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SERIES COMBINATION OF HYBRID FILTER WITH DISTORTED SOURCE VOLTAGE

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ABSTRACT

The use of power electronic devices in industry and domestic applications such as adjustable speed drives, inverters, furnaces, computer applications and other electronics devices let to the injection of harmonics and reactive power in the power system. So harmonic filter is important one for filtering harmonics in the power system. The shunt active and shunt passive filter is designed for compensating 5th and 7th harmonics. Hybrid filter performance was verified through MATLAB/SIMULINK where the source voltage having 3rd harmonic component. Thus the hybrid filter provides an effective harmonic compensation and reactive power compensation.

KEYWORDS— Hybrid power filter, nonideal mains voltage

I. Introduction

The power electronic devices are used for ac power control in the power system. The harmonics injection and reactive power cause disturbance to the customer and interference in the communication line with low system efficiency and poor power factor. Many researchers have provided solutions for harmonic and reactive power compensation [1] and they imposed specific limitations of current harmonics and voltage notches. Passive filter is used for eliminating lower order harmonics and capacitors used for compensating reactive power demand in the system. They have some drawback such as fixed compensation and resonance problems. Then the fundamental frequency reactive power may affect the system voltage regulation.

Here the increased harmonic pollution leads to the development of active filters. The active filter rating depends on harmonics and reactive power to be compensated. Generally active filters required high current rating and higher bandwidth requirement that do not constitute cost effective solution for harmonic mitigation[7].

Hybrid filter with series combination of shunt active and shunt passive filter can overcome the demerits of active and passive filter [2]. The hybrid topology with series combination of active and passive filter reduces the rating of active filter, improves the filtering characteristic of passive filter and greatly reduces the precise tuning of passive filter. It supplies reactive power as per demand and maintains voltage regulation.

Many control strategies, starting from instantaneous reactive power compensation, evolved since the inception of shunt active filters. One of the control strategy based on DC link voltage was discussed [4] [5]. In this method the shunt active filter is to compensate the load side harmonics and reactive power, thereby making the load linear.

Therefore the supply side distortions are imposed on the line current. Even though this method meets the reactive power requirement of the load when the supply voltage distortion occur and the same are imposed on the line current also, where the line current still remains non-sinusoidal even after compensation.

In this paper the instantaneous reactive power algorithm has been used for shunt active filter with some modification that can effectively compensates the harmonics caused by source side distortion also. This proposed method overcomes this drawback by preprocessing supply voltage using park's transformation for that we are using only the fundamental positive sequence component of source voltage for reference current calculation.

Control block diagram and operational principles are discussed below. This proposed method can effectively compensate the harmonics and reactive power even when the source voltage is unbalanced.

II. CONTROL STRATEGY

Most of the active filters are designed based on the instantaneous reactive power algorithm. The instantaneous reactive power algorithm is derived based on the dq0 transformation, where they can calculate the current compensation based on a two-axis system [6]. In this method, the voltage and load current were first transformed into two-axis representation.

The instantaneous real and instantaneous reactive power consumed by the loads was calculated based on this representation system[3]. After compensation, the post compensated current in the two-axis system was required to inversely transform back to the three phase system from the grid; from this the reference signals of compensation current can be obtained.

$$I_a^* = I_m^* \sin(\omega t)$$

$$I_b^* = I_m^* \sin(\omega t - 120°)$$

$$I_c^* = I_m^* \sin(\omega t - 240°)$$

The control strategy proposed here is for making the compensated line current to be sinusoidal and balanced [7]. Therefore the objective includes a sinusoidal reference current calculation and the current control technique for generation of switching pulses to the VSI for a sinusoidal and balanced line current. Where is the amplitude of the desired line current, the phase and frequency of the line current are obtained from the supply voltage. The magnitude of reference line current can get by regulating the DC bus voltage of VSI. The DC-link capacitance of VSI is used as an energy storage element in the system.

For a lossless active filter in the steady state, the real power supply from the supply should be equal to the real load demanded, and no more real power passes through the power converter into the capacitor. Therefore the averaged dc-capacitor voltage can be maintained at the reference voltage level. For a balanced line current under unbalanced source voltage the proposed method to use one phase of source voltage as phase reference and 120 shifter. By this method the harmonics present in the source voltage are reflected in the reference line current. Therefore, a modified algorithm, by preprocessing the source voltage template is proposed to make the compensated the line current sinusoidal.

