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Dynamic Inductive Charging System for EVs.

Dr. A N Ashraya, Chinmayi S, Gagana S, Ganesh R, Ranjan Gowda B K Assistant Professor, Student
Department of Electronics and Communication Engineering, P E S College of Engineering, Mandya.

Abstract: This project presents the development of a Dynamic Inductive Charging System for Electric Vehicles (EVs), offering a safe, flexible, and efficient alternative to conventional plug-in charging. The system employs Inductive Power Transfer (IPT) technology, utilizing magnetic coupling between transmitter and receiver coils to transfer energy wirelessly. By integrating ESP32, relays, and monitoring systems, the prototype enables automated charging with minimal human intervention. This approach addresses the limitations of fossil fuel-based transportation by supporting the adoption of EVs powered by renewable energy. The proposed system demonstrates reliability, convenience, and potential for future large-scale commercialization in sustainable mobility.

I. INTRODUCTION

The rapid transition from conventional fossil fuel-based transportation systems to sustainable and eco-friendly alternatives has become a global priority due to increasing environmental pollution, depletion of non-renewable energy resources, and climate change. The transportation sector contributes significantly to greenhouse gas emissions, encouraging governments and researchers to develop cleaner and more efficient mobility solutions. In this context, Electric Vehicles (EVs) have emerged as a promising alternative to conventional internal combustion engine vehicles because they operate using electrical energy stored in batteries and produce significantly lower harmful emissions. EVs also support the integration of renewable energy sources such as solar and wind power, thereby promoting environmental sustainability and reducing dependence on fossil fuels.

Despite these advantages, the widespread adoption of EVs depends greatly on the availability of efficient and convenient charging infrastructure. Most EVs currently rely on traditional plug-in charging systems, which require physical cable connections and manual intervention. These systems may lead to maintenance issues, mechanical wear, and safety concerns, especially under adverse environmental conditions. In addition, conventional charging methods cannot support charging while the vehicle is moving, which limits driving range and increases charging delays.

To overcome these challenges, Wireless Power Transfer (WPT), particularly Inductive Power Transfer (IPT), has gained significant attention as an advanced charging solution. IPT works on the principle of electromagnetic induction, where electrical energy is transferred wirelessly between transmitter and receiver coils without physical contact. The proposed project, “Dynamic Inductive Charging System for Electric Vehicles,” demonstrates the practical implementation of IPT technology using transmitter and receiver coils, ESP32 microcontrollers, and monitoring systems. The system enables safe, efficient, and automated charging, including dynamic charging while the vehicle is in motion, thereby reducing range anxiety and supporting the future development of smart EV transportation systems.

II. SYSTEM ARCHITECTURE

The proposed work focuses on the design and development of a Dynamic Inductive Charging System for Electric Vehicles using Wireless Power Transfer (WPT) technology based on the principle of electromagnetic induction. The methodology of the project is divided into transmitter-side operation, receiver-side operation, monitoring and control, and dynamic charging implementation.

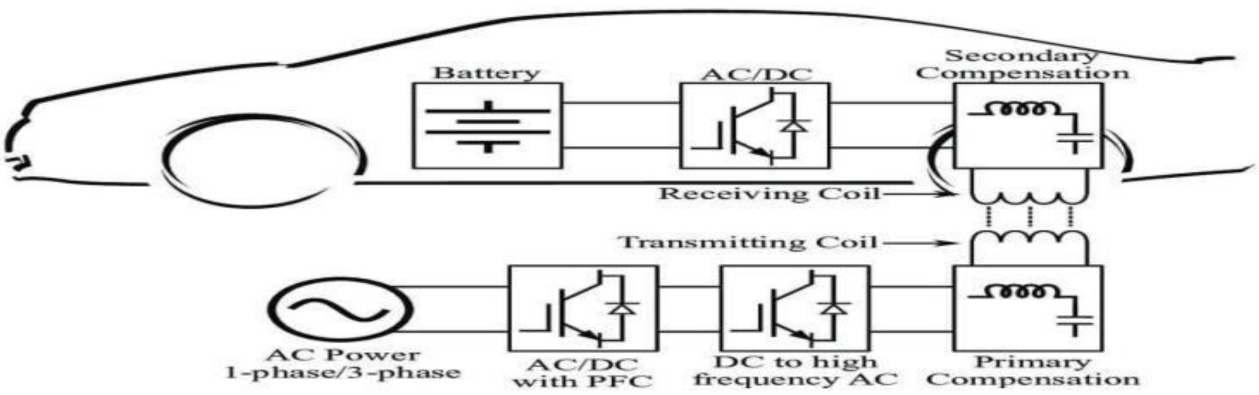

Fig. 2.1: Dynamic Inductive Charging System

Initially, the 230V AC supply is converted into regulated DC using an AC/DC converter and rectifier with Power Factor Correction (PFC). The DC output is then converted into high-frequency AC (20kHz–100kHz) using an inverter. This high-frequency AC is supplied to the transmitter coil through a compensation circuit, which maintains resonance and improves power transfer efficiency. The transmitter coil generates an alternating magnetic field that enables wireless energy transfer.

