

85 kHz Band 44 kW Wireless Power Transfer System for Rapid Contactless Charging of Electric Bus

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Abstract - A 44 kW wireless power transfer (WPT) system is being developed for rapid contactless charging in an electric bus in the 85 kHz band, the candidate frequency for a wireless charging system for light-duty vehicles that is currently undergoing standardization. A two-channel WPT system with currents of opposite phase in the two transmit pads of the channels is introduced to reduce radiated emissions to within the Radio Act limits by cancelling the emission from each channel. In this paper, the measured power for the 44 kW WPT system is shown.

Index Terms — Wireless power transfer, contactless charging, electric bus, EV.

1. Introduction

The widespread deployment of various kinds of electric vehicles such as plug-in hybrid electric vehicle (PHEVs) and battery electric vehicles (BEVs), including light-duty vehicles and heavy-duty vehicles such as electric buses, is expected to be an important development contributing to the emergence of a low-carbon society. Several examples of field operation of wireless battery charging for electric buses

at parking spaces have been demonstrated [1-4]. Typically, they transfer several tens or even hundreds of kilowatts to charge a large-capacity battery in an electric bus. The most widely used current operation frequency band is such as 20 kHz[1,2,4]. In the standardization process, the 85 kHz band is the candidate frequency for a wireless charging system for light-duty vehicles. Therefore, 44 kW rapid contactless charging with a wireless power transfer (WPT) system using the common 85 kHz band for electric buses is being developed in terms of electromagnetic compatibility. For field operation of the WPT system in Japan using the operating frequency of 10 kHz or above, permission to operate as Industrial Facilities Emitting Radio Waves is required in accordance with the Radio Act. A two-channel WPT system with currents of opposite phase in the two pads of the two channels is introduced to reduce radiated emissions to within the Radio Act limits of the magnetic field strength by cancelling the emission from each channel. The measured power for the developed 44 kW WPT system is shown in this paper.

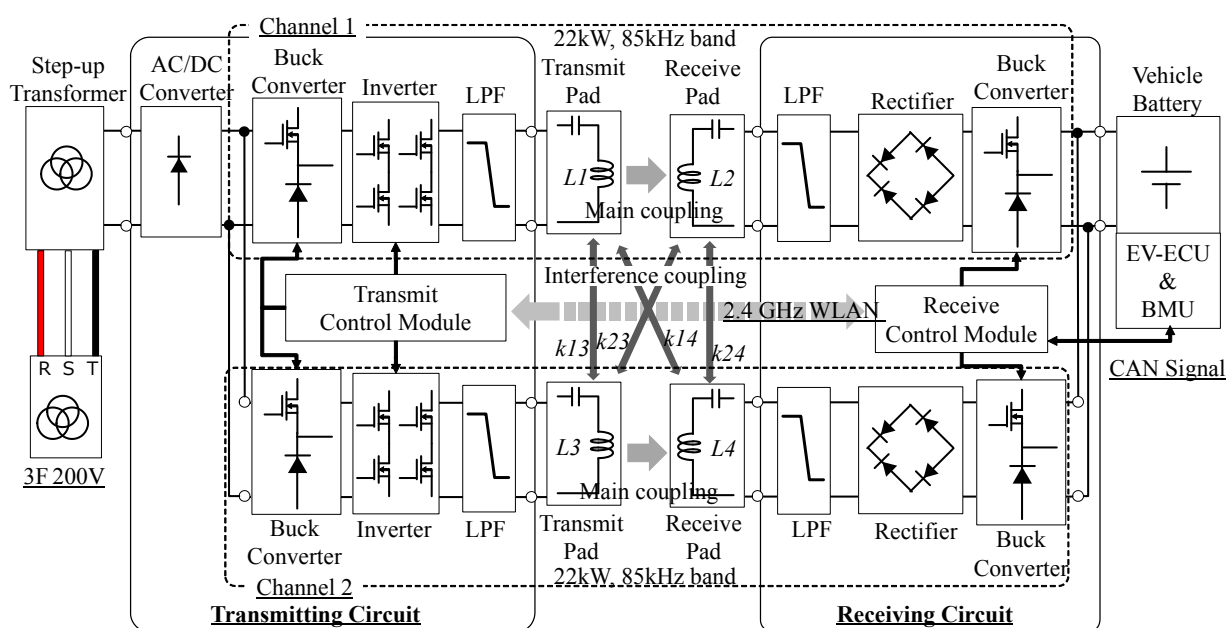


Fig. 1 Block diagram of two-channel WPT system for charging an electric bus

2. Two-channel WPT system with opposite phase

Figure 1 shows a block diagram of the developed two-channel WPT system for contactless charging of electric buses. A transmitting circuit generates two-channel 85 kHz band high-power signals with opposite phase from a commercial power source. A receiving circuit rectifies 85 kHz band high-power signals to DC and charges the battery. A control circuit uses 2.4 GHz wireless LAN for communication. The transmit pads and the receive pads consist of the inductors and compensation capacitors. For leakage inductance compensation, the SS topology [5,6] is adopted in which the compensation capacitors are connected in series with the primary and secondary inductors. Third-order low-pass filters (LPFs) are composed in the transmitting circuit and the receive circuit to reduce the harmonic generated by the inverters and the rectifiers.

In the contactless charging system developed for the electric bus, the transmission distance between charging pads is 105 mm or more. The large air gap can be easily provided by the ordinary kneeling function equipped on most low-floor buses. The system employing buck converters in the transmitting and receiving circuits can have robustness against lateral misalignment of charging pads on both sides. Both ± 100 mm misalignment in the front-rear direction and ± 100 mm misalignment in the right-left direction are allowed.

3. Prototype systems and measured power

The prototype of the developed WPT system is shown in Fig. 2 and Fig.3. The pad size is 800 mm x 640 mm. The distance between the center of the two transmit pads is 896 mm. Fig. 4 shows the measured power for the developed 44 kW two-channel WPT system without misalignment. The battery input DC power of 44 kW is provided at three-phase AC output of 50kW.

4. Conclusion

A 44 kW wireless power transfer system is being developed for rapid contactless charging in an electric bus in the 85 kHz band. The two-channel WPT system with opposite phase and the LPFs is introduced to reduce the radiated emission to within the limits in accordance with the Radio Act. The measured three-phase AC output and battery input power are shown.

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Fig. 2 Prototype of the transmitting circuits and pads



Fig. 3 Prototype of the on-board receiving circuits and pads

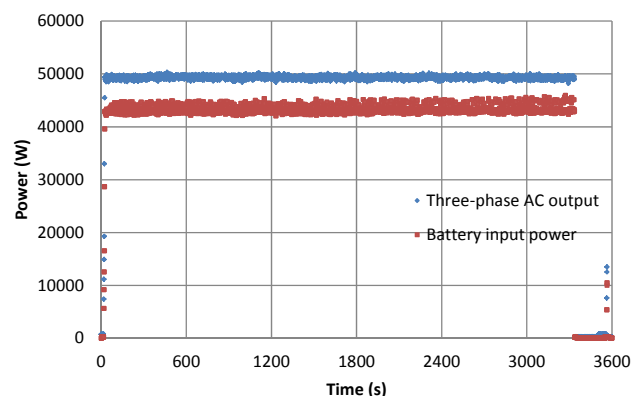


Fig. 4 Measured powers for developed WPT system