学 位 論 文 内 容 の 要 旨

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学 位 論 文 題 名

A study on design optimization and anomaly detection of wireless power transfer
（非接触給電の最適設計および異常検出に関する研究）

In recent decades, wireless power transfer (WPT) has been attracting more and more attention of researchers for its potential as charging system of electrical vehicles and consumer electronics. Proposed one century ago, the most classical theory of WPT – inductive coupling – has been developed a lot, realizing plenty of applications in several areas. Except for the unchanged main objective of transfer efficiency, the safety of WPT system is also important, especially when WPT become practical. Among the works of safety of WPT, the reduction of leakage electromagnetic radiation, and the detection and removal of foreign object are the main purposes. In addition, the effect of coil-misalignment on these performances need to be considered and reduced, as another aspect of anomaly detection of WPT other than foreign object.

In this paper, several researches aiming at these purposes will be introduced. Lots of thoughts and methods from the areas different from electromagnetism and power electronic have been used, to promote the improvement of WPT further.

In chapter 2, works of design optimization of magnetic core in WPT coupler are introduced. In order to obtain brand new optimized shape, topology optimization is used, which can express more complicated shapes that designer is hard to imagine, than parameter optimization. For the expression of topology shape, normalized gaussian network (NGnet) method is applied, in which the topology shape can be described and controlled by discrete variables, allowing us to use evolutionary algorithm to solve the optimization problem. In this way, the topology optimizations have been implemented in the designs of magnetic core in couplers with circular coil, double-D coil, and H-shape core. For each of them, reference models are prepared and compared with the optimized results, to see if the latter have better performances on the objectives they are considering.

In chapter 3, except for the magnetic core, the shape of transmitting coil is considered as the object of design optimization. Based on a multi-layer coils system with a simple individual input control strategy, the shapes of coils are optimized using target field method, considering transfer efficiency and leakage magnetic field simultaneously, under different coil-misalignment conditions. Obtained by evolutionary algorithm as well, the optimized results are compared with the reference model, showing stronger anti-misalignment performance.

In chapter 4, we shift attention to foreign object detection in WPT. Concerning the potential fire risk brought by invaded metal object, a metal object detection (MOD) method is proposed. Based on feature signals extracted from WPT system, MOD is realized by machine learning methods, in which the detection is treated as classification problem. To implement MOD for different WPT coupler, detection coils are introduced to get more feature signals which can help represent the status of system.

Meanwhile, position prediction of receiving coil is realized at the same time, which can be helpful for WPT system to adjust the performances on efficiency and leakage field. Finally, both the MOD and position prediction have been evaluated and show good accuracy.