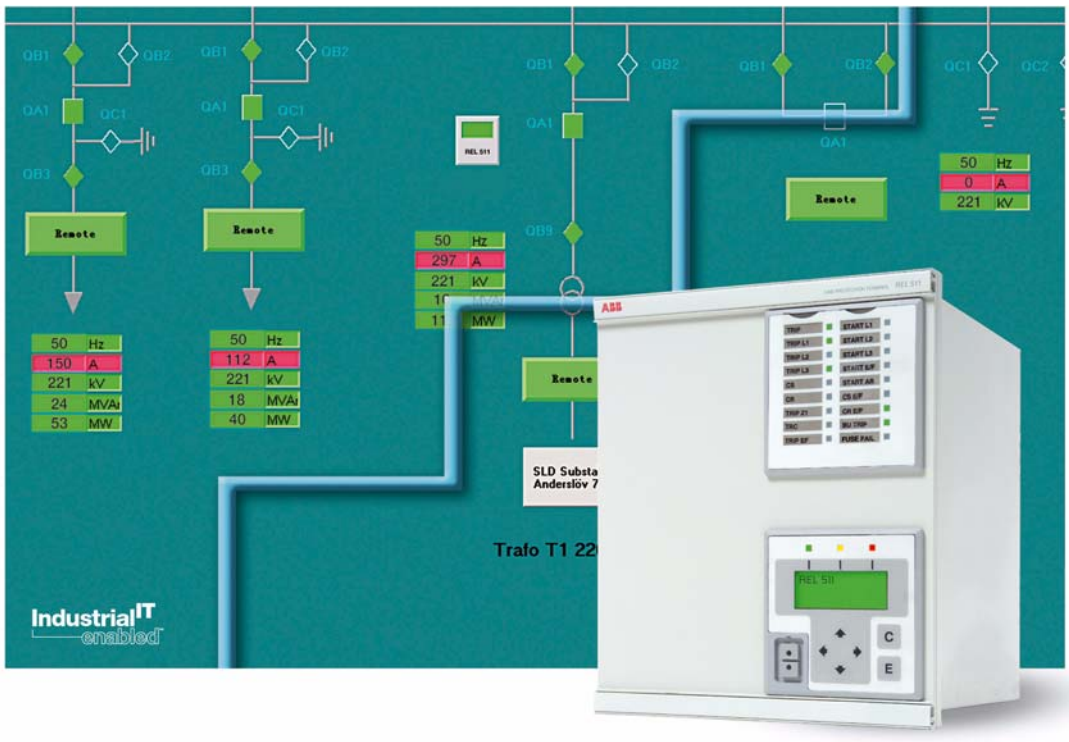
Technical reference manual

Line distance protection terminal for impedance earthed systems REL 511-C2*2.5



Technical reference manual

Line distance protection terminal for impedance earthed systems REL 511-C2*2.5

About this manual

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Manufacturer:

ABB Power Technologies AB
Substation Automation Products
SE-721 59 Västerås
Sweden
Telephone: +46 (0) 21 34 20 00
Facsimile: +46 (0) 21 14 69 18
www.abb.com/substationautomation

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Chapter 1 Introduction

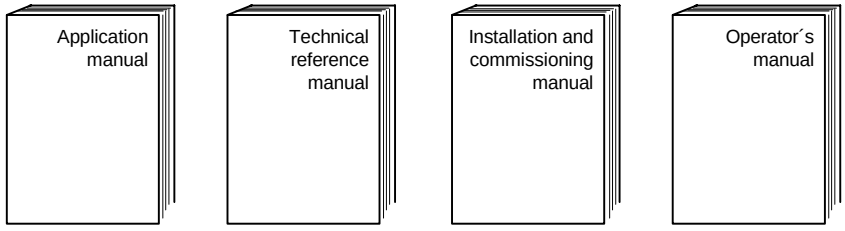
About this chapter

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.

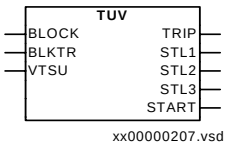


Figure 1: Function block symbol example

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.

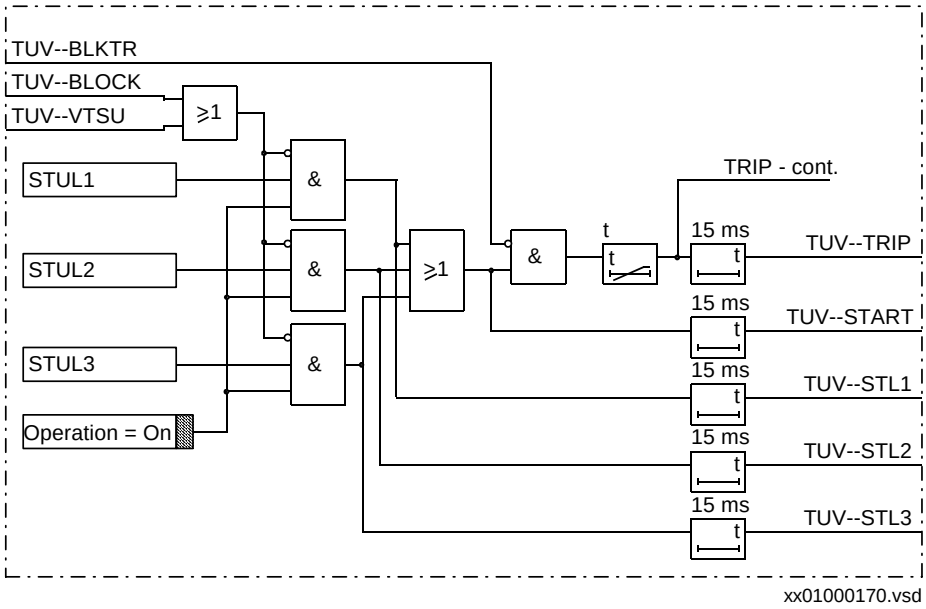


Figure 2: Simplified logic diagram example

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-C2*2.5	Identity number
Operator's manual	1MRK 506 201-UEN
Installation and commissioning manual	1MRK 506 203-UEN
Technical reference manual	1MRK 506 202-UEN
Application manual	1MRK 506 204-UEN
Buyer's guide	1MRK 506 200-BEN

1.5 Revision notes

Revision	Description
A	First revision

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

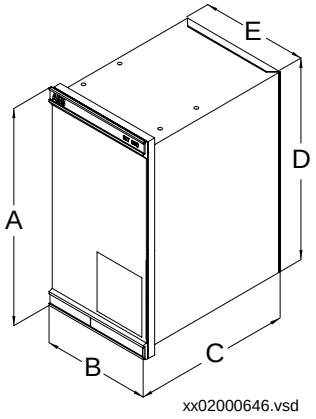


Figure 3: Case without rear cover

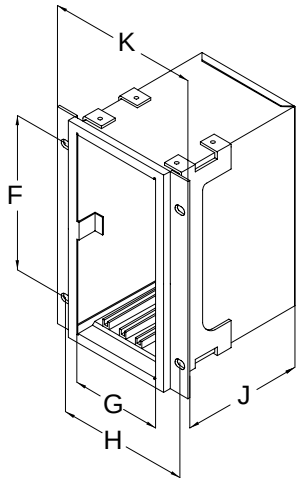


Figure 4: Case without rear cover with 19” rack mounting kit

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	-
										(mm)
The H and K dimensions are defined by the 19” rack mounting kit										

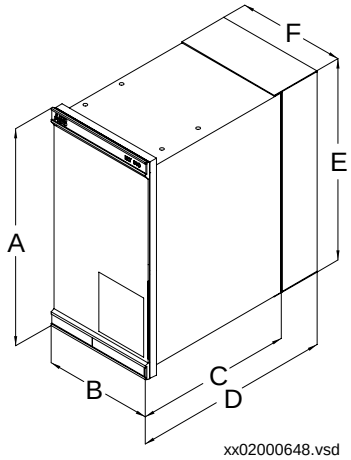


Figure 5: Case with rear cover.

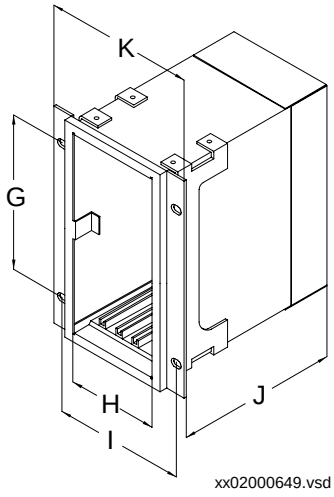


Figure 6: Case with rear cover and 19” rack mounting kit.

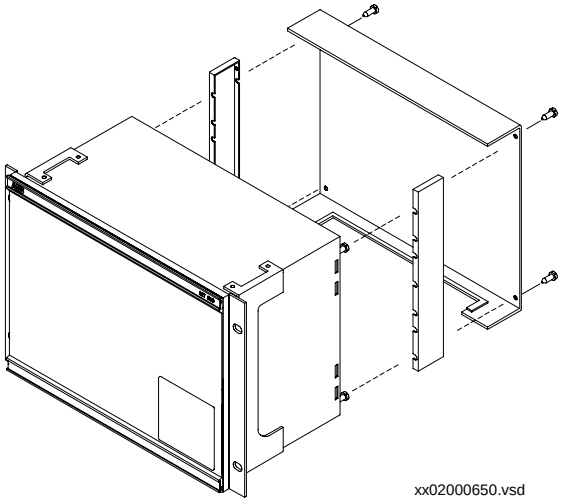
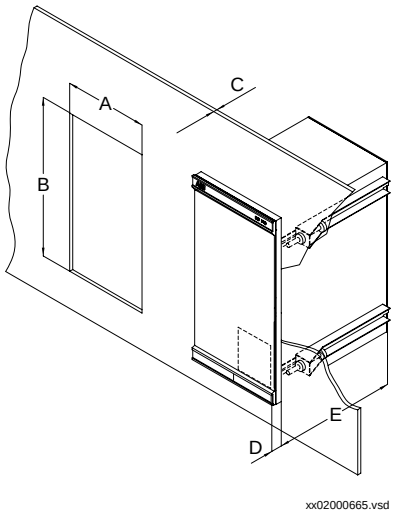


Figure 7: Rear cover case with details.

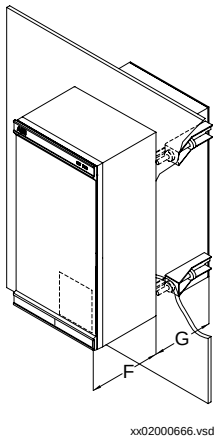
Case size	A	B	C	D	E	F	G	H	J	K
6U, 1/2 x 19”	265.9	223.7	242.1	252.9	205.7	190.5	203.7	-	186.6	-
The H and K dimensions are defined by the 19” rack mounting kit. All dimensions are in millimeters.										

Panel cut-outs for REx 500 series, single case

Flush mounting



Semi-flush mounting



Case size	Cut-out dimensions (mm)	
	A+/-1	B+/-1
6U, 1/2 x 19”	210.1	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.

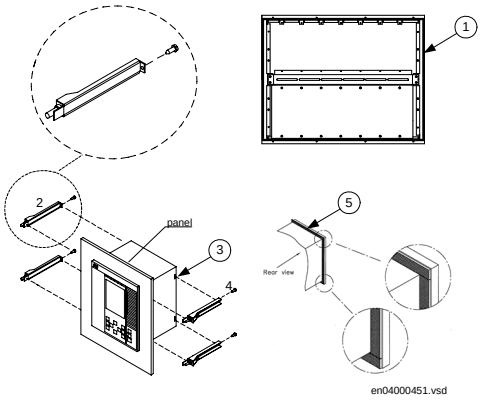
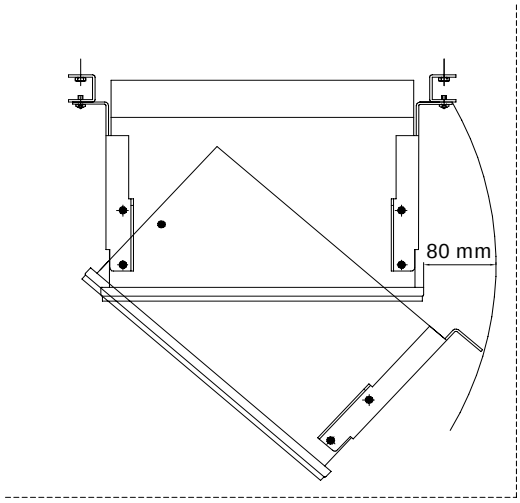


Figure 8: The flush mounting kit

Dimensions, wall mounting



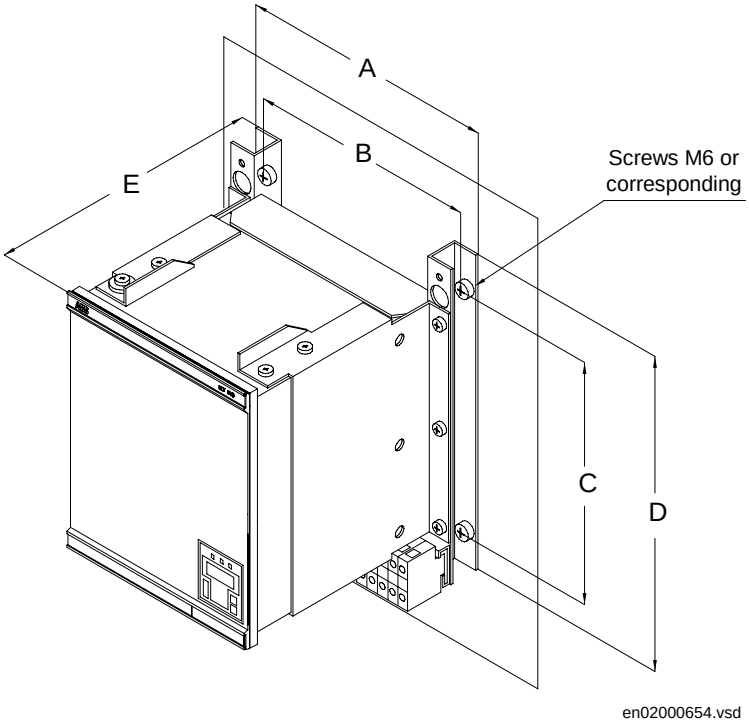


Figure 9: Wall mounting

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

2.2 Weight

Table 12: Weight

Case size	Weight
6U, 1/2 x 19”	≤ 8.5 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

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
Electrostatic discharge		
Direct application	Air 8 kV Contact 6 kV	IEC 60255-22-2, Class III
Fast transient disturbance	4 kV	IEC 60255-22-4, Class A
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
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

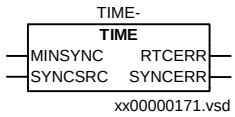
This chapter presents the common functions in the terminal.

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

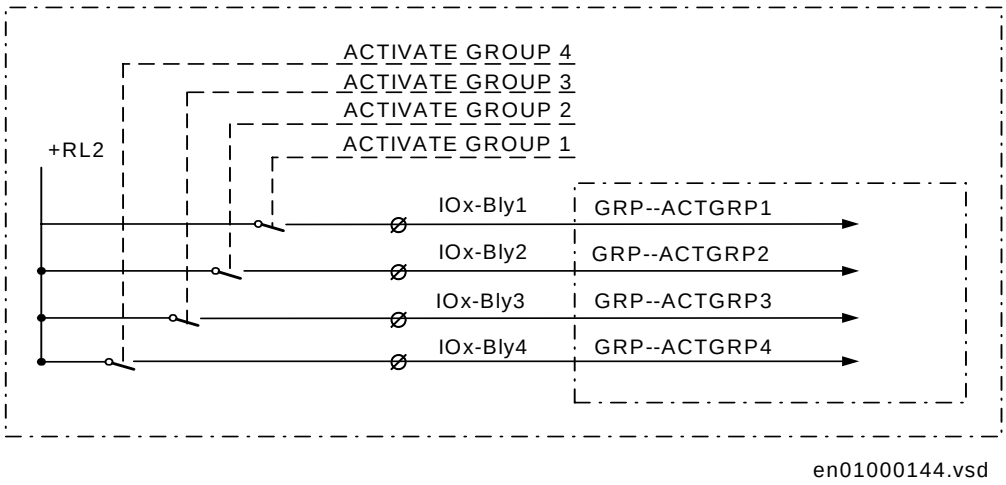
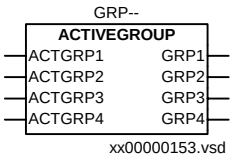


Figure 10: Connection of the function to external circuits

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 1.4.3 "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

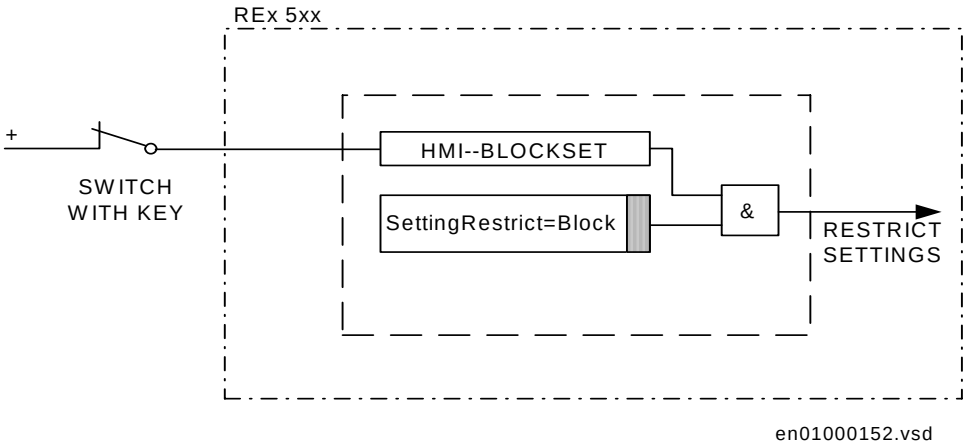


Figure 11: Connection and logic diagram for the BLOCKSET function

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

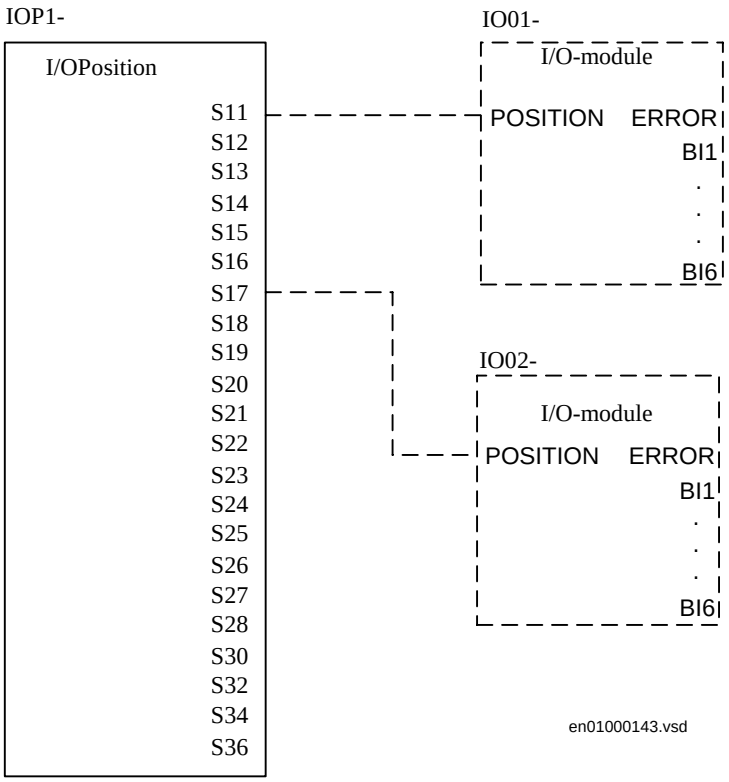
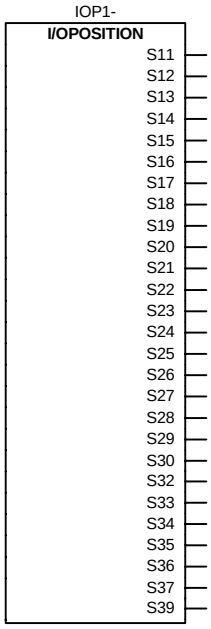


Figure 12: Example of an I/O-configuration in the graphical tool CAP 531 for a REx 5xx with two BIMs.

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)

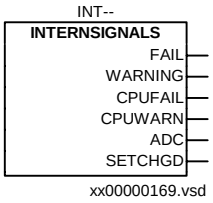
5 Self supervision with internal event recorder (INT)

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

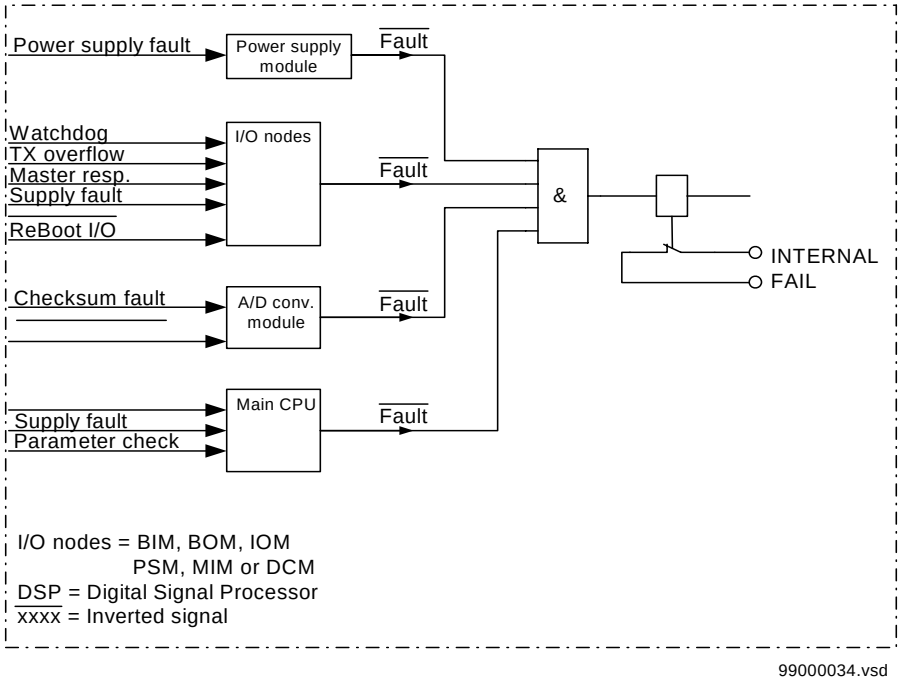


Figure 13: Hardware self-supervision, potential-free alarm contact.

