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

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Introduction

•**Star-Star Transformers** commonly used in power distribution with both windings neutral grounded, leads to double earthing if any of the winding has another grounded star connection in its electrical circuit, as shown in **Figure 1**.

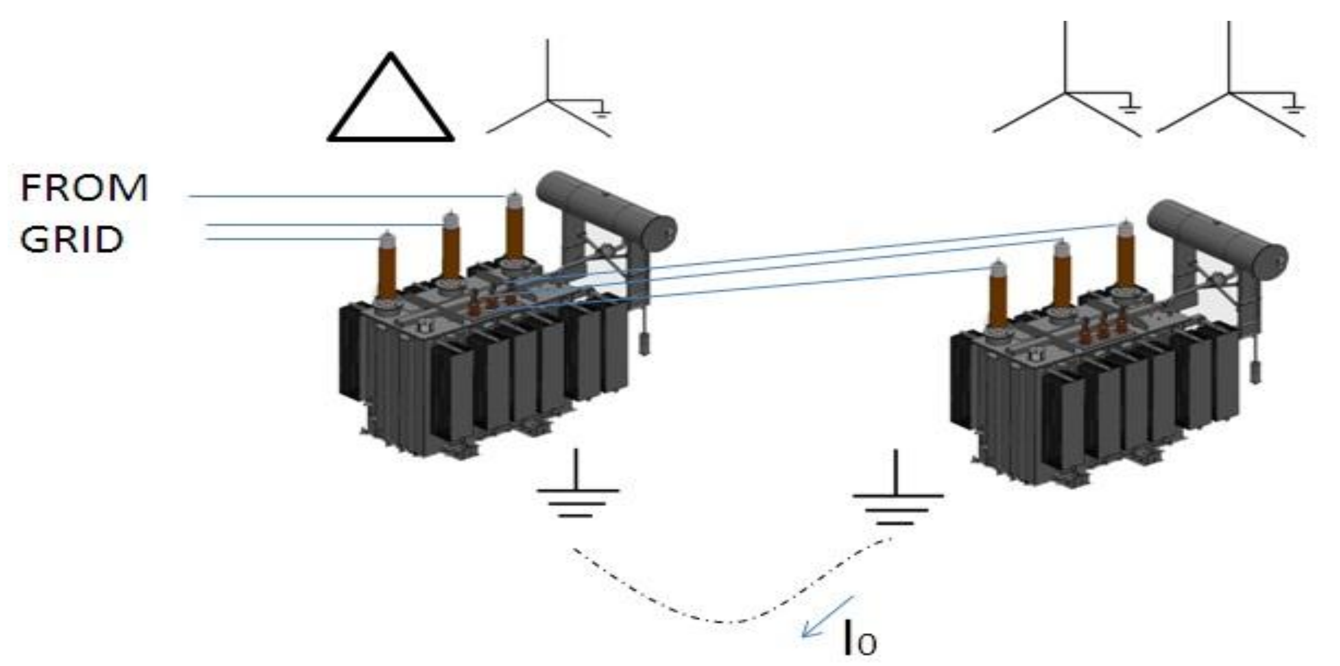

Figure 1: Overall schematic of the problem

- An unexpected small magnitude current I_o flows along the neutral of a healthy transformer under steady state conditions.
- Reason behind the flow of I_o is asymmetry in the magnetic circuit due to asymmetrical disposition of the three limbs of the transformer core, as illustrated by **Figure 2.**

- Knowing the value of current is significant to correctly set the sensitivity of ground fault relays in the system.

