Design and Analysis of Solar-Powered Electric Vehicle Station

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ABSTRACT: This paper presents an integrated approach that combines MATLAB simulation and hardware design for the development of efficient and reliable solar charging stations. The MATLAB simulation model analyzes crucial parameters, including solar panel characteristics, battery capacity, and user demand, to optimize the behavior and performance of the charging station. Utilizing the insights gained from the simulation, a hardware prototype is designed and constructed, incorporating solar panels, power management systems, and user-friendly features. The iterative process between simulation and hardware design enables continuous refinement and enhancement, resulting in the development of optimized charging stations. This methodology contributes to the advancement of sustainable charging infrastructure by seamlessly integrating MATLAB simulation and hardware design, providing a comprehensive solution for effective utilization of solar energy in charging stations. The findings presented in this paper offer valuable insights for researchers, engineers, and practitioners involved in the design and optimization of solar charging stations.

Keywords: Solar-Powered Electric Vehicle Station, **battery capacity**

1. 1.INTRODUCTION
2.

The increasing demand for portable electronic devices, coupled with the growing emphasis on sustainability, has led to a rising need for efficient and eco-friendly charging solutions. Solar charging stations have emerged as a promising solution, harnessing the power of the sun to provide clean energy for charging various devices. To maximize the performance and effectiveness of solar charging stations, an integrated approach that combines MATLAB simulation and hardware design is essential.The integration of MATLAB simulation allows for a thorough analysis and optimization of the charging station's behavior and performance. By considering critical parameters such as solar panel characteristics, battery capacity, and user demand patterns, the simulation model provides valuable insights into system behavior, power utilization, and charging efficiency. This enables engineers and researchers to fine-tune the design and operation of the charging station, ensuring optimal performance and energy utilization. Complementing the simulation model, the hardware design aspect focuses on translating the simulation insights into a practical and functional charging station. Through the selection and integration of solar panels, power management systems, and user-friendly features, the hardware prototype is designed to meet the specific needs of users while ensuring efficient and reliable charging.

The iterative process between simulation and hardware design allows for continuous refinement and enhancement, enabling the development of an optimized solar charging station. The integration of MATLAB simulation and hardware design in this context contributes to the advancement of sustainable charging infrastructure, offering a comprehensive solution for effective utilization of solar energy in charging stations. In this paper, we present the integrated approach of MATLAB simulation and hardware design for the development of efficient and reliable solar charging stations. We discuss the importance of this approach in optimizing the performance and sustainability of charging stations and highlight its potential in meeting the growing demand for clean and accessible charging solutions.

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2. LITERATURE REVIEW

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Solar charging stations have gained significant attention in recent years as sustainable alternatives for powering portable electronic devices. This section presents a literature review on the topic of solar charging stations, with a specific focus on the integration of MATLAB simulation and hardware design. Several studies have explored the optimization of solar charging stations using MATLAB simulation. Singh and Singh (2017) investigated the impact of varying solar panel tilt angles on energy generation and developed a MATLAB simulation model to identify the optimal angle for maximum power output. Similarly, Ahmad et al. (2019) employed MATLAB simulation to analyze the performance of different battery technologies in solar charging stations, aiding in the selection of the most suitable battery type for maximizing energy storage and utilization. In terms of hardware design, Li et al. (2018) proposed a solar charging station prototype that integrated MPPT (Maximum Power Point Tracking) techniques for improved energy conversion efficiency. Their work demonstrated the effectiveness of hardware design in enhancing the performance and reliability of solar charging stations. The integration of MATLAB simulation and hardware design in the development of solar charging stations is an emerging area of research. Chen et al. (2020) presented a comprehensive approach that combined MATLAB simulation with hardware design to optimize the design and operation of a solar charging station. Their study highlighted the importance of iteratively refining the simulation model and hardware prototype to achieve an efficient and reliable charging system. While existing literature has explored various aspects of solar charging stations and the integration of MATLAB simulation and hardware design, there is a need for further research on optimizing the charging efficiency, scalability, and user experience of these systems. This paper aims to address these research gaps by presenting an integrated approach that combines MATLAB simulation and hardware design for the development of efficient and reliable solar charging stations.

