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Cascaded DC-DC Converter with Battery Charger

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ABSTRACT:

It introduces a cascaded dc-dc converter combines both boost and buck converter topologies to extract maximum power. Converter uses two control signals one for maximum power and another for battery charger control providing constant voltage to the battery. The advantage of converter is to extract maximum power by avoiding battery damage causes by variable voltage. Therefore it is reliable to combine battery charger control and maximum power exploitation using two control signals.

A Buck-Boost converter is a type of switched mode power supply that combines the principles Converter and the Boost converter in a single circuit. Like other SMPS designs, it provides a regulated DC output voltage from either an AC or a DC input.

Keywords: DC – Direct Current, AC – Alternating Current, PV – Photo Voltaic, SMPS – Switch Mode Power Supply

INTRODUCTION

DC-DC converters are high-frequency power conversion circuits that use high-frequency switching and inductors, transformers, and capacitors to smooth out switching noise into regulated DC voltages. Closed feedback loops maintain constant voltage output even when changing input voltages and output currents.

DC-DC converters are widely used to efficiently produce a regulated voltage from a source that may or may not be well controlled to a load that may or may not be constant [1].

The buck boost converter is a type of DC-to-DC converter that has an output voltage magnitude that is either greater than or less than the input voltage magnitude.*The Boost converter [2-5]* will produce an output voltage ranging from the same voltage as the input, to a level much higher than the input.

Battery-powered systems, where the input voltage can vary widely, starting at full charge and gradually decreasing as the battery charge is used up. At full charge, where the battery voltage may be higher than actually needed by the circuit being powered, a buck regulator would be ideal to keep the supply voltage steady [6].

However as the charge diminishes, the input voltage falls below the level required by the circuit, and either the battery must be discarded or re-charged; at this point the ideal alternative would be the boost regulator[10].

By combining these two regulator designs it is possible to have a regulator circuit that can cope with a wide range of input voltages both higher and lower than that needed by the circuit [7-9]. Fortunately both buck and boost converters use very similar components; they just need to be re-arranged, depending on the level of the input voltage.

PROPOSED BLOCK DIAGRAM

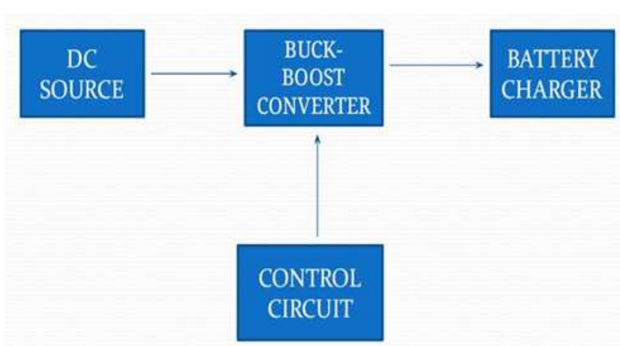


Fig. 1 Block Diagram

Low voltage DC Source is given to the circuit as aN input supply. Buck-Boost Converter is a DC to DC Converter which is used to convert low voltage of DC input , we may use PV also an another input source [11] to high voltage DC output. The input supply is given to the converter as an input. A control circuit is used to control the components in the main circuit shown in Fig. 1. The Buck-Boost Converter is given to the Battery charger. Battery Charger is given as an output here. After converting the low voltage into high voltage, the supply will goes to battery charger. With the help of battery charger we can charge Electric Vehicles easily.

DC-DC CONVERTER:

- DC-DC converters are also known as Choppers. Here we will have a look at
Buck Boost converter which can operate as a DC-DC Step-Down converter or a DC-DC Step-Up converter depending upon the duty cycle, D.A typical Buck-Boost converter is shown in Fig. 2 below

