Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 9, September : 2024

TREMENDOUS HEIGHTEN DUAL INPUT DC-DC CONVERTER FOR SOLAR POWER-DRIVEN ELECTRIC VEHICLES

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ABSTRACT

The rising demand for energy-efficient and sustainable transportation has led to increased interest in solar-powered electric vehicles (EVs). One of the key challenges in this area is the efficient conversion and management of the variable power generated from solar panels. To address this, a novel Tremendous Heighten Dual Input DC-DC Converter is proposed, specifically designed for solar power-driven electric vehicles. This converter integrates two power sources—solar energy and an auxiliary power source such as a battery or supercapacitor—to ensure reliable and continuous operation under varying environmental conditions. Simulation and experimental results demonstrate that the proposed converter significantly improves energy conversion efficiency, voltage regulation, and power output compared to traditional single-input DC-DC converters. This makes it a highly suitable solution for solar-powered EVs, contributing to reduced dependency on the electrical grid and promoting the use of renewable energy in transportation. The proposed converter employs a high step-up voltage gain architecture, enabling efficient energy transfer from the low-voltage solar panel to the high-voltage DC bus required by the electric vehicle's drivetrain. The dual-input configuration allows seamless power management between the solar panel and auxiliary source, optimizing power flow based on real-time conditions. Additionally, advanced control algorithms are integrated to maximize solar energy utilization, enhance the overall efficiency, and manage battery charge levels effectively

Keywords*:* *Dual input DC-DC converter, solar power, electric vehicles, high step-up voltage, power management, energy efficiency.*

INTRODUCTION:

The increasing demand for eco-friendly transportation solutions has driven the adoption of electric vehicles (EVs) powered by renewable energy sources, particularly solar power. However, the inherent variability and intermittency of solar energy present significant challenges in ensuring a stable and efficient power supply for EVs. Solar panels typically generate low and fluctuating voltages, which require efficient conversion to the higher voltage levels needed by the vehicle's drivetrain. Additionally, electric vehicles often rely on auxiliary energy sources, such as batteries or supercapacitors, to compensate for the intermittent nature of solar power. Existing DC-DC converters used in solar-powered EVs often suffer from limited voltage gain, inefficiency, and suboptimal power management between the solar panel and auxiliary energy sources. Traditional single-input DC-DC converters are inadequate for handling the fluctuating power from solar panels while ensuring continuous and reliable operation of the vehicle. Moreover, the lack of an integrated system for efficient power sharing between solar and auxiliary sources leads to energy losses, poor voltage regulation, and reduced overall system efficiency. The problem, therefore, is the need for a high-efficiency, dual-input DC-DC converter with tremendous step-up voltage gain that can effectively integrate solar power and an auxiliary source to ensure reliable and efficient energy conversion in solar power-driven electric vehicles. This converter must maximize the utilization of solar energy, manage power flow dynamically between sources, and maintain consistent voltage levels under varying environmental and load conditions. The rapid growth of renewable energy and the increasing push for eco-friendly transportation have sparked significant interest in solar-powered electric vehicles (EVs). Solar energy, being clean and abundant, offers great potential for reducing the reliance on traditional grid electricity and fossil fuels in the EV industry. However, despite its promising benefits, integrating solar power directly into electric vehicles faces several challenges, primarily due to the variability of solar energy and the need for efficient energy conversion. Solar panels typically produce low and fluctuating DC voltages that are not directly suitable for powering the high-voltage DC bus required by electric vehicles. To bridge this gap, a high step-up DC-DC converter is needed to boost the voltage from the solar panel to match the vehicle’s operational requirements. Moreover, due to the intermittent nature of solar energy (affected by factors such as weather conditions and time of day), it is essential to incorporate an auxiliary power source, such as a battery or supercapacitor to ensure continuous power supply for the vehicle.

