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# A Single Inductor Multiport Power Converter for Electric Vehicle Applications

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**ABSTRACT:** The objective of this project is to propose a novel single inductor multiport power converter tailored for electric vehicle (EV) applications. The converter is designed to efficiently integrate multiple energy sources, providing advantages in load power distribution and flexibility in charging and discharging processes. By leveraging a single inductor, the converter achieves dual-input functionality, accommodating renewable energy sources such as solar PV alongside traditional battery inputs. It offers multiple outputs with varying voltage levels, catering to diverse EV loads including motor drives and auxiliary systems. The converter's compatibility with multilevel inverters enhances system performance by reducing harmonic distortion and torque ripples in EV drive trains. Despite its advanced features, the converter maintains simplicity and cost effectiveness through a streamlined component design. Experimental validation conducted in a laboratory environment confirms the converter's effectiveness and suitability for EV applications.

**KEYWORDS:** Single inductor, Multi-port power converter, Renewable energy, Charging and discharging control, Dual input.

## I. INTRODUCTION

The rapid expansion of electric vehicles (EV) necessitates innovative power management solutions to optimize energy utilization and enhance performance. In response to this demand this paper introduces a pioneering single inductor multiport power converter tailored explicitly for EV applications. The converter aims to address the inherent complexities of integrating multiple energy sources, such as solar photovoltaic (PV) and battery systems, into the EV powertrain while ensuring efficient power distribution and control. By leveraging a single inductor design, the proposed converter offers dual input functionality, accommodating diverse energy inputs and enabling seamless transition between charging and discharging modes. This design not only simplifies the circuitry but also enhances cost effectiveness and reliability.

Furthermore, the converter's multi-port architecture facilitates the provision of multiple output voltage levels, catering to the various loads, from high power motor drives to auxiliary systems like lighting and onboard electronics. Additionally, its compatibility with multilevel inverters further enhances performance by minimizing total harmonic distortion and torque ripples in the EV drivetrain. Through comprehensive theoretical analysis, simulation studies, and experimental validation, this research aims to demonstrate the effectiveness and feasibility of the proposed converter for real world EV applications. By addressing key challenges in EV power management, such as energy efficiency, system complexity, this study contributes to the advancement of sustainable transportation technologies and the transition towards a cleaner and greener mobility future.

## II. LITERATURE REVIEW

1. This paper introduces a novel DC-DC converter designed specifically for electric vehicles applications. The converter is developed to address the increasing demand for efficient power management solutions in EVs, aiming to improve energy utilization, it contributes to the ongoing efforts to develop innovative power management solutions tailored for EV applications.

2. Wang L's research focuses on optimizing real-time control strategies for energy management systems in electric vehicles (EV). This involves selecting the best components, sizing batteries, and developing algorithms to efficiently manage energy flow in different driving conditions. The goal is to enhance EV performance, extend driving range, integrate renewable energy sources effectively. The research includes simulation and experimental validation to ensure the effectiveness and reliability of the proposed strategies.

3. The research aims to optimize energy usage and extend driving range by efficiently controlling the flow of energy between these components. It explores sophisticated energy management algorithms to dynamically allocate power based on driving conditions and battery / super capacitor state-of-charge. Experimental validation is conducted to assess the performance and reliability of the proposed system.

4. This study presents a multifunctional non-isolated dual-input dual-output converter designed for electric vehicle application. This converter efficiently manages power from two input sources, typically a renewable energy source like solar PV and a battery, to provide dual output suitable for various EV loads. It offers flexibility in power distribution and control, enabling seamless integration of renewable energy and optimizing energy utilization in EVs.

5. This study focuses on the design and implementation of an asymmetrical multilevel inverter with reduced components and low voltage stress. This inverter architecture aims to achieve high performance while minimizing the number of components required and reducing voltage stress on the system. The research likely explores innovative circuit configurations and control strategies to optimize efficiency and reliability. This work contributes to advancing the field of power electronics by offering a more efficient and cost-effective solution for multilevel inverters, which can find applications in renewable energy systems, motor drives, and grid-connected systems.

6. Miami and Ardi H's study introduces a novel high step-up DC-DC converter. This converter is designed to efficiently boost low input voltages to higher output voltages, making it suitable for various applications where high voltage conversion is required. The research likely explores innovative circuit topologies and control strategies to achieve high step-up ratios while maintaining efficiency and reliability.

