

Research Paper

# A HIGH EFFICIENCY BUCK-BOOST CONVERTER WITH REDUCED SWITCHING LOSSES

Mayola Miranda<sup>1\*</sup> and Pinto Pius A J<sup>1</sup>

\*Corresponding Author: Mayola Miranda, ✉ [mayolamiranda48@gmail.com](mailto:mayolamiranda48@gmail.com)

This paper proposes a high-efficiency buck-boost converter with reduced switching losses. Four power transistors generate more conduction and more switching losses when the positive and negative buck-boost converter runs in buck-boost mode. Utilizing the mode-select circuit, the projected converter can reduce the loss of switches and let the buck-boost converter run in buck, buck-boost, or boost mode. By the addition of feed-forward techniques, the transient responses are improved when the supply voltages are changed. The analysis and design method of the proposed work is carried out using MATLAB/ Simulink.

Keywords: Feed-forward techniques, Mode select, Buck-boost, Converter, Matlab/simulink

## INTRODUCTION

Today we are using many portable devices such as LED products, notebooks, mobile phones, and car electronic products. And these products use the power converter for application [1]. The challenges for the designer to provide consumers better conveniences are, to improve the conversion efficiency of power converters and to extend life of battery. Hence it is required to design a accurate switching power converters to reduce the more wasted power energy in the converter. It is necessary to provide a regulated non-inverting output voltage from a variable input battery voltage to portable applications which suffer

from the power handling problems. As the battery voltage can be greater than, less than or equal to the output voltage. Hence for this small scale application such as battery it is desirable to control the output voltage of the converter with performance and accuracy. Thus, one should consider a transaction among efficiency, output transients and cost [1]. In order to maintain a constant output voltage from a variable input voltage there are a various topologies that need to be implemented. For instance single- ended primary inductance converters (SEPICs), inverting buck-boost converters, isolated buck-boost converters, Cuk converters, boost

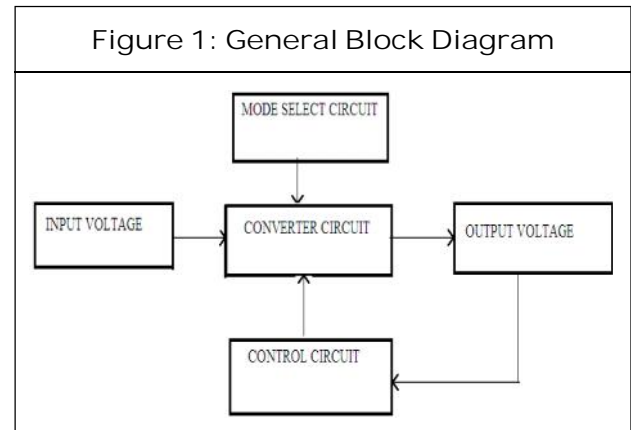
<sup>1</sup> Department of Electrical and Electronics, St. Joseph Engineering College, Vamanjoor, Mangalore, India.

converters and cascaded buck converter. The points of concern for such low-voltage-range power supplies are the efficiency, output ripple, the cost and the space. The above mentioned topologies due to the lower efficiency, high size and cost factors are usually not implemented for such power supplies [3]. Transitions will takes place during the charging and discharging of the battery . During the transition from buck mode to the boost mode the converter loses efficiency and it leads to the spikes in the output voltage. The higher efficiency gives the advantage of longer runtime from identical set of batteries at a given brightness level. While designing such power supplies the size, cost, switching speed, flexibility and efficiency should be considered. To decrease the loss of switches, it is essential to avoid power converters operating in buck–boost mode as the positive buck–boost converter runs in wide-range supply voltages [2]. Therefore, the battery energy is detected by designing a mode select circuit and respective operation mode is selected. Only two power transistors are switched on when the converter runs in buck or the boost mode. The mode-select circuit can decrease the conduction loss and switching loss of the proposed buck boost converter, and the power efficiency can be improved.

This new topology is simulated using MATLAB/Simulink simulation software and simulation results prove that, the design ideas work as expected.

