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A New Dual Output Buck Boost Converter with Low Stress on Components

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ABSTRACT

Modern world is seeking for reduced size, reliable and less price instrumentality Single Input Multiple Output Converters (SIMO) and also the analysis on them are worthy. This is often as a result of there could also be auxiliary circuits additionally with the most power circuit. These auxiliary circuits and ICs work with reduced voltage level. The wide application of SIMO converters embrace telecommunications, industries, light- emitting diode drivers, hybrid electrical vehicles, dc based mostly Nano grids etc. The SIMO converters existing in the market faces some challenges thanks to its circuit and value. So analysis work is progressive underneath this by the engineers. As is acknowledge, topology is that the key issue for the change mode power offer that determines the performance of the system and the choice of parts. a completely unique twin output buck-boost converter with only one dominant switch. The potency of the new buck-boost converter is highest among those converters having a similar range of parts. These benefits make component choice for the converter abundant easier, and it can be used directly in applications needing a negative voltage source. The performance study of the converter is meted out with MATLAB/SIMULINK R2014a. The switching pulses for the control circuit are generated using ds PIC 30F2010 microcontroller**.**

Keywords - Buck Boost Topology, single switch,SIMO

1. INTRODUCTION

DC -DC converters with voltage bucking/boosting area unit needed in several applications, such as electric cell systems, storage batteries, semiconductor diode (LED) product, car electronic devices, and moveable devices [1-3], and might regulate output voltage over a good input voltage vary. As is documented, topology is that the key issue for the switch mode power supply that determines the performance of the system and the selection of parts. Consequently, a lot of analysis has focused on this issue, and plenty of buck-boost topologies have been projected within the past few decades. The only buck-boost converter is that the ancient buck-boost converter. The Cuk converter, the letter converter, and also the Sepic converter area unit the other three basic buck-boost converters. among these three converters, the Cuk converter is special for its continuous input current, continuous output current , and negative output voltage, the latter of that is indispensable and might be used directly for audio amplifiers, signal generators, and knowledge transmission interfaces in applications needing a negative voltage supply [4], whereas the negative output voltage usually desires associate degree extra electrical converter within the feedback circuit change condition of all devices.

Furthermore, demands for low step-down gain for high output current rating applications, such as voltage regulator modules (VRMs) of central processing unit (CPU) boards and battery chargers have increased sharply [16]. To obtain low step-down gain,the duty cycle of the usual buck-boost converters should be very small, which is not recommended for application of pulse width modulation (PWM) controllers. Although a high-frequency transformer can be employed in isolated converters to widen the voltage conversion ratio, the leakage inductor would cause a voltage spike across the power switches or diodes reduce efficiency associated with large switching losses, and lead to serious EMI problems [3,4]. Therefore, it's vital and valuable to explore new buck- boost converters with low diminution gain while not a high- frequency electrical device to beat the shortcomings mentioned higher than on account of skyrocketing industrial needs and economic benefits.

2. TOPOLGY OF COVERTER

A. Buck Boost Converter

Present day power electronic systems need multiple dc outputs at completely different voltage levels. This can be as a result of auxiliary circuits are typically gift additionally to the most power stage, and that they ought to be battery-powered at low voltages. The negative output converter is modification of the buck boost converter and provides output voltage with wide convert ion ratio. Its main power stage contains one power switch (S),three power diodes (D_1,D_2 andD_3), two inductors

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($L_1$and L_2), two capacitors ($C_1$and C_2), and one resistive load R. Power switch S is the only part that needs to be controlled. Here, the current through C_1, C_2, L_1, L_2, D_1,D_2, $D_3$are defined as i_{L1}, i_{L2}, i_{C1}, i_{C2}, i_s, i_{D1}, i_{D2}, and i_{D3},respectively. The voltages across L_1, L_2, C_1, C_2, D_1,D_2 and $D_3$are defined as v_{L1}, v_{L2}, v_{C1}, v_{C2}, v_{D1}, v_{D2}, v_{D3}respectively. The output is connected to the Figure 1 shows a circuit of typical arrangement buck boostconverter.

