International Journal of Advance Research in Science and Engineering
Vol. No.6, Issue No. 09 , September 2017
www.ijarse.com
IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

A Significant Outline to Power Quality using ASP in Power Electronics

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ABSTRACT

With the increasing responsiveness towards conserving power, the existing trends on the road to power generation system is much motivated on exploring on renewable resources. One of the major advantages of embracing of renewable resources is reduced cost of procedure due to reduced maintains as compared to the conventional power generators. Hence, the area has also found to be liable towards acceptance of various forms of renewable resources. However, with the existing of non-linearity of the existing loads owing to the usage of modern electronic devices, it generates potential amounts of harmonics, which should be control by using power filters. Hence, this paper introduces a technique for extrapolative control scheme for harmonic suppression.In order to show validity of the proposed control algorithm, compared conventional p–q theory.

Keywords*: *Power Quality, Power Electronic, Active Power Filter, harmonic Suppression

I. INTRODUCTION

With the increasingly energy crisis and environmental pollution, the use of renewable green energy sources, such as wind and solar, has been becoming popular worldwide. However, how to integrate these renewable sources into a power system, a challenging issue, has been attracting considerable attention [1,2,3,4,5].On one hand, rapid growth of non-linear loads such as power electronic inverters, used to integrate the renewable power sources into the grid, raises drastic power quality issues throughout supply networks. This results in many technical issues such as overheating of transformers, false operation of circuit breakers and relays, reduction in transmission system efficiency, and so on [6,7]. To address such issues, active power filters (APFs) are introduced into the power systems, and accordingly many compensation algorithms have been proposed to direct the control of the APFs. The generalized theory of instantaneous power (GTIP), for instance, was introduced in [8], and this compensation theory was then suggested for an interfaced photovoltaic system in [9]. However, under non-ideal waveforms, the GTIP theory results in highly source-end zero current components [10]. Many other prominent power theories, such as current's physical component [11], conservative power theory [12], the Fryze, Buchholz and Depenbrock method [13], and the p–q–r theory [14,15,16] were also proposed. In [25], a synchronous reference frame (SRF)-based compensation algorithm is introduced to extract the SAPF's references. This method only needs the information of one variable, namely the load-terminal current. In this method, the measured load current is transferred to the synchronous rotating frames, using cosine and sinus functions which are extracted by the phase locked loop (PLL). The generated reference of the SAPF is then synchronized with the supply voltages, using PLL-based orthogonal cosine and sinus signals. This method is unable to perfectly recognize and compensate those harmonic loads which show low impedances at certain frequencies. On the other hand, the APFs with controllable DC/AC inverters are an excellent option to integrate renewable power sources into the power grid as shown in Figure 1, since they give flexible functions to overall interconnected renewable energy sources, so as to supply the power grid and at the same time work as energy conditioners. Developing an accurate control algorithm for the APFs can also enhance the overall efficiency of the integrated renewable sources. problems may pose substantial dares in upcoming which should rely on renewable energies, a novel method is used to achieve more benefits, by using 3-phase 4-leg systems. Three-phase four-Leg Voltage Source Inverter (4L-VSI) of Active Power Filter employment is provided in the procedural literature [13]-[16].The paper has discussed a predictive control algorithm and testing chiefly for this application. Orthodox active power filters are controlled using controllers like PI- type. In comparison to conventional method [17], Output of the conventional PI controller can be controlled by providing load feedback value to a control system [19]. Predictive control algorithm can improve the performance of active power filter especially by obtaining a model during transient operation as it quickly follows the current-reference signal constant DC–voltage is maintained. The paper is describes the some of the significant existing work, he problem identification for current controlled grid-interfacing inverter. planned method for converter model. the research methodology by explaining the concepts of predictive current control technique with mathematical representation. the concepts of current reference generation models using DQ transformation technique. digital simulation study and concluding remarks are discussed

