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EFFICIENT V2V WIRELESS CHARGING SYSTEM

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Abstract: This study focuses on creating a wireless charging system designed specifically for Electric Vehicles (EVs) to enable Vehicle-to-Vehicle (V2V) power transfer. The proposed solution operates on principles of Non-Radiative Wireless Charging, providing a safe and efficient method for transferring energy between vehicles. The primary motivation behind this project is the scarcity of traditional charging stations, leading to the exploration of more adaptable V2V solutions. Our approach utilizes resonant inductive charging technology, facilitating effective energy transfer without the need for physical contact. By carefully designing and implementing this V2V wireless charging system, we aim to improve the accessibility and convenience of charging for electric vehicles. The use of resonant inductive charging not only enhances efficiency but also contributes to creating a more sustainable and flexible charging infrastructure. This research represents a significant step towards advancing the practicality and scalability of V2V wireless charging solutions in the electric mobility sector, addressing key challenges in electric vehicle charging infrastructure.

Index Terms **–** Inductive wireless charging, V2V charging, wireless transmission

I. INTRODUCTION

The transportation sector is undergoing a significant transformation with the rise of Electric Vehicles (EVs) as a sustainable alternative to traditional fossil fuel-powered cars. As society increasingly prioritizes clean energy solutions, the demand for efficient and convenient EV charging methods has become more crucial than ever. Cordless charging, particularly through Resonant Inductive Wireless Charging, has emerged as a promising technology at the forefront of innovation. This concept eliminates the need for physical cords, aligning seamlessly with environmental objectives aimed at reducing reliance on finite fossil fuels. Resonant Inductive Wireless Charging enables power transfer between two coils tuned to the same resonant frequency, overcoming the limitations of traditional charging methods. By integrating this technology into EVs, we have the potential to redefine the charging experience, making it more flexible and user-friendly. Electric cars, powered by electric motors and rechargeable batteries, address growing concerns over environmental sustainability by producing zero tailpipe emissions. This shift represents a significant departure from the environmental drawbacks associated with traditional internal combustion engine vehicles, contributing to improved air quality and reduced climate impact. Moreover, the transition to electric vehicles plays a vital role in reducing dependence on finite fossil fuel resources, supporting global efforts to transition to cleaner energy sources and fostering a more balanced and sustainable energy ecosystem.

Despite the promising outlook of electric vehicles, challenges persist in energy management and charging infrastructure. Conventional methods, often reliant on physical connections, face limitations in terms of convenience and scalability. The need for an extensive network of charging stations, coupled with the time-intensive nature of charging processes, hinders widespread adoption. In addressing these challenges, innovative solutions like cordless charging through resonant inductive wireless charging offer a more flexible and user-friendly approach to maintaining EVs charged and ready for the road. This technology not only addresses the technical aspects of energy transfer but also considers practical implications for EV users. A key advantage of resonant inductive wireless charging is its increased power transmission range compared to traditional methods. This expanded range allows for greater flexibility in positioning the EV over the charging station, mitigating the need for precise alignment and enhancing the user experience. Moreover, this technology opens the door to Vehicle-to-Vehicle (V2V) charging, extending the benefits of cordless charging beyond stationary stations and fostering a dynamic and flexible charging ecosystem among electric vehicles themselves. The convergence of electric vehicles and cordless charging through resonant inductive wireless charging represents a transformative leap towards a sustainable and user-friendly future of transportation. This innovative approach not only addresses environmental concerns but also offers practical solutions to challenges in energy management and charging infrastructure. Subsequent sections will delve deeper into the technical intricacies of creating transmitter and receiver circuits for cordless EV charging, highlighting the innovative solutions that underpin this visionary approach, particularly in the context of V2V charging.

II. EXISTING SYSTEM

1.University of Auckland's Halo:

The University of Auckland in New Zealand has been developing a wireless charging system called Halo, which aims to charge electric vehicles while they are in motion. The system involves transmitting power wirelessly from the road to the vehicle via inductive coupling.

2.Eindhoven University of Technology's SPARC:

The SPARC (Smart Power Accessible Resilient City) project at Eindhoven University of Technology in the Netherlands is exploring wireless charging for electric buses. The project aims to develop a wireless charging infrastructure that allows buses to charge wirelessly at designated stops, improving the efficiency and reliability of public transportation.

3.Toyota's Dynamic Wireless Charging:

Toyota has been researching dynamic wireless charging systems for electric vehicles. They envision a system where vehicles equipped with wireless charging technology can charge while driving on specially equipped roads or highways.

4.Qualcomm Halo:

Qualcomm has been developing wireless charging technology for electric vehicles through its subsidiary, Qualcomm Halo. While their focus has primarily been on stationary wireless charging systems for EVs, they have also explored the potential for dynamic wireless charging technology in the future.

5.WiTricity's Wireless Charging for Autonomous Vehicles:

WiTricity, a company specializing in wireless charging technology, has been researching wireless charging systems for autonomous vehicles. Their technology aims to enable autonomous vehicles to charge wirelessly while parked or in motion, allowing for continuous operation without the need for human intervention.

III. Block diagram and circuit diagram

3.1. BLOCK DIAGRAM

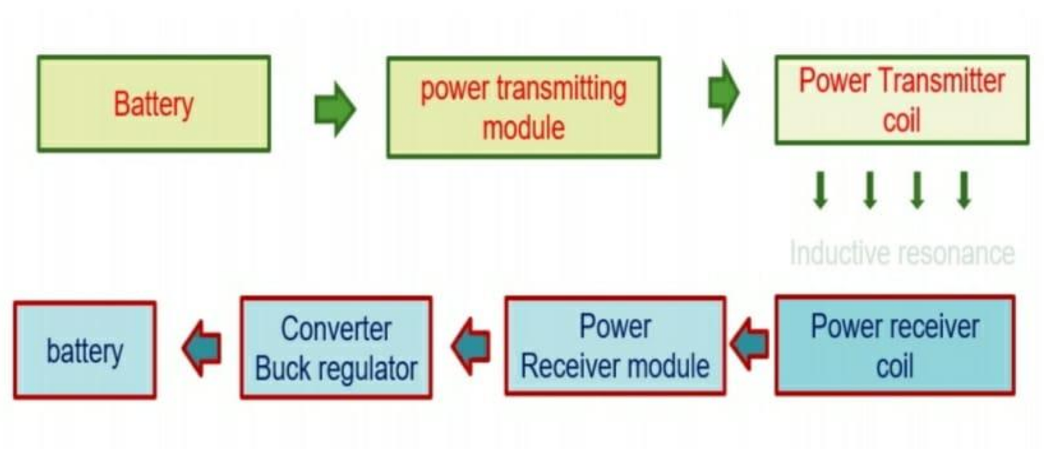

Fig. 1. Block Diagram

Vehicle-to-vehicle (V2V) inductive wireless charging is a cutting-edge technology that enables the transfer of electrical power between two electric vehicles without the need for physical cables. Here's an explanation of the block diagram illustrating the components and their functions:

1.Battery: Each electric vehicle (EV) is equipped with a rechargeable battery that stores electrical energy to power the vehicle's electric motor.

