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Solar Powered Wireless Electric Vehicle Charging Station

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Abstract: The rapid growth of electric vehicles (EVs) has increased the demand for efficient, safe, and sustainable charging infrastructure. Conventional EV charging systems rely heavily on grid power and wired connections, which may lead to increased energy consumption, higher operational costs, and safety concerns such as electrical wear and spark hazards. To address these challenges, this project presents the design and implementation of a Solar-Powered Smart Wireless EV Charging Station with IoT Monitoring. The proposed system utilizes solar energy as the primary power source, ensuring clean and renewable energy utilization.

A solar panel array configured in series-parallel combination supplies power to the system, which is regulated using a Maximum Power Point Tracking (MPPT) charge controller. The MPPT module acts as a smart DC-DC voltage regulator, optimizing power extraction from the solar panels while protecting the battery bank. A 12.6 V Battery Management System (BMS) is employed to safely manage charging and discharging of the lithium-ion battery bank, providing protection against over-voltage, undervoltage, over- current, and cell imbalance.

Wireless charging is implemented using a wireless power transfer module based on electromagnetic induction. When a vehicle is placed on the charging platform, power is transferred wirelessly without physical connectors, improving safety, reliability, and user convenience.

The system automatically detects vehicle presence using infrared sensors and initiates charging accordingly, minimizing energy wastage. An ESP32 microcontroller serves as the central controller, handling sensor data acquisition, control logic, relay operation, LCD display updates, and wireless communication. System parameters such as solar voltage, temperature, humidity, EV charging status, and street-light operation are monitored and displayed in real time using the Blynk IoT platform, enabling remote supervision. Additionally, an automatic solar-based street-lighting feature is incorporated to enhance energy efficiency during nighttime conditions.

Keywords: wireless charging, ESP32 Microcontroller, MPPT, Blynk IoT platform

I. INTRODUCTION

The rapid growth of electric vehicles (EVs) has increased the demand for efficient and sustainable charging systems. Conventional EV charging stations rely heavily on grid electricity and wired connections, which lead to higher energy consumption, safety concerns, and limited automation. To address these challenges, renewable energy–based and intelligent charging solutions are required. Solar energy is a clean and widely available renewable resource that can be effectively used for EV charging applications. However, efficient utilization of solar power requires proper voltage regulation, energy storage, and system monitoring. Wireless charging technology further enhances safety and convenience by eliminating physical connectors and reducing mechanical wear and electrical hazards.

This project presents a Solar-Powered Smart Wireless EV Charging Station with IoT Monitoring**.** The system uses a solar panel array with an MPPT controller for optimal power extraction, a lithium-ion battery bank with a 12.6 V BMS for safe energy storage, and an ESP32 microcontroller for automation and control. Wireless power transfer based on electromagnetic induction is used for contactless EV charging, while vehicle presence detection enables automatic operation.

An IoT platform is integrated to monitor system parameters such as solar voltage, charging status, and environmental conditions in real time. The proposed system offers an eco-friendly, safe, and intelligent EV charging solution suitable for smart campuses and future smart-city applications.

II. LITERATURE REVIEW

The increasing use of electric vehicles (EVs) has created a need for efficient, safe, and eco- friendly charging systems. Many researchers have worked on improving EV charging technologies using renewable energy, wireless power transfer, and IoT systems.Several studies focus on solar-powered EV charging systems.

Researchers have shown that solar energy is a clean and renewable source that can reduce dependency on fossil fuels and grid electricity. However, solar energy has limitations such as variation in sunlight and efficiency issues. To overcome this, MPPT (Maximum Power Point Tracking) techniques are widely used. MPPT helps in extracting maximum power from solar panels and improves overall system efficiency.

Wireless power transfer (WPT) is another important area of research. Traditional wired charging systems have problems like cable wear, electric shock risk, and maintenance issues. Wireless charging, based on electromagnetic induction, provides a safer and more convenient solution. Studies show that wireless charging reduces mechanical losses and improves user comfort, but it suffers from lower efficiency and alignment issues between transmitter and receiver coils.

