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Active & Reactive Power Control Using Solar & Wind Energy Sources

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ABSTRACT

This work presents related to the management of active and reactive power exchange between a distributed generation (DG) source and the grid connected for improved utilization of electricity generated by the DG source such as solar & wind energy. This is based on the recently introduced Availability Based Tariff (ABT) concept for the consumer loads, where the conventional power grid is available. The Simulation of the grid interactive inverter is carried out in MATLAB/SIMULINK environment and experimental results were presented to validate the proposed methodology for control of supplies active and reactive power to the loads and also makes the grid current to a sinusoidal one to improve the power factor and reduce the harmonics in grid current. In addition to current control and voltage control, power quality control is made to reduce the total harmonics distortion. This work offers an increased opportunity to provide distributed generation (DG) use in distribution systems as a reliable source of power generation to meet the increased load demand which helps to provide a reasonable relief to the customers and utilities to meet the increasing load demand.

***Keywords:** Grid interactive inverter, Solar & Wind Resource, Voltage and Current Controller, THD Improvement, Reactive power compensation*

1. INTRODUCTION

As of late the number of technological improvements on the outline of models for energy power by utilizing energy sources not traditional, for example, sun based wind, hydro, biomass and bio fills, geothermal, cells powers . Sustainable power sources, for example, Solar Energy and Wind energy are the sources that energy caught and put away by nature. Because of global warming, new energy sources should be utilized for example, sun oriented and wind energy.

Other energy source can compensate for the difference, when a source is unavailable or insufficient in meeting the load demands. Due to the rapid growth of power electronics techniques applications with photovoltaic (PV) energy and wind energy have been increased significantly. Reactive power control methods are discussed in. These methods are much complicated and require sophisticated measurement and signal processing. The work presented here is about the generation of AC power from solar; the control of active and reactive power flows into the grid, and getting financial benefit from the same.

Distributed Generators (DG) utilizing Environmental-friendly energy sources, like wind, small hydro, and solar have become a major part of the future smart grid/micro grid concept. DGs can be designed to provide ancillary services to the utility such as reactive power support, load An important aspect related to the PV system connected to the electric grid is that it can operate as both an active power generator and reactive power compensator. Voltage source inverter with current control is used for reactive power compensation in grid interconnection of solar-based DG. DG system can feed power into the AC grid through a grid-connected inverter, there is no need for a storage battery, and this will leads to minimizing the cost of installation.

The basic requirement of a grid-interactive inverter operation are active power generator, reactive power compensator and must able to maintain the voltage magnitude at the point of common coupling(PCC) to the desired value. The aim of this work is to select a control and switching strategy for an inverter which is to be used as part of a single-phase rooftop grid-connected PV system capable of improving the power quality in terms of power factor and low THD.

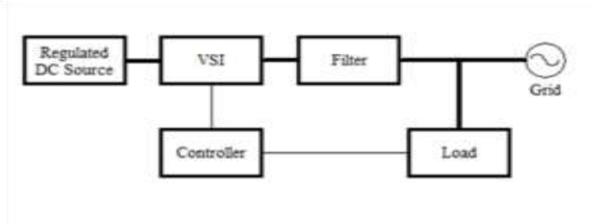

Fig. 1 Block diagram of solar and wind connected grid.

2. SYSTEM CONFIGURATION &CONTROL STRATEGY

The block diagram of the grid-connected Renewable energy conversion system is shown in Fig.2. A 3-phase voltage source converter (VSC) is connected to the grid via a line reactor, synchronization switch and a 3-phase transformer. Gate triggering pulses for the IGBT switch modules of the VSC are generated by controller and are applied to individual gates through gate driver card. The grid voltage is sensed through a small 1-phase stepped down transformer. SPWM technique is adopted for triggering pulse generation. $V_{dc}$is the DC voltage of converter, which is fed by a solar conversion system. Frequency and angle (ωt) of grid voltage is fetched from the voltage signal which is stepped down by transformer. The pulse generated by thecontroller is isolated and amplified using the gate driver circuit. Gate driver circuit consists of isolation ICs and transistors.

