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IMPROVED POWER QUALITY USING ACTIVE FILTER CONTROLLED BY PI AND FUZZY CONTROLLER

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ABSTRACT

Due to using non linear loads, the quality of supply power is affected ,that leads a number of issues like harmonics, voltage sag, voltage swell, light flicker, voltage imbalance , poor power factor, low efficiency of system,. Malfunctioning in system protection, in accuracy in power flow metering, overheating equipment and also disturb other consumers, interference in nearby communication network. These issues affect the performance and the lifetime of the utilities. In order to overcome issues arises due to nonlinear loads power filters were developed. This work proposed an active filter which is controlled by PI controller and fuzzy logic controller to reduce the total harmonic distortion (THD). Here we compared the results without controller, with PI controller and fuzzy logic controller.

***Keywords**: Active power filter, Fuzzy logic controller, Harmonic reduction, PI controller, Simulation and THD.*

I. INTRODUCTION

In recent years, the increasing use of power electronics in the commercial and industry processes results in harmonics injection and lower power factor to the electric power system [16]. Conventionally, in order to overcome these problems, passive R-L-C filters have been used. The use of this kind of filters has several disadvantages. Recently, due to the evolution in modern power electronics, new device called “shunt active power filter (SAPF)” was investigated and recognized as a viable alternative to the passive filters. The principle operation of the SAPF is the generation of the appropriate current harmonics required by the non-linear load. In fact active filters do not present all the typical drawbacks of passive systems such as the detuning of single tuned filters due to changes of system operative conditions and surrounding environment or the generation of resonance at particular frequencies, between the network and filter reactance, that amplifies unwanted harmonics.

Active power filters are more and more capturing the interest of researchers and industries owing to the decreasing quality of power supplied by the electrical distribution companies and the difficulties in fulfilling the constraints imposed by national and international standards only by using traditional compensating strategies. The use of active systems for compensating harmonic distortion and reactive power in the supply electrical networks, both at user level or at a higher voltage level, is now more often preferred to the classical passive compensating methods.

In a modern electrical distribution system, there has been a sudden increase of nonlinear loads, such as power supplies, rectifier equipment, domestic appliances, adjustable speed drives (ASD), etc. As the number of these loads increased, harmonics currents generated by these loads may become very significant. These harmonics can lead to a variety of different power system problems including the distorted voltage waveforms, equipment overheating, malfunction in system protection, excessive neutral currents, light flicker, inaccurate power flow metering, etc.

To reduce harmonic distortion and power factor improvement, capacitors are employed as passive filters. But they have the drawback of bulky size, component aging, resonance and fixed compensation performance. These provide either over- or under-compensation of harmonics, whenever a load change occurs [4]. In order to overcome these problems, active power filters (APFs) have been developed. The voltage-source-inverter (VSI)-based shunt active power filter has been used in recent years and recognized as a viable solution [5].

Active filters, besides, permit the control and the compensation of distorted line currents adapting themselves to the load changes and to changing in working frequency. The most effective and the most diffuse structure in active filtering systems is certainly the shunt one composed by an inverter fed by a capacitor and a passive filter used to inject the compensating currents in the grid (Fig. 1). In order to overcome these problems, active power filters (APFs) have been developed. The voltage-source-inverter (VSI)-based shunt active power filter has been used in recent years and recognized as a viable solution [5]. The control scheme, in which the required compensating currents are determined by sensing line currents only, is given in [6]-[7], which is simple and easy to implement. The scheme uses a conventional proportional plus integral (PI) controller for the generation of a reference current template.

II. ABOUT THE POWER FILTERS

When linear loads are connected to the supply the waveforms are linear. Whereas non linear loads are connected harmonic appears on electric voltage or current. The harmonics are integer multiples of system frequency. This leads to various power quality problems like heating of the devices, mis–triggering of the drives, pulsating output in the motors, etc., a harmonic filter are used to eliminate the harmonics. There are three basic types of harmonics filters given below.

