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Power Quality Improvement using Different Types of Filters in Electrical Power System

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Abstract: This paper describes a different filter for power quality improvement. It deals with the problem related to harmonics due to the nonlinear load. The Harmonic current is drawn with the aid of the nonlinear burden from the supply which results in a distortion of the voltage waveform in a supply-side. This distorted voltage and current may make conductors heat up and can lessen the effectiveness and future of the gear. With the goal that the decrease of harmonics is significant in nowadays life. Here arrangement dynamic channel, shunt dynamic channel, and passive shunt channels are discussed. This filter is utilized to make up for sounds and receptive power. Three-phase thyristor loads are taken as a nonlinear load. For thyristor 180° scheme is used here. Thyristors are fired for two different values of firing angle 0° and 60°. The exhibition of three stage shunt dynamic power channel utilizing instantaneous power hypothesis with PI controller is clarified in this paper. In this work, an arrangement dynamic channel for voltage pay has been confirmed utilizing Synchronous Reference Frame Theory for the age of the reference voltage which is contrasted and steady voltage for heartbeat age utilizing hysteresis band PWM. Simulations are carried out using MATLAB/SIMULINK. simulation results are presented.

Keywords: nonlinear load, harmonic, power quality, active filters, passive shunt filter

I. INTRODUCTION

In the power system, power quality issue become important since 1980. recently most of the electrical equipment used are power electrics have nonlinear characteristics, which is the main cause for a harmonic generation. the nonlinear load is the main cause of current and voltage harmonic generation. Harmonics generation create power loss and excess heat, Due to this power quality degreed. To repay sound and responsive intensity of nonlinear burden filters are used. To repay responsive power and lower request sound created by nonlinear load the most efficient technology is ACTIVE POWER FILTER (APF). [1]

In a power framework current harmonic generation can destroy the line voltage, which creates some adverse effects like equipment overheating, the breakdown of strong-state equipment and obstruction with correspondence frameworks. [2]

Series active filter use to reduce voltage sounds and Shunt dynamic channel use to reduce cutting-edge sound. as current harmonics reduction itself reduce voltage harmonics, so shunt active power filters are highly in useful**.** [3]

Conventional passive filters use Inductor and capacitor, it has merits like simple structure, low running cost, high reliability and low cost of equipment. Also, it compensates harmonics and reactive power.

II. POWER QUALITY IN DISTRIBUTION SYSTEM

Power quality is a straightforward term, yet it depicts a large number of issues that are found in any electrical power system and is an abstract term. The thought of fine and unhealthy power depends on the tip user. On the off chance that a bit of gear works acceptably, the client feels that the power is great. If the gear does not work as planned or flops rashly, there is an inclination that the power is terrible. In the middle of these limits, a few evaluations or layers of intensity quality may exist, contingent upon the viewpoint the power is bad of the Power-user. So, control quality issue present if any voltage, current or recurrence deviation brings in the bad activity of client's gear. It is essential to note that the power quality of source depends only on voltage and the current quality and supply unwavering quality. due to the failure of any equipment voltage will deviate from its normal characteristics hence voltage quality problem occurs.

Power quality problem is common in commercial, industrial and utility network. Natural phenomena are the most frequent cause of power quality problem. [10]

III. TYPES OF FILTERS

As nonlinear load increases harmonics are also increased in the distribution system.to compensate harmonics filter design become more essential for the distribution system. Filter size should be such that it correct voltage profile and compensate harmonics within a tolerable maximum value.

There are mainly two types of Filters.

A) Active filter
B) Passive filter

Active Filter

The Active filter is a kind of simple circuit actualizing an electronic channel which uses dynamic segments like an amplifier, it incorporates into channel structure for improving execution and cost. The dynamic channel is a device which generates harmonics in the same amount as generated by load but it is shifted by 180°. [4] In this way, when these sounds are embedded into the line at the purpose of normal coupling the heap current sounds are wiped out and utility supply ends up sinusoidal.

There are two sorts of a dynamic channel.

