TEKNOKOM : Jurnal Teknologi dan Rekayasa Sistem Komputer
Vol. 5, No. 2, September 2022, pp. 143 - 148
ISSN: 2686-3219, DOI: 10.31943/teknokom.v5i2.81

THE INFLUENCE OF TILT ANGLE ON THE PERFORMANCE OF SOLAR PANELS AS A SMART HELMET POWER SUPPLY IN A MOTORCYCLE SAFETY SYSTEM

Muhammad Sekal Maulidan[1*], Rahmat Hidayat[1], Ridwan Satrio Hadikusuma[1], Ibrahim Lammada[1]
[1]Department of Electrical Engineering, Universitas Singaperbangsa Karawang, Indonesia

ARTICLE INFO
History of the article:
Received August 13, 2022
Revised August 28, 2022
Accepted September 2, 2022
Published September 3, 2022

Keywords:
Solar Panel
Tilt Angle
Irradiation

ABSTRACT

The performance of a solar panel module is strongly influenced by its orientation and tilt angle. Tests have been carried out to track variations in the performance of the solar panel module and electrical parameters at various angles of inclination in the conditions of Karawang and Bogor. There are two experimental modes: 1) a varying slope module under a constant irradiance level, 2) a varying irradiation intensity at the optimal tilt setting. For the former schematic, the irradiation levels were carried out at 2 different locations, and for the later setup, the angle of inclination of the module was varied from 90° and 180° by using a single axis tracer At 90° tilted angle in Karawang test place at rest condition, morning experiment give the result of 5,69V on average while in Bogor the experiment gives 5,46V on average. At 180° tilted angle in Karawang test place at rest condition, morning experiment give the result of 5,49V on average while in afternoon experiment afternoon 3.026V on average. In Bogor test place morning experiment give solar panel 5,2V on average and 3,33V at afternoon experiment. In the electrical parameters of the module, the open circuit voltage, short circuit current, maximum power point voltage and maximum power point current decrease substantially with increasing slope angle, while the charge factor decreases somewhat gradually. Tests in both Karawang and Bogor in the afternoon and afternoon confirmed that the optimal tilt angle on cloudy on with UV index between 1-2 in the morning and 3-4 in the afternoon on average is 180° tilted and directing the solar panel module at this angle will maximize the captured solar energy and thereby improve its performance.

Correspondece:
Muhammad Sekal Maulidan,
Department of Electrical Engineering,
Universitas Singaperbangsa Karawang,
Indonesia,
Email : sekalmaulidan33@gmail.com

This is an open access article under the CC BY-ND license.

INTRODUCTION

The Internet of Things (IoT) technologies offer unique opportunities for organizations to improve their performance, innovativeness and as a result pursue competitive advantages [1]. Where the motorcycle security system is able to provide real-time information and is integrated into a web server via the internet, so that motorcycles can be monitored remotely. Seeing these problems, the author made a digital helmet as a security system on a motorcycle that can detect the location of a motorcycle, turn on and turn off the motorcycle engine, and sound a motorcycle alarm to provide a notification signal to the surrounding environment when the motorcycle is in an unsafe condition. controlled via a web server with a solar panel module as a standalone power supply. a motorcycle security system designed to be integrated with a Digital Helmet that uses Bluetooth to connect to a motorcycle.

The smart helmet system is equipped with solar cells for charging. Then it will be stored in the battery. The battery capacity used is 1000 mAh which is estimated to last about 24 hours when used in driving when the system is active. In the event of theft or use of a motorbike outside the owner's permission, website technology that has been designed and connected to a motorbike can turn off the motorbike engine and turn on the alarm on the motorbike and it will show the position of the motorbike. Basically this tool will detect when the Digital Helmet is far from the motorbike. If the distance between the helmet and the motorbike is 20 meters, the motorbike will stop instantly, then after that this tool will also be connected to the internet to be able to stop the engine and the vehicle owner can turn on the alarm via the website and the alarm will sound repeatedly so that the thief becomes panicked and can attract more attention from the surroundings. This system provides a fairly good level of security for motorcycle users from theft.

