



## SMART EV CHARGING STATION ON GRID GREEN POWER AND WIRELESS CHARGING

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**Abstract** - The increasing demand for electric vehicles (EVs) has created the need for efficient, reliable, and eco-friendly charging infrastructure. Traditional charging systems rely heavily on grid electricity generated from fossil fuels, which contributes to environmental pollution and energy shortages. The proposed system, **Smart EV Charging Station on Grid Green Power and Wireless Charging**, aims to integrate renewable energy sources such as solar power with grid supply to provide sustainable and uninterrupted charging facilities.

This project utilizes green energy generation through solar panels and stores energy in batteries for continuous operation. The system also incorporates wireless charging technology, enabling EVs to charge without physical cable connections. A smart control unit manages energy flow between solar panels, battery storage, and grid supply, ensuring efficient power utilization.

The system enhances energy efficiency, reduces carbon emissions, and supports the transition toward clean transportation. It also improves user convenience and safety by enabling automated charging and monitoring. This project demonstrates the feasibility of combining renewable energy and wireless technology for modern EV infrastructure.

**Keywords:** Electric Vehicles, Wireless Charging, Solar Energy, Smart Charging Station, Green Power, Renewable Energy

### 1. INTRODUCTION

Electric vehicles (EVs) are modern transportation systems that use electrical energy to operate instead of conventional fossil fuels such as petrol and diesel. A smart electric vehicle charging station is an advanced infrastructure designed to supply electrical energy efficiently and safely to electric vehicles. These charging systems are becoming increasingly important due to their environmental benefits, low operating cost, and high energy efficiency, making them essential components in residential, commercial, and industrial applications. Electric vehicle charging stations have a wide range of uses, from small home charging setups to large public charging networks in cities and highways. Despite their advantages, electric vehicle charging systems can face several operational challenges under different environmental and power conditions.

Undetected faults or power interruptions can lead to charging failures, which present a significant problem in areas where electric vehicles are widely used. Charging system failures can cause delays in transportation, reduced user satisfaction, and increased operational costs. Therefore, it is necessary to develop reliable and efficient charging infrastructure to ensure

uninterrupted vehicle operation. Continuous monitoring and management of charging stations are essential to detect system issues at an early stage and take appropriate corrective actions promptly. Early detection of faults improves system efficiency, minimizes energy wastage, reduces maintenance and operational costs, extends the lifespan of system components, and enhances safety, resulting in improved overall system performance. The most common issues encountered in electric vehicle charging stations include power fluctuations, battery overcharging, overheating, voltage instability, and communication failures.

Renewable energy sources such as solar power have become an integral part of modern energy systems, offering sustainable and environmentally friendly solutions for electricity generation. Solar technology has evolved from simple energy generation systems to advanced smart energy management systems used for residential, commercial, and industrial applications. Solar energy is an ideal solution for powering electric vehicle charging stations because it reduces dependence on conventional power sources and lowers carbon emissions. In this study, renewable energy will be integrated with grid power to provide reliable and continuous energy supply for charging electric vehicles through a smart charging system.

The objectives of this study are as follows:

1. Develop a smart electric vehicle charging station using renewable energy sources such as solar power.
2. Design a system for monitoring voltage, current, and battery status to ensure safe and efficient charging.
3. Implement wireless charging technology to provide convenient and safe vehicle charging without physical connections.
4. Evaluate the system's performance and reliability to determine whether it effectively manages energy distribution and charging operations.

This study also aims to provide an improved and sustainable charging solution for electric vehicles, particularly in public charging stations, residential complexes, and commercial facilities. The charging system will focus on generating clean energy, storing power efficiently, and delivering electricity safely to electric vehicles. The operational conditions that will be tested include power availability, charging efficiency, system safety, and energy management performance.

### 2. Related works

Electric vehicle charging stations are increasingly being adopted worldwide due to the growing demand for clean and sustainable transportation systems [1]. During the operation of these charging stations, various technical challenges and power

management issues can occur [2]. One such issue is power overload, which happens when the charging system draws more electrical power than its designed capacity. This condition can lead to excessive heat generation in cables and charging components, increasing the risk of equipment damage and reduced system efficiency. The overload protection limit is generally set slightly above the rated operating current to ensure safe operation of the charging station [2]. Conversely, insufficient power supply occurs when the available electrical energy is lower than the required demand in the charging system [3]. Overvoltage is another problem that occurs when the supply voltage exceeds the rated value of the charging equipment. This condition can increase current flow and stress on the electrical insulation of charging components due to excessive heat dissipation. Conventional charging systems use voltage protection circuits to safeguard the equipment from damage caused by high voltage conditions [1]. On the other hand, undervoltage occurs when the charging station receives a lower voltage supply than expected. Undervoltage can cause inefficient charging performance, increased current consumption, and overheating of electrical components [4]. Traditional systems use voltage regulators and protection relays, but these systems often require delay mechanisms to prevent unnecessary shutdowns caused by temporary voltage fluctuations. These mechanisms depend on sensitive electronic devices and proper calibration for accurate operation.

