REALIZATION OF HYBRID GRID WITH PHOTOVOLTAIC CELL AND WIND ENERGY SYSTEM USING SIMULINK

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Abstract:

The renewable energy sources have been taken the place of the traditional energy sources and especially rapidly developments of photovoltaic (PV) technology and wind energy technology have been put forward these renewable energy sources (RES) in all other RES. The PV based systems have been started to be used widely in domestic applications connected to electrical grid and grid connected PV power generating systems have become widespread all around the world. Also, PV generating systems have been used to support the wind generating systems. So, a hybrid generation system which consists of PV and wind based technology with MPPT technique is investigated for power generating. In this study, a grid connected PV cells and wind based energy generating system was developed with MATLAB/SIMULINK and the results are presented. The hybrid grid can provide a reliable, high quality and more efficient power to consumer. The hybrid grid may be feasible for small isolated industrial plants with both PV systems and wind turbine generator as the major power supply.

Keywords: *Photovoltaic Cell, wind Energy, Hybrid system, grid connection, renewable energy sources and Simulink. wind energy system, modeling, simulation*

I. INTRODUCTION

As energy generation and distribution companies compete in the market place we have seen an increasing interest in renewable and alternative energy sources. In addition to this competition, companies are seeing demands from customers for higher quality and cleaner electricity [1]. Also, considering the worlds coal stocks are reducing and the creation of legislation which is pushing for greener energy solutions [2], we are led to seek new energy generation methods. One solution which is currently attracting attention are micro-grid systems. Micro-grid systems are comprised of several alternative energy sources. They can include solar cells, wind turbines, micro-turbines (natural gas), fuel cells and storage batteries [3]. They are connected in addition to the main power grid and are placed on the site that is to use the system. That is it is connected to the low voltage distribution network through power electronics. There are several reasons why micro-grids are so interesting [4]. In the last few years, energy consumption and prices have hit their highest record since the last energy crisis in the late 1970s. Besides energy prices, strong environmental campaigns to reduce global warming have enhanced the interest in renewable green energy power generation. Solar, wind power and hydrogen as a power carrier are the most attractive green sources of renewable energy [5]. The European Photovoltaic Industry Association (EPIA) estimated that electricity produced by PV will cover about 12% of electricity demand generated in Europe by 2020 [6]. The focus in this paper will be on the photovoltaics type. Detailed descriptions of the different technologies, physics and basics of PV can be found in many textbooks and papers such as [4-7]. Kurtz [8] pointed out that ten years ago the concentrator cell was only ~30% efficient compared with more than 40% today with the potential to approach 50% in the coming years. Si cells have efficiencies of 26% and multi-junction compound cells have efficiencies above 45% (48% in the laboratory) as pointed out in reference [9]. PV modules produce outputs that are determined mainly by the level of incident radiation. As the light intensity increases, photocurrent will be increased and the open-circuit voltage will be reduced [10]. The efficiency of any photovoltaic cell decreases with the increasing temperature which is non-uniformly distributed across the cell [11]. The solar output power can be smoothed by the distribution of solar power in different geographical areas [12-13]. The global penetration of renewable energy in power systems is increasing rapidly especially for solar photovoltaic (PV) and wind systems. The renewable energy counted for around 19% of the final energy consumption worldwide in 2012 and continued to rise during the year 2013 as per 2014 renewable global status report [14]. In this paper, power generation by hybrid technique is proposed using PV cell and wind generation system with MPPT and is validated using MATLAB-Simulink

II. PHOTOVOLTAIC CELL (PV):

When sunlight hits a PV cell, the photons of the absorbed sunlight dislodge the electrons from the atoms of the cell. The free electrons are forced to move through the cell, creating and filling in holes in the cell. It is this movement of electrons and holes that generates electricity. The conversion process of sunlight into electricity is known as the photovoltaic effect. A simple solar cell consist of solid state p-n junction fabricated from a semiconductor. material (usually silicon).In dark, the *IV* characteristic of a solar cell has an exponential characteristic similar to that of a diode. The schematic arrangement of PV system is shown in fig .1.

