DESIGN AND IMPLEMENTATION OF WIRELESS CHARGING SYSTEM FOR ELECTRIC VEHICLE

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CERTIFICATE OF APPROVAL

The project entitled as " **Design And Implementation Of Wireless Charging System For Electric Vehicle** " submitted by **Mohammad Istiak**, bearing Matric ID. **ET-133046** and, **Mohammad Abdullah Al Mamun** bearing Matric ID. **ET-133056** of session **Autumn 2013**, to the Department of Electrical and Electronic Engineering, International Islamic University Chittagong, has been accepted as satisfactory in partial fulfilment of the requirements for the degree of Bachelor of Science in Engineering and approved for the examination held on **14 December, 2017**.

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DECLARATION

It is hereby declared that this work has been done by us and no portion of the work contained in this project has been submitted elsewhere for the award of any degree or diploma.

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All praises and thanks to Allah, the Lord of the world, the most Beneficent, the most Merciful for helping us to accomplish this work.

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We would also like to thanks our parents who gave the inspirations all the time for completing the project.

Authors

ABSTRACT

Wireless power transfer (WPT) using magnetic resonance, it is the technology which could set human free from the annoying wires. WPT technology is developing rapidly in recent years. At kilowatts power level, the transfer distance increases from several millimetres to several hundred millimetres with a grid to load efficiency above 90%. The advances make the WPT very attractive to the electric vehicle (EV) charging applications in both stationary and dynamic charging scenarios. This project used the WPT technology to charge the battery of a car. By introducing WPT in electric vehicles, the obstacles of cost can be easily mitigated. In today's world usage of vehicle rapidly increasing and at the same time decreasing the fuel level and now in electric vehicle wired technology is also repellent and cause electric shock sometimes due to several factors. And sometimes this wired technology of charging causes person injured. Also cost of wired technology is higher due to need of wires. Thus WPT technology can mitigate these factors greatly. By using this technology we can reduce the cost. And charging procedure of this type is very easy, convenient, and safe. In present time of technology wireless power transfer technology is more popular due to its smartness and advantages. By adopting this system it can helps to mitigate several problems occur due to wired technology such as electric shocks, cost, hassles due to wire, charging procedure.

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LIST OF ABBREVIATIONS

MIT	Massachusetts Institute of Technology
AC	Alternating Current
DC	Direct Current
EV	Electric Vehicle
TX	Transmitter
RX	Receiver
LED	Light Emitting Diode
AA	50.5mm*14.5mm
HF	High Frequency
EM	Electro Magnetic
RMS	Root Mean Square
MOSFET	Metal Oxide Semiconductor Field Effect Transistor
PWM	Pulse Width Modulation
GND	Ground
TRIG	Trigger
DIS	Discharge
Vcc	Positive Supply
BJT	Bipolar Junction Transistir
RF	Radio Frequency

CHAPTER 01

INTRODUCTION

1.1 Introduction

Our project was based upon a MIT published paper in the year 2007 titled "Wireless Power Transfer via Strongly Coupled Magnetic Resonances"[1]. The project was researched by former Cornell students Lucas Jorgensen and Adam Culberson in the year 2008 [2]. During the course of this research, we investigated the need and usefulness of wireless power transmission and the feasibility of using magnetic inductive coupling as the means for wireless power transmission. The paper will outline our design process and the logical steps we took in the experimentation and design of our circuits. The first section of the document will explicitly illustrate the goals we set to accomplish during the allotted time frame of three and a half weeks. With the complexity of the problem in mind and what we must accomplish, our team began research on the available means to transmit power without a physical connection.

1.2 Motivation

In this era of technology, all the works are done depending on technology. All types of people are becoming motivated to do all sorts of works to technology, to do more easily within a short time and low cost. The cost-effective charging system achieves high levels of efficiency across the whole power range, from 400 watts to 3.6 kilowatts, while the car and the charging coil can be up to 20 centimeters apart. When it's pouring rain, a driver who has to connect a thick, unwieldy cable between their electric car and a charge spot is sure to get soaked to the skin. But sometimes there's no alternative – the battery is empty. Using wireless inductive systems to charge the car is much more convenient. This involves transmitting energy through the air, or, more precisely, through a time-varying magnetic field. The technology is essentially based around two coils, with one built into a road, a parking space or a garage, and the other fitted to the underbody of the car [3].

In conjunction with suitable capacitors, these coils form a sort of resonant "antenna system for energy transfer. The nearer the two coils are to each other the more efficiently the energy is transferred. Now it is possible & suitable to make vehicles which are charged through electro- magnetic induction process instead of gas/oil based, & this wireless charging system is less cost effective than oil/ gas based & safe than wired charging system.

1.3 Objectives

- The project has a main objective whose achievement is aided by breaking it further down into other smaller specific objectives. This helps in showing comprehensively how the final objective of the project is achieved in a clear and concise manner.
- The main objective of the project is to develop a device for wireless power transfer.
- To decrease the use of oil/gas based vehicles to save the natural fuels.
- To use the wireless charging system instead of wired charging system.

1.4 Project outline

1. Chapter one consists of introduction of the project, motivation, objectives and project outline.
2. Chapter two contains literature review and brief discussion of project.
3. Chapter three includes discussion of the system component and features.
4. Chapter four discussed about circuit diagram and hardware implementation.
5. Chapter five discussed about hardware result analysis.
6. Chapter six is about conclusion of the project.

1.5 Summary

The system has electro-magnetic induction type charging which helps to charge a battery without wire safely. In one words, we shall try to make wireless charging device which reduces the use of natural fuels and to recharge battery easily without wire and to install it anywhere conveniently.

CHAPTER 02

LITERATURE REVIEW

2.1 Introduction

In this chapter the overall project theory and concept will be discussed. The purpose of this project to explain the perspective and method that is used in previous researches or projects and to determine how much this project relate to those research and theory. Moreover, this chapter will show the theory and concept used to solve the project problem. Theoretical understanding is very important as a guide in doing any kind of research.

2.2 History behind wireless charging

The transfer of power was first attempted using radio waves as a medium. Radio waves were first predicted in 1864 by James C. Maxwell. In 1888, Heinrich Hertz showed evidence of radio waves using his spark-gap radio transmitter. Nicola Tesla believed that wireless power transfer was possible and probable. He built what was called the "Tesla Tower" which was a giant coil connected to a 200 feet high tower with ball 3 feet in diameter. Tesla pumped 300kw of power into the device; the coil resonated at 150 kHz. The experiment failed due to the fact that the power diffused in all directions [4]. In the 1960's, much research was put into using microwaves to transmit power. W.C. Brown made what he called a "rectenna". This device received radiofrequencies and converted them into a direct current. Brown succeeded but with low efficiency. Canada successfully flew a fuel-free airplane in 1987 by transmitting a 2.45 GHz, 10 kW microwave to the model plane. Power was also attempted to be transferred through induction. This was first used when, in 1894, M. Hutin and M. Le-Blanc proposed an apparatus and method to power an electric vehicle. However, combustion engines proved more popular and this technology was forgotten for a time [4]. In 1972, Professor Don Otto of the University of Auckland proposed a vehicle powered by induction using transmitters in the road and a receiver on the vehicle. The first application of inductive charging used in the United

States was performed by J.G. Bolger, F.A. Kirsten, and S. Ng in 1978. They made an electric vehicle powered with a system at 180 Hz with 20 kW [4]. In California in the 1980’s, a bus was produced which was powered by inductive charging, and similar work was being done in France and Germany around this time. In 2006, MIT began using resonant coupling. They were able to transmit a large amount of power without radiation over a few meters. This proved to be better for commercial need, and it was a major step for inductive charging. The Wireless Power Consortium (WPC) was established in 2008, and in 2010 they established the standard Qi. In 2012, the Alliance for Wireless Power (A4WP) and the Power Matter Alliance (PMA) were founded. Japan established Broadband Wireless Forum (BWF) in 2009, and they established the Wireless Power Consortium for Practical Applications (WiPoT) in 2013. The Energy Harvesting Consortium (EHC) was also founded in Japan in 2010. Korea established the Korean Wireless Power Forum (KWPF) in 2011 [4]. The purpose of these organizations is to create standards for inductive charging.

2.3 Advantages of wired technology

1. In wired technology charging efficiency is higher than other technology [5].

2. Wired technology required less time for charging than wireless [5].

2.4 Disadvantages of wired technology

Price is a main factor distinguishing wired and wireless technology options in a business. Wireless options command a price premium that can make purchasing wired computers, printers and other devices a financial benefit. Before making the decision to purchase hard wired technology products, a review of the restrictions and limitations of the selections is necessary. Business and employee needs may override any cost considerations. Some of the main disadvantages are as follows:

1. Equipment Portability

Wired technology is not portable. The units must be plugged into power outlets and network ports in order to function. Moving units takes time, energy and, potentially, information technology personnel [5]. These hard wired requirements can make arranging personnel, furniture and equipment difficult. Moves of equipment or employees may require running additional network cabling, installing new electrical outlets and reconfiguring network port structures. Network configuration may limit the options for employee and equipment placement [5].

2. Space

Wired technology components require more desktop space than their wireless counterparts. Office furniture decisions products, such as desktop computers, take up more space than equivalent wireless options. Wires, cables and multiple and employee space allocation must account for the added space needs of wired computer and technology products [5].

3. Employees Mobility

Employees are restricted in their work location when using wired office products. Wireless options allow work in conference rooms, at home, in a coffee shop or at a business contact's physical location. Some employees, such as sales personnel, may require a wireless unit to perform their work duties. Opting for wired technology products may limit the amount and flexibility of work duties [5].

4. Safety

The physical requirements of a wired technology product present some opportunities for damage not noted in wireless products. Cables can be damaged by cleaning crews and mislaid wires can cause tripping hazards. Additionally, always on technology systems may be more prone to electrical surges and damage than wireless units that can be unplugged during storms or power outages [5].

5. Power

Wired units must have power to operate. Stormy weather, electrical problems or a utility wire cut can cause work to stop if the only options are wired technology products. Wireless units with batteries can continue to function for a period of time after being disconnected from power. Work stoppage can hurt productivity and customer service [5].

2.5 Different types of electric vehicle

1. Traditional Hybrid Vehicles: Traditional hybrid vehicles are vehicles with a normal internal combustion engine and an electric battery. It is not usually possible to recharge this battery remotely, but it is recharged by the vehicle itself whilst the car is in motion [6].

2. Plug-in Hybrid Electric Vehicles (PHEV): Plug-in hybrid vehicles also combine an electric motor with a traditional internal combustion engine. However, plug-in electric motors are charged up by plugging the vehicle into a special power station. These vehicles only have a limited range when they are being operated in electric power mode, but they can be switch to traditional fuel power when the electric motor is unable to provide power anymore [6].

3. Fuel Cell Electric Vehicles (FHEV): FHEV cars are powered by an electric motor which is charged-up by combining hydrogen and oxygen to create a chemical reaction. The fuel cell draws in oxygen from around the vehicle which reacts with stored hydrogen. Electricity is generated which powers the motor and moves the vehicle [6].

4. Battery Electric Vehicles (BEV): Battery-operated electric vehicles run entirely on their electric battery. They do not have an alternative fuel source to switch to if the charge of the battery runs down. They are charged using standard charge stations, but they need to be allowed to charge for much longer in order to get the battery to maximum capacity. This helps the vehicle to have a longer range than most of the PHEV vehicles that are on the market [6].

2.6 Luxury EV makers ramp up wireless charging announcements

1. BMW has previously demonstrated wireless charging with the i8, the company uses as a pace car in Formula E racing [7].

2. Already Tesla Model S use wireless charging [7].

3. Audi and Nissan has been vocal about the imperative to "hurry" towards inductive charging as a top executive explained late last year [7].

2.7 WPT (Wireless Power Transmission) technology

WPT technology is an old technology and it was demonstrated by "Nikola Tesla" in the year 1980. Wireless power transmission mainly uses three main systems such as microwaves, solar cells and resonance. Microwaves are used in an electrical device to transmit electromagnetic radiation from a source to a receiver. Accurately the name WPT states that, the electrical power can be transferred from a source to a device without using wires. Basically, it includes two coils they are a transmitter coil & a receiver coil. Where the transmitter coil is powered by AC current to create a magnetic field, which in turn induces a voltage in the receiver coil [8].

