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Adaptive Shunt Active Power Filter for PQ improvement by using Fuzzy logic controller

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ABSTRACT

Active filters are widely employed in distribution system to reduce the harmonics produced by non-linear loads result in voltage distortion and leads to various power quality problems. This paper presents compensation algorithm schemes used for shunt active power filters applied to three-phase systems, allowing harmonic current suppression and reactive power compensation, which results in an effective power factor correction. The strategies used to extract the three phase reference currents are based on the synchronous reference frame method. Although this method is based on balanced three-phase loads, it can also be used for single-phase loads, allowing independent control of all three phases. Accordingly, a fictitious quadrature current needs to be generated through software implementation, and be orthogonal to the measured load current. This creates the fictitious balanced currents in the two-phase stationary reference frame system, allowing the choice of an adequate compensation strategy which will result in either balanced or unbalanced sinusoidal source currents. The advantage of fuzzy control is that it is based on a linguistic description and does not require a mathematical model of the system and it can adapt its gain according to the changes in load.

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INTRODUCTION

Nowadays, there has been a continuous rise of nonlinear loads over the years due to intensive use of power electronic control in industry as well as by domestic consumers of electrical energy. The utility supplying these nonlinear loads has to supply large vars. Moreover, the harmonics generated by the nonlinear loads pollute the utility. The basic requirements for compensation process involve precise and continuous var control with fast dynamic response and on-line elimination of harmonics.

To control the output voltage and reduce undesired harmonics of MLIs, sinusoidal PWM, selective harmonic elimination or programmed PWM and space vector modulation techniques have been conventionally used in MLIs. In this paper the compensation algorithms used to extract the three-phase reference currents are based on the synchronous reference frame (SRF) method. Although the SRF method is based on the balanced three phase loads, it can also be used for single-phase loads, allowing independent control of all three phases. The flexibility to choose the SRF-based controller strategy will determine if the negative, zero or both sequence current components will be compensated. The SRF-based algorithms will be evaluated under unbalanced load conditions and will be applied to APF topologies. Mathematical analyses of the SRF-based algorithms are presented and simulation results are performed to validate the theoretical development and confirm the performance of the shunt APFs.

II.Shunt Active Power Filter:

Shunt active filters are by far the most widely accept and dominant filter of choice in most industrial processes. Fig1 shows the Block diagram of APF. The active filter is connected in parallel at the PCC and is fed from the main power circuit. The objective of the shunt active filter is to supply opposing harmonic current to the nonlinear load effectively resulting in a net harmonic current.

This means that the supply signals remain purely fundamental. Shunt filters also have the additional benefit of contributing to reactive power compensation and balancing of three-phase currents. Since the active filter is connected in parallel to the PCC, only the compensation current plus a small

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amount of active fundamental current is carried in the unit.

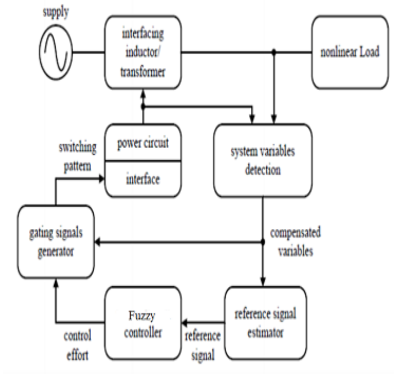

Fig. 1: Block diagram of APF.

For an increased range of power ratings, several shunt active filters can be combined together to withstand higher currents. The APF consists of a DC-bus capacitor (C_f), power electronic devices and a coupling inductors (L_f). Shunt APF acts as a current source for compensating the harmonic currents due to nonlinear loads. This is achieved by "shaping" the compensation current waveform (i_f), using the Current Controlled- VSI. The required compensating currents are obtained by measuring the load current (i_L) and subtracting it from a sinusoidal reference.

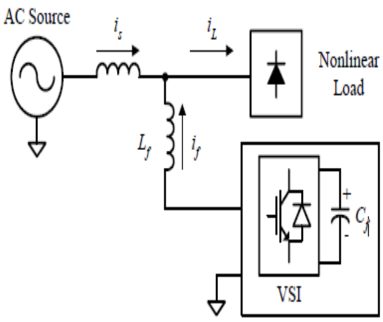

Fig. 2: Configuration of VSI based shuntAPF.

The aim of shunt APF is to obtain a sinusoidal source current (is*)* using the relationship:

$i_s = i_L - i_f$. (1)

Current component (i_L , $_f$) and the current harmonics ($i_{L,h}$) according to

$i_L = i_{L,f} + i_{L,h}$ (2)

Then the compensation current injected by the shunt APF should be

$i_f = i_{L,h}$ (3)

The resulting source current is

$i_s = i_L - i_f = i_{L,f}$ (4)

From the above equation (4) the source current contains only the fundamental component of the nonlinear load current and thus free from harmonics. When the shunt APF performs harmonic filtering, the ideal source current for a nonlinear load connected. In this way the shunt APF completely cancels the current harmonics from the nonlinear load, thus results in a harmonic free source current. The shunt APF can be considered as a varying shunt impedance from the nonlinear load current point of view.

III.*Adaptive Shunt Active Filter:*

SRF controlled shunt APF is shown in Fig.3. It has a three phase three level cascaded type multilevel inverter and it has two control loops, the voltage control loop and the current control loop.

