International Journal of Recent Engineering Research and Development (IJRERD)
ISSN: 2455-8761
www.ijrerd.com || Volume 03 – Issue 03 || March 2018 || PP. 166-170

Power Factor Correction Using Statcom

Raju Kumar[1], Pankaj Sharma[2], Deepshikha Tiwari[3],Varsha Tiwari[4]
[1]*M. Tech scholar, Kopal Institute of Science and Technology, Bhopal, India*,
[2]*M.Tech scholar, Sagar Institute of Science Technology and Engineering, Bhopal, India*
[3]*M.Tech scholar, Kopal Institute of Science and Technology, Bhopal, India*,
[4]*M. Tech scholar, Kopal Institute of Science and Technology, Bhopal, India*,

Abstract: Static Synchronous Compensator i.e. the STATCOM regulates voltage and corrects the power factor at the point of common coupling (PCC) by injecting reactive power. This device plays a vital role as a stability enhancement for small and largetransient disturbances in the power system lab.In this work a new control scheme is introduced which uses one PFC Boost Converter connected in shunt with a diode rectifier to recover the harmonic currents drawn by single phase diode rectifier. The DC link voltage regulator and an output power estimator are used to derive the line current command and a hysteresis current controller is used to track the line current command. If the diode rectifier (Non-linear Load) is not employed, then the PFC boost converter draws purely sinusoidal current from the source side. However, in the presence of diode rectifier the PFC boost converter draws current in such a way that the total current drawn from source becomes purely sinusoidal. The proposed converters provides higher power density, has a simpler control strategy, less harmonic control contents, nearly unity power factor and unidirectional power flow throughout the system.
Keywords: STATCOM, PFC, Power Factor, harmonics.

1. Introduction

In present days due to increased power quality problems by using of switch off/on introduction loads, the nonlinear load and induction motor etc in domestic and in the industries, power-quality problems like harmonics, flicker, andimbalance have become some of very serious concerns. Not only but also, lightning strikes on transmission lines, various network Faults, switching of capacitor banks etccan also create Power quality problems like transients, voltage sag/swell, and interruption. On the other hand, an increase of sensitive loads involving digital electronics and complex process controllers requires a pure sinusoidal supply voltage for proper load operation. To meet such power quality to the standard limits need some sort of compensation. In thecoming years back to mitigate the power quality problems in distribution system by using passive filters like capacitor banks. These research are going very fast to mitigate the power quality problems with help of power conditioning devices[7]. The power conditioning devices used are dynamic voltage restorer (DVR), static compensator (STATCOM), and unified power-quality conditioner (UPQC)(custom power devices)[1]. A static synchronous compensator (STATCOM), also known as a "static synchronous condenser" ("STATCOM")[2], is a regulating device used on alternating current electricity transmission networks. It is based on a power electronics voltage-source converter and can act as either a source or sink of reactive AC power to an electricity network. If connected to a source of power it can also provide active AC power.Fast acting static synchronous compensator (STATCOM), a representative of FACTS family, is a promising technology being extensively used as the state-of-the-art dynamic shunt compensator for reactive power control in transmission and distribution system. Over the last couple of decades, researchers and engineers have made path-breaking research on this technology and by virtue of which, many STATCOM controllers based on the self-commutating solid-state voltage-source converter (VSC) have been developed and commercially put in operation to control system dynamics under stressed conditions. Because of its many attributes, STATCOM has emerged as a qualitatively superior controller relative to the line commutating static VAR compensator (SVC). This controller is called with different terminologies as STATicCOMpensator advanced static VAR compensator, advanced static VAR generator or static VAR generator, STATicCONdenser, synchronous solid-state VAR compensator, VSC-based SVC or self-commutated SVC or static synchronous compensator.

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.

