EUROPROT+

Setting guide to the transient earth-fault protection function

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Document ID: PP-13-21539

Budapest, June 2017

Setting guide version information

Version	Date	Modification	Compiled by
1.0	2014-10-10	First edition	Pócsi-Petri
1.1	2014-10-31	Minor corrections in parameter ranges	Seida
1.2	2016-06-02	Function block renamed to TEF67N; intermittent fault detection explanation extended; float parameter types modified to integer (setting of % instead of *In, *Un); formatting	Erdős

Contents

1 Hardware requirement for the application of the transient earth-fault protection function

1.1 Principle of operation

The main application area for the transient earth-fault protection (TEF67N) function is the earth-fault protection in radial compensated networks.

At the moment of earth-fault inception in a not solidly grounded network, the earth capacitances are suddenly charged or discharged with a high peak but very short current pulse. When sampling these currents, the short duration of these pulses results that in some cases these current pulses cannot be identified at all. To solve this problem, a special hardware circuit preserves the peak value of the zero sequence current component for the subsequent sampling period. This prolongation distorts the peak value, but the polarity is not changed. The transient earth-fault protection function evaluates the polarity of the pulse, related to the polarity of the residual voltage.

The required special module is “CT 5153”. This module is configured with the special circuit for the fourth current input channel. The residual current is to be connected to this channel.

1.2 Setting the parameters for the CT input module

For transient earth-fault protection, only the fourth channel is applied. For this channel:

Enumerated parameter

Parameter name	Title	Selection range	Default
Rated secondary current of the fourth input channel. “1A”, “0.2A” or “0.2 A sens” can be selected by parameter setting, no hardware modification is needed.			
CT4_Ch4Nom_EPar_	Rated Secondary I4	1A, 0.2A or 0.2 A sens	1A
Definition of the positive direction of the fourth current, given as normal or inverted			
CT4_Ch4Dir_EPar_	Direction I4	Normal, Inverted	Normal

Table 1-1 *The enumerated parameter of the current input function for transient earth-fault application*

When selecting “1 A” then the measurement is expected to be accurate in the current range up to 50A peak value, but small currents are measured with low accuracy.

When selecting “0.2 A sens” then the measurement is expected to be accurate in the current range up to 2A peak value only, but large currents are not measured correctly.

The correct setting value is defined using the rated zero sequence charging current of the feeder.

Charging current	Proposed selection
Charging current peak < 2A	“0.2 A sens”
2 A < Charging current peak < 10A	“0.2A”
Charging current peak >10A	“1A”

Table 1-2 *Proposed rated secondary current*

Calculation of the charging current:

$$Io_{charging}^{peak} = \sqrt{2} * \frac{3 * U_0^{rated}}{X_{C0}}$$

Where

U_0^{rated} Rated zero sequence RMS voltage component (phase-to-ground value)

X_{C0} Zero sequence capacitive reactance of the feeder, calculated as:

$$X_{C0} = \frac{1}{\omega * C_0' * l}$$

Where:

ω Rated angular frequency (314 for 50 Hz)

C_0' Zero sequence capacitance of 1 km line/cable

l total length of the line/cable (km).

The rated primary value defines the conversion factor from secondary to primary value. This conversion is performed for displaying the measured values only. (See Table *1-3*.)

Floating point parameter

Parameter name	Title	Dim.	Min	Max	Default
Rated primary current of channel4					
CT4_PriI4_FPar_	Rated Primary I4	A	100	4000	1000

Table 1-3 *The floating point parameter of the current input function for transient earth-fault application*

2 Setting the transient earth-fault protection function

2.1 Enabling the function

Disabling/Enabling of the function and selection of the operating characteristic is performed by setting the „Operation” enumerated type parameter:

Parameter name	Title	Selection range	Default
Enabling or disabling the transient earth-fault protection function and mode selection			
TEF67N_Oper_EPar_	Operation	Off, TransEF, Intermittent	Off

Table 2-1 *Parameter for enabling the transient earth-fault protection function*

To disable the function select parameter value „Off”.

Any other selection enables operation of the function.

The function is disabled also in case if the binary input “Blk” of the function block gets an active signal. The binary signals can be edited by the user in the graphic logic editor of the EuroCap software.

2.2 Selection of the operating mode

For the operating mode there are two choices, selecting the active mode: “TransEF” and “Intermittent”.

