Performance Analysis of Grid Connected Hybrid Wind/PV System

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Abstract - *Renewable Energy Resources are best today to stand against increasingly risk global warming and reduce the use of conventional energy sources the most important sources of such types of resources are Wind and Solar energies which are most the efficient relatively. In wind energy conversion system two masse drive train based wind turbine with zero pitch angles drives Doubly Fed Induction Generator (DFIG). The combined output of WIND/PV is converted into AC by using Synchronous Reference Frame Theory (d-q theory). A model of hybrid wind and photovoltaic system is developed in MATLAB simulation.*

Key Words: **PV System, DFIG, Wind System, WECS, Hybrid Solar and Wind, Photovoltaic System**

1. INTRODUCTION

The increasing demand for conventional energy sources like coal, natural gas and oil is increased the pollution and reduction in its quantity the use of renewable energy sources like wind, solar etc. are now well developed and cost effectively reduced and largely used and it is also eco-friendly. Hybrid energy system means combination of two or more renewable energy sources like wind, solar etc. These hybrid systems can be standalone or can be grid connected. Hybrid system is more reliable because if there is any shortage of power or fault in the renewable energy sources then the loads are directly connected to the grid. The solar energy and wind energy that are used as a input sources of hybrid wind and PV system [1] . A solar system is one which utilizes solar radiation to generate electrical energy. PV cell is generally made from semiconductor material like silicon and can produce direct current from sunlight. The best silicon cell available have an efficiency of about 18%. Wind Power system is a system which converts kinetic energy of air into electrical energy. Wind power is one of the fastest growing renewable energy resources in last few years but individual energy resources either wind or solar may not be effective in terms of cost, efficiency and reliability because it is highly in irregular in nature. So hybrid wind and PV is best suitable for high reliability of power supply.

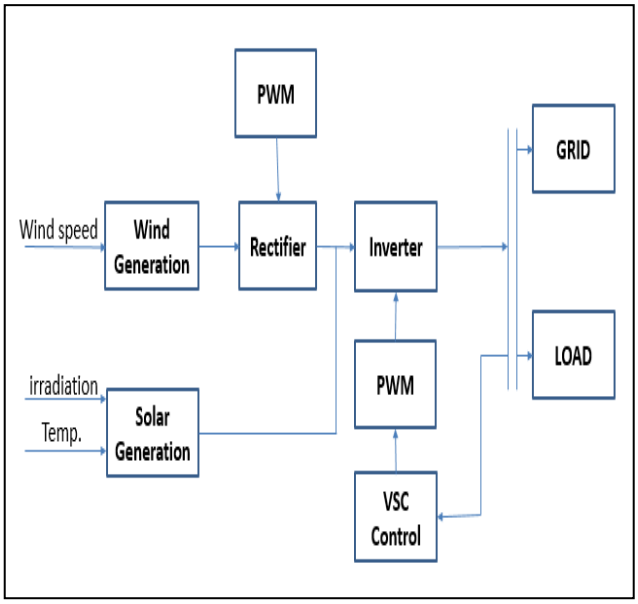

Fig. 1: Schematic diagram of proposed system

In wind and solar hybrid Power system the collective power generated by wind mill and solar energy panel. For the storage of energy generated by hybrid system a battery is used. In this system power is generated by PV module when light radiation available and from windmill when wind source is available.

2. PHOTOVOLTAIC SYSTEMS

Solar cell is a basically p-n junction diode fabricated in a thin layer of semiconductor i.e. silicone. The solar cell converts the electromagnetic radiation of solar energy into electricity through photovoltaic effect. When solar cell exposed to the sunlight, photons with energy greater than the band-gap energy of the semiconductor are absorbed and create some electron-hole pairs which is proportional to the incident irradiation. As the irradiation level is increased the output current of the PV cell also increased. For making the simulation modal of the PV cell we required its equivalent circuit.

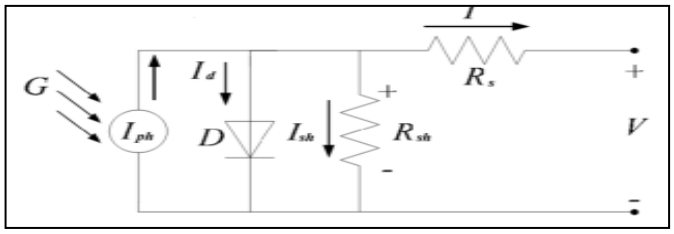

Fig -1: Equivalent circuit of PV cell

Basically an equivalent circuit of a solar cell is a current source in parallel with a diode and resistor. The output of the current source is directly proportional to the solar radiations that hits on the solar cell. During night, the solar cell is not an active device; it works as a passive device i.e. diode, i.e. a p-n junction [2].

