Dual Slope Differential Relay as an Effective Technique for Differential Protection of Y-Y Connected Power Transformer

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Abstract:
This paper carries the idea of selection of dual slope differential relay parameters for various faulty conditions on the system. The differential protection of power transformer is a unit protection scheme. The protective scheme should operate only for the internal fault, and it must be insensitive for any fault outside the zone of protection. That means the protection scheme should not operate for any external through fault and the magnetizing inrush current due to energization of the transformer under no load condition and also due to external fault removal. Fast Fourier Transform technique is used to provide the operating quantity for the dual slope differential relay. The simulation for Y-Y connection of transformer is made using PSCAD software. The snapshots of results for different types of fault are also included in the paper.

Keywords: *FFT, Operating parameters, Slope setting*

1. Introduction

The basic operating principle of differential protection is to calculate the difference between the current entering and leaving the protected zone. There is a phenomenon that occurred during removal of external through fault or due to energization of the transformer under no load condition named magnetizing inrush current. The differential protection scheme should remain insensitive for such magnetizing inrush current. The differential relay should not operate for the external/through fault .The differential protection of power transformer is a unit protection scheme. The protective scheme should operate only for the internal fault, and it must be insensitive for any fault outside the zone of protection.

The protection operates when the differential current exceed the set bias threshold value. For external faults, the differential current should be zero, but error caused by the CT saturation and CT ration error leads to non-zero value. To prevent maloperation the operating threshold is raised by increasing the relay setting.

Maloperation of the differential protection of power transformer may occur due to Magnetizing inrush current, CT saturation and Through Fault Inrush. Among all these three; magnetizing inrush results during excitation of Transformer under no load condition. It can also come in to picture during the energization of parallely connected power transformer. For this setting of 4 relay parameter is very important: i.e.

(1) Differential Current Threshold: Is1
(3) Bias current threshold: Is2
(2) Lower Percentage Bias Setting: K1
(4) Higher Percentage bias setting: K2

1.1 Fft

Fast Fourier Transform technique is used for preventing the maloperation. The secondary current signals from the CTs are sampled at a regular interval. This is an online Fast Fourier Transform (FFT), which can determine the harmonic magnitude and phase of the input signal as a function of time. The input signals first sampled before they are decomposed into harmonic constituents. PSCAD software includes the online FFT block which is shown below.

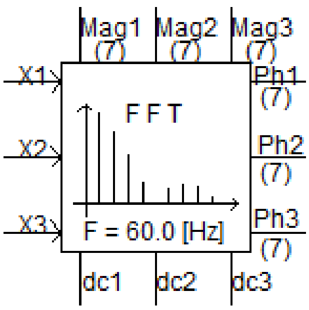


Fig. 1 FFT Block In PSCAD

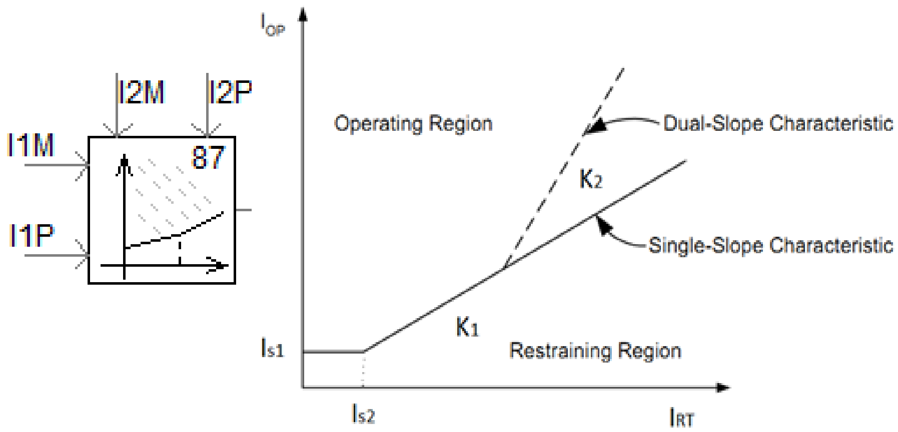


Fig. 2 Dual Slope Differential Relay In PSCAD and the Characteristic

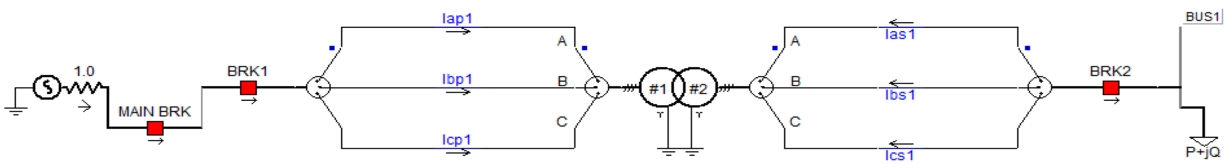


Fig. 3 System Model

T/F: 10 MVA, 66/11KV, Y-Y
Source: 20 MVA, 66KV
Primary CT: 1/100 (Turns ratio)
Secondary CT: 1/600 (Turns ratio)

2. Calculation

At any instance on secondary current waveform at CT secondary side we can calculate the value of the four relay parameter mentioned above.

