iJRASET
International Journal For Research in
Applied Science and Engineering Technology

# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

**Volume:** 13 **Issue:** V **Month of publication:** May 2025

**DOI:** https://doi.org/10.22214/ijraset.2025.70637

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue V May 2025- Available at www.ijraset.com

# IoT-Based Wireless EV Charging System using Solar Energy

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***Abstract: This research presents a prototype of a wireless electric vehicle (EV) charging system that utilizes mutual induction and solar energy to charge a 3.7V (6600mAh) battery while monitoring key battery parameters. The system incorporates a battery monitoring system (BMS) powered by a NodeMCU ESP8266 microcontroller, which continuously tracks the state of charge, battery percentage, voltage, and environmental factors such as temperature and humidity during the charging process. The charging mechanism begins with a solar panel that charges a 12V main battery. This stored energy is then converted from 12V DC to 110V AC using a converter circuit, which supplies power to a set of transmitter coils embedded beneath a roadway platform. Through mutual induction, the receiver coil captures the transmitted energy. A TP4056 charging module then regulates the output to provide a stable 5V supply for efficient battery charging. To ensure real-time monitoring, a voltage divider circuit measures the battery voltage and transmits the data to the ESP8266 microcontroller, which displays the information on an OLED screen and sends updates to a Blynk IoT server. Additionally, a DHT22 sensor is integrated into the system to measure temperature and humidity levels, ensuring safe and efficient charging.***

***This prototype demonstrates a sustainable, wireless EV charging approach that leverages renewable energy and real-time monitoring, offering a promising step towards the future of smart and eco-friendly transportation.***

***Keywords: Wireless EV Charging, Mutual Induction, Solar Energy, Mutual Induction, Battery Monitoring System.***

## I. INTRODUCTION

The transportation sector remains a major contributor to greenhouse gas emissions, heavily relying on fossil fuels. With the increasing demand for electric vehicles (EVs), the need for an efficient and convenient charging infrastructure is critical. Traditional wired charging stations pose challenges in terms of safety, maintenance, and user convenience. Physical connectors are prone to wear and tear, reducing the lifespan of charging stations. Additionally, grid dependency increases carbon emissions if the electricity is sourced from non-renewable power plants. Wireless EV charging using mutual induction offers a transformative solution to these challenges. By eliminating the need for physical connectors, it reduces maintenance requirements and enhances the charging experience. Furthermore, integrating solar energy as the primary power source reduces reliance on fossil fuels, promoting a cleaner and greener environment. This paper introduces a comprehensive IoT-based wireless EV charging system using solar energy. The battery monitoring system (BMS) ensures the safe operation of the system by continuously tracking key battery parameters. With real-time data transmission through the Blynk IoT platform, users gain complete visibility over battery status, enhancing operational reliability. Through experimental results, this research validates the efficiency and feasibility of the proposed system.

## II.LITERATURE REVIEW

| S. No. | Title | Author Name | Content |
|---|---|---|---|
| 1. | Inductively Coupled Power Transfer for EV Charging | K. A. Kalwar, S. Mekhilef | Discusses the principles and efficiency of inductive power transfer systems for EVs. |
| 2. | Power-Efficient Wireless Monitoring System Using ESP8266 | J. Telicko, A. Jakovics | Presents a battery monitoring system using ESP8266 for real-time monitoring. |
| 3. | Wireless Charging of Electric Vehicles | V. Chandran, A. S. | Proposes a solar-powered road embedded with wireless chargers |

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|---|---|---|---|
| | Using Solar | | for dynamic charging. |
| 4. | Inductive Power Transfer for Moving Electric Vehicles | G. A. Covic, J. T. Boys | Explores the challenges and opportunities in dynamic wireless charging for moving vehicles. |
| 5. | IoT-Based Battery Management System for Electric Vehicles | M. Shah, P. Ahmed | Demonstrates an IoT-enabled battery management system for real-time data analysis. |
| 6. | Solar Panel Integration for Wireless EV Charging | H. Vidhya, U. Akshaya | Studies the efficiency improvements of integrating solar panels with wireless charging. |
| 7. | Impact of Environmental Factors on Solar PV Cell Performance | S. Jena, A. K. Naik | Examines the effects of temperature, humidity, and irradiance on solar panel performance. |
| 8. | GSM-Based Low-Cost Monitoring for Renewable Energy Systems | D. Gaurav, D. Mittal | Describes a low-cost GSM-based monitoring system for renewable energy applications. |

