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DESIGN AND ALALYSIS OF DUAL INPUT SINGLE OUTPUT DC-DC CONVERTER FOR DOMESTIC APPLICATION

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Abstract: *The integration of renewable energy systems into domestic applications is rapidly growing due to the depletion of fossil fuels that power most conventional plants. This paper proposes a Dual Input Single Output (DISO) DC-DC converter topology, where the output voltage ratio (5:5 and 7:3) is dynamically managed according to the input energy source. A key advantage of this topology is the adjustable output of each input DC source based on the produced input energy and the required output energy. The proposed system has been implemented and validated using MATLAB simulation, demonstrating effective power distribution from two 12V DC input sources. The simulations confirm the converter's capability to maintain a consistent 12V output under varying duty cycles, ensuring reliable performance across different scenarios. This converter topology enhances the efficiency and reliability of renewable energy systems by managing the charging and discharging cycles of batteries and ensuring redundancy of energy sources. For instance, during periods of low solar output such as nighttime or cloudy days, the system can rely on battery power to maintain a continuous power supply. Additionally, the flexibility in adjusting the input voltage ratio allows for optimal power consumption from renewable sources, thereby reducing dependence on non-renewable energy. This makes the DISO converter a cost-effective and sustainable solution for domestic energy applications.*

1. Introduction

In recent years, advancements in power electronics have revolutionized renewable energy systems and electric vehicles (EVs), aiming to enhance efficiency and performance across various applications. This introduction explores cutting-edge research highlighted in a series of IEEE papers. These studies encompass innovative designs such as dual-input single-output (DISO) converters tailored for grid-connected photovoltaic (PV) microinverters, addressing challenges like variable environmental conditions [1, 2]. Additionally, novel approaches in electric vehicle technology include dual battery charging systems utilizing Arduino control to optimize charging times and efficiency [3].The integration of DC-DC converters plays a pivotal role in enhancing energy harvesting and management in renewable energy sources and low voltage systems [4, 5]. Research has also focused on optimizing electromagnetic energy harvesting for IoT applications through advanced boost converter designs [6]. Moreover, the development of ultra-high step-up converters showcases significant advancements in voltage conversion and efficiency for DC microgrids and renewable energy integration [7].The demand for high step-up converters is further underscored by their application in hybrid renewable energy systems, facilitating bidirectional power flow and reducing voltage stress [8]. Additionally, simplified topologies like dual-output boost inverters demonstrate efficiency gains and cost reductions, crucial for widespread adoption in various power electronics applications [9].In the electric vehicles, bidirectional converters are pivotal for integrating solar PV and utility grid inputs, optimizing charging efficiency [10]. Similarly, the utilization of ultracapacitors alongside batteries in high step-up converters highlights their potential to improve energy storage and efficiency in EV applications [11]. Innovations in converter synthesis aim to streamline design complexity and cost while maintaining robust performance across single-input dual-output (SIDO) and dual-input single-output (DISO) configurations [12].Despite significant advancements in dual-input single-output (DISO) DC-DC converters, there remains a notable gap in standardized performance metrics and comparative studies across various applications. Future research could focus on standardizing efficiency evaluation methodologies and developing versatile designs capable of seamlessly integrating with diverse renewable energy sources and electronic systems. Additionally, further exploration into cost-effective manufacturing techniques and scalability in commercial applications could accelerate the adoption of DISO converters in mainstream energy systems.