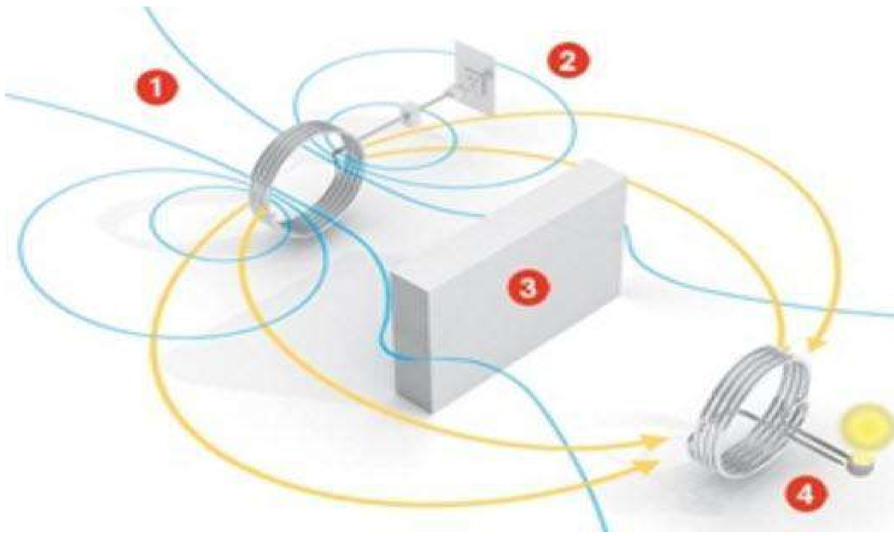

Fig. 2.1: WPT (Wireless Power Transmission) technology [9]

The basics of wireless power transmission include the inductive energy that can be transmitted from a transmitter coil to a receiver coil through an oscillating magnetic field. The DC current supplied by a power source is changed into high frequency AC current by particularly designed electronics built into the transmitter. In the TX (transmitter) section, the AC current increases a copper wire that creates a magnetic field. Once an RX (Receiver) coil is located near to the magnetic field, then the magnetic field can induce an AC current in the receiving coil. Electrons in the receiving device, converts the AC current back into DC current that becomes working power [9].

2.8 Wireless power transfer circuit

The simple wireless power transmission circuit is shown below. The required components of this circuit mainly include 20-30 magnet wire (gauge copper wire), AA battery-2, transistor (2N2222) and LED. The construction of this circuit comprises of a transmitter and a receiver [9]. **Fig. 2.2** shows a typical wireless power transfer circuit.

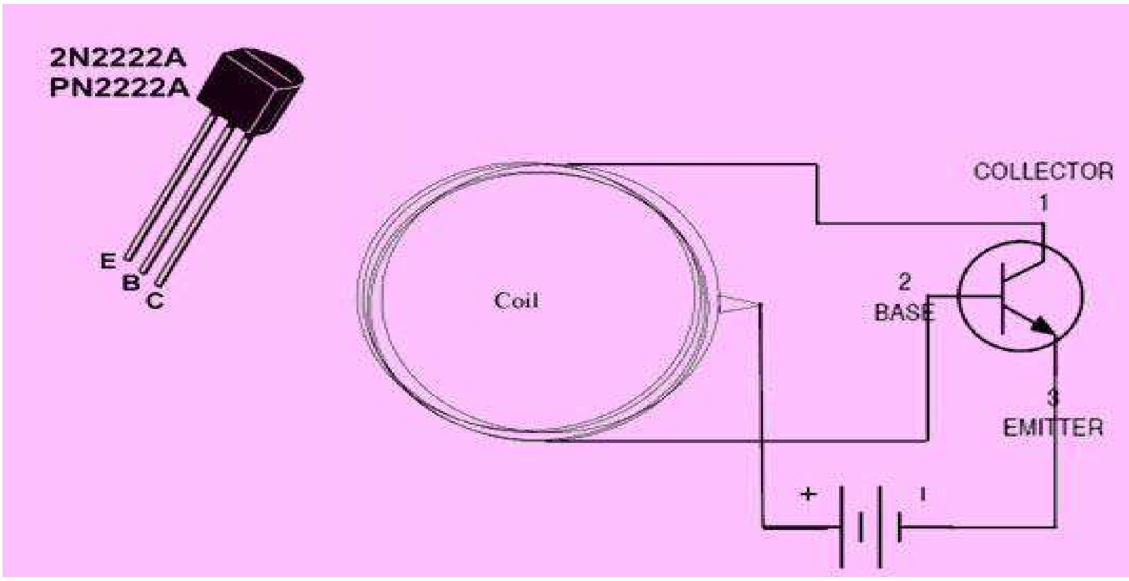

Fig. 2.2: Wireless power transfer circuit [9]

2.9 Transmitter

Carries a sinusoidal (or harmonic) current of frequency f=9700 Hz. This sets up a time varying magnetic field everywhere in space. This is called the primary field Hp. A circular loop of current generates a magnetic field that is the same as that due to a magnetic dipole, with a dipole moment m=IA where I is the current in the Tx and A is the area of the Tx. The representative dipole is located in the center of the loop and is orientated so that it is perpendicular to the plane of the loop. The strength of the magnetic field is that of a magnetic dipole with moment m, and hence it falls off as 1/r^3 [10].

2.10 Receiver

This is also a loop of wire. There is an EMF (Voltage) induced in the receiver that this related to the time rate of change in magnetic flux [10].

2.11 Wireless power transfer circuit working

The wireless power transmission can be defined as the energy can be transmitted from the transmitter to a receiver through an oscillating magnetic field. To accomplish this, power source (DC current) is changed into high frequency AC (Alternating Current) by particularly designed electronics erected into the transmitter. The AC boosts a copper wire coil in the transmitter, which produces a magnetic field. When the receiver coil is placed in proximity of the magnetic field, the magnetic field can make an AC (alternating current) in the receiving coil. Electronics in the receiving coil then alters the AC back into DC which becomes operating power [9].

2.12 Application of wireless power transfer

The main intention of this project is to design a WPT system in 3D space (transfer power within a small range) and the block diagram of this project is shown below. The block diagram of the wireless power transfer mainly builds with HF transformer, capacitors, diode, rectifier, inductor coil filled with air and lamp. The person is mandatory to be worked every year to change the battery. This project is designed to charge a rechargeable battery wirelessly. Since charging of the battery is not possible to be demonstrated, we are providing a DC fan that runs through wireless power [9].

2.12.1 Application of wireless power transfer for home appliances

Now a day the need of wireless technology is increased because of mobility, low cost and easy to maintain. This technology is commonly used for transferring the digital information over the air medium. The wireless power transmission technology is well suited for transferring power to the home appliances without wires such as smart phones, tablets, LED TV's, DVD player and home lighting systems and also for military surveillances. Commonly the Electro Magnetic (EM) waves are used for transferring the electric power through air to get a device powered [11].

The resonant circuit is used for increasing the inductive power of electric power transmission. The resonant inductive coupling method consist of two set of coils primary coil and secondary coil each having a equivalent turn and the primary coil is connected to the power source, the current flows through the coil will induce the magnetic flux then the magnetic flux attracted by the secondary coil which is called tunneling and the secondary coil is connected to the load. When two objects having same frequency then they can transfer the electrical energy among them. To create a resonant two capacitors are need to connect to the each end of the secondary coil which is connected to the load [11]. **Fig. 2.3** Shows the diagram of Resonant Inductive Coupling.

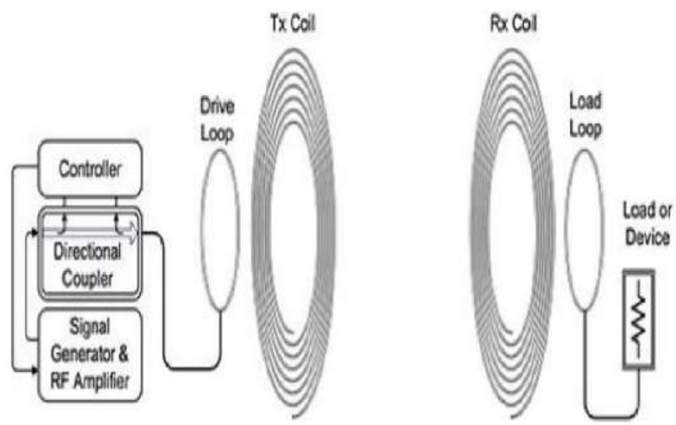

Fig. 2.3: Diagram of resonant inductive coupling [11]

2.13 Boost Converter

Switched mode supplies can be used for many purposes including DC to DC converters. Often, although a DC supply, such as a battery may be available, its available voltage is not suitable for the system being supplied. For example, the motors used in driving electric automobiles require much higher voltages, in the region of 500V, than could be supplied by a battery alone. Even if banks of batteries were used, the extra weight and space taken up would be too great to be practical. The answer to this problem is to use fewer batteries and to boost the available DC voltage to the required level by using a boost converter. Another problem with batteries, large or small, is that their output voltage varies as the available charge is used up, and at some point the battery voltage becomes too low to power the circuit being supplied [12]. However, if this low output level can be boosted back up to a useful level again, by using a boost converter, the life of the battery can be extended. The DC input to a boost converter can be from many sources as well as batteries, such as rectified AC from the mains supply, or DC from solar panels, fuel cells, dynamos and DC generators. **Fig. 2.4** shows the boost converter circuit [12].

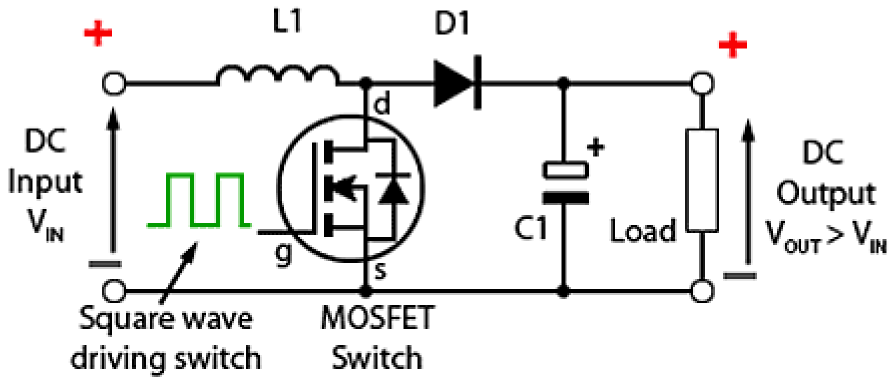

Fig. 2.4: Boost converter circuit [13]

2.14 Charging System of Electric Vehicle

Mode 1: Household socket and extension cord**:** The vehicle is connected to the power grid through standard socket-outlets present in residences, which depending on the country are usually rated at around 10 A. To use mode 1, the electrical installation must comply with the safety regulations and must have an earthing system, a circuit breaker to protect against overload and an earth leakage protection. The sockets have blanking devices to prevent accidental contacts [14].

The first limitation is the available power to avoid risks of:

- Heating of the socket and cables following intensive use for several hours at or near the maximum power (which varies from 8 to 16 A depending on the country).
- Fire or electric injury risks if the electrical installation is obsolete or if certain protective devices are absent.

The second limitation is related to the installation's power management.

- As the charging socket shares a feeder from the switchboard with other sockets (no dedicated circuit) if the sum of consumptions exceeds the protection limit (in general 16 A), the circuit-breaker will trip, stopping the charging [14].

All these factors impose a limit on the power in mode 1, for safety and service quality reasons. This limit is currently being defined, and the value of 10 A appears to be the best compromise.

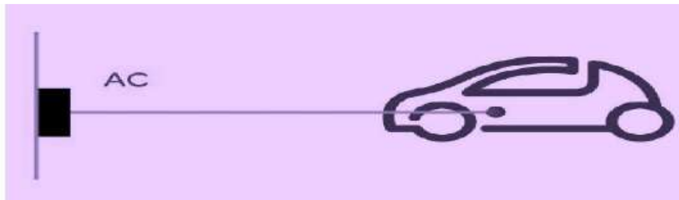

Fig. 2.5: Household socket and extension cord [15]

Mode 2: Domestic socket and cable with a protection device: The vehicle is connected to the main power grid via household socket-outlets. Charging is done via a single-phase or three-phase network and installation of an earthing cable. A protection device is built into the cable. This solution is more expensive than Mode 1 due to the specificity of the cable [14]

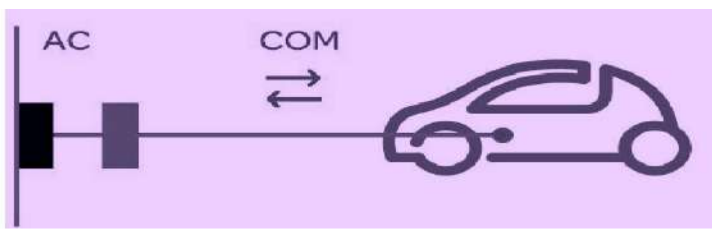

Fig. 2.6: Domestic socket and cable with a protection device [15]

Mode 3: Specific socket on a dedicated circuit: The vehicle is connected directly to the electrical network via specific socket and plug and a dedicated circuit. A control and protection function is also installed permanently in the installation. This is the only charging mode that meets the applicable standards regulating electrical installations. It also allows load shedding so that electrical household appliances can be operated during vehicle charging or on the contrary optimizes the electric vehicle charging time [14].

