Design Of Boost Converter For Active Power Factor Correction

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ABSTRACT

Electronic devices such as SMPS, UPS, rectifier and electronic ballast require DC power supply. These switching devices draw extremely distorted input current (spikes with respect to the line voltage) for a short duration, due to their non-linear nature. Extensive use of these devices has given rise to the need of making power management flexible, smart and efficient. Nonlinear current drawn by these switching devices affects the power quality of the system adversely. It causes adverse effect such as interference with other electrical equipment, increase in Total Harmonic Distortion and poor Power Factor, which results in poor output voltage regulation. Power factor correction (PFC) circuits are being increasingly used to mitigate the problems associated with poor power factor. To improve the power quality of the distribution system two types of power factor correction topologies are enforced, namely Passive power factor correction topology and Active power factor correction topology. This paper primarily focuses on active power factor correction methodology and the prototype developed for DC power supplies. This method of power factor correction is based on current wave shaping technique. Under this technique source current wave is made to get in phase with line voltage. This technique is achieved by implementing voltage control loop and current control loop. This project explains the development of boost converter as a power factor correction controller, operating in continuous conduction mode (CCM).The boost converter is also designed to regulate the output voltage.

Keyword : - Active Power Factor Correction, Passive Power factor correction, Boost Converter, THD, AC-DC System.

1. POWER FACTOR AND ITS IMPORTANCE

Power Factor can be defined as the ratio of real power which is measured in watts (W) consumed by a load divided by the total apparent power which is measured in volt-amperes (VA) flowing between the power source and load. For a DC source, the source current and source voltage are always in phase and therefore maintains a power factor of 1. For electronic circuits containing frequency dependent terms like inductor or capacitor or both which is supplied from the AC supply, the input current does not naturally follow the AC line voltage which results in phase difference between current and voltage.
As power factor is directly proportional to real/active power so poor power factor implies the load is receiving less real power and hence it will demand more power which increases the cost, losses and efficiency of the system.
Conventional Power factor Solutions or we can say Passive Power Factor Correction solutions incorporate banks of capacitors that work as silent reactive power ‘generators’, often housed in a metal cabinet similar to the one that houses residential electrical switchboard.

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2. FACTORS RESPONSIBLE FOR POOR POWER FACTOR:

Major factors responsible for low Power Factor are as follows:
2.1 Inductive Loads: Inductive loads, such as electric motors and transformers, consume reactive power from the system, which reduces the power factor (lagging PF). This is due to the fact that inductive loads cause the voltage and current to become out of phase, which increases the reactive power component of the system.
2.2 Variation in Power System Loading: When the system is lightly loaded, the voltage increases and the current drawn by the machines also increase. This results in low power factor.
2.3 Harmonic Currents: The presence of harmonic current in the system also reduces the power factor. In some cases like faults occuring and improper winding a condition known as 3 phase imbalance occurs which also is one of the reason of low power factor.

3. ACTIVE POWER FACTOR CORRECTION:

There are many ways for the power factor correction. But mainly, it categorized into methods as the Passive method and Active method. Passive PFC approach uses L-C filter as shown. L-C filter is introduced between the supply line and diode rectifier for improving the waveform of the line current. It is simple and rugged technique but being expensive and bulkier in size. Moreover, in this technique power factor cannot be improved effectively whereas the output voltage is also uncontrollable. Active switches are used in association with reactive element in active PFC approach to obtain controllable output voltage. Active power factor correction (APFC) is defined as the to method of improving power factor with the use of active electronic components in the circuits with feedback which controls the shape of the supply current therby improving the power factor. There are a number of commercial PFC controllers that can accomplish this task. Thus, a DC-DC converter is employed and is working at very high frequency and also to get the sinusoidal shape of line current waveform.