On the receiver side, the receiver coil placed under the EV prototype captures the magnetic field and induces an AC voltage through electromagnetic induction. The induced voltage is rectified and filtered into DC to charge the battery. An ESP32 microcontroller monitors charging parameters and displays them on a 16×2 LCD, while LEDs indicate charging status. A motor-driven setup using a DC motor and L298N driver simulates vehicle movement to demonstrate dynamic charging. The system is tested under different coil alignments, distances, and speeds to analyze charging performance and efficiency.

III. WORKING MECHANISM AND FLOWCHART

The block diagram of the Dynamic Inductive Charging System for Electric Vehicles is divided into two sections, namely the Road Side Unit and the Vehicle Side Unit. The Road Side Unit contains all the components responsible for generating and transmitting wireless power, while the Vehicle Side Unit contains the components used for receiving wireless energy, charging the battery, monitoring system parameters, and controlling vehicle movement. The complete system works based on electromagnetic induction for efficient wireless charging of electric vehicles.

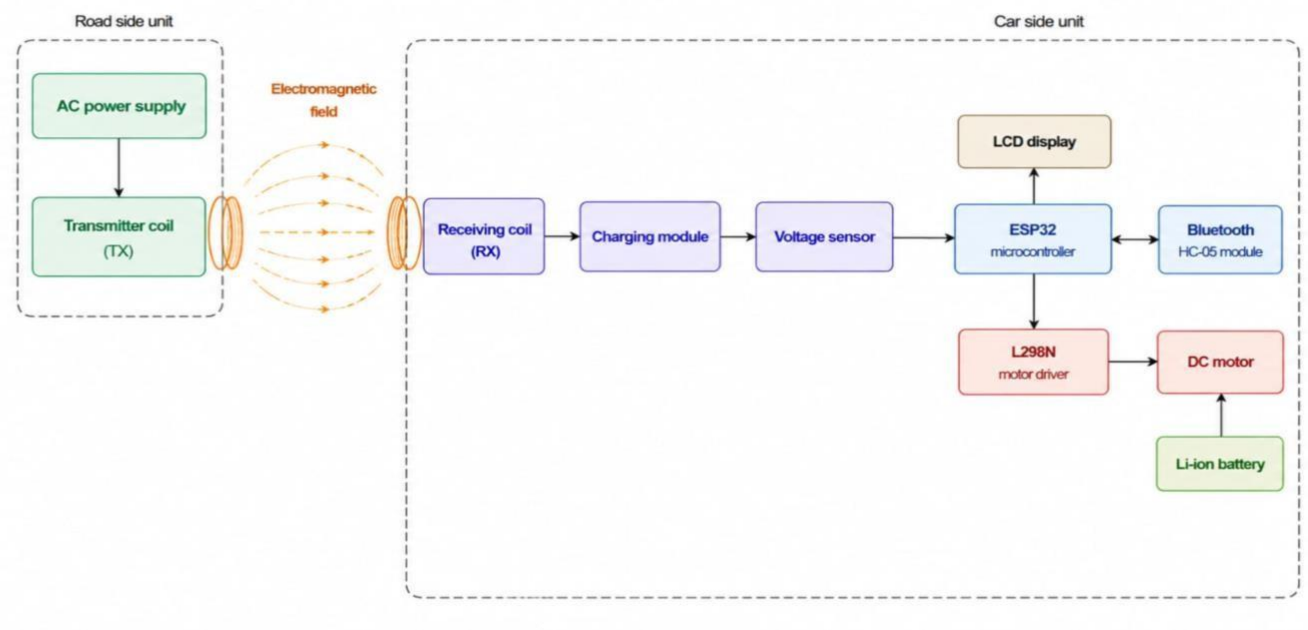

Fig. 2.2: Block Diagram

The block diagram of the Dynamic Inductive Charging System for Electric Vehicles is divided into two sections, namely the Road Side Unit and the Vehicle Side Unit. The Road Side Unit contains all the components responsible for generating and transmitting wireless power, while the Vehicle Side Unit contains the components used for receiving wireless energy, charging the battery, monitoring system parameters, and controlling vehicle movement. The complete system works based on electromagnetic induction for efficient wireless charging of electric vehicles.

The flow chart of the Dynamic Inductive Charging System for Electric Vehicles explains the complete process of wireless power transfer and battery charging. The process starts when the power supply is switched ON. Initially, the AC power supply provides electrical energy to the transmitter side circuit. The supplied power is converted into high-frequency AC and supplied to the transmitter coil through the required power conversion circuits.