2. Block Diagram of proposed input of system with Dual Input-Single Output (DISO) Converter

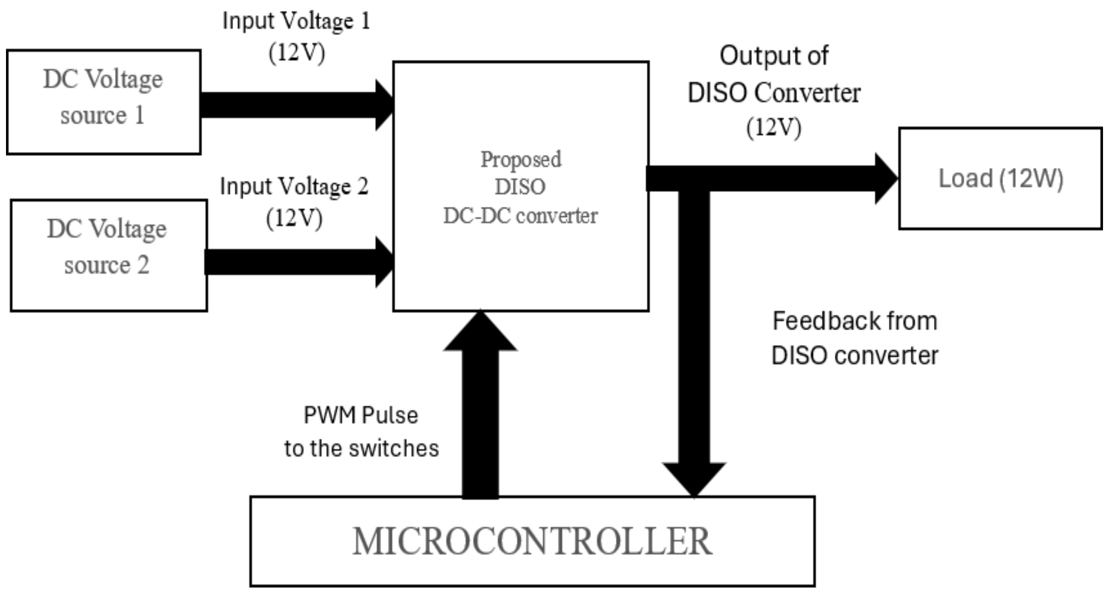

Figure.1: **Block Diagram of proposed input of system**

This system integrates a photovoltaic (PV) module and a battery, each interfaced through a DC-DC converter with a supply voltage of 12V. The power input to the system is derived 70% from the PV panel and 30% from the battery, with an alternative configuration of 50% from each source. The PV module converts solar energy into DC electricity, while the battery provides backup power during low sunlight conditions or at night. The DC-DC converter combines the inputs from both sources and regulates the output voltage or current to ensure continuous motor operation. A microcontroller or PID controller manages the switching of MOSFETs by taking feedback from the output of each converter and providing PWM pulses to the switches. This hybrid system leverages solar energy and stored battery power, optimizing the use of renewable resources and maintaining reliable operation. The fluctuating output from the PV module, dependent on sunlight intensity, is supplemented by the battery to meet the power demand. The DC-DC converter adjusts the input voltages from both sources to match the load requirements, ensuring system resilience and efficiency.

2.1. Dual Input-Single Output (DISO) DC-DC Converter

In this paper, we focus on a dual input single output (DISO) converter, which efficiently manages energy from two different sources. This converter can adjust the input voltage to meet the required output voltage, allowing for a flexible power consumption ratio. For instance, one source, such as a solar panel, can provide 70% of the energy, while a battery supplies the remaining 30% or 50% from each source. This system ensures that maximum energy is used from renewable sources when available, and the battery provides backup during periods of low solar output, like nighttime or cloudy days. The DISO converter enhances the reliability and efficiency of renewable energy systems by managing the charging and discharging cycles of batteries and ensuring redundancy of energy sources. This method not only supports a continuous power supply but also represents a cost-effective investment through optimal power ratio management.

