ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

A Comparative study of MPPT Techniques in Modelling of Solar Photo-Voltaic and PMSG based Wind Hybrid System

D.Jyothsna[1], S.Sridhar[2]

PG Student [PID], Dept. of EEE, JNTU, Anantapuramu, Andhra Pradesh, India[1]

Assistant Professor, Dept. of EEE, JNTU, Anantapuramu, Andhra Pradesh, India[2]

ABSTRACT: In solar photo-voltaic system MPPT technique is used to maximize power output, and a boost converter is used to raise DC voltage and its output is fed to a three phase PWM inverter for converting DC voltage to AC. In this paper a hybrid system based on solar photo-voltaic and wind energy system architecture is proposed. Two renewable energy sources, solar and wind are considered. Depending on availability and requirement, these sources deliver the load together or independently. In wind energy conversion system PMSG is utilized. Two MPPT techniques Perturb and Observe and Incremental conductance are being analysed and compared in the design of solar photo-voltaic system. Simulation study of the proposed system is carried out with MATLAB/Simulink and results are analysed.

KEYWORDS: Hybrid system, photovoltaic system, perturb and observe, incremental conductance, wind generation.

I.INTRODUCTION

As we observe today, the current power generation is mainly based on renewable energy sources because of their abundance in nature. Power can be extracted from fossil fuels at major extent. But now-a-days it is not possible because of limited existence of fossil fuels. Among renewable energy systems solar photo-voltaic and wind energy systems are preferable and popular because of their availability and harmless nature [2]. Wind energy is capable of producing huge amounts of power, but its availability cannot be predicted [1]. Solar power is available during the whole day but the solar irradiance levels change because of the changes in the sun's intensity and shadows caused by many reasons. In general both renewable energy sources are complementary in nature [4].

Hybrid photovoltaic and wind energy system has higher dependability to give steady power than each of them operating individually [6]. Another benefit of the hybrid system is that the amount of the battery storage can be decreased as hybrid system is more reliable compared to their independent operation.

In this paper solar photovoltaic system is comprised of IGBT based boost converter which is used to get required output voltage constantly. Any of the MPPT technique is used to generate the converter's firing pulses [6]. Here two techniques are being used and those are perturb and Observe, Incremental Conductance [7]. By using these two methods Hybrid system is simulated and analysed. In order to change the output voltage of the boost converter from DC to AC, a PWM inverter is employed. The output of the inverter is connected to the load. The output waveform which is generated approaches the desired sinusoidal waveform due to pulse width modulation [9]. A PMSG is driven by wind turbine for power generation. Wind turbine is operated by two masse drive train and the angle of turbine's blade pitch is controlled by pitch angle controller [1].

The power can be generated by solar photo-voltaic system and as well wind energy conversion systems separately and can be given to the loads individually [8]. Both the systems are reliable and the resources required are available plenty in nature. By the combination of both the systems heavy loads can be survived.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

RELATED WORK

This paper presents the comparison of output of the system for two different MPPT techniques; Perturb & Observe, Incremental Conductance. For the first method time taken by the output to reach steady state is more when compared with the later one. Accuracy is more and power loss is less for the incremental conductance method than the perturb and observe method. More number of oscillations of output at the maximum power point is observed for the first method than the second. These are the advantages of the conventional methods which are not briefly analysed before.

.

II.THEORITICAL ANALYSIS

Hybrid system architecture: The block diagram of the hybrid system is shown in the figure below

