Design of Wind-Photovoltaic Energy System

Namrata Singh[1], Sanjay Singh[2]
[1]Electronics, Design & Technology, NIELIT, Gorakhpur
[2] Electronics, Design & Technology, NIELIT, Gorakhpur

ABSTRACT
The pollution free, environment friendly energy solutions are being very popular. This paper presents such an energy system which is able to fulfill above mentioned requirements and at the same time it comprises of a combination of a wind energy system and a photovoltaic energy system. This system allows the two sources to supply energy to the load either separately or simultaneously. In this way, a constant dc supply is made to inverter and hence to the load side also. FFT analysis has been performed to get the THD percentage in the output of the system.

Keywords *– Photovoltaic Energy System, PV output, wind energy system, wind output, THD.*

I. INTRODUCTION
All around the world, we are watching the energy crisis. Supply side of power is unable to fulfill demands. There is a limited quantity of conventional energy on the earth. Fossil fuels are getting depleted day by day. To fulfill energy requirements and to fill the gap between supply and demands, we are moving towards non-conventional energy resources. These non- conventional energy resources are renewable and pollution free too. The non-conventional energy resources provide sustainable solution of energy crisis as well as prove to be savior of environment and the earth for upcoming generations. For non-conventional energy, we have options as geothermal energy, solar/photovoltaic energy, wind energy, ocean energy by tides and hydro power etc. Of all the above mentioned non- conventional energy resources, solar energy and wind energy are most promising after hydro power. Although, photovoltaic/solar energy and wind energy, both are alone sufficient to fulfill demands and also they are the best options in themselves. But, what we see in both of the cases, that they are very much dependent upon several factors. Power obtained from the sun depends upon weather, cloud, tree, taller buildings in cities, and also it is available during daytime only. At the same time, wind energy depends on blow of breeze or air. The nature of wind is very unpredictable, at one time it is present at one place and after moments, it gets disappeared from there and goes to some other place. The unavailability of both, the wind and solar or photovoltaic energy at all the times forces us to think upon solution with an idea that is collaboration of both the energies.

For photovoltaic/solar energy or wind energy systems, we can say that their installation cost is very high while the energy that they generate is not that much to make it worth economically [1]. To utilize the installation or investment cost, energy obtained from the system is needed to be improved. The power obtained from non-conventional energy systems are not fed directly to the load; rather they are firstly passed to a system which makes it compatible with load requirements.

II. PHOTOVOLTAIC ENERGY SYSTEM
The basic element of the photovoltaic system is photovoltaic cell. Photovoltaic cell or PV Cell is nothing but a pn junction device. Fig. 1 describes the structure and operation of PV Cell. Photovoltaic cell works on the principle of photovoltaic or photoconductive effect. Photoconductive effect says that when light falls on the junction of pn junction diode, a current flows in the diode. In a photovoltaic system, radiations from the sun are made to fall on the photovoltaic panel which is also called as solar panel. What we do basically in a photovoltaic panel, we connect various PV Cells in a defined pattern to form an array. These arrays of photovoltaic cells are again connected in a regular pattern to make a solar panel / photovoltaic panel [2].

