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Simulation of Prepaid EV Charging station

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ABSTRACT:

The rapid expansion of Electric Vehicle (EV) adoption has necessitated the development of efficient and user-friendly charging infrastructures. A key advancement in this domain is the implementation of prepaid EV charging stations, which provide enhance load management. This paper presents the design and simulation of a prepaid EV charging station using **MATLAB**. The proposed system incorporates elements of energy distribution, dynamic pricing, load forecasting, all simulated to evaluate efficiency and effectiveness. The results demonstrate the viability of prepaid charging models in optimizing energy use and ensuring fair pricing for consumers, while minimizing grid congestion.

INTRODUCTION

The rapid adoption of Electric Vehicles (EVs) is reshaping transportation systems worldwide, creating a growing need for efficient and scalable charging infrastructure. Traditional EV charging stations often rely on postpaid billing, which can lead to inefficiencies, payment delays, and even fraud. Prepaid EV charging stations, on the other hand, offer a solution where users pay upfront, to access charging services. This model helps streamline the charging process by ensuring that users only pay for the energy consumed before they begin charging. Furthermore, prepaid systems can assist in load management by incentivizing users to charge during off-peak times, thereby alleviating strain on the grid during periods of high demand. This is particularly important in regions where grid stability is a concern due to the increasing number of EVs. The aim of this paper is to simulate the operation of a prepaid EV charging station, where users interact with the station by paying, and the system ensures optimal energy distribution. By integrating load forecasting, dynamic pricing, and energy distribution management, this project explores how such systems can enhance the efficiency of EV charging infrastructure, improve energy management, and offer a more user-friendly charging experience.

LITERATURE REVIEW

The rapid adoption of Electric Vehicles (EVs) has created a need for efficient and scalable charging infrastructure. Traditional postpaid billing systems often face issues such as payment delays and fraud, while prepaid systems address these problems by requiring users to pay upfront. Prepaid billing reduces administrative costs and enhances transparency, as shown by **Liu et al. (2020)**. Dynamic pricing, which adjusts charging costs based on time-of-day or grid demand, helps balance load and reduce peak demand. **Shah et al. (2021)** demonstrated how dynamic pricing can incentivize off-peak charging, optimizing energy consumption. Furthermore, **Li et al. (2021)** highlighted the importance of load forecasting for predicting demand and optimizing resource distribution. Energy storage systems, integrated into charging stations, improve grid stability by storing excess energy and providing it during high-demand periods, as discussed by **Xu et al. (2019)**. These features, when combined, can significantly enhance the efficiency, sustainability, and user experience of EV charging infrastructure.

SYSTEM DESIGN AND METHODOLOGY

SYSTEM COMPONENTS

AC Voltage Source: Generates sinusoidal AC voltage (e.g., 230V, 50Hz). Used to simulate power supply.
Voltage Measurement: Measures voltage between two points. Output goes to a scope or display.
Current Measurement: Measures current through a wire or component. Output sent to Simulink for monitoring.
Circuit Breaker: Acts like a switch. Opens or closes based on a control signal (1 = on, 0 = off).
Rectifier: Converts AC to DC. Built using diodes or blocks like a Universal Bridge.
Battery: Stores electrical energy. Simulates charge/discharge with voltage and capacity settings.
Control System: Manages system behavior using logic, PID, or custom control blocks.

METHODOLOGY

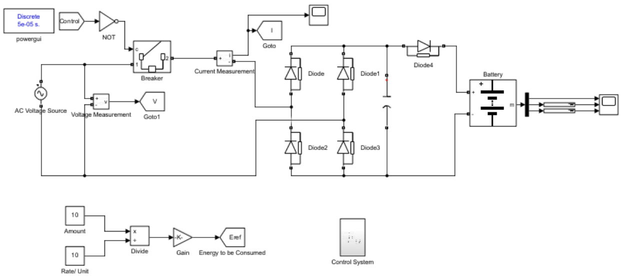
The project follows a structured workflow to monitor and analyze charging process of prerpiad EV charging station:
System Modeling: Model the EV charging station, EV battery, and grid connection using appropriate blocks.

MATLAB Implementation: Use Simulink to create a block diagram representation of the system.
Visualization: Plot the EV battery SOC, charging power, and other relevant parameters.
Data Analysis: Analyze the simulation results to evaluate the performance of the charging station.

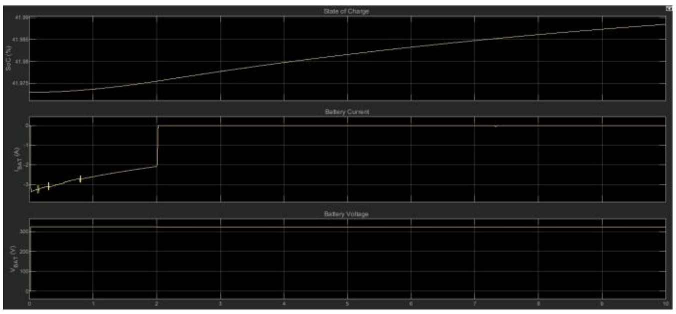
SIMULATION SETUP IN MATLAB/SIMULINK

1. Define system requirements and components.
2. Create the Simulink model (charging units, power sources, meters).
3. Implement prepaid billing system and logic.
4. Introduce dynamic pricing (optional).
5. Implement energy management and load balancing.
6. Create a user interface (Dashboard or MATLAB GUI).
7. Connect the system to the central management system.
8. Run the simulation and analyze results.

MATLAB SIMULATION MODEL



RESULT AND DISCUSSION



This is result of battery charging

This is result of power consumption

DISCUSSION

The simulation results show the behavior of a battery charging system. The first graph indicates a steady increase in the State of Charge (SOC), suggesting consistent charging. The battery current initially rises and then remains stable, reflecting a controlled constant current charging mode. The battery voltage gradually increases, which is typical during charging. In the second graph, a sharp spike followed by a drop represents an initial power surge, likely due to system startup, after which the system stabilizes. Overall, the results confirm proper charging operation and control, suitable for a prepaid EV charging station setup.

CONCLUSION

The MATLAB simulation of a Prepaid EV Charging Station shows how electric vehicles can be charged using a prepaid system. It allows charging only for the amount paid and stops when the battery is full. The system controls and monitors the charging process to work safely and correctly. It also handles simple problems like stopping the charge at the right time. This project helps in understanding how prepaid EV charging can be managed using simulation tools.

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