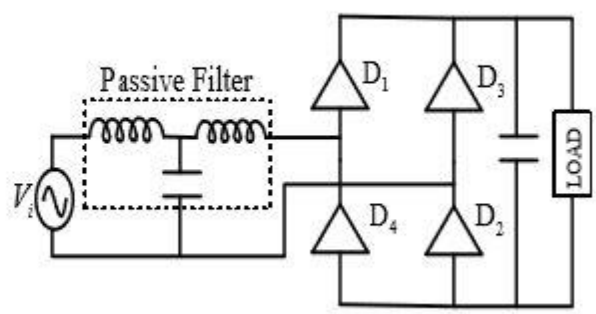

Fig-1 Passive Power Factor Correction Circuit

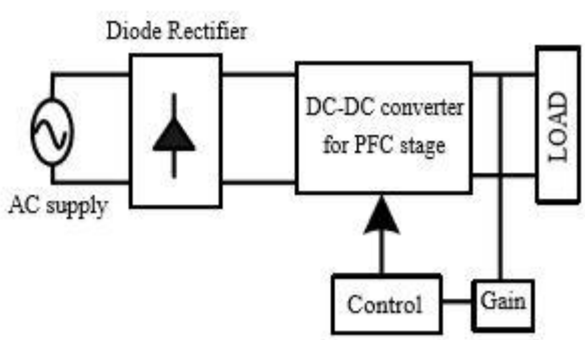

Fig-2 Active Power Factor Correction

4. NEED OF PFC IN DC POWER SUPPLIES:

Passive power factor correction technique has a poor dynamic response and lack of voltage regulation. Hence active power factor correction technique has been used for the development of the proposed prototype. Active PFC can be implemented by using any one of the following topology: Buck topology, Boost Topology and Buck-Boost Topology. The boost topology is most suitable for high performance power factor correction circuit as it draws continuous input current, low EMI filter requirement and increases efficiency of the system. By minimizing the inductor-current ripple, the boost converter reduces current stress and therby increases the current handling capability at heavy loads. It also provides a fast transient response

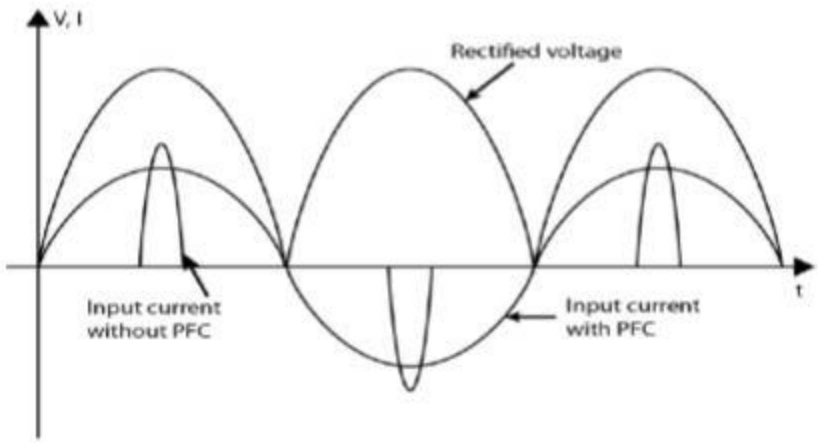

Fig-3-Input current waveform of the nonlinear load with and without power factor correction circuit.

5. IMPLEMENTATION OF ACTIVE PFC CONTROLLER USING BOOST CONVERTER:

Boost converter (DC-DC) is most important step-up chopper applicable in numerous electronics applications. This converter has advantages like less number of analog circuit, good performance, low weight and high accuracy. Nearly unity power factor with significant level of THD for the input current is observed for boost PFC converter.
Block diagram of the boost converter PFC is as shown in following block diagram. It consists of boost inductor, switch (MOSFET, IGBT etc.), fast recovery diode and control circuit. Operation of the boost converter is through the entire line cycle, so the input current is not distorted and is continuous. It has a smooth supply current as an inductor is connected in series with the power source. It is easy to drive, as the switch is source grounded, therefore boost topology is a universal solution for power supplies. The boost converter controls two functions viz: shape of the source current and magnitude of the output voltage. To accomplish this, there are two necessary conditions: first - the output voltage should be higher than the peak of the rectified input voltage, and second – the power flow should be unidirectional.

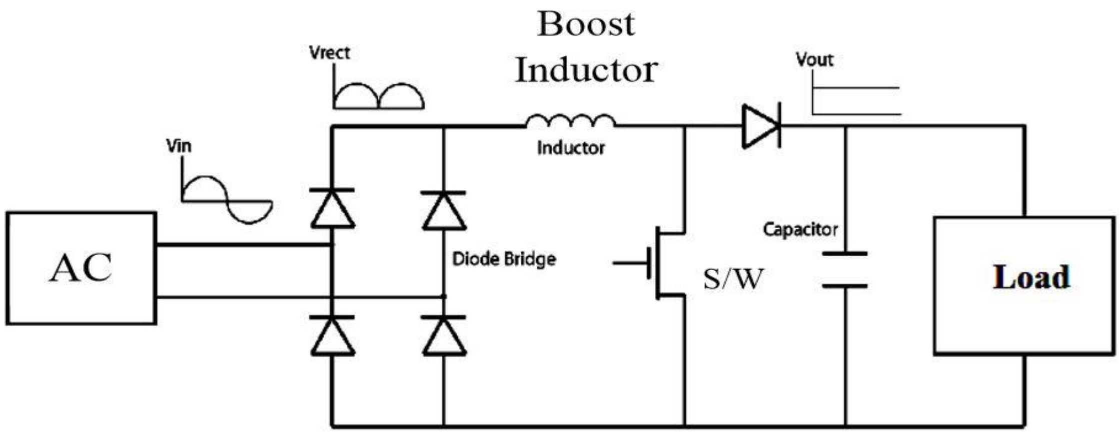

Fig-4 Block Diagram of boost PFC topology.

