DESIGN OF A WIRELESS EV CHARGING SYSTEM FOR EFFICIENT ENERGY TRANSFER

A Project
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Of

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DECLARATION

This is to certify that this project is our original work. No part of this work has been submitted elsewhere partially or fully for the award of any other degree or diploma. Any material reproduced in this project has been properly acknowledged.

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Abstract

This project designs a wireless EV charging system using inductive power transfer (IPT) to enhance energy efficiency and convenience. The system eliminates physical connectors, transferring power via electromagnetic fields. Key challenges like power loss and alignment are addressed through advanced resonance techniques. A prototype is tested for efficiency and charging speed, with potential integration into smart grids for optimized energy use. The goal is to provide a more efficient, safer, and convenient alternative to traditional plug-in charging.

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CHAPTER - 01
INTRODUCTION

1.1 Introduction

In recent years, supply and demand for plug-in electric vehicles (EVs) and plug-in hybrid electric vehicles (HEVs) are increasing very fast. The growing EV market stimulates the demand for more convenient and reliable approaches to recharge the vehicle battery. The existing conductive charging approach requires the high-power charging devices or charging stations to recharge the vehicle within a short time. Also, incompatible plug receptacles also cause the additional inconvenience among different EV models, which limit the fast development of EVs. In order to avoid the physical contact and being plugged in frequently, the wireless power transfer (WPT) technique is proposed for EV charging, which has the distinct and indispensable features for power transmission. Thus, the inconvenience and hazard caused by traditional conductive method can be essentially overcome with wireless charging method. Without the contact by the cable and plug in the WPT system, the shape, size and location of the magnetic core material and coil windings play a crucial role for wireless charging performances, including the charging distance, the power level, and the transmission efficiency. Normally, the primary transmitting side is stationary beneath the ground for both the stationary wireless EV charging and the roadway powered EVs (RPEV) . The power transmitting unit of the primary side can be structured either by an elongated conductor (called a track to delivery power continuously along the track), or a lumped coil pad (to delivery power at discrete locations for stationary EV charging and RPEV). On the other side, the secondary receiving side is located at the bottom of an EV, which is designed for catching the transfer power. The power receiving unit of the secondary side can be structured in different topologies with a lumped coil pad. The purpose of this paper is to give an overview of lumped coil pad designs for wireless EV charging as shown in Fig. 1.

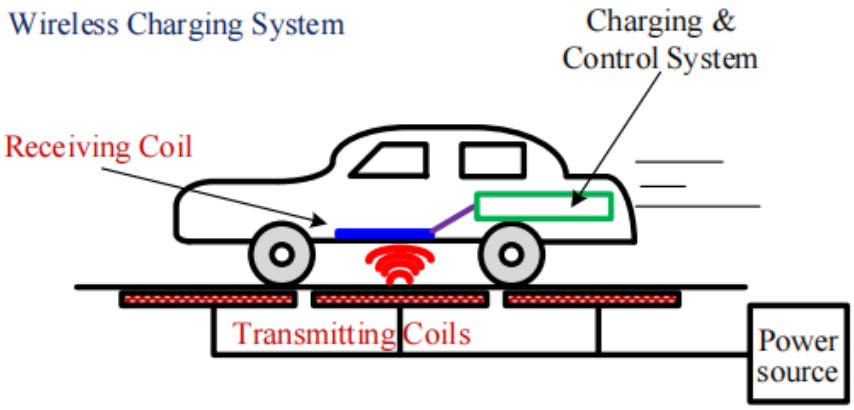


Figure 1.1: Schematic wireless EV charging system.

1.2 Background Study

Basic principle of wireless charging is same as transformer working principle. In wireless charging there are transmitter and receiver, 220V 50Hz AC supply is converted into low voltage, High frequency alternating current and this high frequency AC is supplied to transmitter coil, then it creates alternating magnetic field that cuts the receiver coil and causes the production of AC power output in receiver coil. Then finally, this AC power at receiver side rectified to DC and fed to the battery to charge battery effectively. Here we implement static wireless charging stations. Here vehicle get charged while it is n parking . The power transfers over the air from a stationary transmitter to the receiver coil in a stationary vehicle. It reduces the need for large energy storage which further reduces the weight of the vehicle. Inductive Wireless Charging System (IWC) :- The basic principle of IWC is Faraday's law of induction. Here wireless transmission of power is achieved by mutual induction of magnetic field between transmitter and receiver coil. When the main AC supply applied to the transmitter coil, it creates AC magnetic field that passes through receiver coil and this magnetic field moves electrons in receiver coil causes AC power output. This AC output is rectified and filtered to Charge the EV’s energy storage system. The amount of power transferred depends on frequency, mutual inductance and distance between transmitter and receiver coil.

1.3 Problem Statement

The increasing adoption of electric vehicles (EVs) highlights the limitations of conventional plug-in charging methods, such as inconvenience, wear and tear of physical connectors, and safety risks in wet or harsh conditions. These challenges necessitate a more efficient, user-friendly solution. The wireless vehicle charging system addresses these issues by eliminating the need for physical connections and providing a seamless charging experience. However, challenges such as energy transfer efficiency, alignment of transmitter and receiver coils, and cost-effective implementation remain significant. Developing an efficient and reliable wireless charging system is critical to overcoming these barriers, accelerating EV adoption, and supporting sustainable transportation.

1.4 Motivation

The growing global emphasis on sustainable transportation and the rapid adoption of electric vehicles (EVs) drive the need for innovative charging solutions. Traditional plug-in charging methods often pose challenges such as inconvenience, wear and tear, and safety risks, particularly in adverse weather conditions. The motivation behind developing a wireless vehicle charging system lies in its potential to address these challenges by providing a safe, efficient, and user-friendly alternative. By eliminating physical connectors and enabling seamless energy transfer, this technology enhances the convenience of EV ownership. Additionally, it supports the global shift toward renewable energy integration and eco-friendly transportation systems.

1.5 Objective of Our Project

We have some specific objectives for this project and they are pointed below:

- ✧ Design & Construct of Wireless Charging Vehicles System.
- ✧ To put the whole system into action so that we can observe its practical effects and verify our work.
- ✧ The main objective of this project is to design and construct of Vehicle Charging with Wireless System.
- ✧ To study the system performance for future reference and improvement purpose.

1.6 Methodology

- ✧ Design and construction of a Wireless Charging Vehicles System block diagram & circuit diagram to know which components need to construct it.
- ✧ Collecting the All Components our desired system.
- ✧ Setting all components in a PCB board & soldering. Then assembling the whole block in a board and finally run the system & checking.

CHAPTER - 02
LITERATURE REVIEW

2.1 Introduction

In this section topics related to Wireless Vehicle Charging System. These provide a sampling of problems appropriate for application of IoT Substation Power Monitoring System with Input Output Line Fault Detection. The references are summarized below.