The magnitude of the inverter terminal voltage depends on the DC link capacitor voltage Vc. By controlling the gate signals of the switches, the inverter terminal voltage can be made to lag or lead the AC system voltage, so that real power flows into or out of the inverter circuit. By suitable operation of the switches, a voltage vcomp having a fundamental component Vcomp1 is generated at the output of the inverter. When Vcomp1 > Vs, leading current (with respect to Vs) will be drawn and the inverter supplies lagging vars to the system. The Fuzzy logic controller is used to reduce the load voltage error and makes the system load voltage remains constant.

IV.*Simulation Results:*

Adaptive shunt active filter matlab simulink diagram is shown in Fig 5.Three level multilevel inverter topology is used in VSIs. Fuzzy logic controller is used to control the switching sequence for the inverter. Multilevel inverter output voltage is shown in Fig 5. Load current is shown in Fig 6.DC link voltage is shown in Fig 7.Total Harmonic Distortion(THD) in percentage is shown in Fig 8.

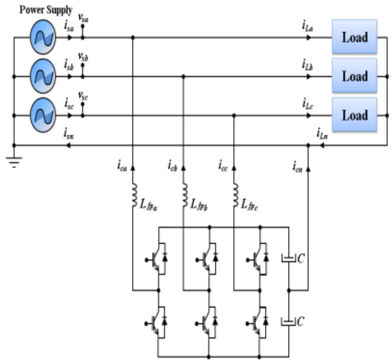

Fig. 3: SRF controlled shunt APF.

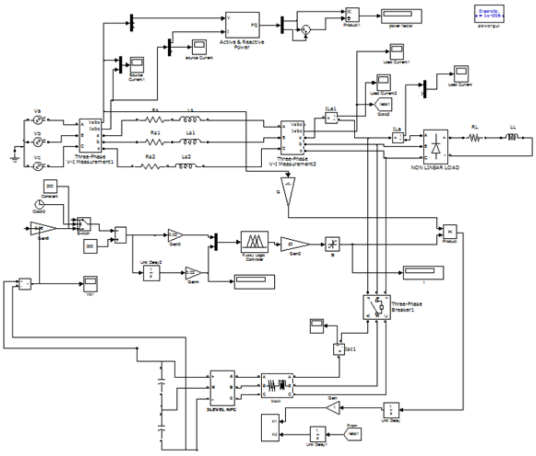

Fig.4: Simulink diagram of Adaptive shunt active power Filter.

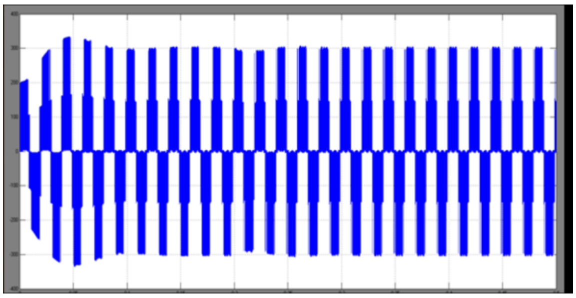

Fig. 5: multilevel inverter output voltage.

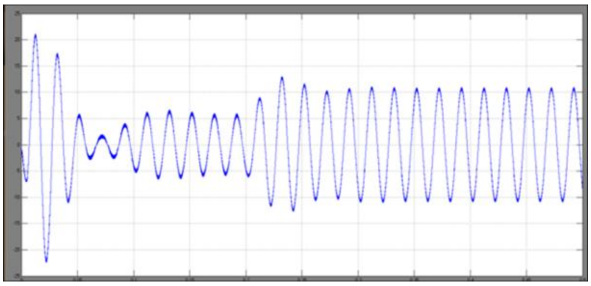

Fig. 6: load current.

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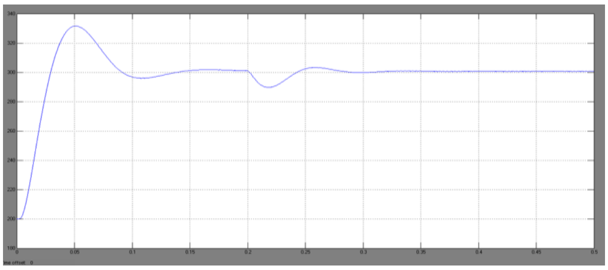

Fig. 7: DC link Voltage.

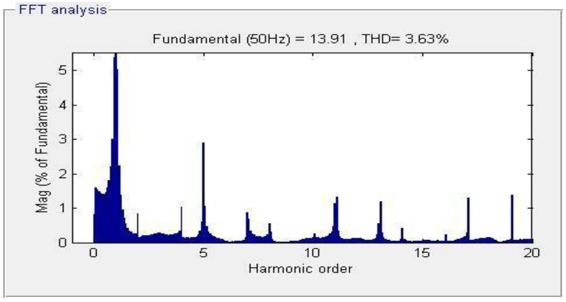

Fig. 8: THD Result.

V.Conclusion:

This paper presented compensation strategies, based on SRF and Fuzzy controller, which can be used in shunt APF topologies, when applied to three-phase systems, which allow harmonic current suppression, reactive and neutral current compensations to be conducted. The SRF-based controllers were used in three phase shunt APF topologies, and performed effectively. The algorithms allow the compensation of both load unbalances to generate sinusoidal and balanced source currents, and control each of the three phases independently. In this case the source currents will be sinusoidal but unbalanced and the THD result is 3.63%.

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