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Modeling Earth Faults in a Power Transformer and Restricted Earth Fault Relay Performance

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ABSTRACT

This paper presents a new method to modeling and discriminate internal faults in power transformer windings. It enables simulation to fault which occurred between any turn and earth of the transformer windings.

In this paper the normal condition of three-phase transformer model and the internal fault are presented by EMTP software for 230KV/63KV power transformer, at last by simulation of restricted earth fault(REF) relay for internal fault is displayed.

KEY WORDS: Power Transformer, Internal Fault, Restricted Earth Fault Relay.

I-INTRODUCTION

Transformers are one of the most important and most expensive components of transmission and distribution networks. The differential relay may gives a trip signal without presence of any ground fault [1], [2]. This can be happen when the power transformers have taps in their primary or secondary sides [3]. To overcome this problem, most of researchers suggested in their methods a high current ratio (setting), which is the ratio between the differential current to the through current [3]. Such methods may have a (25%) setting [4]. Conventional earth fault protection using overcurrent elements fails to provide adequate protection for transformer windings. This is particularly the case for a star-connected winding with an impedance-earthed neutral.

The degree of protection is very much improved by the application of restricted earth fault protection (or REF protection). This is a unit protection scheme for one winding of the transformer. It can be of the high impedance type as shown in Figure1, or of the biased low impedance type. For the high-impedance type, the residual current of three line current transformers is balanced against the output of a current transformer in the neutral conductor. In the biased low-impedance version, the three phase currents and the neutral current become the bias inputs to a differential element.

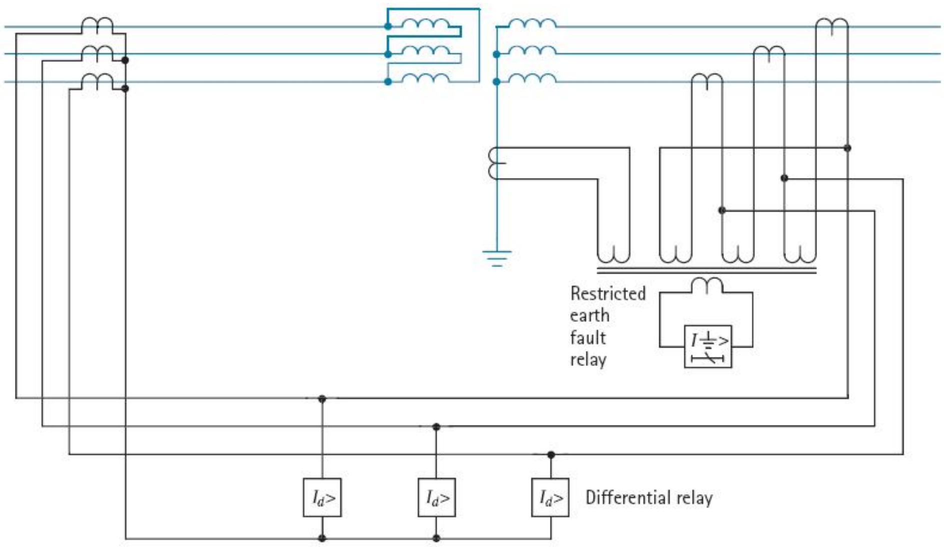

Figure1.Combine differential and restricted earth fault relay

The system is operative for faults within the region between current transformers, which is, for faults on the star winding in question. The system will remain stable for all faults outside this zone.

The advantages to be obtained by the use of restricted earth fault protection, lead to the system being frequently used in conjunction with an overall differential system. The importance of this is shown in Figure 2 from which it will be seen that if the neutral of a star-connected winding is earthed through a resistance of one per unit, an

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overall differential system having an effective setting of 20% will detect faults in only 42% of the winding from the line end [5].