2.1 PASSIVE POWER FILTER (PPF)

It is a type of filter, which consists of only passive components. It consists of linear elements like resistors, capacitors and inductors. They are also called as LC filters, which produce series resonance or parallel resonance that forms a major drawback of this type of filter. Another drawback of PPF is the cost which increases as the voltage rating of the inductor and capacitor increases.

2.2 ACTIVE POWER FILTER (APF)

APF is a type of filter that uses either current or voltage source as its major component. They compensate voltage or current harmonics by injecting the negative of the harmonic signal measured injected signals fed are of same magnitude but in phase opposition with the measured harmonic signals. It is controlled to draw/supply

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a compensated current from/to the utility, such that it eliminates reactive and harmonic currents of the non-linear load. Thus, the resulting total current drawn from the ac mains is sinusoidal. Ideally, the APF needs to generate just enough reactive and harmonic current to compensate the non-linear loads in the line [12].

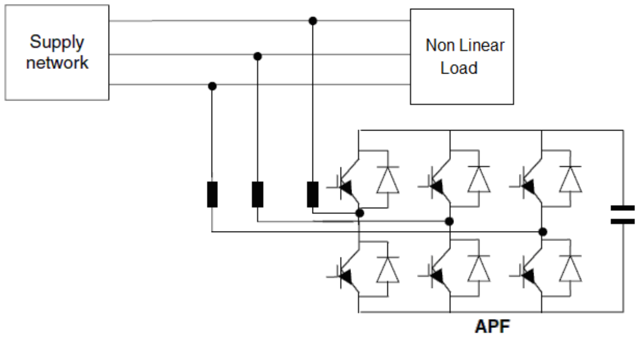


Fig. 1: Active power filter connected with transmission line

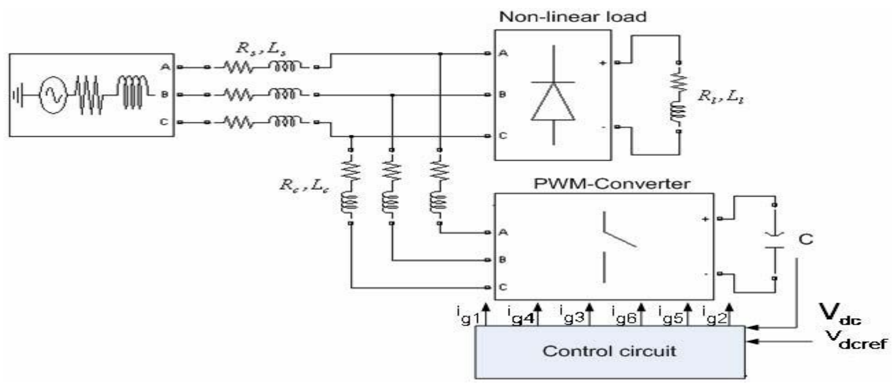
III. ACTIVE FILTER CONTROL SCHEME

APF is a type of filter that uses either current or voltage source as its major component. They compensate voltage or current harmonics by injecting the negative of the harmonic signal measured injected signals fed are of same magnitude but in phase opposition with the measured harmonic signals. Of these two voltage source based APF is more advantages.

IV. PI CONTROL SCHEME

Fig. 2 shows the active power filter compensation system with PI control scheme. In order to implement the control algorithm of a shunt active power filter, the DC capacitor voltage (V_{dc}) is sensed and compared with the reference value (V_{dcref}). The Input of PI controller is the value of Error, $e = V_{dcref} - V_{dc}$, and its output, after a limit, is considered as the magnitude of peak reference current max I . The switching signal for the PWM converter are obtained from comparing the actual source currents (isa , isb ,isc) with the reference current templates (Isa Isb Isc) in a hysteresis current controller. The output pulses are applied to the switching devices of the PWM converter [14].

Since coefficients of PI controller, Kp and Ki , are fixed in this model, the performance of active power filter under random load variation conditions is not as well as ‘fixed load’ condition.