II. RELATED WORK

Zeng et al. [18] implemented a multi-port DC-DC converter for continuous power management. It can be different types and capacities and it uses minimum controllable switch. It is applied for continuous Maximum Power Point Tracking (MPPT) control of wind and solar hydride systems. The obtained results to validate the effective using of proposed converter to achieve efficient point of MPPT. Dai et al. [20] have studied the balanced / unbalanced and linear / non-linear current control in 3-phase 4-leg VSI and carried out using advanced p-q-r techniques, digital proportional integral derivative (PID) control rule and three-dimensional (3D) space vector pulse width modulation . Here, 3-phase 4-leg and PWM are designed separately. The study shows that even though voltage is not symmetrical, the presented algorithm leads to measuring and to generate the harmonic and reactive components of load current. Authors have also demonstrated both by means of simulation and real-time applications. Zhang et al. [21] have presented a scheme to reduce common mode noise in 3-phase 4-leg VSI. This system is based on classical 3-D SVM (Support Vector Machine) and found to produce greater DC-link, reduced harmonic content and low switching loss compare to sinusoidal PWM. Theory, simulation and results gives the details about near-state three-dimensional space-vector modulation switching scheme works under different balanced load conditions. Kim et al. [22] proposed a carried based PWM method for different level-leg PWM VSI with novel offset voltage. This offset voltage is used for switching sequence of all the legs for optimizing the harmonic distortion of output voltages. This method is implemented and tested using 3-level 4-leg VSI and it is verified by spectral analysis, simulation with experimental results. To achieve more benefits from grid-interfacing inverters using 3-phase 4-wire distribution systems are explained by the Singh et al. [23]. Here authors have demonstrated and simulated using Matlab / Simulink and it is validated through DSP processor based results. The study has also used various ACF function to perform and evaluate many functional devices. Chau et al. [24] have presented a new control method to improve dynamic behaviour of shunt active power filter under different loads. This method is tested and compared for large range of different load current and found to be satisfactory to mitigate harmonics for non-linear loads.

III. PROBLEM IDENTIFICATION

Generally, usage of Active Power Filter calls for design of predictive control scheme. However, till date all the schemes that have been introduced in the literature have significant drawbacks pertaining to frequency in terms of oscillation as well as instability factor generated from the load of uncertain features, such schemes results in significant loss of power quality. Hence, it is required that power generation system using renewable resources are required to adhere to standard framework of regulation for efficient distribution of power. Although with the modernization of harmonic suppression scheme to enhance power quality, there are various issues related to it. However, the estimation of the inductance factor over the network is quite challenging leads to degrade the performance of the power electronic devices. Active power filter are more flexible and very fast control response compare to conventional control methods. Active Power Filters (APF) is extensively used to compensate the current harmonics and load Unbalance. Shunt Active Power Filter (SAPF) that is capable of simultaneously compensating problems like current unbalance, current harmonics and also of injecting the energy generated by renewable energy source. The proposed system will take a case study of renewable energy sources to evaluate the issues of harmonic suppression.

IV. PROPOSED SYSTEM

In this section architecture of a schematic power distribution system with Hybrid of (ac-ac and dc-ac) power generation system with an active shunt power filter is discussed in Fig.1. It contains different power generation units like, type-1, type-2 etc., along with variable types of load impedances. Renewable sources like sunlight, wind, ocean etc. are generally used to generate electricity for different applications such as residence, small industries, schools and computer tuitions etc. A hybrid power generation uses AC-AC and DC-DC static pulse width modulation conversion for voltage conversion and more energy storage battery banks. The behavior of electrical energy is random and not predictable, so it may be non-linear, unbalance and 3-phase. Proposed PWM converter and 1st order ripple filter output shown in Fig.2. The nomenclature of the variables used in the study of proposed system tabulated in Table 1.

Figure. 1. Schema of Renewable Power Generation

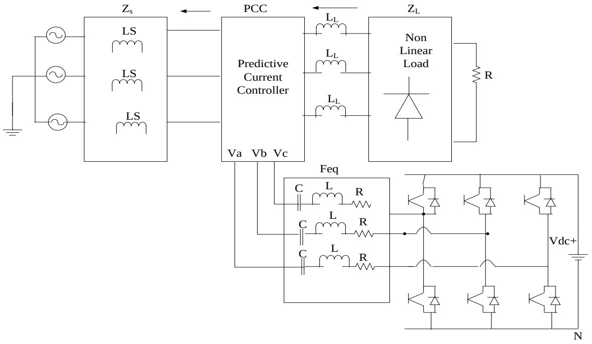

Fig. 2. Proposed 3-phase shunt active power filter

ac	Alternating Current	PLL	Phase Locked Loop
DC	Direct Current	V_{DC}	DC Voltage
PWM	Pulse Width Modulation	V_{Svv}	System Voltage Vector $[V_{Si}, V_{Sj}, V_{Sk}]^T$
PCC	Predictive Current Control	I_{Scv}	System Current Vector $[I_{Si}, I_{Sj}, I_{Sk}]^T$
I_{Ocv}	VSI Output Current Vector $[I_{Oi}, I_{Oj}, I_{Ok}]^T$	I_{Lcv}	Load Current Vector $[I_{Li}, I_{Lj}, I_{Lk}]^T$
I^*_{Orcv}	Reference Current Vector $[I^*_{Ori}, I^*_{Orj}, I^*_{Ork}]^T$	V_{Ovv}	VSI Output Voltage Vector $[V_{Oi}, V_{Oj}, V_{Ok}]^T$
I_N	Neutral Current	R_{filter}	Filter Resistance
L_{filter}	Filter Inductance	Z_{seq}	System Equivalent Impedance
Z_{filter}	Output ripple filter Impedance	Z_{load}	Load Impedance

