WIRELESS ENERGY TRANSFER

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Dedicated to my parents, my siblings and also my colleagues and friends who had been supporting me through thick and thin.

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ABSTRACT

The purpose of this project is to build the prototype model to prove and demonstrate the concept of wireless energy transfer based on magnetic resonance. It consists of a transmitter as an electromagnetic resonator and a receiver to which the device to be powered is attached. The transmitter emits a non-radioactive magnetic field resonating at MHz frequencies, and the receiving unit resonates in that field. The resonant nature of the process ensures a strong interaction between the sending and receiving unit, while interaction with rest of the environment is weak. This project will analyzed the wireless transmission mechanism based on the coupling model of two inductor, and studied the relationship among efficiency,frequency, distance and coil sizes.The maximum efficiency that we succeed to transfer energy is about 30% with the size of coil diameter is 9.5 cm.So, based on resonances theory, we had provided an energy wirelessly to light on a 3V LED within the distance for 6 cm which uses magnetic field as transmission medium.

ABSTRAK

Projek ini bertujuan untuk menghasilkan satu model prototaip untuk menunjukkan dan membuktikan konsep pemindahan tenaga elektrik tanpa wayar melalui resonans magnetik. Prototaip model ini terdiri daripada suatu pemancar sebagai resonator elektromagnetik dan penerima di mana peralatan elektrik seperti LED disambungkan. Pemancar memancarkan medan magnet non-radioaktif pada frekuensi MHz, dan penerima akan menangkap dan persilangan antara medan magnetik akan membolehkan proses penghantaran tenaga elektrik berlaku.Proses resonan memastikan interaksi yang kuat antara unit penghantaran dan penerimaan dan pada masa yang sama akan berinteraksi lemah dengan persekitaran yang lain.Projek ini mengkaji mekanisme penghantaran tenaga elektrik berdasarkan model resonan frekuensi antara dua induktor, dan mengkaji hubungan antara kecekapan, jarak frekuensi, dan saiz koil.Di dalam uji kaji ini,kami berjaya mencapai tahap efisiensi sebanyak 30% dengan menggunakan koil bersaiz diameter 9.5 cm.Jadi, berdasarkan teori resonans,kami menggunakan medan magnet sebagai media penghantaran untuk memberikan tenaga elektrik bagi menyala 3V LED dalam jarak 6 cm.

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CHAPTER 1

INTRODUCTION

Advanced technology has enabled a general variety of portable consumer electronic devices. However, users are still required to manually plug in these devices when battery is used up. Thus, wireless energy transfer (WET) is proposed to realize the possibility of connector battery free electronic devices, which could improve both size and reliability. So, there is the desire dream to use WET technology and eliminate the remaining wired energy connection.

There is a demand for wireless energy transfer system. Wireless data transfer via the Ethernet protocol or mostly known as WIFI was developed around 1988 by NCR Corporation and widely commercialized in 1999.Analysts predict that 100 million people will be using Wi-Fi by 2006. Homes, offices, colleges and schools around the world have installed Wi-Fi equipment to blanket their premises with wireless access to the internet. Wi-Fi access is available in a growing number of coffee shops, airports and hotels too. [9] So, it is not impossible to think that a developed wireless energy transfer technology would have much the same potential in home and business applications as wireless data transfer experienced. There are many applications, such as cell phones, laptop personal computers, and home theatre equipment, in which wireless energy

transfer would be desirable. This study documented the design of a wireless energy transfer system as a basic to more understanding about this system.

In this research, we proposed WET based on electromagnetic resonant coupling. WET is define as the efficient transmission of electric energy from one point to another without the use of wire or any other substance**.**This project will be design bases on the principle of electromagnetism resonant coupling system. When AC power has been supplied through a coil, magnetic field will be generated around the coil. At the moment, if another coil is put aside it, induced current will be produced and caused the magnetic field will also appear around the other coil, which is the reason that the wireless energy transfer is set up between those two coils. Energy will be transfer when both coils will have same resonant frequency.

1.1. Early History of Wireless Energy Transfer

The early history of wireless energy transfer involves two main figures that are Nikola Tesla and the group of researcher from Massachusetts Institute of Technology (MIT).

1.1.1. Nikola Tesla

Nikola Tesla was born on July 9, 1856 in Yugoslavia. Tesla had a special talent that is able to imagine things so well that they seemed real. This allowed him to build mental rather than physical prototypes that led to successful design. The weakness of him is took very poor notes. He only wrote down those things that he seem absolutely necessary or important. Tesla was far beyond his time in his experimentation. In 1899, he went to Colorado Springs to build a laboratory and try to find out some new ideas. One of the ideas was the wireless transmission of energy. He had build a resonant transformer called as Tesla coil, achieved a major breakthrough in his work by

transmitting 100 million volts of electric energy wirelessly. In his experiment, he was able to light 200 lamps, 26 miles away from his lab to light up a bank and run one electric motor.

