Detection of Internal Faults in Transformers By Negative Sequence Current

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ABSTRACT

Initially it is very difficult to find out internal fault in transformer. These internal fault are hazardous and causes overheating of transformer oil and winding, it consequences as insulation failure because of this uninterrupted power supply cannot be continued. It is more difficult to detect internal fault in small ratting transformer. Buchholz Relay is classical method for detecting these internal faults in transformer but this method is based on generation of gasses during faults.

This work deals with a technique which is based on source formation of negative sequence current inside or outside of transformer for detecting internal fault. The protection against these fault with the help of differential relay connected both side of the transformer winding which compare the phase difference of negative sequence current.

Keywords*: Setup I_{np} **-** Negative sequence current for primary winding of transformer, I_{ns} – Negative sequence current for secondary winding of transformer, M_{pre} – Pre set value for magnitude comparison of deferential relay, q_{pre} – Pre set value for phase comparison of deferential relay.*

1. INTRODUCTION

Internal fault of transformer one of the biggest topic to concern due to its low magnitude but high injures effect on transformers. Internal fault current of transformer may damage. The dielectric strength of insulation which was provided at the time of manufacturing between number of turns. But it is very difficult to locate the exact position of internal fault of transformer. Which is also known as turn to turn fault detection. According to IEEE standard it is near to impossible to generate a protection scheme which provide protection against internal fault with required standard of sensity and time of response with exact position.

Percentage differential relay is only available method which provide protection against these type of internal fault but for application of these type protection of scheme the rating of transformer must exceed approximately 10 MVA. Below this rating transformer whatever current is generated during internal fault is not enough high to detect by protection scheme. So low level internal fault or low internal fault of lower rating of transformer having a great challenge of to be sense by protection scheme. Some other protection system like buchholz relay may be also applicable here but due to it is mechanism which is depends upon level of oil takes more time to the sense the fault due to this internal fault becomes very serious some time.

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An effect idea was given by Kang, Lee and et al in 2004 which was based on increment of flux linkage. The sole idea behind this is ratio of primary and secondary flux linkage must be equal to primary and secondary winding under normal operating normal condition of transformers. If it is not so which means the turn ratio is not equal to ratio of primary flux linkage to secondary flux linkage, it is clear indication of presence of internal fault.

In 1918 Dr. C.L. Fortescue present a paper entitled "Method Of Symmetrical Coordinate Applied to solution Of Poly Phase Network" at AIEEE. In which he introduced the basic idea about sequence component. This key idea of positive, negative, zero sequence current which becomes very helpful in study of fault in power system.

Under balance condition working of power system the sequence will be R,Y,B but under faulted condition the magnitude and phase difference between three phase currents are changed incredibly. To study these faulted condition application of sequence currents are in phase. The sequence which have same sequence with original phase known as positive sequence having opposite of original phase is negative and sequence which do not have zero sequence. It is well known that only positive component are always present at always normal working conditions. Zero sequence component are absent.

Which means negative and zero component is also present along with positive sequence component is clear indication of faulted condition. So this concept is applicable to detect turn to turn fault with the help of negative sequence current, which also help generate an effective sensitive, selective and fast response protection system.

2. METHOD OF DETECTION OF INTERNAL FAULT OF TRANSFORMER

The impedance offer by circuit to negative sequence current is known as negative sequence impedance current. Which have a certain magnitude with phase angle. Under this condition of this negative sequence component the circuit will follow Kirchhoff's law. If a power transformer is working under normal operating condition means then will be no external faults as well as internal faults. Then the source of negative sequence current will be zero. Because negative sequence current is absent at normal operating conditions.