Table 1 Nomenclature

This scheme consists of the power system equivalent impedance $Z_{Seq,}$ the ripple filter impedance Z_{filter} and load impedance $Z_{load.}$ A 2-level 4-leg PWM-VSI topology is shown in Fig.2. This topology converts the traditional 3-phase converter with fourth leg added to neutral bus of the system. It will increase the switching state from 8 to 16 and it improves control quality of the output voltage along with flexibility of control. The expression of switching state is given as,

$$V_{uN} = X_u - X_N V_{DC,}\ u = i, j, k, N$$

(1)

Where x indicates the voltage leg, n is the neutral point and the mathematical modeling of filter is obtained from an equivalent circuit shown in figure. 2 and it results,

$$V_{Ovv} = V_{uN} - R_{eq} I_{Ocv} - L_{eq} \frac{d(I_{Ocv})}{dt} \qquad (2)$$

Where R_{eq} and L_{eq} are output parameters and these are expressed by using Thevenins impedance (Z_{eq}). So it is obtained by multiplying of Z_{Seq} and Z_{load} to the addition of Z_{Seq} and $Z_{load.}$ Then the overall added with Z_{filter} it gives final Z_{eq} .

In this model, it consider that Z_{load}>>$Z_{Seq.}$ i.e.., the resistive part of the equivalent impedance neglected, and the reactance is in between the range 3-7% power unit it is acceptable to the real system. Finally in eq (2), $R_{eq} = R_{filter}$ and $L_{eq} = L_{sys} + L_{filter}$

V. RESEARCH METHODOLOGY

A simplified structure of the proposed digital predictive current control shown in Fig.3. This scheme is purely Optimization algorithms. Thus it has to be implemented digitally using microprocessor based hardware. The aim of the controller is to determine the inverter voltage V_{k+1} required to achieve the set point current $V_{k=1}$ on each cycle. A Proposed novel predictive current control scheme is depends on the optimization algorithm, and it is to be developed in a microprocessor is as shown in Fig.3. The analysis of the PCC gives an additional restriction like delays time and approximate. The characteristic of this controller is to predict, the behavior of variable system models. By using this information, the system model selects optimum switching state and it will be applicable to power converter, as the standards of optimization theory. The PC algorithms are to implemented and understand and it can be design with 3 main blocks as shown in fig 3.

A. Current Reference Generator:

A current reference generator is a basic building blocks in analogy circuit design as a bias source for oscillators, amplifiers, PLL'S and etc., all mentioned applications makes extensive use of current reference and their accuracy is strong related to the temperature and process stability of these reference. In the voltage mode can implement a band gap circuit to ensure current biases over a large Lange of temperature range. V_{Svv} and I_{load} are considered as input parameters and I_{Ocv} is the output parameter. Here it will measure a voltage and load current with dc-voltage controller's. This circuit is used to obtain the reference current I_{Ocv} and it is used to compensate with $I_{load.}$

B. Prediction Model:

It is used to predict output current, because it operates in discrete time. So, both must be indicated in digital time domain. This model contains a recursive matrix equation with

prediction system i.e. the sampling time Ts, is convert the control variable at instants of time xTs, and it is also predict the next state of time [x+1] Ts from equation (1) and (2), derived a first order equation is given as,

$$\frac{du}{dt} \approx \frac{u[x+1] - u[x]}{T_S} \qquad (3)$$

The outputs are obtained from predicated value and it can be generated from eq (2) and (3) are,

C. Cost Function Optimization:

$$I_{Ocv}[x+1] = \frac{T_S}{L_{eq}}\left(V_{uN}[x] - V_{Ovu}[x]\right) + \left(1 - \frac{R_{eq} T_S}{L_{eq}}\right) I_{Ocv}[x] \qquad (4)$$

as eq (4) shows that in order to obtain the output current I_{Ocv}, at a time (x+1), the value of V_{Ovv} and the value of output voltage (V_{uN}) required.

Cost function is a optimize model parameters (design variables), it will evaluate the cost and constraint values for the design variables values for an iterations. It can also be used for global sensitivity analysis. Optimization means minimize a cost (objective function) or maximize a cost (objective function). To get optimal switching state, must be applying to the power converter. The predicted values are generated for $I_{Ocv}[x+1]$ and it is compared with reference cost function (g), and is given as,

$$\begin{aligned} g[x+1] = {} & \left(I*_{Ori}[x+1] - I_{Oi}[x+1]^2\right) + \left(I^*_{Orj}[x+1] - I_{Oj}[x+1]\right)^2 \\ & + \left(I*_{Ork}[x+1] - I_{Ok}[x+1]\right)^2 + \left(I^*_{OrN}[x+1] - I_{ON}[x+1]\right)^2 \end{aligned} \qquad (5)$$

When, $g = 0,\ I_{Ocv} = I_{Ocv}*$

Therefore, the cost function achieves a (g) value near to zero. Minimized cost function is applied to the next sampling state. During this state, the switching state creates the less value of g and selected from possible values. This technique selects and produces minimum values and applied it to the converter, when the time is (x+1).

