**Indian Journal of Science and Technology,** *Vol 8(32), DOI: 10.17485/ijst/2015/v8i32/87609, November 2015*
*ISSN (Print) : 0974-6846*
*ISSN (Online) : 0974-5645*

# Interleaved Two Channel Boost Converter for Power Factor Correction using Boundary Conduction Mode

**S. Premkumar[1*], P. Karthick[2] and P. Sivaraj[2]**

[1]Department of EEE, Bharath University, Chennai – 600073, Tamil Nadu, India; prem035@gmail.com

[2]Department of EEE, Vel Tech Dr. RR and Dr. SR Technical University, Chennai – 600073, Tamil Nadu, India

## Abstract

This paper presents the concept of interleaved pulse width modulation to achieve boost converter with power factor correction and regulated DC voltage. The boost converter employs boundary conduction mode and zero current switching to achieve power factor correction. The converter is having a high voltage conversion ratio with wide span of turn ON and OFF period, which will differentiate this proposed converter from the conventional boost converter. The interleaved pulse width modulation will reduce current ripples of input and output currents. The interleaving will also aid to the reduction in size of the inductor and capacitor used for the proposed converter. In this paper the circuit configuration, principle of operation, simulation results, experimental results of the proposed converter are presented.

**Keywords:** Boundary Conduction Mode, Power Factor Correction, Pulse Width Modulation, Zero Cross Switching

## 1. Introduction

The interleaved boost converters are suitable to employ with the application of solar micro inverters, networking and telecom power supplies, high efficiency server power supplies. The above system will require high voltage boost conversion ratio for the smooth operation, this will be effected by the flexible duty cycle operation. In the proposed converter by the use of narrow turn off period the high voltage step up output has been realized[1]. The conventional boost converters cannot produce high voltage step up output because of the restriction in the duty cycle. The difficulty in the conventional boost converters employing high duty cycle is the non linear voltage conversion due to para cyclic resistance regulation of the output voltage. This paper presents new boost converter with high voltage step up output compared to the conventional converter. The proposed converter is working with interleaved pulse width modulation and on boundary conduction mode. By the use of the above techniques the input line current will follow the sinusoidal waveform which will reduce the input ripple current, this helps to get an input power factor improvement and reduction in total harmonic distortion. The proposed converter is employed with unique PWM generator IC FAN9612. This controller is having a control over the output of high voltage conversion ratio, zero cross switching and phase shading facility under low load condition to improve the efficiency. The low load condition refers to less than 12% at this load condition, one of the phases will be isolated from output connectivity and the remaining phase will feed power to the output[2-4].

## 2. Circuit Configuration

There are two circuit modules in the converter to archive high voltage conversion, load voltage regulation and ripple current cancellation. The input AC voltage has been rectified by a bridge rectifier. Inductor L1 and L2 are used to store energy when the switches Q1and Q2 are in ON

* *Author for correspondence*

condition respectively and release through the diode to the output when the respective switch is in off condition. The switches are controlled by the controller with 180 degree phase shift without missing of interleaving between the phases of the converter[5].

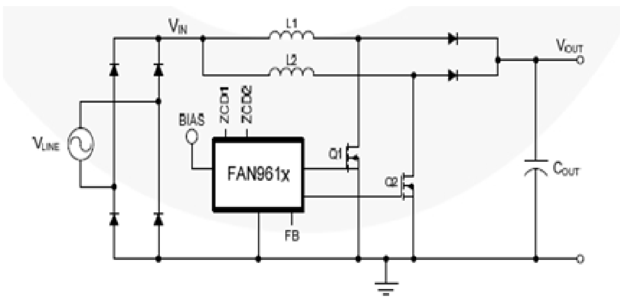


**Figure 1.** Circuit configuration of boost converter.

## 3. Priciple of Operation

The principle of operation is as follows

Boundary Conduction Mode

The main advantage of the Boundary Conduction Mode (BCM) is that, the new switching period is started when the inductor current returns to zero and the voltage wave form are as shown in figure 2