Fig. 2.7: Specific socket on a dedicated circuit [15]

Mode 4: Direct current (DC) connection for fast recharging: The electric vehicle is connected to the main power grid through an external charger. Control and protection functions and the vehicle charging cable are installed permanently in the installation [14].

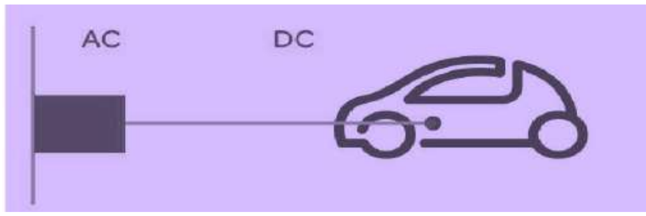

Fig. 2.8: Direct current (DC) connection for fast recharging [15]

2.15 Summary

After observing above history of wireless power transfer, it can be concluded that most of the system used wired connection which has some problem, so here we try to develop a wireless charging system for battery. In next chapter about the methodology of hardware development and components are discussed.

CHAPTER 03

SYSTEM COMPONENTS

3.1 Introduction

The entire primary electrical and electronic components have described in this chapter which used for completion of our final project. In the following section all components are discussed to provide a details concept.

3.2 Hardware requirements

1. Adapter Circuit

2. Resistor

3. Capacitor

4. 555 Timer

5. Transistor

6. Boost Converter Module

7. Diode

8. LED

9. Battery

10. Transmitter Module for Remote

11. Receiver Module for Remote

12. DC motor

13. Laminated Copper Coils

3.2.1 Adapter Circuit

Adapter circuit is shown in **Fig. 3.1**,

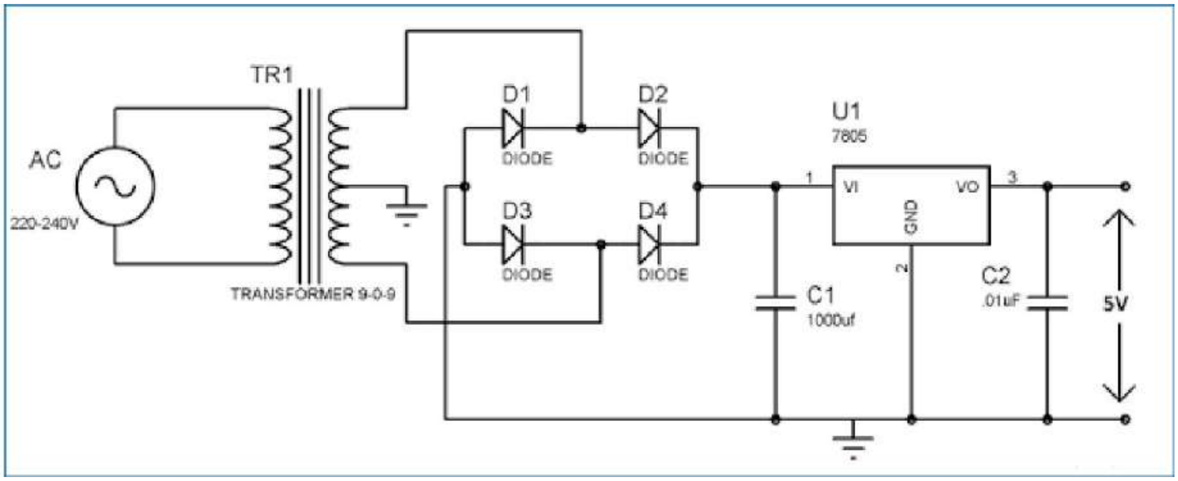

Fig. 3.1: Adapter internal circuit [16]

An adapter circuit is used to convert 230V AC to 5V DC. This requires some steps for converting the voltage level. Thus for this purpose we need a step down converter [16].

3.2.2 Steps to convert 230v AC to 5v DC

The following steps are required for converting 230v to 5v DC.

3.2.2.1 Step Down the Voltage Level

The step down converters are used for converting the high voltage into low voltage. The converter with output voltage less than the input voltage is called as a step-down converter, and the converter with output voltage greater than the input voltage is called as step-up converter. There are step-up and step-down transformers which are used to step up or step down the voltage levels. 230V AC is converted into 12V AC using a step-down transformer [17]. 12V output of step down transformer is an RMS value and its peak value is given by the product of square root of two with RMS value, which is approximately 17V. Step-down transformer consists of two windings, namely primary and secondary windings where primary can be designed using a less-gauge wire with more number of turns as it is used for carrying low-current high-voltage power, and the secondary winding using a high-gauge wire with less number of turns as it is used for carrying high-current low-voltage power. Transformers works on the principle of Faraday's laws of electromagnetic induction [17].

3.2.2.2 Convert AC to DC

230V AC power is converted into 12V AC (12V RMS value wherein the peak value is around 17V), but the required power is 5V DC; for this purpose, 17V AC power must be primarily converted into DC power then it can be stepped down to the 5V DC. But first and foremost, we must know how to convert AC to DC? AC power can be converted into DC using one of the power electronic converters called as Rectifier. There are different types of rectifiers, such as half-wave rectifier, full-wave rectifier and bridge rectifier. Due to the advantages of the bridge rectifier over the half and full wave rectifier, the bridge rectifier is frequently used for converting AC to DC. Bridge rectifier consists of four diodes which are connected in the form a bridge. We know that the diode is an uncontrolled rectifier which will conduct only forward bias and will not conduct during the reverse bias. If the diode anode voltage is greater than the cathode voltage then the diode is said to be in forward bias. During positive half cycle, diodes D2 and D4 will conduct and during negative half cycle diodes D1 and D3 will conduct. Thus, AC is converted into DC; here the obtained is not a pure DC as it consists of pulses. Hence, it is called as pulsating DC power, but voltage drop across the diodes is (2*0.7V) 1.4V. therefore, the peak voltage at the output of this rectifier circuit is 15V (17V-1.4V) approximately [17].

3.2.2.3 Smoothing the ripples using filter

15V DC can be regulated into 5V DC using a step-down converter, but before this, it is required to obtain pure DC power. The output of the diode bridge is a DC consisting of ripples also called as pulsating DC. This pulsating DC can be filtered using an inductor filter or a capacitor filter or a resistor-capacitor-coupled filter for removing the ripples. Consider a capacitor filter which is frequently used in most cases for smoothing. We know that a capacitor is an energy storing element. In the circuit, capacitor stores energy while the input increases from zero to a peak value and, while the supply voltage decreases from peak value to zero, capacitor starts discharging. This charging and discharging of the capacitor will make the pulsating DC into pure DC [17].

3.2.2.4 Regulating 12V DC into 5V DC using voltage regulator

15V DC voltage can be stepped down to 5V DC voltage using a DC step-down converter called as voltage regulator IC7805. The first two digits '78' of IC7805 voltage regulator represent positive series voltage regulators and the last two digits '05' represents the output voltage of the voltage regulator [17].

3.2.2.5 230v to 5v DC-DC Buck Converter

Let us start with the DC regulated power supply circuit designed using a DC-DC buck converter. If we have 230V DC power supply, then we can use a DC-DC buck converter for converting the 230V DC into 5V DC power supply. The DC-DC buck converter consists of Capacitor, MOSFET, PWM control, Diodes and Inductors. The basic topology of a DC-DC buck converter. Voltage drop across the inductor and the changes in electric current flowing through the device are proportional to each other. Hence, the buck converter works on the principle of energy stored in an inductor. The power semiconductor MOSFET or IGBT used as switching element can be used to alternate the buck converter circuit between two different states by closing or opening and off or on using the switching element. If the switch is in on state, then a potential is created across the inductor due to in-rush current which will oppose the supply voltage, thereby reducing the resultant output voltage. As diode is reverse biased, no current will flow through the diode [17].

If the switch is open, then current through the inductor interrupts suddenly and the diode starts conduction, thus a return path is provided to the inductor current. The voltage drop across the energized inductor gets reversed, which can be considered as primary source of output power during this switching cycle and this is due to the this quick change in the current flow. The stored energy of the inductor is continuously delivered to the load and thus inductor current will start to drop until the current rises to its previous value or the next on state. The continuation of delivering energy to the load leads to drop in the inductor current until the current rises to its previous value. This phenomenon is called as output ripple which can be reduced to an acceptable value using a smoothing capacitor in parallel with the output. Thus, DC-DC converter acts as step-down converter [17].

3.2.3 Resistor

A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element as a circuit element. In **Fig. 3.2** a sketch of a resistor is shown. Resistor may be used to reduce current flow and at the same time may act to lower voltage levels within circuits. In electronic circuits, resistors are used to limit current flow to adjust signal levels, bias active elements and transmission lines among other uses. High power resistors that can dissipate many watts of electrical power as heat may be used as part of motor controls, in power distribution systems, or as test load for generators [18].

Fig. 3.2: Resistor [19]

3.2.4 Capacitor

A capacitor (originally known as a condenser) is a passive two-terminal electrical component used to store electrical energy temporarily in an electric field. In **Fig. 3.3** a sketch of a capacitors shown. The forms of practical capacitors vary widely, but all contain at least two electrical conductors (plates) separated by a dielectric (i.e. an insulator that can store energy by becoming polarized). The conductors can be thin films, foils or sintered beads of metal or conductive electrolyte, etc. The non conducting dielectric acts to increase the capacitor's charge capacity [20].

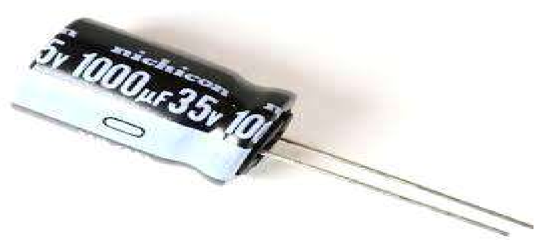

Fig. 3.3: Capacitor [21]

3.2.5 555 Timer

The 555 can operate as an electronic oscillator. Uses include LED and lamp flashers, pulse generation, logic clocks, tone generation, security alarms, pulse position modulation and so on. The 555 can be used as a simple ADC, converting an analog value to a pulse length (e.g., selecting a thermistor as timing resistor allows the use of the 555 in a temperature sensor and the period of the output pulse is determined by the temperature). The use of a microprocessor based circuit can then convert the pulse period to temperature, linearize it and even provide calibration means. In this project we have used astable mode to add high frequency with voltage [22]. The 555 timer IC is shown in **Fig. 3.4**,

Fig. 3.4: 555 Timer [23]

3.2.5.1 555 Timer pin configuration

In **Fig. 3.5** pin configuration of 555 timer is shown [10].

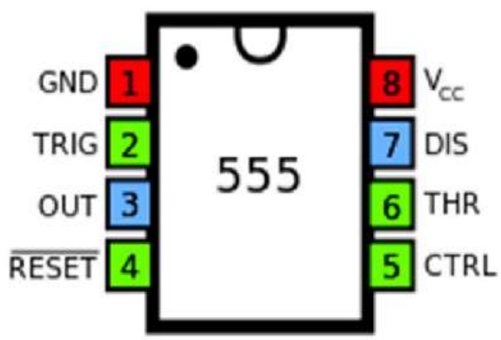

Fig. 3.5: Pin configuration of 555 timer [23]

3.2.5.2 Pin Description of 555 Timer

Pin Description of 555 Timer is given table 1 in Appendix A.

