



SIMULATION OF SOLAR WIND HYBRID SYSTEM

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Abstract —As per developing technology demand for more energy make us find new energy source. The most important field of this search is renewable energy resources. Wind-Solar energy has being popular one, because of their abundant, ease of availability & convertibility to the electrical energy. This work covers realization of a hybrid renewable energy system for a domestic application, which runs under a micro-controller to utilize solar & wind power. Batteries in the system are charged by either wind power or solar power. Solar power or Wind power alone can fluctuate, when use together they provide reliable source of energy. A simulation model is proposed in this project.

Keywords- Solar energy, Wind energy, Solar Wind Hybrid system, Renewable energy, MATLAB simulation

I. INTRODUCTION

Hybrid systems are developed to overcome the drawback of uncertainty of power at all times and to remote locations. Hybrid power system consist different methods of producing electricity are combined to ensure a continuous power supply. A hybrid energy system consisting of two or more generating systems, such as the combination of a wind turbine or diesel generator and a photovoltaic system is termed as a hybrid energy system. From the many alternatives, Photo-voltaic and Wind energy have been considered as promising towards meeting the continually increasing demand for energy. They have been widely used as Hybrid combination for electricity supply in isolated locations far from the distribution network. Solar and wind energy resources vary greatly over time and do not usually match with the time distribution of the load. Solar or wind energy systems alone must be oversized if one of them is used separately, and leading to high electrical energy costs. Integrating solar and wind energy into the one system reduced fluctuations in the output power, improving total system performance and reliability, and reducing the size of storage required. The sizing of hybrid system is more complicated than that of single source system due to higher numbers of variables and parameters to be considered in the optimal design.[1]

II. AIM

The aim of this project is to MATLAB simulation of solar-wind hybrid energy system. This work is expected to help to understand the basics of solar-wind hybrid power generation. A small part of the daily electricity consumption will be reduce with an efficient utilization of solar and wind power. Here we will make a hybrid system where the solar power is stored in a battery and the combination of battery output and wind power output fed to the load.

III. PROBLEM SUMMARY

The demand of electrical energy is increase widely across the whole world. Almost all the electricity generation takes place at a central power station where coal, gas, fossil fuels and nuclear materials are used as the primary fuel source. But if we keep depending on these conventional sources for energy generation then definitely we have to face problems in the future as they are finite sources and these sources also lead to global warming, green house effect and acid rain, etc. For the past few years, new companies have been developing their own small power systems that can be used in locations where there is no electricity or suffer from constant power outages and more than 200 million people live in rural areas without access to grid-connected power. These rural areas are difficult to supply electricity due to inherent problems of location and economy. The costs to install and service the distribution lines are considerably high for remote areas. Different from a generator which is too heavy, too loud and requires fuel these companies and rural areas are focusing on small hybrid systems that use only the sun and the wind to generate electricity. Unlike a generator, a hybrid system uses clean energy, runs quietly and can be easily transported when compared to standard systems.

IV. MATLAB SIMULATION

4.1. MATLAB simulation of solar system

A PV (photovoltaic) cell is a semiconductor device that converts light energy to electrical energy by photovoltaic effect. If the energy of photon (light) is greater than the band gap then the electron is emitted and the flow of electrons creates current. However a PV cell is different from a photo-diode. In a photodiode light falls on the n-channel of the semiconductor junction and it gets converted into current or voltage signal but a PV cell is always forward biased. If electrical conductors are then attached to the positive and negative sides, forming an electrical circuit, the electrons are captured in the form of electric current (photocurrent) [2]. The model of the solar cell can be realized by an equivalent circuit that consists of a current source in parallel with a diode (Fig.1). A solar cell can be modelled by a current source and an diode which is inverted is connected in parallel to it. It has its allowable series and parallel resistance. Series resistance is due to the blocking in the path of flow of electrons from n junction to p junction and parallel resistance is due to the leakage current.

The output current from the PV array is

$$I = I_{sc} - I_d \quad (1)$$

$$I_d = I_0 (e^{qV_d/kT} - 1) \quad (2)$$

Where, I_0 is the reverse saturation current of the diode,

q is the electron charge, V_d is the voltage across the diode,

k is Boltzmann constant (1.38×10^{-19} J/K) and

T is the junction temperature in Kelvin (K).

