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Hysteresis Based Double Buck-Boost Converter

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ABSTRACT

The Double Buck- Boost(DBB) converter is proposed which consists of one controlled switch,two capacitors and two inductors. The operation of the converter is equivalent to the cascade connection of two buck–boost converters,at which the controlled switch is shared by the two stages . The double buck–boost(DBB) converter was designed with a resistive load providing low ripple current, high power factor and low total harmonic distortion. As the film capacitors are used,the filter capacitances can be made small enough and the converter mean time between failures can be increased with the careful design of the converter. A comparative analysis of hysteresis current controller to proposed Double Buck-Boost Converter for 10% input voltage variation,48V output and 70W ac-dc converter is presented.

Keywords—DBB convertert,hysteresis current mode control.

1. INTRODUCTION

In this paper, Double buck–boost (DBB) converter is proposed, thus providing less total harmonic distortion (THD), high power factor (PF). The converter operation is equivalent to combination of two buck–boost converters, in which only one controlled switch was shared by the two stages [1]. Thus, the proposed converter comprises of three diodes, two capacitors, two inductors, and controlled switch, featuring good reliability and low cost. . As the film capacitors are used, the filter capacitances can be made small enough and the converter mean time between failures can be increased with the careful design of the converter [2]. The block diagram representation of a DBB converter is as shown in fig.1. A diode rectifier lets electrical current flow in only one direction and is mainly used for the ac/dc conversion, while the controller operates the switch in such a way to properly shape the input current according to its reference.

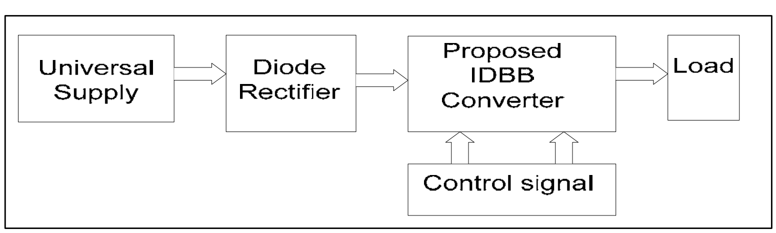

Figure 1 shows the block diagram of double buck–boost (DBB) converter.

A DC to DC converter has to provide a constant DC output voltage. Therefore, the control of the output voltage should be performed in a closed loop manner, using principles of negative feedback. Hysteresis current mode control technique was proposed as this technique has low distorted input current waveforms and it is a variable frequency control mode technique [3].In hysteresis control there is no need of ramp compensation and the inductor current must be sensed. The use of hysteretic controllers for low voltage regulators used in computer and communication systems has been gaining interest due its various advantages which includes fast response and robust with simple design and implementation[4-6].

A 70W load of 48v load voltage has been designed to illustrate the application of the proposed converter. In Section II, the converter design is presented. Section III deals with the design model. In Section IV, the control technique is illustrated. Simulation Results and Conclusion was presented in Section V and VI

I. *Converter Design*

The proposed converter was formed by the combination of two buck–boost converters. With the elements La, Da, Ca, and S1 the input side buck–boost converter is designed and with the elements Lb, Db, Dc, Cb, and S1, the output side buck–boost converter was designed. The reversing polarity in the capacitor Ca in the first converter can be rectified by means of the second converter, which gives a positive output voltage. The input inductor La is operated in discontinuous conduction mode (DCM), the line average current will be proportional to the line voltage, thus providing a unity PF nearly.

