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ANALYSIS ON THE USAGE OF FUZZY FED SVPWM FOR HUNT ACTIVE POWER FILTER FOR REDUCING HARMONICS

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ABSTRACT
The power system becomes non-linear as the usage of power electronics devices increases. These non-linear loads have the potential to draw and dissipate harmonic non-sinusoidal current and voltage at the association point with the utility. These non-sinusoidal currents and voltage are common, and they affect the power grid and harm consumer electronics. Hence, both customers and distributors of electrical power are now concerned about the power quality in power systems. To improve power quality and compensate for reactive power, shunt active power filters are utilized. The harmonic issue is discussed and analyzed in this book. The many traditional and modern harmonic solutions are described. The utilization of a shunt active power filter for harmonic current and reactive power compensation is contemplated. Different control strategies for active power filters notwithstanding unique harmonic extraction strategies are introduced and examined. self tuning filter to improve the Shunt Active Power Filter‘s productivity on account of mutilated and unbalanced voltage system is introduced and talked about various shunt active power filter control systems are executed in MATLAB\SIMULINK and results are classified and examined.
Keywords: Shunt Active power filters, PQ theory, Self-Tuning filter, Harmonics, Power Quality

1. INTRODUCTION

In today's world, inverters and other power electronic equipment are often employed in power systems. Very deeply coded electrical equipment consistently results in enormous cost loss. Concerned about power quality issues are both customers and distributors of electric power. Power electronic devices are non-linear loads that contribute to the system's harmonics. These are the sources of the voltage and current harmonics that injure a system's expensive equipment. The industries' and utilities' equipment will be harmed by the harmonics' source. So, to mitigate these harmonics the active filters are become famous and are expected a great solution for the mitigation of harmonics.

Several control strategies like PI, PID and Fuzzy controller are developed for shunt active filters. The Problem with the PI and PID controller is that the response time will be very high and also the settling time is high, the total harmonic distortion is more, and the power factor is low. There are several control theories are evolved or introduced the space vector pulse width module is an efficient way to calculate the switching time of an inverter. In this paper, the mitigation of harmonics by fuzzy control for shunt active power filters using the SVPWM technique is presented

1.1 SHUNT ACTIVE POWER FILTER

Shunt active filters are used for the compensation of harmonic current source of nonlinear loads to accomplish the reactive power compensation. The shunt active power filter will recognise the worst or odd harmonics in the power system and these harmonics are mitigated by injecting opposite phase shifts with the same magnitude currents injected into the power system. The shunt active power filter control strategy works on the PQ theory which is also called the synchronous reference frame.

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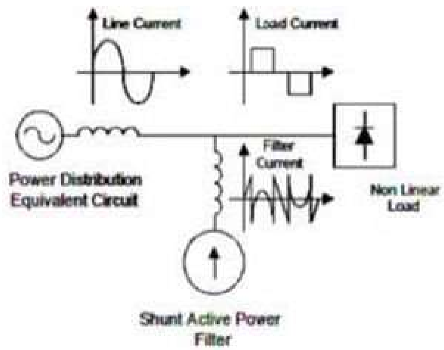

Fig 1.SAPF control strategy

The fig.1 shows is the control strategy of the shunt active power filter. When the non-linear loads are active and produce the harmonic current source the shunt active power filters will sense the odd or polluting harmonics produced in the system. These harmonics are mitigated by a current which has the same magnitude as the opposite phase.

The theory of instantaneous reactive power or PQ Theory or synchronous reference frame theory in threephase circuits was presented by Akagi. The theory remained one of the key concepts used in the improvement of power quality. The raising entrance of shunt active power filters for compensation of nonlinear three-phase loads, a movement that the detailing has added to its utilisation in various control procedures.

The instantaneous reactive power formulation is also called the original formulation. These are used in the three-phase system that generally considers the zero sequence-phase voltages and currents. The instantaneous three-phase voltages and currents in 1-2-3 phase coordinates can be transformed into an αβ0 it is also called the Clarke transformation method. The instantaneous power p-q is based on time-domain transformation from abc phases to three orthogonal axes i.e. αβ0 transformation.

The Clarke transformation or PQ is obtained by the following equations:

$$\begin{bmatrix} v_0 \\ v_\alpha \\ v_\beta \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} v_a \\ v_b \\ v_c \end{bmatrix} \quad (1)$$

$$\begin{bmatrix} i_0 \\ i_\alpha \\ i_\beta \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix} \quad (2)$$

$$e = v_\alpha + j\, v_\beta \;\;\&\;\; i = i_\alpha + j\, i_\beta \quad (3)$$

$$\begin{bmatrix} p \\ q \end{bmatrix} = \begin{bmatrix} v_\alpha & v_\beta \\ v_\beta & -v_\alpha \end{bmatrix} \begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix} \quad (4)$$

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The equations of Clarke transformation are given in equation 1. And if the zero-sequence voltage v_0 and current i_0 are neglected then equation 3 will be obtained and the instantaneous power vectors are obtained as equation 4 and at last, equation 5 states the (α-p, q) (β-p, q) components.

$$\begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix} = \frac{1}{v_\alpha^2+v_\beta^2}\begin{bmatrix} v_\alpha & v_\beta \\ v_\beta & -v_\alpha \end{bmatrix}\begin{bmatrix} p \\ 0 \end{bmatrix} + \frac{1}{v_\alpha^2+v_\beta^2}\begin{bmatrix} v_\alpha & v_\beta \\ v_\beta & -v_\alpha \end{bmatrix}\begin{bmatrix} 0 \\ q \end{bmatrix} \equiv \begin{bmatrix} i_{\alpha p} \\ i_{\beta p} \end{bmatrix} + \begin{bmatrix} i_{\alpha q} \\ i_{\beta q} \end{bmatrix} \quad (5)$$

$$\begin{bmatrix} p_\alpha \\ p_\beta \end{bmatrix} = \begin{bmatrix} v_\alpha i_\alpha \\ v_\beta i_\beta \end{bmatrix} = \begin{bmatrix} v_\alpha i_{\alpha p} \\ v_\beta i_{\beta p} \end{bmatrix} + \begin{bmatrix} v_\alpha i_{\alpha q} \\ v_\beta i_{\beta q} \end{bmatrix} \quad (6)$$

The separation of p and q components of voltage and current and power can be happened by the above equations, which decide the compensation methodology to be applied to a system.

1.2 SVPWM CONTROL THEORY

In the traditional SVPWM method is hard to synthesize the voltage space vector. It uses the Clarke transformation to transform the reference voltages to d-q coordinates. These may take more time. Later on, the reference vectors are chosen by some perfectly selected primary or basic vectors with a specific time duration. In that process, the sector of reference vectors is calculated by their phase angles and the time duration of basic vectors is calculated by the computation of reference vectors‘ phase angle. These computations have huge trigonometric functions and irrational numbers and the computation load will be boundless. These may cause major calculation errors it would corrupt the performance of the shunt active filter.

The solution for this problem is using an effective time concept based on SVPWM which is used to generate the switching signals. By using this SVPWM the actual switching time of VSI is calculated and applied to VSI for the flawless operation of the shunt active power filter.

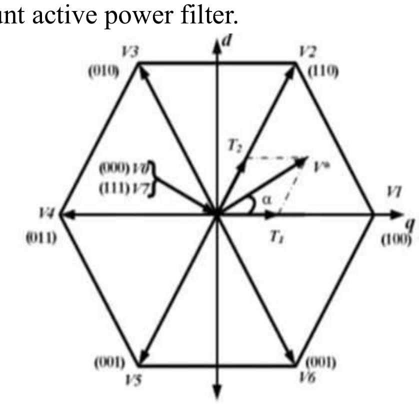

Fig 2. VSI switching states

$$\vec{V}_g = \frac{2}{3}V_{dc}e^{j(g-1)\frac{\pi}{3}}(g=1......6)$$

1.3 FUZZY LOGIC CONTROLLER

The controllers like proportional (P), proportional- integral (PI), and proportional integral derivative (PID) will only give the result as true or false. These will not provide accurate results when nonlinear loads are present. So, to get an efficient result we are using a nonlinear controller like fuzzy. The fuzzy response is faster to a transient condition, and it is easy to design and implement. Fuzzy theory is mostly used in control systems and it is a rule-based system. the main aim of fuzzy is to maintain the constant load when interruption or non-

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linearity is caused in the system. The error is taken by making a difference between the reference voltage or the desired voltage and output voltage.

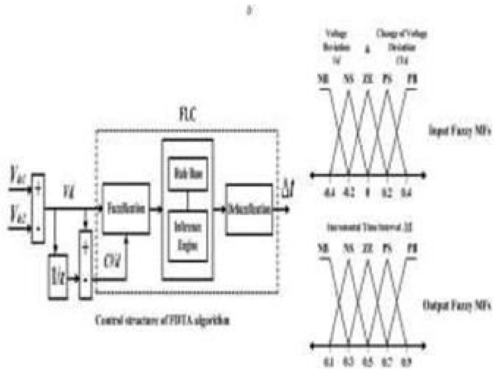

Fig 3. block diagram of fuzzy

The fuzzy controller can provide both small signals and large signals at a time(in the same time) the fuzzy controller can give a dynamic performance at the same time. So the fuzzy controller can make or improve hardness or robustness of dc-dc converter. As the fuzzy is a rule base it has different types of rules. The rules used are _if and them' where if is used for condition and then is used for the conclusion. Based on the change in error value the signal to plant is decided. When the output voltage is higher than the reference voltage then the duty cycle is minimised. When the output voltage is lower than the reference voltage then the duty cycle is increased.

