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IoT Based Wireless Vehicle Charging Station

Harshal Shirsat[1], Atharva Shimpi[2], Om Kadam[3], Qadeer Quadri[4], Prof. Atul Atalkar[5]
Department of Automation and Robotics Engineering[1-5]
Shivajirao S. Jondhale College of Engineering, Shahapur, India

Abstract: *As the new era of the automobile, the industry is rapidly transforming from an IC engine vehicle to an electric vehicle. The demand for an electric vehicle is increasing, these lead to an increase in charging station as well. In this project, a wireless charging system is used to charge the vehicle wirelessly via inductive coupling. we just simply need to park the car on the charging spot. The transmission of electrical energy from source to load from a distance without any conducting wire or cables is called Wireless Power Transmission. The concept of wireless power transfer was the greatest invention by Nikola Tesla. This system doesn't require any human interaction. Wireless power transmission might be one of the technologies that are one step towards the future. This project can open up new possibilities of wireless charging that can use in our daily lives.*
Wireless power transfer (WPT) using magnetic resonance is the technology which could set human free from the annoying wires. In fact, the WPT adopts the same basic theory which has already been developed for at least 30 years with the term inductive power transfer. WPT technology is developing rapidly in recent years. At mill watts to kilowatts power level, the power transfer distance increases from several millimetres to several hundred millimetres with a load efficiency above 90%. The advances make the WPT very attractive to the electric vehicle (EV) charging applications in both stationary and dynamic charging scenarios.
The integration of IoT further elevates the capabilities of the wireless charging system. With IoT, the charging process becomes smarter and more connected. Real-time data can be collected and analysed, allowing for more efficient management of charging stations. IoT enables features such as remote monitoring, predictive maintenance, and dynamic load balancing. The seamless incorporation of WPT and IoT in EV charging addresses challenges related to charging time, range, and cost. This convergence renders traditional battery technology less critical in the mass market adoption of EVs. The project envisions researchers leveraging these state-of-the-art achievements to drive further advancements in WPT and foster the broader expansion of electric vehicles. .

Keywords: Wireless Power Transmission, Inductive Coupling, Electric Vehicle (EV) Charging, Magnetic Resonance, Internet of Things, Dynamic Charging, Load Efficiency, Smart Charging Systems

I. INTRODUCTION

We live in a world of technological advancement. New technologies emerge each and every day to make our life simpler. Despite all these, we still rely on the classical and conventional wire system to charge our everyday electronic gadgets. The conventional wire system creates a mess when it comes to charging several electric vehicles simultaneously. It also takes up a lot of electric sockets at the charging port. At this point, a question might arise. ―What if a single technology can be used to charge these electric vehicles simultaneously without the use of wires and not creating a mess in the process? We gave it a thought and came up with an idea. The solution to this problem is inductive coupling, a simple and effective way of transferring power wirelessly.

Road transportation is the majorly used transportation in the entire world. Usage of the car has drastically increased and the need for petrol and diesel has increased. So recently, Electric vehicles (EVs) are becoming popular, as they decrease reliance on fossil fuels and reduce greenhouse emissions. The problem of the Electric Vehicle is nothing else but the electricity storage technology, which is the major drawback today due to its unsatisfactory energy density, limited

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lifetime, and high cost. So, our project proposes a novel idea to charge the Electric vehicle wirelessly through the inductive power transfer principle using the transmitting and receiving coil while simultaneously decreasing the battery size and improving the convenience and without the requirement of the cable. The electric vehicle can be charged both by the static wireless power transmission (SWPT) and dynamic wireless power transmission (DWPT) method.

II. LITERATURE REVIEW

Supriyadi and Edi Rakhman. [1] demonstrate the effect of wire diameter (AWG) and a number of turns used is directly proportional to the amount of power that can be transferred. When the number of windings increases, more the power will be transferred. When we use the enamelled copper wire of 0.5mm diameter and keep the number of turns to 26, and apply the input frequency of 470KHz. The power efficiency obtained at a distance of 1 cm is about 1.51%. This result can turn on 1 Watt LED lamp.

N.UthayaBanu and Arunkumar. [2] This study representing the various technologies related to Wireless Power Transfer System, which is used to avoid the flux leakage during the transmission of power and to operate the cars with high efficiency and improve the quality parameters. This project also shows the progress of generating power source through renewable energy.

