

**EURO**PROT +

**E4-TR  
configuration description  
(Type: DTRV)**



**Document ID: PP-13-20402  
Budapest, May 2014**

## E4-TR configuration description

---

### User's manual version information

Version	Date	Modification	Compiled by
	17. 10. 2011		Petri
1.0	19.05.2014	Modified: 1.1.3 Hardware configuration Added: 2 External connection	Tóth

CONTENTS

1	Configuration description.....	4
1.1	Application.....	4
1.1.1	Protection functions.....	4
1.1.2	Measurement functions.....	5
1.1.3	Hardware configuration.....	6
1.1.4	The applied hardware modules.....	7
1.2	Meeting the device.....	8
1.3	Software configuration.....	9
1.3.1	Protection functions.....	9
1.3.1.1	Three-phase instantaneous overcurrent protection function (IOC50).....	10
1.3.1.2	Three-phase time overcurrent protection function (TOC51).....	11
1.3.1.3	Residual instantaneous overcurrent protection function (IOC50N).....	14
1.3.1.4	Residual overcurrent protection function (TOC51N).....	15
1.3.1.5	Negative sequence overcurrent protection function (TOC46).....	18
1.3.1.6	Line thermal protection function (TTR49L).....	21
1.3.1.7	Transformer differential protection function (DIF87_3w).....	24
1.3.1.8	Restricted earth fault protection function (DIF87N).....	27
1.3.1.9	Current unbalance function (VCB60).....	29
1.3.1.10	Breaker failure protection function (BRF50).....	31
1.3.1.11	Trip logic (TRC94).....	33
1.3.1.12	Dead line detection function (DLD).....	34
1.3.1.13	Current input function (CT4).....	35
2	External connections.....	38

## 1 Configuration description

The E4-TR 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 E4-TR factory configuration.

### 1.1 Application

The members of the DTRV product line are configured to protect and control high voltage/medium voltage transformers.

#### 1.1.1 Protection functions

The E4-TR configuration measures three phase currents and the zero sequence current component from all three sides of a three winding, three-phase transformer.

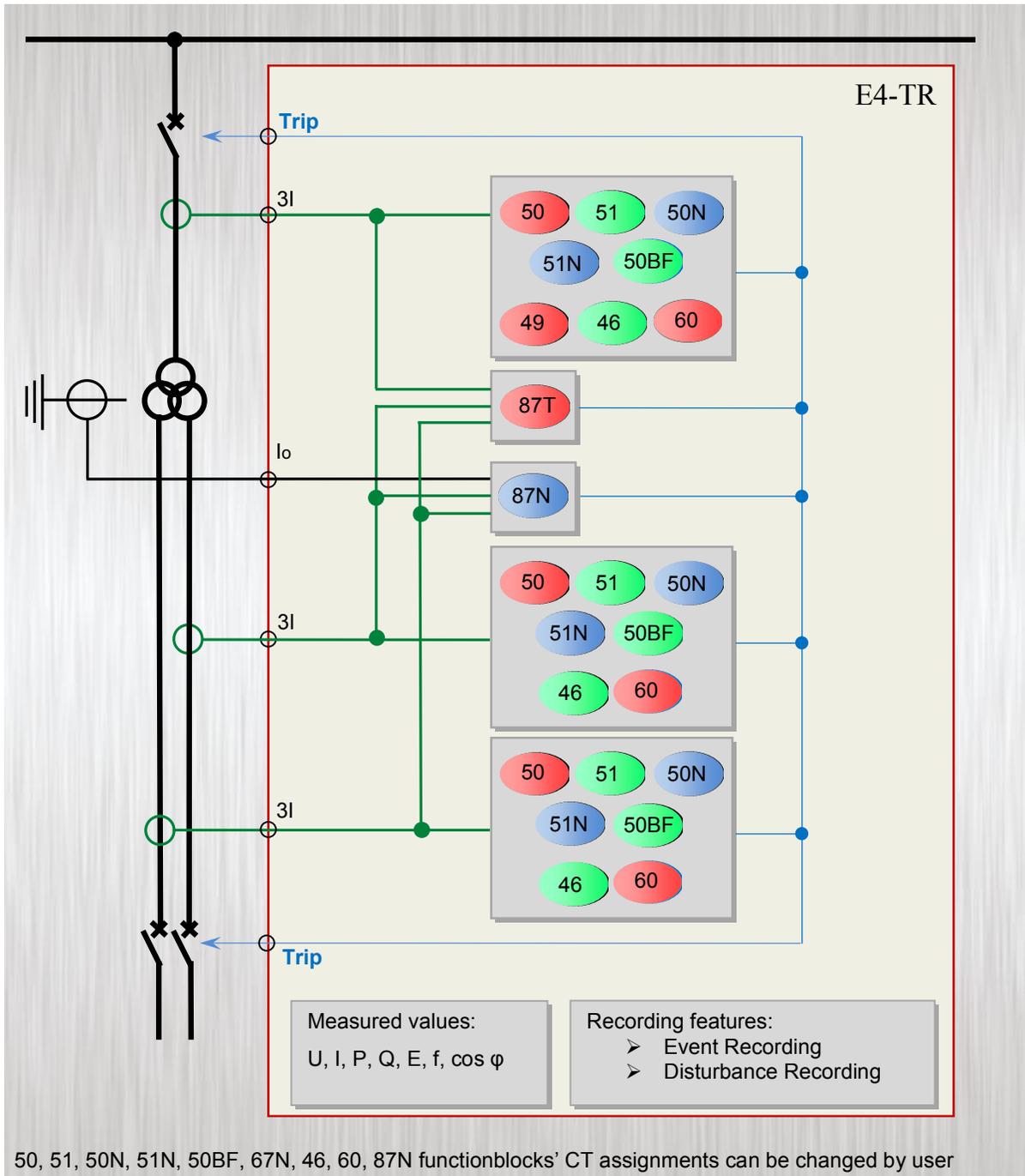
The main protection functions are transformer differential protection and restricted earth-fault protection functions.

