Design And Implementation Of Dual Input Single Output Converter For Real World Applications

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Abstract
With the adding integration of renewable energy sources such as solar, hydro, wind for household energy systems, the need for effective power operation results has come pivotal. In addition to this, battery is used as energy storehouse system to give provisory power when oscillations happen due to renewable sources. This integration helps to manage inflow of power supply without disturbances in real world operations. The present system concentrates on Dual Input Single Output DC- DC converter. It enhances the connection and distribution of energy from binary energy sources. It maximizes the effectiveness while maintaining a steady and reliable energy force through innovative power inflow operation. This work incorporates with basic and improved level of voltage management systems. Initially system is validated for both simulations and hardware with two battery sources of 12 V connected to converters which provides stable output voltage of 12V without fluctuations. Later, the system is improved by considering solar as one input source and battery as another input source. This system showcases effectiveness of dual inputs to converters by providing 150V of AC voltage which suits for real world applications. This work is validated by MATLAB simulations and Hardware implementations, by providing regulated output voltage. It suits for Domestic grid applications when fluctuations occur thorough renewable sources. In order to implement this esp32 Microcontroller and PIC Microcontroller was utilized. The experimental results satisfy with simulation results, verifying the converter's ability to efficiently manage energy flow while minimizing waste. This DC DC conversion approach provides a cost-effective and scalable solution for integrating renewable energy into real world applications. By smartly balancing energy sources, the Dual Input Single Output converter enhances overall efficiency and sustainability. Further, contributes to the higher aim of reducing dependency on nonrenewable fossil fuel based power generation and distribution.

Keywords: DISO Boost, MATLAB, DC input, DISO DC-DC converters.

1. INTRODUCTION

A Dual Input Single Output Converter meant for a system that takes two separate input signals, by processing produces single stable output. This type of approach usually used for Electrical Engineering, signal processing and communication systems applications. The method of combining different sources depends on design of converter, by taking consideration of summing, averaging, filtering, or any other mathematical or logical operations. The output resulting with respect to manipulation of inputs as per converters function. The Dual Input Single Output DC-DC Converter is well known as power converter. It is a power electronic device is designed to manage two DC sources as input and produces regulated single output voltage. This approach usually finds in applications like dual power sources such as either two battery sources or combination of solar panels and battery. By combining these sources of energy by using converters provides consistent output at the load and also because of battery, back up can be possible so that it ensures continuous and reliable power supply to the load. Researchers focus on the concept of various converters in order to comprehend the concept of closed loop regulation. For the sake of modern implementation it needs to be worked on advancements in controller technologies part [1,2]. The other analysis the study of multi inputs by considering battery and supercapacitors for the sake of finding impact of battery systems to implement in upcoming vehicles technology [3,4]. Analysis of three port converter paper studies about PV and battery by considering boost and buck converters. Here author concludes by simulation results and requires hardware implementation [5]. The pioneering work presents implementing the dual converter by using sliding mode control and compared with PI control algorithm to verify effectiveness [6]. In [7], for the implementation of multiple inputs, the authors concentrate on switched capacitors technique and validated in Simulink environment. Additionally, the novel approaches dual converter by considering fuel cells and PV systems to diverse various levels of voltage to motor the load [8]. Compared to all above papers, Bang Le-Huy Nguyen, etal [9] analyses the system with multiple input and output and also validated with experimental setup as expected which suits for modern applications. The Shubahm Gupta [10], used sepic converters for dual converters with the combination of battery and ultracapacitors in order to reach maximum efficiency in hybrid mode of operational systems. Additionally, this paper concentrates on the vehicle to grid and vice versa concept by the use of dual non isolated converters in order to minimize harmful fuels which impacts on environmental conditions and also verified with hardware prototype [11]. In [12], systematic analysis of converters by considering the three port cuk converters with the use of PI controller to control the voltage from source to load and verified for various modes in order to validate the effectiveness of the system. With respect to innovation technique, paper [13] presents switching strategy by defining carriers sawtooth and triangle waveforms for dc standalone system with PV and concluded with sawtooth has good performance. Despite of all analysis, [14] studies about dual converter by considering two dc sources. This study concentrates on future scope of work carried out at [14], by considering the applications. This study operating under dynamic switching actions between two input sources. This approach finds well and good at the condition with respect to demand at load side, faulty inputs or occurrence of system damage. So, that output voltage should be in desired range irrespective of interruptions in system. The processing of the entire system be determined by proposed converters and controlling strategy. Usually, the converter uses Pulse width Modulation Techniques, Proportional Integral Derivative Technique, maximum power point tracking (MPPT), to regulate the power transfer from each input source and maintain high efficiency and implementation carried out using ESP32 and PIC microcontroller.