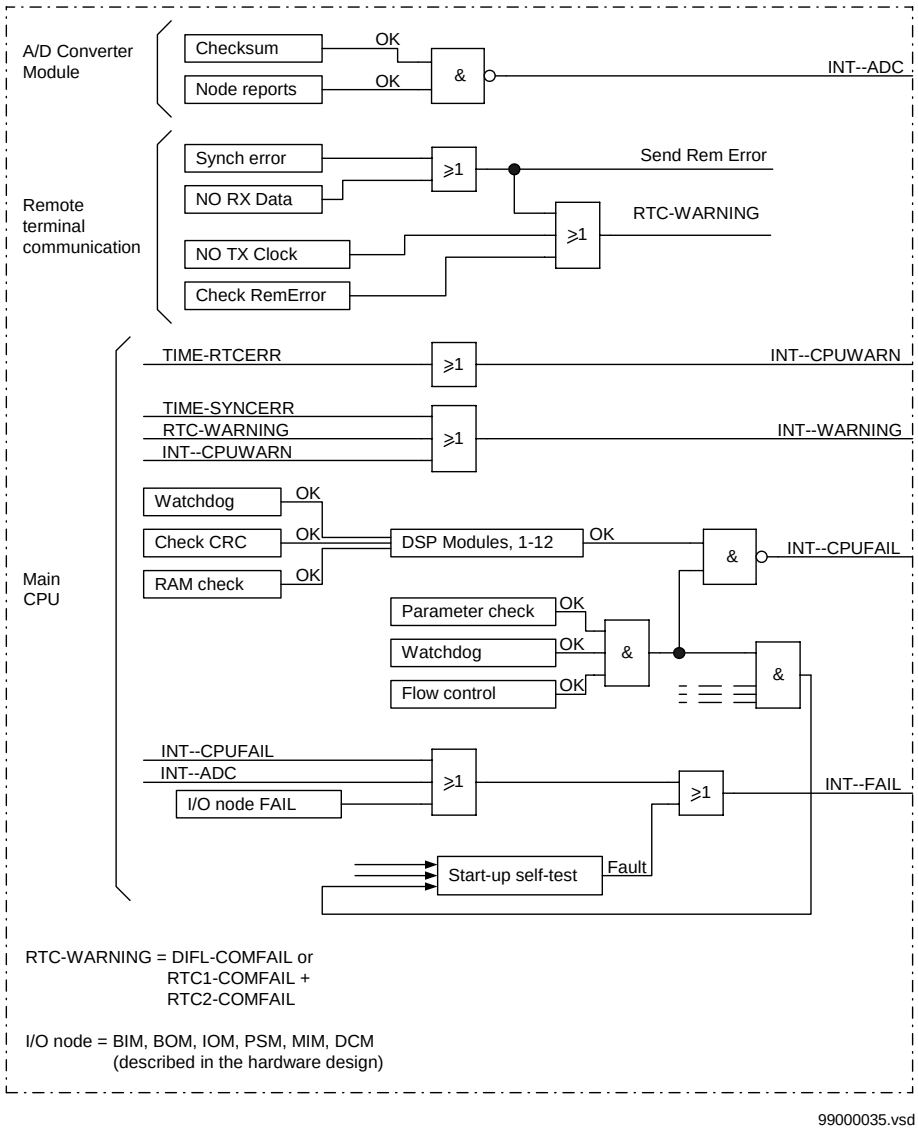


Figure 14: Software self-supervision, function block INTernal signals

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.

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.

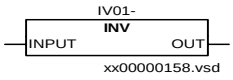


Table 34: Input signals for the INV (IVnn-) function block

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.

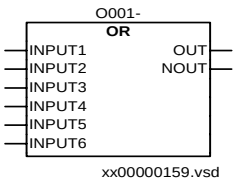


Table 36: Input signals for the OR (Onnn-) function block

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.

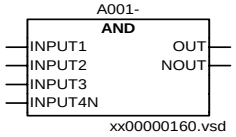


Table 38: Input signals for the AND (Annn-) function block

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).

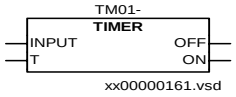


Table 40: Input signals for the TIMER (TMnn-) function block

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.

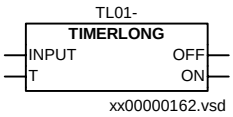


Table 43: Input signals for the TIMERLONG (TLnn-) function block

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.

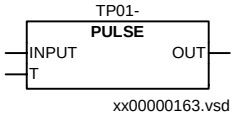


Table 46: Input signals for the TP (TPnn-) function block

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.

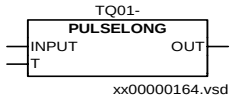


Table 49: Input signals for the PULSELONG (TQnn-) function block

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.

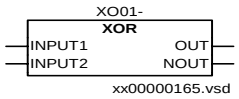


Table 52: Input signals for the XOR (XOnn-) function block

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.

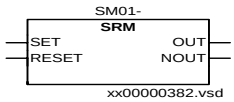


Table 56: Input signals for the SRM (SMnn-) function block

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.

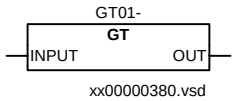


Table 59: Input signals for the GT (GTnn-) function block

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.

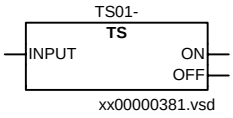


Table 62: Input signals for the TS (TSnn-) function block

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 Technical data

Table 65: CL1 - Configurable blocks as basic

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

Table 66: 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

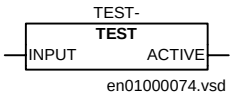
7 Blocking of signals during test (BST)

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 67: 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 68: 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)

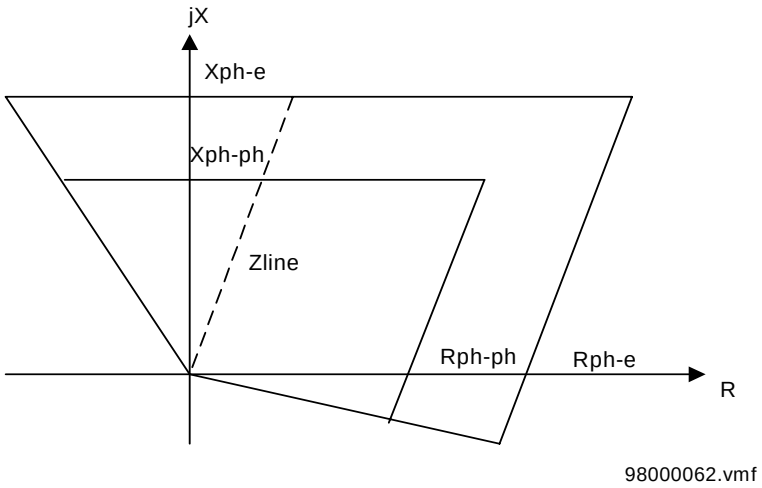
1.1 Application

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

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.

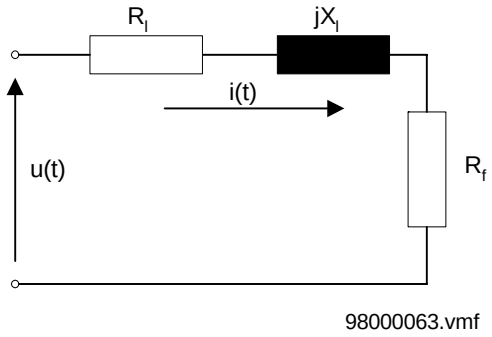
Distance protection zone five has shorter operating time than other zones, but also higher transient overreach. It should generally be used as a check zone together with the SOTF switch onto fault function or as a time delayed zone with time delay set longer than 100ms.

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 16.

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



Where:

R_l = line resistance

R_f = fault resistance

X_l = line reactance

ω = $2\pi f$

f = frequency

Figure 16: 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

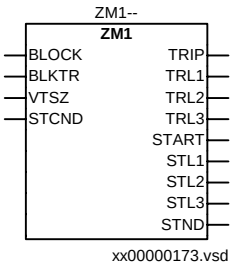


Figure 17: ZM1 function block for single, two and/or three phase tripping

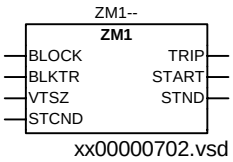


Figure 18: ZM1 function block for three phase tripping

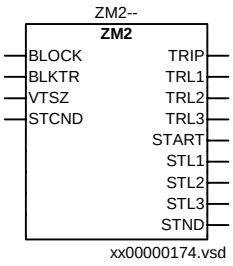


Figure 19: ZM2 function block for single, two and/or three phase tripping

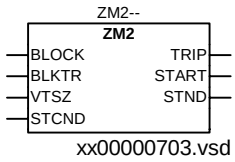


Figure 20: ZM2 function block for three phase tripping

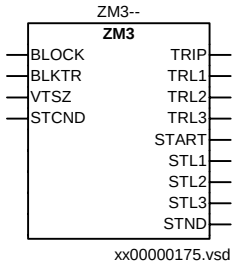


Figure 21: ZM3 function block for single, two and/or three phase tripping

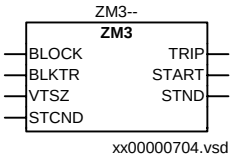


Figure 22: ZM3 function block for three phase tripping

1.4 Function block, zone 4

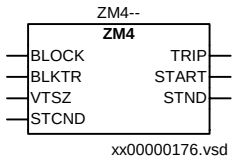


Figure 23: ZM4 function block

1.5 Function block, zone 5

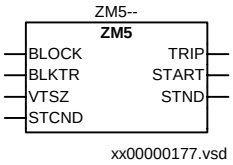


Figure 24: ZM5 function block

1.6 Logic diagram

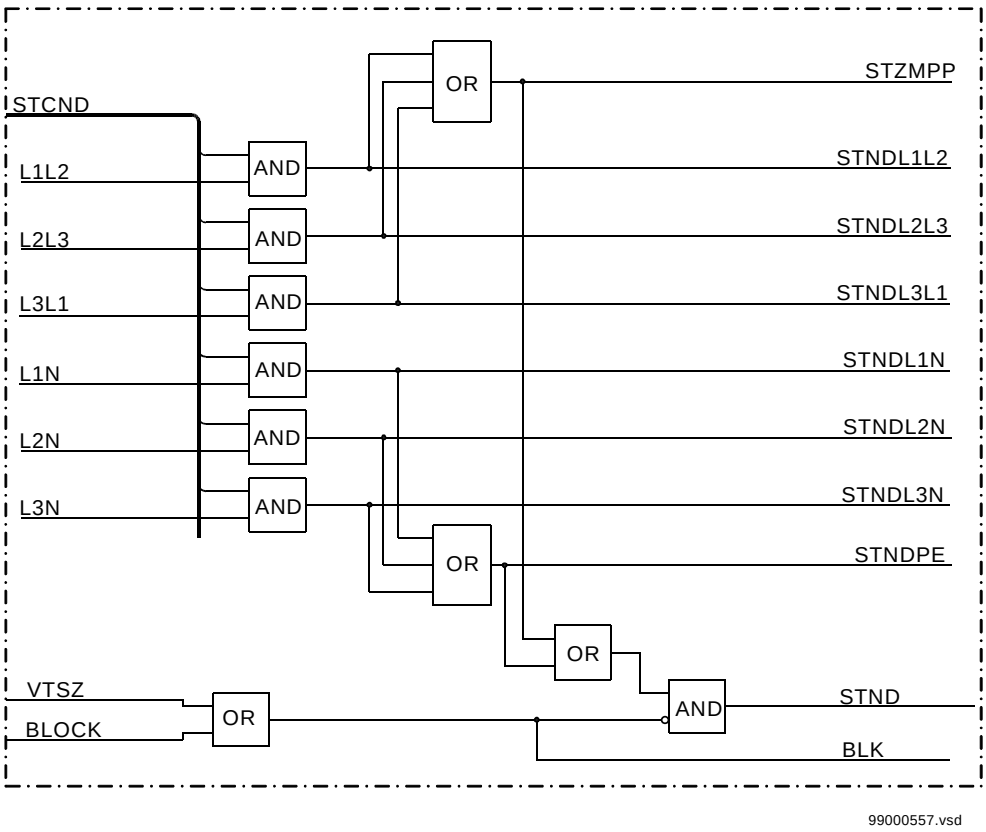


Figure 25: Conditioning by a group functional input signal ZM1--STCND

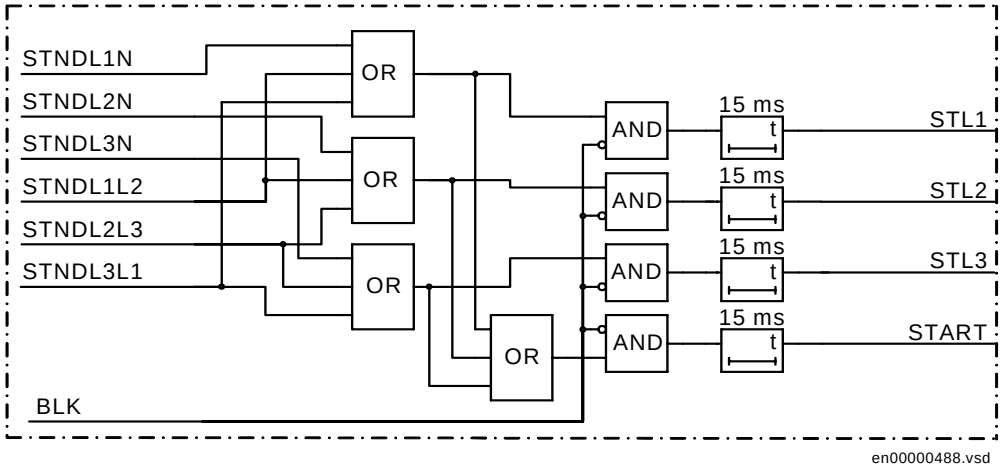


Figure 26: Composition of starting signals in non-directional operating mode

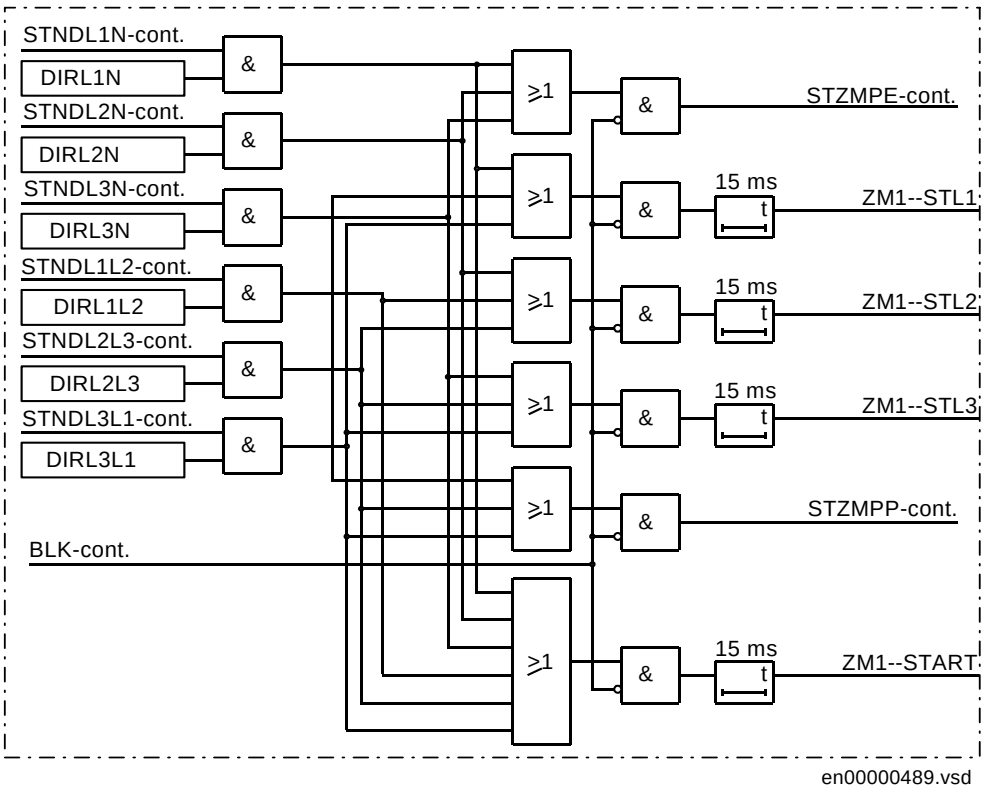


Figure 27: Composition of starting signals in directional operating mode

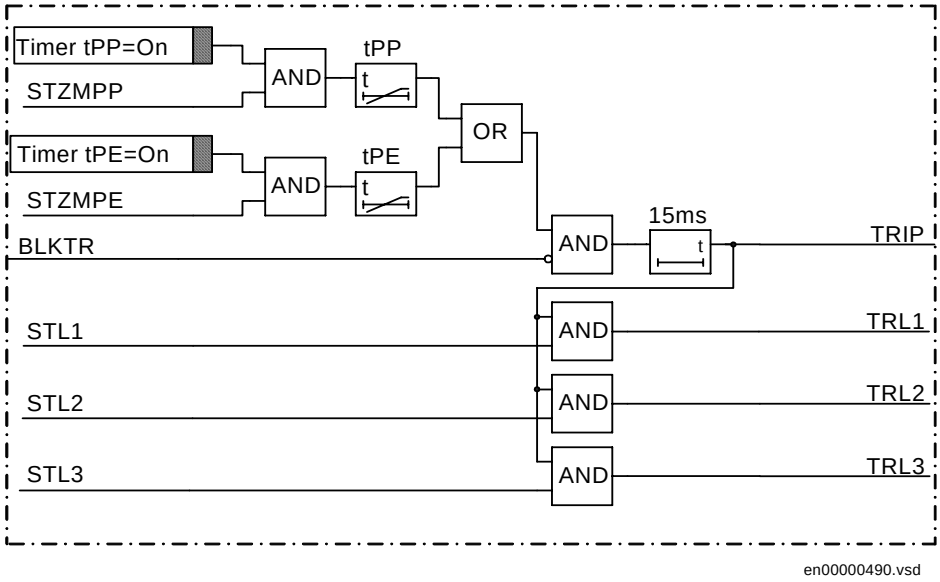


Figure 28: Tripping logic for the distance protection zone one

1.7 Input and output signals, zone 1-3

Table 69: 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 70: 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 71: 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 72: 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 73: 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 74: 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 75: 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 76: 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 77: 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 78: 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 79: 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 80: 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 81: 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 82: 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 83: 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 84: 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, 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 85: 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

1.15 Technical data

Table 86: 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.

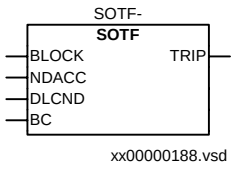
Generally, directional or non-directional overreaching distance or overcurrent protection functions are used as the protection functions to be released for direct tripping during the activated time. When line-side potential transformers are used, the use of non-directional protection zones secures switch-on-to-fault 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

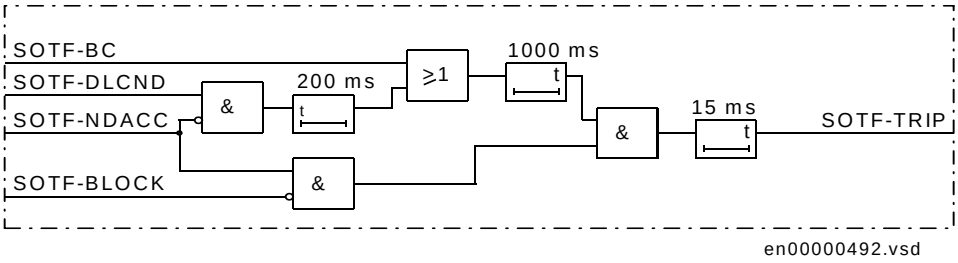


Figure 29: SOTF function - simplified logic diagram

2.5 Input and output signals

Table 87: 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 88: 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 89: 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 90: 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

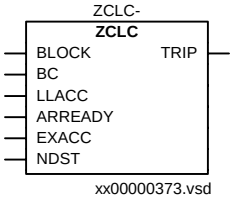
The main purpose of the ZCLC local acceleration logic is to achieve fast fault clearance for faults anywhere on the whole line for those applications where no communication channel is available.

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

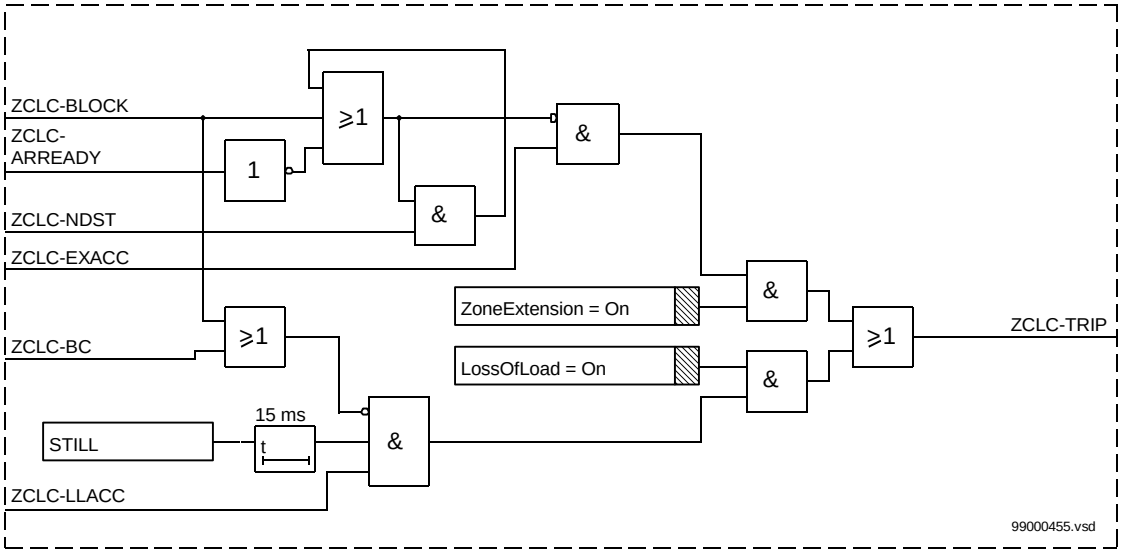


Figure 30: Simplified logic diagram for the local acceleration logic

3.5 Input and output signals

Table 91: 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 92: 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 93: 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.

