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A Grid Interfacing Scheme for renewable energy sources using PV and Fuel cell systems

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Abstract: With the increase in load demand, the Renewable Energy Sources (RES) are increasingly connected in the distribution systems which utilize power electronic Converters/Inverters. In this thesis, Photo Voltaic (PV) system is integrated to a three phase four wire distribution system. The Photo Voltaic (PV) Panel is modeled based on associated equations. The use of non-linear loads in the power system will lead to generation of current harmonics which in turn deteriorate the power quality. Active Power Filters (APF) are extensively used to compensate the current harmonics and load unbalance. In this work, the existing PV inverter acts as Shunt Active Power Filter (SAPF) that is capable of simultaneously compensating problems like current unbalance, current harmonics and also of injecting the energy generated by renewable energy source. The inverter is controlled on the basis of hysteresis control and thus it can be utilized as a power converter injecting power generated from RES to the grid and as a shunt APF to compensate the Load disturbances. It is proposed to investigate in this paper, the performance of PV inverter for various loads. This work is carried out using MATLAB/SIMULINK software..

***Keywords*: Wind power, Distribution Network, Induction Generator, STATCOM, Reactive Power, Harmonics, and 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. In finding solutions to overcome a global energy crisis, the Photo Voltaic (PV) system has attracted significant attention in recent years. The government is providing incentives for further increasing the use of grid-connected PV systems. Renewable Energy Sources are increasingly integrated at the distribution level due to increase in load demand which utilize power electronic converters. Due to the extensive use of power electronic devices, disturbances occur in the electrical supply network. These disturbances are due to the use of non-linear devices. These will introduce harmonics in the power system thereby causing equipment overheating ,damage devices ,EMI related problems etc. Active Power Filters (APF) is extensively used to compensate the current harmonics and load unbalance. This will result in additional hardware requirements. So, in this paper, the existing PV inverter acts as Shunt Active Power Filter (SAPF) that is capable of simultaneously compensating problems like current unbalance, current harmonics and also of injecting the energy generated by RES. The shunt active filter is a voltage source inverter (VSI), which is connected in parallel with load. Shunt Active Power Filter has the ability to keep the mains current balanced and sinusoidal after compensation for various Load conditions.

II.SYSTEM DESCRIPTION

A. TOPOLOGY

Active power filters are power electronic devices that cancel out unwanted harmonic currents by injecting a 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, APFs have been conceived using voltage source converters [5]. This topology has proved better controllability. In this paper, it is shown that using an adequate control strategy, even with a three phase four-wire system, The topology of the investigated APF and its interconnection with the grid is presented in Fig. 1. It consists of a three-leg three-wire voltage source inverter. In this type of applications, the VSI operates as a current controlled voltage source. The proposed system is Three Phase three wire which consists of Photovoltaic system and fuel cell connected to the dc-link of a grid-interfacing inverter as shown in Fig. 1. The voltage source inverter is a key element as it interfaces the renewable energy source to the grid and delivers the generated power. The RES is connected to grid with an inverter coupled to dc-link. The dc-capacitor decouples the Photovoltaic system from grid and also allows independent control of converters on either side of dc-link.

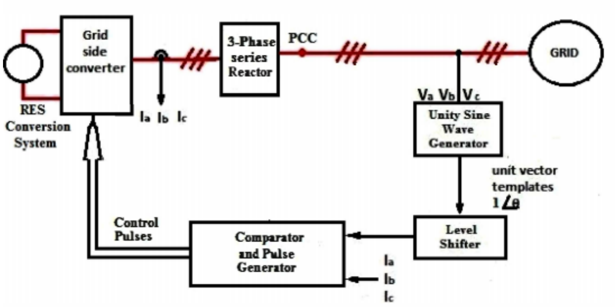

Fig 1.Schematic of the 3 phase grid system interface with renewable energy source using APF

B.VOLTAGE SOURCE CONVERTER (VSC)

A Voltage Source Converter (VSC) is a power electronic device that connected in shunt or parallel to the system. It can generate 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 absorbs reactive power. If the output voltage of the VSC is greater than AC bus terminal voltages, is said to be in capacitive mode. So, it will compensate the reactive power through AC system. The type of power switch used is an IGBT in anti-parallel with a diode. The three phase four leg VSI is modeled in Simulink by using IGBT.

C.CONTROLLER FOR APF

The dc link voltage, Vdc is sensed at a regular interval and is compared with its reference counterpart Vdc*.The error signal is processed in a PI-controller. The output of the pi controller is denoted as Im.The reference current templates (Ia*,Ib*,and Ic*) are obtained by multiplying this peak value (Im) by the three-unit sine vectors (Ua , Ub and Uc) in phase with the three source voltages. These unit sine vectors are obtained from the three sensed line to neutral voltages. The reference grid neutral current (In*) is set to zero, being the instantaneous sum of balanced grid currents. Multiplication of magnitude Im with phases (Ua ,Ub, and Uc) results in the three phase reference supply currents (Ia*,Ib*,and Ic*).

