GE
Digital Energy

UR Series

T35/T60 Reference Winding Selection and CT Ratio Mismatch

Application Note

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This application note outlines how to deal with winding selection and current transformer (CT) ratio mismatch for firmware versions up to 7.1x of the T35 and T60 relays in the UR series. Contact GE Digital Energy to inquire if it applies to subsequent releases.

Introduction

The reference winding (W_{ref}) is the winding to which all other winding currents are scaled. That is, the per-unit values of the differential current and the restraint current are based on the nominal of the CT of the reference winding.

In the UR EnerVista software, reference winding can be selected either automatically or manually. When set to Automatic Selection, the reference winding is selected as one having minimum I_{margin} value based on following equations.

$$I_{rated}[w] = \frac{P_{rated}[w]}{\sqrt{3} \times V_{nom}[w]} \qquad I_{margin} = \frac{\text{CT primary}[w]}{I_{rated}[w]}, \text{ where } w = 1, 2, \ldots w_{total}$$

where P_{rated} is the winding rated MVA, V_{nom} is the winding nominal phase-to-phase voltage, and w is the winding index number.

In the software, the magnitude correction factor M for each winding is calculated based on the following equation.

$$M[w] = \frac{I_{primary}[w] \times V_{nom}[w]}{I_{primary}[w_{ref}] \times V_{nom}[w_{ref}]}, \text{ where } w = 1, 2, \ldots w_{total}$$

Maximum allowed CT ratio mismatch

As indicated in the T35 and T60 instruction manuals, the maximum allowed magnitude compensation factor (and hence the maximum allowed winding current mismatch) is 32. However, a cutoff limit of 46 pu is applied in the firmware (signals after magnitude compensation), which can reduce this CT mismatch range significantly. As a result, signal clamping can occur for the windings with high magnitude compensation factor and potentially cause misoperation on the differential element.

Typically, CT ratio mismatch does not exceed 10 if the CT primary nominal current follows winding nominal current. However, when CT primary current differs significantly from the winding nominal current, CT ratio mismatch can exceed this typical value of 10. In this case, it is possible that the value of the compensated current can exceed 46 pu and be clamped.

This cutoff limit of 46 pu in differential calculations is expected to be removed or expanded in the upcoming releases of firmware. Until then, some actions need to be taken to prevent differential element misoperation caused by the possible signal clamping.

Recommendation

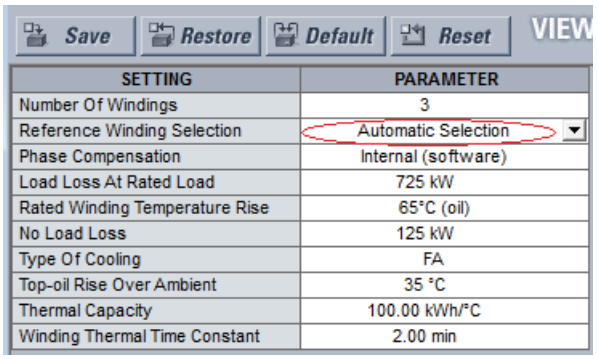
With automatic reference winding selection, the following check needs to be performed: if any winding maximum fault current multiplied by its magnitude compensation factor exceeds 46 pu, then manually reselect the reference winding.

GE recommends that the winding with the maximum magnitude compensation factor be selected as the reference winding. In this case, signal clamping does not occur, but the sensitivity of the differential element needs to be checked and differential element settings (for example, pickup level) need to be adjusted based on the new reference winding.

Example

The following figures provide an example.

Here we verify that Automatic Selection is being used.



SETTING	PARAMETER
Number Of Windings	3
Reference Winding Selection	Automatic Selection
Phase Compensation	Internal (software)
Load Loss At Rated Load	725 kW
Rated Winding Temperature Rise	65°C (oil)
No Load Loss	125 kW
Type Of Cooling	FA
Top-oil Rise Over Ambient	35 °C
Thermal Capacity	100.00 kWh/°C
Winding Thermal Time Constant	2.00 min

We use the information in the following panels to input values into the following equation set.

