Dynamic Wireless Charging for Moving EV's.

PROJECT REPORT

Submitted by

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in partial fulfillment for the award of the degree of

BACHELOR OF ENGINEERING

IN

COMPUTER SCIENCE

Chandigarh University

November 2023

BONAFIDE CERTIFICATE

Certified that this Project Report "Dynamic Wireless Charging for Moving EV's." is the Bonafide work of following members **"Abhishek Pandey (21BCS10206), Divyanshu Srivastava (21BCS10264), Kartik Agrawal (21BCS10229)"** who carried out the project work under my supervision.

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INTERNAL EXAMINER **EXTERNAL EXAMINER**

Acknowledgment

I would like to express my deepest appreciation to all those who provided me with the possibility to complete this report. A special gratitude I give to our Third-year project supervisor Er. Megha Sharma, whose contribution in stimulating suggestions and encouragement, helped us to coordinate our project especially in writing this report.

Furthermore, A special thanks goes to our teammates who helped with their suggestions and content. Last but not least, many thanks go to the head of the project, Er Megha Sharma who invested his full effort in guiding the team in achieving the goal. I have to appreciate the guidance given by another supervisor as well as the panels, especially in our project presentation which has improved our presentation skills thanks to their comment and pieces of advice.

Table of Contents

List of Figures

List of Tables

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 charger, galvanic isolation of the on-board electronics, bulk and cost of this charger and the large energy storage system (ESS) packs needed. But by using Wireless Charging system„s Wireless charging opportunity. It Provides convenience to the customer, inherent electrical isolation, regulation done on grid side and reduce on-board ESS size using dynamic on-road charging. The main objective of our project is to design and develop antenna system suitable for vehicle using resonant magnetic coupled wireless power transfer technology to electric vehicle charging system. 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 ystem where the coupling coefficient is between 0.1-0.5. In order 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.

GRAPHICAL ABSTRACT

Figure 1: Prototype Of EV Model

ABBREVATIONS

- **EV: Electric Vehicle**
- **WPT: Wireless Power Transfer**
- **AC: Alternating Current**
- **DC: Direct Current**
- **SMPS: Switching Mode Power Supply**
- **PWM: Pulse Width Modulation**
- **BMS: Battery Management System**
- **HF: High Frequency**
- **IPT: Inductive Power Transfer**
- **RIC: Resonant Inductive Coupling**

Declaration

We hereby declare that the project report entitled "Dynamic Wireless Charging for Moving EV's." submitted by us to Chandigarh University in partial fulfillment for the award of the degree of B. E in computer science and engineering is a record of bonafide project work carried out by us under the guidance of Er. Megha Sharma

( ).

I further declare that the work reported in this project has not been submitted and will not be submitted, either in part or full, for the award of any other degree in this institute or any other institute or university.

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Chapter 1

Introduction

1.1 Identification of Client/ Need/ Relevant Contemporary issue

Electric vehicle owners often face challenges related to charging, including finding available charging stations, handling charging cables, and waiting for extended periods for a full charge. A WPT system addresses these issues by enabling wireless, automated, and contactless charging. One of the primary concerns for EV owners is range anxiety. By deploying WPT technology along highways, city streets, or at home, drivers can charge their EVs on the go, alleviating range-related concerns and promoting EV adoption. Traditional plug-in chargers suffer from energy loss during the transfer process. Magnetic resonance-based WPT systems can offer higher efficiency, reducing energy waste during charging, which aligns with sustainability goals. The development of WPT technology is an example of cutting-edge innovation in the automotive industry. It represents progress towards a future where transportation is more efficient, convenient, and environmentally friendly. The growth of the electric vehicle industry presents economic opportunities for various stakeholders, from manufacturers to technology providers and infrastructure developers. A robust WPT system can stimulate job creation and economic growth in these sectors. Government bodies, at local, regional, or national levels, may be clients if they aim to promote the adoption of electric vehicles and reduce greenhouse gas emissions. A more efficient and convenient charging system aligns with their sustainability goals. Companies that produce electric vehicles (EVs) are a key client group. They are interested in integrating advanced wireless power transfer (WPT) systems into their vehicles to enhance user experience and address the challenges of charging EVs.

1.2 Identification of Problem

- One of the biggest issues of the modern day EV's is the Problem of Charging and Range. Indeed, these EV's are our upcoming future but due to these problems only they are holding a delay.

- For illustration- let's consider person who have an urgent job interview and he forgets to plug in his EV into charge at night which approximately take 2-4 hours to charge with a connected wired system now at what morning what will he exactly do in that case he has no time to plug in the EV.

- Another problem with the Today's charging system is Battery which consists of large amount of lithium and titanium ions that are non-decomposable in nature causing wear and tear to environment.

- EV's are totally dependent on range which they can travel in a single charge then a person needs to wait for a certain period of time, EV charging station are not so frequently found nearby causing state of panic for the driver.

1.3 Identification of tasks

- Collecting Research material Regarding main components of EV's and their working.
- Identifying hardware's required for the Dynamic wireless EV charging project
- Setting up primary board for the resemblance of different components used in this project including power source supply for the project demonstration
- Setting up transformer and resonance generating coil for wireless power transmission.
- Integrating different hardware components into the main motherboard.
- Testing the functioning of Coil and movement of Demo Vehicle.