## CIRCUIT OF NEW PROPOSED TOPOLOGY

The buck-boost mode is necessary to present a smooth and stable transition among the two



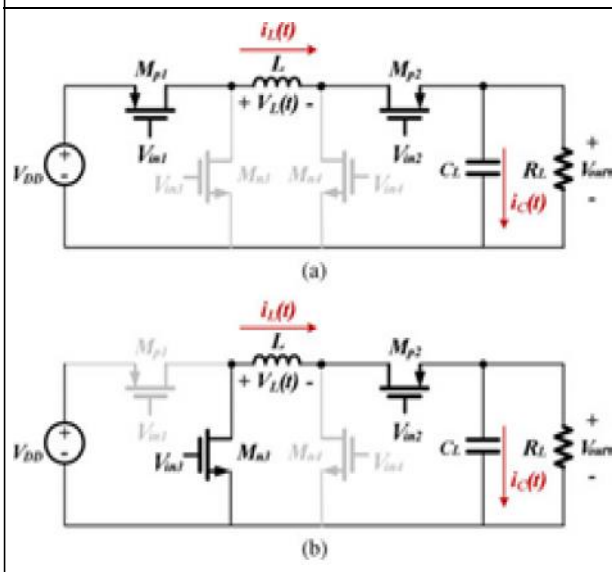
modes [1]. The converter can run in buck, buck-boost and boost modes when the battery voltage decreases. When the input voltage is given to the converter circuit depending on the mode select circuit one of the three converters performs in their respective way [2]. To decrease the loss of switches, it is essential to avoid power converters working in buck boost mode. Therefore, a mode-select circuit is designed to sense the battery energy and select the operation mode. When the converter runs in buck or boost mode, only two power transistors are switched on. The mode-select circuit can decrease the conduction loss and switching loss of the proposed converter, and hence the power efficiency can be improved.

The mode-select circuit can decide the required mode to be operated thus avoiding the overlapping of the modes. It avoids turning on the power transistors at the same time. The mode select circuit determines the operation mode by a control signal from controller.

## OPERATION OF NEW PROPOSED TOPOLOGY

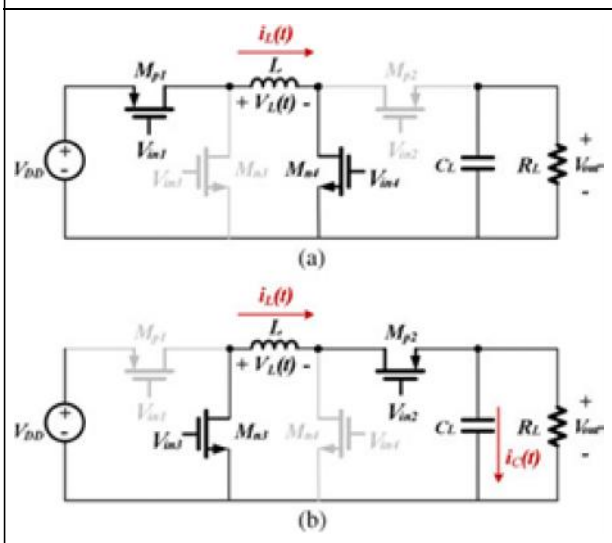
The proposed converter runs in the two operating intervals for buck, boost and buck boost mode i.e., charging and discharging. Figure 2a shows Power transistors Mp1 and

Figure 2: (a) Operation of Charging Interval of Buck Mode, (b) Operation of Discharging Interval of Buck Mode



Mp2 are switched ON the proposed converter operates in the charging interval of buck mode; and the power transistors Mn1 and Mn2 are switched OFF. Figure 2b the power transistors Mp2 and Mn3 are switched ON and the power transistors S1 and S4 are switched OFF.

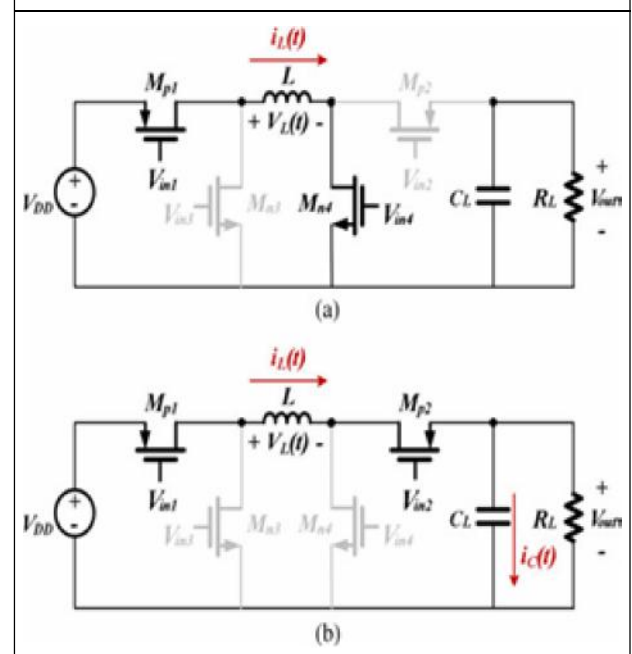
Figure 3: (a) Operation of Charging Interval of Buck Boost Mode, (b) Operation of Discharging Interval of Buck Boost Mode



Similarly the operation of the boost mode and buck boost mode takes place for the charging and discharging intervals.

