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Simulation and Performance Analysis of Solar PV Wind Hybrid Energy System

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ABSTRACT: Electricity is One of the basic needs of human life. The power can be generated by using conventional (Non-renewable) and non-conventional energy sources (Renewable). Someday Conventional energy sources will vanish from the earth due to constant usage. Conventional sources include oil, gas, coal and others. These sources lead to greenhouse gas emission, global warming and air pollution. Due to these drawbacks of conventional sources, the fascination towards the renewable energy sources are increasing. Renewable energy sources like solar, wind, tidal and bio mass etc. are abundant in nature, ecofriendly and recyclable.

KEYWORDS: Cognitive Radio, Spectrum Sensing, Efficient Communication, System Security.

I. INTRODUCTION

In India, due to expansive number of populace and development in industrial and commercial sector, Grid can't offer the sufficient energy demand of consumer. The fundamental issue related with the electric supply by the grid is higher losses. These losses are due to long distance power transmission, large installation cost and high emission of gases. Standalone power generation system is needed so as to full fill the energy stipulation of end consumer or to isolated places.In this project solar and wind energy systems are hybridized because they are complementary in nature as solar energy is available during day time and wind power is available also during night. This leads to uninterrupted power supply to the consumer irrespective of weather condition. Hybrid system has an added advantage as individual power generation system is not totally reliable. In hybrid system if anyone of the system terminates, then the other system will provide the power.Such hybrid system gives more reliability, increased output and may be cost effective.

In a standalone system, the supply of quality voltage to the consumer is the biggest challenge. In a solar/wind energy system certain power quality issues occur. They are voltage variations, flickers and harmonics. The voltage variations are mainly due to the change in the wind speed and solar illuminations. Harmonics generate in the system as converters are connected between source and the load. The proposed hybrid system consists of asynchronous generator, PV array, battery and load. Maximum power point tracking system is used in the solar system to extract the maximum possible power from the PV modules. H-bridge inverter is used to convert the dc power into ac power which supplies the loads. The system is simulated in the Matlab/Simulink software.

II. LITERATURE SURVEY

As population increases, energy consumption increases all over the world. Presently 80% of the world environment is damaging due to use of conventional energy sources. So there is necessary of non-conventional energy sources that will not harm the environment. Some surveys indicate that the demand can increase by 3 times across the world by 2050.
Nandi et al [1] evaluated the feasibility of a proposed wind-pv hybrid power system in Bangladesh and showed t hat wind–PV-battery is economically viable as a replacement for conventional grid energy supply for a community at a minimum distance of about 17 km from grid. Saheb-Koussa et al [2], designed a hybrid energy system consisting of wind and photovoltaic with battery storage with the backup of a diesel generator to ensure continuous power supply in Algeria.Diaf et al [3]. They presented a methodology to perform the optimal sizing of an autonomous hybrid PV/wind system. Their methodology aims at finding the configuration, among a set of systems components, which meets the desired system reliability requirements, with the lowest value of levelized cost of energy and assumed PV/wind hybrid system to be installed at Corsica Island, their results showed that the optimal configuration, which meet the desired system reliability requirements loss of power probability (LPSP = 0) with the lowest levelized cost of energy LCE, is obtained for a system comprising a 125 W photovoltaic module, one wind generator (600W) and storage batteries

(using 253 Ah).Francois Giraud et al [10] analyzed a model for design of wind–photovoltaic system with battery storage for grid connected rooftop system. The system was designed to meet a typical load demand for a given loss of power supply probability. The various parameters like system reliability, power quality, loss of supply and effects of the randomness of the wind and the solar radiation on systems design have been studied. The results showed that the wind and solar systems were complementary to each other and resulted in improved reliability of the system.

