UNIVERSITI TEKNIKAL MALAYSIA MELAKA

WIRELESS PHONE CHARGER

BY USING

INDUCTIVE CHARGING

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Electronic Engineering Technology (Industrial Electronic) with Honours.

by

AMRU SHAHRIL BIN ISHAK

B071310928

921118-14-5229

FACULTY OF ENGINEERING TECHNOLOGY

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DECLARATION

I hereby, declared this report entitled “Wireless Phone Charger by using Inductive Charging” is the result of my own research except as cited in references

Signature : ……

Author’s Name : ……

Date : ….....…….

APPROVAL

This report is submitted to the Faculty of Engineering Technology of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for the degree of Bachelor of Electronic Engineering Technology (Industrial Electronic) with Honours. The member of the supervisory committee is as follow.

……

(Project Supervisor)

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Bismillahirrahmaanirrahim,

In the name of Allah S.W.T, the most compassionate and the most merciful.

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ABSTRACT

This project is about wireless energy transfer by using inductive charging method. Inductive charging is a method that makes use of magnetic field to transmit energy, where in this project, voltage. There is however, no open research about multiple output by using inductive charging, whereas, magnetic field does affect surrounding. This project tries to understand and learn to manipulate the magnetic field for multiple outputs. The concept of multiple outputs foreseen the energy saving during the charging multiple phones at the same time. In the same time, since the project is creating wireless phone charger, the wires to transmit charging now days are prone to breaking is also capable of being solved. Overall, this project is to learn a way to provide energy saving and better solutions to breaking charging wires for mass.

ABSTRAK

Cas induktif ialah teknik yang menggunakan medan megnetik untuk pengalihan tenaga, seperti didalam projek ini, Voltan. Akan tetapi, tiada kajian terbuka mengenai keluaran lebih dari satu dengan menggunakan cas induktif. Projek ini cuba untuk mereka cipta sistem pengecas telefon pintar untuk keluaran banyak. Konsep keluaran lebih dari satu diramalkan sebagai jimat tenaga semasa cas lebih dari satu telefon pintar pada satu masa. Sejak projek ini ialah mengenai pengalihan tenaga tanpa wayar, wayar untuk pengalihan cas pada masa kini terdedah kepada putus mampu diselesaikan. Secara keseluruhan, projek ini ialah mereka cipta sistem untuk menyediakan jimat tenaga untuk mengecas alat elektronik kecil.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Nowadays, the use of smart phone is increased by second. However there are several problems that might occur when using the smart phone. As the phone is used with batteries supply, during charging process, sometimes, the wires that connecting the phone with charger is prone to break. One of the solutions is to use wireless energy transfer to set movement of wire in a fixed place inside the phone. This will eliminate the breakage of copper inside the wire that connecting the phone with charger. Since the inductive charging use magnetic field to transfer energy, an idea come that to reduce, or improve energy saving during those charging phase. The idea and problem creates an opportunity to develop a working wireless phone charger using inductive charging with capabilities of multiple charging, hence the project is started.

1.2 Problem Statement

A smart phone is small electronic device that can be charged with inductive charging technology. But today, smart phone is charged using wire as medium between charger and phone, where wire is prone to break inside the protective seal. Since the charger is using wire medium, the charger require 1 port for each charger and this isn't energy efficient. A smart phone wireless charger will eliminate wire problem and use less port than traditional wired charging.

1.3 Objectives

The objectives of this project are:

1. To investigate the different design of phone charger.
2. To study the capabilities for multiple phone charging using inductive charging
3. To develop a wireless phone charger system.

1.4 Scope

The scopes of this project are to build prototype which is an inductive charging that can only charge a phone that using micro USB cable for charging, with $5V_{DC}$ in.

In this project, Proteus Software will be used to design the circuit for the wireless phone charger using inductive charging system. From the design done, PCB layout will be processed for the prototype.

This project also use LC oscillator to create an oscillating circuit to induce the voltage to the coil of primary, as energy transfer method.

This project also cover until up to 2 devices for charging using prototype of wireless phone charger using inductive charging.

