TEST Engineering & Management

May-June 2020
ISSN: 0193-4120 Page No. 10304 - 10309

Performance analysis of hybrid PV and WIND System for Microgrid Applications

Dr.C.Santhana Lakshmi[1], Dr.D.Prasad[2], N.Tamilvaanan[3], Dr.R.Satheesh Kumar[4]

Article Info
Volume 83
Page Number: 10304 - 10309
Publication Issue:
May - June 2020

Article History
***Article Received**: 19 November 2019*
***Revised**: 27 January 2020*
***Accepted**: 24 February 2020*
***Publication**: 18 May 2020*

Abstract:
Renewable energy sources have become an alternative electrical energy source for power generation. In the last few years, the power generation using PV and wind have been increased significantly. In this study, a hybrid energy system which combines both solar panel and wind turbine generator is proposed as an alternative for conventional source of electrical energy. 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. The entire hybrid system is described given along with comprehensive simulation results that discover the feasibility of the system.

***Keywords**: PV, Wind, P&O algorithm, MPP.*

I.INTRODUCTION

The depletion of natural reserves such as oil coal and other fossil fuel resources have made to the human society to graze towards the renewable energy sources [RES]. In nature, numerous RES are available. Among those solar and wind plays a vital role in power generation. They can also reduce the pollution significantly by generating clean energy. Hence, all the world power generations are moving toward the RES based power generation system. Hence, this work presents a novel hybrid (wind – PV battery) power generation system which can be employed for power distribution in rural/ remote area. Most of the RES requires less maintenance and lower operating costs when compared to fossil fuel power generating station.

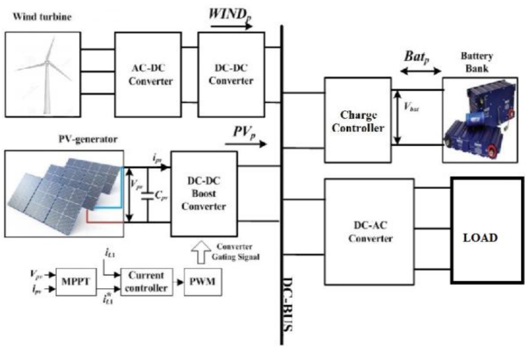

Fig 1. Block diagram of the test system

It comprises PV, wind and battery storage unit. Whenever the RES are not available, the battery is designed in such a way to deliver power to the load. Then the generated DC power is converted into AC using an inverter and is supplied to the AC loads which are connected with it.

II. MODELLING OF PV SYSTEM

* Correspondence Author
[1]**Dr.C.Santhana Lakshmi,** Assistant professor, Department of EEE, Sona College of Technology, Salem 636005.
[2]**Dr.D.Prasad,** Assistant professor, Department of EEE, Sona College of Technology, Salem 636005.
[3]**N.Tamilvaanan,** PG Scholar,Department of EEE, Sona College of Technology, Salem 636005.
[4]**Dr.R.Satheesh Kumar,** Assistant professor, Department of EEE, Sona College of Technology, Salem 636005

May-June 2020
ISSN: 0193-4120 Page No. 3672 - 3680

A PV array consists of several number of PV cells which may be connected either in parallel/series combination. The diode model of a PV cell is depicted in figure 2.

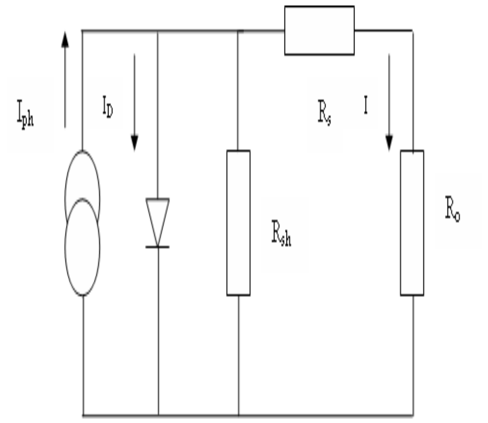

Fig 2. Equivalent circuit of a PV cell.

