INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN: 2278 – 0211 (Online)

Mitigation Of Power Quality Features With The Renewable Energy Sources At The Distribution Level

Mrs.N.Mohana Priyaa
M.Tech.,(Ph.D)., Vivekanandha College Of Engineering For Women

Ms.J.Jayashree
(M.E), Vivekanandha College Of Engineering For Women

Abstract:

Renewable energy resources (RES) are connected in distribution systems utilizing power electronic converters.In this paper the maximum benefits can be achieved from these grid-interfacing inverters when installed in 3-phase 4-wire distribution systems. The inverter is controlled to perform the operation with the active power filter functionality. In this paper the boosting converter is used to inject power generated from RES to the grid, and the shunt APF is utilized to compensate current unbalance, voltage harmonics and load reactive power demand. All of these functions may be accomplished either individually or simultaneously. The combination of grid-interfacing inverter and the 3-phase 4-wire linear/non-linear unbalanced load at the point of common coupling appears as balanced linear load to the grid. This concept is demonstrated with extensive MATLAB/Simulink simulation studies.

***Key words**: Boosting circuit, Active power filter (APF), distribution system, grid interconnection, power quality (PQ),and renewable energy.*

1.Introduction

Renewable energy sources (RES) integrated at distribution level is termed as distributed generation (DG). 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 for safety, reliability and efficient operation of overall network. With the advancement in power electronics and digital control technology, the DG systems can now be actively controlled to enhance the system operation with improved PQ. However, the use of power electronics based equipment which is mainly boosting converter and non-linear loads at PCC to generate harmonic currents may deteriorate the quality of power. Commonly, the voltage source inverters are used with the RES in distributed system. Recently, the control strategies for grid connected inverters incorporating PQ solution have been proposed. The grid interfacing inverter is utilized as active inductor at a certain frequency to absorb the harmonic current, but the exact calculation of inductance is difficult. similar approach in which a active power filter acts as active conductance to compensate the harmonics in distribution network. The control strategy for renewable interfacing inverter based on pq theory is proposed. In this strategy both load current and inverter current sensing is required to damp out the load current harmonics.

The non-linear load current harmonics may result in voltage harmonics and can create a serious PQ problem in the power system network. Active power filters (APF) are extensively used to compensate the load current harmonics and load unbalance at distribution level. Here, the main idea is the maximum utilization of inverter rating which is most of the time underutilized due to intermittent nature of RES. It is shown in this paper that the grid-interfacing inverter can effectively be utilized to perform following important functions: 1) transfer of active power harvested from the renewable resources (wind, solar, etc.); 2) load reactive power demand support; 3) current harmonics compensation at PCC; and 4) current unbalance and neutral current compensation in case of 3-phase 4-wire system. Moreover, with adequate control of grid-interfacing inverter, all the four objectives can be accomplished either individually or simultaneously.

2.System Description And Block Diagram

The proposed system consists of RES connected to the dc-link of a grid-interfacing inverter as shown in Fig. 2. The

voltage source inverter is a key element of a DG system as it interfaces the renewable energy source to the grid and delivers the generated power. The RES may be a DC source or an AC source with rectifier coupled to dc-link. Usually, the fuel cell and photovoltaic energy sources generate power at variable low dc voltage, while the variable speed wind turbines generate 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 on dc-link. The dc-capacitor decouples the RES from grid and also allows independent control of converters on either side of dc-link.

3.DC-Link Voltage And Power Control Operation

Due to the intermittent nature of RES, the generated power is of variable nature. The dc-link plays an important role in transferring this variable power from renewable energy source to the grid. RES are represented as current sources connected to the dc-link of a grid-interfacing inverter. Fig. 1 shows the systematic representation of power transfer from the renewable energy resources to the grid via the dc-link. The current injected by renewable into dc-link at voltage level can be given as

Eqn(1),

$$I_{\mathrm{dc1}} = \frac{P_{\mathrm{RES}}}{V_{\mathrm{dc}}}$$

Where P_{RES} is the power generated from RES.