1.5 Conclusion

After understanding the problem statement, an objectives and work scope of this project is set to fully focus the path for this project. This set of objective will be researched on the next chapter, to fully understand the requirement for designing a wireless phone charger.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Cell phone chargers now days are being standardized mostly because of the power capabilities and wide availability of the USB connectors. Since USB delivers 5 V, all new cell phones are made to be compatible with this voltage level. However, one of the most frequent failures in chargers for rechargeable batteries of compact electronic devices, such as the cellular phone, is from the mechanical contact. Energy transfer utilizing inductive coupling can overcome this contact failure problem by eliminating requirement for mechanical contact from USB for charging. In a comparative study by S. Ho, J. Wang, W. Fu and M. Sun, it is found that a wireless energy transfer technology is feasible to recharge batteries, particularly in implant devices (Ho et al., 2011). By this case we can build in this charger, the primary core of the transformer is in the charger unit and the secondary is attached to the phone.

2.2 Traditional Charging

To understand how traditional charging works, one need to understand the theory behind it. A traditional charging is basically a step down AC power where later will be converted to DC and regulated to 5V for smart phone usage as shown in Figure 3 below. This kind of power transfer method are widely used in current technology for charging a phone, and the output is connected to a smart phone by USB 2.0 with B side of micro USB (Miller, 2007). However, due to the mechanical contact, the cable male and female, prone to damage, of wear and tear. This damage might cause smart phone unable to charge and a perfectly fine but

damaged at connector phone wasted. Example of basic charging is shown in Figure 2.1 below.

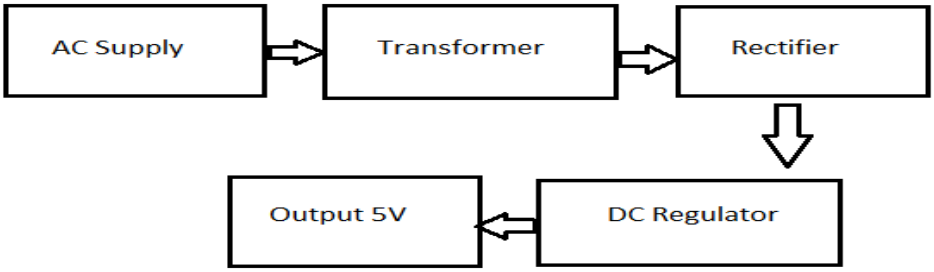

Figure 2.1: Block diagram of traditional charger

2.2.1 Transformer

A transformer is an electrical device that capable to either step up (increase the AC voltage) or either step down (decrease the AC voltage). The capability of doing so is based on electromagnetic induction, which, the induction produces an emf (electromotive force) within a material that conducts electricity which is exposed to time varying magnetic fields. A different current in primary will create a magnetic flux in the transformer material that conduct electricity (core) and this will cause varies of magnetic field of secondary winding, which later will cause an induction of emf at secondary winding thus create a current flow, either high or lower than primary (Calvert, 2001). The secondary high or low output compared to the primary is based on number of turns, in primary and secondary, which can be interpreted as formula below

$$\frac{V2}{V1} = \frac{I1}{I2} = \frac{N2}{N1}$$

where V_2 is voltage at secondary, V_1 voltage at primary, I_1 is current at primary, I_2 current at secondary, N_1 number of turns (coiling) at primary, and N_2 is number of turns (coiling) at secondary. However, this is an ideal transfomer, where there is no loss during power transfer. The real

transfomer have some losses due to eddy current, and/or heat produced by electricity at its core.

2.2.2 Rectifier

A rectifier is an electronic circuit that convert low AC voltage to a low DC voltage. The process of changing positive and negative cycle of voltage to a steady or positive only cycle of voltage is known as rectifying. A basic rectifier use a diode to block a voltage from going positive to negative cycle as diode capable of stopping voltage from flowing from one path to another. Since the capability of diode is to stop flow from one path to another, a single diode is enough to change AC voltage to DC voltage. Since the project only use single phase supply for common usage at home, the project will use either half wave rectifier or full wave rectifier. It is need to be reminded that usage of rectifier will produce a loss around 0.7 Volt per diode use in that particular wave direction.