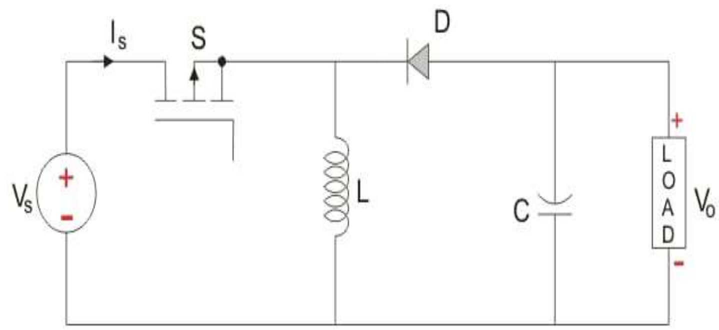


Fig. 2Circuit Diagram Buck-Boost Converterram

- The input voltage source is connected to a solid state device. The second switch used is a diode. The diode is connected, in reverse to the direction of power flow from source, to a capacitor and the load and the two are connected in parallel as shown in the fig. 4 above.
- The controlled switch is turned on and off by using Pulse Width Modulation (PWM).
- PWM can be time based or frequency based. Frequency based modulation has disadvantages like a wide range of frequencies to achieve the desired control of the switch which in turn will give the desired output voltage.
- Time based Modulation is mostly used for DC-DC converters. It is simple to construct and use.
- The frequency remains constant in this type of PWM modulation.
- The *Buck Boost converter* has two modes of operation. The first mode is when the switch is on and conducting.

The buck boost converter is a DC to DC converter. The output voltage of the DC to DC converter is less than or greater than the input voltage. The output voltage of the magnitude depends on the duty cycle. These converters are also known as the step up and step down transformers and these names are coming from the analogous step up and step down transformer. The input voltages are step-up/down to some level of more than or less than the input voltage. By using the low conversion energy, the input power is equal to the output power. The following expression shows the low of a conversion.

Input power (Pin) = Output power (Pout)

For the step up mode, the input voltage is less than the output voltage (Vin<Vout). It shows that the output current is less than the input current. Hence the buck booster is a step up mode.

$$V_{in}<V_{out}$$

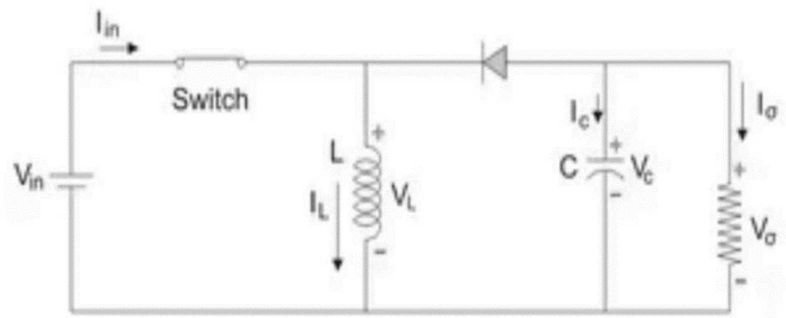
and $$I_{in}>I_{out}$$

In the step down mode the input voltage is greater than the output voltage (Vin>Vout). It follows that the output current is greater the input current. Hence the buck boost converter is a step down mode.

$$V_{in}>V_{out}$$

and $$I_{in}<I_{out}$$

Mode I : Switch is ON, Diode is OFF



The Switch is ON (Shown in Fig.3) and therefore represents a short circuit ideally offering zero resistance to the flow of current so when the switch is ON all the current will flow through the switch and the inductor and back to the DC input source. The inductor stores charge during the time the switch is ON and when the solid state switch is OFF the polarity of the Inductor reverses so that current flows through the load and through the diode and back to the inductor. So the direction of current through the inductor remains the same.

Let us say the switch is on for a time T_{ON} and is off for a time T_{OFF}.

We define the timeperiod, T, as

$T=T_{ON}+TOFF$

And the switching frequency,

$f_{switching}=1/T$

Let us now define another term, the duty cycle,

$D=T_{ON}/T$

Let us analyze the *Buck Boost converter* in steady state operation for this mode using KVL.

$$\therefore V_{in} = V_L$$
$$\therefore V_L = L\frac{di_L}{dt} = V_{in}$$
$$\frac{di_L}{dt} = \frac{\Delta i_L}{\Delta t} = \frac{\Delta i_L}{DT} = \frac{V_{in}}{L}$$

Since the switch is closed for a time $T_{ON} = DT$ we can say that $\Delta t = DT$.

$$(\Delta i_L)_{closed} = \left(\frac{V_{in}}{L}\right) DT$$

While performing the analysis of the Buck-Boost converter we have to keep in mind that

1. The inductor current is continuous and this is made possible by selecting an appropriate value of L.
2. The inductor current in steady state rises from a value with a positive slope to a maximum value during the ON state and then drops back down to the initial value with a negative slope. Therefore the net change of the inductor current over any one complete cycle is zero.