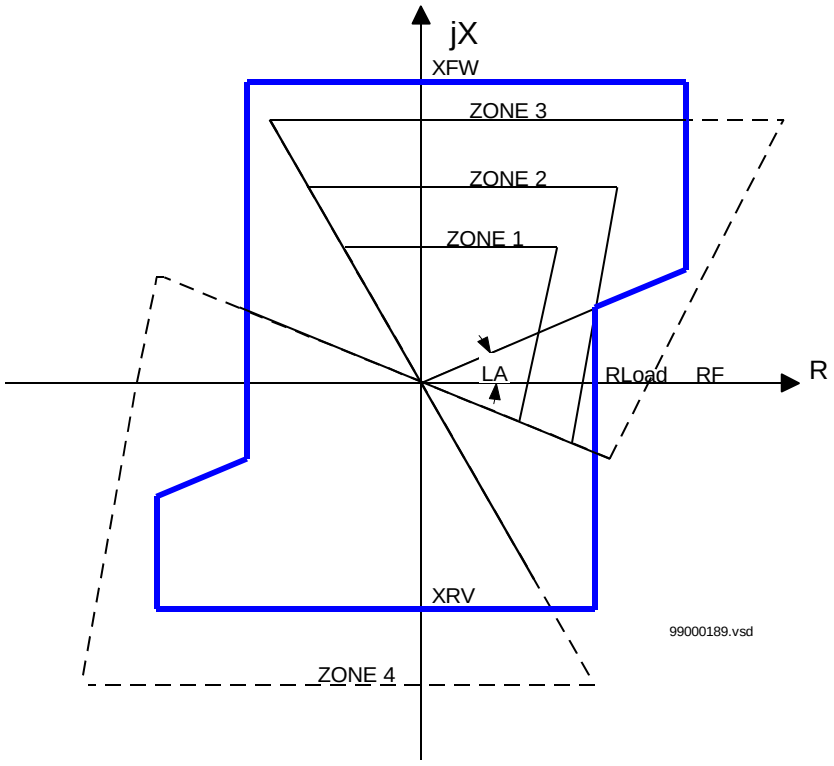
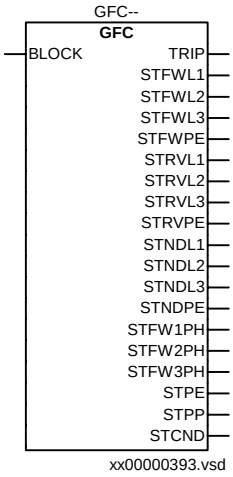


Figure 31: Operating characteristics of the GFC (impedance measuring principle) and zone measuring elements

Figure 31 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

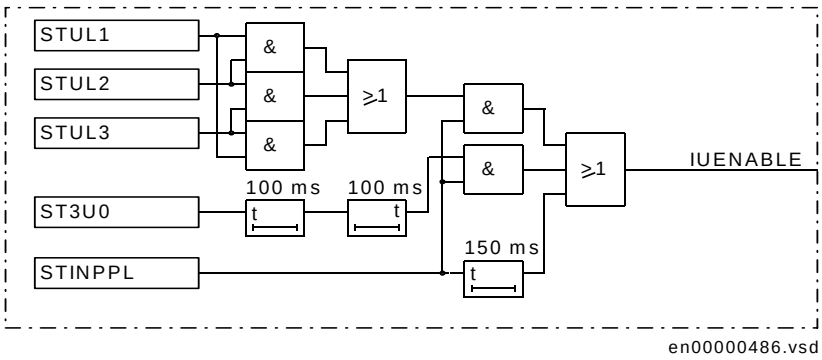


Figure 32: Cross-country fault detection logic

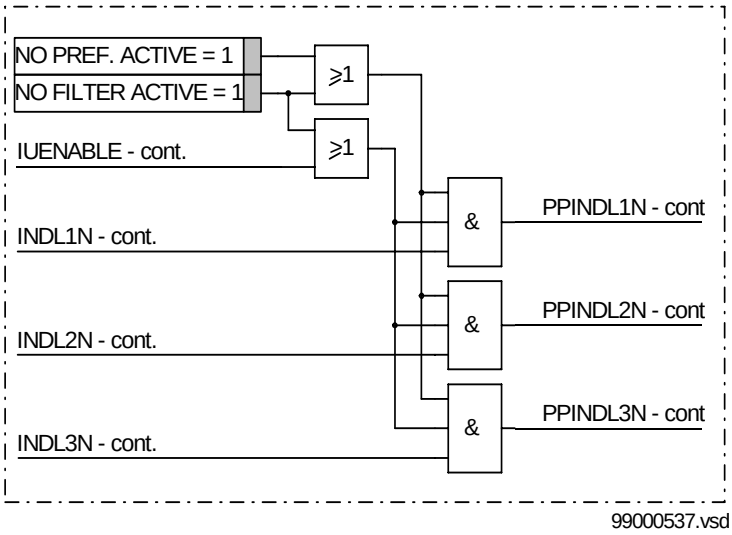


Figure 33: Phase preference logic with no filter setting and no preference setting

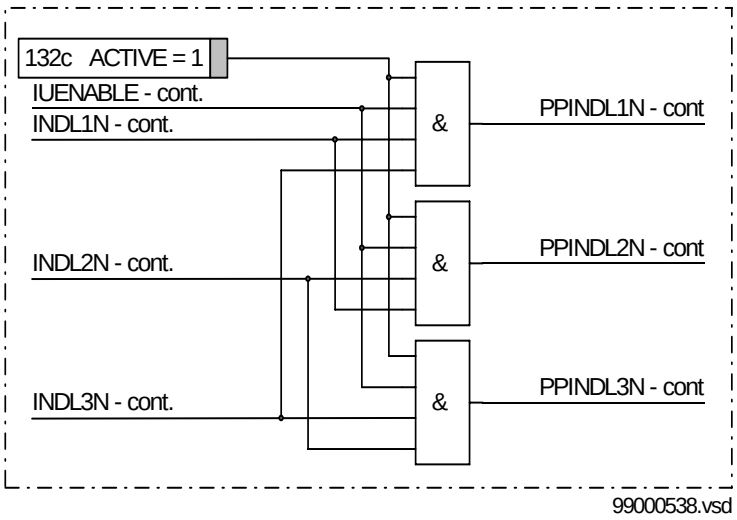


Figure 34: Cyclic phase preference logic with 132c setting active

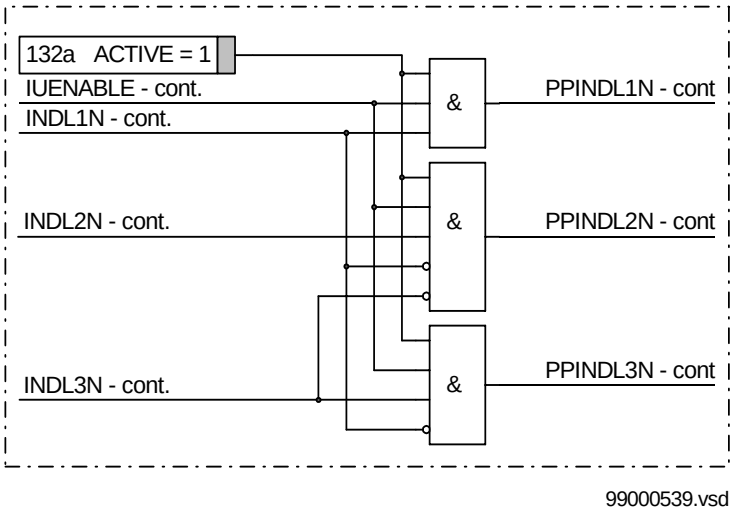


Figure 35: Acyclic phase preference logic with 132a setting active

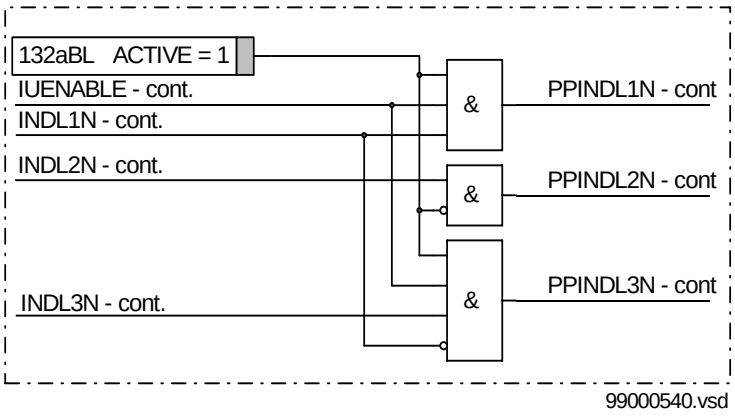


Figure 36: Acyclic phase preference logic with one phase blocked, 132aBL. setting active

4.5 Setting parameters

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

Table 94: 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 95: 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 96: 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 97: Setting parameters for phase preference logic

Parameter	Range	Default	Unit	Description
PhasePref	NoFil-ter/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

4.6 Technical data

Table 98: 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.

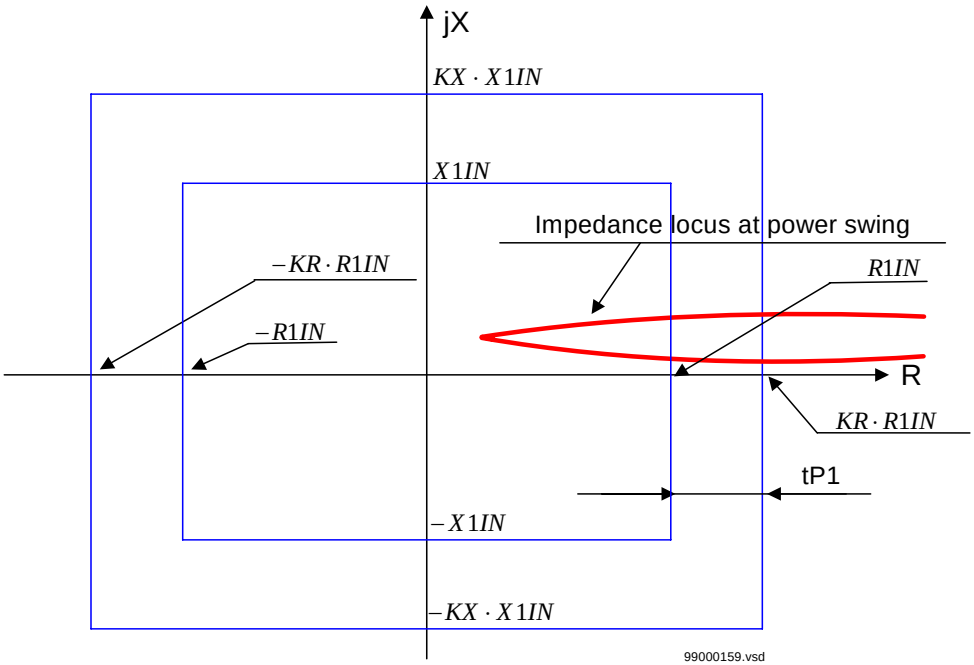
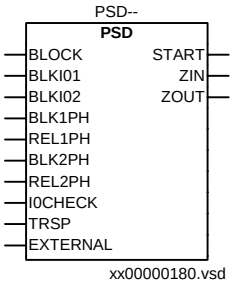


Figure 37: Operating principle and characteristic of the PSD function

5.3 Function block



5.4 Logic diagram

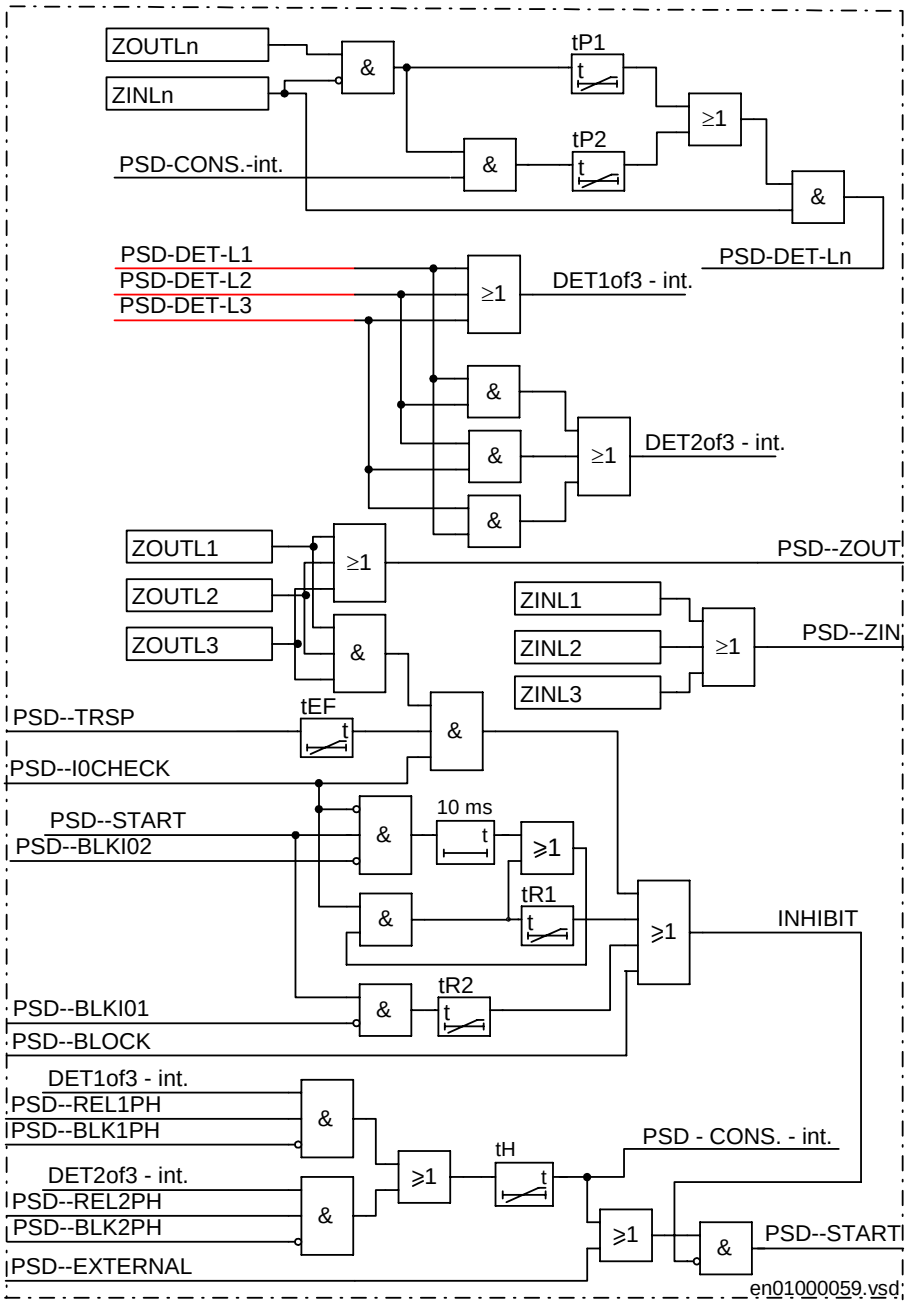


Figure 38: PSD function - block diagram.

5.5 Input and output signals

Table 99: 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 100: 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 101: 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 102: 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 Scheme communication logic (ZCOM)

6.1 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.

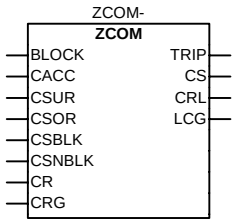
6.2 Functionality

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.

6.3 Function block



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6.4 Logic diagram

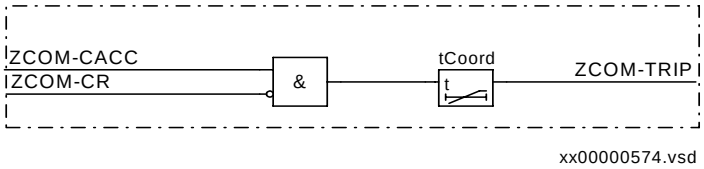


Figure 39: Basic logic for trip carrier in blocking scheme

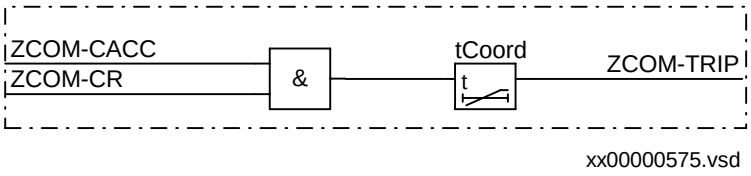


Figure 40: Basic logic for trip carrier in permissive scheme

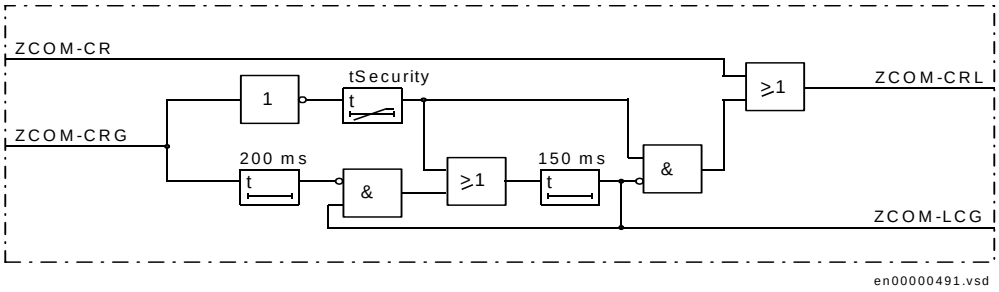


Figure 41: Carrier guard logic with unblock logic

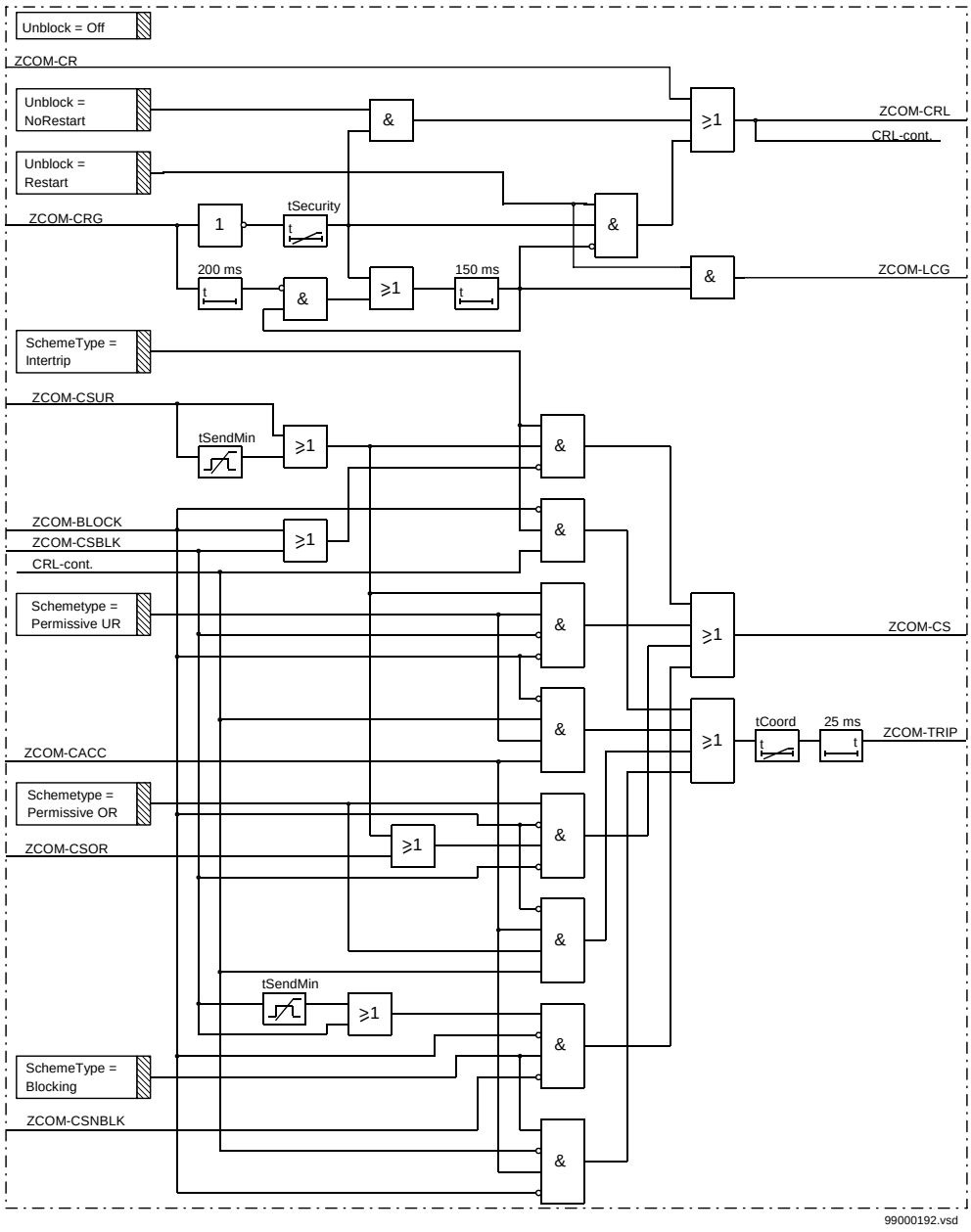


Figure 42: Scheme communication logic for distance or overcurrent protection, simplified logic diagram

6.5 Input and output signals

Table 103: 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 104: 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

6.6 Setting parameters

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

Table 105: 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

6.7 Technical data

Table 106: 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

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

7.1 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.

7.2 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).

7.3 Function block

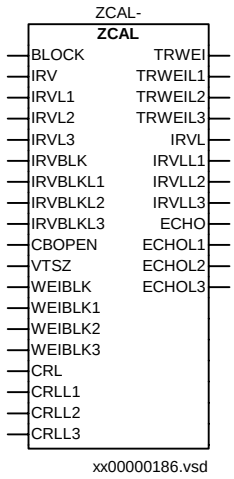


Figure 43: Function block for the ZCAL function, when used together with phase segregated scheme communication logic

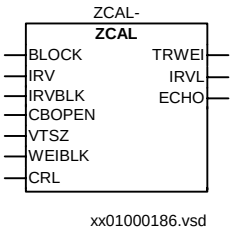


Figure 44: Function block for the ZCAL function, when used together with the three phase scheme communication logic

7.4 Logic diagram

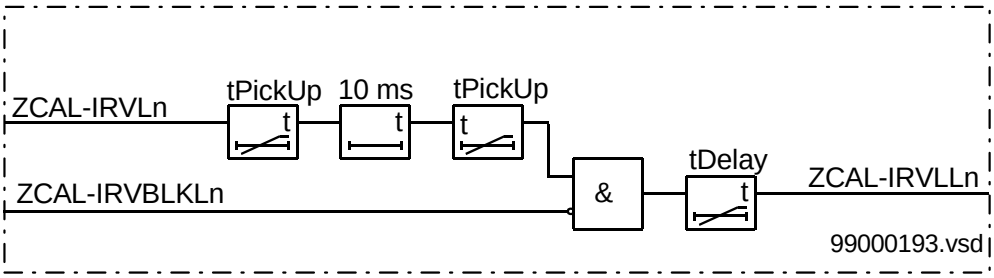


Figure 45: Current reversal logic.

