International Journal of Innovation and Scientific Research
ISSN 2351-8014 Vol. 11 No. 2 Nov. 2014, pp. 445-449
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http://www.ijisr.issr-journals.org/

Design a Phase Interleaving PFC Buck Boost Converter to Improve the Power Factor

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ABSTRACT: In this paper we describe the design of a phase interleaving buck boost converter and simulation of the same by using PSIM software. The important specification of IC UCC28063, which is used for controlling and regulating of buck boost converter is also discussed. The input range is (170-270) VAC and the output voltage is controlled to 216 VDC. This AC-DC buck boost converter operated at high frequency i.e. 25KHZ and maintains the power factor approximately unity. PSIM proved the feasibility of the design and we also used this PFC converter in a 5kva Online UPS system.

KEYWORDS: Phase interleaving, Buck boost, PFC, PWM, AC-DC Converter.

1 INTRODUCTION

The power factor correction is a key area of research in the field of power electronics. The low power factor and high pulsating current in the AC main are the main disadvantage for diode rectifiers and controlled rectifiers. They generate pollution in the power transmission line. The pollutants are current harmonic and reactive power which result in line voltage distortion, heating the core of the transformer etc. Normally a passive filter is used to improve the power quality because of its simple circuit design. The bulky size of the passive component, fixed compensation characteristic and its series and parallel resonance are main drawback of this approach to power factor correction. Another approach is active power filter which eliminates the current harmonics and improve the power factor. The PFC circuit is typically added at the front end of system. Solid state ac-dc conversion is used in adjustable speed drives, switch mode power supplies (SMPS), uninterrupted power supplies (UPS), solar PV, battery chargers, power supplies for telecommunication systems, test equipments etc. Power factor correction (PFC) is necessary for ac-to-dc converters in order to comply with the requirements of international standards, such as IEC 61000–3–2 and IEEE-519. PFC can reduce the harmonics in the line current, increase the efficiency and capacity of power systems. The Active Power Factor Correction (APFC) is a method to improve the power factor near to unity, reduces harmonics distortion noticeably and automatically corrects the distorted line current [2]. The PFC boost converter with continuous conduction mode is highly used for medium and high power application because the continuous current nature of the boost converter is conducting less electromagnetic interference compared to the other topologies like boost and buck boost. The phase interleaving topology of the converter is also one of the best topology for high power application. The main advantages of interleaving topology are sharing the input current due to paralleling of the two phases [5]. Hence our topology is interleaving buck boost topology using the IC UCC28063. The combined capability of power factor correction, active filter and AC-DC converter makes the new technique using PFC buck boost converter to simultaneously, reduce the harmonics current produced from the non-linear load regulate. The dc power supply to the non-linear load and draw nearly sinusoidal current from the supply. This approach does not require any special power device to reduce the current harmonics and power factor correction.

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2 TOPOLOGY

It is a two phase interleaving topology of buck boost converter. The main advantage of phase interleaving topology is that the total input current are divided into two phase, resulting in the current rating reduced the current rating of the switching devices. We can use any numbers of switching device as per the requirement of the application in each phase.

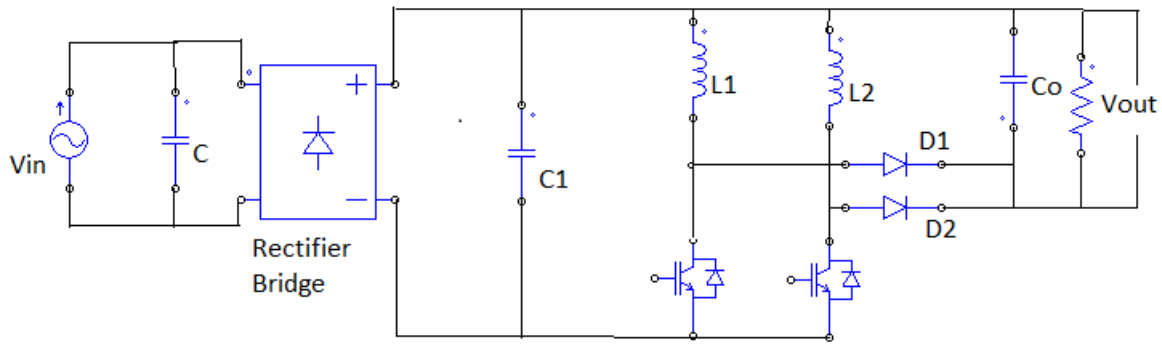

Fig 1: AC-DC Buck boost converter topology

We design the ac-dc buck boost converter of 5Kva capacity. Here we used for switching device in each phase for current sharing purpose,

3 DESIGN ANALYSIS

Here the design of the ac-dc buck boost converter of 4.5kw capacity is describing. In this input range is 170V to 270Vac and output is constant 216Vdc voltage, so that 192v lead acid battery can be connected.

Minimum input voltage = 170Vac

Output power =5KVA = 4.5KW

Output voltage = 216 V dc

Output current = $\frac{output\ power}{output\ voltage}$ = 4500/216 = 20.8A

Load resistance (RL) = $\frac{output\ voltage}{output\ current}$ = $\frac{216V}{20.8A}$ = 10.3Ω

Input current = 4500/170 = 26.4A

Input rms peak current (I p) = 37. 3A = 38A.

