International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 04 | April - 2022 Impact Factor: 7.185 ISSN: 2582-3930

IMPROVEMENT OF POWER QUALITY USING HYBRID ACTIVE POWER FILTER TOPOLOGY

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Abstract - System dependability raises worries about shunt capacitor failure, voltage spikes, voltage instability, and overcurrent due to resonance, among other problems. The power quality problems of the instantaneous sort include many transient phenomena such as voltage sag/dip, swell, noise, and voltage fluctuations. Uniform flow problems include flicker, harmonics current under load, and unstable load currents. For single phase 2 wire, three phase three wire, and three phase four wire designs, the employment of active, passive, hybrid filters in series, shunt, or a combination of them has aided in the balance of linear and nonlinear loads as well as the reduction of distortions. Shunt active power filters have been demonstrated to be useful in eliminating harmonic current in quasi loads. This paper discusses hybrid active power filters with active shunted and passively shunt architectures, passive series and actively shunted configurations, and instantaneous reactive power theory as a control mechanism for harmonics deterioration and performance enhancement. Simulations and test data are used to demonstrate the efficacy of the topology and control technique.

Key Words: THD (Total Harmonic Distortion), harmonics, hybrid power filter, IRPT (Instantaneous Reactive Power Theory).

1. INTRODUCTION

Passive filters were frequently employed to reduce overtones, whereas capacitors were used to improve power factor. Active power filters, on the other hand, are being studied to address their drawbacks, which include their high dependency on system features, fixed remuneration, difficulties of network resonant with impedance, and limited ability to screen out specific frequencies.

Active filters offer a lot of drawbacks, including the following:-

• Increased filter capacity, which might reach up to 80% of demand • Increased filter capacity, which might reach up to 80% of demand

• Due to the high rating, it might be a significantly more expensive option for improving energy performance.

• Filters could not provide a complete solution to both voltage and current-related power quality issues.

• A rise in inefficiencies

The cost of the active filter, on the other hand, rises when its ratings approach 80% of the load. HPFs (hybrid power filters) have been designed to solve the drawbacks of both active and passive filters, and they appear to be more cost effective for balancing non-linear needs.

2. HYBRID POWER FILTERS

The hybrid power filter is a type of filter that incorporates both passive and active filters. They do have the advantage of having active and passive filters together.

The benefits of both shunt passive and series passive filters are combined in a hybrid filter, which eliminates the difficulties that each filter has when used alone. These hybrid filters have better screening properties in a variety of situations. [1]

The hybrid active filter combines passive and active filters to solve the disadvantages of employing active and passive filters independently for reactive power control and repetition reduction. [2-5].

The research looks at hybrid filter architectures such as series passive and shunts active filters, as well as hybrid filters with shunt active and shunt passive filters, and the IRPT control system.

