Integration of On-board Charger, Auxiliary Power Module and Wireless Charger with a Multi-Purpose Magnetic Coupler

Ziwei Liang[1], Liyan Zhu[1], Yue Sun[1], Jie Li[1], Ruiyang Qin[1], Arka Basu[1], Daniel Costinett[1], Hua Bai[1]
[1] The University of Tennessee, Knoxville

INTRODUCTION

- The conductive On-board charger (OBC), Auxiliary Power module (APM) are necessary charging units for Electric vehicles (EVs).
- The wireless power transfer (WPT)-based charger is also attractive because of the advantages of convenience, safety and automation.
- Standalone solutions to offer OBC, APM and WPT charging functions together can be complex and expensive and can lead to low power density.
- High-level integration of charging units is a main trend to offer better charging solution.

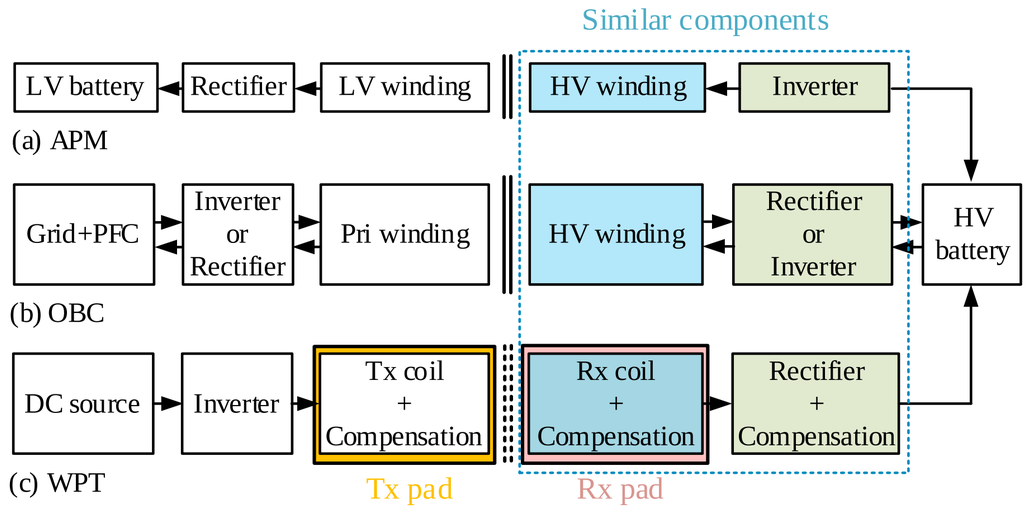


Fig. 1 Block diagram of the EV charging system with standalone OBC, WPT and APM units.