1. shunt dynamic channel
2. series dynamic channel

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1. *Shunt Dynamic Filter*

Shunt dynamic channel generate injects current harmonics have the same magnitude as generated by load current but it is shifted by 180°. [4] shunt channel is used to compensate current harmonics which is generated by load so utility supply becomes sinusoidal. It also compensates reactive power and balances initially unbalanced current. By using an appropriate control scheme active power filter can compensate load power factor. [8]

Fig. 1 demonstrates the essential plan of shunt active filter which makes up for burden current harmonic.

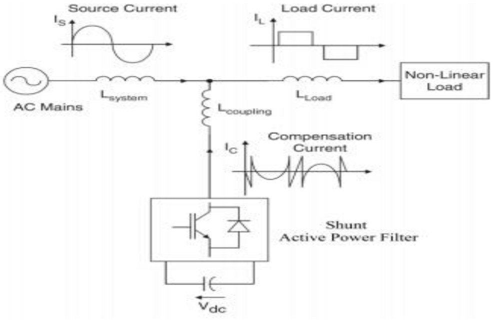

Fig. 1 fundamental plan of shunt active filter [4]

2. *Series Dynamic Filter*

It is outstanding that series dynamic power channels repay current framework twisting brought about by non-linear loads by forcing a high impedance way to the current harmonics which powers the high- frequency currents to move through the LC aloof channel associated in parallel to the load. The high impedance forced by the arrangement dynamic power channel is made by creating a voltage of a similar frequency that the current harmonic segment that should be wiped out. Voltage unbalance is amended by repaying a key recurrence negative and zero succession voltage parts of the framework. [8] Series dynamic channel injects a voltage component which is in series with the supply voltage and that's why it acts as a controlled voltage source, compensating voltage sags, swells, and harmonics on the load side. It is associated before the load in series with the fundamental utilizing coordinating transformer. [7]

Fig. 2 indicates the fundamental scheme of series dynamic filter which compensates load voltage harmonics.

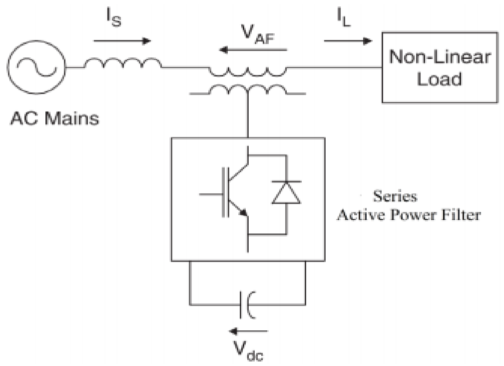

Fig. 2 fundamental plan of series dynamic channel [4]

A. *Passive Filter*

An inactive channel is a course of action of inductances, capacitances, and resistances orderly in such a way, that it goes about as a recurrence discriminator, i.e., it provides low impedance path for harmonics segment or we can say that it permits the passing of several frequencies and discards others. It is conceivable to associate more than one latent channel in either shunt or potentially arrangement setup. [5] There are two types of passive filter. [6]

1. shunt inactive channel
2. series inactive channel

1. *Shunt Inactive Channel*

For the crossing out of the symphonious current in the appropriation framework, it is the most common method. Latent consonant channels are planned on a guideline of either single tuned or bandpass channel innovation. According to its name shunt type channel are associated in framework parallel with the load. The Detached channel offers a low impedance in the system at the tuned recurrence to occupy all the related current and at given tuned recurrence. On account of latent channel dependably have a propensity of offering some receptive power in the circuit so the plan of uninvolved shunt channel happens for the two purposes one is the separating reason and another is to give receptive pay motivation behind rectifying force factor in the circuit at the ideal level. The advantage with the aloof shunt type channel is that it just conveys a small amount of current so the entire framework AC control misfortunes are decreased contrast with arrangement type channel. [6]

2. *Series Passive Filter*

An aloof arrangement channel is considered as a potential solution for consonant moderation for the voltage source sort of symphonious burdens, (for example, diode rectifier with R-L burden channel), It comprises of a lot of low squares tuned shunt channel tuned at fifth, seventh consonant frequencies and high square tuned channel for eleventh consonant recurrence. These latent channels square most prevailing fifth, seventh, and other higher-request sound and hence keeps them from streaming into ac mains. Here, the exhibition of the arrangement channel isn't much reliant on the supply electrical phenomenon. In any case, it brings about a decrease in dc transport voltage because of the voltage drop crosswise over channel parts. [8]

