Improved Configuration for Dc to Dc Buck and Boost Converters

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***Abstract*— Boost dc to dc converter is used to change the input voltage level to a desired output voltage level more than the input voltage magnitude and buck dc to dc converter is used to change the input voltage level to a desired output voltage level less than the input voltage magnitude. This paper proposed a novel method for increasing output power by utilizing two storage elements (inductor and capacitor) for boost converter. By analyzing and simulating with Matlab software, the results are provided. Then it is compared with conventional buck and boost inverter. In this improved converter, two inductors used for feeding the load by two switches of insulated gate bipolar transistor (IGBT) type. One inductor is charged by the source voltage while another inductor was discharging its energy into the load during the same time. With this novel structure, output power generation was almost double and the output voltage reduced to half.**

***Index Terms*— Boost dc-dc converter, buck dc-dc converter, ripple voltage.**

I. Introduction

USING of renewable energy in the upcoming future seems unavoidable ,so output of this sources should be utilized via following the maximum point of the power in sporadic products of production system. Output of these sources should be compatible with consumer and grid condition (Erickson, 1997). So, output energy should be in favorable form by using suitable interface circuits. Energy management of these sources will possible if there is comprehensive control (Camara and et al, 2010). In several power conversion applications, it is required to convert a constant dc voltage source to a variable output dc voltage. This is performed by dc-dc converters. These converters are used in several applications such as renewable energy systems, distributed generation systems, and power factor correction process. In past decade, several studies have been done about reducing the output voltage ripple of dc-dc converters. A good design requires special attentions to many circuit parameters such as ripple voltage, power losses, and etc. In this path these parameters usually act in such a way that improving one parameter might have a big effect on another parameter. In buck and boost converters with one switch, voltage ripple reduction is accomplished by selecting a bigger capacitor at the output but in low transient time, but cost will increase. In order to decrease power losses in the power switches, one can decrease the switching frequency but this process will increase ripple voltage and will have an adverse effect on the output voltage waveform. The changing structure of the converter using new topology can improve the operation of the converter. In this configuration utilizing two storage devices will have lowest damaging effects on circuit parameters. This novel converter has two inductors and two switches which can improve several factors over conventional converter by considering a delay time between these two switches. These factors are namely; output voltage ripple, transient time, and maximum of transferable power (Jahanmahin et al, 2012). Buck dc to dc converter is used to change the input voltage level to a desired output voltage level less than the input voltage magnitude and boost dc to dc converter is used to change the input voltage level to a desired output voltage level more than the input voltage magnitude. This paper proposed a novel method for increasing output power by utilizing two storage elements (inductor and capacitor) for buck and boost converter. By analyzing and simulating with Matlab software, the results are provided. Then it is compared with conventional buck and boost converter. In this improved converters, two inductors used for feeding the load by two switches of insulated gate bipolar transistor (IGBT) type. One inductor is charged by the source voltage while another inductor was discharging its energy into the load during the same time. With this novel structure, output power generation was almost double and the output voltage reduced to half.

II. Simulation and Improved Buck and Boost Converters Fundamental Operation

Figure (1) and (2) shows novel buck and boost converters which are simulated by utilizing Matlab software. In this simulations switches contains switching frequency of 40 kHz and duty cycle of 25 percent.

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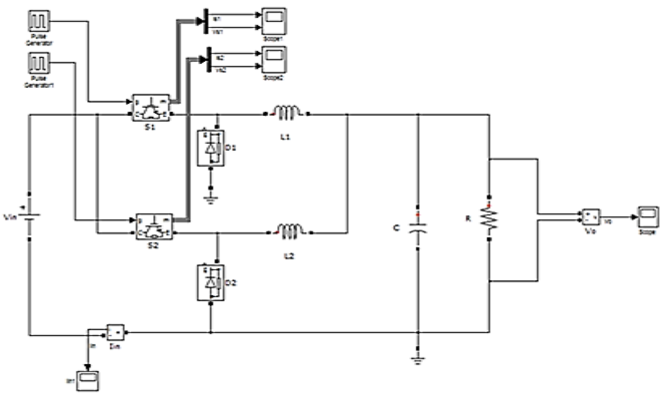
Fig. 1. Improved buck converter.

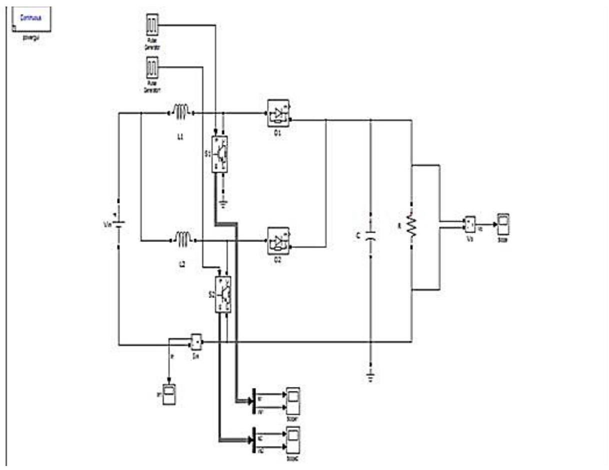
Fig. 2. Improved boost converter.

