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Differential Protection Scheme for Star-Star Transformers using PSCAD

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ABSTRACT: All the electrical equipment have some withstand limits. These limits should never be crossed & it is the role of the protective system to prevent it. Transformer, being costly & critical device, its protection is essential. The protective scheme for power transformer should operate only for the internal fault, but must be insensitive for any fault outside the zone of protection. In power transformer differential protection harmonics are analysed using Fast Fourier Transform (FFT) technique to provide the dual slope differential relay operating characteristics. The relay logic and the algorithm are used to block the Inrush current. The simulation for various winding connection of transformer will be made using PSCAD software.

KEYWORDS: differential protection, PSCAD, FFT, magnetizing inrush current .

I. INTRODUCTION

Transformer protection is essential as its performance directly affects other components performance. According to fault statistics, 10-14% of fault occurring in power system is because of Power Transformers. Also, line to ground fault is most common fault. Power transformers are critical & costly, and have a long lead-time for repair of and replacement (1 year or longer) so it's protection must be effective. Power levels of transformers range from low-power applications, such as consumer electronics power supplies to very high power applications, such as power distribution systems. The type of protection used should minimize the time of disconnection for faults within the transformer and to reduce the risk of catastrophic failure to simplify eventual repair. Different transformers demand different schemes of transformer protection depending upon their importance, winding connections, earthing methods and mode of operation etc. Some other factors which affect transformer protection type are normal service condition, nature of transformer faults, degree of sustained over load, scheme of tap changing, and many other factors. Simple Differential Protection poses several problems in the relay operation which can be easily compensated by another type called Percentage differential relay.

II. MAGNETIZING INRUSH CURRENT

When the transformer is connected to supply, and the instantaneous value of the voltage is not at 90 degree a step change in magnetizing voltage occurs, which causes over fluxing in transformer core , a large transient (6 to 10 times full load) current inrush takes place which only flows through the primary winding and lasts several tenths of a second. Inrush occurs during removal of external fault current or due to energizatiion of transformer under no load. At this time, the first peak of the flux wave is higher than the peak of the flux at the steady state condition. This current appears as an internal fault. As inrush current is flowing only in the primary side of the power transformer. So that, the differential current will have a significant value due to the existence of current in only one side.

The size and the length of this inrush depend on the residual field in the core and the point in the ac cycle the transformer is re-energized. In large transformers in might be ten or twenty times the full-load current initially and it might take several minutes to reduce to negligible values.

In a harmonic blocking scheme, if the percentage of second- or fourth-harmonic current is greater than a set pickup (usually a value not lower than about 15 percent of the fundamental), the differential element is blocked. In a harmonic restraining scheme, the second- and fourth harmonic currents are used to boost the restraint quantity, contributing to the security of the differential element.

III. CT'S RATIO ERROR

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. Some of the primary current or the primary ampere-turns is utilized for magnetizing the core, thus leaving less than the actual primary ampere turns to be "transformed" into the secondary ampere-turns. This naturally introduces an error in the transformation. The error is classified into two-the current or ratio error and the phase error.

CTs create both steady-state and transient errors, which can result in false differential current. Sometimes even in case of no-fault, relay may operate because of various conditions ex Current transformer on both sides may be from different manufacturers, over load, short circuit, etc.

CT ratio differs on both sides because of :

i) Inherent difference in CT characteristic arising out of difference in magnetic circuit, saturation conditions etc.

ii) Unequal d.c. component in the short circuit current.

iii) Saturation of CT magnetic circuit during short circuit condition. Due to these causes the relay may operate even for external faults. The CTs, located in the high voltage and low voltage sides of the power transformer, does not exactly match the power transformer rated currents. Due to this discrepancy, a CTs mismatch takes place, which in turn creates a small false differential current, depending on the amount of this mismatch. Sometimes, this amount of the differential current is enough to operate the differential relay so there will always be an unbalance current in the operating coil of a transformer differential relay. Therefore, CTs ratio correction has to be done to overcome this CTs mismatch by using interposing CTs of multi taps

IV. NUMERICAL PROTECTION

Numerical relay uses micro-processor which works on number representing the instantaneous value of the signal. In numerical relay there is an additional entity 'software' which runs in background & actually runs the relay. Unlike conventional relay which perform comparison for computation, Numerical relay perform real time computation. Possibilities of developing a relay are endless and there is very little standardization. Signals from CT's cannot be directly converted to digital form. So signal has to be passed through a low pass filter because digital processing can only take place after the frequency spectrum of the signal is properly shaped. The analog signal is sampled & held constant during the time the value is converted to digital form.

