HARMONIC REDUCTION BY USING HYBRID ACTIVE POWER FILTER PERFORMANCE IN MICRO GRID DISTRIBUTION SYSTEM WITH A FUZZY LOGIC CONTROLLER

V.Geethika [1], M. Anitha[2]
PG Student[1], Assistant Professor [2]
Dept. of EEE, RVR&JC College of Engineering, Chowdavaram, Guntur, AP, India[1]

Abstract : This paper presents harmonic reduction in distribution system using hybrid filter to improve power quality. Now a days we are using non linear loads in distribution systems.These non linear loads are creating the power quality problems, reduction of voltage and increase the voltage .To improve the power quality different types of methods are there, in that main is the active and passive filter.In this project proposing the hybrid filter both active and passive filter compare with conventional methods.By using this hybrid filter it reduces the harmonics and improve the power quality.In active power filter it has the voltage source inverter (VSI), and storage as an active and then passive filter.The result of the proposed filter improve the power quality in distribution system, the converter has been simulated in MATLAB/SIMULINK platform.

Keywords: Voltage distortion, Non linear loads, Active filters, Passive filters, Matlab.

I. INTRODUCTION:

Harmonics are one of the major concerns in a power system. Harmonics cause distortion in current and voltage waveforms resulting into deterioration of the power system. The first step for harmonic analysis is the harmonics from non-linear loads. The results of such analysis are complex. Over many years, much importance is given to the methods of analysis and control of harmonics. Harmonics present in power system also has non-integer multiples of the fundamental frequency and have a periodic waveform. The harmonics are generated in a power system from two distinct types of loads. First category of loads is described as linear loads [1-2]. The linear time-invariant loads are characterized such that application of sinusoidal voltage results in sinusoidal flow of current. Non-linear loads are considered as the second category of loads. The application of sinusoidal voltage does not result in a sinusoidal flow applied sinusoidal voltage for non-linear devices. Harmonic current is isolated by using harmonic filters in order to protect the electrical equipment from getting damaged due to harmonic voltage distortion. They can also be used to improve the power factor. Generally, current controlled voltage source inverters are used to interface the intermittent RES in distributed system.

Recently, a few control strategies for grid connected inverters intermittent RES in distribution systems as it may pose a threat to network in terms of stability, voltage regulation and power-quality (PQ) issues. Therefore, the DG systems are required to comply with strict technical and regulatory frameworks to ensure safe, reliable and efficient operation of overall network. With the advancement in power electronics and digital control technology, the DG systems can now be actively controlled to enhance the system operation with improved PQ at PCC. However, the extensive uses of power electronics based incorporating PQ solution have been proposed. In [3] an inverter operates as active inductor at a certain frequency to absorb the harmonic current. But the exact calculation of network inductance in real-time is difficult and may deteriorate the control performance. With the advancement in power electronics and digital control technology, the DG systems can now be actively controlled to enhance the system operation with improved PQ at PCC. However, the extensive use of power electronics based equipment and non-linear loads at PCC [3]-[5] generate harmonic currents, which may deteriorate the quality of power. The widespread increase of non-linear loads nowadays, significant amounts of harmonic currents are being injected into power systems. Harmonic currents flow through the power system impedance, causing voltage distortion at the harmonic currents‟ frequencies.

In this work PI controlled Hybrid power filter implemented for the harmonics and reactive power compensation of a nonlinear load.The control scheme is based on sensing line currents only and an approach different from convention ones. The DC capacitor voltage is regulated to estimate the reference current template form system. The role of the DC capacitor is described to estimate the reference current. A design criterion is described for the selection of power circuit components. Both the control schemes are compared and performance of both the controllers is investigated. A detailed simulation program of the schemes is developed to predict the performance for different conditions and simulink models also has been developed for the same for different parameters and operating conditions.

II. HYBRID POWER FILTER

Depending on the system application or electrical problem to be solved, active power filters can be implemented as shunt type, series type, or a combination of shunt and series active filters. These filters can also be combined with passive filters to create hybrid power filters. The shunt-connected active power filter shows the characteristics similar to STATCOM (reactive power compensator of power transmission system) when used with self-controlled dc bus. The shunt active power filters, acts as a current source, injects harmonic compensating current of same magnitude as the load current harmonics but shifted in phase by 180° and thus compensates load current harmonics. The series-connected filter mainly compensates voltage in unbalances and sags/swell from the ac supply and thus protects consumer from inadequate voltage quality.

