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POWER QUALITY IMPROVEMENT BY HARMONIC REDUCTION USING FUZZY LOGIC BASED SHUNT ACTIVE POWER FILTER

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Abstract: *Power quality is the major issue in an inter connected power system. This paper proposes fuzzy logic controller based shunt active power filter for improving the power quality. The proposed Fuzzy logic controller is three input and single output controller. The effectiveness of the proposed controller is compared with conventional PI controller. Matlab/Simulink has been used for the purpose.*

Keywords: *Shunt Active power filter (SAPF), Proportional Integral controller (PI Controller), Fuzzy logic controller (FLC).*

I.INTRODUCTION

Harmonics are usually defined as periodic steady state distortions or deterioration of original voltage and/or current waveforms in power systems where frequency of harmonic wave is an integral multiple of fundamental frequency. Major sources of voltage and current harmonic generation in power system are controlling action of power electronic devices such as chopper, inverter etc. cause imbalance in power system leading to harmonic generation. Non-linear load such as UPS, SMPS, battery charger. Power electronic converter such as high-voltage direct-current power converters, traction and power converters, wind and solar-powered dc/ac converters etc. [1-2] cause harmonic generation owing to their energy conversion and controlling action. Heating material in ac/dc converters acts as a nonlinear load whose controlling action produces harmonics [3-5] due to inherent property of high reactive power requirement.

Harmonics may cause interference and disturbance in power systems network. Some of the major problems include: Harmonic currents present in the power system causes heating of equipment, such as transformers and generators and give huge copper loss. In generators owing to multiple zero crossings of distorted current waveform causes voltage instability and voltage fluctuation. Since frequency of harmonic current is different from that of fundamental may cause improper breaker and switch operation which is undesirable.

Harmonic elimination techniques are used to improve the power system performance with some Objectives. To improve the system power factor and to compensate the reactive power. To maintain a particular THD limit in current harmonic distribution[6-8].

Hence various devices and equipment serves the purpose of harmonic elimination from power system. Some of widely used equipment are[9-10]:

Line reactors (Inductive reactor), Isolation transformers (provide isolation of high power circuit from low power circuit), K-Factor or harmonic mitigating transformers Phase shifting transformer Harmonic filters. But mostly current harmonic filters are used to reduce current harmonics in power system. There are generally two types of harmonic filters are present: i) passive filter and ii) active filters.

Active power filters are very popular because of the following reasons:

1. Widely compensated the THD in source current waveform.
2. Only a single filter can be able to eliminate all the unwanted harmonics.
3. Resonance condition is absent which increase the stability of power system.
4. Filter characteristics changes with load variation due to dynamic response of the filter.

This paper proposes Fuzzy logic based Shunt Active Power filter for improving the power quality by reducing the harmonics in the source current.

II.MODELING OF PV CELL

Solar cell arrays contain solar cells in series and parallel connection. A typical model of solar cell is described as Fig. 1.

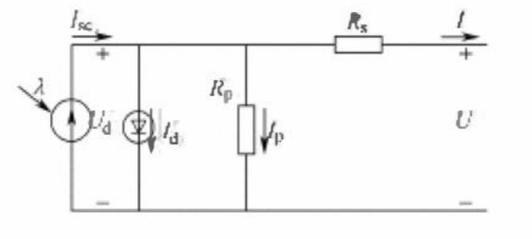

Fig.1. Typical model of Solar cell

The model contains a sola-based curent source, a diode, parallel resistance Rp ad series resistace Rs. Otput of curent source Ise keeps direct proportion to the light inen- sity A. Voltage and curent of diode Ud ad 1d obeys the normal PN diode characteristic curve[5]. Rs is a equivalent value of body resistace and suface resistace of solar cell, in addition to electrode conductor resistace ad metal elec- trode resistance. Rp is a equivalent value of leaking resistance of PN-junction caused by pollution on the cell surface and defect of semiconductor. Outut characteristics of a single sola cell can be described i (l) below.

$$I = I_{sc} - I_0\left[\exp\left(\frac{q(U+IR_s)}{AkT}\right)-1\right]-\frac{U+IR_s}{R_p} \qquad (1)$$

where A is the diode idealistic factor; k is Boltzmann constant, k=1.38xlO-23 J/K; T is Kelvin temperature; and q is an electric charge, q= 1.6x10-19 C; 10 is the reverse saturation current of the diode. 1scr is te photo production short-circuit current uder the standard test conditions (il-lumination intensity lkWlm2 and the ambient temperatue298K).Kl is variation factor of photo production short-circuit current to temperature, K1=O.0017.

