DV7036
configuration description
(Type: DTVA)

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User's manual version information

Version	Date	Modification	Compiled by
Preliminary	2017-09-22		Tóth
Preliminary_2	2019-10-10	PMU function description added	Seida
Preliminary_3	2019-10-17	**Modified:** • 1.1.4 Hardware configuration • 1.1.5 The applied hardware modules • 2 External connection	Seida
Preliminary_4	2020-04-14	Modified: 1.2.3.4 PMU function description and parameter data updated	Seida
1.0	2020-06-17	**Modified:** • Minor correction in Chapter 1.2.3.4 PMU • Updated the HW configuration in Chapter 1.1.4 • Updated Chapter 2	Seida/Tóth
1.1	2020-11-05	**Modified**: • TSYNC module position changed as a recommended option	Tóth

CONTENTS

1 Configuration description

The DV7036 protection device is a member of the ***EuroProt+*** product line, made by Protecta Co. Ltd. The ***EuroProt+*** type complex protection in respect of hardware and software is a modular device. The modules are assembled and configured according to the requirements, and then the software determines the functions. This manual describes the specific application of the DV7036 factory configuration.

1.1 Application

The members of the DTVA product line are configured to protect and control the elements of the high voltage networks. These networks are typically solidly grounded. In these networks the single phase-to-ground faults result high current, so these types of faults need fast protection functions similar to line-to-line faults.

1.1.1 Protection functions

The configured protection functions are listed in the Table below.

Protection functions	IEC	ANSI	DV7036
Three-phase instantaneous overcurrent protection	I >>>	50	X
Three-phase time overcurrent protection	I >, I >>	51	X
Three-phase directional overcurrent protection	I Dir > >, I Dir >>	67	X
Residual instantaneous overcurrent protection	Io >>>	50N	X
Residual time overcurrent protection	Io >, Io >>	51N	X
Residual directional overcurrent protection	Io Dir > >, Io Dir >>	67N	X
Line differential (with charging current compensation)	$3I_dL$ >	87L	X
Distance protection (with Teleprtection and Weak and Infeed Logic)	Z <	21	X
Out-of-step	$\Delta Z/\Delta t$	78	X
Power swing block		68	X
Inrush detection and blocking	I_{2h} >	68	X
Negative sequence overcurrent protection	I_2 >	46	X
Thermal protection	T >	49	X
Definite time overvoltage protection	U >, U >>	59	X
Definite time undervoltage protection	U <, U <<	27	X
Residual overvoltage protection	Uo >, Uo >>	59N	X
Negative sequence overvoltage protection	U_2 >	47	X
Overfrequency protection	f >, f >>	81O	X
Underfrequency protection	f <, f <<	81U	X
Rate of change of frequency protection	df/dt	81R	X
Auto-reclose	0 - > 1	79	X
Fuse failure (VTS)		60	X
Current unbalance protection		60	X
Switch onto fault logic			X
Breaker failure protection	CBFP	50BF	X

Table 1 The protection functions of the DV7036 configuration

The configured functions are drawn symbolically in the Figure below.

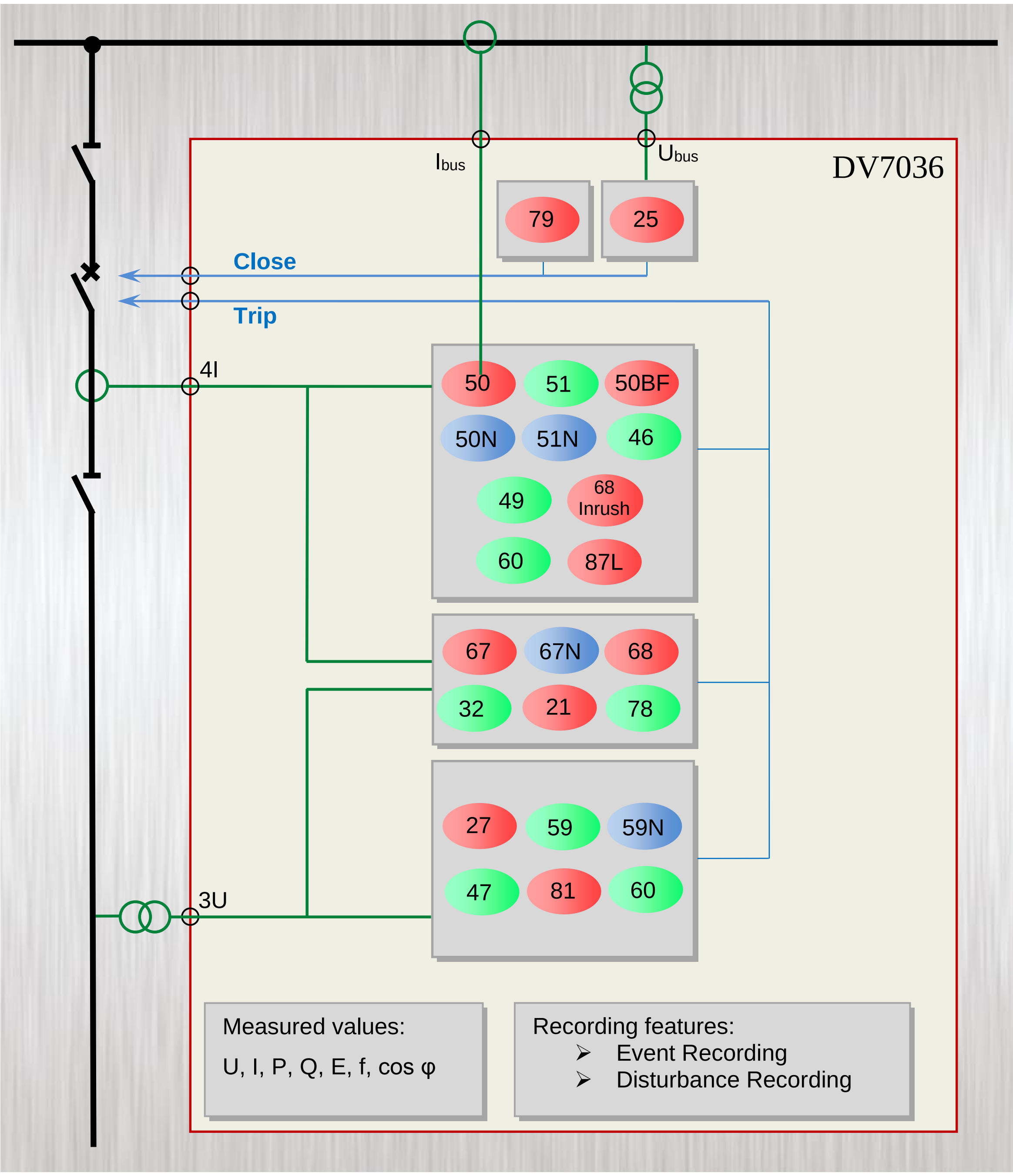


Figure 1 Implemented protection functions

1.1.2 Measurement functions

Based on the hardware inputs the measurements listed in Table below are available.

Measurement functions	DV7036
Current (I1, I2, I3, Io) bus and line	X
Voltage (U1, U2, U3, U12, U23, U31, Uo, Useq) and frequency bus and line	X
Power (P, Q, S, pf) and Energy (E+, E-, Eq+, Eq-)	X
Phase measurement (U1, U2, U3, I1, I2, I3, Upoz, Uneg, Uo, Ipoz, Ineg, Io, f, df/dt)	X
Circuit breaker wear	X
Supervised trip contacts (TCS)	X

Table 2 The measurement functions of the DV7036 configuration

1.1.3 Control functions

Control functions	DV7036
Synchrocheck	X
Circuit breaker control	X
Disconnector control	X

Table 3 The control functions of the DV7036 configuration

1.1.4 Hardware configuration

The *minimum* number of inputs and outputs are listed in the Table below.

Hardware configuration	ANSI	DV7036
Mounting		Op.
Panel instrument case		
Current inputs (4th channel can be sensitive)		4
Voltage inputs		4
Digital inputs		12
Digital outputs		8
Fast trip outputs		4
Temperature monitoring (RTDs) *	38 / 49T	Op.

Table 4 The basic hardware configuration of the DV7036 configuration

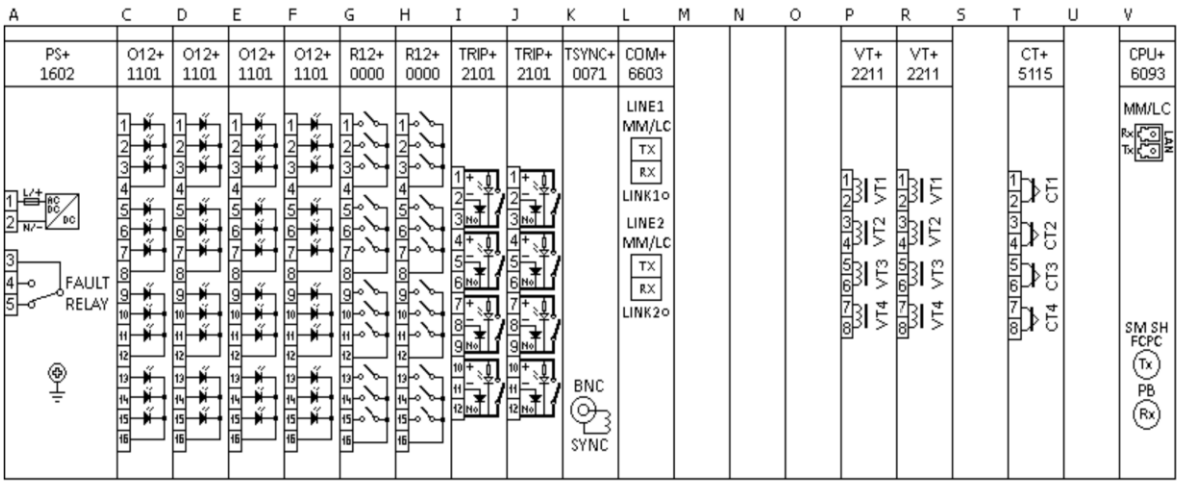


Figure 2 Basic module arrangement of the DV7036_2ends configuration (rear view)

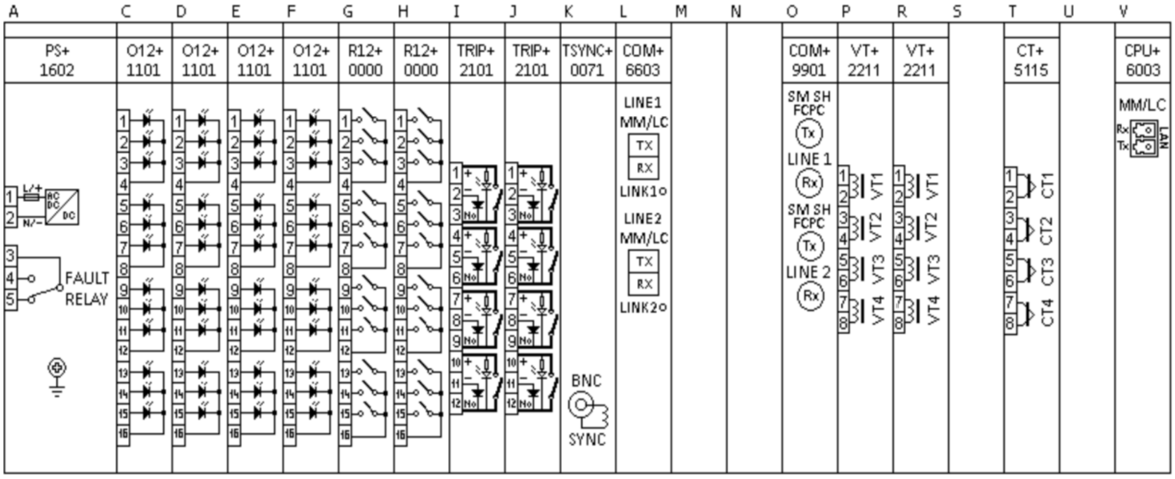


Figure 3 Basic module arrangement of the DV7036_3ends configuration (rear view)

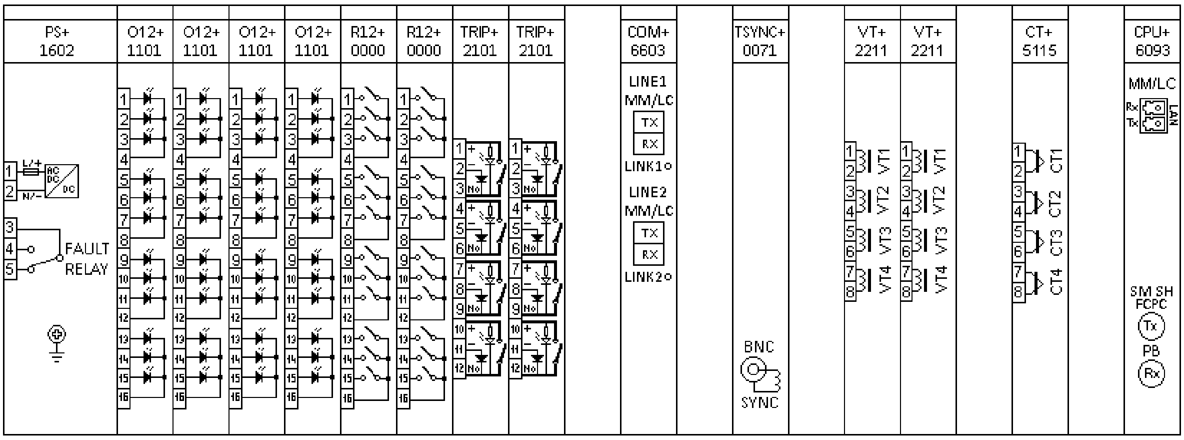


Figure 4 Recommended basic module arrangement of the DV7036_2ends configuration (rear view)

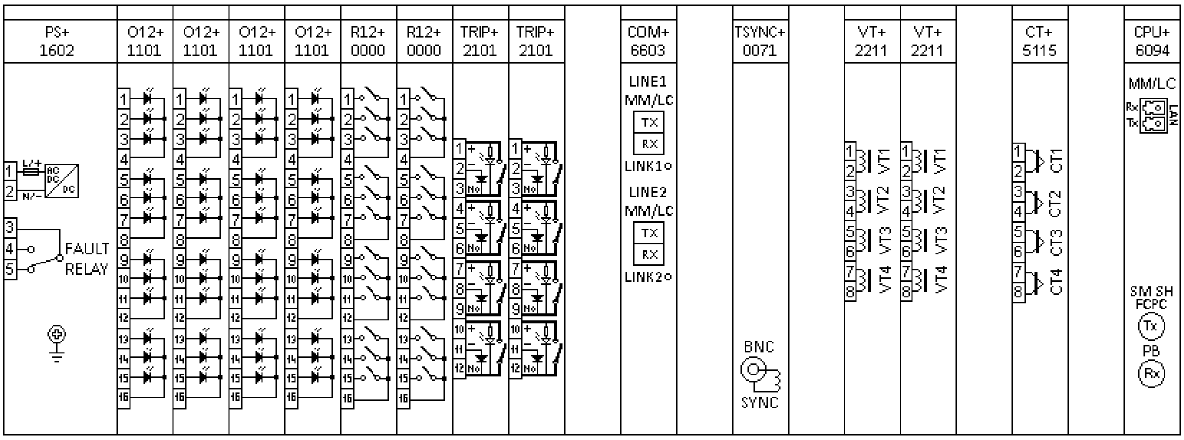


Figure 5 Recommended basic module arrangement of the DV7036_2ends configuration with extended IT security features

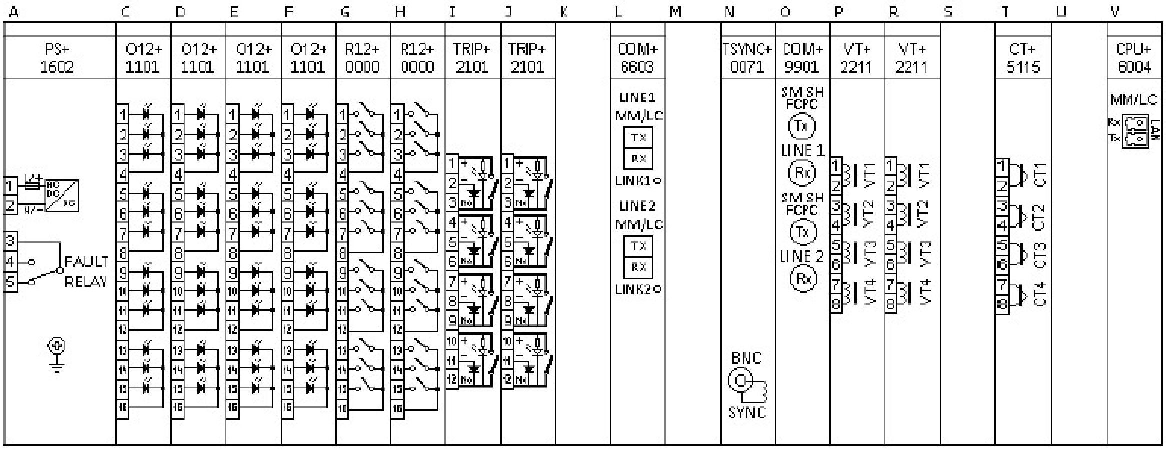


Figure 6 Recommended basic module arrangement of the DV7036_3ends configuration (rear view)

1.1.5 The applied hardware modules

The applied modules are listed in Table 5.

The technical specification of the device and that of the modules are described in the document "***Hardware description***".

Module identifier	Explanation
PS+ 1601	Power supply unit
O12+ 1101	Binary input module
O9S+ 2211	Binary input module with time synchronization
R12+ 00	Signal relay output module
TRIP+ 2101	Trip relay output module
VT+ 2211	Analog voltage input module
CT + 5115	Analog current input module for protection and measurement purposes
COM+ 6603	Communication to RIO
TSYNC+0071	IRIG-B time synchronization module
COM+ 9901	Communication for line differential protection
CPU+ 6003	Processing and communication module (with 3ends version)
CPU+ 6004	Processing and communication module (with 3ends version) with extended IT security features
CPU+ 6093	Processing and communication module (with 2ends version) where the linedifferenctial communication port is integrated on the CPU
CPU+ 6094	Processing and communication module (with 2ends version) where the linedifferenctial communication port is integrated on the CPU with extended IT security features

Table 5 The applied modules of the DV7036 configuration

1.1.5.1 Connector allocation

"A" "B" PS+/1602

Clamp	Title
1	AuxPS+
2	AuxPS-
3	Fault Relay Common
4	Fault Relay NO
5	Fault Relay NC

"C" O12+/1101

Clamp	Title
1	SGF
2	AGF
3	B
4	Opto-(1-3)
5	P5
6	42RT
7	ECAM
8	Opto-(4-6)
9	ANR52
10	63GTAL1
11	63GTAL2
12	Opto-(7-9)
13	ATV
14	BRD
15	AR block (BL_RA)
16	Opto-(10-12)

"D" O12+/1101

Clamp	Title
1	External start L1 (AVV_4_Ext)
2	External start L2 (AVV_8_Ext)
3	External start L3 (AVV_12_Ext)
4	Opto-(1-3)
5	Z2a...(T2_Ext)
6	Z3a...(T3_Ext)
7	...(ALL_GR_Ext)
8	Opto-(4-6)
9	(CUM_SC_Ex)
10	CB open (Posiz_52_AP)
11	CB closed (Posiz_52_CH)
12	Opto-(7-9)
13	ARblock-CB not ready (BRI)
14	Syn_E
15	Syn_I
16	Opto-(10-12)

"E" O12+/1101

Clamp	Title
1	ext. Trip L1 (SC_4_Ext)
2	ext. Trip L2 (SC_8_Ext)
3	ext. Trip L3 (SC_12_Ext)
4	Opto-(1-3)
5	Remote trip (Rx_TS)
6	An_TS/TI
7	Teleprot1 error (An_TP1)
8	Opto-(4-6)
9	Teleprot2 error (An_TP2)
10	TP1 receive DZ (Rx_TP1_DZ)
11	TP2 receive DZ (Rx_TP2_DZ)
12	Opto-(7-9)
13	TP1 receive GAR (Rx_TP1_GAR)
14	TP2 receive GAR (Rx_TP2_GAR)
15	LineDiff error (An_ 87L_Ext)
16	Opto-(10-12)

"F" O12+/1101

Clamp	Title
1	Local
2	(MAI linee Adiacenti)
3	(Rx_TI)
4	Opto-(1-3)
5	(SC_87SB)
6	Man open (52AX)
7	Man close (52CX)
8	Opto-(4-6)
9	-
10	-
11	
12	Opto-(7-9)
13	-
14	
15	-
16	Opto-(10-12)

"G" R12+/1101

Clamp	Title
1	Start L1 (AVV_4_BPU) NO
2	Start L2 (AVV_8_BPU) NO
3	Start L3 (AVV_12_BPU) NO
4	Common (1-3)
5	Z2a...(T2) NO
6	Z3a...(T3) NO
7	Acceleration (ALL_GR) NO
8	Common (4-6)
9	(CUM_SC) NO
10	CB Man Close (CHM_52) NO
11	BOut_G09 NO
12	Common (7-9)
13	BOut_G10 NO
14	BOut_G11 NO
15	BOut_G12 NO
16	Common (10-12)

"H" R12+/1101

Clamp	Title
1	BOut_H01 NO
2	BOut_H02 NO
3	Trip L1 (SC_4_BPU) NO
4	Common (1-3)
5	Trip L2 (SC_8_BPU) NO
6	Trip L3 (SC_12_BPU) NO
7	TP Send DZ (Tx_TP_DZ) NO
8	Common (4-6)
9	TP Send GAR (Tx_TP_GAR) NO
10	LineDif error (An_87L) NO
11	BOut_H09 NO
12	Common (7-9)
13	Tx_TS NO
14	Tx_TI NO
15	BOut_H12 NO
16	Common (10-12)

"I" TRIP+/2101

Clamp	Title
1	3Ph Trip2 (AP_2 Bob) +
2	3Ph Trip2 (AP_2 Bob) -
3	3Ph Trip2 (AP_2 Bob) NO
4	3Ph Trip3 (AP_3 Bob) +
5	3Ph Trip3 (AP_3 Bob) -
6	3Ph Trip3 (AP_3 Bob) NO
7	BOut_I06 +
8	BOut_I06 -
9	BOut_I06 NO
10	BOut_I08 +
11	BOut_I08 -
12	BOut_I08 NO

"J" TRIP+/2101

Clamp	Title
1	Trip L1 (AP_4) +
2	Trip L1 (AP_4) -
3	Trip L1 (AP_4) NO
4	Trip L2 (AP_8) +
5	Trip L2 (AP_8) -
6	Trip L2 (AP_8) NO
7	Trip L3 (AP_12) +
8	Trip L3 (AP_12) -
9	Trip L3 (AP_12) NO
10	CB close (CH_52) +
11	CB close (CH_52) -
12	CB close (CH_52) NO

"P" VT+/2211

Clamp	Title
1	V4 bus->
2	V4 bus<-
3	V8 bus->
4	V8 bus<-
5	V12 bus->
6	V12 bus<-
7	-->
8	-<-

"R" VT+/2211

Clamp	Title
1	V4 line->
2	V4 line<-
3	V8 line->
4	V8 line<-
5	V12 line->
6	V12 line<-
7	-->
8	-<-

"T" CT+/5115

Clamp	Title
1	I4->
2	I4<-
3	I8->
4	I8<-
5	I12->
6	I12<-
7	3Io parallel line->
8	3Io parallel line<-

1.1.5.2 Meeting the device

The basic information for working with the ***EuroProt+*** devices are described in the document “***Quick start guide to the devices of the EuroProt+ product line***”.

*Figure 7 The 84 inch rack of **EuroProt+** family*

1.2 Software configuration

1.2.1 Protection functions

The implemented protection functions are listed in Table 6. The function blocks are described in details in separate documents. These are referred to also in this table.

Name	Title	Document
IOC50	3ph Instant.OC	***Three-phase instantaneous overcurrent protection function block description***
TOC51_low TOC51_high	3ph Overcurr	***Three-phase overcurrent protection function block description***
TOC67_low TOC67_high	3ph Dir.Overcurr	***Directional three-phase overcurrent protection function block description***
IOC50N	Residual Instant.OC	***Residual instantaneous overcurrent protection function block description***
TOC51N_low TOC51N_high	Residual TOC	***Residual overcurrent protection function block description***
TOC67N_low TOC67N_high	Dir.Residual TOC	***Directional residual overcurrent protection function block description***
DIF87L	Line differential	***Line differential protection function block description***
ChargeCurr	Charging Current Compensation	***Charging current compensation in line differential protection function***
DIS21_HV	5 zone HV distance	***Distance protection function block description***
SCH85	Teleprotection	***Teleprotection function***
WEI	Weak end Infeed	***Weak end infeed logic function***
INR68	Inrush	***Inrush detection and blocking***
TOC46	Neg. Seq. OC	***Negative sequence overcurrent protection function block description***
TTR49L	Thermal overload	***Line thermal protection function block description***
TOV59_high TOV59_low	Overvoltage	***Definite time overvoltage protection function block description***
TUV27_high TUV27_low	Undervoltage	***Definite time undervoltage protection function block description***
TOV59N_high TOV59N_low	Overvoltage	***Definite time zero sequence overvoltage protection function block description***
TOF81_high TOF81_low	Overfrequency	***Overfrequency protection function block description***
TUF81_high TUF81_low	Underfrequency	***Underfrequency protection function block description***
FRC81	ROC of frequency	***Rate of change of frequency protection function block description***
REC79HV	HV Autoreclosing	***Automatic reclosing function for high voltage networks, function block description***
VCB60	Current Unbalance	***Current unbalance function block description***
VTS60	Voltage transformer supervision	***Voltage transformer supervision function block description***
SOTFCond	SOTF Condition	***Switch-onto-fault preparation function block description***
BRF50	Breaker failure	***Breaker failure protection function block description***
TRC94_PhS	PhSel. Trip Logic	***Phase-selective trip logic function block description***
DLD	Dead line detection	***Dead line detection protection function block description***

Table 6 Implemented protection functions

1.2.1.1 Three-phase instantaneous overcurrent protection function (IOC50)

The three-phase instantaneous overcurrent protection function (IOC50) operates immediately if the phase currents are higher than the setting value.

The setting value is a parameter, and it can be doubled by graphic programming of the dedicated input binary signal defined by the user.

The function is based on peak value selection or on the RMS values of the Fourier basic harmonic calculation, according to the parameter setting. The fundamental Fourier components are results of an external function block.

Parameter for type selection has selection range of Off, Peak value and Fundamental value. When Fourier calculation is selected then the accuracy of the operation is high, the operation time however is above one period of the network frequency. If the operation is based on peak values then fast sub-cycle operation can be expected, but the transient overreach can be high.

The function generates trip commands without additional time delay if the detected values are above the current setting value.

The function generates trip commands for the three phases individually and a general trip command as well.

The instantaneous overcurrent protection function has a binary input signal, which serves the purpose of disabling the function. The conditions of disabling are defined by the user, applying the graphic equation editor.

Technical data

Function		**Accuracy**
Using peak value calculation		
Operating characteristic	Instantaneous	<6%
Reset ratio	0.85	
Operate time at 2*I_S	<15 ms	
Reset time *	< 40 ms	
Transient overreach	90 %	
Using Fourier basic harmonic calculation		
Operating characteristic	Instantaneous	<2%
Reset ratio	0.85	
Operate time at 2* I_S	<25 ms	
Reset time *	< 60 ms	
Transient overreach	15 %	

**Measured with signal contacts*

Table 7 Technical data of the instantaneous overcurrent protection function

Parameters

Enumerated parameter

Parameter name	**Title**	**Selection range**	**Default**
Parameter for type selection			
IOC50_Oper_EPar_	Operation	Off, Peak value, Fundamental value	Peak value

Table 8 The enumerated parameter of the instantaneous overcurrent protection function

Integer parameter

Parameter name	**Title**	**Unit**	**Min**	**Max**	**Step**	**Default**
Starting current parameter:						
IOC50_StCurr_IPar_	Start Current	%	20	3000	1	200

Table 9 The integer parameter of the instantaneous overcurrent protection function

1.2.1.2 Three-phase time overcurrent protection function (TOC51)

The overcurrent protection function realizes definite time or inverse time characteristics according to IEC or IEEE standards, based on three phase currents. The characteristics are harmonized with IEC 60255-151, Edition 1.0, 2009-08. This function can be applied as main protection for medium-voltage applications or backup or overload protection for high-voltage network elements.