2.2 Literature Review

F. Musavi, W. Eberle, Overview of wireless power transfer technologies for electric vehicle battery charging**,** to date, electric vehicle (EV) charging technology has been needed since the mid-19th century. Disposable batteries were used in the initial electric vehicles, and "charging" technology eventually replaced the "dead" batteries. Because none of these early EV vehicles were mass produced, there was no market for them. Recharging points as a major issue, many homes were built before the early 20th century. Charging the vehicle at the residence was impossible because there was no electricity. In order to make electric vehicles more available to the general public, homes had to be electrified. This would have the desired effect of would lead to an increase in the number of people purchasing and using electric vehicles. In the early years of the twentieth century, 38 percent of the vehicles in the United States were powered by electricity [1].

C. Qiu, K. T. Chau, T. W. Ching, C. Liu, Overview of wireless charging technologies for electric vehicles**,** these automobiles might be charged in two ways: either with the vehicle's batteries in it, or if the battery was taken from the vehicle and charged elsewhere installed on the vehicle in the first place Using this timeline, one may learn about the scientific discoveries that led to the development of solar energy, and how it has evolved through time into electrical vehicle charging source. Solar panels are a fantastic source of power, but it's interesting that it has been reluctant to realize their full potential. During the 1973 oil embargo, solar seemed like a "better option than fossil fuels" because of gas shortage. Demand for energy independence increased, which led to the first wave of solar incentive programs in many states. [2]

T. M. Fisher, K. B. Farley, Y. Gao, H. Bai, Z. T. H. Tse, Electric vehicle wireless charging technology**:** The thesis focuses on charging of EVs from PV at workplaces like office buildings and factories. The reason for this focus is three-fold. First, workplaces offer a relatively large area for installation of PV modules. The working hours of employees during the day largely matches the hours when the sun is shining. This provides ample time to charge the EV battery from the solar energy. Finally, the 7-9 hour long parking of vehicles at the workplace allows the use of lower charging powers, thus reducing the cost and complexity of the EV chargers needed. The long parking times also make it suitable to implement smart charging which helps in reducing the costs further. In order to realize such a solar powered EV charging infrastructure, three elements are essential – system-level design, development of a solar EV charger and formulation of smart charging algorithms. These three research elements form the core of this thesis, and the research gaps in them are explained further. [3]

J. Dai, D. C. Ludois, A survey of wireless power transfer and a critical comparison of inductive and capacitive coupling for small gap applications, IEEE Transactions on Power Electronics 30 (11) (2015) 6017–6029**.** However, EVs are only sustainable if the electricity used to charge them comes from renewable sources and not from fossil fuel based power plants. Where the well-to-wheel greenhouse gas emissions (GHG) from a fuel perspective of a conventional gasoline car is compared with those of a hybrid electric vehicle (HEV), plug-in hybrid electric vehicle (PHEV) and plug-in electric vehicle (PEV) for different cases of the fuel mix for electricity generation (Appendix A). It is evident that any form of an electric car, be it an HEV, PHEV or PEV always has lower well-to-wheel emissions from a fuel perspective than a comparable gasoline car. [4]

Z. Bi, T. Kan, C. C. Mi, Y. Zhang, Z. Zhao, G. A. Keoleian, A review of wireless power transfer for electric vehicles: Prospects to enhance sustainable mobility, Applied Energy 179 (2016) 413–425. At the same time, the emissions of the electric car are itself dependent on how clean the fuel mix is. If EVs are charged from a grid that is predominantly powered by fossil fuels like coal or natural gas, the emissions are significant and not zero, contrary to popular belief. On the other hand, if EVs are charged from a grid which is largely powered by renewable energy, then the net emissions are close to zero. The challenge, then, is to power EVs in the future using sustainable sources of energy. In this section, we provide a review of the related work in chronological order of the year of publication. Various aspects of wireless

charging systems for EVs have been studied, reviewed and presented in the literature since this area of research gained focus a few years ago. [5]

Y. J. Jang, Survey of the operation and system study on wireless charging electric vehicle systems, Transportation Research Part C: Emerging Technologies 95 (2018) 844–866**.** A work in the early days of wireless charging for EVs reviews different technological solutions. Feasibility of each possible solution is evaluated considering the limitations of the cost, available power electronics technology and consumer acceptance. Coupling theory is reviewed and its application for WPT using IPT is further discussed. However, this review is limited in nature, and many aspects, such as SWCS, DWCS, design considerations, control and communication are not discussed and analyzed. Another relatively short review in studies near field inductive power transfer (IPT) using strongly coupled magnetic resonance for wireless charging of EVs. The work also reviews multiple pickup control, misalignment tolerance, shielding methods and simultaneous power and data transmission. However, this work lacks a thorough analysis of the reviewed topics. Moreover, CPT and DWCS are also not reviewed. [6]

C. Panchal, S. Stegen, J. Lu, Review of static and dynamic wireless electric vehicle charging system, Engineering Science and Technology, an International Journal 21 (5) (2018) 922–937. doi: The authors of review the technology companies that have developed the wireless charging solutions for EVs. In addition to this, the authors review the research laboratories and the universities that are working in this field and some of their proposed solutions. The automobile companies that are interested to deploy the wireless charging systems for EVs and their work are also discussed. The safety issues and regulations related to the wireless charging systems are described too. However, this review focuses only on the feasibility, penetration and adaptation of the EV wireless charging systems. Many technical details, such as, different types of charging techniques, and the IPT and the CPT are not reviewed. [7]

D.Ji, Mingsong, J.Yang, W.Yi, “Optimizing the Locations and Sizes of Solar Assisted Electric Vehicle Charging Stations in an Urban Area”, IEEE transaction, Vol. 8, pp. 112772 – 112782, June 2020. The work in reviews and compares the IPT and the CPT for the WPT using analytical modelling and empirical data. The authors conclude that the IPT is preferable for the WPT if the gap is greater than 1 mm. The power densities of the CPT and the IPT couplers are nearly identical for air wireless charging are not considered and analyzed. The

review articles discussed in this paragraph were published in the years 2014 to 2015. These are preliminary studies in which the basic methods and issues related to EV wireless charging systems are discussed. The WPT for EVs is reviewed in from both technical and sustainability perspectives. The work focuses on the IPT for the WPT and briefly discusses the coil design for both the SWCS and the DWCS. Compensation topologies, control methods and power electronics converters for the WPT are also discussed. [8]

D. Ranawat, M.P.R.Prasad, "A Review on Electric Vehicles with the perspective of Battery Management System", Third International Conference on Electrical and Electronics, Communication, Computer Technologies, and Optimization Techniques (ICEECCOT) pp.14-15, December 2018**.** From the sustainability perspective, energy and environmental assessments are made, and economics, policy, health and safety issues are discussed and reviewed. In addition, prospects to enhance sustainable mobility are also described. This review is, however, limited in nature as many topics, such as, the charging process, the CPT, the design parameters, and the magnetic structures for the IPT are not discussed. The authors in provide an in depth review of the wireless charging technologies for EVs. The work provides a comparison of the conductive and the wireless charging systems, which is followed by a detailed description of the stationary and the dynamic systems for wireless charging. Standards related to wireless charging are listed and reviewed. Issues related to sustainability, health, safety, economic analysis and social implications are also discussed in this work. Even though this work reviews and provides a good insight into many functions of EV wireless charging systems, it does not discuss the CPT, battery related issues, and control and communication aspects of these systems. Another work in reviews the deployment, operations and commercialization activities of the charging solutions. Assignment and allocation of charging infrastructure, driving range extension and cost and benefit analysis for wireless charging systems for EVs are also discussed. [9]