3.2.5.3 Astable operation

In astable mode, the 555 timer puts out a continuous stream of rectangular pulses having a specified frequency. Resistor R_1 is connected between V_{CC} and the discharge pin (pin 7) and another resistor (R_2) is connected between the discharge pin (pin 7), and the trigger (pin 2) and threshold (pin 6) pins that share a common node [24]. Hence the capacitor is charged through R_1 and R_2, and discharged only through R_2, since pin 7 has low impedance to ground during output low intervals of the cycle, therefore discharging the capacitor. In the astable mode, the frequency of the pulse stream depends on the values of R1, R2 and C. The astable configuration, with two resistors, cannot produce a 50% duty cycle. To produce a 50% duty cycle, eliminate R1, disconnect pin 7 and connect the supply end of R2 to pin 3, the output pin. This circuit is similar to using an inverter gate as an oscillator, but with fewer components than the astable configuration, and a much higher power output than a TTL or CMOS gate. The duty cycle for either the 555 or inverter-gate timer will not be precisely 50% and will change based off any load that the output is also driving while high (longer duty cycles for greater loads) due to the fact the timing network is supplied from the devices output pin, which has different internal resistances depending on whether it is in the high or low state (high side drivers tend to be more resistive). However, on connecting the pin 7 directly to Vcc an extra current will flow through transistor (within) when it is ON. This may damage the transistor [24]. An alternate method to set the duty cycle practically is to connect a diode parallel to pin 6 & 7. The operation of the diode when connected is explained above. The resultant duty cycle is given as D=R2 / (R1+R2). A series resistor of 100 ohms must be added to each R1 and R2 to limit peak current of the transistor (within) when R1 and R2 are at minimum level. This method of adding a diode has a restriction of choosing R1 and R2 values. An alternate way is to add a JK flip-flop to the output of non-symmetrical square wave generator. But, with this the output frequency is one half of the timer [24].

In **Fig. 3.6** astable operation connection of 555 timer is shown,

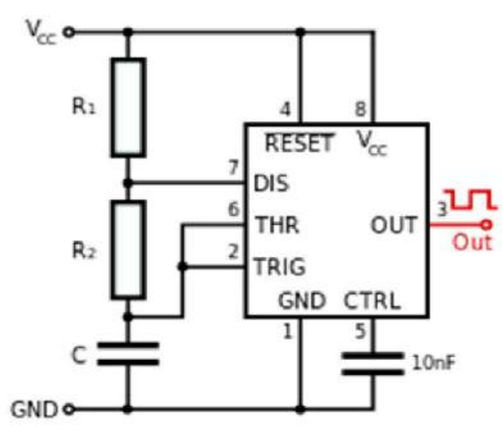

Fig. 3.6: Astable operation connection of 555 timer [24]

3.2.6 Transistor

In this project we have used transistor IRF3205 for switching purpose. We used it because it has fast switching speed of which is faster than BJT. It is from N channel MOSFET family. Figure of IRF3205 is given in **Fig. 3.7** [25].

Fig. 3.7: MOSFET IRF3205 [25]

3.2.6.1 Symbol & Pin Configuration

It has total three pins having different individual functions. Pin configuration & symbol of IRF3205 transistor is given in **Fig. 3.8** [25].

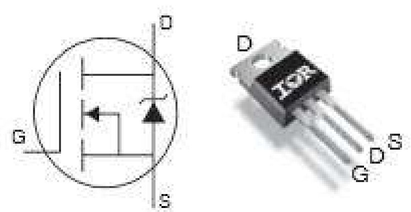

Fig. 3.8: Symbol & Pin configuration of IRF3205 [25]

3.2.6.2 IRF3205 Features

1. Ultra low charge on gate.
2. Improved dv/dt capability.
3. High ruggedness.
4. Avalanche energy specified.
5. Fast switching capability.

3.2.7 Boost Converter Module

Due to lower voltage in the secondary side of coils we need to improve the voltage level through boost converter. **Fig. 3.9** shows the boost converter module,

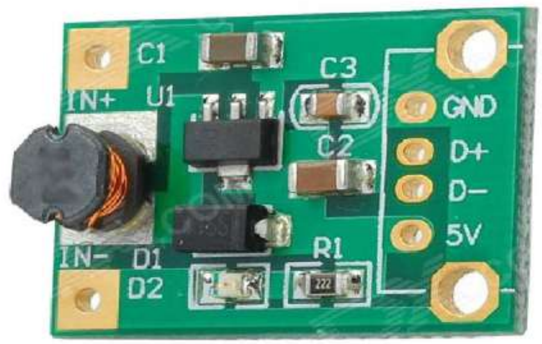

Fig. 3.9: Boost converter module [26].

3.2.7.1 Boost converter operation

1st Stage:

Fig. 3.10 illustrates the circuit action during the initial high period of the high frequency square wave applied to the MOSFET gate at start up. During this time MOSFET conducts, placing a short circuit from the right hand side of L1 to the negative input supply terminal. Therefore a current flows between the positive and negative supply terminals through L1, which stores energy in its magnetic field. There is virtually no current flowing in the remainder of the circuit as the combination of D1, C1 and the load represent a much higher impedance than the path directly through the heavily conducting MOSFET [27].

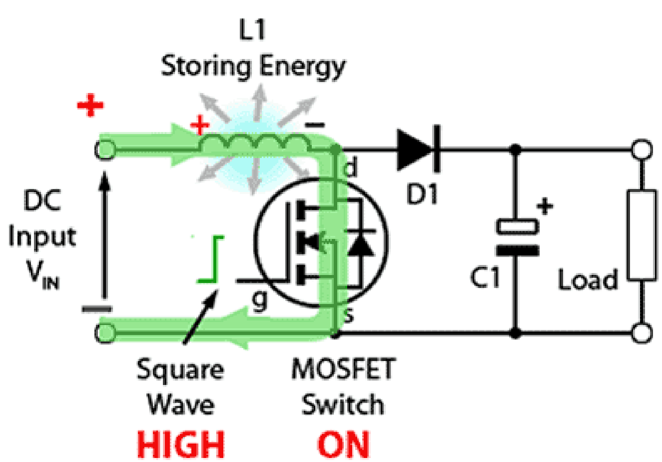

Fig. 3.10: Boost Converter operation at switch on [27]

2^{nd} Stage:

Fig. 3.11 shows the current path during the low period of the switching square wave cycle. As the MOSFET is rapidly turned off the sudden drop in current causes L1 to produce a back e.m.f. in the opposite polarity to the voltage across L1 during the on period, to keep current flowing. This results in two voltages, the supply voltage V_{IN} and the back e.m.f. (V_L) across L1 in series with each other. This higher voltage (V_{IN} +V_L), now that there is no current path through the MOSFET, forward biases D1. The resulting current through D1 charges up C1 to V_{IN} +V_L minus the small forward voltage drop across D1, and also supplies the load [27].

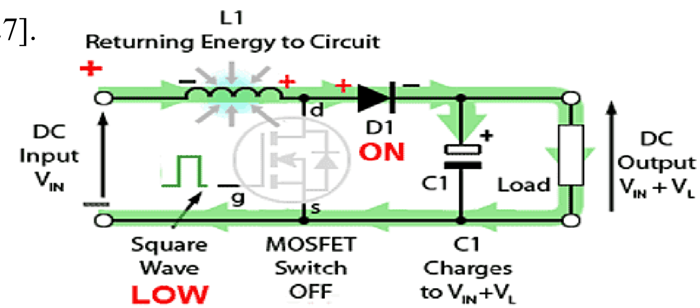

Fig. 3.11: Current path with MOSFET off [27]

3^{rd} Stage:

Fig. 3.12 shows the circuit action during MOSFET on periods after the initial start up. Each time the MOSFET conducts, the cathode of D1 is more positive than its anode, due to the charge on C1. D1 is therefore turned off so the output of the circuit is isolated from the input, however the load continues to be supplied with V_{IN} +V_L from the charge on C1. Although the charge C1 drains away through the load during this period, C1 is recharged each time the MOSFET switches off, so maintaining an almost steady output voltage across boost Converter the load [27].

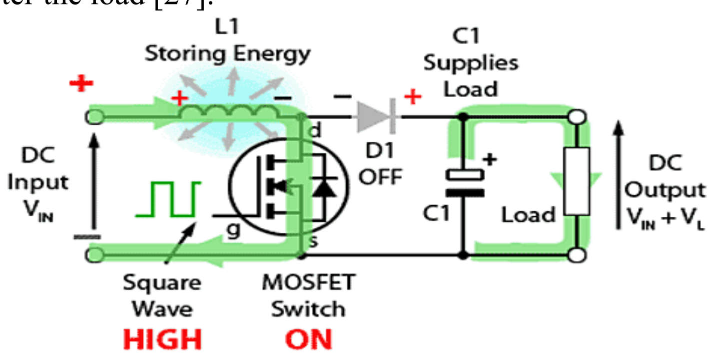

Fig. 3.12: Current path with MOSFET on [27]

3.2.8 Diode

A diode is a two terminal electronic component that conducts current primarily in one direction (asymmetric conductance); it has low (ideally zero) resistance in one direction, and high (ideally infinite) resistance in the other. A semiconductor diode, the most common type today, is a crystalline piece of semiconductor material with a p–n junction connected to two electrical terminals. The most common function of a diode is to allow an electric current to pass in one direction (called the diode's forward direction), while blocking it in the opposite direction (the reverse direction). This unidirectional behavior is called rectification, and is used to convert alternating current (AC) to direct current (DC). However, diodes can have more complicated behavior than this simple on off action, because of their nonlinear current voltage characteristics [28]. The voltage drop across a forward-biased diode varies only a little with the current, and is a function of temperature; this effect can be used as a temperature sensor or as a voltage reference. A semiconductor diode's current voltage characteristic can be tailored by selecting the semiconductor materials and the doping impurities introduced into the materials during manufacture. These techniques are used to create special-purpose diodes that perform many different functions [28]. For example, diodes are used to regulate voltage (Zener diodes), to protect circuits from high voltage surges (avalanche diodes), to generate radio frequency oscillations (tunnel diodes, Gunn diodes, IMPATT diodes), and to produce light (light emitting diodes).

In this project we have used diode to protect the boost circuit against the back voltage from battery. In **Fig. 3.13** diode figure is shown [29].

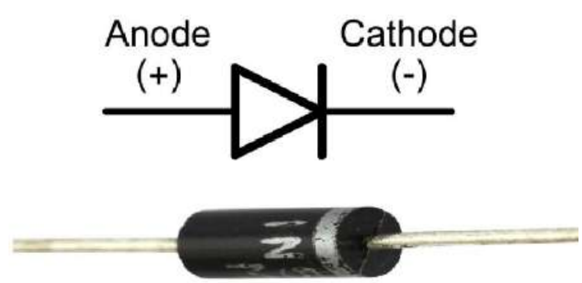

Fig. 3.13: Symbol and figure of diode [29]

3.2.9 LED

A light-emitting diode (LED) is a two-lead semiconductor light source. It is a p–n junction diode that emits light when activated. When a suitable voltage is applied to the leads, electrons are able to recombine with electron holes within the device, releasing energy in the form of photons. This effect is called electroluminescence, and the color of the light (corresponding to the energy of the photon) is determined by the energy band gap of the semiconductor. LEDs are typically small (less than 1 mm^2) and integrated optical components may be used to shape the radiation pattern.

A P-N junction can convert absorbed light energy into a proportional electric current. The same process is reversed here (i.e. the P-N junction emits light when electrical energy is applied to it). This phenomenon is generally called electroluminescence, which can be defined as the emission of light from a semiconductor under the influence of an electric field. The charge carriers recombine in a forward biased P-N junction as the electrons cross from the N-region and recombine with the holes existing in the P-region. Free electrons are in the conduction band of energy levels, while holes are in the valence energy band. Thus the energy level of the holes is less than the energy levels of the electrons. Some portion of the energy must be dissipated to recombine the electrons and the holes. This energy is emitted in the form of heat and light. The electrons dissipate energy in the form of heat for silicon and germanium diodes but in gallium arsenide phosphide (GaAsP) and gallium phosphide (GaP) semiconductors, the electrons dissipate energy by emitting photons [30]. If the semiconductor is translucent, the junction becomes the source of light as it is emitted, thus becoming a light-emitting diode. However, when the junction is reverse biased, the LED produces no light, if the potential is great enough, the device is damaged. In **Fig. 3.14** shows the symbol and figure of LED [31].

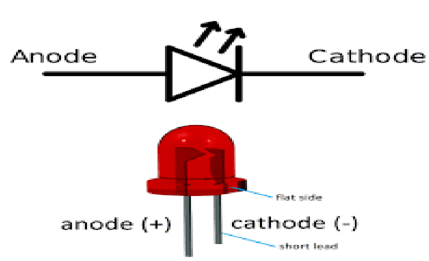

Fig. 3.14: Symbol and figure of LED [31]

3.2.10 Battery

A lithium-ion battery or Li-ion battery (abbreviated as LIB) is a type of rechargeable battery in which lithium ions move from the negative electrode to the positive electrode during discharge and back when charging. Li-ion batteries use an intercalated lithium compound as one electrode material, compared to the metallic lithium used in a non- rechargeable lithium battery. The electrolyte, which allows for ironic movement, and the two electrodes are the constituent components of a lithium-ion battery cell [32]. **Fig. 3.15** shows the lithium-ion rechargeable battery. In our project we have used 3.7 V lithium-ion battery.

