Design and Development of Positions Switching Photovoltaic System

Kim O. Catabian[1], Erwin L. Del Valle[1], Allan A. Galopo [1], Ralph Nikko A. Plata[1]
Lyceum of the Philippines – Laguna, Philippines

***Abstract*—Solar power is one of the most reliable sources of renewable energy. The electricity generated by solar panels is influenced by the intensity of solar radiation and ambient temperature. They will generate maximum electrical power when the intensity of solar radiation received is also maximum, therefore the solar panel must be controlled so that its position is always aligned to the position of the sun. The proposed single axis solar tracking system offers optimal energy conversion process of solar energy into electricity through appropriately orienting the solar panel in accordance with the real position of the sun. The electrical energy harnessed by the photo voltaic system will be used to supply the load sensors of the flood monitoring system in Makiling, Calamba.**

***Keywords*—Photovoltaic system, LDR, energy storage**

INTRODUCTION

The sun is a reliable source of energy. Since the beginning of life on earth, the energy that was received by all living forms was radiated from the sun. It is time now when mankind is in an era that will depend and rely upon the sun as the main source of energy. [1]

Solar energy is now one of the most reliable sources of energy as it uses only rays of the sun for producing electricity. The sun works like a nuclear reactor. It releases energy in forms of tiny packets called photons. The way to convert these tiny packets to electrical energy is known as solar energy.

Solar panel is the main part of any photovoltaic system. A solar panel is a flat construction resembling a window, built with technology that allows it to passively harvest the heat of the sun or create electricity from its energy through a photovoltaic system. It is used to generate electricity through photovoltaic effect. These cells are arranged in a grid-like pattern on the surface of solar panels. Thus, it may also be described as a set of photovoltaic modules, mounted on a structure supporting it. A solar panel is a packaged and connected assembly of 6 x10 solar cells. [2]

Solar trackers are used to increase the energy output from solar panels and solar receivers. A solar tracker is a device which follows the movement of the sun as it rotates from the east to the west every day. Solar trackers are used to keep solar collectors or solar panels oriented directly towards the sun as it moves through the sky every day. Using solar trackers increases the amount of solar energy which is received by the solar energy collector and improves the energy output of the heat or electricity which is generated. In short, trackers direct solar panels or modules toward the sun. These devices change their orientation throughout the day to follow the sun's path to maximize energy capture. In photovoltaic systems, trackers help minimize the angle of incidence (the angle that a ray of light makes with a line perpendicular to the surface) between the incoming light and the panel, which increases the amount of energy the installation produces. Concentrated solar photovoltaic and concentrated solar thermal have optics that directly accepts sunlight, so solar trackers must be angled correctly to collect energy. All concentrated solar systems have trackers because the systems do not produce energy unless directed correctly toward the sun. [3]

Single axis trackers have one degree of freedom that acts as an axis of rotation. The axis of rotation of single axis trackers is typically aligned along a true north meridian. It is possible to align them in any cardinal direction with advanced tracking algorithms. There are several common implementations of single axis trackers. These include horizontal single axis trackers, seven horizontal single axis trackers with tilted modules, vertical single axis trackers, tilted single axis trackers, and polar aligned single axis trackers. The orientation of the module with respect to the tracker axis is important when modeling performance. The horizontal type is used in tropical regions where the sun gets very high at noon but the days are short. On the other hand, the vertical type is used in high latitudes where the sun is not very high but summer days can be very long. [4] In relation to this, the researchers made a development which is the solar tracker system which enables the solar panel to move associated to the sun's movement. The electrical energy collected from the sun will be the key and fuel for the load sensors of Project EFF.

General objective

To design and develop a single axis solar tracking photovoltaic system that will provide enough power to the load sensors for Project EFF.

Specific objectives

1. To design and develop a photovoltaic system that positions the solar panel to where the sun is faced; and
2. To test the functionality and effectivity of system.

