ENHANCEMENT OF POWER QUALITY BY UNIFIED POWER QUALITY CONDITIONER WITH FUZZY-PI CONTROLLERS

Anil Bharati[1], S.K Srivastava[2]

[1] Student of M.tech, [2] Associate Professor, Department of Electrical Engineering, M.M.M Engineering College Gorakhpur(U.P) 273010, India, ***aanilbharti@gmail.com*** *,**sudhirksri05@gmail.com***

Abstract

The nonlinear characteristics of power electronic devices give rise to two important limitations; they generate harmonics and draw lagging current from the utility. The UPQC mitigates harmonics and provides reactive power to the power systems network so as to improve the power factor close to unity. The UPQC is a combination of shunt active and series active power filters connected through a dc bus. The aim of this paper is to make comparative performance analysis and develop control strategies of UPQC based on fuzzy-PI controller.

Keywords: - *UPQC, POWER QUALITY.*

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I. INTRODUCTION

The UPQC is the most versatile and complex of the FACTS devices, combining the features of the STATCOM and the SSSC.

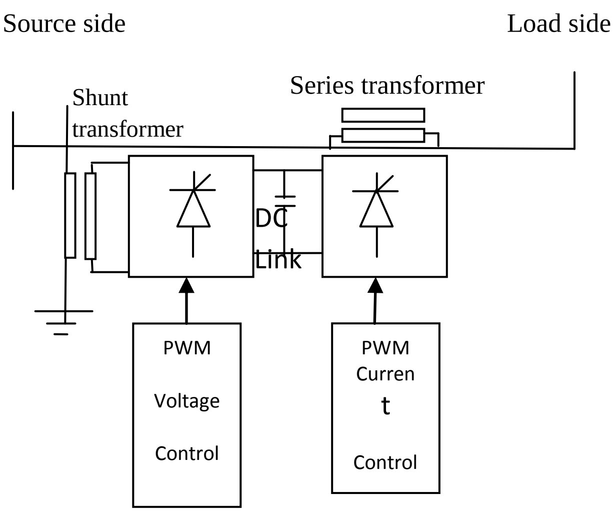

Fig1.Basic line diagram of UPQC

The UPQC can provide simultaneous control of all basic power system parameters, transmission voltage harmonic compensation, impedance and phase angle.

2. MATLAB BASED SIMULINK MODEL OF UPQC

The three-phase system shown in Fig. 2 is considered for verifying the performance of UPQC .Three-phase source feeding this system at one end.

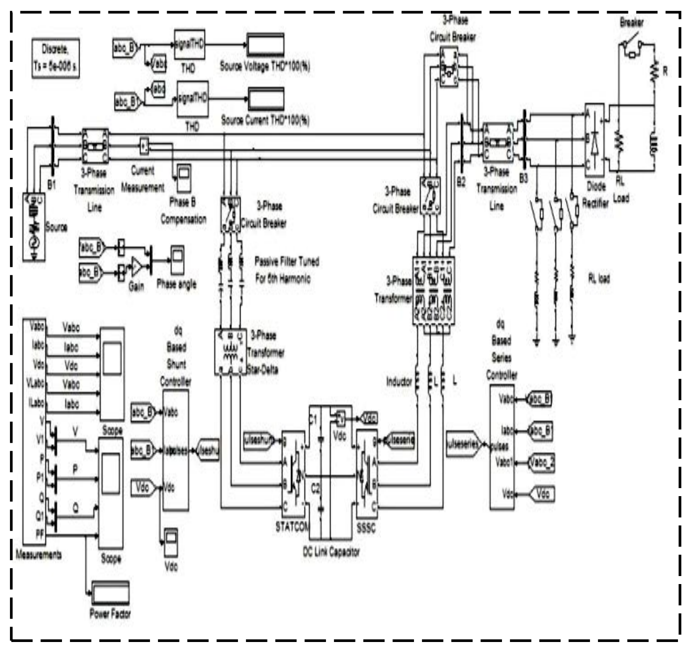

Fig2. Simulink Block model of UPQC

For the best performance, UPQC is placed at the midpoint of the system as shown in Fig. 2 UPQC is placed between two sections B1and B2 of the transmission line

3. PERFORMANCE OF UPQC WITH PI CONTROLLER

When PI based controller is used, the dc link voltage is sensed at regular intervals and is compared with a reference value. The error signal thus derived is processed in a PI controller. A limit is put on the output of the controller to ensure that the shunt active power filter supplies active power of the load through the series active power filter

The STATCOM model in UPQC is connected in shunt with transmission line using step down transformer. The voltage can be regulated to improve the voltage stability of the power system. Thus the main function of the STATCOM is to regulate key bus voltage magnitude by dynamically absorbing or generating power to the ac transmission line.

