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Monitoring of Hybrid EV Charging Station using IoT

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ABSTRACT: The increasing popularity of electric vehicles (EVs) necessitates the development of innovative and sustainable charging solutions. Solar electric vehicle charging stations (SEVCS) with Internet of Things (IoT) integration have emerged as a promising technology, enabling efficient charging operations. However, the intermittent nature of solar energy poses challenges for uninterrupted charging. This research paper explores experimental design, implementation, and benefits of IoT-enabled solar EV charging stations with grid backup capabilities mode for switching sources with solar and supply from utility grid. By combining renewable solar energy with IoT connectivity, these stations offer enhanced functionalities, such as real-time monitoring, remote management, managing user access and data analytics. Additionally, integrating a grid backup system ensures a reliable power supply during periods of insufficient solar energy. The paper discusses the technical aspects, advantages, and potential challenges associated with SEVCS with IoT and grid backup, highlighting their role in advancing sustainable and resilient transportation systems.

KEYWORDS: EVs (Electric vehicles), SEVCS (Solar Electric Vehicle Charging Stations), IoT (Internet of Things), BMS (Battery Management System).

I. INTRODUCTION

In recent years, the integration of Internet of Things (IoT) technology has revolutionized various industries, and EV charging infrastructure is no exception. By incorporating IoT connectivity into SEVCS, charging stations can be remotely monitored, controlled, and optimized for improved efficiency and user experience. Real-time data collection and analysis enable charging station operators to proactively manage charging sessions, monitor energy consumption, and respond to any issues promptly. Additionally, IoT connectivity enhances the overall charging experience for EV users through features such as mobile applications, reservation systems, and seamless payment methods.

While solar energy provides a renewable power source for SEVCS, the intermittent nature of sunlight poses a challenge for uninterrupted charging. To ensure reliable and continuous charging services, SEVCS can be equipped with a backup supply from the grid. By integrating a grid backup system, SEVCS can rely on the electrical grid during periods of low solar irradiance or high charging demand. This integration ensures that EV owners can confidently rely on SEVCS for their charging needs, regardless of environmental conditions or charging demands.

This research paper aims to explore the design, implementation, and benefits of SEVCS with IoT and grid backup. By combining the advantages of solar energy, IoT connectivity, and grid backup, these charging stations offer a sustainable and resilient charging solution for EVs. The paper will delve into the technical aspects, operational considerations, and potential challenges associated with the integration of IoT and grid backup systems into SEVCS infrastructure. Additionally, it will highlight the advantages of this integrated approach, including enhanced charging efficiency, real-time monitoring and control, and grid support. The IoT architecture in EV charging stations comprises several interconnected layers. The sensing layer deploys sensors to collect real-time data on energy consumption, charging status, and environmental factors. The connectivity layer establishes the network infrastructure for seamless communication. The data processing and analytics layer aggregates and analyzes the collected data using machine learning algorithms and data modeling techniques. The cloud platform serves as a central hub for data storage, processing, and remote access to charging stations. The user interface layer provides mobile apps and web portals for users to monitor and interact with the charging infrastructure. The control and management layer optimizes charging operations, balances demand and supply, and integrates with smart grid systems.

Implementing an IoT architecture brings several benefits to EV charging stations. It enables remote monitoring, efficient operation, and cost-effective maintenance. Data-driven insights support optimal energy usage and predictive maintenance. Integration with smart grids allows for demand response programs and grid balancing. Ultimately, the IoT architecture transforms EV charging stations into intelligent and connected infrastructure, delivering efficient charging processes, enhanced user experiences, and sustainable energy management.

II. EXISTING SYSTEM

EV charging stations with IoT technology function by integrating various components and leveraging IoT connectivity for efficient and smart charging of electric vehicles. These stations consist of physical hardware components such as charging points and cables. They are connected to the internet through wired or wireless connectivity options like Wi-Fi or cellular networks, enabling data exchange and remote monitoring. Communication protocols such as OCPP or OICP facilitate interoperability between different charging stations and service providers. A central management system, connected to the charging station through IoT, monitors and controls its operation. This system collects data, manages user authentication, billing, and offers remote management capabilities. Users can interact with the charging station through mobile apps, RFID cards, or touch screens, initiating charging sessions and monitoring progress. Real-time monitoring of the charging station's status, availability, and energy consumption is made possible through IoT connectivity. This data is transmitted to the management system for analysis and optimization.

