Abstract

Algorithm for determining the frequency response of the power transformer windings

Power transformers are one of the most important elements of the energy system, because they guarantee a stable supply of energy to the consumers. In addition, transformers are the most expensive element in the power grid. For this reason, their trouble-free and reliable operation is crucial for maintaining energy security and for proper management of power grid assets. The most effective way to avoid transformer breakdowns is via their proper maintenance, in particular periodic technical condition assessment. One of the diagnostic methods used to assess the technical condition of the active part of the transformer is the frequency response analysis (FRA), which allows to determine mechanical condition to the winding, especially its deformation and displacement.

The aim of the dissertation is related to frequency response modeling in order to support the correct interpretation of the FRA results. The frequency response modeling is one of the development directions of the FRA diagnostic method. The purpose of the frequency response modeling is to collect different types of deformation and to explain their impact on the shape of the FRA curve. Therefore, the thesis of this dissertation is as follow: it is possible to create an effective algorithm that determines the frequency response of the power transformer windings on the basis of its design data, which will improve the process of assessing the technical condition of the active part of the transformer.

The main research goal of this study was to create and test a new numerical algorithm based on the analysis of the electromagnetic field in the transformer and on the analysis of the circuit model of the winding. This new algorithm should be able to reproduce the frequency response of the winding over a wide frequency range.

The dissertation presents a new field model of the active part of the transformer in 2D, which improves the process of FEM analysis of the electromagnetic field by utilizing equivalent parameters of the core material, which leads to the reduction of the finite element mesh size in the computational area. The field model takes into account the influence of the other transformer windings remaining on the same core. In addition, general conditions for the equivalence of the 3D and 2D models were given, which can be applied to any considered case. The presented field model allows to determine the exact *RLC* parameters of the tested transformer winding.

The next stage of the research was to develop an algorithm for determination of the frequency response of the winding. Lumped parameters in three configurations – Π, Γ and T were proposed. In each configuration, a single *RLC* branch represents a single turn. The proposed models consider the interaction between turns, the influence of the remaining windings on the modeled curve and the parallel connections between turns.

Several simulation tests were carried out in order to verify the accuracy of the proposed field model and the numerical algorithms. The test objects were both air and core windings, connected in series and in parallel. The main test object was the winding of the 25 MVA, 120/6,3 kV power transformer. The comparison of the obtained simulation results with the measurement results showed that the developed model reproduces the frequency response with satisfactory accuracy in the entire considered frequency range.