The realized current-based protection functions, including thermal replica protection function and differential functions, are listed in the Table below.

Protection functions	IEC	ANSI	E4-TR
Three-phase instantaneous overcurrent protection	I >>>	50	X
Three-phase time overcurrent protection	I >, I >>	51	X
Residual instantaneous overcurrent protection	Io >>>	50N	X
Residual time overcurrent protection	Io >, Io >>	51N	X
Negative sequence overcurrent protection	I <sub>2</sub> >	46	X
Thermal protection	T >	49	X
Transformer differential	3I <sub>0</sub> T >	87T	3w
Restricted earth fault	REF	87N	X
Current unbalance protection		60	X
Breaker failure protection	CBFP	50BF	X

*Table 1 The protection functions of the E4-TR configuration*

The configured functions are drawn symbolically in the Figure below.



### 1.1.2 Measurement functions

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

Measurement functions	E4-TR
Current (I1, I2, I3, Io)	X
Supervised trip contacts (TCS)	X

Table 2 The measurement functions of the E4-TR configuration

### 1.1.3 Hardware configuration

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

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

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

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

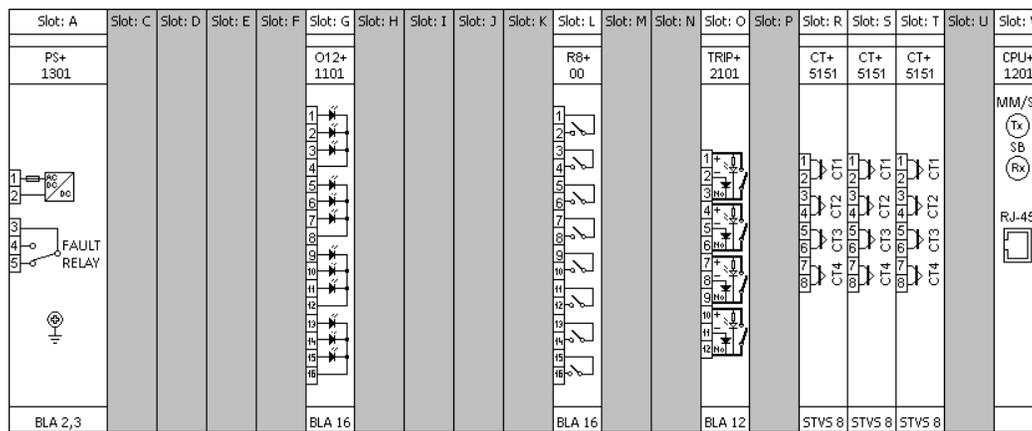


Figure 1 Basic module arrangement of the E4-TR configuration (84TE, rear view)

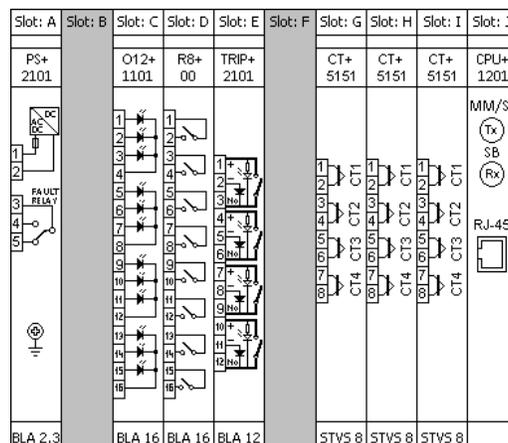


Figure 2 Basic module arrangement of the E4-TR configuration (42TE, rear view)

### 1.1.4 The applied hardware modules

The applied modules are listed in Table 4.

