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AN INTEGRATED APPROACH OF POWER QUALITY IMPROVEMENT BY ACTIVE SHUNT FILTER WITH HYSTERESIS CURRENT CONTROLLER

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ABSTRACT

The important power quality worry presently is the extent of disturbances. Shunt active filters are generally registered in power circulation grids to lighten current wave disturbance & balance the reactive power. Here instant reactive power theory is employed to get attribution balance current for the command of the shunt active filter & hysteresis current controller is employed to incorporate it accurately. Hysteresis current controller is one of the easiest current control processes & the better approved one for active power filter applications, but it endures through an unlike switching frequency, to trounce this drawback an ovate fuzzy hysteresis current controller is being preferred. Presently used controller is designed by clarity as an output of decreasing the length of computations that construct it improve speedily & not depend on burden specifications. The structure was designed & replicated using MATLAB/SIMULINK. The outputs are shown & described they represent the accuracy of the used fuzzy hysteresis controller in increasing the PWM characteristics & thus raising the shunt active power filter characteristics.

Keywords: *Shunt Active Filter, Harmonics, Power Quality Improvement, Hysteresis Current Controller, PWM.*

INTRODUCTION:

This work highlights the disruptive effects of power electronic switching devices on power systems, emphasizing the need to eliminate unwanted signals for stable power distribution. Issues such as heating, ringing effects, low power factor, and power disturbance necessitate the

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removal of disturbances from power distribution networks. The shunt active filter aims to eliminate harmonics produced by nonlinear loads in power systems[1]. The active filter utilizes an IGBT inverter to produce currents that compensate for harmonic terms, maintaining a sinusoidal input current waveform (discusses the p-q process for operating the shunt active filter). The hysteresis current controller is employed to control the active filter (Explaining its control logic and bandwidth considerations).

