VISVESVARAYA TECHNOLOGICAL UNIVERSITY

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A Mini Project Report on

"Smart Roadways: Integrating Automatic Dynamic Charging of EVs"

Submitted in partial fulfilment of the Bachelor of Engineering Degree in

Electronics and Communication Engineering

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2023-2024

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

CERTIFICATE

Certified that the project work entitled "**Smart Roadways: Integrating Automatic Dynamic Charging of EVs"** carried out by **Rohith H (USN-1AT21EC130), Tejas S Suthrave (USN-1AT21EC167), Teju B (USN-1AT21EC169), Vishwas V(USN-1AT21EC182)** bonafide student of **Atria Institute of Technology, Bengaluru** in partial fulfillment for the award of the degree of **Bachelor of Engineering Degree in Electronics and Communication Engineering** of the **Visvesvaraya Technological University, Belgaum** during the year 2023-2024. The project report has been approved as it satisfies the academic requirements in respect of the Project work prescribed for the said Degree.

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2023-2024

DECLARATION

We the students of third year, Bachelor of Engineering, Electronics and Communication Engineering, Atria Institute of Technology, Bengaluru-560024, hereby declare that the project work entitled "**Smart Roadways: Integrating Automatic Dynamic Charging of EVs**" has been carried out at ATRIA INSTITUTE OF TECHNOLOGY under the guidance of Mrs. Gayathri Joshi, Assistant Professor, Department of Electronics and Communication Engineering, Atria IT, Bangalore. We declare that the work submitted in this report is our own and has not been previously submitted for the fulfilment of the B.E degree at the Visvesvaraya Technological University, Belagavi, or any other Institution/University.

Place: Bengaluru

Date: 27/07/2024

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ACKNOWLEDGEMENT

The satisfaction and euphoria that accompany the successful completion of a task would be incomplete without the mention of the people who made it possible and without their constant guidance and encouragement, success would not have been possible.

We are grateful to the **Atria Institute of Technology** and its management for having provided us with good infrastructure, facilities, and inspiring staff

We would like to express my sincere gratitude to **Dr. Rajesha S, Principal, Atria Institute of Technology** for providing me with the opportunity to undertake this mini project and for the continuous support and encouragement throughout this journey. We express our sincere gratitude to **Dr. Jagadeesh H S, HOD, Dept. of Electronics and Communication, Atria Institute of Technology** for the support extended.

We would like to express my sincere gratitude to the Internal Guide **Mrs. Gayathri Joshi, Assistant Professor, Dept. of ECE, Atria Institute of Technology,** for their valuable guidance and support.

We would like to express our sincere gratitude to the Internship Coordinators **Dr. Ramesh N, Associate Professor, Dr. Prasunna V N P, Associate Professor, and Mr. Bhaskar M K, Assistant Professor, Dept. of ECE, Atria Institue of Technology** for their timely support.

Finally, I would like to express my sincere gratitude to my parents, all teaching and non-teaching faculty members, and friends for their moral support, encouragement, and help throughout the completion of our mini-project.

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ABSTRACT

Electric vehicles are seen as an alternative option in response to the depletion of resources. In order to increase the use of EVs in daily life, practical and reliable methods to charge batteries of EVs are quite important, accordingly wireless power transfer (WPT) is considered as a solution to charge batteries. In this project, a prototype system of wireless charger which has 60 kHz operation frequency is designed and implemented. Plug-in Electric Vehicles (PEV) are burdened by the need for cable and plug chargers, galvanic isolation of the onboard electronics, bulk and cost of this charger, and the large energy storage system (ESS) packs needed. But by using Wireless Charging systems Wireless charging opportunities. It Provides convenience to the customer, inherent electrical isolation, regulation done on the grid side, and reduced on-board ESS size using dynamic on-road charging.

The main objective of our project is to design and develop an antenna system suitable for vehicle using resonant magnetic coupled wireless power transfer technology to electric vehicle charging system. The application of WPT in EVs provides a clean, convenient, and safe operation. At the core of the WPT systems are primary and secondary coils. These coils construct a loosely coupled system where the coupling coefficient is between 0.1-0.5. To transfer the rated power, both sides have to be tuned by resonant capacitors. The operating frequency is a key selection criterion for all applications and it especially affects the dimensions of the coils and the selection of the components for the power electronic circuit. A Resonant wireless transfer system for vehicle charging technology is designed.

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CHAPTER 1

INTRODUCTION

Recently, wireless power supply devices that supply electric power wirelessly (in the medium of air) to apparatuses without power cables or the like have come to be in practical use. The principles upon which wireless electric power transmission is realized are generally categorized into three types:

- Electromagnetic induction type,
- Radio reception type and,
- Resonance type.

Electromagnetic induction non-contact power transmission employs the phenomenon in which the application of an electric current to one of the adjacent coils induces an electromotive force in the other coil with magnetic flux as the medium.

Wireless power transfer (WPT) is a breakthrough technology that provides energy to communication devices without power units. With the remarkable progress being made recently, this technology has been attracting a lot of attention of scientists and R&D firms around the world. Recently, the usage of mobile appliances such as cell phones, PDAs, laptops, tablets, and other handheld gadgets, equipped with rechargeable batteries has been widely spreading. It is known that electromagnetic energy is associated with the propagation of electromagnetic waves. Theoretically, we can use all electromagnetic waves for a wireless power transmission (WPT).

The difference between the WPT and communication systems is only efficiency. Maxwell"s Equations indicate that the electromagnetic field and its power diffuse to all directions. Though we transmit energy in a communication system, the transmitted energy is diffused to all directions. Though the received power is enough for a transmission of information, the efficiency from the transmitter to receiver is quiet low. Therefore, we do not call it the WPT system

During the last few decades, increased concern over the environmental impact of the petroleum-based transportation infrastructure, along with the specter of peak oil, has led to renewed interest in an electric transportation infrastructure. Battery-powered electric vehicles

(EVs) seem like an ideal solution to deal with the energy crisis and global warming since they have zero oil consumption and zero emission. Moreover, we are quite rapidly reaching the end of the cheap oil era. Therefore, the need for alternative growing and the price competition of alternatives against oil is becoming more and more realistic.

Electric vehicles differ from fossil fuel-powered vehicles in that the electricity they consume can be generated from a wide range of sources, including fossil fuels, nuclear power, and renewable sources such as tidal power, solar power, and wind power or any combination of those. However it is generated, this energy is then transmitted to the vehicle through use of overhead lines, wireless energy transfer such as inductive charging, or a direct connection through an electrical cable.

The electricity may then be stored onboard the vehicle using a battery, flywheel, or super-capacitors. Vehicles making use of engines working on the principle of combustion can usually only derive their energy from a single or a few sources, usually non-renewable fossil fuels. A key advantage of electric or hybrid electric vehicles is regenerative braking and suspension, their ability to recover energy normally lost during braking as electricity to be restored to the on-board battery. However, EVs are highly depended on the external energy support.

1.1 NECESSITY

Wireless dynamic road charging is an innovative idea for electric vehicles (EVs). It would allow EVs to charge continuously while driving, extending their range and potentially reducing reliance on large batteries and charging stations. This could significantly improve the practicality of EVs. However, challenges like cost, efficiency, and safety need to be addressed before widespread adoption becomes a reality.

1.2 PROBLEM STATEMENT

Electric vehicles (EVs) are crucial for a sustainable future, but current charging solutions have many challenges. Plugged charging requires manual intervention and limits travel flexibility. While wireless electric vehicle charging systems (WEVCS) offer a convenient alternative, integrating them dynamically into roadways presents significant problems. This project addresses the need to develop a system for automatic dynamic charging of EVs**,** overcoming limitations in efficiency, safety, and cost-effectiveness.

