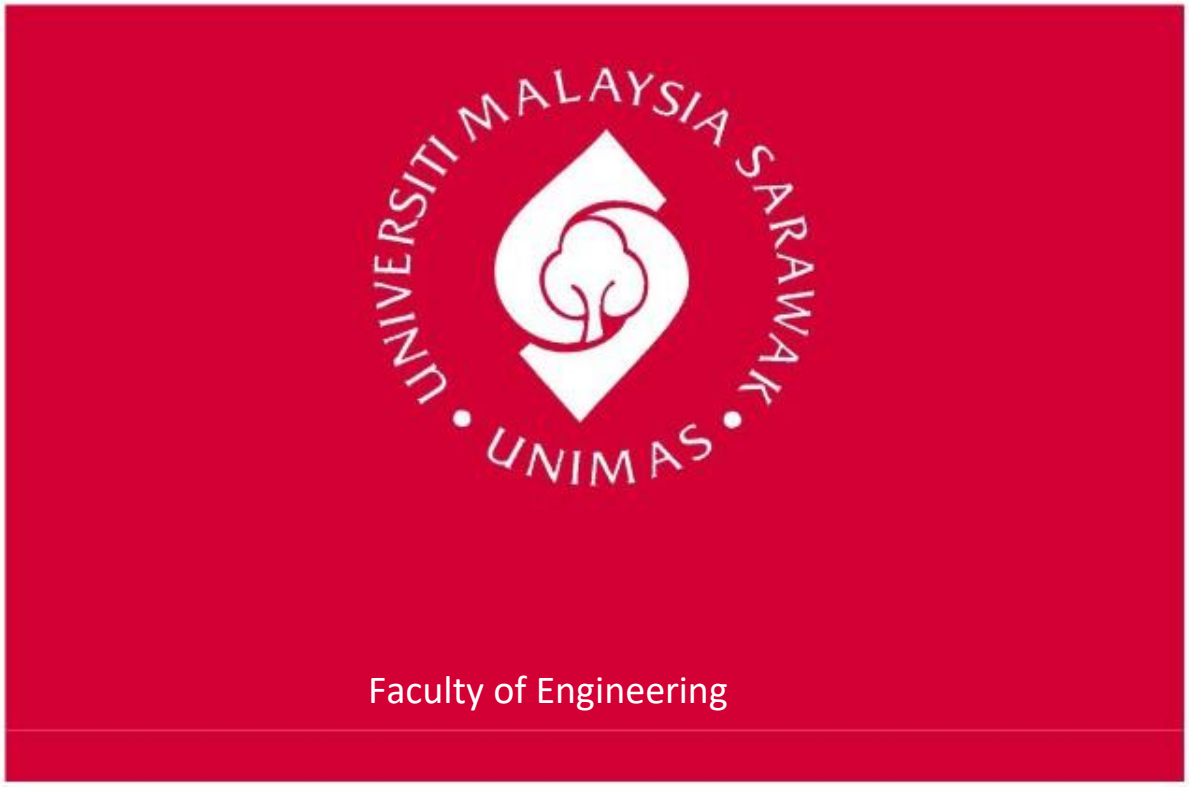

INVESTIGATION OF WIRELESS POWER TRANSFER BY USING VISIBLE LIGHT

Nur Akmal Bin Jamal

Bachelor of Engineering (Hons)

Electrical and Electronics Engineering

2019

UNIVERSITI MALAYSIA SARAWAK

Grade: A-

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Final Year Project Report ☑

Masters ☐

PhD ☐

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INVESTIGATION OF WIRELESS POWER TRANSFER BY USING VISIBLE LIGHT

NUR AKMAL BIN JAMAL

A final year project report submitted in partial fulfilment of
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ABSTRACT

Today with the advancement of technologies and it is widely used in every community where every person is a user of a mobile phone, laptop, notebook and many other electronic device. These electronics supplied power through wired transmission from power supply and/or plug-in cables. Energy transfer via wires or cables creates mess and unpredictable appearances that can cause to a greater power loss and this lead to wireless power transfer transmission. The transmission of wireless power is currently a well-known subject. When a system is within the range of the transmitter, energy can be transferred. The aim of this project therefore is to understand the concept of the wireless power transfer and to examine other kinds of media or medium which are used for the transmission of power instead of the traditional induction coil method. Traditional induction coil is widely used and still it has its own weaknesses and limitation that cause it hard to be used and also harmful when the greater radiation from the coil. The media or the medium that will be used as the transmitter is the visible light which it can be obtain easily and anywhere or any place. The circuit is designed with the aid of multiple software Proteus, Matlab and Fritzing to ensure the design and it hardware can function properly and accordingly to the simulation from the software during implementation of the hardware. The project hardware is also proved by the use of only some key elements such as photovoltaic cells, transistors, voltage controllers, resistors, diodes etc.