2. Power Transmitting Module: This module is responsible for generating and transmitting electrical power wirelessly to another vehicle. It consists of control circuitry and power electronics to regulate the power transfer process.

3. Power Transmitting Coil: The transmitting coil, often referred to as the primary coil, generates a magnetic field when current flows through it. This magnetic field induces a voltage in the receiver coil of the receiving vehicle, facilitating wireless power transfer.

4. Power Receiver Coil: Positioned in the receiving vehicle, the receiver coil (secondary coil) captures the magnetic field generated by the transmitting coil. This induces an alternating current (AC) voltage in the receiver coil, which is then converted into direct current (DC) to charge the vehicle's battery.

5. Power Receiver Module: The receiver module comprises circuitry and components necessary to convert the AC voltage induced in the receiver coil into DC voltage suitable for charging the vehicle's battery.

6. Converter Buck Regulator: This component regulates the voltage level to ensure compatibility with the receiving vehicle's battery charging requirements. It steps down the voltage from the receiver coil to the appropriate level for charging the battery efficiently and safely.

7. Battery: Similar to the battery in the transmitting vehicle, the receiving vehicle also has a rechargeable battery. The battery stores the electrical energy received from the wireless charging process, providing power for the vehicle's propulsion and onboard systems.

3.2 CIRCUIT DIAGRAM

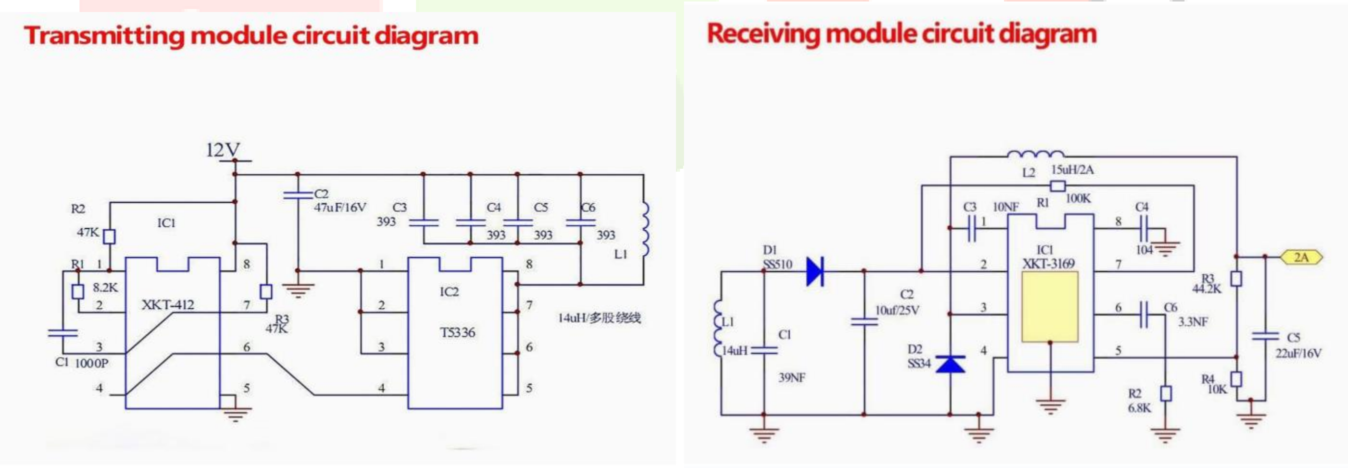

Fig. 2. Circuit diagrams of transmitting and receiving sides

1. Qi Wireless Transmitter Module: This module serves as the power transmitting unit in the transmitting vehicle. It consists of a Qi wireless charging transmitter IC, which generates high-frequency alternating current (AC) signals. These signals are then fed into the transmitter coil (Tx coil) to create a magnetic field for wireless power transfer.

2. Transmitter Coil (Tx Coil): The Tx coil is part of the Qi wireless transmitter module and is responsible for generating the magnetic field used for wireless power transfer. It is typically a coil of wire wound around a ferrite core to enhance magnetic field strength.

3. Receiving Coil (Rx Coil): Positioned in the receiving vehicle, the Rx coil captures the magnetic field generated by the Tx coil. This induces an alternating current (AC) voltage in the Rx coil, which is then rectified and regulated for charging the battery.

4. Qi Wireless Receiver Module: In the receiving vehicle, the Qi wireless receiver module comprises a Qi wireless charging receiver IC. It receives the AC voltage induced in the Rx coil and converts it into direct current (DC) using rectification and voltage regulation circuits.

5. Buck Regulator: The buck regulator is a DC-DC converter that steps down the voltage from the Qi wireless receiver module to a level suitable for charging the vehicle's battery. It ensures that the charging voltage is within the safe operating range of the battery and provides efficient power conversion.

6. Battery: Both the transmitting and receiving vehicles are equipped with rechargeable batteries. The battery in the transmitting vehicle powers the Qi wireless transmitter module, while the battery in the receiving vehicle stores the electrical energy received from wireless charging.

7. Control Circuitry: Each vehicle may include control circuitry to monitor and manage the wireless charging process. This circuitry can regulate the power transfer, communicate between the transmitter and receiver, and ensure safe operation of the charging system.

