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COMPREHENSIVE REVIEW OF A STUDY OF HYBRID FILTER

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Abstract: This paper presents results of a comparative study of Hybrid filter technique, comprise of active and passive stage, which can be implemented in any general distribution supply system. The main filter task in distribution supply system is to mitigate the current dynamics in order to prolong the operational life of delicates supplies, i.e., fuel cell and to reduce the electromagnetic interferences between sensitive electronic circuits connected to the distribution net. The active stage is better the passive stage in order to: 1) In low-frequency range improves its insufficient attenuation and 2) An active filter based on an electronic smoothing inductor. Recent year the rapidly use of nonlinear loads and devices in power system, like thyristor-controlled inductors for FACTS, HVDC transmission converter and ASD (adjustable speed drives). In this paper explain the problem of power quality due to harmonics, harmonic mitigation filter technique and hybrid filter.

Keyword: power quality, harmonics, active filter, hybrid Filter

I. INTRODUCTION

In regular life, there are nonlinear loads that generate harmonic currents. The power electronics devices nonlinearity and the higher switching frequency are mostly conscientious for these harmonic currents which can correlate harmfully with a wide range of power system equipment, control systems, circuit protection, and other harmonic sensitive loads. As a reason of the harmonics can tripping of source supplies, overheat building wirings and can result in failure of total equipment. There are numerous methods to reduce the effect of harmonics, generally harmonic filter method is used. The active power filters to mitigate harmonic problems [1,2]. Then, the application and concepts of active power filters have become more popular and have attracted great attention [3–4]. Concept of harmonic mitigation technique in which, reference current is generated by using the distorted waveform, many theses have been developed like instantaneous reactive power theory (p-q theory), d-q theory, neural network etc. Basically active filter have some disadvantage, on of the main problem is active filter is used for current related problem so reduce this problem using hybrid filter. In this paper present the issue of power quality, problem due to harmonics, harmonic filter technique and idea about hybrid filters.

II. ISSUE OF POWER QUALITY

As per IEEE standard IEEE1100 defines power quality as "the idea of powering and grounding sensitive electronic equipment in a manner suitable for the equipment." Power quality is also explained as: the power quality is a set of electrical limitation that allows a equipment to the function in its planned manner without significant losses of performance and life expectation [3]. It is essential to first understand the power quality variations that can cause issues with sensitive loads. Categories for these types of variations must be developed with a reliable set of definitions so that measurement equipment can be designed in a regular manner and so that information can be shared between different groups performing measurements and evaluations. Rapidly electronic equipment are widely use so that they are affected power quality. Power quality issues are given bellow:

Voltage dip (or sag):

A normal decrease voltage level between 10% and 90 % of the nominal rms voltage at the power frequency, for durations of half cycle to 1 minute. Causes of the Voltage dip/sag are faults on the transmission or distribution network and also fault in consumer's installation equipments.

Very short interruptions:

In the power system there is various interruption of electrical supply for duration from few milliseconds to one or two second, Causes of very short interrupt are mainly due to the protection of opening and automatic reclosure to decommission a faulty section of the network. The major fault causes are insulation failure, lightning and insulator flashover.

A. Voltage spike:

In the power system very fast variation of voltage value for durations from a several microseconds to few milliseconds. These voltage variations may reach thousand of voltage, even in low voltage; causes of voltage spike are lightning, switching of lines or power factor correction capacitors, disconnection of heavy loads.

B. Voltage Swell:

Suddenly increase of the voltage, at the power frequency, outside the normal tolerances, with period of more than one cycle and typically less than a few second. Effect of voltage swell is stop/start of heavy loads, badly dimensioned power sources, badly regulated transformers.

C. Noise:

Superimposing of high frequency signals on the power system waveform of 0 to 30 Hz. Causes of noise are electromagnetic interferences forced by hertzian waves such as microwaves, television diffusion, and radiation due to welding machine.

D. Harmonic distortion:

Current or Voltage waveforms imagine non-sinusoidal shape. The waveform corresponds to the sum of various sine-waves with different magnitude and phase, having frequencies that are multiples of power-system frequency. Causes of harmonics distortion are electrical machines does not working above the knee of the magnetization curve, arc furnaces, welding machines, rectifiers, and DC brush motor. Recent year, generally in power system harmonic is one of the main problems. Problems due to harmonic in power systems are given bellow:

- Electrical devices are function uncertainly at same time of day
- When storm occur at that time equipments are damage
- Without any overloading condition Circuit breakers are operate
- Basis of Frequency, electronic equipments are failing automated system does not work properly.