Detached sort arrangement channel has a property of absolutely inductive sort or LC tuned attributes. The principle part of the passive series channel is AC line reactor and DC connection channel. [6]

IV. DEVELOPMENT OF DIFFERENT FILTERS USING MATLAB

Here planning of a functioning shunt, series and inactive shunt channel are exhibited for successful separating of sound. The structure of the facility circuit incorporates the subsequent 3 important parameters:

1. choice of the reference value of DC facet electrical device voltage,
2. Choice of channel inductor, Lc.
3. Choice of DC facet electrical device, Cdc

A. *Shunt Dynamic Filter*

The reenactment examination Shunt dynamic Power Filter is performed with PI controller. For this reason, a SIMULINK model is created for the Shunt Active Power Filter to explore the presentation during consistent states as properly as transient's condition. Here a three-phase thyristor with RL load is taken as the nonlinear burden is used for which separating is required. Reenactment is done for both consonant and receptive power pay. At that point, a shunt dynamic power channel is added to the framework for higher sifting. In the reproduction power supply with the accompanying parameters is utilized. [5]

A1. Instantaneous Power Theory

Proposed hypothesis dependent on quick values in three-stage control frameworks with or without nonpartisan wire, and is legitimate for unfaltering state or short lived tasks, just as for conventional voltage and current waveforms called as Instantaneous Power Theory or Dynamic Reactive (p-q) hypothesis which comprises of an logarithmic change (Clarke change) of the three-stage voltages in the a-b-c directions to the α-β- 0directions, trailed by the count of the p-q hypothesis quick control segments. [9]

System Data:

Three-phase source Vrms =400v (line to line)
Source inductance Ls = 1mh
Load inductance L_L= 100mh
Load resistance R_L= 1 Ω

Filter data (0°):

Capacitance=20e-6F
D.C reference voltage=220v
Coupling inductor=0.1mh

Filter data (60°):

Capacitance=35e-6F
D.C reference voltage=220v
Coupling inductor=15mh
PI controller gain value (0° & 60°)
K_p=0.2
K_i=1.5

B. Series Dynamic Filter

The Series dynamic channel is demonstrated by a MOSFET put together inverter with a capacitor concerning its DC side which goes about as a vitality stockpiling component during transients. The switches of the inverter are taken as perfect ones. An obstruction is taken in arrangement with the pay inductance to represent the exchanging misfortunes of the dynamic channel.[7] The different parameters of the series dynamic channel are taken as

B1. Synchronous Reference Frame (Srf) Theory

The Series converter has the capacity of repaying the Voltage Problems like Sag. The arrangement controllers have the PLL which supplies the sine and cosine incentive to the abc to dq0 and dq0 to abc change. In arrangement control the reference sign is created by the utilization of abc to dq0 and dq0 to abc. The reference sign created is contrasted and the PCC point voltage and utilizing the hysteresis band Pulse sign is produced. The created sign is given as the entryway heartbeat to the converter. The control methodology of the framework is to control the converter for the infusions of the negative music for the remuneration of the framework. The converter yield is constrained by the door heartbeat given to the IGBT's. This is accomplished by the Synchronous Reference Frame (SRF) Theory. The SRF hypothesis depends on the synchronous machine wherein for the investigation of 3phase framework is made simple. The 3phase framework abc is changed over to the direct and quadrature pivot amounts dq0. For the arrangement APF is considered for the reference signal figuring and heartbeat is produced. [10]

System Data:

Three-phase source Vrms =400v (line to line)
Source inductance Ls = 1mh
Load inductance L_L = 100mh
Load resistance R_L = 1 Ω
Resistance R=0.01Ω
Capacitance C=100mF

Filter data (0°):

Resistance=1e-6Ω
D.C voltage=4000v

Filter data (60°):

