OPEN ACCESS
International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-5, June 2019

Performance Evaluation of Closed Loop Controlled Shunt Active Filter Systems with Different Controllers

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Abstract: *In this paper, improving the dynamic performance of three phase closed loop controlled shunt active filter (SAF) is connected with different controllers Like PI, PR, FOPID and Fuzzy-logic controller. The SAF is executed with Voltage-Source-Inverter (VSI) & the switching-pulses are created utilizing assorted controllers. In this paper open loop three phase system with source disturbance and closed loop controlled SAF with different controllers are simulated. The simulation outcomes are presented to discover the outcome of SAF utilizing PI, PR, FOPID & FL controller are evaluated & the corresponding time-domain-parameters like rise time, settling time, peak time, steady state error are represented. THD is also compared with different controllers. The results showed that Fuzzy Controller system is the only controller has a better response than other controlled system.*

Index Terms: *FLC , FOPID , PR ,Shunt Active Filter (SAF).*

I. INTRODUCTION

One of the major concern in electricity today is power-quality. It turns out to be particularly critical with the presentation of advanced & convoluted gadgets whose execution is exceptionally delicate to the nature of power- supply. The electronic gadgets are exceptionally delicate to unsettling influences & along these lines modern burdens turn out to be less tolerant to control quality issues. As of late, power-engineers are progressively worried over the nature of the electrical power. In current ventures , stack hardware utilizes electronic controllers which are touchy to poor voltage quality and will close down if the supply voltage is discouraged and may disoperation in different ways. A large portion of this load-hardware utilizes electronic switching gadgets which can add to poor system voltage quality. The challenge in electrical energy supply has made more noteworthy business attention to the issues of PQ while equipment is promptly accessible to gauge the nature of the voltage waveform thus measure the issue. Alongside appearance innovation, the association of the overall economy has developed towards globalization and the net revenues of numerous exercises will in general decline. The expanded affectability of most by far of procedures like (modern, benefits and even private) to PQ issues turn the accessibility of electric power with quality a significant factor for energy in each segment. The constant procedure industry and the data innovation administrations are most basic regions. Because of unsettling influence, an enormous measure of money related misfortunes may occur, with the ensuing loss of efficiency &competitiveness. Numerous endeavors have been taken utilities to satisfy buyer necessity; a few shoppers require an abnormal state of power-quality than the dimension given by present day electric systems. This suggests a few estimates must be taken with the goal that more elevated amounts of PQ can be gotten. The FACTS gadgets and custom power gadgets are acquainted with electrical framework to enhance the power nature of the electrical power. DVR, DSATCOM, Active channels, UPQC and so on are a portion of the gadgets used to enhance the power nature of the voltage and current. With the assistance of these gadgets we are able to lessen the issues identified with power quality. The point of this work is to locate a reasonable controller to enhance the dynamic execution of 3 phase closed-loop-controlled-SAF so as to decrease the harmonic-distortion two kinds of filters can be utilized. 1) Active-filter 2) Passive-filter. A passive-filter is made out of just passive-components, for example, L ,C and R. The PF's are cheap. Yet, they are ineffectual because of the failure to adjust to arrange trademark varieties.

Manuscript published on 30 June 2019.
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II. GENERAL CONCEPT OF SHUNT- ACTIVE-POWER- FILTER

This is the most vital setup broadly utilized in dynamic filtering-applications for current-harmonic decrease and power factor enhancement. A shunt APF [1] comprises controllable voltage or current source inverter. The VSI based shunt APF is the most ordinarily utilized sort, because of its notable topology and straight forward establishment technique. SAPF goes about as symphonious current source which infuses an anti-phase however similar size of the consonant &reactive-current as that of non straight load.

Fig.1 demonstrates the setup of APF with non-straight load. The fundamental working rule of APF is that a non sinusoidal waveform at a bus can be adjusted to sinusoidal by infusing current of legitimate extent and waveform.

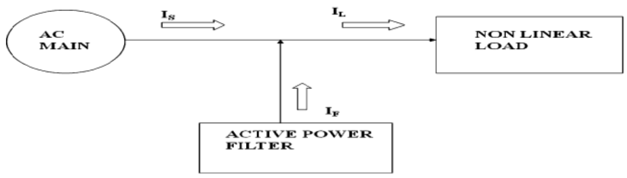

Fig.1 'Basic-concept of-SAF'

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From Fig.1

$$I_L = I_S + I_F \qquad (1)$$

The load- current having essential harmonic- substance & I_F is the harmonic compensating current.

$$I_L + I_H = I_S + I_H \qquad (2)$$

Filter offer harmonic-condition of the-load

$$I_L + I_H = I_S + I_H \qquad (3)$$

$$I_L = I_S \qquad (4)$$

In this method the availability current represents the fundamental wave input yield harmonics. Fig.2 demonstrates the look of SAF with non-straight load and therefore the full-bridge-converter that is broadly speaking accustomed wipe out current harmonics, reactive-power remuneration and adjusting the uneven flows.

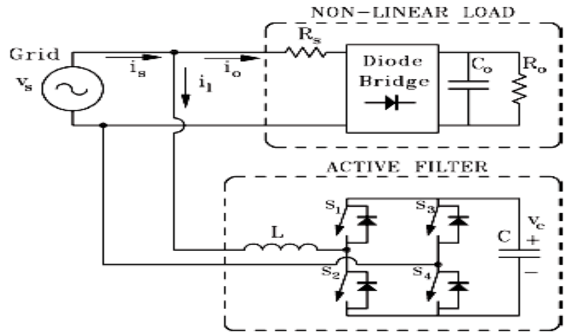

Fig.2 shunt active filter with non linear load

III. CLOSED LOOP CONTROLLED SAF SYSTEMS

Closed-loop-controlled-SAF with various controller [2] is delineated in Fig.3.This outline represents that the 'PI/PR/FOPID/FUZZY-controller' evaluates the reference-voltage & the actual-voltage of the frame work. That is the DC-side capacitor-voltage is sensed & evaluated with a wanted reference-voltage.

