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Correction of Power Factor by Using Static Synchronous Compensator (STATCOM)

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ABSTRACT:

In this paper we introduced a new control scheme which uses one PFC Boost Converter connected in shunt with a diode rectifier to recover the harmonic current drawn by the single phase diode rectifier. The line current command is derived from a dc link voltage regulator and an output power estimator. The hysteresis current controller is used to track the line current command. In absence of diode rectifier (Non-linear Load), the PFC boost converter draws purely sinusoidal current from source. In presence of diode rectifier the PFC boost converter draws current in such a way that the total current drawn from source becomes purely sinusoidal. Merits of the proposed converters include higher power density, simpler control strategy, less harmonic control contents, nearly unity power factor and unidirectional power flow.

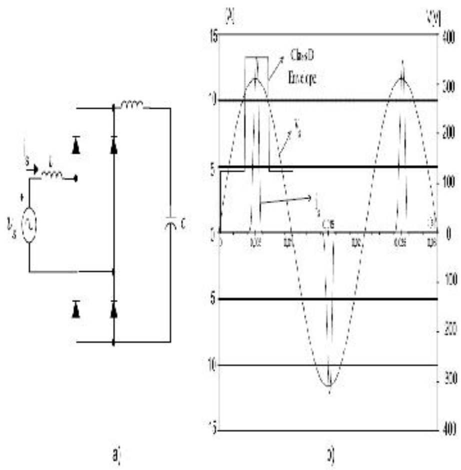
Key Word: PFC Boost Converter, Diode Rectifier.

I. INTRODUCTION:

Due to the growth of nonlinear loads, such as Power Electronics converters, SMPS (Switching Mode Power Supplies), Computer, serious power pollution is produced & reflected in to the distribution & Transmission networks. The low power factor and high pulsating current from the AC mains are the main disadvantages of the diode rectifier and phase controlled rectifier. These circuits generate serious power pollution in the transmission or distribution system. The power pollutants such as reactive power and current harmonics results in line voltage distortion, heating of core of transformer and electrical machines, and increasing losses in the transmission and distribution line. Power factor is defined as the cosine of the angle between voltage and current in an ac circuit. There is generally a phase difference Ø between voltage and current in an ac circuit. Cos Ø is called the power factor of the circuit. If the circuit is inductive, the current lags behind the voltage and power factor is referred to as lagging. However, in a capacitive circuit, current leads the voltage and the power factor is said to be leading. In a circuit, for an input voltage V and a line current I, VIcos Ø –the active or real power in watts or kW. VIsin Ø- the reactive power in VAR or kVAR. VI- the apparent power in VA or kVA. Power Factor gives a measure of how effective the real power utilization of the system. It is a measure of distortion of the line voltage and the line current and the phase shift between them. Power Factor=Real power (Average)/Apparent power Where, the apparent power is defined as the product of rms value of voltage and current. Classical line commutated rectifiers suffer from the following disadvantages:

1) They produce a lagging displacement factor w.r.t the voltage of the utility.

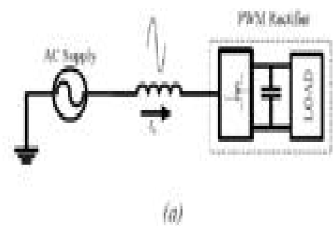
2) They generate a considerable amount of input current harmonics.



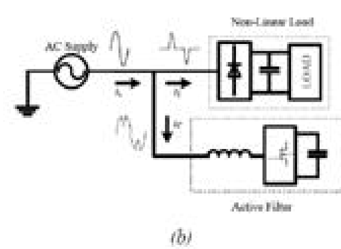
Fig(1): Single phase rectifier (a) circuit (b) waveforms of input voltage and current

Basically we have Ac supply, by using rectifiers we convert pulsating DC, by using filters we convert pulsating DC to Pure dc. Whenever we are using filters, our line current may goes to distorts, nothing but current harmonics. Due to the harmonics source current also distorts. By using custom power devices we control & mitigate our harmonics in our system. But those are very complex & high maintenance. That's why people prefer two stage conversions; here we preferred this two stage conversion. Power electronic converters are essentially required when we need to convert electricity from one form to other. They form an interface between the source and load side. In the last several years, the massive use of single phase power converters has increased the problems of power quality in electrical systems. High-frequency active PFC circuit is preferred for power factor correction. Any DC-DC converters can be used for this purpose, if a suitable control method is used to shape its input current or if it has inherent PFC properties. The DC-DC converters can operate in Continuous Inductor Current Mode – CICM, where the inductor current never reaches zero during one switching cycle or Discontinuous Inductor Current Mode - DICM, where the inductor current is zero during intervals of the switching cycle. As previous we are using some custom power devices for eliminating the harmonics and improve the power factor. Using Custom power devices nothing but facts controllers like filters. Those are very complex circuits and high maintenance cost.

