Active Harmonic Filtering In Grid Connected Dg Unit by Observor

Elam Cheren.SAshok Kumar.LRadhakrishnan.GKavin.R

Abstract: The power quality issues in distribution system increased due to nonlinear load applications. To compensate harmonics for distributed generation (DG) unit interfacing converters, this paper proposes a current controlled method with an observer. The grid is built out of a controlled voltage source driven by cosine signal generator and this work rigged up for fundamental current control. The suggested current controller consists of pair of decoupled control branches which restricts fundamental and harmonic DG currents. The observer separates fundamental and harmonic currents and reference value of current is generated for the inverter. These observer has many advantage like good structure, systematic, no need of band width fixing, non-programmable and sharply tuned filters. The voltage harmonic sum cause addition to the voltage distortion at the point of contact. The conventional feedback procedure minimizes the distortion. The distortion in line current reduces when capacitor value reduced and increase in capacitor value increasethe harmoniccurrent and cause reduction in THD.

Index Terms: Current Controller, Current distortion, Distributed Generation, Filters, Observer, Total Harmonic distortion.

I. INTRODUCTION

The tremendous improvement in semiconductor industry, power electronics devices have acclaimed in industries and also in household electrical devices. Even though these power electronics devices have profited the electrical and electronics industry but these non-linear devices are the important cause of harmonics in the system. Nonlinear loads are similar to current sources supplies current harmonics which passes through the load Point of Common Coupling to the source system. So source impedance seems to have a distorted voltage drop. The Active Power Filter (APF) works on power electronics is a suitable solution to suppress the power system harmonics. A current controlled technique with a pair of control section in which POC voltage and load current is preciselyused as input is suggested without affecting DG unit harmonic compensation accuracy [1]. The sum of the harmonic voltage is the contribution to the distortion and the point of contact voltage.A shunt topology based transformer less active power filter is proposed in [2].The distortion can be minimized by the usual feedback procedure.

Revised Manuscript Received on June 05, 2019

ELAM CHEREN.S, Electrical and Electronics Engineering, Sri Krishna college of Engineering and Technology, Coimbatore, India.

ASHOK KUMAR.L, Electrical and ElectronicsEngineering, PSG college of Technology, Coimbatore, India.

RADHAKRISHNAN.G, Electrical and ElectronicsEngineering, Sri Krishna college of Engineering and Technology, Coimbatore, India.

KAVIN.R, Electrical and Electronics Engineering, Sri Krishna college of Engineering and Technology, Coimbatore, India.

If the capacitor value is reduced the line current distortion reduces. If the capacitor is increased harmonic current would increase and cause worsening of THD. To solve optimization problem non-iterative methods can be used in shunt active power filters [3]. When grid disturbances like balanced and unbalanced condition exists an observer is used as a element of sensorless control system [4]. A technique of computing weighted values of fundamental load current active and reactive components which produce inverter switching pulses [5]. Several active and passive filtering techniques have been suggested to compensate distributionsystem harmonic distortions [6] but addition of filters is not economically viable. Several harmonic identification techniques [7] have been discussed and method based on Fourier transformation in [8],Alternatively enhancement of quality powerin distribution network with flexible grid connected control of DG units [9]–[13],by modifying control references additional harmonic reparation potential is incorporated with the fundamental power generation objective of DG.This is an attractive idea by considering the possible potential from offstage alternative energy sources is mostly inferior than the power value of converter interfaced distributed generation.

The harmonic current reparation techniques is important for exact identification of local utility harmonic current as proposed in [9]–[13].