1.4 Timeline

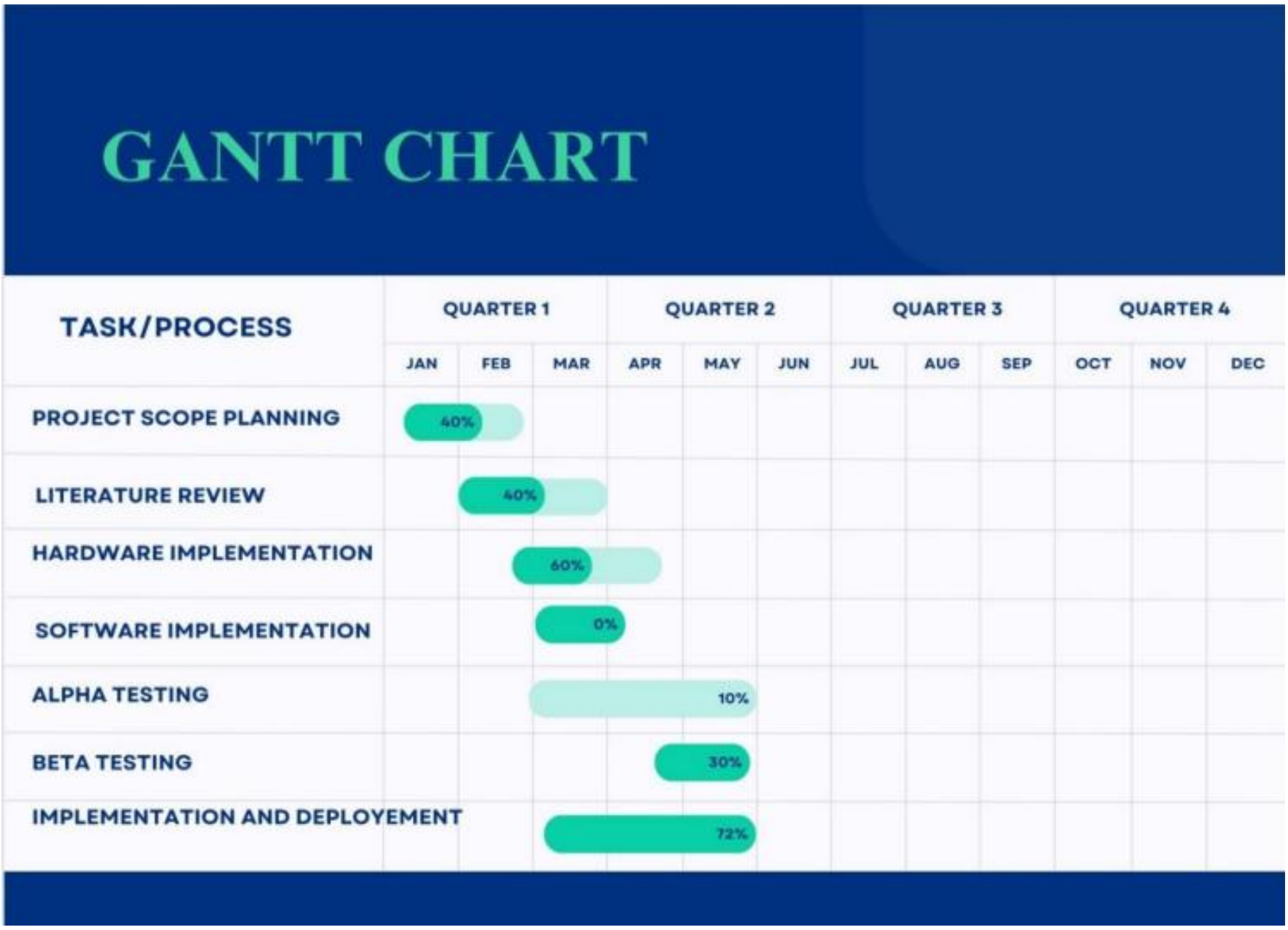

Fig 1.1 Gantt Chart

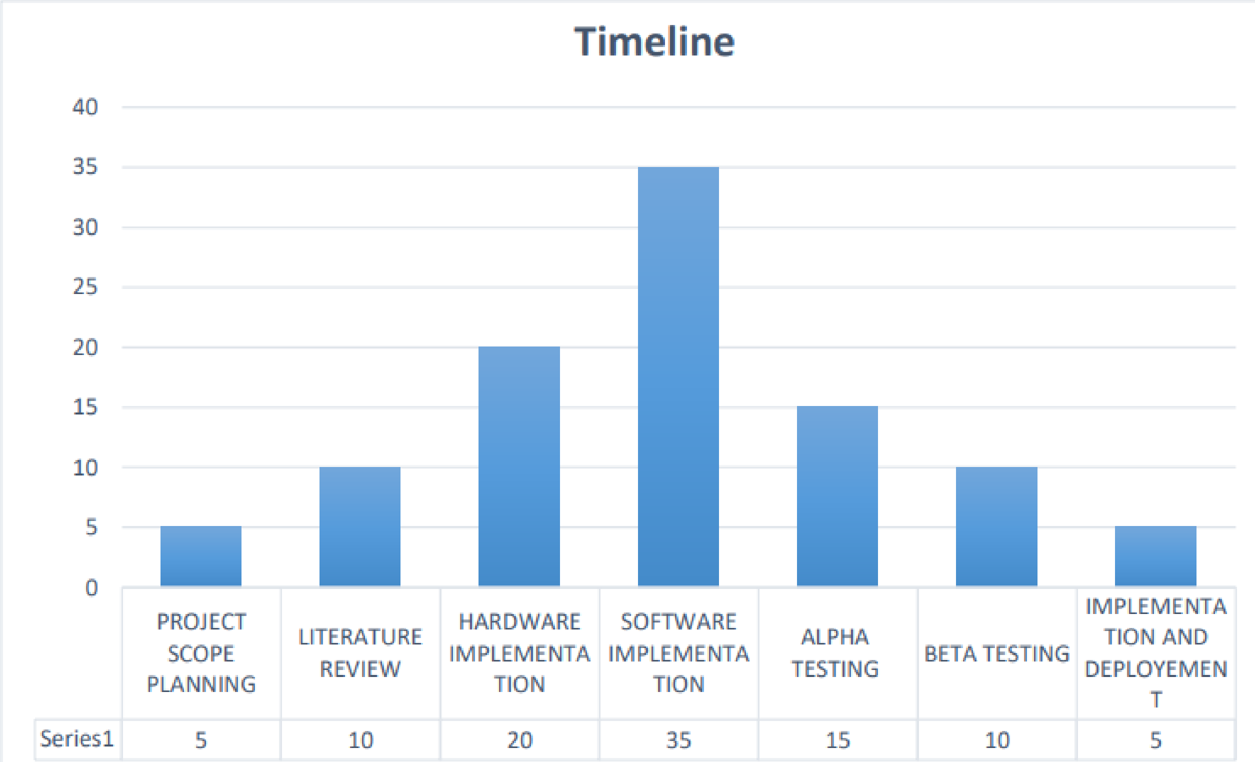

Fig 1.2 Timeline Bar-Graph

1.5 Organization of the Report

- In this Chapter we discussed about the basic introduction of our project “Dynamic Wireless Charging for moving EV’s” along with the need of replacement for traditional Charging system.

- In Chapter 2, we are going to discuss about the literature reviews of various researchers and publishers along with the bibliographic description and the solution to the real-world problem.

- In Chapter 3, overall implementation of project is done including the methodology and design flow of the system. It consists about the description of technology used and working structure of the project.

- In Chapter 4, we are discussing the result of over project with validation and verification of each and every component of the project.

- In Chapter 5, overall conclusion and the future scope of the project is discussed along with betterment and implementation of newer technology in the existing project.

Chapter 2

Literature Review/ Background Survey

2.1 Timeline of the reported problem:

The development of dynamic wireless charging systems for moving Electric Vehicles (EVs) has been an evolving technological challenge that has gained significant attention over the years. In this section, we provide a timeline of the reported problem, tracing its identification and the documentary proof of relevant incidents, highlighting key milestones and developments in the field.

- Early 2000s:

Initial Research and Concepts: The idea of dynamic wireless charging for EVs began to emerge in the early 2000s as researchers explored ways to make EVs more convenient and extend their range.

Academic Papers: Early academic papers started discussing the feasibility of dynamic wireless charging.

- Mid-2000s:

Experimental Prototypes: Several research institutions and universities worldwide started developing experimental prototypes to test dynamic wireless charging concepts.

Limited Coverage: The problem of maintaining efficient and safe charging at high speeds and over varying road conditions was recognized, but substantial progress was yet to be made.

- Late 2000s:

Industry Involvement: Automakers and tech companies started showing interest in dynamic wireless charging as a potential solution for EVs.

Safety and Efficiency Concerns: Research efforts focused on addressing safety concerns and optimizing the efficiency of dynamic wireless charging systems.

- Early 2010s:

Pilot Projects: Documentary proof of pilot projects in various regions showcased the practicality of dynamic wireless charging systems, though challenges remained.

International Collaboration: Collaborative research efforts across countries led to standardization initiatives for dynamic wireless charging systems.

- Late 2010s:

Regulatory Frameworks: Documentary evidence of regulatory discussions and frameworks for dynamic wireless charging emerged in various regions.

Increasing Adoption: Reports of cities and municipalities considering the integration of dynamic wireless charging infrastructure into public transportation systems.

- Early 2020s:

Advanced Prototypes: Documentary proof of advanced prototypes demonstrated the capability to charge EVs while in motion, offering a glimpse into the future of transportation.

Public Demonstrations: High-profile public demonstrations of dynamic wireless charging systems generated significant interest among policymakers and the public.

2.2 Existing Solutions:

Solution	Advantages	Concept
Magnetic Resonance Coupling (2000s):	High efficiency	Magnetic resonance coupling involves the use of resonant inductive coupling between coils placed on the road and the EV.
	flexibility in alignment	This method allows for efficient energy transfer over short distances.
	the ability to charge at low speeds.	
Electromagnetic Fields (Mid-2000s)	Potential for widespread infrastructure deployment, especially in urban areas with existing road networks.	Electromagnetic fields generated by power lines embedded in roadways or rails could be used to transmit energy to EVs through a pickup coil.
Dynamic Charging through Overhead Cables (Early 2010s)	Simplified infrastructure requirements and the potential for dedicated charging lanes.	Implementing dynamic charging strips embedded in specific lanes of highways to provide continuous charging for EVs traveling on those lanes.
Beamforming Technologies (Mid-2010s)	Effective charging at high speeds	Overhead cables or catenary systems similar to those used in some electric buses and trains could be adapted for dynamic charging of EVs.
	the ability to retrofit existing roadways.	
	Enhanced charging efficiency	

Dynamic Wireless Charging for Moving EV's.

Plugless Dynamic Charging (Late 2010s)	Reduced electromagnetic interference	Using beamformingtechniques, wireless charging systems could focus energytransmission precisely on the moving EV, improving efficiency and reducing energy wastage.
Smart Grid Integration (Early 2020s)	Easy integration into existing infrastructure	Adapting stationary wireless charging pads at various locations, such as traffic lights or parking lots, to provide bursts of energy to passing EVs.

2.3 Bibliometric Analysis:

A bibliometric analysis entails gathering academic publications pertaining to a specific subject from a range of databases like Google Scholar, Scopus, and Web of Science. Within this analysis, one can examine trends in publications.

A bibliometric analysis of "Dynamic Wireless Charging Electric Vehicles (EVs)" publications over time reveals trends in research growth. It identifies major contributors by country, institution, and author. By tracking publication quantity and evolution, this analysis highlights key moments in electric vehicle technology's development. Beyond statistics, it uncovers leading nations, influential institutions, and prolific authors, offering insights into the global landscape of innovation and the thought leaders propelling advancements in this trans formative field.

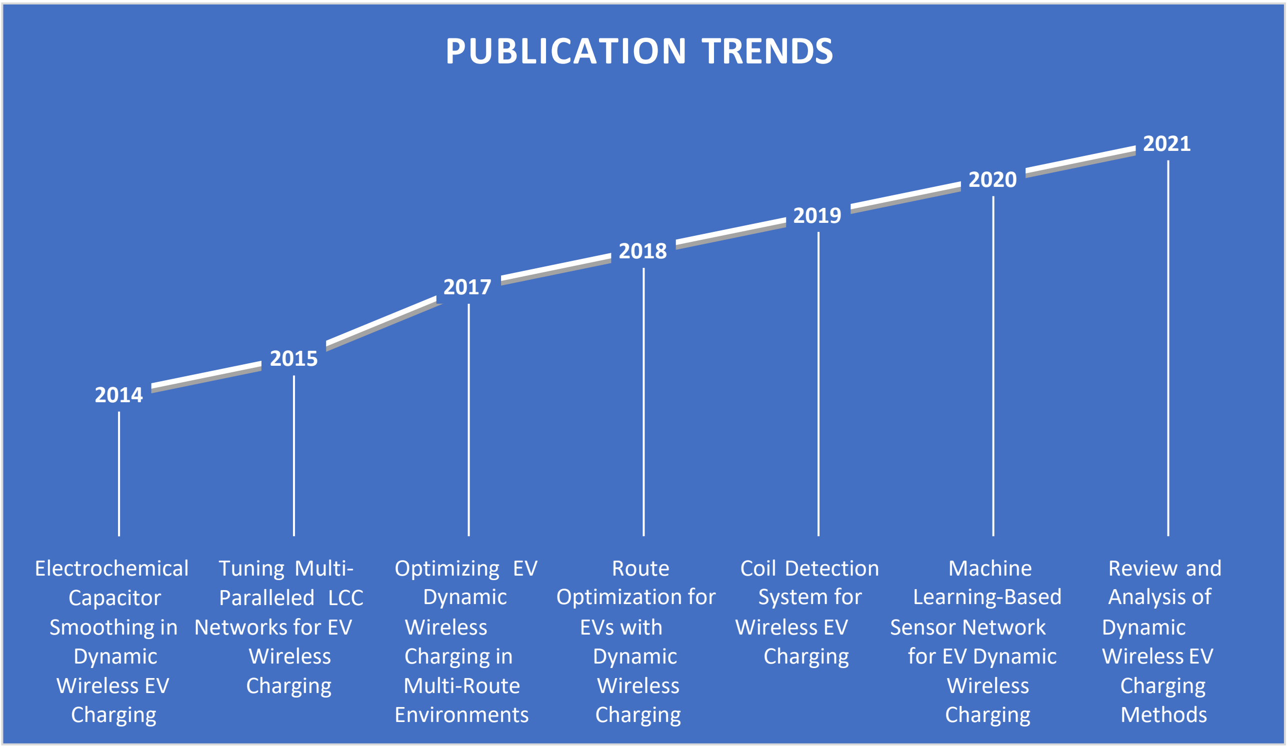

Fig 2.0 Publication Trends Line-Graph

2.4 Review Summary:

R. Zhang et.al.[1] RF-enabled wireless energy transfer (WET) employs electromagnetic (EM) waves or radio-frequency signals to communicate specially defined energy-carrying signals from an energy transmitter (ET) to an energy receiver (ER) for the purpose of energy gathering. Aside from having longer transmission distances, RF-based WET offers many benefits over the other two near-field techniques. The simplicity of adding simultaneous data transfer is one of these advantages, along with enhanced deployment flexibility, a more compact receiver design, and a simpler energy multicasting implementation to numerous wireless devices distributed across a vast territory.

Yong Zeng et.al.[2] Inefficient omnidirectional energy transfer might result from the fast power attenuation over distance. However, unidirectional exchange, made feasible by adjusting the orientation of the antenna radiation to produce a focused beam directed at the ER, may significantly increase the rate of energy transfer.