3-IN-1 INTEGRATED EV CHARGING BOX

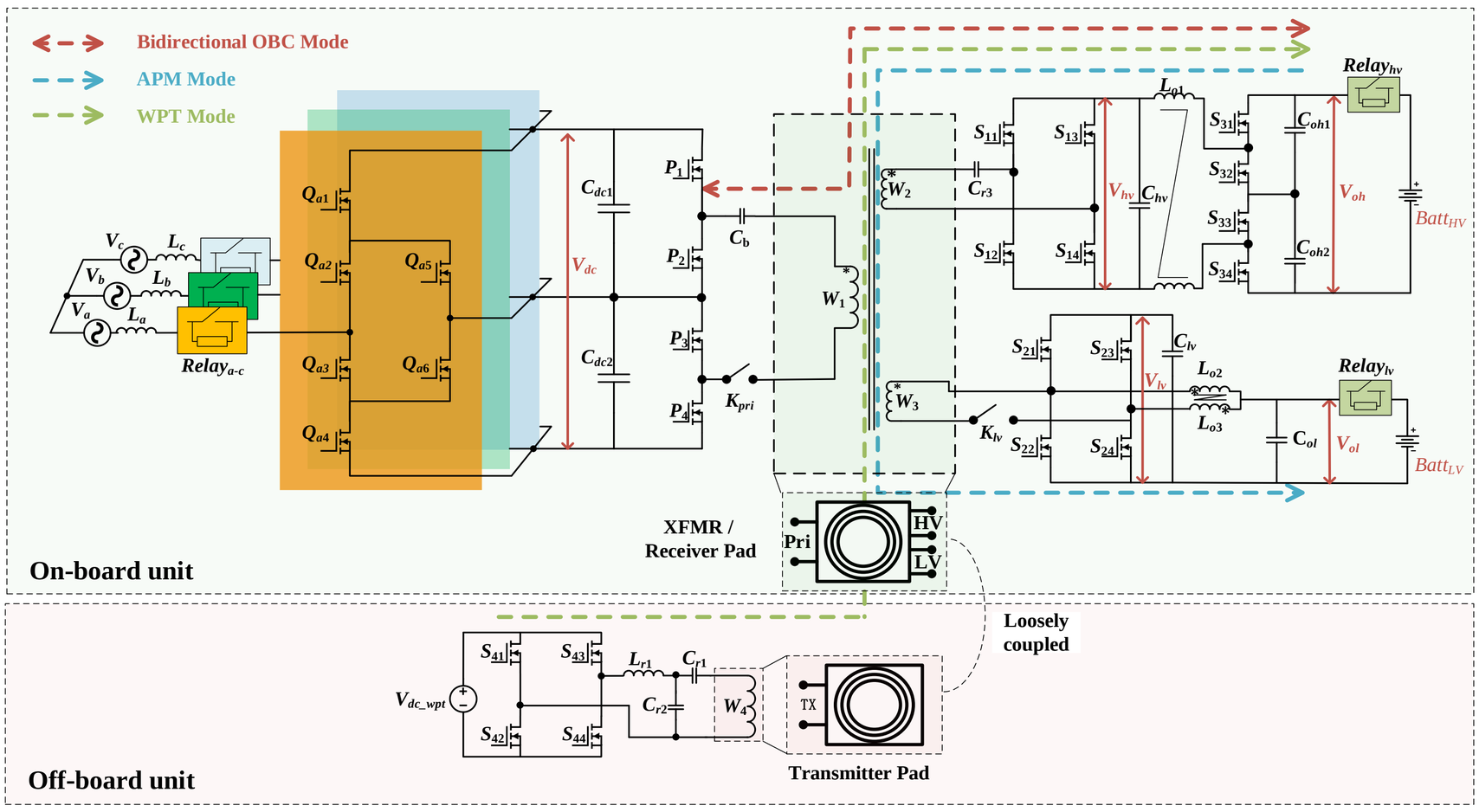
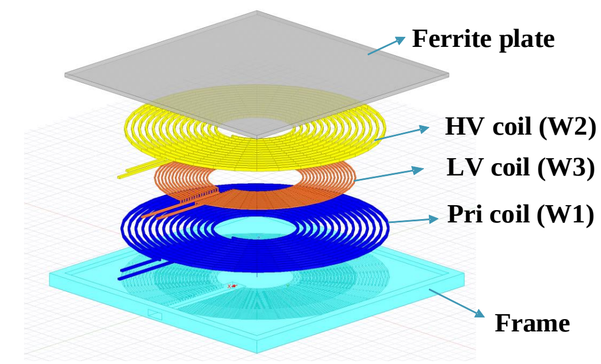
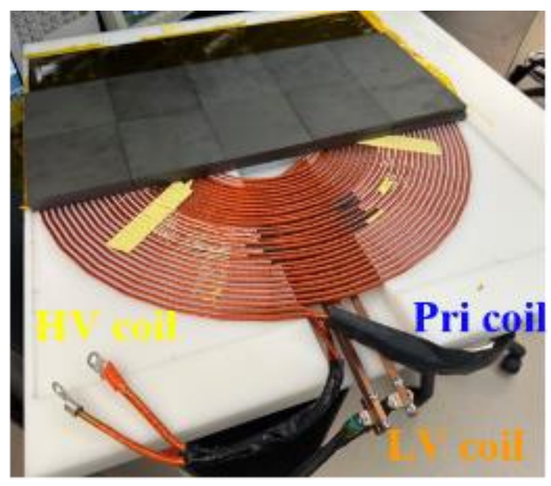


Fig. 2 Block diagram of the proposed fully integrated EV charging system with the OBC, APM and WPT functions using multi-purpose magnetic coupler and shared circuit components.



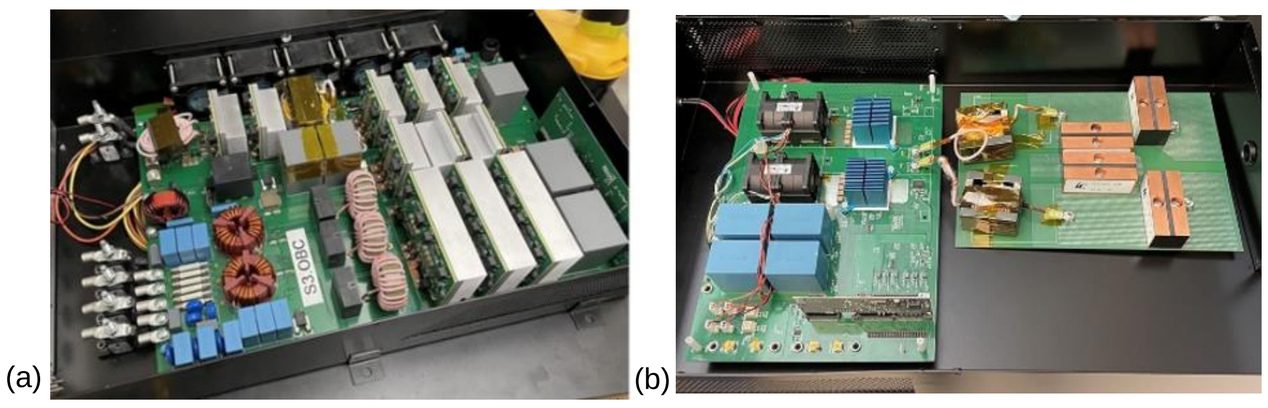
(a) Schematic of the receiver pad.