The definite (independent) time characteristic has a fixed time delay when the current is above the starting current I_s previously set as a parameter.

The standard operating characteristics of the inverse time overcurrent protection function are defined by the following formula:

$$t(G) = TMS\left[\frac{k}{\left(\frac{G}{G_S}\right)^{\alpha} - 1} + c\right] \text{ when } G > G_S$$

where

t(G)(seconds)	theoretical operate time with constant value of G,
k, c	constants characterizing the selected curve (in seconds),
α	constants characterizing the selected curve (no dimension),
G	measured value of the characteristic quantity, Fourier base harmonic of the phase currents (IL1Four, IL2Four, IL3Four),
G_S	preset value of the characteristic quantity (Start current),
TMS	preset time multiplier (no dimension).

	IEC ref	Title	k_r	c	α
1	A	IEC Inv	0,14	0	0,02
2	B	IEC VeryInv	13,5	0	1
3	C	IEC ExtInv	80	0	2
4		IEC LongInv	120	0	1
5		ANSI Inv	0,0086	0,0185	0,02
6	D	ANSI ModInv	0,0515	0,1140	0,02
7	E	ANSI VeryInv	19,61	0,491	2
8	F	ANSI ExtInv	28,2	0,1217	2
9		ANSI LongInv	0,086	0,185	0,02
10		ANSI LongVeryInv	28,55	0,712	2
11		ANSI LongExtInv	64,07	0,250	2

The end of the effective range of the dependent time characteristics (G_D) is:

$$G_D = 20 * G_S$$

Above this value the theoretical operating time is definite:

$$t(G) = TMS\left[\frac{k}{\left(\frac{G_D}{G_S}\right)^{\alpha} - 1} + c\right] \text{ when } G > G_D = 20 * G_S$$

Additionally a minimum time delay can be defined by a dedicated parameter. This delay is valid if it is longer than t(G), defined by the formula above.

Resetting characteristics:

- for IEC type characteristics the resetting is after a fix time delay defined by TOC51_Reset_TPar_ (Reset delay),
- for ANSI types however according to the formula below:

$$t_r(G) = TMS\left[\frac{k_r}{1-\left(\frac{G}{G_S}\right)^{\alpha}}\right] \text{ when } G < G_S$$

where

$t_r(G)$(seconds)	theoretical reset time with constant value of G,
k_r	constants characterizing the selected curve (in seconds),
α	constants characterizing the selected curve (no dimension),
G	measured value of the characteristic quantity, Fourier base harmonic of the phase currents,
G_S	preset value of the characteristic quantity (Start current),
TMS	preset time multiplier (no dimension).

	IEC ref	Title	k_r	α
1	A	IEC Inv	Resetting after fix time delay, according to preset parameter TOC51_Reset_TPar_ “Reset delay”	
2	B	IEC VeryInv		
3	C	IEC ExtInv		
4		IEC LongInv		
5		ANSI Inv	0,46	2
6	D	ANSI ModInv	4,85	2
7	E	ANSI VeryInv	21,6	2
8	F	ANSI ExtInv	29,1	2
9		ANSI LongInv	4,6	2
10		ANSI LongVeryInv	13,46	2
11		ANSI LongExtInv	30	2

The binary output status signals of the three-phase overcurrent protection function are starting signals of the three phases individually, a general starting signal and a general trip command.

The overcurrent protection function has a binary input signal, which serves the purpose of disabling the function. The conditions of disabling are defined by the user, applying the graphic equation editor.

Technical data

Function	Value	Accuracy
Operating accuracy	20 ≤ G_S ≤ 1000	< 2 %
Operate time accuracy		±5% or ±15 ms, whichever is greater
Reset ratio	0,95	
Reset time * Dependent time char. Definite time char.	Approx 60 ms	< 2% or ±35 ms, whichever is greater
Transient overreach		< 2 %
Pickup time *	< 40 ms	
Overshot time Dependent time char. Definite time char.	30 ms 50 ms	
Influence of time varying value of the input current (IEC 60255-151)		< 4 %

** Measured with signal relay contact*

Table 10 Technical data of of the instantaneous overcurrent protection function

Parameters

Enumerated parameters

Parameter name	Title	Selection range	Default
Parameter for type selection			
TOC51_Oper_EPar_	Operation	Off, DefinitTime, IEC Inv, IEC VeryInv, IEC ExtInv, IEC LongInv, ANSI Inv, ANSI ModInv, ANSI VeryInv, ANSI ExtInv, ANSI LongInv, ANSI LongVeryInv, ANSI LongExtInv	Definit Time

Table 11 The enumerated parameters of the time overcurrent protection function

Integer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Starting current parameter:						
TOC51_StCurr_IPar_	Start Current	%	20	1000	1	200

Table 12 The integer parameter of the time overcurrent protection function

Float point parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Time multiplier of the inverse characteristics (OC module)						
TOC51_Multip_FPar_	Time Multiplier	sec	0.05	999	0.01	1.0

Table 13 The float point parameter of the time overcurrent protection function

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Minimal time delay for the inverse characteristics:						
TOC51_MinDel_TPar_	Min Time Delay *	msec	0	60000	1	100
Definite time delay:						
TOC51_DefDel_TPar_	Definite Time Delay **	msec	0	60000	1	100
Reset time delay for the inverse characteristics:						
TOC51_Reset_TPar_	Reset Time*	msec	0	60000	1	100

**Valid for inverse type characteristics*
***Valid for definite type characteristics only*

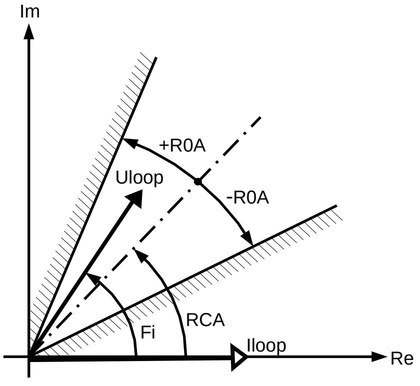
Table 14 The timer parameters of the time overcurrent protection function

1.2.1.3 Three-phase directional overcurrent protection function (TOC67)

The directional three-phase delayed overcurrent protection function can be applied on solidly grounded networks, where the overcurrent protection must be supplemented with a directional decision.

The inputs of the function are the Fourier basic harmonic components of the three phase currents and those of the three phase voltages and the three line-to-line voltages.

Based on the measured voltages and currents from among the six loops (L1L2, L2L3, L3L1, L1N, L2N, L3N), the function selects the one with the smallest calculated loop impedance. Based on the loop voltage and loop current of the selected loop, the directional decision generates a signal of TRUE value if the voltage and the current is sufficient for directional decision, and the angle difference between the vectors is within the setting range. This decision enables the output start and trip signal of a non-directional three-phase overcurrent protection function block, based on the selected current.



The function can be enabled or disabled by a parameter. The status signal of the VTS (voltage transformer supervision) function can also disable the directional operation.

The voltage must be above 5% of the rated voltage and the current must also be measurable.

If the voltages are below 5% of the rated voltage then the algorithm substitutes the small values with the voltages stored in the memory.

The directional decision module calculates the phase angle between the selected loop voltage and the loop current. The reference signal is the current according to *Figure*.

The three-phase non-directional delayed overcurrent function block (TOC51) is described in a separate document. The additional input binary signal enables the operation of the OC function if the directional decision module generates a logic TRUE value, indicating that the phase angle is in the range defined by the preset parameters or that non-directional operation is set by a parameter.

Technical data

Function	Value	Accuracy
Operating accuracy		< 2 %
Operate time accuracy	If Time multiplier is >0.1	±5% or ±15 ms, whichever is greater
Accuracy in minimum time range		±35 ms
Reset ratio	0,95	
Reset time	Approx 100 ms	
Transient overreach	2 %	
Pickup time	<100 ms	
Memory storage time span 50 Hz 60 Hz	 70 ms 60 ms	
Angular accuracy		<3°

Table 15 Technical data of the three-phase directional overcurrent protection function

Parameters

Enumerated parameters

Parameter name	Title	Selection range	Default
Directionality of the function			
TOC67_Dir_EPar_	Direction	NonDir, Forward, Backward	Forward
Operating characteristic selection of the TOC51 module			
TOC67_Oper_EPar_	Operation	Off, DefiniteTime, IEC Inv, IEC VeryInv, IEC ExtInv, IEC LongInv, ANSI Inv, ANSI ModInv, ANSI VeryInv, ANSI ExtInv, ANSI LongInv, ANSI LongVeryInv, ANSI LongExtInv	DefiniteTime

Table 16 The enumerated parameters of the three-phase directional overcurrent protection function

Integer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Operating angle (see *Figure*)						
TOC67_ROA_IPar_	Operating Angle	deg	30	80	1	60
Characteristic angle (see *Figure*)						
TOC67_RCA_IPar_	Characteristic Angle	deg	40	90	1	60
Start current (OC module)						
TOC67_StCurr_IPar_	Start Current	%	20	1000	1	50

Table 17 The integer parameters of the three-phase directional overcurrent protection function

Float point parameter

Parameter name	Title	Unit	Min	Max	Digits	Default
Time multiplier of the inverse characteristics (OC module)						
TOC67_Multip_FPar_	Time Multiplier		0.05	999	0.01	1.0

Table 18 The float point parameter of the three-phase directional overcurrent protection function

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Minimal time delay for the inverse characteristics (OC module):						
TOC67_MinDel_TPar_	Min. Time	msec	50	60000	1	100
Definite time delay (OC module):						
TOC67_DefDel_TPar_	Definite Time	msec	0	60000	1	100
Reset time delay for the inverse characteristics (OC module):						
TOC67_Reset_TPar_	Reset Time	msec	0	60000	1	100

Table 19 The timer parameters of the three-phase directional overcurrent protection function

1.2.1.4 Residual instantaneous overcurrent protection function (IOC50N)

The residual instantaneous overcurrent protection function (IOC50N) block operates immediately if the residual current (3Io) is above the setting value. The setting value is a parameter, and it can be doubled by a dedicated binary input signal defined by the user applying the graphic programming.

The function is based on peak value selection or on the RMS values of the Fourier basic harmonic component of the residual current, according to the parameter setting. The fundamental Fourier component calculation is not part of the IOC50N function.

Parameter for type selection has selection range of Off, Peak value and Fundamental value.

The function generates a trip commands without additional time delay if the detected values are above the current setting value.

The residual instantaneous overcurrent protection function has a binary input signal, which serves the purpose of disabling the function. The conditions of disabling are defined by the user, applying the graphic equation editor.

Technical data

Function		Accuracy
Using peak value calculation		
Operating characteristic (I>0.1 In)	Instantaneous	<6%
Reset ratio	0.85	
Operate time at 2*I_S	<15 ms	
Reset time *	< 35 ms	
Transient overreach	85 %	
Using Fourier basic harmonic calculation		
Operating characteristic (I>0.1 In)	Instantaneous	<3%
Reset ratio	0.85	
Operate time at 2*I_S	<25 ms	
Reset time *	< 60 ms	
Transient overreach	15 %	

**Measured with signal contacts*

Table 20 Technical data of the residual instantaneous overcurrent protection function

Parameters

Enumerated parameter

Parameter name	Title	Selection range	Default
Parameter for type selection			
IOC50N_Oper_EPar_	Operation	Off, Peak value, Fundamental value	Peak value

Table 21 The enumerated parameter of the residual instantaneous overcurrent protection function

Integer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Starting current parameter:						
IOC50N_StCurr_IPar_	Start Current	%	10	400	1	200

Table 22 The integer parameter of the residual instantaneous overcurrent protection function

1.2.1.5 Residual overcurrent protection function (TOC51N)

The residual delayed overcurrent protection function can realize definite time or inverse time characteristics according to IEC or IEEE standards, based on the RMS value of the fundamental Fourier component of a single measured current, which can be the measured residual current at the neutral point (3Io) or the calculated zero sequence current component. The characteristics are harmonized with IEC 60255-151, Edition 1.0, 2009-08.

The definite (independent) time characteristic has a fixed time delay when the current is above the starting current I_S previously set as a parameter.

The standard operating characteristics of the inverse time overcurrent protection function are defined by the following formula:

$$t(G) = TMS\left[\frac{k}{\left(\frac{G}{G_S}\right)^{\alpha} - 1} + c\right] \text{ when } G > G_S$$

where

t(G)(seconds)	theoretical operate time with constant value of G,
k, c	constants characterizing the selected curve (in seconds),
α	constant characterizing the selected curve (no dimension),
G	measured value of the characteristic quantity, Fourier base harmonic of the residual current (INFour),
G_S	preset value of the characteristic quantity (Start current),
TMS	preset time multiplier (no dimension).

	IEC ref		k_r	c	α
1	A	IEC Inv	0,14	0	0,02
2	B	IEC VeryInv	13,5	0	1
3	C	IEC ExtInv	80	0	2
4		IEC LongInv	120	0	1
5		ANSI Inv	0,0086	0,0185	0,02
6	D	ANSI ModInv	0,0515	0,1140	0,02
7	E	ANSI VeryInv	19,61	0,491	2
8	F	ANSI ExtInv	28,2	0,1217	2
9		ANSI LongInv	0,086	0,185	0,02
10		ANSI LongVeryInv	28,55	0,712	2
11		ANSI LongExtInv	64,07	0,250	2

The end of the effective range of the dependent time characteristics (G_D) is:

$$G_D = 20 * G_S$$

Above this value the theoretical operating time is definite:

$$t(G) = TMS\left[\frac{k}{\left(\frac{G_D}{G_S}\right)^{\alpha} - 1} + c\right] \text{ when } G > G_D = 20 * G_S$$

Additionally a minimum time delay can be defined by a dedicated parameter (Min. Time Delay). This delay is valid if it is longer than t(G), defined by the formula above.

Resetting characteristics:

- for IEC type characteristics the resetting is after a fix time delay,
- for ANSI types however according to the formula below:

$$t_r(G) = TMS\left[\frac{k_r}{1-\left(\frac{G}{G_S}\right)^{\alpha}}\right] \text{ when } G < G_S$$

where

$t_r(G)$(seconds)	theoretical reset time with constant value of G,
k_r	constants characterizing the selected curve (in seconds),
α	constant characterizing the selected curve (no dimension),
G	measured value of the characteristic quantity, Fourier base harmonic of the residual current,
G_S	preset value of the characteristic quantity (Start current),
TMS	preset time multiplier (no dimension).

	IEC ref		k_r	α
1	A	IEC Inv	Resetting after fix time delay, according to preset parameter TOC51_Reset_TPar_ “Reset delay”	
2	B	IEC VeryInv		
3	C	IEC ExtInv		
4		IEC LongInv		
5		ANSI Inv	0,46	2
6	D	ANSI ModInv	4,85	2
7	E	ANSI VeryInv	21,6	2
8	F	ANSI ExtInv	29,1	2
9		ANSI LongInv	4,6	2
10		ANSI LongVeryInv	13,46	2
11		ANSI LongExtInv	30	2

The binary output status signals of the residual overcurrent protection function are the general starting signal and the general trip command if the time delay determined by the characteristics expired.

The residual overcurrent protection function has a binary input signal, which serves the purpose of disabling the function. The conditions of disabling are defined by the user, applying the graphic equation editor.

Technical data

Function	Value	Accuracy
Operating accuracy *	$20 \leq G_S \leq 1000$	< 3 %
Operate time accuracy		±5% or ±15 ms, whichever is greater
Reset ratio	0,95	
Reset time * Dependent time char. Definite time char.	 Approx 60 ms	< 2% or ±35 ms, whichever is greater
Transient overreach		2 %
Pickup time	≤ 40 ms	
Overshot time Dependent time char. Definite time char.	 30 ms 50 ms	
Influence of time varying value of the input current (IEC 60255-151)		< 4 %

* *Measured in version In = 200 mA*

Table 23 The technical data of the residual overcurrent protection function

Parameters

Enumerated parameters

Parameter name	Title	Selection range	Default
Parameter for type selection			
TOC51N_Oper_EPar_	Operation	Off, DefinitTime, IEC Inv, IEC VeryInv, IEC ExtInv, IEC LongInv, ANSI Inv, ANSI ModInv, ANSI VeryInv, ANSI ExtInv, ANSI LongInv, ANSI LongVeryInv, ANSI LongExtInv	Definite Time

Table 24 The enumerated parameters of the residual overcurrent protection function

Integer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Starting current parameter:						
TOC51N_StCurr_IPar_	Start Current *	%	5	200	1	50
TOC51N_StCurr_IPar_	Start Current **	%	10	1000	1	50

* *In = 1 A or 5 A*

** *In = 200 mA or 1 A*

Table 25 The integer parameter of the residual overcurrent protection function

Float point parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Time multiplier of the inverse characteristics (OC module)						
TOC51N_Multip_FPar_	Time Multiplier	sec	0.05	999	0.01	1.0

Table 26 The float parameter of the residual overcurrent protection function

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Minimal time delay for the inverse characteristics:						
TOC51N_MinDel_TPar_	Min Time Delay*	msec	0	60000	1	100
Definite time delay:						
TOC51N_DefDel_TPar_	Definite Time Delay**	msec	0	60000	1	100
Reset time delay for the inverse characteristics:						
TOC51N_Reset_TPar_	Reset Time*	msec	0	60000	1	100

**Valid for inverse type characteristics*

***Valid for definite type characteristics only*

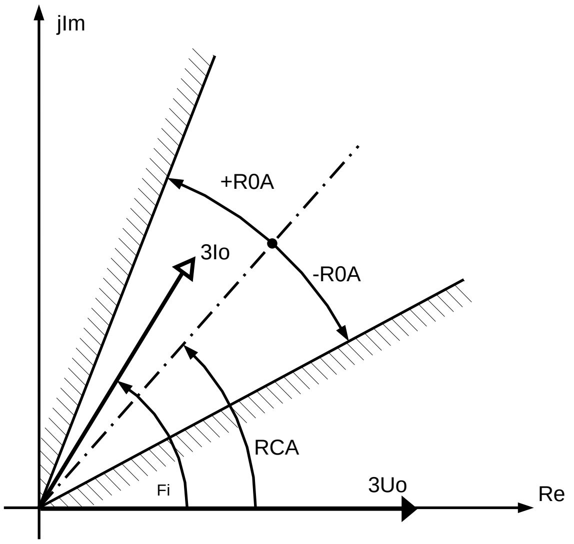
Table 27 The timer parameters of the residual overcurrent protection function

1.2.1.6 Residual directional overcurrent protection function (TOC67N)

The main application area of the directional residual delayed overcurrent protection function is an earth-fault protection.

The inputs of the function are the RMS value of the Fourier basic harmonic components of the zero sequence current (IN=3Io) and those of the zero sequence voltage (UN=3Uo).

The block of the directional decision generates a signal of TRUE value if the UN=3Uo zero sequence voltage and the IN=3Io zero sequence current are above the limits needed for correct directional decision, and the angle difference between the vectors is within the preset range. The decision enables the output start and trip signal of an overcurrent protection function block (TOC51N). This non-directional residual overcurrent protection function block is described in a separate document.



The directional decision module calculates the phase angle between the residual voltage and the residual current. The reference signal is the residual voltage according to the *Figure.*

The output of the directional decision module is OK, namely it is TRUE if the phase angle between the residual voltage and the residual current is within the limit range defined by the preset parameter OR if non-directional operation is selected by the preset parameter (Direction=NonDir).

Technical data

Function	Value	Accuracy
Operating accuracy		< ±2 %
Operate time accuracy		±5% or ±15 ms, whichever is greater
Accuracy in minimum time range		±35 ms
Reset ratio	0,95	
Reset time	Approx 50 ms	±35 ms
Transient overreach	<2 %	
Pickup time	25 – 30 ms	
Angular accuracy Io ≤ 0.1 In 0.1 In < Io ≤ 0.4 In 0.4 In < Io		 < ±10° < ±5° < ±2°
Angular reset ratio Forward and backward All other selection	 10° 5°	

Table 28 The technical data of the residual directional overcurrent protection function

Parameters

Enumerated parameters

Parameter name	Title	Selection range	Default
Directionality of the function			
TOC67N_Dir_EPar_	Direction	NonDir,Forward-Angle,Backward-Angle,Forward-I*cos(fi),Backward-I*cos(fi),Forward-I*sin(fi),Backward-I*sin(fi),Forward-I*sin(fi+45),Backward-I*sin(fi+45)	Forward-Angle
Operating characteristic selection of the TOC51N module			
TOC67N_Oper_EPar_	Operation	Off,DefiniteTime,IEC Inv,IEC VeryInv,IEC ExtInv,IEC LongInv,ANSI Inv,ANSI ModInv,ANSI VeryInv,ANSI ExtInv,ANSI LongInv,ANSI LongVeryInv,ANSI LongExtInv	DefiniteTime

Table 29 The enumerated parameters of the residual directional overcurrent protection function

Short explanation of the enumerated parameter "Direction"

Selected value	Explanation
NonDir,	Operation according to non-directional TOC51N
Forward-Angle	See *Figure*, set RCA (Characteristic Angle) and ROA (Operating Angle) as required
Backward-Angle	RCAactual=RCAset+180°, set RCA (Characteristic Angle) and ROA (Operating Angle) as required
Forward-I*cos(fi)	RCA=0°fix, ROA=85°fix, the setting values RCA and ROA are not applied
Backward-I*cos(fi)	RCA=180°fix, ROA=85°fix, the setting values RCA and ROA are not applied
Forward-I*sin(fi)	RCA=90°fix, ROA=85°fix, the setting values RCA and ROA are not applied
Backward-I*sin(fi)	RCA=–90°fix, ROA=85°fix, the setting values RCA and ROA are not applied
Forward-I*sin(fi+45)	RCA=45°fix, ROA=85°fix, the setting values RCA and ROA are not applied
Backward-I*sin(fi+45)	RCA=–135°fix, ROA=85°fix, the setting values RCA and ROA are not applied

Table 30 The short explanation of the enumerated parameters of the residual directional overcurrent protection function

Integer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
The threshold value for the 3Uo zero sequence voltage, below which no directionality is possible. % of the rated voltage of the voltage transformer input						
TOC67N_UoMin_IPar_	URes Min	%	1	10	1	2
The threshold value for the 3Io zero sequence current, below which no operation is possible. % of the rated current of the current transformer input						
TOC67N_IoMin_IPar_	IRes Min	%	1	50	1	5
Operating angle (See *Figure*)						
TOC67N_ROA_IPar_	Operating Angle	deg	30	80	1	60
Characteristic angle (See *Figure*)						
TOC67N_RCA_IPar_	Characteristic Angle	deg	-180	180	1	60
Start current (TOC51N module)						
TOC67N_StCurr_IPar_	Start Current	%	5	200	1	50

Table 31 The integer parameters of the residual directional overcurrent protection function

Float point parameter

Parameter name	Title	Unit	Min	Step	Step	Default
Time multiplier of the inverse characteristics (TOC51N module)						
TOC67N_Multip_FPar_	Time Multiplier		0.05	999	0.01	1.0

Table 32 *The float point parameter of the residual directional overcurrent protection function*

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Minimal time delay for the inverse characteristics (TOC 51N module):						
TOC67N_MinDel_TPar_	Min Time Delay	msec	50	60000	1	100
Definite time delay (TOC 51N module):						
TOC67N_DefDel_TPar_	Definite Time Delay	msec	0	60000	1	100
Reset time delay for the inverse characteristics (TOC 51N module):						
TOC67N_Reset_TPar_	Reset Time	msec	0	60000	1	100

Table 33 *The timer parameters of the residual directional overcurrent protection function*

1.2.1.7 Charging current compensation in line differential protection

The line differential protection compares the currents at the ends of a line or cable. If the difference is above the characteristic of the protection function then trip command is generated.

In case of long overhead lines or cables the capacitive charging current can be large, needing careful setting of the protection characteristic.

The capacitive charging current, however, can be calculated if the sampled values of the derivative of the phase voltages are available and the positive and zero sequence capacitance values are given as parameter values.

Using the calculated capacitive current at both line ends, the measured currents can be compensated and the operation of the line differential protection function gets more stabile even in case of sensitive characteristic setting values.

Mode of operation
The charging current compensation function block calculates the current compensation with the following algorithm:

The derivatives of the phase voltages are approximated with voltage differences. E.g. in phase L1:

$$\frac{dUL1}{dt} = \frac{UL1(k) - UL1(k-1)}{\Delta t}$$

In this formula
$UL1(k)$ is the sampled value of the voltage at the k-th calculation step,
$UL1(k-1)$ is the sampled value of the voltage one calculation step before,
Δt is the calculation time step.

Using the derivative of the voltage, the charging current is approximated with the formula:

$$iC = C\frac{dU}{dt}$$

In this formula the calculation is performed with symmetrical component values, and
iC is the momentary value of the charging current,
C is the capacitance calculated from the capacitive reactances.

For this calculation the line (or cable) is modeled with the equivalent "π" connection, where the half of the capacitances of the line (or cable) is connected to both ends of the lines. The values are calculated from the total positive and zero sequence capacitive reactances of the line (or cable). These reactances are given as parameter values.

The algorithm calculates the Fourier components of the charging currents.

The difference of the separately calculated Fourier components of the line currents and the Fourier components of the charging currents is the compensated current:

$$Icomp\ x = Ix - ICx$$

In this formula
x is for the phases L1, L2, L3,
$Icomp\ x$ is the compensated current in phase x
$I\ x$ is the measured current in phase x
$IC\ x$ is the charging current in phase x

The line differential protection function gets the compensated current.

The current compensation can be enabled with binary parameter setting, and also the binary input can block the algorithm. In disabled or blocked state the charging current is considered to be zero, the line differential protection function uses the measured line currents.

Summary of the parameters

Enumerated parameter

Parameter name	Title	Selection range	Default
Enabling charging current compensation			
CCC_Comp_EPar_	Compensation	Off, On	Off

Table 1-34 The enumerated parameter of the charging current compensation function

Float parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Positive sequence capacitive reactance of the line or cable						
CCC_XC1_FPar_	XC1	ohm	100	2000	0.1	500
Zero sequence capacitive reactance of the line or cable						
CCC_XC0_FPar_	XC0	ohm	100	2000	0.1	500

Table 1-35 Float parameters of the charging current compensation function

1.2.1.8 Line differential protection function (DIF87L)

The line differential protection function provides main protection for two terminal transmission lines. The line differential protection function does not apply vector shift compensation, thus transformers must be excluded from the protected section.

The operating principle is based on synchronized Fourier basic harmonic comparison between the line ends.

The devices at both line ends sample the phase currents and calculate the Fourier basic harmonic components. These components are exchanged between the devices synchronized via communication channels. The differential characteristic is a biased characteristic with two break points. Additionally, an unbiased overcurrent stage is applied, based on the calculated differential current.

The EuroProt+ protection devices communicate via fiber optic cables. Generally, mono-mode cables are required, but for distances below 2 km a multi-mode cable may be sufficient. The line differential protection can be applied up to the distance of 120 km. (The limiting factor is the damping of the fiber optic channel: up to 30 dB is permitted to prevent the disturbance of operation.)

The hardware module applied is the CPU module of the EuroProt+ protection device. The two devices are interconnected via the “process bus”.

