EUROPROT +

TRIM Inrush current minimizer function

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TRIM Transformer inrush current minimizer function

The inrush current of the transformers is the consequence of the transient saturation of the magnetic core, caused by the energizing voltage. The induced flux starts from the residual flux values of the iron core limbs, and according to the phase angle of the applied phase voltages, it can exceed the saturation flux value. The residual flux values are the result of the former disconnection process.

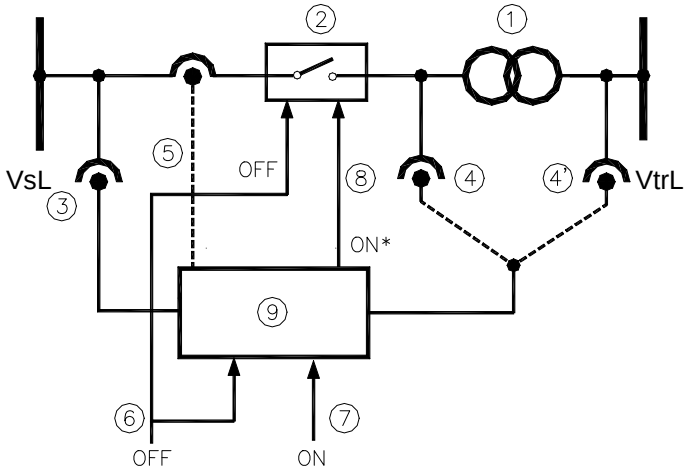
The saturated iron core needs high and distorted magnetizing current, the peak values of which can be several times higher than the rated current peaks. These high current values in the fault current range can overstress the mechanical fixing of the coils and the heating effect can decrease the life span of the transformer, resulting internal faults.

The TRIM (**TR**ansformer **I**nrush current **M**inimizer) function can prevent these high current peaks of the inrush current, using controlled switching.

The details of the principle of operation are described in the PROTECTA document “EuroProt+, Numerical transformer inrush current minimizer, Principle of the operation”

The TRIM function minimizes the inrush current of any kinds of three-phase (or single phase) transformers, applying controlled switching. The close command is synchronized to the momentary values of the supply side voltage. The appropriate moment of closing the circuit breaker is determined using the voltage values, sampled during the preceding disconnection process. Based on these values the residual flux values of the individual transformer iron cores are calculated and these values determine the optimal closing moment.

The application of the function is explained with Figure below.



The device performing the TRIM function (9) minimizes the inrush current of (single or three-phase) transformer (1) by synchronized energizing command to the circuit breaker (2). The moment of closing the contacts of the circuit breaker is synchronized to the positive zero crossing of the signal from the voltage transformer (3) on the supply side of the circuit breaker. To determine the appropriate moment of closing the contacts of the circuit breaker, the values of the “residual flux” in the iron cores of the transformer are needed. The residual flux can be determined with the integration of the voltage signal from the voltage transformer (4), which can be on the primary or secondary (or tertiary) side of the transformer. This voltage transformer must measure the decaying voltage after the OFF command (6) disconnects the transformer. When the measured voltage on the transformer decays to zero, the calculated residual flux values are stored in the memory of the device.

The optimal moment of closing the circuit breaker is (or the optimal moments in case of individual drives for the three phases are) calculated with the aim that after energizing, the

flux-time function could continue as a steady state function. In this case the flux cannot reach the saturation value, and no inrush current can arise.

If input (7) of the device receives the intent to energize the transformer, then the output (8) delivers the synchronized common or individual ON* command to the phases of the circuit breaker.

To measure the current signals from the current transformer (5) is an option only, it is not necessary for the operation of the algorithm, but during the commissioning the displayed peak current is a useful information to check the correct operation of the device.

