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Interfacing of Renewable Energy Sources to Grid with Power-Quality Improvement

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Abstract: In the field of Renewable energy resources (RES) are connected in distribution systems by using power electronic converters. Inside this paper presents a detailed control idea of reach maximum benefit from grid-interfacing inverters put in 3-phase 4-wire distribution systems. The inverter is controlled to perform an electronic device by incorporating active power filter functionality. The inverter can thus be utilized as: 1) Inject power generated from RES to the grid, and 2) unbalance current, load current harmonics, load reactive power demand and load neutral current compensate by shunt active power filter. Those all functions could also be accomplished either individually or simultaneously. With such a control, the mix of grid-interfacing inverter and the 3-phase 4-wire linear/non-linear unbalanced load at PCC appears as balanced linear load to the grid. With using of MATLAB/Simulink software this new concept is demonstrated.

Index Terms: Active Power Filter (APF), Distributed Generation (DG), Power Quality (PQ), Point of Common Coupling (PCC).

I. INTRODUCTION

Utilisation of electrical power at distributed side have become more and more involved concerning meeting the growing energy demand. Seventy 5 percent of total world energy demand is fulfilled by the burning of fossil fuels. But higher cost of fossil fuels and increasing air pollution, global warming concerns, it necessary to seem towards renewable sources as a future energy answer. Since the past decade, there has been a colossal interest in several countries on renewable energy for power generation. The market liberalization and government's encouragement have more accelerated the renewable energy sector growth

Renewable energy source (RES) integrated at distribution level is known as distributed generation (DG). The utility scariest because of the high penetration level of intermittent renewable energy source in distribution systems as it may pose a threat to network in terms of stability, voltage regulation and power-quality (PQ) issues. Therefore, the decigram systems are required to strict technical and regulatory frameworks to conform safe, reliable and efficient operation of overall network. With the advancement in power electronics converter and digital control technology, the systems can now be actively controlled to enhance the system operation with improved PQ at PCC.

Enhance the quality of power by using Power electronics based apparatus and non-linear loads at PCC generate harmonic currents, current controlled voltage source inverters are used to interface the intermittent RES in distributed. system. Recently, a couple of control strategies for grid connected inverters incorporating PQ solution have been proposed. In an inverter operates as active inductor at a certain frequency to soak up the harmonic current. But the exact calculation of network inductance in period is difficult and should deteriorate the control performance. A same approach during which a shunt active filter acts as active conductance to damp out the harmonics in distribution network is proposed in a control strategy for renewable interfacing inverter based on– theory is proposed. During strategy both load and inverter current sensing is required to compensate the load current harmonics

At distribution level side compensate the load current harmonics and load unbalance by using Active power filters (APF). This results in an extra hardware cost. However, during this paper authors have incorporated the features of APF within the grid, conventional inverter interfacing renewable with the grid, with none further hardware cost. Here, the idea behind this approach 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 just in case of 3-phase 4-wire system. Moreover, with adequate control of grid-interfacing inverter, all the four objectives can be accomplished

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either individually or simultaneously. The PQ improve at the PCC will be strictly maintained within the utility standards without additional hardware cost.

