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POWER QUALITY IMPROVEMENT IN THREE PHASE GENERATION SYSTEM USING SHUNT ACTIVE POWER FILTERS

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ABSTRACT

Nonlinear loads in commercial, industrial, and residential applications require the supply of harmonics power, reactive power, and power losses and to minimize the effects of nonlinear loads in electric power systems different solutions have been proposed. In fact, there arenumerous types of compensators proposed to raise the power system quality. One of those compensators is the active power filter (APF). Frequently, the voltage source is chosen to implement the parallel active power filter. Here, APF in shunt isexplored to compare PQ and DQ control theories used in Active power shunt filters. A three phase generator with R.M.S source voltage of 400 and frequency 50 hz is used for electricity generation and a combination of nonlinear loads using R-L and bridge rectifiers is used for consumption. A three phase circuit breaker is used to on-off the filtering circuits as 0.5 second of the total 1 sec simulation time. Current, voltage a power waveforms both at source and load end has been taken for the analysis. Total harmonic distortion (THD) for the current waveform at the source end has been analyzed for three different systems in which first system there is no APF in the circuit. Second two circuits contain APF's that used PQ and DQ control theories for compensating currents. Fast Fourier Transform (FFT) has been used for currents by taking 21 harmonic orders. System without APF's gives THD of 10.85% whereas PQ and DQ based APF's gives 2.093% and 1.665% total harmonic distortion. It has been found that DQ control based APF's are more effective than PQ method.

Keywords: Non-linear Load, Total harmonic distortion (THD), Active power shunt filters, PQ control, DQ control etc.

I. INTRODUCTION

In the power usage industry, an expanding number of renewable energy strategies, and in addition nonlinear and linear loads, are being presented; these devices incorporate the static var compensator (SVC) and nonlinear rectifier, which influence day by day life. Incorporated framework PV and wind energy frameworks deliver certain sounds, heat, and other jumbled power-quality issues, along these lines influencing the supply current and voltage sinusoidal waveform spectra as far as lower framework productivity, overheating of transformers, expanded malfunction of engines and links, expanded power misfortune, need of assurance gadgets, and the constrained life time of generators. A few control frameworks have been planned, created, and acknowledged for dynamic channels. Pay of sounds can be refined in the time area or recurrence space. In time area the control calculations depend on the figuring of a prompt blunder work, while recurrence space control utilizes Fourier investigation of the misshaped current or voltage signals. There are a few strategies for time space control methods connected for dynamic power channels control, for example, the momentary dynamic and receptive power 'pq' hypothesis, synchronous dq reference outline, nonlinear control, PI control, sliding mode control to give some examples. Essentially, there are likewise various recurrence space control systems; for example, Fourier based consonant extraction strategies, Kalman channel control, wavelet change hypothesis and others. Utilizing Fourier changes in the control of dynamic power channels requires considerable calculation and has a languid reaction time. In this manner, time space control methodologies are ideal for continuous control of active power filters [1]. The control methodologies said above are altogether utilized for the control of APFs. In any case, for quickness, just some of time space procedures are talked about in the future which were generally examined in writing.

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- *PQ direct Control*

In [2] instant reactive power model is advancedwhich isbuilt on Clarke transformation of the three phase currents and voltages. The instantaneous reactive and active power can be measured as transformed currents and voltages. Using low pass and high pass filters, the harmonic reactive and active powers could be take out from instantreactive and active powers.

- *Synchronous reference frame control*

In the synchronous 'dq' reference outline control procedure, the load currents are changed from the 'abc' stationary reference edge to the 'dq0' synchronously pivoting outline utilizing the Park's transform. The DC connect voltage is estimated as input to keep up a steady DC transport. Furthermore, a phase-locked loop (PLL) is connected to synchronize the signs with the network voltages. Utilizing low-pass channels the DC segments (ild, ilq) are removed from 'dq' current parts. All things considered the AC amounts (sounds) are expelled from the reference signals.

- *Indirect control*

In the indirect control methodology, the three- phase supply voltages are estimated and the DC transport of the dynamic power channel is kept managed to evaluate the reference values for the sizes of the source streams. With the assistance of PI voltage controllers, the amplitude of the in-stage segments of reference supply streams is assessed. In subtracting load streams from reference supply ebbs and flows, the pay orders can be determined.