- Investigated by using FEM analysis in COMSOL platform

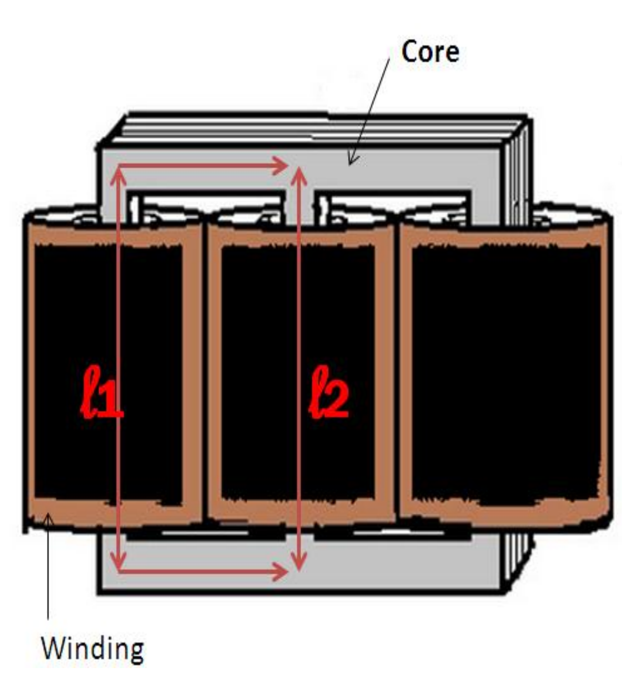

Figure 2: Asymmetry in 3 limbed core with $l_1 > l_2$

Results

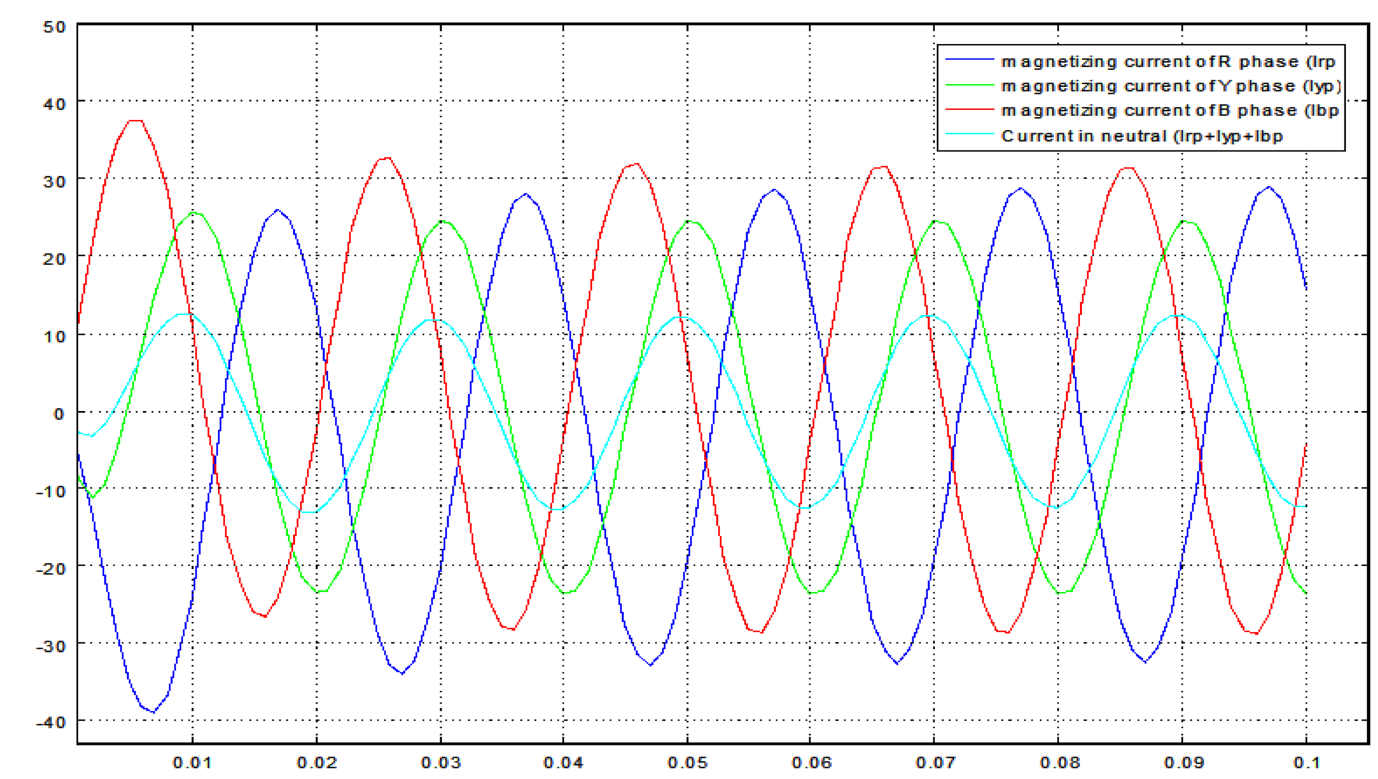

Figure 4: Magnetizing current in 3 phases and non zero neutral current.

