Solar Powered Electric Vehicle Charging System

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Abstract— The Solar Powered E-Vehicle Charging System represents a novel approach to enhance the convenience and ease of electric vehicle charging. This project presents a modified system that aims to address existing challenges in the charging process. With growing interest and research in numerous countries, this project tackles a current problem statement in the field. The primary objective of this project is to provide a comprehensive solution that enables efficient power transmission, even in remote areas. By harnessing the power of solar energy, this innovative charging system offers a sustainable and environmentally friendly approach to support the adoption of electric vehicles. The project report outlines the design, implementation, and evaluation of the Solar Powered E-Vehicle Charging System, highlighting its potential to revolutionize the charging infrastructure and contribute to the broader goal of powering electric vehicles in diverse locations.

Keywords – Inductive Charging, Lithium-Ion Battery, Renewable Energy, Internet of Things.

I. INTRODUCTION

The rapid adoption of electric vehicles (EVs) has underscored the need for an efficient and sustainable charging infrastructure. Conventional EV charging systems are heavily dependent on grid electricity, which is often derived from fossil fuels, leading to carbon emissions and increased energy demand. To address these challenges, renewable energy-based charging solutions have gained significant attention, with solar power emerging as a promising alternative due to its abundance, sustainability, and cost- effectiveness.

This paper proposes a solar-powered electric vehicle charging system that integrates automation to enhance user convenience and charging efficiency.[1]The system is designed to autonomously initiate charging as soon as the vehicle is parked in the designated charging area, eliminating the need for manual intervention. By leveraging wireless power transfer (WPT) technology, the proposed system enhances safety and reduces wear and tear associated with conventional plug-in charging mechanisms.

The automation in this charging system is achieved through a combination of smart sensors, embedded control units, and power management systems, which collectively ensure seamless operation. The system monitors vehicle presence, aligns power transfer components, and dynamically optimizes energy flow based on real-time solar availability and battery state- of-charge. By integrating renewable energy with intelligent automation, this approach not only promotes clean transportation but also enhances grid resilience by reducing peak load demands. Furthermore, the proposed system can be implemented in urban environments, residential spaces, and public charging stations, making it a versatile solution for the future of sustainable mobility. The paper discusses the design, working principle, efficiency considerations, and potential challenges of the system, along with experimental results that validate its feasibility.

II. EXISTING SYSTEM

The current electric vehicle (EV) charging infrastructure[3] predominantly relies on wired charging stations, where vehicles are connected to a power source through cables and plugs. These charging systems are generally classified into AC charging (Level 1 and Level 2) and DC fast charging (Level 3), depending on the power output and charging speed. While this method is widely used, it presents several challenges that limit efficiency, convenience, and sustainability.

In conventional charging setups, electricity is primarily sourced from the power grid, which in many regions is still dependent on fossil fuel-based power generation. This reliance on non-renewable energy contributes to carbon emissions and places additional stress on the electrical grid, particularly during peak demand periods. Although some charging stations integrate renewable energy sources such as solar or wind power, the majority continue to operate using grid electricity, reducing the overall environmental benefits of EV adoption.

Another significant drawback of wired charging systems is the necessity for physical connection between the charging unit and the vehicle. This introduces several practical challenges, including wear and tear of charging cables and connectors, which require frequent maintenance and replacement. Exposure to environmental factors such as rain, dust, and extreme temperatures can further affect the durability and safety of these components. Additionally, the manual process of plugging and unplugging the charging cable can be inconvenient for users, especially in adverse weather conditions or during high-traffic periods at public charging stations.

III. PROPOSED METHODOLOGY

[4]Inductive charging, also referred to as wireless or cordless charging, is a form of wireless power transfer (WPT) that enables the transfer of electrical energy without the need for physical connectors. This technology is particularly beneficial for electric vehicle (EV) charging, as it eliminates the inconvenience of plug-in systems, reduces wear and tear on connectors, and enhances user convenience. By leveraging electromagnetic induction, the system enables seamless energy transfer between a charging pad embedded in the ground and a receiver coil integrated into the vehicle.

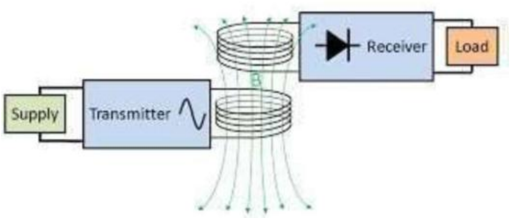

Figure.1: INDUCTIVE CHARGING

In the proposed solar-powered wireless EV charging system, the energy required for charging is harvested from sunlight using photovoltaic (PV) panels. The captured solar energy is converted into electrical power and stored in a battery or directly supplied to the wireless charging unit. The primary coil, installed at the charging station, generates an alternating magnetic field when an EV is parked over it. This magnetic field induces a current in the secondary coil located in the vehicle, thereby enabling efficient and contactless power transfer.