Technical data

Function	Value	Accuracy
Operating characteristic	2 breakpoints and unrestrained decision	
Reset ratio	0.95	
Characteristic accuracy (Ibias>2xIn)		<2%
Operate time (Ibias>0.3xIn)	Typically 35 ms	
Reset time	Typically 60 ms	

Table 36 Technical data of the line differential protection

Parameters

Enumerated parameter for the line differential protection function:

Parameter name	Title	Selection range	Default
Parameter to enable the line differential protection function:			
DIFF87L_Oper_EPar_	Operation	Off, On	Off

Table 37 The enumerated parameter of the line differential protection function

Integer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Parameters of the percentage characteristic curve:						
Base sensitivity:						
DIFF87L_f1_IPar_	Base Sensitivity	%	10	50	1	30
Slope of the second section of the characteristics:						
DIFF87L_f21_IPar_	1st Slope	%	10	50	1	30
Slope of the third section of the characteristics						
DIFF87L_f2_IPar_	2nd Slope	%	50	100	1	70
Bias limit of the first slope:						
DIFF87L_f2Brk_IPar_	1st Slope Bias Limit	%	100	400	1	200
Unrestrained line differential protection current level:						
DIFF87L_HS_IPar_	UnRst Diff Current	%	500	1500	1	800

Table 38 The integer parameters of the line differential protection function

Floating point parameters

Parameter name	Title	Unit	Min	Max	Step	Default
DIFF87L_LocalRatio_FPar_	Local Ratio	-	0.10	2.00	0.01	1.00
DIFF87L_RemoteRatio_FPar_,	Remote Ratio	-	0.10	2.00	0.01	1.00

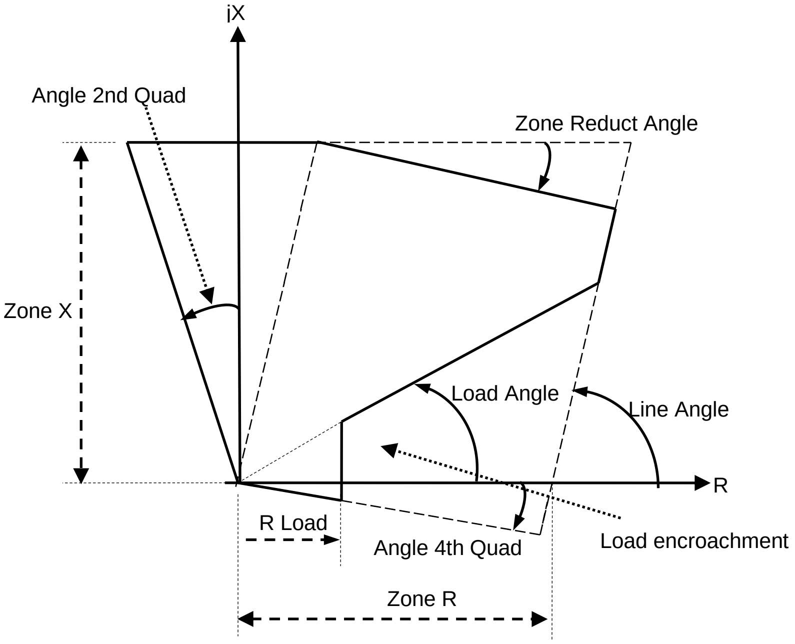
Table 39 The float parameters of the line differential protection function

Timer parameters
The line differential protection function does not have timers.

1.2.1.9 Distance protection function (DIS21)

The distance protection function provides main protection for overhead lines and cables of solidly grounded networks. Its main features are as follows:

- A full-scheme system 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.
- The complex earth fault compensation factor is applied for correct impedance measuring on single-phase-to-earth fault.
- Analogue input processing is applied to the zero sequence current of the parallel line.
- Impedance calculation is conditional of the values of phase currents being sufficient. The current is considered to be sufficient for impedance calculation if it is above the level set by parameter.
- To decide the presence or absence of the zero sequence current, biased characteristics are applied.
- Full-scheme faulty phase identification by minimum impedance detection.
- Five independent distance protection zones are configured.
- The operating decision is based on polygon-shaped characteristics.



- Load encroachment characteristics can be selected (see Figure) determined by two parameters.
- The directional decision is dynamically based on:
    - measured loop voltages if they are sufficient for decision,
    - healthy phase voltages if they are available for asymmetrical faults,
    - voltages stored in the memory if they are available,
- Directional decision of any zones can be reversed.
- The operation of any zones is non-directional if it is optionally selected.
- The distance protection function can operate properly if CVT is applied as well.
- Non-directional impedance protection function or high speed OC protection function is applied in case of switch-onto-fault.
- Distance-to-fault evaluation is implemented (fault locator function).
- Binary input signals and conditions can influence the operation:
    - blocking/enabling
    - VT failure signal
- Integrated high-speed overcurrent back-up function is also implemented.
- The power swing detection function can block the distance protection function in case of stable swings, or it can generate a trip command if the system operates out of step.

Technical data

Function	Range	Accuracy
Number of zones	5	
Rated current In	1/5A, parameter setting	
Rated voltage Un	100/200V, parameter setting	
Current effective range	20 – 2000% of In	±1% of In
Voltage effective range	2-110 % of Un	±1% of Un
Impedance effective range In=1A In=5A	 0.1 – 200 Ohm 0.1 – 40 Ohm	±5%
Zone static accuracy	48 Hz – 52 Hz 49.5 Hz – 50.5 Hz	±5% ±2%
Zone angular accuracy		±3 °
Operate time	Typically 25 ms	±3 ms
Minimum operate time	<20 ms	
Reset time	16 – 25 ms	
Reset ratio	1.1	

Table 40 Technical data of the distance protection function

Measured values

Measured value	Dim.	Explanation
ZL1 = RL1+j XL1	ohm	Measured positive sequence impedance in the L1N loop, using the zero sequence current compensation factor for zone 1
ZL2 = RL2+j XL2	ohm	Measured positive sequence impedance in the L2N loop, using the zero sequence current compensation factor for zone 1
ZL3 = RL3+j XL3	ohm	Measured positive sequence impedance in the L3N loop, using the zero sequence current compensation factor for zone 1
ZL1L2 = RL1L2+j XL1L2	ohm	Measured positive sequence impedance in the L1L2 loop
ZL2L3 = RL2L3+j XL2L3	ohm	Measured positive sequence impedance in the L2L3 loop
ZL3L1 = RL3L1+j XL3L1	ohm	Measured positive sequence impedance in the L3L1 loop
Fault location	km	Measured distance to fault
Fault react.	ohm	Measured reactance in the fault loop

Table 41 Measured values of the distance protection function

Parameters

Enumerated parameters

Parameter name	Title	Selection range	Default
Parameters to select directionality of the individual zones:			
DIS21_Z1_EPar_	Operation Zone1	Off, Forward, Backward	Forward
DIS21_Z2_EPar_	Operation Zone2	Off, Forward, Backward, NonDirectional	Forward
DIS21_Z3_EPar_	Operation Zone3	Off, Forward, Backward, NonDirectional	Forward
DIS21_Z4_EPar_	Operation Zone4	Off, Forward, Backward, NonDirectional	Forward
DIS21_Z5_EPar_	Operation Zone5	Off, Forward, Backward, NonDirectional	Backward
Parameters for power swing detection:			
DIS21_PSD_EPar_	Operation PSD	Off,1 out of 3, 2 out of 3, 3 out of 3	1 out of 3
Parameter enabling “out-of-step” function:			
DIS21_Out_EPar_	Oper OutOfStep	Off, On	Off
Parameter for selecting one of the zones or “high speed overcurrent protection” for the “switch-onto-fault” function:			
DIS21_SOTFMd_EPar _	SOTF Zone	Off, Zone1, Zone2, Zone3, Zone4, Zone5, HSOC	Zone1

Table 42 The enumerated parameters of the distance protection function

Boolean parameters

To generate trip command (0) or to indicate starting only (1):

Parameter name	Title	Default	Explanation
DIS21_Z1St_BPar_	Zone1 Start Only	0	0 for Zone1 to generate trip command
DIS21_Z2St_BPar_	Zone2 Start Only	0	0 for Zone2 to generate trip command
DIS21_Z3St_BPar_	Zone3 Start Only	0	0 for Zone3 to generate trip command
DIS21_Z4St_BPar_	Zone4 Start Only	0	0 for Zone4 to generate trip command
DIS21_Z5St_BPar_	Zone5 Start Only	0	0 for Zone5 to generate trip command

Table 43 The boolean parameters of the distance protection function

Integer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Definition of minimal current enabling impedance calculation:						
DIS21_Imin_IPar_	IPh Base Sens	%	10	30	1	20
Definition of zero sequence current characteristic enabling impedance calculation in phase-to-earth loops:						
DIS21_IoBase_IPar_	IRes Base Sens	%	10	50	1	10
DIS21_IoBias_IPar_	IRes Bias	%	5	30	1	10
Definition of the polygon characteristic angle in the 4th quadrant of the impedance plane:						
DIS21_dirRX_IPar_	Angle 4th Quad	deg	0	30	1	15
Definition of the polygon characteristic angle in the 2nd quadrant of the impedance plane:						
DIS21_dirXR_IPar_	Angle 2nd Quad	deg	0	30	1	15
Definition of the polygon characteristic's zone reduction angle on the impedance plane:						
DIS21_Cut_IPar_	Zone Reduct Angle	deg	0	40	1	0
Definition of the load angle of the polygon characteristic:						
DIS21_LdAng_IPar_	Load Angle	deg	0	45	1	30
Definition of the line angle:						
DIS21_LinAng_IPar_	Line Angle	deg	45	90	1	75
Definition of the ratio of the characteristics for power swing detection:						
DIS21_RRat_IPar_	PSD R_out/R_in	%	120	160	1	130
DIS21_XRat_IPar_	PSD X_out/X_in	%	120	160	1	130
Definition of the overcurrent setting for the switch-onto-fault function, for the case where the DIS21_SOTFMd_EPar_ (SOTF Zone) parameter is set to "HSOC":						
DIS21_SOTFOC_IPar_	SOTF Current	%	10	1000	1	200

Table 44 The integer parameters of the distance protection function

Floating point parameters

Parameter name	Title	Dim.	Min	Max	Default
R and X setting values for the five zones individually:					
DIS21_Z1R_FPar	Zone1 R	ohm	0.1	200	10
DIS21_Z2R_FPar	Zone2 R	ohm	0.1	200	10
DIS21_Z3R_FPar	Zone3 R	ohm	0.1	200	10
DIS21_Z4R_FPar	Zone4 R	ohm	0.1	200	10
DIS21_Z5R_FPar	Zone5 R	ohm	0.1	200	10
DIS21_Z1X_FPar	Zone1 X	ohm	0.1	200	10
DIS21_Z2X_FPar	Zone2 X	ohm	0.1	200	10
DIS21_Z3X_FPar	Zone3 X	ohm	0.1	200	10
DIS21_Z4X_FPar	Zone4 X	ohm	0.1	200	10
DIS21_Z5X_FPar	Zone5 X	ohm	0.1	200	10
Load encroachment setting:					
DIS21_LdR_FPar	R Load	ohm	0.1	200	10
Zero sequence current compensation factors for the five zones individually:					
DIS21_Z1aX_FPar_	Zone1 (Xo-X1)/3X1		0	5	1
DIS21_Z1aR_FPar_	Zone1 (Ro-R1)/3R1		0	5	1
DIS21_Z2aX_FPar_	Zone2 (Xo-X1)/3X1		0	5	1
DIS21_Z2aR_FPar_	Zone2 (Ro-R1)/3R1		0	5	1
DIS21_Z3aX_FPar_	Zone3 (Xo-X1)/3X1		0	5	1
DIS21_Z3aR_FPar_	Zone3 (Ro-R1)/3R1		0	5	1
DIS21_Z4aX_FPar_	Zone4 (Xo-X1)/3X1		0	5	1
DIS21_Z4aR_FPar_	Zone4 (Ro-R1)/3R1		0	5	1
DIS21_Z5aX_FPar_	Zone5 (Xo-X1)/3X1		0	5	1
DIS21_Z5aR_FPar_	Zone5 (Ro-R1)/3R1		0	5	1
Parallel line coupling factor:					
DIS21_a2X_FPar_	Par Line Xm/3X1		0	5	0
DIS21_a2R_FPar_	Par Line Rm/3R1		0	5	0
Data of the protected line for displaying distance:					
DIS21_Lgth_FPar_	Line Length	km	0.1	1000	100
DIS21_LReact_FPar_	Line Reactance	ohm	0.1	200	10
Characteristics for the power swing detection function:					
DIS21_Xin_FPar	PSD Xinner	ohm	0.1	200	10
DIS21_Rin_FPar	PSD Rinner	ohm	0.1	200	10

Table 45 The floating point parameters of the distance protection function

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Time delay for the zones individually:						
DIS21_Z1Del_TPar_	Zone1 Time Delay	ms	0	60000	1	0
DIS21_Z2Del_TPar_	Zone2 Time Delay	ms	0	60000	1	400
DIS21_Z3Del_TPar_	Zone3 Time Delay	ms	0	60000	1	800
DIS21_Z4Del_TPar_	Zone4 Time Delay	ms	0	60000	1	2000
DIS21_Z5Del_TPar_	Zone5 Time Delay	ms	0	60000	1	2000
Parameters for the power swing detection function:						
DIS21_PSDDel_TPar_	PSD Time Delay	ms	10	1000	1	40
DIS21_PSDSlow_TPar_	Very Slow Swing	ms	100	10000	1	500
DIS21_PSDRes_TPar_	PSD Reset	ms	100	10000	1	500
DIS21_OutPs_TPar_	OutOfStep Pulse	ms	50	10000	1	150

Table 46 The timer parameters of the distance protection function

1.2.1.10 Out of Step (Pole slipping) protection function (PSLIP78)

The pole slipping protection function can be applied mainly for synchronous generators. If a generator falls out of synchronism, then the voltage vector induced by the generator rotates slower or with a higher speed as compared to voltage vectors of the network. The result is that according to the frequency difference of the two vector systems, the cyclical voltage difference on the current carrying elements of the network are overloaded cyclically. To protect the stator coils from the harmful effects of the high currents and to protect the network elements, a disconnection is required.

The pole slipping protection function is designed for this purpose.

Main features

The main features of the pole slipping protection function are as follows:

- A full-scheme system provides continuous measurement of impedances separately in three independent phase-to-phase measuring loops.
- Impedance calculation is conditional on the values of the positive sequence currents being above a defined value.
- A further condition of the operation is that the negative sequence current component is less than 1/6 of the value defined for the positive sequence component.
- The operate decision is based on quadrilateral characteristics on the impedance plane using four setting parameters.
- The number of vector revolutions can be set by a parameter.
- The duration of the trip signal is set by a parameter.
- Blocking/enabling binary input signal can influence the operation.

Technical data

Function	Range	Accuracy
Rated current In	1/5A, parameter setting	
Rated Voltage Un	100/200V, parameter setting	
Current effective range	20 – 2000% of In	±1% of In
Voltage effective range	2-110 % of Un	±1% of Un
Impedance effective range In=1A In=5A	 0.1 – 200 Ohm 0.1 – 40 Ohm	±5%
Zone static accuracy	48 Hz – 52 Hz 49.5 Hz – 50.5 Hz	±5% ±2%
Operate time	Typically 25 ms	±3 ms
Minimum operate time	<20 ms	
Reset time	16 – 25 ms	

Table 47 The technical data of the pole slip function

Parameters

Enumerated parameter

Parameter name	Title	Selection range	Default
Parameter for disabling the function			
PSLIP78_Oper_EPar_	Operation	Off, On	Off

Table 48 The enumerated parameter of the pole slip function

Integer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Definition of the number of the vector revolution up to the trip command:						
PSLIP78_MaxCyc_IPar__	Max. cycle number	cycle	1	10	1	1
Definition of the minimal current for the impedance vector calculation						
PSLIP78_I1Low_IPar_	I1LowLimit	%	50	200	1	120

Table 49 Integer parameters of the pole slip function

Float parameters

Parameter name	Title	Unit	Min	Max	Digits	Default
R setting of the impedance characteristics in forward direction						
PSLIP78_Rfw_FPar_	R forward	ohm	0.10	150.00	2	10.00
X setting of the impedance characteristics in forward direction						
PSLIP78_Xfw_FPar_	X forward	ohm	0.10	150.00	2	10.00
R setting of the impedance characteristics in backward direction						
PSLIP78_Rbw_FPar_	R backward	ohm	0.10	150.00	2	10.00
X setting of the impedance characteristics in backward direction						
PSLIP78_Xbw_FPar_	X backward	ohm	0.10	150.00	2	10.00

Table 50 The float parameters of the pole slip function

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Time delay for waiting the subsequent revolution						
PSLIP78_Dead_TPar_	Dead time	msec	1000	60000	1	5000
Generated trip impulse duration						
PSLIP78_TrPu_TPar_	Trip pulse	msec	50	10000	1	150

Table 51 The timer parameters of the pole slip function

1.2.1.11 Switch-onto-fault preparation function (SOTF)

Some protection functions, e.g. distance protection, directional overcurrent protection, etc. also need to decide the direction of the fault. This decision is based on the angle between the voltage and the current. In case of close-up faults, however, the voltage of the faulty loop is near zero: it is not sufficient for a directional decision. If there are no healthy phases, then the voltage samples stored in the memory are applied to decide if the fault is forward or reverse.

If the protected object is energized, the close command for the circuit breaker is received in “dead” condition. This means that the voltage samples stored in the memory have zero values. In this case the decision on the trip command is based on the programming of the protection function for the “switch-onto-fault” condition.

This “switch-onto-fault” detection function prepares the conditions for the subsequent decision.

The function can handle both automatic and manual close commands.
The automatic close command is not an input for this function. It receives the “Dead line” status signal from the DLD (dead line detection) function block. After dead line detection, the AutoSOTF binary output is delayed by a timer with a constant 200 ms time delay. After voltage detection (resetting of the dead line detection input signal), the drop-off of the output signal is delayed by a timer set by the user.
The manual close command is an input binary signal. The drop-off of this signal is delayed by a timer with timing set by the user.

The fault detection is the task of the subsequent distance protection, directional overcurrent protection, etc.

The operation of the “switch-onto-fault” detection function is shown in Figure *8*.

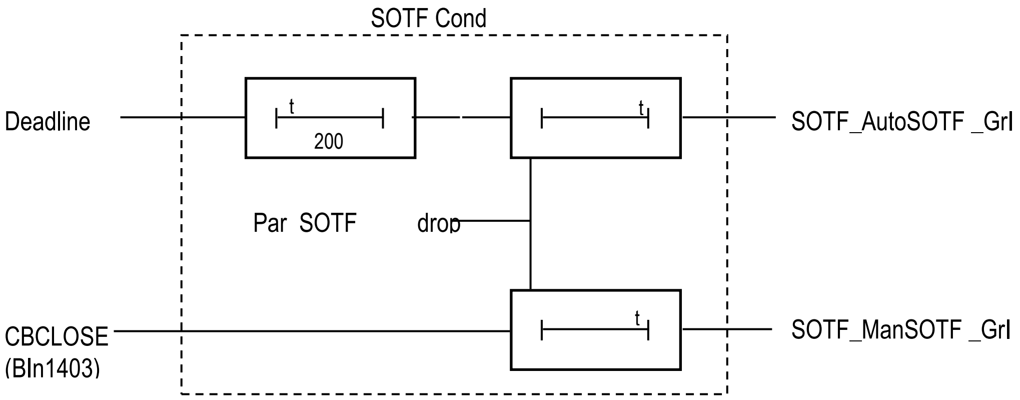


Figure 8 *The scheme of the “switch-onto-fault” preparation*

Technical data

Function	**Accuracy**
Timer accuracy	±5% or ±15 ms, whichever is greater

Table 52 *Technical data of the switch-onto-fault detection*

Parameters

Timer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Drop-off time delay for the signal						
SOTF_SOTFDel_TPar_	SOTF Drop Delay	msec	100	10000	1	1000

Table 53 The timer parameter of the switch-onto-fault detection function

1.2.1.12 Teleprotection function

The non-unit protection functions, generally distance protection, can have two, three or even more zones available. These are usually arranged so that the shortest zone corresponds to an impedance slightly smaller than that of the protected section (underreach) and is normally instantaneous in operation. Zones with longer reach settings are normally time-delayed to achieve selectivity.

As a consequence of the underreach setting, faults near the ends of the line are cleared with a considerable time delay. To accelerate this kind of operation, protective devices at the line ends exchange logic signals (teleprotection). These signals can be direct trip command, permissive or blocking signals.

In some applications even the shortest zone corresponds to an impedance larger than that of the protected section (overreach).

As a consequence of the overreach setting, faults outside the protected line would also cause an immediate trip command that is not selective. To prevent such unselective tripping, protective devices at the line ends exchange blocking logic signals.

The combination of the underreach – overreach settings with direct trip command, permissive of blocking signals facilitates several standard solutions, with the aim of accelerating the trip command while maintaining selectivity.

The teleprotection function block is pre-programmed for some of these modes of operation. The required solution is selected by parameter setting; the user has to assign the appropriate inputs by graphic programming.

Similarly, the user has to assign the “send” signal to a relay output and to transmit it to the far end relay. The trip command is directed graphically to the appropriate input of the trip logic, which will energize the trip coil.

Depending on the selected mode of operation, the simple binary signal sent and received via a communication channel can have several meanings:

- Direct trip command
- Permissive signal
- Blocking signal

To increase the reliability of operation, in this implementation of the telecommunication function the sending end generates a signal, which can be transmitted via two different channels.

NOTE: the type of the communication channel is not considered here. It can be

- Pilot wire
- Fiber optic channel
- High frequency signal over transmission line
- Radio or microwave
- Binary communication network
- Etc.

The function receives the binary signal via optically isolated inputs. It is assumed that the signal received through the communication channel is converted to a DC binary signal matching the binary input requirements.

For the selection of one of the standard modes of operation, the function offers two enumerated parameters, Operation and PUTT Trip. With the parameter Operation, the following options are available: PUTT, POTT, Dir. Comparison, Dir. Blocking, DUTT while with the parameter PUTT Trip: with Start,with Overreach can be set.

Permissive Underreach Transfer Trip (PUTT)

The IEC standard name of this mode of operation is Permissive Underreach Protection (PUP).

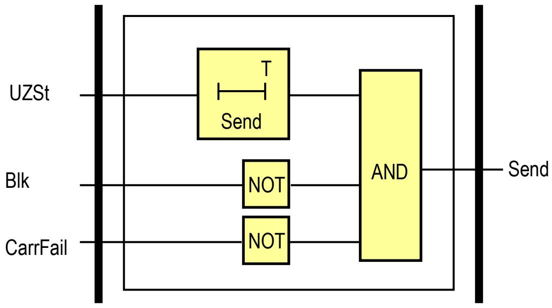
The protection system uses telecommunication, with underreach setting at each section end. The signal is transmitted when a fault is detected by the underreach zone. Receipt of the signal at the other end initiates tripping if other local permissive conditions are also fulfilled, depending on parameter setting.

For trip command generation using the parameter SCH85_PUTT_EPar_ (PUTT Trip), the following options are available:

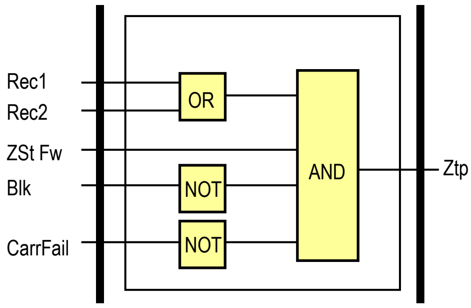
- with Start
- with Overreach

Permissive Underreach Transfer Trip (PUTT) with start

The protection system uses telecommunication, with underreach setting at each section end. The signal is transmitted when a fault is detected by the underreach zone. The signal is prolonged by a drop-down timer. Receipt of the signal at the other end initiates tripping in the local protection if it is in a started state.



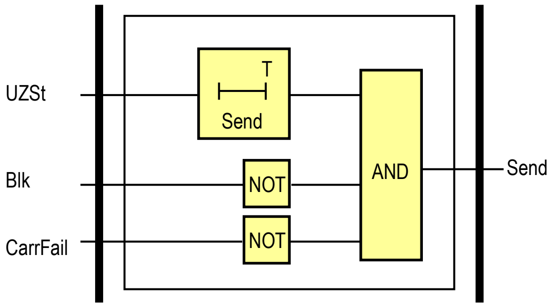
SEND



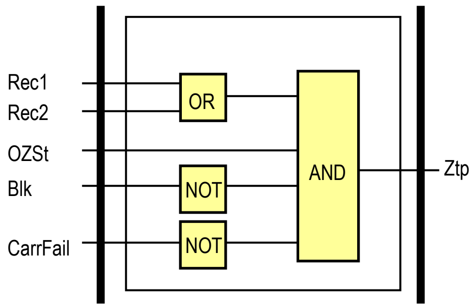
RECEIVE

Permissive Underreach Transfer Trip (PUTT) with Overreach

The protection system uses telecommunication, with underreach setting at each section end. The signal is transmitted when a fault is detected by the underreach zone. The signal is prolonged by a drop-down timer. Receipt of the signal at the other end initiates tripping if the local overreaching zone detects fault.



SEND

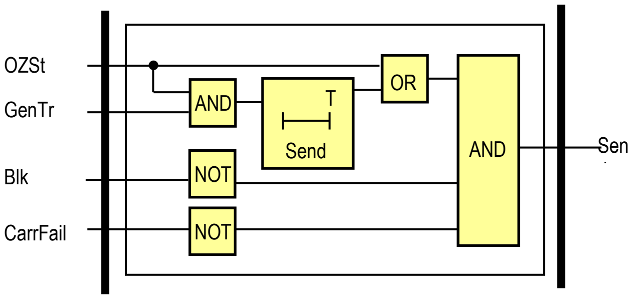


RECEIVE

Permissive Overreach Transfer Trip (POTT)

The IEC standard name of this mode of operation is Permissive Overreach Protection (POP).

The protection system uses telecommunication, with overreach setting at each section end. The signal is transmitted when a fault is detected by the overreach zone. This signal is prolonged if a general trip command is generated. Receipt of the signal at the other end permits the initiation of tripping by the local overreach zone.



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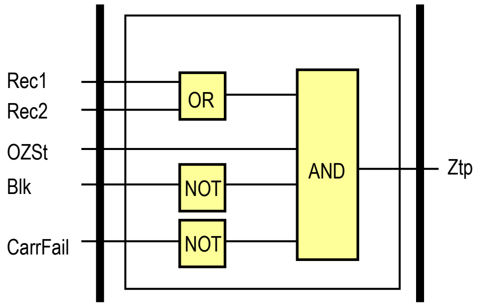

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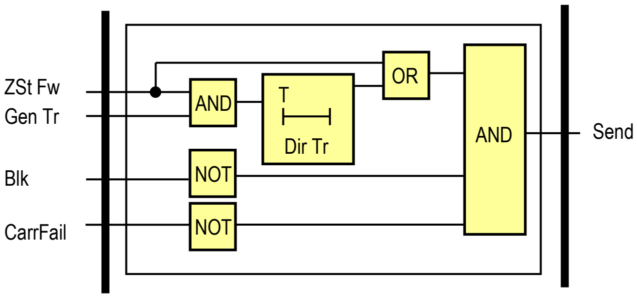
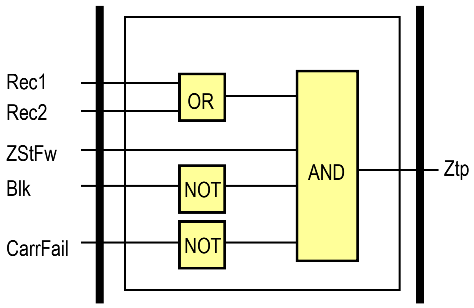
Directional comparison (Dir.Comparison)

The protection system uses telecommunication. The signal is transmitted when a fault is detected in forward direction. This signal is prolonged if a general trip command is generated.
Receipt of the signal at the other end permits the initiation of tripping by the local protection if it detected a fault in forward direction.