Fig. 3.15: Lithium Ion rechargeable battery [33]

3.2.11 Transmitter module for remote

An RF transmitter module is a small PCB sub-assembly capable of transmitting a radio wave and modulating that wave to carry data. Transmitter modules are usually implemented alongside a micro controller which will provide data to the module which can be transmitted. RF transmitters are usually subject to regulatory requirements which dictate the maximum allowable transmitter power output, harmonics, and band edge requirements [34]. In this project we have used a transmitter module for remote to send signal to the receiver to control the car movement which is shown in **Fig. 3.16**.

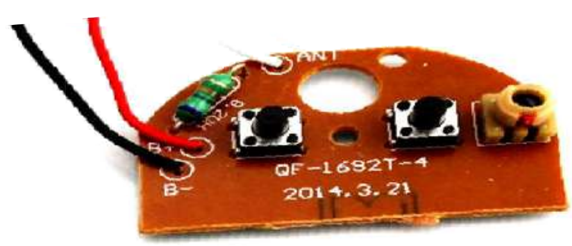

Fig. 3.16: Transmitter module for remote [34]

3.2.12 Receiver module for remote

An RF receiver module receives the modulated RF signal, and demodulates it. There are two types of RF receiver modules: super heterodyne receivers and super-regenerative receivers. Super-regenerative modules are usually low cost and low power designs using a series of amplifiers to extract modulated data from a carrier wave. Super-regenerative modules are generally imprecise as their frequency of operation varies considerably with temperature and power supply voltage. Super heterodyne receivers have a performance advantage over super-regenerative; they offer increased accuracy and stability over a large voltage and temperature range. This stability comes from a fixed crystal design which in the past tended to mean a comparatively more expensive product. However, advances in receiver chip design now mean that currently there is little price difference between super heterodyne and super-regenerative receiver modules [34]. In this project we have used a receiving module for remote to receive the signal from transmitter module to control the car movement which is shown in **Fig. 3.17**.

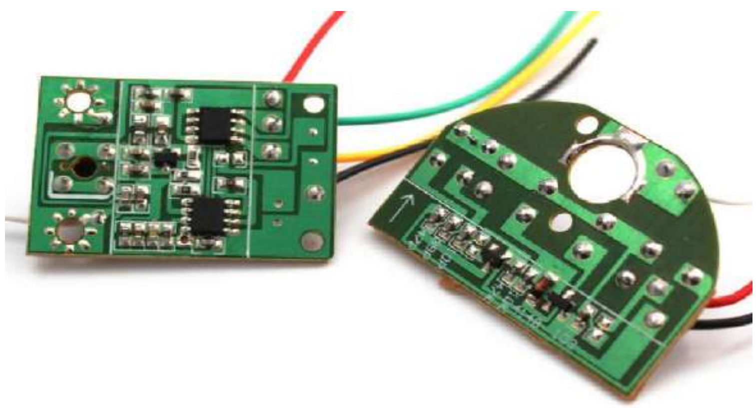

Fig. 3.17: Receiver module for remote [34]

3.2.13 DC motor

A motor is an electrical machine which converts electrical energy into mechanical energy. The principle of working of a DC motor is that "whenever a current carrying conductor is placed in a magnetic field, it experiences a mechanical force". The direction of this force is given by Fleming's left hand rule and its magnitude is given by F = BIL. Where, B = magnetic flux density, I = current and L = length of the conductor within the magnetic field [35]. In this project we have used one dc motor as a component of electric car for forward and reverse moving purpose of car.

Fig. 3.18: DC Motor [36]

3.2.14 Laminated copper coils

For many years now, copper has been one of the primary metals used in both industrial and consumer products. Copper is a malleable and ductile metal, boasting both high thermal and electrical conductivity, which makes it a popular choice to meet versatile industry demands. To meet these evolving demands, All Foils has years of experience tailoring each copper coil order to match even the most exact specifications. Our inventory remains stocked with copper coil products in Alloy 102 and Alloy 110, with other alloys always available upon request. All of our copper coils are available in gauges and thicknesses of up to .010” and in tempers from annealed through full hard. We have the capabilities to supply copper coils on fiber, steel, aluminum, and plastic cores from 1-5/16” to 20” inner diameters [37]. Available in a wide range of gauges, as well as bare, hot tin dipped, and tin plated finishes, our lineup of copper coil products is manufactured to meet the exact needs of an array of applications and industries, including:

1 Circuit Boards

2. Batteries

3. Solar and Alternative Energy

4. Electronics

5. Heat Exchanger

6. And More

We have used 33 turns of copper coils for primary side (transmitting side) windings and 22 turns for secondary coils (receiving side) windings for efficient transmission of power [37].

Primary and Secondary Coil:

Several factors were kept in consideration while designing the number of turns and size of the primary and secondary coil like, flux density, voltage, losses and other variations. If there is a gradual decrease in the number of turns then consequently the voltage and flux density decreases. As the number of turns increases the flux density increases and in turn the variations and losses also increases. Similarly when there is a gradual decrease in the number of turns the flux density and the voltage also decreases [37].

$B = \mu \frac{N}{l} I$ In Tesla

Where,

N= number of turns

l= length of coil,

I= current in Amps And

μ = permeability of free space.

The flux radiated between the coils depends on the Area of the conductor and the flux density as area increase the flux per Webber increases and flux density reduces. The flux radiated is given by: Ø = flux = A * B Where, A=area of the coil [37].

So taking all these parameters into considerations coils are designed. To design primary and secondary coils, the material used is copper. Previously aluminum coils were used which are very cheap but flux radiation is very less [35]. Litz wires are frequently used to lower the parasitic resistance and therefore high Q-factor. Litz coil consists of many individually insulated thin conductor strands wounded in particular patterns. But these wires are prone to skin effect and other proximity effects. So to overcome all these copper wires or hollow copper tube were used even though it's costlier. Copper is a good flux radiator and efficient. So we used copper material in our project for effective wireless power transfer for this miniature model of electric vehicle [37]. **Fig. 3.19** shows the laminated copper coils.

Fig. 3.19: Laminated copper coils [38]

3.3 Summary

This chapter is based on equipment details, which we use for making wireless charging system. A precise overview of the project equipment can be found from this chapter.

CHAPTER 4

CIRCUIT DESIGN AND HARDWARE IMPLEMENTATION

4.1 Introduction

This chapter is product and incorporation of the entire previous chapter discussed so far. After an intensive research on all the available techniques and components, to meet the requirement of the desired system and to satisfy the prime objective of the project, suitable methods, circuit design and implemented through electrical circuits.

4.2 System methodology

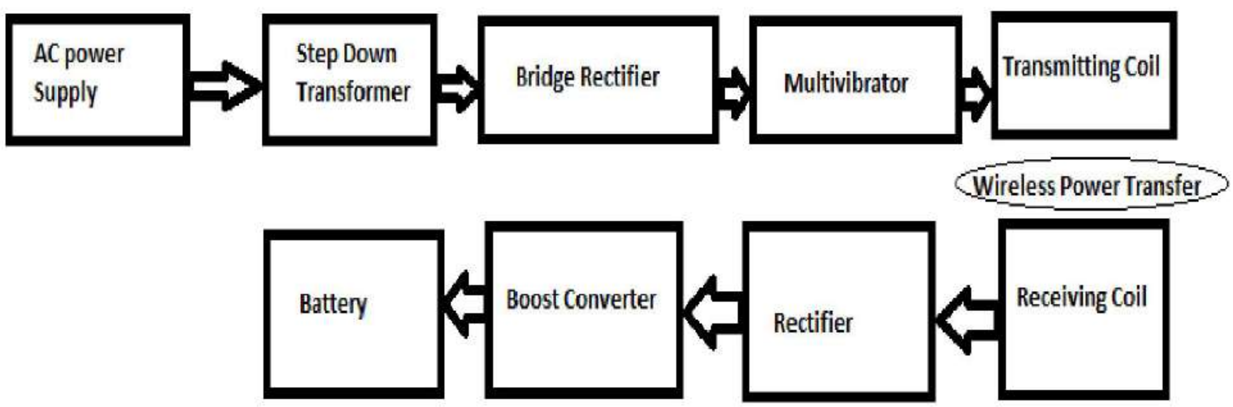

Fig. 4.1: A block diagram of system methodology

4.3 System description according to the block diagram

Fig. 4.1 shows the block diagram of our system. Here we have used 220V AC supply as input to our system. Now a step down transformer is used to minimize the voltage. And rectifier part is used to convert AC voltage into DC voltage. Here 555 timer is used as a stable multivibrator which generate a square wave pulse of very high frequency. Then this high frequency AC voltage is transmitted through transmitting coil. In the receiving coil received this voltage and after rectification we make it to DC Voltage. Due to low voltage here we use a boost converter, to make this low voltage into our desired voltage level which is high enough to charge up our battery.

4.4 Circuit diagram

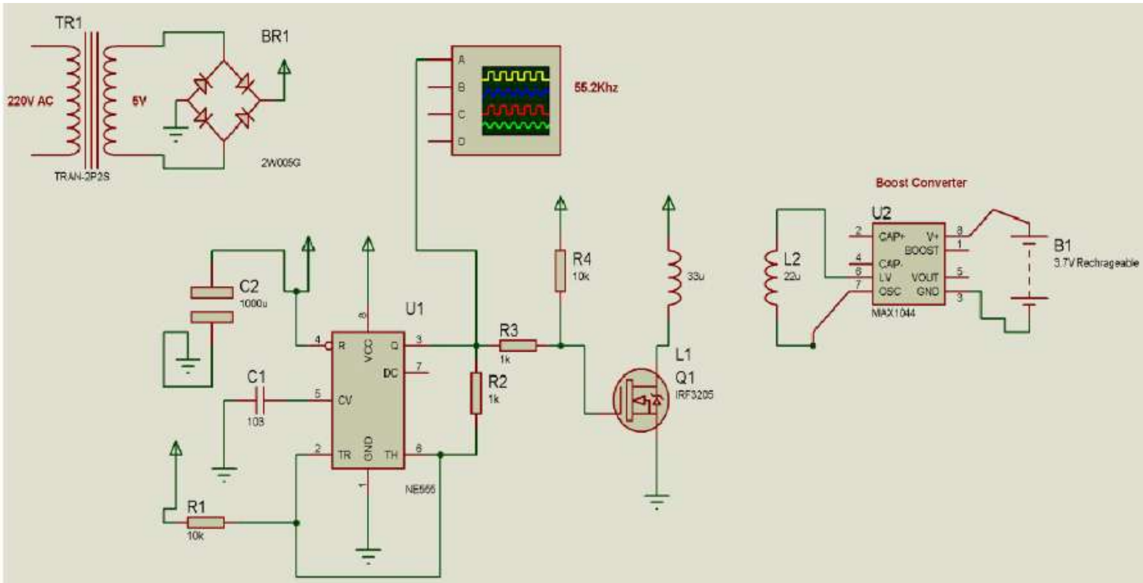

Fig. 4.2: Circuit Diagram

In **Fig. 4.2** system circuit diagram is shown. In our circuit we use a 555 timer which is used here as a stable multivibrator, here it generate a square wave pulse of very high frequency we measure the frequency is near about 55KHz. Then transmit this high frequency AC voltage through transmitting coil. In the receiving coil receive this voltage wirelessly then rectified it into DC voltage, by using boost converter the voltage is step upped to high enough to charge up the battery.

4.5 Hardware implementation

Fig.4.3 shows that complete circuit with transmitting coil, receiving coil and multivibrator circuit.

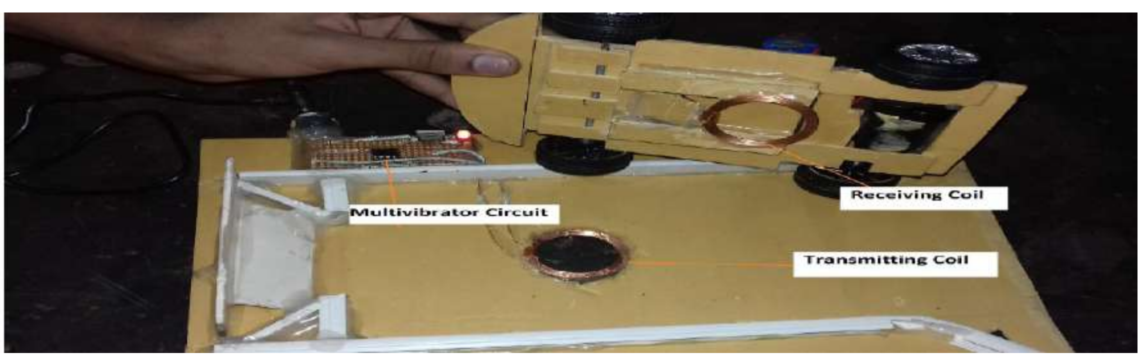

Fig. 4.3: Complete system circuit

Fig. 4.4 shows the circuit diagram of charging station which consist of a multivibrator circuit including 555 timer. A MOSFET transistor is used here for fast switching. Here we used a coil which transmit power that's why it's named primary transmitting coil.