The mathematical model of a PV array is expressed by the following equation:

$$I = n_p I_{ph} - n_p I_s \left[exp\left(\frac{q}{KTA}\right) * \left(V/n_s\right) - 1\right]$$

Thus the PV power can be represented as

$$P = IV = n_p I_{ph} V[(q/KTA)*(V/n_s) - 1]$$

However, the variations in the weather condition, the output of the PV get affected. Hence, to overcome this drawback, an efficient tracking is developed using a MPPT tracker.Among the various types of MPPT tracking algorithm, perturb and observe (P&O) algorithm is commonly implemented in all practical PV system. This is preferred because of its simplicity.

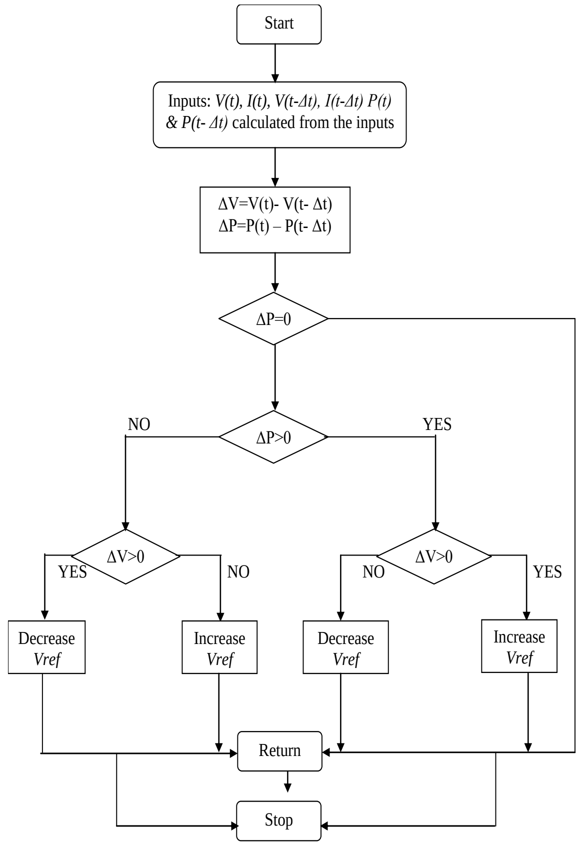

Fig 3. Flowchart of P&O algorithm.

Hence, in this a solar system about 10 kW is designed for power generation. Then, the output of this PV system is connected to the cuk converter.

Modeling of wind turbine

The modeling of wind turbine is based on the availability of wind

$$P_{wind} = \frac{1}{2}\rho A V^3$$

Where

ρ - Air density

A – Total Rotor Area

V- Speed (wind)

Thus, the power generated by the turbine is denoted

$$P_{wt} = C_p . P_{wind}$$

C_p – Coefficient derived from betz limit.

III .BATTERY DESIGN

The energy storage batteries are designed to store the energy produced by the RES. During the failure of RES, the energy stored in the battery is utilized to supply the load. In this work, lead acid

May-June 2020
ISSN: 0193-4120 Page No. 10304 - 10309

batteries of capacity 400V, 6.5 Ah is implemented because of its long period backup.

Thus the power produced by these two sources are combined together the total power will be equal to

$P_T = P_W + P_{PV}$

The combined output obtained from wind and PV is converted into AC using voltage source inverter.

IV. RESULT AND DISCUSSION

To demonstrate the effectiveness of the proposed topology, simulations were carried out using MATLAB simulation.

Fig 4.1, 4.2 represents the I-V and P-V characteristics of a PV module. From fig 4.1 it can be observed that that short circuit current (I_{sc}) of PV module is approximately 8.2A and open circuit voltage (V_{oc}) is approximately 32.9 volts. From fig 4.2, the maximum power is approximately 200W and it occurs at a current of 7.61A and voltage at 26.3V approximately.

