

Survey Paper on Power Quality Improvement Using Active Power Filters

Vishakha V. Jogdand¹, V. M. Panchade²M. E Student, Department of Electrical Engineering, G.H. Raisoni Institute of Engineering and Technology,
Wagholi, Pune, Savitribai Phule Pune University, Pune India.¹Guide, Department of Electrical Engineering, G.H. Raisoni Institute of Engineering and Technology,
Wagholi, Pune, Savitribai Phule Pune University, Pune India.²

ABSTRACT: Power quality issues are basic in the greater part of business, modern and utility systems, power quality issues, for example, voltage varieties, glimmer, Transients, droop, swell, short and long intrusion of supply voltage, Harmonic twisting voltage unbalance influences power quality. There are numerous advancements to diminish such power quality issues so for this study is done on various setups and topologies for force quality change utilizing dynamic force filters. AF innovation is presently having characteristic development for giving pay to music, receptive force, and/or nonpartisan current in air conditioning systems. These distinctive arrangements of APFs have been proposed to repay different force quality issues.

KEYWORDS: Active Power Filter (APF), Power Quality, Reactive power, Harmonics

I. INTRODUCTION

Power quality is a term that implies distinctive things to various individuals. Establishment of Electrical and Electronic Engineers (IEEE) Standard IEEE1100 characterizes power quality as "the idea of driving and establishing delicate electronic gear in a way appropriate for the hardware." Natural marvels, for example, lightning are the most continuous reason for force quality issues. Exchanging marvels bringing about oscillatory homeless people in the electrical supply. Ordinarily aloof L-C channels were utilized to diminish music and capacitors were utilized to enhance the force component of the air conditioner loads. Be that as it may, latent channels have the bad marks of settled pay, huge size, and reverberation. The AF innovation is presently having regular development for giving remuneration to sounds, responsive force, and/or impartial current in air conditioning systems. AF's are likewise used to dispense with voltage music, to manage terminal voltage, to smother voltage flash, and to enhance voltage equalization in three-stage frameworks. Strong State control of air conditioning power utilizing thyristors and other semiconductor switches is generally utilized to encourage controlled electric energy to electrical burdens, for example, movable pace drives (ASD's), heaters, PC power supplies, and so on. Such controllers are likewise utilized as a part of HV dc frameworks and renewable electrical force era. As nonlinear burdens, these strong state converters draw consonant and responsive force segments of current from air conditioning mains. In three-stage frameworks, they could likewise bring about unbalance and draw intemperate nonpartisan streams. The infused sounds, receptive force weight, unbalance, and unnecessary nonpartisan streams cause low framework productivity and poor force variable. They additionally make aggravation different buyers and obstruction in close-by correspondence systems. Broad reviews [5] have been done to evaluate the issues connected with electric force systems having nonlinear burdens. Traditionally latent L-C channels were utilized to diminish music and capacitors were utilized to enhance the force variable of the air conditioner loads. Notwithstanding, inactive channels have the faults of altered remuneration, huge size, and reverberation. The expanded seriousness of consonant contamination in force systems has pulled in the consideration of force gadgets and force framework specialists to create rapid and flexible answers for the force quality issues. Such gear, for the most part known as dynamic channels (AF's) [2], are likewise called dynamic electrical cable conditioners (APLC's), instantaneous receptive force compensators (IRPC's), dynamic force channels (APF's), and dynamic force quality conditioners (APQC's). Lately, numerous productions have likewise showed up [1] on the sounds, responsive force,

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load adjusting, and unbiased current pay connected with direct and nonlinear burdens. This paper goes for exhibiting an extensive overview on the subject of AF's. More than 200 distributions [3] are explored and characterized in six classifications. The principal [1] is on General improvement and study of consonant issues, while the second to fourth classes are on two wire (single stage) [6] three-wire (three stage without unbiased) [5], and four-wire (three stage with impartial) [6] AF's. The fifth classification [9] incorporates the productions on hypotheses of music and receptive force connected with nonlinear burdens. The 6th and last class of productions [2] is on the receptive power and load-adjusting compensators. Be that as it may, a few productions have a place with more than one classification and have been grouped taking into account their overwhelming commitment. This paper is exhibited in seven sections. Beginning with a presentation, the resulting areas cover the best in class of the AF innovation, the diverse setups utilized, the control philosophies, the monetary and specialized contemplations, their choice for particular applications, and the finishing up comments.