2.1 Different Hybrid Active Power Filters Configuration:-

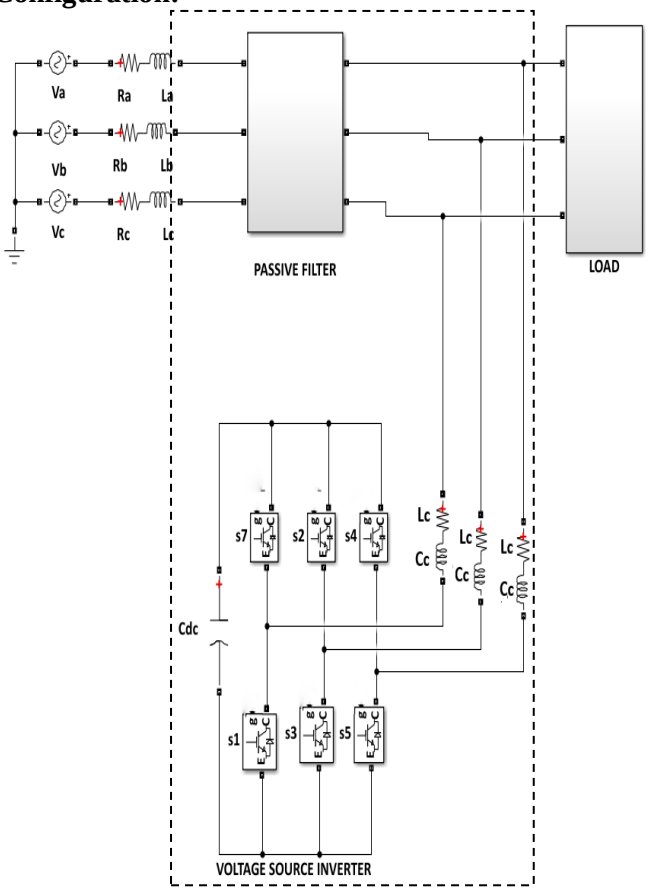

Fig1; Hybrid Filter with Combination of Series Passive and Shunt Active Filter

(A) Combination of Series Passive and Shunt Active Filter

As can be seen in fig. 1, this composition consisted of an The passive filter is linked in sequence with the active filter, which is paired in shunt in this design. The instantaneous reactive power theory is employed as a control approach, resulting in an approach that is comparable to that of the hybrid filter's active shunt and passive shunt combination. Figure 1 depicts a hybrid filter configuration. [7-9].

(B) Shunt Active and Shunt Passive Filter

The order wherein overtones must be adjusted determines the active power filter rating. As an outcome, the APF will be shorter and less costly, with short channel effects being screened. The construction of this filter is based on this basic principle. The shunt-connected passive filter eliminates high-frequency portions, while the shunt-connected active power filter eliminates reduced frequency distortions. [10].

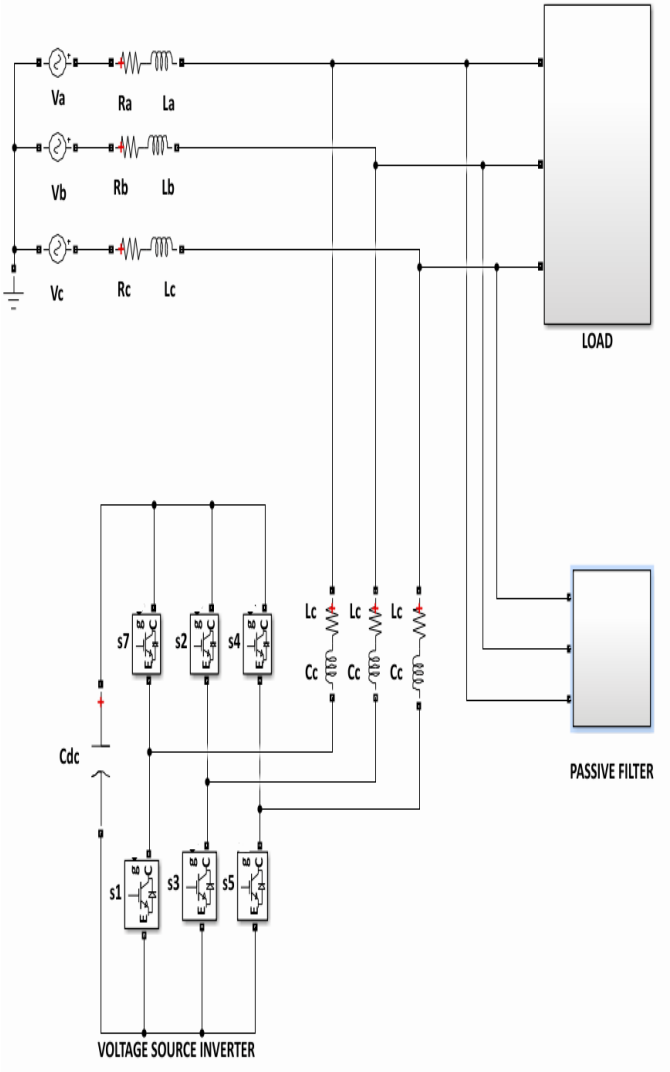

Fig -2: Hybrid Filter with Combination of Shunt Active and Shunt Passive Filter

3. CONTROL STRATEGIES

The overtones are reduced and the power performance is improved by using the filter. The filter should be controlled efficiently in order to achieve the desired outcome. The active shunt and passive shunt based hybrid filters are discussed in this work among the different hybrid filter topologies accessible in the research.