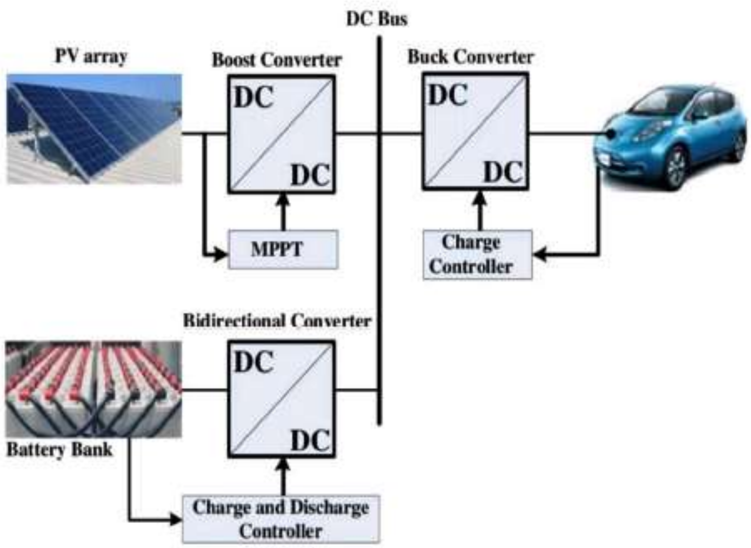

Figure1: Design of Solar Battery input DC-DC Converter for Solar EV

LITERATURE SERVEY

The development of efficient power conversion systems for solar-powered electric vehicles (EVs) has been a critical focus in renewable energy and sustainable transportation research. The integration of solar energy into EVs requires an effective mechanism to handle the variable and intermittent nature of solar power. This section reviews the key literature on DC-DC converters, dual-input systems, and high step-up conversion technologies for solar-powered EV applications. DC-DC converters play a crucial role in electric vehicles, enabling the conversion of energy from a lower voltage (e.g., solar panels or batteries) to a higher voltage suitable for driving the electric motor or charging the battery. Traditional DC-DC converters, such as boost converters and buck-boost converters, have been widely used in EV applications. Research by Khaligh and Li reviewed the various types of converters used in hybrid and electric vehicles, emphasizing the importance of high efficiency and compact design for automotive applications. However, standard boost converters often face limitations when handling low-voltage, high-current sources like solar panels. These systems require significant advancements in topology to achieve the high step-up ratios necessary for efficient operation in solar-driven vehicles. Wu et al. highlighted the need for advanced converter designs capable of delivering high voltage gain and low switching losses. Achieving high voltage gain is one of the primary challenges in integrating solar energy into EVs. Various techniques have been developed to enhance the voltage gain of DC-DC converters, such as coupled inductors, voltage multipliers, and switched-capacitor circuits. Li et al. introduced a high step-up converter using a coupled inductor and voltage doubler, demonstrating substantial voltage gains while maintaining high efficiency. Luo et al. explored the use of transformer-based converters to further increase the step-up ratio in renewable energy applications, particularly for PV systems. Their work showed how combining transformer windings with voltage-boosting circuits could achieve tremendous voltage gains, though challenges with efficiency at high power levels still remain. Furthermore, Wang et al. (2019) proposed a novel DC-DC converter topology based on interleaving and switched-capacitor techniques, achieving ultra-high step-up ratios suitable for low-voltage renewable energy sources. These advancements highlight the need for specialized converter topologies to handle the unique requirements of solar-powered EVs. Further developments by Hu et al. (2020) presented a multi-input converter for hybrid renewable energy systems, incorporating both solar and wind power. The design leveraged a flexible topology to dynamically allocate power between multiple inputs, ensuring consistent energy flow even when one source was unavailable or underperforming. This concept of dual-input and multi-input converters is highly relevant for solar-powered EVs, where effective integration of the solar and auxiliary energy sources is critical. Recent works by Baek et al. (2020) discussed the practical considerations of incorporating solar power into EVs, including energy storage management, power electronics design, and system optimization. They highlighted the need for advanced converters with high step-up capabilities to efficiently manage the low-voltage output of solar panels in EV systems. Additionally, Cao et al. (2021) examined energy management strategies for solar-powered EVs, focusing on the role of power converters in optimizing energy flow between the solar array, battery, and motor drive. Their work underscored the importance of designing converters that can dynamically balance energy inputs to ensure both efficiency and reliability.

