

# Faculty of Electrical and Electronic Engineering Technology



## NUR IMAN MAISARAH BINTI NOR HAIRI

**Bachelor of Electrical Engineering Technology with Honours** 

2021

## DEVELOPMENT OF CAPACITIVE TYPE MOBILE PHONE CHARGER

## NUR IMAN MAISARAH BINTI NOR HAIRI

A project report submitted in partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering Technology with Honours



## UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

### **DECLARATION**

I declare that this project report entitled "Development of Capacitive Type Mobile Phone Charger" is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.



## APPROVAL

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 of Electrical Engineering Technology with Honours.

Signature :	AYSIA A HIS	
Supervisor Name :	DR.AZHAN BIN AB RAHMAN	
1		
Date :	11 JANUARY 2022	
PARAIN		
Signature	اونيۈمرسىتى تيكنيكل مليسيا	
Co-Supervisor NIVE	RSITI TEKNIKAL MALAYSIA MELAKA	
Name (if any)		
Date :		

### DEDICATION

To my beloved mother, Fadhilah Binti Othman, and my beloved father, Nor Hairi Bin Harun, thank you for all the continuous and never ending love and support from the very beginning I started my studies until the end of the semester. To my dearest siblings, Nur Aisyah Balqis and Nur Aina Mardhiah, I thank you for the emotional support and the motivation they have given me. A special thanks to my friends, who is always there for me and for always listened to my whines and whims.



#### ABSTRACT

In the recent years, Wireless Power Transfer (WPT) system is one of a groundbreaking technology that makes everyday life easier. This system allows power transfers from one plate of metal conductor to another without any physical touch. The WPT system is divided into their own category of fields and these category classified into acoustic power transfer (APT), microwave power transfer (MPT), inductive power transfer (IPT), and capacitive power transfer (CPT) and in this particular project the CPT system is chosen for its advantages compared to other system. Moreover, this technology will solve the problem with conventional electrical transmission. The objective of this project is to develop a capacitive type (CPT) mobile phone charger. The CPT system used a SMPS as a supply to the transmitter plate to convert AC supply into DC supply to transfer the electric field to the receiver plate. While, the receiver part will charge the mobile phone. The observation will be made by using a different size of transmitter and receiver plates, the type of material used and the position of the plates to compared the efficiency of the project. As the conclusion, this project is very user-friendly and the goal is to improve the conventional charging system into a wireless system.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Show all

#### ABSTRAK

Dalam beberapa tahun kebelakangan ini sistem Wireless Power Transfer (WPT) adalah salah satu teknologi yang dapat menjadikan kehidupan seharian lebih mudah. Sistem ini membolehkan pemindahan kuasa dari satu plate konduktor ke konduktor yang lain tanpa memerlukan sentuhan secara fizikal. Sistem WPT ini dibahagikan mengikut kategori bidang mereka dan kategori ini dekelaskan kepada acoustic power transfer (APT), microwave power transfer (MPT), inductive power transfer (IPT), and capacitive power transfer (CPT), dan projek ini telah mengkhususkan kepada sistem CPT oleh kerana kelebihan yang ada pada sistem itu berbanding dengan sistem WPT yang lain. Selain itu, teknologi ini diusulkan adalah untuk meyelesaikan masalah yang ada pada sistem electrik konvensional. Objective projek ini adalah untuk menghasilkan system Capacitive power transfer (CPT) untuk mengecas telefon bimbit. System CPT ini menggunakan SMPS sebagai bekalan untuk menukarkan sumber elektrik dari AC kepada DC untuk memberikan bekalan electric daripada plat pemancar kepada plat penerima. Seterusnya, bahagian plat penerima akan mengalirkan elektrik untuk mengecas telefon bimbit. Pemerhatian akan dibuat dengan menggunakan plat yang berukuran berlaian, menggunakan bahan logam yang berlainan dan posisi yang berbeza untuk membezakan kecekapan mereka. Sebagai konklusi, projek ini adalah mesra pengguna dan bertujuan untuk meningkatkan sistem pengecasan konvensional menjadi sistem tanpa wayar.

#### ACKNOWLEDGEMENTS

First and foremost, all praises to Allah (SWT) for the strength and blessing that have been given to me to complete this project. I would like to express my utmost gratitude and appreciation to my supervisor, Dr. Azhan Bin Ab Rahman for his precious guidance, word of wisdom and time in helping me successfully finished my Bachelor Degree Project. I believe without his support and encouragement I would not be able to finish this project victoriously.

I am also indebted to both of my parents, whom I most appreciated for the financial and emotional support throughout all this semester which empower me to finish the project.

Not forgetting my fellow course mate BEEY, my friends that helped me in many ways that I could possibly thank for. Lastly, I would like to thank UTeM for supporting us even in pandemic and as well as other individuals who are not listed here for being very cooperative and helpful.

> اونيۈم سيتي تيڪنيڪل مليسيا ملاك UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## TABLE OF CONTENTS

		PAGI
DEC	LARATION	
APPI	ROVAL	
DED	ICATIONS	
ABS	ГКАСТ	i
ABS	ГКАК	ii
АСК	NOWLEDGEMENTS	iii
TAB	LE OF CONTENTS	i
T IST	OF TABLES	
	OF FLOUDES	
	OF FIGURES	1V
LIST	OF SYMBOLS	vi
LIST	OF ABBREVIATIONS	vii
CHA 1.1 1.2 1.3 1.4 1.5	PTER 1 INTRODUCTION Background Problem Statement Project Objective Scope of Project SITI TEKNIKAL MALAYSIA MELAKA Thesis Organization	1 1 3 3 4 4
CHA	PTER 2 LITERATURE REVIEW	5
2.1	Introduction Wireless Power Transfer (WPT) 2.2.1 A brief history of Wireless Power Transfer 2.2.2 Capacitor 2.2.3 Capacitance 2.2.4 Capacitive Power Transfer (CPT) 2.2.5 Advantages and Disadvantages of Capacitive Power Transfer (Cl	5 6 7 9 12 13 PT) 14
2.3	<ul> <li>2.2.3 Advantages and Disadvantages of Capacitive Power Transfer (Cf Literature Review</li> <li>2.3.1 Application of capacitive power transfer on biomedical implants</li> <li>2.3.2 High power CPT for Railway</li> <li>2.3.3 Application of CCWPT with Quasi-LLC Resonant Converter up</li> </ul>	16 16 18
	<ul> <li>2.3.5 Application of CCWTT with Quasi-EEC Resonant Converter to Electric Vehicles Windows</li> <li>2.3.4 Application of CPT for Electric Vehicle Charging</li> <li>2.3.5 Application of CPT system in Wireless Computer Mouse Charging</li> <li>2.3.6 Application of CPT system for Mobile Charging</li> <li>2.3.7 Summary of literature review</li> </ul>	19 21 ng 23 23 24

2.4	Summary	30
CHAI	PTER 3 METHODOLOGY	31
3.1	Introduction	31
3.2	Methodology	34
3.3	Project Architecture	34
3.4	Experimental setup	34
	3.4.1 Aluminium foil	34
	3.4.2 Switch Mode Power Supply (SMPS)	36
	3.4.3 LED	38
	3.4.4 Multimeter	39
3.5	Project Hardware	40
	3.5.1 Project Integration	40
	3.5.2 Capacitive Plate	41
	3.5.3 Circuit Design	43
3.6	Gantt Chart	44
3.7	Summary	45
	ALAYSIA	
CHAI	PTER 4 RESULTS AND DISCUSSIONS	46
4.1	Introduction	46
4.2	Results and Analysis	46
	4.2.1 Material of conductive plate	46
	4.2.2 Positions	50
	4.2.3 Size of capacitive plate	52
4.3	Summary	55
CHAI	PTER 5 CONCLUSION AND RECOMMENDATIONS	56
5.1	اوتيوم سيني بيڪنيڪي مليسيا م	56
5.2	Future Works	57
REFE	CRENCES	58

