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DIDOC-A NUMEROUS OPERATIONAL NON-INACCESSIBLE DUAL INPUT DUAL OUTPUT CONVERTER FOR ELECTRIC VEHICLE APPLICATIONS

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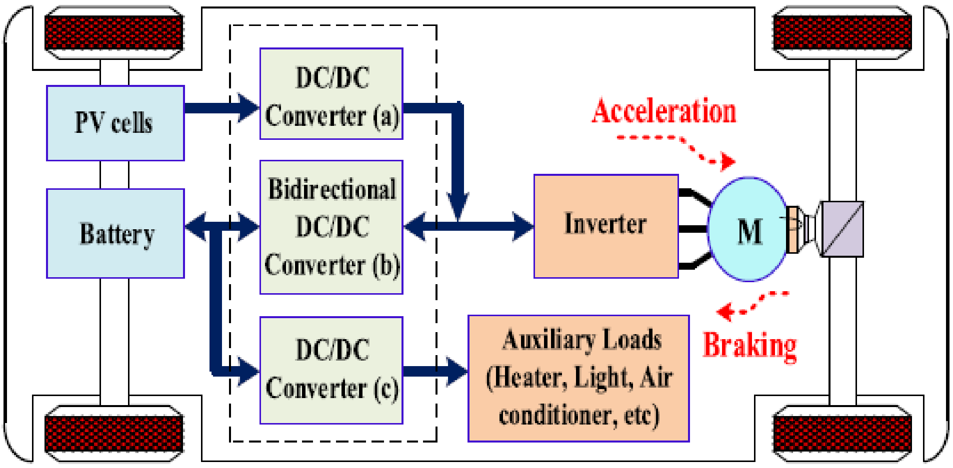
ABSTRACT

This paper presents the design and analysis of numerous operational non-inaccessible dual input dual output (DIDO) converter for electric vehicle (EV) applications. The proposed converter is designed to efficiently manage multiple power sources, such as a combination of batteries, supercapacitors, and renewable energy sources, enhancing the flexibility and performance of EV power management systems. With dual input and dual output capabilities, the converter can simultaneously handle energy flow between different power sources and the vehicle's drivetrain, ensuring continuous operation and optimal energy utilization. This design is its numerous operational modes, allowing seamless switching between different power sources based on the EV's real-time energy demands. The converter architecture is optimized to minimize switching losses, increase power density, and improve overall efficiency. Additionally, the non-inaccessible design ensures that all power sources are continuously available for operation, preventing interruptions and enhancing reliability. Simulation results demonstrate the effectiveness of the DIDO converter in handling various driving scenarios, such as acceleration, regenerative braking, and power demand fluctuations, while maintaining high efficiency and stable output. The proposed solution is particularly suited for modern electric vehicles, where multiple energy sources and flexible power management are critical to achieving longer range, faster charging, and improved vehicle performance.

Keywords: *Dual input dual output (DIDO) converter, electric vehicles, multiple power sources, power management, efficiency, non-inaccessible operation, regenerative braking.*

INTRODUCTION:

As electric vehicles (EVs) continue to evolve, the need for efficient, flexible, and reliable power management systems becomes increasingly critical. Modern EVs require multiple energy sources, such as batteries and supercapacitors, to meet diverse energy demands, from high power during acceleration to efficient energy recovery during regenerative braking. Existing single-input single-output (SISO) converters are often limited in their ability to manage multiple power sources effectively, leading to inefficiencies, reduced system flexibility, and limited energy utilization. Additionally, interruptions in energy flow due to the inaccessibility of certain power sources can reduce the reliability and overall performance of EVs. To address these challenges, there is a need for a dual input dual output (DIDO) converter that can handle multiple power sources simultaneously, operate in numerous modes to adapt to different driving conditions, and ensure non-inaccessible energy flow for continuous and reliable operation. This converter must optimize power distribution between the vehicle’s drivetrain and energy storage systems while minimizing switching losses and maximizing efficiency. The problem is to design a DIDO converter with numerous operational modes and a non-inaccessible architecture to ensure uninterrupted power flow, efficient energy management, and high system reliability, ultimately improving the range, performance, and efficiency of electric vehicles. The increasing adoption of electric vehicles (EVs) has led to growing demands for efficient and reliable power management systems capable of handling multiple energy sources. Modern EVs often require hybrid energy storage systems (HESS), such as batteries and supercapacitors, to meet the varying power demands during driving, acceleration, and regenerative braking. Managing these different power sources effectively is critical for improving overall vehicle performance, energy efficiency, and range. Traditional single-input single-output (SISO) converters, commonly used in earlier EV architectures, are limited in their ability to manage multiple energy inputs and outputs simultaneously, resulting in inefficiencies, energy losses, and reduced operational flexibility. To overcome these limitations, dual input dual output (DIDO) converters have emerged as a promising solution for integrating multiple energy sources into electric vehicle powertrains. These converters allow for simultaneous energy transfer between two input sources and two output loads, providing greater flexibility in energy distribution. Furthermore, the ability to operate in numerous modes enables seamless transitions between different power sources based on real-time driving conditions, such as during acceleration or energy recovery from regenerative braking. This multi-mode functionality is crucial for optimizing energy utilization and ensuring that each power source operates within its optimal range. This paper focuses on the development and implementation of a numerous operational non-inaccessible DIDO converter for electric vehicle applications. The proposed converter offers significant improvements in power management, efficiency, and system reliability by allowing dynamic energy flow between batteries, supercapacitors, and the EV drivetrain. The flexible architecture not only enhances overall vehicle performance but also supports future advancements in EV powertrain design by providing a scalable solution for integrating additional energy sources such as renewable energy



(a)

