EUROPROT+

E1-Feeder configuration description (Type: DTIVA)

PROTECTA HUNGARY

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User's manual version information

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1.0	30.08.2013	Released formatted version with chapter 2	Csaba Olah

CONTENTS

1 Configuration description

The E1-Feeder 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 E1-Feeder factory configuration.

1.1 Application

The members of the DTIVA product line are configured to protect and control the elements of the medium voltage networks.

1.1.1 Protection functions

The E1-Feeder configuration measures three phase currents and the zero sequence current component. It is intended to protect overhead line or cable networks. The choice of the functions is extended with the automatic reclosing function. The realized current-based protection functions, including thermal replica protection function, are listed in the Table below.

Protection functions	IEC	ANSI	E1-Feeder
Three-phase instantaneous overcurrent protection	I >>>	50	X
Three-phase time overcurrent protection	I >, I >>	51	X
Residual instantaneous overcurrent protection	Io >>>	50N	X
Residual time overcurrent protection	Io >, Io >>	51N	X
Inrush detection and blocking	I_{2h} >	68	X
Negative sequence overcurrent protection	I_2 >	46	X
Thermal protection	T >	49	X
Auto-reclose	0 - > 1	79	X
Current unbalance protection		60	X
Breaker failure protection	CBFP	50BF	X

Table 1 The protection functions of the E1-Feeder configuration

The configured functions are drawn symbolically in the Figure below.

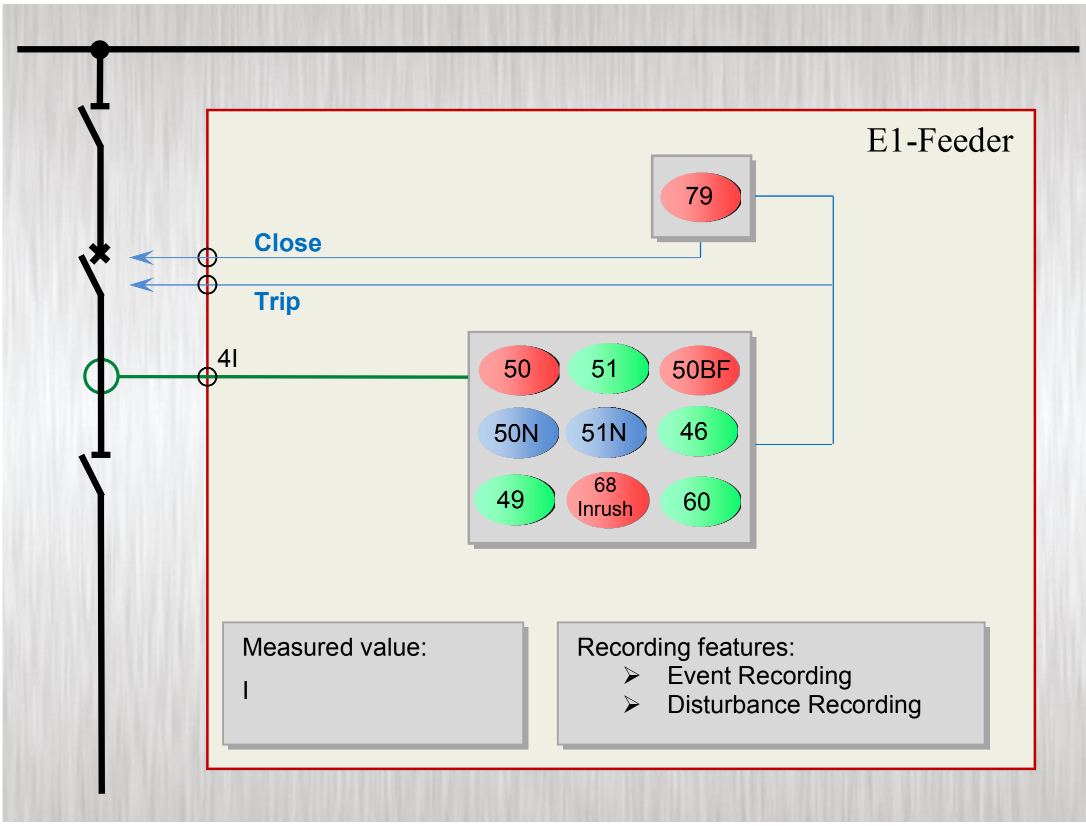


Figure 1 Implemented protection functions

1.1.2 Measurement functions

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

Measurements	E1-Feeder
Current (I1, I2, I3, Io)	X
Circuit breaker wear	X
Supervised trip contacts (TCS)	X