### 3. Methodology

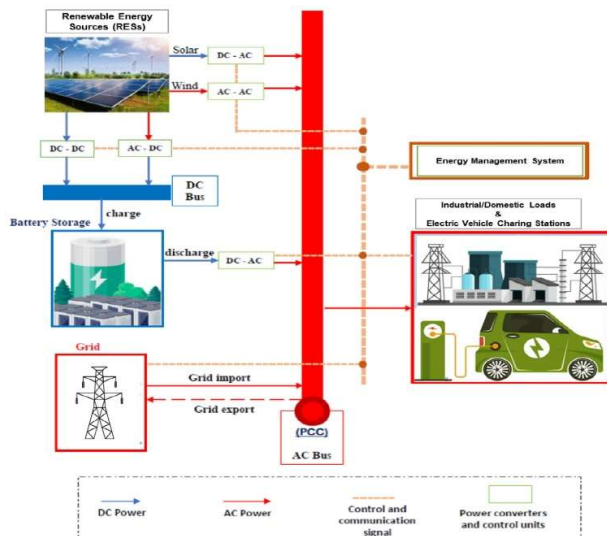


Fig -1: Framework

Figure 1 shows the conceptual framework of the proposed Smart EV Charging Station system where the input, process, and output operations are represented. The input stage includes renewable energy sources such as solar panels and wind turbines along with grid power when

renewable energy is not available. The generated energy is converted using power converters and stored in the battery storage system for continuous supply.

The stored energy is delivered to the electric vehicle charging station and controlled by the energy management system. Sensors monitor parameters such as voltage, current, battery level, and charging status to ensure safe operation. The charging status and fault conditions are displayed on an LCD display and mobile application. The system automatically switches to grid power or disconnects the load during abnormal conditions to maintain reliable charging.

### B. System Block diagram

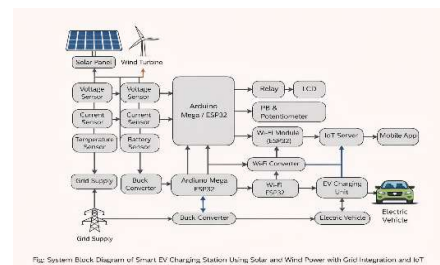
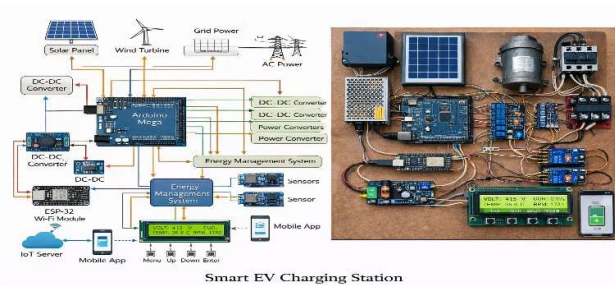


Fig -2: System Block Diagram

Figure 2 shows the system block diagram of the Smart EV Charging Station. The system includes renewable energy sources such as solar, wind, and grid supply connected to sensors and a power supply that feed the microcontroller, Arduino Mega or ESP32. The relay and contactor provide protection when abnormal conditions occur in the charging system. The microcontroller monitors voltage, current, temperature, and battery level for safe operation. The microcontroller is connected to the Wi-Fi module through a buck converter, which sends data to the IoT server and mobile application to display charging status and alerts. The LCD display shows system parameters and fault conditions.

### A. Prototype Development

#### 1) Prototype



According to the system operation, the microcontroller reads data from sensors, analyses and compares the values with preset limits, and then sends the information to the output devices. The display unit shows parameters such as voltage, current, battery level, and charging status to monitor system performance. These parameters help identify whether the system is operating normally. If any abnormal condition is detected, a warning message will be displayed, and the charging supply will be automatically disconnected to protect the system. The system status and fault records are also displayed in the mobile application with the corresponding date and time.