SEND

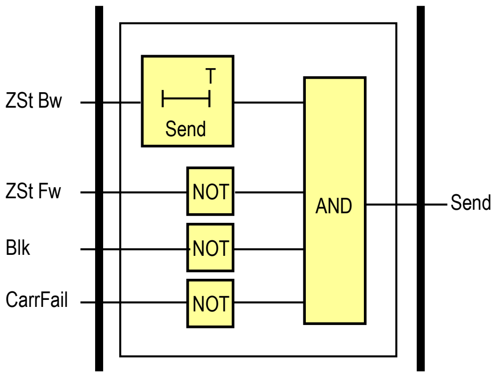


RECEIVE

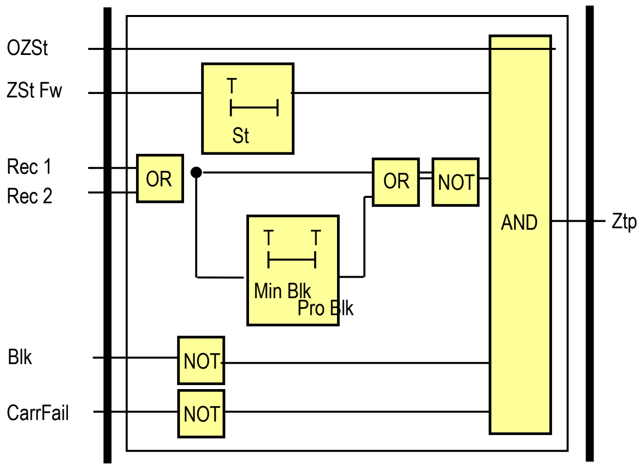
Blocking directional comparison (Dir.Blocking)

The IEC standard name of this mode of operation is Blocking Overreach Protection (BOP).

The protection system uses telecommunication, with overreach setting at each section end. The blocking signal is transmitted when a reverse external fault is detected. The signal is prolonged by a drop-down timer. For the trip command, the forward fault detection is delayed to allow time for a blocking signal to be received from the opposite end. Receipt of the signal at the other end blocks the initiation of tripping of the local protection. The received signal is accepted only if the duration is longer then the parameter *Min.Block Time*, and the signal is prolonged by a drop-down timer.



SEND



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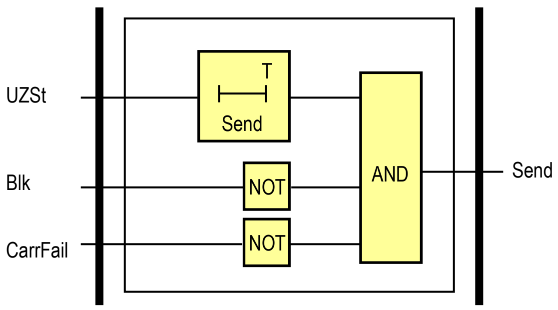
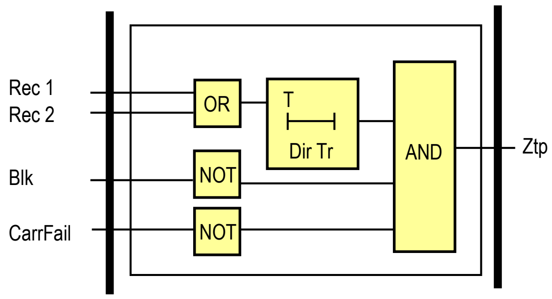
Direct underreaching transfer trip (DUTT)

The IEC standard name of this mode of operation is Intertripping Underreach Protection (IUP). The protection system uses telecommunication, with underreach setting at each section end. The signal is transmitted when a fault is detected by the underreach zone. Receipt of the signal at the other end initiates tripping, independent of the state of the local protection.



SEND



RECEIVE

Technical data

Function	Accuracy
Operate time accuracy	±5% or ±15 ms, whichever is greater

Parameters

Enumerated parameters

Parameter name	Title	Selection range	Default
Parameter for teleprotection type selection:			
SCH85_**Op**_EPar_	Operation	Off, PUTT, POTT, Dir. comparison, Dir. blocking, DUTT	Off
Parameter for PUTT type selection:			
SCH85_**PUTT**_EPar_	PUTT Trip	with Start, with Overreach	with Over-reach

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Send signal prolong time:						
SCH85_**Send**_TPar_	Send Prolong time	ms	1	10000	1	10
Received direct trip delay time for DUTT:						
SCH85_**DirTr**_TPar_	Direct Trip delay DUTT	ms	1	10000	1	10
Forward fault detection delaying for Dir. Blocking:						
SCH85_**St**_TPar_	Z Start delay (block)	ms	1	10000	1	10
Duration limit for Dir. Blocking:						
SCH85_**MinBlk**_TPar_	Min. Block time	ms	1	10000	1	10
Prolong duration for Dir. Blocking:						
SCH85_**ProBlk**_TPar_	Prolong Block time	ms	1	10000	1	10

Binary output status signals

Binary output status signals	Signal title	Explanation
SCH85_**Ztp**_GrI_	Z Teleprot. Trip	Teleprotection trip command
SCH85_**Send**_GrI_	Send signal	Teleprotection signal to be transmitted to the far end

Binary input status signals

The binary input status signals are the results of logic equations graphically edited by the user.

Binary input signals	Signal title	Explanation
SCH85_**Blk**_GrO_	Block	Blocking signal
SCH85_**CarFail**_GrO_	Carrier fail	Signal indicating the failure of the communication channel
SCH85_**Rec1**_GrO_	Receive opp.1	Signal 1 received from the opposite end
SCH85_**Rec2**_GrO_	Receive opp.2	Signal 2 received from the opposite end
SCH85_**ZStFw**_GrO_	Z Gen.start Fw	Protection start in forward direction
SCH85_**UZSt**_GrO_	Z Underreach Start	Start of the underreaching zone (e.g. Z1)
SCH85_**OZSt**_GrO_	Z Overreach Start	Start of the overreaching zone (e.g. Z2)
SCH85_**GenTr**_GrO_	General Trip	General protection trip
SCH85_**ZStBw**_GrO_	Z Gen.start Bw	Protection start in backward direction

1.2.1.13 Weak end infeed logic

The communication schemes for the distance protection applicable for the Protecta EuroProt+ device are described in the document “EuroProt+ Teleprotection function block descrition”. The aim of these schemes is to accelerate the trip time in case of faults at the far line ends, which cannot be covered with the fast Zone1.

The permissive communication schemes

- Permissive underreach transfer trip (PUTT). The IEC standard name of this mode of operation is Permissive Underreach Protection (PUP);
- Permissive overreach transfer trip (POTT). The IEC standard name of this mode of operation is Permissive Overreach Protection (POP);
- Directional comparison;
- Direct underreaching transfer trip (DUTT). The IEC standard name of this mode of operation is Intertripping Underreach Protection (IUP)

need permissive signal from the remote end protection device. If this signal is not received then the trip signal can be generated with the selective time delay only.

The protection at the far end of the line cannot detect the fault if

- The circuit breaker is open in all three phases, or
- The fault current, due to the weak source at the far end, is not enough to detect the fault.

In these cases the “weak end infeed logic” function block can generate the required permissive signal of the far end protection.
The “weak end infeed logic” can be blocked

- by parameter setting (Operation=Off) (Op_Epar=0)
- by blocking input signal (Blk), programmed y the user, using the graphic logic.

If the operation of the function is not blocked then the function can generate binary output signals:

- “WEI trip”: this signal is intended to input in the trip logic to generate a trip signal to the own circuit breaker
- “Send signal”: this signal is the permissive signal, intended to be sent to the protection at the far line end.
- “Send echo”: this signal is the echoed signal received from the far line end device, and to be sent back to the far line end device.

The signal selection is performed using the parameter “Operation”:

- If the setting is “Operation=Echo only” then no signal is generated to he own circuit breaker.
- If the setting is “Operation=Echo and Trip” then both Echo and Trip signals can be generated.

Structure of the weak end infeed logic

Fig.1-2 shows the structure of the weak end infeed logic.

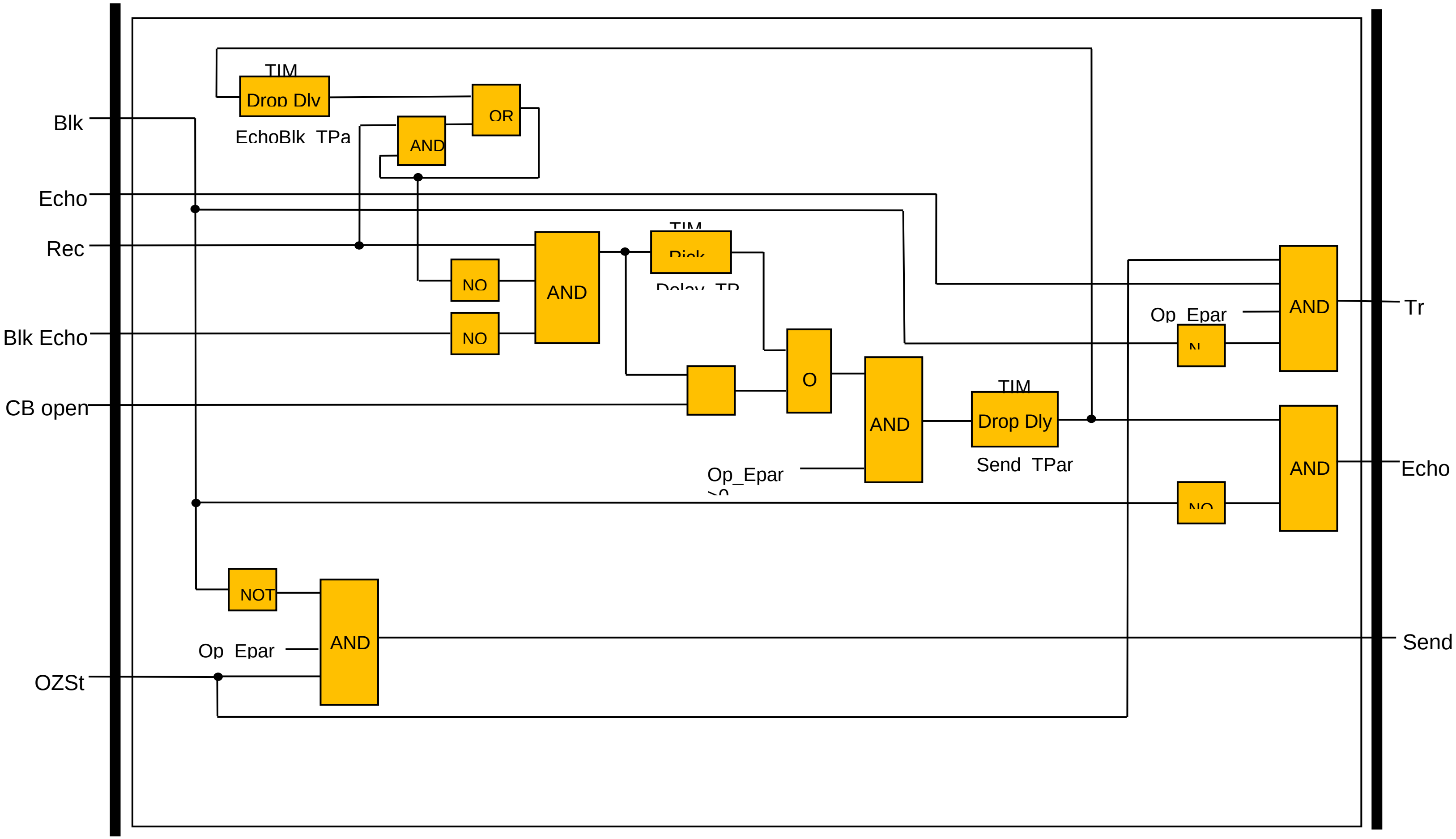


Figure 1-9 Structure of the weak end infeed logic

The short explanation of the logic is as follows:

The function generates a “Send” signal, if forward fault is detected (OZst: the overreach zone started) and the function is enabled (Op_Epar >0) and the function is not blocked (Blk). In this case no “weak end” condition is valid.

Weak end means that either the circuit breaker is open or no forward fault detection is possible due to high source impedance.

If the circuit breaker is open (Input “CB open” signal is active) and permissive signal is received (input “Rec”) then this signal is echoed back to the far end (output signal “Echo”) The drop-delay timer with parameter “Send_Tpar” sets the minimal duration of the Echo signal.

If the circuit breaker is not open then the pick delay timer leaves time for the “Blk Echo” signal (e.g. in case of detection reverse fault) to block echoing. If this signal is not received during the running time then the function generates the “Echo” signal.

The drop delay timer with parameter “EchoBlk_Tpar” prevents repeated signal generation.

The function generates also “Trip signal” if forward fault is detected and received “Echo” signal accelerates trip signal generation. The additional condition is that the parameter setting for “Op_Epar” enables Trip command and the function is not blocked.

Technical data

Function	Value	Accuracy
Timer accuracy	Parameter values	±5% or ±15 ms, whichever is greater

Table 1-54 Technical data of the directional weak end infeed logic

Parameters

Enumerated parameters

Parameter name	Title	Selection range	Default
Disabling or operating mode of the function			
WEI_Op_EPar_	Operation	Off, Echo Only, Echo and Trip	Off

Table 1-55 The enumerated parameters of the directional weak end infeed logic

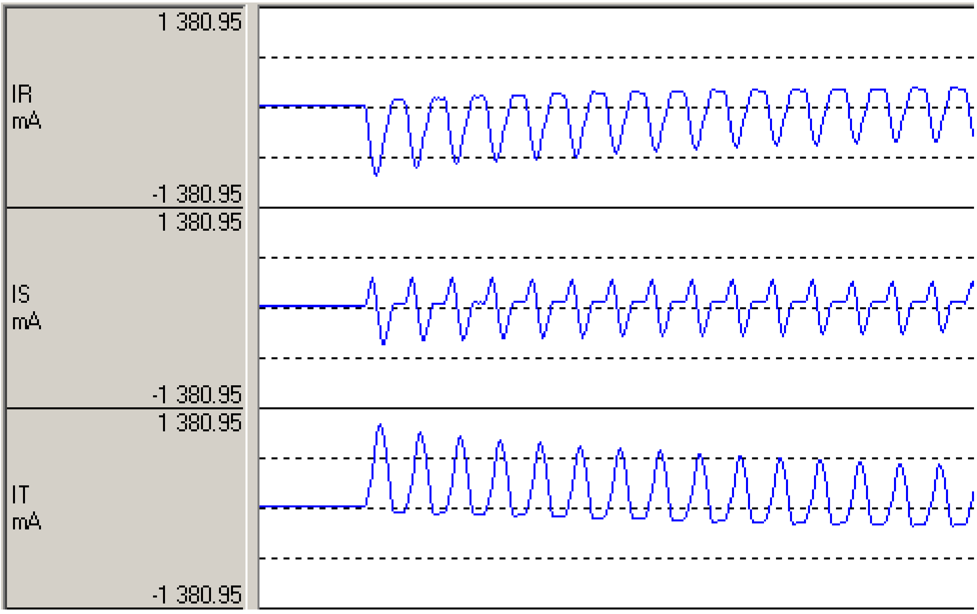
Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
WEI_Send_TPar_	Echo Pulse duration	msec	1	100	1	10
WEI_Delay_TPar_	Echo Delay	msec	1	100	1	10
WEI_EchoBlk_TPar_	Echo Block Time	msec	1	100	1	10

Table 1-56 The timer parameters of the directional weak end infeed logic

1.2.1.14 Inrush detection function (INR68)

When an inductive element with an iron core (transformer, reactor, etc.) is energized, high current peak values can be detected. This is caused by the transient asymmetric saturation of the iron core as a nonlinear element in the power network. The sizing of the iron core is usually sufficient to keep the steady state magnetic flux values below the saturation point of the iron core, so the inrush transient slowly dies out. These current peaks depend also on random factors such as the phase angle at energizing. Depending on the shape of the magnetization curve of the iron core, the detected peaks can be several times above the rated current peaks. Additionally, in medium or high voltage networks, where losses and damping are low, the indicated high current values may be sustained at length. Figure below shows a typical example for the inrush current shapes of a three-phase transformer.



A typical inrush current

As a consequence, overcurrent relays, differential relays or distance relays may start, and because of the long duration of the high current peaks, they may generate an unwanted trip command.

The inrush current detection function can distinguish between high currents caused by overload or faults and the high currents during the inrush time.

The operating principle of the inrush current detection function is based on the special shape of the inrush current.

The typical inrush current in one or two phases is asymmetrical to the time axis. For example, in IT of the Figure above the positive peaks are high while no peaks can be detected in the negative domain.

The theory of the Fourier analysis states that even harmonic components (2^{nd}, 4^{th} etc.) are dominant in waves asymmetrical to the time axis. The component with the highest value is the second one.

Typical overload and fault currents do not contain high even harmonic components.

The inrush current detection function processes the Fourier basic harmonic component and the second harmonic component of the three phase currents. If the ratio of the second harmonic and the base Fourier harmonic is above the setting value of the parameter *2nd Harm Ratio*, an inrush detection signal is generated.

The signal is output only if the base harmonic component is above the level defined by the setting of the parameter *IPh Base Sens.* This prevents unwanted operation in the event that low currents contain relatively high error signals.

The function operates independently using all three phase currents individually, and additionally, a general inrush detection signal is generated if any of the phases detects inrush current.

The function can be disabled by the binary input *Disable*. This signal is the result of logic equations graphically edited by the user.

Using the inrush detection binary signals, other protection functions can be blocked during the transient period so as to avoid the unwanted trip.

Some protection functions use these signals automatically, but a stand-alone inrush detection function block is also available for application at the user's discretion.

Technical data

Function	Range	Accuracy
Current accuracy	20 … 2000% of In	±1% of In

Table 57 Technical data of the inrush detection function

Parameters

Enumerated parameter

Parameter name	Title	Selection range	Default
Disabling or enabling the operation of the function			
INR2_Op_EPar_	Operation	Off,On	On

Table 58 The enumerated parameter of the inrush detection function

Integer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Ratio of the second and basic harmonic Fourier components						
INR2_2HRat_IPar_,	2nd Harm Ratio	%	5	50	1	15
Basic sensitivity of the function						
INR2_MinCurr_IPar_	IPh Base Sens	%	20	100	1	30

Table 59 The integer parameter of the inrush detection function

1.2.1.15 Negative sequence overcurrent protection function (TOC46)

The negative sequence overcurrent protection function (TOC46) block operates if the negative sequence current is higher than the preset starting value.

In the negative sequence overcurrent protection function, definite-time or inverse-time characteristics are implemented, according to IEC or IEEE standards. The function evaluates a single measured current, which is the RMS value of the fundamental Fourier component of the negative sequence current. The characteristics are harmonized with IEC 60255-151, Edition 1.0, 2009-08.

The definite (independent) time characteristic has a fixed delaying time when the current is above the starting current G_S previously set as a parameter.

The standard dependent time characteristics of the negative sequence overcurrent protection function are as follows.

$$t(G) = TMS\left[\frac{k}{\left(\frac{G}{G_S}\right)^{\alpha} - 1} + c\right] \text{ when } G > G_S$$

where

t(G)(seconds)	theoretical operate time with constant value of G,
k, c	constants characterizing the selected curve (in seconds),
α	constant characterizing the selected curve (no dimension),
G	measured value of the characteristic quantity, Fourier base harmonic of the negative sequence current (INFour),
G_S	preset starting value of the characteristic quantity,
TMS	preset time multiplier (no dimension).

	IEC ref		k_r	c	α
1	A	IEC Inv	0,14	0	0,02
2	B	IEC VeryInv	13,5	0	1
3	C	IEC ExtInv	80	0	2
4		IEC LongInv	120	0	1
5		ANSI Inv	0,0086	0,0185	0,02
6	D	ANSI ModInv	0,0515	0,1140	0,02
7	E	ANSI VeryInv	19,61	0,491	2
8	F	ANSI ExtInv	28,2	0,1217	2
9		ANSI LongInv	0,086	0,185	0,02
10		ANSI LongVeryInv	28,55	0,712	2
11		ANSI LongExtInv	64,07	0,250	2

Table 60 The constants of the standard dependent time characteristics

A parameter (Operation) serves for choosing overcurrent function of independent time delay or dependent one with type selection above.

Time multiplier of the inverse characteristics (TMS) is also a parameter to be preset.

The end of the effective range of the dependent time characteristics (G_D) is:

$$G_D = 20 * G_S$$

Above this value the theoretical operating time is definite. The inverse type characteristics are also combined with a minimum time delay, the value of which is set by user parameter TOC46_MinDel_TPar_ (Min. Time Delay).

The negative phase sequence components calculation is based on the Fourier components of the phase currents.

The binary output status signals of the negative sequence overcurrent protection function are the general starting and the general trip command of the function.

The negative sequence overcurrent protection function has a binary input signal, which serves the purpose of disabling the function. The conditions of disabling are defined by the user, applying the graphic equation editor.

Technical data

Function	**Value**	**Accuracy**
Operating accuracy	$10 \leq G_s$ [%] ≤ 200	< 2 %
Operate time accuracy		±5% or ±15 ms, whichever is greater
Reset ratio	0,95	
Reset time * Dependent time charact. Definite time charact.	 approx. 60 ms	<2 % or ±35 ms, whichever is greater
Transient overreach		< 2 %
Pickup time at 2* G_s	<40 ms	
Overshot time Dependent time charact. Definite time charact.	 25 ms 45 ms	
Influence of time varying value of the input current (IEC 60255-151)		< 4 %

* *Measured with signal contacts*

Table 61 Technical data of the negative sequence overcurrent protection function

Parameters

Enumerated parameter

Parameter name	**Title**	**Selection range**	**Default**
Parameter for type selection			
TOC46_Oper_EPar_	Operation	Off, DefinitTime, IEC Inv, IEC VeryInv, IEC ExtInv, IEC LongInv, ANSI Inv, ANSI ModInv, ANSI VeryInv, ANSI ExtInv, ANSI LongInv, ANSI LongVeryInv, ANSI LongExtInv	Definit Time

Table 62 The enumerated parameter of the negative sequence overcurrent protection function

Integer parameter

Parameter name	**Title**	**Unit**	**Min**	**Max**	**Step**	**Default**
Starting current parameter:						
TOC46_StCurr_IPar_	Start Current	%	5	200	1	50

Table 63 The integer parameter of the negative sequence overcurrent protection function

Float point parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Time multiplier of the inverse characteristics (OC module)						
TOC46_Multip_FPar_	Time Multiplier		0.05	999	0.01	1.0

*Valid for inverse type characteristics

Table 64 The float point parameter of the time overcurrent protection function

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Minimal time delay for the inverse characteristics:						
TOC46_MinDel_TPar_	Min Time Delay*	msec	0	60000	1	100
Definite time delay:						
TOC46_DefDel_TPar_	Definite Time Delay**	msec	0	60000	1	100
Reset time delay for the inverse characteristics:						
TOC46_Reset_TPar_	Reset Time*	msec	0	60000	1	100

**Valid for inverse type characteristics*

***Valid for definite type characteristics only*

Table 65 The timer parameter of the negative sequence overcurrent protection function

1.2.1.16 Line thermal protection function (TTR49L)

Basically, line thermal protection measures the three sampled phase currents. RMS values are calculated and the temperature calculation is based on the highest RMS value of the phase currents.

The temperature calculation is based on the step-by-step solution of the thermal differential equation. This method yields “overtemperature”, meaning the temperature above the ambient temperature. Accordingly, the temperature of the protected object is the sum of the calculated “overtemperature” and the ambient temperature.

If the calculated temperature (calculated “overtemperature”+ambient temperature) is above the threshold values, alarm, trip and restart blocking status signals are generated.

For correct setting, the following values must be measured and set as parameters: rated load current is the continuous current applied for the measurement, rated temperature is the steady state temperature at rated load current, base temperature is the temperature of the environment during the measurement and the time constant is the measured heating/cooling time constant of the exponential temperature function.

When energizing the protection device, the algorithm permits the definition of the starting temperature as the initial value of the calculated temperature. The parameter Startup Term. is the initial temperature above the temperature of the environment as compared to the rated temperature above the temperature of the environment

The ambient temperature can be measured using e.g. a temperature probe generating electric analog signals proportional to the temperature. In the absence of such measurement, the temperature of the environment can be set using the dedicated parameter TTR49L_Amb_IPar_ (Ambient Temperature). The selection between parameter value and direct measurement is made by setting the binary Boolean parameter.

The problem of metal elements (the protected line) exposed to the sun is that they are overheated as compared to the „ambient” temperature even without a heating current; furthermore, they are cooled mostly by the wind and the heat transfer coefficient is highly dependent on the effects of the wind. As the overhead lines are located in different geographical environments along the tens of kilometers of the route, the effects of the sun and the wind cannot be considered in detail. The best approximation is to measure the temperature of a piece of overhead line without current but exposed to the same environmental conditions as the protected line itself.

The application of thermal protection of the overhead line is a better solution than a simple overcurrent-based overload protection because thermal protection “remembers” the preceding load states of the line and the setting of the thermal protection does not need so a high security margin between the permitted current and the permitted continuous thermal current of the line. In a broad range of load states and in a broad range of ambient temperatures this permits the better exploitation of the thermal and consequently current carrying capacity of the line.

The thermal differential equation to be solved is:

$$\frac{d\Theta}{dt} = \frac{1}{T}\left(\frac{I^2(t)R}{hA} - \Theta\right)$$, and the definition of the heat time constant is: $$T = \frac{cm}{hA}$$

In this differential equation:

I(t) (RMS)	heating current, the RMS value usually changes over time;
R	resistance of the line;
c	specific heat capacity of the conductor;
m	mass of the conductor;
θ	rise of the temperature above the temperature of the environment;
h	heat transfer coefficient of the surface of the conductor;
A	area of the surface of the conductor;
t	time.

The solution of the thermal differential equation for constant current is the temperature as the function of time (the mathematical derivation of this equation is described in a separate document):

$$\Theta(t) = \frac{I^2 R}{hA}\left(1 - e^{-\frac{t}{T}}\right) + \Theta_o e^{-\frac{t}{T}}$$

where
Θ_o is the starting temperature.

Remember that the calculation of the measurable temperature is as follows:

Temperature(t) = Θ(t)+Temp_ambient

where
Temp_ambient is the ambient temperature.

In a separate document it is proven that some more easily measurable parameters can be introduced instead of the aforementioned ones. Thus, the general form of equation above is:

$$H(t) = \frac{\Theta(t)}{\Theta_n} = \frac{I^2}{I_n^2}\left(1 - e^{-\frac{t}{T}}\right) + \frac{\Theta_o}{\Theta_n} e^{-\frac{t}{T}}$$

where:

H(t) is the „thermal level" of the heated object, this is the temperature as a percentage of the Θ_n reference temperature**.** (This is a dimensionless quantity but it can also be expressed in a percentage form.)

Θ_n is the reference temperature above the temperature of the environment, which can be measured in steady state, in case of a continuous I_n reference current.

I_n is the reference current (can be considered as the nominal current of the heated object). If it flows continuously, then the reference temperature can be measured in steady state.

$\frac{\Theta_o}{\Theta_n}$ is a parameter of the starting temperature related to the reference temperature

The *RMS calculations modul* calculate the RMS values of the phase currents individually. The sampling frequency of the calculations is 1 kHz; therefore, theoretically, the frequency components below 500Hz are considered correctly in the RMS values. This module is not part of the thermal overload function; it belongs to the preparatory phase.

The *Max selection module* selects the maximal value of the three RMS phase currents.

The *Thermal replica module* solves the first order thermal differential equation using a simple step-by-step method and compares the calculated temperature to the values set by parameters. The temperature sensor value proportional to the ambient temperature can be an input (this signal is optional, defined at parameter setting).

The function can be disblaed by parameter, or generates a trip pulse if the calculated temperature exceeds the trip value, or generates a trip signal if the calculated temperature exceeds the trip value given by a parameter but it resets only if the temperature cools below the "Unlock temperature".

The line thermal protection function has two binary input signals. The conditions of the input signal are defined by the user, applying the graphic equation editor. One of the signals can block the line thermal protection function, the other one can reset the accumulated heat and set the temperature to the defined value for the subsequent heating test procedure.