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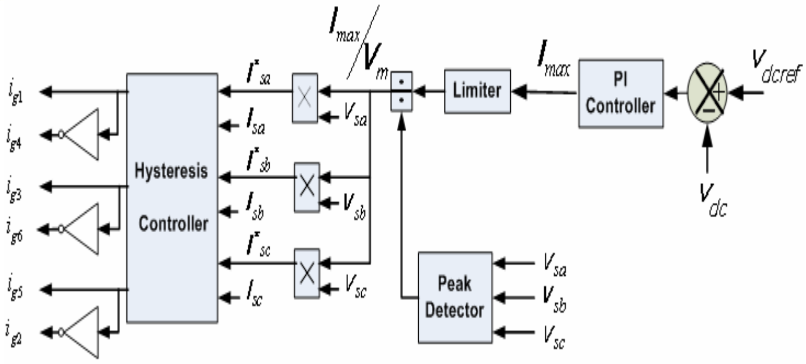

Fig. 2 (a) Active filter system (b) Active filter system using PI controller

V. SIMULINK MODEL OF ACTIVE POWER FILTER

Fig. 3 shows the block diagram of PI/Fuzzy controller used for the controlling of active power filter.

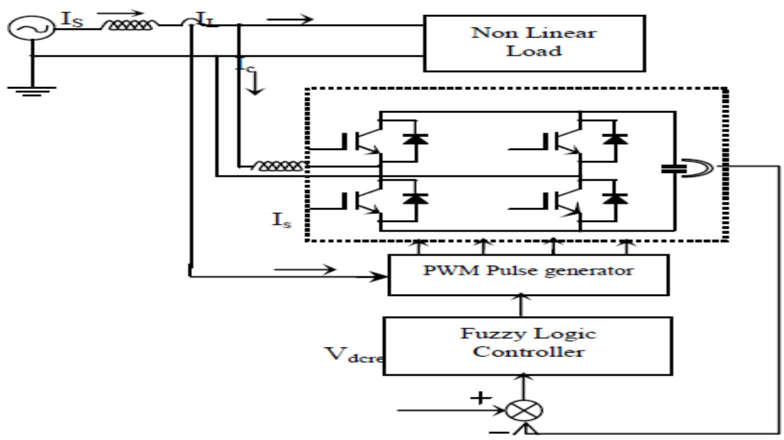

Fig. 3 Block Diagram of PI/Fuzzy controlled improved power quality converter

The simulation is done using MATLAB for the fuzzy logic controlled voltage source PWM rectifier. The complete rectifier system is composed of mainly (1) three phase source, (2) voltage source PWM rectifier, (3) fuzzy controller, and (4) hysteresis controller.

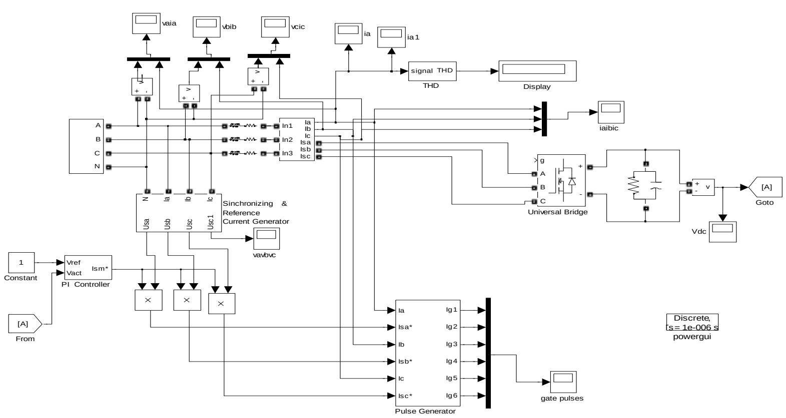

Fig. 4. Simulated power circuit without controller improved power quality converter