These are used for low-power applications. These filters can be used as a substitute to UPS with comparatively very low cost as no energy storing element like battery is used. Moreover overall rating of components is smaller. The series active filters work as hybrid filter topologies with passive LC filters. In case passive LC filters are connected in parallel to the load then series active power filter operates as a harmonic isolator and forcing the load current harmonics to circulate mainly through the passive filter rather than the power distribution system.

The main advantage of this topology is that the rated power of the series active filter is a small fraction of the load KVA rating. In series-shunt active filter the shunt active filter is located at the load side and can be used to compensate for the load harmonics, reactive power, and load current unbalances. And the series filter is at the source side and can act as a harmonic blocking filter. This series-shunt active filter topology has been called the Unified Power Quality conditioner. And other advantage of this topology is regulates the dc link capacitor voltage. The power supplied or absorbed by the shunt portion is the power required by the series compensator. Multilevel inverters are based on hybrid AC filter and recently used for active filter topologies.

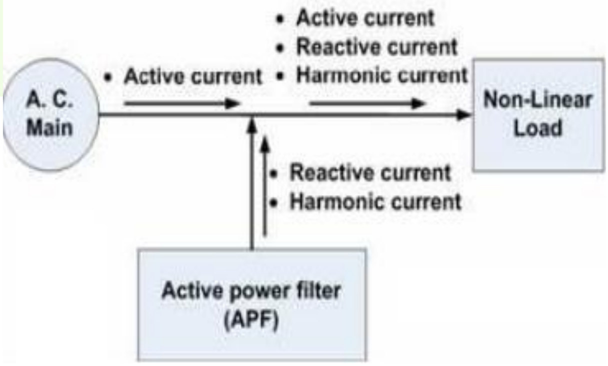

Fig. 1.APF block diagram.

Fig1 shows the basic compensation principle of the three phase shunt APF. It is designed to be connected in parallel with the nonlinear load to detect its harmonic and reactive current and to inject into the system a compensating current. In the conventional p-q theory based control approach for the shunt APF, the compensation current references are generated based on the measurement of load currents. However, the current feedback from the SAPF output is also required and therefore, minimum six CSs are desired in a unbalanced system. In addition, the reference current calculation algorithm are simplified and easily implemented in the experimental prototype. In the reduced current measurement control algorithm, sensing only three-phase voltages, three source currents and a DC-link voltage is adequate to compute reference currents of the three phase SAPF. In this way, the overall system design becomes easier to accomplish and the total implementation cost is reduced.

III. VOLTAGE SOURCE CONVERTERS

The active power filter topologies mostly use voltage source converters. This topology, shown in Fig.2, converts a dc voltage into an ac voltage by appropriately gating the power semiconductor switches. A single pulse for each half cycle can be applied to synthesize an ac voltage. For these purposes most applications requiring dynamic performance.Pulse width modulation is the most commonly used for active power filter. PWM techniques applied to control the VSI for consist of chopping the dc bus voltage to produce an ac voltage of an arbitrary waveform.