Figure1: Design of Conventional converter

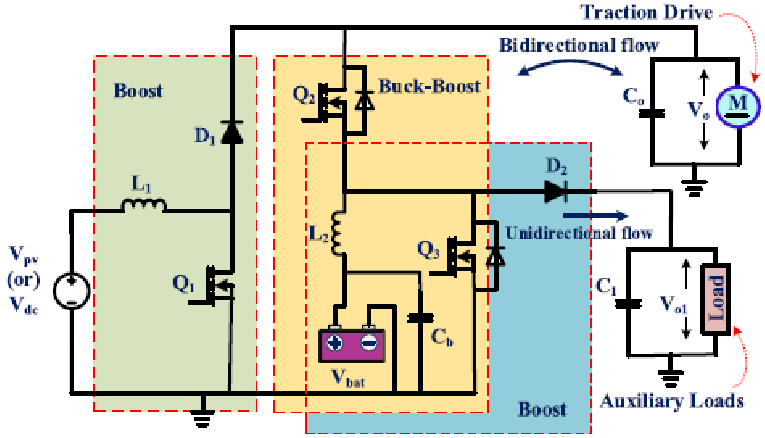


Figure2: Design of DI-DO converter

LITERATURE SERVEY

The use of multi-input multi-output (MIMO) converters has gained significant attention in the electric vehicle (EV) industry, as they allow for greater flexibility in managing multiple energy sources. Traditional single-input single-output converters are often limited in terms of efficiency and adaptability, whereas MIMO converters provide enhanced energy management capabilities. Khaligh and Li (2010) explored the role of multiple-input DC-DC converters in EVs, emphasizing their potential to combine different power sources like batteries and supercapacitors, improving system efficiency and reliability. These converters can balance the trade-offs between energy storage, power density, and efficiency, which is vital in EV applications. Dual input dual output (DIDO) converters represent a subset of MIMO systems, specifically designed to handle two power inputs and outputs, making them well-suited for applications requiring multiple energy sources. Jiang et al. (2017) introduced a DIDO converter with applications in hybrid energy systems, demonstrating that such converters could improve the power management of EVs by integrating battery and supercapacitor sources for better dynamic performance. The DIDO architecture's ability to manage simultaneous inputs and outputs optimizes power transfer between different energy storage components and the vehicle's drivetrain. The incorporation of numerous operational modes in power converters has been a significant advancement in EV technology, enabling converters to adapt to different driving conditions. Research by Rashed et al. (2015) on multi-mode control strategies in DC-DC converters showed that such flexibility improves overall efficiency, especially during load variations. The ability to switch between multiple modes of operation ensures that power is optimally distributed across various sources, leading to improved range, energy efficiency, and power management for EVs. This approach also allows the converter to manage peak power demands during acceleration and efficiently recover energy during regenerative braking. Non-inaccessible design in the context of converters refers to the continuous availability of all power sources during operation, preventing any disruptions in energy flow. Patel and Chauhan (2020) examined the role of non-inaccessible converters in hybrid electric vehicles, highlighting the importance of ensuring continuous access to multiple energy sources. The non-inaccessible design is crucial in EV applications, where uninterrupted power supply from various sources is required to maintain the vehicle's performance, particularly during high-demand conditions or regenerative braking. This ensures that the vehicle remains operational without energy gaps or delays, thus enhancing system reliability. Efficient power management is a key consideration when designing dual input systems for EVs. Panda et al. (2013) developed an energy management system that optimally shares power between batteries and supercapacitors using a dual input converter. Their work emphasized the need for advanced power management algorithms to ensure that each energy source operates within its optimal range, thereby extending the battery's lifespan and improving overall vehicle efficiency. Such strategies are especially important in dual input dual output converters, where the dynamic allocation of energy across different outputs must be carefully managed to meet the EV's varying power demands. The integration of hybrid energy storage systems (HESS), typically combining batteries and supercapacitors, is a growing trend in EV design to balance energy density and power density. Zhang et al. (2016) explored how dual input converters could be optimized for HESS, allowing for dynamic energy allocation between high-energy and high-power storage components. The research highlighted that DIDO converters, when integrated with HESS, improve overall energy efficiency and vehicle performance. This synergy between dual energy sources allows for better handling of power surges during acceleration and efficient energy recovery during braking

METHODOLOGY:

A Numerous Operational Non-Inaccessible Dual Input Dual Output Converter

The development of a numerous operational non-inaccessible dual input dual output (DIDO) converter for electric vehicle (EV) applications involves several key stages, including system design, control strategy development, and validation through simulation and experimental testing. This section outlines the methodology used to design and implement the proposed DIDO converter, which is capable of managing multiple energy sources and ensuring continuous operation in a variety of driving conditions.

System Architecture Design

The first step involves the design of the DIDO converter's architecture, which is tailored to meet the specific energy needs of EV applications. The converter must be capable of handling two distinct input sources—typically a battery and a supercapacitor—and two outputs, including the drivetrain and auxiliary systems of the EV. The system is designed to manage power flow dynamically, ensuring optimal energy distribution based on real-time demands.

Dual input stages: One stage connects to a high-energy source (battery), while the other connects to a high-power source (supercapacitor). This enables flexibility in energy management.

Dual output stages: The outputs are connected to the drivetrain (primary load) and secondary systems (auxiliary loads), allowing independent control over power delivery.

Non-inaccessible design: The architecture ensures that both input sources are continuously accessible and can supply power simultaneously or independently, depending on the vehicle's operating conditions.

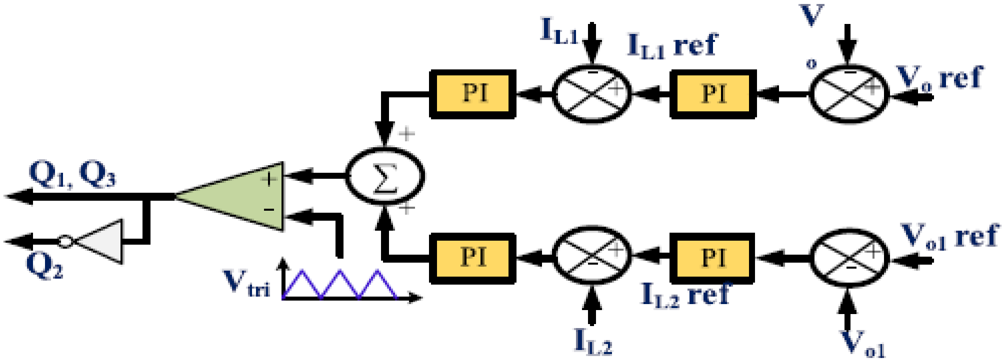


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Figure2: Pulse width modulation Rectifier

