JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Wireless EV Charging Station Using Solar Energy

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Abstract: *This project designs a Wireless Solar EV Charging Station with IoT integration, catering to the rising demand for sustainable EV solutions. By combining solar energy with wireless charging technology, it offers convenience and eco-friendliness. Key features include real-time monitoring, smart grid integration, and robust security measures. The project provides hands-on experience in embedded systems, IoT, wireless communication, and renewable energy integration, fostering interdisciplinary collaboration for sustainable technology solutions.*

Index Terms – Electric Vehicle, EV, Solar, Wireless Charging System, Arduino, Internet of Things, ESP

1. INTRODUCTION:

In today's world, sustainable technologies are crucial for creating a greener future, and the combination of renewable energy and electric vehicles (EVs) is a prime example of innovation. [1] Electric vehicles (EVs) are expected to make up 24% of the U.S. light vehicle fleet by 2030, accounting for 64% of light vehicle sales that year. Therefore, it is crucial to manage EV battery charging to maintain stable power quality in the electrical grids. [2] Transportation is responsible for 64% of global oil consumption, making it the largest sector in terms of energy usage. With the world population expected to reach up to 10 billion by the end of the century, energy demand is projected to rise accordingly. [3] An excellent solution to wireless charging is the ability to charge your vehicle while on the go. However, charging on the go can be susceptible to damage. Our project aims to reduce the risk of constant electric part replacements. [4] By utilizing wireless charging stations, we can reduce electricity loss and make the charging process more efficient by integrating renewable energy sources with IoT. [5] To facilitate the collection and display of data from various sensors, we can use the Arduino Uno R3 integrated with the ESP8266 Wi-Fi module. This setup enables us to monitor the health of the charging system and make the data collected easily accessible.

The main objective behind the development of this project is to introduce an intelligent EV car charging system. With the help of renewable energy sources and an authorization system, we aim to enhance the electric flow and overall efficiency, taking a significant step towards building a healthier environment. Machine Learning (ML) plays a crucial role in this project, especially in controlling and authorizing the current flow to the vehicle, which minimizes energy waste. Our system analyzes the data and calculates the average time required by each Electric Vehicle to charge completely.

2. LITERATURE REVIEW

Table 1 Survey of Existing System

Sr no.	Title	Methodology	Advantages
1	Solar Wireless Electric Vehicle Charging System Using ESP32. Year: 2023 [4]	The project is using electromagnetic induction technique for the wireless transfer of electricity to the vehicle. The principle used to achieve wireless solar charging is Inductive Power transfer.	The efficiency of the Inductive Power Transfer method is high with a rate of 85%.
2	Wireless Charging of Electric Vehicles Using Solar Road Year: 2022 [2]	The system demonstrates how electric vehicles can be charged while moving on the road, eliminating the need to stop for charging. Thus the system demonstrates a solar powered	This EV charging of vehicles without any wires, No need of stop for charging, vehicle charges while moving, Solar power for keeping the charging system going, No external

		wireless charging system for electric vehicles that can be integrated in the road.	power supply needed. monitor their crop on smartphones or on computers.
3	Dynamic Wireless Charging of Electric Vehicles with a Metering System. Year: 2023 **[6]**	The proposed system includes a control algorithm that ensures that only authorized vehicles can pierce and use the transmitted power.	This EV charging of vehicles without any wires, No need of stop for charging, vehicle charges while moving, Solar power for keeping the charging system going, No external power supply needed.
4	Design and analysis of a solar-powered electric vehicle charging station for Indian cities Year: 2023 [7]	an electric vehicle charging station is created using an Arduino microcontroller, wireless charging coil modules, a solar panel, and an ESP32 Wi-Fi module.	Arduino in this module acts as the brain of the module and controls the power flow to the vehicle.
5	SPBCSEV: Solar Power Based Charging Station for Electric Vehicles. Year: 2023 [8]	Other sonar magnetic field produced by the wireless power; the waste of electrical energy is also reduced. The receiver uses the same principle as the radio receiver, where the device must be within range of the transmitter. The system consists of a wireless power transmitter and receiver with a magnetic loop antenna tightly tuned to the same frequency	By the use of resonant electric field the waste of electrical energy is reduced.

