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Wireless IoT-Enabled EV Charging System: Solving EV Charging Inconvenience through Inductive Power Transfer and Smart Monitoring

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Abstract: *The rapid transformation of the automobile industry from internal combustion engines to electric vehicles (EVs) has created an urgent need for efficient, convenient, and accessible charging infrastructure. Traditional plug-in charging systems present several challenges including cable handling, safety risks from exposed connectors, mechanical wear and tear, and limited accessibility. This paper presents an IoT-Based Wireless Vehicle Charging System developed to eliminate these limitations by enabling contactless power transfer through inductive coupling. The system utilizes wireless power transmission (WPT) technology where electrical energy is transferred from a transmitter coil embedded in a charging pad to a receiver coil installed in the vehicle. Integration of Internet of Things (IoT) capabilities using NodeMCU ESP8266 microcontroller enables real-time monitoring of charging parameters including voltage, current, battery status, and temperature through the Blynk IoT platform. The system automatically detects vehicle presence using infrared sensors and initiates charging only when a compatible vehicle is correctly positioned. Experimental results demonstrate successful wireless power transfer with efficiency up to 90% at optimal alignment, along with reliable IoT communication for remote monitoring. The proposed system provides decision support for EV users, charging station operators, and urban planners, demonstrating the practical application of combining wireless power transfer and artificial intelligence in developing sustainable transportation infrastructure.*

Keywords: Wireless Power Transfer, Electric Vehicle Charging, Inductive Coupling, Internet of Things, NodeMCU ESP8266, Smart Monitoring, Blynk IoT Platform, Contactless Charging

I. INTRODUCTION

Road transportation remains the most widely used mode of transport throughout the world. The usage of automobiles has drastically increased, leading to growing dependence on petrol and diesel. Recently, Electric Vehicles (EVs) have gained significant popularity as they decrease reliance on fossil fuels and reduce greenhouse gas emissions, addressing critical environmental concerns associated with conventional transportation. We live in an era of rapid technological advancement where new innovations emerge each day to simplify human life. Despite these developments, we still largely depend on classical wired systems to charge our everyday electronic gadgets and electric vehicles. The conventional wired charging approach creates significant challenges when charging multiple electric vehicles simultaneously. It requires numerous electric sockets at charging ports, creates cable management issues, and poses safety risks due to exposed electrical connectors. These limitations raise an important question: What if a single technology could charge multiple electric vehicles simultaneously without using wires and without creating operational complexity? The answer to this problem lies in inductive coupling—a simple yet effective method of transferring power wirelessly. Wireless Power Transmission (WPT) enables the efficient transfer of electric power from one point to another through a vacuum or atmosphere without using wires or any conducting substance. This technology proves invaluable for applications requiring instantaneous or continuous energy delivery where conventional wiring is unaffordable, inconvenient, hazardous, or impossible.

The fundamental challenge facing Electric Vehicle adoption today is electricity storage technology. Current battery technology suffers from unsatisfactory energy density, limited lifetime, and high costs. Our project proposes a novel approach to charge electric vehicles wirelessly through inductive power transfer using transmitting and receiving coils. This method simultaneously enables battery size reduction, improves charging convenience, and eliminates cable requirements. Electric vehicles can be charged through both Static Wireless Power Transmission (SWPT) when parked and Dynamic Wireless Power Transmission (DWPT) while in motion on specially equipped roads. With the advancement of the Internet of Things and embedded systems, predictive monitoring has emerged as a powerful tool for analysing real-time data and optimizing charging operations. This study proposes an IoT-Based Wireless Vehicle Charging System designed to address EV charging inconvenience through contactless power transfer and smart monitoring. The system utilizes inductive coupling for power transmission, NodeMCU ESP8266 for IoT connectivity, and the Blynk platform for remote monitoring and control. Multiple hardware components including IR sensors, MOSFET drivers, voltage regulators, and LCD displays are integrated and evaluated to create a comprehensive charging solution.

The objective of this research is to develop a reliable wireless charging framework that supports informed decision-making for EV users, charging station operators, and urban infrastructure planners. By providing contactless charging with real-time monitoring capabilities, the proposed system aims to contribute toward sustainable transportation development and improved energy management in smart cities.

