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CURRENT HARMONICS REDUCTION IN DISTRIBUTED GENERATION SYSTEM BY USING SHUNT HYBRID ACTIVE POWER FILTER STRATEGY

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ABSTRACT

The enormous growth of non-linear load is connected to the power system will create unbalancing and inject harmonics current to the source. This unbalancing load and harmonic injection has produce mismatching of power factor. To eradicate those power quality problems using shunt active power filter (SAPF) technique the active switches of shunt active power filter are controlled by using SRF theory. The proposed system is simulated using MATLAB/SIMULINK power system tool box. The simulation result shows that mitigation of power quality problem.

KEYWORDS: SAPF, MATLAB, SIMULINK, SRF and mitigation etc...

INTRODUCTION

Harmonics are produced by using non-linear loads and the unbalanced loads in the distribution system. Proliferation of non-linear loads such as switch-mode power converters, fluorescent lamps, arc furnaces, welding equipment, computer equipment, adjustable-speed drives. Harmonics are present on the power system causes overheating of transformer, over heating of motor, interference with the communication network, low power efficiency, voltage flicker, voltage and current wave form distortion, malfunction and failures of sensitive equipments. Passive LC filters capacitor bank are also used to reduce the power quality problem on the power system. But passive filter is maybe creates resonance on the power system network and also high cost. Active filters are used. According to the load conditions of the system, an appropriate APF topology should be selected to overcome the harmonic related power quality problems. APFs are widely used for eliminating load current harmonics and reactive power compensation.

There are two types of filters are available series active power filter and shunt active power filter. The series active filter injects the voltage in series to the transmission line. the combination of both passive filter and active filter topology is called the hybrid. In order to reduce the current harmonics in the transmission line and also reactive power compensation, power factor improvement by using

the shunt hybrid active power filter topology. Shunt active power filter has a simple structure and easy construction. It is connected in parallel with AC transmission line and need to be sized only for current harmonic drawn by the loads. Shunt active power filter injects the current that precisely correspond to harmonic components drawn by the non-linear load. A shunt HAPF consists of a controllable current source.

In this study, to design the shunt hybrid active filter using the Synchronous Reference frame control technique with PI controller strategy are used, because SRF technique has simple algorithm and good performance. Synchronous reference frame method is based on the transformation of vectors into synchronously rotating direct (d), and quadrature axis (q) reference frames. Synchronous reference frame control method is based is mainly used to generate the current reference for harmonic component.

RELATED WORK

Power distribution system is used to producing the power. Recently many power d system using the non-linear loads and unbalancing loads. These are creating the power quality problems in the distribution system. The power quality problems are sag, swell, overvoltage, under voltage, distortion in the current harmonics and the voltage harmonics. Reducing the current harmonics in the system by using the active power filter. The shunt hybrid active

filter is used for filtering purpose. In conventional method, the IRP technique is used for the reference current generation. But the IRP technique having some disadvantage, which is non casual, so it can't be implemented directly and its complex algorithm. Also, Hilbert transform is used to compute the imaginary variables. In our project we are using the synchronous reference frame control technique with PI controller. The synchronous reference frame

technique is used for reference current generation to the inverter. This technique is simple algorithm and good performance. The shunt hybrid active power filter is used to reduce the current harmonics and compensate the reactive power, and power factor improvement.

