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HARMONIC ELIMINATION USING BOOST CONVERTER

Satheeswaran.K, Nepolean. C, Vikash. M
Department of Electrical and Electronics Engineering, Aksheyaa College of Engineering
raajsathees@gmail.com,

***Abstract* – In this paper, a design of Shunt active Power Filter (APF) to compensate harmonics introduced by various non-linear loads is presented. Nonlinear loads are the major harmonic pollutant in the power system. The proposed harmonic elimination approach has been implemented using a boost converter that compensates the harmonic current drawn by single phase diode rectifier load. In absence of diode rectifier (Non-linear Load), the PFC boost converter draws purely sinusoidal current from source. In presence of diode rectifier the boost converter draws current in such a way that the total current drawn from source becomes purely sinusoidal. The advantage of the proposed topology is its simplicity in deriving the reference current with which the duty cycle for the shunt converter is derived. The boost converter acts as a current source that compensates for harmonic current. Simulation of proposed topology has been carried out in MATLAB.**

Keywords* – *Nonlinear loads, harmonic current, boost converter, power factor, Active power filter.

I. INTRODUCTION

Proliferation of nonlinear loads has increased the problems related to power quality (PQ) issues. 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 are the effects of harmonics introduced by the nonlinear loads. Although conventional passive filter systems are attractive due to their low costs and ease at application, they do not provide satisfactory results in most cases because of their limited and network parameter dependent performances with the development at power semiconductor devices, modern solutions such as active power filters (APF) have become a valuable alternation to solve the PQ problems at customers and utilities various circuit configurations have been proposed in recent years. Power quality problem is defined as voltage, current or frequency deviations. A growing power quality concern is harmonics distortion. Harmonics are caused by the nonlinearity of customer loads. In recent years, active power filters has been developed to suppress harmonics generated by static power converters. A flexible and versatile solution to power quality is offered by active power filters. Currently they are based on PWM converters and connect to low and medium voltage distribution system in shunt or in series. Series active power filter always operates in conjunction with shunt passive filters in order to compensate load current harmonics.

The features of power factor correction, active power filter and AC/DC converter are combined and a new power factor correction technique using Boost converter is proposed to work simultaneously as an active power filter to supply compensated currents that are equal to the harmonic currents produced from the nonlinear loads, and a AC/DC converter supplies the DC power to its load and takes a nearly sinusoidal current from the supply. Hence no dedicated power devices are needed for harmonic cancellation and it reduces the cost of the filter.

The single-phase diode rectifier associated with the boost converter is widely employed in active PFC. In principle, the combination of the diode bridge rectifier and a dc-dc converter with filtering and energy storage elements can be extended to other topologies, such as buck, buck-boost, and Cuk converter [9]. The boost topology is very simple and allows low-distorted input currents, with almost unity power factor using different dedicated control techniques.

Typical strategies are hysteresis control, average current mode control and peak current control [10]. More recently, on cycle control and self-control have also been employed. Some strategies employed three level 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; (i) for each nonlinear load, one separate converter should be employed, (ii) 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 (iii) some strategies use very complex control algorithm. To overcome all these type of problems, a new power factor correction technique using boost converter is proposed.

II. HARMONIC COMPENSATION USING BOOST CONVERTER

The proposed technique consists of one full-bridge diode rectifier and one Boost Converter. Here the full bridge diode rectifier is considered as the non-linear load which is the source of harmonics. A hysteresis current control is adopted to track the required line current command. In this arrangement boost converter can be used to eliminate the harmonic current generated by the diode rectifier. The boost converter supplies the required harmonic current produced by the non-linear load, hence the total arrangement draws a nearly sinusoidal current with improved power factor.

Fig.1 Schematic of Proposed topology

III. Proposed Boost Converter

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 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.

