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A Technique for Shunt Active Filter meld micro grid System

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ABSTRACT
The proposed system presents a control technique for a micro grid connected hybrid generation system ith case study interfaced with a three phase shunt active filter to suppress the current harmonics and reactive power present in the load using PQ Theory with ANN controller. This Hybrid Micro Grid is developed using freely renewable energy resources like Solar Photovoltaic (SPV) and Wind Energy (WE). To extract the maximum available power from PV panels and wind turbines, Maximum power point Tracker (MPPT) has been included. This MPPT uses the "Standard Perturbs and Observe" technique. By using PQ Theory with ANN Controller, the Reference currents are generated which are to be injected by Shunt active power filter (SAPF)to compensate the current harmonics in the non linear load. Simulation studies shows that the proposed control technique performs non-linear load current harmonic compensation maintaining the load current in phase with the source voltage.
***Keywords* -** Active filter, ANN controller, Distributed Energy resources, Harmonic distortion, Micro grid, Maximum power point tracker, Photovoltaic, PQ Theory, Wind Energy

I. INTRODUCTION

Due to an extensive increase in energy demand, and the distinct advantages offered by the micro grid to customers as well as to the utilities such as lower environmental impact, greater reliability, reduced cost and higher efficiency keeping them as fundamental requirements, the present power scenario is sweeping towards the development of a hybrid micro grid as an alternative for the flexible extension of the actual energy distribution network [1]. The basis of the Micro grid conception is to congregate the loads and micro-sources operating as a single controllable system adjoined at a single point of common coupling (PCC) to furnish the power and heat for its local area [2]. Renewable energy sources like solar, wind, Biomass, hydro and Geo thermal power are equipped in a micro grid. Micro sources such as wind turbines and photovoltaic cells are well known for their discontinuity in power generation, the hybrid system which is proposed allows using an adaptive MPPT algorithm along with the method of standard perturbs and observes is to utilize ultimate accessible energy from the renewable energy resources [3].

Micro grid basically incorporates inverter-interfaced distributed energy resources (DER) such as PV arrays, wind turbines, fuel cells, micro turbines which are hooked to the distribution system making the power network weak and drawing non-sinusoidal current from the load yielding to harmonics and circulation of reactive power [4].

Basically the harmonics are materialized into two categories.
• Short Term
• Long Term

Short-term harmonics are mainly associated with enormous voltage distortion and easily noticeable. On the flip side, long-term harmonics yield increased voltage stresses. This harmonic current can collaborate unfavorably with power system equipment like motors and transformers causing over loading, overheating and additional losses and can also create interference with the telecommunication system and may lead to erroneous operation in metering devices. Due to these detrimental effects Standards like IEEE 519-1992, IEC had developed to define a clear-cut framework to control the harmonics. These harmonic distortions of power distribution systems can be compensated using two fashions namely, passive and active filtering [5]-[7]. The passive filtering approach is the least expensive and provides an elementary ordinary solution to suppress the harmonic deformity. But it inherits of several shortcomings such as the components are Bulky in size, dependence on the source impedance, the creation of the resonance problem and there by perturbing the stability of the power distribution system [8]. Therefore, the active power filter appears to be a feasible solution for the compensation of reactive power besides wiping out the harmonic currents.

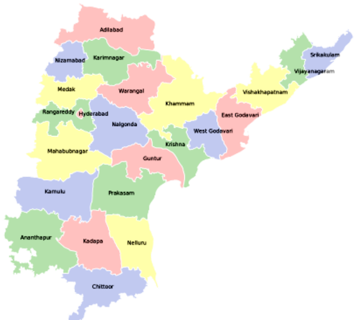
The main focus in designing and controlling of APF is the estimation of compensation current and generation of reference signal. Various schemes such as Fast Fourier Transform (FFT), Kalman filter and artificial neural networks (ANN) which are developed by so many authors are studied for the control of active filters [9]. However, Kalman filter approach is unfit for on-line applications such as active power filtering Even the Fast Fourier

Transform (FFT) technique gives inaccurate results, if the signal has any DC component of decaying type [10]. The ANNs are trained to compute the required harmonic currents depending upon the back propagation rule. This technique leads to imprecise results in the existence of random noise and it requires huge data for training of ANNs [11]. Most of the above-said control techniques are troublesome and complex to employ under non-ideal conditions.