Table 2 The measurement functions of the E1-Feeder configuration

1.1.3 Hardware configuration

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

Hardware configuration	ANSI	E1-Feeder
Mounting		Op.
Panel instrument case		X
Current inputs (4th channel can be sensitive)		4
Voltage inputs		-
Digital inputs		12
Digital outputs		8
Fast trip outputs		4
Temperature monitoring (RTDs) *	38 / 49T	Op.

Table 3 The basic hardware configuration of the E1-Feeder configuration

The basic module arrangement of the E1-Feeder configuration is shown below. (Related to 42TE rack size.)

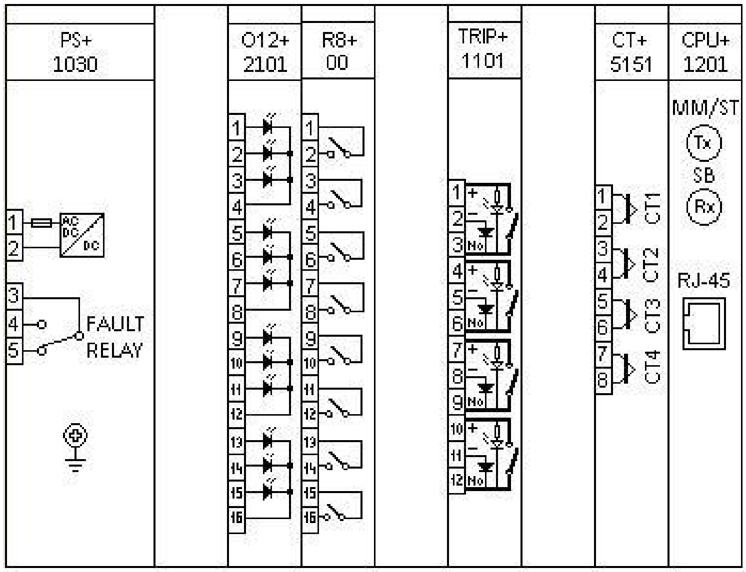


Figure 2 Basic module arrangement of the E1-Feeder configuration (42TE, rear view)

1.1.4 The applied hardware modules

The applied modules are listed in Table 4.

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

Module identifier	Explanation
PS+ 1030	Power supply unit
O12+ 2101	Binary input module
R8+ 00	Signal relay output module
TRIP+ 1101	Trip relay output module
CT + 5151	Analog current input module
CPU+ 1201	Processing and communication module

Table 4 The applied modules of the E1-Feeder configuration

1.2 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 3 The 84 inch rack of ***EuroProt+*** *family*

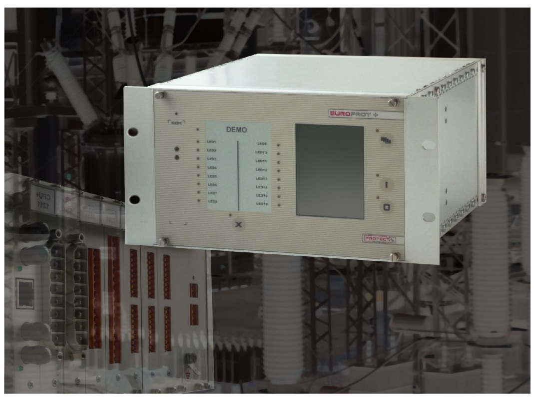


Figure 4 The 42 inch rack of ***EuroProt+*** *family*

Figure 5 The double 42 inch rack of ***EuroProt+*** *family*

1.3 Software configuration

1.3.1 Protection functions

The implemented protection functions are listed in Table 5. 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***
IOC50N	Residual Instant.OC	***Residual instantaneous overcurrent protection function block description***
TOC51N_low TOC51N_high	Residual TOC	***Residual overcurrent protection function block description***
INR68	Inrush	***Inrush detection and blocking protection function block description***
TOC46	Neg. Seq. OC	***Negative sequence overcurrent protection function block description***
TTR49L	Thermal overload	***Line thermal protection function block description***
REC79MV	MV autoreclosing	***Automatic reclosing function for medium voltage networks, function block description***
VCB60	Current Unbalance	***Current unbalance function block description***
BRF50	Breaker failure	***Breaker failure protection function block description***
TRC94	Trip Logic	***Trip logic function block description***
CT4		***Current input function block description***
CB1Pol		***Circuit breaker control function block descrpition***
DisConn		***Disconnector control function block descrpition***