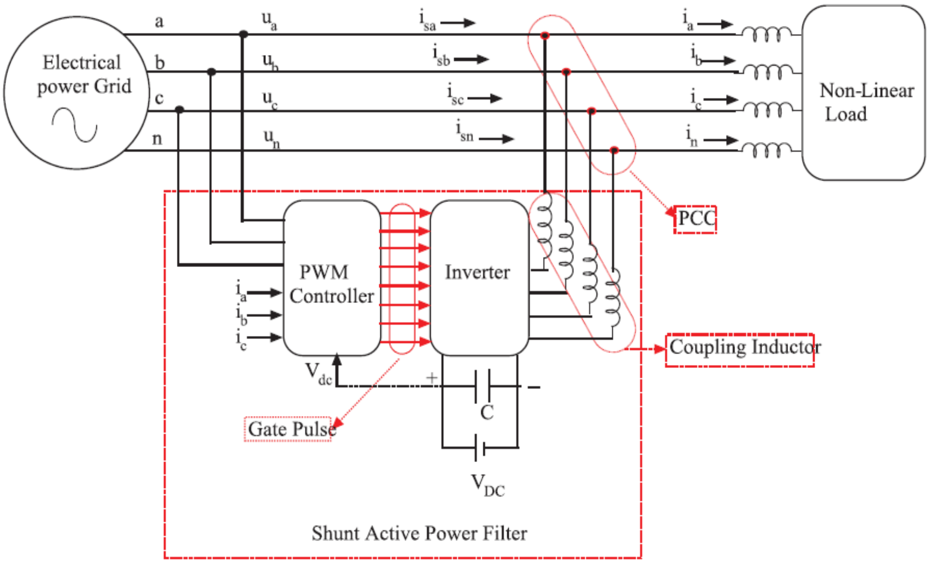

Fig2 Shunt active power filters

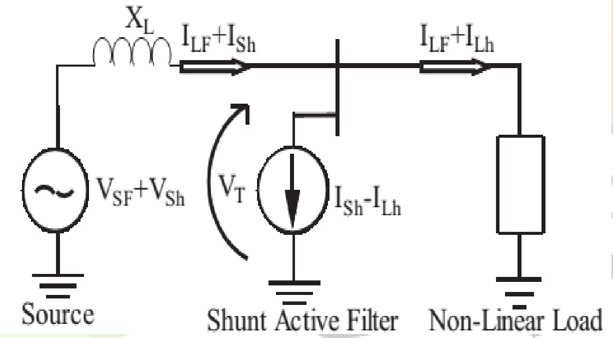

Fig3.PrincipleofShuntCurrent Compensation

Voltage source converters are preferred over current source converter because it has higher efficiency and lower initial cost than the current source converters [3, 4, 9] as shown in Fig.3. They can be readily expanded in parallel to increase their combined rating and their switching rate can be increased if they are carefully controlled so that their individual switching times do not coincide. Therefore, higher-order harmonics can be eliminated by using converters without increasing individual converter switching rates. Because of non linear load current will have harmonics, so load current will be the summation of fundamental and all other harmonics, all harmonics will be integer multiple of fundamental frequency. Load current can be written as

$$i_L(t) = \sum_{n-1}^{\infty} i_n \sin(n\omega t + \varphi_n) = i_l \sin(\omega t + \varphi_l) + \sum_{n=2}^{\infty} \sin(n\omega t + \varphi_n) \quad (1)$$

Instantaneous Load can be written as

$$p_L(t) = v_s(t) \times i_L(t) \quad (2)$$

Putting value of i L(t) from equation (1) in equation (2)

$$p_A(t) + p_R(t) + p_H(t) \quad (3)$$

Here PA(t) is active or fundamental power. Only fundamental component of voltage and current can deliver power to the load and PR(t) is reactive power. Harmonic power denoted by PH(t). So active or real power drawn by the load from the source is

$$p_A(t) = v_m i_1 sin^2\omega t \times cos\varphi_1 = v_s(t) \times i_s(t) \quad (4)$$

Therefore, source current after compensation will be given by equation (5)

$$i_s(t) = {p_A(t)}/{v_s(t)} = i_1 cos\varphi_1 \times sin\omega t = i_m sin\omega t \quad (5)$$

Where $i_m = i_1 cos\varphi_1$

In a practical converter, there are switching, conducting and capacitor leakage losses. So that losses must be supplied by the supply or by the grid itself. So total current supplied by supply will be given as

$$i_{SP} = i_m + i_{slo} \quad (6)$$

Where isp= peak current supplied by source. where islo = loss current of converter supplied by the source.

If total harmonic and reactive power of the load is supplied, by the Active Power Filter then there will not be any harmonic in source current and source current will be in phase with the source voltage. Therefore, the total source current including losses will be given as So compensating current will be given as

$$i_c(t) = i_L(t) - i_S^*(t) \quad (7)$$

It is obvious from above discussion that for instantaneous compensation of reactive power in addition, harmonic power, source (grid) should be able to supply current. Therefore, it is necessary to find $I^*_s(t)$ which is known as reference current.