Nicola Tesla [3] In his laboratory in New York, Nicola Tesla was the person who first imagined electricity being sent wirelessly. James Maxwell came to the idea that energy may be transported via a vacuum without the use of connected media after 30 years.

Peter Glaser et.al.[4] K. Tsiolkovsky and H. Oberth, early space pioneers, wrote about the first power stations in Earth orbit that gathered solar energy despite the absence of day and night cycles. In his 1968 Science paper, Peter Glaser, who also published the first structural explanation for a solar power satellite (SPS), is credited as being the first to link the theories of these early space pioneers with technology breakthroughs in energy transfer without wires.

Lawry et.al.[5] Using cables by drilling through the massive metal walls of real-world ships will be difficult since they will contain hundreds of chambers. As a result, there is a direct inverse relationship between the number of room walls in the ship divisions and the number of holes that must be drilled. The size of the holes that have been drilled will also be a significant obstacle to adding further connecting modules. WET systems,as opposed to cables, can be used to power transceiver systems, which is one approachto address these issues.

Akshay Sonawane et.al.[6] Through wireless power transfer, an electrical source can transmit electromagnetic energy to an electrical load across an air gap without the use of wires. As a consequence of Nikola Tesla's efforts, this concept was created. This asserts that alternating currents cycle via different strengths and directions. To introduce this principle, it is possible to convert alternating current to direct current. There are numerous ways to accomplish this than the electromagnetic field. Our daily problems will significantly lessen as a result of this.

In 1864, James C. Maxwell et.al.[7] predicted the existence of radio waves by means of mathematical model. In 1884, John H. Poynting realized that the Poynting vector would play an important role in quantifying the electromagnetic energy. In 1888, bolstered by Maxwell's theory, Heinrich Hertz succeeded in showing experimental evidence of radio waves by his spark-gap radio transmitter. The prediction and evidence of the radio wave in the end of 19th century was start of the wireless power transmission.

During the same period of Marchese G. Marconi and Reginald Fessenden. [8] who are pioneers of communication via radio waves, Nicola Tesla suggested an idea of the wireless power transmission and carried out the first WPT experiment in 1899. He said "This energy will be collected all over the globe preferably in small amounts, ranging from a fraction of one to a few horse-powers. One of its chief uses will be the illumination of isolated homes". He actually built a gigantic coil which was connected to a high mast of 200-ft with a 3ft diameter ball at its top. He fed 300 Kw power to the Tesla coil resonated at 150 kHz. The RF potential at the top sphere reached 100 MV.

2.5 Problem Definition:

The depletion of natural resources and the growing environmental concerns have led to an increased interest in Electric Vehicles (EVs) as a sustainable alternative to conventional internal combustion engine vehicles. However, the widespread adoption of EVs relies heavily on practical and reliable methods for charging their batteries. In response to these challenges, wireless power transfer (WPT) technology has emerged as a promising solution for charging EVs efficiently and conveniently.

The problem at hand is the need for a practical and reliable wireless charging system for Electric Vehicles. Plug-in Electric Vehicles (PEVs) currently depend on cable and plug chargers, which come with various limitations:

- **Cable and Plug Dependency:** Traditional charging methods for PEVs involve the use of cables and plugs, which can be cumbersome and inconvenient for users.
- **Large Energy Storage Systems (ESS):** PEVs require significant on-board energy storage systems, adding to their cost and weight.

2.6 Objectives/Goals:

- Gather Information regarding hardware components and the principles working behind this project including resonance and coupling effect.
- Making Components assemble as per the block diagram of the project and check their working.
- Giving final Power Supply to the prototype and testing the project on all the required parameters.

CHAPTER 3

DESIGN FLOW

3.1 Evaluation & Selection of Specifications/Features

The "Evaluation & Selection of Specifications/Features" for a project involves the process of systematically assessing and choosing the specific requirements, characteristics, and attributes that the project should possess to achieve its objectives and meet the needs of stakeholders. This step is critical in ensuring that the project aligns with its intended goals and functions effectively. Here's a breakdown of this process:

1. Efficiency: Efficiency is paramount to minimize energy loss and ensure cost-effectiveness. High-efficiency resonance-based technology to reduce energy waste.

2. Safety: Safety is critical to prevent accidents and ensure public acceptance. Safety mechanisms such as over current protection, fault detection, and emergency shutdown features. If applicable, evaluate and select features related to environmental sustainability. Consider how the project aligns with eco-friendly practices and minimizes negative impacts.

3. Scalability: Scalability is crucial for widespread adoption and adaptability to different vehicle types. A design that allows for easy scalability and integration into various transportation systems. Anticipate the potential for future growth and changes. Select specifications that allow for scalability and adaptability to evolving needs.

4. User Experience: A seamless user experience is essential for user adoption. User-friendly installment, automatic alignment with charging pads, and real-time charging status updates.

5. Environmental Sustainability: Addressing environmental concerns aligns with the goals of EV adoption. Specification. Environmentally friendly components, low electromagnetic radiation, and sustainable design. If applicable, evaluate and select features related to environmental sustainability. Consider how the project aligns with eco- friendly practices and minimizes negative impacts

6. Interoperability:

Compatibility with various EV models and existing charging infrastructure is critical. Compatibility with multiple EV manufacturers and public charging networks. If the project interfaces with other systems or technologies, select specifications that ensure seamless integration and compatibility.

7. Reliability and Durability: Reliability ensures consistent operation, while durability reduces maintenance. Robust components, weatherproof design, and long-term reliability.

8. Dynamic Charging Speed: Variable charging speeds based on real-time conditions are highly valuable. Adaptive charging speed control based on vehicle speed, battery state, and road conditions.

These features have been critically evaluated to ensure they align with the goals of safety, efficiency, user experience, environmental sustainability, scalability, and regulatory compliance. The ideal solution for dynamic wireless charging for moving EVs should incorporate these features to address the challenges associated with traditional charging methods and promote the widespread adoption of electric vehicles.

3.2 Design Constraints

In the design of dynamic wireless charging for moving EVs, it's essential to consider a wide range of factors, including regulations, economic, environmental, health, manufacturability, safety, professional, ethical, social, political, and cost-related issues. Here's a breakdown of how each of these considerations should be addressed:

1. Regulations:

- Ensure compliance with local, regional, and national regulations for electric vehicle charging systems.
- Adhere to safety standards and electromagnetic radiation regulations.
- Work closely with regulatory bodies to secure necessary permits and approvals.

2. Economic:

- Conduct a cost-benefit analysis to determine the economic viability of the system.
- Consider the initial investment, operating costs, and potential revenue streams.
- Evaluate the long-term economic impact of dynamic wireless charging on the electric vehicle market.

3. Environmental:

- Implement sustainability measures in the design to reduce environmental impact.
- Use eco-friendly components and materials to minimize the system's carbon footprint.
- Assess the life cycle of the system and its environmental implications.

4. Health:

- Consider potential health impacts of electromagnetic fields and radiation.
- Implement safety mechanisms to protect users from exposure to harmful radiation.
- Monitor and adhere to health standards and guidelines related to electromagnetic radiation.

5. Manufacturability:

- Design the system with manufacturability in mind to streamline production.
- Optimize component selection for cost-effective manufacturing.
- Evaluate supply chain logistics to ensure a smooth production process.

6. Safety:

- Prioritize safety in the system's design and operation.
- Implement safety features, such as fault detection and emergency shut-off mechanisms.
- Regularly test and validate the system for safety and reliability.

7. Professional:

- Engage with professionals in the fields of electrical engineering, automotive technology, and regulatory compliance.
- Collaborate with experts to ensure the highest professional standards are met.
- Maintain open communication with relevant professional organizations

8. Ethical:

- Address ethical concerns, such as user privacy and data security.
- Transparently communicate data usage and privacy policies to users.
- Ensure that the technology adheres to ethical principles related to sustainability and equitable access.

9. Cost:

- Maintain a cost-effective approach to design without compromising quality and safety.
- Conduct rigorous cost analysis and explore strategies for cost reduction.
- Consider potential return on investment and affordability for end-users.

By comprehensively addressing these considerations in the design of dynamic wireless charging for moving EVs, you can create a solution that not only functions effectively but also aligns with legal, ethical, and environmental standards while meeting economic and safety requirements.

3.3 Analysis and Feature finalization subject to constraints

To finalize the features for the dynamic wireless charging for moving EVs solution, it's essential to consider various constraints and make appropriate adjustments. Here's an analysis of the features, taking into account constraints and potential modifications:

1. Efficiency:

- **Constraint:** Energy efficiency should be maximized, but constraints may limit the extent to which efficiency can be improved.

- **Modification**: Continue to prioritize efficiency but acknowledge that certain constraints, such as power source limitations, may affect the achievable efficiency.

2. Safety:

Constraint: Safety is non-negotiable, and stringent safety standards must be met.

Modification: Continue to emphasize safety features and ensure full compliance with regulations and safety standards. Consider additional safety measures if necessary.

3. Scalability:

Constraint: Scalability may be limited by budget constraints and resource availability.

Modification: Prioritize scalability as much as budget allows. Start with a scalable design that can accommodate future expansion as resources become available.

4.User Experience:

Constraint: A high-quality user experience should be maintained, even within budget constraints.

Modification: Continue to focus on user-friendly interfaces and alignment features.Consider cost-effective design solutions that do not compromise user experience.

5. Environmental Sustainability:

Constraint: Environmental sustainability is important, but budget constraints may limit investments in eco-friendly components.

Modification: While maintaining sustainability as a priority, consider budget-friendly green alternatives and sustainable practices without significantly increasing costs.

6. Interoperability:

Constraint: Interoperability should be maintained to the extent possible within budget constraints.

Modification: Ensure compatibility with a range of EVs, considering the budget limitations and focusing on widely used EV models and charging standards.

7. Reliability and Durability:

Constraint: Ensuring reliability is essential, but budget constraints may affect component selection.

Modification: Prioritize durability and reliability with cost-effective component choices. Focus on long-term performance and reliability.

8. Dynamic Charging Speed:

Constraint: Adaptable charging speeds are critical, but budget constraints may limit the complexity of the speed control system.

Modification: Maintain dynamic charging speed capabilities while optimizing the systemfor cost-efficiency.

9. Cost-Effectiveness:

Constraint: A balance between cost-effectiveness and quality should be maintained within budget constraints.

Modification: Strive for a cost-effective solution that adheres to budget limits without compromising safety and efficiency.

