

# GRID INTERFACED RENEWABLE ENERGY SOURCE TO IMPROVE POWER QUALITY USING SAPF

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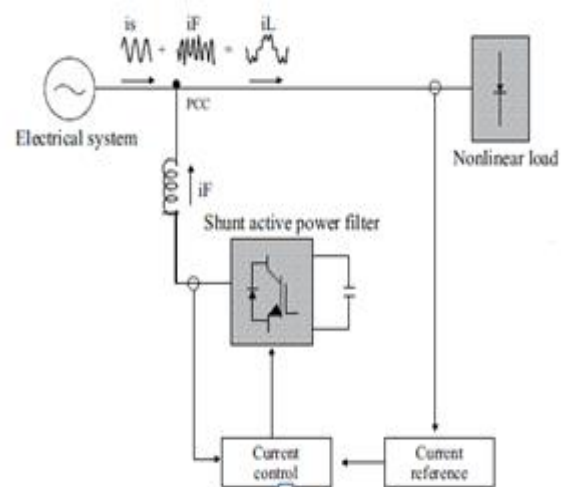
**Abstract** –The living standard demands excessive power from utility due to increasing population and depletion of fossil fuel resources. These issues leads to develop a new sources of energy ie, Renewable energy sources (RES). RES connected to the distributed system is termed as distributed generation (DG), which leads to power quality (PQ) issues such as distortion, irregularity unbalance etc. More usage of power electronics devices with renewable energy sources may reduce quality of power by injecting harmonics in the line. The power quality problem can be overcome by grid interfaced inverter control which compensates the PQ issues while integrating REU. The grid connected with renewable energy source has the capability of injecting active power to the grid, reduces source current distortion and reactive power compensation.

**Key Words:** Renewable Energy, Distributed Generation, Power quality, shunt Active filter

## 1. INTRODUCTION

The living standard of energy demand increases day by day due to overgrowth of population. The fossil fuels is burned and supplied in order to cope up with this energy demand. But the usage of fossil fuels leads to air pollution, global warming etc. The extensive use of fuels increases the cost, as well demands in future. This makes to look over the alternate source ie., Renewable energy sources as the future energy solution for distributed generation. This paper represents the effective solution of shunt active power filter for eliminating the harmonics to maintain the quality of utility power supply. Passive filters are traditionally used but it has the major drawback which leads to resonance problem and poor dynamic performance. Active power filters gives best solution compared to conventional passive filters for the mitigation of harmonic and reactive power disturbance . Active power filters is the device which

generate the same amount of harmonic as generated by the load but 180° phase shifted. The harmonics inserted into the line are eliminated and utility supply become sinusoidal. RES is not connected directly to the grid instead it is connected to the grid interfaced inverter. DC link voltage capacitor is connected to grid interfaced inverter which play important role transferring the active power from RES to grid. Based on the control techniques, the inverter act and inject the compensating harmonics current.



**Fig -1:** Basic shunt active power filter

In figure1 shows that IGBT-based voltage source inverter (VSI) bridges with a common DC bus capacitor were used as the shunt active filter(SAF).

In [1], Abhayrajsinh J. Rana et al. discussed the mitigation of voltage sag by injecting reactive current at PCC using Distribution Static Compensator (DSTATCOM). In [2], Rivas D et al. proposed hybrid scheme is able to compensate displacement power issue and current harmonics at the same time. In [3], Utkal Ranjan Muduli et al. proposed a unique reference