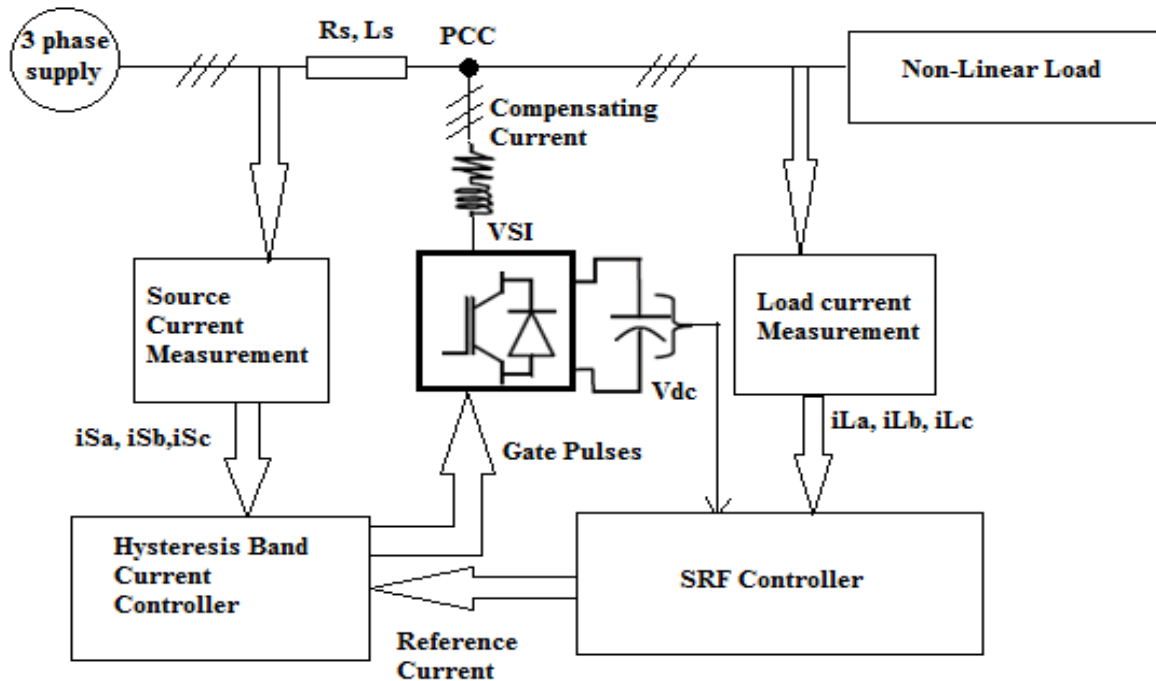


Figure 1: Circuit Diagram of Shunt Hybrid Active Power Filter

SHUNT HYBRID ACTIVE POWER FILTER STRATEGY

The shunt hybrid active power filter strategy consists of three phase voltage source PWM inverter, DC side capacitor, and passive filter. The shunt active filter is made up by using six IGBT/diode switches is used for charging and discharging the capacitor to supply the required compensation current. Switching pulse of six IGBTs can be generated by using hysteresis current controller. This controller is can be used to compensating currents. The shunt hybrid active power filter is connected parallel to the transmission line at the point of common coupling. The shunt active power filter is used to reduce the current harmonics in the power system. It injects the compensating current parallel to

the transmission line. The active filter (three phase voltage source PWM inverter) and the passive filter are connected in series form is called the hybrid. The diode

bridge rectifier is act as a non-linear load. The non-linear load creates the harmonics in the distribution system. The active filter compensates the harmonics generated by nonlinear loads by generating the same harmonic components in opposite phase and reduces the higher order harmonic frequency. The passive filter is used to reduce the lower order harmonic frequency and also used for another function power-factor correction.

PROPOSED CONTROL STRATEGY

The proposed control system is used the synchronous reference frame control technique with PI controller .

SRF control strategy

The synchronous reference frame control technology is used for the generation of reference current and also it's capable of controlling the shunt hybrid active power filter. The control strategy, which generates compensating signal, is based on time domain. In time domain approach, the circuit analysis and algebraic transformations with the change of reference frame are used for simplifying for control

work. The three phase balanced voltage equation is given by,

$$\begin{aligned} v_a &= V_m \sin \omega t \\ v_b &= V_m \sin(\omega t - \phi - 120^\circ) \\ v_c &= V_m (\sin \omega t - \phi + 120^\circ) \end{aligned}$$

(1)

The SRF method is mainly consists of park transformation and inverse park transformation, which allow evaluation of a specific harmonic component of the input signals. In three phase voltage is(Va,Vb,Vc) transformed into the two phase stationary α - β frame by using Clarke transformation.

