Performance Comparative study on DC-DC Boost Converters Non-Isolated Configurations

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***Abstract*—This paper presents a comparative study of DC-DC converters with boost methods of several types of circuits that use PSPICE programming. The whole series is compared by analyzing the maximum Reinforcement stress produced. Measurement of efficiency is now added to the test. The simulation results show that the BCI circuit is able to produce the highest voltage based on testing using 12V and 24V input voltage variations. The output voltage is capable of producing a BCI 106.440 V circuit for 12V input, while a 24V BCI input produces an output voltage of 212,808 V. The efficiency calculation is obtained for the BCI circuit with an input voltage variation of 82,215 % - 82,287 %. Test based on duty cycle, BCI output voltage 363,967 V with a work cycle of 0.9 %. For load variations, this circuit produces an output voltage of 107,459 V with a duty cycle of 0.5 % and a load of 1KΩ. This research is a promising solution in the future as an effort to overcome the electricity energy crisis.**

Keywords*—*Power Electronics, DC-DC Bost Converter, Non-Isolated, High gain voltage,

I. Introduction

The increasing need for electricity and the scarcity of fossil fuels is a serious problem in the future. The need for future solutions to overcome these problems various studies have been developed ranging from finding the latest energy sources that are environmentally friendly to finding new methods to increase voltage. The sun is one of the energy sources that can be converted using solar cells so that the solar radiation energy can be used as electrical energy. This energy source is one of the promising renewable energies in the future.

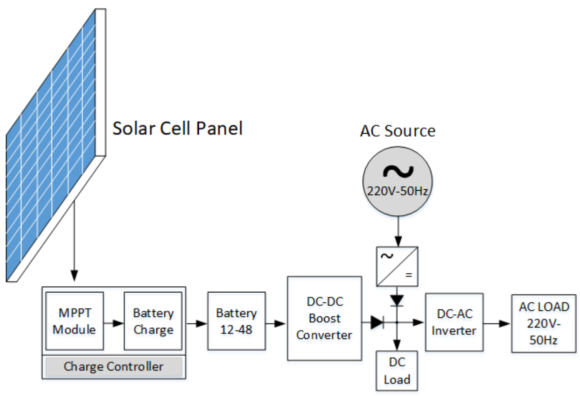


Fig. 1: Photovoltaic system powered by renewable energy.

Fig. 1 shows solar power generation systems that are widely used in home-scale generating systems. In a home switch generator system using DC-DC Boost Converter voltage stability is a very needed factor with a small level of voltage ripple so a control system is needed that is able to overcome these problems. Based on the proposed topology circuit, more in-depth testing is needed to produce a tested DC-DC Boost Converte. Testing is done with 4 stages using SPICE programming with predetermined parameters. In a study of Based on Coupled Inductor (BCI), step-up high-voltage DC-DC was proposed by a paired inductor configuration [1] with the ability of a voltage conversion ratio with recycling of energy leaks in the inductor and low component voltage with high efficiency. In a different study, the DC-DC multilevel boost converter (MBC) was controlled using PWM by providing a different and balanced output voltage capacitor to maximize work from one switch used [2]. The main advantages of this topology are: continuous input current, large boosting voltage and without transformer, which allows high switching frequencies. No less good research is Hybrid Boosting Converter (HBC) with the advantage of the regulatory capability of the impulse structure that is possessed and the strengthening of the voltage multiplier structure [3].

Combining bipolar voltage multipliers, featuring symmetrical configurations, single inductors and single switches, high gain capability with PWM width adjustment range, low component voltage, small output voltage ripple, and flexible extensions, which makes it suitable for front-end PV systems and some other renewable energy applications. In other studies also presented High Gain Boost Converter (HGBC) which can work in simple cycles using paired inductors and activated capacitors [4]. The voltage gain that is easily enlarged, the semiconductor switch voltage is reduced, and the soft switching that can be easily achieved is an advantage in this study. The research titled Voltage Lift Technique Boost Converter (VLTBC) is also proposed with the advantage of a driving voltage technique that can operate quite well presented with a voltage source that is connected directly to the inductor [5] .

