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Comparative Study of Power Quality Improvement Using Active and Passive Filters

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***Abstract* — Nonlinear loads draw non-sinusoidal currents due to the current harmonics generated by them. In modern power distribution systems, the majority of loads draw reactive power and/or harmonic currents from the AC source along with main active power currents. These nonunity power factor linear and nonlinear loads cause low efficiency of the power supply system, poor power factor, destruction of other equipment due to excessive stresses and EMI problems. Passive filter and Active power filter (APF) based on a simple control technique is used to provide reactive power and harmonics compensation for linear and nonlinear loads. This paper compares the working of these filters using MATLAB and simulink. The three- phase PWM-based voltage source inverter is applied to a distorted three-phase 500 kVA, 440 volt, 50 HZ power system under the steady state operating condition. Finally their simulated results of Source Voltage and Current, Filter Voltage and Current & Load Voltage and Current are compared and their respective THDs are obtained. Current wave THDs of power utility line are compared without filters, with Passive Filter and with Shunt Active Power Filter.**

***Keywords* — Passive Filter, Shunt Active Power Filter (APF), PWM-VSI, Total Harmonic Distortion (THD).**

I. INTRODUCTION

With the increasing of nonlinear loads in utility line, harmonic problem has been concerned ever more than before. Those nonlinear loads, such as diode rectifiers, thyristor converters and some electronic circuits, on industrial, commercial and residential equipments, drawing non-sinusoidal currents, pollute the utility line due to the current harmonics generated by them. They have brought about many problems in utility power, such as: Low power factor Low energy efficiency, Interference by EMI and Distortion of line voltage, etc. APF connection is classified in series (series APF) and in parallel (shunt APF). Shunt APF are based on PWM converters and connect to low and medium voltage distribution system. Shunt active power filters operate as a controllable current source. Both schemes are implemented preferable with voltage source PWM inverters, with a dc bus having a reactive element such as a capacitor. Their performance depends on the power rating and the speed of response. The selection of the type of active power filter to improve power quality depends on the source of the problem. Shunt active power filter compensate current harmonics by injecting equal-but- opposite harmonic compensating current. Shunt APF operates as a current source injecting the harmonic components generated by the load but phase shifted by 180^{o}. This principle is applicable to any type of load considered as a harmonic source. Moreover, with an appropriate control scheme, the active power filter can also compensate the load power factor. In this way, the power distribution system sees the non linear load and the active power filter as an ideal resistor. Shunt active power filters are normally implemented with pulse-width modulated voltage source inverters. PWM-VSI operates as a current controlled voltage source.

II. OPERATION OF PASSIVE FILTERS

Passive filters are consisted of tuned series L-C circuits. These filters should be applied as close as possible to the offending loads, preferably at the farthest three to single-phase point of distribution. This will ensure maximum protection for the upstream system, passive filters can be categorized as shunt and series filters. A shunt filter is characterized as a series resonant and trap-type exhibiting low impedance at its tuned frequency. Deployed close to the source of distortion, this filter keeps the harmonic currents out of the supply system. It also provides some smoothing of the load voltage. A series filter is characterized as a parallel resonant and blocking type with high impedance at its tuned frequency. It is not very common because the load can be distorted. So this paper uses the passive shunt filter to control the propagation of harmonic currents.

III. OPERATION OF SHUNT APF

Shunt active power filter compensate current harmonics by injecting equal-but-opposite harmonic compensating current. Shunt power filter needs to pass bidirectional current and it is typically composed of a full bridge or half bridge with an energy storage capacitor at the dc side. The H-bridge is in parallel with a nonlinear load. It is the same as a single-phase of voltage-source inverter (VSI) while working as APF (or as a PWM rectifier).The APF system connected in parallel with the load could cancel the harmonic/reactive components in the line current (*is)* so that the current flow from the power line is sinusoidal and in phase with the power line voltage. In other words, the compensating current (i_L) forces the line current (*is) approach to sinusoid and* unity- power-factor can be achieved by APF system. The currents of the APF system can be expressed as

$Is = Io + I_L$ …….(1)

where *Io is the nonlinear load current.*

It operates in bipolar PWM mode. Operates in two modes and its four switches have the switching frequency of *fs.*