IV. PI CONTROL SCHEME:

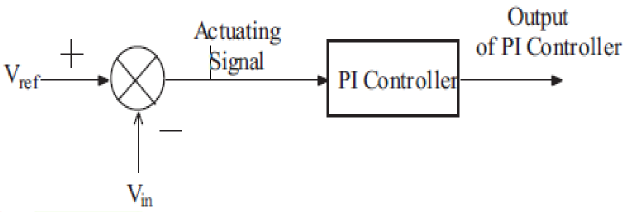

Fig 4 APF control scheme with PI controller

The error signal is fed to PI controller. The output of PI controller has been considered as peak value of the reference current. It is further multiplied by the unit sine vectors (usa, usb, and usc) in phase with the source voltages to obtain the reference currents (isa *, isb *, and isc *). These reference currents and actual currents are given to a hysteresis based, carrier less PWM current controller to generate switching signals of the PWM converter [5]. The difference of reference current template and actual current decides the operation of switches. These switching signals after proper isolation and amplification are given to the switching devices. Due to these switching actions current flows through the filter inductor Lc, to compensate the harmonic current and reactive power of the load, so that only active power drawn from the source.

Fuzzy logic controller

In FLC, basic control action is determined by a set of linguistic rules. These rules are determined by the

System. Since the numerical variables are converted into linguistic variables, mathematical modeling of the system is not required in FC. The FLC comprises of three parts: Fuzzification , interference engine and de-fuzzification.

The FC is characterized as i. seven fuzzy sets for each input and output.

ii. Triangular membership functions for simplicity.

iii. Fuzzification using continuous universe of discourse.

iv. Implication using Mamdani’s, ‘min’ operator.

v. Defuzzification using the height method.

Fuzzification: Membership function values are assigned to the linguistic variables, using seven fuzzy subsets: NB (Negative Big), NM (Negative Medium), NS (Negative Small), ZE (Zero), PS (Positive Small), PM (Positive Medium), and PB (Positive Big).

Table 1 Rule Base Table with 49 Rules

e /ce	NB	NM	NS	Z	PS	PM	PB
NB	NB	NB	NB	NB	NM	NS	Z
NM	NB	NB	NB	NM	NS	Z	PS
NS	NB	NB	NM	NS	Z	PS	PM
Z	NB	NM	NS	Z	PS	PM	PB
PS	NM	NS	Z	PS	PM	PB	PB
PM	NS	Z	PS	PM	PB	PB	PB
PB	Z	PS	PM	PB	PB	PB	PB

V. SIMULATION RESULTS

The hybrid active power filter modeled is developed and simulated in MATLAB with PWM based PI controller. The complete active power filter system is composed mainly of three-phase source, a non-linear load, a voltage source PWM converter, and a PI controller. All these components are modeled separately, integrated and then solved to simulate the system. A load with highly nonlinear characteristics is considered for the load compensation at PCC.