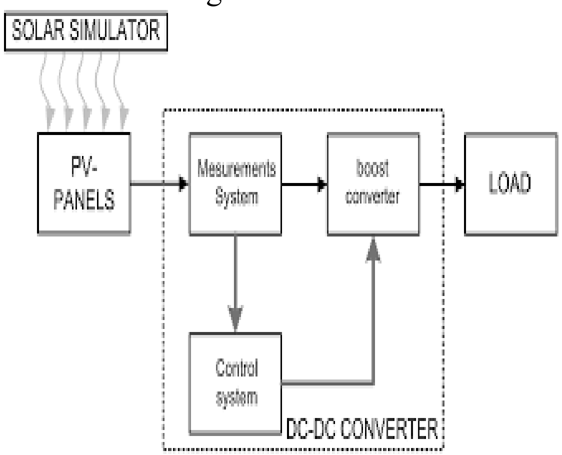

Fig.1 Power generation by photovoltaic cell

However, when the solar energy (photons) hits on the solar cell, energy greater than the band gap energy of the semiconductor, and release electrons from the atoms in the semiconductor material, creating electron-hole pairs. simplest equivalent circuit of a solar cell is a current source in parallel with a diode. The output of the current source is directly proportional to the solar energy (photons) that hits on the solar cell. During darkness, the solar cell is not an active device; it works as a diode, i.e. a p-n junction. It produces neither a current nor a voltage.

III. WIND ENERGY:

For the conversion of energy associated with the wind power to electricity, wind turbines are used which generally of the shown structure. The kinetic energy which is present in the wind can be converted into rotational energy by using wind turbines. The mechanical output which is obtained from the turbine is converted to electrical energy by the wind generator. The range of available wind turbine system is from 600KW to 5MW. The generated energy from the wind turbine depends upon wind velocity which is acting on turbine.

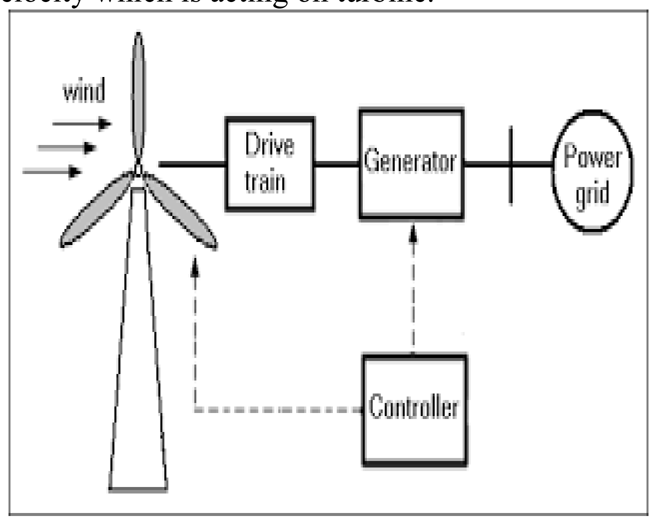

Fig.2 Power generation by wind energy

The wind power is the best means to generate the electrical power in rural areas in order to meet the energy demand. Based on their physical construction such as dimensions, no of blades, axes, power generated wind turbines are classified. For example: based upon the axes structure horizontal and vertical plane turbines. Classification based on number of blades: single blade, two blade and three blade turbine. Classification based on power generation capacity: small power system, moderate power system and big power system. The power output of wind turbine is relating to wind speed with a cubic ratio. Both the first order moment of inertia (J) and a friction based dynamic model for the wind turbine rotor, and a first order model for the permanent magnet generator are adopted. The dynamics of the wind turbine due to its rotor inertia and generator are added by considering the wind turbine response as a second order slightly under-damped system.

IV. PERMANENT MAGNET SYNCHRONOUS GENERATOR:

The dynamic modeling of permanent magnet synchronous generator in d-q axis frame is presented in Fig.1. The following equations are used to express the model of the PMSG as:

The dynamic model of PMSG without damper winding has been developed on rotor reference frame using the following assumptions:

1. Saturation is neglected.
2. The prompted EMF is sinusoidal.
3. Eddy currents and hysteresis losses are negligible.
4. The field current dynamics are neglected.

The d-q model has been developed on rotor reference frame as shown in Fig.3.

