Matlab/Simulink-Based Modeling of Typical Inductive Power Transfer (IPT) System

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Abstract—This paper presents detailed modeling principles of a typical Inductive Power Transfer (IPT) module using the Matlab/Simulink software. The presented model is based on AC-AC Matrix Converter that are implemented by four MOSFET switch followed by resonance LC circuit. The presented models are designed with user-friendly blocks from the Simulink block library. The models provide better understanding of the output current characteristics of a AC-AC Matrix Converter model under resonance frequency conditions. The output current characteristics has frequency 30Khz, sinusoidal form with various amplitude value.

Keywords — Inductive Power Transfer, AC-AC Matrix Converter

I. Introduction

Wireless charging is a technology of transmitting power through an air gap to electrical devices.

Inductive power transfer (IPT) and capacitive power transfer (CPT) are the two most pervasive methods of wireless power transfer. IPT is most common and is applicable to many power levels and gap distances. Conversely, CPT is only applicable for power transfer applications with inherently small gap distances due to constraints on the developed voltage. Despite limitations on gap distance, CPT has been shown to be viable in kW power level applications. A critical comparison submitted in this paper of IPT and CPT for small gap applications wherein the theoretical and empirical limitations of each approach are established [1].

Contactless charging of electric vehicles by means of inductive power transfer is becoming increasingly popular in the recent years. In contrast to wired power interfaces, user friendly and secure wireless links with no physical contact are preferable. Especially in the higher power range (>100kW), three-phase approaches are an encouraging alternative to single phase systems due to great EMC benefits. Effective design and analysis of such inductive power transfer systems containing a three-phase primary as well as a three-phase secondary (pickup) require computation-time provident mathematical models [2] .

By applying capacitive coupling, wireless power transfer can be realized between a transmitter and a receiver. To maximize the power transfer, the default design is to construct resonant circuits by applying a compensation circuit, both at the transmitter and the receiver side. However, to obtain optimal power transfer at variable coupling, an impedance matching system or frequency tuning mechanism is necessary at the transmitter and receiver side, requiring data communication between both sides[3].

a general flow of modeling and controller design for the dynamic Wireless Power Transfer (WPT) system is given to improve the starting speed and stability of the system. In this method, the WPT system is modeled by Generalized State Space Averaging (GSSA) method. A state feedback controller with mutual inductance estimation is designed for a wireless power transfer system of an electric vehicle based on the Buck of secondary side. This controller improved the system response speed and adaptable to dynamic systems [4].

In capacitive wireless power transfer system, effective capacitance of the energy link between the transmitter and receiver changes according to variations in separation distance or degree of alignment in electrodes, which would modify the resonant frequency and degrade the system performance. To compensate for such a change, it is necessary to track the resonance frequency. In this case, frequency control scheme cannot be used for the output voltage regulation. Conventionally, additional DC/DC converter has been adopted in the front of the transmitter or in the back of the receiver for this regulation purpose; however, it increases system complexity and decreases power efficiency. This paper proposes a new single stage topology that can achieve output voltage regulation as well as resonant frequency tracking. By combining asymmetric pulse width modulation scheme with a buck-boost converter, the output voltage is regulated by duty cycle control and the energy link variation can be compensated by frequency control, which is suitable for the wireless power transfer system in practical user scenario [5].

First harmonic analysis (FHA) is arguably the most widely used analytical technique for wireless power transfer (WPT) circuits due to its simplicity. Although FHA can provide

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