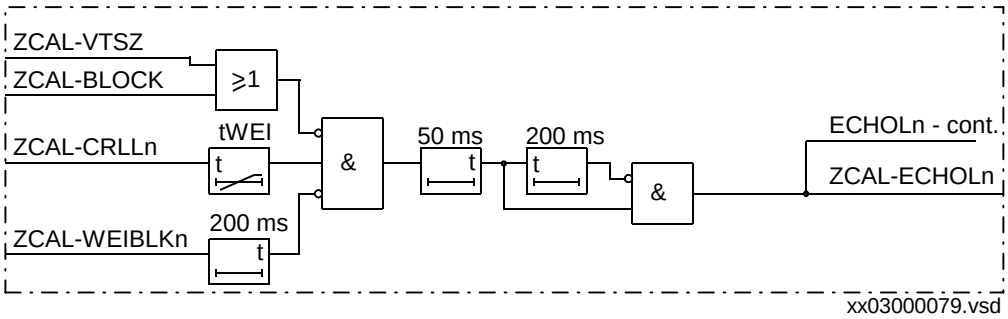


Figure 46: Echo of a received carrier signal by the WEI function.

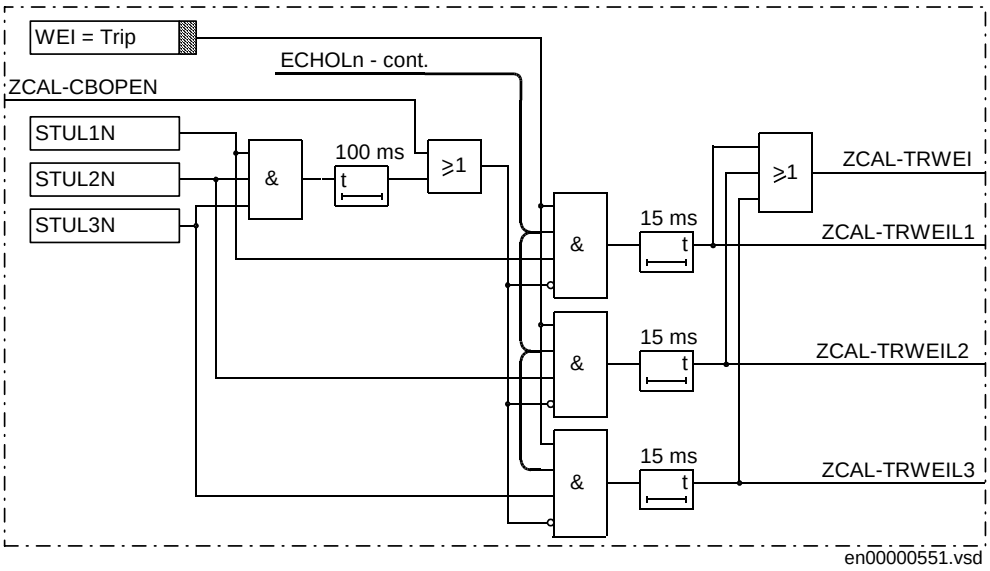


Figure 47: Tripping part of the WEI logic - simplified logic diagram.

7.5 Input and output signals

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

Table 107: 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 108: 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

7.6 Setting parameters

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

Table 109: 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

7.7 Technical data

Table 110: 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 Function block

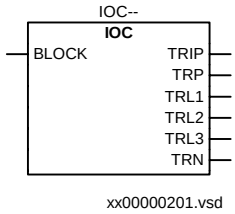


Figure 48: IOC function block phase + N with 1, 2, 3 phase trip

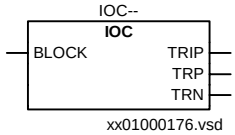


Figure 49: IOC function block, phase + N with 3 phase trip

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

2.1 Application

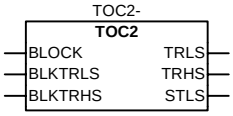
The two current/time stages of overcurrent protection TOC2 improve the possibility to get fast operation for nearby faults by using a high set current stage with short time delay. The low current stage is set with appropriate time delay to get selectivity with the adjacent relays in the system. In networks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

2.2 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.

2.3 Function block



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2.4 Logic diagram

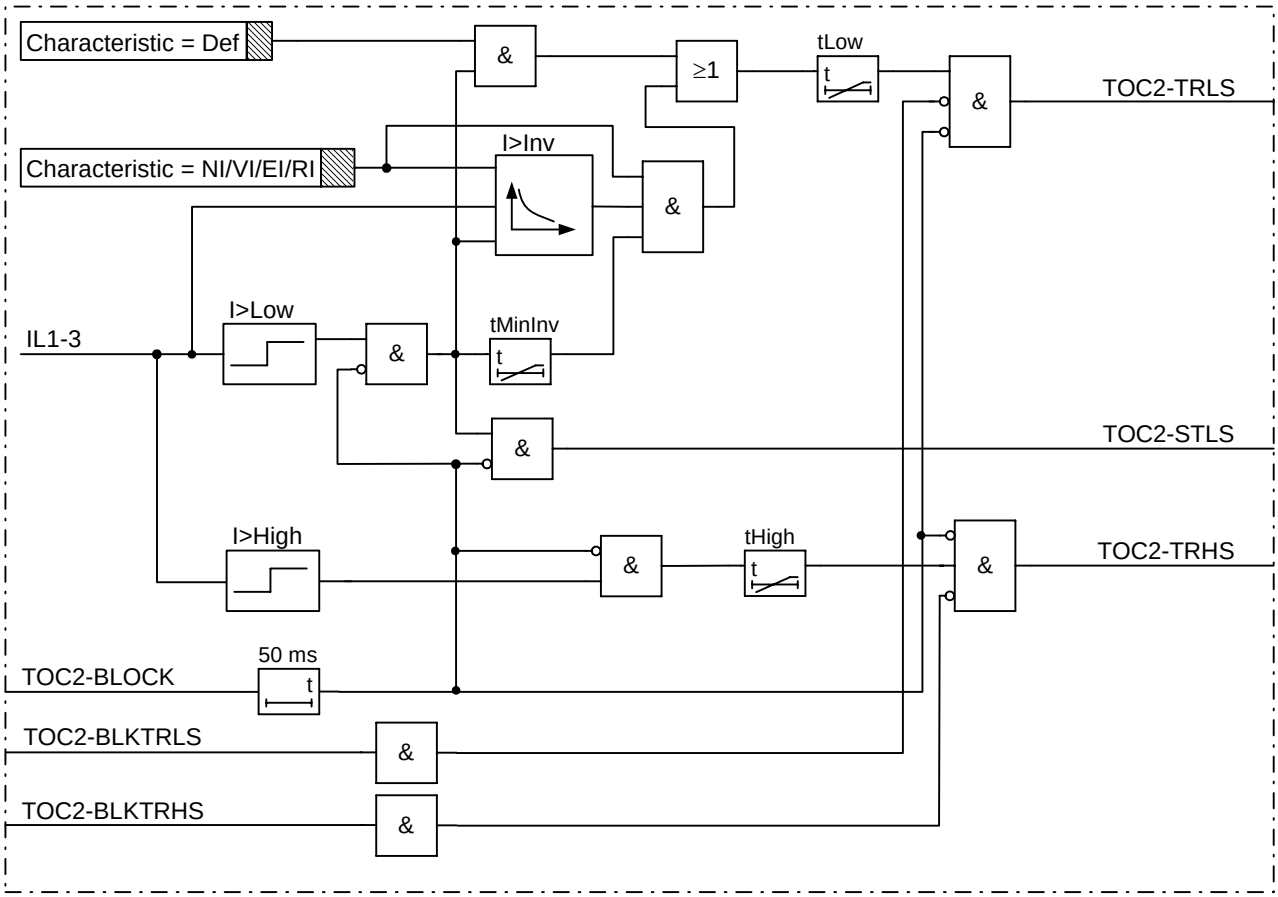


Figure 50: Two step time delayed phase overcurrent protection, simplified logic diagram

2.5 Input and output signals

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

Table 111: 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 112: 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

2.6 Setting parameters

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

Table 113: 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

2.7 Technical data

Table 114: 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%

3 Two step time delayed directional phase overcurrent protection (TOC3)

3.1 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.

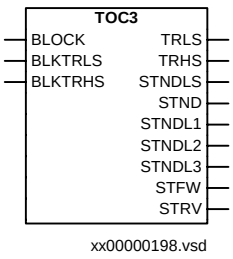
3.2 Functionality

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

3.3 Function block



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3.4 Logic diagram

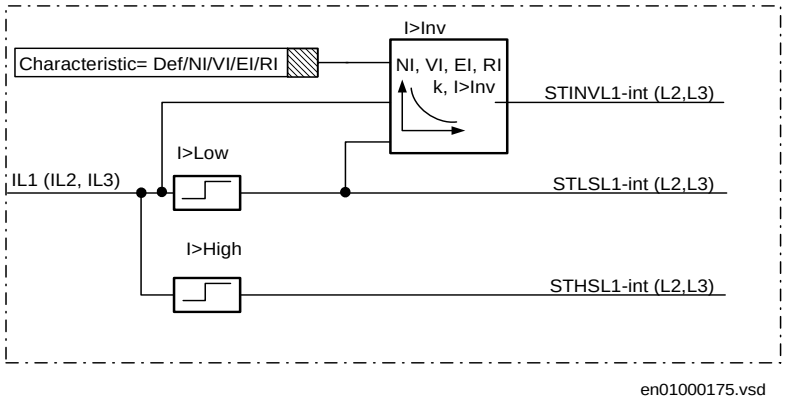


Figure 51: Simplified block diagram for definite and inverse time delayed phase overcurrent function

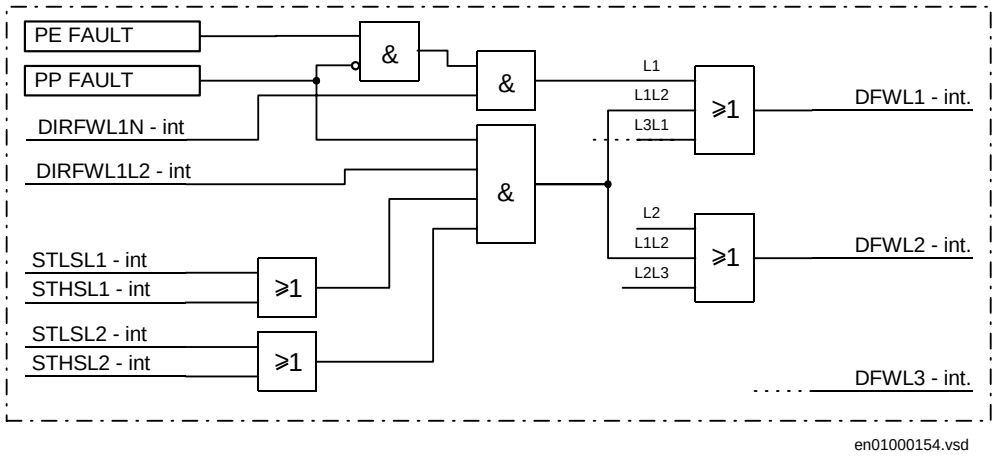


Figure 52: Excerpt from directional phase selection

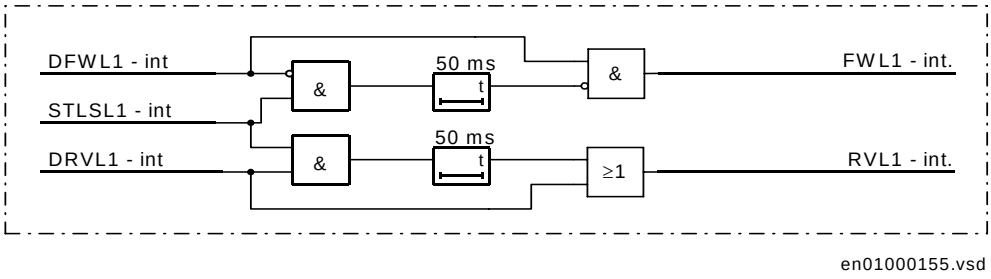


Figure 53: Current reversal logic for one phase and one set step

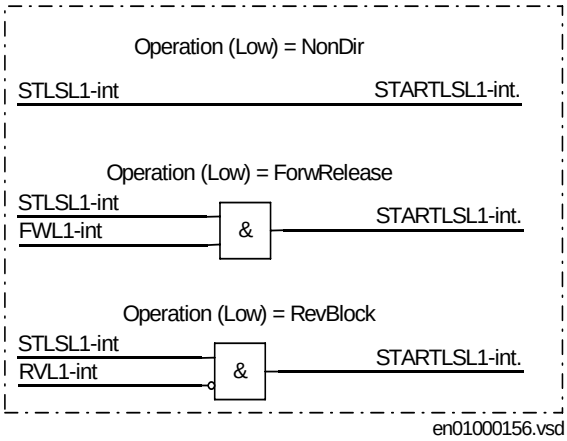


Figure 54: Directional modes of TOC3

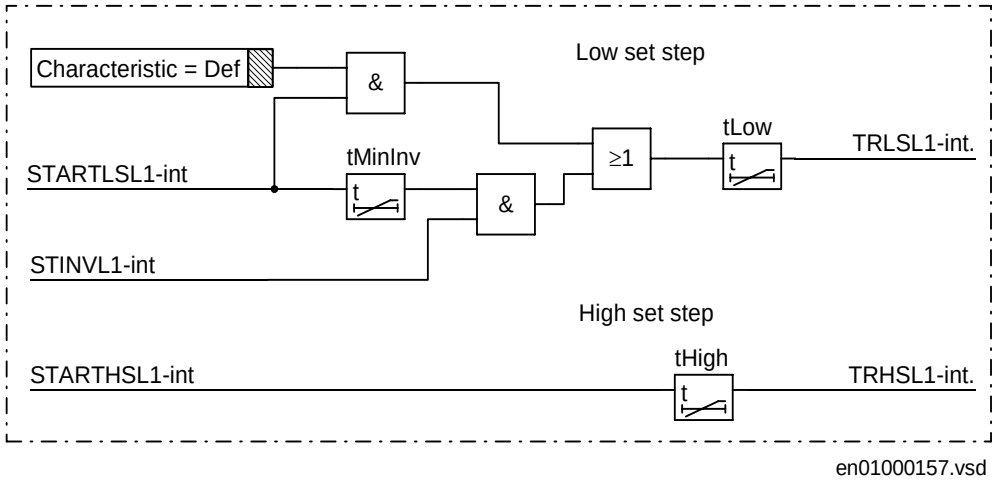


Figure 55: Delayed time operation for low set step and general time delay

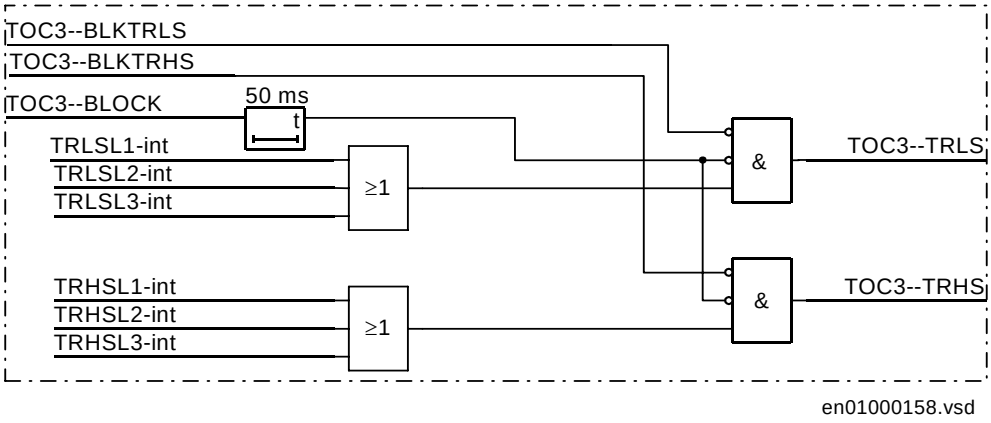


Figure 56: General trip

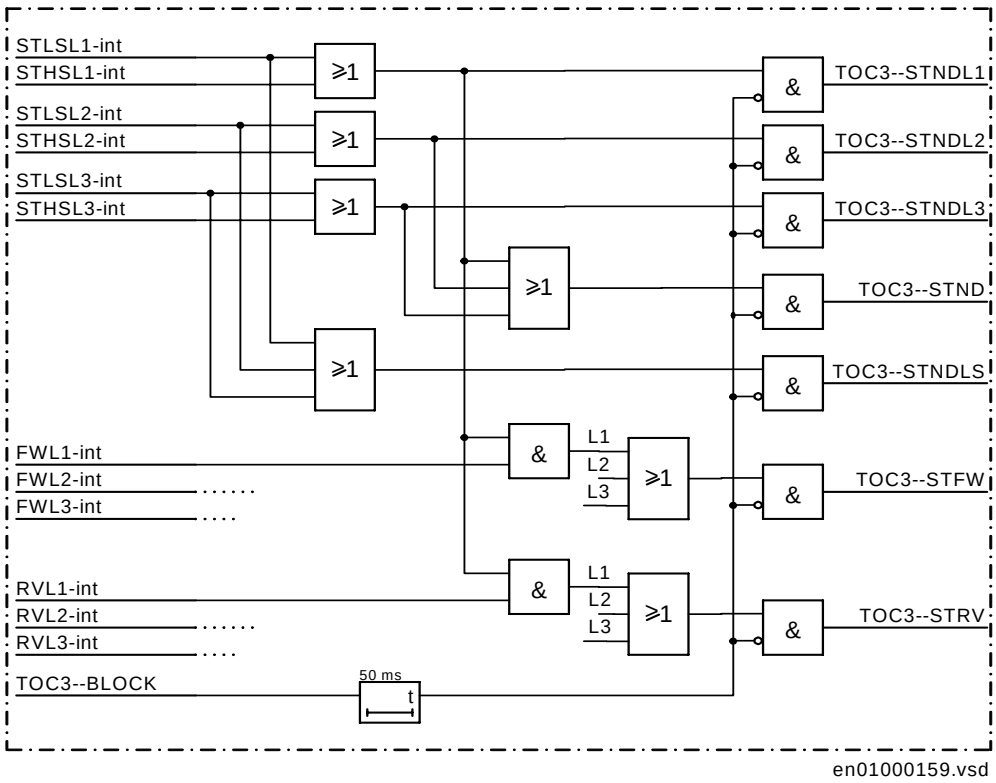


Figure 57: Start signals

3.5 Input and output signals

Table 115: 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 116: 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

3.6 Setting parameters

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

Table 117: 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

3.7 Technical data

Table 118: 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%

4 Sensitive directional residual overcurrent protection (WEF1)

4.1 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.

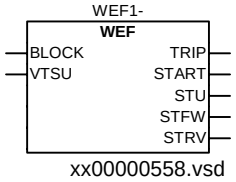
4.2 Functionality

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.

4.3 Function block



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4.4 Logic diagram

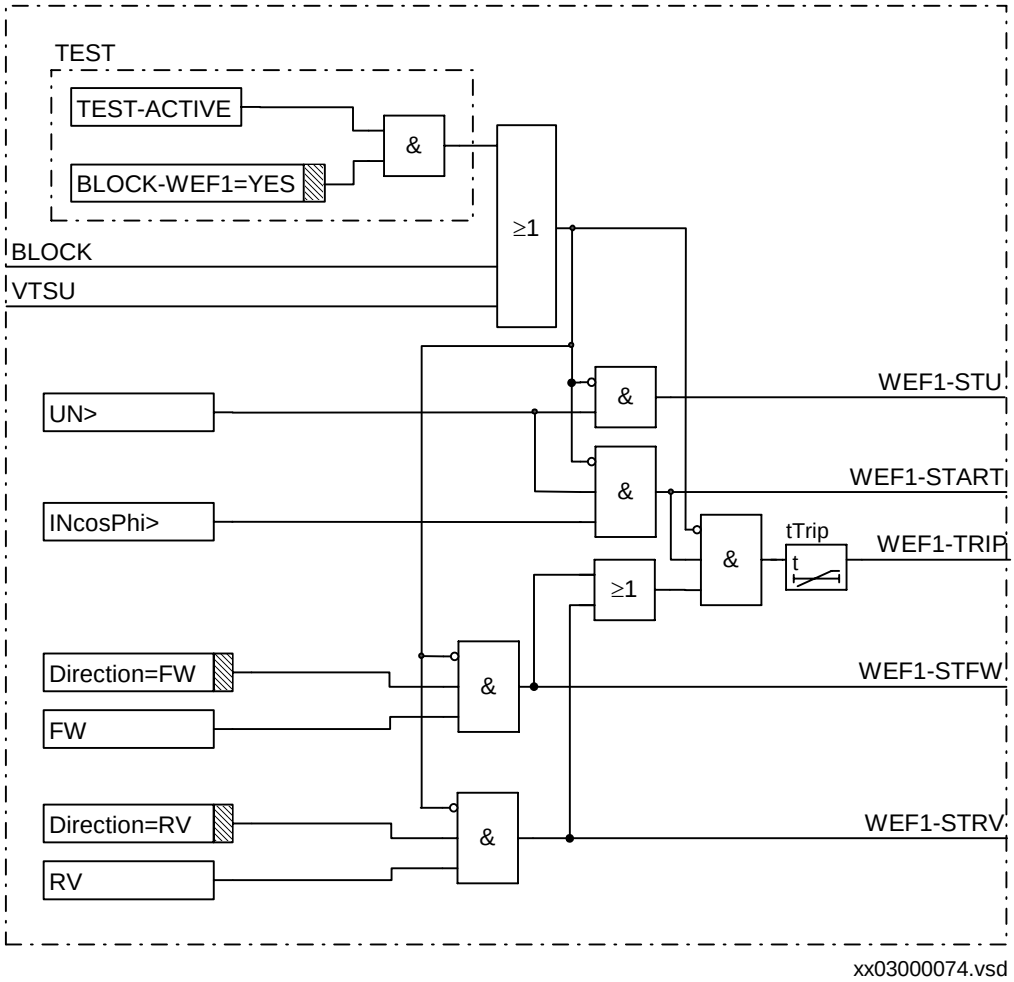


Figure 58: Sensitive directional residual overcurrent protection function, simplified logic diagram

4.5 Input and output signals

Table 119: 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 120: 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

4.6 Setting parameters

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

Table 121: 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

4.7 Technical data

Table 122: 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	

Chapter 6 Voltage

About this chapter

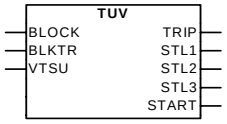
This chapter describes the voltage protection functions.

