AN INTEGRATION OF ADVANCED RENEWABLE ENERGY SOURCES FOR POWER ENHANCING

Kancha Srinivasa Rao[1], G.V.V. Nagaraju[2]

[1]M.Tech Scholar (PS), [2]Asst. Professor, Deptt. of EEE

Nalanda Institute of Engg and Tech. (NIET), Siddharth Nagar, Guntur, A.P, (India)

ABSTRACT

Now days the Renewable energy resources (RES) are being increasingly integrated in distribution systems using power electronic converters. Here in this paper a new control technique for achieving maximum advantages from these grid interfacing inverters when connected in 3-phase balanced distribution system. The inverter is protect to perform as a multi-function device by incorporating active power filter functionality. The grid integrated inverter can thus be make use as 1) acts as a power converter to inject power produced from RES to the grid and 2) Shunt APF to compensate current fluctuations, load current harmonics, the load reactive power required by the grid . All of these functions may be achieved either individually or simultaneously. With this control the integration of the grid interfacing inverter and the 3-phase 3-wire linear/non-linear unbalanced load at point of common coupling appears as balanced liner load to the grid. This novel control concept is explained with extensive MATLAB/Simulink simulation studies and validated through digital signal processor based laboratory experimental results.

Keywords: ***Active Power Filter (APF), Distribute Generation (DG), Distribution System, Grid Interconnection, Power Quality (PQ), Renewable Energy*.**

I.INTRODUCTION

Electric utilities and end users of electric power are becoming increasingly concerned about reaching the growing energy usage. Seventy five percent of across the world energy demand is supplied by the burning of fossil fuels. But growing air pollution, global warming concerns, reducing fossil fuels and their cost have made it necessary to look towards renewable sources as the energy solution for future.

Renewable energy source (RES) connected at distribution stage is named as distributed generation (DG). The utility is concerned due to the high penetration stage of intermittent RES in distribution system as it may pose a effect to network in terms of stability, voltage regulation and power quality (PQ) problems. Therefore the DG systems are desired to comply with strict technical and regulatory frameworks to protect safe, reliable and efficient operation of overall distribution network. With the development in power electronics and digital control technology, the DG systems can now be effectively controlled to improve the system operation with better PQ at PCC. Even though the extensive use of power electronics based device and non-linear loads at PCC generate harmonic currents, which may diminishes the quality of power.

Basically, current controlled voltage source inverters are utilized to interface the intermittent RES in distribution system. Recently a few control techniques for grid connected inverters incorporating PQ solution have been suggested. In an inverter works as active inductor at a certain frequency to absorb the harmonic current. The non-linear load current harmonics may result in voltage harmonics and can generate a serious PQ issues in the power system network. Active power filter (APF) is specially used to compensate the load current harmonics and load fluctuation at distribution level. Here in this paper the main idea is the maximum usage of inverter rating which is most of the cases underutilized to intermittent nature of RES. In this paper the grid interfacing inverter can efficiently be used to perform following important functions 1) transfer of active power generated from the renewable sources(PV, FC etc.) 2) load reactive power demand support 3) current harmonics compensation at PCC and4) current unbalance and neutral current compensation in case of 3-phase 3-wire system. Moreover with required control of grid integrated inverter, all the four objectives can be accomplished either individually or concurrently. The Power Quality parameters at the PCC can hence strictly maintain within the utility standards without extra hardware cost. Here in this paper explains the system under consideration and the controller for grid integrating inverter.

II.EXISTING SYSTEM

The existing system consists of RES integrated to the dc-link of a grid connected inverter. The voltage source inverter is a main element of a DG system as it interfaces the renewable energy sources to the grid and produces the produced power. The RES may be a DC energy source or an AC energy source with rectifier integrated to dc link. Generally the fuel cell and photovoltaic energy sources produces power at variable low dc voltage , while the variable speed wind turbines produces power at fluctuating ac voltage. Thus the power generated from these renewable sources needs power conditioning before integrating on dc link. The dc capacitor integrates the RES from grid and also allows independent control of converters on either side of the dc link.