II. ACTIVE POWER FILTERS

Many passive and active harmonic filters have been studied to fulfill the power quality problems. Passive filtering has been submitted for consideration for harmonic mitigation in the electrical system due to less cost, simplicity, reliability, and control less operation. However, passive filters have the disadvantages of fixed compensation, large size, and resonance. Active power filters (APF) have many advantages over the passive filters. They will suppress supply current harmonics and also the reactive currents. However, these active filters do not cause resonance like passive filters in the power distribution systems. Consequently, the Active Power Filters performances are independent of the power distribution system properties.

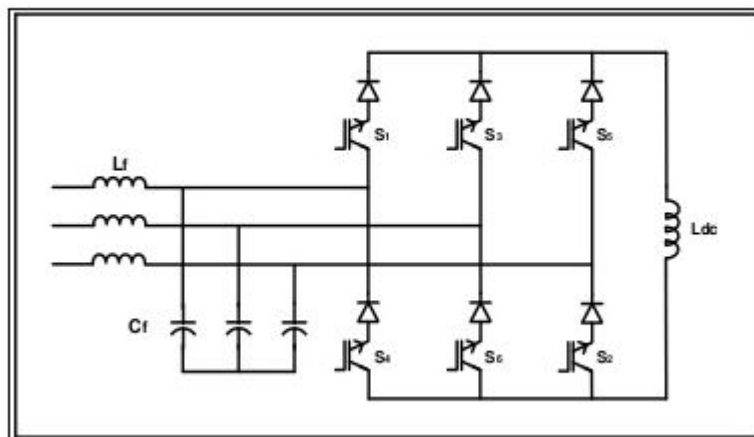


Fig.1 Active Power Filter

III. CLASSIFICATION OF ACTIVE FILTERS

Active Filters can be categorized based on converter type, topology, and the number of phases. Either CSI or VSI bridge structure are the convertor class. The topology can be shunt, series, or a combination of both. The third class is depend on the number of phases, such as two-wire (single phase) and three- or four-wire three-phase systems.

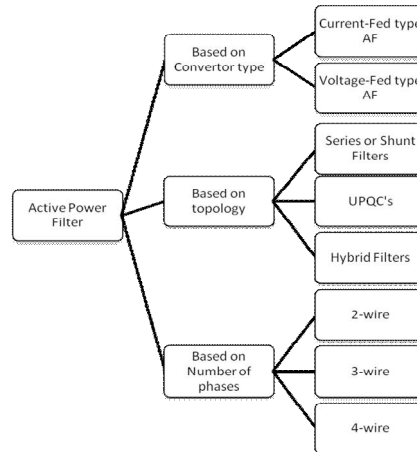


Fig.1 Classification of AF's

A. Converter-Based Classification

In the development of active filters two types of converters used.

Fig. 2 shows the current-fed PWM inverter bridge structure. A current source PWM converter (CSI) is equipped with a dc inductor. It behaves as a non-sinusoidal current source to meet the harmonic current requirement of the nonlinear load. A diode is used in series with the self commutating device (IGBT) for reverse voltage blocking. However, GTO-based configurations do not need the series diode, but they have restricted frequency of switching. They are considered sufficiently reliable but have higher losses and require higher values of parallel ac power capacitors. Moreover, they cannot be used in multilevel or multistep modes to improve performance in higher ratings. The other converter used as an AF is a voltage-fed PWM inverter structure, as shown in Fig. 3. A voltage source PWM converter (VSI) is equipped with a dc capacitor. It has a self-supporting dc voltage bus with a large dc capacitor. It has become more dominant, since it is lighter, cheaper, and expandable to multilevel and multistep versions, to enhance the performance with lower switching frequencies. It is more popular in UPS based applications, because in the presence of mains, the same inverter bridge can be used as an AF to eliminate harmonics of critical nonlinear loads.

