EUROPROT+

E10-Feeder configuration description (Type: DTIVA)

PROTECTA HUNGARY

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CONTENTS

1 Configuration description

The DTIVA-E10-Feeder protection device is a member of the ***EuroProt+*** product line, made by Protecta Co. Ltd. The ***EuroProt+*** type complex protection in respect of hardware and software is a modular device. The modules are assembled and configured according to the requirements, and then the software determines the functions. This manual describes the specific application of the E10-Feeder factory configuration.

1.1 Application

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

1.1.1 Protection functions

The E10-Feeder configuration measures three phase currents, the zero sequence current component and optionally three phase voltage The realized and optional current- and voltage-based protection functions are listed in the Table below.

Protection functions	**IEC**	**ANSI**	**E10-Feeder**
Three-phase time overcurrent protection	I >, I >>	51	**X**
Residual time overcurrent protection	Io >, Io >>	51N	**X**
Capacitor unbalance protection for blocks in bridge connection			***X**
Capacitor unbalance protection for blocks in double star connection			***X**
Loss-of-load (undercurrent) protection function	I<	37	**X**
Capacitor overvoltage protection function			**op.**
Definite time undervoltage protection	U <, U <<	27	**op.**
Definite time overvoltage protection	U >, U >>	59	**op.**
Residual overvoltage protection	Uo>, Uo>>	59N	**op.**
Current unbalance protection		60	**X**

**The suitable function can be selected by the costumer.*

Table 1 The protection functions of the E10-Feeder configuration

1.1.2 Measurement functions

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

Measurements	**E10-Feeder**
Current input (I1, I2, I3, Io)	**X**
Voltage input (U1, U2, U3, Uo)	**op.**
Supervised trip contacts (TCS)	**X**

Table 2 The measurement functions of the E10-Feeder configuration

1.1.3 Hardware configuration

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

Hardware configuration	ANSI	E10-Feeder
Mounting		Op.
Panel instrument case		X
Current inputs		8
Voltage inputs		4 (op.)
Digital inputs		12
Digital outputs		8
Fast trip outputs		2

Table 3 The basic hardware configuration of the E10-Feeder_H configuration

The basic module arrangement of the E10-Feeder_H configuration is shown below. (Related to 42TE rack size.)

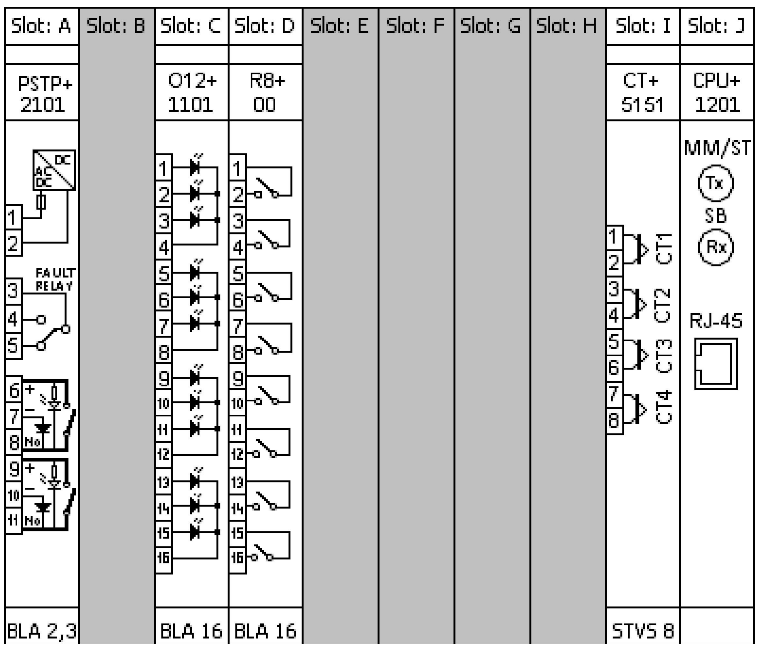


Figure 1 Basic module arrangement of the E10-Feeder_H configuration (42TE, rear view)

1.1.4 The applied hardware modules

The applied modules are listed in Table 4.

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

Module identifier	Explanation
PSTP+ 2101	Power supply unit
O8+ 1101	Binary input module
R8+ 00	Signal relay output module
CT + 5151	Analog current input module
CPU+ 1201	Processing and communication module

Table 4 The applied modules of the E10-Feeder_H 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 2 The 42 inch rack of **EuroProt+** family*

1.3 Software configuration

1.3.1 Protection functions

The implemented protection functions are listed in
*Optional protection function
Table 5. The function blocks are described in details in separate documents. These are referred to also in this table.

Name	Title	Document
TOC51	3ph Overcurr	***Three-phase overcurrent protection function block description***
TOC51N	Residual TOC	***Residual overcurrent protection function block description***
VCB60	Current Unbalance	***Current unbalance function block description***
TUC37	UnderCurrent	***Loss-of-load protection function block description***
CapUnB3	CapUnBal_H	***Capacitor unbalance protection for blocks in bridge connection***
CapUnB1	CapUnBal	***Capacitor unbalance protection for blocks in double star connection***
*CapOV	Capacitor OV	***Capacitor overvoltage protection function block description***
*TUV27	Under Voltage	***Definite time undervoltage protection function***
*TOV59	Over Voltage	***Definite time overvoltage protection function block description***
*TOV59N	Overvoltage	***Definite time zero sequence overvoltage protection function block description***
TRC94	Trip Logic	***Trip logic function block description***

*Optional protection function

Table 5 Implemented protection functions

1.3.1.1 Three-phase time overcurrent protection function (TOC51)

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

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

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

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

where

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

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

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

$$G_D = 20 * G_S$$

Above this value the theoretical operating time is definite:

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

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

Resetting characteristics:

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

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

where

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

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

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

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

Technical data

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

** Measured with signal relay contact*

Table 6 Technical data of of the instantaneous overcurrent protection function

Parameters

Enumerated parameters

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

Table 7 The enumerated parameters of the time overcurrent protection function

Integer parameter

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

Table 8 The integer parameter of the time overcurrent protection function

Float point parameter

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

Table 9 The float point parameter of the time overcurrent protection function

Timer parameters

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

**Valid for inverse type characteristics*

***Valid for definite type characteristics only*

Table 10 The timer parameters of the time overcurrent protection function

1.3.1.2 Residual overcurrent protection function (TOC51N)

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

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

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

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

where

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

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

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

$$G_D = 20 * G_S$$

Above this value the theoretical operating time is definite:

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

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

Resetting characteristics:

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

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

where

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

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

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

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

Technical data

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

* *Measured in version In = 200 mA*

Table 11 The technical data of the residual overcurrent protection function

Parameters

Enumerated parameters

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

Table 12 The enumerated parameters of the residual overcurrent protection function

Integer parameter

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

* *In = 1 A or 5 A*
** *In = 200 mA or 1 A*

Table 13 The integer parameter of the residual overcurrent protection function

Float point parameter

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

Table 14 The float parameter of the residual overcurrent protection function

Timer parameters

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

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

Table 15 The timer parameters of the residual overcurrent protection function

1.3.1.3 Current unbalance function (VCB60)

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

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

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

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

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

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

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

Technical data

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

Table 16 Technical data of the current unbalance function

Parameters

Enumerated parameter

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

Table 17 The enumerated parameter of the current unbalance function

Boolean parameter

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

Table 18 The boolean parameter of the current unbalance function

Integer parameter

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

Table 19 The integer parameter of the current unbalance function

Timer parameter

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

Table 20 The timer parameter of the current unbalance function

1.3.1.4 Loss-of-load (undercurrent) protection function

The loss-of-load (undercurrent) protection function operates when the current decreases below a predetermined value.

This protection function can be applied for fan or pump drives, where the flowing media provides cooling for the motor itself. If this cooling stops, the motor must not remain in operation. In these cases the protection against low load after a given time delay disconnects the motor from the power supply.

It can also stop a motor in case of a failure in a mechanical transmission (e.g. conveyor belt).

A time delay may be required after start of the function to prevent operation during transients of the power systems.

The advantage of this function is its simplicity: no voltage measurement is needed, no power calculations are performed. The operation is based on phase currents only.

The function starts if the current is between the start current as upper limit, defined by the parameter “Start Current)” and the minimal current as lower limit, defined by the parameter “Idle Current”. These limit values are given in percent of the rated current of the protected object. This is defined by the parameter “InMotor/InCT”. This parameter is also given as a percentage.

The function operates in all three phases individually but the general start signal output is generated if the conditions are satisfied in all three phases.

