

Solar Based Wireless Electric Vehicle Charging Station

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ABSTRACT

The increasing adoption of electric vehicles (EVs) has created a growing requirement for efficient, convenient, and environmentally sustainable charging infrastructure. Conventional wired charging systems require physical connectors, depend considerably on grid electricity, and may involve higher maintenance requirements. This paper presents a solar-based wireless electric vehicle charging station that combines photovoltaic energy generation, battery storage, inductive wireless power transfer, vehicle detection, and Internet of Things (IoT)-based monitoring. Solar photovoltaic panels generate DC electrical power, which is regulated through a power controller and stored in a battery. When an electric vehicle is detected, the stored energy is transferred wirelessly through a transmitter and receiver coil based on inductive coupling. An ESP8266 NodeMCU provides system monitoring and IoT connectivity, while an ultrasonic sensor is used for object detection. The system communicates operational information to an IoT platform and provides status notification through an SMS-based mechanism. The proposed system eliminates the need for physical charging cables and provides a scalable approach for renewable-energy-based EV charging. The developed concept is particularly suitable for residential areas, parking facilities, commercial spaces, smart cities, and locations with limited grid infrastructure.

Keywords— Electric vehicle, solar energy, wireless charging, inductive power transfer, photovoltaic system, NodeMCU, IoT, battery storage.

INTRODUCTION

The increasing demand for transportation and the environmental impact of fossil-fuel-based vehicles have created a strong need for cleaner transportation technologies. Electric vehicles have emerged as an important alternative because they do not produce tailpipe emissions and can utilize electricity generated from renewable sources.

However, the widespread adoption of EVs is influenced by the availability, accessibility, and convenience of charging infrastructure. Conventional charging stations generally depend on wired connections and grid electricity, which can create challenges related to installation, accessibility, charging convenience, and infrastructure cost.

Wireless charging provides an alternative approach in which electrical energy is transferred without a direct physical connection between the charging station and vehicle. The principle is based on electromagnetic induction, where an alternating current supplied to a primary coil produces a magnetic field that induces electrical energy in a secondary coil mounted on the vehicle. This eliminates the requirement for physical charging cables and can provide a more convenient charging experience.

Solar energy provides an environmentally sustainable source for powering EV charging infrastructure. Photovoltaic panels convert solar radiation into electrical energy, which can be directly utilized or stored in batteries. Integrating solar generation with wireless EV charging can reduce dependence on conventional electricity sources and support decentralized charging infrastructure. The project report proposes solar generation, power regulation, battery storage, wireless charging, and intelligent monitoring as the principal elements of the charging station.

The proposed system further incorporates vehicle detection and IoT monitoring. The NodeMCU-based controller monitors system operation and communicates information to an IoT platform, enabling remote observation of system status and energy-related information. The overall objective is to develop a sustainable and cable-free charging solution that can be deployed in different environments while providing automated operation and improved user convenience.

LITERATURE SURVEY

Bugatha Ram Vara Prasad [1] presented a solar wireless electric vehicle charging system in 2022, integrating solar energy generation with wireless power transfer to provide a sustainable EV charging solution. Prof. Mrs. Spoorthi B. S. [2] investigated a similar solar wireless EV charging system in 2023, emphasizing the use of renewable energy for convenient and environmentally friendly vehicle charging. O. P. Suresh [3] further studied solar wireless EV charging in 2024, demonstrating the continued development of renewable-energy-based wireless charging infrastructure. These studies establish the feasibility of combining photovoltaic energy with wireless charging technology for electric transportation.

Stavros Sykiotis [4] investigated solar-power-driven EV charging optimization using deep reinforcement learning, highlighting the importance of intelligent energy management for efficient utilization of renewable energy. Lokesh Chandra Das and Myounggyu Won [5] proposed LSTM-based adaptive vehicle-position control for dynamic wireless charging, addressing the importance of accurate vehicle positioning for effective wireless power transfer. Based on these developments, the proposed system integrates solar power generation, battery storage, inductive wireless charging, automatic vehicle detection, NodeMCU control, and IoT-based monitoring into a single EV charging station. This integration aims to improve charging convenience while enabling automated operation and remote monitoring.