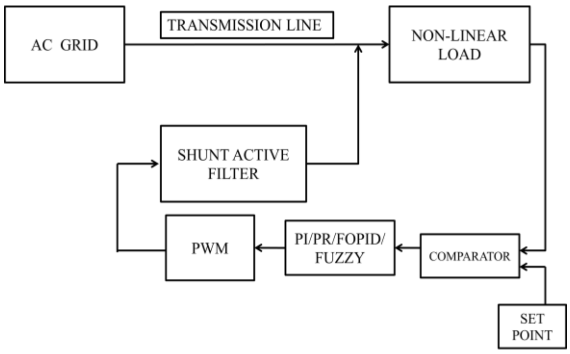

Fig.3 Proposed various controlled SAF system

Source-voltage &source-current qualities are given to reference-generator. It will deliver I_{ref} and given to controller segment .The peak-estimation of the reference current is evaluated by managing the DC-link- voltage. The genuine capacitor voltage is contrasted and a set reference esteem. The error-signal is handled through a PI/PR/FOPID/FUZZY controller. The reference flows and the real flows are contrasted with a PWM, which gives the error-signal for the adjustment method. This error-signal chooses the task of the converter switches.

PI controllers [3] are broadly utilized in the business because of their basic control structure and simplicity of usage, these controllers pose troubles where are some control unpredictability, for example, nonlinearity, stack unsettling influences and parametric varieties. Besides, PI controllers require exact straight scientific models.

The PR[4] tool is a scientific device for managing uncertainty. It is vital to see that there is a private association among PR and Complexity. The PR controlled systems do not need precise scientific model, they can work with loose sources of info, can deal with non-linearity, load-unsettling influences and so forth.

The PR controller is given by

$$V_0(s)=V_i(s)\ K_p+K_i\,(S^2/s^2+\omega^2\,) \qquad (5)$$

where, "K_p" is the Proportional-Gain-term, "K_I" is the Integral-Gain-term and ω_0 is the resonant-frequency. The K_P term resolves the energetic of the framework; band-width, phase& gain-borders.

The FOPID-controller [5] is meant on the idea of fraction-calculus. Regular-PID-controller is utilized in production due to their straightforward plan & advanced-performance. The yield& inputs of the controller are narrated as follows

$$V_0(s)=V_i(s)(K_p+K_i/S^m+k_dS^n) \qquad (6)$$

Here m&n are fractions.

The Fuzzy Logic apparatus [6] is a scientific device for uncertainty. It is critical to see that there is a private association among Fuzziness and Complexity. The upsides of FL-controller do not need precise numerical model, they can work with uncertain sources of information, can deal with non-linearity, load-disturbances and so forth.

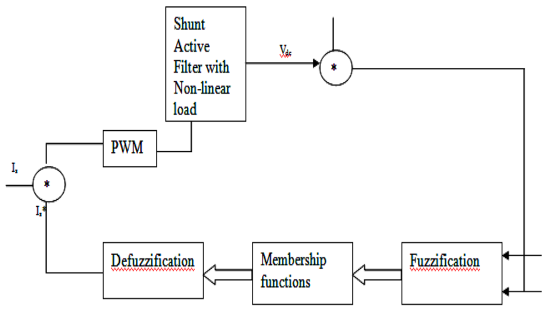

Fig.4 Block diagram of Fuzzy Logic Controller

Fig.4 demonstrates the block-diagram of Fuzzy-Logic-Controller. In the FLC calculation for APF two sources of info are required. The input-sources are error and change in error. The two input-sources were connected by part works. Essentially nine principles are there. Fuzzy-sets bolster an adaptable feeling of membership-capacities. A triangular membership-work has the upside of effortlessness and simple usage and is embraced in the application. The centroid-technique for de-fuzzification is utilized.

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IV. SIMULATION RESULTS

A.Open Loop three phase system with Source Disturbance

Open loop three phase system with source disturbance is given in Fig.4.The obtained voltage response is appeared in Fig.6 and RMS voltage response is appeared in Fig.7 and its value is 290.2 V. Output current and Output power is appeared in Fig.8 and Fig.9 respectively.