IV. PROJECT DESIGN AND WORKING

4.1. PROJECT DESIGN

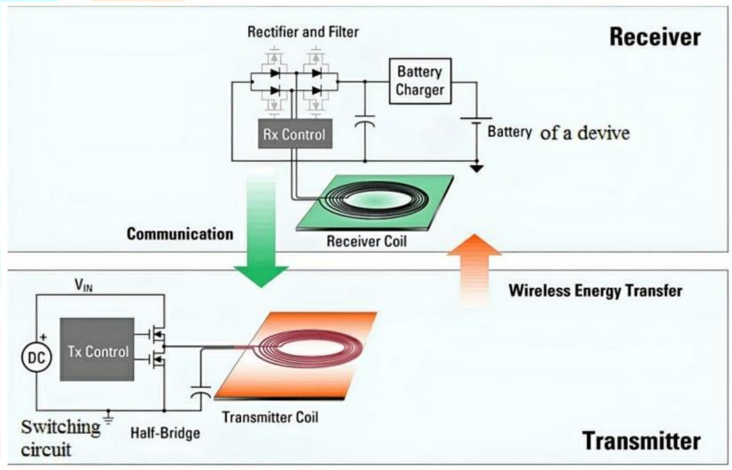

Fig. 3. Project design

Wireless charging systems stand as a pivotal advancement in electric vehicle (EV) technology, heralding a new era of convenience and efficiency for vehicle owners worldwide. This paper delves into the intricate functionality and components comprising a wireless charging system tailored for EVs, scrutinizing its utilization of a battery as the primary power source, integration of a relay module for seamless control, and facilitation of remote management through mobile devices. Central to its operation is the induction of an electric charge via inductive charging, complemented by the pivotal role of a buck regulator in current amplification. Moreover, it scrutinizes the significance of display screens for charge monitoring and the meticulous configuration of charging coils on both sides of the vehicle. Battery technology and effective power management constitute the backbone of EV functionality, with batteries serving as the primary energy reservoir. The efficiency of these batteries and their management systems profoundly influences vehicle performance, necessitating a profound understanding for optimal energy utilization and sustainable charging practices. The relay module emerges as a linchpin in the wireless charging system, enabling precise control and activation. When two vehicles align for charging, the relay module, accessible through a mobile application, orchestrates the process, allowing users remote oversight and control, thus augmenting convenience and flexibility in charging operations. Operational efficiency is further enhanced through the wireless charging module, facilitating power transfer via inductive charging. By inducing an electric charge within the receiver coil of the secondary vehicle, the system initiates the charging process seamlessly, eliminating the need for cumbersome physical connections. This wireless charging paradigm revolutionizes the charging experience, rendering it efficient and hassle-free. The buck regulator assumes a critical role in current amplification, optimizing power flow and ensuring efficient charging, thereby augmenting the system's overall performance and longevity. The integration of display screens within vehicles affords real-time visibility into the charging process, offering invaluable insights into the charge status and progress. This feature empowers vehicle owners to monitor charging operations meticulously, enabling informed decision-making and proactive management of charging needs. The symmetrical configuration of charging coils on both sides of the vehicle ensures seamless communication and power transfer, maximizing charging efficiency and reliability while ensuring compatibility across diverse charging systems.

4.2. WORKING

The wireless charging system for electric vehicles (EVs) operates through a series of coordinated steps to facilitate efficient and convenient charging without the need for physical cables. Here's a breakdown of how the system works:

1. Initiation: The charging process is initiated when two EVs equipped with the wireless charging system are parked in proximity to each other, aligning their respective charging coils.

2. Transmitter Activation: The owner of the transmitting vehicle activates the relay module through a mobile application, signaling the start of the charging process. This module acts as a control mechanism, enabling communication between the vehicles and orchestrating the power transfer.

3. Wireless Power Transfer: The transmitting vehicle houses a Qi wireless transmitter module, which generates high-frequency alternating current (AC) signals. These signals are fed into the transmitting coil, creating a magnetic field.

4. Inductive Charging: The magnetic field induced by the transmitting coil interacts with the receiving coil in the adjacent vehicle. This induces an alternating current (AC) voltage in the receiving coil through electromagnetic induction, initiating the charging process.

5. Buck Regulator Amplification: The receiving vehicle's wireless charging module, comprising a Qi wireless receiver module and a buck regulator, captures the induced AC voltage from the receiving coil. The buck regulator steps down the voltage to an appropriate level for charging the vehicle's battery, amplifying the current for efficient charging.

6. Charge Monitoring: Both vehicles are equipped with display screens that provide real-time visibility into the charging process. Vehicle owners can monitor the charge status and progress, ensuring informed decision-making and proactive management of charging needs.

7. Completion and Disconnection: Once the charging process is complete, the relay module discontinues power transfer between the vehicles. This ensures that the batteries are charged optimally without overcharging, promoting battery health and longevity.

8. Symmetrical Configuration: The charging coils are configured symmetrically on both sides of the vehicles, ensuring seamless communication and power transfer between them. This configuration optimizes charging efficiency and reliability while promoting compatibility with various charging systems.

V. HARDWARES

5.1.1. CONVERTER BUCK REGULATOR

The Converter Buck Regulator, represented by the XL6009 Module, stands as a versatile solution for voltage regulation needs. It boasts an adjustable output voltage feature, offering flexibility to cater to various applications' voltage requirements. This module showcases remarkable efficiency in power conversion, ensuring minimal energy loss during voltage transformation, thereby optimizing overall system performance. Its widespread utilization spans across electronics projects where stable and adjustable voltage output is paramount, making it a cornerstone component in diverse electronic setups.

Fig. 4. Converter buck regulator

Features:

The Converter Buck Regulator, represented by the XL6009 Module, emerges as a versatile solution for addressing voltage regulation requirements across a broad spectrum of electronic applications. Its standout feature lies in its adjustable output voltage capability, allowing users the flexibility to tailor voltage levels to suit the specific needs of their projects. This adaptability renders it well-suited for diverse electronic endeavors with varying voltage demands. Moreover, the XL6009 Module boasts remarkable efficiency in power conversion, ensuring minimal energy loss during voltage transformation and optimizing overall system performance. Its wide-ranging utility spans across various electronics projects where stable and adjustable voltage output is paramount, establishing it as a cornerstone component in numerous electronic setups. Furthermore, with its compact form factor, wide input voltage range, and integration-friendly design, the XL6009 Module offers a user-friendly solution for voltage regulation needs in constrained environments or projects with limited physical space. Additionally, features such as adjustable current limit and overheat protection further enhance its versatility, reliability, and safety in diverse operating conditions. In essence, the XL6009 Module stands as an indispensable tool for electronics enthusiasts and professionals seeking efficient and flexible voltage regulation solutions.

