Progress in Engineering Application and Technology Vol. 4 No. 1 (2023) 384-391
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PEAT

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/peat
e-ISSN : 2773-5303

Powered Solar Phone Charger Using Arduino Solar Tracker in UTHM, Pagoh

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DOI: https://doi.org/10.30880/peat.2023.04.01.040
Received 15 January 2023; Accepted 03 February 2023; Available online 03 February 2023

Abstract: Solar power is one of the renewable energies that had been commonly used to replace the non-renewable energy sources such as fossil fuel since years ago. Residential customers use solar power as one of the alternative power supply to reduce dependency on non-renewable energy. Besides, solar system is also suitable for small application such as solar toy car, remote control plane and also for phone charging application that is important for the user to charge their electronic devices. There are lack of phone charging service in most university and also in UTHM campus. This phone charging station allows UTHM committee to charge their electronic gadget such as mobile phone, iPad and others. The main objective of this project is to develop a free phone charging station with an automatic solar tracking system which will keep the solar panels able to track the sun direction in order to generate maximum the efficiency of the solar system. The power generated by the solar tracker system will be stored in the battery for the phone charging purposes. The system is separated into two systems which are solar tracker and phone charger systems. For the solar tracker system, it is mainly function to track maximum solar energy with the help of two LDR sensors, a servo motor and two 10 kΩ resistors. The system is controlled by using Arduino UNO in order to function as solar tracker. Based on the testing results, it can be concluding that the efficiency of the solar tracking system is higher than the static solar panel output by comparing the output voltage of both systems. At the end of the project, a powered solar phone charger using Arduino solar tracker is designed to benefits all the student in UTHM campus.

Keywords: Solar System, Solar Tracker, Single-Axis Solar Tracker, Arduino UNO

1. Introduction

Renewable energy is energy that has been derived from the earth's nature that is not finite or exhaustible [1]. The electricity of Malaysia mostly is depending on fossil fuel such as natural gas, coal, and oil, while renewable energy such as wind, solar, nuclear, hydroelectric, and geothermal are not

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commonly seemed in Malaysia [2]. Since 1980, Malaysia had implemented the Four Fuel Diversification Strategy which aimed to mix renewable energy with fossil fuel to decrease the usage of the primary sources in Malaysia [3].

Solar power is one of the renewable energy which is very cheap compared to other sources of energy generation [4]. According to the International Energy Agency, solar energy systems will become one of the main sources of electricity and contribute at least 17% of global electricity by the year 2050 [5]. A photovoltaic system can be considered an alternative power system for several applications [6]. The photovoltaic system could be a backup power system to another system while the system needs maintenance or a fault happened. One of the applications of photovoltaics is the battery charger. Besides, other application of photovoltaics is used on a streetlight. Solar cells are placed on each streetlight to supply each streetlight [7].

Therefore, this study is conducted to develop a free charger station with solar tracker in UTHM, Pagoh. A 18 Volt, 10 Watt of the Polycrystalline solar panel with dimension of 350 x 240 x 17 mm is being used to track the solar energy and transform to the electrical energy. The system used a 12 Volt lithium rechargeable battery with 2600 mAH to store the electrical energy. Furthermore, Arduino IDE is a software that used to program the system so that the system will function as solar tracker. The free phone charger will be located at the side of the bus station in UTHM campus in order to benefit UTHM community to charge their phone while waiting the bus. It is hoped that the outcome of this study will encourage the society to reduce the usage of the non-renewable energy in their daily life or indirectly.

1.1 Factors influence the solar cell's effectiveness

A solar cell is an electrical component that converts the solar energy from the sun into electrical energy. The crystalline silicon has a practical efficiency limit up to 27.5% while the theoretical limit is up to 29.5% [8]. The efficiency of the solar cell can be affected by few factors such as the type of solar cell, the ambient conditions, and others [9]. There are a few types of solar planer available today. First, monocrystalline silicon is one of the types of solar cell made from pure monocrystalline silicon without any other impurities. The main benefit of monocrystalline silicon solar cells is high efficiency which will up to 17% [10]. On the other hand, the cost of making a monocrystalline solar cell is much higher because of it need the pure silicon materials. There are many free electrons in the pure silicon structure and the free moving electrons have many spaces to move freely. Thus, the efficiency of the monocrystalline is high [11].