At starting, a time counter is triggered. The function generates a trip command if the time delay defined by the parameter “Time Delay” expires.

The inputs of the loss-of-load protection function are

- the Fourier basic components of three phase currents,
- binary input,
- parameters.

The outputs of the loss-of-load protection function are

- the general start status signal,
- the general trip command.

Technical data

Function	Range	Accuracy
Current accuracy	20 – 2000% of In	±1% of In
Reset ratio at idle current	0.95 0.70	
Operating time accuracy		±5% or ± 15 ms whichever is greater
Minimum operating time	<60 ms	
Reset time	<60 ms	

Parameters

Enumerated parameter

Parameter name	Title	Selection range	Default
Disabling or enabling the operation of the function:			
TUC37_Oper_EPar_	Operation	Off,On	On

Boolean parameters

Parameter name	Title	Default	Explanation
Disabling trip command:			
TUC37_StOnly_BPar_	Start Signal Only	0	If this parameter is set to logic True, then no trip command is generated, only a start signal.

Integer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Ratio of the rated current of the protected object and that of the current input of the device:						
TUC37_CTRatio_IPar_	InMotor/InCT	%	20	150	1	100
Start current related to the rated current of the protected object, below which the function operates:						
TUC37_StCurr_IPar_	Start Current	%	20	100	1	40
Minimal current related to the rated current of the protected object, above which the function operates:						
TUC37_Idle_IPar_	Idle Current	%	1	20	1	10

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Time delay for the trip command:						
TUC37_Delay_TPar_	Time Delay	msec		60000	1	100

Binary output status signals

Binary output status signals	Signal title	Explanation
Start signal of the function block:		
TUC37_GenSt_GrI_	General Start	Start signal of the function block
Trip command of the function block:		
TUC37_GenTr_GrI_	General Trip	Trip command of the function block

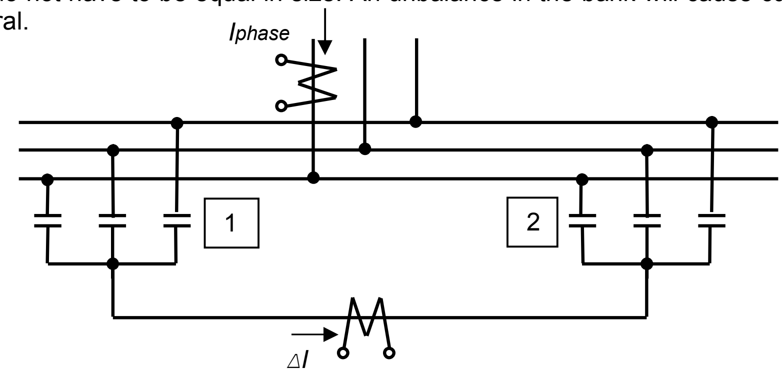
Binary input status signals

The binary inputs are the results of logic equations graphically edited by the user.

Binary input status signal	Signal title	Explanation
Disabling the function:		
TUC37_Blk_GrO_	Block	The programmed True state of this input disables the operation of the function

1.3.1.5 Capacitor unbalance protection function for blocks in double star connection

This version of the capacitor unbalance protection can be applied if the capacitors are arranged in two parallel stars (ungrounded) with a current transformer between the neutrals. The stars do not have to be equal in size. An unbalance in the bank will cause current to flow in the neutral.



The shunt capacitor banks are usually constructed of capacitor units, and the units contain capacitor elements.

There are constructions of the bank where fuses are connected inside a capacitor unit, in series with an element or a group of elements. The fuse is connected in series with the element that the fuse is designed to isolate if the element becomes faulty. After the breakdown of an element, the fuse connected to it will blow and isolate it from the remaining part of the capacitor, which allows the unit to continue in service. The blowing of one or more fuses decreases the capacitance value and additionally it will cause voltage changes within the bank.

If no internal fuses are applied then the breakdown of an element will short-circuit a “layer” of capacitors. The capacitance value increases and additionally it will also cause voltage changes within the bank.

Each time an internal capacitor element fails, a slight change of voltage distribution and current flow within the capacitor bank is encountered. The magnitude of these changes depends upon the number of failed elements and their location within the bank.

The main purpose of the capacitor unbalance protection is to give an alarm or to disconnect the entire capacitor bank when unbalances across healthy capacitors, adjacent to a failed capacitor, are excessive. Normally not more than 10 % unbalance should be allowed (unbalance limit according to (IEC 60871-1 Shunt capacitors for a.c. power systems having a rated voltage above 1000 V - Part 1: General).

If an externally fused capacitor is disconnected by its fuse, a larger voltage and current change is obtained than if single elements are disconnected by internal fuses.

This kind of protection prevents steady-state overvoltage and accelerated aging of the capacitor elements.

Another function of the unbalance protection is to remove the bank from service for a fault not isolated by a fuse or to protect banks that are not internally or externally fused. Unbalance protection is not a replacement for short-circuit protection.

This protection scheme may be used for both internal and external fuses and also in capacitor configurations without fuses. As the sensitivity performance is good, the method is especially useful for internal fuses. The current transformer between the neutral points should be rated for full system voltage.

The related standard permits a considerable amount of asymmetry, which can be up to 10%, consequently in healthy state a relatively high current can flow between the star points. At commissioning the unbalance protection function stores the vector position and the value of the “natural” unbalance current as the reference current $\Delta Iref$ and additionally those of one phase current $Iphase_{ref}$

The reference current is corrected according to the actually measured phase current *Iphase* $Iphase$ and the stored $Iphase_{ref}$ reference phase current

$$\Delta Iref_{corr} = \Delta Iref \frac{Iphase}{Iphase_{ref}}$$

where all current values are complex Fourier base harmonic vectors:

$\Delta Iref$	reference current measured between the neutral points at commissioning,
$\Delta Iref_{corr}$	corrected reference current,
Iphase	measured phase current,
$Iphase_{ref}$	phase current measured at commissioning.

If there are no changes inside the capacitor then no change can be detected in the actually measured unbalance current related to the corrected reference current.

Accordingly the energizing quantity for evaluation is the difference of the measured current between the neutral points and the corrected reference current:

$$G = dI = \Delta I - \Delta Iref_{corr}$$

where all current values are complex Fourier base harmonic vectors:

ΔI	current measured between the neutral points,
$\Delta Iref_{corr}$	corrected reference current (see above).

NOTE: This approach using a single phase current supposes that the asymmetry of the network itself does not change, or the changes are cleared with high speed by other protection functions. If considerable steady-state changes in the symmetry of the network are expected, then the measurement and correction based a single phase current is not sufficient. In this case please consult Protecta Co. Ltd. for solution.

Calibration of the protection is the task of the commissioning to store the reference values for the neutral point current $\Delta Iref$, and that of the phase current $Iphase_{ref}$ in the memory.

For this purpose the function block has a dedicated binary input: *Calibr*. This input must be activated for the calibration. For the physical means for activation see the description of the configuration. This input may be programmed by the user using the graphic logic editor.

The calibration at the moment of activation can be performed only if the conditions for calibration are fulfilled. The conditions for calibration are:

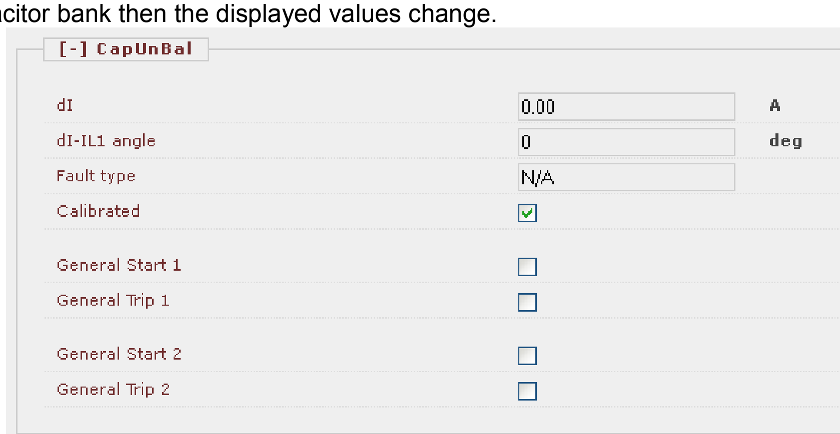
- The phase current has to be less than 2*In of the current input,
- The phase current has to be above 70% of the rated capacitor current,
- The neutral current has to be less than the value set by the dedicated parameter.

The calibrated state is indicated by the dedicated binary output of the function *Calibrated*.

