© APR 2025 | IRE Journals | Volume 8 Issue 10 | ISSN: 2456-8880

IoT Based Wireless Electric Vehicle Charging System

BALKRISHNA GUPTA[1], PRABHAKAR JHA[2], DOLLY GAUTAM[3]
[1,2]Student, Department of Electronics and Telecommunications Engineering, Bhilai Institute of Technology, Durg, Chhattisgarh
[3]Asst. Professor, Department of Electronics and Telecommunications Engineering, Bhilai institute of Technology, Durg, Chhattisgarh

Abstract -Wireless charging technology for electric vehicles (EVs) has emerged as a promising alternative to conventional plug-in charging, offering numerous benefits, including enhanced convenience, reduced wear and tear on connectors, and the potential for faster charging. This paper explores the technological foundations of wireless charging systems for EVs, reviews recent advancements in the field, discusses the challenges faced in implementation, and outlines the future prospects of the technology. As the world transitions to cleaner and more efficient transportation solutions, wireless charging presents a crucial opportunity for reshaping how EVs are powered, making them more user-friendly and efficient. The increasing adoption of Electric Vehicles (EVs) has raised the need for efficient and convenient charging solutions. Traditional wired charging systems present several challenges, including the need for physical connections, limited mobility, and infrastructure constraints. To address these limitations, an IoT-based wireless Electric Vehicle Charging System has been proposed. This innovative approach integrates Internet of Things (IoT) technology with wireless power transfer (WPT) methods, aiming to provide a seamless, efficient, and user-friendly solution for EV charging. This wireless charging infrastructure can significantly improve the EV charging experience by eliminating the need for physical connections, thereby reducing wear and tear on charging components and simplifying the process for users. Moreover, IoT-based analytics can help in the maintenance and management of charging stations by providing real-time data on system health and usage. Overall, the IoT-based wireless Electric Vehicle Charging System presents a step forward in enhancing the convenience, efficiency, and accessibility of EV charging, aligning with the growing demand for sustainable transportation solutions. This innovative approach integrates Internet of Things (IoT) technology with wireless power transfer (WPT) methods, aiming to provide a seamless, efficient, and user-friendly solution for EV charging.

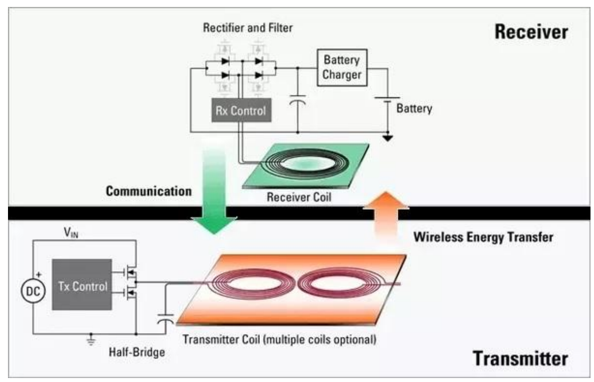

Fig 1.: Wireless Charging Module based on Cu Coil

I. INTRODUCTION

Electric Vehicles (EVs) are increasingly becoming an integral part of the global push towards more sustainable transportation solutions. This surge in adoption is driven by growing concerns over environmental sustainability, the need to reduce greenhouse gas emissions, and the global commitment to combating climate change. Governments, industries, and individuals are making significant efforts to transition from fossil fuel-powered vehicles to electric vehicles, which produce zero tailpipe emissions. This shift is not only beneficial for the environment but also helps reduce dependency on non-renewable energy sources and promotes the use of renewable energy for transportation. However, despite the environmental advantages, the widespread adoption of EVs faces significant challenges, with one of the most prominent being the availability and efficiency of charging infrastructure.

The rise of electric vehicles (EVs) has been one of the most significant developments in the automotive industry over the past decade. As environmental concerns, government regulations, and technological innovations drive the transition away from internal combustion engine vehicles, electric vehicles are increasingly seen as a sustainable solution to reduce greenhouse gas emissions, improve energy efficiency, and curb the negative environmental impacts of traditional vehicles. EVs are heralded as a vital part of the future of transportation, particularly in light of the global push towards renewable energy and zero-emission mobility. However, despite these advantages, one of the key challenges still faced by EV owners and the automotive industry is the issue of efficient and convenient charging infrastructure.

The future of electric vehicle (EV) charging is shifting towards wireless technology, eliminating the need for physical connectors. Wireless EV charging stations will enhance convenience, efficiency, and sustainability by integrating advanced inductive charging systems into public and private infrastructure. This report explores the development, benefits, challenges, and implementation strategies for a futuristic wireless EV charging station.