Since sunlight is the only fuel for the solar panel module system, it is important that the solar panel module is installed properly to receive maximum sunlight and avoid partial shade. To capture the maximum irradiance intensity module must face normal to the incoming sunlight [2-3]. One of the best solutions to maximally intercept solar energy is to apply a solar tracking system to follow the sun's trajectory continuously across the sky [4]. However, the module tracker is a complex system; it is expensive and requires repair and maintenance; hence, not always suitable for applications [5]. Therefore, fixed PV installations with well-engineered tilt angles are still prevalent in the PV industry [6].

Several previous researchers have tried to explore the optimal slope angle relationship, where some researchers found that the installation location is one of the important factors that should be considered in this exercise [7]- several theoretical models for optimal slope have also been proposed. Most of the proposed models are designed for specific locations in the field maximizing solar panel output is strictly an engineering problem defined for each solar panel site and system. Among others, Ebrahimpour. [8], Riyanto [9], Wirajati [10], as: the choice of inclination angle must be between the latitude of the location (φ) and (φ - 15°). This approximation of the combined maximizing angle in the range of ±15° results in a small loss in the total output (below 5%). In addition to the technical perspective, a study also focuses on: the economic perspective of the optimal tilt angle orientation of the solar panel system [11]. Hardiyanto et al. [12] studied the techno-economic optimization of a grid-connected solar panel system, where electricity rates were found to reduce as a result of maintaining an optimal slope. [13] determined optimal orientations for four pricing conditions in Ontario, Canada. The authors found that a slope of 7 to 12° less than the latitude yielded optimal returns in all conditions [14], [15].

RESEARCH METHOD

System Design On Smart Helmets

This section contains the system model by describing the circuit schematic (Solar Panel, Charge Module, Battery, Bluetooth Module HC-06, USB Doctor, Voltmeter, Battery Indicator, 2 Way Switch, Switch) on the helmet system. The block diagram of the interconnection between components is shown in Figure 2.

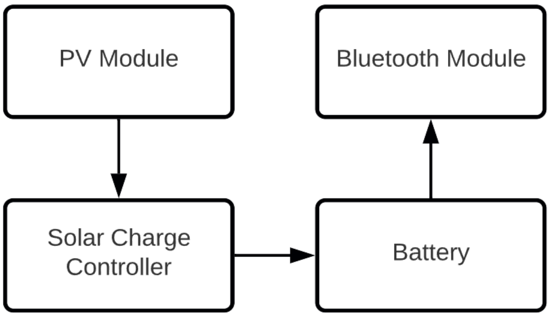

Figure 2. Block Diagram of the System

The system model on the helmet is shown in the schematic circuit drawing on the helmet. The work process on the helmet has 3 parts, namely power input, storage and load. The power input section comes from the solar panel which will later charge the battery via the charge module, then the storage process section which functions to store the power generated by the solar panel which can be monitored via the battery indicator which will then provide power supply to the load, namely the Bluetooth module. The HC-06 will perform wireless serial communication which converts the serial port to bluetooth and will connect the helmet to the motorcycle. Which will later function to control the motor as shown in Figure 3.

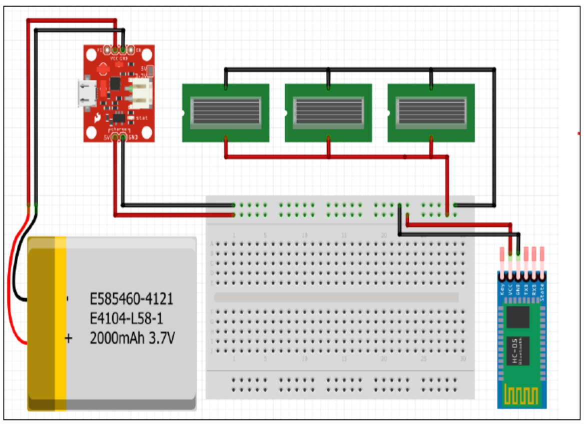

Figure 3. Electronic System Design

Smart Helmet Prototype

Figure 4. Smart Helmet Prototype

This smart helmet uses a box measuring 10 x 10 x 5 cm for the placement of components on the back of the helmet. There are connectors A and B which have a function to supply power to this smart helmet, connector A is where the power input uses a voltage of 12V while connector B is where the power input uses a voltage of 5V.