## III. DESIGN AND IMPLEMENTATION

The overall system consists of a solar power generation unit, a wireless power transmission system, a battery monitoring system (BMS), and an IoT-based monitoring and control module. The solar power system includes a solar panel that converts sunlight into electrical energy, which is then stored in a battery. An AC-DC converter ensures stable voltage output for the wireless charging system. The wireless power transmission system operates on the principle of mutual induction, where an inverter converts DC power into high-frequency AC, which is fed into the transmitting coil (primary coil). This creates an alternating magnetic field, which induces a current in the receiving coil (secondary coil) placed inside the EV. The received AC power is then rectified and regulated before reaching the battery for charging. The battery monitoring system (BMS) consists of sensors that continuously monitor battery parameters such as voltage, battery percentage, humidity, and temperature to prevent overcharging and overheating. A microcontroller processes this data and communicates with an IoT module, which transmits real-time battery health and charging status to a cloud-based or local dashboard.

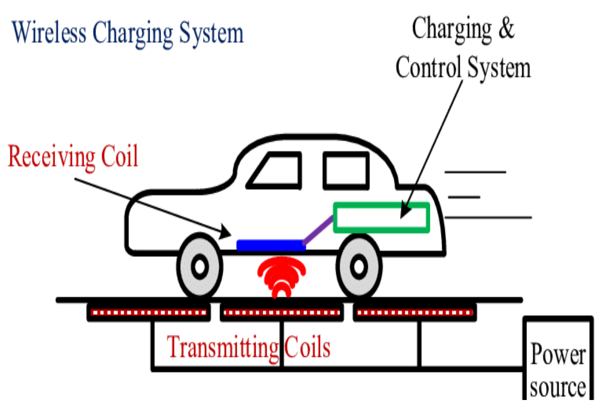


Fig. 1: Wireless EV charging through mutual induction

The fundamental building blocks that constitute the system are as follows:

*A. Solar Panel Array*

A Solar Panel Array is a system of multiple solar panels connected together to generate electrical energy from sunlight. In the context of Wireless EV Charging through Mutual Induction Using Solar with a Battery Monitoring System, the solar panel array plays a crucial role as the primary power source.

*B. Battery Storage Unit*

The Battery Storage Unit is a crucial component of the Wireless EV Charging through Mutual Induction Using Solar with a Battery Monitoring System. It ensures continuous and stable power availability by storing excess energy generated by the solar panel array for use during periods of low or no sunlight.

*C. Inverter Circuit*

In the Wireless EV Charging Through Mutual Induction Using Solar with a Battery Monitoring System. It is responsible for converting direct current (DC) power from the battery storage unit into alternating current (AC) power, which is required for the wireless power transfer (WPT) system.

*D. Wireless Charging Module*

Contains the transmitter and receiver coils. It enables contactless power transfer from the charging station to the electric vehicle (EV) battery using mutual induction.

*E. Battery Monitoring System (BMS)*

The battery monitoring system (BMS) consists of sensors that continuously monitor battery parameters such as voltage, battery percentage, humidity and temperature to prevent overcharging and overheating. A microcontroller processes this data and communicates with an IoT module, which transmits real-time battery health and charging status to a cloud-based or local dashboard. Users can monitor system performance remotely.

*F. Load (EV Battery)*

The EV battery is the final recipient of the wirelessly transmitted power.

## IV. HARDWARE AND COMPONENTS

*A. ESP 8266 Microcontroller*

The ESP8266 microcontroller is a highly integrated Wi-Fi-enabled system-on-chip (soc) designed for iot applications, making it an excellent choice for wireless communication in this project. It features a low-power 32-bit microprocessor, a built-in Wi-Fi module, and various GPIO pins for interfacing with sensors and other components. The ESP8266 supports multiple communication protocols such as UART, SPI, and I2C, allowing seamless integration with the Battery Monitoring System (BMS) to transmit real-time data on voltage, current, and temperature. Its built-in TCP/IP stack enables wireless connectivity, allowing remote monitoring and control of the charging process via a mobile app or cloud server. The microcontroller is also energy-efficient, making it well-suited for solar-powered applications. With its cost-effectiveness, small form factor, and powerful processing capabilities, the ESP8266 enhances the automation and smart management of the wireless EV charging system, ensuring real-time tracking and efficient power distribution.