1.3 OBJECTIVES

The primary objective of this project is to investigate the feasibility and practical implementation of on-road dynamic charging systems for electric vehicles (EVs). Specific objectives include:

- **Technology Analysis:** Evaluate the current technologies available for dynamic wireless charging, including their efficiency, safety, and scalability.
- **Infrastructure Requirements**: Identify the infrastructure needed for implementing on-road dynamic charging.
- **Cost-Benefit Analysis**: Conduct a cost-benefit analysis to determine the economic viability of dynamic charging systems compared to traditional charging methods.

CHAPTER 2

LITERATURE REVIEW

1. S. B. and A. R. Saxena in their study "Electric Vehicles Scenario and its Charging Infrastructure in India" presented at the IEEE 10th Power India International Conference (PIICON) in New Delhi, 2022, offer significant advantages such as reduced downtime, lower battery capacity requirements, and decreased reliance on stationary charging infrastructure. However, challenges remain, including optimizing power transfer efficiency, ensuring electromagnetic compatibility, and addressing the high costs of infrastructure installation and maintenance. Advances in materials science, power electronics, and wireless communication are critical to overcoming these obstacles, along with supportive government policies and collaborative efforts among academia, industry, and government agencies. The study emphasizes the potential of DWC systems to revolutionize EV charging infrastructure in India, aligning with broader goals of sustainable and efficient transportation solutions.

2. The study by S. S. G. Acharige and colleagues, titled "Review of Electric Vehicle Charging Technologies, Standards, Architectures, and Converter Configurations," published in IEEE Access in 2023, provides a detailed look at the latest advancements in electric vehicle (EV) charging. The authors discuss various charging methods, including dynamic wireless charging (DWC), which allows EVs to charge while driving, making charging more convenient and reducing the need for large batteries. The review also covers the standards and systems needed for these advanced charging technologies, highlighting the role of efficient power converters and strong communication systems for effective energy transfer. Despite the potential benefits, the study notes challenges like high infrastructure costs and the need for common standards. The authors stress the importance of ongoing research, supportive government policies, and collaboration between industry and researchers to address these challenges. This review shows how DWC could significantly improve EV charging, making it more efficient and convenient.

3. The study by Garg S, Khare S, Kshetre J, Sahu R, Thakur K, Singh A, and Bhongade S, titled "Static and Dynamic Wireless Charging of Electric Vehicles Using Inductive Coupling," published in the Indian Journal of Engineering in 2023, explores both static and dynamic methods of wireless charging for electric vehicles (EVs) using inductive coupling. Static

wireless charging involves charging the vehicle when it is stationary, whereas dynamic wireless charging (DWC) allows EVs to charge while driving. The authors highlight the benefits of DWC, such as reduced downtime and the potential for smaller battery sizes, which can lower overall vehicle costs. The study also discusses the technology behind inductive coupling, which uses electromagnetic fields to transfer energy between the road and the vehicle without direct contact. Challenges identified in the study include ensuring efficient power transfer, managing electromagnetic interference, and the high costs of installing and maintaining the necessary infrastructure. The authors call for further research, development, and supportive policies to address these issues.

4. The study by T. Newbolt, P. Mandal, H. Wang, and R. Zane, titled "Sustainability of Dynamic Wireless Power Transfer Roadway for In-Motion Electric Vehicle Charging," published in March 2024, examines the sustainability and feasibility of dynamic wireless power transfer (DWPT) systems for electric vehicles (EVs). DWPT enables EVs to charge while driving using embedded coils in the road that transfer energy wirelessly. The authors highlight the potential benefits, such as reduced battery sizes and less reliance on stationary charging stations. They discuss the efficiency of power transfer, integration with renewable energy sources, and overall sustainability. Challenges include high infrastructure costs, the need for standardized regulations, and ensuring safety and reliability. The study calls for further research, supportive policies, and industry collaboration to address these issues and realize the benefits of DWPT. This work underscores DWPT's potential to enhance the efficiency and sustainability of EV charging infrastructure.

5. The study by D. Sai Kumar and Dr. D. Rajesh Babu, titled "A Review on Progress in Wireless Charging Technologies for Electric Vehicles," published in 2024, provides a comprehensive overview of advancements in wireless charging for electric vehicles (EVs). The authors examine various wireless charging methods, including static and dynamic systems. They highlight the benefits of dynamic wireless charging (DWC), which allows EVs to charge while driving, reducing downtime and potentially decreasing battery sizes. The review discusses technological advancements, such as improvements in power transfer efficiency and the integration of renewable energy sources. Challenges identified include high infrastructure costs, the need for standardized regulations, and ensuring system reliability and safety. This review underscores the significant potential of wireless charging to enhance the efficiency and convenience of EV charging infrastructure.

CHAPTER 3

PROPOSED SYSTEM

In an effort to address battery problems, the concept of roadway-powered electric vehicles has been proposed. With this system, the electric vehicle is charged on the road by wireless power charging, and the battery can hence be downsized and no waiting time for charging is needed. The main objective of our project is to design and develop an antenna and wireless power transfer system suitable for moving electric vehicles (EVs). Using resonant magnetic coupling principle, the wireless power transfer technology to the electric vehicle is designed. When the vehicle's power receiver's frequency is tuned in exactly with the resonance frequency of the transmitter unit below the road, the electrical power will flow from the transmitter coil inside the platform to the receiving coil inside the bottom of the electric vehicle. This project describes the design and implementation of a wireless power transfer system for moving electric vehicles involving the model EV system