Mode II : Switch is OFF, Diode is ON

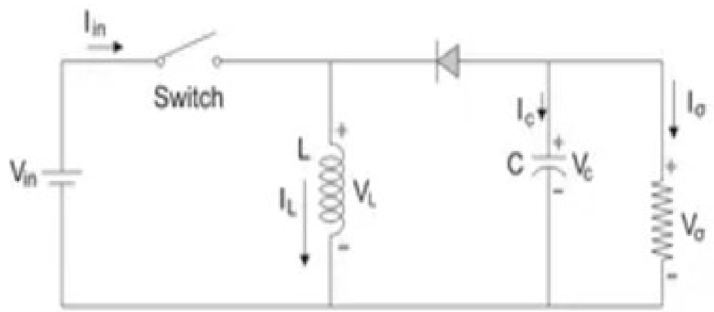


Fig. 4Switch OFF

In this mode shown in Fig. 4, the polarity of the inductor is reversed and the energy stored in the inductor is released and is ultimately dissipated in the load resistance and this helps to maintain the flow of current in the same direction through the load and also step-up the output voltage as the inductor is now also acting as a source in conjunction with the input source. But for analysis we keep the original conventions to analyze the circuit using KVL.
Let us now analyze the Buck Boost Converter in steady state operation for mode II using KVL.

$$\therefore V_L = L\frac{di_L}{dt} = V_o$$

$$\frac{di_L}{dt} = \frac{\Delta i_L}{\Delta t} = \frac{\Delta i_L}{(1-D)T} = \frac{V_o}{L}$$

Since the switch is open for a time

$$T_{OFF} = T - T_{ON} = T - DT = (1-D)T$$

we can say that

$$\Delta t = (1-D)T$$

It is already established that the net change of the inductor current over any one complete cycle is zero.

$$\therefore (\Delta i_L)_{closed} + (\Delta i_L)_{open} = 0$$

$$\left(\frac{V_o}{L}\right)(1-D)T + \left(\frac{V_{in}}{L}\right)DT = 0$$

$$\frac{V_o}{V_{in}} = \frac{-D}{1-D}$$

Modes of Buck Boost Converters:

There are two different types of modes in the buck boost converter. The following are the two different types of buck boost converters.

- Continuous conduction mode.
- Discontinuous conduction mode.

Continuous Conduction Mode:

In the continuous conduction mode the current from end to end of inductor never goes to zero. Hence the inductor partially discharges earlier than the switching cycle.

Discontinuous Conduction Mode:

In this mode the current through the inductor goes to zero. Hence the inductor will totally discharge at the end of switching cycles.

LITHIUM ION BATTERY

In this work battery is used as load. We take Lithium ion battery

A **lithium-ion battery** or **Li-ion battery** is a type of rechargeable battery. Lithium-ion batteries are commonly used for portable electronics and electric vehicles and are growing in popularity for military and aerospace application.

In the batteries, lithium ions move from the negative electrode through an electrolyte to the positive electrode during discharge, and back when charging. Li-ion batteries use an intercalated lithium compound as the material at the positive electrode and typically graphite at the negative electrode. The batteries have a high energy density, no memory effect (other than LFP cells)and low self-discharge.

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Lithium is good for **batteries** for three main reasons. First, it is highly reactive because it readily loses its outermost electron, making it easy to get current flowing through a **battery**. Third, **lithium**-ion **batteries** are rechargeable, because **lithium** ions and electrons move easily back into negative electrodes.

SIMULATION CIRCUITS & RESULTS:

CIRCUIT DIAGRAM:

WITH RIPPLE:

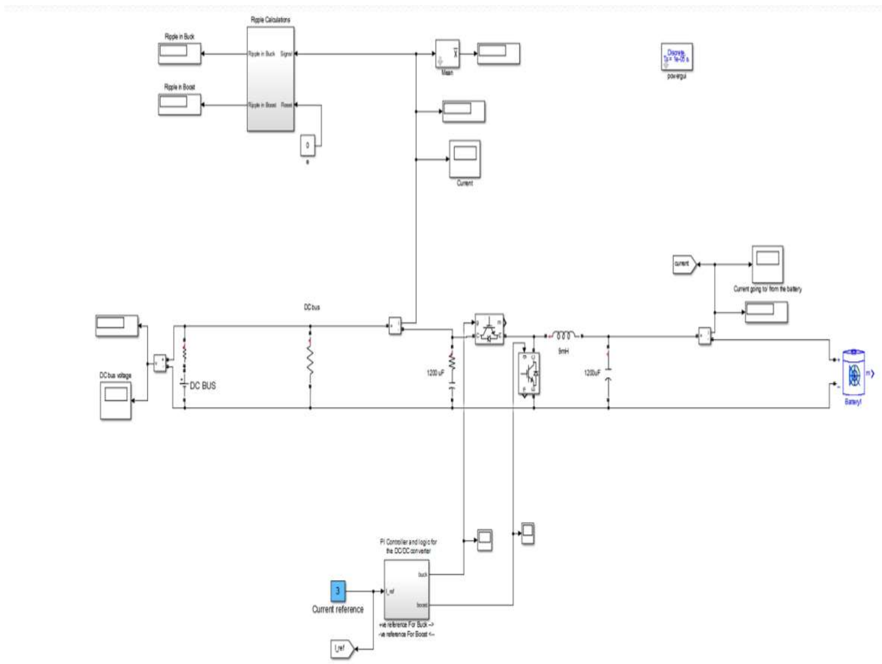

Fig. 5Circuit Diagram with Ripple Block Diagram

WITH RIPPLE:

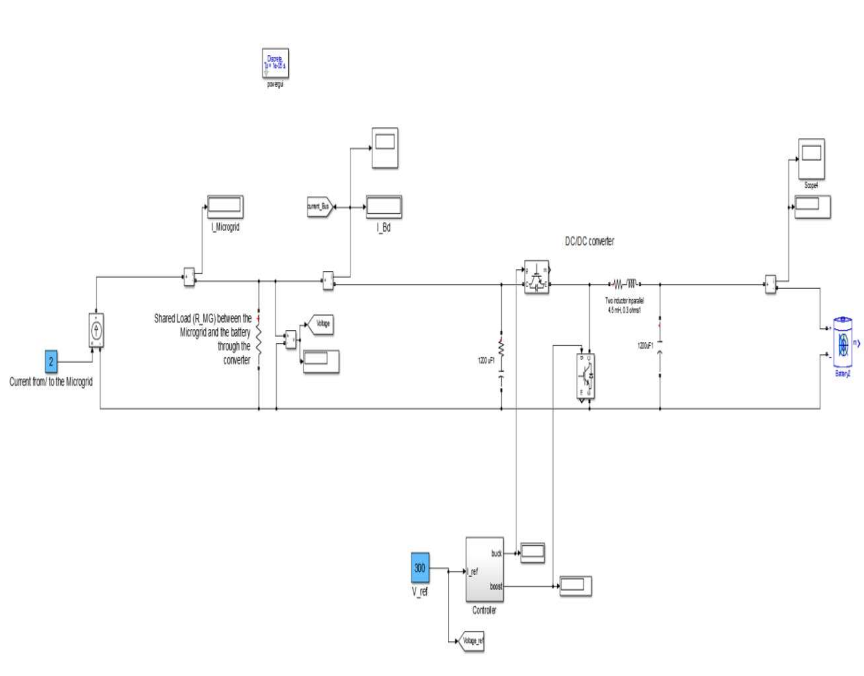

Fig. 6Circuit Diagram without Ripple Block Diagram

OUTPUT VOLTAGE WAVEFORM:

INPUT: For I=2amp, f=25Hz

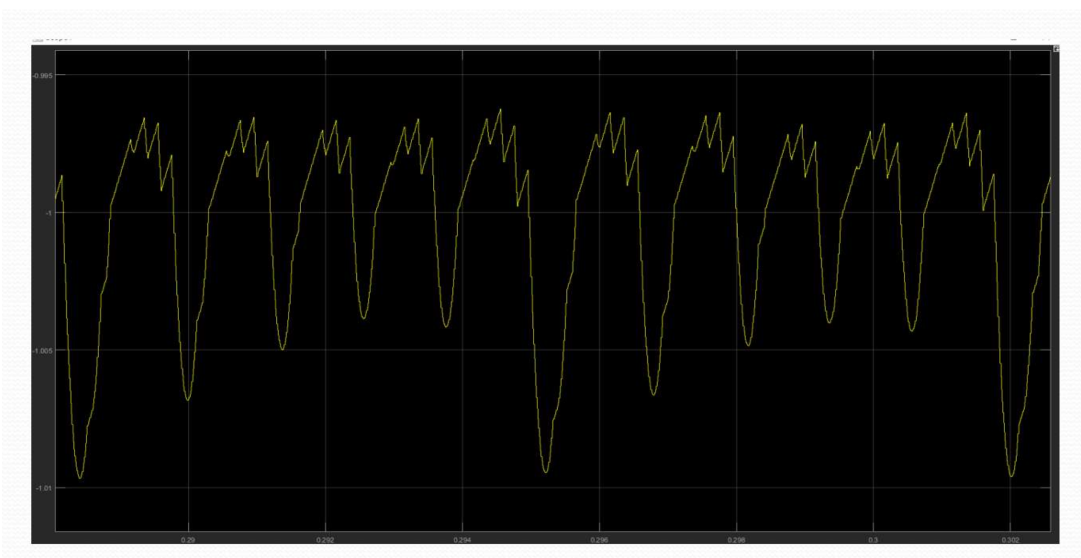

Fig. 7Output Voltage Waveformram

OUTPUT CURRENT WAVEFORM :

