E4-DRFP
configuration description
(Type: DTIVA)

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User's manual version information

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1.0	2015-02-06	First edition	Seida
1.1	2016-01-08	2 External connection corrected	Seida
2.0	2021-04-23	**Updated:** 1.3.2.1Railway distance protection function (DIS21R) – supplemented with the information about the option of MHO-characteristics **Added:** 1.3.2.2Wrong phase coupling protection (WPC21)	Seida
2.1	2023-07-07	Clarification about the impedance parameters in chapter 1.3.2, Table 9	Seida

CONTENTS

1 Configuration description

The E4-DRFP (**D**igital **R**ailway **F**eeder **P**rotection) protection device is a member of the ***EuroProt+*** product line, made by Protecta Co. Ltd. The ***EuroProt+*** type devices are complex and modular protections in respect of hardware and software. 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 E4-DRFP 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. The E4-DRFP configuration can be applied for all protection and auxiliary functions for single phase AC traction supply systems.

1.1.1 Protection functions

The devices with E4-DRFP configuration measure the current and the voltage of the railway overhead wire. These measurements allow the Railway distance protection function, which is the main function of this application, extended with Teleprotection and Switch onto fault and Fault locator functions.

The configured protection functions are listed in the Table below.

Protection functions	IEC	ANSI	E4-DRFP
Railway distance protection	Z <	21	X
Wrong phase coupling protection	Z <	21	X
Overcurrent protection	I>	51	X
Thermal overload	T >	49	X
Definite time overvoltage protection	U >	59	X
Definite time undervoltage protection	U <	27	X
Auto-reclose	0 - > 1	79	X
Circuit breaker wear			X
Teleprotection		85	X
Switch onto fault logic			X

Table 1 The protection functions of the E4-DRFP configuration

The configured functions are drawn symbolically in the Figure below.

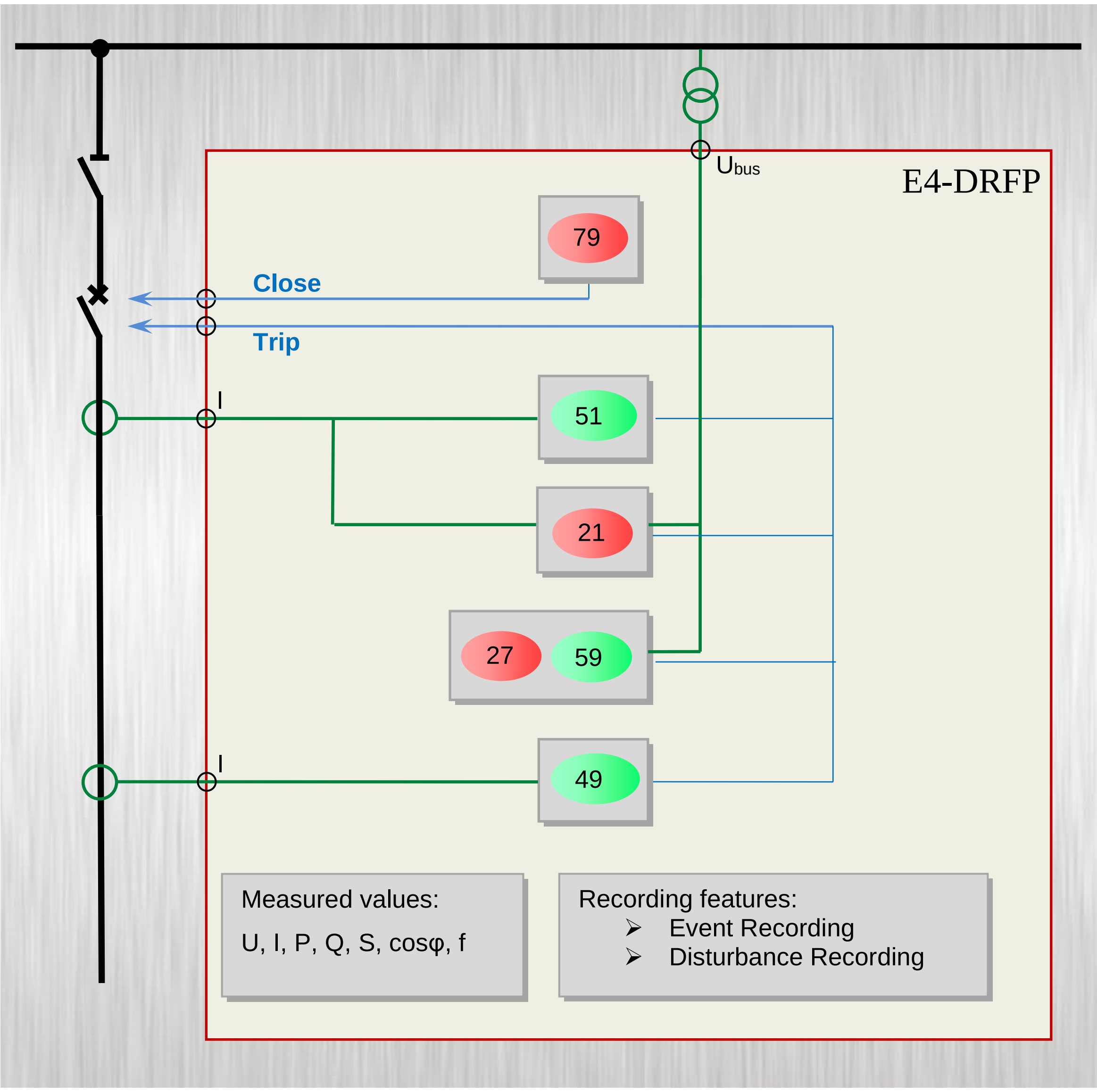


Figure 1 Implemented protection functions

1.1.2 Measurement functions

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

Measurement functions	E4-DRFP
Current (I (CT – Z<, IDMT), I (CT – Th. Ol.))	X
Voltage and frequency	X
Power (P, Q, S, cosφ)	X
Circuit breaker wear	X
Supervised trip contacts (TCS)	X

Table 2 The measurement functions of the E4-DRFP configuration

1.1.3 Hardware configuration

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

Hardware configuration	ANSI	E4-DRFP
Mounting		Op.
Panel instrument case		X
Current inputs (4th channel can be sensitive)		4
Voltage inputs		4
Digital inputs		12
Digital outputs		8
Fast trip outputs		2
Temperature monitoring (RTDs) *	38 / 49T	Op.

Table 3 The basic hardware configuration of the E4-DRFP configuration

The basic module arrangement of the E4-DRFP configuration is shown below.

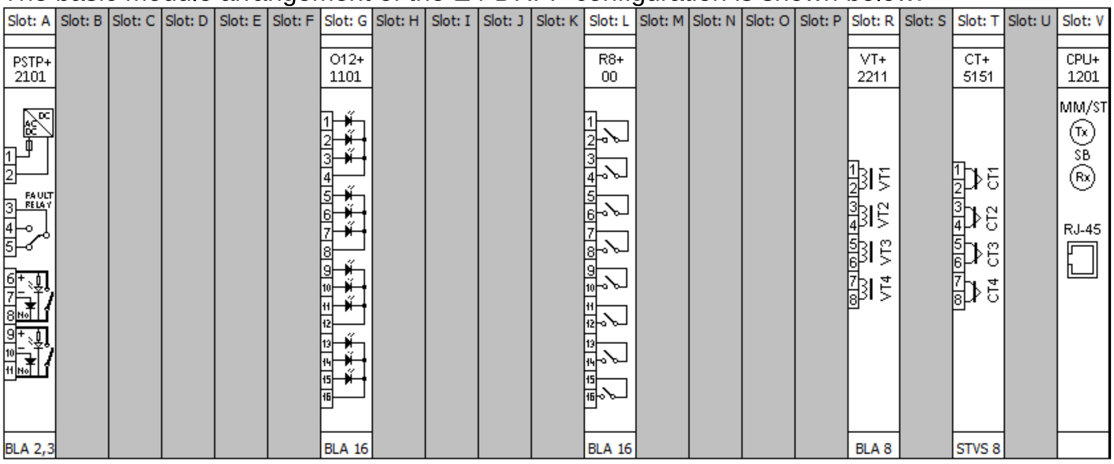


Figure 2 Basic module arrangement of the E4-DRFP configuration (84HP, rear view)

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
PSTP+ 2101	Power supply modul with trip contacts
O12+ 1101	Binary input module
R8+ 00	Signal relay output module
VT+ 2211	Analog voltage input module
CT + 5151	Analog current input module
CPU+ 1201	Processing and communication module

Table 4 The applied modules of the E4-DRFP 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 84HP rack of ***EuroProt+*** *family*

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

1.3 Software configuration

1.3.1 The implemented functions

The implemented 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
DIS21R	Railway distance	***Distance protection for railway application, function block description***
TOC51R	Overcurrent	***Overcurrent protection for railway application, function block description***
TTR49R	Thermal overload	***Line thermal protection function block description for railway application***
TOV59R	Overvoltage	***Definite time overvoltage protection function block description for railway application***
TUV27R	Undervoltage	***Definite time undervoltage protection function block description for railway application***
REC79MV	MV Autoreclosing	***Automatic reclosing function for medium voltage networks, function block description***
CBWear	Circuit breaker wear	***Circuit breaker wear monitoring function block description for railway application***
SCH85	Teleprotection	***Teleprotection function block description***
SOTFCond	Switch onto fault condition	***Switch-onto-fault preparation function block description***
TRC94	Trip logic	***Trip logic function block description***
CT4R	CT4 module	***Current input function block description for railway application***
VT4R	VT4 module	***Voltage input function block description for railway application***
CB1Pol	Circuit breaker	***Circuit breaker control function block descrpition***
MXU_LM	Line measurement	***Line measurement function block descrpition***
DRE	Distirbance rec	***Disturbance recorder function block description***
Reset	Reset	***Reset control function block description***

Table 5 Implemented functions

1.3.2 Protection functions

1.3.2.1 Railway distance protection function (DIS21R)

The distance protection function provides main protection for overhead lines in railway application. The main features of the function are as follows:

- The selected algorithm fits the requirements of the railway overhead line application.
- Continuous measurement of impedance in the loop between the overhead line and the earth.
- Impedance calculation is conditional of the values of the current being sufficient. The current is considered to be sufficient for impedance calculation if it is above the defined value.
- Five independent distance protection zones are configured.
- The operating decision is based on selectable polygon- or MHO-shaped characteristics.
- The directional decision is dynamically based on:
  - measured loop voltage if it is sufficient for decision,
  - voltage samples stored in the memory if they are available,
- The operation of any zones can be directional or non-directional if it is optionally selected.
- Non-directional impedance 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.