DSTATCOM's major goal is to mitigate power concerns depending on current. DSTATCOMs minimise reactive power, poorly balanced currents and harmonic components, that are the most popular power quality oriented problems that are relied on current, and it also aids in the source of balanced sinusoidal waveform with the help of the Dc link of the supply voltage inverter based DSTATCOM.

With the help of the DC link of the power supply alternator centred DSTATCOM, it also assists in the generation of steady sinusoidal waveform.

A number of control techniques can help in the development of triggering pulses that enable inverter operation. [8]. The control method proposed in this study is instantaneous reactive power theory.

3.1 Instantaneous Reactive Power Theory

The block diagram of instantaneous reactive power theory is shown in fig 3.

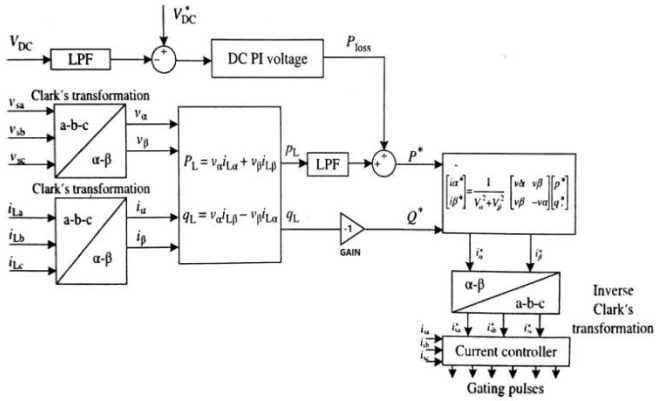

Fig -3: Instantaneous Reactive Power

The current (three phase) and voltages at the point of common connection are reflected in monitoring, yielding instantaneous active and reactive power. To reduce rippling components, the Butterworth filter recognizes and processes the position of common coupling values (three phase). [11]

Clark's reduction is used to translate three phase output values into two phase - orthogonal observations, with orthogonal dimensions provided as(v_0, v_α, v_β).

$$\begin{pmatrix} V_\alpha \\ V_\beta \end{pmatrix} = \sqrt{\frac{2}{3}} \begin{pmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{pmatrix} \begin{pmatrix} V_{sa} \\ V_{sb} \\ V_{sc} \end{pmatrix} \quad (1)$$

The conversion of 3 phase output current to two phase - orthogonal coordinates is defined in as follows:

$$\begin{pmatrix} i_{L\alpha} \\ i_{L\beta} \end{pmatrix} = \sqrt{\frac{2}{3}} \begin{pmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{pmatrix} \begin{pmatrix} i_{La} \\ i_{Lb} \\ i_{Lc} \end{pmatrix} \quad (2)$$

Demand side instantaneous active power is :-

$$p_L = v_\alpha i_{L\alpha} + v_\beta i_{L\beta} \quad (3)$$

The load side instantaneous reactive power can be given as:-

$$q_L = v_\alpha i_{L\alpha} - v_\beta i_{L\beta} \quad (4)$$

Approximation of the 3 source current is as follows:-

$$\begin{pmatrix} i^*_{sa} \\ i^*_{sb} \\ i^*_{sc} \end{pmatrix} = \sqrt{\frac{2}{3}} \begin{pmatrix} 1 & 0 \\ -\frac{1}{2} & -\frac{\sqrt{3}}{2} \\ -\frac{1}{2} & \frac{\sqrt{3}}{2} \end{pmatrix} \begin{pmatrix} v_\alpha & v_\beta \\ -v_\beta & v_\alpha \end{pmatrix}^{-1} \begin{pmatrix} p^* \\ q^* \end{pmatrix} \quad (5)$$

For the synthesizing of voltage source inverter modulation pulses, the standard current in this instantaneous reactive power theory configuration is tested with the current supply.