Let take the instance: t=0.8sec, (NOTE: the supply current runs in the line at t=0.505 sec)
(NOTE: take vector sum for calculating differential current threshold and take arithmetic sum for calculating bias current threshold)

2.1 Under Normal Condition

2.1.1 Primary side of T/F

$$I_{ap1} = -275A$$

$$I_{ap2} = I_{ap1} \otimes \frac{N_1}{N_2} = -275 \otimes \frac{1}{100} = -2.75A$$

2.1.2 Secondary Side of T/F

$$I_{as1} = 1247A$$

$$I_{ap2} = I_{ap1} \otimes \frac{N_1}{N_2} = 1247 \otimes \frac{1}{600} = -2.07A$$

$$I_{DIFF} = I_{ap2} + I_{as2}$$

$$I_{DIFF} = (-2.75) + 2.07 = 0.68$$

$$slopeK_1 = \frac{I_{DIFF}}{I_{BIAS}} = \frac{0.68}{2.4} = 0.282 \approx 30\%$$

$$I_{BIAS} = \frac{I_{ap2} + I_{as2}}{2}$$

$$I_{BIAS} = \frac{2.7 + 2.07}{2} = 2.41$$

Slope K_2 will be selected based on the relay operating criterion given for the dual slope relay.

3. Relay Parameter Setting

IS1: The basic differential current setting
K1: The lower percentage bias setting
IS2: The bias current threshold setting
K2: The higher percentage bias setting
The tripping criteria can be formulated as:

Case 1

I bias< Is2
Idiff> K1 * I bias + Is1 THEN TRIP

Case 2

I bias> = Is2
Idiff> K2 * I bias – (K2 – K1) * Is2 + Is1 THEN TRIP

3. 1 Analysis of Waveform and Relay Operation under No-Load Conditio

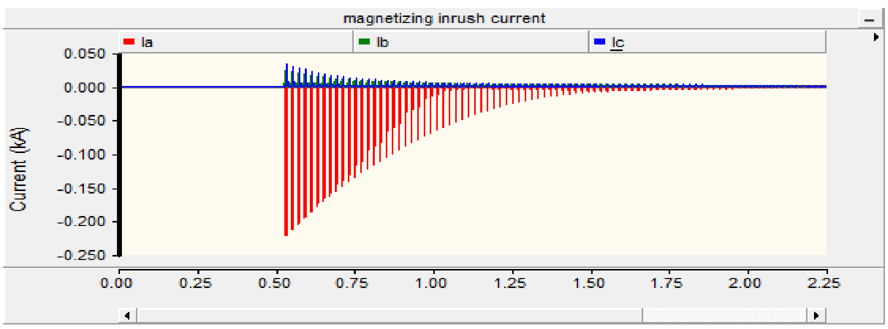


Fig. 5 Magnetizing Inrush Current

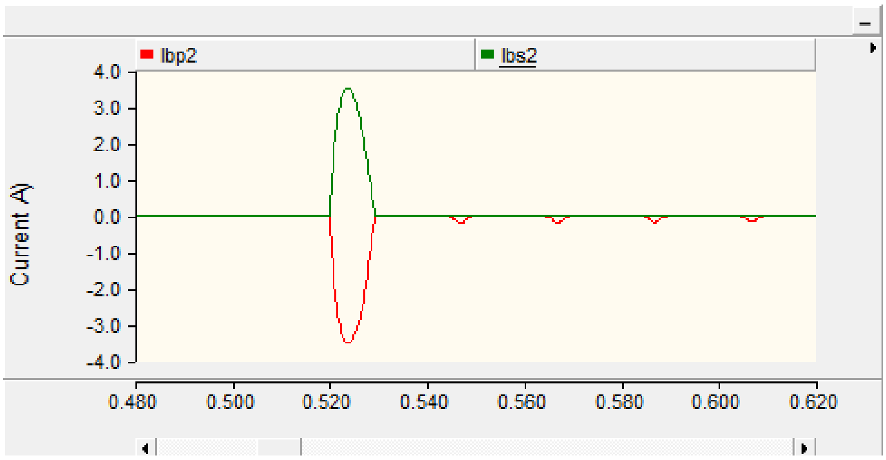


Fig. 6 Ct Secondary Pilot Wire Current

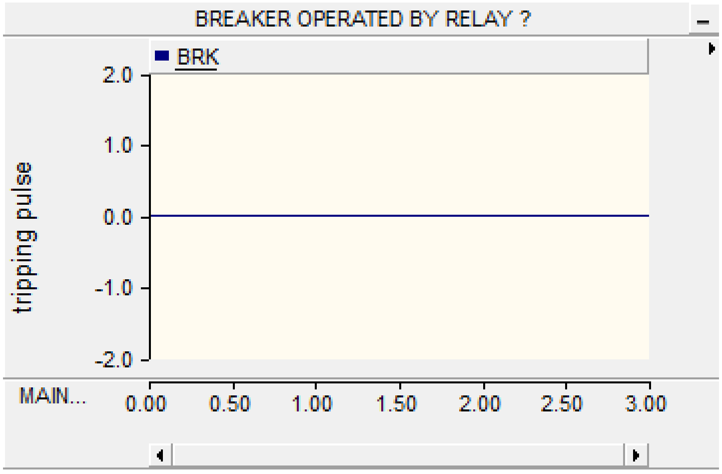
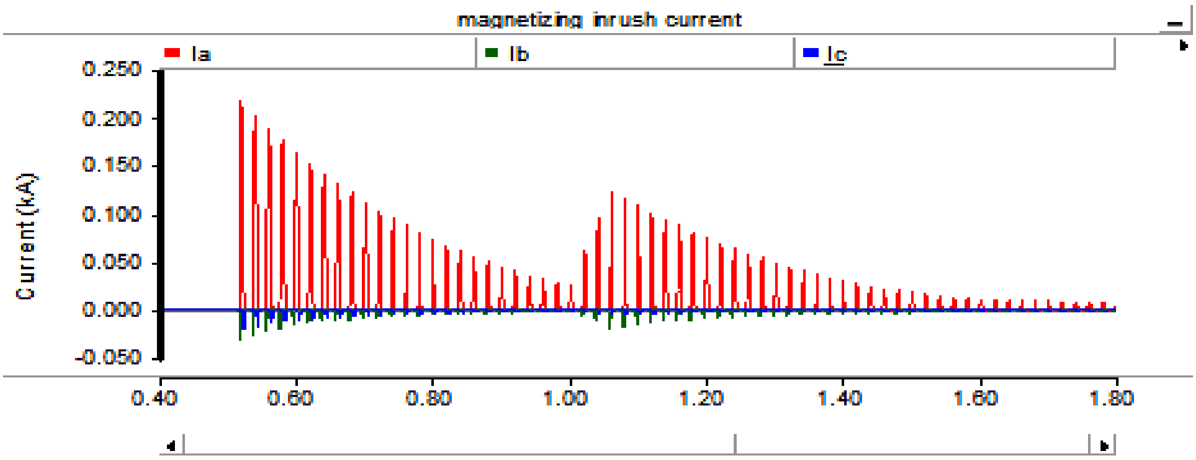
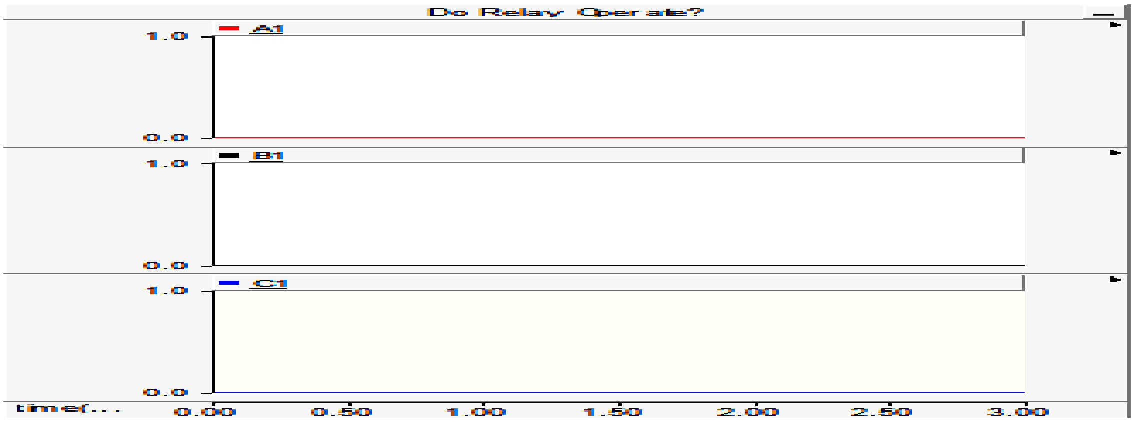