Table 5 Implemented protection functions

1.3.1.1 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 6 Technical data of 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 7 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 8 The integer parameter of the instantaneous overcurrent protection function

1.3.1.2 Three-phase time overcurrent protection function (TOC51 low, high)

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 9 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 10 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 11 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)						
TOC67_Multip_FPar_	Time Multiplier	sec	0.05	999	0.01	1.0

Table 12 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 13 The timer parameters of the time overcurrent protection function

1.3.1.3 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 14 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 15 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 16 The integer parameter of the residual instantaneous overcurrent protection function

1.3.1.4 Residual overcurrent protection function (TOC51N low, high)

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:

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

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:

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

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 *	$20 \le G_S \le 1000$	< 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 17 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 18 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 19 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 20 The float parameter of the residual overcurrent protection function

Timer parameters

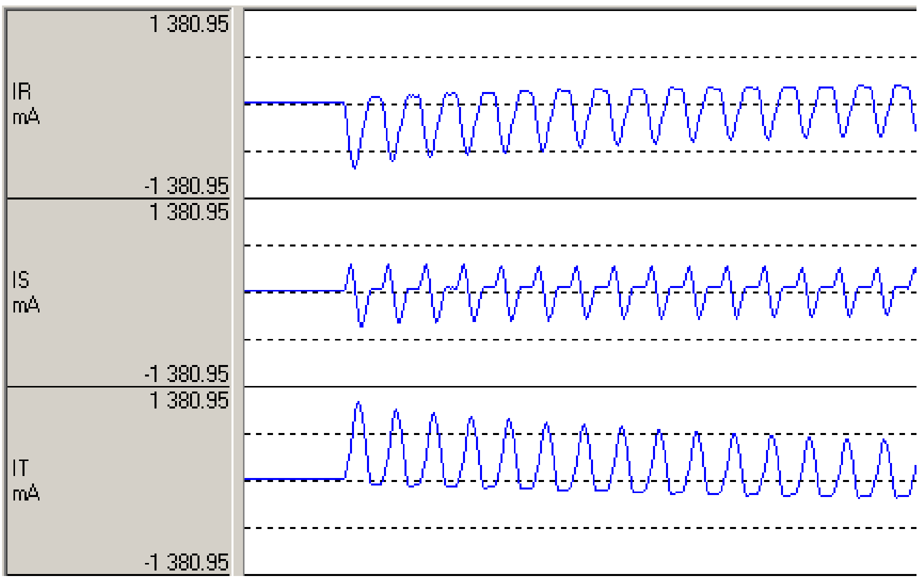
Parameter name	Title	Unit	Min	Max	Step	Default
Minimal time delay for the inverse characteristics:						
TOC51N_MinDel_TPar_	Min Time Delay*	msec	0	60000	1	100
Definite time delay:						
TOC51N_DefDel_TPar_	Definite Time Delay**	msec	0	60000	1	100
Reset time delay for the inverse characteristics:			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

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

Table 21 The timer parameters of the residual overcurrent protection function

1.3.1.5 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 22 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 23 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 24 The integer parameter of the inrush detection function

1.3.1.6 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 25 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	$10 \le G_s$ [%] ≤ 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 26 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 27 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 28 The integer parameter of the negative sequence 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
Time multiplier for the inverse characteristics:						
TOC46_Multip_TPar_	Time Multiplier*	msec	100	60000	1	100

**Valid for inverse type characteristics*

***Valid for definite type characteristics only*

Table 29 *The timer parameter of the negative sequence overcurrent protection function*

1.3.1.7 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):

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

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 30 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 31 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 32 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 33 The boolean parameter of the line thermal protection function

1.3.1.8 Auto-reclose protection (REC79MV)

The MV automatic reclosing function can realize up to four shots of reclosing for medium-voltage networks. The dead time can be set individually for each reclosing and separately for earth faults and for multi-phase faults. All shots are of three phase reclosing.