IoT integration enables smart charging features and load management. By analyzing data from multiple stations and considering factors like grid load and pricing, the charging station management system optimizes charging schedules, balancing power demand and maximizing grid utilization charging stations with IoT can integrate with renewable energy sources like solar panels or wind turbines. This integration allows for monitoring of renewable energy generation and aligning it with charging demand, promoting sustainable and eco-friendly charging practices. Secure payment systems are supported by IoT-enabled charging stations, allowing for convenient billing. The management system tracks charging sessions, calculates energy consumption, and generates invoices or facilitates online payment methods. The data generated by IoT-connected charging stations can be analyzed for insights. Charging patterns, usage trends, and energy consumption data help optimize infrastructure planning and inform business decisions.

In summary, EV charging stations with IoT technology offer efficient and intelligent charging capabilities. They provide real-time monitoring, enable smart charging and load management, integrate with renewable energy sources, facilitate secure payments, and offer valuable data insights for optimization and decision-making.

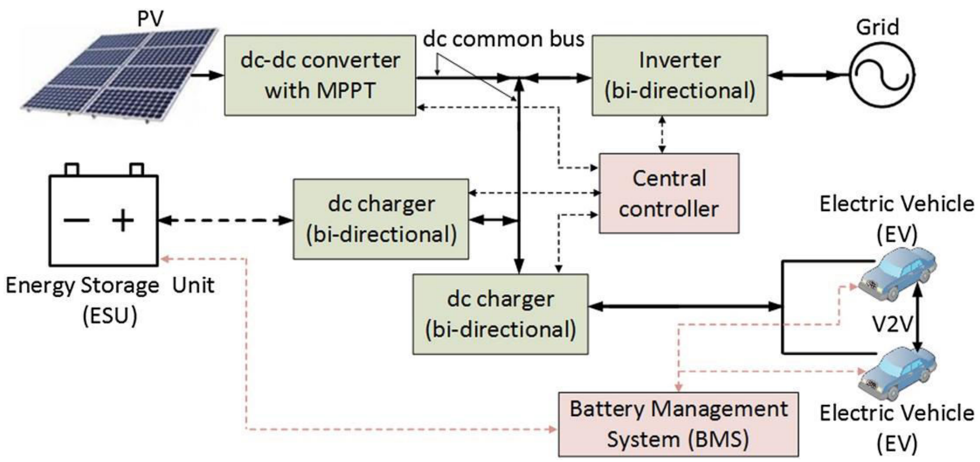

Fig.1. Existing Solar EV charging station

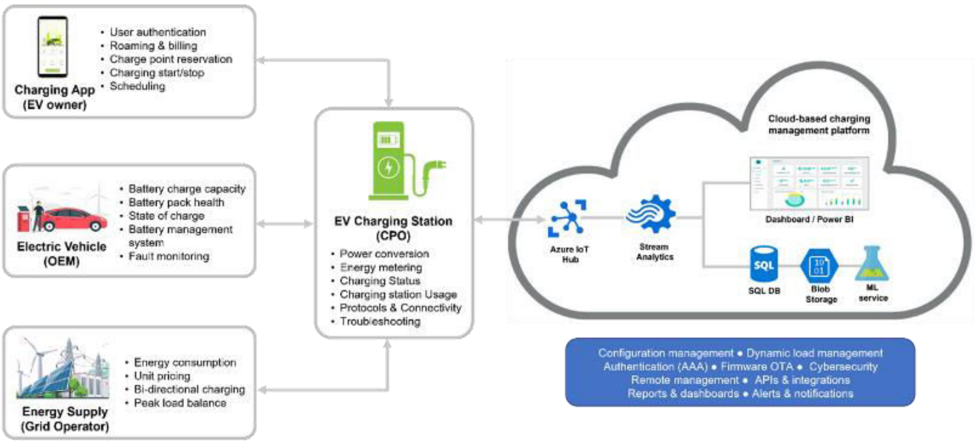

Fig.2. IoT model in existing systems

III. PROSPOSED SYSTEM

A solar EV charging station with IoT and grid backup combines solar energy generation, advanced connectivity, and grid backup capabilities to provide reliable and sustainable charging for electric vehicles.

