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Reduction of Total Harmoic Distortion with Facts Devices Using Pi and Fuzzy Controller

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ABSTRACT

The quality of the power is affected by many factors like harmonic contamination, due to the increment of non-linear loads, such as large thyristor power converters, rectifiers, voltage and current flickering due to arc in arc furnaces, sag and swell due to the switching of the loads etc. Recent times due to increased usage of loads, maintaining the quality of power is major challenging for control engineer. In this paper presents the reduction of Total Harmonic Distortion (THD) with the help of Unified Power Quality Conditioner (UPQC) and Static Synchronous Compensator (STATCOM) by using Fuzzy logic controller and compare with PI controller. The output results are carried out by using MATLAB software.

Key Words: UPQC, STATCOM, Power quality, Fuzzy Logic Controller.

1. INTRODUCTION

Power quality is one of the major concerns in the present era. It has become important, especially with the introduction of sophisticated devices, whose performance is very sensitive to the quality of power supplied. Power quality problem is an occurrence manifested as a nonstandard voltage, current or frequency that results in a failure of end use equipment [1]. The main objective of devising UPQC is the combined use of series-active and shunt-active filters chiefly to compensate negative-sequence current and harmonics as the SCR controlled capacitor banks compensate reactive power in power frequency [2]. Modeling and simulation of custom power conditioners happen to be inevitable as power electronics-based equipment in use for augmenting power quality in distribution networks [3]. Extended merit of the UPQC includes the following: it has a similar feature to SCR controlled capacitor banks of achieving load compensation resulting in drawing the balanced sinusoidal currents in the current control mode [4, 5]. In addition it is also the most comprehensive power quality enhancing device for susceptible nonlinear loads, which need exact sinusoidal input supply [6]. UPQC can also be operated in different possible configurations for single-phase (2-wire) and 3-phase (3-wire and 4-wire) networks, diverse compensation approaches, and recent developments are also found in the field [7]. Thus this conditioner can achieve reasonable power quality improvement, reducing the power disturbances that are supplied to the customers by the mains using the series unit. Additional facilities for PQ (i.e., mains power interruptions) can be offered to the customers (custom power) from the shunt units [8]. To reiterate again the main principle of UPQC is to ensure quality supply voltage and load current disturbances, namely, sags, swell, imbalance, harmonics, reactive currents, and current unbalance produced by the nonlinear loads [9,10].

Fully digital controller based on the TMS320F2812 DSP platform which is implemented for the reference generation as well as control purposes is proposed [11].

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To improve the power quality by compensating the voltage sag [12, 13] .The main focus of this proposed system is to improve the power quality by compensating the voltage sag and eliminating the harmonics in the distribution network using a fuzzy logic [12, 13] based technique.