## LIST OF TABLES

TABLE	TITLE	PAGE
Table 2.1	Comparison of the main Wireless Power Transfer (WPT) technologies	6
Table 2.2	Lists of dielectric constant of a several materials (at room temperature)	10
Table 2.3	Relative permitivity of EV exterior	20
Table 2.3.7	Summary of literature review	24
Table 3.1	Conductives in ascending order	35
Table 3.2	SMPS Specification	37
Table 3.3	LED Specification	38
Table 3.4	Gantt chart	42
Table 4.1	Copper Plate	42
Table 4.2	Aluminium Plate	42
Table 4.3	اويوبرسيني تيڪنيڪل مليسيا Zinc Plate	42
Table 4.4	Voltage at the receiver part using Plate A as the receiver	42
Table 4.5	Voltage at the receiver part using smaller plate (10cm x 13cm) as the receiver	42
Table 4.6	Using Big plate (Plate A) for transmitter and receiver plates	42
Table 4.7	Using Small plate (Plate B) for transmitter and receiver plates	42
Table 4.8	Big receiver plate	42
Table 4.9	Small receiver plate	42

## LIST OF FIGURES

FIGURE	TITLE	PAGE
Figure 1.1	Power system components in Malaysia	2
Figure 1.2	The categories of wireless power transfer system	2
Figure 2.1	A common structure of Wireless Power Transfer	6
Figure 2.2	Nikola Tesla at Columbia College in 1891, demostrating wireless transmission	8
Figure 2.3	Different type of capacitors	9
Figure 2.4	Symbols of capacitors	9
Figure 2.5	Structure of capacitive power transfer system	12
Figure 2.6	The diagram of CCWPT system application in bio implants	17
Figure 2.7	Schematic diagram of human tissue and capacitive plates: (a) Rx capacitive plates placed under Muscle and (b) Rx capacitive plates	
Figure 2.8	Railway configuration of CPT system	17 18
Figure 2.9	U Structure of designed CPT system ALAYSIA MELAKA	19
Figure 2.10	Coupling capacitor implementation	20
Figure 2.11	The proposed system of CCWPT on electric vehicle's windows	20
Figure 2.12	Modified LLC system	21
Figure 2.13	Structure of two plates compact CPT	22
Figure 2.14	Prototype design for wireless mouse charging	23
Figure 3.1	Flowchart of the project	32
Figure 3.2	Block Diagram of the project	34
Figure 3.3	Aluminium foil	35
Figure 3.4	Switch Mode Power Supply (SMPS)	36
Figure 3.5	LED	37

Figure 3.6	Multimeter	38
Figure 3.7	Project integration	39
Figure 3.8	Arrangement of Transmitter plate and Receiver plate	41
Figure 3.9	Plate A (13.5cm x 20.5cm)	41
Figure 3.10	Plate B (20cm x 28cm)	42
Figure 3.11	Plate C (15cm x 15cm)	42
Figure 3.12	Hardware circuit	43
Figure 4.1	Copper Plate	47
Figure 4.2	Zinc Plate	47
Figure 4.3	The position which receiver plate placed on transmitter plate: (a) Section A (b) Section C and (c) Section C اوينون سيني تيڪنيڪل مليسيا ملاك	54
	UNIVERSITI TEKNIKAL MALAYSIA MELAKA	

## LIST OF SYMBOLS

F	-	Farad
Q	-	Charge
V	-	Voltage
$m^2$	-	Area of conductive plate
т	-	Distance
F/m	-	Permittivity of dielectric material



## LIST OF ABBREVIATIONS

WPT	-	Wireless Power Transfer
CPT	-	Capacitive Power Transfer
SMPS	-	Switch Mode Power Supply
EV	-	Electric Vehicle
LED	-	Light Emitting Diode
CCWPT	-	Capacitve Coupling Wireless Power Transfer
IPT	-	Inductive Power Transfer
DC	-	Direct Current
AC	-	Alternating Current



#### **CHAPTER 1**

#### **INTRODUCTION**

#### 1.1 Background

The main components of power system are power generation, transmission, distribution and load. Electrical power transmission includes a bulk movement of electrical energy from power station for the power generation. From there it will go into a large substation for transmission. In transmission, the voltage will be transformed into a higher voltage 500kV, 275kV, 132kV, and 66kV. After that, for distribution the electrical power will be transformed into a lower voltage that is 33kV or 11kV to be distributed to small industries or factories. For the consumers load, the voltage will be further stepped down to 415V and 230V depending on their sector such as commercial or for residential use as shown in Figure 1.1. Types of conventional power transfer used to transmit electrical power are overhead lines, underground lines, submarine cables, HVAC and HVDC. But one of the major problems in conventional power transmission and distribution is that they have a significant loss during the operation. Furthermore, the downside of using the conventional system is that they used a huge amount of cables that sometimes interrupting the view and for underground line they have to dig into the ground so it will be harder to repair or to install the lines which makes it more expensive.



Figure 1.1 Power system components in Malaysia.

Which is why based on the problems stated above, wireless power transfer (WPT) is chosen as an alternative option to replace the conventional power transfer (Rozario, 2016). Wireless power transfer offers multiple benefits such as, WPT allows for charging of multiple devices and also they have universal compatibility (Lu et al., 2017). In addition, they reduce the use of wires. There is a various type of WPT technology shown in Figure 1.2 :



Figure 1.2 The categories of wireless power transfer system (Lu et al, 2017).

#### **1.2 Problem Statement**

Nowadays, everyone in the household use their own electronics devices and this will lead to an increase number of wires connected to the wall socket. This condition may be hazardous if the long wires got tangled up with each other and tripped someone in the household especially kids. The cables also can be damage because of rodent bites and manhandling (Rozario, 2016). For this reason, a solution must be made to reduce the usage of wires connecting to the power source.

Moreover, as of today, only a flagship smartphone uses the wireless power transfer technology. These smartphones often costs the most as it is the latest and more grandeur than the last smartphone that the brand releases so the price is usually very expensive.

With the development of capacitive phone charger we can also help to conserve earth from electronic pollution. Since, it is hard to dispose electronic waste (E-waste) and human health is at risks if it is done improperly.

These days having a phone is just like breathing where it is essential for everyone. Therefore, in this work, a capacitive wireless power transfer is used to charge the phone without using any electrical wire and in hope that this project may produce a capacitive power transfer charger that is cheaper than the wireless charger available in the market.

#### **1.3 Project Objective**

The main objectives that need to accomplish at the end of this project are:

- a) To develop a capacitive wireless power transfer to power the load.
- b) To transfer the electricity by using two plates of conductor.
- c) To analyse the effectiveness of the system when using capacitive power transfer.

#### **1.4** Scope of Project

The scope of this project are as follows:

- a) Design a capacitive type mobile phone charger of wireless power transfer
- b) Generate DC output
- c) Produce the hardware so that electrical energy can be transmitted through and is connected to the plates to charge the load.

#### **1.5** Thesis Organization

The outline of this thesis will explain all about the development of capacitive type phone charger project. This thesis have a total of five chapters, which consists of the project introduction, literature review, methodology, result and discussion and lastly the conclusion and future recommendation of the project. Firstly, chapter one will be about the introduction of the conventional system that is used today for transfer system. It also includes the problem statement, objectives and the scope of the project.

Then, in chapter two a more detailed research is conducted in order to write the literature review and background studies.

In chapter three, research methodology shows the method used to develop the project.

Next, for chapter four, the result of the experiments are presented and discussed in order to form an analysis.

