EUROPROT +

Capacitor overvoltage protection function

PROTECTA HUNGARY

Budapest, May 2018.

User's manual version information

Version	Date	Modification	Compiled by
1.0	2012-10-10	First edition	Gyula Poka Kornel Petri
1.1	2018-05-30	Minor corrections	Erdős

Capacitor overvoltage protection function

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

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

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

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

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

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

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

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

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

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

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

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

Technical data

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

Parameters

Enumerated parameters

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

Integer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Capacitor nominal current, related to the rated current of the current transformer. The integral of this current defines the nominal basic harmonic voltage, the peak value of which is the reference for overvoltage detection.						
CapOV_NomCurr_IPar_	Rated current	%	15	120	1	100
Value of the overvoltage, related to the rated voltage of the capacitor, to start the warning stage of the function						
CapOV_I2Start_IPar_	Warning Start	%	80	120	1	100
Reset time setting for Stage 1						
CapOV_Reset_IPar_	Reset Time	sec	1	60000	1	3600
Definite time delay for Stage 2						
CapOV_Delay2_IPar_	Warning Delay	sec	1	3600	1	60

Floating point parameter

Parameter name	Title	Dim.	Min	Max	Step	Default
Time multiplier for the inverse type characteristic						
CapOV_K_FPar_	Time Multiplier	-	0.20	2.00	0.01	1.00

Binary output status signals

Binary output status signals	Signal title	Explanation
CapOV_Str1L1_GrI_	Start1 L1	Start of Stage 1 in phase L1
CapOV_Str1L2_GrI_	Start1 L2	Start of Stage 1 in phase L2
CapOV_Str1L3_GrI_	Start1 L3	Start of Stage 1 in phase L3
CapOV_Str2L1_GrI_	Start2 L1	Start of Stage 2 in phase L1
CapOV_Str2L2_GrI_	Start2 L2	Start of Stage 2 in phase L2
CapOV_Str2L3_GrI_	Start2 L3	Start of Stage 2 in phase L3
CapOV_Trip1_GrI_	Trip1	Trip command of Stage 1
CapOV_Trip2_GrI_	Trip2	Trip command of Stage 2 (usually assigned as Warning)

Binary input status signals

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

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