



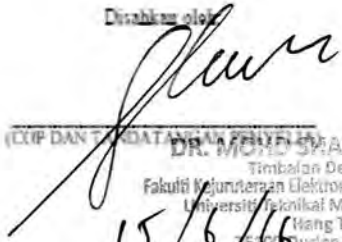
A DEVELOPMENT OF WIRELESS POWER TRANSFER USING CAPACITIVE
METHOD FOR MOUSE CHARGING APPLICATION

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This Report Is Submitted In Partial Fulfillment of Requirement for the Bachelor
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	UNIVERSITI TEKNIKAL MALAYSIA MELAKA FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER						
	BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA II						
Tajuk Projek	A Development of Wireless Power Transfer For Mouse Charging Application By Using Capacitive Approach						
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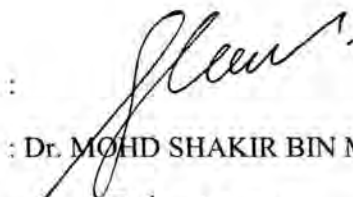
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Dedicated to my mother, my father, my siblings and also my colleagues and friends
who had supporting me through thick and thin.

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ABSTRACT

Wireless power transfer (WPT) is a technology that implements the non-contact power transmission within a distance. Because of its ability to make a contactless power transmission, WPT enhances the flexibility movement of the devices. There are three types of wireless power transfer which are inductive power transfer method (IPT), capacitive power transfer method (CPT), and acoustic power transfer method (APT). among of this three methods of wireless power transfer, the capacitive power transfer method got advantages on the confining the electric field between coupled plates, does not affected with the metal interference, and does not have coil heating effect. Therefore we focused on the capacitive power transfer to develop the mouse charging system. This project aims to develop wireless mouse charging system using capacitive based method. Capacitive power transfer will enable the power transmission from the mouse-pad to the wireless mouse. There is no battery required to make the wireless mouse to operate. To be more specific, a high efficiency Class-E converter is designed to be used to convert the DC source into AC. The compensation circuit of resonant tank also been designed in this project to improve the efficiency of whole operating circuit. The performances analysis of the developed prototype is discussed and the future recommendation of this technique is also presented.

Keywords: Wireless Power Transfer (WPT), Capacitive Power Transfer (CPT), wireless mouse charging

ABSTRAK

Pemindahan kuasa tanpa wayar (WPT) adalah satu teknologi yang menjalankan operasi penghantaran kuasa dalam jarak tanpa ada sebarang sentuhan. Dengan keupayaannya untuk membuat penghantaran kuasa tanpa sentuhan, WPT dapat meningkatkan fleksibiliti pergerakan sesuatu alat peranti. Terdapat tiga jenis pemindahan kuasa tanpa wayar iaitu kaedah pemindahan kuasa secara beraruh (IPT), kaedah pemindahan kuasa secara berkemuatan (CPT), dan kaedah pemindahan kuasa secara bunyi (APT). Antara ini tiga kaedah pemindahan tenaga tanpa wayar, kaedah pemindahan kuasa secara berkemuatan mempunyai kelebihan untuk mengurung medan elektrik di antara plat. Selain itu, ia tidak terjejas dengan gangguan halangan logam, dan tidak mempunyai kesan pemanasan pada gegelung peraruh. Justeru, kami memfokuskan kepada pemindahan kuasa secara berkemuatan untuk membangunkan sistem pengecasan tetikus tanpa wayar. Projek ini bertujuan untuk merekacipta sistem pengecasan tetikus tanpa wayar menggunakan kaedah pemindahan kuasa secara berkemuatan. Dengan ini, tetikus tanpa wayar boleh digunakan tanpa penggunaan bateri. Secara terperinci, penukar Kelas-E berkecekapan tinggi direka bagi menukarkan sumber DC kepada AC. Litar pampasan tangki salunan juga telah direka bentuk dalam projek ini untuk meningkatkan kecekapan operasi keseluruhan litar. Analisis kebolehan prototaip yang dicipta dibincangkan dan cadangan masa hadapan teknik ini turut dipersembahkan.