In this paper, Maximum Power point tracking (MPPT) controller using standard Perturbs and observe approach [12] is used for both the Photovoltaic (PV) array and the permanent magnet synchronous generator (PMSG) wind turbine generation system. The instantaneous active and reactive power theory (PQ theory) strategy has been implemented for the estimation of reference currents. The stationary reference frame (abc) variables are transformed into the Synchronous orthogonal reference frame (αβ0) in the prospective approach. This analysis was primitively particularized for three-phase systems by Akagi in 1983 [13], and later it was extended by various researchers [14]-[17]. In this contemplated theory, the three phase system can be represented as a single phase system by altering the load current and grid voltage by 90°, thus facilitating the single phase system to be represented as a fictitious two-phase system. The proposed PQ theory with the ANN controller yields a ripple free DC voltage across the capacitor compared with the shunt active filter with PI controller .When compared to the other frequency-domain techniques, this approach has an outstanding compelling response and it requires lesser computational strain

II. Over view of the Proposed System

In the proposed system, a Hybrid micro grid equipped by Solar and wind energy is interfaced with a Shunt active filter using the PQ theory for the generation of reference currents with ANN controller is developed. Maximum power point tracker (MPPT) controller using standard Perturbs and observe approach is used to get hold of the maximum accessible power from the distributed energy resources (DER'S) like Photovoltaic (PV) array and permanent magnet synchronous generator (PMSG) wind turbine generation system.



By Considering all attributes for power generation from DES are considered and Concluded Solar PV, Wind Energy and Fuel Cell have good potential So among them Solar and Wind are considered.

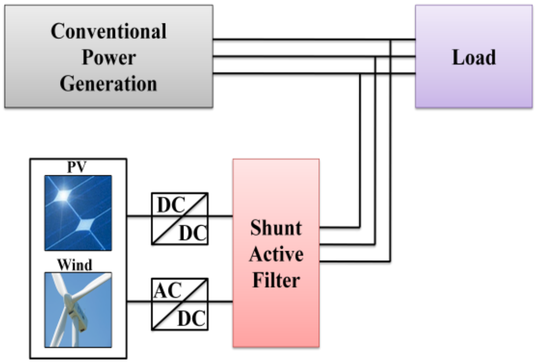


Fig.1 Overview of the proposed system

A. *PV ARRAY*

The PV cell can be epitomized by an electrical equivalent circuit in which the current source is placed in parallel with the diode as depicted in the figure 2. The solar cell acts like a diode during the darkness and therefore it neither produces a current nor a voltage. Thus, the diode evaluates the I-V characteristics of the cell [18]. The internal resistance to the current flow is indicated by the series resistance R_S, and it counts on the impurities, PN junction depth and contact resistance. The shunt resistance R_{Sh} and the leakage current to ground inversely associated to each other. A slight increase in R_S can diminish the PV output greatly. The PV conversion efficiency is most receptive to the small variations in R_s, but it is impassive to the variations in R_{Sh}.

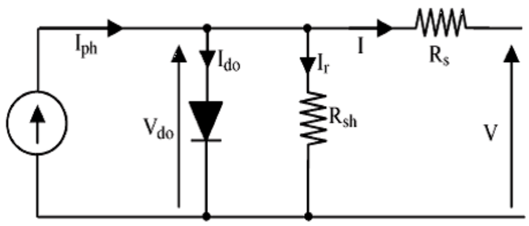


Fig.2.Equivalent circuit of PV Cell

The output current I and the output voltage V of a solar cell [19] are provided by (1), (2) as follows

$$I = I_{ph} - I_0(\exp(\frac{q}{n.k.T}V) - 1 \quad (1)$$

$$V = V_{d0} - R_s I \quad (2)$$

Here, I_{ph} is the photocurrent, I_0 is the reverse saturation current, I_{do} is the average current through the diode, n indicates the diode factor, q is the electron charge (q = 1.6^*10^{-19}), k is the Boltzmann's constant (k = 1.38^*10^{-23}), and T is the solar array panel temperature. *Rs* indicate the intrinsic series resistance of the solar cell. *Rsh* is the equivalent shunt resistance of the solar cell, and its value is very large. If the circuit is opened, then the current I=0, and the open circuit voltage V_{oc} is symbolized by (3) as follows

$$V_{OC} = (\frac{n.k.t}{q}) \text{ In } (\frac{I_{ph}}{I_o}+1) \approx (\frac{n.k.t}{q}) \text{ In } (\frac{I_{ph}}{I_O}) \quad (3)$$

