Renewable energy based interleaved boost converter

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Abstract— *Nowadays, there is a demand to increase the power generation capacity because of steadily rising electrical energy consumption. In order to achieve this, renewable energy sources are the best option. Among all the renewable energy sources, solar power generation system tops the list. For increasing the output of these sources we need a suitable boost converter. Interleaved boost converter (IBC) is one of such converter which consists of several identical boost converters connected in parallel and controlled by interleaved method, which has same switching frequency and phase shift. The advantages of using IBC over conventional boost converter are increased efficiency, improved reliability, reduced current peak value and these converter cells have good current sharing characteristics. The proposed method provides the increased output voltage along with efficiency. The proposed strategies have been verified with the help of MATLAB/SIMULINK.*

***Keywords*—interleaved boost converter, renewable energy, Solar energy, current sharing, efficiency,**

1. INTRODUCTION

The global electrical energy consumption is steadily rising and consequently there is a demand to increase the power generation capacity without harming the environment. Renewable energy sources are the best options due to their effective operation and also they do not pollute the environment, the way burning the fossil fuels does. Solar power generation system tops the list of renewable energy sources, as the other sources such as wind, hydro, tidal sources even when taken them together will not meet the demand as the solar energy source does.

But for our application we need more amount of voltage than what we are getting from solar cells, to achieve this, we need to boost up the output voltage. For this purpose we need to use Interleaved method to improve power converter performance interms of efficiency. The Interleaved consists of several identical boost converters connected in parallel.

The key feature of IBC compared to convention boost converters.

1. Increased output voltage and efficiency.
2. Good current sharing characteristics.
3. Reduced current peak value.
4. Improved reliability.
5. Low input current ripple.

As the output current is divided by the number of phases, the current stress on each MOSFET's is reduced. Each mosfet is switched at the same frequency but at a phase difference of 180 degrees. The desired output voltage for a given input voltage is depends on the duty ratio. For example, if the input voltage is 60V and the desired output voltage is 120V then we have to keep the duty cycle at 0.5. Since, we are using two similar inductors in the circuit this will leads to equal sharing of the input current.

Here, in this proposed method two phase IBC is chosen since the ripple content reduces with increase in number of phases. But, if the number of phases increased further without much decrease in ripple content, the complexity of circuit increases very much, thereby increasing the cost of implementation. Hence, as a tradeoff between the ripple content and the cost complexity, number of phases are chosen as two.

2. OPERATION OF IBC

Since as we are using two phases the converter is driven 180 degrees out of phase, this is because the phase shift is given by 360/n. where n stands for number of phases. Hence its clear that the phase shift is depends the number of phases used.

When gate pulse is given to the first for time t_1, the current across the inductor rises and energy is stored in the inductor. When the switch s_1 in the first phase turned off, the energy stored is transferred to the load through the output diode SD_1. The inductor and the capacitor serve as voltage sources to extend the voltage and to reduce the voltage stress on the switch. The increasing current rate across the output diode is controlled by inductances the phases. Now the gate pulse is given to the second phase during the period t_1 to t_2 when the switch in the first phase is turned off.When the switch in the second phase turned ON the inductor charges for the same time and transfers energy to the load in the similar way as in the first phase. Therefore two phases feed the load continuously. Thus the proposed converter operates in continuous conduction mode.

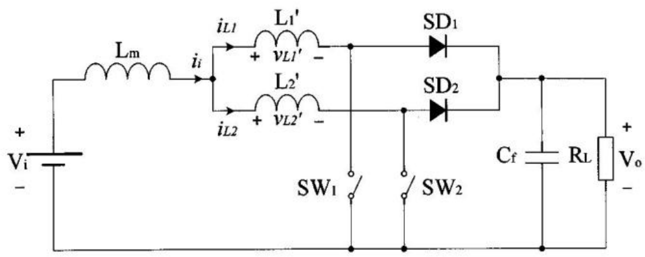

Fig - 1: circuit diagram of IBC

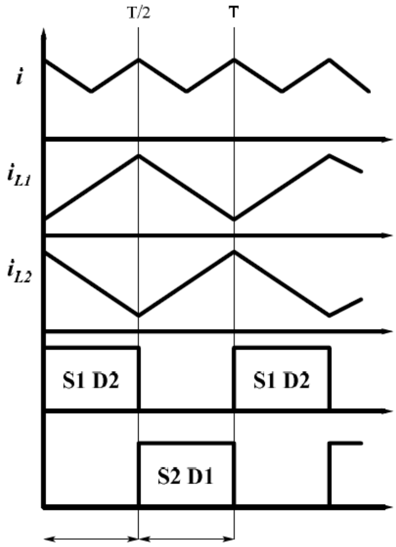

Fig – 2:inductor current waveforms

3. DESIGN OF IBC

The design process involves the proper selection of inductor, duty cycle, resistance and capacitor values.