3.1.DC-Link Equivalent Diagram

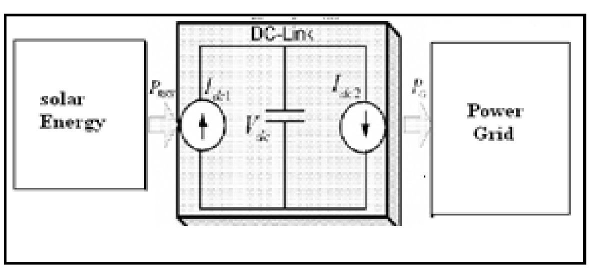

Figure 1: DC link Topology

The current flow on the other side of dc-link can be represented as,

Eqn(2),

$$I_{dc2} = \frac{P_{inv}}{V_{dc}} = \frac{P_G + P_{Loss}}{V_{dc}}$$

Where P_{inv},P_G and P_{loss} are total power available at grid-interfacing inverter side, active power supplied to the grid and inverter losses, respectively

3.2.Schematic Of Proposed Renewable Based Distributed Generation System

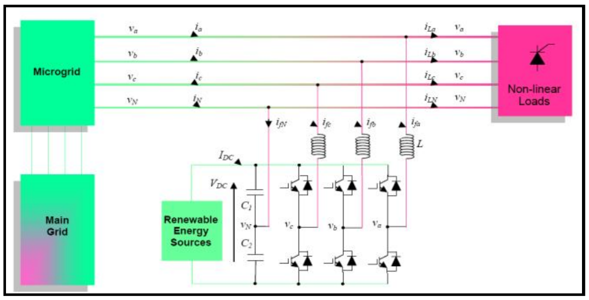

Figure 2: Topology of renewable energy based distributed generation system.

4.Control Of Grid Interfacing Inverter

The control diagram of grid- interfacing inverter for a 3-phase 4-wire system is shown in Fig. 3. The fourth leg of inverter is used to compensate the neutral current of load. While performing the power management operation,the inverter is actively controlled in such a way that it always draws/ supplies fundamental active power from/ to the grid. If the load connected to the PCC is non-linear or unbalanced or the combination also compensates the harmonics, unbalance, and neutral current. The duty ratio of inverter switches are varied in a power cycle such that the combination of load and inverter injected power appears as balanced resistive load to the grid. The regulation of dc-link voltage carries the information regarding the exchange of active power in between renewable source and grid. Thus the

output of dc-link voltage regulator results in an active current (I_m). The multiplication of active current component (I_m) 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(I_n^*) is set to zero, being the instantaneous sum of order low pass filter (LPF) to eliminate the presence of switching ripples on the dc-link voltage and in the generated reference current signals. The difference of this filtered dc-link voltage and reference dc-link voltage is given to a discrete- PI regulator to maintain a constant dc-link voltage under

varying generation and load conditions. The instantaneous values of reference three phase grid currents are computed as, Eqns (3),(4)&(5) are,

$$I_a^* = I_m \cdot U_a$$
$$I_b^* = I_m \cdot U_b$$
$$I_c^* = I_m \cdot U_c.$$

The neutral current, present if any, due to the loads connected to the neutral conductor should be compensated by forth leg of grid-interfacing inverter and thus should not be drawn from the grid. In other words, the reference current for the grid neutral current is considered as zero and can be expressed as

$$I_n^* = 0.$$

5.Simulation Results

In order to verify the proposed control approach to achieve multi-objectives for grid interfaced 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 currents at unity power factor (UPF) despite of highly unbalanced nonlinear load at PCC under varying renewable generating conditions. An unbalanced 3-phase 4-wire nonlinear load, whose unbalance, harmonics, and reactive power need to be compensated, is connected on PCC. The waveforms of grid voltages, grid currents, balanced grid currents. The actual dc-link voltage is sensed and unbalanced load current and inverter currents are shown in Fig. 4. The corresponding Line Voltage of grid , load and inverter are shown in Fig. 5.