The calibration values are stored in non-volatile memory, separately for each parameter set.

The *Reset* binary input resets the calibrated state.

Among the “on-line” information the function continuously displays the magnitude and the angle of the ΔI current measured between the neutral points. At the moment of calibration this vector resets to zero vector (see Figure below, dI=ΔI). At the same time the “Calibrated” field on the screen displays a check-mark. If however after calibration any changes happen within the capacitor bank then the displayed values change.



The capacitor unbalance protection function is configured with two independent stages.

For the first stage definite time characteristic and several types of inverse characteristics can be selected.

The second stage is definite time characteristic.

The inverse time operating characteristics are defined by the formula below:

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

where

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

The constant values k, c and α of the standard dependent time characteristics, see below.

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

The end of the effective range of the inverse 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 setting. 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 of the inverse time delay is as follows.

- For IEC type characteristics the resetting is after a fix time delay defined by the parameter CapUnB1_Reset_TPar_ (Reset Time),
- 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 starting value of the characteristic quantity (parameter: CapUnB1_StCurr1_IPar_, Start current 1),
TMS	preset time multiplier (no dimension).

The resetting constants of the standard dependent time characteristics are shown below.

	IEC ref	**Title**	**k_r**	**α**
1	A	IEC Inv	Resetting after fix time delay, according to preset parameter CapUnB1_Reset_TPar_ “Reset Time”	
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

Fault location

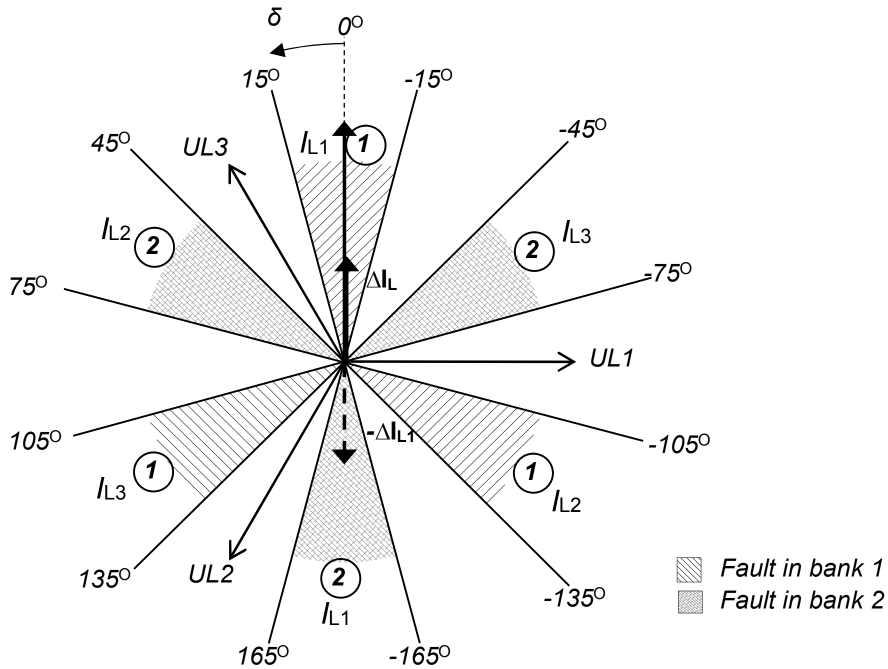
The vector measurement enables identification of the faulty capacitor unit. The positive directions of the currents *Iphase* and ΔI are as indicated in Figure above.

If the capacitor elements are not fused then the breakdown of a capacitor element will short-circuit a “layer” of capacitors. The resultant capacitance, consequently the capacitive current increases, as in the following explanation.

If a fault inside unit 1 in the phase L1 is considered, it increases the capacitance value. This event can be modelled by an additional capacitor connected parallel to the capacitor in unit 1 phase L1. It is obvious that this additional current is in phase of the current of the original phase capacitor "*IL1*". Consequently the Δ*I* current measured in the neutral point is in phase with the current of the original phase capacitor. To permit some asymmetry changes in the network and some measuring error, this current is inside the shaded area between -15 ° and +15 °. The on-line measurement will display the increased "*dI*" value with "*dI-IL1 angle*" in this range. The related event indicates "L1-1".

Similarly if an additional capacitor is added to phase L2, then the Δ*I* current measured in the neutral point is in phase with the current IL2. The phase angle related to phase IL1 is -120°, and it is in the range of -105 ° and -135 °. The related event indicates "L2-1".

If for example the added capacitor is in unit 2 in phase L2 then the vector is in the range of +45 ° and +75°. The related event indicates "L2-2".



If however the capacitor elements are individually fused then the breakdown of a capacitor element is disconnected from the "layer" of capacitors. The resultant capacitance decreases, and the result is opposite to the explanation above.

For correct evaluation the information is needed: whether internal fuses are applied or not. This is to be set by the Boolean parameter "Internal fuse".

The event list related to the capacitor faults can contain the following messages:

Message	Explanation
L1-1	Fault in phase L1, unit 1
L2-1	Fault in phase L2, unit 1
L3-1	Fault in phase L3, unit 1
L1-2	Fault in phase L1, unit 2
L2-2	Fault in phase L2, unit 2
L3-2	Fault in phase L3, unit 2

NOTE: The fault location is active in "*Calibrated*" state only. The event is registered at the moment of trip command generation.

Technical data

Function	Value	Accuracy
Pick-up starting accuracy	$20 \le G_S \le 1000$	< 5 %
Pickup time	< 40 ms	
Angle accuracy		<1 degree*
Reset ratio	0,9	
Reset time Dependent time char. Definite time char.	 approx 60 ms	< 2% or ±35 ms, whichever is greater
Operate time accuracy		±5% or ±15 ms, whichever is greater

** Valid if the negative sequence component of the network voltage is < 5%*

Parameters

Enumerated parameters

Parameter name	Title	Selection range	Default
Enabling or disabling the capacitor unbalance protection function			
CapUnB1_Oper1_EPar_	Operation Stage 1	Off,DefinitTime,IEC Inv,IEC VeryInv,IEC ExtInv,IEC LongInv,ANSI Inv,ANSI ModInv,ANSI VeryInv,ANSI ExtInv,ANSI LongInv,ANSI LongVeryInv,ANSI LongExtInv	Off
CapUnB1_Oper2_EPar_	Operation Stage 2	Off,On	Off

Boolean parameters

Parameter name	Title	Default	Explanation
CapUnB_IntFuse_BPar_	Internal fuse	0	0 means no internal fuse 1 means capacitor units with internal fuse

Integer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Current setting for the capacitor unbalance protection function, first stage						
CapUnB1_StCurr1_IPar_	Start Current 1	%	10	100	1	10
Current setting for the capacitor unbalance protection function, second stage						
CapUnB1_StCurr2_IPar_	Start Current 2	%	5	100	1	10
Nominal current of the capacitor, as percent of the rated input current						
CapUnB1_NomCurr_IPar_	Inom capacitor	%	15	120	1	100
ΔI setting, at calibration the current between the neutral points must be below this level						
CapUnB1_dIMax_IPar_	dI maxcalib	%	5	50	1	10

Float point parameter

Parameter name	Title	Dim.	Min	Max	Default
Time multiplier setting for the inverse type characteristics, first stage					
CapUnB1_Multip_FPar_	Time Multiplier	sec	0.05	999	1.0

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Minimum time delay for the inverse type characteristics (valid, if this characteristic is selected), first stage						
CapUnB1_MinDel_TPar_	Min Time Delay	msec	0	60000	1	100
Definite time delay for the first stage (valid, if this characteristic is selected)						
CapUnB1_DefDel_TPar_	Definite Time Delay	msec	0	60000	1	1000
Reset time setting, first stage						
CapUnB1_Reset_TPar_	Reset Time	msec	0	60000	1	100
Definite time delay for the second stage						
CapUnB1_Delay2_TPar_	Delay Stage 2	msec	0	60000	1	1000

Binary output status signals

Binary output signals	Signal title	Explanation
CapUnB1_GenSt1_GrI_	General Start 1	General start signal for stage 1
CapUnB1_GenTr1_GrI_	General Trip 1	General trip command for stage 1
CapUnB1_GenSt2_GrI_	General Start 2	General start signal for stage 2
CapUnB1_GenTr2_GrI_	General Trip 2	General trip command for stage 2
CapUnB1_Calib_GrI_	Calibrated	True, if the function has been calibrated

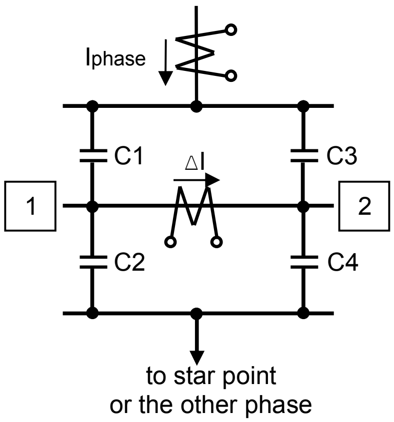
Binary input status signals

The conditions of the binary input signals are defined by the user, applying the graphic logic editor.

