Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF 1 MHz CAPACITIVE WIRELESS POWER TRANSFER COUPLER FOR CHARGING SYSTEM

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Bachelor of Electric Electronics Engineering Technology with Honours

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DEVELOPMENT OF 1 MHz CAPACITIVE WIRELESS POWER TRANSFER COUPLER FOR CHARGING SYSTEM

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A project report submitted
in partial fulfillment of the requirements for the degree of
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Tajuk Projek : Development of 1MHz Capacitive Wireless Power TransferCoupler For Charging System

Sesi Pengajian : 2022/2023

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Supervisor Name : Suziana Binti Ahmad

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I hereby declare that I have checked this project report, and, in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor degree of Electric and Electronics Engineering Technology with Honours.

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Date	:	

DEDICATION

To my beloved mother, Siti Norlitah Mustapa

, and father Nurashid Bin Samat,and

Honourable supervisor Dr. Suziana Ahmad

ABSTRACT

Charging stations with capacitive interfaces are simple and inexpensive. Two important benefits are the low level of electromagnetic waves and the possibility to integrate energy and data transmission across the same channel. A capacitive power transfer circuit based on soft switching is suggested, which employs series resonant frequency to facilitate successful high frequency, medium voltage operation. The package includes research that predicts fundamental constraints on the highest possible efficiency for a given amount of coupling capacitance, which is used to establish the ideal circuit control parameters and operating point. Automatic tuning loops ensure that the circuit performs at the optimal frequency a under a broad range of coupled capacitance and load conditions. With only 20 pF of coupling capacitance, an example interface achieves respectable efficiency at 30V. The frequency is adjusted to 1 MHz by an automated tuning loop, allowing a wide range of applications in the nominal coupling capacitance. The duty cycle is also automatically modified to keep the output power to the load at its highest efficiency.

ABSTRAK

Stesen pengecasan dengan kaedah kapasitif adalah mudah dan murah. Dua faedah penting ialah tahap rendah gelombang elektromagnet dan kemungkinan untuk mengintegrasikan tenaga dan penghantaran data merentasi saluran yang sama. Litar pemindahan kuasa kapasitif berdasarkan pensuisan elektronik dicadangkan, yang menggunakan frekuensi resonansi siri untuk memudahkan operasi frekuensi tinggi, voltan sederhana yang berjaya. Pakej ini termasuk penyelidikan yang meramalkan kekangan asas pada kecekapan tertinggi yang mungkin untuk jumlah kapasitans gandingan tertentu, yang digunakan untuk mewujudkan parameter kawalan litar dan titik operasi yang ideal. Gelung penalaan automatik memastikan bahawa litar berfungsi pada frekuensi yang optimum di bawah julat luas kapasitans berganding dan keadaan beban. Dengan hanya 20 pF kapasitans gandingan, antara contoh kaedah mencapai kecekapan yang bersuasaian pada 30V. Frekuensi dilaraskan kepada 1 MHz oleh gelung penalaan automatik, membenarkan pelbagai aplikasi dapat digunakan kapasitans gandingan nominal. Kitaran tugas juga diubah suai secara automatik untuk memastikan kuasa keluaran kepada beban pada kecekapan tertinggi.

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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

CHAPTER 1

INTRODUCTION

1.1 Background

Wireless power distribution is gaining popularity for charging and powering portable electronics such as electric vehicles, smartphones, cameras, and laptop computers. The most common option nowadays is an inductive link between a charging station that serves as the transmitter and a receiver, which is usually a portable device. Electrical coils are installed in both the transmitter and the receiver. When the transmitter and receiver are brought into close physical proximity, power passes from the transmitter to the receiver. This project will look at a different method for delivering electricity that uses a capacitive, rather than inductive. The field is restricted between conductive plates in the capacitive interface, effectively eliminating the need for magnetic flux regulating and shielding components, which add volume and cost to inductive solutions.

Capacitive power transfer systems are hence referred as CPT. As shown in figure 1, capacitive power transfer systems (CPT) are one of the options presented in the search for wireless power transmission alternatives. In many ways, the CPT system is comparable to the IPT system. In comparison to IPT systems, CPT technology offers a number of advantages. In CPT systems, electric fields are utilized to deliver power, and a large portion of the electric field is restricted between the capacitive contact. The use of an electric field rather than a magnetic field reduces electromagnetic interference in the system (EMI). Capacitive systems can transport both power and data at the same time while maintaining signal separation.

