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Solar Efficiency Measurement Using Arduino

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Abstract: This project aims to develop a measurement of solar energy using Arduino Board technology. In this research, four parameters that been measured are temperature, light intensity, voltage and current. The temperature was measured using temperature sensor. The light intensity was measured using light dependent resistor (LDR) sensor. The voltage was measured using the voltage divider because the voltage generated by the solar panel are large for the Arduino as receiver. Lastly for the current was measured using the current sensor module that can sense the current generated by the solar panel. These parameters as the input value for the Arduino and the output was display at the Liquid Crystal Display (LCD) screen. The LCD screen display output of the temperature, the light intensity, the voltage and the current value. The purpose of Arduino to convert the analog input of parameter to the digital output and display via LCD screen. Other than that, this project also involve with a design to ensure that device case are easy to be carry around.

1 Introduction

Rising fossil fuel and burning fuel such as coal, global warming and severe weather conditions have compelled many nations to look for alternative sources to reduce reliance on fossil based fuels. Solar energy is one of the most promising renewable sources that is currently being used worldwide to contribute for meeting rising demands of electric power. Solar power is a conversion of sunlight into electricity, sunlight was collect either directly by using photovoltaics or indirectly using concentrated of solar energy. Photovoltaics was initially use as a power source for a small and medium-size applications from the calculator powered by a single solar cell to a remote homes powered by an off-grid rooftop photovoltaics system. As the cost of solar electricity has fallen, the number of grid-connected solar photovoltaics systems has grown into the millions and utility scale solar power stations with hundreds of megawatts are being built. Solar photovoltaic is becoming inexpensive, low-carbon technology to harness renewable energy from the sun. This paper presented by Arindam Bose *et.*describe a potential a solar system using two set of stepper motor, the light sensor and the concave mirror.

The purpose of this paper to improve the power collection efficiency 65% with developing the track of solar panel perpendicular. The output I-V curve from this project are the maximum current is 1.56A nad the maximum voltage are 20V with solar irradiance = 500W/m2 and temperature = 34.5°C.

This paper are focus on measure the solar power using Arduino. This design paper are to measured parameters: light intensity, voltage and current and temperature using multiple sensor. The main part in this project are the solar panel, the light sensor, the temperature sensor, a voltage divider, the current sensor and the LCD screen to display.

2. Key word: Photovoltaic, Arduino, Sensor, Temperature, Voltage, Current,

3. Solar Panel Monitoring Methods

There are various methods of monitoring solar power generation, consumption, and performance. Some of these methods of solar power monitoring include:

- **Direct PC Connection**

In this method, the inverter is connected to a PC either using a Bluetooth device or a CAT5 cable. Here, you can download a free monitoring software from the website of the inverter's manufacturer. This method gives you the data logging advantage, and it is one of the cheapest solar monitoring methods.

- **Use of Mobile Devices**

With the advancement of new technology, you can now monitor your solar system from your smart phone. Since most inverters allow for Bluetooth integrations, you can, therefore, connect it to your mobile device and conveniently monitor it from there. This method enables you to remotely monitor your PV system, as well as allowing you to control core settings to make custom usage-profiles. The system allows for wireless solar energy monitoring. Also, depending on your settings, you can remotely view data using internet connections or via SMS texts.

- **Monitoring Display Unit**

Traditionally, this was the main and only way of monitoring your solar system. The method involves the gathering of data from one or multiple combined inverters and displaying it on the display unit. The data is collected either using Bluetooth units or through the CAT5 cable. And, although a dedicated display is an extra cost, it allows you to monitor your system through the display.

- **Internet-Based Monitoring**

With this method, the energy production information is sent to a router, which makes it accessible on the internet. Then, since each user has a password-protected dedicated website, you can easily access the information. One good thing about this method is that you can get access to this data at any time remotely. However, the card that you will plug into the inverter, together with the router, will be an additional cost for the user. You can use a DAS type system to remote dial into your system's performance.

- **Use of Historic Data Viewing Features**

The current solar monitoring units allow for easy integrations with various data storage systems. Therefore, the system gives you the ability to view your system's past performance data

4. Specification of Components

This part are discusses the main components that used on this research.