4. SIMULATION RESULTS

To test the network behavior and performance, the suggested technique is implemented in MATLAB. The simulation is performed in real-life conditions, and the results have been compared and assessed.
The accompanying are the several design frameworks for the software:-

Source voltage (per phase) =240 volts.

The passive filter parameters for a Series Passive and Shunt Active Filter design are listed below :-

Table -1: Passive Filter Specification

	Passive Filter Parameters		
	Resistance (ohms)	Inductance (mH)	Capacitance (μF)
5th order harmonics	0.03	14	25
7th order harmonics	0.03	6	25

The passive filter parameters for a combined shunt active and shunt passive filter design are as follows :-

Table -2: Passive Filter Specification

	Passive Filter Parameters		
	Resistance (ohms)	Inductance (mH)	Capacitance (μF)
5th order harmonics	0.01	2.5	40
7th order harmonics	0.01	3.3	30

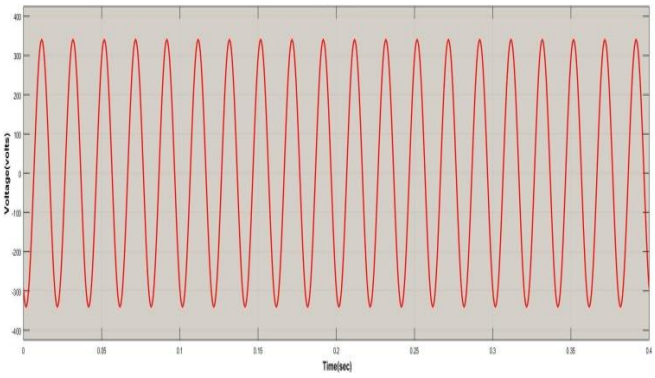

Fig -4: Source voltage waveform

Arrangement 1: Series passive shunt active based hybrid filter

The source current of series passive shunt active filter with only passive compensation only is shown in fig (5). The control strategy used is instantaneous reactive power theory.

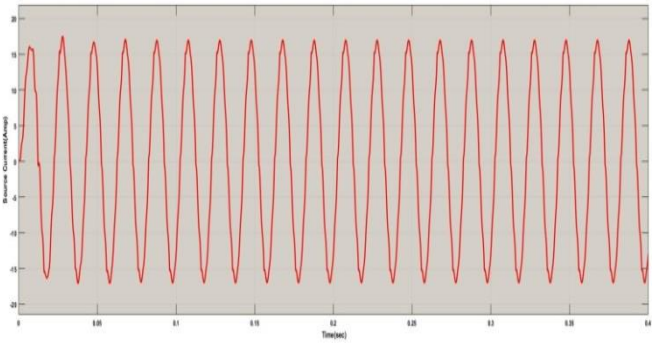

Fig -5: Source current waveform with passive filter only

Figure 5 shows the input current of a series passive shunt active filter without remuneration. The regulating method appears to be instantaneous reactive power theory. Filters were used to eliminate the distortions. When a hybrid filtration system, which combines passive and active filters, is used, THD is 4.45 percent. When a hybrid filter is used, the source current waveform is shown in Figure 6.

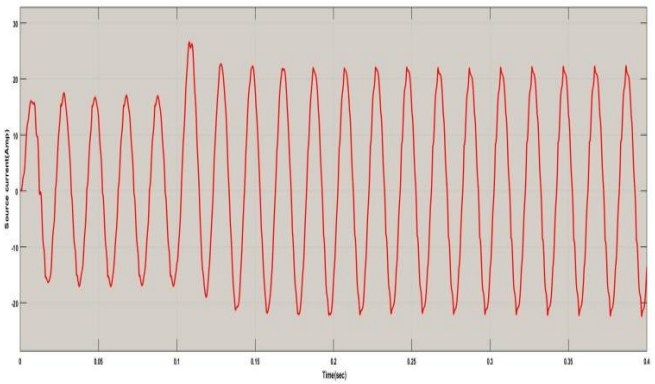

Fig -6: Source current waveform with hybrid filter compensation

Arrangement 2: Shunt active and shunt passive based hybrid filter

The input current spectrum is shown in Figure 7 before adjustment.

