Hybrid Analysis of Wind Power System and PV Array

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Abstract*-Renewable energy from wind turbine and solar photovoltaic are the most environment-friendly type of energy to use. Hybrid energy systems with renewable generation are built in many remote areas where the renewable resources are abundant and the environment is clean. Hybrid energy system is the integration of wind, solar, hydro etc different renewable energy sources to that of existing transmission distribution system. This paper deals with the modeling and simulation of a grid connected PV Wind Hybrid Power System. Both the systems are connected parallel and then connected to the grid. The output of PV and wind after combining is given to the inverter. The main problems of hybrid system are involved with stability and power quality. For these problems improvement inverter's gate pulse is controlled. The harmonic analysis of grid voltage and current is done and THD is obtained. Nowadays hybrid power systems are increasingly used.*

Keywords*-*PV, Wind, Inverter, Converters, PWM, Hybrid energy system, Solar system, Diesel Generator

I. INTRODUCTION

Renewable energy resources are the primary contributor to attain sustainable energy production. The increasing demand for conventional energy sources like coal, natural gas and oil is forcing people towards the research and development of renewable energy sources or non-conventional energy sources. Many renewable energy sources like wind, solar etc are now well developed, cost effective and largely used. These energy sources are environment friendly. Hybrid energy system is the combination of two or more renewable energy sources like wind, solar, hydro etc . These provide a clean and ecofriendly energy. These hybrid systems can be standalone or can be grid connected. The grid connected hybrid system are more reliable to deliver continuous power to the grid 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 hybrid power system consist of two Renewable energy sources which are solar energy and wind energy that are used as a input sources. A wind turbine converts mechanical energy into electrical energy and it produces ac output voltage and this ac output voltage is converted to dc by the help of ac to dc converter or rectifier. A PV cell converts the light energy into electrical energy and produces dc output voltage. Also a diesel generator system is connected as a conventional source of energy. The reliability to deliver continuous supply to load is more for grid connected hybrid wind and PV system. If there occurs any problem with the energy sources then the loads are connected to the grid.

The scope of this paper is to model a grid connected hybrid power system together with combining a diesel generator. In this model, outputs of these two sources are determined. The input for these two sources are solar radiation and wind speed. The modeling of both PV system and wind is done. The analysis of the output of system is made.

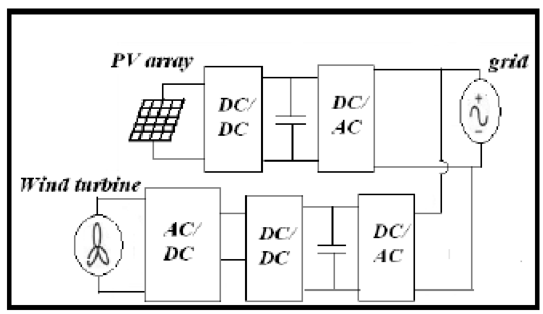

Fig-1: Block diagram of grid-connected hybrid PV/wind energy system

II. MODELING OF POWER SOURCES

2.1 Modeling of Solar PV System

PV cell are made up of semiconductor materials, which are treated so as to form an electric field, with positive and negative side. The model of a PV cell can be represented by a current source in parallel with a diode. The current source represents the current generated by photons (Iph or IL). The output is constant under constant incident radiations of light and under constant temperature. Rs and Rsh are the series and shunt resistance of the circuit. Rs consists of the contact resistance of the cables as well as the resistance of semiconductor itself. Parallel or shunt resistance Rp includes leakage currents at the photovoltaic cell edges. This is usually in the range of kΩ and so they have almost no effect on the current-voltage characteristics. The diode determines the current voltage characteristic of the cell. The output of the current source is directly proportional to the light falling on the cell.