5.1.2. LI-ION BATTERY

The Li-ion 18650 Battery emerges as a stalwart energy solution in the realm of rechargeable lithium-ion batteries. Operable within a voltage range of 7.5V, it delivers a steady power supply suitable for an extensive array of applications. With a commendable capacity of 1500mAh, this battery variant boasts ample energy storage capabilities, catering to prolonged usage durations. Its versatility extends across a multitude of devices, including GPS units, iPods, PSPs, CCTV cameras, tablets, and industrial equipment, owing to its high energy density and steadfast performance

Fig. 5. Battery

5.1.3. BATTERY HOLDER

Fig. 6. Battery holder

The Electronic Spices Battery Holder epitomizes convenience and reliability in housing two 18650 lithium-ion batteries. Featuring a sleek black design, each holder exudes a professional appearance while serving as a robust enclosure for DIY projects. The inclusion of a DC 5.5x2 connector enhances usability, facilitating easy connectivity for powering devices or recharging batteries. Crafted with durability and compactness in mind, this battery holder seamlessly integrates into various DIY electronics endeavors, ensuring a dependable power source for an array of portable gadgets and electronic applications.

5.1.4. WIRELESS TRANSMITTING AND RECEIVING COIL

Fig. 7. Wireless transmitting and receiving coil

The Wireless Transmitting and Receiving Coil, embodied by the Qi Wireless Charging Module, revolutionizes the charging landscape with its wire-free charging prowess. Functioning as a transmitting coil, it generates and transmits power wirelessly to a compatible receiving coil housed within the target device. Requiring a DC 5V 2A input for operation, this module ensures ample power provision for efficient charging processes. With a modest coil diameter of 43mm, it seamlessly integrates into charging pads or devices, offering a hassle-free and cable-free charging solution. Its applications extend across smartphones, smartwatches, and other portable electronic devices supporting Qi wireless charging technology, ushering in a new era of convenient and efficient charging experiences.

5.1.5. BLUETOOTH MODULE

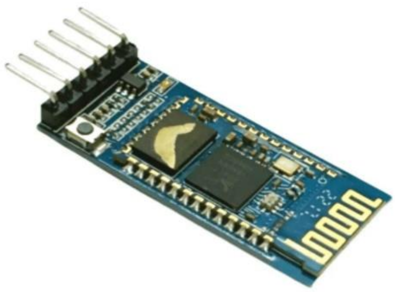

Fig. 8. Bluetooth module

The HC-05 Bluetooth Module with Baseplate operates exclusively as a slave device, allowing it to connect to various phones and computers equipped with Bluetooth capabilities. However, it cannot establish connections with other slave-only devices like keyboards or other HC-06 modules. To communicate with other slave devices, a master module such as the HC-05, capable of functioning as both master and slave, is required. In slave mode, the HC-05 Bluetooth module cannot initiate connections but can accept incoming connections from other Bluetooth-enabled devices. Conversely, the master mode enables the initiation of connections to other devices. Key features of the HC-05 Bluetooth module include a working current of 30 mA for matching and 8 mA for communication, seamless connection compatibility with computers, Bluetooth adapters, and PDAs, and utilization of the CSR mainstream Bluetooth chip adhering to Bluetooth V2.0 protocol standards. Additionally, it supports customizable baud rates, boasts Bluetooth Specification v2.0+EDR compliance, and offers security features such as authentication and encryption. Its profiles include Bluetooth serial port functionality, offering versatility and ease of integration into various electronic projects and applications.

5.1.6. RELAY MODULE

The "5V 10A 1 Channel Relay Module" serves as an electronic switch that can be controlled by a low-voltage signal, typically from a microcontroller or other digital circuit. This specific relay module is designed to operate at 5 volts and handle a maximum current of 10 amps. The term "HIGH TRIGGER" refers to the relay's activation method. In this case, the relay is triggered or activated when a HIGH voltage signal is applied to its input. When the input signal reaches a certain threshold voltage (typically close to the supply voltage), the relay switches from its default state (usually OFF) to its activated state (usually ON). The HSN code 8543 classifies electrical machinery and equipment and parts thereof, including relays, under Chapter 85 of the Harmonized System of Nomenclature (HSN). Specifically, HSN code 8543 pertains to electrical machines and apparatuses having individual functions, not specified or included elsewhere in Chapter 85. In summary, the "5V 10A 1 Channel Relay Module HIGH TRIGGER" is a relay module designed to switch high-current loads using a 5-volt control signal, with the relay being activated when a HIGH voltage signal is applied to its input. Its classification under HSN code 8543 identifies it as an electrical apparatus for specific functions within the broader category of electrical machinery and equipment.

Fig. 9. Relay module

5.1.7. DOUBLE LAYER SMART CAR CHASSIS KIT

The "4WD Double Layer Smart Car Chassis Kit" offers an immersive journey into the realm of robotics for enthusiasts seeking to delve into DIY projects. Boasting a robust four-wheel drive system and a unique double-layer design, this kit provides a sturdy foundation for constructing a customizable smart car. Its integration of smart features, such as sensor compatibility and programmable capabilities, enables enthusiasts to explore a wide range of applications, from obstacle avoidance to line following. By encouraging hands-on assembly and experimentation, the kit serves as a gateway for enthusiasts to gain practical experience in robotics, electronics, and coding. Additionally, its classification under the HSN code 8504 underscores its recognition as an electrical apparatus suitable for global trade and regulatory purposes. Assembling and programming the 4WD Double Layer Smart Car Chassis Kit not only fosters technical skills but also sparks creativity and innovation in the dynamic field of robotics.

Fig. 10. Double layer smart car chassis kit

VI. IMPLEMENTATION SCOPE

1. TECHNOLOGY OVERVIEW:

- Inductive wireless charging, rooted in the principle of electromagnetic induction, facilitates the transfer of electrical energy between two coils: a transmitter and a receiver, via a magnetic field.
- This technology revolutionizes the charging paradigm by eliminating the need for physical connectors, thus offering a seamless and efficient charging experience.
- With the transmitter coil typically installed on the ground or infrastructure and the receiver coil integrated into the vehicle, inductive charging optimizes convenience while minimizing wear and tear on charging ports.
- Its inherent advantages, including reduced maintenance costs and enhanced durability, underscore its significance in shaping the future of electric vehicle (EV) charging infrastructure.