The only difference between these switches is delay time, it means that delay time of one switch is zero and delay time of second switch is half of the switching period ($^{T}/_{2}$). Figures (3-6) show switches voltage and current in improved buck and boost converters.

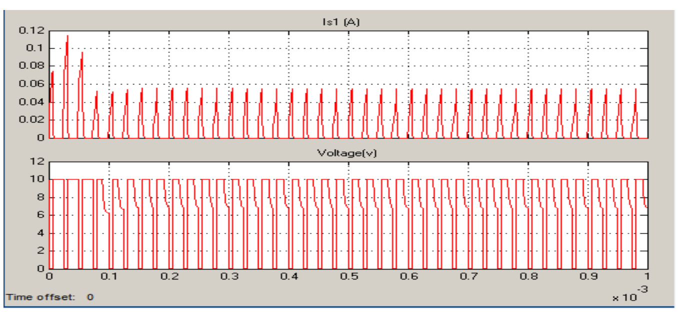

Fig. 3. One switch voltage and current buck converter.

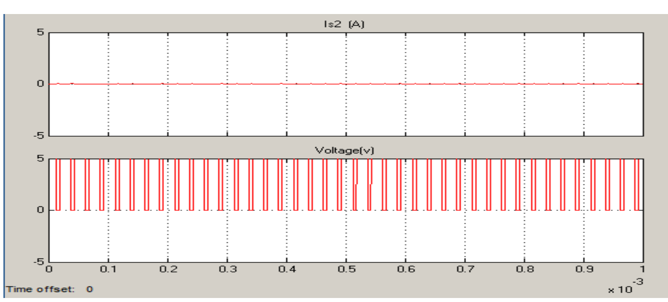

Fig. 4. Two switch voltage and current buck converter.

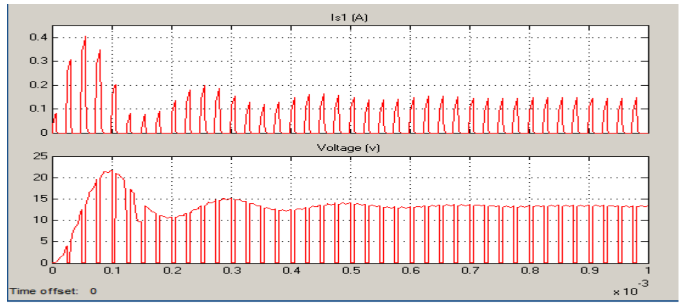

Fig. 5. One switch voltage and current boost converter.

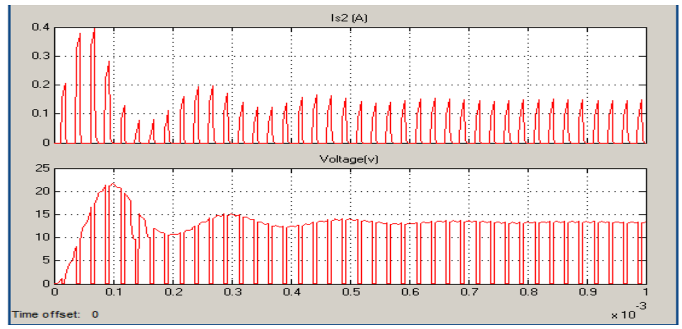

Fig. 6. Two switch voltage and current boost converter.

III. Simulations Results and Advantages

Figures (7) and (8) respectively show conventional Buck and converters simulated circuits.

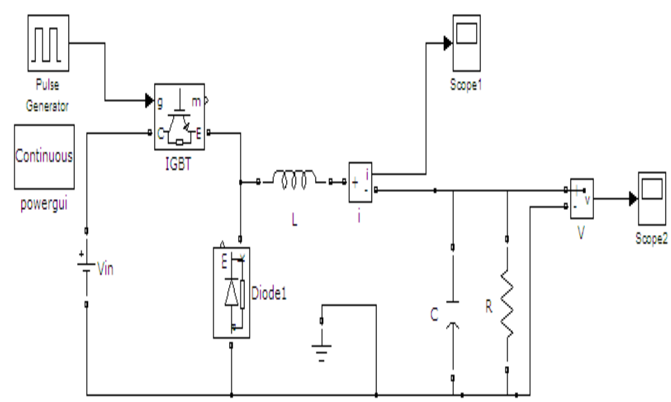

Fig. 7. Conventional buck converter.