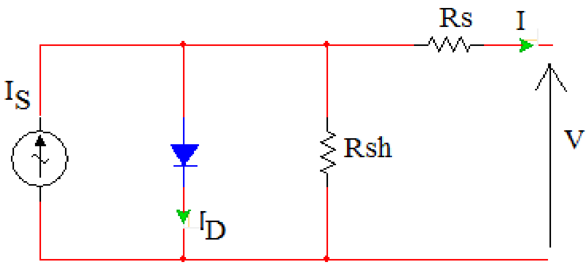

Fig-2: PV cell equivalent circuit

The current through diode and solar cell output current is given by,

$$I_D = I\left(e^{\frac{q(V+IR_s)}{kT}} - 1\right)$$

$$I = I_L - I_D - I_{sh}$$

$$I = I_L - I\left(e^{\frac{q(V+IR_s)}{kT}} - 1\right) - \frac{V + IR_s}{R_{sh}}$$

Where:
I: Solar cell current (A)
Ish: Light generated current (A) [Short circuit value assuming no series/ shunt resistance]
ID: Diode saturation current (A)
q: Electron charge (1.6×10-19 C)
k: Boltzman constant (1.38×10-23 J/K)
T: Cell temperature in Kelvin (K)
V: solar cell output voltage (V)
Rs: Solar cell series resistance (Ω)
Rsh: Solar cell shunt resistance (Ω)

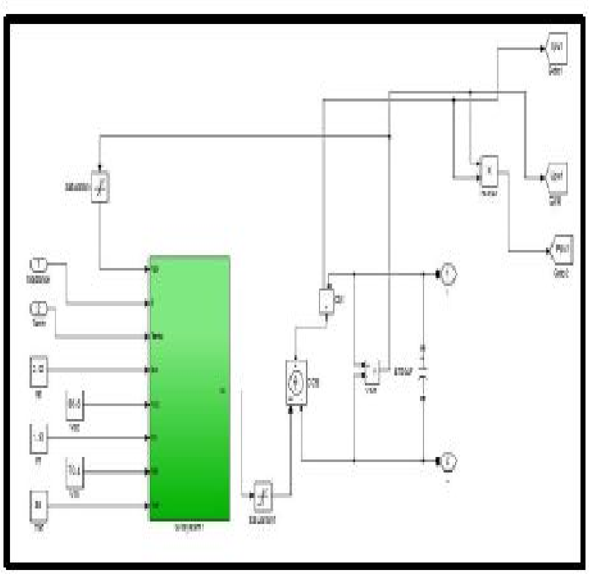

Fig-3: Simulink Model of PV system

Table 1: Parameters of PV system at 25^o C, 1000W\m^2

PARAMETER	RATING
Imp	1.89 A
Vmp	70.0 V
Isc	2.01 A
Voc	86.7 V
Rs	0.56 Ω
Ki	0.00279 A/K
Ns	34

2.2 Modeling of Wind Energy Conversion system

Wind energy system converts the kinetic energy of wind into the form of electrical energy. The kinetic energy of air of mass (m) moving at speed (v) can be expressed by the equation,

$$E = \frac{1}{2} m v^2$$
$$m = \rho A v t$$

The power of wind is given by,

$$P_w = \frac{1}{2} \rho A v^3$$

The specific power or power density of a wind is given by,

$$P_{den} = \frac{1}{2} \rho v^3$$

Where, ρ: Air density.

A: Rotor swept area.

d: Distance (m).

m: mass of air =air density*volume

= ρ*A*d.

v: Distance/time (m/s).