2. SYSTEM DESIGN AND COMPONENTS:

- The architecture of a vehicle-to-vehicle inductive charging system encompasses essential components such as the transmitter unit, receiver unit, and control unit.
- The transmitter unit, comprising the transmitting coil, power electronics, and communication interface, orchestrates the generation of the electromagnetic field and oversees the charging process.
- In contrast, the receiver unit encompasses the receiving coil, rectifier circuitry, and battery management system, tasked with converting the received energy into usable electricity and managing the charging process efficiently.
- Additionally, the control unit assumes a pivotal role in ensuring seamless communication between the transmitter and receiver units, enforcing safety protocols, and monitoring critical charging parameters for optimal performance.

3. CHARGING PROTOCOL AND STANDARDS:

- The establishment of standardized charging protocols, spearheaded by organizations like the Society of Automotive Engineers (SAE) through initiatives like SAE J2954, is instrumental in fostering interoperability and compatibility within the EV ecosystem.
- These standards delineate communication protocols, power transfer specifications, and safety requirements, providing a common framework for wireless charging systems.
- By adhering to standardized protocols, inductive charging systems can seamlessly integrate with various vehicle types and manufacturers, fostering widespread adoption and streamlining the charging process for end-users.

4. SAFETY AND REGULATORY COMPLIANCE:

- Safety considerations form the cornerstone of vehicle-to-vehicle inductive charging systems, encompassing aspects such as electromagnetic field exposure and electrical safety.
- Adherence to stringent regulatory standards set forth by authorities like the Federal Communications Commission (FCC) and Underwriters Laboratories (UL) is imperative to ensure the safety and reliability of inductive charging systems.

- Furthermore, compliance with automotive safety standards such as ISO 26262 enhances the overall safety and reliability of inductive charging systems, instilling confidence among stakeholders and end-users alike.

5. EFFICIENCY AND PERFORMANCE:

- Efficiency stands as a critical determinant of the performance of vehicle-to-vehicle inductive charging systems, influencing energy transfer rates and charging times.
- Factors like coil alignment, distance between transmitter and receiver coils, and power levels exert significant influence on charging efficiency.
- Through the adoption of advanced technologies like dynamic charging control and sophisticated power management algorithms, system efficiency can be optimized, minimizing energy losses and enhancing overall performance.

6. INTEROPERABILITY AND COMPATIBILITY:

- The interoperability of inductive charging systems, facilitated through standardized protocols, plays a pivotal role in enabling seamless communication and compatibility between vehicles from different manufacturers.
- Standardization fosters an ecosystem where EVs equipped with inductive charging capabilities can interface effortlessly with various charging infrastructure, regardless of make or model.
- Designing flexible charging systems that support multiple charging protocols and accommodate diverse vehicle types and battery chemistries enhances interoperability, driving widespread adoption and market acceptance.

7. INFRASTRUCTURE REQUIREMENTS:

- The deployment of vehicle-to-vehicle inductive charging infrastructure necessitates meticulous planning and consideration of various factors, including location suitability, power capacity, and grid integration.
- Infrastructure may encompass a range of charging solutions, including roadside chargers, dedicated charging lanes, or stationary charging pads installed in parking lots or garages.
- Integration with existing power grid infrastructure, coupled with the implementation of smart grid technologies, facilitates efficient energy management, grid stability, and seamless integration of inductive charging into the broader energy ecosystem.

8. USER EXPERIENCE AND CONVENIENCE:

- Delivering a seamless and convenient charging experience is paramount to driving user acceptance and adoption of inductive charging technology.
- User-friendly interfaces, automated features such as automated parking and charging initiation, and integration with navigation systems enhance user experience and convenience.
- Designing charging systems that require minimal user intervention and offer flexibility in charging locations further enhances convenience and encourages EV adoption among consumers.

9. COST ANALYSIS AND ECONOMIC VIABILITY:

- Conducting comprehensive cost-benefit analyses and evaluating the economic viability of vehicle-to-vehicle inductive charging systems are essential for stakeholders involved in deployment and operation.
- Factors to consider include installation costs, maintenance expenses, total cost of ownership, and potential revenue streams such as energy sales and service fees.
- Exploring innovative business models, such as vehicle-to-grid integration and demand response services, unlocks new avenues for monetizing inductive charging infrastructure and enhancing its economic viability.

10. FUTURE TRENDS AND RESEARCH DIRECTIONS:

- Continued research and development in inductive charging technology pave the way for addressing existing challenges and unlocking new opportunities for innovation.
- Emerging technologies such as dynamic charging, advancements in coil design and materials, and applications beyond vehicle-to-vehicle charging offer potential enhancements in efficiency, performance, and convenience.
- Exploring wireless power transfer in diverse environments and applications, coupled with ongoing advancements in electric vehicle technology, holds promise for shaping the future of transportation electrification and mobility solutions.

VII. APPLICATION

The application of vehicle-to-vehicle inductive wireless charging holds immense potential across various sectors and use cases, revolutionizing the way we perceive and utilize electric vehicles (EVs). Some of the key applications include:

1. FLEET OPERATIONS:

- In industries reliant on fleets of electric vehicles, such as logistics and transportation, vehicle-to-vehicle inductive charging can streamline operations by enabling continuous charging during transit.
- Fleet vehicles equipped with inductive charging capabilities can replenish their batteries while on the move, minimizing downtime and maximizing operational efficiency.

2. PUBLIC TRANSPORTATION:

- In the realm of public transportation, inductive wireless charging presents an opportunity to enhance the efficiency and sustainability of bus fleets and light rail systems.
- Charging infrastructure embedded in roadways or at bus stops can wirelessly recharge buses and trams during scheduled stops, ensuring uninterrupted service and reducing the need for lengthy charging breaks.

3. URBAN MOBILITY:

- In urban environments, where space is often limited, vehicle-to-vehicle inductive charging offers a convenient solution for EV owners residing in apartments or condominiums without dedicated charging infrastructure.
- Parking spaces equipped with inductive charging pads enable EV owners to wirelessly charge their vehicles while parked, eliminating the need for cumbersome charging cables and dedicated charging stations.

4. EMERGENCY SERVICES:

- Emergency response vehicles, such as ambulances and fire trucks, rely on swift deployment and uninterrupted operation to fullfill their lifesaving missions.
- Vehicle-to-vehicle inductive charging ensures that emergency vehicles remain powered up at all times, enabling rapid response to incidents without the need for frequent returns to charging stations.

5. MILITARY APPLICATIONS:

- In military operations, where mobility and agility are paramount, vehicle-to-vehicle inductive charging can enhance the efficiency and effectiveness of electric-powered military vehicles.
- Deployable charging infrastructure enables military convoys to maintain operational readiness and sustain mission-critical activities in remote or hostile environments.