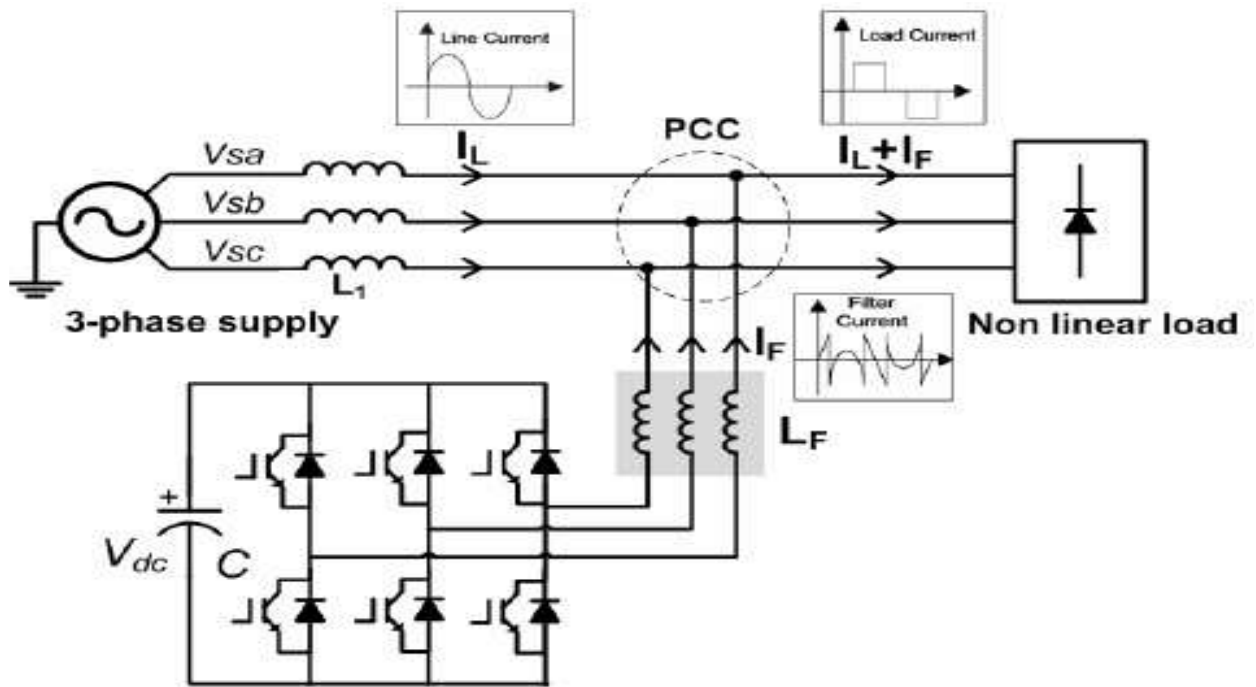


Figure 2: Three Phase Shunt Hybrid Active Power Filter

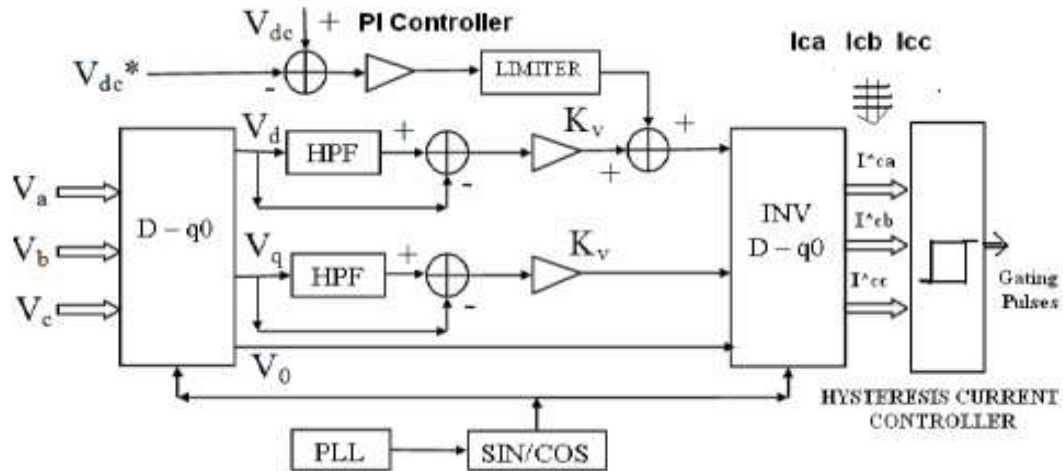


Figure 3: Synchronous Reference Frame Current Controller

$$\begin{bmatrix} V_\alpha \\ V_\beta \end{bmatrix} = \begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix}$$

(2)

Park transformation is transformed two phase stationary into synchronously rotating reference frame of direct and quadrature axis.

$$\begin{bmatrix} I_d \\ I_q \end{bmatrix} = \begin{bmatrix} \cos\omega t & \sin\omega t \\ -\sin\omega t & \cos\omega t \end{bmatrix} \begin{bmatrix} I_\alpha \\ I_\beta \end{bmatrix}$$

(3)

The high pass filter (HPF) is used to extract the dc component and it's given to the comparator. The voltage Gain is amplified the output error voltage of the comparator results. The output gives to inverse park transformation. The compensating current is produced, given to the hysteresis current controller. The controller producing the switching pattern of the current to the voltage source inverter.

PI CONTROLLER

The PI controller is mainly used to reduce the steady state error. The proportional gain and the integral gain constants are used to correct the steady state value.

The PI controller is defined by transfer function,