Various ambient conditions should be considered to calculate the efficiency of a solar cell. Module temperature is one of the parameters which is most influence the solar cell system from the aspect of system efficiency and output voltage. A study by [12] has find out that the power output of a solar cell will drop up to 23 % when the solar cell temperature was operated between 25 and 60°C. The [13] had determined that the dust on the solar cell will affect the efficiency of the solar cell. From this study, three similar types of solar cell with different thickness of dust on the surface were used to determine the efficiency of the solar cell. As a result, the solar cell without dust had the highest output voltage among the three solar cells while the solar cell covered with a thick layer of dust had the lowest output voltage. The solar cell cannot absorb all solar energy from the sun due the dust had blocked the light intensity at the surface of the solar cell [14].

1.2 Increases the efficiency of the solar cells

A study by [15] had find out that the efficiency of the solar cell can be increased by concentrating the light and providing a cooling system. Mirror was used to concentrate the light on the solar cells. Besides, another way to increase the efficiency of the solar cell is to optimize the panel's angle. [16] had determined the optimization and performance of bifacial solar modules. At the end of the research, it can conclude that three parameters can optimize the electricity yield of the bifacial solar cell which are elevation, azimuth angle, and tilt angle. These three parameters are mutually dependent.

A solar tracker is the best way that can help to improve the efficiency of the solar cell by adjusting the position of the solar cell. The solar cell can work the produce the maximum electricity during the daytime compared to the static solar cell. From the research of [17], there are 5 types of solar trackers which are passive tracker, semi-passive tracker, chronological tracker, manual tracker, and activity tracker. Each type of solar tracker had its specific operation to track the sunlight. A passive tracker is using mechanical theory to track the sunlight [18]. From research by [19] a semi-passive tracking concentrator was developed that will reduce sun-tracking movement and mechanical effort. Geographical coordinate and astronomical knowledge is well used for the chronological tracker. Active tracker is using a photo-resistor sensor in the electric system. The system is operated with the sensor to move the position of the solar cell to face the direction of the sun. The research of [20] said that the activity tracker can be separated into two main solar tracking systems which is single-axis solar tracking and dual-axis tracking system.

2. Materials and Methods

Basically, this project is divided into two main parts which is the solar tracker system and the phone charger system. For the solar tracker system, it has several main components such as Arduino UNO, servo motor, LDR sensor, and solar planer. Overview of the main system component and the relationship between each component can be represent by the block diagram shown as Figure 1. From the block diagram in Figure 1, it can be seen clearly that the system starts with the detection of the LDR sensor. When the LDR sensor detects the light intensity, it will send a signal to the Arduino. After Arduino receives the signal, it will send the instruction to the servo motor to rotate the solar cell. The solar cell will convert the solar energy to electrical energy and store it in a rechargeable battery. Then, the load receives electricity from the battery.

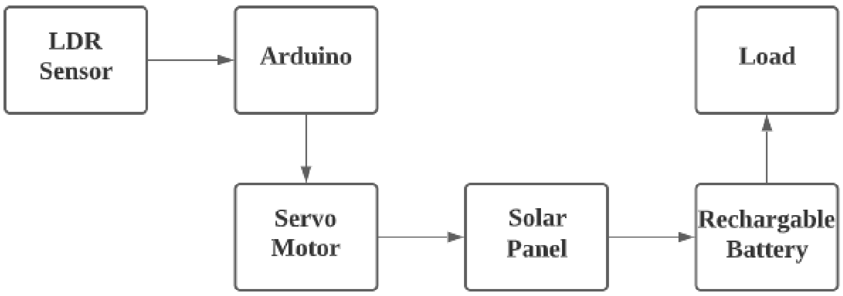


Figure 1: Block diagram of the system.

2.1 Materials

The component that was used to design the powered solar phone charger using Arduino solar tracker is shown in below. These are the main components of the whole project. A solar controller is electronic device that manage the power that converted from the solar cell to the battery. With the help of the solar controller, it can ensure that the battery does not overcharge during the daytime and that the extra power generated does not flow back to the solar cells. A Servo motor is an electronic device that allows for precise control of angular with the help of a motor. The main function of the servo motor is to rotate an object at specific angles or distances. Light-dependent resistor (LDR) sensors can be called “Photoelectronic Devices” or “Photo sensors” because the function of the LDR sensor is to detect the intensity of light and then convert it to an electrical signal. When the light intensity is high, the resistance of the LDR sensor will become low. Arduino is an electronic platform that enables users to create interactive electronic objects and it main function is to control the whole solar tracker system.

- 18 v, 10 w polycrystalline solar planer
- 10 A solar controller
- 12 v 2600 mAh rechargeable battery
- MG995 Servo motor
- LDR sensor
- Arduino UNO
- 10k Ω Resistor

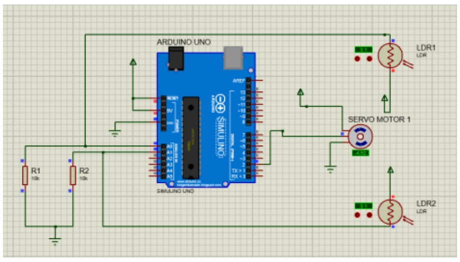
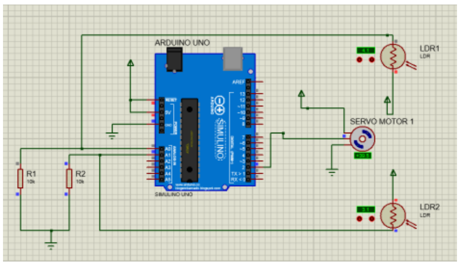
3. Results and Discussion

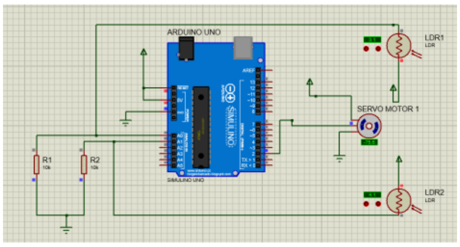
Preliminary result of solar tracker system is conducted by using Proteus 8 Professional apps. After that, two prototype which are the solar tracker system and fixed solar system were built to test the performance of the solar tracker system. The experiment was carried out to get the output power of both systems then comparing both result to find out which system had a better performance. The software simulation result show in Table 2.

3.1 Software Simulation

The solar tracker circuit is designed and simulated through the Proteus Professional 8 apps. From the simulation, it is easy to design the circuit and test its functionality of the circuit. If one of the LDR sensor detect the sunlight, the resistance of the LDR will decrease and the Arduino UNO will receive the change of the LDR sensor then the servo motors were rotate until reach the equilibrium condition again. Table 2 shows the rotation of servo motor.

Table 2: Software simulation result

Condition	Servo motor	Simulation Figures
Both LDR sensor in equilibrium condition	Stationary. (-4.52)	
LDR 1 sensor detect light	Servo motor move in anticlockwise direction. (+39.5°)	

LDR 2 sensor detect light	Servo motor move in clockwise direction. (-75.6°)	

3.2 Hardware testing

In hardware testing, two systems which are fixed system and tracking system are tested with the same experiment to get the reading of output power. Both systems use 18 V, 10 W polycrystalline solar planers and placed in the same place for 5 days. The output voltage of both systems was collected and recorded every 1-hour interval from 8 am to 5 pm. The multimeter is used to collect the data. All the data were tabulated and plotted in a graph to compare both performances. Figure 2 shows the output voltage on day 1. From the graph, it is clearly seen that the output voltage of the tracking system is higher than the fixed system. Another experiment is also carried out to investigate the position of the fixed solar panel with the tracking system. The result of the experiment is shown in Figure 3 and it can be conclude that the tracking system is the most efficiency system among three system.

