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CONVEX DOUBLE-D TRANSMITTER FOR POWER STABILIZATION IN SEGMENTED DYNAMIC WIRELESS EV CHARGING

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Abstract
Dynamic Wireless Power Transfer (DWPT) addresses electric vehicle (EV) range constraints, yet segmented transmitter arrays suffer from severe power dips at inter-coil switching instants. To address this, this paper proposes a novel Convex Double-D (CDD) transmitter topology incorporating a convex extension along the longitudinal direction, functioning as a magnetic bridge that pre-emptively engages the receiver's leading edge while prolonging trailing-edge coupling, thereby transforming the sharp coupling coefficient drop into a smooth transition. On the secondary, a Double-D Quad-Compensation (DDQC) receiver with orthogonal quadrature coils is employed to decouple lateral and longitudinal misalignment effects, complemented by a position-based segmented excitation strategy. Simulation results at 85 kHz with a 200 mm air gap demonstrate that the system achieves a nominal output power of 7.79 kW, with a transient fluctuation of only 3.14% at switching instants and a maximum ripple of 8.4%, substantially outperforming conventional DD-based segmented system designs.
Keywords
Dynamic Wireless Charging, Electric Vehicles, Transmitter Structure, Power Stablization

ВЫПУКЛЫЙ ДВУХКАНАЛЬНЫЙ D-ПЕРЕДАТЧИК ДЛЯ СТАБИЛИЗАЦИИ МОЩНОСТИ В СЕГМЕНТИРОВАННОЙ ДИНАМИЧЕСКОЙ БЕСПРОВОДНОЙ ЗАРЯДКЕ ЭЛЕКТРОМОБИЛЕЙ

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Аннотация
Динамическая беспроводная передача энергии (ДБПЭ) решает проблему ограниченного запаса хода электромобилей (ЭМ), однако сегментированные массивы передатчиков подвержены резким провалам мощности в моменты межкатушечного переключения. Для решения данной проблемы в настоящей работе предложена новая топология передатчика «выпуклая двойная Д» (CDD), включающая выпуклое расширение в продольном направлении, функционирующее как магнитный мост, который заблаговременно вовлекает переднюю кромку приёмника во взаимодействие, одновременно продлевая связь по задней кромке, преобразуя резкое падение коэффициента связи в плавный переход. На вторичной стороне применён приёмник типа DDQC с ортогональными квадратурными катушками для разделения эффектов поперечного и продольного рассогласования, дополненный позиционной стратегией сегментированного возбуждения. Результаты моделирования на частоте 85 кГц при воздушном зазоре 200 мм показывают, что система обеспечивает номинальную выходную мощность 7,79 кВт при переходном колебании мощности лишь 3,14% в моменты переключения и максимальной

пульсации 8,4%, существенно превосходя традиционные сегментированные системы на основе двойной Д.
Ключевые слова
Динамическая беспроводная зарядка, электромобили, конструкция передатчика, стабилизация мощности

Dynamic Wireless Power Transfer (DWPT) using segmented transmitter arrays offers superior efficiency and electromagnetic compatibility for electric vehicles (EVs) [1], yet suffers from severe power dips at inter-coil switching instants due to abrupt mutual inductance discontinuities [2]. Conventional Double-D (DD) structures fail to mitigate these fluctuations [3], while Double-D Quadrature (DDQ) configurations substantially increase system complexity [4]. A novel Convex Double-D (CDD) transmitter in proposed in this paper, paired with a Double-D Quad-Compensation (DDQC) receiver and a synchronized segmented control strategy, offering a purely geometric solution without additional compensation circuits.

The CDD structure modifies the conventional rectangular DD coil by incorporating a precisely engineered convex extension along the longitudinal direction of vehicle movement, functioning as a magnetic bridge that reshapes the coupling profile during coil transitions. In conventional DD systems, the coupling coefficient decays rapidly as the receiver departs from an active transmitter before sufficient engagement with the subsequent coil is established, producing a sharp V-shaped mutual inductance dip. The CDD geometry addresses this by pre-emptively engaging the leading edge of the receiver's magnetic circuit before full coil alignment, while simultaneously prolonging the trailing-edge interaction. This dual-action mechanism transforms the abrupt discontinuity into a shallow, smooth transition. On the secondary side, the DDQC receiver integrates DD coils augmented with orthogonal quadrature coils aligned along the X-axis and Y-axis, decoupling lateral and longitudinal misalignment effects and capturing leakage flux components that escape standard unipolar coils, thereby enhancing power transfer robustness. A position-based segmented control strategy energizes only the two transmitter coils adjacent to the instantaneous receiver position, creating a moving excitation window. System-level simulations at 85 kHz with a 200 mm air gap validate the design. The system achieves a nominal output power of 7.79 kW, limiting the transient power fluctuation to only 3.14% at switching instants, with a maximum ripple of 8.4% across the entire movement cycle, significantly superior to conventional DD-based segmented system designs [3], [4].

In conclusion, these results confirm that the CDD system effectively suppresses power pulsation through purely structural optimization, achieving superior transient stability without additional circuit complexity. Future work will focus on experimental prototype validation and foreign object detection tests leveraging the DDQC structural symmetry.

Literature

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