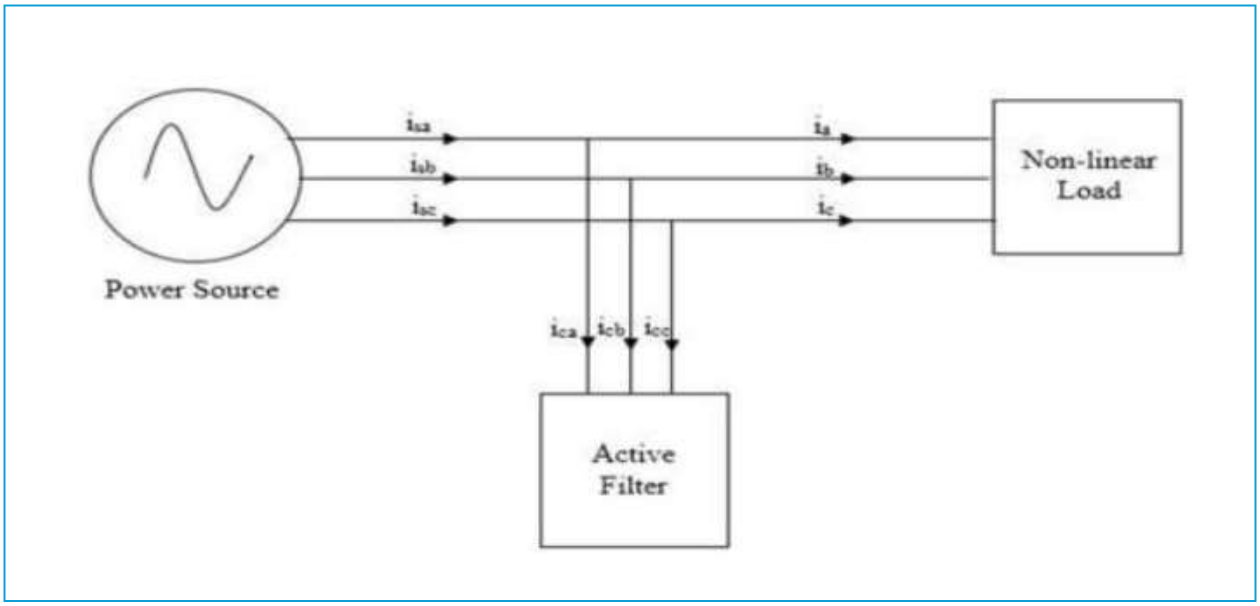

Figure1: Working of Shunt active filter

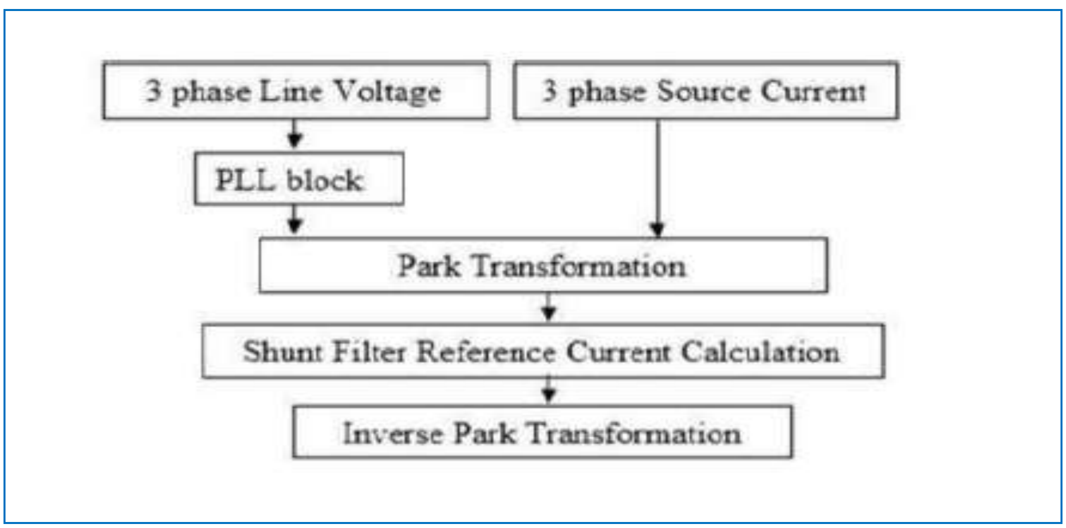

Figure2: D-Q process control strategy

Power electronic switching device in conjunction with nonlinear loads causes serious harmonic problems in power systems due to their inherent property of drawing harmonic current and reactive power from AC supply mains[2]. They cause voltage unbalance and neutral current problems in the power system, Describes the simulation set up with values of the shunt active power filter, including coupled inductor and resistor, DC-coupled capacitor, supply inductor, supply resistor, load resistor, and load inductor, are provided, and introducing the D-Q process for differentiating harmonic portions from basic portions [3]. The Controller Design outlines the design parameters for a 400V, 50Hz system and describes the simulation setup using MATLAB/Simulink.

With the distortion of current and voltage waveform due to the presence of harmonic effect the power system equipment that are connected to maintain steady and reliable power flow in the power system. Major effects include overheating, capacitor failure, vibration, resonance problems, low power factor, overloading, communication interference, and power fluctuation [4]. Thus, to improve the performance it is required to eliminate harmonics from the power utility system. One of the methods used for elimination is the use of a shunt active power filter (SAPF) in which a reference current is generated to remove distortion from the harmonic currents. Shunt active power filters continuously monitor the harmonics current and reactive power flow in the network and generate reference current from the distorted current waveform [5]. Thus, the dynamic closed-loop action of SAPF helps the reduction of harmonics and compensation of reactive power on a real- time basis with little time delay. SAPF can be used with different current control strategies such as the d-q method, fuzzy logic controller, p-q method, neural networks, etc. which helps remove effective harmonic from the power system [6].

LITERATURE SERVEY

This work traces the historical perspective of harmonic distortion, noting its intermittent concerns throughout the history of electric power systems. Early studies by Steinmetz in 1916 focused on third harmonic currents caused by saturated iron in transformers. Harmonic problems resurfaced with rural electrification and telephone service, leading to interference issues addressed by filtering and design limits. In the contemporary context, power electronic loads, such as adjustable-speed drives (ASD) and switch-mode power supplies, are identified as the primary sources of harmonics. The proliferation of these loads, from low to high-voltage applications, has reintroduced power system harmonics as a significant problem [7].

