Design and Implementation of Multi-Junction PV Cell for MPPT to Improve the Transformation Efficiency

Vipasha Sharma, Harpreet Kaur, Inderpreet Kaur

ABSTRACT--- In the paper it represent the phenomenon of the PV cell or panel or traves the dissimilar model, like as Double diode or Single diode .Main principle of the paper is design and implementation of MJSC to improved its transformation efficiency using simulink/MATLAB. To accomplished the simulation of Double diode or Single diode has been developed. Simulation modified result represent that the tandem cell can give 3- times larger efficiency as comparison to conventional cell. The method was eventually utilization is to finding out affect of the radiation or temperatures in the generation of electricity. MPPT technique was used to improve the multi-junction solar cell implementation for improvement of transformation efficiency. I-V or P-V graph represent double diode model give more precise result as contrast of single diode. The MJSCS decrease the temperature Influence or increase the size of band gap in simulation to improve the transformation efficiency.

Index Terms— Transformation efficiency, multi-junction PV cell, MPPT, solar cell, double/single diode models.

I. INTRODUCTION

Solar energy system is more and more essential energy resource, that is the sustainable or in equipped conditions, and a contamination free source of energy. Therefore, it has a numerous of benefits for environmental above the fossil fuel source of energy. According to report of IEA in 2014 which is entire worldwide production of power energy is approximately one% as supply from the solar cell [1]. And the estimation by the International Energy Agency, the PV or determined solar energy can be become the major main sector for the production of electricity in the upcoming year. The electro-magnetic spectrum principle describe that is the higher energy available only if we have shorter wave-length. Therefore, PV cell developments can be use in different kind of the materials to raise the ability of the broad for rising the PV cell transformation efficiency. Hence, the inquiry is undertake to detail possible raise the transformation efficiency of MJSC to give to upcoming year development.

To multi-junction solar cell is use as a combination of different type of material for a larger range of band gap. That can be improve the capacity of the absorption of Sunlight, crossways the spectrum of sunlight to attain the higher efficiency in the energy transformation. This situation a numeral of single diode has been combined or assemble to develop a MJSC's. The uppermost layer of MJSC's utilize as a largest band gap or the lower one layer decrease a band gap, photo-voltic solar cell junction is to response the precise missing spectrum state the earlier could not be absorb. The main cause for achieving the higher efficiency but MJSCs is that for reduce terminal heat loss.

Considerably due to energy transformation taking place across the shorter to larger wavelength of availability of inputs light spectrum [2]. By applying the different type MPPT method for improvement the performance multi-junction PV cell. MPPT used in P&O(Perturb and Observe), fixed voltage and incremental conduction technique. The main aim of this paper the output of these two developed maximum power point tracking technique [3-8].

In this paper there is a three main aim to attain. The First one is, deliberation of the different types of materials to be employed in a each multi-junction solar cell layer. That is require band gap energy matching and lattice matching. The distinctive material, for example Si, Al, AS and Ge has been separately used.

The second one is, single diode or double diode system has been used to contrast the P-V or I-V graphs responses by the changeable the irradiance or temperature. The triple or single diode models has also simulation or examined so as to explore distinctiveness the MJSCs. In the addition off, maximum power point tracking is found to be a compulsory part in photo-voltic systems for additional improvement of the transformation efficiency inside of MJSC.

In the section one represents about the all-inclusive significance of the multi-junction solar cell & provides the introduction to make known the technique has used, in section two it is the conditions is about the PV methodology or related technologies which specify procedure of project executions one by one, in section third it is simulate results or discussion, and in section fourth includes the conclusion .

II. METHODOLOGY OR PRINCIPLE OF PV CELL

A) Double and Single Diode Models

To classify the examine to procedure of sunlight transfer, a general technique is to construct the model or it representation the equivalent diagram of the p-n –p transistor . The stochastic process or its substitute equation are use to perform simulation of the solar temperature and irradiance condition. Solar system is a non-linear function,

Revised Manuscript Received on April 05,2019.