current, extraction methodology using adaptive detection algorithm that is able to extract the harmonic content from the load current. In [4], Liango et al. proposed modified IcosΦ controller primarily based shunt active filter as an interface between renewable energy sources and grid. In [5], Weimin Chinese et al. proposed LLCL-filter-based grid-tied inverter that effectively will suppress the attainable resonances though the grid inductance varies during a wide selection. In [6], Joao Afonso et al. present a APF as a reliable and cost- efficient solution to power quality problems. In [7], Mukhtiar Singh et al. mentioned most advantages obtained from a unique control strategy for grid-interfacing inverters in distribution system. In [8], Jiang Zeng et al. proposed optimal voltage primarily vector based hysteresis current control methodology with constant switching frequency for Active power filter is used. In [9], Zubair Ahmed Memon et al. proposed a design of hybrid active filter to reduce current disturbance produced by power electronics based devices. . In [10], Sudheer Kasa et al. presents I cos ANFIS control primarily based Dynamic Active Power Filter (DAPF) to enhance the power quality of the grid at supply side. In [11], Roshan Haste et al. presents a control techniques of Grid interfaced inverter is done either individually or combined to overcome the unbalanced effects of all types of loads at distribution level. In [12], Vishnu Prasad et al. proposed grid connected PV system is implemented with adaptive HCC for inverter control. In [13], Sreya grace mathew, fossy mary chacko proposed a Hysteresis current control method to generate gate pulses which is used to compensate reactive power and current harmonics. In [14], Akshay S. Shirbhate, Prof.Suhas D. Jawal presents that shunt active filter is one the best configuration which can be used to compensate harmonic current, reactive power, neutral current unbalance current. In [15], Jain Sun proposed a impedance analysis based approach for multi-inverter system which mitigating resonance and other stability and power quality problems. In [16], Pichai Jintakosonwit, Hideaki Fujita et al. proposes cooperative control of multiple active filters based on voltage detection for harmonic damping throughout a distribution system level.

## 2. PROPOSED WORK

In this paper, the proposed work consists of renewable energy source connected to the dc link of the grid interfacing inverter as shown in Figure 1. The connected load is non-linear characteristics which generates harmonics in the line. In this system, grid interfaced inverter acted as a shunt active power filter. Solar (PV) is not connected directly to grid common coupling point (CCL) instead it is connected through the shunt active power filter. The quality of power is maintained by shunt active power filter which is controlled by PI controller. Shunt active power filter inject the current based on the control algorithm. Shunt active filter compensate load current harmonics by injecting equal-but opposite harmonic compensating current and compensate the reactive power at common coupling point (CCL). By compensating reactive power, it brings unity power factor and also supply more active power from the solar energy source to the grid.

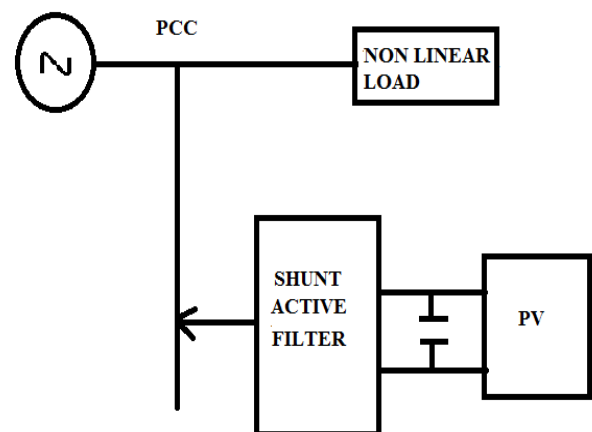


Fig -2: Block diagram

### 2.1 Modeling of PV model

The chosen model is the single diode model with series and parallel resistors for greater accuracy is shown in figure 2.

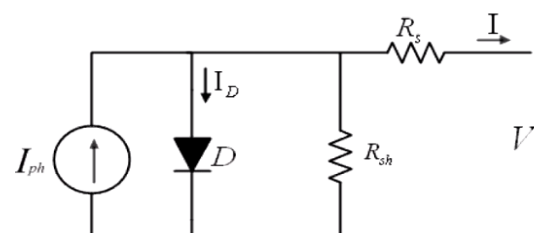


Fig -3: Solar cell

Using the below equation the PV are modeled.

**Photocurrent  $I_{ph}$ :-**

$$I_{ph} = (I_{scr} + k_i * (T_K - T_{ref})) * (\lambda / 1000) \tag{1}$$

**Module Saturation Current  $I_0$ :-**

$$I_{rs} = I_{rr} * (T / T_r)^3 * \exp(q * E_g / (k * A) * ((1 / T_r) - (1 / T))) \tag{2}$$

**Module Output Current  $I_{pv}$ :-**

$$I_D = n_p * I_{ph} - n_p * I_0 * (\exp(q * (V_{pv} + I_{pv} R_s) / (k * T * A * n_s)) - 1) \tag{3}$$