Fig. 7 Breaker Status

3.2 Analysis of Waveform and Relay Condition for ABC-G External Fault at Load Side

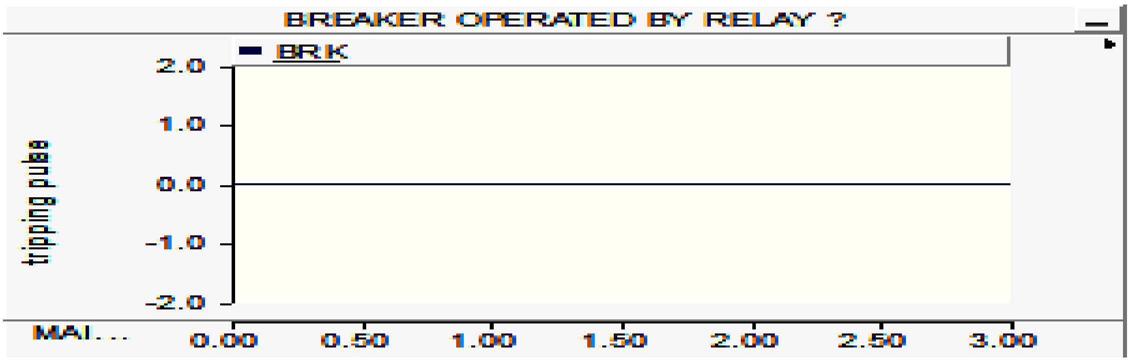


(a) Magnetizing Inrush Current



(b) Relay Status for All Three

(c) Differential and Bias Current



(d) Breaker Status

Fig. 8 Waveform for ABC-G External Fault

3.3 Analysis of Waveform for Faults A-G Internal (T=1sec) BC Internal (T=1.9sec) And ABC-G External Faults (T=1.5sec)

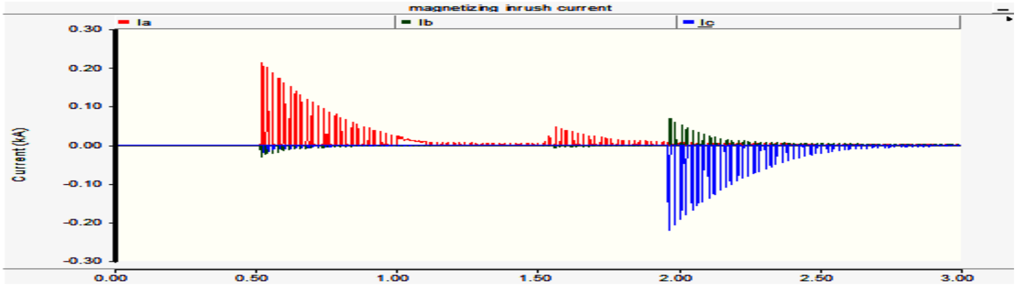


Fig. 9 Magnetizing Current For Different Fault Condition

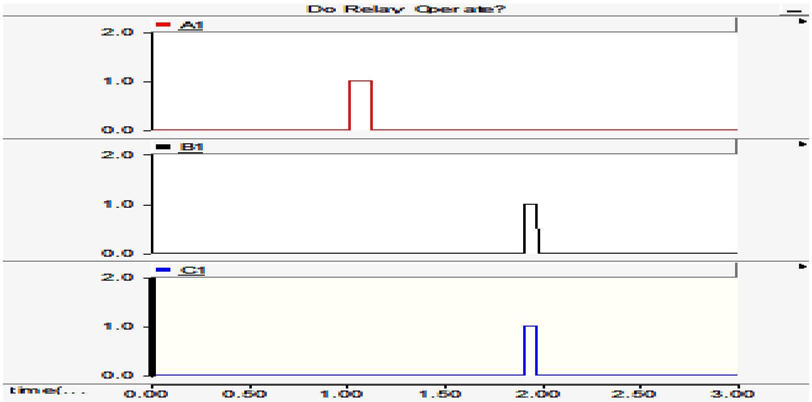


Fig. 10 Relay Operation For Internal Fault

4. Conclusion

Effective setting of the four basic parameters of the dual slope differential relay will prevent any maloperation of the differential protection scheme. FFT is used to provide the different harmonic content in the supply signal. To provide safe operation of differential relay the differential current threshold is to be raised under no-load condition, but care must be taken for the relay sensitivity for internal fault. The second slope K_2 is selected based on the CT saturation possibility. For Y-Y T/F the settings are given in figure 8. For any connection i.e. Y-Y1, Y-Y11, Y-Y6, etc. the signals output from FFT are phase shifted and the differential protection scheme will operate satisfactorily.

5. References

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