POWER ENHANCEMENT IN BOOST CONVERTER COMPARED WITH BUCK-BOOST CONVERTER UNDER VARYING INDUCTANCE VALUES

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Abstract

Aim: The use of DC-DC converters is rapidly expanding. This converter changes the voltage level from one form to another. The value of the power level likewise varies from minimum to maximum. However, thanks to rapid advancements in DC to DC converter technology, a lot of topologies are now accessible. This research examines the contributions of different converters, such as a Buck Boost converter and a Boost converter.

Materials and Methods: In which the return values of selected converters at the same input are evaluated at a fixed duty cycle with load inductance change. A sample of 7 samples from each group is taken by changing the load inductance and a G power of 0.80 is implemented to analyze the efficiency.

Results: According to the results, the boost converter system has a higher overall mean output power of 776.9143W than the buck-boost converter, which has an output power of 531.3714W. The significance value is 0.014 ($p<0.05$, statistically significant).

Conclusion: As per the results, the recommended system has a higher output power of 776.91W for the selected data than the buck-boost converter, which has a lower output power of 531.37W.

Keywords: Novel Boost Converter, Buck-Boost converter, Voltage Gain, Load Inductance, Efficiency, Power electronics.

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1. Introduction

Arrangements with step-up/down functionality are one of the most popular forms of DC–DC converters throughout many commercial applications, such as sustainable energy applications (Meinagh et al. 2019). Zeta, Cuk, and Sepic converters can generate high voltage gain with low input magnitude (Mirsamadi et al. 2010). These frameworks, however, have some severe flaws. Furthermore, these converters use a maximum duty value to achieve a high voltage gain, but that might result in a variety of issues, including decreased efficiency, increased control system costs, high-frequency malfunctions, and transient response hindrances (Surya et al. 2017). By incorporating certain simple step-up/down blocks into conventional converters, more acceptable voltage gains can be achieved with lower conduction losses and smaller inductors, as shown in (Surya et al. 2017). Electric vehicles, DC microgrids (Wai, Lin, and Duan, __.), electric propulsion, industrial machinery, battery storage specific mechanical systems (Brekken et al. 2010), and renewable energy applications are only a few of the uses for these converters.

Nearly 1248 articles were found in Google Scholar and 392 articles have been posted in IEEE Xplore based on the suggested converter. The performance analysis of buck-boost, cuk, SEPIC, positive output super lift, and ultra-lift converters is reviewed and compared (Sivakumar et al. 2016). A combination of different resources is presented in (Okedu, Tahour, and Aissaoui 2020) and its limitations are listed. The employment of the converter in the ripple current reduction process of PV-array setup is reviewed and analyzed (Priyadarshi et al. 2017). Other than designing a converter and taking care of circuit configuration, a special care upon following factors such as switching loss, conduction loss, capacitor loss is essential. In solar power generation systems, the converter is used to link the solar panel to a load on the grid in order to balance the electricity between them (Verma et al. 2020). The efficiency, oscillation, components count, and voltage sharing of each converter are all evaluated and discussed (Jeremy et al. 2020). Battery charging adapters are an application for DC-DC converters(Siwakoti 2019). A motor driven wheelchair or a prosthetic hand are examples of converters used as chargers.

Our institution is passionate about high quality evidence based research and has excelled in various domains (Vickram et al. 2022; Bharathiraja et al. 2022; Kale et al. 2022; Sumathy et al. 2022; Thanigaivel et al. 2022; Ram et al. 2022; Jothi et al. 2022; Anupong et al. 2022; Yaashikaa et al. 2022; Palanisamy et al. 2022).Depending upon the overall analysis of the various converters,(Chung 2004) the Novel Boost Converter is the best choice for maximizing voltage gain while maintaining a low duty ratio. The goal is to create a voltage compensation converter that is appropriate. The MATLAB software was used to create the converter. This study will also analyze the advantages and disadvantages of converters. Finally, the characteristics of the converter are assessed in order to choose the best layout for future implementation.

