GENERALIZED CIRCUIT MODEL FOR SHIELDED CAPACITIVE WIRELESS POWER TRANSFER

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出版情報：Kyushu University, 2021, 博士（工学）, 課程博士
バージョン：

様式３） Form 3

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論 文 名　：GENERALIZED CIRCUIT MODEL FOR SHIELDED CAPACITIVE WIRELESS POWER TRANSFER

（シールド型電界結合ワイヤレス電力伝送の一般化回路モデル）

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区　　分　：甲
Category　：Kou

論　文　内　容　の　要　旨
Thesis Summary

Wireless power transfer (WPT) become one of the interest topic in engineering and technology industry due the WPT promising an energy sustainability in delivering energy. WPT transfers power between the supply source and electronic devices without using cables and it is more reliable and convenience . WPT can be applied to charging system unmaneed aerial vehicial (UAV) , electric vehicle others. Performance of the CPT system depending on several major factors includes resonance condition, impedance matching condition, electric field and voltage stress between plate, loss and efficiency. Each of the components in CPT system such as inductor and coupling plate effects the performance factor of CPT. An internal resistance of the inductor contributes to the loss and efficiency decreasing in CPT system. In additional, the internal series resistance gives influence on resonance and impedance matching condition in asymmetric configuration of CPT. Misalignment of the coupling plates contributes the loss and efficiency decreased. The coupler design of coupling plates is crucial to minimize the electric field in term of safety consideration and voltage stress between the plates is crucial to comply the voltage stress breakdown limit. Thus, the generalized model of shielded capacitive power transfer (S-CPT) has been introduced on this work with both symmetric and asymmetric topologies.

The work focuses on the shielded capacitive power transfer (S-CPT) system including inverter and rectifier. The first part is the analysis on the S-CPT system in which the work purposes to model and design S-CPT system both in symmetric and asymmetric configuration. The analysis includes the resonance condition, impedance matching condition, voltage stress between plate and efficiency of the system. The finding on the system generates the generalized circuit in which can be form into symmetric and asymmetric configuration of S-CPT system. Hardware experimental is setup to valid the analysis work. Second part is the fabrication of the complete system of S-CPT system in which consist of the inverter, CPT, rectifier and the load. Hardware experimental is set up to investigate the performance of the S-CPT and the voltage stability on the shielding plates.

Chapter 1 covers on the introduction to the wireless power transfer (WPT) system, the issue on the capacitive power transfer (CPT), the objective of the work and the scope of the work.

The thesis organization is described in this chapter.

Chapter 2 describes on the overview of the capacitive power transfer (CPT) system technology in which had done by many researchers. The CPT system includes the AC-DC inverter, the compensation system of the CPT and the coupling design. The advantages and disadvantages of the systems are also included. In addition, several work contributions and publications related to the research are provided. In addition, several work contributions and publications related to the research are provided.

Chapter 3 covers on the methodology of the S-CPT work. First stage of the work is study and investigation on the CPT system in WPT system. Next, the work covers on the analysis of S-CPT system using algebraic method and performance of the S-CPT system is demonstrated. The example-method is used to explain the flow of the work for better understanding in both Matlab and LTSpice simulation. The Class E Power E with 6.78 MHz is also included in this chapter.

Chapter 4 discusses on the analysis of the shielded capacitive power transfer (S-CPT) by introducing the generalized model for 13.56 MHz as an operating frequency. The S-CPT model is analysed based the resonance condition, matching condition, voltage stress breakdown and the efficiency. The findings on the analysis is the generalized circuit model in which it can be formed into symmetric and asymmetric topology. The process on the analysis is explained in details in this chapter. The recommendation guideline for wireless power application using the generalized circuit is fully discussed. An experimental to validate the analysis findings is presented.

Chapter 5 covers on the development of the symmetric and asymmetric S-CPT system. The development start with the simulation and continue with the validation on the hardware using the experimental set up. An inverter and coupler structure designed are also included. Both symmetric and asymmetric topology using the developed generalized model and hardware is demonstrated in 6.78 MHz of an operating frequency.

Chapter 6 concludes all the finding on the S-CPT system and the summarization of the research work. The future recommendation is included.

This thesis proposes a new approach of capacitive power transfer by introducing the generalized circuit model in shielded capacitive power transfer (S-CPT). The generalized circuit can be formed into symmetric and asymmetric configuration with the flexibility on the design in which it can be designed regarding to the requirements such as stability system, lightweight, different operating frequency and scalable in power range from few Watts to kilowatts application. The details on the mathematical calculation on the analysis, the symmetric and asymmetric topologies with compressive circuit model are presented in this work. Hardware implementation is done to validate the analysis. Results shows the good agreements between the hardware and analysis part. Moreover, the simulation is done to investigate the details on circuit analysis before the hardware is implemented.