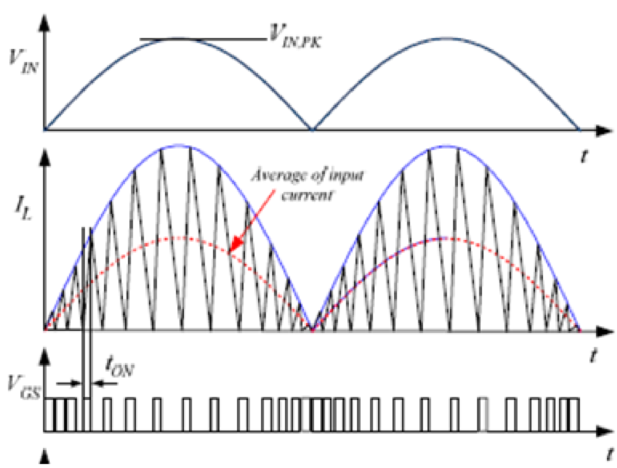


**Figure 2.** Inductor current wave form in BCM.

The controller used in this project will use the BCM algorithm for controlling the converter operation. The current wave form of inductor is triangular; the average value in every switching period is proportional to the sinusoidal input voltage. This process of operation leads the converter, uses the BCM operation to arrive an excellent power factor correction in the application. The frequency of operation is based on the instantaneous value of input voltage, the inductor value, output voltage and output power. The limitation of the operating frequency is based on the resonance between boost inductor and the parasitic capacitances of the switching device and the diode in every switching period. The Electro Magnetic Interference (EMI) filter used in the input side will minimize the noise induced by the ripple current[6].

### 3.1 Priciple of Interleaving

The control of two converters operating parallel in BCM with 180 degree out of phase is called as interleaving operation of converters. This method reduces considerably the current ripples in the input and output of the power supply and the requirement of filters of the converter. The interleaving reduces the current and thermal stresses of the components employed in the converter. The above properties and variable frequency of each converter are controlled by the controller employed in this converter[7].

### 3.2 Principle of PWM Generation

The boost converter works on BCM will operate on variable frequency and generate PWM pulses when the inductor current reaches zero, the zero current crossing is sensed by the secondary of the inductor used in the converter. The signal from the secondary and the timer signal will initiate the start of the switching cycle through a flip flop output[8].

### 3.3 Conduction Interval Operation

In BCM the conduction period completion is controlled by the PWM comparator, when the ramp wave form exceeds the control voltage provided by the error amplifier. Also in addition to the PWM comparator, the current limit and the Maximum on Time (MOT) signals put together will terminate the conduction time of the converter[9].

### 3.4 Phase Management

The output power in BCM will determine the output frequency of the converter. The converter operating frequency increases at light loads to maintain the output voltage at desired level. At light loads the peak inductor current will get reduced, due to this, the on time and the interval to reach the current to maximum or zero are reduced. To improve efficiency at light load, the controller disables one of the two converters, when the output power falls below a defined value and maintain high efficiency of the converter as shown in Figure 3. When the load is increased by a defined level both the converters will come to operation to feed the load requirement.

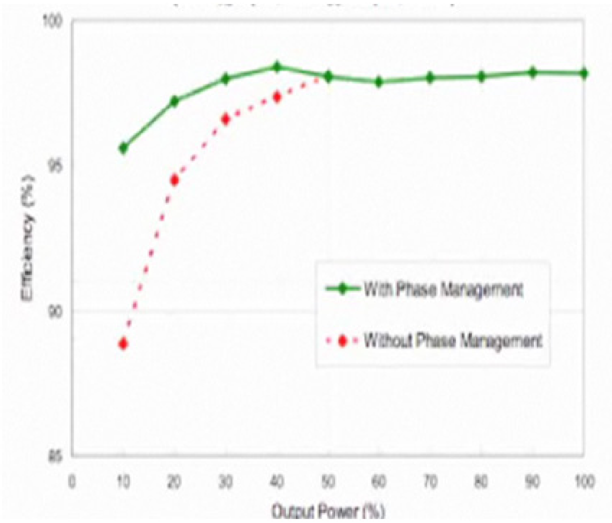


**Figure 3.** Phase management vs efficiency.

### 3.5 Soft Starting of Converter

In this converter closed loop soft start is employed. The reference voltage of the error amplifier is slowly increased to its final value. When the current and power limits of the converter are properly taken into consideration, the output voltage of the converter follows the reference voltage. This ensures that the error amplifier stays in regulation during soft start and the output voltage overshoot can be eliminated.