III. PROPOSED HYBRID SYSTEM

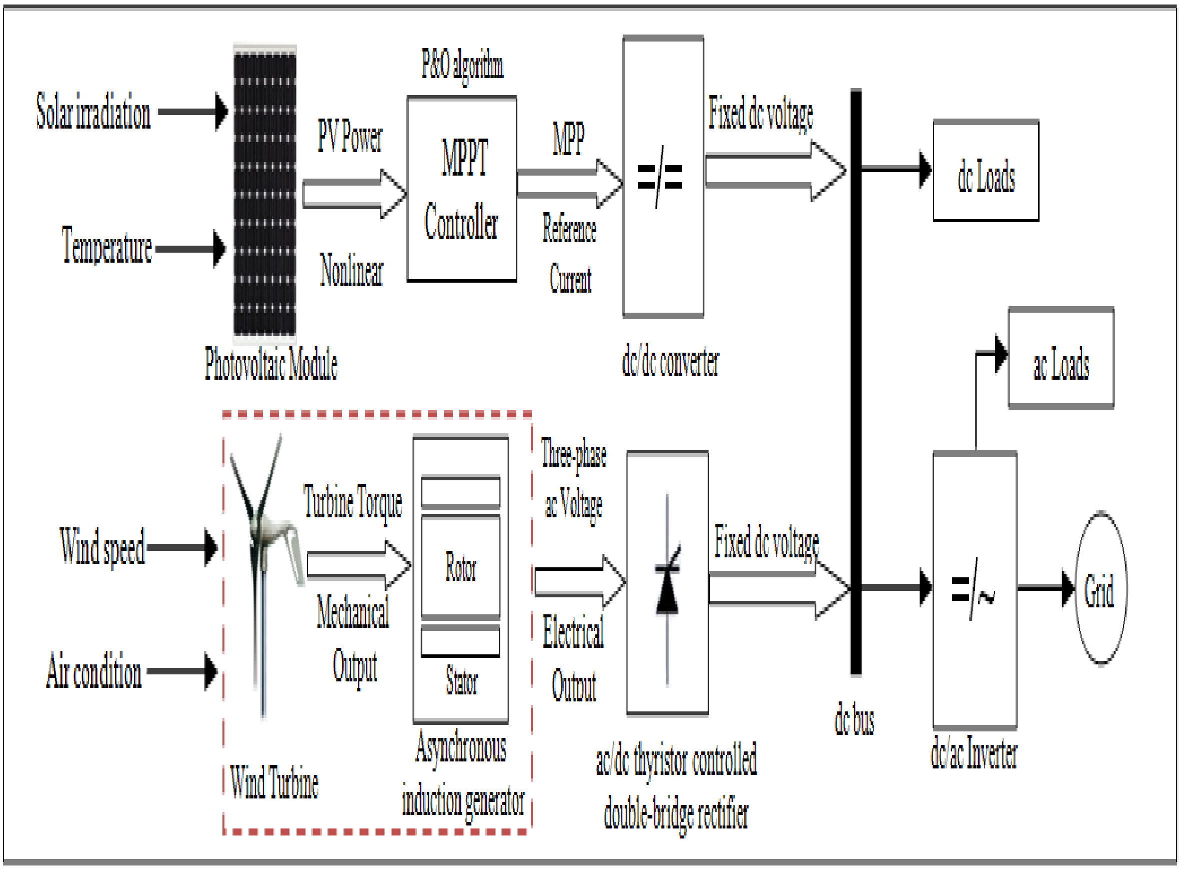


Fig.1 Block diagram of the proposed system

The hybrid system consists of photovoltaic module, wind system, dc-dc buck converters, dc-ac inverters, battery and the load as shown in above figure.1 Wind system consists of wind turbine, permanent magnet synchronous generator and rectifier circuit. Input of the pv system is sun light and for wind system is varying wind speed. Output voltage of both the system will be different. For reliable operation voltage must be maintained constant. Therefore dc link is connected across both systems. Dc output voltage from both the system is connected to the dc link which maintains constant dc output voltage. Battery is used to store the energy generated from both the systems and discharges whenever load is higher than the generation or during peak hours. Therefore power can be supplied to the load from both the systems separately or simultaneously which enhances the reliability.