In the last study also presented a conventional Quadratic converter compared to the new Quadratic converter using the addition of diodes (CLD) capacitors. The proposed Quadratic Boost Converter (QBC) CLD cell addition has better characteristics than the results of previous studies [6]. Finally this paper presents the results of a comparison of all types of circuits. Tests performed on several different topologies of

DC-DC Boost Converter circuits based on variations in input voltage, variations in duty cycle, and load variations.

II. System Design and Modeling

The entire circuit is modeled first with the addition of nodes at each connection point. giving nodes at the connection point aims to facilitate the writing of text-based circuits in SPICE programming [7].

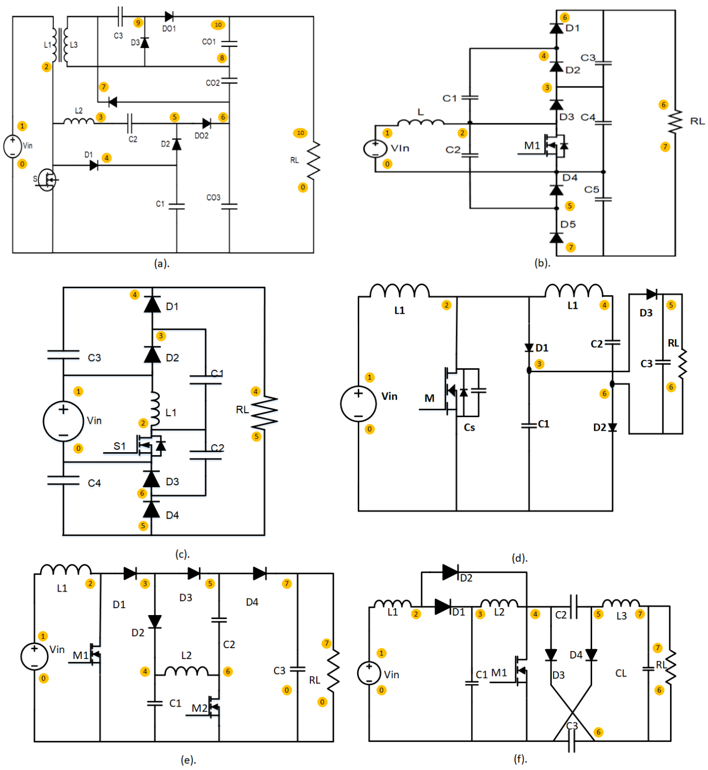


Fig. 2: Topology of the tested circuit (a) BCI [1]. (b) MBC [2]. (c) HBC [3]. (d) HGBC [4]. (e) VLTBC [5]. (f)QBC [6].

Fig. 2 shows that the six types of circuits to be tested have different complexity in each series. The number of constituent components that vary between inductors, mosfets, diodes, and different capacitors is a determinant in the voltage doubling system. MOSFET technology based on Silicon Carbide (SiC) has increased output power and operating level voltage, while Gallium Nitride (GaN) material has a switching speed better than conventional MOSFETs [8] , [9].

The use of diodes is also included as a power switch that serves to bias forward voltage also included in each circuit based on its working cycle. Each series of series is tested using the same parameters then the results are compared. Can be seen in Table I the same parameter settings are intended to be able to provide an exact comparison between input voltage and output voltage that are operated and produced from each circuit.

Fig. 3 is a pulse of testing conducted on six different types of circuits with testing techniques carried out based on the following stages.

