Novel Design for Power Factor Correction Using FACTS Device and Soft Computing Tools

Shubham Gedam, Prema Daigavane, and Tushar Guhe

Abstract The present study outlines the development of an innovative control strategy, wherein a PFC boost converter is integrated in reverse with a rectifying diode, to effectively recuperate current bearing harmonics to produce by a single-phase semiconductor rectifier. The line power command receives two distinct inputs, namely a regulator of voltage for the direct current (DC) link and an estimator of output power. The current controller's oscillation is employed to monitor the line current command. In the absence of a diode rectifier (a non-linear load), it can be inferred that the power factor correction (PFC) boost converter solely draws sinusoidal electricity from the source. The utilization of a rectifying diode in a PFC boost converter results in the automatic current draw, which facilitates the generation of a sinusoidal current, equivalent to the entirety of the current generated by the source. This phenomenon can be observed in a typical academic writing format. The proposed converters exhibit a near ideal power factor, enhanced power density, a streamlined control mechanism, and a reduction in the number of harmonic control constituents.

Keywords Soft computing tools · Fuzzy logic · Power quality · Power stability · Power factor

S. Gedam (✉) · P. Daigavane
Electrical Department, G.H. Raisoni College of Engineering, Nagpur, India
e-mail: shubham.gedam.mtechps@ghrce.raisoni.net

P. Daigavane
e-mail: prema.diagavane@raisoni.net

T. Guhe
Janki Electromech, Nagpur, India

1 Introduction

Power electronics converters, Switching Mode Power Supplies (SMPS), and other non-linear loads are becoming more and more common and computers, has led to the generation of significant levels of power pollution that are manifest in the distribution and transmission networks. The diode rectifier and phase controlled rectifier's main drawbacks are their subpar power factors and high levels of pulsed current flowing from the alternating current (AC) mains. The aforementioned circuits are capable of generating a substantial amount of energy. Reactive power and current harmonics are notable instances of power pollutants that result in the distortion of line voltage, elevated levels of thermal energy in transformer and electrical machinery cores, together with increased transmitting and disseminating line losses. The power factor in an AC circuit is denoted by the sine of the angle that the voltage and current made with one another. Inside of a circuit, the active or real power, denoted as VI cos and measured in units of watts or kilowatts, is present as a consequence of a V for the input voltage and an I for the resultant line current. The reactive power, which is expressed as VAR or kVAR, is commonly referred to as VIsin in academic literature. The power factor statistic serves as a gauge for a system's actual power efficiency. The measurement of in academic discourse, the line voltage and current's phase shift and distortion are encountered. By dividing the average real power by the appearance power, the power factor is calculated. The product of the root mean square values of current and voltage determines how much power is perceived. This formulation belongs to the paradigm of academic writing due to its technical and specialized use of terminology. Conventional line commutated rectifiers are associated with certain drawbacks, namely a displacement factor that lags behind the utility's voltage (Fig. 1).

(1)   They produce a large number of input current harmonics.
(2)   The input current has a lot of harmonics produced by them.

The present study involves the utilization of an AC power supply and implements rectifiers to transform pulsed DC. Furthermore, filters are used to facilitate the conversion of pulsed DC into a stable and refined form of DC. The utilization of filters may result in the distortion of our line current, characterized by the presence of current harmonics. Source current is distorted as a result of the harmonics. We are able to manage and reduce the harmonics in our system by employing specialized power devices. But some require considerable maintenance and are highly sophisticated. Because of this, two stage conversions are more popular; in this case, we picked this two stage conversion. When converting electricity from one form to another, power electronic converters are essentially necessary. Between the source and load sides, they serve as an interface. The ubiquitous implementation of single-phase power converters in recent years has notably amplified the predicaments with power quality in electrical networks. It is advised to use a high-frequency active power factor correction (PFC) circuit to handle the power factor issue. Any DC-DC converters are considered to be adequate for this application. If the input current is regulated suitably or if it inherently exhibits power factor correction (PFC) properties. Two distinct
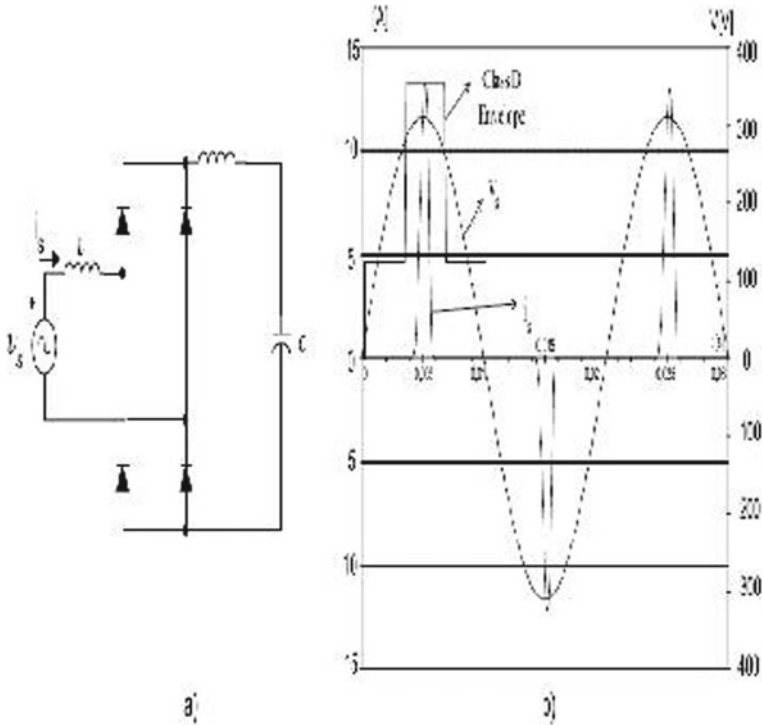
Fig. 1 Single-phase rectifier **a** circuit **b** waveforms of input voltage and current