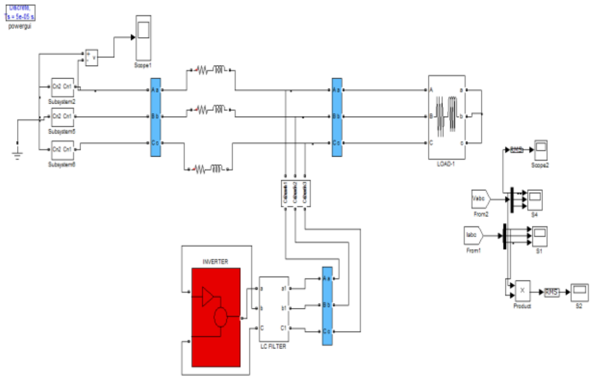

Fig.4. Simulink Model of the open loop three phase system with disturbance

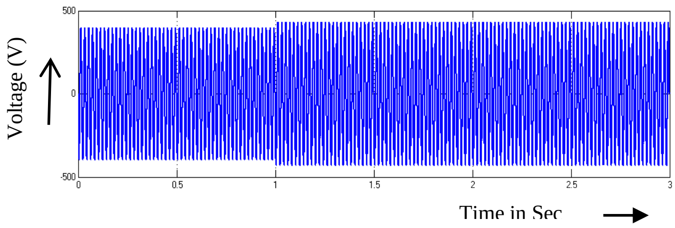

Fig.5 Representation of input voltage

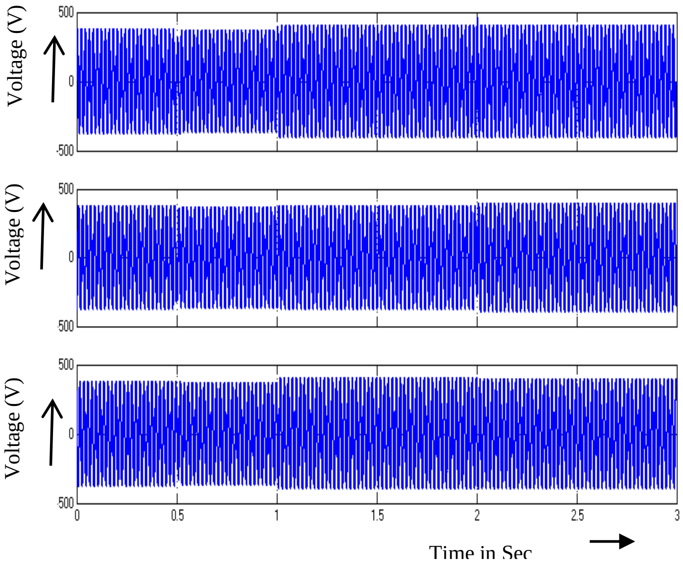

Fig.6 Representation of Output voltage

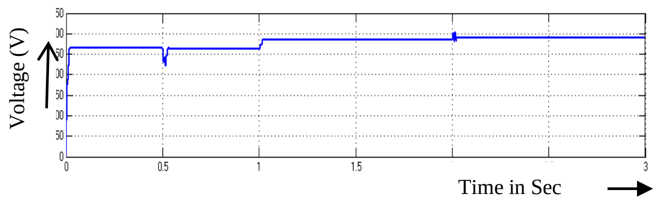

Fig.7 Representation of RMS Output voltage

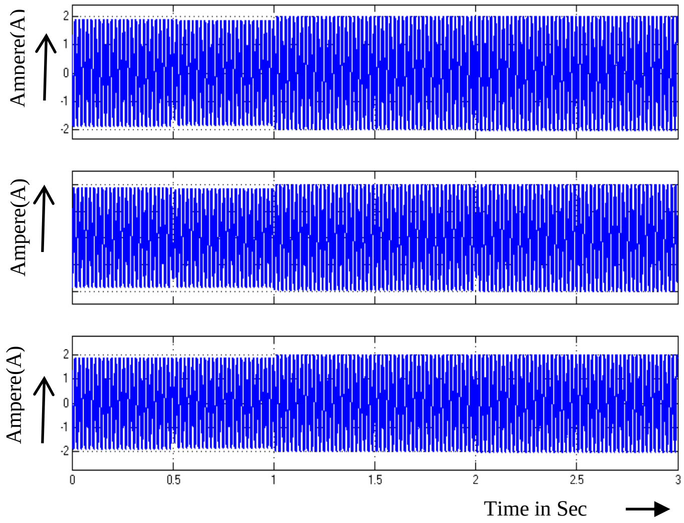

Fig.8 Representation of Output current

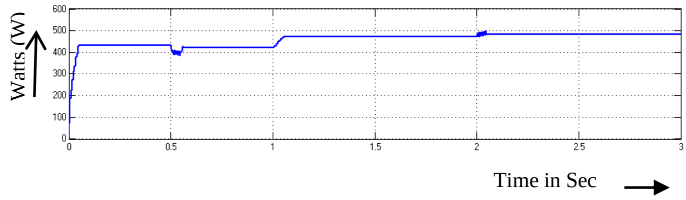

Fig.9 Representation of Output power

B. Closed loop three phase SAF system with PI controller

Closed loop three phase system with PI -controller is shown in Fig.10.The obtained voltage response is appeared in Fig.12 and RMS voltage response is appeared in Fig.13.and its value is 282.9 V. Output current and Output power is appeared in Fig.14 and Fig.15 respectively.THD is appeared in Fig.16 and its value is 6.09 %.

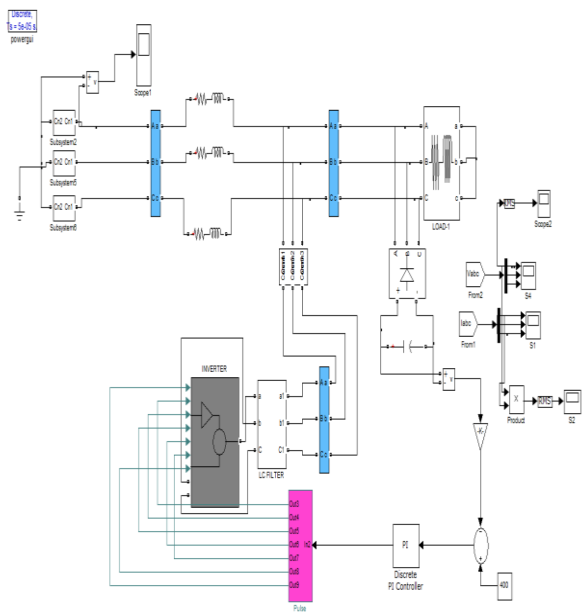

Fig.10 Simulink Model of the closed loop three phase system with PI controller

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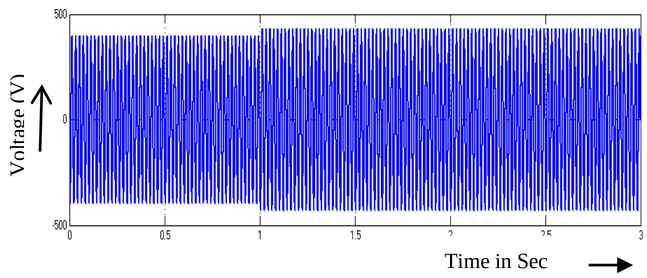