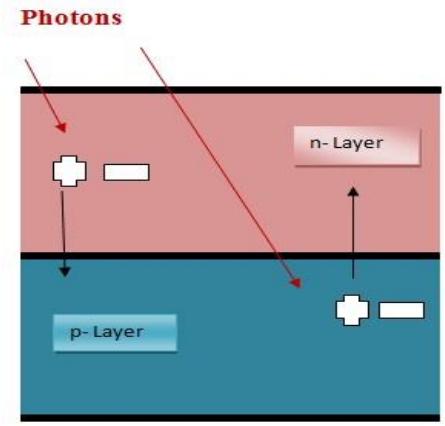

Fig. 1. Photovoltaic cell

III. WIND ENERGY SYSTEM

Wind is the motion of the gas molecules in the atmosphere. Wind power is one of the most reliable, pollution free, environment- friendly self renewing energy resource which would provide a continuing supply of non polluting energy. Wind energy is very unpredictable as its quantum may vary from time to time and is an intermittent and unpredictable resource. The wind power is proportional to the cube of wind velocity that is given in (m/hr) and to the area swept by the propeller given in (sq. ft.) For the amount of energy that we need to gain from wind depends on the most important factor which is the wind speed. For the turbine at different wind speeds, the power curve of a wind is a plot that indicates how much electrical power output will be obtained. A wind turbine is a machine that converts the kinetic energy of the wind motion to mechanical energy transmitted by the shaft attached to it. [3] A generator coupled to the shaft further converts this mechanical energy to electric energy, thereby generating electricity. We have a machine, named wind mill for wind energy conversion. Wind mills have the conventional gear box to boost up the rotational speed of the turbine that is of the order of 100 (RPM) to the speed of an electric generator of reasonable size of the order of nearly 3000 (RPM). There are two types of wind turbines: (i) the horizontal axis type, and (ii) the vertical axis type. The horizontal axis types are used mostly.

IV. MODELLING

Both the photovolaic system and wind energy syatems have been modeled separately. Then we have built another model which comprises of both photovoltaic and wind energy system and that is our proposed model.

Modeling Of Photovoltaic System

Depending on the working of photovoltaic cell, its equivalent circuit can be drawn as shown in fig. 2. Here I_{ph} is photon current i.e. light generated current, R_{sh} is shunt resistance responsible for (i) Non-ideal nature of the Cell, (ii) Presence of impurities in the cell, (iii) It provides short-circuit path near the junction and R_s is the series resistance that comes into effect due to resistance offered by semiconductor material and metallic contacts present in the cell [2]. Ideally series resistance i.e. R_s is zero and shunt resistance i.e. R_{sh} is infinite. If we want to keep our model for PV Cell as simple as possible, we can neglect the effect of shunt resistance i.e. R_{sh} and thus the last term from the equation will be omitted.

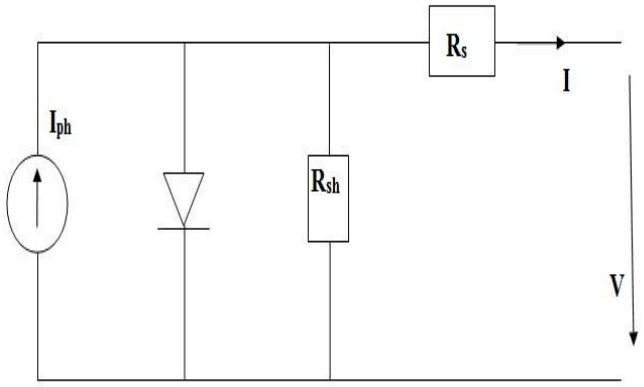

Fig. 2. Equivalent circuit of photovoltaic cell

The diode in the equivalent circuit of the photovoltaic cell is the one which determines the current voltage characteristic of the cell. The output of the photovoltaic current source is directly proportional to the light radiations falling on the cell. The open circuit voltage increases logarithmically according to the Shockley equation which describes the interdependence of short circuit current and open circuit voltage in the photovoltaic cell.

$$I = I_L - I_O \exp\left(q(V-IR_S)/AkT - 1\right); \qquad \text{(i)}$$

Where I_o = dark saturation current,
I = output current of PV Cell,
V = output voltage of PV Cell,
k = Boltzmann constant
A= diode quality factor
T = absolute temperature
R_s = series resistance
R_{sh} = shunt resistance

From Equation (i), we got the link to create simulink model of photovoltaic cell in the matlab environment.