Battery storage systems are also an essential part of EV charging. Researchers have highlighted the importance of Lithium-ion batteries due to their high energy density and long life. A Battery Management System (BMS) is required to protect batteries from overcharging, over- discharging, and overheating. Proper battery management improves safety and increases battery lifespan.Recent research also focuses on IoT-based smart charging systems. IoT platforms allow real-time monitoring of parameters such as voltage, temperature, charging status, and energy usage.

Microcontrollers like ESP32 are commonly used due to their built-in Wi-Fi capability and low power consumption. These systems help in automation, remote monitoring, and efficient energy management.

Some researchers have combined solar energy, wireless charging, and IoT into a single system. These integrated systems are suitable for smart cities, parking areas, and campuses. However, challenges such as high initial cost, low wireless charging efficiency, and dependence on solar availability still exist. From the reviewed literature, it is clear that integrating solar power, wireless charging, battery management, and IoT can create a smart and sustainable EV charging system. This project builds upon these concepts and aims to provide an efficient, automated, and eco-friendly solution.

III. PROBLEM STASTMENT

The increasing adoption of electric vehicles has created a strong need for reliable and sustainable charging infrastructure. Most existing EV charging systems depend on conventional grid electricity and wired charging methods, which result in high energy consumption, increased operational costs, and safety risks such as electric shock, sparking, and connector wear.

Additionally, traditional charging stations require manual supervision and lack intelligent control features such as automatic vehicle detection, optimized energy usage, and real-time monitoring. The absence of renewable energy integration further increases the carbon footprint and limits the scalability of EV charging solutions.

Another major challenge is the inefficient utilization of solar energy due to voltage fluctuations, improper battery management, and lack of power regulation. Without proper monitoring and control, energy wastage and battery damage may occur.

Therefore, there is a need for a smart, solar-powered, wireless EV charging system that can automatically detect vehicle presence, safely regulate power, efficiently store energy, and provide real-time monitoring through IoT, while minimizing human intervention and improving overall system safety and efficient.

IV. METHODOLOGY

The development of the Solar Powered Wireless EV Charging Station was carried out using a systematic and step-by-step approach to ensure safe operation, efficient energy utilization, and reliable system performance. The complete methodology is explained as follows:

1) System Design and Planning: The project began with a detailed study of EV charging systems, solar power generation, wireless power transfer, and IoT-based monitoring. Based on this study, a block diagram was designed to define the interaction between the solar panel, MPPT controller, battery bank, wireless charging module, ESP32 controller, sensors, and IoT platform.
2) Solar Power Generation: A solar panel array was constructed using multiple solar panels connected in series and parallel combinations to obtain the required voltage and current. The generated solar energy acts as the primary power source for the system.
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4) Voltage Regulation using MPPT: The output of the solar panel is connected to a 12V MPPT charge controller. The MPPT acts as a smart DC–DC voltage regulator that optimizes power extraction from the solar panel and safely regulates the voltage before charging the battery bank.

5) Battery Bank and Protection: A 12.6V lithium-ion battery bank is formed using 3.7V cells connected in series. A 12.6V Battery Management System (BMS) is used between the MPPT and the battery bank to provide over-charge, over-discharge, short-circuit, and cell balancing protection.
6) DC-DC Buck Conversion: The battery bank supplies 12V DC, which is stepped down to 5V using a DC-DC buck converter. This regulated 5V supply is used to power the wireless charging transmitter module and other low-voltage electronics.
7) Wireless Power Transfer: Wireless charging is implemented using electromagnetic induction. When an EV model is placed on the charging platform, energy is transferred from the transmitter (TX) coil to the receiver (RX) coil without physical contact, ensuring safe and spark-free charging.
8) Vehicle Detection and Automation: IR sensors are installed on each charging platform to detect vehicle presence. The ESP32 controller processes sensor inputs and automatically enables or disables charging relays, eliminating manual intervention.
9) Microcontroller and IOT Integration: The ESP32 microcontroller acts as the main controller of the system. It monitors solar voltage, battery status, temperature, humidity, and charging states. All important parameters are sent to the Blynk IoT platform using Wi-Fi for real-time monitoring.
10) Display and Alert System: A 16×2 LCD displays system status such as solar voltage, charging state, battery charging.
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17) Vehicle Detection and Automation: IR sensors are installed on each charging platform to detect vehicle presence. The ESP32 controller processes sensor inputs and automatically enables or disables charging relays, eliminating manual intervention.
18) Microcontroller and IOT Integration: The ESP32 microcontroller acts as the main controller of the system. It monitors solar voltage, battery status, temperature, humidity, and charging states. All important parameters are sent to the Blynk IoT platform using Wi-Fi for real-time monitoring.
19) Display and Alert System: A 16×2 LCD displays system status such as solar voltage, charging state, battery charging indication, and EV availability. LEDs and a buzzer provide visual and audio alerts for charging and system events.
20) Street Light Automation: Based on the actual solar voltage, the system automatically controls street lights using relay logic. Lights turn ON during low solar voltage (night) and turn OFF when sufficient solar voltage is available (day).
21) Testing and Validation: Each subsystem was tested individually and then integrated into the complete system. The system performance was verified under different solar conditions and vehicle presence scenarios to ensure reliability and stability