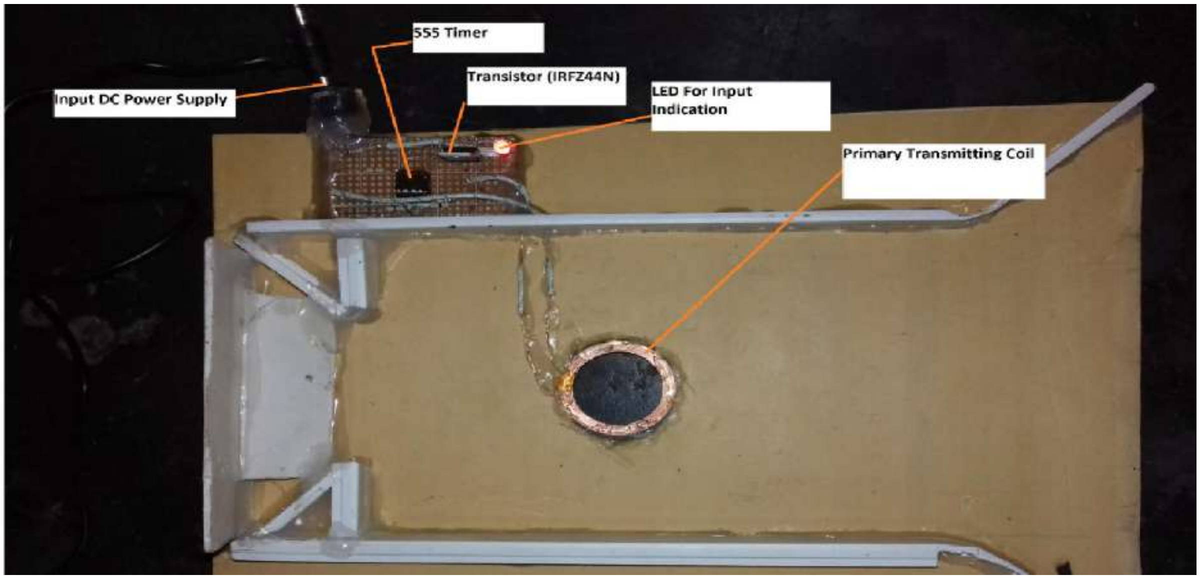

Fig. 4.4: Charging station circuit diagram

Fig. 4.5 shows that miniature model of electric vehicle which consist of receiving coil, here we use two LED one is for wireless power transfer indication, another one is for battery charging. For control the electric vehicle here we use a remote for this we use a receiving signal module to the vehicle. A remote is also used which is consist of transmitting signal module.

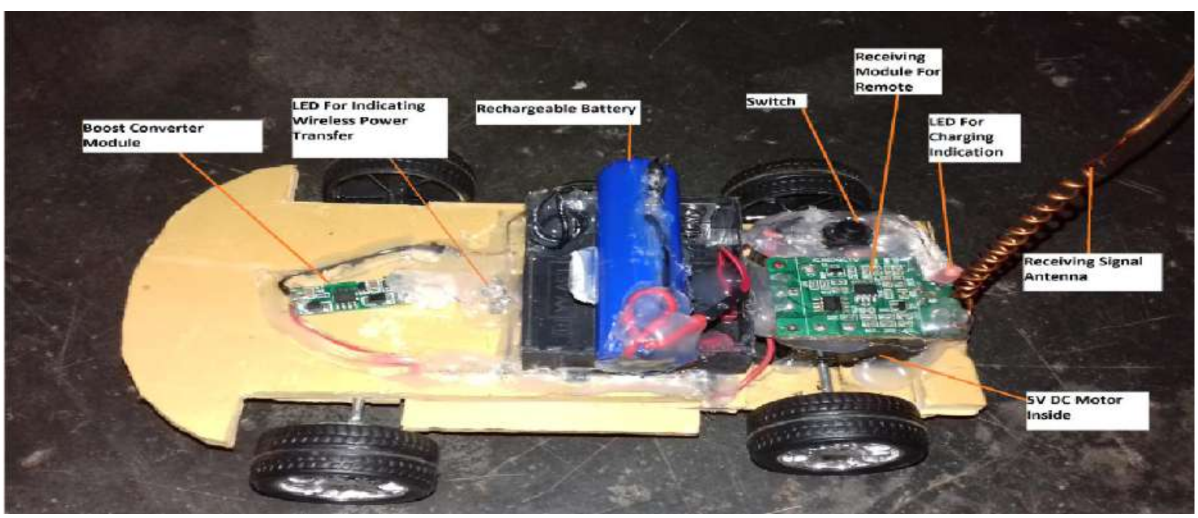

Fig. 4.5: Electric Vehicle battery charging circuit diagram

4.6 Cost analysis

The overall cost of the project is about 1261 taka which is discussed on table 2 in Appendix B.

4.7 Summary

This chapter is based on circuit diagram and hardware implementation. The objectives of the project were met. An electronic device that wirelessly transmits power and then charges a battery was developed.

CHAPTER- 5

RESULT ANALYSIS

5.1 Introduction

In this chapter all the observation data of wireless power transfer are shown for different distance and time. For different types of distance between primary and secondary coil we measure the output voltage. We also observe the time required for fully charge the battery.

5.2 Observation

At a distance of 11 mm between the two coils, we were able to transmit enough power to power a 4.5V battery. As the distance of separation between the coils was increasing, the indicator LED got dimmer. It was evident from this simple experiment itself that the power transmitted was related to the distance of separation between the coils. To demonstrate the presence of evanescent waves being produced which transferred power from the transmitter coil to the receiver coil, we measured the voltage across the 4.5V battery at varying distances and orientations. We took measurements starting at a distance of 11mm between the coils in 10 mm increments up to a distance of 61mm of separation. We found that the voltage changed with distance due to the imperfect match in the coils. The distance was then adjusted to find the maximum output voltage at every measurement.

5.3 Observation of wireless power transfer

Fig. 5.1 shows that a simple miniature model of a electric car with battery. Battery of this electric car is charged by wireless power transfer.

Fig. 5.1: Miniature model of electric car with battery

5.3.1 Normal condition

When there is no power transfer between primary and secondary coil, at this time the LED is not glowing because it cannot find any voltage, from the **Fig. 5.2** below we see that the LED is not glowing.

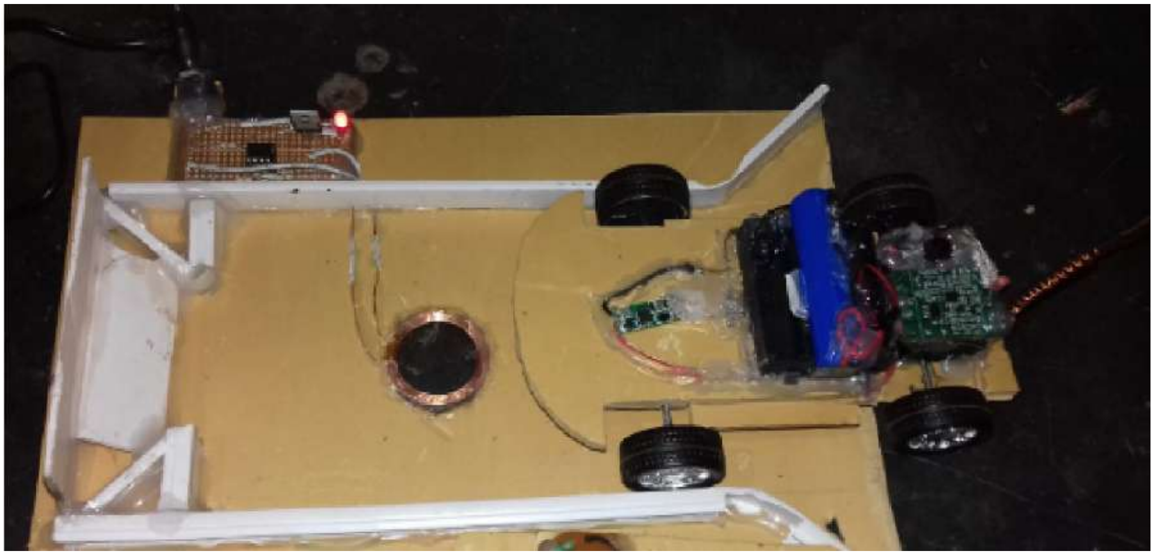

Fig. 5.2: Miniature model of electric car with no power transfer

5.3.2 LED to indicate the Wireless power transfer

when electrical vehicle reached at the charging station LED indicate the wireless power transfer. Here this LED is used for indicating the wireless power transfer. **Fig. 5.3** indicate the wireless power transfer.

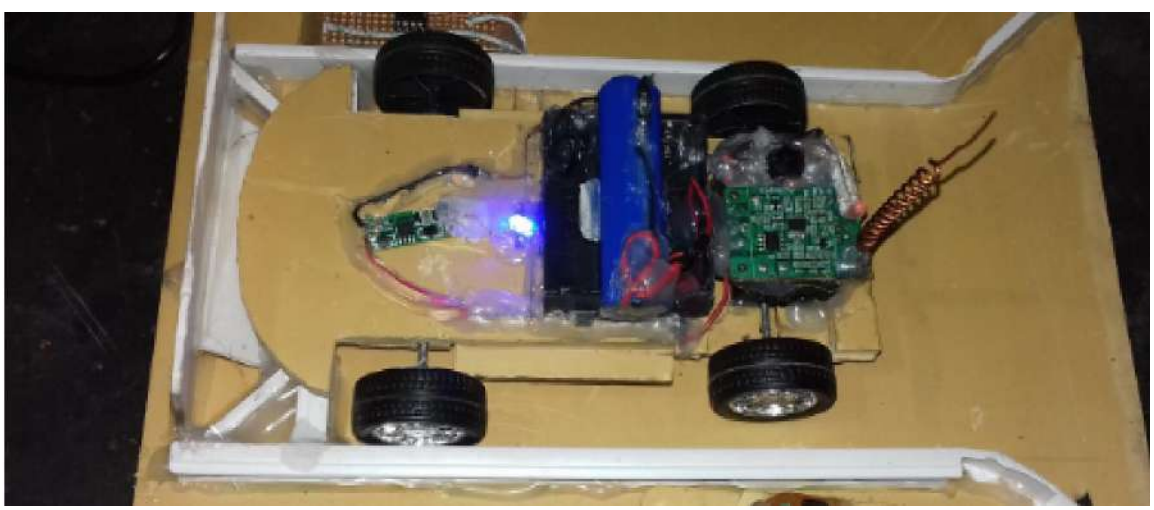

Fig. 5.3: LED to indicate the wireless power transfer

5.4 Observation of battery charging

From the beginning of charging, LED is glowing softly. **Fig. 5.4** shows that LED is glowing softly because battery is starting charge at that time.

Fig. 5.4 : LED is glowing softly

After a little bit time left, it is near about 10-15 minute LED glow increase. Because battery is storing a little bit charged at that moment. **Fig. 5.5** shows that LED glow increase from the previous one.

Fig. 5.5 : LED glow increased

Finally when the battery is charged fully it require near about 35-40 minute to charging the battery full. **Fig. 5.6** shows that LED glow increased gradually from the previous one because battery is fully charged at this time.

Fig. 5.6 : LED is glowing brightly

5.5 Observation of voltages

5.5.1 Measuring the input voltage and frequency across the transmitter side

First of all our input was 230V ac then we convert and rectified it into 5V DC by using DC power supply. After adding multivibrator our input is 1.46V AC. **Fig. 5.7** shows the input voltage across transmitter side.

Fig. 5.7: Input voltage measuring across the transmitter side

After adding multivibrator a high frequency is generated which is 55 KHZ. For wireless power transfer a high frequency pulse is needed. **Fig. 5.8** shows the input frequency across transmitter side.

Fig. 5.8: Input frequency measuring across the transmitter side

5.5.2 Measuring the output voltage across the receiver side

Here we measure the output voltage across the receiver side after wireless power transfer here we get 0.78V AC approximately. **Fig. 5.9** shows the output voltage of receiving coil.

Fig. 5.9: Output voltage measuring across the receiver side

5.5.3 Measuring the output voltage after using boost converter

Because of wireless power transfer we get a very low AC voltage here for charging the battery we need DC voltage. So here we use a boost converter module which make the AC voltage to DC and step up it to 4.83 volt DC. **Fig. 5.10** shows the output voltage after using boost converter module.