When selecting „ ***TransEF***” option for the “Operation” parameter, the testing the polarity of the current peak is triggered at the moment of increasing the residual voltage above the limit “Min Res Voltage”. The polarity of the highest current peak compared to the polarity of the residual voltage within a limited time span around the trigger decides the direction of the fault. The current peak should be above the limit “Min Res Current”. The forward/backward decision is kept until the residual voltage drops below the voltage limit again. The output signal is either “StartFW” or “StartBW”. The required parameter setting is summarized in Table *2-2*. The Un and IN values are the rated values of the measuring transformers (e.g. for current transformers the reference is the selected “Rated Secondary I4” , i.e. 1A or 0.2 A for the secondary, or “Rated Primary I4” for the primary values.)

Integer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Minimal residual voltage, enabling the operation of the function						
TEF67N_Uomin_IPar_	Min Res Voltage	%	5	50	1	10
Minimal residual current, enabling the operation of the function						
TEF67N_Iomin_IPar_	Min Res Current	%	10	500	1	50

Table 2-2 *Integer parameters of the transient earth-fault protection function*

The fault direction is evaluated only if both the measured residual voltage and the residual current peak are above the limits respectively.

When selecting „***Intermittent***” option, in addition to the TransEF mode, in this mode of operation the function counts the decisions at every subsequent current peak value. If a new peak is detected *in the same direction* within the time span (defined by the parameter “Reset Time”) then the time measurement restarts. If the count of the decisions in the same direction is at least the value defined by the parameter “Peak Count”, then the output signal “Intermittent” indicates the detected intermittent nature of the fault.
The direction of the counted peaks is decided by the first detected peak. The decision and also the counters reset if there is no new peak detected within the running time of the timer which is set by the parameter “Reset Time”. Additionally to Table *2-2*, the following tables show parameters to be set: (See Table *2-3* and Table *2-4*.

Integer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Required number of the counted peaks to detect intermittent fault						
TEF67N_PeakRep_IPar_	Peak Count		2	1000	1	5

Table 2-3 *Additional integer parameters of the transient earth-fault protection function*

Timer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Reset time after the last detected peak. If it expires, the counting starts over from 1.						
TEF67N_IntDrop_TPar_	Reset Time	msec	100	60000	1	1000

Table 2-4 *Timer parameter of the transient earth-fault protection function*

In this operating mode the evaluation is performed similarly as in “TransEF” mode, i.e. that both the measured residual voltage and the residual current peak are above the limits respectively. The earth-fault is declared to be “Intermittent” if “Peak Count” number of subsequent decisions detect the earth-fault in the same direction, and there is no longer time delay between the subsequent decision then the time defined with parameter “Reset Time “.

3 Application of the binary signals

The binary output signals, generated by the TEF67N transient earth-fault protection function are:

Binary status signal	Title	Explanation
TEF67N_StartFW_GrI_	StartFW	Fault detected forward
TEF67N_StartBW_GrI_	StartBW	Fault detected backward
TEF67N_Intermittent_GrI_	Intermittent	Intermittent fault detected

Table 3-1 *The binary output status signals of the transient earth-fault protection function*

The first two signals indicate the detected fault direction in „TransEF" operating mode. The third signal is applied in "Intermittent" operating mode selection.

The usual application of these signals is warning and faulty bay identification. For any other purposes these signals may be applied in the graphic logic editor as input signals.

The transient earth-fault protection function **has binary input signals**, which serve the purpose of disabling and resetting the function**. The conditions are defined by the user, applying the graphic equation editor.**

Binary status signal	Title	Explanation
TEF67N_Blk_GrO_	Blk	General blocking status signal
TEF67N_Reset_GrO_	Reset	This input signal resets the count of intermittent faults and also the measured time span

Table 3-2 *The binary input signal of the transient earth-fault protection function*

Using the "Blk" input, the function may be blocked by external signals. The logic combination of the blocking conditions is to be edited by the user according to the requirements, using the graphic logic editor.

The proposed application of the "Reset" signal is during testing the function to start a new measuring cycle in "Intermittent" mode of operation.

4 Setting example

Suppose the following application:

Network voltage 22 kV, $U_0^{rated} = \frac{22000}{\sqrt{3}} = 12702\ V$
Voltage transformer: 22000/√3/100/3 on the open delta side.

Length of the feeder l=25 km
Zero sequence capacitance $C_0' = 0.007\ \mu F/km$
Current transformers: 300/5 A.

