FUNCTION BLOCK DESCRIPTION

Residual overcurrent protection function

ANSI 51N/51G, IEC Io> / Io>>

PROTECTA HUNGARY

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PROTECTION, AUTOMATION AND CONTROL FOR POWER INDUSTRY

VERSION INFORMATION

VERSION	DATE	MODIFICATION	COMPILED BY
Preliminary	2009-10-30	Preliminary version, without technical information	Petri
	2010-10-05	Naming revision	Csipke
1.0	2010-11-11	First edition	Petri
1.1	2011-04-19	Operation above GT added	Petri
1.2	2016-08-30	Timer parameters' minimum values corrected; minor formatting	Erdős
1.3	2022-08-11	Range and default values of some parameters and the accuracy of the Reset time updated	Seida
2.0	2024-12-10	New documentation design, new chapters, IEC61850 info added	Ádám, Erdős
2.1	2025-03-13	Minor correction	Ádám

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USED SYMBOLS

Additional information

Useful information for settings.

Important part for proper usage.

1 Operation principle

The residual 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.

1.1 Operating characteristics

1.1.1 Independent time characteristic

$$t(G) = t_{OP} \text{ when } G < G_S$$

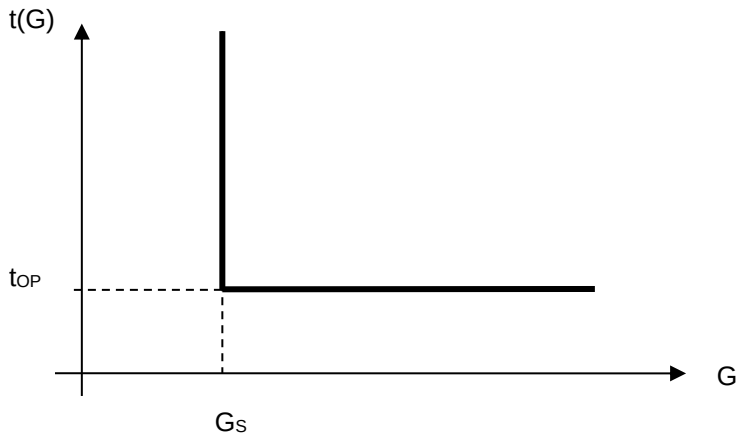

Figure 1-1 Overcurrent independent time characteristic

Where

t_{OP} (seconds)	theoretical operating time if G > G_S, fix, according to the preset parameter,
G	measured value of the characteristic quantity, Fourier base harmonic of the residual current,
G_S	preset value of the characteristic quantity (TOC51N_StCurr_IPar_, Start current).

1.1.2 Standard dependent time characteristics

Operating characteristics:

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

Where

t(G)(seconds)	theoretical operate time with constant value of G,
k_r, 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 (TOC51N_StCurr_IPar_, Start current),
TMS	preset time multiplier (no dimension).

Table 1-1 The constants of the standard dependent time characteristics

	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

Resetting characteristics:

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

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 (TOC51N_StCurr_IPar_, Start current),
TMS	preset time multiplier (no dimension).

Table 1-2 The resetting constants of the standard dependent time characteristics

	IEC REF	TITLE	K_R	α
1	A	IEC Inv	Resetting after fix time delay, according to preset parameter TOC51N_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 inverse type characteristics are also combined with a minimum time delay, the value of which is set by user parameter TOC51N_MinDel_TPar_ (Min. Time Delay).

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:

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

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

1.2 Structure of the residual overcurrent protection algorithm

Figure 1-2 shows the structure of the residual overcurrent protection (TOC51N) algorithm.