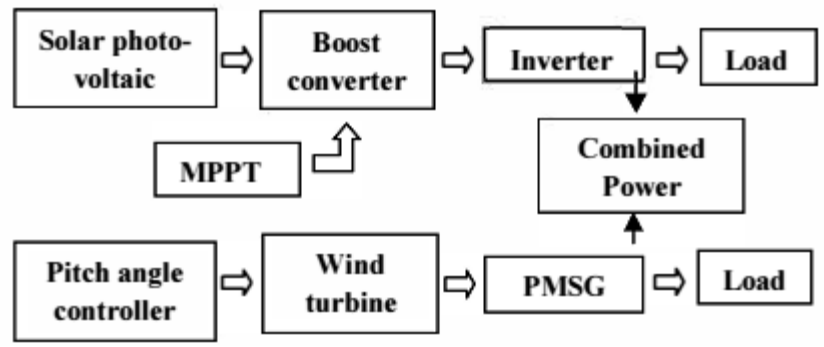

Fig.1 Block diagram of hybrid system

The output of the solar panel is connected to a boost converter to get the higher output voltage and supplied to the load and wind energy conversion system is generating 400V by permanent synchronous generator and its output is supplied to the load. Powers of both systems are combined for other applications.

III.PV CELL MODELING

A photovoltaic cell directly converts sunlight into electricity. Cells can be connected together to form a module or an array. The direct output from the module may serve some small loads like DC motors or lighting systems, but to provide power to fit more sophisticated demands, power electronic converters are needed. A PV cell is essentially a semiconductor diode where the p-n junction is exposed to light. The equivalent circuit of a PV cell is shown in fig.2. An ideal solar cell is modeled by a current source and a diode in parallel with it. No solar cell is ideal; it consists of series resistance which has very small value and a parallel resistance of high value.

Applying Kirchhoff's current law to the junction where I_{ph},diode,R_{sh},R_s meet, we get,

$$I_{ph}=I_d+I_{Rp}+I \quad \text{and} \quad I=I_{ph}-(I_d+I_{Rp})$$

PV cell current is given by the equation below

$$I=I_{ph}-(I_o\,[e\,(V+IR_s/V_T)-1]+V+IR_s/R_p)$$

Where I_{ph} : photo current, I : cell current, I_o : reverse saturation current, V : cell voltage, R_s : series resistance R_{sh} : shunt resistance, V_T : Thermal voltage

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

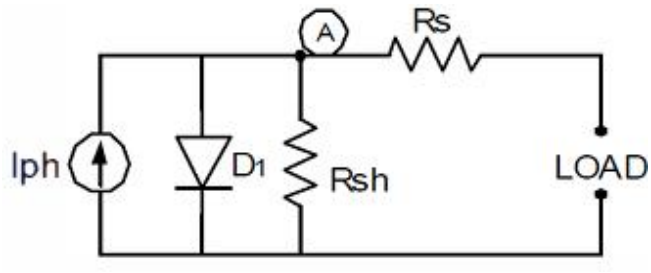

Fig.2 PV cell circuit model

Modelling of solar PV system

Solar cell is the building block of PV array. The photo current I_{ph} depends on the solar radiation and cell temperature is given by

$$I_{ph}= [I_{scr}+K_i (T-T_r)] S/100$$

Where I_{scr} : cell short circuit current at reference temperature and radiation, K_i : short circuit current temperature coefficient, S : solar radiation in MW/cm^2

As the working temperature of the PV cell increases, the output current of PV module increases, but the maximum power output decreases. Since the increase in the output current is much less than the decrease in the voltage, the total power decreases at high temperatures. The temperature increase around the solar cell has a negative impact on the power generation capability. Increase in temperature is accompanied by decrease in open circuit voltage value and the efficiency of the solar cell is reduced.

IV.DC-DC BOOST CONVERTER

A boost converter is a DC to DC voltage converter with output DC voltage greater than the input DC voltage. It is an SMPS containing at least two semiconductor switches. Filters made of capacitor and inductors which are placed at the output stage of the converter are used to reduce the ripple of the voltage and current respectively.
The basic operating principle of the converter consists of two states

1. In ON state, switch is closed, resulting in an increase in the inductor current.
2. In OFF state, switch is opened, resulting in a decrease in the inductor current.

A boost converter is used to increase the voltage level of 70V dc of solar panel to 410V dc. Firing pulses for the boost converter are being generated by using two MPPT techniques; perturb and observe, incremental conductance and their results are being analysed separately.

