

FUNCTION BLOCK DESCRIPTION

Capacitor overvoltage protection function

ANSI: 59C





VERSION INFORMATION

VERSION	DATE	MODIFICATION	COMPILED BY
1.0	2012-02-01	First edition	Petri
1.0	2012-11-05	Formatting	Petri
1.1	2018-05-30	Minor corrections	Erdős
2.0	2024-07-31	New documentation design Function block overview, testing notes chapter added	Ádám, Erdős

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USED SYMBOLS



Additional information



Useful information for settings.



Important part for proper usage.

1 Operation principle

1.1 Application

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

A moderated overvoltage can be tolerated for a relatively long time; the high overvoltages however need fast disconnection. The characteristic of this overvoltage protection function is a certain kind of inverse type characteristics, defined in international standards (IEC 60871-1 Shunt capacitors for a.c. power systems having a rated voltage above 1000 V – Part 1: General, or ANSI/IEEE C37.99 Capacitor Banks, Guide for Protection of Shunt).

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

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

1.2 Mode of operation

The capacitor overvoltage protection function measures phase currents. The phase voltages as a function of the time can be calculated by integration of the current time function of the phases:

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

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

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

1.3 Operating characteristics

1.3.1 Inverse type tripping characteristic

The international standards (IEC 60871-1 or ANSI/IEEE C37.99) define the operate time, as the maximum duration for some values of the power frequency voltage. Based on these standards the characteristic is defined on the following discrete values: (shown in Table 1-1.)

Table 1-1 Admissible voltage levels in service

VOLTAGE FACTOR *U _N V R.M.S.	MAXIMUM DURATION DEFINED IN THE STANDARDS	MAXIMUM DURATION IN SECONDS
1	Continuous	
1.15	30 min in every 24 h	1800 s
1.2	5 min	300 s
1.3	1 min	60 s
1.4	15 s	15 s
1.7	1 s	1 s
2.0	0.3 s	0.3 s
2.2	0.12 s	0.12 s

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

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

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

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

The number of the overvoltages is considered in this protection function as follows:

If the voltage peak is above $1.1 * U_{Npeak}$ then additionally to the accumulation, a reset time measurement is started. Then

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

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

1.3.2 Definite time warning characteristic

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

2 Overview

The function block of the capacitor overvoltage 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. On the right, the updated version is shown with renamed and rearranged outputs and analogue inputs (from system version 2.10 and up).

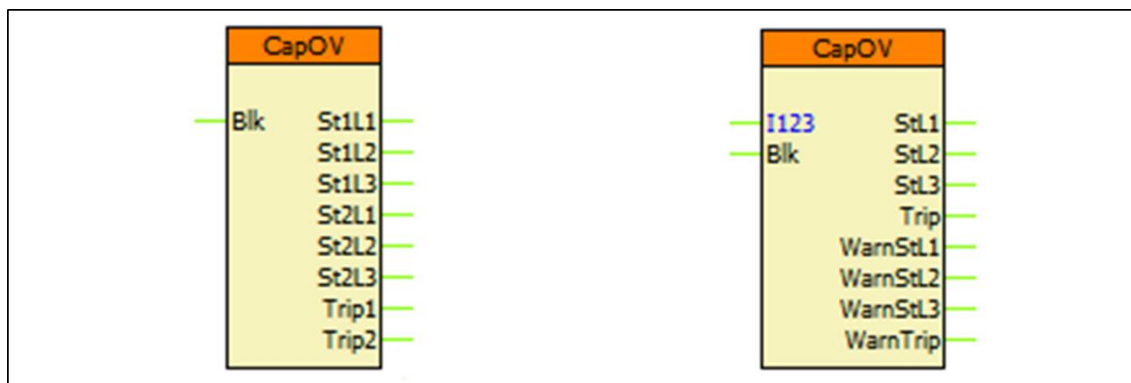


Figure 2-1 The function block of the capacitor overvoltage protection function

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 capacitor overvoltage protection function

TITLE	DIM	RANGE	STEP	DEFAULT	EXPLANATION
Operation	-	Off, On	-	Off	Enabling or disabling the capacitor overvoltage protection function
Rated current	%	10 - 120	1	100	Capacitor nominal current, related to the rated current of the current transformer. The integral of this current defines the nominal basic harmonic voltage, the peak value of which is the reference for overvoltage detection.
Reset Time	sec	1 - 60000	1	3600	Reset time setting for Trip stage (Stage 1)
Time Multiplier	-	0.20 – 2.00	0.01	1.00	Time multiplier for the inverse type characteristic
Warning Start	%	80-120	1	100	Value of the overvoltage, related to the rated voltage of the capacitor, to start the Warning stage (Stage 2) of the function
Warning Delay	sec	1-3600	1	60	Definite time delay for Warning stage (Stage 2)

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.