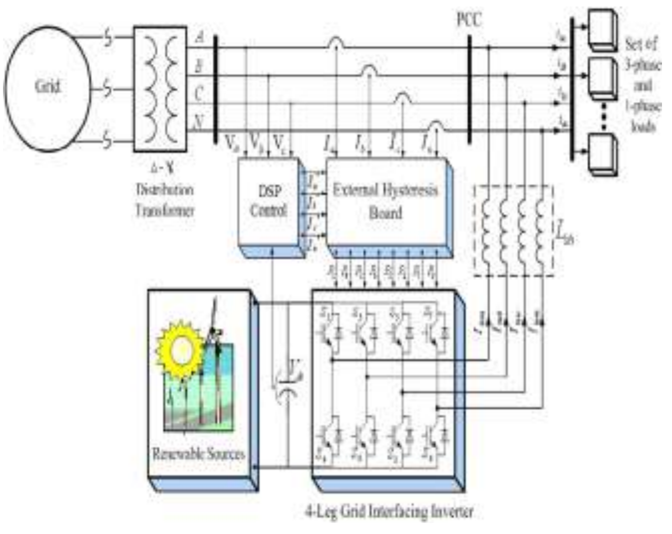

Fig.1. Schematic of Proposed Renewable Based Distributed Generation System

2.1 Coupled DC-Link Voltage and Power Control Operation

Due to the intermittent nature of RES, the produced power is of varying nature. The dc link plays vital role in transferring this variable power from renewable energy sources to the grid. RES are presented as current sources integrated to the dc link of a grid interfacing inverter. The schematic presentation of power transfer from the renewable energy sources to the grid through the dc link. The current injected by renewable into dc link at voltage level Vdc.

2.2 Control of Grid Interfacing Inverter

The control diagram of grid interfacing inverter for a 3-phase 4-wire system. The main aim of existed approach is to regulate the power at PCC during different operating conditions. While performing the power management operation, the inverter is quickly controlled in such a way that it always absorbs/delivers fundamental active power from / to the grid. If the load integrated to the PCC is non-linear or unbalanced or the combination of both the loads, the presented control technique also compensate the harmonics, unsymmetrical, and neutral current.

The duty ratio of inverter switches are changed in a power cycle such that the combination of load and inverter delivered power appears as balanced resistive load integrated to the grid. The management of dc link voltage carries the data regarding the exchange of active power in between renewable source and grid. Hence the output of dc link voltage regulator results in an active current component (Im) with unity grid voltage vector templates produces the reference grid currents. The grid synchronizing angle got from phase locked loop (PLL) is utilized to produce unity vector template.

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

$$U_b = Sin(\theta - \frac{2\pi}{3}) \quad (2)$$

$$U_b = Sin(\theta + \frac{2\pi}{3}) \quad (3)$$

The dc link voltage (V_{dc}) is and passed through a first order low pass filter (LPF) mitigate the presence of switching ripples on the dc link voltage$(V_{dc}^*)$is given to a discrete PI controller to control a constant dc link voltage under changing generation and load operating conditions. The instantaneous values of reference three phase grid currents are calculated as follows.

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

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

$$I_c^* = I_m.U_c \quad (6)$$

The neutral current available if any due to the loads integrated to the neutral wire should be balanced by fourth leg of grid integrated inverter and hence should not be absorbed from the grid.

III.PROPOSED SYSTEM

In order to correct the recommended control technique to accomplish multi objectives for grid interconnected DG systems coupled to a 3-phase 3-wire network, general study of simulation using MATLAB/Simulink platform. A 3 leg current controlled voltage source inverter is accurately maintained to achieve balanced sinusoidal grid currents along with unity power factor (UPF) despite of highly unsymmetrical nonlinear load at PCC under varying renewable power generating conditions. A RES with fluctuating output power is coupled with the dc link of grid interconnected inverter. An unsymmetrical 3-phase 3-wire nonlinear load, unsymmetrical, harmonics, and reactive power need to be balanced, is integrated on PCC. The waveforms of grid voltage(V_a, V_b, V_c), grid currents(I_a, I_b, I_c),unsymmetrical load currents and inverter currents are verified in the Mat Lab. The corresponding active power and reactive powers of grid (P_{grid}, Q_{grid}) load (P_{load}, Q_{load}). Positive values of grid active and reactive powers and inverter active-reactive powers imply that these powers flow from grid side towards PCC and from inverter on the way to PCC respectively. The active power and reactive powers absorbed by the load are represented by positive signs.

Initially the grid integrated inverter is not integrated to the network (i.e., the load power requirement is totally provided by the grid only). Hence before integration of inverter there are some disturbances in the grid current profile. After grid interfacing inverter is integrated to the network the inverter starts injecting the current in such a way that the profile of grid currents starts changing from unsymmetrical nonlinear load to symmetrical sinusoidal currents have been verified in this paper

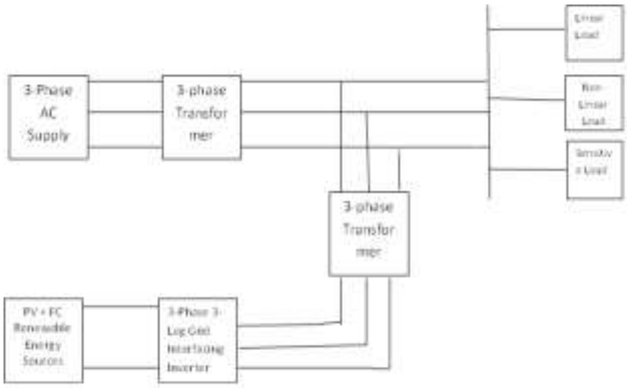

Fig.2. Schematic Diagram of Proposed System

The inverter starts delivering active power provided by RES. Since the generated power is more than the load power demand the excess power is fed back to the grid. The negative sign of $Pgrid$ after starting the current injected to the grid, that the grid is now accepting power from RES. Likewise the grid interfacing inverter also provides the load reactive power requirement on the distribution generation. Hence the inverter is in operation the grid only delivers/absorbs fundamental active power.

