World Applied Sciences Journal 30 (Innovation Challenges in Multidiciplinary Research & Practice): 144-147, 2014
ISSN 1818-4952

DOI: 10.5829/idosi.wasj.2014.30.icmrp.21

DC-DC Boost Converter for Grid-tied Renewable Energy Generation Systems

Zeeshan Shahid, Sheroz Khan, AHM Zahirul Alam and Musse Muhamod Ahmed

Department of ECE, Kulliyah of Engineering,
International Islamic University Malaysia, Kuala Lumpur, Malaysia

Submitted: Jan 5, 2014; **Accepted:** Feb 24, 2014; **Published:** Mar 12, 2014

Abstract: In on-board electronic circuits the use of DC-DC converters is very common for translation and stability of DC levels. These converters are used primarily to step-up or step-down DC levels, they are also employed for steady DC voltage output generated from ambient energy sources such as solar and wind power. In such converters, an inductor plays a major role by being fluxed to get magnetized to a constant voltage level and then it is de-fluxed by diverting the current using a switching electronic device. This paper studies the effect of change in inductance on the resulting output voltage in a boosting mode. The results are standardized to a variety of inductance coil by given geometrical dimensions. The experimental and analytical details of the design is explained and discussed thoroughly, also resulting voltage outputs against each change in inductance level its effect are presented to be having a reasonably matched level in comparisons to results in recently reported research work. The potential applications of this work can be in zero-crossing, frequency, phase and amplitude synchronization in grid-tied inverters.

Key words: Inverters · Low pass filter · Sinusoidal waveform

INTRODUCTION

Renewable energy sources of solar, wind and thermal are used for generation of electrical power. Such generation is normally in DC form as shown in Figure 1. However, being dependent on diverse environmental parameters the output of these sources vary from high to low or vice versa even in a single day. Thus to make this generated energy in usable form, it has to be processed by conditioning it into assuming appropriate voltage value. A DC-DC inverter is the initial step to be used in this transformation application [1-4].

DC-DC converters are becoming the mainstream elements in DC generation and distribution systems. From DC transmission systems to highly sensitive very low power integrated circuits (ICs) these converters are becoming highly focused research area [5], make it clearer for applications ranging from light current devices to heavy current appliances. DC-DC converters being reported these days suggest many modern techniques for making an efficient and stable supply almost independent of the environmental changes. The most common and most effective method used is that of Buck and Boost converters. The Boost converters are used to step up the voltage supply from a lower level to a higher level. Similarly a Buck converter is used to step down a voltage from a higher level to lower required level [6-8].

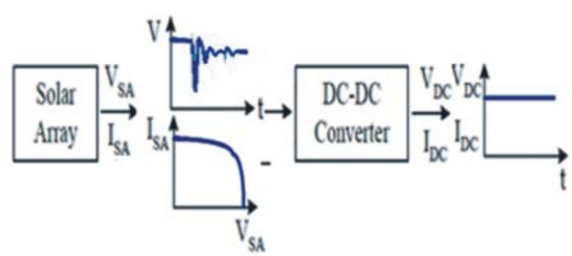

Fig. 1: DC-DC converter Overview.

In this paper the effect of change in inductance on output voltage of DC-DC boost converter is analysed. The change in inductance studied in this work is from 0 µH to 1000 µH. The output voltage against each level value of inductance is shown in graphical format.

Theoretical Details and Circuit Diagram: An inductor possess a property based on its function opposing change in current and it is this property making up the key

Corresponding Author: Zeeshan Shahid, Department of ECE, Kulliyah of Engineering, International Islamic University Malaysia, Kuala Lumpur, Malaysia.

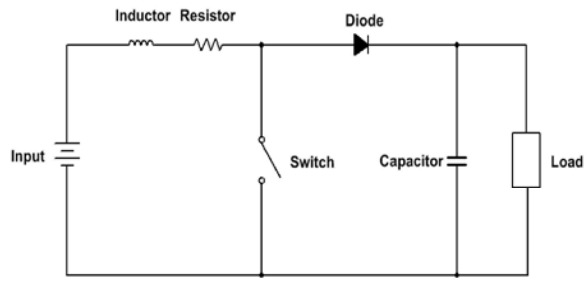

Fig. 2: DC-DC Boost Converter Circuit

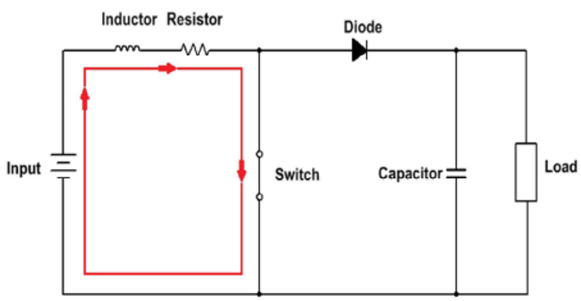

Fig. 3: When the switch is on (t=0)