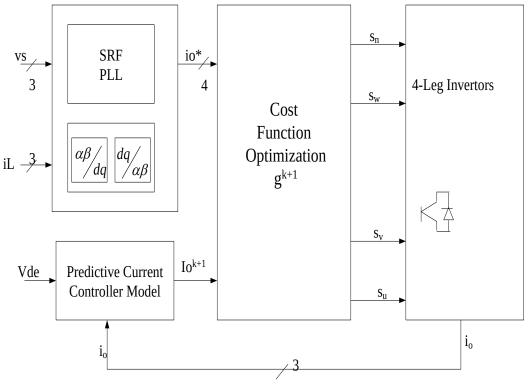

Fig.3. Proposed Predictive Control Scheme

VI. DQ-TRANSFORMATION SCHEME

The current reference generator subjected to the quality has to measure and analyse in order to get current reference signal of the shunt active filter system, here we have 3 types of strategies: 1. Load current detection, 2. Supply current detection, 3. Voltage detection. In harmonic detection mainly 2 types of control strategies for analyzing and voltage and current harmonics from distorted waveforms. In synchronous reference PI controller, integrator is used to remove the steady state error of DC components of the 0-d-q coordinate reference signals. With this 0-d-q frame theory, current harmonics represented as components within the corresponding reference frame and integrators removes the steady state error of harmonics components. By the usage of Park transformation, reference signal are first converted into 0 −α − β stationery frame. The PI control eliminated steady state error, achieve a good. Theis algorithm further explained, where voltage reference frame signal in 0-d-q rotation frames. And it is converted bank to a-b-c stationary frame, there are 0-drotating frame convert back to q-b-c items.

A dq-based current generator method is used to produce an active power filter current signal. This method shows a fast and exact signal tracking capability. This avoids fluctuations in voltage and current and reference signal affect compensating performance and it is obtained from I_{load} (load current) shown in fig.4. To calculate this, the reference current required to the converter to compensate reactive power, current harmonics and imbalanced current. The displacement power factor and maximum total harmonic distortion of the load defined as,

$$\frac{X_{APF}}{X_L} = \frac{\sqrt{Sin(\phi)_{(L)} + MTHD_{(L)}^{\;2}}}{\sqrt{1 + MTHD_{(L)}^{\;2}}} \qquad (6)$$

Where $MTHD_{(L)}$ indicates maximum harmonic current and f_s indicates sampling frequency. The frequency of maximum current components is equal to half of the converter switching frequency. SRF transformation is similar to phase detector, it is working based on the principle relies on regulating to zero of the rotation frame. It is especially helpful in weak 3-phase systems, where we require very fast and robust phase detection to inverter synchronization, but it may be more difficult to achieve due to varying frequency. It must be trade off noise rejection with fast tracking capabilities. This scheme operates in rotating reference frame. Therefore the contents should be multiply by Cos (wt), Sin (wt) components. By the application of dq-transformation, the d-current is synchronized with the phase-to-neutral system voltage, and then q current is phase-shifted by 90^0. The reference signals like Sin (wt) and Cos (wt) are produced from a Synchronous-reference frame phase-locked loop (SRF-PLL) and it generated a pure sinusoidal waveform, when the voltage is distorted. The measured error along with non-liner loads are set to cause voltage unbalancing, harmonics. These are avoided by designing of SRF-PLL. Eq (7) Indicates relationship between real current $I_{load}(t)$ (u = i, j, k) and associated d_p components (I_d and I_q) .

$$\begin{bmatrix} I_d \\ I_q \end{bmatrix} = \qquad (7)$$

$$\sqrt{\frac{2}{3}}\begin{bmatrix} Sin(wt) & Cos(wt) \\ -Cos(wt) & Sin(wt) \end{bmatrix}\begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix}\begin{bmatrix} I_{Li} \\ I_{Lj} \\ I_{Lk} \end{bmatrix}$$

Here, the Low pass filter is used to extract the constant dc component of I_d (phase Current) and to generate harmonic reference current I_d. Then, the original id current is added with the low pass filter current to generate reference harmonic current I_d. The reactive reference component current (I^*_q) is also obtained by phase shifting the reactive current component (I_q) by 180^0. Then by adding the modified active power reference signal (I_e) to the d-components to keep a DC-voltage as constant. Then they obtained resulting signals namely, I_d* and I_q* sent back to 3-ϕ system by applying the inverse Part and Clark transformation [11] is given in.