Technical data

Function	Accuracy
Operate time at I>1.2*Itrip	<3 % or <± 20 ms

Table 66 *Technical data of the line thermal protection function*

Parameters

Enumerated parameter

Parameter name	Title	Selection range	Default
Parameter for mode of operation			
TTR49L_Oper_EPar_	Operation	Off, Pulsed, Locked	Pulsed

Table 67 *The enumerated parameter of the line thermal protection function*

The meaning of the enumerated values is as follows:

Off the function is switched off; no output status signals are generated;

Pulsed the function generates a trip pulse if the calculated temperature exceeds the trip value

Locked the function generates a trip signal if the calculated temperature exceeds the trip value. It resets only if the temperature cools below the “Unlock temperature”.

Integer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Alarm Temperature						
TTR49L_Alm_IPar_	Alarm Temperature	deg	60	200	1	80
Trip Temperature						
TTR49L_Trip_IPar_	Trip Temperature	deg	60	200	1	100
Rated Temperature						
TTR49L_Max_IPar_	Rated Temperature	deg	60	200	1	100
Base Temperature						
TTR49L_Ref_IPar_	Base Temperature	deg	0	40	1	25
Unlock Temperature						
TTR49L_Unl_IPar_	Unlock Temperature	deg	20	200	1	60
Ambient Temperature						
TTR49L_Amb_IPar_	Ambient Temperature	deg	0	40	1	25
Startup Term.						
TTR49L_Str_IPar	Startup Term	%	0	60	1	0
Rated Load Current						
TTR49L_Inom_IPar_	Rated Load Current	%	20	150	1	100
Time constant						
TTR49L_pT_IPar_	Time Constant	min	1	999	1	10

Table 68 *The integer parameters of the line thermal protection function*

Boolean parameter

Boolean parameter	Signal title	Selection range	Default
Parameter for ambient temperature sensor application			
TTR49L_Sens_BPar_	Temperature Sensor	No, Yes	No

Table 69 *The boolean parameter of the line thermal protection function*

1.2.1.17 Definite time overvoltage protection function (TOV59)

The definite time overvoltage protection function measures three voltages. The measured values of the characteristic quantity are the RMS values of the basic Fourier components of the phase voltages.

The Fourier calculation inputs are the sampled values of the three phase voltages (UL1, UL2, UL3), and the outputs are the basic Fourier components of the analyzed voltages (UL1Four, UL2Four, UL3Four). They are not part of the TOV59 function; they belong to the preparatory phase.

The function generates start signals for the phases individually. The general start signal is generated if the voltage in any of the three measured voltages is above the level defined by parameter setting value.

The function generates a trip command only if the definite time delay has expired and the parameter selection requires a trip command as well.

The overvoltaget protection function has a binary input signal, which serves the purpose of disabling the function. The conditions of disabling are defined by the user, applying the graphic equation editor.

Technical data

Function	Value	Accuracy
Pick-up starting accuracy		< ± 0,5 %
Blocking voltage		< ± 1,5 %
Reset time U< → Un U< → 0	 60 ms 50 ms	
Operate time accuracy		< ± 20 ms
Minimum operate time	50 ms	

Table 70 Technical data of the definite time overvoltage protection function

Parameters

Enumerated parameter

Parameter name	Title	Selection range	Default
Enabling or disabling the overvoltage protection function			
TOV59_Oper_EPar_	Operation	Off, On	On

Table 71 The enumerated parameter of the definite time overvoltage protection function

Integer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Voltage level setting. If the measured voltage is above the setting value, the function generates a start signal.						
TOV59_StVol_IPar_	Start Voltage	%	30	130	1	63

Table 72 The integer parameter of the definite time overvoltage protection function

Boolean parameter

Parameter name	Title	Default
Enabling start signal only:		
TOV59_StOnly_BPar_	Start Signal Only	FALSE

Table 73 The boolean parameter of the definite time overvoltage protection function

Timer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Time delay of the overvoltage protection function.						
TOV59_Delay_TPar_	Time Delay	ms	0	60000	1	100

Table 74 The timer parameter of the definite time overvoltage protection function

1.2.1.18 Definite time undervoltage protection function (TUV27)

The definite time undervoltage protection function measures the RMS values of the fundamental Fourier component of three phase voltages.

The Fourier calculation inputs are the sampled values of the three phase voltages (UL1, UL2, UL3), and the outputs are the basic Fourier components of the analyzed voltages (UL1Four, UL2Four, UL3Four). They are not part of the TUV27 function; they belong to the preparatory phase.

The function generates start signals for the phases individually. The general start signal is generated if the voltage is below the preset starting level parameter setting value and above the defined blocking level.

The function generates a trip command only if the definite time delay has expired and the parameter selection requires a trip command as well.

The operation mode can be chosen by the type selection parameter. The function can be disabled, and can be set to “1 out of 3”, “2 out of 3”, and “All”.

The overvoltage protection function has a binary input signal, which serves the purpose of disabling the function. The conditions of disabling are defined by the user, applying the graphic equation editor.

Technical data

Function	Value	Accuracy
Pick-up starting accuracy		< ± 0,5 %
Blocking voltage		< ± 1,5 %
Reset time U> → Un U> → 0	 50 ms 40 ms	
Operate time accuracy		< ± 20 ms
Minimum operate time	50 ms	

Table 75 Technical data of the definite time undervoltage protection function

Parameters

Enumerated parameter

Parameter name	Title	Selection range	Default
Parameter for type selection			
TUV27_Oper_EPar_	Operation	Off, 1 out of 3, 2 out of 3, All	1 out of 3

Table 76 The enumerated parameter of the definite time undervoltage protection function

Integer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Starting voltage level setting						
TUV27_StVol_IPar_	Start Voltage	%	30	130	1	52
Blocking voltage level setting						
TUV27_BlkVol_IPar_	Block Voltage	%	0	20	1	10

Table 77 The integer parameters of the definite time undervoltage protection function

Boolean parameter

Parameter name	Title	Default
Enabling start signal only:		
TUV27_StOnly_BPar_	Start Signal Only	FALSE

Table 78 The boolean parameter of the definite time undervoltage protection function

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Time delay of the undervoltage protection function.						
TUV27_Delay_TPar_	Time Delay	ms	0	60000	1	100

Table 79 The timer parameter of the definite time undervoltage protection function

1.2.1.19 Residual definite time overvoltage protection function (TOV59N)

The residual definite time overvoltage protection function operates according to definite time characteristics, using the RMS values of the fundamental Fourier component of the zero sequence voltage (UN=3Uo).

The Fourier calculation inputs are the sampled values of the residual or neutral voltage (UN=3Uo) and the outputs are the RMS value of the basic Fourier components of those.

The function generates start signal if the residual voltage is above the level defined by parameter setting value.

The function generates a trip command only if the definite time delay has expired and the parameter selection requires a trip command as well.

The residual overvoltage protection function has a binary input signal, which serves the purpose of disabling the function. The conditions of disabling are defined by the user, applying the graphic equation editor.

Technical data

Function	Value	Accuracy
Pick-up starting accuracy	2 – 8 % 8 – 60 %	< ± 2 % < ± 1.5 %
Reset time U> → Un U> → 0	 60 ms 50 ms	
Operate time	50 ms	< ± 20 ms

Table 80 Technical data of the residual definite time overvoltage protection function

Parameters

Enumerated parameter

Parameter name	Title	Selection range	Default
Parameter for enabling/disabling:			
TOV59N_Oper_EPar_	Operation	Off, On	On

Table 81 The enumerated parameter of the residual definite time overvoltage protection function

Integer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Starting voltage parameter:						
TOV59N_StVol_IPar_	Start Voltage	%	2	60	1	30

Table 82 The integer parameter of the residual definite time overvoltage protection function

Boolean parameter

Parameter name	Title	Default
Enabling start signal only:		
TOV59N_StOnly_BPar_	Start Signal Only	FALSE

Table 83 The boolean parameter of the residual definite time overvoltage protection function

Timer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Definite time delay:						
TOV59N_Delay_TPar_	Time Delay	ms	0	60000	1	100

Table 84 The time parameter of the residual definite time overvoltage protection function

1.2.1.20 Over-frequency protection function (TOF81)

The deviation of the frequency from the rated system frequency indicates unbalance between the generated power and the load demand. If the available generation is large compared to the consumption by the load connected to the power system, then the system frequency is above the rated value. The over-frequency protection function is usually applied to decrease generation to control the system frequency.

Another possible application is the detection of unintended island operation of distributed generation and some consumers. In the island, there is low probability that the power generated is the same as consumption; accordingly, the detection of high frequency can be one of the indication of island operation.

Accurate frequency measurement is also the criterion for the synchro-check and synchro-switch functions.

The accurate frequency measurement is performed by measuring the time period between two rising edges at zero crossing of a voltage signal. For the acceptance of the measured frequency, at least four subsequent identical measurements are needed. Similarly, four invalid measurements are needed to reset the measured frequency to zero. The basic criterion is that the evaluated voltage should be above 30% of the rated voltage value.

The over-frequency protection function generates a start signal if at least five measured frequency values are above the preset level.

Time delay can also be set.

The function can be enabled/disabled by a parameter.

The over-frequency protection function has a binary input signal. The conditions of the input signal are defined by the user, applying the graphic equation editor. The signal can block the under-frequency protection function.

Technical data

Function	Range	Accuracy
Operate range	40 - 70 Hz	30 mHz
Effective range	45 - 55 Hz / 55 - 65 Hz	2 mHz
Operate time		min 140 ms
Time delay	140 – 60000 ms	± 20 ms
Reset ratio		0,99

Table 85 Technical data of the over-frequency protection function

Parameters

Enumerated parameter

Parameter name	Title	Selection range	Default
Selection of the operating mode			
TOF81_Oper_EPar_	Operation	Off,On	On

Table 86 The enumerated parameter of the over-frequency protection function

Boolean parameter

Parameter name	Title	Default
Enabling start signal only:		
TOF81_StOnly_BPar_	Start Signal Only	FALSE

Table 87 The boolean parameter of the over-frequency protection function

Float point parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Setting value of the comparison						
TOF81_St_FPar_	Start Frequency	Hz	40	60	0.01	51

Table 88 The float point parameter of the over-frequency protection function

Timer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Time delay						
TOF81_Del_TPar_	Time Delay	msec	100	60000	1	200

Table 89 The timer parameter of the over-frequency protection function

1.2.1.21 Underfrequency protection function (TUF81)

The deviation of the frequency from the rated system frequency indicates unbalance between the generated power and the load demand. If the available generation is small compared to the consumption by the load connected to the power system, then the system frequency is below the rated value. The under-frequency protection function is usually applied to increase generation or for load shedding to control the system frequency.

Another possible application is the detection of unintended island operation of distributed generation and some consumers. In the island, there is low probability that the power generated is the same as consumption; accordingly, the detection of low frequency can be one of the indications of island operation.

Accurate frequency measurement is also the criterion for the synchro-check and synchro-switch functions.

The accurate frequency measurement is performed by measuring the time period between two rising edges at zero crossing of a voltage signal. For the acceptance of the measured frequency, at least four subsequent identical measurements are needed. Similarly, four invalid measurements are needed to reset the measured frequency to zero. The basic criterion is that the evaluated voltage should be above 30% of the rated voltage value.

The under-frequency protection function generates a start signal if at least five measured frequency values are below the setting value.

Time delay can also be set.

The function can be enabled/disabled by a parameter.

The under-frequency protection function has a binary input signal. The conditions of the input signal are defined by the user, applying the graphic equation editor. The signal can block the under-frequency protection function.

Technical data

Function	Range	Accuracy
Operate range	40 - 70 Hz	30 mHz
Effective range	45 - 55 Hz / 55 - 65 Hz	2 mHz
Operate time		min 140 ms
Time delay	140 – 60000 ms	± 20 ms
Reset ratio		0,99

Table 90 Technical data of the under-frequency protection function

Parameters

Enumerated parameter

Parameter name	Title	Selection range	Default
Selection of the operating mode			
TUF81_Oper_EPar_	Operation	Off, On	On

Table 91 The enumerated parameter of the under-frequency protection function

Boolean parameter

Parameter name	Title	Default
Enabling start signal only:		
TUF81_StOnly_BPar_	Start Signal Only	FALSE

Table 92 The boolean parameter of the under-frequency protection function

Float point parameter

Parameter name	Title	Unit	Min	Max	Digits	Default
Preset value of the comparison						
TUF81_St_FPar_	Start Frequency	Hz	40	60	0.01	49

Table 93 The float point parameter of the under-frequency protection function

Timer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Time delay						
TUF81_Del_TPar_	Time Delay	ms	100	60000	1	200

Table 94 The timer parameter of the under-frequency protection function

1.2.1.22 Rate of change of frequency protection function (FRC81)

The deviation of the frequency from the rated system frequency indicates unbalance between the generated power and the load demand. If the available generation is large compared to the consumption by the load connected to the power system, then the system frequency is above the rated value, and if it is small, the frequency is below the rated value. If the unbalance is large, then the frequency changes rapidly. The rate of change of frequency protection function is usually applied to reset the balance between generation and consumption to control the system frequency.

Another possible application is the detection of unintended island operation of distributed generation and some consumers. In the island, there is low probability that the power generated is the same as consumption; accordingly, the detection of a high rate of change of frequency can be an indication of island operation.

Accurate frequency measurement is also the criterion for the synchro-switch function.

The source for the rate of change of frequency calculation is an accurate frequency measurement.

In some applications, the frequency is measured based on the weighted sum of the phase voltages.

The accurate frequency measurement is performed by measuring the time period between two rising edges at zero crossing of a voltage signal. For the acceptance of the measured frequency, at least four subsequent identical measurements are needed. Similarly, four invalid measurements are needed to reset the measured frequency to zero. The basic criterion is that the evaluated voltage should be above 30% of the rated voltage value.

The rate of change of frequency protection function generates a start signal if the df/dt value is above the setting value. The rate of change of frequency is calculated as the difference of the frequency at the present sampling and at three periods earlier.

Time delay can also be set.

The function can be enabled/disabled by a parameter.

The rate of change of frequency protection function has a binary input signal. The conditions of the input signal are defined by the user, applying the graphic equation editor. The signal can block the rate of change of frequency protection function.

Technical data

Function	Effective range	Accuracy
Operating range	-5 - -0.05 and +0.05 - +5 Hz/sec	
Pick-up accuracy		±20 mHz/sec
Operate time	min 140 ms	
Time delay	140 – 60000 ms	± 20 ms

Table 95 Technical data of the rate of change of frequency protection function

Parameters

Enumerated parameter

Parameter name	Title	Selection range	Default
Selection of the operating mode			
FRC81_Oper_EPar_	Operation	Off,On	On

Table 96 The enumerated parameter of the rate of change of frequency protection function

Boolean parameter

Parameter name	Title	Default
Enabling start signal only:		
FRC81_StOnly_BPar_	Start Signal Only	True

Table 97 The boolean parameter of the rate of change of frequency protection function

Float point parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Setting value of the comparison						
FRC81_St_FPar_	Start df/dt	Hz/sec	-5	5	0.01	0.5

Table 98 The float point parameter of the rate of change of frequency protection function

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Time delay						
FRC81_Del_TPar_	Time Delay	msec	100	60000	1	200

Table 99 The timer parameter of the rate of change of frequency protection function

1.2.1.23 Auto-reclose protection function (REC79HV)

The HV automatic reclosing function for high voltage networks can realize up to four shots of reclosing. The dead time can be set individually for each reclosing and separately for single-phase faults and for multi-phase faults.

The starting signal of the cycles can be generated by any combination of the protection functions or external signals of the binary inputs. The selection is made by graphic equation programming.

The automatic reclosing function is triggered if as a consequence of a fault a protection function generates a trip command to the circuit breaker and the protection function resets because the fault current drops to zero or the circuit breaker's auxiliary contact signals open state. According to the preset parameter values, either of these two conditions starts counting the dead time, at the end of which the HV automatic reclosing function generates a close command automatically. If the fault still exists or reappears, then within the "Reclaim time" started at the close command the protection functions picks up again and the subsequent cycle is started. If no pickup is detected within this time, then the HV automatic reclosing cycle resets and a new fault will start the procedure with the first cycle again.

At the moment of generating the close command, the circuit breaker must be ready for operation, which is signaled via a binary input (CB Ready). The Boolean parameter „ CB State Monitoring" enables the function. The preset parameter value (CB Supervision time) decides how long the HV automatic reclosing function is allowed to wait at the end of the dead time for this signal. If the signal is not received during this dead time extension, then the HV automatic reclosing function terminates.

Depending on binary parameter settings, the automatic reclosing function block can accelerate trip commands of the individual reclosing cycles. This function needs user-programmed graphic equations to generate the accelerated trip command.

In case of a manual close command which is assigned to the logic variable "Manual Close" using graphic equation programming, a preset parameter value decides how long the HV automatic reclosing function should be disabled after the manual close command.

The duration of the close command depends on preset parameter value "Close command time", but the close command terminates if any of the protection functions issues a trip command.

The HV automatic reclosing function can control up to four reclosing cycles. Depending on the preset parameter value "Reclosing cycles", there are different modes of operation:

Disabled	No automatic reclosing is selected,
1. Enabled	Only one automatic reclosing cycle is selected,
1.2. Enabled	Two automatic reclosing cycles are activated,
1.2.3. Enabled	Three automatic reclosing cycles are activated,
1.2.3.4. Enabled	All automatic reclosing cycles are activated.

The function can be switched Off /On using the parameter "Operation"

The user can also block the HV automatic reclosing function applying the graphic equation editor. The binary status variable to be programmed is "Block".

Depending on the present parameter value "Reclosing started by", the HV automatic reclosing function can be started either by resetting of the TRIP command or by the binary signal indicating the open state of the circuit breaker.

If the reset state of the TRIP command is selected to start the HV automatic reclosing function, then the conditions are defined by the user applying the graphic equation editor. The binary status variable to be programmed is "AutoReclosing Start".

If the open state of the circuit breaker is selected to start the HV automatic reclosing function, then additionally to programming the “AutoReclosing Start“ signal, the conditions for detecting the open state of the CB are defined by the user applying the graphic equation editor.

For all four reclosing cycles, separate dead times can be defined for single-phase-reclosing after single-phase trip commands (as a consequence of single-phase faults) and for three-phase-reclosing after three-phase trip commands (as a consequence of multi-phase faults).

The different dead time settings of single-phase-reclosing and three-phase-reclosing can be justified as follows: in case of a single-phase fault, only the circuit breakers of the faulty phase open. In this case, due to the capacitive coupling of the healthy phases, the extinction of the secondary arc at the fault location can be delayed. Consequently, a longer dead time is needed for the fault current to die out than in the case of a three-phase open state, when no coupled voltage can sustain the fault current.

From other point of view, in case of a transmission line connecting two power systems, only a shorter dead time is allowed for the three-phase open state because, due to the possible power unbalance between the interconnected systems, a large angle difference can be reached if the dead time is too long. If only a single phase is open, then the two connected healthy phases and the ground can sustain the synchronous operation of both power systems.

Special dead time can be necessary if a three-phase fault arises near either substation of a line and the protection system operates without tele-protection. If the three-phase dead time is too short, the HV automatic reclosing may attempt to close the circuit breaker during the running time of the second zone trip at the other side. Consequently, a prolonged dead time is needed if the fault was detected in the first zone.

Dead time reduction may be applicable if healthy voltage is measured in all three phases during the dead time, this means that no fault exists on the line. In this case, the expiry of the normal dead time need not be waited for; a reclosing attempt can be initiated immediately.

If, during the cycles, the three-phase dead time is applied once, then all subsequent cycles will consider the three-phase dead time settings, too.

Three-phase reclosing can be disabled by a preset parameter value.

At the end of the dead time, reclosing is possible only if the circuit breaker can perform the command. The conditions are defined by the user applying the graphic equation editor.

Reclosing is possible only if the conditions required by the “synchro-check” function are fulfilled. The conditions are defined by the user applying the graphic equation editor. The HV automatic reclosing function waits for a pre-programmed time for this signal. This time is defined by the user. If the “SYNC Release” signal is not received during the running time of this timer, then the “synchronous switch” operation is started.

The separate function controls the generation of the close command in case of relatively rotating voltage vectors on both sides of the open circuit breaker to make contact at the synchronous state of the rotating vectors. For this calculation, the closing time of the circuit breaker must be defined.

When the close command is generated, a timer is started to measure the “Reclaim time”. If the fault is detected again during this time, then the sequence of the HV automatic reclosing cycles continues. If no fault is detected, then at the expiry of the reclaim time the reclosing is evaluated as successful and the function resets. If fault is detected after the expiry of this timer, then the cycles restart with the first reclosing cycle.

If the manual close command is received during the running time of any of the cycles, then the HV automatic reclosing function resets.

After a manual close command, the HV automatic reclosing function does not operate for the time period defined by a parameter.

In case of evolving faults i.e. when a detected single-phase fault changes to multi-phase fault, the behavior of the automatic reclosing function is controlled by the preset parameter value “Evolving fault“. The options are “Block Reclosing” or “Start 3Ph Rec.”

Depending on binary parameter settings, the automatic reclosing function block can accelerate trip commands of the individual reclosing cycles.

Technical data

Function	Accuracy
Operating time	±1% of setting value or ±30 ms

Table 100 Technical data of the rate of auto-reclose function

Parameters

Enumerated parameters

Parameter name	Title	Selection range	Default
Switching ON/OFF the HV automatic reclosing function			
REC79_Op_EPar_	Operation	Off, On	On
Selection of the number of reclosing sequences			
REC79_CycEn_EPar_	Reclosing Cycles	Disabled, 1. Enabled, 1.2. Enabled, 1.2.3. Enabled, 1.2.3.4. Enabled	1. Enabled
Selection of triggering the dead time counter (trip signal reset or circuit breaker open position)			
REC79_St_EPar_	Reclosing Started by	Trip reset, CB open	Trip reset
Selection of behavior in case of evolving fault (block reclosing or perform three-phase automatic reclosing cycle)			
REC79_EvoFlt_EPar_	Evolving Fault	Block Reclosing, Start 3Ph Rec.	Block Reclosing

Table 101 The enumerated parameters of the rate of auto-reclose function

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Dead time setting for the first reclosing cycle for single-phase fault						
REC79_1PhDT1_TPar_	1. Dead Time 1Ph	msec	0	100000	10	500
Dead time setting for the second reclosing cycle for single-phase fault						
REC79_1PhDT2_TPar_	2. Dead Time 1Ph	msec	10	100000	10	600
Dead time setting for the third reclosing cycle for single-phase fault						
REC79_1PhDT3_TPar_	3. Dead Time 1Ph	msec	10	100000	10	700
Dead time setting for the fourth reclosing cycle for single-phase fault						
REC79_1PhDT4_TPar_	4. Dead Time 1Ph	msec	10	100000	10	800
Dead time setting for the first reclosing cycle for multi-phase fault						
REC79_3PhDT1_TPar_1	1. Dead Time 3Ph	msec	0	100000	10	1000
Special dead time setting for the first reclosing cycle for multi-phase fault						
REC79_3PhDT1_TPar_2	1. Special DT 3Ph	msec	0	100000	10	1350
Dead time setting for the second reclosing cycle for multi-phase fault						
REC79_3PhDT2_TPar_	2. Dead Time 3Ph	msec	10	100000	10	2000
Dead time setting for the third reclosing cycle for multi-phase fault						
REC79_3PhDT3_TPar_	3. Dead Time 3Ph	msec	10	100000	10	3000
Dead time setting for the fourth reclosing cycle for multi-phase fault						
REC79_3PhDT4_TPar_	4. Dead Time 3Ph	msec	10	100000	10	4000
Reclaim time setting						
REC79_Rec_TPar_	Reclaim Time	msec	100	100000	10	2000
Impulse duration setting for the CLOSE command						
REC79_Close_TPar_	Close Command Time	msec	10	10000	10	100
Setting of the dynamic blocking time						
REC79_DynBlk_TPar_	Dynamic Blocking Time	msec	10	100000	10	1500
Setting of the blocking time after manual close command						
REC79_MC_TPar_	Block after Man.Close	msec	0	100000	10	1000
Setting of the action time (max. allowable duration between protection start and trip)						
REC79_Act_TPar_	Action Time	msec	0	20000	10	1000
Limitation of the starting signal (trip command is too long or the CB open signal received too late)						
REC79_MaxSt_TPar_	Start Signal Max Time	msec	0	10000	10	1000
Max. delaying the start of the dead-time counter						
REC79_DtDel_TPar_	DeadTime Max Delay	msec	0	100000	10	3000
Waiting time for circuit breaker ready to close signal						
REC79_CBTO_TPar_	CB Supervision Time	msec	10	100000	10	1000
Waiting time for synchronous state signal						
REC79_SYN1_TPar_	Syn Check Max Time	msec	500	100000	10	10000
Waiting time for synchronous switching signal						
REC79_SYN2_TPar_	SynSw Max Time	msec	500	100000	10	10000

Table 102 The timer parameters of the rate of auto-reclose function

Boolean parameters

Parameter name	Title	Default	Explanation
REC79_CBState_BPar_	CB State Monitoring	0	Enable CB state monitoring for “Not Ready” state
REC79_3PhRecBlk_BPar_	Disable 3Ph Rec.	0	Disable three-phase reclosing
REC79_Acc1_BPar_	Accelerate 1.Trip	0	Accelerate trip command at starting cycle 1
REC79_Acc2_BPar_	Accelerate 2.Trip	0	Accelerate trip command at starting cycle 2
REC79_Acc3_BPar_	Accelerate 3.Trip	0	Accelerate trip command at starting cycle 3
REC79_Acc4_BPar_	Accelerate 4.Trip	0	Accelerate trip command at starting cycle 4
REC79_Acc5_BPar_	Accelerate FinTrip	0	Accelerate final trip command

Table 103 The boolean parameters of the rate of auto-reclose function

1.2.1.24 Voltage transformer supervision function (VTS60)

The voltage transformer supervision function generates a signal to indicate an error in the voltage transformer secondary circuit. This signal can serve, for example, as a warning, indicating disturbances in the measurement, or it can disable the operation of the distance protection function if appropriate measured voltage signals are not available for a distance decision.

The voltage transformer supervision function is designed to detect faulty asymmetrical states of the voltage transformer circuit caused, for example, by a broken conductor in the secondary circuit.

(Another method for detecting voltage disturbances is the supervision of the auxiliary contacts of the miniature circuit breakers in the voltage transformer secondary circuits. This function is not described here.)

The user has to generate graphic equations for the application of the signal of this voltage transformer supervision function.

This function is interconnected with the “dead line detection function”. Although the dead line detection function is described fully in a separate document, the explanation necessary to understand the operation of the VT supervision function is repeated also in this document.

The voltage transformer supervision function can be used in three different modes of application:

Zero sequence detection (for typical applications in systems with grounded neutral): “VT failure” signal is generated if the residual voltage (3Uo) is above the preset voltage value AND the residual current (3Io) is below the preset current value.

Negative sequence detection (for typical applications in systems with isolated or resonant grounded (Petersen) neutral): “VT failure” signal is generated if the negative sequence voltage component (U2) is above the preset voltage value AND the negative sequence current component (I2) is below the preset current value.

Special application: “VT failure” signal is generated if the residual voltage (3Uo) is above the preset voltage value AND the residual current (3Io) AND the negative sequence current component (I2) are below the preset current values.

The voltage transformer supervision function can be activated if “Live line” status is detected for at least 200 ms. This delay avoids mal-operation at line energizing if the poles of the circuit breaker make contact with a time delay. The function is set to be inactive if “Dead line” status is detected.

If the conditions specified by the selected mode of operation are fulfilled (for at least 4 milliseconds) then the voltage transformer supervision function is activated and the operation signal is generated. (When evaluating this time delay, the natural operating time of the applied Fourier algorithm must also be considered.)

NOTE: For the operation of the voltage transformer supervision function the “ Dead line detection function” must be operable as well: it must be enabled by binary parameter setting, and its blocking signal may not be active.