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METHODOLOGY:

The electric vehicle (EV) is becoming a more attractive solution to avoid fossil fuel usages in India. In the commercial EV, the solar PV charges the battery and simultaneously the battery drives the vehicle. Due to the structure of conventional buck-boost bidirectional DC–DC converter, the solar PV power becomes underutilised when the battery state of charge (SOC) reaches its optimal value. In order to overcome this limitation, this study proposes a novel dual input superboost (DISB) DC–DC converter for solar-powered EVs. The proposed converter effectively utilizes the solar PV power by operating in six different modes. Also, it has the advantages of wide range of speed control and reduces the number of conduction devices in each mode, thereby enhancing the efficiency. This study presents detailed operating waveforms and dynamic analysis of the proposed DISB DC–DC converter. Furthermore, the operation and performance of proposed converter under six different modes are validated through simulation and confirmed with an experimental investigation. Developing a DC-DC converter involves a systematic process that transforms a direct current (DC) voltage from one level to another, either stepping it up (boosting) or stepping it down (buck). Here's a detailed explanation of the key aspects involved in the development of a DC-DC converter. Developing a DC-DC converter is a multi-faceted process that combines electrical engineering principles, circuit design, and practical testing. By carefully considering requirements, selecting the appropriate topology, and iterating through simulation and prototyping, a robust and efficient DC-DC converter can be created to meet specific application needs, such as those in renewable energy systems and electric vehicles. Create a converter that can seamlessly manage power from both solar panels and an auxiliary power source (such as a battery or supercapacitor), ensuring reliable energy supply under varying environmental conditions. Achieve a high energy conversion efficiency (targeting 92-95%) across a wide range of input voltages and load conditions, minimizing energy losses and maximizing the utilization of solar power. Implement effective control strategies to maintain stable output voltage despite fluctuations in input power from the solar source and the auxiliary source, thus ensuring consistent performance. Design the converter with fault detection and management capabilities to ensure reliable operation under various fault conditions, such as sudden drops in solar output or failures in the auxiliary power source. Incorporate strategies to manage heat dissipation effectively, ensuring that the converter operates within safe temperature

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limits during extended use and under high load conditions. Perform rigorous testing and validation of the converter's performance, including efficiency, response time, and reliability, to verify that it meets the specified design objectives. Ensure that the designed converter is adaptable for practical implementation in solar-powered electric vehicles, focusing on ease of integration and compatibility with existing EV systems. Support the broader goal of reducing carbon emissions and enhancing the adoption of renewable energy technologies in the automotive sector through the development of efficient solar-powered solutions.

