*International Journal of Engineering & Technology*, 7 (2) (2018) 913-916

International Journal of Engineering & Technology

*Website: www.sciencepubco.com/index.php/IJET*
*doi: 10.14419/ijet.v7i2.11262*
***Research paper***

# Optimizing solar energy for houses with slanting type roofs

**Muhammed Sabri Salim ***

*Laser & Optical Electronics Engineering School, Alnaharin University, IRAQ*
**Corresponding author E-mail: muhsabri1967@yahoo.com*

**Abstract**

During the daily sun cycle, the falling rays are of varying intensity on the solar panel reducing the energy generated from it. This is evident in the energy production of solar panels that are installed on the slanted surfaces of homes scattered in the rain regions of the world. In this research, the reasons for the low efficiency of energy production of solar panels that are installed on the A-frame designs of homes were studied and solved. The design of an integrated tracking system is developed based on fuzzy logic control using an open source code that can be easily modified. The performance and characteristics of the solar tracking device are tested experimentally to test its suitability for use with slanted roofs homes. The integrated solar localization system offers economical and efficient solar monitoring, as well as open source programming, which allows for future improvements and changes. In addition, the single-axis fuzzy tracking system was good for moving both panels in less than five seconds towards the sun. The adoption of the proposed design provides an extremely accurate tracking system and therefore, maximizes the potential of power generated by the solar panel since it will meet the sun's rays from dawn to dusk. The economic effect of the proposed design is to approximately double the value of electrical power received compared to the fixed design.

***Keywords***: *Renewable Energy; Fuzzy Logic Control; Embedded Systems; Solar Tracker; Sensing; Solar Panels.*

## 1. Introduction

The sun is one of the elements of sustainable energy. So researchers are focusing on inventing new ways to maximize solar power. The new technology has succeeded in generating electricity from the sun by collecting the sun's rays by the so-called solar panel. A solar panel is a group of solar cells that are connected serially to each other. The physical concept of the solar panel is to convert the sun into electrical energy as long as this radiation falls on the cells of the solar panel. However, as a result of the daily sun cycle, the falling rays are of varying intensity on the solar panel reducing the energy generated from it. [1-3] to maximize energy collected from sun by solar panel, a solar tracking system is developed. Single-axis solar trackers moving on single direction, which include several types such as polar aligned, vertical, horizontal, and tilted. The dual-axis solar tracking system has the ability to move on two different axes. Such systems continue to guide solar panels to the direction of sunlight. Therefore, the maximum possible energy generated from solar panels is supported by dual-axis tracking systems. This is evident in the energy production of solar panels that are installed on the slanted surfaces of homes scattered in the rain regions of the world. Features in A-frame designs are the gable roof that extends almost to the ground level for rainwater drainage. These surfaces have been used to install solar panels. Since these surfaces are approximately opposite, the light falling on them will be more intense on one side than the other, as shown in Figure (1). In particular, and to solve this problem, one axis tracking systems will be included in the solar panel. The idea of the tracking system that is integrated with the solar module is based on the principle of the sunflower work (Helianthus annuus). i.e. its function is to track the position of the sun during its daily session. To locate the sun, a number of light sensors are used to determine the position of the sun with high precision. the sun positions signals where collected from sensors are sent to the main processing unit. Solar panels are directed to the site where the angle is vertical between the falling sun and the solar panel using active or passive control system. In this research, design a Fuzzy controller system to control the altitude direction of the solar panel using linear actuators. The microprocessor (ATMega16U2) is used here as the main processing unit for the embedded tracking system. The proposed system is appropriate in terms of design and cost to solve the problem of houses with A-frame designs as will be seen in the following paragraphs. [4-6]

