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Fuzzy Controlled Based IPQC at Various Load Conditions for Improvement of Power Quality

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ABSTRACT: This paper presents a hybrid fuzzy logic controlled based improved power quality conditioner used to counterbalance for harmonic distortion in three-phase system. The IPQC employs a very simplest methodology for the calculation of the reference compensation current based on FFT Analysis. The presented improved power quality conditioner is able to operate in different load conditions (balanced, unbalanced, variable). passive type harmonic power filters, modern active type harmonic power filters have the favourable multiple functions: harmonic filtering, damping, reactive-power control for power factor correction and voltage regulation, load balancing, voltage-flicker reduction etc., Classical filters may not have adequate performance in fast varying conditions. The proposed methodology is extensively tested for wide range of different Loads with Improved dynamic behaviour of IPQC using hybrid fuzzy logic controller.

KEYWORDS: Active power filter, Hybrid fuzzy controller, IPQC (Improved Power Quality Conditioner), Power Quality Improvement.

I.INTRODUCTION

Power quality is a growing concern for a wide range of customers. Most of the essential international standards define Power quality as the super natural characteristics of the utility electrical supply provided under normal operating conditions, which does not disrupt or disturb the customer's processes. However, it is most valuable to notice that the quality of power supply implies basically voltage quality and supply reliability, uninterrupted flow of energy at such as un-notched sinusoidal voltage at the fundamental magnitude level and frequency. Usually the term power quality refers to maintaining a sinusoidal waveform of bus voltages at rated voltage and frequency .The waveform of electric power at generation stage is purely sinusoidal and free from any distortion. Many of the Power conversion and consumption equipment are also designed to function under pure sinusoidal voltage waveforms. However, there are many devices that misshape or distort the waveform.

Harmonic interference problems render by bulge solid state converters become progressively serious as they are widely used in industrial applications and transmission/distribution systems. Nonlinear loads drawing misshape sinusoidal Currents from three-phase sinusoidal voltages from power generating stations. High-power diode or thyristor rectifiers, cyclo-converters, and arc furnaces are typically characterized as Harmonic- producing loads, because electric power utilities the individual nonlinear loads installed by high-power consumers on power distribution systems in many cases. Each of these loads produces a high amount of harmonic current. The utilities can determine the point of common coupling (PCC) of high-rated consumers who place their own harmonic-producing loads on power distribution systems .One of the eliciting proposals to compensate the power quality problems.

Modern active harmonic power filters are outstanding in filtering performance, smaller in physical size, and more adaptable in application, compared to handed-down passive harmonic filters using capacitors, inductors, and/or resistors. However, the active filters are slightly humble in cost and operating loss, compared to the passive filters, even at present. Active power filters conscious for power conditioning are also referred to as "active power line conditioners," "active power quality conditioners," "improved power quality conditioners (IPQCs)," etc.

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II.SHUNT ACTIVE POWER FILTER PROPOSED SYSTEM

In an ultra modern electrical distribution system, there has been a rapid increase of nonlinear loads, such as power Electronic apparatus like power supplies, rectifier equipment, domestic appliances, and adjustable speed drives (ASD), etc. As the number of these loads may increases, harmful harmonics currents generated by these loads may become very considerable. These harmful harmonics can cause to a variety of different power quality problems including the distorted voltage waveforms, malfunction in system protection, equipment overheating, excessive neutral currents, inaccurate power flow metering, light flicker etc.

It may goes to efficiency reduction by drawing reactive current component from the distribution network. In order to overcome these problems, active power filters (APFs, named as IPQC) have been developed. The voltage-source inverter (VSI)-based shunt active power filter is a new technology has been implemented in recent years and recognized as a viable solution, in which the required compensation currents are resolved by sensing line currents only, which is simple and easy to design. The scheme uses a traditional proportional plus integral (PI) controller for generating reference current signal. IPQC is supported under the basis of shunt active power filter, the compensation procedure is based on the instantaneous real- reactive power theory; it provides good and better compensation characteristics in steady state condition as well as transient state conditions. The instantaneous real- reactive power theory generating reference current signals required to compensate the distorted line current harmonics and also reactive power. It also tries to maintain the dc-bus voltage across the capacitor at constant value. The main and important characteristic of this real- reactive power theory is the simple 1244 and easy of the calculations, which involves algebraic calculations etc..