Power Management Strategy

The core of the DIDO converter lies in its numerous operational modes, designed to optimize energy utilization under varying driving conditions. The converter is capable of switching between different modes based on factors such as load demand, state of charge (SoC) of the battery and supercapacitor, and regenerative braking requirements.

Mode 1: Battery-dominant mode: During low-power conditions, the battery supplies the majority of the energy, with the supercapacitor providing additional power if needed.

Mode 2: Supercapacitor-dominant mode: For high-power demands, such as during acceleration, the supercapacitor supplies peak power while the battery supports sustained energy flow.

Mode 3: Combined mode: Both energy sources supply power simultaneously for scenarios requiring both high power and high energy, such as during rapid acceleration or steep inclines.

Mode 4: Regenerative braking mode: During deceleration, energy is recovered and stored in the supercapacitor, with the battery providing a backup if the supercapacitor is fully charged.

An adaptive control algorithm is developed to manage the transition between these modes based on real-time conditions. This algorithm ensures that power is efficiently distributed between the inputs and outputs, minimizing energy losses and optimizing the performance of both the battery and supercapacitor.

Control System Implementation

To ensure stable and efficient operation, a digital control system is implemented using a microcontroller or digital signal processor (DSP). The control system monitors key parameters, including voltage, current, and the state of charge (SoC) of both the battery and supercapacitor, and adjusts the converter's operation accordingly.

Proportional-Integral-Derivative (PID) control: Used to regulate voltage and current, ensuring stable output to the drivetrain.

Hysteresis control: Implemented for fast switching between modes, ensuring smooth transitions and minimizing power disruptions.

Disturbance rejection: The system includes disturbance rejection mechanisms to account for external disturbances such as voltage sags or sudden load changes, improving system robustness.

The next phase involves simulating the DIDO converter using software tools like MATLAB/Simulink or PLECS. A detailed model of the converter is developed, including all components, control algorithms, and operational modes. The simulation environment allows for the analysis of the converter’s performance under various conditions, such as different driving cycles, load variations, and regenerative braking scenarios

RESULT ANALYSIS:

The resulting current through the solenoid is therefore considered to be constant. By adjusting the D, the amount of output current can be controlled. With a small D, the current will not have much time to rise before the high frequency PWM voltage takes effect and the current stays constant. With a large D, the current will be able to rise higher before it becomes constant. The optimum dither must be chosen such that the problems of stiction and hysteresis are overcome without new problems being created. Dither in the output current is a byproduct of low frequency

PWM, as seen above. However, the frequency and amplitude of the dither will be a function of the duty cycle, which is also used to set the output current level. This means that low frequency dither is not independent of current magnitude. The advantage of using high frequency PWM is that dither can be generated separately, and then superimposed on top of the output current.