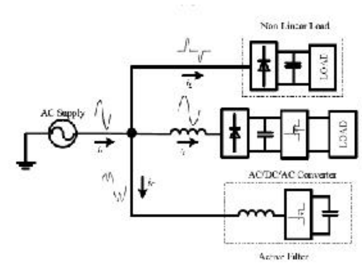
a) Passive power filters
b) Active power filters
c) Hybrid power filters



Passive Power Filter



Active Power Filter



Hybrid Power Filter

Typical strategies are hysteresis control, average current mode control and peak current control. More recently, on cycle control and self control have also been employed. Some strategies employed three levels PWM AC/DC converter to compensate the current harmonics generated by the diode rectifier. Some strategies employed active power filter to compensate the harmonic current generated by the non-linear load. Disadvantages of these strategies are; (a) for each nonlinear load, one separate converter should be employed, (b) due to presence of more switching devices used in some strategies, switching losses occurs is more, as the switching losses depend upon the no of switching devices (c) some strategies use very complex control algorithm. To overcome all these type of problems, a new power factor correction technique using PFC boost converter is proposed.

II. PROPOSED CONCEPT:

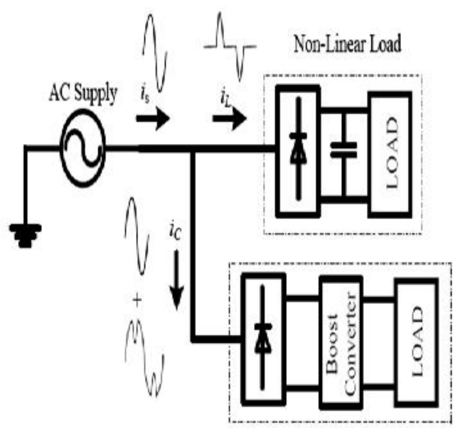


Fig 2: Schematic Diagram of Statcom

This uses less no of switching devices, simple control strategy and uses one converter to compensate the harmonic current generated by the non-linear load. The Power factor correction technique is proposed in this paper in order to avoid harmonic pollution along the power line caused by a single phase diode rectifier. The proposed arrangement acts as a current source connected in parallel with the nonlinear load and controlled to produce the harmonic currents required for the load. In this way, the ac source needs only to supply the fundamental currents. This configuration consists of one PFC boost converter which is connected in shunt with the non-linear load (diode rectifier) to compensate the harmonic current drawn by the non-linear load. This configuration uses hysteresis current control technique to track the line current command. Hence the total arrangement draws nearly sinusoidal current from source. Power switch in the proposed converter are controlled to draw a nearly sinusoidal line current with low current distortion and low total harmonic distortion (THD) of supply current waveform and also regulate the DC bus voltage.

Control Scheme:

- Basically we have so many control schemes, some of the following are,
- Voltage follower Technique
- Average Current Control Technique
- VFT- Consider only load side parameters.
- AVCT- Consider load side & source side parameters.

III. PROPOSED CONTROL SCHEME:

This method allows a better input current waveform. Here the inductor current is sensed and filtered by a current error amplifier whose output drives a PWM modulator. In this way the inner current loop tends to minimize the error between the average input current and its reference.

This reference is usually obtained by multiplying a scaled replica of the rectified line voltage Vg times the output of the voltage error amplifier, which sets the current reference amplitude as shown in Fig. In this way, the reference signal is naturally synchronized and always proportional to the line voltage which is the condition to obtain unity power factor.

The advantages of this technique includes Constant switching frequency, No need of compensation ramp, Control is less sensitive to commutation noises, Better input current waveforms than for the peak current control.