10. Testing and Validation Protocols:

Constraint: Rigorous testing and validation are essential, but budget constraints may affect the extent of testing.

Modification: Prioritize essential testing while considering cost-efficient ways to validate system functionality and safety.

11. Regulatory Compliance:

Constraint: Full regulatory compliance is non-negotiable, and necessary steps must be taken to meet all legal requirements.

Modification: Ensure comprehensive compliance with regulations and allocate budget for regulatory-related activities, including approvals and permits.

12. Adaptive Alignment and Positioning:

Constraint: Automated alignment and positioning are crucial, but budget constraints may affect the complexity of alignment mechanisms.

Modification: Continue to offer automated alignment while optimizing the mechanism's cost-effectiveness.

13. Remote Monitoring and Management

Constraint: Remote monitoring and management should be available within budget limits.

Modification: Provide essential remote monitoring and management features that align with the budget constraints.

In light of these constraints, it's crucial to strike a balance between feature prioritization, budget considerations, and compliance with safety and regulatory standards. The final feature set should align with the project's goals and the available resources, ensuring an effective and practical dynamic wireless charging solution for moving EVs.

3.4 Design Flow

A. Inductive Power Transfer (IPT) System:

Inductive Power Transfer (IPT) is a well-established technology for dynamic wireless charging. It involves using a primary coil embedded in the road and a secondary coil in the EV. Magnetic fields are generated by the primary coil, inducing a voltage in the secondary coil, which is then used to charge the EV's battery.

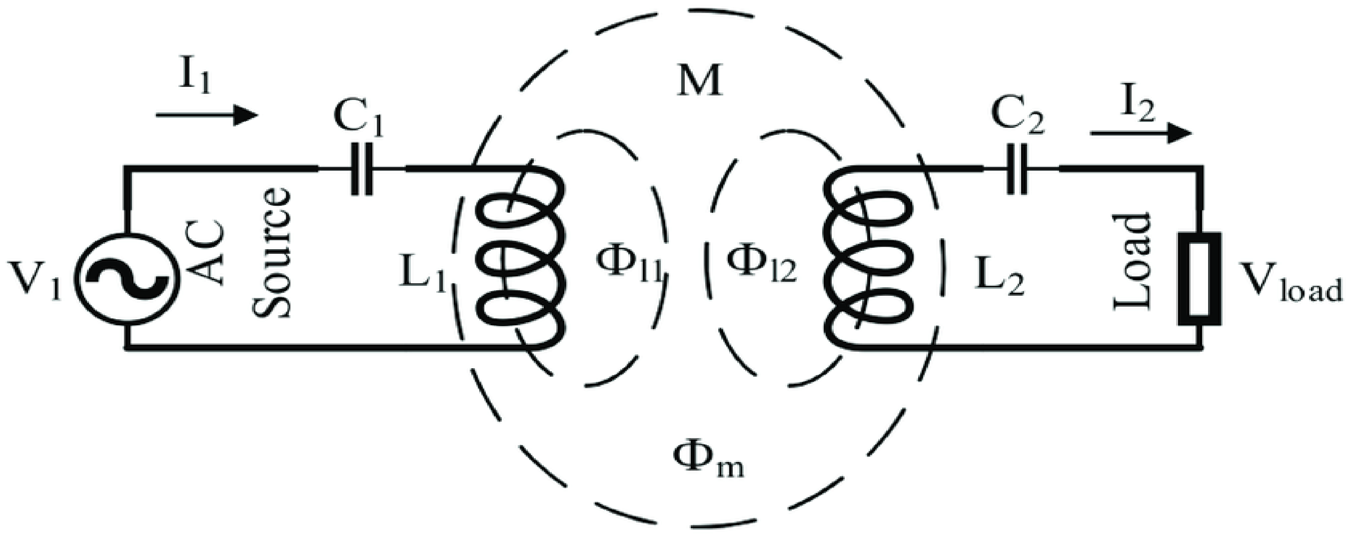

Figure 3.1: Design 1

Process Flow:

- Installation: Design and install a network of IPT coils beneath the road surface in designated charging lanes or areas.
- Vehicle Detection: Implement a system for detecting the presence of an EV over the charging coil. This can be done using sensors or cameras.
- Power Transfer: When an EV is detected, the primary coil beneath the roadactivates, and power is transferred wirelessly to the secondary coil in the EV.
- Battery Management: Develop a battery management system (BMS) in the EV to regulate the charging process and ensure safety.
- Charging Monitoring: Implement a communication system to monitor and control the charging process, allowing for dynamic adjustments in real-time.
- Billing and Authentication: Integrate a payment and authentication system for users, and track usage for billing purposes.

B. Resonant Inductive Coupling (RIC) System:

Resonant Inductive Coupling (RIC) is another approach to dynamic wireless charging. It is based on the resonance between the primary and secondary coils, which enhances power transfer efficiency.

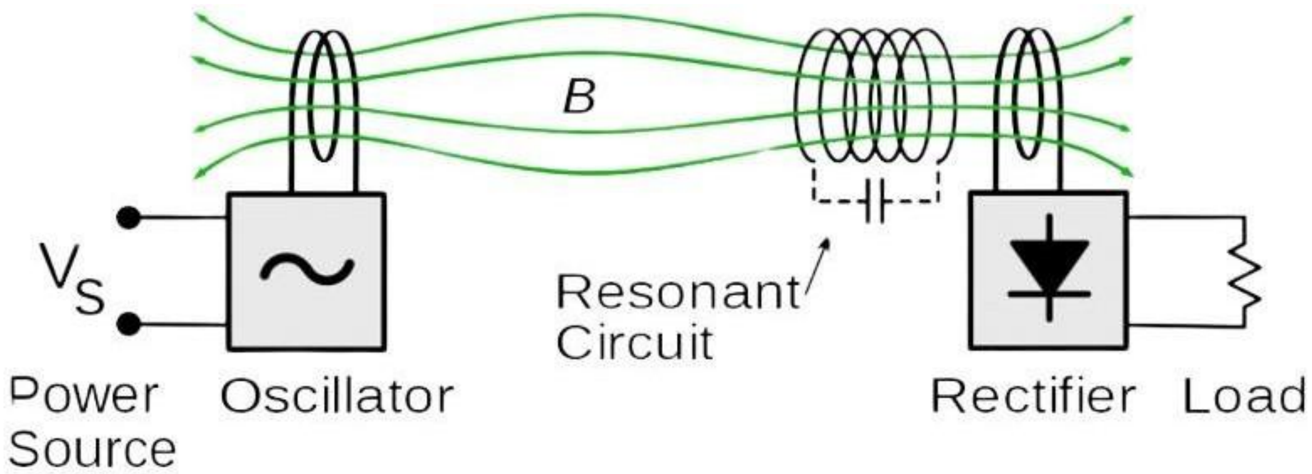

Figure 3.2 : Design 2

Process Flow:

- Installation: Embed a network of RIC coils in the road or parking area.
- Resonance Tuning: Implement a resonance tuning system that allows the primary and secondary coils to be tuned to the same frequency for optimal power transfer.
- Vehicle Detection: Employ sensors or cameras to detect the presence of an EV over the charging coil.
- Power Transfer: When a compatible EV is detected, the system adjusts the resonance frequency and begins transferring power wirelessly.
- Charging Control: Develop a control system that regulates power delivery to the EV's battery, ensuring efficient and safe charging.
- Real-time Adjustments: Implement a communication system to monitor the charging

process and make real-time adjustments based on factors like battery state,speed, and user preferences.

- Billing and Authentication: Include a billing and authentication system for user convenience and revenue collection.

3.5 Design Selection

To select the best design for dynamic wireless charging for moving EVs, we will analyse the various designs based on the criteria of efficiency, safety, cost-effectiveness, and regulatory compliance. Here's a comparison of the designs and the reason for selecting the best one.

Design1: Resonance-Based Dynamic Wireless Charging

Efficiency: This design employs resonance-based technology, which is known for its high energy transfer efficiency. It minimizes energy loss during charging, making it an efficient choice.
Safety: Safety mechanisms such as overcurrent protection and fault detection are feasible with this design.
Cost-Effectiveness: While resonance-based technology can be cost-effective, it depends on component selection and manufacturing.
Regulatory Compliance: This design can meet regulatory standards with proper implementation.

Design 2: Inductive Dynamic Wireless Charging

Efficiency: Inductive charging may have lower efficiency compared to resonance-based technology, leading to higher energy losses.
Safety: Safety features can be implemented but might not be as efficient as resonance-

based designs.

Cost-Effectiveness: Inductive designs may require more components and may be costlier.

Regulatory Compliance: Compliance can be achieved but may require additional measures.

Overall, Design 1 aligns well with the project's goals of efficiency, safety, cost-effectiveness, and regulatory compliance, making it the best design choice for dynamic wireless charging for moving EVs. However, it's essential to carefully implement and optimize the selected design to achieve the desired performance and reliability.

Certainly, here's a tabular comparison of the three designs for dynamic wireless charging for moving EVs:

Criteria	Resonance-Based	Inductive
Efficiency	High efficiency	Moderate efficiency
Safety	Effective safety	Safety features
Safety features	Potentially cost-effective	Costlier
Regulatory Compliance	More likely to meetstandards	Compliance possible
Scalability	Suitable for scalability	Scalability Possible
Environmental Impact	Can be designed with sustainability in mind	Higher environmentalimpact

Table 1: Features Comparison of Different models

Conclusion:

The Resonance-Based Dynamic Wireless Charging design appears to be the most promising choice based on its efficiency, safety, potential cost-effectiveness, regulatory compliance, scalability, and environmental impact. It also offers the potential for an enhanced user experience. However, each design has its own advantages and challenges, and the final success of any design will depend on careful implementation, component selection, and adherence to regulatory standards.