J.Traube, F.Lu, D.Maksimovic, J.Mossoba, M.Kromer, P.Faill, S.Katz, B.Borowy, S.Nichols, L.Casey, "Mitigation of Solar Irradiance Intermittency in Photovoltaic Power Systems With Integrated Electric- Vehicle Charging Functionality", IEEE Transactions On Power Electronics, Vol. 28, No. 6, June 2013. This review focuses on systems, operations and economics of the EV wireless charging systems and does not discuss technical details, such as, the IPT, the CPT, the compensation topologies and the magnetic structures. Wireless transformer structures with different ferrite shapes are reviewed in. In addition, the SWCS

and the DWCS are reviewed in the light of developments made by the industry, the universities and the research laboratories. However, this article does not discuss the charging process, communication and control related issues of the EV wireless charging systems. This paragraph has reviewed the articles published in the period from 2016 to 2018. The work during this period discusses economics and social implications of the wireless charging systems in addition to the technical aspects. The work in [36] reviews various aspects of an inductive wireless charging solution in detail. Some of the key aspects of an EV charging system are reviewed, summarized and compared. [10]

G.Alkawsi, Y.Baashar, D.Abbas, A.Ahmed Alkahtani, S.KiongTiong, "Review of Renewable Energy-Based Charging Infrastructure for Electric Vehicles" Appl. Sci., Vol. 11, pp. 3847, Apr. 2021. A few of these include coil design, compensation topologies and communication between the ground and vehicle assembly. Particularly, the work investigates the use of superconducting material in the coil design and its potential impact on a wireless charging system is also discussed. In addition, standards, health and safety issues and costs related to EV wireless charging systems are discussed and reviewed. Even though this work is a detailed review, it does not cover some important topics related to an EV wireless charging system. For example, the battery related issues are not discussed. In addition, the IPT and the CPT are not compared in sufficient detail. In a relatively short review, wireless charging of EVs using the IPT with strongly coupled magnetic resonance is discussed. Various aspects of the IPT, such as, operating principles, compensation technologies, charging distance, power level and misalignment tolerance are also reviewed. [11]

G.Zhang1, J.Lai1, S.Feng1, W.Shi, "Green Solar Electric Vehicle Changing the Future Lifestyle of Human", Land, Sea, Air, and Space Vehicles, Boca Raton, FL, USA: CRC Press, June 2003. However, this review is restricted only to the IPT and associated topics and many further details of the EV wireless charging are not discussed. Authors in give a detailed review of wireless charging systems for high power transfer applications. Laboratory prototypes and commercial systems for high power wireless charging are discussed and reviewed with respect to compensation networks, magnetic pad designs, power electronics converters, and communication and control strategies. The work, however, is dedicated only to the high power wireless charging applications, and therefore does not discuss topics related to the common wireless charging systems, such as, the charging process, the CPT, and the battery

related issues. Different technologies used for the WPT for the charging of EVs are discussed and reviewed in. [12]

Md.Sohail Tanveer, S.Gupta, R.Rai, N.Kumar Jha, "Solar based electric vehicle charging station", 2nd International Conference on Power Energy, Environment and Intelligent Control (PEEIC), doi. 978-1-7281-1793- 5/19/IEEE, 2019. After describing various charging modes, this work proceeds to review the near field and the far field WPT for the charging of EVs. This review article focuses on different types of WPT methods and their performance comparison. It does not discuss some important topics, such as, design considerations, compensation networks, the charging pad, communication and control of an EV wireless charging system. The articles discussed in this paragraph were published in the period from 2019 to 2021. These articles present further advancements and detailed technical reviews of the EV wireless charging technology. [13]

SAE Standard J1772, "SAE Electric Vehicle and Plugin Hybrid Electric Vehicle Conductive Charge Coupler," Oct. 2010. Our current work provides a review of the EV wireless charging systems with a unique perspective. The general WPT methods are described before discussing wireless charging in EVs. In addition, these wireless charging systems are discussed in the context of both SWCS and DWCS. Summaries of the stationary and the dynamic wireless charging systems with quantitative details are also provided. Furthermore, this work takes a wider view of wireless charging research. For example, different types of batteries and battery models are also discussed, as the batteries are significant when discussing a charging system. [14]

2.3 Summery

From the literature discussed above, we gained a lot of knowledge and we inspired to do this project. We were able to do it with everyone tireless work.

CHAPTER - 03
SYSTEM ARCHITECTURE

3.1 System Description

In this project, we have used a SMPS which has a Transformer to step down the input AC supply to get our desired value and then using the rectifier circuit and filter inside we get a DC output. Then the regulator IC has been used to output a regulated 5V, And the Vehicle Battery Charge Provide to Transmitter Receiver Coil.

3.2 Block Diagram

Here we plot our system instrument, connected through a line and make a diagram of our system. Which will help the project instruments organization.

