International Journal of Combined Research & Development (IJCRD)
eISSN: 2321-225X;pISSN:2321-2241 Volume: 4; Issue: 9; September -2015

Improving the Dynamic Performance of Grid Connected Renewable Energy Sources by Using APF

T.A.Sivakumar[1],M.Mary Linda[2], M.Renisha[3], D.J.Prijin Rani[4]

[1] *Assistant professor, Department of Electrical and Electronics Engineering, Ponjesly college of engineering, Nagercoil-3, India*
[2] *Professor, Department of Electrical and Electronics Engineering, Ponjesly college of engineering, Nagercoil-3, India*
[3] *PG Student, Department of Electrical and Electronics Engineering, Ponjesly college of engineering, Nagercoil-3, India*
[4] *PG Student, Department of Electrical and Electronics Engineering, Ponjesly college of engineering, Nagercoil-3, India*

[1]sksivakumar98@gmail.com, [2]mm.linda2002@gmail.com , [3]ranieee92@gmail.com, [4]prijinrani37@gmail.com

***Abstract*— With the reduction in fossil fuels and increase in load demand, the renewable energy sources are connected in the distribution system. In this thesis, the grid interfacing inverters are installed in 3 phase 4 wire distribution system which improves the dynamic performance of the distribution system. It utilizes the inverter as a power converter to inject the power generated from renewable energy source to the grid and shunt active power filter to compensate the problems like current unbalance, load current harmonics, load reactive power and load neutral current. The linear or non linear unbalanced load connected to the point of common coupling appears as balanced linear load to the grid by varying the duty ratio of inverter.**

***Index Terms*—distribution system, dynamic performance, grid interfacing inverter, renewable energy source, shunt APF.**

I. INTRODUCTION

DUE to the advancement in power electronics, the quality of power at the distribution system integrated with renewable energy source can be improved. This makes reduction in air pollution, meeting the load demands and reducing the cost of fossil fuels.

The improvement of power quality at PCC enhances the system operation by controlling the DG systems. The non-linear loads at the point of common coupling generates large amount of harmonic currents due to power electronic based equipment which affects the quality of power [1-4].

Generally, current controlled voltage source inverters are used to interface the renewable energy source to the grid. In cascaded multilevel inverter is used, it requires a separate dc source for each H-bridge[5]. A similar approach such as a shunt active power filter is used in order to damp out the harmonics is proposed.

The active power filter use power electronic devices in conjunction with the passive elements for their operation. Active power filter have an advantage of varying compensation characteristics and lesser size[6]. The active power filter control is implemented in three stages. In the first stage the essential voltage and current signals are sensed using power transformer to gather accurate system information. In the second stage, compensating commands in terms of current and voltage levels are derived based on control methods and active power filter configuration. In the third stage of control, the gating signals for the solid state devices of active power filter are generated using pulse width modulation [7,8].

Distributed generation systems are the suitable form to offer high reliable electric power supply. Distributed generation systems are often connected to the utility grid through power electronic converters. A grid connected inverter provides the necessary interface of the distributed generation to the phase, frequency and amplitude of the grid voltage and disconnects the system from the grid when islanding. The non-linear load current harmonics may result in voltage harmonics and can create a serious power quality problem in the power system network [9,10]. A flexible and versatile solution for improving the power quality uses shunt active power filter. Active power filters has become an extensive tool used to compensate the load current harmonics and load unbalance at distribution level.