He claimed that can transfer electrical energy at 95% efficiency, but he technology had to be shelved because the effects of transmitting such high voltages in electric arcs would have been disastrous to human and electrical vicinity [1]. Tesla theories of the wireless transmission of energy were a little different than today's vision. It was centered on his consideration of the earth as a giant conductor. Tesla transferred energy directly through the earth's surface [2].

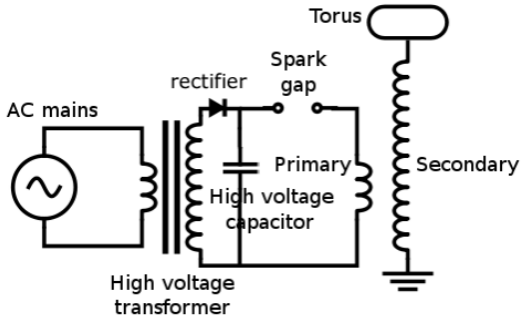

Figure 1.1.1: Basic configuration of Tesla coil.

By referring to figure 1.1.1, the high voltage capacitor forms two resonant circuits: one with the primary coil, and another with the secondary coil. The voltage is supplied by the high voltage transformer. The spark gap consists of two electrodes separated by a gap, filled with an inert gas. When high enough voltage is applied across it, a spark forms, ionizing the gas, and allowing conduction. As the voltage across the spark gap increases, the charge across the capacitor also increases. When the gap sparks, the capacitor discharges into the primary and the secondary. Thus, the voltage "bounces" back and forth at an extremely high rate. When the rate of discharge between the capacitor and primary coil, matches that of the capacitor and secondary coil, the two

circuits will be in resonance. The voltage rises to such high levels that it is discharged through the discharge terminal in the form of an electric arc [1].

1.1.2 MIT Scientist

In 2007, for the first time after almost 120 years, a group of scientist from the Massachusetts Institute of Technology (MIT) led by professor Marin Soljacic had a breakthrough in the principle of wireless energy transfer and carried out a middle distance wireless energy transfer by resonance coupling of electromagnetism, where its efficiency was about 40%[8]. By using electrodynamics induction, they successfully wirelessly powered a 60W light bulb from a distance of 2 meters.MIT researchers has proposed a high frequency more than 10MHz scheme based on strongly coupled resonance for medium range and non radiative wireless energy transfer. The scheme which is considered to be non-radiative and anti-jamming could achieve a medium range wireless energy transfer. They investigated the range and rate of coupling and the interference of extraneous objects in the view of magnetic field coupling [3].

1.2 Problem Statement

Wireless energy transfer is useful in cases where instantaneous or continuous energy transfer is needed but interconnecting wires are inconvenient, hazardous, or impossible. There are few problems that officially lead us to contribute this project. The main problem is users have to plug in their electric device when the battery runs out. Many of today's electronic devices, such as cell phones, laptop computers, and personal digital organizers, is that despite their portability and ability to communicate wirelessly, these devices still require regular charging usually by plugging into a wall outlet.The second problem of statement is the battery that we are uses today; most of them are environmentally unfriendly. This is because the electrolyte and the lead content in the battery can cause environmental damage and difficult to decompose in the land. The

third problem of statement is high cost of wiring and maintenance. With wireless energy transfer model, the wiring system at homes or offices also can be reduces.

Wireless transfer energy is an intimidating task because few people have ever been able to perform it efficiently at longer distance and then only with a very low amount of power. Even though there are many applications that would benefit from the ability to transfer energy wirelessly such as the charging of laptop personal computers and cell phones, but the theories about the wireless energy transfer are still very little and studies about it are only from physics. So, this prototype is important to show and demonstrate the concept of the wireless energy transfer to the public hopefully the appropriate technology will be developed from time to time to satisfy these applications.

1.3 Objective

This report proposes a wireless energy transfer prototype that is targeted at delivering enough power to light up a 3V of LED. It was used as the target for the amount of energy needed at the receiving coil. This project is a starter idea for the next consumer products after this. So, at the beginning of this project, we only focus on the production of prototype models to help people to more understand about the concept of wireless energy transfer. The objective of this study is first to investigate the principle of the electrical energy transmission, efficiency optimizing the structure and parameters, and determining the controlling method.The second objectives is to build a prototype model that can delivered electrical to light up a 3V LED receiver wirelessly.

1.4 Scope of Work

When we discuss about transferring energy without wire, the method of transferring must be choose. In this project, we choose to transfer energy wirelessly based on magnetic couple resonator. The reason we choose this method on transferring

energy is because it non radiative and have the big potential to be apply to the electronic consumer.

The scope that covered in this project is only on hardware. For the aspects of hardware it consists of a transmitter, a handmade air core inductor which acts as an electromagnetic resonator and a receiver, another copper coil of similar dimensions to which the 3V LED to be powered is attached. We use 12V transformer to step down voltage from 240V to 12V. We will supply 12V AC to make the coil to oscillate and produce magnetic field. It also will connect to function generator to supply high frequency to transmitter. We will analyze the parameter based on frequency and distance. Means, from the prototype model we will show how the distance will affect the transferring of electrical energy transmitter to receiver.