3. Circuit Diagram of Dual Input-Single Output (DISO) DC-DC Converter Design

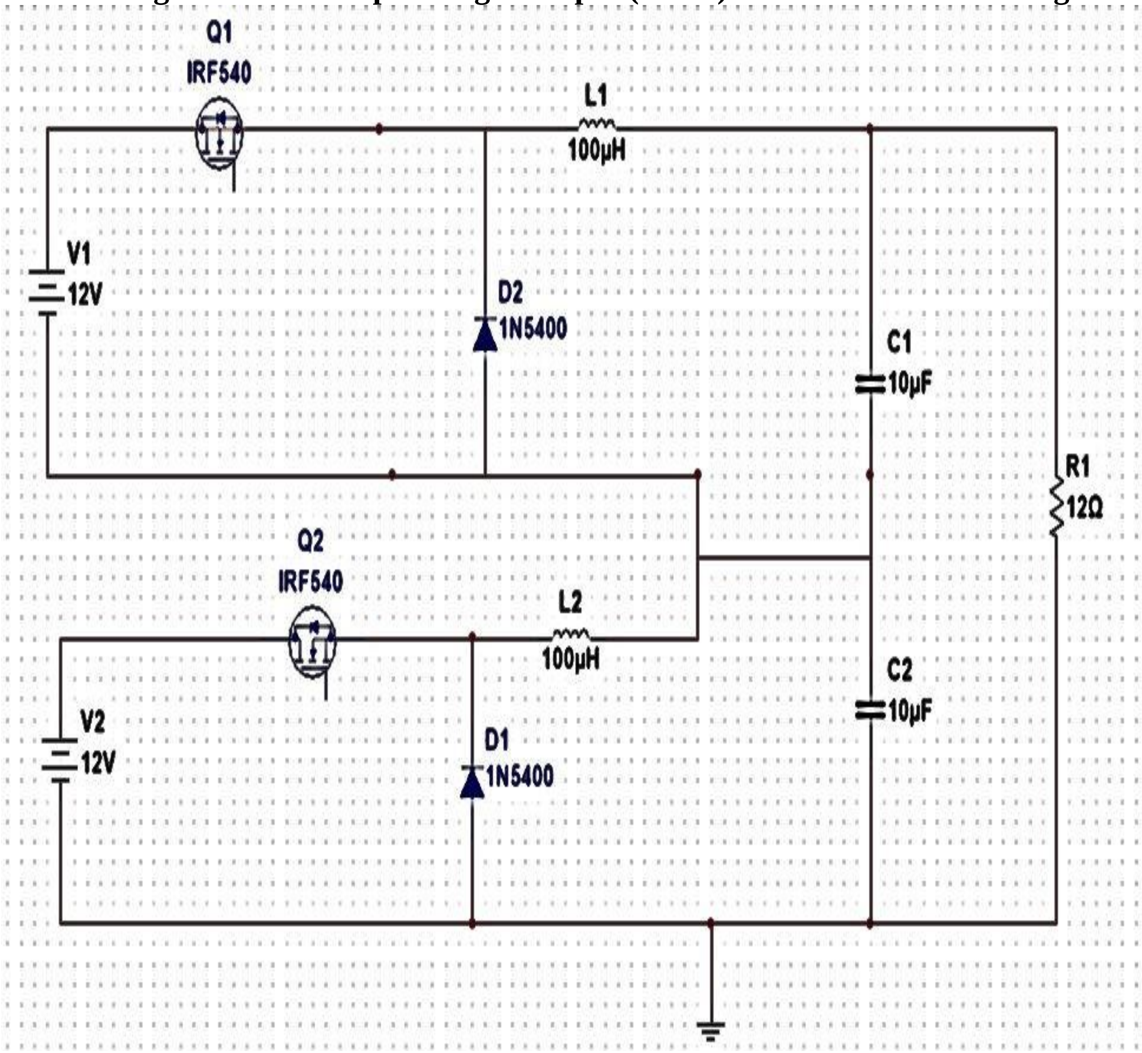

Figure.2: Dual Input-Single Output (DISO) DC-DC Converter

This is a circuit diagram of Dual Input-Single Output (DISO)comprises two DC voltage supplies, each providing 12V (V1 = 12V and V2 = 12V). The design includes two MOSFETs and two diodes to manage the switching and rectification of the inputs. Inductors L1 and L2 are each 100µ H, while capacitors C1 and C2 are each 10µF. The load resistor (R-Load) is 12Ω, and the output power (Po) is 12W.The DC-DC converter combines the inputs from both voltage sources, regulated by the MOSFETs and diodes to ensure a stable output. The inductors and capacitors are selected to filter and smooth the voltage and current, providing a consistent supply to the load. This configuration ensures efficient power conversion and delivery to the load, maintaining reliable operation under varying input conditions.

4.Design of Dual Input-Single Output (DISO) DC-DC Converter

The Dual Input Single Output (DISO) converter is essentially a combination of two DC-DC converters. In this case, both converters are designed using a Buck converter topology, which steps down the input voltage to a lower output voltage.

 Input Voltage (V_S1 and V_S2):

- Both input sources provide 12V each.

$$V_{S1} = V_{S2} = 12\text{V}$$

 Switching Frequency (fs):

- The converters operate at a switching frequency of 100 kHz.
  f_s=100KHz

 Output Voltage (Vo):

- The combined output voltage is the sum of the outputs from each converter.

$$V_{01}+V_{02} = 6\text{V} + 6\text{V} = V_0 = 12\text{V}$$

 Duty Cycle (D1 and D2):

- The duty cycle is the ratio of the output voltage to the input voltage for each converter.

$$D_1 = D_2 = \frac{V_{01}}{V_{S1}} = \frac{6}{12} = 50\%$$

 Inductor Calculation (L):

- Assuming a 30% ripple current

Δi_L=0.3x I_{LOAD}= 0.3x1A=0.3

- The inductor value is calculated using the formula

$$\text{L} = L_1 = L_2 = \frac{(V_{in} - V_{out}).D}{\Delta i_L * f_s} = \frac{(12-6)*0.5}{0.3*100*10^3} = 100\mu H$$

 Capacitor Calculation (C):

- Assuming a ripple voltage,
  $\Delta V_{out}$of 1% of output voltage =0.06V
- The capacitor value is calculated using the formula:

$$\text{C} = C_1 = C_2 = \frac{\Delta i_L}{8*f_s.\Delta V_{out}} = \frac{0.3}{8*100*10^3*0.06} = 10\mu F$$

5. MATLAB Simulation of Dual-Input Singe-Output (DISO)

The MATLAB simulation for each objective have been simulated and results have been executed for two ratios.

