Hysteresis Current Control in Three Phase Shunt Active Power Filter using Adaptive Fuzzy Dividing Frequency Control and Passive Filter

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Abstract - Due to fast advancement in technology and electronics equipment number of non-linear loads are increasing exponentially, cause the harmonics occur in the power system. Power quality has turned into a noteworthy research topic in power distribution systems because of a critical increment of harmonic contamination caused by expansion of nonlinear loads such as diode rectifiers, switching power supplied and different sorts of line associated power converters and so on. The reliability and performance of ant APF system largely affected by control algorithm it uses. Shunt active power filter is generally utilized as a part of current electrical circulation system and it needs a precise control algorithm that gives robust execution under source and load unbalances. A hybrid three - phase shunt active power filter has been proposed in this work based on the adaptive fuzzy dividing frequency control method. Modeling of proposed model has been done on Matlab and simulation has done on Matlab simulink.

Index Terms- Shunt Active Power Filter, adaptive fuzzy control method, Three phase SAPF, Power Quality Control, Nonlinear Load, Harmonics.

I. INTRODUCTION

Active Filters are commonly used for providing harmonic compensation to a system by controlling current harmonics in supply networks at the low to medium voltage distribution level or for reactive power or voltage control at high voltage distribution level. These functions may be combined in a single circuit to achieve the various functions mentioned above or in separate active filters which can attack each aspect individually. The block diagram presented in figure 1.1 shows the basic sequence of operation for the active filter. This diagram shows various sections of the filter each responding to its own classification.

The reference signal estimator monitors the harmonic current from the nonlinear load along with information about other system variables. The reference signal from the current estimator, as well as other signals, drives the overall system controller. This in turn provides the control for the PWM switching pattern generator. The output of the PWM pattern generator controls the power circuit through a suitable interface. The power circuit in the generalized block diagram can be connected in parallel, series or parallel/series configurations, depending on the transformer used.

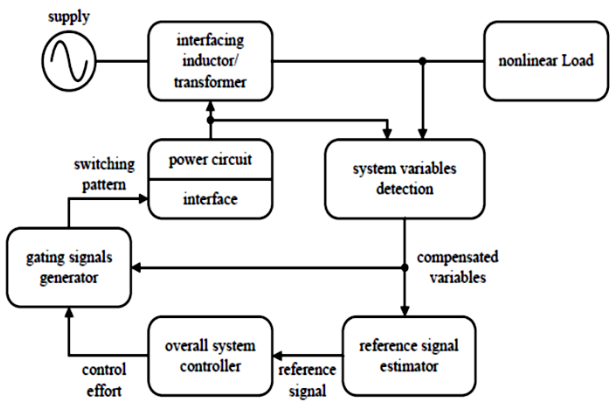

Figure 1.1 Generalized Block diagram for APF.

There are large number of advantages of APFs compare to passive filters. They will suppress supply current harmonics and also the reactive currents. Moreover, these active filters do not cause resonance like passive filters in the power distribution systems. Consequently, the APFs performances are independent of the power distribution system properties.

Shunt active filters are by far the most widely accept and dominant filter of choice in most industrial processes. 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 amount of active fundamental current is carried in the unit. For an increased range of power ratings, several shunt active filters can be combined together to withstand higher currents.

II. HYBRID ACTIVE POWER FILTER

For power filtering operation many of the controllers are implemented based on analogue circuits. Due to this, the performance of the APF is effected by the signal drift. Digital controllers using DSPs or microcontrollers are preferable, primarily due to its flexibility and immunity to noise. But the high-order harmonics are not filtered effectively by using digital methods. This happens because of the hardware limitation of sampling rate in real-time application. Moreover, the utilization of fast switching power electronic switches (i.e. MOSFETs, IGBTs) in APF application causes switching frequency noise to appear in the compensated source current. Additional filtering circuit is required to reduce this switching frequency noise and to prevent interference with other sensitive equipments.