IV. SIMULATION MODEL OF HYBRID SYSTEM

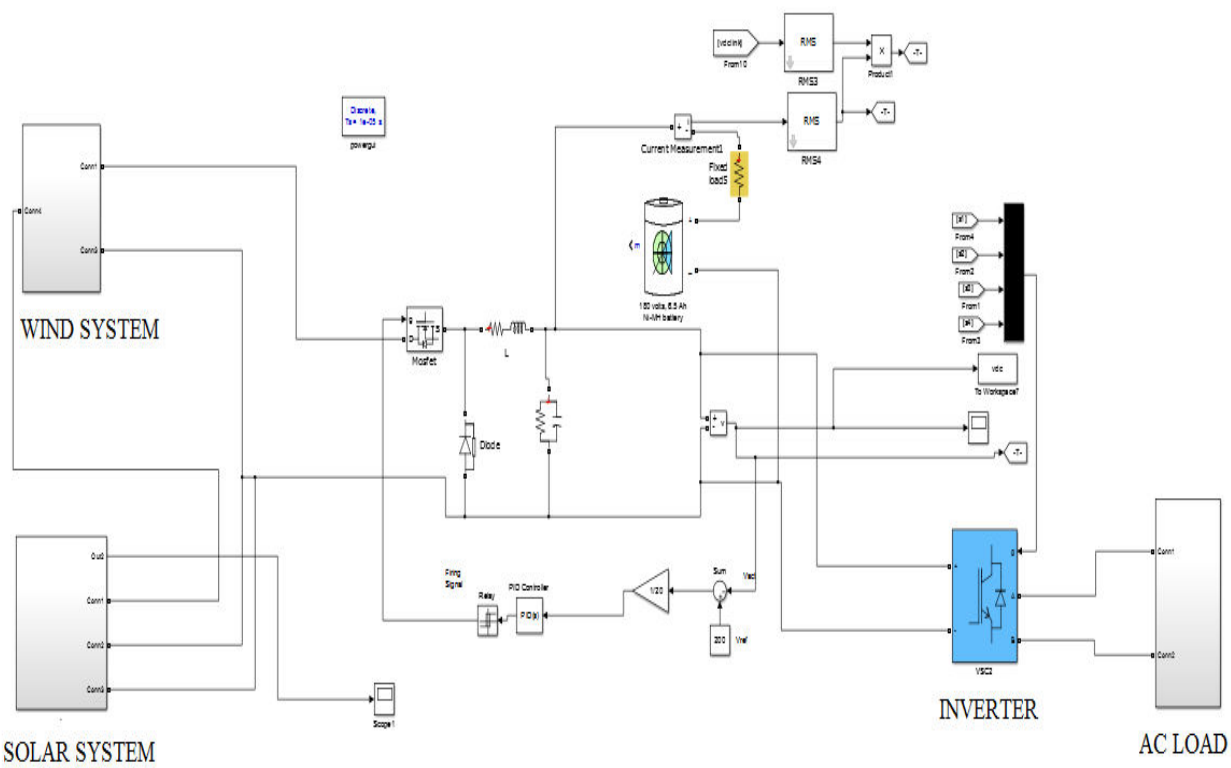


Fig.2:Simulink model of hybrid system

The hybrid model contains solar and wind system. The PV system consists of PV panel of rating 3KW, open circuit voltage (V_{oc}) =64.2V and short circuit current I_{sc}=5.96A. Number of cells used in series are 96. Inputs to the PV panel are different irradiation levels at constant temperature of 25^{o}C. Boost converter is used to increase the voltage level irrespective of the input voltage level. This converter is a combination of inductor, diode and IGBT. The dc output voltage is fed into the DC bus. This maintains the voltage at reference value i.e.200V.

The wind system consists of wind turbine, asynchronous generator and rectifier. The speed of the wind is not same at all the time. This varying speed is given as input to the wind turbine which converts kinetic energy of air into mechanical energy. Mechanical energy from the turbine is used to run the generator of nominal power 1.5MW, 400V (line-line) and frequency 50Hz. Generator converts mechanical torque into electromagnetic torque. The output from the generator is ac voltage; universal bridge rectifier is used to convert ac voltage into dc voltage. Constant voltage is obtained by the dc-dc converter. This dc voltage is fed into the DC link which maintains the voltage at 200V. Storage battery is used to charge and discharge the power in unbalanced load condition. Inverter is used to convert dc voltage into ac. The output of inverter is given to the ac load.

Simulink model of solar PV system

Figure 3 depicts the Simulink model of solar PV system. The entire PV system consists of three PV arrays connected in series. This system is designed to obtain voltage and power at different irradiance levels.