From equation 1 and equation 2

$$I = I_{sc} - I_0 (e^{qV_d/kT} - 1) \quad (3)$$

By suitable approximations,

$$I = I_{sc} - I_0 (e^{q(V+IR_s)/nkT} - 1) \quad (4)$$

where, I is the photovoltaic cell current, V is the PV cell voltage, T is the temperature (in Kelvin) and n is the diode ideality factor.

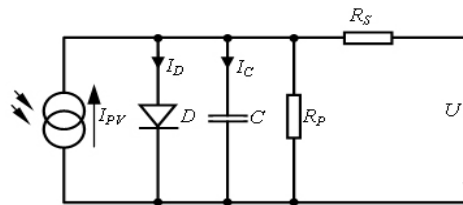


FIG:1 EQUIVALENT CIRCUIT DIAGRAM OF SOLAR CELL

Standard functions and blocks of Matlab and Simulink were used to obtain this model. Its structure is presented in Fig2. The output of the PV module is processed by an energy conversion block implemented with a PWM IGBT inverter.

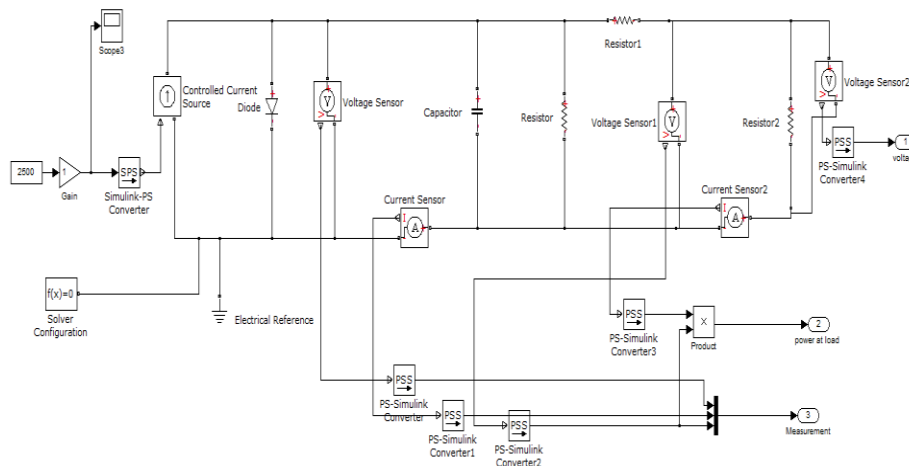


FIG:2 SIMULINK MODEL OF PV MODULE

4.2. MATLAB simulation of wind system

Modelling the wind energy converter is made considering the following assumptions:

- Friction is neglected;
- Stationary wind flow;
- Constant, shear-free wind flow;
- Rotation-free flow;
- Incompressible flow ($\rho=1.22 \text{ kg/m}^3$);
- Free wind flow around the wind energy converter

The kinetic energy of air of mass m moving at speed v can be expressed as:

$$K = \frac{1}{2} mv^2 \dots\dots\dots(5)$$

During time period t , the mass (m) of air through a given area A at speed v is:

$$m = \rho Avt \dots\dots\dots(6)$$

Where ρ is the density of air (kg/m^3).

Based on the above two equations, the wind power is

$$P = \frac{1}{2} \rho Av^3 \dots\dots\dots(7)$$

Power Extracted from Wind:

From wind is the difference between the upstream and the down-stream wind powers [7]

$$P = \frac{1}{2} H_m(v^2 - v_0^2) \dots\dots\dots(8)$$

Where v is the upstream wind velocity at the entrance of the rotor blades, v_0 is the downstream wind velocity at the exit of the rotor blades. H_m is the mass flow rate, which can be expressed as:

$$H_m = \rho A[(v + v_0)/2] \dots\dots\dots(9)$$

Where; A is the area swept by the rotor blades.