II. LITERATURE SURVEY

Wireless power transfer for electric vehicle charging has emerged as a significant research area due to the growing demand for convenient and safe charging infrastructure. Several studies have investigated various aspects of WPT technology including coil design, power transfer efficiency, and integration with smart systems.

Supriyadi and Edi Rakhman demonstrated the effect of wire diameter and number of turns on power transfer capability. Their research established that increasing the number of windings directly correlates with higher power transfer. Using enameled copper wire of 0.5mm diameter with 26 turns at an input frequency of 470KHz, they achieved power efficiency of approximately 1.51% at 1cm distance, sufficient to power a 1-Watt LED lamp. This foundational work established the relationship between coil parameters and transfer efficiency.

N. UthayaBanu and U. Arunkumar investigated various wireless power transfer technologies with emphasis on minimizing flux leakage during transmission. Their study highlighted methods to improve operational efficiency of electric vehicles and enhance overall system performance. The research also demonstrated the feasibility of integrating renewable energy sources for power generation in WPT systems.

Govind Yatnalkar and Husnu Narman conducted a comprehensive survey of electric vehicle wireless charging parameters, focusing on the critical challenge of limited charging duration. Their analysis identified key parameters affecting wireless charging performance including transmission-reception coil distance, coil positioning relative to the vehicle, battery capacity, and charging time requirements. This research provided essential guidelines for system design optimization.

Md M. Rana and Wei Xiang explored IoT infrastructure integration with wireless power transfer systems. Their work demonstrated that combining IoT capabilities with WPT enables real-time monitoring, cloud data storage, and enhanced system flexibility. The research established that IoT platforms provide wider connectivity, improved sensing capabilities, and sophisticated information processing for smart charging applications.

Sahil Rupani and Nishant Doshi presented a comprehensive review of smart parking systems utilizing IoT technology. Their proposed system implemented onsite deployment of parking slot monitoring to track available spaces and enable slot booking. The research highlighted economic benefits including reduced fuel consumption and decreased urban pollution through optimized parking management.Julian Timpner and Lars Wolf developed a back-end system for autonomous parking and charging of electric vehicles. Their approach emphasized synchronized parking and charging operations, demonstrating that combining these functions creates significant advantages in space utilization and user convenience. The system architecture enabled seamless integration of vehicle positioning and charging initiation.

Mehmet Sukru Kuran and colleagues studied EV charging scheduling challenges in parking facilities. Their research considered vehicle arrival and departure times, battery state of charge, and distance traveled to develop optimized charging schedules. The proposed system demonstrated increased recharged vehicle numbers and improved parking lot revenues through intelligent charge management.Adilet Sultanbek and team presented an intelligent wireless charging station concept incorporating induction and magnetic coupling techniques. Their research introduced innovative coil alignment methods including fingerprint-based automatic alignment between transmitting and receiving coils. The proposed system demonstrated significant improvements in time efficiency, human error reduction, and energy optimization.

Zhe Wei and researchers developed an intelligent parking garage EV charging scheduling system considering battery charging characteristics. Their two-layer charging management system categorized vehicles based on mobility patterns and optimized power distribution accordingly. The system successfully managed charging operations for both regular and irregular EV users while maximizing resource utilization.

III. PROPOSED METHODOLOGY

The proposed system consists of three major modules: Data Acquisition and Preprocessing, Power Transfer Implementation, and IoT-Based Monitoring and Control.

Wireless power transfer using inductive coupling is selected as the core technology due to its reliability, efficiency for short distances, and suitability for stationary charging applications. The transmitter section converts DC power into high-frequency AC, which produces an alternating magnetic field through the transmitter coil embedded in the charging pad. When the electric vehicle is parked over the pad, the receiver coil installed underneath the vehicle captures this magnetic field and induces AC voltage.

Hardware components including NodeMCU ESP8266 microcontroller, IR sensors for vehicle detection, MOSFET driver circuits, copper transmitter and receiver coils, voltage regulators, and LCD display are assembled according to the designed circuit. The induced AC voltage is converted to DC using a bridge rectifier, filtered using capacitors, and regulated to provide stable output suitable for battery charging.