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LIST OF ABBREVIATIONS

WPT	-	Wireless Power Transfer
CPT	-	Capacitive Power Transfer
IPT	-	Inductive Power Transfer
APT	-	Acoustic Power Transfer
MOSFET	-	Metal Oxide Semiconductor Field Effect Transistor
ZVS	-	Zero Voltage Switching

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CHAPTER I

INTRODUCTION

In this chapter, wireless power transfer (WPT) will be discussed and the types of the techniques of WPT will be explained. A summary and the aim of this project will also be presented and discussed in this section.

1.1 Project Background

Wireless Power Transfer also known as WPT or wireless energy transmission is a power transmission process of electrical energy from the power source to the electrical consuming device without using any discrete manmade conductor [1]. This technology has been used widely in order to transfer the electrical energy from the source to the electrical devices by eliminating the usage of the wires and any connectors. This type of power transmission can cover from the low power application such as home appliances up to the high power industrial system. Wireless power transfer was first demonstrated by Nikola Tesla in the 1890s [2]. He was

powering 25 fluorescent lamps on the street by using the power source without any wires. Wireless power transfer has been divided into several techniques based on their method of transferring power. Figure 1.1 shows the parts of the wireless power transfer that has been used widely in power transmission systems.

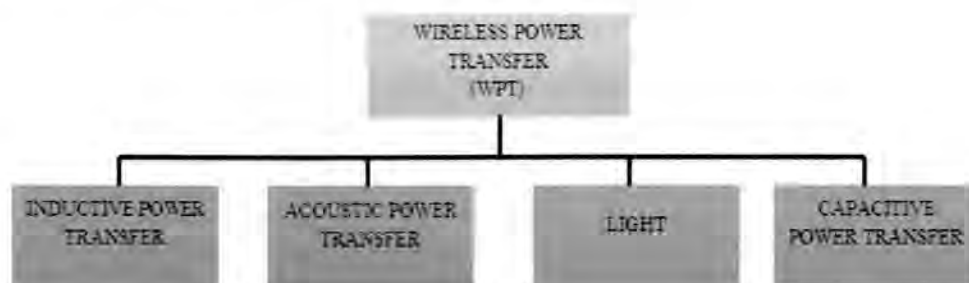


Figure 1.1: Wireless Power Transfer Classification

Those three types of power transfer is the most popular method that being used in the power transmission. Inductive power transfer is the most common and is applicable to many power levels and gap distances [3]. This type of power transfer use the electromagnetic induction that being applied in the system to transmit power from transmitter to the receiver via inductive coupling. However, this type of power transmission got a transmission problem when it comes to the metal interference. The magnetic flux cannot pass through the magnetic material and will disturb the power transmission of the power transfer.

On the other hand, the acoustic power transfer is the method of power transmission that uses acoustic coupling through ultrasonic propagation wave to transfer energy [4]. This type of power transmission can transmit the energy through the metal medium that cannot be achieved by the IPT. The other power transfer method is the optical coupling energy or light power transfer that operates correspondingly to far-field electromagnetic and microwave energy transfer. The laser diode creates the optical power beam and the photovoltaic diodes are converted to the electrical energy to be supplied to the receiver. This type of power

transmission can transmit large amount of energy but the efficiency will be dropped due to the light diffraction when it operates in a long distance [5].

Although the inductive power transfer being the most popular wireless power transmission method, the APT and CPT have advantages over the IPT weakness. The APT has a capability to transform energy over a large distance and be able to sustain competency across a conductive propagation medium [5]. However, APT got disadvantages when it cannot reach the high transmission efficiency because it has large acoustic impedance mismatch of transmitter and receiver. The capacitive power transfer has ability of metal penetration and coil heating effect that might reduce the efficiency of the system. Hence, the CPT approach will be used in this project due to its advantages. The basic operating principles of CPT will be discussed in the following chapter.