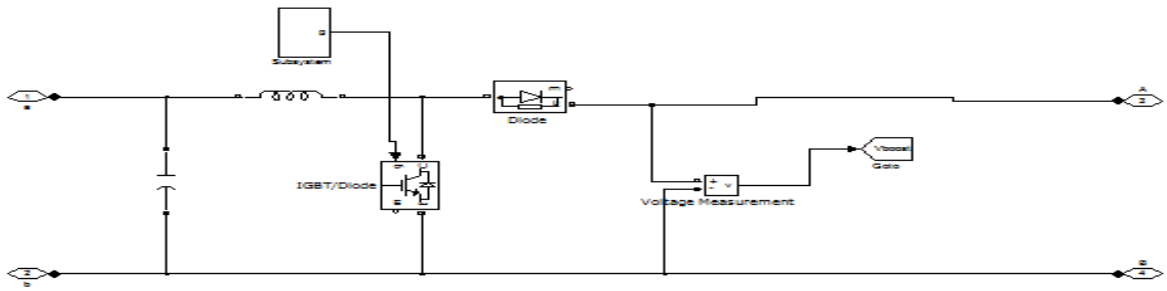

Fig.3 simulink diagram of boost converter-perturb and observe

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

The above model represents a boost converter, in which the pulses for IGBT are generated by using perturb and observe MPPT technique. In this method incrementing and decrementing of the parameter is done based on the requirement. Output varies in accordance with the input change.

The below model represents a boost converter in which the triggering pulses generated for the IGBT are controlled by incremental conductance, MPPT technique. By changing the conductance or by increasing the conductance the output is varied.

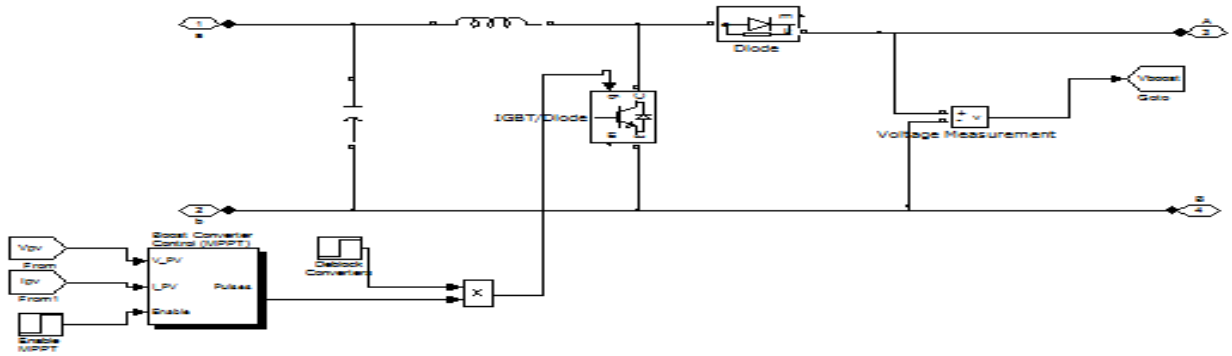

Fig.4 simulink diagram of boost converter-incremental conductance

V.PROPOSED MPPT TECHNIQUES

These techniques are used to maximize the output power of the PV array in solar systems by tracking continuously the maximum power point which depends on the temperature of the solar panel and the solar irradiance conditions. According to maximum power transfer theorem, the power output of a circuit is maximum when the thevenin impedance of the circuit matches with the load impedance. By changing the duty cycle of the boost converter we can match the source impedance to load impedance. This duty cycle is determined by MPPT techniques.

1. Perturb & Observe

The perturb and observe algorithm is based on the observation of the array output power and on the perturbation of the power based on the increments of the array voltage or current. The algorithm continuously increments or decrements the reference voltage or current based on the previous power sample value. It is the simplest method and the cost of implementation is less and is easy to implement. The time complexity of this algorithm is very less but on reaching very close to the MPP it does not step at the MPP and keeps on perturbing in both the directions .The common problem in perturb and observe algorithm is the array terminal voltage is perturbed every MPPT cycle: when the MPP is reached, the output power oscillates around the maximum, resulting in power loss in the PV system.