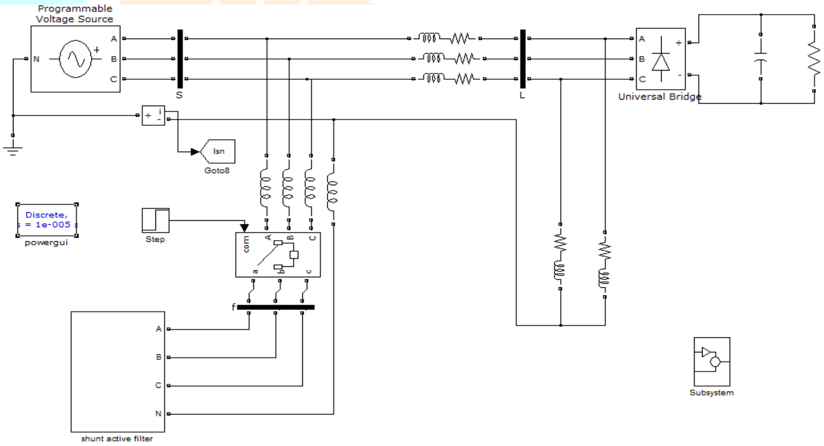

Fig 5 Simulink circuit of the proposed method

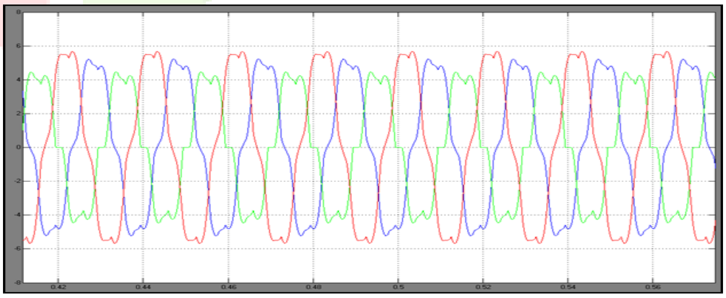

Fig 6 Source current when the compensator is not connected

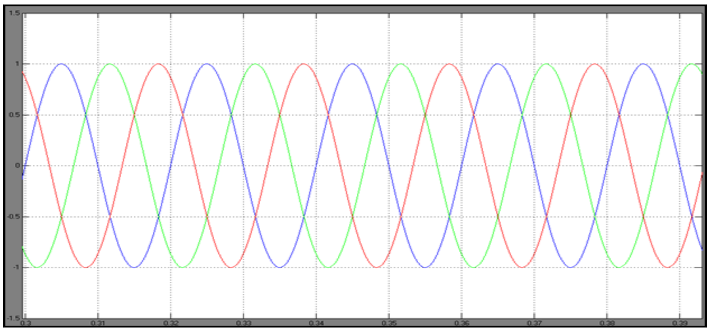

Fig 7 Source current when the compensator is connected

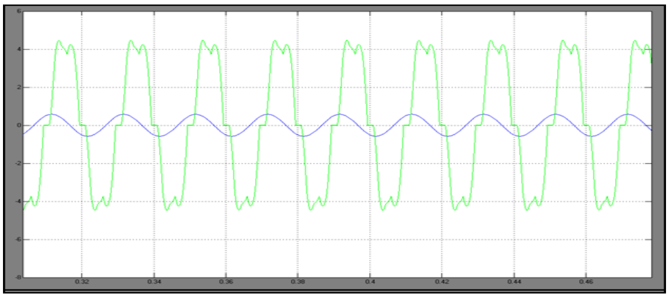

Fig 8 Phase difference between Source Voltage and Current without Compensation

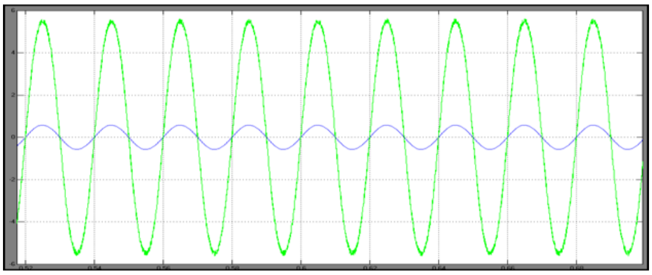

Fig 9 Phase difference between Source Voltage and Current without Compensation

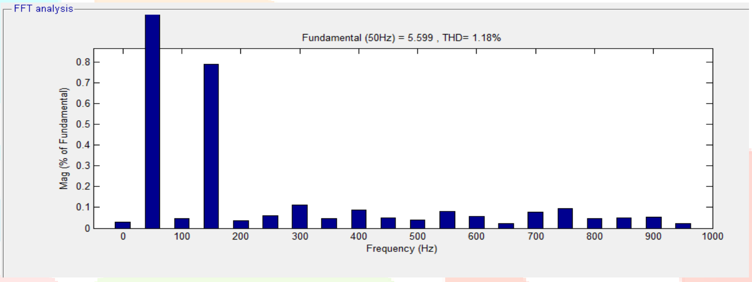

Fig 10 Total harmonic distortion of the system of the conventional PI method

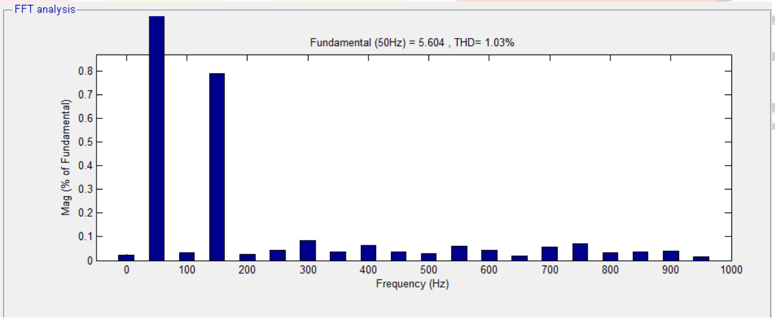

Fig 11 Total harmonic distortion of the system of the conventional FUZZY method

CURRENTS	BEFORE COMPENSATION	WITH **PI** CONTROLLER	WITH FUZZY CONTROLLER
PHASE **A**	12.07	2.65	1.18
PHASE **B**	19.47	2.36	1.03
PHASE **C**	10.28	2.80	1.27