When current flows through the transmitter coil, an alternating magnetic field is generated around it. This magnetic field acts as the medium for wireless power transfer between the roadside unit and the vehicle side unit. When the electric vehicle moves over or is placed near the charging pad, magnetic coupling takes place between the transmitter coil and the receiver coil. Due to electromagnetic induction, an AC voltage is induced in the receiver coil mounted underneath the vehicle.

The induced AC voltage from the receiver coil is supplied to the rectifier circuit. The rectifier converts AC voltage into a smooth DC voltage suitable for battery charging. Filter capacitors are used to reduce ripple content and improve output stability. The converted DC power is then supplied to the rechargeable battery. In the proposed system, the battery gets charged wirelessly without using physical charging cables or connectors, thereby improving convenience and safety.

The ESP32 microcontroller continuously monitors charging parameters such as battery voltage, charging status, and system condition. The LCD display shows charging information for user monitoring, while the LED indicator provides a charging indication. The motor driver controls the DC motor used in the prototype model for simulating vehicle movement during dynamic charging operation.

Thus, the flow chart explains the complete operation of the Dynamic Inductive Charging System from power generation to wireless power transfer, AC to DC conversion, battery charging, and real-time monitoring of the system.

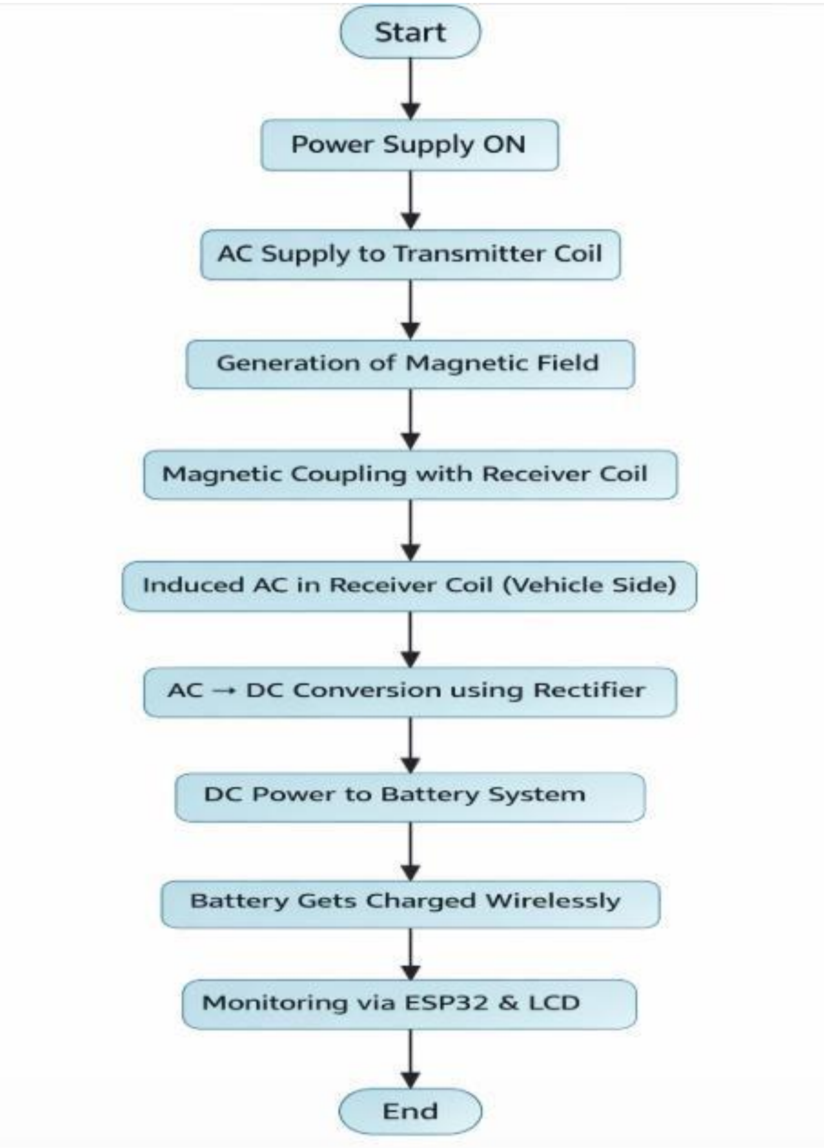

Fig 2.3: Flow Chart for the Proposed System

IV. RESULT

The project focused on designing and developing a prototype for dynamic inductive charging based on electromagnetic induction principles. The system was carefully designed by selecting appropriate transmitter and receiver coils, considering parameters such as the number of turns, coil diameter, and alignment to ensure efficient magnetic coupling. A high-frequency inverter, along with a compensation circuit, was used to generate a strong alternating magnetic field for effective wireless power transfer. During development, the transmitter coil was connected to a power supply through the inverter, while the receiver coil was linked to a rectifier and load (battery). The complete setup was assembled and tested by varying the distance and alignment between coils, where output voltage and current were measured. The results confirmed successful wireless power transfer without physical contact, with sufficient induced voltage to power a load, demonstrating the effectiveness of inductive charging.