Connect the analog input modules according to Figure 4-1

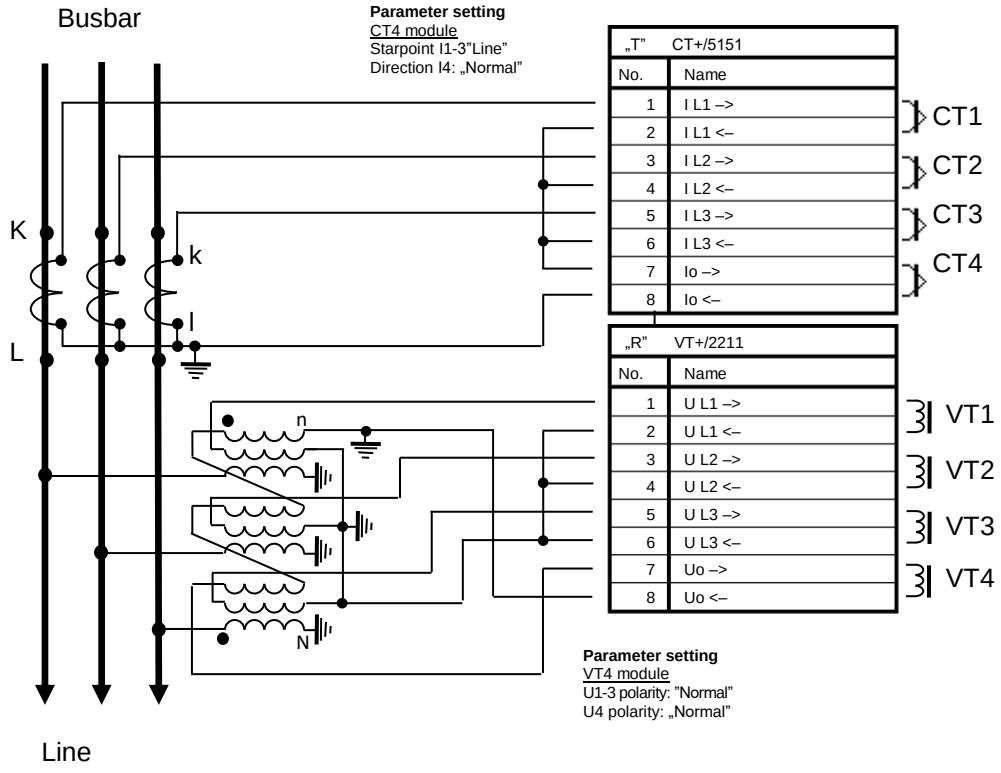

Figure 4-1Reference connection of the instrument transformers

Calculation of the capacitive charging current peak:

$$Io_{charging}^{peak} = \sqrt{2} * \frac{3*U_0^{rated}}{X_{C0}} = \sqrt{2} * \frac{3*U_0^{rated}}{\frac{1}{\omega*C_0'*l}} = \sqrt{2} * \frac{3*12702}{\frac{1}{314.159*0.007*10^{-6}*25}} = 2.96A$$

This charging current requires rated secondary current selection:

Rated Secondary I4 = 0.2 A (See Table *1-2*).

If the connection is according to Figure 4-1 then the setting for the direction is:

Direction I4 = Normal

Similarly:

Direction U4 = Normal

The expected minimal residual voltage “Min Res Voltage” should be above the expected highest asymmetry voltage but below the expected lowest fault voltage. The setting needs experience and measurements on the network. The following setting is usually correct:

Min Res Voltage = 30%

The expected minimal residual current “Min Res Current” should be below normal charging current, calculated for the secondary of the current transformer.

$$I_{fault}^{min} = \frac{I_{charging}^{RMS}}{a_{CT}} = \frac{\frac{2.96A}{\sqrt{2}}}{\frac{300}{5}} = 34.9\ mA$$

For the current input above the selection is “Rated Secondary I4” = 0.2 A.

Calculation of the pu. value:

$$3Iomin = \frac{34.9\ mA}{200\ mA} = 0.1745$$

The calculated setting is:

Min Res Current = 15%

5 Testing the transient earth-fault protection function

The function evaluates transient signals. Unfortunately most relay test sets cannot simulate these transients. The only possibility is to replay recorded signals. The source of these signals should be either records of earth-faults on the network, recorded with high sampling rate, or simulation with application of dedicated software.