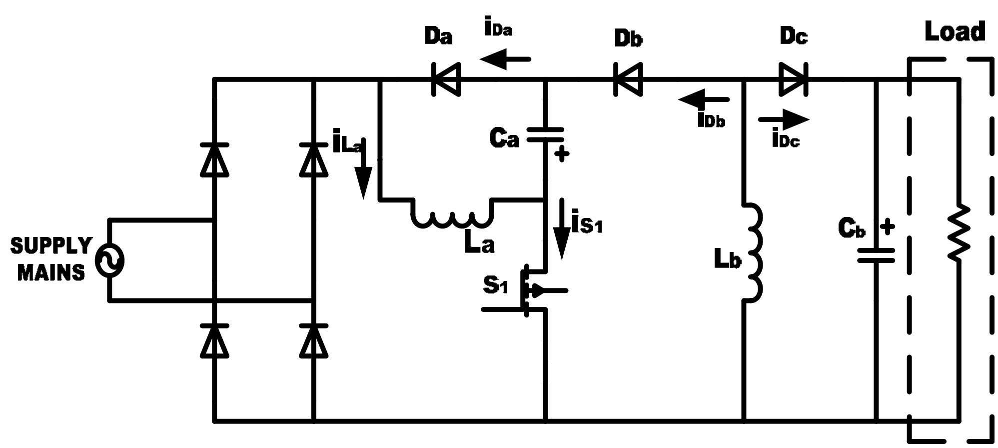

Figure2 shows the circuit diagram of a DBB converter

Figure 2 represents the proposed converter. The output inductance Lb can be operated either in DCM or continuous conduction mode (CCM). When it operates in DCM, even it has the benefit of providing a bus voltage across Ca independent of output power and the duty cycle, it requires a high output capacitance value in order to achieve low ripple current through the load.

In order to have a reduced output capacitance value and as the current ripple is less in CCM, the output inductor Lb was operated in CCM. In addition, the other stage operation in CCM with duty cycle under 0.5 reduces the low-frequency voltage ripple. The film capacitor which has high life rating compare to electrolytic capacitors is used as output capacitor.

II. Design Model

The input inductance La can be calculated for a given output power as

$$L_a = \frac{D^2 V_s^2}{4 P_o f_s} \qquad (1)$$

The bus capacitor Ca is calculated in order to limit the low ripple frequency.Ca can be calculated as

$$C_a = \frac{D^2}{8 V_B \pi L_1 f_s f_L \Delta V_{B\_LF}} V_s^2 \qquad (2)$$

The output inductance and capacitance Lb and Cb are

$$L_b = \frac{D V_B}{0.5 \Delta I_{LO\_HF} f_s} \qquad (3)$$

$$C_b = \frac{D V_O}{\Delta V_{O\_HF} f_s} \qquad (4)$$

Where IO is the load current, ΔVO_HF is the high-frequency peak-to-peak output voltage ripple and ΔILo_HF represents high-frequency peak-to-peak current ripple.

The line voltage is considered as 230 Vrms with a 50-Hz line frequency and a switching frequency of 50 kHz. The load is selected as resistive. By assuming constant current through the load, the converter must admit line voltage variation of 10%. By selecting 40% as duty cycle and by using formulae (1), (2), (3)and (4) the parameters are calculated as

Input Inductance La=1.2mH

Input Capacitance Ca=33.3mF

Output inductance Lb= 1.68mH

Output capacitance Cb= 16.7mF

Load Voltage V0= 48V

Load Current I0 = 1.458A

2. CONTROL TECHNIQUE FOR THE PROPOSED CONVERTER

Hysteretic control power converters are inherently fast response with easy implementation and it give excellent transient performance as it response to load change and disturbances right after the transient. Hysteretic control, also known as bang-bang control or ripple regulator control, maintains the converter output voltage within the hysteretic band centered about the reference voltage [7]. The well known characteristics of hysteretic Control were the varying frequency.

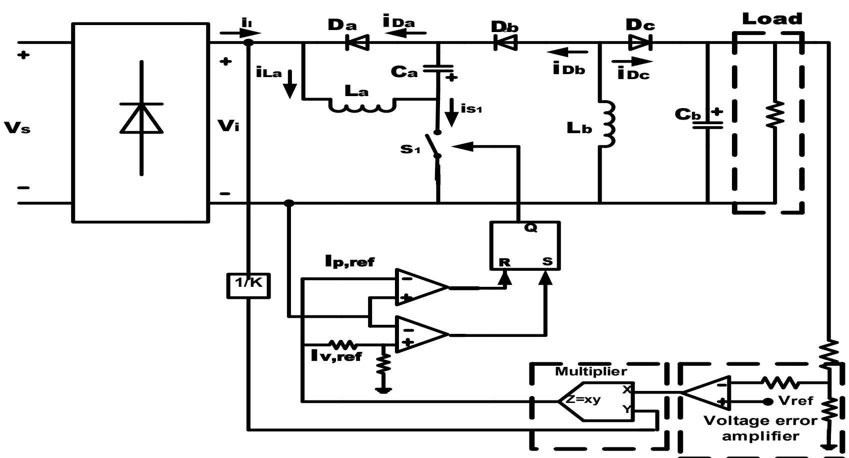

Figure3 shows hysteresis mode control.