4.1. Solar Cell In this research, the panel solar is polycrystalline type are be used with 12V, 250mA, 3W as a source. The size of the panel is 145mm X 145mm as shown in

Figure 1. Solar Panel Polycrystalline Type

4.2 The**. Arduino Board** The Arduino Uno is microcontroller board based on the ATmega328 datasheet as shown in Figure 2. It has 14 digital input and output pins: 6 pins used PWM outputs and 6 pins is analog input such as the clock speed is 16MHz, the ceramic resonator, the USB connection, the power jack, the ICSP header and the reset button.

Figure 2. The Arduino Board

4.3. Light Sensor A Light Dependent Resistor (LDR) or photo resistor is device whose resistivity is a function of the incident electromagnetic radiation which means it is light sensitive devices. These components also called a photo conductors, photo conductive cells or simply photocells [11]. The LDR function on the principle based on photo conductivity which an optical phenomena. Figure 3 shows the resistance vs illumination graph of LDR

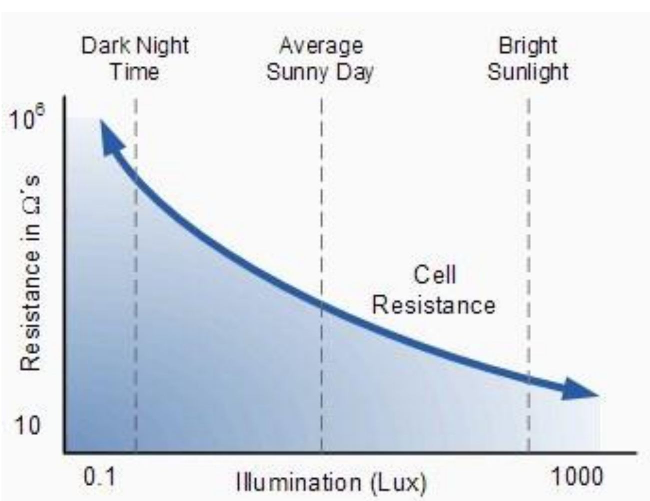

Figure 3. The resistance VS illumination Graph of LDR

4.4. Circuit Simulation

Figure 4 shown the block diagram of the research and the complete of simulation circuit for this project that have been develop by using Proteus 8 Professiona. In this simulation circuit, it consist three main parts : the voltage divider, the LED light indicator, the temperature sensor, LDR sensor and the LCD screen display. The power generated from the solar panel is 12V approximately. Inside the circuit have LDR sensor for detect the light intensity. Next, the temperature sensor have detect the temperature changing [17-18, 20]. In this project, the main controller are use the Arduino Uno and its need the power supply [16, 19, 21]. The power supply for this controller is 5V. Then, the Arduino Uno must have coding for it to function as desired. Lastly, the LCD is to display the output that have written in the coding inside the Arduino Uno.

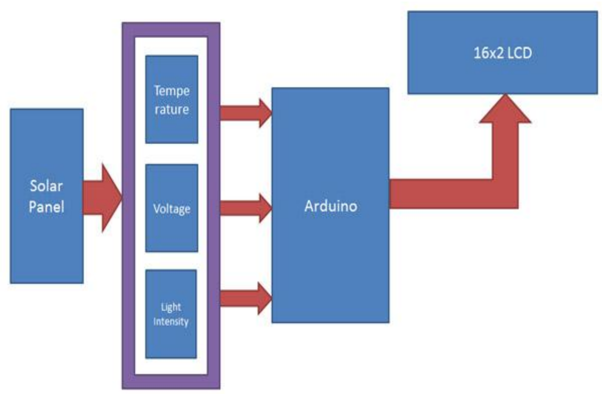

Figure. 4 The block diagram of the research

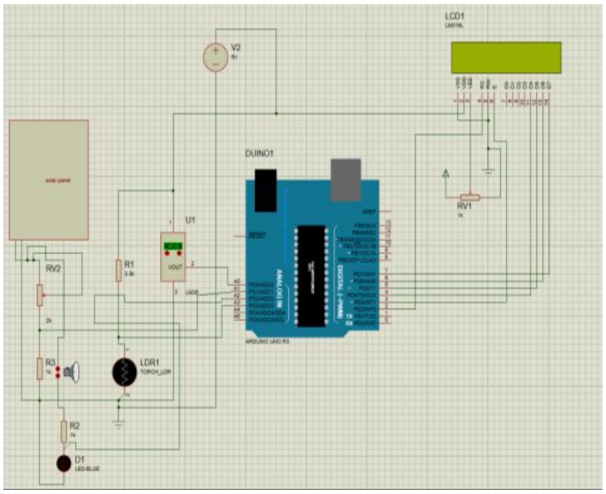

Figure. 5 Simulation

5. Result and Analysis

5.1. Simulation Results

Figure 6 shown the results of the temperature . It varies depend on the temperature sensor setting during the simulation. The Table 1 shown the simulation result of light intensity and the output voltage. From the simulation results shown that the circuit are function is very well and can be continue to the hardware development. **Fig. 6.** The temperature virtual terminal output **Table 1.**