Fig.11 Representation of Input voltage

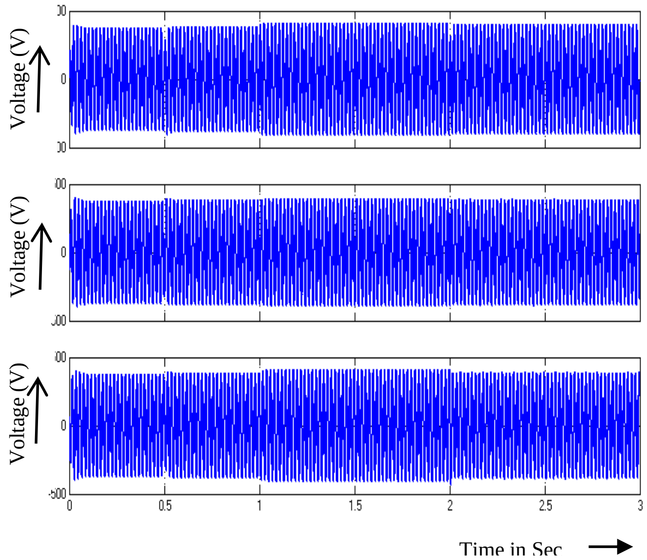

Fig.12 Representation of Output voltage

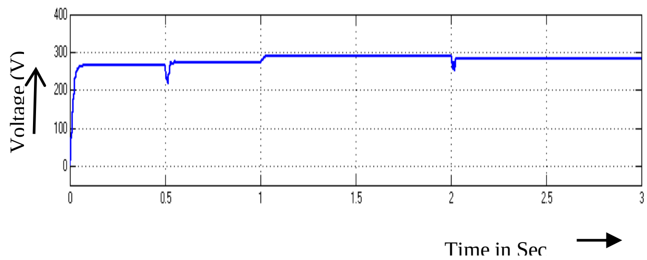

Fig.13 Representation of RMS Output voltage

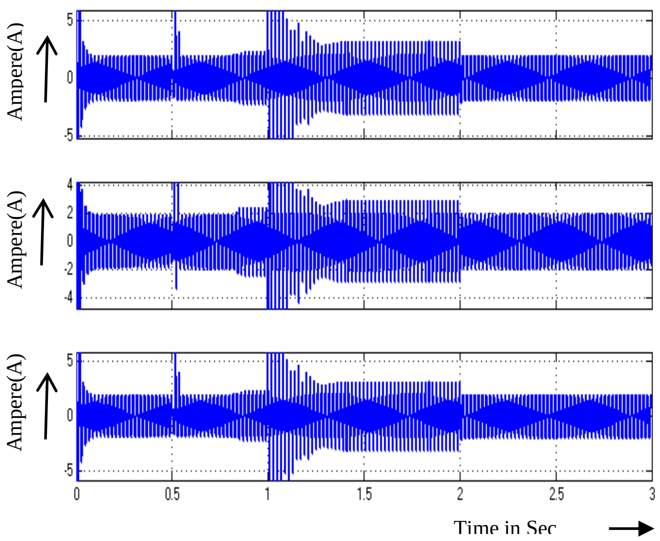

Fig.14 Representation of Output current

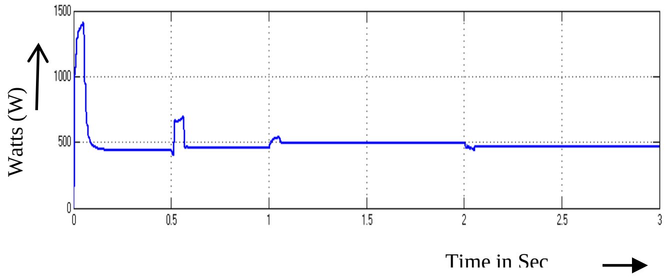

Fig.15 Representation of Output power

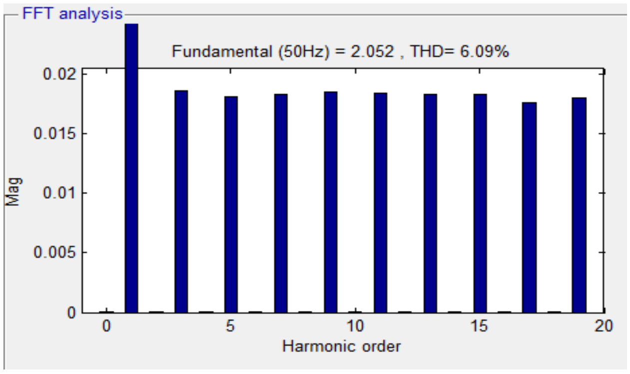

Fig.16 Representation of THD

C. Closed loop three phase SAF system with PR controller

Closed loop three phase system with PR -controller is shown in Fig.17. The obtained voltage response is appeared in Fig.18 and RMS voltage response is appeared in Fig.19 its value is 280.6 V. Output current and Output power is appeared in Fig.20 and Fig.21 respectively. THD is appeared in Fig. 22 and its value is 4.96 %.