Govind Yatnalkar and Husnu Narman. [3] present a survey of Duration of Charging of Electric Vehicles is limited. Therefore, wireless charging is important for Electric Vehicles in order to overcome the charging duration problem. This paper also provides a current scenario of the art in electric vehicle wireless charging and the parameters that require for charging section. The most important parameters for electric vehicle wireless charging are the distance between the transmission and reception coils, the position of the coils placed on Electric Vehicle, battery sizes, and the time for charging.

III. METHODOLOGY

The proposed system is designed to implement a wireless power transmission (WPT) based electric vehicle charging system integrated with IoT for smart monitoring and control. The overall architecture consists of a transmitter section and a receiver section. The transmitter side includes a power source, preferably a solar panel combined with a DC supply, which feeds a high-frequency inverter circuit. This inverter converts DC power into high-frequency alternating current that is supplied to a transmitting coil embedded in the wireless charging path (WCP). On the receiver side, a receiving coil is mounted underneath the electric vehicle, which captures the transmitted magnetic field and converts it into electrical energy. This induced alternating current is then passed through a rectifier and filter circuit to obtain a stable DC output suitable for charging the vehicle battery.

The working principle of the system is based on inductive coupling, where power is transferred through mutual inductance between two coils without any physical connection. When high-frequency AC flows through the transmitter coil, it generates an alternating magnetic field around it. If the receiver coil is placed within this magnetic field, a voltage is induced across it due to electromagnetic induction. This induced voltage is then rectified and used to charge the battery, enabling efficient and contactless energy transfer. The system supports both static wireless power transfer (SWPT) and dynamic wireless power transfer (DWPT). In static mode, charging occurs when the vehicle is stationary over a charging pad, whereas in dynamic mode, charging takes place while the vehicle is moving over a specially designed electrified service road (EVSR) embedded with multiple transmitter coils. These coils are activated selectively when the presence of a vehicle is detected, ensuring efficient utilization of energy.

To enhance system intelligence and usability, IoT technology is integrated into the design. Various sensors are used to monitor parameters such as voltage, current, temperature, and charging status. This data is transmitted to a cloud platform through a microcontroller with wireless communication capabilities, enabling real-time monitoring, fault detection, predictive maintenance, and remote accessibility. Additionally, control and protection mechanisms are incorporated to ensure safe operation. These include alignment detection to ensure proper positioning of coils, overvoltage and overcurrent protection circuits, thermal monitoring to prevent overheating, and automatic switching mechanisms to activate power transfer only when required.

The implementation of the system involves several steps, including the design and simulation of the inductive coupling circuit, fabrication of transmitter and receiver coils, development of inverter and rectifier circuits, integration of IoT modules, and installation of the wireless charging path on a service road. The system is then tested under both static and dynamic conditions to evaluate its performance. Key performance parameters include power transfer efficiency, transmission distance, charging time, system reliability, and accuracy of IoT-based monitoring. The proposed methodology aims to eliminate the dependency on wired charging systems, reduce complexity, enhance safety, and enable continuous charging of electric vehicles, thereby contributing to the advancement of sustainable and smart transportation systems.

IV. SYSTEM ARCHITECTURE AND DESIGN

The output produced by timer ic is applied to inverter circuit to invert the oscillating signal and refer as signal 2 while signal 1 for a non-inverted oscillating signal. This both original and inverted oscillating signal is applied to MOSFET driver ic to generate a high and low pulses to trigger the gate of the MOSFET terminal. This forms as a driver circuit. This driver circuit sent the Alternating current to the LC circuit. This current across the inductor and the capacitor produces the magnetic field.

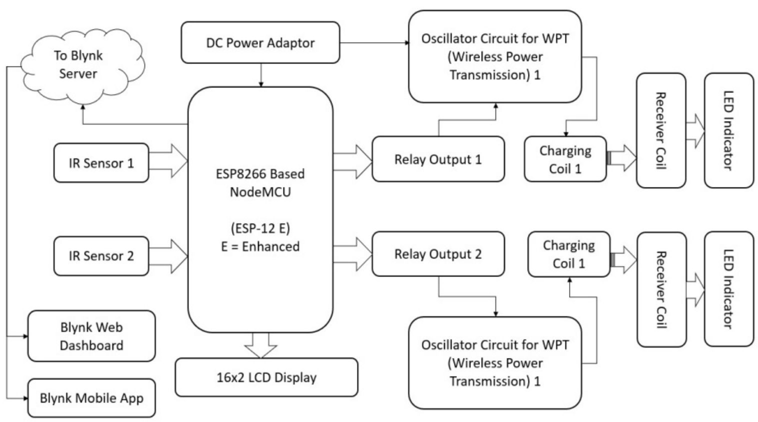

Figure 4.1: System Block Diagram

The coil from the primary side gets energy and it creates the magnetic field around the coil.