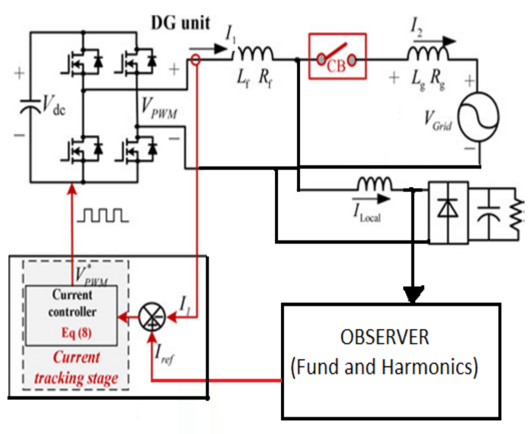

Fig.1 DG System with observer based current compensation potential

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The instantaneous value of active and reactive is taken into consideration for detection scheme in [14], second-order generalized integrator (SOGI) in [15], and the detection based oncancellation of delayed signal in [18]. After all the harmonic separation methods considerably boost the computing load of distributed generation controllers. Complicated techniques of harmonic extraction might not be accepted economically for a distributed generation unit with restricted computing capability. Alternatively, an impressive harmonic detection techniques was presented in [16] and [17]. To absorb local load harmonics by regulating DG output current the primary grid current can be made to be sinusoidal by direct control technique. Under this condition local load current is consider for the grid current regulation loop as a disturbance. Ifgrid current is controlled directly a smaller stability margin exists in the DG system. The above all methods needs additional filters for harmonic compensation and PLL [20] adoption for power control scheme. This work proposesa harmonic compensation technique for current-controlled DG and with the observer block power control and harmonic compensation can be achieved. The proposed method showsharmonic compensation and power control without using POC harmonic voltage detection or take out harmonic current of any local nonlinear load. Another advantage of this method is no need of additional filters.

II. MODELLING OF ACTIVE FILTER

The main effect of harmonic current distortion is overheating of components like transformers and cables. The large 3rd, 5th, 7th, 9th etc harmonic currents cause a heavy distortion of the mains voltage. Generally passive L-C filters was added to eradicate non-linear load generated harmonics. The power system equivalent impedance influences the restitution tendency of passive filters which generate either shunt or cascade resonance within the service power source.Active power filters are impressive tools for the reparation of non-linear load current harmonics, reactive powerand balancing non-linear and fluctuating loads. This paper proposes a parallel active filters to remove the unfavourable harmonics and reparate the nonlinear load reactive power by introducing the reparation currents into the supply AC lines.It is a current source with the load equivalent amplitude and opposite phase which injects the harmonic current into the AC supply lines. Any type of load can be applied with this principle. A current controlled VSI with required passive components can act as active power filter. The filter is regulated to gather/supply a reparation current from/to the load, such that it eliminate the non-linear load harmonics and reactive currents. Then the output current from the AC mains is sinusoidal. To compensate the non-linear loads in the line the active power filter required to produce harmonic and reactive current.

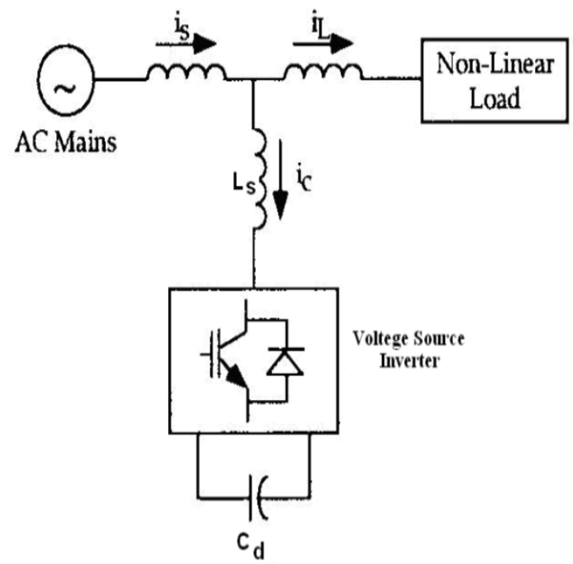

Fig.2 Schematic diagram of shunt active power filter

A voltage source inverter, DC energy storage device and coupling inductance are major components of active power filter [19]. The compensation current is produced by the inverter which charge and discharge the capacitor. The energy storage is done by the capacitor (C_d), smoothing and ripple reduction is performed by inductance (L_S) of active power filter injected harmonic current. Theactive power and reactive power is supplied by the AC power and capacitor of active power filter respectively.