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V. SYSTEM OVERVIEW

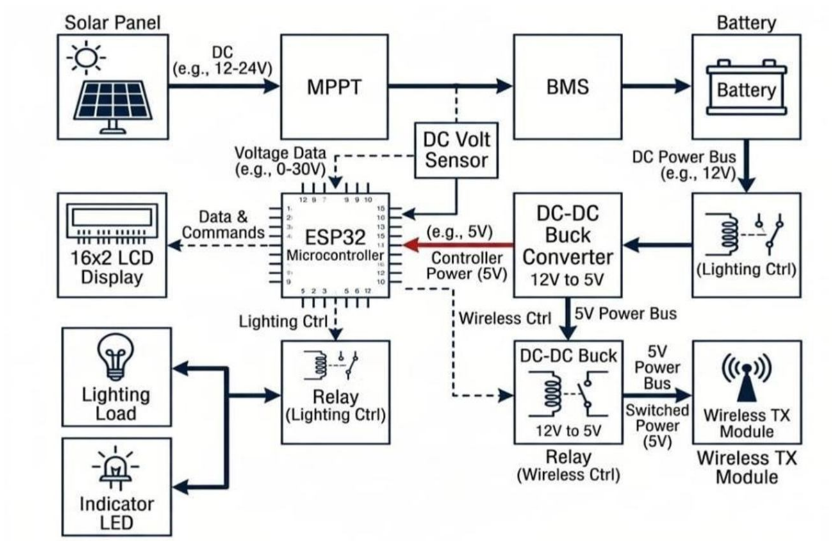

Fig 1: Block Diagram

The block diagram of the Solar Powered Wireless EV Charging Station represents the overall flow of power and control in the system.

Solar panels generate DC electrical energy, which is supplied to the MPPT charge controller. The MPPT regulates and optimizes the solar voltage and safely charges the battery bank. A 12.6V Battery Management System (BMS) is connected between the MPPT and the battery bank to protect the lithium-ion cells from overcharging, over-discharging, and imbalance.

The battery bank provides a stable 12V DC supply to the system. This voltage is stepped down to 5V using a DC-DC buck converter, which powers the wireless charging transmitter module and low-voltage electronics.

Wireless power transfer is achieved using a transmitter (TX) and receiver (RX) coil based on electromagnetic induction. When the vehicle is placed on the charging platform, power is transferred wirelessly to the receiver side.

The ESP32 microcontroller acts as the central control unit. It monitors solar voltage, battery status, vehicle presence using IR sensors, and environmental parameters such as temperature and humidity. Based on these inputs, the ESP32 controls relays for charging and street light automation.

A 16×2 LCD displays real-time system information, while LEDs and a buzzer provide status indications. Using Wi-Fi connectivity, the ESP32 sends system data to the Blynk IoT platform for remote monitoring and visualization.

VI. WORKING PRINCIPLE AND PROCESS

Fig 2: projrct photo

The Solar Powered Wireless EV Charging Station operates by integrating solar energy harvesting, battery energy storage, wireless power transfer, and IoT-based automation into a single smart system.