Resistance=1e-6Ω
D.C voltage=1000v

C. Shunt Inactive Channel

Shunt passive filter is modelled with R, L and C. here it is used to reduced lower order harmonics. The different parameters of the shunt latent channel are taken as

System Data:

Three-phase source V_{rms}=400v (line to line)
Source inductance L_S= 1mh
Load inductance L_L= 100mh
Load resistance R_L= 1 Ω

Filter data (0°):

Quality factor=345
Reactive Power Q=2500

Filter data (60°):

Quality factor=345
Reactive Power Q=5000

V. SIMULATION RESULTS AND ANALYSIS.

Execution of shunt dynamic power channel, arrangement dynamic power channel, and shunt aloof power channel is checked with the utilization of MATLAB programming. In the proposed plan 3 phase thyristor (180° scheme) baseload have been considered as nonlinear load. Here thyristors are fired at two different angles at 0° and 60°. For this two-firing angle for all three above shunt active, arrangement dynamic and shunt detached channel and without channel, simulation is done. Here results are shown for dynamic power, receptive power, control factor, and sound. In this power factor and active power improves, reactive power and harmonics are reduced. In table 1 shows the result before and after compensation for 0° firing angle and table 2 shows the result before and after compensation for 60° firing angle.

Performance of shunt and arrangement dynamic and shunt passive power channel is checked with the utilization of MATLAB programming. In the proposed plan RL load have been considered as nonlinear load. Fig. 3 shows the performance of a system without a filter. Fig. 6 demonstrates the exhibition of a system with a shunt dynamic channel. Fig. 9 demonstrates the performance of a framework with a series dynamic channel. Fig.12 shows the performance of a system with a shunt passive filter.

Fig. 4 & 5 shows voltage and current waveform for three-phase thyristor system for α=0° & 60° respectively without a filter. Fig. 7 & 8 shows voltage and current waveform for three-phase thyristor system for α=0° & 60° respectively with shunt active filter after compensation.

Fig. 10 & 11 shows voltage and current waveform for three-phase thyristor system for α=0° & 60° respectively with series active filter after compensation.

Fig. 7 & 8 shows voltage and current waveform for three-phase thyristor system for α=0° & 60° respectively with shunt passive filter after compensation.