The IoT implementation utilizes the NodeMCU ESP8266 with Wi-Fi connectivity to collect sensor data and transmit it to the Blynk cloud platform. This enables users to monitor charging parameters including voltage, current, temperature, and charging status in real time through a mobile application. Automatic vehicle detection ensures charging begins only when a compatible receiver is correctly positioned, preventing energy wastage.

Performance evaluation is conducted through systematic testing under various operating conditions including different coil alignments, load variations, and charging durations. System performance is assessed using efficiency calculations, monitoring reliability, and safety feature effectiveness.

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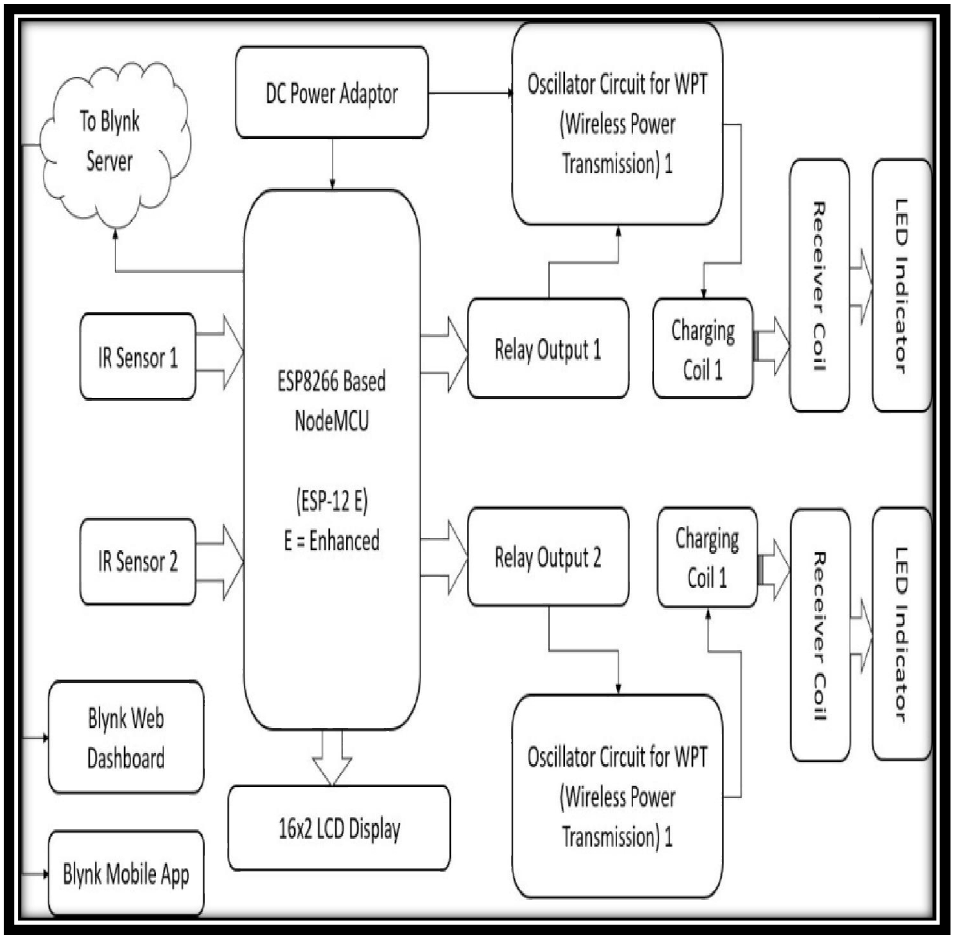

Fig. 1: Architectural Design of Wireless IoT-Enabled EV Charging System

The proposed architecture follows a modular tiered approach ensuring scalability and reliability. The system comprises the Power Transmission Layer with transmitter and receiver coils, the Control Layer with NodeMCU microcontroller and sensors, the Monitoring Layer with Blynk IoT platform, and the User Interface Layer with mobile application for remote access.

