Comparison of Spiral Circular Coil and Helical Coil Structures for Wireless Power Transfer System

Authors : Zhang Kehan, Du Luona

Abstract : Wireless power transfer (WPT) systems have been widely investigated for advantages of convenience and safety compared to traditional plug-in charging systems. The research contents include impedance matching, circuit topology, transfer distance et al. for improving the efficiency of WPT system, which is a decisive factor in the practical application. What is more, coil structures such as spiral circular coil and helical coil with variable distance between two turns also have indispensable effects on the efficiency of WPT systems. This paper compares the efficiency of WPT systems utilizing spiral or helical coil with variable distance between two turns, and experimental results show that efficiency of spiral circular coil with an optimum distance between two turns is the highest. According to efficiency formula of resonant WPT system with series-series topology, we introduce M^2/R_{-1} to measure the efficiency of spiral circular coil and helical coil WPT system. If the distance between two turns s is too close, proximity effect theory shows that the induced current in the conductor, caused by a variable flux created by the current flows in the skin of vicinity conductor, is the opposite direction of source current and has assignable impart on coil resistance. Thus in two coil structures, s affects coil resistance. At the same time, when the distance between primary and secondary coils is not variable, s can also make the influence on M to some degrees. The aforementioned study proves that s plays an indispensable role in changing M^2/R_{-1} and then can be adjusted to find the optimum value with which WPT system achieves the highest efficiency. In actual application situations of WPT systems especially in underwater vehicles, miniaturization is one vital issue in designing WPT system structures. Limited by system size, the largest external radius of spiral circular coil is 100 mm, and the largest height of helical coil is 40 mm. In other words, the turn of coil N changes with s. In spiral circular and helical structures, the distance between each two turns in secondary coil is set as a constant value 1 mm to guarantee that the R2 is not variable. Based on the analysis above, we set up spiral circular coil and helical coil model using COMSOL to analyze the value of M^2/R_{-1} when the distance between each two turns in primary coil sp varies from 0 mm to 10 mm. In the two structure models, the distance between primary and secondary coils is 50 mm and wire diameter is chosen as 1.5 mm. The turn of coil in secondary coil are 27 in helical coil model and 20 in spiral circular coil model. The best value of s in helical coil structure and spiral circular coil structure are 1 mm and 2 mm respectively, in which the value of M^2/R_{-1} is the largest. It is obviously to select spiral circular coil as the first choice to design the WPT system for that the value of M^2/R_{-1} in spiral circular coil is larger than that in helical coil under the same condition.

Keywords : distance between two turns, helical coil, spiral circular coil, wireless power transfer

Conference Title : ICISEEE 2017 : International Conference on Information Science, Electronics and Electrical Engineering
Conference Location : London, United Kingdom
Conference Dates : January 19-20, 2017