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A Control Approach for Grid Connected Inverter in Distribution System with Improvement of Power Quality

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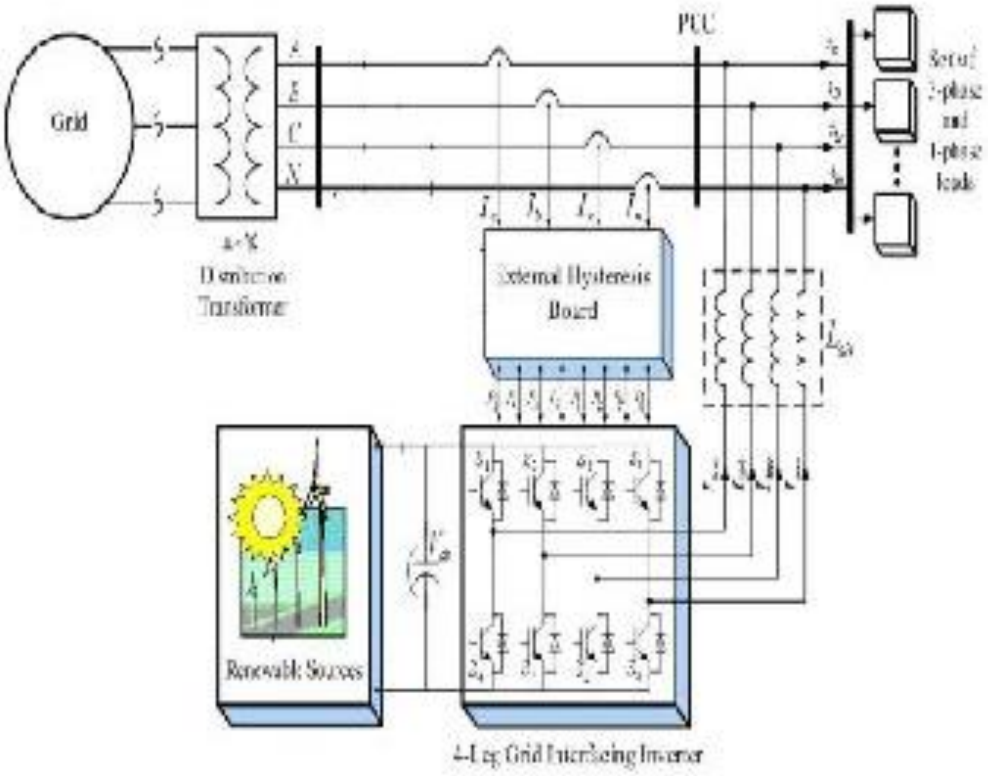
Abstract: **This paper suggests a new method that consists of grid interface inverter in three phase four wire distribution systems that is capable of simultaneously compensating problems like current unbalance, load voltage harmonics and load reactive power demand. This inverter is also used as power converter to inject power to the grid. With such a control, the combination of grid interfacing inverter and three phase four wire linear/nonlinear unbalanced load at a point of common coupling appears as balanced linear load to the grid. This new control concept is demonstrated with extensive MATLAB/SIMULINK SIMULATION STUDIES.**

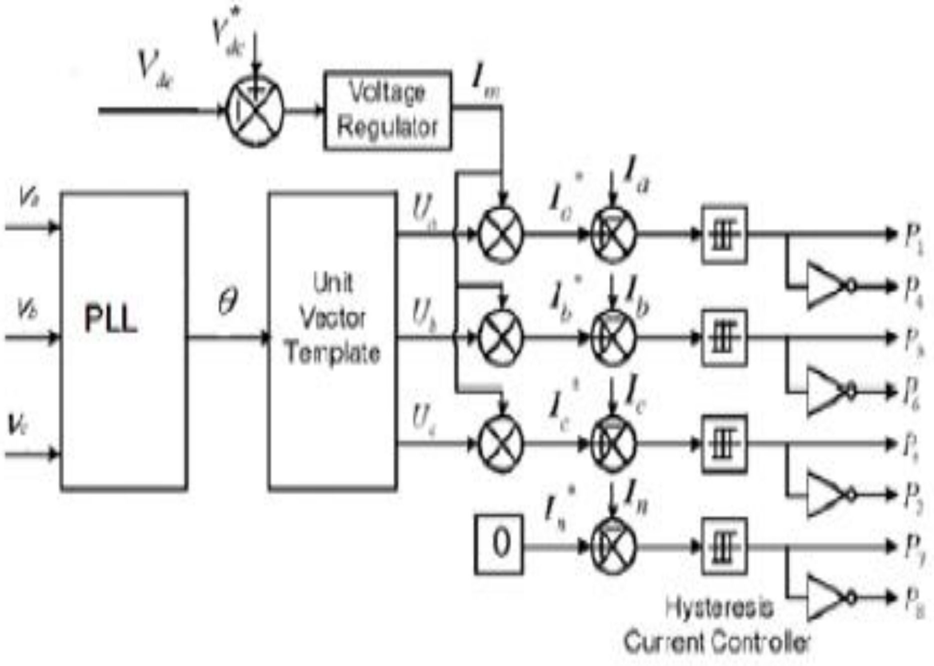
Keywords: **Grid, interfacing inverter, power quality.**

