UNIVERSITI TEKNIKAL MALAYSIA MELAKA

OPTIMIZATION OF WIRELESS CHARGING SYSTEM BASED ON INDUCTION MECHANISM

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree in Electronics Engineering Technology (Telecommunications) (Hons.)

by

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of the Bachelor's Degree in Electronics Engineering Technology (Telecommunications) (Hons.). The member of the supervisory is as follow:

……

(MOHD FAUZI AB RAHMAN)

ABSTRAK

Dalam era sains dan teknologi pada masa kini, setiap orang merupakan pengguna bagi peranti elektronik seperti telefon bimbit, komputer riba, kamera dan banyak lagi. Alatan elektronik sedia ada masa kini dibekalkan oleh sumber kuasa melalui wayar. Akibat daripada perkembangan penghantaran kuasa tanpa wayar bagi menggantikan penghantaran tenaga secara konvensional iaitu kuasa elektrik tanpa persentuhan, gandingan induktif telah menjadi kenyataan. Gandingan induktif ini dapat memberikan penghantaran kuasa yang selamat, dipercayai, cekap serta sebahagian besarnya imun kepada kesan penggunaan serta alam sekitar. Dalam projek ini, pengecasan induktif yang memindahkan tenaga dari penghantar ke penerima melalui gandingan induktif telah direkabentuk. Penghantar menghantar tenaga melalui induksi kepada alat-alat elektrik, dan kemudian menyimpan tenaga itu dalam bateri. Oleh kerana terdapat jarak di antara gegelung penghantar dan gegelung penerima, pengecasan induktif juga dikenali sebagai pemindahan tenaga tanpa wayar yang memerlukan jarak tertentu.

ABSTRACT

In this present era of science and technology, everyone is users for electronic devices such as mobile phones, laptops, cameras and many more. Existing portable electronic devices today are supplied by wired transmission from the power supply. Due to the development of wireless power transmission, replacing conventional wire energy transmission in electrical power systems with no contact, inductive couplings becomes possible. Inductive couplings can provide safe, reliable, and efficient power transmission that is largely immune to the effects of wear and environment. In this project, the inductive charging transfers energy from transmitter to receiver through inductive coupling is designed. The transmitter sends energy through induction to the electrical devices, and then stores the energy in batteries. Because there is a gap between the transmitter coil and the receiver coil, inductive charging also known as a wireless energy transfers that requires a certain distance for operation.

DEDICATION

Especially to my beloved parents, siblings, supervisor, co-supervisors, lecturers and all my friends for their eternal support, encouragement and inspiration during doing this thesis until completed.

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TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

AC	-	Alternating Current
CPT	-	Capacitive Power Transfer
cm	-	centimetre
DC	-	Direct Current
DMM	-	Digital Multi Meter
EMF	-	Electromagnetic Force
H	-	Henry
ICPT	-	Inductive Coupling Power Transfer
IPT	-	Inductive Power transfer
IC	-	Integrated Circuit
mm	-	millimetre
PCB	-	Printed Circuit Board
RF	-	Radio Frequency
SWG	-	Standard Wire Gauge
V	-	Volt
W	-	Watt

CHAPTER 1
INTRODUCTION

1.1 Background

For more than a century now, we are using electricity and for all these years, the electricity is transmitted through wire cables to commercial and home units. We also use various electronic gadgets which uses electricity through wire cables. However, after such development of research on power transmission, it is revealed to be possible through wireless transmission of electricity. In 1831, Michael Faraday discovered induction and stated that electromagnetic forces can travel through space. The first concept that electricity can be transmitted without wire was demonstrated by Nikola Tesla in 1893 during which he demonstrated the wireless illumination of phosphorescent lamps at world exposition in Chicago. Induction is the prime principle used to transmit electricity for shorter distances. Other means like RF energy is used for short range electricity transmission. The short range electricity transmission can be used to light electric gadgets and also to charge batteries wirelessly. The main advantage of this wireless transmission technique is that we can totally do away with wires which will help us to bring the electricity to nook and corner of the world. Efficiency is the main criteria for this technology. RF energy transmission is having the least efficiency ratio while induction charger is having the most efficiency.

The design of wireless inductive charger is the production of electricity across a conductor situated in a changing magnetic field moving or a conductor moving through a changing magnetic field. When a conductor is subjected through a changing magnetic field, a current is induced in the conductor and this current can be stored or used. The transfer of energy takes place by electromagnetic coupling through process known as mutual induction. This process works only in short distances and can be used to run electric gadgets.