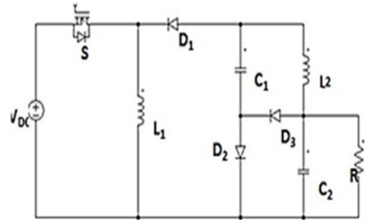

Figure 1. Buck Boost Converter

B. A Dual Output Buck Boost Converter

Modern world is seeking for reduced size; reliable and less cost equipment Single Input Multiple Output Converters (SIMO) and the research on them are worthy. It is very important and valuable to explore new buck-boost converters with low step-down gain without a high-frequency transformer to overcome the shortcomings mentioned above on account of increasing industrial requirements and economic bene- fits.Its main power stage contains one power switch (S), three power diodes (D_1 two inductors (L_1 and L_2), two capacitors (C_1, C_2andC_3), and one resistive load R.

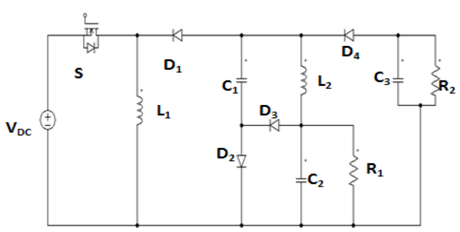

Figure 2. Novel buck boost Converter

Power switch S is the only part that needs to be controlled. The voltages across L_1,L_1,C_1,C_2,D_1, are defined as v_{L1}, v_{L2},v_{C1},v_{C2},v_{D1}, respectively. Figure.2 shows a circuit of typical arrangement novel buck boost converter.

C. Modes of Operation

• Mode 1 in this mode, switch S are turned on. The diodes D_2 are turned on at the same time.

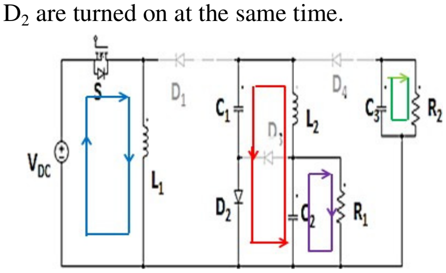

Figure 3. Operating Circuit of Mode 1

D_1, D_3 and D_4 are reverse biased, v_{in} charges L_1 through S, inductor L_2 is demagnetized, and both charge pump capacitor C_1 and output capacitors C_2 and C_3 are discharged. Figure.3 shows the equivalent circuit diagram of mode1.

•Mode 2 Switch S is turned off, diodes D_1,D_3 and D_4 are forward biased, and D_2 is reverse biased. It can be seen that the energy stored in inductor L_1

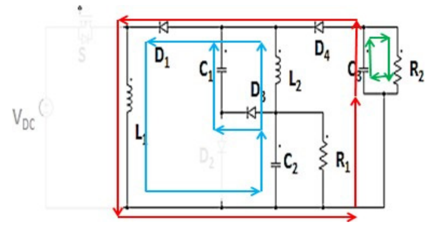

Figure. 4. Operating Circuit of Mode 2

isreleased to C_1, C_2, and L_2 via diodes D_1 and D_3. At the same time, inductor L2 is magnetized. Figure.4 shows the equivalent circuit diagram of the converter and current paths for this mode is also shown. Figure.5 shows the typical time domain waveforms of this proposed buck-boost converter. Operating in CCM; one can see that there are two typical modes when it operates in CCM.

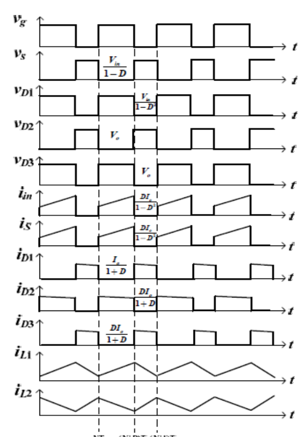

Figure 5.Theoretical wave form

3. DESIGN OF COMPONENTS

The buck boost converter is designed at input voltage(V_{in}) 24. The converter operates at 50 kHz and an output power of 9.6 W(step down)and 28.8 W (step up). The duty ratio D[1] is calculated as follows;

$$\frac{V_O}{V_{in}} = \frac{D^2}{1-D^2} \quad (1)$$

In practical applications, the ripple of the inductor is another important requirement for the whole system.