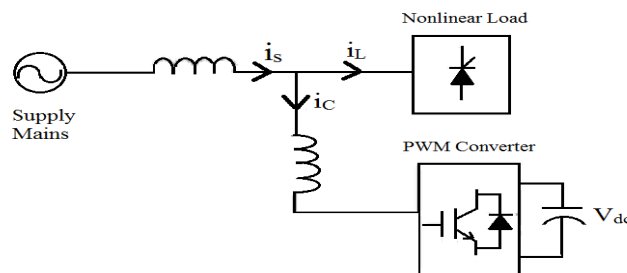


Fig.2 Current-fed type AF

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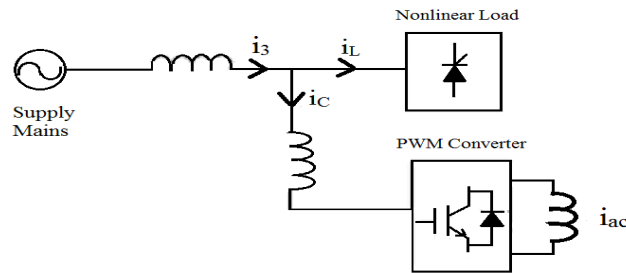


Fig.3 Voltage-fed type AF

B. Topology-Based Classification

AF's can be classified based on the topology used as series or shunt filters and unified power quality conditioners use a combination of both. Combinations of active series and passive shunt filtering are known as hybrid filters. Fig. 2 is an example of an active shunt filter, which is most widely used to eliminate current harmonics, reactive power compensation (also known as STATCOM), and balancing unbalanced currents. It is mainly used at the load end, because current harmonics are injected by nonlinear loads. It injects equal compensating currents, opposite in phase, to cancel harmonics and/or reactive components of the nonlinear load current at the point of connection. It can also be used as a static var generator (STATCOM) in the power system network for stabilizing and improving the voltage profile. Fig. 3 shows the basic block of a stand-alone active series filter. It is connected before the load in series with the mains, using a matching transformer, to eliminate voltage harmonics, and to balance and regulate the terminal voltage of the load or line. It has been used to reduce negative-sequence voltage and regulate the voltage on three-phase systems. It can be installed by electric utilities to compensate voltage harmonics and to damp out harmonic propagation caused by resonance with line impedances and passive shunt compensators. Fig. 4 shows a unified power quality conditioner (also known as a universal AF), which is a combination of active shunt and active series filters. The dc-link storage element (either inductor or dc-bus capacitor) is shared between two current source or voltage-source bridges operating as active series and active shunt compensators. It is used in single-phase as well as three-phase configurations. It is considered an ideal AF which eliminates voltage and current harmonics and is capable of giving clean power to critical and harmonic-prone loads, such as computers, medical equipment, etc. It can balance and regulate terminal voltage and eliminate negative-sequence currents. Its main drawbacks are its large cost and control complexity because of the large number of solid-state devices involved. Fig. 5 shows the hybrid filter, which is a combination of an active series filter and passive shunt filter. It is quite popular because the solid-state devices used in the active series part can be of reduced size and cost (about 5% of the load size) and a major part of the hybrid filter is made of the passive shunt L-C filter used to eliminate lower order harmonics. It has the capability of reducing voltage and current harmonics at a reasonable cost. There are many more hybrid configurations but for the sake of brevity, they are not discussed here; however, details can be found in the respective references.

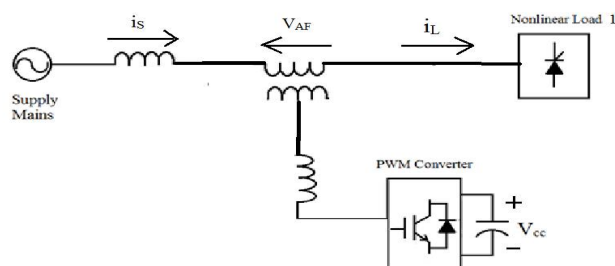


Fig.3 Series-type APF.