*B. Solar Panel*

A solar panel is a renewable energy device that converts sunlight into electrical energy using photovoltaic (PV) cells. These cells are made of semiconductor materials, typically silicon, which generate electricity when exposed to sunlight through the photovoltaic effect. In this project, the solar panel array serves as the primary energy source for the wireless EV charging system, ensuring sustainability and reducing reliance on conventional grid power. The generated DC electricity is regulated by a charge controller, which optimizes power flow and protects the battery from overcharging. Depending on the type of solar panel used, such as monocrystalline, polycrystalline, or thin-film, efficiency and power output may vary. The selection of a high-efficiency solar panel enhances system performance, ensuring continuous and reliable power supply for wireless energy transfer and battery charging.

*C. Power Converter*

A power converter device that converts DC (Direct Current) to AC (Alternating Current) is an essential component in the wireless EV charging system. This device, commonly known as an inverter circuit, is responsible for transforming the DC power stored in the battery storage unit into high-frequency AC, which is necessary for wireless power transmission through mutual induction.

The inverter typically consists of MOSFETS (Metal-Oxide-Semiconductor Field-Effect Transistors) or IGBTS (Insulated-Gate Bipolar Transistors) that switch the DC input at high speeds, generating an AC output. This alternating current is then supplied to the transmitter coil in the wireless charging module, creating a fluctuating magnetic field that induces power transfer to the receiver coil in the EV. The efficiency of the inverter plays a critical role in minimizing energy losses and ensuring a stable and reliable charging process. Additionally, advanced inverters may include PWM (Pulse Width Modulation) control for improved efficiency and protective circuits to prevent voltage fluctuations, overheating, and short circuits. By integrating a high-performance DC-AC converter. The power converter used in the project takes 12V DC as Input and give supply of 110v AC.

### *D. Battery*

A battery is a crucial component in an electric vehicle (EV), serving as the primary energy storage unit that powers the motor and other vehicle functions. In this wireless EV charging system, the battery receives power through mutual induction between the transmitter and receiver coils, eliminating the need for physical charging cables. The battery used in evs is typically a Lithium-Ion (Li-Ion) battery, known for its high energy density, long lifespan, and efficiency. To ensure safe and optimal charging, a Battery Monitoring System (BMS) is incorporated, which tracks critical parameters such as voltage, current, temperature, and state of charge (soc). This prevents overcharging, deep discharging, and overheating, thereby extending battery life and enhancing performance. The integration of a solar-powered charging system further promotes sustainability by using renewable energy to charge the battery, reducing dependence on conventional electricity sources. The combination of efficient battery storage, wireless charging, and solar energy makes this system a smart, eco-friendly, and future-ready solution for modern EV technology.

### *E. Coils*

Coils play a fundamental role in the wireless EV charging system, enabling power transfer through mutual induction. The system consists of two primary coils: the transmitter coil and the receiver coil. The transmitter coil is embedded in the charging pad, which is connected to an inverter circuit that converts DC power into high-frequency AC. When current flows through the transmitter coil, it generates a changing magnetic field. This magnetic field induces an electromotive force (EMF) in the receiver coil, which is installed on the EV. The induced AC voltage in the receiver coil is then rectified and regulated to provide DC power for charging the battery. The efficiency of power transfer depends on factors such as coil alignment, resonance tuning, and coil design. By optimizing the coil structure, such as using high-permeability core materials and resonance compensation techniques, the system can achieve higher efficiency and reduced energy losses, making wireless charging more effective and reliable.

### *F. TP 4056 Charging Module*

The TP4056 charging module is a compact, efficient, and highly reliable lithium-ion battery charging controller that ensures safe and stable charging. It is commonly used for single-cell Li-Ion or Li-Polymer batteries and features a constant current (CC) and constant voltage (CV) charging mode for optimal performance. The module includes an integrated protection circuit, preventing overcharging, over-discharging, and short circuits, which enhances battery longevity and safety. Equipped with a micro-USB or Type-C input, it efficiently regulates the charging process while maintaining a stable 4.2V output. The TP4056 also supports automatic charge termination when the battery reaches full capacity, preventing overheating or battery degradation. Due to its cost-effectiveness, ease of use, and high efficiency, the TP4056 is widely used in battery-powered projects, making it a vital component in energy storage systems.