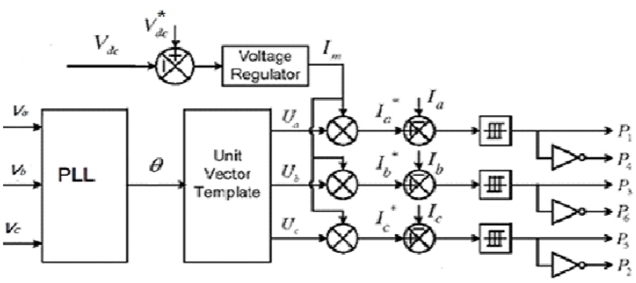

Fig. 2. Block diagram representation of grid-interfacing inverter control.

The grid synchronizing angle (θ) obtained from phase locked loop (PLL) is used to generate unity vector.

$$U_a = \mathrm{Sin}(\theta) \tag{1}$$

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

$$U_c = \mathrm{Sin}(\theta + \frac{2\pi}{3}) \tag{3}$$

The actual dc-link voltage (V_{dc}) is sensed and passed through a first-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 (V^*_{dc}) is given to a discrete- PI regulator to maintain a constant dc-link voltage under varying generation and load conditions. The dc-link voltage error V_{dcerr} (n) at nth sampling instant is given as:

$$V_{\mathrm{dcerr}(n)} = V^*_{\mathrm{dc}(n)} - V_{\mathrm{dc}(n)}. \tag{4}$$

The output of discrete-PI regulator at the sampling instant is expressed as

$$I_{m(n)} = I_{m(n-1)} + K_{PV_{\mathrm{dc}}}(V_{\mathrm{dcerr}(n)} - V_{\mathrm{dcerr}(n-1)}) + K_{IV_{\mathrm{dc}}} V_{\mathrm{dcerr}(n)} \tag{5}$$

Where K_{PVdc} = 10 and K_{IVdc} = 0.05 are proportional and integral gains of dc-voltage regulator. The instantaneous values of reference three phase grid currents are computed as

$$I^*_a = I_m \cdot U_a \tag{6}$$

$$I^*_b = I_m \cdot U_b \tag{7}$$

$$I^*_c = I_m \cdot U_c. \tag{8}$$

The reference grid currents (I^*a, I^*b,I^*c) are compared with actual grid currents (Ia, Ib,Ic) to compute the current errors as

$$I_{\mathrm{aerr}} = I^*_a - I_a \tag{9}$$

$$I_{\mathrm{berr}} = I^*_b - I_b \tag{10}$$

$$I_{\mathrm{cerr}} = I^*_c - I_c \tag{11}$$

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These current errors are given to hysteresis current controller. The hysteresis controller then generates the switching pulses (P_1 *to* P_8) for the gate drives of grid-interfacing inverter.

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 S_1 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 hb is the width of hysteresis band. On the same principle, the switching pulses for the other remaining three legs can be derived.

III. HYSTERESIS CONTROLLER

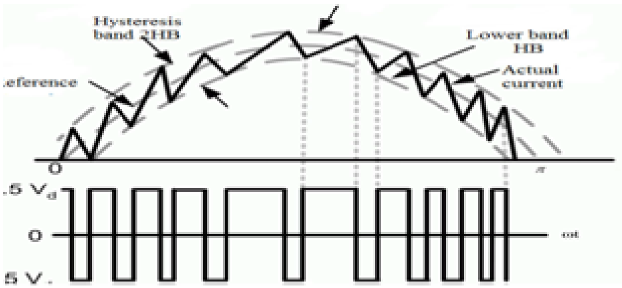

Fig.3. Hysteresis current Modulation

With the hysteresis control, limit bands are set on either side of a signal representing the desired output waveform [6]. The inverter switches are operated as the generated signals within limits. The control circuit generates the sine reference signal wave of desired magnitude and frequency, and it is compared with the actual signal. As the signal exceeds a prescribed hysteresis band, the upper switch in the half bridge is turned OFF and the lower switch is turned ON. As the signal crosses the lower limit, the lower switch is turned OFF and the upper switch is turned ON. The actual signal wave is thus forced to track the sine reference wave within the hysteresis band limits.