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

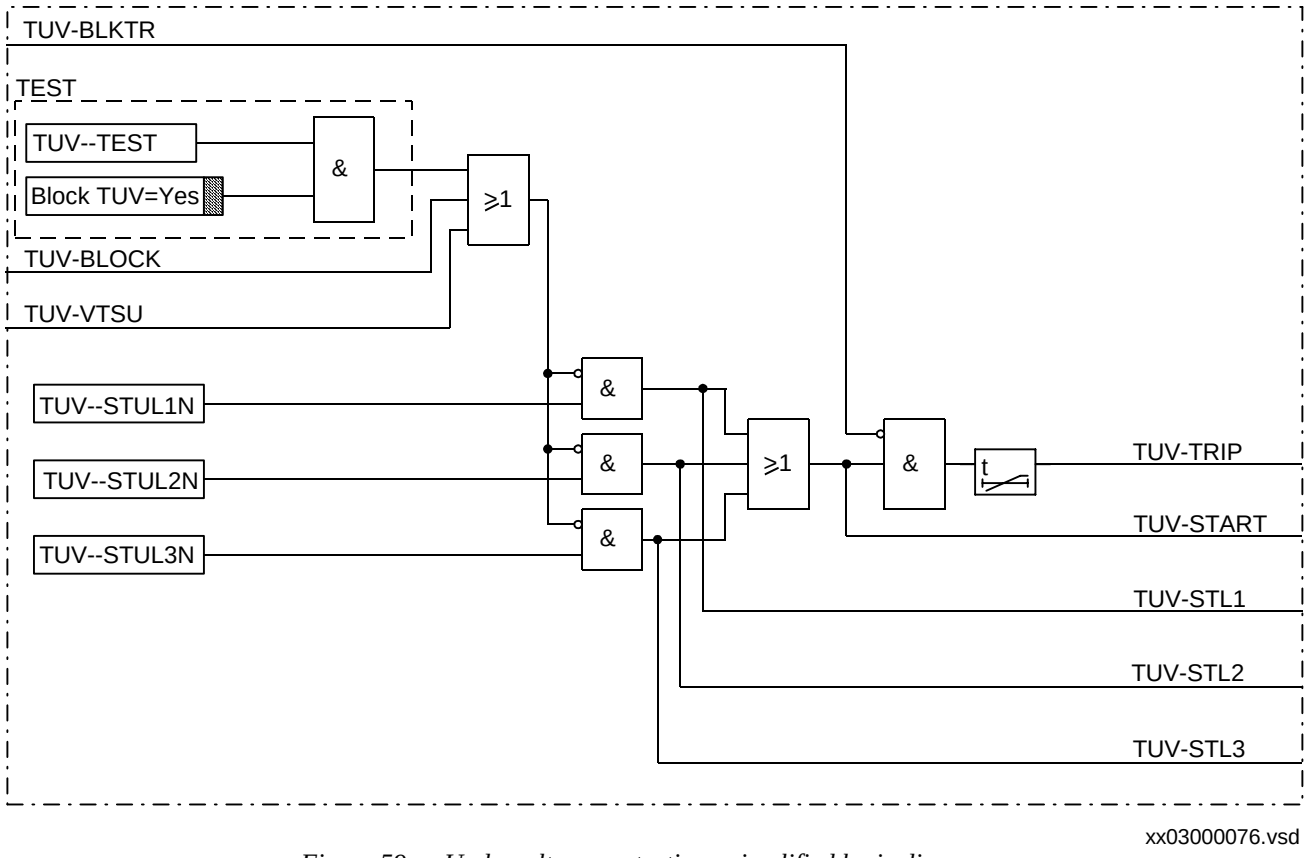


Figure 59: Undervoltage protection - simplified logic diagram

1.4 Input and output signals

Table 123: 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 124: 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 125: 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 126: 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.

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.

2.3 Function block

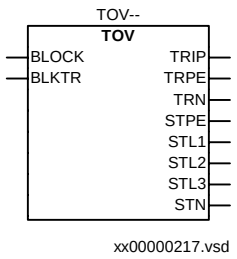
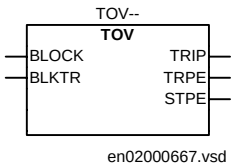


Figure 60: TOV function block, phase and residual overvoltage



2.4 Logic diagram

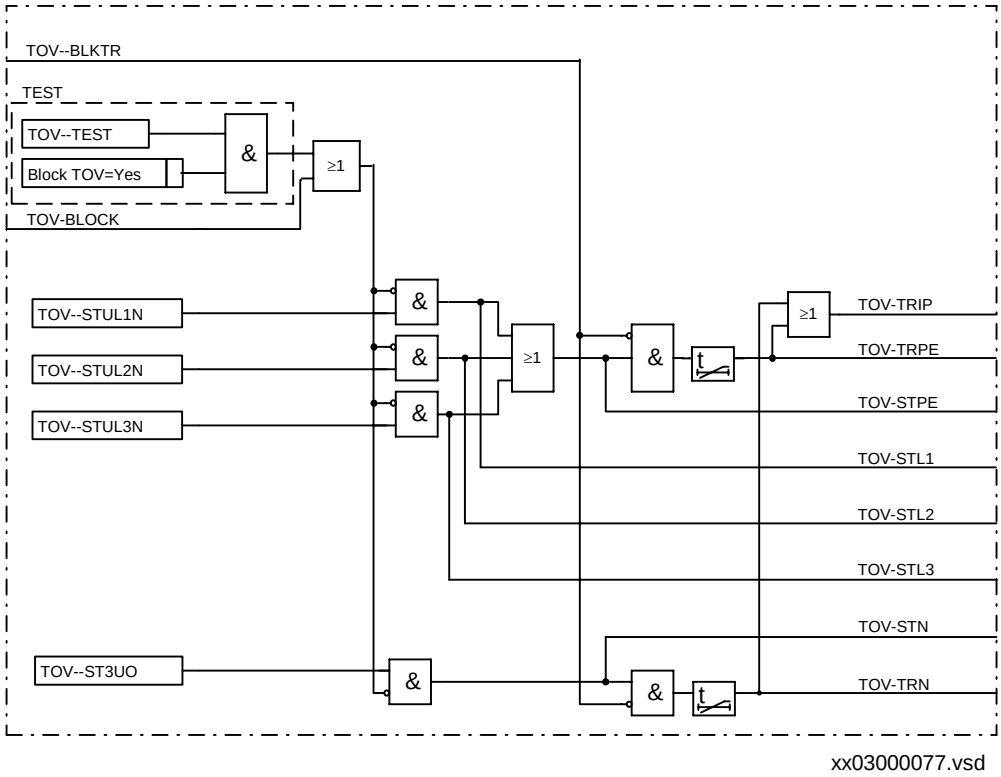


Figure 61: TOV, logic diagram

2.5 Input and output signals

Table 127: 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 128: 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 129: 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 130: 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 Dead line detection (DLD)

1.1 Application

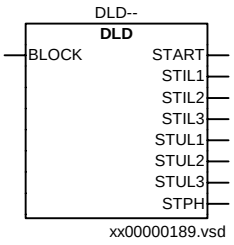
The main purpose of the dead line detection is to provide different protection, control and monitoring functions with the status of the line, i.e whether or not it is connected to the rest of the power system.

1.2 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.

If Switch onto fault logic (SOTF) and/or Fuse failure (FUSE) are selected, Dead line detection (DLD) is automatically included in the terminal.

1.3 Function block



1.4 Logic diagram

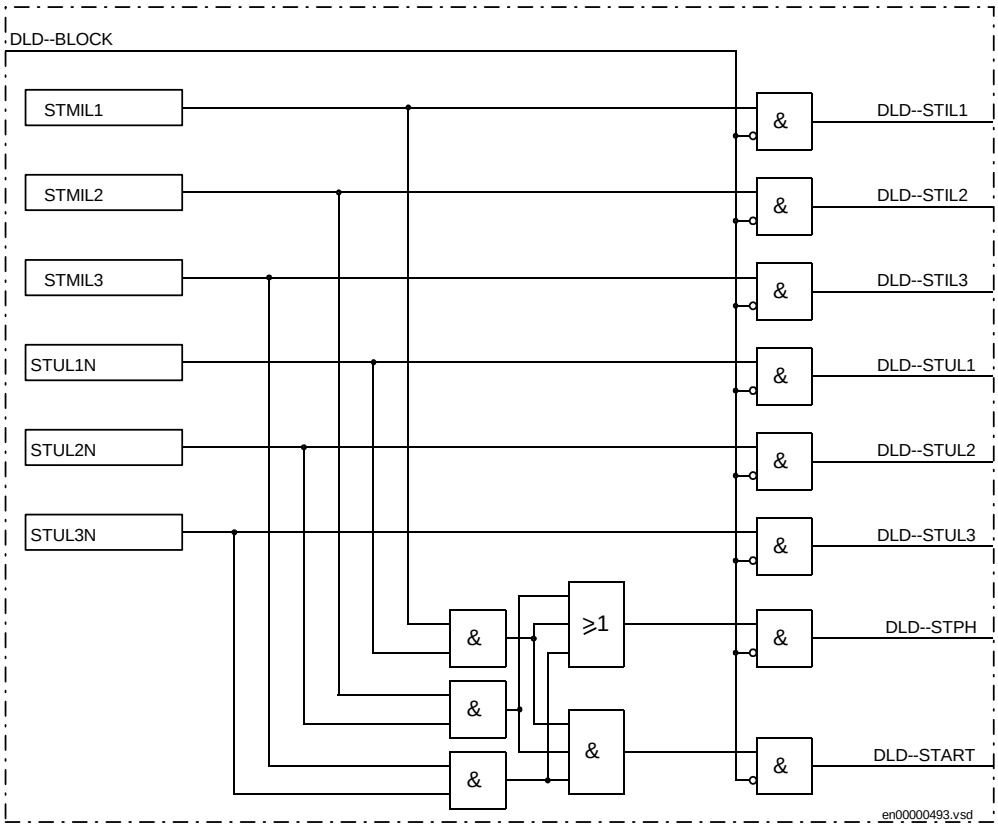


Figure 62: DLD - simplified logic diagram of a function

1.5 Input and output signals

Table 131: 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 132: 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

1.6 Setting parameters

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

Table 133: 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)

1.7 Technical data

Table 134: 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 Fuse failure supervision (FUSE)

1.1 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 the negative sequence measurement principle is recommended in isolated or high impedance earthed systems.

1.2 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.

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.

1.3 Function block

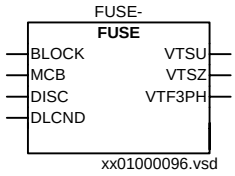


Figure 63: Function block, negative sequence

1.4 Logic diagram

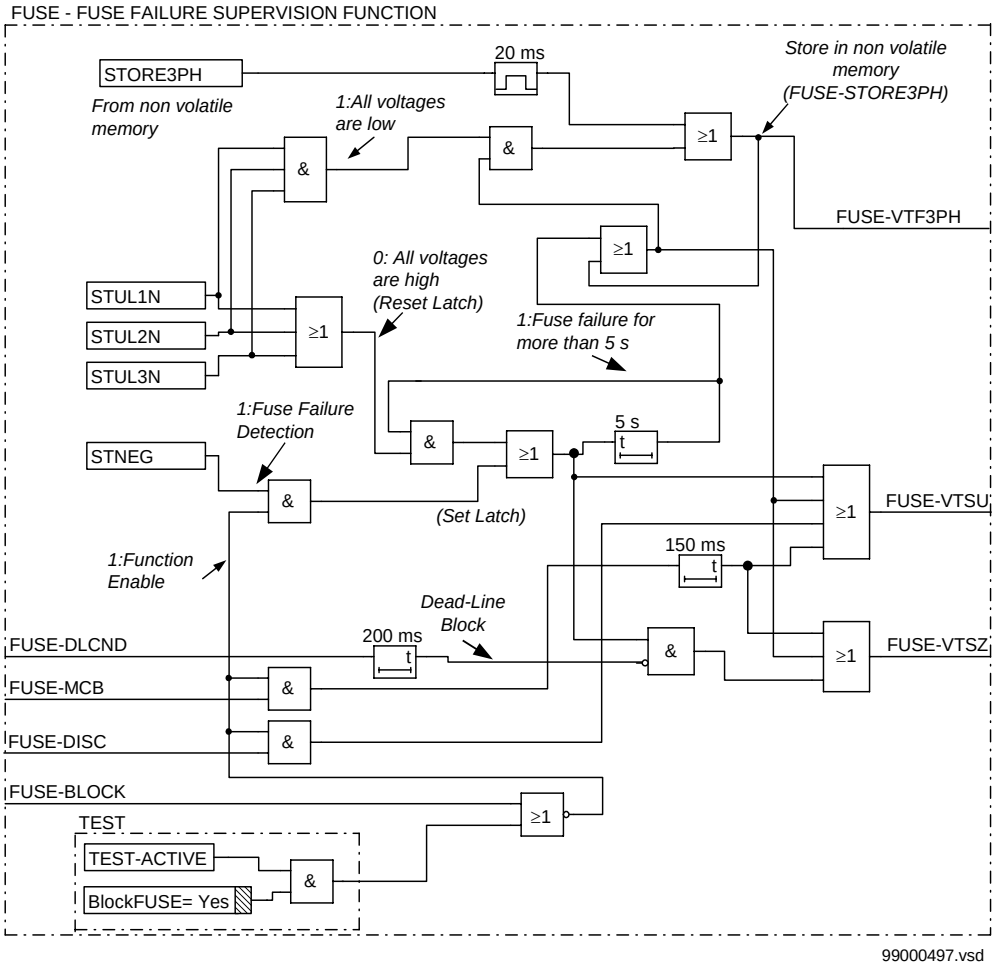


Figure 64: Simplified logic diagram for fuse failure supervision function, negative sequence.

1.5 Input and output signals

Table 135: 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 136: 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

1.6 Setting parameters

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

Table 137: 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

1.7 Technical data

Table 138: 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

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.

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.

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

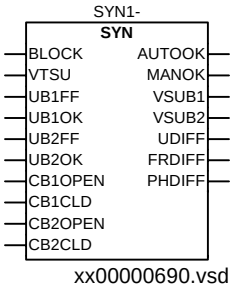


Figure 65: Function block for single CB

1.4 Logic diagram

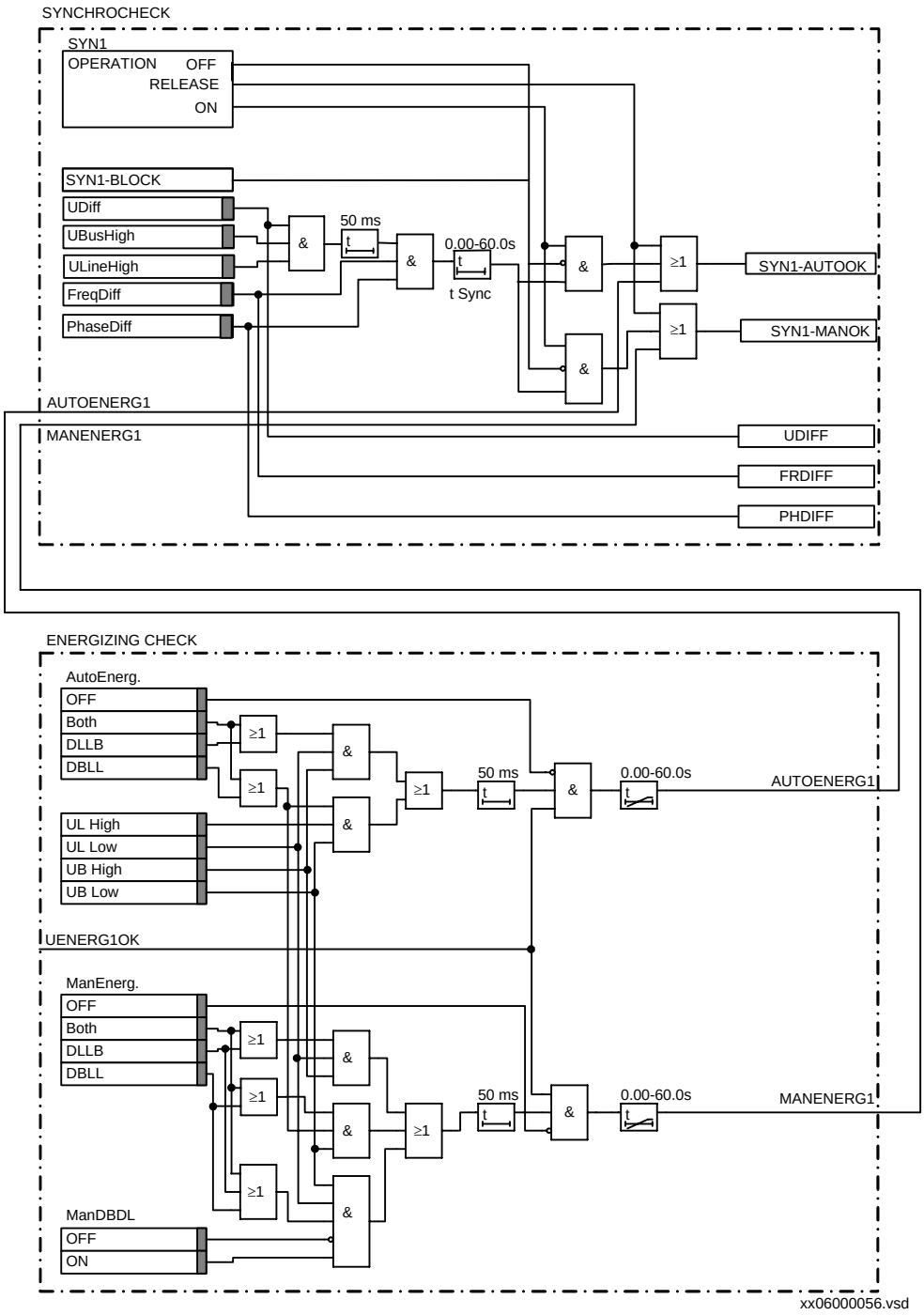


Figure 66: Simplified logic diagram, synchrocheck and energizing check, The internal signal

UENERG1OK refers to the voltage selection logic.

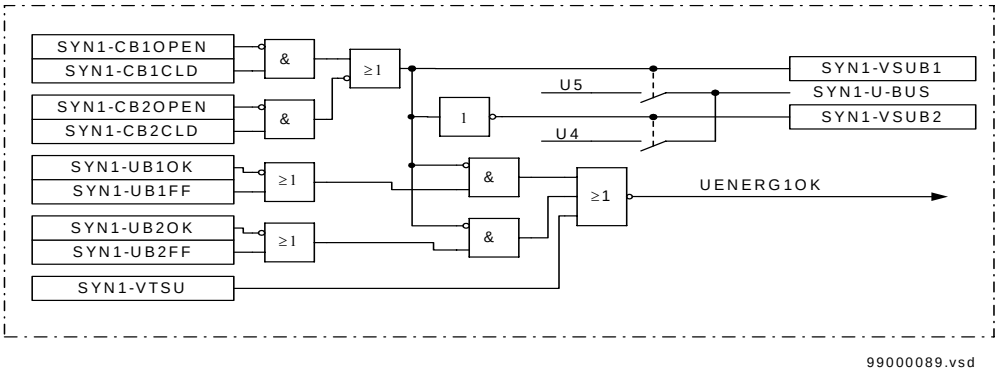


Figure 67: SYN, simplified voltage selection logic in a double bus, single breaker arrangement

1.5 Input and output signals

Table 139: 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 140: 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

1.6 Setting parameters

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

Table 141: 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

Parameter	Range	Default	Unit	Description
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

1.7 Technical data

Table 142: 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 143: 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

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.

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.