There are basically two approaches to reduce of power quality problems; the first approach is called load conditioning, which ensures that the device is less sensitive to power disturbances, allowing the processing even under significant voltage distortion. The second approach is to put in line conditioning systems that counteracts the power system disturbances. There are various solution to voltage and current quality problems is offered but recent year filter techniques is one of the beast solution. The filter is classified based on converter type, topology, and the number of phases. Generally topology base filter is used. Topology is classified as passive and active filter. Passive filter have disadvantages over the active filter. Active filters can be classified based on the topology used as shunt and series filters, and unified power quality conditioners used a combination of both. The combination of shunt and series filters is known as hybrid filters. Different active filter basic diagram is given below:

III. ACTIVE FILTER

The purpose of the active power filter connection by end users is to compensate current imbalance or current harmonics of their own harmonic-producing loads. The current harmonic mitigation by active filter is organized in a closed loop manner. In our power supply system, the active power filter will inject and draw the compensating current to the line based on the changes of the load [5].

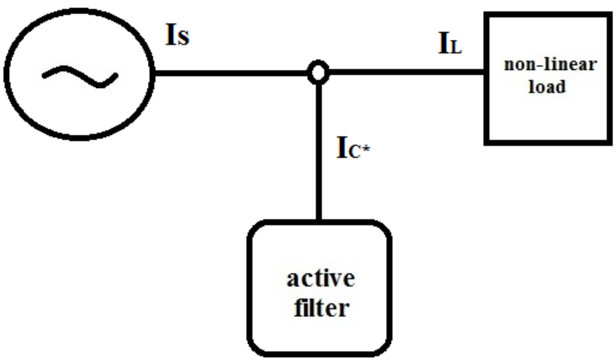

Fig.1: active power filter [3]

For the following equation, the source current is equal to the load current and filtering current [5]:

$$I_s = I_L + I_c^* \quad \ldots 1$$

Active Filter is further classified as series active filter, shunt active filter, unified power quality conditioner (UPQC) and hybrid filter. The basic structures of all filters are given below:

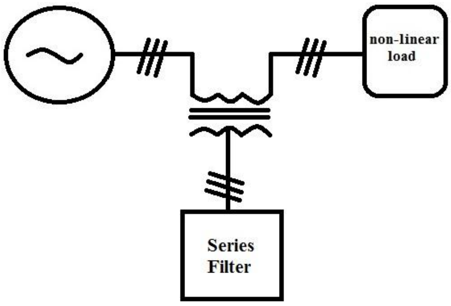

Fig.2: Series active power filter [3]

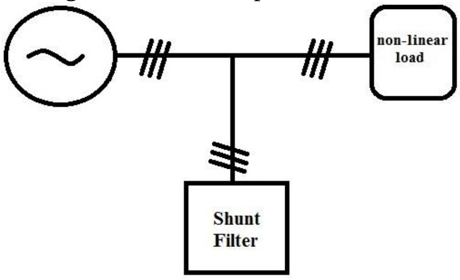

Fig.3: Shunt active power filter [3]

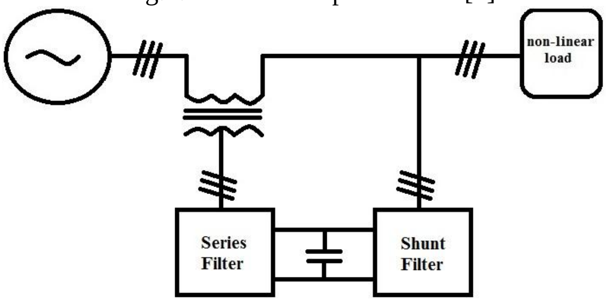

Fig.4: Unified Power Quality Conditioner [3]