I. INTRODUCTION

Due to increasing air pollution, global warming concerns, diminishing fossil fuels and their increasing cost have made it necessary to look towards Renewable Energy Sources (RES) as a future energy solution. Since the past decade, there has been an enormous interest in many countries on renewable energy for power generation since the past decade, there has been an enormous interest in many countries on renewable energy for power generation. However, the extensive use of power electronics based equipment and non-linear loads at PCC generate harmonic currents, which may deteriorate the quality of power. The widespread increase of non-linear loads nowadays, significant amounts of harmonic currents are being injected in to power systems. The utility is concerned due to the high penetration level of intermittent RES in distribution systems as it may pose a threat to network in terms of stability, voltage regulation and power-quality (PQ) issues. Therefore, the DG systems are required to comply with strict technical and regulatory frameworks to ensure safe, reliable and efficient operation of overall network. In [8] Power quality problems associated with distributed power (DP) inverters, implemented in large numbers onto the same distribution network, are investigated. The general objective is to investigate the power quality problems and the interaction of the inverters with the distribution network. However, the extensive use of power electronics based equipment and non-linear loads at PCC generate harmonic currents, which may deteriorate the quality of power Generally, current controlled voltage source inverters are used to interface the intermittent RES in distributed system. Recently, a few control strategies for grid connected inverters incorporating PQ solution have been proposed. In [11], a control method is presented which enables equal sharing of linear and nonlinear loads in three-phase power converters connected in parallel, without communication between the converters. But the exact calculation of network inductance in real-time is difficult and may deteriorate the control performance The loads based on power electronic devices generally pollute the nearby network by drawing non sinusoidal currents from the source. The rapid switching of electronic devices creates additional problems. This makes voltages and currents at point of common coupling (PCC) highly distorted. One of the best solutions to compensate both current and voltage related problems, simultaneously, is the use of Unified Power Quality Conditioner (UPQC). Reference [6] is based on a unified approach for load and source compensation using Unified Power Quality Conditioner (UPQC).Performance of this UPQC has been evaluated with a typical industrial load with realistic parameters supplied by a polluted distribution network.



Schematic of the proposed renewable energy system



Block diagram representation of grid- interfacing inverter control

II. SYSTEM DESCRIPTION

The proposed system consists of DC source which may be renewable energy source(RES) connected to the d.c-linc of a grid connected inverters shown in fig.1. The DC source coupled to dc-link. Usually the fuel cell and photovoltaic energy source generate power at variable low dc voltage, while the variable speed wind turbines generated power at variable ac voltage. Thus, the power generated from these renewable sources needs power conditioning (i.e. dc/dc or ac/dc) before connecting dc-link. This dc-link terminal connected to the inverter, which converts ac voltage then the resultant inverter terminals connected to grid.

A. Voltage source converter (VSC):

A **power inverter**, or **inverter**, is an electrical device that changes direct current (DC) to alternating current (AC);[1] the converted AC can be at any required voltage and frequency with the use of appropriate transformers, switching, and control circuits. Solid-state inverters have no moving parts and are used in a wide range of applications, from small switching power supplies in computers, to large electric utility high-voltage direct current applications that transport bulk power. Inverters are commonly used to supply AC power from DC sources such as solar panels or batteries. The inverter performs the opposite function of a rectifier.

B. L-filter:

Polynomials, poles and element values are presented for normalized “L” filters having a 3dB cutoff frequency of 1 radian per second. In order to transform these values for a particular application it will be necessary to perform frequency and/or impedance scaling. Simple methods and formulas for such scaling can be found in any filter design text. Element values are provided for implementing LC ladder solutions for each filter. The particular values given are for filters with equal source and load terminations, where RS and RL equal 1. Because of the large number of possible source and termination resistances, the case of unequal terminations is

better handled by a computer program than by tables.