3.6 Implementation Methodology

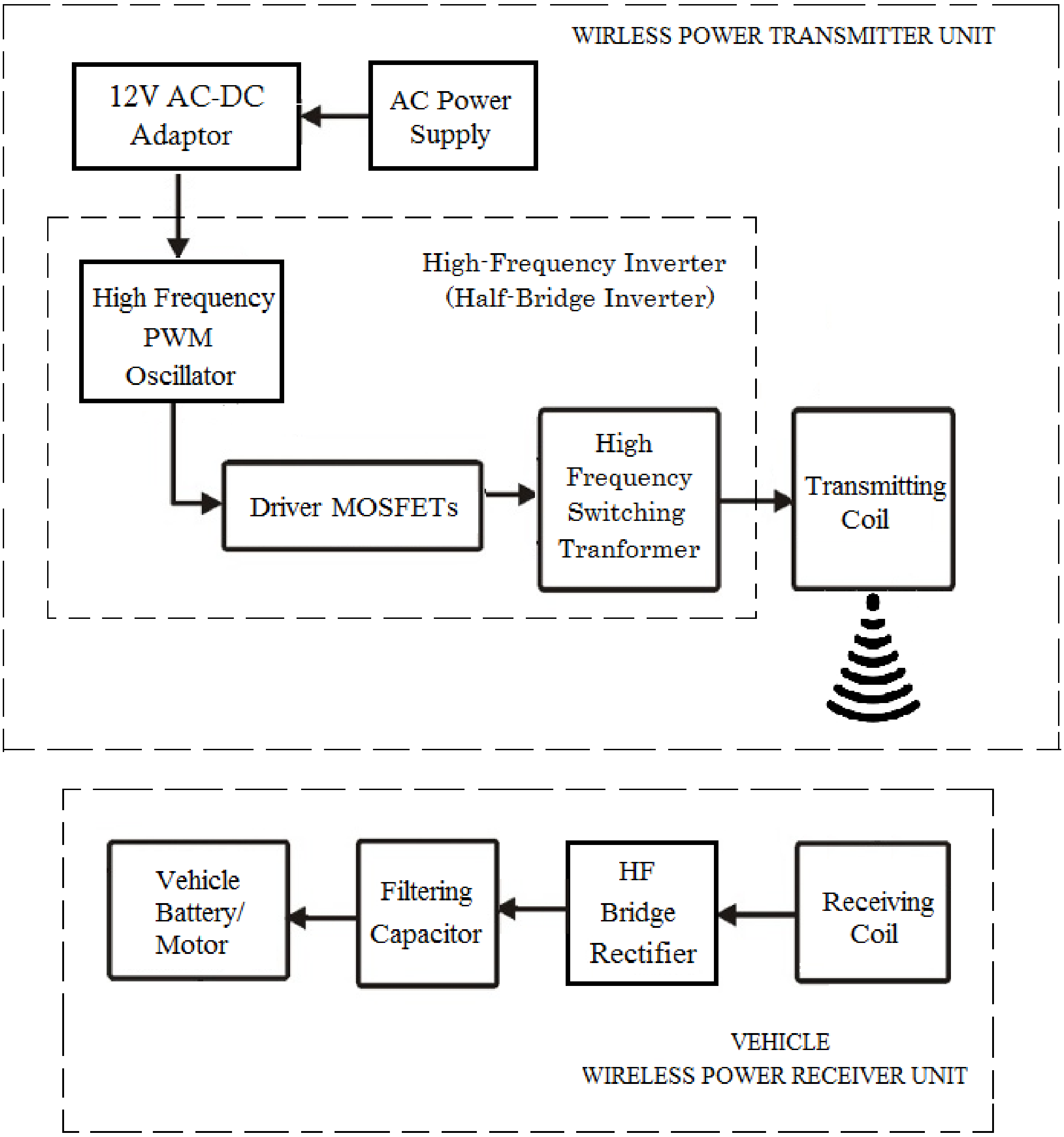

Fig 3.3: Block Diagram

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 PWM2are 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. like 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 version 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 appings, one is center tap for DC current input and 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.

Transmitter Circuit Diagram

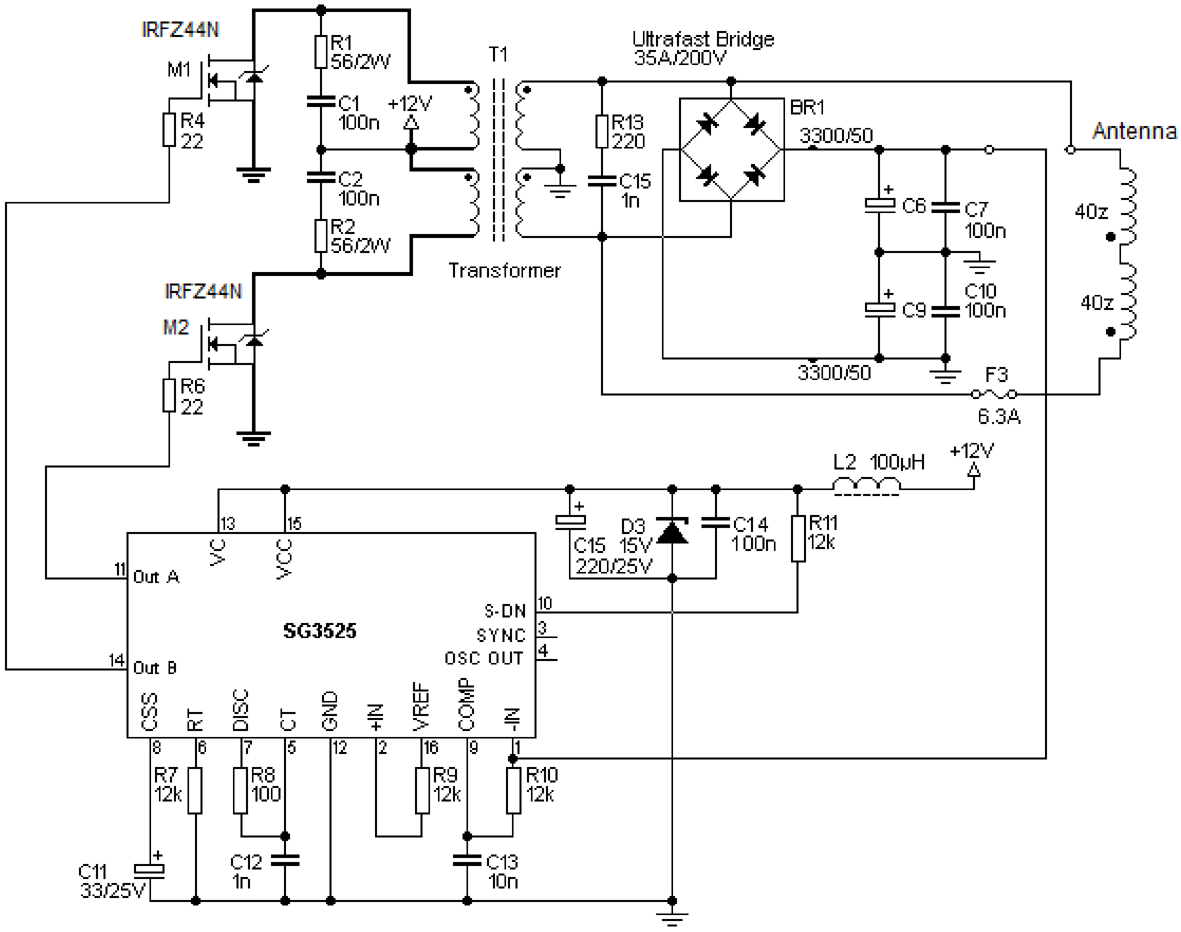

Figure 3.4: Transmitter Circuit Diagram

Vehicle Receiver Circuit Diagram

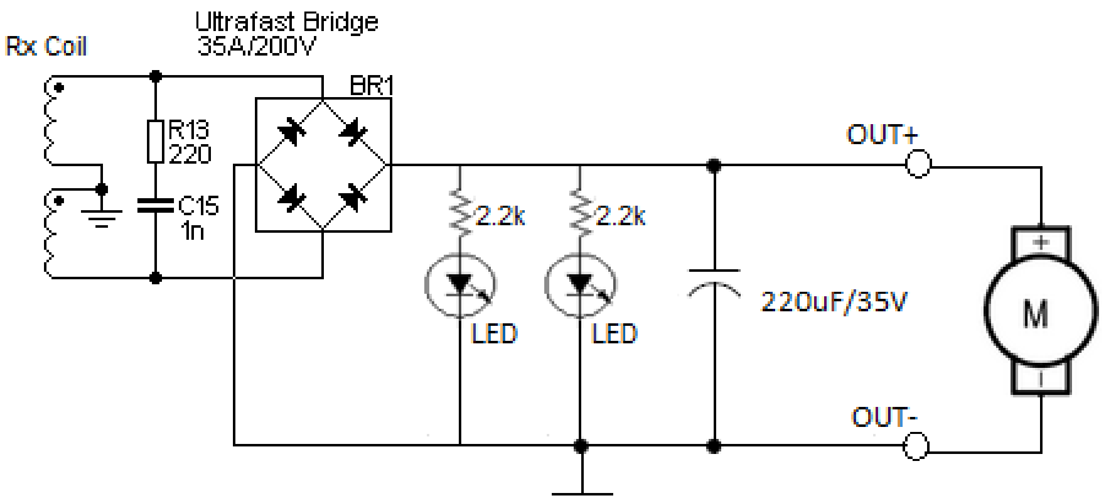

Figure 3.5: Vehicle Receiver Circuit Diagram

Input and Output of High Frequency Inverter

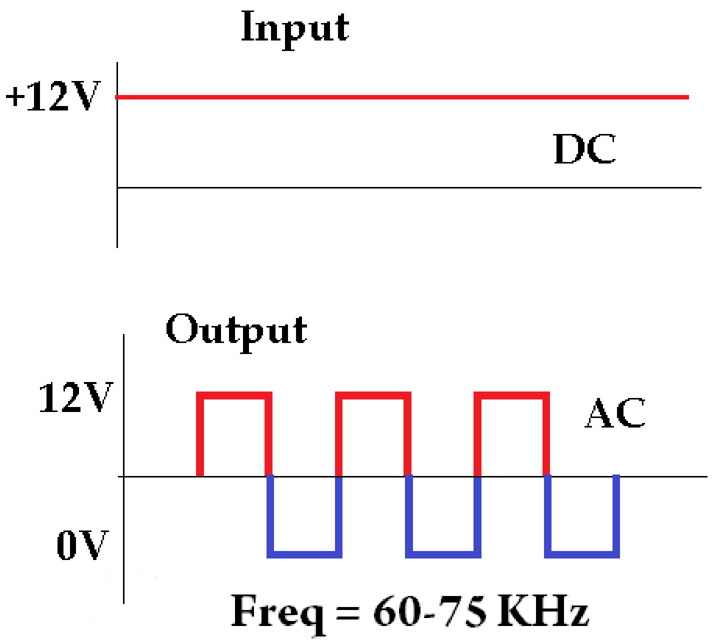

Figure 3.6: Input and Output of High Frequency Inverter

CIRCUIT EXPLANATION

Transmitter Section

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 center 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.