1.1: Functionality of the Proposed System

- Reliability and Resilience: With two input sources, if any input degrades, the system operates effectively without interruption. Also provides back up power when availability of less voltage and power
- Quality of Power and Stability: Load sharing reduces the stress on converter then losses occur due to heat dissipation also reduces. It improves lifespan of system by increasing efficiency. It ensures with stable output voltage.
- Flexibility and Scalability: By connecting two converters parallelly, it is more flexible to operate by doubling the available power capacity. This approach adapts to various energy sources and expandable

- Energy Utilization: By considering two input power, energy can be utilized efficiently. And also optimize overall power usage. Multiple sources like renewable, battery can be combined effectively to reach maximum efficiency. That is efficient management of power from two sources.
- Simple Design: The system architecture reduces the complexities because of single stable output voltage. It reduces wear and tear on system components. Need of less Maintenance where components replacement is easier.
- Voltage Summing: By combining output voltages allows higher and stable output voltage, which suits for real world applications with high efficiency.

2. METHODOLOGY

The proposed system suits for real world applications like household or grid by interfacing with battery, renewable sources to a DC-DC converter to power load.

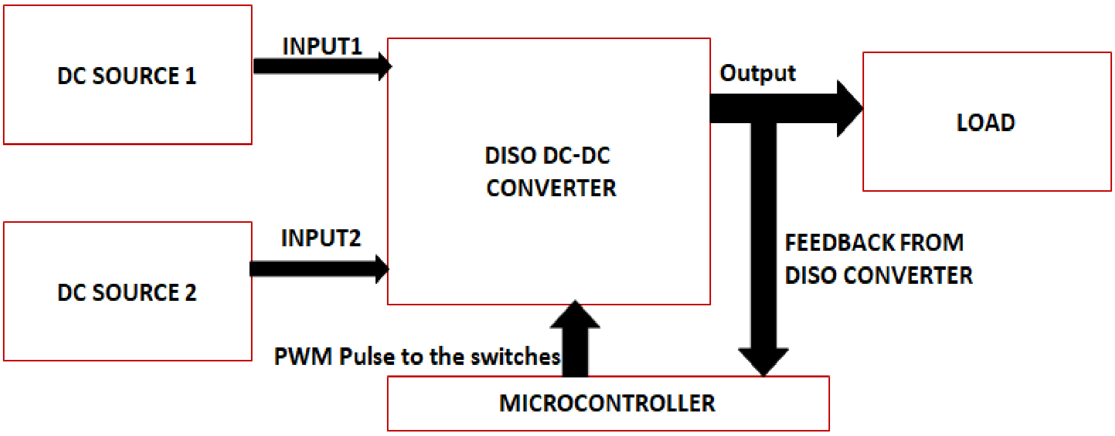

Fig 1: Block Diagram of dual input single output converter topology

Fig.1 shows the block diagram of a dual converter. For example 60% of input derived from the PV panel and 40% from the battery. Now power is channeled into a duo pack electrical module for motor control. The renewable module converting it into DC electricity. Initially simulation demonstrates by considering two 12V input DC sources. The battery acts as an alternative power source, providing backup during fluctuations occurs due to environmental conditions. The main motto of the proposed system is to combine both DC DC converters output voltages and producing stable 12V output voltage. This type of interfacing stabilizes the system and helps to provide optimal performance. This system suits for hybrid mode of operations to ensure continuous operation without break and loss.

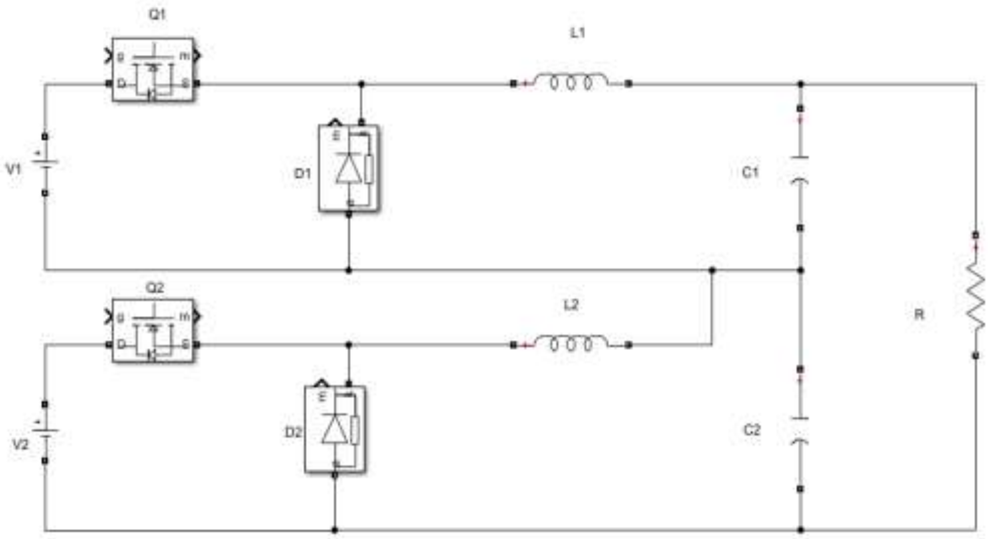

Fig 2: Connection diagram of Basic Model of dual converter

It helps to reach demands produced by systems within time. For example electric vehicles can depend on solar and also back up battery. It improves reliability of a system for real world applications. Overall, this system becomes more effective for powering the motor, integrating renewable energy sources and many more.The Fig. 2 represents the basic connection diagram of converters. Circuit diagram of Dual Input-Single Output (DISO) comprises two DC voltage supplies and with considering applications. 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 100µH, while capacitors C1 and C2 are each 10µF. The load resistor (R-Load) is 12Ω. Filters are selected to prevent ripples and attain stable output voltages without disturbances. This can be enhanced by fig.3.The Fig.3 shows improved dual converter with consideration of applications like PV and Battery.

