Development of Wireless Power Induction Cooker Using Magnetic Induction-based Technology

Wonho Jang[1], **Seonghun Lee**[2], **Jeongsug Yeom**[3], **Byungduk Min**[4], **Goonyeon Kim**[1], **and Sangho Choi**[1]

[1]Electromagnetic Wave Technology Institute of RAPA, Seoul, Korea
[2]Creative Innovation Center of LGE, Seoul, Korea
[3]Komatech, Seoul, Korea
[4]R&D Department of Green Power, Suwon, Korea

Abstract— -Magnetic induction technology offers higher power transmission and higher efficiency of power transmission than magnetic resonance technology in the wireless power transmission. We have developed a wireless power induction range which has over 90% dc-to-dc wireless power transmission efficiency and transmission power up to 2.4 kW. We used 20 kHz frequency to resonate between transmission coil and reception coil. EMF level is below 30% according to the ICNIRP 2010 measured by the IEC 62233 measurement method.

1. INTRODUCTION

The growth of the wireless power transmission technology is propelled by the increased demand in smartphones, the consumer goods industry, and consumers' inclination toward wireless connectivity. The market is further driven by the increasing efficiency in technologies as well as new emerging application areas. Wireless power transmission (WPT) systems are becoming ubiquitous with applications in powering smartphones, transportation and a range of kitchen appliance devices such as induction cooker. In Korean kitchen appliances, induction cooker sales increase dramatically in the last five years. The second is a deep-fat fryer and the third is electric grill. IH (Induction Heating) range is new product in the induction cooker up to now. We had noticed that IH + WPT cooker is new integrated product for the kitchen appliance. We call it is WPIC (Wireless Power induction cooker) In the 2020 the wireless power revenue will expect 13 billion USD and the consumer electronics including appliances will project 4 billion USD as well.

2. DESIGN PROCEDURE

WPIC is required to meet wider margin of alignment to cook conveniently and to prepare foreign object detection mode to avoid fire and harmful damage to the human body. The level of EMC is limited by the CISPR 11 regulation and the level of EMF is limited by the ICNIRP guideline.

2.1. Resonator Design

We made disk type resonators, two transmission coils and one reception coil. Figure 1 shows the simulation picture of the electromagnetic field distribution between transmission and reception coils. Figure 2 shows the prototype resonators.

Figure 3 shows the shielding ferrite construction to minimize the leakage of the magnetic field.

2.2. Inverter Design

We selected a full-bridge inverter to get higher power output and higher efficiency.

2.3. Communication Part Design

We have developed both an out-of-band communication and a time multiplexing (in-band) communication method. We used a Bluetooth Low Energy (BLE) for out-of-band communication.

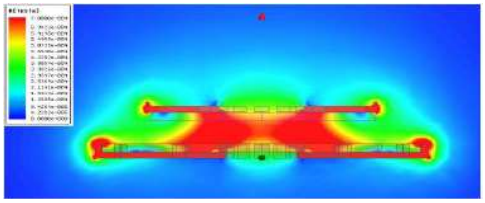

Figure 1: Coil shielding part simulation by Maxwell.

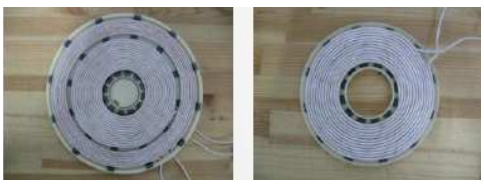

Figure 2: Transmission and reception resonators.

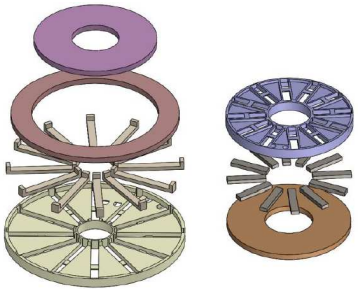

Figure 3: Tx and Rx coil & ferrite assembly.

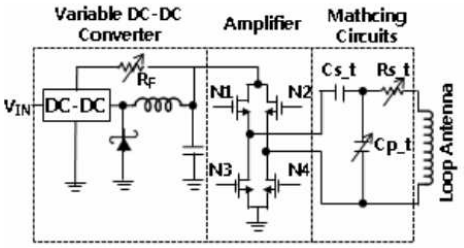

Figure 4: The circuit diagram of the Full-bridge Inverter

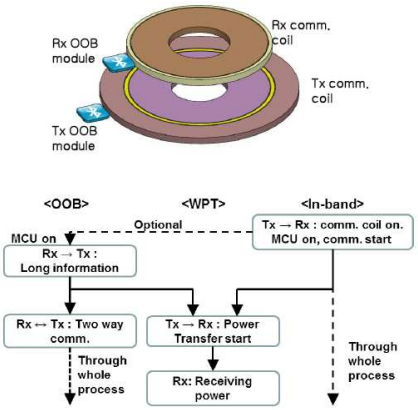

Figure 5: The configuration of out-of-band (OOB) and time multiplexing communication.

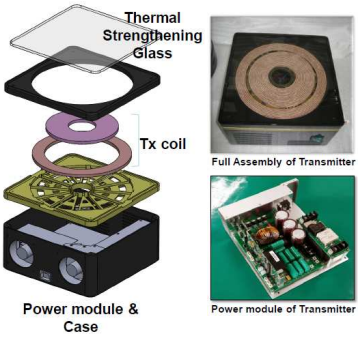

Figure 6: The configuration of 3D modeling of transmitter and picture of prototype transmitter and power module.