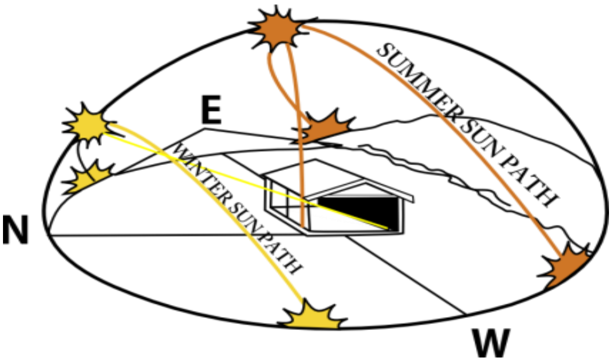


**Fig. 1:** Sun Path During Winter and Summer Sessions.

## 2. Embedded solar tracking system

There are three design elements that can achieve maximum energy production using solar panels, as follows: First of all, it studies the current problem and develops an algorithm to solve it optimally. Secondly, design a high-resolution sensor node to detect the intensity of light falling on the solar panel.
Third, the design of a rapid response control system able to identify the descending angle of the solar beam and generate high precision solar coordinate data. As a result, the adoption of the above design

points provides an extremely accurate tracking system and therefore, maximizes the potential of power generated by the solar panel since it will meet the sun's rays from dawn to dusk. The proposed research focuses on design and simulation of a prototype of the integrated solar localization system. This model will cover the scope as follows:

- Guide two solar panels at an angle from – 45º to 225º vertically.
- Use two light sensors a light-resistant type (LDR).
- Using fuzzy logic control theory (FLC) to analyze the data of the sun's fall, and then control the angle of the solar panels to achieve maximum power.

## 3. Related work

The tracking system for solar movement during the day is an essential part of the conversion system of solar energy into electricity. Where many researchers and companies specialize in the development of new tracking methods. The earth needs a full year to orbit in an orbit called elliptical as the center of this orbit is the sun. The equatorial level and celestial earth intersect at the polar axis and celestial level. The sun moves to the earth in a slant at the celestial equator at an angle of 23.458 degrees. Where the angle of solar deviation (δ) is equal to zero in the days 20/12 and 22/23 of March. [5-7].

The Earth circulates around the polar axis only one cycle. This can be illustrated by the simultaneous determination of the Sun's position hour angle (v) generated by the rotation of the celestial sphere around the polar axis. The hour angle is equal to zero at noon while increasing in the east. The horizon is a large orthogonal circle with the vertical axis figure 2. The latitude (φ) of the position can be defined as the angle formed by the radial line that joins the position at the center of the earth and subtracts the line at the equatorial level. The axis of rotation of the Earth crosses the surface of the Earth at 90º north latitude and 90 º latitude of the South Pole. Any point on the earth's surface can be described by the intersection of latitude and a longitude angle (6). Many surveys are carried out to calculate the solar positions and define the relationship between the established parameters. Walraven uses a FORTRAN program to calculate the value of the parameter for the Sun position within 0.018 of precision. The calculated parameters were elevation local azimuth real times and time decline sunset and sunrise (7).

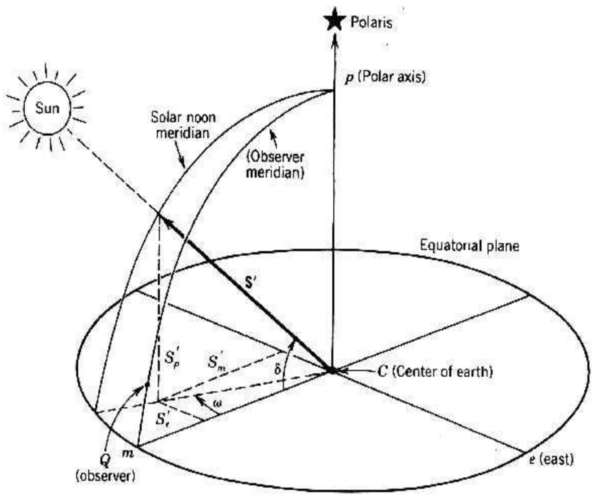


**Fig. 2:** Graphic Depiction of Solar Angles [5].

In the fixed solar collectors, the projection of the collector area at the orthogonal level to the directions of the solar radiation is given by the cosine function of the angle of incidence (θ) as shown in Figure 3. The greater value of (θ) angle is the lower the power. The energy generated by theoretical calculations using a localization system approach at 1000 w / m$^2$ in the orthogonal region with radiation ($S_0$). [8] [9].