5.1MATLAB Simulation of Dual-Input Singe-Output (Diso) Converter For Voltage Ratio 5:5

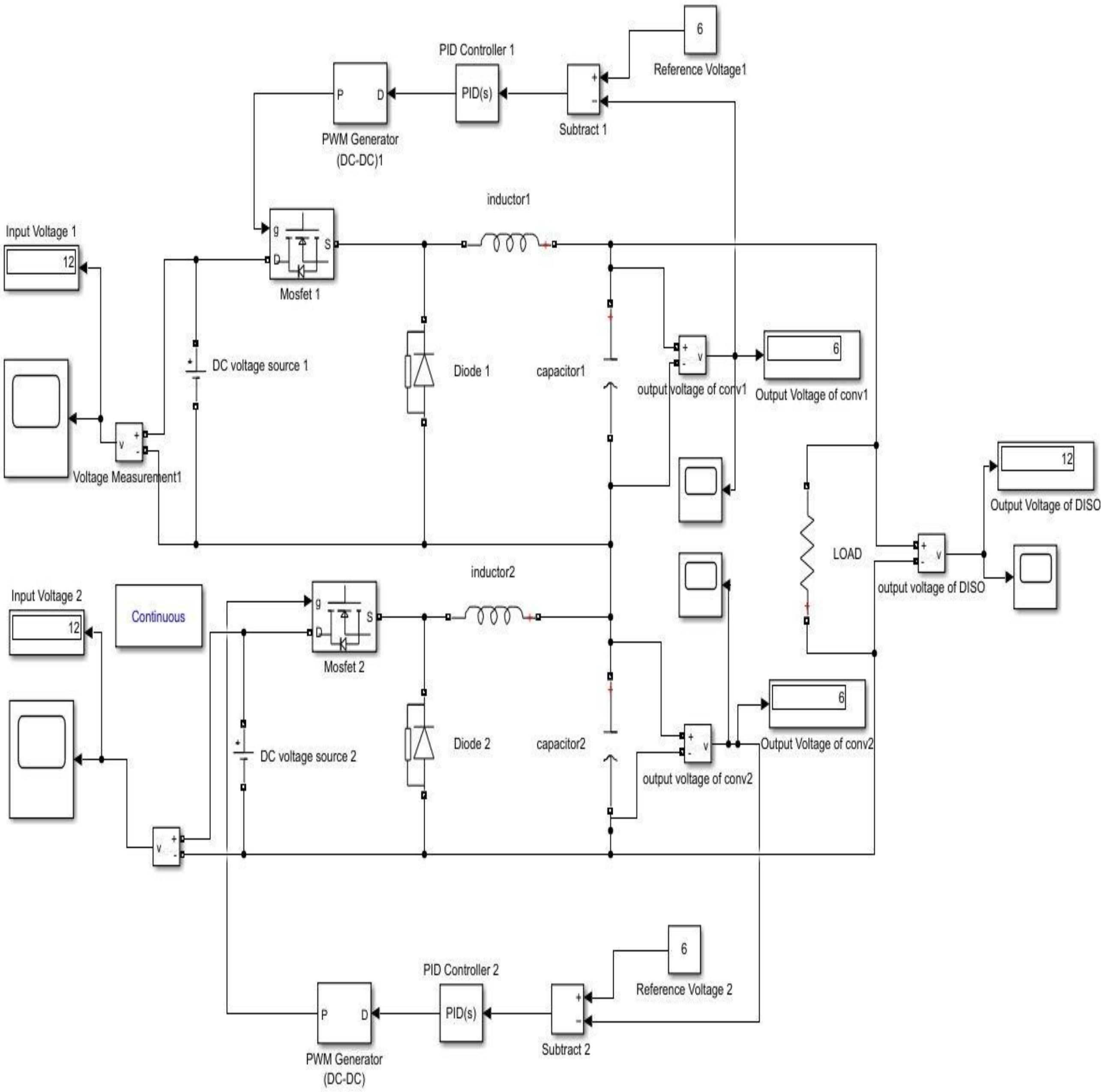

Figure.3: Dual Input-Single Output (DISO) DC-DC Converter

The MATLAB simulation for the dual input single output converter is based on a Buck Converter design. The system incorporates two DC voltage sources, V1 and V2, each providing 12V. The circuit elements include inductors L1 and L2 each rated at 100µH, capacitors C1 and C2 each rated at 10µF, and a load resistor RL of 12Ω. The duty cycles for the two sources are D1=50% and D2=50%, resulting in output voltages Vo1 = 6V and Vo2 = 6V, respectively, which combine to give a total output voltage Vo of 12V, with an output current Io of 1A and output power Po of 12W.The converter takes energy from each source according to the specified ratio and provides a combined output voltage of 12V. The primary objective of this design is to maximize the use of reliable energy sources such as solar or wind (DC voltage source 1), while minimizing dependence on battery power (DC voltage source 2). For a ratio of 5:5, the voltage contribution from DC voltage source 1 is 6V, which is 50% of 12V.