### 3.6 Zero Current Detection

The internal sense circuit is working as a differentiator to catch the valley point of the drain wave form. The maximum source current during zero current detection is limited to 0.5mA. The resistor used in between the auxiliary winding and the ZCD pin of the controller is used to limit the current. The $R_{ZCD}$

$$R_{ZCD} = \frac{1}{0.5mA} . \frac{Vo}{2} . \frac{N_{AUX}}{N_{BOOST}}$$

resister will be calculated as

### 3.7 Compensation by Error Amplifier

The output of the error amplifier is proportional to the input power and independent of the input voltage. The controller phase management circuit will sense the error amplifier output and drives the switches for single phase or two phase operation based on the load level threshold limit of power limit.

## 4. Simulation Characteristics

In the simulation part of the converter, both conventional and proposed circuits are simulated in MATLAB Simulink and the output waveforms are depicted.

### 4.1 Conventional Converter

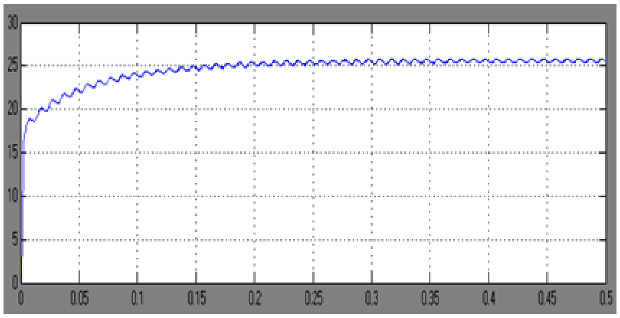

**Figure 4.** Output voltage of conventional converter.

In the above output voltage graph (figure 4), the output steadily increasing from origin and reaches the maximum value. From the graph we find that the output voltage is having ripples, which will affect the total performance of the circuit and increased size in the design value of the filter components.

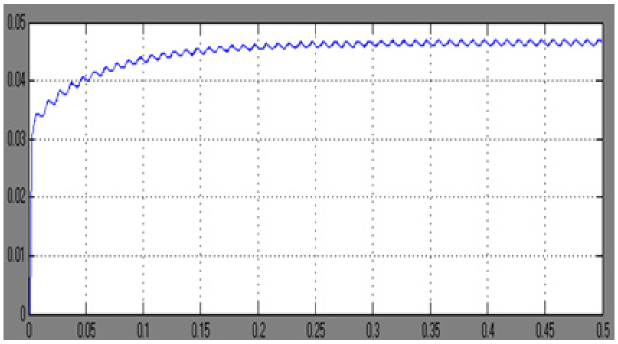

**Figure 5.** Output current of conventional converter.

In the above output current graph (figure 5), the current will follow the voltage waveform and steadily increasing to the maximum value, but with ripples in the wave form, which will affect the performance of the converter.

### 4.2 Proposed Converter

In the figure 6, the output voltage of the proposed converter is shown, from the waveform it is ensured that, the output voltage is free from ripples and providing a steady voltage output to the load and improved performance of the converter.