2.2 SUMMARY OF LITERATURE SURVEY

Table 1 is summary of study related to existing systems. Based on this survey, following are some observations enlisted.

- EV charging of vehicles have limited accessibility, dependence on the grid, and the need for wired connections.[1,2,4,5]
- Various methods of charging are used such as Inductive Power transfer [4], solar road [2] and other IoT techniques.
- Initial Investment and Affordability: High upfront costs can be prohibitive, particularly for small-scale farmers, limiting their ability to access new technologies [7,8].

We need to design system to overcome the limitations of existing system.

3. PROBLEM STATEMENTS AND OBJECTIVES

3.1 Problem Statements

In today's rapidly evolving world, the increasing demand for sustainable transportation solutions has led to the widespread adoption of Electric Vehicles (EVs). However, the existing EV charging infrastructure faces challenges such as limited accessibility, dependence on the grid, and the need for wired connections. This project aims to address these issues by developing a Wireless Solar EV Charging Station with Arduino Uno R3 integration. The primary goal is to create an efficient and eco-friendly charging solution that harnesses solar energy to power electric vehicles. The integration of ESP8266, a powerful microcontroller, will enable smart and seamless communication between the charging station and the EV. This connectivity will not only allow users to monitor and control the charging process remotely but also facilitate real-time data exchange for optimal energy management. The project will delve into the design and implementation of a wireless charging system that utilizes solar panels to harvest energy from the sun. The Arduino Uno R3 will play a crucial role in managing the wireless communication protocols and ensuring the secure and efficient transfer of power from the solar panels to the electric vehicle. Additionally, the system will be designed with scalability in mind, allowing for future expansion and integration with the Internet of Things (IoT) ecosystem

3.2 Objectives

1. To Implement IoT infrastructure: Set up a network of interconnected IoT devices to collect real-time data on various aspects like data analysis, data visualization, etc.

2. To Design smart interventions: Create and implement responsive solutions based on AI and ML insights to enhance urban planning, energy efficiency, and overall infrastructure development.
3. To Measure and assess impact: Evaluate the efficacy of implemented smart solutions through measurable indicators like energy savings, reduced traffic congestion, optimized resource utilization, and improved quality of life for urban inhabitants.