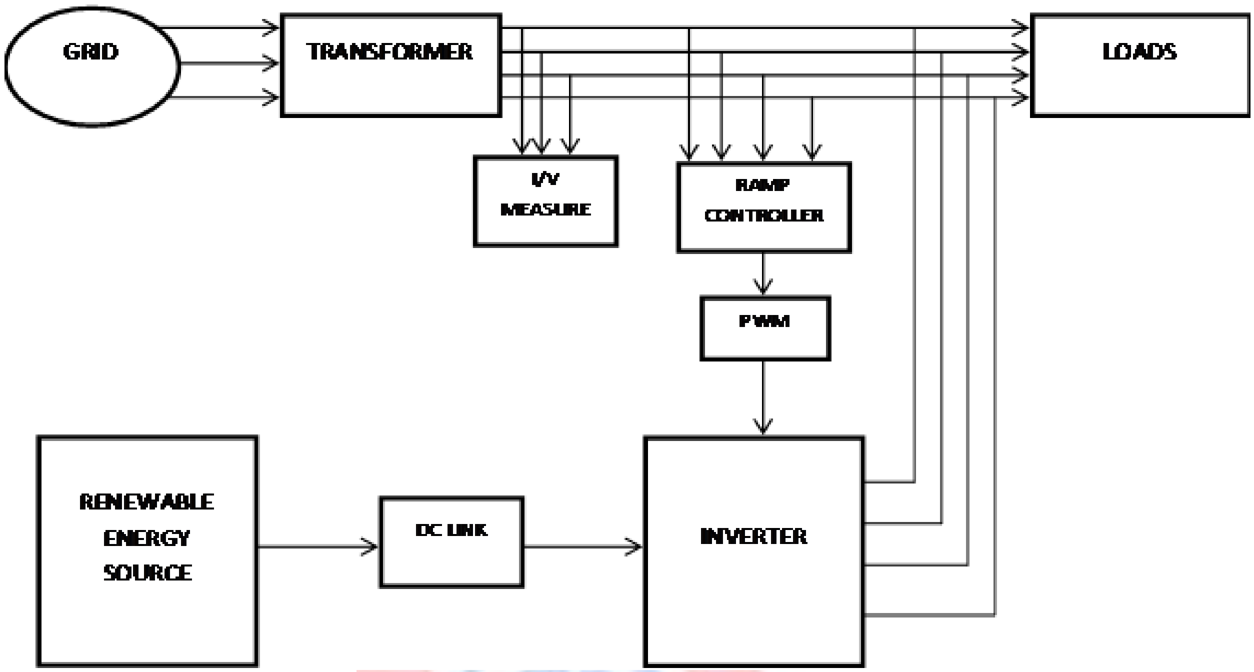

Fig.1. Renewable energy source based distribution generation system

II. SYSTEM MODEL

The renewable energy source is connected to the distribution system through grid interfacing inverter. The voltage source inverter is the primary element in transferring the power from renewable energy source to distribution system. The renewable energy source may be a AC or DC source with rectifier connected to the dc-link. Normally, the fuel cell and photovoltaic cell generates low dc voltage power, whereas the wind turbine with variable speed generates variable ac voltage power. Thus the generated power from the renewable energy sources requires power conditioning before connecting to the dc-link. The dc capacitor decouples the renewable energy source from the grid and allows independent control of converters on either side of dc-link.

A. Grid interfacing inverter

A grid interfacing inverter is a power electronic device that is connected in shunt to the system. It generates a sinusoidal voltage with any required magnitude, frequency and phase angle. It also converts the DC voltage across storage devices into a set of three phase AC output voltages. It is also capable to generate or absorb reactive power. If the output voltage of the VSC is greater than AC bus terminal voltages, it is said to be in the capacitive mode. So, it will compensate the reactive power through AC system. The IGBT is used as a power switch that is connected in anti parallel with the diode.

B. Control of four leg grid interfacing inverter

The fourth leg of an inverter is used to compensate the load neutral current. This allows it to maintain balanced output voltage in case of unbalanced and non-linear loads. The main aim is to regulate the power at the point of common coupling during 1) P_{RES}= 0, 2) P_{RES}< Total load power (PL), 3) $P_{RES} > P_L$. The inverter switches duty ratio are varied in a power cycle such as the injected power of load and inverter combination appears as balanced resistive load to the grid. The DC link voltage regulation carries the information regarding the exchange of active power in between source RES source and grid. Thus, the output of DC link voltage regulator results in an active current (I_m).