TABLE 1: THD (%) COMPARISION OF VOLTAGE SOURCE TYPE OF NON-LINEAR LOAD

CURRENTS	BEFORE COMPENSATION	WITH **PI** CONTROLLER	WITH FUZZY CONTROLLER

PHASE **A**	13.76	3.88	1.60
PHASE **B**	24.90	4.10	1.79
PHASE **C**	12.07	3.04	1.13

TABLE 2: THD(%) COMPARISION OF CURRENT SOURCE TYPE OF NON-LINEAR LOAD

VI. CONCLUSION

Power quality improvement by using Hybrid active power filter simulated in MATLAB is implemented for harmonic and reactive power compensation of the non-linear load at PCC. In hybrid filter we have the active and passive filter because of its accurate performance. It is found from the simulation results that hybrid active power filter improves power quality of the distribution system by eliminating harmonics and reactive power compensation of non-linear load. It is found from simulation results that shunt active power filter improves power quality of the power system by eliminating harmonics and reactive current of the load current, which makes the load current sinusoidal and in phase with the source voltage.

VII. REFERENCES:

[1] C.-S. Lam, M.-C.Wong Y.-D. Han, "Hysteresis current control ofhybrid active power filters" Published in IET Power Electronics,doi: 10.1049/iet-pel.2011.0300

[2] Vinod Khadkikar, "Enhancing Electric Power Quality UsingUPQC:A Comprehensive Overview" IEEE Transactions on PowerElectronics, Vol. 27, No. 5, May 2012

[3] S. Orts-Grau, F. J. Gimeno-Sales, A. Abellan-Garcia, S. Segui-Chilet, and J. C. Alfonso-Gil, "Improved Shunt Active PowerCompensator for IEEE Standard 1459 Compliance" IEEETransactions on Power Delivery, Vol. 25, No. 4, October 2010

[4] Reyes S. Herrera and Patricio Salmeron, "Instantaneous ReactivePower Theory: A Comparative Evaluation of DifferentFormulations" IEEE Transactions On Power Delivery, Vol. 22,No. 1, January 2007

[5] Reyes S. Herrera, Patricio Salmeron, and Hyosung Kim,"Instantaneous Reactive Power Theory Applied to Active PowerFilter Compensation: Different Approaches, Assessment, and
Experimental Results" IEEE Transactions On IndustrialElectronics, Vol. 55, No. 1, January 2008

[6] Yunwei Li, D. MahindaVilathgamuwa and Poh Chiang Loh,"Microgrid Power Quality Enhancement Using a Three-PhaseFour-Wire Grid-Interfacing Compensator" IEEE Transactions OnIndustry Applications, Vol. 41, No. 6, November/December 2005

[7] A.Elmitwally, SAbdelkader and M.EI-Kateb, "Neural networkcontrolled three-phase four-wire shunt active power filter" IEEPower Generation & transmission Vol. 147, N0.2 March 2000

[8] J. A. Barrado, R. Grino and H. Valderrama-Blavi, "Power-QualityImprovement of a Stand-Alone Induction Generator Using aSTATCOM With Battery Energy Storage System" IEEE
Transactions On Power Delivery, Vol. 25, No. 4, October 2010

[9] Rade M. Ciric, Antonio PadilhaFeltrin, and Luis F. Ochoa,"Power Flow in Four-Wire Distribution Networks—GeneralApproach" IEEE Transactions On Power Systems , Vol. 18, No. 4,November 2003

[10] P. Salmeron, J. C. Montano, J. R. Vazquez, J. Prieto, and A. Perez,"Compensation in Nonsinusoidal, Unbalanced Three-Phase Four-Wire Systems With Active Power-Line Conditioner" IEEETransactions On Power Delivery, Vol. 19, No. 4, October 2004.