Study Of Switching And Analysis Behaviour Between Fault And Magnetizing Inrush Current In Transformer

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Abstract

A new scheme to classify between internal fault current and inrush current of power transformer is presented in this paper conventionally this paper presents a novel technique for three phase transformer protection, which the method effectively identify Magnetizing inrush currents from internal fault currents. This technique employs symmetrical components. When transformer is switched, inrush current happens. This current has some Features, which it is enough for identify itself. In this paper, by extract these features, a new criterion is proposed to discriminate inrush currents from internal faults in power transformers. In faulty time such as switching or short circuit, the value of negative sequence for differential current is different from positive sequence value. Helping this feature, new criterion is introduced. Simulations show this criterion works properly in over-flux and CT saturation condition too. The simulated results presented clearly, the proposed algorithm can accurately discriminate between an internal fault and a magnetizing inrush current in power transformer protection in all cases.

***Keywords**:* inrush current, internal fault, Symmetrical component, transformer protection, type of Faults, Transformer energizing, PSCAD

I. INTRODUCTION

Power transformer forms an important link between generation and transmission of power system. It is essential that a transformer gives a very stable, reliable and efficient performance during normal service. Failure of power transformer completely disrupts the supply of area fed from it. When transformer internal faults occur, immediate disconnection of the faulted transformer is necessary to avoid extensive damage and preserve power system stability The magnetizing inrush occurs in transformers whenever polarity and magnitude of residual flux do not agree with polarity and magnitude of instantaneous value of flux. Whenever there is a large and sudden change in the input terminal voltage of a transformer (either due to switching-in or due to recovery from external fault), large current is drawn by the transformer from supply. Similar condition is encountered when a transformer is energised in parallel with another transformer already in service, and this situation is known as sympathetic inrush'. This large current from the source results in the saturation of the transformer core.

1.1 Improved Protection Schemes:

This paper proposes an analysis of the symmetrical components obtained during inrush and during internal fault conditions, By introducing a symmetrical component conversion can decouple three-phase system into three independent sequence equivalent networks, namely positive, negative and zero sequence network. Therefore these three sequence networks can be analyzed separately.

II. SYMMETRICAL COMPONENTS APPROACH

Under symmetrical load condition fault absence is characterized by the absence of negative and zero sequence currents within the delta winding. Internal faults and inrush generate an asymmetrical current demand from the supply source, due to the unbalanced magnetization of the core. It is easier to analyze the performance of the damaged transformer when it is delta-connected. An internal fault causes a distortion in the flux distribution in the locality of the damaged turn. As a result, the coil e.m.f. when damaged is also affected by the fault and thus a different current distribution may be observed in the damaged winding. The voltage distortion in the damaged coil results in a zero sequence current which flows within the delta winding. It has been found however, that the zero sequence current is not due to load or source asymmetries. This zero sequence current is in consequence an indicator of the fault existence and the zero sequence current within the delta winding leads to characteristic positive and negative sequences values. Either unbalanced loads or internal faults do generate negative sequence currents and the zero sequence current within the delta winding implies the arising of positive and negative sequences in the primary lines. Finally, line currents at the supply side are distorted, since the positive and negative sequences found within the delta winding are to be translated in the same line sequences. Another zero sequence generation is observed when the transformer is energized. In such cases, there is an asymmetrical magnetization of the core, which yields also the circulation of a zero sequence current within the delta winding. As in the case of internal fault, the instantaneous measurement and transformation of currents shows that positive and negative currents are also present and therefore faults and inrush may be detected.

