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Power Quality Enhancement by Using Hybrid Filter: A Review

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***Abstract*: -- When the non-linear load is linked to the distribution system, it acts as a source of power quality problem which affects the performance of distribution system. This complication is increasing day by day. Hence power quality enhancement is important in the power system. To overcome the power quality issue and in order to enhance the power quality, several topologies of the filter are adopted. This paper is intended to review the hybrid filter for power quality enhancement and different control techniques of the active filter. This hybrid filter is based on the series topology which consists of three phase non-linear load and connecting the active filter (AF), passive filter (PF) in series and in parallel respectively at the point of common coupling (PCC), for the power quality enhancement of the distribution system. The series active filter forces to flow the harmonics in the passive shunt filter, due to this, harmonics eliminate and also it compensates the reactive power. The advantage of this strategy is that the series active filter rating is reduced in between 3% to 6%. This paper presents the very appropriate solution for harmonics mitigation and compensation of reactive power using series hybrid filter topology.**

***Index Terms* – Hybrid filter, Series active filter, Passive shunt filter, Power quality enhancement.**

I. INTRODUCTION

Nowadays, power quality problem is rise in the electrical system. In past decades power electronic devices were developed to control adjustable speed drive (ASD), furnaces, DC motor drive, electronics power supplies, electronic ballasts etc. Some of this power electronics are based appliances not only inject harmonics in the distribution system through point of common coupling (PCC), but also draws the reactive power from distribution system and behaves as a non-linear load [1-7]. This non-linear load deteriorates the power factor and efficiency of distribution system [1]. Also it affects the performance of system, There are some undesirable conditions occurs including overheating, failure of insulation, disturbs nearby consumer and components of the protective device, electronics communication network. These problems cause the interruption in distribution system [1-5]. It is required to enhance the power quality of distribution system.

To achieve the maximum efficiency of a power system and to overcome the power quality problems, many devices are enacted, amongst which passive and active filtering are two approaches mainly used to solve the power quality problem [2]. The passive filter (PF) is a traditionally used solution to minimize the harmonics along with the compensation of reactive power. Passive filter is advantageous because it is less expensive, simple and has a reliable structure. But also passive filter has some drawback in the compensation feature, the passive filter is controlled by the source impedance, passive filter designed depending on the system and they may cause unwanted resonance condition which affect the distribution system stability, the other drawback of passive filter is that it cannot able to changing condition in the network hence passive filter is not a suitable solution for power quality problems [3-7]. Recent development in the power electronics has introduced active filter (AF) as an alternative to passive filter. The active filter is increasingly being used for harmonic mitigation, this filter are available in different configurations. Moreover, unlike passive filter it does not cause the resonance in existing system and also the active filter designed does not depend upon the system. When fast switching of transistor is used in the active filter, a high range frequency noise occur which leads electromagnetic interference in distribution system. In some typical applications rating of the active filter is relatively near to the load since in the many cases the active filter is becomes expensive for the power quality enhancement [3-8]. Coming back to these problems in power system, a new technology in hybrid filter is developed which is the best cost-effective solution, for the harmonic mitigation & compensation of reactive power [4]. In this topology the active filter and passive filter both are present. A hybrid filter structure is available either in series or in parallel. This paper shows overview of the hybrid filter based on series topology, where the active filter (AF), passive filter (PF) are connected in series and in parallel respectively at point of common coupling (PCC). Actually, the origin of this topology is that active filter force the harmonic to flow in the passive filter so that harmonics eliminate & also reactive power compensates [4-8].

II. POWER QUALITY ENHANCEMENT

In distribution system power quality problem occur which caused by non-linear load installation [10]. The load considered as non-linear, when load impedance varies with the

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applied voltage. This changing impedance is the current drawn by the non-linear load, which is not sinusoidal even when the load is linked to the sinusoidal voltage supply. This non-sinusoidal current interacts with the impedance of distribution system then voltage distortions occur, it affects the distribution system components and load. On AC side due to the poor power quality low power factor and voltage unbalance occur. In this way non-linear load is source of power quality problem. Hence power quality enhancement is necessary. There are different types of custom devices installed in the distribution system. In below section the hybrid filter configuration is described for power quality enhancement [9-10].

