Performance Analysis of Power Quality Improvement using Shunt Active Power Filter

G. Jegadeeswari

Abstract: *Nowadays, the usage of non-linear loads in power system is more sufficient. For example, UPS, inverters, converters, etc. These loads make the supply current as non-sinusoidal and distorted form, which is called harmonics. At this time Active power filters have been developed to improve power quality. In this Paper, a Shunt Active Power Filter (SAPF) control scheme has proposed to eliminate the current harmonics and improve the power quality. The shunt active power filter controlled by using the different controllers such as (PI, PID, Fuzzy logic, Pq Theory and hysteresis controller). In our proposed system, Hysteresis controller and Instantaneous power theory were used to reduce the harmonics current using the shunt active power filter. And both controllers' results are compared, and then find which controller is most suitable to control the shunt active power filter in term of total harmonic reduction. MATLAB/SIMULINK power system toolbox is used to simulate the proposed system.*

Keywords: *Power Quality, Shunt Active Power Filter (SAPF), Hysteresis Current Controller, Harmonics, MATLAB/Simulink.*

I. INTRODUCTION

Nowadays, non linear loads in the distribution system generate power quality issue for power engineers. The utilization of power electronics device at the end consumer side is growing enormously because of the advancement in the semiconductor technology. The use of power electronics devices gives rise to problems like reactive power disturbance, disturbance to other consumer, harmonic generation, poor power factor, low system efficiency, heating of devices, etc. This adverse may becomes extensive in future year, hence it is very significant mitigate this problems.

Mainly there are two approaches for the mitigation of power quality problems. The primary approach is load conditioning, which guarantee that the load is resistant harmonics. Equipments are made less responsive to power disturbance and harmonics, which is not so likely practically. The other solution is power line conditioning. In this approach line conditioning system is installed at point of common coupling (PCC) that counteracts or suppresses for the adverse consequence created by non linear harmonic creating loads.

Conventionally passive filters were used to deal with reactive power disturbance problems and harmonic production. But they were facing major drawbacks like resonance problem, fixed compensation characteristics, large size, effect of source impedance on performance etc. so this result became less attractive. Consequently the conception of active power filter was introduced by Machida and Sasaki in 1971. Active power filters gives efficient result when compared to conventional passive filters for the mitigation of harmonic and reactive power disturbance problems.

II. ACTIVE POWER FILTERS

It compensates the load current by injecting equal but opposite harmonic compensating current. It offers a low impedance path to harmonic currents at its tuned frequency. It acts as the current source that supplies the compensating current that the load needs and has a phase shift of 180 degree.

An active Power filter satisfies the drawbacks of the Passive filters. Active power filters classified into two types. They are Shunt active power filter and Series active power filter. These paper discuss about to remove the current harmonics, so we consider only Shunt active filters. It is made up of MOSFET, IGBT, and GTO-Transistors etc.

Fig. 1 shows the basic scheme of shunt active power filter which compensate load current harmonics by injecting equal but opposite harmonic compensating current.

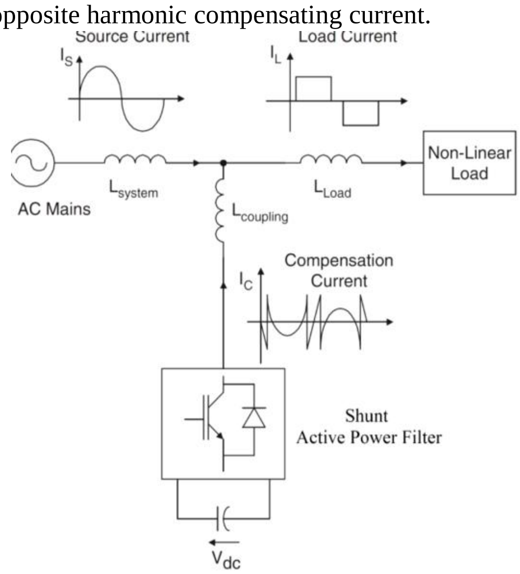

Fig. 1: Basic scheme of shunt active power filter

Mostly shunt active power filter operates as a current source injecting the harmonic components generated by the load but phase shifted by 180°. As shown in Fig.2 series active power filters operate mainly as a voltage regulator and as a harmonic isolator between the nonlinear load and the utility source.

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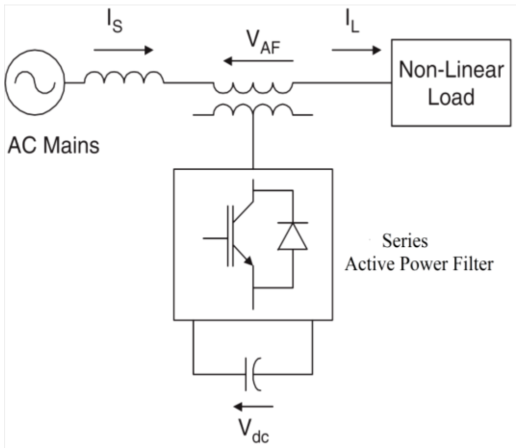


Fig. 2: Basic scheme of series active power filter

The series active filter injects a voltage component in series with the supply voltage and removes harmonic components in voltage waveforms and therefore can be regarded as a controlled voltage source, compensating voltage sags and swells on the load side. Basically shunt active power filter are more efficient and less cost when compared to series active power filters since most of the non linear loads generate current harmonics. In addition series active power filter needs sufficient protection scheme. The combined shunt and series active filter is known as Unified Power Quality Conditioner (UPQC).

III. HYSTERESIS CURRENT CONTROL TECHNIQUE

The SAPF acts as an external current source and it consists of a dc link capacitor arrangement. This can be charged when High current pulse occurs in supply due to non-linear load. Then discharged when Low current pulse occurs in supply due to non-linear load. The rate of charging and discharging was controlled by switches S1-S6.

The switching S1-S6 was controlled by Hysteresis controller, this controller having inputs of,

i. Actual current

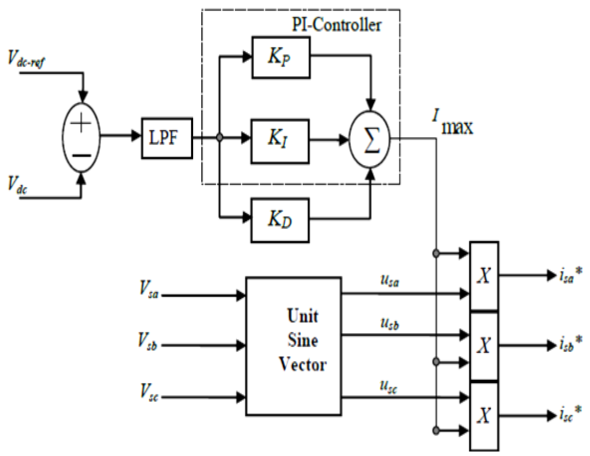
ii. Reference current

Actual current: It can be obtained from main supply

Reference current: It can generated from the Reference current generator

Reference current generator

It has the input values of *Vdc ref, Vdc and line voltages*



$$V_{sa} = V_{sm}\sin(\omega t)$$

$$V_{sb} = V_{sm}\sin(\omega t - 120^o)$$

$$V_{sc} = V_{sm}\sin(\omega t + 120^o)$$

where,

V_{sm} - peak value of the source voltage,

$\omega = 2\pi f$ -fundamental angular frequency.

$$u_{sa} = V_{sa} / V_{sm} = \sin\omega t,$$

$$u_{sb} = V_{sb} / V_{sm} = \sin(\omega t - 120^0) \quad and$$

$$u_{sc} = V_{sc} / V_{sm} = \sin(\omega t + 120^0)$$

The comparison result of the voltage error e(v) Vdc ref Vdc . Low Pass Filter (LPF) is introduced to filter out higher order ripples as well as harmonic components and allows the fundamental components. Then it can be fed to the PI controller where, the proportional and integral gains are chosen either heuristically or mathematically. This controller estimates the magnitude of peak reference current I_{max} by controlling the dc-link capacitor. This estimated magnitude of peak current multiplies with an output of unit sine vector templates, which generates the required reference currents.

$$i_{sa}{}^* = I_{max} * u_{sa} = I_{max}\sin\omega t,$$

$$i_{sb}{}^* = I_{max} * u_{sb} = I_{max}\sin(\omega t - 120^0) \quad and$$

$$i_{sc}{}^* = I_{max} * u_{sc} = I_{max}\sin(\omega t + 120^0)$$

Hysteresis controller

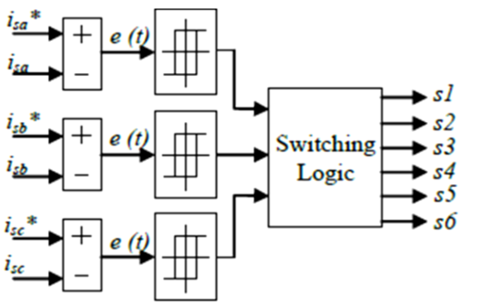
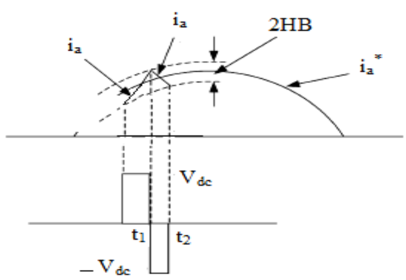