The sampled & hold value is passed on to ADC through multiplexer so that number of input signals can be accommodated. ADC passes this digital information to the microprocessor. Microprocessor issues trip signals to one of the bits of the output port which is suitably processed to make it compatible with trip coil of the CB.

The idea is to estimate phasor value of current on both the sides of the transformer & then finding the phasor difference between them. If the magnitude of this difference is substantial, an internal fault is indicated & trip signal is issued.

V. Algorithm for Differential Protection & Slope Settings:

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. Magnetizing inrush results during excitation of Transformer under no load condition. It can also come in to picture during the energization of parallel connected power transformer.

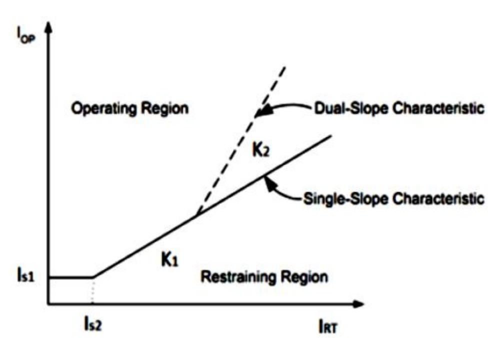


Fig 1: Dual Slope characteristics in PSCAD

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

Case 1

I Idiff> K2

bias< Is2

Idiff> K1 * I bias + Is1 THEN TRIP

Case 2

I bias> = Is2

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

A three phase view of graphic display is taken. Specified parameters are shown at the terminals. Source impedance type R/L is taken. Source control is fixed. Base MVA is taken as 300 MVA. Base voltage is taken as 230 KV. 3 phase high voltage display of CB is shown. Three single phase transformer each of 100 MVA on each phase is taken with winding 1 rated voltage of 230 KV and winding 2 rated voltage of 132 KV. Leakage reactance is taken as 0.1.Breakers are connected on source side of transformer.