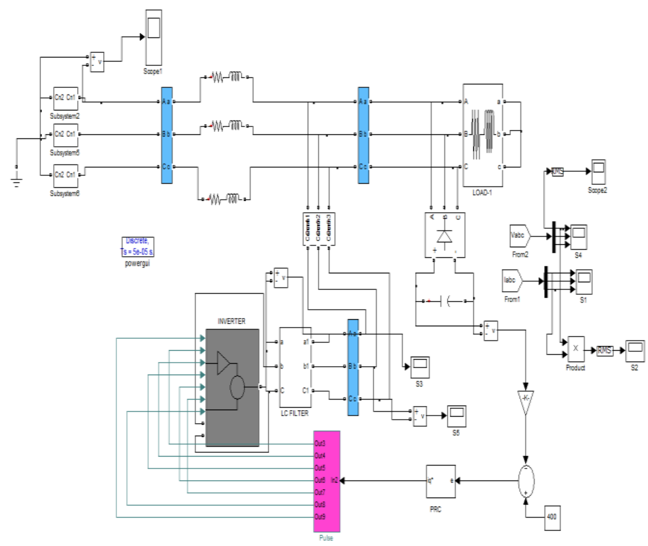

Fig.17 Simulink Model of the closed loop three phase system with PR controller

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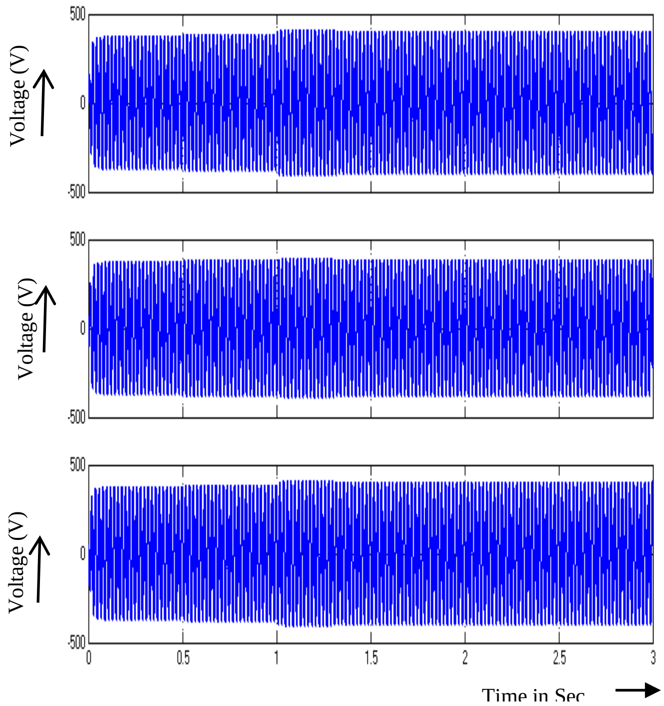

