

System Technology

"Making True Single-Stage EV Charging Practical: System-Level Redesign of a Dual-Active-Bridge On-Board Charger Enabled by Bidirectional GaN and Closed-Form Control"

This paper presents a system-level redesign of automotive on-board chargers that makes true single-stage isolated AC/DC EV charging practical through the combination of a Dual Active Bridge architecture, monolithic bidirectional GaN devices, and a patent-pending closed-form Triple Phase Shift control strategy.

Rather than optimizing conventional multi-stage topologies incrementally, the work rethinks the OBC from first principles and shows that a single-stage DAB approach can remove both the intermediate DC-link capacitor and the PFC boost stage while preserving galvanic isolation, bidirectional capability, and grid compliance.

The proposed implementation is enabled by bidirectional GaN integration, which replaces conventional back-to-back SiC arrangements to reduce conduction losses and simplify switching, together with a deterministic fixed-frequency control law operating at 140 kHz and executable on standard automotive microcontrollers without lookup tables, iterative optimization, or adaptive tuning. Using only grid voltage, battery voltage, and power reference as instantaneous inputs, the control computes the required phase shifts to regulate power flow, maintain volt-second balance and ZVS across the AC cycle, and suppress magnetizing current and crossover distortion.

A 7.5 kW prototype for 230 Vac / 50 Hz and 300–400 V battery operation validates the concept, achieving up to 98% peak efficiency, power factor above 99.5%, grid-current THD below 1.9%, and power density beyond 5.1 kW/L in a 1.45 L implementation.

The paper demonstrates that coordinated architecture selection, wide-bandgap device innovation, and closed-form control can provide a practical pathway toward compact, high-efficiency, bidirectional EV charging systems.

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