2. Incremental Conductance

The disadvantage of perturb and observe method to track the peak power under fast Varying atmospheric condition is overcome by IC method. The IC can determine that the MPPT has reached MPP and stop perturbing the operating point, if this condition is not met, the direction in which the MPPT operating point must be perturbed can be calculated using the relation dI/dV and –I/V. This relationship is derived from the fact that dP/dV is negative when the MPPT is to the right of the MPP and positive when it is to the left of the MPP. This algorithm has advantages over P&O and it can determine when the MPPT has reached the MPP, where P&O oscillates around the MPP. Also, incremental conductance can track rapidly increasing and decreasing irradiance conditions with higher accuracy than P and O. This method computes the maximum power and controls directly the extracted power from the PV.This method offers different advantages: good tracking efficiency, response is high and well control for the extracted power.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

VI.WIND ENERGY CONVERSION SYSTEM

Wind energy conversion system comprises of wind turbine, permanent magnet synchronous generator, two masse drive train and pitch angle controller.

1. Modelling of wind turbine

Wind turbine converts kinetic energy of the wind into mechanical energy transmitted by the shaft. Here we used prebuilt wind turbine model in SIMULINK to provide torque to the generator

2. Permanent magnet synchronous generator

Here**,** wind turbine is coupled with a permanent magnet synchronous generator. A Permanent magnet synchronous machine block is taken in simulink. Sign of the torque input determines whether the machine operates as a generator or as a motor. If sign of torque is positive, it works as motor and if the sign is negative, it works as a generator**.**

3. Wind turbine and drive train

Here, wind energy conversion system is operated by two masse drive train. The differential equations governing its mechanical dynamics are: $T_{sh}=K_{sh}\Theta_{tw}+D_t\, d\Theta_{tw}/Dt$

Where, T_{sh} is shaft torque, K_{sh} is shaft stiffness, Θ_{tw} is shaft twist angle, D_t is damping coefficient, H_t is inertia constant of the turbine, H_g is inertia constant of PMSG.

4. Pitch angle control

The wind power from the flowing air captured by wind turbine can be expressed as:

$$P_{wt}=0.5\rho S V_w^3 Cp(\beta, \lambda)\ ;\ \lambda= \omega R/V_w$$

Where P_{wt} is the wind power, ρ is the air density; S is the effective rotor swept area, V_w is the wind speed, C_p is the power coefficient, β is the pitch angle, λ is the tip speed ratio given by,

VII.HYBRID SYSTEM MODEL

It is the combination of both solar photovoltaic system and wind energy conversion system. Hence the system can supply the power to load individually or combindally. For both the MPPT methods Hybrid system is common. The only difference is in the generation of triggering pulses for the boost converter.