5.2. Matlab Simulation Of Dual-Input Singe-Output (Diso) Converter For Voltage Ratio 7:3

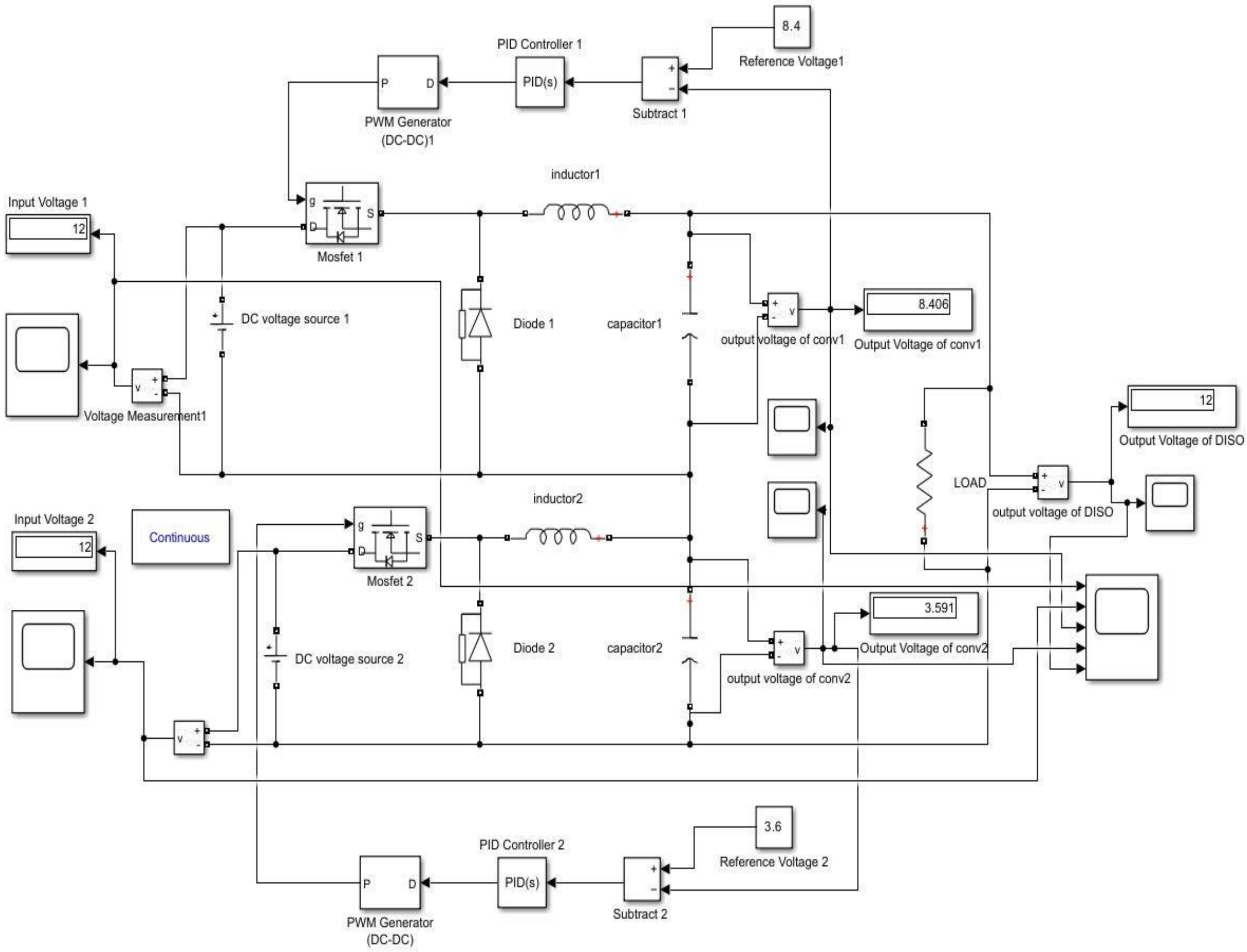

Figure.4: Dual Input-Single Output (DISO) DC-DC Converter

The MATLAB simulation for the dual input single output converter is based on a Buck Converter design. The system incorporates two DC voltage sources, V1 and V2, each providing 12V. The circuit elements include inductors L1 and L2 each rated at 100µH, capacitors C1 and C2 each rated at 10µF, and a load resistor RL of 12Ω. The duty cycles for the two sources are D1=70% and D2=30%, resulting in output voltages Vo1 = 8.4V and Vo2 = 3.6V, respectively, which combine to give a total output voltage Vo of 12V, with an output current Io of 1A and output power Po of 12W.The converter takes energy from each source according to the specified ratio and provides a combined output voltage of 12V. The primary objective of this design is to maximize the use of reliable energy sources such as solar or wind (DC voltage source 1), while minimizing dependence on battery power (DC voltage source 2). For a ratio of 7:3, the voltage contribution from DC voltage source 1 is 8.4V, which is 70% of 12V, and the voltage contribution from DC voltage source 2 is 3.6V, which is 30% of 12V.

6. Results and Discussions:

The MATLAB simulation of the dual input single output converter, designed as a Buck Converter, demonstrates the effectiveness of a balanced power distribution. With two 12V DC voltage sources (V1 and V2), inductors of 100µH, capacitors of 10µF, and a load resistor of 12Ω, the system achieves a stable output of 12V. The duty cycles are set at 50% for both sources (D1=50% and D2=50%), resulting in Vo1 = 6V and Vo2 = 6V. The combined output voltage is 12V with an output current of 1A and output power of 12W. This balanced configuration ensures equal utilization of both energy sources, providing a reliable and steady output.

6.1.Simulation Result Of Input And Output Of The Dual Input-Single Output (Diso) Converter For Voltage Ratio 5:5

