

## IoT-based Smart EV Level 1 Charger: A Review

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### Abstract

*This study presents the design and development of an IoT-based smart Level 1 charger for electric vehicles. The proposed system provides an intelligent and automated charging solution that optimizes the charging process, monitors the electricity consumption, and ensures the safety of the environment and the users. The system consists of a charging station equipped with a Wi-Fi module, a microcontroller, an LCD display, and an Android mobile application for remote monitoring and control. The charging station communicates with the cloud server, which enables data analysis, billing, and payment processing services. The system is designed to be user-friendly and compatible with most electric vehicles. The results indicate that the proposed smart Level 1 charger offers several advantages over traditional charging solutions, such as cost-effectiveness, energy efficiency, and real-time monitoring and control. The system also has the potential to support a wide range of smart grid applications, such as load balancing, demand response, and renewable energy integration.*

**Keywords:** Electronic vehicle (EV), EVSE, authentication, management, wired connection, electricity

### INTRODUCTION

Whether you are an electric vehicle (EV) owner or considering becoming one, charging is a crucial aspect of driving an EV. As the mass adoption of EVs looms on the horizon, smart charging solutions will be crucial for both charging point network operators and the national electricity grid. A significant issue in entering the EV market is the lack of proper charging platforms or infrastructures in cities, particularly societies, apartments in cities that have shared electricity setups or electricity meters that do not meet the requirements of EV owners. However, advancements on the internet of things (IoT), sensors, and communication platforms have the potential to create new solutions to these problems. Furthermore, the issue of EV charging in rental housing poses a challenge, particularly in condominiums where there may be reluctance to install charging stations and safety concern with the

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electrical systems. Due to the lack of preparedness for new EV charging system in most residential buildings, shared electrical installations and building boundaries become a significant barrier to adoption. As the number of EVs on the road rises, there is an increasing need for charging infrastructure, such as charging stations in garages and parking structures. An accessible charging station may be a necessary condition for long-distance commuters to guarantee their ability to complete the whole trip and arrive home. Many EV drivers choose to plug in even when charging is not necessary to reduce range anxiety, shorten the charge-discharge cycle, and lessen battery damage. Lack of charging stations might make EVs less practical and increase range anxiety, which would discourage consumers from using

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EVs. Charging stations that support numerous vehicles simultaneously with a specific infrastructure are one way to solve this problem.

## LITERATURE SURVEY

### Battery Monitoring System in Smart Microgrid

To track the functioning and effectiveness of batteries in a smart microgrid system, a battery monitoring network based on the internet of things (IoT) has been created in this work. An intelligent electronic device (IED) hybrid inverter, photovoltaic (PV) battery pack, grid connection, and electrical load are all components of this smart microgrid. The Human Machine Interface (HMI), data collecting algorithm, cloud system, and Internet of Things explained briefly in their study. According to IEC61724, data collecting was slated to occur every minute. ExtJS/HTML5 framework is used to show the information from the battery monitoring system as part of the battery management system (BMS) on a Human Machine Interface (HMI), which may be accessed from desktop or mobile devices. According to analytical findings, the total BMS-IoT-based data acquisition execution time to the cloud server is  $19.54 \pm 18.00$  seconds. The outcome of the cloud database server's availability monitored data is  $92.92 \pm 6.00\%$ , which demonstrates satisfactory results for the reliability of BMS-IoT system data acquisition [1].

### Internet of Things Enabled Solution

Worldwide, EV use is growing as more nations transition to pollution-free transportation. The infrastructure for EV charging will become essential as the number of EVs rises [2]. An Internet of Things system will undoubtedly improve the efficiency of EV charging and examine its effects. Both V2G and transit systems benefit from this technique. The suggested system will facilitate city living and enhance urban planning. We can simply handle the entire V2G system with IoT, which will undoubtedly save time and money. The task at hand is developing an intelligent application to establish a connection with the grid and ascertain its various tariff rates. Electric vehicles are becoming more and more well-liked worldwide as more nations strive towards having pollution-free transportation. Infrastructure for charging electric vehicles will become essential as the number of these vehicles rises. An Internet of Things enabled solution will enhance city planning and optimise EV charging performance. Because batteries are a popular form of energy storage, determining their state of charge is essential. The paper reviewed IoT-based smart charging infrastructure for EVs. It discusses the benefits of smart charging, challenges, and various architectures of IoT-based smart charging infrastructure. It also explores the integration of renewable energy sources and the role of blockchain in smart charging infrastructure. The review concludes that IoT-based smart charging infrastructure for EVs is a promising solution for the adoption of sustainable mobility.