(b) Manufactured receiver pad.

Fig. 3 Three-winding charging pad design.

PROTOTYPE AND TEST VERIFICATION



(a) (b)

Fig. 4 Experimental prototype of the proposed 3-in-1 EV charging box. (a) On-board unit. (b) Off-board unit.

- A prototype was built, and all functions are verified by experiments, including 10.3 kW OBC, 6.6 kW WPT, 3.7 kW vehicle-to-load (V2L) and 800 W APM.
- Two conventional HF transformers, two HV active bridges were eliminated compared with the standalone solution.
- More than 2-L volume and $500 cost reduction can be expected benefited from the proposed highly integrated structure.
- More functions, such as OBC+APM, V2G and so on, are possible based on the proposed structure, which is still undergoing.

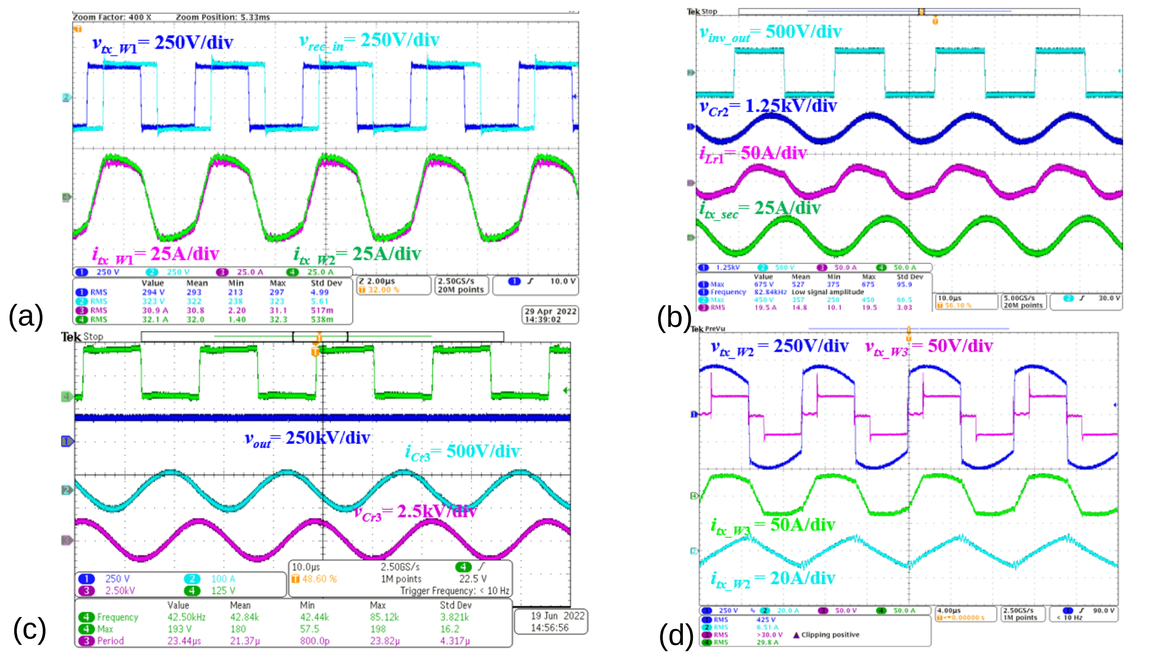


Fig. 5 Key waveforms: (a) OBC; (b) WPT inverter; (c) WPT secondary sync rectifier; (d) APM mode.

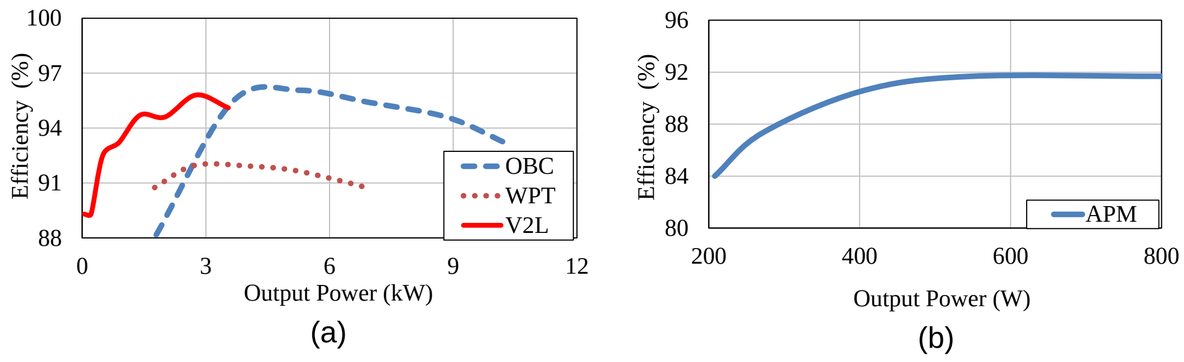


Fig. 6 Efficiency of different modes: (a) OBC, WPT and V2L, (b) APM.