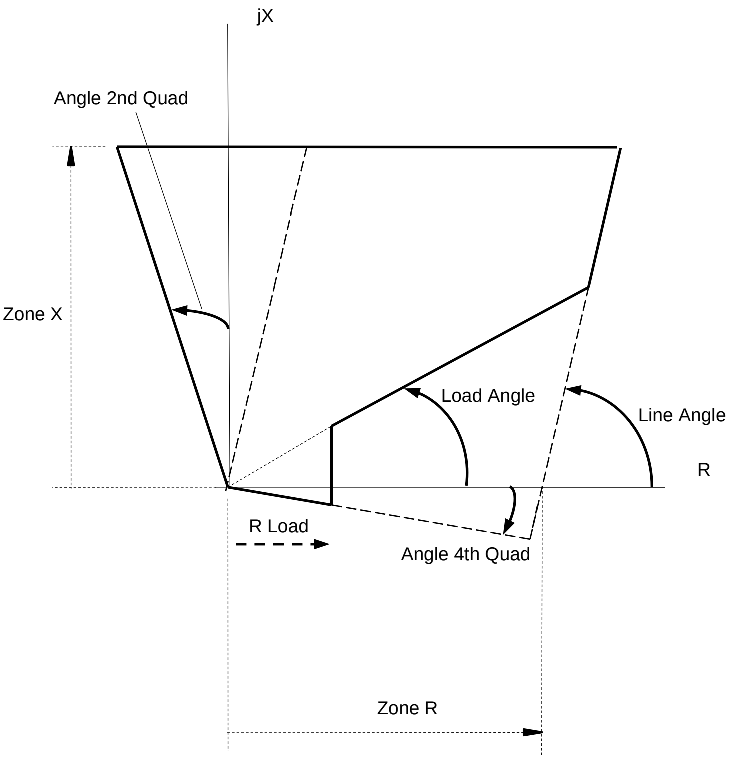
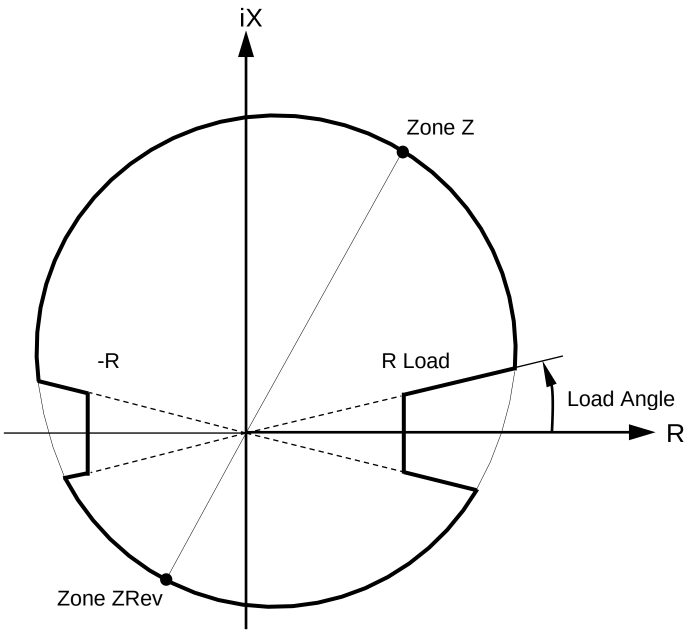


Figure 5 The polygon characteristics of the distance protection function on the complex plane



Note: For Zone 1: Zone 1 ZRev=0

Figure 6 The MHO-characteristics of the distance protection function on the complex plane

Technical data

Function	Value
Number of zones	5
Rated current (In)	1/5A, parameter setting
Rated voltage (Un)	100/200V, parameter setting
Effective range – current	50% – 2000% In
Operating range – current	10% – 5000% In
Effective range – voltage	10% – 130% Un
Operating range – voltage	0% – 130% Un
Effective and operating range – frequency fn = 50 Hz fn = 60 Hz	 49Hz – 51Hz 58.8Hz – 61.2Hz
Impedance effective setting range (secondary values; may differ from the technical setting range of the parameters) Un = 57,74V; In = 1A Un = 57,74V; In = 5A	 0.1 –200Ω 0.1 – 40Ω
Characteristic accuracy ε_X Un = 57,74V In = 1A; fn = 50 Hz Un = 57,74V In = 1A; fn = 60 Hz	 ± 1,6 % ± 1,8 %
Characteristic accuracy ε_R Un = 57,74V In = 1A; fn = 50 Hz Un = 57,74V In = 1A; fn = 60 Hz	 ± 3,6 % ± 2,8 %
Basic directional accuracy	± 0,9°
Operate time (Zone 1)	27ms ± 8ms
Min. operate time	19 ms
Time delay accuracy (t = 30 sec)	± 2,7 ms
Reset time	68 ms
Reset ratio	1.1

Table 6 Technical data of the 5-zone distance protection

Parameters

The parameters of the distance protection function are explained in the following tables.

Enumerated parameters

Parameter name	Title	Selection range	Default
Parameter to select characteristics chape			
DIS21_CharType_EPar_	Characteristics Type	Polygon, MHO	Polygon
Parameter to select the distance zones, involved in the SOTF function:			
DIS21_SOTFMd_EPar_	SOTF Zone	Off, Zone1, Zone2, Zone3, Zone4, Zone5	Off
Parameters to select directionality of the individual zones:			
DIS21_Z1_EPar_	Operation Zone1	Off, Forward, Backward	Off
DIS21_Z2_EPar_	Operation Zone2	Off, Forward, Backward, NonDirectional	Off
DIS21_Z3_EPar_	Operation Zone3	Off, Forward, Backward, NonDirectional	Off
DIS21_Z4_EPar_	Operation Zone4	Off, Forward, Backward, NonDirectional	Off
DIS21_Z5_EPar_	Operation Zone5	Off, Forward, Backward, NonDirectional	Off

Table 7 The enumerated 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_	I Base Sens	%	10	30	1	20
Definition of the polygon characteristic angle in the 2nd quadrant of the impedance plane:						
DIS21_dirRX_IPar_	Angle 2th Quad*	deg	0	30	1	15
Definition of the polygon characteristic angle in the 4th quadrant of the impedance plane:						
DIS21_dirXR_IPar_	Angle 4nd Quad*	deg	0	30	1	15
Definition of the load angle (parameter for the Load encroachment):						
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

*These parameters are available only for the polygon characteristics.

Table 8 The integer parameters of the distance protection function

Floating point parameters

Parameter name	Title	Dim.	Min	Max	Default
R and X **secondary** impedance setting values of the polygon characteristics 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
Secondary impedance setting values of the MHO characteristics for the five zones individually:					
DIS21_Z1X_FPar	Zone1 Z	ohm	0.01	200	10
DIS21_Z2X_FPar	Zone2 Z	ohm	0.01	200	10

DIS21_Z3X_FPar	Zone3 Z	ohm	0.01	200	10
DIS21_Z4X_FPar	Zone4 Z	ohm	0.01	200	10
DIS21_Z5X_FPar	Zone5 Z	ohm	0.01	200	10
DIS21_Z2R_FPar	Zone2 ZRev*	ohm	0.01	200	10
DIS21_Z3R_FPar	Zone3 ZRev*	ohm	0.01	200	10
DIS21_Z4R_FPar	Zone4 ZRev*	ohm	0.01	200	10
DIS21_Z5R_FPar	Zone5 ZRev*	ohm	0.01	200	10
Load encroachment setting (**secondary** value!):					
DIS21_LdR_FPar	R Load	ohm	0.1	200	10
Data of the protected line for displaying the distance to fault (the **secondary** reactance value should be given):					
Line Length	km	0.1	1000	100	
Line Reactance	ohm	0.1	200	10	

* Active only if "Operation Zone 2…5" is set to "Non-directional". Zone 1 cannot be set for non-directional characteristics.

Table 9 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

Table 10 The timer parameters of the distance protection function

1.3.2.2 Wrong phase coupling protection (WPC21)

Railway catenaries are typically fed from three phase distribution networks via traction substations. In order to keep the total load symmetrical in the three-phase network the traction transformers are connected to different phase to phase voltages. Each catenary segment is fed from one traction substation and the power is distributed radially. Between the traction segments coupling breakers might be installed. When one traction transformer is out of service, the affected traction can be fed from the neighboring segment via this breaker.

The picture below shows a typical layout:

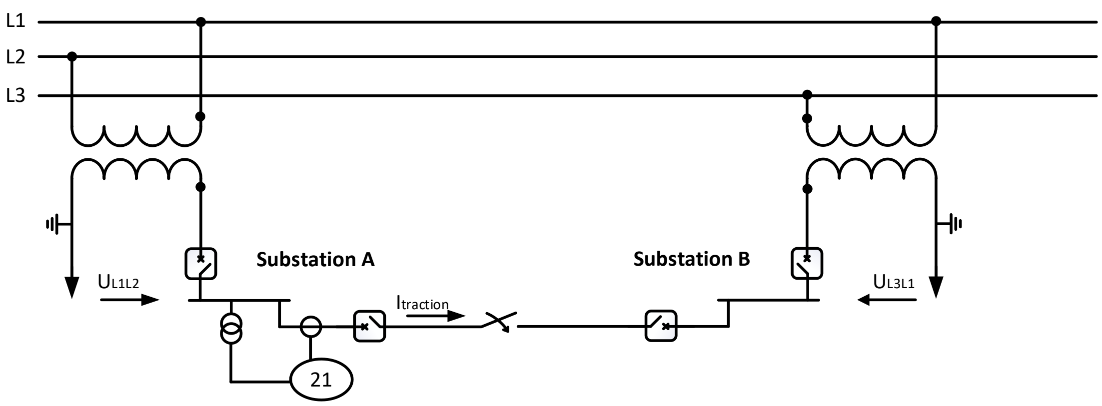


Figure 7 Typical layout of a traction power system

If the coupling breaker is switched on accidentally when both traction transformers are connected to the their own traction segments a short circuit current will flow through the traction due to the asynchronous voltage sources. This situation is known as wrong phase coupling.

In this case the fault current is driven by the voltage difference of the local and remote sources. However, only the local voltage can be measured by the protection relay which distorts the impedance measurement of the distance protection function. If the remote voltage is leading the local source voltage the calculated impedance will be pushed into the second quadrant of the complex impedance plane. This means that only the WPC protection function of the side with the lagging source voltage will operate.

The wrong phase coupling protection is a special distance protection zone where special impedance characteristic (see below) has been implemented in the second quadrant.

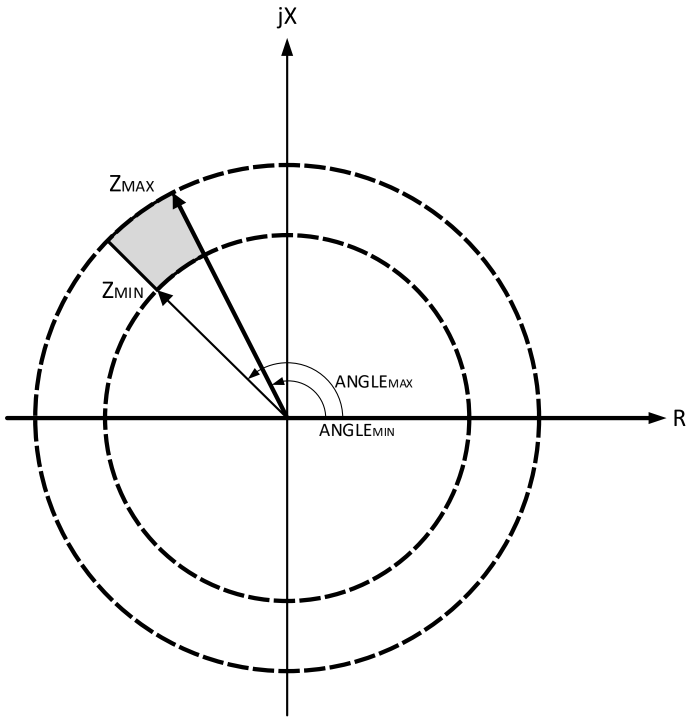


Figure 8 The characteristics of the Wrong phase coupling protection function on the complex plane

Technical data

Function	Value
Number of zones	1
Rated current (In)	1/5A, parameter setting
Rated voltage (Un)	100/200V, parameter setting
Operating range – current	10% – 5000% In
Operating range – voltage	0% – 130% Un
Effective and operating range – frequency fn = 50 Hz fn = 60 Hz	 49Hz – 51Hz 58.8Hz – 61.2Hz
Impedance effective setting range (may differ from the technical setting range of the parameters) Un = 57,74V; In = 1A Un = 57,74V; In = 5A	 0.1 –200Ω 0.1 – 40Ω
Operate time	60ms ± 8ms
Time delay accuracy (t = 30 sec)	± 2,7 ms
Reset ratio	1.1

Table 11 Technical data of the Wrong phase coupling protection

Parameters

TITLE	DIM	RANGE	STEP	DEFAULT	EXPLANATION
Operation	-	Off, On	-	Off	Enabling the function
I Base Sens	%	10 – 30	2	20	Start current of the function
Z Max	ohm	0.10 - 200.00	0.01	20.00	The outer border of the WPC-characteristic on the impedance plane.
Z Min	ohm	0.10 - 200.00	0.01	10.00	The inner border of the WPC-characteristic on the impedance plane.
Angle max	deg	100 - 170	1	145	The minimal angle of the impedance for WPC detection.
Angle min	deg	90 - 135	1	100	The maximal angle of the impedance for WPC detection.
Time Delay	msec	200 – 60000	1	200	Definite time delay of the trip command

1.3.2.3 Teleprotection function (SCH85)

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).