The source voltages are transformed into d-q reference frame using park's transformation. After transformation n^{th} order positive sequence component becomes $(n-1)^{th}$ order component becomes $(n-1)^{th}$ order component and n^{th} order component becomes $(n+1)^{th}$ order component in d-q reference frame. The fundamental component of source voltage becomes a dc component in d-q reference frame which should be filtered out using a low-pass filter. This filtered dc value after counter transformation into 3-phase component can be used for unit templates for reference current calculation. Thus this modification filters out the effect of source side distortion in the line current.

In order to drive the line currents to trace the reference currents an effective current control technique has to be used for generating the switching pulses of the VSI. Hysteresis control is implemented here for this purpose. In this control line currents are sensed and compared with the reference currents. The error in each phase is sent to the hysteresis control, Where in a switching pulse is generated to the upper switch of the VSI, if this error s less than the lower hysteresis band and a switching pulse is generated to the lower switch of the VSI if the error is found more than the upper hysteresis band.

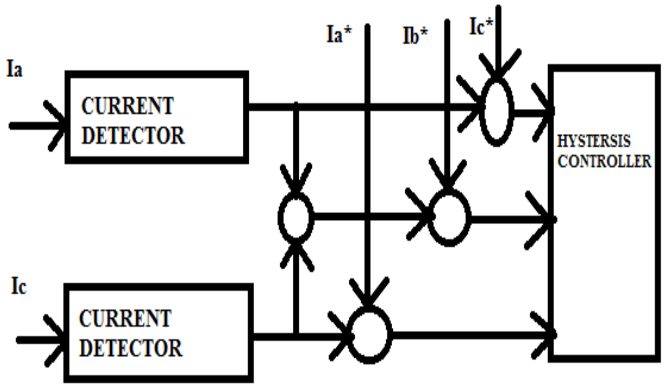

Fig1.1 Block diagram for control strategy

III.PROPOSED METHOD

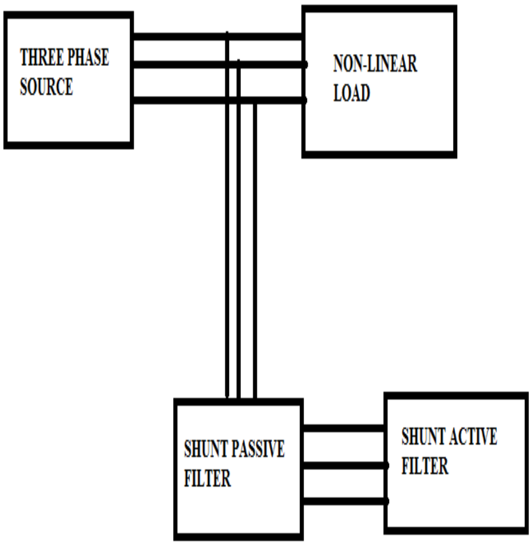

Fig1.2 Block diagram for series combination of shunt active and passive filters

The fig1.2 represents three-phase source and non-linear load. Where the shunt passive filter and shunt active filter are connected in series with the line. Passive filter provides cost effective mitigation for harmonics and reactive power from supply. Active filter can effectively compensate the harmonics and can meet the reactive power demand.

The hybrid filter with series combination of active filter and passive filter reduces the rating of active filter, which also improves the filtering characteristics and reduces the precise tuning of passive filter.