Receiver Section

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.

Practical Application of Dynamic Wireless Charging EV

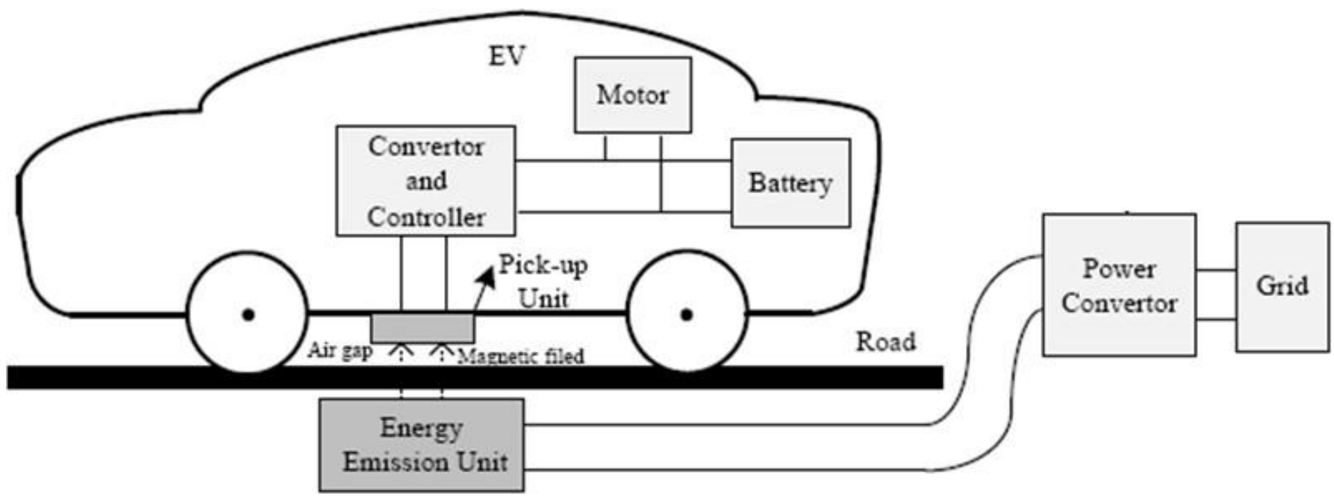

Figure 3.7: Practical Application

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.

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:

$$M = k\sqrt{L_1 L_2}$$

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

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 the 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 4

RESULTS ANALYSIS AND VALIDATION

4.1 Implementation of solution

Original Snapshots of the project model:-

Figure 4.1: Vertical Ferrite Core Transformer circuit

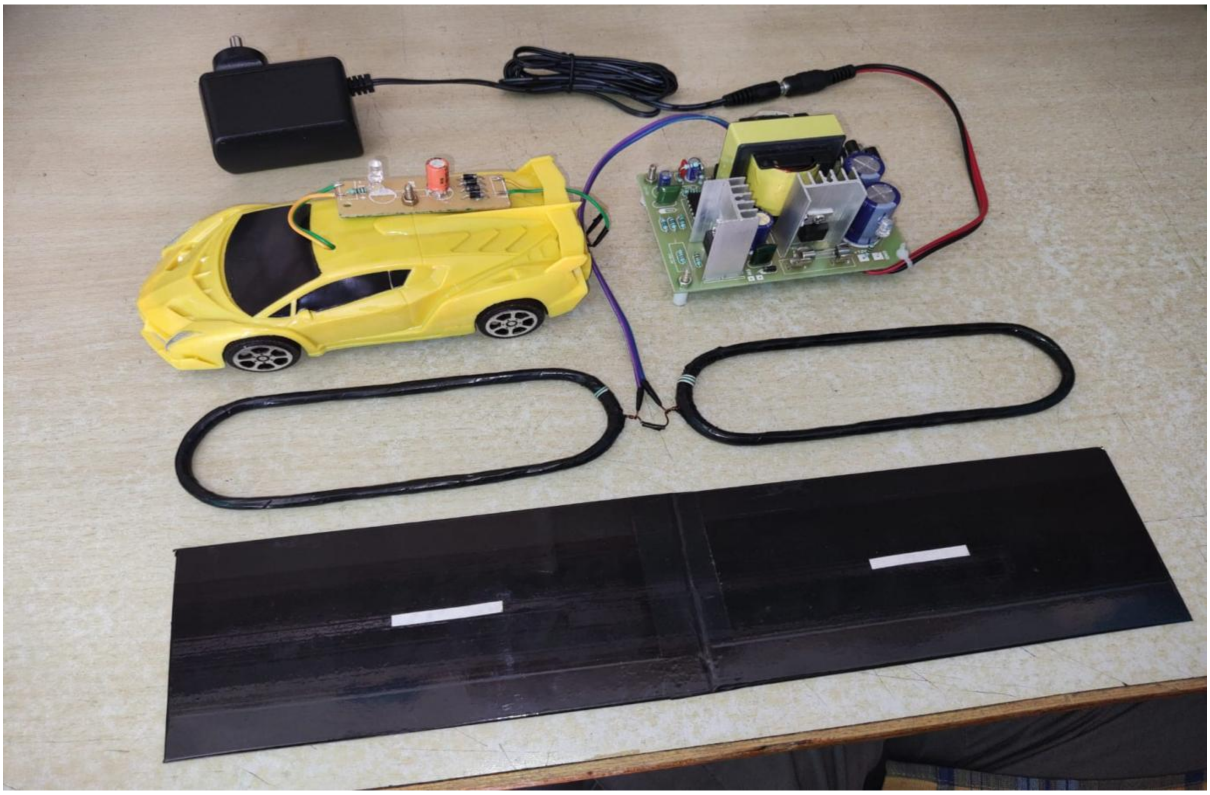

Figure 4.2: Complete Project Model

1. Analysis: Project "Dynamic Wireless Charging for Moving Electric Vehicles" highlights its potential to revolutionize electric vehicle charging. By adopting resonance-based wireless charging technology, the project aims to increase efficiency, reduce environmental impact, and enhance user experience. This innovative approach aligns with sustainability goals and has the capacity to accelerate EV adoption. However, challenges may arise during implementation, requiring rigorous testing and adherence to safety and regulatory standards for the project's success.

2. Design Drawings/Schematics/Solid Models: With the use of tools like Canva,Auto-cad,draw.io and CoppeliaSim the work on the 3D and 2D of the model were built and finalized.

3. Report Preparation:

Document Editing: For writing expert reports, outlining project requirements, and describing the system's implementation, use Microsoft Word, Google Docs, or LaTeX.

4.Testing/Characterization/Interpretation/Data Validation:

- **Testing:** Conduct experiments to gather data on how a system or material behaves under specific conditions.

- **Characterization:**Analyze in-depth properties and behavior, using techniques like microscopy or spectroscopy.

- **Interpretation:** Make sense of the data, extract meaning, and identify patterns and relationships.

- **Data Validation:** Ensure data accuracy and reliability by assessing factors like accuracy, precision, consistency, and completeness.

4.2 WIRELESS POWER TRANSMISSION

Wireless power transmission is not a new idea. Nikola Tesla demonstrated transmission of electrical energy without wires in early 19th century. Tesla used electromagnetic induction systems. William C Brown demonstrated a micro wave powered model helicopter in 1964. This receives all the power needed for flight from a micro wave beam. In 1975 Bill Brown transmitted 30kW power over a distance of 1 mile at 84% efficiency without using cables. Researchers developed several techniques for moving electricity over long distance without wires. Some exist only as theories or prototypes, but others are already in use.

Consider an example, in this electric device recharging without any plug-in. The device which can be recharged is placed on a charger. Supply is given to the charger and there is no electrical contact between charger and device.

Previous schemes for wireless power transmission included attempts by the late scientist Nikola Tesla and the Microwave power transmission. Both Tesla's design and the later microwave power were forms of radiative power transfer. Radiative transfer, used in wireless communication, is not particularly suitable for power transmission due to its low efficiency and radiative loss due to its Omni directional nature.

THEORETICAL BACKGROUND

The principle of Evanescent Wave Coupling extends the principle of Electromagnetic induction. Electromagnetic induction works on the principle of a primary coil generating a predominantly magnetic field and a secondary coil being within that field so a current is induced within its coils. This causes the relatively short range due to the amount of power required to produce an electromagnetic field. Over greater distances the non-resonant induction method is inefficient and wastes much of the transmitted energy just to increase range. This is where the resonance comes in and helps the efficiency dramatically by "tunneling" the magnetic field to a receiver coil that resonates at the same frequency.

Theoretical analysis shows that by sending electromagnetic waves around in a highly angular waveguide1, evanescent waves are produced which carry no energy. If a proper resonant waveguide is brought near the transmitter, the evanescent waves can allow the energy to tunnel to the power drawing waveguide, where they can be rectified into DC power. Since the electromagnetic waves would tunnel, they would not propagate through the air to be absorbed or be dissipated, and would not disrupt electronic devices or cause physical injury.

METHODS OF WIRELESS POWER TRANSMISSION

- Inductive coupling
- Transformer coupling
- Resonant Inductive Coupling
- Radio and Microwave Energy Transfer

Inductive Coupling

The coupling between two electric circuits through inductance linked by a common changing magnetic field.

Transformer Coupling

Electrical energy transferred from one circuit to another with by use of a magnetic core.

Radio & Microwave Energy Transfer

To use RF or Microwave energy for transmitting power, in which the radiated RF energy from an antenna is extracted and converted into usable energy through a receiving antenna.

Resonant Inductive Coupling

The inductive coupling is the resonant coupling between the coils of two LC circuits with the same resonant frequency, transferring energy from one coil to the others.

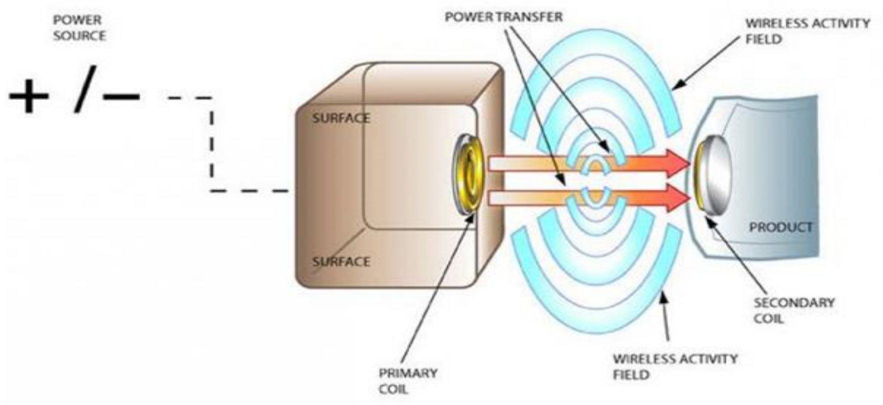

Figure 4.3: Resonant Inductive Coupling

With inductive resonance, electromagnetic energy is only transferred to recipient devices that share the identical resonant frequencies as the energy source, so energy transfer efficiency is maintained, even when misalignment occurs.