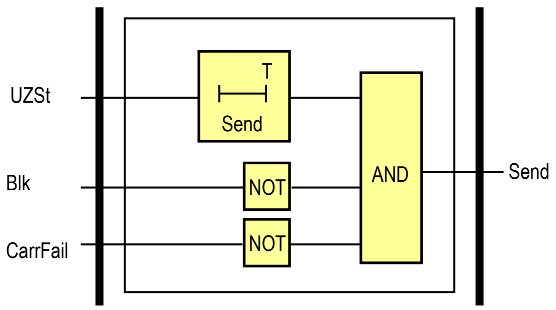
The protection system uses telecommunication, with underreach setting at each section end. The signal is transmitted when a fault is detected by the underreach zone. Receipt of the signal at the other end initiates tripping if other local permissive conditions are also fulfilled, depending on parameter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



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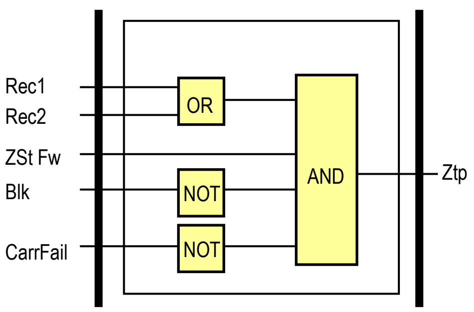

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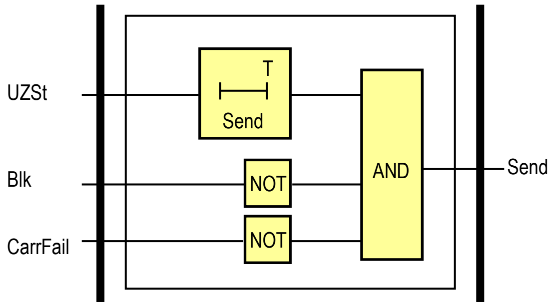
Permissive Underreach Transfer Trip (PUTT) with Overreach

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.



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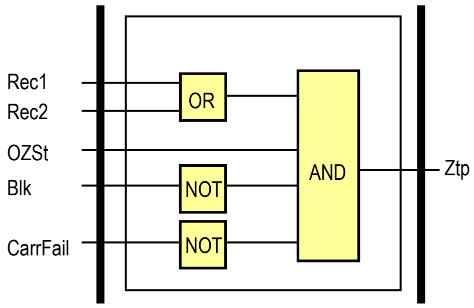

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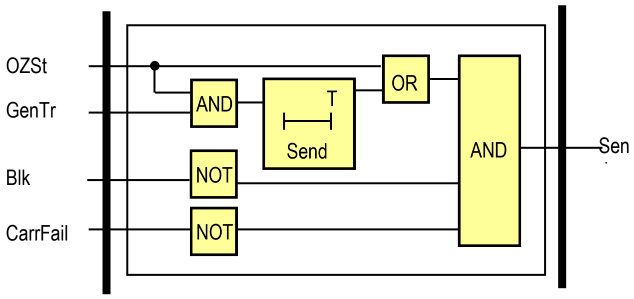
Permissive Overreach Transfer Trip (POTT)

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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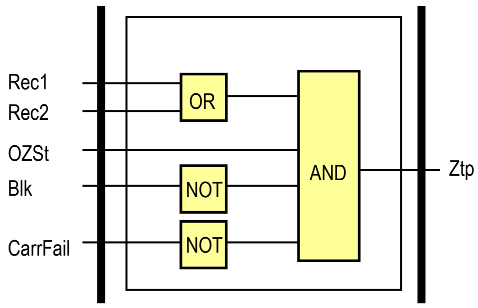

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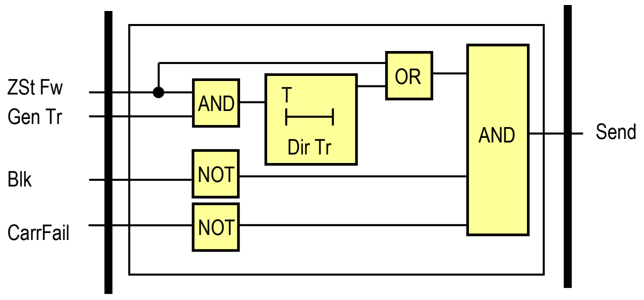
Directional comparison (Dir.Comparison)

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.



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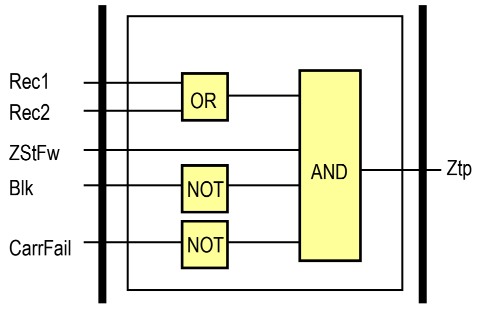

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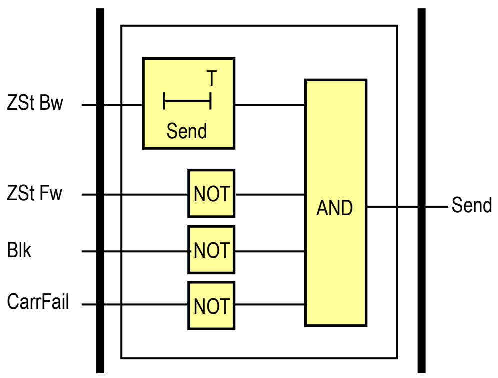
Blocking directional comparison (Dir.Blocking)

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.



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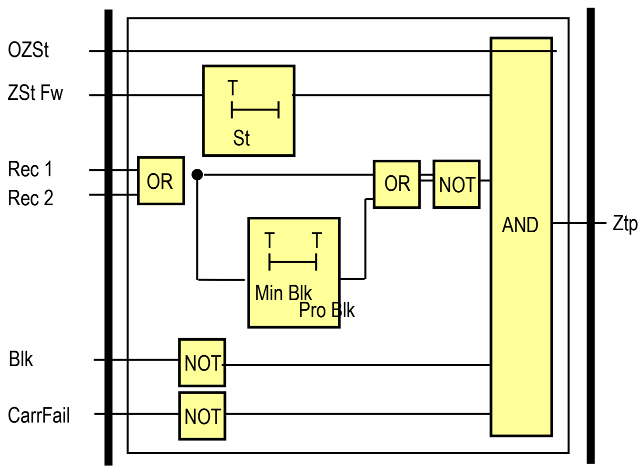

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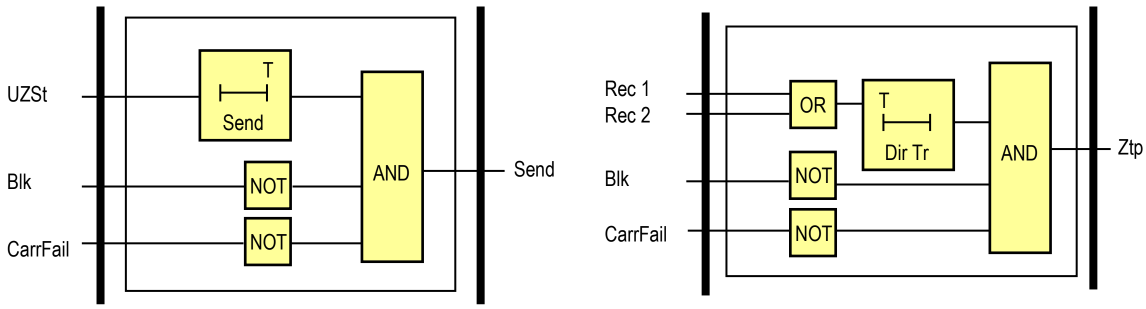
Direct underreaching transfer trip (DUTT)

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.



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Technical data

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

Table 12 Technical data of the Teleprotection function

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

Table 13 Enumerated parameters of the Teleprotection function

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

Table 14 Timer parameters of the Teleprotection function

1.3.2.4 Switch onto fault condition function (SOTFCond)

Some protection functions, e.g. distance protection, directional overcurrent protection, etc. 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-in 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.

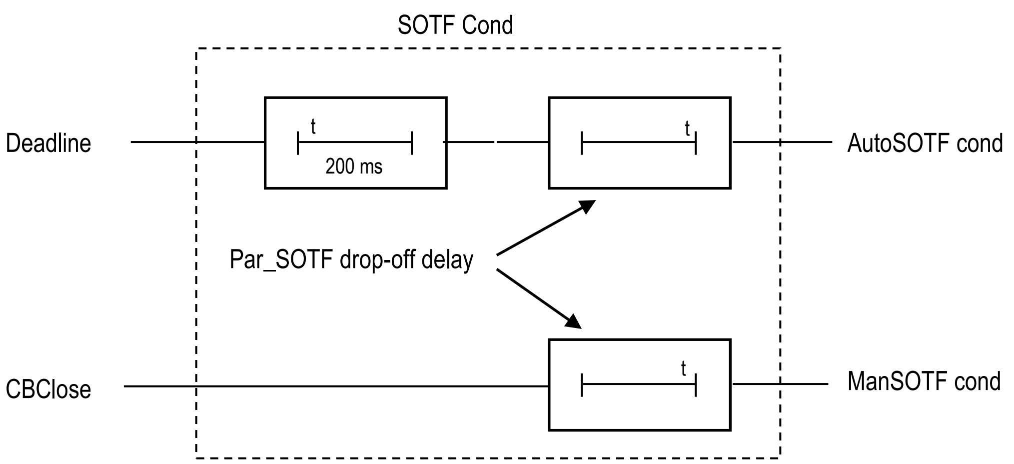
If the protected object is energized, the close command for the circuit breaker is received in “dead” condition. This means that the voltage samples stored in the memory have zero values. In this case the decision on the trip command is based on the programming of the protection function for the “switch-onto-fault”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

This “switch-onto-fault” (SOTF) detection function prepares the conditions for the subsequent decision. The function can handle both automatic and manual close commands.

The function receives the “Dead line” status signal from the DLD (dead line detection) function block. After dead line detection, the binary output signal AutoSOTF 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 this output signal is delayed by a timer (SOTF Drop Delay) set by the user. The automatic close command is not used it is not an input for this function.

The manual close command is a binary input signal. The drop-off of the binary output signal ManSOTF is delayed by a timer (SOTF Drop Delay) set by the user. The timer parameter is common for both the automatic and manual close command.

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



The binary input signals of the “switch-onto-fault” detection function are:

- CBClose Manual close command to the circuit breaker,
- DeadLine Dead line condition detected. This is usually the output signal of the DLD (dead line detection) function block.

The binary output signals of the “switch-onto-fault” detection function are:

- AutoSOTF cond Signal enabling switch-onto-fault detection as a consequence of an automatic close command,
- ManSOTF cond Signal enabling switch-onto-fault detection as a consequence of a manual close command.

Technical data

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

Table 15 Technical data of the Switch onto fault condition function

Parameters

Timer parameter

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

Table 16 The timer parameter of the Switch onto fault function

1.3.2.5 Overcurrent function for railway application (TOC51R)

The overcurrent protection function realizes definite time or inverse time characteristics according to IEC or IEEE standards, based on the current input. The characteristics are harmonized with IEC 60255-151, Edition 1.0, 2009-08. This function can be applied as main protection for railway 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 current (I_Four),
G_S	preset value of the characteristic quantity (TOC51_StCurr_IPar_, 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

Table 17 The constants of the standard dependent time characteristics

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 parameter TOC51_MinDel_TPar_ (Min Time Delay). This delay is valid if it is longer than t(G), defined by the formula above.

The inverse characteristic is valid above G_T =1,1* G_S. Above this value the function is guaranteed to operate.