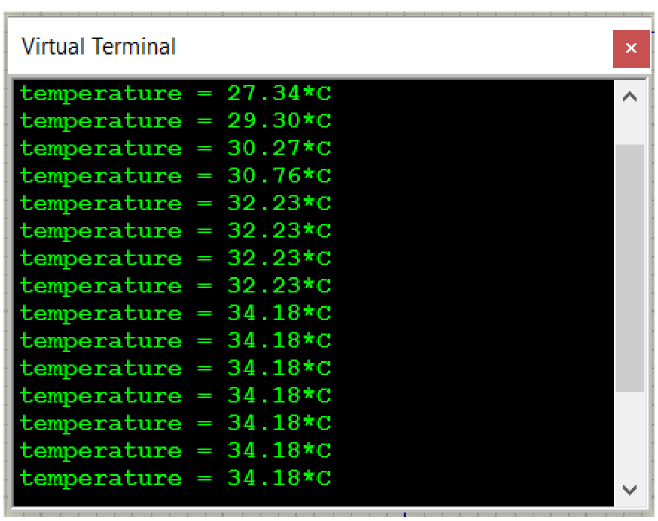

Figure 6. The temperature virtual terminal output

LDR (Lux)	LDR intensity	Output Voltage (V)
0.1	11	0.05
10.1	372	1.81
20.1	520	2.53
30.1	607	2.96
40.1	667	3.23

Table 1. LDR simulation result

5.2. Measurement Results

These sections are divided to three main parts: the light intensity, the voltage versus light intensity and the output power. Results of Light Intensity The light intensity have been recorded in the three days with the solar panel in the sunrise position as shown in Figure 7. Based on the result, the highest light intensity was 980 Lux at 2.00pm, while the lowest light intensity was 700 Lux at 5.00pm. The light intensity have been recorded in the three days with the solar panel in the sunrise position as shown in Figure 7. Based on the result, the highest light intensity was 970 Lux at 11.00am, while the lowest light intensity was 350 Lux at 5.00pm.The light intensity have been recorded in the three days with the solar panel in the sunrise position as shown in Figure 8. Based on the result, the highest light intensity was 970 Lux at 11.00am, while the lowest light intensity was 350 Lux at 5.00pm. The light intensity have been recorded in the three days with the solar panel in the sunrise position as shown in Figure9 . Based on the result, the highest light intensity was 950 Lux at 12.00pm, while the lowest light intensity was 830 Lux at 5.00pm.