Lastly, chapter five is the conclusion of the overall project. It will summarises the main points from chapter one until chapter four of the thesis. After that, a future recommendation is proposed for the betterment of the project for a future research.

#### **CHAPTER 2**

#### LITERATURE REVIEW

#### 2.1 Introduction

Literature review is fundamentally an overview of the project and the objectives. It is also a comparison of the differences and the similarities of the perspectives of the work of multiple authors. The study is generally comes from books, dissertations, scholarly articles and other published material whether physically or electronically. The review produces a summary, advantages and limitation of the area of research and its application. The information gathered is to provide a deeper understanding for the project.

#### 2.2 Wireless Power Transfer (WPT)

Wireless Power Transfer (WPT) is a system that allows electrical power to be supplied through air from one electrical network to another electrical network without the necessity of using the current-carrying wires (Lu et al., 2017). This process use the Faraday's law of electromagnetic induction. In order for the wireless power transfer to work the frequency of the transmitter and the receiver must be in resonance. Figure 2.1 depicts a transmitter coil powered by an electric source produces a magnetic field around it and then a second in which connected to the receiver is introduced in the same field with the same resonant frequency for the electric current to flow.



Figure 2.1 A common structure of Wireless Power Transfer (WPT) system (Lu et al.,

2017).

Table 2.1 Comparison of the main Wireless Power Transfer (WPT) technologies

	MALAYSIA	4			
	Electric Field	Magnet	ic Field	Electromag	metic Field
	AINO	Inductive	Resonant		Optical
Technology	Capacitive	Power	Inductive	Microwaves	(laser)
-	NUMERCIT	Transfer	Coupling		Radiation
	NIVERSII	TEKNIKA	LMALAYS	IA MELAKA	
Range	Short	Short	Mid	Far	Far
Frequency	kHz-MHz	kHz-MHz	kHz-MHz	GHz	>THz
Duono cotion	Non-	Non-	Non-	Dadiativa	Dodiativa
Propagation	radiative	radiative	radiative	Radiative	Kaulative
Strength	Very high	Very high	High	Low	High
Coupling	Metal plate		Turned wire	Phased	Lasers,
Dovico	alastrodes	Wire coils	coils		
Device	electrodes		COHS	arrays/	photocells,

		parabolic	lenses
		dishes	

Recently, WPT technology has been widely spread and garnered more attention due to its safety reasons, the cost, the high output power and more commercially successful. There are two main types of WPT that is capacitive power transfer (CPT) and inductive power transfer (IPT). Therefore, this project will only be focusing on capacitive power transfer (CPT).

### 2.2.1 A Brief History of Capacitive Power Transfer

In 18th century, for the near field applications, Nikola Tesla was the first person who started to experiment with it using capacitive power transfer (CPT). Figure 2.2 shows how Tesla attempted to transfer the electricity wirelessly by using capacitive power transfer coupling at Columbia College, New York. Tesla was aiming to transfer approximately 300kW of power by using a radio wave of 150 kHz but regrettably the experiment failed due to diffusion of the wireless power (Karabulut et al., 2018).



Figure 2.2 Nikola Tesla at Columbia College in 1891, demonstrating wireless transmission

(Karabulut et al, 2018).

However, at the time electromagnetic induction (IPT) was more commercially used in wireless power transfer system. In the early 1900's, Tesla plays a pivotal part in developing several IPT methods such as radio based WPT. Nevertheless, in 1966, the first officially recorded CPT application potent was observed. In the study, 100 kHz of frequency was used on the transmitter and the receiver to transfer the electric as a design for underwater systems (Karabulut et al., 2018). Then, until the beginning of 2000's, because of the simple structure and confined radiation field finally the capacitive coupling started to garnered more attention in small consumer electronics (Lu, 2017). But at the time CPT system potential for higher power application have not been realize (Dai, 2017).

#### **Capacitive Power Transfer (CPT)**

#### 2.2.2 Capacitor

Capacitor is a passive device that has the capability to store electrical charge when the capacitor is connected to a voltage source. A capacitor consists of two conductors that arranged in a close together but insulated from each other (Electronics tutorial, 2021). There are a variety of capacitor sells in the market, ranging from small size capacitor for low application to a large power factor capacitor and yet the function for the capacitor remains the same. That is to store electrical charge. Common type of capacitor includes electrolytic capacitor, tantalum capacitor, sliver mica capacitor, film capacitor and variable capacitor (Braza, 2021). In figure 2.3 shows a different types of capacitor and figure 2.4 shows the symbols of capacitor according to their types.



Figure 2.3 Different type of capacitors (Schrader, 2011)



Figure 2.4 Symbols of capacitors (Wikipedia, 2011)

The fundamental form of a capacitor comprises at least two conductive (metal) plates placed in parallel but not touching with each other. They are separated either via air or by insulating material such as ceramic, plastic, mica, waxed paper or in a form of a liquid gel that widely known as Dielectric (Britannica, 2021).

	Material	Dielectric constant	
AL MA	Vacuum	1.00	
Salt TEKILIE	Air Oil	1.00	$\boldsymbol{\Lambda}$
ملاك ملاك	Polyethylene Beeswax	2.26 2.80	ونيو
UNIVE	Fused quartz	3.78	
	Water	80.00	
	Calcium titanate	168.00	
	Barium titanate	1,250.00	

Table 2.2 Lists of dielectric constant of a several materials (at room temperature)

#### 2.2.3 Capacitance

Investigation of load profiles of residential, commercial and industrial load segments to determine load factor (LF) and loss factor (LsF) were considered in the analytical models

Capacitance is stated as the ratio of the electric charge on (metal) plate of two or more conductor to the voltage between them. Named by Michael Faraday (1791-1867) a British physicist and chemist, the unit for the size of capacitor called Farad (abbreviated to F) and each one farad carried 1 coulomb of charge on every conductor plate (Electronics tutorial, 2021). An ideal capacitor represented by constant capacitance, C in farads, the positive and negative charge, Q and the voltage, V.



Where ;

C = capacitance in farad, F

Q = charge

V = voltage, V

 $\varepsilon_0$  = permittivity of dielectric material, (8.84 x 10<sup>-12</sup>), F/m

A = area of conductive plate,  $m^2$ 

d = distance, m

#### 2.2.4 Capacitive Power Transfer (CPT)

Capacitive power transfer is one of the implementation of WPT system. In order to create a wireless and environment friendly world, many researcher and developer has realise the benefits of wireless power transmission has to offer. Especially the advantages of capacitive power transfer system that lie in its low cost, save and easy to find material. Over the years, a lot of researched have been done on CPT system and based on recent studies CPT system is applicable for a short range distance and in low power applications such as mobile phone charger, biomedical devices and integrated circuits (IC) (Lu et al., 2017). Nevertheless, the CPT system can also be use in high power applications such as electric vehicles, railway and synchronous machine excitation (Liang et al., 2021)(Hyun Yi, 2020).

The structure of the capacitive power transfer (CPT) is basically comes from the principle operation of a capacitor which is, dielectric material is in between two parallel metal foils that is very thin in size to act as insulator to separate the foils . The term "di" in the word dielectric literally mean in between two things and electric definition it detain the electric field. Capacitive power transfer uses plate coupled through electricity. Capacitive coupling allows the transfer of electric fields through a conductive coupling plates (Lu et al., 2017).



Figure 2.5 Structure of capacitive power transfer system (Lu et al, 2017).

The operation of capacitive power transfer is that the plates must be connected in series the electric field coupler will functions. A high frequency voltage is required to drive the primary plates to act as a transmitter. Then, whenever the secondary plates come closer to the primary plate, alternating current (AC) will be generated between the plates and this will result in displacement current to flow through it. Therefore, there will be a power transfer to the load without any physical contact between the two primary and secondary plates as Figure 2.5 illustrates (Lu et al., 2017).



