Power Factor Correction for Boost Converter

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Abstract: *In an electrical power system, a load with low power factor draws more current than a load with higher power factor for the same amount of useful power transferred. Power supplies with power factor correction (PFC) are becoming necessary for much industrial purpose to meetharmonic regulation and good power quality. Nonlinear loads such as rectifiers, distort the currentwaveform from the system. In such cases active orpassive power factor correction may be used tocounteract the distortion and raise the power factor. Linear loads with low power factor can be correctedwith a passive network of capacitors or inductors. Bridgeless single phase DC-DC active power factorcorrection for rectifier based BOOST topology isdescribed.Peak current control method is being used. Simulation is done for both open loop and closed loop system and the power factor obtained in closed loop system is better when compared to open loop system. Also by doing power factor correction, the power factor of the closed loop system is brought nearer to unity.*

Keywords: DC-DC Converters, Power Factor Correction Techniques, PROTEUS

1. Introduction

In recent years Switch Mode Power Supply technologies (SMPS) are developed rapidly. In different application SMPSsupplies are used as AC to DC sources for electronics products. But main disadvantages of this off line SMPS is that itdraws a pulsating current so it has low power factor and high RMS line current. So, due to increasing demand of highpower factor and good power quality Power Factor Correction is important part. Active Power Factor Correction (APFC) for DC-DC converters is economical and efficient. Inthis the different DC-DC converters topologies and their advantages and disadvantages are discussed. As these DC-DCconverters are worked as a non-linear load so it is important to study the effect of non-linear load and about harmonicsand need of improving power factor [1]. Method of improving power factor is activepower factor correction which has different types with their own advantages and disadvantages. The problem of lowpower factor can be improved by the power factor correction techniques. There are different power factor correction techniques. This paper discusses peak current control method. Power converter with PFC works with high frequency and it draws a sinusoidal AC current which is in phase with AC input voltage. This APFC method is interposed between AC main and DC load. And non-linear load is appearing as a linear load for the AC line. The main objective of this paper is the Power Factor Correction for Boost converter. If power factor of the system is poor then large amount of current is drawn from the supply [3]. So, the power factor correction is essential in power system to achieving good power. Advantages of Boost converter over other DC-DC converters are that output of Buck converter is always less than input and it requires an additional passive filter and output of buck converter is discontinuous and input current does not follow line voltage at zero crossing. When Boost and SEPIC converters are operated the output of both converters are discontinuous with high ripple. The drawback of Buck-Boost converter is when it operates there is high current stress on semiconductor devices and discontinuous input current which increase the THD.

Compared to other converters boost converter gives continuous input and output current with low current ripple and due to these advantages boost converter is best for the power factor correction.

2. Power Factor Correction

Due to the non-linear relationship of voltage and current all types of converters are producing harmonics. Thisharmonic distortion in current waveform will lead to poor power factor [2]. Poor power factor increase the value of RMS current, but the power delivered is small. So it is important task to improve power factor and reduce harmonics distortion to achieve good quality power. The parameter of boost converter is given in Table I.

Table 1: Simulation Parameters

Simulation Parameters	Values
Input Voltage	12 V
Frequency	50 Hz
Inductor L1	5 mH
Capacitor C1	1 nF
Capacitor C2	47μF
Load	1000 Ω
Switching Frequency	20 KHz
Duty Cycle	50%
Output Voltage	24 V

Power factor can be calculated by the equation:
*P F= 360*f*ΔT*

Where f = frequency in Hz
ΔT = displacement between input voltage and input current waveforms in ms

Power factor correction method is to improve power factor by suitable devices. The objective of power factorcorrection circuit is to make input power supply behave like purely resistive load.There are two methods of Power factor correction. They are Passive Power Factor Correction Method andActive Power Factor Correction Method.

Passive Power Factor Correction Method is used to improve the power factor for non-linear load [4]. In this method we useonly passive elements like capacitors and inductors to improve the nature of line current. But the size of passiveelements will increase as the level of voltage is increase [5]. And this method is used to improve power factor only up to 0.9, this is not used for industrial application.