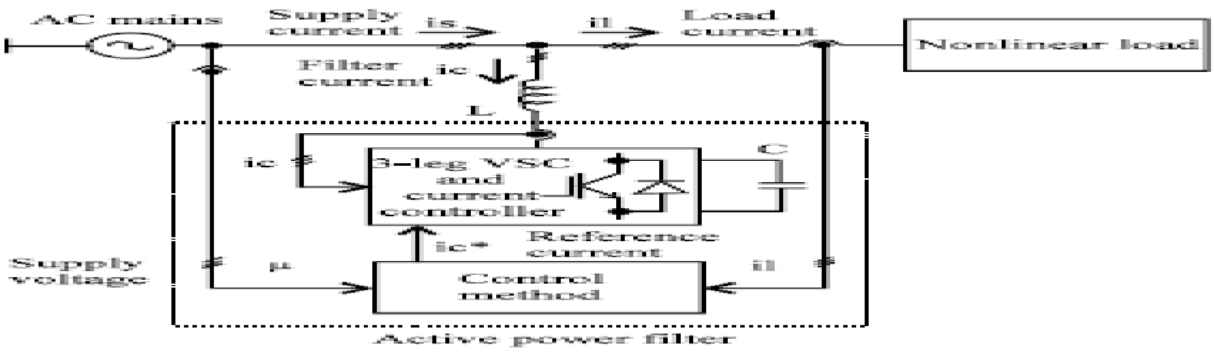

Fig.1. Block diagram representation of shunt active power filter

Instantaneous real- reactive power conditioner, this block diagram as shown in Fig.4. But as far as we know, a comprehensive approach has not been available for modelling and analysis of hybrid fuzzy logic controlled based IPQC using MATLAB/ Simulink platform.

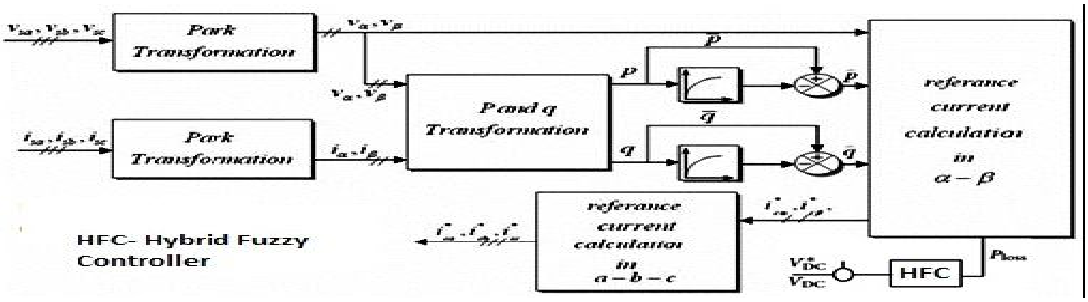

Fig.2. Reference current generator using instantaneous real- reactive power theory

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III. CONCEPT OF INSTANTANEOUS POWER THEORY

The proposed instantaneous real-reactive power theory is designed based up on conventional or formal p-theory or instantaneous power theory concept and uses simple arithmetic and algebraic manipulations. And also manipulate in both transient and steady-state as well as for generic voltage and current power systems. Mostly the active power filter generates the oscillative portion of the instantaneous active current of the load then source current will be pure sinusoidal.