III. HARMONIC EXTRACTION METHODS

A considerable number of published methods which represent various topologies and strategies for active power filtering control. In the frequency domain approach, the distorted current or voltage signals is applied with Fourier transform to draw out the compensating signals. The Fast Fourier Transform (FFT) techniquedetermines the phase and magnitude of the load current. Time domain harmonic extraction methods [21] depend on instantaneous compensating signal derivative of either current or voltage signals pattern from the distorted current or voltage signals.

This paper adopts current Control schemewhich is the core of the active filter since it states switching frequency, time response of the converter and the precise to trail the reference current. This method provides instantaneous current corrective response, automatic peak current limitation, simple implementation, good dynamic response and unconditional stability. The control parameters like slope of the switching surface cannot be retrieved instantly from power stage component values.

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IV. SIMULATION OF CURRENT CONTROLLER

The simulation outcome of the current controller are shown. The results prove the validity of adaptive harmonic elimination technique in the attenuation of lower order harmonics. This method reduces the non-linear loaddistortion which is presented in the experimental results. The Grid also is built out of a voltage controlled voltage source, driven by a cosine signal generator.The ladder filter has been replaced by an LC filter. This is an equivalent filter and is quite a good LPF. The inverter is suddenly linked to the grid by a switch at t = 0.06 second.The grid and inverter voltage values are approximately in phase (A PLL if used will guarantee this. However, in the above circuit, PLL was not used.Basically the circuit is rigged up for fundamental current control. This current is made to pass through the load, using the power amplifier (namely the Inverter).The fundamental current and harmonic currents are separated by using an observer block. The observer is made to separate up to 13^{th} harmonics. To find the gamma value of observer MATLAB programming is used. The equation used to find the gamma values are given below.

$$G^t = place(A^t, C, P)$$

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P is the designed pole location.
A is the n*n matrix and C is the n*1 matrix.

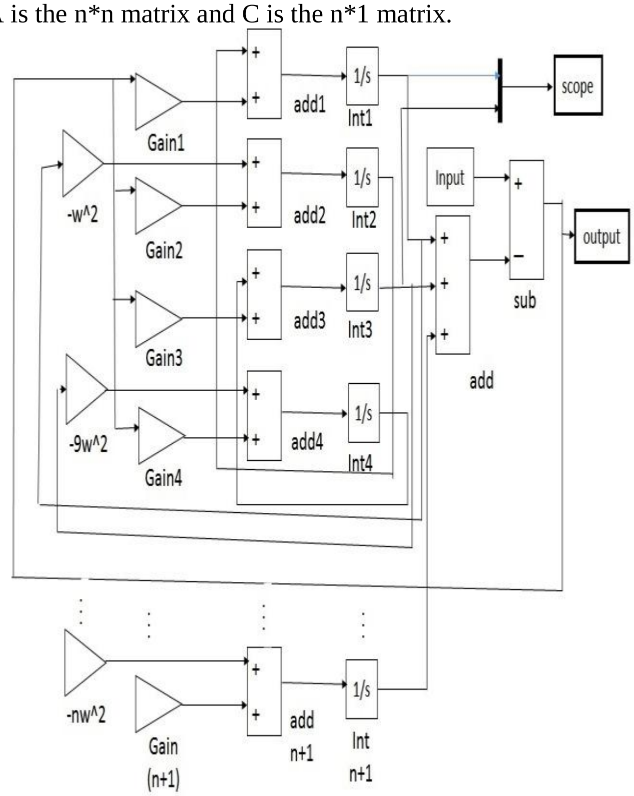

Fig.3 Observer upto nth harmonics

Fig.3 shows the observer up to n^{th} harmonics, it means this observer separate fundamental and n^{th} harmonics. If we give the harmonics rich signal to this observer, the output of the observer will be fundamental and n^{th}harmonics separately.Initialising of the observer needs observer poles. Observer poles are nothing but the character equation roots. If the roots are very nearer to the zero will gives better results but takes more time to converge.There are five output ports for this observer for Fundamental,3^{rd},5^{th},$7^{th}$and 9^{th} harmonics.In this workthe observer can block up to 13^{th} harmonics.