This work explains how power electronic loads, by drawing currents only during specific intervals of the fundamental frequency, create non-sinusoidal waveforms. The resulting distortion can interact with system impedance, causing voltage distortion and potential resonance issues. The harmonic analysis involves Fourier analysis, breaking down distorted waveforms into harmonic components. Total harmonic distortion (THD) is introduced as a common measure, applicable to both current and voltage. Voltage THD below 5% is generally considered acceptable, while values above 10% are deemed problematic for sensitive equipment. The paper categorizes harmonic sources into saturable devices and power electronic devices. Saturable devices, such as transformers and fluorescent lamps with magnetic ballasts, produce harmonics due to iron saturation. Power electronic devices, including switch-mode power supplies and converters, draw power intermittently, leading to high harmonic distortion. Harmonic resonance, occurring when system frequencies correspond to those produced by nonlinear loads, is discussed. Parallel and series resonance scenarios are explained, emphasizing the potential for voltage distortion and its impact on power systems. The importance of understanding the response of the power system at each harmonic frequency is highlighted. The paper outlines the short-term and long-term effects of harmonics on power system components and loads. Short-term effects include nuisance tripping of sensitive loads, while long-term effects involve increased resistive losses and voltage stresses. Harmonics' impact on meter accuracy, blown capacitor fuses, failed capacitor cans, transformer overheating, and overloaded neutrals are discussed [8].

Common causes of harmonic problems are identified as excessive harmonic current injection from nonlinear loads and interaction between harmonic currents and system frequency response. Solutions include limiting harmonic current injection, modifying system frequency response, and employing filters or active control devices. The responsibility for controlling harmonics is shared between end-users and utilities, and the paper references IEEE Standard 519 as a framework for addressing harmonic problems.

METHODOLOGY:

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An Active Filter for Unbalanced Three-Phase System Using Synchronous Detection Method:

The introduction emphasizes the prevalence of unbalanced three-phase systems in distribution networks due to static load characteristics. The paper acknowledges the challenges in power factor correction and voltage regulation caused by unbalanced feeder voltages. Traditional methods, such as instantaneous power theory, are mentioned for detecting and compensating reactive and harmonic currents. However, limitations arise when dealing with significantly unbalanced voltage sources. The paper introduces the equal current synchronous detection method as an alternative for reactive and harmonic current compensation in unbalanced three-phase systems. The proposed method processes per-phase operations, determining compensation components shared among phases. Three approaches are outlined: (a) equal real power sharing, (b) equal line current in each phase, and (c) equal load resistance in each phase. The equal current approach is chosen due to its better profile of line current after compensation. The hardware implementation of the proposed method involves a calculating circuit, a control, and trigger circuit, and a compensating power circuit. The equal current distribution circuit is illustrated, requiring careful adjustment of multipliers and dividers during implementation. The active power filter comprises three single-phase inverters with a common capacitor or DC source. Simulation and experiment results demonstrate the successful compensation of unbalanced load currents, achieving sinusoidal, balanced, and properly phased line currents.

Performance Comparison of Three-Phase Active- Power-Filter Algorithms:

The rapid development of power semiconductors and electronics has led to widespread usage of power-electronic equipment. However, these systems often exhibit input current harmonics and poor power factor, causing various issues such as transformer overheating, machinery disturbance, and voltage distortion. Addressing these problems is crucial for improving power efficiency and meeting electrical criteria. Traditional solutions like passive LC filters and power capacitors have limitations, leading to the development of active power filters. The focus is on three-phase active-power filters capable of suppressing harmonics, compensating reactive power, and balancing three- phase currents.

Active Filters for Power Quality Improvement:

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This work provides a comprehensive review of active filters (AFs) used for compensating harmonic and reactive power in various AC power networks. It covers different AF configurations, control strategies, component selection, economic and technical considerations, and application-specific choices. Aimed at researchers and application engineers dealing with power quality issues, the review includes over 200 research publications for quick reference. The introduction highlights the significance of solid-state control in feeding power to electrical loads and the associated issues caused by nonlinear loads, leading to harmonic and reactive power components. Traditional passive filters were limited, paving the way for dynamic solutions like active filters. AFs are classified based on converter type (current-source or voltage-source), topology (shunt, series, or hybrid), and the number of phases (two-wire, three-wire, or four-wire). configurations, include active shunt, active series, unified power quality conditioners, and hybrid filters. They are

1. Converter-Based Classification: The project classifies active filters based on the type of converter used. It distinguishes between current-fed pulse-width modulation (PWM) inverter bridge structures and voltage-fed PWM inverter structures. This classification considers the nature of the current or voltage source in the AF.
2. Topology-Based Classification: The topology-based classification involves categorizing active filters as series filters, shunt filters, or a combination of both. Active filters can be further classified as unified power quality conditioners, which combine active shunt and active series filters, and hybrid filters, which are a combination of active series and passive shunt filters.
3. Supply-System-Based Classification: The supply-system-based classification divides active filters into two-wire (single-phase), three-wire (three-phase without neutral), and four-wire (three-phase with neutral) systems. This classification is based on the configuration of the power supply and load systems.