Vipasha Sharma M.E(EE) Research Scholar, Chandigarh University, Punjab, India. (sharma.vidya09@gmail.com)
Harpreet Kaur Ph.d Research Scholar, Chandigarh University, Punjab, India. (harpreetchanni@yahoo.in)
Inderpreet Kaur Professor, Chandigarh University, Punjab, India. (E-Mail:inder_preet74@yahoo.in)

so the utilization of double diode (fig. 2) or single (fig 1) system is the basic practical [3-5]

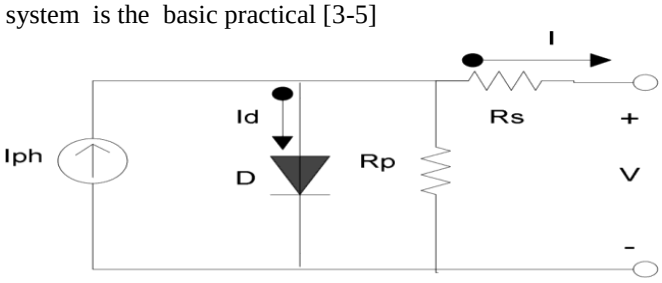

Figure 1: Equivalent circuit diagram of single diode model

The simplification Photo-voltaic cell arrangement or the subsequent formula describe from the circuit diagram of KCL

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

I_d is the current carrying diode which is directly proportional to the $I_o$diode saturation current, or which can be represent as

$$I_d = I_0 \left(\frac{V}{N_S - V_T} \right) \quad (2)$$

Here:-
I_d - diode current
I_o - saturation current of diode (A)
I_{ph} - leakage current in parallel resistance
N_s- no. of series cell
V_T- thermal voltage (V)

In general term R_s is the series resistance i.e. correlated to the drop in the voltage or losses in the internal current flow, or the R_p is parallel resistance i.e. correlated to its leakage current of reversed biased that is impacts the efficiency on the photo-voltaic model .

$$I = I_{Ph} - I_{D1} - I_{D2} - I_P$$

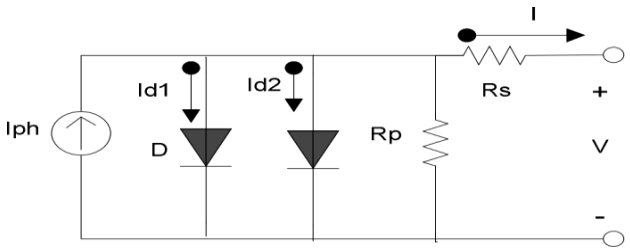

Figure 2: Equivalent circuit diagram of double diode model

A) The Multi-junction solar cell :-

The triple junction solar cell is the arrangement of 3 single p-n junctions , i.e. is connected through its channel or window junction to maintain the its polarization or to makes its photon's to going through its layer simply[7]. The circuit diagram of triple junction diode as shown in below fig

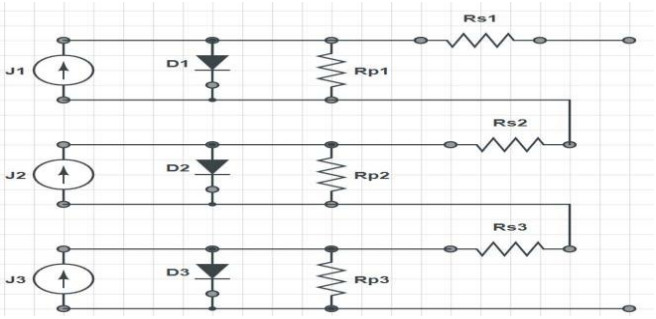

Fig:3 Identical circuit diagram of a 3- junctions solar cell

Identical circuit diagram to its the single junction diode model, density of current J_1, J_2, J_3 to their separate cells expressed in the (4),(5)

By KCL [8]

$$J_1 = J_{ph1} - J_{D1} - J_{pr1} \quad (4)$$

$$J_D = J_0 (e^{\frac{q(V+JAR_1)}{nkT}} - 1) \quad (5)$$

Here the,

k - Boltzmann constant 1.38064852 × 10-23 m^2 kg s^{-2} K^{-1}.
D - diode diffusion factor.