The device calculates the moment of the close command generation with milliseconds accuracy, and the close command for the circuit breaker is started considering the closing time of the circuit breaker too, in order to control the closing to the calculated moment. If the deviation of the subsequent closing times of the circuit breaker is too high, then the efficiency of the controller is low. In order to optimize the effect, it is required that the deviation of the closing time should be within the range of ± 2 ms.

The device can control three-phase circuit breakers with individual drives for all three phases. In this case the efficiency is high, practically no switching transient is generated; the steady state can be started without considerable transients. In this case no inrush current can be detected.

If the phases are operated with a common drive, and the individual phases are mechanically delayed to each other, the inrush current is suppressed below the peak value of the transformer rated current. The mechanical time delay should be defined in milliseconds (e.g.: 5-0-5 ms, 0-6.66-3.33 ms or 0-0-0 ms).

The energizing of transformers with different connection groups needs different closing strategies. Based on the dedicated parameter “Vector group” the algorithm automatically selects the optimal closing moment for the circuit breaker poles.

The primary voltage measurement signed as VsL is supposed to be on the supply side of the circuit breaker. This is the prospective voltage, after closing the circuit breaker this voltage energizes the transformer. The positive zero crossing of phase VsL1 voltage is the time reference to delay the closing moments of the circuit breaker phases.

The transformer side voltage (VtrL) is measured by a voltage transformer which is continuously connected to the transformer even in de-energized state. The location of the voltage transformer can be either between the circuit breaker and the transformer or on the secondary side of the transformer. Depending on the connection group of the transformer, the algorithm calculates the coil voltages.

The algorithm does not apply the measured current for control purposes. They are only needed for disturbance recording to check the efficiency of the controlled switching.

In some applications the rated voltages of the transformer do not match exactly the rated voltage of the VT-s. For these cases the matching factors to be set as parameter values serve the purpose of more accurate operation.

The transformer inrush current minimizer function has binary input status signals. The conditions are defined by the user applying the graphic equation editor.

The operation of the algorithm needs the information if the circuit breaker gets a trip command. Of course, the circuit breaker gets this command directly too, the device does not delay the trip command.

The device receives the intent to energize the transformer, and if the parameter for operation is set to “On” then it passes the close command to the circuit breaker applying the calculated time delay. In inactive state (“Bypass”) the command is passed over without calculated time

delay. If the operation mode of the function is “Off” then the command is not transmitted to the circuit breaker at all.

The operation can be blocked if the “Block” status is active. During this time no close command is passed to the circuit breaker.

Commissioning of the device is an easy procedure, supported by the on-line information.

The on-line blocks for the voltage inputs (VT4) display the magnitude and phase angle of the measured phase voltages. Check the correct phase sequence and phase assignment.

Check the correct parameter setting according to the application. At this stage the value of the parameter “CB TravTime” is not defined, leave it for the first energizing as the default value.

Among the on-line information of the TRIM function the “winding voltages” can be found. In energized state of the transformer the supply side and the transformer side voltages are expected to be in good coincidence. If not then set the “PrimSideCorr” and/or “SecSideCorr” multiplication factors to result approximately equal calculated voltage values.

The first energizing of the transformer via the TRIM function is uncontrolled, but the program measures the circuit breaker operating time (“CB TravTime”). This operating time is an input parameter as well, which must be set correctly, according to the measured and displayed value. (Remark: additionally to the CB pole travel time this measured time includes the internal time delay of the algorithm as well.)

During the next OFF switching, the device determines the residual flux values, and the subsequent ON commands are synchronized, so no high inrush current peak values are expected.

The integrated event recorder function stores the measured circuit breaker operating time for several events, if it is needed then the average of the stored information can be a basis for a subsequent parameter correction.

The event recorder stores the measured current peak values for evaluation. The value is in %, related to the rated peak value of the CT.

The integrated disturbance recorder function supports the detailed analysis of the transformer energizing and disconnecting phenomena.