The SSSC which is connected by series transformer with transmission line generates three-phase voltage of controllable magnitude and phase angle. This voltage injection in series with the transmission line is almost in quadrature with the line current and hence emulates an equivalent inductive or capacitive reactance in series with the transmission line. A small part of this injected voltage is in phase with the transmission line current supplying the required losses in the Inverter Bridge and transformer.

Simulation Results of UPQC Using PI Controller:-An ideal three-phase sinusoidal supply voltage of 11kV, 50Hz is applied to the non-linear load (diode rectifier feeding an RL load) injecting current harmonics into the system. Fig. 3.(a) shows supply current in three phase before compensation from 0s to 0.1s, and after compensation from 0.1s to 0.4s. Shunt inverter is able to reduce the harmonics from entering into the system.

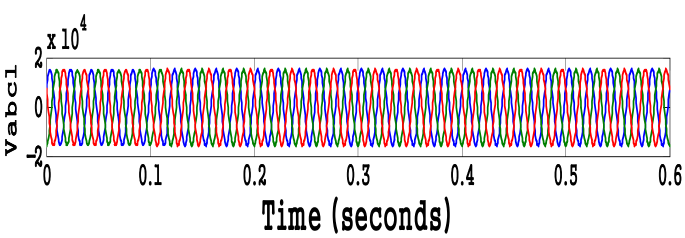

Fig 3(a) source voltage

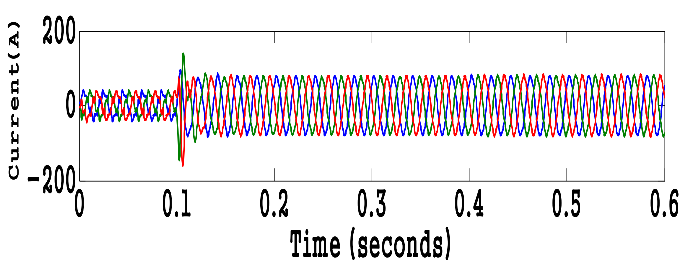

Fig 3(b) Source current

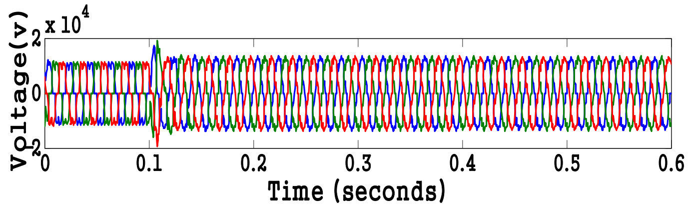

Fig 3(c) load voltage

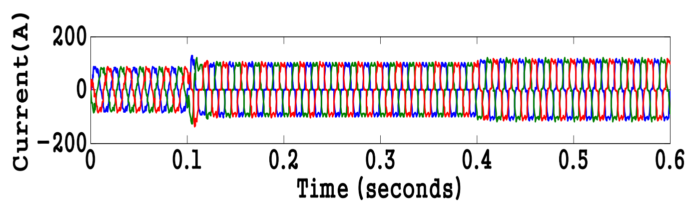

Fig 3(d) load current

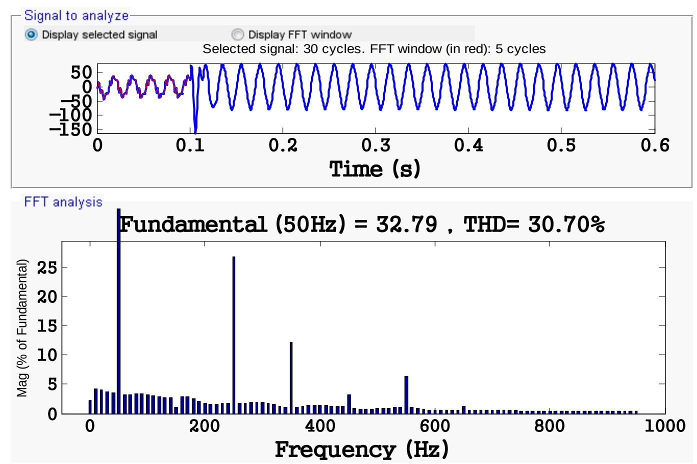

Fig 4(a) Distorted source current THD=30.7%

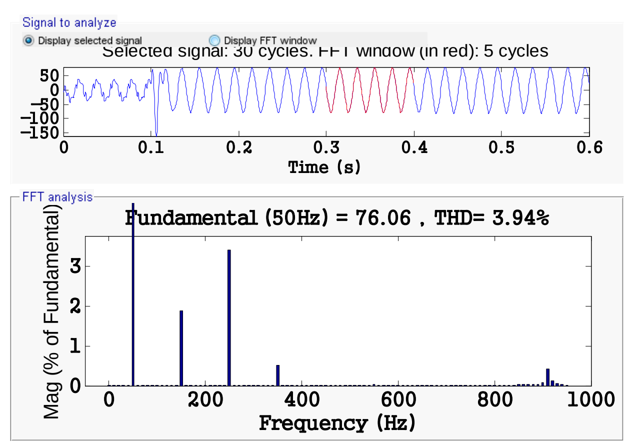

Fig 4(b) Compensated source current THD=3.94%

The Total Harmonic Distortion (THD), which was 30.70% Fig.4 (a) before compensation was effectively reduced to 3.94 % Fig. 4(b) after compensation using PI controller.

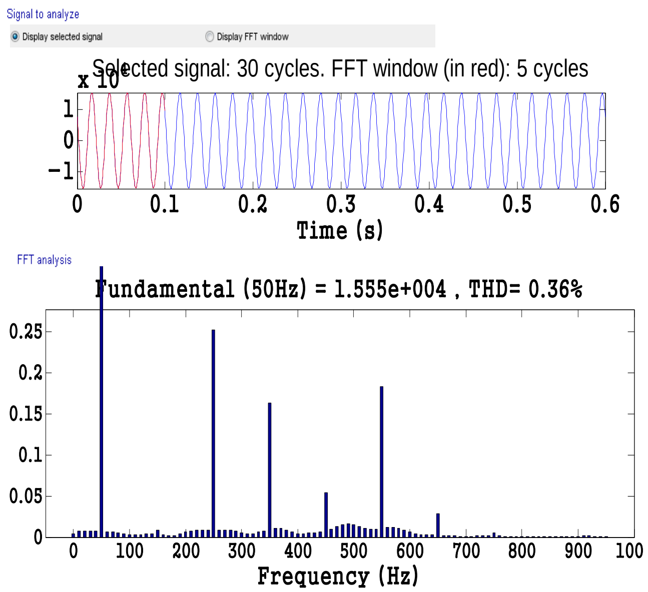

Fig4(c) Distorted Source voltage THD=0.36%

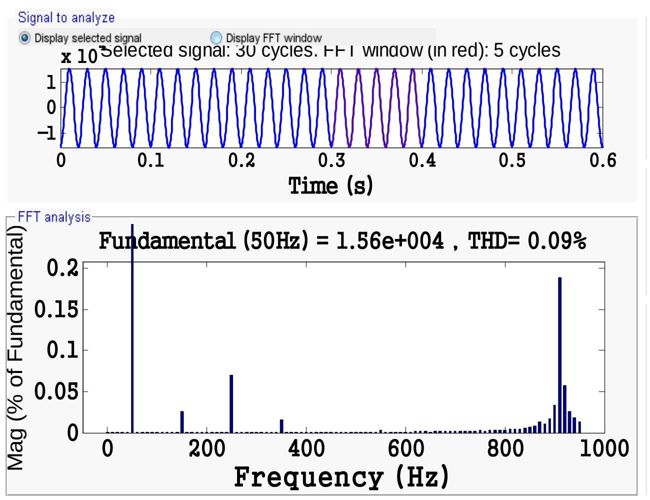

Fig4(d) compensated Source voltage THD=.09%

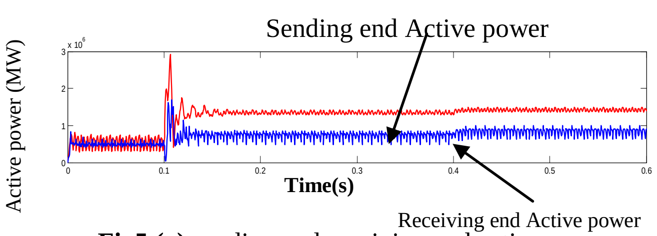

Fig5 (a) sending and receiving end active power

Reactive power (VA)