ABSTRAK

Hari ini dengan kemajuan teknologi dan ia digunakan secara meluas dalam setiap komuniti di mana setiap orang adalah pengguna telefon mudah alih, komputer riba, komputer riba dan banyak peranti elektronik lain. Elektronik ini membekalkan kuasa melalui penghantaran berwayar dari bekalan kuasa dan / atau kabel pemalam. Perpindahan tenaga melalui kabel atau kabel menghasilkan penampilan yang tidak dapat diramalkan dan boleh menyebabkan kehilangan daya yang lebih besar dan ini membawa kepada penghantaran pemindahan kuasa tanpa wayar. Penyampaian kuasa tanpa wayar kini menjadi subjek yang terkenal. Apabila sistem berada dalam julat pemancar, tenaga boleh dipindahkan. Oleh itu, matlamat projek ini adalah untuk memahami konsep pemindahan kuasa tanpa wayar dan untuk mengkaji jenis atau media lain yang digunakan untuk penghantaran kuasa dan bukannya kaedah gegelung induksi tradisional. Gegelung induksi tradisional digunakan secara meluas dan masih mempunyai kelemahan dan batasannya sendiri yang menyebabkan sukar untuk digunakan dan juga berbahaya apabila radiasi yang lebih besar dari gegelung. Media atau media yang akan digunakan sebagai pemancar adalah cahaya yang dapat dilihat dengan mudah dan di mana sahaja atau di mana-mana tempat. Litar ini direka bentuk dengan bantuan pelbagai perisian Proteus, Matlab dan Fritzing untuk memastikan reka bentuk dan perkakasan ini berfungsi dengan baik dan sesuai dengan simulasi dari perisian semasa pelaksanaan perkakasan. Perkakasan projek juga dibuktikan dengan penggunaan hanya beberapa unsur utama seperti sel fotovoltaik, transistor, pengawal voltan, perintang, diod dll.

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CHAPTER 1

INTRODUCTION

A wireless power transfer (WPT) has grown and it is now possible to transfer power without the need for current-carrying wires or physical connectors which only need to supply power through an air gap. Most of the devices now can use WPT to supply power as recharge mobile phones and tablets, drones, cars, even transportation equipment[1].

In 1980, Nikola Tesla has demonstrated that there are three wireless electricity transmissions: solar cells, microwaves and resonance. As in electrical devices, electromagnetic radiation is using microwaves to transmit from source to a receiver. Essentially, two coils are involves which are the transmitter and a receiver coil. AC current is used to power the transmitter coil where the magnetic field is produce. Therefore, in turns it will induce a voltage in the receiver coil[2].

The remarkable and innovative development of the WPT with a wide application ranging from cell charger to meet all sort of energy thriving application on earth. There are the list of factor that impact the development of the WPT technology.

The first factor is device mobility and the innovation of wireless power transmission enables electronic gadgets to be charged wirelessly without cable connection. They really don't have to be connected to the AC outlet. The carriage of battery- based nodes3 wired chargers in WSN 's is neglected by this wireless charging strategy and no need to search for the plug- in point to connect it. The load is charged simply by receiving it in WPT, there are different sorts of wireless transmission to the charging zone. The existing high- power transmission lines, cables and towers are completely eliminated [3].

Next is the WPT technology is cost- effective and is not wasted. The WPT is very cost-effective compared to the traditional wired power transfer platform. The power is transferred directly to the air medium load by simply affixing a receiver coil to the load. No need to replace the damaged cables. The amount of electrical waste was reduced by the deletion of cables. Resonant magnetic power is used to reduce power wastage[3].

In addition, the efficient and safe is also the factor that affects the development of the WPT. Wireless power can be used in safe environments such as explosive or corrosive atmospheres, underwater or any place where there is a risk of safety when an electrical connection is made or a corresponding flash is broken. In wired power transmission, the power can suffer from high voltage damage [3].

Furthermore, the reduction in maintenance has also affected WPT's development. Maintaining power lines is a very complicated process in the traditional method. The copper cables are damaged and loosened due to the high load transfer; these situations are handled by the human interface by tightening or replacing new cables. These issues are addressed through the WPT approach [3].