2. Materials and Methods

The research was performed in the Power Electronics lab, Department of Electrical and Electronics Engineering, Saveetha School of Engineering, Saveetha Institute of Medical And Technical Sciences. This work involves two groups of efficiency values. Group 1 is Novel boost converter and group 2 is buck boost converter that has a sample size of 7 efficiency values in each group from the dataset and G power is taken for testing. Matlab R2021a software tool kit is used to write the code and to simulate (Garg et al. 2017). Using matlab the efficiency values has been calculated for the required algorithm and then results have been compared based on the inductance values.

The sample preparation of group 1 was done by collecting the different efficiency by varying the inductance values of boost converter, here the parameters considered are efficiency and inductance. Group 2 sample preparation was done by collecting the different efficiency values by varying the inductance of the buck boost converter, here the efficiency and inductance are parameters considered.

Novel Boost Converter

A Novel boost converter (step up converter) is a DC-DC power converter that steps up voltage(with stepping down current) from its input supply to output load.It is a class of switched-mode power supply (SMPS) containing at least two semiconductors and at least one energy storage element: a capacitor,inductor, or the two in combination (Callegaro, Martins, and Barbi 2014). To reduce voltage ripple, filters made of capacitors (sometimes in combination with inductors) are normally added to such a converter's output (load-side filter) and input (supply-side filter) as shown in Fig. 1, Boost converters are highly nonlinear systems and a wide variety of linear and nonlinear control techniques for voltage gain for achieving good voltage regulation with large load variations have been explored. Novel Boost Converter are used in electronics to generate a DC output voltage that is greater than the DC input, therefore boosting up the supply voltage. Boost converters are often used in power supplies for white LEDs, battery packs for electric automobiles, and many other applications.

Buck Boost Converter

The Buck-boost converter is a type of DC-DC converter that has an output voltage magnitude that is either greater than or less than the input voltage magnitude. It is equivalent to a flyback converter using a single inductor instead of a transformer. Two different topologies are called Buck-boost converter. (Sankarganesh and Thangavel 2014). Both of them can produce a range of output voltages, ranging from much larger (in absolute magnitude) than the input voltage, down to almost zero in Fig. 2, In the inverting topology, the output voltage is of the opposite polarity than the input. This is a switched mode supply with a similar circuit topology to the Novel Boost Converter and the buck boost converter. The output voltage is adjustable based on the duty cycle of the switching transistor on the basis of voltage gain. One possible drawback of this converter is that the switch does not have a terminal at ground; this complicates the driving circuitry. However, this drawback is of no consequence if the power supply is isolated from the load circuit (if, for example, the supply is a battery) because the supply and diode polarity can simply be reversed. When they can be reversed, the switch can be on either the ground side or the supply side.

A Google collab open source stage with a center i5, tenth era processor and 8GB RAM is utilized for proposed work.

Statistical Analysis

For statistical analysis of boost converters and buck-boost converters, SPSS software is employed. The load inductance is the independent variable, whereas output power is the dependent variable. All techniques are subjected to two independent group analysis tests to establish their maximum efficiency.

3. Results

Fig. 3,shows the incoming and outgoing power obtained from the present system. The suggested study's power on source and load is graphically shown in Fig. 4.

The existing model had a standard deviation of 73.096 with a standard error of 27.627 using 7 samples, but the suggested scheme had a standard deviation of 4.111 with a standard error of 1.5538 using 7 samples (Table 2). The significance level is 0.014, which is significantly lower than 0.05. Table 1 shows the Simulation results of Existing and Proposed methods. In relation to fluctuations in load inductance, the equivalent load power (dependent variable) is determined (Independent variable).

With load inductance varying from 100mH to 700mH, Table 2 illustrates a T-test comparison of the current and recommended systems. A boost converter's average output power is 776.914, which is higher than a buck-boost converter's average output power of 531.371. Table 3 shows an Independent Samples test that compares the efficiency of the proposed and existing systems.