At certain time the active power from RES is increased to calculate the operating performance of system under variable power production from RES. This results in improved magnitude of inverter current. As the power required by the load is treated as constant, this surplus power produced from RES flows towards grid, which can be noticed from the improved magnitude of grid current as indicated by its profile. The equivalent variations in the inverter and grid currents can be observed from the simulation results. The active and reactive power flows between the inverter, load and grid during improve and reduction of energy generation from RES can be also observed from the Simulink results. The dc link voltage across the integrated grid during the different operating conditions is controlled at constant level in order to simplify the active and reactive power transfer. Hence from the simulation results, it is clear that the grid interconnected inverter can be effectively utilized to balance the load reactive power, current fluctuation and current harmonics in addition to active power injection from RES. This allows the grid to deliver/collect sinusoidal and symmetrical power at unity power factor.

IV.CONTROL STRATEGY FOR PROPOSED SYSTEM

The RES is matched utilizing an auxiliary controlled converter which delivers changing active power at the dc link of an insulated gate bipolar transistor (IGBT) based 3-leg voltage source inverter integrated to grid. A 3-phase non-linear load, balanced of 3-phase non-linear balanced load, 1-phase R-L load connected at the load side. The experimental responses are divided into three kinds of operation in order to elevate the validity if suggested controller. First mode of operation considers an instant when there is no power production from RES. Under such situation the grid interconnected inverter is used as shunt APF to improve the power quality of power at PCC. While in second mode of operating point of the inverter supplies RES active power into grid and also integrates the active power filtering performance. In the third operating condition, the dynamic operation of suggested controller is verified.

The experimental response for simultaneous active power filtering and RES power supplying mode as observed. Here in this paper it is considered that the produced power at grid interconnected inverter is more than the total load power requirement. Hence after meeting the load power requirement the excess RES power flows towards grid. The responses of grid, load and inverter currents are observed.

Initially it is considered that the system is working under different operating points (i.e non-linear load current harmonics and reactive power compensation). After few cycles the power available at dc link is initially improves and then diminishes, which can be observed from the magnitude of supplied inverter current profile. The equivalent decrease (for improved power level at dc link) and increase (for diminished power level at dc link) in grid current amplitude can also be observed in this paper.

Hence the suggested controller exactly balances any changes in real power at dc link and accurately feeds it to the main grid. Smooth variations from different operating conditions. The interchanging of total active and reactive powers between integrated grid, load applied on the grid. The negative sign of total grid side active power indicates that the excess power produced by RES transfer towards grid side. Hence this paper validates that the grid interconnected inverter can simultaneously be used to supplies power produced from RES to PCC and to enhance the power quality of the grid.

V.CONCLUSION

Here in this paper introduced a new control of an existing grid interconnected inverter to improve the power quality at PCC for a 3-phase Distribution system. It has been shown that the grid interconnected inverter can be accurately used for power conditioning without affecting its general operation of real power transfer. The grid interconnected inverter with the proposed approach used to

1) Inject real power produced from RES to the grid , and/or
2) Operate as a shunt active filter (APF)

This control technique thus eliminates the necessity for add extra power conditioning equipment to improve the power quality at the PCC. General LMLAB/Simulink simulation as well as the DSP based experimental results have authenticated the proposed system and have shown that the grid interconnected inverter can be used as multipurpose equipment.

It is additional demonstrated that the power quality enhancement can be accomplished under three different operating scenarios 1) $P_{RES} = 0$, 2) $P_{RES} < P_{load}$ 3) $P_{RES} > P_{load}$. The current disturbances, current harmonics and reactive power at the load, due to unsymmetrical and nonlinear load connected to the PCC, are compensated accurately hence the grid side currents are always controlled as balanced and sinusoidal at power factor maintained at unity. Moreover the load neutral current is stopped from flowing into the grid side by balancing it locally from the accurate control strategy. When the power produced from the RES is greater than the total load power requirement, the grid interconnected inverter with the recommended control technique not only satisfies the total load active and the requirement of reactive power (with harmonics elimination) but also delivers the excess produced sinusoidal active power to the grid at maintaining the unity power factor (UPF).

REFERENCES

[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. fonso, "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.imbus, "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. tockman, 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.

[9] 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.

AUTHOR DETAILS

	**Kancha Srinivasa Rao**, Pursuing Mtech (PS), Nalanda institute of Engineering and Technology(NIET), Siddharth Nagar, Kantepudi village, satenepalli Mandal, Guntur Dist., A.P., India
	**G.V.V. Nagaraju**, working as an Asst. professor (EEE) at Nalanda institute of Engineering and Technology (NIET), Siddharth Nagar, Kantepudi village, satenepalli Mandal, Guntur Dist., A.P., India