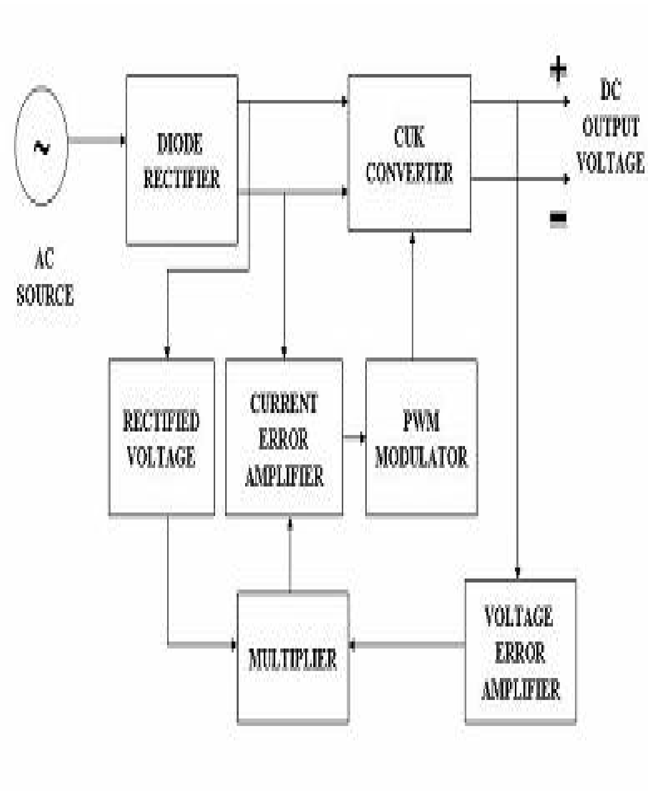


Fig 3: Block Diagram of proposed control strategy

IV. SIMULATION MODELLING:

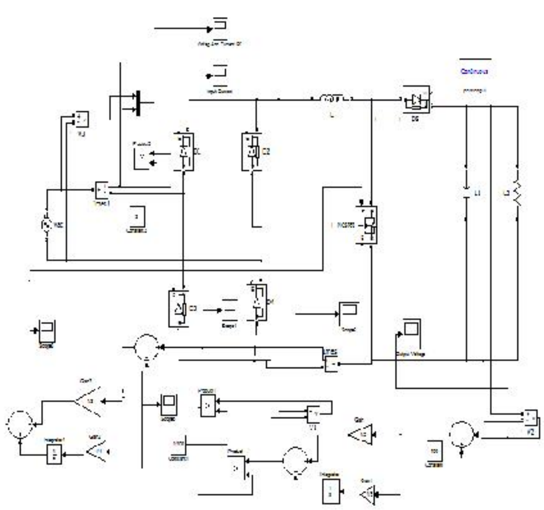


Fig 4: Simulation diagram

V. SIMULATION RESULTS:

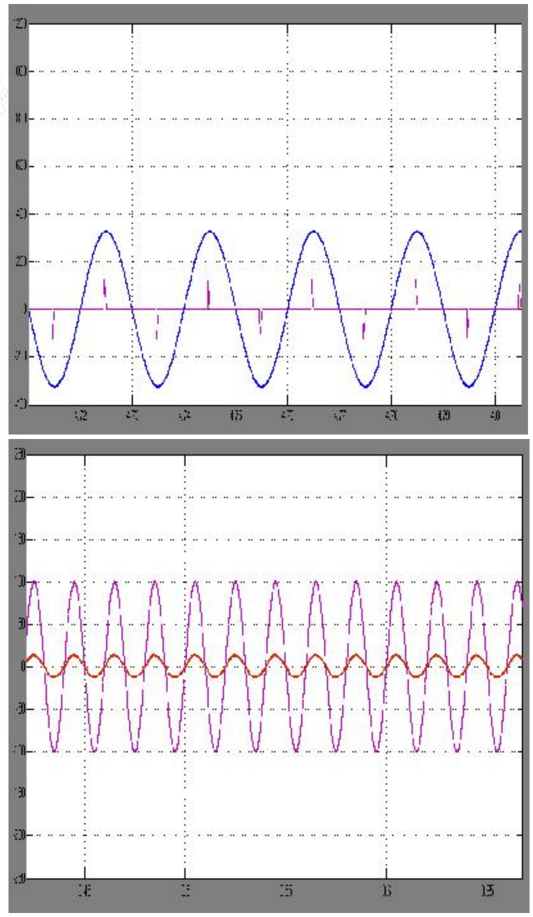


Fig 5: Output Voltages & Currents

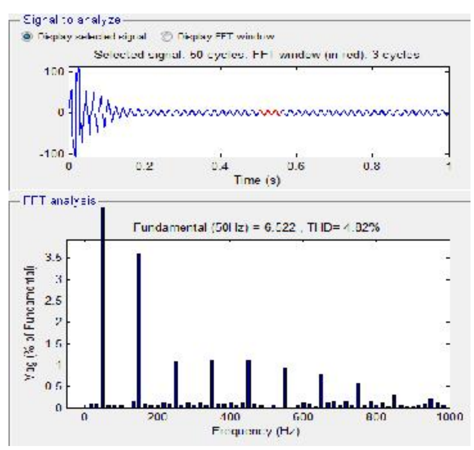


Fig 6: Input currents & Total Hormonic spectrum

VI. CONCLUSION:

This paper has presented one new and interesting AC/DC boost-type converters for PFC applications. Without using any dedicated converter, one converter can be used to eliminate the harmonic current generated by the other non-linear load. With the help of simulation study, it can be concluded that, this configuration removes almost all lower order harmonics, hence with this configuration we can achieve power factor nearer to unity, THD less than 5%. However, this technique can be limited to application where the non-linear load (pulsating) current is less and fixed. Besides, the literature review has been developed to explore a perspective of various configurations of for power factor correction techniques.

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