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 (TOC51_StCurr_IPar_, 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

Table 18 The resetting constants of the standard dependent time characteristics

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 19 Technical data of the overcurrent protection function

Parameters

Enumerated parameter

Parameter name	Title	Selection range	Default
Parameter for type selection			
TOC51R_Oper_EPar_	Operation	Off, Definite Time, IEC Inv, IEC VeryInv, IEC ExtInv, IEC LongInv, ANSI Inv, ANSI ModInv, ANSI VeryInv, ANSI ExtInv, ANSI LongInv, ANSI LongVeryInv, ANSI LongExtInv	Off

Table 20 The enumerated parameters of the overcurrent protection function

Integer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Starting current parameter:						
TOC51R_StCurr_IPar_	Start Current	%	10	1000	1	50

Table 21 The integer parameters of the overcurrent protection function

Float parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Time multiplier of the inverse characteristics (OC module)						
TOC51R_Multip_FPar_	Time Multiplier		0.05	999	0.01	1.0

Table 22 Float parameter of the OC function block

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Minimal time delay for the inverse characteristics:						
TOC51R_MinDel_TPar_	Min Time Delay *	msec	0	60000	1	100
Definite time delay:						
TOC51R_DefDel_TPar_	Definite Time Delay **	msec	0	60000	1	100
Reset time delay for the IEC type inverse characteristics:						
TOC51R_Reset_TPar_	Reset Time*	msec	0	60000	1	100

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

Table 23 Timer parameters of the overcurrent protection function

1.3.2.6 Line thermal protection function for railway application (TTR49R)

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

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 (of the environment). Accordingly, the temperature of the protected object is the sum of the calculated "overtemperature" and the ambient temperature.

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 TTR49R_Amb_IPar_ (Ambient Temperature). The selection between parameter value and direct measurement is made by setting the binary parameter TTR49R_Sens_BPar_ (Temperature sensor). (Special HW input module is required.)

If the calculated temperature (calculated "overtemperature"+ambient temperature) is above the threshold values, status signals are generated:

TTR49R_Alm_IPar_ (Alarm temperature)
TTR49R_Trip_IPar_ (Trip temperature)
TTR49R_Unl_IPar_ (Unlock temperature)

For correct setting, the following values must be measured and set as parameters:

TTR49R_Inom_IPar_	(Rated load current: continuous current applied for the measurement)
TTR49R_Max_IPar_	(Rated temperature: the steady state temperature at rated load current)
TTR49R_Ref_IPar_	(Base Temperature: the temperature of the environment during the measurement of the rated values)
TTR49R_pT_IPar_	(time constant: 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:

TTR49R_Str_IPar_	(Startup Temp.: Initial temperature above the temperature of the environment as compared to the rated temperature above the base temperature)

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 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:

$$\frac{d\Theta}{dt} = \frac{1}{T}\left(\frac{I^2(t)R}{hA} - \Theta\right) \qquad (1)$$

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.)

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

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 that 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 (2) is:

$$H(t) = \frac{\Theta(t)}{\Theta_n} = \frac{I^2}{I_n^2}\left(1 - e^{-\frac{t}{T}}\right) + \frac{\Theta_o}{\Theta_n} e^{-\frac{t}{T}} \qquad (3)$$

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_0 is the starting temperature above the temperature of the environment
- 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.

The RMS calculation module calculates the RMS values of the current. 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 function; it belongs to the preparatory phase.
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.

Binary output status signals

The binary output status signals are listed in Table *24* blow.

Binary output signals	Signal title	Explanation
TTR49R_Alm_GrI_	Alarm	Alarm signal of the line thermal protection function
TTR49R_GenTr_GrI_	General Trip	General trip signal of the line thermal protection function
TTR49R_Lock_GrI_	Reclose locked	Line reclose blocking signal of the line thermal protection function

Table 24 The binary output status signals of the line thermal protection function

Binary input status signals

The line thermal protection function has two binary input status signals. One of them serves to disable the function; the other one resets the accumulated heat. Resetting serves test purposes only, if the heating calculation needs to start at a clearly defined temperature. Using this signal, the testing engineer need not wait until the cooling reaches the required starting temperature of the subsequent heating test.

Both binary input status signals are defined by the user, applying the graphic equation editor.

The binary input status signals of the line thermal protection function are shown in Table *25* blow.

Binary input status signals	Title	Explanation
TTR49R_Blk_GrO_	Block	Output status of a graphic equation defined by the user to disable the line thermal protection function.
TTR49R_Reset_GrO_	Reset	Output status of a graphic equation defined by the user to reset the accumulated heat and set the temperature to the defined value for the subsequent heating test procedure.

Table 25 The binary input signals of the line thermal protection function

On-line measured value

On-line measured value	Explanation
TTR49R_Temp_OLM_	The calculated temperature.

Table 26 The on-line measured value of the line thermal protection function

Technical data

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

Table 27 Technical data of the line thermal protection function

Parameters

Enumerated parameter

Parameter name	Title	Selection range	Default
Parameter for mode of operation			
TTR49R_Oper_EPar_	Operation	Off, Pulsed, Locked	Off

Table 28 The enumerated parameters 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						
TTR49R_Alm_IPar_	Alarm Temperature	deg	60	200	1	80
Trip Temperature						
TTR49R_Trip_IPar_	Trip Temperature	deg	60	200	1	100
Rated Temperature						
TTR49R_Max_IPar_	Rated Temperature	deg	60	200	1	100
Base Temperature						
TTR49R_Ref_IPar_	Base Temperature	deg	0	40	1	25
Unlock Temperature						
TTR49R_Unl_IPar_	Unlock Temperature	deg	20	200	1	60
Ambient Temperature						
TTR49R_Amb_IPar_	Ambient Temperature	deg	0	40	1	25
Startup Term.						
TTR49R_Str_IPar	Startup Term	%	0	60	1	0
Rated Load Current						
TTR49R_Inom_IPar_	Rated Load Current	%	20	150	1	100
Time constant						
TTR49R_pT_IPar_	Time Constant	min	1	999	1	10

Table 29 The integer parameters of the line thermal protection function

Boolean parameter

Boolean parameter	Signal title	Selection range	Default
Parameter for ambient temperature sensor application (Special HW input module is required)			
TTR49L_Sens_BPar_	Temperature Sensor	No, Yes	No

Table *30 The Boolean parameter of the line thermal protection function*

1.3.2.7 Definite time overvoltage function for railway application (TOV59R)

The definite time overvoltage protection function measures a voltage. If it is above the level defined by parameter setting, then a start signal is generated.

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

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

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
Drop-off ratio		± 0.5 %
Minimum operate time	50 ms	

Table 31 Technical data of the overvoltage protection function

Parameters

Enumerated parameters

Parameter name	Title	Selection range	Default
Enabling or disabling the overvoltage protection function			
TOV59R_Oper_EPar_	Operation	Off, On	Off

Table 32 The enumerated parameters of the overvoltage protection function

Integer parameters

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.						
TOV59R_StVol_IPar_	Start Voltage	%	30	130	1	110

Table 33 Integer parameters of the overvoltage protection function

Boolean parameter

Parameter name	Title	Default	Explanation
TOV59R_StOnly_BPar_	Start Signal Only	0	Selection if starting and trip signal or starting signal only is to be generated. Set 0 for trip command generation.

Table 34 The Boolean parameter of the overvoltage protection function

Timer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Time delay of the overvoltage protection function.						
TOV59R_Delay_TPar_	Time Delay	ms	0	60000	1	100

Table 35 The timer parameter of the overvoltage protection function

Parameter name	Title	Default	Explanation
TOV59R_StOnly_BPar_	Start Signal Only	0	Selection if starting and trip signal or starting signal only is to be generated. Set 0 for trip command generation.

Table 36 The Boolean parameter of the definite time overvoltage protection function

The **binary output status signals** of the definite time overvoltage protection function are listed in *Table* 37 below.

Binary output signals	Signal title	Explanation
TOV59R_GenSt_GrI	General Start	Starting of the function
TOV59R_GenTr_GrI_	General Trip	Trip command of the function

Table 37 *The binary output status signals of the definite time overvoltage protection function*

1.3.2.8 Definite time undervoltage function for railway application (TUV27R)

The undervoltage protection function measures a voltage. If it is below the level defined by parameter setting value (and above the defined minimum level), then a start signal is generated.

The function generates a start signal. The general start signal is set if the voltage is below the preset parameter setting value (and above the defined minimum level).

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

The **binary output status signals** of the definite time undervoltage protection function are listed in *Table* 38.

Binary output signals	Signal title	Explanation
TUV27R_GenSt_GrI	General Start	Starting of the function
TUV27R_GenTr_GrI_	General Trip	Trip command of the function

Table 38 *The binary output status signals of the definite time undervoltage protection function*

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 39 *Technical data of the undervoltage protection function*

Parameters

Enumerated parameters

Parameter name	Title	Selection range	Default
Enabling or disabling the undervoltage protection function			
TUV27R_Oper_EPar_	Operation	Off, On	Off

Table 40 *The enumerated parameters of the undervoltage protection function*

Integer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Starting voltage level setting. If the measured voltage is below the setting value, the function generates a start signal.						
TUV27R_StVol_IPar_	Start Voltage	%	30	100	1	80
Blocking voltage level setting. If the measured voltage is below the setting value, the function blocks the start signal.						
TUV27R_BlkVol_IPar_	Block Voltage	%	0	20	1	10

Table 41 *Integer parameters of the undervoltage protection function*

Boolean parameter

Parameter name	Title	Default	Explanation
TUV27R_StOnly_BPar_	Start Signal Only	0	Selection if starting and trip signal or starting signal only is to be generated. Set 0 for trip command generation.

Table 42 The Boolean parameters of the undervoltage protection function

Timer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Time delay of the undervoltage protection function.						
TUV27R_Delay_TPar_	Time Delay	ms	0	60000	1	100

Table 43 Timer parameters of the undervoltage protection function

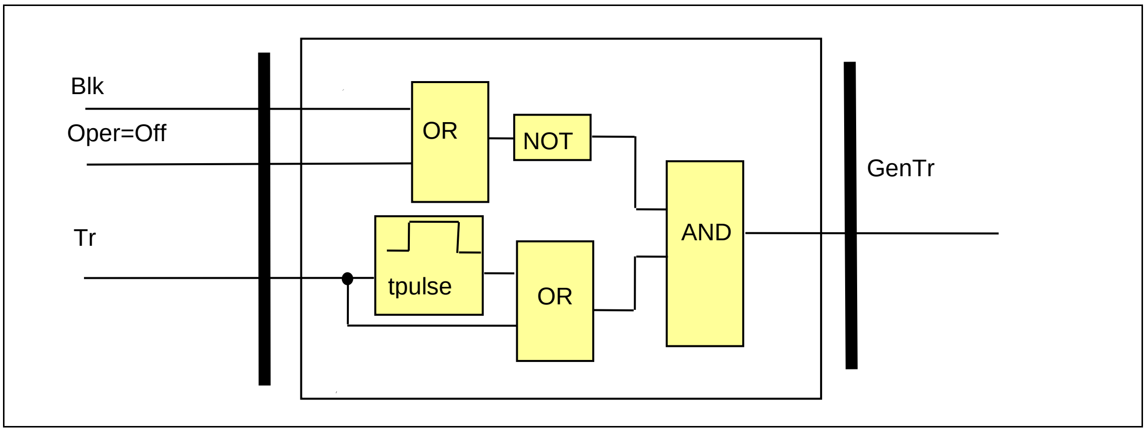
1.3.2.9 Trip logic function block (TRC94)

The simplified 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.

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



The logic scheme of the decision logic

Technical data

Function		Accuracy
Impulse time duration	Setting value	<3 ms

Table 44 Technical data of the Trip logic function

Parameters

Enumerated parameters

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

Table 45 Enumerated parameters of the Trip logic function

Timer parameters

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 46 Timer parameters of the Trip logic function

1.3.2.10 Automatic reclosing function for medium voltage networks (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 47 Technical data of the Automatic reclosing 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 48 Enumerated parameters of the Automatic reclosing 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 (See detailed description - Table 5)						
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 49 Timer parameters of the Automatic reclosing 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 50 Boolean parameters of the Automatic reclosing function

1.3.2.11 Circuit breaker wear function (CBWear)

If a circuit breaker interrupts a current, the electric arc between the contacts results some metal loss. If the metal loss due to the burning of the electric arc becomes substantial, the contacts must be replaced.

Manufacturers define the permitted number of short circuits by formulas such as:

$$\Sigma\, n * I^{k} = \text{CycNum}$$

where

n = number of short circuits
k = exponent
I = short-circuit current, kA (RMS)
CycNum = total value of weighted breaking currents.