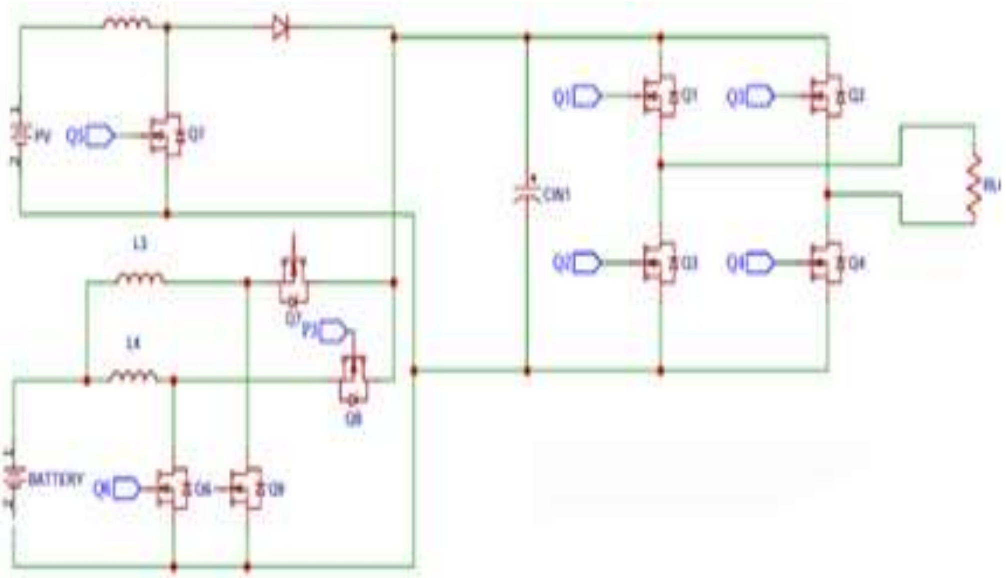

Fig 3: Connection diagram of improved dual converter with consideration of applications

PV comprises with boost converter and battery connected with buck boost bidirectional converters. It 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.

2.1 Design Calculations of Basic Converter topology

This converter is the combination of two DC DC converters i.e. having binary inputs and single output. Here, two converters are considered as buck converters which are connected parallelly to produce required amount of stable voltage.

- Input Voltage (V_{in1} and V_{in2} in V):

$$V_{in1} = V_{in2} = 12V$$

- Output Voltage (V_{out} in V): Output voltage is the resultant voltage that is summation of the output voltages of each converter.

$$V_{out1}+V_{out2} = 7.2V + 4.8V = V_{res} = 12V$$

- Duty Cycle (D_1 and D_2): It is defined as the ratio of the output voltage to the input voltage for each converter.

$$D_1 = \frac{V_{out1}}{V_{in1}} = \frac{7.2}{12}100 = 60\%$$

$$D_2 = \frac{V_{out2}}{V_{in2}} = \frac{4.8}{12}100 = 40\%$$

- Operating switching frequency of the converters, f_{sw}= 100 kHz.
- Inductor Calculation (L in μH):
  - Suppose 30% ripple current (ΔI_L) is considered for each converters, then

$\Delta I_L = \frac{30}{100}$ x I_{LOAD}= 0.3x1=0.3A

  - Calculating the inductor value with respect to the formula

$$L_1 = \frac{(V_{in1} - V_{out1}).D1}{\Delta I_L * f_{sw}} = \frac{(12-7.2)*0.6}{0.3*100*10^3} = 96\mu H$$

$$L_2 = \frac{(V_{in2} - V_{out2}).D2}{\Delta I_L * f_{sw}} = \frac{(12-4.8)*0.4}{0.3*100*10^3} = 96\mu H$$

- Capacitor Calculation (C in μF):
  - Suppose 1% ripple voltage (ΔV_{out}) is considered for each converters, then ΔV_{out} is 1% of individual converter output voltage
  - Calculating the capacitor value with respect to the formula

$$C_1 = \frac{\Delta I_L}{8*f_{sw}.\Delta V_{out}} = \frac{0.3}{8*100*10^3*0.072} = 5.2\mu F$$

$$C_2 = \frac{\Delta I_L}{8*f_{sw}.\Delta V_{out}} = \frac{0.3}{8*100*10^3*0.048} = 7.8\mu F$$

2.2 Design Calculations of converter when solar and battery are considered as two input sources. Here, Boost converter topology is considered. Calculations of inductor and capacitor are as follows. Agenda is to maintain stable individual output voltage by using this type of converter prototype model.