The starting signal of the cycles can be generated by any combination of the protection functions or external signals of the binary inputs.

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 MV automatic reclosing function generates a close command automatically. If the fault still exits or reappears, then within the "Reclaim time" the protection functions picks up again and the subsequent cycle is started. If the fault still exists at the end of the last cycle, the MV automatic reclosing function trips and generates the signal for final trip. If no pickup is detected within this time, then the MV 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 the binary input “CB Ready“. The preset parameter value “CB Supervision time“ decides how long the MV 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 MV 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.

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 MV automatic reclosing function can control up to four reclosing cycles. Depending on the preset parameter values “EarthFaults Rec,Cycle“ and “PhaseFaults Rec,Cycle“, there are different modes of operation, both for earth faults and for multi-phase faults:

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 MV automatic reclosing function applying the graphic equation editor. The binary status variable to be programmed is “Block”.

Depending on the preset parameter value “Reclosing started by“, the MV 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 MV 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 MV 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 line-to-line faults and for earth faults. The dead time counter of any reclosing cycle is started by the starting signal but starting can be delayed.

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. If no synchronous switching is possible, then the MV automatic reclosing function resets.

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

The MV automatic reclosing function can be blocked by a binary input. The conditions are defined by the user applying the graphic equation editor.

Technical data

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

Table 34 Technical data of the auto-reclosing protection function

Parameters

Enumerated parameters

Parameter name	Title	Selection range	Default
Switching ON/OFF the MV automatic reclosing function			
REC79_Op_EPar_	Operation	Off, On	On
Selection of the number of reclosing sequences in case of earth faults			
REC79_EFCycEn_EPar_	EarthFault RecCycle	Disabled, 1. Enabled, 1.2. Enabled, 1.2.3. Enabled, 1.2.3.4. Enabled	1. Enabled
Selection of the number of reclosing sequences in case of line-to-line faults			
REC79_PhFCycEn_EPar_	PhaseFault RecCycle	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

Table 35 The enumerated parameters of the auto-reclosing protection function

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Dead time setting for the first reclosing cycle for line-to-line fault						
REC79_PhDT1_TPar_	1. Dead Time Ph	msec	0	100000	10	500
Dead time setting for the second reclosing cycle for line-to-line fault						
REC79_PhDT2_TPar_	2. Dead Time Ph	msec	10	100000	10	600
Dead time setting for the third reclosing cycle for line-to-line fault						
REC79_PhDT3_TPar_	3. Dead Time Ph	msec	10	100000	10	700
Dead time setting for the fourth reclosing cycle for line-to-line fault						
REC79_PhDT4_TPar_	4. Dead Time Ph	msec	10	100000	10	800
Dead time setting for the first reclosing cycle for earth fault						
REC79_EFDT1_TPar_	1. Dead Time EF	msec	0	100000	10	1000
Dead time setting for the second reclosing cycle for earth fault						
REC79_ EF DT2_TPar_	2. Dead Time EF	msec	10	100000	10	2000
Dead time setting for the third reclosing cycle for earth fault						
REC79_ EF DT3_TPar_	3. Dead Time EF	msec	10	100000	10	3000
Dead time setting for the fourth reclosing cycle for earth fault						
REC79_ EF DT4_TPar_	4. Dead Time EF	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_	SynCheck 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 36 The timer parameters of the auto-reclosing protection function

Boolean parameters

Parameter name	Title	Default	Explanation
REC79_CBState_BPar_	CB State Monitoring	0	Enable CB state monitoring for “Not Ready” state
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 37 The boolean parameters of the auto-reclosing protection function

1.3.1.9 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 38 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 39 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 40 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 41 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 42 The timer parameter of the current unbalance function

1.3.1.10 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 43 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 44 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 45 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 46 The timer parameters of the breaker failure protection function

1.3.1.11 Trip logic (TRC94)

The simple trip logic function operates according to the functionality required by the IEC 61850 standard for the “Trip logic logical node”. This simplified software module can be applied if only three-phase trip commands are required, that is, phase selectivity is not applied.