1. Thermal voltage equation, $V_t = \frac{k\,Top}{q}$ (2.1)

2. Open circuit voltage, $V_{oc} = V_t \ln(\frac{Iph}{Is})$ (2.2)

3. Diode Current, $I_d = [e^{\frac{(V+I\,Rs)}{(n\,VtCNs)}} - 1]\, I_s\, N_p$ (2.3)

4. Diode Current, $I_d = [e^{\frac{(V+I\,Rs)}{(n\,VtCNs)}} - 1]\, I_s\, N_s$ (2.4)

5. Saturation Current, $I_s = I_{rs}(\frac{Top}{Tref})^3 e^{[\frac{q\,Eg}{n\,k}(\frac{1}{Top}-\frac{1}{Tref})]}$ (2.5)

6. Reverse Saturation Current, $I_{rs} = \frac{Isc}{[e^{(\frac{Voc\,q}{k\,c\,Top\,n})}-1]}$ (2.6)

7. Shunt Current, $I_{sh} = \frac{V+I\,Rs}{Rp}$ (2.7)

8. Phase Current, $I_{ph} = G_k\,[I_{sc} + K_i\,(T_{op} - T_{ref})\,]$ (2.8)

9. Load Current, $I = I_{ph}\,N_p - I_d - I_{sh}$ (2.9)

Now the load current of the PV cell as we get above is generated using MATLAB environment. All the above equations are performed in MATLAB and we get the load current and the output voltage.

2.1 Rating of PV Generation

Table -1: Rating of PV generation

1 module	36cell connected in series
Power of 1 Module	60W
Voltage of 1 Module	21 V
No. of module connected in series	12
No. of modul connected In Parallel	2
Total O/P Voltage	250V
Total O/P Power	1500 W

3. WIND TURBINE SYSTEM

Because of the differential solar heating of the earth's surface the movement of air masses produces it causes wind is also produced. The strength and direction of the wind decide by Seasonal variations in the energy received from the sun. The fundamental equations governing the mechanical power capture of the wind turbine rotor blades, which drive the electrical generator, are given by;

$$P_{wind} = 0.5 C_p * A_p * V^3 \quad (3.1)$$

Where,

ρ: Air density (kg/m3)

A: Area swept by the rotor blades

V: Velocity of air (m/sec),

C_p: Power coefficient of the wind turbine

The amount of aerodynamic torque T_w in N-m is given by the ratio between the power extracted from the wind and the turbine rotor speed W_w in rad/s, as follows;

$$Tw = P_w / W_w \quad (3.2)$$

3.1 DFIG Wind Turbine

Wind turbines use a doubly-fed induction generator (DFIG) consisting of an AC-DC-AC IGBT-based PWM converter and a wound rotor induction generator. The rotor is fed at variable frequency through the AC-DC-AC converter while the stator winding is connected directly to the 50 Hz grid [3]. The DFIG turbine technology allows extracting maximum energy from the wind for low wind speeds by optimizing the turbine speed, while during gusts of wind it minimizing mechanical stresses on the turbine.

Table -2: Rating of Wind Turbine

Power Output	1500 W
Rated Wind Speed	15 m/s
Blade Pitch Angle	0 degree
Air Density	1.225 kg/m3
Output Voltage	400 V

This wind turbine output is 3-phase AC power is again converted into the DC power using the 3-phase bridge rectifier. The bridge rectifier output and solar output is combined and given to the universal bridge inverter that will give the 3-phase AC power which is connected to the grid.

3.2 Simulation of Wind Turbine

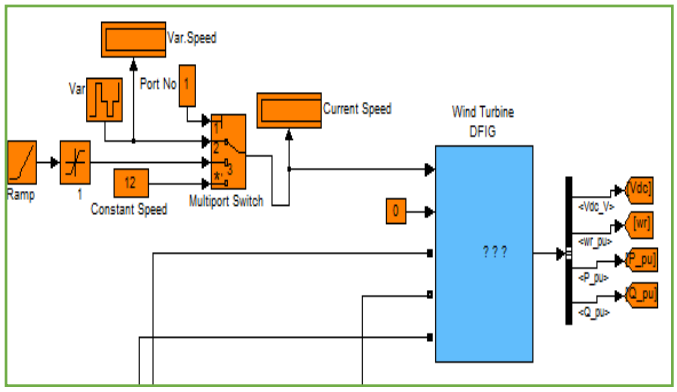

Fig -2: Simulation of Wind Turbine

This is the simulation model which I have done in MATLAB hear I used the wind turbine which output is given to the 3 phase universal bridge. Now the output of the bridge we can see from the scope which is connected to the bridge.