$$GPI(s) = KP + KI/s \tag{4}$$

PHASE LOCKED LOOP

The phase locked loop is a control system, which generates the output signal, whose phase is matched with the input signal. In the conventional PLL, the three phase supply current vector are transformed into two phase d-q rotating frames by using park transformations at fundamental frequency.

Then, the actual direct axis voltage is compared with the reference voltage; it produces the error voltage signal. The output of the comparator to the transfer function. The output of the PLL is locked into the phase angle of utility voltage, at that time, $V_{de}=0$ and $V_{dq}=V_m$ under the dq reference is controlled by feedback loop under steady state condition. The proportional and the integral constant of the PLL should be selected properly, because it's affect the PLL output.

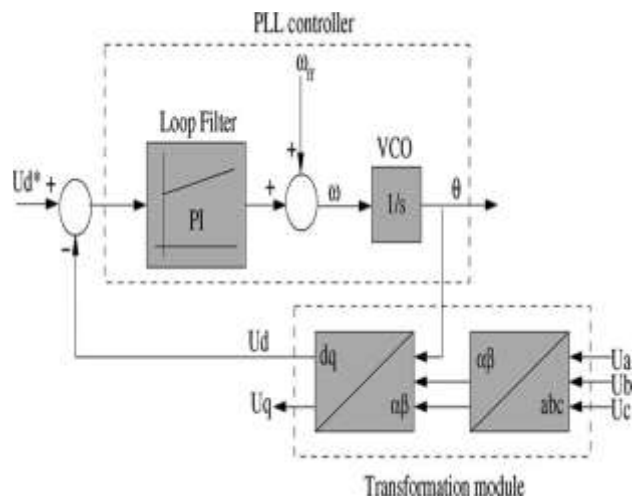


Figure 4: Phase Locked Loop

HYSTERESIS CURRENT CONTROLLER

The hysteresis current controller is used for generate the switching pattern to the voltage source inverter. There are many methods are available to the current control for active power filter, such as the current control, pulsewidth modulation control. Because it quick current controllability and easy implementation method.

