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Comparison of PFC Circuit Topologies

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ABSTRACT: *The equipment connected to an electricity distribution network usually needs rectification. The conventional single phase diode rectifier uses a large electrolytic capacitor to reduce DC voltage ripple, which produces a non-sinusoidal line current. So power factor correction (PFC) techniques are gaining attention now a day. The boost topology is most popular than others in PFC applications. This paper presents a two-phase interleaved boost converter which ensures 180˚ phase shift between the two interleaved converters. The PI controller is used to reshape the input current so as to reduce the harmonics.*

Keywords : *Boost converter, Interleaved Boost converter, PI controller, Power factor correction*

I.   INTRODUCTION

Single phase diode rectifiers are the most commonly used circuits for application where the input is the ac supply. These classical converters operate by rectifying the input ac line voltage and filtering it with large capacitor. The filter capacitor reduces the ripple present in the output voltage but introduces distortion in the input current which reduces the power factor. So PFC techniques are used. Improvements that can be achieved by passive PFC techniques are limited. Much better result can be achieved by active PFC technique [1]. The most popular topology for active PFC is boost converter as it draws continuous input current. This input current can be manipulated by average current mode control technique [2][3]. But there are ripple in the input current due to inductor of boost converter which can be minimized by using two phase interleaved boost converter [4][5][6]. In two phase interleaved boost converter two boost converters operate in 180˚ out of phase. The input current is the sum of two inductor currents. As the inductor's ripple currents are out of phase they cancel each other out and reduce input ripple current that the boost converter cause. This paper introduces average current mode control of interleaved boost converter using PI controller which provides higher power factor and also provides better control. In this paper simulation of single phase diode rectifier, simulation of Boost converter with PI controller and then simulation of interleaved boost converter with PI controller is given to show that average current mode controlled interleaved boost converter with PI controller provides best power

II.   POWER FACTOR IMPROVEMENT

Power factor is the ratio of real or true power to apparent power[6]. Power Factor is the cosine of the phase angle between current and voltage. Power factor is the ratio between the kW and the kVA drawn by an electrical load where the kW is the actual load power and the kVA is the apparent load power. Active Power is the base line and is the "real" usable power measured and paid for in kW. Reactive power is the vertical or that part of the supply which causes the inductive load. The reactive power in is measured in kVAr (kilo volt-amperes reactive).

III.   BENEFITS OF POWER FACTOR IMPROVEMENT

The load on the cables and switches is reduced.
1.   The supply is now able to support additional load.
2.   The charges made by the electricity supply company are likely to be reduced [6].
3.   Any charges for excess reactive power are avoided.
4.   System losses are reduced.
5.   Distribution equipment runs cooler and lasts longer[7][8].

IV.   SIMULATION BASED ANALYSIS OF POWER FACTOR IMPROVEMENT
(a) Single phase diode rectifier.

Single phase diode rectifiers are commonly used for ac-dc conversion[9]. But the rectified dc voltage contains fair amount of ripple. To reduce this ripple a filter capacitor is used[10]. The filter capacitor reduces the ripple present in the output voltage but introduces distortion in the input current which reduces the power factor[11]. So PFC techniques are used. Improvements that can be achieved by passive PFC techniques are limited. Much better result can be achieved by active PFC technique[12][13][14][15][16]. The most popular topology for active PFC is boost converter. This input current can be manipulated by average current mode control work is carried out in MATLAB- Simulink capacitor voltage capacitor the power factor becomes poor and introduces several problems including reduction of available power and increased loss.
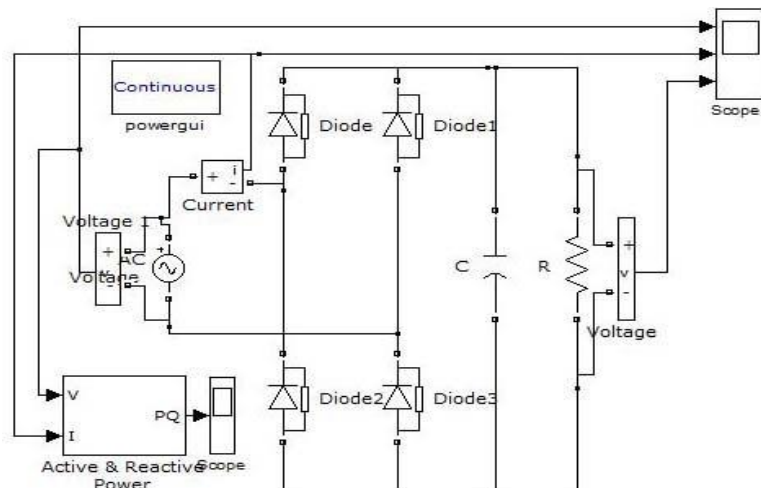