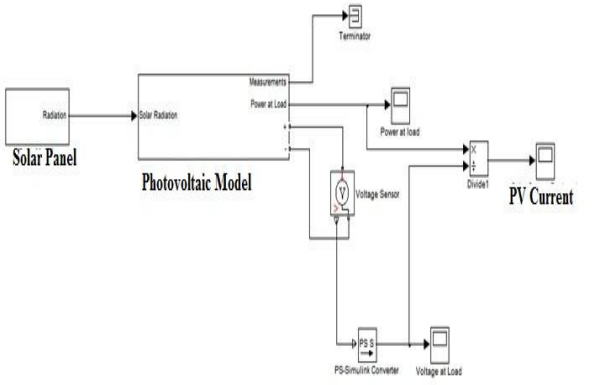

Fig. 3. Simulink library PV model

The photovoltaic system consists of basically three blocks (i) solar panel block, (ii) PV model block, and (iii) power conditioning unit block. The solar panel block is modelled for solar radiations. The matlab simulink library contains many such characteristics for different solar radiations.the photovoltaic model block is created by studying the equivalent model of photovoltaic cell. The photovoltaic model is given in next fig.4. Different matlab simulink library features have helped in creating this PV module.

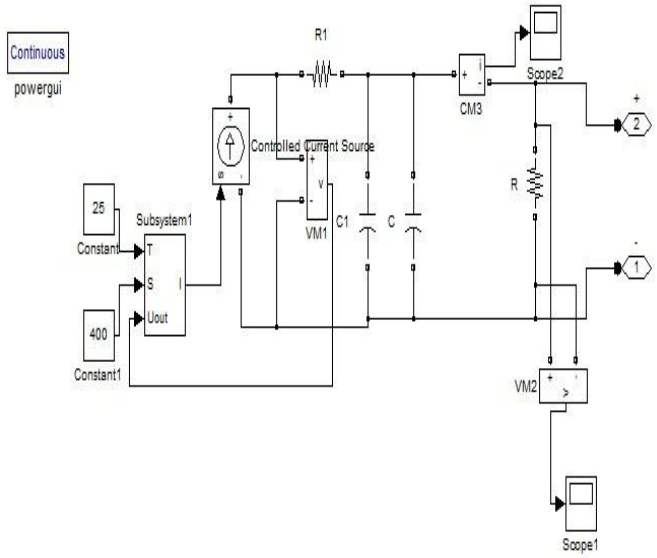

Fig. 4. Simulink implementation of Photovoltaic module

Modeling Of Wind Energy System

This simulation model of wind generator having subsystem block three phase transformer to connect with PMDC generator supply to generator to control the rotor speed and measure electromagnetic torque, various parameter can be measure output power connected to the rectifier.

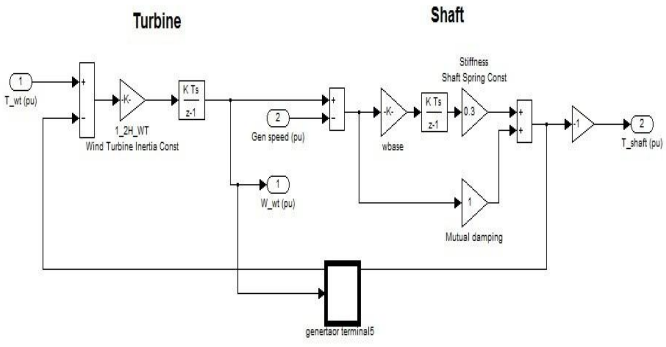

Fig. 5. Simulink implementation of wind module

Power from the wind turbine, real and reactive power, is basically controlled by the wind-side Converter and stalled by the wind blade [4]. Below rated wind speeds, the real power from the wind Generator is regulated to capture the maximum wind energy from varying wind speed. Reactive power generation is maintained at zero to minimize the thermal rating of the generator and the converter. Above rated wind speeds the maximum power control is overridden by stall regulation for constant power. In this study, the wind blade is assumed to be ideally stall regulated at rated power so that rotor speed can keep constant at rated speed under high wind speeds.