$$\begin{bmatrix} X1' \\ X2' \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -W^{\wedge}2 & 0 \end{bmatrix} \begin{bmatrix} X1 \\ X2 \end{bmatrix} + \begin{bmatrix} r1 \\ r2 \end{bmatrix} e$$

e is the error of the observer and it is given as feedback.The Fig.4 shows ladder filter replaces LC filter which is equivalent and quite good low pass filter. Fig.5 represents proportional and resonance controller which has LPF removes spikes and not harmonics. $V_p$is the voltage reference for processing pulse width modulation (PWM), $K_p$currentController proportional gain $G_{cur}(s)$,$K_{ih}$is the gain of resonant controller at the order h, ω_{ch}resonant controller cut-off frequency, and ω_{ch}isthe angular frequency value at fundamental and selected harmonicfrequencies.

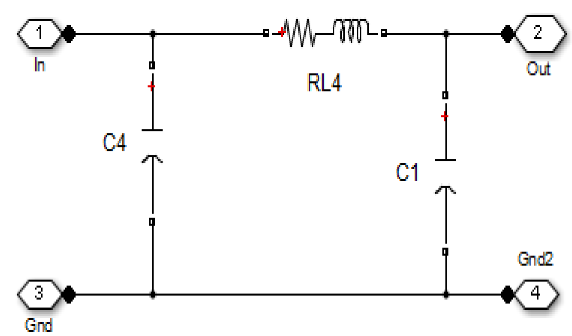

Figure. 4 Ladder Filter (Elemental)

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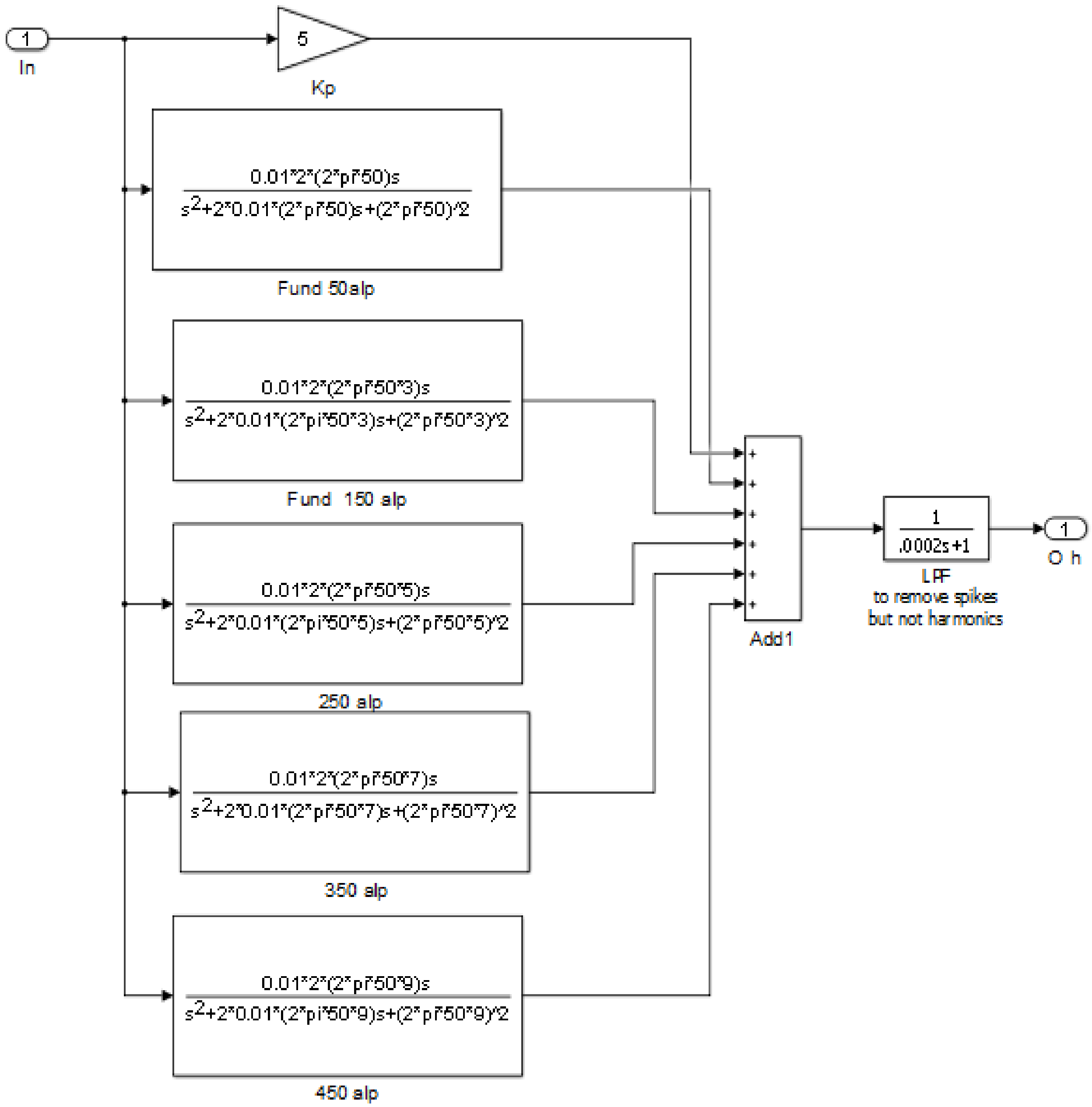