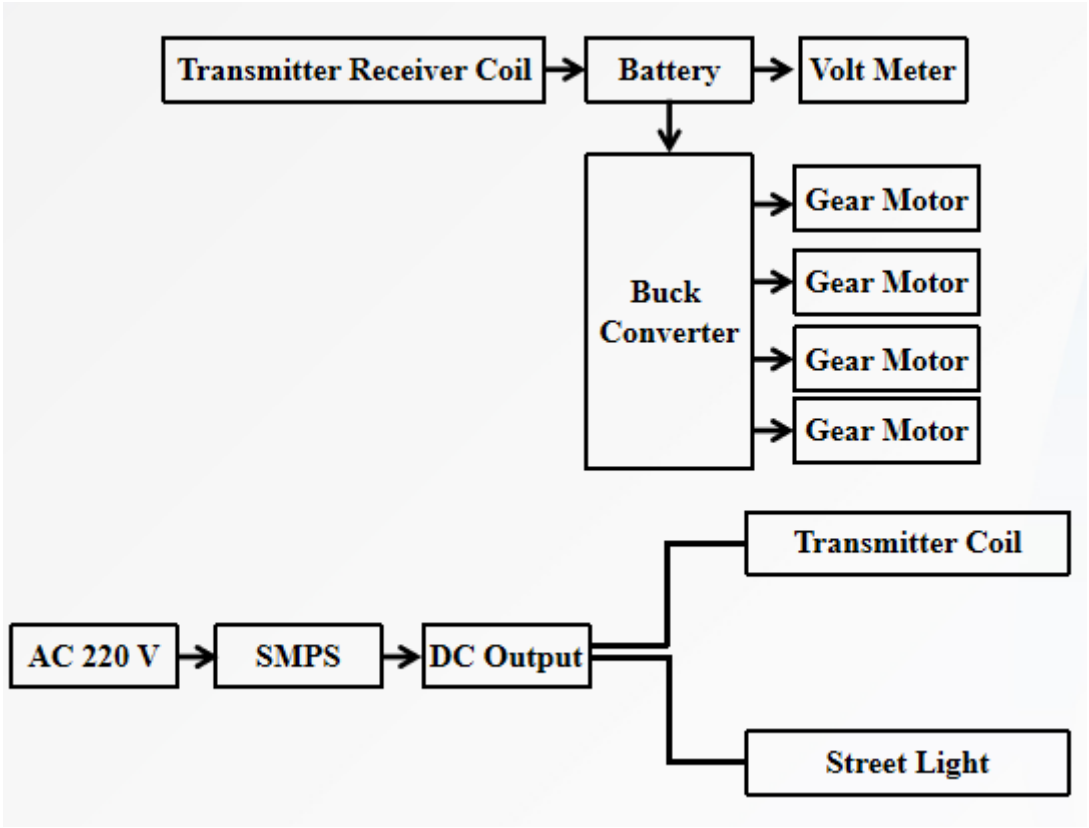


Figure 3.1: Block Diagram of Our Project

3.3 Schematic Diagram

The schematic diagram here is representing the electrical circuit and the components of the project. Here we have used standardized symbols and lines.

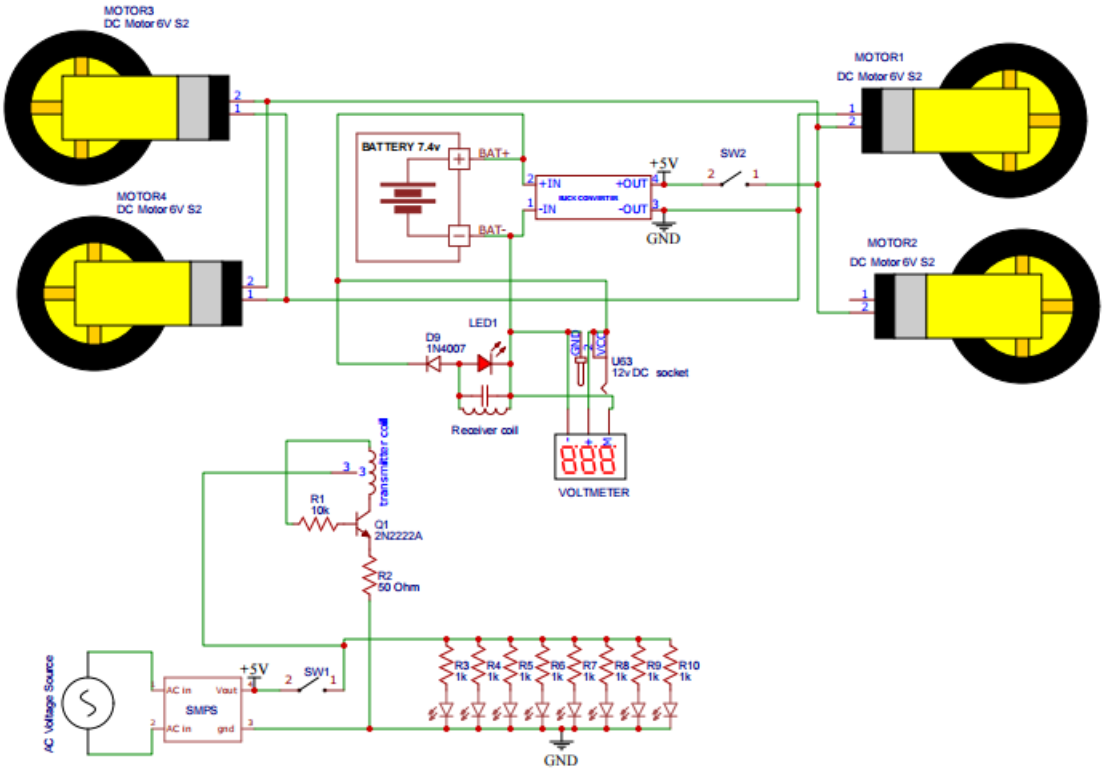


Figure 3.2: Schematic Diagram of Our Project

3.4 Working Principle

The wireless vehicle charging system operates via electromagnetic induction. A Switched-Mode Power Supply (SMPS) converts AC power into a regulated DC, supplying energy to the transmitter coil at the charging station. This coil generates an alternating electromagnetic field when energized.

A receiver coil installed in the vehicle captures this electromagnetic field and converts it into electrical energy through induction. This energy charges the vehicle's battery and And Volt Meter Displays Show the voltage. Resonance tuning between the coils ensures efficient power transfer. The system eliminates physical connectors, offering a safe, convenient, and efficient method to charge electric vehicles, supporting sustainable transportation solutions.

3.5 Project Prototype Image



Figure 3.3: Project Prototype Image

3.6 Cost analysis

Table 1: Component's Name and Purpose of Use.

Sl. no	Particulars	Specification	Qty.	Unit Price (Taka)	Total Price (Taka)
1	Gear Motor	6V DC	4	180	720
2	SMPS	5V, 5Amp	1	500	500
3	Wheel		4	120	480
4	Battery	3.7V	2	100	200
5	Buck Converter	LM2596	1	150	150
6	Wireless coil	5V 2A	2	400	800
7	Street Light		8	5	40
8	Volt Meter		1	150	150
9	Others				1500
				Total	4390/=

CHAPTER - 04
HARDWARE & SOFTWARE DETAILS

4.1 Required Instrument and Software

Hardware List

1. SMPS
2. Gear Motor
3. Wheel
4. Battery
5. Buck Converter
6. Wireless Coil
7. Volt Meter

Software

1. Easy EDA

4.2 SMPS

A switched-mode power supply (switching-mode power supply, switch-mode power supply, switched power supply, SMPS, or switcher) is an electronic power supply that incorporates a switching regulator to convert electrical power efficiently. Like other power supplies, an SMPS transfers power from a DC or AC source (often mains power) to DC loads, such as a personal computer, while converting voltage and current characteristics. Unlike a linear power supply, the pass transistor of a switching-mode supply continually switches between low-dissipation, full-on and full-off states, and spends very little time in the high dissipation transitions, which minimizes wasted energy. A hypothetical ideal switched-mode power supply dissipates no power. Voltage regulation is achieved by varying the ratio of on-to-off time (also known as duty cycles). In contrast, a linear power supply regulates the output voltage by continually dissipating power in the pass transistor. This higher power conversion efficiency is an important advantage of a switched-mode power supply. Switched-mode power supplies may also be substantially smaller and lighter than a linear supply due to the smaller transformer size and weight.