1.2 Project Overview

The capacitive method has been selected to be implementing in this project due to its advantages over IPT and APT. It has ability to overcome the metal interference problem that IPT cannot go through. However, the efficiency of the of the system will decreased when the transmitter plate and the receiver plate is misaligned. This is because the misaligned of the transmitter and the receiver will limit the amount of the energy that can be transfer from the power source to the load. This problem is just like the problem that encountering the APT system. The APT system got a problem which is related to the mismatch impedance matching. Because of that, the efficiency of the system would be decrease due to the large amount of mismatch impedance matching. Compared these two power transfer system, capacitive power transfer is more suitable than acoustic power transfer to be implemented because of its flexibility of movement. This project aims to develop a wireless mouse charging application by using capacitive method. This capacitive method enables the mouse to operate on the mouse-pad without using a wire. The

wireless power transmission will be conducted in this system from the mouse-pad to the wireless mouse. This power transmission system will eliminate the usage of the battery on the wireless mouse. To be more specific, a converter with high efficiency is designed at the transmitter part to convert DC supply to AC supply. Meanwhile a compensation circuit is designed to improve the efficiency of the whole system. A mouse prototype is being developed in order to prove the proposed method. At the end of this project, a prototype of wireless mouse charging using capacitive method is developed and the analysis of the efficiency performance is completed.

1.3 Motivation

Computer mouse has went through an evolution years by years from the bigger in size become smaller, from the ordinary computer mouse to the tailless computer mouse and wireless mouse. The wireless mouse is more preferable by the using due to its convenient to be use because of the flexibility of the movement. From the evolution of this ordinary mouse, we can see that the wires usage has been eliminated by implementing the WPT on this system. This wireless mouse it the battery-powered electronic device which is only can be operated when the battery power is still available. Usually, this battery-powered electronic device comes with its own charger and batteries. The usage of the battery actually can increase the electronic waste issue and can be harmful to the environment. This is because battery is made up from the chemical substances which is dangerous and can cause poisons. Most of the wireless mouse is powered by using the battery. The usage of the battery can cause a few problem such as inconvenient battery replacement, battery cost replacement and the battery disposal that might be harm to the environmental surrounding. Therefore, this project is proposed and will be developed based on the CPT method. The usage of the battery is the wireless mouse will be replaced with the capacitive plates that designed based on the consideration that will affect the power transmission efficiency. The consideration while developing the prototype is being discussed in the scope of work section. This wireless mouse charging system can be

commercialized since it has advantage in opposing the replacement on the ordinary wireless mouse.

1.4 Problem Statement

Nowadays we are often to use technologies to ease our daily life. Most of the electronic appliances are equipped with the battery to make it mobile and can be carried to everywhere such as wireless mouse and wireless keyboard for personal computer. Wireless power transfer has been introduced to overcome the problem encountered with the usage of the battery. Battery got a life-span. It need to be replaced or recharge to ensure that some of the electronic device operation can be undergoing without any power failure. Wireless power transfer has been divided into several techniques. The most popular technique that has been used is inductive power transfer. This IPT method use the magnetic field that has been created by using coil that induced current in another coupled coil to help the power can be transferred wirelessly. But there are problem with this type of power transfer. It must deal with the coil heating problem that can reduce the efficiency of the charging application. The other problem that might effects the efficiency of the system is the metal interference between coupled coils. This interference will disturb the magnetic flux and will reduce the range of the wireless power transfer. Meanwhile acoustic power transfer is the new technique for the wireless power transmission. This transmission use the sound wave propagates to transmit power to the source. This type of transmission is suitable to be used in long range transmission. It is inconvenient to be implementing this system to wireless mouse charging system application due to its range of transmission. Furthermore, APT has a problem to deal with the impedance mismatch. This problem can affect the efficiency of the power transfer. So that, the capacitive power transfer is more preferable to be used in this system due to its advantages in overcome the IPT and APT limitation. Some of the electronic devices have come with their own charger to recharge the battery when it is out of power. This is not being a big issue about the battery disposal when it is no longer can be used because the devices use the rechargeable battery. But it would be better if the

use of the battery can be eliminated. Sometimes, the devices that use the rechargeable battery need to be recharge at its charging station. At that time the device cannot be used in order to make the device is fully recharged. That's means the transmitter on the charger and the receiver at the device need to be fully aligned in order to make a successful power charging. This will limit the flexibility of the movement of that device. Therefore, a wireless mouse charging system has been proposed for this project. Since the any computer mouse need to be close with the mouse-pad, capacitive power transfer is being chosen because of it can transmit a power in a short range. CPT also can overcome the problem with the coil heating effect and alignment problem that can affect the efficiency performance. CPT use the power that being created from the electric field between two plates. The development of wireless mouse charging system will focus on the short range power transfer. It will be able to charge the mouse while the mouse is being used. It will be on the charging mode as long as the mouse is placed on the mouse-pad.