Table 2-2 Analogue input signal of the capacitor overvoltage protection function

ANALOGUE INPUT SIGNAL	SIGNAL TITLE	EXPLANATION
CapOV_I123_AnIn_	3phase current	Input for 3-phase current

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 The binary input status signal of the capacitor overvoltage protection function

BINARY INPUT STATUS SIGNAL	EXPLANATION
CapOV_Blk_GrO_	Output status of a graphic equation defined by the user to disable the capacitor overvoltage protection function.

2.2.4 Binary output signals (graphed input statuses)

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

With the function's update for the 2.10 system, some outputs have been renamed.

Table 2-4 The binary output status signals of the capacitor overvoltage protection function, system 2.8

BINARY OUTPUT SIGNALS	SIGNAL TITLE	EXPLANATION
CapOV_St1L1_Grl_	Start L1 – Inverse Char	Start of Stage 1 in phase L1
CapOV_St1L2_Grl_	Start L2 – Inverse Char	Start of Stage 1 in phase L2
CapOV_St1L3_Grl_	Start L3 – Inverse Char	Start of Stage 1 in phase L3
CapOV_St2L1_Grl_	Start L1 – Warning Stage	Start of Stage 2 in phase L1
CapOV_St2L2_Grl_	Start L2 – Warning Stage	Start of Stage 2 in phase L2
CapOV_St2L3_Grl_	Start L3 – Warning Stage	Start of Stage 2 in phase L3
CapOV_Trip1_Grl_	Inverse Char Trip	Trip command of Stage 1
CapOV_Trip2_Grl_	Warning Stage Trip	Trip command of Stage 2 (usually assigned as Warning)

Table 2-5 The binary output status signals of the capacitor overvoltage protection function, system 2.10 and up

BINARY OUTPUT SIGNALS	SIGNAL TITLE	EXPLANATION
CapOV_StL1_Grl_	Start L1 – Inverse Char.	Start of Trip stage (Stage 1) in phase L1
CapOV_StL2_Grl_	Start L2 – Inverse Char.	Start of Trip stage (Stage 1) in phase L2
CapOV_StL3_Grl_	Start L3 – Inverse Char.	Start of Trip stage (Stage 1) in phase L3
CapOV_WarnStL1_Grl_	Start L1 – Warning Stage	Start of Warning stage (Stage 2) in phase L1
CapOV_WarnStL2_Grl_	Start L2 – Warning Stage	Start of Warning stage (Stage 2) in phase L2
CapOV_WarnStL3_Grl_	Start L3 – Warning Stage	Start of Warning stage (Stage 2) in phase L3
CapOV_Trip_Grl_	Inverse Char. Trip	Trip command of Trip stage (Stage 1)
CapOV_WarnTrip_Grl_	Warning Stage Trip	Trip command of Warning stage (Stage 2)

2.2.5 On-line data

Visible values on the on-line data page:

Table 2-6 The displayed on-line data of the capacitor overvoltage protection function

SIGNAL TITLE	DIMENSION	EXPLANATION
Start L1 – Inverse Char	-	Start of Trip stage (Stage 1) in phase L1
Start L2 – Inverse Char	-	Start of Trip stage (Stage 1) in phase L2
Start L3 – Inverse Char	-	Start of Trip stage (Stage 1) in phase L3
Inverse Char Trip	-	Trip command of Trip stage (Stage 1))
Start L1 – Warning Stage	-	Start of Warning stage (Stage 2) in phase L1
Start L2 – Warning Stage	-	Start of Warning stage (Stage 2) in phase L2
Start L3 – Warning Stage	-	Start of Warning stage (Stage 2) in phase L3
Warning Stage Trip	-	Trip command of Warning stage (Stage 2)
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 2-7 Events of the capacitor unbalance protection function

EVENT	VALUE	EXPLANATION	IEC61850 DATA ATTRIBUTES*
Inverse Char. Start	-	Start of Trip stage (Stage 1)	CAPOVTPOV1\$ST\$Str
Warning Stage Start	-	Start of Warning stage (Stage 2)	CAPOVWPTOV1\$ST\$Str
Inverse Char. Trip	-	Trip command of Trip stage (Stage 2)	CAPOVTPOV1\$ST\$Op
Warning Stage Trip	-	Trip command of Warning stage (Stage 2)	CAPOVWPTOV1\$ST\$Op

*The IEC61850 Data Attributes can only be found in system version 2.10 and up.

2.3 Technical data

2-8 Technical data of the overvoltage protection function

FUNCTION	VALUE	ACCURACY
Pick-up starting accuracy		< 1%
Operate time accuracy	at $I_n=100\%$	< 5%

2.3.1 Notes for testing

Normally in the EuroProt+ devices the trip contacts are assigned to the Trip Logic function block, and not to the protection function blocks. Because of this the testing personnel must make sure that the Trip Logic is switched on ('Operation' parameter is set to other than 'Off') before starting the testing, otherwise there will be no physical trip on the relay.

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 (2.8.x.xxxx)! Checking and modifying the analogue assignments in these cases are done by using the EuroCAP Software Configuration menu.