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Power Factor Correction of Three Phase Rectifier with Interleaved Boost Converter

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ABSTRACT: This paper proposes a method of improving the power factor of a three phase rectifier by using a interleaved boost Converter with Power Factor Correction Controller. When compared to Power Factor Correction and THD minimizations of three phase rectifier with single phase rectifier , Power Factor Correction of three phase rectifier with interleaved boost converter Method is good because here THD is very low . Average Current Control technique has been discussed in this paper. Modelling of the PFC Controller using MATLAB/ Simulink is carried out and the results are verified..

KEYWORDS: Three phase uncontrolled rectifier , Interleaved boost converter, Power Factor Correction, Average Current Control, MATLAB/Simulink.

I.INTRODUCTION

Single phase rectifier with Power Factor Correction (PFC) has been discussed in many papers [1-5]. But coming to the practical case three phase rectifiers are commonly used for high power applications. Power factor correction is becoming more important nowadays, as we are more concerned about the reduction of harmonic components in the supply side. Power Factor Correction can be of two types: Active or Passive [6]. Passive power factor correction involves the use of linear elements like inductors and capacitors to improve the power factor and minimize harmonic components in the power supply. Passive power factor correction for high power applications requires large inductors and capacitors. So, Active power factor correction is used in high power applications. In active power factor correction methods, the input current is forced to follow the input voltage, so the ratio between voltage and current will be maintained constant and the power factor will be unity, whole circuit emulates as a simple resistor by the power supply [7]. When the ratio between voltage and current deviates from the constant, results in phase displacement ,harmonic distortion or both in the power supply, and deteriorate the power factor [8].

Power factor is defined as the ratio of real input power to the RMS value voltage and current of the load or power factor corrector input. Phase displacement is the measure of reactance of the input impedance of the active power factor corrector. Reactance either in inductive or capacitive form will cause phase displacement of input current waveform with respect to input voltage waveform. Harmonic distortion is the measure of the non-linearity of the input impedance of the active power factor corrector. Distortion increases the RMS value of current without increasing total power being drawn. A non-linear load has a poor power factor because the total power delivered is less compared to RMS value of current. When harmonic distortion alone is considered, power factor deteriorates to 0.999 for 3% of Total Harmonic Distortion (THD) .

II. ACTIVE POWER FACTOR CORRECTION

Boost converter topology is commonly used for power factor correction circuits the input current is continuous and produces lowest level of conducted noise and best input current waveform. In this topology, the output capacitor absorbs the input power pulsation, thus the ripple on the output voltage is reduced [10]. Only disadvantage of this topology is that the output voltage is always higher than the input voltage. In boost converter topology, Power factor correction is achieved by forcing the input current to follow the input voltage waveform. Active power factor correction can be achieved by two methods- average current control technique and peak current control technique. Both these techniques use current loop feedback to control the input current. Compared to average current control, peak current control has a low gain and wide bandwidth. So, by using average current control technique, a better power factor can be achieved and this technique also allows a better input current waveform .