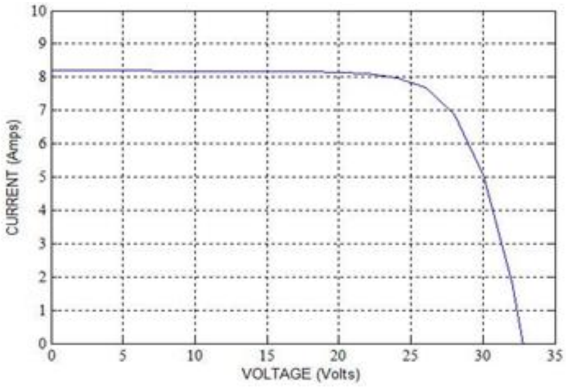

Fig. 4.1 V-I curve of PV module.

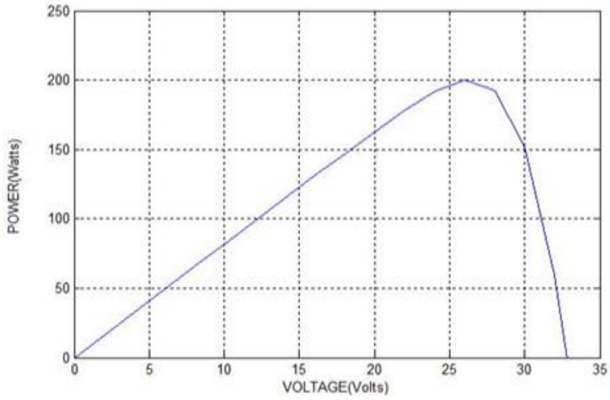

Fig. 4.2 P-V curve of PV module.

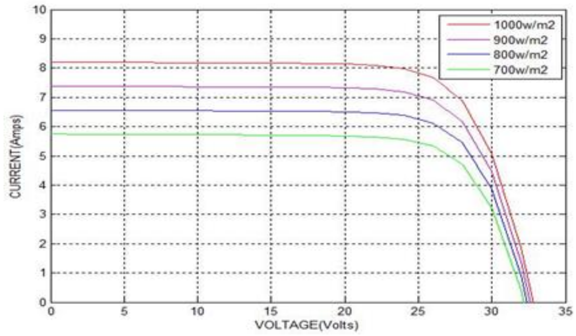

Fig. 4.3 Effect of variation of irradiation on I-V characteristics

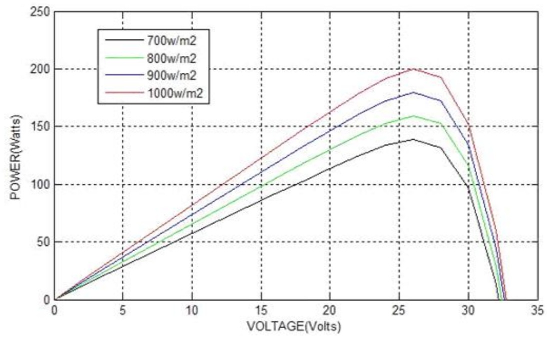

Fig. 4.4 Effect of variation of irradiation on P-V characteristics

Fig 4.3 and 4.4 shows the effect of change in solar irradiation on PV characteristics. From fig 4.3, it is observed that the increase the solar irradiation short circuit current increases. Variation in Solar irradiation effects mostly on current, if there is an increase solar irradiation from 700 w/m^2 to 1000 w/m^2 current increases from 5.7A to 8.2A approximately but effect of variation of solar irradiation on voltage is very less. Fig 4.4 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.

TEST Engineering & Management

May-June 2020
ISSN: 0193-4120 Page No. 3672 - 3680

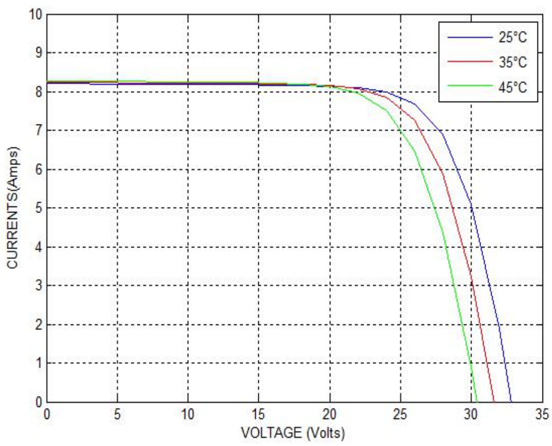

Fig. 4.5 Effect of variation of temperature on I-V characteristics

The outcome of variation of temperature on I-V characteristics is shown in the fig 4.5. From the fig 4.5, the variation of temperature mostly effects voltage, as the increase the temperature voltage decreases but current remains almost unaltered. Fig 4.6 shows effect of temperature variation on the P-V characteristics. As temperature increases power generated decreases, because on increment of temperature voltage decreases.