III. Theoretical background

The symmetrical component transformation for an arbitrary three-phase set of variables (balanced or unbalanced), for example the three-phase current, and inverse transformation is given in (1) and (2).

$$\begin{bmatrix} I0 \\ I1 \\ I2 \end{bmatrix} = \frac{1}{3} \times \begin{bmatrix} 1 & 1 & 1 \\ 1 & \alpha & \alpha^2 \\ 1 & \alpha^2 & \alpha \end{bmatrix} \times \begin{bmatrix} Ia \\ I\,b \\ Ic \end{bmatrix} \text{-------- (1)}$$

Here I_1 , I_2 and I_0 denote the positive, negative and zero sequences respectively. And

$\alpha = 1\llcorner 120^0 = -0.5 + j0.866$

In general application in power system analysis, we typically begin with information in "phase variables" denoted by subscripts a, b, and c. Note that phase variables corresponds to actual physical quantities. The value of converting physical quantities to symmetrical components is in visualizing and quantization the degree of unbalanced system network. For a balanced three-phase system, it won't be difficult to calculate that the zero and negative sequences are zero, and the positive sequence is equal to phase a, no matter current or voltage.

IV. Proposed Algorithm

Any three-phase voltage and current consist of three components in sequence space which are related to each other as follows:

$$\begin{bmatrix} I0 \\ I1 \\ I2 \end{bmatrix} = \frac{1}{3} \times \begin{bmatrix} 1 & 1 & 1 \\ 1 & \alpha & \alpha^2 \\ 1 & \alpha^2 & \alpha \end{bmatrix} \times \begin{bmatrix} Ia \\ I\,b \\ Ic \end{bmatrix}$$

Here I_1 ,I_2 and I_0 denote the positive, negative and zero sequences respectively. And

$\alpha = 1\llcorner 120^0 = -0.5 + j0.866$

Also $1+\alpha+\alpha^2=0$ if currents I_a, I_b and I_c are balanced (i.e., $I_a = I\llcorner 0$, $I_b = I \llcorner -120^0$ and $I_c = I \llcorner +120^0$). So existence of the negative components means that the system is unbalanced. except over a transient period that may be as a result of different switching method or non identical saturated case of three-phase transformers, three phases are almost affected simultaneously during switching event. Consequently, the negative component is not considerably changed in this case. On the other hand, faults are classified into symmetrical and asymmetrical parts. The major feature of these faults is the large value of the negative component, such that there are the theoretical following cases-

For phase–ground fault

$$I_2 = I_1 = \frac{V_f}{Z_0 + Z_1 + Z_2 + (3Z_f)} \quad \text{...... (2)}$$

Where Z_f is the fault impedance between the line and ground Z_0, is the zero component impedance Z_1, is the positive component impedance, and Z_2 is the negative
component impedance.
For phase-phase fault:

$$I_2 = -I_1 = \frac{V_f}{Z_1 + Z_2 + Z_f}. \quad \text{..... (3)}$$

The criterion function for discriminating fault from non fault switching is defined as follows:

$$R = \frac{|I1| - |I2|}{|I1| + |I2|} \quad \text{----- (4)}$$

Since there is a considerable negative component in the asymmetrical fault case, according to criterion function the value of R is close to zero. In the switching case, the negative component is very small and R is close to 1.

In the switching case, the negative component is very small and R is close to 1. Except over a transient period that may be as a result of different switching methods or a non identical saturated case of three-phase transformers, three phases are almost affected simultaneously and the three-phase network has not a major unbalance, during the switching event. In the calculation of I2 and I_1 in equation (1), Ia ,Ib , and Ic are phasor value (amplitude of the fundamental harmonic). Therefore, dc values and its harmonics are largely eliminated. So the difference in dc value in the current is not important. According to the above, R<0.35 indicates the fault; otherwise, over current is the result of switching. The suggested criterion is based on the different behavior of the current components during fault and non fault conditions and is independent of the amplitude of the current which is advantageous. The reason is that it operates based on the relative difference between the negative and positive component of the current. Another advantage of the suggested criterion function is that its proper operation is independent of the power system balancing. Actually, the suggested criterion function in the asymmetrical distribution networks also operates properly. The reason is that during the asymmetrical fault, the negative component of current increases and the value of R is much smaller than that before fault event. Thus, it is enough that the threshold value be lower than at the value of R in the normal state of the network.