- The converter operating switching frequency, f_{sw}= 5 kHz.
- Input Voltage, V_{in}= 12 Volts
- Inductor Calculation (L in μH):
- Input Current, I_{in} = 0.7882 Amps
- For duty ratio of 0.454
- Output Voltage, $V_o = \frac{V_{in}}{1-D}$ = 21.9 Volts
- Input capacitor, $C_{in} = \frac{I_{in\,.\,D}}{\Delta V_{in}.\,f}$ = 509μF
- Inductor, $L = \frac{V_{in\,.\,D}}{\Delta I_L.\,f}$ =6mH
- Output Capacitor, $C_{out} = \frac{I_{out\,.\,D}}{\Delta V_{out}.\,f} = 130\mu F$

VALIDATION OF SIMULATION ANALYSIS

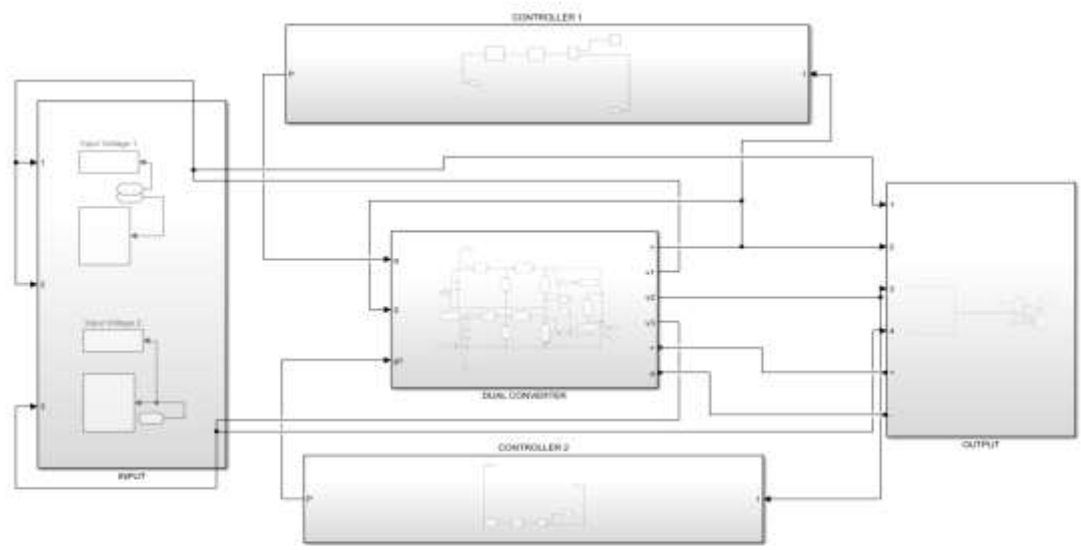

Fig.4: Simulation as per basic converter topology with voltage ratio of 6:4

Fig.4 represents dual input single output DC DC converter simulation done with MATLAB platform. It is designed through two parallel Buck Converters analysed with proper power distribution. Here, two inputs of same voltages are considered i.e. V_{in1} and V_{in2} of 12V. Inductors L_1 and L_2 of 96µH, capacitors C_1 and C_2 of 5.2µF and 7.8µF and load resistor of 12Ω by this system helps to reach required amount of voltage that is 12V. The duty cycles (D_1 and D_2) are set to 6:4 ratio that is D_1 and D_2 are 60% and 40% respectively resulting in V_{out1}= 7.2V and V_{out2}= 4.8V. In order to get resultant output voltage $V_{res} = 12$V with an current of 1A results in 12Watts power. This simulation suits and also verified for all duty cycle ratios. With respect to need of the system, this converter operates effectively. This balanced power distribution provides efficient operation with good efficiency.

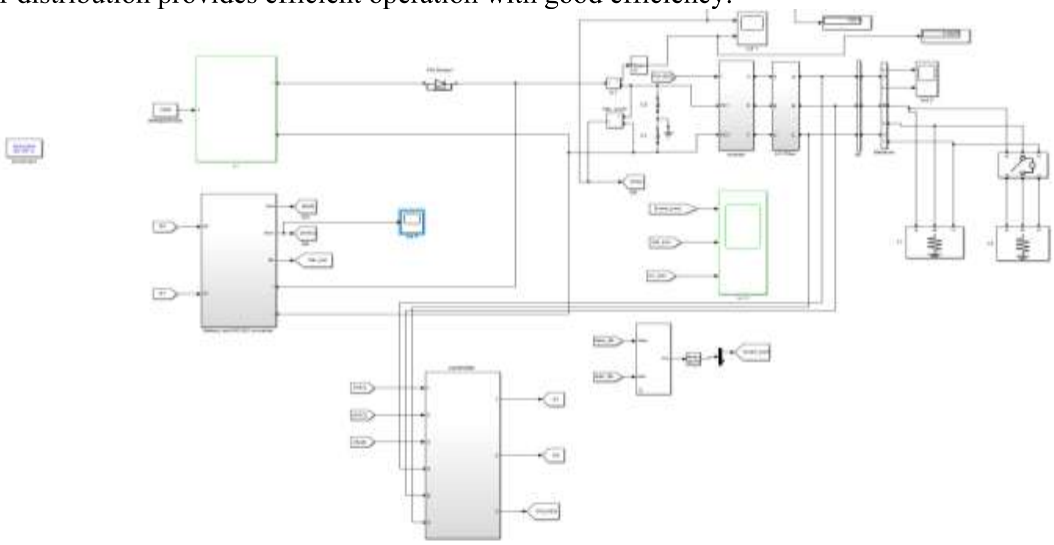

Fig.5: MATLAB Simulation of converter with considering when solar and battery are considered as two input sources.