As a consequence, the hybrid filter is used to decrease the aberrations in the input current. The THD of the arrangement with the combo screen is 4.23 percent. After correction, the source current waveform is shown in Figure 8.

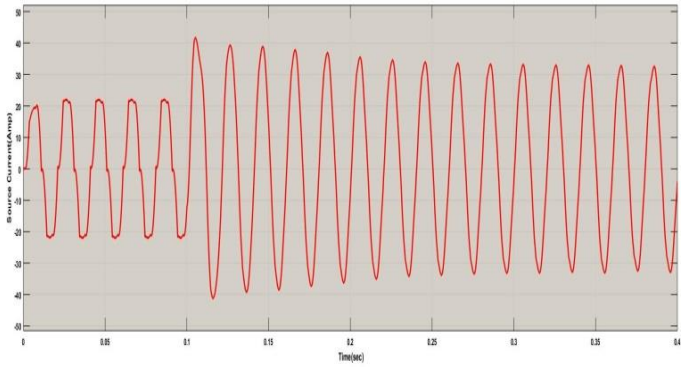

Fig -7: Source current waveform without filter compensation

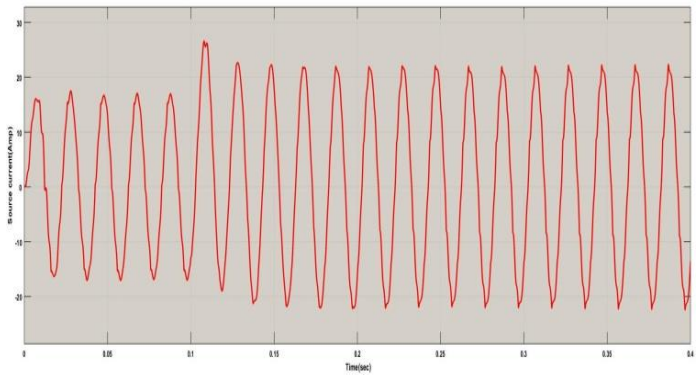

Fig 8: Source current waveform with compensation

Figure 9 depicts the DC link capacitor value.

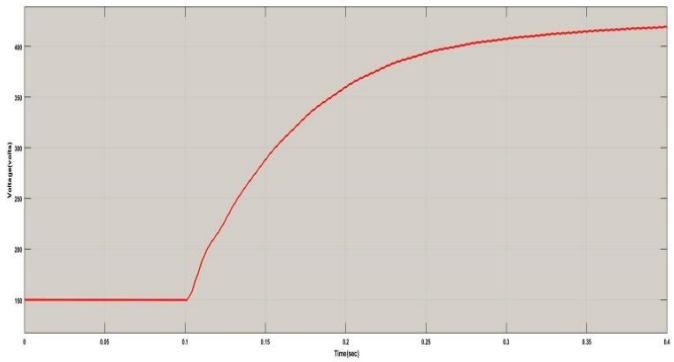

Fig 9: DC link capacitor voltage

5. CONCLUSIONS

The use of switching devices has produced in a huge increase in the structure's energy needs. Non-linear load increases cause a considerable increase in percent Harmonic distortion. The number of faults increases as the % Total harmonic distortion grows. The architecture of numerous hybrid filters are explored, as well as their regulation mechanisms. Based on a comparative investigation of such designs, the active series and passive shunt combination of hybrid filter is judged to be beneficial, as it improves overall performance by minimizing distortions to a great extent. The harmonics compensation characteristic of the passive filter, as well as the load side power factor, have improved as a consequence of the recommended control approach.

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