The mathematical modelling of the PV system is done with the help of following steps

Step 1: Modelling of photocurrent of the diode

The photocurrent of the diode is varies linearly with intensity of solar irradiation, the equation 1 shows the relation between the photo current and solar irradiation. Figure 4 shows the simulation modelling of photocurrent of the diode.

$$Ipv = [Isc + \{Ki*(T-Trk)\}] * (\frac{G}{1000}) \qquad ...(1)$$

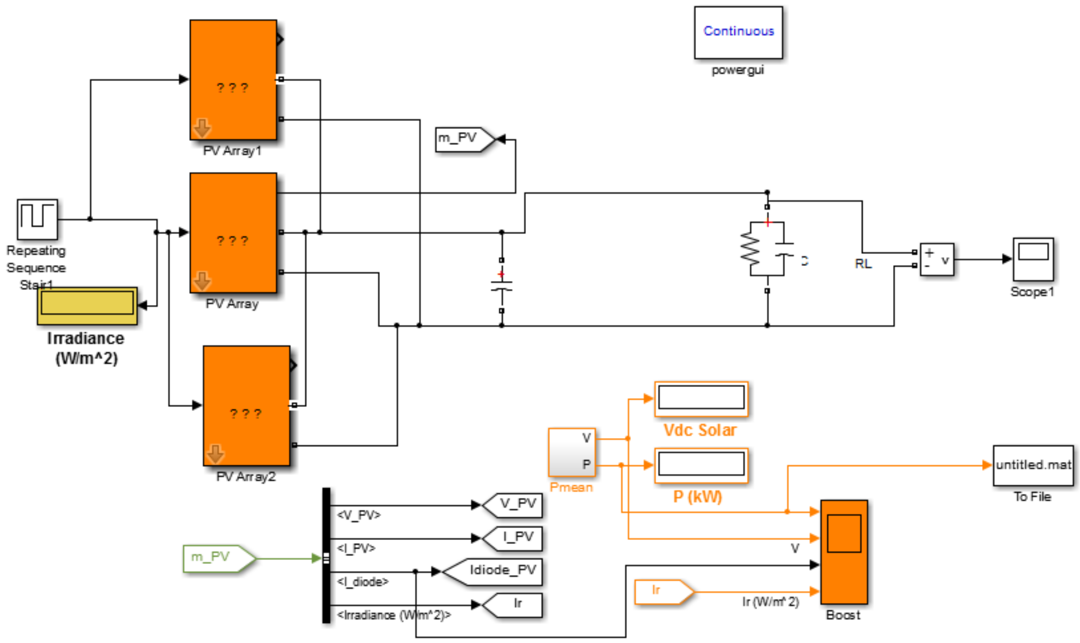


Fig.3 Simulink model of solar PV system

Where,

Ipv = Photo current of the diode, Isc = Short circuit current (A), Ki = Short circuit current of cell at 25 ^{o}C, T = Working temperature, Trk = Nominal temperature, Ir = solar irradiation.

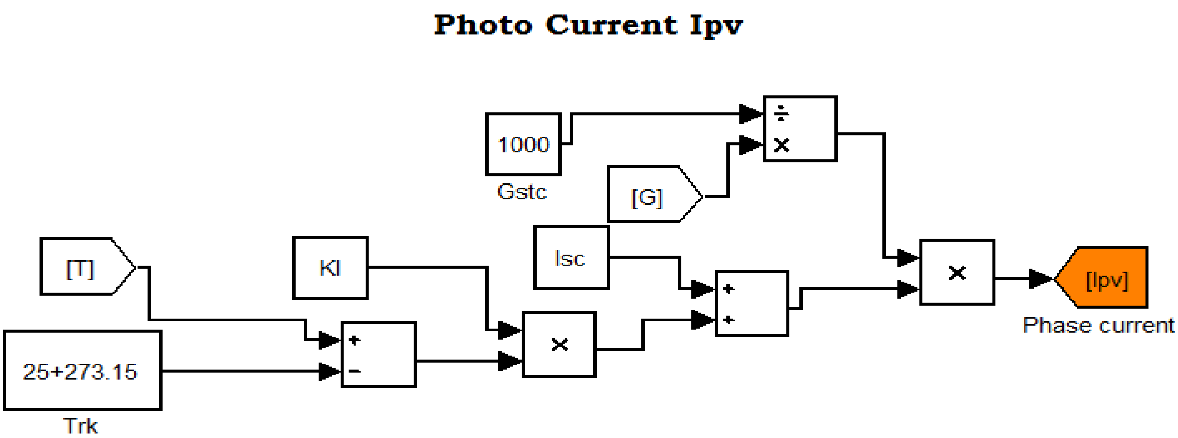


Fig 4 Modelling of photocurrent of the diode

Step 2: Modelling of reverse saturation current of the diode

The reverse saturation current depends on the open circuit voltage and the operating temperature of the PV cells, which can be observed in the equation 2. The modelling of reverse saturation current of the diode is modelled as shown in figure 5.

$$Irr = \frac{Isc}{[\exp\{\frac{q*Voc}{Ns*K*A*T}\}-1]} \ldots..(2)$$

Where,

q = Electron charge = 1.6 x 10^{-19} C, Voc = open circuit voltage, Ns = Number of cells connected in series, A = Ideality factor of the diode = 1.2, K = Boltzmann's constant = 1.3805 x 10^{-23} J/K.