Fig.5 represents simulation of prototype model of dual input converter when solar and battery considered as two input sources. The boost converter and buck boost bidirectional converter are used. For controlling the system PID Controllers are considered. Here, PV input is about 12V and Battery Input is about 6V. PV input is 12 V which is boosted upto 24V and combining with battery which producing 110V dc output voltage. This output voltage is well suits for real world applications like grid or household why because 110V dc voltage is equal to 150V ac Voltage. Simulation analysis provides optimal performance and stable output voltage with reliable operation.

3. HARDWARE IMPLEMENTATION AS PER SIMULATION ANALYSIS

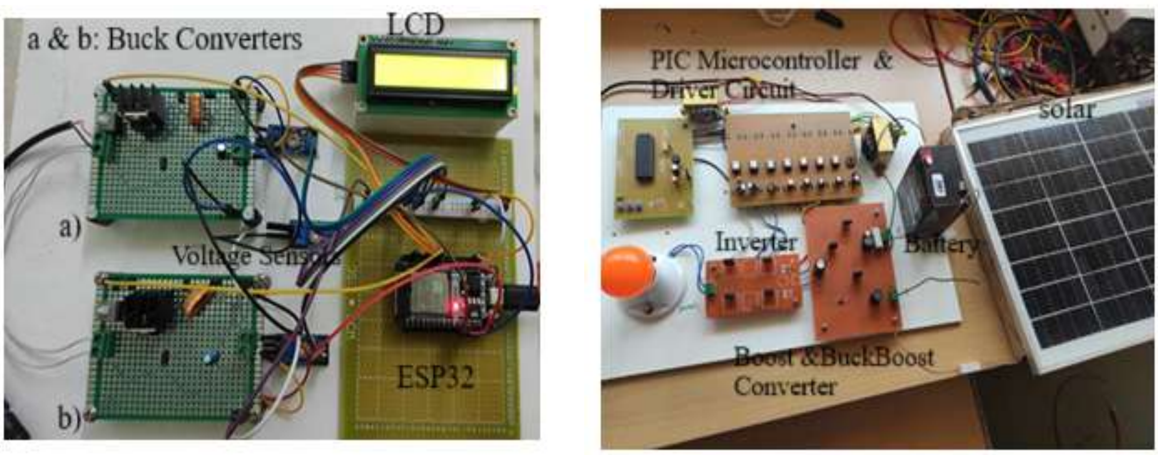

Fig. (i) Fig. (ii)

Fig.6 (i) and (ii): Implementation of converter models

As per the hardware implementation, the fig.6(i) shows basic simulation model of the dual input single output converter designed with respect to Buck Converter standards that is already calculated. The model includes L_1 and L_2 of 100μH, C_1 and C_2 of 10μF, Mosfet of IRF540N, LCD Display of 16*2 , 5V and voltage sensor of capacity 25V are the components used. By using Micro USB Cable to provide 12V DC supply to each buck converter i.e. V_{in1} and V_{in2}. ESP32 microcontroller is utilized where the duty cycles are set at algorithm resulting in output voltages. The resultant output voltage is varying from 10V to 12V with an output current of 1A and output power of 12W with respect to providing pwm pulses to Mosfet. The Fig.6 (ii) shows improved converter model implementation includes the dual input converter as per boost converter standards as solar and battery as two input sources. The model includes PV Panel of 12V, 10W, inductor of 6mH, Capacitor of 470 μF, PIC16F877A controller board with driver circuit having 12 V supply, Mosfet of IRF3205, Battery voltage of 6 V, PCB board, regulator of 7805 and rectifier W10. This type of hardware initialization helps to utilize both energy sources to reach reliable and steady output.

4. RESULTS AND DISCUSSION

This chapter discusses about simulation and hardware results. Initially, from dual input single output converter the results are validated by providing 7.2V and 4.8V from two converters and getting stable 12V output voltage.