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

Module identifier	Explanation
PS+ 1301	Power supply unit (in 84TE)
PS+ 2101	Power supply unit (in 42TE)
O12+ 1101	Binary input module
R8+ 00	Signal relay output module
TRIP+ 2101	Trip relay output module
CT + 5151	Analog current input module
CPU+ 1201	Processing and communication module

*Table 4 The applied modules of the E4-TR configuration*

## 1.2 Meeting the device

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



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



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



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

## 1.3 Software configuration

### 1.3.1 Protection functions

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

Name	Title	Document
IOC50	3ph Instant.OC	<b><i>Three-phase instantaneous overcurrent protection function block description</i></b>
TOC51_low TOC51_high	3ph Overcurr	<b><i>Three-phase overcurrent protection function block description</i></b>
IOC50N	Residual Instant.OC	<b><i>Residual instantaneous overcurrent protection function block description</i></b>
TOC51N_low TOC51N_high	Residual TOC	<b><i>Residual overcurrent protection function block description</i></b>
TOC46	Neg. Seq. OC	<b><i>Negative sequence overcurrent protection function block description</i></b>
TTR49L	Thermal overload	<b><i>Line thermal protection function block description</i></b>
DIF87_3w	Transformer Differential	<b><i>Transformer differential protection function block description</i></b>
DIF87N	Restricted EF	<b><i>Restricted Earth Fault protection function block description</i></b>
VCB60	Current Unbalance	<b><i>Current unbalance function block description</i></b>
BRF50	Breaker failure	<b><i>Breaker failure protection function block description</i></b>
TRC94	Trip Logic	<b><i>Trip logic function block description</i></b>
DLD	Dead line detection	<b><i>Dead line detection protection function block description</i></b>
CT4		<b><i>Current input function block description</i></b>

*Table 5 Implemented protection functions*

### 1.3.1.1 Three-phase instantaneous overcurrent protection function (IOC50)

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

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

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

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

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

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

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

#### Technical data

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

\*Measured with signal contacts

Table 6 Technical data of of the instantaneous overcurrent protection function

#### Parameters

##### Enumerated parameter

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

Table 7 The enumerated parameter of the instantaneous overcurrent protection function

##### Integer parameter

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

Table 8 The integer parameter of the instantaneous overcurrent protection function

### 1.3.1.2 Three-phase time overcurrent protection function (TOC51)

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

\* Measured with signal relay contact

Table 9 Technical data of the instantaneous overcurrent protection function

**Parameters****Enumerated parameters**

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

Table 10 The enumerated parameters of the time overcurrent protection function

**Integer parameter**

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

Table 11 The integer parameter of the time overcurrent protection function

**Float point parameter**

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

Table 12 The float point parameter of the time overcurrent protection function

**Timer parameters**

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

\*Valid for inverse type characteristics

\*\*Valid for definite type characteristics only

Table 13 The timer parameters of the time overcurrent protection function

### 1.3.1.3 Residual instantaneous overcurrent protection function (IOC50N)

The residual instantaneous overcurrent protection function (IOC50N) block operates immediately if the residual current ( $3I_0$ ) is above the setting value. The setting value is a parameter, and it can be doubled by a dedicated binary input signal defined by the user applying the graphic programming.

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

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

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

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

#### Technical data

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

\*Measured with signal contacts

Table 14 Technical data of the residual instantaneous overcurrent protection function

#### Parameters

##### Enumerated parameter

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

Table 15 The enumerated parameter of the residual instantaneous overcurrent protection function

##### Integer parameter

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

Table 16 The integer parameter of the residual instantaneous overcurrent protection function

### 1.3.1.4 Residual overcurrent protection function (TOC51N)

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 (3I<sub>0</sub>) 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<sub>s</sub> 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 <sub>s</sub>	preset value of the characteristic quantity (Start current),
TMS	preset time multiplier (no dimension).