This paper aims to provide a detailed exploration of wireless charging systems for electric vehicles, discussing the underlying principles of the technology, the different types of wireless charging methods, their advantages and challenges, and the ongoing research and innovations that are driving this technology forward. In this introduction, we will first examine the broader context of electric vehicles and the challenges related to their charging infrastructure. We will then explore how wireless charging can potentially address these issues, highlighting the advantages of this emerging technology and the motivations behind its development.

II. METHODOLOGY

The wireless charging process begins with the use of WPT, which involves the transmission of energy from the charging station (transmitter) to the vehicle (receiver) without the need for physical cables. Among the various WPT methods, inductive charging is the most widely used for EVs. Inductive charging relies on two coils: one coil is embedded in the charging pad installed on the ground, while the other is placed inside the vehicle. When the vehicle is parked over the charging pad, the coils create a magnetic field that transfers energy from the pad to the vehicle, charging its battery

The next step is the integration of IoT sensors and devices into the wireless charging system. IoT sensors are embedded within the charging stations and vehicles to monitor key parameters such as charging status, temperature, alignment, and power transfer efficiency. The IoT-enabled system can collect and transmit real-time data to a cloud-based platform, allowing users to monitor the charging process remotely. IoT technology also enables predictive maintenance by detecting potential faults and sending alerts for necessary repairs or adjustments.

III. BLOCK DIAGRAM

The block diagram for the IoT-based wireless charging system for EVs is designed to illustrate the interactions between the different components of the system, including the vehicle, charging station, IoT sensors, and user interface in figure 1.

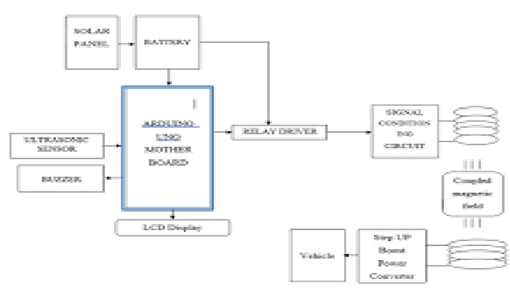

Figure 1: Block Diagram

ESP232 is the main component of the project as it control and monitor the parameters, IR sensor will detect the presences of the vehicle and sends the signal to ESP232. Depending upon the vehicle position, relay is turned on to energize the transmitter coil.

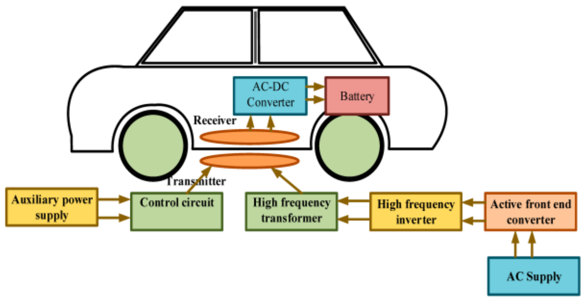

Fig 3: Charging Architecture with use of Copper Coils

The receiver coil present in the vehicle gets energized by the transmitter coil by mutual coupling, the energy produced is given to AC to DC converter, and the converter is connected to the battery. The battery gives power to the motor to run.

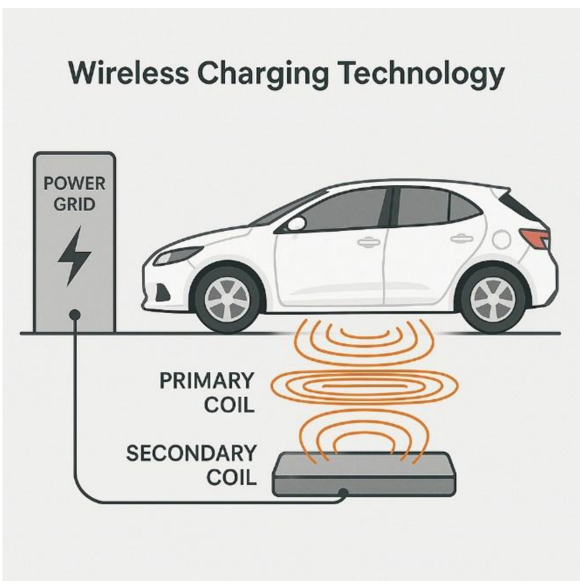

Fig 2: Circuit Diagram

IV. WIRELESS CHARGING ARCHITECTURE

The wireless charging architecture for EVs is a sophisticated system comprising multiple components working together to transfer power from a stationary charging pad to a moving vehicle efficiently. This architecture enables users to charge their vehicles without the hassle of physical connectors, improving convenience and reliability. As this technology evolves, future enhancements will focus on increasing efficiency, reducing costs, and expanding wireless charging coverage to accommodate more widespread EV adoption.