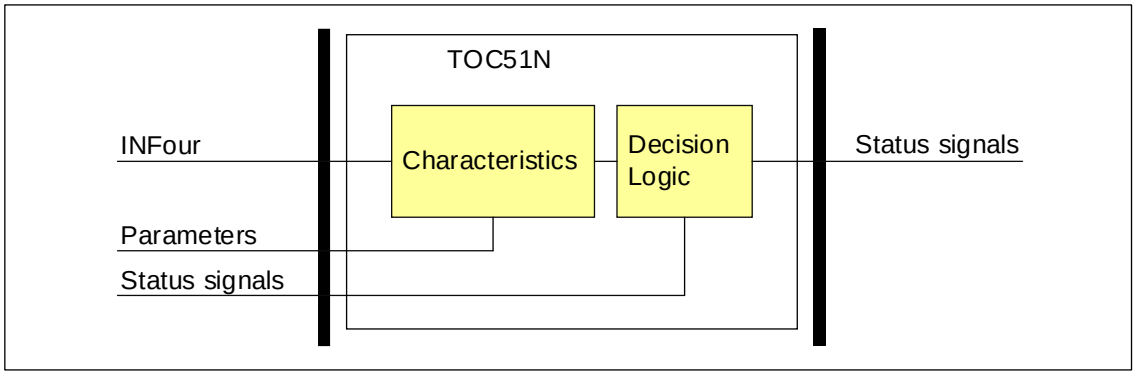

Figure 1-2 Structure of the residual overcurrent protection algorithm

The **inputs** are

- the RMS value of the fundamental Fourier component of the residual current (IN=3Io),
- parameters,
- status signals.

The **outputs** are

- the binary output status signals.

The **software modules** of the residual overcurrent protection function:

Characteristics

This module calculates the required time delay based on the RMS value of the fundamental Fourier component of the residual current.

Decision logic

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

The following description explains the details of the individual components.

1.3 The definite time and the inverse type characteristics (Characteristics)

This module calculates the required time delay based on the Fourier components of the residual current. The formulas applied are described in Chapter 1.1.

The **inputs** are the basic Fourier components of the residual current (INFour) and parameters.

The **outputs** are the internal status signals of the function. These indicate the started state and the generated trip command if the time delay determined by the characteristics expired.

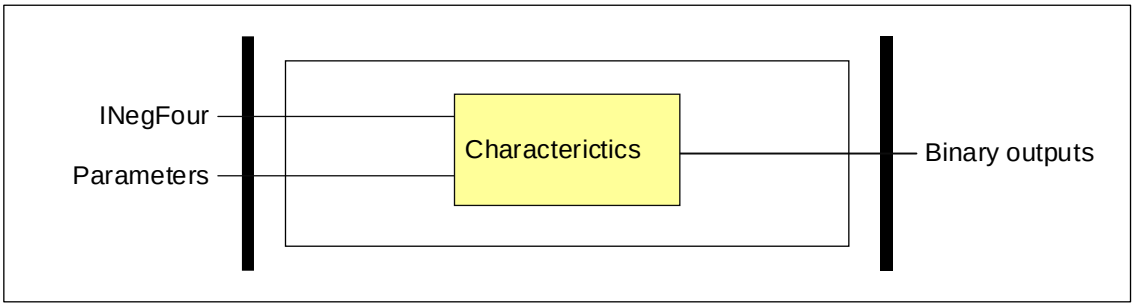

Figure 1-3 Schema of the characteristic calculation

Table 1-3 The enumerated parameters of the residual overcurrent protection function

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	Off

Table 1-4 The integer parameters of the residual overcurrent protection function

PARAMETER NAME	TITLE	UNIT	MIN	MAX	STEP	DEFAULT
Starting current parameter						
TOC51N_StCurr_IPar_	Start Current	%	10	1000	1	50

Table 1-5 Float parameter of the OC function block

PARAMETER NAME	TITLE	UNIT	MIN	MAX	STEP	DEFAULT
Time multiplier of the inverse characteristics (OC module)						
TOC51N_Multip_FPar_	Time Multiplier	-	0.05	15.00	0.01	1.00

Table 1-6 Timer parameters of the residual overcurrent protection function

PARAMETER NAME	TITLE	UNIT	MIN	MAX	STEP	DEFAULT
Minimal time delay for the inverse characteristics						
TOC51N_MinDel_TPar_	Min Time Delay *	msec	40	60000	1	100
Definite time delay						
TOC51N_DefDel_TPar_	Definite Time Delay **	msec	40	60000	1	100
Reset time delay for the inverse characteristics						
TOC51N_Reset_TPar_	Reset Time*	msec	60	60000	1	100

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

Table 1-7 The binary output status signals of the residual overcurrent protection function

BINARY OUTPUT SIGNAL	SIGNAL TITLE	EXPLANATION
TOC51N_St_Grl_	Start L1	Starting of the function
TOC51N_Tr_Grl_	Trip L1	Trip command of the function