	IEC ref		k <sub>r</sub>	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<sub>D</sub>) 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)

$k_r$

$\alpha$

$G$

$G_S$

TMS

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

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

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

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

#### Technical data

Function	Value	Accuracy
Operating accuracy *	$20 \leq G_S \leq 1000$	< 3 %
Operate time accuracy		$\pm 5\%$ or $\pm 15$ ms, whichever is greater
Reset ratio	0,95	
Reset time * Dependent time char. Definite time char.	Approx 60 ms	< 2% or $\pm 35$ ms, whichever is greater
Transient overreach		2 %
Pickup time	$\leq 40$ 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  $I_n = 200$  mA

Table 17 The technical data of the residual overcurrent protection function

**Parameters****Enumerated parameters**

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

Table 18 The enumerated parameters of the residual overcurrent protection function

**Integer parameter**

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

\*  $I_n = 1\text{ A or }5\text{ A}$

\*\*  $I_n = 200\text{ mA or }1\text{ A}$

Table 19 The integer parameter of the residual overcurrent protection function

**Float point parameter**

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

Table 20 The float parameter of the residual overcurrent protection function

**Timer parameters**

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

\*Valid for inverse type characteristics

\*\*Valid for definite type characteristics only

Table 21 The timer parameters of the residual overcurrent protection function

### 1.3.1.5 Negative sequence overcurrent protection function (TOC46)

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

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

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

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

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

where

$t(G)$ (seconds)

$k, c$

$\alpha$

$G$

$G_s$

$TMS$

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

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

Table 22 The constants of the standard dependent time characteristics

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

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

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

$$G_D = 20 * G_s$$

Above this value the theoretical operating time is definite. The inverse type characteristics are also combined with a minimum time delay, the value of which is set by user parameter TOC46\_MinDel\_TPar\_ (Min. Time Delay).

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

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

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

### Technical data

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

\* Measured with signal contacts

Table 23 Technical data of the negative sequence overcurrent protection function

### Parameters

#### Enumerated parameter

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

Table 24 The enumerated parameter of the negative sequence overcurrent protection function

#### Integer parameter

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

Table 25 The integer parameter of the negative sequence overcurrent protection function

**Timer parameters**

Parameter name	Title	Unit	Min	Max	Step	Default
Minimal time delay for the inverse characteristics:						
TOC46_MinDel_TPar_	Min Time Delay*	msec	0	60000	1	100
Definite time delay:						
TOC46_DefDel_TPar_	Definite Time Delay**	msec	0	60000	1	100
Reset time delay for the inverse characteristics:						
TOC46_Reset_TPar_	Reset Time*	msec	0	60000	1	100
Time multiplier for the inverse characteristics:						
TOC46_Multip_TPar_	Time Multiplier*	msec	100	60000	1	100

\*Valid for inverse type characteristics

\*\*Valid for definite type characteristics only

*Table 26 The timer parameter of the negative sequence overcurrent protection function*

### 1.3.1.6 Line thermal protection function (TTR49L)

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

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

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

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

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

The ambient temperature can be measured using e.g. a temperature probe generating electric analog signals proportional to the temperature. In the absence of such measurement, the temperature of the environment can be set using the dedicated parameter TTR49L\_Amb\_IPar\_ (Ambient Temperature). The selection between parameter value and direct measurement is made by setting the binary Boolean parameter.

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

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

The thermal differential equation to be solved is:

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

In this differential equation:

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

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

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

where

$\Theta_o$  is the starting temperature.

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

$$\text{Temperature}(t) = \Theta(t) + \text{Temp\_ambient}$$

where

Temp\_ambient is the ambient temperature.

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

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

where:

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

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

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

$\frac{\Theta_o}{\Theta_n}$

is a parameter of the starting temperature related to the reference temperature

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

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

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

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

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

**Technical data**

Function	Accuracy
Operate time at $I > 1.2 \cdot I_{trip}$	$< 3\%$ or $< + 20$ ms

*Table 27 Technical data of the line thermal protection function*

**Parameters****Enumerated parameter**

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

*Table 28 The enumerated parameter of the line thermal protection function*

The meaning of the enumerated values is as follows:

- Off           the function is switched off; no output status signals are generated;
- Pulsed       the function generates a trip pulse if the calculated temperature exceeds the trip value
- Locked       the function generates a trip signal if the calculated temperature exceeds the trip value. It resets only if the temperature cools below the “Unlock temperature”.