C. Grid:

An **electrical grid** is an interconnected network for delivering electricity from suppliers to consumers. It consists of generating stations that produce electrical power, high-voltage transmission lines that carry power from distant sources to demand centers, and distribution lines that connect individual customers. Power may be located near a fuel source, at a dam site, or to take advantage of renewable energy sources, and are often located away from heavily populated areas. They are usually quite large to take advantage of the economies of scale. The electric power which is generated is stepped up to a higher voltage at which it connects to the transmission network. The transmission network will move the power long distances, sometimes across international boundaries, until it reaches its wholesale customer (usually the company that owns the local distribution network). On arrival at a substation, the power will be stepped down from a transmission level voltage to a distribution level voltage. As it exits the substation, it enters the distribution wiring. Finally, upon arrival at the service location, the power is stepped down again from the distribution voltage to the required service voltage(s).

D. Non linear load:

A load is considered non-linear if its impedance changes with the applied voltage. The changing impedance means that the current drawn by the non-linear load will not be sinusoidal even when it is connected to a sinusoidal voltage. These nonsinusoidal currents contain harmonic currents that interact with the impedance of the power distribution system to create voltage distortion that can affect both the distribution system equipment and the loads connected to it.

III. PROPOSED CONTROL OF GRID INVERTER

A. PI controller :

A **PI Controller** (proportional-integral controller) is a special case of the PID controller in which the derivative(D) of the error is not used. A PI controller can be modeled easily in software such as Simulink or Xcos using a "flow chart" box involving Laplace operators:

The combination of proportional and integral terms is important to increase the speed of the response and also to eliminate the steady state error. The PID controller block is reduced to P and I blocks only as shown in figure

A **proportional-integral controller** (**PI controller**) is a control loop feedback mechanism (controller) widely used in industrial control systems. A PID controller calculates an *error* value as the difference between a measured process variable and a desired set point. The controller attempts to minimize the *error* by adjusting the process through use of a manipulated variable.

The PID controller algorithm involves three separate constant parameters, and is accordingly sometimes called **three-term control**: the proportional, the integral and derivative values, denoted *P*, *I*, and *D*. Simply put, these values can be interpreted in terms of time: *P* depends on the present error, *I* on the accumulation of past errors, and *D* is a prediction of future errors, based on current rate of change. The weighted sum of these three actions is used to adjust the process via a control element such as the position of a control valve, a damper, or the power supplied to a heating element.

B. Voltage control :

A **voltage controller**, also called an **AC voltage controller** or **AC regulator** is an electronic module based on either thyristors, TRIACs,SCRs or IGBTs, which converts a fixed voltage, fixed frequency alternating current (AC) electrical input supply to obtain variable voltage in output delivered to a resistive load. This varied voltage output is used for dimming street lights, varying heating temperatures in homes or industry, speed control of fans and winding machines and many other applications, in a similar fashion to an autotransformer. Voltage controller modules come under the purview of power electronics. Because they are low-maintenance and very efficient, voltage controllers have largely replaced such modules as magnetic amplifiers and saturable reactors in industrial use.

IV. SIMULATION RESULTS

In order to verify the proposed control approach to achieve multi-objectives for grid connected DG systems connected to a 3-phase 4-wire network, an extensive simulation study is carried out using MATLAB/Simulink. A 4-leg current controlled voltage source inverter is actively controlled to achieve balanced sinusoidal grid current at unity power factor (UPF) despite of highly unbalanced nonlinear load at PCC. Here 3 cases are simulated

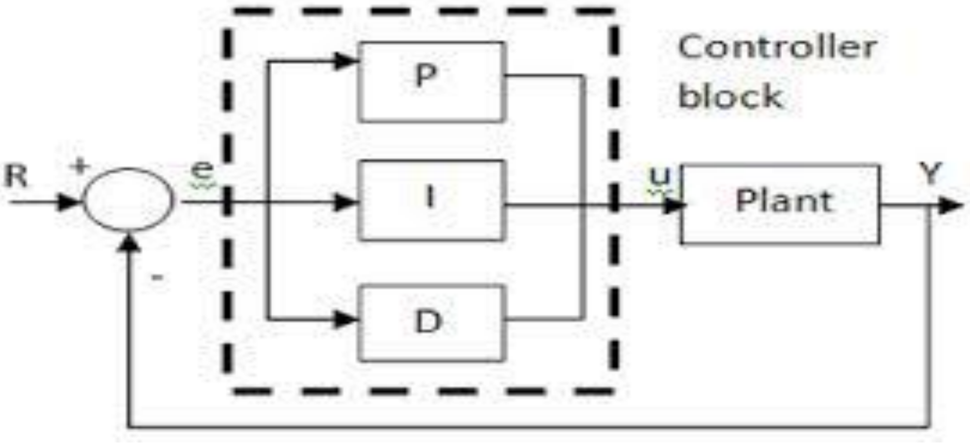
Case1: When Balanced load directly connected to grid without RES