**2.2 Control Algorithm of Grid Interfaced Inverter**

From the source voltage ( $V_{abcs}$ ), the maximum voltage  $V_m$  is calculated. The actual voltage is compared with reference voltage and it is passed through a first PI controller. The current from the PI controller is multiplied with unit vector component, which generates inphase reference current ( $I_{sad}, I_{sbd}, I_{scd}$ ). The maximum voltage ( $V_m$ ) is compared with reference voltage ( $V_{mref}$ ) and it is passed through a second PI controller, which results as a current. This current from PI controller is multiplied by unit vectors to generate the quadrature reference current ( $I_{saq}, I_{sbq}, I_{scq}$ ). The addition of inphase reference current & quadrature reference current, it generates the reference currents ( $I_{abcref}$ ).

The reference current, is compared with the actual source current and it is given to hysteresis current controller (HCC). HCC generates switching pulses for grid interfacing inverter. Based on the control technique, the shunt active filter inject the current. This current cancels the harmonic of source current and compensates the reactive power.

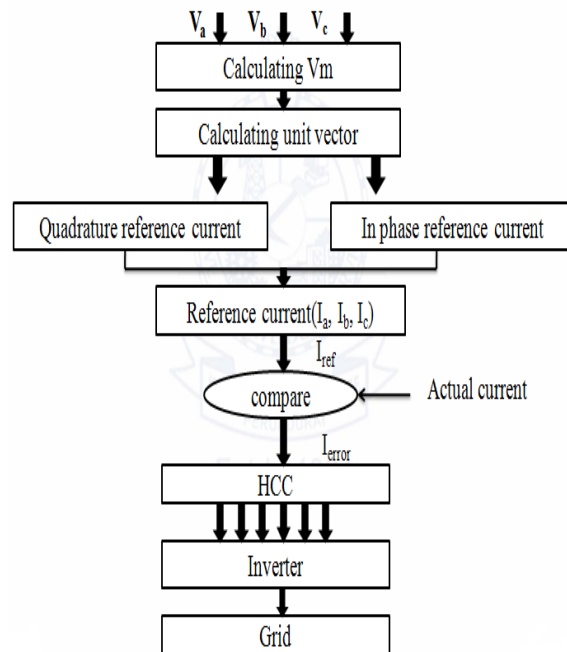


Fig -4: Flow chart for unit template algorithm

**3. RESULT & DISCUSSION**

**3.1 System without Filter**

In proposed method, a system is carried out without Filter. It is observed that the current waveform is non sinusoidal due to harmonics in the line. This is mainly due to non linear load and power electronics components connected across it.

Table -1: System Parameters for Simulation

S. No.	PARAMETERS	VALUES
1.	Source Voltage	220V
2.	Frequency	50HZ
3.	DC Link Voltage ( $V_{dc}$ ref)	400V
4.	DC capacitance	4000 $\mu$ F
5.	Solar Energy Unit	228W/M <sup>2</sup> , 10+273.15 k
6.	Load (RL)	36 $\Omega$ , 10e <sup>-3</sup>
7.	Source impedance	1 $\Omega$ , 0.005e-3

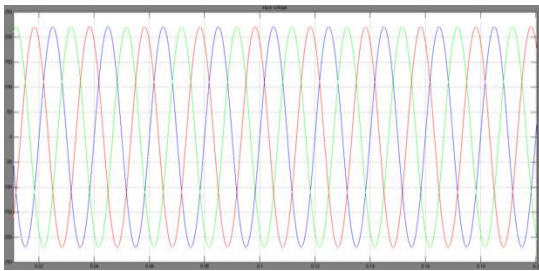


Fig -5: Source Voltage (without filter)

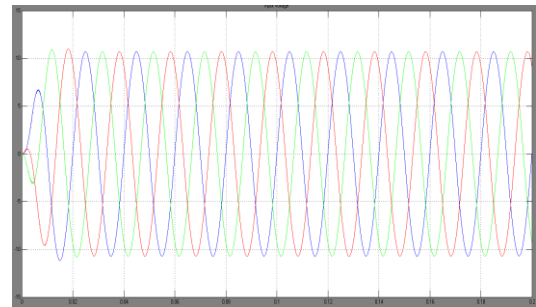


Fig -8: Reference Current ( $I_{asref}$ ,  $I_{bsref}$ ,  $I_{csref}$ )