#### 2.2.5 Advantages and Disadvantages of Capacitive Power Transfer (CPT)

Investigation of load profiles of residential, commercial and industrial load segments to determine load factor (LF) and loss factor (LsF) were considered in the analytical models.

Although it was inductive wireless power transfer (IPT) was the first WPT to be introduced but it is capacitive wireless power transfer (CPT) that is widely operated in the industry. This is because of the advantages that CPT has compared to IPT system.

I. Negligible eddy-current loss

In CPT system, the electric fields are used as the energy transfer in order to transfer electrical power from the transmitter into the receiver. So there will be no concern for the eddy-current loss unlike IPT system. Consequently, it may be used in places that have inevitable metal materials. To operate an IPT system, the energy transfer that is used is a high-frequency magnetic field through the coils of wire. Thus the magnetic fields produce eddy-current losses in the metal causing a notable rise of temperature in the application of high and low power system. Also, if the field produces a particularly large amount of heat, there could be a fire hazard (Lu et al., 2017).

II. Low cost and weight

When compared to IPT system, the CPT system is proven to be in a much lower cost and also in weight. This is because in IPT system, they contain two coils that work as a coupled transformer. To transfer enough power, the amount of the current is increased since the coupling coefficient in IPT system is very little. Moreover, when taking a consideration of the depth of the conductor functioning in a high frequency, a fairly large amount of Litz-wire is required. In addition to using ferrite iron's magnetic plates to magnify the magnetic coupling of both sides. Therefore, increases the cost and the weight of the system (Dai, 2017).

On the contrary to IPT system, in CPT system the material used for the plates can be aluminium sheet on whatever the thickness and materials because it will not significantly influence the system. Furthermore, the price of aluminium is a lot cheaper when compared to the Litz-wire that is made by copper and thus, the cost and weight is reduce (Pratik, 2019).

III. Good misalignment performance

Based on the article experimental results, the CPT system has a superior performance when in misalignment than the IPT system. For CPT system, the system can keep up a 89.4% efficiency when there is a 300mm misalignment. However for IPT, the system can only maintain 56% when there is a 310mm misalignment (Lu et al., 2017).

IV.Can be transmitted through metal

Unlike IPT system, CPT system can be transmitted and penetrate through metal and shielded body. In addition, the magnetic field of CPT system also has a good antiinterference ability (Lu et al., 2017).

رسيتى تيكنيك

Disadvantages

# A. Low efficiency TEKNIKAL MALAYSIA MELAKA

The higher the frequency, the higher the power losses and in CPT system it is the conductives loss in the compensation inductors that contribute to the power loss.

B. Strong magnetic field

Unlike IPT system that can undeniably be shielded through metal, it is hard for CPT system to be shielded. This will lead to the electric field to pass through the metal material easily.

C. Low power density

#### 2.3 Literature review

#### 2.3.1 Application of capacitive power transfer on biomedical implants

Based on an article by (Narayanamoorthi et al., 2017) in the article stated that a class E power amplifier and a capacitive coupled wireless power transfer was used to ma biomedical implants. The purpose of the research was to model and optimize the class E amplifier for capacitive coupled wireless power transfer system (CCWPT) to be applied in MHz range application on biomedical implants such as a pacemaker or other devices that used WPT technology. The CCWPT system is used together with inductive-capacitive-inductive (LCL) to improve the efficiency and maintain required impedance compression.

In addition, for robust operation. This application use a class E power amplifier to achieve a high frequency as theoretically class E has the highest efficiency compared to other power amplifier classes aside from the part that they operate under zero voltage switching (ZVS) and zero voltage derivative switching (ZVDS) properties. Furthermore, LC compensation circuit was added to the transmitter (Tx) side in order the enhance the voltage on Tx plate. Figure 2.6 displays the location of the biomedical device application on human body and Figure 2.7 shows the positions of Tx and Rx plates on different layer of human skin (Narayanamoorthi et al., 2017).



Figure 2.6 The diagram of CCWPT system application in bio implants (Narayanamoorthi

et al., 2017).

AALAYS

The experiment then was done by putting the transmitter (Tx) and receiver (Rx) onto a solution that mimicked human tissue by referring the IEEE standard properties of human tissues to get an accurate result (Narayanamoorthi et al., 2017).



Figure 2.7 Schematic diagram of human tissue and capacitive plates: (a) Rx capacitive plates placed under Muscle and (b) Rx capacitive plates placed under Skin

(Narayanamoorthi et al., 2017).

#### 2.3.2 High Power CPT for Railway

Based on (Liang et al., 2021)stated that WPT system was an alternative method that they chose to power the railway replacing the conventional method that uses pantograph-catenary (PC) method in order to power the locomotives. Furthermore, the CPT system was proven to remove most of the limitations of the PC method. As shown in Figure 2.8, for railway application only two plates are used for power system supply. Sending plate ( $P_2$ ) is the transmitter plate while receiver plate ( $P_3$ ) represent the receiver plate. The LCLC-CL compensation technology as shown in Figure 2.9, is designed to make sure the coupler distribution in a safe working situation, as the system a high power transmission. As the result shows, the output for voltage and current for the inverter is are almost in phase with each other and when the transfer power is at 3kW the DC-DC efficiency is 92.46%. Therefore, the design method of this journal is proven (Liang et al.,

2021).



Figure 2.8 Railway configuration of CPT system (Liang, et al, 2021).



Figure 2.9 Structure of designed CPT system. LCLC-CL compensation (Liang et al, 2021).

# 2.3.3 Application of CCWPT with Quasi-LLC Resonant Converter using Electric Vehicle Windows

According to (Hyun Yi, 2020) a capacitive coupling wireless power transfer with quasi-LLC resonant converter was use on electric vehicle's windows to charge the electric vehicle (EV). After taking a consideration of other material parts of the car to become the conductor, glass is chosen for having the largest relative permittivity in addition to having a large area. Since the front and the back windows of the car is large. For the electrode, a transparent Indium Tin Oxide (ITO) was used to make sure that even when the car is in charging mode the window view will not be completely blocked since it was placed inside of the car. For the outside of the car, the material for electrode used was copper plate. Then, for the car glass windows consist of 2 sheet of glass and a polyvinyl butyral (PVB) film placed between the glasses as illustrated in Figure 2.10. Figure 2.11 shows how EV is charged through their windows.



Table 2.3 Relative permittivity of EV exterior

Figure 2.11 The proposed system of CCWPT on electric vehicle's windows (Hyun Yi,

2020).

#### 2.3.4 Application of CPT for Electric Vehicle Charging

Based on CPT system that mostly utilized in a low power and small gap application is because of the system have a low efficiency and high voltage that is generated across the coupling interface. However, to overcome this limitation (Rozario et al., 2016) implemented a CPT system using modified LLC topology as shown in Figure 2.12 and dual topology for charging an EV.



In this case the LLC converter offers a capability to buck and boost that will redeem useful for application in EV. In addition, the modified version has multiple benefits such as small frequency variation over a wide range, high power density and many more. Moreover, the Dual LC topology will help to overcome the high voltage problem in the CPT system (Rozario et al., 2016). This method is also supported by an article by (Rozario, 2016) that used two modified topology. The first topology capable of high power transfer for small air-gap application while the second topology is Dual topology function is to decrease the voltage stress. Furthermore, they produced a very high efficiency under misalignment condition.

Article by (Al-Saadi et al., 2019) stated that the result for efficiency under misalignment by using unipolar CPT system is different according to their respective
shapes. In this study, they experimented by using plates shaped in ring or square for CPT system and it is proven that a square shaped plates produced a higher frequency when compared. For the CPT system, they used material made out from copper as the conductor for transmitter and receiver plates and air as the dielectric material. This method is chosen because unipolar CPT system structure is simpler than bipolar capacitive coupler, because they only used two plate to generate electricity, one for the transmitter and another on the receiver side.