III. AVERAGE CURRENT CONTROL METHOD

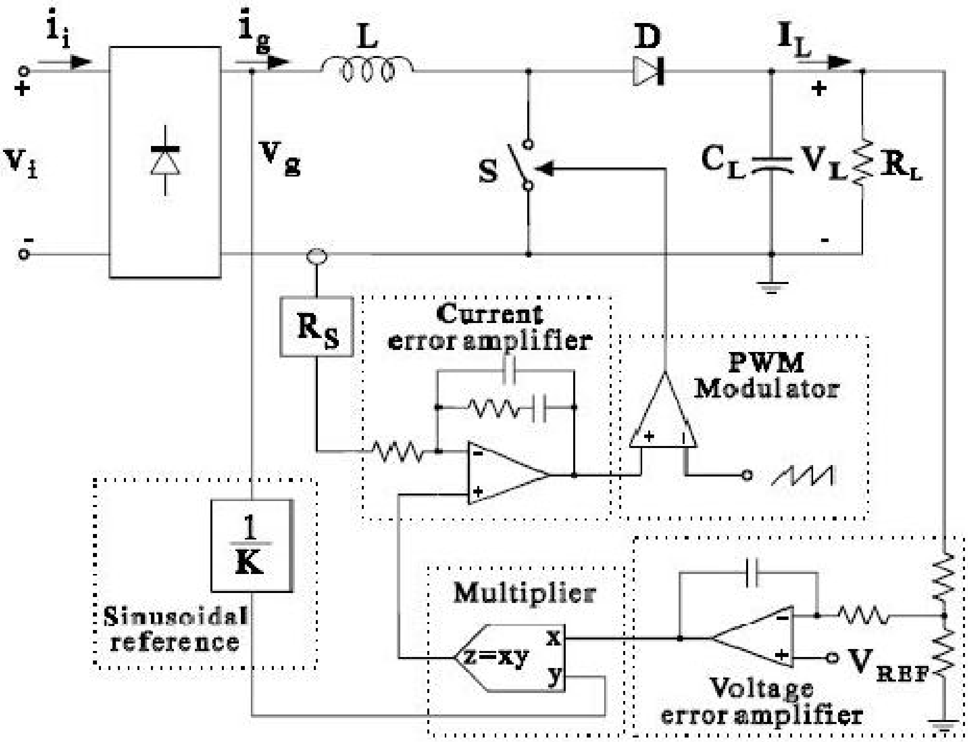

Fig. 2. Average Current Control Technique

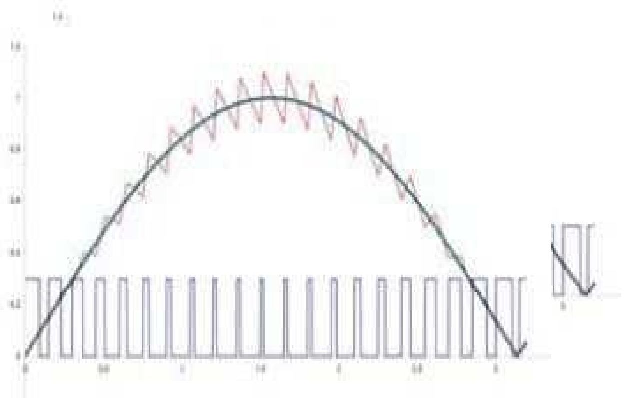

Fig. 3. Switch waveforms ith input current waveform

The block diagram for average current control method is shown in Fig.2. The input current and switching waveforms are shown in Fig.3. In this the current through the inductor is sensed and is given to a current erroramplifier, which drives the Pulse Width Modulation (PWM) Modulator. Thus the error between the average current ig and reference current has been reduced by the current loop. The converter works in continuous conduction mode.

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IV.IINTERLEAVED BOOST CONVERTER