Case1: When Unbalanced load directly connected to grid without RES

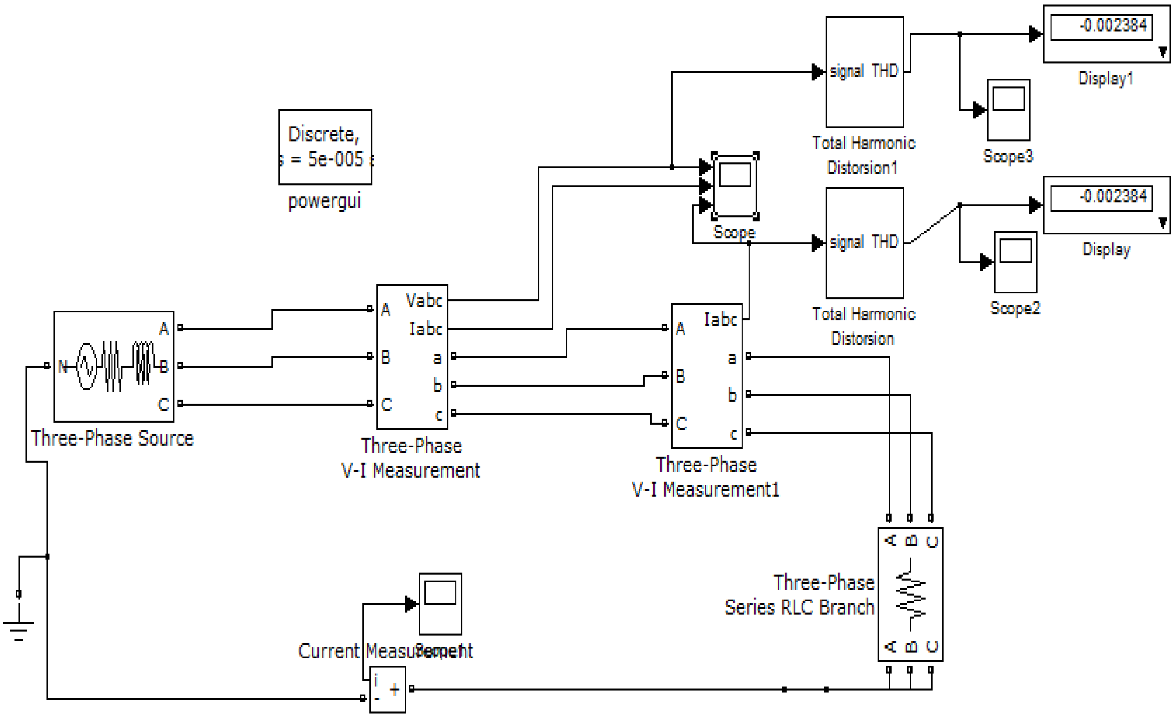
Case1: When Unbalanced load directly connected to grid with grid connected inverter control