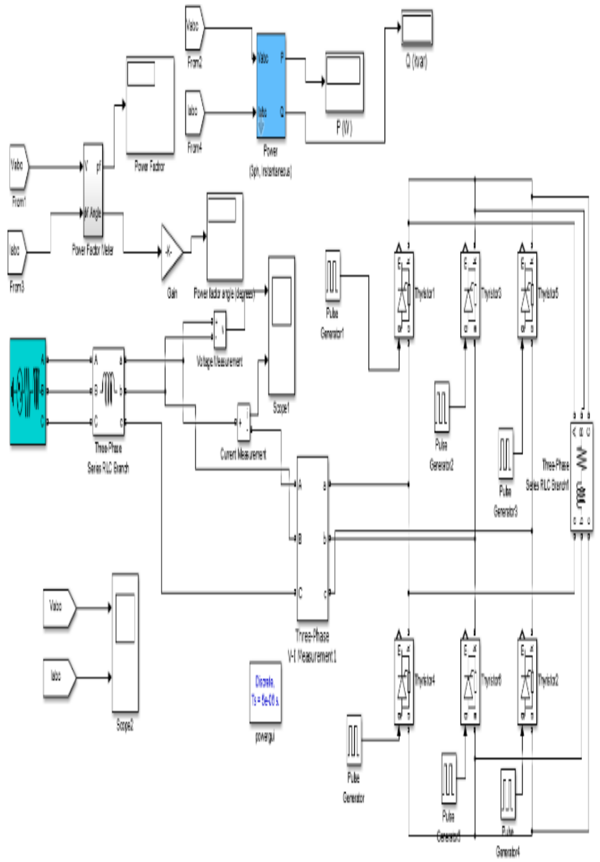

Fig. 3 simulation of three-phase thyristor system without a filter

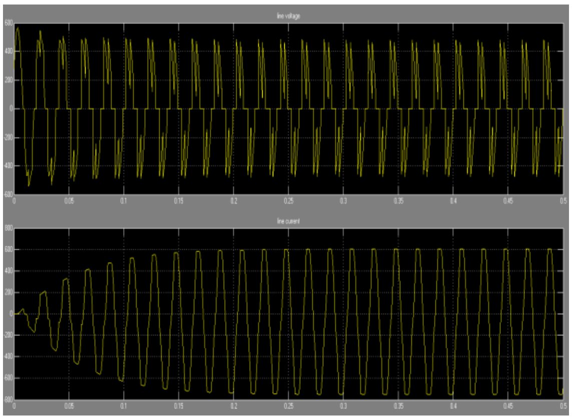

Fig. 4-line voltage and current waveform for the three-stage thyristor system for α=0° without filter

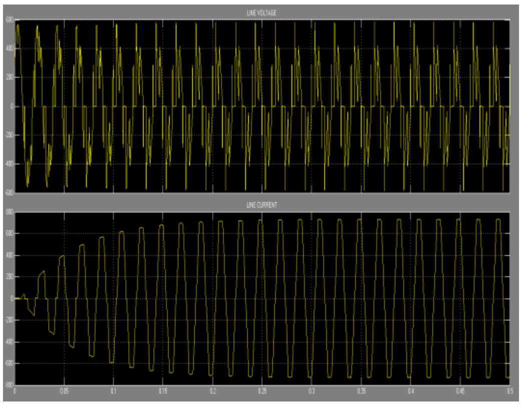

Fig 5. line voltage and current waveform for Three-stage thyristor system for α=60° without filter

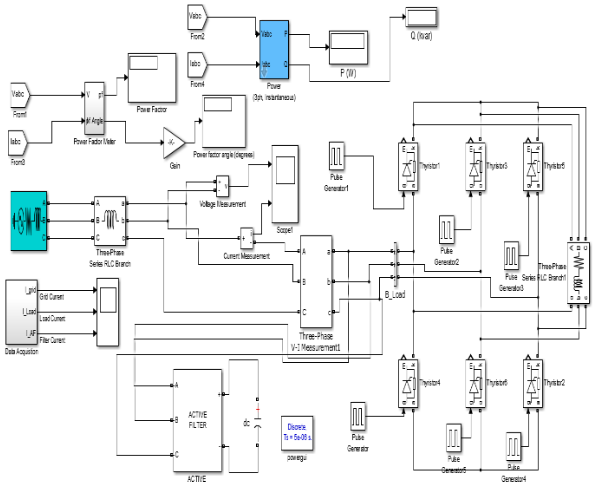

Fig. 6 simulation of three-phase thyristor with active shunt filter

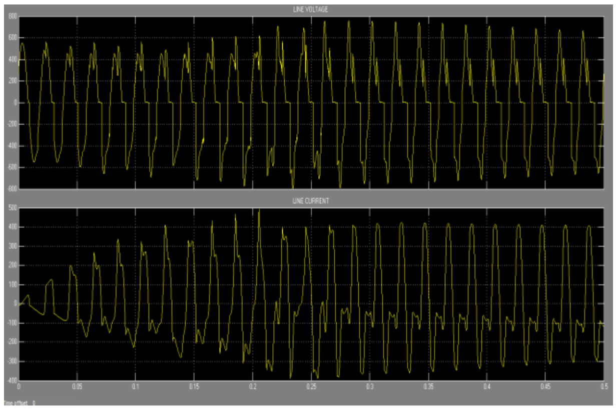

Fig. 7 line voltage and current waveform for Three-phase thyristor system for α=0° with active shunt filter

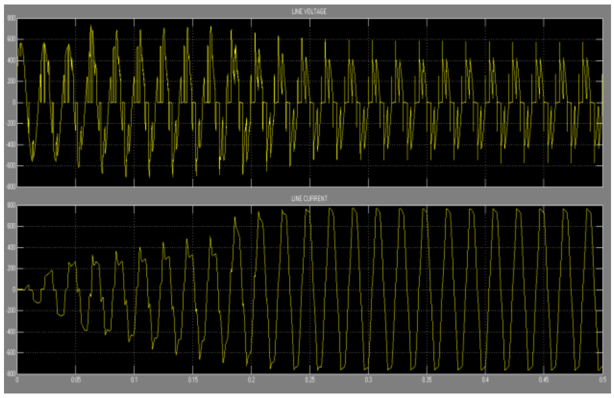

Fig 8. line voltage and current waveform for Three-stage thyristor system for α=60° with shunt active filter