RESULT ANALYSIS:

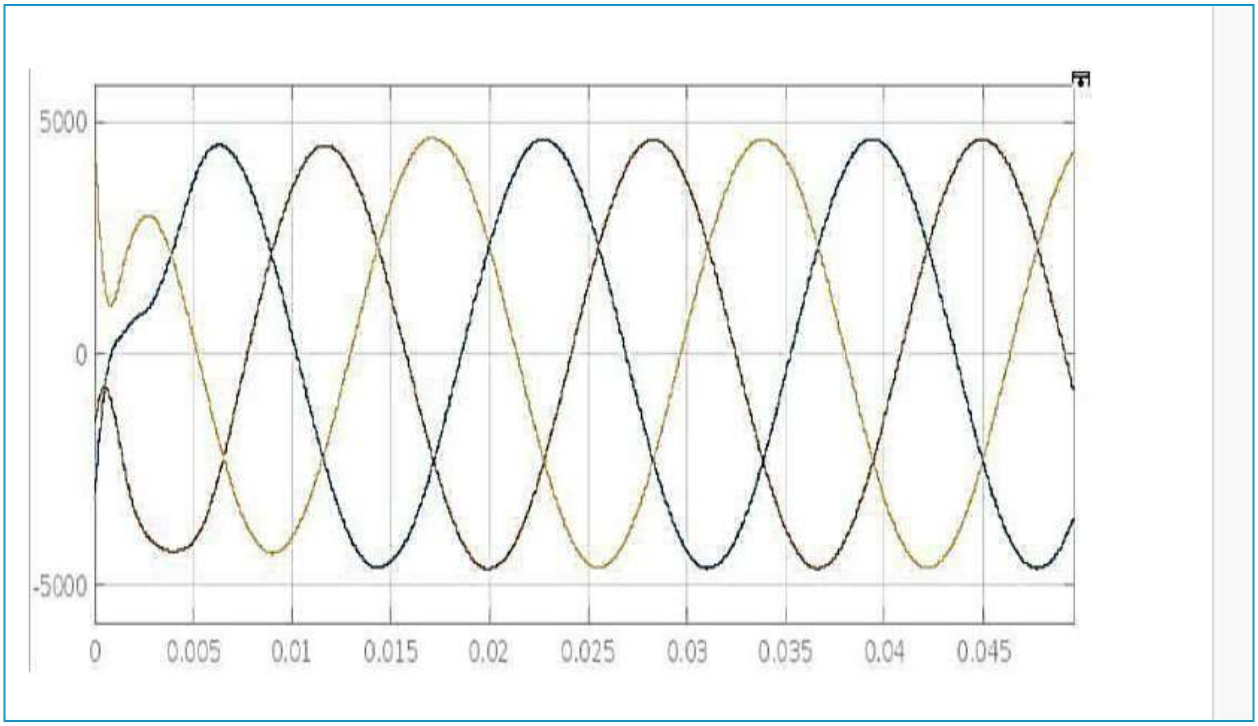

Figure3: Load voltage with harmonics.