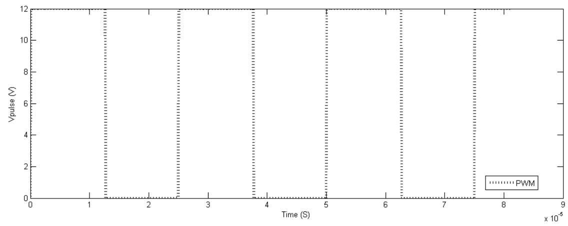


Fig. 3: Pulse Widh Modulation

1) *Testing based on input voltage variations*. In this test, it is conducted to determine the ability to voltage voltage based on different sources of voltage input. Reference voltage is chosen as the battery voltage in general, namely $12V$-$24V$ with a frequency made constant. R1KΩ load is used to find out the voltage generated. The output voltage, power and efficiency values are analyzed based on the graph of response to time.
2) *Testing based on Dutycycle variations*. In this test the value of dutycycle is made varying from 0.1 $\%$ to 0.9 $\%$. Battery source voltage is used $12V$ with a constant frequency of $80KHz$. The use of load R1KΩ to determine the change in output voltage generated based on the variation of dutycycle given. The value of the output voltage, power, and work efficiency of the circuit are analyzed based on the graph of response to time.
3) *Testing based on load variations* This test is carried out using varying load values to determine the ability to host stresses with different load levels. Load is used 100-1KΩ with $12V$ source voltage, dutycycle is used is a constant value. Output voltage, Power, and efficiency are analyzed based on the graph of response to time

III. Simulation Results

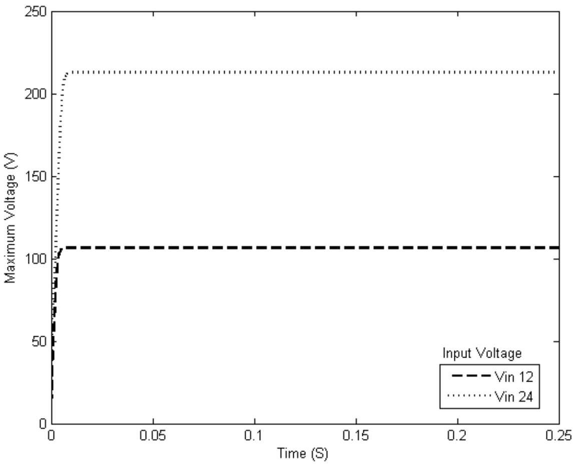
A. Test Results based on input voltage variations

This section presents the simulation results based on different input voltages. In the test, the results obtained are arranged in Table. I as follows.

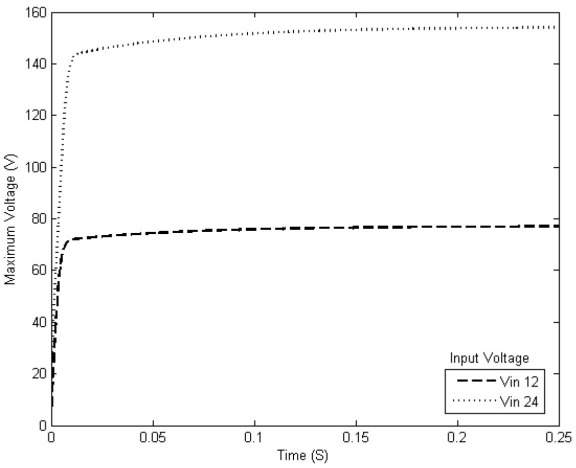
TABLE I: Simulation results with input voltage variations

Circuit	Voltage (V)				Efficiency (%)		Time (s)
	Input		Output				
BCI	12	24	106.440	212.808	82.215	82.287	250m
MBC	12	24	77.003	154.021	58.970	60.305	250m
HBC	12	24	80.064	160.186	92.798	92.761	250m
HGBC	12	24	77.479	155.038	73.293	75.444	250m
VLTBC	12	24	95.165	124.417	54.617	35.064	250m
QBC	12	24	128.342	136.530	42.201	22.506	250m

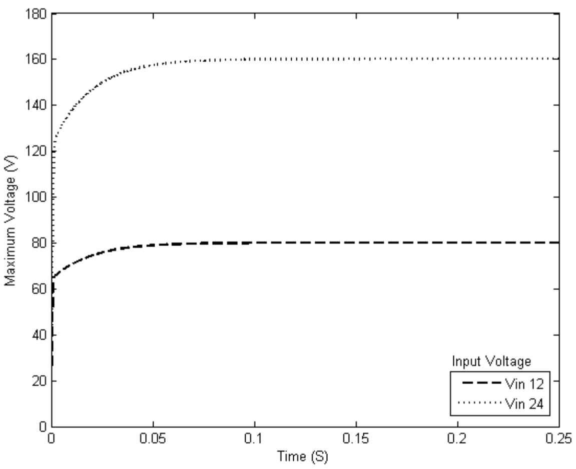
Fig. 4 is a graph of simulation results using different input voltage responses for the following types of circuits: a.BCI b.MBC c.HBC and Fig. 5 is a graph of the simulation results for the following types of circuits: a.HGBC b.VLTBC c. QBC