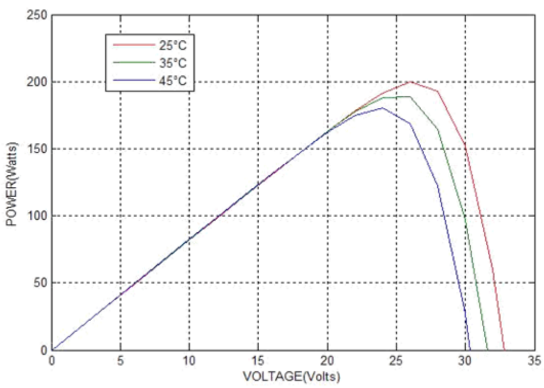

Fig. 4.6 Effect of variation of temperature on P-V characteristics.

V. SIMULATION RESULT OF WIND ENERGY SYSTEM

Fig 4.7 shows turbine power characteristics at different wind speed. From the fig 4.7 it is observed that as wind speed increases turbine output power also increases.

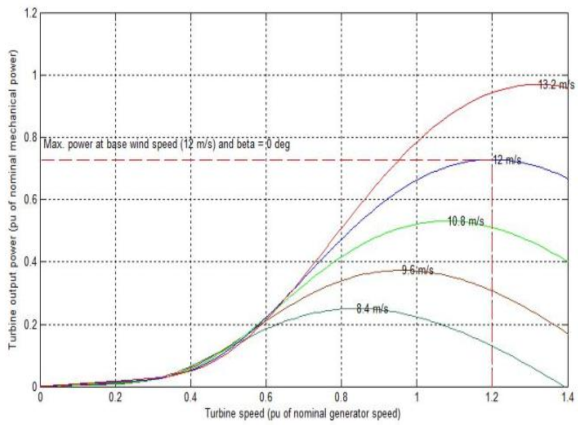

Fig 4.7 Turbine Power characteristics (pitch angle beta=0°)

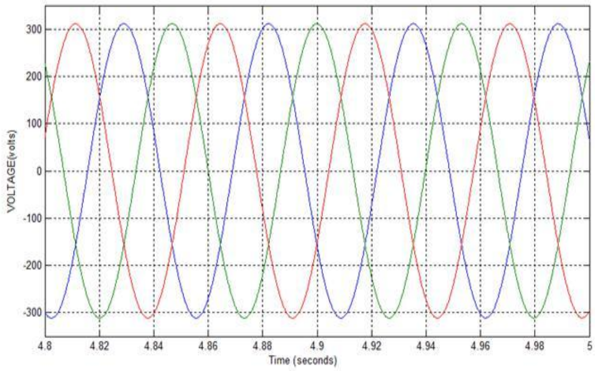

Fig 4.8 Three phase line output voltage of PMSG.

VI. CHARGING/ DISCHARGING CHARACTERISTICS OF BATTERY

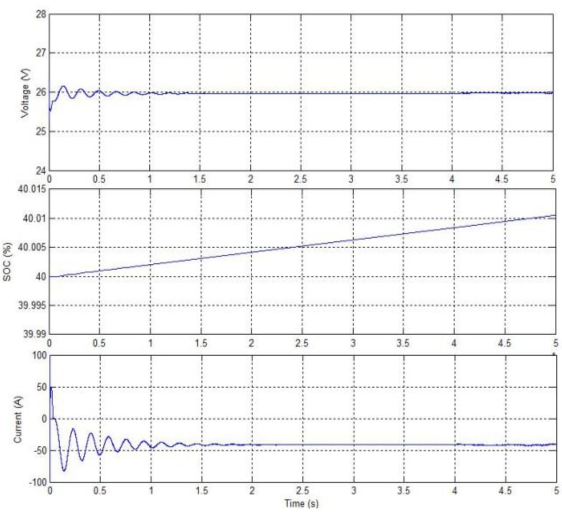

Fig 4.9. Charging characteristics of battery

From fig 4.9 it is observed that during charging, SOC of the battery is gradually increasing and also

