ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN ELECTRICAL, ELECTRONICS, INSTRUMENTATION AND CONTROL ENGINEERING
Vol. 3, Issue 7, July 2015

Harmonic Mitigation using Hybrid Filters

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Abstract: This project deals with the power quality issues in distribution system caused by harmonics produced due to unbalanced and non linear loads. In recent years the use of non linear load is tremendously increasing which result in production of harmonics in the power system. The harmonics causes adverse effect on end user equipment which results in maloperation of equipment. Therefore it becomes necessary to provide easy and economical system to improve the power quality of the supply. So for eliminating the harmonics, hybrid filters are used. A hybrid filter is combination of series active filter and shunt passive filter. A series active is a power electronics based flexible AC transmission based device which is nothing but a voltage source inverter injecting the voltage in the line and is used to improve the filtering characteristics of the passive filter. In literature, various methods have already been suggested for harmonic mitigation. The study is carried out by three phase dynamic simulation of distribution system component model. The simulation has been carried out using MATLAB which shows the satisfactory performance of the hybrid filter to improve the system dynamics.

Keywords: Harmonics, Series ctive Filter, Shunt Passive Filter, Non Linear Loads, Power Quality.

I. INTRODUCTION

The modern world is dealing with problem of power quality deterioration. Power quality is an issue that is becoming increasingly important to electricity consumers at all levels. The characteristics of power quality enable the power supply to work properly. Power quality refers to maintain a near sinusoidal power distribution bus voltage at rated magnitude and frequency. Voltage magnitude, waveform and frequency are the major factors that dictate the quality of a power supply. Use of extensive non linear power electronic loads is one of the major reasons for producing the harmonic in the power system which deteriorates the quality of power supply. Main sources of harmonics in power system are the non linear power electronic equipment such as drives, rectifiers, inverters or loads with switch mode power supply such as television sets, computers, fluorescent and energy saving lamps. Some detrimental effects of harmonics are – maloperation of controlled devices, additional losses in transformers, capacitors and rotating machines, additional noise from motors and other apparatus, telephone interferences and causing parallel and series resonance frequencies.Therefore, it becomes necessary to use the harmonic eliminating devices to maintain the quality of power supply at the consumer end. The harmonic reducing methods are passive filter, active filter and hybrid filters. In this projectwe are using the combined topology of shunt passive and series active filter called as hybrid filter. The advantage of using series active filter is it improves the filtering characteristics of shunt passive filter and the shunt passive filter reduces the cost of series active filter. Thus the entire system becomes more economical. It has been found that hybrid filter works effectively and removes all the harmonics generated by unbalanced and non linear loads.

II. GENERAL DESCRIPTION OF THE SYSTEM

In this project we mitigate the harmonics which are produced due to power electronic switching devices. For mitigating the harmonics we mainly used the series active filter in support with the shunt passive filter called the hybrid filter. Filtering characteristics of power system mainly depends on the source impedance by inserting the series active filter (SAF) in line with power system act as variable active impedance by varying these in appropriate manner filtering characteristics can be improved. Series active filter is basically a dynamic voltage regulator which injects the voltage dynamically in the line to balance the voltages at source and load sides. The series active filter is operated in such a fashion that it does not supply or absorb any average real power in the steady state. The SAF consists of a voltage source inverter (VSI) to realize filter. The output of the VSI is connected in series with the distribution feeder through a series transformer. This device employs IGBT/diode that are operated in hysteresis pulse width modulation (HPWM) fashion. The VSI can regulate the load voltage at given magnitude and also phase angle. This can be established through real power exchange between the dc source and the ac system through the inverter. In this project we are using the synchronous reference frame(d-q) theorem to improve the performance of series active filter. By using the shunt passive filter in addition with series active filter reduces the cost to considerable level so that system becomes economical. The circuits of Fig. 1 and Fig. 2 show the block diagram and the proposed system respectively.

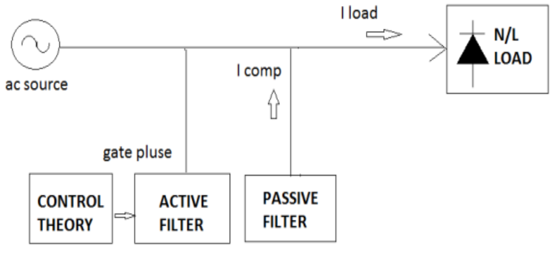

Fig. 1 Block diagram

The main components of the proposed system are the shunt passive filter, the series active filter, the current transformers (CT's), synchronous reference(d-q)theorem along with hysteresis pulse width modulation (HPWM) control circuit. The shunt passive filter, connected in parallel with the load, is tuned to eliminate the fifth and

DOI 10.17148/IJIREEICE.2015.3729

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seventh harmonics and presents a low-impedance path for the other load current harmonics. It also helps to partially correct the power factor by compensating the reactive power. The series active filter, working as a sinusoidal current source in phase with the line voltage supply, keeps "unity power factor," and presents very high impedance for current harmonics. The CT's allow for the isolation of the series filter from the mains and the matching of the voltage and current rating of the filter with that of the power system.