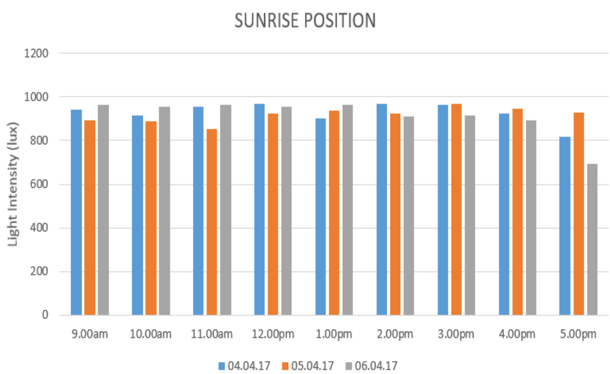

Fig. 7. Result of light intensity for sunrise position

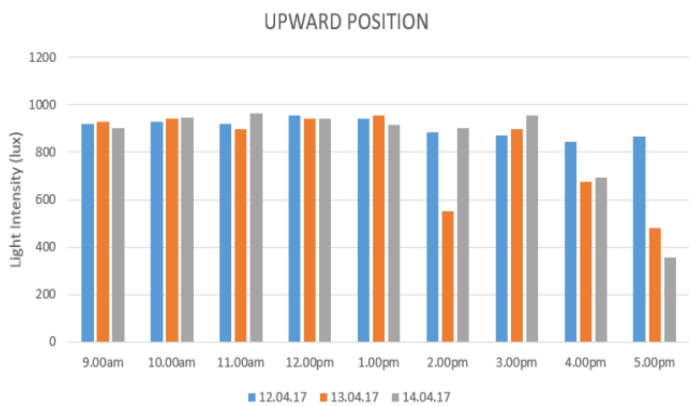

Fig.8. Result for light intensity for upward position

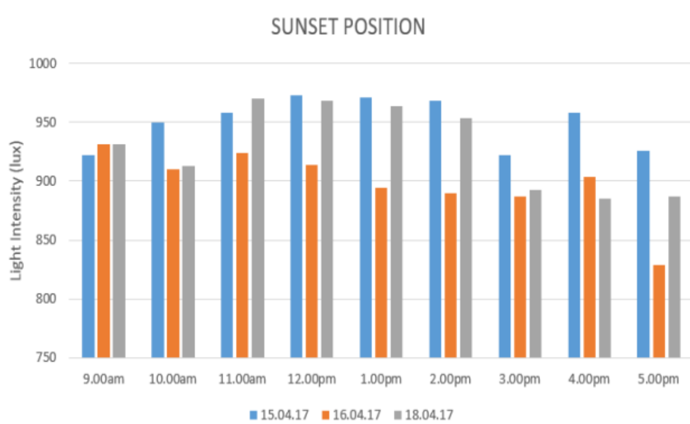

Fig. 9. Result for light intensity for sunset position

Table 2 shown the maximum and the minimum of the light intensity that have been recorded according to their solar panel position.

Position	Sunrise	Upward	Sunset
Maximum (Lux)	980 Lux at 2.00pm	970 Lux at11.00am	950 Lux at12.00 pm
Minimum (Lux)	700 Lux at 5.00pm	350 Lux at 5.00pm	830 Lux at 5.00pm

Table 2

5.2. Results of Voltage versus Light Intensity

The result voltage versus light intensity for the solar panel in sunrise position as shown in Figure10. The highest voltage recorded was 14.75V at 11.00am with light intensity was 945 Lux and the lowest voltage recorded was 9.17V at 5.00pm with light intensity was 695 Lux. The result voltage versus light intensity for the solar panel in upward position as shown in Figure 11. The highest voltage recorded was 13.11V at 10.00am with light intensity was 929 Lux and the lowest voltage recorded was 6.3V at 5.00pm with light intensity was 357 Lux. The result voltage versus light intensity for the solar panel in sunset position as shown in Figure 12. The highest voltage recorded was 12.57V at 1.00pm with light intensity was 964 Lux and the lowest voltage recorded was 11.19V at 9.00am with light intensity was 931 Lux.

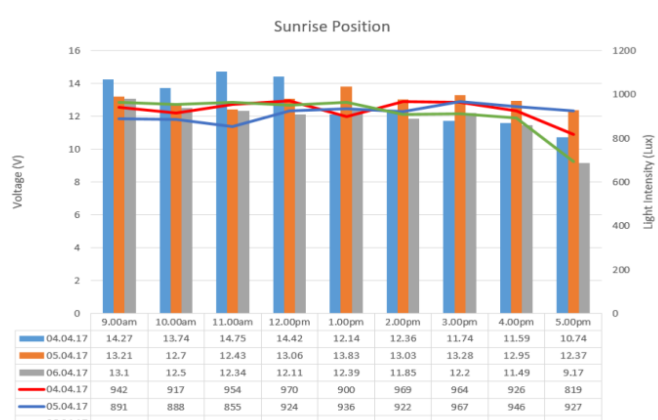

Fig. 10. Voltage versus light intensity for sunrise position.

Table 3 shown the maximum and minimum value of voltage and light intensity for each of the position. From the shows that, the higher voltage value, the light intensity also have higher value. The present of light intensity will affect the voltage produce by the solar panel.

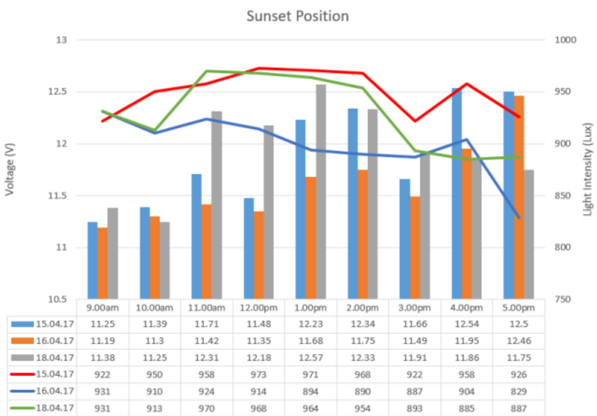

Fig. 11. Voltage versus light intensity for sunset position.