Under faulted condition location of negative sequence source will change either inside or outside of transformer.
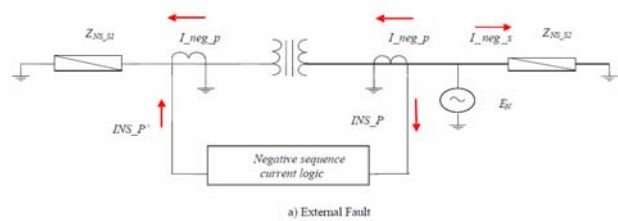
Fig.1. Direction of Negative Sequence Currents During External Fault Condition

Above figure (1) shows about the external faulted conditions current the source of negative sequence current is present outside the transformer in such condition. Primary winding of transformer and secondary winding of transformer on the same side. So the direction of flow of negative sequence current is given by figure.

I_{np} will enter into the transformer and I_{ns} leave transformer. So the phase sequence with respect to transformer winding are opposite to each other. if we count I_{np} as a I_{np} having phase angle of 0^0. Then I_{ns} will count as I_{ns} having phase angle of 180^0. So this phase difference of 180^0 shows that current is entering and leaving transformer properly. Hence there is no presence of into the transformer. It is present outside the transformer.
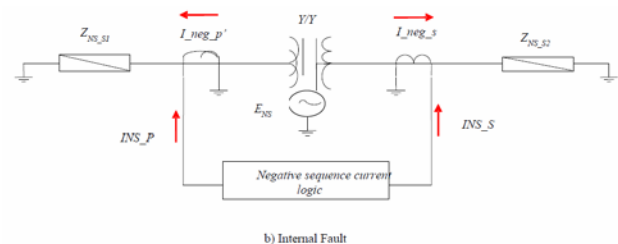
Fig.2. Direction of Negative Sequence Current in Internal Fault Condition

I_{np} will leave the transformer and I_{ns} leave transformer. So the phase sequence with respect to transformer winding are same to each other. Thus if we count I_{np} as a I_{np} having phase angle of 0^0. Then I_{ns} will count as I_{ns} having phase angle of 0^0. So this phase difference of 0^0 shows that currents are leaving transformer. Means the negative sequence source is present inside the transformer. Hence there is an internal fault is present into the transformer.

3. PROTECTION TECHNIQUE

This protection scheme is only applicable when there is no phase difference between primary winding current and secondary winding current due to manufacturing of transformer. Which means if the primary winding of transformer is connected in delta then secondary winding must be also connect in delta or primary winding of transformer is connected in star then secondary winding must be also connect in star. Either in delta or in star to generate same phase in both side of current Under normal operating condition. this second limitation of this protection technique is turn ratio should be one. These two limitation are basically indicate about protection scheme. Applied protection scheme is based on two types of comparison. Which are magnitude dependent comparison and phase dependent comparison.

The first stage is magnitude dependent comparison-

In this stage negative sequence currents that is primary side negative sequence currents and secondary side negative sequence currents are compared by connection circuit of differential relay connected both side of transformer. Relay is already set at 1% of preset value (M_{pre}). If the outcome of the comparison is less than preset value of differential relay than second stage is will not execute. In case if out- come of comparison is more than preset value than only second stage comparison will execute. Phase angle comparison is second stage of comparison in this type of protection scheme. In this stage the phase angle between primary side negative sequence currents and secondary side negative currents are compared. The pre set (θ_{pre}) value for this stage is zero degree (0^0). But for practical application zero degree pre set value

do not make effective sense. Due to presence of linkage and linkage reactance in core of transformer. So the actual set value of pre set value for phase comparison stage must be calculated according to the rating of transformer before application of this protection scheme. Let this calculated value is denoted by $è^0$.

Then,

(1) If the comparison between phase angle of primary side negative sequence current to the phase angle of negative sequence current is less than value pre set value è. Which means the fault is external and trip signal will issue according to external fault of transformer.

(2) If the comparison between phase angle of primary side negative sequence current to the phase of negative sequence current is greater than value for pre set value è (near to 180^0). Which means the fault is internal and trip signal will issue according to this internal fault to disconnect the transformer from the main power system.