$$L_1 > \frac{(1-D^2)^2 * R}{0.4f} \quad (2)$$

The value of inductor is selected as larger value of both calculated L_1

$$L_2 > \frac{D(1-D^2)*R}{0.4f} \quad (3)$$

The value of inductor is selected as larger value of both calculated L_2. The capacitor C_1 and C_2 is designed according to the peak-to-peak voltage ripple.

$$C_1 > \frac{1}{0.1(1+D)*R*f} \quad (4)$$

$$C_2 > \frac{D^2}{0.002(1+D)*R*f} \quad (5)$$

According to proper design equations the inductors and capacitors designed. By using approximated value of components simulation carried out in MATLAB/SIMULINK R2014a. Prototype designed in same voltage. Same output capacitor and load are used in second out.

4. SIMULATION RESULTS AND ANALYSIS OF CONVERTER

MATLAB is a high-performance language which integrates computation, visualization, and programming in an easy to use environment. SIMULINK is a software package for modeling, simulating, and analyzing dynamical systems. The Simulink model is shown in Figure 6.

TABLE I
SIMULATION PARAMETERS

Parameters	Specification
Input voltage V_{in}	24V
Switching frequency f_s	50kHz
Output voltage	-36V& -12V
Inductor L_1 ,L_2	546μH,976μH
Capacitors C_1, C_2	10μF,90μF
Resistance	15 Ω & 45Ω

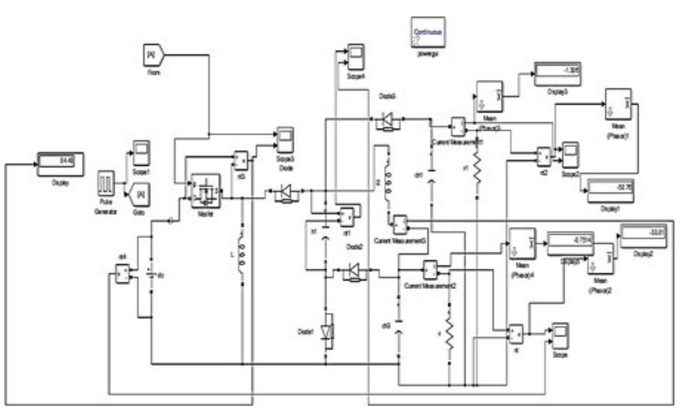

Figure 6. Simulink Model of Buck Boost converter

A. Simulation Results of the Converter in Buck Mode

The simulation results of the buck boost converter in Buck mode are shown in the following figures. It can be seen that the input voltage Vdc is 24 V and the output voltage Vo -10 V and -15.34 V. This verifies the voltage gain. The switching frequency is chosen to be 50 kHz and the