7. The study proposes a non-isolated multi-input single-output DC/DC converter designed specifically for photovoltaic power generation systems. This converter efficiently manages power from multiple photovoltaic sources to provide a single output. The research likely focuses on developing innovative circuit topologies and control strategies to optimize energy conversion efficiency and reliability. By enabling the integration of multiple photovoltaic sources, this converter design aims to enhance the performance and scalability of photovoltaic power generation systems for various applications.

8. This review provides an overview of selection parameters and synthesis methods for multi-input converters tailored for electric vehicles (EVs). It examines key factors considered in the design process and summarizes various synthetic techniques used to develop efficient multi-input converters.

9. The study introduces a dual current pump module design to enhance the transient response of step-down DC-DC converters. This module likely employs innovative circuitry to provide additional current during transient periods, improving the converter's ability to respond quickly to changes in load or input voltage.

10. The study presents a variable step size perturb and observe (P&O) Maximum Power Point Tracking (MPPT) algorithm for photovoltaic systems based on fuzzy logic.

### III. PROPOSED MODEL

The proposed model delineates two primary operational modes: Charging Mode and Discharging Mode, each integral to the system's functionality.

#### Charging Mode:

In this operational state, the photovoltaic voltage ( $V_{pv}$ ) serves the dual purpose of supplying power to the loads and replenishing the battery ( $V_{bat}$ ). Activation of the Charging Mode occurs when the power demanded by the load falls below the available power, facilitating the charging of the battery. During this mode, switches S1, S2, and S4 are active, while switch S3 remains inactive. The adjustment of the total output voltage ( $V_T = V_{pv} + V_{bat}$ ) is orchestrated by



activating switch S1. Meanwhile, switch S2 governs the regulation of the battery charging current ( $I_{bat}$ ), ensuring it remains at the required level. Additionally, switch S4 is responsible for controlling the voltage output  $V_{pv}$ . Charging Mode comprises four distinct switching conditions within a single switching period, with each condition influencing the behaviour of the switches and the flow of energy through the various components of the system.