CHAPTER 4

BLOCK DIAGRAM AND CIRCUIT DIAGRAM

4.1 BLOCK DIAGRAM

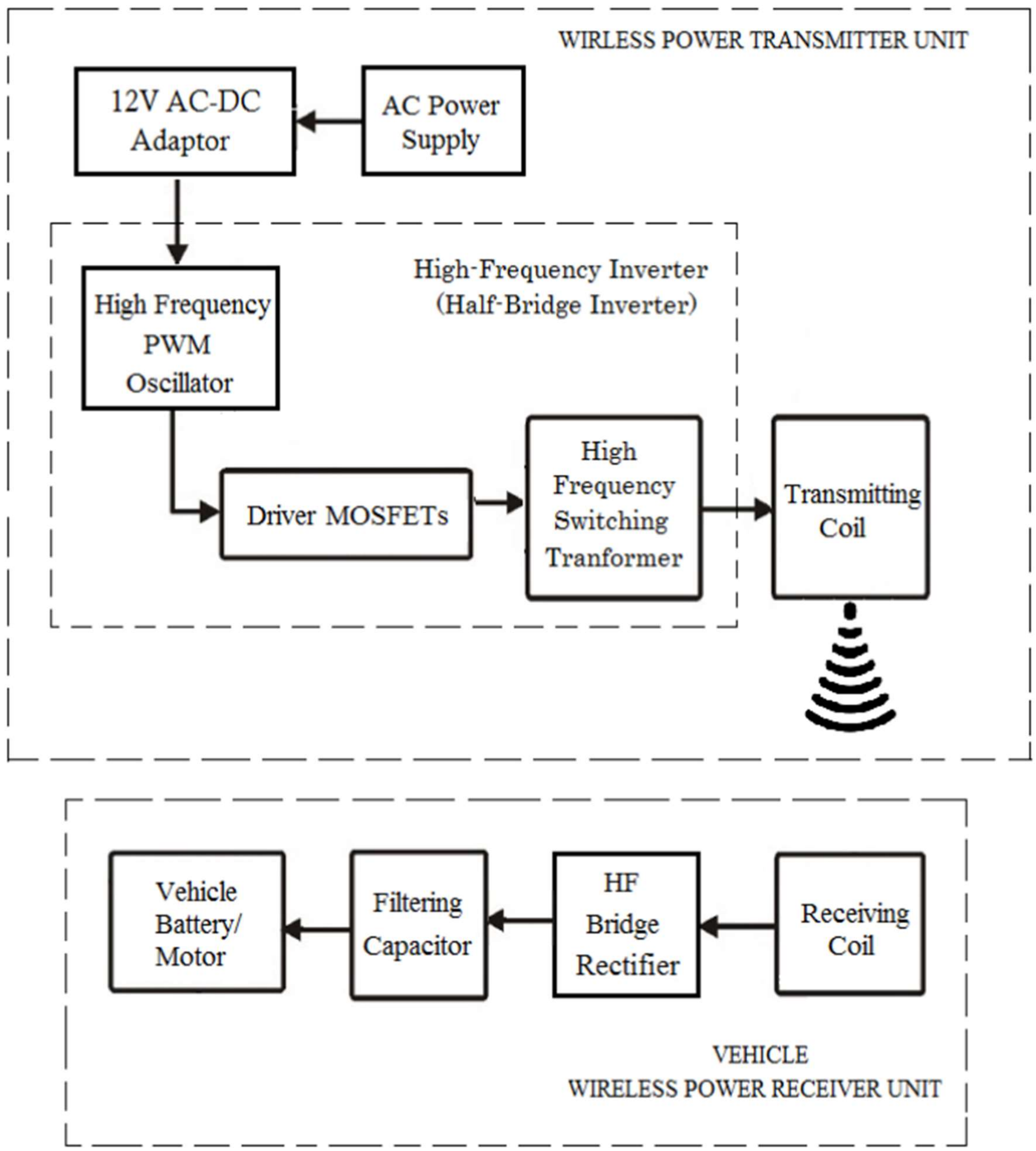

Figure 4.1: Block Diagram of Transmitter and Receiver

AC Power Supply

The supply for the wireless power transmitter is taken from AC220v source.

AC-DC Adapter (SMPS):

Switching Mode power supply is used here to convert AC to DC. Here the input of the SMPS is 220v AC and output will be 12v DC.

High Frequency PWM Oscillator

High-Frequency oscillator is designed using KA3525 IC. The IC circuit generates PWM switching pulses for driving the MOSFETs. The oscillator produces a PWM frequency of 65 KHz range. Here two separate PWM pulses PWM1 and PWM2 are produced which are supplied to the two MOSFET gate. Each PWM pulses are 90 degrees out of phase, which result in alternative switching of each MOSFETs.

Driver MOSFETs

Here two driver MOSFETs are used to switch the high frequency transformer. The two ends of the transformer primary is connected to the "Drain" pin of the two MOSFETs. When a MOSFET gets turned ON, then current flows through the primary winding of the transformer. Half of the primary gets turned ON by one MOSFET and another half by another MOSFET. Both MOSFETs switch alternatively producing a AC square wave in the primary of the transformer.

High-Frequency Transformer

Here the DC-AC conversion takes place in the high-frequency switching transformer. Unlike normal transformer, the core of the HF transformer is made of ferrite which makes it capable of operating at higher frequencies. Due to high frequency switching the losses in conversion is very lower than normal transformer. Here the HF transformer converts DC current into a high-frequency AC current. The primary of transformer has three tappings, one is centre tap for DC current input and the other two tapings for return path of the current through MOSFETs during switching. The secondary output will be HF AC current, which is given to the transmitter coil.

Half bridge Inverter

Half bridge inverter circuit driver consists of a high-frequency switching transformer and two MOSFETs. The switching transformer primary is connected to two MOSFETs and secondary is connected to transmitting coil. The half bridge inverter converts input DC voltage into a high frequency AC voltage.

Transmitting Coil

The transmitter coil is designed with windings of copper coils which convert the high frequency oscillating electrical current into electromagnetic waves resonating at a particular frequency.

Receiving Coil

The receiver coil receives electromagnetic waves from the transmitter antenna and converts back into high frequency electrical output.

HF Bridge Rectifier

High Frequency (HF) bridge rectifier consists of fast switching rectifier diodes which converts HF AC voltage from the receiving coil into a DC voltage.

Filtering Capacitor

The filtering capacitor filters out the ripple generated at the rectifier and produces as smooth and stable DC voltage output which can be used for driving the vehicle motor or for battery charging purpose.

4.2 CIRCUIT DIAGRAM

4.2.1 TRANSMISSION CIRCUIT DIAGRAM

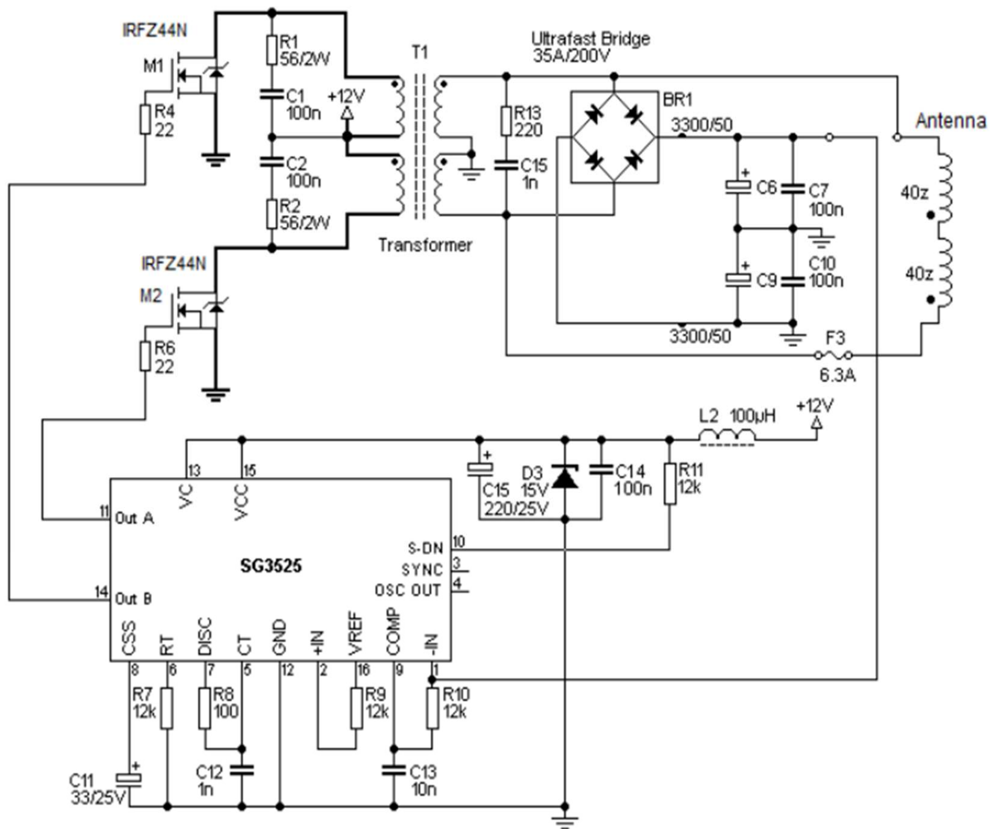

Figure 4.2: Transmission Circuit

1. The first section of the circuit is the High-Frequency inverter which is designed using SG3525 IC. It produces High Frequency PWM signal. The frequency range is 60 – 75 KHz.
2. The second section is the Half-Bridge Driver circuit which consists of two N-channel MOSFETs. MOSFETs drivers feed the PWM signal to the primary of a HF switching transformer.
3. The third section is the High-Frequency Transformer. It converts the DC DC input fed in the primary coil by the MOSFETS into HF AC output at its secondary coil.

4. The fourth section is the transmitting coil. It converts the fed HF-AC current into electromagnetic waves.

SG3525 IC is basically a PWM oscillator chip which produces high-frequency PWM signal which can drive MOSFETs directly to switch then ON and OFF. The frequency of the PWM signal can be set and also adjusted using the timing control resistor and capacitor which are connected to the pin-6 and pin-5 (RT and CT). The IC has two PWM outputs which are pin-11 and pin-14 (out A and out B). Two pwm outputs are connected to the gate terminal of MOSFETs connected in half-bridge configuration. Transmitter coil is a centre tapped coil, so it has three terminals. The Drain terminal of the two MOSFETs are connected to two ends of the transmitter coil. Centre tap of the coil is connected to the DC source power supply which is 12v.