V. Simulation

To show the advantage of the proposed algorithm, a part of a distribution system shown in Fig.1 is modeled; using the EMTDC/ PSCAD package. The network parameter of the 2-bus distribution system is illustrated in this figure. Several nonfault events are applied to this system along with some short circuit events at different times. The simulation results show that how the proposed algorithm could help the overcurrent relay to discriminate fault from nonfault events. The following cases are presented here:

• Transformer energizing;

5.1 Inrush due to switching-in

Initial magnetizing due to switching a transformer in is considered the most severe case of an inrush. When a transformer is de-energized (switched-off), the magnetizing voltage is taken away, the magnetizing current goes to zero while the flux follows the hysteresis loop of the core. This results in certain remanent flux left in the core. When, afterwards, the transformer is re-energized by an alternating sinusoidal voltage, the flux becomes also sinusoidal but biased by the remanence. The residual flux may be as high as 80-90% of the rated flux, and therefore, it may shift the flux-current trajectories far above the knee-point of the characteristic resulting in both large peak values and heavy distortions of the magnetizing current A detailed study of a typical case is presented below. In this case transformer at busbar 1-2 is switched on at instant t= 0.25s and three-phase currents are measured at busbar 7. Fig. 2 shows these three-phase currents. As shown in Fig. 3, except over a transient period, R is close to 1 and is larger than setting R= 0.35s that shows nonfault case. In this case tripping signal is prevented.

5.2 Fault: L-L Fault

In this case at instant t=0.25 sec and three-phase currents are measured. Fig.5.2 (a) shows these three-phase currents. In Fig.5.2 (b), R is close to zero that shows a fault case in which the tripping signal is issued.

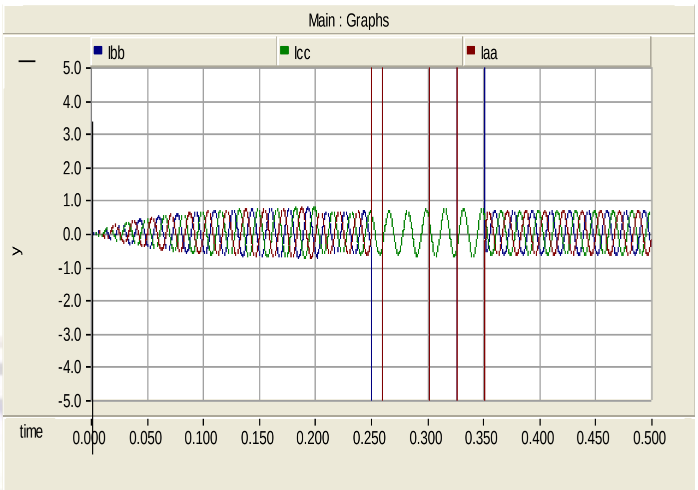

Fig 5.2 (a): Three-phase currents (L-L Fault

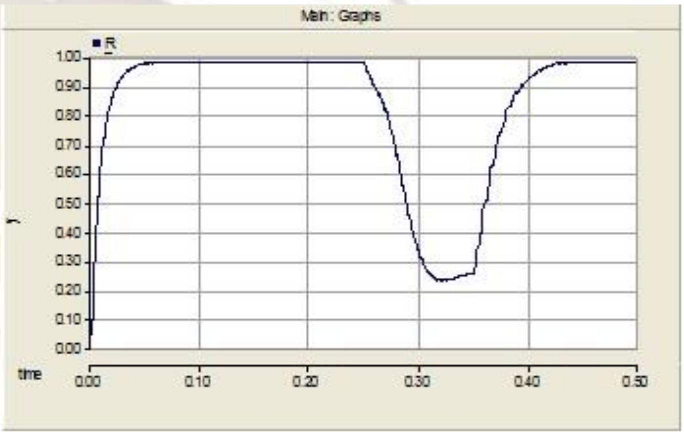

Fig 5.2 (b): Criteria Function Value R for L-L fault

VI. Conclusion

Transformer switching cause problems because mal-operation of power system relays. method is presented to identify inrush currents from internal fault currents. First, symmetrical component of inrush current or internal fault current extracted. Then, a new criterion introduced to discriminate inrush currents from internal faults. In transformer.

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