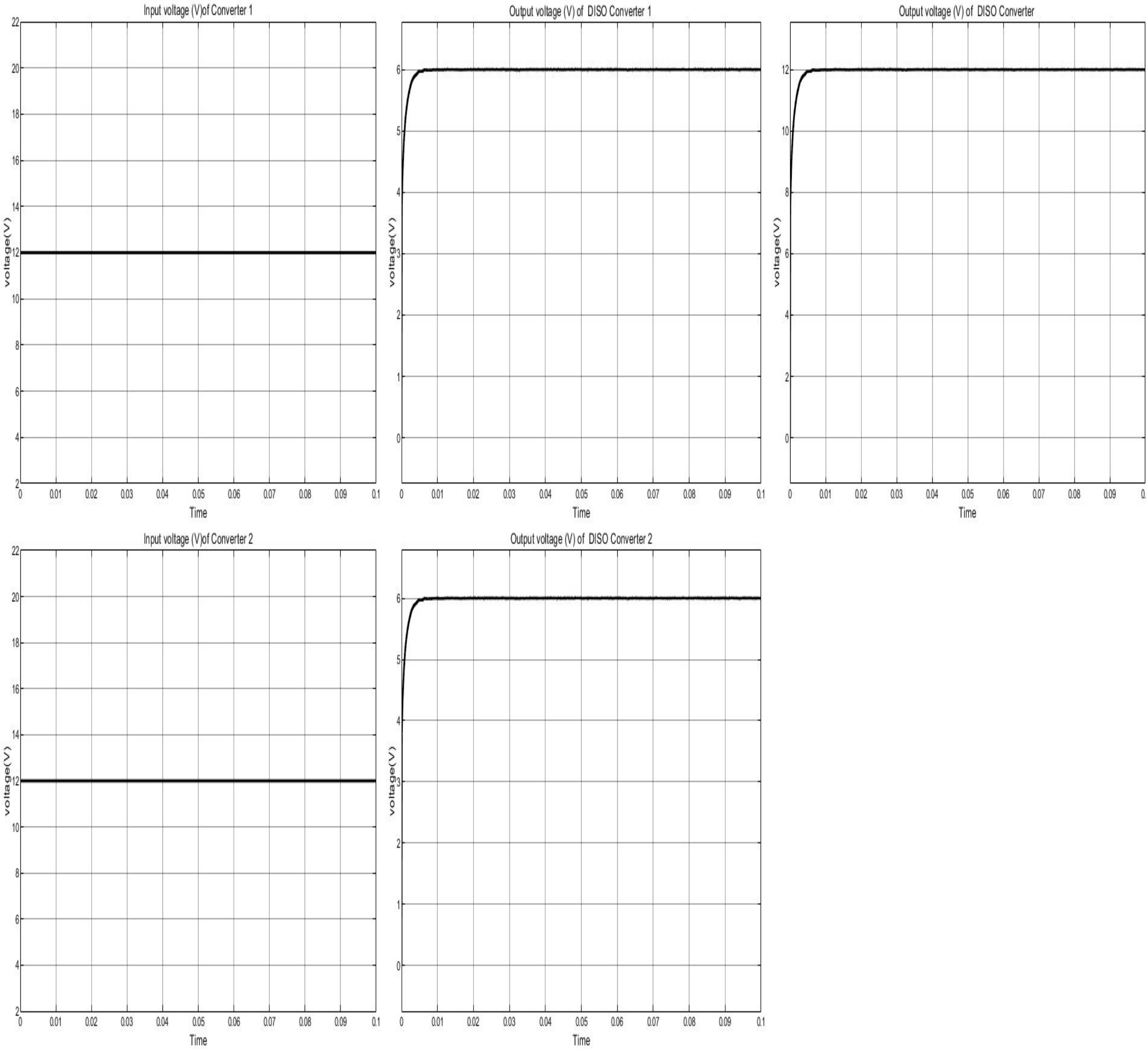

Figure.5**: Simulation Waveforms of input and output of the Dual Input-Single Output (DISO) Converter**

6.2.Simulation Result Of Input and Output Of The Dual Input-Single Output (Diso) Converter for Voltage Ratio 7:3