$$\begin{bmatrix} I^{*}_{Ori} \\ I^{*}_{Orj} \\ I^{*}_{Ork} \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} \frac{1}{\sqrt{2}} & 1 & 0 \\ \frac{1}{\sqrt{2}} & -\frac{1}{2} & \sqrt{\frac{3}{2}} \\ \frac{1}{\sqrt{2}} & -\frac{1}{2} & -\sqrt{\frac{3}{2}} \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 \\ 0 & Sin(wt) & -Cos(wt) \\ 0 & Cos(wt) & Sin(wt) \end{bmatrix} \begin{bmatrix} I_{Ocv} \\ I^{*}_{rd} \\ I^{*}_{rq} \end{bmatrix} \tag{8}$$

The current that flows through (I^{*}_{OrN}) (neutral current load) of the load is obtained as given eq (8) and it is phase shifted by $180^{0.}$

$$I^{*}_{OrN} = -(I_{Li} + I_{Lj} + I_{Lk}) \tag{9}$$

The main advantage of the Park and Clark transform scheme is that it permits to develop a linear controller in dc-voltage control loop. The disadvantage of this transform is that it uses a 2nd order harmonic component to generate i_d and i_q under unbalanced operating conditions, because the 2nd order harmonics cannot be removed from i_d and i_q.

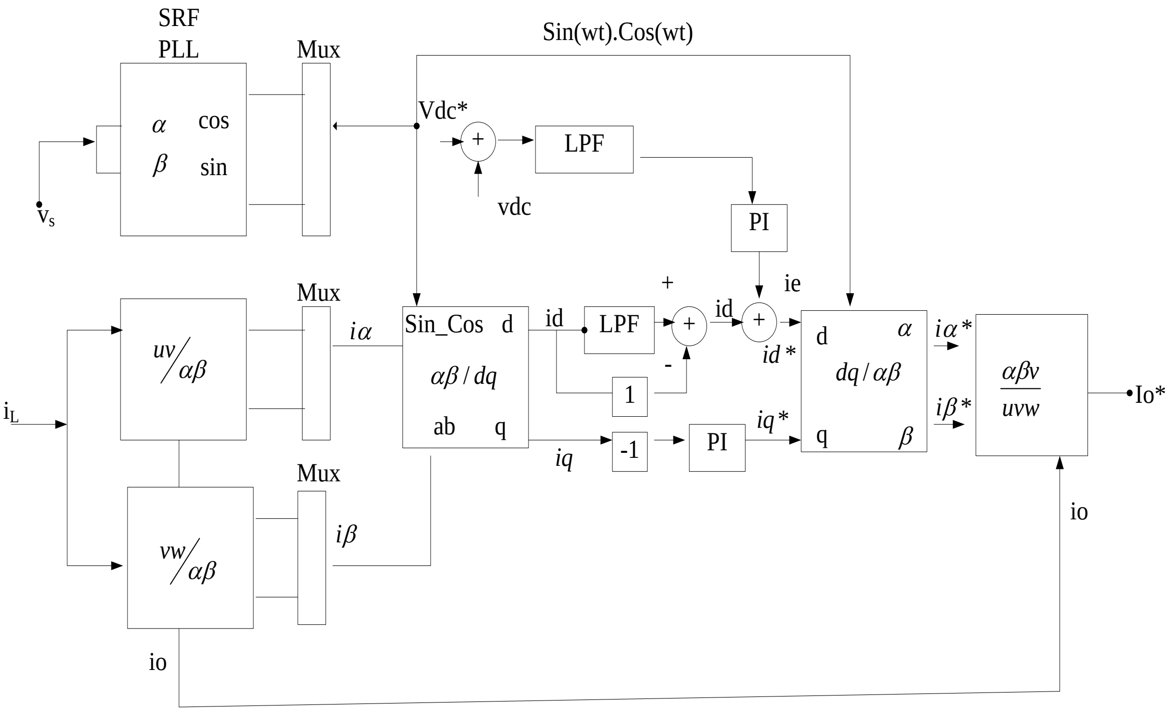

Fig.4. Reference Current generator diagram using dq-based transformation

It from Fig (6) H(s) is the closed loop transfer function, G(s) is first-order system (DC-Voltage transfer function) $V_{DC}*$ is reference voltage generated from shunt active power filter. Above Fig.(6) deals with the DC-Voltage converter and it is controlled with a PI controller followed by LPF. In this system the cost function is developed based on only current reference to avoid weighting factors. In different operating conditions the weighting factors are not defined. In addition, the dynamic response of voltage across the capacitor will not affect the transient current response, because of this reason PI controller are used in dc-voltage control. In this Fig.4, the DC-voltage V_{DC} is compared with a constant reference value $V_{DC}*$. The error signal(e) is processed by a Low pass filter and PI controller with gain factor K_p and T_i. These are calculated based on dynamic requirements. The dc-voltage transform is represented by a first order system is given in eq (10).