1.4 The decision logic (Decision logic)

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

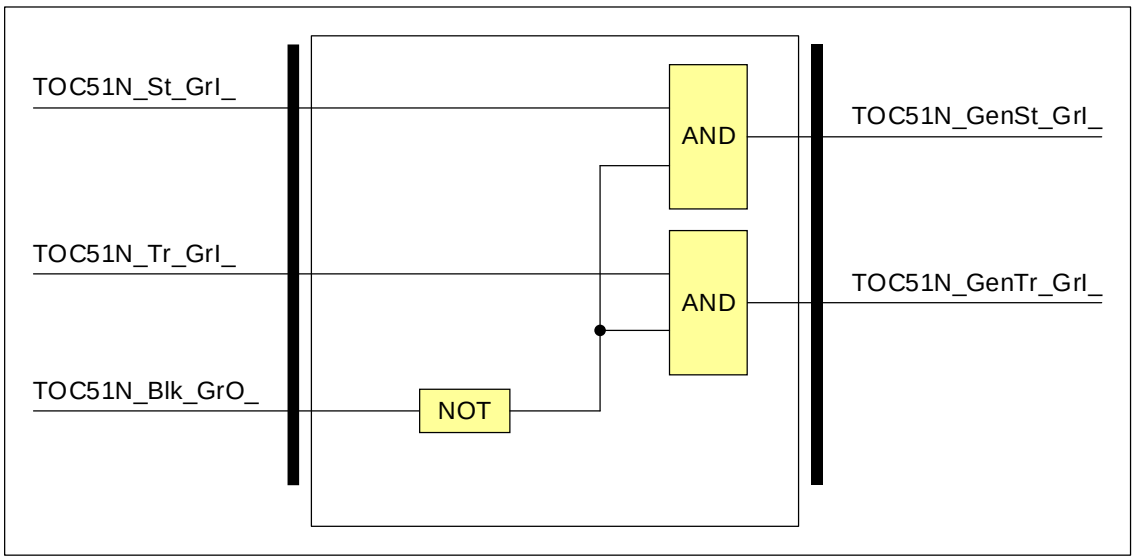

Figure 1-4 The (simplified) logic scheme of the residual overcurrent protection function

Table 1-8 The binary input status signals of the residual overcurrent protection function

BINARY INPUT SIGNAL	SIGNAL TITLE	EXPLANATION
TOC51N_St_GrI_	Start L1	Starting of the function
TOC51N_Tr_GrI_	Trip L1	Trip command of the function

Binary status signals

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.

Table 1-9 The binary input signal of the residual overcurrent protection function

BINARY STATUS SIGNAL	EXPLANATION
TOC51N_Blk_GrO_	Output status of a graphic equation defined by the user to disable the residual overcurrent protection function.

Table 1-10 The binary output status signals of the residual overcurrent protection function

BINARY OUTPUT SIGNAL	SIGNAL TITLE	EXPLANATION
TOC51N_GenSt_GrI_	General Start	General starting of the function
TOC51N_GenTr_GrI_	General Trip	General trip command of the function

2 Overview

The function block of the residual overcurrent protection function is shown in Figure 2-1. This block shows all binary input and output status signals that are applicable in the graphic equation editor.

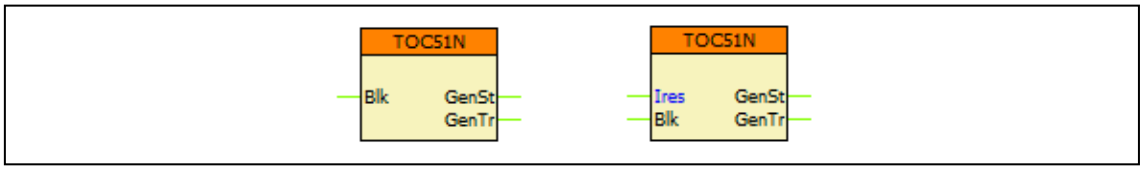

Figure 2-1 The function block of the residual overcurrent protection function

2.1 Settings

2.1.1 Parameters

The parameters are listed as they are seen on the local or remote HMI.