Figure 4.1: SMPS

Switching regulators are used as replacements for linear regulators when higher efficiency, smaller size or lighter weight are required. They are, however, more complicated; their switching currents can cause electrical noise problems if not carefully suppressed, and simple designs may have a poor power factor. Switched-mode power supplies are classified according to the type of input and output voltages. The four major categories are:

- AC to DC
- DC to DC
- DC to AC
- AC to AC

A basic isolated AC to DC switched-mode power supply consists of:

- Input rectifier and filter
- Inverter consisting of switching devices such as MOSFETs
- Transformer
- Output rectifier and filter
- Feedback and control circuit

The input DC supply from a rectifier or battery is fed to the inverter where it is turned on and off at high frequencies of between 20 KHz and 200 KHz by the switching MOSFET or power transistors. The high-frequency voltage pulses from the inverter are fed to the transformer primary winding, and the secondary AC output is rectified and smoothed to produce the required DC voltages. A feedback circuit monitors the output voltage and instructs the control circuit to adjust the duty cycle to maintain the output at the desired level.

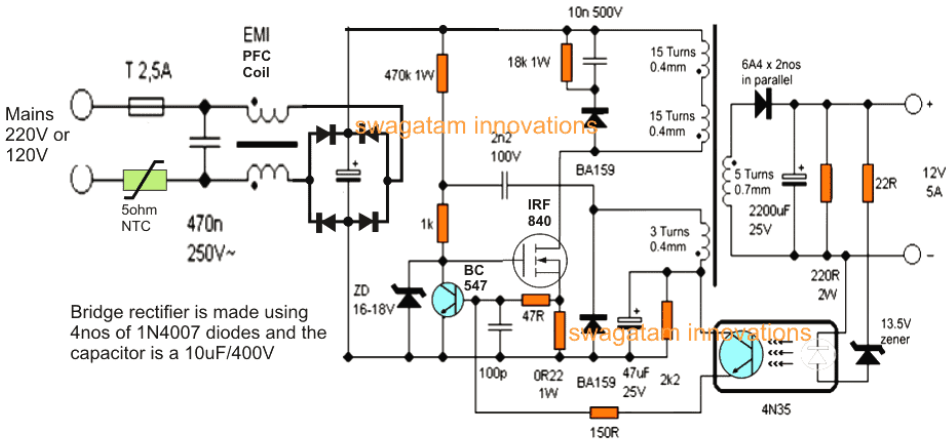


Figure 4.2: SMPS Circuit

Basic working concept of an SMPS

A switching regulator does the regulation in the SMPS. A series switching element turns the current supply to a smoothing capacitor on and off. The voltage on the capacitor controls the time the series element is turned. The continuous switching of the capacitor maintains the voltage at the required level.

Design basics

AC power first passes through fuses and a line filter. Then it is rectified by a full-wave bridge rectifier. The rectified voltage is next applied to the power factor correction (PFC) pre-regulator followed by the downstream DC-DC converter(s). Most computers and small appliances use the International Electrotechnical Commission (IEC) style input connector. As for output connectors and pin outs, except for some industries, such as PC and compact PCI, in general, they are not standardized and are left up to the manufacturer.

There are different circuit configurations known as topologies, each having unique characteristics, advantages and modes of operation, which determines how the input power is transferred to the output. Most of the commonly used topologies such as flyback, push-pull, half bridge and full bridge, consist of a transformer to provide isolation, voltage scaling, and multiple output voltages. The non-isolated configurations do not have a transformer and the power conversion is provided by the inductive energy transfer.

Advantages of switched-mode power supplies:

- Higher efficiency of 68% to 90%
- Regulated and reliable outputs regardless of variations in input supply voltage
- Small size and lighter
- Flexible technology
- High power density
- Disadvantages:
- Generates electromagnetic interference
- Complex circuit design
- Expensive compared to linear supplies

Switched-mode power supplies are used to power a wide variety of equipment such as computers, sensitive electronics, battery-operated devices and other equipment requiring high efficiency. Linear voltage IC regulators have been the basis of power supply designs for many years as they are very good at supplying a continuous fixed voltage output. Linear voltage regulators are generally much more efficient and easier to use than equivalent voltage regulator circuits made from discrete components such a zener diode and a resistor, or transistors and even op-amps.The most popular linear and fixed output voltage regulator types are by far the 78… positive output voltage series, and the 79… negative output voltage series.

These two types of complementary voltage regulators produce a precise and stable voltage output ranging from about 5 volts up to about 24 volts for use in many electronic circuits. There is a wide range of these three-terminal fixed voltage regulators available each with its own built-in voltage regulation and current limiting circuits. This allows us to create a whole host of different power supply rails and outputs, either single or dual supply, suitable for most electronic circuits and applications. There are even variable voltage linear regulators available as well providing an output voltage which is continually variable from just above zero to a few volts below its maximum voltage output.

Switch Mode Power Supply

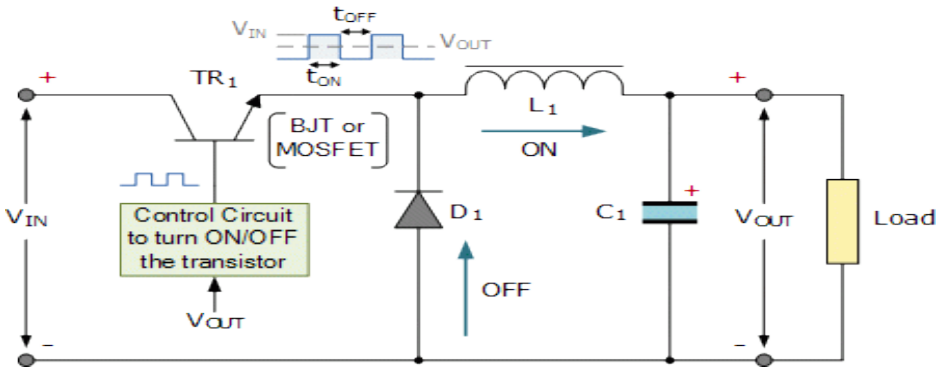


Figure 4.3: SMPS Circuit Connection

Most DC power supplies comprise of a large and heavy step-down mains transformer, diode rectification, either full-wave or half-wave, a filter circuit to remove any ripple content from the rectified DC producing a suitably smooth DC voltage, and some form of voltage regulator or stabilizer circuit, either linear or switching to ensure the correct regulation of the power supplies output voltage under varying load conditions. Then a typical DC power supply would look something like this:

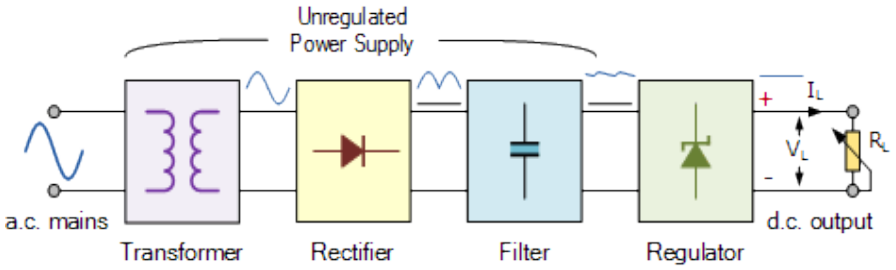


Figure 4.4: DC Power supply way

These typical power supply designs contain a large mains transformer (which also provides isolation between the input and output) and a dissipative series regulator circuit. The regulator circuit could consist of a single Zener diode or a three-terminal linear series regulator to produce the required output voltage. The advantage of a linear regulator is that the power supply circuit only needs an input capacitor, output capacitor and some feedback resistors to set the output voltage.