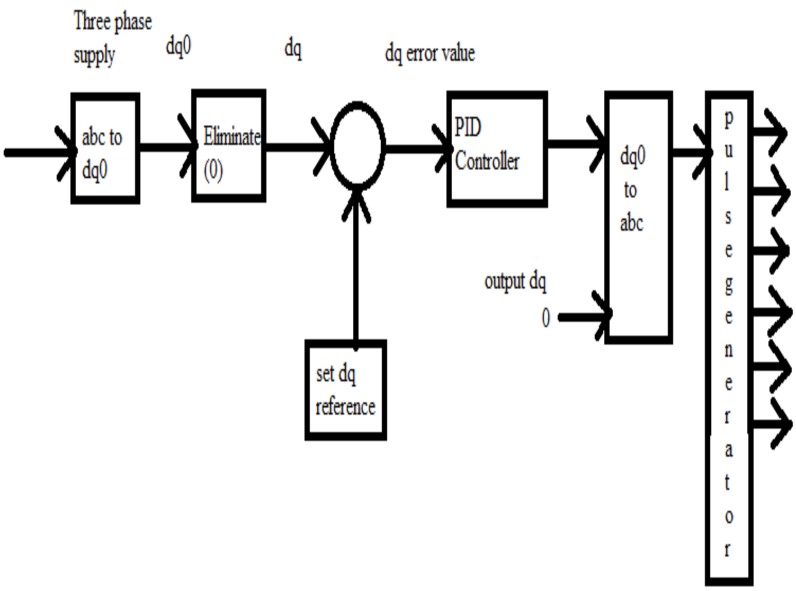

Fig1.3 Block diagram for controller

The fig1.3 represents the controller block diagram. Where three phase supply from the grid and they are converted into dq0 transformation. By eliminating the 0^{th} term we get dq alone, setting dq reference value by comparing the actual value and reference value we get dq error value.PID controller output depends on the erroneous value. Then converting dq0 to abc value they are given as input to the pulse generator, by varying the amplitude can generate six pulse and given as input to the three-phase inverter.