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

The trip requirements are programmed by the user, using the graphic equation editor. The aim of the decision logic is

- to define a minimal impulse duration even if the protection functions detect a very short-time fault.
-

Technical data

Function		Accuracy
Impulse time duration	Setting value	<3 ms

Table 47 Technical data of the simple trip logic function

Parameters

Enumerated parameter

Parameter name	Title	Selection range	Default
Selection of the operating mode			
TRC94_Oper_EPar_	Operation	Off, On	On

Tables 48 The enumerated parameter of the decision logic

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

Table 49 Timer parameter of the decision logic

1.3.1.12 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 50 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 51 The integer parameters of the dead line detection function

1.3.1.13 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 52 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 53 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 54 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 55 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 6 shows an example of how the calculated Fourier components are displayed in the on-line block. (See the document “EuroProt+ Remote user interface description”.)

[-] CT4 module

Current Ch - I1	0.84	A
Angle Ch - I1	-9	deg
Current Ch - I2	0.84	A
Angle Ch - I2	-129	deg
Current Ch - I3	0.85	A
Angle Ch - I3	111	deg
Current Ch - I4	0.00	A
Angle Ch - I4	0	deg

Figure 6 Example: On-line displayed values for the current input module

1.3.1.14 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 56 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 57 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 58 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 59 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”.

1.3.1.15 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 60 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 61 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 62 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 63 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

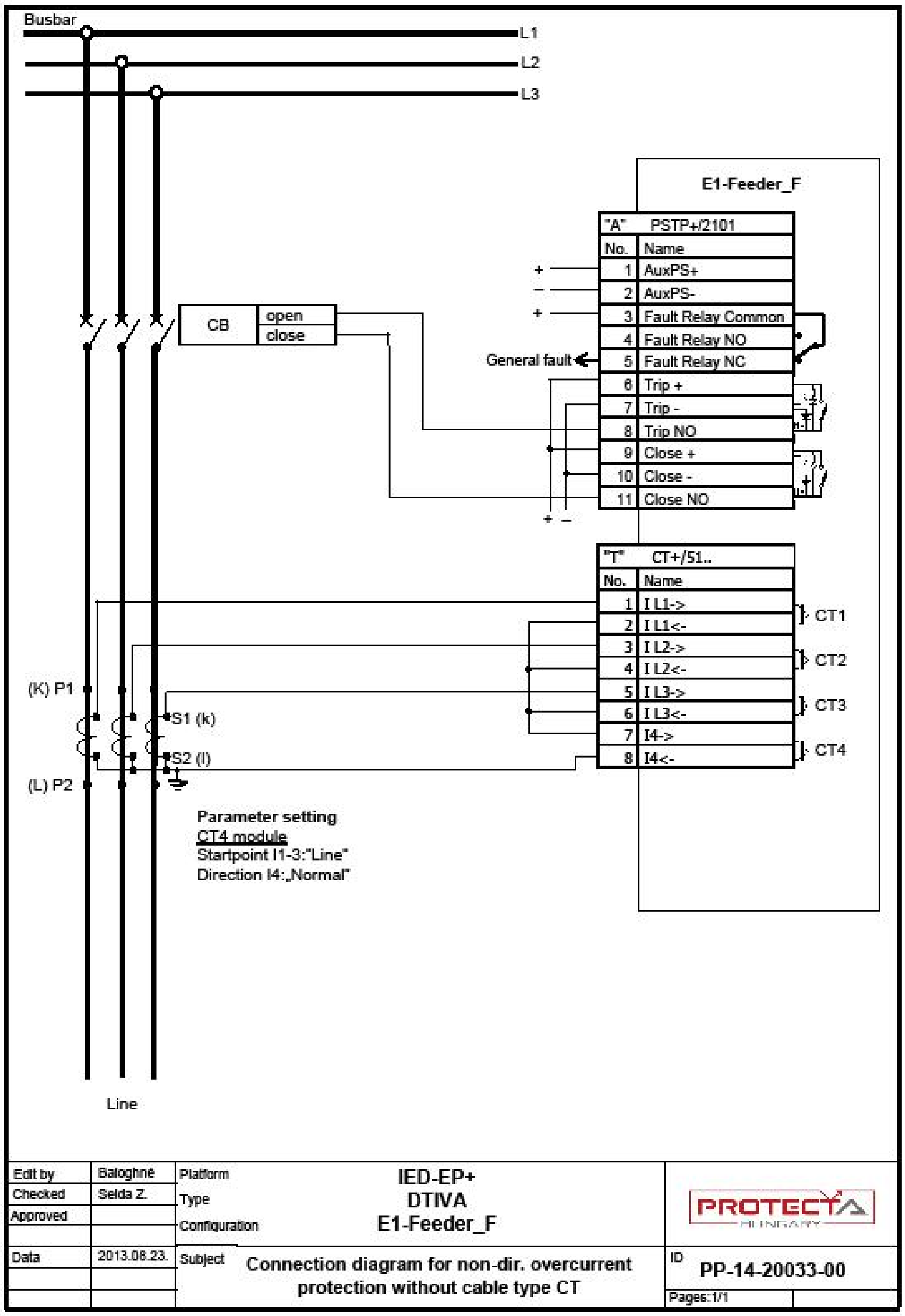
The available control channel to be selected is:

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

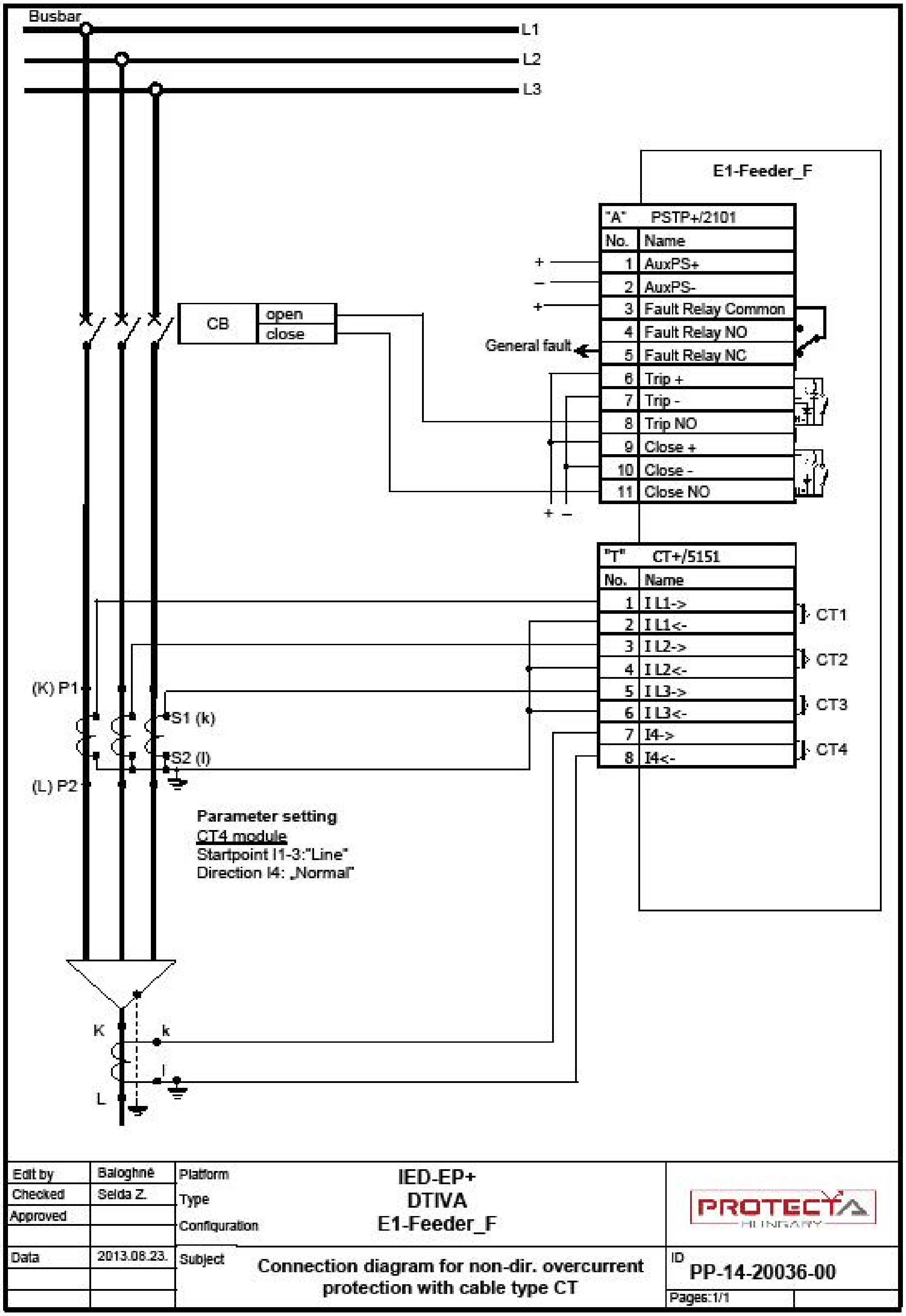
Using this channel, the pushbuttons on the front panel of the device can be assigned to close or open the disconnector. These are the “Local commands”.