Positive values of grid active-reactive powers and inverter active-reactive powers imply that these powers flow from grid side towards PCC and from inverter towards PCC, respectively. The active and reactive powers absorbed by the load are denoted by positive signs.

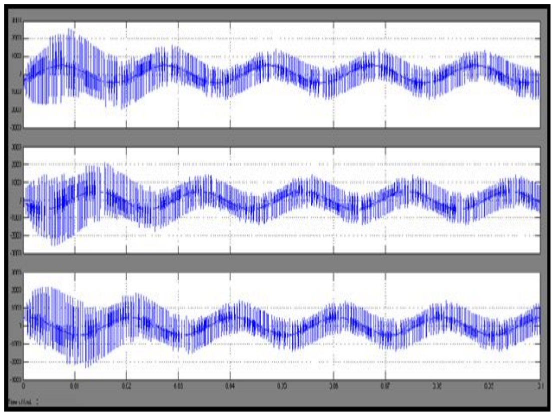

Figure 4: Simulation results: Line Currents

Initially, the grid-interfacing inverter is not connected to the network (i.e., the load power demand is totally supplied by the
grid alone).The grid-interfacing inverter is connected to the network.

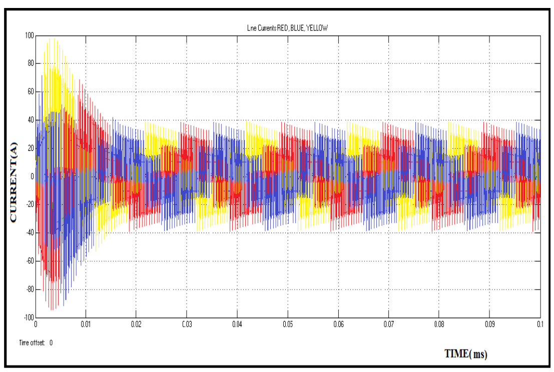

Figure 5: Simulation results: Line voltage

6.Experimental Validation

Fig.6 shows the experimental results for active power filtering mode of operation when there is no power generation from RES.