(a) BCI

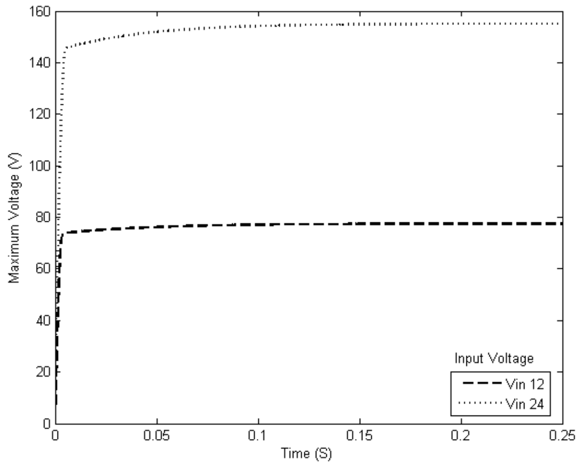


(b) MBC

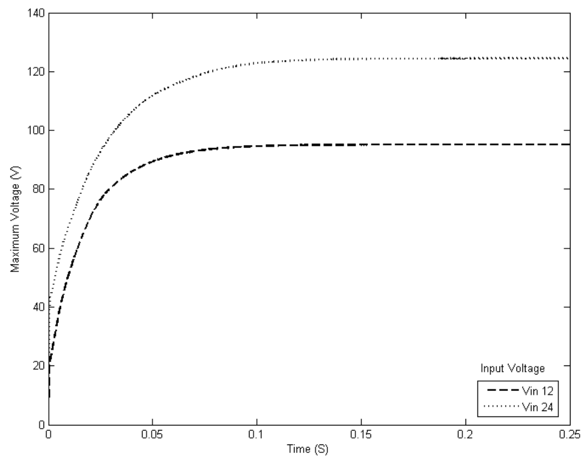


(c) HBC

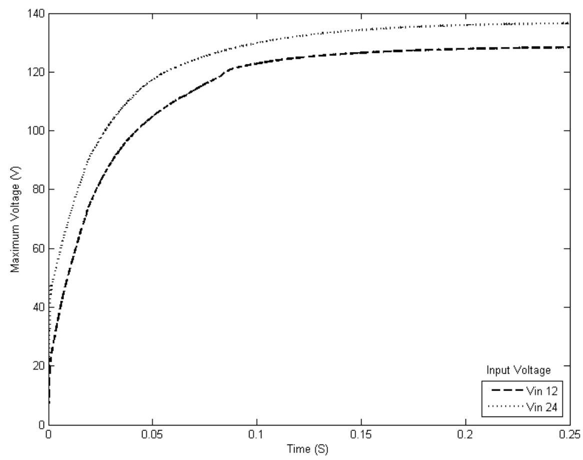
Fig. 4: Output voltage with various inputs Topology 1-3.



(a) HGBC



(b) VLTBC



(c) QBC

Fig. 5: Output voltage with various inputs topology 4-6.

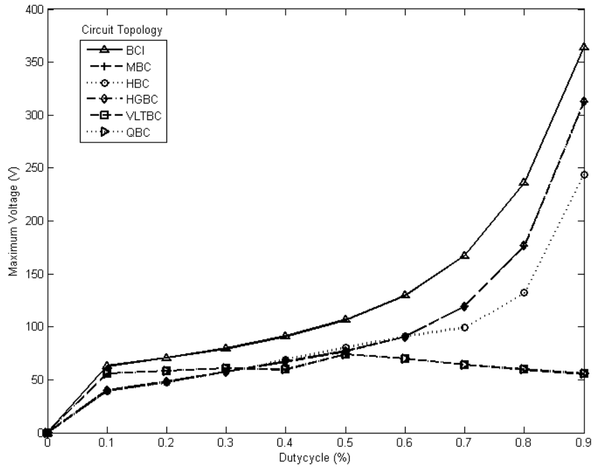
B. Test Results based on Duty cycle variations

Tests are carried out with a transient time of $250ms$. The short transient time specified causes some measurements not to be in a stady state($*nss$). Based on the simulations carried out, the compiled results obtained in Table. II as follows. The six types of circuits are capable of producing varied output voltages, the highest voltage capable of being produced from a series of BCI types with dutycycle 0.9 % capable of producing an output voltage of 363,967 V with the resulting efficiency of 55,853 %. The highest efficiency can be produced by a series of HBC types with efficiency of 92,819 % with a cycle of 0.5 %. The response charts of the six types of series are presented in the following discussion.