1.2 Problem Statement

Today, almost each and everything are wireless or cordless. And these have definitely increased the standard of living. With many users owning more than one handheld device, the resulting collection of bulky chargers is inconvenient to use. In this project, inductive charging will ensure that the cell phones, laptops, iPods and other power hungry devices get charged on their own, eliminating the need of plugging them in. Even better, because of inductive charging some of the devices won't require batteries to operate. Tangles of wires and bulky chargers are no longer required. Inductive charging carries a far lower risk of electrical shock, when compared with conductive charging, because there are no exposed conductors.

Wireless power just about freedom from power cords and convenience; it also changes the way manufacturers can design devices. Eliminating the power socket is a major step toward a sealed and even thinner smartphone that’s waterproof and dustproof. Such a device would at the same time be more reliable and rugged, and it would not need a flat edge to mount the power socket on. The availability of wireless charging everywhere would further allow designers to consider smaller batteries because users would be able to simply top up their battery charge as needed.

The transmission of electric power without wires or connectors has been proven to be reliable and convenient. However, wireless charging systems were designed for a particular product or application and could not work universally for a wide range of

devices with different sizes and shapes. Also, the wireless chargers provide power to battery with lower efficiency compared by using the wires chargers.

1.3 Project Objectives

The objectives of this project are to:

(i) Investigate the near field wireless power transfer application. The investigation consists of the comparison between a few methods in transferring power wirelessly over short distance. The inductive power transfer via inductive coupling will be proposed as the most efficient method in this investigation.
(ii) Design a wireless power system to transmit voltage wirelessly from the source to device. The wireless battery charger for electronic gadgets is designed based on induction charging technique consists of transmitter and receiver.
(iii) Test and evaluate the wireless charging performance in transmitting the power to battery. Measurements such as output voltage, energy transfer efficiency, and wave forms will be analyzed.

1.4 Project Scopes

The scopes of the project can be illustrated as in K-Chart shown in Figure 1.1:

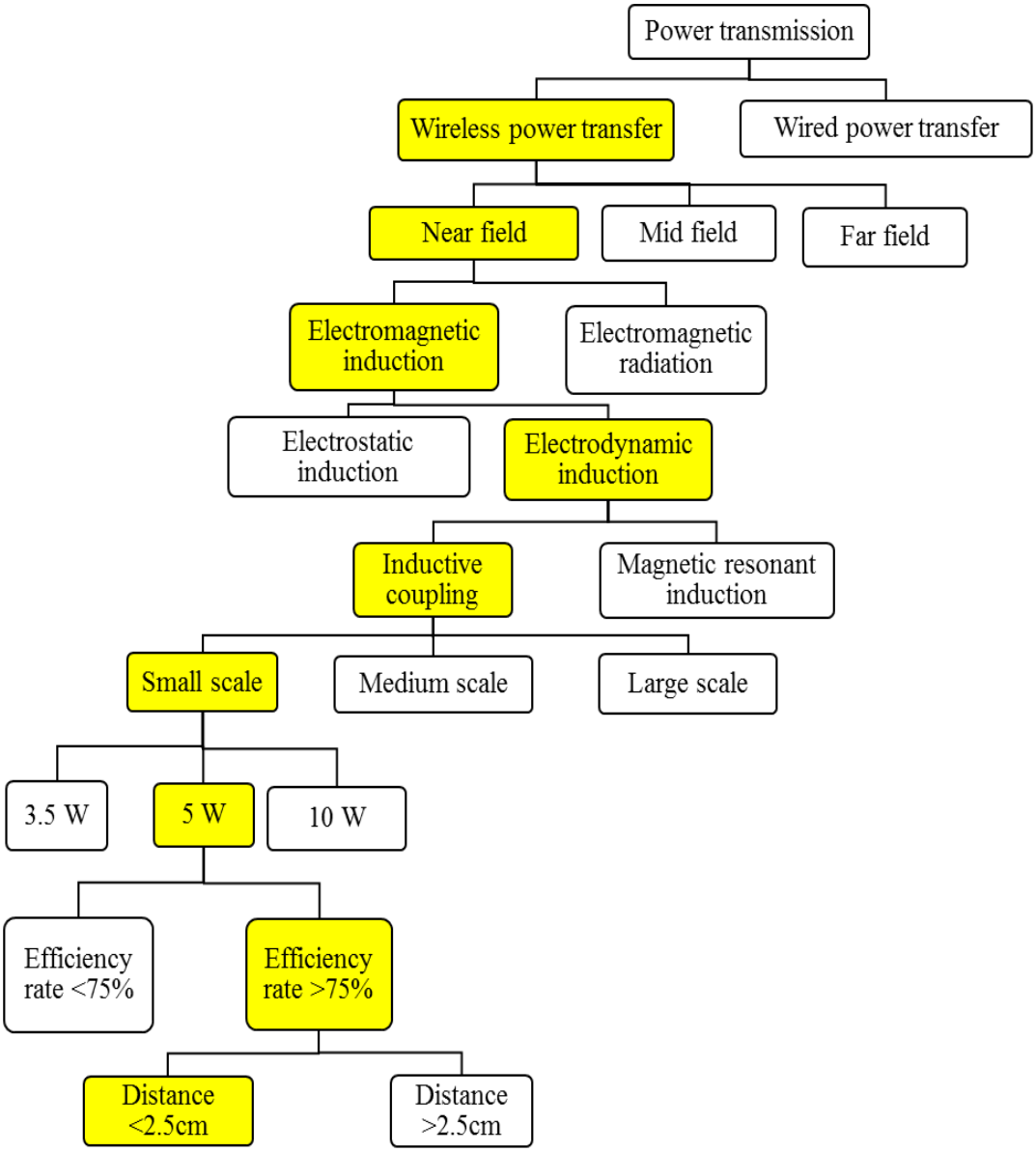

Figure 1.1: K-chart

The work scopes of this project are listed out so that this project does not goes off the course. The scopes also made to achieve the objectives of project. In this project, we are creating a small scale project of wireless charger. The wireless charger will be designed and constructed based on electromagnetic induction method which is inductive coupling. This charger can only charge portable electronic devices with rechargeable battery and a few devices can be charged at the same time. The efficiency of the wireless power transmission is minimum 75%. The scope also

limiting the capability of this wireless charger to transfer 5W at a maximum distance of 2.5 cm, which is sufficient to charge a regular mobile phone.

1.5 Project Significance

Nowadays, the portable electronic devices are very popular. Hence, as the usage of these portable electronic devices is increasing, so does the demands to have longer battery life which are also increasing. Periodically, these device's batteries need to be recharged or replaced. It is inconvenient to change or charge the battery especially when without the presence of any power outlet around users. Therefore, the wireless battery charger is expected to eliminate all the difficulties with today's battery technology. For the handheld device users, it create such convenience as they do not have to worry about charging their devices and still have a working device. This project should help to wirelessly charge up the batteries which can save time and money in a long run for the general public.

1.6 Thesis outline

There are all five chapters being structures in this thesis and every chapter will elaborate in detail about this project. Chapter one states the overview and introduction of the project which inclusive of project background, project objectives, problem statement, project significance and scope of work.

Chapter two will explain and discuss on the literature review of the wireless power transmission that being in research before. In this chapter also will provide the explanations of method used in this project to transmit energy based on the scope. The concept of the research and how it is related to the theory is also discussed in this chapter.

Chapter three discusses the methodology that I use to transmit the energy wirelessly. In this chapter it will be presented using the three stages in flow chart. It will describes the methods and technique selected for implementation in this project.

Chapter four is analyses and displaying all the results obtained and the limitation of the project. All analyses are concentrated on the result and the overall performance of the wireless power transfer. From the result, the analysis was do to see the project is function properly. All the simulation, data collection and analysis that were obtained from the project will be discussed in detail. The result was compared with the outlined objectives in order to state the hypothesis and conclusion of the project.

Chapter five concludes the whole research work and states recommendation for the future research work. In this chapter, conclusions are made on achieving the objective of the project.

1.7 Conclusion

The transmission of power without any wire through induction is discovered by Michael Faraday in 1831 and demonstrated by Nikola Tesla in 1893. This project is a small scale project conducted to design the one of the techniques in wireless power transmission which is through induction charging. The design will only focus on the electronic gadgets to able to transmit power of 5W to battery. This project purposely to create the convenience for the gadget users instead of using connector and bulky chargers. Several devices can be charged at the same time.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The development of charging system that have the capability of wireless power transfer is a recent trend in designing the power supply. In other words, the power supply will not be plugged into the charging device. For a long time, the technology of wireless power transfer have existed, but the recent development and interest of market have allowed it to be more practical, and hence brought to the center of attention, (A. Kurs, 2007).

