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Power Quality Improvement by using Shunt Active Filters in Distribution System

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ABSTRACT:-Electrical power quality has important factor in electrical power system. There is extensive use of non linear loads, creates power quality problems. Nowadays the growth in electronic devices applications increasing the non linear loads in power systems because most of these devices involve uses regulated power supply such as SMPS, Choppers etc but because of the non linearity involved with the controlling process, it produces undesired harmonics and reactive power components which causes the heating, vibration electromagnetic interference etc. Hence to mitigate these problems many methods are suggested such as use of passive LC filters and other controlled active power filters (APF) with different controlling algorithms and topologies. In this paper we present the necessary modeling and simulations are carried out in MATLAB environment using SIMULINK and power system block set tool boxes. The behavior of different configurations of active and passive tuned filters on power quality studied.

Key Words: Active Power Filters (APF), Total Harmonics Distortion, Reactive power

I. INTRODUCTION

Electronically controlled devices are more suitable device than the transformer based devices for the AC to AC or AC to DC converters generally used for voltage regulation or controlling of induction motors and other devices because of lowest cost, fast and simple controllability, smaller size. The main drawback of such systems that they produce the unwanted harmonics which could cause serious problems such as excessive heating, vibrations, lowering the power factor and electromagnetic interference. Now even these drawbacks it's a preferable choice because of its more advantages.

To reduce the harmonics conventionally passive L-C filters were used and also capacitors were employed to improve the power factor of the ac loads. But the passive filters have several drawbacks like fixed compensation, large size and resonance problem. To mitigate the harmonics problem, the active power filter (APF) is a popular approach in electrical power system.

II. ACTIVE POWER FILTER

The active power filters are used to suppress harmonic distortion in power system. The active filters use power electronic converters in order to inject harmonic components to the system that cancel out the harmonics in supply current caused by non linear loads.

2.1. Configuration of Active Power Filters on topology, converter type and the number of phases.

The topology of active power filter is classified in to three types.

- Shunt Active Power Filters
- Series Active Power Filters
- Hybrid Active Power Filters

The converter type is mainly two types

- Voltage Source Inverter (VSI)
- Current Source Inverter (CSI)

Finally based on the phases the Active Power Filter mainly two types

- Two-wire (Single Phase) System
- Three or Four-wire three phase system

2.2. Control Unit of Active Power Filters

The active power filter (APF) is a popular approach for cancelling the harmonics in power system. The main component in the APF is the control unit the control. [1]

1. **Harmonic Extraction Technique:** Harmonic Extraction is the process in which reference current is generated by using the distorted waveform. Many theories have been developed such as p-q theory (instantaneous reactive power theory), d-q theory, frieze controller, PLL with fuzzy logic controller, neural network etc. Out of these theories, more than 60 % researcher works consider using p-q theory and d-q theory due to their accuracy, robustness and easy calculation.

2. **Current Modulator:** Current modulator is mainly used to provide the gate pulse to the active power filter (inverter). There are many techniques used for giving the gating signals to PWM VSI such as sinusoidal PWM, triangular PWM, hysteresis current controller, adaptive hysteresis current controller, space vector modulation and space vector with hysteresis current controller etc.

   The above described two control techniques (harmonics extraction technique and current modulator technique) are main research focus on many researchers in the recent years. It may be noted that either harmonics extraction technique or current modulator can be used individually or both at a time.

III.SHUNT ACTIVE POWER FILTER:

The proposed topology for reactive power compensation and harmonic mitigation using Shunt Active Power Filter (SAPF) is shown in fig.1. the proposed scheme consist of shunt active power filter connected in parallel with a distribution system. Distribution system consists of a wide percentage of harmonic producing non linear loads. Shunt active power filters compensate current harmonics by injecting equal but opposite harmonic compensating current [2]. In this case, the shunt active power filter operates as a current source injecting the harmonic components generated by the load but phase shifted by 180 degree. As a result, components of harmonic currents contained in the load current are cancelled by the effect of the active filter, and source current remains sinusoidal and in phase with the respective phase to neutral voltage. This principle is applicable to any type of load considered as a harmonic source. Moreover, within appropriate control scheme, the active power filter can also compensate the load power factor [3]. In this way, the power distribution system sees the non-linear load and the active power filter as an ideal resistance. The compensation characteristics of shunt active filter is shown in fig.2.

3.1. Operation of Shunt Active Power Filter

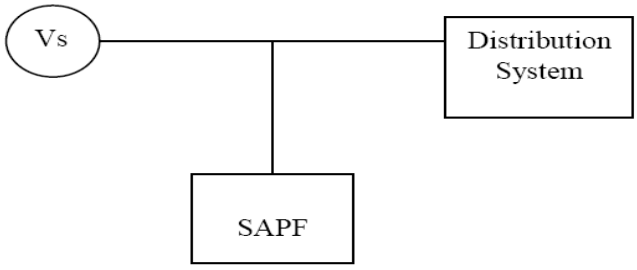

Fig. 1 Proposed topology

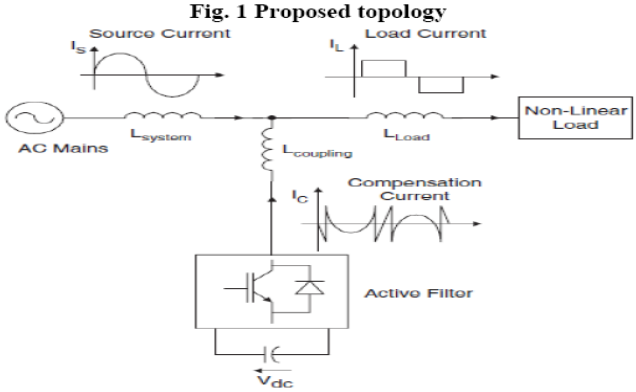

Fig. 2 Compensation characteristics of a SAPF

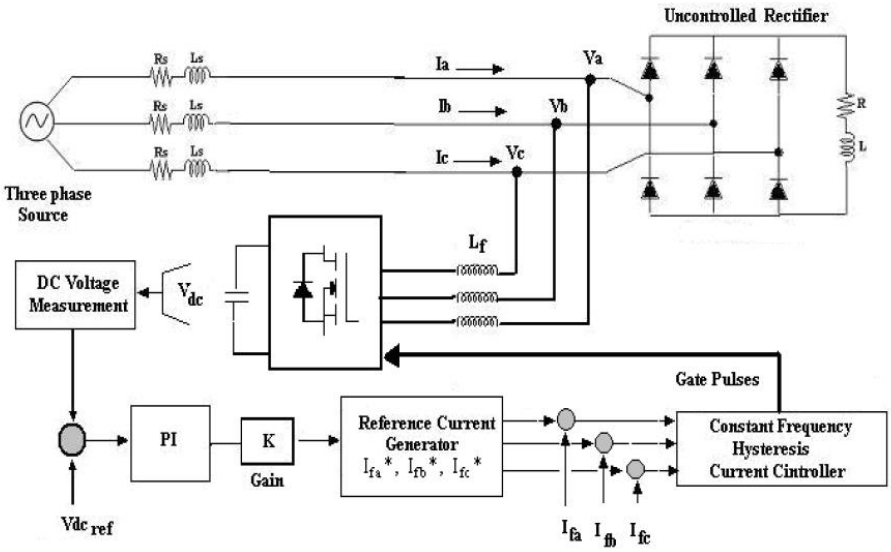

Fig. 3. Shunt Active Power Filter with the proposed control technique

Figure 3 shows the schematic representation of a shunt active power filter connected in a three phase system feeding a non linear load.

Voltage Va, Vb, Vc and current Ia, Ib, Ic indicate the phase voltages and currents at the load side respectively. The active power filter is connected in parallel with the load to suppress the harmonics. The shunt active filter generates the compensating currents Ifa, Ifb, Ifc to compensate the load currents Ia, Ib, Ic so as to make the current drawn from the source as sinusoidal and balanced. The performance of the active filter mainly depends on the technique used to compute the reference

current and the control strategy followed to inject the desired compensation current into the line. In this paper. The instantaneous p-q theory is used to determine the current reference. (Ifa*, Ifb* and Ifc*) [3]

3.3. Simulation and Performance Investigation of Shunt Active Power Filter

In this section the simulation analysis of shunt active power filter is described for R-L load and FFT analysis has been carried out simultaneously.