Binary input signals	Signal title	Explanation
CapUnB1_Reset_GrO_	Reset	Resetting the calibrated state
CapUnB1_Calibr_GrO_	Calibr	Binary input for calibration
CapUnB1_Blk_GrO_	Blk	Blocking input

1.3.1.6 Capacitor unbalance protection function for blocks in bridge connection

This version of the capacitor unbalance protection can be applied if the capacitors in the phases are arranged in bridge connection (“H configuration”), according to Figure below.



(drawing in one phase only)

The capacitors in each phase are arranged in two branches with a current transformer connected between midpoints or close to midpoints of the two branches. Failures anywhere in the branches will cause an unbalance current to flow through the current transformer.

This method is suitable for large capacitor banks since the total bank will be divided into separate protection zones. The method is not influenced by phase voltage unbalances. It may be used in delta- or star-connected banks with the neutral grounded or ungrounded.

The shunt capacitor banks are usually constructed of capacitor units, and the units contain capacitor elements.

There are constructions of the bank where fuses are connected inside a capacitor unit, in series with an element or a group of elements. The fuse is connected in series with the element that the fuse is designed to isolate if the element becomes faulty. After the breakdown of an element, the fuse connected to it will blow and isolate it from the remaining part of the capacitor, which allows the unit to continue in service. The blowing of one or more fuses decreases the capacitance value and additionally it will cause voltage changes within the bank.

If no internal fuses are applied then the breakdown of an element increases the capacitance value and additionally it will cause voltage changes within the bank.

Each time an internal capacitor element fails, a slight change of voltage distribution and current flow within the capacitor bank is encountered. The magnitude of these changes depends upon the number of failed elements and their location within the bank.

The main purpose of the capacitor unbalance protection is to give an alarm or to disconnect the entire capacitor bank when unbalances across healthy capacitors, adjacent to a failed capacitor, are excessive. Normally not more than 10 % unbalance should be allowed (unbalance limit according to (IEC 60871-1 Shunt capacitors for a.c. power systems having a rated voltage above 1000 V - Part 1: General).

If an externally fused capacitor is disconnected by its fuse, a larger voltage and current change is obtained than if single elements are disconnected by internal fuses.

This kind of protection prevents steady-state overvoltage and accelerated aging of the capacitor elements.

Another function of the unbalance protection is to remove the bank from service for a fault not isolated by a fuse or to protect banks that are not internally or externally fused. Unbalance protection is not a replacement for short-circuit protection.

The related standard permits a considerable amount of asymmetry, which can be up to 10%, consequently in healthy state a relatively high current can flow through the current transformer. At commissioning the unbalance protection function stores the vector position and the value of the “natural” unbalance currents as three reference currents $\Delta Iref$ and additionally those of one of the phase currents $Iphase_{ref}$ *(= IL1).*

The reference currents are corrected according to the actually measured phase currents *Iphase* $Iphase$ and the stored $Iphase_{ref}$ $Iphase_{ref}$ reference phase current.

$$\Delta Iref_{corr} = \Delta Iref \frac{Iphase}{Iphase_{ref}}$$

where all current values are complex Fourier base harmonic vectors for the phases individually:

$\Delta Iref$	reference current measured in the bridge of all three phases at commissioning,
$\Delta Iref_{corr}$	corrected reference currents of all three phases,
Iphase	measured phase current of one of the three phases (*IL1)*,
$Iphase_{ref}$	phase current of one of the three phases measured at commissioning (*IL1).*

The correction is performed with one phase current in all three phases separately.

NOTE: This approach using a single phase current supposes that the asymmetry of the network itself does not change, or the changes are cleared with high speed by other protection functions. If considerable steady-state changes in the symmetry of the network are expected, then the measurement and correction based a single phase current is not sufficient. In this case please consult Protecta Co. Ltd. for solution.

If there are no changes inside the capacitor then no change can be detected in the actually measured unbalance current related to the corrected reference current.

Accordingly the energizing quantity for evaluation is the difference of the measured currents in the bridges and the corrected reference current:

$$G = dI = \Delta I - \Delta Iref_{corr}$$

where all current values are complex Fourier base harmonic vectors:

ΔI	currents measured in the bridge,
$\Delta Iref_{corr}$	corrected reference currents (see above).

NOTE: The correction is performed in all three phases separately with one phase current.

This is the task of the commissioning to store the reference values for the bridge currents $\Delta Iref$, and that of one of the phase currents $Iphase_{ref}$ in the memory.

For this purpose the function block has a dedicated binary input: *Calib*. This input must be activated for the calibration. For the physical means for activation see the description of the configuration. This input may be programmed by the user using the graphic logic editor.

The calibration at the moment of activation can be performed only if the conditions for calibration are fulfilled. The conditions for calibration are:

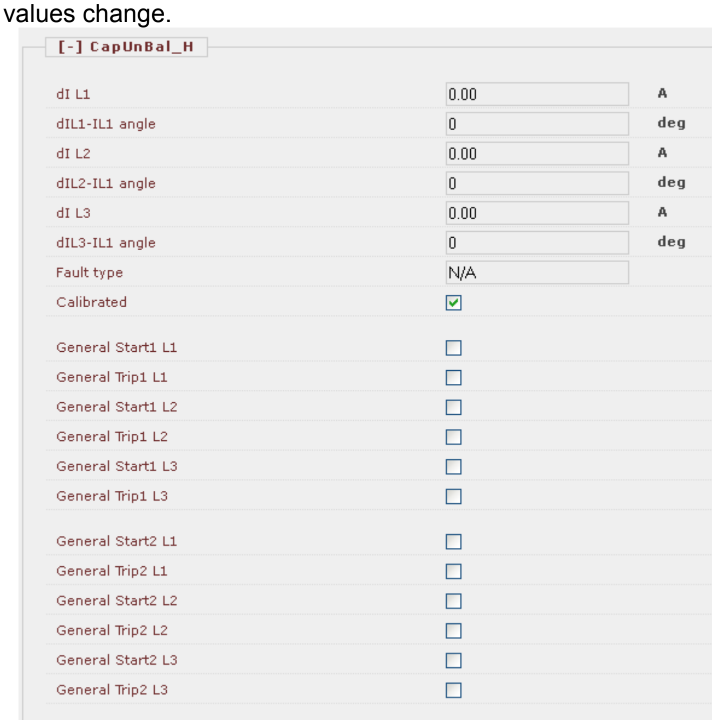
- The phase currents have to be less than 2*In of the current input,
- The phase currents have to be above 70% of the rated capacitor current,
- The bridge currents have to be less than the value set by the dedicated parameter.

The calibrated state is indicated by the dedicated binary output of the function *Calibrated*. This output gets in “true” state only if the calibration procedure in all three phases was successful.

The calibration values are stored in non-volatile memory, separately for each parameter set.

The *Reset* binary input resets the calibrated state.

Among the “on-line” information the function continuously displays the ΔI currents and their angles measured in the bridges. At the moment of calibration this vectors reset to zero vector (see Figure below, dI=ΔI). At the same time the “*Calibrated*” field on the screen displays a check-mark. If however after calibration any changes happen within the capacitor bank then the displayed values change.



The capacitor unbalance protection function is configured with two independent stages.

For the first stage definite time characteristic and several types of inverse characteristics can be selected.

The second stage has a definite time characteristic.

The inverse time operating characteristics are defined by the formula below:

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

where

t(G)(seconds)	theoretical operate time with constant value of *G*,
k, c	constants characterizing the selected curve (in seconds),
α	constants characterizing the selected curve (no dimension),
G	measured value of the characteristic quantity, Fourier base harmonic value, see section 1.2.3,
G_S	preset starting value of the characteristic quantity,
TMS	preset time multiplier (no dimension).

The constant values k, c and α of the standard dependent time characteristics, see below.

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

The end of the effective range of the inverse 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 setting. This delay is valid if it is longer than t(G), defined by the formula of the operating characteristics above.

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

Resetting characteristics of the inverse time delay is as follows.

