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Transferred Voltages due to Single Phase Earth Fault on Power Transformers

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Abstract

In the event of an earth fault in one of the two systems of a three-winding transformer, an increase in the star-point voltage occurs in the disturbed system. This voltage is transferred to the undisturbed systems due to capacitive coupling, to affected earth faulty system and to earth. As a result, three phase voltages to earth are different in magnitude and phase position compared to their undisturbed service status.

In this paper the mesh analysis method is used to calculate the neutral point shift of the faulted winding necessary to obtain values of transferred voltages to the unaffected winding (the one which is not earth faulted). The results are analyzed to investigate the influence of winding and network neutral grounding (insulated, solidly grounded, grounded over impedance) on the results.

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Keywords: Power transformer, transient voltages, overvoltages, ground fault, neutral phase shift

1. Introduction

The most frequent causes of temporary over voltages are faults, load rejection, resonance and ferroresonance. The magnitude of over voltages due to ground faults depends on the method of system grounding (solidly grounded, resistance grounded, high resistance grounded or ungrounded systems), the equivalent sequence impedances seen

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from the fault location and the fault impedance. Their duration depends on the fault clearance time and therefore on the design of the protection system. An estimation of the duration and magnitude of these over voltages is crucial for selection of surge arresters in most power systems. [1]

The grounding system determines the over voltages that can occur during a fault to ground. A single phase to ground fault shifts the ground potential at the fault location, depending on the severity of this shift on the grounding configuration. On a solidly grounded system with a good return path to the grounding source, the shift is usually negligible. On an ungrounded system, a full offset may occur and the phase-to-ground voltage on the unfaulted phases approaches the phase-to-phase voltage value. [2]

Nomenclature

HV	high voltage winding of a transformer
MV	middle voltage winding of a transformer
LV	low voltage winding
EFF	Earth fault factor

2. Calculation

Model for single-phase to earth short circuit on MV side is presented in **Pogreška! Izvor reference nije pronađen.**, where U_{rHV_U}, U_{rHV_V} and U_{rHV_W} are rated voltages for each phase on HV side of the transformers with corresponding network inductance Z_{NHV}. U_{rMV_U}, U_{rMV_V} and U_{rMV_W} are rated voltages for each phase on MV side of the transformers with corresponding network inductance Z_{NMV}.

The calculation of the parameters from Fig. 1 is presented in [3]. Two different cases were considered:

- MV network solidly grounded ($Z_{Ngr} = 0$ in Fig. 1)
- MV network ungrounded ($Z_{Ngr} = \infty$ in Fig. 1)

Each of those two cases will be analyzed for a range of transformer ground impedances $0 \leq Z_{gr} \leq \infty$.

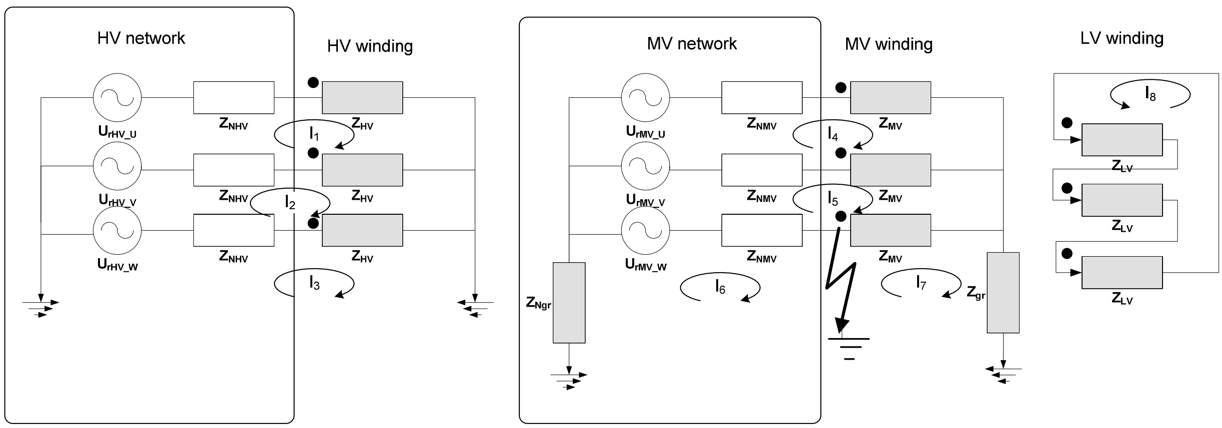

Fig. 1 Model for single phase to earth fault on MV side

For short-circuit on MV side, new position of neutral point is calculated according to Fig. 1:

$$U_{NMV} = I_7 \cdot Z_{gr} \left[kV \right] \tag{1}$$