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AIN SHAMS UNIVERSITY FACULTY OF ENGINEERING Electrical

Power and Machines Engineering

Modelling and analysis of a wireless power transfer system

A Thesis submitted in partial fulfillment of the requirements of

the degree of Master of Science in Electrical Engineering

(Electrical Power and Machines Engineering)

by

Ahmed Ragab Mohamed Lotfy

Bachelor of Science in Electrical Engineering

(Electrical Power and Machines Engineering)

Faculty of Engineering, Ain Shams University, 2014

Supervised By

Prof. Dr. Ahmed Abdelsattar
Prof.Dr. Mostafa Ibrahim Mohamed Marei
Dr. Mohamed Mokhtar

Cairo - (2021)

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Date: / / 2021

Statement

This thesis is submitted as a partial fulfilment of Master of Science in Electrical Engineering, Faculty of Engineering, Ain shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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Thesis Summary

Recently, the Wireless power transfer systems (WPT) has grasped more attention, one of the main challenges in WPT systems is performance degradation when the receiver's position and characteristics vary. The variations in the system parameters like load impedance and coupling factor in WPT systems affect performance characteristics such as output voltage and power. The system efficiency degrades as the parameters vary from the optimum operating conditions. Therefore, the first section of this thesis is devoted to a thorough theoretical review of different compensation topologies in order to better understand how they function and, as a result, to help in the construction of a generalized inductive power transfer (IPT) structure based on the parameters to be optimized.

In this thesis, the double-sided inductor–capacitor–capacitor (LCC) compensation topology is adopted due to the following reasons. The unity power factor can be easily achieved by tuning reactive power in secondary side. Other benefits include that the zero-voltage switching (ZVS) for MOSFETs is independent on the variation of coupling coefficient and load states. The LCC compensation is the most commonly used topology in literature because it reduces current tension in the inverter, has a large misalignment tolerance, and it is load independent. One of the main challenges of converters used for the IPT systems is the increased switching loss as the switching frequency rises. Switching losses are reduced using the ZVS and ZCS strategies. To achieve ZVS, the feedback diode must conduct before the MOSFET. As a result, the MOSFET module must run at a negative current. In another word, the current must lag behind the voltage which means that the entire input converter's impedance must be inductive in this situation.

A Photovoltaic (PV) based battery charger utilizing IPT interface system is proposed in the thesis. Because of nonlinear characteristics of the PV, the maximum power point tracking (MPPT) is achieved by controlling the phase displacement angle or the pulse width of the quasi-square pulse inverter connected to the transmitting coil of the IPT system. As a result, the power transferred to the secondary-side, which is connected to a battery bank, is regulated. In addition, the LCC compensation network is tuned to realize ZVS where any inverter switch is turned-on. Moreover, for quasi-square wave operation, where the duty ratio of the IPT inverter is controlled, the ZVS is attained for switches in one-leg during turn-on and for the other leg during turn-off.

The thesis presents the detailed design of the IPT-based PV interface system to achieve ZVS in the primary side at rated conditions to minimize the switching loss. The feasibility and dynamic performance of the proposed IPT-based PV interface system are investigated by means of simulation studies using PSCAD/EMTDC package.

Key words: Wireless power transfer, Double-sided LCC compensation, zero voltage switching, PV systems, MPPT control.

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Ahmed Ragab Mohamed Lotfy

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Table of Contents

List of Figures

List of Tables

List of Abbreviations

DWPT	Dynamic wireless power transfer
EM	Electromagnetic
IPT	Inductive power transfer
LCC	Inductor-capacitor-capacitor
PF	Power factor
PV	Photovoltaics
Rx	Receiver
Tx	Transmitter
WPT	wireless power transfer
ZPA	Zero Phase Angle