III. FUZZY LOGIC CONTROLLER

In this work fuzzy logic controller is designed with three inputs for reducing the harmonics and proper load sharing.

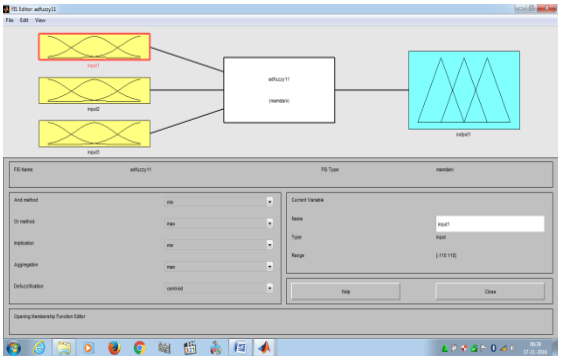

Fig.2 Structure of Proposed Fuzzy Controller.

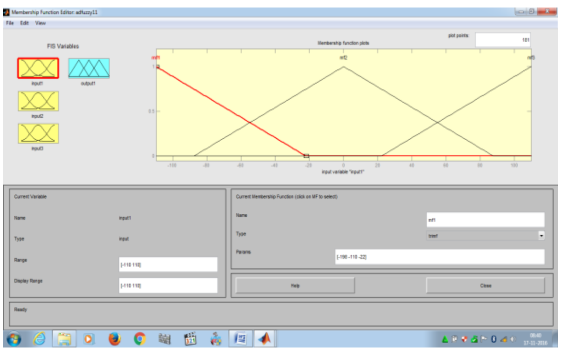

Fig.3 Input1 membership functions of Proposed Fuzzy Controller.

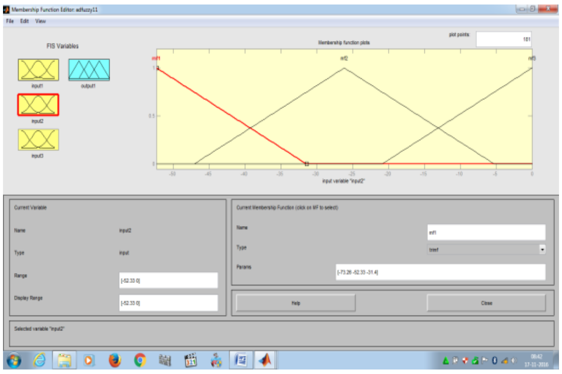

Fig.4 Input2 membership functions of Proposed Fuzzy Controller.

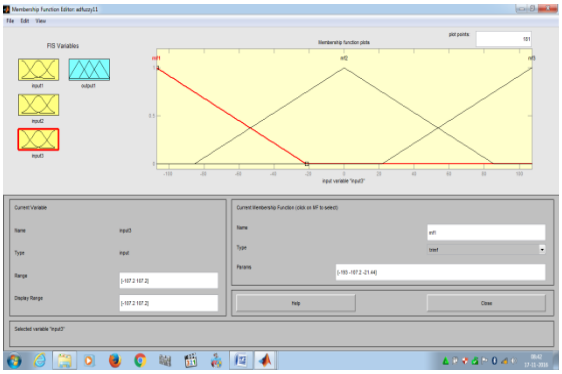

Fig.5 Input3 membership functions of Proposed Fuzzy Controller.