2.3 Function block

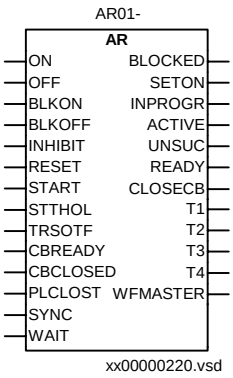


Figure 68: AR Function block: Three phase

2.4 Logic diagram

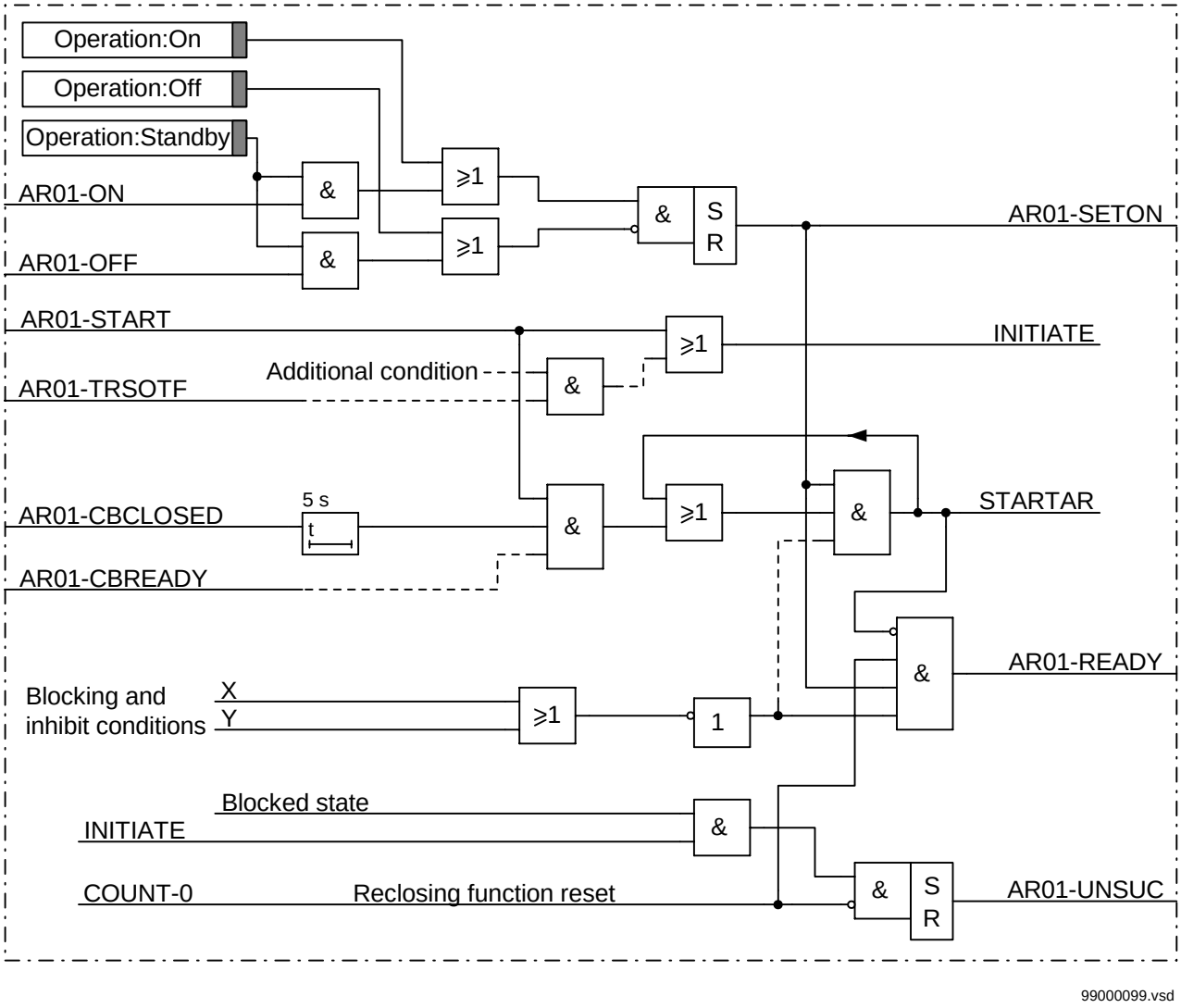


Figure 69: Auto-reclosing on/off control and start

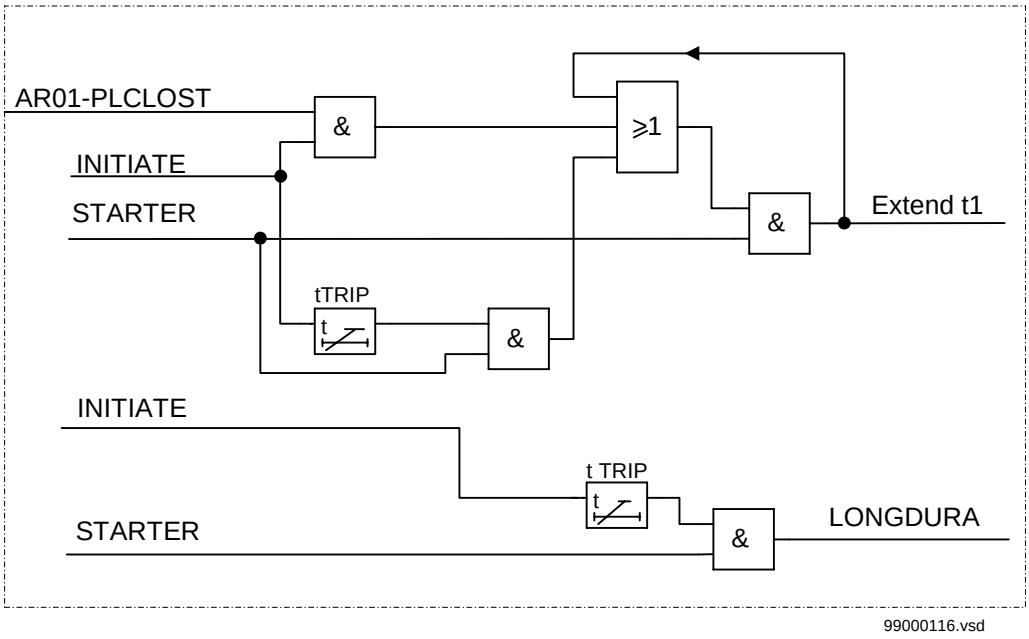


Figure 70: Control of extended AR open time, shot 1

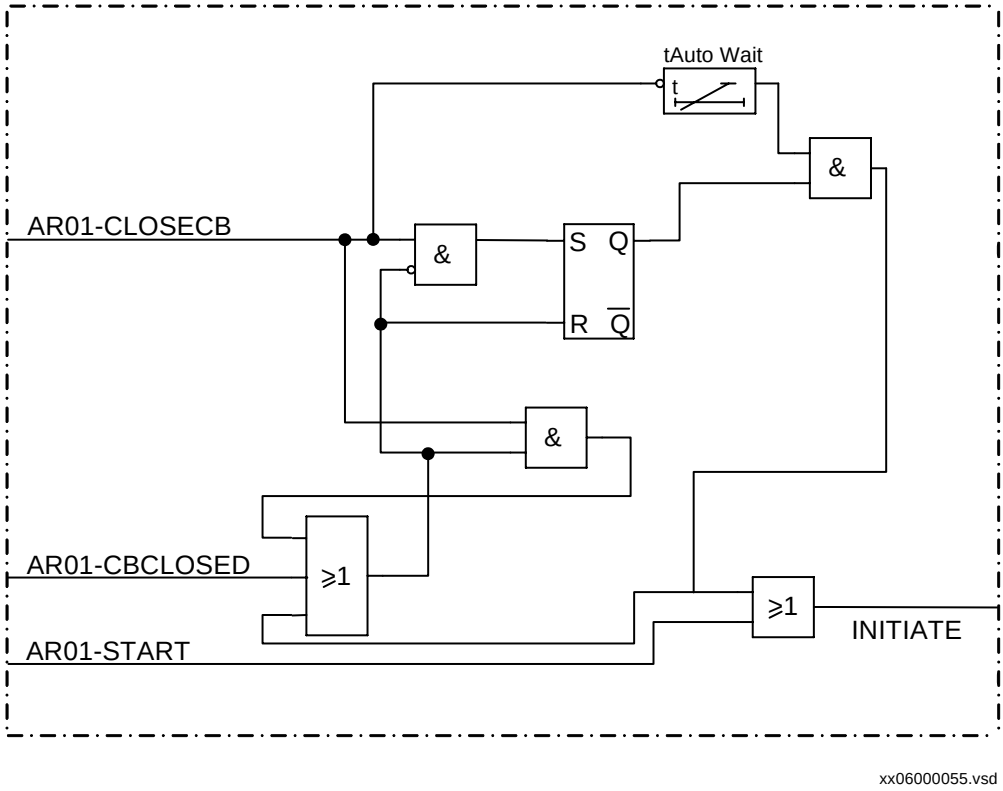


Figure 71: Automatic proceeding of shot 2 to 4

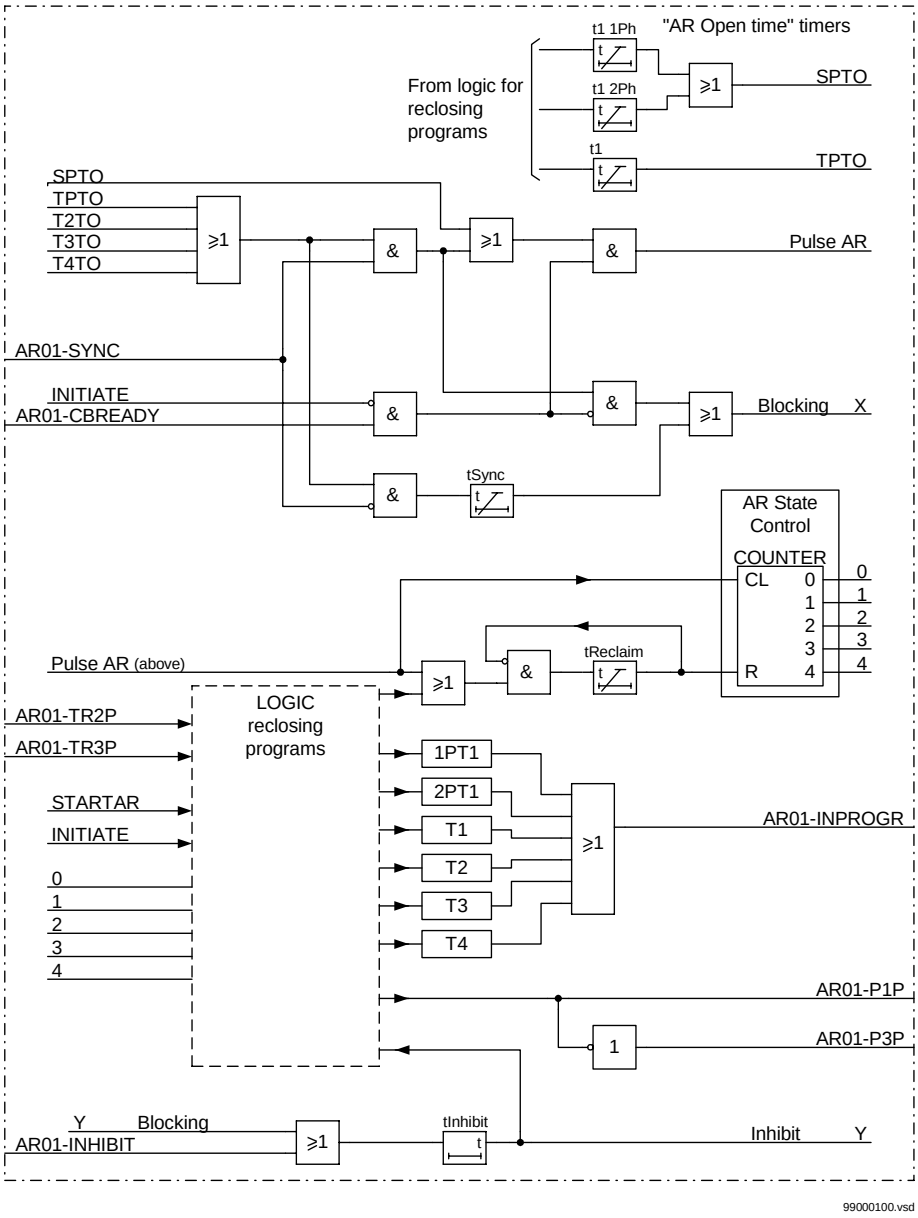


Figure 72: Reclosing checks and "Reclaim" and "Inhibit" timers

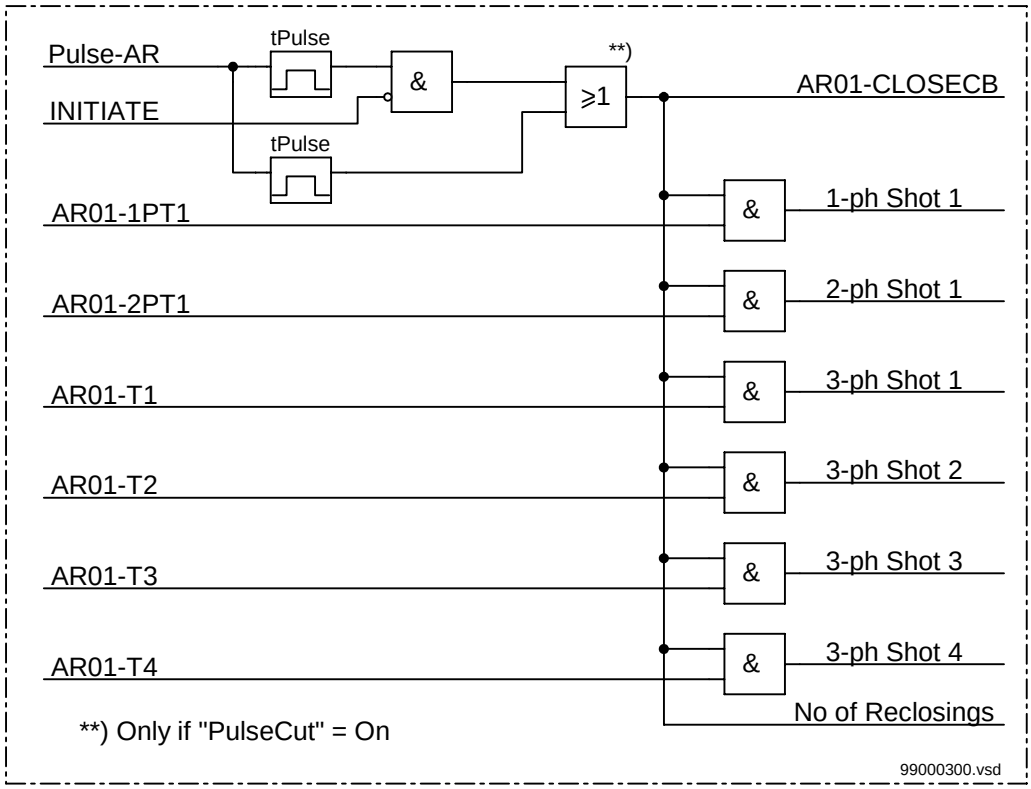


Figure 73: Pulsing of close command and driving of operation counters

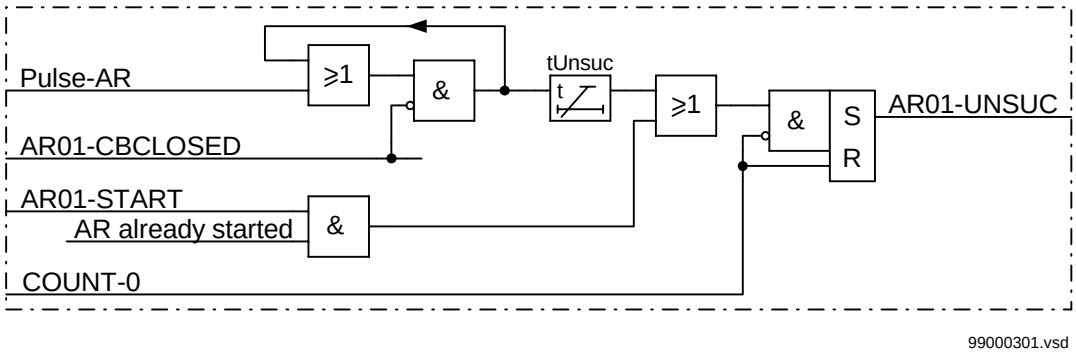


Figure 74: Issuing of the AR01-UNSUC signal

2.5 Input and output signals

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

Table 144: 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
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 145: 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
CLOSECB	Close command to circuit breaker
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 146: Autorecloser counter values AR (AR---)

Viewed data (default labels used, data is example values)	Counter value
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 147: 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
Extended t1	Off, On	Off	-	Extended dead time for loss of permissive channel
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

Parameter	Range	Default	Unit	Description
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
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 148: AR - Autorecloser

Parameter	Setting range	Accuracy
Automatic reclosing open time:		
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

Parameter	Setting range	Accuracy
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 149: 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

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.

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.

1.3 Input and output signals

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

Table 150: Input signals for the TR (TRnn-) function block

Signal	Description
BLOCK	Block trip logic
TRIN	Trip all phases

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

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

Table 151: Output signals for the TR (TRnn-) function block

Signal	Description
TRIP	General trip output signal

1.4 Setting parameters

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

Table 152: Setting parameters for the trip logic TR (TR---) function

Parameter	Range	Default	Unit	Description
Operation	Off / On	Off	-	Operating mode for TR function
tTripMin	0.000-60.000 Step. 0.001	0.150	s	Minimum duration of trip time

1.5 Technical data

Table 153: 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 High speed binary output logic (HSBO)

2.1 Application

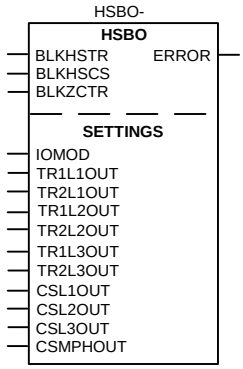
The time taken for signals to be transferred from binary inputs to protection functions, and from protection functions to binary outputs contributes to the overall tripping time. The main purpose of the HSBO high speed binary output logic is to minimize overall tripping times by establishing the critical connections to/from the binary outputs/inputs in a more direct way than with the regular I/O connections.

2.2 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.

2.3 Function block



2.4 Logic diagram

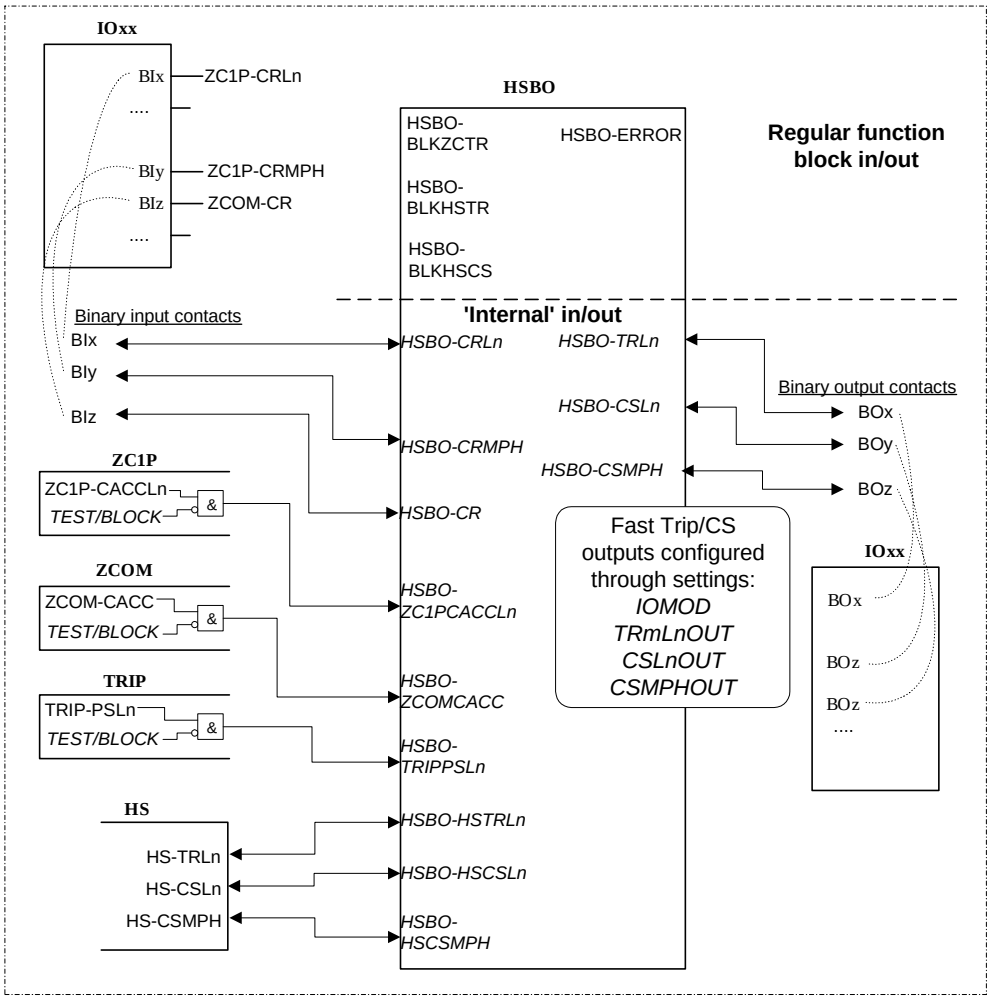


Figure 75: High speed binary output, simplified logic diagram

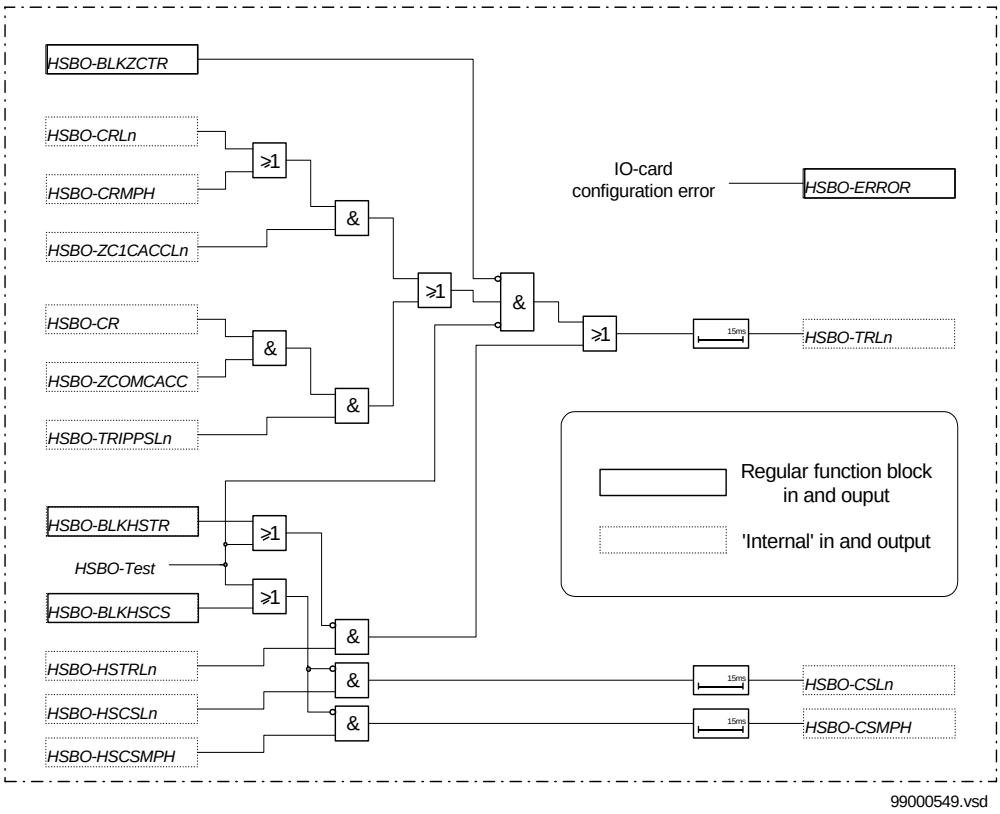


Figure 76: Simplified logic diagram of the HSBO function logic.

2.5 Input and output signals

Table 154: 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 155: Output signals for the HSBO (HSBO-) function block

Signal:	Description:
ERROR	Error output if configuration of ‘fast’ outputs does not correspond to actual hardware

2.6 Setting parameters

Table 156: 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.

3 Event function (EV)

3.1 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.

3.2 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.

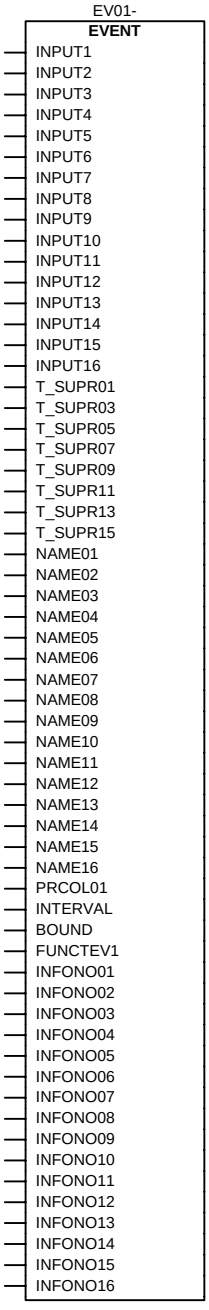
Each event function block has 16 connectables corresponding to 16 inputs INPUT1 to INPUT16. Every input can be given a name with up to 19 characters from the CAP 540 configuration tool.