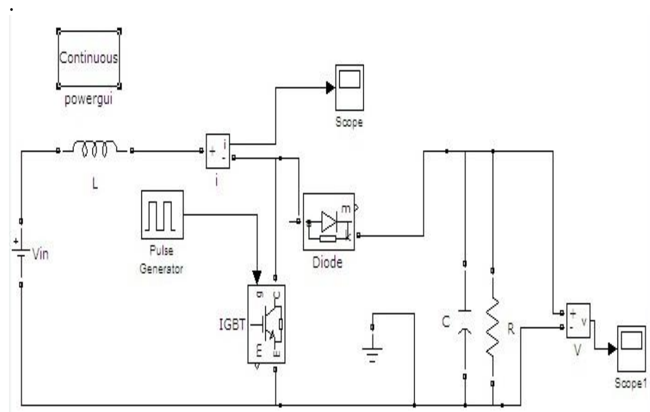

Fig. 8. Conventional boost converter.

Figures (9-12) respectively show conventional and improved buck converter simulation output. The outputs are compared with each other and then novel converter advantages will be discussed.

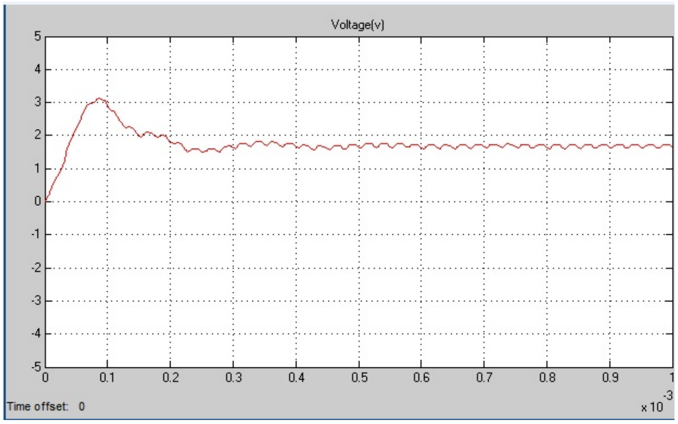

Fig. 9. Conventional buck converter.

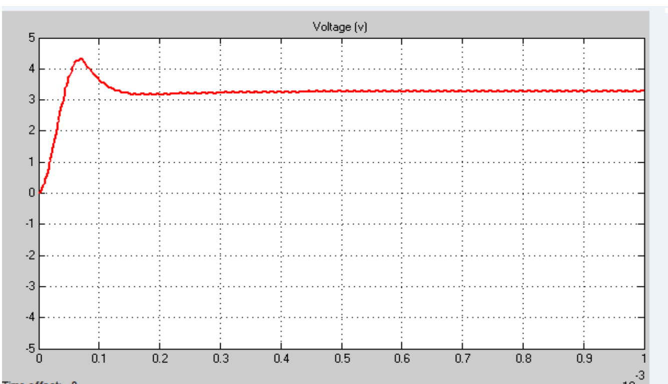

Fig. 10. Improved buck converter.

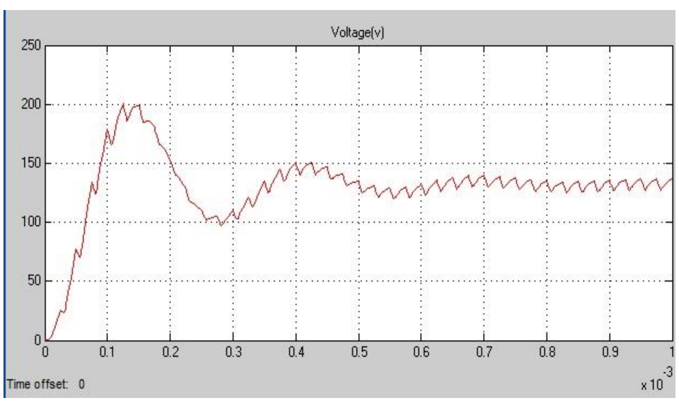

Fig. 11. Conventional Boost converter.

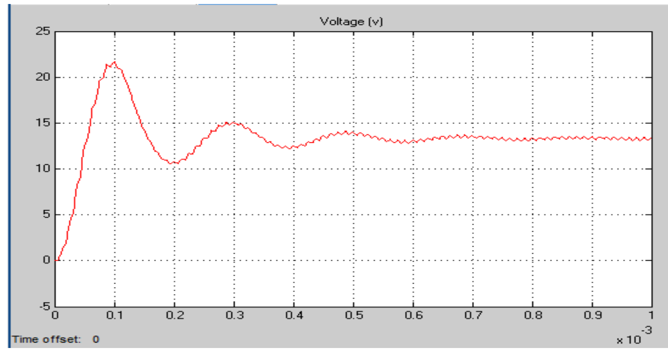

Fig. 12. Improved Boost converter.