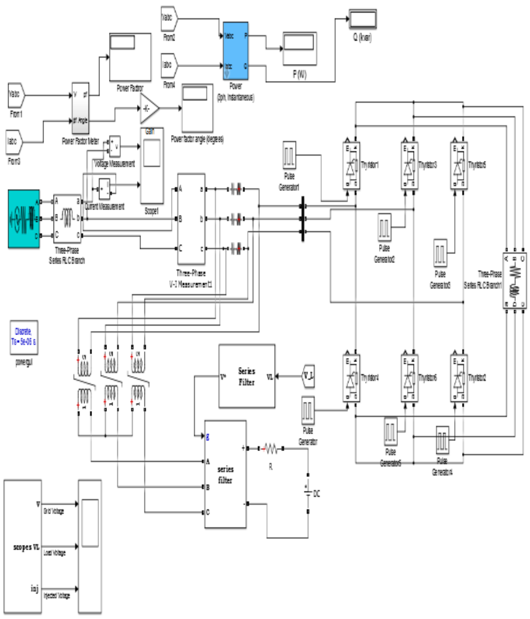

Fig 9 simulation of three-stage thyristor with arrangement dynamic channel

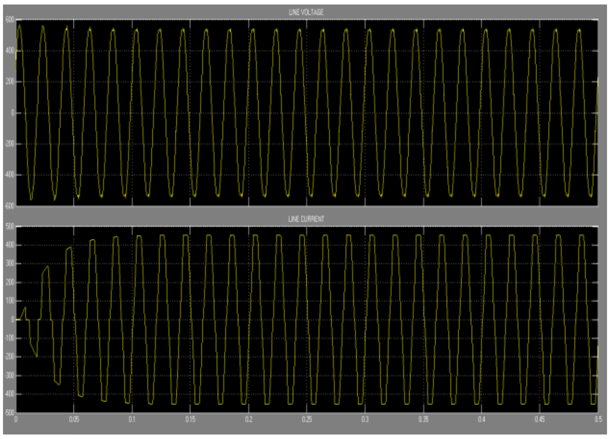

Fig 10 line voltage and current waveform for three-phase thyristor system for α=0° with series active filter

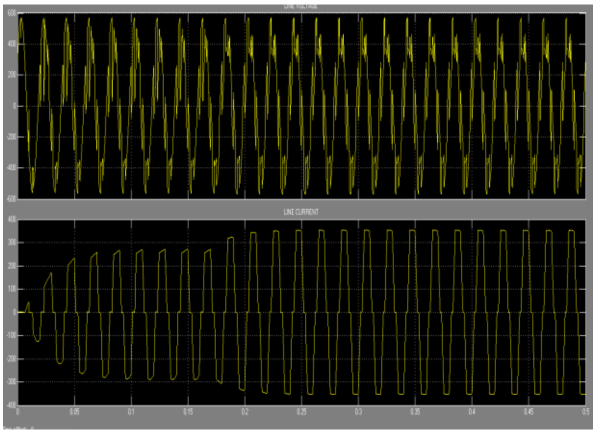

Fig 11 line voltage and current waveform for three-phase thyristor system for α=60° With series active filter