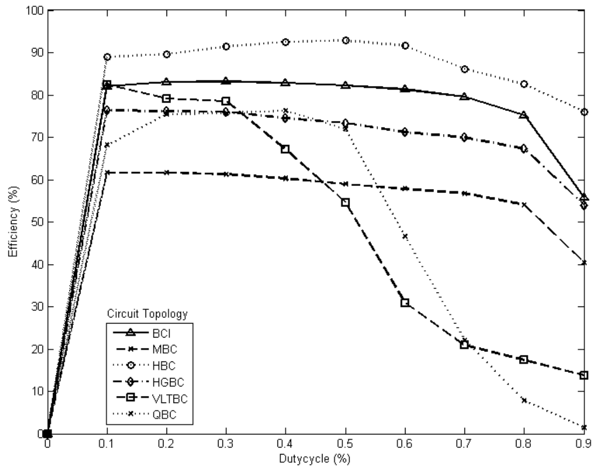
TABLE II: Simulation results with Duty cycle response.

Circuit	Voltage (V)		Efficiency (%)	DutyCycle (%)
	Input	Output		
		62.818	82.019	0.1
		70.698	82.990	0.2
		79.545	83.093	0.3
		90.985	82.862	0.4
BCI	12	106.439	82.228	0.5
		129.567	81.297	0.6
		166.981	79.526	0.7
		236.061	75.241	0.8
		363.967	55.853	0.9
		39.829	61.552	0.1
		47.861	61.562	0.2
		57.352	61.268	0.3
		67.044	60.267	0.4
MBC	12	77.003	58.969	0.5
		90.370	57.813	0.6
		119.383	56.716	0.7
		176.430	54.067	0.8
		312.189	40.304	0.9
		39.484	88.876	0.1
		47.211	89.650	0.2
		57.747	91.384	0.3
		68.908	92.573	0.4
HBC	12	80.063	92.819	0.5
		90.766	91.591	0.6
		99.043	86.145	0.7
		132.015	82.507	0.8
		243.422	76.015	0.9
		39.848	76.357	0.1
		47.897	76.108	0.2
		57.440	76.009	0.3
		67.155	74.509	0.4
HGBC	12	77.478	73.301	0.5
		90.360	71.194	0.6
		119.510	69.972	0.7
		176.666	67.287	0.8
		312.933	53.938	0.9
		39.144	82.412	0.1
		53.696	79.075	0.2
		73.182	78.524	0.3
		79.270	67.072	0.4
VLTBC	12	95.162	54.546	0.5
		83.416	30.863$*nss$	0.6
		76.412	20.848$*nss$	0.7
		74.749	17.370$*nss$	0.8
		72.958	13.802$*nss$	0.9
		26.262	68.125	0.1
		50.074	75.453	0.2
		76.496	75.689	0.3
		115.806	76.224	0.4
QBC	12	185.829	71.879	0.5
		180.202	46.630	0.6
		150.189	22.016$*nss$	0.7
		95.285	7.8148$*nss$	0.8
		42.208	1.4671$*nss$	0.9

Fig. 6 is an output voltage graph based on dutycycle which is given with efficiency, which can be produced based on the cycle given.



(a) Maximum Output Voltage-Dutycycle



(b) Effisiensi-Dutty cycle

Fig. 6: Maximum Output Voltage and Efficiency.