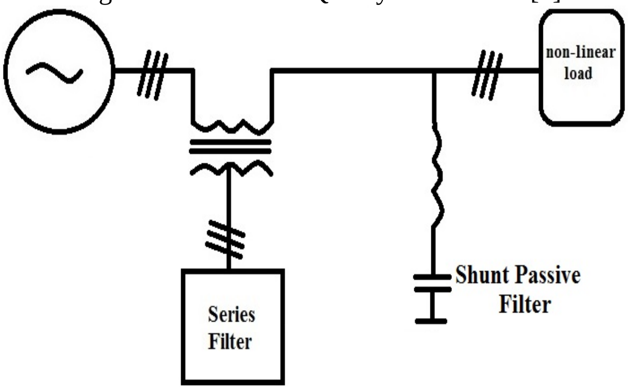

Fig.5: Hybrid filter [3]

In the Active filter, series active filter is used to mitigate only voltage related problems, shunt active filter is used to mitigate current related problems, so to mitigate both current and voltage problems UPQC is used. Using the hybrid filter it get better result over the UPQC and easy to applicable for reduce the current and voltage harmonics [12].

IV. HYBRID FILTER

Hybrid active filter, combination of active and passive filter, the passive filter's benefit of great capacity with that of active filter possibility to realized dynamic compensation, therefore to get the requirements of wide range of dynamic compensation. Accordingly, it has gained thought from experts in the area of reactive power compensation and harmonic suppressing [6].

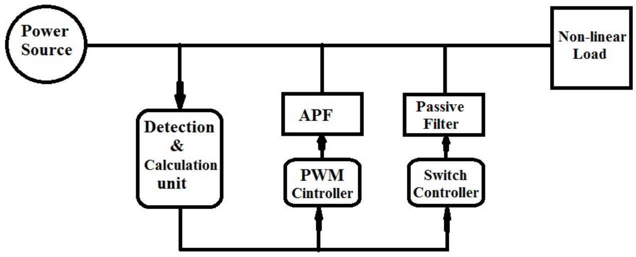

Fig.6: Basic Diagram of Hybrid filter [6]

Illustrate in the figure 5, hybrid filter is connected with parallel: which mainly consider three units as: detection of harmonic and reactive current detection and calculation unit, power filter and active power filter unit. In this system, power filter is used to compensate a majority of low order harmonics and high order harmonics and also most reactive power, whereas APF is for the residual harmonic order and a small reactive power which flow into the hybrid filter.

The advantages of the hybrid filter are as follows:

A low switching frequency IGBT inverter is employed to support the input utility voltage and to compensate for reactive power[7].

- A low voltage high switching frequency MOSFET inverter is working for harmonic current mitigation.
- The MOSFET and IGBT inverters allocate the same dc-link via a split capacitor bank, therefore simplifies control.
- The necessary dc-link voltage of the IGBT inverter is lower, while its main purpose is to support fundamental voltage. Consequently, the proposed active power filter system operates at lower voltage compared to the conventional single stage APF.
- By employing appropriate shielding in the isolation transformer at the output of the high-switching frequency inverter, overall noise can be reduced.
- The proposed hybrid active filter system is essentially more stable and can adapt to sudden load changes.
- In big industrial systems, the function of the IGBT inverter can be replaced by a rotating synchronous machine.

V. BASIC TOPOLOGIES OF HYBRID ACTIVE FILTER

There are three basic topologies of hybrid filter applicable to the power system for harmonic mitigation.

Topology I

This topology is proposed by M.Takeda in 1987, is illustrating in Fig. 6. The hybrid active filter is a parallel combination of a PAPF (parallel-active power filter) and also a PPF (parallel-passive filters). Both filters the active filter and passive filter are connected in parallel with the non-linear load. The function of the active filter is to mitigate for harmonic after passive filter.

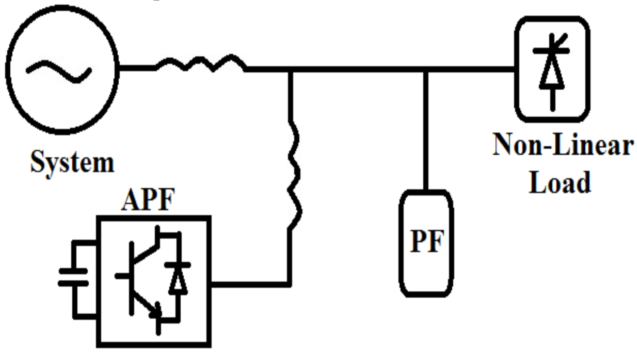

Fig.7: System Configuration of Topology I [7]

Basically, a parallel active filter has been considered as a CS (current source) connected in parallel with the load. The mitigation approach of this filter is same as the principle of active filter to inject harmonic current into the ac system, which are the same amplitude but at a 180°phase shift to that of the load current harmonics. The basic diagram of single-phase harmonic equivalent circuit is presented in Fig. 6.