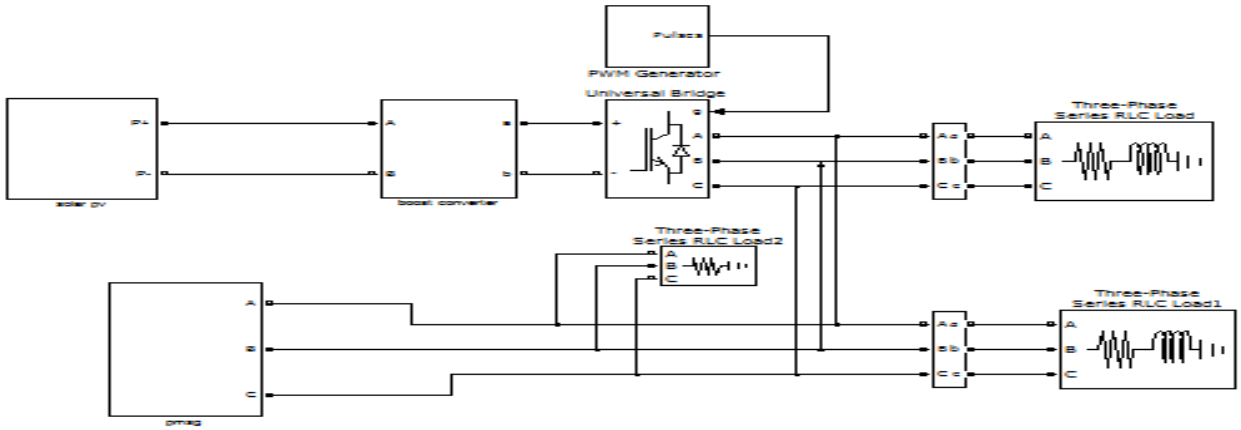

Fig.5 simulink model of hybrid system

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

VIII.SIMULATION RESULTS

Simulation is done on Matlab and the results are shown below. Comparison of the output voltages at the boost converter in two cases are shown below.

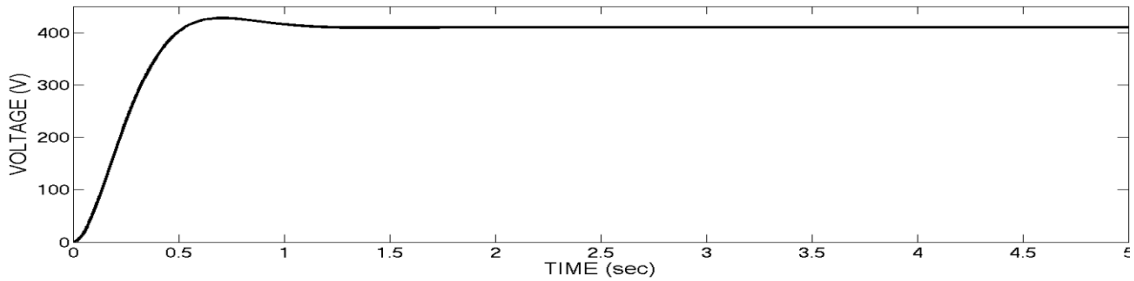

Fig.6 output voltage after boosting for perturb and observe method

By observing the above waveform, there is a linear rise in the voltage upto 430V and decreased to 410V. It takes about 1.2 sec to reach the steady state.

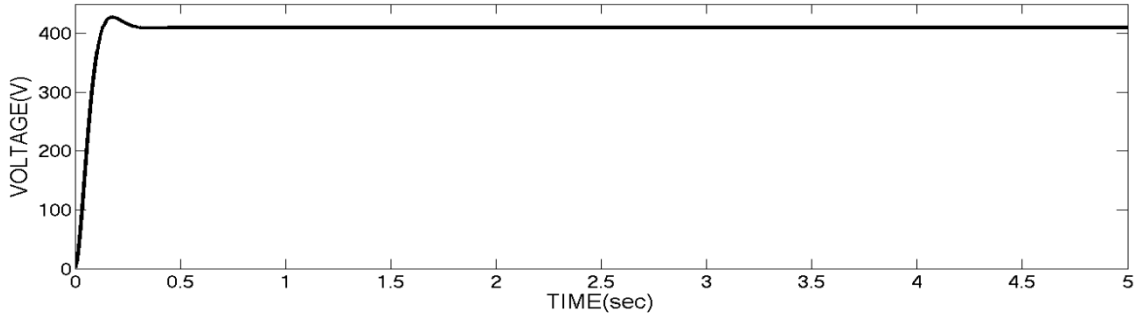

Fig.7 output voltage after boosting for incremental Conductance method

In the above waveform, voltage reached steady state in 0.3sec. Comparing both the waveforms voltage is around 410V in both the cases but steady state is reached in less time in incremental conductance method.

