Differential Protection Of Y-Y And Δ-Δ Connected Power Transformer

Mayurdhvajsinh P. Gohil, Jinal Prajapati, Ankit Rabari

***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 Δ-Δ connection of transformer is made using PSCAD software. The snapshots of results for different types of fault are also included in the paper.**

Key Words*: *FFT, operating parameters.

I. 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 mal-operation the operating threshold is raised by increasing the relay setting.

Mal-operation 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.4 relay parameter is very important: i.e.

IS1: The basic differential current setting

K1: The lower percentage bias setting

IS2: The bias current threshold setting

K2: The higher percentage bias setting

II. FFT

Fast Fourier Transform technique is used for preventing the mal-operation. 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.

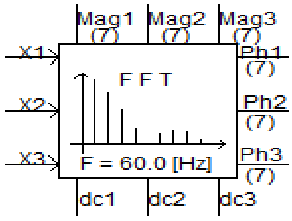
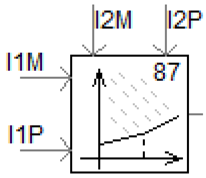


Fig.1 . FFT block in PSCAD



Dual Slope Differential Relay in PSCAD

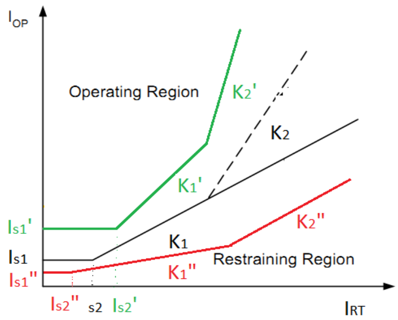


Fig. 2 Dual Slope Differential Relay characteristics

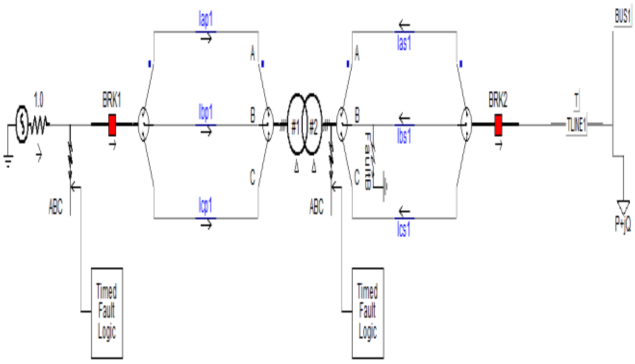


Fig. 3 System model

T/F: 10 MVA, 66/11KV, Δ-Δ, 50Hz

Primary CT: 5/300 (Turns ratio)

Source: 20 MVA,66KV

Secondary CT: 5/1800 (Turns ratio)

III. 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=1sec, (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)

A. RELAY SETTING:

Pilot wire current at the primary and secondary side of the power T/F just after the Energization i.e. t=0.52 sec

Primary side of T/F:

$$I_1 = -6.70 \qquad I_2 = 3.21$$

Hence,

The differential current:

$I_{DIFF} = I_1 + I_2$(Vector sum)

$I_{DIFF} = (-6.70) + (3.21)$

$$I_{DIFF} = 3.49\ A$$

The Bias current: (Arithmetic sum)

$$I_{BIAS} = \frac{I_1 + I_2}{2}$$

$$I_{BIAS} = \frac{6.70 + 3.21}{2} = 4.95$$

Hence,

Slope 1$=\frac{I_{DIFF}}{I_{BIAS}} = \frac{3.5}{4.95} = 0.70$

So, let Slope K1=70%

Under the normal operating condition at any time the differential current is not increasing beyond1 A.
So, let differential current threshold be 1.0i.e. IS1=1.0
Slope K2 will be selected based on the relay operating criterion given for the dual slope relay.

The tripping criteria can be formulated as:

CASE 1:

$$I_{bias} < I_{s2}$$

If$I_{diff} > K_1 \times I_{bias} + I_{s1}$ THEN TRIP

CASE 2:

$$I_{bias} < I_{s2}$$

If,

$$I_{diff} > K_2 \times I_{bias} - (K_2 - K_1) \times I_{s2} + I_{s1}$$

THEN TRIP

1. Analysis of waveform and relay operation under no-load condition

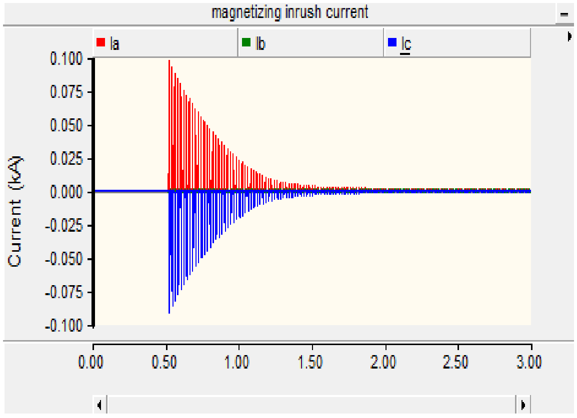


Fig. 4 Magnetizing Inrush current

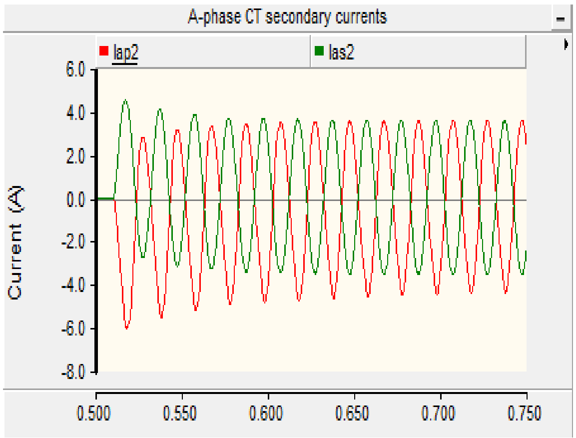


Fig. 5 CT Secondary current matching

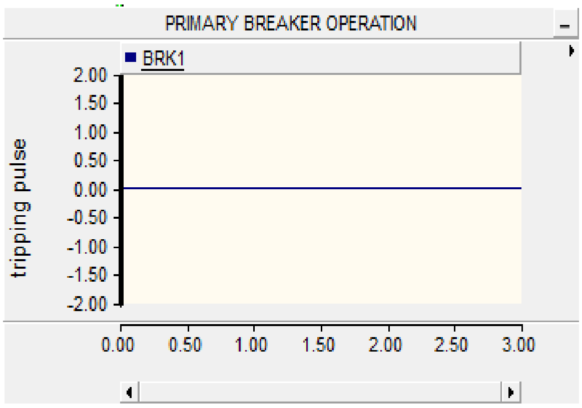


Fig. 6 Breaker operation under normal condition

2. Analysis of waveform and relay operation under no-load condition

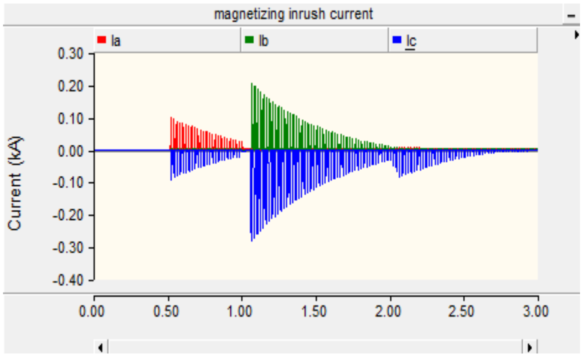


Fig. 7 Magnetizing Inrush current under faulty cundition

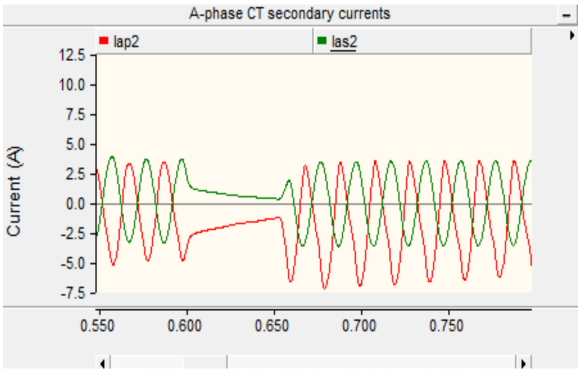


Fig. 8 CT secondary current matching under fault (t=o.6sec)

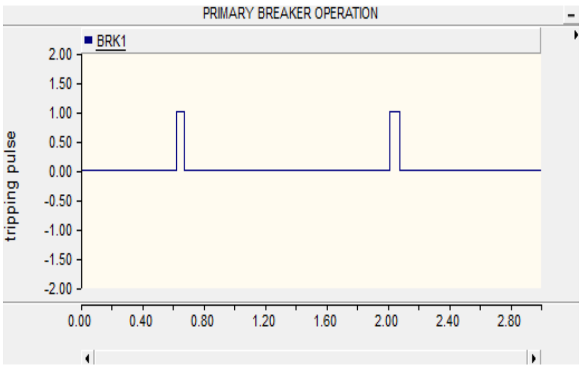


Fig.9 Breaker operation only during internal fault(t=0.6s & t=2s)

IV 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 K2 is selected based on the CT saturation possibility. If we are providing protection to only Y-Y T/F the settings can be more economical as a view of reliability but if we want to protect $\Delta - \Delta$T/F the we need to take care of all the cases for which the relay should not mal operate. For any connection i.e.$\Delta\Delta 1$, $\Delta\Delta 11$, $\Delta\Delta 6$ *and* $YY1$, $YY11$, $YY6$ etc. the signals output from FFT are phase shifted and the differential protection scheme will operate satisfactorily. The dual slope relay parameter settings are displayed in Table 1.

Sr. No	Differential Relay Parameter Setting		
	Parameter	**Symbole (P.U)**	**Value**
1	**Differential current threshold**	**IS1**	**1.9**
2	**Lower percentage bias setting**	**K1**	**0.6**
3	**Bias current threshold setting**	**IS2**	**1.2**
4	**Higher percentage bias setting**	**K2**	**0.8**

REFERENCES

[1] A Transformer Protection Technique with Immunity to CT Saturation and Ratio- Mismatch Conditions AUTHOR: T.S. Sidhu, Senior Member IEEE.

[2] The Influence and Countermeasure to Transformer Differential Protection of CT

[3] The Analysis of Operation Characteristic of Transformer Differential Protection Based on Virtual Third Harmonic Theory Deshu Chen, Senior Member, IEEE, Wei Chen, Member, IEEE, Xianggen Yin, Zhe Zhang, Yufeng.

[4] Practical experience in setting transformer differential inrush restraint. Rich hunt joeschaefer bob bentert Ge.

[5] Anders E. Zonst, "Understanding theFFT A Tutorial on the Algorithm & Software for Laymen, Students, Technicians & Working Engineers"

[6] Scott Cooper Eastern Regional Manager, " Hands On Relay School Transformer Protection Open Lecturer", Manta Test Systems

[7] Draft IEEE guide for protecting power transformer, Power system relaying committee, USA, 2006.

[8] MT Partenaire, "Current Transformer Selection Guide, Groupe Schneider"

[9] Rich Hunt, Joe Schaefer, Bob Bentert, "Practical Experience In Setting Transformer Differential Inrush Restraint", GE Multiline Florida Power & Light Company Florida.