INPUT: For V=286v:

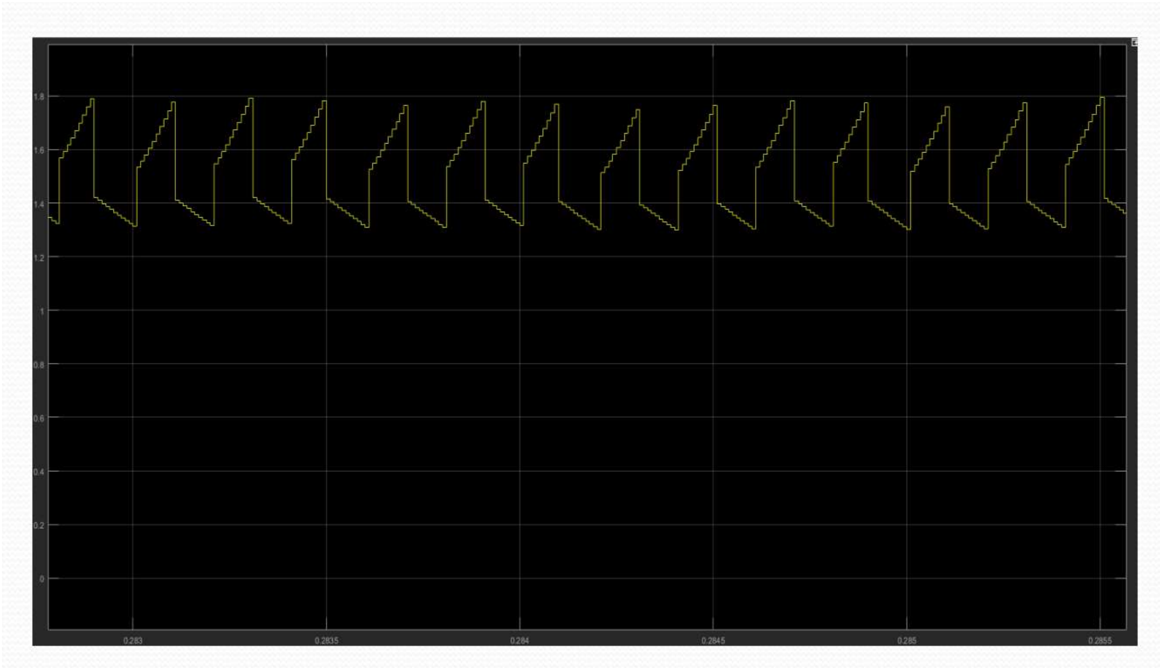

Fig. 8Output Current Waveform Ripple Block Diagram

Simulated circuit diagram for converter with battery. First circuit diagram Fig. 5 gives the battery performance with ripple. Second circuit diagram Fig. 6 gives the output waveform adding filter components without ripple.

Fig.7 gives the relevant output voltage waveform for the input current of 2A with frequency of 25Hz.Fig.8 gives the relevant output current waveform for the input voltage of 286 volts. 25Hz.

ADVANTAGES:

- Highly Efficient.
- Prevents from over charging.
- Battery has higher energy density than other rechargeable batteries (Lithium-Ion Battery).
- It is used to increase voltage from partially lowered battery voltage.
- Battery life will be high as we use solar.
- Not harmful to environment.

CONCLUSION

An attempt has been made to make a simulated model of ‘Cascaded DC to DC Converter with Battery Charger’. It consists of all the theory of hardware and software used. The propagated model is used to charge up the electric vehicles within less period of time. As consumption of electricity is increasing day by day, we are using a battery charger with the help of a converter to decrease the consumption of electric power as it requires high maintenance and highly economical.

In the future, a full-scale dc/dc converter will be built for a typical mid-size vehicle for a real world application. Research will be carried out to fill the future energy demand since it is economy and renewable.

In the future if we are successful in generating higher power with less solar panels then this method for transmission of power from solar will be cost effective and maintenance free.

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