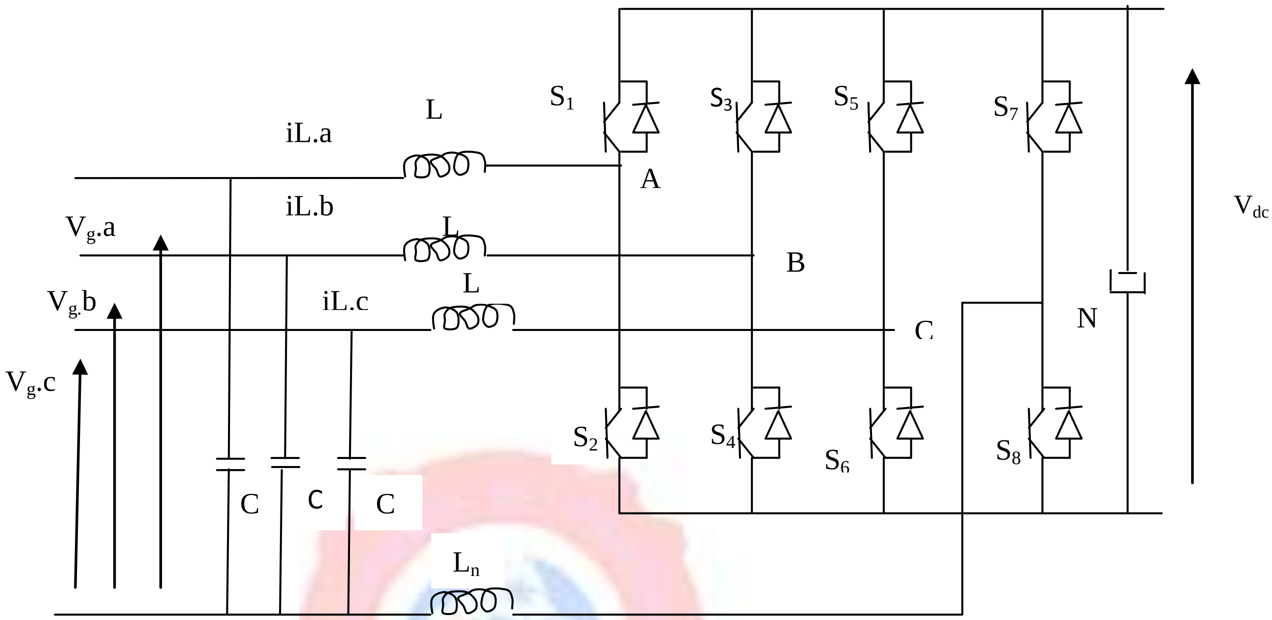

Fig.2. Four leg Grid Interfacing Inverter

The multiplication of active current component with unity grid voltage vector templates (U_a, U_b and U_c) generates the reference grid currents (I_a^*, I_b^* and I_c^*). The reference grid neutral current is set to zero, being the instantaneous sum of balanced grid current. The grid synchronizing angles (θ) obtained from phase lock loop (PLL) is used to generate unit vector template

$$U_a = \sin\theta \quad (1)$$

$$U_b = \sin(\theta - 2\pi/3) \quad (2)$$

$$U_c = \sin(\theta + 2\pi/3) \quad (3)$$

The actual DC link voltage (V_{dc}) is detected and passed through first order low pass filter to eliminate switching ripples present in DC link voltage and generated reference current signals. The difference of this filtered DC link voltage and reference DC link voltage (V_{dc}^*) maintains a constant dc-link voltage under varying load condition.

Reference 3-phase grid currents are

$$I_a^* = I_m.\, U_a \quad (4)$$

$$I_b^* = I_m.\, U_b \quad (5)$$

$$I_n^* = 0 \quad (6)$$

$$I_c^* = I_m.\, U_c \quad (7)$$

Current errors are computed as

$$I_{aerr} = I_a^* - I_a \quad (8)$$

$$I_{berr} = I_b^* - I_b \quad (9)$$

$$I_{cerr} = I_c^* - I_c \quad (10)$$

$$I_{nerr} = I_n^* - I_n \quad (11)$$

This hysteresis controller then generates the switching pulses (P_1 to P_8) for gate drives of grid interfacing inverter. The average model of 4-leg inverter can be obtained by the following state space equation

$$dI_{Inva} / dt = (V_{Inva} – V_a) / L_{sh} \quad (12)$$
$$dI_{Invb} / dt = (V_{Invb} – V_b) / L_{sh} \quad (13)$$
$$dI_{Invc} / dt = (V_{Invc} – V_c) / L_{sh} \quad (14)$$
$$dI_{Invn} / dt = (V_{Invn} – V_n) / L_{sh} \quad (15)$$
$$dV_{dc/dt} = I_{Invad} – I_{Invbd} – I_{Invcd} – I_{Invnd} / C_{dc} \quad (16)$$

Hence, to produce the desired sinusoidal output voltage, the steady state duty cycles are time varying sinusoidal. But, to apply classical control techniques we need a DC operating point.

$$V_{Inva} = (P_1 – P_4)/2 * V_{dc} \quad (17)$$
$$V_{Invb} = (P_3 – P_6)/2 * V_{dc} \quad (18)$$
$$V_{Invc} = (P_5 – P_2)/2 * V_{dc} \quad (19)$$
$$V_{Invn} = (P_7 – P_8)/2 * V_{dc} \quad (20)$$

Similarly the charging currents I_{Invad}, I_{Invbd}, I_{Invcd} and I_{Invnd} on dc bus to the each leg of inverter can be expressed as

$$I_{Invad} = I_{Inva} (P_1 – P_4) \quad (21)$$
$$I_{Invbd} = I_{Invb} (P_3 – P_6) \quad (22)$$
$$I_{Invcd} = I_{Invc} (P_5 – P_2) \quad (23)$$
$$I_{Invnd} = I_{Invn} (P_7 – P_8) \quad (24)$$

C. Switching Control of IGBT

The switching pattern of each IGBT inside inverter can be formulated on the basis of error between actual and reference current of inverter, which can be explained as:

If $I_{Inva} < (I_{Inva}^* - h_b)$ then upper switch S_1 will be OFF (P_1=0) and lower switch S_4 will be ON (P_4=1) in the phase "a" leg of inverter.