2 External Connections

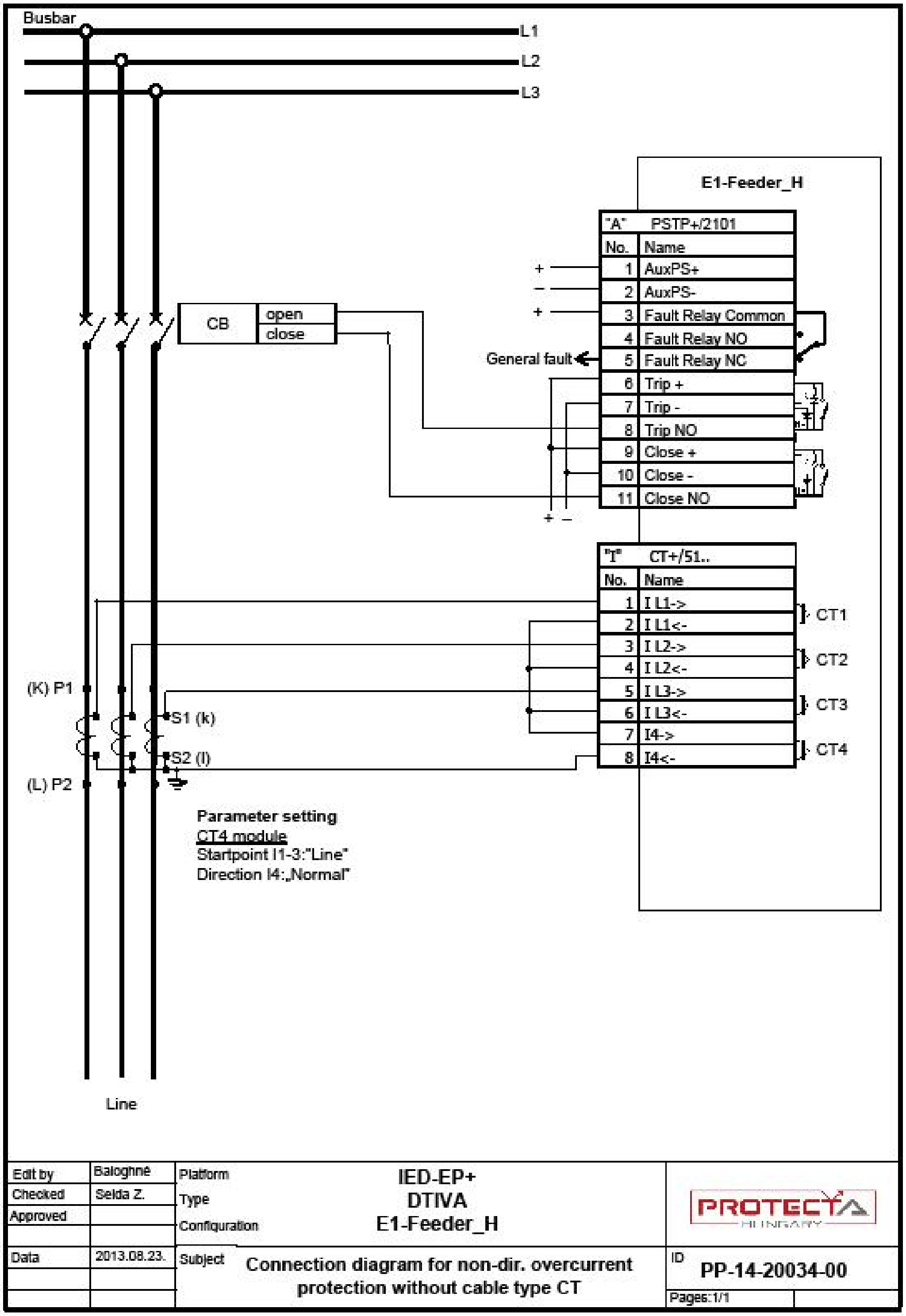
2.1 The 84 inch rack of EuroProt+ without Cable Type