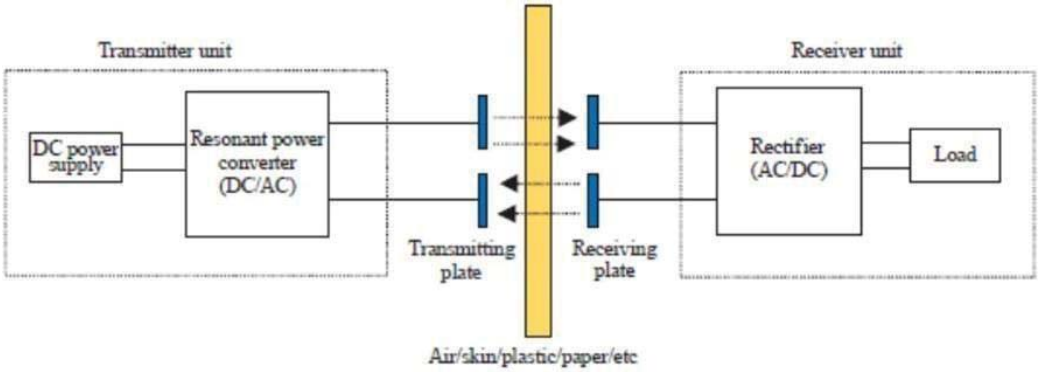

Figure 1 : Circuit build structure for capacitive wireless transfer

The electric field coupling component is a critical component of the entire WPT system. The electric field coupler acts as two capacitor plates connected in series during CPT operation. To drive the two major plates in the CPT system, a high frequency voltage is required. An alternating electric field is produced between two secondary plates when they are put near together, resulting in displacement current flowing through it. As a result, power can be delivered to the load without direct electrical contact, while the primary and secondary plates have some flexibility of movement. The capacitive coupling structure might be rectangle, cylinder, disc, or matrix in many combinations depending on the purpose.

The receiver unit will manage the collected power and drive the load according to the requirements. The power gathered by the receiver side is rarely directly usable by the load. The rectifier circuit in the receiver unit normally comes with power flow controls to regulate the gathered power, as shown in Figure 1. Any position change on the receiver side can produce mismatch between the coupling plates when powering or charging a moving load. This might result in a large voltage drop and a reduction in power transfer capability. As a result, power flow control circuits are frequently required to keep the output power constant.

1.2 Problem Statement

1MHz capacitive power transfer (CPT) is a viable and important replacement for traditional inductive power transfer (IPT). It transfers electric power via high-frequency electric fields, which has three distinct advantages: little eddy-current loss, cheap cost and weight, and great misalignment performance. CPT systems' power and efficiency that using 1MHz frequency resonance have considerably increased in recent years, reaching a level that is acceptable for electric vehicle charging applications. This study examines recent advances in CPT technology, with an emphasis on two essential technologies: compensation circuit architecture and capacitive coupler structure. To contribute the dynamic of future power transfer method, the CWPT can optimize the cost of using cables by charging wirelessly as well it is many flexibilities for the way it applies and the simplicity to engage. As technology for wireless power transfer progress, as well as several significant concerns in actual implementations. Based on these assessments, further research directions can be defined, and CPT technology applications can be pushed.

1.3 Project Objective

This chapter contains a detailed overview of project objectives:

a) To apply coupler structure for 1MHz capacitive wireless power transfer (CWPT) using LTSpice software simulation circuit for charging system.
b) To implement the CWPT coupler structure using metal plate.
c) To evaluate the performance of 1MHz CWPT using in both the both simulation and experimental set up.

1.4 Scope of Project

This project's scope is designed to inform the features and circuit simulation of components included in this project. The 1MHz capacitive power transfer (CPT) can perform the total electrical energy transferring from transmitter circuit through coupling of two metals and to the receiver circuit unit and will be monitor the output power whereas the condition whether it is functioning well or not via a simulation in LTSpice software in real time by observing the graph data when running the simulation.

The two metal plates function as a capacitive coupler and the electric field will magically moving between the space of each plate. This two-plate metal are connected into two separate circuit called the primary side and the secondary side. Both side of circuit may look the same, but it delivers a distinct function as the primary side are the transmitter side which consist of vital waveform generator, and compensation circuit consist of capacitor and inductor.

The secondary side also have a compensation circuit to compensate the electric field received. Next, fabricate the capacitive coupler using 1MHz. The waveform generator also fixed to 1MHz frequency with 30V rated in simulation but 20v in hardware testing. In addition, due of the advantages of 1MHz power supply, this project will use the capacitive power transfer can perform in different scenario and conditions. Experimental set up includes voltage input with frequency at 1Mhz that generates to the coupler to test the functionality effectiveness. wirelessly to output.

1.5 Research Outline

The main chapter is detailed on the of the coupling interface of the CPT system'sbehavior and characteristics. Chapter2 of the paper provides a concise overview.A survey of the literature on capacitive wireless power transfer systems, including the notion of coupling capacitance and the various configurations for CPT systems and comparison on between those two. In chapter 3, the features and behavior of the coupling capacitor are investigated, and solutions for wide air gaps and high-power applications are proposed. Section 4 provides a general framework for designing capacitive interfaces. In this section, will go through the most crucial things to think about.