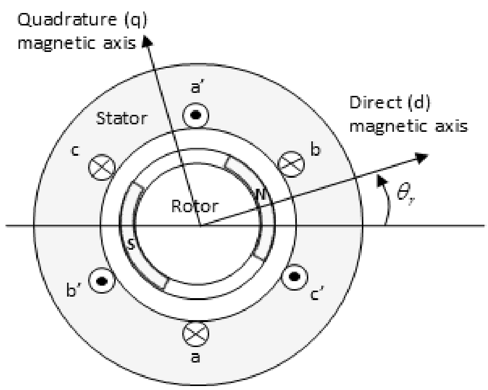

Fig.3. D-Q model of Permanent magnet synchronous motor

The voltage equations of the PMSG with reference to rotor reference frame is

$$Vq = R_s i_q + \omega_r \lambda_d + \rho\lambda_q \quad (1)$$

$$Vd = R_s i_d - \omega_r \lambda_q + \rho\lambda_d \quad (2)$$

The flux Linkages equations are given by

$$\lambda_q = L_q i_q \quad (3)$$

$$\lambda_d = L_d i_d + \lambda_f \quad (4)$$

Substituting equqations3 and 4 in 1 and 2 we have the voltage equations as,

$$Vq = R_s i_q + \omega_r (L_d i_d + \lambda_f) + \rho L_q i_q \quad (5)$$

$$Vd = R_s i_d - \omega_r L_q i_q + \rho L_d i_d + \lambda_f \quad (6)$$

The voltage equations are represented in matrix form as

$$\begin{bmatrix} V_q \\ V_d \end{bmatrix} = \begin{bmatrix} R_s + \rho L_q & \omega_r L i_d \\ -\omega_r L_q & R_s + \rho L_d \end{bmatrix} \begin{bmatrix} i_q \\ i_q \end{bmatrix} + \begin{bmatrix} \omega_r \lambda_f \\ \rho\lambda_f \end{bmatrix} \quad (7)$$

The developed torque of PMSM is being given by

$$T_e = \frac{3}{2}\left(\frac{P}{2}\right)\left(\lambda_d i_q - \lambda_q i_d\right) \quad (8)$$

The mechanical Torque equation is

$$T_e = T_L + B\omega_m + J\frac{d\omega_m}{dt} \quad (9)$$

The rotor mechanical speed form from above equation is

$$\omega_m = \int\left(\frac{T_e - T_L - B\omega_m}{J}\right)dt \quad (10)$$

$$\omega_m = \omega_r\left(\frac{2}{P}\right) \quad (11)$$

Where ω_r -is the rotor electrical speed.

ω_m -is the rotor mechanical speed

V. PROPOSED HYBRID POWER SYSTEM USING MPPT:

The proposed system presents power-control strategies of a grid-connected hybrid generation system with versatile power transfer.

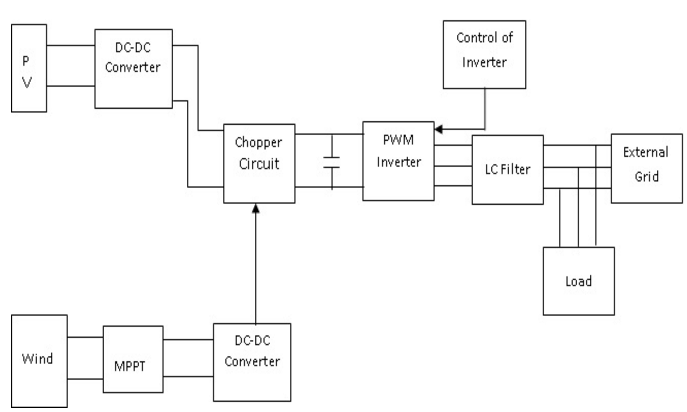

Fig.4 Proposed Hybrid grid based on PV Cell and Wind power system

This hybrid system allows maximum utilization of freely available renewable energy sources like wind and photovoltaic energies. To realize the corresponding concept, an adaptive MPPT algorithm along with standard perturbs and observes method will be used for the system. Also, this configuration allows the two sources to supply the load separately or simultaneously depending on the availability of the energy sources. The turbine rotor speed is the main determinant of mechanical output from wind energy and Solar cell operating voltage in the case of output power from solar energy. Permanent Magnet Synchronous Generator is coupled with wind turbine for attaining wind energy conversion system. The inverter converts the DC output from non-conventional energy into useful AC power for the connected load. This hybrid system operates under normal conditions which include normal room temperature in the case of solar energy and normal wind speed at plain area in the case of wind energy.

VI. SIMULATION RESULTS:

Simulation results with step changes in load demand, wind speed, and ambient temperature are analyzed. The initial wind speed is 10 m/s. Wind speed increases, at t=10s, from 10 to 12 m/s and decreases to 8 m/s at t=16s. The solar cell initially supplies power at the irradiation 400W/m2 and temperature 25°. The power tracking performance of the hybrid topology with respect to load demand change and environmental variations controlled by MPPT system.