**Integer parameters**

Parameter name	Title	Unit	Min	Max	Step	Default
Alarm Temperature						
TTR49L_Alm_IPar_	Alarm Temperature	deg	60	200	1	80
Trip Temperature						
TTR49L_Trip_IPar_	Trip Temperature	deg	60	200	1	100
Rated Temperature						
TTR49L_Max_IPar_	Rated Temperature	deg	60	200	1	100
Base Temperature						
TTR49L_Ref_IPar_	Base Temperature	deg	0	40	1	25
Unlock Temperature						
TTR49L_Unl_IPar_	Unlock Temperature	deg	20	200	1	60
Ambient Temperature						
TTR49L_Amb_IPar_	Ambient Temperature	deg	0	40	1	25
Startup Term.						
TTR49L_Str_IPar_	Startup Term	%	0	60	1	0
Rated Load Current						
TTR49L_Inom_IPar_	Rated Load Current	%	20	150	1	100
Time constant						
TTR49L_pT_IPar_	Time Constant	min	1	999	1	10

*Table 29 The integer parameters of the line thermal protection function*

**Boolean parameter**

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

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

### 1.3.1.7 Transformer differential protection function (DIF87\_3w)

The differential protection function provides main protection for transformers, generators or large motors, but it can also be applied for overhead lines and cables of solidly grounded networks or for the protection of any combination of the aforementioned objects.

Version DIF87\_3w can be applied to protect three-winding transformers. The simpler version DIF87\_2w does not process analogue inputs from the tertiary side.

The three-phase power transformers transform the primary current to the secondary side according to the turns ratio and the vector group of the transformers. The Y (star), D (delta) or Z (zig-zag) connection of the three phase coils on the primary and secondary sides causes the vector shift of the currents. The numerical differential protection function applies matrix transformation of the directly measured currents of one side of the transformer to match them with the currents of the other side.

In Protecta's transformer differential protection the target of the matrix transformation is the delta (D) side. Thus the problem of zero sequence current elimination in case of an external ground fault is also solved.

The method of the matrix transformation is defined by the „Code“ parameter identifying the transformer vector group connection.

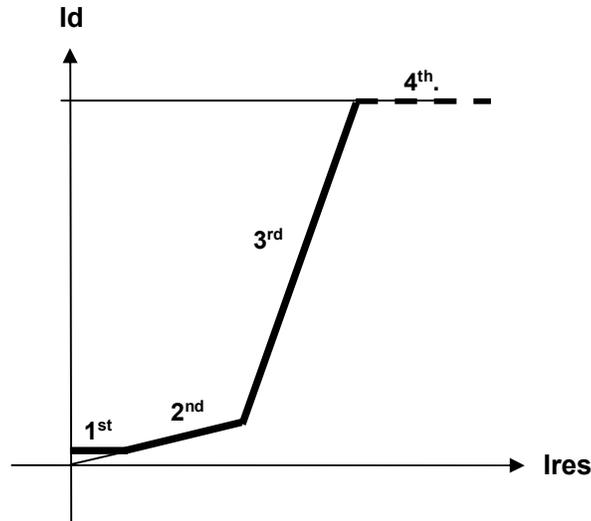
The differential current can be high during the transients of transformer energizing (inrush current) due to the current distortion caused by the transformer iron core asymmetrical saturation. In this case, the second harmonic content of the differential current is applied to disable the false operation of the differential protection function.

The differential current can be high in case of the over-excitation of the transformer due to the current distortion caused by the transformer iron core symmetrical saturation. In this case, the fifth harmonic content of the differential current is applied to disable the false operation of the differential protection function.

The harmonic analysis calculates the basic Fourier components of the three differential currents. These results are needed for the high-speed differential current decision and for the second and fifth harmonic restraint calculation.

The software modules evaluate and compare the result with the parameter values set for the second and fifth harmonic. If the harmonic content relative to the basic harmonic component of the differential currents is high, a restraint signal is generated immediately and a timer is started at the same time. If the duration of the active status is at least 25 ms, then the resetting of the restraint signal is delayed by an additional 15 ms.

The decision logic module decides if the differential current of the individual phases is above the characteristic curve of the differential protection function. It compares the magnitudes of the differential currents and those of the restraint currents for evaluation of the “percentage differential characteristics”. This curve is the function of the restraint current, which is calculated based on the sum of the magnitude of the phase-shifted phase currents (see Figure below).



The characteristic curve has four sections. The first section is the base sensitivity, the second one serves to compensate the turns ratio deviation e.g. due to the operation of the on-load tap changer, the third is to eliminate false operation caused by the CT saturation and the fourth one is the unrestricted differential function. The slope of the third section is constant, it is 2.

