# Design and Simulation of Grid Connected Wind Photovoltaic Hybrid System using MATLAB

**Abhishek Kaundal[1] Nitesh Chauhan[2] Vikas Pathania[3] Amit Kumar Thakur[4] Harpreet Kaur Channi[5]**

[1,2]Department of Electrical Engineering

[1,2]Chandigarh University, Gharuan, Mohali, India

*Abstract*— Renewable energy sources have become a popular alternative electrical energy source where power generation in conventional ways is not practical. In the last few years the photovoltaic and wind power generation have been increased significantly. In this study, we proposed a hybrid energy system which combines both solar panel and wind turbine generator as an alternative for conventional source of electrical energy like thermal and hydro power generation. A simple control technique which is also cost effective has been proposed to track the operating point at which maximum power can be coerced from the PV system and wind turbine generator system under continuously changing environmental conditions. In this paper the entire hybrid system is described given along with comprehensive simulation results that discover the feasibility of the system. A software simulation model is developed in Matlab/Simulink.

***Keywords:*** Alternative, Generation, MATLAB, Simulink, Environment

## I. INTRODUCTION

Due to the critical condition of industrial fuels which include oil, gas and others, the development of renewable energy sources is continuously improving. This is the reason why renewable energy sources have become more important these days. Few other reasons include advantages like abundant availability in nature, eco-friendly and recyclable. Many renewable energy sources like solar, wind, hydel and tidal are there. Among these renewable sources solar and wind energy are the world's fastest growing energy resources. With no emission of pollutants, energy conversion is done through wind and PV cells. Day by day, the demand for electricity is rapidly increasing. But the available base load plants are not able to supply electricity as per demand. So these energy sources can be used to bridge the gap between supply and demand during peak loads. This kind of small scale stand-alone power generating systems can also be used in remote areas where conventional power generation is impractical. In this project, a wind-photovoltaic hybrid power generation system model is studied and simulated. A hybrid system is more advantageous as individual power generation system is not completely reliable. When any one of the system is shutdown the other can supply power. A block diagram of entire hybrid system is shown below in figure 1.