6. PERSONAL MOBILITY:

- For individual EV owners, vehicle-to-vehicle inductive charging offers a convenient and hassle-free alternative to traditional charging methods.
- Wireless charging infrastructure installed in residential garages, parking lots, and public spaces enables EV owners to effortlessly recharge their vehicles while parked, eliminating the need for manual connection and disconnection of charging cables.

7. AUTONOMOUS VEHICLES:

- In the realm of autonomous vehicles, vehicle-to-vehicle inductive charging plays a pivotal role in enabling hands-free charging capabilities.
- Autonomous vehicles equipped with inductive charging technology can autonomously navigate to designated charging zones and wirelessly replenish their batteries, further advancing the concept of seamless mobility and automation.

VIII. COST OF THE PROJECT

Table 1. Cost of the project

Sl. No	Item	Number of Items (N)	Cost of the item/ one item (In Rs)	Cost (In Rs)
1.	Wireless charging module	1	2,646	2,646
2.	Step up boost module	1	260	260
3.	Battery holder	2	178	356
4.	Li-ion battery	4	599	2396
5.	Wireless Bluetooth serial transceiver module	2	426	853
6.	Motor driver module	2	299	598
7.	One channel relay module	2	80	160
8.	Double layer smart car chassis kit	2	999	1998
9.	Battery charger	1	210	210
10.	Miscellaneous		1000	1000
11.	Tools		970	970
Total Cost of the product				11,447

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IX. ADVANTAGES AND DISADVANTAGES

9.1. ADVANTAGES

1. Convenience: Vehicle-to-vehicle inductive wireless charging eliminates the need for physical cables, offering a hassle-free and convenient charging experience for EV owners.

2. Flexibility: The wireless nature of inductive charging allows for greater flexibility in charging locations, enabling EVs to be charged while parked in various settings, such as residential garages, parking lots, and public spaces.

3. Increased Efficiency: Inductive charging systems can be designed to automatically initiate and terminate charging sessions based on the proximity of vehicles, optimizing energy transfer efficiency and reducing wasted energy.

4. Reduced Wear and Tear: By eliminating the need for physical connectors, inductive charging minimizes wear and tear on charging ports, extending the lifespan of both the charging infrastructure and EVs.

5. Safety: Inductive charging systems can incorporate safety features such as automatic shut-off mechanisms and real-time monitoring of charging parameters, enhancing overall safety during the charging process.

9.2. DISADVANTAGES

1. Lower Efficiency: Inductive charging systems typically exhibit lower efficiency compared to wired charging methods, resulting in longer charging times and potentially higher energy losses.

2. Cost: The installation and deployment of vehicle-to-vehicle inductive charging infrastructure can be cost-prohibitive, requiring significant upfront investment in infrastructure and technology.

3. Alignment Challenges: Achieving optimal alignment between transmitter and receiver coils is crucial for efficient energy transfer in inductive charging systems. However, misalignment or deviation from the optimal charging position can result in reduced charging efficiency and slower charging rates.

4. Limited Range: Inductive charging systems typically have a limited charging range, requiring vehicles to be parked in close proximity to charging pads or stations for effective charging. This limitation may restrict the practicality of inductive charging for certain applications, particularly in high-traffic or densely populated areas.

5. Interoperability Issues: Compatibility and interoperability between different inductive charging systems and EV models can pose challenges, potentially limiting the adoption and widespread implementation of this technology. Standardization efforts are necessary to address these interoperability issues and promote seamless integration of inductive charging infrastructure with various EV platforms.

X. RELEVANCE OF PROJECT WITH RESPECT TO SOCIAL AND INDUSTRIAL NEEDS

1. ENHANCED CONVENIENCE AND ACCESSIBILITY:

- Wireless charging technology heralds a paradigm shift in the charging experience for electric vehicle (EV) owners, eliminating the cumbersome process of physically connecting charging cables.
- This streamlined approach offers unparalleled convenience, particularly in urban environments where access to traditional charging stations may be limited or congested.
- By enabling drivers to seamlessly charge their vehicles without the hassle of handling cables or waiting for their vehicles to charge, wireless charging enhances the overall user experience and promotes greater adoption of EVs.

2. EXPANDED CHARGING INFRASTRUCTURE:

- Leveraging existing vehicles as mobile charging points extends the reach and accessibility of EV charging infrastructure, particularly in areas with limited access to stationary charging stations, such as rural regions or underserved communities.
- This innovative approach transforms EVs into active participants in the charging ecosystem, effectively expanding the coverage and availability of charging options across diverse geographical areas.
- By utilizing vehicles as mobile charging nodes, the deployment of wireless charging infrastructure becomes more flexible and scalable, addressing the challenges of expanding EV adoption and charging accessibility.

3. EXTENDED DRIVING RANGE:

- Dynamic wireless charging technology has the potential to alleviate range anxiety among EV drivers by enabling continuous battery replenishment while on the move.
- This groundbreaking capability extends the practicality and feasibility of EVs for long-distance travel, ensuring that drivers can embark on journeys with confidence, knowing that their vehicles will receive continuous charging support along the way.
- By offering continuous charging opportunities during travel, dynamic wireless charging enhances the driving range of EVs and promotes their integration into mainstream transportation systems.

4. EFFICIENCY AND SUSTAINABILITY:

- Wireless charging systems optimize energy transfer efficiency, minimizing energy losses during the charging process and maximizing the utilization of renewable energy sources.
- Integration with renewable energy sources, such as solar or wind power, reduces reliance on fossil fuels and contributes to the overall sustainability of EV charging infrastructure.
- By reducing greenhouse gas emissions and environmental impact, wireless charging technology plays a crucial role in advancing the transition to clean and sustainable transportation solutions.

5. INTEGRATION WITH SMART MOBILITY SOLUTIONS:

- Wireless charging technology seamlessly integrates with smart mobility platforms, enabling intelligent scheduling and optimization of charging activities based on real-time data and demand.
- Through intelligent charging scheduling, wireless charging systems maximize energy efficiency, minimize congestion at charging stations, and enhance the overall efficiency and effectiveness of transportation systems.
- By harnessing the power of data analytics and connectivity, wireless charging facilitates the development of innovative mobility solutions that prioritize energy efficiency, sustainability, and user convenience.

6. TECHNOLOGICAL INNOVATION AND COLLABORATION:

- The development of wireless charging technology requires collaboration across diverse engineering disciplines, driving innovation and technological advancement in electromagnetics, power electronics, and automotive engineering.