- For IEC type characteristics the resetting is after a fix time delay defined by the parameter CapUnB1_Reset_TPar_ (Reset Time),
- 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, see section 1.2.3,
G_S	preset starting value of the characteristic quantity (CapUnB3_StCurr1_IPar_, Start current 1),
TMS	preset time multiplier (no dimension).

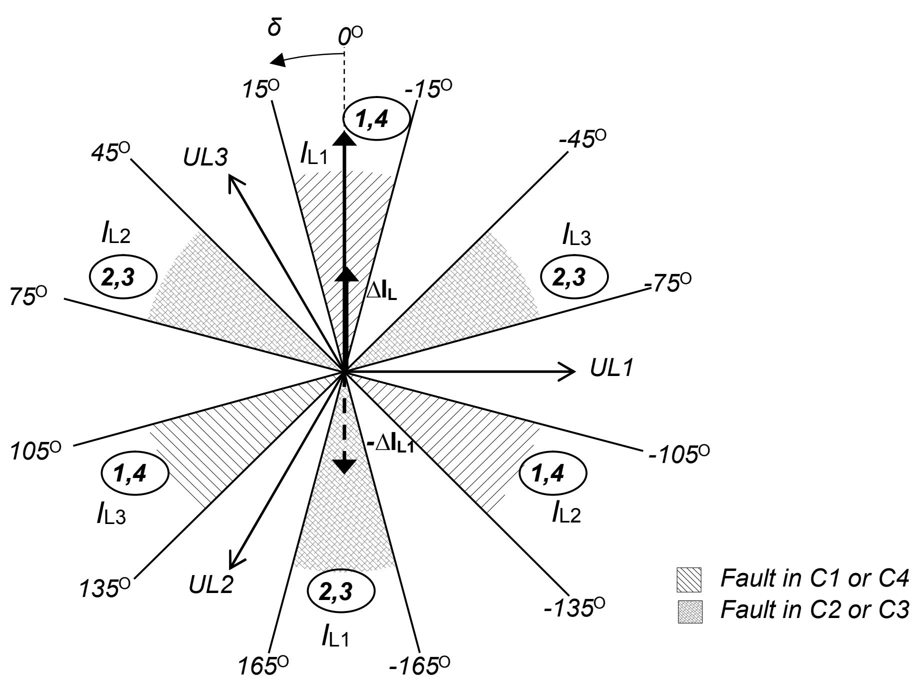
The resetting constants of the standard dependent time characteristics are shown below.

	IEC ref	Title	k_r	α
1	A	IEC Inv	Resetting after fix time delay, according to preset parameter CapUnB3_Reset_TPar_ "Reset Time"	
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

Fault location

The vector measurement enables identification of the faulty capacitor unit. For the explanation of the principle of fault location consider the positive direction of the current I_{phase} and ΔI as indicated in Figure above, the current ΔI flows from capacitor unit 1 to capacitor unit 2.

Now consider a fault in phase L1, inside unit 1 in the capacitor C1, which increases the capacitance value, consequently decreases the impedance related to the impedance of C3. The current in C1 increases related to the current of C3, consequently the current flows from the unit 1 towards the unit 2. It is obvious that this current is in phase with the current of the original phase capacitor "*IL1*", as it is indicated in Figure below. Consequently the Δ*I* current measured in the bridge is in phase with the current of the original phase capacitor. To permit some asymmetry changes in the network and some measuring error, this current is inside the shaded area between -15 ° and +15 °. The on-line measurement will display the increased "*dI*" value with "*dI-IL1 angle*" in this range. The related event indicates "L1-1". The same current vector flows if the value of the capacitor 4 increases, here the event should be "L1-4". Based on the current measurement these two events cannot be separated so the common fault identification is: " L1-1 or L1-4"



If the capacitor elements are not fused then the breakdown of a capacitor element will short-circuit a “layer” of capacitors. The capacitance increases and consequently also the capacitive current increases. This case was described in the explanation above.

If however the capacitor elements are individually fused then the breakdown of a capacitor element is disconnected from the “layer” of capacitors. The resultant capacitance decreases, and the result is opposite to the explanation in Figure above.

For correct evaluation the information is needed: whether internal fuses are applied or not. This is to be set by the Boolean parameter *Internal fuse*.

The event list related to the capacitor faults can contain the following messages:

Message	Explanation
L1-1 or L1-4	Fault in phase L1, C1 or C4
L2-1 or L2-4	Fault in phase L2, C1 or C4
L3-1 or L3-4	Fault in phase L3, C1 or C4
L1-2 or L1-3	Fault in phase L1, C2 or C3
L2-2 or L2-3	Fault in phase L2, C2 or C3
L3-2 or L3-3	Fault in phase L3, C2 or C3

NOTE: The fault location is active in “*Calibrated*” state only. The event is registered at the moment of trip command generation.

Technical data

Function	Value	Accuracy
Pick-up starting accuracy	$20 \le G_S \le 1000$	< 5 %
Pickup time	< 40 ms	
Angle accuracy		<1 degree
Reset ratio	0,9	
Reset time Dependent time char. Definite time char.	approx 60 ms	< 2% or ±35 ms, whichever is greater
Operate time accuracy		±5% or ±15 ms, whichever is greater

Parameters

Enumerated parameters

Parameter name	Title	Selection range	Default
Enabling or disabling the capacitor unbalance protection function			
CapUnB3_Oper1_EPar_	Operation Stage 1	Off, DefinitTime, IEC Inv, IEC VeryInv, IEC ExtInv, IEC LongInv, ANSI Inv, ANSI ModInv, ANSI VeryInv, ANSI ExtInv, ANSI LongInv, ANSI LongVeryInv, ANSI LongExtInv	Off
CapUnB3_Oper2_EPar_	Operation Stage2	Off, On	Off

Boolean parameters

Parameter name	Title	Default	Explanation
CapUnB3_IntFuse_BPar_	Internal fuse	0	0 means no internal fuse 1 means capacitor units with internal fuse

Integer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Current setting for the capacitor unbalance protection function, first stage						
CapUnB3_StCurr1_IPar_	Start Current 1	%	10	100	1	10
Current setting for the capacitor unbalance protection function, second stage						
CapUnB3_StCurr2_IPar_	Start Current 2	%	5	100	1	10
Nominal current of the capacitor, as percent of the rated input current						
CapUnB3_NomCurr_IPar_	Inom capacitor	%	15	120	1	100
ΔI setting, at calibration the current in the bridge must be below this level						
CapUnB3_dIMax_IPar_	dI maxcalib	%	5	50	1	10

Float point parameter

Parameter name	Title	Dim.	Min	Max	Default
Time multiplier setting for the inverse type characteristics					
CapUnB3_Multip_FPar_	Time Multiplier	sec	0.05	999	1.0

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Minimum time delay for the inverse type characteristics, first stage (valid, if this characteristic is selected)						
CapUnB3_MinDel_TPar_	Min Time Delay	msec	0	60000	1	100
Definite time delay for the first stage (valid, if this characteristic is selected)						
CapUnB3_DefDel_TPar_	Definite Time Delay	msec	0	60000	1	1000
Reset time setting, first stage						
CapUnB3_Reset_TPar_	Reset Time	msec	0	60000	1	100
Definite time delay for the second stage						
CapUnB3_Delay2_TPar_	Delay Stage 2	msec	0	60000	1	1000

Binary output status signals

Binary output status signals	Signal title	Explanation
CapUnB3_GenSt1L1_GrI_	General Start 1 L1	General start signal for stage 1 phase L1
CapUnB3_GenTr1L1_GrI_	General Trip 1 L1	General trip command for stage 1 phase L1
CapUnB3_GenSt2L1_GrI_	General Start 2 L1	General start signal for stage 2 phase L1
CapUnB3_GenTr2L1_GrI_	General Trip 2 L1	General trip command for stage 2 phase L1
CapUnB3_GenSt1L2_GrI_	General Start 1 L2	General start signal for stage 1 phase L2
CapUnB3_GenTr1L2_GrI_	General Trip 1 L2	General trip command for stage 1 phase L2
CapUnB3_GenSt2L2_GrI_	General Start 2 L2	General start signal for stage 2 phase L2
CapUnB3_GenTr2L2_GrI_	General Trip 2 L2	General trip command for stage 2 phase L2
CapUnB3_GenSt1L3_GrI_	General Start 1 L3	General start signal for stage 1 phase L3
CapUnB3_GenTr1L3_GrI_	General Trip 1 L3	General trip command for stage 1 phase L3
CapUnB3_GenSt2L3_GrI_	General Start 2 L3	General start signal for stage 2 phase L3
CapUnB3_GenTr2L3_GrI_	General Trip 2 L3	General trip command for stage 2 phase L3
CapUnB1_Calib_GrI_	Calibrated	True, if the function has been calibrated

Binary input status signals

The conditions of the binary input signals are defined by the user, applying the graphic logic editor.

