Plagiarism Checker X - Report

Originality Assessment

6%

Overall Similarity

Date: May 2, 2023
Matches: 193 / 3312 words
Sources: 15

Remarks: Low similarity detected, check with your supervisor if changes are required.

Verify Report:
Scan this QR Code

 The 2nd International Joint Conference on Science and Technology (IJCST) 2017 IOP Publishing IOP Conf. Series: Journal of Physics: Conf. Series 953 (2018) 012048 doi :10.1088/1742-6596/953/1/012048 Modelling of electric characteristics of 150-watt peak solar panel using Boltzmann sigmoid function under various temperature and irradiance A A N G Sapteka1, A A N M Narottama1, A Winarta2,3, K Amerta Yasa1, P S Priambodo4, and N Putra3 1Electrical Engineering, Politeknik Negeri Bali, Jimbaran, Bali, 80361, Indonesia 2Mechanical Engineering, Politeknik Negeri Bali, Jimbaran, Bali, 80361, Indonesia 3Mechanical Engineering, Universitas Indonesia, Depok, 11 Jawa Barat, 16424, Indonesia 4Electrical Engineering, Universitas Indonesia, Depok, Jawa Barat, 16424, Indonesia E-mail: sapteka@pnb.ac.id Abstract. Solar energy utilized with solar panel is a renewable energy that needs to be studied further. The site nearest to the equator, it is not surprising, receives the highest solar energy. In this paper, a modelling of electrical characteristics of

150-Watt peak solar panels using Boltzmann sigmoid function under various temperature and irradiance is reported. Current, voltage, temperature and irradiance data in Denpasar, a city located at just south of equator, was collected. Solar power meter is used to measure irradiance level, meanwhile digital thermometer is used to measure temperature of front and back panels. Short circuit current and open circuit voltage data was also collected at different temperature and irradiance level. Statistically, the electrical characteristics of 150-Watt peak solar panel can be modelled using Boltzmann sigmoid function with good fit. Therefore, it can be concluded that Boltzmann sigmoid function might be used to determine current and voltage characteristics of 150-Watt peak solar panel under various temperature and irradiance. 1. Introduction Research on current and voltage modelling on solar cells was carried out by Eckstein in 1990 at The University of Wisconsin - Madison. Eckstein wrote about the Effect of temperature and irradiance on I-V characteristics in the Solarex MSX-30 module [1]. Soto W D, Klen S A and Beckman W A studied about ideality factor parameters, reverse saturation current, light current, shunt resistance, and series resistance of diode at irradiance level of 1000 W/m2 and the cell temperature is 250C [2]. Chenni R, Makhlouf M, Kerbache T and Bouzid A examined series resistance modelling of solar cells and the effect of mounting photovoltaic cells in series and parallel [3]. Dzimano wrote about neural network modelling using single diode as a model of solar cell structure [4]. Villalva M G, Gazoli J R and Filho E R investigated current modelling that consists of solar cell current, saturation current and incorporating thermal voltage parameter [5]. Priambodo P S, Poespawati N R and Hartanto D wrote about open circuit voltage of solar cell output. This voltage is determined by photogenerated current, 12 diode saturation current at reverse bias condition and temperature. The diode saturation current depends on the structure design and the choice of materials for solar cell diode, while photogenerated

(2018) 012048 doi :10.1088/1742-6596/953/1/012048 current depends on the illumination intensity as well [6]. Our group research at Universitas Indonesia also examined the utilization of heat pipe on cold surface of thermoelectric with low-temperature heatsink from a solar cell simulated with combination of a bulb and a collector plate [7]. Bellia H, Youcef R and Fatima M studied about a detail modelling 8 of the effect of irradiance and temperature on the parameters of Photovoltaic module. The chosen model was a single diode model with both series and parallel resistors for greater accuracy [8]. Humada A M, Hojabri M, Mekhilef S and Hamada H M examined techniques based on single diode and double diode models. 7 The main parameters of interest was photocurrent, reverse diode saturation current, ideality factor of diode, series resistance, and shunt resistance [9]. In this paper, 5 the current and voltage characteristics are modelled using Boltzmann sigmoid function with good fit. According to our knowledge, the use of Boltzmann sigmoid function to model the electric characteristics of solar panel has not been studied yet. This paper is written preliminary research of thermal management on solar cell to improve its efficiency. As stated by other researchers, the efficiency of solar panels decreases as the panels' temperature increases [10-19]. Therefore, it is important to study about thermal management on solar panel. 2. Methodology 13 This research was conducted in Denpasar City located at 8°35'31" to 8°44'49" south latitude and 115°00'23" to 115°16'27" east longitude in June 2017. Current and voltage data was collected using 150-Watt peak solar panel at various temperatures and irradiance levels. Temperature data was taken at front and back panel. Temperature data collection was done using TMP36 temperature sensor which has ±2 oC accuracy with 0.5 oC linearity. The average temperature (TM) was processed based on the front panel temperature (FPT) and back panel temperature (BPT) of solar panel. Irradiance (Irr) data collection was done using Lutron Solar Power Meter SPM-1116SD with 10 W/m2 accuracy and 0.1 W/m2 resolutions for irradiance<1000 W/m2 and resolution of 1 W/m 2 for irradiance≥1000 W/m2. Further data was processed with Origin software for fitting process. The results obtained from the fitting process indicate that parameters in Boltzmann Sigmoid Function

(BSF) in Equation (1) have adjusted R2 values close to 1 with current-voltage curve of 150-Watt peak solar panel. 1 1 These parameters are then used to determine the current-voltage characteristics of 150-Watt peak solar panel at different irradiance and temperature levels. 3. Result and Discussion 3.1. Data Observation The observation was conducted using 150-Watt peak polycrystalline solar panel. It yields irradiance (Irr), front panel temperature (FPT), back panel temperature (BPT), current and voltage data as shown in Table 1. During the observation, 10 short circuit current (ISC) and open circuit voltage (VOC) and 5 (five) current and voltage pairs (I1-V1 to I5-V5) data was collected. Table 1. Irradiance, temperature, current and voltage data of 150 Watt-peak solar panel. Irradiance (W/m2) FPT (oC) BPT (oC) ISC (A) VOC (V) V1 (V) I1 (A) V2 (V) I2 (A) V3 (V) I3 (A) V4 (V) I4 (A) V5 (V) I5 (A) 103-105 30.44 30.69 0.83 18.5 6.1 0.82 10.6 0.81 14.8 0.78 16.2 0.7 17.9 0.32 241-258 38.19 39.88 2.08 18.4 6.9 2.03 10 2 14.4 1.91 15.9 1.65 -- -304-308 35 34 2.39 19.4 5.9 2.39 10.6 2.37 14.9 2.33 16.7 2.04 18.1 1.33 382-390 38.38 37.44 3.08 19.5 6.3 3.05 10.9 3.01 15 2.94 16.5 2.61 18 1.76 448-454 41.25 38.44 3.55 19.5 6 3.4 10.2 3.4 14.2 3.3 16.7 2.8 18.3 1.5 546-556 41.63 39.13 4.35 19.7 6.5 4.2 10 4.1 14.4 4.1 16.6 3.5 18.3 2.03

31234567890 ‘’“” The 2nd International Joint Conference on Science and Technology (IJCST) 2017 IOP Publishing IOP Conf. Series: Journal of Physics: Conf. Series 953 (2018) 012048 doi :10.1088/1742-6596/953/1/012048 Table 2. Irradiance, temperature, current and voltage data of 150 Watt-peak solar panel (cont’d) Irradiance (W/m2) FPT (oC) BPT (oC) ISC (A) VOC (V) V1 (V) I1 (A) V2 (V) I2 (A) V3 (V) I3 (A) V4 (V) I4 (A) V5 (V) I5 (A) 650 46.19 42.75 5.21 19.6 6.4 5 10.3 5 14.9 4.8 16.8 3.8 18.5 1.8 820-830 49.5 46.81 6.56 19.5 6.7 6.3 9.7 6.3 14.4 6.2 16.2 5.2 18.6 1.6 900 55.69 52.81 7.2 19.5 6.9 6.8 10.6 6.8 14.3 6.6 16.9 4.5 18.7 1.27 995-998 54.81 50.63 7.95 19.3 6.1 7.7 10.1 7.6 14.3 7.2 16.8 4.7 18.6 1.6 998-1006 52.5 48 7.98 19.4 6.3 7.7 10.5 7.7 14 7.3 16.1 6.1 18.9 1.1 983-1000 57.31 55.19 7.88 19.4 6.2 7.65 10.6 7.6 14.9 6.7 16.7 4.4 18.5 1.7 1020-1040 57.19 54.48 8.2 19.4 6.1 7.9 10.3 7.8 14.6 6.8 16 3.8 18.4 0.9 1020-1060 51.56 40.25

8.09 19.5 6.6 7.85 10.2 7.8 14.9 6.87 16.3 5.58 18.5 2.01 1150-1170 49.31 49.13 9.15 20 6.1 9.02 10.8 8.97 14.5 8.42 16.9 5.71 18 3.84 3.2. Data Exploration The obtained data is then processed using Origin software. The results of data exploration are shown in Figure 1 for current-voltage relation at different irradiance levels, whereas in Figures 2 and 3 for current-voltage relations with different temperature means (TM) at particular irradiance. Figure 1. Current-voltage characteristics on 150-watt peak solar panels. remark L1 : Irradiance = 103-105 W/m2, TM = 30.56 0C. L2 : Irradiance = 241-258 W/m2, TM = 39.03 0C. L3 : Irradiance = 304-308 W/m2, TM = 34.5 0C. L4 : Irradiance = 382-390 W/m2, TM = 37.91 0C. L5 : Irradiance = 448-454 W/m2, TM = 39.84 0C. L6 : Irradiance = 546-556 W/m2, TM = 40.38 0C. L7 : Irradiance = 650 W/m2, TM = 44.47 0C. L8 : Irradiance = 820-830 W/m2, TM = 48.15 0C. L9 : Irradiance = 900 W/m2, TM = 54.25 0C. L10 : Irradiance = 995-998 W/m2, TM = 52.72 0C. L11 : Irradiance = 1150-1170 W/m2, TM = 49.22 0C.

41234567890 ‘’“” The 2nd International Joint Conference on Science and Technology (IJCST) 2017 IOP Publishing IOP Conf. Series: Journal of Physics: Conf. Series 953 (2018) 012048 doi :10.1088/1742-6596/953/1/012048 Figure 2. Current-voltage characteristics with temperature difference at Irr ≈ 1030 W/m2. Figure 3. Current-voltage characteristics with temperature difference at Irr ≈ 1000 W/m2. 3.3. Data Fitting Based on the data obtained in Table 1 and the curves shown in Figures 1-3, fitting process is used to obtain current-voltage characteristic equations for 150 Watt-peak polycrystalline type solar panel. The fitting process shows that BSF gives results with a reduced chi-square statistic value near 0 and adjusted R2 approaching 1. The result of data fitting using BSF is shown in Table 2.

51234567890 ‘’“” The 2nd International Joint Conference on Science and Technology (IJCST) 2017 IOP Publishing IOP Conf. Series: Journal of Physics: Conf. Series 953 (2018) 012048 doi :10.1088/1742-6596/953/1/012048 Table 3. Irradiance, temperature, BSF parameters and statistics of 150-Watt peak solar panel. Irradiance (W/m2) TM (oC) Boltzmann Sigmoid Function Parameters Statistics Reduced Chi-square Adj R-square 103-105 30.565 0.82016 -71.77800 23.86800 1.20043 6.19279×10-5 0.99941 241-258 39.035 2.04103 -23.51702 21.93816 1.44755 0.00144 0.99778 304-308 34.50 2.38612 -2.77884 19.56473 1.07986 1.42928×10-4 0.99982 382-390 37.91 3.05141 -3.69267 19.72963 1.20282 8.81763×10-4 0.99932 448-454 39.84 3.44124 -3.04574 19.34902 1.22187 0.00595 0.99666 546-556 40.38 4.22192 -3.50454 19.46560 1.25871 0.01031 0.99604 650 44.47 5.08239 -3.56772 19.13747 1.31445 0.0106 0.99737 820-830 48.15 6.40337 -2.51055 18.41101 1.16759 0.01733 0.99756 900 54.25 6.94410 -2.11574 18.08592 1.18958 0.03418 0.9961 995-998 52.72 7.79526 -5.21083 18.69723 1.56387 0.03334 0.99686 998-1006 50.25 7.80523 -5.85533 18.96515 1.4874 0.01594 0.99861 983-1000 56.25 7.76106 -3.21984 18.09081 1.54328 0.04181 0.99589 1020-1040 55.83 7.99027 0.17302 15.92966 0.83264 0.10617 0.99127 1020-1060 45.90 7.94694 -5.49052 18.88610 1.66215 0.01217 0.99882 1150-1170 49.22 9.08778 -2.68868 18.27200 1.42616 0.01519 0.99875 Figure 4. Relation between irradiance and A1. Table 4. Linear statistics for relation between irradiance and A1. Intercept Slope Statistics Value Std err Value Std err Adj R-square 0.01156 0.03702 0.00777 5.44987×10-5 0.99951 From Figure 4 and Table 4, it can be stated that the relation between irradiance and A1 follows Equation (2).

0.00777 0.01156 2

61234567890 ‘“” The 4 2nd International Joint Conference on Science and Technology (IJCST) 2017 IOP Publishing IOP Conf. Series: Journal of Physics: Conf. Series 953 (2018) 012048 doi :10.1088/1742-6596/953/1/012048 Meanwhile the relation between irradiance and A2 5 is shown in Fig. 5 and Table 4. This relationship indicates an exponential relationship. Figure 5. Relation between irradiance and A2. Table 5. Exponential statistics for relation between and irradiance and A2. Statistics Value Std err Value Std err Value Std err Reduced Chi-square Adj R-square -2.42692 1.50446 -215.36358 38.53096 -0.01084 0.00164 14.32301 0.96744 From Figure 5 and Table 5, it can be stated that the relation between irradiance and A2 follows Equation (3).

2.42692 215.36358 . 3 The relation between irradiance and x0 is shown in Figures 6 and Table 5. This relation indicates an exponential decay relationship. Table 6. Exponential decay statistics for relation between irradiance and x0. Statistics Value Std err Value Std err Value Std err Reduced Chi-square Adj R-square 18.34933 0.29824 9.07315 1.28965 213.09862 44.25401 0.26048 0.91376

 Figure 6. Relation between irradiance and x0. From Figure 6 and Table 6, it can be stated that the exponential decay relationship between irradiance and parameter x0 follows Equation (4). 18.34933 9.07315 . 4 Meanwhile the relation between irradiance level and dx parameter 5 is shown in Fig. 7 and Table 6. This relation indicates an irregular relationship. Figure 7. Relation between irradiance with dx parameter. Table 7. Descriptive statistics of dx. Mean Std dev Min Median Max 1.27935 0.14429 1.07986 1.22187 1.56387

 From Figure 7 and Table 7, it can be stated that the relation between irradiance and dx is represented by Equation (5). 1.27935 5 Modelling results using BSF with parameter values determined by Equation (1-5) for 150-Watt peak polycrystalline solar panel for irradiance level of 650 W/m2, 820-830 W/m2 and 995-998 W/m2 are shown in Figure 8. Figure 8. Modelling of electric characteristics using BSF of various irradiance. remark L1 : Irradiance = 650 W/m2, TM = 44.47 0C. BSF L1 : Result of L1 using boltzmann sigmoid function L2 : Irradiance = 820-830 W/m2, TM = 48.15 0C. BSF L2 : Result of L2 using boltzmann sigmoid function L3 : Irradiance = 995-998 W/m2, TM = 52.72 0C. The difference test between measurement data of some irradiance levels with BSF result is done by paired sample t-test method. Test results in Table 8 show that at the 0.05 level, there is no significant difference between the measurement data and the Boltzmann sigmoid function. Table 8. Paired sample t test result of BSF and various irradiance level. Irradiance (W/m2) t statistic Prob>[t] 650 -2.0038 0.09194 820-830 -2.3785 0.05488 995-998 -2.3916 0.05391 Remark All rows at the 0.05 level, the difference of the population means is NOT significantly different from the test difference (0).

 The result of modelling using BSF using Equation (1-5) for 150-Watt peak type polycrystalline solar panel for specific level irradiance with temperature difference are shown in Figures 9 and 10.   Figure 9. Modelling of electric characteristics using BSF of Irr ≈ 1000 W/m2. remark L1 : Irradiance ≈ 1000 W/m2, TM = 56.25 0C. BSF L1 : Result of L1 using BSF L2 : Irradiance ≈ 1030 W/m2, TM = 50.25 0C. BSF L2 : Result of L2 using BSF   Figure 10. Modelling of electric characteristics using BSF of Irr ≈ 1030 W/m2. remark L1 : Irradiance ≈ 1030 W/m2, TM = 55.83 0C. BSF L1 : Result of L1 using BSF L2 : Irradiance ≈ 1030 W/m2, TM = 45.90 0C. BSF L2 : Result of L2 using BSF

 The difference test between measurement data on a particular irradiance (with temperature difference) with BSF result is done by paired sample t-test method. Test results in Table 9 show that at 0.03 level, there is no significant difference between measurement data and BSF result. Table 9. Paired sample t test result of BSF and various temperature. Irradiance (W/m2) TM   (oC) t statistic Prob>[t] ≈ 1000 56.25 -2.61653 0.03977 ≈ 1000 50.25 -2.45506 0.04945 ≈ 1030

55.83 -1.86680 0.11117 ≈ 1030 45.90 -2.05055 0.08618 Remark All rows at the 0.03 level, the difference of the population means is NOT significantly different from the test difference (0).

4. Conclusion BSF 5 can be used to determine the electric characteristics of 150-Watt peak polycrystalline-type solar panels at various irradiance and temperature levels. The BSF parameter values for solar panels are determined in Equation (1-5). Statistics show that at the 0.05 level, 6 there is no significant difference between the measurement data of various irradiance levels with BSF results and at the 0.03 level, there is no significant difference between the measurement data of various level temperatures at a certain level irradiance with BSF results.

5. Acknowledgment Our gratitude goes to the Directorate of Research and Community Service (DRPM), Ministry of Research and Higher Education, Republic of Indonesia, and the Centre for Research and Community Service (P3M) of Politeknik Negeri Bali for the financial support given in this Post-Doctoral Research.

6. References [1] Eckstein J H 1990 Detailed Modelling of Photovoltaic System Components (Madison: University of Wisconsin) pp 28-32 [2] Soto W D, Klen S A and Beckman W A 2006 Solar Energy 80 78-88 [3] 15 Chenni R, Makhlouf M, Kerbache T and Bouzid A 2007 Energy 32 1724-30 [4] Dzimano G 2008 Modelling of Photovoltaic Systems (Ohio: The Ohio State University) pp 3540 [5] Villalva M G, Gazoli J R and Filho E R 2009 10th Brazilian Power Elec. Conf. [6] Priambodo P S, Poespawati N R and Hartanto D 2011 Solar Cell, Silicon Based – Wafer Technologies ed L A Kosyachenko pp 1-27 [7] Djafar Z, Putra N and Koestoer R A 2013 App. Mechanics and Materials 302 410-415 [8] Bellia H, Youcef R and Fatima M 2014 NRIAG J. of Astronomy and Geophysics 3 53-51 [9] Humada A M, Hojabri M, Mekhilef S and Hamada H M 2016 Renewable and Sustainable Energy Rev. 56 494-509 [10] Teo H G, Lee P S and Hawlader M N A 2012 Applied Energy 90 309-315 [11] Du B, Hu E and Kolhe M 2012 Renewable and Sustainable Energy Rev. 16 6713-6732 [12] Tarabsheh A A, Voutetakis S, Papadopoulus A I, 14 Seferlis P, Etier I and Saraereh O 2013 Chemical Eng. Trans. 35 1387-1392. [13] Moharram K A, Abd-Elhady M S, Kandil H A and El-Sherif H 2013 Ain Shams Eng. J. 4 869877

 [14] Chinamhora T, Cheng G, Tham Y and Irshad W 2013 Proc. Inter. Conf. on Energy and Sustainability pp. 20-23 [15] Wu S and Xiong C 2014 Inter. J. of Low-Carbon Tech. 0 1-9 [16] Koundinya S and Krishnan A S 2014 Inter. J. of Mechanical Eng. and Tech. 5 216-223 [17] Abdulgafar S A, Omar O S and Yousif K M 2014 Inter. J. of Innovative Research in Science, Eng. and Tech. 3 8127-8231 [18] Gotmare J A, Borkar D S and Hatwar P R 2015 Inter. J. of Advanced Tech. in Eng. and Science 03 447-454 [19] Du Y, Fell C J, Duck B, Chen D, Liffman K, Zhang Y, Gu M, and Zhu Y 2016 Energy Conversion and Management 108 60-67

Sources

1 http://ijcst.trunojoyo.ac.id/
INTERNET
1%

---

2 eprints.upnjatim.ac.id/7738/6/IJCST_2017...
INTERNET
1%

---

3 https://google.iopscience.iop.org/article/10.1088/1742-6596/953/1/012048/pdf
INTERNET
1%

---

4 http://repository.polimdo.ac.id/2195/1/Similarity Check-Development of Souvenir Production Transaction Processing System.pdf
INTERNET
1%

---

5 https://www.intechopen.com/chapters/43396
INTERNET
<1%

---

6 https://www.numerade.com/ask/question/what-woulda...
INTERNET
<1%

---

7 https://www.sciencedirect.com/science/article/pii/S1364032115013180
INTERNET
<1%

---

8 https://www.sciencedirect.com/science/article/pii/S2090997714000182
INTERNET
<1%

---

9 https://google.iopscience.iop.org/article/10.1088/1742-6596/1509/1/012010/pdf
INTERNET
<1%

---

10 https://www.sunwize.com/tech-notes/testing-pv-modules/
INTERNET
<1%

---

11 https://www.ui.ac.id/
INTERNET
<1%

---

12 https://cdn.intechopen.com/pdfs/22410/InTech-Solar_cell.pdf
INTERNET
<1%

---

13 https://eudl.eu/pdf/10.4108/eai.10-11-2020.2303425
INTERNET
<1%

---

14 https://www.citethisforme.com/topic-ideas...
INTERNET
<1%

15	https://sci-hub.se/10.1016/j.energy.2006.12.006 INTERNET <1%	

EXCLUDE CUSTOM MATCHES	ON
EXCLUDE QUOTES	OFF
EXCLUDE BIBLIOGRAPHY	OFF