Chapter 6
Design and Development of Compensation Topologies in WPT Using MATLAB Programming and MATLAB Simulink

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ABSTRACT

Wireless power transmission devices are growing in acceptance and usefulness. This chapter will discuss, examine, and contrast various compensation topologies for the transfer of inductive power. The classification of topology is changed. The difficulties of the five primary topological needs, standards, safety, and the physical underpinnings of compensatory labour are given considerable emphasis. The IPT is found to favour topologies with a series of main compensations over the four conventional systems for charging devices. If the output voltage is low, the series-parallel method is preferable since it allows for the smallest possible size of the secondary side coil. The resonance load and the magnetic coupling coefficient frequency do not affect the series-series solution. The comparative results are given in tables, graphs, and dependencies for ease of display and understanding utilising Matlab programming and Matlab Simulink. Each application has its own set of core topologies. A "one-stop" information source and selection guide for compensatory topologies in terms of devices and power level are two potential uses for the results of this research, which is the primary benefit of the study. The literature review and recent market trends for wireless power transmission devices point to the most promising future paths for topologies.

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INTRODUCTION

The governments of several nations promote research into alternative energy sources and electric vehicles as a plan for future technological advancement (Xia et al., 2012; Wang et al., 2004). Consequently, efforts are also being made to actively develop wireless communication as an alternative to connectors for power transfer and data transmission between devices (Musavi & Eberle, 2014; Barnard et al., 1997). When it comes to Wireless Power Transfer (WPT), the capacitive and inductive techniques are the most practical (Lu et al., 2016). Additionally, magnetic inductive coupling ensures safety, is easy to set up and use, and is very efficient at close range (Ameri et al., 2016; Aditya & Williamson, 2014).

Thus, inductive approaches and methods with resonance as their type have been successfully distributed industrially and to the general public, especially for high-power applications (Patil et al., 2018; Bieler et al., 2002). The main rectifier in the grid converts direct current to alternating current, and the high-frequency inverter is responsible for this process (Zahid et al., 2013). The device's energy is transmitted from its primary side to its secondary side via a primary resonant circuit Cp-Lp that is connected with magnetic coils (Cannon et al., 2009). The eventual current after rectifying, filtering, and transmission to the load (RL) (Zhang & Mi, 2016; Fernandes & de Oliveira, 2015).

Using electromagnetic induction, the WPT employs a near-field electromagnetic field (EMF) (Kan et al., 2017). The secondary winding is subjected to the action of an alternating magnetic field due to Ampre's and Faraday's laws. Transformers with a large air gap exacerbate low-voltage leakage (Shevchenko et al. 2019).

This results in a higher leakage inductance compared to traditional transformers (Sudheer et al., 2015). Without financial compensation, the effectiveness of IPT is typically below 50% (Lu et al., 2015). It is necessary to add compensating capacitors and reactive power to the primary and secondary sides in order to compensate for the leakage inductance (Abou Houran et al., 2018; Albert et al., 2023). The power delivery efficiency decreases exponentially with increasing distance between the coils (Tseng et al., 2013).

The inductive power transfer system with resonance, or IPT with compensating circuits, will be discussed in the paper's later sections (Song et al., 2017; Buragadda et al., 2022; Chakravarthi & Venkatesan, 2021). N_1, N_2 are the primary and secondary sides' respective turn counts; I_1, V_1, I_2, V_2 are the primary and secondary sides' current and voltage; C_1, C_2 are compensating resonant capacitors; and R is the load resistance and magnetic flux (Shevchenko et al. 2019).

CLASSIFICATION OF DIFFERENT TOPOLOGIES

A topology with at least one resonant element on one side can be thought of as the compensation for an inductive energy transfer (Abdullahi et al., 2023).

1. Location
    - One-sided
        - Simple S & P
    - Multi-sided
        - Modified
        - Complicated