Binary input status signals	Signal title	Explanation
CapUnB3_Reset_GrO_	Reset	Resetting the calibrated state
CapUnB3_Calibr_GrO_	Calibr	Binary input for calibration
CapUnB3_Blk_GrO_	Blk	Blocking input

1.3.1.7 Capacitor overvoltage protection function

The power frequency voltage of a network can be high due to voltage fluctuation and regulation or due to the voltage rise at light load. The shunt capacitors connected to the network need protection against high steady state voltage, because the voltage over the rated level accelerates the aging of the material inside the capacitor.

A moderated overvoltage can be tolerated for a relatively long time; the high overvoltages however need fast disconnection. The characteristic of this overvoltage protection function is a certain kind of inverse type characteristics, defined in international standards (IEC 60871-1 Shunt capacitors for a.c. power systems having a rated voltage above 1000 V - Part 1: General, or ANSI/IEEE 37.99 Capacitor Banks, Guide for Protection of Shunt).

The function has additionally a definite time warning stage, the setting of which is independent of that of the inverse type tripping stage.

The capacitors on a network in most cases have no dedicated voltage measurement, the voltage transformers on the busbar measure voltage even in disconnected state of the capacitors. To avoid these kinds of problems, this protection function measures the currents in the phases of the capacitor, and calculates the voltages in the phases independently. The warning and trip decision is based on the calculated voltage values. The phase voltages as a function of the time can be calculated by integration of the current time function of the phases:

$$u(t) = \frac{1}{C}\int i(t)dt$$

This integral, which is evaluated using a simple numerical method, considers also the higher harmonic contents of the current up to the 10^{th} harmonic. All harmonics with higher ordinal number are filtered out.

The function does not consider the transient values caused by switching procedures, these values are filtered out. The decision is based on the steady state values, since the time delay can be several minutes, and only the symmetrical peak values are considered. The calculated and found peak values are related to the rated power frequency peak voltage. If the voltage is above the setting value then the time is weighted according to the inverse type characteristic, and based on the time multiplier setting (K). These values are added (accumulated). If this accumulated time exceeds the limit, the function generates the trip command.

The international standards (IEC 60871-1 or ANSI/IEEE 37.99, see above) define the operate time, as the maximum duration for some values of the power frequency voltage. Based on these standards the characteristic is defined on the following discrete values (these admissible voltage level in service shown in Table below):

Voltage factor * U_N V R.M.S.	Maximum duration defined in the standards	Maximum duration in seconds
1	Continuous	
1.15	30 min in every 24 h	1800 s
1.2	5 min	300 s
1.3	1 min	60 s
1.4	15 s	15 s
1.7	1 s	1 s
2.0	0.3 s	0.3 s
2.2	0.12 s	0.12 s

Additionally the characteristic can be modified by the time multiplier setting (K).

According to the standards, the amplitudes of the overvoltages that may be tolerated without significant deterioration of the capacitor depend on:

- their total duration,
- their total number and
- the capacitor temperature.

The *total duration* of the overvoltage is covered by the accumulation.

The *number of the overvoltages* is considered in this protection function as follows:
If the voltage peak is above 1.1 * U_{Npeak} then additionally to the accumulation, a reset time measurement is started. Then

- If the accumulated value reaches the trip value then the trip command is generated.
- If the voltage peak drops below 1 * U_{Npeak} then both the integral and the reset time measurement reset to zero.
- If the voltage peak drops below 1.1 * U_{Npeak} but above 1 * U_{Npeak} then the integral is “frozen”, and the reset time keeps on counting. In this state
    - If the voltage peak is above 1.1 * U_{Npeak} again then the accumulation is going on starting with the “frozen” value.
    - If the reset time measurement gets above the reset time setting without trip generation then both the integral and the reset time measurement reset to zero.

Concerning the effect of the *ambient temperature*, this simple protection function does not include direct ambient temperature measurement. It is the task of the user to set the appropriate time multiplier value (K), to accelerate the trip command for the worst case expected temperature (or delay the trip command if the ambient temperature is continuously below the rated temperature of the capacitor type test).

This protection function has additionally a definite time warning stage, the setting of which is independent of that of the inverse type tripping stage.

Technical data

Function	Value	Accuracy
Pick-up starting accuracy		< 1%
Operate time accuracy	at In=100 %	<5 %

Parameters

Enumerated parameters

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

Integer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Capacitor nominal current, related to the rated current of the current transformer. The integral of this current defines the nominal basic harmonic voltage, the peak value of which is the reference for overvoltage detection.						
CapOV_NomCurr_IPar_	Nominal current	%	10	120	1	100
Value of the overvoltage, related to the rated voltage of the capacitor, to start the warning stage of the function						
CapOV_I2Start_IPar_	Stage2	%	80	120	1	100
Reset time setting for Stage 1						
CapOV_Reset_IPar_	ResetTime_Stage1	sec	1	60000	1	3600
Definite time delay for Stage 2						
CapOV_Delay2_IPar_	Delay Stage2	sec	1	3600	1	60

Float point parameter

Parameter name	Title	Dim.	Min	Max	Default
Time multiplier for the inverse type characteristic					
CapOV_K_FPar_	K	-	0.20	2.00	1.00

Binary output status signals

Binary output status signals	Signal title	Explanation
CapOV_Str1L1_Grl_	Start1 L1	Start of Stage 1 in phase L1
CapOV_Str1L2_Grl_	Start1 L2	Start of Stage 1 in phase L2
CapOV_Str1L3_Grl_	Start1 L3	Start of Stage 1 in phase L3
CapOV_Str2L1_Grl_	Start2 L1	Start of Stage 2 in phase L1
CapOV_Str2L2_Grl_	Start2 L2	Start of Stage 2 in phase L2
CapOV_Str2L3_Grl_	Start2 L3	Start of Stage 2 in phase L3
CapOV_Trip1_Grl_	Trip1	Trip command of Stage 1
CapOV_Trip2_Grl_	Trip2	Trip command of Stage 2 (usually assigned as Warning)

Binary input status signals

The conditions of the binary input signal are defined by the user, applying the graphic logic editor.

Binary input status signal	Title	Explanation
CapOV_Blk_GrO_	Block	Output status of a graphic equation defined by the user to disable the capacitor overvoltage protection function.

1.3.1.8 Definite time undervoltage protection function (TUV27)

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

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

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

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

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

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

Technical data

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

Table 1 Technical data of the definite time undervoltage protection function

Parameters

Enumerated parameter

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

Table 2 The enumerated parameter of the definite time undervoltage protection function

Integer parameters

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

Table 3 The integer parameters of the definite time undervoltage protection function

Boolean parameter

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

Table 4 The boolean parameter of the definite time undervoltage protection function

Timer parameters

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

Table 5 The timer parameter of the definite time undervoltage protection function

1.3.1.9 Definite time overvoltage protection function (TOV59)

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

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

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

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

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

Technical data

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

Table 6 Technical data of the definite time overvoltage protection function

Parameters

Enumerated parameter

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

Table 7 The enumerated parameter of the definite time overvoltage protection function

Integer parameter

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

Table 8 The integer parameter of the definite time overvoltage protection function

Boolean parameter

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

Table 9 The boolean parameter of the definite time overvoltage protection function

Timer parameter

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

Table 10 The timer parameter of the definite time overvoltage protection function

1.3.1.10 Residual definite time overvoltage protection function (TOV59N)

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

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

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

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

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

Technical data

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

Table 11 Technical data of the residual definite time overvoltage protection function

Parameters

Enumerated parameter

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

Table 12 The enumerated parameter of the residual definite time overvoltage protection function

Integer parameter

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

Table 13 The integer parameter of the residual definite time overvoltage protection function

Boolean parameter

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

Table 14 The boolean parameter of the residual definite time overvoltage protection function

Timer parameter

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

Table 15 The time parameter of the residual definite time overvoltage protection function

1.3.1.11 Trip logic (TRC94)

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

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

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

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

Technical data

Function		Accuracy
Impulse time duration	Setting value	<3 ms

Table 16 Technical data of the simple trip logic function

Parameters

Enumerated parameter

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

Tables 17 The enumerated parameter of the decision logic

Timer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Minimum duration of the generated impulse						
TRC94_TrPu_TPar_	Min Pulse Duration	msec	50	60000	1	150

Table 18 Timer parameter of the decision logic

1.3.2 Control functions

1.3.2.1 Circuit breaker control function block (CB1Pol)

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

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

Main features:

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

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

Technical data

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

Table 19 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 20 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 21 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 22 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”.