From (8) and (9), the mechanical power extracted by the rotor is given by:

$$P = \frac{1}{2} \rho A[(v + v_0)/2] * (v^2 - v_0^2) \dots\dots\dots(10)$$

Now we have

$$P = \frac{1}{2} \rho Av^3 C_p \dots\dots\dots(11)$$

C_p is called the power coefficient of the rotor or the rotor efficiency. It is the fraction of the upstream wind power, which is captured by the rotor blades and has a theoretical maximum value of 0.59. In practical designs, maximum achievable C_p is between 0.4 and 0.5 for high-speed, two blade turbines and between 0.2 and 0.4 for low-speed turbines with more blades.[3] A MATLAB Simulink model, based on the equations mentioned above, was developed for the wind generator module. This model is shown in Figure 4.

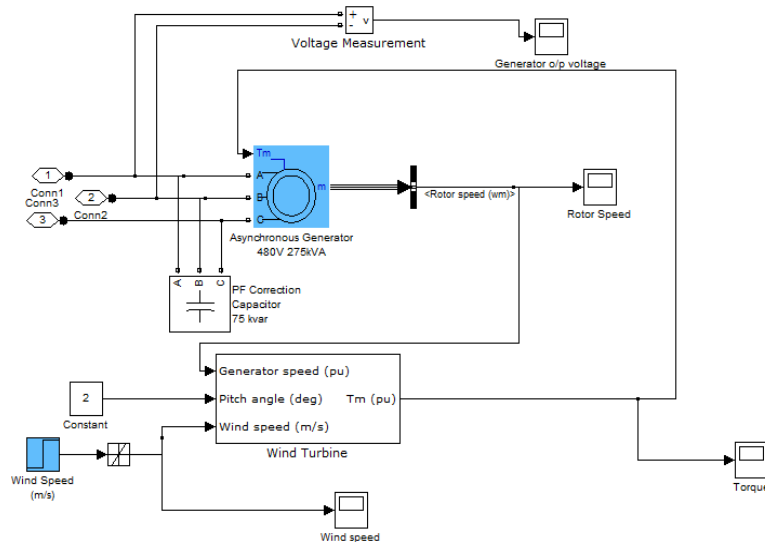


FIG: 4 SIMULINK MODEL OF WIND SYSTEM

The Wind Turbine Induction Generator model is much of complicated part of whole simulation model. It consists of Induction Generator & Wind Turbine. Wind Turbine shown in fig.5. There is three input given to the wind turbine model. First is Generator speed (ω_r pu) in pu of the nominal speed of the generator, second input is pitch angle in degrees and third input is the wind speed in m/s. The output is the torque applied to the generator shaft.

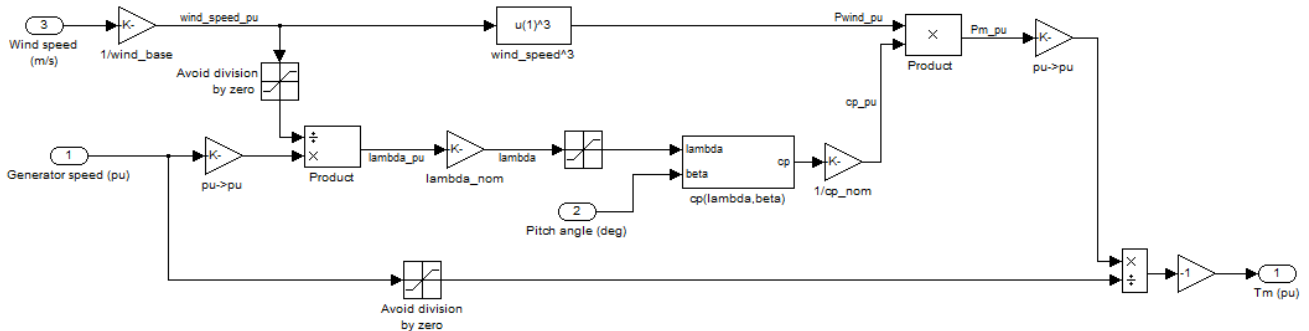


FIG: 5 SIMULINK MODEL OF WIND TURBINE

4.3 MATLAB simulation of battery

Thevenin equivalent battery model is shown in fig:6 [4]. This model consists of a capacitor (C), to represent the polarization capacitance and a shunt resistor R_b to represent its self-discharge. R_d and R_c are the resistors connected to the two parallel branches of the circuit and each diode facing the opposite direction respectively. This type of construction is to enable different resistances to be used to model the charging and discharging behavior of the internal resistance of the battery. The open circuit voltage, internal capacitor voltage and the terminal voltage are represented by V_o , V_p and E_o . [5]