METHODOLOGY

Conceptual framework

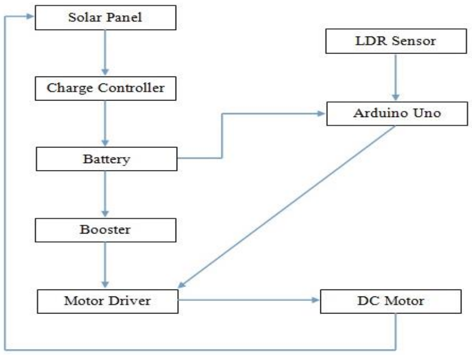

Figure 1. System block diagram

As we can see, the solar panel and LDR sensor are the actuators of the system. The LDR sensor and motor driver are connected to the Arduino as it is supplied by the battery. The booster is tapped to the battery so that it can supply the motor driver that is supposed to drive the DC motor which is connected to the solar panel.

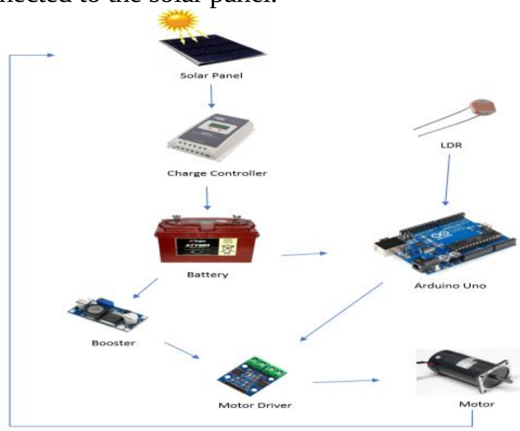

Figure 2. Pictorial diagram

The pictorial diagram represents the actual structure of devices that will be used to make the photovoltaic system. It also represents the connections of the system.

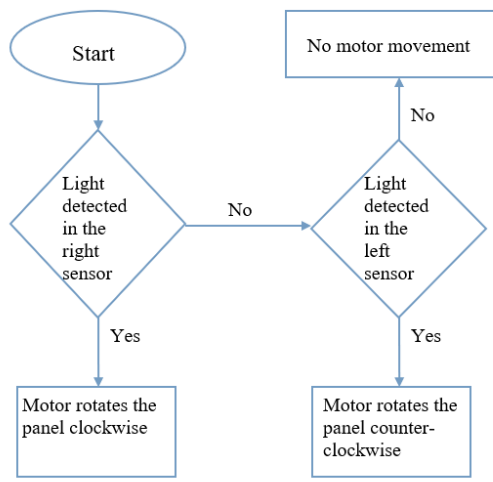

Figure 3. System flowchart

Presented on the system flowchart is how the microcontroller will perform decision making. When the system starts operation, the LDR sensors will send a signal to the microcontroller whether the sun is faced left or right. Then, the motor acts on the received signal. It will rotate the panel clockwise or counter-clockwise depending on the received signal.

DESIGN CONSIDERATIONS

The design of the system was conversed by the proponents to accumulate the specific requirements and specifications of the components. Several researches were conducted by the proponents about the solar tracking system, and information were gathered that proved the requirements of the system which are valid in the proposed study.

Development of prototype

The developmental method of research is used in the study as their basis of fulfillment for the procedures and objectives intended to achieve the outcome. This method aims not only the development and design but also the evaluative process, products, in order to meet the stated effectiveness of the functionalities.

Developmental method of research is the most appropriate to use since the study is aimed as a power source for the sensors for Project EFF. In accordance to legitimacy, the researchers performed a series of data gathering trials to determine the efficiency of the project.

Software specifications

Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which six can be used as PWM outputs), six analog inputs, a 16MHz quartz crystal, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. You can tinker with your Uno without worrying too much about doing something wrong, worst case scenario, you can replace the chip for a few dollars and start over again.

Prototype construction

In order to gather the data and results of this project, every component had undergone testing.

Figure 4. Solar panel, sprocket, and motor

The proponents tested several types of solar panels and types of motor before coming up with the best choice. This project used one solar panel, rated 300 watts and 12V. A chain and sprocket set is used for the movement of the solar panel. The motor used is a DC motor rated 24VDC.

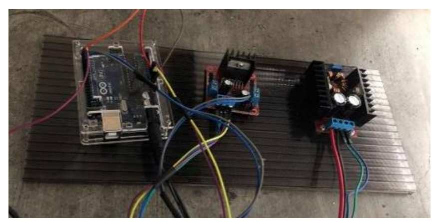

Figure 5. Electronic components

To perform the proposed project, Arduino Uno R3 is used. The microcontroller is then connected to different parts of the system. A motor driver is used to control the movement of the DC motor. A DC step up booster is used to step up the voltage from 12V to 24V DC, to sustain high voltage load.

