Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF 13.56MHz CAPACITIVE WIRELESS POWER TRANSFER WITH DIFFERENT DIELECTRIC MATERIAL FOR CHARGING SYSTEM

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Bachelor of Electrical and Electronics Engineering Technology with Honours

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DEVELOPMENT OF 13.56MHz CAPACITIVE WIRELESS POWER TRANSFER WITH DIFFERENT DIELECTRIC MATERIAL FOR CHARGING SYSTEM

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DEDICATION

To my beloved mother, Norasikin

and father, Abdul Manaf

and honorable supervisor Dr.Suziana Ahmad

ABSTRACT

In order to perform wireless power transfer, capacitive wireless power transfer (CWPT) employs an electric field as a means of transmission (WPT). This system's low eddy current loss, easy system construction, and significant plasticity of the coupling coupler have recently attracted a great deal of attention. The CWPT system has greatly improved transfer power, system efficiency, and transfer distance as a result of continual research and discussion. Research on capacitive coupler structures and high-frequency power converters is summarised in this article, which also serves to show the basic working principle of the CWPT system. Medical equipment, consumer communications, transportation, and other modes of conveyance are all included in the application of CWPT technology. This research will focus more on the emission of electric fields because safety is a major concern in CWPT. A six-plate capacitive coupler can be used to minimise the electric field by identifying the optimal circuit parameter values for various dielectric materials. The results of the experiments will show that the recommended solution is effective.

Keywords: Wireless Power Transfer (WPT), Capacitive Wireless Power Transfer (CWPT).

ABSTRAK

Untuk melakukan pemindahan kuasa tanpa wayar, pemindahan kuasa wayarles kapasitif (CWPT) menggunakan medan elektrik sebagai alat penghantaran (WPT). Kehilangan arus pusar rendah sistem ini, pembinaan sistem yang mudah, dan keplastikan yang ketara pada pengganding baru-baru ini telah menarik perhatian ramai. Sistem CWPT telah mempertingkatkan kuasa pemindahan, kecekapan sistem dan jarak pemindahan dengan ketara hasil daripada penyelidikan dan perbincangan yang berterusan. Penyelidikan mengenai struktur pengganding kapasitif dan penukar kuasa frekuensi tinggi diringkaskan dalam artikel ini, yang juga berfungsi untuk menunjukkan prinsip kerja asas sistem CWPT. Peralatan perubatan, komunikasi pengguna, pengangkutan dan cara pengangkutan lain semuanya termasuk dalam aplikasi teknologi CWPT. Penyelidikan ini akan memberi lebih tumpuan kepada pelepasan medan elektrik kerana keselamatan adalah kebimbangan utama dalam CWPT. Pengganding kapasitif enam plat boleh digunakan untuk meminimumkan medan elektrik dengan mengenal pasti nilai parameter litar optimum untuk pelbagai bahan dielektrik. Keputusan eksperimen akan menunjukkan bahawa penyelesaian yang disyorkan adalah berkesan.

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LIST OF SYMBOLS

δ	-	Voltage angle
µ	-	Micro
p	-	Pico
Ω	-	Ohm
ε	-	Permittivity
π	-	Phi

LIST OF ABBREVIATIONS

V	-	Voltage
A	-	Ampere
WPT	-	Wireless Power Transfer
CWPT	-	Capacitive Wireless Power Transfer
IWPT	-	Inductive Wireless Power Transfer
EV	-	Electric Vehicle
EF	-	Electric Field
PWM	-	Pulse Width Modulation
AC	-	Alternating Current
DC	-	Direct Current
EMI	-	Electromagnetic Interference

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CHAPTER 1

INTRODUCTION

1.1 Background

Wireless power transmission has been around for over a century. The most popular type of wireless power transfer employs magnetics (inductors or cores). Magnetic fields are used to transmit power in IPT systems. Because the magnetic fields produced have a detrimental impact on the devices in its area, insulation for the IPT system and the device in its vicinity is necessary. There are a few potential drawbacks to adopting a wirelessly inductive system [1].

Capacitive power transfer systems are therefore abbreviated as CPT. In the search for alternatives to wired power transmission, capacitive power transfer systems (CPT) are one of the options presented. In many aspects, the CPT system is comparable to the IPT system. In contrast, CPT technology has several advantages over IPT devices. In CPT systems, electric fields are utilised to transmit power, and a substantial amount of the electromagnetic field is restricted to capacitive contacts. Using an electric field as opposed to an electrical flux decreases electromagnetic interference in the system (EMI). While retaining signal separation, capacitive systems can transfer both energy and data. The majority of converters used in capacitive systems are resonant and operate in either the zero-voltage switching (ZVS) or zero-current switching (ZCS) zone, making CPT systems highly efficient [2].