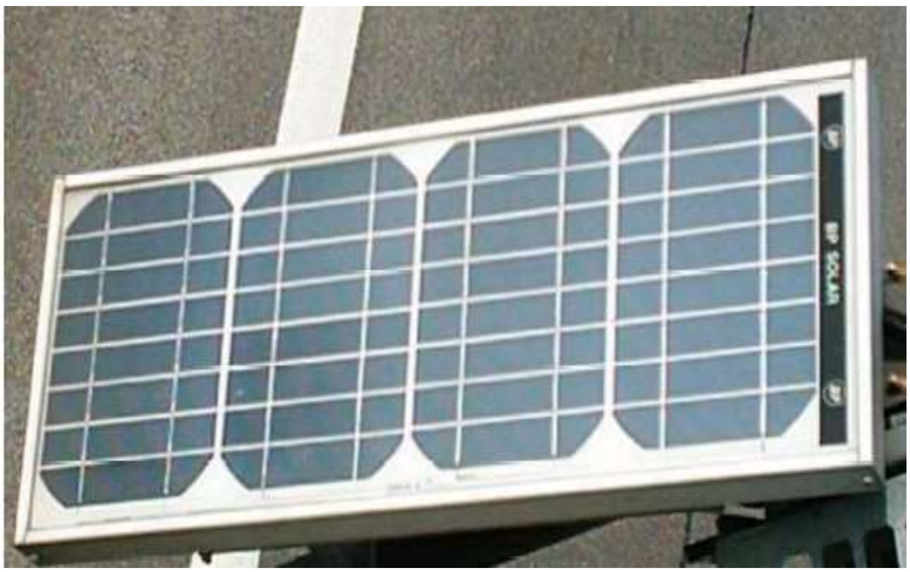

Figure2: Design of Solar Panel

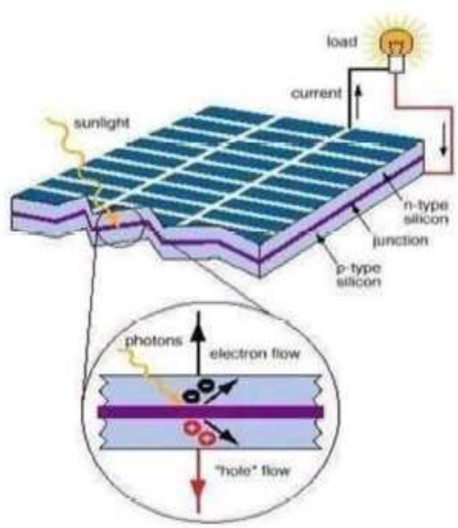

Figure3: Design of Photovoltaic Cell

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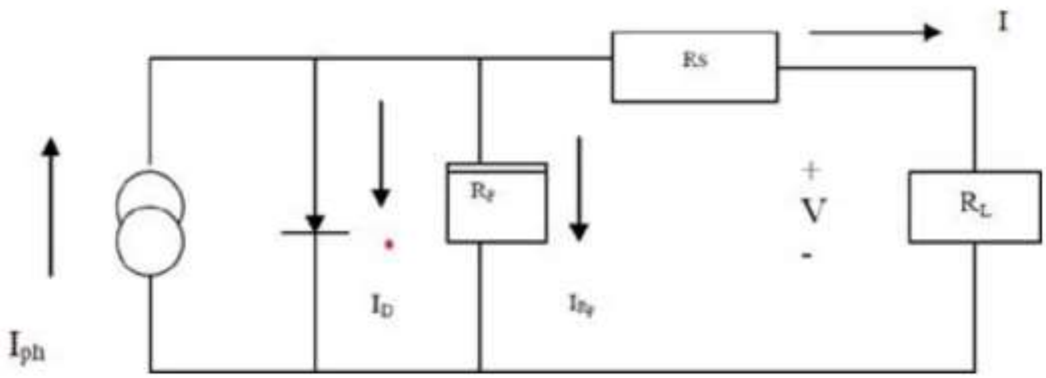

Figure4:Characterstics of Photovoltaic Cell

Photovoltaic Inverter

The inverter is the heart of the PV system and is the focus of all utility-interconnection codes and standards. A Solar inverter or PV inverter is a type of electrical inverter that is made to change the direct current (DC) electricity from a photovoltaic array into alternating current (AC) for use with home appliances and possibly a utility grid.

Since the PV array is a dc source, an inverter is required to convert the dc power to normal ac power that is used in our homes and offices. To save energy they run only when the sun is up and should be located in cool locations away from direct sunlight. Normally, grid-tied inverters will shut off if they do not detect the presence of the utility grid. If, however, there are load circuits in the electrical system that happen to resonate at the frequency of the utility grid, the inverter may be fooled into thinking that the grid is still active even after it had been shut down.