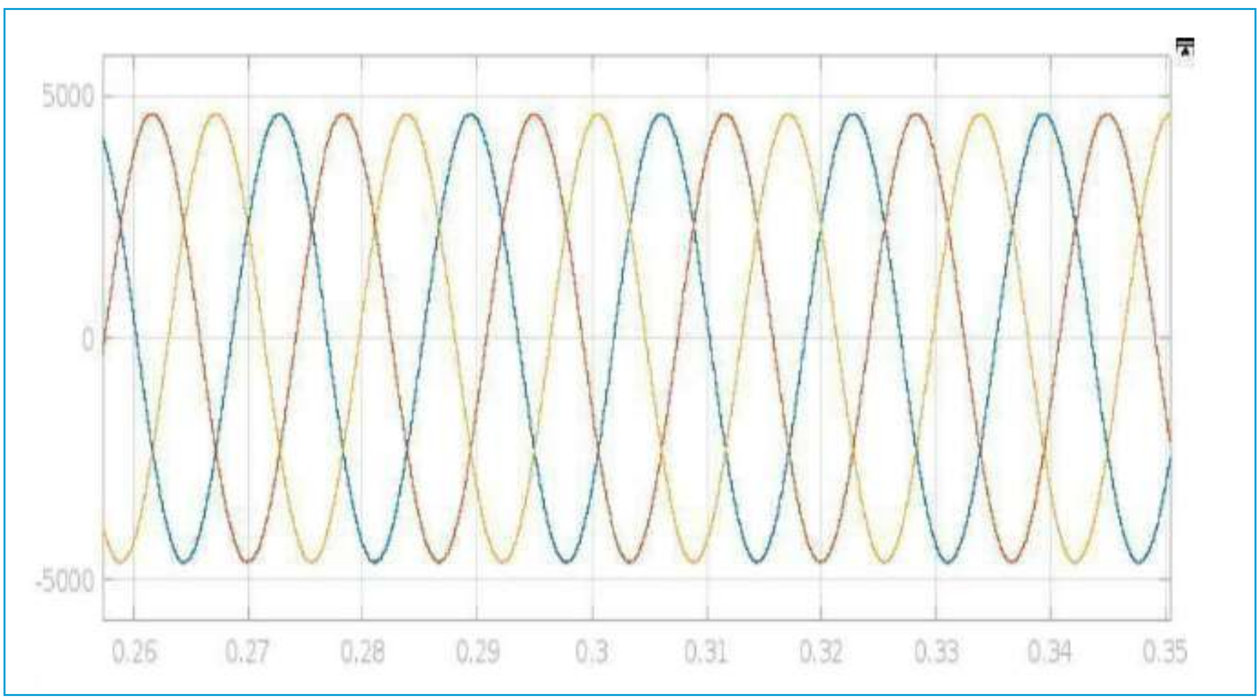

Figure4: Load voltage with harmonics

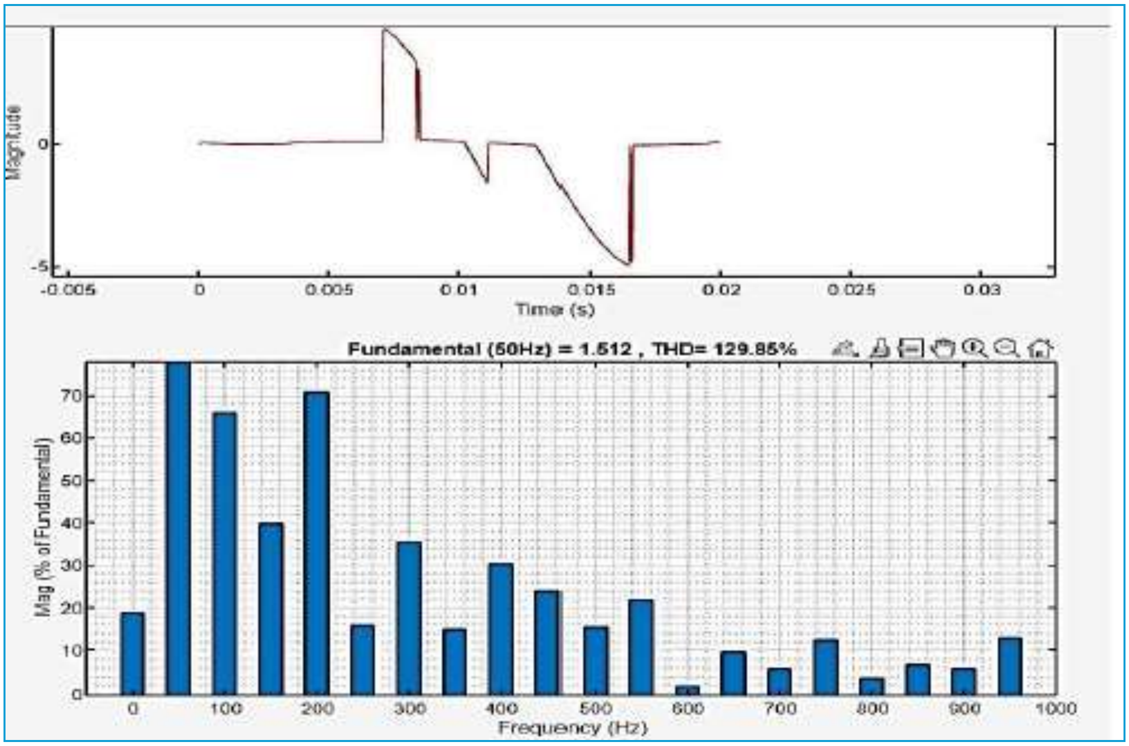

Figure5: FFT analysis of source voltage and total harmonic distortion without active shunt filter