Save | Restore | Default | Reset | VIEW ALL mode

PARAMETER	WINDING 1	WINDING 2	WINDING 3
Source	345 (SRC 1)	138 (SRC 2)	13.8 (SRC 3)
Rated MVA	675.000 MVA	675.000 MVA	143.700 MVA
Nominal Phs-phs Voltage	345.000 kV	138.000 kV	13.800 kV
Connection	Wye	Wye	Delta
Grounding	Within zone	Within zone	Not within zone
Angle Wrt Winding 1	0.0 deg	0.0 deg	-30.0 deg
Resistance	10.0000 ohms	10.0000 ohms	10.0000 ohms

Save | Restore | Default | Reset | VIEW ALL mode

PARAMETER	SOURCE 1	SOURCE 2	SOURCE 3
Name	345	138	13.8
Phase CT	F1	F5	M1
Ground CT	None	None	None
Phase VT	None	None	None
Aux VT	None	None	None

Save | Restore | Default | Reset | VIEW ALL mode

PARAMETER	CT F1	CT F5	CT M1
Phase CT Primary	2000 A	2000 A	4000 A
Phase CT Secondary	5 A	5 A	5 A
Ground CT Primary	1 A	1 A	1 A
Ground CT Secondary	1 A	1 A	1 A

$$I_{rated}[1] = \frac{675}{\sqrt{3}*345} = 1129.6\ A \qquad I_{margin}[1] = \frac{2000}{1129.6} = 1.77$$

$$I_{rated}[2] = \frac{675}{\sqrt{3}*138} = 2824\ A \qquad I_{margin}[2] = \frac{2000}{2824} = 0.71$$

$$I_{rated}[3] = \frac{143.7}{\sqrt{3}*13.8} = 6012\ A \qquad I_{margin}[3] = \frac{4000}{6012} = 0.66$$

Because $I_{margin}[3]$ is less than $I_{margin}[2]$ and $I_{margin}[3]$ is less than $I_{margin}[1]$, the winding 3 is the reference winding by Auto Selection.

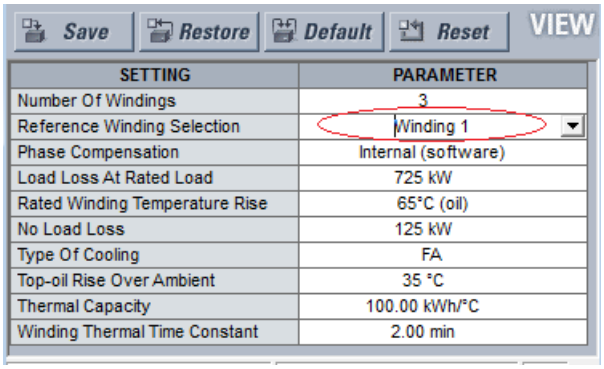
Now let us calculate the magnitude compensation factor of each winding.

$$M[1] = \frac{2000 * 345}{4000 * 13.8} = 12.5; \quad M[2] = \frac{2000 * 138}{4000 * 13.8} = 5; \quad M[3] = \frac{4000 * 13.8}{4000 * 13.8} = 1$$

Selecting the largest value and assuming that the maximum fault current of winding 1 is 4 pu, then IxM[1] = 4*M[1] = 4*12.5 = 50 pu.

Because 50 pu is greater than 46 pu, the reference winding needs to be reselected manually. Based on the recommendation in the previous section, set winding 1 as the reference winding because it has the highest magni-

tude compensation factor. The following figure shows manual setting of winding 1 as the reference winding.



SETTING	PARAMETER
Number Of Windings	3
Reference Winding Selection	Winding 1
Phase Compensation	Internal (software)
Load Loss At Rated Load	725 kW
Rated Winding Temperature Rise	65°C (oil)
No Load Loss	125 kW
Type Of Cooling	FA
Top-oil Rise Over Ambient	35 °C
Thermal Capacity	100.00 kWh/°C
Winding Thermal Time Constant	2.00 min