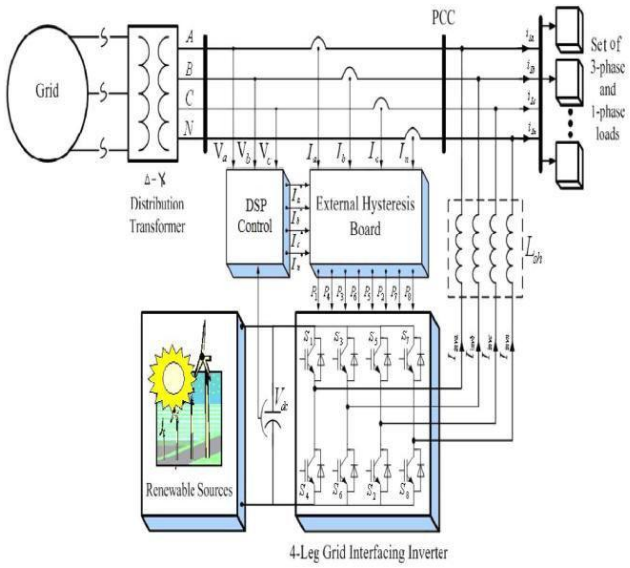

Fig. 1. Schematic of proposed renewable based distributed generation system

II. SYSTEM DESCRIPTION

The network consists of RES connected to the dc-link of a grid-interfacing inverter as shown in Fig. 1. The voltage source inverter is main component DG system as it interfaces the renewable energy source to the grid and delivers the generated power. The proposed system consist of RES (solar, wind) connected to the dc link of the grid interfacing inverter as shown in Fig. The RES may be a DC source or an AC source with rectifier coupled to dc-link. Most of the fuel cell and PV energy sources generate power at inconstant 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 control of converters on side of dc-link.

Active power filters are power electronic devices produce unwanted harmonic currents by injecting compensation current which cancels harmonics in the line current. Shunt active power filters compensate load current harmonics by injecting equal-but opposite harmonic compensating current. Generally, four-wire APFs have been conceived using four leg converters. This topology has better controllability than the classical three-leg four-wire.

A. 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

$$I_{dc1} = \frac{P_{RES}}{V_{dc}} \quad (1)$$

Where P_{RES} is the generated power from RES. The current flow on the other side of dc-link can be represented as,

$$I_{dc2} = \frac{P_{inv}}{V_{dc}} = \frac{P_G + P_{LOSS}}{V_{dc}} \quad (2)$$

Where, P_{INV}- total power available at grid-interfacing inverter side, P_G- active power supplied to the grid and inverter losses, and P_{LOSS}- inverter losses. If inverter losses are negligible then, $P_{RES} = P_G$.

$$\mathrm{Vm} = \sqrt{(\tfrac{2}{3} * (\mathrm{Va} * \mathrm{Va}) + (\mathrm{Vb} * \mathrm{Vb}) + (\mathrm{Vc} * \mathrm{Vc}))} \quad (1)$$

$$\mathrm{Ua} = \frac{\mathrm{Va}}{\mathrm{Vm}} \quad (2)$$

$$\mathrm{Ub} = \frac{\mathrm{Vb}}{\mathrm{Vm}} \quad (3)$$

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$$\mathrm{Uc} = \frac{\mathrm{Vc}}{\mathrm{Vm}} \quad (4)$$

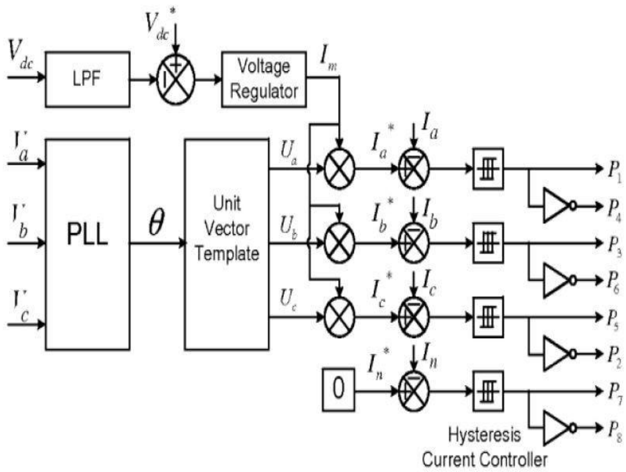

Fig.2. Block diagram representation of grid-interfacing inverter control.

Ua, Ub, Uc are Unit vector templates. The above equations are used for obtaining this unit vector templates. For obtaining the multiplication of active current here using PI controller

$$\mathbf{V=L*di/dt} \quad \mathbf{(5)}$$

$$\mathrm{i} = \frac{1}{\mathrm{L}} \quad (6)$$

$$\mathrm{i} = \frac{\mathrm{V}}{\mathrm{L}}\mathrm{t} \quad (7)$$

Im is the multiplication of active current.

$$\mathrm{Ia}' = \mathrm{Im} * \mathrm{Ua} \quad (8)$$

$$\mathrm{Ib}' = \mathrm{Im} * \mathrm{Ub} \quad (9)$$

$$\mathrm{Ic}' = \mathrm{Im} * \mathrm{Uc} \quad (10)$$

Above equations 8, 9 &10 are the reference currents. Actual grid currents are taken from the grid i.e. Ia, Ib, Ic.

