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Zero Sequence Circuit of Three-legged Core Type Transformers

Jialong Wang (Basler Electric) and Raluca Lascu (DTE Energy)

Abstract

Fault current estimation is essential in developing setting protective elements. Sequence equivalent circuits have been developed and used widely in fault calculation.

In most literature, the sequence equivalent circuits are approximate due to the omission of the magnetizing impedance. In practical situations, it is a very good approximation to exclude the large magnetizing impedance in positive and negative sequence equivalent circuits. However, a more accurate zero sequence circuit may be needed, depending on both the transformer core structure and the winding connections.

This paper will introduce the core-type and shell-type core structures. The magnetizing impedance is small when the core is saturated and should be included in the zero sequence circuit in the following two cases:
1) Three-legged core type transformer
There is no physical return path to the bottom core yoke, and the zero sequence flux has to go through the high magnetic reluctance through the air gap, structural steel and the tank. The magnetic impedance, which is inversely proportional to the magnetic reluctance, is typically in the range between 40% and 150%.
2) Shell type transformer and four- or five-legged core type transformer
The lateral core leg(s) is sized to carry the flux of one phase. When zero sequence voltage approaches 33% of the rated voltage or higher, the core saturates and the magnetic impedance drops dramatically.

Although a Y-YG connection is not recommended in IEEE C57.105-1978, legacy installations do exist. Analysis of unbalanced condition in the Y-YG transformer is not easily available. In order to study the Y-YG transformer in unbalanced condition, zero sequence circuit will be developed. For a load side phase ground fault of a three-legged core type transformer, the fault current can be calculated or estimated. To verify that fault current does flow in a Y-YG transformer in the grounded winding for a phase fault, a high impedance fault was staged in the grounded side of a three-phase Y-YG transformer (18 MVA, 13.8kV/4160V), with the secondary neutral grounded through a 4 ohm resistor.