2.2.2.1 Half wave rectifier

A half wave rectifier is a rectifier use only single diode to block the incoming AC from flowing back. However, there is limit in half wave rectifier, such as, since the diode only blocks half of the full wave of AC voltage; another half of the AC voltage is wasted. Since the wasted voltage, half wave rectifier only produce or yield half or lower voltage output. The half wave also produce more noise compared to full wave rectifier, thus more filtering to eliminate noise of AC, and produce better output (Knott, 1999). Example Figure 2 below shows a positive cycle of a basic half wave rectifier.

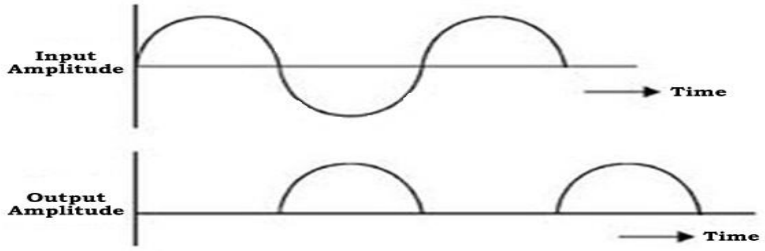

Figure 2.2: Half wave rectifier and activation on positive phase

2.2.2.2 Full wave rectifier

A full wave rectifier uses both, negative and positive cycle of AC voltage thus, maximizing the output voltage, and creating lesser power loss. The design of full wave rectifier is shown in Figure 2.3 below