modes of operation, Discontinuous Inductor Current Mode and Continuous Inductor Current Mode, can be employed in converting DC to DC. In the former mode, the inductor current remains non-zero throughout the switching cycle, while in the latter mode, the inductor current approaches zero periodically during each cycle. As in the past, we are employing some specialized power equipment to reduce harmonics and raise power factor. The charge's aftereffects. Changes are made to the power factor to make it more resemble an AC power supply circuit. Nothing except facts controllers and filters for custom power devices. These circuits have a high maintenance cost and are quite complicated. Employing some specialized power equipment to reduce harmonics and raise power factor. The charge's aftereffects. Changes are made to the power factor to make it more resemble an AC power supply circuit. Nothing except facts controllers and filters for custom power devices. These circuits have a high maintenance cost and are quite complicated (Figs. 2 and 3).

(A) Passive filtering.
(B) Active filtering.
(C) Powerful hybrid systems.

Peak current control, mode control of the average current, and hysteresis control are commonly utilized methodologies in the field. The employment of on-cycle
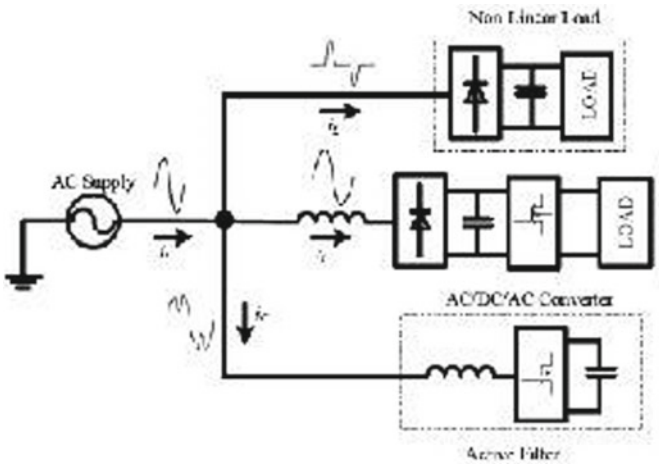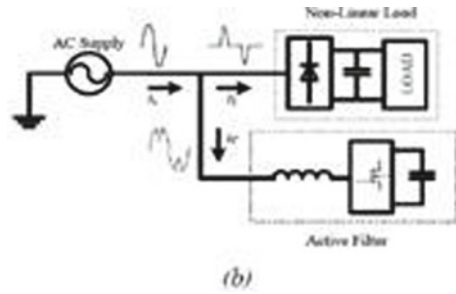
Fig. 2 Active filtering

Fig. 3 Powerful hybrid

control and self-control has experienced a recent surge. In order to mitigate the deleterious effects of the diode rectifier's generated current harmonics, a three-level pulse width modulation (PWM) alternating current/direct current (AC/DC) converter has been employed by various means. In order to mitigate the production of harmonic currents stemming from non-linear loads, a number of solutions have employed the use of active power filters. The limitations of these methods encompass the need to employ a distinct converter for each non-linear load and a higher incidence of switching losses in certain approaches due to their dependence on an augmented count of switching devices. Some strategies entail highly intricate control algorithms. A novel approach to improve power factor correction efficiency by implementing a PFC boost converter is proposed as a potential solution aimed at effectively addressing the various associated issues.

