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Solar Powered EV Charging System with Boost Converter

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Abstract:

The rapid growth of electric vehicles (EVs) has increased the demand for sustainable and efficient charging infrastructure. This paper presents a Solar Powered EV Charging System with a DC–DC boost converter for reliable and eco-friendly EV charging. The proposed system uses photovoltaic (PV) panels to generate solar energy, while an MPPT-based boost converter regulates and increases the output voltage for efficient battery charging.

The system incorporates components such as a solar array, boost converter, PWM controller, Arduino Nano, and battery management system to ensure stable operation and safe charging. Experimental results show that the converter maintains a constant output voltage with controlled charging current under varying solar conditions. The proposed model reduces dependency on the conventional power grid, improves renewable energy utilization, and supports green mobility. Due to its low cost, compact design, and scalability, the system is suitable for rural, off-grid, and smart-city EV charging applications.

Keywords — **Electric Vehicle Charging, Boost Converter, MPPT, Renewable Energy, Solar Powered EV Charger**

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I. INTRODUCTION

The rapid increase in the use of electric vehicles (EVs) has created a strong need for efficient and sustainable charging infrastructure. Conventional EV charging systems mainly depend on grid electricity, which increases power demand and indirectly contributes to environmental pollution due to the use of fossil fuels in electricity generation [1]. As a result, integrating renewable energy sources into EV charging systems has become an important area of research.

Solar energy is one of the most promising renewable energy sources because it is clean, abundant, and environmentally friendly. A solar-powered EV charging system can reduce dependency on the conventional power grid while supporting green and sustainable transportation [2]. However, the output voltage of solar photovoltaic (PV) panels varies with solar irradiance and temperature, making efficient power regulation essential for reliable battery charging.

This paper presents a Solar Powered EV Charging System with a DC–DC Boost Converter for efficient EV battery charging. The proposed system uses solar PV panels to generate DC power, while a boost converter increases and regulates the voltage to the required charging level. An MPPT (Maximum Power Point Tracking) technique is incorporated to maximize power extraction from the solar panels under varying environmental conditions [3].

The system also includes a PWM controller, Arduino Nano, battery management arrangement, and protection circuitry to ensure safe and stable operation. The proposed model is designed to be cost-effective, compact, and suitable for rural, off-grid, and smart-city applications [4]. By combining renewable energy with efficient power electronics, the system provides an eco-friendly and reliable solution for future EV charging infrastructure [5].

II. LITERATURE REVIEW

Several researchers have worked on the development of solar-powered electric vehicle (EV) charging systems to reduce dependency on fossil fuels and promote sustainable transportation. Previous studies mainly focused on integrating solar photovoltaic (PV) systems with EV charging infrastructure using efficient power electronic converters and energy management techniques [6].

Wu et al. proposed the integration of a bidirectional inverter with buck–boost MPPT converters for DC distribution applications. Their work highlighted the importance of efficient power conversion and maximum power extraction from solar PV systems. Erickson and Maksimović explained the fundamentals of power electronics and the operation of DC–DC converters, which form the basis for boosting converter design in renewable energy applications.

Patel and Agarwal developed an MPPT scheme for PV systems operating under varying environmental conditions. Their research demonstrated that MPPT techniques significantly improve solar energy utilization efficiency. Sharma presented a solar-based EV charging station for sustainable transportation and showed that renewable energy integration can reduce dependency on the conventional power grid. Similarly, Singh developed a low-cost solar EV charger using PWM control techniques for small-scale charging applications.

Kumar performed a techno-economic analysis of solar EV charging stations and concluded that solar-powered charging systems offer long-term economic and environmental benefits. Patel proposed a solar-powered charging system for electric two-wheelers suitable for rural and off-grid applications [7]. Recent studies also focused on smart inverter control strategies and efficient charging management for improving system performance and reliability.

From the reviewed literature, it is observed that efficient voltage regulation, MPPT control, and renewable energy integration are essential for EV charging applications. However, many existing systems are either grid-dependent or costly. Therefore, the proposed project focuses on developing a compact, low-cost, and efficient solar-powered EV charging system using a DC–DC boost converter and controlled charging mechanism for sustainable and reliable operation.

III.METHODOLOGY

The proposed solar powered EV charging system is designed to provide an efficient and eco-friendly method for charging electric vehicle batteries using renewable solar energy. The complete system mainly consists of a solar photovoltaic (PV) array, MPPT controller, DC–DC boost converter, battery charging unit, Arduino Nano controller, and protection circuitry [8].