### *G. OLED Display*

An OLED (Organic Light Emitting Diode) display is a high-contrast, energy-efficient screen technology that is widely used in embedded systems for real-time data visualization. In this wireless EV charging system, the OLED display serves as a key interface for monitoring battery parameters, including voltage, current, temperature, and state of charge (soc). Unlike traditional lcds, OLED displays do not require a backlight, making them brighter, thinner, and more power-efficient. They offer sharp visibility even in low-light conditions, which is beneficial for outdoor or automotive applications. The display is typically controlled using an NODEMCU ESP 8266 microcontroller via I2C communication, ensuring seamless integration with the Battery Monitoring System (BMS). With its compact size, low power consumption, and high-resolution output, an OLED display enhances the usability and efficiency of the EV charging system by providing real-time feedback on charging status, battery health, and system performance.

### H. IR Sensor

An Infrared (IR) sensor is an electronic device that detects infrared radiation emitted by objects and is widely used in automation and sensing applications. In this project, an IR sensor can be utilized for vehicle detection and alignment, ensuring proper positioning of the EV over the wireless charging pad. It consists of an IR transmitter and receiver; the transmitter emits infrared light, which reflects off an object and is detected by the receiver. Based on the reflected signal, the system determines the presence or distance of an object. This functionality enhances the efficiency of wireless power transfer (WPT) by ensuring optimal alignment between the transmitter and receiver coils. Additionally, IR sensors can be used for safety mechanisms, detecting foreign objects or obstructions on the charging pad to prevent interference. Due to their low power consumption, quick response time, and reliability, IR sensors are an essential component in modern wireless charging and automation systems.

### I. Relay

A relay used with an IR sensor acts as an automatic switch that controls high-power devices based on the sensor's detection. In this project, the IR sensor detects the presence of an EV over the charging pad, and the relay is triggered to activate or deactivate the wireless charging system accordingly. When the IR sensor detects the vehicle, it sends a signal to the relay module, which then completes the circuit, allowing power to flow to the wireless charging transmitter. If the EV moves away or is not properly aligned, the relay disconnects the power supply, preventing energy wastage and ensuring safety. The relay provides electrical isolation, allowing a low-power IR sensor to control high-power components like the wireless charging circuit. This integration enhances automation, reduces manual intervention, and improves the efficiency and reliability of the charging system.

## V. CASE STUDY

The increasing adoption of electric vehicles (EVs) necessitates efficient and sustainable charging solutions. Traditional wired charging methods rely on grid power, contributing to fossil fuel dependence and requiring physical connectors prone to wear and tear. To address these challenges, this study explores a wireless EV charging system that utilizes mutual inductance for power transfer, is powered by solar energy, and integrates an IoT-based battery monitoring system using the ESP8266 microcontroller. The wireless charging system operates using a primary coil connected to a solar power source, generating an alternating magnetic field that induces current in a secondary coil embedded in the EV. An H-bridge inverter converts direct current (DC) from the solar panels into high-frequency alternating current (AC), optimizing power transfer efficiency. The proposed system was implemented and tested under various environmental conditions. The following table presents key experimental data:

| S. No. | Parameter | Value | Unit |
|---|---|---|---|
| 1. | Battery Voltage | 3.6 | V |
| 2. | Battery Current | 2 | A |
| 3. | Transmitter Coil Voltage | 110v | V (AC) |
| 4. | Transmitter Coil Current | 0.91 | A |
| 5. | Receiver Coil Voltage | 8-11 | V (AC) |
| 6. | Receiver Coil Current | 0.56 | A |
| 7. | Battery Temperature | 36 | °C |
| 8. | Humidity | 60 | % Ah |
| 9. | Charging Time | 10 | Hrs. |
| 10. | Charging Efficiency | 5-10 | % |

The results indicate an energy transfer efficiency of 5 to 10 %, demonstrating the system's effectiveness. The battery monitoring system successfully tracked and displayed real-time data on the Blynk Server.

## VI. CONCLUSION

In Conclusion, this Research Paper highlights the wireless charging of a 3.7V battery using solar while monitoring the battery conditions like battery voltage, battery percentage, temperature and humidity of the battery using ESP 8266 microcontroller which monitors battery conditions like battery voltage, battery percentage, temperature and Humidity which regularly send its data to blynk Iot server using inbuilt Wi-Fi in the ESP 8266 Processor.

