Application Note

Substation Automation and Protection Division

Influence Of The Equal And Unequal CT Ratios On The Setting Of REL 352 Relays

Introduction

This application note will show how to calculate and pick the settings on the relay for the general application case, both CT at the two line end have the equal CT ratio, and CT's at two line ends have unequal ratios.

Application

Consider the line that is protected with REL352 relays at both ends like in Fig. 1

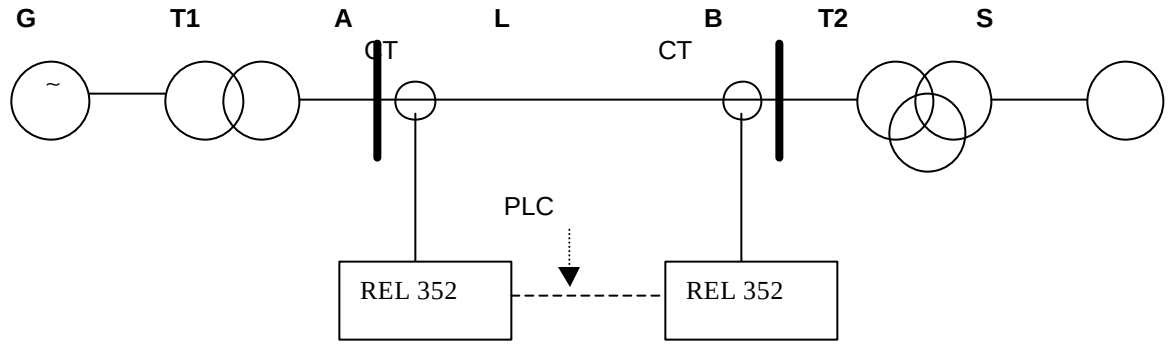

Figure 1 – Power system example for setting

The data that will be used in setting calculation is as follows:

G: Generator with nominal voltage of 13.8kV, nominal power 80MVA and impedance16%,

T1: Two winding transformer with nominal power of 80MVA, nominal voltage 13.8/115kV, short-circuit impedance 11%, vector group delta – star,

L: Line of 30 miles length, positive and negative impedance is 24 Ohm and zero impedance is 82 Ohm,

T2: Three winding transformer with nominal power 150MVA, nominal voltage 230/115/13.2 kV with short circuit impedance Xhm=5.5%, Xhl=36%, Xml=28%, vector group star-star-delta,

S: System equivalent, nominal voltage is 230 kV, positive and negative impedance is 3%, zero impedance is 4%, all of them calculated at 100 MVA and 230 kV base.

The fault current distribution is presented in Table1.

Table 1 – System Fault Currents

FAULT	STATION A	STATION B
Three - phase	1484.3 A	2022.2 A
Phase to ground	2103.4 A	1661.6 A
Load	37 MVA	

For the given load of 37 MVA, nominal load current is:

$$I_n = S_n/(\sqrt{3} * U_n) = 37.000/(\sqrt{3} * 115) = 185.76 \text{ A}.$$

Select current transformer with rated primary value of 200 A and rated secondary value of 5 A.

1. Determination of the sequence coefficients (Co;C1;C2):

1.1 Current transformer ratios are the same at each line end:

REL 352 uses sequence filter to obtain positive, negative and zero sequence currents. These currents are then combined into one quantity as:

$$IT = -C_1 I_1 + C_2 I_2 + C_o I_o$$

Where I_1, I_2 and I_o are positive, negative and zero sequence A phase currents. The sequence filter setting C_1;C_2;Co must be the same at the two line ends.

As may be seen from Table 1, minimum fault current for internal phase to ground fault is greater than 67% of three phase fault current at both line ends. For this case sequence coefficients are (case 1 on the page 5-64 in the Instruction Leaflet 40-201.9B):

C_1=0.1
C_2=0.7
Co=0.0

The IKEY setting at both line ends are set 0.75 A. Local Positive (LP) Level is set 1.5 A.