Another important method to improve power factor is Active Power Factor Correction Method (APFC). This method isbased on switch mode converter technique and is designed to compensate for distortion as well as displacement of input current waveform. Main advantages of this method are that we can improve power factor up to 0.99 and automatic correction of AC input voltage can be obtained.

Here peak current control APFC method is used. In this method switch is turned on at constant frequency which is controlled by a clock signal. When the positive rampof inductor current and external ramp reaches to the reference current the switch becomes turned off. Reference signal is sinusoidal current which is obtained by the multiplying replica of rectified line voltage time the output of the voltage error amplifier. This reference signal is the condition to obtain unity power factor

Advantages of Peak current control method:
(1) Constant switching frequency.
(2) No need of compensation ramp.
(3) Only switch current must be sensed and this can be accomplished by a current transformer.
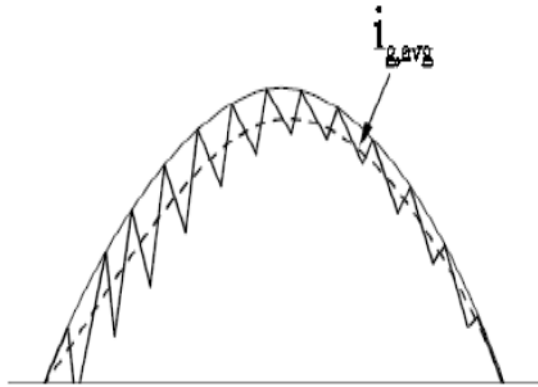
Figure 1: Peak Current Control

Figure 1 represents peak current control method. In advanced power supply systems, peak current control offers many advantages including improved load line regulation, cycle by cycle current limiting and protection and better flux balancing. Peak current control places a fast current loop inside thevoltage control loop. This loop senses the inductor current and uses this information as the ramp signal to the pulse width modulation comparator. This loop can interrupt the drive to the output devices in the propagation delay time of the pulse width modulator, when a fault is detected.
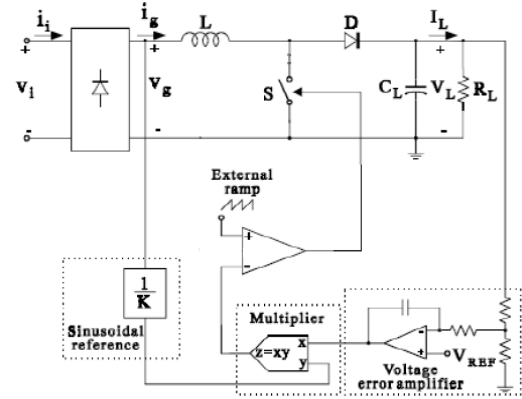

Figure 2: Circuit Diagram

Figure 2 indicates the proposed circuit diagram, it consist of three sections. Rectifier, boost converter and a control circuit. The output of boost converter is given to voltage error amplifier, where it is being compared with a reference voltage and the error voltage is amplified and given to a multiplier. To the other terminal of multiplier current signal is given. The output of the multiplier is given to a comparator, which compares the signal with a ramp signal. The Switching pulse so produced from the comparator is used for triggering the switch used in the boost converter.