Data Retrieval

Data collection was carried out in 2 different locations, which are in Karawang and Bogor at 2 different times, in the morning and evening. Tests are only carried out at 90° and 180° angles tilted. Outdoor experiments were carried out on different cloudy sunny days at different tilt angle conditions with the same mono-crystalline silicon (m-Si) solar panel module. Solar radiation, module electrical parameters and different temperature data were collected non-stop from 8:00 WIB in the morning test and 16:00 WIB in the afternoon test. In Karawang test place, from the weather report on climeradar.com, in five-time morning experiment the average of the UV index is 4. From the same source of data, the evening time experiment is being held while the UV index is 2. In Bogor test place, the UV index in morning experiment is 3 on average and 1 in evening experiment.

Then, the data collected daily were carefully screened for irregular and asymmetric irradiation intensity and only reasonable values were considered every 30 min interval. Therefore, the corresponding recording parameters (ambient and module temperature and module electrical parameters) are curated based on specific radiation values, such as for 200, 300, 400 … up to 1000 W/m2. That is, after filtering and curation, the parameters measured at a certain angle of inclination are set and assigned to nine specific radiation levels (200 to 1000 W/m2 at 100 W/m2 intervals). For all slope angles, data were collected and structured in the same way provided that the trend curve of the ambient temperature on the experimental day nearly corresponded to the representative day (the first day of the experiment). In this way, an even distribution of solar irradiance and ambient temperature on different experimental days can be maintained. However, wind speed and humidity on different days are not essentially the same and errors resulting from these variations are ignored in the performance evaluation.

RESULTS AND DISCUSSION

The effect of the variation of the slope of the module on the electrical parameters of the solar panel and the temperature of the solar cell has been explored in this research experiment. Experimental studies both indoors and outdoors have been carried out to make comparisons between the results. Another objective of the outdoor study is to experimentally determine the effect of the optimal tilt angle for the conditions of Karawang and Bogor.

Testing of Solar Panels on Rest Conditions in Karawang

Table 1. Testing of Solar Panels with 180° Tilling Angle

Experiment	Place	Time	Tilt Angle	Sun Direction	V Out	A Out
Experiment 1	Karawang	Morning	180°	East	5.60	2.5
Experiment 2	Karawang	Morning	180°	East	5.62	2.6
Experiment 3	Karawang	Morning	180°	East	5.34	2.8
Experiment 4	Karawang	Morning	180°	East	5.48	2.7
Experiment 5	Karawang	Morning	180°	East	5.42	2.6

Voltage and current on the solar panel test located in Karawang in the morning and at rest, the experiment was carried out 5 times with a tilt angle of 180°. the graph of the test results obtained from the data in table 1, namely the solar panel test located in Karawang in the morning and at rest, with a tilt angle of 180° can be seen in figure 5.

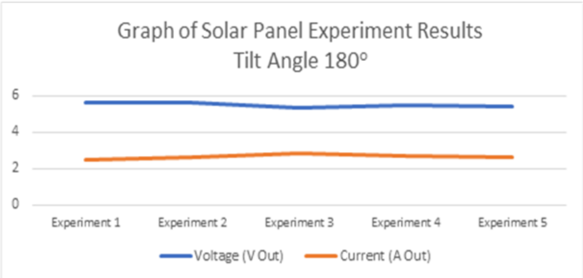

Figure 5. The Effect of Angle on Voltage and Current in the Morning

Table 2. Testing of Solar Panels with 90° Tilling Angle

Experiment	Place	Time	Tilt Angle	Sun Direction	V Out	A Out
Experiment 1	Karawang	Morning	90º	East	5.72	3.5
Experiment 2	Karawang	Morning	90º	East	5.70	3.4
Experiment 3	Karawang	Morning	90º	East	5.65	3.5
Experiment 4	Karawang	Morning	90º	East	5.70	3.3
Experiment 5	Karawang	Morning	90º	East	5.68	3.4

Table 2 above is a table of the results of measuring voltage and current on the solar panel test located in Karawang in the morning and in a state of silence, experimented 5 times with an angle of 90° facing east. a graphic image of the test results obtained from the data in table 2, namely the solar panel test located in Karawang in the morning and at rest, with an angle of 90° facing east, can be seen in Figure 6.