- *Sliding mode control*

Sliding mode control (SMC) is one of the nonlinear control strategies that present huge characteristics regarding vigor, exactness, basic usage and simple tuning. The controller is likewise inhumane to variety of the framework parameters. SMC frameworks are assigned to drive the framework directions onto a particular surface in the state space, specifically sliding surface. The sliding surface can be picked by subtracting load streams from reference supply ebbs and flows or by extra numerical handling of the blunder. At the point when the sliding surface is accomplished, sliding mode control keeps the states on the nearby neighborhood of the sliding surface. Plan of SMC incorporates two stages, starting outline of the proper sliding surface and afterward a control law to compel the framework directions to reach and remain on the sliding surface [3].

- *PQ Indirect Current Control*

The circuitous current control is basic and offers a decent execution and does not require much equipment contrasted with other control strategies, for example, coordinate current control system. In backhanded current control, the source streams are taken as the reference current segments for examination, and a functioning force normal segment just course through control conspire and responsive part is zero. All things considered the exchanging charges are inferred [4]. The enlarged utilization of electronic gadgets connected to the power change make unsafe results the power quality (PQ) of both transmission and circulation levels. The non-straight qualities of these gadgets that depend on semi-conductors can cause symphonious sullying by drawing a non-sinusoidal current from the power supply. Customarily, passive power filters (PPF) are introduced to relieve the most overwhelming sounds, and adjust for the receptive substance required by the heaps. In spite of the fact that, this arrangement is described by the effortlessness, ease and simple upkeep, it can't be a solid arrangement since it very relies upon the network impedance, which has a fluctuating nature. In addition, PPFs are exceedingly touchy to varieties in the heap parameters and are inclined to reverberation with the line/stack impedance. To conquer these disadvantages, the shunt active power filters (SAPFs) have gotten much thoughtfulness regarding be an elective answer for PQ issues. In this paper, two dynamic shunt channel based control speculations has been executed in three stage age framework, in which non-straight loads re-created utilizing variation RLC branches that are associated in arrangement and parallel. A concise review identified with work has been given in area II.

II. LITERATURE

S. Parthasarathy et al. (2015) tried the VSI based Shunt Active Harmonic Filter (SAHF) and associated in parallel with the Non-Linear load. The pq and dq speculations created in the proposed work is checked systematically and numerically. The perfect case, where the source voltages and in addition the heaps in the three stages are adjusted, the real pay streams produced by the shunt Active Harmonic Filter for the three stages are found to take after the particular reference remuneration ebbs and flows precisely in reproduction. The

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proposed strategy lessens the sounds from 30.5% to 8.07% and 30.5% to 5.74% individually for controlled rectifier with pq and dq hypothesis [5].

Ali Chebabhi et al. (2016) proposed B3L-3DSVM procedure for create the entryway exchanging heartbeats and adjusting the dc transport voltage capacitors in same circumstances of a three stage three level NPC four-leg SAPF with a Nonlinear Back-Stepping Controllers (NBSC) for directed the dc transport voltage capacitors and the SAPF infused streams for control quality change in a four wire dispersion organize [6].

WajahatUllahTareen et al. (2017) give the state-of-the art and solid points of view on the transformer less, latent parts of APF and matrix associated sustainable power source frameworks. This audit gives an expansive point of view to scientists, makers, and architects who manage music and power quality issues. To upgrade the power nature of the DER and DPGS, imaginative and novel advancements have been accounted for in the field on matrix associated inverters [7].

SoumyaRanjan Das et al. (2017) recreated the total model with the product in MATLAB/Simulink. They broke down the reenactment of the two distinctive design of hybrid channel with p-q, d-q hypothesis and RLS calculation. Simulation result shows that by interfacing inactive channel the symphonious current substance get decreased and change in the present wave shape is seen with huge upgrades in the THD values. However, on last stage it has been discovered that utilizing dynamic power channel, music in current were essentially dispensed with, which made the waveforms of the current to approach towards sinusoidal from non-sinusoidal waveforms [8].

Arun Shankar V.K. et al. (2017) introduced a proper reference control strategy with SAPF for a three stage dissemination arrange associated with changing burdens to upgrade the power quality. Programming interface controller and fluffy based matlab-simulink demonstrate has been recreated for SAPF with a specific end goal to dispose of the symphonious components because of nonlinear load. A FPGA show has been created for the proposed current segment (Id - Iq) control strategy and the execution of the same is checked with the remuneration of current sound and to beat dynamic load changes [9].