B) Maximum power point Tracking Techniques

The algorithmic program for P&O technique are used to measurement its voltage or current for its instant power output. Then the contrast of the power output in the time current point is make up of the earlier output of time power point. If the two power output are the same, it illustrate the state for maximum of output power is being achieve. The below fig.4 show the curve of the voltage curve and the output power [9].

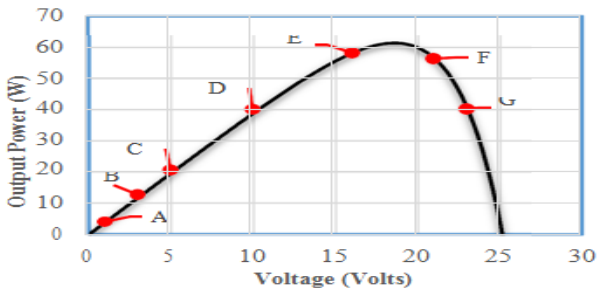

Figure 4: Proposed Method diagram

To the above fig.4 we observed the projected technique was developing for the uses the every points (from A to G point) in figure as suppose operative points. If its starting test is placed in the A point, the voltage or current of operational point A can calculate or its power output that can also be obtaining. After the adjustments of changing in its voltage, power output can we achieved in the operative point B, that is grater than it's the power output A.

Therefore, changing he value or level can be find out by the setting the value of B or A. Because the ΔP is the larger, therefore most important voltage changes can be occur in its results. So, uses its procedure, its output result can be obtained fast the operative point C. While the output power is obtained the in point E and cross the MPPT's is to obtained operative point in F, the changes in the ΔP is smaller than the earlier than, result at the lower adjustments in voltages is being execute. These is specially therefore, if the function point is move to obtained point G that is used to adjusting the MPPT is response back in the direction of the maximums output.

So, the open circuit voltage of PV cell can be calculated in the starting by the set the value of current is zero [12]. Below figure5 flowchart is shown the different logical steps to implementation of MPPT technique.