The differential 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.

#### Measured values

Measured value	Dim.	Explanation
Idiff. L1	In %	The calculated differential current in phase L1 (after vector group compensation)
Idiff. L2	In %	The calculated differential current in phase L2 (after vector group compensation)
Idiff. L3	In %	The calculated differential current in phase L3 (after vector group compensation)
Ibias L1	In %	The calculated restraint current in phase L1 (after vector group compensation)
Ibias L2	In %	The calculated restraint current in phase L2 (after vector group compensation)
Ibias L3	In %	The calculated restraint current in phase L3 (after vector group compensation)

Remark: The evaluated basic harmonic values of the measured input phase currents (without vector group compensation) help the commissioning of the differential protection function. These evaluations however are performed by an independent software measuring module, so this chapter excludes the description of these measurements.

*Table 31 The measure values of the transformer differential protection function*

**Enumerated parameters**

Parameter name	Title	Selection range	Default
Parameter to enable the differential protection function:			
DIF87_Op_EPar_	Operation	Off, On	On
Parameter to select connection group of the transformer coils in primary-secondary relation:			
DIF87_VGrSec_EPar_	Pri-Sec VGroup*	Dy1,Dy5,Dy7,Dy11,Dd0,Dd6,Dz0,Dz2,Dz4,Dz6,Dz8,Dz10,Yy0,Yy6,Yd1,Yd5,Yd7,Yd11,Yz1,Yz5,Yz7,Yz11	Dd0
Parameter to select connection group of the transformer coils in primary-tertiary relation:			
DIF87_VGrTer_EPar_	Pri-Ter VGroup*	Dy1,Dy5,Dy7,Dy11,Dd0,Dd6,Dz0,Dz2,Dz4,Dz6,Dz8,Dz10,Yy0,Yy6,Yd1,Yd5,Yd7,Yd11,Yz1,Yz5,Yz7,Yz11	Dd0

\* If the connection of the primary winding in primary-secondary and primary tertiary relation is selected in contradiction then the protection function is automatically disabled, and the function generates a warning signal.

*Table 32 The enumerated parameters of the transformer differential protection function*

**Boolean parameter**

Parameter name	Title	Default	Explanation
DIF87_0Seq_BPar_	Zero Seq Elimination	True	

*Table 33 The boolean parameter of the transformer differential protection function*

**Integer parameters**

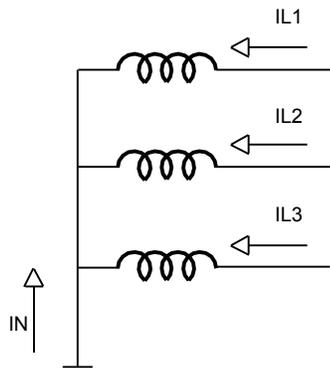
Parameter name	Title	Unit	Min	Max	Step	Default
Parameters for the current magnitude compensation:						
DIF87_TRPr_IPar_	TR Primary Comp	%	20	500	1	100
DIF87_TRSec_IPar_	TR Secondary Comp	%	20	500	1	100
DIF87_TRTer_IPar_	TR Tertiary Comp	%	20	200	1	100
Parameter of the second harmonic restraint:						
DIF87_2HRat_IPar_	2nd Harm Ratio	%	5	50	1	15
Parameter of the fifth harmonic restraint:						
DIF87_5HRat_IPar_	5th Harm Ratio	%	5	50	1	25
Parameters of the percentage characteristic curve:						
Base sensitivity:						
DIF87_f1_IPar_	Base Sensitivity	%	10	50	1	20
Slope of the second section of the characteristics:						
DIF87_f2_IPar_	1st Slope	%	10	50	1	20
Bias limit of the first slope:						
DIF87_f3_IPar_	1st Slope Bias Limit	%	200	2000	1	200
Unrestrained differential protection current level:						
DIF87_HCurr_IPar_	UnRst Diff Current	%	800	2500	1	800

*Table 34 The integer parameters of the transformer differential protection function*

