Accurate Transfer-Power Measurement for Wireless Charging of Electric Vehicles Under Misalignment (AGSR_41)

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Electric vehicles (EVs) will soon become the dominant mode of ground transportation with wireless power transfer (WPT) as one of the primary modes of charging. For fairness, the cost for lost energy must be appropriately assigned among the stakeholders. To do this, losses in WPT must be disaggregated for metering. Misalignment between a vehicle and a charger degrades both power and efficiency. This degradation is a financial loss; a mere 1% reduction can cost up to $1 billion worldwide emphasizing the need to accurately measure the transferred power under misalignment. Transfer-power measurement (TPM) provides fair metering for WPT in EVs. TPM employs sense coils between the transmitter coils (Tx) and receiver coils (Rx) to determine the transferred power from the magnetic field. Two sense coils are enough for TPM when the Tx and Rx positions are always fixed. However, misalignment of coils leads to errors which can be corrected by using more sense coils. In this paper, TPM under misalignment using multiple sense coils is introduced, which gives implicit information about the misalignment with a new algorithm. A quadratic approximation of coupling coefficients under misalignment is used to correct the errors. This minimizes errors making the transformation of the sense coil voltages to transfer power appear invariant to misalignment. Sense coil positions and radii are optimized using penalty functions. Numerical models from precise theory confirm the fidelity of the approximation and experimental results concur. The results on experiments are better than the most stringent $\pm$0.2% standard (ANSI C12.20-Class.2). The error is decreased by five times than the results in previous research which used only two sense coils.