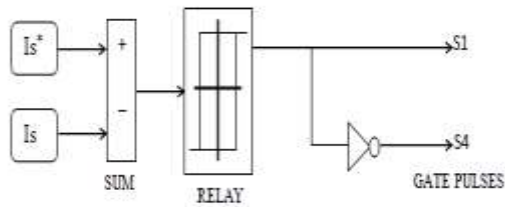


Figure 5: Hysteresis Current Controller

The current controller can to be used to control the compensating current.

Ratings and Parameters of the SHAPF

Table -1: Specification and parameters of the SHAPFs

SYSTEM PARAMETERS	VALUES
Supply Voltage(V_s)	230 V
Supply frequency(F_s)	50 HZ
Passive filter resistance and Inductance values (R_F, L_F)	$1\Omega, 10\text{mH}$
Inverter side capacitor voltage(V_{dc})	$1600\mu\text{F}$
Rectifier based R,L load	$7\Omega, 20\text{mH}$

SIMULATION RESULTS

Simulation Results for Supply Voltage before and after compensation

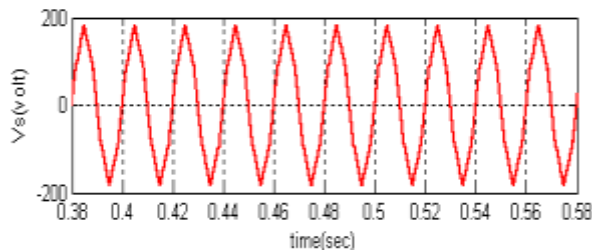


Figure 6: Supply voltage before compensation.

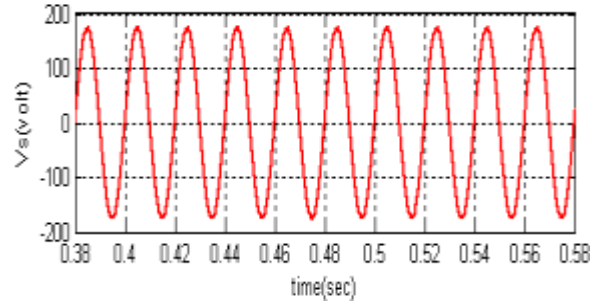


Figure 7: Supply voltage after compensation

Simulation Results for Supply Current before and after compensation

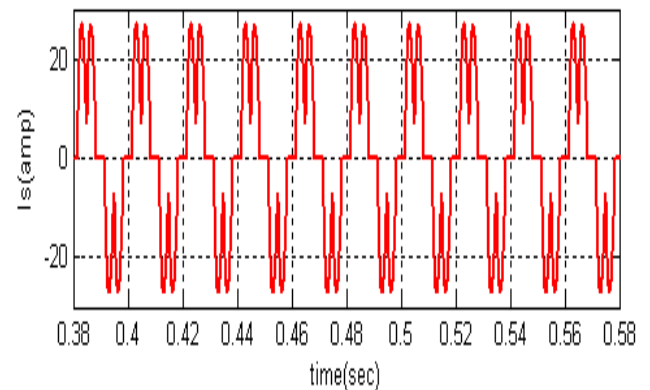


Figure 8: Supply current before compensation.

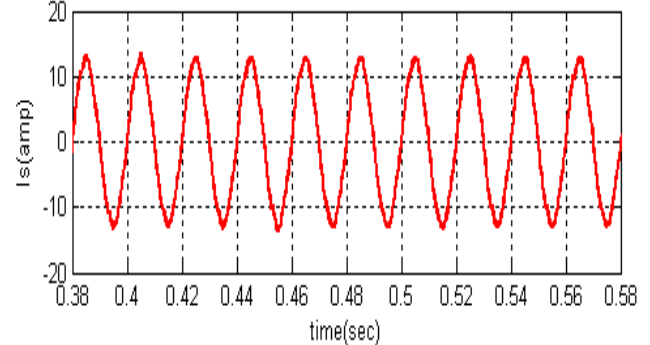


Figure 9: Supply current after compensation

From the obtained results, the harmonic level of supply current will be reduced from before and after compensation and also achieved balancing current waveform.