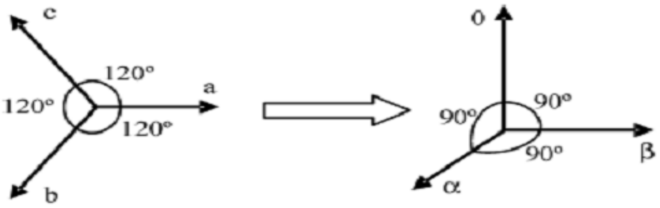


Figure 3: α-β-0 coordinates transformation

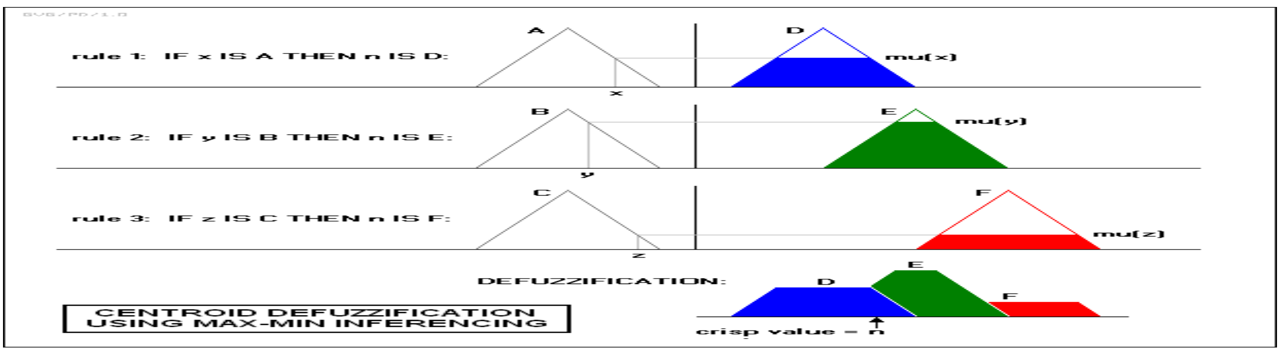
The instantaneous power theory or p-q theory was introduced by Akagi in 1983. This terminology uses algebra Transformation also knows as Clarke transformation for three phase current and voltage. The three phase voltage and current are transformed into α -β using eq. (1) and eq. (3), where i abc are three phase line current and v abc are three phase line voltage .

$$i_{\alpha\beta 0} = \sqrt{2/3}\begin{bmatrix} 1 & -1/2 & -1/2 \\ 0 & \sqrt{3/2} & -\sqrt{3/2} \\ 1/\sqrt{2} & 1/\sqrt{2} & 1/\sqrt{2} \end{bmatrix} i_{abc}$$

$$v_{\alpha\beta 0} = \sqrt{2/3}\begin{bmatrix} 1 & -1/2 & -1/2 \\ 0 & \sqrt{3/2} & -\sqrt{3/2} \\ 1/\sqrt{2} & 1/\sqrt{2} & 1/\sqrt{2} \end{bmatrix} v_{abc}$$

IV. HYBRID FUZZY LOGIC CONTROLLER DESIGNING

The general block diagram of FLC is shown in Fig. 2. The main objective of the designed FLC is to maintain the performance obtained by ‘standard design’ while reducing the complexity of fuzzy rule base design. FLC has mainly four internal components from which input has to be processed to come out as output. Fig. 2 shows these components that are fuzzification, rule base, inference engine, and defuzzification. Mamdani type fuzzy inference engine is used for this particular work. In, defuzzification process the combined output fuzzy set produced from the inference engine is translated into a crisp output value of real-world meaning. Among the various defuzzification techniques centre of gravity (COG) is chosen for this work because of its known merits .



Most commercial fuzzy products are rule-based systems that receive current information in the feedback loop from the device as it operates and control the operation of a mechanical or other device . A fuzzy logic system has four blocks as shown in Fig. 2. Crisp input information from the device is converted into fuzzy values for each input fuzzy set with the fuzzification block. The universe of discourse of the input variables determines the required scaling for correct per-unit operation. The scaling is very important because the fuzzy system can be retrofitted with other devices or ranges of

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operation by just changing the scaling of the input and output. The decision-making-logic determines how the fuzzy logic operations are performed (Sup-Min inference), and together with the knowledge base determine the outputs of each fuzzy IF-THEN rules. Those are combined and converted to crispy values with the 5 defuzzification block. The output crisp value can be calculated by the center of gravity or the weighted average.