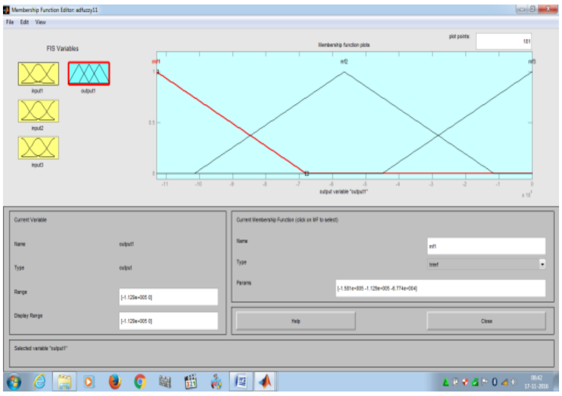

Fig.6 Output membership functions of Proposed Fuzzy Controller.

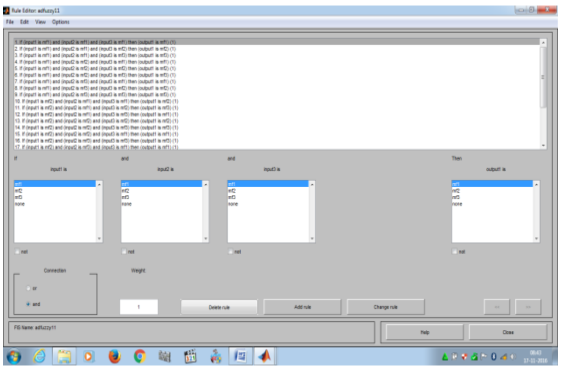

Fig.7 Rules of Proposed Fuzzy Controller.

IV. TEST SYSTEM & RESULTS

The proposed controller is compared with a PI controller with test system consists of Grid, Active power filter with PV Cell as DG and non-linear load.

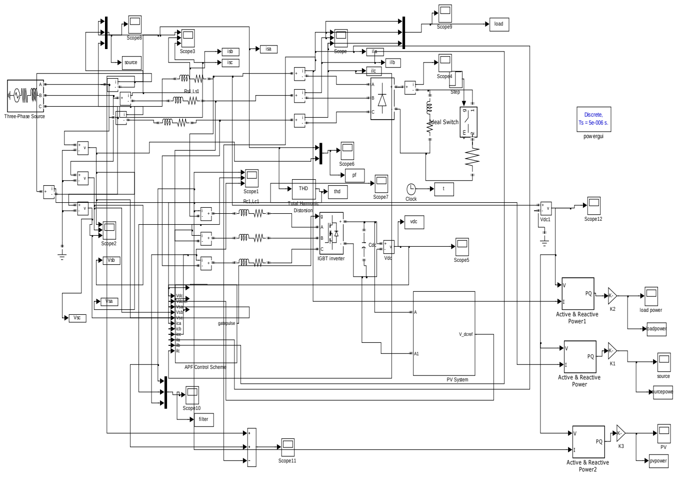

Fig.8 Simulation diagram.