Table 2-1 Parameters of the residual overcurrent protection function

TITLE	DIM	RANGE	STEP	DEFAULT	EXPLANATION
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		Off	Parameter for type selection
Start Signal Only	-	FALSE, TRUE		FALSE	
Start Current *	%	10 – 1000	1	50	Starting current parameter
Time Multiplier	-	0.05 – 15.00	0.01	1.00	Time multiplier of the inverse characteristics (OC module)
Min Time Delay **	msec	40 – 60000	1	100	Minimal time delay for the inverse characteristics
Definite Time Delay ***	msec	40 – 60000	1	100	Definite time delay
Reset Time**	msec	60 – 60000	1	100	Reset time delay for the inverse characteristics

2.2 Function I/O

This section describes briefly the analogue and digital inputs and outputs of the function block.

2.2.1 Analogue inputs

Graphic Analogue inputs *(only from firmware version 2.10.2.3010 and up)*

The sources of the analogue inputs are defined by the user, applying the graphic equation editor (*Logic Editor*). Parts written in **bold** are seen on the left side of the function block in the Logic editor.

The function uses the following analogue signals as inputs:

Table 2-2 Analogue input signal of the residual overcurrent protection function

ANALOGUE INPUT SIGNAL	SIGNAL TITLE	EXPLANATION
TOC51N_**Ires**_AnIn_	Residual current	For *51N (calculated 3Io)* operation, connect 3ph current signal (I123 output of the CT function) For *51G (measured 3Io)* operation, connect 1ph current signal (I4 output of the CT function)

The applied analogue connectors must be identical to the analogue input type (i.e. voltage to voltage input etc.), Invalid connections are not allowed.

2.2.2 Analogue outputs

The function has no analogue output signals.

2.2.3 Binary input signals (graphed output statuses)

The conditions of the inputs are defined by the user, applying the graphic equation editor (logic editor). The part written in **bold** is seen on the function block in the logic editor.

Table 2-3 Binary input status signal of the residual overcurrent protection function

BINARY INPUT SIGNAL	EXPLANATION
TOC51N_**Blk**_GrO_	Output status of a graphic equation defined by the user to disable the residual overcurrent protection function.

2.2.4 Binary output signals (graphed input statuses)

The binary output status signals of the residual overcurrent protection function. Parts written in **bold** are seen on the function block in the logic editor.

Table 2-4 Binary output status signals of the residual overcurrent protection function

BINARY OUTPUT SIGNAL	SIGNAL TITLE	EXPLANATION
TOC51N_**GenSt**_Grl_	General Start	General starting of the function
TOC51N_**GenTr**_Grl_	General Trip	General trip command of the function

2.2.5 On-line data

Visible values on the on-line data page:

Table 2-5 The displayed on-line data of the residual overcurrent protection function

SIGNAL TITLE	DIMENSION	EXPLANATION
General Start	Off, On	General starting of the function
General Trip	Off, On	General trip command of the function
Current input assignment		*Status of the graphical analogue input (if exists) (Complete if OK, Missing if not connected)*

2.2.6 Events

The following events are generated in the event list, as well as sent to SCADA according to the configuration.

Table 2-6 Events of the residual overcurrent protection function

EVENT	VALUE	EXPLANATION	IEC61850 DATA ATTRIBUTES
General Start	Off, On	General starting of the function	F1PTOC1STStr
General Trip	Off, On	General trip command of the function	F1PTOC1STOp

2.3 Technical data

Table 2-7 Technical data of the residual overcurrent protection function

FUNCTION	VALUE	ACCURACY
Operating accuracy *	20 ≤ G_S ≤ 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	< 5% 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*

2.3.1 Notes for testing

As written in Chapter 2.2.1, whether the function uses calculated or measures 3Io current, is defined by the current signal connected to its analogue input. In the earlier (2.8 system) version, this was defined by the analogue input assignment of the function itself. If not sure about the assignment, check the .epcs file of the device.

Additional notes for Graphic Analogue inputs *(only from firmware version 2.10.2.3010 and up):*

Starting from the firmware version **2.10.2.3010**, the majority of the function blocks can be updated to be equipped with graphic analogue inputs which **allow the user to assign the functions' analogue inputs by applying the graphic equation editor**.

The analogue connections of these functions can be checked by examining the source that is connected to their inputs (just like examining the source of a logic signal).

These functions must be placed in the Logic Editor and their graphic analogue inputs must be connected to make them operate. If a connection is intact, the online status of the corresponding analogue input will show "Complete". If it is missing, the status will be "Missing" and the function will not operate.

Note that these graphical inputs do not exist in the earlier firmware/function versions! Checking and modifying the analogue assignments in these cases are done by using the EuroCAP Software Configuration menu.