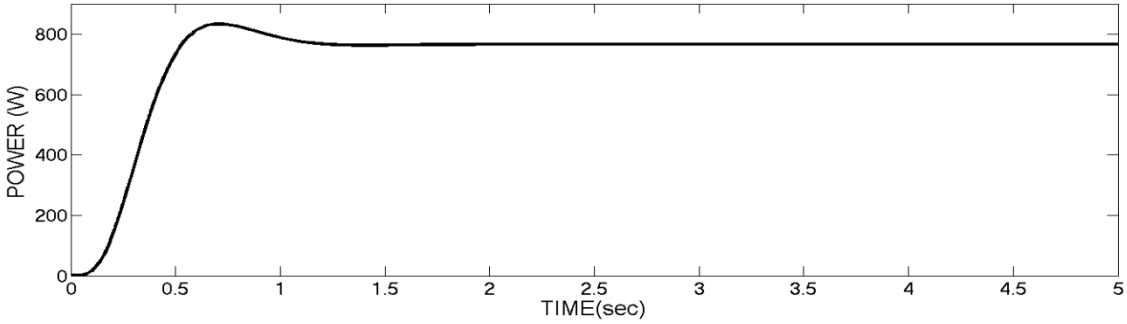

Fig.8 maximum output power of PV system for perturb and observe method

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

From the above waveform, we can say that the maximum power for perturb and observe technique takes nearly 0.9sec to reach steady state value that is 800 watts. In the below waveform, power output takes 0.25sec to reach final state.

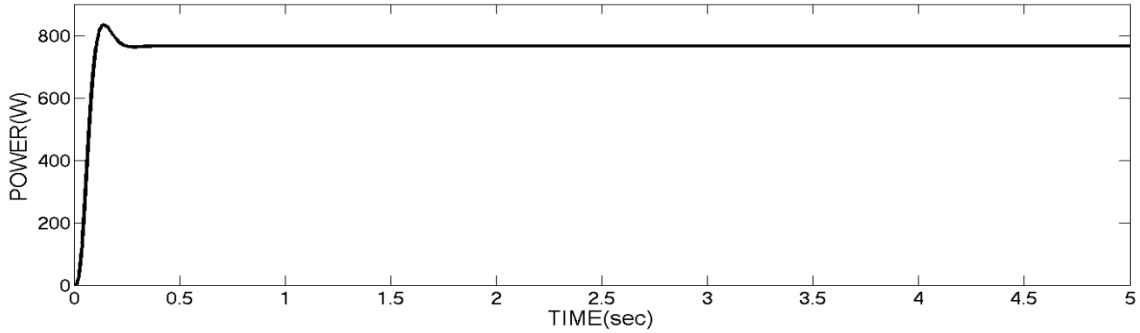

Fig.9 maximum output power of PV system for incremental conductance method

Comparing the two waveforms of maximum output power, steady state is reached quickly in the case of incremental conductance and there is reduction in the ripple. Here the output power is around 800 watts.

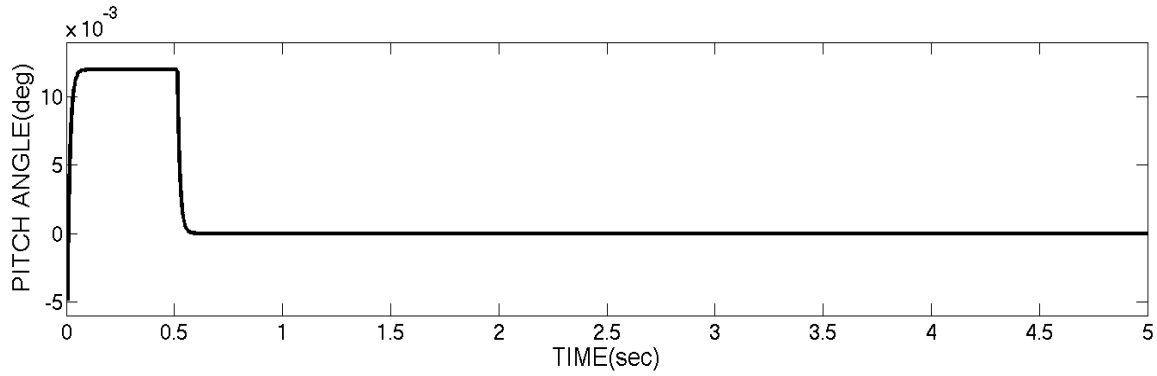

Fig.10 pitch angle of the wind turbine

Here we have taken pitch angle as zero, and it depends on turbine shaft. From the above we can say that the pitch angle does not become zero at once. It takes about 0.5sec to reach it.