The paper by Arunkumar and Vijith presented an overview of smart charging of EVs [3]. It discussed the benefits of smart charging, various techniques used for smart charging, and the integration of smart charging with the electricity grid. It also analysed the role of incentives and regulations in promoting smart charging. They concluded that smart charging could lead to a reduction in electricity costs, peak load management, and increased adoption of renewable energy sources.

The suggested approach by Hatim *et al.* is useful for transportation systems since it enables semiautonomous battery charging of electric vehicles with little assistance from humans [4]. The calculation of the SoC value and transmission of the data to webhost were the main topics of this work. The Android app allows the user to access the data. On the app, the user can also find the locations of local charging stations and transaction histories. The user can quickly determine whether to continue with the charging process by allowing the app to charge after learning about the condition of automobile battery. The system will carry out the charging activity, compute the associated charges, take the money out of the owner's e-wallet, and deposit it into the owner of the charging station's account after receiving the user's acknowledgment. In this sense, semi-autonomous charging using Internet of Things based smart charging has been created to track battery condition.

A clever framework for charging electric vehicles has been developed by Prajapati and Prajapati and is currently in use: the Internet of Things based Smart Electric Vehicle (EV) [5]. It is an EV charging framework that is based on products and systems and is designed with smart charge planning, multiplexing (connecting many vehicles to a single circuit), and adaptability in mind.

The primary goal of the study of Sharma *et al.* is to decarbonize energy production and consumption by optimising low-carbon technologies utilising rule-based algorithms on a single, networked platform [6]. Pareek *et al.* goes over some basic terms related to charging stations, such as levels and types [7]. Many methods are presented to address these issues, along with a brief overview of lithium-ion battery charging techniques and the Battery Management System (BMS).

### **VANADIUM REDOX FLOW BATTERY SYSTEM**

Solar-powered batteries in control rooms for EV charging stations, integrated switchable glazing topology has been used to provide passive HVAC (heating, ventilation, and air conditioning) during the day by the Bhattacharjee *et al.* [8]. To support sustainable travel and green energy, a solar PV source has been built on the roof of the building alongside the EV charging station. As a long-term energy storage solution, the system has been linked with a vanadium redox flow battery (VRFB) to assure energy security. It has been proved that an Internet of Things based smart scheduling of solar PV, VRFB storage, and the local distribution grid can supply the building glazing load requirement under real-time dynamic climatic conditions.

A seamless interchange of information across multiple verticals is necessary for the interaction of an EV charging station with the infrastructure of a smart city. By using the one M2M platform to make the charge point compliant, this horizontal information flow is made possible. To do this, Devendra *et al.* offered the design and construction of an EV charging station that complies with the one M2M platform and follows the OCPP communication standard [9]. They also go over several use scenarios that demonstrated how the EV charger's functionality has expanded because of data access from other Internet of Thing's devices.

The development of IoT-based EV Charging system involves multiples efforts and few are referred to in this study [6–11]. The power intake rate and the outgoing power rate are both included in the tariff rates. The app will also show the battery SOC when the user enters the grid. The major goal is to decarbonize both energy production and consumption by optimizing low carbon technologies using a single networked platform and rule-based algorithms.

### **SMART CHARGING WITH CONTROL AND OPTIMIZATION FOR EVS**

This study provides a review of smart charging with control and optimization for EV's. It discusses various optimization techniques such as Genetic Algorithm, Particle Swarm Optimization, and Ant Colony Optimization for smart charging [8].

It also explores the role of communication protocols such as OCPP, OCPI, and ISO 15118 in smart charging. The review presented by Barman *et al.* concluded that smart charging with control and optimization can lead to efficient charging, reduced load on the electricity grid, and cost savings [12].

### **Design, Development and Performance Evaluation of a Smart Level 1 EV Charger with Automatic Scheduling**

This study presents a case study of the design, development, and performance evaluation of a smart Level 1 EV charger with automatic scheduling. It discusses the hardware and software design of the charger and its integration with IoT. The study evaluates the performance of the charger in terms of power consumption and cost savings [10]. The results show that the smart charger is efficient, cost-effective, and can lead to load management on the electricity grid.