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.

3.3 Function block



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3.4 Input and output signals

Table 157: 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.

3.5 Setting parameters

Table 158: 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.

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 functionality

Requirement for trig condition of the 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.

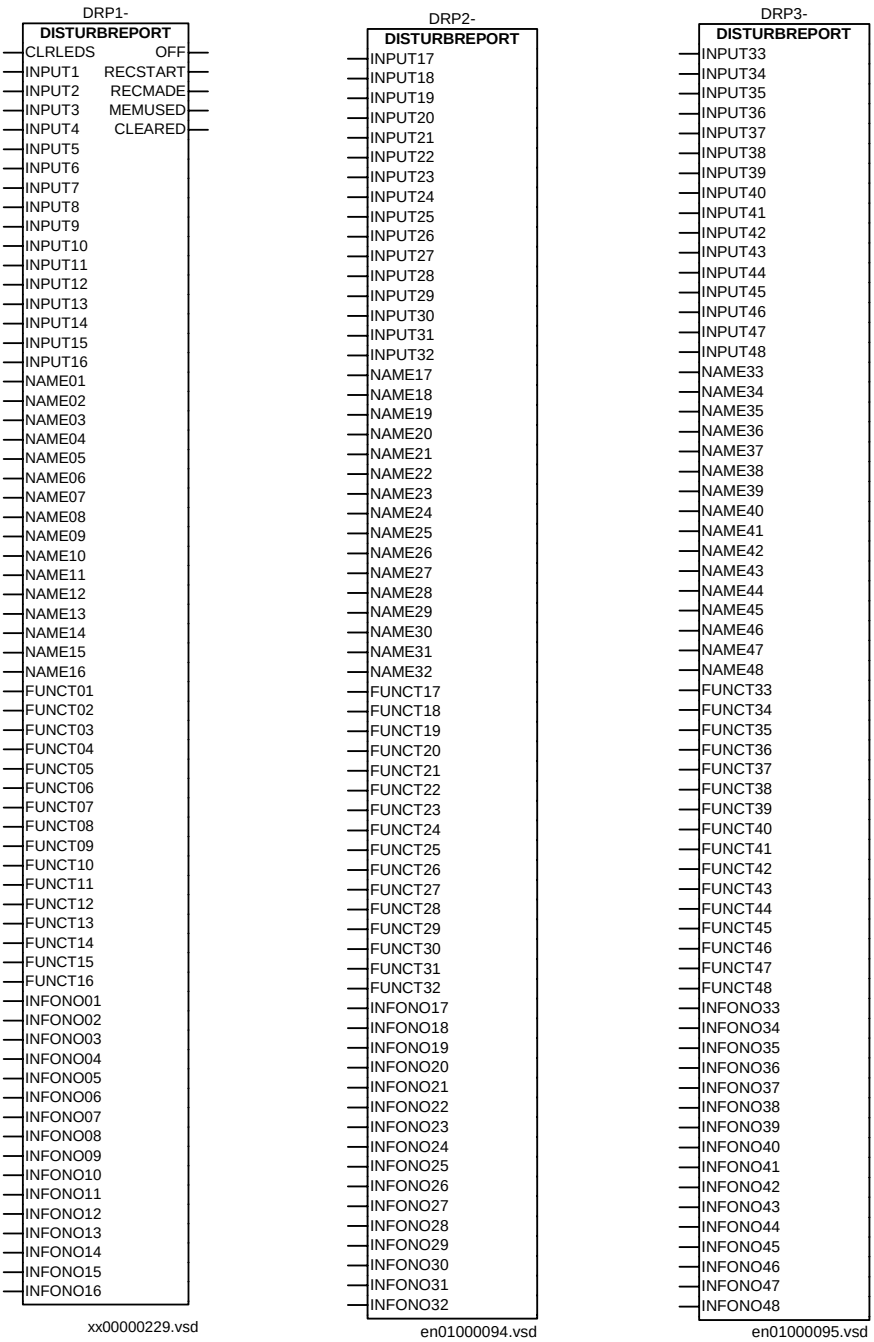
The collection is started by a trigger. Any binary input signal or function block output signal can be used as a trigger. The analog signals can also be set to trigger the data collection. Both over levels and under levels are available. The trigger is common for all subsystems, hence it activates them 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 159: 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 160: 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 161: 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 162: 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 163: 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 164: 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 165: 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 166: 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 167: 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 168: 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 169: 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 170: 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
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 171: 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.

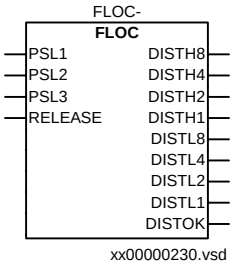
In case of double circuit lines, the influence of the zero-sequence mutual impedance Zm0 is compensated for by considering the residual current on the parallel line.

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 172: 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 173: 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 174: 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 175: 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 Supervision of AC input quantities (DA)

6.1 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.

6.2 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).

6.3 Function block

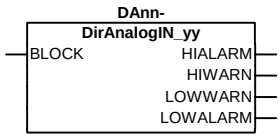


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Table 176: AC monitoring function block types

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

6.4 Input and output signals

Table 177: 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 178: 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

6.5 Setting parameters

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

Table 179: 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

6.6 Technical data

Table 180: Mean values (AC-monitoring)

Function	Nominal range	Accuracy
Frequency	(0.95 - 1.05) x f_r	± 0.2 Hz
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

Chapter 12 Data communication

About this chapter

This chapter describes the data communication and the associated hardware.

1 Serial communication

1.1 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 181: "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.

1.2 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 181.

Table 181: 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.

1.3 Setting parameters

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

Table 182: 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

1.4 Serial communication, SPA

1.4.1 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.

1.4.2 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.

1.4.3 Setting parameters

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

Table 183: 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 184: 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

1.4.4 Technical data

Table 185: 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 186: Serial communication (RS485)

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

Table 187: 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

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

1.5.1 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.

1.5.2 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.

1.5.3 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 188: 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 189: 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 190: 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

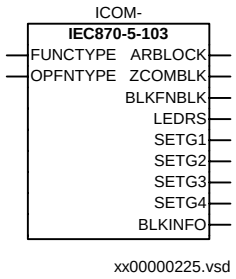
Table 191: Interoperability, physical layer

	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 192: 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

1.5.4 Function block



1.5.5 Input and output signals

Table 193: 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 194: 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.

1.5.6 Setting parameters

Table 195: 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 196: 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 197: 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 198: 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 199: 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 200: 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 201: 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 202: 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 203: IEC command

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

1.5.7 Technical data

Table 204: Serial communication (IEC 60870-5-103)

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

Table 205: Serial communication (RS485)

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

1.6 Serial communication, LON

1.6.1 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.

1.6.2 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.

1.6.3 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 206: 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 207: 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 208: 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 209: 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.

1.6.4 Technical data

Table 210: LON - Serial Communication

Function	Value
Protocol	LON
Communication speed	1.25 Mbit/s

1.7 Serial communication modules (SCM)

1.7.1 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.

1.7.2 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.

1.7.3 Technical data

Table 211: 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 212: 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 213: 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 13 Hardware modules

About this chapter

This chapter describes the different hardware modules.

1 Modules

Table 214: 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 215: Application specific modules

Module	Description
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
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

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 216: 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
Operative range	(0.001-1.5) x U_r	
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 Technical data

Table 217: BIM, PSM - Binary inputs

Inputs	**RL24**	**RL48**	**RL110**	**RL220**
Binary inputs	BIM: 16, PSM: 4			
Debounce frequency	5 Hz (BIM),			
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 218: BOM, PSM - Binary outputs

Function or quantity		**Trip and Signal relays**	**Fast signal relays**
Binary outputs		BOM: 24, PSM: 4	
Max system voltage		250 V AC, DC	250 V AC, DC
Test voltage across open contact, 1 min		1000 V rms	800 V DC
Current carrying capacity	Continuous	8 A	8 A
	1 s	10 A	10 A
Making capacity at inductive load with L/R>10 ms	0.2 s	30 A	0.4 A
	1.0 s	10 A	0.4 A
Breaking capacity for AC, cos φ>0.4		250 V/8.0 A	250 V/8.0 A
Breaking capacity for DC with L/R<40ms		48 V/1 A	48 V/1 A
		110 V/0.4 A	110 V/0.4 A
		220 V/0.2 A	220 V/0.2 A
		250 V/0.15 A	250 V/0.15 A
Maximum capacitive load		-	10 nF
Power consumption for each output relay		≤ 0.15 W	

Table 219: Power consumption

Module	Power consumption
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

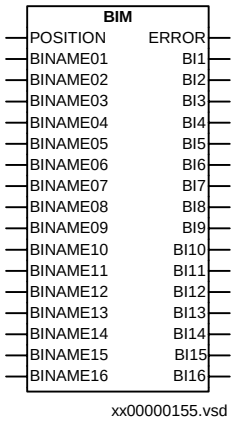


Figure 77: Binary input module

5.4 Input and output signals

Table 220: 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 221: Output signals for binary input module BIM

Signal	Description
ERROR	Binary module fail
BI1-BI16	Binary input data

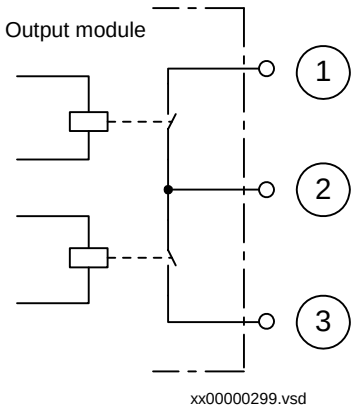
6 Binary output module (BOM)

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 78: Relay pair example

6.3 Function block

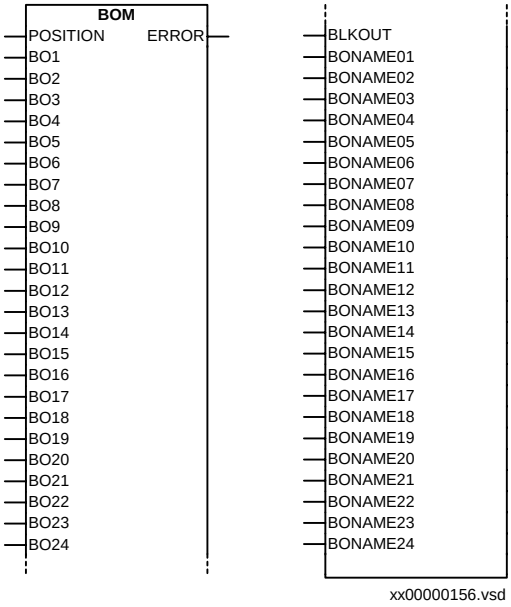


Figure 79: Binary output module

6.4 Input and output signals

Table 222: 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 223: Output signals for binary output module BOM

Signal	Description
ERROR	Binary module fail

7 Power supply module (PSM)

7.1 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.

7.2 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.

7.3 Function block

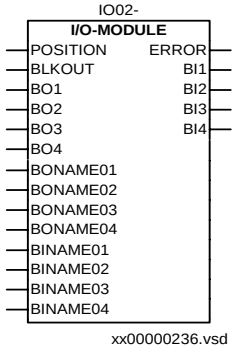


Figure 80: Binary I/O on the power supply module PSM

7.4 Input and output signals

Table 224: 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 225: 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

7.5 Technical data

Table 226: PSM - Power Supply Module

Quantity	Rated value	Nominal range
Auxiliary dc voltage	EL = (48 - 250) V	± 20%

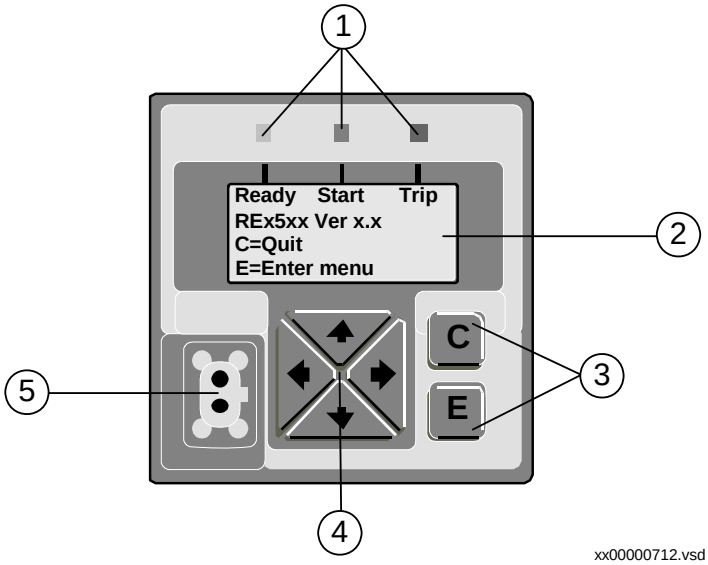
8 Local LCD human machine interface (LCD-HMI)

8.1 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.

8.2 Design



1. Status indication LEDs
2. LCD display
3. *Cancel* and *Enter* buttons
4. Navigation buttons
5. Optical connector

Figure 81: 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.

9 Serial communication modules (SCM)

9.1 SPA/IEC

Refer to chapter Data communication.

9.2 LON

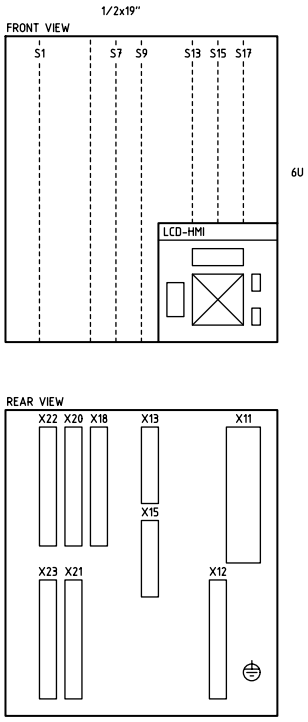
Refer to chapter Data communication.

Chapter 14 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	S1	X11,12
ADM	S7	-
MPM	S9	X13,15
PSM	S13	X18
BIM	S15	X20,21
BOM	S17	X22,23

TABLE 1

Figure 82: Hardware structure of the 1/2 of full width 19” case

1.2 Terminal diagram, REL 511-C2

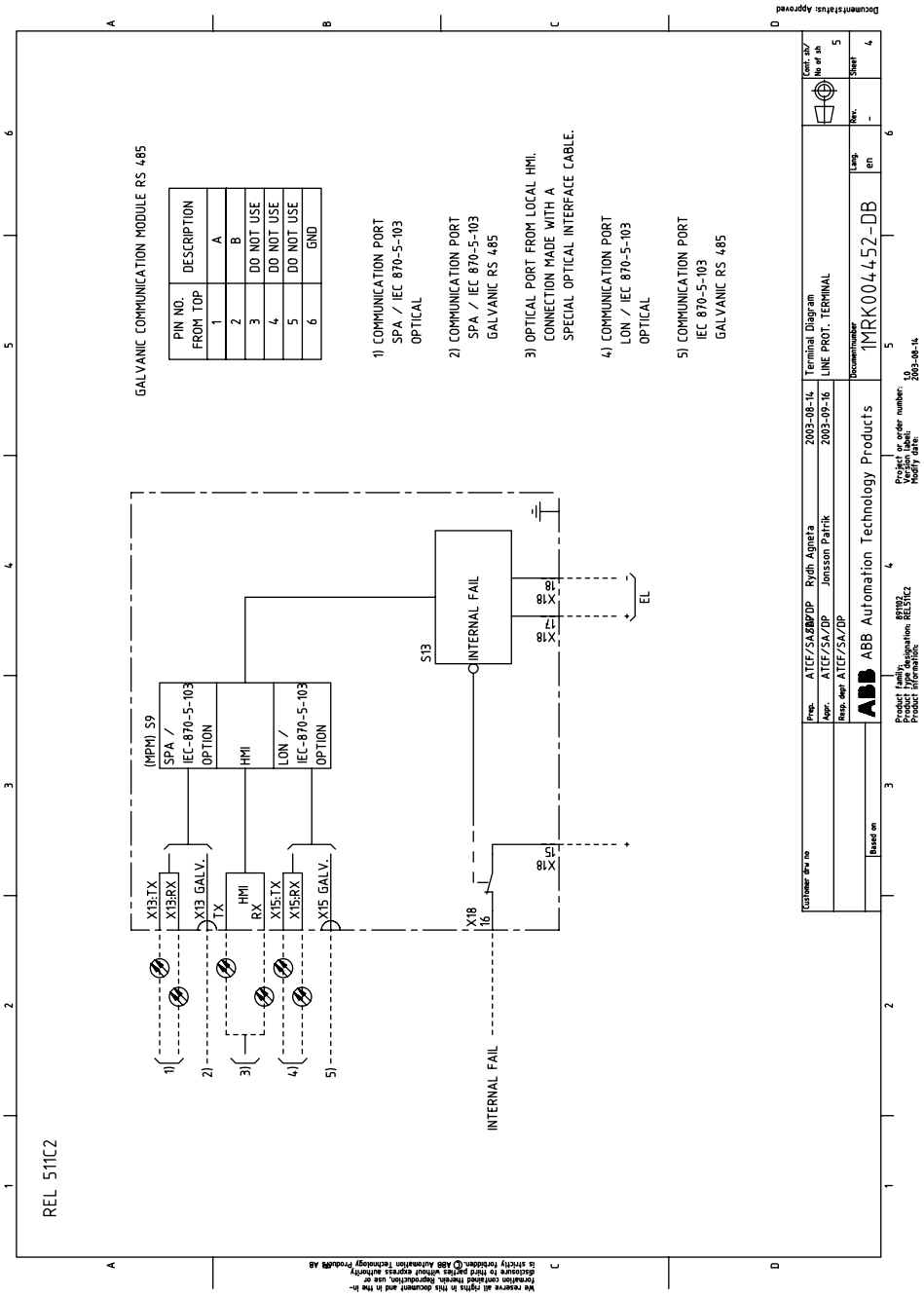


Figure 83: REL 511-C2

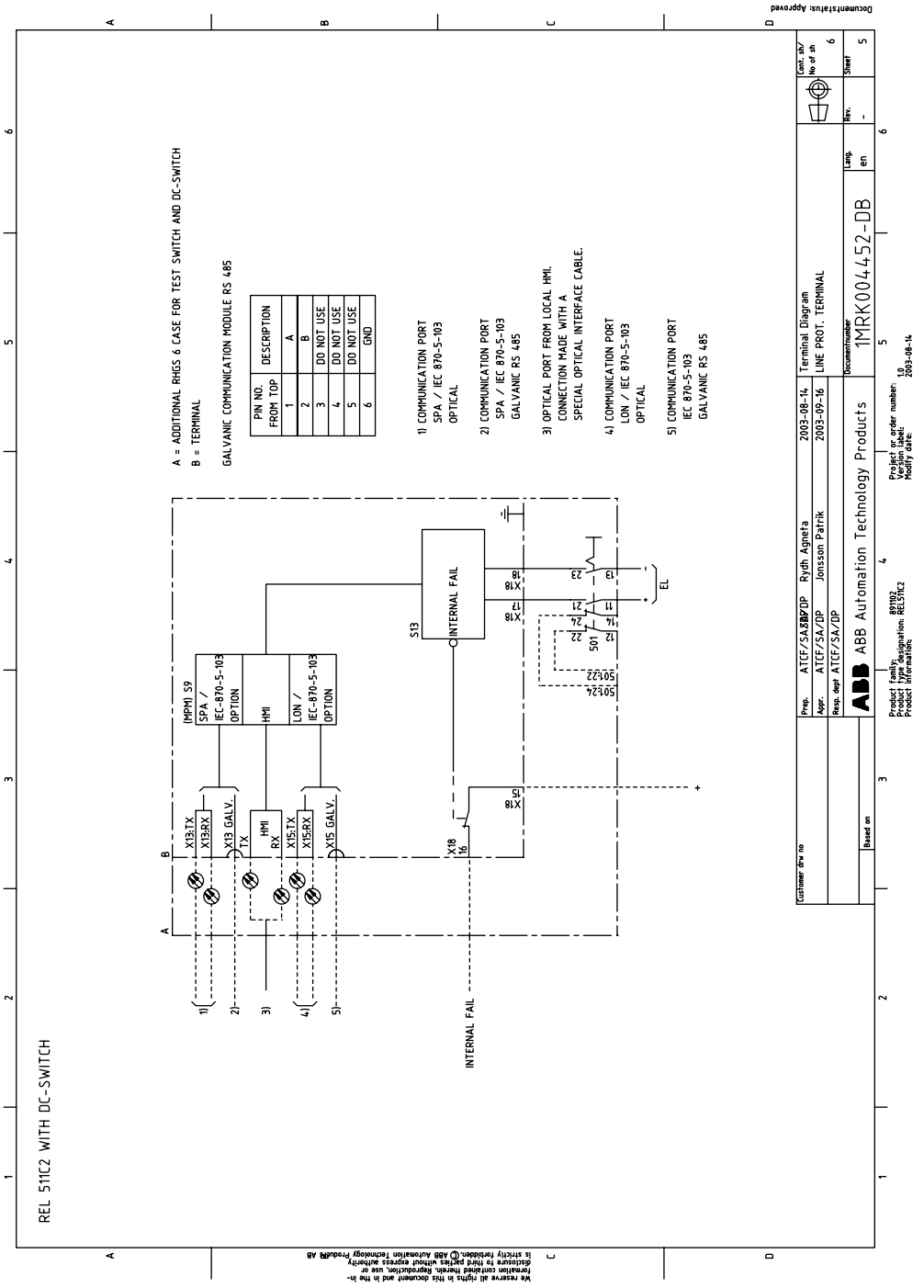


Figure 84: REL 511-C2 with DC-switch

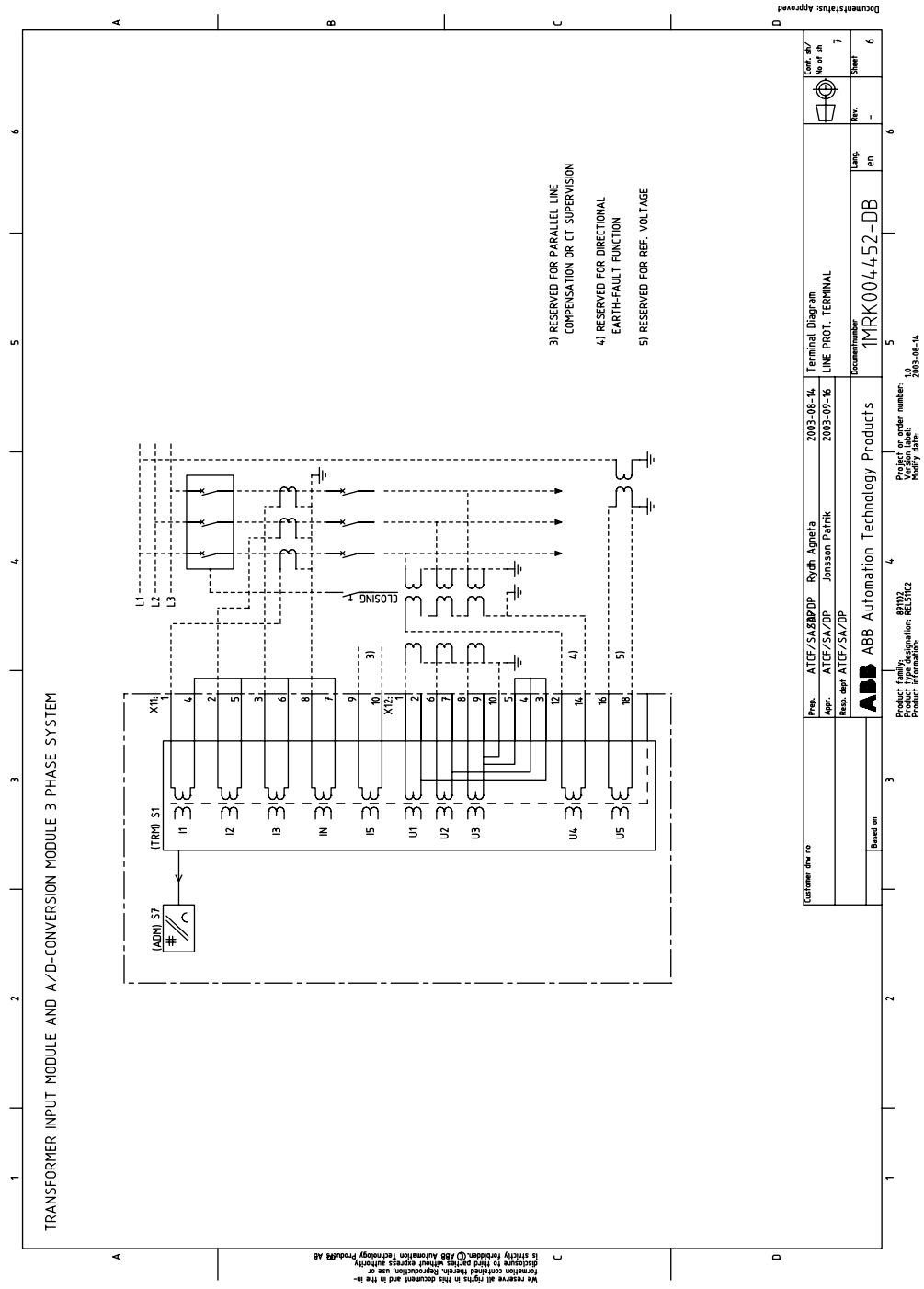


Figure 85: REL 511-C2, transformer input module and A/D conversion module 3 phase system