V. MATLAB/SIMULINK MODELLING AND SIMULATION RESULTS

The compensated electrical network was developed in MATLAB/Simulink, and the strategy was applied to a three balanced & variable loads. The simulation part is carried out three cases

1. Non-linear load without Filter
2. Non-linear load based shunt active power filter.
3. Non-linear load hybrid fuzzy controlled based shunt active power filter at different load Conditions.

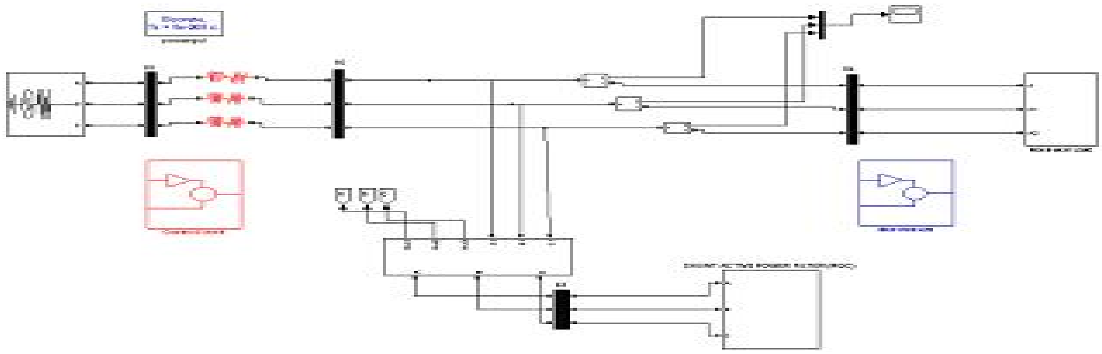

Fig.4. Simulink block diagram representation of shunt active hybrid type power filter (IPQC)

Case 1: Non-linear load without Filter:

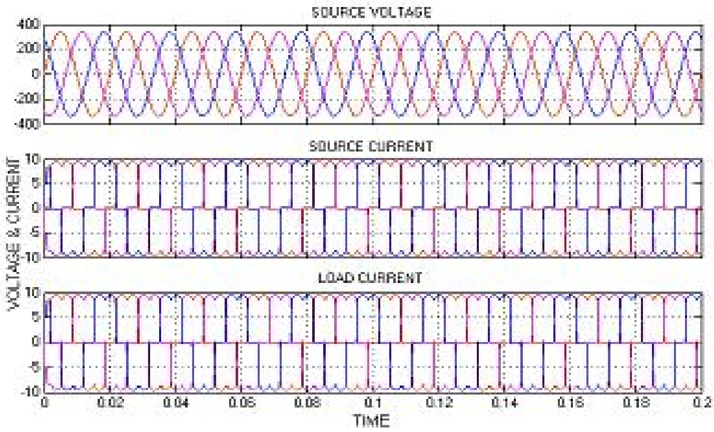

Fig.5 represents the three phase source voltages, three phase source currents and load currents respectively without Active power filter. Here evaluates the without shunt active power filter load current and source currents are same.

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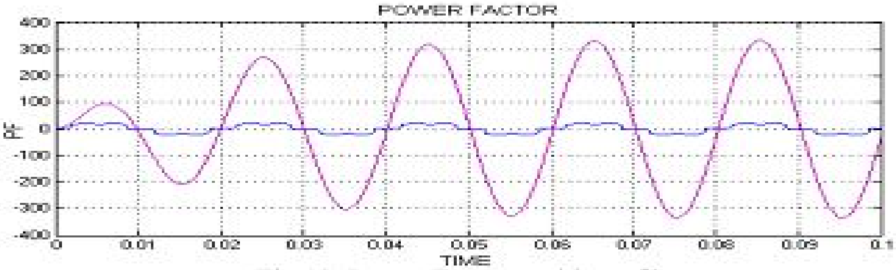

Fig.6 represents the power factor of the system without shunt active power filter.

