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Consequence of an unbalanced supplying condition on a distribution transformer

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***Abstract*-- Most of the time transformers work under balanced supplying conditions. However, after some fault conditions or anomalous switching operations, zero sequence component in excitation may be expectable. Transformers behavior under zero sequence excitation may be very different from usual behavior and might become dangerous.**

Some simulations are performed with the Alternative Transients Program (ATP), representing a three-legged core type three-phase transformer with a model available in the ATP library.

Results show overvoltages and high saturated currents on the unloaded transformer. The proper use of the three-legged core type transformer model, enables to evidence the influence of the characteristics of zero sequence transformer on the development of such overvoltages and high transformer currents.

Besides, regardless load conditions, important homopolar currents are observed flowing to ground from the transformer high voltage neutral. The resultant homopolar fluxes could cause heating and damage in a three-legged core type transformer.

***Keywords* -- transformer cores, ferroresonance.**

I. NOMENCLATURE

LV: Low Voltage
HV: High Voltage

II. INTRODUCTION

The zero sequence behavior of a transformer, which can be excited under unbalanced conditions, depends mainly on core configuration and winding connections.

Grounded-wye connected windings always provide a path for zero sequence current. That is why a grounded-wye to grounded-wye transformer presents a finite homopolar impedance from either sides. The impedance value depends, among other things, on core configuration.

A five-legged core form or a shell form configuration, always provide zero sequence fluxes with a path totally placed inside the iron of the core. Consequently, the zero sequence magnetizing inductance for these core configurations is very high and similar to the positive sequence inductance.

On the other hand, in a three-legged core type, zero sequence fluxes cannot circulate exclusively in the core, and are forced to return through the insulation surrounding the core and through the transformer tank. As this path presents a high reluctance, the zero sequence magnetizing inductance is much lower than the positive sequence magnetizing inductance.

III. CASE STUDY

The case studied, based on a real case, consists of a three-legged core type, grounded-wye to grounded-wye, three-phase distribution transformer, fed through an underground cable. Two circuit breakers exist at each end of the cable. A simplified equivalent circuit is depicted in Fig. 1.

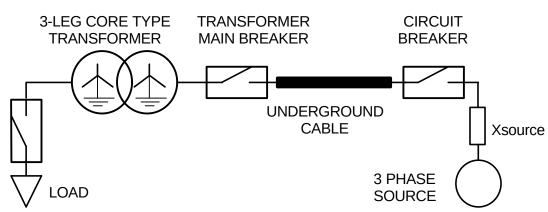

Fig. 1 - Simplified circuit representation.

The three phase equivalent source and its inductance, represent the 50Hz, 132 kV power system. The cable length is 13.5 km and its positive and zero sequence capacitance is 0.404 μF/km.

The following information about the transformer is known:

1. Rated power - 40 MVA (three-phase)
2. Rated voltages - 132 kV/13.86 kV (line to line values)
3. Two winding transformer: grounded-wye to grounded-wye connection (YNyn0)

Table 1 shows transformer specifications data from positive sequence tests. Table 2 shows positive sequence saturation curve obtained from excitation test at LV side (13.86 kV line to line). Table 3 shows transformer zero sequence parameters.

TABLE I
TRANSFORMER POSITIVE SEQUENCE PARAMETERS

Excitation losses	24 kW
Excitation current	0.15 %
Short-circuit losses	176 kW
Short-circuit impedance	13.3 %

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