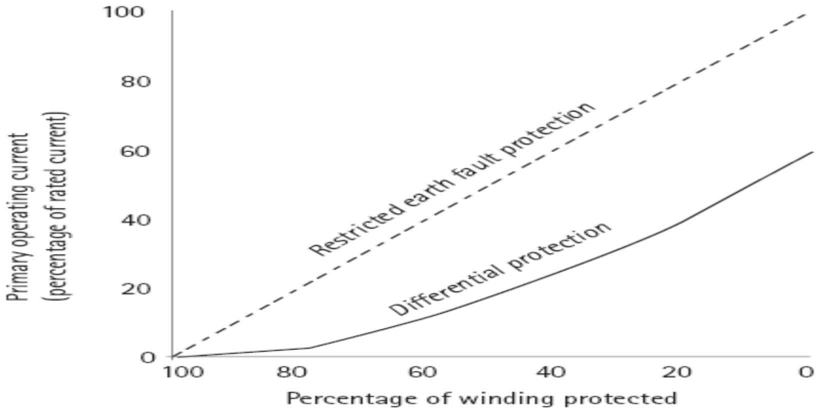

Figure2. Amount of winding protected when transformer is resistance earthed and ratings of transformer and resistor are equal

At first, the basic theory and algorithm are explained, afterward simulation results for earth fault condition in transformer is presented by using EMTP software. At last, by simulating the restricted earth fault relay the operation of this relay is shown in earth fault condition at power transformer.

II. THEORY OF RESTRICTED EARTH FAULT RELAY

The biased differential relay is not sensitized for certain earth faults within winding. This situation occurs in case of transformer is resistance or impedance earthed and current in the internal fault is disproportionately low.
The earth fault protection gets improved by the application of unit differential or restricted earth fault systems.
The requirement of REF protection:
i) It should be of single type
ii) Operating current sensitivity of at least 10%
iii) Be tuned with system frequency
iv) High or low impedance principle
v) Suitable value on non-linear resistor to limit peak voltage during in-zone faults

Restricted earth fault protection is often applied even when the neutral is solidly earthed. Since fault current then remains at a high value even to the last turn of the winding, virtually complete cover for earth faults is obtained. This is an improvement compared with the performance of systems that do not measure the neutral conductor current. Earth fault protection applied to a delta-connected or unearthed star winding is inherently restricted, since no zero sequence components can be transmitted through the transformer to the other windings. Both windings of a transformer can be protected separately with restricted earth fault protection, thereby providing high-speed protection against earth faults for the whole transformer with relatively simple equipment. A high impedance relay is used, giving fast operation and phase fault stability.

III. SIMULATION RESULTS OF TRANSFORMER EARTH FAULT

A three-phase 230/63 kV power system including a 100 km transmission line and 230/63 KV(160 MVA) power transformer, as shown in Fig. 3 has been used. Simulation studies were performed using EMTP software [6-8].The earth fault was applied in the power transformer.Fig.4 shows a simulated waveform of earth faults current at primary winding. Because amplitude of current is low, current differential relay is not sensitized for this fault within winding.

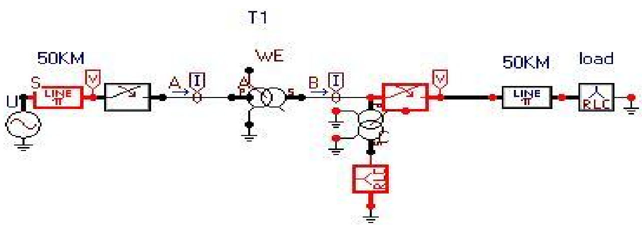

Fig.3 The considered power network

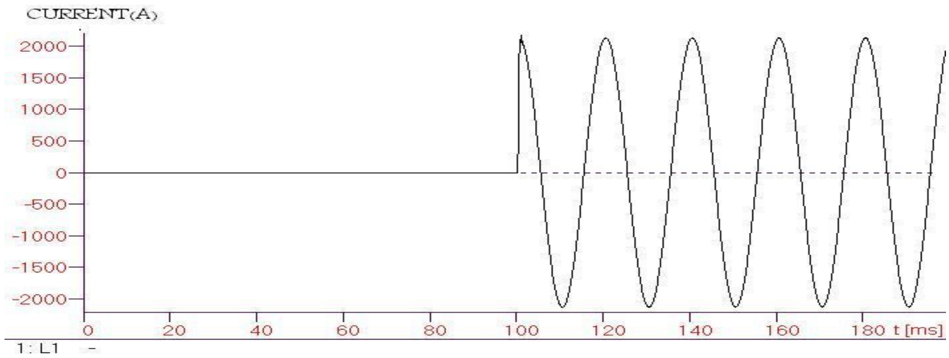

Fig.4 Simulated waveform of the fault current (earth fault) in the case of %5 the primary winding short circuit