Josep M. Guerrero et al. (2018) proposes an enhanced open circle procedure in light of NLS approach for synchronizing the RCC of the SAPF. The proposed systems demonstrated it is effectiveness in extricating the principal segment of the voltage and assessments its stage even under clamor defiled information. Additionally, the proposed strategy is contrasted and progressed PLLs (MCCF– PLL and MAF– PLL) to demonstrate its precision and the quick powerful reaction [10].

III. PROPOSED WORK

- *Instantaneous Real and Reactive Power Theory (p-q method)*

This hypothesis considers the immediate responsive power emerges from the swaying of intensity amongst source and load and it is material for sinusoidal adjusted/unequal voltage however comes up short for non-sinusoidal voltage waveform. It fundamentally 3 phase framework as a solitary unit and plays out Clarke's change (a-b-c directions to the α-β-0 directions) over load current and voltage to acquire a repaying current in the framework by assessing quick dynamic and receptive intensity of the system framework. The p-q technique control methodology in square outline shape is appeared in fig 1.

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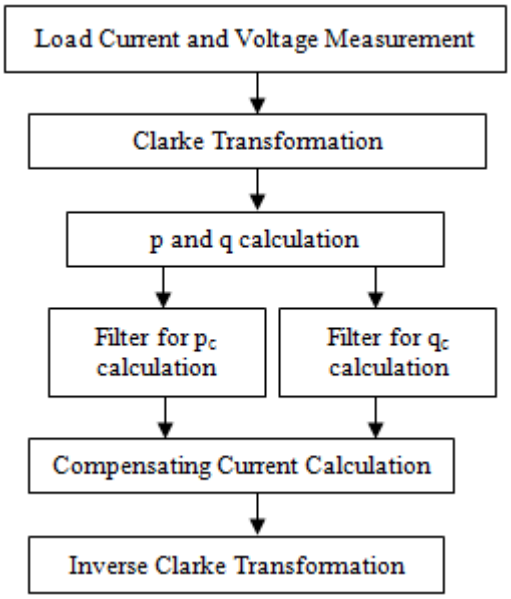

Fig 1: P-Q method control strategy

This hypothesis takes a shot at dynamic key as its promptly figured power from the immediate current and voltage in 3 phase circuits. Since the power recognition occurring promptly so the harmonic exclusionfrom the system happen immediately when contrasted with other recognition technique. In spite of the fact that the technique investigation the power immediately yet the symphonious concealment incredibly relies upon the gating succession of three stage IGBT inverter which is controlled by various current controller, for example, hysteresis controller, PWM controller, triangular carrier current controller. In any case, among this hysteresis current controlled technique is generally utilized because of its heartiness, better exactness and execution which offer dependability to control framework.

- *Synchronous Reference Frame theory (d-q method)*

Another strategy to isolate the symphonious segments from the key parts is by creating reference outline current by utilizing synchronous reference hypothesis. In synchronous reference hypothesis stop transform is done to change three load current into synchronous reference current to wipe out the music in source current. The primary favorable position of this strategy is that it contemplate just load current for producing reference current and thus free on source current and voltage bending. A different PLL square it utilized for keeping up synchronism amongst reference and voltage for better execution of the framework. Since immediate move isn't making place in this technique so the strategy is tad moderate than p-q technique for recognition and removal of harmonics. Fig 2 illustrates the d-q strategy with basic flow chart.

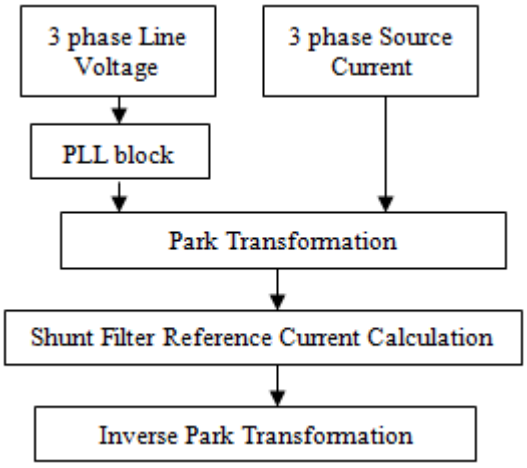

Fig2: D-Q method control strategy

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IV. RESULTS AND DISCUSSIONS

Simulation is implemented on a stable Non –Linear Load comprising of a bridge rectifiers and R-L load as shown below:

Table I: System Parameters

Source Voltage (r.m.s)	400 Volt
System Frequency	50Hz

Table II: Active Power Filter (APF) Parameters

Coupling Inductance Load	.0004H
Coupling Inductanace source	.00001H
Dc link capacitance	4700e-6F
Source inductance	.000010H
Load inductance	0.0004H

Table III: Unbalanced Load Parameters

Series RL Branch1	
Resistance=1e50 ohm	Inductance=.0001H
Parallel RC Branch2	
Resistance=50 ohm	Capacitance =1e-6F
Series R Branch3	
Resistance=1 ohm	
Rectifier RL branch	
Resistance=30 ohm	Inductance=.00030H

The simulation outcome wasacquired in MATLAB/Simulink environment by using Sim-power system Toolbox. Here a breaker is utilized to demonstrate the examination throughout ON and OFF time of the Active power Filter. A minor bending in voltage and current waveform is perceivedin the course of exchanging of breaker which can be expelled by utilizing thermistor in arrangement with series with DC link capacitor.

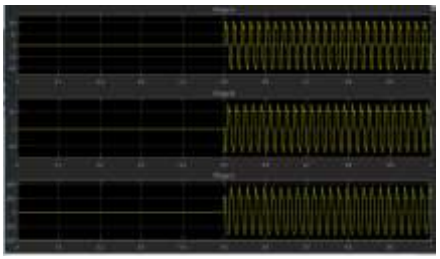

Fig3: Phase wise source current waveform without using active shunt filter

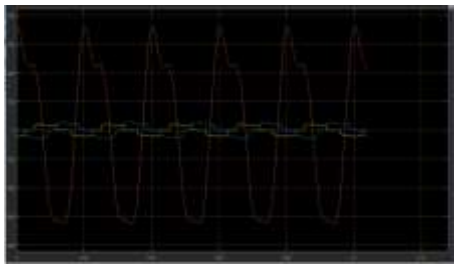

Fig4: Collective three phase source current waveform without using active shunt filter

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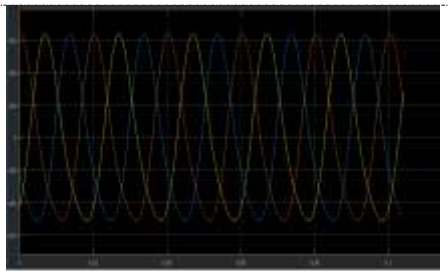

Fig 5: Collective three phase source voltage waveform without using active shunt filter

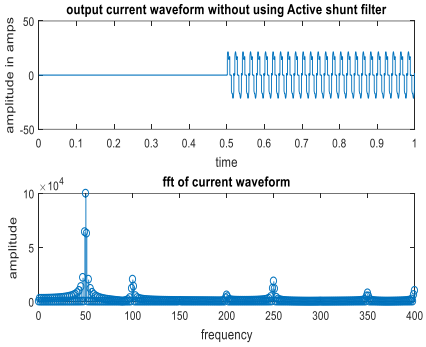

Fig6: Harmonic analysis of current waveform using FFT using 21 order harmonics according to 50hz frequency gap without using active power shunt filters

Table IV: THD without using Active power shunt filter

THD without using Active power shunt filter	10.8523 percent

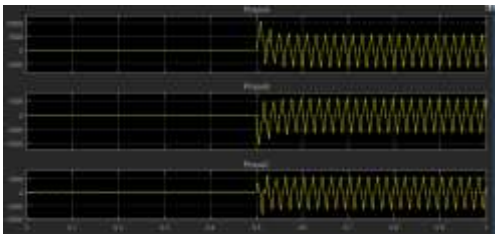

Fig7: Phase wise source current waveform using P-Q control based active power shunt filter

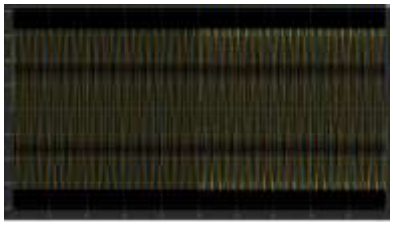

Fig8: Collective three phase source voltage waveform with using active shunt filter