4. PROPOSED SYSTEM

4.1 SYSTEM ARCHITETURE

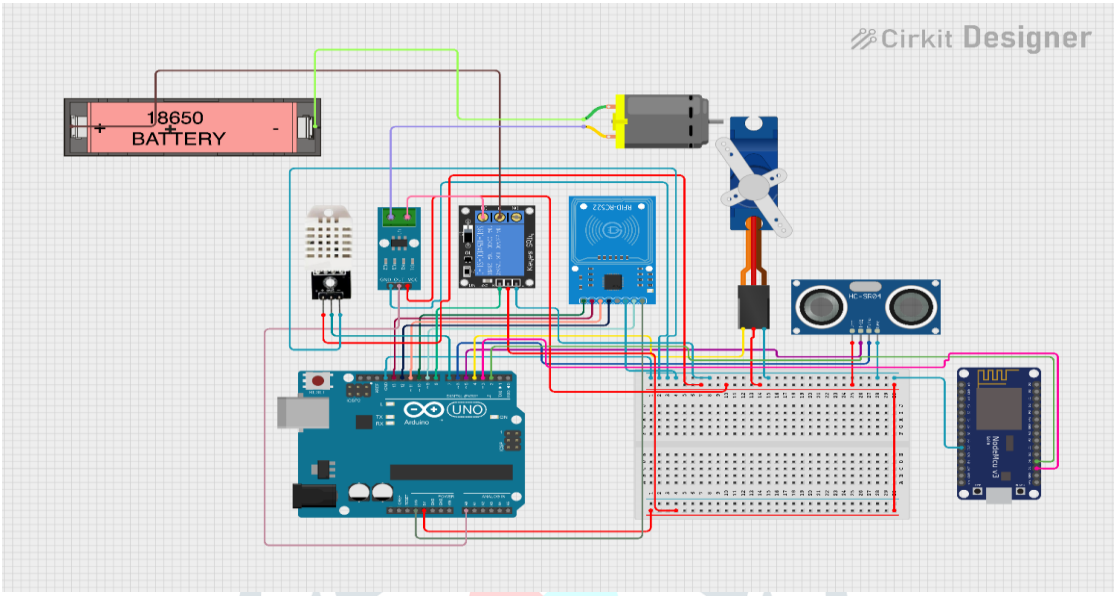


Fig 1 System Architecture

As shown in Fig 1, The NodeMCU is connected to the Arduino Uno R3 to upload the data collected from various sensors. These sensors include a Current Sensor (plate_number_1), a Temperature and Humidity Sensor DHT22, and an Ultrasonic Sensor HC-SR04. The Arduino Uno R3 is powered by a 5V power supply, while the NodeMCU and the sensors are powered by the 3.3V power supply from the Arduino Uno R3. The data collected by the Arduino Uno R3 is then sent to the NodeMCU, which uploads it to Firebase and ThingSpeak for visualization and monitoring purposes.A 6V Solar Panel is connected as an input to the wireless charging system, which is connected to the current sensor. From the current sensor, it is connected to a relay, and from the relay to the Wireless Charging module. An RFID (plate_number_2) is attached for authentication purposes. The current will only pass through the relay to the charging coil if the RFID card is authorized.

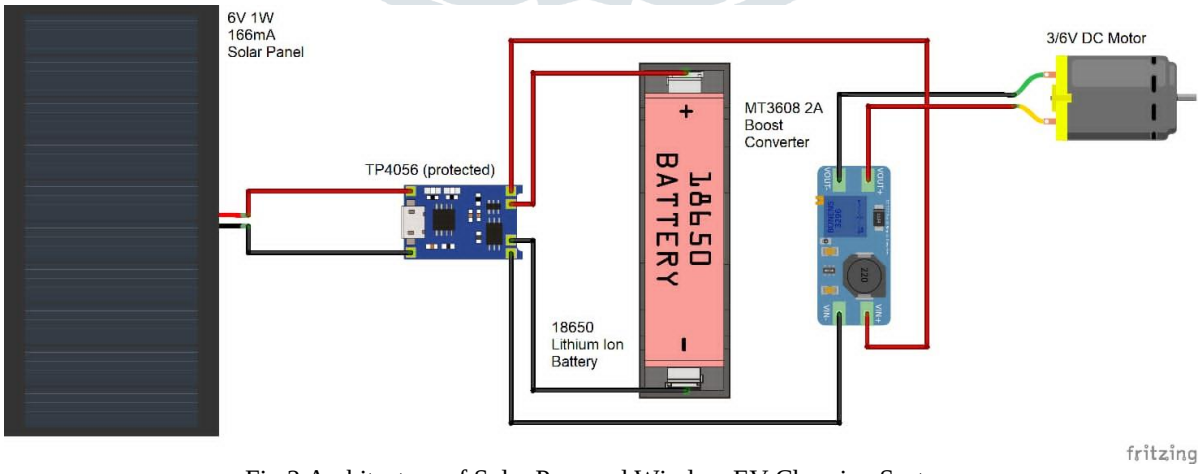


Fig 2 Architecture of Solar Powered Wireless EV Charging System

Fig 2 shows the architecture of Solar Powered Wireless EV Charging System. The tow systems are connected to monitor and control the EV charging automatically. Following steps are followed -

1. Initialize the system,
2. Connect to Wi-Fi and monitor sensors like Temperature, humidity, current, and ultraviolet.
3. Analyze data to make a visual representation of the collected data.
4. Repeat the cycle when a new car arrives, logging data and checking for maintenance.

5. Experimental Setup

5.1 IOT description:

This IoT project combines Arduino Uno R3 with RFID authentication, a relay-controlled charging process, and real-time current monitoring using the ASC712 sensor. The ESP8266 Module enables remote monitoring and control via web or mobile interfaces. Environmental conditions are monitored with the DHT22 sensor for comfort and energy efficiency, while an Ultrasonic Sensor detects nearby vehicles to activate the charging station automatically. Renewable energy is integrated through a Solar Panel to supplement power, supported by a Rechargeable Battery for continuous operation and backup power during outages. The Wireless Charging Module allows devices with compatible receivers to charge wirelessly, offering convenient and sustainable charging for electric vehicles and electronics. Together, these components create an advanced IoT system that optimises energy usage and enhances user experience.