III. CONFIGURATION OF HYBRID FILTER

A. Classification of hybrid filter

The hybrid filter is classified on the account of supply system, converter type, how many elements used in topology. For feeding of non-linear load supply can be used single phase, three phases (three wire), three phase (four wire) and converter type can be used voltage source inverter (VSI), current source inverter (CSI) and the elements can be used one, two or more than two where either active filter or passive filter. Fig. 1 shows classification of hybrid filter. The active and the passive filters are combined and hybrid filter formed. Mainly, four combination of hybrid filters configuration are available [8].

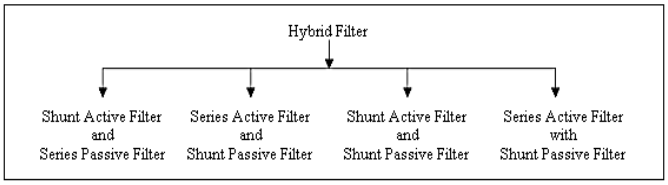

Figure 1 Classification of hybrid filter

B. Selection ceteria of hybrid filter

For consumer, it is important to choose the hybrid filter for the definite application. Selection criteria of hybrid filter is based on the following factor

- Supply of system
- Compensation needed in current
- Compensation needed in voltage
- Range of compensation required
- Type of load
- Cost, Size, Weight, Efficiency, Environment factor

These factors give guideline for the design and selection of the hybrid filter. The selection process is also based on type of load in the distribution system. Mainly there are three categories of the load.

The first is voltage source, second is current source and third is the combination of both sources. In third type of load both kind of the load voltage source and current source is combined together. For such combined type of
the load, the passive parallel filter and active series filter is used in the hybrid filter for a power quality problem [8].

C. Hybrid filter topology

In passive filter the resonance issue is occur and when fast switching of the transistor is used in the active filter then high range frequency noise occur which leads to the electromagnetic interference in distribution system. Due to these limitations of the active filter and passive filter, the hybrid filter topology is explained for power quality enhancement.

The hybrid series filter consist of the three phase voltage source inverter (VSI), ripple filter, coupling transformer, passive filter are used [11], [12]. The series active filter is mitigates the harmonics current, which is cause by the non-linear load. By the giving the high impedance path for the current harmonics which force to flow the current harmonics in the passive filter. Due to this principle of the hybrid filter eliminates harmonics, reactive power compensates and power quality improved. When passive filter connected parallel to the non-linear load then active filter act as a voltage regulator and harmonic isolator [13]. By using coupling transformer the inverter and ripple filter are connected to the distribution systems and also with electrolytic capacitor gives the self-supporting dc bus. By these elements the series active filter is compose.

The function of coupling transformer is that, to meet the current and voltage value of the inverter with distribution system and also it isolates the inverter from source. When harmonic voltage is injected across coupling transformer, harmonic isolation obtained. These voltages are subtracted from the source to maintain ideal sinusoidal voltage in the non-linear load this is the main advantage of series active filter over the shunt active filter. Power quality is improved with the help of this advantage.

The turn ratio of the coupling transformer depends on different parameters. To decrease voltage of the primary winding and amplitude of the inverter, the transformer ratio will be large. The ripple filter is connected in parallel to secondary winding of the coupling transformer. Turn ratio of the transformer is affecting the rating of ripple filter. To avoid the high frequency ripple voltage in the coupling transformer at the terminal of primary winding, which is generated by the switching of voltage source
inverter (VSI), the ripple filter is connect to the output side of inverter [16]. The passive filter consists of number of capacitance, inductance and resistance. The Passive filter is connected in between active filter and non-linear load as shown in fig 2. A several types of the passive filter are

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available according to frequency response of the passive filter. Commonly, single tuned and high pass filter is used for the harmonics mitigation. The single harmonics eliminates by the single tuned filter and high pass filter reduces the harmonics above the fixed frequency. In high pass filter, first order, second order, third order verities of topology are available [12]. Fig. 2 shows the two single tuned filters which is the series combination of capacitor and inductor is connected in shunt to distribution system. The value of capacitor and inductor of single tuned filter is set in such way that branch impedance equal to zero, which is close to the harmonics frequency. In this way it gives path to the harmonics. The capacitor rating is fixed by requirement of the reactive power and the inductor rating is selected on the basis of particular harmonics frequency. Fig 2 also the