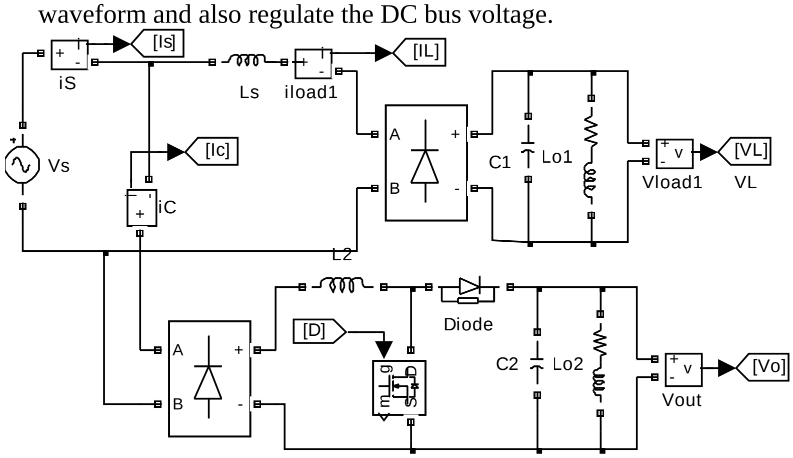

Fig.2 Simulink model of proposed converter

IV. Control Scheme

The control scheme adopted in this proposed technique is very simple and can be practically implemented easily. Fig. 5 shows the block diagram representation of the adopted control scheme. Vo* is the reference voltage that is expected at the output of the boost converter & Vo is the actual output of the boost converter. The error in the output voltage is given to the voltage controller.

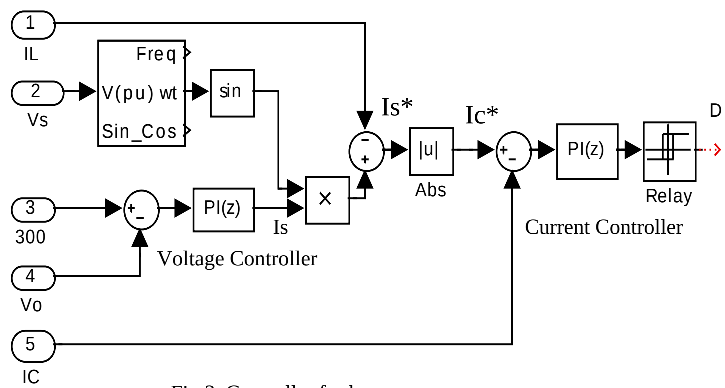

Fig.3 Controller for boost converter

The voltage controller (PI controller) processes the error signal and produces appropriate current signal (Is). The current signal (Is) is multiplied with unit sinusoidal template which is produced by using phase locked loop (PLL), to produce Issin ωt. The load current I_L subtracted from the Issin ωt to produce the reference current signal Is*. As the boost inductor current can't be alternating, the absolute circuit gives the absolute value of the reference current signal Is* that is Ic*. The actual signal (Ic) and the required reference signal (Ic*) are given to the current controller to produce the proper gating signal. The current controller adopted is a hysteresis current controller. Upper and lower hysteresis band is created by adding and subtracting a band 'h' with the reference signal Ic* respectively. The inductor current is forced to fall within the hysteresis band. When the current goes above the upper hysteresis band, i.e. Ic*+h, the pulse is removed resulting the current forced to fall as the current will flow through the load. When the current goes below the lower hysteresis band i.e. Ic*-h, the pulse is given to the switch, so the current increases linearly. In this way the switching of the power switch can be done to track the reference current command & the resultant current drawn by both the

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loads will be nearly sinusoidal with low harmonic content and low total harmonic distortion (THD); hence the power factor of the supply can be improved. As the capacitor is connected in the load side, to hold the DC output voltage, when the instantaneous value of the supply voltage is more the than DC output voltage current will supplied by the source.

V. SIMULATION STUDIES

The proposed power converter is simulated using MATLAB Simulink tool and the results were obtained as shown in Fig.4. The values taken in the simulation circuit are given in the below table.