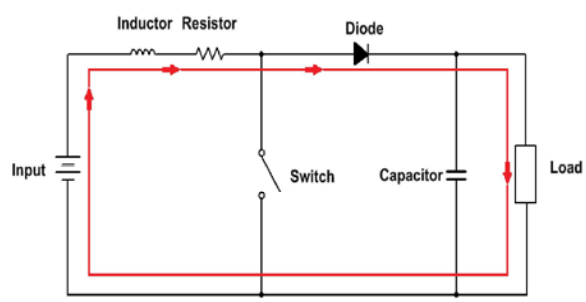

Fig. 4: When the switch is off (t=1)

driving principle of the boost converter. When triggered the output voltage of the boost converter gets higher than its input because of the tendency of inductor to store energy and release it when required.

The basic circuit diagram of boost converter is as shown in Figure 2. Here, the inductor is acting as a storage device getting de-magnetized when the switch is turned ON. The diode functions to make sure unidirectional flow of energy on to the load side and capacitor is used for filtering purpose.

The boost converter has got two working phases as shown in Figure 3 and Figure 4. Figure 3 represents the phase when the Switch is closed. The direction of current is clockwise which passes through the inductor on to the ground. In this stage the inductor stores the energy which can be stated as;

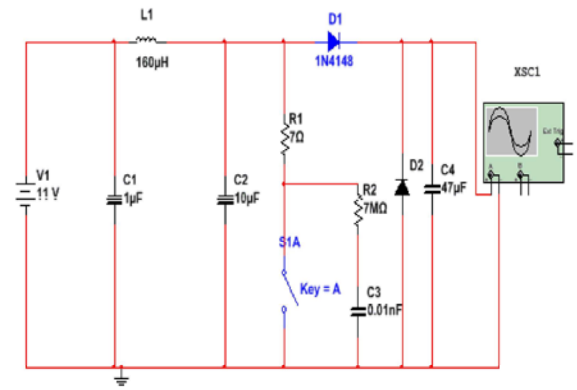

Fig. 5: Boost converter circuit Diagram

When the switch is on (t=0);

$$I(t) = \frac{V_s}{R} e^{-t\frac{R}{L}} \tag{1}$$

$$V_R = V_S - V_L \tag{2}$$

When then switch is turned OFF (t=1)

$$V_{Load} = V_S + V_L - V_D \tag{3}$$

$$\frac{d^2v}{dt^2} + \frac{1}{RC}\frac{dv}{dt} + \frac{v}{LC} = 0 \tag{4}$$

The above equation shows that the resulting current and the output voltage will be oscillatory which need the values of R, C and L at proper setting-analysis of the ongoing research.

In Figure 4, the second phase of working is shown where the switch is opened is presented, the stored energy is released by the inductor in order to be supplied to the load side. In this phase, the inductor is also acting like a source-making the two sources get connected in series to result in a higher output voltage.

Figure 5 shows the circuit configuration of DC-DC boost converter drawn in Mutisim simulation tool.

The diode D2 is a freewheeling diode while R2 and C3 are used to reduce any high current surging spikes. The inductance L1 is made to vary from 0 µH to 1000 µH with the voltage input of 11V.

RESULTS AND DISCUSSION

The presented experiments have highlighted the configuration of DC-DC boost converter for desired output voltage. In the condition when input voltage is not