If, in the active state, the conditions for operation are no longer fulfilled, the resetting of the function depends on the mode of operation of the primary circuit:

- If the “Live line” state is valid, then the function resets after approx. 200 ms of time delay. (When evaluating this time delay, the natural operating time of the applied Fourier algorithm must also be considered.)
- If the “Dead line” state is started and the “VTS Failure” signal has been continuous for at least 100 ms, then the “VTS failure” signal does not reset; it is generated continuously even when the line is in a disconnected state. Thus, the “VTS Failure” signal remains active at reclosing.
- If the “Dead line” state is started and the “VTS Failure” signal has not been continuous for at least 100 ms, then the “VTS failure” signal resets.

Technical data

Function	**Value**	**Accuracy**
Pick-up voltage Io=0A I2=0A		 <1% <1%
Operation time	<20ms	
Reset ratio	0.95	

Table 104 Technical data of the voltage transformer supervision function

Parameters

Integer parameters

Parameter name	**Title**	**Unit**	**Min**	**Max**	**Step**	**Default**
Integer parameters of the dead line detection function						
DLD_ULev_IPar_	Min Operate Voltage	%	10	100	1	60
DLD_ILev_IPar_	Min Operate Current	%	2	100	1	10
Starting voltage and current parameter for residual and negative sequence detection:						
VTS_Uo_IPar_	Start URes	%	5	50	1	30
VTS_Io_IPar_	Start IRes	%	10	50	1	10
VTS_Uneg_IPar_	Start UNeg	%	5	50	1	10
VTS_Ineg_IPar_	Start INeg	%	10	50	1	10

Table 105 The integer parameters of the voltage transformer supervision function

Enumerated parameter

Parameter name	**Title**	**Selection range**	**Default**
Parameter for type selection			
VTS_Oper_EPar_	Operation	Off, Zero sequence, Neg. sequence, Special	Zero sequence

Table 106 The enumerated parameter of the voltage transformer supervision function

1.2.1.25 Current unbalance function (VCB60)

The current unbalance protection function (VCB60) can be applied to detect unexpected asymmetry in current measurement.

The applied method selects maximum and minimum phase currents (RMS value of the fundamental Fourier components). If the difference between them is above the setting limit, the function generates a start signal. It is a necessary precondition of start signal generation that the maximum of the currents be above 10 % of the rated current and below 150% of the rated current.

The Fourier calculation modules calculate the RMS value of the basic Fourier current components of the phase currents individually. They are not part of the VCB60 function; they belong to the preparatory phase.

The analog signal processing module processes the RMS value of the basic Fourier current components of the phase currents to prepare the signals for the decision. It calculates the maximum and the minimum value of the RMS values and the difference between the maximum and minimum of the RMS values of the fundamental Fourier components of the phase currents as a percentage of the maximum of these values (ΔI>). If the maximum of the currents is above 10 % of the rated current and below 150% of the rated current and the ΔI> value is above the limit defined by the preset parameter (Start Current Diff) an output is generated to the decision module.

The decision logic module combines the status signals to generate the starting signal and the trip command of the function.

The trip command is generated after the defined time delay if trip command is enabled by the Boolean parameter setting.

The function can be disabled by parameter setting, and by an input signal programmed by the user with the graphic programming tool.

Technical data

Function	Value	Accuracy
Pick-up starting accuracy at In		< 2 %
Reset ratio	0.95	
Operate time	70 ms	

Table 107 Technical data of the current unbalance function

Parameters

Enumerated parameter

Parameter name	Title	Selection range	Default
Selection of the operating mode			
VCB60_Oper_EPar_	Operation	Off, On	On

Table 108 The enumerated parameter of the current unbalance function

Boolean parameter

Parameter name	Title	Explanation	Default
Selection for trip command			
VCB60_StOnly_BPar_	Start Signal Only	0 to generate trip command	0

Table 109 The boolean parameter of the current unbalance function

Integer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Phase difference current setting						
VCB60_StCurr_IPar_	Start Current Diff	%	10	90	1	50

Table 110 The integer parameter of the current unbalance function

Timer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Time delay						
VCB60_Del_TPar_	Time Delay	msec	100	60000	100	1000

Table 111 The timer parameter of the current unbalance function

1.2.1.26 Breaker failure protection function (BRF50)

After a protection function generates a trip command, it is expected that the circuit breaker opens and the fault current drops below the pre-defined normal level.

If not, then an additional trip command must be generated for all backup circuit breakers to clear the fault. At the same time, if required, a repeated trip command can be generated to the circuit breakers which are a priori expected to open.

The breaker failure protection function can be applied to perform this task.

The starting signal of the breaker failure protection function is usually the trip command of any other protection function assigned to the protected object. The user has the task to define these starting signals using the graphic equation editor, or if the operation of the individual phases is needed, then the start signals for the phases individually.

Two dedicated timers start at the rising edge of the start signals at the same time, one for the backup trip command and one for the repeated trip command, separately for operation in the individual phases. During the running time of the timers the function optionally monitors the currents, the closed state of the circuit breakers or both, according to the user's choice. The selection is made using an enumerated parameter.

If current supervision is selected by the user then the current limit values must be set correctly. The binary inputs indicating the status of the circuit breaker poles have no meaning.

If contact supervision is selected by the user then the current limit values have no meaning. The binary inputs indicating the status of the circuit breaker poles must be programmed correctly using the graphic equation editor.

If the parameter selection is "Current/Contact", the current parameters and the status signals must be set correctly. The breaker failure protection function resets only if all conditions for faultless state are fulfilled.

If at the end of the running time of the backup timer the currents do not drop below the pre-defined level, and/or the monitored circuit breaker is still in closed position, then a backup trip command is generated.

If repeated trip command is to be generated for the circuit breakers that are expected to open, then the enumerated parameter Retrip must be set to "On". In this case, at the end of the retrip timer(s) a repeated trip command is also generated in the phase(s) where the retrip timer(s) run off.

The pulse duration of the trip command is not shorter than the time defined by setting the parameter Pulse length.

The breaker failure protection function can be disabled by setting the enabling parameter to "Off".

Dynamic blocking (inhibition) is possible using the binary input Block. The conditions are to be programmed by the user, using the graphic equation editor.

Technical data

Function	Effective range	Accuracy
Current accuracy		<2 %
Retrip time	approx. 15 ms	
BF time accuracy		± 5 ms
Current reset time	20 ms	

Table 112 Technical data of the breaker failure protection function

Parameters

Enumerated parameters

Parameter name	Title	Selection range	Default
Selection of the operating mode			
BRF50_Oper_EPar_	Operation	Off, Current, Contact, Current/Contact	Current
Switching on or off of the repeated trip command			
BRF50_ReTr_EPar_	Retrip	Off, On	On

Table 113 The enumerated parameters of the breaker failure protection function

Integer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Phase current setting						
BRF50_StCurrPh_IPar_	Start Ph Current	%	20	200	1	30
Neutral current setting						
BRF50_StCurrN_IPar_	Start Res Current	%	10	200	1	20

Table 114 The integer parameters of the breaker failure protection function

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Time delay for repeated trip command generation						
BRF50_TrDel_TPar_	Retrip Time Delay	msec	0	10000	1	200
Time delay for trip command generation for the backup circuit breaker(s)						
BRF50_BUDel_TPar_	Backup Time Delay	msec	60	10000	1	300
Trip command impulse duration						
BRF50_Pulse_TPar_	Pulse Duration	msec	0	60000	1	100

Table 115 The timer parameters of the breaker failure protection function

1.2.1.27 Directional over-power protection function (DOP32)

The directional over-power protection function can be applied to protect any elements of the electric power system mainly generators if the active and/or reactive power has to be limited.

Technical data

Function	Effective range	Accuracy
P,Q measurement	I>5% In	<3%

Table 116 Technical data of the directional over-power protection function

Parameters

Enumerated parameter

Parameter name	Title	Selection range	Default
Switching on/off of the function			
DOP32_Oper_EPar_	Operation	Off,On	On

Table 117 The enumerated parameter of the directional over-power protection function

Boolean parameter

Parameter name	Title	Default
Selection: start signal only or both start signal and trip command		
DOP32_StOnly_BPar_	Start Signal Only	0

Table 118 The Boolean parameter of the directional over-power protection function

Integer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Direction angle						
DOP32_RCA_IPar_	Direction Angle	deg	-179	180	1	0

Table 119 Integer parameter of the directional over-power protection function

Float parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Minimum power setting						
DOP32_StPow_FPar_	Start Power	%	1	200	0.1	10

Table 120 Float parameter of the directional over-power protection function

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Definite time delay of the trip command						
DOP32_Delay_TPar_	Time Delay	msec	0	60000	1	100

Table 121 Timer parameter of the directional over-power protection function

1.2.1.28 Directional under-power protection function (DUP32)

The directional under-power protection function can be applied mainly to protect any elements of the electric power system, mainly generators, if the active and/or reactive power has to be limited in respect of the allowed minimum power.

Technical data

Function	Effective range	Accuracy
P,Q measurement	I>5% In	<3%

Table 122 Technical data of the directional under-power protection function

Parameters

Enumerated parameter

Parameter name	Title	Selection range	Default
Switching on/off of the function			
DUP32_Oper_EPar_	Operation	Off, On	On

Table 123 The enumerated parameter of the directional under-power protection function

Boolean parameter

Parameter name	Title	Default
Selection: start signal only or both start signal and trip command		
DUP32_StOnly_BPar_	Start Signal Only	0

Table 124 The Boolean parameter of the directional under-power protection function

Integer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Direction angle						
DUP32_RCA_IPar_	Direction Angle	deg	-179	180	1	0

Table 125 Integer parameter of the directional under-power protection function

Float parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Minimum power setting						
DUP32_StPow_FPar_	Start Power	%	1	200	0,1	10

Table 126 Float parameter of the directional under-power protection function

Timer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Definite time delay of the trip command						
DUP32_Delay_TPar_	Time Delay	msec	0	60000	1	100

Table 127 Timer parameter of the directional under-power protection function

1.2.1.29 Phase-selective trip logic (TRC94_PhS)

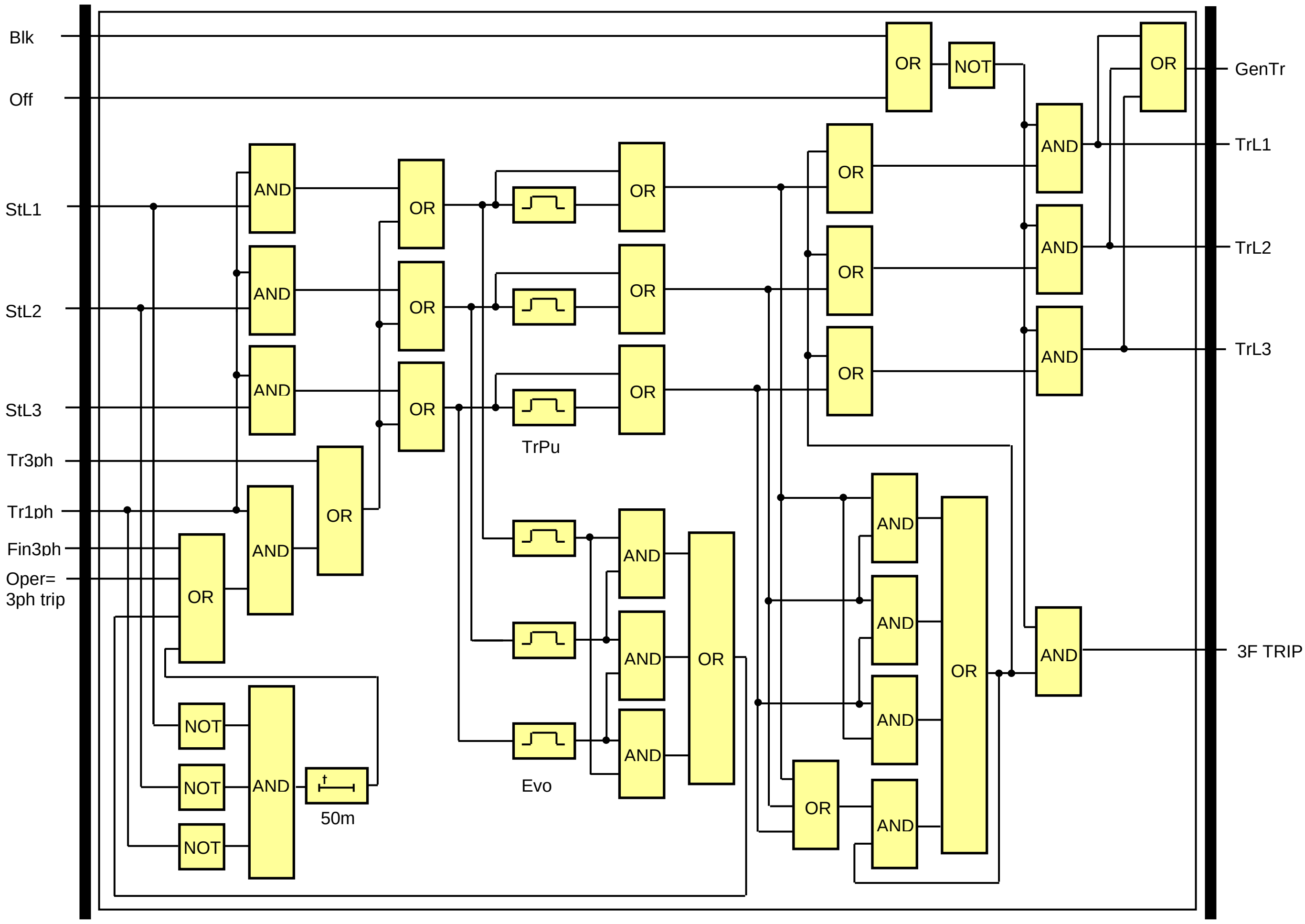
The phase-selective trip logic function operates according to the functionality required by the IEC 61850 standard for the “Trip logic logical node”.

The function receives the trip requirements of the protective functions implemented in the device and combines the parameters and the binary signals into the outputs of the device.

The trip requirements are programmed by the user, using the graphic equation editor. The decision logic has the following aims:

- define a minimal impulse duration even if the protection functions detect a very short time fault,
- in case of phase-to-phase faults, involve the third phase in the trip command,
- fulfill the requirements of the automatic reclosing function to generate a three-phase trip command even in case of single-phase faults,
- in case of an evolving fault, during the evolving fault waiting time include all three phases into the trip command.

The decision logic module combines the status signals and enumerated parameters to generate the trip commands on the output module of the device.



Technical data

Function	Accuracy
Timer accuracy	±5% or ±15 ms, whichever is greater

Table 128 *Technical data of the phase-selective trip logic function*

Parameters

Enumerated parameter

Parameter name	Title	Selection range	Default
Selection of the operating mode			
TRC94_Oper_EPar_	Operation	Off, 3ph trip, 1ph/3ph trip	3ph trip

Tables 129 *The enumerated parameter of the phase-selective trip logic function*

Timer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Minimum duration of the generated impulse						
TRC94_TrPu_TPar_	Min Pulse Duration	msec	50	60000	1	150
Waiting time for evolving fault						
TRC94_Evo_TPar_	Evolving Fault Time	msec	50	60000	1	1000

Table 130 *Timer parameter of the phase-selective trip logic function*

1.2.1.30 Dead line detection function (DLD)

The “Dead Line Detection” (DLD) function generates a signal indicating the dead or live state of the line. Additional signals are generated to indicate if the phase voltages and phase currents are above the pre-defined limits.

The task of the “Dead Line Detection” (DLD) function is to decide the Dead line/Live line state.

> Criteria of “Dead line” state: all three phase voltages are below the voltage setting value AND all three currents are below the current setting value.
>
> Criteria of “Live line” state: all three phase voltages are above the voltage setting value.

The details are described in the document ***Dead line detection protection function block description.***

Technical data

Function	Value	Accuracy
Pick-up voltage		1%
Operation time	<20ms	
Reset ratio	0.95	

Table 131 Technical data of the dead line detection function

Parameters

Integer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Integer parameters of the dead line detection function						
DLD_ULev_IPar_	Min. Operate Voltage	%	10	100	1	60
DLD_ILev_IPar_	Min. Operate Current	%	2	100	1	10

Table 132 The integer parameters of the dead line detection function

1.2.1.31

1.2.2 Control functions

1.2.2.1 Circuit breaker control function block (CB1Pol)

The Circuit breaker control function block can be used to integrate the circuit breaker control of the EuroProt+ device into the station control system and to apply active scheme screens of the local LCD of the device.

The Circuit breaker control function block receives remote commands from the SCADA system and local commands from the local LCD of the device, performs the prescribed checking and transmits the commands to the circuit breaker. It processes the status signals received from the circuit breaker and offers them to the status display of the local LCD and to the SCADA system.

Main features:

- Local (LCD of the device) and Remote (SCADA) operation modes can be enabled or disabled individually.
- The signals and commands of the synchro check / synchro switch function block can be integrated into the operation of the function block.
- Interlocking functions can be programmed by the user applying the inputs “EnaOff” (enabled trip command) and “EnaOn” (enabled close command), using the graphic equation editor.
- Programmed conditions can be used to temporarily disable the operation of the function block using the graphic equation editor.
- The function block supports the control models prescribed by the IEC 61850 standard.
- All necessary timing tasks are performed within the function block:
    - Time limitation to execute a command
    - Command pulse duration
    - Filtering the intermediate state of the circuit breaker
    - Checking the synchro check and synchro switch times
    - Controlling the individual steps of the manual commands
- Sending trip and close commands to the circuit breaker (to be combined with the trip commands of the protection functions and with the close command of the automatic reclosing function; the protection functions and the automatic reclosing function directly gives commands to the CB). The combination is made graphically using the graphic equation editor
- Operation counter
- Event reporting

The Circuit breaker control function block has binary input signals. The conditions are defined by the user applying the graphic equation editor. The signals of the circuit breaker control are seen in the binary input status list.

Technical data

Function	**Accuracy**
Operate time accuracy	±5% or ±15 ms, whichever is greater

Table 133 Technical data of the circuit breaker control function

Parameters

Enumerated parameter

Parameter name	Title	Selection range	Default
The control model of the circuit breaker node according to the IEC 61850 standard			
CB1Pol_ctlMod_EPar_	ControlModel*	Direct normal, Direct enhanced, SBO enhanced	Direct normal

**ControlModel*

- Direct normal: only command transmission
- Direct enhanced: command transmission with status check and command supervision
- SBO enhanced: Select Before Operate mode with status check and command supervision

Table 134 Enumerated parameter of the circuit breaker control function

Boolean parameter

Boolean parameter	Title	Explanation
CB1Pol_DisOverR_BPar_	Forced check	If true, then the check function cannot be neglected by the check attribute defined by the IEC 61850 standard

Table 135 Boolean parameter of the circuit breaker control function

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Timeout for signaling failed operation						
CB1Pol_TimOut_TPar_	Max.Operating time	msec	10	1000	1	200
Duration of the generated On and Off impulse						
CB1Pol_Pulse_TPar_,	Pulse length	msec	50	500	1	100
Waiting time, at expiry intermediate state of the CB is reported						
CB1Pol_MidPos_TPar_	Max.Intermediate time	msec	20	30000	1	100
Length of the time period to wait for the conditions of the synchron state. After expiry of this time, the synchro switch procedure is initiated (see synchro check/ synchro switch function block description)						
CB1Pol_SynTimOut_TPar_	Max.SynChk time	msec	10	5000	1	1000
Length of the time period to wait for the synchro switch impulse (see synchro check/ synchro switch function block description). After this time the function resets, no switching is performed						
CB1Pol_SynSWTimOut_TPar_	Max.SynSW time*	msec	0	60000	1	0
Duration of the waiting time between object selection and command selection. At timeout no command is performed						
CB1Pol_SBOTimeout_TPar_	SBO Timeout	msec	1000	20000	1	5000

* If this parameter is set to 0, then the "StartSW" output is not activated

Table 136 Timer parameters of the circuit breaker control function

Available internal status variable and command channel
To generate an active scheme on the local LCD, there is an internal status variable indicating the state of the circuit breaker. Different graphic symbols can be assigned to the values. (See Chapter 3.2 of the document "EuroCAP configuration tool for EuroProt+ devices").

Status variable	Title	Explanation
CB1Pol_stVal_Ist_	Status	Can be: 0: Intermediate 1: Off 2: On 3: Bad

The available control channel to be selected is:

Command channel	Title	Explanation
CB1Pol_Oper_Con_	Operation	Can be: On Off

Using this channel, the pushbuttons on the front panel of the device can be assigned to close or open the circuit breaker. These are the "Local commands".

1.2.2.2 Disconnector control function (DisConn)

The Disconnector control function block can be used to integrate the disconnector control of the EuroProt+ device into the station control system and to apply active scheme screens of the local LCD of the device.

The Disconnector control function block receives remote commands from the SCADA system and local commands from the local LCD of the device, performs the prescribed checking and transmits the commands to the disconnector. It processes the status signals received from the disconnector and offers them to the status display of the local LCD and to the SCADA system.

Main features:

- Local (LCD of the device) and Remote (SCADA) operation modes can be enabled or disabled individually.
- Interlocking functions can be programmed by the user applying the inputs “EnaOff” (enabled trip command) and “EnaOn” (enabled close command), using the graphic equation editor.
- Programmed conditions can be used to temporarily disable the operation of the function block using the graphic equation editor.
- The function block supports the control models prescribed by the IEC 61850 standard.
- All necessary timing tasks are performed within the function block:
    - Time limitation to execute a command
    - Command pulse duration
    - Filtering the intermediate state of the disconnector
    - Controlling the individual steps of the manual commands
- Sending trip and close commands to the disconnector
- Operation counter
- Event reporting

The Disconnector control function block has binary input signals. The conditions are defined by the user applying the graphic equation editor. The signals of the disconnector control are seen in the binary input status list.

Technical data

Function	Accuracy
Operate time accuracy	±5% or ±15 ms, whichever is greater

Table 137 Technical data of the disconnector control function

Parameters

Enumerated parameters

Parameter name	Title	Selection range	Default
The control model of the disconnector node according to the IEC 61850 standard			
DisConn_ctlMod_EPar_	ControlModel*	Direct normal, Direct enhanced, SBO enhanced	Direct normal
Type of switch			
DisConn_SwTyp_EPar_	Type of Switch	N/A,Load break, Disconnector, Earthing Switch, HS Earthing Switch	Disconnector

**ControlModel*

- Direct normal: only command transmission
- Direct enhanced: command transmission with status check and command supervision
- SBO enhanced: Select Before Operate mode with status check and command supervision

Table 138 Enumerated parameters of the disconnector control function

Boolean parameter

Boolean parameter	Title	Explanation
DisConn_DisOverR_BPar_	Forced check	If true, then the check function cannot be neglected by the check attribute defined by the IEC 61850 standard

Table 139 Boolean parameter of the disconnector control function

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Timeout for signaling failed operation						
DisConn_TimOut_TPar_	Max.Operating time	msec	10	20000	1	1000
Duration of the generated On and Off impulse						
DisConn_Pulse_TPar_	Pulse length	msec	50	30000	1	100
Waiting time, at expiry intermediate state of the disconnector is reported						
DisConn_MidPos_TPar_	Max.Intermediate time	msec	20	30000	1	100
Duration of the waiting time between object selection and command selection. At timeout no command is performed						
DisConn_SBOTimeout_ TPar_	SBO Timeout	msec	1000	20000	1	5000

Table 140 Timer parameters of the disconnector control function

Available internal status variable and command channel

To generate an active scheme on the local LCD, there is an internal status variable indicating the state of the disconnector. Different graphic symbols can be assigned to the values. (See Chapter 3.2 of the document “EuroCAP configuration tool for EuroProt+ devices”).

Status variable	Title	Explanation
DisConn I_stVal_Ist_	Status	Can be: 0: Intermediate 1: Off 2: On 3:Bad

The available control channel to be selected is:

Command channel	Title	Explanation
DisConn _Oper_Con_	Operation	Can be: On Off

Using this channel, the pushbuttons on the front panel of the device can be assigned to close or open the disconnector. These are the “Local commands”.

1.2.2.3 Synchrocheck function (SYN25)

Several problems can occur in the electric power system if the circuit breaker closes and connects two systems operating asynchronously. The high current surge can cause damage in the interconnecting elements, the accelerating forces can overstress the shafts of rotating machines or, at last, the actions taken by the protective system can result in the unwanted separation of parts of the electric power system.

To prevent such problems, this function checks whether the systems to be interconnected are operating synchronously. If yes, then the close command is transmitted to the circuit breaker. In case of asynchronous operation, the close command is delayed to wait for the appropriate vector position of the voltage vectors on both sides of the circuit breaker. If the conditions for safe closing cannot be fulfilled within an expected time, then closing is declined.

The conditions for safe closing are as follows:

- The difference of the voltage magnitudes is below the declared limit,
- The difference of the frequencies is below the declared limit and
- The angle difference between the voltages on both sides of the circuit breaker is within the declared limit.

The function processes both automatic reclosing and manual close commands.

The limits for automatic reclosing and manual close commands can be set independently of each other.

The function compares the voltage of the line and the voltage of one of the bar sections (Bus1 or Bus2). The bus selection is made automatically based on a binary input signal defined by the user applying the graphic equation editor.

As to voltages: any phase-to-ground or phase-to-phase voltage can be selected.

The function processes the signals of the voltage transformer supervision function and enables the close command only in case of plausible voltages.

There are three modes of operation:

- Energizing check:
    - Dead bus, live line,
    - Live bus, dead line,
    - Any Energizing Case (including Dead bus, dead line).
- Synchro check (Live line, live bus)
- Synchro switch (Live line, live bus)

If the conditions for “Energizing check” or “Synchro check” are fulfilled, then the function generates the release command, and in case of a manual or automatic close request, the close command is generated.

If the conditions for energizing or synchronous operation are not met when the close request is received, then synchronous switching is attempted within the set time-out. In this case, the rotating vectors must fulfill the conditions for safe switching within the declared waiting time: at the moment the contacts of the circuit breaker are closed, the voltage vectors must match each other with appropriate accuracy. For this mode of operation, the expected operating time of the circuit breaker must be set as a parameter value, to generate the close command in advance taking the relative vector rotation speed into consideration.

The started checking procedure can be interrupted by a cancel command defined by the user in the graphic equation editor.

In “bypass” operation mode, the function generates the release signals and simply transmits the close command.

The function can be started by the switching request signals initiated both the automatic reclosing and the manual closing. The binary input signals are defined by the user, applying the graphic equation editor.

Blocking signal of the function are defined by the user, applying the graphic equation editor.

Blocking signal of the voltage transformer supervision function for all voltage sources are defined by the user, applying the graphic equation editor.

Signal to interrupt (cancel) the automatic or the manual switching procedure are defined by the user, applying the graphic equation editor.

