

Performance Investigations On Dual Source Coupled Inductor DC-DC Converter

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Abstract— The increasing demand for efficient and reliable power conversion systems in renewable energy and hybrid applications has led to the development of multi-input DC–DC converters. This paper presents the performance investigation of a dual-source coupled inductor DC–DC converter designed to integrate two independent DC sources, such as a solar photovoltaic (PV) panel and a battery. The converter utilizes a coupled inductor topology to achieve high voltage gain, reduced switching stress, and improved energy transfer efficiency. The coupled inductor enhances the voltage boosting capability while minimizing ripple and conduction losses. Detailed analysis of operating modes, switching sequences, and design parameters is carried out and validate the performance of the converter under different load and input conditions.

Keywords— Dual Input DC–DC Converter, PWM Control, Renewable Energy Systems

I. Introduction

With increasing demand for more efficient power management system designs, engineers have come up with sophisticated power electronics devices capable of merging power from two or more power sources. Currently, numerous electrical and electronic systems have multiple power sources with most of them being utilized in renewable energy systems such as photovoltaic solar cells, battery packs, fuel cells, and integrated power systems. A Dual Input DC-DC Converter refers to a power electronics device whose function involves converting power from two DC power sources to one output voltage. These converters find wide applications in integrated renewable energy systems which generate their power from different sources like photovoltaic solar cells and battery packs. With the implementation of Pulse Width Modulation (PWM) control approaches, the switching components in these converters can easily be regulated to provide accurate voltage regulation, increased conversion efficiencies, and optimal power balancing between the power sources. The operation of these converters can be analyzed using simulations whereby the various parameters including input voltages, input currents, switching signals, inductor voltages, inductor currents, output voltages, and output currents are taken into consideration.

II. Procedure Methodology

The converter operates by using two power sources and transforming their DC to a regulated voltage output. This is made possible by the application of the Pulse Width Modulated (PWM) signals used to regulate the process of switching of the MOSFETs to achieve power contribution balance and proper power allocation among the two power sources. During operation, the switches will alternate energy conversion from the input sources to the inductor before being sent to the output stage. This enables the converter to operate in either buck or boost mode depending on the duty cycle of the switches. Simulation analysis of the converter's performance can be done through an analysis of such variables as input voltages, input currents, gate pulses, inductor voltage, inductor current, output voltage, and output current. The inductor stores energy during switching while the capacitor filters the output voltage to maintain a stable supply to the load.

Duty Ratio > 0.5 – Boost Model

When the duty ratio is greater than 0.5, the converter operates in boost mode and the output voltage becomes higher than the input voltage. More energy is stored in the inductor during the ON period and transferred to the load during the OFF period.

Duty Ratio < 0.5 – Buck Model

When the duty ratio is less than 0.5, the converter operates in buck mode and the output voltage becomes lower than the input voltage. Less energy is transferred to the output, producing a reduced regulated voltage.

Circuit Model

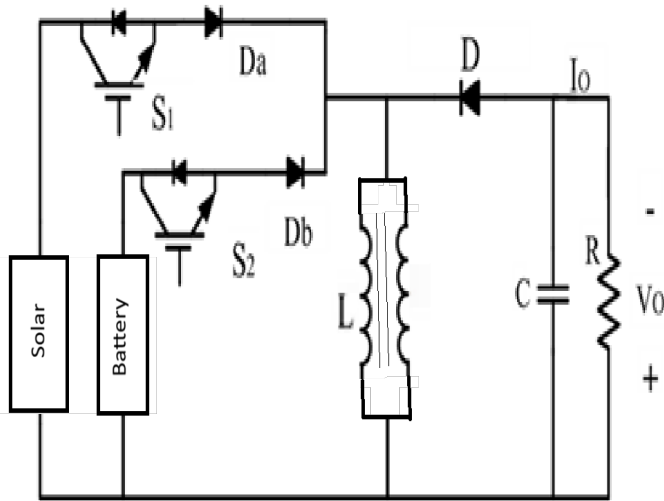


Fig 1: Circuit diagram of the DIDC converter

The proposed converter consists of two DC input sources V_1 and V_2 switches S_1 and S_2 , diodes D_a , D_b , and (D) , an inductor L , capacitor C , and load resistance R . The switches are controlled by Pulse Width Modulation (PWM) signals to regulate the switching operation of the converter. The two input sources supply power alternately through the controlled switches, while the diodes provide proper current flow paths during switching intervals. The inductor stores and transfers energy, the capacitor filters the output voltage, and the load resistance represents the connected output load. The converter performance is analysed through simulation by observing source voltages, source currents, switching pulses, inductor voltage, inductor current, output voltage, and output current under various duty cycle conditions.

Mode 1 – Operation: In Mode 1, switch S_1 is turned ON and the inductor stores energy from the first input voltage source V_1 , while the output capacitor supplies energy to the load.