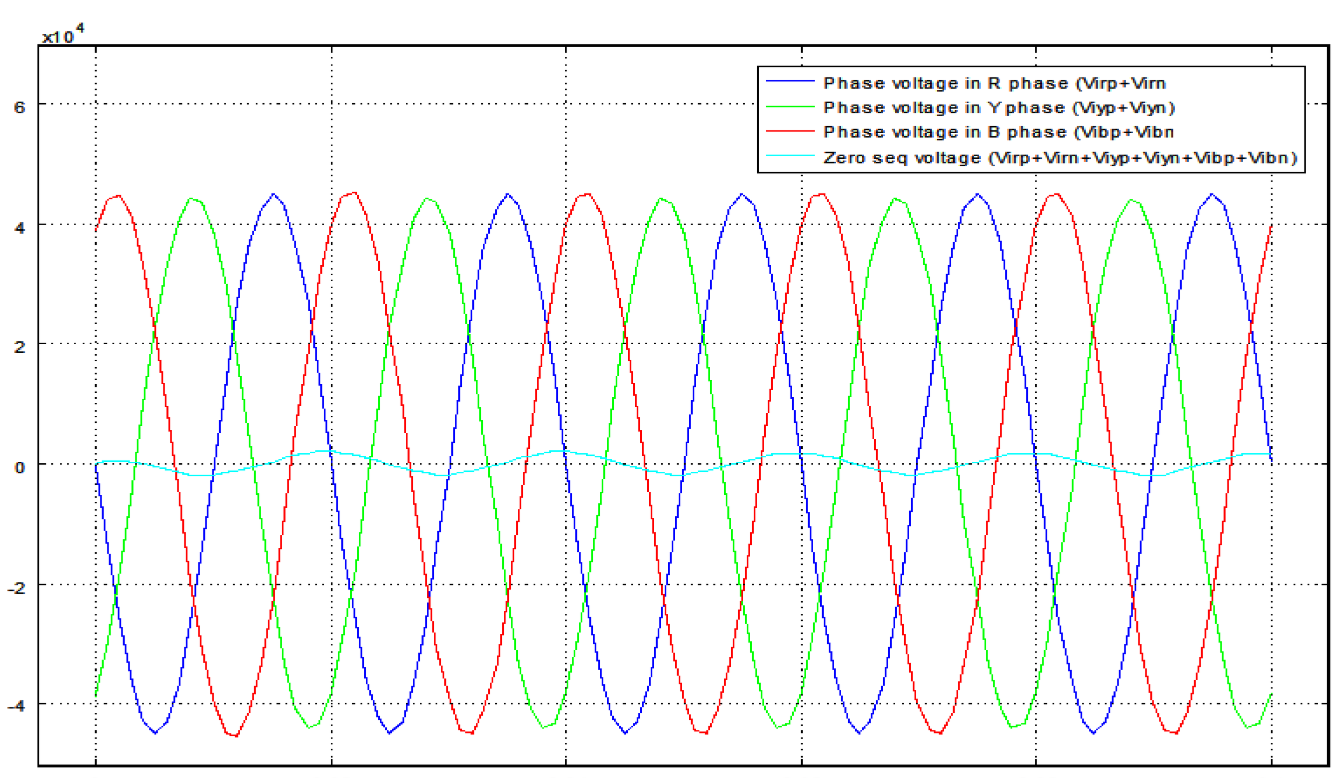

Figure 5:Asymmetric Induced voltages in 3 phases with the zero sequence component that give rise to zero sequence flux.

Computational Method

•The dimension of the core and other parameters of a 31.5 MVA transformer are extracted.