1.5 Methodology

The prototype of WET consists of AC voltage power supply, 12V step down transformer, capacitor, transmitter and receiver inductor and 3V BLUE LED. To design the prototype, it all starts with the transmitter coil. From our calculation, the transmitter coil needs to create 126.4 KHz square wave AC signal. The secondary coil must have the same frequency because the wireless energy transfer system operates at resonance frequency. Thus, we start to build inductor by using a plastic circular coil former and enameled cooper wire. The construction of handmade inductor must be doing with carefully because it is very sensitive. It is to make sure that we get the accurate value of inductance. If we do not get the actual value of inductance, it is difficult to us to setup the proper frequency which enables to transfer electrical energy wirelessly.

After that, we calculate the appropriate value of capacitor that we must used by depend on the resonance frequency of the transmitter coil. So, to make easier to determine the frequency, we will use oscillator circuit. The oscillator circuit is a combination of an inductance with a capacitor for frequency determination, called as

LC oscillator. Resonance of a circuit relating capacitors and inductors occurs because the collapsing magnetic field of the inductor generates an electric current in its windings that charges the capacitor, and then the discharging capacitor provides an electric current that builds the magnetic field in the inductor, and the process is repeated continuously. The overall process will be explained more detailed in chapter 3.

1.6 Thesis Outline

The remainder of this thesis is organized as follows:
Chapter 2, *Theoretical Review*, in this part, we will describe in detail the concept of electromagnetic involved in the design of wireless energy transfer model. This is will help us to more understand how the wireless energy transfer works.

Chapter 3, *Literature Review*, analyzes the history of wireless energy transfer. This chapter considers historical references to wireless energy transfer as well as an analysis of the contemporary works dealing with the subject. In this part, we will analysis the others method of transferring energy as comparison to the method that we use. It also considers issues and concerns related to wireless energy transfer.

Chapter 4, *Research Methodologies*, shows the experimental procedure that was made in order to build the prototype system. Each component of the prototype is discussed and will be explain detailed.

Chapter 5, *Result and Discussion*, shows the result that was performed in order to verify the prototype was working properly. These chapters also will shows how the system performed in the various wireless energy transmission trials that were performed. It also will discuss and analyze the result that we get from the experiment.

Chapter 6, *Conclusions and Recommendations*, draws conclusions from the results, and recommends future areas for research.

CHAPTER 2

THEORETICAL REVIEW

2.0 Understanding the Concept of Electromagnetic Inductive Coupling.

In this part, we will describe in detail the concept of electromagnetic involved in the design of wireless energy transfer model. This is will help us to more understand how the wireless energy transfer works.

2.1 Concept of Electromagnetism

Magnetism is a basic force of nature that causes certain types of material to attract or repel each other. Permanent magnet is an example of objects having stable magnetic fields. Oscillating magnetic fields diverge with time, and can be supplied by alternating current flowing on a wire. The strength, direction, and level of magnetic fields are regularly visualized by drawings of the magnetic field lines.

Electromagnetism is the strength that causes the interaction between charged particles. The area in which this happens is called electromagnetic fields. Electromagnetism produces both electric fields and magnetic field. Both fields are

simply different aspects of electromagnetism, and therefore are basically related. Thus, a changing electric field generates a magnetic field and on the other hand a changing magnetic field generates an electric field. This effect is called electromagnetic induction, and is the starting point of operation for wireless energy transfer system

The figure 2.1.1 below shows the form of the magnetic field around the wire. A circular magnetic field develops around the wire. The field generated is perpendicular to the wire and that the field's direction depends on which direction the current is flowing in the wire. Because the magnetic field around a wire is circular and perpendicular to the wire, an easy way to increase magnetic field is to coil the wire.

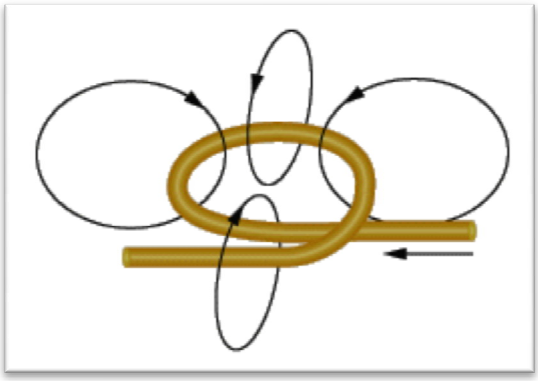

Figure 2.1.1 The magnetic field around wire.

For example, if you wrap your wire around a nail, connect the wire to the battery and bring one end of the nail close to the compass, we will find that it has a much larger effect on the compass. In fact, the nail behave just like a bar magnet.

2.2 Electromagnetic Induction

Electromagnetic induction is a term used to describe the construction of electromagnetic force by two apparently quite different mechanisms. The first one is the