Due to the using of high-frequency output, the creation of magnetic flux will be very strong. When the flux from the primary coil links with the secondary coil or Receiver coil, this will induce the current in inductor and capacitor connected in parallel. The voltage generator across the LC circuit is Alternating current and this A.C. signal is applied to Bridge rectifier circuit. This circuit converts the Alternating current into Direct current and the capacitor is connected to the output to generate a smooth DC signal. The Voltage regulator is used to limit the voltage to prevent the damage to the load.

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A. Hardware Architecture

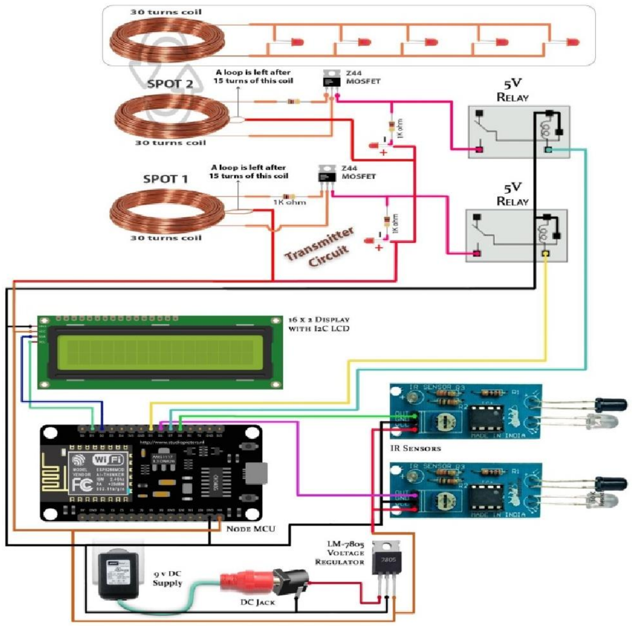

Figure 4.2: Hardware Connections

V. HARDWARE COMPONENTS

Transmitter Coils (30 Turns Coil)

The system uses multiple 30-turn copper coils placed at different charging spots (SPOT 1 and SPOT 2). These coils act as transmitting elements and generate an alternating magnetic field for wireless power transfer through inductive coupling.

MOSFET (Z44 MOSFET)

Each transmitting coil is driven by a Z44 MOSFET, which acts as a high-speed electronic switch. It controls the current flow through the coil, enabling efficient generation of the magnetic field required for power transmission.

Relays (5V Relay)

The circuit includes 5V relays to control the power supply to the transmitter coils. These relays ensure that only the required charging spot is activated based on vehicle detection, improving energy efficiency.

IR Sensors (Infrared Sensors)

IR sensors are used to detect the presence of a vehicle over a charging spot. When a vehicle is detected, the sensor sends a signal to the controller to initiate the charging process

Microcontroller (NodeMCU – ESP8266)

The NodeMCU (ESP8266) acts as the central control unit. It processes signals from the IR sensors and controls the MOSFETs and relays accordingly. It also enables IoT-based monitoring through its built-in Wi-Fi capability.

Display Unit (16×2 I2C LCD)

A 16×2 LCD display with I2C interface is used to show system status such as active charging spot and charging condition, while reducing wiring complexity.

Power Supply (9V DC Supply)

The system is powered using a 9V DC adapter, which provides the initial input power for the circuit.

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Voltage Regulator (LM7805)

An LM7805 voltage regulator is used to convert the 9V input into a stable 5V supply required for the microcontroller, sensors, relays, and display.

VI. SOFTWARE COMPONENTS

Arduino IDE

The Arduino IDE is used as the primary development platform for writing, compiling, and uploading code to the NodeMCU (ESP8266). It provides a simple interface for programming the microcontroller using embedded C/C++. In this project, it is used to implement the control logic for IR sensor input processing, relay and MOSFET switching, and communication with IoT platforms.