If the circuit is short circuited, the output voltage V=0, the average current through the diode is generally ignored, and the short circuit current I_{sc} is expressed by (4)

$$I_{sc} = \text{I} = \frac{I_{ph}}{1+\frac{R_s}{R_{sh}}} \quad (4)$$

Lastly, the PV output power P, is asserted by

$$\text{P} = \text{VI} = (I_{ph} - I_{do} - \frac{V_{d0}}{R_{sh}}) \quad (5)\backslash$$

1) Perturb and Observe (P&O)

Perturb and observe algorithm has been used to elicit the ultimate accessible power from the solar panel. To achieve this, a slight perturbation is introduced in the system. The perturbation is preceded in the incremental direction, if the power increases because of the introduced perturbation [20]. And if the power is reached to the peak value then at the next off the power decreases and the perturbation direction will be reversed. After reaching the steady state, the algorithm pivots around the peak point. The perturbation size is stored up to a small value to keep the power variation in a small range. The module reference voltage is set by referring to the peak voltage of the PV module with the help of controller and thus it acts by sliding the point of the module to that particular voltage level.

B. Wind Turbine

In this paper the modeling of the wind turbine driven by PMSG is described. The three bladed rotor is the most important and visible part of the wind turbine. The working principle of the wind turbine can be described in two processes that are accomplished by its vital components: the rotor extracts the kinetic energy from the wind passing over the blades and it converts into mechanical torque. The job of the generating system is to convert the mechanical torque into electricity.

1) Mathematical model of Wind Turbine

Under constant acceleration, the kinetic energy of an object of mass *'m'* and velocity *'v'* is equal to the work done W in displacing the object from the rest to a distance 's' under force F, i.e.,

$$E=W=Fs \quad (6)$$

Therefore the kinetic energy of an object of mass *'m'* with velocity 'v' is

$$\text{E} = \frac{1}{2}mv^2 \quad (7)$$

The power from the wind is given by the rate of change of energy

$$\text{P} = \frac{dE}{dt} = \frac{1}{2}v^2\frac{dm}{dt} \quad (8)$$

As mass flow rate is given by $\frac{dm}{dt} = \rho A\frac{dX}{dt}$

And the rate of change of distance is given by $\frac{dX}{dt} = v$

We get $\frac{dm}{dt} = \rho Av$

Hence from the equation (4), the power can be defined as

$$\text{P} = \frac{1}{2}\rho Av^3 \quad (9)$$

The swept area of the turbine can be estimated from the length of the turbine blades using the equation for the area of a circle.

$$A = \pi r^2 \quad (10)$$

Where 'r' is the radius and is identical to the blade length. The mechanical power available from the wind turbine is expressed as

$$P_{Turbine} = \frac{1}{2}\rho AC_p(\boldsymbol{\lambda}, \beta)v^3 \quad (11)$$

Where ρ is the air density (typically 1.225 kg/m^3), A is the area swept by the rotor blades, C_p is the coefficient of power conversion and v is the wind speed(in m/s). The tip speed ratio $\boldsymbol{\lambda}$ is given by

$$\lambda = \frac{\boldsymbol{\omega_m R}}{v} \quad (12)$$

Where ω_m and R are the rotor angular velocity (in rad/sec) and rotor radius (in m) respectively. The wind turbine mechanical output torque is given by

$$T_m = \frac{1}{2}\rho AC_p(\boldsymbol{\lambda}, \beta)v^3 \frac{1}{\omega_m} \quad (13)$$

If the swept area of the blade and air density are constant, the value of C_p is a function of $\boldsymbol{\lambda}$ and it is maximum at the particular λ_{opt} . Then

$$P_{Turbine} = \frac{1}{2}\rho AC_{pmax} v^3 \quad (14)$$

The mechanical torque obtained from the wind turbine is fed to the permanent synchronous generator, the AC power is converted to DC and it acts as auxiliary supply voltage to the shunt active filter [20]

C. Shunt Active Filter

The Shunt Active Filter comprises of Voltage source inverter (VSI) fed through a DC capacitor to mitigate the harmonics. The chore of the shunt active filter is to compensate the load current harmonics by injecting the equal and opposite compensating current which are phase-shifted by 180^0.The shunt active power filter with ANN controller is contemplated to act as a current source by injecting the equal and opposite harmonic components that are generated by the load.