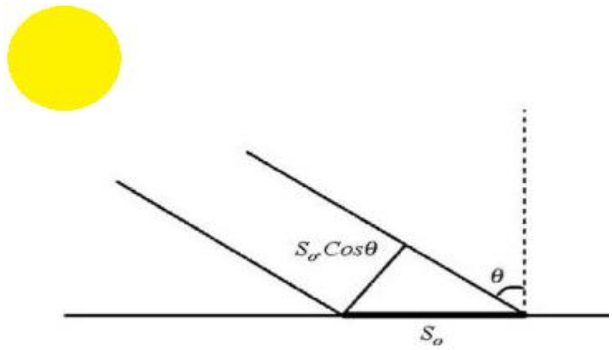


**Fig. 3:** Graphic Depiction of Solar Angles [8].

Therefore, the accumulated energy over 12 hours a day of the tracking system is greater compared to the energy generated by the fixed systems being facing the sun during noon only. Two common types of tracking systems are single-axis and two-axis. The two-axis tracking devices are more precise by directing the solar panel toward the sun. Generally, the choice of one type of tracking system depends on several factors including the nature of the use, accuracy required, and cost. As mentioned above, solar energy is very useful for generating electricity used in homes, factories, and other applications. In this paper, the emphasis was placed on the efficiency of energy generated by the solar panel installed on the roofs of buildings or houses with slanted surfaces. Such houses are scattered in the rainy areas where architects have found a way to drain rainwater on roofs of buildings or houses in geographical areas that are characterized by a lot of rain during the year. Accordingly, two or more panels (depending on the surface area of the house and the solar panel used) are installed on both sides of the slanted surface as shown in Figure (4). Therefore, the maximum capacity of the panels will be produced alternately according to the path of the sun and geographical house coordinate thus reduce the efficiency of energy production. This problem was adopted as a motive that requires finding solutions in this research. [10-12]

Most researchers in the development of solar tracking devices did not address the improvement of energy generated from the solar panels installed on the houses with slanting type roofs, so this research will study the amount of power generated from solar panels installed on the roof of these homes and then find practical and theoretical solutions to improve the production of energy.

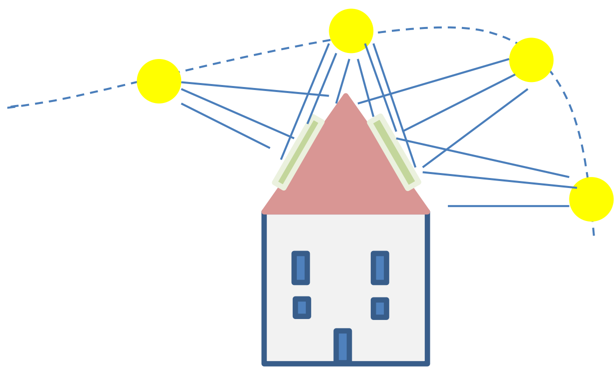

**Fig. 4:** Solar Light Intensity Based House Graphic Coordinate.

## 4. Embedded system designing approach

A one-axis solar tracking system that controls two solar panels will follow the sun during the daily movement of the sun in a single vertical position. The tracking process is performed using a two light sensor. The data of all the sensors will be read and compared to the fuzzy controller where the solar panels move to the position of the sun using two linear actuators. Figure (5) shows that the angle at which the first solar panel moves differs from the other panel angle based on the angle of falling sunlight. The positivity features of the proposed system are to obtain the maximum capacity of the solar panels using a simple adjustment and the lowest material cost compared to the energy generated.

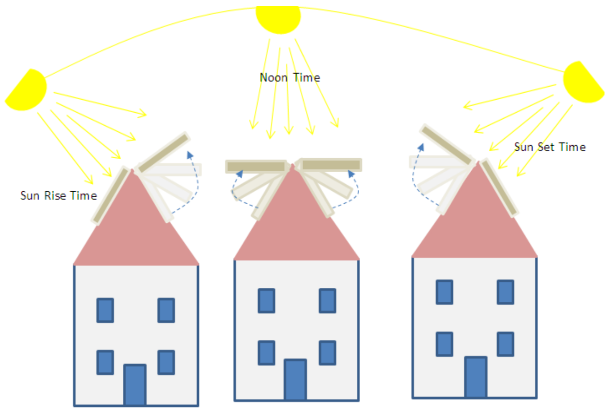


**Fig. 5:** The Various Altitude Angles for Solar Panel According to Sun Position.

## 5. System design

The hardware used in the system can be described in simple components, starting with the main part of the systems which acts as the main controller of the system. The ATMega16U2 based on a 16MHz CPU as the main processing unit that has a number of GPIOs that link the board to four LDR sensors and the two linear actuators that are connected to the Solar Panel and a digital voltmeter.