Similar information is conveyed by the diagram below. This shows the number of permitted interruptions (logarithmic scaling) versus short-circuit current (logarithmic scaling) that the contacts in a circuit breaker can manage before the metal loss due to burning becomes so significant that the contacts must be replaced.

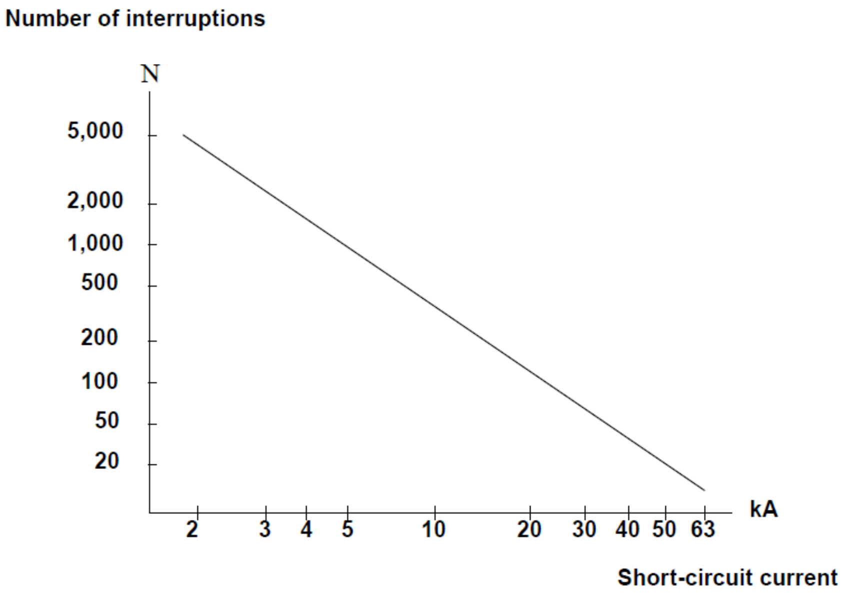


Figure 9 Example: Number of permitted interruptions as the function of the interrupted current

The straight line of the curve is defined by two points:

- The number of permitted interruptions of 1 kA current (CycNum - 1kA)
- The number of permitted interruptions of the rated breaking current of the circuit breaker (CycNum – I Rated Trip).

The circuit breaker wear monitoring function finds the maximum value of the current of each interruption and calculates the wear caused by the operation performed. If the sum of the calculated wear reaches the limit, a warning signal is generated. This indicates the time of the required preventive maintenance of the circuit breaker.

The procedure of monitoring starts at the receipt of a trip command on the dedicated input (Trip). For the start of this procedure, the circuit breaker also needs to be in closed state. This signal is received on the dedicated binary input (CB Closed).

The procedure of identifying the maximum current value terminates when the current falls below the minimum current defined by the parameter CBWear_Imin_FPar_ (Min Current) AND the circuit breaker gets in open position. This signal is received on the dedicated binary input (CB Open).

The procedure also stops if the time elapsed since its start exceeds 1 s. In this case no CB wear is calculated.

Based on the characteristic defined above, the function calculates the wear caused by the operation performed. If the sum of the calculated wear reaches the limit defined by the parameter CBWear_CycNumAlm_IPar_ (CycNum - Alarm), a warning signal is generated (Alarm). This indicates the advised time of the preventive maintenance of the circuit breaker.

The accumulated “wear” of the circuit breaker is stored on non-volatile memory; therefore, the value is not lost even if the power supply of the devices is switched off.

This information is displayed among the on-line data as “Actual wear”. This counter indicates how many 1 kA equivalent switches were performed since the last maintenance (reset).

When preventive maintenance is performed, the accumulated “wear” of the circuit breaker must be reset to 0 to start a new maintenance cycle. The circuit breaker wear monitoring function offers two ways of resetting:

- Binary True signal programmed to the “Reset” input of the function
- Performing a direct command via the Commands menu of the supervising WEB browser (for details, see the “Europrot+ manual”, “Remote user interface description” document).

The **inputs** of the circuit breaker wear monitoring function are

- the Fourier components of the current,
- binary inputs,
- parameters.

The **output** of the circuit breaker wear monitoring function is

- the Alarm binary output status signal.

Technical data

Function	Range	Accuracy
Current accuracy	20 – 2000% of In	±1% of In
Accuracy in tracking the theoretical wear characteristics		5%

Table 51 Technical data of the circuit breaker wear monitoring

Parameters

The parameters of the circuit breaker wear monitoring function are explained in the following tables.

Enumerated parameter

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

Table 52 The enumerated parameter of the circuit breaker wear monitoring function

Integer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Permitted number of trip operation if the breaking current is 1kA						
CBWear_CycNumIn_IPar_	CycNum - 1kA		1	100000	1	50000
Permitted number of trip operation if the breaking current is InTrip (See floating parameter "Rated Trip Current")						
CBWear_CycNumInTrip_IPar_	CycNum – I Rated Trip		1	100000	1	100
Permitted level of the weighted sum of the breaking currents						
CBWear_CycNumAlm_IPar_	CycNum - Alarm		1	100000	1	50000

Table 53 *The integer parameters of the circuit breaker wear monitoring function*

Floating point parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Rated current of the circuit breaker						
CBWear_InCB_FPar_	In CB	kA	1	50	0.01	1
Rated breaking current of the circuit breaker						
CBWear_InTrCB_FPar_	Rated Trip Current	kA	10	100	0.01	10
Minimum level of the current below which the procedure to find the highest breaking current is stopped						
CBWear_Imin_FPar_	Min Current	kA	0.10	0.50	0.01	0.10

Table 54 *The floating-point parameters of the circuit breaker wear monitoring function*

1.3.3 Control functions

1.3.3.1 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 55 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 56 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 57 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 58 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”.

1.3.4 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.

Source	**On-line measurand**	**Unit**	**Decimal digits**
VT4 module	Voltage	V	-2
	Angle - U	deg	0
CT4 module	Current (CT - Z<, IDMT)	A	-2
	Angle - I (CT - Z<, IDMT)*	deg	0
	Current (CT - Th.Ol)	A	-2
	Angle - I (CT - Th.Ol)*	deg	0
Railway Distance	Fault location	km	-1
	Fault react.	ohm	-2
	Loop R	ohm	-3
	Loop X	ohm	-3
Thermal Overload	Calc Temperature	o	0
Line measurement	Active Power - P	kW	-2
	Reactive Power - Q	kVAr	-2
	Apparent Power - S	kVA	-2
	Power factor		-2
	Current (CT - Z<, IDMT)	A	0
	Current (CT - Th.Ol)	A	0
	Voltage	kV	-1
	Frequency	Hz	-2

**The reference angle is the phase angle of “Voltage”*

Table 59 Measured analog values

1.3.4.1 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.) For railway applications all four channels are independent. Consequently all four current inputs need 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 calculated Fourier basic component values for on-line displaying.

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_Ch_x_Nom_EPar_ (Rated Secondary I_x_) where _x_=1…4. 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_Ch_x_Dir_EPar_ (Starpoint I_x_) where _x_=1…4. 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 ±1digit	20 – 2000% of In *	±1% of In

** CT 5151, 5102*

Table 60 Technical data of the current input function

Parameters

The parameters of the current input function are explained in the following tables.

Enumerated parameters

Parameter name	Title	Selection range	Default
Rated secondary current of the input channels. 1A or 5A is selected by parameter setting, no hardware modification is needed.			
CT4_Ch1Nom_EPar_	Rated Secondary I1	1A,5A	1A
CT4_Ch2Nom_EPar_	Rated Secondary I2	1A,5A	1A
CT4_Ch3Nom_EPar_	Rated Secondary I3	1A,5A	1A
CT4_Ch4Nom_EPar_	Rated Secondary I4	1A,5A	1A
Definition of the positive direction of the currents, given as normal or inverted			
CT4_Ch1Dir_EPar_	Direction I1	Normal,Inverted	Normal
CT4_Ch24Dir_EPar_	Direction I2	Normal,Inverted	Normal
CT4_Ch3Dir_EPar_	Direction I3	Normal,Inverted	Normal
CT4_Ch4Dir_EPar_	Direction I4	Normal,Inverted	Normal

Table 61 The enumerated parameters of the current input function

Floating point parameters

Parameter name	Title	Dim.	Min	Max	Default
Rated primary current of channels					
CT4_PriI1_FPar_	Rated Primary I1	A	100	4000	1000
CT4_PriI2_FPar_	Rated Primary I2	A	100	4000	1000
CT4_PriI3_FPar_	Rated Primary I3	A	100	4000	1000
CT4_PriI4_FPar_	Rated Primary I4	A	100	4000	1000

Table 62 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.

On-line measurements

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 I1
Angle Ch – I1	degree	Vector position of the current in channel I1
Current Ch – I2	A(secondary)	Fourier basic component of the current in channel I2
Angle Ch – I2	degree	Vector position of the current in channel I2
Current Ch – I3	A(secondary)	Fourier basic component of the current in channel I3
Angle Ch – I3	degree	Vector position of the current in channel I3
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 63 The measured analogue values of the current input function

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. (The first input module is the one, usually configured closer to the CPU 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”.)

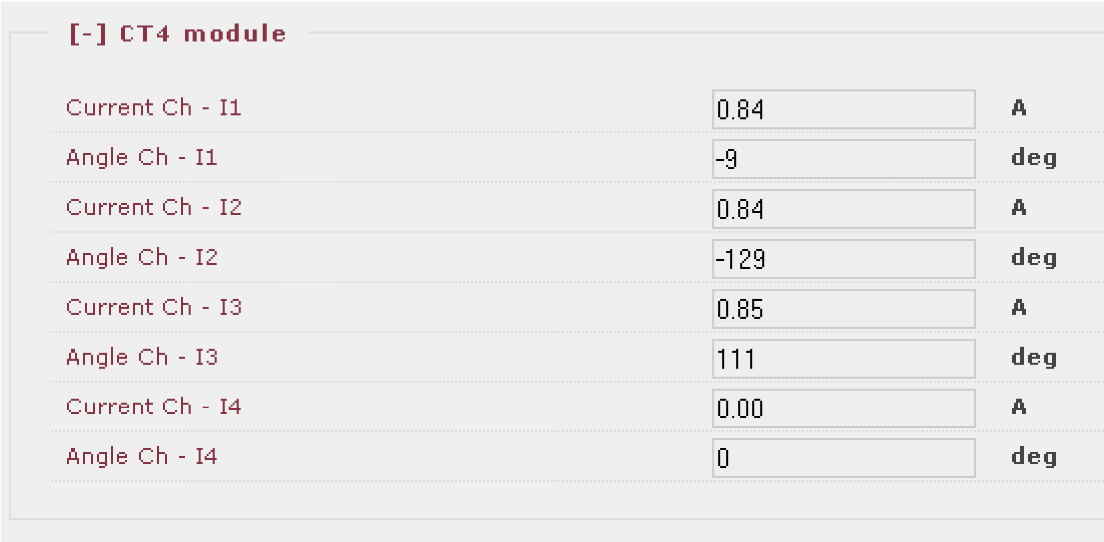


Figure 10 *Example: On-line displayed values for the current input module*

1.3.4.2 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.) 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 calculated basic Fourier component values for on-line displaying.

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, no hardware modification is needed. 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 VT secondary windings must be set to reflect actual physical connection of the main VTs. The associated parameter is VT4_Ch_x_Nom_EPar_ where _x_= 1…4 (Connection U_x_ where _x_= 1…4). The selection can be: Ph-N or Ph-Ph.

The Ph-N option is applied in 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.

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.

If needed, the phase voltages can be inverted by setting the parameter VT4_Ch_x_. Dir_EPar_ where _x_= 1…4 (Direction U_x_ where _x_= 1…4). This selection applies to each of the channels. This inversion may be needed in protection functions such as distance 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 modified 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.

Technical data

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

Table 64 Technical data of the voltage input function

Parameters

The parameters of the voltage input function are explained in the following tables.

