고성능 무선충전 시스템 개발

조철희, 진아비, 장해용, 김동희
전남대학교 전기공학과

Developed high performance wireless charging system

Cheol Hee, Jo, Ya Fei Chen, Hai Long Zhang, Dong Hee Kim
Chonnam National University

ABSTRACT

In this paper, a wireless charging system for drones is developed. The system is consists of PFC(Power Factor Correction), Full Bridge inverter, S S(Series Series) resonant circuit and Full Bridge rectifier. The parameters of the S S resonant circuit is designed and calculated. According to these parameters and the switching devices, the system model without PFC is setted up with thermal module devices in PSIM. When output voltage is setted to 50[V] and input voltage is changed from 100[V] to 380[V] , The efficiency of the system model is measured by simulation.

1. Introduction

Compared to the cable charging, wireless power transfer (WPT) technology is more secure and convenient due to its feature of having no wires. This technology has received increasing attention in many fields, especially in recent years. Additionally, many WPT studies have been conducted for mobile phones and electric vehicles [1 2].

In order to compensate the reactive power in the wireless charging system, capacitor is used to compensate the coupler inductor circuit. There are four kinds of compensate circuit , S S topology is used in this paper because of the capacitor value in this topology is independent of coupler inductor. Low efficiency is the biggest shorting in wireless chargeing system because of the fixed input in inverter. Therefore, before doing the experience , the total loss of the wireless charging system should be calculated under different input voltage conditions of inverter. In according to the relationship about the input voltage and efficiency of the system, appropriate input voltage can be selected.

2. Content

2.1 Operating Principle of the Proposed System

The diagrame of the proposed system is shown in Fig 1. The power transmitter is consists of an Full Bridge inverter and a primary coil., The power receiver is consists of a secondary coil and a Full Bridge rectifier. shown below. The PFC is used to convert a AC voltage from grid to DC voltage and to improve the power factor.

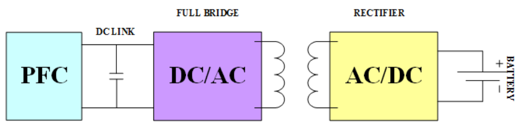

Figure 1. Overall diagram of wireless charging system

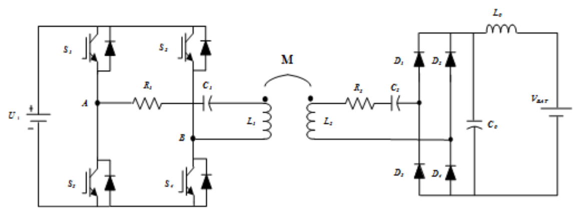

Figure 2. The cicuit diagram of the IPT converter using S S topology.

In the wireless charging system, due to the leakage inductor on the primary side and the secondary side is so large, must be compensated by capacitor to improve the transmission efficiency. In the several compensate topologies, due to the compensation capacitor is not affected by the change of loads, the S S topology is chosen in this paper. The Fig 2 shows the IPT(Inductive Power Transfer) converter. In the power transmission part, by the symmetrical control of switches $S_1 - S_4$, the square wave can be generated on V_{ab}. In the resonant circuit of primary side amd secondary side, R_1 and R_2 is loop resistor, L_1 and L_2 is the inductor of the coils, C_1 and C_2 is the compensating capicitors.

In this paper, the resonant frequency is setted to 80 kHz. By experiment, the value of the inductor can be tested and the value of capacitor can be obtained by quation (1),(2).

Table I. The specifications of the primary and the secondary coil

	Primary Coil	Secondary Coil
magnetic substance	Ferrite	Not used
Turns	24	10
Size	25cmX25cmX2cm	12cmX12cmX0.01

Table II. The inductor and mutual inductor values

Measured Data (Distance between Tx and Rx =2cm)	
Mutual inductance equation model	
Lp	202.935uH
Lk1	197.949uH
Ls	7.56uH
Lk2	7.38uH
Rp/Rs	3.58/0.8423Ω
M12	6.14uH
M21	6.09uH
M	6.11uH
k	0.156
Cp	0.524uF
Cs	19.5nF

$$C_s = \frac{1}{w_o^2 L_s} \quad (1)$$

$$C_p = \frac{C_s L_s}{L_p} \quad (2)$$

The output AC voltage of the full bridge inverter is connected to full bridge rectifier ,therefore, the output DC voltage of the rectifier can be charged to battery.

The specifications of the primary and the secondary coil are shown as Tab I.

The inductor values and mutual inductor measured by the experiment are shown as Tab II.

The relationship between inductor and mutual inductor is shown as follow equations.

$$M_{12} = \sqrt{L_p L_s - L_{lk1} L_s} \quad (3)$$
$$M_{21} = \sqrt{L_s L_p - L_{lk2} L_p}$$
$$M = \sqrt{M_{12} M_{21}}$$
$$k = \frac{M}{\sqrt{L_p L_s}}$$

Table 3 The specification of the Mosfet and Diode

Used Device	Device name
MOSFET	Infineon IPB65R150CFD
Diode	IXYS DSS6 015AS

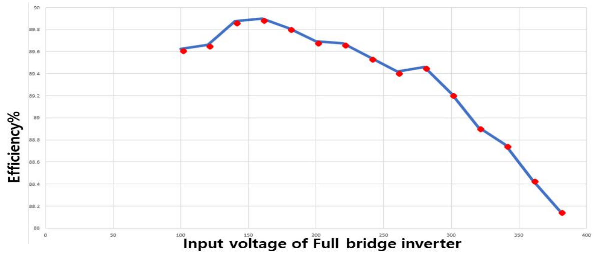

Figure 3. System efficiency under different input voltage

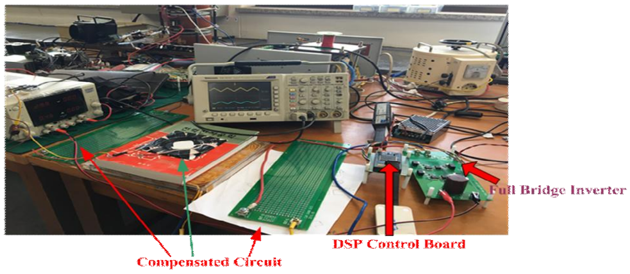

Figure 4. Experiment setup of the IPT system

2.2 Analysis of loss

The output voltage of the rectifier is constant at 50 V and the output power is constant at 300 W. PSIM is used to analysis the loss of the circuit through thermal module analysis method. The specification of the Mosfet and Diode is shown in Tab.3

According to IPT converter and compensate circuit proposed in this paper ,there have switching loss, diode loss, copper loss on primary and secondary side . The loss of the system depends on the variation of the input voltage of the inverter.

When the output voltage of the rectifier is fixed at 50 V and the input voltage of the inverter is changed from 100 V to 380, the efficiency of the system is shown in Fig3.

3. Conclusion

A thermal Module analysis method is proposed in this paper. The power loss of IPT converter and compensate circuit is simulated in PSIM. Through Thermal Modultaion of PSIM, it is confirmed that the best efficiency of the inverter is 160 volts, which represents 89.89 %.

This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIT) (No. NRF 2017R1C1B2010057)

References

[1] N.G. Hingorani, "Power Electronics in Electric Utilities : Role of Power Electronics in Future Power System", Proceedings of the IEEE, Vol. 76, No. 4, pp. 481 482, 1988, April.

[2] Curtis F. Gerald, Applied Numerical Analysis: Second Edition, Addison Wesley Publishing Company, Inc. pp. 1 14, 1978.