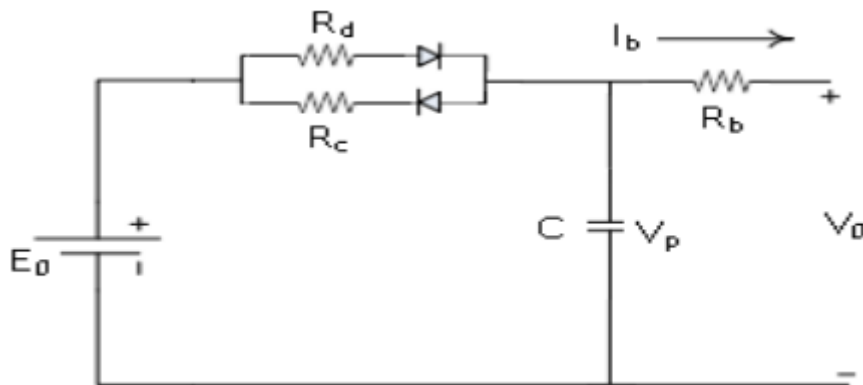


FIG: 6 THEVENIN EQUIVQLENT BATTERY MODEL

The equation for the circuit model is:

$$V_p = 1/C [\{ (V_o - V_b) / R_d \} - I_b] \dots\dots\dots(12)$$

And

$$V_p = V_b - I_b * R_b \dots\dots\dots(13)$$

MATLAB simulink model of battery is shown in figure:7 which is based on this thevenin equivalent battery model.

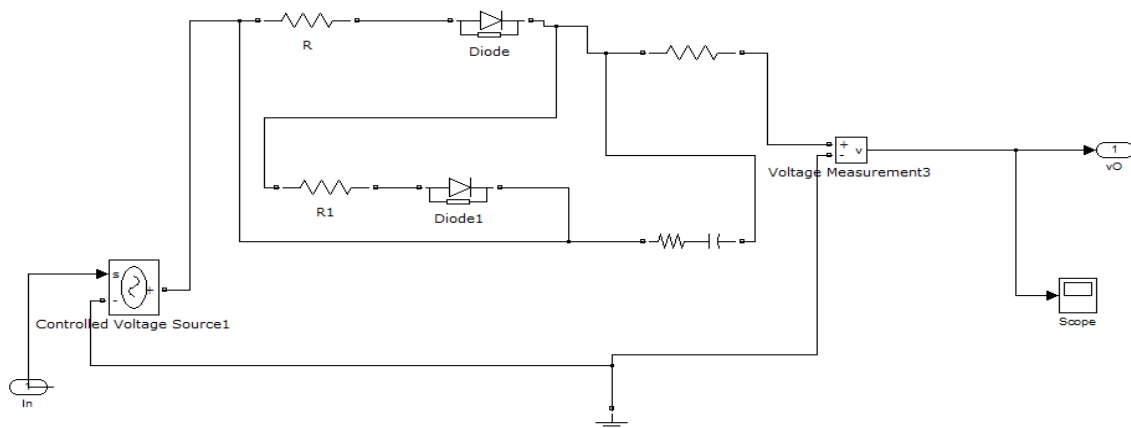


FIG: 7 SIMULINK MODEL OF BATTERY

4.4. MATLAB simulation of hybrid system

Using the Sim. Library a hybrid system shown in Fig.8. It contains power generation blocks from renewable energy sources such as sun, wind, battery blocks, measurements blocks for electrical parameters and inverter.