Blynk IoT (Android/Web Application)

Blynk IoT is used as the user interface for remote monitoring and control of the system. It allows real-time visualization of parameters such as charging status, active charging spot, and system conditions. Through the mobile or web application, users can monitor the system remotely, receive updates, and manage operations, making the charging system smarter and more interactive.

ESP8266WiFi Library

The ESP8266WiFi library enables Wi-Fi connectivity for the NodeMCU. It is responsible for connecting the device to a local network and facilitating communication with the Blynk IoT platform. This library allows data transmission between the hardware system and cloud-based applications, supporting real-time monitoring and control features.

VII. RESULTS AND DISCUSSION

The developed system successfully demonstrates wireless power transmission for electric vehicle charging using inductive coupling along with IoT-based monitoring. The transmitter coils were able to generate a stable alternating magnetic field, and the receiver coil successfully captured this energy and converted it into usable DC power for charging. The system operated effectively in both static (vehicle stationary) and semi-dynamic conditions, validating the feasibility of contactless charging.

The IR sensor-based detection mechanism accurately identified the presence of a vehicle over specific charging spots, and the NodeMCU controller activated the transmitter coil through MOSFETs and relays. This selective activation reduced unnecessary power consumption and improved overall system efficiency. The relay switching and MOSFET control were observed to be stable and responsive, ensuring smooth operation of the system without delays.

The integration of IoT using Blynk enabled real-time monitoring of the charging process. Parameters such as charging status and active charging spot were successfully displayed on both the 16×2 LCD and the mobile/web application. This confirms that the system can be extended for smart grid applications and remote management of EV charging infrastructure.

However, the system performance depends significantly on coil alignment and distance between transmitter and receiver. It was observed that efficiency decreases as the gap increases or alignment shifts. Additionally, the prototype operates at a low power level, making it suitable for demonstration purposes but requiring further enhancement for real-world EV applications. Thermal effects and power losses in switching components were minimal but should be considered in large-scale implementations.

Overall, the project validates that wireless EV charging integrated with IoT is feasible, safe, and efficient for future transportation systems. The system reduces dependency on wired connections, enhances user convenience, and opens possibilities for dynamic charging roads, which can significantly improve EV range and adoption. Further improvements can include higher power transfer capability, better coil design, and advanced control strategies to increase efficiency and scalability.

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VIII. APPLICATIONS

The proposed wireless power transmission system for EVs has wide applications in modern transportation and smart infrastructure. It can be used in electric vehicle charging stations for contactless charging in parking areas such as malls, offices, and residential complexes. The system is also suitable for dynamic charging roads, where vehicles can charge while moving, reducing dependency on large battery storage. It can be implemented in public transport systems like electric buses and taxis for continuous operation. Additionally, the technology can be extended to consumer electronics, medical implants, and industrial automation systems where wired connections are inconvenient or unsafe.

IX. ADVANTAGES

The system offers several advantages over conventional charging methods. It provides contactless power transfer, eliminating the need for cables and reducing wear and tear. The charging process is safer, as there are no exposed conductive parts, minimizing the risk of electric shock. It enhances user convenience by enabling automatic charging without manual intervention. The integration of IoT allows real-time monitoring and smart control, improving efficiency and reliability. Furthermore, dynamic charging capability can reduce battery size requirements and extend the driving range of electric vehicles.

X. LIMITATIONS

Despite its benefits, the system has certain limitations. The efficiency decreases with increased distance and misalignment between transmitter and receiver coils. The current prototype supports only low power levels, making it less suitable for direct real-world EV charging without further scaling. The initial installation cost of wireless charging infrastructure, especially for dynamic roads, is high. Additionally, energy losses and heat generation in switching components can affect overall performance. Proper shielding and alignment mechanisms are also required to avoid interference and ensure safety.

XI. CONCLUSION

In conclusion, the project successfully demonstrates a wireless power transmission system for electric vehicle charging using inductive coupling integrated with IoT technology. The system provides a safe, efficient, and user-friendly alternative to conventional wired charging methods. By enabling both static and dynamic charging, it addresses key challenges such as limited battery range and charging inconvenience. Although there are limitations related to efficiency and scalability, the proposed system highlights the potential of wireless charging in future smart transportation systems. With further advancements in power electronics, coil design, and infrastructure development, this technology can play a crucial role in accelerating the adoption of electric vehicles and achieving sustainable energy goals.

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