If $I_{Inva} > (I_{Inva}^* - h_b)$, then upper switch S1 will be ON (P_1=1) and lower switch S_4 will be OFF (P_4=0) in the phase "a" leg of inverter.

Where h_b is the width of the hysteresis band. Similarly the other IGBT switches can also be turned ON by the same principle.

D. Simulation Results

To study the performance of a grid interfacing inverter connected to the distribution system is carried out using MATAB/simulink. The grid voltage is shown in fig. 3. The grid is interconnected with the renewable energy source such as the wind voltage, current, real power, reactive power is shown in fig. 4.

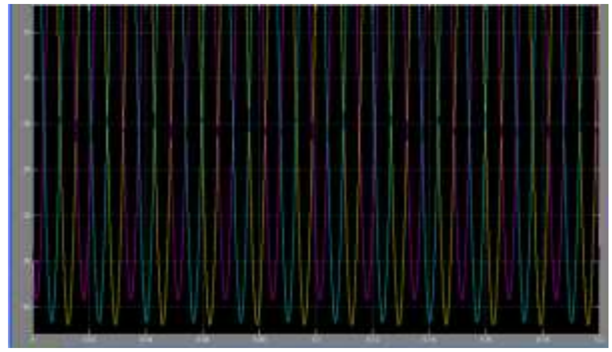

Fig.3. Grid voltage

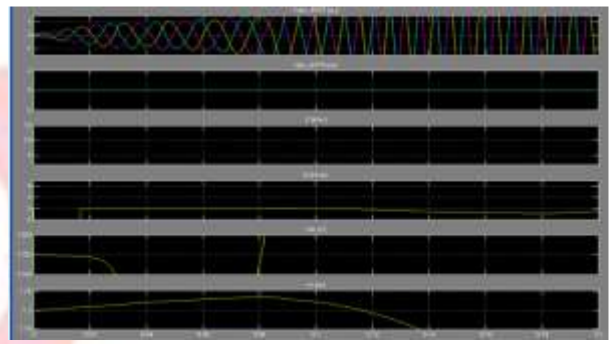

Fig.4. Wind voltage, current, real power, reactive power

In order to improve the quality of power, the grid interfacing inverter operates as a power converter and the shunt active power filter. The load current and the inverter voltage are shown in fig. 5 and the control voltage is shown in fig. 6.

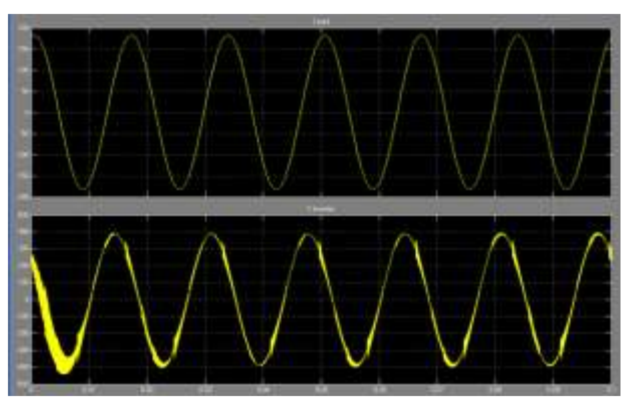

Fig.5. Load current, inverter voltage

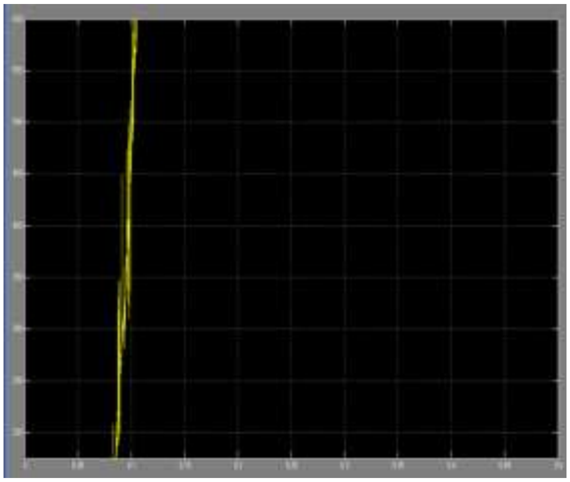

Fig. 5. Rectifier control output voltage

The inverter consists of an IGBT switches, in order to turn ON the switches it requires gate pulses, the pulses for each IGBT switches is shown in fig. 6.

