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IOT BASED WIRELESS EV CHARGING STATION WITH REAL TIME ENERGY MONITORING AND MANAGEMENT

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Abstract:

The rapid adoption of electric vehicles (EVs) has increased the demand for efficient and intelligent charging infrastructure. This paper presents an IoT-based wireless EV charging station integrated with real-time energy monitoring and management. The system utilizes Wireless Power Transfer (WPT) technology to enable contactless charging, thereby improving safety and user convenience. An ESP8266-based IoT module is used to monitor key electrical parameters such as voltage, current, power, and battery state in real time. The collected data is transmitted to a cloud platform for visualization and analysis. A DC-DC converter ensures stable power delivery, while a Battery Management System (BMS) enhances safety by preventing overcharging and thermal issues. Additionally, solar energy integration improves sustainability by reducing reliance on grid power. The proposed system demonstrates improved efficiency, reliability, and energy optimization compared to conventional charging methods.

Key Words: EV Charging, IoT, Wireless Power Transfer, Energy Monitoring, Smart Grid, Renewable Energy

1. Introduction:

The growing concerns over environmental pollution and depletion of fossil fuels have accelerated the transition toward electric vehicles (EVs). EVs offer a cleaner and more sustainable alternative to conventional internal combustion engine vehicles by reducing greenhouse gas emissions and improving energy efficiency. However, the success of EV adoption largely depends on the availability of efficient and user-friendly charging infrastructure. Traditional wired charging systems, although widely used, present several limitations such as mechanical wear, safety risks, and inconvenience due to manual operation.

Wireless Power Transfer (WPT) technology has emerged as a promising solution to overcome these limitations by enabling contactless energy transfer between the charging station and the vehicle. This technology improves user convenience and reduces maintenance requirements. Furthermore, the integration of Internet of Things (IoT) technology enhances the functionality of charging systems by enabling real-time monitoring, remote access, and intelligent energy management. By combining WPT, IoT, and renewable energy sources such as solar power, it is possible to develop a smart and sustainable EV charging system. This paper focuses on the design and development of such a system to improve charging efficiency, safety, and environmental sustainability.

2. Literature Survey:

Recent advancements in wireless EV charging systems have focused on improving efficiency, reliability, and system intelligence. Researchers have explored various WPT techniques, including inductive and resonant coupling, to enhance energy transfer efficiency and reduce losses. Studies have shown that coil alignment, frequency tuning, and compensation techniques play a critical role in determining system performance.

Advanced control strategies such as closed-loop control and disturbance rejection methods have been proposed to maintain stable voltage and current under varying operating conditions. In addition, artificial intelligence and machine learning approaches have been introduced to predict system parameters and optimize performance. IoT-based systems have gained significant attention due to their ability to enable real-time monitoring, fault detection, and predictive maintenance.