## 2) Software Development

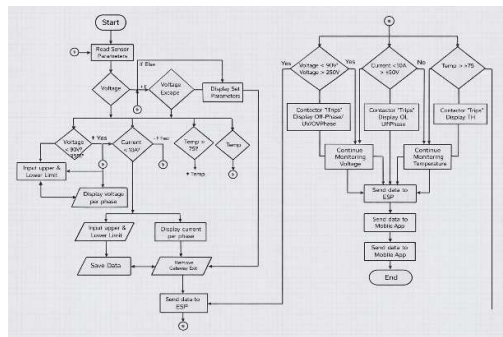


Fig. 4. The Algorithm Flow Chart

Figure 4 shows the flow chart of the algorithm used in the Smart EV Charging Station system. In setting the parameters, the first option on the LCD screen is Enter or Escape. The previously saved limits will be displayed when Escape is selected. Voltage, current, battery level, and temperature are the parameters displayed when Enter is pressed. Once Voltage is selected, the measured values are shown, and the upper and lower limits can be adjusted. The limits are saved after the user completes the settings. To return to the main menu, the Escape key is pressed. The other parameters work in the same way. The sensors collect data as input, and the gathered data is compared with preset limits. The system is in a fault condition if the measured data exceeds the upper limit. The charging supply will be shut off, and the LCD display will indicate the fault type. If the data falls below the lower limit, the same action will be taken. If no errors occur, the system continues monitoring. After monitoring, the data is sent to the Wi-Fi module, then to the server, and finally to the mobile application.

## 4.Results and Discussion

Figure 5 illustrates the data collection flowchart, which outlines the process of monitoring, analyzing, and transmitting system information in the Smart EV Charging Station. The process begins with the Wi-Fi module establishing a connection to the available network and obtaining the current date and time for proper data logging and synchronization. Once the connection is established, the microcontroller reads the data collected from various sensors that monitor important system parameters such as voltage, current, battery level, temperature, and charging status. These parameters are continuously

analyzed and compared with predefined safe operating limits stored in the system memory..

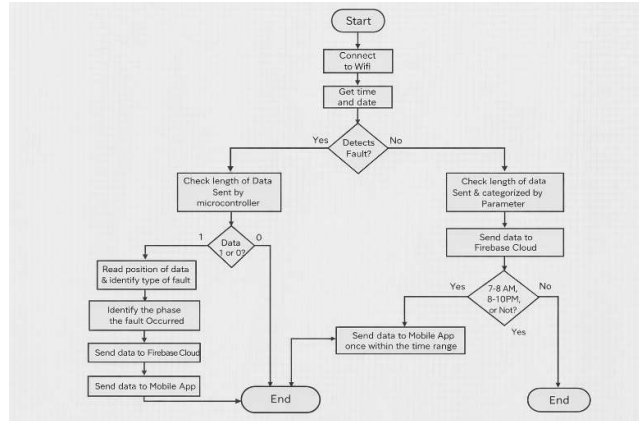


Fig. 5. Data Collection Flowchart

The results presented above demonstrate the corrective actions taken by the Smart EV Charging Station system when the measured voltage exceeds the specified upper limit or falls below the minimum allowable value. Similar protective responses were observed when the measured current or temperature values exceeded their predefined safety thresholds. These conditions indicate abnormal system behaviour that may lead to equipment damage or unsafe operation if not properly controlled.

During fault conditions, the charging system is automatically isolated from the power supply using a relay or contactor mechanism to prevent further damage to the equipment and ensure user safety. The type of fault and system status are immediately displayed on the LCD screen, allowing users to quickly identify the problem and take appropriate corrective measures. In addition, the system records all fault events in the data storage system for future analysis and maintenance planning.

Once a fault is detected, the microcontroller evaluates the transmitted data value to determine whether the system status indicates a fault condition or normal operation. If the data value corresponds to a fault condition, the system identifies the specific parameter responsible for the fault and records the corresponding system location and operating status. This information is then transmitted to the cloud storage platform and subsequently to the mobile application, enabling real-time remote monitoring and alert notifications.

Data collected from multiple experimental trials demonstrate that the system consistently responded correctly to various operating conditions and successfully transmitted monitoring data to the mobile application without failure. The summarized results indicate that the system achieved a high level of reliability and operational accuracy during testing. Furthermore, comparisons between sensor readings and reference measurement devices showed minimal variation, confirming that the system provides consistent, stable, and

precise data collection and monitoring performance under different operating scenarios.