Mode 2 – Operation: In Mode 2, switch S_2 is turned ON and the inductor stores energy from the second input voltage source

source V_2 , while the output capacitor supplies energy to the load.

Mode 3 – Operation: In Mode 3, both switches S_1 and S_2 are turned OFF. The stored energy in the inductor is transferred through diode D to the capacitor and load resistance R , maintaining the output voltage.

III. Result

The design of the Dual Input DC-DC Converter aimed at integrating energy from two distinct input sources and producing an output voltage with uniform characteristics. The signals generated by the PWM technique facilitate the operation of the switching elements, making it operational regardless of any changes in the duty cycle. It operates efficiently under various loads and is capable of distributing the input power between the two input sources efficiently. The performance of this design through simulations shows that it performs optimally in the buck and boost topologies.

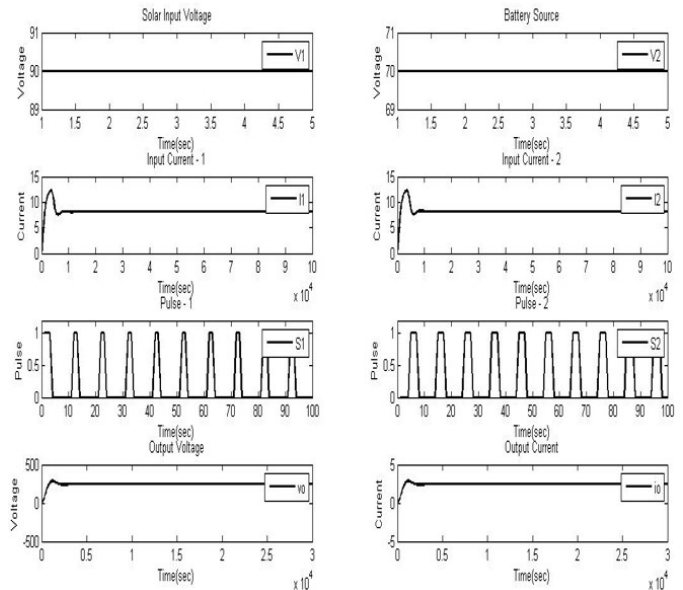


Fig 2: Boost Operation at Duty Ratio 60%

The simulation waveform results demonstrate that the proposed Dual Input DC-DC Converter successfully combines two DC input sources of 90 V and 70 V and operates in boost mode at a 30% duty cycle. Both input sources jointly supply the load with effective current sharing, as indicated by the similar source current waveforms, while the inductor current remains continuous with low ripple, confirming stable

continuous conduction mode operation. The gate pulse signals for both MOSFET switches maintain a 30% duty ratio with proper phase displacement, enabling controlled switching action. The inductor voltage exhibits periodic stepped pulses corresponding to the switching intervals, while the output voltage rises rapidly during startup, reaches a peak value of 140 V, and then settles to approximately 117 V under a 10 Ω load. The output current stabilizes near 11.7 A, validating proper boost conversion performance, enhanced voltage gain, regulated output behaviour, and stable converter operation.

performance, regulated output behaviour, and stable converter operation.

Table

V1	V2	D%	I1	I2	Vo	Io	Pin	Pout	Eff
90	70	30	0.53	0.54	54.3	0.54	85.5	29.3	34.29
90	70	50	2.13	1.59	120	1.2	303	144	47.5
90	70	60	8.7	8.8	263	2.6	1399	684	48.7
90	70	80	8.712	8.846	263	2.6	1403	684	48.9
90	70	90	10.94	6.4	270	2.7	1432	729	50.9

Efficiency Graph:

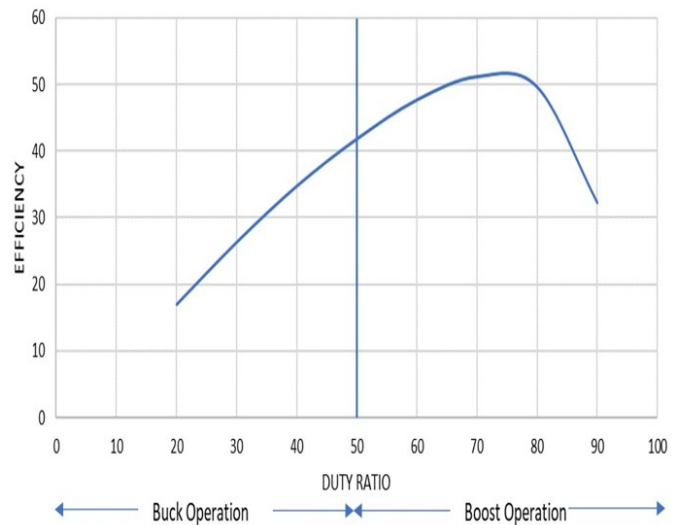


Fig 4: Efficiency Graph

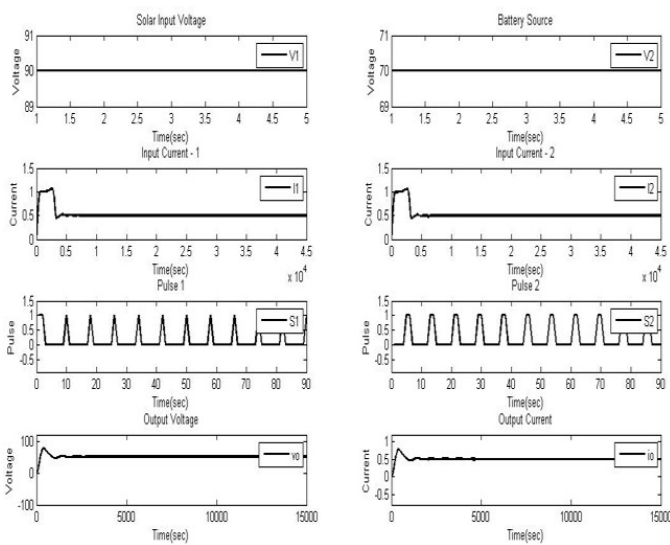


Fig 3: Buck Operation at Duty Ratio 30%

The simulation waveform results demonstrate that the proposed Dual Input DC-DC Converter successfully combines two DC input sources of 90 V and 70 V and operates in buck mode at a 20% duty cycle. Both input sources jointly supply the load with effective current sharing, as indicated by the similar source current waveforms, while the inductor current remains continuous with low ripple, confirming stable continuous conduction mode operation. The gate pulse signals for both MOSFET switches maintain a 30% duty ratio with proper phase displacement, enabling controlled switching action. The inductor voltage exhibits periodic stepped pulses corresponding to the switching intervals, while the output voltage rises smoothly during startup and settles to approximately 50 V under a 10 Ω load. The output current stabilizes near 5 A, validating proper buck conversion

IV. Discussion

The converter demonstrates the advantages of combining multiple DC sources into a single regulated output voltage. Compared to conventional single-input converters, the dual-input converter improves power reliability, enhances source utilization, and enables efficient integration of renewable energy sources. The system exhibits stable performance under varying load conditions with proper power sharing between the input sources and satisfactory voltage regulation. Simulation results confirm reliable converter operation in both buck and boost modes, making the proposed system suitable for applications such as hybrid renewable

energy systems, battery energy storage systems, electric vehicles, and portable power devices.

V. CONCLUSION

The Dual Input DC–DC Converter provides an efficient solution for combining power from two DC sources and delivering a regulated output voltage. The PWM-based control technique allows effective switching of MOSFETs and ensures stable output voltage regulation under different operating conditions. The system demonstrates reliable operation, proper power sharing between the input sources, and improved power management performance. Simulation results confirm satisfactory converter behaviour in both buck and boost modes with stable voltage and current characteristics. Due to its simple design, cost-effectiveness, and efficient operation, the converter is suitable for renewable energy systems, battery-powered devices, hybrid power systems, electric vehicles, and portable electronic applications.

REFERENCES

- [1] B. G. Dobbs and P. L. Chapman, “A multiple-input DC–DC converter topology,” *IEEE Power Electronics Letters*, 2003.
- [2] Y. C. Liu and Y. M. Chen, “A systematic approach to synthesizing multi-input DC–DC converters,” *IEEE Transactions on Power Electronics*, 2009.
- [3] Y. M. Chen, Y. C. Liu, and S. H. Lin, “Double-input PWM DC/DC converter for high/low-voltage sources,” *IEEE Transactions on Industrial Electronics*, 2006.
- [4] N. Muntean, M. Gavris, and O. Cornea, “Dual input hybrid DC–DC converters,” *IEEE EUROCON Conference*, 2011.
- [5] B. Karthikeyan, K. Sundararaju, and R. Palanisamy, “A dual input single output non-isolated DC–DC converter for multiple source applications,” *Frontiers in Energy Research*, vol. 10, 2022.
- [6] Z. Rehman, I. Al-Bahadly, and S. Mukhopadhyay, “Dual input–dual output single inductor DC–DC converter,” in *Proc. IEEE IECON*, Yokohama, Japan, 2015, pp. 4848–4853.
- [7] P. Farhadi, M. A. Bagherpour, and N. Bagherpour, “A novel dual input high step-up DC–DC converter with one bidirectional port for renewable energy systems,” *Journal of Power Technologies*, vol. 99, no. 3, pp. 1–10, 2019.
- [8] S. Zhen, R. Yang, and D. Wu, “Design of hybrid dual-path DC–DC converter with improved efficiency over wide input voltage range,” in *Proc. IEEE ISCAS*, 2021, pp. 1–5.
- [9] M. A. Hannan, S. Mutashar, S. A. Samad, and A. Hussain, “Energy management system using multi-input DC–DC converters,” *IEEE Transactions on Industrial Electronics*, vol. 63, no. 1, pp. 445–454, 2016.