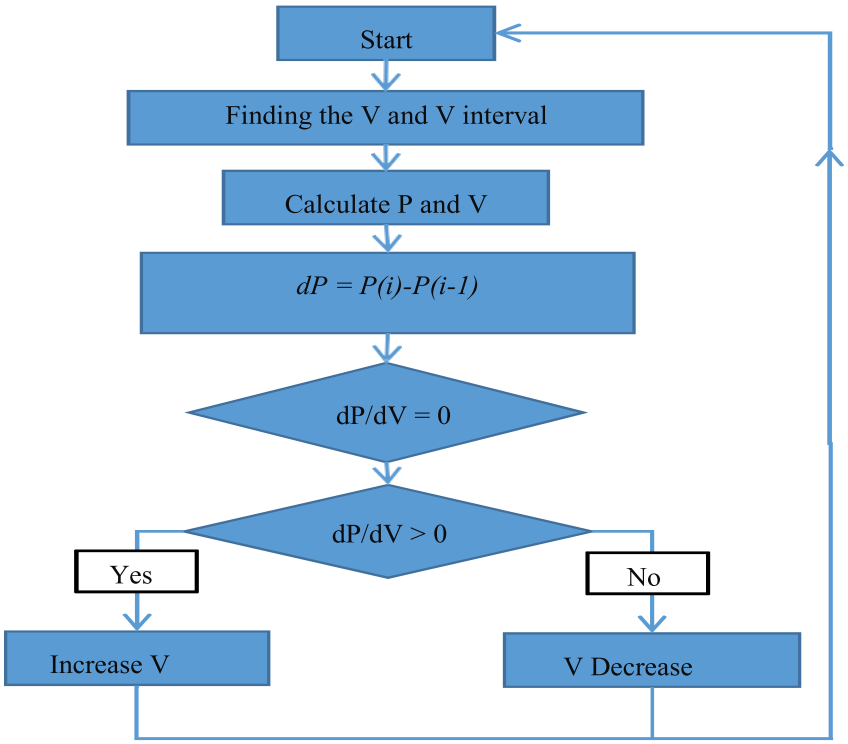

Fig 5: Optimized method Flow Chart

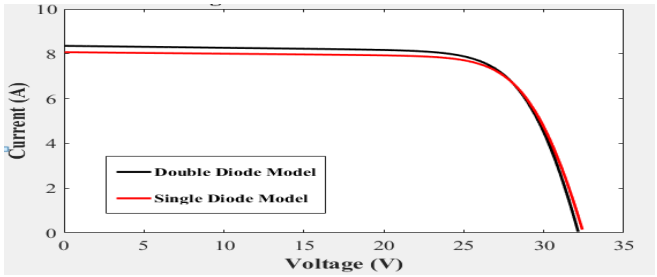

Fig 6: Schematic Diagram of double and single diode I-V curve simulation system.

III. DISCUSSION AND SIMULATION RESULT

The feature of the simulation double or single diode model is performed at the STC in sort to discover the manipulate of put on its an extra diode. The graph of I-V curve for single or double diode model are represent in the fig. 6. Double diode has more operational current as comparison of single diode model. Therefore the operational voltage are larger in the double diode representation, that is reflected in the feature the p-n junction diode model.

The equivalent *P-V* graph are describe in fig.7. in these, the graph of PV of the double or single diode representation function is represented at the STC. Gradient power is rapidly increased at the double representation of double diode as compression of representation of single diode. 209.2 W is the maximum power in the double diode model.

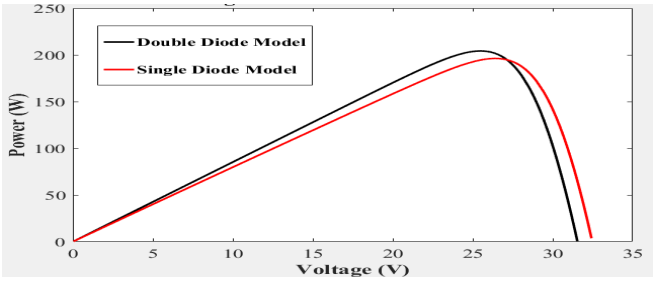

Fig 7: Double and Single diode model P-V curve

So the, representation of double diode model is a additional apposite for the operation in the realistic conditions, or representation of single diode is sufficiently accurate for hypothetical analysis.

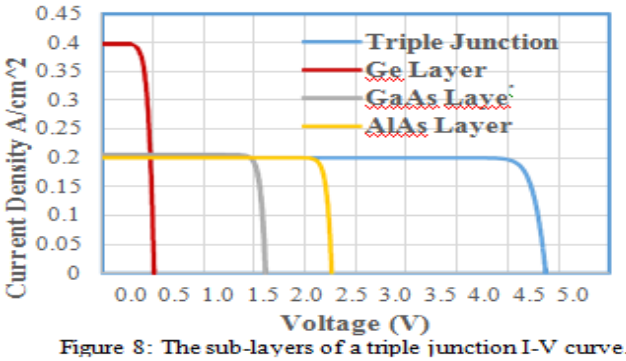

Figure 8: The sub-layers of a triple junction I-V curve.

The GeAs, Germanium Aluminum Arsenic which is provide the 1.607 eV, 0.507 eV or 2.266 eV, correspondingly. This gave us the open total circuit voltages ~4.38 mV. In above situation , it is shows in the contributions in voltage in the every layer is the greatly related to the band gap of energy.

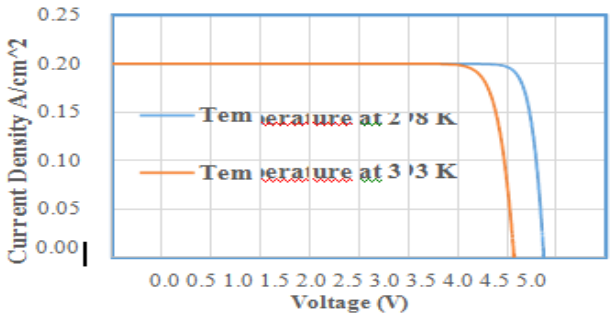

Figure 9: Temperature varying with triple-junction characteristics

Investigation to change in temperature is response from 298°Kelvin to 393°K, is originate that the here is a only the 0.3 V dissimilarity among them is show in the fig.9. Therefore, current model prediction that the changes in the temperature it should contain small control in the operation of real world in the Multi-junction solar cell.