The charging station utilizes solar panels to harness renewable energy from the sun. This clean energy is used to power the charging infrastructure, reducing reliance on fossil fuels, and lowering carbon emissions. Excess solar energy can be stored in batteries for later use or fed back into the grid. IoT technology enables real-time monitoring and control of the charging station. Sensors and meters collect data on energy production, charging sessions, and station status. This data is transmitted to a central management system via IoT connectivity, allowing operators to remotely monitor and manage the charging infrastructure.

In addition to solar power, the charging station is equipped with grid backup capabilities. This means that during periods of low sunlight or high charging demand, the station can draw electricity from the grid to ensure uninterrupted charging services. The charging station management system intelligently switches between solar power and grid power based on demand and availability. Grid backup functionality also enables the charging station to participate in demand response programs. During peak electricity demand periods, the station can reduce or adjust its power consumption to support grid stability and load balancing.

By combining solar energy, IoT connectivity, and grid backup capabilities, this type of charging station offers reliable and sustainable charging services for electric vehicles. It promotes the use of clean energy, reduces dependence on the grid, and contributes to a more resilient and efficient energy infrastructure.

Working of proposed system:

A solar EV charging station with IoT and grid backup operates through the integration of various components and functionalities to ensure reliable and sustainable charging for electric vehicles. Here is a detailed explanation of its working and the key components involved:

1) Solar Panels: The charging station incorporates solar panels or photovoltaic (PV) arrays to capture sunlight and convert it into electricity. These panels are typically mounted on the station's roof or nearby structures, maximizing exposure to sunlight for efficient energy generation.

2) Solar Inverter: The generated DC (direct current) electricity from the solar panels is converted into AC (alternating current) electricity through a solar inverter. This AC power is used to operate the charging station and supply electricity to the connected electric vehicles.

3) Energy Storage System: The charging station includes an energy storage system, usually in the form of batteries, to store excess solar energy. During periods of low sunlight or high charging demand, the stored energy is utilized to ensure continuous charging services. This energy storage system enhances the station's reliability and reduces dependence on the grid.

4) IoT Connectivity: The charging station is equipped with IoT connectivity, enabling seamless communication between the station and the central management system. This connectivity allows for real-time monitoring, data exchange, and remote management of the charging infrastructure.

5) Sensors and Meters: Various sensors and meters are deployed within the charging station to collect data on crucial parameters. These may include solar energy production, battery state of charge, charging sessions, station availability, and power consumption. The sensors and meters provide valuable data for monitoring, analysis, and optimization of the charging station's performance.

6) Central Management System: The charging station is linked to a central management system or backend software through the IoT connectivity. The central management system receives and processes the data collected from the sensors and meters, enabling operators to remotely monitor and manage the charging infrastructure. It provides functionalities such as real-time monitoring, fault detection, optimization of charging operations, and remote control of charging processes.

7) Grid Backup Integration: The charging station is designed with grid backup capabilities to ensure uninterrupted charging services. In situations where solar energy generation is insufficient or the battery storage is depleted, the station can switch to drawing electricity from the grid as a backup power source. This seamless transition to grid power ensures continuous availability of charging services to electric vehicle users.

8) User Interface: The charging station features user-friendly interfaces, typically through mobile apps or touch screens, that allow users to interact with the station. Users can initiate charging sessions, monitor charging progress, receive notifications, and access additional services. The user interface provides a convenient and intuitive experience for electric vehicle owners.