The block diagram representation of hysteresis mode control is as shown in the figure3.According to this control method, switch S1 is turned on when the inductor current goes beneath the IV,ref i.e., lower reference value and it is turned off when the inductor current goes beyond the IP,ref i.e., upper reference value [8]. As shown in figure4, IPref, IVref are the two sinusoidal current references which represent the peak and valley of the inductor current. Thus, it gives rise to a variable frequency control. With this control technique there is no need of any compensation ramp and there are low distorted input current waveforms [10].

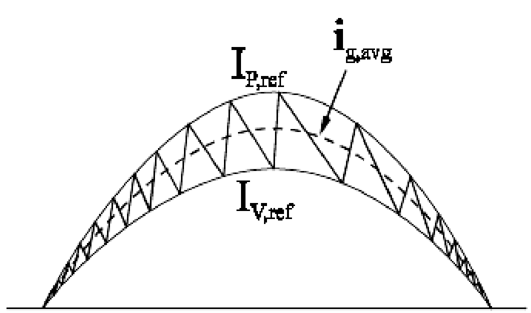

Figure 4. Hysteresis Current waveforms

Near zero crossing of line voltage, the switch can be kept open by introducing dead times in the line current in order to evade high switching frequency.

3. SIMULATION RESULTS

The Double Buck-Boost Converter was simulated by using MATLAB/SIMULINK and the resulting waveforms are shown below. The input voltage and current waveform for 230V supply voltage of 70W load is as shown in the Figure 5.

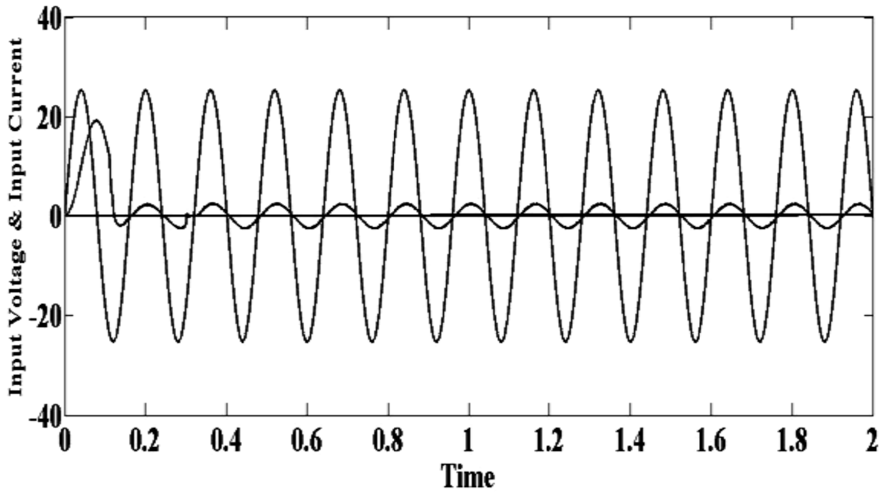

Figure 5. Input Voltage and Current waveforms

For a supply voltage of 230 Vrms of 70W load, the regulated output voltage for the proposed converter is maintained as 48V as shown in fig.6.

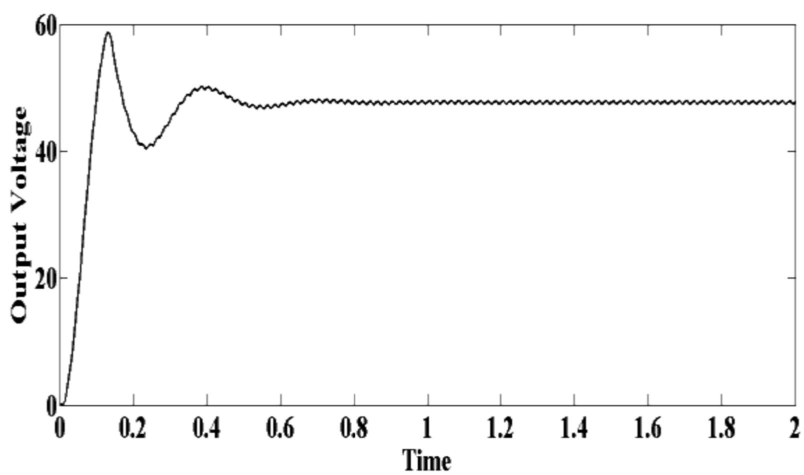

Figure 6.output voltage waveform

The regulated output load current for 230 V supply voltage of 70W load for the proposed converter is maintained as 1.458A s as shown in fig.7.