1) Extraction of Reference Compensation Currents

The shunt active filter need to estimate the reference current for each phase of the non linear load, and the voltage of the DC bus must be maintained constant and relevant gating signals has to be generated by the control circuit in accordance with the error signal that is being generated. The suppression of the harmonics can be implemented in time domain or frequency domain. In the present proposed scheme, P-Q theory has been implemented. The three-phase voltages and currents in *abc* co-ordinates are altered to *αβo* co-ordinates (15) & (16), followed by the computation of instantaneous power components.

$$\begin{bmatrix} V_o \\ V_\alpha \\ V_\beta \end{bmatrix} = \sqrt{\tfrac{2}{3}} \begin{bmatrix} 1/\sqrt{2} & 1/\sqrt{2} & 1/\sqrt{2} \\ 1 & -1/2 & -1/2 \\ 0 & \sqrt{3}/2 & -\sqrt{3}/2 \end{bmatrix} \begin{bmatrix} V_a \\ V_b \\ Vc \end{bmatrix} \quad (15)$$

$$\begin{bmatrix} i_o \\ i_\alpha \\ i_\beta \end{bmatrix} = \sqrt{\tfrac{2}{3}} \begin{bmatrix} 1/\sqrt{2} & 1/\sqrt{2} & 1/\sqrt{2} \\ 1 & -1/2 & -1/2 \\ 0 & \sqrt{3}/2 & -\sqrt{3}/2 \end{bmatrix} \begin{bmatrix} i_a \\ i_b \\ ic \end{bmatrix} \quad (16)$$

$$\begin{bmatrix} p \\ q \end{bmatrix} = \begin{bmatrix} V_\alpha & V_\beta \\ -V_\beta & V_\alpha \end{bmatrix} \begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix} \quad (17)$$

$p= V_\alpha i_\alpha + V_\beta i_\beta$ Instantaneous Real power

$q=V_\alpha i_\beta - V_\beta i_\alpha$ Instantaneous Imaginary power

To grab the reference compensation current in $\alpha - \beta$ co-ordinates, invert the expression (17),

$$\begin{bmatrix} i_{c\alpha}^* \\ i_{c\beta}^* \end{bmatrix} = \frac{1}{V_\alpha^2 + V_\beta^2} \begin{bmatrix} V_\alpha & -V_\beta \\ V_\beta & V_\alpha \end{bmatrix} \begin{bmatrix} p_x \\ q_x \end{bmatrix} \quad (18)$$

The reference compensation current in *o* co-ordinate is considered to be i_0 itself, as the zero sequence current must be compensated and is given by (19)

$$i_{co}^* = i_o \quad (19)$$

An inverse transformation has been applied to the equation (16) to procure the reference compensation currents in *abc* co-ordinates

$$\begin{bmatrix} i_{ca}^* \\ i_{cb}^* \\ i_{cc}^* \end{bmatrix} = \sqrt{\tfrac{2}{3}} \begin{bmatrix} 1/\sqrt{2} & 1 & 0 \\ 1/\sqrt{2} & -1/2 & \sqrt{3}/2 \\ 1/\sqrt{2} & -1/2 & \sqrt{3}/2 \end{bmatrix} \begin{bmatrix} i_{co}^* \\ i_{c\alpha}^* \\ i_{c\beta}^* \end{bmatrix} \quad (20)$$

The reference neutral current is delineated by

$$i_{cn}^* = -(i_{ca}^* + i_{cb}^* + i_{cc}^*) \quad (21)$$

A fictitious two-phase system is elaborated using a single phase system resulting in π/2 lag or π/2 lead and the resultant two phase system can be asseverated in $\alpha - \beta$ co-ordinates. The α axis and β axis quantities are considered to be the original load voltages and load currents respectively. Whereas the π/2 lead load or π/2 lag voltages are treated as α axis quantities and π/2 lead or π/2 lag load currents are treated as β axis quantities. The π/2 lead is considered in the proffered work to achieve a two phase system for each phase and it is expressed in (22), (23).