$$G(S)=\frac{V_{DC}}{I_e}=\frac{3}{2}\left(\frac{K_p V_{Svv}\sqrt{2}}{C_{DC}V*_{DC}}\right) \qquad (10)$$

The closed-loop Transfer Function (H(s)) is given in eq (12) and (11)

$$H(s)=K_P\left[1+\frac{1}{T_i.s}\right] \qquad (11)$$

$$\frac{V_{DC}}{I_e}=\frac{\frac{w_n{}^2}{a}.(s+a)}{s^2+2\xi w_n.s+w_n{}^2} \qquad (12)$$

Where, ξ → damping ratio and ξ =1

w_n→ natural frequency and w_n = 2Π.100 red/sec

a→ constant value.

Here, by the application of natural frequency w_n, critically damped outputs are obtained with less voltage oscillations. and T_i (Integer time) is given as, $T_i=\frac{1}{a}$

The proportional gain constant (K_p) is calculated as,

$$\xi=\sqrt{\frac{3}{8}\left(\frac{K_p V_{Svv}\sqrt{2.T_i}}{C_{DC}V*_{DC}}\right)} \qquad (13)$$

And $$w_n=DC\sqrt{\frac{3}{2}\left(\frac{K_p V_{Svv}\sqrt{2}}{C_{DC}V*_{DC}T_i}\right)} \qquad (14)$$

VII. SIMULATION RESULTS

Figure.5 shows the simulation model for 3-phase 4-leg PWM converter. It has beenThis work is carried out using MATLAB/SIMULINK 2014 software. The main objective is to verify the current harmonics components of the novel control system under different operating conditions. The proposed predictive current control algorithm was programmed and it is implemented in real time interface. It contains input sources V_{Svv}, $I_{ref\_Isource}$ and Load current(I_{load}) and output is V_{DC}. It uses a non-linear load and predictive control algorithm. This converter has 3-leg connected to natural bus of the system. It improves control flexibility and quality of the output and is suitable for current unbalanced compensation.

Above Fig.2 indicates the input source voltage (phase to natural source voltage), given to the 3-phase 4-leg PWM converter. The above waveform shows 3 different ac input. It contains 3 different voltages of 35kv(p-p) shown in Fig.6. This input signal is given to predictive current control block through source impedance (Z_{Seq}). The simulated results shows that the proposed current control scheme, it effectively removes the unbalanced currents, the above Fig.7(a)(b)(c).indicates the $I_{ref\_Isource}$, gain of $I_{ref\_Isource}$ and I_{source_Iload}(Load current) respectively. The signal $I_{ref\_Isource}$ is a reference current source is obtained from shunt active harmonic filter. This signal is given to predictive current control model as a referenece current. In predictive current control the frequency is taken as 60Hz. i.e., f=60Hz. The load current(I_{load}) also a current signal generated from Non-linear loads and it is given to Predictive current control model. $I_{ref\_Isource}$ current signal generated form shunt active harmonic filters. The above Fig.8 indicates output for simulation model for the 3-phase 4-leg PWM converter. This simulation results shows that the proposed predictive current control algorithms effectively eliminates unbalanced currents.

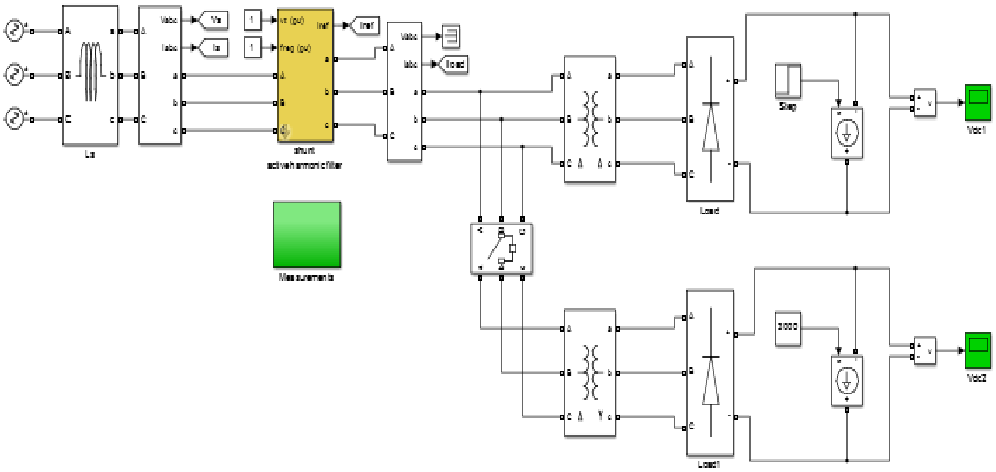

Figure. 5. A Schemaic diagram of proposed 3-phase shunt active power filter.