4. RESULT AND DISCUSSION

As the result shown in fig (3). Which is showing the phase displacement 0^0. According to given data in figure(3). In this figure the phase displacement between primary side negative sequence current and negative side negative sequence current is 1.428^0 as per calculation. Which means it is less than pre set value of differential value (the pre set value of differential relay is 2.245^0) which means the fault is external as the figure (4) shows in the result. Where the comparison
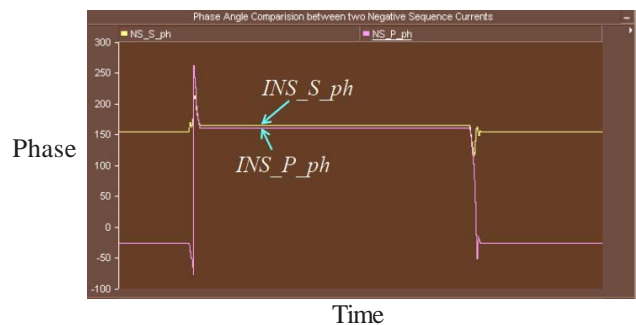

Fig. 3. Phase Difference in External Fault of Transformer

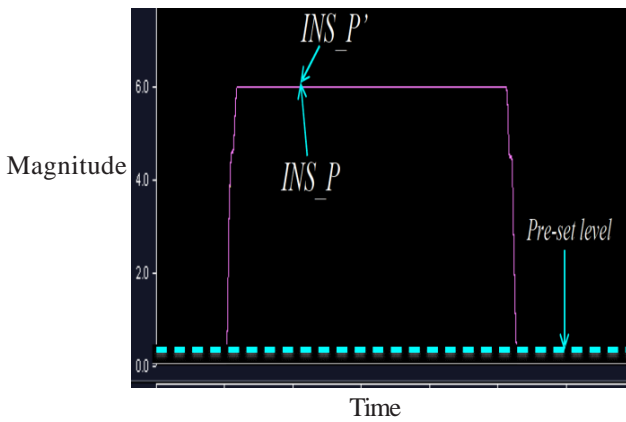between amplitude is less than 1%. So the secondary stage comparison will take place. Which is phase comparison.

Fig.4. Magnitude difference in internal fault of transformer

As figure (5) which is showing the phase displacement 180^0. According to given data in figure(5). In this figure the phase displacement between primary side negative sequence current and negative side negative sequence current is 1.428^0 as per calculation. Which means it is less than pre set value of differential value (the pre set value of differential relay is 2.245^0) which means the fault is internal as the figure (4) shows in the result.
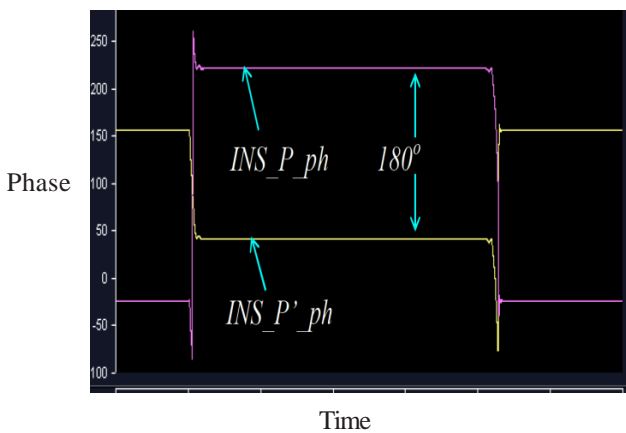

Fig. 5. phase difference in internal fault of transformer

Where the comparison between amplitude is less than 1%. So the secondary stage comparison will take place which is phase comparison.

5. CONCLUSION

This paper describe about the protection scheme of transformer based on negative sequence currents. Which is vary insufficient easy and effective to applied on the basis of protection scheme depends upon negative sequence currents many other types of protection systems can be developed which is based on signals which generate due to comparison of phase angle. As shown in figure (5) and by application of this protection scheme we can protect of high rating of transformer against minor internal faults

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