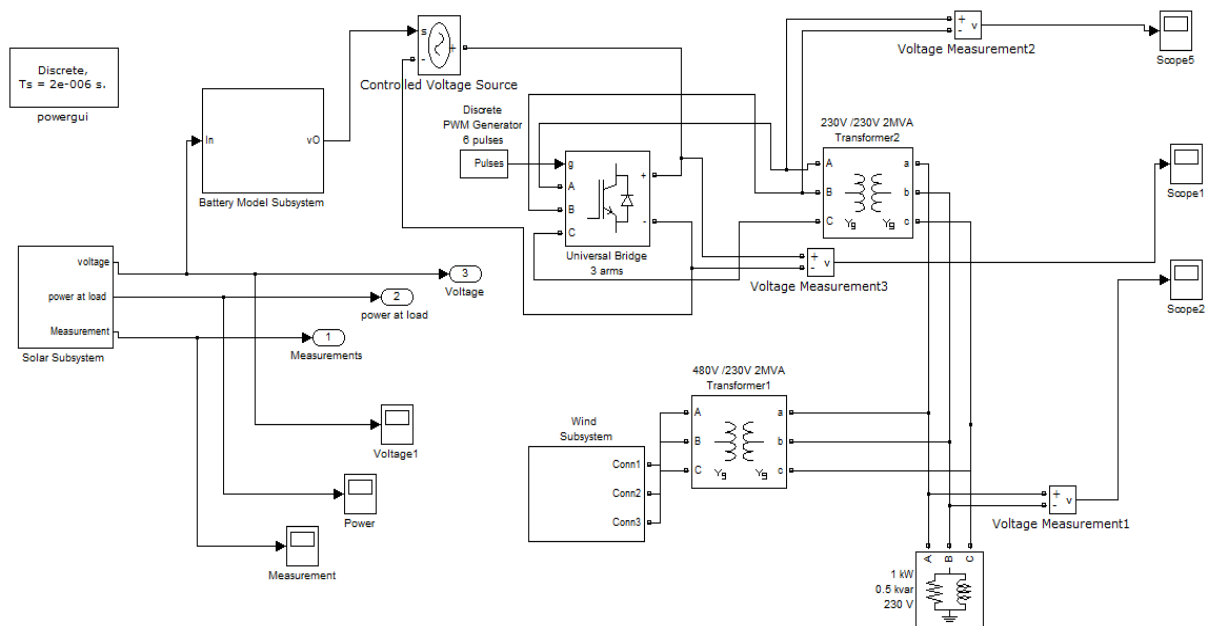


FIG: 8 SIMULINK MODEL OF HYBRID SYSTEM

The solar irradiation is given as input to PV system. The PV system converts this irradiation into DC power. This DC power is supplied to inverter which is convert DC power in to Ac power. AC power is then supplied to the load via transformer. The wind speed is converted to mechanical energy by the wind turbine. The wind turbine is connected to generator. The generator converts the mechanical energy into electrical energy. The output from generator is a three phase AC output, which is supplied to the load via transformer.

V. RESULT

Following figures shows the waveform of the output of solar - wind and hybrid system.