**Table -1: Sample Table format**

Table 1  
*Reliability of the Smart EV Charging Station to Detect Faults*

Corrective Action Applied On	Pass	Fail
Overvoltage	30	0
Undervoltage	30	0
Overcurrent	30	0
Undercurrent	30	0
Overtemperature	30	0
Low Battery Level	30	0
Power Supply Failure	30	0
Power Supply Failure	30	0

$$\begin{aligned}
 \text{Reliability} &= \frac{\text{Pass}}{\text{Pass} + \text{Fail}} \times 100\% \\
 &= \frac{210}{(210 + 0)} \times 100\% \\
 &= 100\%
 \end{aligned}$$

The researchers also propose testing the system's capability to manage multiple electric vehicle charging points simultaneously. For improved functionality, they suggest implementing a larger database system to store charging history and fault records, allowing previous data to be accessed through the mobile application. Furthermore, the ability to remotely control the charging process at any time through the mobile application would provide greater flexibility and user convenience.

### Acknowledgment

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### 4. Conclusions and Recommendations

1. The researchers successfully developed a smart electric vehicle charging station system powered by renewable energy sources such as solar and wind energy along with grid supply support. Additionally, the system was capable of monitoring important parameters such as voltage, current, battery level, and temperature, and detecting abnormal conditions in the charging process. The measured parameters could be monitored through an LCD display and a mobile application in real time. Furthermore,

the researchers were able to collect and store data related to charging operations and system faults occurring at specific times during the day. Compared to conventional charging systems, the proposed system provided improved monitoring capabilities, remote access, real-time data visualization, and efficient energy management, effectively incorporating the concept of the Internet of Things for smart energy monitoring and control.

Following the system testing and performance evaluation, the researchers confirmed that the developed system provided accurate parameter readings, which were essential because the system's protective actions depended on reliable sensor data. The tests successfully demonstrated the accuracy and reliability of the system by utilizing Internet of Things technology as a communication and data transfer platform between the charging station and the mobile application. The system's reliability was evaluated through multiple experimental trials and was found to operate consistently and respond correctly to fault conditions, achieving a high level of operational reliability. It is important to note that this study mainly focused on electrical and operational.

Additionally, the project cost could be reduced by using compact and energy-efficient control devices with built-in wireless communication modules.

### REFERENCES

- [1] S. Abulanwar, A. Ghanem, M. E. M. Rizk, and W. Hu, "Adaptive synergistic control strategy for a hybrid AC/DC microgrid during normal operation and contingencies," *Appl. Energy*, vol. 304, Dec. 2021, Art. no. 117756.
- [2] A. Goroumaru, Y. Endo, N. Takehiro, Y. Kawagoe, and D. Frenkel, "Promotion of EV shift by smart charging service," in *Proc. 9th Int. Conf. Renew. Energy Res. Appl. (ICRERA)*, Sep. 2020, pp. 457–460.
- [3] G. Parise, M. Allegri, and R. Pennacchia, "Modular distribution system for EV parks," in *Proc. AEIT Int. Conf. Electr. Electron. Technol. Automot. (AEIT AUTOMOTIVE)*, Nov. 2021, pp. 1–6.
- [4] A. K. Singh, A. K. Mishra, K. K. Gupta, P. Bhatnagar, and T. Kim, "An integrated converter with reduced components for electric vehicles utilizing solar and grid power sources," *IEEE Trans. Transport. Electric.*, vol. 6, no. 2, pp. 439–452, Jun. 2020.
- [5] A. Choudhary, S. Fatima, and B. K. Panigrahi, "State of the art technologies in fault diagnosis of electric vehicles: A component-based review," *IEEE Trans. Transport. Electric.*, vol. 9, no. 2, pp. 2324–2347, Sep. 2023.
- [6] Y.-C. Chen, C.-P. Pan, C.-L. Lin, C.-H. Hwang, and H. Chen, "Photovoltaic energy harvesting in indoor



environments,” in *Proc. IEEE Int. Instrum. Meas. Technol. Conf. (IMTC)*, May 2018, pp. 1–5.

[7] V. Martynyuk, G. Il'chuk, and R. Petrus, “Energy harvesting systems from photovoltaic modules,” in *Proc. IEEE 12th Int. Conf. Electron. Inf. Technol. (ELIT)*, May 2021, pp. 138–143.

[8] S. Rahman, S. Saha, S. N. Islam, M. T. Arif, M. Mosadeghy, M. E. Haque, and A. M. T. Oo, “Analysis of power grid voltage stability with high penetration of solar PV systems,” *IEEE Trans. Ind. Appl.*, vol. 57, no. 3,

[9] pp. 2245–2257, May 2021. Y. Xiang, S. Hu, Y. Liu, X. Zhang, and J. Liu, “Electric vehicles in smart grid: A survey on charging load modelling,” *IET Smart Grid*, vol. 2, no. 1, pp. 25–33, Mar. 2019.