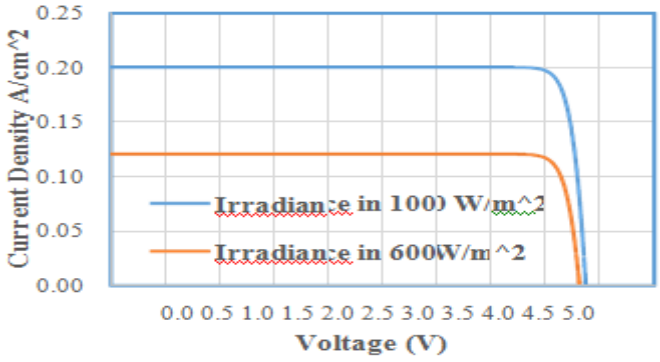

Figure 10: Irradiance varying in the triple junction model.

The voltage of open-circuit doesn't have significant changes but it have in the irradiance shift to 600 W/m^2 to 1000 W/m^2 as in current flow or current density have been a different vary to 0.125A/cm^2 to 0.2A/cm^2 as shown in diagram 10.

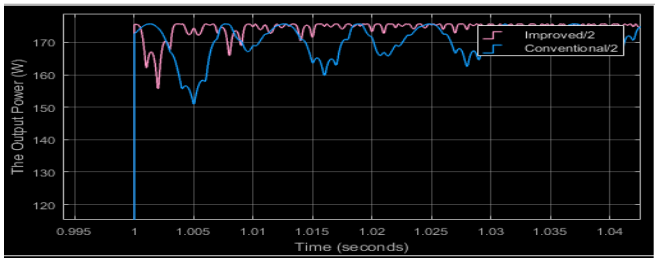

Fig. 11: Optimization Perturb &Observe technique representation while increase in the irradiance.

Fig.11 optimization of Perturb & Observe technique outputs, which reveal the start of irradiance changing, improvement technique (pink line) have a very different amplitude as comparison to the the formal technique (blue line) since as we know duty cycle is the modify method. This is depend upon its ΔP, comparison to the t is constant reference which generate the feedback error in the formal control technique. Even throughout the initialize process, primary amplitude is improved technique is important. So, this models predict using improve the MPPT method or P&O procedure should produce the larger output,and higher stable system operation.

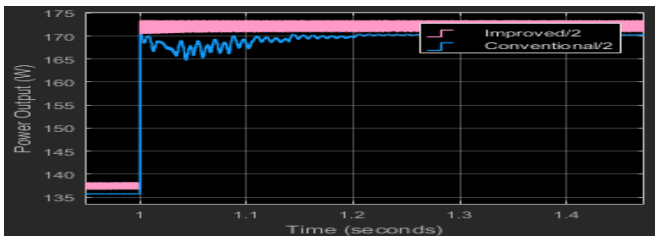

Fig. 12: When irradiance increase Optimized incremental conductance method performance

Figure 12 show the optimization technique has the good result to find out the MPPT, with greater stability (i.e., less output fluctuation) or faster settlement period.

Output of the contrast among these two improve technique to forecast that there could be a advantages in Implementation to the improve the incremental conductance or P&O for enhanced Maximum power point tracking .

IV. CONCLUSION

The represent the paper, the 1st part is all says simulated of double or single diode representation. As the result or simulated analyze, it is shown the there is a not significant dissimilarity among double and single diode representation at the smaller irradiance for example 400 W/m^2 to 600 W/m^2. But as in the irradiance rises, the distinction become additional important. The simulated results comes, the higher power optimized in then representation of double diode is 209.2 W as comparison to the 204.1 W in the representation of single diode in STC.

The 2nd portion is all about the results are formed by the process of simulation of multi junction. Here is a major dissimilarity forecast among multi-junction or single. The forecast affects at irradiance or temperature or the load

factor calculations have been describe in the paper. The production of entire voltage is depending on its every layers' contribute, and there is limited value of current at multi junction by its small value of current obtained, That is set as arrange to make the most of the performance.