The load voltage and current in α-β coordinates for the phase 'a', can be represented by π/2 lead as,

$$\begin{bmatrix} v_{La\_\alpha} \\ v_{La\_\beta} \end{bmatrix} = \begin{bmatrix} v_{La}^* (\omega t) \\ v_{La}^* (\omega t + \frac{\pi}{2}) \end{bmatrix} = \begin{bmatrix} v_{Lm} \sin(\omega t) \\ v_{Lm} \cos(\omega t) \end{bmatrix} \quad (22)$$

$$\begin{bmatrix} i_{La\_\alpha} \\ i_{La\_\beta} \end{bmatrix} = \begin{bmatrix} i_{La} (\omega t + \varphi L) \\ i_{La} [(\omega t + \varphi L) + \frac{\pi}{2} \end{bmatrix} \quad (23)$$

Where,

v_{La}^* = the reference load voltage

v_{Lm} =magnitude of the desired load voltage.

Likewise for phase 'b' and 'c', the load voltage and current in $\alpha - \beta$ coordinates are represented respectively by $\pi/2$ lead as,

$$\begin{bmatrix} v_{Lb\_\alpha} \\ v_{Lb\_\beta} \end{bmatrix} = \begin{bmatrix} v_{Lb}^* (\omega t) \\ v_{Lb}^* (\omega t + \frac{\pi}{2}) \end{bmatrix} = \begin{bmatrix} v_{Lm} \sin(\omega t - 120°) \\ v_{Lm} \cos(\omega t - 120°) \end{bmatrix}$$

$$\begin{bmatrix} i_{Lb\_\alpha} \\ i_{Lb\_\beta} \end{bmatrix} = \begin{bmatrix} i_{Lb} (\omega t + \varphi L) \\ i_{Lb} [(\omega t + \varphi L) + \frac{\pi}{2} \end{bmatrix} \quad (25)$$

$$\begin{bmatrix} v_{Lc\_\alpha} \\ v_{Lc\_\beta} \end{bmatrix} = \begin{bmatrix} v_{Lc}^* (\omega t) \\ v_{Lc}^* (\omega t + \frac{\pi}{2}) \end{bmatrix} = \begin{bmatrix} v_{Lm} \sin(\omega t + 120°) \\ v_{Lm} \cos(\omega t + 120°) \end{bmatrix}$$

$$\begin{bmatrix} i_{Lc\_\alpha} \\ i_{Lc\_\beta} \end{bmatrix} = \begin{bmatrix} i_{Lc} (\omega t + \varphi L) \\ i_{Lc} [(\omega t + \varphi L) + \frac{\pi}{2} \end{bmatrix} \quad (27)$$

Instantaneous active power and reactive power can be characterized by equation (28) and (29),

$$p_{L,abc} = v_{L,abc\_\alpha} . i_{L,abc\_\alpha} + v_{L,abc\_\beta} . i_{L,abc\_\beta} \quad (28)$$

$$q_{L,abc} = v_{L,abc\_\alpha} . i_{L,abc\_\beta} - v_{L,abc\_\beta} . i_{L,abc\_\alpha} \quad (29)$$

In consideration of the phase 'a', the instantaneous load active and instantaneous load reactive powers can be represented by,

$$\begin{bmatrix} p_{La} \\ q_{La} \end{bmatrix} = \begin{bmatrix} V_{La\_\alpha} & V_{Lb\_\beta} \\ -V_{Lb\_\beta} & V_{La\_\alpha} \end{bmatrix} \begin{bmatrix} i_{La\_\alpha} \\ i_{La\_\beta} \end{bmatrix} \quad (30)$$

Where,

$$P_{La} = \bar{P}_{La} + \tilde{P}_{La} \quad (31)$$

$$q_{La} = \bar{q}_{La} + \tilde{q}_{La} \quad (32)$$

In (31) and (32), $\bar{P}_{La}$ and $\bar{q}_{La}$ delineate the dc components. Whereas $\tilde{P}_{La}$ and $\tilde{q}_{La}$ delineate the ac components. The phase fundamental instantaneous load active and reactive power components are derived from p_{La} and q_{La} respectively by employing a low pass filter.