2. AN OVERVIEW OF UNIFIED POWER QUALITY CONDITIONER

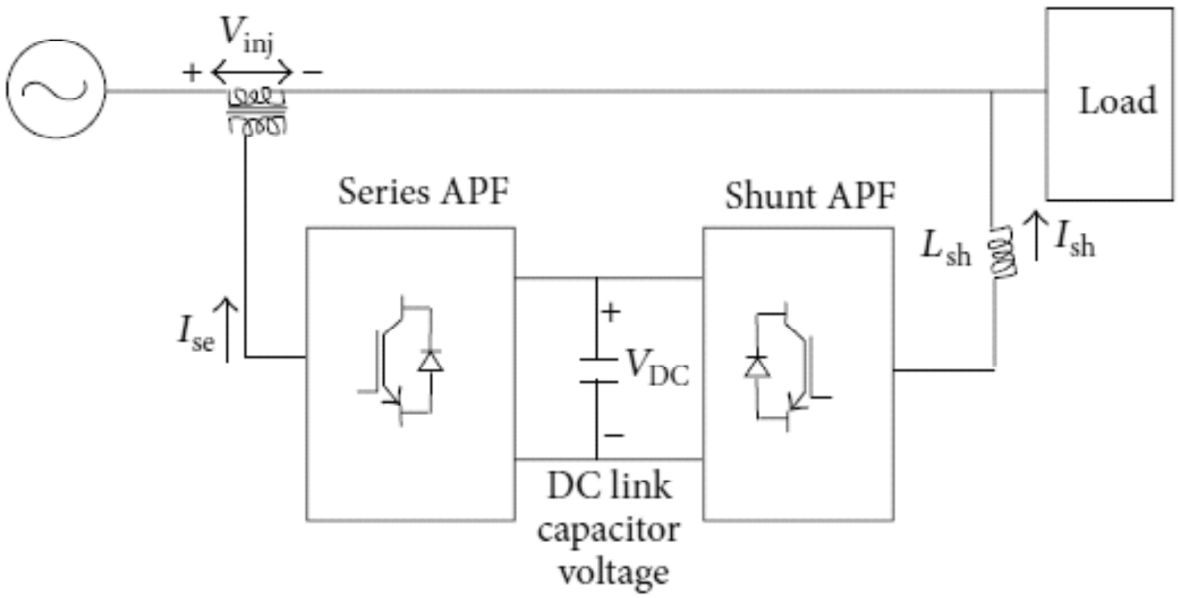

Figure 1: Schematic Diagram of UPQC

UPQC is one of the custom power devices used at the electrical power distribution systems to improve the power quality of distribution system customers [2]. UPQC could be used to cancel current harmonics, to compensate reactive power, to eliminate voltage harmonics, to improve voltage regulation, to correct voltage and current imbalances, to correct voltage sag or swell, and to avoid voltage interruptions [3]. UPQC consists of both shunt and series compensators. A shunt compensator is used to cancel the disturbances in current whereas series compensator is used to cancel disturbances in voltage. Shunt compensator could be connected to the left or right of the series compensator. Ideally, shunt compensator injects current to achieve purely balanced sinusoidal source currents in phase with the supply voltages at rated magnitude and frequency. On the other hand, series compensation is used to inject voltage to maintain terminal voltage at rated magnitude and frequency. The schematic diagram of a three-phase UPQC is shown in Figure 1.

The shunt active filter performs the following functions:

a) To provide compensation of the load harmonic currents to reduce voltage distortions

b) To provide load reactive power demand

c) To maintain the DC-link voltage to a desired level.

To perform the first two functions, the shunt active filter acts as a controlled current source and its output current should include harmonic, reactive and negative phase sequence components in order to compensate these quantities in the load current.

Voltage source inverters are used for shunt and series compensation. One may note that both voltage source inverters are supplied from a common DC link capacitor. One of the voltage source inverters is connected in parallel with the AC system while the other one is connected in series with the AC system through injection transformers. The inverter connected in parallel, together with its control circuit, forms the shunt compensation circuit. On the other hand, the inverter connected in series with appropriate control circuit forms the series compensation circuit. For the successful operation of the UPQC, the DC capacitor voltage should be at least 150% of the maximum line-line supply voltage. To regulate the capacitor voltage constant, either a PI controller or a fuzzy logic controller could be used