2. Power Factor Correction

The power factor correction is referred as the minimization of the line current harmonic. The main objective of the thesis is the power factor correction i.e.; maintaining a least phase angle between the input voltage and current with improved THD level i.e. keeping the harmonic content to a minimum level. The effect of harmonic and its problems on power system is observed as significant and hence Electricity regulatory commissions and utilities, all over the world is penalizing the users for harmonic dumping into the supply lines. Central Electricity Regulatory Commission of India has given guideline to Institute of Electrical and Electronics Engineers (IEEE) Standard 519-92 on permissible limits for harmonics in the electrical system. Both the utility and users should know and understand the standard and the essential of limits specified.

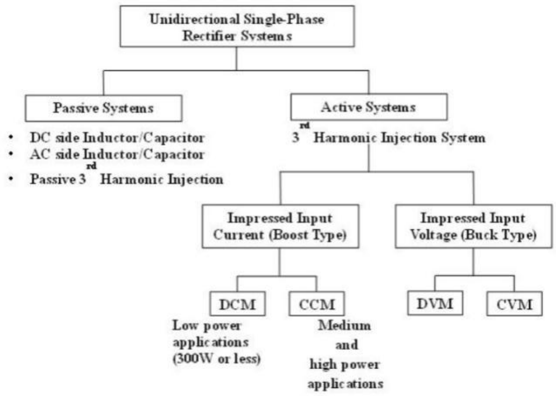

Fig. 1 : Classification of PFC Method based on Mode of Switching

because of the non-linear loads in the distribution network, line current harmonics are introduced as in the fig. 2, which need to be minimized. There are numbers of procedures for the power factor correction. But mainly, it categorized into methods as; “Passive method” and “Active method”. L-C filter is used in “Passive PFC approach”. L-C filter is introduced between the supply line and diode rectifier toimprove the shape of the line current as in fig. 2. It is simple and rugged technique but bulky in size and expensive. Moreover, in this technique power factor cannot be highly improved and output voltage is not controllable. Active switches are used in association with reactive element for “Active PFC approach” as in fig. 3 for the improvement of line current shape and to obtain controllable output voltage. For this DC-DC converter is in employment and is working at high frequency to make shape of the line current waveform as sinusoidal. Boost, buck, buck-boost, flyback, cuk, or sepic topologies are the commonly used PFC DC-DC converter topologies. Mainly Boost Converter topology is more suitable for PFC application and is widely used for PFC pre-regulation application.

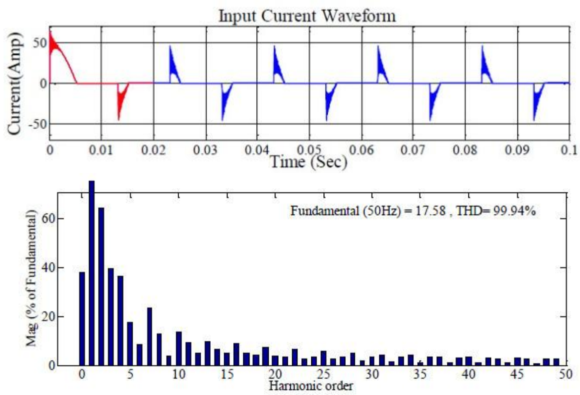

Fig. 2 : Waveforms of AC-DC System without any PFC circuit Input Current and THD

There are many benefits power factor viz. thevoltage distortion is less,all the power is active, small RMS current, higher number of loads can be fed etc.Also there are many advantages of circuits with PFC like Several cost saving factor like the electrical loads (SMPS, Electronic ballast unit or other electrical load) become much simpler. And because of the smaller RMS current with PFC, it permits to use small, much cost effective mains rectifiers to the manufacturer of electrical load.Input voltage for the DC electrical load becomes comparatively stable and thus regulated. Moreover, theAC-DC system operates on wide-range power supply because of PFC.

3. Control Scheme for Boost PFC

The PFC control strategy is categorized as Active Control Method and Automatic control of line current. For CCM, active control method is used,however theautomatic control method is related to DCM operation of converter. Although Severalcontrol methods are available there under active control techniques.