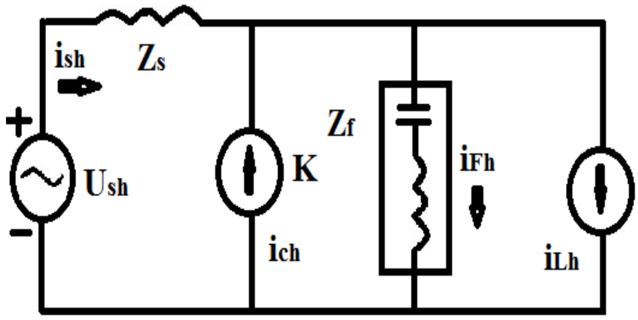

Fig.8: Equivalent circuit of single-phase harmonic for Topology I [7]

USh is source voltage at harmonic frequency. ZS is the source impedance. ZF is the equivalent passive filter impedance. iLh is the equivalent harmonic current. iCh is the active filter current injecting into system. K is the equivalent transfer function of the active filter. The control scheme of the active filter is:

iCh = KiLh ….(2)

iSh can be derived from Fig. 6.

$$Ish = \frac{(1-K)ishZf + Ush}{Zs + Zf} \quad ….(3)$$

Here the source voltage Ush is very small and When (1-K)=0, equation (3) shows that the source current becomes sinusoidal.

Topology II

This topology is proposed by F.Z.PENG in 1938 [9, 10] is illustrate in Fig. 7. The hybrid active filter consists of SAPF (series-active power filter) and PPF (parallel-passive filter). The series active power filter is used to remove the parallel passive filter's problems, such as influences and resonance of the source impedance, and enhance compensation performance.

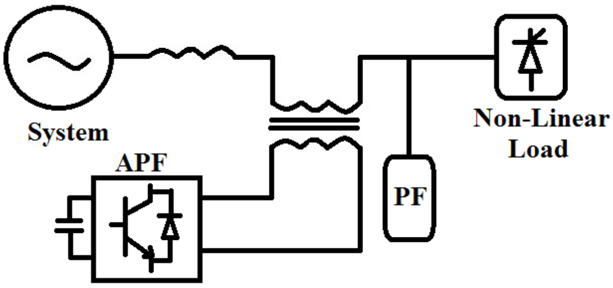

Fig.9: System Configuration of Topology II [7]

Using of basic passive filters is the higher the source impedance, the better the filtering characteristic. Though, the source impedance should display a negligible amount of impedance at the fundamental frequency as a result that it does not cause any substantial fundamental voltage drop, and the two contradictive requirements can be satisfied only by inserting active impedance in series with the ac source. The passive filter is connected in parallel with a load to mitigate the load harmonics. The AF (active filter) in series with the source impedance operates to get better compensation characteristics of the passive filter. At this time, the active filter purpose is not to mitigate the load harmonics but to solve the problems of the passive filter. The diagram of single-phase harmonic equivalent circuit is illustrated in Fig. 8.

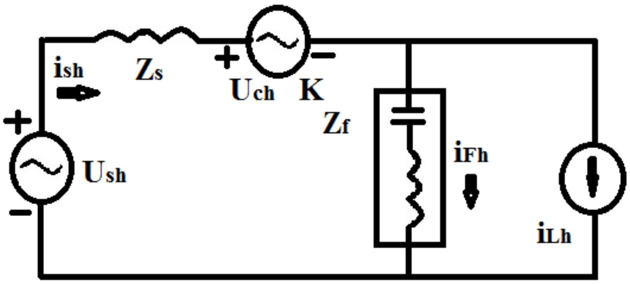

Fig.10: Equivalent circuit of single-phase harmonic for Topology II [7]

Suppose simplicity's sake that the AF (active filter) is an ideal controllable voltage. USh Voltage source at harmonic frequency is zero, ZS is the impedance source, ZF is the equivalent passive filter impedance and iLh is the equivalent harmonic current. The AF is controlled to display zero impedance on the fundamental frequency and K pure resistance on the frequencies of the load harmonics. UCh is the AF voltage and K is the equivalent transfer function of the AF. The basic control scheme of the AF is:

Uch = Kish …. (4)

The harmonic current flowing in the source, which is created by both the source harmonic voltage USh the load harmonic current iLh, is given as follows:

$$ish = \frac{\text{ZfILh}}{\text{K+Zs+Zf}} + \frac{\text{Ush}}{\text{K+Zs+Zf}} \quad ….(5)$$

If consider the active is controlled so that the value of resistance is higher than that of the source impedance, variations in the source impedance have no effect on the compensation characteristics of the PF. Shows equation (5) that if iSh=0 at that time the value of K is infinite, the compensation characteristics become ideal.

Topology III

This topology is proposed by Hideaki Fujita and Hirofumi Akagi in 1990 [11] is illustrate in fig. 9. The hybrid active filter is a series arrangement of PAPF and PPF, consisting of a PF and an APF which are connected in series with each other. This combination is installed in parallel with a non-linear load. The passive filter consists of a 5th- and 7th-tuned high pass filter and LC filter. All the harmonics through into the passive filter and the AF is controlled as a current controlled voltage source and also injects appropriate compensating harmonic currents.

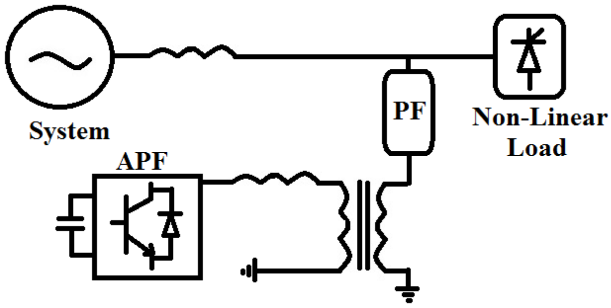

Fig.11: System Configuration of Topology III [7]

In this topology, the AF forces to all the harmonics contained in the load current to flow into the passive filter, hence no harmonic current flows in the source. The basic function of the AF is to remove the problems inherent in using of the passive filter alone and also addition, no fundamental voltage is applied to the AF. As a results in a better reduction of the voltage rating of the AF [10]. The diagram of the single-phase harmonic equivalent circuit is illustrated in Fig. 11.

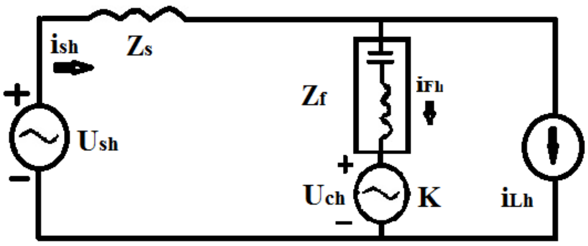

Fig.12: Equivalent circuit of single-phase harmonic for Topology III [7]

Consider that the AF is an ideal controllable voltage source. Here, USh is voltage source at harmonic frequency, ZS is the source impedance, ZF is the equivalent passive filter impedance, iLh is the equivalent harmonic current.

When the AF is connected, and is controlled as a voltage source at that time the equation is:

UCh = KiSh ….(6)

The harmonic source current iSh and the output of the AF UCh are given by the following equations:

$$ish = \frac{\text{Zf iLh}}{\text{K+Zs+Zf}} \quad ….(7)$$

$$Uch = Kish = \frac{\text{KZf iLh}}{\text{K+Zs+Zf}} \quad ….(8)$$

If consider K >> Z, K would control the filtering characteristics and K acts as a resistor to damp parallel resonance between ZF and ZS. On the fundamental frequency, in order to decrease the Voltage-Ampere rating of the active filter, the active filter current is controlled such that the fundamental frequency voltage drops across the PF, i.e. the fundamental voltage across the AF is zero. This results in a huge voltage rating reduction of the active filter.

VI. CONCLUSION

This paper gives the different types of power quality problems and also gives the power quality problems due to harmonics. Harmonic filter technique is used to mitigate the current harmonics as well as voltage harmonic problems. Harmonic filter have different classification, hybrid filter is easy to implement compare to the other filter like shunt, series and unified power quality conditioner. The study the theoretical analysis is verified that hybrid filters have good topology to mitigate the current harmonics and voltage harmonics.

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