Fig. 4 Schematic diagram of STATCOM
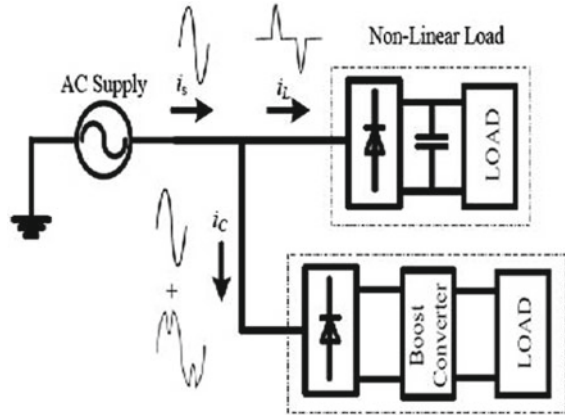
2 Suggestive Concept

The harmonic current produced when non-linear loads are used is mitigated by means of a singular converter, a limited number of switching devices, and a simplified control mechanism. The present study proposes the implementation of power factor correction methodology to mitigate the harmful effects of harmonic pollution resulting from a diode rectifier for a single phase on the power line. The suggested configuration functions as a contemporaneous source, which is connected in parallel to the non-linear load, and is fine-tuned to generate the specific harmonic currents required by the load. Through this approach, the alternating current source is only required to supply the fundamental currents. In parallel with the diode rectifier, a power factor correction (PFC) boost converter is used to reduce the negative impacts of the harmonic current caused by the non-linear load. To monitor the current command line in this configuration, hysteresis current control is employed. Consequently, the complete configuration indubitably generates a sinusoidal electric current flow from the power source. The suggested converter's power switches are modulated in a manner that enables the generation of an almost sinusoidal line current characterized by low current distortion, minimal total harmonic distortion, and stable DC bus voltage regulation (Fig. 4).

3 Control Plan

In general, we have a wide variety of control mechanisms, including the following technique for voltage followers.

(1) Common Current Control Method.
(2) VFT: Only take into account load-side parameters.
(3) AVCT: Take source and load sides into account parameter.

4 Proposed Control Scheme

This methodology yields an enhancement in the quality of input current waveform. In this scenario, a contemporary error amplifier is utilized to drive a pulse width modulation modulator and perceptibly detects and filters the current passing through the inductor. The internal current loop effectively mitigates the discrepancy between the reference and mean input current by adopting the following approach.

One common technique for establishing a reference current involves the multiplication of the output from the voltage error amplifier, which is responsible for setting the amplitude of the current reference signal (as shown in the accompanying figure), by a suitably scaled copy of the rectified line voltage Vg. This methodology involves ensuring that the reference signal remains consistently proportional to the line voltage whilst being intrinsically synchronized. This measure is deemed essential to achieving a power factor of unity. The proposed technique confers several advantages, including an unvarying switching frequency, the lack of a compensatory ramp, a reduced susceptibility to commutation-related interference, and superior input current waveforms as compared to peak current control.

In this model when STATCOM is applied on the output side of the system it can improves the power quality and it shows the decreasing of THD of the system hence it improves the power factor.
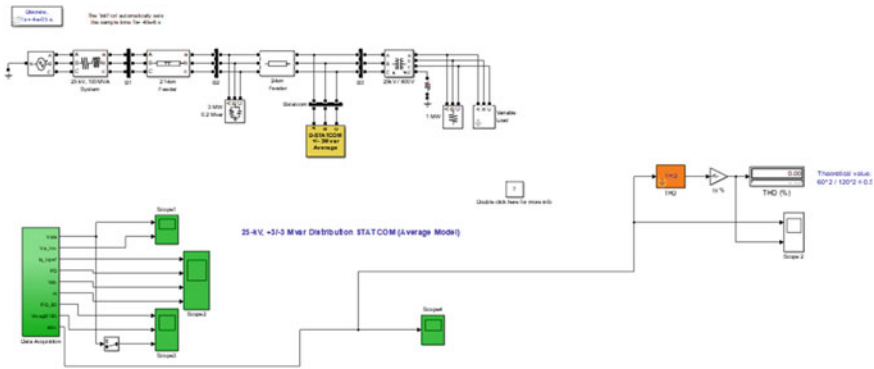
5 Simulation Modelling

See Fig. 5.

Fig. 5 Simulation modelling

6   Proposed Fuzzy Logic Control

Comparing the FLC to traditional PI controllers, the FLC is a new controller. Utilizing this controller enhanced the system's responsiveness and stability. Here, a series of logics were employed to create FLC operation. There is no need for a mathematical strategy. Both building and using this controller are simple. The DC link voltage regulation is very important in the suggested work. The DC link voltage was managed to seamlessly control D STATCOM operation. Therefore, the voltage at the DC link is adjusted here with the aid of FLC. The rules that are applied in the proposed system are shown in the table (Fig. 6).

