FUZZY Logic Based Space Vector PWM Controlled Hybrid Active Power Filter for Power Conditioning

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Abstract:- This paper investigates the comparative analysis of a Hybrid Active Power Filter with PI based SVPWM controller and fuzzy based space vector PWM controller for mitigating the harmonics, improving the power factor and increasing the distribution power of the three phase distribution system. This paper concluded that the power conditioning by fuzzy based SVPWM hybrid active power filter is superior than PI controller based SVPWM technique. In the proposed control filters three control circuits are used such as PI control unit, fuzzy unit and SVPWM control unit. Fuzzy arithmetic's are used for adjusting proportional–integral coefficients timely. The desired output voltage is generated based on generated reference voltage by fuzzy based SVPWM. A MATLAB code is developed to generate the SVPWM switching pulses fed to the two-level inverter topology. Simulations are carried out using MATLAB. It is found that the %THD has been improved from 2.67 to 1.57and power factor is improved to 0.9718. The simulation results shows that the effectiveness and feasibility of the proposed filter.

Key words:- Hybrid Active Power Filter, Fuzzy Logic Controller, IGBT Inverter, Space Vector PWM, Total Harmonic Distortion (THD), Distribution system.

1 Introduction

Power quality is the main problem that the industry is facing today. The quality of power has been deteriorating with the presence of various current and voltage harmonics, low power factor, voltage sags and swells, flicker and many other disturbances. Among the various disturbances, Harmonic distortion [1] is one of the most serious power quality problems. Particularly, in the distribution systems, harmonics are the major concerned problem. The growing use of electronic equipments is one of the major causes to impute the harmonics, which led to distortion of voltage and current waveforms and increased reactive power demand in ac mains as they pass through the system impedance.

However, in the present situation various power quality improvement solutions are available; Isolate harmonic loads on separate circuits (with or without harmonic filters), Harmonic mitigating transformers, Phase shifting (zig-zag) transformers, Filter capacitor banks, Line Reactors, K-Rated / Drive Isolation Transformers, Harmonic Mitigating / Phase Shifting Transformers, Passive parallel / series tuned Filters and Active Filters[2-4].

Passive filtering is the simplest conventional solution to reduce the harmonics. But they have many demerits such as; a) the number of passive filters installed would depend on the number of harmonic component to be compensated, this demands for the information of harmonic content to be know in advance. b) These cannot function under the saturated conditions, c) At some frequencies, these filters may lead to resonance. All the above demerits of the filters are overcome by the use of active filters. But, for high-power applications, the Active filters are not cost effective due to their large rating and high switching-frequency requirement of the pulse width modulation inverter. For harmonic current tracking controls, there are two schemes .One is the linear current control and the other is nonlinear current control. Hysteresis nonlinear control method is simple but leads to a widely varying switching frequency [5]. This limitation has been improved with variable hysteresis band switching strategies but it requires a complex controller to achieve satisfactory performance. Predictive current control offers the best potential for precise current control, but the implementation of a practical system can be difficult and complex.

Recently, fuzzy logic controllers (FLC) [6-8] have received a great deal of attention for their application in active power filters (APFs). The advantages of FLC over conventional controllers are that they do not require an accurate mathematical model, can work with imprecise inputs, can handle non-linearity and are more robust than the conventional controllers. The Mamdani type of FLC is used for the control of an APF and it gives better results, but it has the drawback of a larger number of fuzzy rules.

In this paper, Fuzzy based SVPWM controller was

voltage of 230V (rms) and switching frequency of 5kHz, the simulation results with PID controlled SVPWM and fuzzy controlled SVPWM hybrid active filter are shown. Table.3 shows parameter values required for circuit configuration shown in Fig.2.

Table.3 Parameter values

System parameters	Values of parameters			
Supply system	230 V (rms), 50 Hz, three-phase supply			
Passive		*L/mH*	*C/μF*	*Q*
	Output filter	0.2	60	
	11^{th} turned filter	1.77	49.75	50
	13^{th} turned filter	1.37	44.76	50
	6^{th} turned filter	14.75	C_F:19.65, C_I:690	
APF	C_{dc}=1000µf, Vref = 750V,C_f = 24µf, L_f = 30 mH			

Fig.9. shows the simulation results of hybrid active power filter when PID controlled SVPWM technique is considered for generating the required switching pulses for the operation of the active filter. It shows the simulation waveforms of source voltage, load current after compensation and source current after compensation. From the figures, it can be observed that there is some asymmetry during the initial conditions in the source voltage and source current waveforms, whereas the load current waveforms are distorted in nature.Fig.10 shows the simulation results of hybrid active power filter when fuzzy controlled SVPWM technique is considered for generating the required switching pulses for the operation of the active filter. It shows the simulation waveforms of source voltage, load current and source current after compensation. From the figures, it can be observed that under nonlinear load condition the magnitude of three phase source voltage, source current and load current are made equal, made in phase with each other and also shows that the reduction of harmonics is better.

The simulation of harmonic spectrum of hybrid active power filter when PI based SVPWM controller is considered. Fig.11.1shows the harmonic spectrum of the load current after compensation is done. Fig.11.2. shows the harmonic spectrum of the source current after compensation is done. The harmonic spectrum of the load current and source current shows that the %THD is reduced from 21.78 to 2.72. It also observed that the magnitude of the 5th, 7th, 11th and 13th harmonics is large enough in source current harmonic spectrum.

The simulation of harmonic spectrum of hybrid active power filters when fuzzy based SVPWM controller is considered. Fig.12.1. shows the harmonic spectrum of the load current after compensation is done. Fig.12.2. shows the harmonic spectrum of the source current after compensation is done. The harmonic spectrum of the load current and source current shows that the %THD is reduced 1.57 in both. It also observed that the magnitude of the 5th, 7th, 11th and 13th harmonics are evidently reduced by fuzzy based SVPWM controller based hybrid active power filter when compared to PI based SVPWM technique.

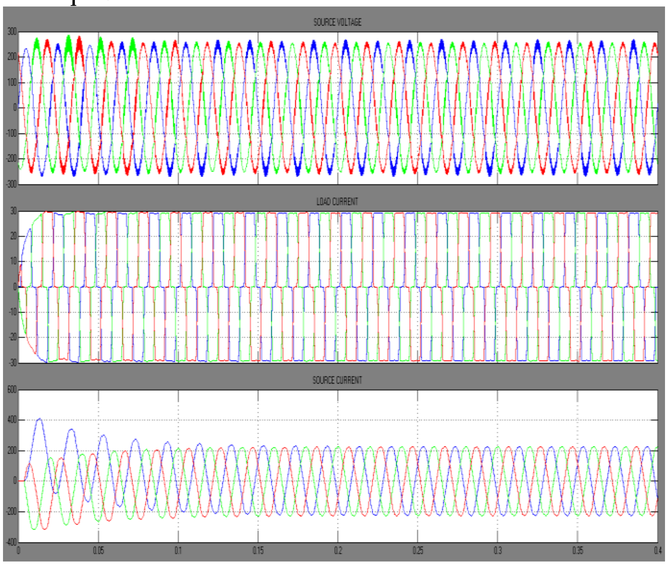

Fig. 9 Wave Forms of PID based SVPWM

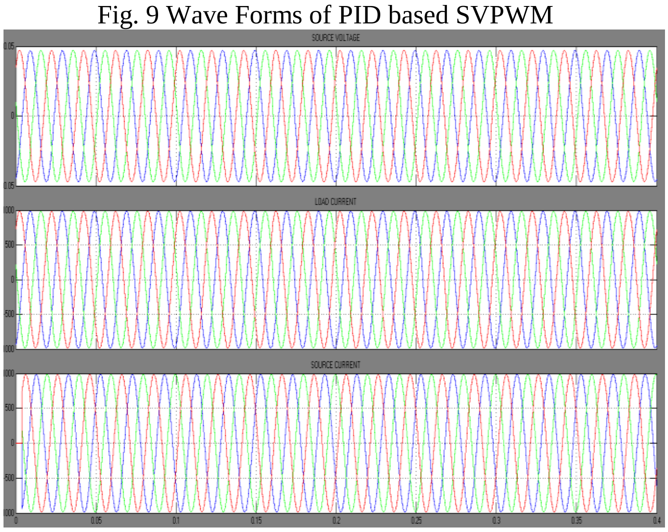

Fig. 10 Wave Forms of Fuzzy based SVPWM

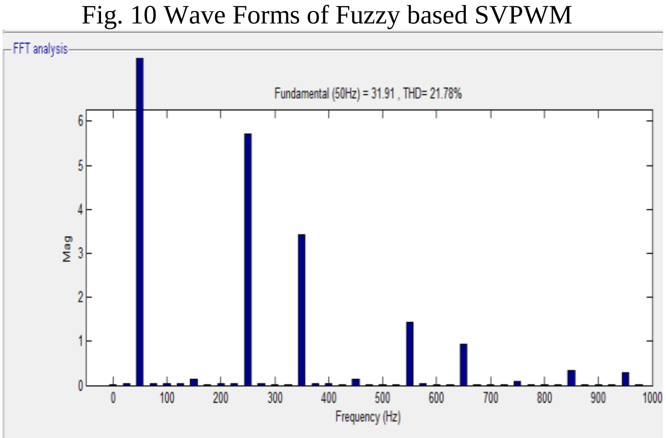

Fig.11.1 Load current Harmonic for PID based SVPWM

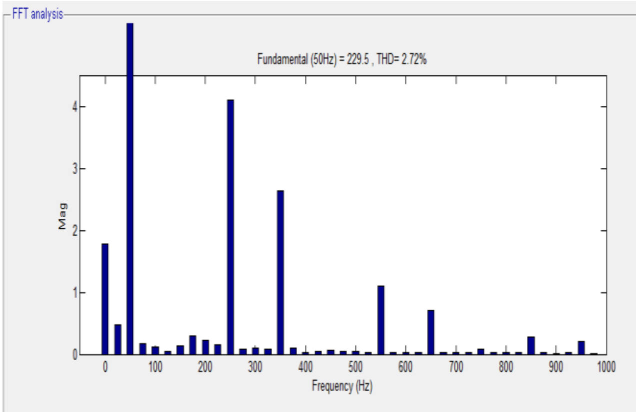

