Journal of
Biomedical Imaging and bioengineering

Abstract

A novel energy method for calculating the port equivalent stray capacitance of a single layer multi-turn iron core inductor

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Abstract:

The stray capacitance of an inductor or a voltage transformer winding is one of the most crucial parameters of the component. It influences the behavior of the switching power converters that leads to the low output efficiency, as well as the current impulse of a switch circuit driven by the steep pulse, which brings EMI (electromagnetic interference) to the system. The value of winding stray capacitance provides a theoretical basis for the measures (for instance, inserting an additional device or reducing the stray capacitance by optimizing the structure of the winding) to be taken to suppress the impact of them on the system. The number of turns, shape/dimensions of the wire cross-section, winding technology, insulation distribution, and the iron core all affect the stray capacitance of the winding. This paper focuses on the influence of the iron core on winding stray capacitance. The stray capacitance and the storage capacity of the electric field energy are mapping to each other. Firstly, by using the finite element method (FEM), we calculate and compare the electric field energy, capacitances of the adjacent turns, capacitances of the non-adjacent turns of the same structure air core inductor and iron core inductor under the same excitation conditions. The results show that the electric field energy of the iron core winding, as well as the stray capacitances between adjacent turns and non-adjacent turns, are higher than that of the air core inductor. It indicates that the iron core expands the electric field energy stored capacity of the multi-conductor system, which can be attributed to the iron core reducing the efficacious distance between turns of the winding. Due to the high potential difference between non-adjacent turns of windings, the proportion of electric field energy stored in the corresponding stray capacitance in the total electric field energy of the multi-conductor system in the iron core inductor is significantly higher than that of the air core inductor. In the condition of the same structure and excitation, the increased electric field energy of the iron core inductor comparing to the air core inductor is numerically equal to that stored in the capacitances between winding and iron core. So, a closed-form equation of the iron core floating potential is derived based on the partial capacitance theory. After, the electric field energy stored in the inductor is calculated according to winding and iron core potential. The analytical calculation results of the iron core floating potential, electric field energy, and the terminal equivalent capacitance of the wingding are consistent with the results of FEM. The above method avoids the difficulty of analytical calculation of stray capacitances between non- adjacent turns of the iron core inductor in the traditional energy method as well as has the advantage of time-saving compared to FEM. To further increase the calculation accuracy of a large-scale iron core inductor, a semi-analytical method is proposed based on a basic-cell.

Biography:

Da Liang received the B.S. in electrical engineering and automation and M.S. in electrical engineering from Southwest Jiaotong University, Chengdu, China, in 2015 and 2018, respectively. He is currently working toward the Ph.D. degree with the Key Laboratory of Magnetic Suspension Technology and Maglev Vehicle, Ministry of Education in Southwest Jiaotong University, Chnegdu, China. His current research interests include electromagnetic suspension control technology, maglev vehicle stimulation, and design of magnetic components in maglev vehicle.

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3rd Edition of New Frontiers in Renewable Energy and Resources | March 22-23, 2021 | Paris, France

Citation: Da Liang; A novel energy method for calculating the port equivalent stray capacitance of a single layer multi-turn iron core inductor; Euro Renewable Energy 2021; March 22-23, 2021; Paris, France.