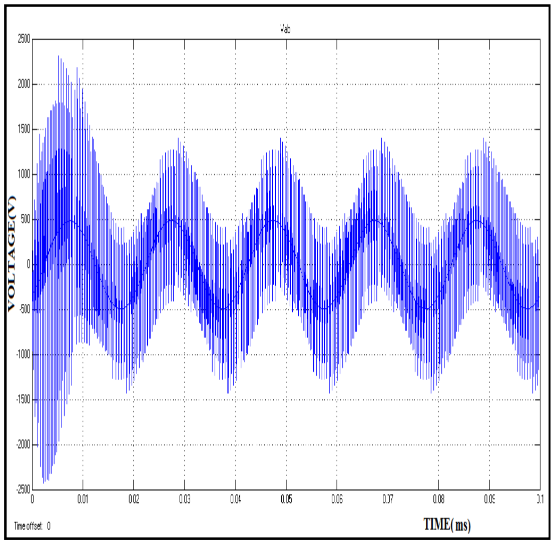

Figure 6(a): 600v AC waveform with ripples

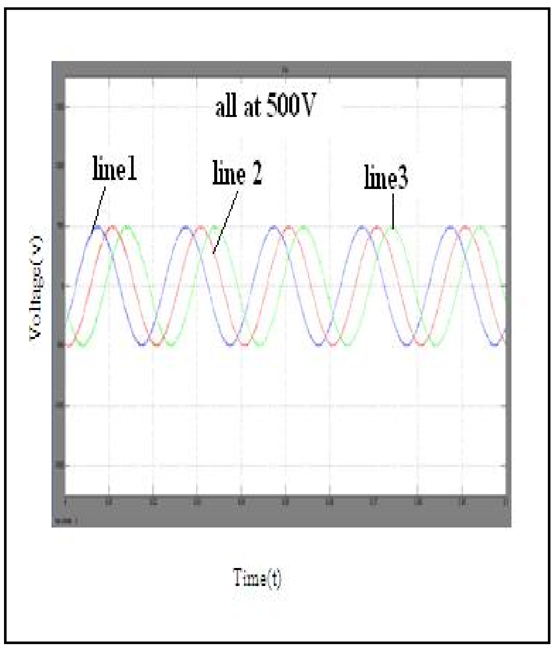

Figure 6(b): 600v AC waveform without ripples

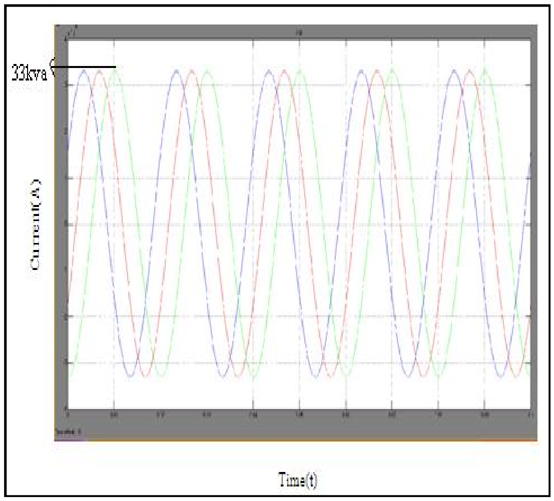

Figure 6(c): 33KVA AC waveform without ripples injecting into grid

The RES is emulated using an auxiliary controlled converter, which injects varying active power at the dc-link of an insulated gate bipolar transistor (IGBT) based 4-leg voltage source inverter connected to grid. Under such condition, the grid-interfacing inverter is utilized as shunt APF to enhance the quality of power at PCC. While in second mode of operation, the inverter injects RES active power into grid and also incorporates the active power filtering functionality. In the third mode, the dynamic operation of proposed controller is examined. The experimental results are given in Figs. 6(a,b,c&d). All the voltage and current waveforms are captured utilizing an oscilloscope, whereas, the active and reactive powers are captured in real-time using ControlDesk Developer environment.

7.Conclusion

In this paper the grid-interfacing inverter have 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 Inject real power generated from RES to the grid using boosting circuit, and/or, operate as a shunt Active and passive Power Filter (APF and PPF).

This approach thus eliminates the need for additional power conditioning equipment to improve the quality of power at PCC. It is further demonstrated that the PQ enhancement can be achieved. The current unbalance, current harmonics and load reactive power, due to unbalanced and non-linear load connected to the PCC, are compensated effectively

such that the grid side currents are always maintained as balanced and sinusoidal at unity power factor. the grid-interfacing inverter with the
proposed control approach delivers the excess generated sinusoidal active power to the grid at unity power factor.

8.Reference

1. 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.
2. 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.
3. U. Borup, F. Blaabjerg, and P. N. Enjeti, “Sharing of nonlinear load in parallel-connected three-phase converters,” IEEE Trans. Ind. Appl., vol. 37, no. 6, pp. 1817–1823, Nov./Dec. 2001.
4. 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.
5. J. P. Pinto, R. Pregitzer, L. F. C. Monteiro, and J. L. Afonso, “3-phase 4-wire shunt active power filter with renewable energy interface,” presented at the Conf. IEEE Rnewable Energy & Power Quality, Seville, Spain, 2007.
6. 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.
7. 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, “Powerelectronic systems for the grid integration of renewable energy sources: A survey,” IEEE Trans. Ind. Electron., vol. 53, no. 4, pp. 1002–1016, Aug. 2006.
8. B. Renders, K. De Gusseme, W. R. Ryckaert, K. Stockman, L. Vandevelde, 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