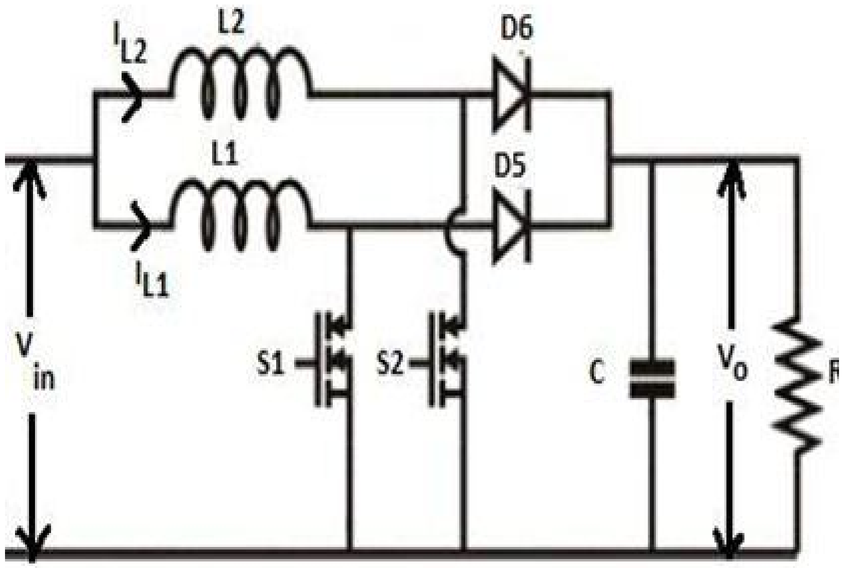

Fig.4 interleaved boost converter

A two-limb parallel connected conventional boost converter is shown in Fig.4 this is typically called an interleaved boost converter. This converter is used to improve power factor For a step-up application, an equivalent interleaved boost converter offers several advantages over a conventional boost converter; such as a lower current ripple on the input and output stages. Therefore, there is there is the opportunity to minimise the output capacitor filter that is often quite large in the conventional boost . In addition, it effectively increases the switching frequency without increasing the switches losses. Furthermore, it provides a fast transient response to load changes and improves power handling capabilities. A higher efficiency may be realized by splitting the input current into two paths, substantially reducing i^2R losses and inductor AC losses. This also gives low stresses on components due to the current split which increases the power processing capability [9]. However, using an interleaved converter increases the number of power handling components and circuit complexity which may lead to an increase in cost. However, in renewable energy systems, long-term improved power generation can help to offset this disadvantage [9]. The topology of the interleaved boost converter consists of two limbs operating at 180 degrees out of phase from each other. Typically, each branch operates in the same fashion as a conventional boost converter previously described in Chapter four. When S1 turns on, the current ramps up in L1 with a slope depending on the input voltage storing energy in L1, D1 is off during this time since the output voltage is greater than the input voltage. When S2 turns off, the L2 inductor delivers part of its stored energy to output capacitor and the load, the current in L2 ramps down with a slope dependent on the difference between the input and output voltage. One half of a switching period later, S2 also turns on, completing the same cycle of events

V. RESULT AND DISCUSSION

The MATLAB Simulink model of interleaved boost PFC converter average current mode control by PI controller is shown in Fig.5

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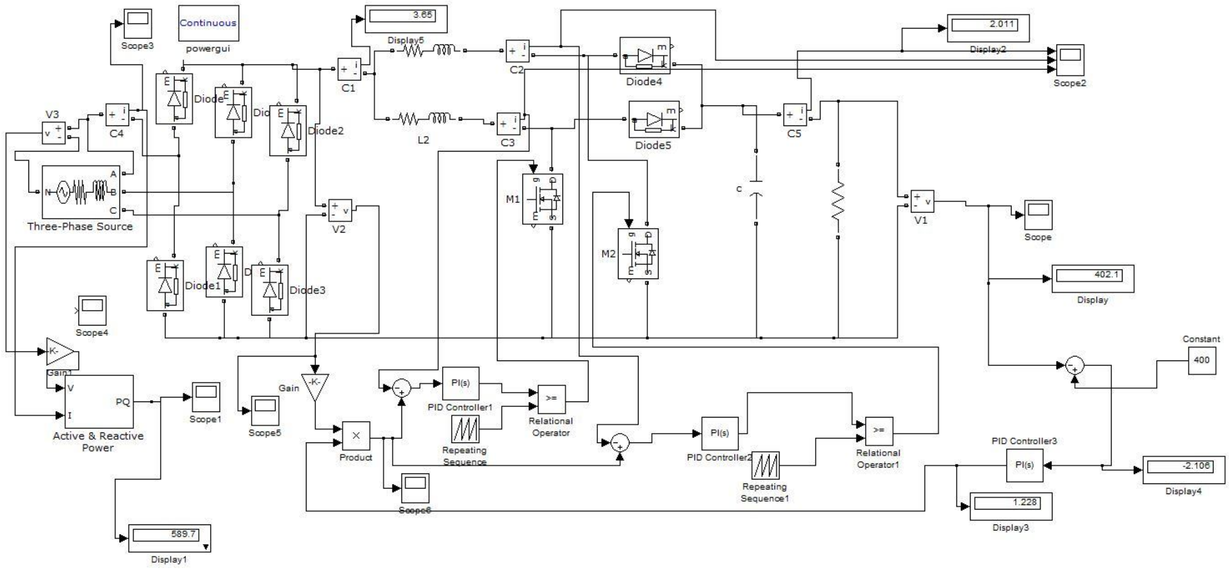
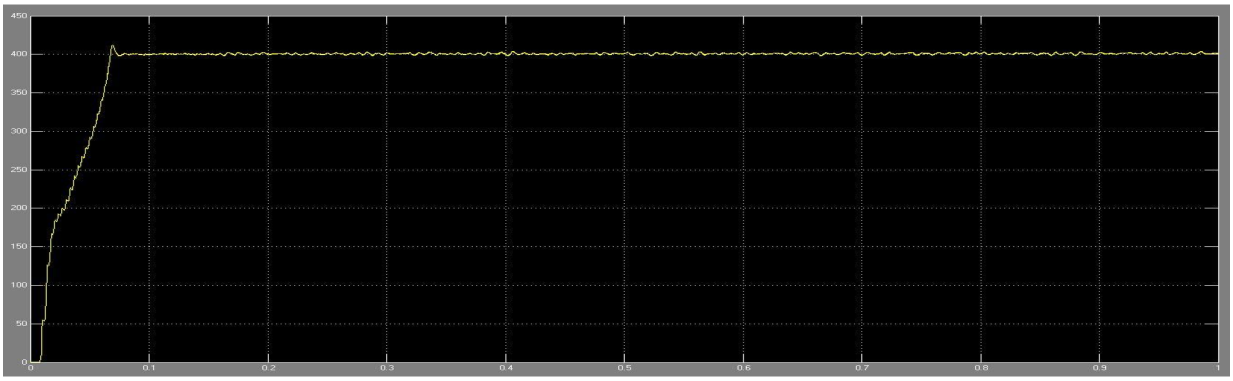