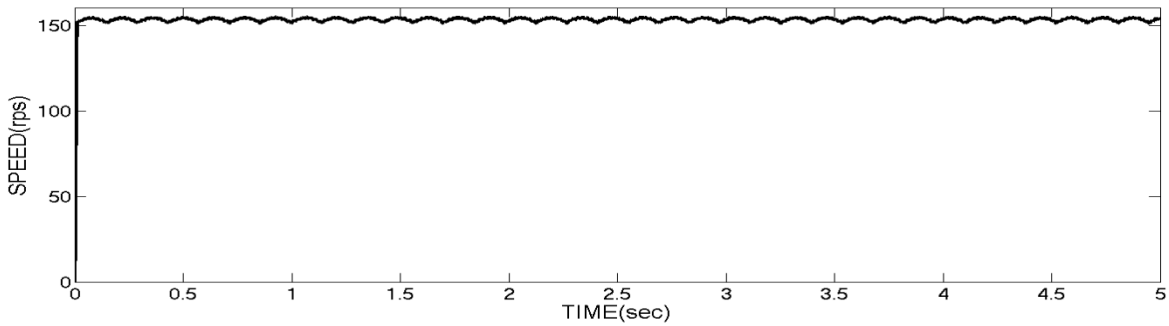

Fig.11 speed of the PMSG

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

Here pitch angle is maintained at zero by using pitch angle controller. The speed of the PMSG is nearly 152 rad/sec and input wind speed is maintained at 15 m/s. By changing the input irradiance value and input wind speed, the output voltage and power get changed.

IX.CONCLUSION

This paper provides a hybrid system comprises of solar photovoltaic and wind energy conversion systems. In turn the boost converter in the solar system is analysed by two MPPT techniques. By observing we can conclude that incremental conductance method is preferable to perturb and observe method.

In future this hybrid system can be designed using Intelligent Control techniques. It can be analysed by using other available MPPT techniques.

REFERENCES

[1] Ruchika, Gour Rithika, Jain pulkit, Rashmi, Mittal Rajveer, Deswal S.S.'PMSG based Isolated Wind Energy Conversion system (WECS) for Variable load', IEEE, 978-1-4673-0934-9/12, 2012.
[2] Solanki C.S, 'Solar photovoltaic's fundamentals, technologies and application' second edition.
[3] A. Pandey, N. Dasgupta, and A.K. Mukerjee, "Design issues in implementing MPPT for improved tracking and dynamic performance", 32nd IECON, pp.4387-4391, Nov.2009.
[4] M.R. Islam, R.Saidur, "Usage of solar energy and its status in Malaysia, "Engineering e- transaction, vol.5, no.1, pp.6-10, 2010.
[5] Aeronautics and Space Administration (NASA-CR-149364) National, Solar Cell Array Design Handbook, vol.1, Jet Propulsion lab, 1976.
[6] T.Esram and P.L.Chapman,"Comparison of photovoltaic array maximum power point tracking techniques", IEEE Trans, Energy conversion, vol.22, no.2, June 2007.
[7] N.Femia, D.Granozio, G.Petrone,"Predictive and Adaptive MPPT perturb and observe method,"IEEE Trans.Aerosp, vol.43, no.3 July 2007.
[8] R.J.Wai, W.H.Wang and C.Y.Lin, "High performance stand alone photovoltaic generation system", IEEE Trans,ind. Electron, vol.55, no.1, pp.240-250, Jan.2008
[9] F.Liu, S.Duan, "A Variable step size INC MPPT method for PV system", IEEE Trans.vol.55, no.7, Jul.2008.
[10] F.Liu and P.xu, "Analysis and Improvement of maximum power point tracking algorithm based on incremental conductance method for PV Array", IEEE PEDS, pp.637-641, 2007.

.