(de) \ (e)	NB	NS	ZO	PS	PB
NB	NB	NB	NB	NS	ZO
NS	NB	NB	NS	ZO	PS
ZO	NB	NS	ZO	PS	PB
PS	NS	ZO	PS	PB	PB
PB	ZO	PS	PB	PB	PB

Table 1 rules for error and error change

2. SIMULATION RESULTS

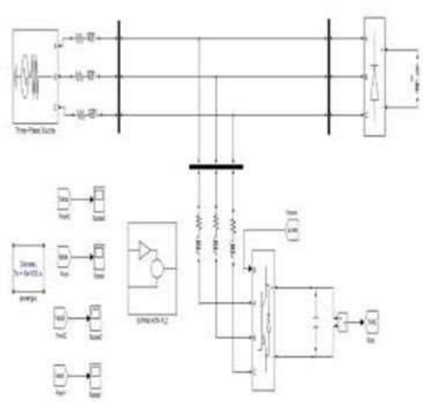

Fig 4. simulation diagram of fuzzy fed SVPWM based SAPF

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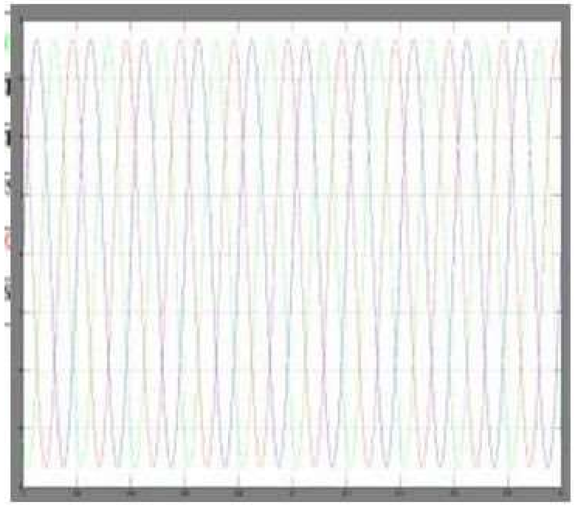

Fig 5. Source current with SAPF

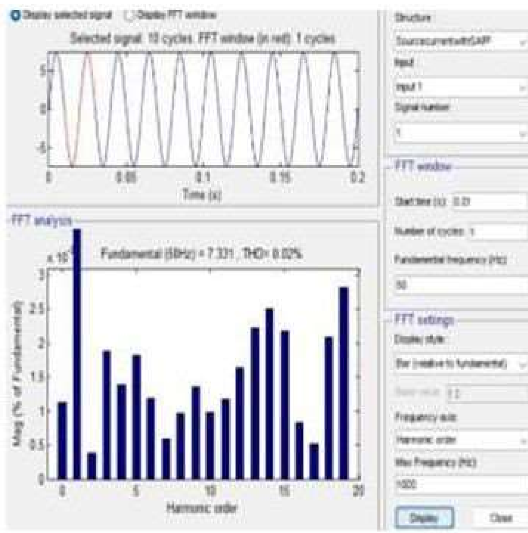

Fig 6. Source current THD% with SAPF

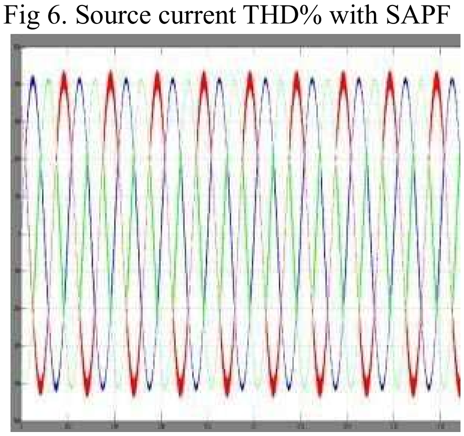

Fig 7. Source voltage with SAPF

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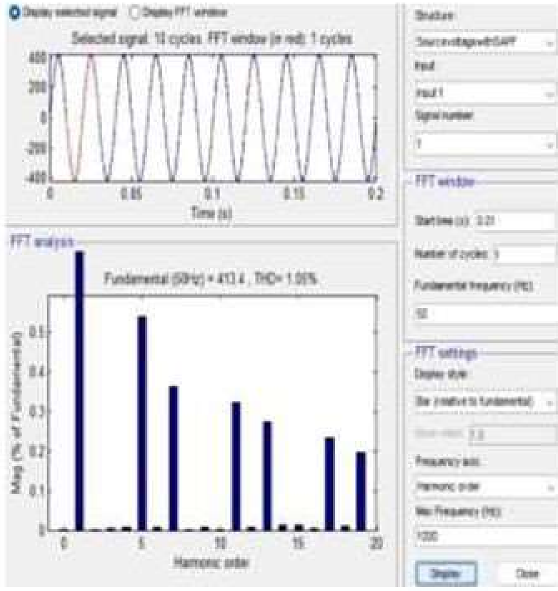

Fig 8. Source voltage THD% with SAPF

CONCLUSION

This paper presents a cost-effective and reliable solution for the power quality improvement in a three-phase power system by using a shunt active power filter. When a shunt active power filter is connected to the power system the harmonics get compensated and the source need to supply a balanced current.

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