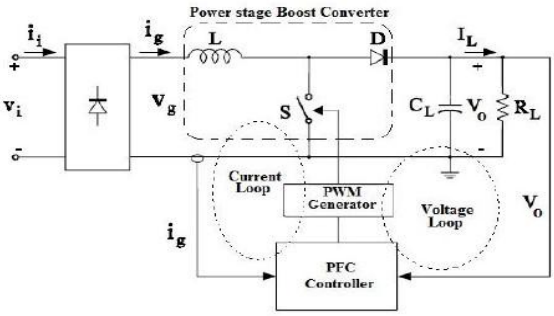

Fig. 3 : Principle of Control Scheme of Boost PFC

This uses less no of switching devices, simple control strategy and uses one converter to compensate the harmoniccurrent 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 discussed 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. Therefore the total arrangement draws nearly sinusoidal current from source. Power switch in this proposed converter are controlled to draw sinusoidal line current with very low current distortion and less THD of supply current waveform and thus also regulate the DC bus voltage.

4. Proposed Scheme:

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 reduce the error between the average input current and the reference value. 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. Therefore, the reference signal is synchronized and always proportional to the line voltage which is the necessary conditionfor obtaining unity power factor. The advantages of this technique includes Constant switching frequency, No need of compensation ramp, Control is comparative less sensitive to commutation noises, Better input current waveforms than for the peak current control.

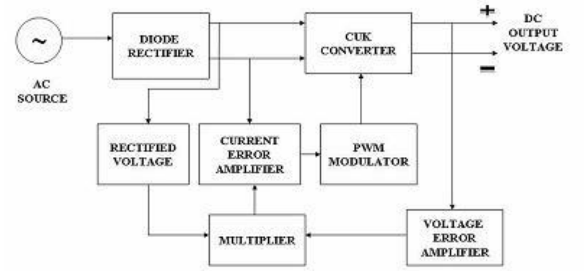

Fig. 4 : Block Diagram of Proposed Control Scheme

5. Results:

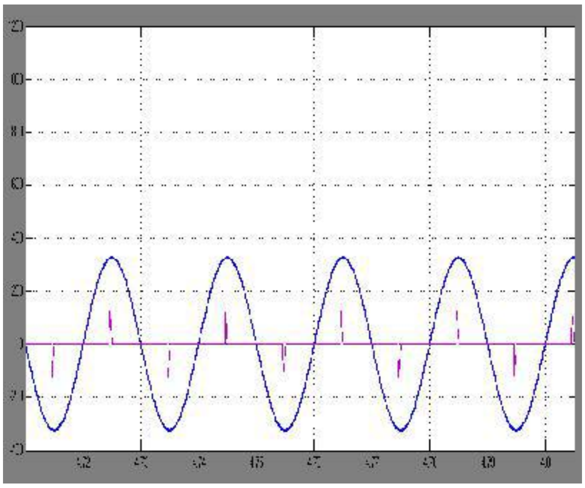

Fig.5 : Output Voltage

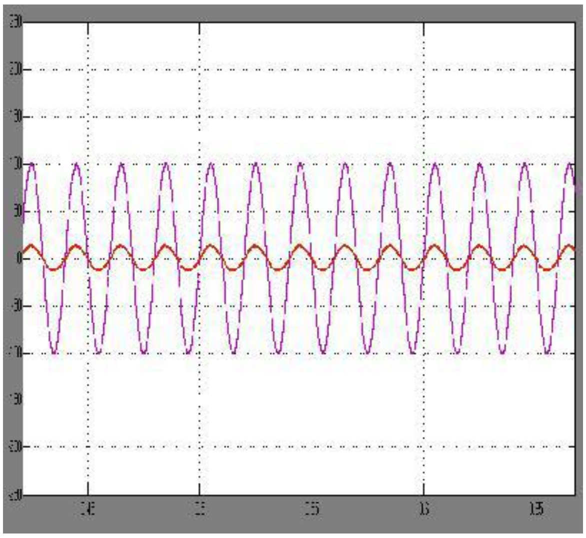

Fig.5 : Output Current

5. Conclusion:

In this paper a new and 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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