May-June 2020
ISSN: 0193-4120 Page No. 10304 - 10309

during charging current is negative. It is found that 40% SOC battery voltage is around 26 volts, as state of charge of battery is increased battery voltage exceeded its nominal voltage.

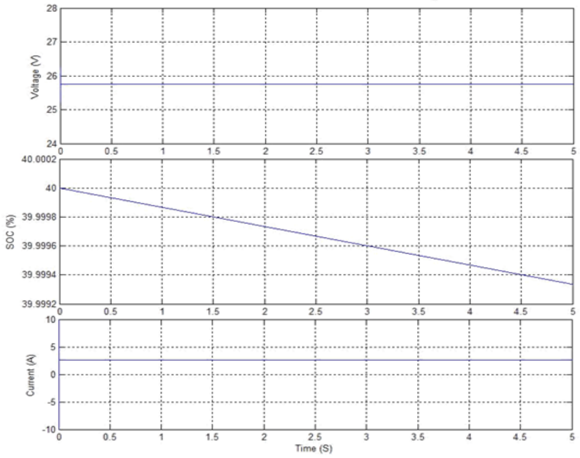

Fig 4.10. Discharging characteristics of battery.

From fig 4.9, during discharging, battery start supplying constant voltage and state of charge start decreasing and also during discharging current become positive, which shows battery is supplying the power to the load.

VII. COMBINED PV AND WIND SUPPLY TO THE LOAD

Figure 4.10 depicts the current and voltage waveforms of system.

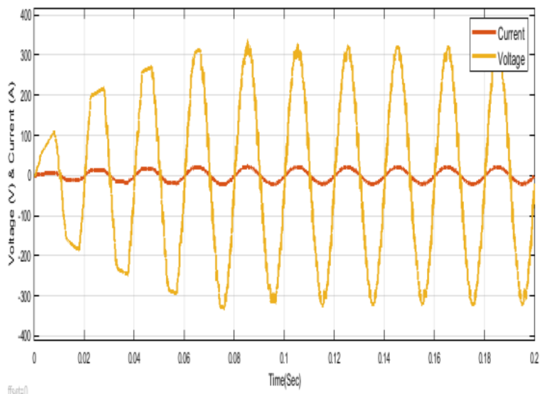

Figure 4.11. Voltage and current waveform of the system.

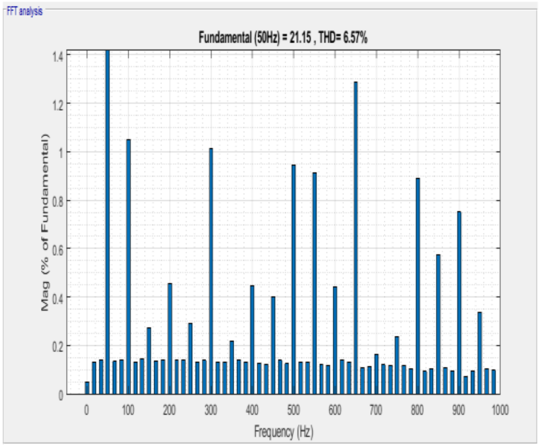

Fig 4.12. FFT analysis

From the figure, the total harmonic distortion (THD) considering the maximum frequency as 500 Hz is found out to be 6.50%. From the figure, it is concluded that this proposed system exhibits higher harmonics due to the presence of more switching devices in the power generation unit.

VIII. CONCLUSION

This proposed scheme of wind–solar hybrid system considerably improves the performance of the WECS in terms of enhanced generation capability. The solar PV augmentation of appropriate capacity with minimum battery storage facility provides solution for power generation issues during low wind speed situations.