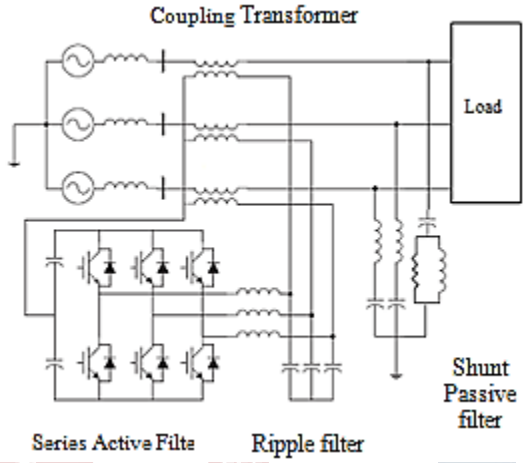

Figure 2 Proposed system configuration

second order high pass filter, this filter composed by parallel combination of resistor and inductor with series capacitor. The rating of resistor in the second order high pass filter is set on the sharpness of high frequency harmonics and losses [13]. The passive filter compensates the reactive power which results in less bourdon on the active filter, It reduces the rating of active filter in between 3%-6% so that cost of the hybrid filter is reduce for the power quality enhancement.

IV. REFERENCE SIGNAL EVALUATION TECHNIQUE

There are different types of reference signal evolution techniques implemented on the hybrid filter. Commonly, there are two methods are used, first method is frequency domain compensation and second method is time domain compensation. The frequency domain compensation is used for the single phase system and also for the three phase system. This frequency domain method is stands on Fourier series. The time domain compensation method is operated for the three phase system. The time domain compensation method is very simple to operate. This method stands on the instantaneous derivation, command of the compensation in voltage and in current form. For hybrid filter explained in this paper the command of compensation is in form of voltage [8], [13-14]. The Fig. 3 shows different reference signal evolution techniques of the time domain and frequency domain method. In this technique of the active filter all information about the harmonics and other different parameters is send to the reference signal evaluator drive, the reference signal evaluator drive act as system controller. It controls the gating signal of the generator, this generator of the output control the active filter.

V. CONTROL TECHNIQUES

According to evaluated compensation reference signal its control the active filter and accurate gating signal is generated by switching. The control technique affect the performance of the active filter, for the proper working of the active filter the selection and implementation of control technique is important [14]. To generate the gating signal different type of pulse width modulation (PWM) controller are used. A controller is the heart of the active filter, the control techniques stand on the overall system. These PWM Controllers are operating on processor through the software and in the hardware analogue. Nowadays these PWM controllers are used with the software of processor. By using software processor based PWM controller, the cost reduces, it also reduces components so that its enhance the reliability. Hence use of the PWM controller is increased. The derivative compensation order is compare to signal sensory feedback signal and there is no error in PWM controller and digital signal create. Many PWM controllers of closed-loop are available, including carrier-less PWM controllers (hysteresis, on/off etc.), carrier-based PWM controller such as PI, dead beat, sliding-mode controller (SMC), and many controller are implemented with the help of software in the processor already use for deriving compensating commands. These digital (high/low) gating signal is buffer isolation and uninterrupted for the gating, if when solid state-switching devices of active filters is operated in hybrid filter. These control techniques reduces the THD (total harmonic distortion) of the supply current less than 5%, which obeys the IEC 61000-3, IEEE 519 standards [8], [14].

VI. FUTURE DEVLOPMENT

The hybrid filter technology is developed and used in small and high rating of the power system. In hybrid filter rating of the active filter reduces, by using passive filter. Then there can be use MOSFET as switching device in the VSI of active filter

which operated with high switching frequency, by giving fast response the size of the ripple filter, DC capacitor and also conduction losses are may be reduce. This is the better technology of hybrid filter. When protection systems was modify in the hybrid filter then fault occur in hybrid filter is avoid so that failure of hybrid filter is may reduce. Also in development of different control technology of the active filter may eliminates the sensor. By using magnetic material in the passive parts of the hybrid filter the size of passive elements, capacitor and inductor can reduce. In this way new development in the hybrid filter, this filter topology is an alternative for existing technology of power quality enhancement [8].

VII. CONCLUSION

In hybrid filter both characteristics of the active filter and passive filter are combined so that the harmonics eliminates and reactive power compensates. By connecting the passive filter the, rating of active filter connected in series is reduced. Also it helps to reduce burden on the active filter, hence it result in the fast switching and less conduction losses occur. Due to low rating of active filer the cost of hybrid filter is reduced. The hybrid filter is reduced THD of supply closely to the prescribed limit as per standard, hence the supply power quality is improved. In this way the hybrid filter is good option for power quality enhancement.

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