Fig.11.2 Source current harmonic of PID based SVPWM

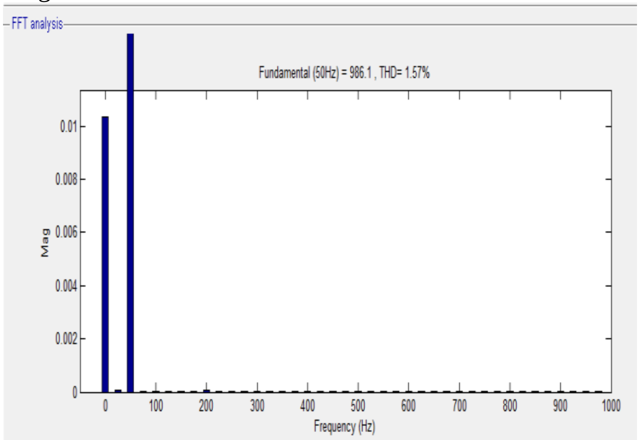

Fig12.1 Load current Harmonic for Fuzzy SVPWM

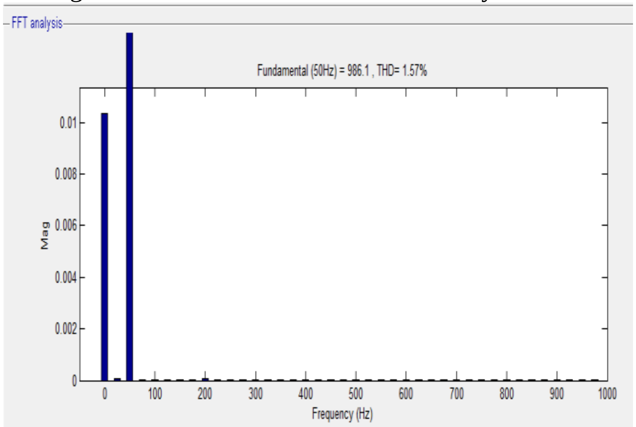

Fig.12 .2 Source current harmonic of Fuzzy SVPWM

7 Conclusion

In this paper, in detailed analysis of the hybrid active power filter using fuzzy logic based SVPWM control methodology is explained. This method requires a very simple algorithm, which can be able to compensate the harmonic content from both source as well as load current efficiently. Simulations are carried out in MATLAB / Simulink to obtain the performance of proposed filter. From the simulation results it is observed that %THD is reduced from 21.78 to 2.72 with hybrid active power filter when PI based SVPWM controller is considered and the harmonic spectrum of the load current and source current shows that the %THD is reduced 1.57 in both currents when fuzzy based SVPWM controller is considered. So the proposed controlled filters such as PI based SVPWM and fuzzy based SVPWM controlled hybrid active power filters can be able to reduce the total harmonic distortion efficiently. Whereas, among the two, fuzzy based SVPWM controlled hybrid active filter not only functioning on source side but also functioning efficiently on load side to made phases with each other, to made magnitudes equal and to reduce the total harmonic distortion.

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