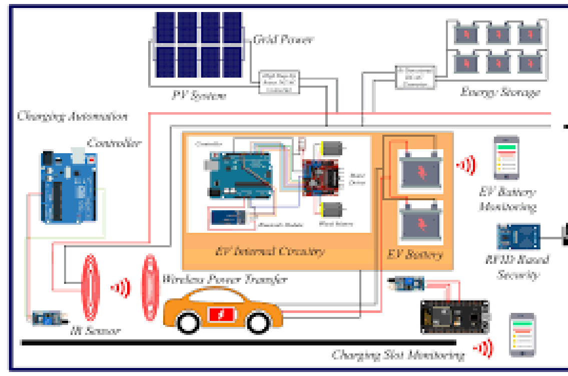

Fig 4 : Charging Architecture of an Automated Wireless Charging Station

V. FUTURE ADVANCEMENTS

Future advancements in wireless charging for electric vehicles (EVs) are set to revolutionize the way we power transportation. One of the most significant improvements will be in charging efficiency, with new technologies like resonant inductive coupling and advanced semiconductor materials such as Gallium Nitride (GaN) and Silicon Carbide (SiC) pushing wireless power transfer efficiency beyond 95%, making it nearly as effective as wired charging. Additionally, high-power wireless charging systems capable of delivering 50 kW to 100 kW are in development, significantly reducing charging times and making wireless fast charging a reality. A major breakthrough on the horizon is dynamic wireless charging, where roads embedded with charging coils will allow EVs to charge while driving. Countries like South Korea and Germany are already testing this technology, which could eventually eliminate range anxiety and reduce the need for large EV batteries.

Standardization efforts, such as the SAE J2954 standard, are also gaining traction, ensuring that different EV models can seamlessly use wireless charging infrastructure. This technology will be especially beneficial for autonomous vehicles, enabling self-driving taxis, delivery fleets, and public transport systems to charge without human intervention. Integration with Vehicle-to-Grid (V2G) systems will allow EVs to wirelessly return excess energy to the grid, supporting smart energy management. Urban areas and parking spaces are likely to see widespread adoption of wireless charging pads, where EVs can recharge automatically while parked, making the process effortless for drivers. As manufacturing costs decrease, wireless charging is expected to become more affordable, accelerating mass adoption across personal, commercial, and public transportation sectors. With these innovations, wireless EV charging is poised to become a key component of the future smart cities, making EV ownership more convenient, efficient, and sustainable.

Fig 5 : On The Move Charging Setup

VI. HARDWARE COMPONENTS

The power supply unit will provides +5V for the components to work. IC AMC is used for providing a constant power of +5V. The ac voltage, typically 220V, is connected to a transformer, which steps down the ac voltage down to the level of the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation.

Node MCU :- NodeMCU is an open-source, low-cost development board based on the ESP8266 Wi-Fi module. It is designed to enable easy development and deployment of Internet of Things (IoT) projects, thanks to its built-in Wi-Fi connectivity and compact size. NodeMCU is widely used for building IoT solutions because it simplifies the process of connecting physical devices to the internet, making it suitable for a variety of applications, from home automation to sensor networks.

Figure 7: Node MCU

Wireless Power Supply Transmitter Receiver Charging Coil Module:-The 12V 2A Large Current Wireless Charger Module Transmitter Receiver Charging Coil Module is for a variety of small electronic products, wireless charging, power supply development, and design, with a small size, easy to use, high efficiency, and low price characteristics.

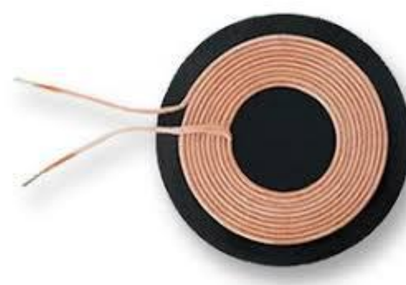

Figure 6: Charging Coil

Specifications:
- Model: XKT-412.
- Input Voltage: 12V.
- Output Voltage: 12V.
- Operating Current: 1.2-2 A.
- Receive Coil: 3mm, the receiver output 5V / 1A current
- Transmitter Length × Width × Height(mm) : 17 * 12 * 4
- Receiver Length × Width × Height(mm) : 24 * 10
- 3
- Coil Height: 2mm
- Coil Diameter: 38mm

Relay:- A relay is an electrical component used to control the flow of current in a circuit by using an electromagnet to open or close a switch. It acts as a "switch" that is operated by an electrical signal, typically a low-power signal, to control a larger, higher-power circuit. Relays are widely used in automation systems, IoT applications, motor control, and in a variety of other electronic systems.