Fig. 3: Hysteresis Current Controllers

Switching Condition,

if ia < (ia*- HB) upper switch is OFF and lower switch is ON and if ia > (ia*+ HB) upper switch is ON and lower switch is OFF



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Hysteresis Current Control (HCC) technique is basically an instantaneous feedback current control method of PWM, where the actual current continually tracks the command current within a hysteresis band. Basic working principle of the HCC technique is shown in Fig. 3.

IV. SIMULATION RESULTS

In this paper, the simulation model of proposed shunt active power filter is shown in below figures. The simulation model is done by using MATLAB / SIMULINK. The analyses of current harmonic and power quality improvement for proposed Simulink are given below in fig 4:

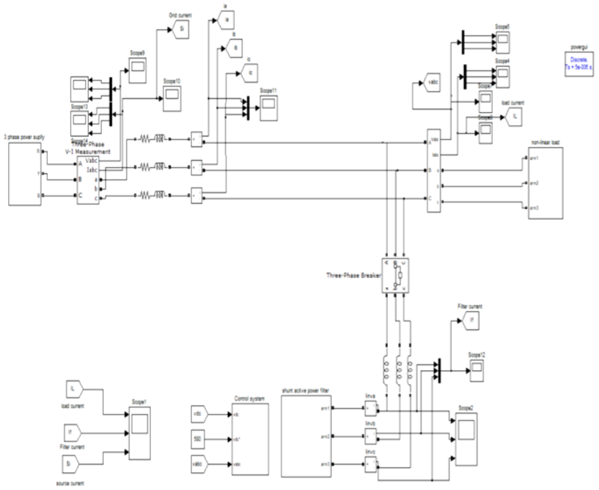

Fig 4: SIMULINK Model of Shunt Active Power Filter

Performance of shunt active power filter is checked with the use of MATLAB software. In the proposed scheme two types of loads have been considered as nonlinear loads: (i) Resistive rectifier load and (ii) Inductive rectifier load. Fig. 5 shows the performance of shunt active power filter under without filter.

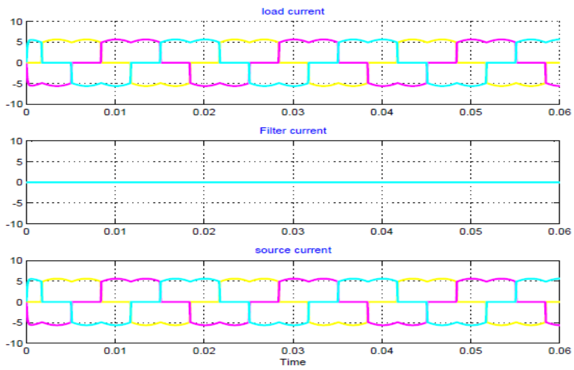

Fig 5: Without Filter

Fig. 5 shows the performance of shunt active power filter under with filter.

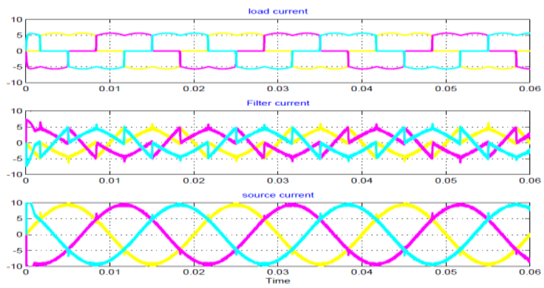

Fig 6: With Filter

V. CONCLUSION

The shunt active power filter performance was analyzed by using the hysteresis controller with PI reference current generator. The non-sinusoidal source current waveform is converted into sinusoidal current waveform even though the non-linear load is connected in the end-user of the power distribution system. The current harmonics waveform are reducing by injecting the opposite angle current waveform on the source side, using the shunt active power filter controlled by a hysteresis controller and improved the quality of power by more level of reducing the harmonics. Finally shows the result of the source side voltage and current waveform without the shunt active power filter and with shunt active power filter. This model developed by using the Matlab/Simulink.

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