The final result of simulated is obtain to the difference of two MPPTs technique. The modeling forecast improved by the use of P&O technique as comparison of improvement incremental conductance technique can be examined. Both the technique has disadvantages advantages. The improvement P&O technique simulation forecast a good performance of MPPT accuracy and stability of the ysytem, while the improvement incremental conductance technique is effective in the time response.

REFERENCES

1 T. Markvart, L. Castaner, and A. J. McEvoy, Practical Handbook of Photovoltaics: Fundamentals and Applications (2nd). Mexico DF, Mexico: Elsevier (2012).

2 Khan, M.S.A., Miah, M.A.R., Rahman, S.R., Iqbal, M.M., Iqbal, A., Aravind, C.V., Huat, C.K.Technical analysis of security management in terms of crowd energy and smart living (2018) Journal of Electronic Science and Technology, 16 (4), pp. 367-378. DOI: 10.11989/JEST.1674-862X.80716117

3 S. Qazi, S. Anwar, and H. Efstathiadis, Handbook of Research on Solar Energy Systems and Technologies (1st.). Hershey, PA: IGI Global (2012)

4 D. M. Bagnall, and M. Boreland, Photovoltaic technologies. Energy Policy, 36(12), 4390-4396, 2008. doi: 10.1016/j.enpol. 2008.09.070

5 Hajibeigy, M.T., Aravind, C.V., Al-Atabi, M., Hoole, P.R.P. 56218279500;24831942700;12766292700;14067324200 ; Heat response model for phase layered topology in a photovoltaic thermal system(2017) Indonesian Journal of Electrical Engineering and Computer Science, 7 (1), pp. 52-60.DOI: 10.11591/ijeecs.v7.i1.pp52-60

6 M. Thakur and B. Singh, "A MATLAB /Simulink Modal of Triple-Junction Solar Cell and MPPT Based on Incremental Conductance Algorithm for PV System", Int'l J. of Engineering Research and Applications, vol. 5, no. 9, pp. 92-95, 2015.

7 Hajibeigy, M.T., Aravind, C.V., Rashmi, W. Analysis of Malaysian ecotourism performance using hybrid photovoltaic thermal (PVT) system (2018) Journal of Engineering Science and Technology, 13 (Special Issue on the ninth eureca 2017), pp. 143-156.

8 O. Adebanjo, P. P. Maharjan, P. Adhikary, M. Wang, S. Yang, and Q. Qiao, "Triple junction polymer solar cells. Energy and Environmental Science, 6(11), pp. 3150-3170, 2013. doi:10.1039

9 M. Thakur and B. Singh, "A MATLAB /Simulink Modal ofTriple-Junction Solar Cell and MPPT Based on Incremental Conductance Algorithm for PV System", Int'l J. of Engineering Research and Applications, vol. 5, no. 9, pp. 92-95, 2015.

10 T. Esram and P. L. Chapman, "Comparison of photovoltaic array maximum power point tracking techniques," IEEE Trans. Energy Convers., vol. 22, pp. 439~449, June 2007.

11 S. K. Kollimalla and M. K. Mishra, "A novel adaptive P&O MPPT algorithm considering sudden changes in the irradiance," IEEE Trans. Energy Convers., vol. 29, pp. 602~610, 2014.

12 D. P. Hohm and M. E. Ropp, "Comparative study of maximum power point tracking algorithms," Progress in Photovoltaics: Research and Applications, vol. 11, no. 1, pp. 47–62, Jan. 2003.

13 S. S. Bhatara, R. F. Iskandar, and M. R. Kirom, "Design and simulation of maximum power point tracking (MPPT) system on solar module system using constant voltage (CV) method", AIP Conference Proceedings, vol. 1712, no. 1, 2016.

14 P. Murphy, M. Xie, Y. Li, M. Ferdowsi, N. Patel, F. Fatehi, A. Homaifar, F. Lee, "Study of Digital vs Analog Control", Power Electronics Seminar Proceedings (CPES Center for Power Electronics Systems), pp.203-206, 2002.