These factor leads too many benefits of the WPT. These benefit people in terms of safety, durability, ease of use and aesthetics. As for it safety factor, it is much safer to use because there will be no short circuiting or any electric shocks could happen which is safer not just for the user but also for children or animals. It also will be no corrosion that can happen as there is no wire are use in the system. In term of durability, it does not need any maintenance as there is no moving part is involve in the system. As for WPT using an inductive coupling, it is water and also whether proof. Therefore, it is not affected to the dirt and chemicals. As for it design, it is very strong, tough and does not occupy much space. It also does not need wires that could tear and the connections are consistent and secure. WPT can be very convenient and ease to use. It does not need any electrical plugs and it also can be doing two task in one time which is data transfer and charging wireless. As for charging, it can connected automatically and it can be used by all types of charging which make it easier implanted devices charging. In terms of WPT aesthetics, it can prevent unnecessary street clutter, aware of the historic city aesthetics, maintain valuable footpath area and also remove the untidy overhead cables[4].

Beside that there also a drawbacks for the wireless power transfer which are related to the biological effects, safety, costs, security and performances. For biological effects, the resonant inductive coupling has a lower transmission technique compared to microwaves, but has a far lower range. As for safety reason, the radiation level given out from WPT is equal of cellular phones. Besides that, the cost for implementing WPT systems is very high costs as it can lead to lower spreading rate. As for the security reasons, it can transfer wirelessly, the power can be easily stolen. The disadvantages of WPT on the performance are that it has the low efficiency and increased resistive heating compare to the direct contacts. Besides, the Qi standards only

available for the lower power transfer up to 5W.as for the connection from the transmitter to the receiver; it must have a clear line of sight and also media through which they are travel. As for the mobility, WPT such as inductive and microwave are not suitable for powering a moving target[4].

1.1. Problem Statement

As for inductive coil power transfer the coil structures is using a magnetic field coupling that are compose of a transmitting (TX) coil and a receiving coil (RX) coil, due to this it will produce an electromagnetic-field (EMF) noise. Electromagnetic-field is formed around the coil when the current flows through the TX or RX coil. An EMF noise is the source of interference where the field is interfering with another devices or system although the fields are used for power transmission. Example of EMF problem can be seen on AM radio. EMF noise is distributed around the TX and RX coils when a WPT system using a magnetic field coupling is operating. Thus, the EMF noise interferers with the AM radio and result a beeping sound can be heard when the radio is located near the WPT system[5].

Next, the unstable atom is due to the radiation of wireless power transfer and it is the form of wave particles which transfer or spread in the form of particle or wave or rays through the space. As for EMF, it is dividing into other different types of radiation which is radio, microwave, infrared, and ultraviolet radiation. The x-rays are ionizing radiation that has enough energy to eject the electron from the atom or molecule and also change the chromosomes, gene and other component of cells[6].

The limitation of wire or cable also case a problem to the user. Wire and cable on a charger may look untidy and also easily damage because of keep folding the cable. With now mobile phone there also different type of usb cable used by certain phone may cause it hard to share cable with others.

From the efficiency point of view and also the distance, wireless inductive power transfer only favorable as in general power application if only the receiver and transmitter coil is close to each others. It is not feasible for inductive power to transfer power in larger space due to the very low efficiency [7].

1.2. Scope of Project

This project is to investigate and study the wireless power transfer using a visible light. PWT using visible light lead to a safer usage of power transfer where it is non-radiative method as visible light is safer than induction coil and others energy in the energy spectrum and has a big potential to be applied to the electronic consumer nowadays. The project will focus on the visible light which LED, incandescent light, and fluorescent light will be use as the transmitter. The reason for these type of visible light is selected because these kind of light is practically use in the house or at any place. Therefore when there is these type of light presence, the device will automatically charge just like the solar power principle but with the use of visible light.

The PWT using visible light will be measured the power efficiency, distance of parameter that going to be analyze, it current and voltage. Hardware for this project will be mainly to investigate and test the power transfer using a visible light whether it may light up the LED and transfer power. For this project the component that are needed are LED and incandescent/fluorescent/LED light as for the transmitter and also as a load to test the power transfer, photoelectric as the receiver end, battery as the source. The transmitter and receiver will play a huge role in term of power transfer as light source is very easy to get and it may produce energy everywhere as long there is a light.

1.3. Objectives

i. This project is to understand the concept of wireless power transmission.
   - Wireless power transfer is widely used for transmitting data and charging where there are many method for WPT such as inducting coil, microwave, infrared and radio wave

ii. This project is also aim to investigate whether the visible light can transfer power.
   - Visible light has energy where this energy can be harvest to electrical energy by using the photodiode which has the same principle as the solar energy.

iii. To develop a safe and easier wireless power transmission.
   - Harvesting power from the visible light is much safer and also light source can be finding anywhere and any place.