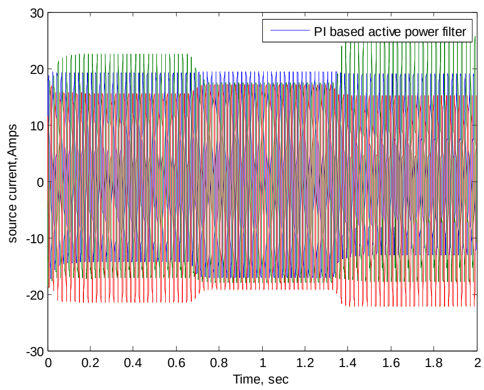

Fig.9a

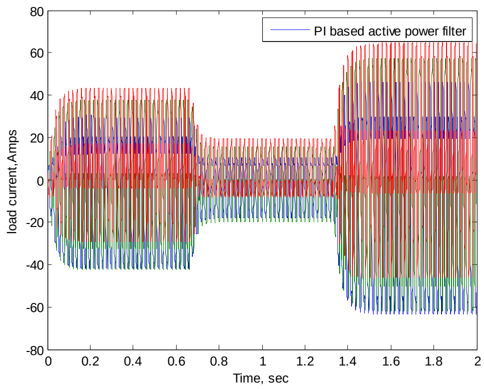

Fig.9b

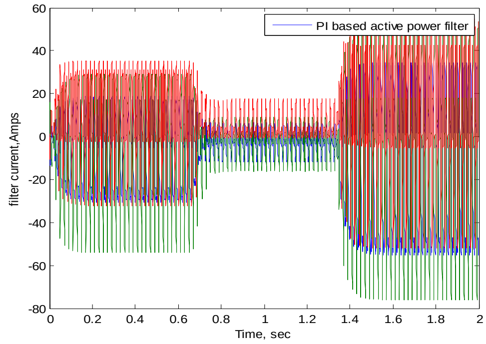

Fig.9c

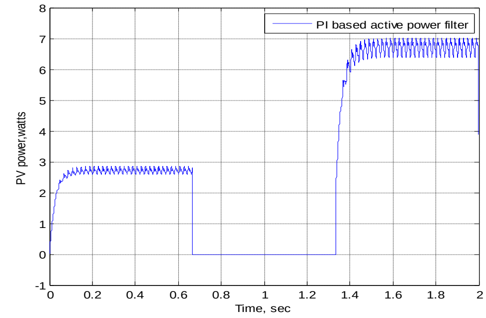

Fig.9d

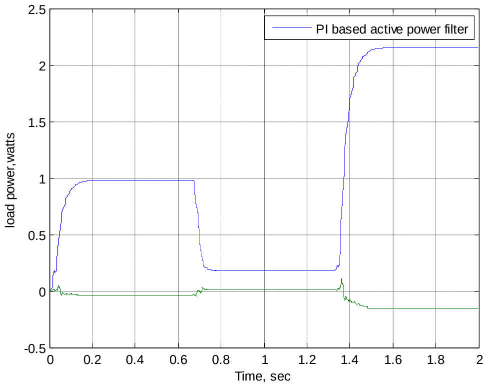

Fig.9e

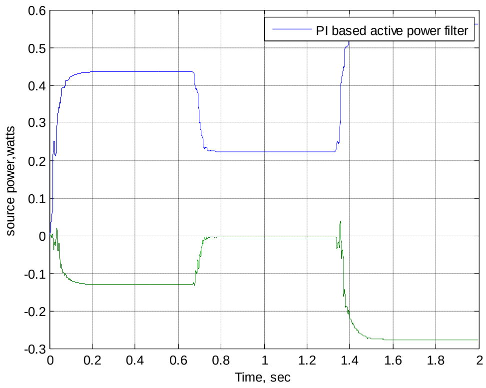