From this we can says that when power quality is improved in system automatically power factor in the system also improves.

When we applied D STATCOM with fuzzy logics we have seen that to improvement wave form quality.

From Fig. 09 it is seen that when we applied D STATCOM the fluctuation of graph is more wavy or we can say that the graph of the current is more transient in nature but when we applied fuzzy logic control (FLC) the nature of the current graph is less transient and they will approach near to the steady state stability as shown in Fig. 7.

From Fig. 8 shows the current nature of graph is more fluctuating in nature but when we applied a fuzzy logic control it shows Fig. 10 is the current nature of the graph is more stable.
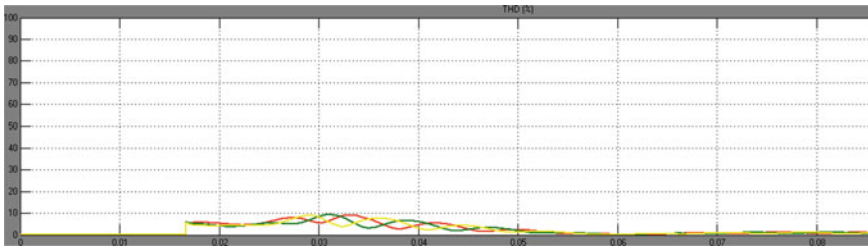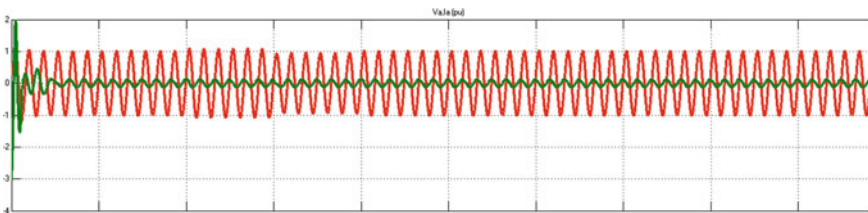

Fig. 6   Reduced THD near about 2% graph

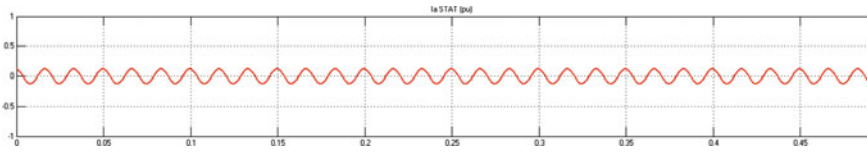**Fig. 7**   Simulation result after connected fuzzy logic control (FLC)

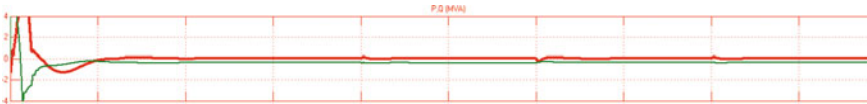**Fig. 8** Current wave form after connected fuzzy logic control

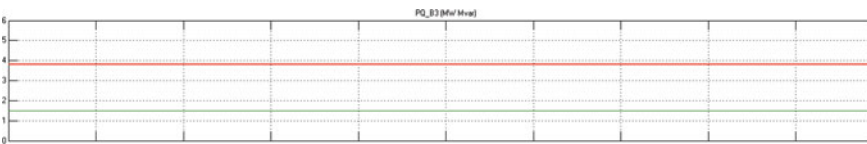**Fig. 9** Active power (P) in watt and reactive power (Q) in VAR

Fig. 10 Active power (P) in PU and reactive power (Q) in PU

When comparing with Figs. 9 and 11 it is seen that the active power (P) and reactive power (Q) is more stable when applied FLC control. And less stable when we applied D STATCOM.

Figure 10 shows the active power in per unit and reactive power in per unit the graph must be approach steady state stability limit.

7   Conclusion

In this work, a novel AC/DC boost-type converter for power factor correction (PFC) applications is presented. It has some intriguing and distinctive features. The harmonic current produced by the non-linear load might theoretically be reduced by a single converter, eliminating the need for a second converter. Considering the outcomes of a modelling analysis the design in question was found to completely get rid of all lower order harmonics. It is possible to get a power factor close to unity and a THD measurement about 2%. This method is only applicable in situations where the non-linear load exhibits pulsing electrical current while consistent, is quite small. Additionally, in the evaluation of related literature, a scholarly investigation of various configurations of power factor correction approaches has been conducted. But when we applied to the fuzzy logic control the nature of the graph becomes comes to more stable than D STATCOM. And is seen that the quality active and the reactive power must be approach to the steady stability. And hence from above discussion we can

conclude that when power quality is improved then automatically power factor of the system also improved.

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