1. *System parameters:*

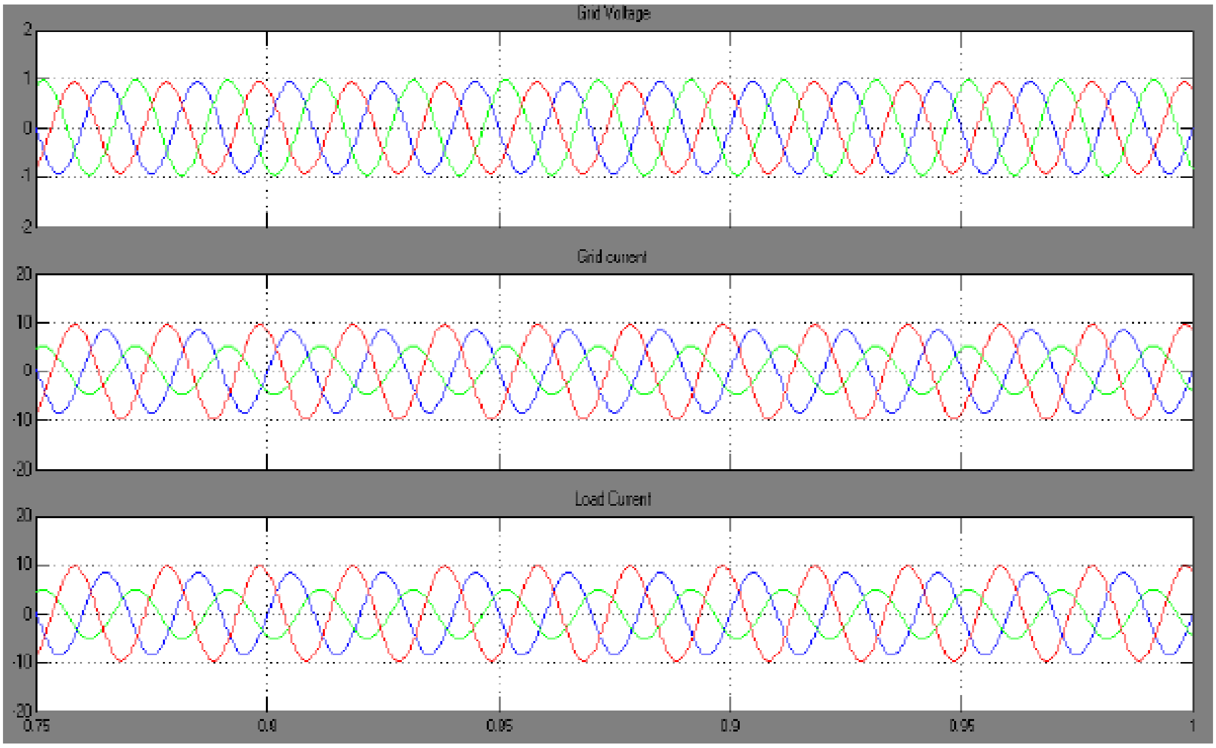
➢ Grid (3-phase supply) in r.m.s	Vg=230v (r.m.s),50 Hz
➢ 3-phase load	R=26.66ohm
➢ 1-phase non linear Load (A-N)	R=36.66ohm, L=10Mh
➢ 1-phase non linear Load (C-N)	R=26.66ohmL=10mH
➢ Dc link voltage	Vdc=300v



2. Balanced load directly connected to grid without RES:



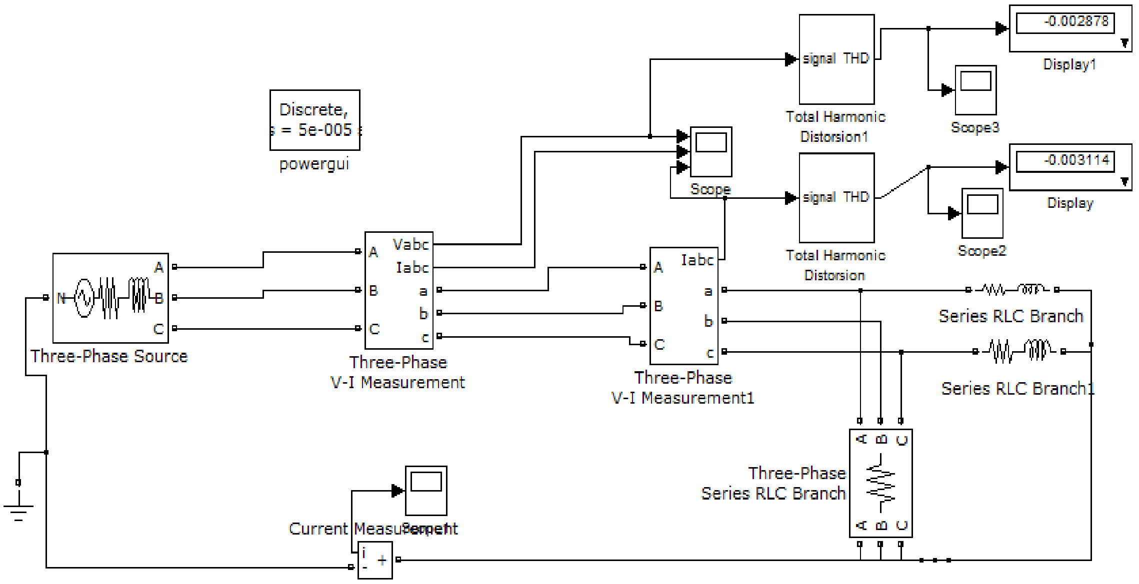
Simulink model when balanced load directly connected to grid without RES