Modeling Of the Proposed Wind-PV Energy System

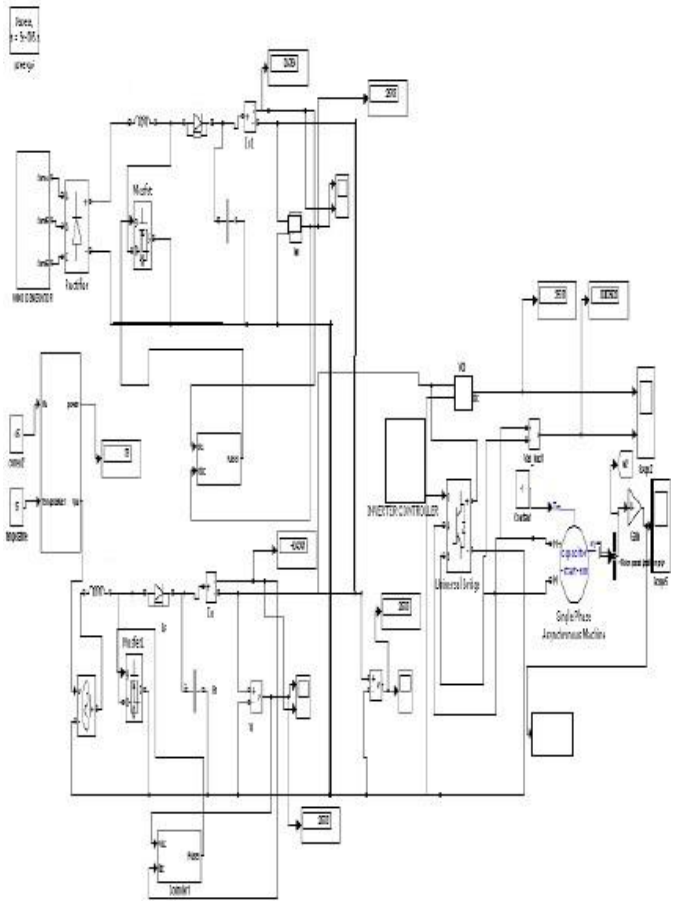

Fig. 6. Proposed Wind-PV simulink model

The wind energy system and the photovoltaic system have been combined as a single module in the fig.6 simulink implemented diagram of proposed Wind-PV energy system. This following simulink implementation contains power generation blocks for both wind energy system and photovoltaic energy system. After the energy generation blocks, there comes energy conversion blocks to convert energy generated from renewable sources

into suitable form so that it can be used by load or grid effectively.

V. RESULTS

To get the results,we need to simulate the model. We have used solar irradiation, temperature and wind speed as the input to the model. At the output we can get photovoltaic power, wind power, wind voltage, total output voltage because of both wind and photovoltaic energy systems. The following figures will show the waveforms of photovoltaic output voltage,wind output voltage, wind-photovoltaic output voltage and the fft analysis of whole ystem that shows the THD which we have tried tto reduce upto 9.87%.