III.HYSTERESIS CURRENT CONTROL

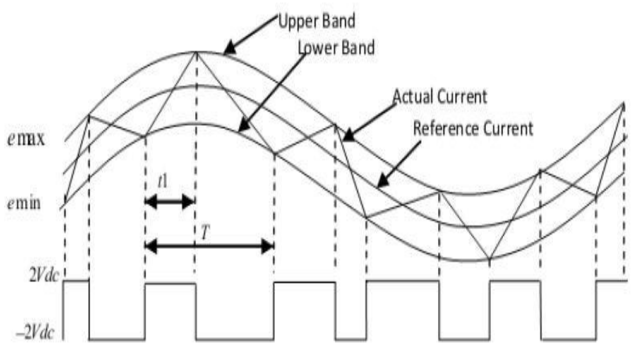

Fig.3. Waveform of Hysteresis current controller

HCC is the flexible technique to execute. In 1985 BROD and NOVOTNY were developed this technique. The VSI gate control signals are brought out from hysteresis band current controller. Hysteresis current control is implemented with a closed loop control system. In a VSI (Voltage Source Inverter) error signals are used for controlling the switches. Error is calculated between 2 currents. They are Desired Current and Inverter Current/Reference Grid Current. If the

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error crosses the upper value of the band then upper switch will OFF and lower switch will ON. If the error crosses the lower limit of the hysteresis band, the lower switch of the inverter arm is turned off and the upper switch is turned on.

IV. SIMULATION RESULTS

The proposed system is implemented in the academic environment and the results generated in the computer simulation using MATLAB Software are displayed below

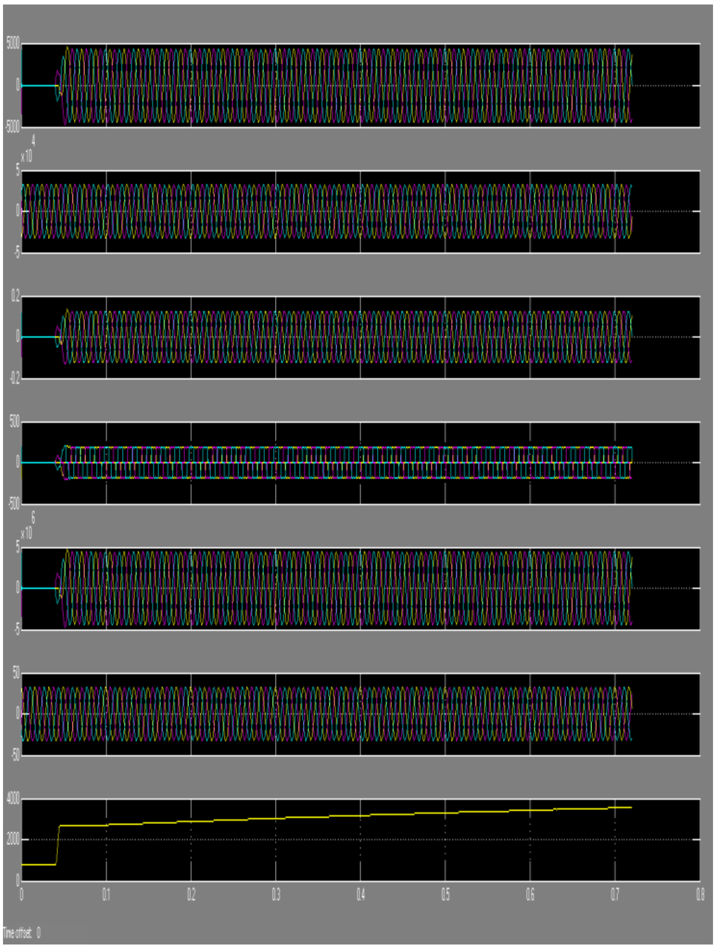

Fig. 1 (a) grid voltage (b)grid current (c)load voltage (d)load current (e)inv. voltage (f) inv. Current (g)dc voltage