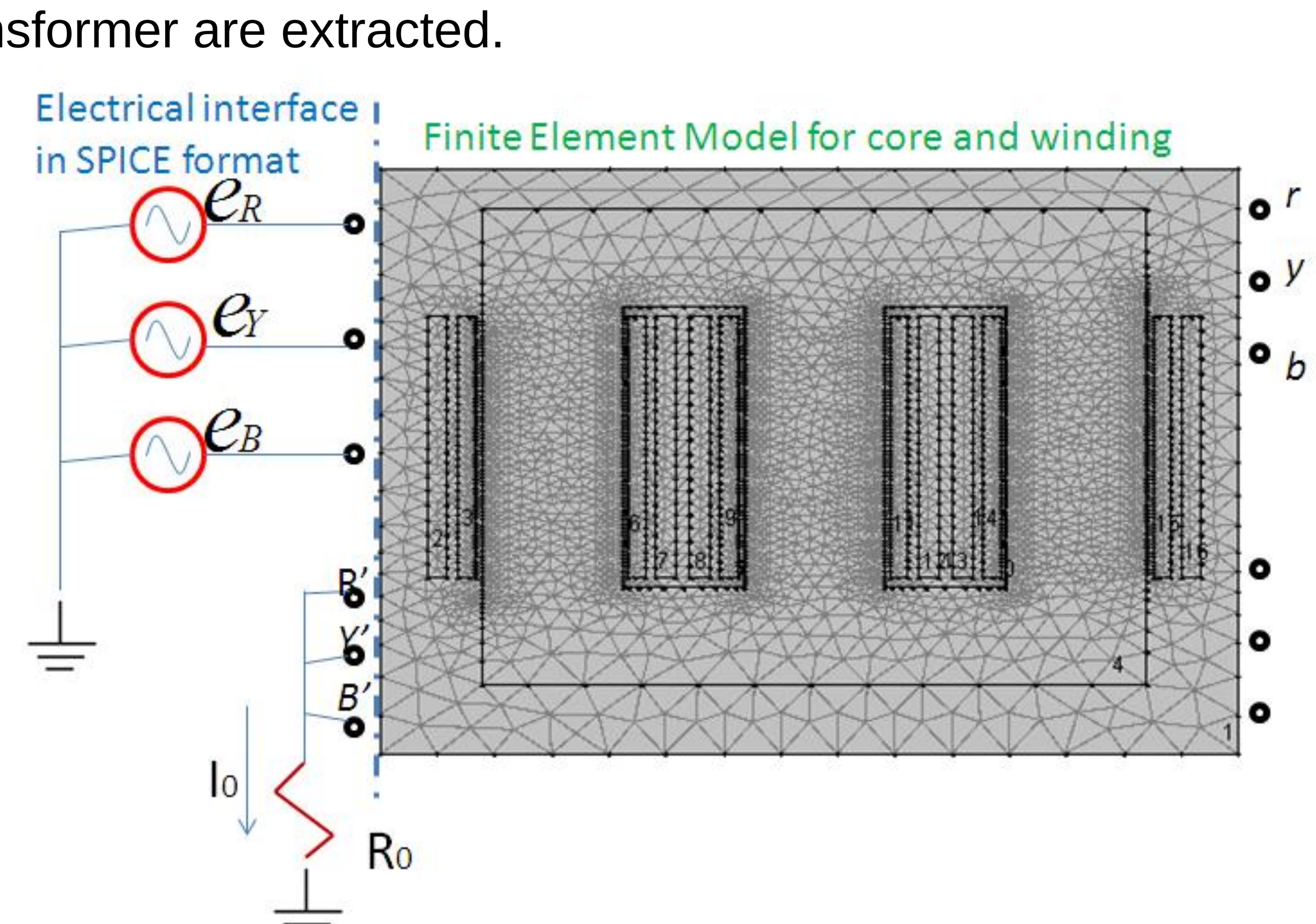

Figure 3. FEM model of magnetic field being excited by an electrical interface in SPICE format.

$$\sigma \frac{\partial}{\partial t}\left(A_{\text{ext}} + A_{\text{red}}\right) + \nabla \times \left(\mu^{-1} \nabla \times \left(A_{\text{ext}} + A_{\text{red}}\right)\right) = \mathrm{J}^{\theta}$$

Conclusions

•The waveform of the neutral current is concurrent to the mathematically derived result, as per the following equation.

$$i_0 = \frac{\left(1 - \frac{S_2}{S_1}\right)}{3[R_0\{\frac{3S_0}{S_1} + \left(2 + \frac{S_2}{S_1}\right)\frac{1}{3}\} - Z_1]}[e\angle 0° - e\angle 240°]$$

- Following this method, Zero Sequence Flux can be calculated that will prevent the critical heating of transformer tank.

- Earth fault relays can be set accordingly to enhance the selectivity of protection instruments.

References

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