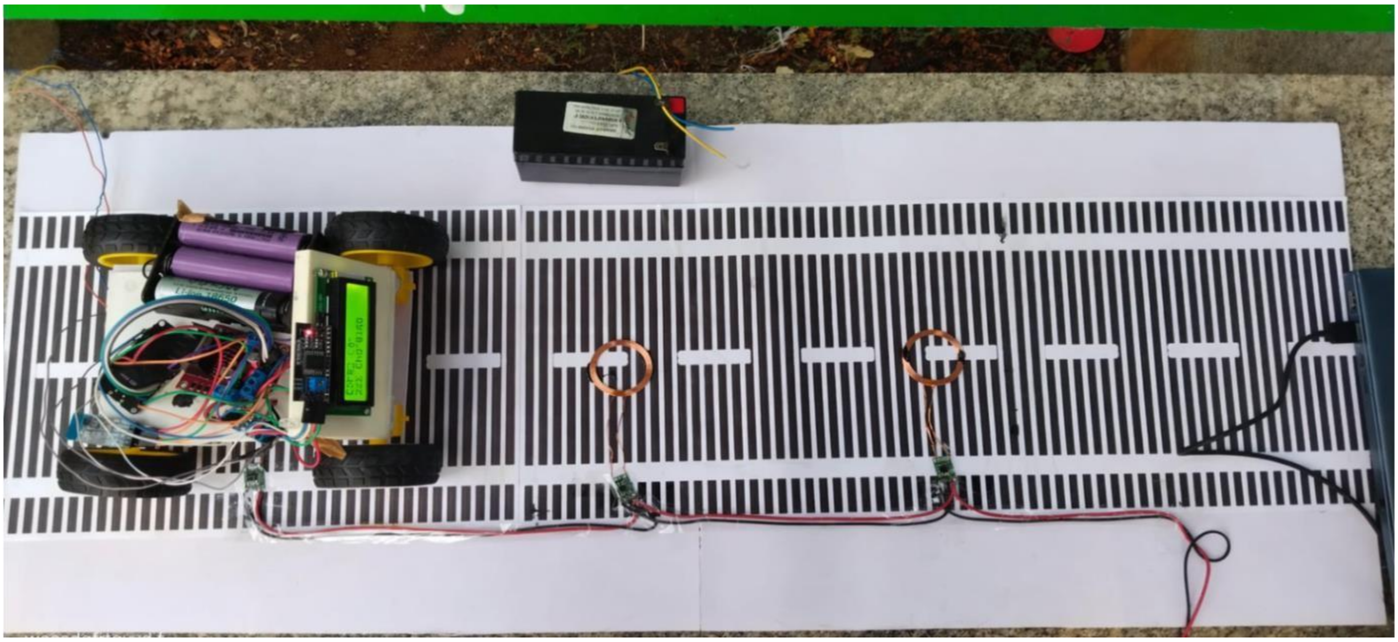

Fig 4.1 Dynamic inductive charging system for EV's Prototype

An ESP32 microcontroller was integrated to enable monitoring and control of the charging. Dynamic Inductive Charging System for EVs process. The system included voltage and current sensors for real-time data acquisition, along with an LCD display and Blynk application for user interaction. The ESP32 was programmed using Arduino IDE, allowing data transmission over Wi-Fi and live status updates. Furthermore, a motor-driven setup was designed to simulate vehicle movement, where the receiver coil was mounted on a moving platform passing over the transmitter coil. Testing showed that real-time monitoring worked efficiently, and dynamic charging was successfully achieved even during motion. However, minor variations occurred due to alignment changes, continuous power transfer was maintained, validating the concept of charging electric vehicles while in motion.

Fig 4.2 Successfully charging the battery of EV's through the coil

V. CONCLUSION

The proposed "Dynamic Inductive Charging System for Electric Vehicles" successfully demonstrated wireless power transfer using electromagnetic induction. The system efficiently transferred energy from the transmitter coil to the receiver coil without physical contact, proving the feasibility of contactless EV charging. An ESP32 microcontroller enabled real-time monitoring of charging parameters, while the motor- driven setup validated continuous charging during vehicle movement. The project highlights the advantages of inductive charging, including safety, convenience, reduced wear, and suitability for future smart transportation systems, making it a reliable and eco-friendly EV charging solution.