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OPTIMAL DESIGN OF COMBINED CURRENT-VOLTAGE INSTRUMENT TRANSFORMER BY USING FEM-3D AND GENETIC ALGORITHM

ABSTRACT

The instrument transformers are significant components of the power systems measurement equipment. Therefore, they should satisfy the restrictive metrological criteria specified by the standards (low voltage, current and phase displacement errors of the transformed voltages and currents). In the paper a novel and original approach to the analysis and optimal design of 20 kV combined current-voltage instrument transformer (CCVIT) will be given. The CCVIT is a complex nonlinear electromagnetic system with two magnetically coupled measurement magnetic cores for transformation of the measured voltages and currents and two electrical systems in one housing, which leads to increased metrological errors. The analytical design methods can be applied on simple electromagnetic structures, which is not the case with the CCVIT. The application of modern numerical CAD methods is indispensable. The finite element method and the original program package FEM-3D is used for analysis of the magnetic field distribution in the 3D domain of the transformer. This enables the exact calculation of the main flux in the cores and the windings leakage fluxes. The leakage reactances of the transformer windings will be calculated. The objective function for optimal design of the CCVIT is the minimum of the mutually coupled voltage and current error of the voltage transformation core and of the current transformation core, respectively. The initial design is accomplished through analytical transformer design methods. The stochastic optimization method known as genetic algorithm (GA) is used for optimal design. In the mathematical model of the CCVIT all the quantities which affect the objective function are made to be dependent on 11 input optimization variables. The FEM-3D results are used as input data in the GA based original software program. The goal of the calculation is metrological optimal design of CCVIT with improved accuracy class.

Keywords: Instrument transformer, Finite element method, Genetic algorithm, Optimal design, Metrological characteristics.