1.4. Topics Outlines

Final year project will be included with five chapters and each chapter conducted will contained all details about the WPT using visible light. For the first chapter which is the introduction, this chapter explained and gives overview on the WPT. It will elaborated briefly about the WPT which including the problem statements, WPT obligations, objectives of the project and the scope of works as guidance to investigate and develop a working prototype of WPT using a visible light.

For the next chapter which is chapter 2 is about the literature review. This chapter contained the elaboration, explanation and research on the main ideas of the WPT using visible light. It also considers historical references to the WPT as well on the analysis of the contemporary works dealing with the subject. Besides that, literature review considers the issues and concerns related to what is all about the WPT.

For chapter 3 which is the methodology, an experimental procedure prototype of the circuit is built in order to test the WPT of the visible light. During the methodology, each of the steps designing the prototype is discussed and explains briefly. Besides from the design procedure, the hardware implementation also will be explained in this chapter with a few calculations for the energy transfer.

Next, for Chapter 4 is the result and discussion. In this chapter, it will shows the result that will be collected from the hardware implementation and calculation is made. The result will be recorded, explained and compared with each other in detailed and the graph of the result will be presented accordingly.

Finally, Chapter 5 will be the conclusion and recommendation. From all the result and analysis collected, conclusion will be made as the study of the project is successful or not. As for the recommendation will made whether there is any recommendation can be made to increase the chance of the project to be more successful.

CHAPTER 2

LITERATURE REVIEW

2.1. Basic of Wireless Power Transfer

Nikola Tesla began to invent the famous Tesla coils early 1889, which are wirelessly transferable. The history of wireless power transfer began. Research has begun on the transfer of wireless power. Tesla tests explain the bulk of modern inductive transduction methods, such as those used by Tesla to enhance transmission power through a strongly connected resonating circuit. Secondly, the secondary side of self-capacity was used to improve the quality factor. Finally, Spark releases have been used above the air-gap to improve the resonant circuit's power. William C. Brown invented the basic system of microwave beams in 1964, a point-to-point wireless transmission system[8].

In 1968, US engineer Peter Glaser suggested that a solar power plant be built into space and further demonstrated that solar power could be transmitted to earth by the form of microwaves and then by OPEN ACCESS energy[8].

In the 1970's, enormous progress was made in the SPS project, indicating the achievement of this technology for the transmission of electrical energy by people. Wireless power transmission brought back to the world in 2007, a strong combined magnetic resonance system (MRM) was suggested by the MIT research team led by Professor Marin Soljacic and which transfers 60 watts wired with an efficiency of more than 40 percent over 2 meters. In 2008 Korea Advanced Science and Technologies Institute researchers developed a prototype of electric road vehicles (EV) called online system efficiency electronic vehicles with an efficiency of about 70 % [8].

Some of the common wireless charging methods are carried out by direct induction and resonant magnetic induction. Other approaches include the use of electromagnetic radiation as a microwave or laser and the use of natural media electric wiring. Electromagnetic induction, electrostatic induction, electromagnetic radiation, microwave method, laser process and

electrical conduction are some of the most common methods used for wireless transmitting of electricity[8].

2.2. Wireless Electricity Transmission (WET) technology

Wireless power transmission is a process in which electricity is transferred from the power source to an electricity load in any type of system. This process is unique because the system is not connected to a power source by using any type of wiring[9].

Wireless power is primarily transmitted by means of a microwave, and cables, towers and grid stations do not need to be used. It is possible to develop three methods or approaches shown below[9].

2.2.1. Short range (Induction)

For example, the transformer in which a transfer is made because of mutual induction is only a few centimetres[9].

2.2.2. Moderate range (Adaptive Inductive Coupling)

The Witricity of Adaptive Inductive Coupling means that electronic objects can be charged automatically using wireless power transfer technology. Our technology's ability to secure, efficient and long-range power transmission can enhance products. This wireless principle is based on the use of coupling resonant objects to transfer power to objects without the use of any cable[9].

2.2.3. Long range

Wireless energy plans require electricity to be moved over several miles. The technology of sending power to Earth is the long distance wireless power. Many new techniques exist, but here we only use two[9].

2.2.3.1. Solar Power Satellite (SPS)

Use of Satellite Solar Power (SPS). This task is often accomplished with the use of the high-Earth solar energy satellite (SPS). This satellite transforms sunlight into energy; microwaves are the energy. The microwave signals are transmitted to a ground / main grid (MGS) antenna. These waves are transferred from MGS to a BGS (Base Grid) so-called rectenna that converts the electricity from the microwave into DC. In each house, there is an energy recipient or energy router. In the grid station, the information on energy and electricity required for each house is available[9].