The grid-interfacing inverter is not connected to the system. Therefore, before time t=0.77 s, the grid current in. Fig.1(b). Connect the network by the grid- interfacing inverter. the inverter starts injecting the current in such a way that the profile of grid current starts changing from unbalanced nonlinear to balanced sinusoidal current as shown in Fig. 1. As the inverter also supplies the load neutral current demand, the grid neutral current becomes zero after t=0.77 s. At t=0.77 s, when the inverter starts injecting active power generated from RES (Pres ≈ Pinv). Power genrated is more than the load power demand the additional power is fed back to the grid. After time 0.72 s, negative sign of power of grid is now receiving power from RES. the grid-interfacing inverter also supplies the load reactive power. When the inverter is in operation the grid only supplies/receives fundamental active power. A 4-leg current controlled voltage source inverter is controlled to achieve balanced sinusoidal grid currents at unity power factor (UPF) highly unbalanced nonlinear load at PCC under varying renewable generating conditions. A RES with variable output power is connected on the dc-link of grid-interfacing inverter. An unbalanced 3-phase 4-wire nonlinear load, whose unbalance, harmonics, and reactive power need to be compensated, is connected on PCC. Grid voltage, grid currents, unbalanced load current and inverter currents waveform shown in Fig.

Positive values of grid active-reactive powers and inverter active-reactive powers imply powers flow from grid side towards PCC and from inverter towards PCC, respectively. The active and reactive powers soak up by the load are denoted by positive signs shown in fig.2 that shows PQ.

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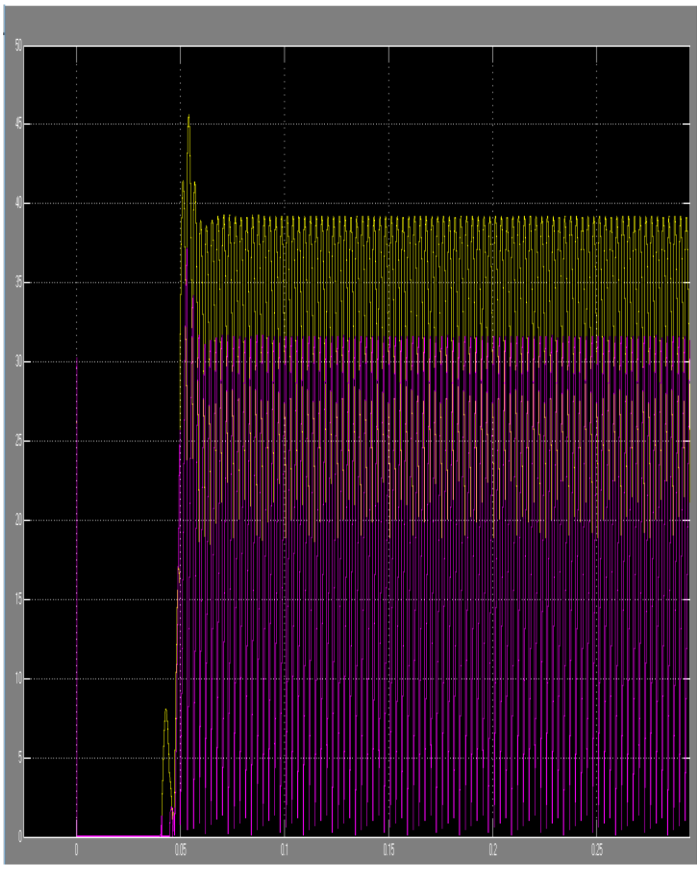

Fig.2 P-Q grid

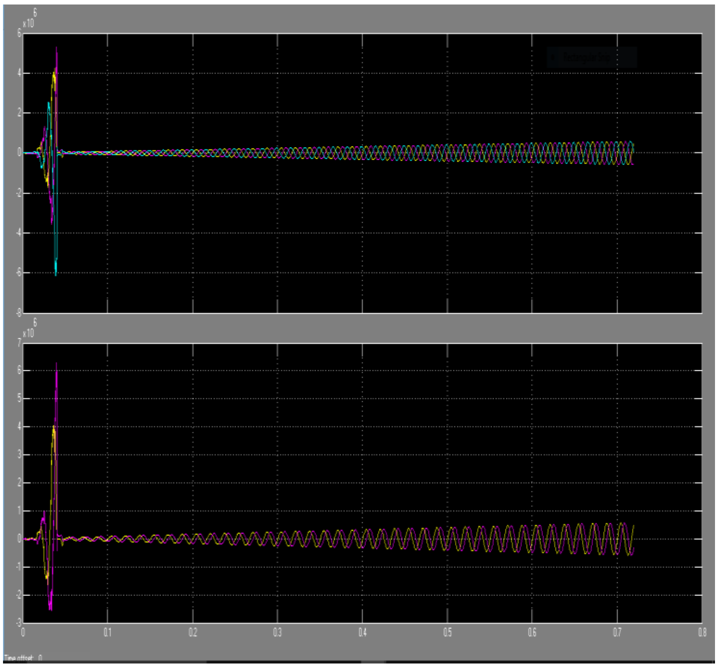

Fig.3 Compenstion Current

This current is compensated for by the fourth leg of the shunt APF, thus reducing the supply neutral current to zero as depicted in Fig.3 Before placing the inverter the source current is unbalanced after inverter operation the source current unbalance is compensated at 0.1 seconds. And also compensates the neutral current at source. This Load current is in unbalanced, neutral current is flows in this load current.

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V. SIMULINK MODEL

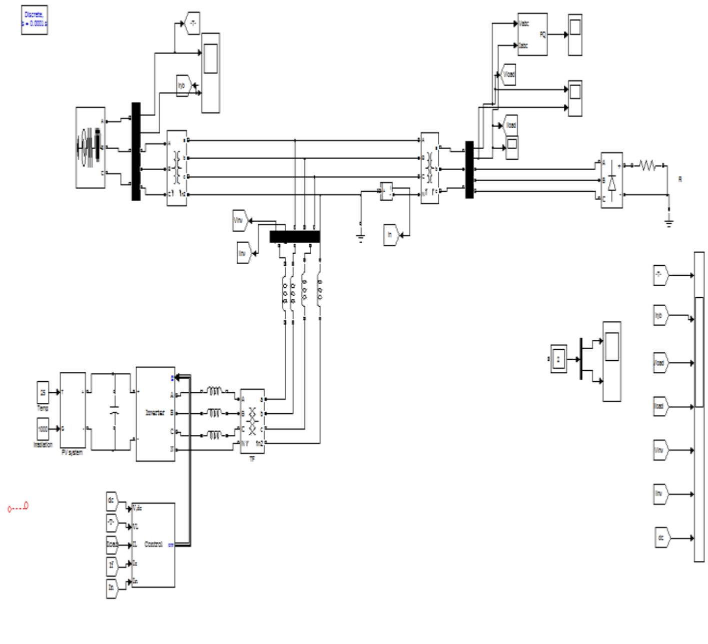

Fig.4 simulink model of grid interfacing of RES at distribution side with P-Q improvement

VI. CONCLUSION

This Thesis have a unique control of associate degree existing grid interfacing electrical converter to rise the standard of power at PCC for a 3-phase 4-wire DG system. it's been shown that the grid-interfacing electrical converter will be effectively used for power learning while not touching its traditional operation of real power transfer. The grid-interfacing electrical converter with the planned will be used to:
i. In the grid used to Inject real power generated from RES, ii. This approach eliminates the necessity for added power to boost the standard of power at PCC. By the using shunt active power filter in depth MATLAB/Simulink simulation results have valid the planned approach and have shown that the grid-interfacing electrical converter will be used as a multi-function device.

It is more incontestable that the PQ sweetening will be achieved beneath 3 completely different scenarios: 1) PRES=0, 2) PRES P Load, and 3) PRES P Load. the load neutral current is put a stop of from flowing into the grid side by the fourth leg of electrical converter is compensating. when the generated from RES is the entire load power demand, the grid-interfacing electrical converter with the planned management approach not solely fulfils the total load active and reactive power (with harmonic compensation) delivers the surplus generated curving active power to the grid at unity power issue.

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