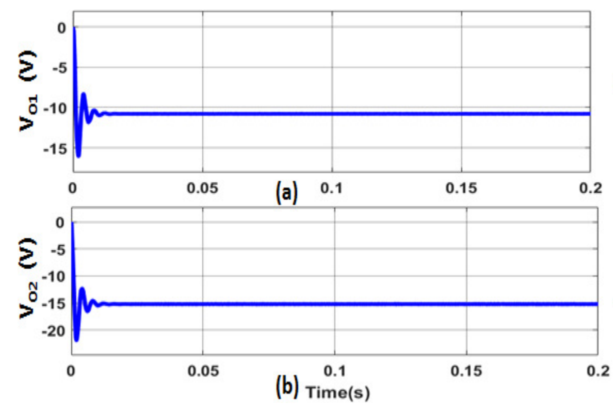

Figure 7. Output voltages

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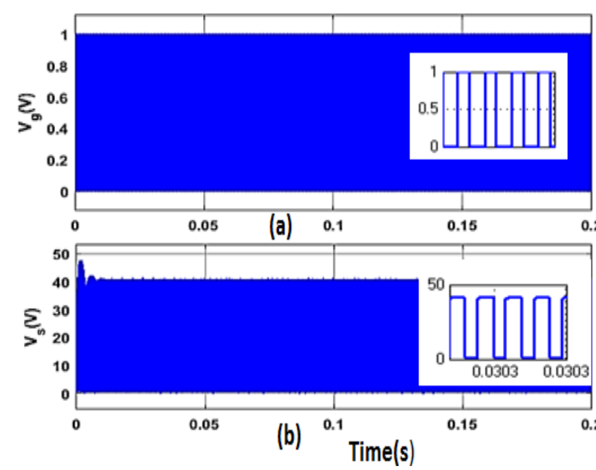

Figure 8.(a) Gate pulse to switch and (b) Voltage stress across switch

Figure shows gate pulse switch and voltage across switch S. Figure 9 shows capacitor voltages. Voltage across switch is 40 Vwhen the main switch is ON, inductor L_1 is charging. Whereas, when the main switch is OFF, the inductor L_1 discharges. Whereas, When the main switch SOFF, the inductor L1 discharges.

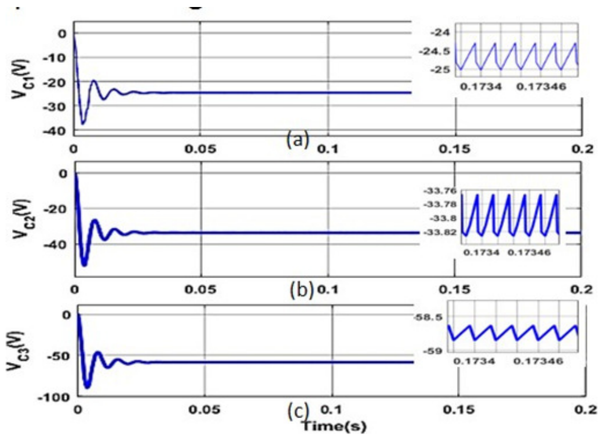

Figure 9. (a) Capacitor voltage V_{C1},(b) Capacitor voltage V_{C2} ,(c) Capacitor voltage V_{C3}

The current ripples of the inductorsL_1 and $L_2$are shown in figure. The voltage across the capacitors C_1, C_2 and $C_3$and their zoomed versions are shown in the Figure.9. When the main switch is ON, capacitor $C_1$is charging. Whereas, when the main switch is OFF, the inductor C_1discharges.

B. Simulation Results of the Converter in Boost Mode

The simulation results of the dual out DC-DC converter in Boost mode are shown in the following figures. It can be seen that the input voltage V_{dc} is 24 V and the output voltage Vo -59.6 V and -33.4 V. This verifies the voltage gain. Figure.10 shows gate pulse switch and voltage across switch S.

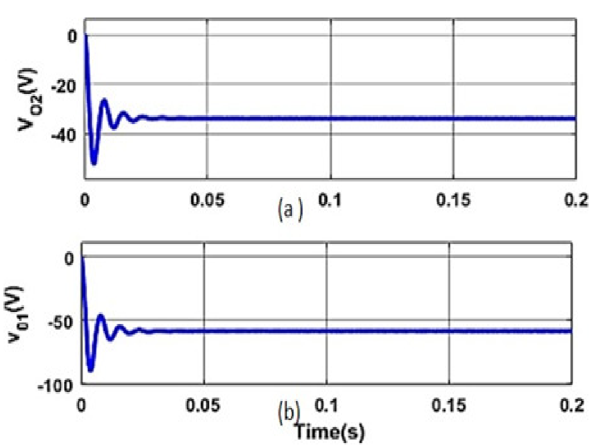

Figure .10Output Voltages

The switching frequency is chosen to be 50 kHz and the duty ratio of S is equal to 0.7208.