Based on (Lu et al., 2018) they used the bottom of the vehicle and the earth ground to transfer power. Figure 2.13 illustrates the electric flowed from the transmitter,  $P_2$  and the receiver that is the earth ground provides the current-returning path into the ground,  $P_1 ext{.} P_3$  is the vehicle chassis. This CPT system also uses a compensation circuit that is a full bridge rectifier circuit and a low pass filter to give an AC excitation to primary side.



Figure 2.13 Structure of two plate compact CPT (Lu et al, 2018).

(Regensburger, 2020) states that an EV could run on modified capacitive coupling plates and incorporates L-section matching networks produce gain and reactive compensation. The design system for this project is quite similar to (Lu et al., 2018) as the transmitter and the receiver is placed on the vehicle chassis and on the road. This system is proven by producing a high efficiency performance for capacitive charging system.

### 2.3.5 Application of CPT system in Wireless Computer Mouse Charging

According to (Mohd Shakir et al., 2016) a Class E converter is placed on the transmitter which is inside the wireless computer mouse. The function is to make sure that the DC source from transmitter can convert into a high frequency AC voltage in order for the receiver plate located on the mouse pad to receive the frequency and started charging the mouse. The location of the transmitter and the receiver is as shown in Figure 2.14. Although at the end of the experiment the system was unable to transmit enough electric field to charge the wireless computer mouse but it was successful considering that it manage to light up the LED which show the power is actually transferring.



### 2.3.6 Application of CPT system for Mobile Charging

(Silva et al., 2015) proposed a mobile charging by using CPT with low coupling capacitance by using LC resonance. This paper also include a rectifying bridge and filter in their application and used two metal conductives placed in parallel to act as transmitter and the receiver of the circuit.

No.	Author	Title	of the	Application	Remarks
		project	/ Year		
1		· · · · 1			
1.	Fei Lu	High	Power	Electric	- Using a double-sided LCLC
		Capaci	tive	vehicle	compensation circuit.
		Power	Transfer	Charging	- The system power increased
		for	Electric		to several kW from several
		Vehicle	e		tens of watts.
		Chargi	ng		
	AL MAL	Applic	ations		- Increased in transfer distance
	RAIL R	(2017)	AWA		to hundreds of mm from
	E LE				before is less than 1 mm.
	PARA ING				- Increased of efficiency
	با ملاك	مليس	ڪل	، تيڪني	transfer to 90% from 30%.
	UNIVER	SITI T	EKNIK	AL MALAYS	- Voltage and power loss can
					significantly affect the CPT
					system.
2.	Guilherme G. da	Capaci	tive	Mobile	-LC resonance is used to
	Silva and Clovis	Wirele	ss Power	Charging	achieve a high efficiency.
	A. Petry	Transfe	er System		-Uses two metal plates as the
		Applie	d to		transmitter and the receiver
		Low-P	ower		

# 2.3.7 Summary of literature review

		Mobile Device		-System efficiency can be
		Charging		effected if the switching
		(2015)		frequency increases.
3.	Narayanamoorthi	Class E Power	Low power	-Using capacitive coupled
	R, Vimala Juliet	Amplifier	biomedical	wireless power transfer
	A, Bharatiraja	Design and	implants	(CCWPT)
	Chokkalingam,	Optimization		-To improves efficiency and
	Sanjeevikumar	for the		maintain required impedance
	Padmanaban,	Capacitive		compression, an inductive-
	Zbigniew	Coupled		capacitive-inductive (LCL) is
	M.Leonowicz	Wireless Power		designed for robust operation.
	* AINI	Transfer System		
	با ملاك	in Biomedical	, تىكنى	-The power amplifier (PA)
		Implants (2017)	· · · ·	efficiency could be decreased
	UNIVER	SITI TEKNIK/	AL MALAYS	by the coupling distance and
				load.
4.	Deepak Rozario	Design of	Battery	-Used Dual LC topology
		Contactless	Charging	method for capacitive power
		Capacitive	Application	transfer.
		Power Transfer		-The topology used produced a
		Systems for		better efficiency for small air
		Battery		

		Charging		gap application.
		88		Set attraction
		Application		-The second topology
		(2016)		decreased the voltage stress
				and suitable for large air gap
				application.
				-The limitation is the
				requirement of charging an
				IEV determined by its battery
		5 m m m		pack.
	MAL	YSIA MA		
	Kulles	EL RKA		
5.	Brandon	Capacitive	Electric	-The system utilizes capacitive
	Regensburger	Wireless Power	Vehicle	coupler and include a L-
	Jake	Transfer	Charging	section matching networks in
		Systems for	C	order to provide gain and
	UNIVER	Electric Vehicle	AL MALAYS	reactive compensation into the
		Charging		system.
		(2020)		-Transferring 3.75 kW with a
				very high efficiency at 94.7%,
				with a power transfer density
				of 49.4 kW/ $m^2$ .
				-Impact of foreign objects such
				as water will notably affect the

				system's performance.
6	Deepak Rozario	Modified	Electric	-This research is trying to
0.		D		
	Vamsi Krishna	Resonant	Vehicle	subdue the disadvantages of
	Pathipati, Akash	Converters for	Charging	CPT system for small gap
	Ram, Najath	Contactless for		application by using modified
	Abdul Azeez,	Contactless		LLC topology and dual
	Sheldon S.	Capacitive		topology.
	Willianson	Power Transfer		-Based on the experiments,
	and the second	Systems used in		LLC method is suitable for
	EK III	EV Charging		small distance and high power
	T II	Applications		application while the dual
	PARATING	(2016)		
	she	1.15		topology is suitable for a long
	ט מועב	_ میس	" " (	distance applications.
	UNIVER	SITI TEKNIK/	AL MALAYS	For LLC method the
				limitation is that the
				capacitance decreased as the
				distance between plates grew
				larger and it's the opposite for
				dual topology.
7.	Shakir Saat, Ong	Development of	Mouse	-Method used is a high
	Zhen Guat,	Wireless Pwer		efficiency Class-E converter to

	Farah Khalidah	Transfer using	Charging	convert the source from DC to
	Abdul Rahman,	Capacitive		AC.
	A.A. Isa and	Method for		-The efficiency of the system
	A.M. Darsono	Mouse		is improved by connecting it to
		Charging		a compensation circuit.
		Application.		The second data and the second
		(2016)		-The power transmitted was
				inadequate to power the
				wireless mouse. Nevertheless,
		14		the LED was lit and it shows
	AL MAL	YSIA ME		that the concept is proven.
	() TEKNIN	AKA	JT	ЪM
8.	Jianying Liang,	A Design	Railway	-By using LCLC-CL topology
	Donghua Wu	Method of		as the system as it requires a
	and Jin Yu	Compensation		high power.
	UNIVER	Circuit for	AL MALAYS	-No voltage distribution
		High-Power		system despite using a high
		Dynamic		power CPT system application
		Capacitive		
		Power Transfer		-During high power
		System		transmission, a high insulation
		Considering		material is needed in order to
		Coupler		diminish the risk of system
		Voltage		breakdown.