3. Simulation Model
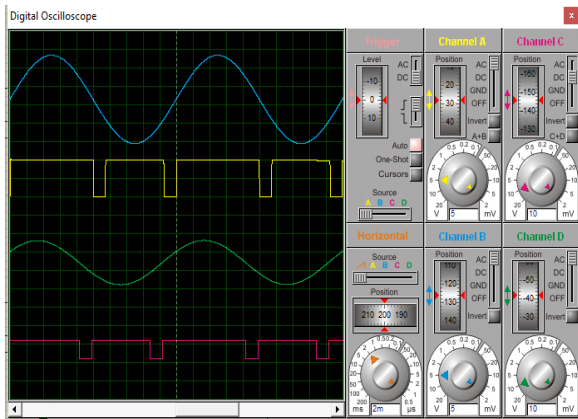
I. Boost converter without power factor correction

Figure 3 represents the simulation diagram of boost converter without powerfactor correction.
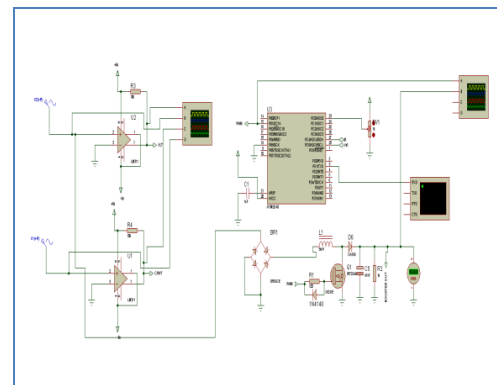
Figure 3: Simulation diagram of boost converter without power factor correction

From the diagram it is clear that the output voltage of Boost converter without power factor correction is 22.4 v.
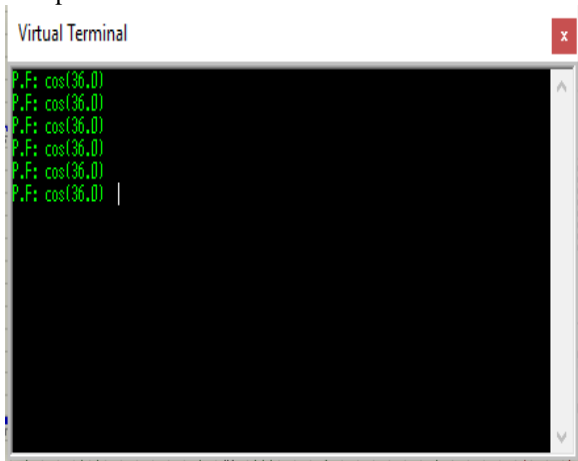
Figure 4 represents the input voltage and input current waveforms of Boost converter without power factor correction.

Figure 4: Input voltage and current waveforms

From the above figure, it is clear that the input voltage and current are not in phase. When the boost converter is operated without power factor correction it draws high input current with high ripple. The input line current and voltage is also not in phase and it has low power factor which is undesirable for industrial application.

Figure 5 represents the power factor of boost converter without power factor correction.
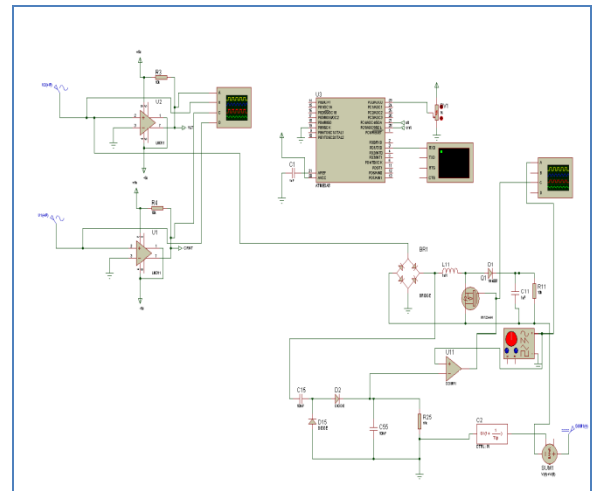

Figure 5: Input Power Factor of boost converter without power factor correction

The power factor is obtained as 0.81.

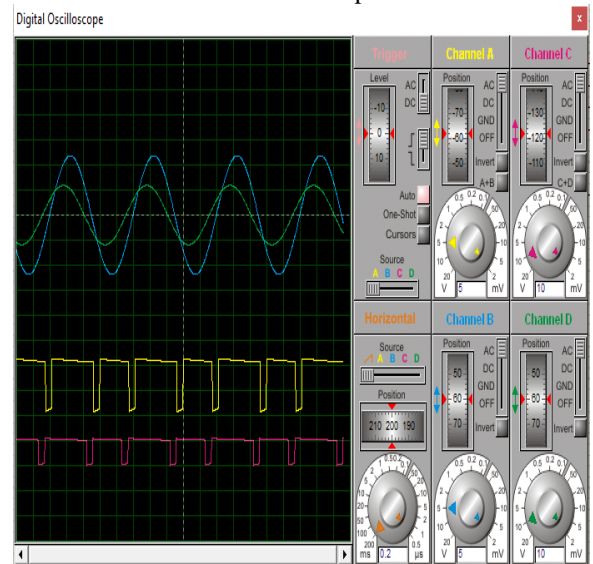**II. Boost converter with power factor correction**

Figure 6 represents the simulation of boost converter with power factor correction.