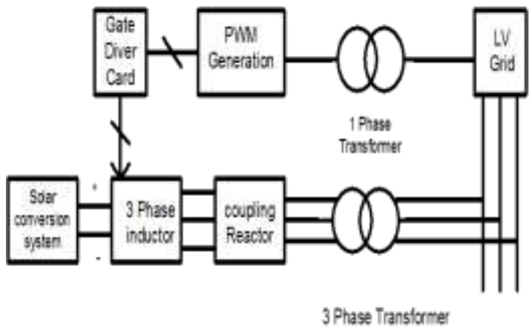

Fig 2- Block diagram of the grid-connected distributed generation system

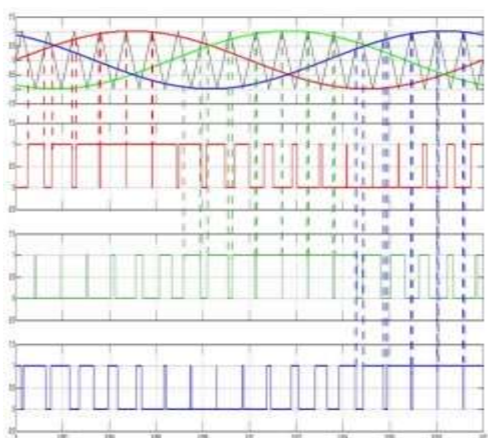

Fig 3-Three-phase modulating sine wave compared with triangular carrier wave and triggering pulses with reference three-phase sine wave. In this technique, the modulation index affects the amplitude of the fundamental output voltage.

To examine the factors affecting active and reactive power flow between two sources, let us consider the two active sources separated by an inductive reactance as shown in Fig.4

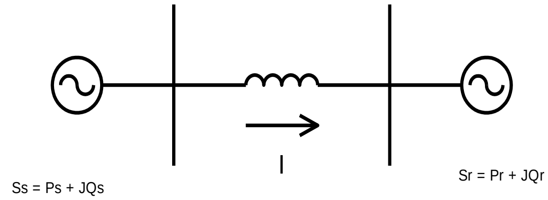

Fig. 4-Equivalent Circuit Diagram

The power flow of the system is governed by the following equations:

$$P_s = (E_s E_r \sin \delta) / X; \qquad \text{---------------------------(1)}$$

$$Q_s = (E_s^2 - E_s E_r \cos \delta) / X; \text{------------------------(2)}$$

where P_s is active power; Q_s is reactive power; E_s is sending end voltage; E_r is receiving end voltage, and X is line reactance. From (1) and (2), active power transfer depends mainly on the phase angle difference between the voltages of both ends ($P * \delta$), and it flows from the side having leading phase angle.

Reactive Power transfer mainly depends on the voltage amplitudes of both ends ($Q\ E_s$, E_r), and it flows from the higher voltage amplitude side to the lower voltage amplitude side. Reactive power cannot be transmitted over a long distance since it would require a large voltage gradient to do so. An increase in reactive power transfer causes an active as well as reactive power losses. Here, the grid plays the role of one active voltage source, while the photovoltaic conversion system with VSC plays the role of another one. By using the converter, the DC electrical output of solar PV is converted into AC electrical power. The amplitude and phase angle of three-phase AC output voltage at converter terminals are controlled by modulation index (m) and phase shifting of the reference signal respectively. According to (1) and (2), by varying m, the voltage amplitude of the converter terminal is varied, which controls reactive power flow between the grid and converter. By varying the phase angle δ, the active power flow is controlled between the converter and grid. So by a change in modulation index m and phase angle δ, the active and reactive power flow can be controlled between the converter terminals and grid.

3. RENEWABLE ENERGY SOURCES

A renewable electricity generation technology harnesses a naturally existing energy flux and converts that flux into electricity. It must be located at the place where natural energy flux is available to occur. This technology is differed from the conventional fossil-fuel and nuclear electricity generation.