Fig.18 Representation of Output voltage

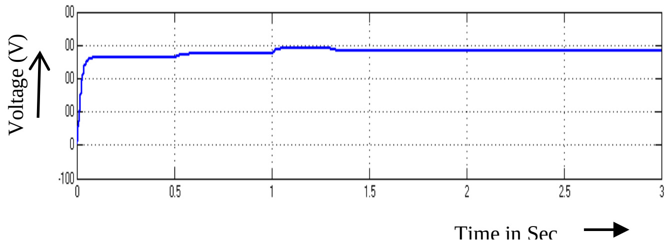

Fig.19 Representation of RMS Output voltage

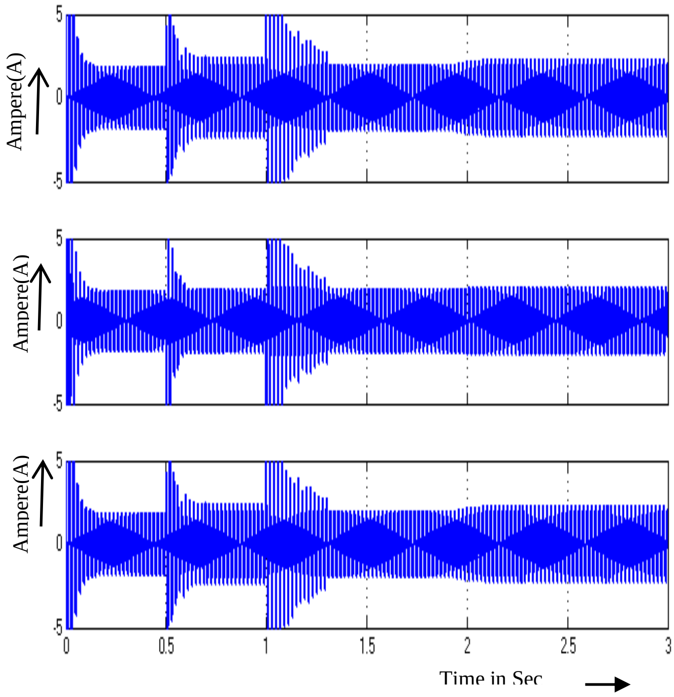

Fig.20 Representation of Output current

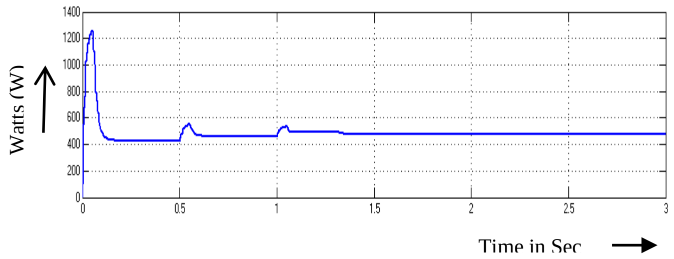

Fig.21 Representation of Output power

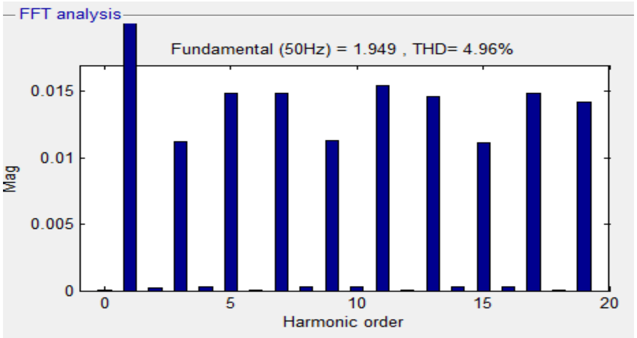

Fig.22 Representation of THD

D.Closed loop three phase SAF system with FOPID controller

The closed loop three phase system with FOPID controller is given in Fig.23.The PR controller is replaced by FOPID. The obtained voltage response is shown in Fig.24 and the RMS voltage response is shown in Fig.25 and its value is 278.7 V. Output current and Output power is appeared in Fig.26 and Fig.27 respectively.THD is appeared in Fig.28 and its value is 4.66 %.

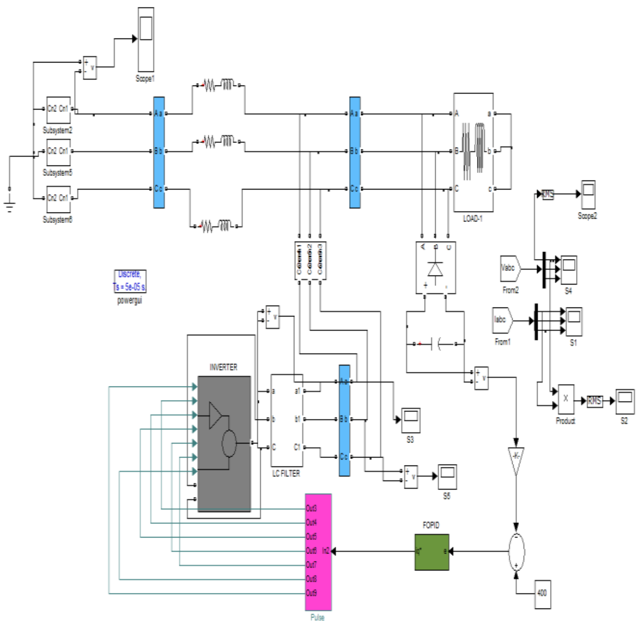

Fig. 23 Simulink Model of the closed loop SAF system with FOPID controller

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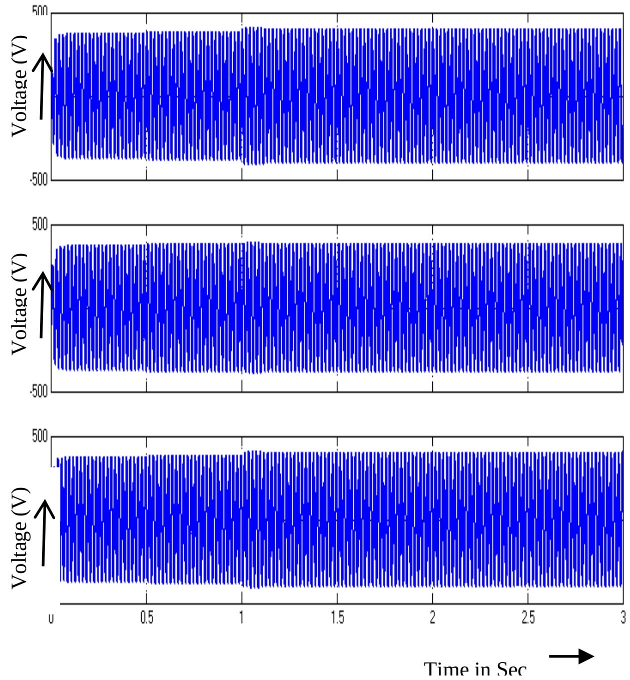