1) Duty cycle

$$\frac{V0}{Vin} = \frac{1}{1-D}$$

$$D = 1 - \frac{V0}{Vin}$$

$$D = 1 - \frac{120}{60} = 0.5$$

2) Resistance

$$R_L = \frac{V0}{I0}$$

$$R_L = \frac{120}{12} = 10\ \Omega$$

3) Capacitor

$$C = \frac{D*V0*T}{R*\Delta V0}$$

Take f_s = 1 KHz

$$T = \frac{1}{fs} = \frac{1}{1\ K} = 1 * 10^{-3} \text{ sec}$$

$\Delta V0 \simeq 0.5\%$ = voltage ripple

$$C = \frac{0.5*120*1*10^{-3}}{10*05} = 120 * 10^{-3} \text{ F}$$

4) Inductor

$$L = \frac{Vin*D}{m*n*f*\Delta I}$$

m = number of switches per channel
n = number of channels
ΔI = input current ripple $\simeq$ 0.5 %

$$L = \frac{60*0.5}{1*2*100*0.5} = 30 \text{ mH}$$

Both the inductors used here are of similar rating that is both are having 1 mH of inductance. Since, we are using two similar inductors this will help us in sharing the input currents equally. And also, the inductor peak current rating is also reduced, thereby reducing the inductor rating and cost of inductor.

4. SIMULATION RESULTS AND DISCUSSION

According to the design, the circuit diagram of simple IBC and simple Boost converters along with their application is plotted using MATLAB/SIMULINK and their respective voltage and corresponding speed of the motor are noted and compared.

The figs 3 and 4 shows that the output voltage of IBC is 118 V where as that of conventional boost converter is only 106 V. This clearly shows us that the efficiency of IBC is more than that of the boost converter.

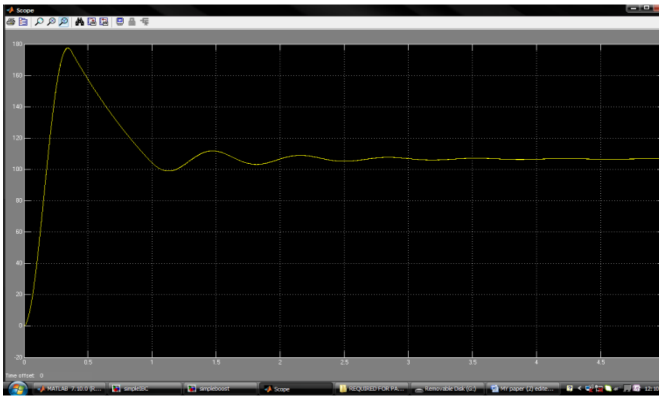

Fig - 3: output voltage waveform of boost converter

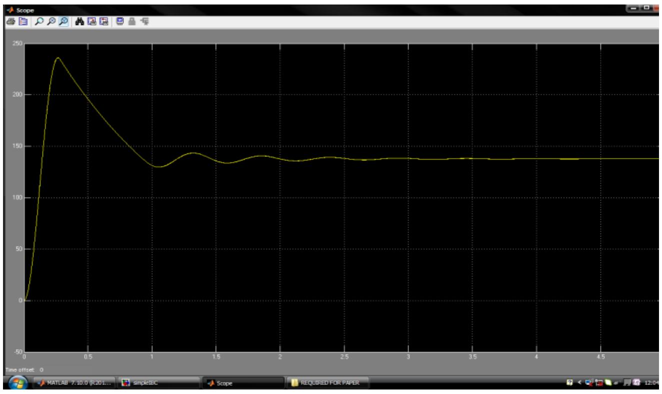

Fig – 4: output voltage waveform IBC

Fig 5 and shows the motor speed variants for Boost converter and IBC respectively. This shows that the speed of the motor also depends on the type of converter we use. With the same design values if we use boost converter we can get only around 800 rpm but if we replace that boost with our proposed IBC we can get nearly 1200 rpm of motor speed. This will help in increasing the motor efficiency.