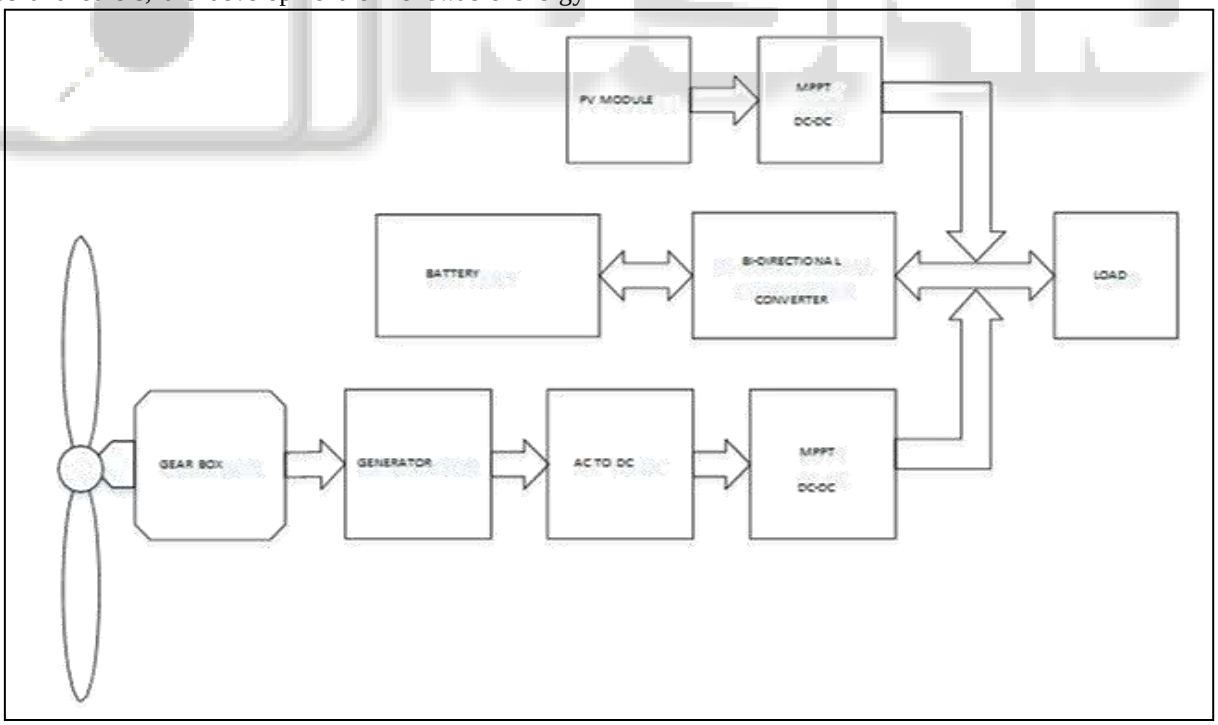


Fig. 1: Block diagram of hybrid system

The entire hybrid system comprises of PV and the wind systems. The PV system is powered by the solar energy which is abundantly available in nature. PV modules, maximum power point tracing systems make the PV energy system. The light incident on the PV cells is converted into electrical energy by solar energy harvesting means. The maximum power point tracking system with Perturb & absorb algorithm is used, which extracts the maximum possible power from the PV modules. The ac-dc converter is used to converter ac voltage to dc. Wind turbine, gear box, generator

 

and an AC – DC converter are included in the wind energy system. The wind turbine is used to convert wind energy to rotational mechanical energy and this mechanical energy available at the turbine shaft is converted to electrical energy using a generator. To coerce the maximum power from wind system we used a maximum power point tracking system. Both the energy systems are used to charge a battery using bi-directional converter. Bidirectional converter and the battery form the common additional load to the wind and PV energy systems. Hybrid generation systems that use more than a single power source can greatly enhance the certainty of load demands all the time. Even higher generating capacities can be achieved by hybrid system. In stand-alone system we can able to provide fluctuation free output to the load irrespective of weathers condition. To get the energy output of the PV system converted to storage energy, and constant power delivered by the wind turbine, an efficient energy storage mechanism is required, which can be realized by the battery bank.

## II. LITERATURE REVIEW

Due to high demand of energy and limited availability of conventional energy, non- conventional sources become more popular among researchers. A lot of research work is going on to enhance the power efficiency of non-conventional sources and make it more reliable and beneficial. Hybrid generation system uses more than one source, so that we can extract energy from different sources at the same time which enhances the efficiency. From [2],[3] the working of PV /Wind hybrid system is understood, different topologies that can be used for the hybridization of more than one system and also about advantages and disadvantages of hybrid system. From [1], [4] and [5] basic details of PV cell, PV module, PV array and their modeling are studied. Also, the behavior of PV modules at varying environmental conditions like solar irradiation and temperature are studied. Behavior of PV module during partial shading condition and also how it's bad effects can be minimized is explained in [6]-[8]. Different MPPT techniques, their advantages and disadvantages and why MPPT control is required is explained in [9]-[11].The wind energy system, its working and also techniques to extracts the maximum power from the wind energy system is understood from [13]- [17]. From [18]-[20] study about different type of bi-directional converters, their working and how to use them in battery charging and discharging is carried out.

## III. OBJECTIVES

The main objective of the thesis is to implement a power system that is a hybrid of both Photovoltaic and wind powers. The step by step objectives are

1) To study and model PV cell, PV array and PV panels
2) To study the characteristic curves and effect of variation of environmental conditions like temperature and irradiation on them
3) To study the PV module's behaviour under partial shading condition
4) To trace the maximum power point of operation the PV panel irrespective of the changes in the environmental condition.

## IV. METHODOLOGY

### *A. Photovoltaic Arrangement*

It contains PV modules or arrays, which convert solar energy in the form of solar irradiation into electric energy. The dc-dc converter changes the level of the voltage to match it with the electrical appliances that are supplied by this system. This DC-DC converter may be either buck or boost or buck-boost contingent on the required and available voltage levels. The maximum power point tracing system coerces the maximum power from the PV modules as shown in figure 2. A bi-directional converter which is able to supply the current in both the directions is used to charge the battery when there is a power surplus and the energy stored by the battery is discharged into the load when there is a power deficit.