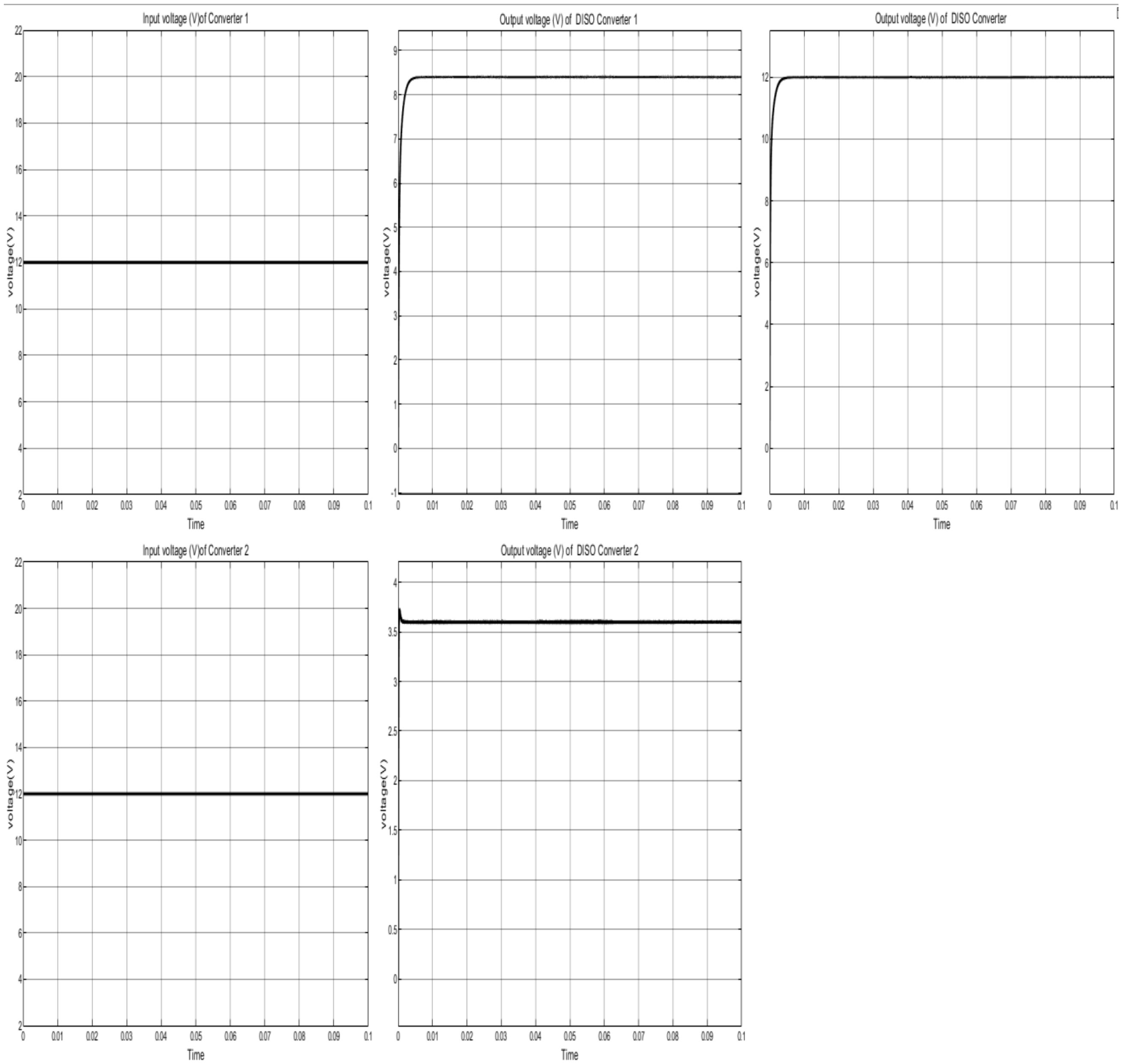

Figure.6**: Simulation Waveforms of input and output of the Dual Input-Single Output (DISO) Converter**

The simulation illustrates the performance of the converter when prioritizing energy from a more reliable source. With the same components, the duty cycles are adjusted to 70% for the primary source (D1=70%) and 30% for the secondary source (D2=30%), resulting in Vo1 = 8.4V and Vo2 = 3.6V. The combined output voltage remains 12V with an output current of 1A and output power of 12W. This configuration demonstrates the converter's capability to preferentially draw 70% of its power from a reliable source, such as solar or wind (DC voltage source 1), while relying only 30% on the battery (DC voltage source 2). The simulation confirms that the system can efficiently manage and integrate multiple power sources, ensuring a consistent and sustainable power supply.

6.3. Simulation results are tabulated: Table-1

Objectives	DC Input Voltage Supply of each converter	Duty cycle ofeach converter	DC output Voltage of each converter	Output Current of each converter	Output Power of DISO	DC output Voltage of DISO	Output Currentt of DISO	Output Power of DISO
Objective 1	V_{S1}=12V	D1=50%	Vo1=6V	Io1=1A	Po1=6W	Vo=12V	Io=1A	Po=12 W
	V_{S2}=12V	D2=50%	Vo2=6V	Io2=1A	Po2=6W			
Objective 2	V_{S1}=12V	D1=70%	Vo1=8.4V	Io1=1A	Po1=8.4 W	Vo=12V	Io=1A	Po=12 W
	V_{S2}=12V	D2=30%	Vo2=3.6V	Io2=1A	Po2=3.6 W			

Figure.7: Tabulation of simulation result