		Distribution for Railway Applications. (2021)		
9.	Mohammed Al-	Analysis of	Electric	-This thesis studies the ring
	Saadi, Ammar	Charge Plate	Vehicles	and square plates
	Al-Gizi, Sadiq	Configurations	Batteries	configurations in unipolar CPT
	Ahmed, Sarab	in Unipolar	Charging	for the uses of the batteries
	Al-Chlaihawi,	Capacitive		charging in EV.
	Aurelian Craciuescu	Power Transfer System for the Electric Vehicles Batteries Charging (2019)	پ تيڪني ۱ MALAYS	<ul> <li>The result shows that the square coupler has better angular misalignment.</li> <li>The limitation is that both plates cannot have a large misalignment as it can cause the efficiency to drop.</li> </ul>
10.	Kang Hyun Yi	Capacitive	Electric	-A high frequency operation
		Coupling	Vehicle	using capacitive coupling
		Wireless Power		wireless power transfer
		Transfer with		-This study results show that a
		Quasi-LLC		1.6 kW of output power

Resonant	produce a high efficiency of
Converter using	96%.
Electric	-Quasi-LLC resonant operates
Vehicle's	with two transformers to
Windows	reduce the switching losses.
(2020)	

### 2.4 Summary

AALAYSIA

This chapter is a comprehensive study that discusses, analyses published information and synthesises the literature of a particular study. The first part of the chapter, introduces the readers to the definition and the background of wireless power transfer (WPT) and capacitive power transfer (CPT). It covers on their history, definition in detailed and the advantages and disadvantages of CPT system. Then, the latter part of the chapter is the literature review of the previous works dating from 2016 until 2021. Lastly, their application methods, limitation and the advantages of their study is summaries in a table.

### **CHAPTER 3**

### METHODOLOGY

## 3.1 Introduction

This chapter will explain and discuss the methods used in order to write the report and the process of developing 'Capacitive Type Mobile Phone Charger' project. The methodology was explicitly explained the "what" and "how" of the project by listing the material and tools used and the reason for choosing these methods. In addition, the reasoning will ensure a convincing and reliable results that achieve the objectives of this paper. This chapter also include the flowchart of the project that describes the steps of making this project from the beginning till the final output/product.

Every step is done carefully to avoid error or to prevent the project from working incorrectly than what to be expected. Furthermore, by following the steps it will be easier to detect where the problem is coming from. The project schedule will follow closely on the timeline that is planned in the Gantt chart. It is crucial to follow the schedule in order to make certain that the project can be carried out on time as planned.

# 3.2 Methodology

This thesis presents a wireless power transfer by using two plates conductor as tramitter and receiver in order to charge a mobile phone and Figure 3.1 is the illustration of the flowchart for the development of Capacitive Type Mobile Phone Charger project methodology.



Figure 3.1 Flowchart of the project

Based on the flowchart above, this project methodology starts by doing a research on literature review based the topic that is related to capacitive power transfer (CPT) and wireless power transfer technology. The information is gathered from multiple sources such as from journal article, conference paper and online article. After that, gantt chart and flowchart of the project methodology is done to make sure the project can be completed right on schedule and to avoid a hectic schedule. Then, for the project circuit, hardware circuit construction after designing the project. There will be two conductive metal plates in order to make a wireless power transfer.

Next, the circuit will be tested. If it pass and manage to operate successfully it will go the next process that is result and data analysis but if the project failed, an error occurred, the process will go back to designing the circuit.

For when the project is done successfully the data will be analyse and will be collected for the continuation of report writing.

Finally, after the report is done and finalized, the report then will be submitted to the supervisor and panels for marking. Lastly, after the report and the presentations is done the BDP II is completed.



### 3.3 **Project Architecture**

This is the block diagram to show the operation of the project. From the power being supply to the charging the mobile phone.



Figure 3.2 Block diagram of the project

In this project, the switch mode power supply (SMPS) will provide the voltage source. Then, the current will flow through transmitter plate and the medium then through the receiver plate to power the load.

#### **3.4** Experimental setup

MALAYSIA

# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

3.4.1 Aluminium foil

Aluminium are a good conductor since it allows electricity flow through it easily. In electrical connections, aluminium generates an electrically resistive oxide surface, which can cause the connection to overheat. Aluminium is used in high-voltage transmission lines that are enclosed in steel for additional protection.

The regular aluminium foil sold in the market typically 0.016mm wide, and 0.024mm medium. The foils are thin and brittle and are usually laminated in order to make them thicker. Hence, the size dimension and the thickness of the foil will affect the efficiency of the power transfer. In this project an extra thick aluminium foil is used.

This aluminium foil is shaped into a plate and cut in different sizes in order to take data analysis. The sizes of aluminium plates used are Plate A (13.5cm x 20.5cm), Plate B (20cm x 28cm) and Plate C (15cm x 15cm).



### 3.4.2 Switch Mode Power Supply (SMPS)

The Switch Mode Power Supply is a device containing electronic circuit that includes a switching regulator for converting one form of electrical power into another form using switching devices. This SMPS take AC input and converts it to DC using rectifier and filter. A power MOSFET amplifier is used to perform the switching action. MOSFET transistors have a low on-resistance and can withstand high currents. This then causes switcing frequency pulses between 20 an 200kHz at primary winding. After that, the transformer smoothed and rectified the output voltage using the rectifier and filter in order to produced the DC voltage.

The SMPS is used to supply the transmitter plate with DC voltage supply. The SMPS is very high in efficiency and produced less losses, thus promote energy saving. The design is compact and light. In addition, SMPS also produced a clean and pure DC voltage which is highly suitable for noise sensitive application and can be used to supply constant current, suitable for DC motor, LED lighting, battery charging device and instrumentation device. In this project the rating of SMPS that is used is 12V 30A.



Figure 3.4 Switch Mode Power Supply

No.	Features	Description
1.	Input Voltage	110V - 240V
2.	Output Voltage	12VDC
3.	Output Current	30A
4.	Dimension	21.5cm x 11.5cm x 5cm (L x H x W)
5.	Cooling Fan	Yes

Table 3.2 SMPS Specification



### 3.4.3 LED

A light-emitting diode (LED) falls under a catogory of semiconductor device that function by emitting light when there is a presence of current flowing through the device. The light is produced when the electrons from the current jump from hole to hole (from Ptype material to N-type material). If the LED is put in reverse direction, the current will not flow. The LED is used as an indicator to see if there is a power transfer from transmitter plate to receiver plate and the led will be place on the receiver circuit.



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Table 3.3 LED Specification

No.	Features	Descriptions
1.	Forward Voltage	2.8V - 3.2V
2.	Size	5mm
3.	Operating Temperature	-20°C to 100°C

## 3.4.4 Multimeter

A multimeter is a device use to measure a variety of electrical properties. Most conventional multimeter able to measure voltage, current and resistance is referred to as volt-ohm-milliammeter (VOM) since the multimeter has the function a voltmeter, ammeter and ohmmeter equipped in it. Some other multimeter comes with additional functions such as measuring temperature and volume.



# 3.5 **Project hardware**

# **3.5.1 Project integration**

The assembly of the project.



The figure 3.7 shows a block diagram sequence of the 'Development of Capacitve Type Mobile Phone Charger'. The SMPS act as the supply which converts AC into DC of 12V and 30A. It is then will flow through the transmitter plate and by using paper as the medium the electric will flow to the receiver plate. The function of the medium is to test the functionality of the wireless capacitive power transfer. The LED is used as the circuit load.

# 3.5.2 Capacitive Plates

The arrangement of the transmitter plates and the receiver plates. In between the transmitter and receiver plates there is also a medium.



So as to analyse the data of voltage output, the aluminium are cuts into 3 differrent sizes. And each size will have 4 sets of plates to make sure there is a pair for trnasmitter plate and another pair for the receiver plate. The sizes are Plate A (13.5cm x 20.5cm), Plate B (20cm x 28cm) and Plate C (15cm x 15cm).



Figure 3.9 Plate A (13.5cm x 20.5cm)



Figure 3.10 Plate B (20cm x 28cm)



# 3.5.3 Circuit Design

Project hardware tested with SMPS as supply and LED as the load. The medium used was paper as shown in Figure 3.12.