Technical data

Function	Effective range	Accuracy in the effective range
Rated Voltage Un	100/200V, parameter setting	
Voltage effective range	10-110 % of Un	±1% of Un
Frequency	47.5 – 52.5 Hz	±10 mHz
Phase angle		±3 °
Operate time	Setting value	±3 ms
Reset time	<50 ms	
Reset ratio	0.95 Un	

Table 141 Technical data of the synchro check / synchro switch function

Parameters

Enumerated parameters

Parameter name	Title	Selection range	Default
Selection of the processed voltage			
SYN25_VoltSel_EPar_	Voltage Select	L1-N,L2-N,L3-N,L1-L2,L2-L3,L3-L1	L1-N
Operation mode for automatic switching			
SYN25_OperA_EPar_	Operation Auto	Off, On, ByPass	On
Enabling/disabling automatic synchro switching			
SYN25_SwOperA_EPar_	SynSW Auto	Off, On	On
Energizing mode for automatic switching			
SYN25_EnOperA_EPar_	Energizing Auto	Off, DeadBus LiveLine, LiveBus DeadLine, Any energ case	DeadBus LiveLine
Operation mode for manual switching			
SYN25_OperM_EPar_	Operation Man	Off, On, ByPass	On
Enabling/disabling manual synchro switching			
SYN25_SwOperM_EPar_	SynSW Man	Off, On	On
Energizing mode for manual switching			
SYN25_EnOperM_EPar_	Energizing Man	Off,DeadBus LiveLine, LiveBus DeadLine, Any energ case	DeadBus LiveLine

Table 142 The enumerated parameters of the synchro check / synchro switch function

Integer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Voltage limit for "live line" detection						
SYN25_LiveU_IPar_	U Live	%	60	110	1	70
Voltage limit for "dead line" detection						
SYN25_DeadU_IPar_	U Dead	%	10	60	1	30
Voltage difference for automatic synchro checking mode						
SYN25_ChkUdA_IPar_	Udiff SynCheck Auto	%	5	30	1	10
Voltage difference for automatic synchro switching mode						
SYN25_SwUdA_IPar_	Udiff SynSW Auto	%	5	30	1	10
Phase difference for automatic switching						
SYN25_MaxPhDiffA_IPar_	MaxPhaseDiff Auto	deg	5	80	1	20
Voltage difference for manual synchro checking mode						
SYN25_ChkUdM_IPar_	Udiff SynCheck Man	%	5	30	1	10
Voltage difference for manual synchro switching mode						
SYN25_SwUdM_IPar_	Udiff SynSW Man	%	5	30	1	10
Phase difference for manual switching						
SYN25_MaxPhDiffM_IPar_	MaxPhaseDiff Man	deg	5	80	1	20

Table 143 *The integer parameters of the synchro check / synchro switch function*

Floating point parameters

Parameter name	Title	Dim.	Min	Max	Default
Frequency difference for automatic synchro checking mode					
SYN25_ChkFrDA_FPar_	FrDiff SynCheck Auto	Hz	0.02	0.5	0.02
Frequency difference for automatic synchro switching mode					
SYN25_SwFrDA_FPar_	FrDiff SynSW Auto	Hz	0.10	1.00	0.2
Frequency difference for manual synchro checking mode					
SYN25_ChkFrDM_FPar_	FrDiff SynCheck Man	Hz	0.02	0.5	0.02
Frequency difference for manual synchro switching mode					
SYN25_SwFrDM_FPar_	FrDiff SynSW Man	Hz	0.10	1.00	0.2

Table 144 *The floating point parameters of the synchro check / synchro switch function*

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Breaker operating time at closing						
SYN25_CBTrav_TPar_	Breaker Time	msec	0	500	1	80
Impulse duration for close command						
SYN25_SwPu_TPar_	Close Pulse	msec	10	60000	1	1000
Maximum allowed switching time						
SYN25_MaxSw_TPar_	Max Switch Time	msec	100	60000	1	2000

Table 145 *The timer parameters of the synchro check / synchro switch function*

1.2.3 Measuring functions

The measured values can be checked on the touch-screen of the device in the “On-line functions” page, or using an Internet browser of a connected computer. The displayed values are secondary voltages and currents, except the block “Line measurement”. This specific block displays the measured values in primary units, using VT and CT primary value settings.

Analog value	Explanation
VT4 module	
Voltage Ch – U1	RMS value of the Fourier fundamental harmonic voltage component in phase L1
Angle Ch – U1	Phase angle of the Fourier fundamental harmonic voltage component in phase L1*
Voltage Ch – U2	RMS value of the Fourier fundamental harmonic voltage component in phase L2
Angle Ch – U2	Phase angle of the Fourier fundamental harmonic voltage component in phase L2*
Voltage Ch – U3	RMS value of the Fourier fundamental harmonic voltage component in phase L3
Angle Ch – U3	Phase angle of the Fourier fundamental harmonic voltage component in phase L3*
Voltage Ch – U4	RMS value of the Fourier fundamental harmonic voltage component in Channel U4
Angle Ch – U4	Phase angle of the Fourier fundamental harmonic voltage component in Channel U4*
CT4 module	
Current Ch - I1	RMS value of the Fourier fundamental harmonic current component in phase L1
Angle Ch - I1	Phase angle of the Fourier fundamental harmonic current component in phase L1*
Current Ch - I2	RMS value of the Fourier fundamental harmonic current component in phase L2
Angle Ch - I2	Phase angle of the Fourier fundamental harmonic current component in phase L2*
Current Ch - I3	RMS value of the Fourier fundamental harmonic current component in phase L3
Angle Ch - I3	Phase angle of the Fourier fundamental harmonic current component in phase L3*
Current Ch - I4	RMS value of the Fourier fundamental harmonic current component in Channel I4
Angle Ch - I4	Phase angle of the Fourier fundamental harmonic current component in Channel I4*
Distance protection function (DIS21_HV)	
Fault location	Measured distance to fault
Fault react.	Measured reactance in the fault loop
L1N loop R	Resistive component value of impedance in L1-N loop
L1N loop X	Reactive component value of impedance in L1-N loop
L2N loop R	Resistive component value of impedance in L2-N loop
L2N loop X	Reactive component value of impedance in L2-N loop
L3N loop R	Resistive component value of impedance in L3-N loop
L3N loop X	Reactive component value of impedance in L3-N loop
L12 loop R	Resistive component value of impedance in L12 loop
L12 loop X	Reactive component value of impedance in L12 loop
L23 loop R	Resistive component value of impedance in L23 loop
L23 loop X	Reactive component value of impedance in L23 loop
L31 loop R	Resistive component value of impedance in L31 loop
L31 loop X	Reactive component value of impedance in L31 loop

Synchrocheck function (SYN25)	
Voltage Diff	Voltage different value
Frequency Diff	Frequency different value
Angle Diff	Angle different value
Line measurement (MXU_L) (here the displayed information means primary value)	
Active Power – P	Three-phase active power
Reactive Power – Q	Three-phase reactive power
Apparent Power – S	Three-phase power based on true RMS voltage and current measurement
Current L1	True RMS value of the current in phase L1
Current L2	True RMS value of the current in phase L2
Current L3	True RMS value of the current in phase L3
Voltage L1	True RMS value of the voltage in phase L1
Voltage L2	True RMS value of the voltage in phase L2
Voltage L3	True RMS value of the voltage in phase L3
Voltage L12	True RMS value of the voltage between phases L1 L2
Voltage L23	True RMS value of the voltage between phases L2 L3
Voltage L31	True RMS value of the voltage between phases L3 L1
Frequency	Frequency
Metering (MTR)	
Forward MWh	Forward MWh
Backward MWh	Backward MWh
Forward MVArh	Forward MVArh
Backward MVArh	Backward MVArh
Line thermal protection (TTR49L)	
Calc. Temperature	Calculated line temperature

* *The reference angle is the phase angle of “Voltage Ch - U1”*

Table 146 Measured analog values

1.2.3.1 Current input function (CT4)

If the factory configuration includes a current transformer hardware module, the current input function block is automatically configured among the software function blocks. Separate current input function blocks are assigned to each current transformer hardware module.

A current transformer hardware module is equipped with four special intermediate current transformers. (See Chapter 5 of the EuroProt+ hardware description document.) As usual, the first three current inputs receive the three phase currents (IL1, IL2, IL3), the fourth input is reserved for zero sequence current, for the zero sequence current of the parallel line or for any additional current. Accordingly, the first three inputs have common parameters while the fourth current input needs individual setting.

The role of the current input function block is to

- set the required parameters associated to the current inputs,
- deliver the sampled current values for disturbance recording,
- perform the basic calculations
  - Fourier basic harmonic magnitude and angle,
  - True RMS value;
- provide the pre-calculated current values to the subsequent software modules,
- deliver the basic calculated values for on-line displaying.

Operation of the current input algorithm

The current input function block receives the sampled current values from the internal operating system. The scaling (even hardware scaling) depends on parameter setting. See parameters CT4_Ch13Nom_EPar_ (Rated Secondary I1-3) and CT4_Ch4Nom_EPar_ (Rated Secondary I4). The options to choose from are 1A or 5A (in special applications, 0.2A or 1A). This parameter influences the internal number format and, naturally, accuracy. (A small current is processed with finer resolution if 1A is selected.)

If needed, the phase currents can be inverted by setting the parameter CT4_Ch13Dir_EPar_ (Starpoint I1-3). This selection applies to each of the channels IL1, IL2 and IL3. The fourth current channel can be inverted by setting the parameter CT4_Ch4Dir_EPar (Direction I4). This inversion may be needed in protection functions such as distance protection, differential protection or for any functions with directional decision.

These sampled values are available for further processing and for disturbance recording.

The performed basic calculation results the Fourier basic harmonic magnitude and angle and the true RMS value. These results are processed by subsequent protection function blocks and they are available for on-line displaying as well.

The function block also provides parameters for setting the primary rated currents of the main current transformer. This function block does not need that parameter setting. These values are passed on to function blocks such as displaying primary measured values, primary power calculation, etc.

Technical data

Function	Range	Accuracy
Current accuracy	20 – 2000% of In	±1% of In

Table 147 Technical data of the current input

Parameters

Enumerated parameters

Parameter name	Title	Selection range	Default
Rated secondary current of the first three input channels. 1A or 5A is selected by parameter setting, no hardware modification is needed.			
CT4_Ch13Nom_EPar_	Rated Secondary I1-3	1A,5A	1A
Rated secondary current of the fourth input channel. 1A or 5A is selected by parameter setting, no hardware modification is needed.			
CT4_Ch4Nom_EPar_	Rated Secondary I4	1A,5A (0.2A or 1A)	1A
Definition of the positive direction of the first three currents, given by location of the secondary star connection point			
CT4_Ch13Dir_EPar_	Starpoint I1-3	Line,Bus	Line
Definition of the positive direction of the fourth current, given as normal or inverted			
CT4_Ch4Dir_EPar_	Direction I4	Normal,Inverted	Normal

Table 148 *The enumerated parameters of the current input function*

Floating point parameters

Parameter name	Title	Dim.	Min	Max	Default
Rated primary current of channel1					
CT4_PriI1_FPar_	Rated Primary I1	A	100	4000	1000
Rated primary current of channel2					
CT4_PriI2_FPar	Rated Primary I2	A	100	4000	1000
Rated primary current of channel3					
CT4_PriI3_FPar_	Rated Primary I3	A	100	4000	1000
Rated primary current of channel4					
CT4_PriI4_FPar_	Rated Primary I4	A	100	4000	1000

Table 149 *The floating point parameters of the current input function*

NOTE: The rated primary current of the channels is not needed for the current input function block itself. These values are passed on to the subsequent function blocks.

The **measured values** of the current input function block.

Measured value	Dim.	Explanation
Current Ch - I1	A(secondary)	Fourier basic component of the current in channel IL1
Angle Ch - I1	degree	Vector position of the current in channel IL1
Current Ch – I2	A(secondary)	Fourier basic component of the current in channel IL2
Angle Ch – I2	degree	Vector position of the current in channel IL2
Current Ch – I3	A(secondary)	Fourier basic component of the current in channel IL3
Angle Ch – I3	degree	Vector position of the current in channel IL3
Current Ch – I4	A(secondary)	Fourier basic component of the current in channel I4
Angle Ch – I4	degree	Vector position of the current in channel I4

Table 150 *The measured analogue values of the current input function*

NOTE1: The scaling of the Fourier basic component is such that if pure sinusoid 1A RMS of the rated frequency is injected, the displayed value is 1A. (The displayed value does not depend on the parameter setting values “Rated Secondary”.)

NOTE2: The reference of the vector position depends on the device configuration. If a voltage input module is included, then the reference vector (vector with angle 0 degree) is the vector calculated for the first voltage input channel of the first applied voltage input module. If no voltage input module is configured, then the reference vector (vector with angle 0 degree) is the vector calculated for the first current input channel of the first applied current input module.

Figure 10 shows an example of how the calculated Fourier components are displayed in the on-line block. (See the document “EuroProt+ Remote user interface description”.)

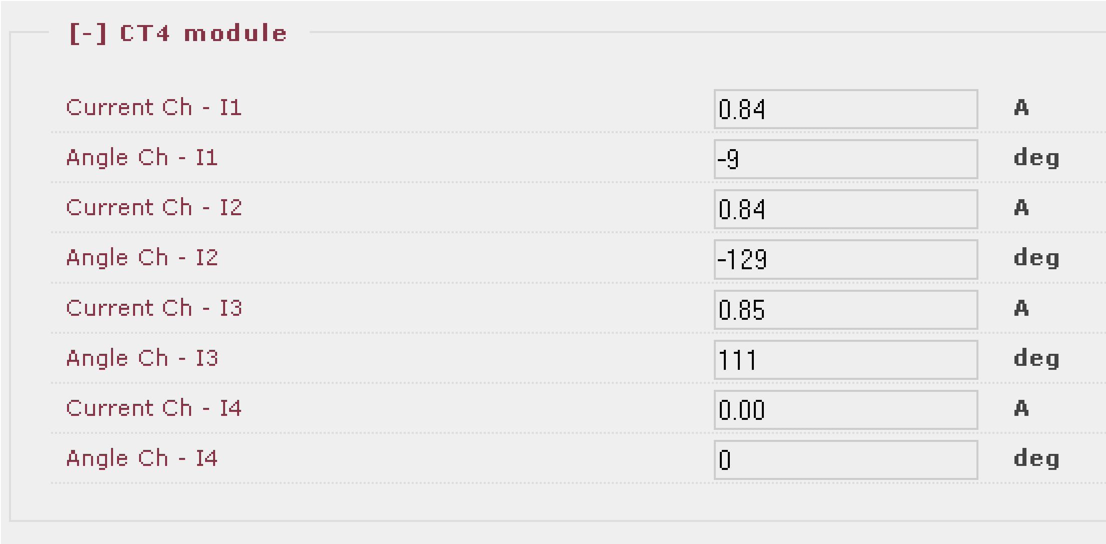


Figure 10 Example: On-line displayed values for the current input module

1.2.3.2 Voltage input function (VT4)

If the factory configuration includes a voltage transformer hardware module, the voltage input function block is automatically configured among the software function blocks. Separate voltage input function blocks are assigned to each voltage transformer hardware module.

A voltage transformer hardware module is equipped with four special intermediate voltage transformers. (See Chapter 6 of the EuroProt+ hardware description document.) As usual, the first three voltage inputs receive the three phase voltages (UL1, UL2, UL3), the fourth input is reserved for zero sequence voltage or for a voltage from the other side of the circuit breaker for synchron switching. All inputs have a common parameter for type selection: 100V or 200V.

Additionally, there is a correction factor available if the rated secondary voltage of the main voltage transformer (e.g. 110V) does not match the rated input of the device.

The role of the voltage input function block is to

- set the required parameters associated to the voltage inputs,
- deliver the sampled voltage values for disturbance recording,
- perform the basic calculations
    - Fourier basic harmonic magnitude and angle,
    - True RMS value;
- provide the pre-calculated voltage values to the subsequent software modules,
- deliver the basic calculated values for on-line displaying.

Operation of the voltage input algorithm

The voltage input function block receives the sampled voltage values from the internal operating system. The scaling (even hardware scaling) depends on parameter setting. See the parameter VT4_Type_EPar_ (Range). The options to choose from are 100V or 200V. This parameter influences the internal number format and, naturally, accuracy. (A small voltage is processed with finer resolution if 100V is selected.)

The connection of the first three VT secondary winding must be set to reflect actual physical connection. The associated parameter is VT4_Ch13Nom_EPar_ (Connection U1-3). The selection can be: Ph-N, Ph-Ph or Ph-N-Isolated.

The Ph-N option is applied in solidly grounded networks, where the measured phase voltage is never above 1.5-Un. In this case the primary rated voltage of the VT must be the value of the rated PHASE-TO-NEUTRAL voltage.

The Ph-N option is applied in compensated or isolated networks, where the measured phase voltage can be above 1.5-Un even in normal operation. In this case the primary rated voltage of the VT must be the value of the rated PHASE-TO-PHASE voltage.

If phase-to-phase voltage is connected to the VT input of the device, then the Ph-Ph option is to be selected. Here, the primary rated voltage of the VT must be the value of the rated PHASE-TO-PHASE voltage. This option must not be selected if the distance protection function is supplied from the VT input.

The fourth input is reserved for zero sequence voltage or for a voltage from the other side of the circuit breaker for synchron switching. Accordingly, the connected voltage must be identified with parameter setting VT4_Ch4Nom_EPar_ (Connection U4). Here, phase-to-neutral or phase-to-phase voltage can be selected: Ph-N,Ph-Ph

If needed, the phase voltages can be inverted by setting the parameter VT4_Ch13Dir_EPar_ (Direction U1-3). This selection applies to each of the channels UL1, UL2 and UL3. The fourth voltage channel can be inverted by setting the parameter VT4_Ch4Dir_EPar_ (Direction U4). This inversion may be needed in protection functions such as distance protection, differential protection or for any functions with directional decision, or for checking the voltage vector positions.

Additionally, there is a correction factor available if the rated secondary voltage of the main voltage transformer (e.g. 110V) does not match the rated input of the device. The related parameter is VT4_CorrFact_IPar_ (VT correction). As an example: if the rated secondary voltage of the main voltage transformer is 110V, then select Type 100 for the parameter "Range" and the required value to set here is 110%.

These sampled values are available for further processing and for disturbance recording.

The performed basic calculation results the Fourier basic harmonic magnitude and angle and the true RMS value of the voltages. These results are processed by subsequent protection function blocks and they are available for on-line displaying as well.

The function block also provides parameters for setting the primary rated voltages of the main voltage transformer. This function block does not need that parameter setting. These values are passed on to function blocks such as displaying primary measured values, primary power calculation, etc. Concerning the rated voltage, see the instructions related to the parameter for the connection of the first three VT secondary winding.

Parameters

Enumerated parameters

Parameter name	Title	Selection range	Default
Rated secondary voltage of the input channels. 100 V or 200V is selected by parameter setting, no hardware modification is needed.			
VT4_Type_EPar_	Range	Type 100,Type 200	Type 100
Connection of the first three voltage inputs (main VT secondary)			
VT4_Ch13Nom_EPar_	Connection U1-3	Ph-N, Ph-Ph, Ph-N-Isolated	Ph-N
Selection of the fourth channel input: phase-to-neutral or phase-to-phase voltage			
VT4_Ch4Nom_EPar_	Connection U4	Ph-N,Ph-Ph	Ph-Ph
Definition of the positive direction of the first three input channels, given as normal or inverted			
VT4_Ch13Dir_EPar_	Direction U1-3	Normal,Inverted	Normal
Definition of the positive direction of the fourth voltage, given as normal or inverted			
VT4_Ch4Dir_EPar_	Direction U4	Normal,Inverted	Normal

Table 151 *The enumerated parameters of the voltage input function*

Integer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Voltage correction						
VT4_CorrFact_IPar_	VT correction	%	100	115	1	100

Table 152 *The integer parameter of the voltage input function*

Floating point parameters

Parameter name	Title	Dim.	Min	Max	Default
Rated primary voltage of channel1					
VT4_PriU1_FPar	Rated Primary U1	kV	1	1000	100
Rated primary voltage of channel2					
VT4_PriU2_FPar	Rated Primary U2	kV	1	1000	100
Rated primary voltage of channel3					
VT4_PriU3_FPar	Rated Primary U3	kV	1	1000	100
Rated primary voltage of channel4					
VT4_PriU4_FPar	Rated Primary U4	kV	1	1000	100

Table 153 *The floating point parameters of the voltage input function*

NOTE: The rated primary voltage of the channels is not needed for the voltage input function block itself. These values are passed on to the subsequent function blocks.

Function	Range	Accuracy
Voltage accuracy	30% … 130%	< 0.5 %

Table 154 Technical data of the voltage input

Measured values

Measured value	Dim.	Explanation
Voltage Ch - U1	V(secondary)	Fourier basic component of the voltage in channel UL1
Angle Ch - U1	degree	Vector position of the voltage in channel UL1
Voltage Ch – U2	V(secondary)	Fourier basic component of the voltage in channel UL2
Angle Ch – U2	degree	Vector position of the voltage in channel UL2
Voltage Ch – U3	V(secondary)	Fourier basic component of the voltage in channel UL3
Angle Ch – U3	degree	Vector position of the voltage in channel UL3
Voltage Ch – U4	V(secondary)	Fourier basic component of the voltage in channel U4
Angle Ch – U4	degree	Vector position of the voltage in channel U4

Table 155 The measured analogue values of the voltage input function

NOTE1: The scaling of the Fourier basic component is such if pure sinusoid 57V RMS of the rated frequency is injected, the displayed value is 57V. (The displayed value does not depend on the parameter setting values “Rated Secondary”.)

NOTE2: The reference vector (vector with angle 0 degree) is the vector calculated for the first voltage input channel of the first applied voltage input module.

The figure below shows an example of how the calculated Fourier components are displayed in the on-line block. (See the document EuroProt+ “Remote user interface description”.)

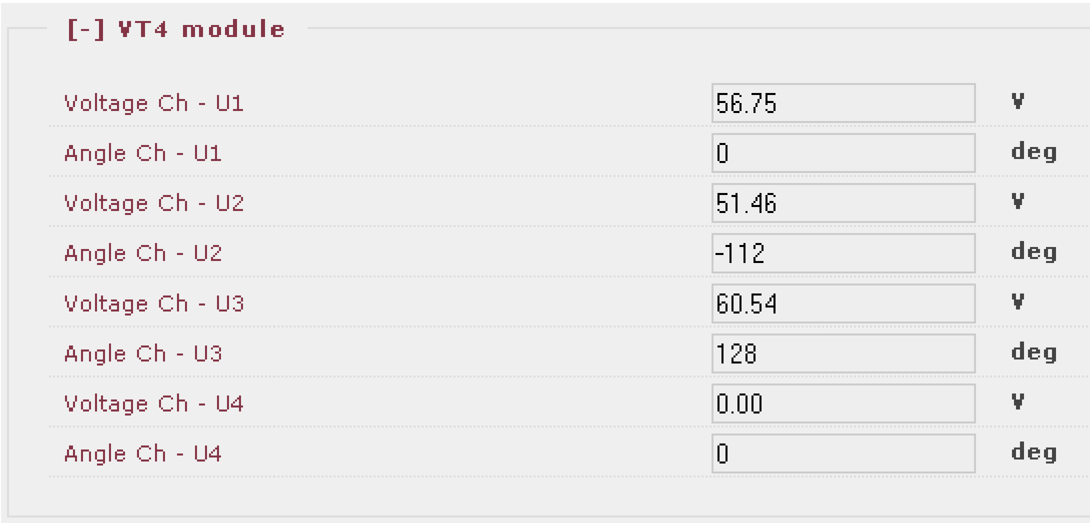


Figure 11 Example: On-line displayed values for the voltage input module

1.2.3.3 Line measurement function (MXU)

The measurement

The input values of the EuroProt+ devices are the secondary signals of the voltage transformers and those of the current transformers.

These signals are pre-processed by the “Voltage transformer input” function block and by the “Current transformer input” function block. These function blocks are described in separate documents. The pre-processed values include the Fourier basic harmonic phasors of the voltages and currents and the true RMS values. Additionally, it is in these function blocks that parameters are set concerning the voltage ratio of the primary voltage transformers and current ratio of the current transformers.

Based on the pre-processed values and the measured transformer parameters, the “Line measurement” function block calculates - depending on the hardware and software configuration - the primary RMS values of the voltages and currents and some additional values such as active and reactive power, symmetrical components of voltages and currents. These values are available as primary quantities and they can be displayed on the on-line screen of the device or on the remote user interface of the computers connected to the communication network and they are available for the SCADA system using the configured communication system.

Reporting the measured values and the changes

It is usual for the SCADA systems that they sample the measured and calculated values in regular time periods and additionally they receive the changed values as reports at the moment when any significant change is detected in the primary system. The “Line measurement” function block is able to perform such reporting for the SCADA system.

Operation of the line measurement function block

The **inputs** of the line measurement function are

- the Fourier components and true RMS values of the measured voltages and currents,
- frequency measurement,
- parameters.

The **outputs** of the line measurement function are

- displayed measured values,
- reports to the SCADA system.

NOTE: the scaling values are entered as parameter setting for the “Voltage transformer input” function block and for the “Current transformer input” function block.

The measured values

The **measured values** of the line measurement function depend on the hardware configuration. As an example, Table *156* shows the list of the measured values available in a configuration for solidly grounded networks.

Measured value	Explanation
MXU_P_OLM_	Active Power – P (Fourier base harmonic value)
MXU_Q_OLM_	Reactive Power – Q (Fourier base harmonic value)
MXU_S_OLM_	Apparent Power – S (Fourier base harmonic value)
MXU_I1_OLM_	Current L1
MXU_I2_OLM_	Current L2
MXU_I3_OLM_	Current L3
MXU_U1_OLM_	Voltage L1
MXU_U2_OLM_	Voltage L2
MXU_U3_OLM_	Voltage L3
MXU_U12_OLM_	Voltage L12
MXU_U23_OLM_	Voltage L23
MXU_U31_OLM_	Voltage L31
MXU_f_OLM_	Frequency

Table 156 *Example: Measured values in a configuration for solidly grounded networks*

Another example is Figure *12*, where the measured values available are shown as on-line information in a configuration for compensated networks.

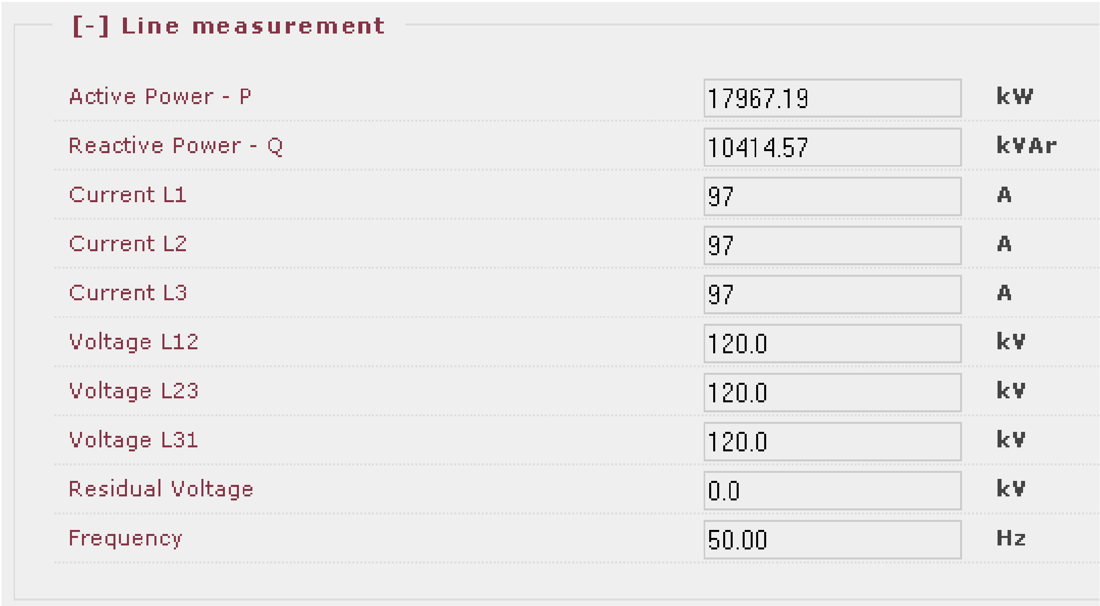


Figure 12 *Example: Measured values in a configuration for compensated networks*

The available quantities are described in the configuration description documents.

Reporting the measured values and the changes

For reporting, additional information is needed, which is defined in parameter setting.
As an example, in a configuration for solidly grounded networks the following parameters are available:

Enumerated parameters

Parameter name	Title	Selection range	Default
Selection of the reporting mode for active power measurement			
MXU_PRepMode_EPar_	Operation ActivePower	Off, Amplitude, Integrated	Amplitude
Selection of the reporting mode for reactive power measurement			
MXU_QRepMode_EPar_	Operation ActivePower	Off, Amplitude, Integrated	Amplitude
Selection of the reporting mode for apparent power measurement			
MXU_SRepMode_EPar_	Operation ApparPower	Off, Amplitude, Integrated	Amplitude
Selection of the reporting mode for current measurement			
MXU_IRepMode_EPar_	Operation Current	Off, Amplitude, Integrated	Amplitude
Selection of the reporting mode for voltage measurement			
MXU_URepMode_EPar_	Operation Voltage	Off, Amplitude, Integrated	Amplitude
Selection of the reporting mode for frequency measurement			
MXU_fRepMode_EPar_	Operation Frequency	Off, Amplitude, Integrated	Amplitude

Table 157 *The enumerated parameters of the line measurement function*

The selection of the reporting mode items is explained in Figure *13* and in Figure *14*.