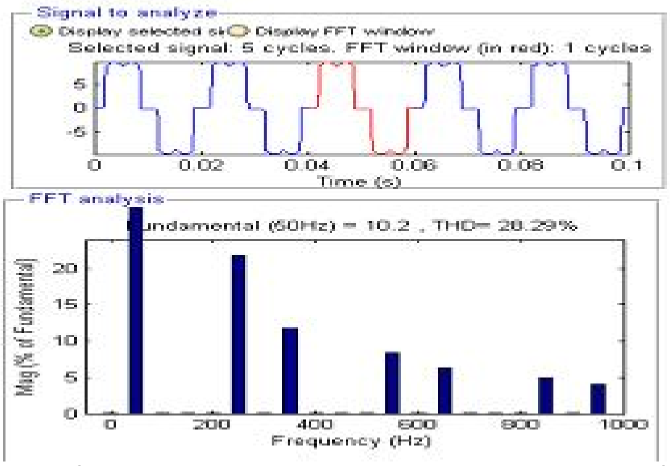

Fig.7 represents the FFT analysis of Phase –A Source current without shunt active power filter. The THD of source current is 28.29%.

Case 2: Non-linear load with dc link controlled based shunt active power filter:

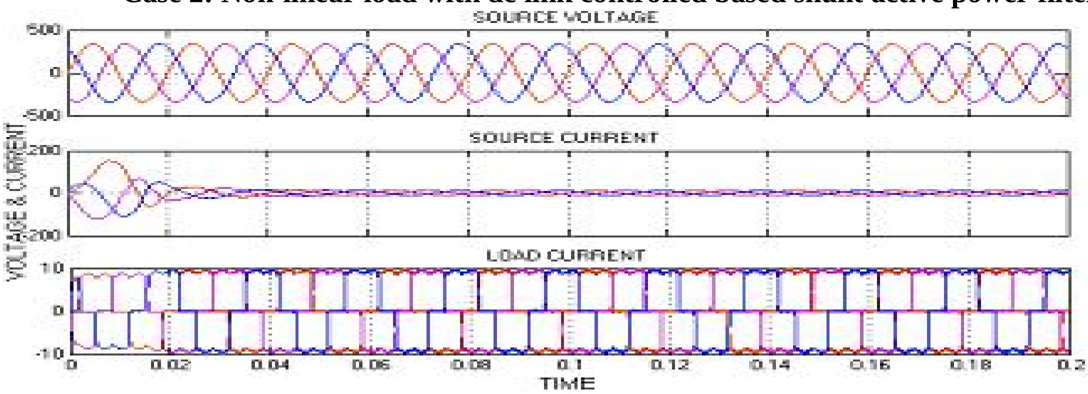

Fig.8 represents the three phase source voltages, three phase source currents and load currents respectively with dc link controlled based shunt active power filter. Here evaluates the with shunt active power filter load current are distorted and source currents are harmonic free response.

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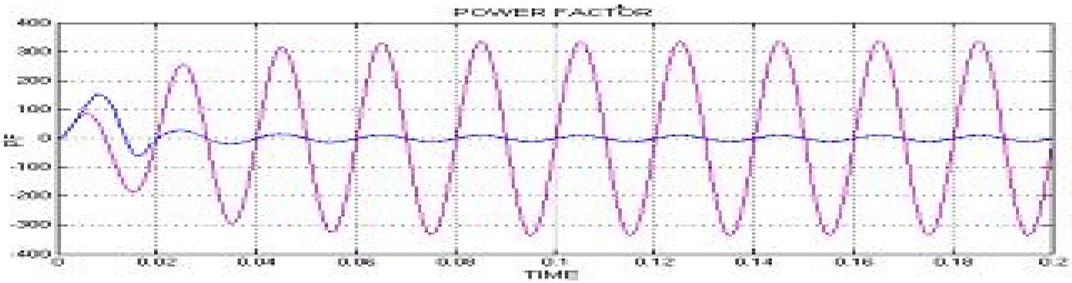

Fig.9. represents the power factor of the system with dc link controller based shunt active power filter.

Case 3: Non-linear load with hybrid fuzzy controlled based shunt active power filter at different load conditions.