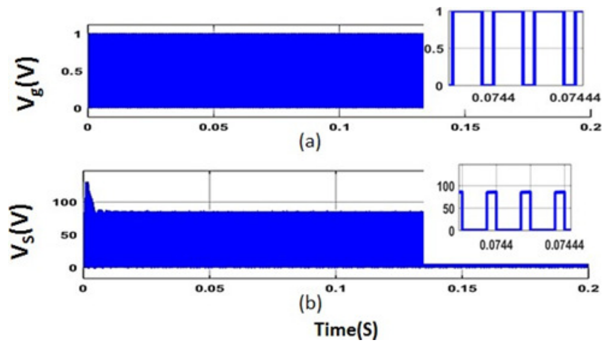

Figure 11. (a) Gate pulse to switch and (b) Voltage stress to Switch

Voltage across capacitors C_1, C_2 and $C_3$and their zoomed versions are shown in the Fig.14. When the main switch is ON, capacitor C_1 is charging. Whereas, when the main switch is OFF, the inductor C_1 discharges. The voltage ripples of the capacitors C_1 C_2 and C_3 are shown in figure.

The dual output buck boost converter has been simulated. The converter has been operated in buck and boost mode by varying duty ratio

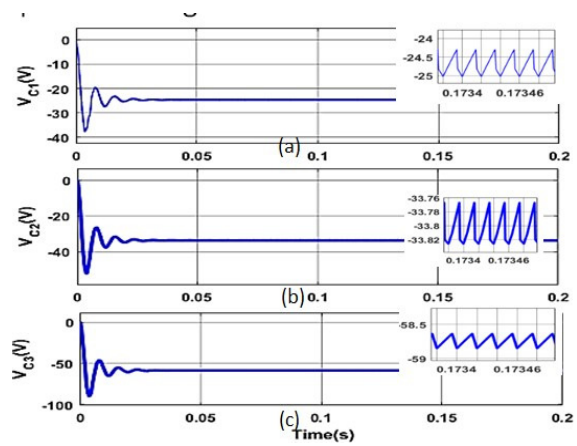

Figure12.(a))Capacitor voltage V_{C1},(b) Capacitor voltage V_{C2} ,(c) Capacitor voltage V_{C3}

C.Efficiency Vs. OutputPower

Efficiency of power equipment is defined at any load as the ratio of the power output to the power input. The efficiency is the fraction of the input power delivered to the load. A typical curves for the variation of efficiency as a function of output power is shown in Figure. 13 and 16. The converter efficiency is around 90% for 28.8W output power for R load in boostmode. The converter efficiency is around 85% for 9.6W output power for buck mode. The efficiency is around 89% for 28.8W output power for RL load. The converter efficiency is around 82% for 9.6W output power for RL load

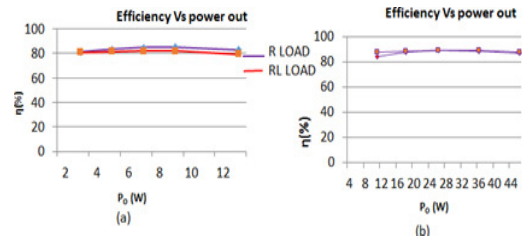

Figure.13 Efficiency Vs Power out (a) step up,(b)step down

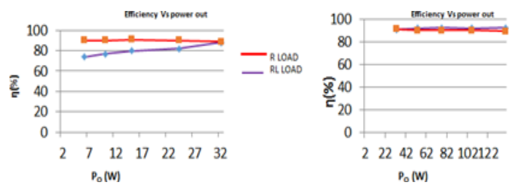

Figure.14 Efficiency Vs. Power out (a) step up, (b) step down

D. Stress Vs. DutyCycle

The plot of voltage stress of diode as a function of duty cycle is shown in Figure 15 (a.) The plot of voltage stress of switch as a function of duty cycle is shown in Figure. 15(b) For a duty cycle of 0.72 the voltage stress is 84 V. The voltage stress increase with increasing duty cycle. The plot of current stress of inductor as a function of duty cycle is shown in Figure 16(a).

The current stress of inductor L_1 is increase with increasing duty ratio. But the current stress of inductor L_2 is decrease with increasing duty ratio. The voltage stress increase with increasing duty cycle. The plot of voltage stress of capacitor as a function of duty cycle is shown in Figure 16(b).