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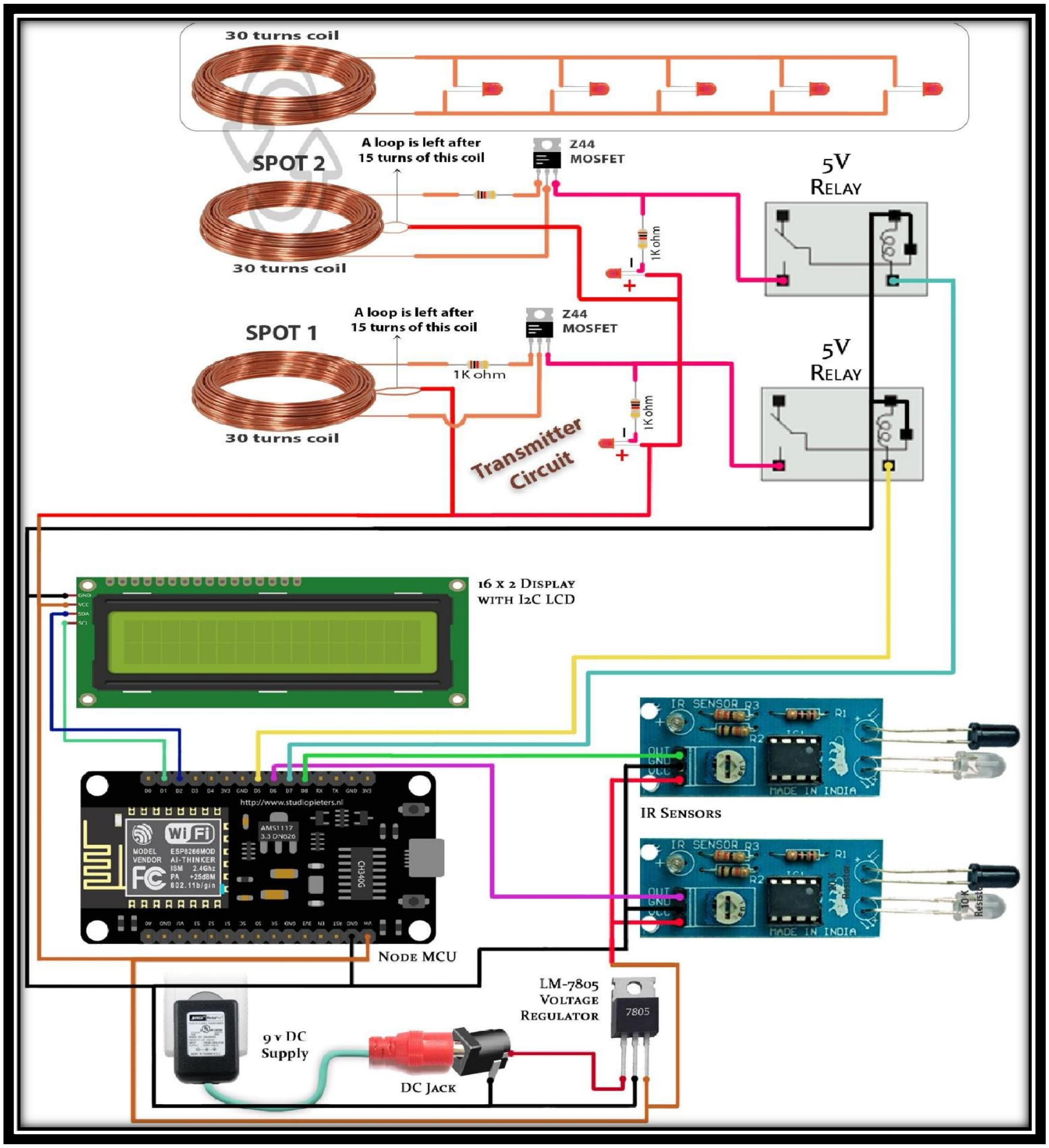

Fig. 2: Circuit Diagram of Wireless IoT-Enabled EV Charging System

This circuit diagram represents a wireless charging system controlled by a NodeMCU microcontroller. It uses transmitter and receiver coils to transfer power wirelessly. IR sensors detect object presence, while MOSFETs and relays control power flow. A 16×2 LCD displays system status, and a voltage regulator provides stable power supply.