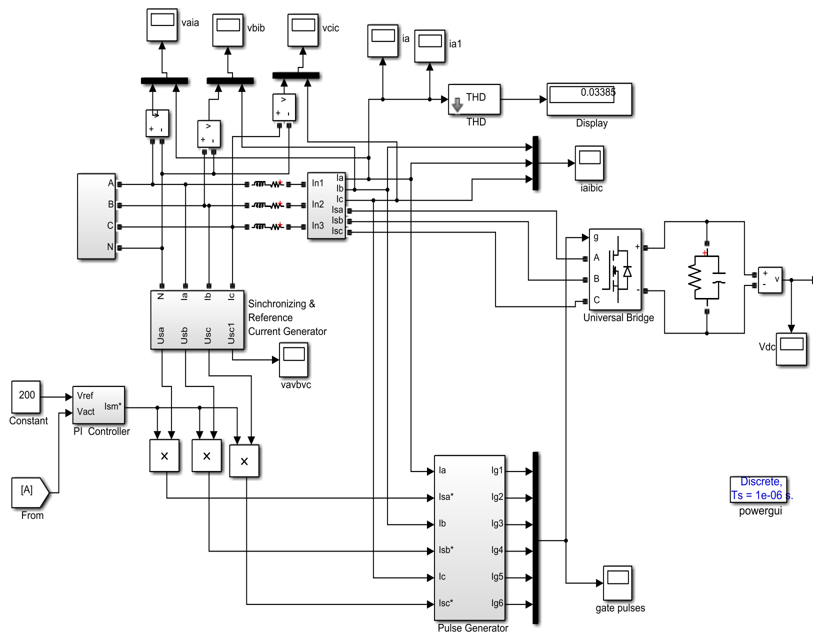

Fig. 5. Simulated power circuit with PI controller improved power quality converter

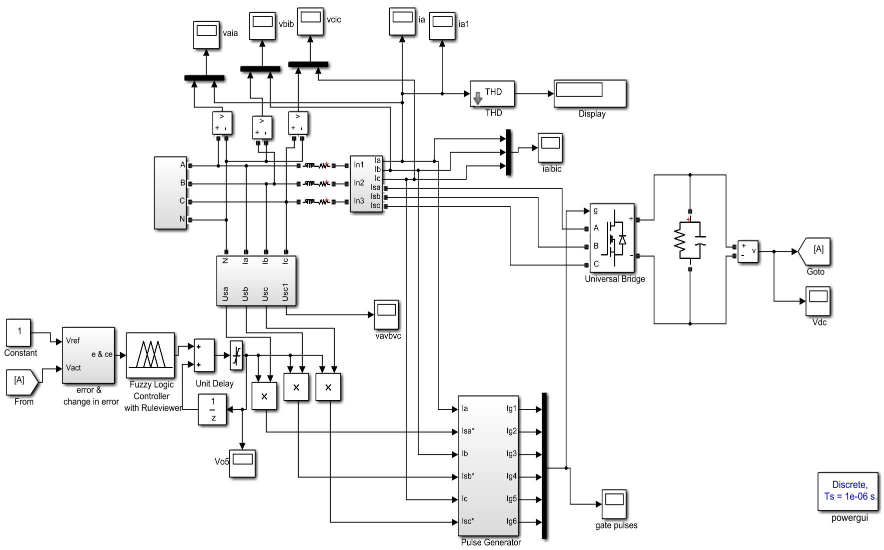

Fig. 6. Simulated power circuit with fuzzy controller improved power quality converter

VI. SIMULATION RESULTS

The current and voltage waveform of the conventional three phase rectifier without controller is shown in fig 6. The current waveform for one cycle and its harmonica spectrum is shown in fig 7. The current is non sinusoidal and total harmonica distortion (THD) is very high (88.84%). To make the current sinusoidal and THD within permissible limit current controller is used. On using PI controller current is sinusoidal and total harmonic distortion is low (3.39%) its harmonic spectrum is shown in fig8. For further harmonic reduction fuzzy

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controller is used that make very low (2.11%) total harmonic distortion, its harmonic spectrum is shown in fig 9.fig9.1 shows three phase current characteristics with fuzzy controller.