IV. MATLAB MODELEING AND SIMULATION RESULTS

Fig.5 Matlab/Simulink Model of proposed power circuit, along with control circuit. The power circuit as well as control system are modeled using Power System Block set and Simulink. The grid source is represented by three-phase AC source. Three-phase AC loads are connected at the load end. APF is connected in shunt and it consists of PWM voltage source inverter circuit and a DC capacitor connected at its DC bus. An IGBT-based PWM inverter is implemented using Universal bridge block from Power Electronics subset of PSB. Snubber circuits are connected in parallel with each IGBT for protection. Simulation of APF system is carried out for linear and non-linear loads.

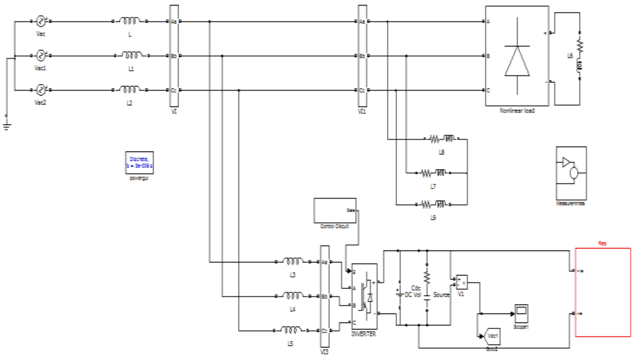

Fig.4 Matlab/Simulink of Proposed Statcom-Power Circuit

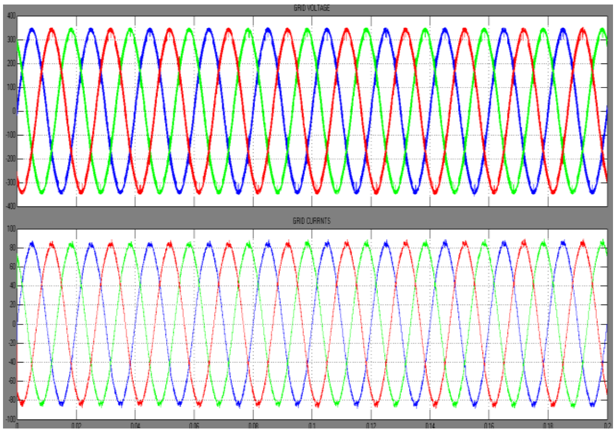

Fig.5. simulation results for grid side voltages and currents

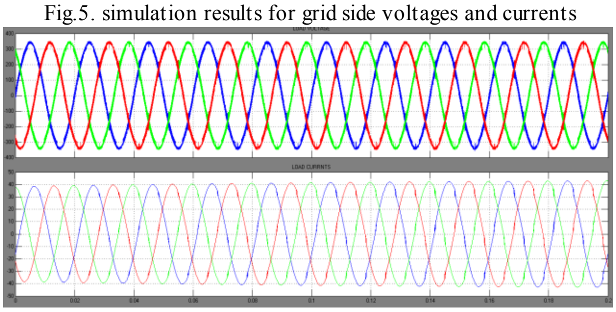

Fig.6. simulation results for load voltage and current

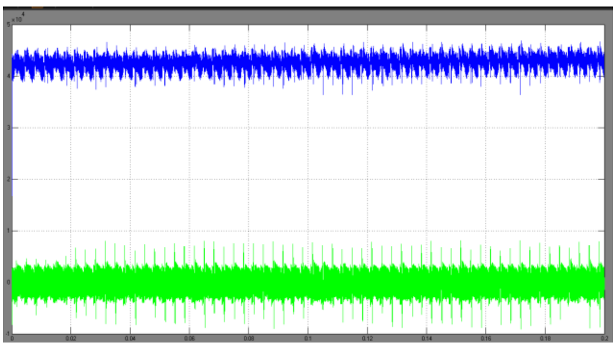

Fig.7. simulation results for active and reactive power

From fig. 6 we know that if non linear load present at the grid side the current shapes are sinusoidal, then we can improve the power quality of the system.

V. CONCLUSION

In this paper the APF -based HCC control scheme for power quality improvement in grid connected renewable energy system and with several load conditions are presented. The power quality issues and its consequences on the consumer and electric utility are discussed. The operation of the control system developed for the APF in MATLAB/SIMULINK for maintaining the power quality is simulated. It has a capability to cancel out the harmonic parts of the grid current. It support the reactive power demand for the wind generator and load at PCC in the grid system, giving an opportunity to enhance the power quality in the transmission line. This paper analysed a control of three phase grid interfacing inverter improve the quality of power at PCC for a 3 phase 3 wire system applied to various load conditions, here we preferred linear & non-linear load. This also makes real power flow at instantaneous demand of the load. Rapid injection or absorption of reactive/real power flow in the power system can be made possible through battery energy storage and APF..

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