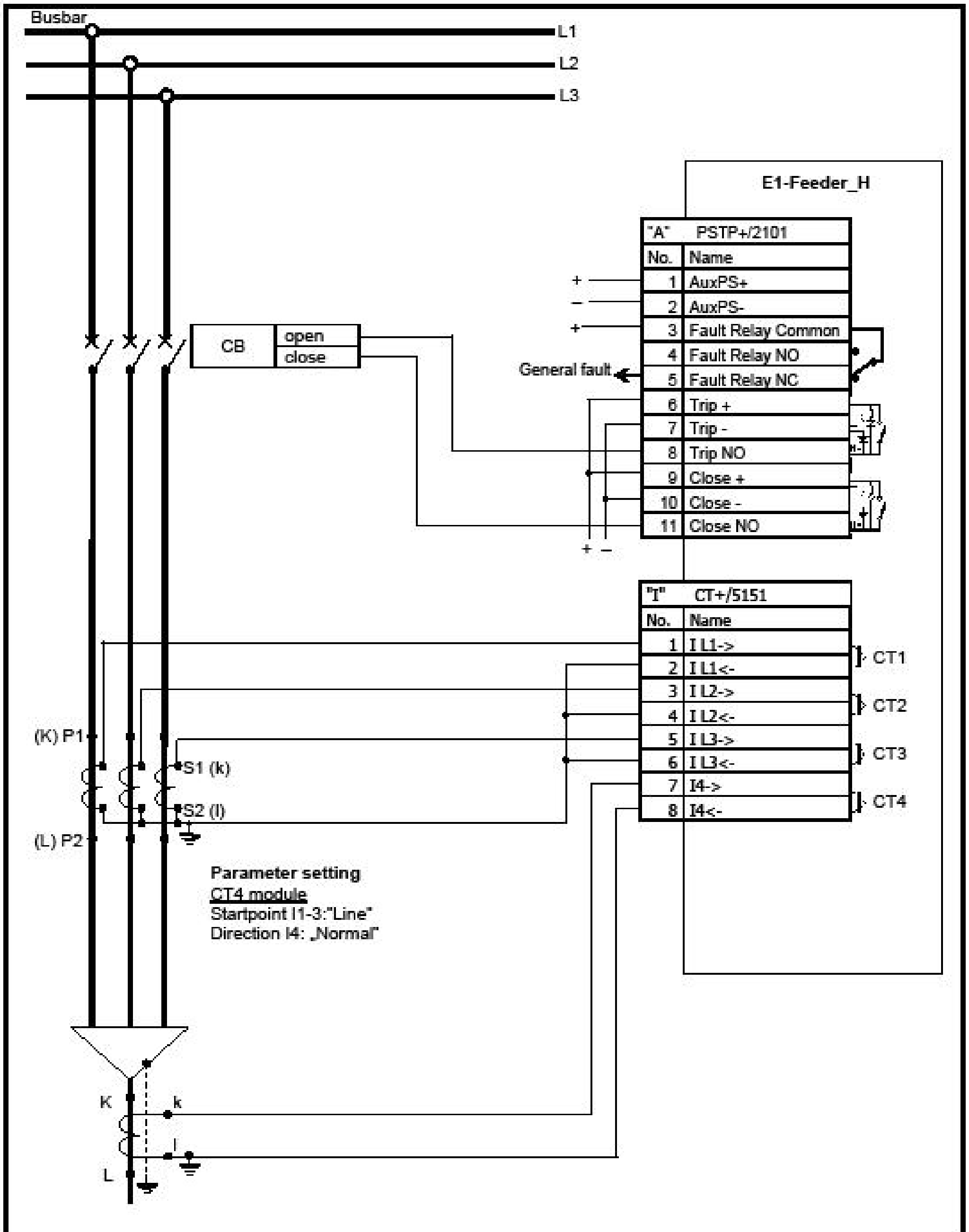
2.2 The 84 inch rack of EuroProt+ with Cable Type



2.3 The 42 inch rack of EuroProt+ without Cable Type



2.4 The 84 inch rack of EuroProt+ with Cable Type



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