Fig. 5.10: Output voltage measuring after using boost converter

5.6 Observation from oscilloscope

Here we a get a pure dc wave shape after using adapter. Our input voltage is 5V DC which we measure earlier, from **Fig. 5.11** we observed this input DC wave shape.

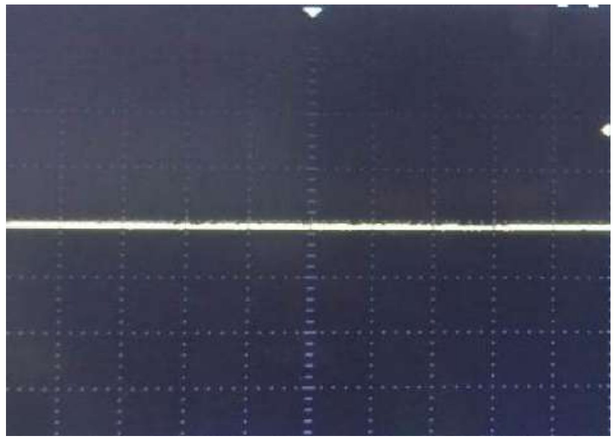

Fig. 5.11: Input DC wave shape

Fig. 5.12 shows the output wave shape of 555 timer. Here we a get a half square wave shape. It's frequency is very high near about 55KHz which we generate by using 555 timer here 555 timer operates in astable mood, that's why a half square wave is generated here.

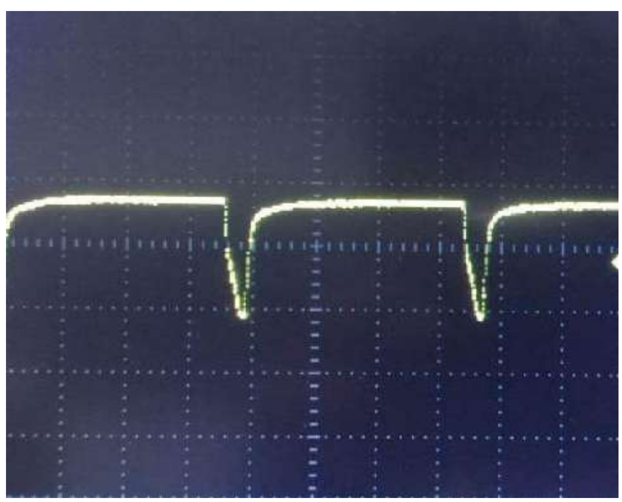

Fig. 5.12: Output wave shape of 555 timer

After using a transistor here we a get a amplified half square wave shape. Here we use a MOSFET transistor named IRF3205 which has fast switching capability then BJT. Here frequency still remain constant which is near about 55KHz and voltage is 1.43V AC.

Fig. 5.13 shows the input wave shape of transmitting coil.

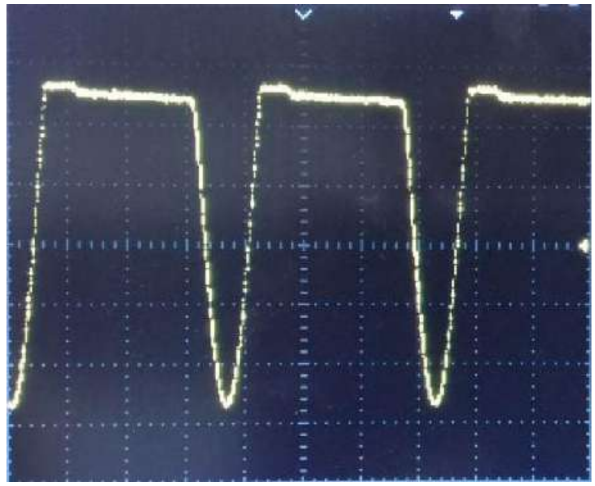

Fig. 5.13: Input wave shape of transmitting coil

Fig. 5.14 shows the output wave shape of receiver side. Because of wireless power transfer magnitude of this wave shape is varied according to flux induced in secondary coil. Here we get near about 0.78V AC voltage.

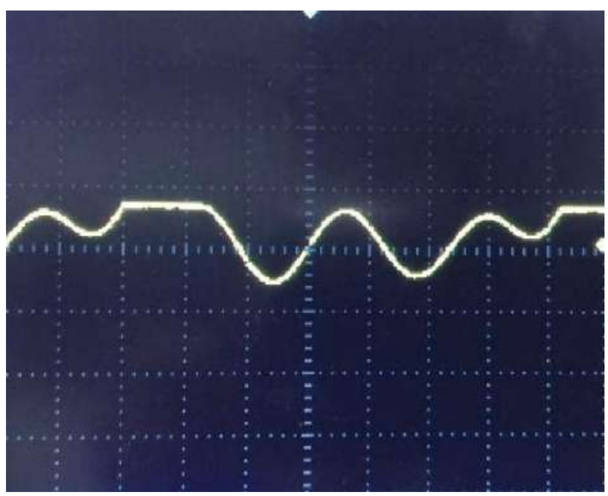

Fig. 5.14: Output wave shape of receiver side

In earlier we see that our voltage is very low due to wireless power transfer and this is an AC voltage. So here we make this AC voltage into DC voltage by using rectifier. After that we use a boost converter here because voltage was very low, here we get near about 4.8V DC after using this boost converter, which is high enough to charge up a 3.7V battery fully.

Fig. 5.15 shows the output wave shape after using boost converter from the battery charging side.

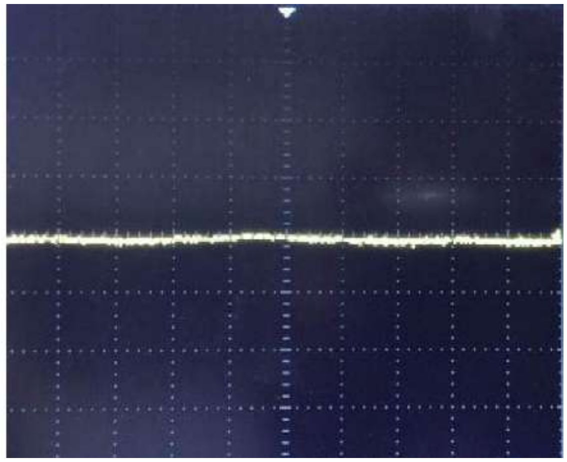

Fig. 5.15: Output wave shape after using boost converter

5.7 Distance vs. power configuration

The coils were arranged in the configuration as shown below and power measurements were taken as a function of distance between the coils. Based upon the data we collected, the following **Fig. 5.16** shows power as a function of distance between the coils,

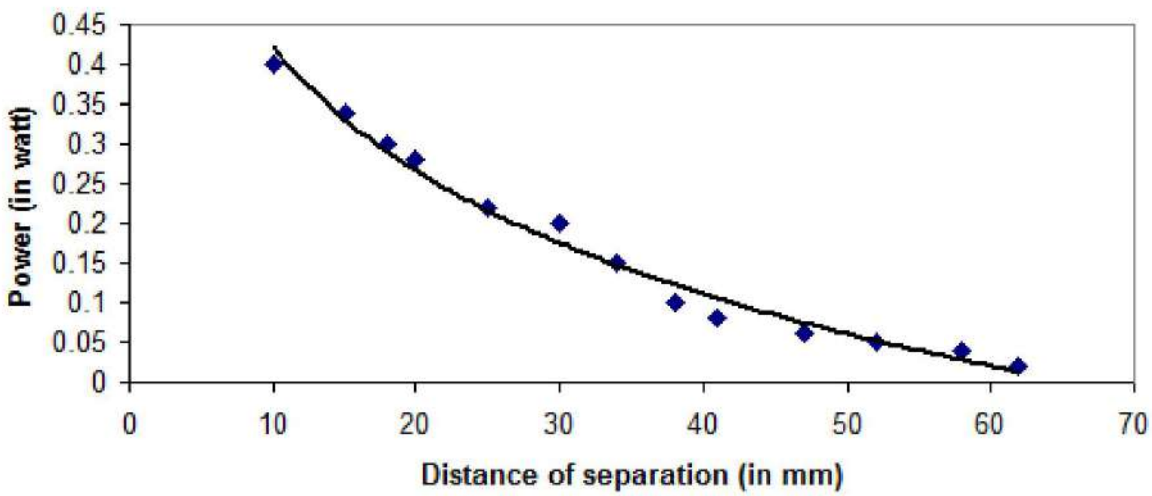

Fig. 5.16: Distance vs. power graph

From above distance vs. power curve we observed that the output power of the secondary coil decayed gradually as the distance of separation between the coils was increasing. The following efficiency table is made by the data we collected. **Table 5.1** shows the efficiency as a function of distance between the coils,

Table 5.1: Efficiency as a function of distance between the coils

Sl. No	Input	Distance (in mm)	Output	Efficiency
1	Input Voltage = 5V DC Input Current = 0.7 A Input Power = 3.5 W	10	Output Voltage = 4.8V DC Output Current = 80 mA Output Power = 0.4 W	12%
2	Input Voltage = 5V DC Input Current = 0.7 A Input Power = 3.5 W	25	Output Voltage = 4V Dc Output Current = 60 mA Output Power = 0.26 W	7%
3	Input Voltage = 5V DC Input Current = 0.7 A Input Power = 3.5 W	40	Output Voltage = 2V DC Output Current = 40 mA Output Power = 0.08 W	3%
4	Input Voltage = 5V DC Input Current = 0.7 A Input Power = 3.5 W	60	Output Voltage = 1V DC Output Current = 20 mA Output Power = 0.02 W	1%

5.8 Time vs. voltage configuration

The output voltage of the secondary coil rectified by using rectifier then step up this voltage by using boost converter, after that this voltage is used for charging the battery. There is a time required for charging the battery full. Battery voltage increase till then full charged as the time left. Here we observed the time required by using stop watch for charging the battery, based upon the data we collected, the following **Fig. 5.17** shows voltage of the battery as a function of time,

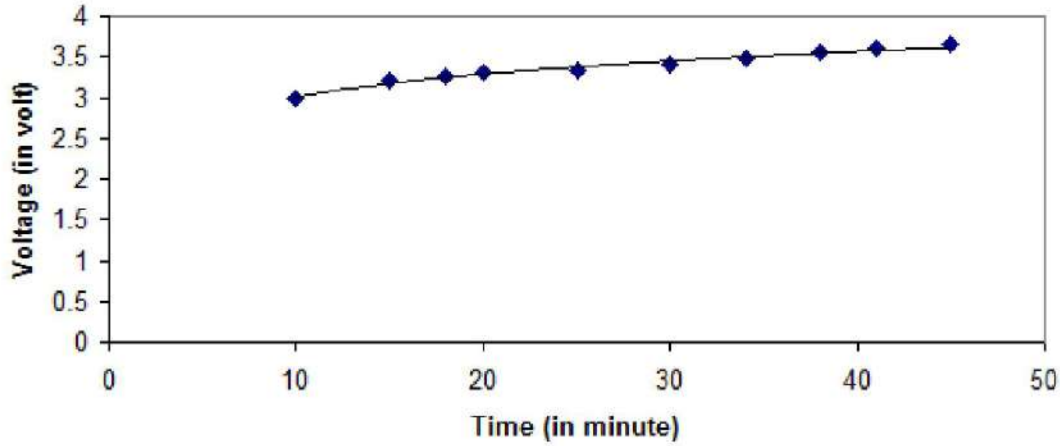

Fig. 5.17: Time vs. Voltage graph

From above time vs. voltage curve we observed that the voltage of the battery increased gradually as the time left. The following table is made by the data we collected,

Table 5.2: Battery voltage as a function of time

Serial No	Time (in minute)	Voltage (in volt)
1	10	3V DC
2	25	3.32V DC
3	30	3.43V DC
4	35	3.51V DC
5	40	3.63V DC

5.9 Discussion

In this project here we design An electronic device that wirelessly transmits power and then charges batteries was developed. Here voltage is varied with the distance of transmitting and receiving coil. A minimum time is required for charging the battery fully.

5.10 Summary

In this chapter the observation of voltages and notice of the wireless power transfer are shown. Here we first measure our input ac voltage then converting it into 5V DC voltage which is made by a simple 220V AC to 5V DC adapter. Then we add a multivibrator circuit which can generate a very high frequency near about 55KHz. Then we observed that input voltage become 1.46V AC which we gave into the transmitting coil. Then this power transmitted for the receiving coil. In receiving coil we got .766V AC approximately. Then we rectified it and step up it into 4.8 volt which is enough to charge a 3.7V DC battery.