"Amplitude" mode of reporting

If the "Amplitude" mode is selected for reporting, a report is generated if the measured value leaves the deadband around the previously reported value. As an example, Figure *13* shows that the current becomes higher than the value reported in "report1" PLUS the Deadband value, this results "report2", etc.

For this mode of operation, the Deadband parameters are explained in Table *158*.

The "Range" parameters in Table *158* are needed to evaluate a measurement as "out-of-range".

Floating point parameters

Parameter name	Title	Dim.	Min	Max	Step	Default
Deadband value for the active power						
MXU_PDeadB_FPar_	Deadband value - P	MW	0.1	100000	0.01	10
Range value for the active power						
MXU_PRange_FPar_	Range value - P	MW	1	100000	0.01	500
Deadband value for the reactive power						
MXU_QDeadB_FPar_	Deadband value - Q	MVAr	0.1	100000	0.01	10
Range value for the reactive power						
MXU_QRange_FPar_	Range value - Q	MVAr	1	100000	0.01	500
Deadband value for the apparent power						
MXU_SDeadB_FPar_	Deadband value - S	MVA	0.1	100000	0.01	10
Range value for the apparent power						
MXU_SRange_FPar_	Range value - S	MVA	1	100000	0.01	500
Deadband value for the current						
MXU_IDeadB_FPar_	Deadband value - I	A	1	2000	1	10
Range value for the current						
MXU_IRange_FPar_	Range value - I	A	1	5000	1	500
Deadband value for the phase-to-neutral voltage						
MXU_UPhDeadB_ FPar_	Deadband value – U ph-N	kV	0.1	100	0.01	1
Range value for the phase-to-neutral voltage						
MXU_UPhRange_ FPar_	Range value – U ph-N	kV	1	1000	0.1	231
Deadband value for the phase-to-phase voltage						
MXU_UPPDeadB_ FPar_	Deadband value – U ph-ph	kV	0.1	100	0.01	1
Range value for the phase-to-phase voltage						
MXU_UPPRange_ FPar_	Range value – U ph-ph	kV	1	1000	0.1	400
Deadband value for the current						
MXU_fDeadB_FPar_	Deadband value - f	Hz	0.01	1	0.01	0.02
Range value for the current						
MXU_fRange_FPar_	Range value - f	Hz	0.05	10	0.01	5

Table 158 *The floating-point parameters of the line measurement function*

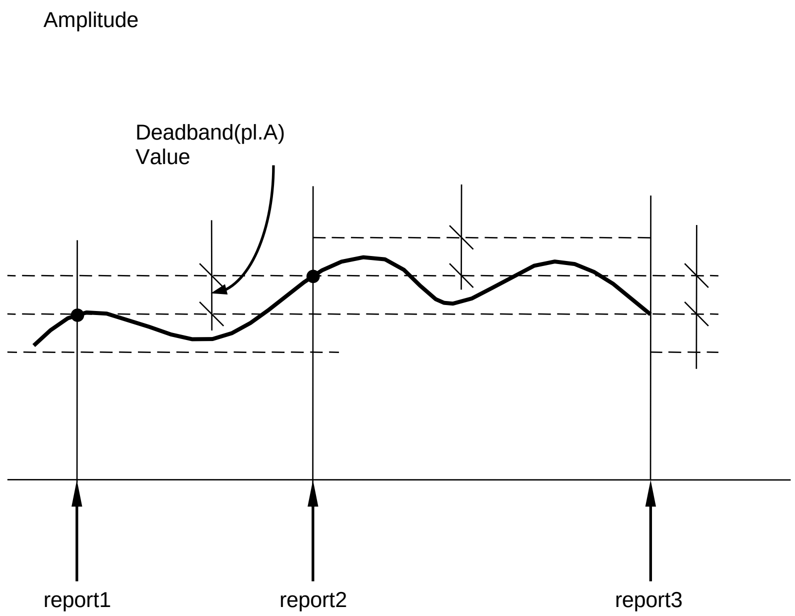


Figure 13 *Reporting if "*Amplitude*" mode is selected*

"Integral" mode of reporting

If the "Integrated" mode is selected for reporting, a report is generated if the time integral of the measured value since the last report gets becomes larger, in the positive or negative direction, then the (deadband*1sec) area. As an example, Figure *14* shows that the integral of the current in time becomes higher than the Deadband value multiplied by 1sec, this results "report2", etc.

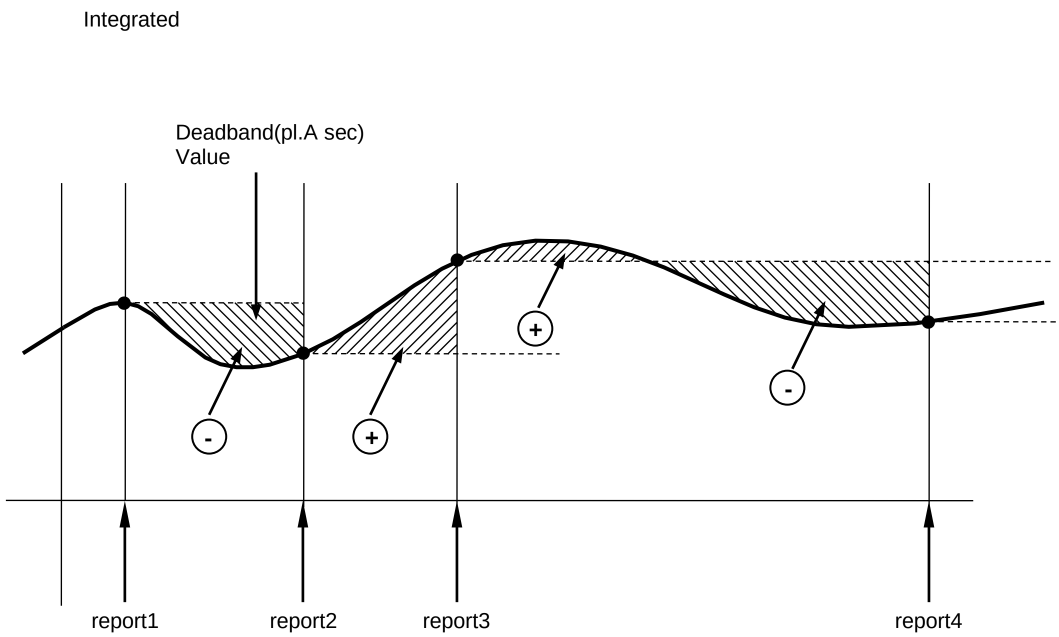


Figure 14 *Reporting if "*Integrated*" mode is selected*

Periodic reporting

Periodic reporting is generated independently of the changes of the measured values when the defined time period elapses. The required parameter setting is shown in Table *159*.

Integer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Reporting time period for the active power						
MXU_PIntPer_IPar_	Report period P	sec	0	3600	1	0
Reporting time period for the reactive power						
MXU_QIntPer_IPar_	Report period Q	sec	0	3600	1	0
Reporting time period for the apparent power						
MXU_SIntPer_IPar_	Report period S	sec	0	3600	1	0
Reporting time period for the voltage						
MXU_UIntPer_IPar_	Report period U	sec	0	3600	1	0
Reporting time period for the current						
MXU_IIntPer_IPar_	Report period I	sec	0	3600	1	0
Reporting time period for the frequency						
MXU_fIntPer_IPar_	Report period f	sec	0	3600	1	0

Table 159 *The integer parameters of the line measurement function*

If the reporting time period is set to 0, then no periodic reporting is performed for this quantity.

All reports can be disabled for a quantity if the reporting mode is set to “Off”. See Table *157*.

Technical data

Function	Range	Accuracy
Current accuracy		
with CT/5151 or CT/5102 modules	0,2 In – 0,5 In	±2%, ±1 digit
	0,5 In – 20 In	±1%, ±1 digit
with CT/1500 module	0,03 In – 2 In	±0,5%, ±1 digit
Voltage accuracy	5 – 150% of Un	±0.5% of Un, ±1 digit
Power accuracy	I>5% In	±3%, ±1 digit
Frequency accuracy	U>3.5%Un 45Hz – 55Hz	2mHz

Table 160 *Technical data of line measurement*

1.2.3.4 Phasor measurement unit (PMU)

The PMU function supports the IEEE C37.118-1 and -2 standards. It can report the three phase voltage phasors, the three phase current phasors, the positive and the negative sequence voltage and current phasors in both rectangular and polar format. The measured frequency and rate of change of frequency values are also reported. Standard trigger signals are freely configurable by the EuroCAP software.

The functionblock is synchronized by the IRIG-B signal connected to the TSYNC time synchron module. The performance class (P or M) of the PMU function is user selectable by parameter and can keep better TVE value than 1%.

The frame rate of the reporting can be set with the „Frame rate” parameter to 10, 25 or 50 frame/sec at 50Hz nominal frequency and 12, 30, 60 frame/sec at 60Hz nominal frequency. The configuration and command frames are transmitted over TCP protocol while the data frames over UDP protocol. The reporting can be spontanauous or controlled by TCP command frames. In both mode spontanauos CFG-2 frames are sent in every minute over UDP protocol. CFG-3 frame is not supported. Maximum 5 interrogation center's addresses and port numbers can be preprogrammed, but only one can be connected at a time.

Each phase voltage and phase current input has an amplitude and phase correction parameter. The errors of the primary instrument transformers can be compensated by these correction factors. The internal measuring transformers are factory calibrated.

In addition to the standard binary and analogue signals up to 8 user defined binary signals can be configured and reported to the interrogation centers.

Protecta relay has “holdover” capability which allows the clock to maintain accurate time over a period of time when it is not receiving valid IRIG-B time source. During periods of lost IRIG-B timesource signal, the Protecta deivces use their own internal reference clock, which maintains the required timing accuracy for approximately 30 seconds.

Parameters

Title	Dim	Range	Step	Default	Explanation
Parameters of the reporting					
Reporting Mode	–	Off, Spontanaeous TX, TCP/UDP method	–	Off	*Off*: Stream switched off, *Spontanaeous TX*: Stream switched on and directed to the first interrogation center *TCP/UDP method*: Stream switched on by the connected interrogation center
Reporting Format	–	Rectangular, Polar	–	Rectangular	Phasor format
Data type	–	Integer, Float	–	Integer	Data type of the reported values
Frame rate	fps	10 (12) fps, 25 (30) fps, 50 (60) fps	–	10 (12) fps	Frame rate of the reporting in case of 50 Hz (60 Hz) system frequency.
Performance class	–	P class, M class	–	P class	Selected standard performance class
Stream ID	–	1 – 65534	1	1	Stream ID

TCP Command Port					
TCP Command Port	–	1024 – 65534	1	4712	TCP port number for the command and configuration frames
Adresses of the 1..5 interrogation centers					
IP Address 1	–	0.0.0.0-255.255.255.255	1	0.0.0.0	IP address if interrogation center 1
UDP Port 1	–	1024 – 65534	1	4713	UDP Port number with interrogation center 1
IP Address 2	–	0.0.0.0-255.255.255.255	1	0.0.0.0	IP address if interrogation center 2
UDP Port 2	–	1024 – 65534	1	4713	UDP Port number with interrogation center 2
IP Address 3	–	0.0.0.0-255.255.255.255	1	0.0.0.0	IP address if interrogation center 3
UDP Port 3	–	1024 – 65534	1	4713	UDP Port number with interrogation center 3
IP Address 4	–	0.0.0.0-255.255.255.255	1	0.0.0.0	IP address if interrogation center 4
UDP Port 4	–	1024 – 65534	1	4713	UDP Port number with interrogation center 4
IP Address 5	–	0.0.0.0-255.255.255.255	1	0.0.0.0	IP address if interrogation center 5
UDP Port 5	–	1024 – 65534	1	4713	UDP Port number with interrogation center 5
Amplitude and phase correction parameters					
Amplitude Correction U4	–	0.7 – 1.3	0.001	1	Ampitude correction of the external voltage transformer U4
Phase Correction U4	deg	-120 – 120	0.1	0	Phase correction of the external voltage transformer U4
Amplitude Correction U8	–	0.7 – 1.3	0.001	1	Ampitude correction of the external voltage transformer U8
Phase Correction U8	deg	-120 – 120	0.1	0	Phase correction of the external voltage transformer U8
Amplitude Correction U12	–	0.7 – 1.3	0.001	1	Ampitude correction of the external voltage transformer U12
Phase Correction U12	deg	-120 – 120	0.1	0	Phase correction of the external voltage transformer U12

Amplitude Correction I4	–	0.7 – 1.3	0.001	1	Amplitude correction of the external current transformer I4
Phase Correction I4	deg	-120 – 120	0.1	0	Phase correction of the external current transformer I4
Amplitude Correction I8	–	0.7 – 1.3	0.001	1	Amplitude correction of the external current transformer I8
Phase Correction I8	deg	-120 – 120	0.1	0	Phase correction of the external current transformer I8
Amplitude Correction I12	–	0.7 – 1.3	0.001	1	Amplitude correction of the external current transformer I12
Phase Correction I12	deg	-120 – 120	0.1	0	Phase correction of the external current transformer I12

Table 161 *The parameters of the Phasor measurement unit function*

On-line data

Visible values on the on-line data page:

Signal title	**Dimension**	**Explanation**
SignalValid	-	IRIG-B000 time synchronisation signal is connected and valid
Time Locked	-	IRIG-B time synchronisation signal is connected and the system clock has sufficient accuracy
HoldOver	-	“Holdover” mode: IRIG-B time synchronisation signal is not connected but the system clock still has sufficient accuracy
UL1	kV	Vector magnitude of the voltage in phase L1
UL1 angle	deg	Vector position of the voltage in phase L1
UL2	kV	Vector magnitude of the voltage in phase L2
UL2 angle	deg	Vector position of the voltage in phase L2
UL3	kV	Vector magnitude of the voltage in phase L3
UL3 angle	deg	Vector position of the voltage in phase L3
IL1	A	Vector magnitude of the current in phase L1
IL1 angle	deg	Vector position of the current in phase L1
IL2	A	Vector magnitude of the current in phase L2
IL2 angle	deg	Vector position of the current in phase L2
IL3	A	Vector magnitude of the current in phase L3
IL3 angle	deg	Vector position of the current in phase L3
Frequency	Hz	Frequency
ROCOF	Hz/sec	Rate of change of frequency

Time source setting

The Protecta device provides Phasor Measurement Unit (PMU) capabilities when connected to an IRIG-B (IRIG-B000, unmodulated) time source via the dedicated TSYNC+0071 syncorization module.

The following settings must be applied so that the IRIG-B time synchronization mode will be used.

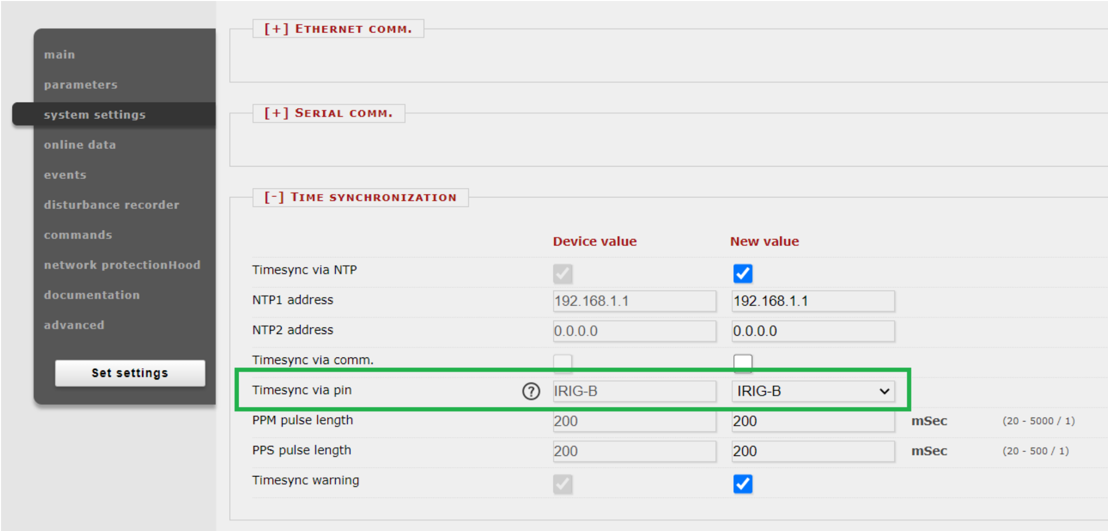


Figure 15 *IRIG-B setting*

1.2.4 Disturbance recorder

The DV7036 configuration contains a disturbance recorder function. The details are described in the document shown in Table 162.

Name	Title	Document
DRE	Disturbance Rec	***Disturbance recorder function block description***

Table 162 Implemented disturbance recorder function

The recorded analog channels:

Recorded analog signal	Explanation
V4 line	Measured voltage of line in phase L1
V8 line	Measured voltage of line in phase L2
V12 line	Measured voltage of line in phase L3
V4 bus	Measured voltage of bus in phase L1
V8 bus	Measured voltage of bus in phase L2
V12 bus	Measured voltage of bus in phase L3
I4	Measured current for protection purposes in phase L1
I8	Measured current for protection purposes in phase L2
I12	Measured current for protection purposes in phase L3
I4N	Measured current of parallel line Io for protection purposes

Table 163 Disturbance recorder, recorded analog channels

The recorded binary channels:

Recorded binary signal	Channel source signal
Trip	TRC94_GenTr_GrI_ (General Trip)
Backup Trip	BRF50_BuTr_GrI_ (Backup Trip)
OutOfStep Trip	DIS21_OutTr_GrI_ (OutOfStep Trip)
PSD Detect	DIS21_PSDDet_GrI_ (PSD Detect)
SOTF Trip	DIS21_SOTFTr_GrI_ (SOTF Trip)
DIS Start L1	DIS21_GenStL1_GrI_ (GenStart L1)
DIS Start L2	DIS21_GenStL2_GrI_ (GenStart L2)
DIS Start L3	DIS21_GenStL3_GrI_ (GenStart L3)
Z1 Start	DIS21_Z1St_GrI_ (Z1 Start)
Z2 Start	DIS21_Z2St_GrI_ (Z2 Start)
Z3 Start	DIS21_Z3St_GrI_ (Z3 Start)
Z4 Start	DIS21_Z4St_GrI_ (Z4 Start)
Z5 Start	DIS21_Z5St_GrI_ (Z5 Start)
Z1 Trip	DIS21_Z1Tr_GrI_ (Z1 Trip)
Z2 Trip	DIS21_Z2Tr_GrI_ (Z2 Trip)
Z3 Trip	DIS21_Z3Tr_GrI_ (Z3 Trip)
Z4 Trip	DIS21_Z4Tr_GrI_ (Z4 Trip)
Z5 Trip	DIS21_Z5Tr_GrI_ (Z5 Trip)
Res Dir OC Start Low	TOC67N_GenSt_GrI_1 (Start)
Res Dir OC Start High	TOC67N_GenSt_GrI_2 (Start)
Undervoltage Start Low	TUV27_GenSt_GrI_1 (General Start)
Unbalance Start	VCB60_GenSt_GrI_ (General Start)
VT Failure	VTS_Fail_GrI_ (VT Failure)
Release Aut	SYN25_RelA_GrI_ (Release Auto)
Syn Command	SYN25_SynSW_GrI_ (Syn Cmd Comm)
REC Blocked	REC79_Blocked_GrI_ (Blocked)
REC Close	REC79_Close_GrI_ (Close command)

Table 164 Disturbance recorder, recorded binary channels

Enumerated parameter

Parameter name	Title	Selection range	Default
Parameter for activation			
DRE_Oper_EPar_	Operation	Off, On	Off

Table 165 *The enumerated parameter of the disturbance recorder function*

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Pre-fault time:						
DRE_PreFault_TPar_	PreFault	msec	100	1000	1	200
Post-fault time:						
DRE_PostFault_TPar_	PostFault	msec	100	1000	1	200
Overall-fault time limit:						
DRE_MaxFault_TPar_	MaxFault	msec	500	10000	1	1000

Table 166 *The timer parameters of the disturbance recorder function*

1.2.5 Event recorder

The events of the device and those of the protection functions are recorded with a time stamp of 1 ms time resolution. This information with indication of the generating function can be checked on the touch-screen of the device in the “Events” page, or using an Internet browser of a connected computer.

Source	Event	Value
Common	Mode of device	N/A,on,blocked,test,test/blocked,off
	Health of device	N/A,Ok,Warning,Alarm
VT Supervision	VT Failure	off,on
Line Differential	Trip L1	off,on
	Trip L2	off,on
	Trip L3	off,on
	Trip	off,on
	CommFail1	off,on
	CommFail2	off,on
5 zone HV Distance	Z1 Start	off,on
	Z1 Trip	off,on
	Z1 FaultLoop	N/A,L1-N,L2-N,L3-N,L1-L2,L2-L3,L3-L1,L1-L2-L3
	Z2 Start	off,on
	Z2 Trip	off,on
	Z2 FaultLoop	N/A,L1-N,L2-N,L3-N,L1-L2,L2-L3,L3-L1,L1-L2-L3
	Z3 Start	off,on
	Z3 Trip	off,on
	Z3 FaultLoop	N/A,L1-N,L2-N,L3-N,L1-L2,L2-L3,L3-L1,L1-L2-L3
	Z4 Start	off,on
	Z4 Trip	off,on
	Z4 FaultLoop	N/A,L1-N,L2-N,L3-N,L1-L2,L2-L3,L3-L1,L1-L2-L3
	Z5 Start	off,on
	Z5 Trip	off,on
	Z5 FaultLoop	N/A,L1-N,L2-N,L3-N,L1-L2,L2-L3,L3-L1,L1-L2-L3
	SOTF condition	off,on
	SOTF Trip	off,on
	Start L1	off,on
	Start L2	off,on
	Start L3	off,on
	Start Neut	off,on
	PSD Detect	off,on
	OutOfStep Trip	off,on
	Fault Loc. km	float
Teleprotection	Receive signal 1	off,on
	Receive signal 2	off,on
	Teleprot. Trip	off,on
	Send signal	off,on
	Carrier Failed	off,on
Weak end Infeed	Receive Echo Signal	off,on
	WEI Trip	off,on
	Send Echo Signal	off,on
3ph DT Overcurr.50EMR1	Start L1	off,on
	Start L2	off,on
	Start L3	off,on
	General Start	off,on
	General Trip	off,on

3ph DT Overcurr.50EMR2	Start L1	off,on
	Start L2	off,on
	Start L3	off,on
	General Start	off,on
	General Trip	off,on
Res Dir Overcurr.GAR1	Start	off,on
	Trip	off,on
Res Dir Overcurr.GAR2	Start	off,on
	Trip	off,on
Current Unbalance	General Start	off,on
	General Trip	off,on
Neg Seq Overcurrent	General Start	off,on
	General Trip	off,on
UnderVoltage	Start L1	off,on
	Start L2	off,on
	Start L3	off,on
	General Start	off,on
	General Trip	off,on
Synchrocheck	Release Auto	off,on
	In progress Auto	off,on
	Close Auto	off,on
	Release Man	off,on
	In progress Man	off,on
	Close Man	off,on
HV AutoReclosing	Blocked	off,on
	Close Command	off,on
	Status	Not Ready,Ready,In progress,Successful
	Actual cycle	Not Running,1.,2.,3.,4.
	Final Trip	off,on
Breaker Failure	Retrip L1	off,on
	Retrip L2	off,on
	Retrip L3	off,on
	Backup Trip	off,on
PhSel. Trip Logic	Trip L1	off,on
	Trip L2	off,on
	Trip L3	off,on
	General Trip	off,on
Circuit Breaker	Status	Intermediate,Off,On,Bad
Disconnector1	Status	Intermediate,Off,On,Bad
Disconnector2	Status	Intermediate,Off,On,Bad
GGIO16	Input01…Input16	off,on

Table 167 List of the possible events

1.2.6 TRIP contact assignment

The outputs of the "phase selective trip logic function" are connected directly to the contacts of the trip module (TRIP+/2101 module in position "O").

Binary status signal	Title	Connected to the contact TRIP+/2101 module in position "O"
TRC94_GenTr_GrI_	General Trip	Trip

Table 168 The connected signals of the phase-selective trip logic function

To the inputs of the "phase-selective trip logic function" some signals are assigned during factory configuration, some signals however depend on the programming by the user**. The conditions are defined by the user applying the graphic equation editor.** The factory defined inputs and the user defined inputs are in "**OR**" relationship.

Input	Binary status signal	Explanation
3Ph Trip	DIS21_SOTFTr_GrI_ OR IOC50_GenTr_GrI_ OR IOC50N_GenTr_GrI_	Trip command of the switch onto fault logic OR Trip command of the instantaneous overcurrent protection function OR Trip command of the residual instantaneous overcurrent protection function
1Ph Trip	DIS21_Z1Tr_GrI_ OR DIS21_Z2Tr_GrI_ OR DIFF87L_GenTr_GrI_	First zone trip command of the distance protection function OR Second zone trip command of the distance protection function OR Trip command of the line differential protection function
Trip L1	DIS21_Z1StL1_GrI_ OR DIS21_Z2StL1_GrI_ OR DIFF87L_TrL1_GrI_	First zone L1 trip command of the distance protection function OR Second zone L1 trip command of the distance protection function OR L1 trip command of the line differential protection function
Trip L2	DIS21_Z1StL2_GrI_ OR DIS21_Z2StL2_GrI_ OR DIFF87L_TrL2_GrI_	First zone L2 trip command of the distance protection function OR Second zone L2 trip command of the distance protection function OR L2 trip command of the line differential protection function
Trip L3	DIS21_Z1StL3_GrI_ OR DIS21_Z2StL3_GrI_ OR DIFF87L_TrL3_GrI_	First zone L3 trip command of the distance protection function OR Second zone L3 trip command of the distance protection function OR L3 trip command of the line differential protection function
Fin3Ph	n.a.	Forcing three-phase trip even in case of single-phase fault

Block	n.a.	Blocking the outputs of the phase-selective trip logic function

Table 169 *The factory defined binary input signals of the trip logic function*

The user defined signals are listed in Table *170*.

Input	Binary status signal	Explanation
1ph Trip	TRC94_Tr1ph_GrO_	Request for single-phase trip command
3ph Trip	TRC94_Tr3ph_GrO_	Request for three-phase trip command
Block	TRC94_Blk_GrO_	Blocking the outputs of the phase-selective trip logic function

Table 170 *The user defined binary input signals of the trip logic function*

1.3 LED assignment

On the front panel of the device there are “User LED”-s with the “Changeable LED description label” (See the document “***Quick start guide to the devices of the EuroProt+ product line***”). Some LED-s are factory assigned, some are free to be defined by the user.

No.	LED title	LED source signal static	LED source signal flashing	Color	Rem.
1	General Trip	TRC94_GenTr_Grl_ (General Trip)		r	1
2	Z1 Trip	DIS21_Z1Tr_Grl_ (Z1 Trip)		r	1
3	Z2 Trip	DIS21_Z2Tr_Grl_ (Z2 Trip)		r	1
4	Z3 Trip	DIS21_Z3Tr_Grl_ (Z3 Trip)		r	1
5	Z4 Trip	DIS21_Z4Tr_Grl_ (Z4 Trip)		r	1
6	Z5 Trip	DIS21_Z5Tr_Grl_ (Z5 Trip)		r	1
7	Dis Start	Dis_Start ()		y	1
8	AR Blocked	REC79_Blocked_Grl_ (Blocked)		r	0
9	EMR OC Trip	OC_Trip (EMR OC Trip)		r	1
10	(LED3110)			r	1
11	Voltage Trip	TUV27_Trip ()		r	1
12	(LED3112)			r	1
13	(LED3113)			r	0
14	AutoReclose	REC79_Close_Grl_ (Close comma...		y	1
15	(LED3115)			r	1
16	(LED3116)			r	1

Table 171 LED assignment

2 External connection