PROBLEM STATEMENT

Traditional EV charging systems require physical cables and may depend heavily on conventional grid electricity. The availability of charging stations, charging convenience, infrastructure cost, and dependence on non-renewable energy sources can limit the expansion of EV charging infrastructure.

OBJECTIVES

The major objectives are:

1. To develop a solar-powered wireless charging system for electric vehicles using inductive power transfer.
2. To integrate vehicle detection and IoT-based monitoring for automated and intelligent operation.

PROPOSED SYSTEM

The proposed system is a solar-based wireless electric vehicle charging station that integrates photovoltaic energy generation, battery storage, wireless power transfer, vehicle detection, and IoT-based monitoring. The solar panel converts sunlight into electrical energy, which is regulated by a power controller and stored in a battery. When an electric vehicle is detected at the charging station, the stored energy is supplied to the wireless charging transmitter. The transmitter coil generates an alternating electromagnetic field, which is received by the receiver coil installed on the vehicle and converted into electrical energy for charging.

An ESP8266 NodeMCU is used as the control and communication unit. An ultrasonic sensor detects the presence of the vehicle, and the controller processes the measured distance to determine the charging-slot status. In the implemented system, a distance below 25 cm indicates object detection, after which the servo mechanism is activated and the slot status is changed to "Full." The NodeMCU sends system-status information to the Thing Speak IoT platform through Wi-Fi and provides SMS notifications when the slot status changes. When the vehicle is absent, the

system returns to the empty-slot condition. Thus, the proposed system provides renewable-energy-based, cable-free EV charging with automated detection and remote monitoring.