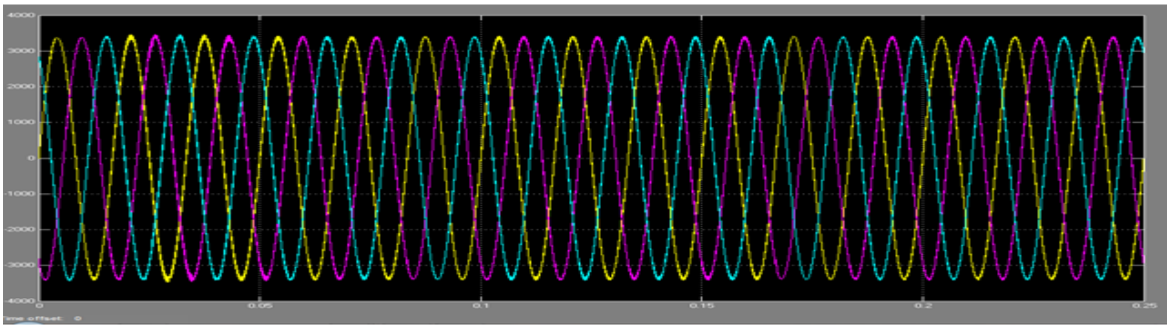

Figure.6. Input Source Voltage (V_{Svv})

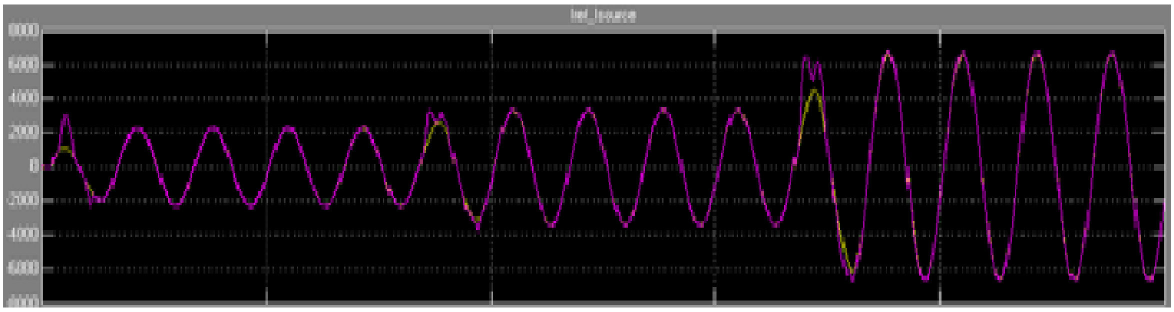

Figure. 7(a). reference input current source ($I_{ref\_Isource}$)

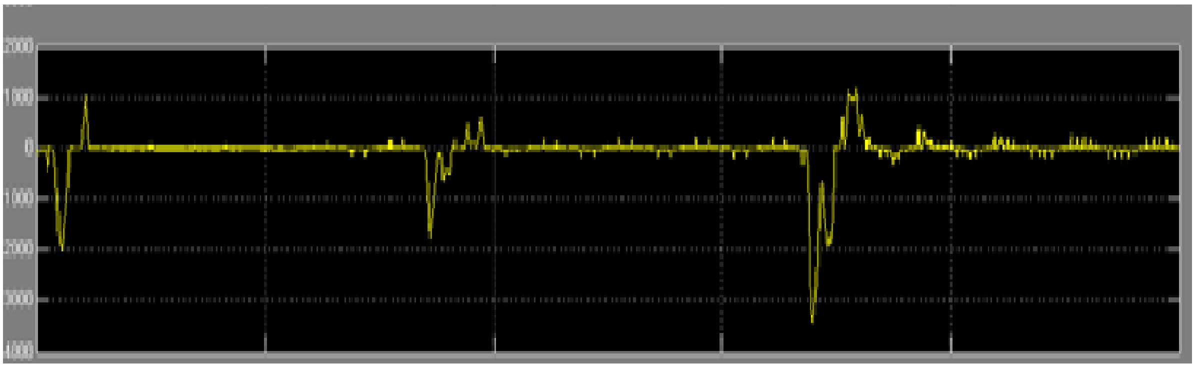

Figure. 7(b). Gain of ($I_{ref\_Isource}$)