Hybrid APFs Combinations are can be designed to compensate for higher powers without excessive costs for high-power switching. But the major disadvantage of this configuration is the fact that passive filters can only be tuned for a specific predefined harmonic and thus cannot be easily changed for loads which have varying harmonics.

As shown in figure 2.1 (a), this hybrid APF is a combination of shunt APF and a passive filter connected in parallel with the nonlinear load. Thus the objective function of the Hybrid APF is divided into two parts i.e the lower order harmonics are filtered by the shunt APF, while the higher order harmonics are filtered by the passive High Pass filter.

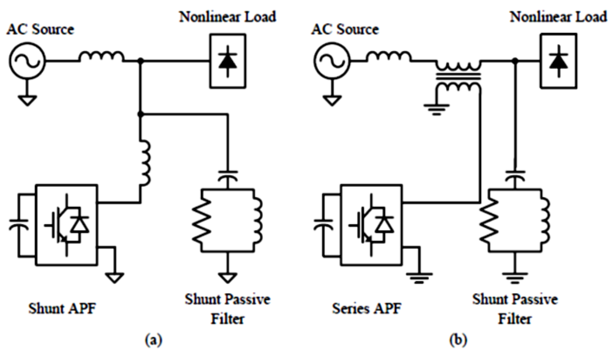

Figure 2.1 Hybrid APFs: (a) Combination of Shunt APF and Shunt Passive Filter and (b) Combination of Series APF and Shunt passive Filter.

As shown in figure 2.1 (b) the system configuration of hybrid series APF is the combination of series APF and shunt passive filter. By injection of controller harmonic voltage source this hybrid series active filter is controlled to act as a harmonic isolator between the source and nonlinear load. This type of hybrid active filter is controlled in such a way that it offers zero impedance at fundamental frequency and high impedance at all undesired harmonic frequencies. Passive filters are often easier and simple to implement and do not require any control circuit. This deserves to be most beneficial.

III. PROPOSED METHODOLOGY

Based on the detected harmonic current in the network, the APF can compensate harmonics by influencing the inverter to produce harmonics whose size is equivalent to harmonic current however the phase is its inverse. However, as parallel HAPFs in Figs. 3.1 if APF produces harmonics as same order from PPF, the execution of the PPF might be checked, regardless of whether a mischance happens for the over current of PPF. In other words, only for HAPF, there is no compelling reason to control some order of harmonics, as it can waste the compensation limit effectively. This is the motivation to adopt the partitioning frequency-control technique.

The equivalent circuit of three-phase can be received as shown in Fig.3.1, where A ,B,C are three phase of input AC power source output is feed to a non linear load. C_a,C_b.C_c are three output capacitors and i_{La}, i_{Lb}, i_{Lc} are three load currents. A passive filter is connected with three power phases parallel and fuzzy active power filter is also connected as illustrated in figure.

The traditional linear feedback controller (PI controller, state feedback control, and so forth) is used to enhance the dynamic response and/or potentially to build the stability edge of the closed loop system. However, However, these controllers may exhibit a poor steady-state error for the harmonic reference signal. Figure 3.1 illustrated block representation of proposed system with adaptive fuzzy dividing frequency control scheme, which comprises of two control units listed below:

a. Generalized integrator control unit.

b. Fuzzy balancing unit.

The summed up integrator, which can overlook the impact of greatness and stage, is utilized for partitioning frequency integral control, while to balance PI coefficients a fuzzy arithmetic is utilized.