Total I p =160A

Operating frequency = 25 KHz

Time period T =1/F =1/25 kHz= 40µs,

Duty cycle D = $\frac{240}{240+216}$ = 0.47

We know that the duty cycle (D) = $\frac{Ton}{T}$

Ton = T * D = 40µs * 0.47 = 19µs.

Calculate the inductance using the following formula:

L = $\frac{Vdt}{di}$ = $\frac{240*19\mu s}{160/8}$ = 228µH

So inductance L = 228µH. (with EE-65 core)

Output capacitor = 4700µf/450V,

The selection of switching device (IGBT) is done on the bases of peak current, collector voltage and operating frequency. According to this requirement we selected the IGBT- K40H1203 whose rating is 40A/1200V and operating at high frequency.

4 SIMULATION RESULT

After fixing all these parameters we have simulated the circuit in PSIM software and the results are given below:

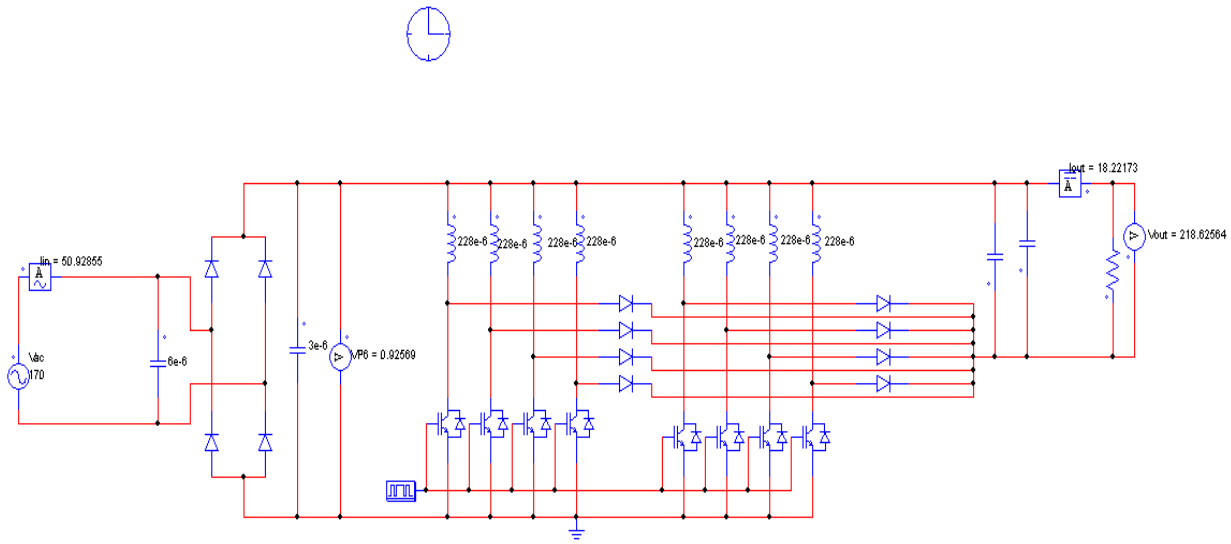

Fig 2: simulated circuit of PFC buck boost converter

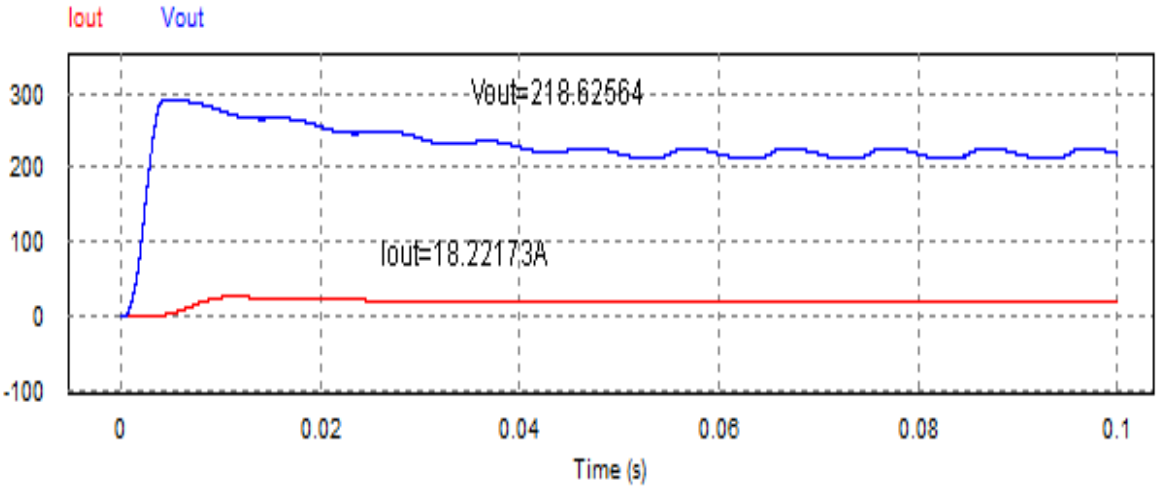

Fig 3: Waveform of Output voltage and output current

5 APPLICATION

We got satisfactory results from the simulation of the PFC converter circuit. Then we have decided to implement the 4.5kw UPS system with the same. We used this PFC buck boost converter at front end, and the dc output is given to the inverter input. A battery bank of (16 battery) is also connected at the output of ac-dc buck boost converter. The power diagram of the full system is given below:

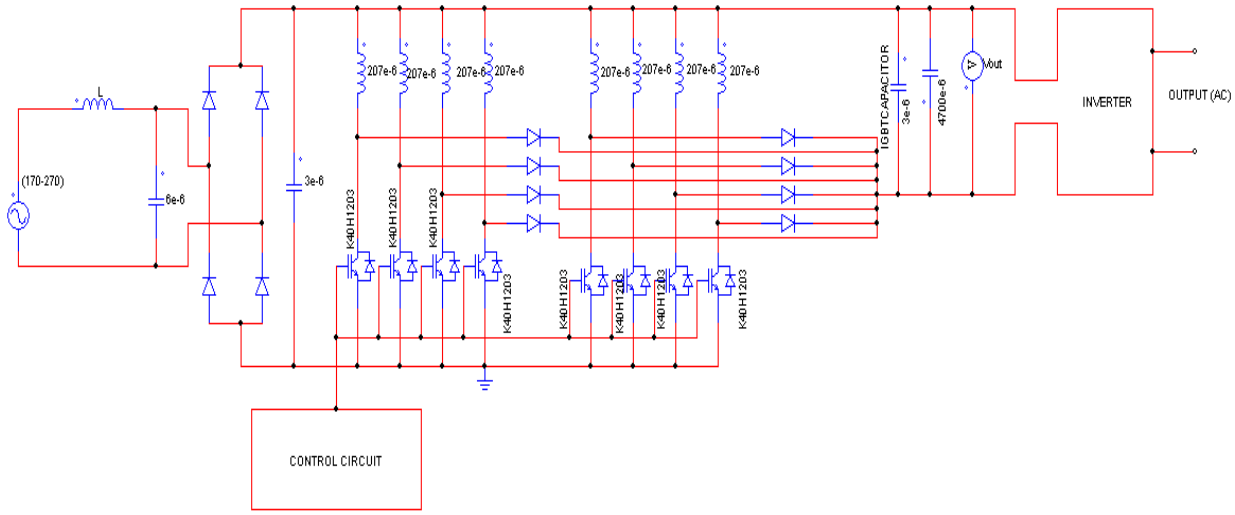

Fig 4: circuit diagram of online UPS system with PFC buck boost converter

According to this diagram we made the hardware and results are giving later. Here we used IC UCC2063 for controlling the PFC and regulate the output voltage, whose diagram is show in figure.5.

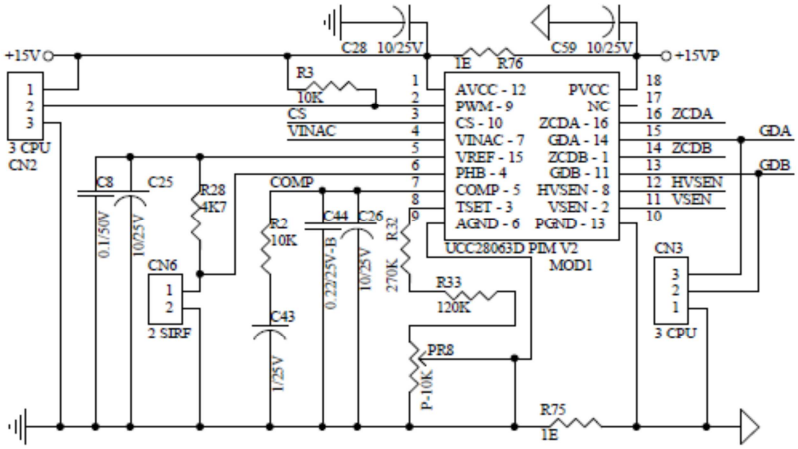

Fig 5: Buck Boost PFC Pre Regulator

6 PRACTICAL RESULT OF PFC CONVERTER

The following reading are taken to check the performance of the system, and got the maximum efficiency is 93% at almost full load condition. Power factor of system is 0.98 and total harmonic distortion is 7% according to the following reading.

Sr. No.	INPUT (AC)		PFC OUTPUT(DC)		PFC EFFICIENCY
	Current	Voltage	Current	Voltage	
1.	11.9	228.9	11.2	220.5	92.40%
2.	18.2	227	17.2	220.3	91.70%
3.	22.4	223	21	220.3	93%

7 CONCLUSION

In this topology we achieved a power factor 0.98 and total harmonics is 7% with good efficiency. Its performance is better than any other conventional topology. One other advantage is that we did not require separate charger to charge to the

battery bank, because we connect the battery bank at the output of the PFC buck boost converter. It provides the regulated dc output even if input voltage varies from 170v to 270 ac. Thus it's an optimal converter in terms of performance, efficiency and provides unidirectional (dc) power.

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