Figure 6: Simulation with power factor correction

The output voltage of boost converter with power factor correction is obtained as 24 v.

Figure 7 shows the input voltage and input current waveforms of boost converter with power factor correction.

**Figure 7:** Input Voltage and current Waveform

From the above figure it is clear that the input voltage and input current waveforms are almost in phase when compared to input voltage and input current waveform which is obtained from boost converter without power factor correction.

Figure 8 represents the power factor obtained from the boost converter with power factor correction. The obtained power factor is 0.92.
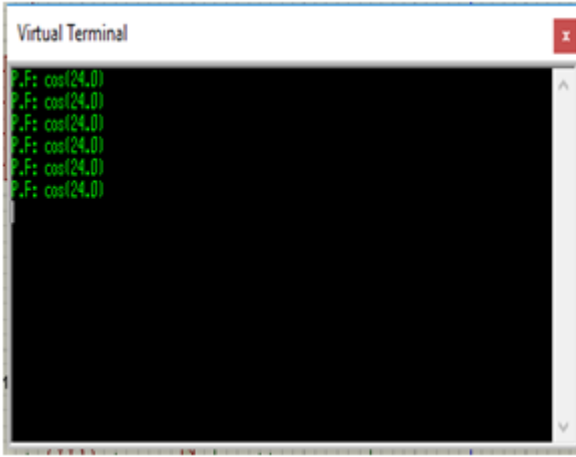
Figure 8: Input power factor after power factor correction

Figure 9 represents the switching pulse which is generated from power factor correction circuit. This is used to switch on and off the MOSFET present in the boost converter.
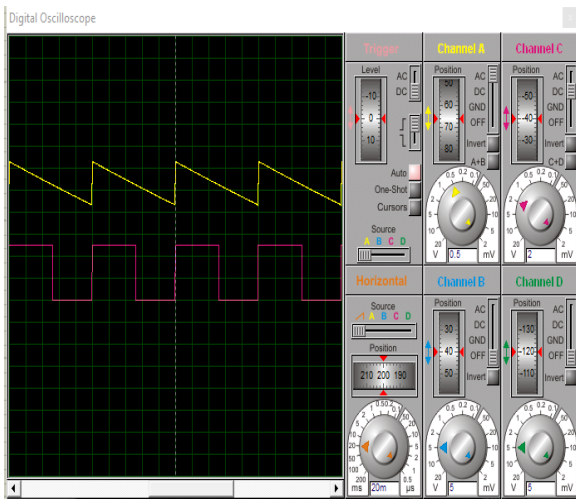
Figure 9: Switching pulse to MOSFET

4. Results

The following results are obtained

Table 2: Comparative result of open loop and closed loop

Parameter	Open Loop	Closed Loop
Output Voltage Of Boost	22.4	24
Power Factor	0.81	0.92

Table II represents the results obtained from the open loop and closed loop simulation of boost converter.In open loop, without power factor correction boost output is obtained as 22.4 v and power factor is obtained as 0.81 whereas on closed loop, with power factor correction, boost output is obtained as 24 v and power factor is improved to 0.92. From the above results it is very well clear that the active power factor correction method can bring the power factor closely towards unity.

5. Conclusion

This paper discussed the detailed study about the harmonics and effect of non-linear load (DC-DC converter) on input line current and on power factor. Due to low power factor input line current has high harmonics and it is not in phase with the input line voltage. So power factor is poor and it will draw pulsating line current. To overcome this problem power factor techniques are used which is also discussed in this paper. By using peak current control technique the input line current follows the input line voltage and power factor is brought closer to unity.

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