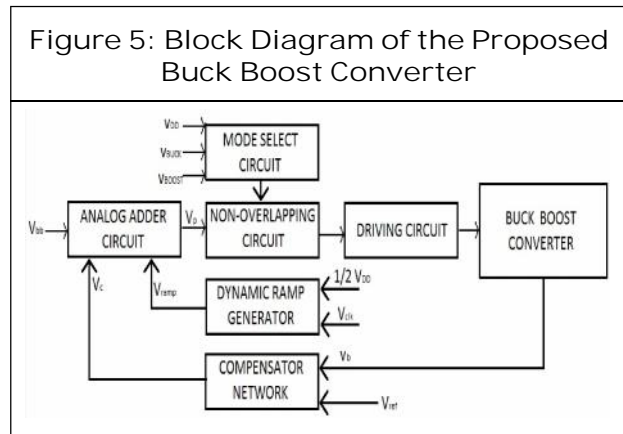
Figure 4a Power transistors Mp1 and Mn4 are switched ON Proposed converter operates in the charging interval of boost mode; and the power transistors Mn3 and Mp2 are switched OFF. Figure 4b the power transistors Mp1 and Mp2 are switched ON and the power transistors Mn3 and Mn4 are switched OFF.

Figure 4: (a) Operation of Charging Interval of Boost Mode, (b) Operation of Discharging Interval of Boost Mode



### OPERATION OF NEW PROPOSED CONVERTER

The block diagram consists of several circuits like Analog adder circuit, Non overlapping circuit. Mode select circuit, Dynamic ramp generator, Compensator network, Level shifter circuit, and driving circuit. When the proposed converter runs, the output from the buck boost converter feeds back the voltage  $V_b$  to the compensator network. Then the error signal



$V_c$  from the compensator is fed to the analog-adder circuit.

The analog-adder circuit adds the supply voltage  $V_{DD}$  and the error signal  $V_c$  to generate a signal  $V_{add}$ . The output error signal of the compensator can be considered half of the supply voltage  $V_{DD}$  by using the analog adder circuit so that the compensator can attain the widest bandwidth, in which transient response is fastest.  $V_{add}$  is compared with a dynamic ramp generator output which depends on the supply voltage  $V_{DD}$  so that the transient response could be improved while the supply voltage  $V_{DD}$  and the load current  $I_{load}$  changed. The digital PWN signal  $V_p$  is sent to non overlapping circuit and generates four signals. Then, the driving circuit drives the power transistors depending on the operation mode, which includes buck mode, boost mode, and buck-boost mode. The operation mode is controlled by the mode-select circuit by sending a control signal to the non overlapping circuit.

### SIMULATION RESULTS

A buck-boost converter with mode-select circuit has been simulated and results are obtained. Figure 6 shows the simulation result of proposed converter operating in boost

mode. Supply voltage = 3 v, output voltage = 4.5 v for boost mode. Figure 7 shows the simulation result of proposed converter operating in buck mode with supply voltage = 3.7 v, output voltage = 3.3 v. Figure 8 shows the simulation result of proposed converter operating in buck-boost mode. Supply voltage = 2.7 v, output voltage = 3.3 v.

Figure 6: Experimental Results of the Proposed Converter as the Supply Voltage  $V_{DD}$  is 3 V; the Proposed Converter Operates in Boost Mode, the Output Voltage  $V_{out}$  is 4.5 V

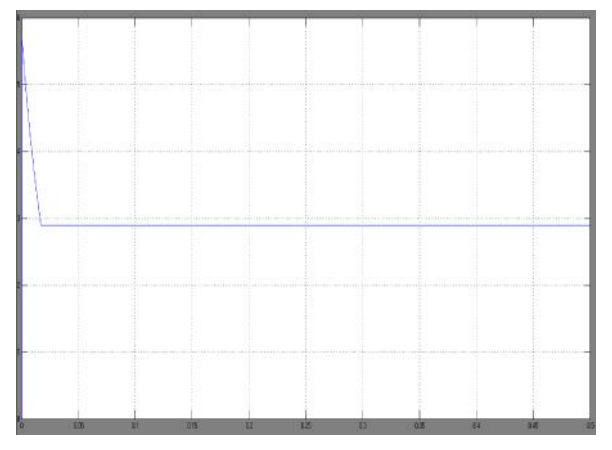


Figure 7: Experimental Results of the Proposed Converter as the Supply Voltage  $V_{DD}$  is 3.7 V; the Proposed Converter Operates in Boost Mode, the Output Voltage  $V_{out}$  is 3.3 V