1.2 Current transformer ratios are different at each line end:

Suppose that we have line CT's in substation A with ratio 200/5 and CT's in the substation B is 400/5 (only to represent different CT ratio). The keying current (IKEY) setting and LP setting must be the same at both line ends and not changed, i.e. IKEY=0.75A and LP=1.5A. However to get dependable protection scheme for this case some setting modifications of sequence coefficients must be done. These coefficients should be modified at line end with **higher** CT ratio. In our case all sequence coefficient must be multiplied with 2 (400/200) at the line end with **higher** CT ratio, i.e.

C_1=0.2
C_2=1.4
C_0=0.0

Test Results:

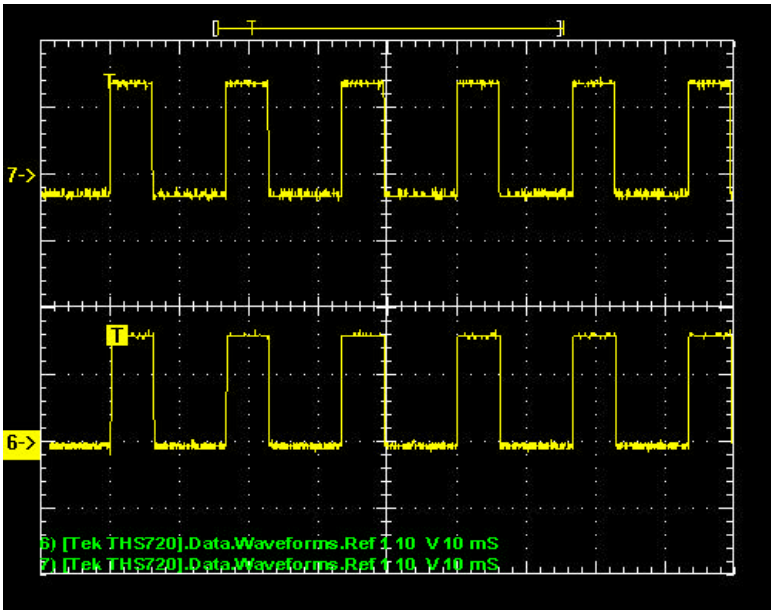

Figure 2 - The waveform of local and remote signals for the equal CT ratio at each end

It is obvious that both waveform (Local Negative, signal No7 in the Figure2 and Remote IT's keying signal No6) are identical in the sense of pulse width (6.2ms in this case). This will assure safe trip because coincidence time of these two signals is greater than 4ms.

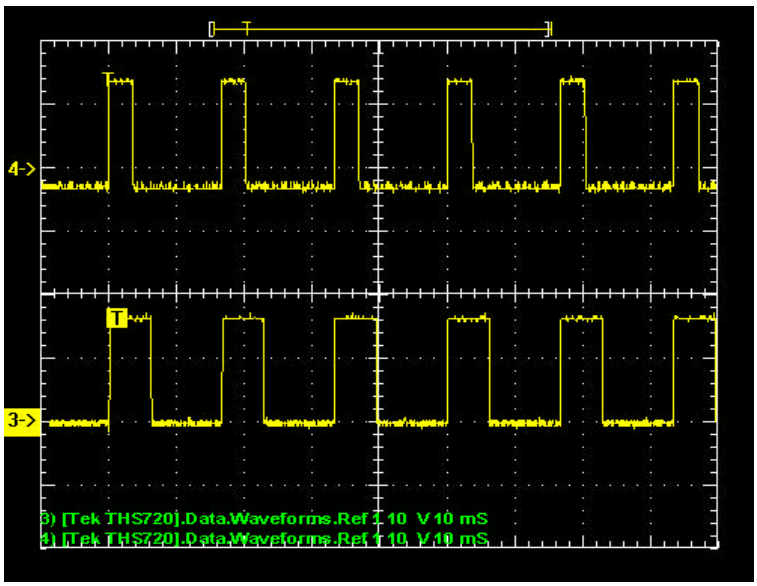

Figure 3.The waveform of local and remote signals for the different CT ratio at each end.

In the test arrangements different CT ratios at each end (200/5 and 400/5) were simulated, and the setting of sequence coefficients the same, i.e. C_0=0, C_1=0.1, C_2=0.7 (of course wrong setting). From Figure 3. it is obvious that trip is not assured because remote keying signal has pulse width of 2ms. So coincidence time is less than 4ms, no trip signal for the internal fault. The reason was unchanged sequence coefficients at line end with higher CT ratio.

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