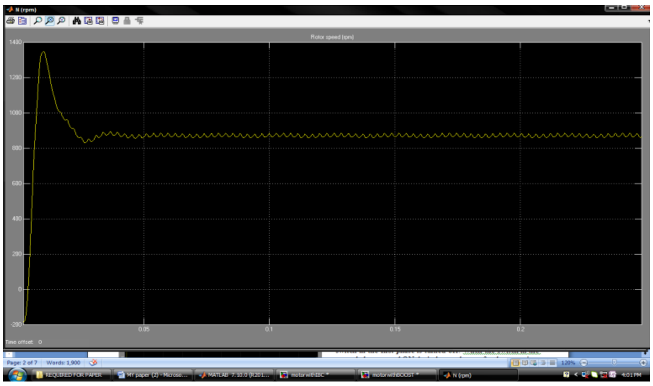

Fig – 5: motor speed waveform with boost converter

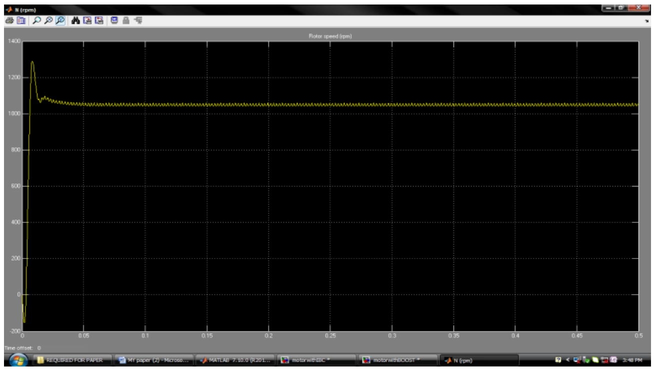

Fig – 6: motor speed with IBC

The below tabular column is prepared by taking different input power and their corresponding output power are noted down. And then the efficiency is calculated. For this obtained results the graph of efficiency versus output power is plotted. This graph clearly shows that, the efficiency of the proposed converter increases with increase in output power.

INPUT SIDE			OUTPUT SIDE			% η
V volts	I Amps	P watts	V volts	I amps	P watts	% η
5	1.8	9	9.2	0.91	8.372	93.02
12	4.6	55.2	22.9	2.29	52.44	95
60	24	1440	117.9	11.8	1391.22	96.6
120	48	5760	237	23.68	5612.9	97.43
200	80	16000	395	39.5	15602.5	97.8

Chart – 1: output power and efficiency for different input power

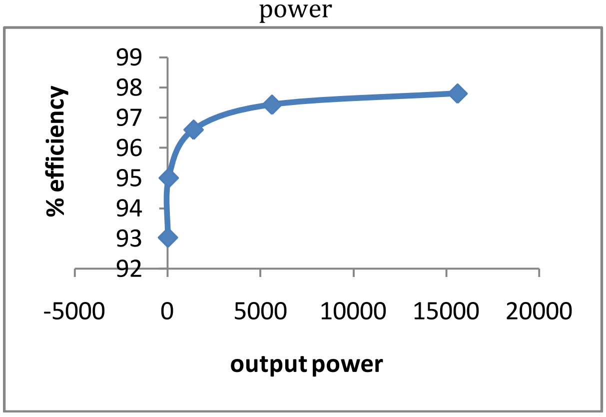

Fig – 7:graph of obtained results

5. EXPERIMENTAL SETUP

Fig – 8: Experimental setup

The above figure represents the experimental setup of Interleaved boost converter in running a BLDC motor. This model consists of totally 8 switches 2 are of IBC's and the rest 6 are of inverter. The driving signals for these switches are given from the pic microcontroller. The input supply from the solar panel is given to the IBC and the output of IBC is used for running the BLDC motor.

6. CONCLUSIONS

This paper shows the design and implementation of interleaved boost converter. Comparison between conventional boost converter with the proposed IBC along their application in running a BLDC motor with the motor speed variation is shown by using MATLAB/SIMULINK. From the obtained results we can conclude that, the IBC has higher boosting capacity, reducedinductor peak current and increased efficiency compared to that of conventional boost converters. This graph of efficiency versus output power is plotted and this graph clearly shows that, the efficiency of the proposed converter increases with increase in output power

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