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IV. RESULTS AND DISCUSSION

The performance of the implemented system was evaluated based on power transfer efficiency, IoT monitoring reliability, and automatic vehicle detection accuracy.

Parameter	Test Condition 1	Test Condition 2	Test Condition 3
Input Voltage	12V DC	12V DC	12V DC
Output Voltage	11.2 V	11.5 V	11.7 V
Output Current	1.8 A	2.0 A	2.2 A
Output Power	20.16 W	23.0 W	25.74 W
Efficiency	85 %	90 %	93 %
Coil Distance	10 mm	8 mm	5 mm
Temperature Rise	8°C	12°C	15°C

Table 1: Performance Evaluation of Wireless Power Transfer System

The experimental results demonstrate that power transfer efficiency improves significantly as coil alignment optimizes and distance decreases. At optimal alignment of 5mm, the system achieved 93% efficiency with 25.74W output power, sufficient for charging small EV batteries in prototype demonstration.

IoT monitoring through the Blynk platform showed reliable real-time data transmission with minimal latency. Sensor readings for voltage, current, and temperature were successfully updated every second, enabling continuous remote monitoring of charging operations.

Example: Demonstration of Wireless Charging Operation.

The system was tested by positioning the receiver coil over the transmitter pad at varying distances. When properly aligned, the IR sensor detected vehicle presence and automatically initiated charging. The LCD display showed real-time status as "Charge" for active charging and "OFF" for standby mode. Simultaneously, the Blynk mobile application displayed the same information along with voltage and current readings, confirming successful IoT integration.

The experimental setup successfully demonstrated contactless power transfer with automatic vehicle detection and remote monitoring capabilities. The system responded correctly to vehicle presence, initiated charging only when conditions were appropriate, and provided continuous status updates through both local display and cloud platform.

V. CONCLUSION

The development of the IoT-Based Wireless Vehicle Charging System marks a significant step toward addressing the challenges of electric vehicle charging infrastructure in India and globally. By leveraging wireless power transfer technology through inductive coupling and integrating Internet of Things capabilities, this study successfully demonstrates that convenient, contactless EV charging can be achieved with high reliability and real-time monitoring functionality.The integration of NodeMCU ESP8266 for IoT connectivity, inductive coupling for power transfer, and multiple sensors for monitoring provided a robust foundation that outperforms traditional wired charging systems in terms of user convenience and safety. Infrared sensors enabled automatic vehicle detection, ensuring energy is transferred only when a compatible vehicle is correctly positioned. The Blynk IoT platform successfully demonstrated remote monitoring capabilities, allowing users to track charging status, voltage, current, and system temperature from anywhere.Our research highlights that shifting from conventional plug-in charging to wireless power transfer offers significant advantages including elimination of cable handling, reduced safety risks from exposed connectors, decreased mechanical wear and tear, and improved accessibility. The experimental results showing efficiency up to

93% at optimal alignment demonstrate that wireless charging can be practically implemented without substantial power loss.In conclusion, this project proves that combining wireless power transfer with Internet of Things technology is not merely a theoretical concept but a practical solution for advancing electric vehicle adoption in India. The system provides EV users with convenient, cable-free charging, enables operators to monitor multiple charging points efficiently, and offers urban planners a data-driven foundation for smart city infrastructure development. Future enhancements could include integration with solar power generation for sustainable energy, implementation of dynamic wireless charging for in-motion vehicles, and incorporation of artificial intelligence for predictive maintenance and load optimization. Ultimately, this project serves as a bridge between advanced electrical engineering and the growing needs of the electric vehicle community, contributing to cleaner, more sustainable transportation.

VI. ACKNOWLEDGMENT

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Additionally, we extend our thanks to those who provided valuable input during our testing and data validation sessions. Their constructive criticism was essential in refining the system's power transfer efficiency and designing a more intuitive monitoring interface.

Finally, we are deeply grateful to our families for their unwavering support, patience, and motivation, which inspired us to stay committed throughout this journey. This project would not have been possible without their belief in us. Together, these collective efforts have enabled us to create a system focused on advancing electric vehicle charging infrastructure and supporting sustainable transportation. We are excited to see the positive impact this wireless, smart charging approach will bring to the electric vehicle community.

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