## PROBLEM STATEMENT

The inadequate charging infrastructure in residential (apartment) buildings poses a significant hurdle for those entering the electric vehicle (EV) market. One of the key issues is the unpreparedness of these buildings for the new reality, which results in a shared electricity problem that falls short of meeting the needs of EV owners.

## OBJECTIVE

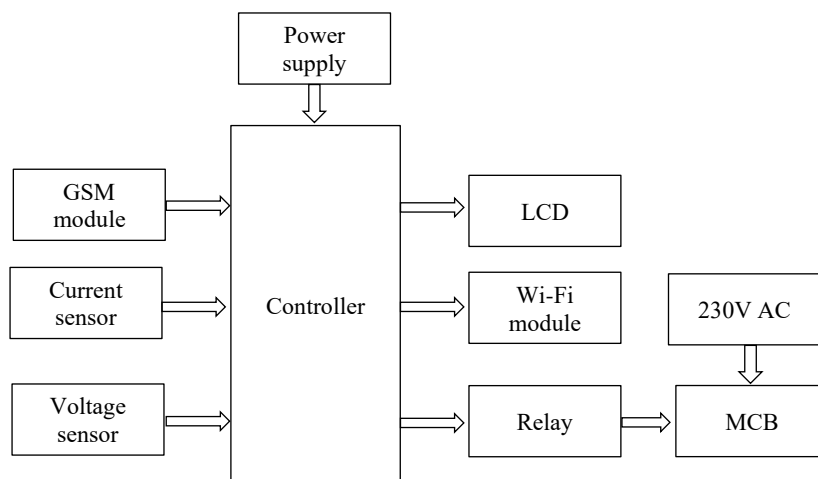
The objectives are developing an affordable and efficient charging infrastructure with high density; employing a straightforward level 1 charging system; integrating IoT technology to monitor energy consumption; and enabling individuals to earn additional revenue by installing these chargers in their spare spaces.

The goals include establishing a dense and cost-effective charging point network; utilizing a basic level 1 charging setup; implementing an IoT interface to track energy usage; and creating supplementary income opportunities for those with available space to install these chargers.

The aim is to construct a dense charging infrastructure that is both inexpensive and efficient; utilize a simple level 1 charging system; incorporate an IoT interface to monitor energy consumption; and enable individuals to earn extra income by installing these chargers in their spare space.

## PROPOSED METHODOLOGY

The IR sensor and RFID reader are turned on when the webserver sends an enable message to them. The EV uses an RFID tag and reader to identify itself when it stops in front of the charging station. It checks to see if the car is registered on the Android app and sends the vehicle's details to the web server as shown in Figure 1. It waits for the webhost to transmit the start charging command after authenticating and recognising the car, and when it receives it, it connects the charger to the EV to begin the charging process. When a car starts charging as soon as it receives a stop message from the webhost, at which point it gives the webhost the information about the start of the charging time. On receiving stop message, it records the end of charging period and sends the information to the webhost and stops the power supply. Additionally, it disconnects the EV's charger, allowing it to continue travelling. An alarm message is displayed by an Android application if the system-on-a-chip falls below a preset threshold. It has a Check Level button that shows the state of the SoC at that moment. It comprises of a button that indicates charging stations that are close by creating a link to a Google Map. It has a charge button where the user can submit commands to charge something. Additionally, it has a history button that accesses the web server's transaction history. Figures 1 and 2 show the block diagram of the proposed system, and presentation of the charging station.



**Figure 1.** Block diagram of the proposed system.

### Hardware Used

ESP32, 16X2 Display, ACS 712 Current Sensor, GSM Module, MCB, 5 V Relay, ZMPT101B AC Single Phase voltage sensor.

