Liquid-Cooled GaN-Based Integrated EV Onboard Charger with Bidirectional OBC and APM Functions

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MOTIVATION
• Usually for an EV, all the power units are designed and installed separately. That means they need multiple enclosures and cooling systems, leading to higher costs.
• There’s a trend towards using reconfigurable battery packs in EVs, allowing configurations at 400V for charging compatibility and 800V for more driving power. This necessitates OBC capable of charging both 400 & 800V batteries and APM that can accommodate a wide input range of 180V to 900V.

OBJECTIVES
• To integrate an APM with EV on-board charger thereby saving the size and cost.
• To charge both 400V, and 800V batteries using only 650V GaN HEMTs.

CHALLENGES
• Developing a multi-stage converters coordination for the Soft Start-up and Shut-down process to avoid potential large inrush current or overvoltage.
• Securing ZVS for both OBC and APM.
• Maintain high performance for different operation scenarios.

SYSTEM SCHEMATIC AND HARDWARE PROTOTYPE:

EXPERIMENTAL TEST VERIFICATION:

OBC Mode:

V2L Mode:

APM Mode:

CONCLUSIONS:
• Tested proposed iCharger at 11kW for OBC & V2L mode and 2kW for APM.
• The proposed charger can accommodate both 400V and 800V batteries and offer bidirectional OBC and APM functions, which are enabled by the multi-level and three-port converter topology with a three-winding transformer.

FUTURE WORKS:
• Different modulation methods including DPS, and TPS can be implemented to increase the efficiency for the OBC stage at very light load conditions.
• Investigate the bi-directionality of the APM.