1.5 Objectives

- a) To develop a wireless mouse charging prototype using capacitive power transfer method.
- b) To design a class E converter to improve the efficiency of whole circuit.
- c) To analyze the efficiency performance of the developed prototype.

1.6 Scope of Work

This wireless mouse charging system prototype is designed in the small scale low power consumption model that can operate up to 5V power supply. This prototype only can be used in the short range power transmission which is make the mouse only can operate within a gap between transmitter and receiver. The mouse-pad will be act as the transmitter that which contain 17cm x 17cm big copper plate while the wireless mouse will be act as the receiver that contain 17cm x 17cm big

copper plate. The efficiency of this prototype based on the alignment of the copper plate from both transmitter and receiver. Alignment between transmitter and receiver plates is the most important factors that affecting the performance of CPT systems because any misalignment can cause a drop in the output power [6]. When the copper plate got a misaligned structure, the uncoupled area cannot transmit the power from transmitter to the receiver. This will reduce the efficiency of the circuit.

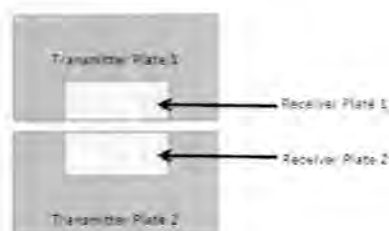


Figure 1.2: Fully Aligned and Coupled Situation

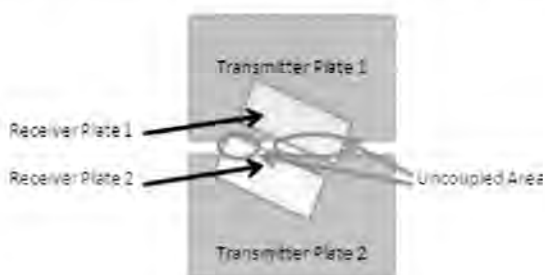


Figure 1.3: Misaligned situation

A suitable converter has been designed to produce a high frequency of voltage to ensure that the load can get enough power to make it operate. CPT needs a high frequency voltage to drive the electric field coupler. A converter is needed to convert the DC supply into AC supply so that it can flow through the electric field coupler. The class-E converter is most suitable converter because it has low switching losses with high frequency output. A compensation circuit is designed on the transmitter and receiver part in order to encounter the power loss during charging problem. The conceptual design of the prototype is shown in Figure 1.4. Based on the figure below, the mouse-pad will be attached to the transmitting plate. A DC supply from the USB port is supply to the transmitter part which is also act as the

primary circuit. Then the high frequency converter will convert that DC voltage into AC voltage in order to be transferred to the receiving part. That AC voltage will flow through the capacitive coupling. The receiver plate is attached to the wireless mouse that act secondary pick-up.

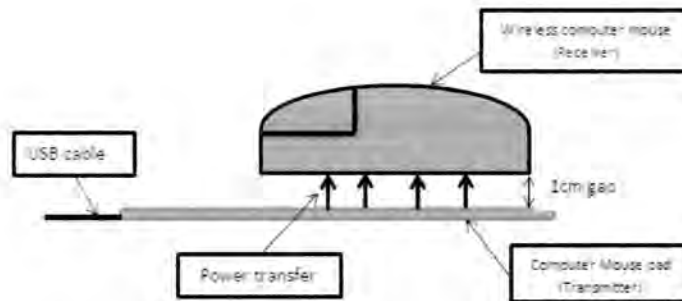


Figure 1.4: Conceptual Design of Wireless Mouse Charging Prototype

1.7 Project Planning

The project planning has been follow step by step in order to make the project complete on time given. The flow of this project is based on the problem statement, objectives of the project, and the scope of work. Thus, a Gantt chart is constructed for the project progress.