### Communication Device for EV Charging

Given that a Nissan Leaf gets 29 kWh of energy per 100 miles and has a typical drive of 12.6 miles, 3.7 kWh of energy is needed to refuel the EV after the average trip. 7.2 kW can be supplied via a dedicated, 30 A (40 A peak), 240 V circuit that offers a level 2 charger. After wastefulness mishaps, this translates to 6.6 kW entering the battery [3]. Installations at shopping centres or other public areas where EVs may be parked for shorter periods of time and commutes may be longer than usual may not meet consumer needs; sharing a 30 A circuit may be necessary. Each of the four EVs can charge at a full 30 A if the level 2 EVSE has a 120 A circuit. A transformer may act as a bottleneck if numerous chargers in this configuration are connected to it [11, 13]. A 100 kVA transformer can accommodate a maximum of 13 EVs charging at 7.2 kW/piece. The first 13 EVs to arrive at maximum charging speed can be charged in this situation by a group of four or more EVSEs with 16 or more charge points. By placing the 14th EV in a queue or reducing the power allotment so that the other EVs may power the 14th, the control system can implement algorithms that limit the total amount of power consumed by the EVSEs. If the 1.5 kW (120 V, 12.5 A) four routes divided by the level 1 EVSE do not meet the specified energy requirements, the EVSE can be configured to divide the four 120V circuits amongst the four charge points. This means that only two plug focuses, each averaging 0.75 kW, can share each circuit. Many EVSEs could be safely connected to a single circuit in the unlikely event that a 1.5 kW level 1 circuit is overly controlled for 4 EVs, as might happen at airport parking garages where EVs may stay for extended periods of time. The optimal number of EV plug focuses to circuit will depend on the regular charge requirement. A 1.5 kW circuit can transmit 36 and 252 kWh/week.

### Network Topology for Systems

These topologies can vary from local networks linked to more centralised controllers that branch together to form a tree-like structure, to a single central controller that directly controls every EVSE. The system's objectives and the best way to interface with the wider grid determine the ideal topology. There are a few competing reasons. In terms of DR and grid control, a centralised controller might provide the network with more control over the larger grid. It is possible that more localised controllers are more resilient than centralised ones. One charging station platform is presented in Figure 2. Furthermore, in terms of power quality and reaction to local shortages and outages, a localised controller that has direct communication with the local grid may be able to meet the needs of the grid more effectively. No matter where an EVSE is situated, the present architecture uses a single central server that is connected to a network to control all of the EVSEs on the network.



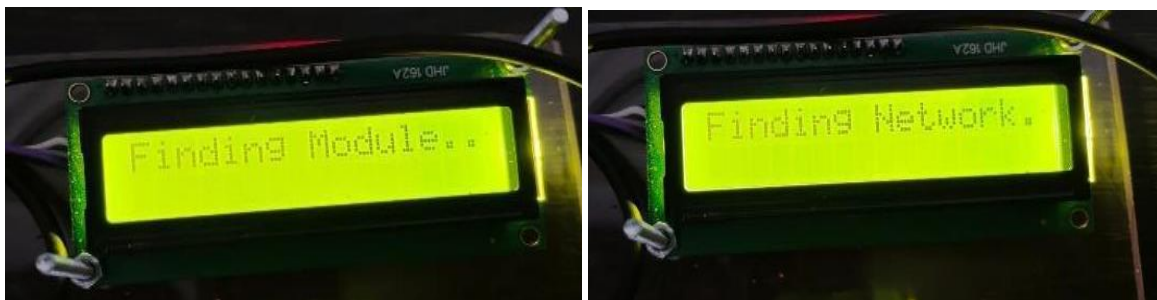
**Figure 2.** Presentation of the charging station.

## RESULT

When the system is ON, GSM module is initialized, then finding module message is shown on LCD screen or display. When Wi-Fi module is connected to the network, then network-found message is shown on LCD, as shown in Figure 3.

After “system ready” message is shown on LCD display, the system gets ready to take payment and charging is enabled for the electric vehicle. After a definite time, corresponding to payment ends, the charging will stop automatically as shown in Figure 4.

Level 1 chargers are relatively inexpensive to install and do not require any specialized equipment, making them a cost-effective charging option for home use. Level 1 chargers are very convenient as they can be easily plugged into any standard household outlet, which makes it easy for EV owners to charge their vehicles at home. Level 1 chargers are compatible with all types of EVs, which means that EVs’ owners can use these chargers irrespective of the make or model of their electric vehicles. Level 1 chargers consume less electricity compared to higher-level chargers, which makes them more energy efficient and environmentally friendly.



**Figure 3.** LCD displaying GSM module initialization.



**Figure 4.** LCD displaying system ready.

### Issue which still needs to be resolve

- *Security issues:* The system needs to be protected from hackers or security threats.
- *Slow charging:* Level 1 chargers are known for their slow charging.