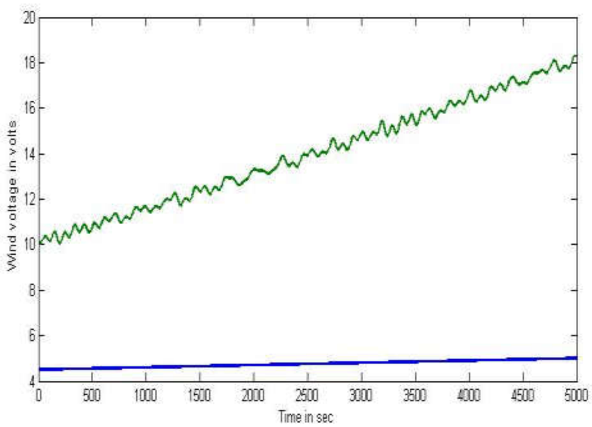

Fig.5 Voltage induced across wind source

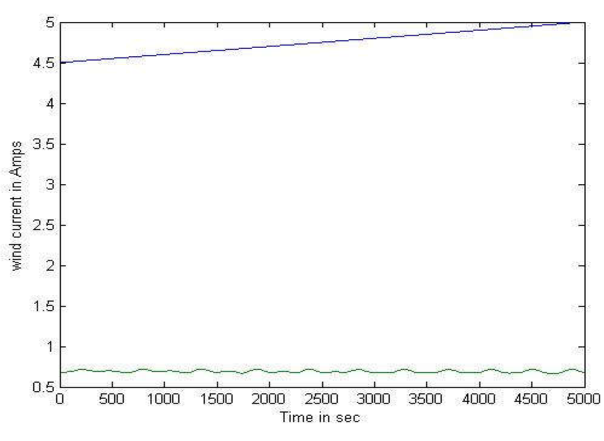

Fig.6 Currents induced by wind source

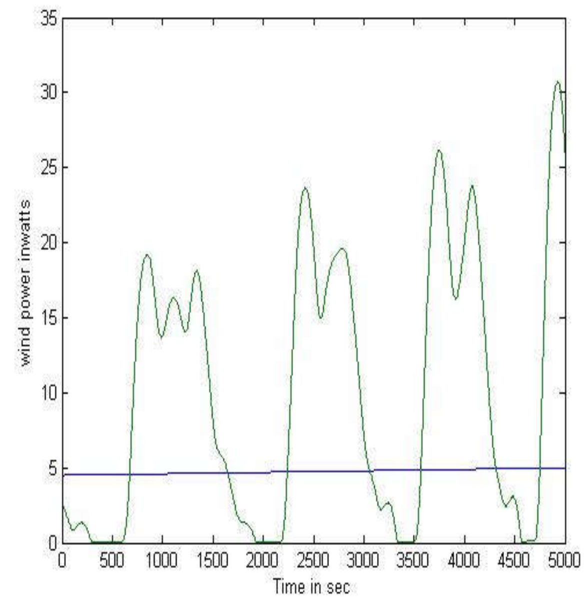

Fig 7 Power generated by the wind source

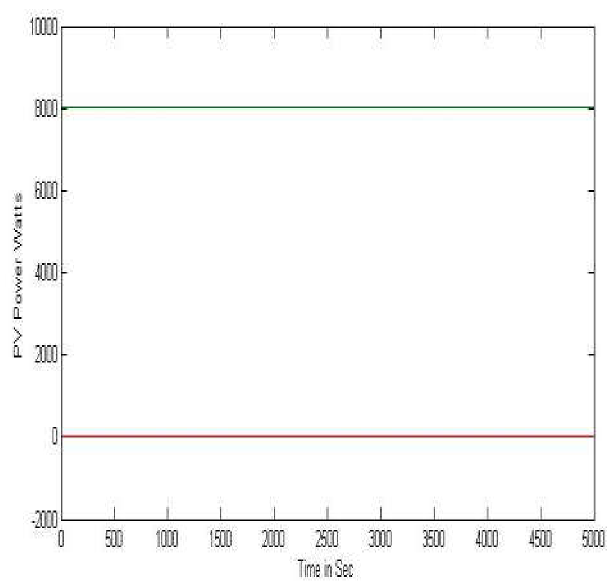

Fig 8 Power generated by the PV Cells

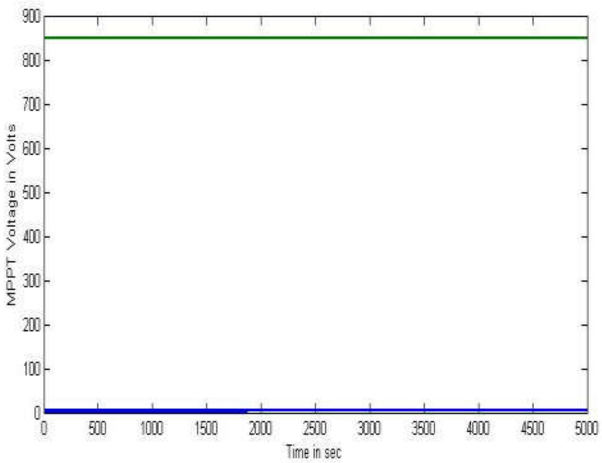

Fig.9 MPPT voltage of the proposed hybrid power generation system

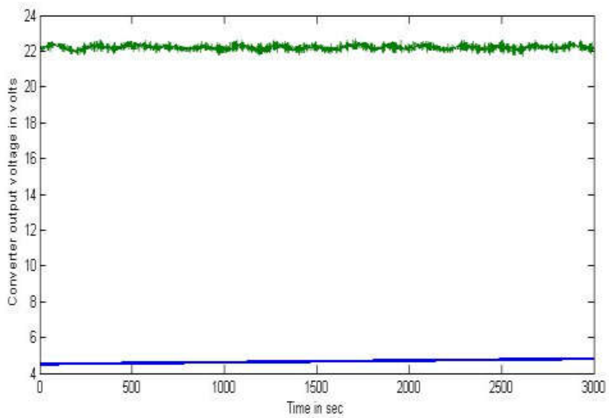

Fig.10 DC Converter voltage of the proposed hybrid power generation system

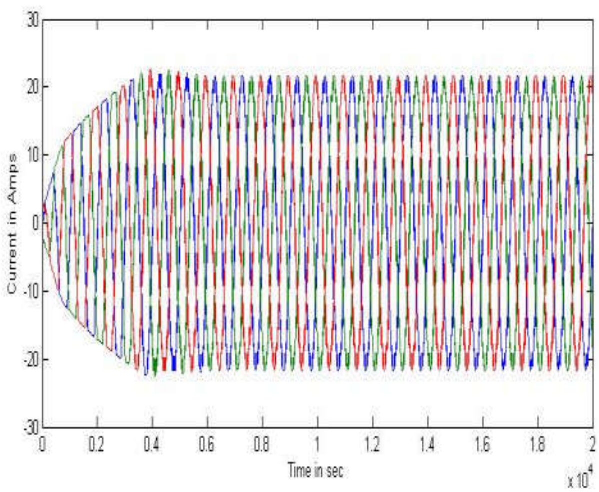

Fig.11 Output currents of the proposed hybrid power generation system

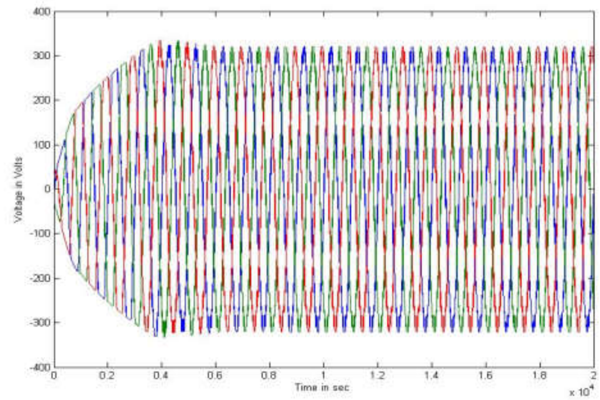

Fig.12 Output Voltages of the proposed hybrid power generation system

VII. CONCLUSION:

The modeling of hybrid grid using Wind and PV cell for power system configuration is done in MATLAB/SIMULINK environment. The present work mainly includes the grid tied mode of operation of hybrid system. The model is developed to maintain stable system under various loads and resource conditions. The simulation result shows that, it is possible to have a good response of grid-connected hybrid energy system. The hybrid grid can provide a reliable, high quality and more efficient power to consumer. The hybrid grid may be feasible for small isolated industrial plants with both PV systems and wind turbine generator as the major power supply.

VIII. REFERENCES:

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