- By fostering collaboration and knowledge sharing, wireless charging technology stimulates further advancements and breakthroughs in related fields, paving the way for new applications and solutions beyond EV charging.
- The potential applications of wireless charging technology extend beyond EV charging, including areas such as consumer electronics, medical devices, and industrial automation, highlighting its versatility and transformative impact on various industries.

XI. SIMULATION AND RESULT ANALYSIS

11.1 RESULT ANALYSIS

The result analysis and simulation of the vehicle-to-vehicle charging project, centred on resonant inductive charging (RIC), offer insights into the efficiency, reliability, and overall performance of the charging system. Through comprehensive testing and evaluation, various parameters such as energy transfer efficiency, temperature management effectiveness, and battery health monitoring are assessed to ensure the project's viability and effectiveness in real-world applications.

1. ENERGY TRANSFER EFFICIENCY:

- The primary objective of the project is to optimize energy transfer efficiency during the charging process. Simulation results provide quantitative data on the efficiency of wireless power transfer between the transmitter and receiver coils.
- Parameters such as coil alignment, resonant frequency tuning, and power levels are analyzed to determine their impact on energy transfer efficiency.
- The simulation also evaluates the effects of environmental factors such as distance between vehicles and ambient electromagnetic interference on charging efficiency.

2. SMART CHARGING ALGORITHMS:

- Smart charging algorithms play a crucial role in optimizing the charging process and ensuring efficient energy transfer. Simulation studies focus on evaluating the performance of these algorithms under various charging scenarios.
- Algorithms are tested for their ability to dynamically adjust charging parameters such as voltage, current, and charging duration based on real-time feedback from the charging system.
- Simulation results demonstrate the effectiveness of smart charging algorithms in maximizing energy transfer efficiency while minimizing charging time and maintaining battery health.

3. CONTINUOUS BATTERY MONITORING:

- Real-time battery monitoring capabilities are essential for proactive maintenance interventions and optimizing overall battery performance. Simulation studies assess the accuracy and reliability of battery monitoring systems in detecting and diagnosing potential issues.
- Parameters such as battery voltage, current, temperature, and state of charge are monitored and analyzed during charging cycles.
- Results from battery monitoring simulations provide valuable insights into battery health and performance, enabling predictive maintenance and optimization of charging strategies.

4. SMART NETWORKING SYSTEM:

- The establishment of a smart networking system enables seamless communication and collaboration between EVs in the charging network. Simulation studies focus on evaluating the performance and scalability of the networking system under various load conditions.
- Parameters such as communication latency, packet loss, and network throughput are analysed to assess the system's reliability and responsiveness.
- Results from networking simulations demonstrate the system's ability to facilitate dynamic charging coordination among EVs, allowing for efficient resource allocation and load balancing within the charging network.

11.2 SIMULATION

The vehicle-to-vehicle charging project, centered on resonant inductive charging (RIC), represents a pioneering effort in advancing electric vehicle (EV) technology. This initiative integrates smart charging algorithms, continuous battery monitoring, and innovative temperature management using Phase Change Material (PCM). Smart algorithms optimize the charging process, ensuring efficient energy transfer and enhancing system reliability. PCM technology regulates temperature dynamics, mitigating heat-related challenges and preserving EV battery health. Continuous battery monitoring enables real-time assessment, facilitating proactive maintenance and optimizing battery performance. Resonant inductive charging revolutionizes traditional charging by eliminating physical connections, enhancing user convenience, and fostering a flexible charging infrastructure. A smart networking system enables seamless communication among EVs, facilitating dynamic collaboration in charging activities. This holistic approach addresses evolving challenges in EV charging, prioritizing user-friendliness, sustainability, and cutting-edge technology to shape the future of electric transportation.