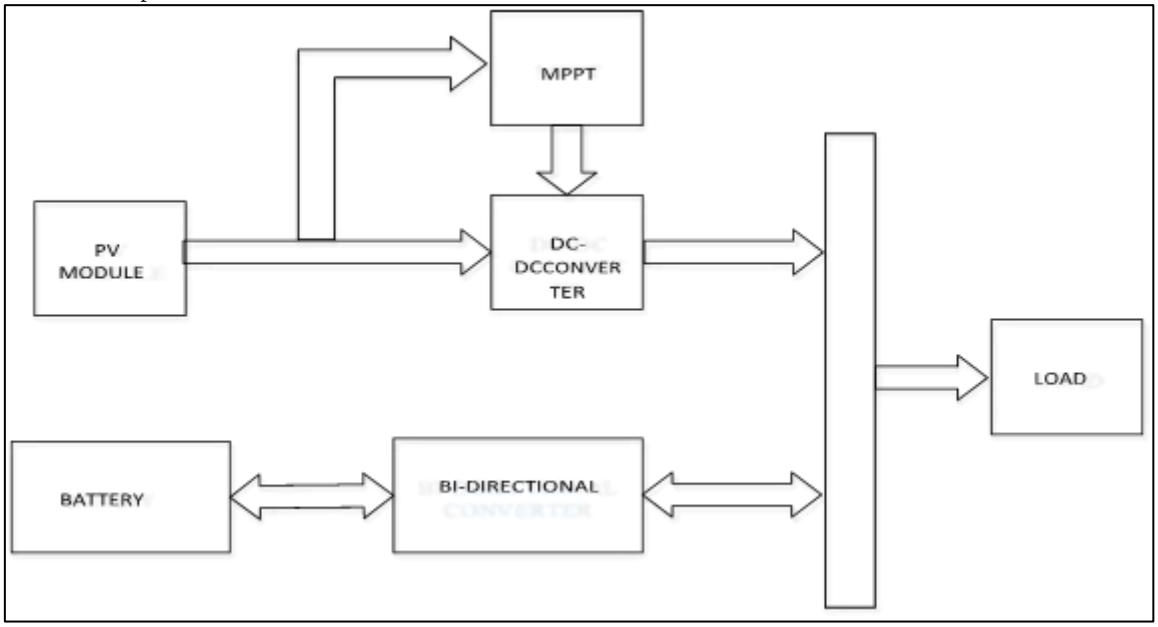


Fig. 2: Overall block diagram of PV energy system

 

## V. MAXIMUM POWER POINT TRACKING

Maximum power point tracing (MPPT) system is an electronic control system that can be able to coerce the maximum power from a PV system. It does not involve a single mechanical component that results in the movement of the modules changing their direction and make them face straight towards the sun. MPPT control system is a completely electronic system which can deliver maximum allowable power by varying the operating point of the modules electrically [9].

### *A. MPPT algorithm*

There are many algorithms which help in tracing the maximum power point of the PV module. They are following:

1) P&O algorithm
2) IC algorithm
3) Parasitic capacitance
4) Voltage based peak power tracking
5) Current Based peak power tracking

## VI. WIND POWER SYSTEM

The schematic diagram of the wind energy system is manifested in figure below in figure 3.