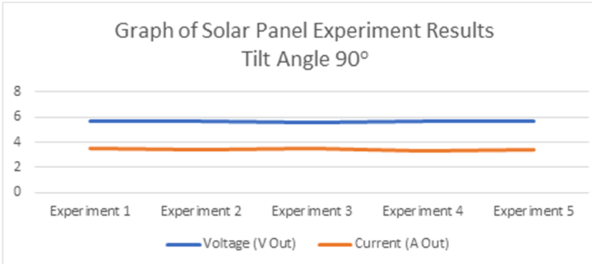

Figure 6. The Effect of Angle on Voltage and Current in the Morning

Table 3. Testing of Solar Panels with 180° Tilling Angle

Experiment	Place	Time	Tilt Angle	Sun Direction	V Out	A Out
Experiment 1	Karawang	Afternoon	180º	East	3.04	2.4
Experiment 2	Karawang	Afternoon	180º	East	3.05	2.3
Experiment 3	Karawang	Afternoon	180º	East	3.00	2.1
Experiment 4	Karawang	Afternoon	180º	East	3.03	2.0
Experiment 5	Karawang	Afternoon	180º	East	3.01	2.1

Table 3 above is a table of the results of measuring voltage and current on the solar panel test located in Karawang in the afternoon and in a state of silence, experimented 5 times with a tilt angle of 180°. the graph of the test results obtained from the data in table 3, namely the solar panel test located in Karawang in the afternoon and at rest, with a tilt angle of 180° as shown in Figure 7.

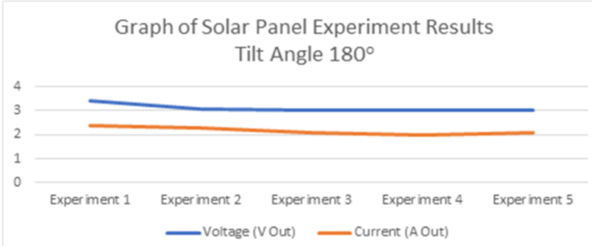

Figure 7. The Effect of Angle on Voltage and Current in the Afternoon

Testing Solar Panels on Rest Condition in Bogor

Table 4. Testing of Solar Panels with 180° Tilling Angle

Experiment	Place	Time	Tilt Angle	Sun Direction	V Out	A Out
Experiment 1	Bogor	Morning	180º	East	5.23	2.5
Experiment 2	Bogor	Morning	180º	East	5.15	2.6
Experiment 3	Bogor	Morning	180º	East	5.18	2.5
Experiment 4	Bogor	Morning	180º	East	5.20	2.3
Experiment 5	Bogor	Morning	180º	East	5.26	2.5

Table 4 above is a table of the results of measuring voltages and currents on the solar panel test located in Bogor in the morning and in a state of silence, the experiment was carried out 5 times with a tilt angle of 180°. the graph of the test results obtained from the data in table 4, namely the solar panel test located in Bogor in the morning and at rest, with a tilt angle of 180° can be seen in Figure 8.

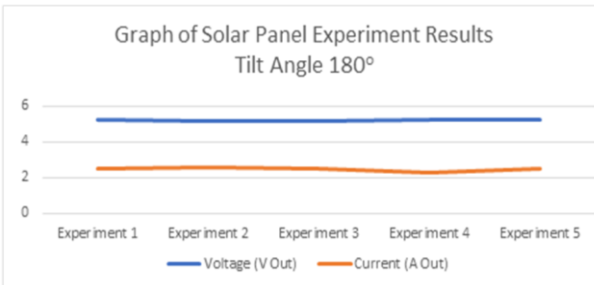

Figure 8. The Effect of Angle on Voltage and Current in the Morning

Table 5. Testing of Solar Panels with 90° Tilling Angle

Experiment	Place	Time	Tilt Angle	Sun Direction	V Out	A Out
Experiment 1	Bogor	Morning	90°	East	5.40	3.3
Experiment 2	Bogor	Morning	90°	East	5.39	3.1
Experiment 3	Bogor	Morning	90°	East	5.52	3.2
Experiment 4	Bogor	Morning	90°	East	5.46	3.3
Experiment 5	Bogor	Morning	90°	East	5.55	3.1