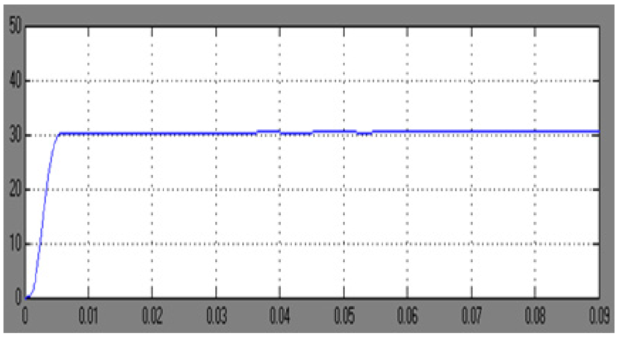


**Figure 6.** Output voltage of proposed converter.

In the figure 7, the output current is unlike the conventional converter with ripples, the wave form of proposed converter indicates that, the current is free from ripples and producing a steady current flow to the output load and improved performance of the converter.

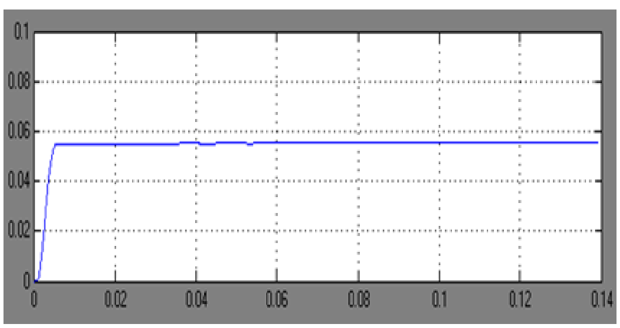


**Figure 7.** Output current of proposed converter.

## 5. Experimental Results

The experimental results are arrived after hardware assembly of the proposed converter, the selection of the components as per the design requirement and populated on a PCB for testing in the laboratory. The controller FAN9612 used for the control of the circuit operation including PWM generation after sensing the ZCD to get high conversion ratio boost output has been verified.

In the above figure 8, shows that the gate drive signal produced by the controller after satisfying the ZCD and valley point detection has been fed to the MOSFET for operation.

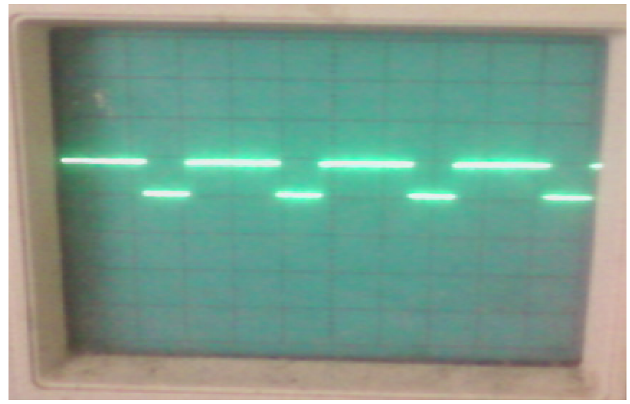

**Figure 8.** Gate drive signal.

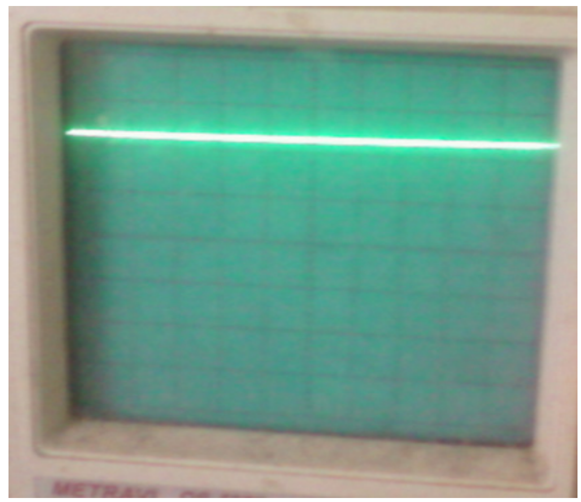

**Figure 9.** Output voltage waveform.

In the above figure 9, the output voltage developed by the converter with boost conversion ratio has been verified.