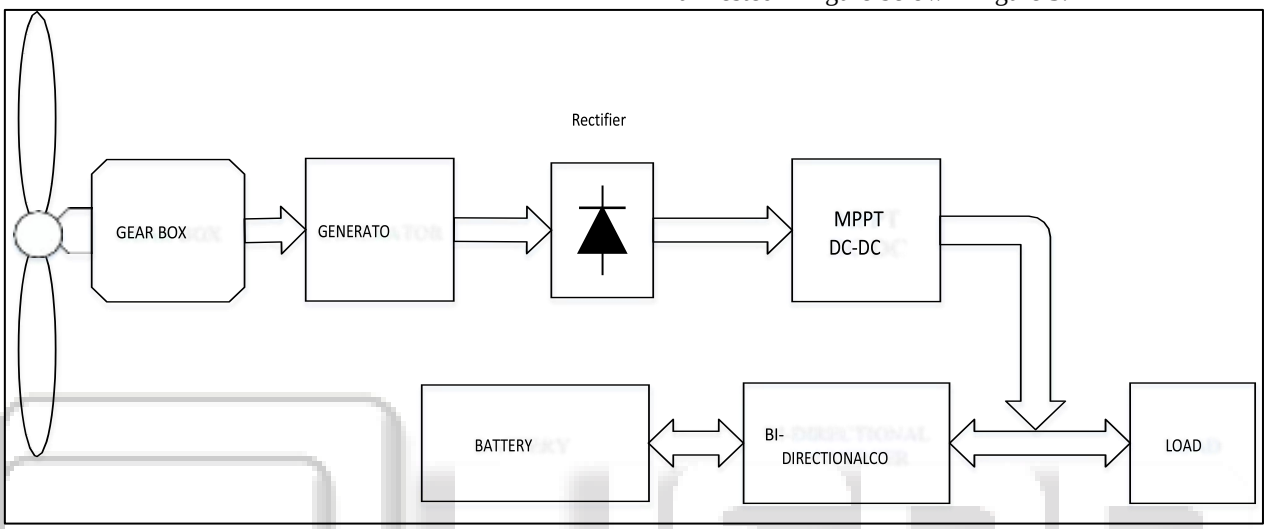


Fig. 3: Overall diagram of wind energy system

This system comprises of a wind turbine which transforms wind's kinetic energy into rotating motion, a gear box to match the turbine speed to generator speed, a generator which converts mechanical energy into electrical energy, a rectifier which converts ac voltage to dc, a controllable dc-dc converter to trace the maximum power point, a battery is charged and discharged through directional converter.

## VII. RESULTS AND FUTURE SCOPE OF WORK

### *A. Results:*

Figure 4 shows the system Matlab simulink model. Figure 5- 7 shows the important output waveforms.

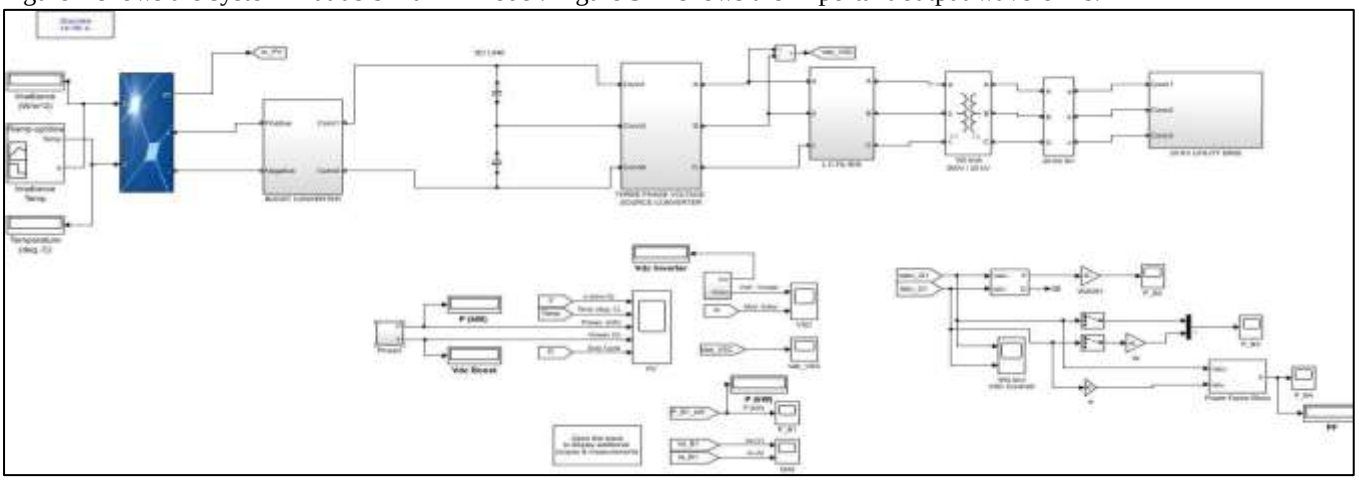

Fig. 4: Simulink model

 