One of the key advantages of this approach is its automated operation. The system is designed to detect the presence of a vehicle, align the coils for optimal energy transfer, and initiate charging without any manual intervention. This eliminates the need for drivers to connect or disconnect charging cables, making it particularly useful in smart parking systems, autonomous vehicle infrastructure, and urban mobility solutions.

Additionally, the integration of solar energy with wireless charging enhances sustainability by reducing reliance on fossil fuel-based electricity. It also contributes to grid stability by decentralizing power distribution, especially when coupled with energy storage solutions. With advancements in WPT technology, such as resonant inductive coupling and dynamic wireless charging, EVs could potentially charge while in motion, further enhancing their efficiency and range.

This innovative approach to EV charging represents a significant step toward the development of smart, sustainable, and user-friendly transportation ecosystems. The paper explores the design considerations, efficiency factors, and potential challenges associated with implementing solar- powered wireless EV charging, paving the way for a cleaner and more efficient future in mobility.

IV. PROTOTYPE IMPLEMENTATION

The prototype of the product is divided into three modules,

- Transmitter Module
- Automation Module
- Receiver Module Transmitter Module:

Figure.2: TRANSMITTER MODULE

The Transmitter Module comprises of an inverter circuit with an input port to connect the power source, and a transmitter coil to produce magnetic field for inducing the current to the receiver unit. The input DC power is inverted into AC power and supplied to the transmitter coil. The inductive coil produces magnetic field around the coil. This when comes in contact with the secondary coil, an emf will be induced.

Automation Module:

V. OUTPUT AND INFERENCES

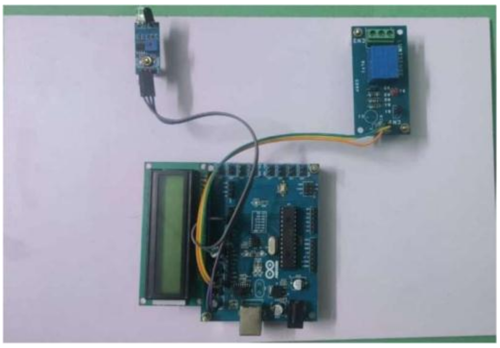

Figure.3: AUTOMATION MODULE

The automation module is a key component of the solar-powered wireless EV charging system, enabling seamless and efficient charging without manual intervention. It uses motion sensors to detect the presence of a vehicle in the designated parking area and triggers the charging process. Once a vehicle is detected, the system activates a relay switch that allows current to flow to the transmitter coil, ensuring that power is supplied only when needed. This process is managed by an Arduino microcontroller, which processes sensor data and controls the relay operation to optimize energy efficiency and prevent unnecessary power loss.

To enhance user experience, an LCD display is integrated into the system to provide real-time status updates, including charging activation, system readiness, and error notifications. This allows users to monitor the operation of the charging module easily.

Receiver Module:

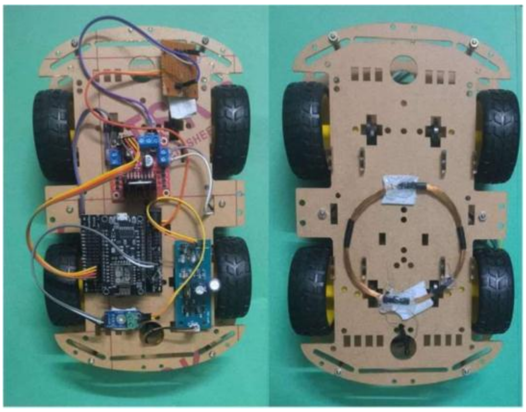

Figure.4: RECEIVER MODULE

The Receiver Module is solely installed in the vehicle. It consists of two parts, one is the receiver coil and the other is the circuit and microcontroller which is responsible for rectifying and monitoring the current flow to the battery. The receiver coil is aligned with the transmitter coil to interact with the magnetic field produced in the transmitter coil. A rectifier circuit is used to convert the AC current into DC current as the induced current will always be alternating current. A voltage sensor is placed to verify the flow of current in the circuit. An ESP 8266 microcontroller is used to connect to an IoT application.

The wireless EV charging prototype operates through a combination of automated sensing, power conversion, and inductive energy transfer to ensure efficient and seamless charging. The process begins with an IR sensor, which detects the presence of a vehicle in the designated charging area. This data is sent to an Arduino microcontroller, which acts as the central control unit. Upon confirming vehicle presence, the microcontroller triggers a relay switch, allowing current to flow into the transmitter module. Since inductive charging requires an alternating current (AC) supply, an inverter circuit is used to convert the direct current (DC) generated by the solar panels into AC. Once converted, the AC power is supplied to the transmitter coil, which generates an alternating magnetic field around it.