Fig.24 Representation of Output voltage

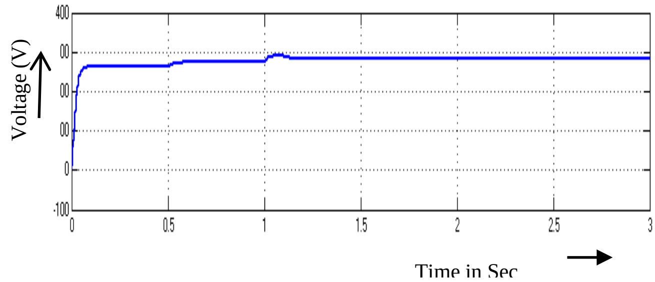

Fig.25 Representation of RMS Output voltage

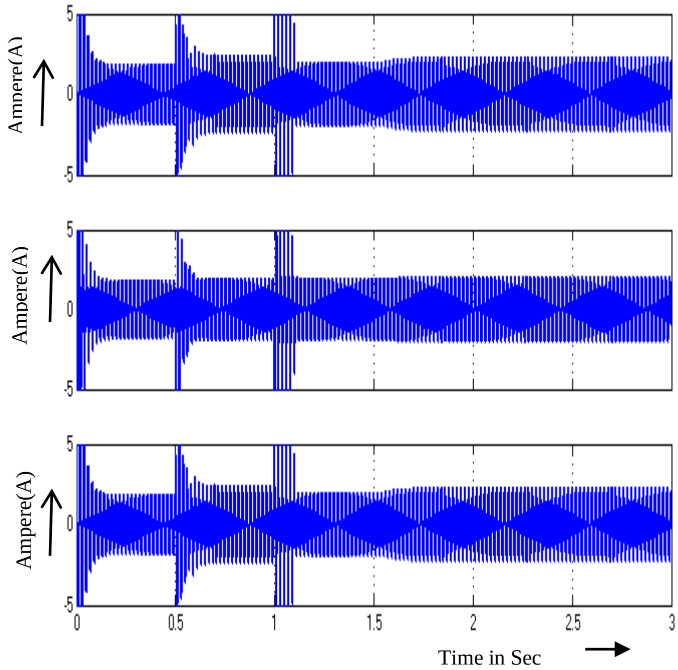

Fig.26 Representation of Output current

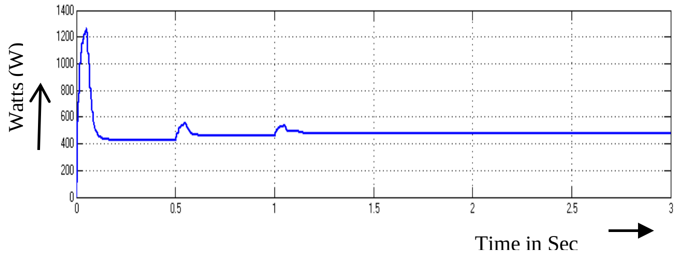

Fig.27 Representation of Output power

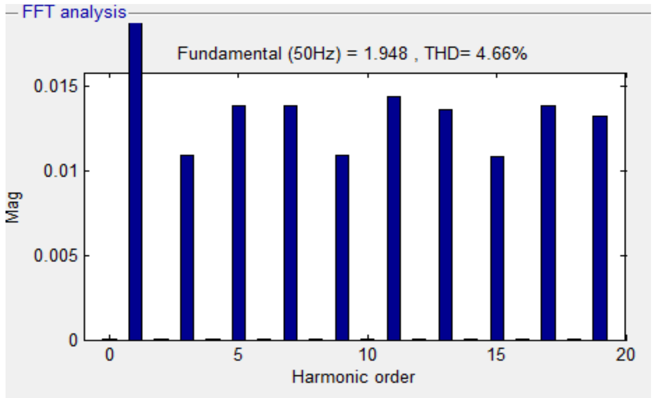

Fig.28 Representation of THD

E. Closed loop three phase SAF system with fuzzy controller

The closed loop TPSAF-System with FLC as appeared in Fig.29.The FOPID controller is replaced by Fuzzy. The obtained voltage response is shown in Fig.30 and the RMS voltage response is shown in Fig.31 and its value is 277.4 V. Output current and Output power is appeared in Fig.32 and Fig.33 respectively.THD is appeared in Fig.34 and its value is 3.55 %.

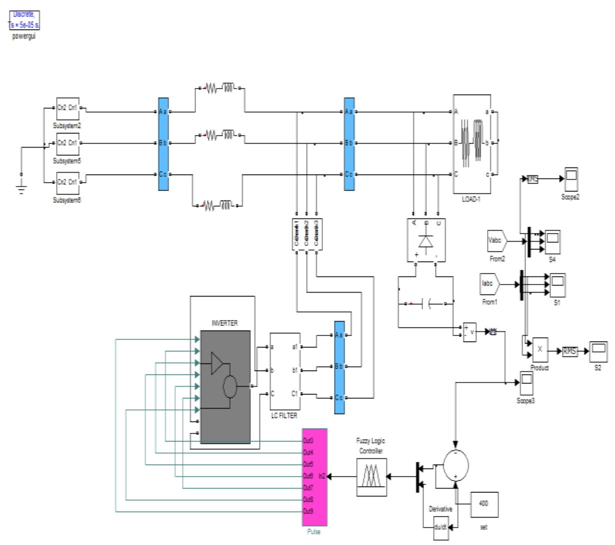

Fig.29 Simulink Model of the Closed Loop System with FLC

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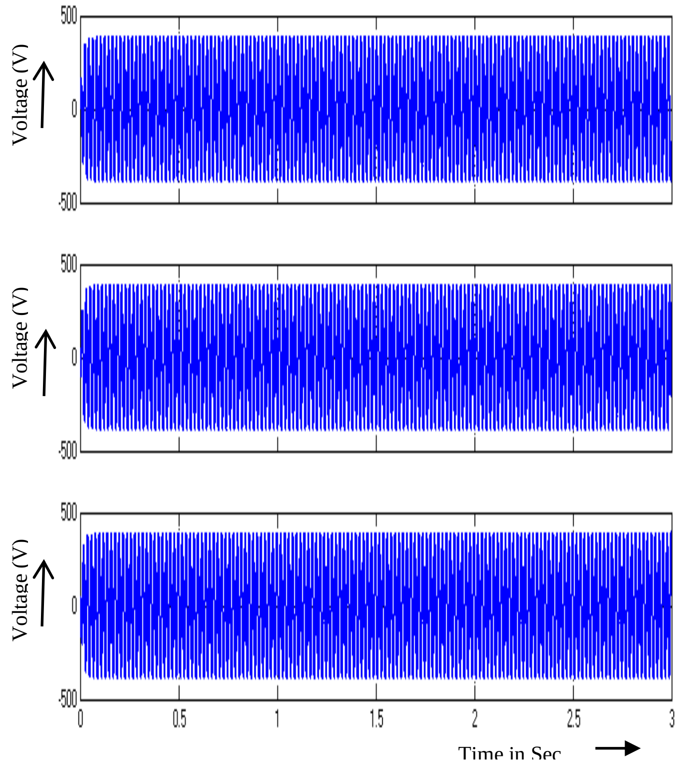