Figure 8 : Relay

Battery:- A battery is a device that stores electrical energy in the form of chemical energy and converts it into electrical energy when needed. Batteries are essential components in a wide range of electronic devices, from small gadgets like smartphones to large systems like electric vehicles (EVs) and renewable energy storage solutions. They are critical for powering devices without a direct connection to a power grid, offering portability, convenience, and flexibility.

Figure 9: Battery

IR Sensor:- An Infrared (IR) Sensor is an electronic device that detects infrared radiation, typically emitted by objects in its surroundings, and converts the detected infrared light into an electrical signal. IR sensors are widely used in various applications, including motion detection, temperature measurement, and proximity sensing. Infrared radiation is part of the electromagnetic spectrum, with wavelengths longer than visible light but shorter than microwaves, usually in the range of 700 nm to 1 mm.

Figure 11: IR Sensor

VII. IMPLEMENTATION

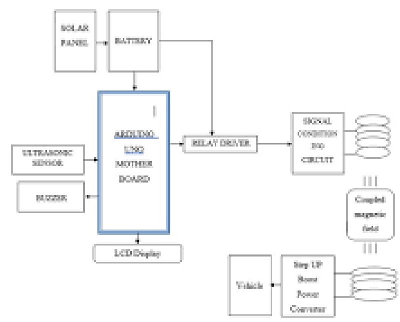

Figure 10: Flow Chart

VIII. FUTURE ADVANCEMENTS

1. Increased Charging Efficiency
2. High-Power Wireless Charging (Fast Charging)
3. Dynamic Wireless Charging (In-Motion Charging)
4. Autonomous Charging Integration
5. Vehicle-to-Grid (V2G) and Smart Charging
6. Charging While Parked at Home

IX. RESULT

Wireless charging for Electric Vehicles (EVs) is a revolutionary technology that allows the transfer of electrical energy from a charging station to an EV without the need for physical connectors. The underlying architecture of wireless charging systems for EVs relies on a few critical components, including the charging pad (transmitter), receiver coil, power electronics, communication systems, and a control unit. Below is a detailed breakdown of the architecture involved in a typical wireless charging system for EVs..

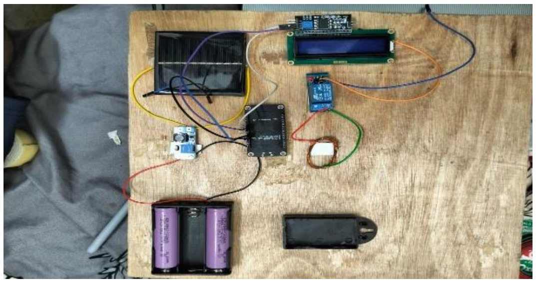

Figure12 : Complete Project Photo

CONCLUSION

Wireless charging architecture for Electric Vehicles (EVs) represents a significant step forward in the convenience, efficiency, and scalability of EV charging infrastructure. By leveraging Wireless Power Transfer (WPT) technologies such as inductive charging, resonant inductive coupling, and capacitive charging, the wireless charging system eliminates the need for physical cables and connectors, offering greater flexibility and ease of use for EV owners. This architecture reduces wear and tear associated with traditional wired charging stations and provides the potential for seamless, hands-free charging experiences. Integrating Internet of Things (IoT) technology with wireless charging systems further enhances their functionality. Through real-time monitoring, remote diagnostics, predictive maintenance, and optimization of charging schedules, IoT-enabled wireless charging systems improve operational efficiency and reduce downtime. This integration not only increases the convenience of EV charging but also contributes to the overall sustainability of the EV ecosystem by optimizing energy consumption and minimizing the environmental impact.

ACKNOWLEDGMENT

We would like to thank Bhilai Institute of Technology Durg Department of Electronics and Telecommunication Engineering for encouraging us to proceed with this project. We would also like to express our deep and sincere gratitude to our HoD and the person who guided us in this project, Dr. Arun Kumar, Department of Electronics and Telecommunication Engineering, BIT Durg, for giving us the opportunity to do research and providing invaluable guidance throughout this research. He has educated us the methodology to hold out the analysis and to present the analysis works as clearly as doable. We would like to extend our gratitude to the faculty in-charge Prof. Amar Kumar Dey & Prof. Kiran Dewangan . It was an excellent learning experience, to understand unmet needs during calamities and we have tried to solve them in an effective manner.

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