TABLE I
VOLTAGE RIPPLE IMPROVEMENT PERCENT

	Conventional boost	Improved boost
Voltage ripple improvement percent (%)	85	95

TABLE II
HARMONIC DISTORTION AMONT

	Conventional boost	Improved boost
Harmonic distortion percent (%)	78	63

This novel buck and boost converter contains ripple voltage, transient response time and harmonic distortion amount which is less than conventional buck and boost converter. Tables 1 and 2 show respectively voltage ripple improvement percentage before and after configuration improvement and harmonic distortion amount before and after configuration improvement.

IV. Analysis of The Novel Buck Converter

While IGBT1 is switched on, a voltage drops on L_1 with the magnitude of V_{in} -V_{out} out in a DT seconds. When IGBT1 is switched off, a voltage drops on L_1 which measures -V_{out} and it will take (1-D) T seconds. So:

$$(V_{in}-V_{out})DT+V_{out}(1-D)T=0 \qquad (1)$$

Therefore the expression for the input voltage (V_{in}) and average of output voltage (V_{out}) can be as formula (2):

$$V_{out} = D\,V_{in} \qquad (2)$$

In buck converter, the more the width of the pulse, the more will be the output voltage, and in the maximum width of pulse, the output voltage will be the same as input voltage.

V. Analysis of The Novel Boost Converter

While IGBT1 is switched on, a voltage drops on L_1 with the magnitude of V_{in} in a DT seconds. When IGBT1 is switched off , a voltage drops on L_1which measures V_{in} -V_{out} and it will take (1-D)T seconds. So:

$V_{in}DT + (V_{in}$-$V_{out})$ (1-D)T=0 (3)

Therefore the expression for the input voltage (V_{in}) and average of output voltage (V_{out}) can be summarized as:

V_{out} = V_{in} /(1 -D) (4)

In boost converter, the less the width of the pulse, the less will be the output voltage, and in the minimum width of pulse, the output voltage will be the same as input voltage.

The results were obtained by comparison between output of simulated buck and boost converter and one reference buck and boost converter which the numerical results of this comparison are shown in tables 3 and 4 respectively:

TABLE III
RIPPLE AMOUNT AND TRANSIENT RESPONSE TIME

Tape circuit	Ripple amount (V)	Transient response time
Simulated conventional buck and boost converter	0.25	0.2×10^{-3}S
Conventional buck and boost converter	0.25	1×10^{-3}S

TABLE IV
RIPPLE AMOUNT AND TRANSIENT RESPONSE TIME

Tape circuit	Ripple amount (V)	Transient response time
Simulated conventional buck and boost converter	*0.12*	0.12×10^{-3}s
Conventional buck and boost converter	0.12	0.5×10^{-3}s

VI. Conclusion

This paper presented the analysis, simulation and experimental results of new configuration of novel Buck and Boost dc-dc converter successfully. For improving Buck and Boost converters operation, the structure changed in a way that one IGBT switch and one inductor are added to the structure and a novel configuration of Buck and Boost converter is obtained. Novel Buck and Boost converter operation was based on delay time between these two switches. The first switch delay time was zero second and the second switch delay time was half of the switching period ($^{T}/_{2}$). Improved and conventional Buck and Boost converters circuit are simulated by using Matlab software. Then the output of these simulations are obtained. The results showed that novel converters have less amount of harmonic distortion and transient response time and higher output power (almost twice as much) as well as lower ripple factor (half) when compared to the conventional converters.

References

[1] Jahanmahin .M (2012). Improve Configurations for Dc to Dc Buck and Boost Carters. Department of Electrical Engineering Shahid Beheshti University, Tehran, Iran, IEEE Catalog Number: CFP121 IJ-ART.

[2] Erickson, R and Maksimovic, D. (1997), "Fundamentals of Power Electronics". New York: Chapman & Hall.

[3] Camara, MB. Gualous, H. Gustin, F. Berthon, B. Dakyo, B. (2010) DC/DC converter design for super capacitor and battery power management in hybrid vehicle applications-polynomial control strategy. IEEE Transactions on Industrial Electronics. 57(2), 857-597. Available: http://ieeexplore.ieee.org/document/5075550/

[4] Wester, GW. (1990). Describing-function analysis of a ripple regulator with slew-rate limits and time delays. Power Electronics Specialists Conference. 341-346. Available: http://ieeexplore.ieee.org/document/131208/