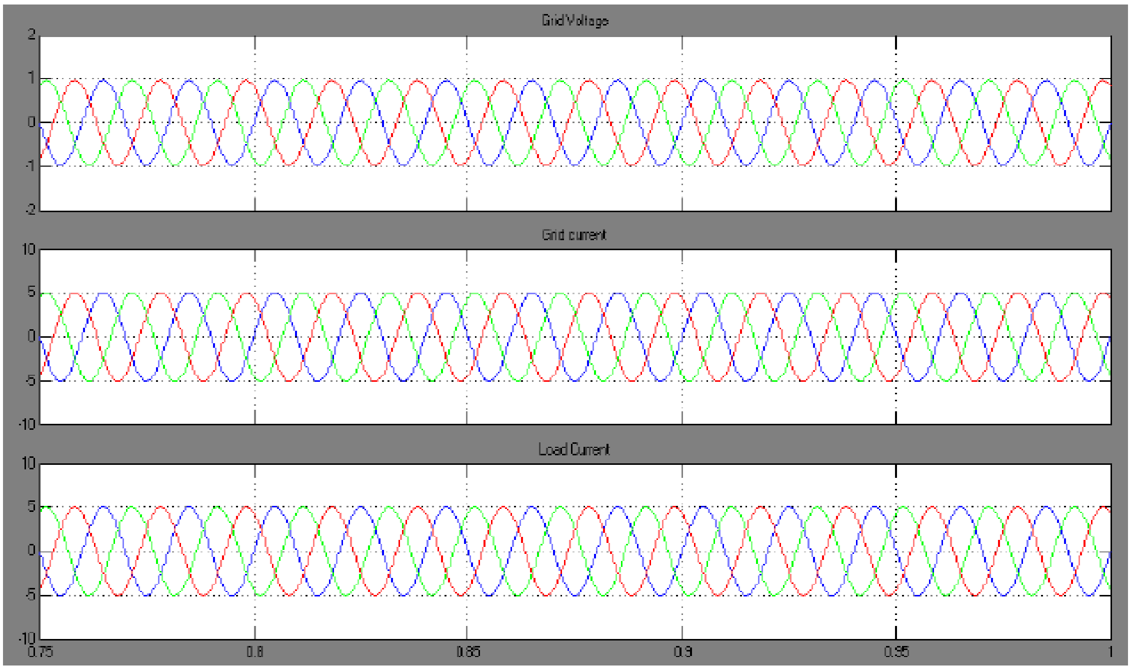
Simulation results: a) Grid voltage, b) Grid current, c) Load currents when balanced load directly connected to the grid without RES

The waveforms of grid voltage, grid current and load current are shown in above fig. It shows that all the three resultant waveforms (i.e. Grid voltage, Grid current, Load current) are balanced when balanced nonlinear load connected directly to the grid.