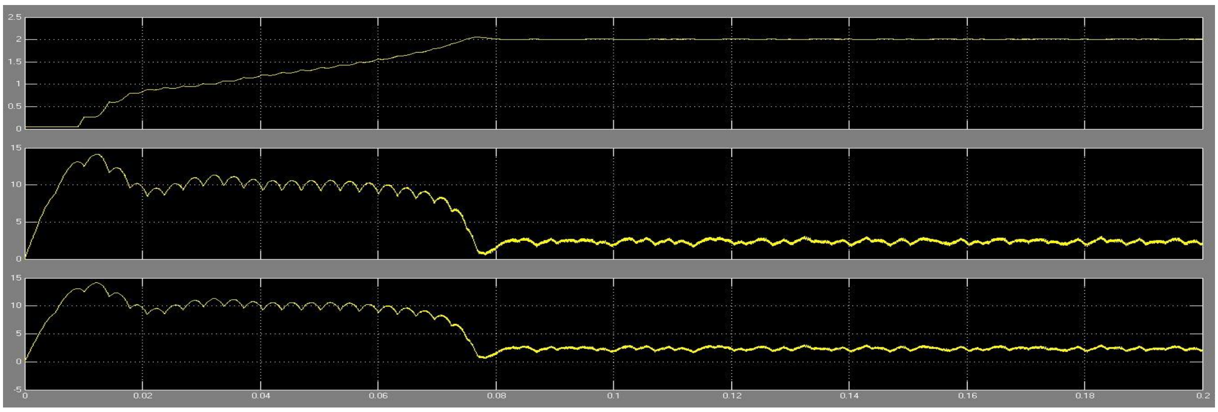
Fig;5 Simulation block diagram of three phase rectifier with interleaved boost converter

The output voltage waveform is given below as shown in fig 6



Fig;6 output wave forms of interleaved boost converter

The output current waveforms and inductor current waveforms $I_{L1}$and I_{L2} is given below respectively as shown in fig:7



Fig;7 output current waveforms and inductor current waveform I_o ,I_{L1} and I_{L2}