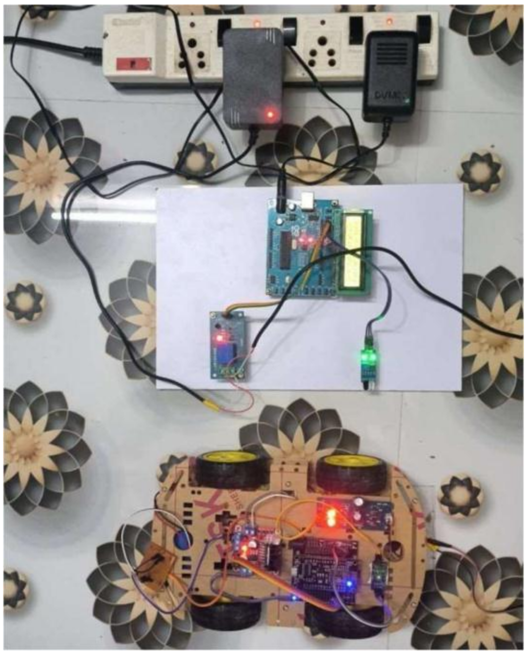

Figure.5: WORKING PROTOTYPE

As the receiver coil, embedded in the electric vehicle, enters this magnetic field, it gets induced with an AC voltage, facilitating wireless power transfer. To make this power suitable for charging the EV's battery, a rectifier circuit converts the induced AC back into DC. The system also includes a voltage sensor, which continuously monitors and verifies the voltage levels to ensure stable and efficient charging. This entire process is executed autonomously, eliminating the need for manual intervention while optimizing energy transfer efficiency. By integrating renewable energy with wireless charging technology, this system enhances the sustainability and practicality of EV charging, paving the way for a smarter and more eco-friendly transportation infrastructure.

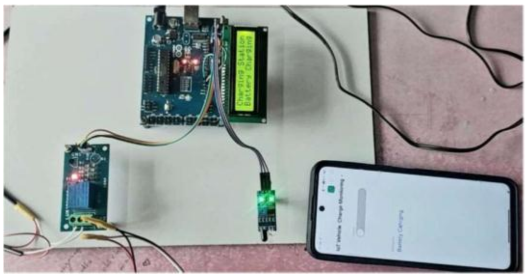

Figure.6: IoT APPLICATION

The ESP8266 microcontroller is integrated into the system to enable IoT connectivity, allowing users to remotely monitor the charging status of their electric vehicle through a dedicated application. By linking the charging system to an online platform, users can access real-time data, including charging progress and system activity, from anywhere. Additionally, an LCD display is incorporated alongside the Arduino controller to provide on-site status updates, ensuring that users have both local and remote access to critical information. This integration enhances user convenience, improves system transparency, and makes the solar-powered wireless EV charging system more adaptable to smart grid and connected vehicle applications.

Supply Voltage (V)	Induced Voltage at Secondary Coil (V)	Battery Capacity (Ah)	Charging Time (Approx.)
12V (Lead-Acid Battery)	8V – 10.5V	1.3Ah	1 – 1.5 hours
12V (Lead-Acid Battery)	8V – 10.5V	4Ah	3 – 4 hours
12V (Lead-Acid Battery)	8V – 10.5V	7Ah	5 – 6 hours
12V (Lead-Acid Battery)	8V – 10.5V	12Ah	8 – 10 hours

Figure 7: INFERRED RESULT (TABLE)

VI. CONCLUSION

The solar-powered wireless EV charging system offers an efficient and sustainable solution for electric vehicle charging by integrating renewable energy, automation, and wireless power transfer technology. By harnessing solar power, the system reduces reliance on conventional grid electricity, promoting environmental sustainability. The incorporation of automated vehicle detection using sensors, along with Arduino-based relay switching, ensures seamless operation without manual intervention. Additionally, IoT connectivity through the ESP8266 microcontroller enhances user convenience by enabling real-time monitoring of the charging status.

This system demonstrates the potential for wireless power transfer to improve charging efficiency and user experience, while eliminating the wear and tear associated with conventional plug-in methods. Although challenges such as power transfer efficiency and implementation scalability exist, further advancements in inductive charging technology, energy management, and IoT integration can enhance performance and reliability. By providing a clean, automated, and user-friendly charging solution, this approach contributes to the development of smarter and more sustainable transportation infrastructure.

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