In consequence, the instantaneous fundamental load active and reactive power for phase-a are portrayed by the equation (33), (34)

$$P_{La,1} = \bar{P}_{La} \quad (33)$$

$$q_{La,1} = \bar{q}_{La} \quad (34)$$

In the same way, the fundamental instantaneous load active power and reactive powers for phases-b and c can be enumerated as in the equations (35)-(38)

$$P_{Lb,1} = \bar{P}_{Lb} \quad (35)$$

$$q_{Lb,1} = \bar{q}_{Lb} \quad (36)$$

$$P_{Lc,1} = \bar{P}_{Lc} \quad (37)$$

$$q_{Lc,1} = \bar{q}_{Lc} \quad (38)$$

Total power is given by equation (39) as follows

$$P_{L,Total} = P_{La,1} + P_{Lb,1} + P_{Lc,1} \quad (39)$$

$$P_{s/ph}^* = (P_{L,Total})/3 \quad (40)$$

Equation (40) signifies the distributed per phase fundamental active power demand. In order to achieve a perfectly balanced source currents, each phase of utility should supply that much amount of distributed per phase fundamental active power demand. The reference compensating currents can be represented in a perfectly balanced three-phase system by taking the inverse of equation (30).

$$\begin{bmatrix} i^*_{Sa\_\alpha} \\ i^*_{Sa\_\beta} \end{bmatrix} = \begin{bmatrix} V_{La\_\alpha} & V_{La\_\beta} \\ -V_{La\_\beta} & V_{La\_\alpha} \end{bmatrix}^{-1} \cdot \begin{bmatrix} P^*_{s/ph} + P_{dc/ph} \\ 0 \end{bmatrix} \quad (41)$$

In equation (41), $P_{dc/ph}$ implies the explicit amount of per-phase active power need to be taken from the source so as to maintain a constant level of dc-link voltage and also to overcome the losses linked with SAF.

Therefore, Equation (42), (43) & (44) represent the reference source currents for phase a, phase b and phase c, respectively.

$$i^*_{Sa}(t)=\{v_{La\_\alpha}(t)/(v^2_{La\_\alpha} v^2_{La\_\beta})\}.\{P^*_{s/ph}(t)+ P^*_{dc/ph}(t)\} \quad (42)$$

$$i^*_{Sb}(t)=\{v_{Lb\_\alpha}(t)/(v^2_{Lb\_\alpha} + v^2_{Lb\_\beta})\}.\{P^*_{s/ph}(t)+ P^*_{dc/ph}(t)\} \quad (43)$$

$$i^*_{Sc}(t)=\{v_{Lc\_\alpha}(t)/(v^2_{Lc\_\alpha} + v^2_{Lc\_\beta})\}.\{P^*_{s/ph}(t)+ P^*_{dc/ph}(t)\} \quad (44)$$

By simply adding the entire sensed load currents as in (45), the reference neutral current signal can be extracted.

$$i_{L\_n}(t) = i_{La}(t) + i_{Lb}(t) + i_{Lc}(t) \quad (45)$$

The proffered model computes the balanced per phase fundamental active power ,the dc link voltage control Stationed on Fast acting DC link voltage controller and the reference neutral current extraction as shown in the below Figure(2) respectively.

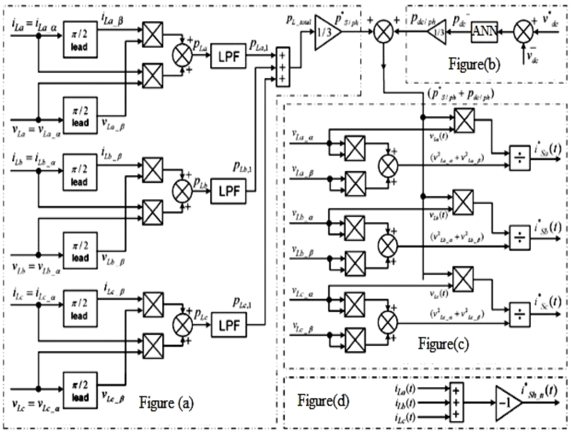


Fig .3 (a) Calculation of Per phase Fundamental Active Power (b) DC link voltage control loop (c) The Generation of Reference source current (d) Neutral Current Compensation.