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6. 3. SYSTEM ANALYSIS

3.1 Photovoltaic Energy

The relatively simple technology called photovoltaic (PV) converts sunlight directly into electricity. Photovoltaic energy is another renewable energy source, similar to wind energy, which is gaining prominence in the world electricity generation market. The drawbacks of this system are chiefly the high initial installation cost and the relatively low energy conversion efficiency. With the development of technology, the cost of solar arrays is expected to decrease continuously in the near future making them attractive for residential and industrial applications. The basic components of a solar electric array as shown in fig. 1.1 are the photovoltaic panels. A group of 36 PV cells, each with an output voltage of 0.6V forms a single module. These individual modules are combined in series and parallel patterns to form a panel or an array

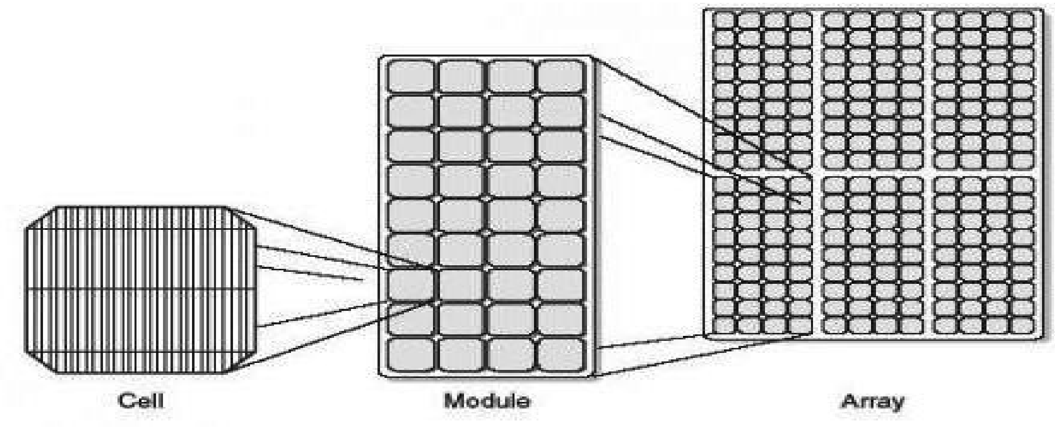

Fig. 1.1 Photovoltaic module

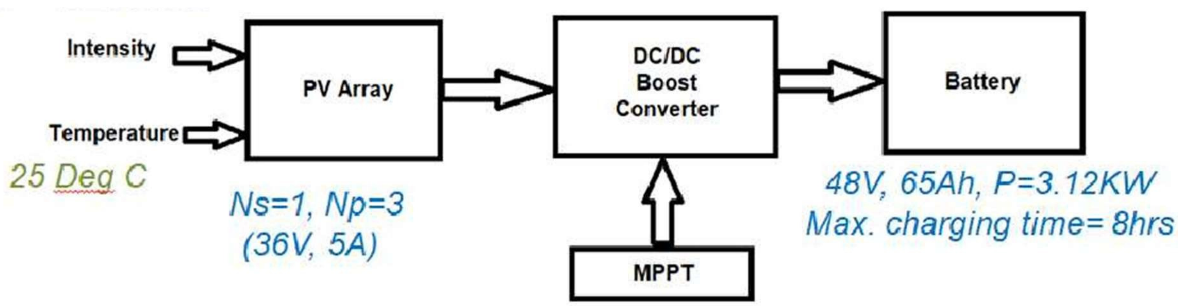

Fig. 1.2 Block diagram of Solar powered EV charging Station module

3.2 Solar powered EV charging station

Solar-powered EV charging stations consist of solar panels installed on the station's roof or in nearby areas, such as parking canopies or ground-mounted arrays. These panels convert sunlight into electricity through the photovoltaic (PV) effect. The generated electricity is then used to charge electric vehicles connected to the charging station.

These charging stations are typically equipped with charging infrastructure, including charging connectors, cables, and control systems. The charging connectors may vary depending on the region and the type of electric vehicles supported, such as AC (alternating current) or DC (direct current) connectors. In conclusion, solar-powered EV charging stations represent an innovative solution at the intersection of renewable energy and sustainable transportation. They leverage solar power to charge electric vehicles, reducing carbon emissions and promoting a greener and more sustainable future.