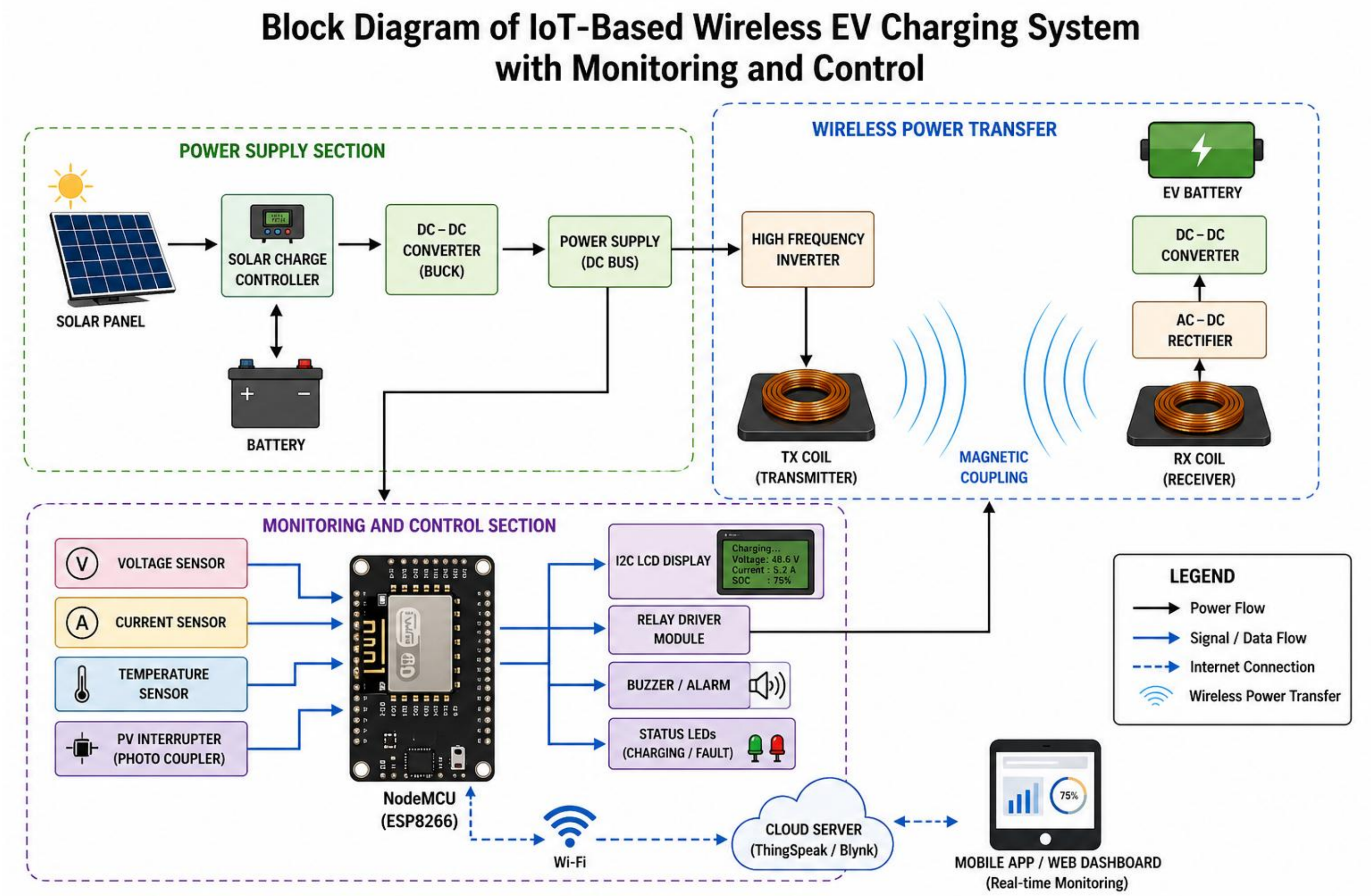
Despite these advancements, challenges such as high implementation cost, energy losses, and electromagnetic interference remain significant. Therefore, there is a need for an integrated solution that combines efficient wireless power transfer, intelligent monitoring, and renewable energy integration. The proposed system addresses these challenges by incorporating IoT-based monitoring and solar energy support into a wireless charging framework.

3. Proposed System:

The proposed system is an IoT-based wireless EV charging station designed to provide efficient, safe, and convenient charging. It consists of a wireless power transfer unit, an IoT communication module, a DC-DC converter, a battery management system, and a solar energy source. The transmitter coil generates an alternating magnetic field when supplied with power, and the receiver coil mounted on the vehicle captures this field to generate electrical energy through electromagnetic induction.

The induced AC power is converted into DC using a rectifier and then regulated by a DC-DC converter to ensure stable voltage and current for battery charging. Sensors are used to measure electrical parameters such as voltage, current, and temperature. These parameters are transmitted to a cloud platform using an ESP8266 IoT module, enabling real-time monitoring and remote access. The integration of a Battery Management System ensures safe charging by preventing overcharging, overheating, and deep discharge.