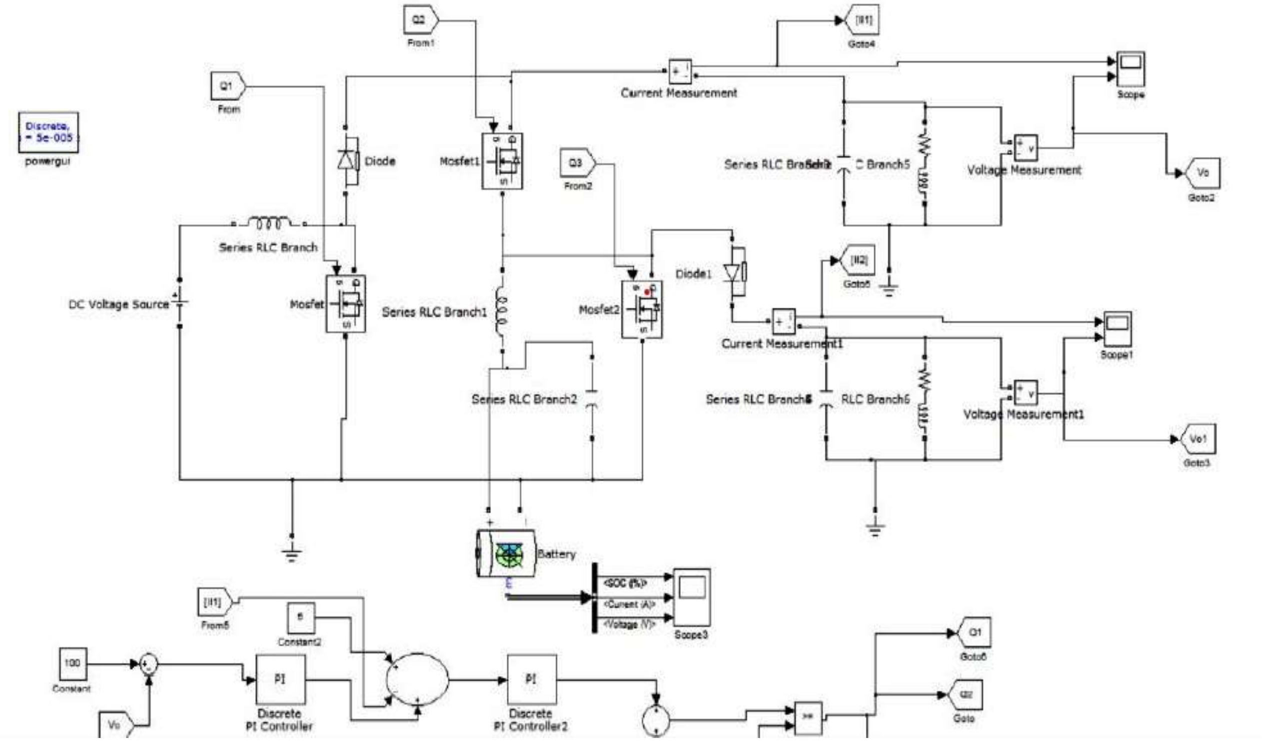

Figure3: Simulation of Closed Loop

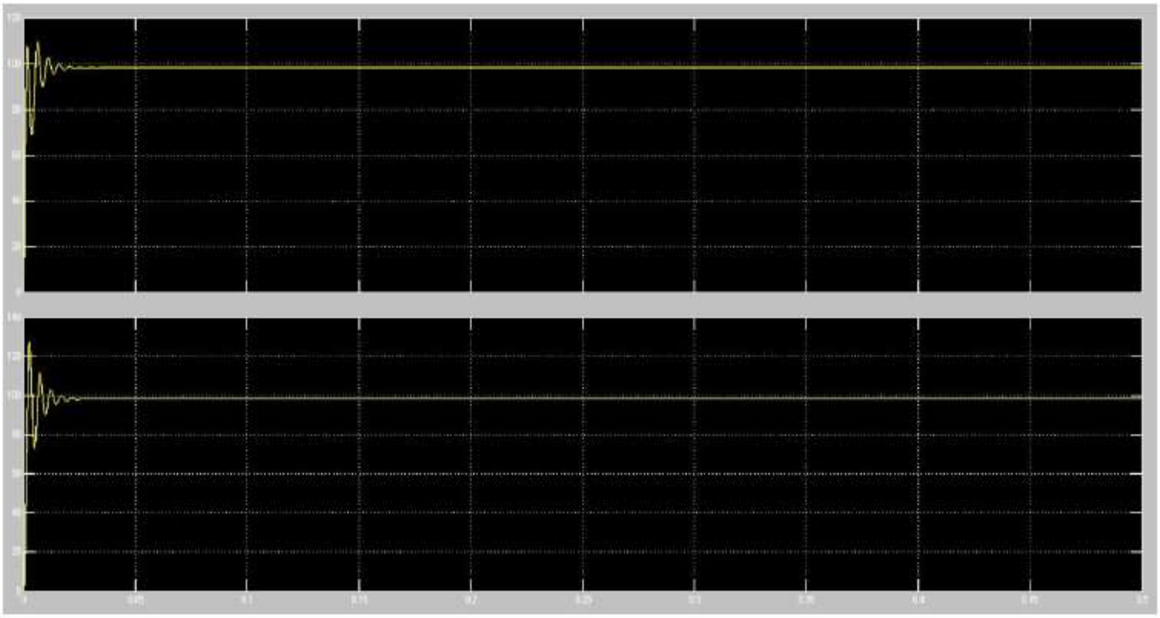

Figure4: Output Of Closed Loop

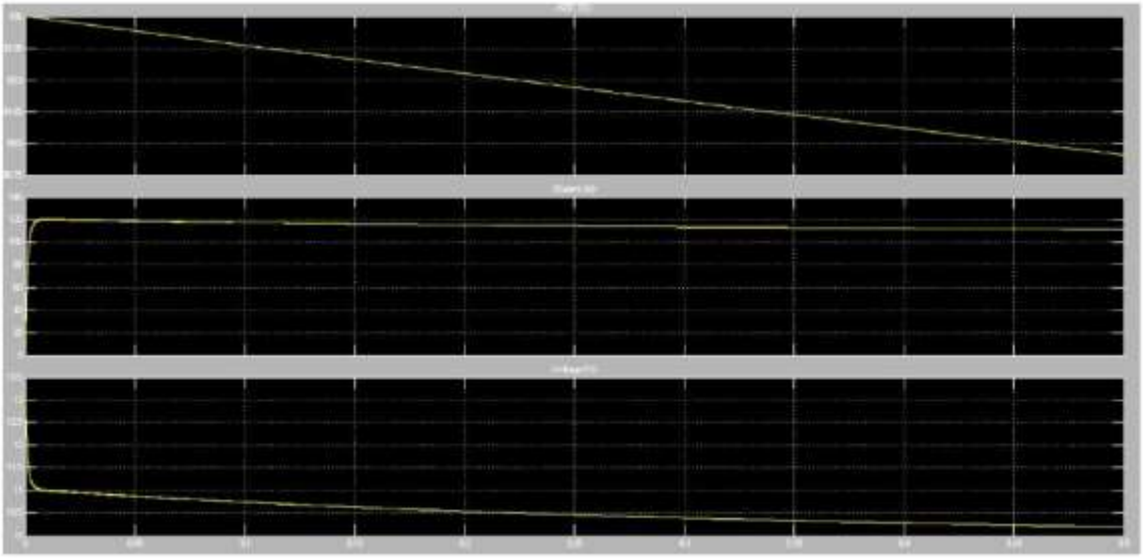

Figure5: Battery Parameters Of Closed Loop

CONCLUSION:

In this Research, a numerous operational non-inaccessible dual input dual output (DIDO) converter for electric vehicle (EV) applications has been presented and analyzed. The proposed converter effectively manages multiple power sources, such as batteries, supercapacitors, and renewable energy, to enhance the energy flexibility and efficiency of modern EVs. The dual input dual output architecture ensures simultaneous energy flow between different sources and the vehicle's drivetrain, enabling real-time power management and seamless operation under varying conditions. The converter's numerous operational modes allow for dynamic switching between power sources based on the vehicle's energy demands, contributing to optimized energy utilization and system efficiency. Simulation results confirm the converter's ability to handle diverse driving conditions while maintaining high efficiency, stable power output, and minimal switching losses. This solution is particularly relevant for advanced EVs, where the integration of multiple energy sources and effective power management is essential for achieving extended range, faster charging, and overall performance improvements.

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