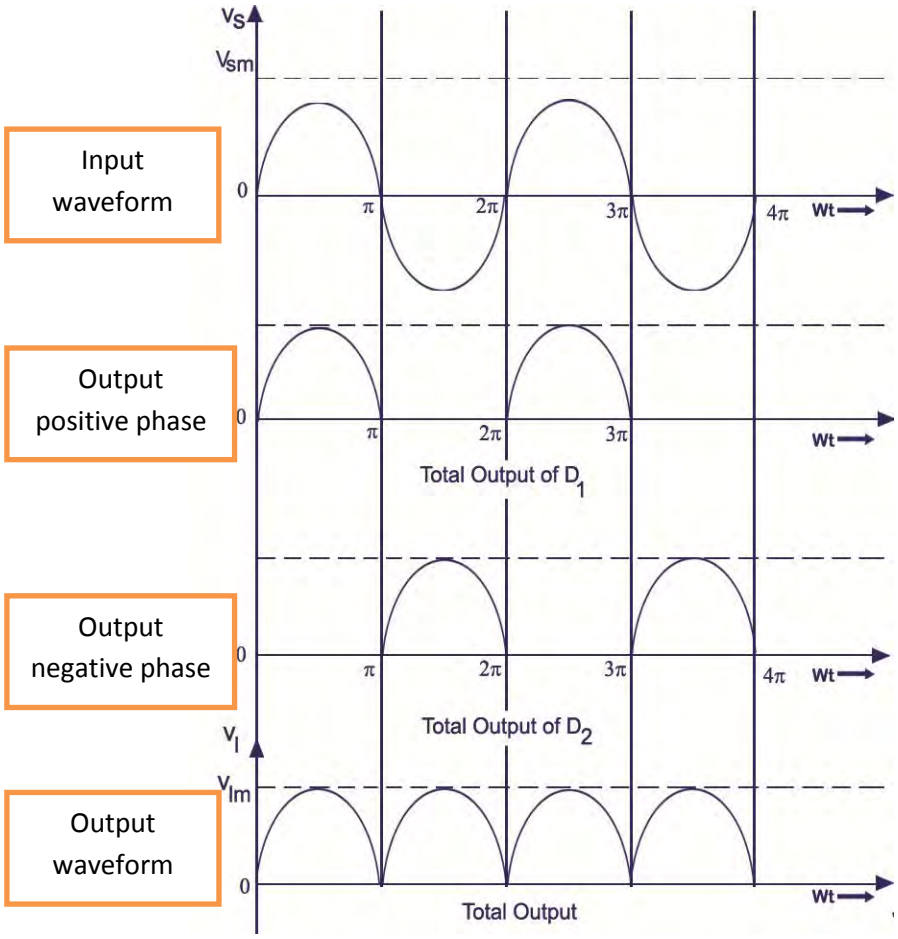

Figure 2.3: Full wave rectifier activation on positive and negative phase

Example shown in Figure 2.3 above, the full wave rectifier use all of voltage cycle. And since the voltage cycle is both forward biased, the output is a pulsating DC that is easier to smooth noises by using a capacitor. However, compared to half wave rectifier, for each cycle positive or negative of full wave rectifier, the output is using two diodes, thus need to be reminded that compared to half wave rectifier, the output of full wave rectifier have losses around 1.7 volt.

2.2.3 Voltage Regulator LM7805

A typical commonly used for 5 volt output voltage regulator is LM7805. It is capable to be used in normal condition temperature between -40°C and 125°C. Since smart phone use around 5 volt 1 amp input for charging, the LM7805 is suitable choice to regulate the output to desired value. The LM7805 also small enough to be fit in casing of typical smart phone. Since the voltage in capability of LM7805 maximum of 35 volt, it is easier to control the output of rectifier, and simpler circuit for creating a stable 5 volt 1 amp output circuit (fairchildsemi.com, 2014).

2.2.4 USB cable

Universal Serial Bus (USB) is a hardware interface for communicating devices such as keyboards, mouse, joystick, storage device, smart phone etc. According to USB 2.0 Specification Engineering Change Notice (ECN) #1: Mini-B connector (usb.org, 2000), the design for USB 2.0 is shown in Figure 2.4 below

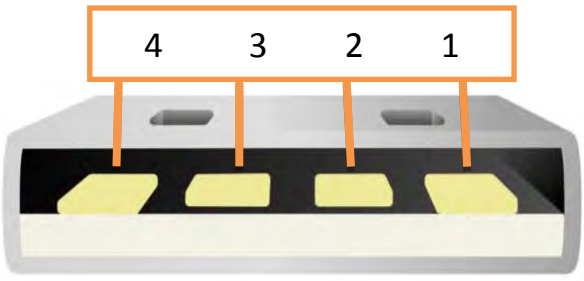

Figure 2.4: USB wiring pin

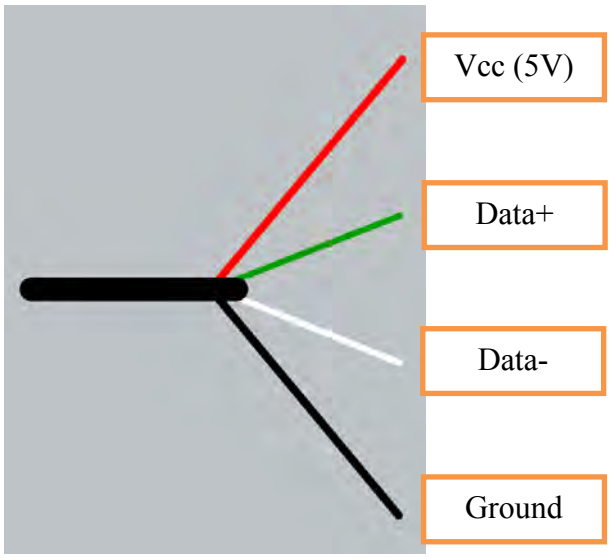

Figure 2.5: USB wiring colour code

Requirement for using USB is to understand the colour coding. The Figure 2.4 and Figure 2.5 show the colour coding of a mass used USB A type connector. If you cut open a USB 2.0 cable you will see 5 different wires. There is a shielding wire which protects data transfer between devices from interferences. There is also, according the Figure 2 which have Red and Black wire where power is transferred from one device to another device. Then there are White and Green wires which form D- and D+ which are used for data transfer. The USB bus can supply $5V_{DC}$ regulated power to each port on pins 1 and 4 according to Figure 2.44, the pins 1 and 4 are longer than the data pins to ensure that the power pins connect first and next the Data pins. Low power devices can then therefore be powered from USB there by eliminating the need of separate power supply such as power adapter.

