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# TWO INPUT POSITIVE DC-DC BUCK-BOOST CONVERTER TOPOLOGY

**Laxmi Deshpande[1], V. Champa[2] and Parimala S.K.[3]**

[1,3]Assistant professor, Department of EEE, BNMIT, Bangalore

[2]Associate professor, Department of EEE, BMSCE, Bangalore

E-mails: [1]laxmi.hitali@gmail.com [2]champakuls@yahoo.com [3]parimala.sa@gmail.com

**Abstract:** A new multiple-input hybrid energy conversion topology is presented. The proposed topology is capable of combining different energy sources with different voltage-current characteristics, while achieving low part number and bi-directional operational. The Multiple-input converters have many applications such as grid connected integrated hybrid generation systems, fuel cells, micro grid-based telecom power systems, uninterruptible power supplies, electric and hybrid electric vehicles. Compare to previous multiple-input buck-boost converter, the proposed topology provides positive output voltage; it is capable of bi-directional operation; and it has the capability of operating in buck, boost, and buck-boost modes. A fixed frequency switching strategy is considered and analytical analyses as well as detailed device level simulation results are presented for a two input Buck-Boost converter.

**Keywords:** dc-dc converter, energy diversification, multiple-input converter.

## 1. Introduction

Most electrical systems are supplied by one kind of energy source, whether it is batteries, wind, solar, utility, etc. Certain special cases are powered by two sources, such as, uninterruptible power supplies. Future distributed power systems will require interfacing different kinds of energy sources. Multiple-input energy sources have the capability of diversifying different energy sources and increasing the reliability of the system with improved flexibility, and utilization of preferred energy sources [1]. In most cases, one sourcemay be preferential to others, or perhaps, a simultaneous combination of sources is appropriate for optimal energy/economic use. Therefore, multiple-input power converters are required to enable multiple-source technology. Such converters have received limited attention, thus far. A topology for achieving combinations of multiple dc sources is presented. The different operating modes are investigated and verified by experimentation. Many of the renewable sources have dc voltage and current characteristics. Therefore, a multiple–input dc–dc converter is of practical use. In this paper, we present a topology capable of accommodating a number of inputs. The topology is derived from the buck-boost converter. It can operate bi-directionally without any need for additional converters. It can operate in all

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three buck, boost, and buck-boost modes. It provides positive output voltage. Another merit of this circuit is that the inductor is shared by both inputs. As a result, by sampling the inductor current and monitoring the gate signals, all the input currents can be monitored with only one sensor. The scope of this paper is to introduce the topology, drive the output voltage relationships equations for the two-input (TI) buck topology in continuous and discontinuous conduction modes. Deriving similar equations for MI buck-boost topology follows the same procedure.

## 2. Circuit Topology

The circuit topology of the proposed TIPBB converter is shown in Fig. 1. There are N input voltages Vi and N input currents Ii (i=1: N). These inputs are connected to one terminal of the inductor through bidirectional Si (i=1: N) switches. These switches can be realized as two parallel MOSFETs, or other switch combinations. The output voltage and current are Vout and Iout, respectively.

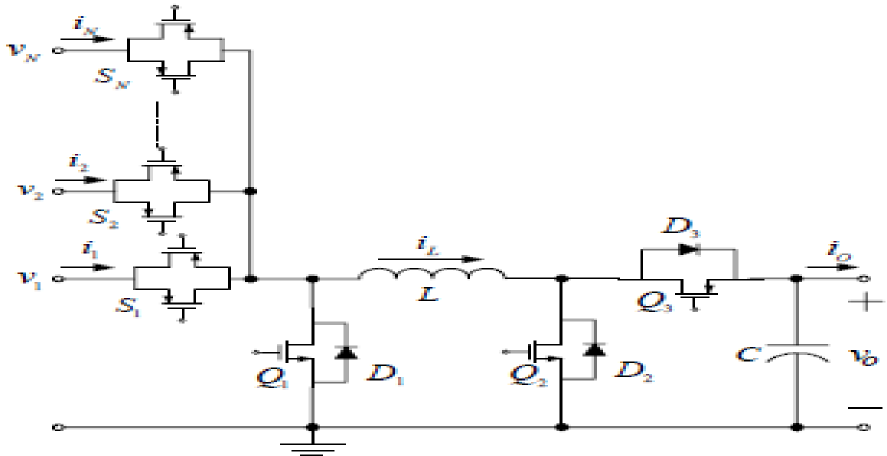


**Fig.1** TIPBBC circuit Topology

The table shown below shows the position of switches for different operating modes.