The illumination level in the LDRs is changing with the sun position changes. Therefore, the comparator voltage is no longer equal to zero volts, so the output of FLC generates information to linear actuators that make the panels turn to follow the sun. LDR1 and LDR2 are regulated such that the linear actuator is stills when the LDRs get the same amount of sunlight i.e. the Verror voltage is equal to 0 volts. Verror is then fed to two fuzzy logic controllers in which each controller is responsible for operating of a linear actuator. Figure 6 shows the general architecture of the system. [13-16]

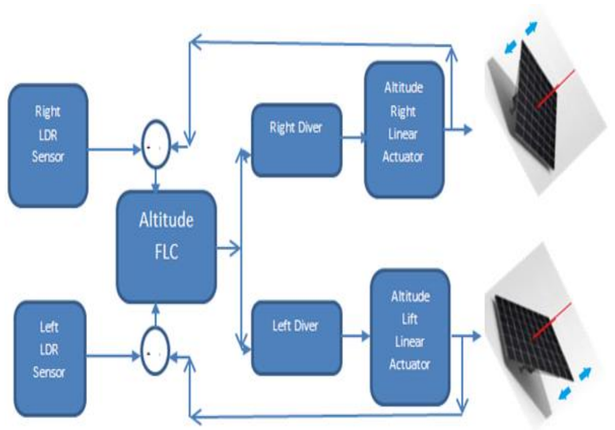


**Fig.6:** General System Architecture.

## 6. Simulation of slanted roof solar tracking system

The Simulink complete fuzzy logic system controller for solar tracking is built using the Matlab package software R2017a and shown in figure 7. The simulation of the proposed design is started with input layer in which the sensing sunlight are fed from LDRs. Sun position Detecting layer can be defined as a comparison circuit for left and right LDRs voltages which called error voltage (Ve = Vl - Vr). The error voltage is fed to a single stage of FLC where FLC Function is for placing on each Solar Panel at 90° with respect to sunlight by controlling both altitudes of Solar Panel. The output of the FLC ranges from 0-100% duty cycle per assist device connected to two linear actuator driver blocks. The main function of the system controller is to have the solar tracking speedy follow the input position profile by accelerating at a constant rate to reach the set speed and then to same deceleration Speedwell to stop. The linear actuator layer consists of a controlled Voltage source and direction that includes up to four power switches connected in a bridge configuration to feed single linear actuator motor. [13]

## 7. Evaluation criteria

The efficiency of the proposed system for buildings with inclined surfaces is compared with the fixing systems. The difference in the percentage accumulated between these systems will be recorded for 8 hours and different angles. Furthermore, the weather was classified as cloudy and partly cloudy. Finally, the response time of the system is calculated.

## 8. Results and discussion

The results indicate that the tracking system showed an increase in voltage throughout the day in contrast to the fixed system figure 8. In the fixed system, although one solar panel is encountered at 90 degrees at a given time of day, the total voltage of this system is much lower than the proposed tracking system. The reason is that the intensity of the sunlight is on only one panel. While we observe that in the tracking system, the intensity of the sunlight on the panels is equal, generating the maximum energy from both. Figure 8 shows a significant difference in energy percentage in both systems over most of the hours except in the noon, where the energy difference in both systems is low.