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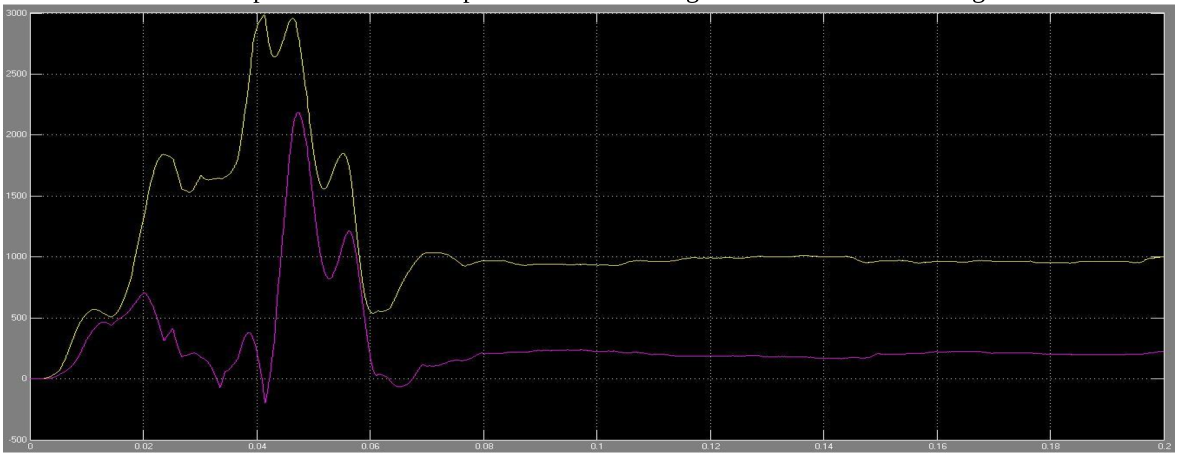
The active power and reactive power waveforms is given below as shown in figure 8

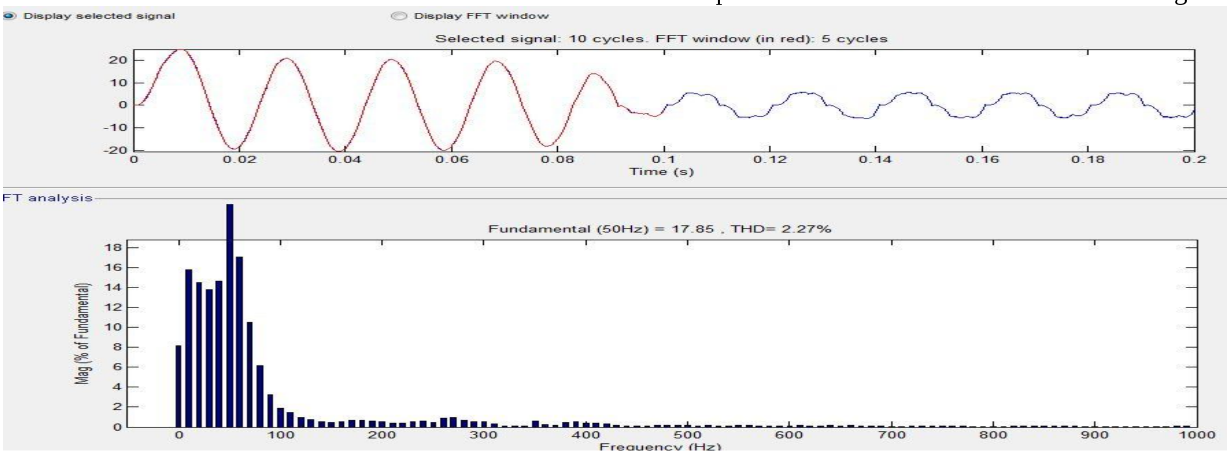


Fig;8 Active power and reactive power waveforms

Active power= 1000watt Reactive power = 130 VAR

Power factor= 0.99

The total harmonic distortion waveforms of input current as shown in figure 9



Fig; 9 THD waveform of input current

The THD of input current is 2.37% which is very low in comparison when we use single phase rectifier [1]

VI.CONCLUSION

Conventional method of improving power factor will increase the size of inductor and capacitor for high power applications. Active power factor correction can be used in high power application as size gets reduced. By correcting both the distortion power factor and displacement power factor, efficiency of the system is improved.In Active Power factor correction technique, the input current is forced to follow the input voltage waveform, their by achieving a power factor near unity. In addition to that Active Power factor correction will give a regulated output voltage. PFC using average current control is modeled in MATLAB/Simulink software. Power factor of the circuit is improved to 0.99 by using active power factor correction though the THD is 2.27%. .

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