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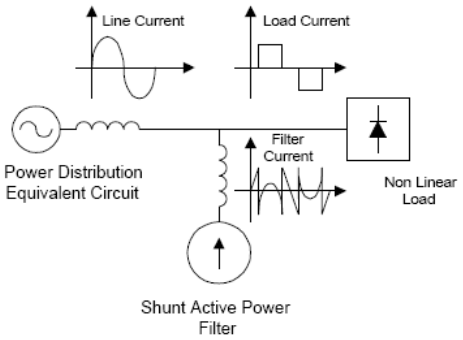

Fig.1. Compensation characteristics of a shunt active power filter

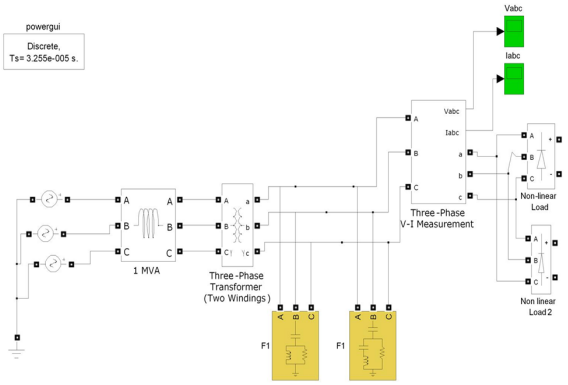

Fig.2 Simulated Model for power Distribution System using Passive Filter

IV. Modeling and Analysis

The simulated model of three-phase system comprises of a source, nonlinear load and a shunt passive filter is shown in fig 2. A passive filter is designed as a series combination of reactors and capacitors. The size of a filter is defined as the reactive power that the filter supplies at the fundamental frequency. It is substantially equal to the fundamental reactive power supplied by the capacitors.

The active power filter is composed of standard three-phase PWM based neutral point clamped (NPC) voltage source inverter bridges with two dc-bus capacitors to provide an effective current control. A PWM current control is employed to give fast response of the active filter. Figure 3 shows the neutral point clamped two three-phase (PWM) voltage source inverter is simulated by MATLAB/SIMULINK, is connected in parallel to a harmonic polluted, 500 kVA power distribution system. Here, two dc-bus capacitors are connected to the input side by replacing the dc voltage source. Harmonics have little contribution to the capacitors charge because of their higher frequency, but the reactive current may dominate voltage ripples of the dc capacitors at the fundamental frequency. The modeled system comprises an ac source, non-linear load, the shunt active power filter. The components of the system are analyzed separately and integrated to develop the complete model for the simulation. The modeled system for Passive filter comprises an ac source, non-linear load and the Passive filter.

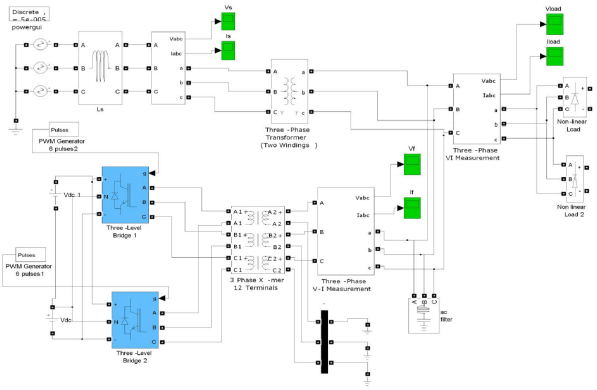

Fig.3. Simulated Model for Shunt APF on power Distribution System

V. Simulation Results

In this paper the passive and active power filters are simulated in MATLAB and simulink in order to compensate the harmonic current. The three phase three wire system is used as a source which is connected to a nonlinear load. The fig 2 shows the simulated model of shunt APF connected to the power system. The simulated model for passive filter is shown in fig 3. The modeled system comprises an ac source, non-linear load, the shunt active power filter/passive filter and the control scheme. The components of the system are analyzed separately and integrated to develop the complete model for the simulation. Figures 4-8 present the Load, the Filter and the Source current waveform of phase- 1without power filter & with passive and active filters. With Passive filter connected, THD is reduced but resonance does not allow a greater reduction. With APF, THD is reduced to a great extent.