4. SIMULATION AND RESULTS

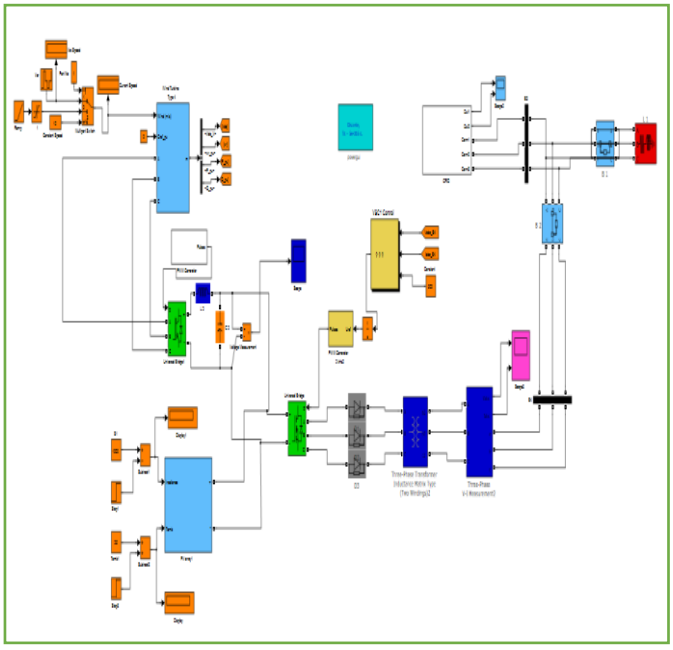

Fig -3: Simulation of Hybrid Wind/PV System

As shown in the simulation model Wind and Solar hybrid Power system is the collective power generating system by wind mill and solar energy panel. For different wind speed and solar irradiation the output of the universal bridge inverter according to that we have to change. This system achieve by changing the gate pulses which are given to the universal bridge inverter. The output of the universal bridge inverter is directly connected to the grid and the load .

4.1 Results

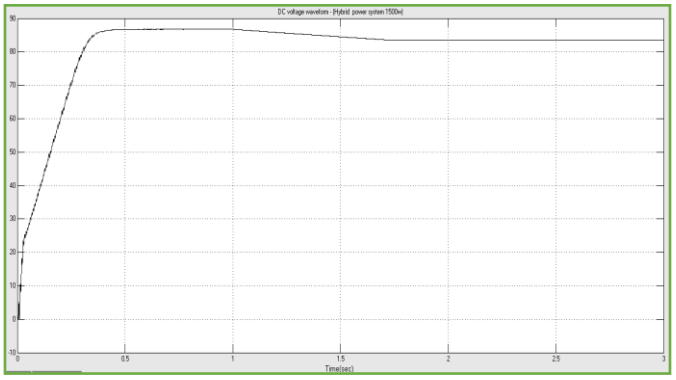

Fig -4: DC Output voltage Waveform of Hybrid System

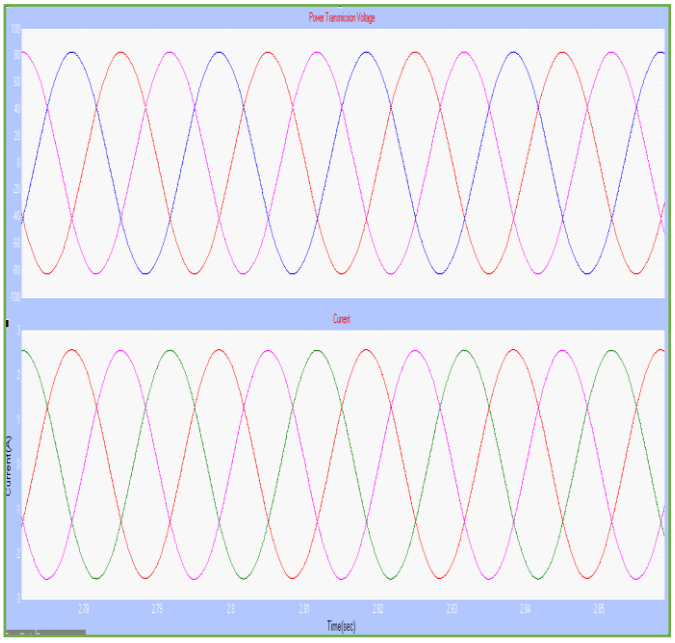

Fig -5: Waveform of Output Voltage and Current at grid side

5. CONCLUSION

This paper presented the modeling, simulation and Control of a grid connected PV and Wind Hybrid Power System which is simulated in Matlab/Simulink environment. It is observed that the maximum power from PV array it extracted using MPPT system. In Wind Energy Conversion system DFIG based wind turbine used. The combination of PV and Wind is given to the grid after converting to AC by the help of PWM,VSC controller and Universal bridge inverter.

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