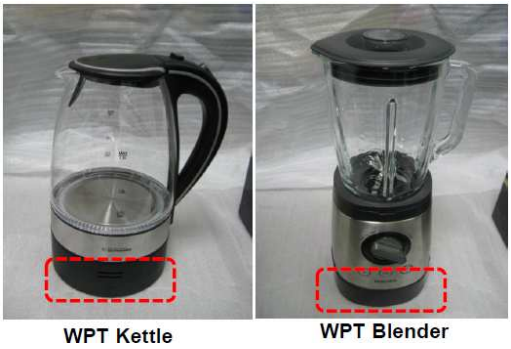

Figure 7: The pictures of WPT kettle and WPT blender.

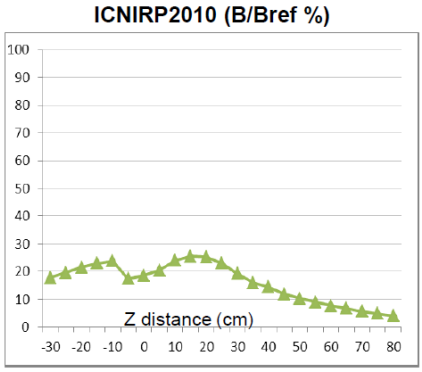

Figure 8: The measured result of the EMF levels.

2.4. Prototype-transmitter

We made the transmitter for a stand-alone and a built-in type in the kitchen countertop. We designed the heat dissipation structure in the transmitter such as fins, fans and a ventilation duct. The transmitter is compatible as an IH (Induction Heating) type and a Wireless Power Transmission (WPT) type with a thermal strengthen glass. Both the wireless power kitchen appliances and IH appliances can use the transmitter at the same time.

2.5. Prototype-receiver

We made a receiver as a module type for several appliances. Heat dissipation structure is designed such as a fin and a duct. DC power output from the reception coil in the appliances could be changed to AC power output to feed to the receiver heating coil in the kettle or to drive the motor in the mixers.

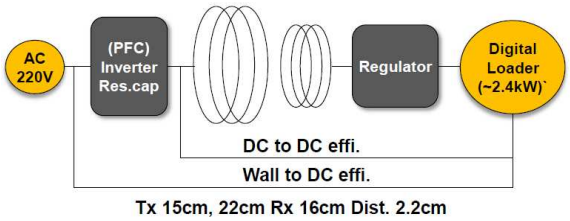

Figure 9: The efficiency test setup.

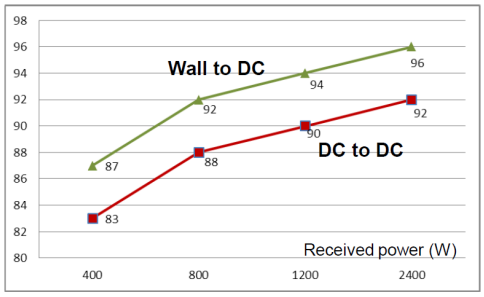

Figure 10: The measured efficiency result.

3. EMF AND EFFICIENCY MEASUREMENT

WPIC systems are ISM equipment, and are required to meet free-space electric and magnetic-field levels to conform to limits provided by CISPR 11 standard on wanted emissions at the operating frequency and its harmonics, and also on unwanted (spurious) emissions up to 18 GHz.

We measured EMF based on IEC 62233 with Narda EHP-200A, 9 kHz∼100 kHz frequency measurement bandwidth. Sweep the probe from −50 cm to 100 cm in z-direction at 30 cm apart from Transmission coil. Reference the guideline ICNIRP 2010. At 2 kW received power condition, the EMF level compared to the ICNIRP guideline is below 30%.

We configured the efficiency test set as a Figure 9. The Wall to DC efficiency is 96% maximum at the 2.4 kW power transmission point.

4. CONCLUSION

We made a prototype wireless power transmission induction cooker. It is a new product of wireless kitchen appliance. We achieved good wireless power transmission efficiency, 96% maximum at the 2.4 kW. We also conform to the CISPR 11 standard and ICNIRP guideline. The standardization process of the product is working at the Wireless Power Consortium.

ACKNOWLEDGMENT

This work was supported by ICT R&D program of MSIP/IITP. [14-911-01-005, Development of wireless power transfer and IH convergence technology using mid-power magnetic induction technology].

REFERENCES

1. "Industrial, scientific and medical equipment — Radio-frequency disturbance characteristics — Limits and methods of measurement," International Special Committee on Radio Interference CISPR Std. CISPR 11, 2010.
2. Balanis, C. A., *Antenna Theory: Analysis and Design*, John Wiley and Sons, Inc., Chichester, Brisbane, New York, Toronto, Signapore, 2005.
3. ICNIRP, "Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz)," *Health Physics*, Vol. 74, No. 4, 494–522, Apr. 1998.
4. ICNIRP, "Guidelines for limiting exposure to time-varying electric and magnetic fields (1 Hz to 100 kHz)," *Health Physics*, Vol. 99, No. 6, 818–836, Dec. 2010.
5. IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz, IEEE Std. C95.1, 1992.
6. IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz, IEEE Std. C95.1, 2005.
7. ICNIRP, "Response to questions and comments on guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz)," *Health Physics*, Vol. 75, No. 4, 438–439, 1998.