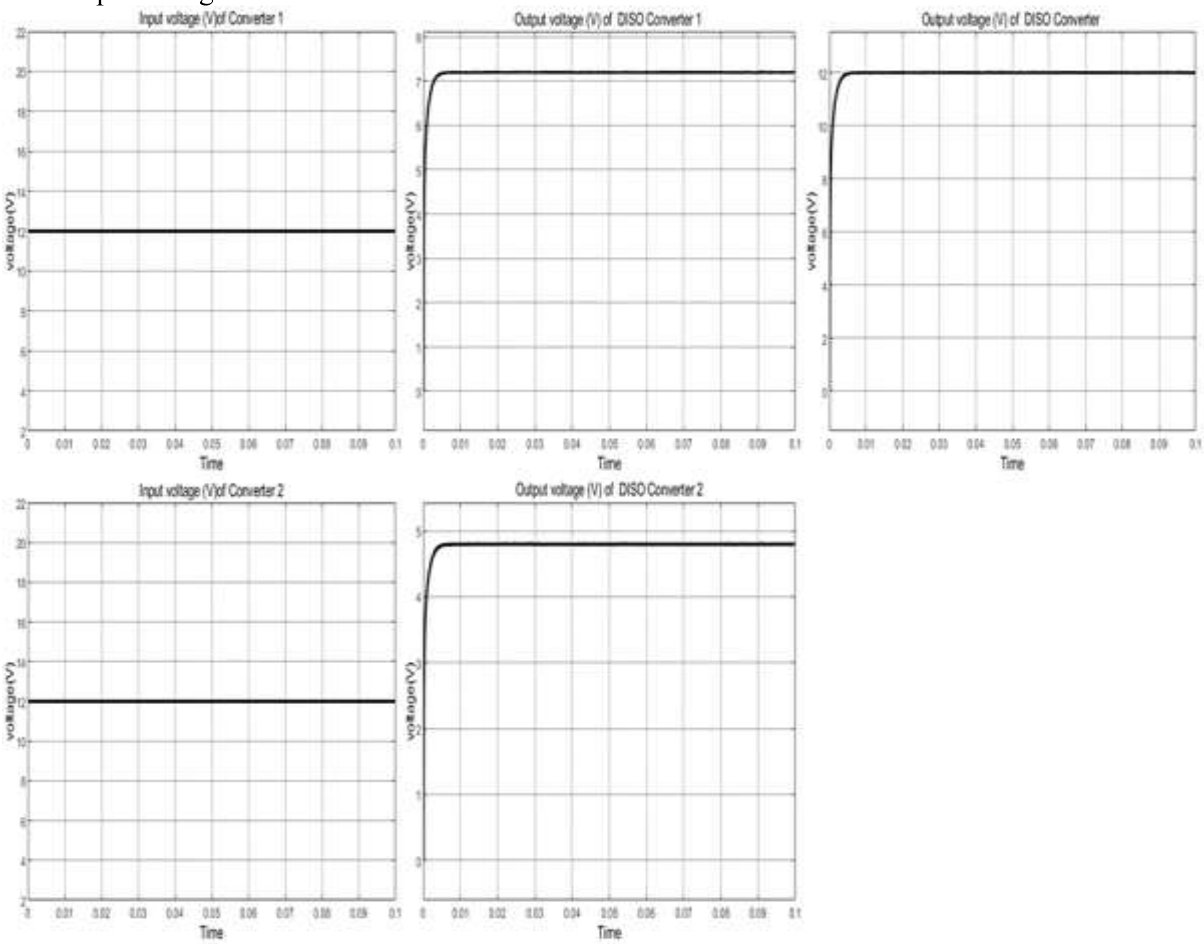

Fig.7: Simulation Result of Input and Output of Dual Input-Single Output DC-DC converter for Voltage Ratio 6:4,