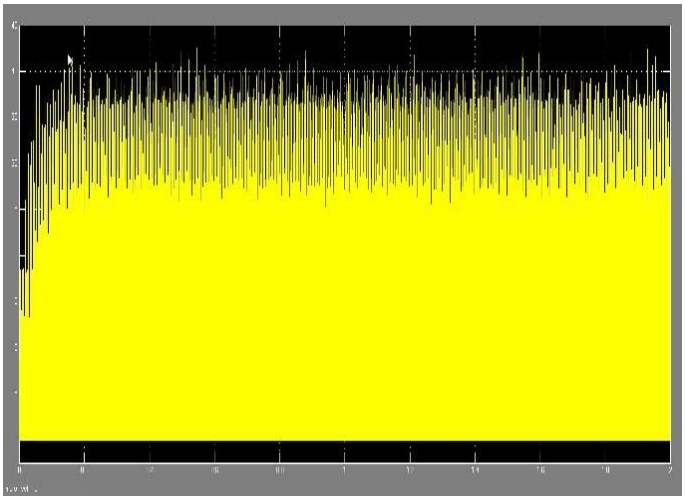

Fig. 7. Output voltage for photovoltaic energy system

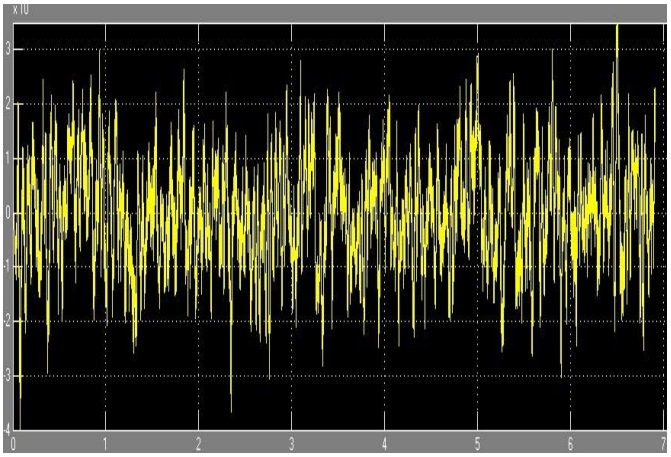

Fig. 8. Output voltage for wind energy system

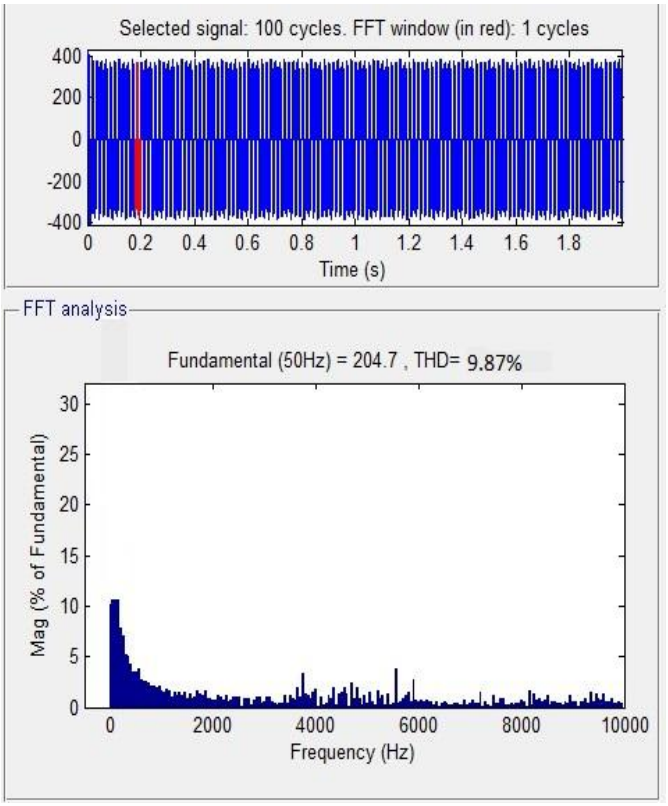

Fig. 9. THD of the proposed system

V. CONCLUSION

By having a look on the various results that we have got from simulation of wind energy system and photovoltaic system alone and then combination of both energy systems, we can say that in combination of both energy systems, we get better results in terms of load voltages, load currents and THD percentage. Thus the proposed wind-PV energy system proves to be better than wind energy system and photovoltaic energy system working alone.

REFERENCES

[1] S. Ahmed, A. Jaber, and R. Dixon, "*Renewable 2010 global status report," Renewable Energy Policy Network for the 21st Century (REN21), pp. 15, 2010.*

[2] D. Dolan, J. Durago, J. Crowfoot, and Taufik, "Simulation of a photovoltaic emulator," *North American Power Symposium*, pp. 1- 6, 2010.

[3] M. E. Haque, M. Negnevitsky, and K. M. Muttaqi, "A novel control strategy for a variable-speed wind turbine with a permanent-magnet synchronous generator," *IEEE Trans. Ind. Appl.*, vol. 46, no. 1, pp. 331–339, Jan./Feb. 2010.

[4] M. E. Haque, K. M. Muttaqi, and M. Negnevitsky, "Control of a stand alone variable speed wind turbine with a permanent magnet synchronous generator," in

Proc. IEEE Power and Energy Society General Meeting, Jul. 2008, pp. 20–24

NAMRATA SINGH has received the B.Tech degree in Electronics and Communication Engineering from SRMCEM, luckow in 2011. She is currently pursuing M.Tech in Electronics, Design and technology from the Department of Electronics, Design and Technology, National Institute of Electronics and Information Technology (NIELIT) (An Autonomous body of Department of Electronics & Information Technology, Government of India) Gorakhpur Centre, MMM Engineering College Campus, Gorakhpur-273010.