2.2.5 Micro USB

As the phasing out of mini USB (Miller, 2007), the usage of micro USB is suggested as next generation charging and data transfer female and male connector port. Typical smart phone have a port that used for both charging and for data transfer. A layout of micro USB is shown in Figure 2.6 below, based on micro USB datasheet (micro-USB_1_01, 2011).

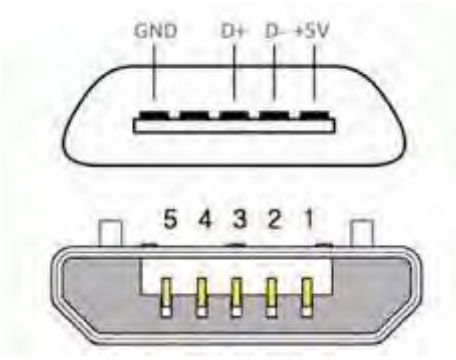

Figure 2.6: Mirco USB wiring pin

Same as in chapter 2.3 USB, to understand micro USB is to understand the pin. The important of number of pin for charger is pin 1 and 5. The pin 1 is the Vcc or supply. This will be the input voltage and will be connected to the smart phone. The pin 5 will be the ground or negative terminal. A completed circuit from phone and charger will later cause voltage able to flow and charge the smart phone.

2.3 Inductive Charging (Wireless charging)

Inductive charging is capable to charge wirelessly a device, whether how big or small the devices are. An example of current usage of inductive charging is to charge a hybrid or electric transport (Wu et al., 2011). A basic understanding of inductive charging is a transmission of power is based on coil where it is near each other. A block diagram in Figure 2.7 show a basic components in inductive charging

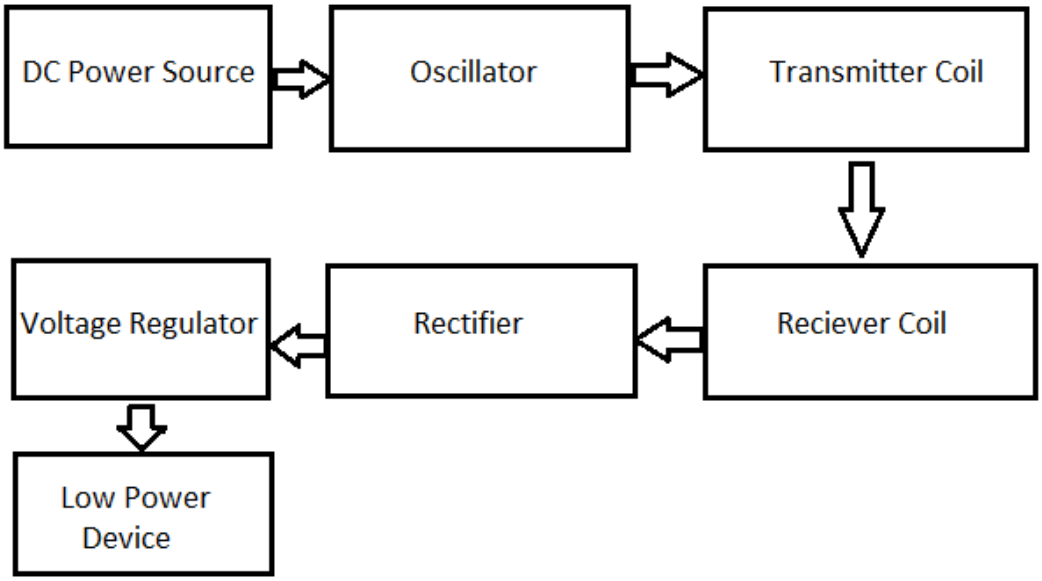

Figure 2.7: Block diagram of inductive charging

Inductive charging (also known as wireless charging) uses an electromagnetic field to transfer energy between two devices. Energy is sent through an inductive coupling charger to an electrical device, which can then use that energy to charge batteries or run the device. Induction chargers use an induction coil to create an AC electromagnetic field from within a charging base, and a second induction coil in the portable device takes power from the electromagnetic field and converts it back into electric current to charge the devices. The two induction coils in proximity combine to form an electrical transformer, or known as air core transformer. Greater distances between primary and secondary coils can be achieved when the inductive charging system uses resonant inductive coupling.