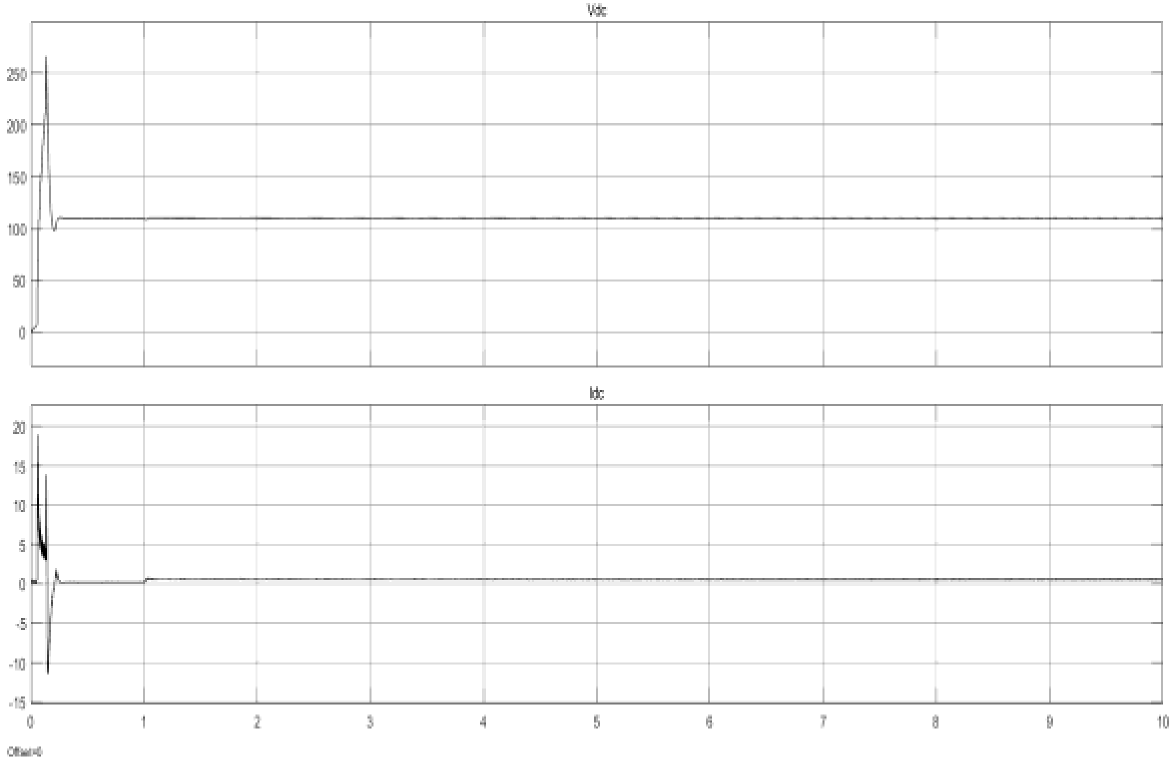

Fig.8: Simulation Result of Output Voltage of Dual Input-Single Output (DISO) DC-DC converter with Considering Application as Solar and Battery

This system suits for different ratios, this is validated for 6:4 duty ratio. Similarly, in hardware implementation also achieved 12V output voltage. From Fig 8, the system with solar and battery as two input sources, which producing 110V dc voltage that is equivalent to 155V of AC voltage and validated in hardware by producing ~150V AC voltage and system which suits for real world applications.

Fig. 9: Output voltage with respect to PWM Pulses

Fig.10: Output voltage

The Fig.9 shows outcomes for the Basic Model of Dual Input-Single Output (DISO) DC-DC converter. In the LCD I2C display, it includes output voltages of buck converter 1 and buck converter 2 i.e. V_{out1} and V_{out2} and PWM pulses of converters with respect to program fed using Arduino IDE Environment and also the corresponding output voltage i.e. V_{res}. Here $V_{out1}$is 5.54V and V_{out2} is 6.48V and got V_{res}. as 12V which is the resultant voltage by combining both converters voltage i.e. V_{out1} and V_{out2}. These Voltages vary with respect to PWM pulses which can be controlled by ESP32 microcontroller. Demonstration system producing stable 12V output with respect to varying PWM pulses for different ratios. This proposed system suits for all different ratios of PWM pulses which produces 12V stable output voltage practically. Results showing output voltage with respect to manual mode and automatic mode with respect to algorithm fed to node MCU ESP32 microcontroller. Through automatic mode of algorithm, output is analysed and fedback automatically till producing stable output irrespective of giving manual PWM pulses.

Fig.10 represents demonstration results of dual input single output converter when solar and battery considered as two input sources. The entire operation works on 3 modes. In Mode 1, PV is connected and battery is not connected where voltage flows from PV to load. From this mode voltage get up to 150V AC output voltage. Mode 2 is the case of battery need to be charged from PV source. So, PV is connected as input source producing 8.2V and boosting up to 23V. Later the boosted voltage is bucked in order to charge battery. Mode 3 is the case of connecting both PV i.e. 12V and battery i.e. 6V sources as input which resulting to 162.3 V AC. In prototype simulation model, results got 110 volts dc output voltage which is equivalent to 155.563 AC voltage after converting DC to AC. So, that demonstration shows optimal performance with good efficiency providing required voltage which well suits for grid and household applications.

5. CONCLUSION

The design and simulation of the Dual Input converter with and without applications have been analyzed. Transitioning to the experimental phase to validate the design through hardware implementation and real-world testing. This study holds significant potential for applications in renewable energy systems, hybrid energy storage, and reliable power systems, offering modularity, redundancy, and efficiency. Study scaled up with design of DISO Boost converters and tested for solar and battery as two input sources which provide output voltage of 150V AC suits for grids applications. This approach is helps to raise the use of renewable energy and minimizing rely on fossil fuels. Through the use of fossil fuels in technological world leads to ruin of land, health and leading to depletion of fuels. So, the improved models enhance the overall energy performance of residential power networks. This ensures optimal utilization of available energy resources and providing a reliable power supply for household applications. It includes the hardware implementation of the designed circuit. The hardware implementation is validated with simulations done in MATLAB environment.

It ensures that the converter can effectively manage the energy from two DC input sources and maintain the stable output with different conditions. This work effectively provides reliable and cost-effective method in real world applications for incorporating renewable energy sources. In future, the engineers/researchers have to concentrate on designing converters, control circuitry and component selection. Further, handle the issues by reducing losses and increasing efficiency with respect to coordination between two sources, different level of voltage management and protection for the fault occurrences in the system. Thereby proving its practicality and efficiency for real-world applications. Particularly, since the need for integrating renewable energy sources into the grid keeps rising, DISO DC-DC converters' adaptability and efficiency make them a vital part of modern power management systems.