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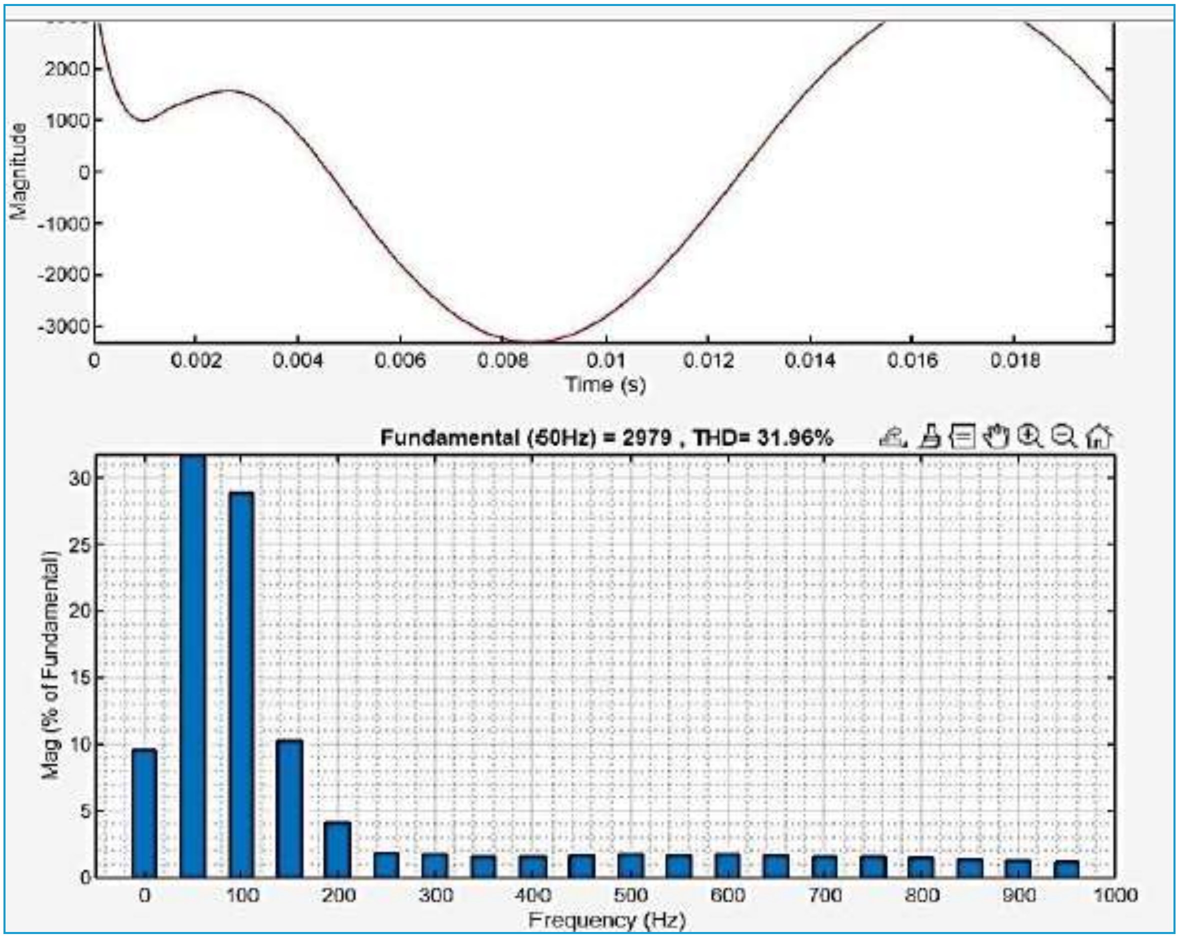

Figure5: FFT analysis of source voltage and total harmonic distortion with active shunt filter

CONCLUSION:

The performance analysis of the shunt active filter using instantaneous d-q theory has been carried out. Simulation results show the effectiveness of a shunt active power filter for harmonic elimination indistorted source current. We also observe a reduction of total harmonic distortion. The Proposed Methodology is used to improve power quality issues with the help of a more advanced controlling methodology. However, more advanced methodologies of control methods have been introduced such as adaptive fuzzy hysteresis band-current controller, and space phasor-based hysteresis current controller. The structure was designed & replicates using MATLAB/SIMULINK. The outputs are shown & described they represent the accurate of the used fuzzy hysteresis controller in increasing the PWM characteristics & thus raise the shunt active power filter characteristics.

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