3.1. Wind Energy

Figure 5 represents a basic block diagram to produce electricity using wind turbine. It consists of two or three propeller or blade at the top of the turbine around a shaft. The wind circulation creates force on the shaft to rotate the rotor of the generator which produces electromagnetic induction. The flux across the conductor is changed to produce electricity. Two types of propeller are used in the wind turbine, namely drag type and lift type. The drag type propeller has higher torque and slow rotating speed. Horizontal Axis Wind Turbine (HAWT) uses lift type propeller. Lower air pressure is created on the leading edge while higher air pressure is created at the tail edge.

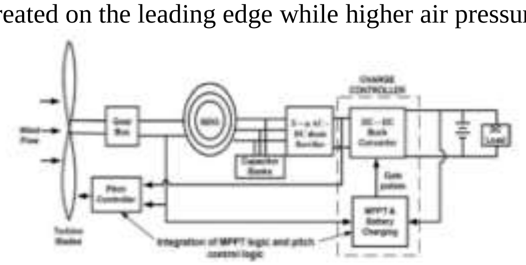

Fig.5 -Wind Energy Generation Process

Induction generator consumes more reactive power. To overcome this problem, double fed induction generator (DFIG) is widely used. An inverter is used that controls the torque and real and reactive power of the machine by controlling the current.

3.2 Solar energy

A basic block diagram to produce electricity using solar system is represented in Fig.6. Solar system consists of solar cells that convert the light energy into electricity. When the photons of the sunlight hit the solar cell, it absorbs the photons.

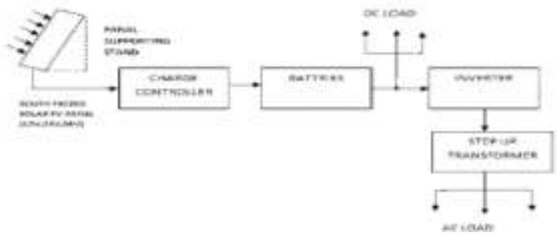

Fig. 6-solar energy generation process

The current produced by the solar system is known as light-generated current. The photons absorbed by the solar cell produce electron-hole pairs . The carriers are collected by using a p-n junction to separate the electron and hole. When the minority carriers reach to the p-n junction, it is swept by the electric field. By connecting the emitter and base together, the light generated by carriers flows through the external circuit.

4. SIMULATION AND RESULTS

The simulation of the Solar and wind system described in bellow was performed using simulink as shown in figure 7. The components used for PV and wind are shown in figures 8,and output of PV Model as shown in figure 9 and MATLAB simulation of wind system 10, respectively. The output responses of the PID controller are interpreted through a MATLABfunction. The output responses of wind system respectively are shown in figure 11. The mean load curve is shown in figure 12.