**Table 1:** Position of different switches for different topologies

| Mode of operation | Switch Q1 | Switch Q2 | Switch Q3 | Diode D1 | Diode D2 | Diode D3 |
|---|---|---|---|---|---|---|
| Buck | off | off | off | on | Off | off |
| Boost | off | on | off | off | Off | on |
| Buck-Boost | off | on | on | on | Off | off |

## 3. Circuit operation of two input Buck Converter

In the proposed TIBBC a two input buck-boost converter is designed, which can operate in both continuous and discontinuous mode, where the output depends on the two input voltages and their respective duty ratio.

### 3.1 Continuous conduction mode Buck topology

In continuous conduction mode (CCM) inductor current is always greater than zero. Therefore, at least one of $S_i$ switches or $D_1$ is "on" at all times. If at least one of $S_i$ switches is on, $D_1$ is off, but if all Si switches are off, then $D_1$ is on. If several Si switches are on, then the inductor voltage is equal to the highest of the voltages for which the respective Si switch is on minus the output voltage. Defining switching signals as (i =1: *N*), such that a 1 corresponds to on switching state and a zero corresponds to off switching status [1], and with the assumption that the output capacitor is sufficiently large so that the output voltage is almost constant, the inductor voltage is,

$$\mathbf{V_{out} = \sum Deff(i)\, V(i)}$$

Where i=1 to N. (sequence of input switches)

**For two input converter in Buck topology**

Case1: $D_1 > D_2$ then, $V_{out} = D_1 V_1$.

This is the output voltage for a single input normal buck converter, where second input (lower voltage) does not enter in.

Case2: $D_2 > D_1$, then $V_{out} = D_1 V_1 + (D_2 - D_1) V_2$.

### 3.2 Discontinuous conduction mode

Similar to the CCM, if several active switches are on, then the inductor voltage is equal to the highest of the voltages for which the respective switch is on. Therefore, only one Si switch conducts at a time. Depending on the magnitudes of input and output voltages two different cases are possible.

1. Magnitude of all the input voltages is higher than the output voltage.
2. Magnitude of some of the input voltages is less than the output voltage.

A case of inputs where all the inputs are higher than the output is considered in this project. When the magnitudes of all input voltages are higher than output voltage, the inductor stores energy at the instant D1 turns on is $\frac{1}{2} L i_p^2$.

Whereas, change in the inductor current during $j^{th}$ interval is given by,

$\mathbf{(\Delta I_j) = (V_j - V_{out})/L * Deff * T}$ (where T is the time period)

The magnitude of the peak inductor current ($I_{peak}$) is calculated by,

$$\mathbf{I_{peak}} = j \sum_i (\Delta I) = \mathbf{T/L} \sum_{j=0}^{i} Deff \ \mathbf{* \ (Vj\text{-}Vout)} \quad \mathbf{Or} \quad \mathbf{I_{peak} = (\Delta I_1) + (\Delta I_2).}$$

When, all the switches are off, the stored energy of the inductor passes to the load and the capacitor.