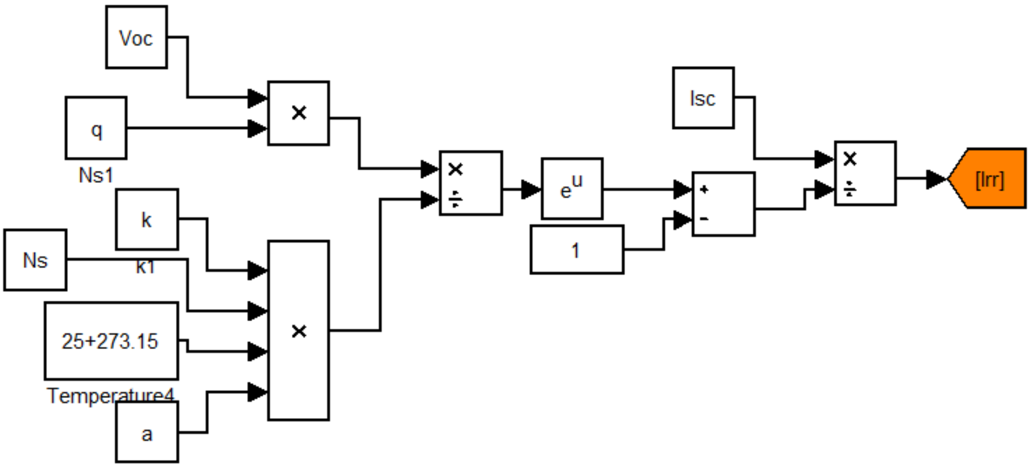


Fig 5 Modelling of reverse saturation current of the diode

Step 3: Modelling of the saturation current of the diode

As quality of the material increases, the saturation current decreases and it can be increased by increasing the operating temperature. Saturation current mainly depends on the parameters such as temperature, energy gap, ideality factor, Boltzmann constants, diffusion constant as shown in the equation 3 and the modeling of the saturation current is shown in the figure 6.

$$Id = Irr * \left(\frac{T}{Trk}\right)^3 * \left[\ \exp\left\{\frac{Eg*q}{K*A} * \left(\left(\frac{1}{Trk}\right) - \left(\frac{1}{T}\right)\right)\right\}\right] \quad ....(3)$$

Where,

Id = saturation current of the diode, Eg = Band gap energy of the semiconductor = 1.1eV

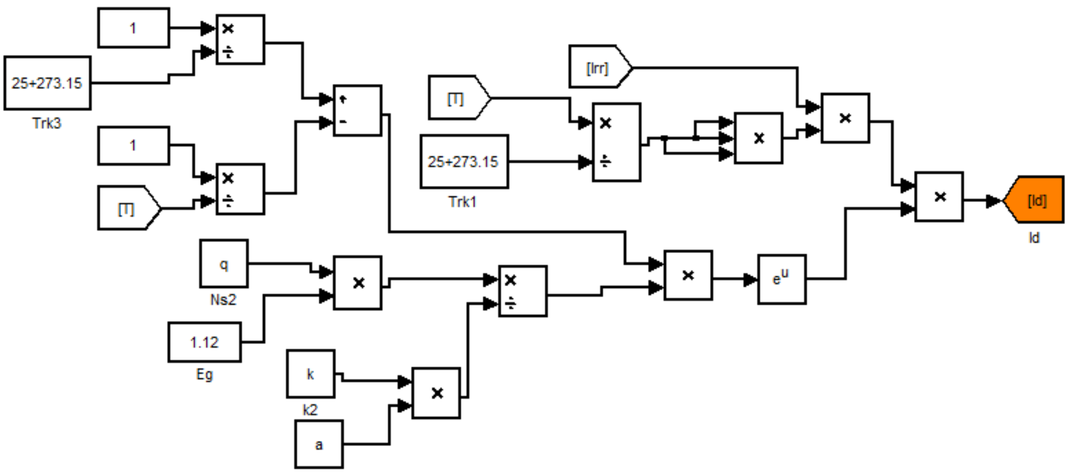


Fig.6 Modelling of saturation current of the diode

Step 4: Modelling of output current of the PV panel

The output of the PV panel is obtained with the help of equation 4 and the modeling of PV panel is shown in the figure 7 and 8.