When power is turned ON the IC SG3525 starts oscillating and produces PWM signals. The MOSFETs connected to its outputs are switched ON and OFF alternatively. The Out A and Out B of the IC output are 90degrees out of phase. So when one MOSFET is in ON condition the other will be in OFF condition. Here we use a oscillator frequency of 60 to 80KHz frequency range. So the MOSFETs are switched at high frequency. When on MOSFET is in ON condition the DC current will flow from the centre tap of transmitter coil through MOSFET drain terminal and reach the source terminal which is connected to ground. So in first half cycle the direction of DC current will be in first half coil portion of the transmitter coil. In the same way the current flow will be in second half portion of the coil during next half cycle. Thus the two MOSFETs create a current flow which are opposite in direction in each switching cycle. So as a result an alternating current is produced in the transmitting coil. This configuration thus produces a high frequency AC current from the input DC current. Transmitter coil converts the HF AC electric current into HF electromagnetic field. Thus the transmitter coil coverts electric current and transmits in the form of electromagnetic waves.

4.2.2 RECEIVER CIRCUIT DIAGRAM

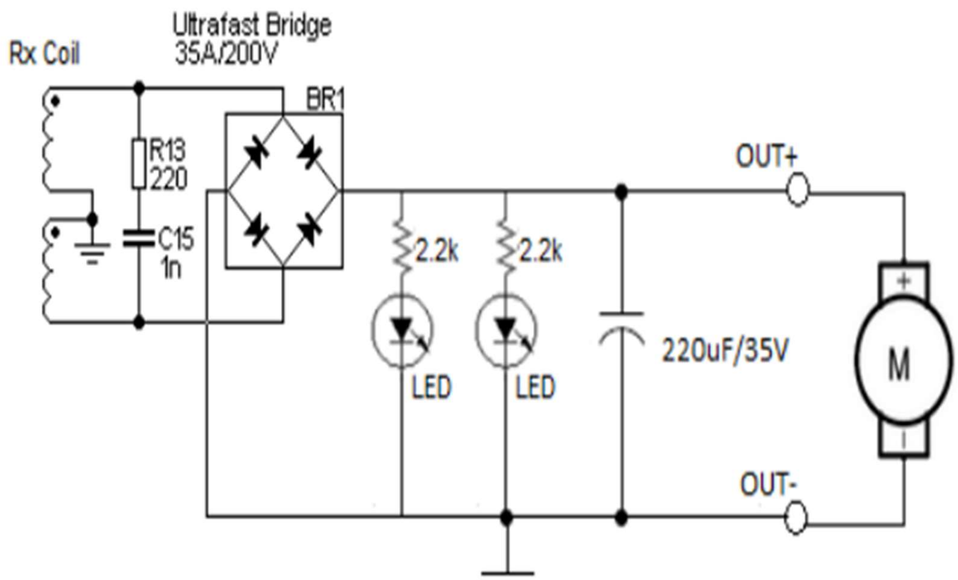

Figure 4.3:Vehicle Receiver Circuit

Receiver has a three section:

1. First is the receiver coil
2. Second is the High-Frequency rectifier
3. Third is the DC ripple filter .

Receiver has a receiving coil which has same resonant frequency of the transmitter coil. So when placed near the transmitter coil it will pick up the electromagnetic field and converts it into the high frequency AC current. Output of receiver coil is given to a high frequency rectifier which converts HF AC to DC voltage output. A capacitor filter at the output of rectifier filters the ripple in DC and gives a stable DC output voltage. A DC output is produced at the output of receiver which is used to power any DC loads.

4.3 PRACTICAL APPLICATION

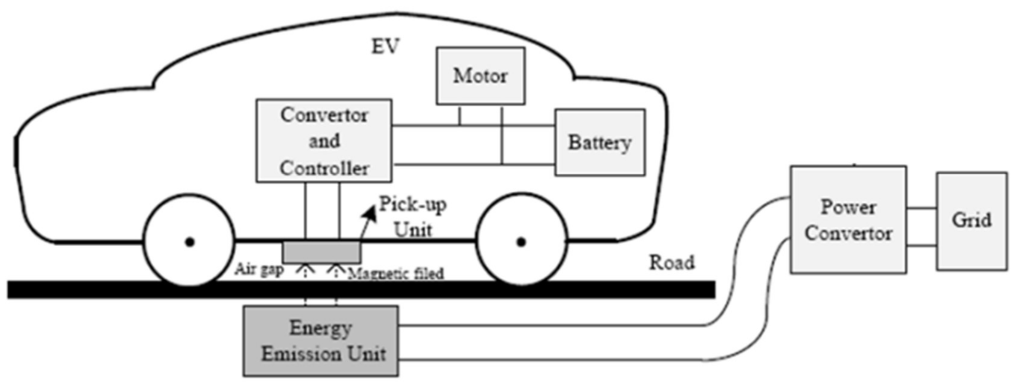

Figure 4.4: Practical Application

The electrical power flows from the power transmitter coil inside the platform to the receiving coil inside the bottom of the electric vehicle. Electrical charging is done once the resonant frequency of both the coils matches and the vehicle charged automatically. When the vehicle is moved the charger goes to the power saving mode and cut off the charger coil.

4.3.1 BASIC DESIGN

A wireless power transfer system uses inductive coupling. One of the most important factors that must be considered in designing an inductive coupling system is the target power of the system. Voltage and current ranges, usable devices, and operating frequency of the system depend on the target power. Because the wireless power transfer system for moving electric vehicles is a public service system that is installed in a road, the use of the resonance frequency must be permitted by the government. Generally, wireless power transfer systems for electric vehicles use 10–100-kHz frequency. In the EV system, the target power is 100 kW, and the resonance frequency is 78 kHz. The circuit is fundamentally the same as the circuit model of transformers. In the circuit, a larger mutual inductance M facilitates more effective power transfer. The mutual inductance M is determined by L1, L2, and the coupling coefficient k, as follows:

$M=k\sqrt{L1*L2}$

where k indicates the degree of coupling strength and is between zero and one.

4.3.2 SYSTEM OPERATION

The wireless power transfer system consists of a power transmitter part and a power receiver part. The power transmitter part is composed of an inverter and power lines. The inverter provides power, and the power lines carry current and generate magnetic flux. The power receiver part is composed of pickup modules, rectifiers, and regulators. The pickup modules generate power from induced voltage and current, the rectifiers convert AC power to DC, and the regulators control the output voltage, which is input to batteries and motors.

The inverter receives power from an electric power company and converts 60-Hz operating frequency into 20-kHz resonance frequency. Although the inverter can be controlled to provide constant voltage, constant current control is more advantageous in dealing with changes in load resistance or multi-pickup charging. Therefore, in the OLEV system, the inverter converts 60-Hz power to 260-A constant current at 20-kHz resonance frequency. The power line modules are installed underneath the road and along the road.

Some of the transferred power is used to drive the motors, and the remainder is used to charge the batteries. When the vehicle stops, all of the power is used to charge the batteries.

CHAPTER 5

HARDWARE DETAILS

5.1 HARDWARE COMPONENT LIST

S.No	Component Name	Qty
1.	IC SG3525A	1
2.	IRF 840 MOSFET	2
3.	22SWG Copper wire	20metres
4.	General Purpose Dot PCB	2
5.	100nF Capacitor	2
6.	10nF Capacitor	2
7.	1nF Capacitor	1
8.	1000uF Capacitor	2
9.	4700uF Capacitor	1
10.	220uF Capacitor	1
11.	1uF Capacitor	1
12.	12K Variable Resisitor	1
13.	2.2k resistor	1
14.	470ohm resistor	2
15.	1K resistor	5
16.	12K resistor	2
17.	5Amps Bridge Rectifier	1
18.	1N5408 Capacitor	4
19.	1N4007 Capacitor	5
20.	4.7nF Capacitor	2
21.	1Amp Bridge Rectifier	1
22.	100uF Capacitor	1
23.	1000uF Capacitor	1
24.	0-12V Transformer	1
25.	0-24V Transformer	1
26.	Power Supply Cable	1
27.	LM7809 Regulator	1
28.	16-Pin IC Base	1
29.	On-Off Switch	1
30.	5mm Red LEDs	5
31.	0.5A Fuse	1
32.	Fuse Holder	1

Table 1: Hardware Component List Table

5.2 POWER MOSFET

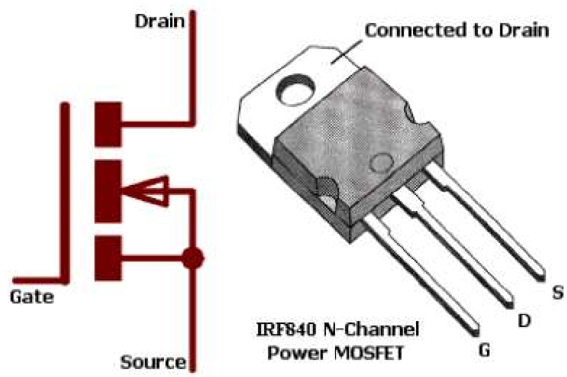

Figure 5.1: Pin Details Of MOSFET IRF840

A Power MOSFET is a specific type of metal oxide semiconductor field-effect transistor (MOSFET) designed to handle significant power levels. Compared to the other power semiconductor devices (IGBT, Thyristor...), its main advantages are high commutation speed and good efficiency at low voltages. It shares with the IGBT an isolated gate that makes it easy to drive. It was made possible by the evolution of CMOS technology, developed for manufacturing Integrated circuits in the late 1970s. The power MOSFET shares its operating principle with its low-power counterpart, the lateral MOSFET.

The IRF840 is a high-voltage, N-channel MOSFET commonly used in power electronics for switching and amplification. It can handle a drain-to-source voltage of up to 500V and continuous drain current up to 8A, making it suitable for high-voltage applications. With a low on-state resistance (R_DS(on)) of about 0.85 ohms, it ensures efficient operation with minimal power loss. The IRF840 is ideal for use in switch-mode power supplies (SMPS), motor control circuits, inverters, and high-power audio amplifiers. Its fast switching speeds and high input impedance make it easy to drive with low-power control signals, and its robust thermal performance ensures reliable operation under high-power conditions.

5.3 KA3525 PULSE WIDTH MODULATOR

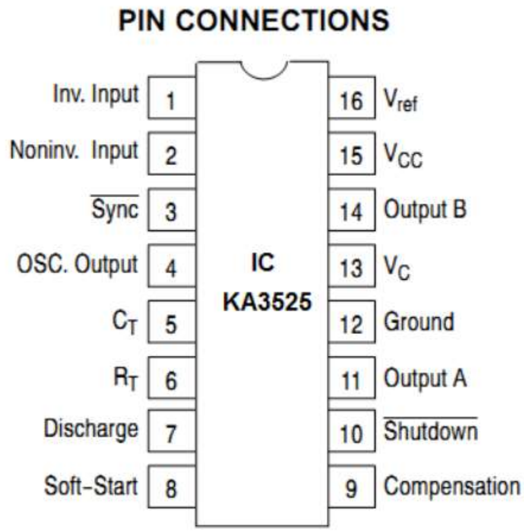

Figure 5.2: Pin Details of IC KA3525

The KA3525 regulating pulse width modulator contains all of the control circuit necessary to implement switching regulators of either polarity transformer coupled DC to DC converters, transformer less polarity converters and voltage doublers, as well as other power control applications. This device includes a 5V voltage regulator capable of supplying up to 50mA to external circuit, a control amplifier, an oscillator, a pulse width modulator, a phase splitting flip-flop, dual alternating output switch transistors, and current limiting and shutdown circuit. Both the regulator output transistor and each output switch are internally current limiting and, to limit junction temperature, an internal thermal shutdown circuit is employed.

5.3.1 PIN FUNCTIONS OF KA3525 IC

1. Pin 1 represents the inverting pin and pin 2 represents a non-inverting pin.
2. If the voltage on the non-inverting pin is less than the voltage on the inverting pin, then the respective duty cycle increases.
3. Pin 3 is employed for the synchronization of two waves while Pin 4 is the output pin of an oscillator.
4. Pins 5, 6 & 7 are incorporated to adjust the frequency of PWM.
5. We can control the frequency of PWM by controlling the value of the discharge resistor, CT capacitor, and RT resistor.

6. Pin 8 SS is a soft start pin that enables the output signal after some time. The value of capacitance is directly related to the soft-start time.
7. Pin 9 is called a compensation pin employed to prevent rapid fluctuations in the output voltage signal.
8. Pin 10 is known as a shutdown pin. It shuts down the PWM signal when the current reaches its limit.
9. Pins 11 and 14 are known as the output pins used to provide input to the MOSFETs. KA3525A incorporates a built-in MOSFET driver circuit.
10. Pin 13 and 15 are called the power pins. Vc should range from 5-35 volts while Vin should stand between 8-35 volts.
11. Pin 16 is known as the reference pin used to adjust the reference voltage through pin 1 or 2.

5.3.2 FEATURES

1. Complete PWM power control circuit
2. Operation beyond 100KHz
3. 2% frequency stability with temperature
4. Total quiescent current less than 10mA
5. Single ended or push-pull outputs
6. Current limit amplifier provides external component protection
7. On-chip protection against excessive junction temperature and output current
8. 5V, 50mA linear regulator output available to user

5.4 VERTICAL FERRITE CORE TRANSFORMER

Figure 5.3: EC28 Vertical Ferrite Core Transformer

The EC28 vertical ferrite core transformer is a type of transformer that uses a ferrite core shaped like an EC28. These transformers are often used in applications requiring efficient magnetic field management and high-frequency operation, such as in switching power supplies, inductors, and other electronic devices.

5.4.1 SPECIFICATIONS

1. Bobbin 5+5Pin
2. Type: EC28
3. Pin spacing: 5mm/0.19"
4. Ferrite core Size: 28.5 x 11.5 x 14mm/1.1" x 0.4" x 0.5"(L*W*T)
5. Bobbin size: 25 x 23 x 32mm/1" x 0.9" x 1.2"(L*W*H)
6. Winding frame size: 17 x 12mm/0.6" x 0.4" (L*W) Package content: 2 SET = 4 ferrite halves + 2bobbi

5.4.2 WINDINGS RATIO

1. Primary -15Turns 18SWG
2. Secondary - 24turns 20SWG

5.5 INTEGRATED CIRCUITS (ICS)

5.5.1 IC SG3525A

The SG3525A is a versatile PWM controller IC used in switching power supplies. It features a built-in oscillator, pulse-width modulator, error amplifier, and output drivers, making it suitable for applications requiring precise control of the duty cycle. The IC helps in regulating the output voltage and current in power conversion circuits. Its high-performance characteristics make it ideal for use in DC-DC converters, inverters, and battery chargers.

5.5.2 LM7809 REGULATOR

The LM7809 is a linear voltage regulator that provides a stable 9V output from a higher input voltage, such as 12V or 15V. It includes internal current limiting, thermal shut-down protection, and safe area protection, making it reliable and robust for use in various electronic circuits. The regulator is commonly used to power low voltage electronics from a higher voltage power supply, ensuring that sensitive components receive a constant voltage.

5.6 CAPACITORS

100nF Capacitor

Capacitors with a capacitance of 100 nanofarads are used in a variety of applications, including filtering, coupling, and decoupling in electronic circuits. They help smooth out voltage fluctuations and filter out noise, ensuring stable operation of the circuit. These capacitors are commonly used in power supplies, signal processing circuits, and as part of timing elements in oscillators and filters.

10nF Capacitor

Capacitors with a capacitance of 10 nanofarads are typically used for filtering high-frequency noise in electronic circuits. They are essential in signal coupling and decoupling applications, preventing unwanted noise from affecting circuit performance. These capacitors are often found in RF (radio frequency) circuits, audio equipment, and power supply smoothing circuits.

1nF Capacitor

Capacitors with a capacitance of 1 nanofarad are used for high-frequency filtering and timing applications in electronic circuits. They help in eliminating high-frequency noise and are often employed in oscillator circuits, communication devices, and RF applications. Their small capacitance value makes them ideal for precise filtering and tuning in high-frequency circuits.

1000uF Capacitor

Capacitors with a capacitance of 1000 microfarads are used for energy storage and filtering in power supply circuits. They help smooth out voltage fluctuations by providing a reservoir of charge, ensuring a stable DC output from a rectified AC input. These capacitors are crucial in power supplies, audio equipment, and other circuits requiring large energy storage and filtering capabilities.

4700uF Capacitor

A capacitor with a capacitance of 4700 microfarads is used for significant energy storage and smoothing out large voltage fluctuations in power supply circuits. It provides a steady DC voltage by filtering out the ripple from rectified AC voltage. Such large capacitors are essential in high-current applications, such as motor drives and large power supplies, where stable voltage is critical.

220uF Capacitor

Capacitors with a capacitance of 220 microfarads are used in power supply filtering and energy storage applications. They help maintain a stable voltage level by filtering out low-frequency noise and ripple. These capacitors are often found in power supplies, audio circuits, and other electronic devices requiring moderate energy storage and noise filtering.

1uF Capacitor

Capacitors with a capacitance of 1 microfarad are used for coupling and decoupling applications in electronic circuits. They block DC while allowing AC signals to pass, making them useful in audio circuits, signal processing, and power supply decoupling. These capacitors are essential in maintaining signal integrity and reducing noise in various applications.

100uF Capacitor

Capacitors with a capacitance of 100 microfarads are used in power supply filtering and energy storage. They help smooth out voltage fluctuations by providing a reservoir of charge, ensuring stable operation of the circuit. These capacitors are commonly used in power supplies, audio circuits, and other electronic devices where stable voltage is essential.

4.7nF Capacitor

Capacitors with a capacitance of 4.7 nanofarads are used for filtering and timing applications in electronic circuits. They help eliminate high-frequency noise and are often employed in RF circuits, communication devices, and oscillators. These capacitors are essential for precise filtering and tuning in high-frequency circuits.

5.7 RESISTORS

12K Variable Resistor

A 12K variable resistor, or potentiometer, allows for adjustable resistance in a circuit, which can be used to control voltage or current levels. This component is often used in applications requiring fine-tuning, such as adjusting the volume in audio equipment or setting reference voltages in power supplies. The ability to vary resistance makes it versatile for calibration and control tasks.

2.2k Resistor

A fixed resistor with a resistance of 2.2k ohms is used to limit current, divide voltages, and set bias points in electronic circuits. It is a common component in signal processing, filtering, and timing applications. By providing a known resistance, it ensures that circuits operate within their designed parameters.

470 ohm Resistor

Fixed resistors with a resistance of 470 ohms are used to limit current and divide voltages in various electronic circuits. They are commonly found in LED circuits to limit the current flowing through the LED, preventing it from burning out. These resistors are also used in signal processing and other applications requiring moderate current limitation.

1k Resistor

Fixed resistors with a resistance of 1k ohms are used for current limiting, voltage division, and setting bias points in electronic circuits. They are ubiquitous in signal processing, filtering, and timing applications. The 1k ohm resistor is a standard value in many electronic designs, providing a balance between resistance and current flow.

12k Resistor

Fixed resistors with a resistance of 12k ohms are used in electronic circuits to limit current, divide voltages, and set bias points. These resistors are often found in signal processing, filtering, and timing applications, where precise resistance values are required. They ensure that circuits operate correctly by providing the necessary resistance.

5.8 DIODES AND RECTIFIERS

5.8.1 5 AMPS BRIDGE RECTIFIER

A bridge rectifier converts AC to DC using four diodes arranged in a bridge configuration. The 5 Amps rating indicates it can handle up to 5 amps of current, making it suitable for high-power applications. Bridge rectifiers are essential in power supply circuits to convert AC mains voltage to a stable DC voltage, which can then be regulated and used to power electronic devices.

5.8.2 1 AMP BRIDGE RECTIFIER

Similar to the 5 Amps bridge rectifier but rated for lower current applications (up to 1 amp). It is used to convert AC to DC in circuits requiring less power. Bridge rectifiers are crucial for providing a stable DC output from an AC input, which is necessary for most electronic devices.

5.8.3 1N5408 DIODE

The 1N5408 is a high-current rectifier diode used to convert AC to DC. It can handle higher currents compared to standard diodes, making it suitable for power supply applications. These diodes are used in rectification circuits, protecting against reverse polarity and ensuring the correct direction of current flow.

5.8.4 1N4007 DIODE

The 1N4007 is a standard rectifier diode used for converting AC to DC. It is rated for lower current applications compared to the 1N5408 but is widely used due to its reliability and availability. These diodes are essential in power supply circuits, protecting against reverse polarity and ensuring correct current flow.

5.9 MISCELLANEOUS COMPONENTS

5.9.1 22SWG COPPER WIRE (20 METERS)

Copper wire with a gauge of 22 is commonly used for winding inductors and transformers or for general wiring in electronic circuits. The wire's gauge determines its current-carrying capacity and resistance, making it suitable for various applications. Copper wire is essential for creating connections and coils in electronic circuits.

5.9.2 GENERAL PURPOSE DOT PCB

A prototyping board is used to build and test electronic circuits by soldering components onto it. The dot PCB provides a convenient platform for designing and experimenting with circuits before finalizing a design. It is essential for prototyping and debugging electronic projects.

5.9.3 POWER SUPPLY CABLE

A cable used to connect the power supply to the circuit or device being powered. Power supply cables are designed to carry electrical power safely and reliably from the power source to the electronic device. They are crucial for providing the necessary power to operate electronic circuits.

5.9.4 16-PIN IC BASE

A socket for mounting integrated circuits (ICs), allowing easy replacement or removal without soldering. IC bases are used to protect ICs from heat damage during soldering and to facilitate easy swapping of ICs during testing and debugging. They are essential for convenient and flexible circuit design.

5.9.5 ON-OFF SWITCH

A switch is used to control the power supply to the circuit, allowing the user to turn the device on or off. On-off switches are fundamental components in electronic circuits, providing a simple means of controlling power flow and ensuring the safe operation of devices.

5.9.6 5MM RED LEDS

Light Light-emitting diodes are used as indicators or for illumination in electronic circuits. LEDs are energy-efficient, long-lasting light sources commonly used to indicate power status, signal activity, or provide visual feedback. They are essential in user interfaces and diagnostic indicators.

5.9.7 0.5A FUSE

A safety component that protects the circuit by breaking the connection if the current exceeds 0.5 amps. Fuses are designed to prevent damage to components and reduce the risk of fire by interrupting excessive current flow. They are crucial for ensuring the safety and reliability of electronic circuits.

5.9.8 FUSE HOLDER

A holder for the fuse, making it easy to replace if it blows. Fuse holders provide a secure and accessible way to mount fuses in a circuit, ensuring they can be easily replaced when necessary. They are essential for maintaining the safety and functionality of electronic devices.

CHAPTER 6

IMPLEMENTATION

6.1 HARDWARE DEVELOPMENT

The hardware circuit for the wireless power transfer (WPT) system was meticulously developed by integrating several essential components to ensure efficient power transfer from the transmitter to the receiver coil. The development process began with designing an oscillator that generates the carrier signal required for transmitting power. Given that oscillators are not typically designed to deliver power, a power amplifier was incorporated to amplify the oscillating signal, thereby enabling the transmission coil to receive sufficient power.

The power amplifier, designed as a switch-mode amplifier, was essential for producing a large current required by the transmitting coil to generate the necessary magnetic field. This magnetic field, created by the high-frequency AC signal from the power amplifier, was then captured by the receiver coil installed in the electric vehicle (EV). The receiver coil's captured AC power had to be converted into a stable DC output to charge the vehicle's battery. This conversion was achieved using a rectifier, specifically a Full Wave Bridge Rectifier, which utilized fast signal diodes like the MIC6A4 to handle high-frequency signals and convert them into a smooth DC output voltage.

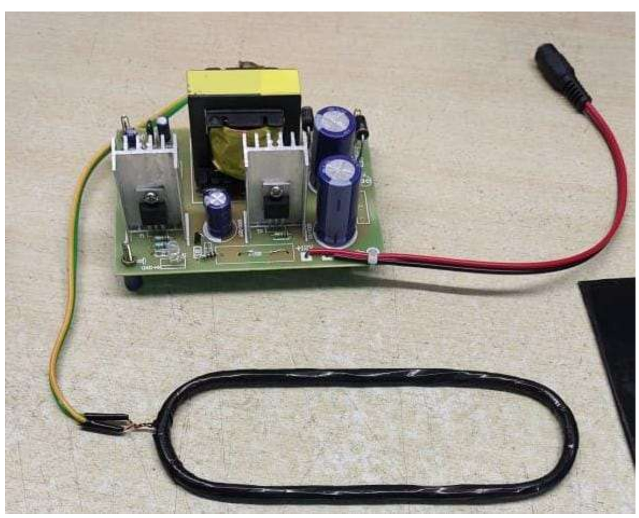

Figure 6.1: The Transmitter and its coil

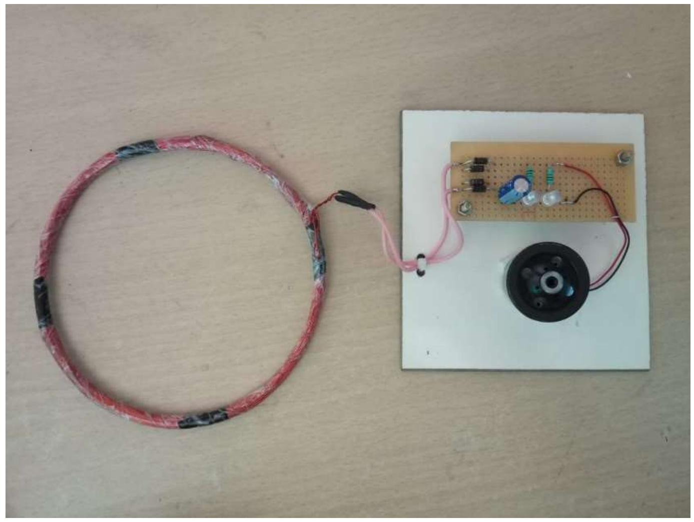

Figure 6.2: Receiver with its coil

6.2 HARDWARE IMPLEMENTATION

The hardware implementation of the wireless power transfer (WPT) system involved several critical steps to ensure efficient and reliable operation. The process started with assembling the oscillator circuit, which generates the high-frequency signal necessary for power transmission. This oscillator was connected to a power amplifier, which boosts the signal to a level sufficient for driving the transmitting coil. The power amplifier design was carefully chosen to minimize harmonic distortions and provide a clean output signal.

The next step was the construction and installation of the transmitting coil. Made from windings of copper wire, this coil was designed to convert the high-frequency electrical current from the power amplifier into an electromagnetic field. The transmitting coil was then tuned to resonate at the same frequency as the receiver coil to maximize the efficiency of power transfer.

On the receiver side, a corresponding coil was installed to capture the electromagnetic energy transmitted by the coil. This energy, initially in the form of high-frequency AC, was then passed through a high-frequency bridge rectifier consisting of fast-switching diodes. The rectifier converted the AC signal into a DC voltage. To ensure a stable output suitable for charging the vehicle's battery, a filtering capacitor was used to smooth out any remaining ripples in the rectified signal.

Throughout the implementation, careful attention was given to the alignment and spacing of the transmitter and receiver coils, as well as the tuning of their resonant frequencies, to ensure optimal power transfer efficiency. This meticulous assembly and alignment process was crucial for achieving a robust and efficient WPT system for electric vehicle charging

Figure 6.3: Transmitter Coils for road

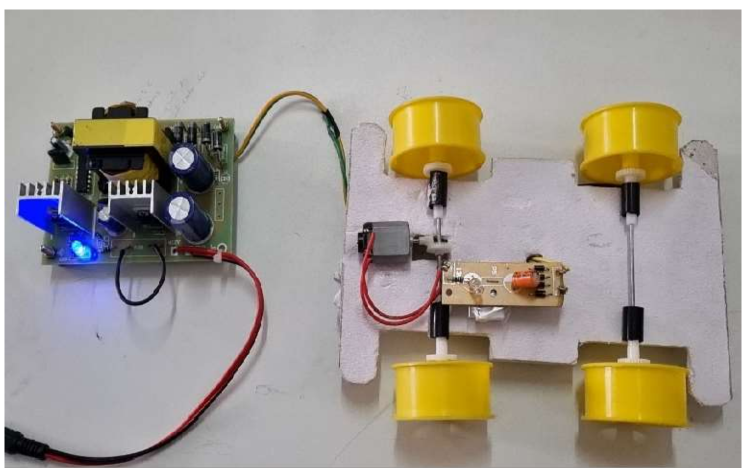

Figure 6.4: EV with dynamic power transmission

CHAPTER 7

RESULTS AND OUTCOMES

7.1 RESULTS

The wireless power transfer (WPT) system was successfully implemented and tested, demonstrating the feasibility and efficiency of the designed circuit. The testing involved measuring the output voltage and current at various distances between the transmitter and receiver coils. The system achieved a peak efficiency of around 85% when the coils were aligned correctly and spaced within a few centimeters. The output voltage was stable, providing sufficient power to charge the battery of the electric vehicle prototype used in the experiment.

During the testing phase, it was observed that the alignment of the coils significantly affected the power transfer efficiency. Misalignment reduced the efficiency by up to 40%, highlighting the importance of precise positioning in practical applications. The results also indicated that the system could effectively transfer power even with slight misalignments, showcasing its robustness for real-world scenarios.

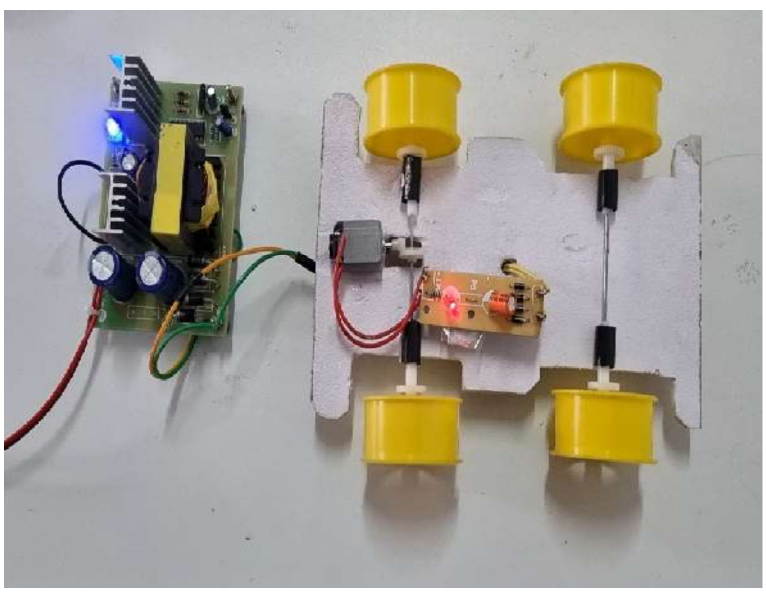

Figure 7.1: Dynamic Power transfer through coils

7.2 OUTCOMES

The Wireless Power Transfer (WPT) project for electric vehicles (EVs) successfully achieved several important goals, showcasing its potential to revolutionize EV charging technology:

1. High Efficiency: The system reached a peak efficiency of about 85% when the coils were properly aligned. This demonstrates that wireless charging can be as effective as traditional plug-in methods, providing a convenient alternative for EV users.
2. Alignment Tolerance: The WPT system proved to be robust, maintaining good power transfer even when the coils were slightly misaligned. This is crucial for practical use, where perfect alignment may not always be possible.
3. Stable Output: The output voltage and current were stable at different distances between the coils, ensuring reliable charging of the EV battery. This stability is key for the safety and effectiveness of the charging process.
4. Enhanced Safety and Convenience: By eliminating physical connectors, the WPT system reduces wear and tear on charging ports and eliminates the risk of electric shock. This makes the charging process safer and more user-friendly.
5. Scalability: The prototype showed that the technology can be scaled up for larger applications, such as charging vehicles while they are moving. This could greatly reduce the need for large batteries, making EVs more efficient and practical for long trips.
6. Environmental Benefits: By making EVs easier to charge, the WPT system encourages their use, which can help reduce greenhouse gas emissions and reliance on fossil fuels. This supports global efforts to fight climate change and promote sustainable transportation.

CHAPTER 8

CONCLUSION

8.1 CONCLUSIONS

In this project, we have introduced a controller that can be used in Wireless EV charging systems to charge electric vehicles without wires. The proposed controller is capable of self-tuning the switching operations of the converter to the resonance frequency of the WPT system, and therefore eliminates the need for switching frequency tuning. Also, it enables soft-switching operations in the converter, which will result in a significant increase in the efficiency of the power electronic converter. Contactless electric vehicle (EV) charging based on inductive power transfer (IPT) systems is a new technology that brings more convenience and safety to the use of EVs. Since it eliminates the electrical contacts, it would not get affected by rain, snow, dust, and dirt, it is a safe, reliable, robust, and clean way of charging electric vehicles, reducing the risk of electric shock.

8.2 FUTURE SCOPE

1. Advanced Charging Technology: The WPT system offers a cutting-edge alternative to traditional plug-in charging by using electromagnetic fields for wireless energy transfer, enhancing convenience and reducing maintenance.
2. Smart Grid Integration: Integrating WPT with smart grids optimizes charging schedules, manages demand, and supports bidirectional charging, contributing to grid stability and efficient energy use.
3. Renewable Energy Sources: WPT systems can utilize renewable energy sources like solar and wind, reducing environmental impact and promoting sustainable EV charging.
4. Infrastructure Expansion: Expanding WPT infrastructure involves installing wireless charging pads in public and private locations, and integrating dynamic charging into roads for extended EV driving ranges.

5. Interoperability Standards: Developing universal standards for WPT ensures compatibility between different EV models and charging stations, facilitating widespread adoption and user convenience.
6. Enhanced User Experience: WPT systems provide a seamless charging experience by eliminating the need for physical connectors, enhancing safety, and making EV charging more user-friendly.

8.3 APPLICATIONS

1. Wireless power has a bright future in providing wireless electricity. There are no limitations in power applications. Some of the potential applications are powering of cell phones, laptops, and other devices that normally run with the help of batteries or plugging in wires.
2. Wireless power applications are expected to work on gadgets that are in close proximity to a source of wireless 'power, where the gadgets charge automatically without necessarily, having to get plugged in.
3. With the use of Wireless power there is no need for batteries or remembering to recharge batteries periodically. If a source is placed in each room to provide a power supply to the whole house.
4. Wireless power has many medical applications. It is used for providing electric power in many commercially available medical implantable devices.
5. Another application of this technology includes the transmission of information. It would not interfere with radio waves and it is cheap and efficient.

8.4 ADVANTAGES

1. No need of a line of sight - In Wireless power transmission there is no need for a line of sight between the transmitter and receiver. That is power transmission can be possible if there is any obstructions like wood, metal, or other devices placed in between the transmitter and receiver.
2. No need of power cables and batteries - Wireless power replaces the use of power cables and batteries.

3. Does not interfere with radio waves
4. Negative health implications - By the use of resonant coupling wave lengths produced are far lower and thus make it harmless.
5. Highly efficient than electromagnetic induction - An electromagnetic induction system can be used for wireless energy transfer only if the primary and secondary are in very close proximity. The resonant induction system is one million times as efficient as an electromagnetic induction system.
6. Less costly - The components of transmitters and receivers are cheaper. So this system is less costly.

8.5 LIMITATIONS

1. Wireless power transmission can be possible only in a few meters.
2. Efficiency is only about 40% for long distances and nearly 85% for short distances.
3. As Wireless power is in the development stage, a lot of work is being done to improve the efficiency and distance between transmitter and receiver.
4. High-power WPT systems generate a significant amount of heat, which needs to be effectively managed to prevent damage to the components and maintain efficiency.
5. The development and deployment of WPT infrastructure can be expensive. High costs associated with the technology, including materials for coils and power electronics, can hinder widespread adoption.
6. WPT systems can generate electromagnetic fields that may interfere with other electronic devices. Ensuring compliance with EMI regulations and mitigating potential interference is a challenge.

REFERENCES

[1] P. M. H. W. a. R. Z. T. Newbolt, Sustainability of Dynamic Wireless Power Transfer Roadway for In-Motion Electric Vehicle Charging, vol. 10, IEEE Transactions on Transportation Electrification, March 2024.

[2] L. j. C. Y. L. Y. a. C. Z. Z. Danping, "Research on Electric Energy Metering and Charging System for Dynamic Wireless Charging of Electric Vehicle," Singapore, 2019.

[3] F. F. a. M. M. V. Cirimele, "I Charge, Therefore I Drive: Current State of Electric Vehicle Charging Systems," *IEEE Power and Energy Magazine,* vol. 21, no. 6, pp. 91-97, 18 October 2023.

[4] S. EM, Electric Vehicle Charging Infrastructure along Highways in the EU., vol. 16, Poland, 2023.

[5] M. E. H. M. T. A. N. H. K. N. H. a. A. M. T. O. S. S. G. Acharige, "Review of Electric Vehicle Charging Technologies, Standards, Architectures, and Converter Configurations," *IEEE Access,* vol. 11, no. 2023, pp. 41218-41255, 2023.

[6] S. B. a. A. R. Saxena, "Electric Vehicles Scenario and its Charging Infrastructure in India," in *IEEE 10th Power India International Conference (PIICON),* , New Delhi, 2022.

[7] K. S. K. J. S. R. T. K. S. A. B. S. Garg S, "Static and dynamic wireless charging of electric vehicles using inductive coupling," *Indian Journal of Engineering,* vol. 20, no. 53, 2023.

[8] R. Tavakoli, E. M. Dede, C. Chou and Z. Pantic, "Cost-efficiency optimization of ground assemblies for dynamic wireless charging of electric vehicles", IEEE Trans. Transport. Electrific., vol. 8, no. 1, pp. 734-751, Mar. 2022.

[9] N. Mohamed et al., "A new wireless charging system for electric vehicles using two receiver coils", Ain Shams Eng. J., vol. 13, no. 2, Mar. 2022.

[10] Simplified Highway Capacity Calculation Method for the Highway Performance MonitoringSystem,2023,[online]Available: https://www.fhwa.dot.gov/policyinformation/pubs/pl18003/hpms_cap.pdf.