4.3 CONCEPT OF RESONANT WIRELESS POWER TRANSFER

Resonance

Resonance is a phenomenon that occurs in nature in many different forms. In general, resonance involves energy oscillating between two modes, a familiar example being a mechanical pendulum in which energy oscillates between potential and kinetic forms. In a system at resonance, it is possible to have a large build up of stored energy while having only a weak excitation to the system. The build-up occurs if the rate of energy injection into the system is greater than the rate of energy loss by the system.

The behavior of an isolated resonator can be described by two fundamental parameters, its resonant frequency and its intrinsic loss rate, Γ. The ratio of these two parameters defines the quality factor or of the resonator () a measure of how well it stores energy.

An example of an electromagnetic resonator is the circuit shown in Figure, containing an inductor, a capacitor and a resistor.

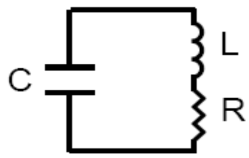

Figure 4.4: Electromagnetic Resonator

Example of a Resonator

In this circuit, energy oscillates at the resonant frequency between the inductor (energy stored in the magnetic field) and the capacitor (energy stored in the electric field) and is dissipated in the resistor. The resonant frequency and the quality factor for this resonator are

$$\omega_0 = \frac{1}{\sqrt{LC}}$$

And

$$Q = \frac{\omega_0}{2\Gamma} = \sqrt{\frac{L}{C}}\frac{1}{R} = \frac{\omega_0 L}{R}$$

The expression shows that decreasing the loss in the circuit, i.e., reducing, increases the quality factor of the system. In highly-resonant wireless power transfer systems, the system resonators must be high-Q in order to efficiently transfer energy. High-Q electromagnetic resonators are typically made from conductors and components with low absorptive (also sometimes referred to as ohmic, resistive, series resistive, etc.) losses and low radiative losses, and have relatively narrow resonant frequency widths. Also, the resonators may be designed to reduce their interactions with extraneous objects.

Coupled Resonators

If two resonators are placed in proximity to one another such that there is coupling between them, it becomes possible for the resonators to exchange energy. The efficiency of the energy exchange depends on the characteristic parameters for each resonator and the energy coupling rate, κ, between them. The dynamics of the two resonator system can be described using coupled-mode theory, or from an analysis of a circuit equivalent of the coupled system of resonators. One equivalent circuit for coupled resonators is the series resonant circuit

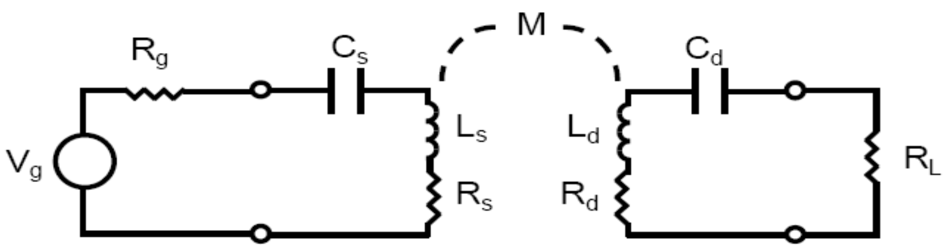

Figure 4.5: Equivalent circuit for the coupled resonator system

Here the generator is a sinusoidal voltage source with amplitude at frequency with generator resistance. The source and device resonator coils are represented by the inductors and, which are coupled through the mutual inductance M, where.

$$M = k\sqrt{L_s L_d}$$

Each coil has a series capacitor to form a resonator. The resistances and are the parasitic resistances (including both ohmic and radiative losses) of the coil and resonant capacitor for the respective resonators.

$$U = \frac{\omega M}{\sqrt{R_s R_d}} = \frac{\kappa}{\sqrt{\Gamma_s \Gamma_d}} = k\sqrt{Q_s Q_d}$$

We have the ability to choose the generator and load resistances which give the best system performance (or use an impedance transformation network to match to other resistance values). If we choose

$$\frac{R_g}{R_s} = \frac{R_L}{R_d} = \sqrt{1+U^2}$$

Then the efficiency of the power transmission is maximized

Here one can see that highly efficient energy transfer is possible in systems with large values of. Note that the impedance matching described above is equivalent to the coupled mode

$$U = \frac{\omega M}{\sqrt{R_s R_d}} = k\sqrt{Q_s Q_d}$$

theory treatment that shows that work extracted from a device can be modeled as a circuit resistance that has the effect of contributing an additional term w, to an unloaded device object's energy loss rate d, so that the overall energy loss rate is given by

$$\Gamma'_d = \Gamma_d + \Gamma_W$$

And that the efficiency of the power transmission is maximized when

$$\frac{\Gamma_W}{\Gamma_d} = \sqrt{\left[1 + \left(\kappa^2 / \Gamma_s \Gamma_d\right)\right]} = \sqrt{1 + k^2 Q_s Q_d} = \sqrt{1 + U^2}$$

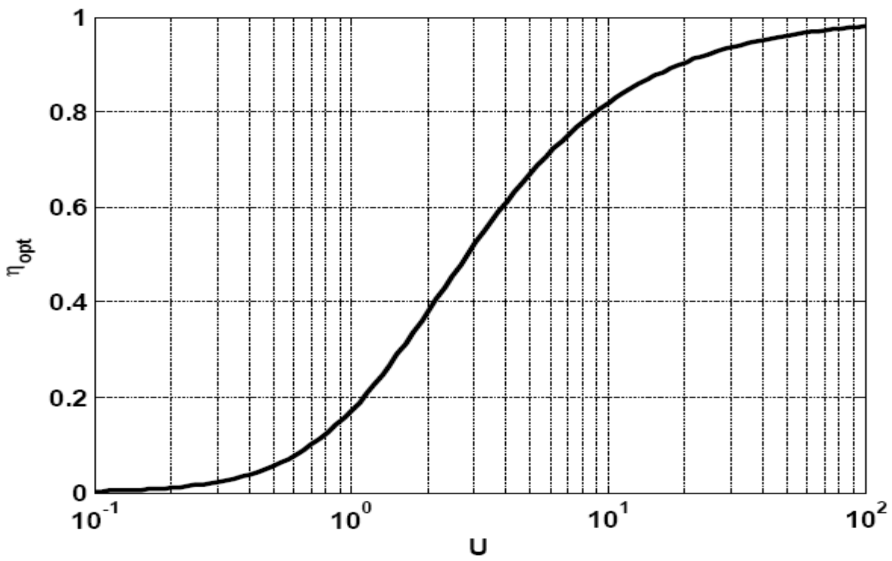

Figure 4.6: Optimum efficiency of energy transfer

Note that the best possible efficiency of a wireless power transmission system only depends on the system figure-of-merit, which can also be written in terms of the magnetic coupling coefficient between the resonators, , and the unloaded resonator quality factors, and

Knowing the resonator quality factors and the range of magnetic coupling between them for a specific application, one can use Equations to determine the best efficiency possible for the system.

TRANSMITTER UNIT

With all the necessary background research completed it became clear what basic design components the entire system would require. First we needed a method to design an oscillator, which would provide the carrier signal with which to transmit the power. Oscillators are not generally designed to deliver power, thus it was necessary to create a power amplifier to amplify the oscillating signal. The power amplifier would then transfer the output power to the transmission coil. Next, a receiver coil would be constructed to receive the transmitted power. However, the received power would have an alternating current, which is undesirable for powering a DC load. Thus, a rectifier would be needed to rectify the AC voltage to output a clean DC voltage. Finally, an electric load would be added to complete the circuit design.

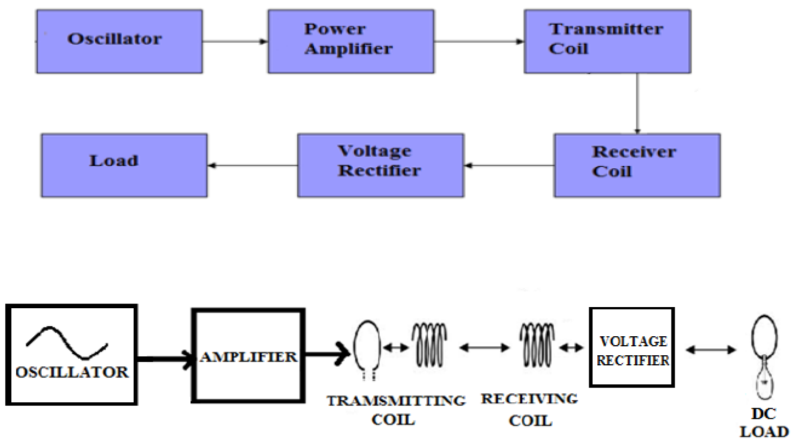

Figure 4.7: Transmitter and Receiver Unit

VOLTAGE RECTIFIER

A rectifier would be needed to rectify the AC voltage received from the receiver coil to drive a DC load. A type of circuit that produces an output waveform that generates an output voltage which is purely DC or has some specified DC component is a Full Wave Bridge Rectifier. This type of single phase rectifier uses four individual rectifying diodes connected in a closed loop "bridge" configuration to produce the desired output. The smoothing capacitor connected to the bridge circuit converts the full-wave rippled output of the rectifier into a smooth DC output voltage.