6. COMPETING INTERESTS:

The authors have no relevant financial or non-financial interests to disclose. The authors declare that they have no competing interests.

REFERENCES

[1] Stutee Patra, Aditi Chatterjee, K C Patra, “A Comparative of Multiport DC-DC Converters in Microgrid using small-signal Modelling”,IEEE 2nd International Symposium on Sustainable Energy, Signal Processing and Cyber Security ,2022, DOI: 10.1109/iSSSC56467.2022.10051601

[2] Muhammad Mubashir Alam, Dylan D.-C.LU, et.al., “A Modular Four-Port DC-DC Converter for Battery Management Systems”, International Future Energy Electronics Conference (IFEEC) 2023 IEEE, DOI: 10.1109/IFEEC58486.2023.10458618

[3] Soroush Naeiji, Seyed Ehsan Abdollahi , et.al.,”An Improved Bidirectional Non-Isolated Dual-Input DC-DC Converter for Electric Vehicles Application”,14th Power Electronics, Drive Systems, and Technologies Conference (PEDSTC) 2023 IEEE, DOI: 10.1109/PEDSTC57673.2023.10087176

[4] G Ramanathan, C Bharatiraja, “Ultra-Gain Two-Input Two-Output DC–DC Converter for Electric Vehicle Application”, International Conference on Sustainable Technology and Advanced Computing in Electrical Engineering, 159-175, 2023/1/19, DOI:10.1007/978-981-99-9235-5_12

[5] Tian Cheng, Dylan D.C. Lu, SMIEEE, Andrew Gong, Dries Verstraete, “Analysis of a Three-Port DC-

DC Converter for PV Battery System Using DISO Boost and SISO Buck Converters". DOI: 10.1109/AUPEC.2015.7324842
[6] Amirhossein Hosseini, Saeed Hosseinnataj, "Bidirectional DISO DC-DC Converter Based on Fixed-Frequency Sliding Mode Control Strategy", 32nd International Conference on Electrical Engineering (ICEE) ,2024 IEEE,DOI: 10.1109/ICEE63041.2024.10667701
[7] Farid Mohammadi , Amir Khorsandi , "Dual-Input Single-Output High Step-Up DC-DC Converter for Renewable Energy Application",International Conference on Electrical Engineering (ICEE),2023 IEEE, DOI: 10.1109/ICEE59167.2023.10334737
[8] Bairabathina Saikumar, Balamurugan S, "Dual-Input Single-Output Non-Isolated DC–DC Converter for GIHEVs",Innovations in Power and Advanced Computing Technologies (i-PACT), 2021 IEEE, DOI:10.1109/I-PACT52855.2021.969675
[9] Bang Le-Huy Nguyen, Honnyong Cha,et.al.,"Family of Integrated Multi-Input Multi-Output DC-DC Power Converters", The 2018 International Power Electronics Conference, DOI: 10.23919/IPEC.2018.8507791
[10] Shubahm Gupta, M M Lokhande, "Isolated DISO High Gain DC-DC Converter for Efficient Power Flow Management in HESS for EV Applications", 2023 IEEE International Conference on Power Electronics, Smart Grid and Renewable Energy, 2023 IEEE, DOI: 10.1109/PESGRE58662.2023.10404610
[11] Gangavarapu Guru Kumar, Kumaravel Sundaramoorthy, "Dual-Input Nonisolated DC–DC Converter With Vehicle-to-Grid Feature", IEEE Journal Of Emerging And Selected Topics In Power Electronics, Vol. 10, No. 3, JUNE 2022, DOI: 10.1109/JESTPE.2020.3042967
[12] Laxmidhar Senapati, AnupKumar Panda, ManMohan Garg, "A Systematic Approach to Synthesize a Non-Isolated TPCC With Fully Reconfigurable Structure for RES", IEEE Journal Of Emerging And Selected Topics In Power Electronics, Vol. 8, No. 4, DECEMBER 2020, DOI: 10.1109/TCSII.2022.3166976
[13] M. R. Al-Soeidat, H. Aljarajreh, H. A. Khawaldeh, et.al., "A Reconfigurable Three-Port DC–DC Converter For Integrated PV- Battery System," IEEE J. Emerg. Sel. Topics Power Electron., vol. 8, no. 4, pp. 3423–3433, Dec. 2020, doi: 10.1109/JESTPE.2020.3006886
[14] Santhosh H.A , Umavathi M , "Design And Analysis Of Dual Input Single Output Dc-Dc Converter For Domestic Application", African Journal of Biological Sciences, Santhosh H.A/Afr.J.Bio.Sc.6(Si4)(2024) ISSN: 2663-2187 https://doi.org/10.48047/AFJBS.6.Si4.2024.4066-4075.
[15] P Ramesh, M Umavathi, C Bharatiraja, G Ramanathan, S Athikkal, "Development of a PMSM motor field-oriented control algorithm for electrical vehicles", Materials Today: Proceedings (Q2) 65, 176-187, 2022, https://doi.org/10.1016/j.matpr.2022.06.080