Figure 6. Solar charge controller

To ensure long battery life and high efficiency, the proponents used MPPT solar charge controller instead of PWM because of its flexibility with higher voltages compared with the operating voltage of the battery system.

Figure 7. Light dependent resistor (LDR)

A light dependent resistor (LDR) is used to sense which direction has the highest sunlight intensity that will produce the peak voltage.

MEASURED RESULTS AND INTERPRETATION

Time	Voltage(V)	Current(A)	Power(W)
7:00 am	12	1.37	16.44
8:00 am	35	3.8	133
9:00 am	37	4.4	162.8
10:00 am	38	4.3	163.4
11:00 am	37	4.4	162.8
12:00 pm	35	4	140
1:00 pm	37	4.2	155.4
2:00 pm	37	4.4	162.8
3:00 pm	37	4.4	162.8
4:00 pm	35	3.9	171.5
5:00 pm	14	1.7	23.8

The starting time of the trial is 7:00 am and ended at 5:00 pm. The proponents measured and recorded the voltage every 60 minutes. Based on the data, the peak voltage that the system can get is 38V at 10:00 in the morning. The voltage generated is directly proportional to the current that is acquired by the system. The power generated can supply efficiently to the load sensors of Project EFF.

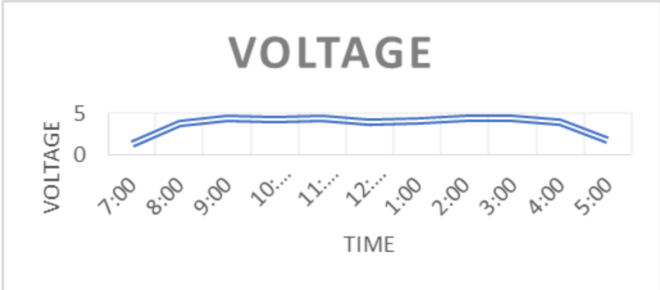

Figure 8. Voltage graph

Around 10:00 am, the system can get the peak voltage which is 38V.

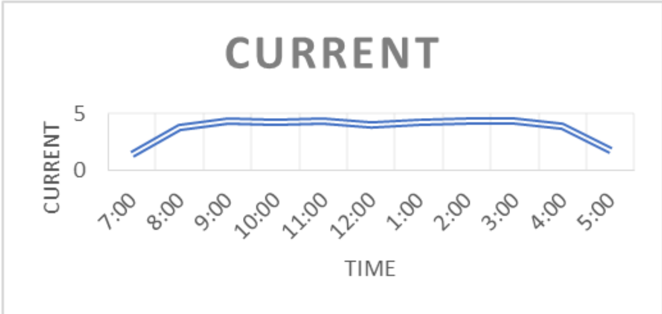

Figure 9. Current graph

The current is almost constant between 9:00 am to 4:00 pm.

CONCLUSION

A photovoltaic system which switches positions was designed to supply power to the flood monitoring system. The required program was written that specified the various actions required for the system to work.

The results gathered in testing the photovoltaic system were analyzed. Based on the power requirement of the load sensors and power output of the solar panel, the photovoltaic system can provide the needed power supply for the sensors of the flood monitoring station of Project EFF.

RECOMMENDATION

For future projects, one may consider the use of a more effective motor and sensor which consumes less power without sacrificing efficiency.

Future researchers can also design a system which tracks the sun with consideration to the location where it is installed. A system that determines the latitude and longitude of a certain location, analyzes its relationship to the sun's position and aligns itself to the angle with most power output.

A dual axis solar tracking system can also be made but motor power consumption can be an issue. Although with the right motor, this can be more effective as an energy harnessing device.

REFERENCES

[1] Dr. A. Mathur, "An Optimized System Configuration Design for Mini Solar Power Plants: A Conceptual Analysis," 2015.

[2][3][4] K. I. Chowdhury, M. Alam, and P. Shams Bakshi, "Performance Comparison between Fixed Panel, Single-axis and Dual-axis Sun Tracking Solar Panel System," 2017.

[5] T. Bui, T. Bui, C. Davis, and S. Holman, "Portable Solar Tracker (Senior Design 1)," 2011.

[6] S. Görtz, "Battery Energy Storage for Intermittent Renewable Electricity Production."

[7] G. R. