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DESIGN OF ECO-FRIENDLY AUTOMATED SOLAR WATER PUMPING SYSTEM-A LITERATURE REVIEW

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Abstract - Solar energy is one of the most important renewable energy sources that have been gaining increased attention in recent years. Solar energy is plentiful, has the greatest availability as compared to other energy sources. The amount of energy supplied to the earth in one day by the sun is sufficient to satisfy the demand of the total energy needed to the earth for one year. Solar power system provides a continuous, reliable power solution that is easily employed, cost effective and requires little maintenance. Solar power system is the one which can be conveniently installed and transported. It also has the perfect characteristics of self-control, self-protection, needing no attention, compact structure, elegant outline and convenience for using.
The paper presents the literature survey of different papers which particularly describes the various controlling systems for solar water pumping system and the use of MPPT to enhance the power extraction from PV panels. The literature survey also deals with use of solar charge controller and its design, selection of motors, solar inverters, etc.

***Key Words*:** DC-DC boost converter, MATLAB/SIMULINK, MPPT, P & O algorithm, solar charge controller ,Solar water pumping system, etc.

1. INTRODUCTION

Photovoltaic (PV) technology has developed rapidly over the last two decades from a small scale, specialist industry supplying the United State Space program to a broadly based global activity [1]. The application of PV electromechanical system for water pumping has received increasing attention because of the expected cost reduction in PV array. More than two billion people, mostly in developing countries, live in remote areas without access to grid-connected power [2].

Gradually decreasing energy sources and increasing demand for energy in recent years, makes more efficient and positive use of current water resources together with global warming and drought. Therefore efficient water management plays important role in irrigated agricultural cropping system. Since the sources utilized for the purpose of producing electricity are limited and their prices gradually increase researches for new alternatives for irrigation system becomes more important [3].

It is common to use diesel to power generators in agricultural operations. While these systems can provide power where needed, there are some drawbacks as:

- Noise of generator & fumes so produced can disturb livestock.
- Fuel cost add up, and spills can contaminate the land.
- Significant maintenance of generator [4].

The solar energy is the best alternative for agricultural needs. Solar energy that is sensitive to environment, clean and requiring no maintenance. When it is considered by means of requirement for irrigation, the advantage of PV system is that water demand and increasing for sun shining are compatible characteristically. In summer months obtained solar energy increases and also natural water requirement of trees increases. Photovoltaic powered water pumping system have been studied by researchers in many years. Studies mostly concentrated on DC motors cause of energy obtained from solar panel is DC. These are shown that better results were obtained for performance analysis.

Photo irrigation system has advantages than flooding irrigation. Some of these are, bringing utilization of water sources more efficient, preventing erosion and growing of weeds only by irrigating the requested areas, decreasing moisture stress , no operation cost, providing opportunity for local energy sources and exhibiting a parallel point of view with water requirement. In terms of automation, developed wireless technologies, researches focused on automatic irrigation with sensors in agricultural systems. The advantages of using wireless sensor is to reduce wiring and piping costs, and easier to install and maintenance especially large areas. Disadvantages of it are their high initial capital costs, the variability of the yield of the solar panels according to the prevailing weather conditions and in high temperature efficiency decreases. At the current prices of PV modules, the cost of the proposed photovoltaic powered water pumping system is found to be less expensive than the cost of the conventional fuel system. The expected reduction in the prices of photovoltaic modules in the near future will make photovoltaic powered water pumping system more feasible.

2. PROPOSED METHODOLOGY

The literature survey proposed in the paper is basically made for the study of water pumping system using solar energy through A.C. pump, to study its characteristics and pumping efficiency. Fig.1 shows the block diagram representation of the methodology being studied.

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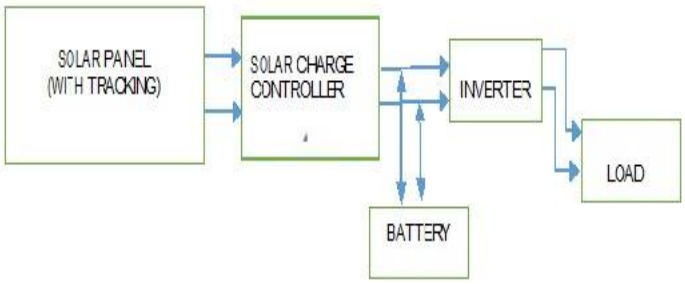

Fig- 1: Block Diagram

3. VARIOUS CONFIGURATION OF SOLAR-POWERED WATER PUMPING SYSTEM

The different types of solar water pumping system utilize in practice are [04], [05], [08], [13]

- Battery-coupled solar water pumping system.
- Direct-coupled solar water pumping system

3.1. Battery-coupled solar water pumping system

Battery-coupled solar water pumping systems consists of PV panels, charge control regulator, batteries, pump controllers, pressure switch and tank and DC water pump as shown in figure. The electric current produced by PV panels during daylight hours charges the batteries and the batteries in turn supply power to the pump anytime whenever the water is needed.

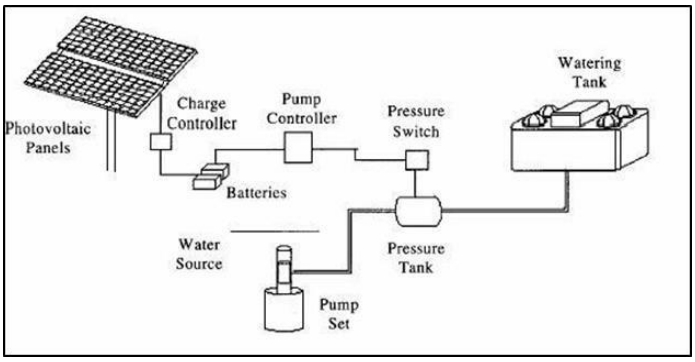

Fig- 2: Battery Coupled Solar Water Pumping

3.2. Direct-Coupled Solar Water Pumping System

As shown in figure, the pump (motor) is directly connected to the module. The amount of water pumped is totally dependent on the amount of sunlight hitting the panels and type of pump.

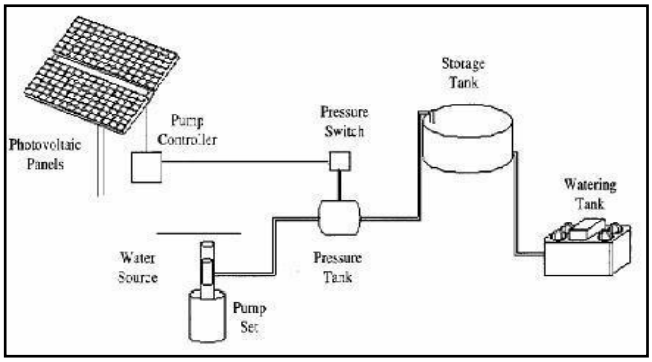

Fig -3: Direct Coupled Solar Water Pumping System

4. LITERATURE SURVEY

From the literature survey, it is fact that the solar power based pumping system can be employed with large benefits.

In 2002, [1] k. k. Tse, et.al. presented a paper, presented a novel MPPT for PV panels using switching frequency modulation (which can be considered as power electronics approach).

In 2004, [02], Mohanlal Kolhe, et.al. presented a paper on the application of stand-alone directly coupled PV electromechanical system for water pumping. The paper illustrates the performance of PV powered dc permanent magnet motor coupled with centrifugal pump and hence the selection criteria of suitable PV electromechanical system for water pumping application.

In 2012, [03], Mahir DURSUN and Semith OZDEN presented a paper on application of solar power automatic pumping system, illustrates the use of solar powered BLDC for irrigation purpose of dwarfcherry trees. The use of sun tracking is made for increasing the efficiency of the system.

In 2005, [04], B. Eker proposed a paper on solar power water pumping system which illustrate the working of direct coupled solar water pumping system. The system mainly uses dc water pump for proper functioning.

In 2009, [05], Taufik, et.al. proposed a paper on modelling and simulation of PV water pumping system. The paper illustrate the pumping system with MPPT, MPPT algorithm and simulation of the system without and with MPPT on MATLAB and its comparison. The paper also illustrate the use of dc water pump and study of its output.

In 2011, [06], M. Abu-Aligah proposed a paper for designing of PV water pumping system and its comparison with diesel powered pump. The paper includes all necessary steps required to built PV solar water pumping system. Again in 2011, [07], Md. Ashiquzzaman, et.al. proposed a paper which illustrates the use of cost effective solar charge controller by using PIC to control and co-ordinate the function of the system properly.

Again, in 2012, [08], Rajib Barman Roy proposed a paper on design and performance analysis of solar PV dc water pump system. The paper explains theoretical and experimental aspects of dc water pumping system using DC-DC buck converter and micro-controller based solar tracking system for improvement in efficiency of the water pumping system. Again in 2012, [09], S. M. Cinar and E. Akarsial proposed a paper on the design of an intelligent battery charge controller for PV panels. The controller so proposed is to overcome the

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problem of mismatching the voltage of PV panel and load or battery. The battery charge controller is designed by the use of microcontroller. The paper also represents the discharge algorithm to execute a program, embedded within a microcontroller and use of GUI for the control of controller.

In 2013, [10], K. B. Rohit, et.al. presented a paper on solar water pumping system which particularly explains the use of PV arrays to store the energy into battery and use of boost converter whose output is fed to SPWM inverter which provides AC power to 1Ø induction motor. Again in 2013, [11], Dezso sera, et.al. proposed a paper on the analysis of P&O and incremental conductance algorithm of MPPT under static and dynamic conditions which helps in selection process of MPPT for industrial application and research purpose. The paper also concluded that both the algorithm are nearly equivalent.

In 2014, [12], Velvizhi J. and D. Padma Subramanian presented a paper on performance enhancement of PV Based solar water pumping system which includes the design procedure for implementation of maximum power using P and O algorithm from PV panels. The paper also gives TIBC with auxiliary transformer set up used in the system. The total enhancement in the system performance is explain on the basis of simulation made in MATLAB. Again in 2014, [13], Faruk Bin Poyen, et.al. proposed a paper which represents the use of different sensors in PV water pumping system to measure the water content in the field. The paper thoroughly explains the algorithm for design of system with all components along with sensors. It also explains the scope of the system proposed and the possible drawback.

In 2014, [14], B. Madan Lal, et.al. proposed a paper on solar water fed adjustable speed drive system, which illustrates the use of MPPT in PV arrays to get maximum DC output along with the use of boast converter. The output of boost converter is fed to the inverter which is fed to ASD{Adjustable Speed Drive}. The paper also explains v/f control of induction motor. The whole system developed is simulated in MATLAB/SIMULINK IN 2014, [15], S. Harishankar, et.al. proposed a paper on solar powered smart irrigation system which illustrates how automatic irrigation conserves electricity by reducing the usage of grid power and conservation of water by reducing water loss.

In 2014, [16], Probeer Sahw and Prerna Gaur presented a paper illustrates the study of 1Øinduction motor as centrifugal water pump, to which input is given by an inverter using SPWM and PAM. The simulation of output of drives with respect to various input parameters are represented.

In 2015, [17], A. Bouchkour presented a paper on PV pumping system using Buck-boost converter. The paper represents the simulation of output of centrifugal pump which is fed by asynchronous 3Øvoltage inverter with sine triangle PWM and output of pump by making connection with PV panel by integration of MPPT control. [18] Prof. Dr. Mohamed M. Algazar, et.al presented a paper illustrating the method of MPPT using fuzzy logic control by simulation. The result of the simulation are compared with those obtained without MPPT. This concluded the increase in efficiency of capturing of energy from PV panels.

In 2015, [19], Vishwa Nath Maurya, et.al. presented a paper gives the scope of PV water pumping system as a sustainable solution to enhance water use efficiency in irrigation. The paper also explains the functioning of various components used in the system briefly. It also explains the possible advantages and limitations of PV system.

In 2013, [20], Rooble, et.al. presented a paper which gives a low voltage, low cost and high efficiency based solar maximum power point tracking system for greenhouse applications.

In 2013, [21], Mahit Gunes, et.al. proposed a paper on mathematical model of solar cell using one diode equivalent system on SIMULINK.

In 2005, [22], Guo Heng, et.al. proposed a paper which utilizes the hybrid MPPT control strategy for standalone solar pumping system without backup batteries and concludes that use of hybrid MPPT will overcome the drawback of classical MPPT.

In this paper [23], Gazi Mohammad Sharif, et.al. presented a paper which gives design and construction of microcontroller based MPP PWM charge controller for PV application. The paper also gives flow chart of PWM charge control program.

In 2010, [24], A. V. Boicea , et.al. presented a paper which gives the comparison of operating characteristics of grid connected PV system with single axis and dual axis trackers at different latitudes. This concludes that dual axis tracker enhance the performance of South Italy site (≈30%) and reduce the operating and maintenance cost.

In 2013, [25], Deepthi S., et.al. presented a paper which gives the comparison of the efficiencies of single axis and dual axis tracking system with the fixed mount, which comes to the conclusion that dual axis tracking system enhances the efficiency of the PV system.

In 2013, [26], Mostefa Ghassoul presented a paper which explains the design of solar tracking system, which is driven by microcontroller {PIC 18F452}.

In 2013, [27], Nishant Singh presented a paper on an improved Grid connected PV generation inverter control system which concludes that use of PWM inverter make the voltage and current waveform of the grid tend to sine wave effectively and quickly and reaches the power factor nearer to unity.

In 2005, [28], Yanqing Li. Et.al. p[resented a research paper on PV generation inverter control theory, which describes two methods for the inverter control.

In 2015, [29], P. B. Mahajan and A. A. Bhole presented a paper which represent the modeling of PV module in simple way with the relevant I-V and P-V characteristics.

In 2012, [30], Tiberiu Tudorache and Liviu Kreindler proposed a paper on the design of the solar tracker system {mechanical one} for PV plant, which utilizes single axis tracking system for optimization of conversion of solar energy to electrical energy.

In 2014, [31], Kamal Keshvani, et.al. proposed a paper on modelling and simulation of PV array using MATLAB/SIMULINK with their relevant equation and characteristics, which shoes their approximate behavior for different atmospheric conditions.

In this paper, [32], P. Andradra and J. Castro presented a paper on solar PV water pumping system using a linear actuator. Linear actuator is double sided flat, two phase, variable reluctance linear stepper motor

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that moves a piston type of water pump with the help of rope, a pulley and a counter weight. The paper illustrates the control of linear actuator by an electronic circuit that manages the power generates by PV array.

In 2013, [33], William Christopher and Dr. R. Ramesh proposed a paper on the comparison of P and O and INC MPPT techniques (algorithm) for enhancing the power quality. MATLAB/SIMULINK tool box has been used for performance evaluation of both MPPT by a PV array.

In 2014, [34], Tekeshwar Prasad Sahu et.al. proposed a paper on the simulation and analysis of P and O MPPT algorithm for PV array using cuk converter, to maximize power output, on MATLAB/SIMULINK.

IN 2014, [35], Williams K. Francis, et.al. proposed a paper gives simulation of PV module with P and O and dc link capacitor droop control technique. A hardware model setup was monitored through software LABVIEW, ECOSENSE.

In 2007, [36], TJUKUP MARNOTO, et.al. presented a paper on mathematical model of multi crystalline PV modules for determining its performance characteristics.

5. CONCLUSIONS

From the literature survey we can say that, the implementation of single axis tracking system will enhance the efficiency of PV system than that we get from fixed mounting. The SIMULINK model shows the enhancement in the PV system. From the literature survey, we can say that incremental conductance (INC) MPPT technique gives better result than P and O MPPT technique {as studied from its characteristics}. The use of cuk converter can overcome the drawback of used of DC-DC converter. The most efficient and advanced methods is by the use of fuzzy logic control for MPP. But by cost consideration P and O MPPT technique implementation with DC-DC boost converter is easy.

REFERENCES

1. K. K. Tse, M. T. Ho, Henry S.H. Chung and S.Y. (Ron) Hui, *"A Novel Maximum Power Point Tracker for PV Panels Using Switching Frequency Modulation"*, IEEE Transactions on Power Electronics, Vol. 17, No. 6, pp 980-989, November 2002.
2 Mohanlal Kolhe, J. C. Joshi, and D. P. Kothari, "Performance Analysis of a Directly Coupled Photovoltaic Water-Pumping System", IEEE Transactions on Energy Conversion, vol. 19, no. 3, pp 613- 618, September 2004.
3. Mahir DURSUN and Semih OZDEN, "Application of Solar Powered Automatic Water Pumping in Turkey", International Journal of Computer and Electrical Engineering, Vol.4, No.2, pp 161-164, April 2012.
4. B. Eker, "Solar Powered Water Pumping Systems", Trakia Journal of Sciences, Vol. 3, No. 7, pp 7-11, 2005.
5.Mohammad Taufik, Makbul Anwari, Taufik, Akihiro Oi, "Modeling and Simulation of Photovoltaic Water Pumping System", 2009 Third Asia International Conference on Modelling & Simulation, pp 497- 502, 2009.
6. M. Abu-Aligah, "Design of Photovoltaic Water Pumping System and Compare it with Diesel Powered Pump", Jordan Journal of Mechanical and Industrial Engineering, vol. 5, no. 3, pp 273- 280, June 2011.
7. Md. Ashiquzzaman, Nadia Afroze, Md. Jabed Hossain, Umama Zobayer, and Md. Mottaleb Hossain, "Cost Effective Solar Charge Controller Using Microcontroller", Canadian Journal on Electrical and Electronics Engineering, Vol. 2, No. 12, pp 571-576, December 2011.
8. Rajib Baran Roy, "Design and Performance Analysis of the Solar PV DC Water Pumping System", Canadian Journal on Electrical and Electronics Engineering, Vol. 3, No. 7, pp 403- 412, September 2012.
9. S. M. Cinar and E. Akarslan, "Design of an Intelligent Battery Charge Controller for PV Panels", 2012.
10. K. B. Rohit, Prof. G. M. Karve, Prof. Khatri, "Solar Water Pumping System", International Journal of Emerging Technology and Advanced Engineering, Volume 3, Issue 7, pp 323-337, July 2013.
11. Dezso Sera, Laszlo Mathe, Sergiu Viorel Spataru and Remus Teodorescu, "On the Perturb-and- Observe and Incremental Conductance MPPT Methods for PV Systems", IEEE Journal of Photovoltaics, Vol. 3, No. 3, pp 1070-1078, July 2013.
12.Velvizhi.J,D.Padma Subramanian, "Performance Enhancement of PV Based Water Pumping System", International Journal of Innovative Technology and Exploring Engineering (IJITEE), Volume-3, Issue-10, pp 36-40, March 2014.
13. Faruk Bin Poyen, Pankaj Saha, Deep Mukherjee, "Sensor and Solar Based Irrigation- Eco Friendly Approach",International Journal of Innovative Research in Science, Engineering and Technology, Volume 3, Special Issue 3, pp 688- 695, March 2014.
14. B.Madan lal, U.Raja Kiran, Sushma Gupta and Savita Nema, "Solar Power Fed Adjustuable Speed Drive System", IJRET: International Journal of Research in Engineering and Technology, Volume: 03 Issue: 04, pp 816- 820, Apr. 2014.
15. S. Harishankar, R. Sathish Kumar, Sudharsan K.P, U. Vignesh and T.Viveknath, "Solar Powered Smart Irrigation System", Advance in Electronic and Electric Engineering, Volume 4, Number 4 (2014), pp. 341- 346, 2014.
16. Probeer Sahw and Prerna Gaur, "Photovoltaic Powered Centrifugal Water Pump", International Journal of Electronic and Electrical Engineering, Volume 7, Number 3 (2014), pp. 247-254, 2014.
17. A. Bouchakour, L. Zaghba, M. Brahami, and A. Borni, "Study of a Photovoltaic System Using MPPT Buck- Boost Converter", Vol. 3, No. 1, pp 65-68, February 2015.
18. Prof. Dr.Mohamed M. Algazar, Assist. Prof. Dr. Hamdy AL-monier, Eng. Mohamed Ezzat El Kotb Salem and Dr. Hamdy Abd EL-halim, "Maximum Power Point Tracking Using Fuzzy Logic Control", 2011.
19. Vishwa Nath Maurya, et.al. "Scope and Review of Photovoltaic Solar Water Pumping System as a Sustainable Solution Enhancing Water Use Efficiency in Irrigation" American Journal Biological and Environmental Statistics, Volume 1, Special Issue 1, pp 1-8, 2015.
20. Rooble, S.Chatterji, Shimi S.L. "SOLAR MAXIMUM POWER POINTTRACKING SYSTEM AND ITS APPLICATION TO GREENHOUSE" , International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering ,Vol. 2, Issue 6, pp 2162-2168, June 2013
21. Mahit Günes, et. al., "Mathematical Model Derivation of Solar Cell by Using OneDiode Equivalent Circuit via SIMULINK", International Journal of Education and Research Vol. 1 No. 12, pp 1-12, December 2013.

ISSN: 2583-6129
DOI: 10.55041/ISJEM02086

22. Rooble, S.Chatterji, Shimi S.L. "SOLAR MAXIMUM POWER POINT TRACKING SYSTEM AND ITS APPLICATION TO GREENHOUSE" , International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering ,Vol. 2, Issue 6, pp 2162-2168, June 2013
23. Mahit Günes, et. al., "Mathematical Model Derivation of Solar Cell by Using OneDiode Equivalent Circuit via SIMULINK", International Journal of Education and Research Vol. 1 No. 12, pp 1-12, December 2013.
24. Guo Heng, Xu Zheng, Li You-Chun and Wang Hui, "A Novel Maximum Power Point Tracking Strategy for Stand-alone Solar Pumping Systems", 2005 IEEE/PES Transmission and Distribution Conference & Exhibition: Asia and Pacific Dalian, China.
25. Gazi Mohammad Sharif, S. M. Mohaiminul Islam, Khosru Mohammad Salim, "Design & Construction of Microcontroller Based maximum power point PWM Charge Controller for Photovoltaic Application".
26. A.V. Boicea, P. Di Leo, G. Graditi and F. Spertino, "Comparison of Operating Parameters in Grid Connected Photovoltaic Systems with Single/Double Sun–Trackers at Different Latitudes", SPEEDAM 2010 International Symposium on Power Electronics, Electrical Drives, Automation and Motion.
27. Deepthi.S, et. al., "Comparison of Efficiencies of Single-Axis Tracking System and Dual-Axis Tracking System with Fixed Mount", International Journal of Engineering Science and Innovative Technology (IJESIT), Volume 2, Issue 2, pp 425-430, March 2013
28. Mostefa Ghassoul, "Design of an Automatic Solar Tracking System to Maximize Energy Extraction", International Journal of Emerging Technology and Advanced Engineering, Volume 3, Issue 5, pp 453-460, May 2013.
29. NISHANT SINGH, "An improved grid connected pv generation inverter control system".
30. Yanqing Li, et. al., "Research of An Improved Grid-connected PV Generation Inverter Control System", 2010 International Conference on Power System Technology.
31. P. B. Mahajan, A. A. Bhole, "MODELING OF PHOTOVOLTAIC MODULE", International Research Journal of Engineering and Technology (IRJET), Volume 02, Issue 03, pp 496-500, June- 2015.
32. Tiberiu Tudorache, Liviu Kreindler, "Design of a Solar Tracker System for PV Power Plants", Acta Polytechnica Hungarica, Vol. 7, No. 1, 2010.
33. Kamal Keshavani, et. al., "Modelling and Simulation of Photovoltaic Array Using Matlab/Simulink", IJEDR, Volume 2, Issue 4, pp 3742-3751, 2014.
34. P.Andrada and J.Castro, "Solar photovoltaic water pumping system using a new linear actuator".
35. William Christopher and Dr.R.Ramesh,"Comparative Study of P&O and InC MPPT Algorithms", volume-02, Issue-12, pp-402-408, 2013.
36. Tekeshwar Prasad Sahu, et. al., "Simulation and Analysis of Perturb and Observe MPPT Algorithm for PV Array Using CUK Converter", Advance in Electronic and Electric Engineering, Volume 4, Number 2, pp. 213-224, 2014.
37. Williams K. Francis, et. al., "MATLAB/Simulink PV Module Model of P&O And DC Link CDC MPPT Algorithm with Labview Real Time Monitoring And Control Over P&O Technique", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 3,Special Issue 5, December 2014.
38. TJUKUP MARNOTO, et. al., "Mathematical Model for Determining the Performance Characteristics of Multi-Crystalline Photovoltaic Modules", Proc. Of the 9th WSEAS Int. Conf. on Mathematical and Computational Methods in Science and Engineering, Trinidad and Tobago, November 5-7, 2007.