The actual power extracted by rotor blades from wind is the difference between the upstream wind power and downstream wind powers,

$$P_w = \frac{1}{2} * K_m (V^2 - V_0^{\ 2})$$

Where V is the upstream wind velocity at the entrance of the rotor blades, V0 is the downstream wind velocity at the exit of the rotor blades. Km is the mass flow rate, which can be expressed as,

$$K_m = \rho A \frac{v+v_0}{2}$$

$$P = \frac{1}{2}[\rho A \frac{v+v_0}{2}](v^2 - v_0^2)$$

Let,

$$C_p = \frac{1}{2}(1+\frac{v_0}{v})[1-(1-\frac{v_0}{v})^2]$$

Where Cp is the power coefficient

$$P_m = .5\rho A C_p(\lambda, \beta) v^3$$

Where, λ is the tip speed ratio and β is the pitch angle

$$T_m = \frac{P_m}{\omega_r}$$

Table 2: Parameters of wind Turbine mode

PARAMETER	RATING
Rated Power	200 KW
Rated Wind Speed	15 m/s
Blade Radius	2.5 m
Blade Pitch Angle	0 Degree
Air density	1.225 Kg/m³
Rated rotor speed	21.03 rad/s

In order to get maximum power from the wind turbine the pitch angle is made equal to zero degrees.

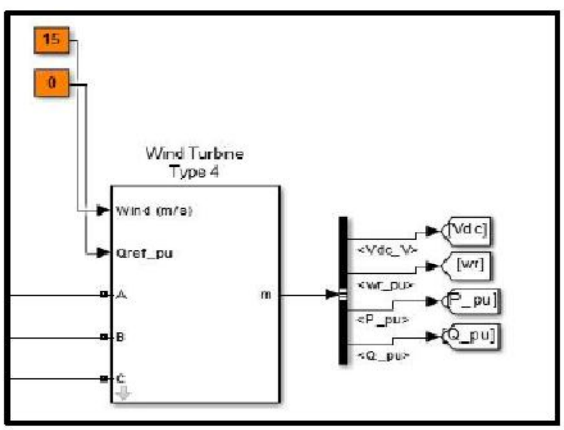

Fig-4: Simulink model of Wind Turbine

2.3 Modeling of Diesel generator system

The basic components of diesel generation system are excitation, governor and synchronous generator. A governor can be defined as the mechanical or electromechanical device for automatically controlling the speed of an engine. A diesel generator set coverts the fuel energy into mechanical energy in diesel engine and then converts the mechanical energy into electrical energy.

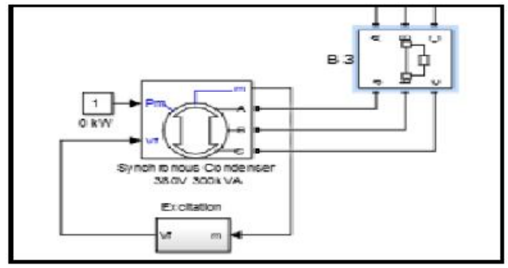

Fig-5: Basic model of diesel generator set

III.SIMULATION RESULT OF HYBRID POWER SYSTEM

For the simulation, solar irradiance and wind speed are used. The data is the input of PV and Wind energy system. The waveforms of the PV and Wind energy generation system are shown and also the waveform of grid voltage and current is obtained. The Fourier transfer analysis of grid voltage and current is done and the harmonics is calculated of both the grid voltage and current.