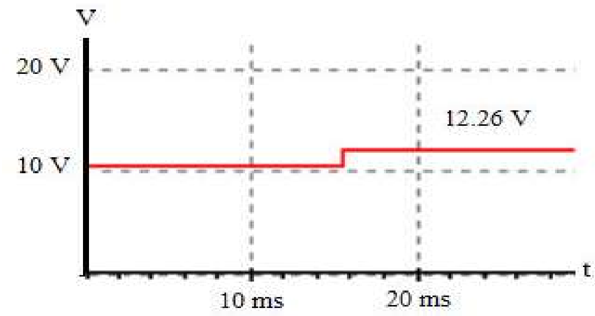

Fig. 5: Output voltage with inductance of 160 µH at 11 V input

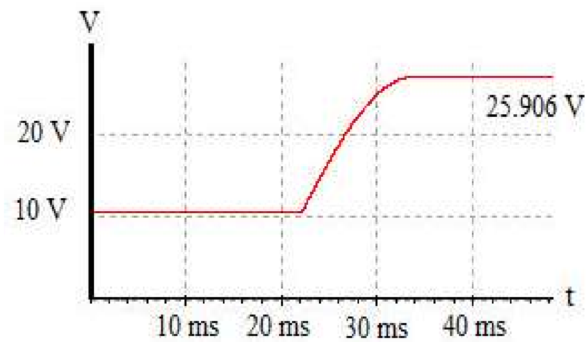

Fig. 6: Output voltage with inductance of 1mH at 11 V input

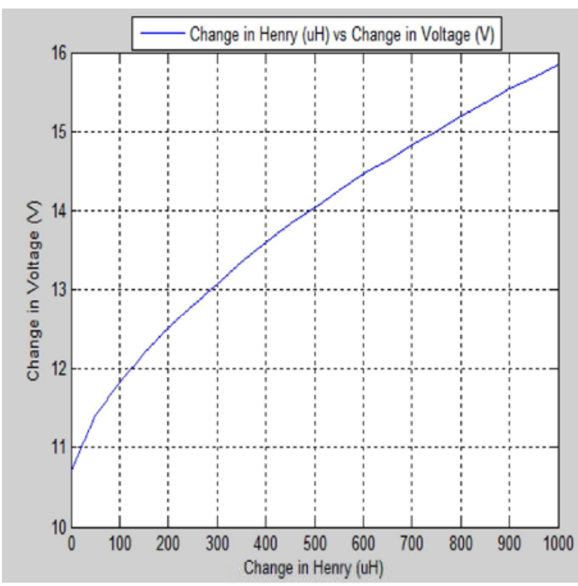

Fig. 7: Change in Inductance effect on Output Voltage

in the required range the necessary voltage level can be achieved by varying the inductance. Figure 5 and 6, shows a step-up output voltage of 12.26 V and 25.906 V at inductance of 160µH and 1000µH at input of 11V respectively.

The relationship between these changes in the values of inductor and output voltage appears to be linear over a certain range variations as in Figure 7, which shows the linear graphical plot for inductance variation from 0µH to 1mHat 11Vinput voltage.

ACKNOWLEDGEMENT

This work is supported by Research Grant No. EDW B13-032-0917 by the RMC International Islamic University Malaysia for which the authors are grateful.

CONCLUSION

This papers presents the simulation results of the effectiveness of DC-DC converter in boosting a voltage as a result of inductor changes during changing and discharging. The working principle and theoretical details of the circuits are explained. Also, results for each inductance level against voltage output and its effect on circuit are shown in details using simulation waveforms and MATLAB plots. The input voltage of 11V for 160µH change becomes 12.26V while a change of 1000µH brings an output voltage of 29.906V.

REFERENCES

1. David Dening, 2011. "A Buck-or-Boost Converter Module With Embedded Inductor and Fast Current Limit", IEEE Transactions On Power Electronics, 26: 12.
2. Masatoshi Uno and Koji Tanaka, 2011. "Single-Switch Cell Voltage Equalizer Using Multi-stacked Buck-Boost Converters Operating in Discontinuous Conduction Mode for Series-Connected Energy Storage Cells", IEEE Transactions On Vehicular Technology, 60(8): 3635.
3. Zeeshan Shahid, Sheroz Khan, AHM Zahirul Alam Musse Muhamod Ahmed and Siti Hazwani Yaacob, 2013. "DC-DC Boost Converter for Grid-tied Renewable Energy Generation Systems", International conference on Innovation Challenges in Multidiciplinary Research & Practice ICIRP, Kuala Lumpur.
4. Hwu, K.I., Member, IEEE and T.J. Peng, 2012. "Novel Buck-Boost Converter Combining KY and Buck Converters", IEEE Transactions On Power Electronics, 27: 5.

5. Li, W., Y. Zhao, Y. Deng and X. He, 2010. 'Interleaved converter with voltage multiplier cell for high step-up and high-efficiency conversion', IEEE Trans. Power Electron., 25(9): 2397-2408.
6. Changchien, S.K., T.J. Liang, J.F. Chen and L.S. Yang, 2010. 'Novel high step-up DC-DC converter for fuel cell energy conversion system', IEEE Trans. Ind. Electron., 57(6): 2007-2017.
7. Carlos Restrepo and Javier Calvente, 2011. Angel Cid-Pastor, Abdelali El Aroudi and Roberto Giral, "A Non-inverting Buck-Boost DC-DC Switching Converter With High Efficiency and Wide Bandwidth", IEEE Transactions on Power Electronics, 26: 9.
8. Sarvi, M. and M. Keshmiri, 2013. "A Fuzzy-PD Controller to Improve the Performance of HVDC System" World Applied Sciences Journal, 22(9): 1210-1219.