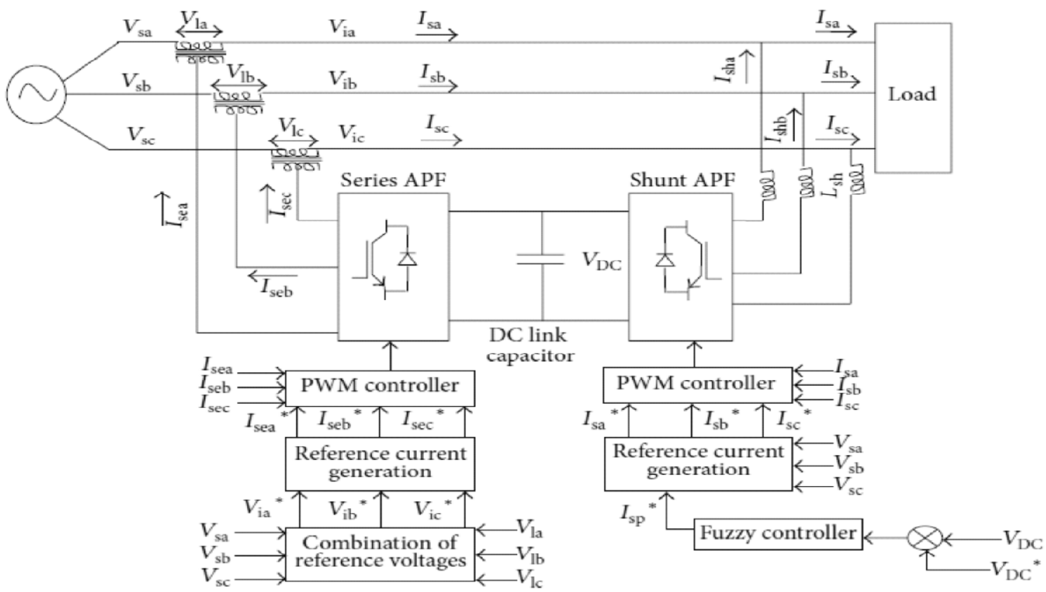

Figure 2: Proposed Diagram of UPQC

DESIGN OF DC-LINK BUS CAPACITOR VOLTAGE

DC link voltage is maintained at a desired value under all operating conditions. It can be shown that apart from the power loss due to line and winding resistances, a certain amount of power needs to be supplied to or absorbed by the capacitor to restore a voltage during a voltage disturbance. For example, if voltage sag occurs in phase "a", va is higher than the normal value; the dc-link capacitors will supply the power through the series active filter. In the proposed scheme Fuzzy controller is used to control the capacitor voltage. The input to Fuzzy controller is the error between the actual capacitor voltage and its desired value. The output of the Fuzzy is added to the reference current component. The shunt active filter acts like a regulator. Its currents are used to adjust the capacitor voltages to within a certain range.

3. FUZZY LOGIC CONTROLLER (FLC)

Fuzzy set theory exhibits immense potential for effective solving of the uncertainty in the problem. It is an outstanding mathematical tool to handle the uncertainty arising due to vagueness. Fuzzy logic control is divided into fuzzification, inference and defuzzification as shown in figure 3.

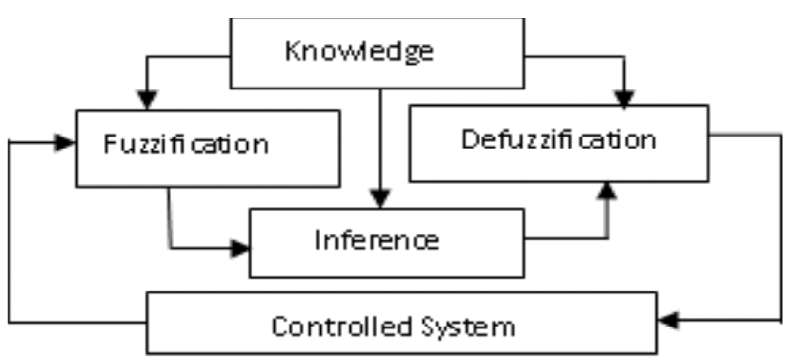

Figure 3: Fuzzy logic controller

FUZZIFICATION

Input variable transformed to the linguistic variables depends on the control variables such as error and change of error

ERROR CALCULATION

Error is calculated from the difference between actual value and reference value.

CHANGE OF ERROR

Change of error is the difference between the variation of error at current sampling and its previous sampling.

C (k) = E (k)-E (k-1)

The input values of the fuzzy logic controller are connected to the output values by if-then rules. If-then rule is defined as “If (error is negative large and change of error is negative large) then output is negative large.

KNOWLEDGE BASE

Knowledge base includes the fuzzy membership functions defined for each control variables and the necessary rules that specify the control goals using linguistic variables.

INFERENCE MECHANISM

It should capable of simulating human decision making and influencing the control actions based on fuzzy logic. In the inference mechanism rules are based by the user on the basis of these rules output of fuzzy logic controller is controlled.

DEFUZZIFICATION

In the defuzzification process, the controller output represents as linguistic labels by fuzzy set are converted to the analog signals.”Weighted Average” method which is the special case of”Mamdani Model” is selected for the defuzzification process.

