

Date: 1 July 2021

Dear ICIC Express Letters Editor,

Thank you for considering our paper entitled by 'ARDUINO UNO AVR ATMEGA328 MICROCONTROLLER BASED DUAL AXIS SOLAR TRACKER DESIGN', Reference No.: ICICELB-2105-010; Author(s): Syafaruddin, Gassing, Faizal A Samman, Nidya Umniyah and Fifi Febriyana, in the publication of ICIC Express Letters, Part B: Applications.

We would like to thank to reviewers for the beneficial comments and suggestions in order to improve the quality of the paper. We have revised our paper according to the ICIC-ELB template and answered the following the reviewer comments as shown in the bold font as follows:

Best regards,

Syafaruddin

Universitas Hasanuddin, Indonesia

The paper is generally well written and organized. The results presented in the paper seem correct, and potentially useful in practice. The techniques employed to tackle the problems are generally standard with some novelties. The paper can be accepted for publication subject to some necessary minor changes as below:

Thank you for your beneficial comments and suggestion to improve the quality of our paper.

Answer for Reviewer Comments:

Comments:

1) The review on existing studies is not enough. It has been found that no reviewed references are published in recent years; therefore, the motivation of this work, that is, why to explore dual axis solar tracker design to capture much output power and energy of solar panel, can't be justified.

The literature review has been improved by including the citation of articles published in the last five years as follows:

Several designs of solar tracker have been published in scientific community. The design of two-dimensional axis of solar tracker has been reviewed considering the trajectory movement and functional model for the efficient and effective tracking system performance [5]. Also, an intelligent control of solar tracker has been successfully proposed in single and dual axis control system movements to increase the performance of solar tracker, to estimate the accurate trajectory movement of Sun across the horizon, to maximize the output power generation of solar panel with solar tracking system [6]. Similarly, a machine learning model is utilized as the accurately predictive model of real-time monitoring of energy production from solar panels supported by dual-axis trackers under different climate condition [7]. These previous approaches are then improved by

considering the accumulative parasitic energy losses during tracking movement in order to optimize the annual solar energy production for fixed position and dual-axis solar tracker of solar panels [8].

The performance of solar tracker is improved by auxiliary electronic sensor components. There was a design of solar tracker with the utilization of light dependent resistor (LDR) [9]. The tracking mechanism is designed as a low-cost active tracking system of dual-axis trajectory movement with closed-loop control, utilizing Light Dependent Resistor (LDR) sensors as the inputs of the system to adapt the geographical position of solar panel [10]. However, it is quite tricky to determine the optimal angle for LDR placement since the sunlight direction is time-variable. The approach of solar tracker design with energy saving regarding the control mechanism has been also proposed with tele-control using global positioning system (GPS) [11]. The controller will always try to move the solar panel in the maximum direction of sunlight with the reference signals from the GPS and embedded with Proportional Integral Derivative (PID) for high accuracy trajectory. However, such approach has given and added complexity design with of course the additional costs. The solar tracker with microcontroller has been designed with the fixed angle movement of solar panel based on the Sun movement in the equator region [12]. However, the Sun displacement crossing the equator is by seasonal movement with variably astronomical position. Therefore, it is still necessary to have manual adjustment periodically in order to have maximum tracking performance. In this respect, it is still quite challenging to design a solar tracker with simple design and control algorithm, low power consumption and cost with maximum tracking performance.

- [5] Emmanuel Karabo Mpodu, Zeundjua Tjiparuro, Oduetse Matsebe, 'Review of dual axis solar tracking and development of its functional model', *Procedia Manufacturing*, Vol. 35, pp. 580-588, 2019
- [6] Nadia AL-Rousan, Nor Ashidi Mat Isa, Mohd Khairunaz Mat Desa, 'Efficient single and dual axis solar tracking system controllers based on adaptive neural fuzzy inference system', *Journal of King Saud University - Engineering Sciences*, Vol. 32, No. 7, pp 459-469, 2020
- [7] Mohammed Ali Jallal, Samira Chabaa, Abdelouhab Zeroual, 'A novel deep neural network based on randomly occurring distributed delayed PSO algorithm for monitoring the energy produced by four dual-axis solar trackers', *Renewable Energy*, Vol. 149, pp. 1182-1196, 2020
- [8] Ming-Hui Tan, Tze-Koon Wang, Chee-Woon Wong, Boon-Han Lim, Tiong-Keat Yew, Woei-Chong Tan, An-Chow Lai, Kok-Keong Chong, 'Optimization Study of Parasitic Energy Losses in Photovoltaic System with Dual-Axis Solar Tracker Located at Different Latitudes', *Energy Procedia*, Vol. 158, pp. 302-308, 2019
- [9] Fábio Moacir Hoffmann, Rolf Fredi Molz, João Victor Kothe, Elpidio Oscar Benitez Nara, Leonel Pablo Carvalho Tedesco, 'Monthly profile analysis based on a two-axis solar tracker proposal for photovoltaic panels', *Renewable Energy*, Vol. 115, pp. 750-759, 2018
- [10] Chaowanam Jamroen, Preecha Komkum, Sompol Kohsri, Wuttinan Himananto, Siriwat Panupintu, Sorawit Unkat, 'A low-cost dual-axis solar tracking system based on digital logic design: Design and implementation', *Sustainable Energy Technologies and Assessments*, Vol. 37, pp. 1-14, 2020
- [11] M.H.M.Sidek, N.Azis, W.Z.W.Hasan, M.Z.A.Ab Kadir, S.Shafie, M.A.M.Radzi, 'Automated positioning dual-axis solar tracking system with precision elevation and azimuth angle control', *Energy*, Vol. 124, pp. 160-170, 2017
- [12] Syafaruddin, Ranu Fauzan, Andika S. Amir, Hajime Miyauchi, 'Microcontroller ATmega8535 Based Solar Tracker Design for PV System Applications in Equator Region', *International Journal of Control and Automation*, Vol.7, No.4, pp.217-234, 2014