IV.SIMULATION RESULTS

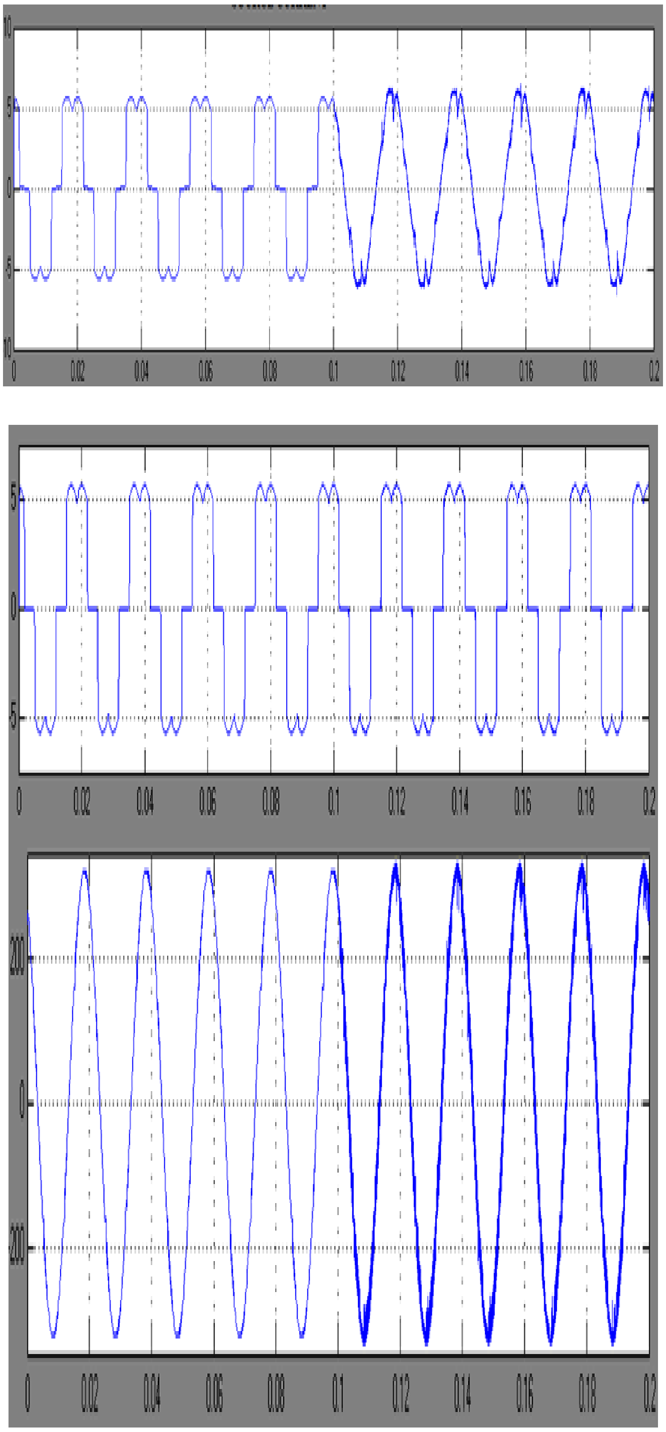

Fig 1.4 simulation result for series combination of hybrid filter

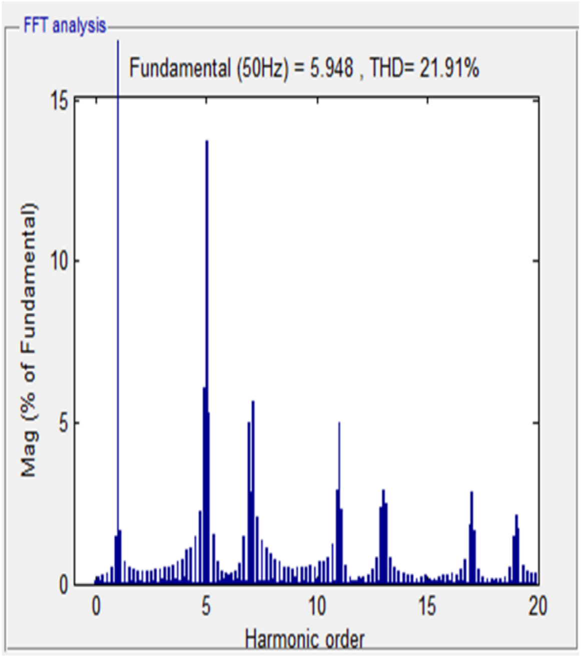

Fig 1.5 FFT analysis for hybrid filter in series combination

	Source voltage (Vs)	Load current(I_{load})	Line current(I_{line})	Compensating current(I_c)
Series combination of hybrid filter	25.23	30.65	21.91	25.18

Table 1. TDD values for various parameters

	Reactive Power (KVAR)	Filter Inductance (mH)	Filter Capacitance (μF)
5^{th} harmonics (Q=40)	0.5	40	10
7^{th} harmonics (Q=40)	0.5	20.4	10
11^{th} harmonics (Q=50)	1	4.2	20

Table 2. Passive filter parameters

The active filter parameters are L_c=3.35mH, R_c=0.4 Ohms, DC-link capacitance C_{DC}= 2200μF, DC-link reference voltage $V_{dc,ref}$= 400Volts for series Hybrid filter topology.

Fig1.3 shows the simulation results for series combination of passive and active filter. The source voltage (V_s) is having aTHD of 12.21%, and the load current (I_{load}) having a THD of 21.91%. The line current(I_s) after compensation is having 7.33%. The peak value of supply current is found less than the peak value of load current that shows the supply current is carrying only the active component of load current and active component of compensating current. The DC-link voltage of the VSI is maintained at 400Volts.

To drive the line currents to trace the reference currents an effective current control technique has to be used for generating the switching pulses for the VSI. Hysteresis control is implemented for this purpose. In this control the line current are compared and sensed with the reference current. Therefore this modification filters out the effect of source side distortions in the line current.

The topology of hybrid filters are simulated using MATLAB/SIMULINK and the results are compared under non-ideal supply voltage with a 0.1pu 3^{rd}m harmonic negative sequence component in the source voltage. The rms value of the fundamental component is 230Volts. The various design values of passive filter are shown in Table2.

V.CONCLUSION

The results show the use of hybrid filter topology for harmonic and reactive power compensation. However, hybrid filter topology with a series combination of active and passive filters is installed in place of an already existing passive filter, to make efficient. The passive filter performance might have affected due to changes in the system parameters. This topology helps in improving the performance of passive filter and the active filter can be used at a lower rating. In this paper, a new algorithm has been proposed to improve the active filter performance under nonideal main voltages. The performance of control strategy used here is simple and effectively compensates the load generated harmonics and nullifies the effect of source voltage harmonics in the line.

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