Initially, the solar panels capture sunlight and convert it into DC electrical energy. Since the output of solar panels changes continuously with sunlight intensity and temperature, an MPPT (Maximum Power Point Tracking) technique is used to extract maximum available power from the PV array [9]. This helps improve the overall efficiency of the system under varying environmental conditions.

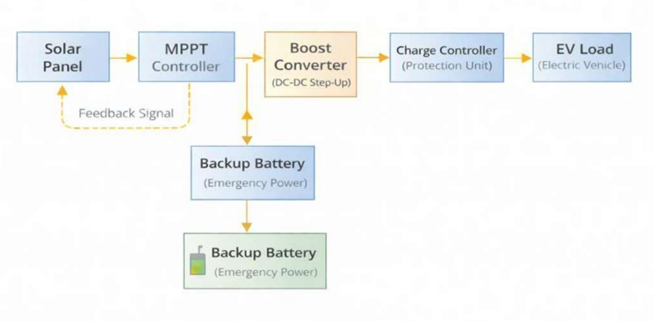

Fig.1 Block Diagram

The output obtained from the solar panel and MPPT stage is then supplied to the DC–DC boost converter. The boost converter increases the low DC voltage from the solar panels to the required charging voltage suitable for the EV battery. PWM control is used to regulate the switching operation of the converter and maintain a stable output voltage.

An Arduino Nano is used as the main control unit of the system. It continuously monitors important parameters such as solar voltage, battery voltage, charging current, and system status. The real-time operating conditions are displayed on a 2×16 LCD display for easy monitoring [10].

To ensure safe charging operation, protection circuits such as overvoltage protection, reverse current protection, and controlled charging mechanisms are included in the system. The battery charging process is carefully controlled to avoid overcharging and improve battery life.

The developed prototype was tested under different input voltage conditions to evaluate its performance. The experimental results confirmed stable output voltage, reliable charging operation, and efficient utilization of solar energy [11]. Thus, the proposed methodology provides a compact, cost-effective, and sustainable solution for modern EV charging applications.

IV. SIMULATION

The implementation of the proposed solar powered EV charging system was carried out in different stages, including hardware assembly, circuit integration, programming, and testing. Initially, the solar PV panels were connected in a suitable series–parallel configuration to obtain the required voltage and current output. The generated DC power was supplied to the MPPT controller for maximum power extraction.

The output from the MPPT stage was connected to the DC–DC boost converter, which increased the voltage to the required battery charging level. The boost converter circuit was designed using the XL7005A IC along with PWM control through the TL494 controller for stable voltage regulation.

An Arduino Nano was programmed to monitor important parameters such as solar voltage, output voltage, charging current, and battery condition. A 2×16 LCD display was interfaced with the controller to display real-time system information. Voltage sensing and feedback operations were carried out using the LM358 operational amplifier.

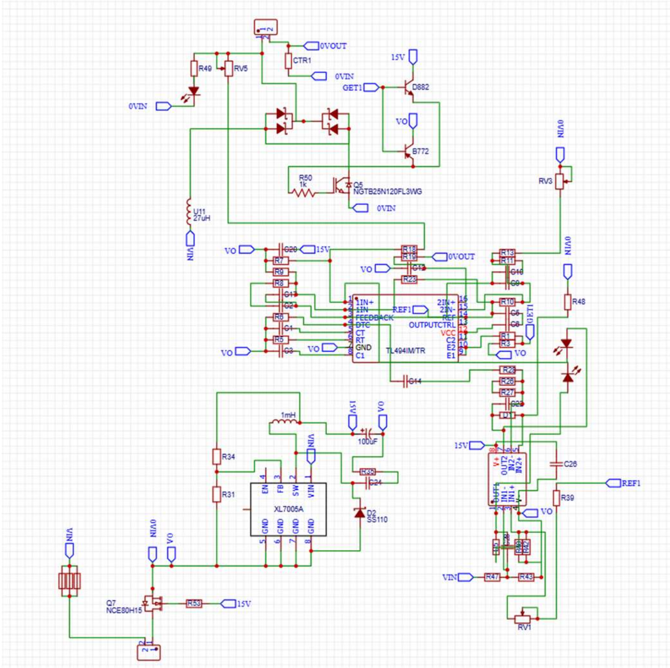

Fig.2 Schematic Diagram

After hardware integration, the complete system was tested under different solar input conditions. The charging performance, output voltage stability, and protection feature such as overvoltage and reverse current protection were verified successfully. The implemented prototype demonstrated reliable operation and effective utilization of solar energy for EV battery charging.