3.3 Battery System

Battery's open circuit voltage (OCV) is also known as the nominal voltage. It is the voltage potential that a battery can produce without being charged or loaded. Battery's open circuit voltage per cell is tightly involved with its state of charge. Generally, a lithium-ion battery has a rated voltage of 3.6V/cell to 3.7V/cell, and a cut-off discharge voltage of 2.75V/cell. The LIR14500 battery utilized in this project provides a nominalvoltageof3.7V/cell.

3.4 charger

In this section, we are going to discuss about the integrated simulation model of Solar panel, DC/DC converter along with MPPT algorithm with Li-ion battery pack. The hardware prototype is been developed and their results are displayed.From the characteristics of the Li-ion battery, to charge a battery of 48V, atleast we have to maintain a voltage of 54 to 57 at the input terminal of the battery and also it should be constant. Suitable capacitance filters and diodes are used at input and out stages of the boost converter.

Simulation Results

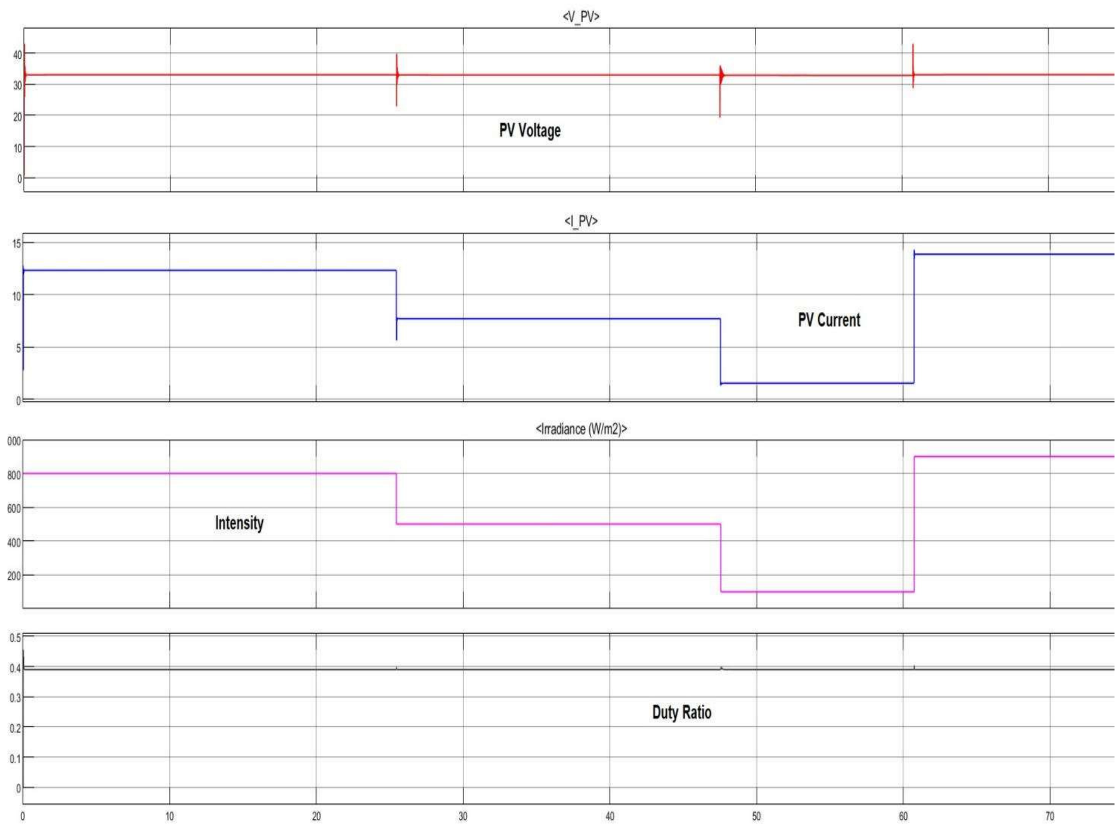

Figure: Simulation results shows PV Output voltage, PV Output current, Intensity variation and Duty ratio