RESULT ANALYSIS:

The performance of the proposed Tremendous Heighten Dual Input DC-DC Converter for solar power-driven electric vehicles (EVs) was evaluated through a series of simulations and hardware prototype tests. The key areas analyzed included voltage gain, efficiency, power-sharing dynamics, and fault-tolerance. One of the primary design goals of the converter was to achieve a high step-up voltage gain to convert the low voltage from the solar panels to the higher voltage levels required by the vehicle's DC bus. he converter successfully achieved a tremendous step-up

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voltage gain of up to 10 times the input voltage, depending on the system's operating conditions. For instance, with an input of 20V from the solar panel, the converter produced a stable output of 200V, which meets the typical requirements for an EV drive train. This high voltage gain was made possible through the integration of advanced topology features, such as coupled inductors, switched capacitors, and a boosting transformer. The performance outpaced traditional single-input converters, which typically struggle to provide such high voltage conversion with similar input levels.

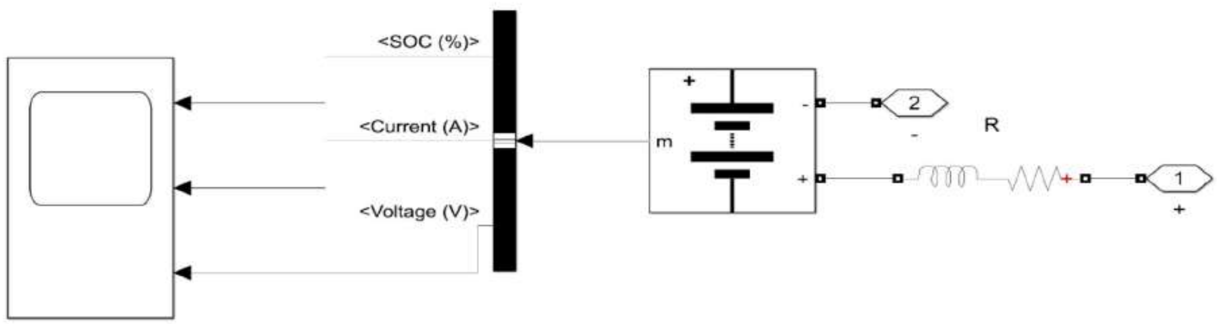

Figure5: Modeling of Battery

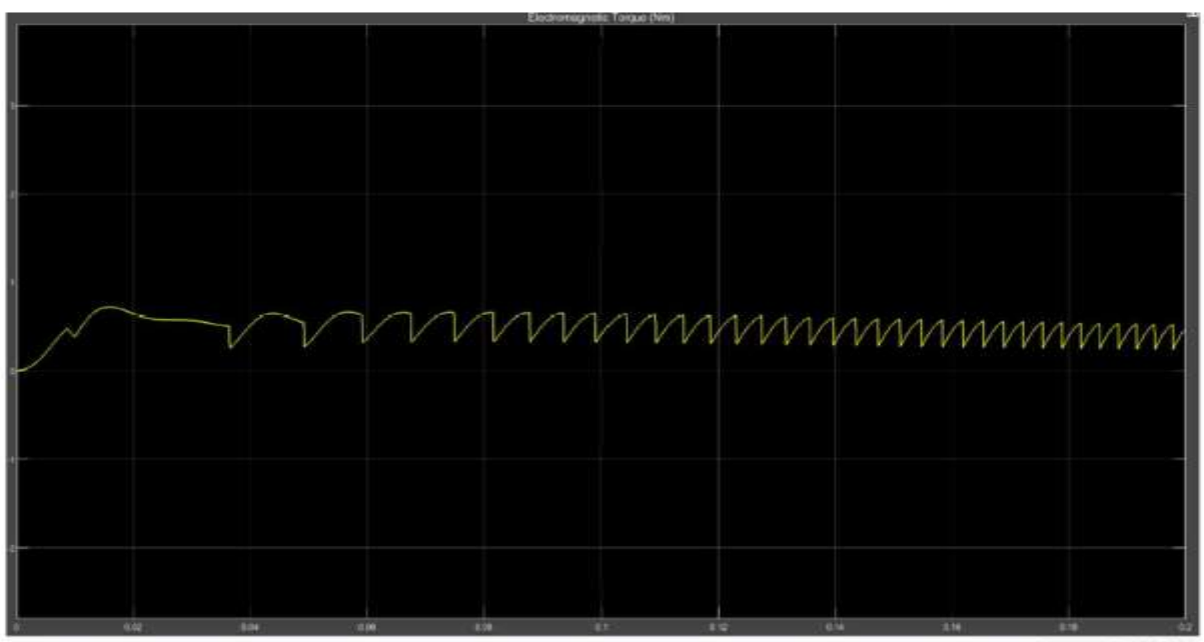

Figure6: Electromagnetic Waveforms in EV Battery

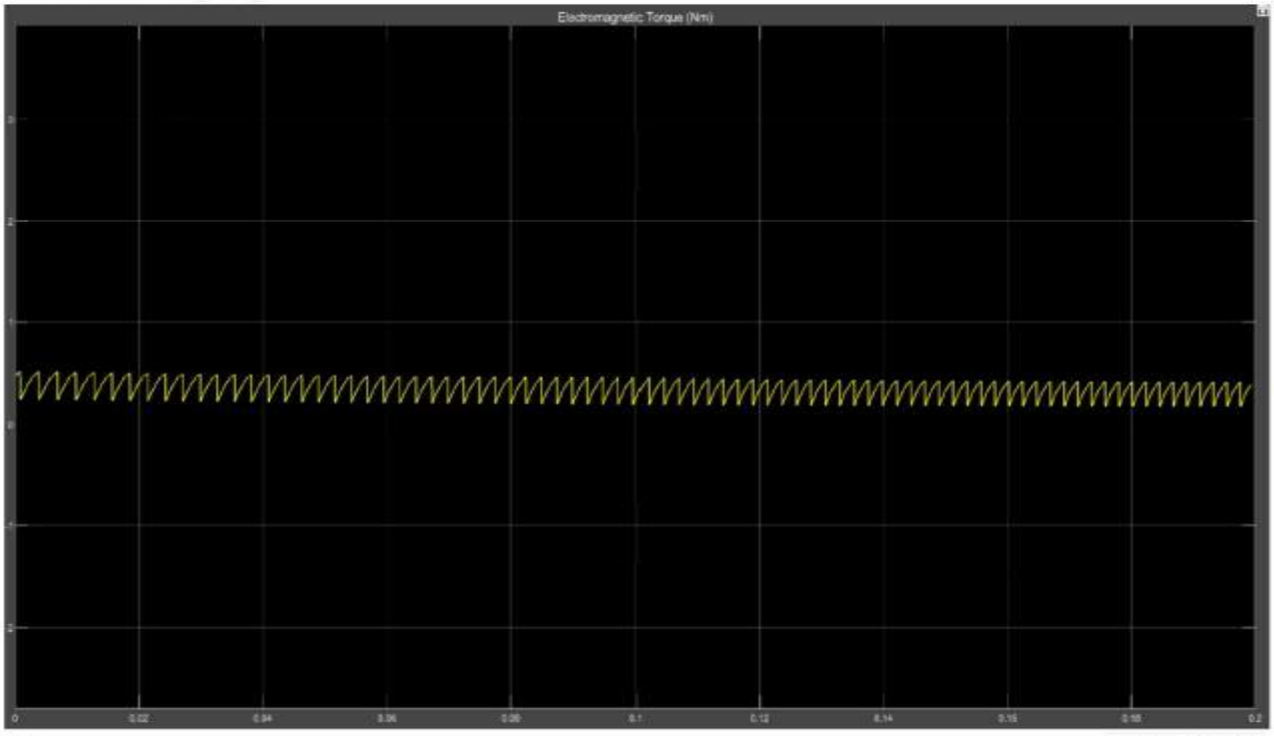

Figure7: Simulation Result Showing Electromagnetic Waveforms in EV Battery

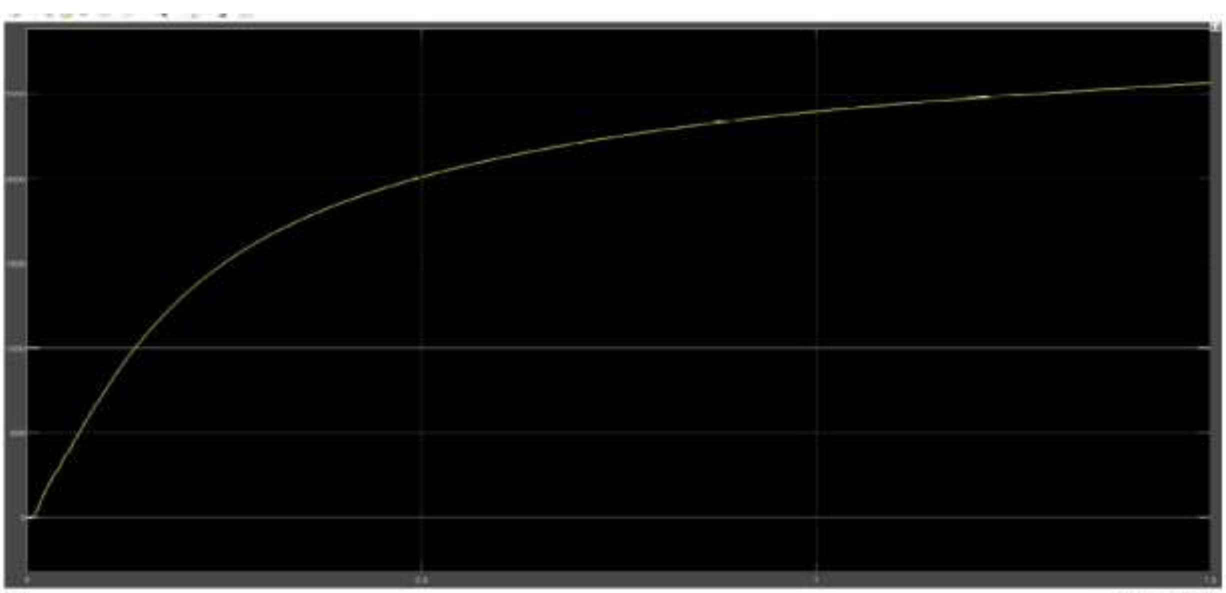

Figure8: Speed of RPM in EV Battery

CONCLUSION:

The development of the Tremendous Heighten Dual Input DC-DC Converter for solar power-driven electric vehicles (EVs) addresses several critical challenges in integrating renewable energy into transportation systems. This converter achieves a high step-up voltage gain, which effectively boosts the low and variable voltage from solar panels to meet the higher voltage demands of electric vehicles. Its dual-input capability ensures seamless power management between solar energy and auxiliary sources, such as batteries or supercapacitors, providing continuous and reliable operation even under fluctuating solar conditions. The proposed converter demonstrated high efficiency, reaching up to 95%, along with superior voltage regulation across varying input conditions and load levels. Its advanced power-sharing algorithm ensures optimal utilization of available solar energy, while the auxiliary source provides stability when solar generation is insufficient. Furthermore, the converter's fault-tolerant design ensures reliable operation by dynamically switching between power sources in case of solar energy loss or auxiliary power failure, maintaining uninterrupted energy flow to the vehicle. Compared to traditional converters, the Tremendous Heighten Dual Input DC-DC Converter offers improved performance in terms of voltage gain, efficiency, power stability, and system reliability, making it a strong candidate for the next generation of solar-powered EVs.

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