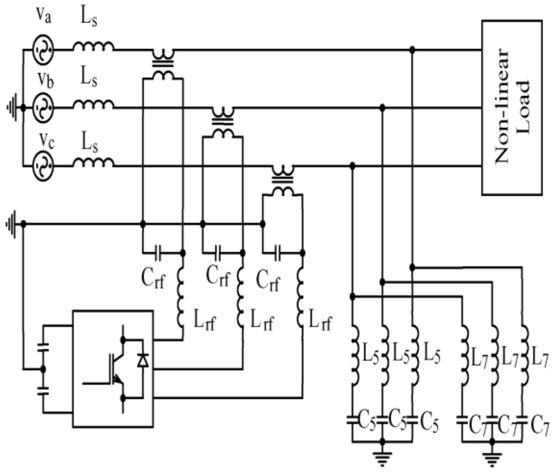

Fig. 2 Proposed systems

SHUNT PASSIVE FILTER

Shunt passive filters consists of resistors, inductors and capacitors. They are not expensive and are often used to restrict the harmonic currents from entering the power system thereby minimizing the effect of harmonics due to nonlinear loads. Also, the passive filters are kept close to the source of harmonic generation i.e. the nonlinear loads. Doing so, the passive filters produce better results in reducing the harmonic effect. Fig. 3 shows a three phase representation of distribution system with the nonlinear load and shunt passive filter.

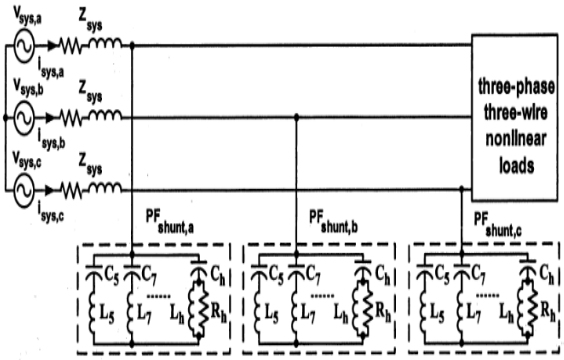

Fig. 3 Three phase shunt passive filter

SERIES ACTIVE FILTER

A series active filter constitutes a synchronous reference frame and hysteresis control with an LC passive output filter. To compensate some of the voltage disturbances, namely sags, the series active power filter injects active power. The series active filter control theory is applied to a three phase system. In other point of view the proposed topology can be understood as three single phase series active power filters. Hence the Fig. 4 represents a single phase series active filter.

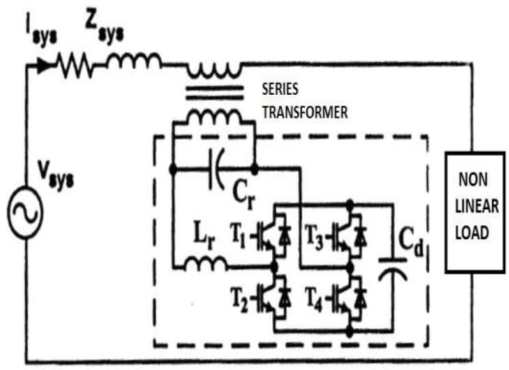

Fig. 4 Single Phase Series Active Filter

SYNCHRONOUS-REFERENCE-FRAME THEOREM:

The performance of the active filter mainly depends on the methodology adopted to generate the reference current and the control strategy adopted to generate the gate pulses.

HYSTERESIS CURRENT CONTROLLER

HCPWM controller derives the switching signals of the inverter power switches in a manner that reduces the current error. Fig 5 represents the Hysteresis current controller.