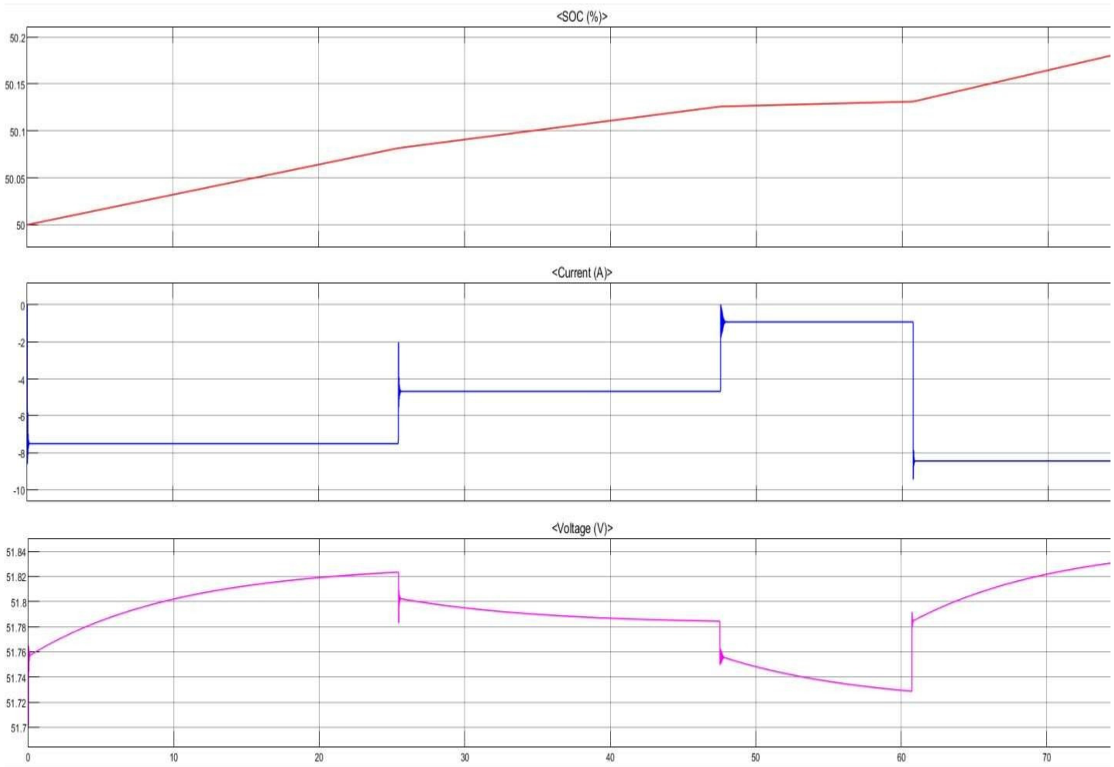

Figure 6.3: Simulation results shows output voltage, current and SOC of 48V, 65Ah Li-ion battery

From the simulation results it's seen that, for change in variation of intensities, the output voltage of the PV array is constant and only the current varies. With the help of MPPT technique, we are able to obtain the maximum power from the solar panel and converted to twice the output of the boost converter. The duty ratio variation is automatically done by the P and O algorithm. The battery SOC is seen clearly that the slope of charging is steep when the intensity is high. The corresponding current variation and voltage variation is observed. The current is the display is negative at the battery end, so it clear shown that the battery is charging. The below tabulation clearly shown the parameters that are varying as the intensity varies.

Table 6.1: Variation of Charging Current for variation in Intensity

Intensity (W/m2)	V_pv (V)	I_pv (A)	C_time (hr)	V_batt (V)	C_batt (A)
800	36.3	12.5	4.16	52	-7.8
500	36.1	7.5	6.9	51.8	-4.6
100	36	1.7	29.5	51.6	-1.2
900	36.5	14.3	3.6	52.3	-9.6

Conclusion

A standalone Electrical Vehicle charging station based on a Photovoltaic energy source is proposed. The system contains a PV panels, boost converter, buck convertor, bidirectional convertor, ESS batteries, and the Electrical Vehicle batteries. The control system is combination of four controllers, MPPT, EV charger, and the storage converter controller and A capacitor is added to regulate the battery current during charge and discharge operations, and the reference value of the current is positive for charging operations, and negative value for discharging operations. The system is built separately in MATLAB Simulink as every convertor is been built and tested alone, and we got an excellent outcome for every single convertor, the second we aggregate the components to a whole system the results went very far from accepted, we changed and calculated the capacitors, inductors, and resistors all over again till we got the desired output shown in this paper.

FUTURE WORKS:

- Develop multiple charging stations with both grid and solar integrated
- Develop wireless charging circuit with IOT application
- To develop solar tracking system for maximum power tracking
- To develop grid connected solar integrated charging station for cost reduction and faster recovery of installation cost

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