Fig 1: Simulink diagram of single phase diode rectifier
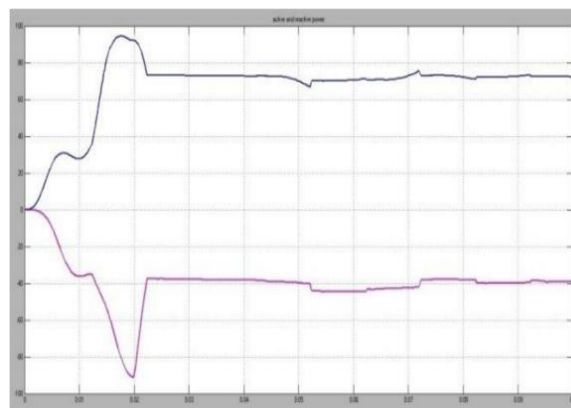

Fig 2: Active and Reactive power waveform

At first simulation of single phase diode rectifier is performed. The MATLAB-Simulink model of single phase diode rectifier with filter capacitor is shown in Fig.1. The Active and reactive power waveforms are shown in Fig.2.Power factor can be calculated by active and reactive power. In this case the input power factor is 0.8756.

(b)Boost converter and interleaved boost converter
For boost converter

To prevent the problem of pulsating input current PFC techniques are used[8]. Best result can be obtained by using active PFC techniques based on switch mode power converters[16]. The boost topology is by far more popular than other PFC techniques. The circuit diagram of a boost converter is shown in below
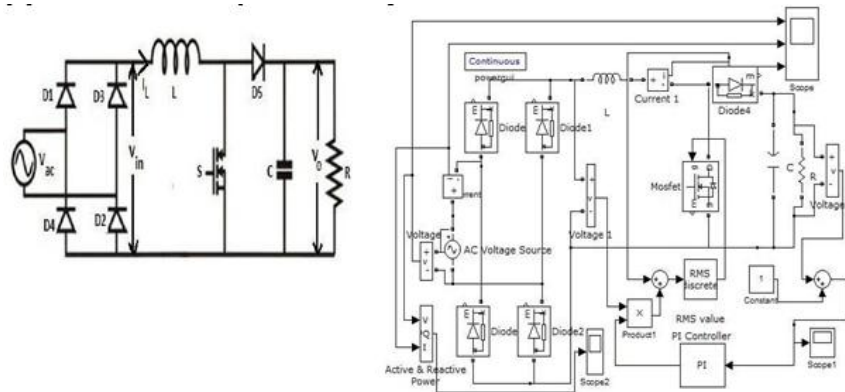
Fig 3 : Circuit diagram and SIMULINK diagram of boost converter

When the switch S is on the current IL rises and flows throughinductor L. When switch S is off the current IL decreases and flows through L, diode D5, C, and R. The current IL falls until switch S is turned on again.So when switch S is on

$$\frac{dI_L}{dt} = \frac{V_{in}}{L} \qquad (1)$$

Again when switch S is off

$$\frac{dI_L}{dt} = \frac{V_o - V_{in}}{L} \qquad (2)$$

Here Vin is the rectified input voltage and Vo is the output voltage. So the boost converter draws continuous input current. This input current can be controlled to follow a sinusoidal reference using average current mode control technique. To improve the power factor boost converter can be used. The MATLAB-Simulink model using boost converter is shown in Fig.3. The active and reactive power wave forms are shown in Fig.4.
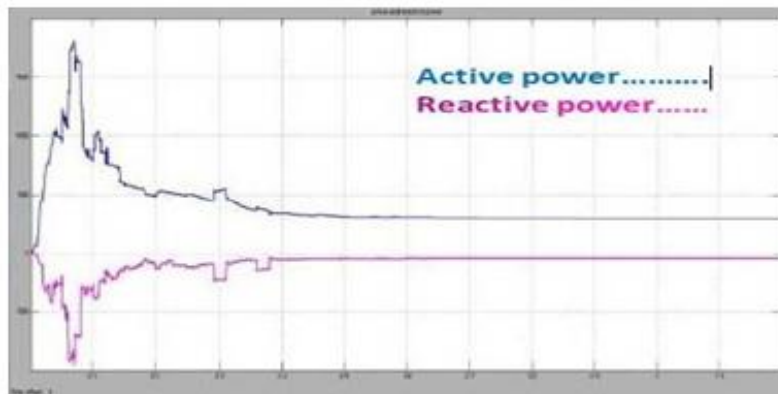

Fig 4: Active and Reactive power waveform

Power factor can be calculated by active and reactive power calculation. In this case the input power factor is 0.9877.

V.   RESULT

The comparison of input power factor for different circuit topologies has been shown in following Table 1. It is seen that best power factor is obtained in case of boost converter other than circuit topology.

Table 1: Various power factor for different topology

Circuit topology	Power factor
Single phase diode rectifier	0.8756
Boost converter	0.9877

VI.   CONCLUSION

The power factor correction circuits have been simulated by MATLAB Simulink in this research. It is seen that best power factor is obtained in case of boost converter with average current mode control using PI controller. The power factor may be further improved if fuzzy controller is used in place of PI controller. Also interleaved boost converter can be another improvement as well.

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