Simulation Results for Power Factor correction before and after Compensation

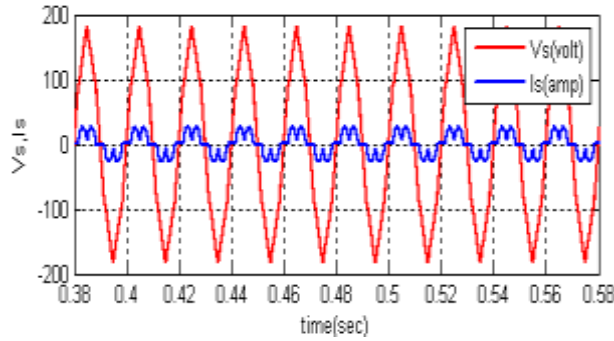


Figure 10: Power factor before compensation.

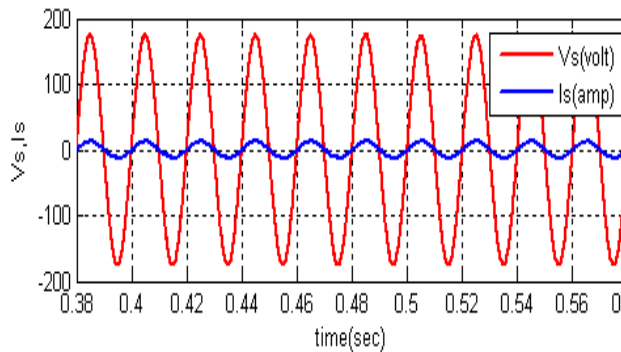


Figure 11: Power factor after compensation.

Simulation Results For Actual and Reference Current

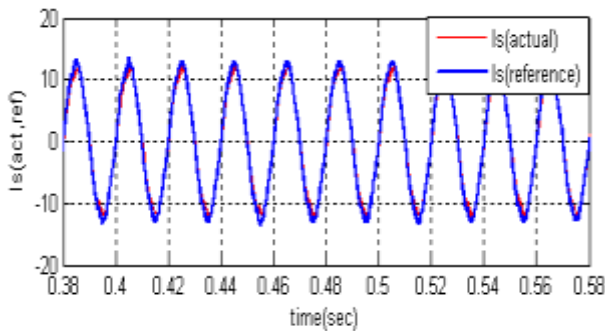


Figure -12: Actual and reference current.

From the results, it is observed that the reference supply current is tracking with actual supply current with good accuracy.

Simulation Results for Actual and Reference Dc-Voltage

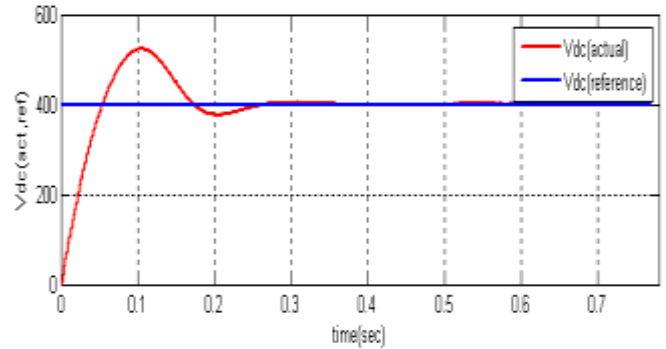


Figure 13: Actual and reference dc-voltage.

From the obtained results, the peak overshoot value of actual and reference DC-Link voltage (Vdc) is 42.5%.

THD analysis for Supply Voltage before and after Compensation

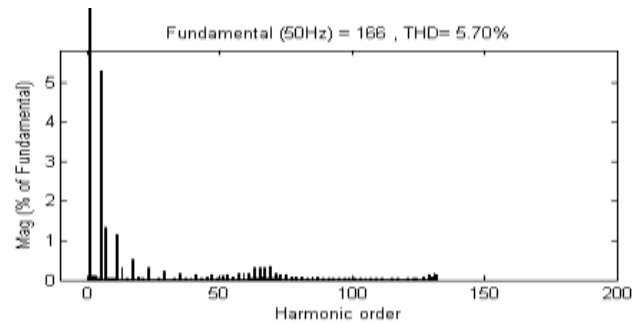


Figure -14: THD analysis for supply voltage before compensation.