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 voltage inputs (main VT secondary)			
VT4_Ch1Nom_EPar_	Connection U1	Ph-N, Ph-Ph,	Ph-N
VT4_Ch2Nom_EPar_	Connection U2	Ph-N, Ph-Ph,	Ph-N
VT4_Ch3Nom_EPar_	Connection U3	Ph-N, Ph-Ph,	Ph-N
VT4_Ch4Nom_EPar_	Connection U4	Ph-N, Ph-Ph,	Ph-N
Definition of the positive direction of the first three input channels, given as normal or inverted			
VT4_Ch1Dir_EPar_	Direction U1	Normal,Inverted	Normal
VT4_Ch2Dir_EPar_	Direction U2	Normal,Inverted	Normal
VT4_Ch3Dir_EPar_	Direction U3	Normal,Inverted	Normal
VT4_Ch4Dir_EPar_	Direction U4	Normal,Inverted	Normal

Table 65 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 66 The integer parameter of the voltage input function

Floating point parameters

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

Table 67 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.

On-line measurements

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

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 68 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 first voltage input module is the one, usually configured closer to the CPU 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”.

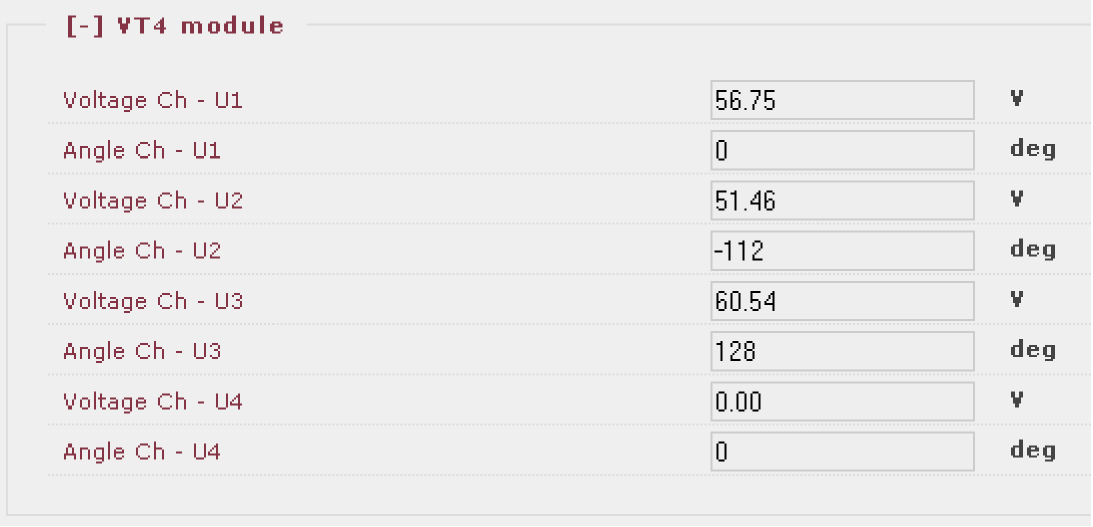


Figure 11 Example: On-line displayed values for the voltage input module

1.3.4.3 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. Table 69 shows the list of the measured values available in the E4-DRFP configuration.

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_Fi_OLM_	Power factor
MXU_I1_OLM_	Current (CT - Z<, IDMT)
MXU_I2_OLM_	Current (CT – Th.Ol)
MXU_U1_OLM_	Voltage
MXU_f_OLM_	Frequency

Table 69 Example: Measured values in the E4-DRFP configuration

Reporting the measured values and the changes

For reporting, additional information is needed, which is defined in parameter setting.
In the E4-DRFP configuration 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_	ReportDB ActivePower	Off, Amplitude, Integrated	Off
Selection of the reporting mode for reactive power measurement			
MXU_QRepMode_EPar_	ReportDB ActivePower	Off, Amplitude, Integrated	Off
Selection of the reporting mode for apparent power measurement			
MXU_SRepMode_EPar_	ReportDB ApparPower	Off, Amplitude, Integrated	Off
Selection of the reporting mode for current measurement			
MXU_IRepMode_EPar_	ReportDB Current	Off, Amplitude, Integrated	Off
Selection of the reporting mode for voltage measurement			
MXU_URepMode_EPar_	ReportDB Voltage	Off, Amplitude, Integrated	Off
Selection of the reporting mode for frequency measurement			
MXU_fRepMode_EPar_	ReportDB Frequency	Off, Amplitude, Integrated	Off

Table 70 The enumerated parameters of the line measurement function

The selection of the reporting mode items is explained in Figure *12* and in Figure *13*.

“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 *12* 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 71.

The “Range” parameters in Table 71 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	kW	0.1	10000	0.01	10
Range value for the active power						
MXU_PRange_FPar_	Range value - P	kW	1	100000	0.01	500
Deadband value for the reactive power						
MXU_QDeadB_FPar_	Deadband value - Q	kVAr	0.1	10000	0.01	10
Range value for the reactive power						
MXU_QRange_FPar_	Range value - Q	kVAr	1	100000	0.01	500
Deadband value for the apparent power						
MXU_SDeadB_FPar_	Deadband value - S	kVA	0.1	10000	0.01	10
Range value for the apparent power						
MXU_SRange_FPar_	Range value - S	kVA	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 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 71 The floating-point parameters of the line measurement function

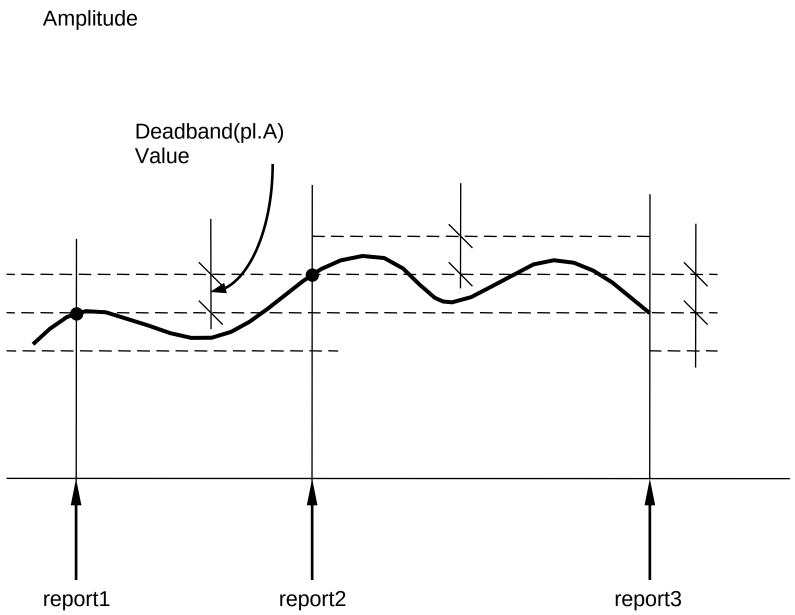


Figure 12 *Reporting if “*Amplitude*” mode is selected*

"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 *13* shows that the integral of the current in time becomes higher than the Deadband value multiplied by 1sec, this results "report2", etc.

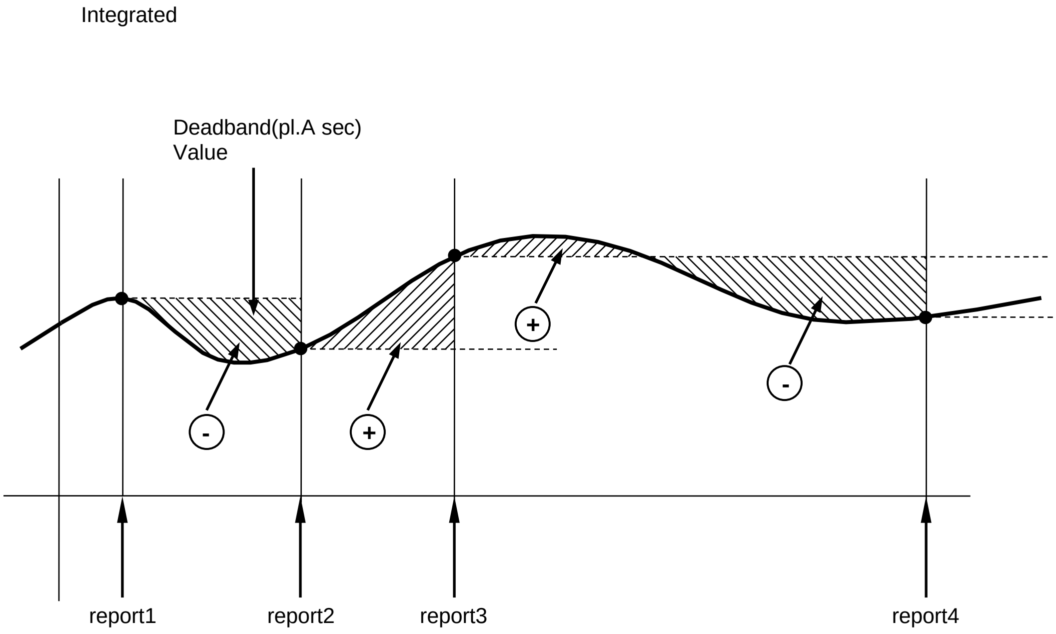


Figure 13 *Reporting if "*Integrated*" mode is selected*

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 72.

Integer parameters

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

Table 72 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 70.

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 73 Technical data of line measurement

1.3.5 Disturbance recorder

The disturbance recorder function can record analog signals and binary status signals. These signals are configured using the EuroCAP software tool.

The disturbance recorder function has a binary input signal, which serves the purpose of starting the function**. The conditions of starting are defined by the user, applying the graphic equation editor.** The disturbance recorder function keeps on recording during the active state of this signal but the total recording time is limited by the timer parameter setting.

The pre-fault time, max recording time and post-fault time can be defined by parameters.

If the triggering conditions defined by the user - using the graphic equation editor – are satisfied and the function is enabled by parameter setting, then the disturbance recorder starts recording the sampled values of configured analog signals and binary signals.

The analog signals can be sampled values (voltages and currents) received via input modules or they can be calculated analog values (such as negative sequence components, etc.)

The number of the configured binary signals for recording is limited to 64, and up to 32 analog channels can be recorded.

The available memory for disturbance records is 12 MB.

The function applies 20 sampling in a network period. Accordingly for 50 Hz, the sampling frequency is 1 kHz. (For 60 Hz the sampling frequency is 1.2 kHz.)

As an example, for 50 Hz, if the duration of the record is 1000 ms then one analog channel needs about 7 kB and a binary channel needs 2 kB, Using the following formula the memory size can be estimated:

Memory size of a record = (n*7 kB+ m*2 kB)*record duration(s)

Here n,m: are the number of analog and binary channels respectively.

During the operation of the function, the pre-fault signals are preserved for the time duration as defined by the parameter “PreFault”.

The recording duration is limited by the parameter “Max Recording Time” but if the triggering signal resets earlier, this section is shorter.

The post-fault signals are preserved for the time duration as defined by the parameter “PostFault”.

During or after the running of the recording, the triggering condition must be reset for a new recording procedure to start.

The records are stored in standard COMTRADE format.

The procedure for downloading the records is described in detail in the EuroProt+ manual "Remote user interface description", Chapter 4.7. The three files are zipped in a file .zip. This procedure assures that the three component files (.cfg, .dat and .inf) are stored in the same location.

The evaluation can be performed using any COMTRADE evaluator software. Protecta offers the **"srEval"** software for this purpose. The application of this software is described in detail in the "srEval manual". This manual can be downloaded from the following Internet address: http://www.softreal.hu/product/sreval_en.shtml.