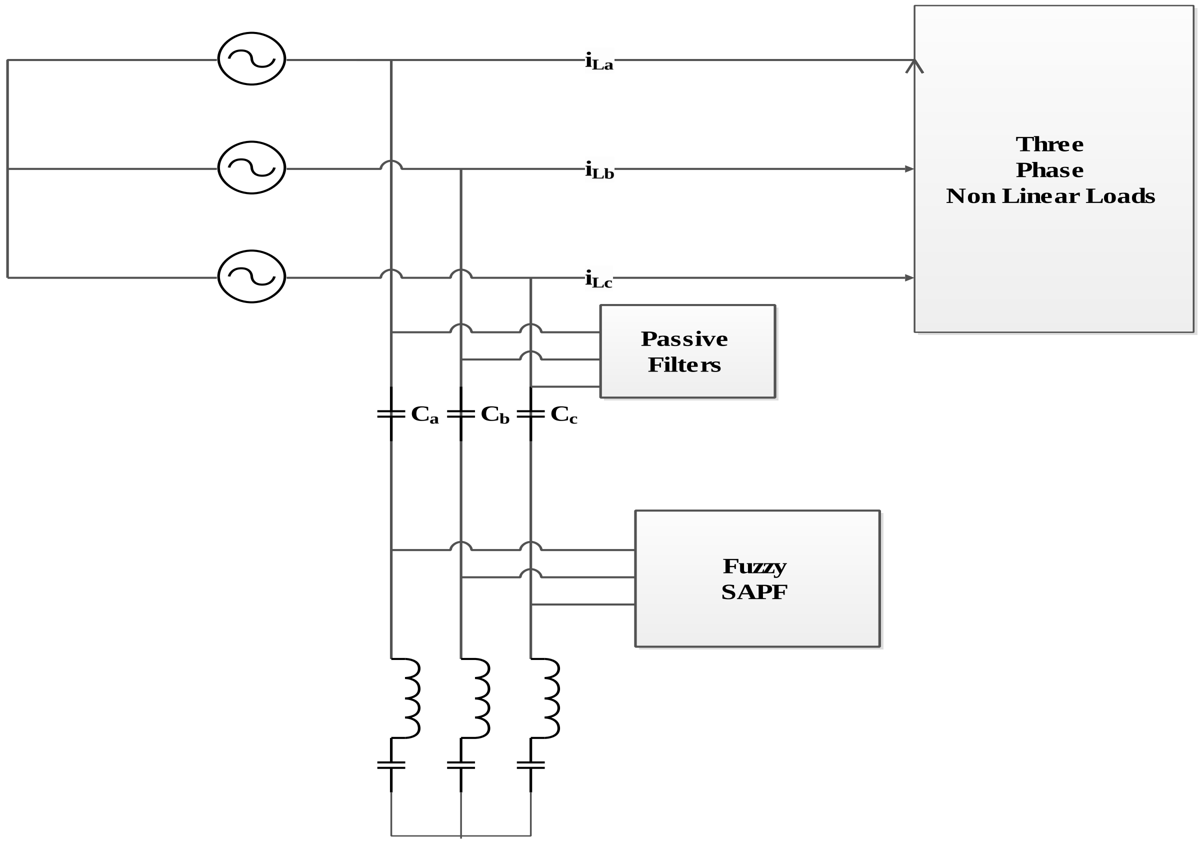

Figure 3.1 Proposed Hybrid APF Model.

IV. SIMULATION RESULTS

Modeling of proposed Hybrid Three-Phase Shunt Active Power Filter Based On The Adaptive Fuzzy Dividing Frequency-Control Method has done on Matlab R2011a and Simulation has done on Matlab Simulink. Simulation waveform of proposed work has given in figure 4.1 to figure 4.6. Simulation results confirms the outstanding performance of proposed work against existing base work. Three-phase source current waveforms obtained by A, B, C phases. Figure 4.2 Im(t) when load is connected. Figure 4.3 Dynamic responses of isa and Im(t) when the load1 is disconnected from PCC (POWER FACTOR). Fig. 4.4 Steady-state waveforms of load current, active filter current, source current and spectrums of load and source currents for phase A. Figure 4.5 Steady-state waveforms of single-phase source currents and source voltage for phase A b Source voltage and current for phase A (scale: 2 A/div, 20 V/div). finally figure 4.6 shows the THD is 0.81%.

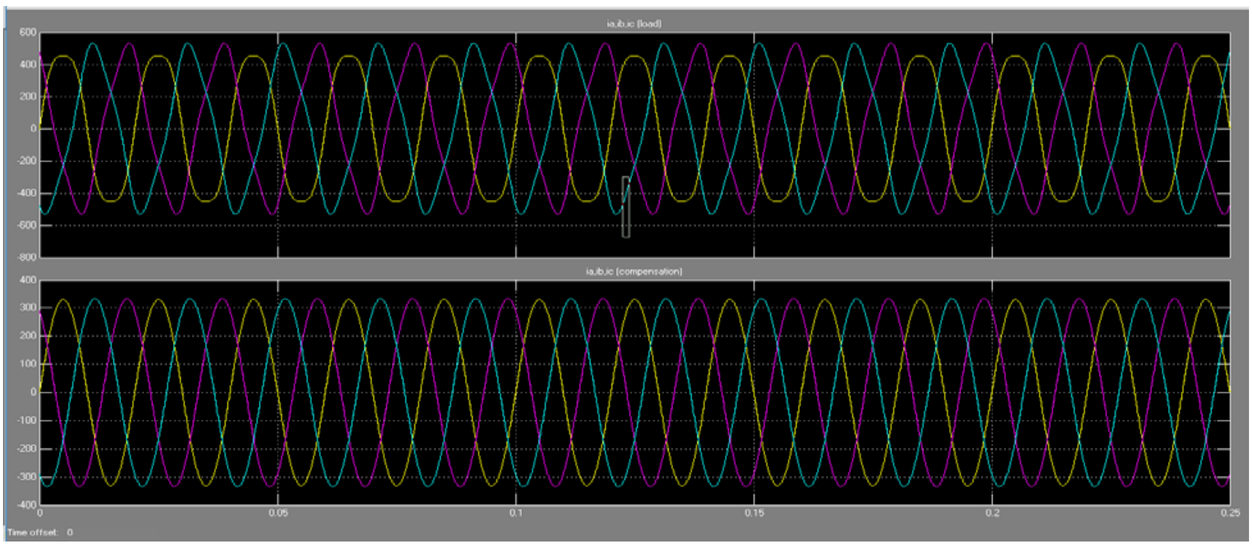

Figure 4.1 Three-phase source current waveforms obtained by A, B, C phases.