C. Simulation results based on variations in expenses

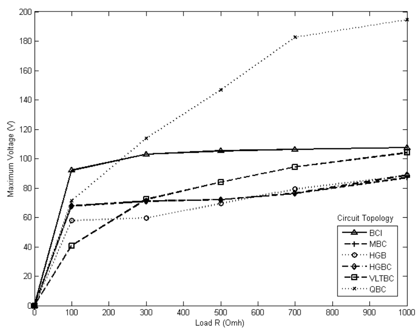
In this section presents the results of analysis of circuit response based on load. All circuits are modeled and tested using loads that vary from 100-1KΩ. Dutycycle is set to fixed mode with a fixed frequency. Flow and power measurements are also included in experimental analysis to complete the data in the measurement results table.

Table. III can be seen the maximum output voltage along with the efficiency of the six types of circuits based on load variations. The highest output voltage can be produced by a BCI type circuit with an output voltage of 107,459 V with a input voltage of $12V$. The highest efficiency was obtained from the HBC series of 93,508 % with a voltage output that was able to produce 57,734 V.

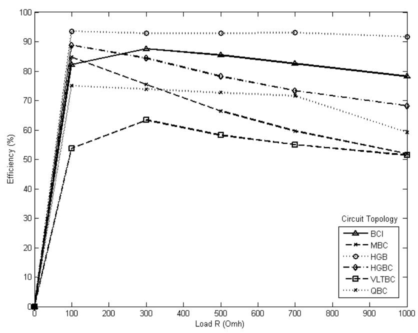
Fig. 7 is a response graph of the output voltage and efficiency of the six types of circuits tested.

TABLE III: Simulation results with Load Response.

Circuit	Voltage (V)		Efficiency (%)	Load R (Ω))
	Input	Output		
BCI	12	92.087	82.184	100
		103.054	87.605	300
		105.360	85.456	500
		106.363	82.550	700
		107.459	78.146	1000
MBC	12	67.784	84.720	100
		70.994	75.497	300
		71.970	66.426	500
		76.212	59.611	700
		87.076	51.942	1000
HBC	12	57.734	93.508	100
		59.705	92.793	300
		69.288	92.829	500
		79.193	93.024	700
		88.578	91.669	1000
HGBC	12	68.022	88.764	100
		71.123	84.383	300
		72.015	78.183	500
		76.320	73.320	700
		88.763	68.224	1000
VLTBC	12	40.708	53.734	100
		72.242	63.357	300
		84.089	58.244	500
		94.288	55.043	700
		103.998	51.366	1000
QBC	12	71.103	75.012	100
		113.661	73.864	300
		146.604	72.677	500
		182.570	71.614	700
		194.541	59.185	1000



(a) Maximum Voltage-Load (R)



(b) Efficiency-Load (R)

Fig. 7: Maximum Boosting voltage and Efficiency.

IV. Conclusions

Finally, this paper has presented the simulation results several types of circuits with CCM (Continuous Conduction Mode) testing methods for MOSFET signal switching. The experimental results were made in several response stages including responses with different variations of input voltage, responses with different duty cycles, responses to 100-1K resistive load responses. The choice of input voltage variations will affect the voltage increase so that the desired output voltage variation can be achieved. While the selection of sequential duty cycle cycles is intended to get the working circuit stability when given the minimum and maximum switcing. The selection of simulation parameters is carried out using the train error method, based on the results of the maximum stress gain and efficiency obtained. The simulation results show that the BCI circuit is able to produce the highest voltage based on testing using $12V$ and $24V$ input voltage variations. The output voltage is able to produce a BCI 106.440 V circuit for $12V$ input, while a $24V$ BCI input produces an output voltage of 212,808 V. Calculation of efficiency is obtained for BCI circuits with input voltage variations 82,215 % - 82,287 %. Test based on duty cycle, BCI output voltage 363,967 V with a work cycle of 0.9 %. For load variations, this circuit produces an output voltage of 107,459 V with 0.5 % duty clycle and 1K Ω load. So the part you want to achieve now can finally be fulfilled by recommending a series of topologies which is considered a reliable circuit topology that can be tested and can be applied in solar power generation systems in the future.

Acknowledgement

The authors gratefully acknowledge the Ministry of Research, Technology and Higher Education of the Republic of Indonesia (by *Direktorat Riset & Pengabdian Masyarakat–DRPM*) for funding our research under the scheme of "Post-Graduated Colleagium Research Grant" (*Hibah Penelitian Tim Pasca Sarjana*) in the year 2018 and 2019.

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