This chapter will explain and discuss about the literature review on wireless power transmission that have been in research before. These studies and researches will be used as the reference in this project development. This review will focus on the near field wireless power transfer, electromagnetic induction, inductive coupling, magnetic field, wireless charger and its advantages.

2.2 Wireless Power Transfer Systems

Wireless Power Transfer is defined as an efficient transmission of electric power from one point to another through vacuum or an atmosphere without the use of wire or any other substance, (Yusop, et al., 2012). The history of wireless power

transmission can be traced back to the late of 19th century, which Maxwell predicted in his "Tretise on Electricity and Magnetism" that power could be transmitted from one point to another in free space. While Heinrich Rudolf Hetrz experimenting based on Maxwell's equation which was a monumental step towards the direction. Nikola Tesla also performed the experiments that are consideres as the most serious demonstrations in showing the capability of wireless power transmission eventhough his attempts to send power to space failed, (Prasanth, 2011).

The wireless transmission is beneficial where interconnected wires are inconvinient, hazardous or impossible. For users with disabilities, wireless charging is a suitable option since instead of connecting power cable to device, it can be placed on the charging plate. The user can keep a track on the charging amount on the devices in order to avoid overcharging or overheating. The increasing number of portable devices for example tablets, cell phones, etc. provide inconvinience to seperately charge all of them and had to carry number of chargers everywhere the user go. Hence the wireless charging provides ideal solution for this problems, (Supe, et al., 2014).

2.3 Electromagnetic Induction

Electromagnetic Inductive Power Transfer (IPT) is a popular method to transfer power wirelessly over a short distance. There are two fundamental laws of physics used in this technique which are Faraday's Law and Ampere's Law, (Prasanth, 2011).

In inductive power transfer system, the process is where electrical power is transmitted wirelesslyfrom source to an object that requires power. The pros of using inductive power transfer is it eliminates the inconvinient and hazardous wires and cables, (Dunne, 2009).

Based on the near distance coupling between the transmitter and the receiver, the induction wireless power transfer techniques can be classified into the following:

1. Electrostatic Induction
2. Electrodynamic Induction

2.3.1 Electrostatic Induction

Electrostatic Induction or Capacitive power transfer (CPT) is a method to wirelessly transfer power between two electrodes of capacitor assembly. Electric field are formed and displacement current maintains its continuity, when high frequency source ac voltage is supplied to the plates of capacitor that are placed close to each other. Hence, in this technique, the electric field is the energy carrier media, thus it is the dual of IPT, (Prasanth, 2011).

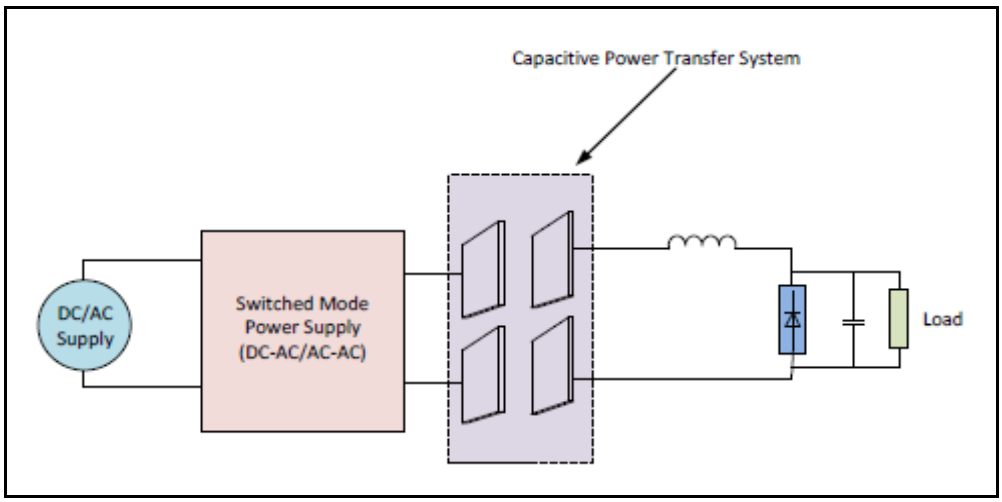

Figure 2.1: Electrostatic CPT system

2.3.2 Electrodynamic Induction

The IPT systems function based on the exchange of magnetic field which is created when an alternating current through a primary coil induced the voltage into secondary coil through air. The resonant mode coupling of the coils is established by means of capacitive compensation in order to improve the power transfer efficiency.