3. Unbalanced load directly connected to grid without RES:



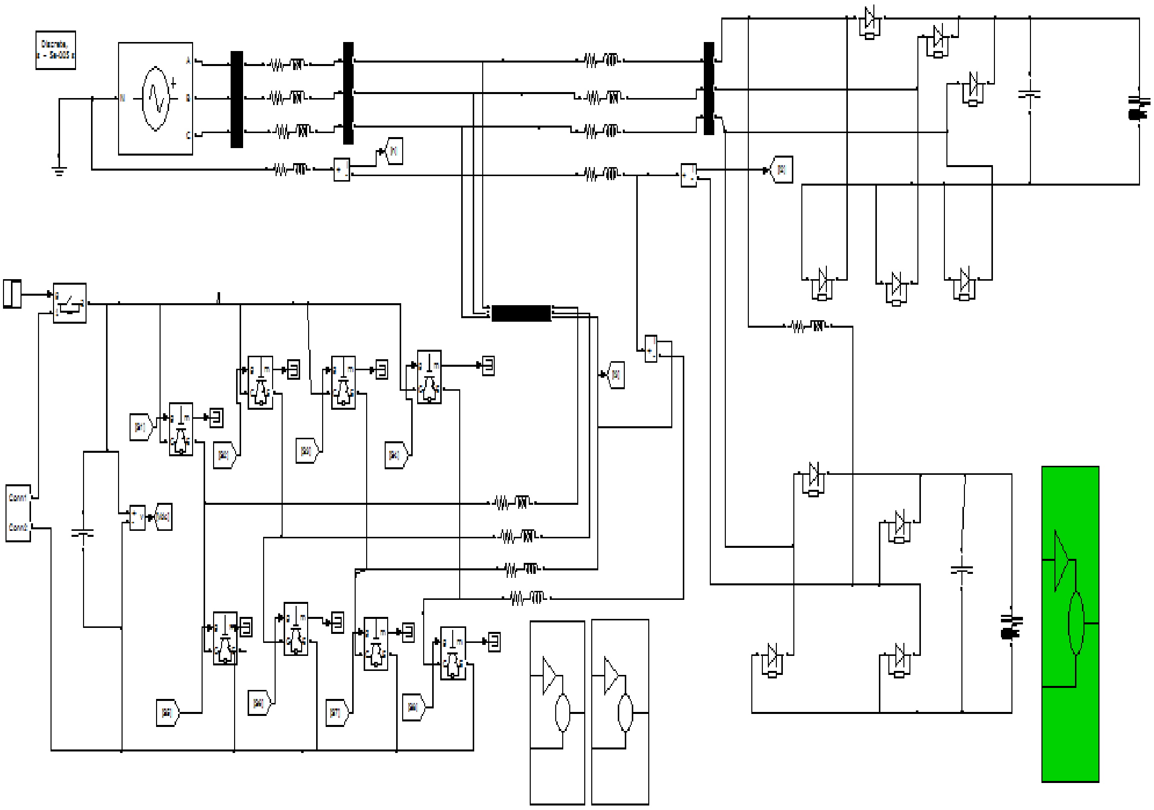
Simulation model when unbalanced load directly connected to grid without RES



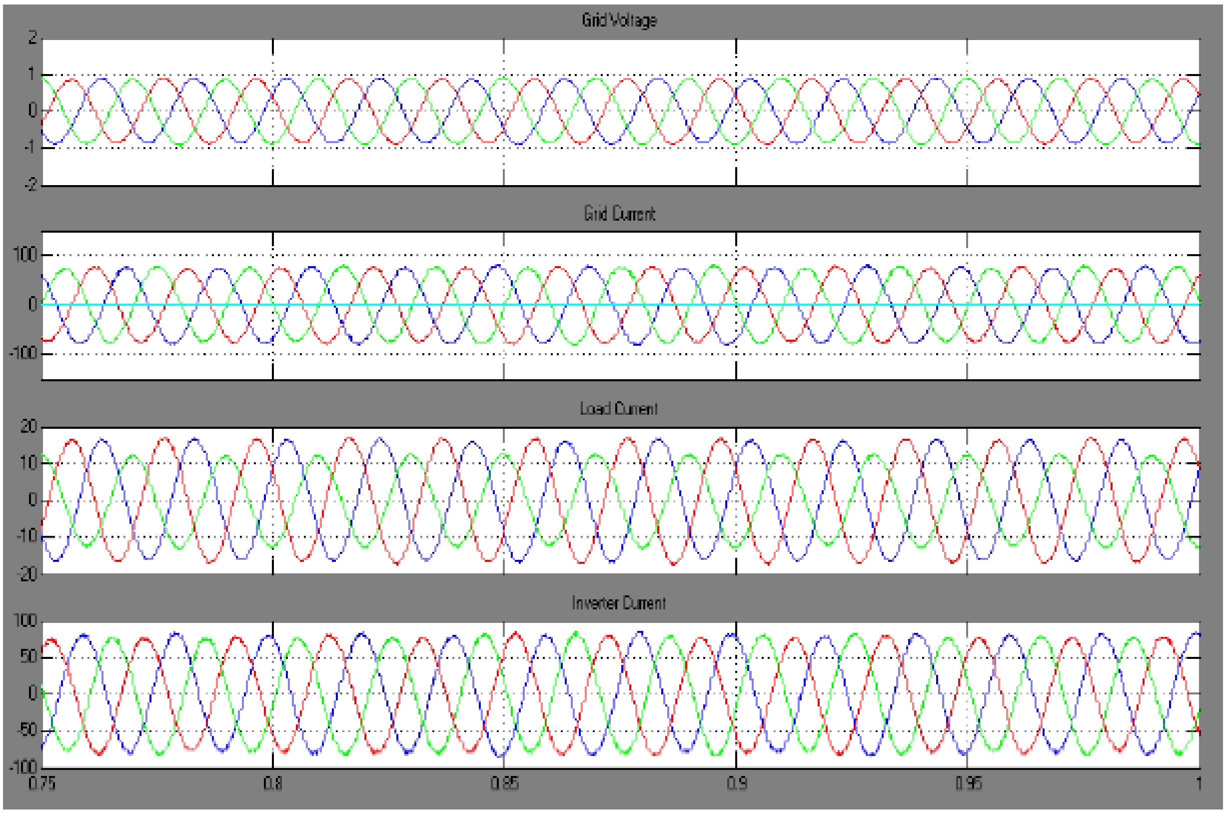
Simulation results : a) Grid voltage, b) Grid current, c) Load currents when unbalanced load directly connected to grid without RES