In the project firstly we are collecting solar energy through solar panel that stores the energy in a 12V battery and then this DC supply is converted to AC by a Inverter circuit which transmits the transmission coils built on the track then the supply is received by receiver coil placed below the EV prototype then that supply through the receiver coil is converted to AC and charges the batteries using TP 4056 charging Module.

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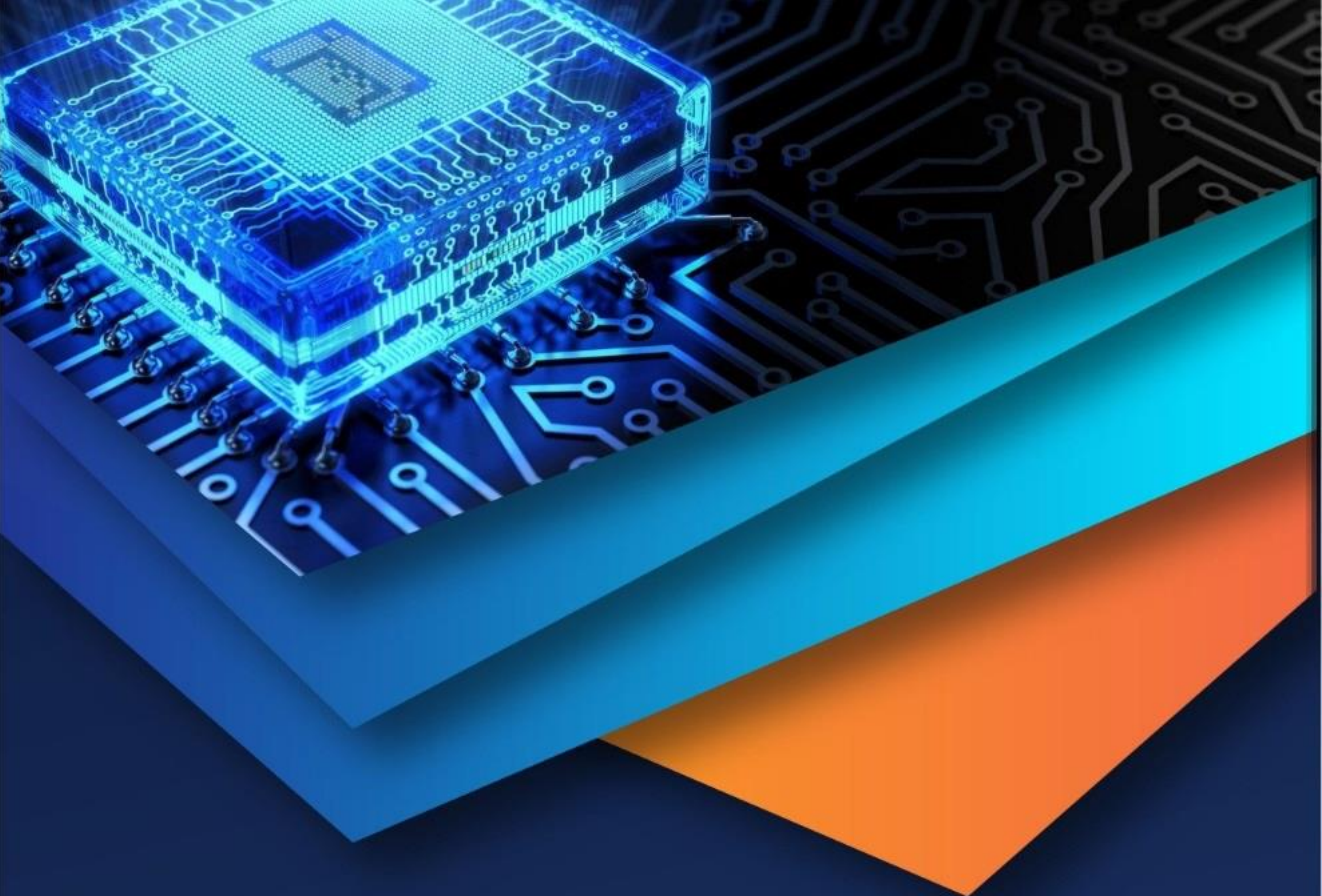


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