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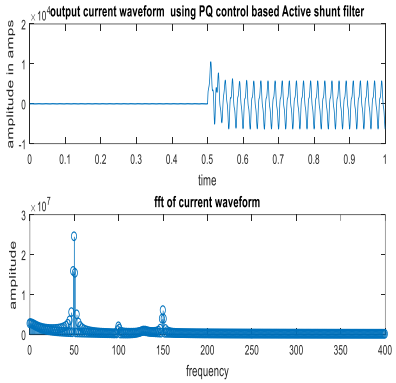

Fig9: Harmonic analysis of current waveform using FFT using 21 order harmonics according to 50hz frequency gap using PQ control theory based active power shunt filters

Table V: THD with using P-Q based Active power shunt filter

THD with using P-Q based Active power shunt filter	2.0928 percent

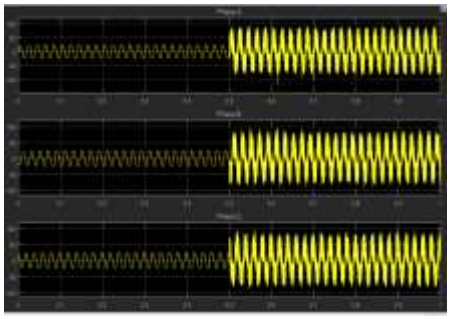

Fig10: Phase wise source current waveform using D-Q control based active power shunt filter

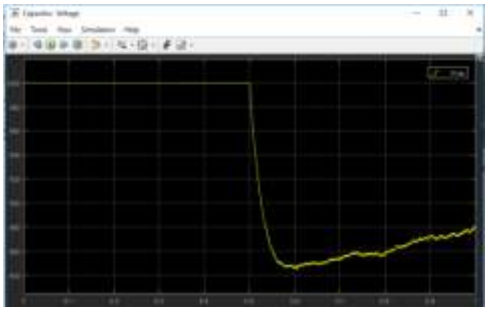

Fig 11: Capacitor voltage of DQ theory based coupling capacitor

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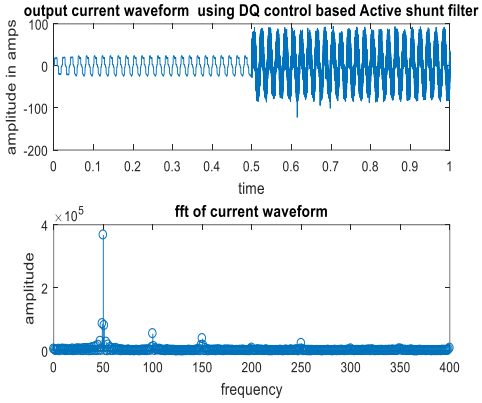

Fig12: Harmonic analysis of current waveform using FFT using 21 order harmonics according to 50hz frequency gap using DQ control theory based active power shunt filters

Table VI: THD with using D-Q based Active power shunt filter

THD with using D-Q based Active power shunt filter	1.6653 percent

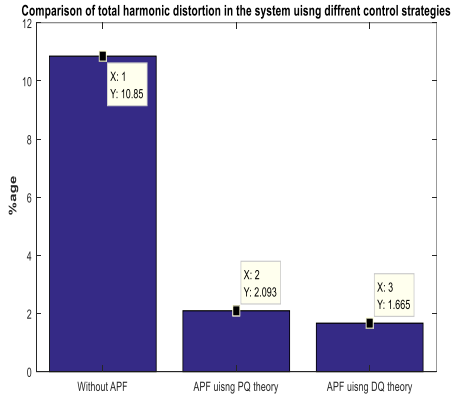

Fig13: Comparison of total harmonic distortion in the system using different control strategies

V. CONCLUSION

In this paper, PQ and DQ theory based active power shunt filter controls has been presented and compared on a similar transmission system in which single three phase generator and Non-linear loads containing rectifiers and RLC circuits has been designed. PQ theory mechanisms with the instantimaginary and real power of the supply and is also called as instantaneous active-reactive power theory while DQ theory deals with the rotating axis and is likewisecalled as the synchronous reference frame theory. Experimental results has been compared by calculating THD and FFT of THD of source current waveforms of the systems without APF, using APF with DQ control theory and APF with PQ control theory. FFT analysis of the circuit carried out with and without filtershows that the harmonic component present in the source is compensated with use of Active power shunt filters. Further it is also seen that harmonic is compensated to a greater extent while using d-q control strategy instead of p-q i.e. the THD of source current is almost reduces by half while using the d-q method.

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