2.2.3.2. WET Technology (Without SPS)

Using WET (Without SPS) technology. Another way is very straightforward. Electricity can be produced at MGS by (hydro, thermal, wind, solar) and converted into microwaves by reverse réctennes or microwaves and transferred to the Base Grid Station (BGS) by sending antennas and transmitting electricity to the home wirelessly, as discussed in section 2.2.3.1. [9].

2.3. Wireless Portable Communication Apparatus Charger

Mobile communication devices generally include clashes divided into folder, bar-type devices, swing devices and sliding devices. Personal Digital Assistants (PDAs) and laptop computers are also included in the table communication devices. Mobile communication equipment uses its energy source from a charged battery pack, so battery chargers are insignificant supplies[10].

A battery pack is connected with a charger for applying a voltage to the battery pack by means of a mechanical contact between their contacts terminals in accordance with a method of charging used at the moment. A charging terminal of the battery pack contacts a conductive output terminal that is attached to a charger during charging in a conventional charging system. Different kinds of battery packages have their own chargers for such a charging system, which cannot be used with others[10].

An interface connector that is embedded in a terminal is connected by a connection cable in a pin mode using another conventional charging method.

However, conventional battery chargers are generally inferior to mechanical contact, but are not in good contact. For example, foreign materials may cover the power-supply terminal and thus disrupt electrical contact. In addition, after extended use, the battery packs or charge terminal may be worn down and thus cannot be supplied properly[10].

Typically conventional chargers don't work with various battery packing types. In conventional art, a dedicated charger must therefore also be manufacterized on the basis of the size and shape of the battery pack as well as the placement of the contact terminal each time new type of terminal is developed and manufactured. This increases loaders ' production costs[10].

Furthermore, conventional battery chargers have only one basic function to connect to electrically charging battery packages. In other words, no additional function for the terminals to be sterilized or cleaned to remove any foreign substances is provided[10].

2.4. Basics of Solar Photo Voltaic Technology

Sunlight is directly converted into electricity by solar cells which scientists also call the electrical phenomenon (PV). PV is named after a power transmission action (photons) known as PV effect (voltage). The component, which semi-conducting material, silicone which has been found in sand, generates electric charge when exposed to sunlight, was found in the year 1954 by researchers at Bell Telefone. Satellites and other things, including calculators and clocks, were soon to be applied to solar cells [11].

The old solar cells are produced from a semiconductor, silicon, which is typically flat, and are generally the most economic. Solar cells of second generation are known as thin film solar cells due to they consist of amorphous semiconductor or non-silicon materials for example a metal chemical compound. Thin film solar cells only use a few micrometres thick layers of semiconductor materials. Due to their flexibility, thin film solar cells are doubled as shingles and tiles on the top, façades or skylight glazing. [11].

Solar cell unit of third generation that is produced from many new materials, in addition to semiconducting materials, including solar ink mistreatment, standard printing press technologies, solar colours and conductive plastic. Some new solar cells utilize plastic lenses or mirrors to focus daylight on a small piece of PV material with high potency. The PV material

cost a lot of money, but as a result of this very little is required, these systems become cost - effective for utility and commercial application. Since the lenses should be pointed to the sun, however, the application of concentrated collectors is limited to the most sunlight parts of the country[11].

2.5. Monocrystalline Silicon Cells

Solar cells made from thin silicon wafers are the oldest solar cell technology and still the most popular and efficient. These are called monocrystalline solar cells because the cells are split from large, carefully controlled single crystals. The cells are usually a few inches wide, and several cells are placed in a grid to create a panel [12].

They have a higher efficiency which is up to 24.2 percent compared to other types of cells, which means that you get more power from an area of the panel. This is useful if you have only a limited area for mounting the panels or if for aesthetic reasons the installation is small. However, the production of large pure silicon crystals is a very energy-intensive and difficult process, which makes the production costs of this type of panel the highest in all solar panel types historically [12].

Production methods have improved though, and over the years prices have fallen considerably both for raw silicone and for the production of panels from monocrystalline solar cells, driven partly by competition with the production of other types of panels [12].

Another problem that needs to be remembered in relation to panels made of single-crystalline silicon cells is that they lose their efficiency with the increase in temperature in the region of 25ºC, so that air circulates through and under panels, thereby improving their efficiency [12].

2.6. Polycrystalline Silicon Cells

It is less expensive to manufacture silicon wafers in moulds using various silicon crystals rather than a single crystal as the growth conditions must not be tightened up. In this way, a number of silicone crystals are interlocking. Panels based on these cells are cheaper per unit area, but slightly more efficient than monocrystalline panels which is up to 19.3 percent [12].