IV. SMULATION OF CURRENT DIFFERENTIAL RELAY AND RESTRICTED EARTH FAULT RELAY

The performance of the current differential relay and restricted earth fault are evaluated via TACS (Transient Analysis of Control Systems) in EMTP. The output of this program is a control signal, which controls the opening/closing of the transformer circuit breaker. Circuit breaker is simulated using TACS control switch, which is known as code13. With this type of switch, if the control voltage is positive the switch remains closed, otherwise the switch will be open [9-12]. Typically, current differential relay and restricted earth fault are applied to a 230/63 KV (160 MVA) power transformer. The considered circuit is as shown in Fig.3. Fig.5 shows the current differential relay can not discriminate earth fault (near to neutral) in power transformer. But Fig.6 shows the restricted earth fault relay was able to discriminate earth fault.

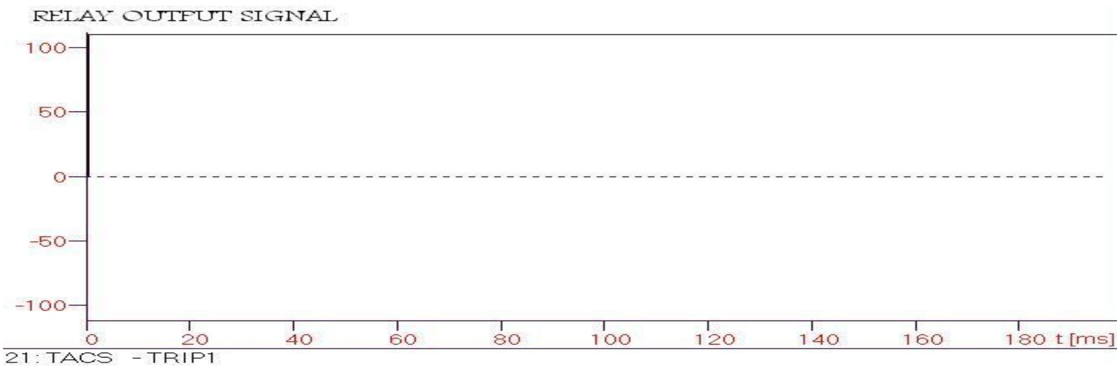

Fig.5 Current differential relay's output signal of the same case as Fig.4

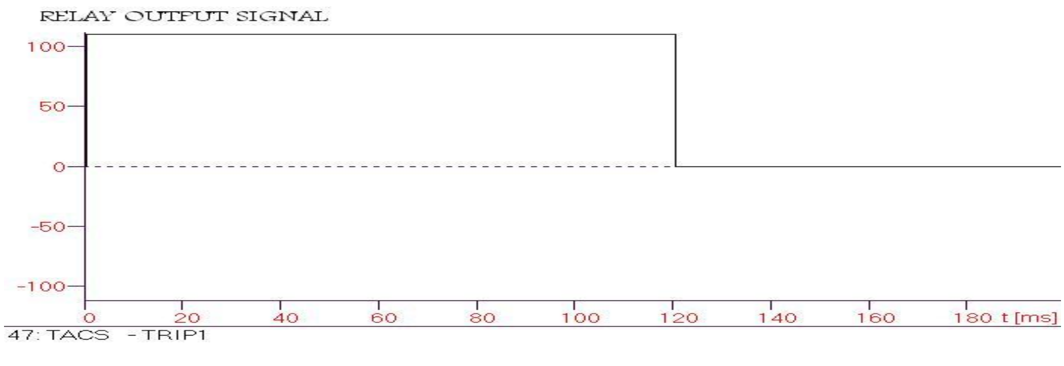

Fig.6 Restricted Earth fault relay's output signal of the same case as Fig.4

V. CONCLUSION

This paper describes results of testing restricted earth fault relay in power transformer. The current differential relay is not sensitized for certain earth faults within winding. This situation occurs in case of transformer is resistance or impedance earthed and current in the internal fault is disproportionately low. The earth fault protection gets improved by the application of restricted earth fault relay. In this paper the restricted earth fault relay is tested using EMTP/ATP as well as an earth fault simulation program and gave reliable and accurate results.

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