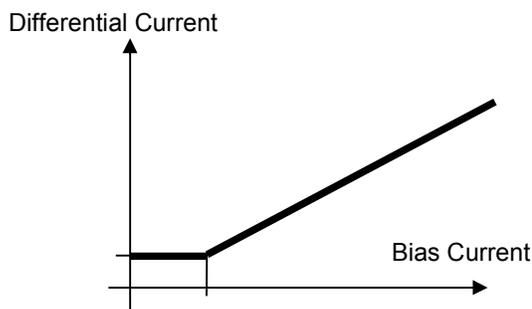
Function	Value	Accuracy
Operating characteristic	2 breakpoints	
Reset ratio	0,95	
Characteristic accuracy		<2%
Operate time, unrestrained	Typically 20 ms	
Reset time, unrestrained	Typically 25 ms	
Operate time, restrained	Typically 30 ms	
Reset time, restrained	Typically 25 ms	

*Table 35 The functions of the transformer differential protection function*

**1.3.1.8 Restricted earth fault protection function (DIF87N)**



The restricted earth-fault protection function is basically a low-impedance differential protection function based on zero sequence current components. It can be applied to protect one side winding of transformers with grounded neutral against single-phase-to-earth fault (see Figure). The function compares the measured neutral current at the star point ( $I_N$ ) and the calculated zero sequence current component of the phase currents ( $I_{L1}$ ,  $I_{L2}$ ,  $I_{L3}$ ) and generates a trip command if the difference of these currents is above the characteristics.



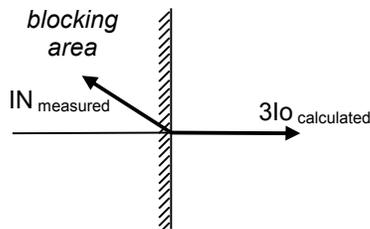
The function performs the necessary calculations for the evaluation of the “percentage differential characteristics”, and decides to trip if the differential current is above the characteristic curve of the zero sequence differential protection function. This curve is the function of the restraint (Bias) current, which is the maximum of the phase currents and the current of the neutral point.

$$Differential\ Current = I_{L1Four} + I_{L2Four} + I_{L3Four} + I_{NFour}$$

$$Bias\ Current = MAX(I_{L1Four}, I_{L2Four}, I_{L3Four}, I_{NFour})$$

Note: Four = Fourier

Additionally the function compares the direction of the neutral current and that of the calculated zero sequence current. In case of small zero sequence component of the high fault currents in the phases, this decision improves the stability of the function.



In this system, if the angle between the calculated zero sequence current  $3I_o$  and the measured neutral current  $I_N$  is out of the range of  $\pm 90$  degrees, then the restricted earth fault protection can be blocked (see the Figure). For the directional decision, the positive directions are drawn in Figure above. The output signal of the directional decision module can block the restricted earth-fault protection function.

A Boolean parameter of the restricted earth-fault protection function serves to enable the directional checking of the measured and calculated zero sequence currents.

The restricted earth-fault protection function generates a trip signal if the differential current as the function of the bias current is above the differential characteristic lines and the function is not blocked by the directional decision. Additionally the operation of the function is enabled by parameter setting. The conditions of enabling are defined by the user applying the graphic equation editor.

**Technical data**

Function	Value	Accuracy
Operating characteristic	1 breakpoint	
Reset ratio	0,95	
Characteristic accuracy		<2%
Operate time, restrained	typically 20 ms	
Reset time, restrained	typically 25 ms	

*Table 36 The technical data of the restricted earth fault protection function*

**Parameters****Enumerated parameter**

Parameter name	Title	Selection range	Default
Parameter to enable the zero sequence differential protection function:			
DIF87N_Oper_EPar_	Operation	Off, On	On

*Table 37 The enumerated parameter of the restricted earth fault protection function*

**Boolean parameter**

Parameter name	Title	Default	Explanation
DIF87N_DirCheck_BPar_	Directional check	True	Enabling the directional checking of the measured and calculated zero sequence currents

*Table 38 The boolean parameter of the restricted earth fault protection function*

**Integer parameters**

Parameter name	Title	Unit	Min	Max	Step	Default
Parameters for the current magnitude compensation:						
DIF87N_TRPri_IPar_	Io Primary Match	%	20	500	1	100
DIF87N_TRNeut_IPar_	Neutral Match	%	100	1000	1	500
Base sensitivity:						
DIF87N_f1_IPar_	Base Sensitivity	%	10	50	1	30
Slope of the second section of the characteristics:						
DIF87N_f2_IPar_	Slope	%	50	100	1	70
Break point of the characteristic line:						
DIF87N_f2Brk_IPar_	Base Sens Bias Limit	%	100	200	1	125

*Table 39 The integer parameters of the restricted earth fault protection function*