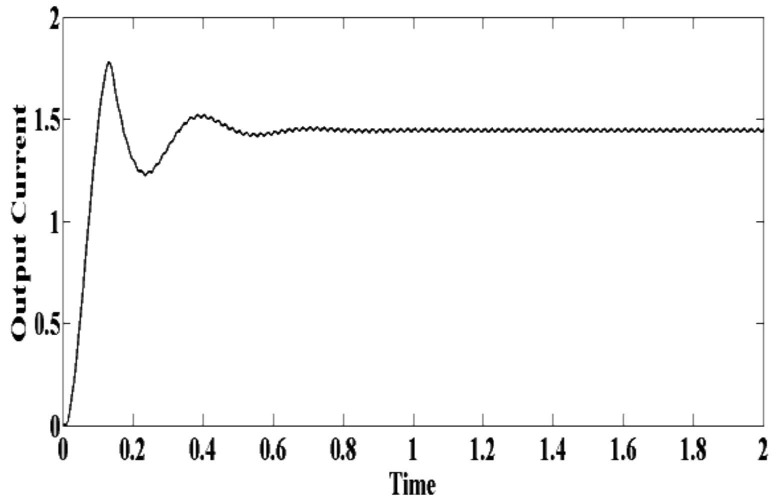

Figure7. Output current waveform

The THD of the proposed DBB converter with hysteresis control is very low as shown in Figure.8

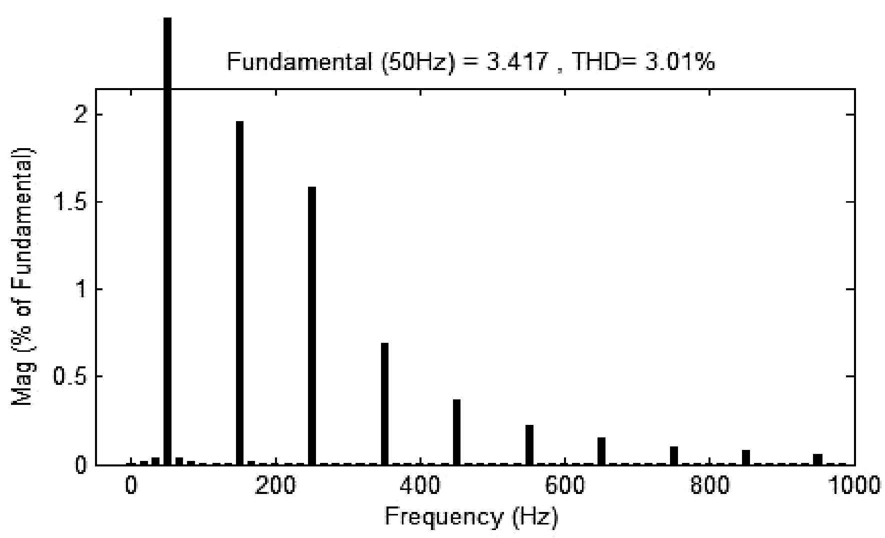

Figure8.THD representation for 230v supply voltage

The variation of output voltage and current variation for 70W load at different supply voltages is tabulated as shown in table1

Table-1. For a 70W load

Vs	V0	Io
210	47.63	1.36
220	48.97	1.384
230	47.73	1.446
240	49.85	1.51
250	47.73	1.437

Table 2 shows the variation of output voltage, output current, power factor and THD for different loads of 25W, 30W and 70W at a supply voltage of 230 Vrms.

Table-2.for a supply voltage of 230V

LOAD	V0	Io	P.F	THD
25W	47.63	0.512	0.988	3.19
30W	48.97	0.635	0.991	2.59
70W	47.73	1.446	0.992	2.59

4. CONCLUSION

A DBB converter was proposed with hysteresis current control for different load applications. The two buck– boost converter was combined by using only one controlled switch. By operating the input converter in DCM a high input PF can be attained. Without using a high output capacitance value a low current ripple can be obtained by operating the second stage in CCM. This configuration can stably maintain the output voltage and current to required level. In this way, the converter can be implemented by using only film capacitors, avoiding the use of electrolytic capacitors and increasing the converter mean time between failures. Thus the proposed DBB converter can provide high power factor and low total harmonic distortion.

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