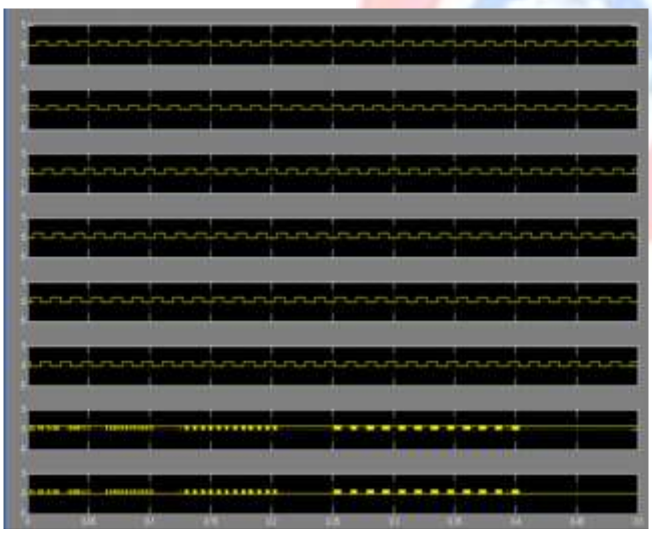

Fig. 6. Pulses for each IGBT switches

III. CONCLUSION

The quality of power at PCC for a 3-phase 4-wire DG system can be improved by interfacing inverter to the grid . The inverter can be effectively utilized for power condition without affecting the normal operation of real power transferring. The grid interfacing inverter can be utilized to inject real power generated from RES to the grid and operate as a shunt active power filter. This eliminates the need for additional power conditioning equipment to improve the quality of power at PCC. The current unbalance, current harmonics and load reactive power due to unbalanced and non linear load connected to the PCC are compensated effectively.

REFERENCES

[1] Y. Jaganmohan Reddy, K. Padma Raju, Y. VenkataPavan Kumar, "Use of DC Motor-Generator Set for power Quality Improvement in a Renewable Energy Based Hybrid Power System." International Journal on Recent Trends in Engineering & Technology, Vol. 05, No. 02, Mar 2011.

[2] Jazeri, .B.Mozafari," A Novel DG grid interface control strategy for active power injection management and power quality improvement" IPSC,Tahran,Iron, Nov-2011.

[3] S.K.Khaden, M.Basu ,M.F.Conlon ," Power quality in grid connected renewable energy systems: Role of custom power devices". ICERPQ, Granda,spain, Mar-2010.

[4] J.H.R. Enslin and P.J.M. Heskes, " Harmonic interaction between a large number of distributed power inverters and the distribution network,"IEEE Trans. Power Electron.vol. 19, no. 6,pp. 1586–1593, Nov. 2004.

[5] G. Satyanarayana, K.N.V Prasad, G. Ranjith Kumar, K. Lakshmi Ganesh, "Improvement of power quality by using hybrid fuzzy controlled based IPQC at various load conditions," Energy Efficient Technologies for Sustainability (ICEETS), 2013 International Conference on , vol., no.,pp.1243,1250, 10-12 April 2013.

[6] Babaei E. "A cascade multilevel converter topology with reduced number of switches," IEEE Trans. Power Electron.,vol.23,no.6,pp 2657-2664,Nov.2008.

[7] Karuppanan P, Kamala KantaMahapatrab" PLL Synchronization With PID Controller Based on Shunt Active Power Line FILTER." International Journal of Computer and Electrical Engineering,Vol.3,No.1, February 2011.

[8] M. Singh and A. Chandra, "Power maximization and voltage sag/swell ride-through capability of PMSG based variable speed wind energy conversion system," in Proc. IEEE 34th Annu. Conf. Indus. Electron.Soc., pp. 2206–2211, 2008.

[9] H. Tao, J. L. Duarte, and M. A. M. Hendrix, "A distributed fuel cell based generation and compensation system to improve power quality," in Proc. IEEE International Power Electronics and Motion Control conference (IPEMC'06), Shanghai, China, pp. 1–5, Aug. 2006.

[10] Bart Meersman, Bert Renders, Lieven Degroote, Tine Vandoorn,Jeroen De Kooning and Lieven v and evelde," Overview of three -phase inverter topologies for distributed generation purposes" April 18-21, 2010.