4.3 Gear Motor

Gear motors are mechanisms that adjust the speed of electric motors, leading them to operate at a certain speed. They are composed of a series of gears that make up a kinematic chain, working on a set of rotary parts. Their main purpose is to allow the reduction from an initial high speed to a lower one without negatively affecting the mechanism. In addition to this adjustment, a gear motor is in charge of adjusting the mechanical power of a system.



Figure 4.5: Gear Motor

Mechanical components that complement gear motors

Gear motors are composed of an electric motor and gears, which form the kinematic chain – the fundamental component of the gear ratio.

Kinematic chain

A motor's speed reducer is composed of a speed reducer and its gears. This speed reducer is basically a variable speed drive that allows for the speed to be reduced and increased at the output shaft.

Gears

Gears are toothed wheels made of metal or plastic (and new materials with each passing day) that transmit motion when meshing with each other. They are defined by their number of teeth and their size. In addition, they may have straight-cut or helical teeth.

Motors

The five types of motors that see the most use in gear motors are:

- Brushed motors, with brushes normally made out of carbon. They are bidirectional and may be used with DC or AC. They have a service life of about 3000 hours.
- Asynchronous motors, which are brush less single-direction motors. They are highly limited.
- Synchronous brush less motors, which may be single-direction or bidirectional. They have a constant speed if the frequency of the power source is stable.
- Brush less DC motors that use a driver and can attain high speeds.
- Stepper DC brush less motors. They can be positioned with an average precision of 7.5º.

4.4 Wheel

The 65mm Yellow Robot Wheel is a durable and lightweight accessory designed specifically for BO (Battery Operated) motors. Made from high-quality plastic, this wheel ensures optimal performance for small robotic projects. Its 65mm diameter provides a good balance of speed and torque, making it ideal for beginner and advanced robotic applications. The robust tread design enhances traction on various surfaces, ensuring smooth movement and stability. Easy to mount on BO motors, the wheel is perfect for DIY robots, line followers, obstacle avoiders, and remote-controlled vehicles. Its bright yellow color adds a vibrant touch to your robot's design.



Figure 4.6: Wheel

Features:

- Robust Nylon Rim: Reinforced nylon construction provides superior strength and durability.
- Grippy Rubber Tires: High-quality rubber ensures maximum traction on various surfaces.
- Sponge Liner: The integrated sponge liner enhances tire strength and durability.
- Upgraded Tread Design: The optimized tread pattern provides excellent grip and traction.
- Precise Fit: Designed for seamless integration with your robot's motor.

Specifications:

- Diameter: 65mm
- Width: 28mm
- Tire Material: Rubber
- Rim Material: High-strength plastic
- Color: Yellow

4.5 Battery

Lithium batteries are primary batteries that have metallic lithium as an anode. These types of batteries are also referred to as lithium-metal batteries. They stand apart from other batteries in their high charge density and high cost per unit. Depending on the design and chemical compounds used, lithium cells can produce voltages from 1.5 V (comparable to a zinc–carbon or alkaline battery) to about 3.7 V.

Disposable primary lithium batteries must be distinguished from secondary lithium-ion or a lithium-polymer, which are rechargeable batteries. Lithium is especially useful, because its ions can be arranged to move between the anode and the cathode, using an intercalated lithium compound as the cathode material but without using lithium metal as the anode material. Pure lithium will instantly react with water, or even moisture in the air; the lithium in lithium-ion batteries is in a less reactive compound.

Lithium batteries are widely used in portable consumer electronic devices. The term "lithium battery" refers to a family of different lithium-metal chemistry, comprising many types of

cathodes and electrolytes but all with metallic lithium as the anode. The battery requires from 0.15 to 0.3 kg of lithium per kWh. As designed these primary systems use a charged cathode, that being an electro-active material with crystallographic vacancies that are filled gradually during discharge.



Figure 4.7: 3.7V Battery

Product Specification

Table 2: Specification for Battery

Voltage	3.7 V
Product Type	Lithium-Ion
Battery Capacity	2200mAh
Weight	45 g
Model Number	ICR 18650

4.6 Buck Converter

A buck converter (step-down converter) is a DC-to-DC power converter which steps down voltage (while drawing less average current) from its input (supply) to its output (load). It is a class of switched-mode power supply (SMPS) typically containing at least two semiconductors (a diode and a transistor, although modern buck converters frequently replace the diode with a second transistor used for synchronous rectification) and at least one energy storage element, a capacitor, inductor, or the two in combination. To reduce voltage ripple, filters made of capacitors (sometimes in combination with inductors) are normally added to such a converter's output (load-side filter) and input (supply-side filter). It is called a buck converter because the voltage across the inductor “bucks” or opposes the supply voltage.



Figure 4.8: DC -DC Buck Converter

DC-DC Buck Converter Step Down Module LM2596 Power Supply is a step-down(buck) switching regulator, capable of driving a 3-A load with excellent line and load regulation. These devices are available in fixed output voltages of 3.3 V, 5 V, 12 V, and an adjustable output version. The LM2596 series operates at a switching frequency of 150kHz, thus allowing smaller sized filter components than what would be required with lower frequency switching regulators.

Specifications of DC-DC Buck Converter Step Down Module LM2596 Power Supply :

- Conversion efficiency: 92% (highest)
- Switching frequency: 150KHz
- Output ripple: 30mA maximum)
- Load Regulation: ± 0.5%
- Voltage Regulation: ± 0.5%
- Dynamic Response speed: 5% 200uS
- Input voltage:4.75-35V
- Output voltage:1.25-26V(Adjustable)
- Output current: Rated current is 2A, maximum 3A (Additional heat sink is required)
- Conversion Efficiency: Up to 92% (output voltage higher, the higher the efficiency)
- Switching Frequency: 150KHz
- Rectifier: Non-Synchronous Rectification
- Module Properties: Non-isolated step-down module (buck)
- Short Circuit Protection: Current limiting, since the recovery
- Operating Temperature: Industrial grade (-40 to +85) (output power 10W or less)

4.7 Transmitter Coil and Receiver Coil

There are different shapes of coil used in WPT systems. Among them, the circular coil is the most effective structure in high-frequency wireless transfers as there are no sharp edges. So, the eddy current is kept to minimum. The high magnetic field produced by the coil causes better

Transmitter Coil. The coil of the RF transmitter, inside the MR imager is used in excitation of the spins. Also called transmit-only coil it is used to create the B1 field. As a radio frequency generator send this coil bursts of RF pulses. These pulses serve to disturb the spins in the patient.