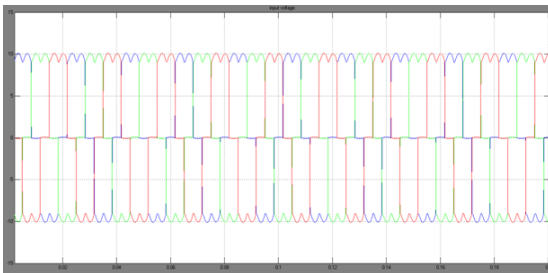


Fig -6: Source & load Current (without filter)

In FFT analysis, Total Harmonics Distortion of source and load current without filter is 29.92% is shown in figure 5.

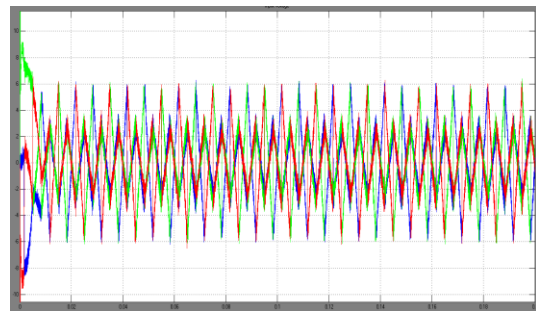


Fig -9: Compensating current ( $I_a$ ,  $I_b$ ,  $I_c$ )

### 3.2 DC link voltage

The DC link voltage across the capacitor ( $V_{dc}$ ) is around 400V is shown in figure 7.

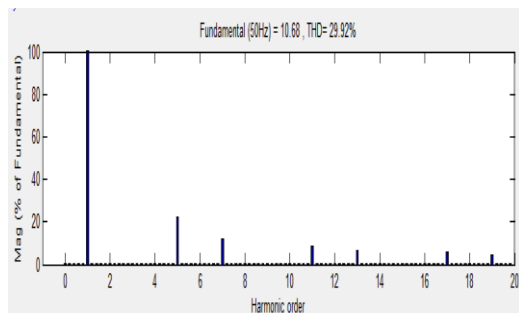


Fig -7: FFT Analysis (source & load current)

### 3.2 System with Filter

RES is connected to the inverter through dc link capacitor. The inverter will act based on control Algorithm. From Algorithm, the reference current is generated which is sinusoidal waveform is shown in figure 12. The reference current generated is compared with source current. and the compensating current are shown in figure 6.