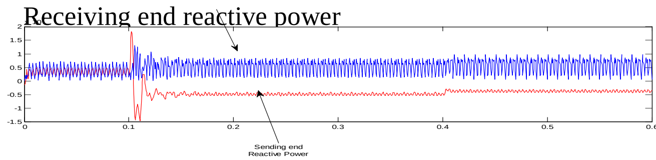

Fig5 (b) Receiving and sending end reactive power

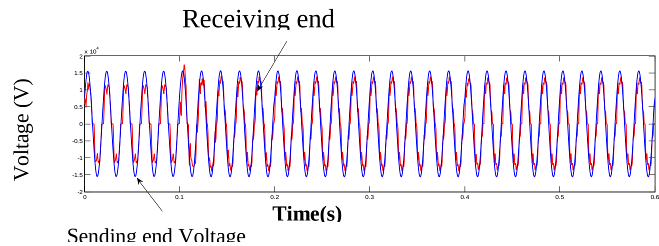

Fig5(c) Sending and receiving end

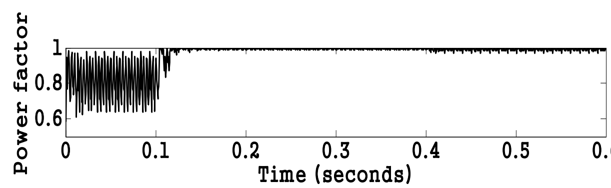

Fig 5(d) Power factor

4. PERFORMANCE OF UPQC WITH FUZZY LOGIC CONTROLLER

In fuzzy logic, the linguistic variables are expressed by fuzzy sets defined on their respective universes. Error (input) can be selected as current, voltage or impedance, according to selected control type. The output of the fuzzy logic controller is the angle signal and the pulse generator provides firing pulses to thyristors. The fuzzy control is basically a nonlinear and adaptive in nature, giving the robust performance in the cases where in the effects of parameter variation of controller is present.