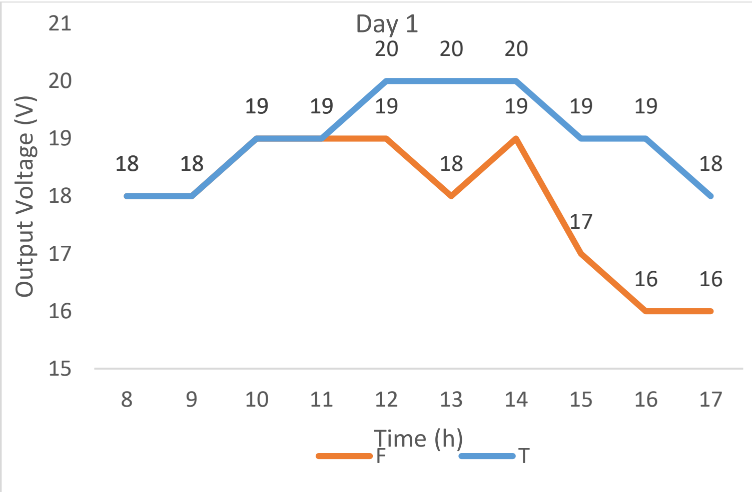


Figure 2: The experiment of fixed and tracking system.

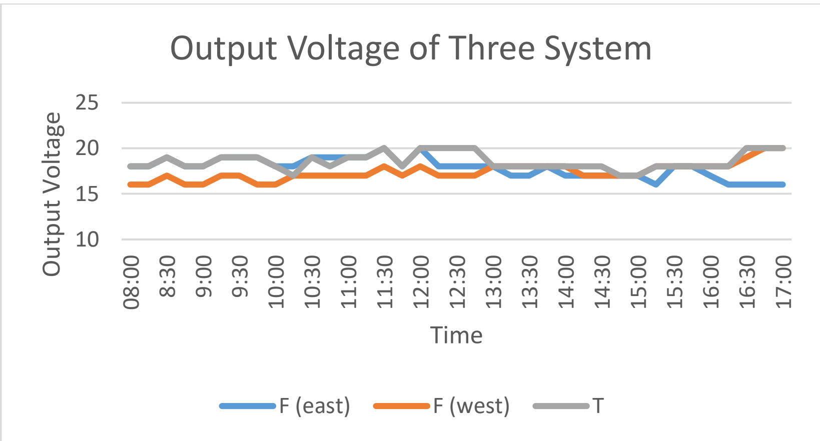


Figure 3: The result of position.

A tilted angle, β is a slope angle at which solar panel is mounted to face the sun. For the titled angle of this prototype is located at the center of the solar tracker. It is because the solar panel is fixed at the center therefore the titled angle is taken from the fixed-point. In conclusion, the tilted angle of the solar panel decreases as the sun's path moves from east to the west. Figure 3 shows the tilted angle of the prototype.

Figure 4: The tiled angle of the prototype.

Moreover, another experiment was carried out to test the load charging process of the prototype. The power bank initially had 21% of the energy. After 7 hours of charging, the battery is charged to 51 %. A total of 30% had increased in this experiment during that period. From the data collected, the power bank needed an average of 15 minutes to increase by 1 % of the energy. At a certain time, when the output of the tracking system is higher, a shorter time taken needed for the power bank to increase by 1 %. Thus, the output of the solar planer is slightly affecting the efficiency of the load charging process. From the result, it can be proved that the developed prototype is able to charge load without any difficulties and suitable for charging any electronic equipments and can be used for UTHM community application. Figure 5 shows the charging load testing connection used in evaluating the reliability of the prototype.

Figure 5: Charging load testing.

4. Conclusion

Solar tracking system is a relevant system to be developed as it can help to increase the efficiency of solar PV modules. This project provides solution in increasing the efficiency of the solar panel by tracking the path of sun automatically. The main components are Arduino Uno, two LDR sensors, and also solar controller in implementing solar tracking system as a solar charging station for UTHM campus implementation. The Arduino IDE is used to design and upload the coding of the tracking system to the Arduino UNO while Proteus 8 Professional used to simulate the tracking circuit. This project successfully functioned as tracking system using servo motor to rotate the solar panel. It sends the signal to the Arduino UNO whether to move the servo motor in clockwise or anticlockwise direction. The testing results were conducted to analyze the performances of the tracking system solar system by comparing the solar tracking system with the fixed solar system. In order to evaluate the solar charging ability, the charging load testing is conducted and the result shows that 30% had increased in 7 hours of charging.

Acknowledgement

The authors would also like to thank the Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia for its support.

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