6. Hardware and Software Requirements

6.1 Software requirement

Minimum software requirement –

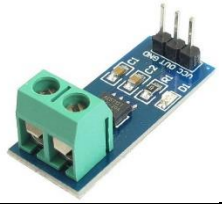
i. Operating System: Windows7 or higher versions

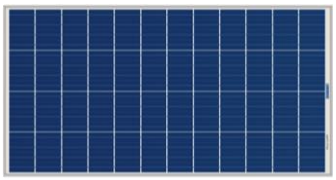
ii. Arduino IDE – Arduino IDE (Integrated Development Environment) is an open-source software platform used for writing, compiling, and uploading code to Arduino microcontrollers. It provides a user-friendly interface for programming Arduino boards.
ThingSpeak :ThingSpeak is an IoT platform developed by MathWorks (the company behind MATLAB) that allows users to collect, analyze, and visualize data from IoT devices in real-time.

iii. Visual Studio Code: Visual Studio Code (VS Code) is a free, open-source code editor developed by Microsoft that is known for its user-friendly interface and extensibility. It supports a wide range of programming languages and features a marketplace with thousands of extensions to customize its capabilities. The editor includes an integrated terminal, IntelliSense for code completion, and debugging tools. It also integrates with Git and other version control systems. VS Code offers themes, customization, and workspace management to enhance productivity. Collaboration is supported with extensions like Live Share, and you can work efficiently with code snippets and multiple cursors.

All the hardware requirements of this project are explained in detail in Table 2.

Table 2 List of Hardware Components

Component	Description
Arduino Uno R3 	Microcontroller board based on ATmega328P. Widely used for prototyping and DIY projects. The Arduino Uno R3 is a widely used microcontroller board based on the ATmega328P chip. It is a fundamental component in the Arduino ecosystem and is favored for its ease of use and versatility in prototyping and DIY electronics projects
RFID RC522 Reader Module 	The RFID RC522 is a low-cost, high-performance 13.56 MHz RFID reader/writer module that is widely used for contactless communication and access control applications. It supports the ISO/IEC 14443A standard for communication with RFID tags and cards. The module offers a simple interface for communication with a microcontroller using the Serial Peripheral Interface (SPI) protocol. RFID RC522 can read and write data to RFID cards and tags, making it suitable for projects involving identification, authentication, and tracking. Its popularity stems from its affordability, ease of use, and compatibility with various microcontrollers such as Arduino and Raspberry Pi.
Current Sensor ASC712 	Measures AC or DC current up to a specified range. Provides analog voltage output proportional to measured current. The Current Sensor ASC712 is a sensor module used for measuring AC or DC currents in electrical circuits. It provides an analog voltage output that is proportional to the current flowing through the sensor
Relay 	Electromechanical switch for controlling high-power devices with low-voltage signals from Arduino. A relay is an electromechanical device used in electronics and electrical circuits to control a high-power load (such as lights, motors, or appliances) using a low-power signal (from a microcontroller, sensor, or other electronic circuit). It works by using a small current to energize an electromagnet, which then mechanically switches a larger current to the load.
ESP8266 NodeMCU Module	The ESP8266 NodeMCU is a low-cost, open-source development board based on the ESP8266 Wi-Fi microcontroller. It combines the ESP8266 chip with a built-in USB interface, making it easy to program and connect to other devices. The board supports various programming languages, including Lua and Arduino, and features multiple GPIO pins for interfacing with