TABLE 1. System Parameters

S.No	Name	Value
1	Supply voltage	230V (P-P), 50Hz
2	Source impedance	0.1mH
3	Boost Inductor	2mH
4	Output of Boost Converter	300V
5	Non-linear Load	20mH, 500Ω, 1000µF
6	Boost Converter	470µF, 100Ω, 10mH

The values taken in the simulation circuit are given below. The input supply is taken as 230V with source impedance at 1mH and boost converter impedance at 5mH. The different results obtained are shown & explained briefly.

Fig.4 shows different waveforms of the system after compensation using PFC boost converter. As we know, the more harmonics content in the supply current increases the total harmonic distortion (THD) of the system hence the overall power factor of the system decreases.

This harmonic current should be removed at the point of generation. So to remove the harmonic current generated by the non-linear load, a PFC boost converter is connected in shunt with the non-linear load & the compensating current is shaped in such a way that the total current drawn by the total arrangement becomes sinusoidal. The source feels the total arrangement to be resistive load and supply nearly sinusoidal current with nearly unity power factor. The current drawn by the non-linear load is shown in Fig. 4 (a) and the compensating current wave form is- shown in the Fig. 4 (b) resulting supply current to be nearly sinusoidal shown in Fig. 4 (d). Using FFT analysis, we can see the harmonic content in the supply current with proposed technique is almost neglected. The lower order harmonics content in the load current almost removed and only fundamental current drawn from the supply shown in Fig. 4 (d), resulting supply current to reduce to 13% and improve the supply power factor to 0.987.

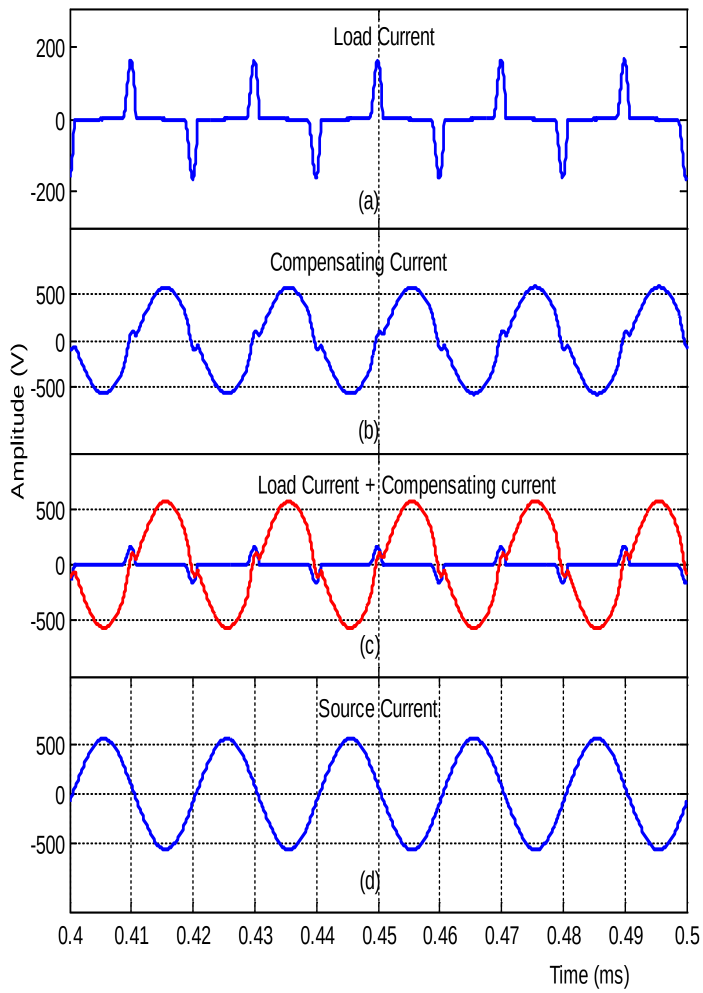

Fig.4. Simulation waveforms of proposed converter

V. CONCLUSION

This paper has presented one new AC/DC boost-type converters for harmonic reduction. 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 15%. 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. Further this work can be extended for compensating harmonics introduced by different nonlinear loads.

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