III. SIMULINK RESULTS

The Performance of shunt active filter interfaced with a hybrid micro grid system is simulated and modeled using MATLAB/SIMULINK and SimPower System Block set is crafted. Figure 4(a) and 4(b) represents the phase to neutral voltage and grid current of the phase 'a', grid current compensated with integrated DG units respectively.

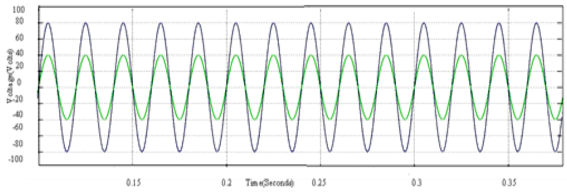


Fig.4 (a) The Phase to neutral voltage and grid current for the phase 'a'

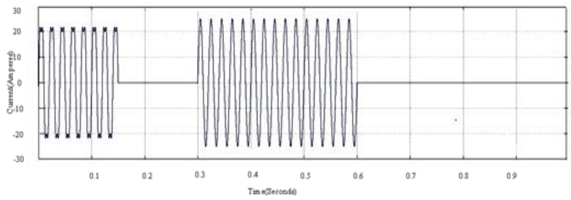


Fig.4 (b) Grid Current Compensated with integrated DG units

The Steady state operation of the contemplated micro grid link for the injection of the maximum available power to the grid continuously is traced graphically in the figure 4(c).

The Grid voltage and current compensated with DG system and the grid voltage after interfacing with shunt active filter are delineated pictorially in the figure 4(d) i & ii, figure 4(e) respectively.

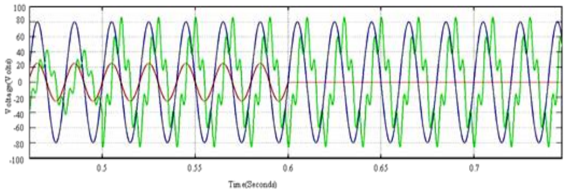


Fig.4(c) Steady-state operation of the proposed micro grid system link

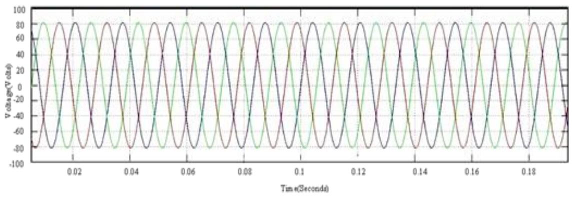


Fig.4(d) i Grid Voltage compensated with DG system

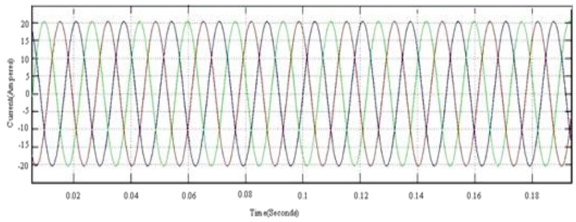


Fig.4(d) ii Grid current compensated with DG System

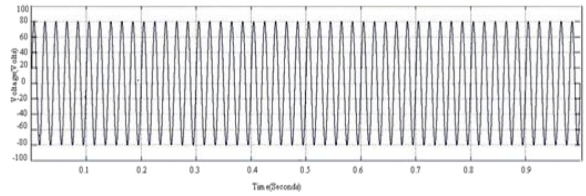


Fig.4(e) Grid Voltage with SAF

The load current waveform with for different loads and the Injection Current waveform of by Shunt active filter are shown in the figure 4(f) and figure 4(g) respectively.

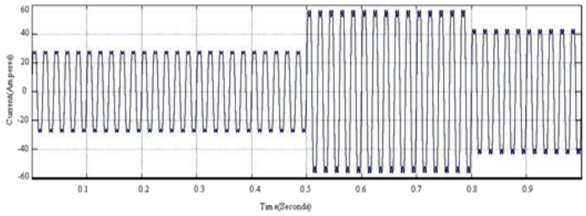


Fig.4(f) Load current variations with changed load

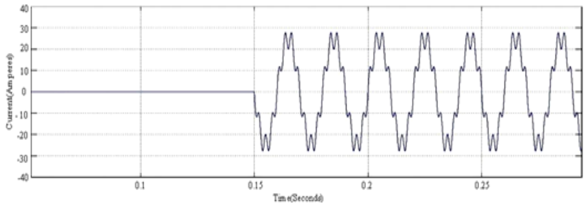


Fig.4(g) Injection Current of SAF

The difference in the load voltage before doing the compensation and after doing the compensation and the compensated voltage and distorted current are portrayed graphically in the figure 4(h) and figure 4(i) respectively.