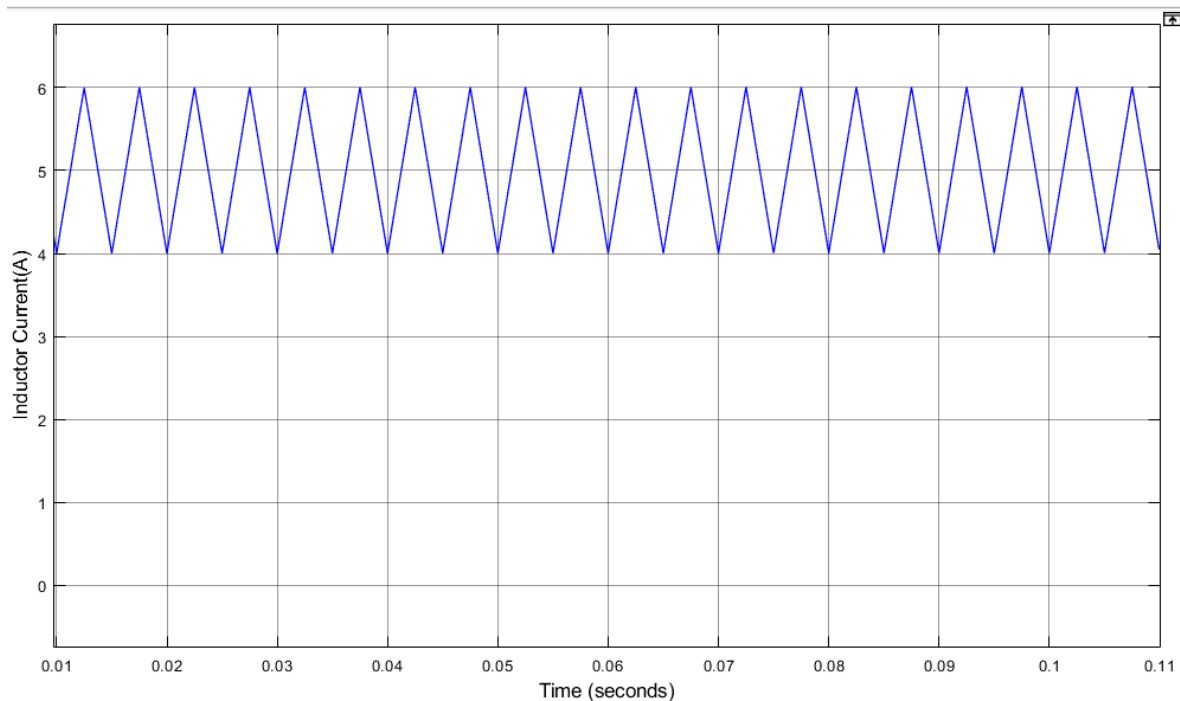
**Discharging Mode:**

Conversely, Discharging Mode facilitates the delivery of power to the loads using both the photovoltaic voltage ( $V_{pv}$ ) and the battery voltage ( $V_{bat}$ ). During this operational phase, switches S1, S3, and S4 are activated, while switch S2 is rendered inactive. Much akin to Charging Mode, each switch assumes a specialized role in the process of power delivery from the sources to the load. Specifically, switch S1 facilitates the adjustment of the current passing through the battery, ensuring it aligns with the required value. Meanwhile, switch S3 maintains the total output voltage ( $V_T = V_{pv} + V_{bat}$ ) at a consistent level, while switch S4 regulates the voltage output  $V_{pv}$ . The manipulation of both  $V_T$  and  $V_{pv}$  during Discharging Mode directly influences the output voltage  $V_{bat}$ . Similar to its counterpart, Discharging Mode also undergoes four distinct switching conditions within a single switching period, each exerting its own impact on the behaviour of the switches and the energy flow across the system's components.

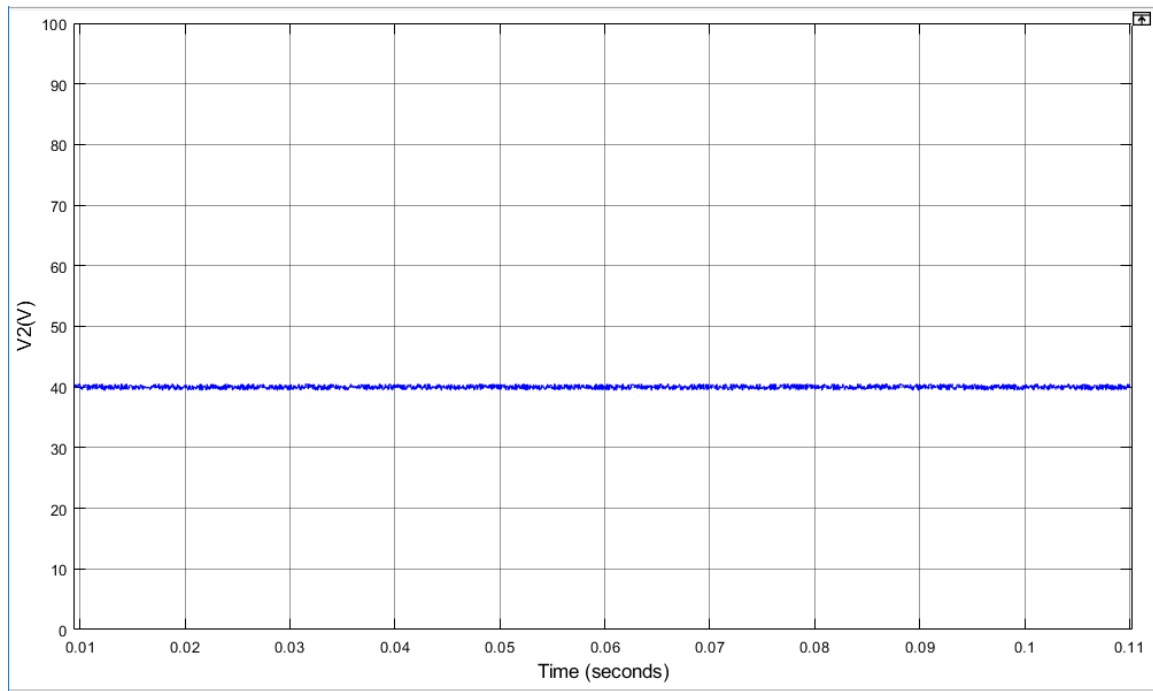
In essence, both Charging Mode and Discharging Mode encompass intricate interactions between switches and various system components to effectively manage the flow of power, thereby ensuring the efficient charging and discharging of the battery while adequately supplying power to the connected loads. The detailed elucidation provided furnishes a comprehensive insight into the precise functionalities and behaviours of the switches and components within each mode and switching condition, elucidating the operational intricacies of the proposed model.