5. MATLAB MODEL:

5.1 Simulink Model Without PFC:

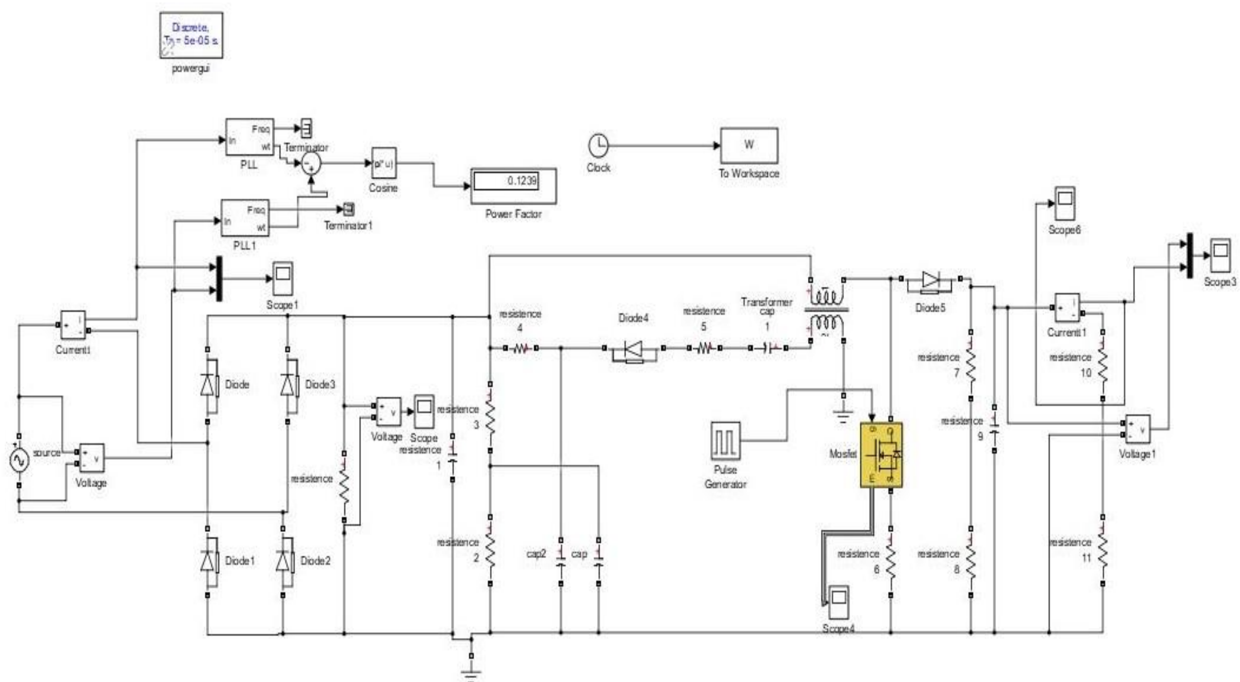

Fig-5 Simulation model without PFC using MATLAB

5.2 Output

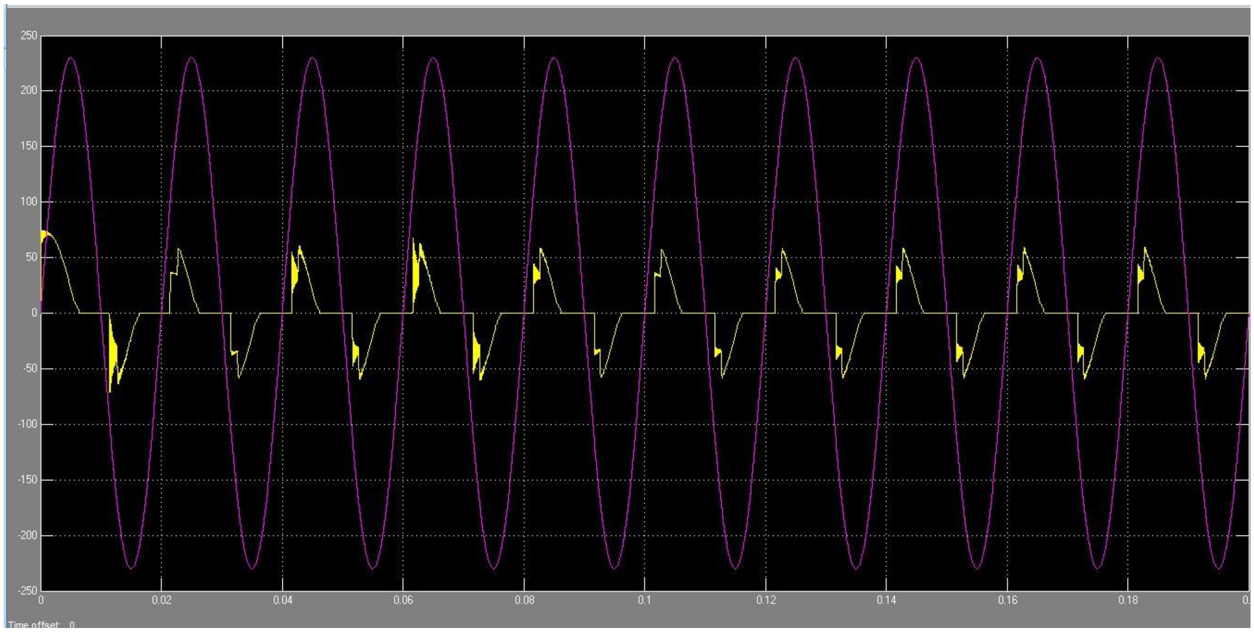

Fig-6 Output of Simulation model without PF

5.3 Simulink Model Using PFC:

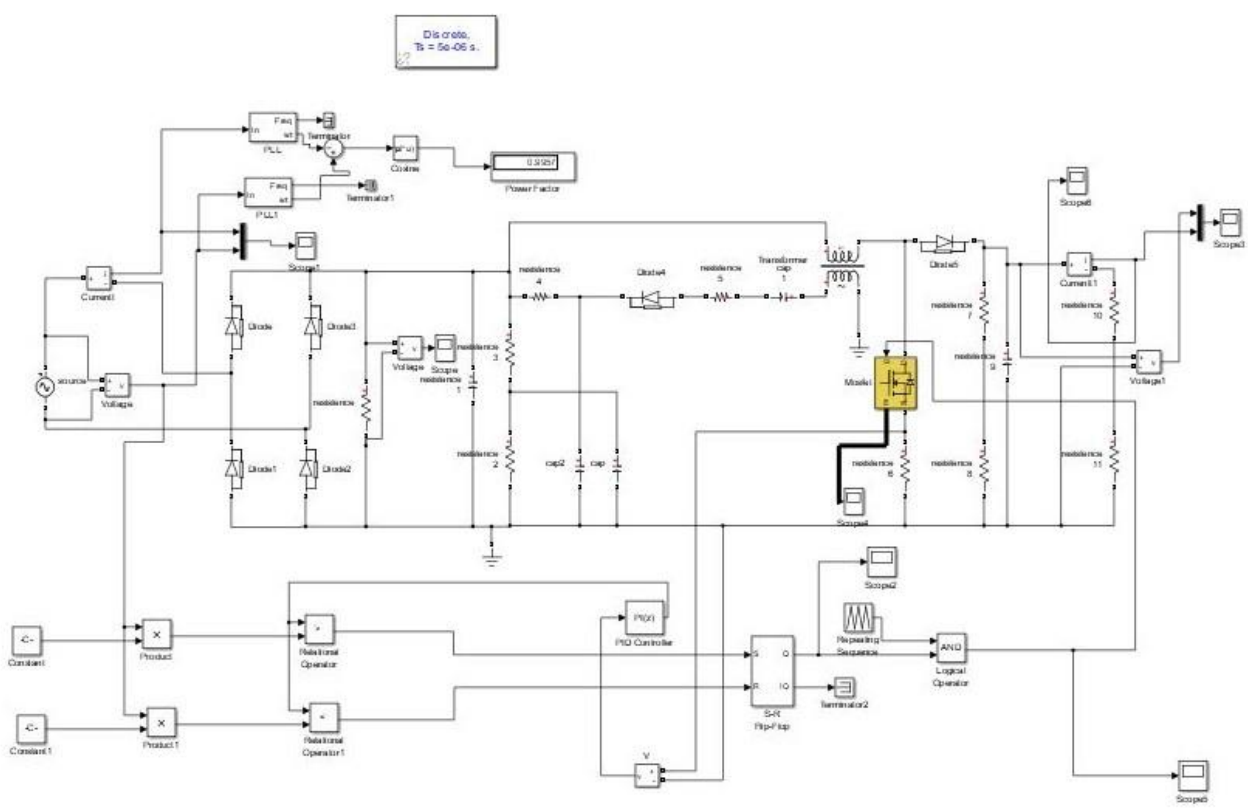

Fig-7 Simulation model with PFC

5.4 OUTPUT

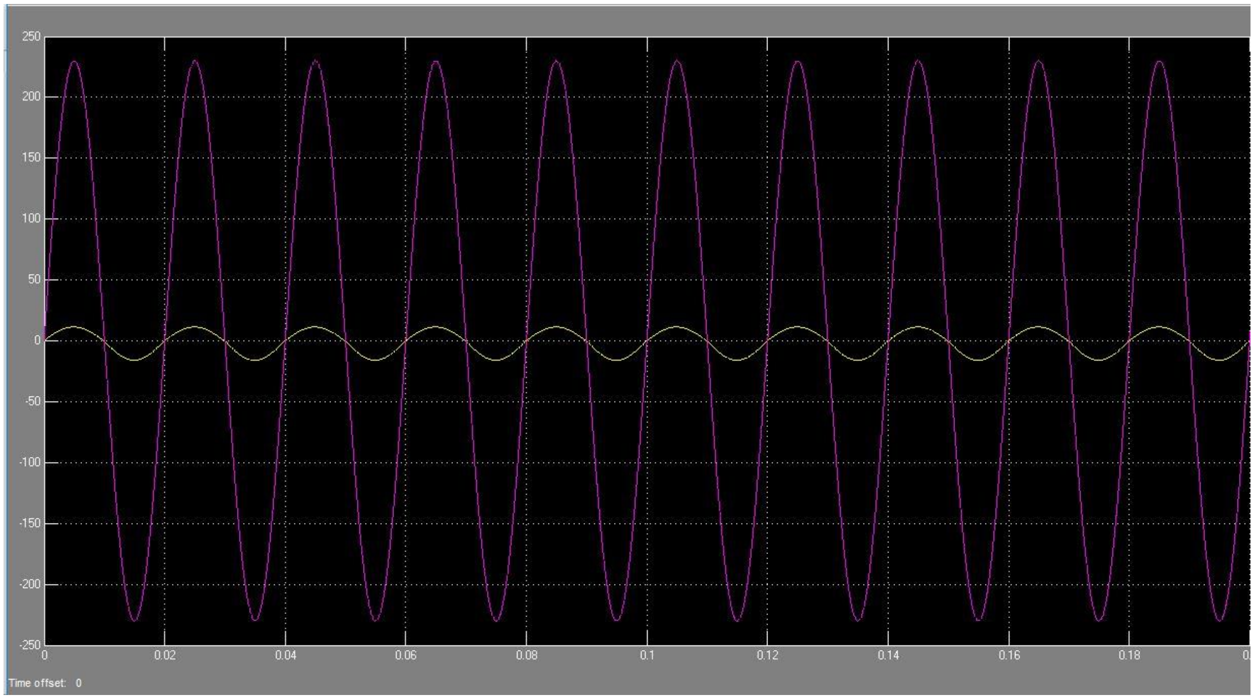

Fig-8 Output of Simulation model with PFC

6. CONCLUSIONS

The simulation model of the boost power factor correction converter has been explained. Implementation of the boost active PFC controller for power supplies improves PF significantly. Due to presence of PFC the wave shape of source current is improved which represents reduction in harmonics. New research and development in control techniques, solid state devices will further increase transient response, very high dynamic stability, reliability and power quality.

7. REFERENCES

[1] Sujata Powniker, Member and Sachin Shelar, Member,IEEE AISSMS's IOIT, Pune, India

[2]. Kartikesh Kumar Jha Dept. of Electrical Engg, BIT Mesra,Ranchi, Bidyut Mahato Dept.of Electrical Engg,ISM Dhanbad, and Prem Prakash Dept. Of Electrical Engg, BIT Mesra, Ranchi, India.3rd Int'l Conf. |RAIT-2016|

[3] Book by N. Mohan, Power Electronic: Converters, Applications, and Design.

[4]. Sujata Nazarkar and Sachin Shelar, "DESIGN & SIMULATION OF ACTIVE POWER FACTOR CONTROLLER USING BOOST CONVERTER" IJIERT , ISSN: 2394-3696 ,Vol 3, Issue3, Mar.-2016.

[5] Book by B.K.Bose, "Modern power electronics and AC Drives".