Fig.5 Proportional and Resonance Controller

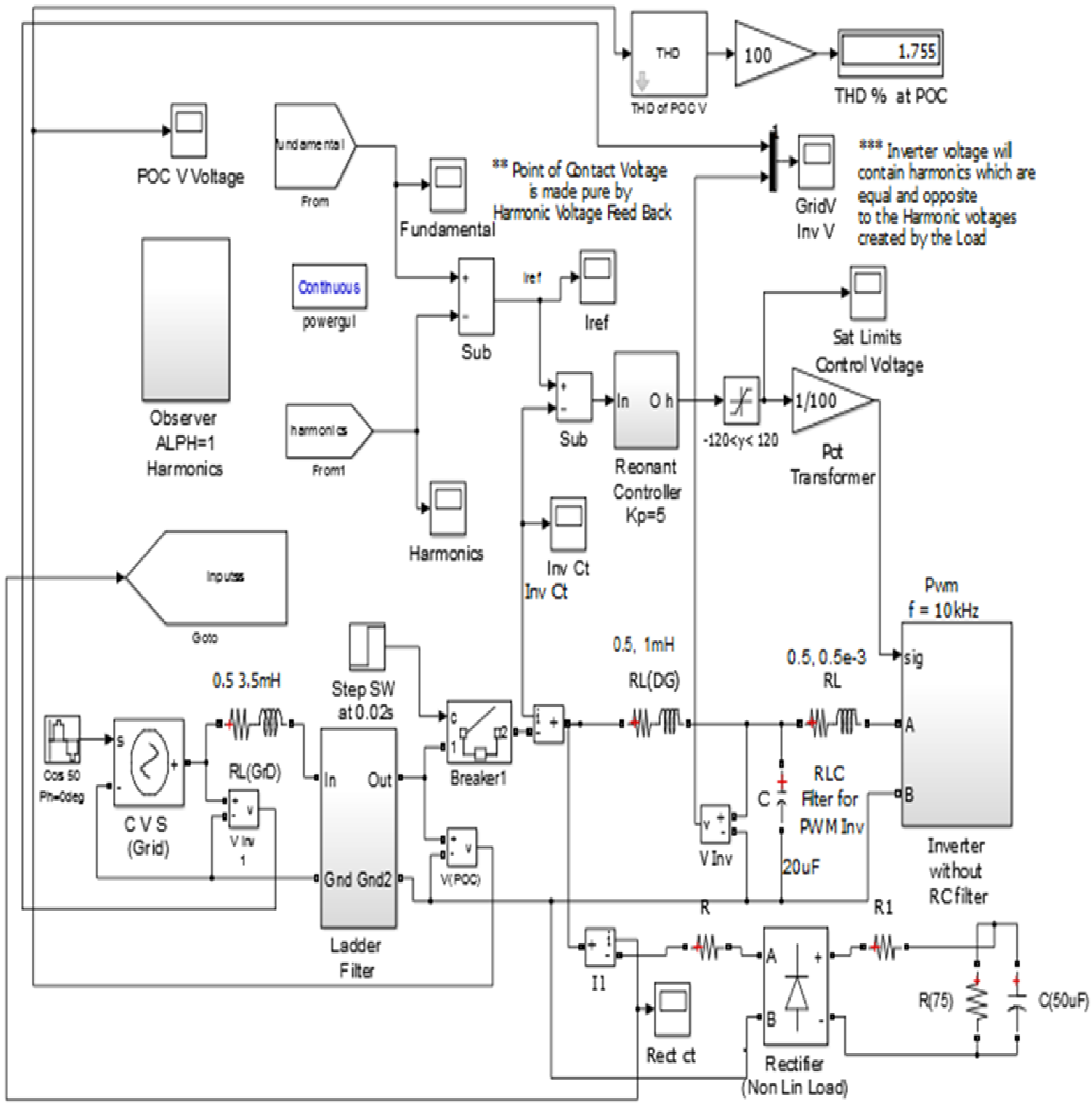

Fig.6Single phase inverter as DG with Harmonic Compensation.

In the simulation shown in Fig.6 a single phase inverter is used as distributed generator. The total harmonic distortion is in acceptable limit by this approach. With single phase inverter as a distributed generator the harmonic elimination can be done successfully. Fig. 7 and Fig.8shows the observer output upto 3rd harmonics and 9th harmonics.