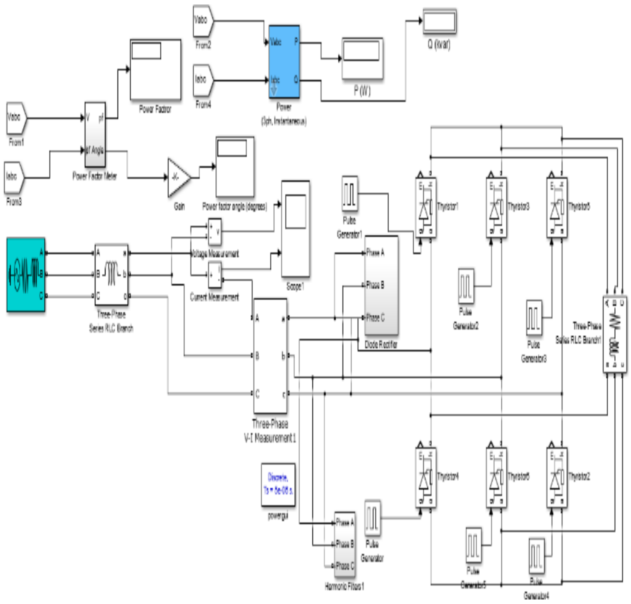

Fig 12 simulation of three-phase thyristor with passive filter

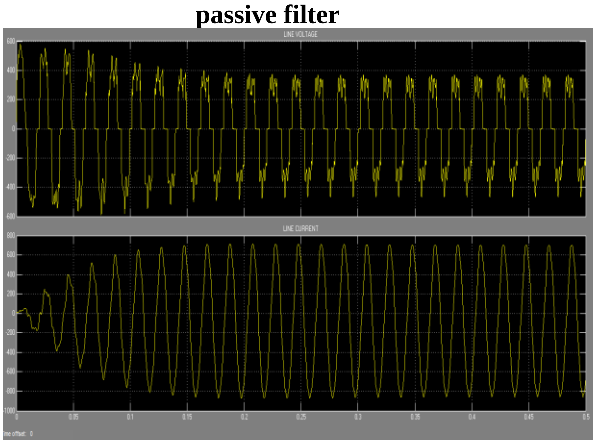

Fig 13 line voltage and current waveform for Three-stage thyristor system for α=0° with passive filter

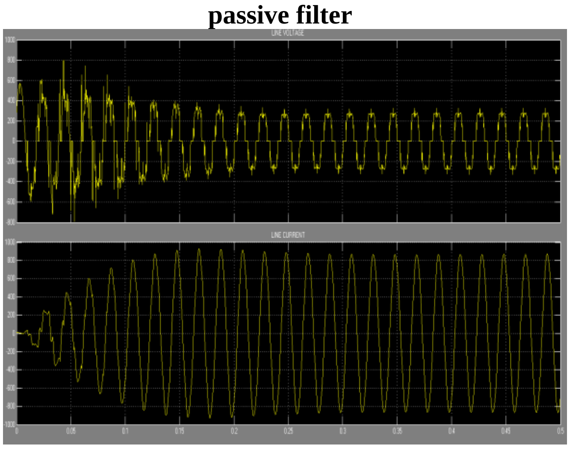

Fig 14 line voltage and current waveform for three-phase thyristor system for α=60° with passive filter

For α=0°, for this situation, before the addition of the power channel, Total Harmonic Distortion (THD) of supply current was 43.24 % and source voltage was 14.28%. after the addition of shunt dynamic channel THD of supply current 39.23% and source voltage, 8.41% comes down. after the addition of series dynamic channel THD of supply current 41.57% and source

voltage, 4.87% comes down. after the inclusion of shunt aloof channel THD of supply current 38.96% and source voltage, 13.80% comes down.
For α=60°, for this situation, before the addition of the power channel, THD of supply current was 64.57 % and source voltage was 14.22 after the addition of shunt dynamic channel THD of supply current 61.56% and source voltage, 11.57% comes down. after the addition of series dynamic channel THD of supply current 61.38% and source voltage, 11.82% comes down. after the inclusion of shunt aloof channel THD of supply current 62.76% and source voltage, 12.15% comes down.

