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Modeling and Analysis of Parasitic Capacitance of High-Frequency High-Voltage Transformer Using Finite-Element Method

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The high-frequency high-voltage (HFHV) transformer acts as a key part for galvanic isolation, energy transmission and voltage conversion in high-frequency resonant converter. And the performance is highly affected by the parasitic parameters, especially the parasitic capacitance. However, the existing techniques have a lot of shortcomings when determining the parasitic capacitance of multi-section multi-layer multi-turn HFHV transformers. A methodology has been proposed to predict the parasitic capacitance of multi-section, multi-layer and multi-turn secondary winding of HFHV transformer based on a 2D-axisymmetric model using finite-element analysis (FEA) software of COMSOL. The magnetic field produced by the coils and the corresponding voltage of each turn were evaluated. The electric field distribution along the windings was analyzed. A 20 kHz, 40 kW transformer with the input voltage of 380 V and the output voltage of 25 kV was designed. The capacitance of the windings with different number of sections, layers and turns was investigated. And an optimum structure of winding was derived, consisting of 9 sections, 9 layers and 4 turns. The winding was manufactured and the parasitic capacitance was measured by the LCR meter using frequency sweeping method. Compared to the classical analytical method with the maximum error of 21%, the method proposed in this paper drastically reduces the error to be less than 10%. The error resources of the classical analytical method are analyzed by the electric energy distribution.

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