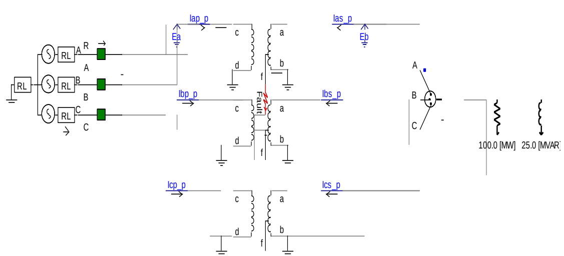


Fig 2: Simulation for internal fault

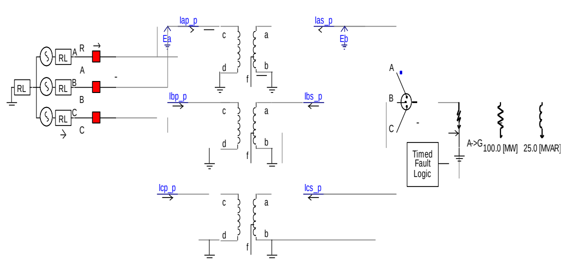


Fig 3: Simulation for external fault

VI. RESULTS

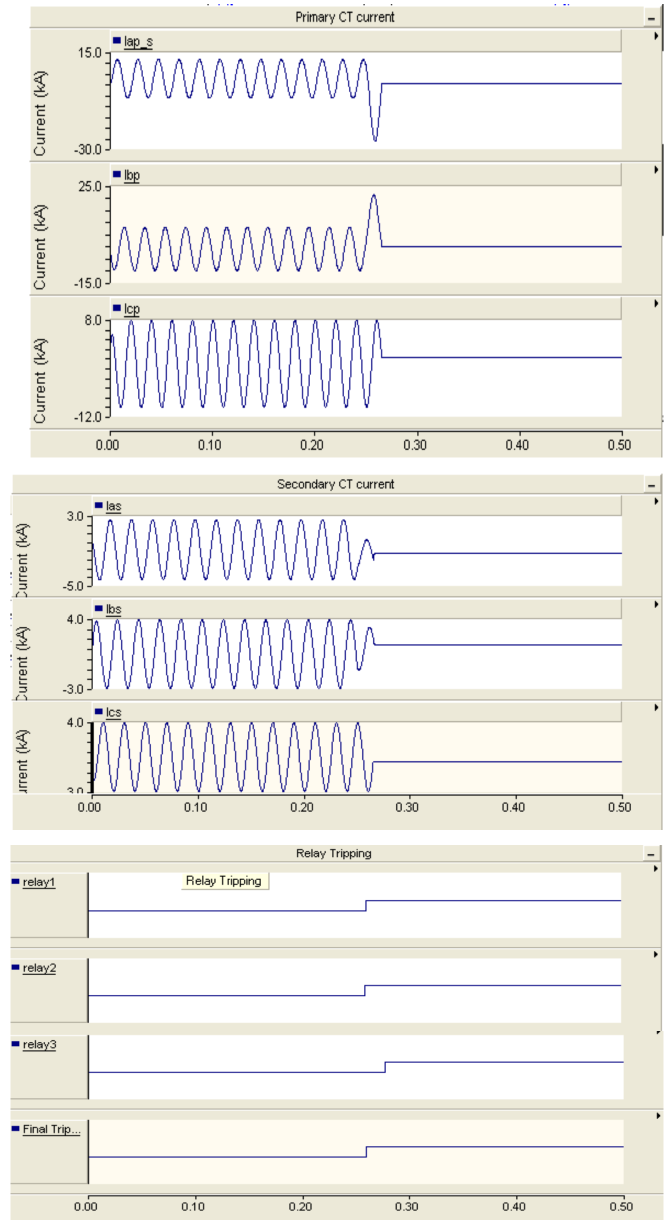
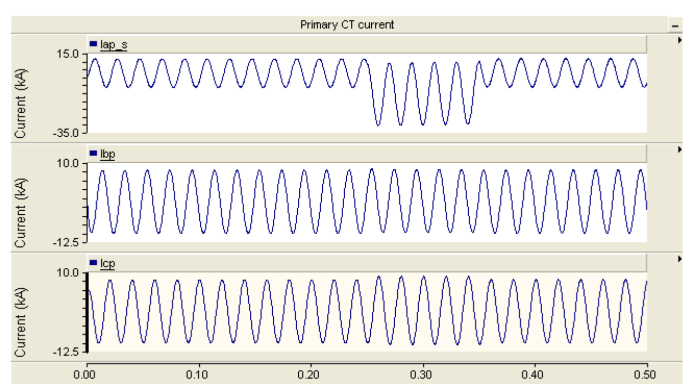


Fig 4: Results for internal fault



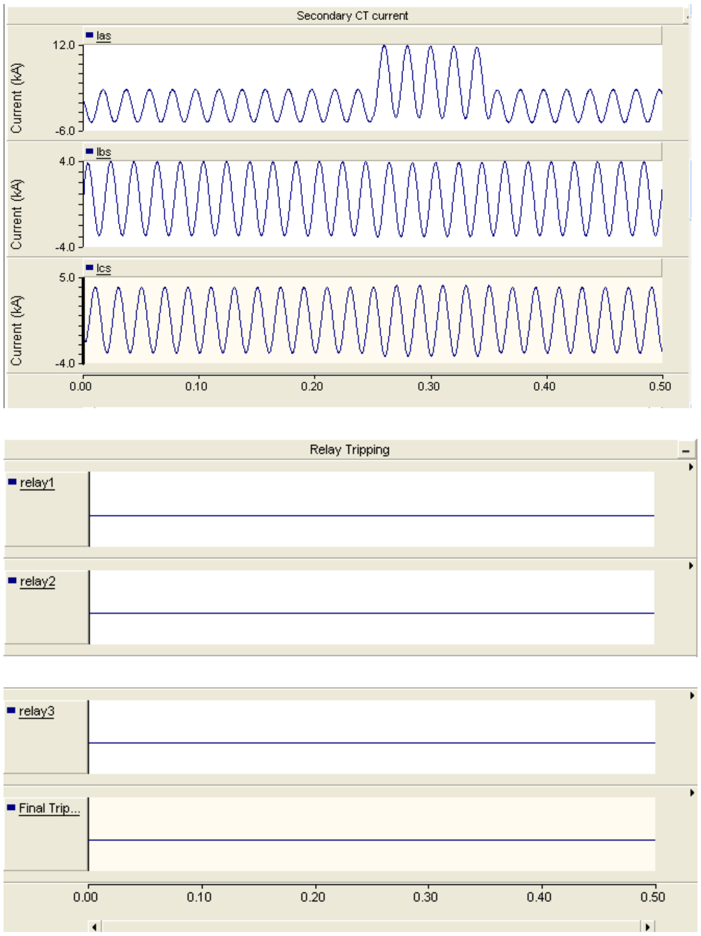


Fig 5: Results for external fault

VII. CONCLUSION

By performing simulations on PSCAD/EMTDC software, transformer internal fault and external fault is examined. Observing the results, it can be seen that Differential protective scheme operates only for the internal fault and the protection scheme does not operate for any external fault and the magnetizing inrush current. Screenshots of the result are shown.

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