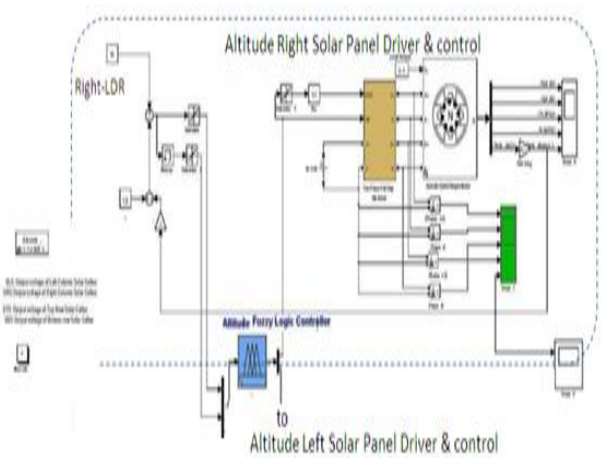


**Fig. 7:** Simulink Diagram of Shows Part of Research Proposed Fuzzy Solar Tracking System.

In contrast, in the proposed tracking system, both panels are exposed to the same amount of light intensity that occurs throughout the day. Both fixed and proposed tracking systems show little variation during the first hour of the day, but the difference becomes apparent later because the energy generated by the tracking device is due to the gathering of the two solar panels; this also applies to the hours of sunset. In the evening, the difference becomes equal between the two systems because of the lack of daylight, although the solar panels face the sun. Figure 9 shows the time needed to reach the correct angle of the solar panel are less than 5 seconds. In order to clarify this, the day can be divided into two parts relative to the time taken to direct the solar

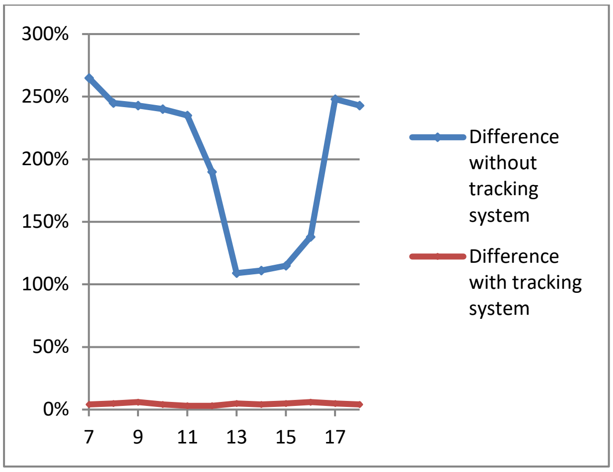


**Fig. 8:** Percentage Power Difference between: Right and Left Solar Panels With Tracking System (Red Curve), Static and Track Systems (Blue Curve) For The Sunny Day.

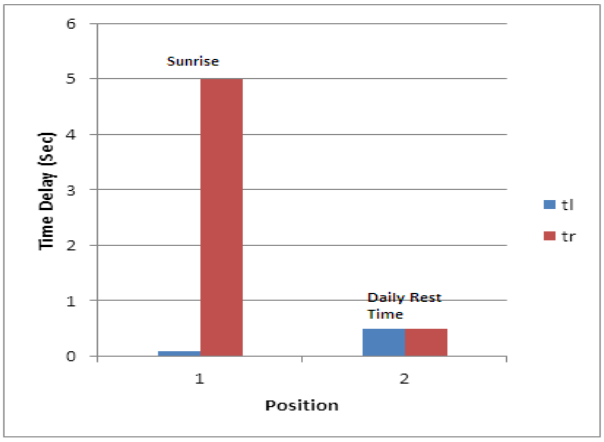


**Fig. 9:** Time Delay Measurement for the Proposed Tracking System.

panel (time delay), sunrise and rest of day. Each of the panels is assumed angled at a 45 °, as shown in Figure 10. During the sunrise, where one of the panels almost face the sun and thus need a little time to adjust its position, while the second panel is far from the sun where it must move at an angle of 90 ° to face the sun and therefore the time required to be large. For the rest of the day, the delay time is equal to both panels due to continuous monitoring of the sun. For example, the two panels are moved approximately with the same ratio until the right panel returns to 45° angle while the left reaches 90 °.


**Fig. 10:** Installation and Variation of Solar Panels Angle at a Sunrise Time.

For $10^0$ of solar panel deflection from the reference level ($0^0$) in plane altitude, the linear actuator motor with $1.8^0$ is required for five angular steps to reach the reference level as is shown in fig. 11.