V. RESULT AND DISCUSSION

The proposed solar powered EV charging system was tested under different input voltage conditions to evaluate its performance and reliability. During testing, the solar PV system successfully generated DC power, and the MPPT controller effectively extracted maximum available power from the solar panels. The DC–DC boost converter maintained a stable output voltage of approximately 50 V for EV battery charging.

The experimental results showed that as the input voltage increased from 15 V to 30 V, the charging current gradually decreased from 2.3 A to 0.9 A while maintaining a constant output voltage. This confirmed the proper operation of the boost converter and PWM control circuit. The Arduino Nano continuously monitored system parameters and displayed real-time information on the LCD display [5].

Fig.3: Solar Array

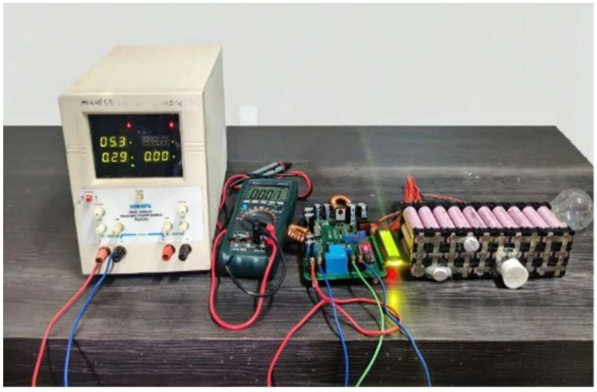

Fig.4: Hardware Setup

The protection circuits, including overvoltage protection and reverse current protection, operated successfully during testing and improved system safety and reliability. The overall system demonstrated stable performance under varying solar conditions and ensured controlled battery charging.

TABLE I
Testing Results

Sr. No.	Input Voltage (V)	Output Voltage (V)	Charging Current (A)
1	15	50	2.3
2	18	50	2
3	22	50	1.7
4	25	50	1.3
5	30	50	0.9

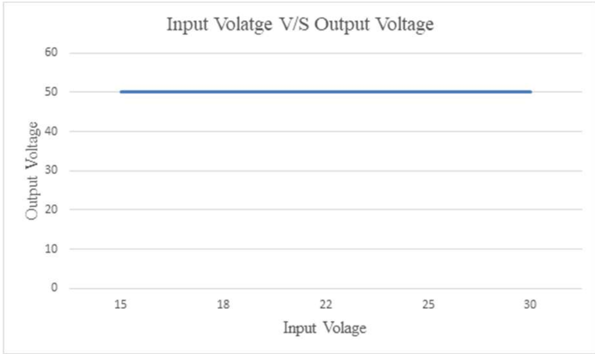

Fig.5: Output Voltage Graph

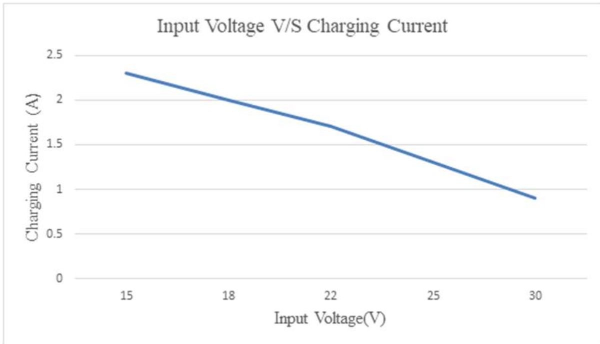

Fig.6: Charging Current Graph

The obtained results confirm that the proposed system can effectively utilize solar energy for EV charging applications while reducing dependency on the conventional power grid. The system is suitable for low-cost, eco-friendly, and off-grid charging applications with future scalability for higher power requirements.

V. CONCLUSION AND FUTURE SCOPE

The proposed solar powered EV charging system was tested under different input voltage conditions to evaluate its performance and reliability. During testing, the solar PV system successfully generated DC power, and the MPPT controller effectively extracted maximum available power from the solar panels. The DC–DC boost converter maintained a stable output voltage of approximately 50 V for EV battery charging.

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Nano continuously monitored system parameters and displayed real-time information on the LCD display.

The protection circuits, including overvoltage protection and reverse current protection, operated successfully during testing and improved system safety and reliability. The overall system demonstrated stable performance under varying solar conditions and ensured controlled battery charging.

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