A key feature of the proposed system is the integration of solar energy, which provides a renewable power source for charging. This reduces dependence on the grid and enhances system sustainability. The overall system is designed to operate automatically, allowing users to charge their vehicles simply by parking over the charging pad.



4. Methodology:

Conventional EV charging systems rely on wired connections and offer limited monitoring and control capabilities. These systems require manual operation and do not support real-time data analysis or integration with renewable energy sources. As a result, they suffer from inefficiencies and reduced user convenience.

The proposed methodology addresses these limitations by integrating wireless charging, IoT monitoring, and solar energy. Wireless power transfer eliminates the need for physical connectors, improving safety and convenience. IoT technology enables real-time monitoring of system parameters and supports intelligent decision-making. Solar energy integration ensures sustainable power usage and reduces operational costs.

The system operation is based on electromagnetic induction, where the induced voltage in the receiver coil depends on mutual inductance and operating frequency. The DC-DC converter regulates the output voltage based on duty cycle control, ensuring efficient energy transfer. The battery state of charge is continuously monitored to maintain safe charging conditions. MATLAB Simulink is used to model and simulate the system for performance evaluation.

5. Simulation and Results:

Simulation of the proposed system is carried out using MATLAB Simulink to analyze its performance under various operating conditions. The simulation model includes components such as the wireless power transfer system, DC-DC converter, battery model, and IoT monitoring interface. The results demonstrate stable voltage and current output, indicating effective energy transfer and regulation.

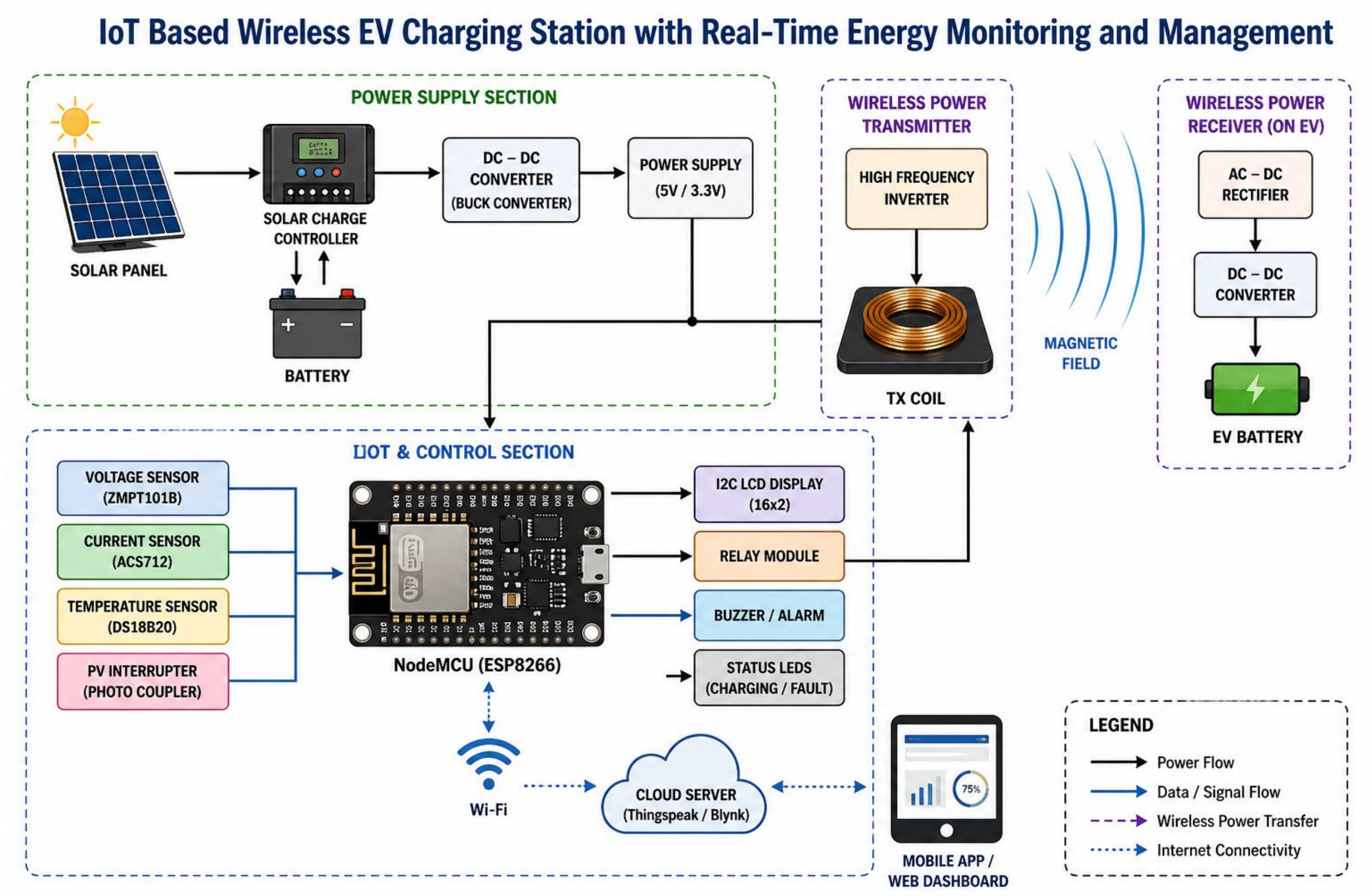
The system achieves an efficiency of more than 85% under normal operating conditions. Even under slight misalignment of coils, the system maintains acceptable performance, highlighting its robustness. The battery state of charge increases in a controlled manner, ensuring safe and efficient charging. Thermal analysis shows that temperature remains within safe limits due to effective battery management.