### 1.3.1.9 Current unbalance function (VCB60)

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

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

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

*The analog signal processing module* processes the RMS value of the basic Fourier current components of the phase currents to prepare the signals for the decision. It calculates the maximum and the minimum value of the RMS values and the difference between the maximum and minimum of the RMS values of the fundamental Fourier components of the phase currents as a percentage of the maximum of these values ( $\Delta I$ ). If the maximum of the currents is above 10 % of the rated current and below 150% of the rated current and the  $\Delta I$  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 40 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 41 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 42 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 43 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 44 The timer parameter of the current unbalance function*

### 1.3.1.10 Breaker failure protection function (BRF50)

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

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

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

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

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

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

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

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

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

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

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

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

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

#### Technical data

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

*Table 45 Technical data of the breaker failure protection function*

**Parameters****Enumerated parameters**

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

*Table 46 The enumerated parameters of the breaker failure protection function*

**Integer parameters**

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

*Table 47 The integer parameters of the breaker failure protection function*

**Timer parameters**

Parameter name	Title	Unit	Min	Max	Step	Default
Time delay for repeated trip command generation						
BRF50_TrDel_TPar_	Retrip Time Delay	msec	0	10000	1	200
Time delay for trip command generation for the backup circuit breaker(s)						
BRF50_BUDeI_TPar_	Backup Time Delay	msec	60	10000	1	300
Trip command impulse duration						
BRF50_Pulse_TPar_	Pulse Duration	msec	0	60000	1	100

*Table 48 The timer parameters of the breaker failure protection function*

### 1.3.1.11 Trip logic (TRC94)

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

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

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

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

#### Technical data

Function		Accuracy
Impulse time duration	Setting value	<3 ms

Table 49 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 50 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 51 Timer parameter of the decision logic

### 1.3.1.12 Dead line detection function (DLD)

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

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

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

Criteria of “Live line” state: all three phase voltages are above the voltage setting value.

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

#### Technical data

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

*Table 52 Technical data of the dead line detection function*

#### Parameters

##### Integer parameters

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

*Table 53 The integer parameters of the dead line detection function*

### 1.3.1.13 Current input function (CT4)

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

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

The role of the current input function block is to

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

#### Operation of the current input algorithm

The current input function block receives the sampled current values from the internal operating system. The scaling (even hardware scaling) depends on parameter setting. See parameters CT4\_Ch13Nom\_EPar\_ (Rated Secondary I1-3) and CT4\_Ch4Nom\_EPar\_ (Rated Secondary I4). The options to choose from are 1A or 5A (in special applications, 0.2A or 1A). This parameter influences the internal number format and, naturally, accuracy. (A small current is processed with finer resolution if 1A is selected.)

If needed, the phase currents can be inverted by setting the parameter CT4\_Ch13Dir\_EPar\_ (Starpoint I1-3). This selection applies to each of the channels IL1, IL2 and IL3. The fourth current channel can be inverted by setting the parameter CT4\_Ch4Dir\_EPar\_ (Direction I4). This inversion may be needed in protection functions such as distance protection, differential protection or for any functions with directional decision.

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

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

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

#### Technical data

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

Table 54 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 55 The enumerated parameters of the current input function*

**Floating point parameters**

Parameter name	Title	Dim.	Min	Max	Default
Rated primary current of channel1					
CT4_PrI1_FPar_	Rated Primary I1	A	100	4000	1000
Rated primary current of channel2					
CT4_PrI2_FPar	Rated Primary I2	A	100	4000	1000
Rated primary current of channel3					
CT4_PrI3_FPar_	Rated Primary I3	A	100	4000	1000
Rated primary current of channel4					
CT4_PrI4_FPar_	Rated Primary I4	A	100	4000	1000

*Table 56 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 57 The measured analogue values of the current input function*

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

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

is the vector calculated for the first current input channel of the first applied current input module.

*Figure 6* shows an example of how the calculated Fourier components are displayed in the on-line block. (See the document "EuroProt+ Remote user interface description".)



The screenshot shows a web-based configuration interface for a CT4 module. It features a table with four columns: parameter name, numerical value, and unit. The parameters are grouped by channel (I1, I2, I3, I4), with each channel having a 'Current Ch' and an 'Angle Ch' parameter. The values are displayed in input fields, and the units are indicated to the right of each field.

[-] CT4 module		
Current Ch - I1	0.84	A
Angle Ch - I1	-9	deg
Current Ch - I2	0.84	A
Angle Ch - I2	-129	deg
Current Ch - I3	0.85	A
Angle Ch - I3	111	deg
Current Ch - I4	0.00	A
Angle Ch - I4	0	deg

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

## 2 External connections