Table 5 above is a table of the results of measuring voltages and currents on the solar panel test located in Bogor in the morning and in a state of silence, experimented 5 times with an angle of 90° facing east. a graphic image of the test results obtained from table 2 data, namely the solar panel test located in Bogor in the morning and at rest, with a tilt angle of 90° facing east can be seen in Figure 9.

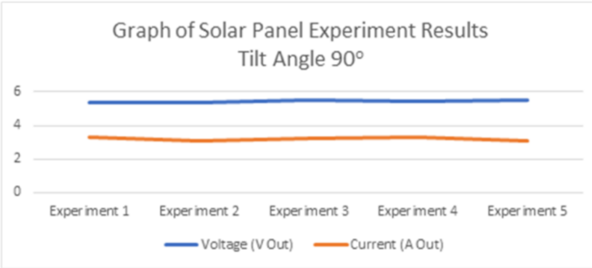

Figure 9. The Effect of Angle on Voltage and Current in the Morning

Table 3. Testing of Solar Panels with 180° Tilling Angle

Experiment	Place	Time	Tilt Angle	Sun Direction	V Out	A Out
Experiment 1	Bogor	Afternoon	180°	East	3.33	2.4
Experiment 2	Bogor	Afternoon	180°	East	3.21	2.3
Experiment 3	Bogor	Afternoon	180°	East	3.4	2.3
Experiment 4	Bogor	Afternoon	180°	East	3.25	2.2
Experiment 5	Bogor	Afternoon	180°	East	3.46	2.5

Table 6 above is a table of the results of measuring voltages and currents on solar panel testing located in Bogor in the afternoon and at rest, experimented 5 times with an angle of 180°. the graph of the test results obtained from the data in table 6, namely the solar panel test located in Karawang in the afternoon and in a state of silence, with an angle of 180° as shown in Figure 10.

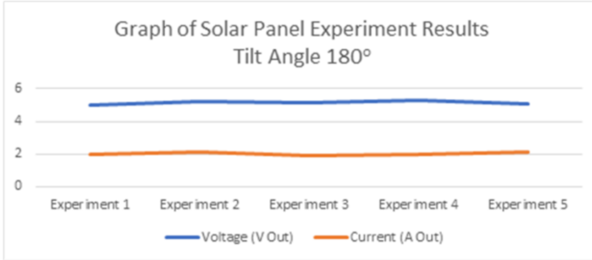

Figure 10. The Effect of Angle on Voltage and Current in the Afternoon

CONCLUSION

Solar power generation depends on many factors, among which the slope of the module is very important. The operative intercept of solar radiation plays an important role in the performance of the solar panel system, where the tilt angle works as one of the control parameters. The effect of tilted angel is less significant. At 90° tilted angle in Karawang test place at rest condition, morning experiment give the result of 5,69V on average while in Bogor the experiment gives 5,46V on average.

At 180° tilted angle in Karawang test place at rest condition, morning experiment give the result of 5,49V on average while in afternoon experiment afternoon 3.026V on average. In Bogor test place morning experiment give solar panel 5,2V on average and 3,33V at afternoon experiment.

REFERENCES

[1] C. Eleanor, P. Marina, T. D. Claudia M, and B. David. “Internet of Things: Aspiration, implementation and contribution.” Journal of Business Research. vol. 139, pp. 69-80, February 2022. DOI 10.1016/j.jbusres.2021.09.025.

[2] P.D. Lund, “Data for global power demand and solar PV output matching”, Data in Brief, vol. 19, pp. 1694–1715, August 2018. DOI. 10.1016/j.dib.2018.06.054

[3] S. Wendlandt and F. Popescu “Photovoltaic Energy Yield Prediction Using An Irradiance Forecast Model Based On Machine Learning

For Decentralized Energy Systems", 36th EU PVSEC France, September 2019.