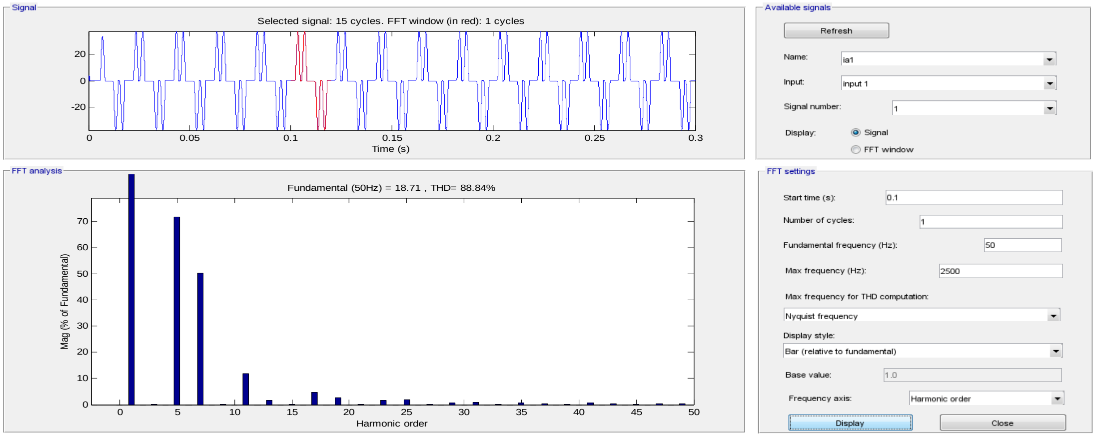

Fig. 7. Harmonics spectrum without controller

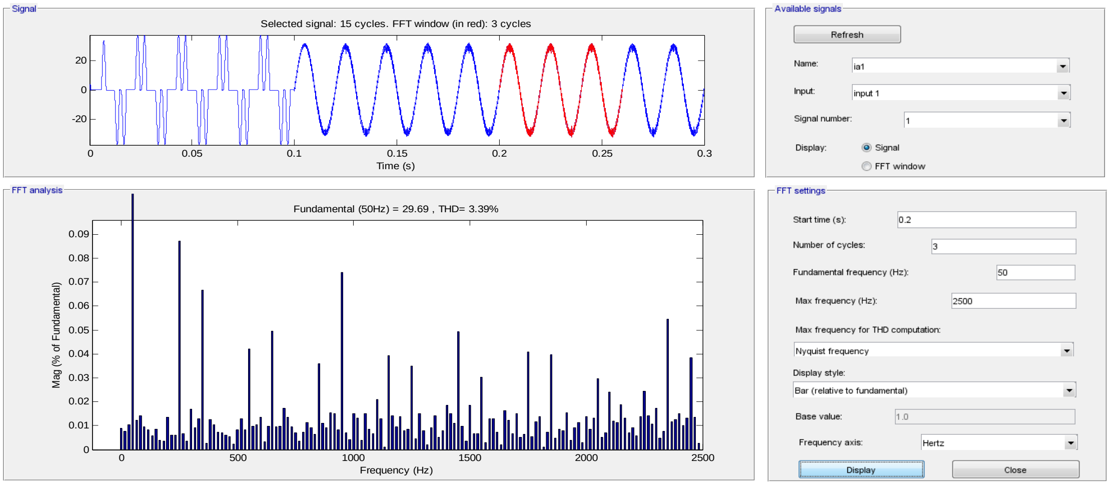

Fig.8. Harmonics spectrum with PI controller

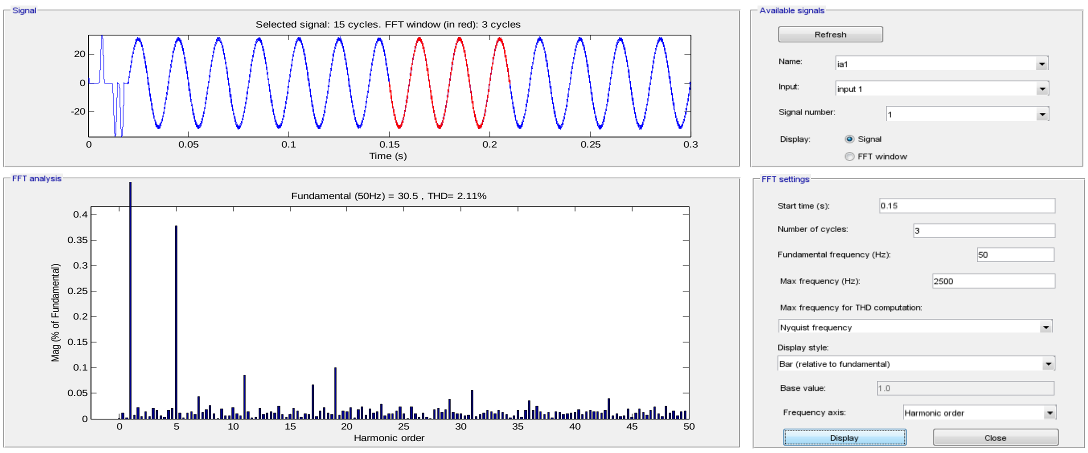

Fig.9. Harmonics spectrum with fuzzy controller

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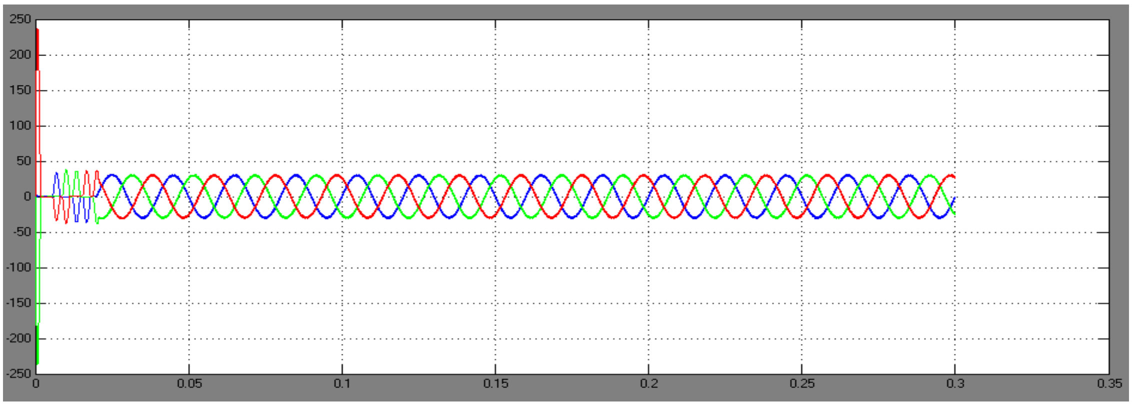

Fig.9.1 Three phase current characteristic with Fuzzy controller

Tabel: Total harmonic distortion comparison chart by various controllers

S.No.	Name of Controller	Obtained THD
1	Without any controller	88.84%
2	With PI controller	3.39%
3	With Fuzzy controller	2.11%

VI. CONCLUSION

Based on the simulation results, it can be concluded that, PI controlled PWM rectifier perform satisfactory with fuzzy controller for the compensation of line current. After compensation, line current become sinusoidal, balanced and in phase with respective source voltage and reduces the total harmonic distortion (THD) of source current from simulation result that the transient performance of the source current and DC side capacitor voltage is better for the PI controller and fuzzy controller in term of the setting time and % rise/fall in DC link voltage. Fuzzy controller is comparable with that PI controller.

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