# **3.6 Gantt Chart**

	Tasks							PSM 1													PSI	M 2						
No.	Week	1	2	3	4	5	6	7 8	9	10	11	12	13	14	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	PSM1 Briefing																											
2	Title selection and registeration																											
3	Study the project background			N.																								
4	Discussion with supervisor	100	a, bert		P.	100																						
5	Module 1 : Introduction	1				10	1																					
6	Progress work evaluation 1																											
7	Module 2 : Literature Review						177																					
8	Summary for literature review						7							1														
9	Drafting for Chapter 3 : Methodology							2																				
10	Starting on simulation/hardware																											
11	Submit 1st draft report to supervisor																											
12	Progress work evaluation 2																											
13	Submit report to panel																											
14	BDP 1 Presentation										1						1											
15	Chapter 4 : Result and data	10																										
16	Analysis result and data	11	10																									
17	Drafting result and discussion																											
18	Chapter 5: Conclusion and recommendation							1				1		1.0						- 4								
19	Drafting Chapter 4 and 5	. 61				10				5	1																	
20	Updating the report to SV		~		5		1			1				200	18			11		y~~	7							
21	Compile report PSM 2				19		Ĵ			1				64	1	1. 10		6		14								
22	Final report																											
23	BDP 2 Presentation																											
	UNIN	/E	: R	31				KNI	KA	١L	. N	īΑ	l La	A١	15	IA	N N	лΕ		AI	K A	٩.						

# 3.7 Summary

This chapter presents the proposed methodology in order to develop a capacitive type mobile phone charger. The project methodology is the major part of this project in order to ensure the smooth journey for the execution of this project and a successful outcome. The gantt chart plays the big part on making sure the developer to keep in track their progress.



### **CHAPTER 4**

### **RESULTS AND DISCUSSIONS**

### 4.1 Introduction

The result and discussion on the development of capacitive type mobile phone charger is presented in this chapter. Every analysis decision is explained in their sections. The analysis was done by varying couples of variables in order to compare the data produced.

## 4.2 **Results and Analysis**

First of all, the analysis is done by using Switch Mode Power Supply (SMPS) rating 12V and 30A as the supply to the transmitter part. Then, the transmitter and receiver plate is divided into three different sizes which is Plate A (13.5cm x 20.5cm), Plate B (20cm x 28cm) and Plate C (15cm x 15cm). There are 3 variation of the variable in order to analyse which combination is the best to produce the highest efficiency and the medium that is used in this experiment is paper. The load used for this analysis is LED.

### 4.2.1 Material of conductive plate

This analysis will be conducted using three different types of conductive metal as the transmitter plate and receiver plate to received voltage. In this experiment paper was used as the medium and the number of paper put in the middle is up to 3 papers analyse which material has the highest efficiency of the received voltage. The finding are tabulated in Table 4.1, 4.2 and 4.3.



Figure 4.1 Copper Plates



Table 4.1 Copper Plate

Number of paper	Voltage with Load (V)	Voltage with no Load (V)	LED (V)	Average (V)	Efficiency (%)			
1.	3.20	2.06	3.20	2.82	23.5			
2.	3.16	1.14	3.16	2.49	20.75			
3.	3.14	1.13	3.14	2.47	20.58			

Number of paper	Voltage with Load	Voltage with no	LED (V)	Average (V)	Efficiency (%)		
	(V)	Load (V)					
1.	3.14	1.34	3.15	2.54	21.17		
2.	3.11	0.91	3.12	2.38	19.83		
3.	3.08	0.39	3.09	2.19	18.25		

Table 4.2 Aluminium Plate

Table 4.3 Zinc Plate

Number of	Voltage	Voltage			Efficiency
	with Load	with no	LED (V)	Average (V)	(0/)
paper	(V)	Load (V)			(%)
1.	3.11	1.90	3.10	2.70	22.5
2.	3.09	1.13	3.07	2.43	20.25
2	2.00	0.70	200	2.20	10.09
3.	3.06	00.78	3.02	4.29	19.08
U	NIVERSITI	TEKNIKAL	MALAYSI	A MELAKA	

Secondly, the result of the comparison are summarised in the graph in Figure 4.1 below. From the graph in can be concluded that the voltage received for copper plate has the highest value. This is due to copper placed the highest compared to aluminium and zinc in the best conductor of electricity list (refer table 3.1)..



Figure 4.1 Graph for Average voltage vs Number of paper

The different types of metal conductor of transmitter and receiver plate are measured by varying the number of paper that are used as the medium. This is to analyze which of the three conductor copper, aluminium and zinc plate would have the highest efficiency. Based on the graph shown in Figure 4.1 it is known that the the highest voltage is achieved when using copper as plates and when the distance between the transmitter and receiver plate is shorter indicates that the thickness of the medium affect the transmission performance . When the paper is added to 3 papers, the voltage at receiver drops to 2.47V compared to when there is only 1 piece of paper between the plates the voltages is at the highest, 2.82V.

## 4.2.2 **Positions**

Using plate B (20cm x 28cm) as the fixed transmitter and plate A (13.5cm x 20.5cm) as the receiver and position the receiver at 3 different part of the transmitter which is Section A, Section B and Section C as shown in Figure 4.3. Similarly, by using paper as the medium for the transmitter and receiver plates.



Figure 4.3 The position which receiver plate placed on transmitter plate: (a) Section A (b)

Section	C and (c) S	ection C	

	Voltage with	Voltage with	. 9	~ ( ) " )	Efficiency
Position U	Load (V)	no Load (V)	LED (V)	Average (V)	(%)
Section A	0.56	0.016	0.4	0.33	2.75
<i></i>				• • •	
Section B	3.2	2.46	3.2	2.95	24.6
Section C	2.31	0.03	1.99	1.44	12

Table 4.4 Voltage at the receiver part using Plate A as the receiver

Position	Voltage with Load (V)	Voltage with no Load (V)	LED (V)	Average (V)	Efficiency (%)
Section A	3.08	0.16	3.09	2.11	17.6
Section B	3.19	1.64	3.20	2.68	22.3
Section C	3.15	0.21	3.16	2.17	18.1

Table 4.5 Voltage at the receiver part using smaller receiver (10cm x 13cm)



Figure 4.2 Graph for Average voltage vs Positions

Based on Figure 4.2 it can concluded that the highest voltage received is when the plate is placed at Section B compared to Section A and Section C. This is because the position of the receiver plates at Section B is fully alligned with the transmitter plate which makes the coupled area greater hence, higher voltage. When the receiver plates are

misaligned from transmitter plates, there are uncoupled area which reduces the voltage at the receiver plates.

# 4.2.3 Size of the capacitive plate

For this analysis the data is taken by variating the sizes of transmitter plate and the receiver plate. By using the same size of transmitter plate and receiver plate to using bigger size transmitter plate and small size receiver and vice versa.

Number of	Voltage with Load	Voltage with no	LED (V)	Average (V)	Efficiency
paper	MALAYS/4	14			(%)
No.	(V)	Load (V)			
1. #	3.19	1.3	3.19	2.56	21.33
2.	3.16	0.75	3.16	2.36	19.67
3.	3.14	0.43	3.15	2.24	18.67
6	Ho lund	a Kai	<u> </u>	un raisa	
_			. 6	· ( J.)	