**IV. RESULTS & DISCUSSION**

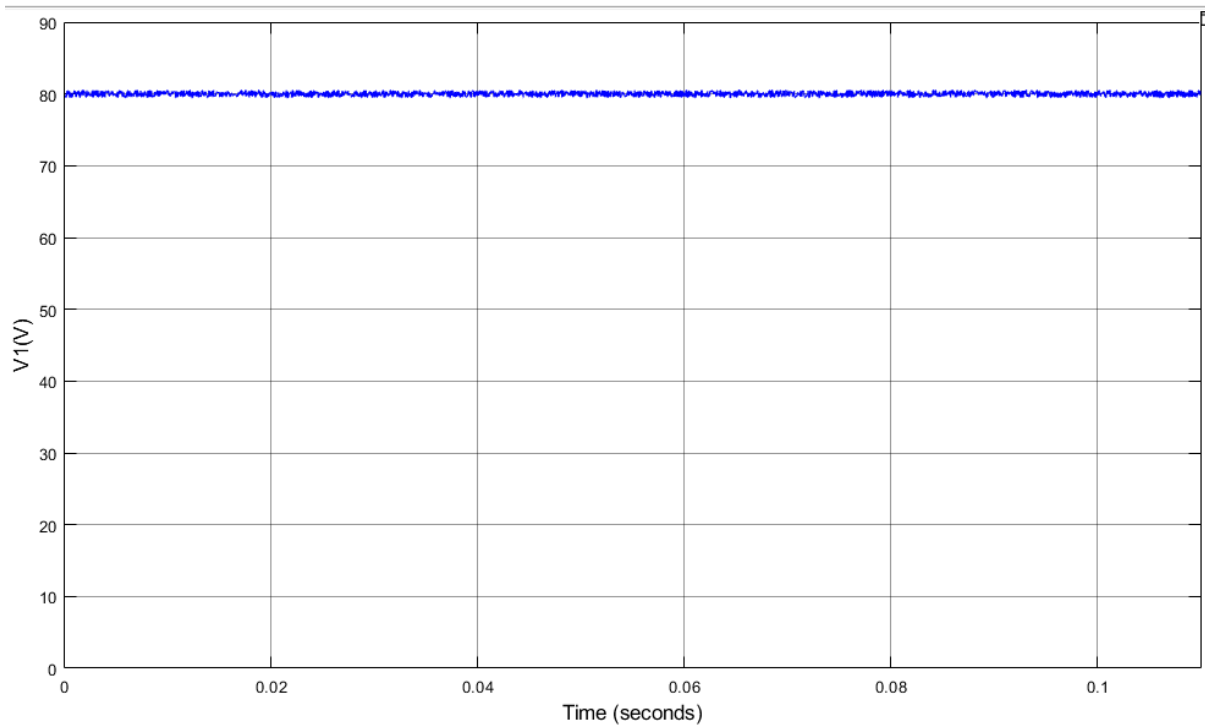
CASAE\_1: Discharging Mode



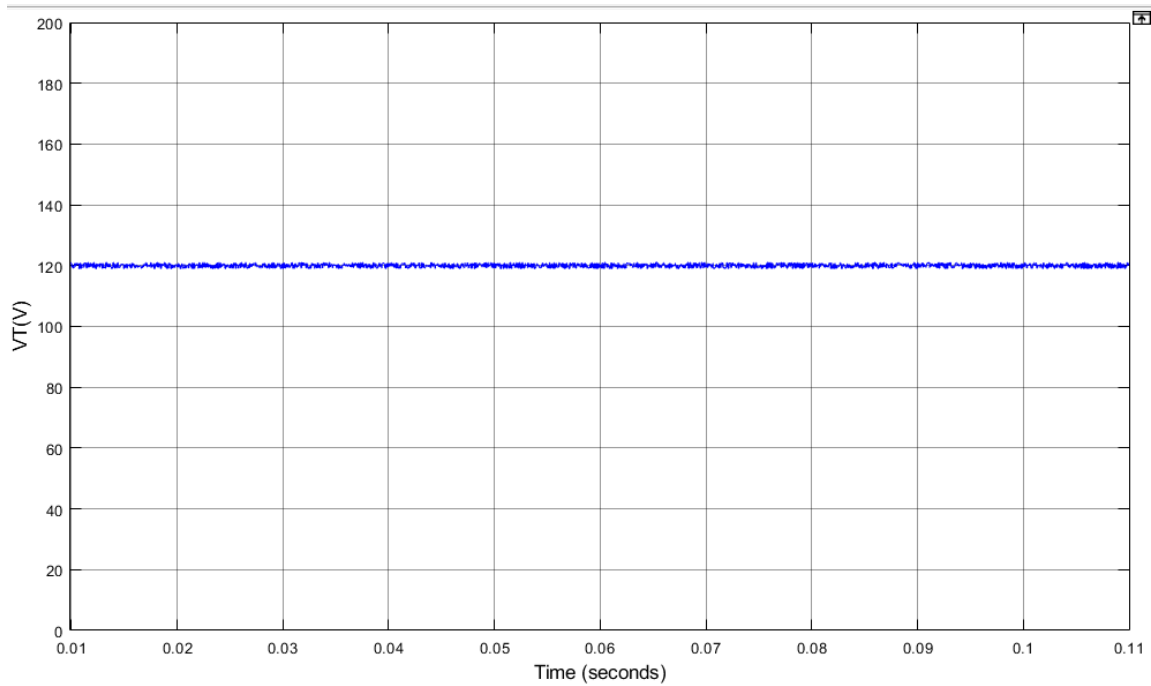
Inductor Current



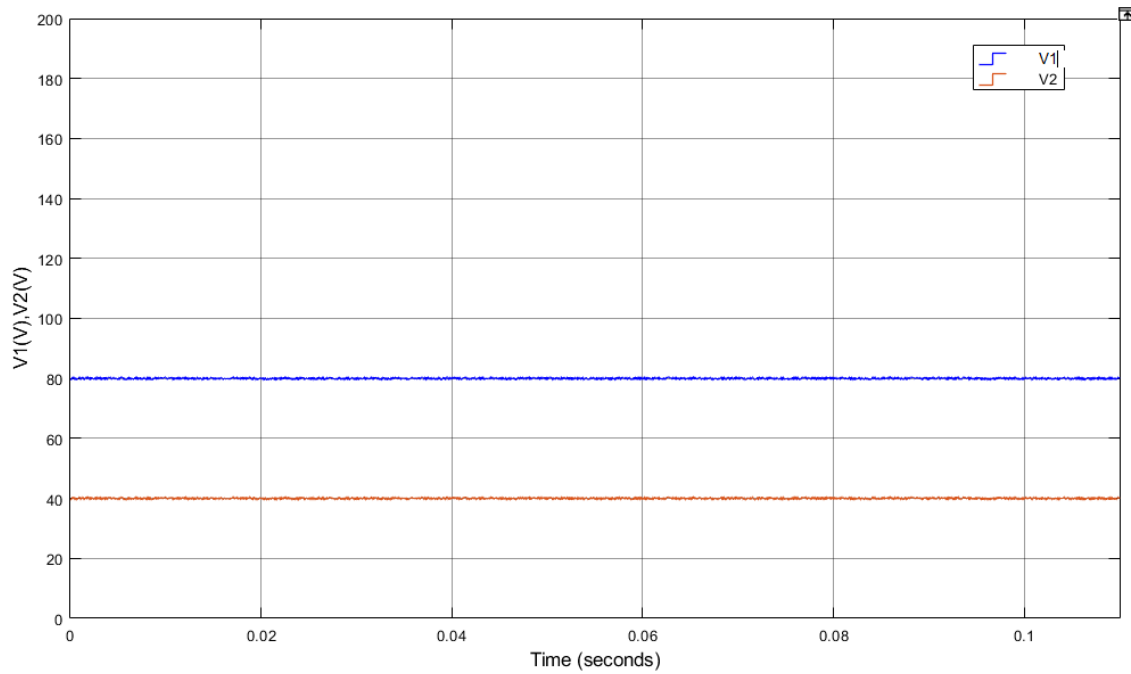
Output voltage 2



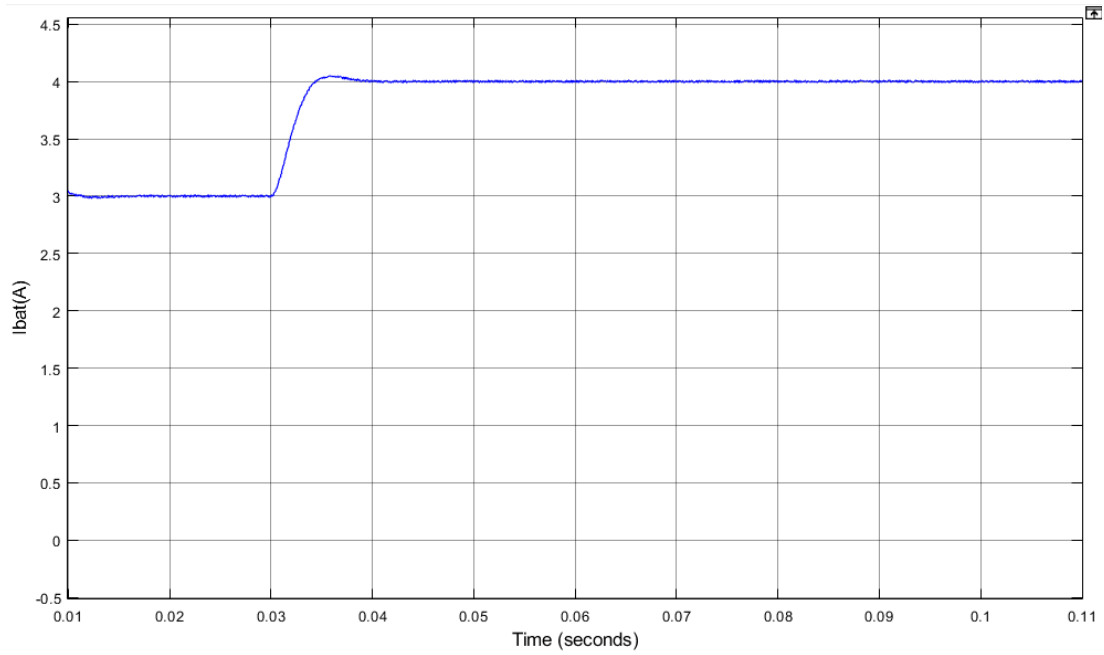
Output Voltage\_1



Total Output Voltage

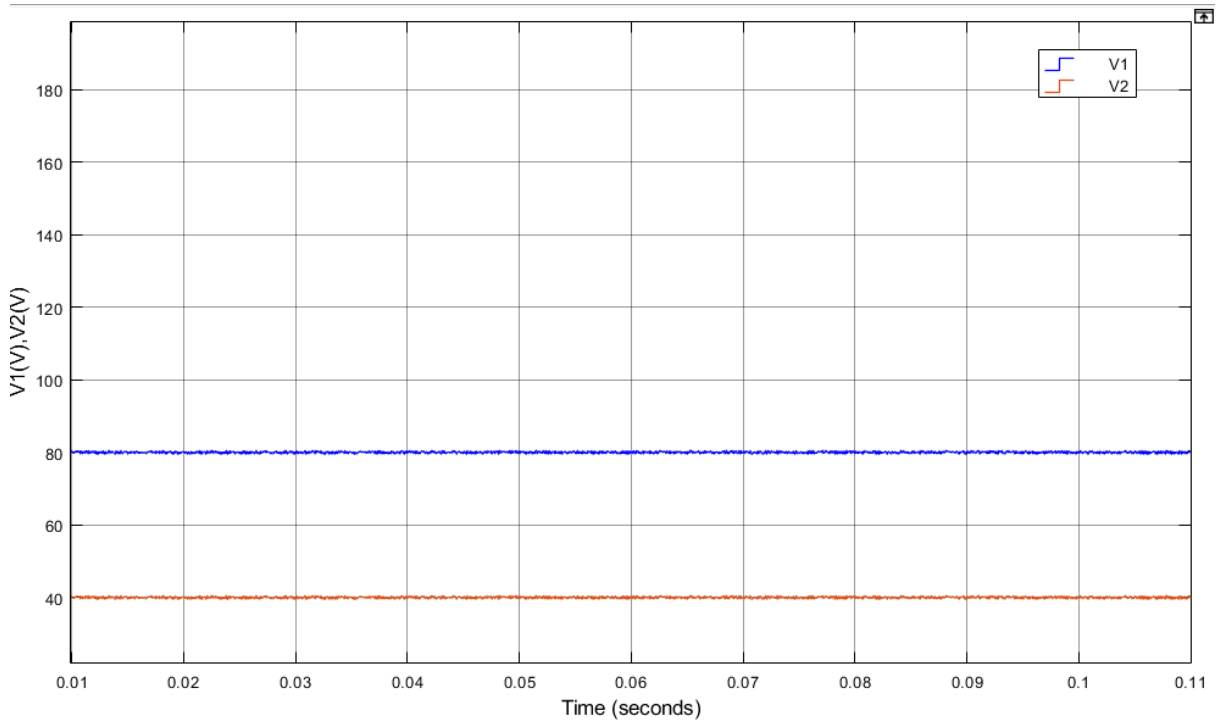


Output voltages in battery charging mode.

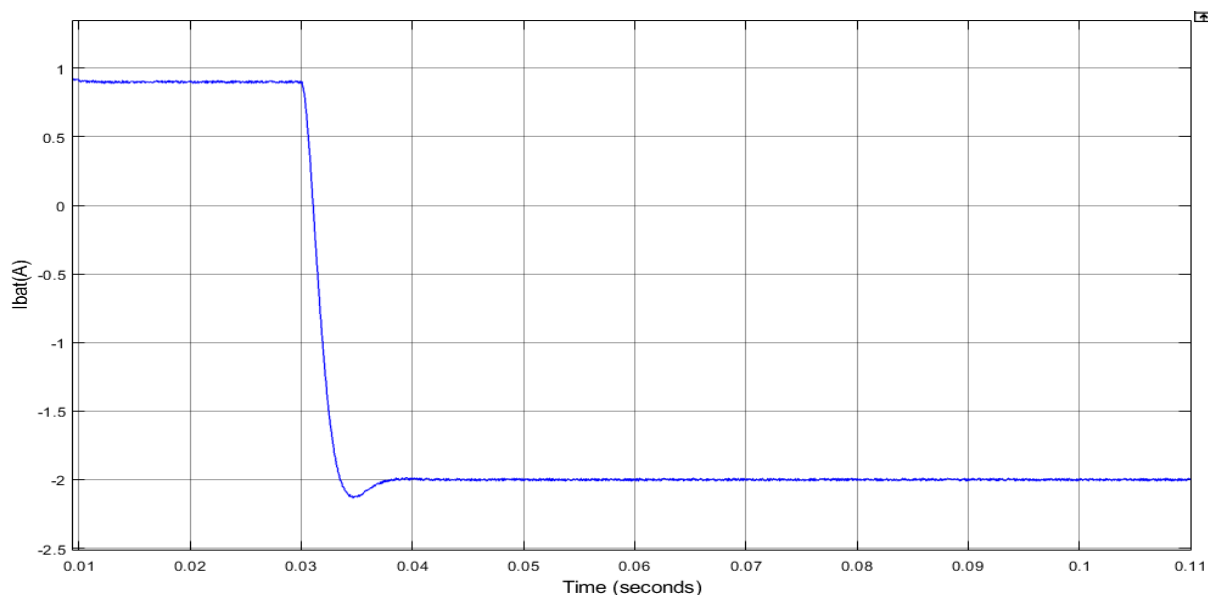


Change of battery reference current.

CASE\_2: Charging Mode



Battery voltages at desired value.



Change of battery reference current

The results and discussion of the "Single Inductor Multiport Power Converter for Electric Vehicle Applications" focus on evaluating the converter's efficiency, performance, stability, and suitability for EV use. It includes analysis of voltage/current regulation, power delivery capability, stability under various conditions, power quality, control strategy effectiveness, comparative analysis with existing solutions, and suggestions for future improvements. This section provides insights into the converter's strengths, weaknesses, and potential for enhancing EV power systems.

## V. CONCLUSION

In conclusion, the development and testing of the single inductor multi-port power converter represents a significant step forward in the advancement of the electric vehicle technology. Thorough rigorous theoretical analysis, simulation studies, and experimental validation, this research has demonstrated the effectiveness and feasibility of the proposed converter for real world EV applications. By efficiently integrating multiple energy sources, including solar photovoltaic (PV) and battery systems, the converter offers enhanced flexibility and control charging and discharging processes, thereby optimizing energy utilization and enhancing overall performance.

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