	sensors, actuators, and other components. ESP8266 NodeMCU offers Wi-Fi connectivity, making it ideal for Internet of Things (IoT) projects. Its affordability and versatility have made it a popular choice for hobbyists and developers working on wireless and networked applications.
DHT22 Sensor 	Temperature and humidity sensor. Provides accurate readings for environmental monitoring and control. The DHT22 sensor, also known as the AM2302, is a digital temperature and humidity sensor widely used in electronics and IoT applications. It provides accurate measurements of temperature and relative humidity, making it suitable for environmental monitoring and control.
Ultrasonic Sensor 	Uses sound waves to measure distance. Calculates object distance based on echo return time. An ultrasonic sensor is a device that uses sound waves at frequencies higher than the human audible range to measure distances to nearby objects. Ultrasonic sensors are commonly used in various applications, including robotics, automation, and proximity detection.
Solar Panel 	Converts sunlight into electrical energy. Used for charging batteries or powering electronic devices.
Rechargeable Battery 	Stores electrical energy for powering Arduino projects when not connected to a power source.
Wireless Charging Module 	Allows wireless charging of devices using electromagnetic induction. Ideal for mobile and IoT applications. A wireless charging module is a device that enables the wireless transfer of electrical power to compatible devices without the need for physical connections. It utilizes electromagnetic induction or resonance to transmit power wirelessly from a charging pad or transmitter to a receiver built into the target device.
Servo Motor 	A servo motor is an electromechanical device that allows precise control of angular position, speed, and torque. It consists of a motor, a position sensor (often a potentiometer), and a control circuit. Servo motors can rotate to a specified angle based on input signals, making them ideal for applications requiring accurate positioning, such as robotics, remote-controlled vehicles, and automated machinery. They come in various sizes and power ratings, providing a wide range of motion and speed control options for different tasks.

7. RESULTS

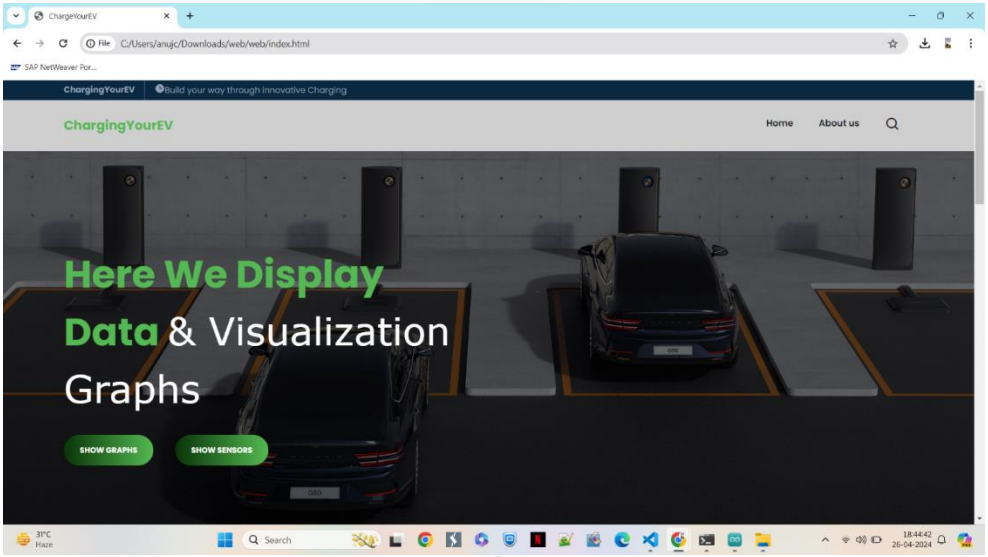


Fig 3 Home Page

Fig 3 displays the home page of the Wireless EV Charging Station Using Solar Energy. It is a web application, designed to display the sensor readings and the respective visualization buttons for the sensors. Fig 4 shows the screen of the web application showing different sensor readings from the Firebase Realtime Database which is a cloud-based platform that enables users to store and retrieve data. The Realtime Database also allows users to display real-time readings from attached sensors.