By harnessing solar energy, utilizing IoT connectivity, incorporating energy storage systems, and integrating grid backup capabilities, solar EV charging stations with IoT and grid backup offer reliable and sustainable charging solutions for electric vehicles. These stations promote clean energy usage, enhance charging infrastructure resilience, and provide a seamless experience for electric vehicle owners.

Working of proposed system (with respect to the prototype):

In Solar EV charging station-based prototype model, the work involves maximum use of solar energy for charging of EVs with about 70% contribution by solar and remaining by grid. The grid will provide supply to the station during night times, cloudy or unsettled weather conditions and failures in solar system. So, a 40W 12V solar panel is being used as a DC supply along with AC supply of 230V from the single-phase home supply which is then converted to DC supply by use of SMPS (Switched Mode Power Supply).

The load consists of a battery connected in series with 3.7V rated each with BMS (Battery Management System) and Voltage sensor to monitor the voltage and ensure safe charging of batteries. Temperature and humidity sensors to monitor weather conditions and IR sensors to indicate vacant slots. ESP8266 as a microcontroller with all the inputs coming to it from sensors and LCD display. If the output power of Solar system reduces below 12V then gird supply operates.

ADVANTAGES:

Solar power integration in charging stations reduces dependence on the grid, lowers carbon emissions, and promotes renewable energy sources. It leads to cost savings through net metering and feed-in tariff programs. Solar power ensures continuous charging availability during grid outages, manages peak loads, and contributes to grid stability. IoT connectivity enables remote monitoring, efficient energy utilization, and enhances the user experience with real-time updates, remote payment options, and access control. It also provides data-driven insights for charging patterns, energy consumption, and performance optimization. Overall, solar power integration with IoT brings sustainability, cost savings, resilience, and improved charging infrastructure.

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IV. DIAGRAMS RELATED TO THE PROJECT