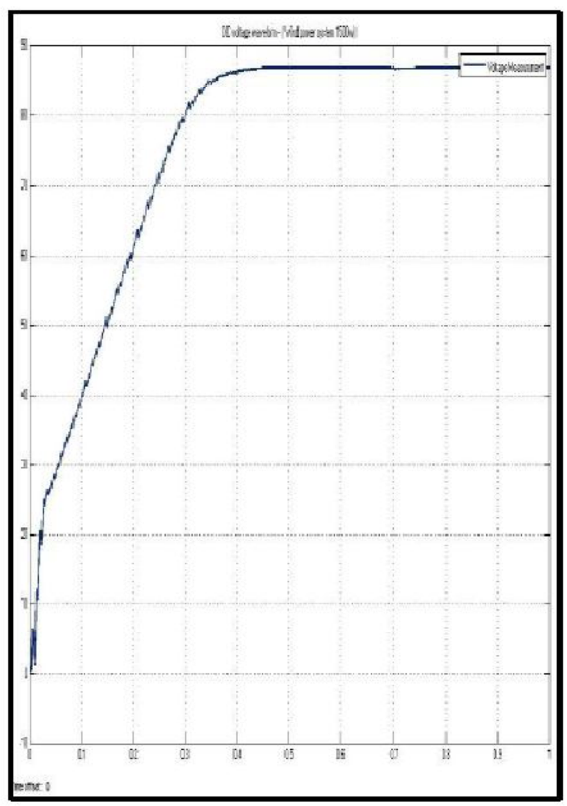

Fig-7: DC Voltage of wind turbine

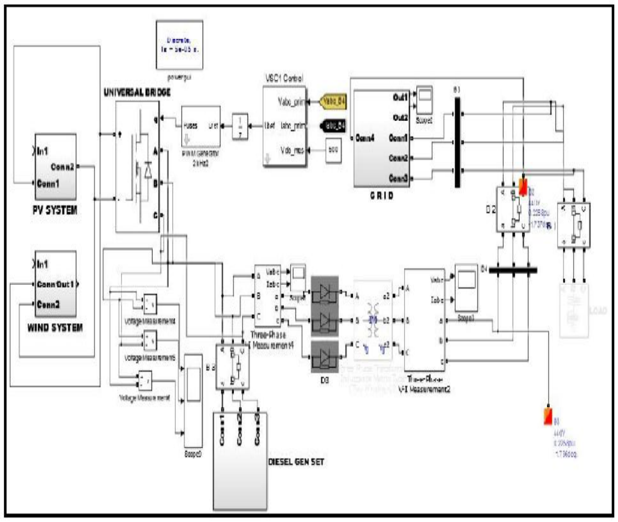

Fig-8: Simulation model of wind PV hybrid power system

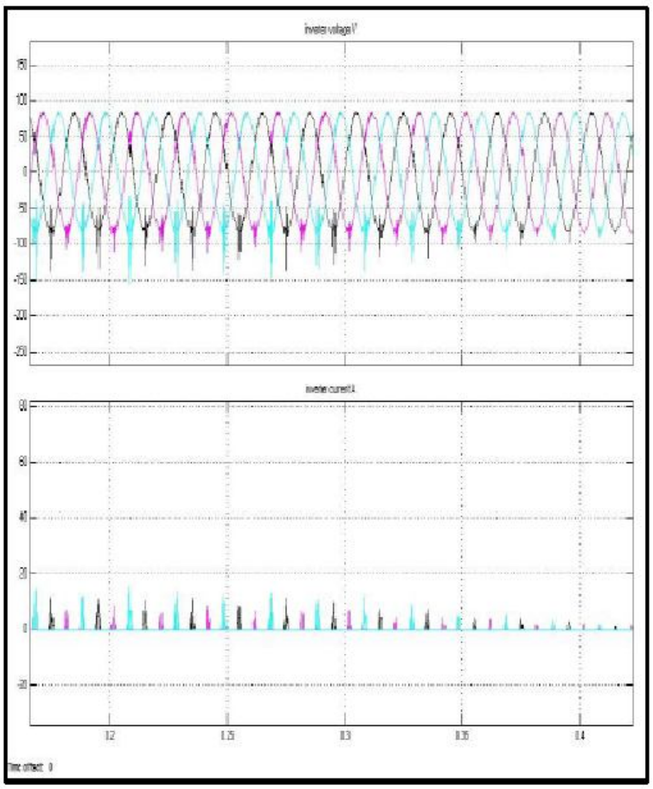

Fig-9: Invertor voltage and current

IV. CONCLUSION

This paper presented the modeling and simulation of a grid connected PV Wind Hybrid Power System. The system is simulated in Matlab/ Simulink. The PV output and the wind output after converting to dc by the help of rectifier is given to the inverter. And then the combination of PV and Wind is given to the grid. The harmonic analysis of the grid voltage and current performed and the THD is obtained which comes out to be 1.63%.

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