BLOCK DIAGRAM

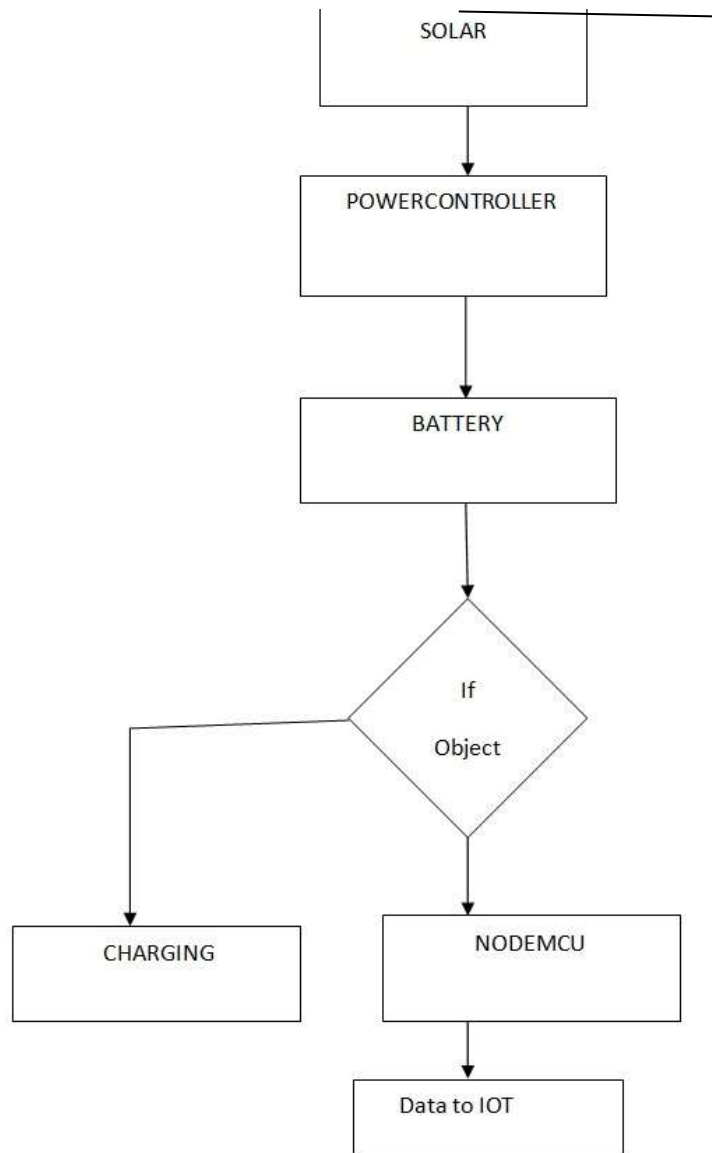


Fig 1 block diagram

METHODOLOGY

The proposed system begins with solar energy generation, where photovoltaic panels convert sunlight into DC electrical energy. The generated power is supplied to a power controller, which regulates the voltage and current and supports maximum power utilization. The regulated energy is stored in a battery, which acts as the energy source for the wireless charging unit. When an electric vehicle is positioned at the charging station, the ultrasonic sensor detects its presence by measuring the distance. If the measured distance is below the predefined threshold of 25 cm, the NodeMCU identifies the vehicle as present and activates the corresponding control mechanism.

After vehicle detection, the stored electrical energy is supplied to the wireless transmitter coil, which generates an alternating electromagnetic field. The receiver coil mounted on the vehicle captures this electromagnetic energy and

converts it into electrical energy for battery charging. The ESP8266 NodeMCU continuously monitors the system and communicates the charging-slot status through Wi-Fi. The collected information is transmitted to the Thing Speak IoT platform for remote monitoring, while status changes can also be communicated through SMS notification. When the vehicle leaves the charging position, the sensor detects the absence, the system changes the slot status to “Empty,” and the charging-related monitoring operation is updated accordingly.