REFERENCES

1. Natsheh, E.M.; Albarbar, A.; Yazdani, J., "Modeling and control for smart grid integration of solar/wind energy conversion system," 2nd IEEE PES International Conference and Exhibition on Innovative Smart Grid Technologies (ISGT Europe),pp.1-8, 5-7 Dec. 2011.
2. Bagen; Billinton, R., "Evaluation of Different Operating Strategies in Small Stand-Alone Power Systems," IEEE Transactions on Energy Conversion, vol.20, no.3, pp. 654-660, Sept. 2005

May-June 2020
ISSN: 0193-4120 Page No. 3672 - 3680

3. S. M. Shaahid and M. A. Elhadidy, “Opportunities for utilization of stand-alone hybrid (photovoltaic + diesel + battery) power systems in hot climates,” Renewable Energy, vol. 28, no. 11, pp. 1741–1753, 2003
4. Goel, P.K.; Singh, B.; Murthy, S.S.; Kishore, N., "Autonomous hybrid system using PMSGs for hydro and wind power generation," 35th Annual Conference of IEEE Industrial Electronics, 2009. IECON '09, pp.255,260, 3-5 Nov. 2009.
5. Foster, R., M. Ghassemi, and A. Cota, Solar energy: renewable energy and the environment. 2010, Boca Raton: CRC Press.
6. Salam, Z.; Ishaque, K.; Taheri, H., "An improved two-diode photovoltaic (PV) model for PV system," 2010 Joint International Conference on Power Electronics, Drives and Energy Systems (PEDES) & 2010 Power India, pp.1,5, 20-23 Dec. 2010.
7. Yuncong Jiang; Qahouq, J.A.A.; Orabi, M., "AC PV solar system distributed architecture with maximum power point tracking," IEEE 34th International Telecommunications Energy Conference (INTELEC), pp.1-5, Sept. 30 2012-Oct. 4 2012.
8. Paul C.-P. Chao • Wei-Dar Chen • Chih-Kuo Chang . Maximum power tracking of a generic photovoltaic system via a fuzzy controller and a two-stage DC–DC converter . 30 September 2011 / Accepted: 23 April 2012 / Published online: 9 May 2012
9. Villalva MG, Gazoli JR. Comprehensive approach to modeling and simulation of photovoltaic arrays. IEEE Trans Power Electron 2009;24:1198–208.
10. Faranda, R. and Leva, S. (2008) Energy Comparison of MPPT Techniques for PV Systems. WSEAS Transactions on Power Systems, 3, 447-455.
11. Zainal Salam, Jubaer Ahmed, Benny S. Merugu “The application of soft computing methods for MPPT of PV system: A technological and status review ” ELSEVIER Applied Energy 107 (2013) 135–148
12. Nur Atharah Kamarzamana, Chee Wei Tan, “A comprehensive review of maximum power point tracking algorithms for photovoltaic systems, “Renewable and Sustainable Energy Reviews,vol.37,pp585-598,Sep 2014
13. Ridha BENADU', Brahim KHIARI' , Anis SELLAMI “ Predictive Current Control Strategy for a Three-Phase Grid Connected PhotovoltaicWind Hybrid System” 978-1-4673-9768-1/16/$31.00 ©2016 IEEE
14. Dong-Min Miao; Jian-Xin Shen, "Comparative study on permanent magnet synchronous generator systems with various power conversion topologies," 2013 Fourth International Conference on Power Engineering, Energy and Electrical Drives (POWERENG), pp.1738- 1743, 13-17, May 2013.
15. Salam, Z.; Ishaque, K.; Taheri, H., "An improved two-diode photovoltaic (PV) model for PV system," 2010 Joint International Conference on Power Electronics, Drives and Energy Systems (PEDES) & 2010 Power India, pp.1,5, 20-23 Dec. 2010.
16. S.Saib, A.Gherbi “Simulation and Control of hybrid renewable energy system connected to the grid” 978-1-4673-7172-8/15/$3l.00 ©2015IEEE