Solar panels generate DC electrical energy when exposed to sunlight. These panels are connected in a suitable series–parallel configuration to obtain the required voltage and current. The generated solar voltage is first regulated using an MPPT charge controller, which acts as a smart DC–DC regulator. It ensures maximum power extraction from the solar panels while protecting the battery bank from overvoltage.

After the MPPT controller, a 12.6 V Battery Management System (BMS) is connected to safeguard the lithium-ion battery bank. The BMS provides cell balancing, over-charge, over- discharge, and short-circuit protection, ensuring safe and reliable battery operation.

The stored 12 V DC energy from the battery bank is stepped down to 5 V DC using a DC–DC buck converter, which supplies power to the wireless charging transmitter (TX) module. The wireless charging system works on the principle of electromagnetic induction. The transmitter coil generates an alternating magnetic field, which induces an electric current in the receiver (RX) coil when an EV is placed on the charging platform.

Vehicle presence on the charging platform is detected using IR sensors. Once a vehicle is detected, the ESP32 microcontroller activates the relay to enable wireless charging automatically. Visual indicators and buzzer alerts provide charging status feedback.

Simultaneously, the ESP32 continuously monitors system parameters such as solar voltage, temperature, humidity, charging status, and street light operation**.** This data is displayed locally on an LCD and remotely on the Blynk IoT application through WiFi connectivity. Additionally the system controls automatic street lighting based on solar voltage levels, turning the lights ON during low solar conditions and OFF during sufficient daylight, thus minimizing energy wastage.

VII. FUTURE SCOPE

The Solar Powered Wireless EV Charging Station demonstrates a sustainable and intelligent charging solution. However, with further research and development, the system can be enhanced and expanded in several ways:

1) High-Power Wireless Charging: The current prototype supports low-power wireless charging suitable for demonstration and small EV models. In the future, high-power resonant wireless charging systems can be implemented to support real electric vehicles.
2) Fast Charging Capability: By integrating higher-rated MPPT controllers, advanced DC-DC converters, and fast- charging algorithms, the system can be upgraded to reduce charging time.
3) Grid–Solar Hybrid System: The project can be extended to operate in hybrid mode, where grid power automatically supports the system during low solar availability, ensuring uninterrupted charging.
4) Battery Health Monitoring: Advanced Battery Management Systems (BMS) with State of Charge (SoC) and State of Health (SoH) estimation can be integrated for improved battery life and safety.
5) User Authentication and Billing: RFID cards, mobile app authentication, or QR-based access can be added to enable controlled usage and energy billing for public charging stations.

VIII. CONCLUSION

The solar-powered wireless EV charging system presents an efficient and environmentally friendly solution for electric vehicle charging. By integrating solar photovoltaic technology with wireless power transfer, the system reduces dependence on conventional grid electricity and minimizes carbon emissions. The use of inductive coupling enables safe, contactless energy transfer, eliminating mechanical wear and reducing maintenance requirements. The proposed system demonstrates that renewable energy can be effectively utilized for wireless EV charging with proper power conditioning, control, and energy storage. Although wireless charging efficiency is lower compared to wired methods, advancements in power electronics and resonant coupling techniques can significantly improve performance. Overall, the solar-powered wireless EV charging system offers a sustainable, safe, and convenient approach for future EV infrastructure and supports the growing demand for clean transportation.

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REFERENCES

[1] S. M. G. Swathika, "IoT-Enabled Solar EV Charger with RSA-Based MPPT Controller," Frontiers in Energy Research, 2026.
[2] A. P. Adith et al., "Solar-Based Smart Charging Station with Wireless Power Transfer (WPT) for Electric Vehicles and Monitoring using IoT," IJRASET, 2025.
[3] P. Jain et al., "IoT-Based Wireless EV Charging System using Solar Energy," IJRASET, 2025.
[4] S. Chatterjee et al., "Solar Energy-Supported User-Friendly EV Charging Solution Based on IoT," Journal of The Institution of Engineers (India), 2024.
[5] S. A. Kashani et al., "State-of-the-Art Research on Wireless Charging of Electric Vehicles Using Solar Energy," Energies, 2023.
[6] Solar energy-powered wireless charging system for EV applications, Renewable Energy Journal, 2025.