The IoT module successfully transmits real-time data to the cloud platform, enabling remote monitoring and analysis. The integration of solar energy further improves system performance by reducing grid dependency. Simulation results indicate that solar contribution can significantly lower energy consumption from conventional sources, enhancing sustainability.

6. Hardware and Software Implementation:

The hardware implementation of the proposed system includes components such as NodeMCU (ESP8266), voltage and current sensors, wireless charging coils, solar panels, and a battery system. The NodeMCU module serves as the central controller and communication unit, enabling data transmission to the cloud.

The software is developed using Arduino IDE and Embedded C programming. The program is responsible for sensor data acquisition, processing, and communication. Real-time data is displayed on a cloud platform, allowing users to monitor system performance remotely. The system operates automatically, ensuring efficient and reliable charging without manual intervention.



7. Results and Discussion:

The proposed IoT-based wireless EV charging system offers significant advantages over conventional charging methods. The elimination of physical connectors reduces wear and improves safety. Real-time monitoring enables intelligent control and efficient energy management. The integration of solar energy enhances sustainability and reduces operational costs.

The system demonstrates high efficiency, stable operation, and reliable performance under different conditions. The use of IoT technology improves user experience by providing remote access and real-time updates. Overall, the proposed system addresses the limitations of traditional charging infrastructure and provides a smart and scalable solution for modern EV charging requirements.

8. Conclusion and Future Scope:

This paper presents an IoT-based wireless EV charging system with real-time energy monitoring and renewable energy integration. The system improves efficiency, safety, and user convenience while supporting sustainable energy practices. The combination of wireless power transfer, IoT technology, and solar energy provides a comprehensive solution for modern EV charging challenges.

Future work can focus on enhancing system performance through dynamic wireless charging for moving vehicles, integration with smart grid systems, and the use of artificial intelligence for energy optimization. These advancements will further improve the efficiency and scalability of EV charging infrastructure, supporting the global transition toward clean and sustainable transportation.

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