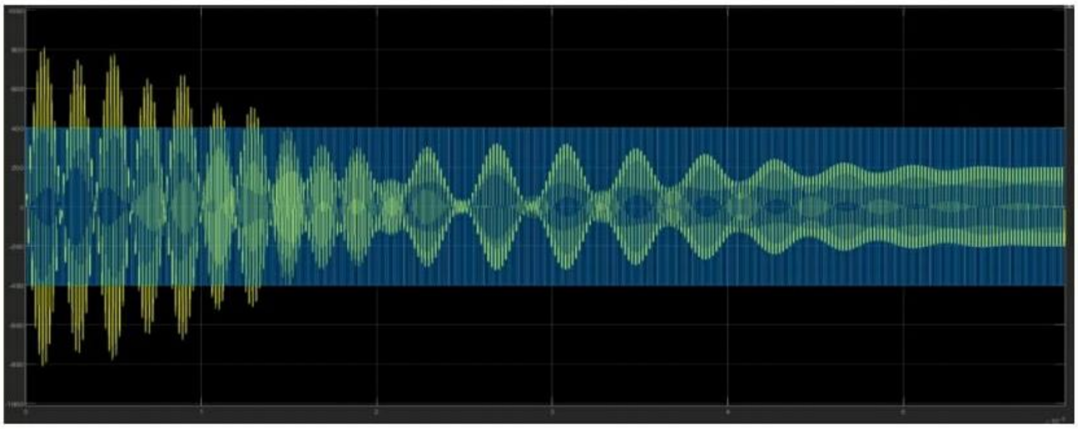

Fig .11. Voltage and current graph in transmitting side

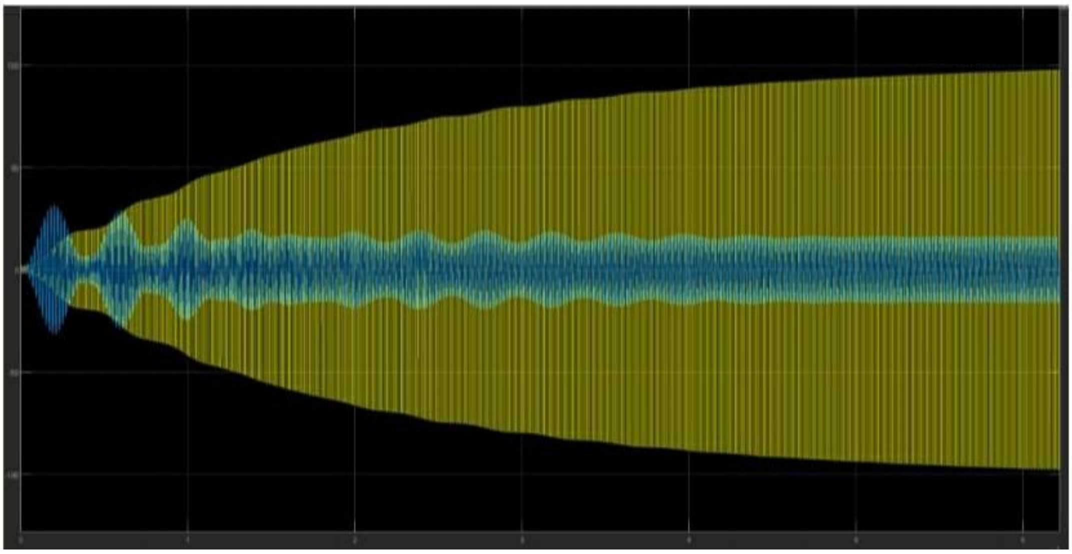

Fig.12. Voltage and current graph in receiving side

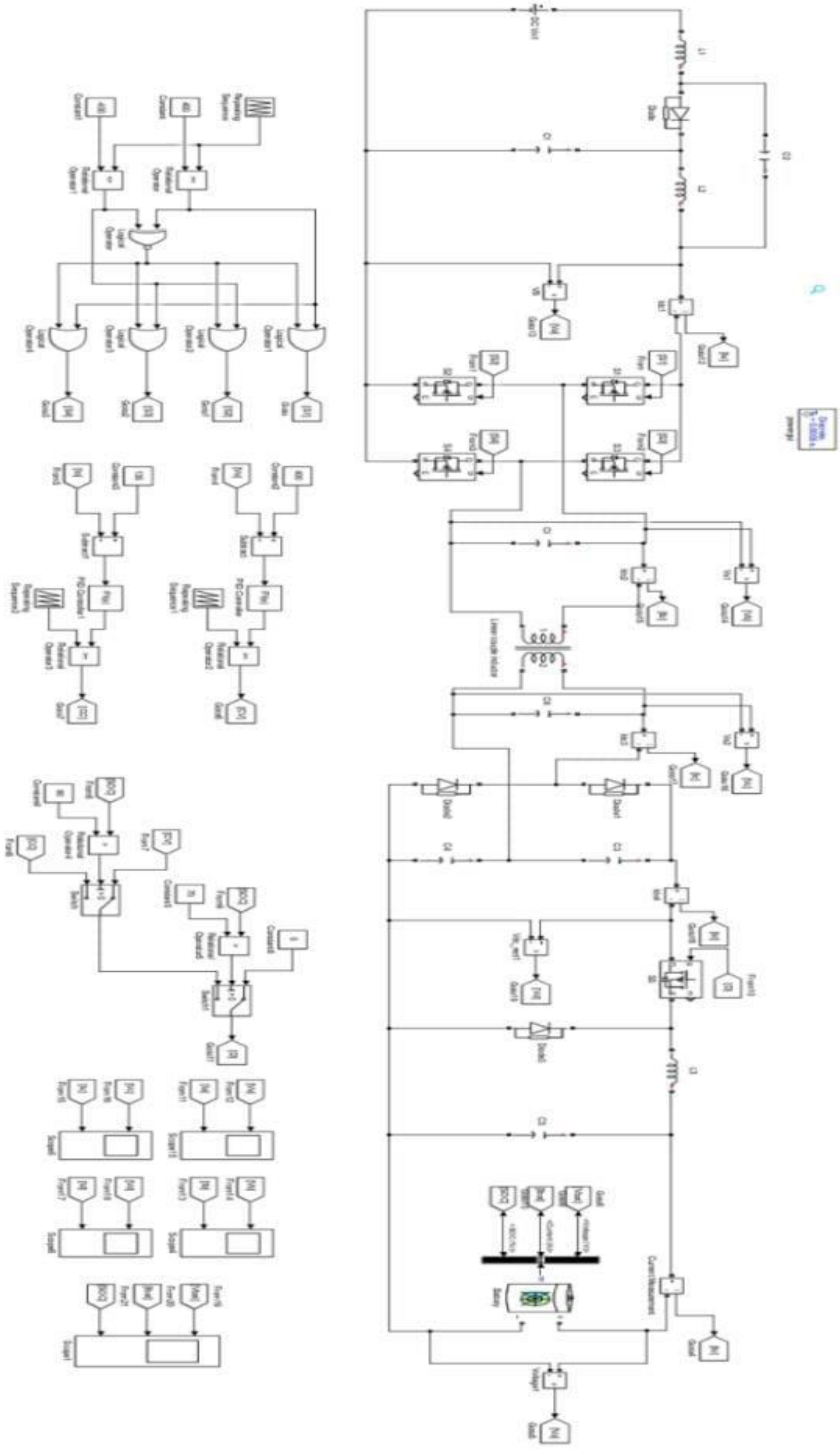

Fig.13. Simulation

XII.CONCLUSIONS

In conclusion, the envisioned project on vehicle-to-vehicle charging using resonant inductive charging (RIC) emerges as a groundbreaking initiative poised to revolutionize the electric vehicle (EV) charging landscape. By strategically focusing on objectives such as increased range, optimal infrastructure utilization, and minimized battery degradation, the project addresses critical challenges in the electric mobility sector. The comprehensive approach, encompassing smart networking, Phase Change Material (PCM) for temperature management, and wireless charging technologies, positions this endeavor at the forefront of innovation. However, the project's success hinges on overcoming significant challenges, including high initial setup costs, technological complexities, and the imperative establishment of standardized protocols. The meticulous methodology involving feasibility assessment, technology prototyping, and battery health research is pivotal in gauging the practicality and viability of the proposed system. As the project progresses through the outlined work plan, continuous adaptation to emerging technologies and industry standards will be crucial for ensuring relevance and competitiveness. In evaluating the feasibility, the project presents immense potential to transform the EV charging paradigm, offering a more sustainable, collaborative, and efficient charging network. The anticipated advantages, including increased EV range, smart infrastructure usage, and prolonged battery life, position this initiative as a catalyst for advancing the electric mobility ecosystem. However, close attention must be paid to potential drawbacks and unforeseen challenges during the project's lifecycle. Ultimately, if successfully executed, the vehicle-to-vehicle charging project could contribute significantly to achieving a more sustainable and user-friendly future for electric vehicles, aligning with broader environmental and technological goals in the transportation sector.

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