The table-1 depicts the MATLAB simulation results for a Dual Input-Single Output (DISO) Converter operating under two distinct scenarios. In both scenarios, the converter is designed with two 12V DC input voltage sources, each regulated by specific duty cycles to manage power distribution. Objective 1, illustrates a balanced configuration with both sources contributing equally, each operating at a 50% duty cycle, resulting in individual outputs of Vo1=6V and Vo2=6V. The combined output (DISO) maintains a stable 12V output with an output current (Io) of 1A and total output power (Po) of 12W. In Objective 2, the converter prioritizes one source with a 70% duty cycle (V_S1), resulting in a higher output voltage of Vo1=8.4V, while the second source (V_S2) operates at a 30% duty cycle, producing Vo2=3.6V. The DISO output again consolidates to 12V with Io=1A and Po=12W. These simulations validate the converter's capability to efficiently manage power inputs from multiple sources while ensuring a consistent and reliable output voltage suitable for various applications.

7. Conclusion

The DISO Converter design proves effective in harnessing and integrating power from multiple DC sources, optimizing energy usage while ensuring reliable output under varying conditions. These simulation outcomes validate its potential for applications reliant on renewable energy sources like solar and supplementary sources such as batteries. The converter's ability to dynamically adjust power distribution ratios highlights its utility in scenarios where maximizing energy from preferred sources is essential, contributing to sustainable and efficient power management solutions. Future research could focus on further optimizing the converter design, improving efficiency evaluation methodologies, and exploring scalable manufacturing techniques for commercial deployment.

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