15 Esram, T., Chapman, P. "Comparison of photovoltaic array maximum power point tracking techniques," IEEE Transactions of Energy Conversion, vol. 22, no. 2, pp. 439-449, June 2007.

16 Villalva, M.G.; Gazoli, J.R.; Filho, E.R.; , "Comprehensive Approach to Modeling and Simulation of Photovoltaic Arrays," Power Electronics, IEEE Transactions on , vol.24, no.5, pp.1198-1208, May 2009.

17 S. Ahmad, M. T. Rashid, C. S. Ferdowsy, S. Islam and A. H. Mahmood, "A technical comparison among different PV-MPPT algorithms to observe the effect of fast changing solar irradiation,"2015 IEEE International WIE Conference on Electrical and Computer Engineering (WIECON-ECE), Dhaka, 2015, pp. 155-158.

18 Wang NianCHun, Sun Zao, K. Yukita, Y. Goto, K. Ichiyanagi, "Research of PV Model and MPPT Methods in Matlab," Power and Energy Engineering Conference, 2010

19 Ravi Nath Tripathi, Alka Singh, Manoj Badoni, "A MATLABSimulink-Based Solar Photovoltaic Array (SPVA) Module with MPPT," 2013 International Conference on Emerging Trends in Communication, Control, Signal Processing and Computing Applications (C2SPCA),2013 International Conference, Banglore, 2013,pp. 1-6.

20 M. S. Iftekhar, M. R. Hasan, R. Banik, R. Umar and C. Barua, "Maximum power point tracking using Very high frequency resonant DC/DC converter for photovoltaic systems," 2015 International Conference on Electrical Engineering and Information Communication Technology (ICEEICT), Dhaka, 2015, pp. 1-6.

21 David Sanz Morrales, "Maximum Power Point Tracking Algorithms for Photovoltaic Applications," School of Science and Technology, Aalto University, 2010.

22 Ramesh, G.P., Aravind, C.V. Design aspects of blade shape and position for the MAGLEV vertical axis wind turbine (2015) Lecture Notes in Electrical Engineering, 326, pp. 933-940. DOI: 10.1007/978-81-322-2119-7_91

23 C. Liu, B. Wu and R. Cheung "Advanced algorithm for MPPT control of photovoltaic systems", Canadian Solar Buildings Conference Refereed Paper, Montreal, August 20-24, 2004 .

24 Pongratananukul, Nattorn, "Analysis and simulation tools for solar array power systems" University of Central Florida 2005, pp24-27.

25 Silje Odland Simonsen, "Development of a Grid Connected PV System for Laboratory Use", MSc Dissertation, Department of Electric Power Engineering, Norwegian University of Science and Technology, July 2009, page 46

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

26 Gargas, Eugene, “Analysis of Solar MPPT Techniques with a Simulation of the Perturb and Observe Algorithm”, Final Report presented 24.04.2008 to Prof. Khaligh, page 6-8, accessed on 26.12.2013 at users.ece.gatech.edu/~egargas3

27 Dhople, S. V., and Garcia, D., “Estimation of photovoltaic system reliability and performance metrics,” IEEE Trans. Power Syst., Vol. 27, No. 1, pp. 554–563, February 2012.

28 A.El Fadili, F. Giri, A. El Magri, “Reference voltage optimizer for maximum power tracking in single-phase grid-connected photovoltaic systems” Journal of Control and Systems Engineering, 2013.

29 F. Murtaza, H. A. Sher, M. Chiaberge, D. Boero, M. De Giuseppe, and K. E. Addoweesh, “Comparative analysis of maximum power point tracking techniques for PV applications,” in Proceedings of the 16th International Multi Topic Conference (INMIC ’13), pp. 83–88, IEEE, Lahore, Pakistan, December 2013.

30 A. Nouri, B. Dennai and H. Khachab, "The influence of solar illumination shading on the theoretical performance of multi-junction photovoltaic cells," 2017 International Conference on Green Energy Conversion Systems (GECS), Hammamet, 2017, pp. 1-4