$$I = (Np * Ipv) - (Np * Id)\ \ \left[\exp\left\{\frac{\left(\frac{q}{Ns*A*K*T}\right)}{V+Io*Rs} - 1\right\}\right] \quad ....(4)$$

Where,

Np = No. of modules connected in parallel, Rs = series resistance ,Vt = diode thermal voltage.

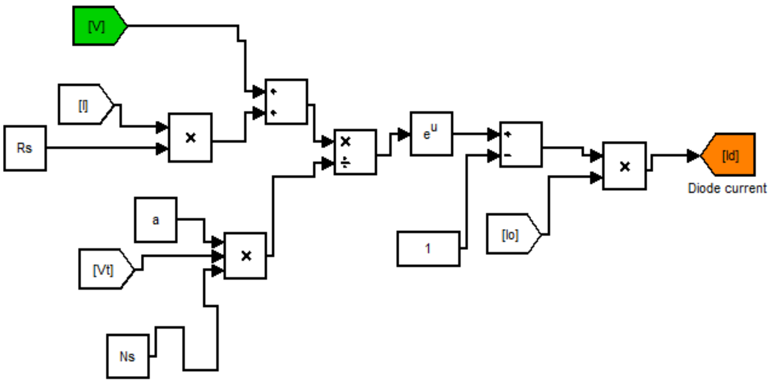


Fig 7 Modelling of diode current

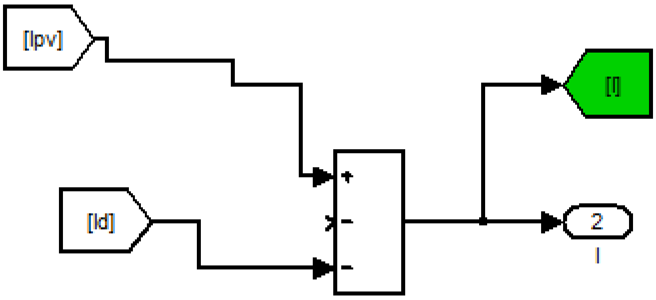


Fig 8 Modelling of output current of the panel

The parameters used for the modelling of PV module are shown in table I.

Sl.no	Parameter	Value
1	Imp	54.7
2	Vmp	5.58
3	P_{max}	305
4	I_{SC}	5.96
5	Voc	64.2
6	Ns	5
7	Np	66

Table I: Parameters of PV module

V. RESULT AND DISCUSSION

The simulation analysis of hybrid solar PV/Wind system consisting of 3KW and 1.5MW with battery storage element is carried out with the help of MATLAB/Simulink software. The analysis is carried out with different irradiance levels and with different wind speeds. Voltage profile of the system is shown in following figures.

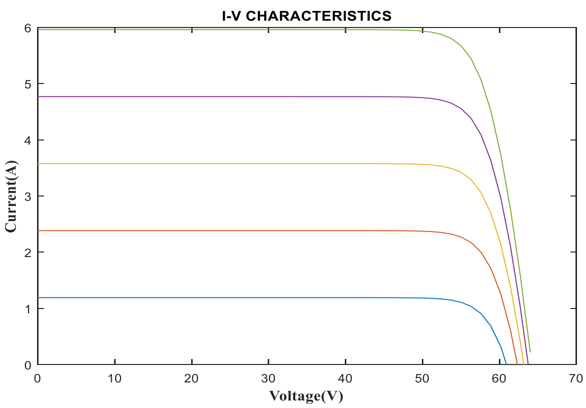
The output power of the solar PV system at different irradiance level is shown in table II.

Irradiance(w/m^2)	Voltage(v)	Power(KW)
200	292.7	2.14
400	305.13	2.34
600	312.06	2.46
800	316.89	2.54
1000	320.60	2.60

Table II: change in power w.r.t irradiance

From the above table we can observe that as irradiance level increases from 200 W/m^2 to 1000 W/m^2 , the power also increases. Maximum power is obtained at 1000W/m^2.