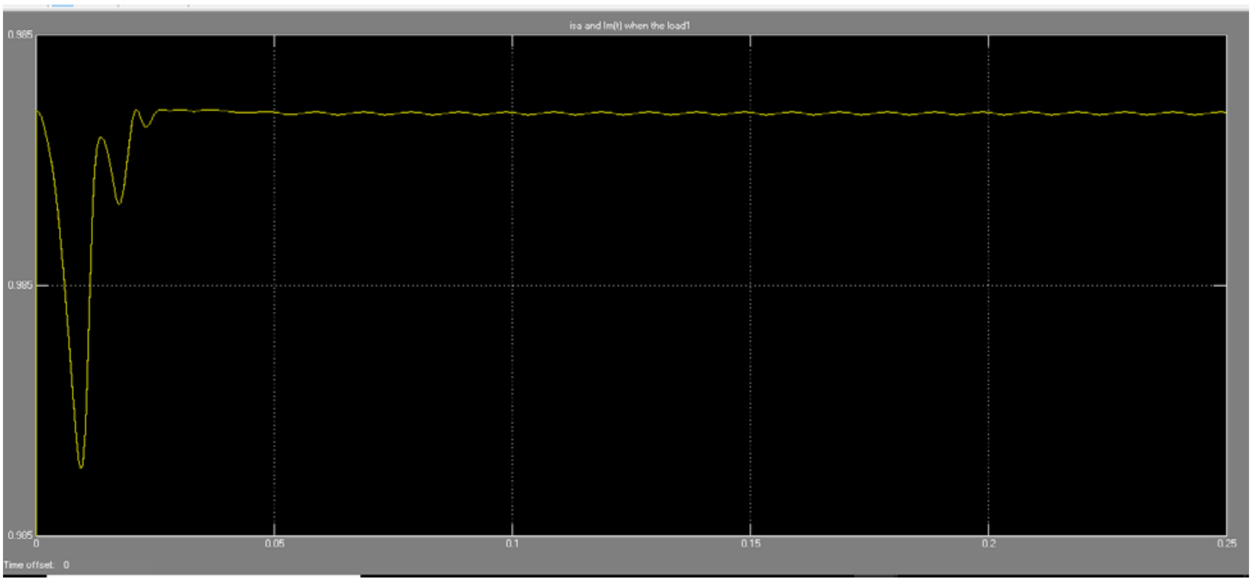

Figure 4.2 Im(t) when load is connected.

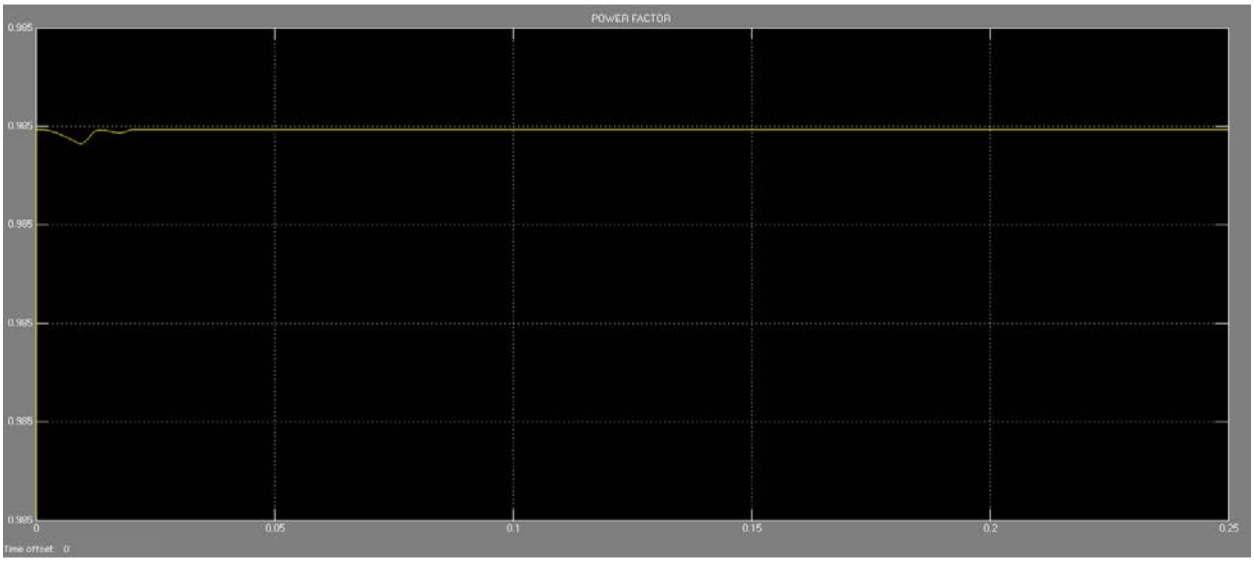

Figure 4.3 Dynamic responses of isa and Im(t) when the load1 is disconnected from PCC (POWER FACTOR).