[4] S. A. S. Sidik, B. V. Taringan and G. Gusnawati. "Pengaruh Besar Sudut Cermin Terhadap Efisiensi Panel Surya." Jurnal Fisika: Fisika Sains dan Aplikasinya, vol. 7(1), pp. 56-63, 2022.

[5] X. Liu, Q. Tan, Y. Niu and R. Babaei "Techno-economic analysis of solar tracker-based hybrid energy systems in a rural residential building: A case study in South Africa." International Journal of Green Energy, p. 1-20, February 2022. DOI. 10.1080/15435075 .2021.2024545

[6] C. Rodrigo, S. Elissandro, L. Lutero and B. Natasha. "Study Comparison of the Efficiency of a Photovoltaic System with Fixed Panels and with Solar Tracker in the Northwest of Brazil." International Journal of Advanced Engineering Research and Science. vol. 9, pp. 183-189. DOI. 10.22161/ijaers.94.21.

[7] M. J. Yun, Y. H. Sim, S. I. Cha, S. H. Seo, and D. Y. Lee. "3-Dimensional dye sensitized solar cell sub-module with oblique angled cell array for enhanced power and energy density output utilizing non-linear relation in cosine law of light incident angle." Solar Energy, vol. 177, pp. 355-363, January 2019. DOI. 10.1016/j.solener.2018.11.023.

[8]. A. Ebrahimpour , "Calculate optimum solar cell angle based on maximum solar intensity and minimum solar cell temperature" SSRN, p. 15, March 2, 2022. DOI. 10.2139/ssrn.4047979 [Online]. Available SSRN, https://ssrn.com/abstract=4047979

[9]. S. D. Riyanto, Supriyono and F. Hazrina, "Optimizing of Electric Power Solar Cell by Various Angle Using the Activator Panel Based on the Timer and Light Sensor," 2018 International Conference on Applied Science and Technology (iCAST), 2018, pp. 109-114, October 2018. DOI. 10.1109/iCAST1.2018.8751564.

[10]. Wirajati, I. G. A. Bagus, and I. M. A. K. Natha. "Pengaruh sudut kemiringan dan arah penempatan terhadap daya keluaran pada modul panel surya." Journal of Applied Mechanical Engineering and Green Technology vol. 2.1, pp. 5-9, 2021.

[11]. S. Hariyanto. "Rancang Bangun Reflector Untuk Mengoptimalkan Daya Serap Matahari Pada Panel Surya Dengan Variasi Sudut Guna Menghasilkan Daya Optimal." Jurnal Ilmiah Telsinas Elektro, Sipil dan Teknik Informasi, vol. 4(1), pp. 41-45, 2021.

[12]. D. L. Hardianto and A. A. Hasyim. "Analisis Keluaran Energi Listrik Pada Panel Surya 60 WP Ditinjau dari Sudut Kemiringan Terhadap Pengaruh Suhu dan Iradiasi Matahari" Dr. dissertation, Dept. Electrical., Univ. Muhammadiyah Surakarta., Surakarta, 2022.

[13]. M. J. Mayer and G. Gróf. "Techno-economic optimization of grid-connected, ground-mounted photovoltaic power plants by genetic algorithm based on a comprehensive mathematical model." Solar Energy, vol. 202, pp. 210-226, May 2020. DOI. 10.1016/j.solener.2020.03.109.

[14]. H. Z. Al Garni, A. Awasthi and David Wright, "Optimal orientation angles for maximizing energy yield for solar PV in Saudi Arabia." Renewable Energy, vol. 133, pp. 538-550, April 2019. DOI. 10.1016/j.renene.2018.10.048.

[15]. M. Kouhestani, F. Byrne, J. Johnson, D. et al. "Evaluating solar energy technical and economic potential on rooftops in an urban setting: the city of Lethbridge," Canada. Int J Energy Environ Eng , vol 10, pp. 13–32, March 2019. DOI. 10.1007/s40095-018-0289-1