1.3.2.2 Disconnector control function (DisConn)

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

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

Main features:

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

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

Technical data

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

Table 23 Technical data of the disconnector control function

Parameters

Enumerated parameters

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

**ControlModel*

- Direct normal: only command transmission
- Direct enhanced: command transmission with status check and command supervision

- SBO enhanced: Select Before Operate mode with status check and command supervision

Table 24 Enumerated parameters of the disconnector control function

Boolean parameter

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

Table 25 Boolean parameter of the disconnector control function

Timer parameters

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

Table 26 Timer parameters of the disconnector control function

Available internal status variable and command channel

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

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

The available control channel to be selected is:

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

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

1.3.3 Measuring functions

The measured values can be checked on the touch-screen of the device in the "On-line functions" page, or using an Internet browser of a connected computer. The displayed values are secondary voltages and currents.

Analog value	Explanation
CT4_ module	
Current Ch - I1	RMS value of the Fourier fundamental harmonic current component in phase L1
Angle Ch - I1	Phase angle of the Fourier fundamental harmonic current component in phase L1*
Current Ch - I2	RMS value of the Fourier fundamental harmonic current component in phase L2
Angle Ch - I2	Phase angle of the Fourier fundamental harmonic current component in phase L2*
Current Ch - I3	RMS value of the Fourier fundamental harmonic current component in phase L3
Angle Ch - I3	Phase angle of the Fourier fundamental harmonic current component in phase L3*
Current Ch - I4	RMS value of the Fourier fundamental harmonic current component in Channel I4
Angle Ch - I4	Phase angle of the Fourier fundamental harmonic current component in Channel I4*
VT4 module	
Voltage Ch – U1	RMS value of the Fourier fundamental harmonic voltage component in phase L1
Angle Ch – U1	Phase angle of the Fourier fundamental harmonic voltage component in phase L1
Voltage Ch – U2	RMS value of the Fourier fundamental harmonic voltage component in phase L2
Angle Ch – U2	Phase angle of the Fourier fundamental harmonic voltage component in phase L2*
Voltage Ch – U3	RMS value of the Fourier fundamental harmonic voltage component in phase L3
Angle Ch – U3	Phase angle of the Fourier fundamental harmonic voltage component in phase L3*
Voltage Ch – U4	RMS value of the Fourier fundamental harmonic voltage component in Channel U4
Angle Ch – U4	Phase angle of the Fourier fundamental harmonic voltage component in Channel U4*
CapUnB1 module	
dI	ΔI current measured between the neutral points
dI-IL1 Angle	ΔI current angle between the neutral points
CapUnB3 module	
dI L1	ΔI current measured in the bridge phase L1
dIL1-IL1 Angle	ΔI current angle in the bridge phase L1
dI L2	ΔI current measured in the bridge phase L2
dIL2-IL1 Angle	ΔI current angle in the bridge phase L2
dI L3	ΔI current measured in the bridge phase L3
dIL3-IL1 Angle	ΔI current angle in the bridge phase L4

* The reference angle is the phase: "Voltage Ch - U1" if the voltage functions are selected, in the other case the reference angle is the phase: "Current Ch - I1"

Table 27 The measured analogue values

1.3.3.1 Voltage input function (VT4)

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

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

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

The role of the voltage input function block is to

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

Operation of the voltage input algorithm

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

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

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

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

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

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

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

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

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

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

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

Parameters

Enumerated parameters

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

Table 28 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 29 The integer parameter of the voltage input function

Floating point parameters

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

Table 30 The floating point parameters of the voltage input function

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

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

Table 31 Technical data of the voltage input

Measured values

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

Table 32 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”.)

NOTE10: The reference vector (vector with angle 0 degree) is the vector calculated for the first voltage input channel of the first applied voltage input module.

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

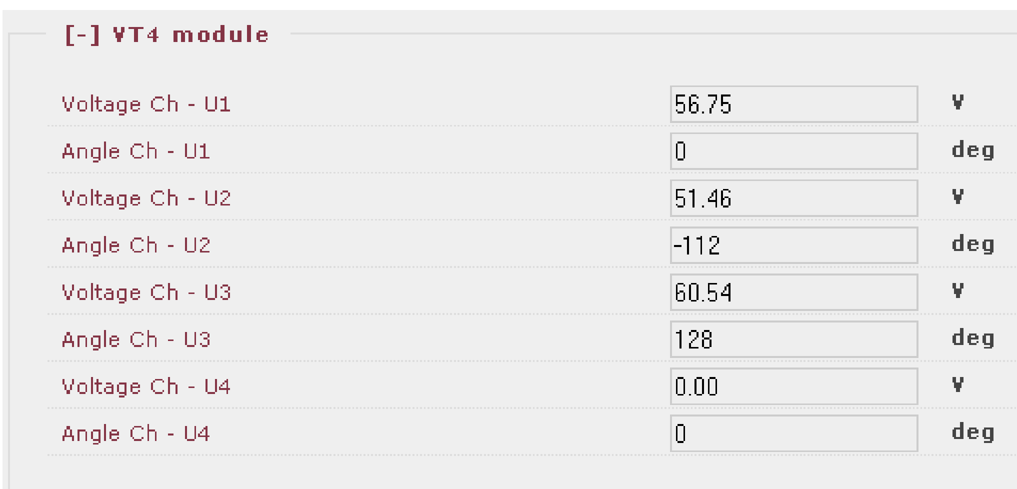


Figure 1 Example: On-line displayed values for the voltage input module

1.3.3.2 Current input function (CT4)

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

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

The role of the current input function block is to

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

Operation of the current input algorithm

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

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

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

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

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

Technical data

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

Table 33 Technical data of the current input

Parameters

Enumerated parameters

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

Table 34 The enumerated parameters of the current input function

Floating point parameters

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

Table 35 The floating point parameters of the current input function

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

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

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

Table 36 The measured analogue values of the current input function

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

NOTE10: The reference of the vector position depends on the device configuration. If a voltage input module is included, then the reference vector (vector with angle 0 degree) is the vector calculated for the first voltage input channel of the first applied voltage input module. If no voltage input module is configured, then the reference vector (vector with angle 0 degree) is the vector calculated for the first current input channel of the first applied current input module.

Figure 2 shows an example of how the calculated Fourier components are displayed in the on-line block. (See the document “EuroProt+ Remote user interface description”.)

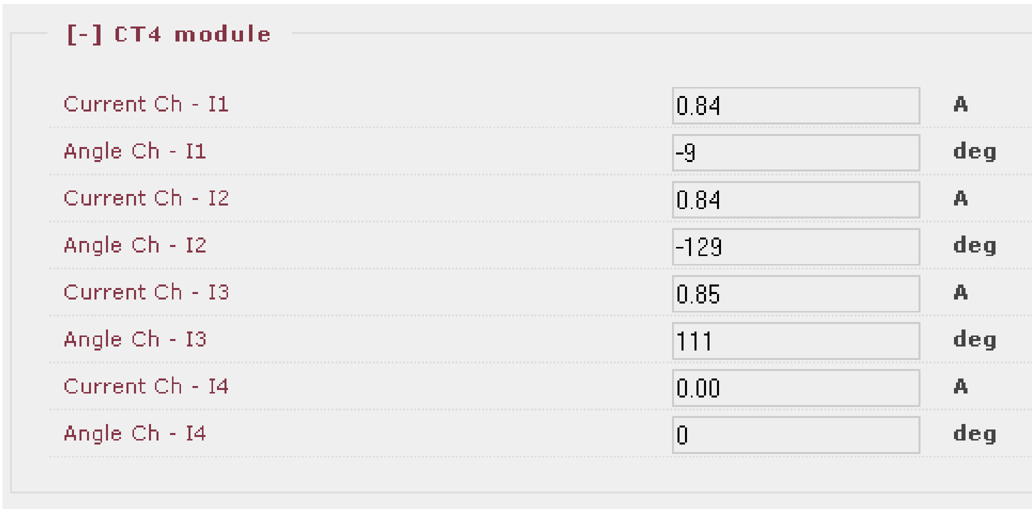


Figure 2 Example: On-line displayed values for the current input module

1.3.4 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.