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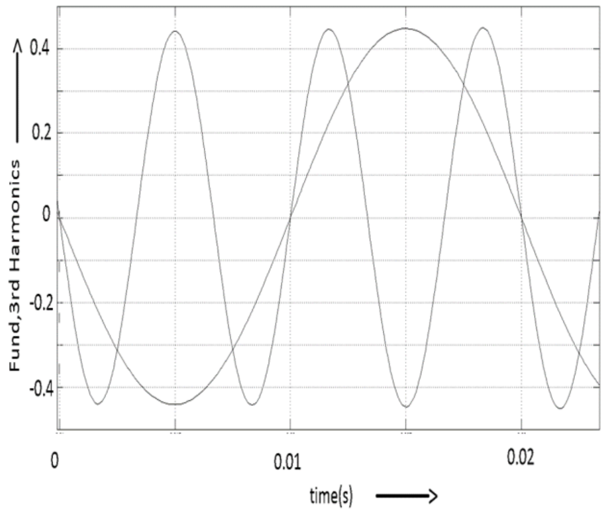

Fig.7 Observer Upto 3rd Harmonics

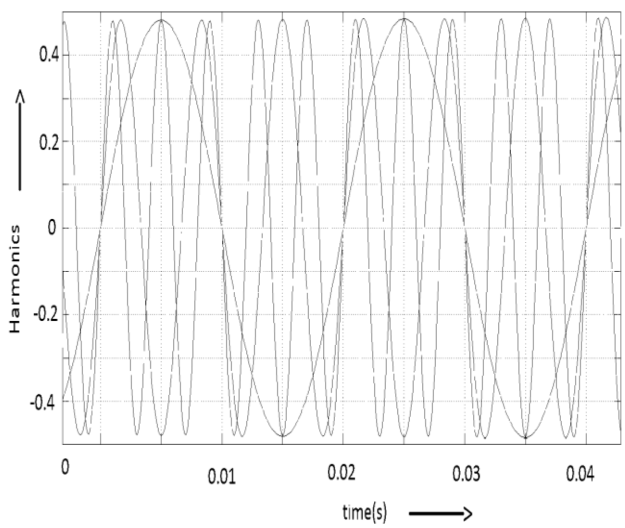

Fig.8 Observer Upto 9th Harmonics

Fig.9 shows load side rectifier current and inverter, grid voltage of single phase inverter as distributed generator with harmonic compensation is shown in Fig.10.