4. SIMULATION RESULT FOR STATCOM WITH FUZZY LOGIC CONTROLLER

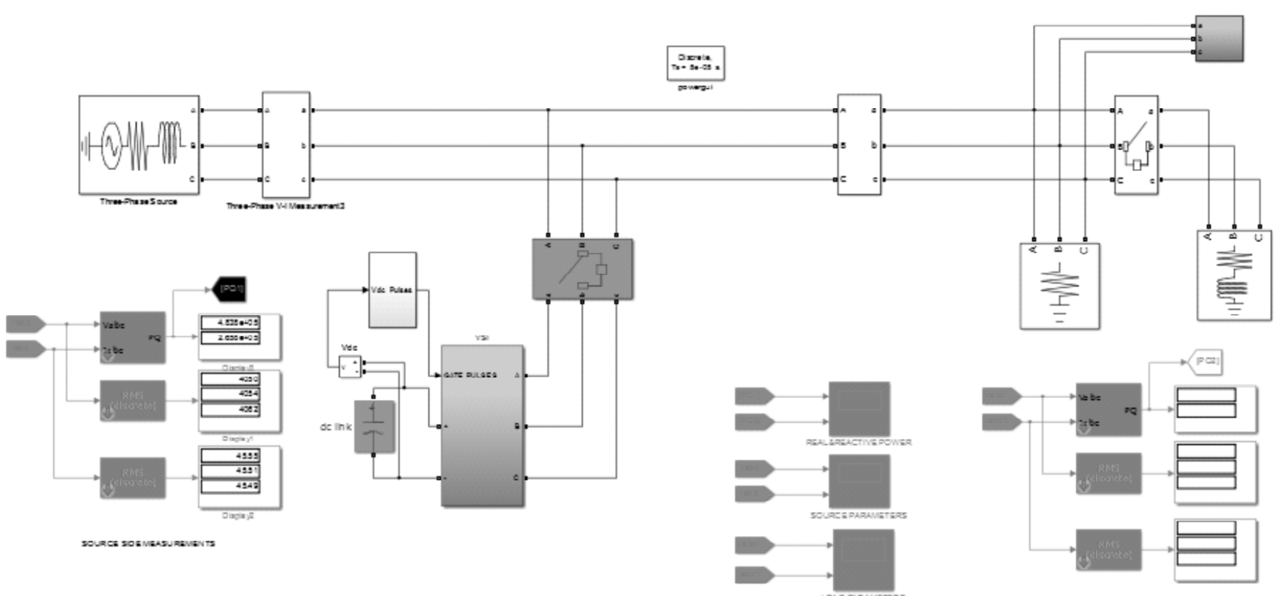

Figure 4: Simulation diagram for STATCOM

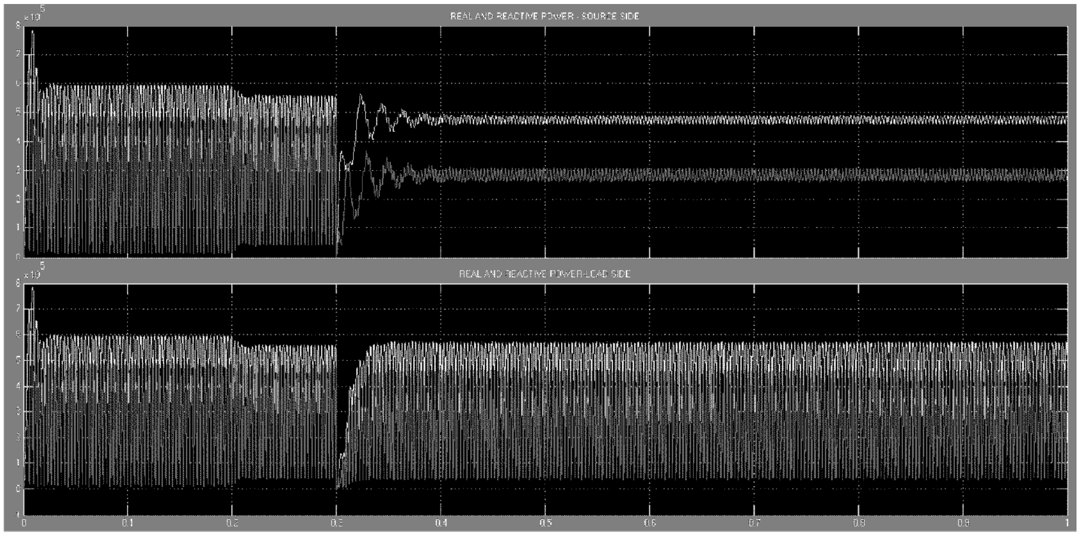

Figure 5: Real and Reactive power for load and source side

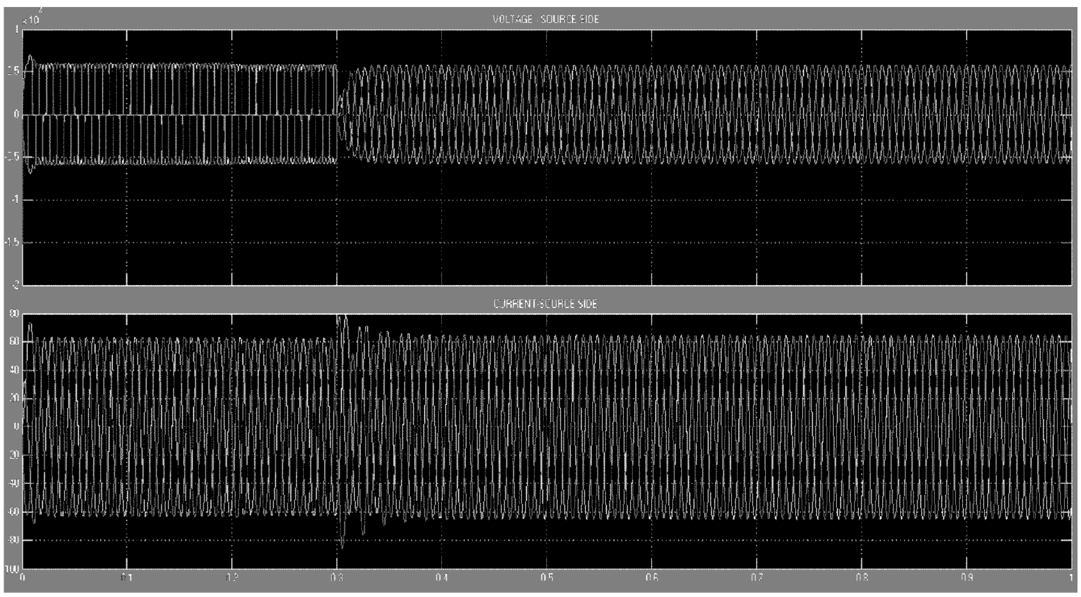

Figure 6: Source side voltage and current