Table 1 simulation result for 180° scheme for α=0

sr no		Power factor	Active power	Reactive power	THD				THD			
					Voltage THD	3rd	5th	7th	Current THD	3rd	5th	7th
1	without filter	0.9799	956.6	471.9	14.28	2.41	6.51	6.32	43.24	16.48	14.10	9.16
2	shunt active filter	0.9953	1200	-81.59	8.41	0.41	2.56	2.94	39.23	14.61	12.29	5.89
3	series active filter	0.9985	1238	-332.4	4.87	0.58	0.95	0.66	41.57	16.28	4.47	4.56
4	passive shunt filter	0.999	1003	-130.2	11.07	2.06	5.12	4.88	35.23	10.80	13.57	8.74

Table 2 simulation result for 180° scheme for α=60°

sr no		Power factor	Active power	Reactive power	THD				THD			
					Voltage THD	3rd	5th	7th	Current THD	3rd	5th	7th
1	without filter	0.9644	636.5	1107	14.22	1.91	3.62	3.69	64.57	17.89	24.81	12.77
2	shunt active filter	0.982	725.3	1078	11.57	0.58	3.20	2.27	61.56	14.38	22.62	11.01
3	series active filter	0.9868	646.9	1050	11.82	0.68	3.14	2.24	61.38	14.14	22.41	11.12
4	passive shunt filter	1	707	47.81	12.15	1.46	3.49	2.46	62.76	16.59	16.39	8.74

Table 1 and 2 show results of a simulation for α=0° and α=60° before and after compensation. Here in table dynamic power, receptive power, control factor and, sound values are given. By using a dynamic channel, arrangement dynamic channel and shunt passive filter power factor and reactive power are improved. As well reactive power and harmonics are reduced.

VI. CONCLUSION

In this paper the exhibition investigation of shunt dynamic power channel, series active power filter and shunt passive power filter have been completed. Reproduction results demonstrate the adequacy of the above said power channel for symphonious end in contorted supply current and voltage. Active power and power factor also improved, reactive power also reduced.from table 1 it is concluded that power factor is getting good at value 0.999 using a passive filter and also reactive power is also reduced at a value -130.2 from 471.9. but voltage harmonics are reduced a minimum value in case of a series active filter at a value of 4.87 from 14.28. current harmonics are reduced a minimum value in case of a passive filter at a value of 35.23 from 43.24. with all filter, it is seen that 3rd,5th and, 7th harmonics are reduced at a good value. Hence by using this filters power quality can be improved to a good value.from table 2 it is concluded that power factor is getting good at value 1 using a passive filter and also reactive power is also reduced at a value 47.81 from 1107. but voltage harmonics are reduced a minimum value in case of shunt active filter at a value of 11.57 from 14.22. current harmonics are reduced a minimum value in case of a series active filter at a value of 61.38 from 64.57. with all filter, it is seen that 3rd,5th and, 7th harmonics are reduced at a good value. Hence by using this filters power quality can be improved to a good value.So here harmonics are reduced at a good value in both the case when firing angle 0° and 60° is by using an active filter. Also, active power and power factor are increased at a good value.

VII. FUTURE SCOPE

Here in this paper, the performance of a shunt active filter is discussed by using a PI controller, by using this value of THD are reduced. But instead of this PI controller, any other controller can be used like fuzzy, ANFIS, etc. by using this controller THD values can be reduced to a good value.

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Prof (Dr). Nimit Shah has completed his Bachelor of Engineering in Biomedical and Instrumentation Engineering from Saurashtra University, Master of Engineering in Electrical Engineering (Automatic Control & Robotics) and PhD in Electrical Engineering from M. S. University Baroda. He is currently working as Associate Professor in Electrical Engineering department in C.U shah college wadhwan. He has 14 years of teaching experience. He has published 20+ manuscripts in various international journals and international conference. He has guided 8 candidates in ME and currently guiding 4 candidates in Ph.D. His area of interest includes Power Electronics, Soft Computing, and Medical Image Processing.

Prof (Dr). Dhaval R Bhojani is currently working as Assistant Professor in Department of Electronics & Communication Engineering in Government Engineering College Rajkot, Gujarat, India. He is having teaching experience of more than 13 years in various institutes. He has done his Ph.D. in year 2013. He has published 15+ manuscripts in various international journals. Also, he has filled the patent on his Ph.D. thesis. He has guided 6 candidates in ME and currently guiding 2 candidates in Ph.D. His domains of interest are Electrical and Electronics Engineering, Image Processing, Embedded Systems, and Industrial Automation. He has been associated with many professional bodies as lifetime member. He has been awarded with best mentor award for startups in SSIP conference.