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Fig.4. Source current waveform & THD without filter

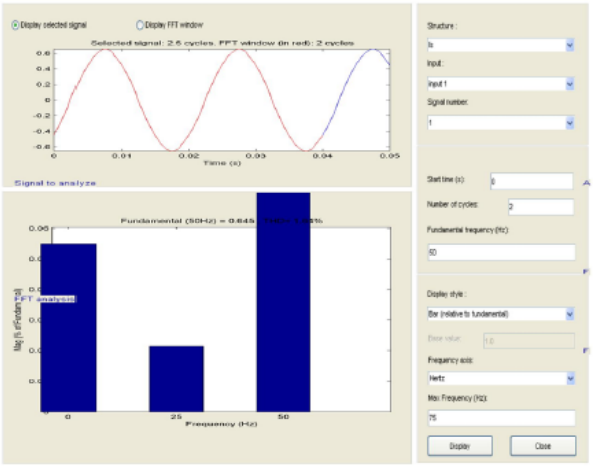

Fig.7. Source current waveform & THD with APF

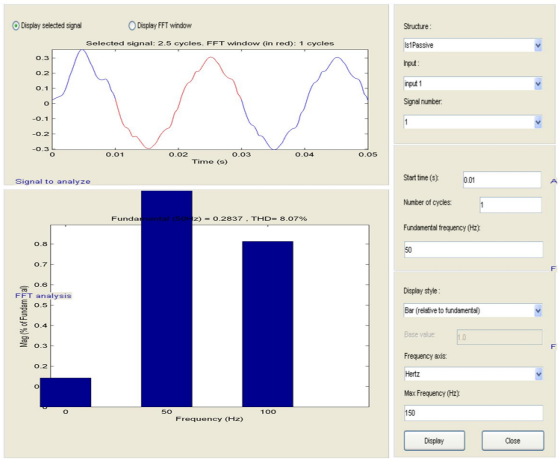

Fig.5. Source current waveform & THD with Passive Filter

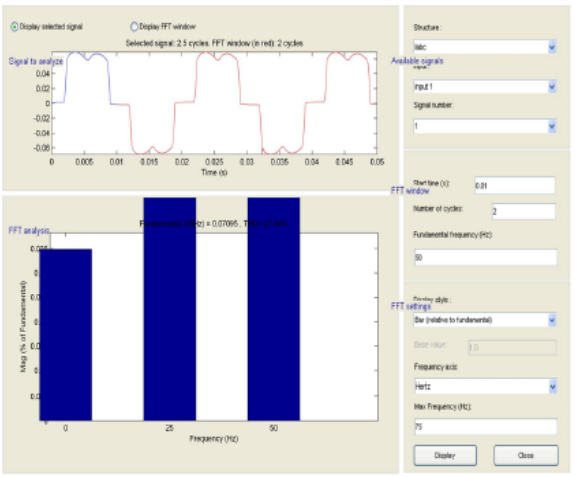

Fig.8 Load current waveform & THD with APF

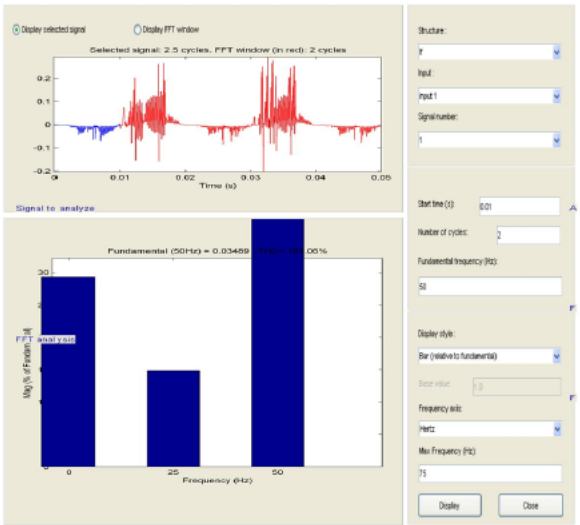

Fig.6 APF current waveform & THD

VI. CONCLUSION

Table1

S.No.	Compensation Technique	Source Current Distortion (% THD)
1	Before compensation	26.86
2	After compensation with PASSIVE FILTER	9.07
3	After compensation with APF	2.64

Table I shows the simulation results of the Power Distribution System without compensation, with APF & with Passive Filter compensating a diode rectifier with a RL load. The line current THD of the APF is dropped from about 26.86% to about 2.64% and the PF is improved from 0.65 to 0.98. Line current THD using Passive Filter is dropped from about 26.86% to about 9.07%. From Table, it can be seen that the THD and PF are much improved by the APF. It brings the THD of the system below 5%, the limit imposed by the IEEE-519

standard. So the use of shunt APF effectively eliminates the reactive and harmonic components of the load current and makes the line current near sinusoidal. It also improves the Power factor of the system.

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