Fig.9f

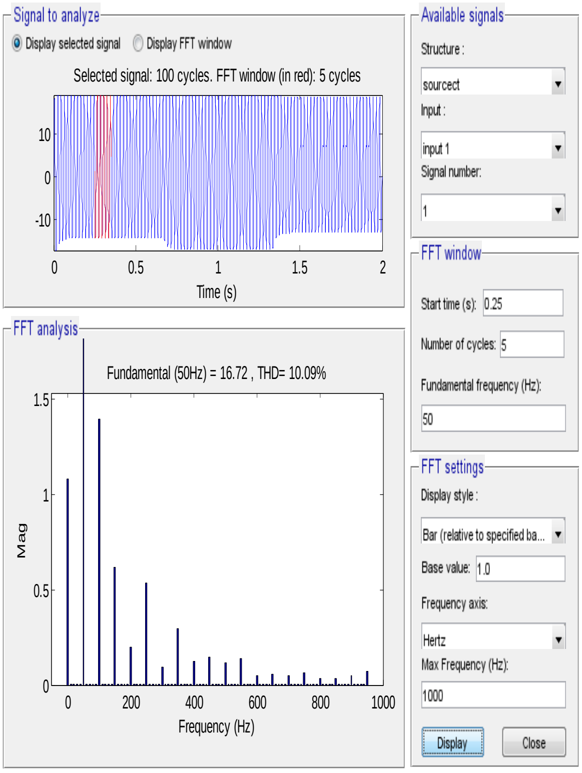

Fig.9g

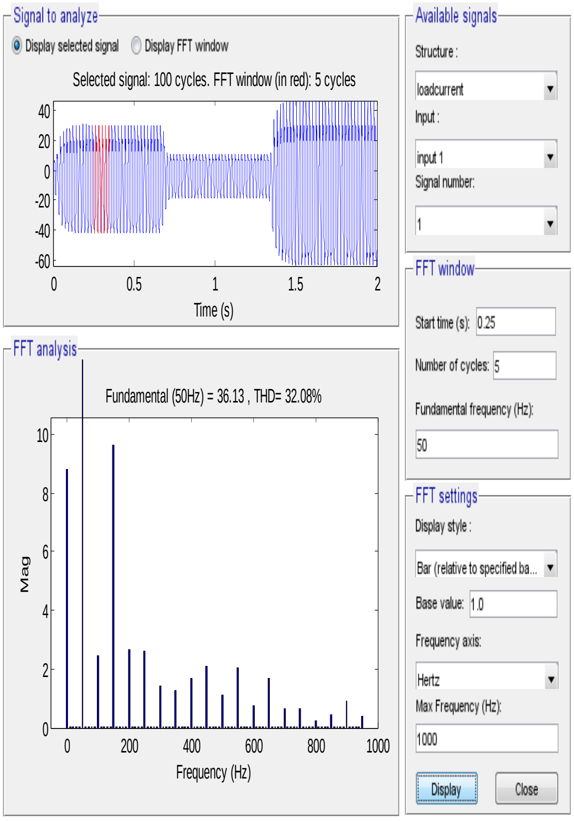

Fig.9h

Figure.9 indicates the variation of source, load and PV system currents and power and also THD of source current with conventional PI controller.