*B. Simulation results of PV module*

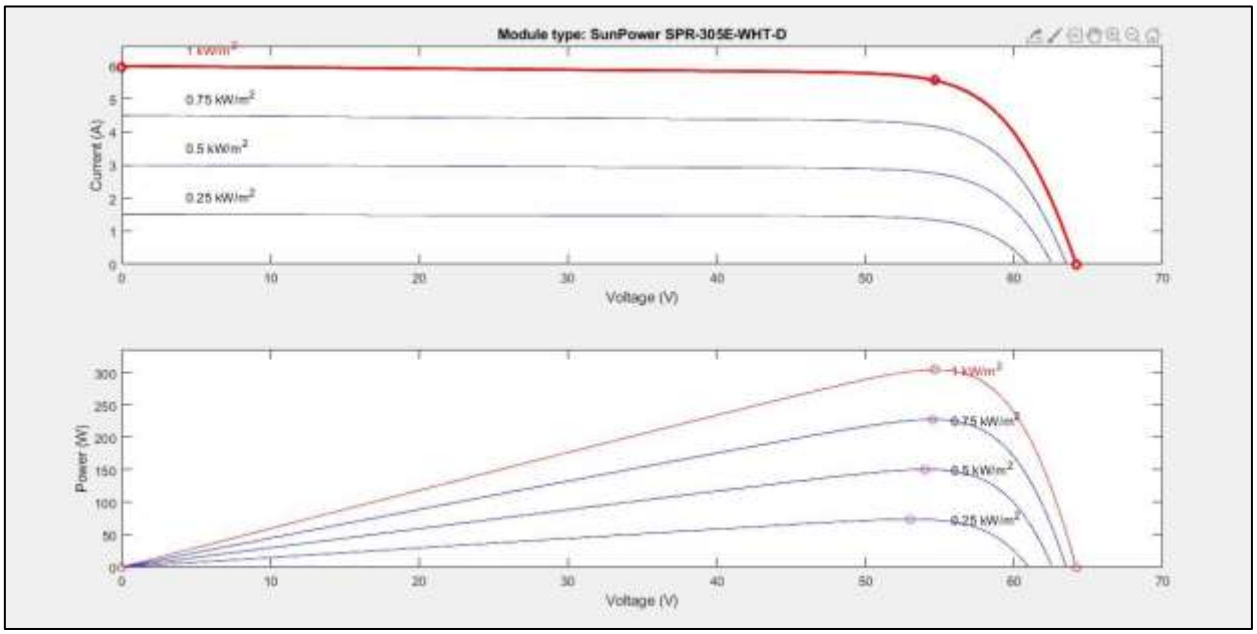


Fig. 5: (a) Current-voltage (I-V) characteristics of PV array. (b) Power-voltage (P-V) characteristics of PV array.

Performance of PV station during variation of the solar irradiance is shown in figure 6.

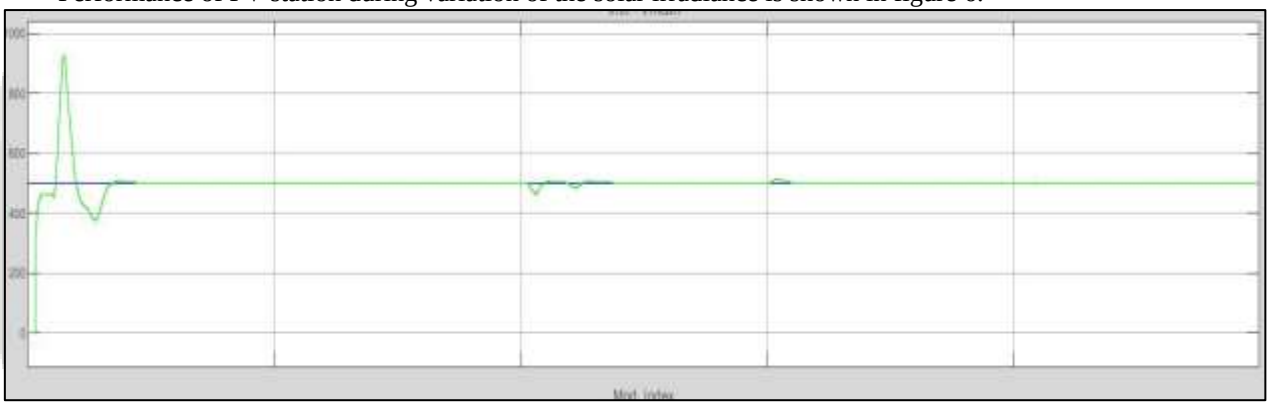

Fig. 6(a): PV DC-link Voltage.