Parameters

Enumerated parameter

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

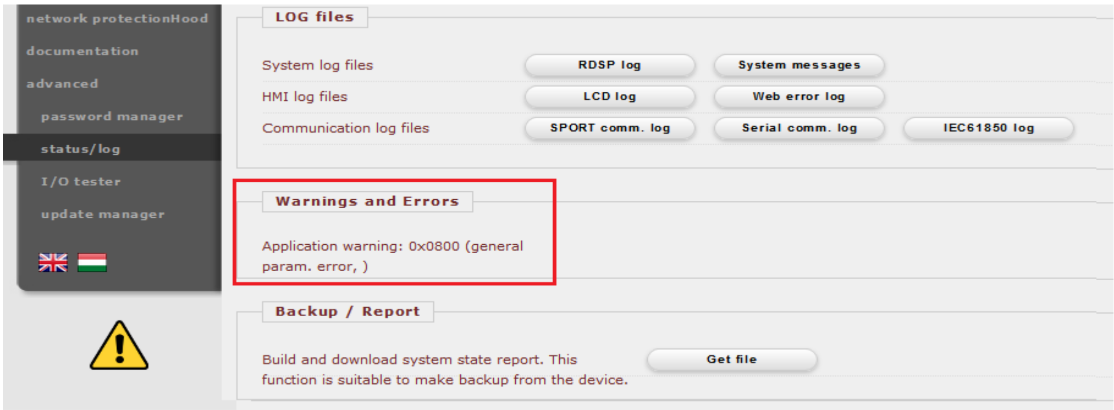
Table 1-74 The enumerated parameter of the disturbance recorder function

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_	Max Recording Time	msec	500	10000	1	1000

Table 1-75 The timer parameters of the disturbance recorder function

NOTE.: The device gets automatically in "Warning" state and sends the following warning message if the sum of the pre-fault time and post-fault time is longer than the overall-fault time. The corresponding message in the RDSP log file is: „Wrong DR settings. PreFault + PostFault must be less than MaxFault. Check the parameters."



The recorded channels of the E4-DRFP configuration are listed in the following tables.

Recorded analog signal	**Channel source signal**	**Unit**
VT	MAn_R01 (VT)	%
CT(Z<;IDMT)	MAn_T01 (CT(Z<,IDMT))	%
CT(ThOL)	MAn_T02 (CT(ThOL))	%
Recorded binary signal	**Channel source signal**	
Z1 Start	DIS21_Z1St_GrI_ (Z1 Start)	
Z1 Trip	DIS21_Z1Tr_GrI_ (Z1 Trip)	
Z2 Start	DIS21_Z2St_GrI_ (Z2 Start)	
Z2 Trip	DIS21_Z2Tr_GrI_ (Z2 Trip)	
Z3 Start	DIS21_Z3St_GrI_ (Z3 Start)	
Z3 Trip	DIS21_Z3Tr_GrI_ (Z3 Trip)	
Z4 Start	DIS21_Z4St_GrI_ (Z4 Start)	
SOTF Trip	SOTF_Trip ()	
Teleprot. send	SCH85_Send_GrI_ (Transm. signal)	
Z Teleprot. Trip	SCH85_Ztp_GrI_ (Z Teleprot. Trip)	
I> Start	TOC51R_GenSt_GrI_ (General Start)	
I> Trip	TOC51R_GenTr_GrI_ (General Trip)	
Th. OL Alarm	TTR49L_Alarm_GrI_ (Alarm)	
Th. OL Trip	TTR49L_GenTr_GrI_ (General Trip)	
U> Start	TOV59R_GenSt_GrI (General Start)	
U> Trip	TOV59R_GenTr_GrI_ (General Trip)	
U< Start	TUV27R_GenSt_GrI (General Start)	
U< Trip	TUV27R_GenTr_GrI_ (General Trip)	
Low Gas inp.	BIn_G04 (Low Gas)	
Low Gas Trip	LowGas_latched ()	
General Trip	TRC94_GenTr_GrI_ (General Trip)	
AR Start inp.	BIn_G09 (AR Start)	
AR Close	REC79_Close_GrI_ (Close command)	
Final trip	REC79_FinTr_GrI_ (Final Trip)	
Reclose locked by th. OL	TTR49L_Lock_GrI_ (Reclose locked)	
AR Disable inp.	BIn_G07 (AR Disable)	
AR Enable inp.	BIn_G08 (AR Enable)	
CB Opened inp.	BIn_G01 (CB Opened)	
CB Closed inp.	BIn_G02 (CB Closed)	
Manual Close inp.	BIn_G03 (Manual Close)	
Manual Close cmd.	Close_command ()	

Table 76 Disturbance recorder, recorded analog and binary channels

1.3.6 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. They can be reported to the SCADA system, as well.

The possible events of the devices with E4-DRFP configuration are listed in Table 77.

Source	**Event**
Common	Mode of device
	Health of device
Railway Distance	Z1 Start
	Z1 Trip
	Z2 Start
	Z2 Trip
	Z3 Start
	Z3 Trip
	Z4 Start
	Z4 Trip
	Z5 Start
	Z5 Trip
	Fault Loc. km
Teleprotection	Receive signal 1
	Receive signal 2
	Teleprot. Trip
	Send signal
	Carrier Failed
Overcurrent	General Start
	General Trip
Thermal Overload	Alarm
	General Trip
OverVoltage	General Start
	General Trip
UnderVoltage	General Start
	General Trip
Trip Logic	General Trip
MV AutoReclosing	Blocked
	Close Command
	Status
	Actual cycle
	Final Trip
CB Wear	Alarm
4Ch Counter	Z1 Start
	Z2 Start
	Z3 Start
	Z4 Start

Source	**Event**
4Ch Counter	Z1 Trip
	Z2 Trip
	Z3 Trip
	Z4 Trip
4Ch Counter	OverCurrent Start
	OverCurrent Trip
	Th. Overload Alarm
	Th. Overload Trip
4Ch Counter	OverVoltage Trip
	UnderVoltage Trip
	AR Close Cmd
	Counter_4
4Ch Counter	Counter_1
	Counter_2
	Counter_3
	Counter_4
4Ch Counter	Counter_1
	Counter_2
	Counter_3
	Counter_4
16Ch Event	Switch Onto Fault
	Low Gas Signal
	CB Failure
	VT midget CB failure
	Close cmd. from MC input
	Input06
	Input07
	Input08
	Input09
	Input10
	Input11
	Input12
	Input13
	Input14
	Input15
	Input16

Table 77 List of the possible events

1.3.7 TRIP contact assignment

The outputs of the “trip logic function” are connected directly to the contacts of the power supply-trip module (PSTP+/2101 module in position “A”).

Binary status signal	**Title**	Connected to the contacts PSTP+/2101 module in position “A”
TRC94_GenTr_GrI_	General Trip	Trip
TRC94_GenTr_GrI_	General Trip	Backup Trip

Table 78 The connected signal of the trip logic function

To the inputs of the “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
Trip	DIS21_Z1Tr_GrI_ OR DIS21_Z2Tr_GrI_ OR DIS21_Z3Tr_GrI_ OR DIS21_Z4Tr_GrI_ OR DIS21_Z5Tr_GrI_ OR DIS21_SOTFZTr_GrI_ OR TOC51R_GenTr_GrI_ OR TTR49R_GenTr_GrI_ OR TOV59R_GenTr_GrI_ OR TUV27R_GenTr_GrI_ OR SCH85_Ztp_GrI_	First, or second, or third, or fourth, or fifth zone trip command of the distance protection function OR Trip command of the switch onto fault logic OR Trip command of the overcurrent protection function OR Trip command of the line thermal protection function OR Trip command of the overvoltage protection function OR Trip command of the undervoltage protection function OR Teleprotection trip command.
Block	The latched “Low gas” binary input signal.	Blocking the outputs of the trip logic function

Table 79 The factory defined binary input signals of the trip logic function

The user defined signals are listed in Table 80.

Input	Binary status signal	Explanation
Trip	TRC94_Tr_GrO_	Request for trip command
Block	TRC94_Blk_GrO_	Blocking the outputs of the trip logic function

Table 80 The user defined binary input signals of the trip logic function

1.3.8 Special logics

The E4-DRFP configuration contains some special factory configured logics. These are defined in the graphical logic editor of the EuroCAP configuration tool and so these can be modified freely by the users (with the proper eligibilities). This chapter summarizes these special logics. However, it does not contain every detail, for details please check the graphical logic equations of the configuration in the EuroCAP tool!

1.3.8.1 Low gas logic

If the binary input „BIn_G04 (Low Gas)" is active, the trip logic, the autoreclose function and the manual close command to the circuit breaker are blocked. That means that in this state no trip and no close command will be generated. This blocking is latched if the "Low gas inp. latched" binary user defined parameter is checked. In this case the blocking of the trip logic will not be reset until

- the BIn_G04 (Low gas) input resets AND
- {a reset command is given by the user in the local state of the device on the LCD-screen (see chapter 1.4.2) OR
- a reset command is given by the user in the remote state of the device from the SCADA system, from the web-page of the device (commands menu) or via the BIn_G05 (Remote Reset) binary input.

1.3.8.2 VT midget CB logic

If the VT midget CB is in open state, the Railway distance protection function is blocked. The E4-DRFP configuration has a dedicated binary input for signalling this state, which is the „BIn_G06 (VT midget CB)". This input can sign both of the closed or the open state of the VT midget CB. The user can define with the „VT midget CB OK level on input" binary user defined parameter whether this input signs the closed or the open state. If this parameter is checked it means that the binary input BIn_G06 signs the closed state of the VT midget CB.

1.3.8.3 Starting and external blocking of the Automatic reclosing function

The Automatic reclosing function has two types of starting conditions in the E4-DRFP configuration. The first is the starting by external input: if the "Bin_G09 (AR start)" binary input has been activated, the Automatic reclosing function starts the first (or the next) cycle. The other type of conditions is which the user can define by the matrix. If min. one of the selected rows is active (e.g. "Z1 trip" row is selected and the distance protection function is tripping in the first zone), then the Automatic reclosing function starts the first (or the next) cycle, as well. The user can choose from the following conditions for starting of the Automatic reclosing function:

- Z1 trip
- Z2 trip
- Z3 trip
- Teleprotection trip
- Overcurrent trip
- Th. Overload trip
- Overvoltage trip
- Undervoltage trip

There are some conditions in which the Automatic reclosing function is automatic blocked (e.g. after manual close for a certain settable time) and which are described in chapter 1.3.2.10 or in the detailed description of the function. However, the user can block and enable manually the function, as well. This can be done

- on the LCD screen, see chapter 1.4.2,
- performing a direct command via the Commands menu of the supervising WEB browser,
- giving an impulse to the binary inputs "Bin_G07 (AR disable)" for blocking and "Bin_G08 (AR enable)" for enabling the function.

After the manual enabling of the function it will be active only when it is not blocked by other conditions.

1.3.8.4 Manual close commands

Manual close commands can be given

- by the Circuit breaker function block from the SCADA system or performing a direct command via the Commands menu of the supervising WEB browser, see chapter 1.3.3.1,
- by the "BIn_G03 (Manual Close)" binary input, if the "Manual close inp. enable" binary user defined parameter is checked.

Both type of close command is enabled only if

- none of the protection functions give a trip command AND
- the timer of the „final trip" signalling of the Automatic reclosing function block is not running (see chapter 1.3.2.10) AND
- there is no (latched) low gas signalling.

The close command is given on the „BOut_L01 (Close)" binary output contact.

1.3.8.5 Failure signalling

There are some failures of the circuit breaker or of the secondary wiring which can be detected and signed by the device.

Circuit breaker failure: if the trip logic function is giving a trip command and the circuit breaker is closed based on its two bit state signals longer than the time which is given by the „CB failure" user defined timer parameter, „CB Failure" event will be generated.

Trip circuit failure: if the circuit breaker is closed based on its two bit state signals and min. one of the two „trip circuit supervision" signals of the two trip contacts is missed for longer time than which is set by „CB intermediate time" user defined timer parameter, the „Trip circ. fail." LED lights yellow. This LED is not latched.

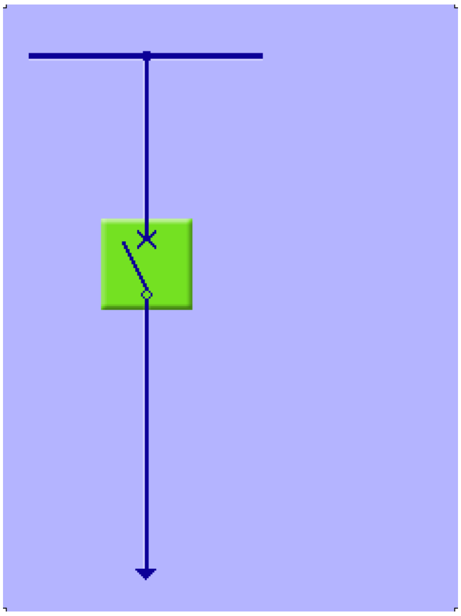
Circuit breaker discrepancy: if the status signals coming from the circuit breaker are conflicting, i.e. both of closed and open are active, or none of them is active for longer time than which is set by „CB intermediate time" user defined timer parameter, the „CB discrepancy" LED lights yellow. This LED is not latched.