Table 3. The maximum and minimum value for each position

Position	Sunrise	Upward	Sunset
Maximum	14.75V (11.00am) with 954 Lux	13.11V (10.00am) with 929 Lux	12.57V (1.00pm) with 964 Lux
Minimum	9.17V (5.00pm) with 695 Lux	6.3V (5.00pm) with 357 Lux	11.19V (5.00pm) with 931 Lux

5.3 Results of Output Power

The result of output power with the solar panel in the sunrise position was shown in Figure 13. The highest power produce was 2.4W at 4.00 pm, while the lowest power produce 0.3W at 5.00 pm. The result of output power with the solar panel in the upward position was shown in Figure 13. The highest power produce was 1.7W at 12.00pm, while the lowest power produce 0.38W at 5.00pm. The result of output power with the solar panel in the sunset position was shown in Figure. The highest power produce was 1.63W at 5.00pm, while the lowest power produce 1.21W at 9.00am

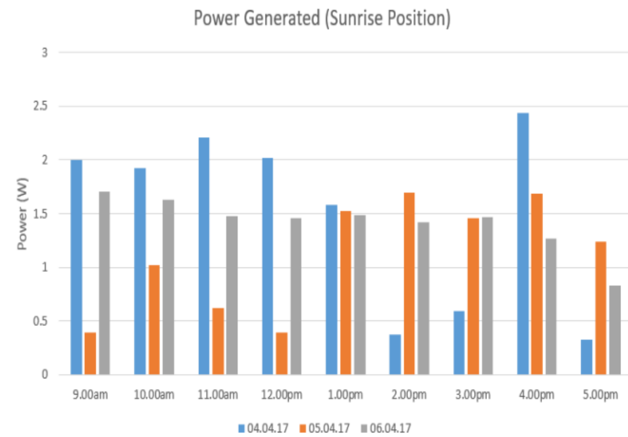

Fig. 12. Power from the sunrise position

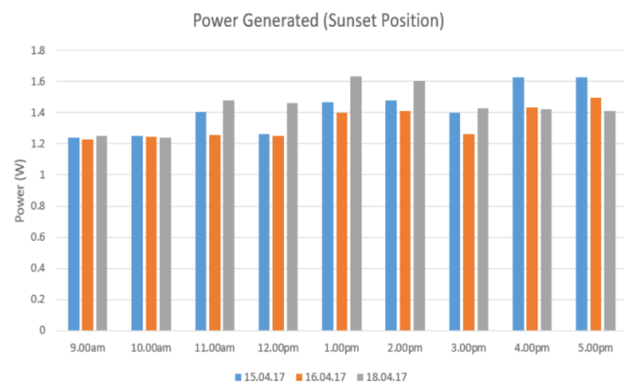

Fig. 13. Power from the sunset position

Table 4 shown the maximum and minimum power generated by the solar according to its type of position. For the sunrise position, the maximum power generated is 2.4W, while the minimum power generated is 0.4W. For the upward position, the maximum powergenerated is 1.7W and the minimum power generated is 0.38W.

Table 4. Maximum and minimum output power

Position	Sunrise	Upward	Sunset
Maximum (W)	2.4W at 4.00pm	1.7W at 12.00pm	1.63W at 5.00pm
Minimum (W)	0.4W at 5.00pm	0.38W at 5.00pm	1.21 at 9.00am

6. Conclusion

In the conclusion, the project is achieve all of the objective are : to measure solar panel parameter such as the temperature, light intensity, voltage and current. Using the temperature sensor that sense the changes in surrounding temperature, for the light intensity parameter was by using the LDR sensor, for the voltage parameter was by using the voltage divider method in order to reduce the maximum value of the solar panel to the voltage value suitable for the Arduino of power supply and lastly the current parameter was by using the current sensor module. Next, to find the best position and time for the solar power effectively energize the electricity. The data from measurement part shows that the best position of the solar panel effectively energize was the sunrise position with the highest voltage value which is14.75V at time 11.00am have been recorded. At this time the light intensity was 954 lux and the temperature was at 34.32°C. Lastly, to develop a portable device for measuring the solar energy can be achieve with developing the light in weight of the casing of the device and the neat arrangement of the electrical component inside the casing.

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