Performance of wind farm during constant wind speed is shown in figure 7(a) -7(c).

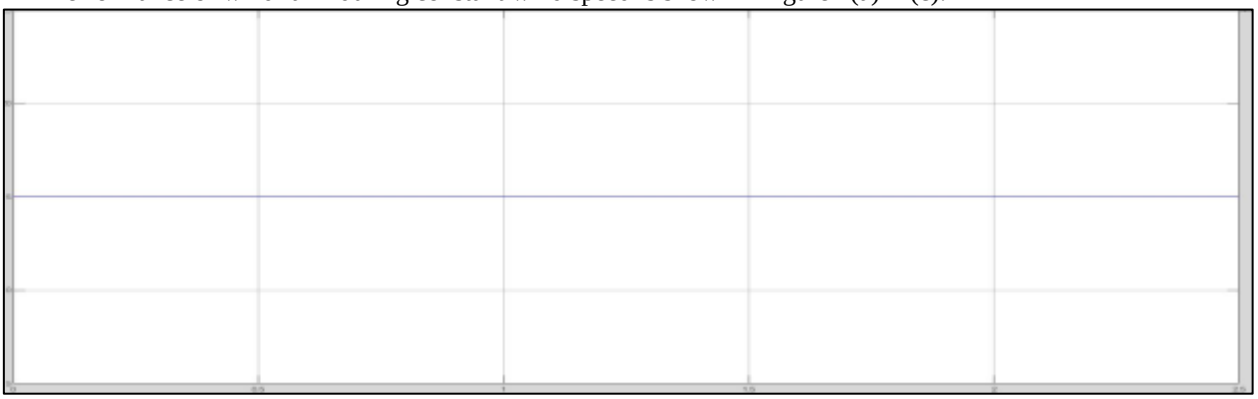

Fig. 7(a): Wind speed profile.

 

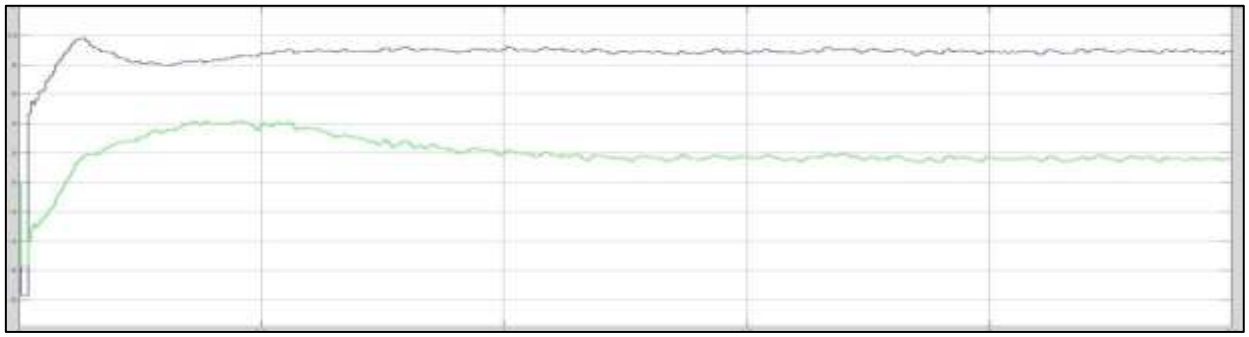

Fig. 7(b): Injected active and reactive power from the wind farm.

Fig. 7(c): The power factor of the wind farm.

## VIII. CONCLUSIONS

1) PV cell, module and array are simulated and effect of environmental conditions on their characteristics is studied.
2) Wind energy system has been studied and simulated
3) Maximum power point of operation is tracked for both the systems using P&O algorithm
4) Both the systems are integrated and the hybrid system is used for battery charging and discharging

## IX. FUTURE SCOPE

1) MPP can be tracked using different algorithms(e.g. intelligent MPPT)
2) Battery charge controller can be designed for more reliable operation and better battery life.