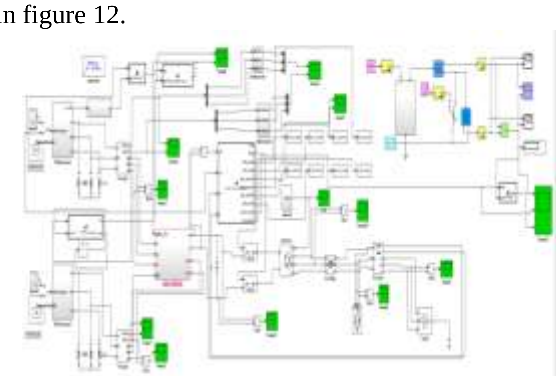

Fig 7- Overall MATLAB simulink model of the PV & Wind system

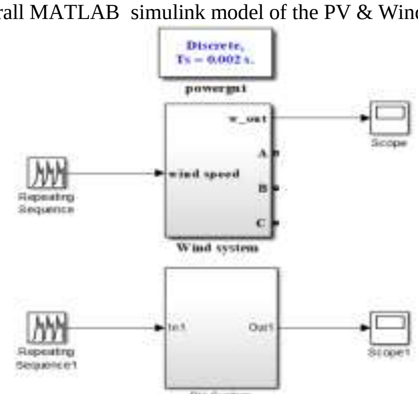

Fig 8- PVSystem and Wind system

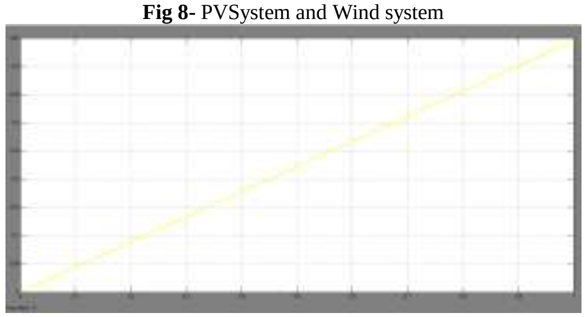

Fig 9 – PV OUTPUT

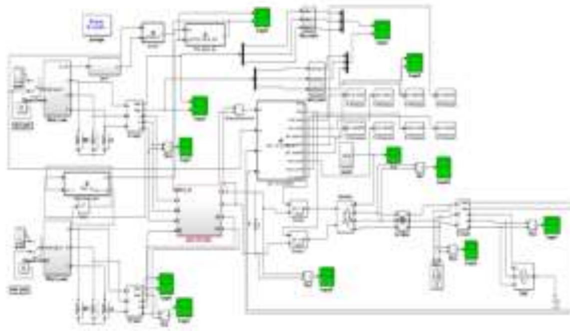

Fig 10- MATLAB simulation of Wind System

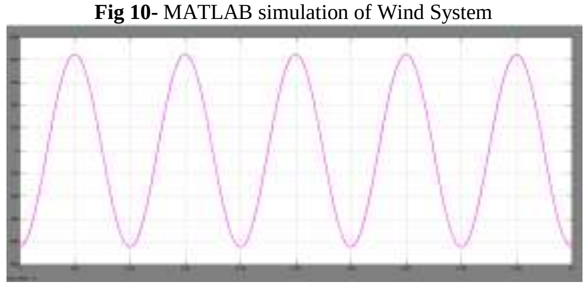

Fig 11- Output of wind system

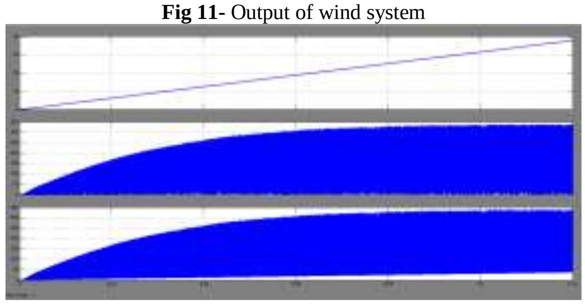

Fig 12- maximum output of Solar and wind system

As the load varies with time as shown in above figure, the switching of grid connection and battery storage system is performed by the PIDcontroller in order to minimize the difference between required power and available power. The two system are combine and both system gives maximum output.It is observed that during non-availability of solar energy grid support is turned on. During the latter period when wind energy is not available, solar generation and battery power support the demand.

5. CONCLUSIONS

The simulation of active and reactive power control using Solar and Wind system. and the results obtained from MPPT and PWM control technique improves the power quality i.e THD and the power factor. The simulation also shows that power transfer of active and reactive power from the inverter to grid. The reactive power required for the load is completely provided from the inverter. The compare the system and get maximum output from it. in the MATLAB Simulink environment. The rectifier and Inverter is used for the reduction of THD. The results show that the controller is capable for reactive power compensation, and maintaining constant voltage at the grid satisfying standard for grid interconnection. That is the THD is lessthan5% 3.74 and the power factor is 0.9977 which is near to unity. At the last integrate both system and get Maximum power output from the Solar and Wind system. This work can be extended to cascaded inverter configuration and reliability analysis has to be made as a better option for future studies.

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