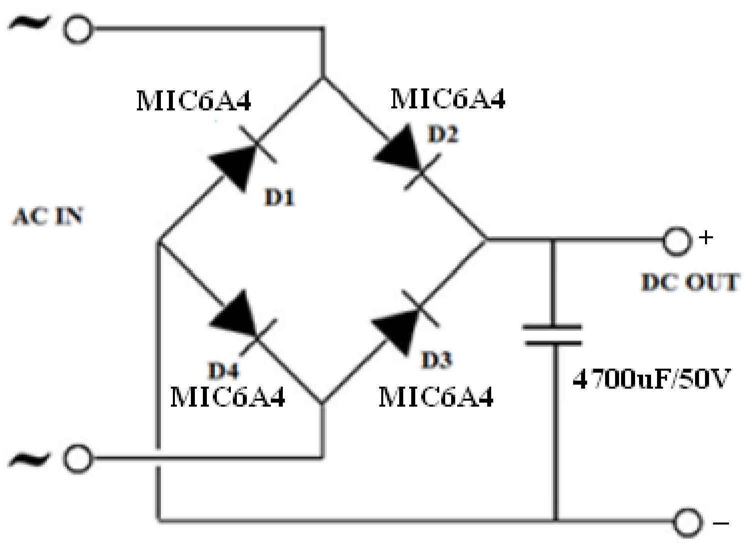

Figure 4.8: Bridge Rectifier

Since the diodes had to rectify AC signals of Megahertz frequencies, fast signal diodes, MIC6A4, had to be used for the bridge circuit. However we did not implement this circuit with our final setup as we did not drive a DC load with our setup.

OSCILLATOR

There are two general classes of oscillators: sinusoidal and relaxation. Op-Amp sinusoidal oscillators operate with some combination of positive and negative feedback to drive the op-amp into an unstable state, causing the output to transition back and forth at a continuous rate. Relaxation Op-Amp oscillators operate with a capacitor, a resistor or a current source to charge/discharge the capacitor, and a threshold device to induce oscillation.

POWER AMPLIFIER/ DRIVER

In order to generate the maximum amount of flux which would induce the largest voltage on the receiving coil, a large amount of current must be transferred into the transmitting coil. The oscillator was not capable of supplying the necessary current, thus the output signal from the oscillator was passed through a power amplifier to produce the necessary current. The key design aspect of the power amplifier was to generate enough current while producing a clean output signal without large harmonic distortions. For this purpose, we utilized a simple switch-mode amplifier design whose design aspects are described below.

SWITCHING MOSFET'S

The main idea behind the switch-mode Power Amplifier technology is to operate a MOSFET in saturation so that either voltage or current is switched on and off. The figure below shows the circuit diagram of the switch-mode power amplifier.

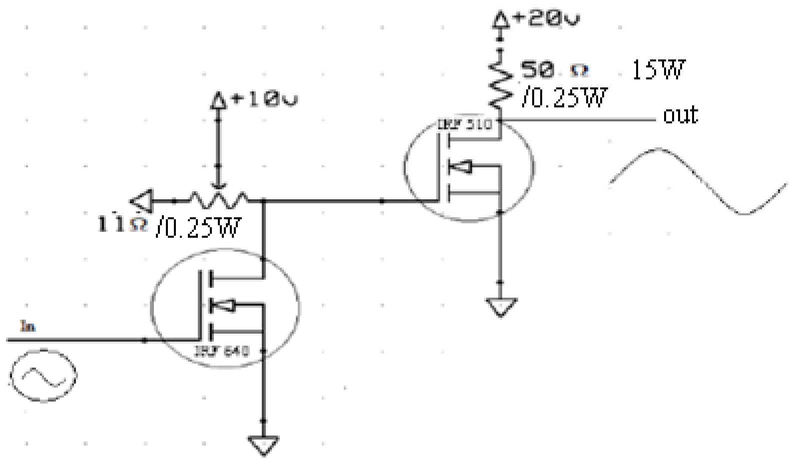

Figure 4.9: Switching MOSFET'S

Our switch-mode design consisted of a MOSFET IRF 510, which when turned on allowed large current from the DC power supply to flow through the resistor of 50 Ohms and through the transmitting antenna to transfer current from the power supply through the transmitting coil. The current and voltage required to drive the gate of the MOSFET IRF 510 was supplied by the MOSFET IRF 640 whose gate was driven by the input signal from a Hewlett Packard signal generator. The maximum voltage when the coils were tuned at resonance was recorded to be around 102.3V.

TRANSMITTER AND RECEIVER COILS

The transmitter and receiver circuit combined is called the coupling circuit. It is the heart of the entire system as the actual wireless power transfer is carried out here. The efficiency of the coupling circuit determines the amount of power available for the receiver system. The coils had a resonant frequency of 4.8 – 5.3 MHz, which could be tuned with our oscillator (later a signal generator) to get to the resonance frequency of the coils.

CHAPTER 5

CONCLUSION AND FUTURE WORK

5.1. Conclusion

In the pursuit of dynamic wireless charging for moving Electric Vehicles (EVs), a thorough analysis and comparison of three prominent charging technologies—Resonance-Based, Inductive, and Capacitive—have been conducted. The ultimate choice of technology is paramount for achieving the project's objectives, including efficiency, safety, cost-effectiveness, regulatory compliance, scalability, and environmental impact.

The Resonance-Based Dynamic Wireless Charging technology stands out as the most promising choice due to its demonstrated high efficiency, effectiveness in implementing safety features, potential for cost-effectiveness, likelihood of meeting regulatory standards, and scalability. Additionally, it aligns with sustainability goals and offers the potential for an enhanced user experience.

In the anticipated outcome of implementing Resonance-Based Dynamic Wireless Charging technology, we expect to achieve significant gains in the efficiency of charging moving EVs. This technology has the potential to minimize energy loss during charging, thereby reducing costs and the environmental footprint of EVs. Moreover, it promotes user convenience and trust by offering safety features, a user-friendly interface, and real-time status updates.

Key Points in the Conclusion:

Technology Selection: After a thorough comparative analysis, the Resonance-Based Dynamic Wireless Charging technology emerged as the most promising choice. Its high efficiency, effective safety features, potential for cost-effectiveness, regulatory compliance, and scalability make it the preferred technology.

Expected Outcomes: Implementing Resonance-Based technology is expected to significantly increase the efficiency of charging moving EVs. This technology minimizes energy loss during charging, reducing operational costs and environmental impact. Users can expect a seamless and convenient charging experience, enhancing trust and adoption of EVs.

Deviation from Expected Results: While the chosen technology holds great promise, deviations from expected results may occur. These deviations can be attributed to technical challenges, budget constraints, and regulatory complexities. The achievement of full potential relies on meticulous implementation and adherence to safety and environmental standards.

Reasons for Deviations: Potential deviations may result from additional investments needed to meet safety and regulatory requirements, challenges in optimizing user experience, and unforeseen manufacturing complexities. Mitigating deviations requires a comprehensive approach that addresses all aspects of the project.

In summary, dynamic wireless charging for moving EVs represents a transformative innovation in the transportation industry. By selecting the Resonance-Based technology and focusing on safety, regulatory compliance, and sustainability, we can work towards a future where EV charging is efficient, safe, and environmentally responsible, promoting the widespread adoption of electric vehicles.

5.2. Future work

To ensure that the dynamic wireless charging project for moving EVs remains relevant and adaptable to changing trends, it's crucial to plan for future work and upgrades. Here are some key areas for improvement and enhancement:

1. **Increased Power and Efficiency:** Research and develop technologies to enhance the power transfer capability and efficiency of dynamic wireless charging systems. This can reduce charging times and make EVs more practical for long journeys.

2. **Standardization and Interoperability:** Work towards standardizing dynamic wireless charging protocols to ensure interoperability among different EVs and charging infrastructure. This will promote widespread adoption and convenience for EV owners.

3. **Smart Grid Integration:** Explore ways to integrate dynamic wireless charging systems with smart grids to optimize energy distribution and reduce strain on the electrical grid during peak charging times.

4. **Enhanced Safety Features:** Continue to improve safety mechanisms, such as real-time obstacle detection, collision avoidance, and dynamic power control, to ensure the safety of both EVs and pedestrians.

5. **User Experience Enhancements:** Focus on user experience improvements, including mobile apps for charging status monitoring, payment integration, and reservation systems for charging spot.

6. **Environmental Sustainability:** Research and implement more sustainable materials and manufacturing processes for the charging infrastructure to reduce the environmental footprint.

7. **Bidirectional Charging:** Investigate the feasibility of bidirectional charging, allowing EVs to not only receive power but also supply excess energy back to the grid, increasing the value of EVs as distributed energy resources.

8. **Cybersecurity and Data Privacy:** Enhance cybersecurity measures to protect the communication between the EV and charging infrastructure, safeguarding against potential cyber threats. Also, ensure strict data privacy controls.

9. **Innovative Infrastructure Deployment:** Develop new methods for deploying dynamic wireless charging infrastructure, such as embedding charging coils in road surfaces or creating dedicated charging lanes on highways.

10. **Adaptability to Emerging EV Technologies:** Stay up-to-date with advancements in EV technologies, such as solid-state batteries and rapid charging systems, to ensure compatibility and efficient charging.

11. **Community Engagement:** Involve local communities and governments in the deployment of dynamic wireless charging infrastructure to address their specific needs and concerns.

12. **Economic Models and Incentives:** Research and develop economic models and incentives to encourage the adoption of dynamic wireless charging, such as reduced charging costs during off-peak hours and tax incentives for infrastructure development.

13. **Public Awareness and Education:** Launch educational campaigns to inform the public about the benefits of dynamic wireless charging and its role in reducing emissions and enhancing urban mobility.

14. **Collaboration and Research:** Foster collaboration with universities, research institutions, and industry partners to continuously advance the technology and address emerging

challenges.

By focusing on these areas for future work and upgrades, the dynamic wireless charging project can remain relevant, adaptable, and increasingly beneficial for the public. This will help meet the evolving needs and trends in the electric vehicle and sustainable transportation sectors

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MANUAL

Hardware Components List

S.No	Component Name
1.	IC SG3525A
2.	IRF 840 MOSFET
3.	24SWG Copper wire
4.	EC28 Ferrite Core Transformer 12V
5.	Printed PCB
6.	100nF Capacitor
7.	10nF Capacitor
8.	1nF Capacitor
9.	1000uF Capacitor
10.	4700uF Capacitor
11.	220uF Capacitor
12.	1uF Capacitor
13.	12K Variable Resisitor
14.	2.2k resistor
15.	470ohm resistor
16.	1K resistor
17.	12K resistor
18.	5Amps Bridge Rectifier
19.	1N5408 Diode
20.	1N4007 Diode
21.	4.7nF Capacitor
22.	Power Supply Cable
23.	12V DC Socket
24.	16-Pin IC Base
25.	On-Off Switch
26.	5mm Red LEDs
27.	0.5A Fuse
28.	PCB Mount Fuse Holder
29.	BA159 Diode
30.	Power supply Rectifier PCB
31.	100uF 50V Capacitor
32.	TO-220 Heat Sink
33.	Mounting Screws
34.	Spacers