## 4. Simulation Circuit for two input Buck Converter

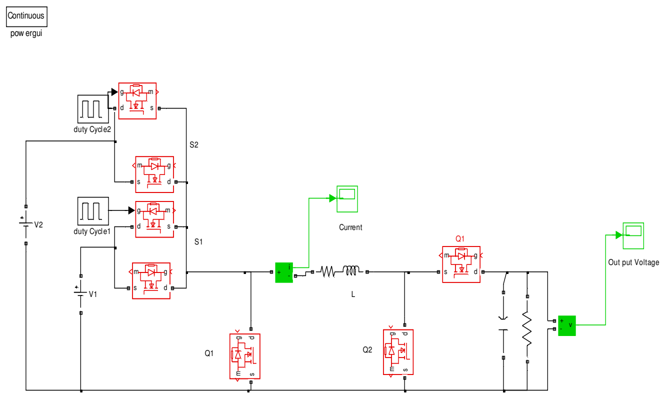


**Fig2.** Simulation set-up for Buck converter

## 5. Hardware set-up for Two input Buck -boost converter

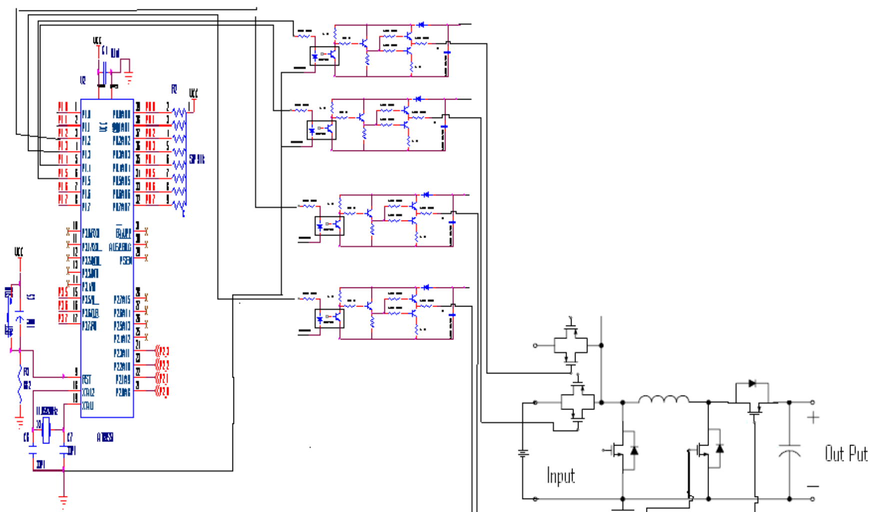


**Fig 3.** The complete hardware circuit of TIPBBC

## 6. Results

A two-input positive buck-boost converter is considered. For CCM, the two inputs voltages are 10V & 7V. The capacitance is 500 μF. The MOSFETs are modeled with 2SK2095N. The switching frequency is 50 kHz. In Fig. 4, the average output voltage as predicted by a detailed device level simulation is plotted for a two-input PBBC for buck topology. The duty cycle of the 10 V source input is 0.4, while the other duty cycle $D_2$ is varied. Once $D_2$ exceeds D1, the converter not behaves like a single-input buck converter, anymore. As shown the output voltage increases significantly. Operation of the converter in buck topology is analyzed the two inputs chosen are 10 V and 7 V, where magnitude of input voltages is higher than the output voltage.

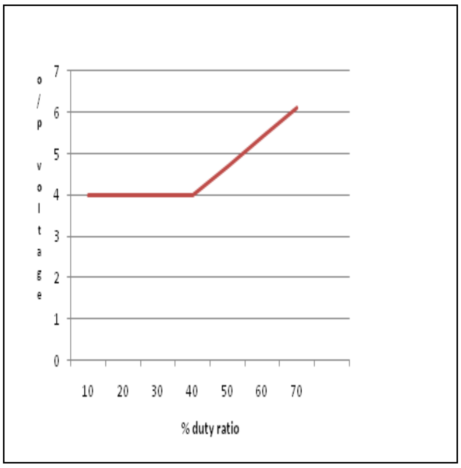


**Fig 4.** CCM Mode with D2 varied and D1 = 0.4

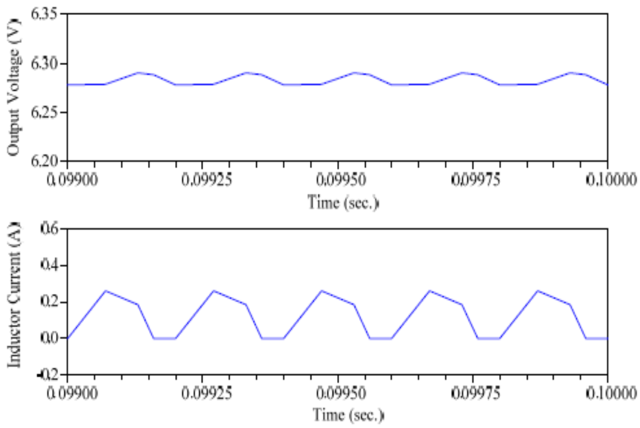


**Fig 5.** Output voltage &inductor current for two input buck converter with V1=10V & V2=7V in DCM

**Table 2:** Comparison of Hardware &Simulation Results ($V_1$ = 10V &$V_2$ = 7V

| Sl. No | %D1 | %D2 | Hardware output voltage(volts) | Simulated output voltage(volts) |
|---|---|---|---|---|
| 1 | 25 | 25 | 2.08 | 2.17 |
| 2 | 50 | 50 | 5.94 | 6 |
| 3 | 60 | 50 | 8.51 | 8.62 |
| 4 | 50 | 25 | 5.62 | 5.68 |

## 7. Conclusion

Multiple-input dc-dc positive buck-boost converter is introduced. Compare to the negative multiple-input buck-boost topology, it has advantages in terms of positive output voltage without any additional transformer, capability of operation in different converter topologies (buck, boost and buck-boost), as well as bidirectional operation. It is a promising topology for diversification of multiple energy sources. Analytical analyses are presented considering ideal and lossless) components, which shows basis for understanding the operation of the converter and is helpful for control development. Detailed (device level) analyses are presented for a two-input converter operating in buck topology and compared with the ideal analytical results. Future work will address control, power management, application of this topology in hybrid electric vehicles; and grid connected diversified renewable energy sources.

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