In addition, the CPT system's diverse characteristics make it applicable to a vast array of applications. CPT is utilised in a variety of fields, including medicine and charging electric vehicles. CPT systems are typically employed for less than 1cm distances and low-power applications. In contrast, an IPT system can be used to transmit high power across vast air gaps.

Aside from that, as comparing to well-established IPT systems, CPT systems have various limitations and drawbacks. Understanding the coupling interfaces, which are important for power transfer from the primary to the secondary side of the system, is vital for overcoming the shortcomings of CPT systems. The electric field is well restricted between the plates, and safety precautions must be taken in certain conditions to maintain the electric field contained.

1.2 Problem Statement

Currently, electric vehicles can only be charged using a plug-in connection. The issue arises when the user must identify the charging port yet the charging cable is lost or destroyed. The objective of this research is to create a capacitive wireless power transmission system. This project's concept can be adapted to any electric vehicle, including buses, cars, and light rail. It will establish a new method for charging electric vehicle batteries that is more convenient than the current plug-in connection. When using capacitive wireless power transfer (CWPT) to charge an electric vehicle, there is no physical connection or touch between the vehicle and the power source [3].

Since the operation is fully automated, no human intervention is required to finish the billing procedure. Although the principle of wireless power transmission is well understood and has been implemented in industrial applications, its applications in the transportation industry are still in their infancy. Individuals can receive an electrical shock if the current plug-in cable system for electric vehicles is compromised. The wireless charging approach for electric vehicles can prevent this scenario from occurring because no wires or cables are required and the energy is transferred in electromagnetic form; hence, no one will feel an electrical shock during this type of energy transfer.

1.3 Project Objective

This chapter contains a detailed overview of project objectives:

a) To apply coupler structure for 13.56 MHz capacitive wireless power transfer with different dielectric material using LTspice software simulation circuit for charging system.

b) To implemented 13.56 MHz capacitive wireless power transfer (CWPT) coupler structure using metal plate.

c) To evaluate the performance of 13.56 MHz capacitive wireless power transfer (CWPT) using analysis method in both hardware and software simulation experimental set up.

1.4 Scope of Project

The following are the details of the project' scope:

a) This project considered as high-performance capacitive wireless power transfer (CWPT) system of 13.56 MHz.

b) Fabrication of 13.56MHz capacitive wireless power transfer (CWPT) coupler with air core inductor.

c) LT Spice was used for modelling design and simulation in this project.

d) Experimental set up includes voltage input with frequency at 13.56Mhz that generates to the coupler to test the functionality effectiveness wirelessly to output.

1.5 Research Outline

The primary chapter goes into detail on the behaviour and properties of the CPT system's coupling interface. The second chapter of the study provides a brief literature analysis of the capacitive wireless power transfer system, the notion of coupling capacitance, as well as the many configurations available for CPT systems and their comparison. In Chapter 3, the methodologies has been presented. All the method based on development of the project will recorded in this chapter. Chapter 4 is essentially the simulation's outcome. All the results are discussed and compared to one another.

a)

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter is organized to overview the research about the previous project and gives literally a fundamental information which will contribute the large body of knowledge about the project. In addition, this chapter also present the comparison on type of power converter and type of compensation. All the information gathered is mostly based on related research paper and journal about the project.

2.2 Research, Ideology and Concept Previous Project

Past research and study on Development of 13.56MHz capacitive wireless power transfer with dielectric material for charging system.

2.2.1 Maximum Available Power of Undersea Capacitive Coupling in a Wireless Power Transfer System

To transmit power between coupling plates, a capacitive power transfer (CPT) system employs the alternating electric field idea. The CPT system is an ideal wireless power transmission system due to its simple design, low cost and weight, minimal electromagnetic interference (EMI), limited capacity to penetrate through metals, and good misalignment performance [4]. CPT has been proposed for electric car, underwater vehicle, and ship charging applications due to these intrinsic properties. An analogous model is one technique to model capacitive coupling plates (couplers). To investigate the highest feasible efficiency of a CPT system based on this model, the coupling coefficient (k), the quality factor (Q), and their extended product (kQ) are employed. The study is