Effect of variation of irradiation



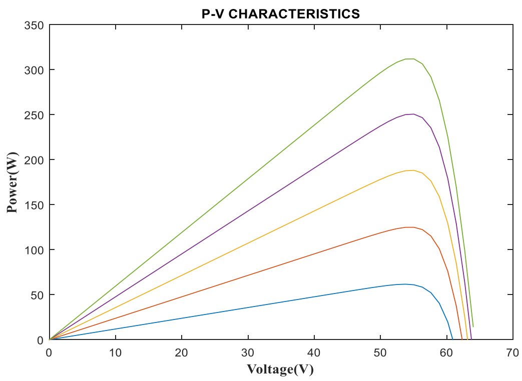


Fig. 9(a) and 9(b) Effect of variation of irradiation on I-V characteristics and P-V characteristics

In fig 9(a) and 9(b) we can see the effect of change in solar irradiation on PV characteristics. From fig 9(a) we observe that as we increase the solar irradiation short circuit current increases. Variation in Solar irradiation effects mostly on current, as we can observe from fig 9(a) as we increase solar irradiation from 2oo w/m2 to 1ooo w/m2 current increases from 1.2A to 6A approximately but effect of variation of solar irradiation on voltage is very less. Fig 9(b)shows the effect of variation of solar irradiation on P-V characteristics. As solar irradiation increases, power generated also increases. Increase in power is mainly due to increment in current.

Results obtained from the PV system at irradiance level of 1000 W/m^2

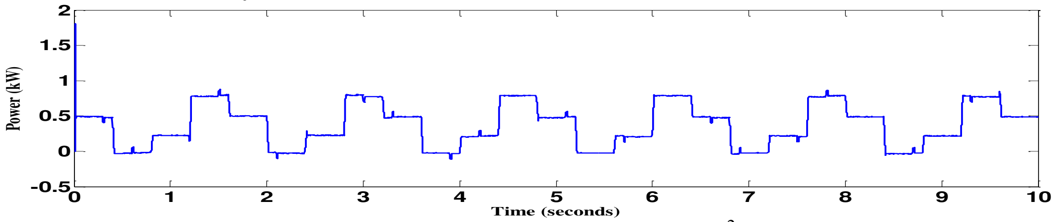


Fig.10: PV output power at 1000w/m^2

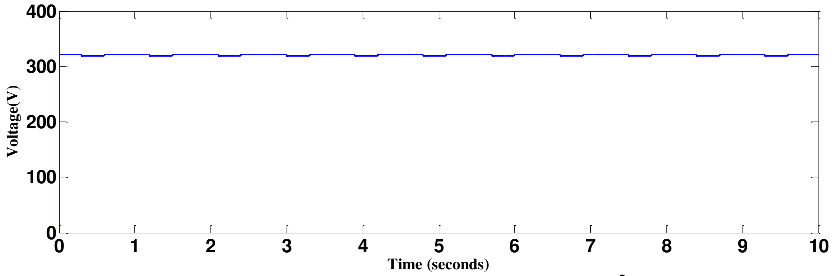


Fig 11. PV output power at 1000w/m^2

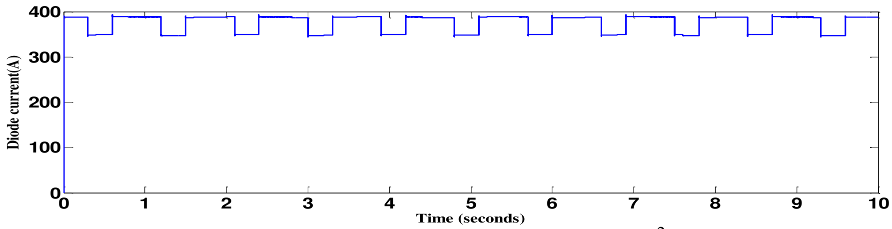


Fig.12 showsDiode current at 1000w/m^2

VI. CONCLUSION

This work describes a hybrid energy system with variable speed wind generation, photovoltaic system along with power electronic interface under stand-alone mode. Due to variations in wind speed and solar irradiation AC voltage varies. Battery system is used to maintain the balance between the source and load. The available power from the PV system is highly dependent on solar radiation. To overcome this deficiency of the PV system, the PV module was integrated with the wind turbine system. Hybrid wind system and solar PV system performance has been analyzed. This system is expected to meet up electricity demand in a remotes area. The performance of the developed system is evaluated in MATLAB/SIMULINK.

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