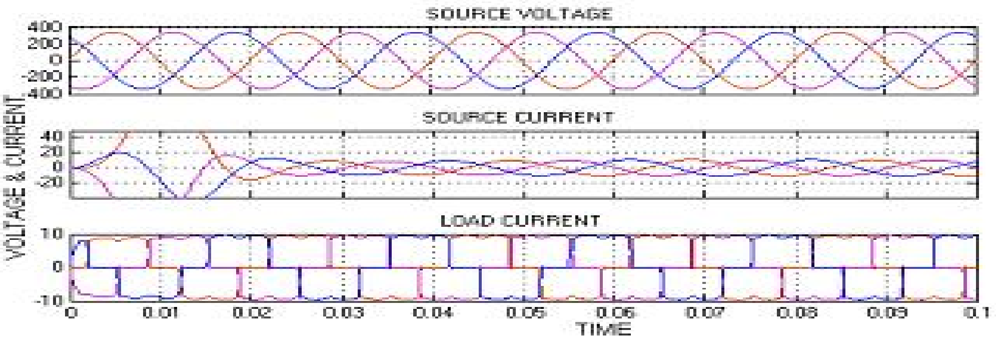

Fig.10. represents the three phase source voltages, three phase source currents and load currents respectively with hybrid fuzzy based shunt active power filter with fixed balanced load.

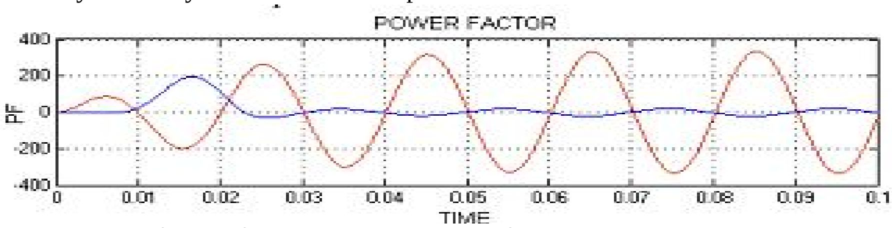

Fig.11 represents the power factor of the system with hybrid fuzzy controlled based shunt active power filter.

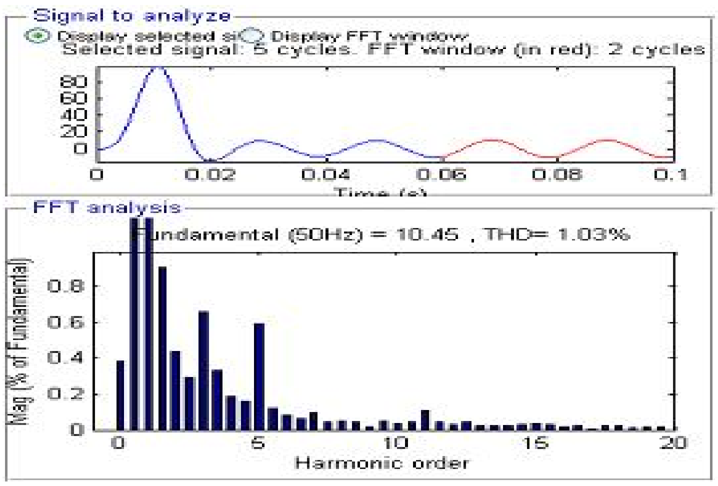

Fig.12 represents the FFT analysis of Phase –A Source current with hybrid fuzzy based shunt active power filter. The THD of source current is 1.03%.

VI. CONCLUSION

Before the active filter was started, a large amount of harmonic current still remained in source current. This means that the "pure" passive filter provides unsatisfactory performance in terms of harmonic filtering. After the active filter was started source current, became almost sinusoidal, showing that the active filter improves the filtering performance of the passive filter. The comparative results of both the cases proves that the performance of shunt active power filter with hybrid-fuzzy controller is superior to that with conventional P-I controller. Thus, by using hybrid-fuzzy controller the transient response of power system network has been improved greatly and the dynamic response of the same has been made faster.

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BIOGRAPHY

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