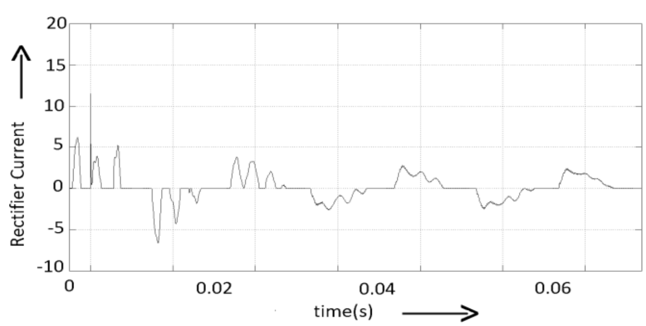

Fig.9 Rectifier Current load side

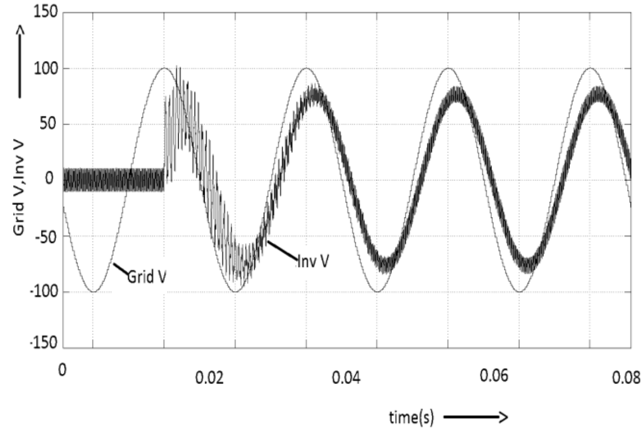

Fig.10 Inverter Voltage and Grid Voltage

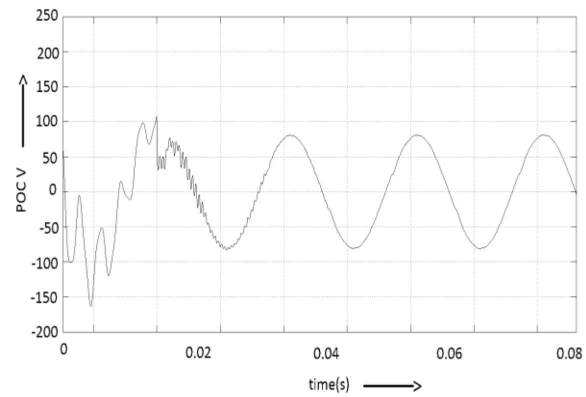

Fig.11 POC Voltage

The point of coupling voltage and inverter current shows in Fig.11 and Fig.12 represents that system harmonic values of voltage and current are considerably reduced. Implementation of observer gives active elimination of harmonics and less total harmonic distortion.

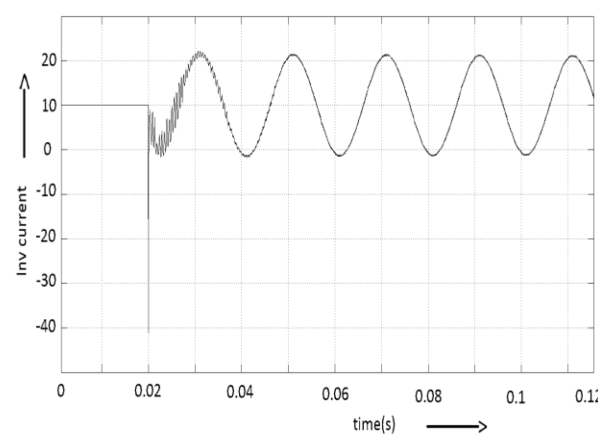

Fig.12 Inverter Current

V. CONCLUSION

This work proposes a simple harmonic reparation method for converter interfaced current-controlled distributed generation unit. Thisapproachcomprehend power control and harmonic compensation with the help of observer block. The separation of fundamental and various harmonics is done by observer block. Another advantage of this method is no need of additional filters. The distributed generator inverter itself eliminate harmonic effectively. The PLLs adoption and primary power control is managed by a closed loop power control method. Even when harmonic reparationworks are triggered in the distribution generation unit or the PCC voltage alters the suggested power control strategy assure exact power control. The THD at PCC is around 1.755 % which is in acceptable value ensures the positivity of the proposed method.

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