Recent improvements to this resonant system include using a movable transmission coil (i.e. mounted on an elevating platform or arm) and the use of other materials for the receiver coil made of silver plated copper or sometimes aluminium to minimize weight and decrease resistance due to the skin effect. However, the weakness of inductive charging will cause some losses during transfer of energy from primary to secondary coil.

2.3.1 Oscillator

Oscillator is an electronic circuit that produces an oscillating wave of either current of voltage. Typically, oscillator produces sine wave. Oscillator functioning by changing DC to AC. Since this project use inductive charging, a way to change DC to AC is required to oscillate through inductor for transmission through air medium.

2.3.1.1 RC Oscillator

An RC oscillator, component consists of resistor, capacitor, and op-amp, example in Figure 2.8. Since RC oscillator is using feedback mechanism of op-amp, they use several resistor and capacitor to produce a sine wave. However, RC oscillators have low frequency stability, as it depends on resistor and capacitor, where value can change due to temperature (Stevens and Manning, 1971). The feedback RC is to provide correct phase shift at desired frequency so the full circle have 360 degree of phase shift, and resulting a sine wave. As the feedback through a series of RC component, several energy losses are due. To compensate, an amplifier (op-amp) provide gain, where the total gain is higher or equal to unity, the circuit will oscillate.

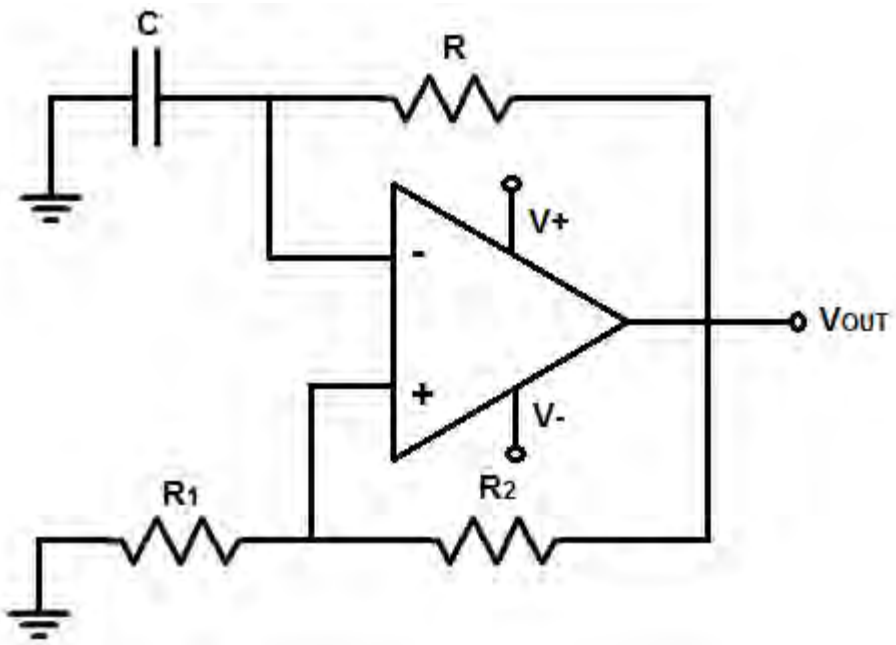

Figure 2.8: Basic RC oscillator circuit using op-amp

2.3.1.2 LC Oscillator

AN LC oscillator, component consists of inductor and capacitor, example in Figure 2.9. LC oscillator is using a concept where capacitor store electric charge between it plate and depend on voltage across it, while inductor store energy in magnetic field depending on current through it. Later, the current will flow from capacitor to inductor, and induce magnetic field while reduce voltage on capacitor. After depleting the voltage reservoir in capacitor, the current through inductor will cause the capacitor to charge up in reverse polatrity. This cause a flow that alternate between negative and positive through inductor and reservoir of capacitor, and cause an alternating current occurs in the inductor. However, there will be losses, but it normally compensated by adding or replenished from external circuit, making it capable of continuously oscillate. This process can happens very fast up to million time per second, thus creating MHz or Mega Hertz of frequency.