Table 4.6 Using Big plate (Plate A) for transmitter and receiver plates

Table 4.7 Using Small plate (Plate B) on transmitter and receiver plates

Number of paper	Voltage with Load	Voltage with no	LED (V)	Average (V)	Efficiency (%)
	(V)	Load (V)			
1.	3.11	1.46	3.12	2.56	21.33
2.	3.08	1.29	3.09	2.49	20.75
3.	3.02	0.21	3.01	2.08	17.33

Number of paper	Voltage with Load (V)	Voltage with no Load (V)	LED (V)	Average (V)	Efficiency (%)
1.	3.09	0.67	3.10	2.29	19.08
2.	3.05	0.37	3.07	2.16	18
3.	3.03	0.2	3.02	2.08	17.33

Table 4.8 Big receiver plate

Table 4.9 Small receiver plate

Number of paper	Voltage with Load (V)	Voltage with no Load (V)	LED (V)	Average (V)	Efficiency (%)
1.	3.10	1.23	3.11	2.48	20.67
2.	3.09	0.22	3.09	2.13	17.75
3.	3.03	0.15	3.04	2.07	17.25

UNIVERSITI TEKNIKAL MALAYSIA MELAKA



Figure 4.3 Graph of Average voltage vs Number of paper

The purpose of this analysis is to investigate which of the pairing between big transmitter plate pair with big receiver plate, small transmitter plates with small receiver plates, small transmitter plate with big receiver plates or big transmitter plate with small receiver plate would produced the highest average received voltage and the highest frequency. At 1 piece of paper both small plate transmitter and receiver and big transmitter and receiver plate produced the same number of voltage, 2.56V as shown in Figure 4.3. They also obtained the same highest efficiency. This is due to both of them have the same size for transmitter and receiver plate which makes the plates fully alligned with each other. Thus, transfer the highest electrical fields.

### 4.3 Summary

In this chapter, the part of studies shows the implementation and the applicability of the proposed system of development of capacitive type mobile phone charger. By comparing these experiments results, it is understand that the size of the plates, the position of the receiver plates and the distance between the transmitter plates and receiver plates plays an major role in investigating the relation between the electric transmission and the efficiency. The shorter the distance, the higher the transmission performance between the transmitter plate and receiver plate. In addition, misalignement will produced unwanted uncoupled area which affects the voltage gain by the receiver part. It should be avoided in order to minimize losses during transmission and efficiency drop. But unfortunately, in this analysis, there was too much power loss when the electric field is transmitted between the transmitter plate and the receiver plate. Hence, making it unable to supply enough power to charge the mobile phone but the LED lights up.

> اونيوم سيتي تيڪنيڪل مليسيا ملاك UNIVERSITI TEKNIKAL MALAYSIA MELAKA

#### **CHAPTER 5**

### CONCLUSION AND RECOMMENDATIONS

## 5.1 Conclusion

To conclude all, this project explained and presents the development of capacitive type mobile phone charger. The proposed method are done by using SMPS 12V 30A as the supply which connects to the transmitter plate and receiver plate by using paper as the medium is submitted successfully. Based on the data analysis, the size of the receiver plate, the position and the thickness of the medium does affect the efficiency performance of the capacitive coupling plate. This is tested by varying up to 3 pieces of paper in between the plates and repeat the process using a different dimension of aluminium plates.

The bigger the receiver plate, the greater the voltage at the receiver plate. Futhermore, misalignments creates unwanted uncoupled area hence, reduces the voltage. In addition, the type of conductor material also influenced the voltage received in the receiver plates. Based on the data the highest efficiency are in this order copper plate, aluminium plate and last zinc plate. Moreover, the transmission performance are also influenced by the thickness of the medium as the thickness grows the voltages at the receiver plate will decrease.

Based on the analysis done in Chapter 4, while conducting the project, LED manage to light up successsfully thus proving the point that there is a power transmission between the capacitive plate. To conclude all, this project has successfully transmitted the power by using capacitive coupling plate. However, the voltage received are not enough to charge the mobile phone but it is enough to be able lo light up the LED. This is because of

there was too much power loss when transmitting the electric field from transmitter plate to receiver plate. Therefore, proving the relevancy and the opportunity of capacitive type mobile phone charger in near future.

# 5.2 Future Works

For future improvements, the accuracy of this developments could be enhanced as follows:

- i) Consider boosting the SMPS to a higher voltage and frequency.
- Convert the DC from transmitter plate into AC to transfer more electric field and minimize losses.
- iii) Regulate the DC voltage of capacitive plate in order to get high voltage and supply other electronic devices and to stablize the voltage output.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
## REFERENCES

Al-Saadi, M., Al-Gizi, A., Ahmed, S., Al-Chlaihawi, S., & Craciunescu, A. (2019).

Analysis of Charge Plate Configurations in Unipolar Capacitive Power Transfer System

for the Electric Vehicles Batteries Charging. Procedia Manufacturing, 32, 418–425.

https://doi.org/10.1016/j.promfg.2019.02.235

Hyun Yi, K. (2020). Capacitive coupling wireless power transfer with quasi-llc resonant converter using electric vehicles' windows. Electronics (Switzerland), 9(4).

https://doi.org/10.3390/electronics9040676

Karabulut, A., Bilic, H. G., & Ozdemir, S. (2018). Capacitive Power Transfer Theory and the Overview of its Potential. October.

Liang, J., Wu, D., & Yu, J. (2021). A design method of compensation circuit for highpower dynamic capacitive power transfer system considering coupler voltage distribution for railway applications. Electronics (Switzerland), 10(2), 1–17. https://doi.org/10.3390/electronics10020153

Lu, F. 2017, High Power Capacitive Power Transfer for Electric Vehicle Charging Applications, University of Michigan.

Lu, F., Zhang, H., & Mi, C. (2017). A review on the recent development of capacitive wireless power transfer technology. Energies, 10(11). https://doi.org/10.3390/en10111752
Lu, F., Zhang, H., & Mi, C. (2018). A Two-Plate Capacitive Wireless Power Transfer
System for Electric Vehicle Charging Applications. IEEE Transactions on Power
Electronics, 33(2), 964–969. https://doi.org/10.1109/TPEL.2017.2735365
Narayanamoorthi, R., Vimala Juliet, A., Bharatiraja, C., Padmanaban, S., & Leonowicz, Z.
M. (2017). Class E power amplifier design and optimization for the capacitive coupled

wireless power transfer system in biomedical implants. Energies, 10(9).

https://doi.org/10.3390/en10091409

Pratik, U. 2019, Design of Capacitive Wireless Power Transfer Systems with Enhanced Power Density and Stray Field Shielding, Utah State University.

Regensburger, B. (2020). Capacitive Wireless Power Transfer Systems for Electric Vehicle Charging, Cornell University

Rozario, D. (2016). Design of Contactless Capacitive Power Transfer Systems for Battery Charging Applications. 1–115. https://ir.library.dc-

uoit.ca/xmlui/bitstream/handle/10155/652/Rozario\_Deepak.pdf?sequence=1%0Ahttp://hdl. handle.net/10155/652

Rozario, D., Member, S., Pathipati, V. K., Member, S., Ram, A., Member, S., Azeez, N. A., Williamson, S. S., & Member, S. (2016). Modified Resonant Converters for

Contactless Capacitive Power.pdf. 4510-4517.

Silva, G. G. da, & Petry, C. A. (2015). Capacitive Wireless Power Transfer System

Applied to Low-Power Mobile Device Charging. International Journal of Electrical

Energy, 3(4), 230–234. https://doi.org/10.18178/ijoee.3.4.230-234

Saat, S., O. Guat, F. Rahman, A. Isa and A. M. Darsono. Development of Wireless Power Transfer using Capacitive Method For Mouse Charging Application. International Journal of Power Electronics and Drive Systems 7 (2016): 460-471.

Braza, J. What is a capacitor. Available online 5 May 2021:

https://www.circuitbasics.com/what-is-a-capacitor/

Introduction to Capacitors. Available online 5 May 2021: https://www.electronics-

tutorials.ws/capacitor/cap\_1.html

Capacitor. Available online 5 May 2021: https://en.wikipedia.org/wiki/Capacitor

Dai, J. 2017, Power Electronics Design for High Power Capacitive Power Transfer, The

University of Wisconsin – Madison.