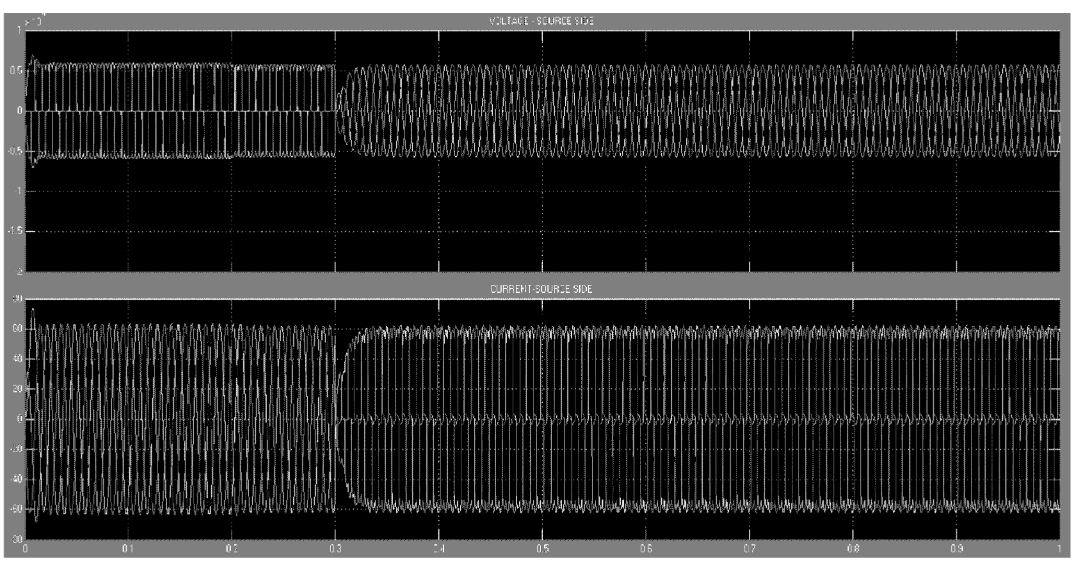

Figure 7: Load side voltage and current

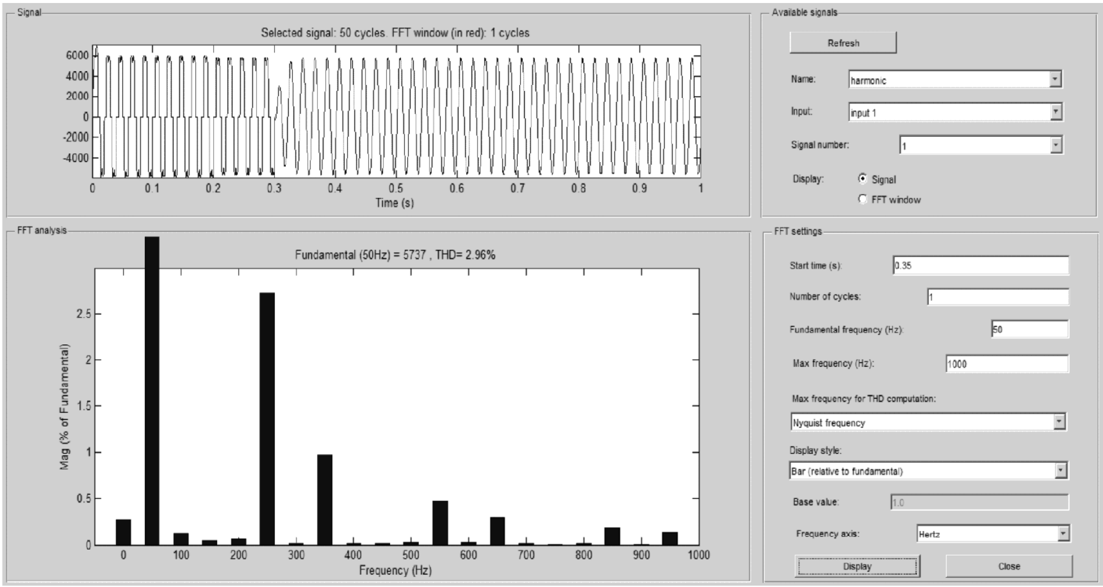

Figure 8: Total Harmonic Distortion level of 2.96%

5. SIMULATION RESULT FOR UPQC WITH FUZZY LOGIC CONTROLLER

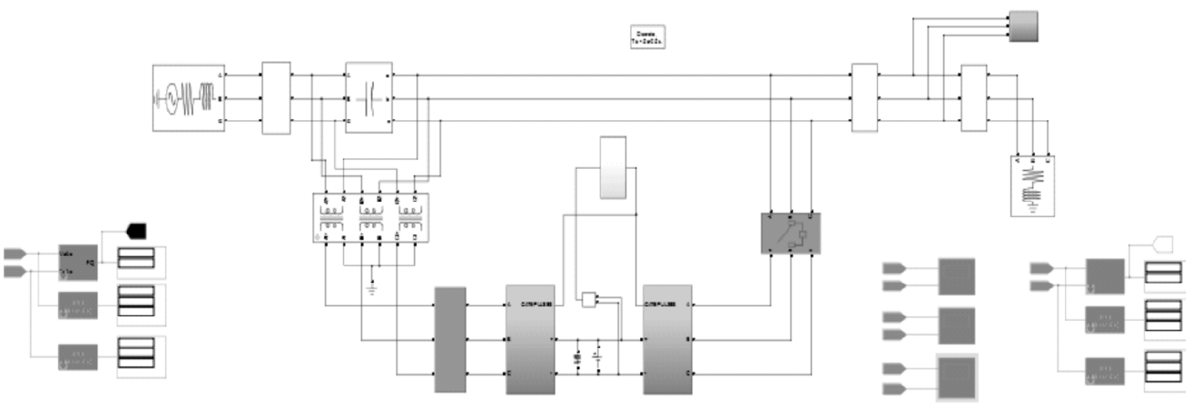

Figure 9: Simulation diagram for UPQC

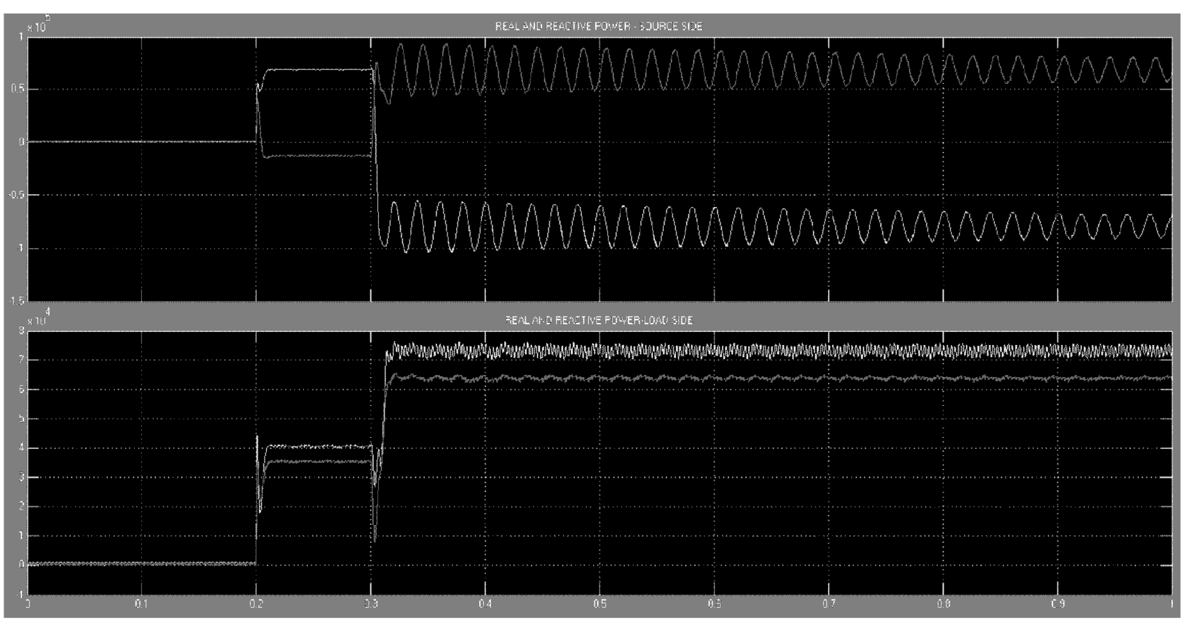