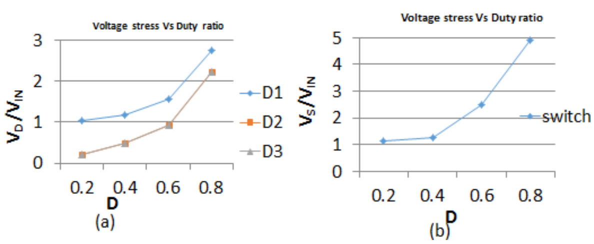

Figure.16. (a) Voltage Stress of diodes Vs. Duty cycle

(b) . Voltage Stress of switch Vs. Duty cycle

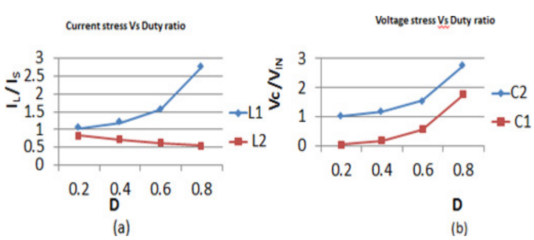

Figure.17. (a) Current Stress vs. Duty cycle

(b) Voltage Stress Vs. Duty cycle

E.Gain vs. Duty Ratiocurve

The plot of voltage gain as a function of duty ratio is shown in Figure 18. According to this figure, the voltage gain is 2.4 when the duty cycle is equal to 72% in Buck mode and if duty ratio is smaller than 42% the gain reduces. Also, if the voltage gain is 1.4 when the duty cycle is equal to 72%.

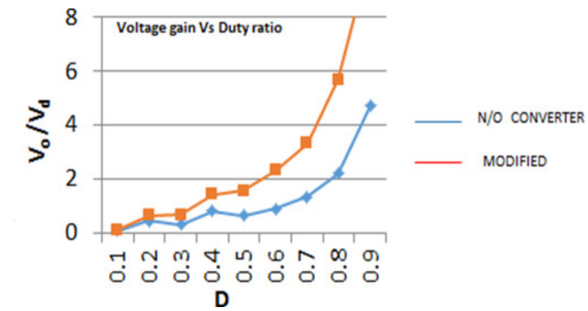

Figure.18. Gain Vs Duty ratio

F. Comparison

The comparison between conventional and novel buck boost converter is given in table 1. Compared to the conventional converter, the modified converter uses less diode. The modifiedconverter has a higher efficiency than the conventional with the increasing output power.

TABLE 2 COMPARISON OF CONVENTIONAL AND MODIFIED CONVERTER

	`Conventional Buck Boost Converter	BUCK BOOST [3]	N/O CONVERTER [4]	MODIFIED CONVERTER
Switches	1	2	1	1
Diode	1	2	3	4
capacitor	1	2	2	3
Inductor	1	2	2	2
Efficiency	83%(step up) 70%(step down)	85%(step up) 73%(step down)	89.2%(step up) 85%(step down)	90%(step up) 86%(step down
Voltage stress on switches	90.96V(Step down) 70.95(step up)	90 V(step up) 69V(step down)	86V(step up) 40V(step down	84V(step up) 40V(step down

Single out buck boost converter and dual out buck boost converter are stimulated according to designed parameters. One of the output is similar to previous converter but the second out in both modes is different. Based on comparisons among the same kind and same number of components, the proposed converters current and voltage stresses on the power switch are less than or equal to those ofcomparative converters, and the current stress on inductor L_2, the voltage stress on the charge pump capacitor.

5. CONCLUSION

A dual output voltage DC-DC converter topology is presented in this project. A novel buck-boost converter with only one controlling switch. The current and voltage stress analysis of the switching device available in the converter is carried out to ensure the proper selection of the switching devices. The measured efficiency of the converter in both Buck and Boost modes is 86% and 90% with R load respectively. The efficiency of the proposed buck-boost converter is highestamong those converters having the same number of elements. These advantages make component selection for the proposed converter much easier, and it can be used directly in applications needing a negative voltage source.

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