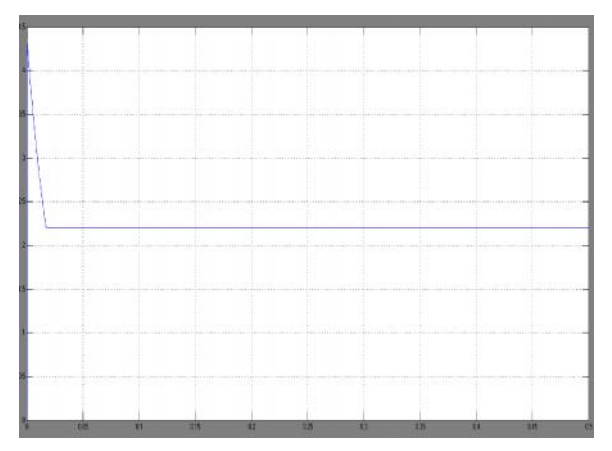
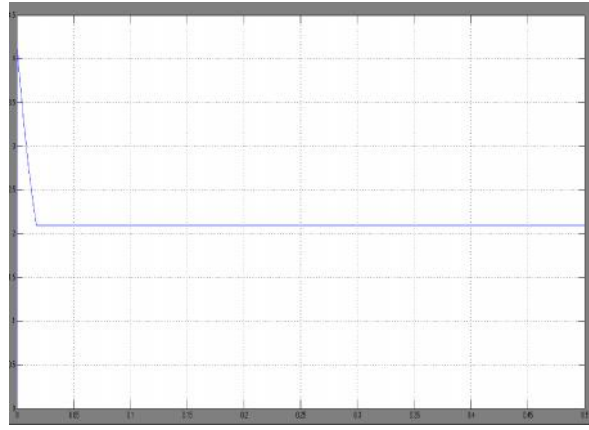


Figure 8: Experimental Results of the Proposed Converter as the Supply Voltage VDD is 2.7 V; the Proposed Converter Operates in Boost Mode, the Output Voltage Vout is 3.3 V



## CONCLUSION

The execution of a buck-boost converter with mode-select circuit is proposed in this paper. The losses are reduced by using a mode select circuit. When operated at high frequency four power transistors produce more conduction losses and switching losses. The converter can be operated in three different modes such as buck, boost and the buck boost mode by using a mode select circuit. Therefore, the mode-select circuit is intended to detect battery energy and choose the operating mode. The transient responses are improved by using the feed-forward techniques. By using the above mentioned techniques, the proposed converter improves power efficiency and extends the battery life.

## REFERENCES

1. Boopathy K and Bhoopathy Bagan K (2011), "Analysis and Design of a Real Time Positive Buck Boost Converter Using Digital Combination Method to Improve the Output Transient", *European Journal of Scientific Research*.
2. Chen P-N Shen and Hwang Y-S (2013), "A High Efficiency Positive Buck-Boost Converter with Mode-Select Circuit and Feedforward Techniques", *IEEE Trans. Power Electron.*, Vol. 28, No. 9.
3. Guo R, Liang Z and Huang A Q (2012), "A Family of Multimodes Charge Pump Based dc-dc Converter with High Efficiency Over Wide Input and Output Range", *IEEE Trans. Power Electron.*, Vol. 27, No. 11, pp. 4788- 4798.
4. Lee C F and Mok P K T (2002), "On-Chip Current Sensing Technique for CMOS Monolithic Switching-Mode Power Converter", in *Proc. IEEE Int. Symp. Circuits Syst.*, May, pp. 265-268.
5. Maity S and Suraj Y (2012), "Analysis and Modeling of an FFHC-Controlled dc-dc Buck Converter Suitable for Wide Range of Operating Conditions", *IEEE Trans. Power Electron.*, Vol. 27, No. 12, pp. 4914-4924.
6. Vijaykaran K and Jeyashanthi J, "A Positive Buck-Boost DC-DC Converter with Mode-Select Circuit Using PID Controller", *Power Electronics & Drives*, Department of EEE, Sethu Institute of Technology, Pulloor, Kariapatti, Virudhunagar, Tamilnadu.
7. Wei C-L, Chen C-H, Wu K-C and Ko I-T (2012), "Design of an Average Current-Mode Non Inverting Buck-Boost dc-dc Converter with Reduced Switching and Conduction Losses", *IEEE Trans. Power Electron.*, Vol. 27, No. 12, pp. 4934-4943.