Figure 10: Real and Reactive power for load and source side

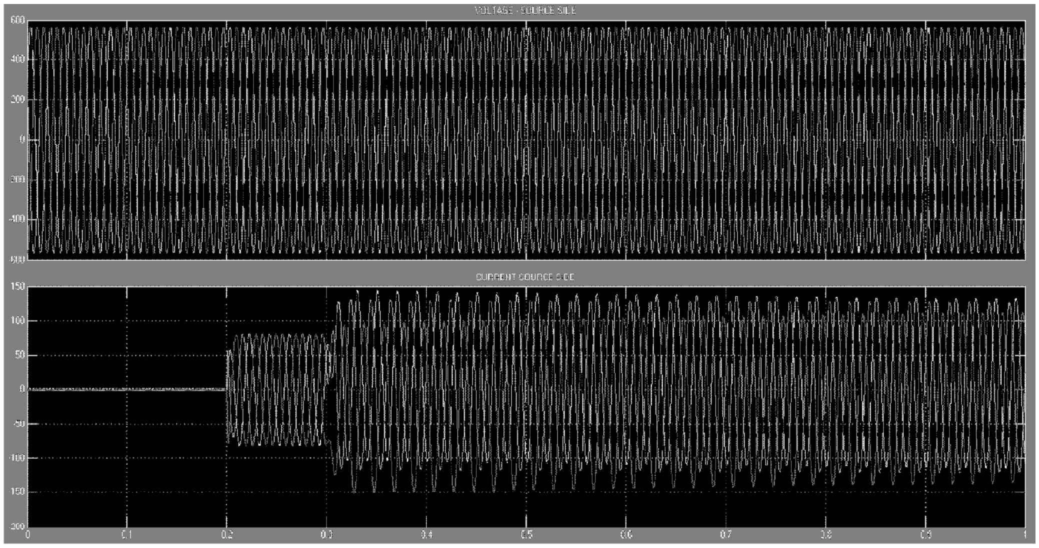

Figure 11: Source side voltage and current

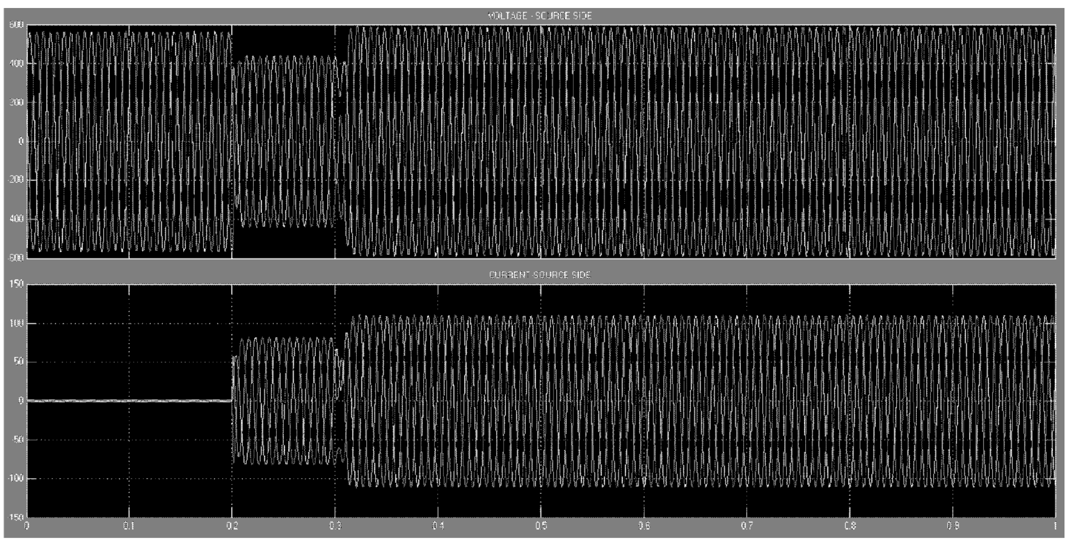

Figure 12: Load side voltage and current

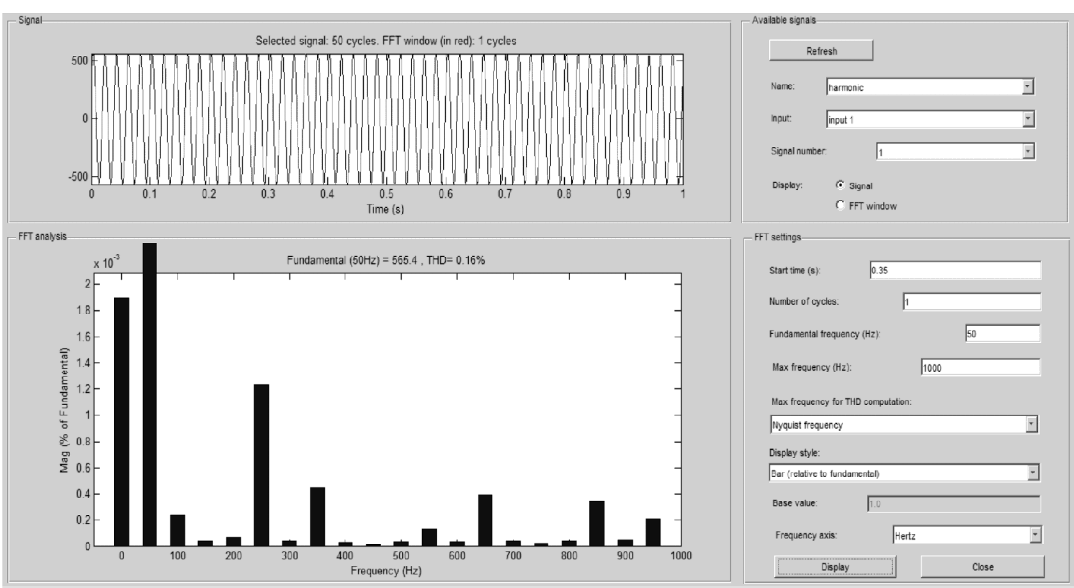

Figure 13: Total Harmonic Distortion level of 0.16%

6. RESULT COMPARISION (FFT ANALYSIS THD LEVEL)

DEVICE CONTROLLER	*PI CONTROLLER*	*FUZZY LOGIC CONTROLLER*
STATCOM	8.05%	2.96%
UPQC	3.26%	0.16%

PI controller based THD level outputs get from the paper [14]

CONCLUSION

The Results obtained from the simulation shows better performance of UPQC and STATCOM with fuzzy logic controller used when compare to PI controller in terms of harmonic compensation and dc capacitor voltage balancing at load terminals in switching as well as unbalanced conditions. Under this condition the dynamic response of fuzzy logic controller proved to be faster than PI controller. Hence it is proved that fuzzy logic controller is superior then PI controller.

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