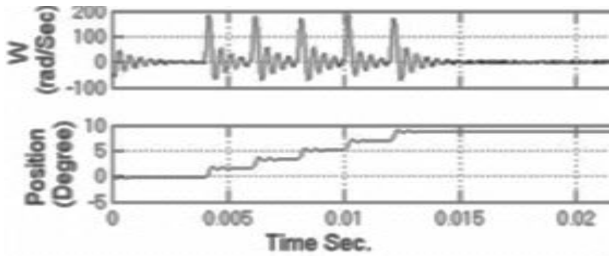


**Fig. 11:** The Angular Velocity and Position at 10° Altitude Movement for the Right Linear Actuator.

## 9. Conclusion

One-track tracking systems have solved the problem of low energy efficiency generated by solar panels used on slanted roofs. As the amount of energy generated by the systems is less than those that use the proposed system and specifically to those that prove on slanted surfaces. Demonstrate the efficiency of the fuzzy controller by processing data received from sensors and show accurate results of the sun location and follow-up it. In addition, the single-axis fuzzy tracking system was good for moving both panels in less than five seconds towards the sun. Doubling the electric power generated by the proposed design compared to the energy output of the fixed design. This increase in energy generated is due to the adoption of the proposed traceability system, because solar panels will meet the sun's rays from dawn to dusk. In addition, the proposed tracking system of houses or buildings with sloping surfaces can be used regardless of the weather is cloudy or partly cloudy.

## References

[1] Abdelkader, H. I., Saber, M., & Awed, A. S. (n.a), Efficiency Improvement of Sun Tracking Systems Controlled by FPGA, International Journal of Scientific & Engineering Research, 5(11), (2012), 364-379.

[2] Ayoub, H. improving the energy capture of solar collectors. Sustainable Engineering, Renewable Energy Systems & the environment, 156-160, (2012).

[3] Barsoum, N. Fabrication of dual-axis solar tracking controller project. Intelligent Control and Automation, 2(02), 57, (2010). https://doi.org/10.4236/ica.2011.22007.

[4] Bingöl, O., Altıntaş, A., & Öner, Y. Microcontroller based solar-tracking system and its implementation. Pamukkale University Journal of Engineering Sciences, 12(2), 343-348, (2011).

[5] Clifford, M. J., & Eastwood, D, Design of a novel passive solar tracker, Solar Energy, 77(3), 269-280, (2004). https://doi.org/10.1016/j.solener.2004.06.009.

[6] Crowston, K., & Howison, J., The social structure of free and open source software development, First Monday, 10(2), (2005). http://firstmonday.org/ojs/index.php/fm/article/view/1207/1127. https://doi.org/10.5210/fm.v10i2.1207.

[7] Deb, G., & Roy, A. B. Use of solar tracking system for extracting solar energy, International Journal of Computer and Electrical Engineering, 4( 1), 42-46, (2005).

[8] DeMicheli, G., & Sami, M. Eds, Hardware/software Co-design, Springer Science & Business Media, Vol.310, (2013).

[9] Eseosa, O., & Roland, U, Design and Simulation of Solar Monitoring Tracking System, IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE), 4 (5), 35-39, (2013).

[10] Ferdaus, R. A., Mohammed, M. A., Rahman, S., Salehin, S., & Mannan, M. A., Energy Efficient Hybrid Dual Axis Solar Tracking System. Journal of Renewable Energy, 1-12, (2014).

[11] Khan, M. T. A., Tanzil, S. S., Rahman, R., & Alam, S. S., Design and construction of an automatic solar tracking system. In Electrical and Computer Engineering, International Conference on, pp. 326-329, (2010).

[12] William B. Stine and Michael Geyer, Power From The Sun, (2001), http://www.powerfromthesun.net/index.html

[13] Houssamo, I., Locment, F., Sechilariu, M., Maximum power tracking for photovoltaic power system: Development and exprimental comparison of two algorithms, Renewable Energy, Vol. 35 no. 10, pp 2381- 2387, (2010). https://doi.org/10.1016/j.renene.2010.04.006.