Fig.30 Representation of Output voltage

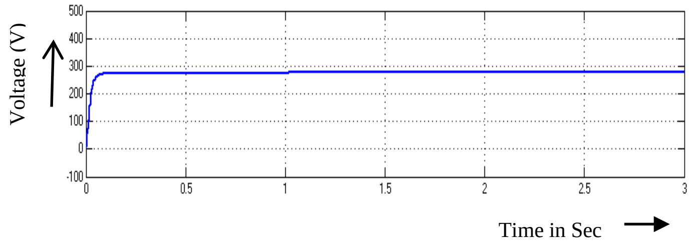

Fig.31 Representation of RMS output voltage

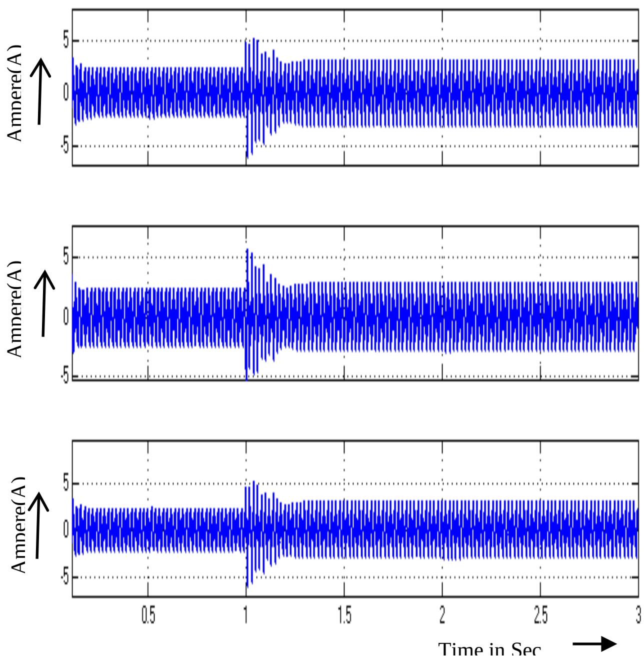

Fig.32 Representation of Output current

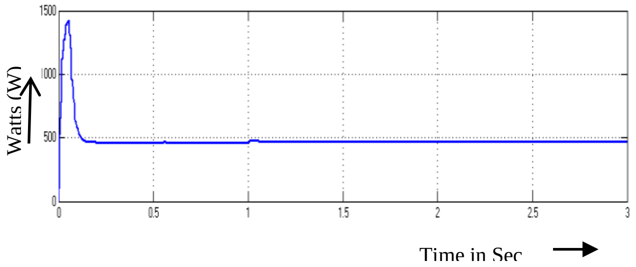

Fig.33 Representation of Output power

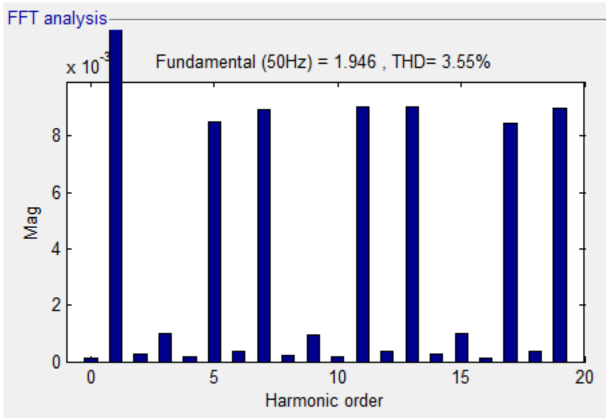

Fig.34 Representation of THD

Table I provides the summary of performances with PI, PR, FOPID & FL controlled SAF. It tends to be seen that the reaction is faster with Fuzzy logic controller.THD is found to be minimum with FL controller. Therefore FLC based active filter is better response than other controllers.

Table. I Summary of performances with PI, PR, FOPID &FL controlled SAF systems

Controller	T_r	T_s	T_p	e_{ss}	THD
PI	1.2	2.2	1.4	2.2	6.09%
PR	1.13	1.4	1.3	1.8	4.96%
FOPID	1.1	1.3	1.2	1.4	4.66%
FUZZY	0.9	1.1	0.8	0.9	3.55%

V. CONCLUSION

Three phase open loop and closed loop SAF system with PI, PR, FOPID and FLC are simulated & outcomes are presented. By giving source disturbance time domain parameters are measured under open loop and closed loop SAF with different controllers. The settling time is as low as 1.1 sec with FLC and steady state error is reduced to 0.9 V using FLC. The THD in FL controlled system is 3.55%.The response of Fuzzy- logic - controlled TPSAF is faster than other controlled SAF.

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The current - work deals with the TPSAF investigation. In Multi-Bus-System (MBS), the dynamic performance can be improved using different - controllers to be tried in future.

APPENDIX

Table. II Simulation Parameters

S.no	Parameters	Values
1	Voltage	280V and 35V
2	Line Impedance	10Ω and 10mH
3	Load Impedance	200Ω and 50mH
4	LC filter	0.1H,250 µF
5	Frequency	50 Hz

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