CHAPTER 06

CONCLUSION

6.1 Conclusion

The objectives of the project were met. An electronic device that wirelessly transmits power and then charges batteries was developed. We were able to design coils, receiving station for the system design process.

Conclusions that were drawn from the project study are as follows:

1. Based on the theory of wireless charging via inductive coupling, which was the method used in the project, it was seen that various aspects i.e. distance, resonant frequency, quality factor; coil turns ratio determine the efficiency of WPT. In addition there is an exponential decay for power versus the distance of separation.

2. From the analysis it was seen that at 0 mm separation distance, the power transfer was most efficient as seen by the brightness of the test lights.

3. From the project WPT for short range or near field occurred up to a distance of 11 mm after which the power transferred began to significantly drop.

4. It can also be concluded that WPT can be used in other applications. In the project we were able to charge a 5V battery from power that was transmitted wirelessly.

5. Lastly, we can conclude that WPT is not affected by non-magnetic materials shielding the two coils. This therefore means that it can be effectively used in the medical field to charge pacemakers and other devices.

6.2 System Advantages and Limitations

This project is made with best of capabilities and dedication. Details were taken care of preparing it. The problems encountered in various steps were taken into account and eliminated to much extent so they may not harm the project functioning. Also certain areas were thought of before hand and worked upon, so as to prevent them from becoming a limitation for the project. But every system is not perfect in all aspects. They have some associated limitation. In the following advantages and limitations are listed.

6.2.1 Advantages

1. Allows for charging of multiple devices. This is achieved by changing the coil geometry, as well as allocating large charging surface areas such as table tops and charging benches.

2. High charging speeds: though at the moment wireless charging offers a slower charging rate than the wired option, advances in resonance and induction technology promises an increased charging rate and improved efficiency in the future.

3. Wireless power transfer allows for greater spatial freedom between the power source and the device. This means that the two do not have to be precisely aligned for power transfer.

4. Eliminating charging cords enables engineers to make compact and watertight devices, thus maximizing on safety, and varied use such as in deep-sea applications.

5. Prevents corrosion and sparking by eliminating mechanical connectors and wired contacts.

6. Reduces costs associated with maintaining and replacing mechanical connectors.

6.2.2 Limitations

1. Slow Performance: One of the reasons that wireless charging has not been fully integrated is that it can still be slower and less efficient than a traditional charger. Having said this, it is important to mention that this factor is technology-dependent. Certain wireless chargers simply cannot reach the same level of efficiency as traditional charging, so the process tends to be slower. In addition, the heat generated in certain types of wireless charging technologies is generally higher in comparison with the conventional way of charging.

2. Less Efficiency: It has less efficiency than wired power transfer.

3. Interference in the wave of tissue that could occur anytime. Disorders-disorders can be caused by weather or other disruptions.

4. Though it is not possible to charge vehicle batteries with small electronic devices like 555 timer, MOSFET etc.

6.3 Future Work

There can be significant research work that can be done in the future of this research.

1. Future work includes the improvement of efficiency during charging of battery.

2. More fastest charging.

3. Also, reduction in the size of the transmitting and receiving coils and utilizing the regulated signal to power a DC load could be something that could be worked in the future as a means to make this system feasible for practical applications.

REFERENCES

[1] Andre Kurs, Aristeidis Karalis, Robert Moffatt, J. D. Joannopoulos, Peter Fisher, Marin Soljacic, “Wireless Power Transfer via Strongly Coupled Magnetic Resonances”, Vol. 317, no. 5834, pp. 83-86, 2007.

[2] Wireless Power Transmission Using Magnetic Resonance, 06-11-2017, retrived from: http://www.cornellcollege.edu/physics/courses/phy312/StudentProjects/MagneticResonance/Magnetic-Resonance.html

[3] About Wireless Charging and Discharging, 06-11-2017, retrived from: https://www.fraunhofer.de/en/press/research-news/2015/august/Wireless-charging-and-discharging-for-electric-vehicles.html

[4] Menno Treffers, “History, Current Status and Future of the Wireless Power Consortium and the Qi Interface Specification.” *IEEE Circuits and Systems Magazine*, Vol. 15, no. 2, pp. 28–31, 2015.

[5] Jafaru Ibrahim, Tonga Agadi Danladi, Musefiu Adrinola, "Comparative Analysis Between Wired And Wireless Technologies in communications: A review", *Proceedings of 99th The IER International Conference,* Mecca, Saudi Arabia, 23rd-24th March 2017.

[6] Different Types of Electric Vehicle, 11-11-2017, retrived from: https://www.transportenergy.org.uk/different-types-of-electric-vehicle/

[7] Mainstream Electric Car Makers Race to Wireless EV Charging, 12-11-2017, retrived from: https://www.pluglesspower.com/learn/mainstream-electric-cars-are-headed-towards-wireless-charging/

[8] William C. Brown, "The history of wireless power transmission," *Solar Energy*, Vol. 56, no.1, pp. 3-21, January 1996.

[9] Wireless Power Transfer Circuit, 05-11-2017, retrieved from: https://www.elprocus.com/wireless-power-transfer-circuit-and-working/

[10] Basic electromagnetic induction transmitter and receiving coils, 15-11-2017, retrieved from: https://www.eoas.ubc.ca/courses/eosc350/content/2011/Labs/em/EM_lab.html

[11] Arjun Sharma, “Application of Wireless Power Transfer for Home Appliances using Inductive Resonance Coupling”, *International Journal of Engineering Trends and* Technology , Vol. 16, pp. 159-163, Oct 2014.

[12] Muhammad H. Rashid, *Power Electronics Circuits Devices and Application*, 3rd Edition, pp.190-194.

[13] Boost converter, 2017-11-05, retrieved from: http://www.learnabout-electronics.org/PSU/psu32.php

[14] Charging System for Electric Vehicle, 03-11-2017, retrieved from: https://en.wikipedia.org/wiki/charging-station

[15] Charging system of electrical cars, 04-11-2017, retrieved from: http://www.learnaboutelectronics.org/PSU/psu32.php

[16] Adapter internal circuit, 05-11-2017, retrieved from: https://circuitdigest.com/electroniccircuits/cell-phone-charger-circuit-diagram

[17] Adapter Circuit Operation, 05-11-2017, retrieved from: https://www.elprocus.com/steps-to-convert-the-230v-ac-to-5v-dc/

[18] Knowlton, A.E (Ed.), *Standard Handbook for Electrical Engineers,* 8th Edition, McGraw-Hill, 1949, pp. 597,

[19] Resistor, 2017-11-06, retrieved from: https://www.fabtolab.com/resistors-10k

[20] Charles Alexandar , Matthew Sadiku , *Fundamentals of Electric Circuit*, 3rd Edition, New York:McGraw-Hill,1993, pp. 206.

[21] Capacitor, 05-11-2017, retrieved from: http://www.oddwires.com/10pcs-nichicon-1000uf-35v-radial-electrolytic-capacitor-10-pack/

[22] Howard M. Berlin, *555 Timer Applications Sourcebook with Experiments*, 2nd Edition; Sams Publishing,2002, pp. 218; ISBN 978-8176567909. (1st Edition in 1976)

[23] 555 timer, 05-11-2017, retrieved from: https://en.wikipedia.org/wiki/555_timer_IC

[24] Astable Operation of 555 Timer, 03-11-2017, retrieved from: http://www.circuitstoday.com/555-timer-astable-multivibrator

[25] About transistor IRF3205, 05-11-2017, retrieved from: https://www.theengineeringprojects.com/2017/09/introduction-to-irf3205.html

[26] Boost Converter Module, 11-11-2017, retrived From: http://www.dx.com/p/dc-dc-1-5v-converter-booster-module-274695#.WiGGVFvGzIV

[27] Boost Converter Operation, 05-11-2017, retrieved from: http://www.learnabout-electronics.org/PSU/psu32.php

[28] Robert L. Boyelstead, Louis Nashelsky, *Electronic Devices and Circuit Theory,* New Edition,Pearson Education International, 2013-2014, pp. 59.

[29] Diode, 06-11-2017, retrieved from: https://www.electrical4u.com/diode-working-principle-and-types-of-diode/

[30] Robert L. Boyelstead, Louis Nashelsky, *Electronic Devices and Circuit Theory,* New Edition,Pearson Education International, 2013-2014, pp. 41-47.

[31] LED and its symbol, 06-11-2017, retrieved from: http://www.mainbyte.com/ti99/electronics/led/symbol.html

[32] About Lithium-Ion Battery, 09-11-2017, retrieved from: https://www.energy.gov/eere/articles/how-does-lithium-ion-battery-work

[33] Lithium ion battery 3.7v, 09-11-2017, retrieved from: http://www.ejtechgroup.com/index.php

[34] RF module basics, 07-11-2017, retrieved from: https://www.elprocus.com/rf-module-transmitter-receiver/

[35] B. L. Theraja, A. k. Theraja, *A text Book of Electrical Technology*, Vol. II, S.Chand & Company Ltd. ,2001, pp. 822-837.

[36] DC motor 2v to 5v, 14-11-2017, retrieved from: https://www.norwegiancreations.com/2015/12/embedded-tutorial-dc-motors/

[37] Gousia Sultana, Deepak. TR, Pratiksha Bhusan, Mohammed Azeem, Swathi.G.N. "Design and Implementation of Wireless Power Transfer Charging System on Miniature Model", *SSRG International Journal of Electrical and Electronic Engineering*, Vol. 3, pp. 44-48 ,4 March 2016.

[38] Laminated copper coils, 12-11-2017, retrieved from: http://www.builderdepot.co.uk/copper-coil-microbore-soft-8mm-x-25m.html

APPENDIX A

Table 1: Pin description of 555 Timer

555 Pin	Pin name	Pin purpose
1	GND	Ground supply: ground reference voltage (zero volts).
2	TRIG	Trigger: when this input falls below ½ of CTRL voltage (typically ⅓ V_{CC}, CTRL being ⅔ V_{CC} by default if CTRL is left open), the OUT pin goes high and a timing interval starts. More simply, as long as the trigger is kept at low voltage, OUT will be high. Output of the timer totally depends upon the amplitude of the external trigger voltage applied to this pin.
3	OUT	Output: the push-pull (P.P.) output is driven to GND or approximately 1.7 V below +VCC. (Note: CMOS timer parts can drive output up to V_{CC} rail.) A 1 nF decoupling capacitor be connected at the output pin in circuits that connect to digital logic inputs, which may help minimize 555 output switching noise from causing problems.
4	RESET	A timing interval may be reset by driving this input to GND, but the timing does not begin again until RESET rises above approximately 0.7 volts. Overrides TRIG, which overrides THR.
5	CTRL	Control (or Control Voltage or CV): provides "control" access to the internal voltage divider (by default is ⅔ V_{CC}). By applying a voltage to the Control Voltage input one can alter the timing characteristics of the device. In most applications, this pin is not used, thus it is recommended to connect a low-noise 10 nF decoupling capacitor (film or C0G ceramic) between Control pin and Ground pin to filter noise on the higher reference voltage. The control pin input can be used to build an astable multivibrator with a frequency-modulated output.
6	THR	Threshold: when the voltage at THR ("threshold") is greater than that at CTRL (⅔ V_{CC} if CTRL is open) the timing (OUT high) interval ends.

7	DIS	Discharge: open-collector output, which may discharge a capacitor between intervals. In phase with output.
8	V_{CC}	Positive supply: the guaranteed voltage range of bipolar parts are typically 4.5 volt to 15 volts (some parts rated up to 16 volts or 18 volts), though most bipolar parts will operate at voltages as low as 3 volts. (Note: CMOS timer parts have a lower minimum voltage rating.) It is recommended that a 100 nF decoupling capacitor be connected as close as possible to this pin, and optionally a 10 to 100 uF reservoir capacitor (depending on the load connected to the output pin). These capacitance values are a starting point for consideration instead of mandatory values that must be used.

APPENDIX B

Table 2 : Cost details of system components

Sl.No	Component Name	Unit price (Taka)	Quantity	Cost (Taka)
1.	DC Adapter Circuit	100	1	100
2.	Resistor	2.5	4	10
3.	Capacitor	10	2	20
4.	555 Timer	40	1	40
5.	Transistor	20	1	20
6.	Laminated Copper Coils	1200	150gm	200
7.	Boost Converter Module	150	1	150
8.	Rechargeable Battery	130	1	130
9.	LED	3	2	6
10.	Transmitter module for remote	200	1	200
11.	Receiver module for remote	200	1	200
12.	DC Motor	80	1	80
13.	Diode	5	1	5
14.	Others			100
TOTAL COST				**1261**