1.4 LCD screens

A general description can be found about the handling the LCD-screens in the document „LCD touchscrenn interface description": http://www.protecta.hu/epp-english/SW_guide/europrot_lcd_english_V1.0.pdf

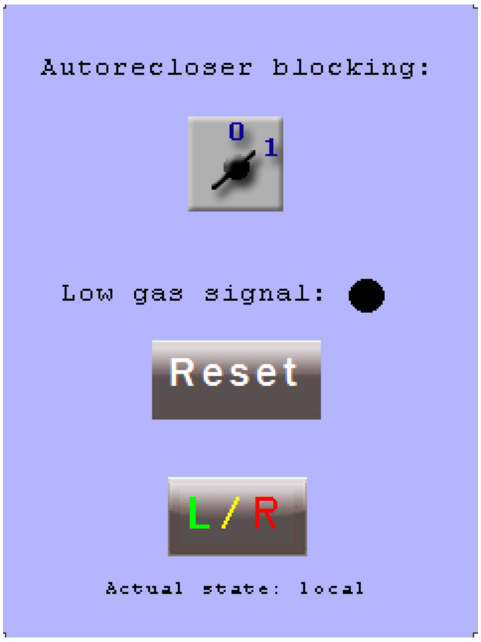
The special LCD-screens of the E4-DRFP configuration are presented in this chapter. These screens can be edited also by users with Master view in the EuroCAP tool.

1.4.1 Schema



On this screen the state of the circuit breaker can be checked. It has four states based on the two bit state signals of the circuit breaker: intermediate (0-0), open (1-0), closed (0-1) or bad (1-1).

1.4.2 Control



On this screen you can

- block and enable the Automatic reclosing function. For blocking touch the switch symbol, and then push the 'I' button! For enabling touch the switch symbol, and then push the '0' button! The switch button shows the actual status of the blocking/enabling.
- reset the latched low gas signal, if the binary input („BIn_G04 (Low Gas)") signal itself is not more active. For hat touch the "Reset" soft button and then push the 'I' button! This soft button can be controlled only if the device is in local state. You can switch the state of the device by the "L/R" soft button. You can check whether the latched low gas signal is active on the LED-symbol with „Low gas signal" label on this screen. If it is red, the latched low gas signal is active.

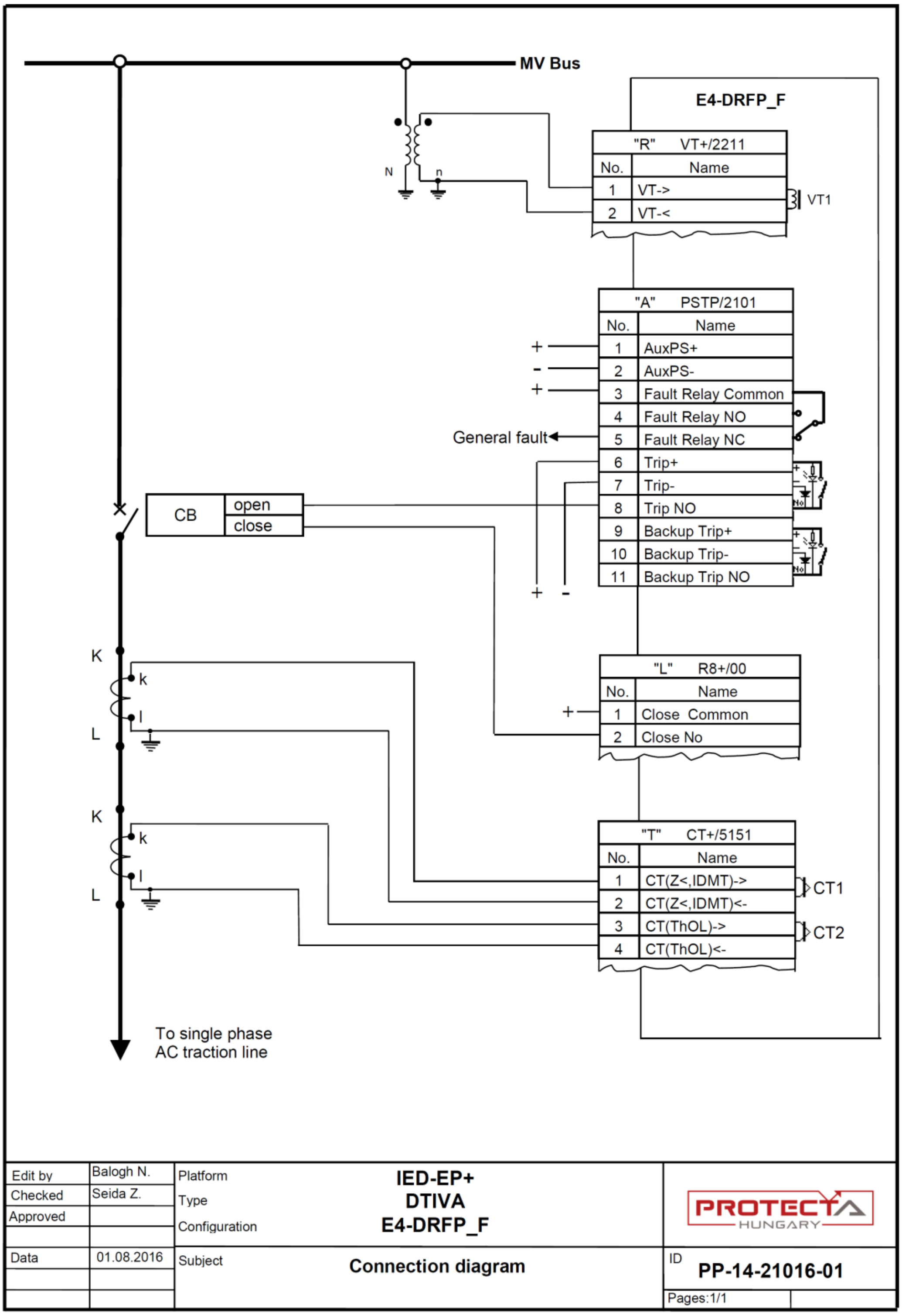
1.5 LED assignment

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	Color	Latched
1	Final Trip	REC79_FinTr_GrI_ (Final Trip)	r	1
2	General Trip	TRC94_GenTr_GrI_ (General Trip)	r	1
3	Z< Gen. Trip	DIS21_GenTr ()	r	1
4	I> Trip	TOC51R_GenTr_GrI_ (General Trip)	r	1
5	Therm.OL Trip	TTR49L_GenTr_GrI_ (General Trip)	r	1
6	U> Trip	TOV59R_GenTr_GrI_ (General Trip)	r	1
7	U< Trip	TUV27R_GenTr_GrI_ (General Trip)	r	1
8	AR Blocked	REC79_Blocked_GrI_ (Blocked)	y	0
9	SOTF Trip	SOTF_Trip ()	r	1
10	Trip circ. fail.	TC_Failure ()	y	0
11	CB discrepancy	CB_discrepancy ()	y	0
12	LED3112		r	0
13	LED3113		r	0
14	LED3114		r	0
15	LED3115		r	0
16	LED3116		r	0

Table 81 LED assignment

2 External connection



3 Connection assignment

This chapter includes the factory configured connection assignment of the E4-DRFP configuration, which belongs to the following (not basic!) module arrangement:

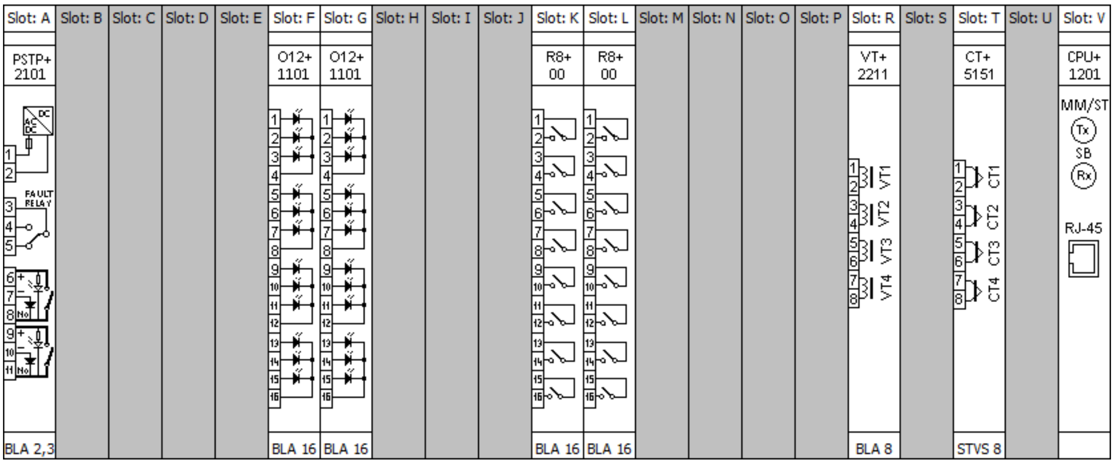


Figure 14 Module arrangement for the given factory configured connection assignment

"A" PSTP+/2101

Clamp	Name	Target designation
1	AuxPS+	
2	AuxPS-	
3	Fault Relay Common	
4	Fault Relay NO	
5	Fault Relay NC	
6	Trip +	
7	Trip -	
8	Trip NO	
9	Backup Trip +	
10	Backup Trip -	
11	Backup Trip NO	

"F" O12+/1101

Clamp	Name	Target designation
1	BIn_F01	
2	BIn_F02	
3	BIn_F03	
4	Opto-(1-3)	
5	BIn_F04	
6	BIn_F05	
7	BIn_F06	
8	Opto-(4-6)	
9	BIn_F07	
10	BIn_F08	
11	BIn_F09	
12	Opto-(7-9)	
13	BIn_F10	
14	BIn_F11	
15	BIn_F12	
16	Opto-(10-12)	

"G" O12+/1101

Clamp	Name	Target designation
1	CB Opened	
2	CB Closed	
3	Manual Close	
4	Opto-(1-3)	
5	Low Gas	
6	Remote Reset	
7	VT midget CB	
8	Opto-(4-6)	
9	AR Disable	
10	AR Enable	
11	AR Start	
12	Opto-(7-9)	
13	Teleprot. Error	
14	Carrier recieve	
15	BIn_G12	
16	Opto-(10-12)	

"K" R8+/00

Clamp	Name	Target designation
1	BOut_K01 Common	
2	BOut_K01 NO	
3	BOut_K02 Common	
4	BOut_K02 NO	
5	BOut_K03 Common	
6	BOut_K03 NO	
7	BOut_K04 Common	
8	BOut_K04 NO	
9	BOut_K05 Common	
10	BOut_K05 NO	
11	BOut_K06 Common	
12	BOut_K06 NO	
13	BOut_K07 Common	
14	BOut_K07 NO	
15	BOut_K08 Common	
16	BOut_K08 NO	

"L" R8+/00

Clamp	Name	Target designation
1	Close Common	
2	Close NO	
3	Carrier send Common	
4	Carrier send NO	
5	BOut_L03 Common	
6	BOut_L03 NO	
7	BOut_L04 Common	
8	BOut_L04 NO	
9	BOut_L05 Common	
10	BOut_L05 NO	
11	BOut_L06 Common	
12	BOut_L06 NO	
13	BOut_L07 Common	
14	BOut_L07 NO	
15	BOut_L08 Common	
16	BOut_L08 NO	

"R" VT+/2211

Clamp	Name	Target designation
1	VT->	
2	VT<-	
3	MAn_R02->	
4	MAn_R02<-	
5	MAn_R03->	
6	MAn_R03<-	
7	MAn_R04->	
8	MAn_R04<-	

"T" CT+/5151

Clamp	Name	Target designation
1	CT(Z<,IDMT)->	
2	CT(Z<,IDMT)<-	
3	CT(ThOL)->	
4	CT(ThOL)<-	
5	MAn_T03->	
6	MAn_T03<-	
7	MAn_T04->	
8	MAn_T04<-	