Fig. 5 shows a comparison of two groups' output for maximum output power in the present study versus the suggested study. Using a boost converter could lead to more consistent results.

4. Discussions

The conventional and proposed study are evaluated and compared. The suggested system is more economical than the conventional system.

Two different DC-DC converters, a boost converter and a SEPIC converter, were explored based on the prior literature analysis (Rajakumari, Felshiya Rajakumari, and Deshpande 2019). When comparing output voltage ripple, total harmonic distortion, and power factor, the boost converter obtains 4 percent, 0.9, and 0.2, whereas the buck-boost converter reaches 6 percent, 0.82, and 0.25. Solar energy is interfaced with a Buck boost converter, SEPIC, and CUK converter (Surya, Irawan, and Zuhri, 2017). When employing a buck-boost converter with a solar irradiation of 1000 W/m2, the generated voltage is 150W, which is higher than the CUK and SEPIC converters. Solar energy combined with buck, buck-boost, CUK, and SEPIC converters has an efficiency rating of 99.85%, 99.064%, 97.074%, and 97.244%, respectively (Luthfansyah, Suyanto, and Bangura 2020). The boost converter is the most economical in a series connection of N number of PV cells, followed by the CUK and finally the SEPIC converter, according to the findings (Bubovich 2017). The right selection of a converter is a vital factor that has a significant impact on the power conversion system. Aside from selecting an effective DC-DC converter design, it's also vital to incorporate a suitable control technique for best performance. The open loop operation of the stated converter is unable to identify the load necessary at that moment. As a result, the effectiveness of the system will be harmed. To remedy this problem, a closed loop feedback control system must be used to analyze the load needed before starting to create DC voltage. This is addressed by a variety of control techniques (Mumtaz et al. 2021).

To overcome the limitations indicated above, a special control technique can be utilized to track the section's output voltage efficiently, resulting in enhanced efficiency, high precision, and reduced tracking time.

5. Conclusion

As per the results, the recommended system has a higher output power of 776.91W for the selected data than the buck-boost converter, which has a lower output power of 531.37W. Based on T test analysis the significance value is observed to be 0.014 ($p<0.05$) which is statistically significant.

Declaration

Conflicts of Interest

No conflict of interest in this manuscript.

Author Contributions

Author MT was involved in data collection, data analysis, and manuscript writing. Author SJR was involved in data validation and review of manuscripts.

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Tables and Figures

Table 1: Simulation results of Existing and Proposed method

Load inductance (mH)	**Output Power (W)**	
	Boost converter	**Buck-Boost converter**
100	778.8	638
200	780.6	601.1
300	780.2	539.9
400	778.1	519.4

Load inductance (mH)	Output Power (W)	
	Boost converter	**Buck-Boost converter**
100	778.8	638
200	780.6	601.1
300	780.2	539.9
400	778.1	519.4
500	777.6	528.4
600	774.2	470.5
700	768.9	422.3

Table 2: Output power calculation using seven samples selected for each group.

Group Statistics					
	GROUP NAME	**N**	**Mean**	**Standard Deviation**	**Standard Error Mean**
Output Power (W)	**Boost converter**	7	776.9143	4.11113	1.55386
	Buck-boost converter	7	531.3714	73.09641	27.62785

Table 3: The independent sample test revealed a substantial variation in inductance and output power among the suggested two stages and the standard single stage. Significance value is observed to be 0.014 ($p<0.05$) which is statistically significant..