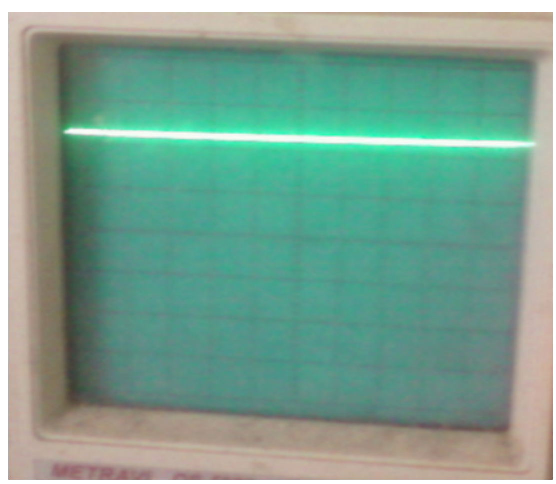

**Figure 10.** Output current wave form.

In the above figure10, it is observed that the current waveform is following the voltage wave form by the controlled operation of the converter through the controller. This will aid the experimental results to achieve better power factor improvement near to unity.

## 6. Conclusion

The two channel boost converter for power factor correction using BCM has been designed and tested in the laboratory and the results are obtained. From the experimental results, it ensures that the proposed converter can be used for high voltage step up ratio and unity power factor requirement loads. The simulation results are compared with the experimental results, the comparison shows that the results are in line with the expected results.

## 7. References


1. Lin BR, Chao CH, Chien CC. Interleaved boost- flyback converter with boundary conduction mode for power factor correction. 6th IEEE conference on Industrial Electronica and Application. 2011 June. p. 1828–33.
2. Li W, He X. ZVT interleaved boost converter for high efficiency, high step-up DC-DC conversion. IET Proceedings Electric Power Application. 2007; 1(2): 284–90.
3. Palaneeswari SM, Rajan PM, Silambanan S, Jothimalar. Blood lead in End-Stage Renal Disease (ESRD) patients who were on maintainence haemodialysis. Journal of Clinical and Diagnostic Research. 2012; 6(10): 1633–5. ISSN: 0973 - 709X.
4. Sharmila S, Rebecca LJ, Saduzzaman M. Effect of plant extracts on the treatment of paint industry effluent. International Journal of Pharma and Bio Sciences. 2013; 4(3):B678–86. ISSN: 0975-6299.
5. Rebecca JL, Dhanalakshmi V, Sharmila S. Effect of the extract of ULVA sp on pathogenic microorganisms. Journal of Chemical and Pharmaceutical Research. 2012; 4(11):4875–8.
6. Sharmila D, Saravanan S. Efficacy of lead on germination growth and morphological studies of Horse Gram Dolichos biflorus Linn. Journal of Chemical and Pharmaceutical Research. (2012); 4(11):4894–6. ISSN: 0975-7384.
7. Saduzaman M, Sharmila S, Jeyanthi Rebecca L. Efficacy of leaf extract of Moringa oleifera in treating domestic effluent. Journal of Chemical and Pharmaceutical Research. 2013; 5(2):139–43. ISSN: 0975-7384.
8. Choi H. Application note AN-6086 Design consideration for interleaved boundary conduction mode PFC using FAN9611/12. 2010 Apr.
9. Fair Child Corporation-FAN9612 Interleaved Dual BCM PFC Controller – Data sheet- Rev 1. 1. 6. 2008.
10. Kimio T, Natarajan G, Hideki A, Taichi K, Nanao K. Higher involvement of subtelomere regions for chromosome rearrangements in leukemia and lymphoma and in irradiated leukemic cell line. Indian Journal of Science and Technology. 2012 Apr; 5 (1):1801–11.
11. Cunningham CH. A Laboratory Guide in Virology. 6th ed. Minnesota: Burgess Publication Company; 1973.
12. Sathishkumar E, Varatharajan M. Microbiology of Indian desert. In: Sen DN, editor. Ecology and Vegetation of Indian Desert. India: Agro Botanical Publication; 1990. p. 83–105.
13. Varatharajan M, Rao BS, Anjaria KB, Unny VKP, Thyagarajan S. Radiotoxicity of Sulfur-35. Proceedings of 10th NSRP; India. 1993. p. 257–8.
14. 01 Jan 2015. Available from: http://www.indjst.org/index.php/vision