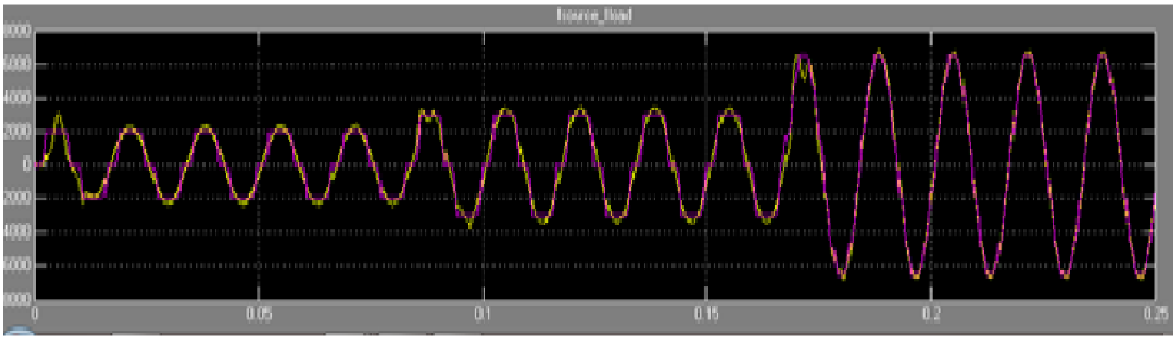

Figure. 7(c). Load Current (I_{source_Iload})

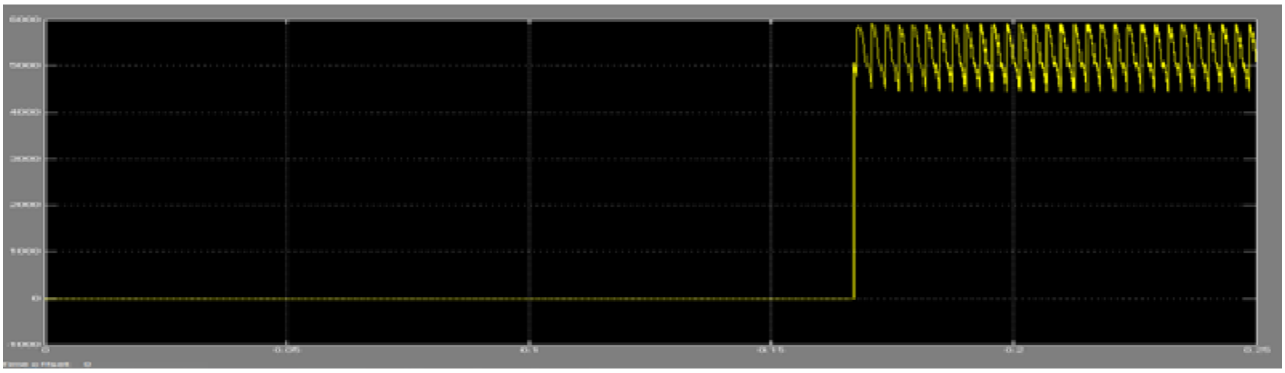

Figure.8. output voltage (V_{DC})

Fig.8 indicates DC-Voltage is stable throughout the process of whole shunt active power filter operations. The simulation results for 3-ϕ shunt power active Filter-I has been developed using Matlab-Simulink model. Here, V_{Svv}, load current, $I_{ref\text{-}Isources}$ are used as input signals and V_{DC} is the output signal. This converter has 3-leg connected to neutral bus of the system. It improves control flexibility and quality of the output and is suitable for current unbalance compensation. In this simulation V_{Svv} waveform indicates source voltage. It contains 3 voltage of amplitude 35 kV (p-p) as shown in figure (1). In Fig.6 different colour waveform indicates 3 different input sources. The next signal $I_{ref\text{-}ISources}$ is a References current source is obtained from shunt active harmonic filter. This signal is given to the Predictive current control (PCC) model as a reference current. In Predictive current control, the frequency is taken as 60Hz. References current source is obtained from shunt active harmonic filter. This signal is given to the Predictive current control (PCC) model as a reference current. In Predictive current control, the frequency is taken as 60Hz. Load Current (I_{load}) also a current signal generated from Non-linear loads and it is send to PCC model. Then, the next signal gives gain of $I_{ref\_Isource}$ current signal generated from shunt active harmonics filters. V_{DC} is the output voltage signal obtained from 3-ϕ shunt active power filter.

VIII. CONCLUSION

In the recent development of semi conductor devices in power electronics and control circuits, a new generation of equipment for power quality, namely active power filters was developed. Its more advantages over existing methods means, are more flexible and very fast control output. The shunt active power filter comprises 2 parts: the reference current computation and the current control. Here we have 2 basic for generating reference current; based on the pq theory. This paper gives by presenting the principle of active filtering and basic power theory. As for the distorted or unsymmetrical load voltage system, the p-q theory has shows limitations and calculates reference current methods.

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