Independent Sample Test

		Levene's Test for Equality of Variances		T-test for Equality of Means						
		F	**Sig.**	**T**	**Df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Differences**	**95% Confidence Interval of the Difference**	
									Lower	**Upper**
Output Power (Watts)	**Equal Variances assumed**	8.279	.014	8.873	12	.001	245.5428	27.67151	185.2518	305.8339
	Equal Variances not assumed			8.873	6.038	.001	245.5428	27.67151	177.9361	313.1495

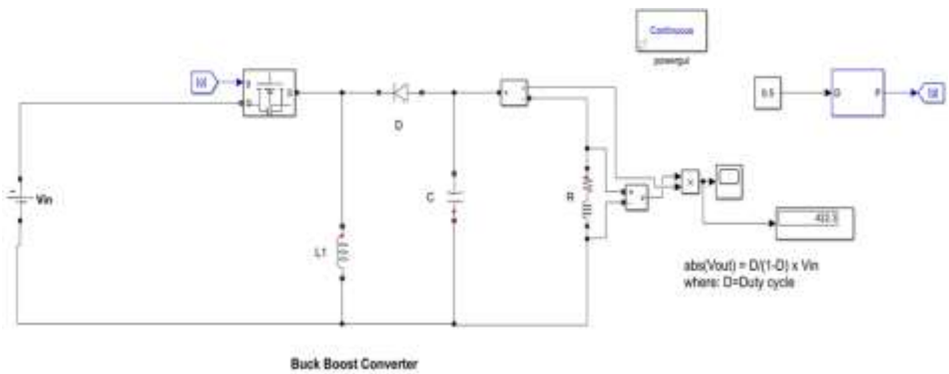

Fig.1. Simulink structure of existing system

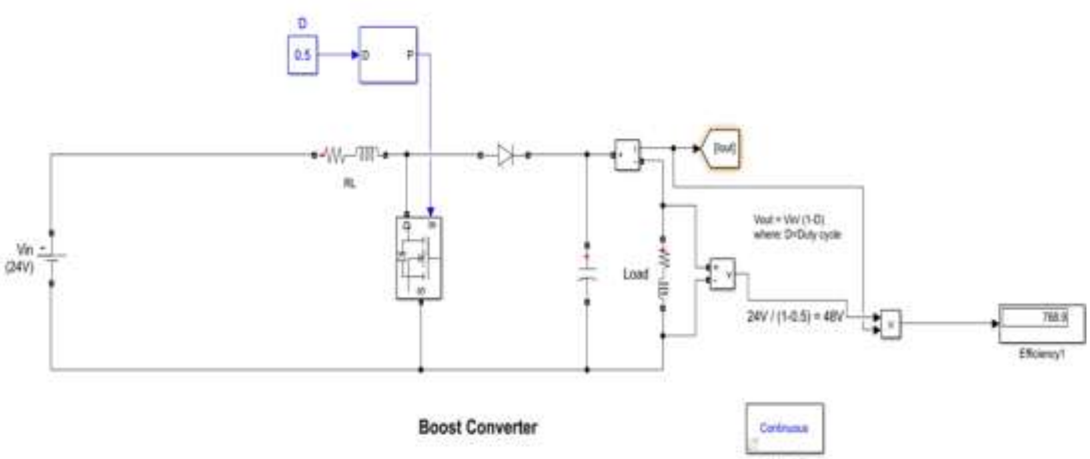

Fig.2. Simulink structure of the suggested method

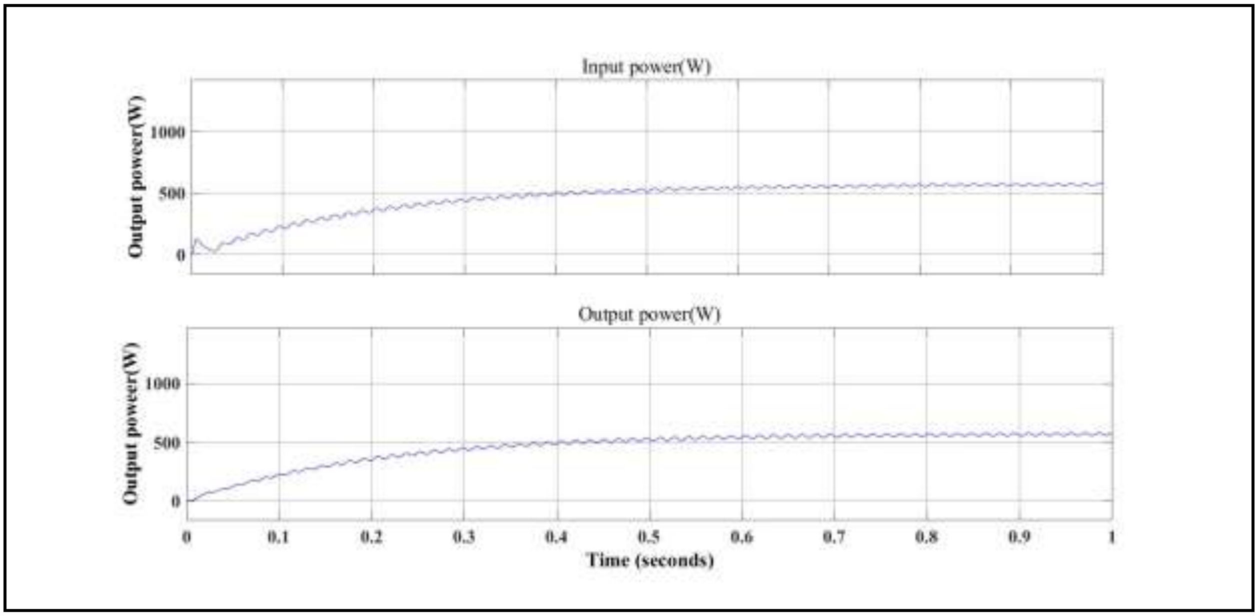

Fig.3. Input and output power calculated from existing system

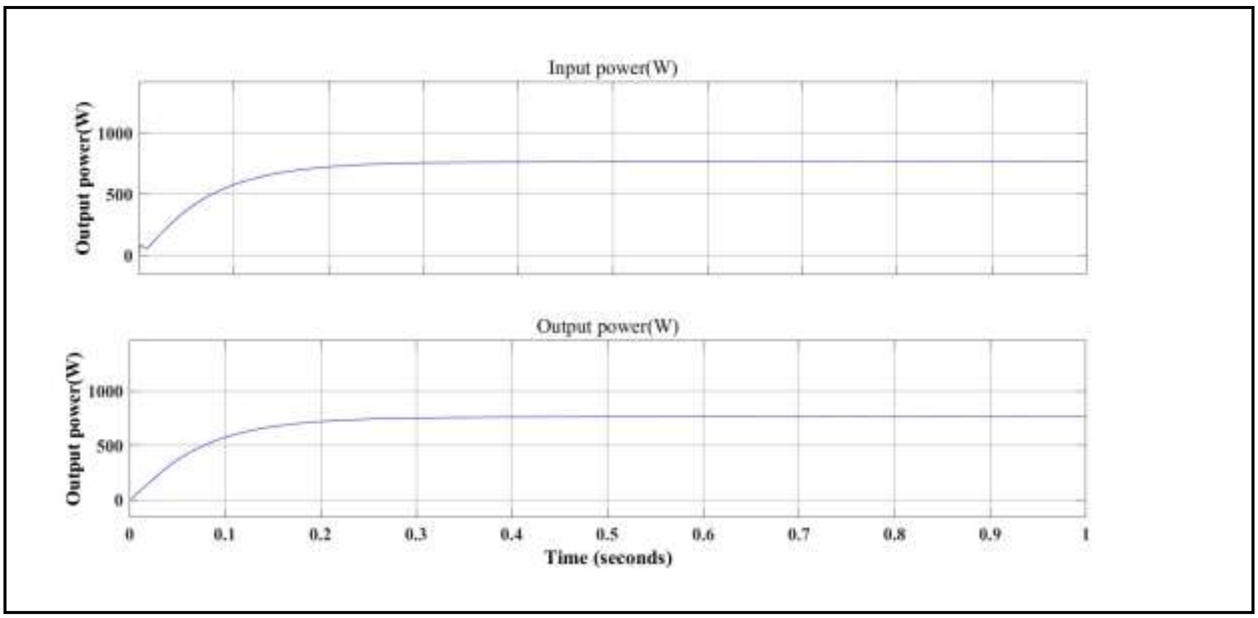

Fig.4. Input and output Voltage and current gain of proposed system measured across load