The waveforms of grid voltage, grid current and load current when unbalanced load directly connected to grid without inverter are shown in above fig. It shows that all the three resultant waveforms (i.e. Grid voltage, Grid current, Load current) are become unbalanced linear and 1-phase unbalanced nonlinear loads connected directly to the grid.

4. Unbalanced load connected to grid with grid connected inverter control:



Simulation results of unbalanced load connected to grid with grid connected inverter control



This table describes the percentage voltage changes in without connecting RES to the grid and with connecting RES to the grid interfacing inverter

	Vabc	**Iabc**	**%Vabc**
Without connecting RES	**0.002878**	**0.002495**	**0.2878%**
With connecting RES	**0.0005383**	**0.07633**	**0.05383%**

V. CONCLUSION

This paper has presented a novel control of an existing grid interfacing inverter to improve the quality of power at PCC for a 3-phase 4-wireDGsystem. It has been shown that the grid-interfacing inverter can be effectively utilized for power conditioning without affecting its normal operation of real power transfer. The grid-interfacing inverter with the proposed approach can be utilized to: i) inject real power to the grid, and/or, ii) operate as a shunt Active Power Filter (APF). The current unbalance, voltage harmonics and load reactive power, due to unbalanced and non-linear load connected to the PCC, are compensated effectively. Moreover, the load neutral current is prevented from flowing into the grid side by compensating it locally from the fourth leg of inverter. This approach thus eliminates the need for additional power conditioning equipment to improve the quality of power at PCC. Extensive MATLAB/Simulink simulation as well as the DSP based experimental results have validated the proposed approach and have shown that the grid interfacing inverter can be utilized as a multi-function device.

REFERENCES

[1] Mukhtiar Singh, Vinod Khadkikar, Ambrish Chandraand Rajiv K. Varma ―Grid Interconnection of Renewable Energy Sources at the Distribution Level With Power-Quality Improvement Features‖ IEEE Transactions on Power Delivery, vol. 26, no. 1, january 2011

[2] 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., 2008, pp. 2206–2211.

[3] F. Blaabjerg, R. Teodorescu,M. Liserre, and A. V. Timbus, ―Overview of control and grid synchronization for distributed power generation systems,‖ IEEE Trans. Ind. Electron., vol. 53, no. 5, pp. 1398–1409,Oct. 2006.

[4] J. M. Carrasco, L. G. Franquelo, J. T. Bialasiewicz, E. Galván, R. C. P. Guisado, M. Á. M. Prats, J. I. León, and N. M. Alfonso, ―Power-electronic systems for the grid integration of renewable energy sources:A survey,‖ IEEE Trans. Ind. Electron., vol. 53, no. 4, pp. 1002–1016,Aug. 2006.

[5] Renders, K. De Gusseme, W. R. Ryckaert, K. Stockman, L. Van-develde, and M. H. J. Bollen, ―Distributed generation for mitigating voltage dips in low-voltage distribution grids,‖ IEEE Trans. Power Del., vol. 23, no. 3, pp. 1581–1588, Jul. 2008.

[6] V. Khadkikar, A. Chandra, A. O. Barry, and T. D. Nguyen, ―Application of UPQC to protect a sensitive load on a polluted distribution network,‖ in Proc. Annu. Conf. IEEE Power Eng. Soc. Gen. Meeting, 2006, pp. 867–872.

[7] J. M. Guerrero, L. G. de Vicuna, J. Matas, M. Castilla, and J. Miret, ―A wireless controller to enhance dynamic performance of parallel inverters in distributed generation systems,‖ IEEE Trans. Power Electron., vol. 19, no. 5, pp. 1205–1213, Sep. 2004.

[8] 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.

[9] P. Jintakosonwit, H. Fujita, H. Akagi, and S. Ogasawara, ―Implementation and performance of cooperative control of shunt active filters for harmonic damping throughout a power distribution system,‖ IEEE Trans. Ind. Appl., vol. 39, no. 2, pp. 556–564, Mar./Apr. 2003.