RESULTS AND DISCUSSION

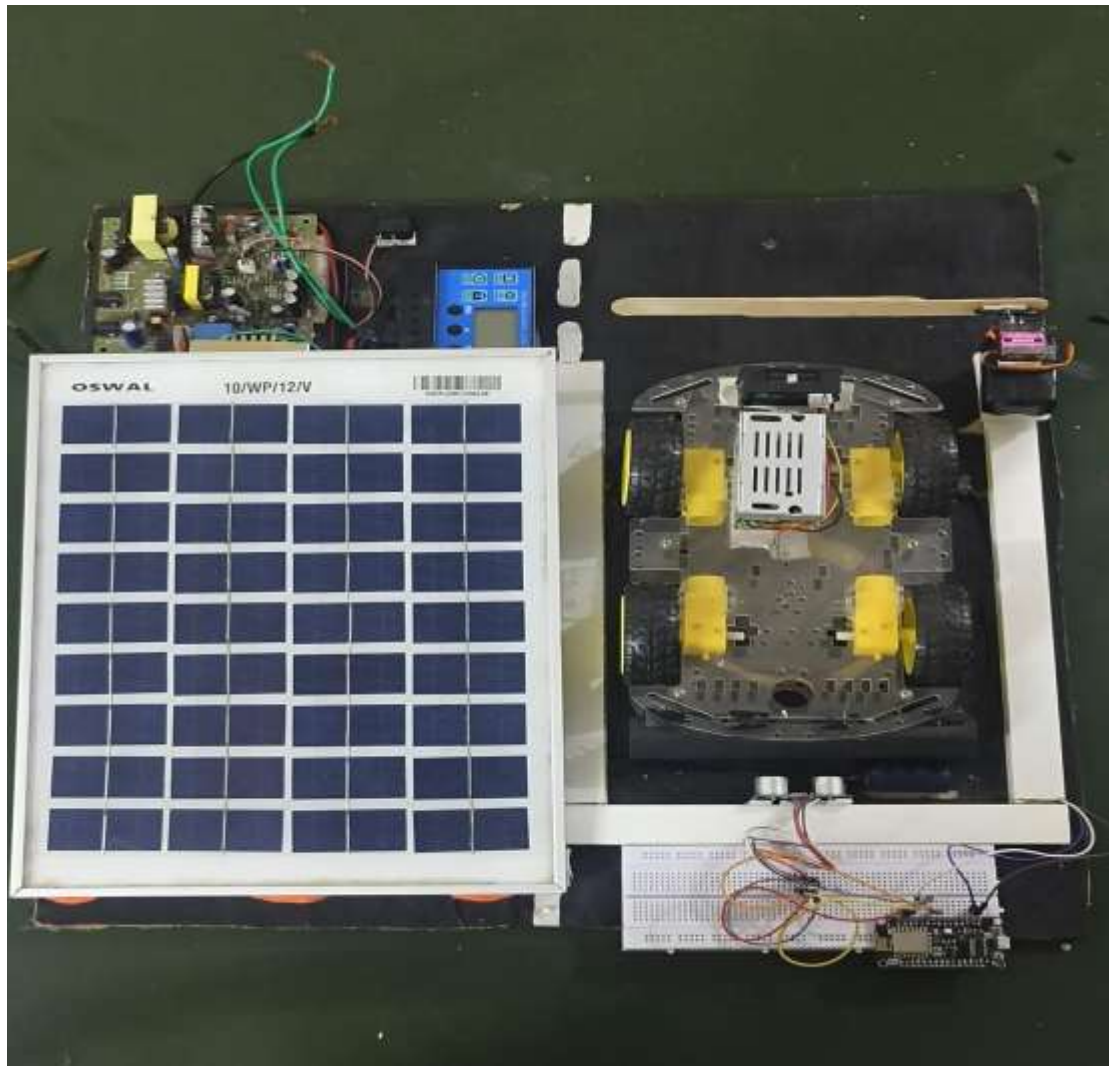
The developed system demonstrates the feasibility of combining solar energy generation with wireless EV charging. The report identifies a seamless charging experience as one of the principal outcomes because the wireless configuration eliminates the requirement for physical charging connections. This simplifies the charging process and reduces mechanical wear associated with conventional connectors.

The integration of photovoltaic generation provides a renewable source of energy for the charging station. The system reduces dependence on conventional electricity and provides improved resilience in locations where grid availability may be limited. The report also identifies optimized energy transfer and energy-use management as important benefits of the proposed inductive charging arrangement.

The IoT implementation provides remote monitoring of operational information. The NodeMCU transmits system information to the IoT platform, while the implemented notification mechanism communicates status changes. The ultrasonic detection mechanism provides automated identification of an occupied charging position, with the controller responding to the predefined distance threshold.

The system therefore combines renewable energy, wireless power transfer, automated detection, and IoT monitoring into a single charging-station architecture. However, the report does not provide sufficient numerical experimental measurements such as measured charging power, charging efficiency, coil-to-coil transfer efficiency, charging time, or percentage battery-state improvement. Therefore, these parameters should be experimentally measured and reported in future validation studies rather than assigning unsupported numerical values.

Fig 2 hardware setup



CONCLUSION

This paper presents a solar-based wireless electric vehicle charging station integrating photovoltaic generation, battery storage, inductive wireless power transfer, vehicle detection, and IoT-based monitoring. The proposed architecture addresses important limitations of conventional wired EV charging by eliminating physical charging cables and utilizing renewable solar energy. The system uses a power controller for solar-energy regulation, battery storage for energy availability, transmitter and receiver coils for wireless power transfer, and an ESP8266 Node MCU for monitoring and communication.

The developed concept provides a convenient and sustainable approach to EV charging and can be adapted for residential, commercial, public, and remote applications. The combination of renewable energy and wireless charging provides a promising direction for future smart transportation infrastructure. Further experimental validation with quantitative charging-efficiency, power-transfer, and battery-performance measurements will strengthen the technical evaluation and support large-scale implementation.

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