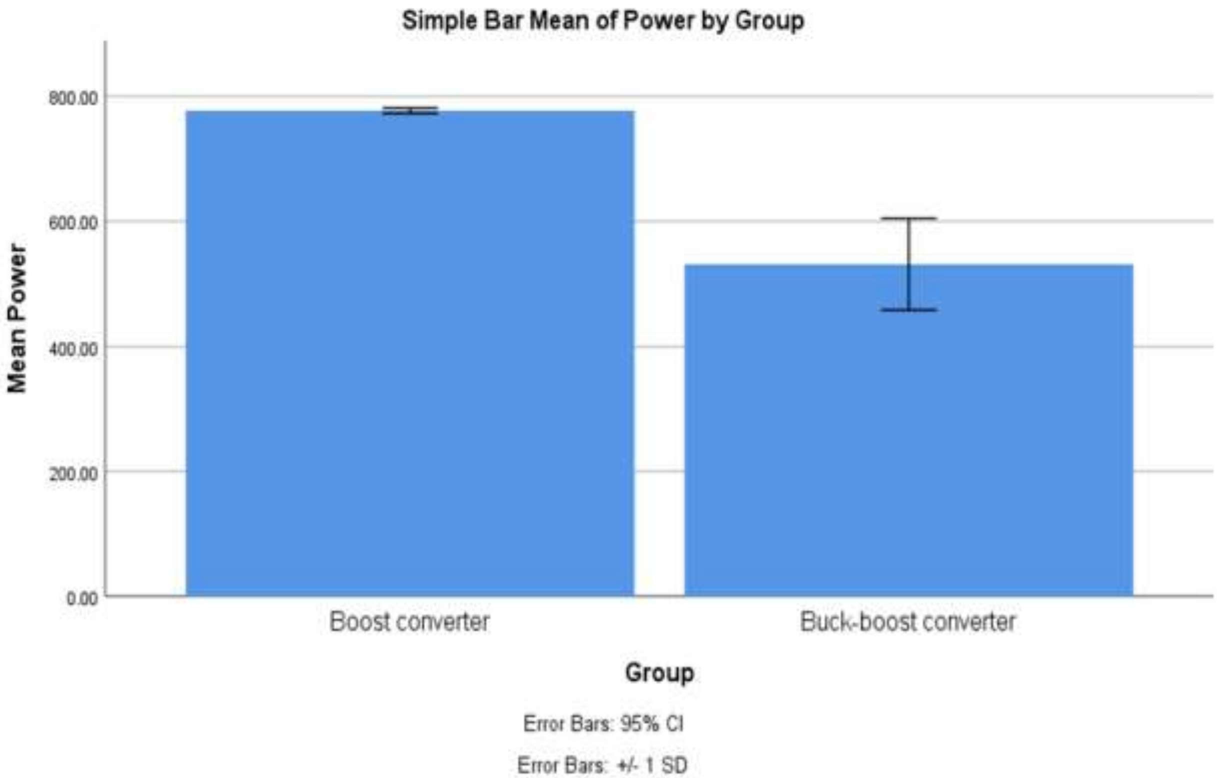

Fig. 5. The mean power of the boost converter and buck converter and the standard deviation of boost converter is slightly better than buck boost converter. X Axis : Boost converter vs buck-boost converter. Y Axis : Mean power of detection ±1SD