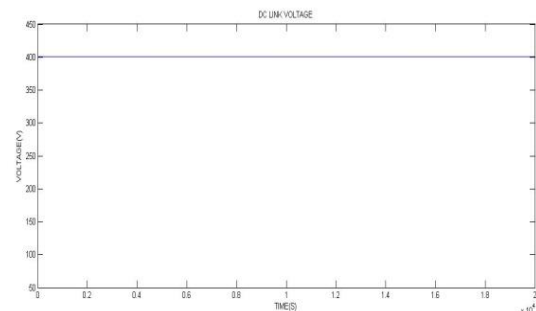


Fig -10: DC Link Voltage

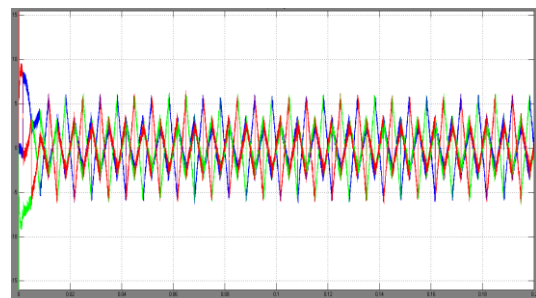


Fig -11: Filter Current

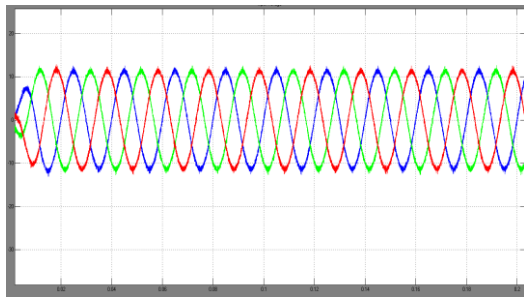


Fig -12: Source Current

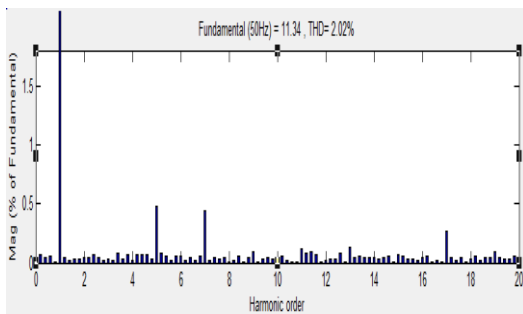


Fig -13: DC Link Voltage

The distorted source current waveform is turned into a sinusoidal current with amplitude of 10 A is shown in figure 9. The THD of source current is reduced from 29.87% to 2.02%. The THD value of system with and without filter is shown in table 2.

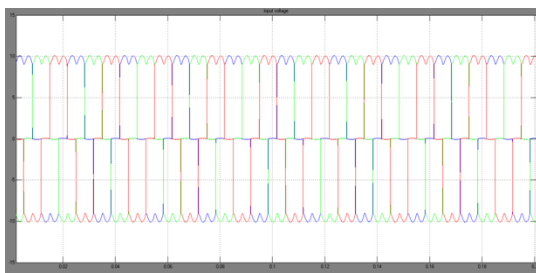


Fig -14: Load Current

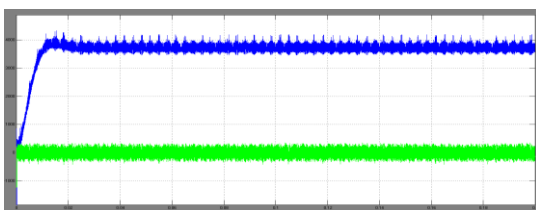


Fig -15: Active and Reactive Power from Grid

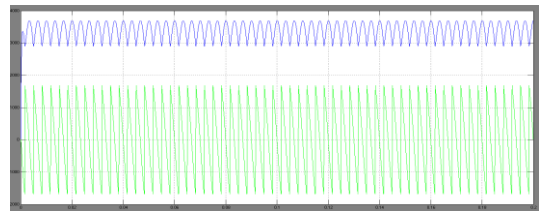


Fig -16: Active and Reactive Power to Load

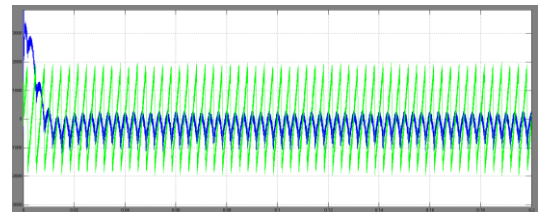


Fig -17: Active and Reactive Power Injected to Grid

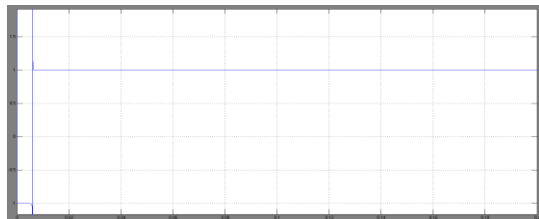


Fig -18: Power factor

Table -2: THD Values of System (with and Without Filter)

S. No	Particulars	Magnitude of current	THD of Source Current
1.	System without Filter	10 A	28.5 %
2.	System with Filter	11 A	2.02 %

The THD value of current is reduced to 2%. The active power from the load is nearly 3900 W and reactive power to the load is 1900 W is shown in the figure 13. Active and Reactive Power Injected to Grid is almost 0 W (active) & 1900 W (reactive) is shown in figure 14. The Active & reactive power from the load is subtracted with the active & reactive power injected to the grid. Therefore Active & reactive power from grid is around 3900W and 0W is shown in the figure 12.

Since the reactive power is compensated it leads to unity power factor is shown in figure 15.

#### 4. CONCLUSION

This Paper has proposed an efficient unit template algorithm of grid interfacing inverter to eliminate the current harmonics, and to compensate the reactive power demand at common coupling point. It has been found that total harmonic distortion of grid current reduced from 29.92% to 2.02% and it results in unity power factor.

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