3.4. Simulation Result

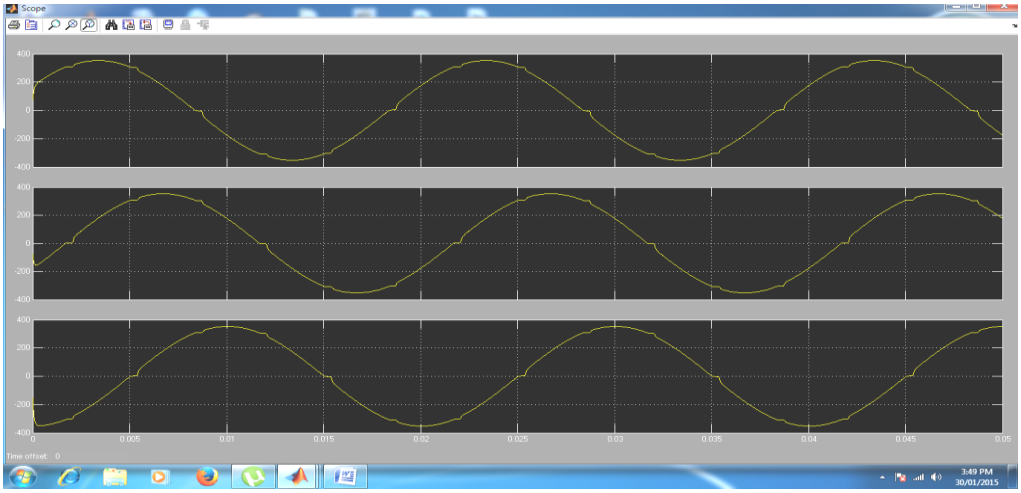

Figure 4 Source Voltage before Compensation

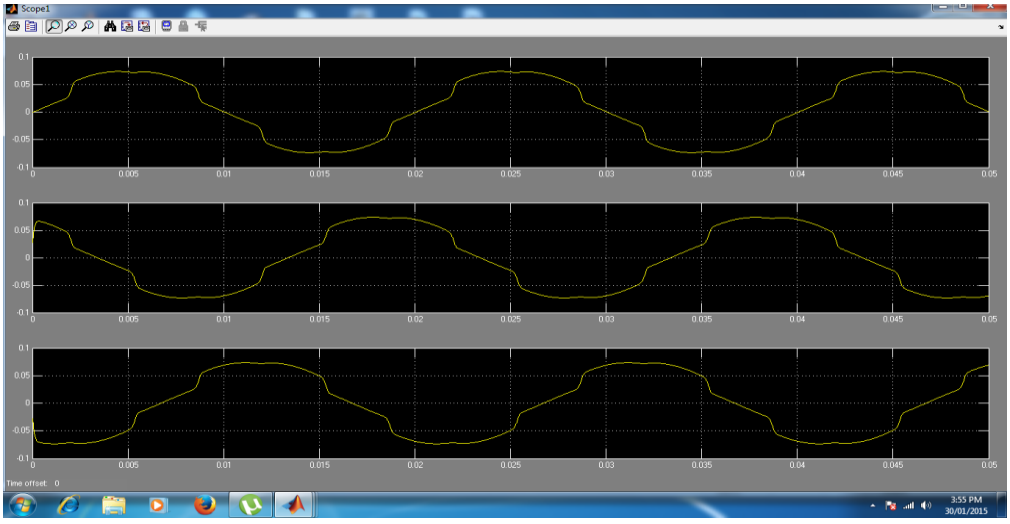

Figure 5 Load Current before Compensation

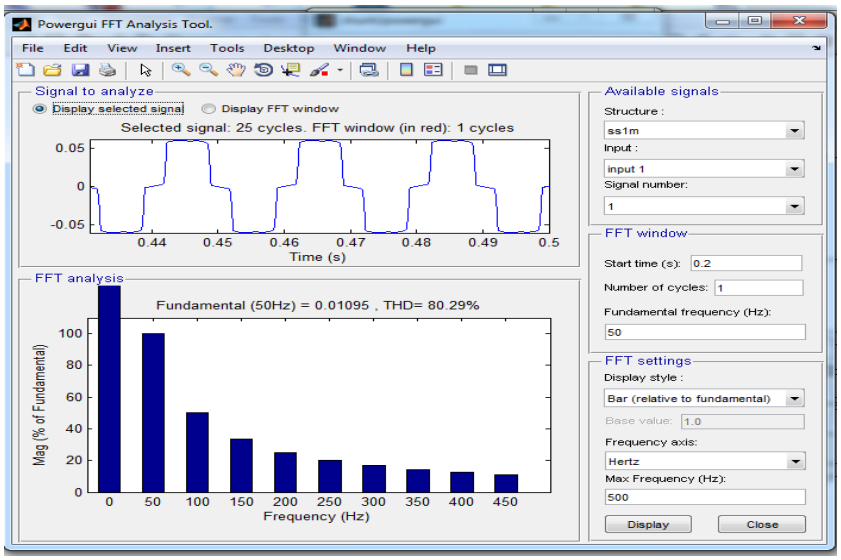

Figure 6 FFT Analysis for Load Current

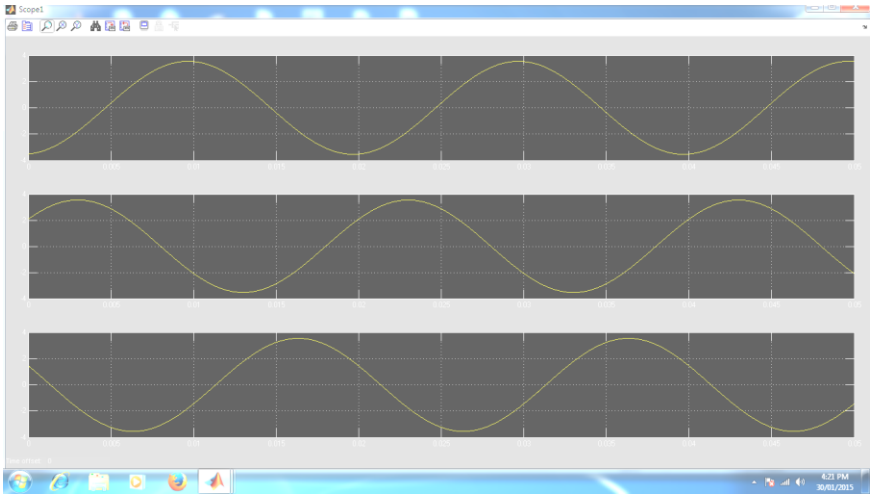

Figure 7 Load Current after Compensation

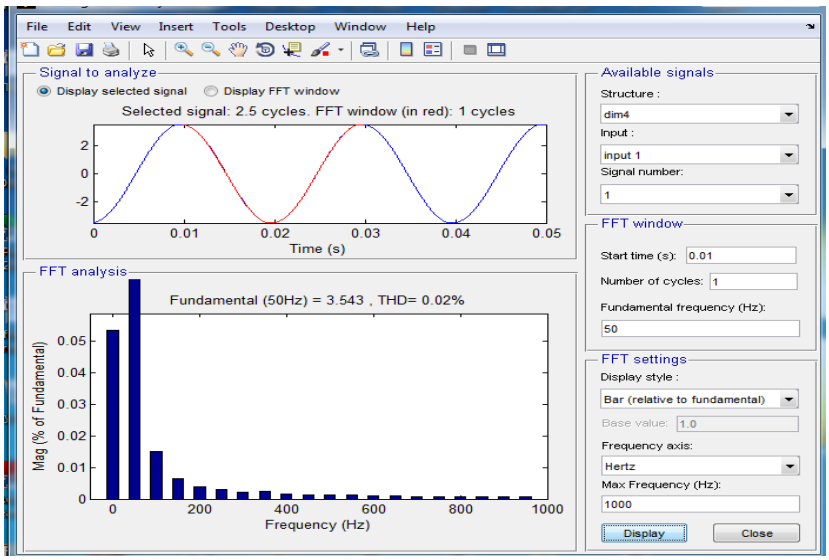

Figure 8 FFT Analysis for Load Current after compensation

Load Type	THD (%) Load Current Before Compensation	THD (%) Load Current After Compensation
R –L Load	80.29 %	0.02 %

Table 1 THD Analysis for Shunt Active Power Filter for R - L Load

It is clear from the table that the performance of the system improves and the THD is reduced from 80.29 % to 0.02 %.

IV. Conclusion

A MATLAB based model of shunt active power filter has been simulated for R – L load using the instantaneous reactive power theory technique. The simulation result shows that the load current harmonics are compensated very effectively by using Shunt Active Power Filter.

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