## REFERENCES

[1] T. Salmi, M. Bouzguenda, A. Gagtli, "MATLAB/Simulink based modeling of solar photovoltaic cel," International journal of renewable energy research, vol.2, no.2, 2012.
[2] S. Meenakshi, K.Rajambal, S. Elangovan "Intel igent controller for stand-alone hybrid generation system," IEEE, May. 2006.
[3] Nabil A. Ahmed, Masafumi Miyatake, "A stand-alone hybrid generation system combining solar photovoltaic and wind turbine with simple maximum power point tracking control," IPEMC 2006, IEEE, 2006.
[4] M. G. Vil Alva, J. R. Gazoli, "Modeling and circuit based simulation of photovoltaic arrays," Brazilian power electronics conference (COBEP), 2009.
[5] Marcelo Gradel a Vil Alva, Jonas Rafel Gazoli, "Comprehensive approach to modeling and simulation of photovoltaic arrays," IEEE transaction on power electronics, vol.24, no.5, May 2009.
[6] Hiren Patel and Vivek Agarwal, "Matlab based modeling to study the effect of partial shading on PV array characteristics," IEEE transaction on energy conversion, vol.23, no.1, March 2008.
[7] Mohammed Abdulazeez, Ires Iskender, "Simulation and experimental study of shading effect on series and paral el connected PV modules," IEEE transaction on energy conversion, vol.27, no.2, March 2008.
[8] SiyuGuo, Timothly Michael Walsh, "Analyzing partial shading of PV module by circuit modeling," IEEE 2011.
[9] Zhou Xuesong, Song Daichun, Ma Youjie, Chen Deshu, "The simulation and design for MPPT of PV system based on Incremental conductance method," Wase International conference on information engineering, 2010.
[10] Azadeh Safari, Saad Mekhilef, "Simulation and Hardware Implementation of Incremental Conductance MPPT with Direct Control Method Using Cuk Converter," IEEE transaction on industrial electronics, vol. 58, no. 4, April 2011.
[11] Mihnea Rosu-Hamzescu, Sergiu Oprea, "Practical guide to implementing Solar panel MPPT algorithm," Microchip technology Inc, 2013.M. Gengaraj, J. Jasper Gnanachandran, "Modeling of a standalone photovoltaic system with charge controller for battery energy storage system," International Journal of Electrical Engineering, vol.6, no. 3, 2013.
[12] M. Gengaraj, J. Jasper Gnanachandran, "Modeling of a standalone photovoltaic system with charge controller for battery energy storage system," International Journal of Electrical Engineering, vol.6, no. 3, 2013.
[13] T. Taftichat, K. Agbossou, "Output power maximization of a permanent magnet synchronous generator based stand-alone wind turbine system," IEEE ISIE July 9-6 2006.
[14] Roger Gules, Juliano De pellegrin Pacheco, "Maximum power point tracking system with Parallel connection

 

for PV stand-alone application," IEEE transaction on industrial electronics, vol.55, no.7, July 2008
[15] S. Rahmani, Ab. Hamadi, A. Ndtoungou, "Performance evaluation of a PMSG-based variable speed wind generation system using maximum power point tracking," IEEE electrical power and energy conference 2012.
[16] Majid Jamil, Ravi Gupta, "A review of power converter topology used with PMSG based wind power generation," IEEE, 2012.
[17] Eftichios Koutroulis, Kostas Kalaitzakis, "Design of a maximum power tracking system for wind-energy conversion application," IEEE Transaction on industrial electronics, vol. 53, no.2, April 2006.
[18] C. Lin, S. yang, G.W. Wu, "Study of a non-isolated bidirectional dc-dc converter," IET power electronics. vol.6, 2013.
[19] M. Ahmadi, K. Shenai, "New, Efficient, low-stress buck-boost bidirectional dc-dc converter," IEEE, 2012.
[20] Zhil ing Liao, Xinbo Ruan, "Control strategy of bi-directional dc-dc converter for a novel stand-alone photovoltaic power system," IEEE vehicle power and propulsion conference (VPPC), September 2008.
[21] Mohd. Hasan Ali, "WIND ENERGY SYSTEMS Solutions for Power Quality and Stabilization" 2012.

 