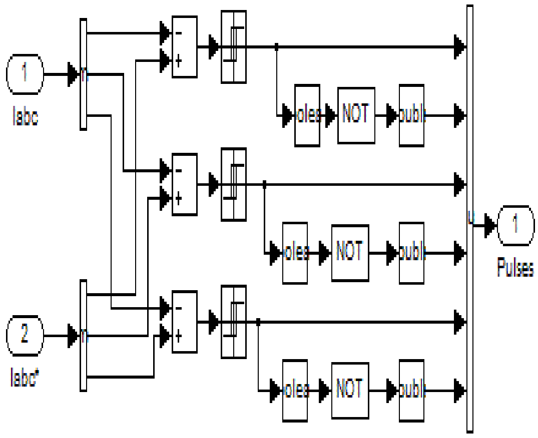

Fig 5 Hysteresis current controller

III. SIMULATION RESULTS

3.1 WITHOUT FILTER

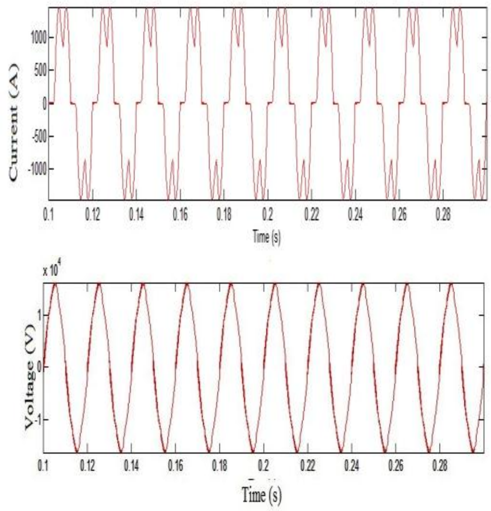

Fig.6 Source Output due to Non Linear and Unbalanced Load

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Vol. 3, Issue 7, July 2015

3.2 WITH FILTER

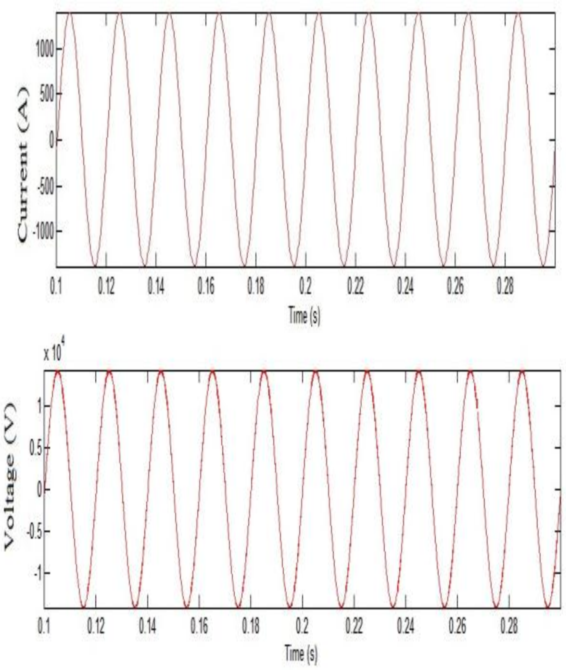


Fig.7 Source Output due to Non Linear and Unbalanced Load

3.3 WITHOUT FILTER

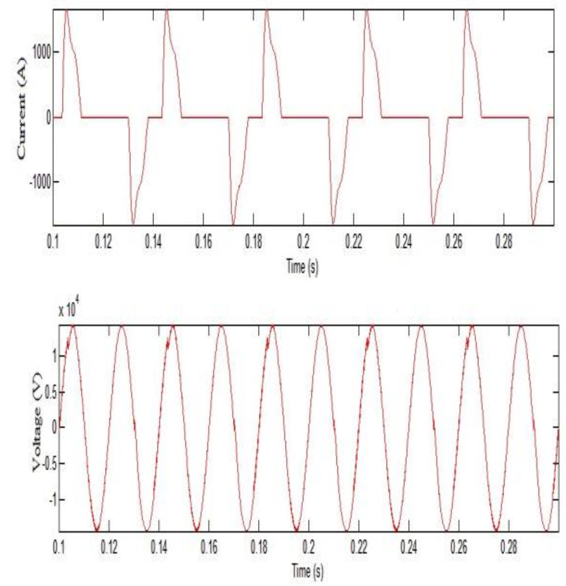
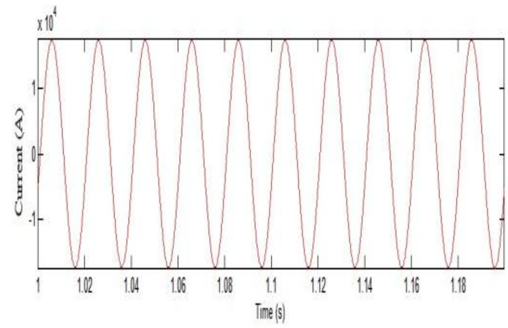


Fig.8 Source Output due to Thyristor Load

3.4 WITH FILTER



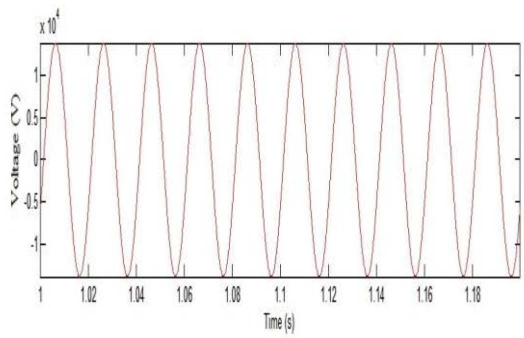


Fig.9 Source Output due to Thyristor Load

3.5 THD ANALYSIS

Table I

Parameters	Before Mitigation for non-linear load (THD)	After Mitigation for non-linear load (THD)	Before Mitigation For thyristor load (THD)	After Mitigation For thyristor load (THD)
Supply voltage	5.63%	1.43%	3.67%	0.05%
Supply current	29.42%	1.86%	80.37%	0.12%

IV. CONCLUSION

Hybrid filter combines the advantages of both passive and active filter for non linear and unbalanced load. The result shows satisfactory performance in which the harmonics on the load current those appear on the source side are completely removed and the current becomes balanced sinusoidal as well as the load voltage is free from harmonics resulting in balanced sinusoidal waveform. The reactive power compensation provides improved power factor and reduces the losses in devices. The quality of supply power is improved so as to meet the requirement of the system.

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