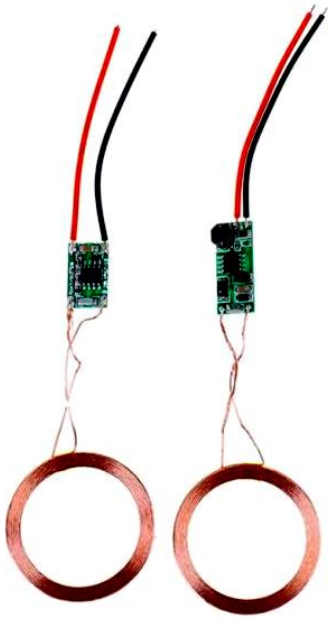


Figure 4.9: Transmitter and Receiver Coils

Receiver Coil. A coil, or antenna, positioned within the imaging volume and connected to the receiver circuitry that is used to detect or receive the MR signal from the patient as the disturbed spins relax back into their equilibrium distribution. Also called receive-only coil.

4.8 Volt Meter

A voltmeter is an instrument used for measuring electric potential difference between two points in an electric circuit. It is connected in parallel. It usually has a high resistance so that it takes negligible current from the circuit. Analog voltmeters move a pointer across a scale in proportion to the voltage measured and can be built from a galvanometer and series resistor. Meters using amplifiers can measure tiny voltages of micro volts or less. Digital voltmeters give a numerical display of voltage by use of an analog-to-digital converter.

Voltmeters are made in a wide range of styles, some separately powered (e.g. by battery), and others powered by the measured voltage source itself. Instruments permanently mounted in a panel are used to monitor generators or other fixed apparatus. Portable instruments, usually equipped to also measure current and resistance in the form of a multimeter, are standard test instruments used in electrical and electronics work. Any measurement that can be converted to a voltage can be displayed on a meter that is suitably calibrated; for example, pressure, temperature, flow or level in a chemical process plant.



Figure 4.10: Digital Voltmeter

General-purpose analog voltmeters may have an accuracy of a few percent of full scale and are used with voltages from a fraction of a volt to several thousand volts. Digital meters can be made with high accuracy, typically better than 1%. Specially calibrated test instruments have higher accuracies, with laboratory instruments capable of measuring to accuracies of a few parts per million. Part of the problem of making an accurate voltmeter is that of calibration to check its accuracy. In laboratories, the Weston cell is used as a standard voltage for precision work. Precision voltage references are available based on electronic circuits.

4.9 Easy EDA

Easy EDA is a web-based EDA tool suite that enables hardware engineers to design, simulate, share-publicly and privately-and discuss schematics, simulations and printed circuit boards. Other features include the creation of a bill of materials, Gerber files and pick and place files and documentary outputs in PDF, PNG and SVG formats. Easy EDA allows the creation and editing of schematic diagrams, SPICE simulation of mixed analogue and digital circuits and the creation and editing of printed circuit board layouts and, optionally, the manufacture of printed circuit boards.

Subscription-free membership is offered for public plus a limited number of private projects. The number of private projects can be increased by contributing high quality public projects, schematic symbols, and PCB footprints and/or by paying a monthly subscription. Registered users can download Gerber files from the tool free of charge; but for a fee, EasyEDA offers a PCB fabrication service. This service is also able to accept Gerber file inputs from third party tools.

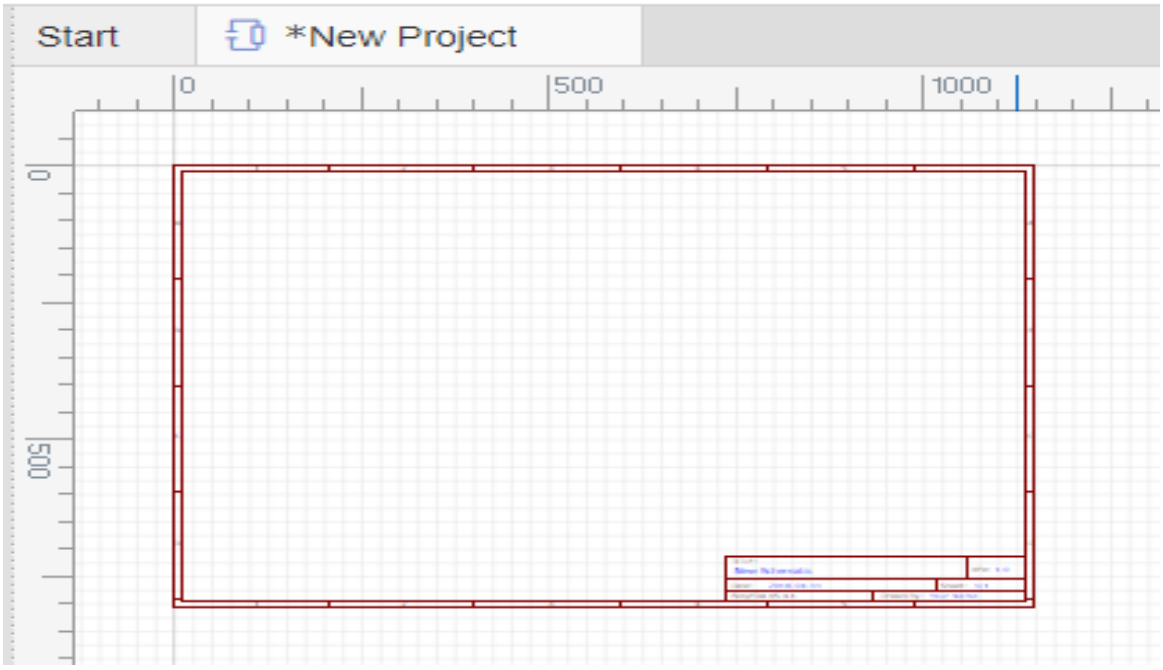


Figure 4.11: EasyEDA Software Interface

CHAPTER - 05
RESULTS ANALYSIS

5.1 Result

After finally completing this project, we ran it & we observed the output of this project. We can see that it is working well as expected. After making our project we observe it very careful. It works as we desire. Our project give output perfectly and all equipment are work perfectly. We check how much it works and we get perfect output from this project.

- Finally, we have completed our project successfully & check our project its run accurately according to our objective.
- First the DC current of the coil will go with 12-volt DC's.
- And Convert with a 220-volt AC step down transformer will go to the bridge rectifier circuit through the 12-volt AC current. And we will get the output of the bridge rectifier 12-volt DC.
- The battery will be charged with Receiver Coils. And the SMPS will run with its energy and Street light will be on.
- The vehicle is charged, move the vehicle to the charging side and the coil will continue to charge.
- And Volt Meter Displays Show the voltage

Table

Transmitter Coil

Voltage (V)	Ampere (A)	Resistance (Ω)
5	1.63	1.3

Receiver Coil

Voltage (V)	Ampere (A)	Resistance (Ω)
1.8	0.2	1.1

Calculation

To calculate the charging time for a battery, use the formula:

Charging Time (hours) = Battery Capacity (Ah) / Charger Output (A)

Here:

Battery Capacity = 2.2 Ah

Charger Output = 0.2 A

Charging Time = 2.2 / 0.2

= 11 hours

5.2 Advantages

There are certainly many advantages of our project and some of the major ones have been given below:

- Smart Electric Vehicle charging system.
- Pollution Free
- Low maintenance Cost.
- Magnetic field radiation problem is avoided
- The system is user friendly.
- Eliminates shock and tripping risks
- Charges while parked or in motion
- Functions in rain or snow
- Making it easy to charge without plugging.