1. Block diagram of proposed system

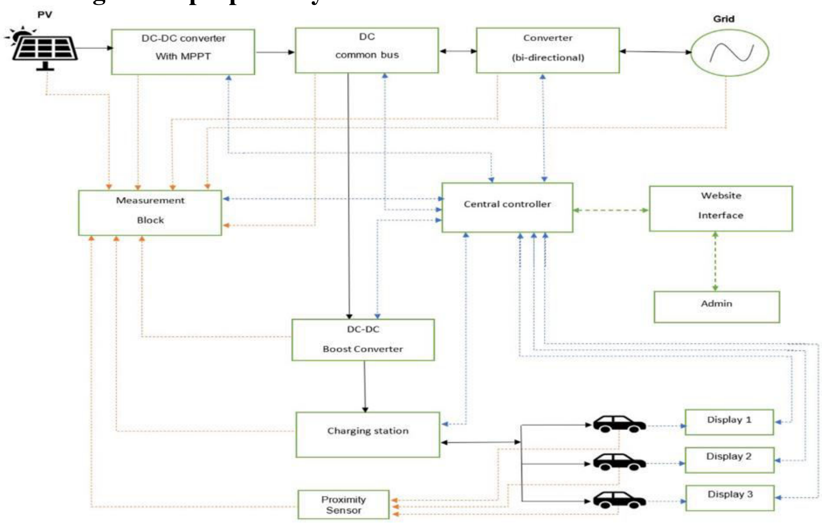

Fig-2: Solar EV charging station with IoT and grid backup

2. Block diagram of prototype of proposed system

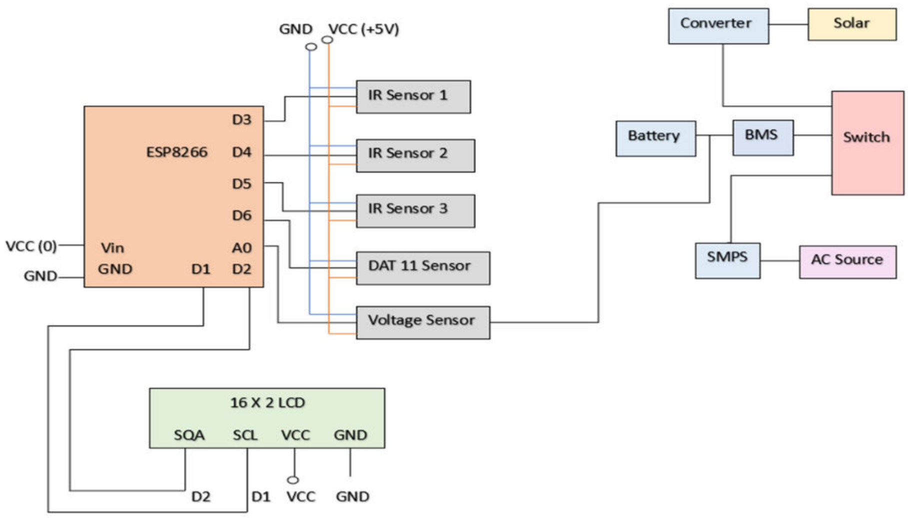

Fig-3: Prototype model

V. RESULTS

In the prototype system, two results were obtained, one result consisting of reading by usage of Solar powered DC supply of 11.88V and AC rectified DC voltage of similar value of 11.78V and the slot reading with the use of IR sensors obtained on BLYNK APP and LCD display as shown below:

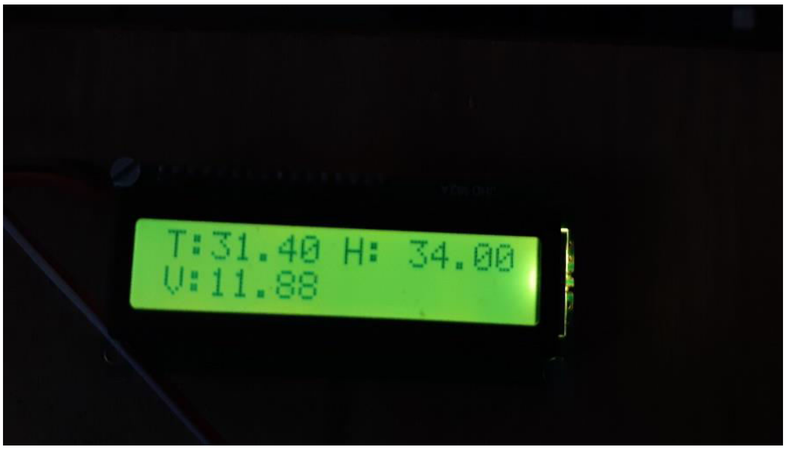

Fig-5: Reading of DC supply voltage and slot indication on BLYNK app

VI. IMPLEMENTATION CONCERN

Implementing a solar-based EV charging station with IoT connectivity and grid backup presents several challenges. First, the upfront cost can be substantial, making it financially challenging for some organizations. Additionally, solar energy generation is subject to environmental factors, potentially limiting availability during cloudy periods. Mismatched energy demand and supply may require grid backup or energy storage solutions. Integrating the charging station with the grid and ensuring reliable backup can be complex. Planning for scalability and capacity is crucial, as future expansion may require additional infrastructure. IoT connectivity introduces security concerns, necessitating robust encryption and secure communication protocols. Limited grid backup capacity and the need for a sustainable business model further complicate implementation. By addressing these challenges with careful planning and expertise, successful implementation can be achieved.

VII. CONCLUSION

In conclusion, this research paper has explored the implementation of a solar-based EV charging station with IoT connectivity and grid backup. While this innovative solution offers numerous benefits, several challenges need to be addressed for successful implementation. The upfront cost, limited solar energy generation, and potential mismatch between energy demand and supply require careful financial planning and energy management strategies. Integration with the electrical grid, ensuring reliable backup, and addressing scalability are critical technical considerations. IoT connectivity introduces security concerns, despite these challenges, the adoption of solar-based EV charging stations with IoT and grid backup can significantly contribute to sustainable transportation and the reduction of carbon emissions. Future research should focus on advancing energy storage technologies, optimizing grid integration, and improving the financial viability of such implementations. By addressing these aspects, we can further promote the widespread adoption of solar-based EV charging stations, ultimately contributing to a greener and more sustainable future.

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