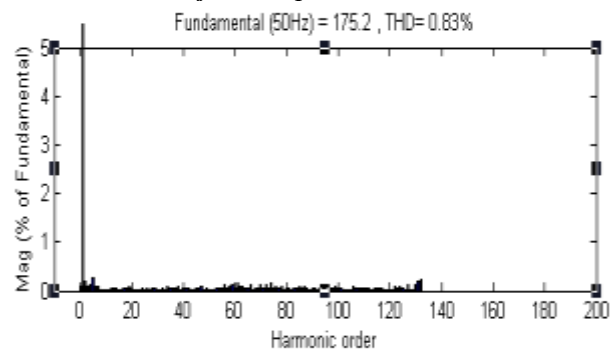


Figure -15: THD analysis for supply voltage after compensation.

From the obtained results, the THD% of the source voltage for before compensation is found to be 5.80%

whereas after compensation, the THD for the source voltage is noticed to be 0.83%. From the analysis, with (SHAPFs) 85.68% of source voltage THD is reduced.

THD Analysis For Supply Current before and after Compensation

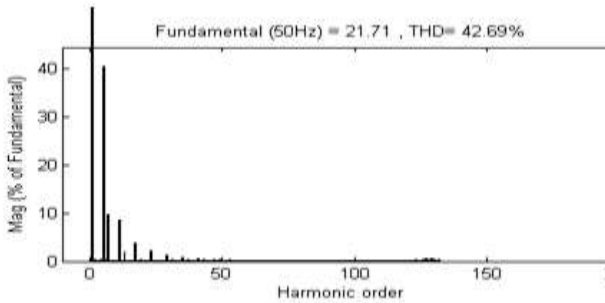


Figure -16:THD analysis for supply current before compensation

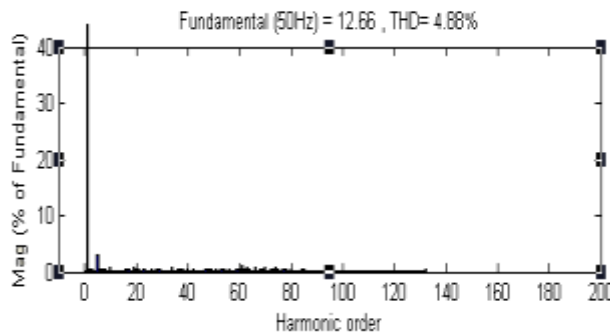


Figure -17:THD analysis for supply current after compensation

From the obtained results, the THD% of the source current for before compensation is found to be 42.69% whereas after compensation, the THD for the source current is noticed to be 4.88%. From this analysis, with (SHAPFs) 88.56% of source current THD is reduced.

Performance of THD Analysis of Supply Voltage

Table 2: Performance of THD Analysis of Supply Voltage

Three phase supply voltage	THD analysis for operatingcondition I(%)		
	Before compensation	After compensation	Reduction of THD
Vsa	5.80	0.83	85.68

Vsb	5.76	0.73	87.32
Vsc	5.75	0.76	86.78

Performance of THD Analysis of Supply current

Table 3: Performance of THD Analysis of Supply Current

Three phase supply current	THD analysis for operatingcondition I(%)		
	Before compensation	After compensation	Reduction of THD
Isa	42.69	4.88	88.56
Isb	42.79	4.61	89.22
Isc	42.70	4.35	89.81

CONCLUSION

In this paper,the shunt hybrid active power filter is proposed for distributed generation system.In this present study, the synchronous reference frame based control strategy was used for reducing the Current harmonics generated by non-linear load.Harmonic currents are effectively cancelled and maintained the unity power factor.And also it's give the better performance and efficiency.

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