Technical data

Function	Effective range	Accuracy
Measurement		
Current effective range	20 – 2000% of In	±1% of In
Voltage effective range	2-110 % of Un	±1% of Un
Effectiveness of control		
Single pole control	by ± 2ms CB time inaccuracy	Ipeak < 0.5x In_peak
Three-phase control	by ± 2ms CB time inaccuracy	Ipeak < In_peak

Parameters

Enumerated parameters

Parameter name	Title	Selection range	Default
Selection of the operating mode			
Trim_Oper_EPar_	Operation	Off, On, ByPass	Off
Selection of the transformer vector group (seen from the switched side)			
Trim_VGroup_EPar_	Vector group	Yd1,Yd5,Yd7,Yd11,Yy0,Yy6, Dy1,Dy5,Dy7,Dy11,Dd0,Dd6	Yd11
Circuit breaker lag type*			
Trim_LagType_EPar_	Lag type	SinglePole, Lag-0-0-0, Lag-3-0-3, Lag-5-0-5	SinglePole
Location of the transformer side voltage measurement			
Trim_SecSide_EPar_	Utr Side	Primary, Secondary *	Primary

** the transformer is expected to be energized from the primary side*

Integer parameter

Parameter name	Title	Unit	Min	Max	Step	Default
Voltage, below this level the transformer is considered to be switched off						
Trim_ULimit_IPar_	U limit	%	5	30	1	10
Correction factor for the supply side voltage measurement Untr_pr/UnVT						
Trim_PrimCorr_IPar_	PrimSideCorr	%	85	115	1	100
Correction factor for the transformer side voltage measurement Untr_sec/UnVT						
Trim_SecCorr_IPar_	SecSideCorr	%	85	115	1	100

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Traveling time of the circuit breaker when closing as it is displayed by the function						
Trim_TravTime_TPar_	CB TravTime	msec	30	500	1	80

Summary of the on-line measured values

On-line measured values	Title	Explanation
Trim_CBTime_OLM_	Last CBClose	CB travelling time measured during the last performed close command*
Trim_LastInr_OLM_	Last Inrush	Max current peak measured during the last performed close command**
Trim_UTA_OLM_	US Winding A	Calculated voltage of the winding on limb A, based on the source side phase voltage
Trim_UTB_OLM_	US Winding B	Calculated voltage of the winding on limb B, based on the source side phase voltage
Trim_UTC_OLM_	US Winding C	Calculated voltage of the winding on limb C, based on the source side phase voltage
Trim_UFA_OLM_	UT Winding A	Calculated voltage of the winding on limb A, based on the transformer side phase voltage
Trim_UFB_OLM_	UT Winding B	Calculated voltage of the winding on limb B, based on the transformer side phase voltage
Trim_UFC_OLM_	UT Winding C	Calculated voltage of the winding on limb C, based on the transformer side phase voltage

** The measured time includes also the contact operating time in the device and the transient time of the circuit breaker. In case of correct setting this value should coincide with the parameter setting "CB TravTime".*

*** The value is in %, related to the rated peak value of the CT.*

Binary input status signals

The conditions of the binary input status signals are defined by the user applying the graphic equation editor.

Binary input status signal	Title	Explanation
Trim_Blk_GrO_	Block	Blocking the operation of the function
Trim_Open_GrO_	Open	It is logic true if the circuit breaker gets an open command
Trim_Close_GrO_	Close	Close request to the circuit breaker. The function controls the moment of generation the command to be given to the circuit breaker

Generated binary output status signals

Generated binary output status signal	Title	Explanation
Direct commands to the circuit breaker		
Trim_CloseL1_GrI_	Close L1	Close command to CB phase L1
Trim_CloseL2_GrI_	Close L2	Close command to CB phase L2
Trim_CloseL3_GrI_	Close L3	Close command to CB phase L3
User applicable output status signals		
Trim_Oper_GrI_	Operate	Operation of the function
Trim_UnSucc_GrI_	Unsuccessful	Unsuccessful operation