## CONCLUSION

The Internet of Things based smart EV level 1 charger has enormous potential to revolutionize the electric vehicle charging landscape. This technology offers a range of benefits, including improved energy efficiency, cost savings, and reduced environmental impact. The implementation of IoT in EV charging stations enables us to monitor, manage, and optimize the charging process. This research work presented the design and implementation of an IoT-based smart Level 1 charger that can communicate with other devices and the cloud, enabling remote monitoring and control of the charging process. The smart charger can also optimize the charging process based on energy availability, price, and user preferences. Overall, this study contributes to the ongoing research in the field of IoT-based smart EV charging systems and provides insights into the potential for IoT to improve the sustainability and efficiency of the transportation sector.

### Future Scope

IoT-based smart Level 1 charger for electric vehicles is vast and offers numerous opportunities for research and development. The integration of renewable energy sources, optimization of charging time and cost, improving charging efficiency, battery analytics and management, V2G integration, and cybersecurity are some of the potential areas for further exploration.

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### REFERENCES

1. Friansa Koko, Irsyad Nashirul Haq, Bening Maria Santi, Deddy Kurniadi, Edi Leksono, Brian Yulianto. Development of battery monitoring system in smart microgrid based on internet of things (IOT). *Procedia Eng.* 2017; 170: 482–487. Elsevier.
2. Khajenasiri Iman, Abouzar Estebarsari, Marian Verhelst, Georges Gielen. A review on internet of things solutions for intelligent energy control in buildings for smart city applications. *Energy Procedia.* 2017; 111: 770–779. Elsevier. <https://www.sciencedirect.com/science/article/pii/S1876610217302692>.
3. Arunkumar P, Vijith K. IOT Enabled smart charging stations for Electric Vehicle. *Int J Pure Appl Math.* 2018; 119(7): 247–252.
4. Tejal Hatim, Sakshi Agarkar, Prajakta Kadam. IoT Based Smart Charging of Electric Vehicle. *International Engineering Research Journal (IERJ).* 2020; 3(4): 6255–6257. <http://www.ierjournal.org/pupload/vol3iss4/IoT%20Based%20Smart%20Charging%20of%20Electric%20Vehicle.pdf>
5. Apoorv Prajapati, Hetal Prajapati. IOT Enabled smart charging station for electrical vehicles. *J Emerg Technol Innov Res (JETIR).* 2020 Jan; 7(1): 749–752.
6. Esha Sharma, Bharath S, Adarsh Devaramani, Deepti Sr, Saravana Kumar. IOT Enabled Smart Charging Stations for Electric Vehicles. *Journal of Telecommunication Study (JTS).* 2019; 4(2): 34–39.
7. Pareek S, Sujil A, Ratra S, Kumar R. Electric vehicle charging station challenges and opportunities: A future perspective. In *2020 IEEE International Conference on Emerging Trends in Communication, Control and Computing (ICONC3).* 2020 Feb 21; 1–6.
8. Ra N, Ghosh A, Bhattacharjee A. IoT-based smart energy management for solar vanadium redox flow battery powered switchable building glazing satisfying the HVAC system of EV charging stations. *Energy Convers Manag.* 2023 Apr 1; 281: 116851.
9. Devendra D, Mante S, Niteesh D, Hussain AM. Electric Vehicle Charging Station using Open Charge Point Protocol (OCPP) and oneM2M Platform for Enhanced Functionality. In *TENCON 2021–2021 IEEE Region 10 Conference (TENCON).* 2021 Dec 7; 01–05.
10. Ejaz W, Anpalagan A. Internet of Things enabled electric vehicles in smart cities: Technologies, Big Data and Security. In: *Internet of Things for Smart Cities.* Cham: Springer; 2019; 39–46.
11. Sbordone D, Bertini I, Di Pietra B, Falvo MC, Genovese A, Martirano L. EV fast charging stations and energy storage technologies: A real implementation in the smart micro grid paradigm. *Electr Power Syst Res.* 2015 Mar 1; 120: 96–108.
12. Barman P, Dutta L, Bordoloi S, Kalita A, Buragohain P, Bharali S, Azzopardi B. Renewable energy integration with electric vehicle technology: A review of the existing smart charging approaches. *Renew Sustain Energy Rev.* 2023 Sep 1; 183: 113518.
13. Hu J, Morais H, Sousa T, Lind M. Electric vehicle fleet management in smart grids: A review of services, optimization, and control aspects. *Renew Sustain Energy Rev.* 2016 Apr 1; 56: 1207–26.