5.3 Application

Some of the application areas of the project has been pointed out below:

- Ideal for public parking, Residential areas, and Commercial locations.
- The automatic system can be implemented in areas where Dynamic Renewable Energy is necessary.
- Suitable for electric buses and delivery vans, enabling efficient overnight charging

5.4 Limitations

It is a demo project so we found some limitation. In future we will work for reduce this kind of limitation. These limitations are –

- It is a demo project so its accuracy is 85%.
- Since it is a demo project, simple task can be done with it.
- This project can now be only used for small scale purposes.

CHAPTER - 06
DISCUSSION & CONCLUSION

6.1 Discussion

While working on our project, we did face some difficulties as it is a very complex system but the end results, we came up with were quite satisfactory. We have put the whole system through several tasks to validate our work and also have taken necessary notes for future improvements. Some future recommendations that we have involves improvement in system design and wiring, adding features for more efficient.

6.2 Future Scope

The model can be improved by making some changes in the program and components. Some suggestions are given below.

- In future, we are looking forward to improving our whole system design to make it more efficient.
- In Future, we are adding cc tv camera for road sides.
- Remote Monitoring and Management
- In future, we are thinking about making the system IoT enabled so that wirelessly the whole system can be observed.

6.3 Environmental Impact

The development of a wireless EV charging system offers several environmental benefits. By enabling more efficient energy transfer, the system reduces energy losses during the charging process, contributing to a decrease in overall energy consumption. This reduction in energy demand can help lower the carbon footprint of electric vehicles, especially when integrated with renewable energy sources. Additionally, the elimination of physical connectors reduces the need for raw materials like copper and plastic, supporting a more sustainable and resource-efficient design. As wireless charging systems gain widespread adoption, they could further reduce the environmental impact of charging infrastructure by minimizing wear and tear on components, extending the lifespan of the system, and decreasing the frequency of replacements. Furthermore, integrating the wireless system with smart grid technologies can optimize energy distribution, reducing the need for fossil fuel-based power during peak demand times and promoting a cleaner, greener grid.

6.4 Conclusion

Wireless charging is one of the most convenient charging infrastructures in Electric Vehicles. It is expensive, but still attracts a lot of researchers. Because Electric Vehicles can operate for many hours without stopping for recharging, they will become really autonomous. Perhaps the most exciting aspect is that EVs equipped with wireless charging technology en route can have substantially smaller batteries. As a result, this technology decreases the environmental effect as well as the cost of electric vehicle adoption.

References

[1] F. Musavi, W. Eberle, Overview of wireless power transfer technologies for electric vehicle battery charging, IET Power Electronics 7 (1) (2014) 60–66. doi:https://doi.org/10.1049/ iet-pel.2013.0047.

[2] C. Qiu, K. T. Chau, T. W. Ching, C. Liu, Overview of wireless charging technologies for electric vehicles, Journal of Asian Electric Vehicles 12 (1) (2014) 1679–1685. doi:10.4130/jaev.12.1679.

[3] T. M. Fisher, K. B. Farley, Y. Gao, H. Bai, Z. T. H. Tse, Electric vehicle wireless charging technology: A state-of-the-art review of magnetic coupling systems, Wireless Power Transfer 1 (2) (2014) 87–96. doi:10.1017/wpt.2014.8.

[4] J. Dai, D. C. Ludois, A survey of wireless power transfer and a critical comparison of inductive and capacitive coupling for small gap applications, IEEE Transactions on Power Electronics 30 (11) (2015) 6017–6029. doi:10.1109/TPEL.2015.2415253.

[5] Z. Bi, T. Kan, C. C. Mi, Y. Zhang, Z. Zhao, G. A. Keoleian, A review of wireless power transfer for electric vehicles: Prospects to enhance sustainable mobility, Applied Energy 179 (2016) 413–425. doi:https://doi.org/10.1016/j.apenergy. 2016.07.003.

[6] Y. J. Jang, Survey of the operation and system study on wireless charging electric vehicle systems, Transportation Research Part C: Emerging Technologies 95 (2018) 844–866. doi:https://doi.org/ 10.1016/j.trc.2018.04.006.

[7] C. Panchal, S. Stegen, J. Lu, Review of static and dynamic wireless electric vehicle charging system, Engineering Science and Technology, an International Journal 21 (5) (2018) 922–937. doi: https://doi.org/10.1016/j.jestch.2018.06.015.

[8] D.Ji, Mingsong, J.Yang, W.Yi, “Optimizing the Locations and Sizes of Solar Assisted Electric Vehicle Charging Stations in an Urban Area”, IEEE transaction, Vol. 8, pp. 112772 – 112782, June 2020.

[9] D.Ranawat, M.P.R.Prasad, “A Review on Electric Vehicles with the perspective of Battery Management System”, Third International Conference on Electrical and Electronics, Communication, Computer Technologies, and Optimization Techniques (ICEECCOT) pp.14-15, December 2018.

[10] J.Traube, F.Lu, D.Maksimovic, J.Mossoba, M.Kromer, P.Faill, S.Katz, B.Borowy, S.Nichols, L.Casey, “Mitigation of Solar Irradiance Intermittency in Photovoltaic Power Systems With Integrated Electric- Vehicle Charging Functionality”, IEEE Transactions On Power Electronics, Vol. 28, No. 6, June 2013.

[11] G.Alkawsi, Y.Baashar, D.Abbas, A.Ahmed Alkahtani, S.KiongTiong, “Review of Renewable Energy-Based Charging Infrastructure for Electric Vehicles” Appl. Sci., Vol. 11, pp. 3847, Apr. 2021.

[12] G.Zhang1, J.Lai1, S.Feng1, W.Shi, “Green Solar Electric Vehicle Changing the Future Lifestyle of Human”, Land, Sea, Air, and Space Vehicles, Boca Raton, FL, USA: CRC Press, June 2003.

[13] Md.Sohail Tanveer, S.Gupta, R.Rai, N.Kumar Jha, “Solar based electric vehicle charging station”, 2nd International Conference on Power Energy, Environment and Intelligent Control (PEEIC), doi. 978-1-7281-1793- 5/19/IEEE, 2019.

[14] SAE Standard J1772, “SAE Electric Vehicle and Plugin Hybrid Electric Vehicle Conductive Charge Coupler,” Oct. 2010.