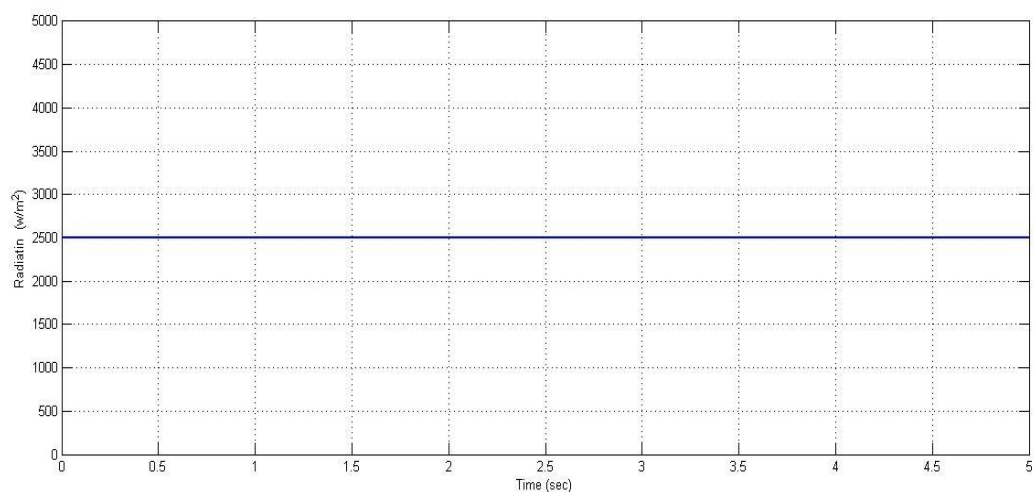


FIG: 9 IRRADIATION WAVEFORM OF SOLAR SYSTEM

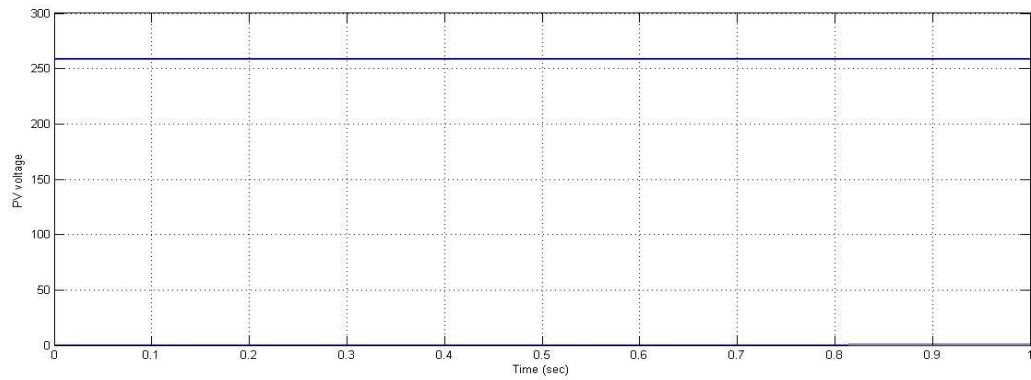


FIG: 10 OUTPUT VOLTAGE WAVEFORM OF SOLAR SYSTEM

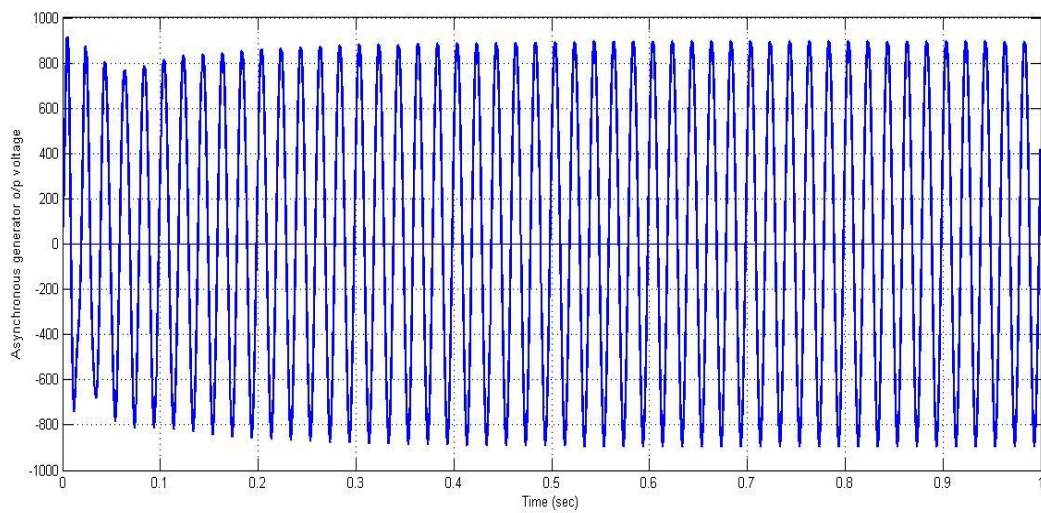


FIG: 10 GENERATOR OUTPUT VOLTAGE

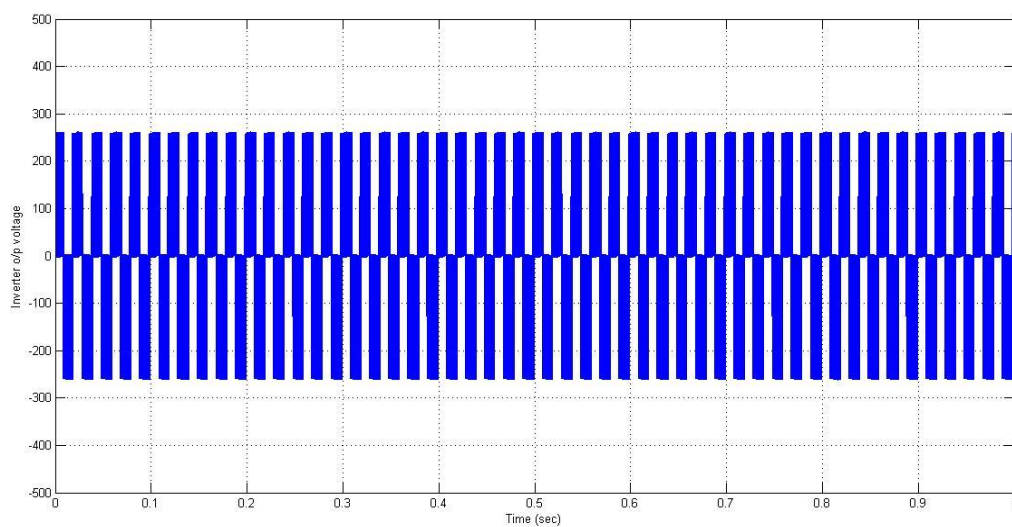


FIG: 11 OUTPUT VOLTAGE WAVEFORM OF INVERTER

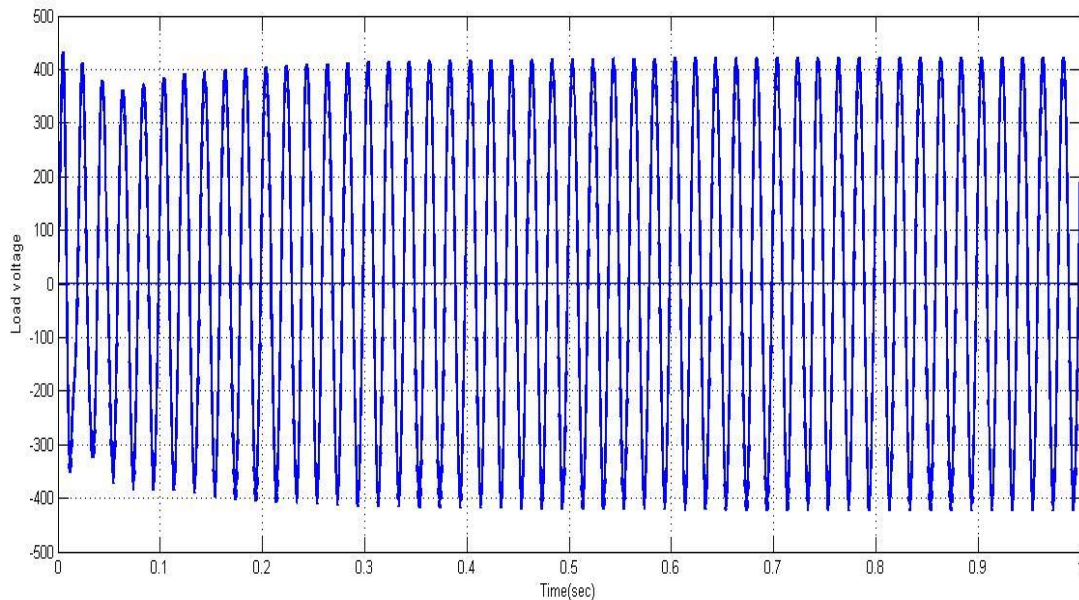


FIG: 12 OUTPUT VOLTAGE WAVEFORM OF LOAD

Conclusion-In this paper, a standalone PV/WT hybrid power system is designed and modelled for remote area power applications. The model has been implemented using the MATLAB/SIMULINK software package, and designed with a dialog box like those used in the SIMULINK block libraries. The available power from the PV System is fluctuate because it is highly dependent on solar radiation. To overcome this deficiency of the PV system, this PV module was integrated with the wind turbine system,

REFERENCES

1. IJSRD - International Journal for Scientific Research & Development| Vol. 2, Issue 01, 2014 | ISSN (online): 2321-0613
2. Shishir Kumar Pradhan, "Modeling and Simulation of PV array with boost converter: An open Loop Study" A thesis presented for the Bachelor of Technology Degree Department Of Electrical Engineering National Institute Of Technology
3. G.D. Rai, "A book of Non conventional energysources"
4. Basker Vairamohan, "State of Charge Estimation Of Batteries." A thesis presented for the Master of Science Degree, The University of Tennessee, Knoxville.
5. <http://www.diva-portal.org/smash/get/diva2:608407/ATTACHMENT01> "DYNAMIC MODELING, MONITORING AND CONTROL OF ENERGY STORAGE SYSTEM"