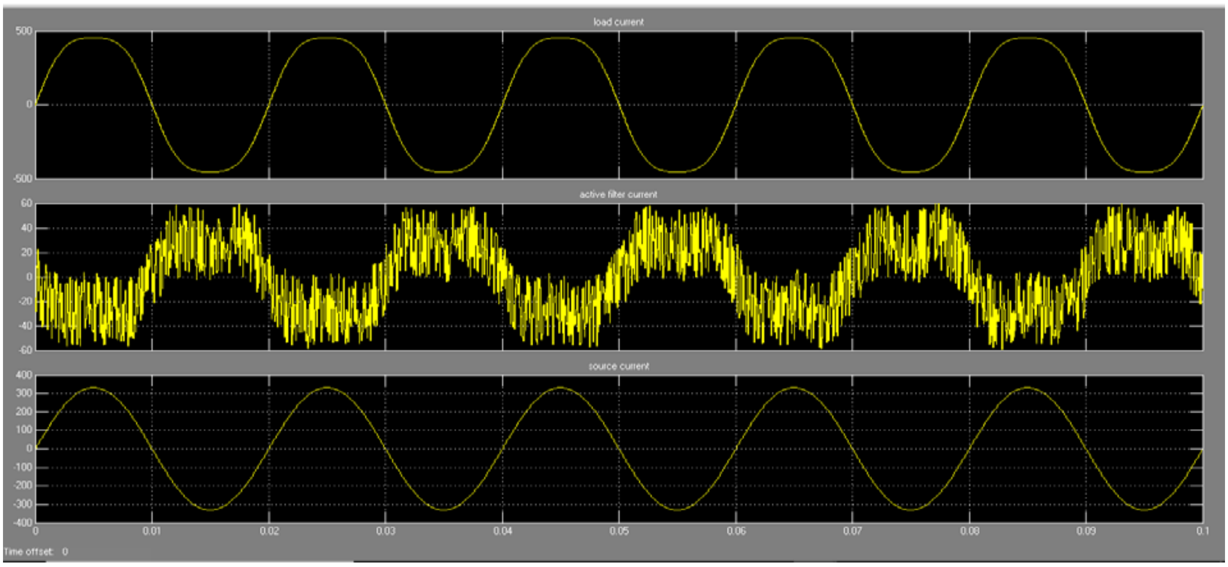

Figure 4.4 Steady-state waveforms of load current, active filter current, source current and spectrums of load and source currents for phase A.