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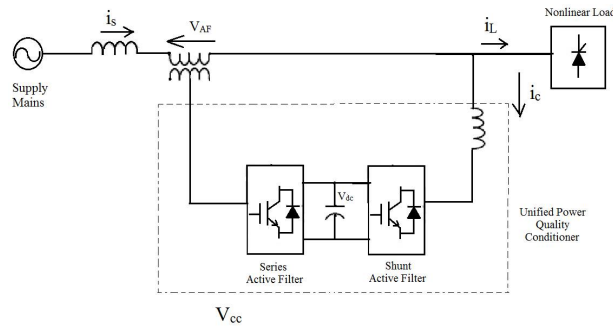


Fig.4 Unified power quality conditioner as universal AF.

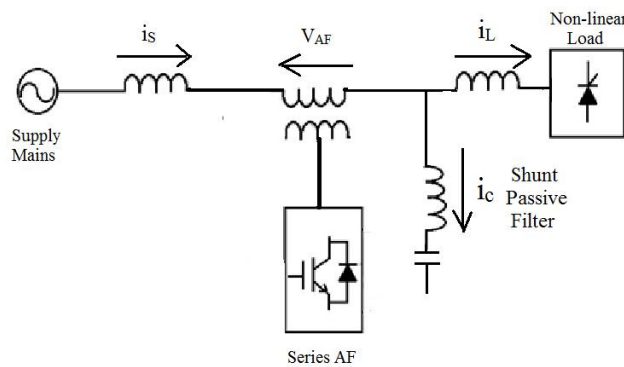


Fig.5 Hybrid Active Filter

C. Supply-System-Based Classification

This classification of AF's is based on the supply and/or the load system having single-phase (two wire) and three-phase (three wire or four wire) systems. There are many nonlinear loads, such as domestic appliances, connected to single-phase supply systems. Some three-phase nonlinear loads are without neutral, such as ASD's, fed from three-wire supply systems. There are many nonlinear single-phase loads distributed on four-wire three-phase supply systems, such as computers, commercial lighting, etc. Hence, AF's may also be classified accordingly as two-wire, three-wire and four-wire types.

1) Two-Wire AF's: Two-wire (single phase) AF's are used in all three modes as active series active shunt and a combination of both as unified line conditioners. Both converter configurations, current-source PWM bridge with inductive energy storage element and voltage-source PWM bridge with capacitive dc-bus energy storage elements, are used to form two-wire AF circuits. In some cases, active filtering is included in the power conversion stage to improve input characteristics at the supply end. Figs. 6-8 show three configurations of active series, active shunt, and a combination of both with current-source bridge, using inductive storage elements. Similar configurations, based on a VSI bridge, may be obtained by considering only two wires (phase and neutral) at each stage of Figs. 2-4. In the case of a series AF with voltage-fed converter, sometimes the transformer is removed and load is shunted with passive L-C components. The series AF is normally used to eliminate voltage harmonics, spikes, sags, notches, etc., while the shunt AF is used to eliminate current harmonics and reactive power compensation.

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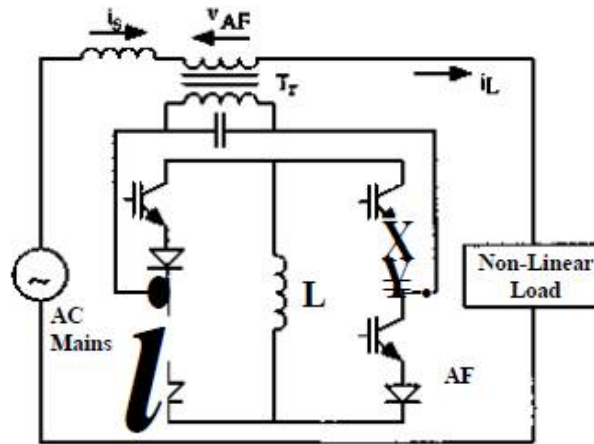


Fig.6. Two-wire series AF with current-source converter.