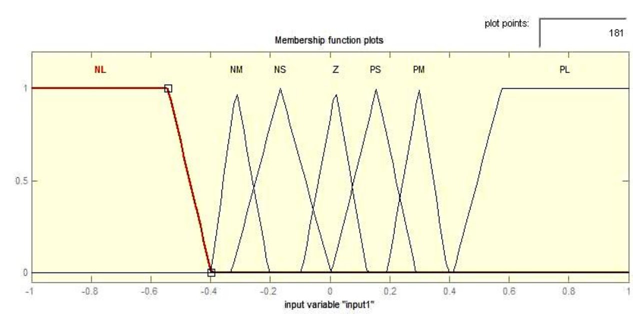

Fig 6(a) input 1

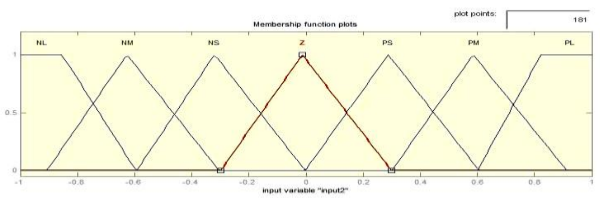

Fig 6(b) input 2

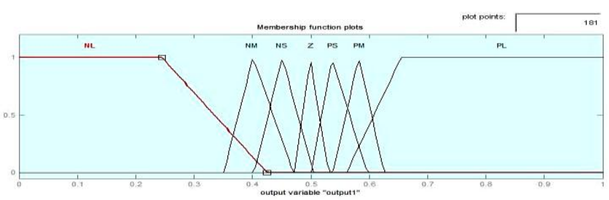

Fig6(c) output

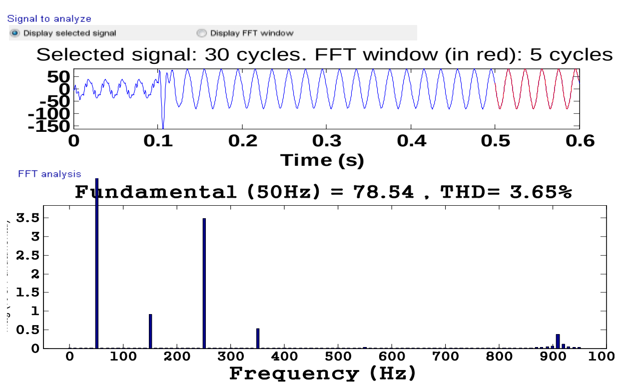

Fig.7 (a) compensated source current THD using Fuzzy logic controller = 3.62%

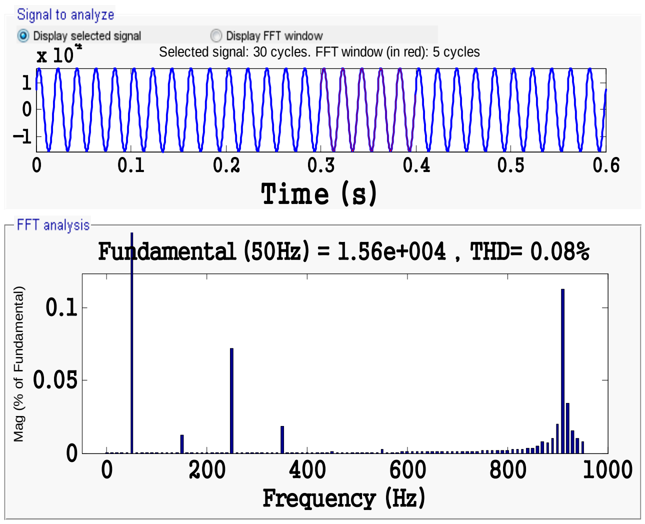

Fig7 (b) source voltage THD using Fuzzy logic controller =.08%

CONCLUSIONS

The Results obtained from the simulation shows better performance of UPQC when fuzzy logic controller used then that of 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.

Table 1.1 shows simulated performance parameters of PI controller and fuzzy logic controller.

S.no	Factor	PI Cont Roller	Fuzzy Cont Roller
1	Source current THD	3.94%	3.52%
2	Dynamic response	Slow (0.20s)	Fast (0.10s)
4	Capacitor charging	Slower	Faster
5	Capacitor voltage balance under unbalanced load condition	Less stable	More stable
6	Source current THD with switching RL load	3.65%	3.59%

1. Source current THD:-

As shown in table, before compensation when UPQC not connected, source current THD is 30.70%, due to non linear RL load. The dominant harmonic is 5th harmonic and its magnitude is 29.5% of fundamental component. There is passive filter LC connected on shunt side which is tuned to 5th harmonic. Source current THD after compensation when UPQC connected at 0.1s and PI controller used, source current THD is reduced to 3.94% and the magnitude of the 5th harmonic also reduces to 3.81% of fundamental component. But when PI controller replaced by the fuzzy logic controller, source current THD reduces to 3.52%. And the magnitude of the 5th harmonic also reduces to 3.76% of fundamental component. So in the 1st, 3rd factor of Table 4.1, fuzzy controller proves to be more a advantageous.

2. Dynamic response

This parameter is the measurement of how quickly controllers respond to the situation, in table 4.1 dynamic response shows the time taken by the controller to reduce THD from 30.70% to 3.94%. as shown, time taken by PI controller is 0.20s and time taken by the fuzzy controller is 0.15s. Hence it is proved that dynamic response of th PI controller is faster than the fuzzy logic controller.

3. DC capacitor voltage regulation

The dc link voltage that feeds both the shunt and series inverters. The capacitor is effectively charged to the reference voltage, vdc drawing the charging current from the supply. Once it is charged to required value, it is held constant using PI and fuzzy controller. There is no drop in the capacitor voltage. Fig. 2.20 shows the dc link voltage which reflects more the disturbance in the supply voltage because use of PI controller. But when fuzzy controller replaced, as shown in Fig. 3.6c, it shows less fluctuation and hence smoother exchange of real power between STATCOM and SSSC.

It is clearly evident from the Table 1.1 that in terms of source current THD, Dynamic response, capacitor charging, Capacitor voltage balance under unbalance load condition, Source current THD with switching RL load, fuzzy logic control having an edge over PI controller.

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