The motivation of this work regarding dual axis solar tracker: "This paper deals with new approach of dual-axis solar tracker design utilizing the Arduino Uno AVR

Atmega328 microcontroller as the main controller. The work is claimed more advanced than the single axis-based microcontroller for automatic tracking system [12]. The proposed design has several prominent designs where the automatic reset system is provided to bring the solar panel facing the East direction automatically during morning time to wait the Sun starts shining."

[12] Syafaruddin, Ranu Fauzan, Andika S. Amir, Hajime Miyauchi: 'Microcontroller ATmega8535 Based Solar Tracker Design for PV System Applications in Equator Region', *International Journal of Control and Automation*, Vol.7, No.4, pp.217-234, 2014

The utilization of dual axis solar tracker has been justified in the results of measurement and the statement is supported with another literature study as follows: "In this respect, much output power can be yielded with solar tracker movement compared to the system without solar tracker [17]. Significant output power is obtained with 4 and 6 times higher at 10a.m and during afternoon at 4p.m, respectively."

[17] Walter Nsengiyumva, Shi Guo Chen, Lihua Hu, Xueyong Chen: 'Recent advancements and challenges in *Solar Tracking Systems (STS): A review*', *Renewable and Sustainable Energy Reviews*, Volume 81, Part 1, pp. 250-279, 2018

2) In the end of the Introduction, the organization of this paper is recommended to be summarized to make the structure clear.

It has been added the structure of our article at the end of Section 1: The article is organized as follows. The literature review regarding the significancy study of solar trackers has been shown in this section 1. In Section 2, the configuration of proposed systems is presented. Section 3 provides the information of tracking algorithm and design of dual axis solar tracker. Following in Section 4, testing performance and discussion are presented. Finally, Section 5 shows the conclusion of this study.

3) In the analysis of output power of solar panel without solar tracker under clear sky measurement shown in Figure 5, it is mentioned that the minimum output power is obtained during afternoon (2p.m-4p.m) times with the range output of 2.8-23W; however, from the figure, the range is presented as 2.8-36W.

This part has been corrected according to information results in Figure 5 as follows: "The maximum output power of solar panel is obtained between 12a.m and 1p.m with range output of 50-56W. The minimum power is obtained during morning (10a.m) and afternoon (4p.m) times with the output power of 12W and 2.8W, respectively."

4) In the paragraph below Figure 6, authors stated that the results show that the solar panel with tracker produces 24.5-42W during the period of 8a.m-11a.m and 46-56W during the period of 12a.m-2p.m, but as seen from Figure 6, the results of output seem not correct, with 48W of 11a.m and 60W of 1p.m.

This part has also been corrected as follows:

"The results show that the solar panel with tracker produces 24.5-60W during the period of 8a.m-1p.m and the output power start decreasing from 46W at 2p.m to 32W at 4p.m.

5) In the Conclusions, some further research directions as an integral part are expected to be indicated.

The future study has been indicated in the last part of Conclusion as "In future, the multi-axis of solar tracker is developed by considering the astronomical position of Sun across the sky and geographical location of solar panels in order to maximise the output power and efficiency performance of solar panels."

6) The format of References should be paid attention to. Authors only provided the authors' names, journal source and the detailed volume information, without the paper titles.

Thank you for the important correction on this part. The reference format has been corrected to include the title of the articles.

7) No recently published references are cited; therefore, it is suggested to cite more up-to-date references from mainstream journals, for example, the paper titled "Integration of Solar Tracker and Maximum Power Point Tracking for Improving Photovoltaic (PV) System Efficiency" in International Journal of Innovative Computing, Information and Control, vol.16, no.2, pp.429-443, DOI: 10.24507/ijicic.16.02.429, 2020.

The literature review of this article has been improved by adding the related references in the last five years including the recommended article.

8) English presentation is not satisfying. Too many incomplete expressions exist, such as "Is due to all power needs to the solar tracker is from the terminal output of PV panels", "However, the Sun displacement crossing the equator is seasonal movement with variably position may occur" and "so that the solar panel moving horizontally and vertically based on this maximum voltage". Authors have to carefully check and improve the presentation to meet the publication needs.

Thank you for this beneficial comment to improve the quality of our paper. The language problems have been properly checked and corrected.
