

Analyzing an Unexpected Neutral Current in a Star-Star Transformer Under Steady State Condition

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Abstract

In power distribution a star-star transformer, with both windings' neutral grounded is extensively used for bidirectional mode of power flow; usually for easy detection of earth fault. But this leads to double earthing if any of the winding has another grounded star connection in its electrical circuit, as shown in Figure 1.

It is observed that such a connection leads to continuous flow of current in the neutral of a healthy transformer under steady state condition. The reason attributed to it is asymmetry in the core of a three limbed transformer due to disposition of three limbs in one plane. This leads to asymmetry in the magnetic circuit, so the flux due to MMF generated by currents in each winding travels unequal path. This is reflected as asymmetry in magnetizing current of each phase and hence a zero sequence current in the neutral on getting low impedance path through neutrals.

The accurate modeling of the transformer is imperative to get accurate results. Using COMSOL Multiphysics' ACDC module, a precise representation of geometry, material properties and excitation is done. The modeling is achieved by voltage fed at terminal through external voltage source along with FEM formulation. The problem in hand has cause in magnetic domain and the effect is observed in electrical domain. In this coupled problem field and circuit variables are solved simultaneously.

The transformer with geometry and schematic configuration as shown in Figure 2 is charged under no load condition by external source with a resistor of 17 ohm introduced between neutral and ground; executed in Electrical Circuit physics. Ferromagnetic core is considered with a linear permeability with a typical B-H curve. Simulating the time harmonic model gives the plot of magnetizing current in phases (Figure 3) along with a substantial neutral current value. Induced voltages in the phase windings along with their zero sequence components are also obtained as shown in Figure 4.

In the obtained plot it is apparent that magnetizing current is fairly asymmetrical with a zero sequence neutral current. This could be used in setting the sensitivity of ground fault relay. The

induced voltage in the phase windings are marginally asymmetrical with a zero sequence component. This leads to a flow of zero sequence flux that finds path through tank of the transformers. COMSOL Multiphysics' Electrical Circuit physics has made the modeling accurate. Solving field and circuit variables simultaneously has led to establish the asymmetry in current and induced voltage due to asymmetry in core of the transformer.

Reference

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Figures used in the abstract

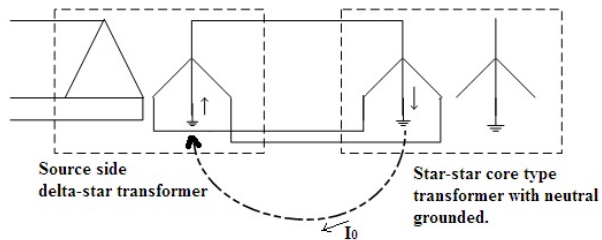


Figure 1: A star-star transformer being charged by delta-star transformer with all neutrals solidly grounded leading to a negligible zero sequence current

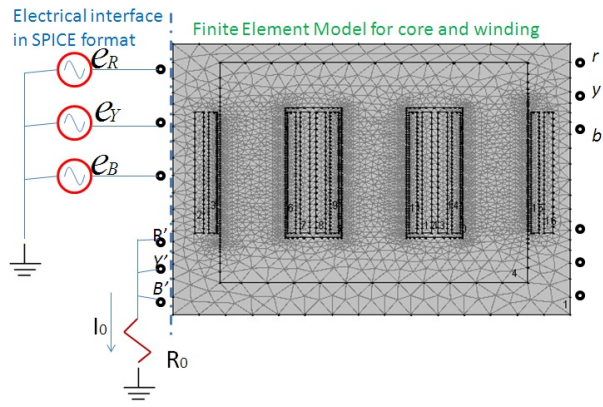


Figure 2: Meshed geometry of transformer with voltage fed external source and grounded neutral.

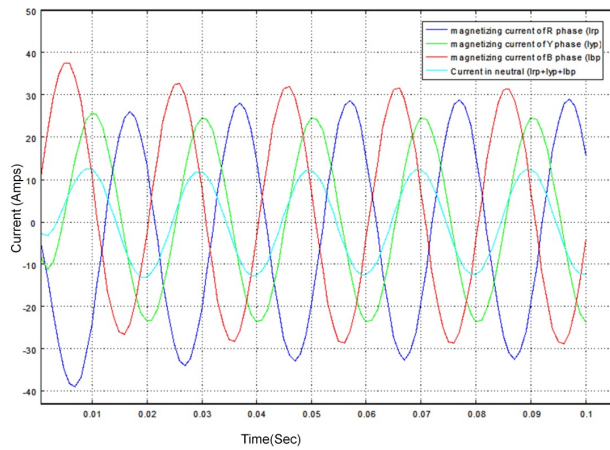


Figure 3: Magnetizing current in three phases and current in neutral. Neutral current depicted in light blue.

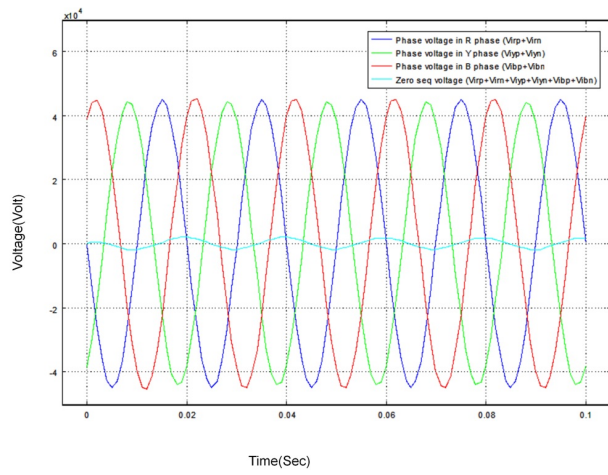


Figure 4: Induced voltage in phase winding and zero sequence voltage when the transformer grounded by a resistor.