The output power obtained from the PV panel and the wind turbine generating system are shown in the figure 4(j) and the figure 4(k) respectively.

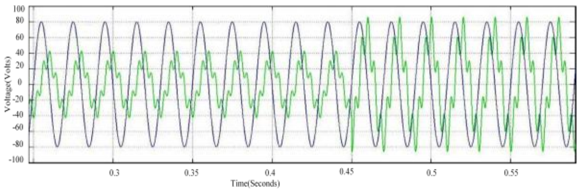


Fig.4(h) Load Voltage with and without Compensation

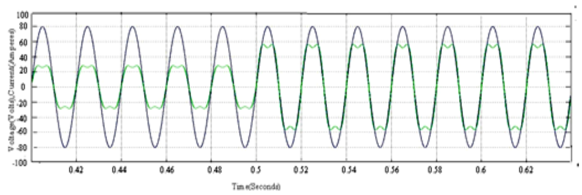


Fig.4 (i) Compensated voltage and distorted current

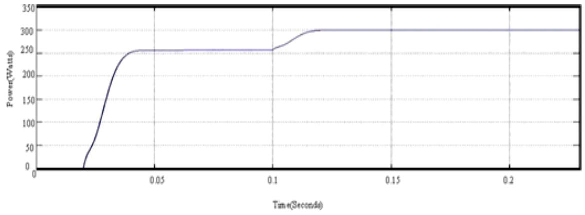


Fig.4 (j) PV Power

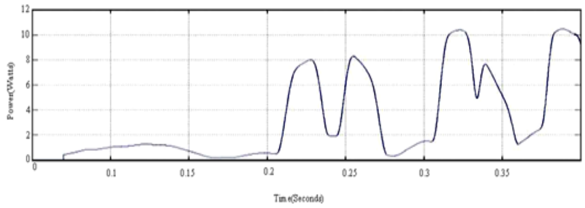


Fig.4(k) Wind power

The voltage and current variations of the wind turbine generating system are presented in the figure 4(l) and the figure 4(m) correspondingly.

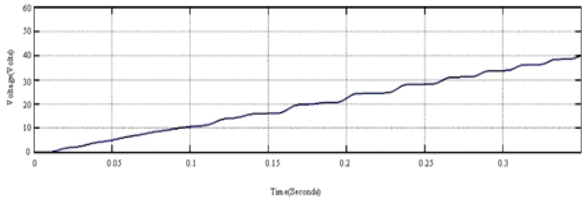


Fig.4(l) Wind Voltage Variations

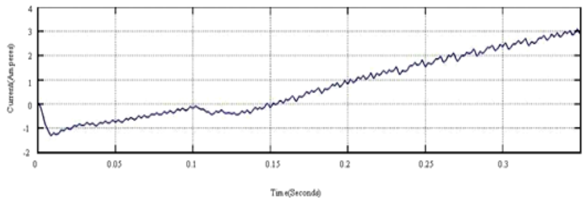


Fig.4(m) Wind Current Variations

IV. CONCLUSION

A multi objective control algorithm has been proposed and presented in this Paper for the grid-connected converter-based DG interface. Adaptability of the proposed hybrid micro grid in both transient state and steady state operations has been verified through simulation results. Another benefit from the proffered control method is that the control loops are considered to be independent of active and reactive power and it portrays fast dynamic response in tracking reactive power variations. In this, the models are developed for all the converters to maintain stable system under various loads, resource conditions and also the control mechanism are studied. The Micro Grid can provide a reliable, high quality and more efficient power to the consumer. After simulating the developed model in the SIMULINK, the results unfold that in all the conditions, the load voltage and source current are in phase and therefore the integrated DG systems can act as power factor corrector devices by improving the power factor at

PCC. The results revealed that the proposed hybrid micro grid system can provide required harmonic load currents in all situations. The proposed control approach can be applied for numerous types of DG resources as power quality enhancement devices in a customer power Distribution network.

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