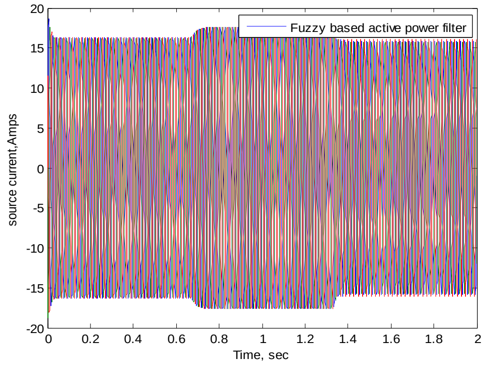

Fig.10a

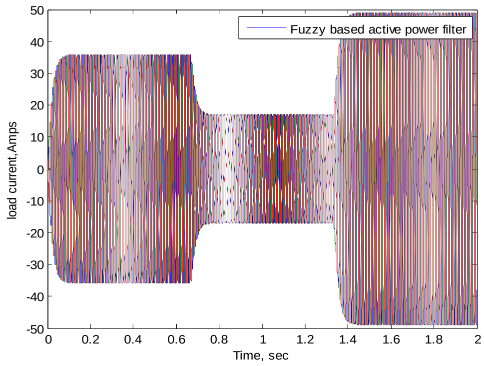

Fig.10b

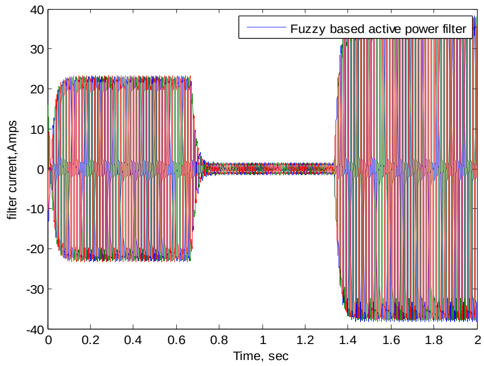

Fig.10c

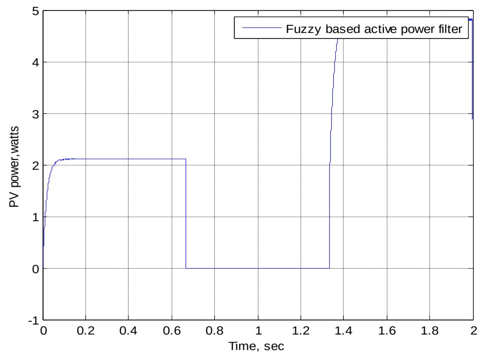

Fig.10d

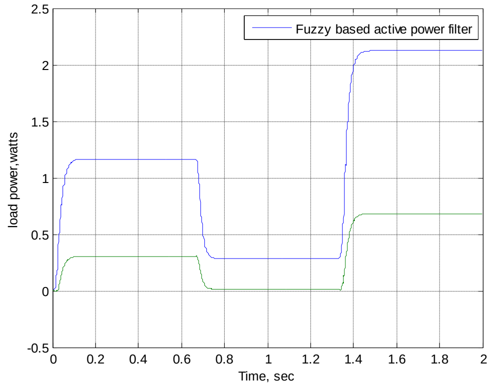

Fig.10e

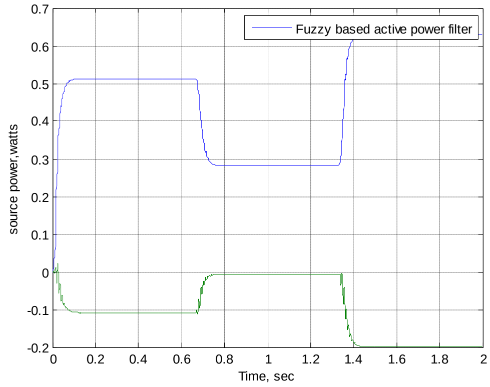

Fig.10f

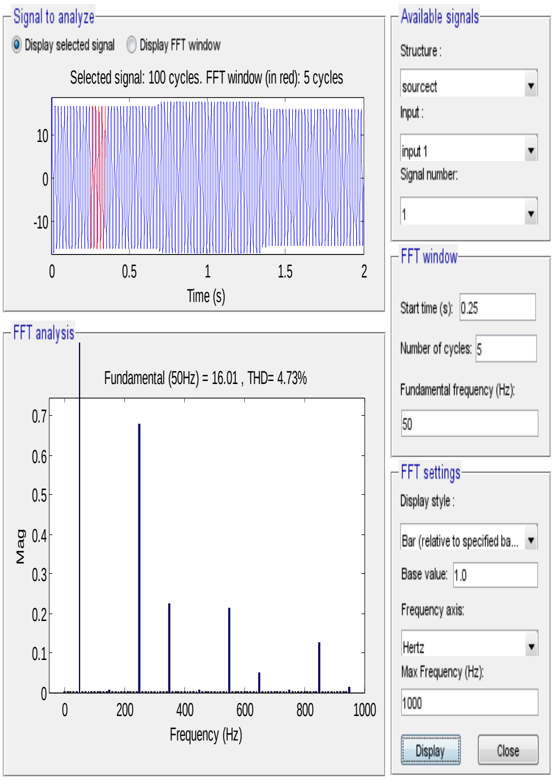

Fig.10g

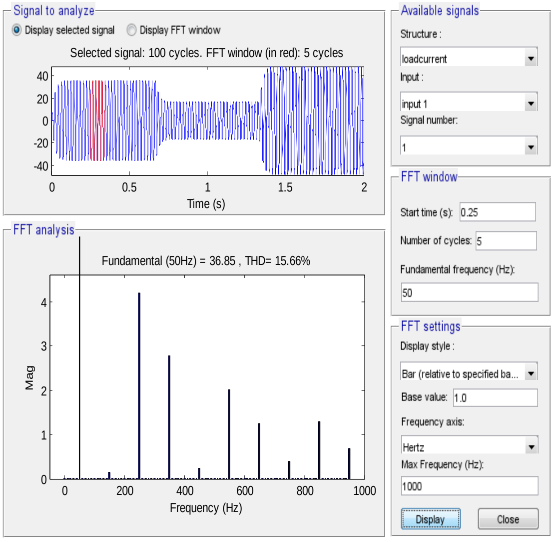

Fig.10h

Figure.10 indicates the variation of source, load and PV system currents and power and also THD of source current with proposed Fuzzy logic controller.

VI. CONCLUSION

The proposed fuzzy logic controller reduces the THD effectively than PI controller. Proposed controller eliminates the presence of LPF filter, therefore number of controlling components are reduced so this controller is a cost effective one.

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