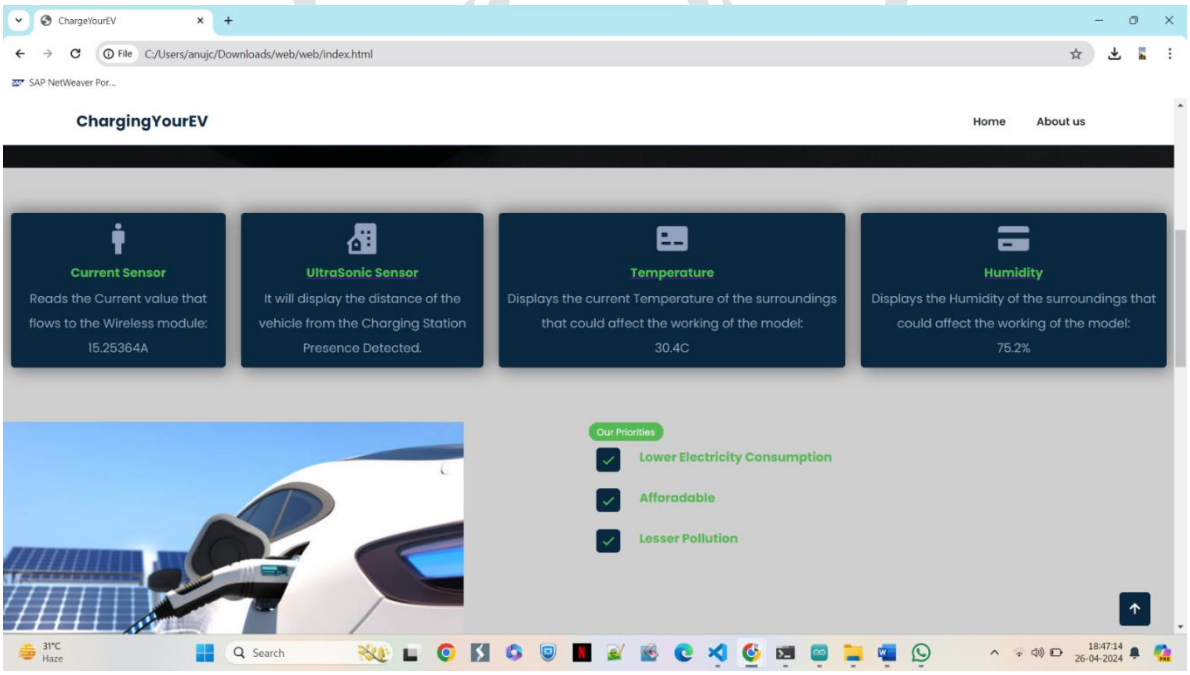


Fig 4 Sensor Readings, Collected from Firebase Realtime Database

Fig 5 ThingSpeak Visualization

Fig 5 shows the crucial part of the project which displays the overall live graph of the hardware components connected to the system. It allows us to monitor the system's health, and the working of the system. This graph helps us to monitor the system's health and functionality. It shows us the levels of humidity and temperature in the surrounding environment, which are key factors in determining the optimal conditions for the system to operate efficiently. High temperatures in the surrounding environment can have a negative impact on the system, which could lead to overheating and eventual breakdown.

8. Conclusion and future work

The development of Wireless Solar EV Charging Stations integrating Arduino Uno R3 technology signifies a pivotal step forward in sustainable transportation solutions. By leveraging renewable energy and IoT advancements, this initiative embodies a user-friendly and eco-conscious approach to electric vehicle charging. The incorporation of Arduino Uno R3 integrated with ESP32 enables seamless wireless communication, real-time monitoring, and remote control capabilities, optimizing efficiency and reliability. Users benefit from intuitive IoT interfaces for accessing charging data, monitoring energy usage, and scheduling charging sessions conveniently. This project epitomizes the potential of modern engineering to create smarter, greener infrastructure for electric vehicles, setting the stage for continuous innovation in sustainable transportation. As the global wireless electric vehicle charging market accelerates towards surpassing $825 million by 2027, driven by increasing adoption and environmental awareness, ongoing technological advancements like resonant electromagnetic induction and fast charging technologies promise enhanced accessibility and efficiency. The evolving landscape of static and dynamic wireless charging systems offers flexibility for EV users, supported by renewable energy integration that underscores the industry's commitment to sustainability. Overcoming challenges such as energy efficiency, infrastructure costs, and billing methods is imperative for widespread adoption, while strategic partnerships and collaborations among industry leaders are poised to propel innovation and refine wireless EV charging technologies, shaping a more sustainable future in transportation..

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