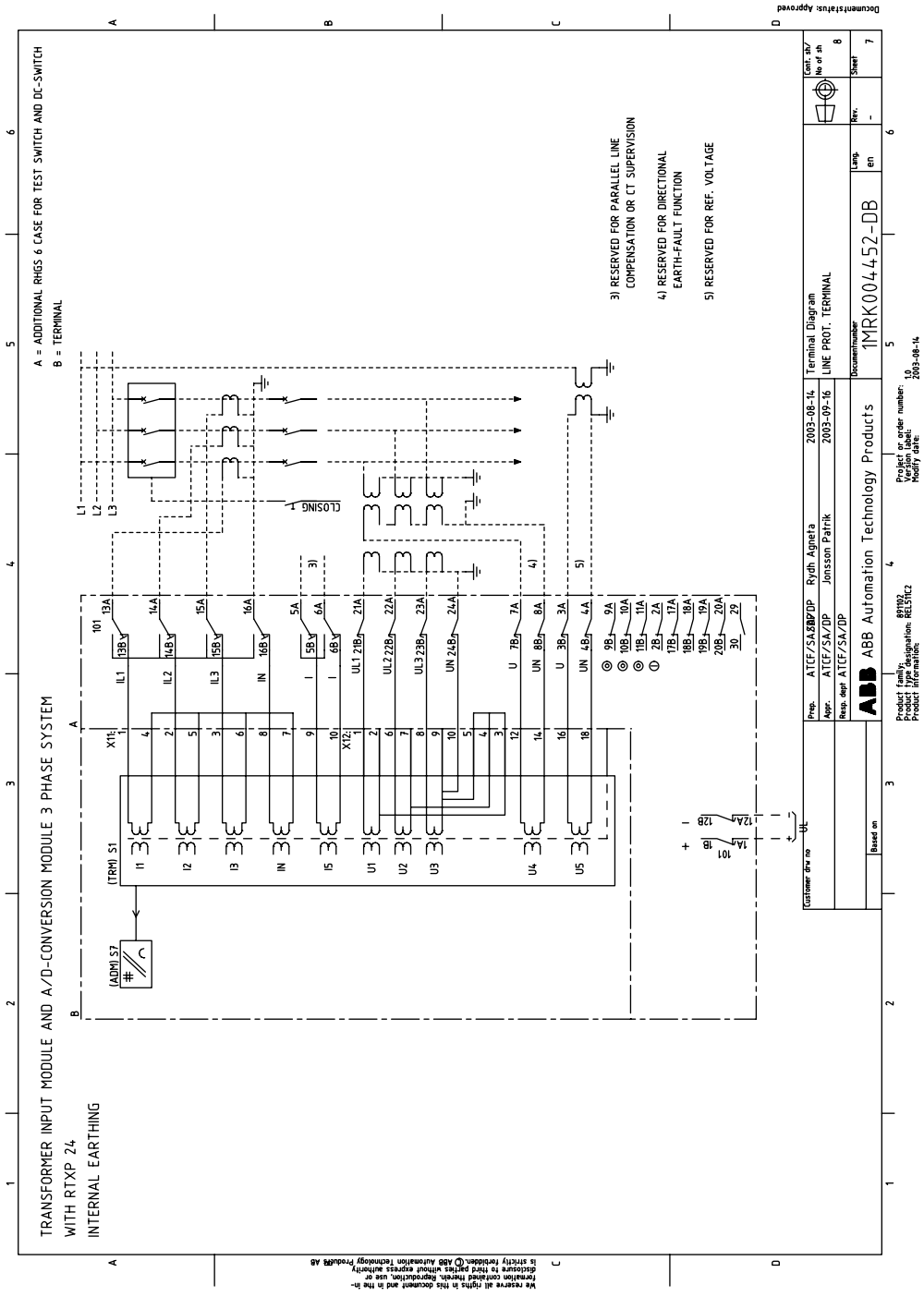


Figure 86: REL 511-C2, transformer input module and A/D conversion module 3 phase system with RTXP 24, internal earthing

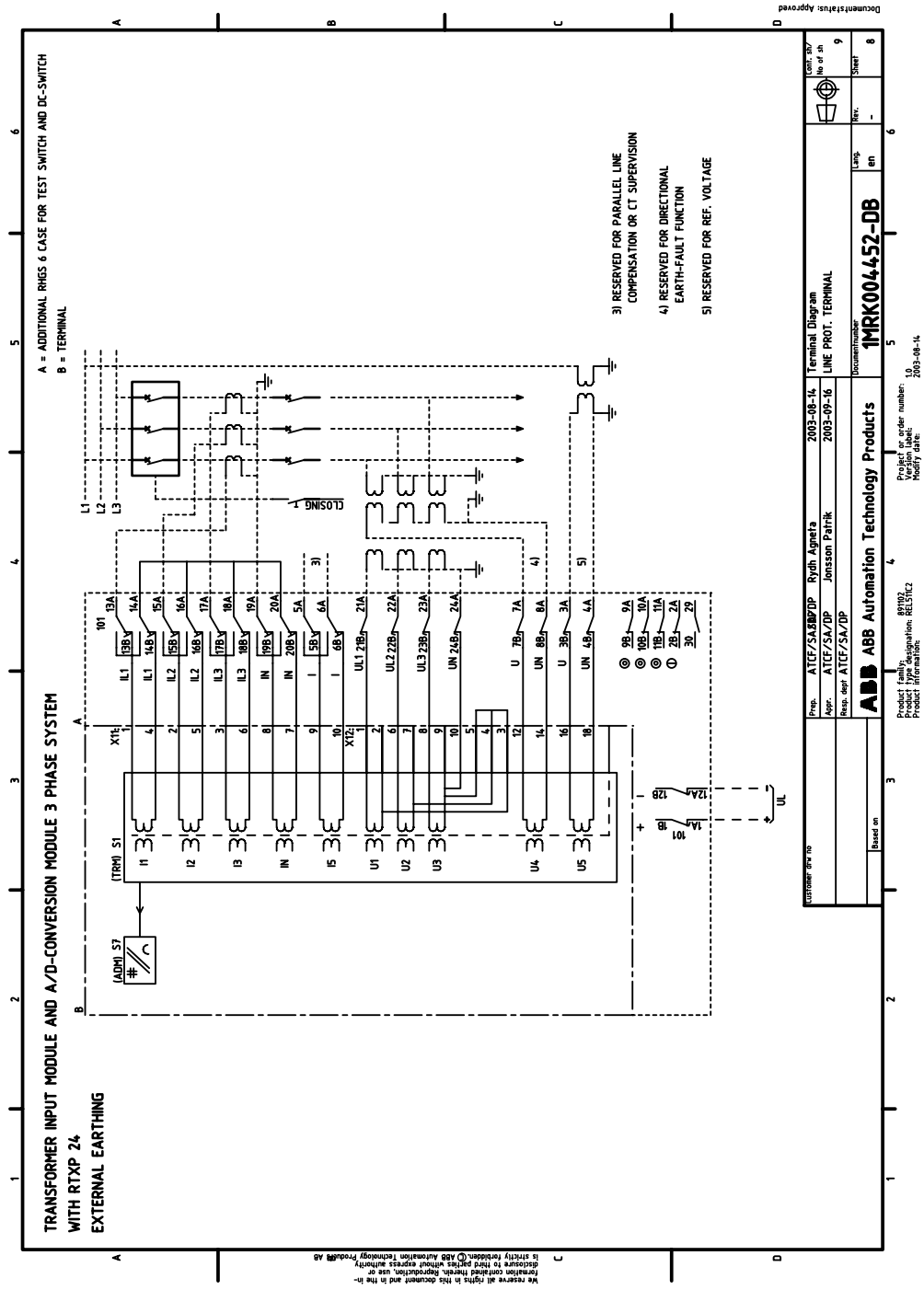


Figure 87: REL 511-C2, transformer input module and A/D conversion module 3 phase system with RTXP 24, external earthing

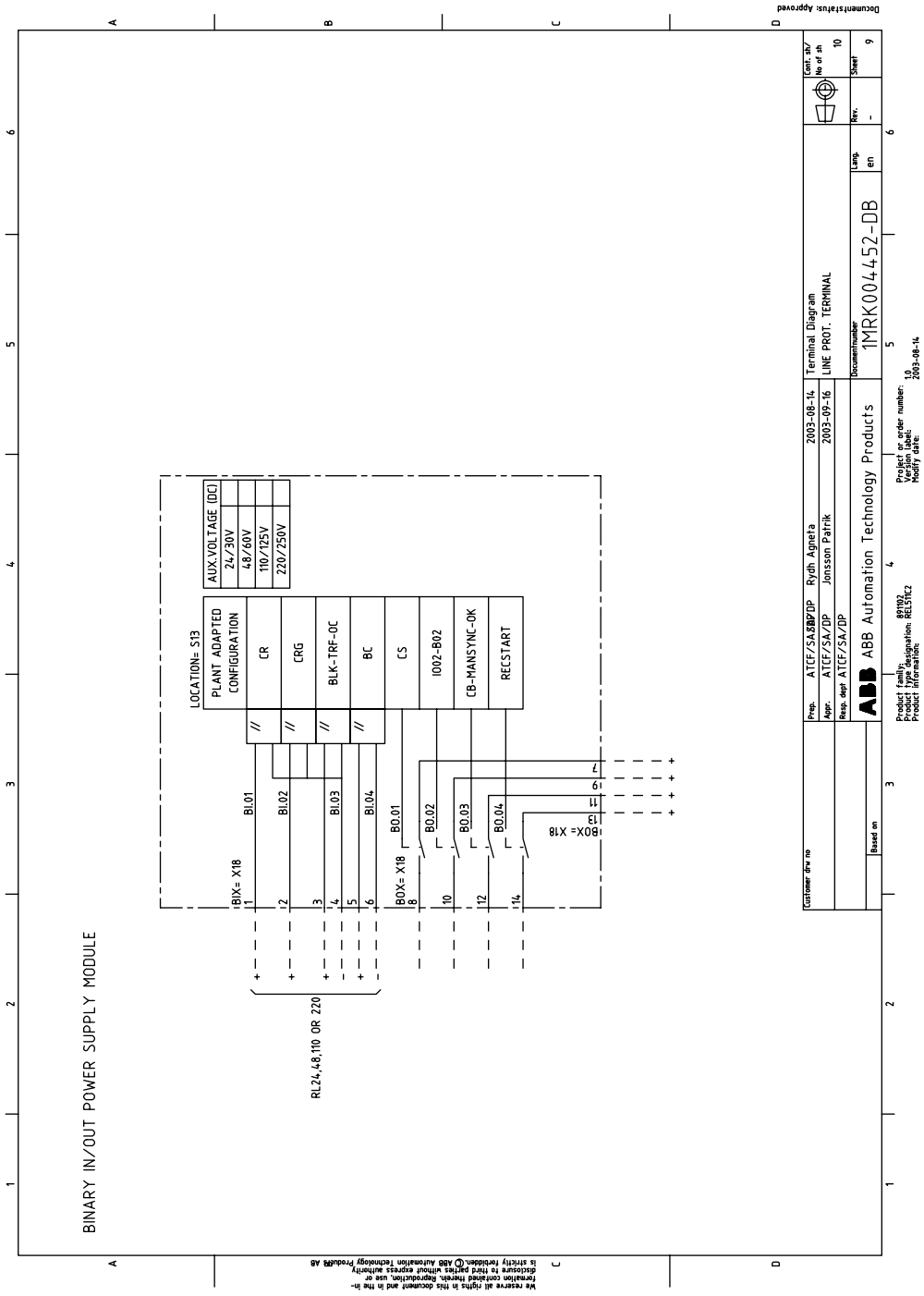


Figure 88: REL 511-C2, binary in/out power supply module

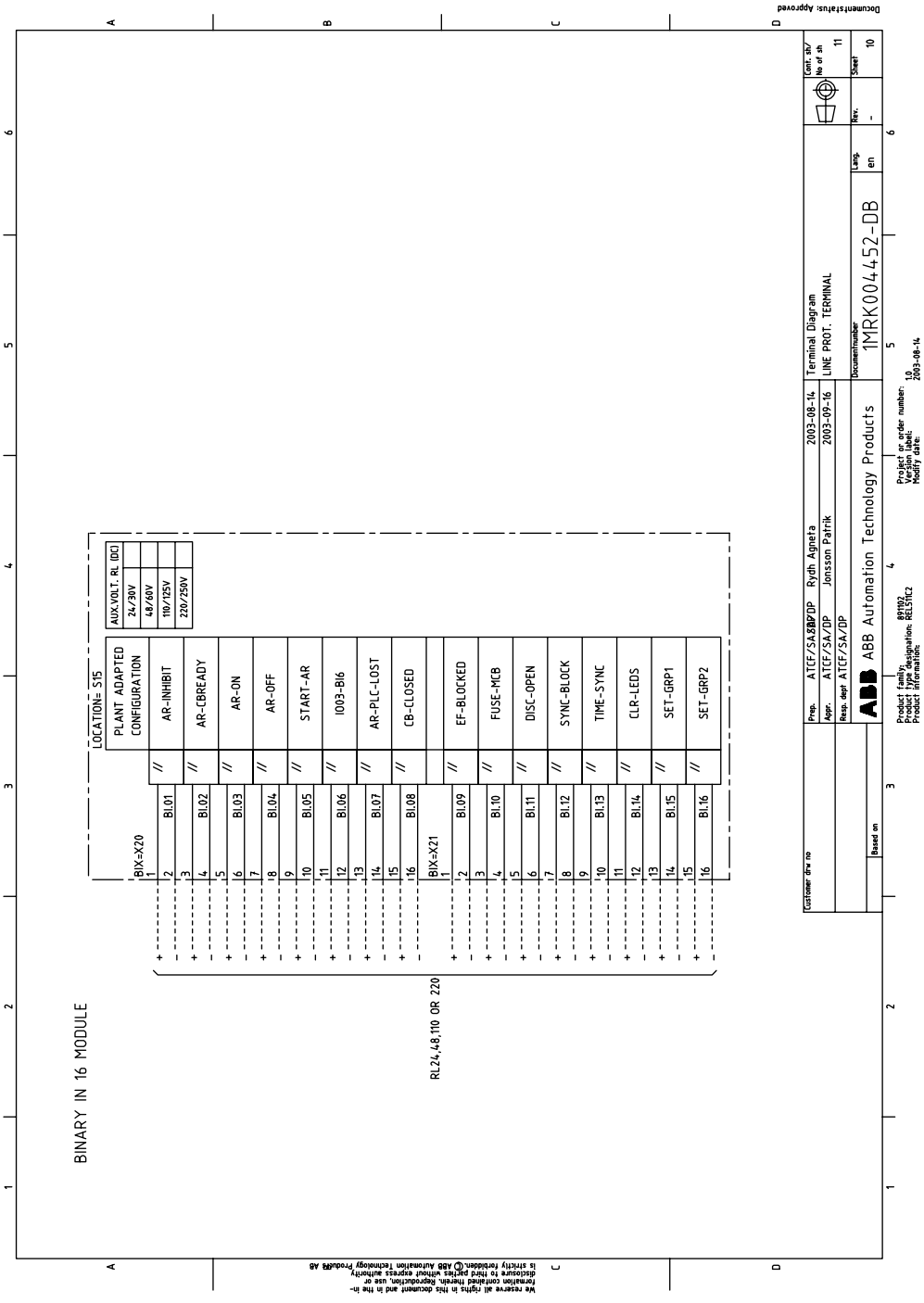


Figure 89: REL 511-C2, binary in 16 module

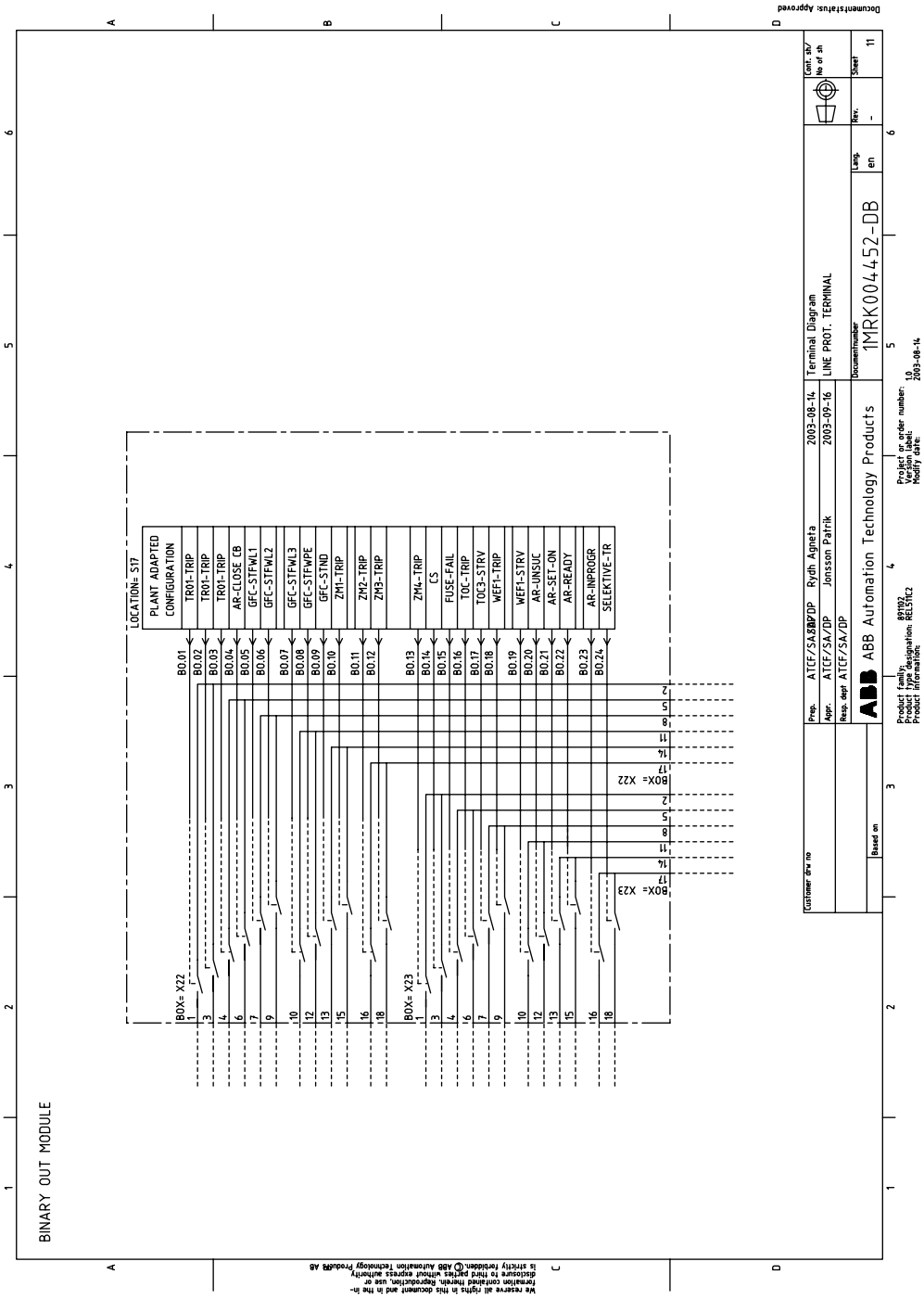


Figure 90: REL 511-C2, binary out module

Chapter 15 Configuration

About this chapter

This chapter refer to the configuration in CAP 540.

1 Configuration

Configuration of REL 511 C2 is available as templates in the latest version of CAP 540.

ABB Power Technologies AB
Substation Automation Products
SE-721 59 Västerås
Sweden
Telephone: +46 (0) 21 34 20 00
Facsimile: +46 (0) 21 14 69 18
www.abb.com/substationautomation

1MRK 506 202-UEN

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