Event	**Explanation**
Common	
Mode of device	Operating mode of the device
Health of device	Health state of the device
Current unbalance protection function (VCB60)	
General Start	Current unbalance protection function general start
General Trip	Current unbalance protection function general trip
Three-phase overcurrent protection function (TOC51_1)	
Start L1	Low setting stage start signal in phase L1
Start L2	Low setting stage start signal in phase L2
Start L3	Low setting stage start signal in phase L3
General Start	Low setting stage general start signal
General Trip	Low setting stage general trip command
Three-phase overcurrent protection function (TOC51_2)	
Start L1	High setting stage start signal in phase L1
Start L2	High setting stage start signal in phase L2
Start L3	High setting stage start signal in phase L3
General Start	High setting stage general start signal
General Trip	High setting stage general trip command
Residual overcurrent protection function, both of branches *(TOC51N_1)*	
General Start	Low setting stage general start signal
General Trip	Low setting stage general trip command
Residual overcurrent protection function, both of branches (TOC51N_2)	
General Start	High setting stage general start signal
General Trip	High setting stage general trip command
Capacitor overvoltage protection function (CapOV)	
Start 1	Start of Stage 1
Start 2	Start of Stage 2
Trip 1	Trip command of Stage 1
Trip 2	Trip command of Stage 2
Definite time overvoltage protection function (TOV59_1)	
Start L1	Low setting stage of start signal of phase L1
Start L2	Low setting stage of star signal of phase L2
Start L3	Low setting stage of star signal of phase L3
General Start	Low setting stage of general start signal
General Trip	Low setting stage of general trip command
Definite time overvoltage protection function (TOV59_2)	
Start L1	High setting stage of start signal of phase L1
Start L2	High setting stage of star signal of phase L2
Start L3	High setting stage of star signal of phase L3
General Start	High setting stage of general start signal
General Trip	High setting stage of general trip command
Definite time undervoltage protection function (TUV27_1)	
Start L1	Low setting stage of start signal of phase L1

Start L2	Low setting stage of star signal of phase L2
Start L3	Low setting stage of star signal of phase L3
General Start	Low setting stage of general start signal
General Trip	Low setting stage of general trip command
Definite time undervoltage protection function (TUV27_2)	
Start L1	High setting stage of start signal of phase L1
Start L2	High setting stage of star signal of phase L2
Start L3	High setting stage of star signal of phase L3
General Start	High setting stage of general start signal
General Trip	High setting stage of general trip command
Definite time overvoltage protection function (TOV59_1)	
General Start	Low setting stage of general start signal
General Trip	Low setting stage of general trip command
Definite time overvoltage protection function (TOV59_2)	
General Start	High setting stage of general start signal
General Trip	High setting stage of general trip command
Capacitor unbalance protection function (UnCap)	
General start 1	General Start of Stage 1
General start 2	General Start of Stage 2
General Trip 1	General Trip command of Stage 1
General Trip 2	General Trip command of Stage 2
Loss-of-load (undercurrent) protection function (TUC37)	
General Start	General Start
General Trip	General Trip command
Trip logic function (TRC94)	
General Trip	General trip command of the trip logic

1.3.5 Disturbance recorder

The DTIVA-E10-Feeder_H configuration contains a disturbance recorder function. The details are described on the website in the following document: **"Disturbance recorder function block description".**

The recorded analog channels:

Recorded analog signals	Explanation
*UL1	Measured voltage of line 1
*UL2	Measured voltage of line 2
*UL3	Measured voltage of line 3
*Uo	Calculated voltage of the fourth voltage input channel (Uo)
IL1	Measured current in line 1
IL2	Measured current in line 2
IL3	Measured current in line 3
I4	Measured current of the fourth current input channel (Io)

*If the voltage-based functions are selected

Table 37 Disturbance recorder, recorded analog channels

The recorded binary channels:

Recorded binary signal	Explanation
General Trip	General trip command
CapUnB1 or CapUnB3 Gen Trip 1	Trip command of the stage 1 of the capacitor unbalance function
CapUnB1 or CapUnB3 Gen Trip 2	Trip command of the stage 2 of the capacitor unbalance function
TOC51 Trip Low	Trip command of the low setting three-phase overcurrent function
TOC51 Trip High	Trip command of the high setting stage three-phase overcurrent function
TOC51N Trip 1	Trip command of the low setting stage residual overcurrent function
TOC51N Trip 2	Trip command of the high setting stage residual overcurrent function
TUC37	Trip command of the loss of load (undercurrent) function
*TOV59 Trip 1	Trip command of the low setting stage definite time overvoltage protection function
*TOV59 Trip 2	Trip command of the high setting stage definite time overvoltage protection function
*TUV27 Trip 1	Trip command of the low setting stage definite time undervoltage protection function
*TUV27 Trip 2	Trip command of the low setting stage definite time undervoltage protection function
*TOV59N Trip 1	Trip command of the low setting stage res. overvoltage protection function
*TOV59N Trip 2	Trip command of the high setting stage res. overvoltage protection function

Table 38 Disturbance recorder, recorded binary channels

Enumerated parameter:

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

Table 39 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	50	500	1	200
Post-fault time:						
DRE_PostFault_TPar_	PostFault	msec	50	1000	1	200
Overall-fault time limit:						
DRE_MaxFault_TPar_	MaxFault	msec	200	5000	1	1000

Table 40 The timer parameters of the disturbance recorder function

1.3.6 TRIP contact assignment

The outputs of the “trip logic functions” are connected directly to the contacts of the PSTP+/2101 module in position “**A**”.

Binary status signal	**Title**	Connected to the contact PSTP+/2101 module in position “A”
TRC94_GenTr_Grl_	General Trip	Trip

Table 41 The connected signal of the phase-selective trip logic function

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

The factory defined signals are listed in Table *42*.

Input	**Binary status signal**	**Explanation**
Trip	-	-
Block	n.a.	Blocking the outputs of the trip logic function
Ext Open	n.a.	External open command

Table 42 The factory defined binary input signals of the trip logic function

The user defined signals are listed in Table *43*.

Input	**Binary status signal**	**Explanation**
Trip	TOC51_GenTr_Grl_1 OR TOC51_GenTr_Grl_2 OR TOC51N_GenTr_Grl_1 OR TOC51N_GenTr_Grl_2 OR TUC37_GenTr_Grl_ OR CapUnB_GenTr_Grl_ OR TOC37_GenTr_Grl_ OR *TUV27_GenTr_Grl_11 OR *TUV27_GenTr_Grl_1 OR *TOV59_GenTr_Grl_2 OR	General trip command of the overcurrent protection function for the low setting stage OR General trip command of the overcurrent protection function for the high setting stage OR General trip command of the residual overcurrent protection function for the low setting OR General trip command of the residual overcurrent protection function for the high setting stage OR General trip command of the loss of load (undercurrent) protection function OR General trip command of the capacitor unbalance protection function OR General trip command of the undercurrent protection function General trip command of undervoltage protection function for the low setting stage OR General trip command of undervoltage protection function for the high setting stage OR General trip command of overvoltage protection function for the low setting stage OR General trip command of overvoltage protection

	*TOV59_GenTr_GrI_22 OR TOV59N_GenTr_GrI_1 OR *TOV59N_GenTr_GrI_2	function for the high setting stage OR General trip command of res. overvoltage protection function for the low setting stage OR General trip command of res. overvoltage protection function for the high setting stage
Block	TRC94_Blk_GrO_	Blocking for the primary side
Ext Open	TRC94_ExtOpen_GrO	External open command for the primary side

Table 43 The user defined binary input signals of the phase-selective trip logic function

1.4 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. The following table shows the LED assignment of the E10-Feeder configuration.

LED	Explanation
General Trip	Trip command generated by the TRC94 function
OC Trip Low	Trip command generated by the low setting stage phase overcurrent protection functions
OC Trip High	Trip command generated by the high setting stage phase overcurrent protection functions
OCN Trip	Trip command generated by the residual overcurrent protection functions for the both of branches
CapUn Trip	Trip command of the capacitor unbalance protection function
UC Trip	Trip command of the loss of load (undercurrent) protection function
LED7	Free LED
*OV Trip Low	Trip command generated by the low setting stage overvoltage protection functions
*OV Trip High	Trip command generated by the high setting stage overvoltage protection functions
*UV Trip Low	Trip command generated by the low setting stage undervoltage protection functions
*UV Trip High	Trip command generated by the high setting stage undervoltage protection functions
*OVN Trip Low	Trip command generated by the low setting stage res. undervoltage protection functions
*OVN Trip High	Trip command generated by the high setting stage res. undervoltage protection functions
LED15	Free LED
LED16	Free LED

Table 44 The LED assignment