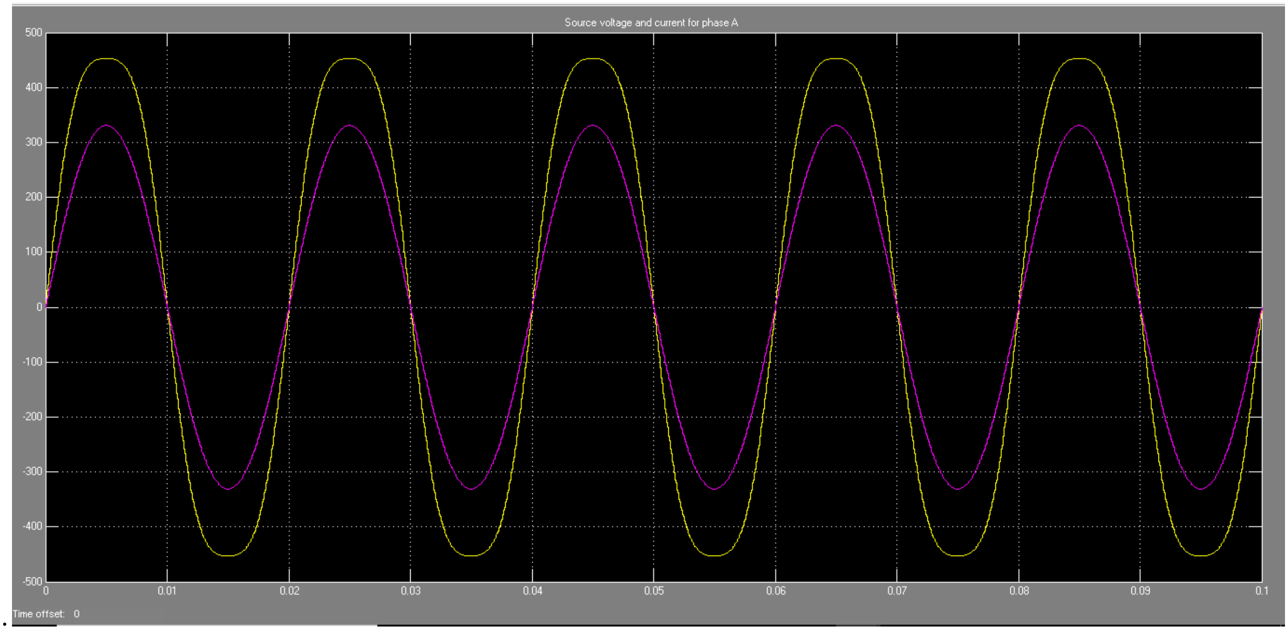

Figure 4.5 Steady-state waveforms of single-phase source currents and source voltage for phase A b Source voltage and current for phase A (scale: 2 A/div, 20 V/div).

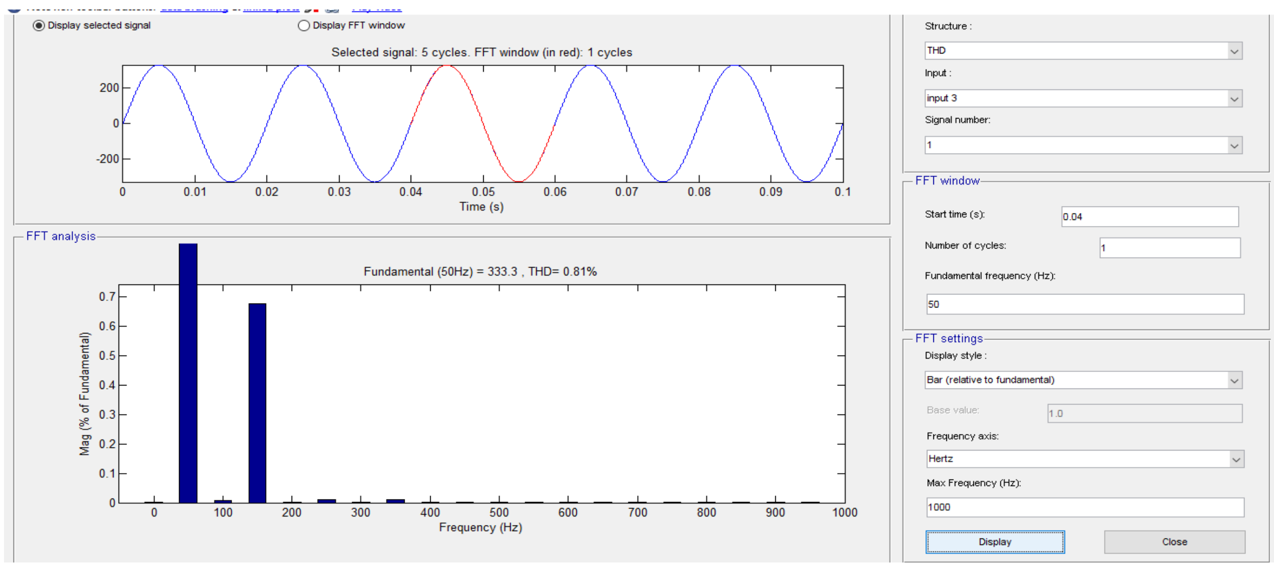

Figure 4.6 THD is 0.81%

V. CONCLUSION AND FUTURE SCOPES

A three-phase shunt active power filter based on the adaptive fuzzy dividing frequency-control method is modeled with respect to the importance of power quality and harmonic reduction. Among various control strategies, has been proposed by using shunt active power filter for optimizing harmonic elimination and decreasing switching frequency by adding a zero sequence and also it is expected to generate much lower distortion in the output compared with existing work [1]. According to the results obtained and by comparison, there is an optimization in THD values. Accordingly, proposed work, not only decreases switching frequency but also, generates lower total harmonic distortion (THD) in output.

As a future work, this proposed control method is expected to be improved in near future or it might be optimized by changing the switching algorithms and by applying the stronger controller method for making currents able to follow their references as fast as possible.

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