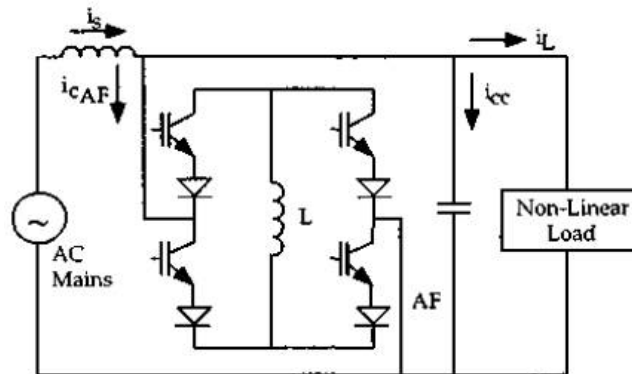


Fig. 7. Two-Wire shunt AF with current-source converter.

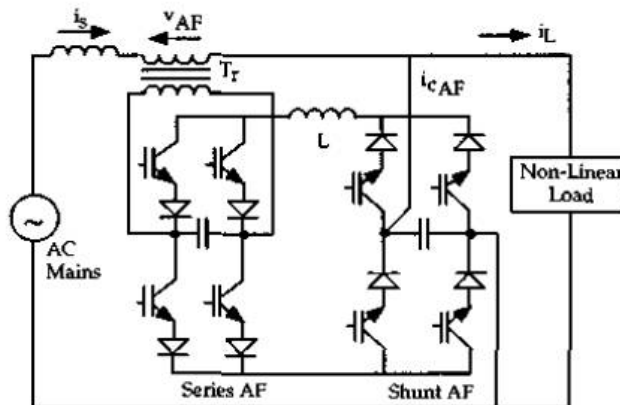


Fig. 8. Two-wire unified power quality conditioner with current-source converter.

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2) Three-Wire AF's: Three-phase three-wire nonlinear loads, such as ASD's, are major applications of solid-state power converters and, lately, many ASD's, etc., incorporate AF's in their front-end design. A large number of publications have appeared on three-wire AF's with different configurations. All the configurations shown in Figs. 1-5 are developed, in three-wire AF's, with three wires on the ac side and two wires on the dc side. Active shunt AF's are developed in the current-fed type (Fig. 1) or voltage fed type with single-stage (Fig.2) or multistep/multilevel and multiseries configurations. Active shunt AF's are also designed with three single-phase AF's with isolation transformers for proper voltage matching, independent phase control, and reliable compensation with unbalanced systems. Active series filters are developed for stand-alone mode (Fig. 3) or hybrid mode with passive shunt filters (Fig. 5). The latter (hybrid) has become quite popular to reduce the size of power devices and cost of the overall system. A combination of active series and active shunt is used for unified power quality conditioners (Fig. 4) and universal filters

3) Four-Wire AF's: A large number of single-phase loads may be supplied from three-phase mains with neutral conductor. They cause excessive neutral current, harmonic and reactive power burden, and unbalance. To reduce these problems, four-wire AF's have been attempted. They have been developed as:

- 1) Active shunt mode with current feed and voltage feed;
- 2) Active series mode; and
- 3) Hybrid form with active series and passive shunt mode.

IV. CONCLUSION

The advanced active filters characterized by low-cost, high efficiency, high-performance, and value-added functions for the customers will come onto the market in the near future, thus being viable and cost-effective in power conditioning. A large number of AF configurations are available to compensate harmonic current, reactive power, neutral current, unbalance current, and harmonics. Active Power Filter can mitigate some types of power quality disturbances such as harmonics, reactive power and unbalanced load currents. These disturbances can cause misoperation of highly automated systems and malfunction of sensitive loads connected to point of common coupling (PCC) which increases the economical cost of fault. APF can be very effective solution such a high technology industrial plants or the group of customers having sensitive loads in Custom Power Park or Power Quality Park. This paper has been mainly concentrated on the converter topologies and the control algorithms. A number of APF topologies have been reviewed. With this study, the findings about APF studies in the literature and thus the trends of APF through the years are clearly observed.

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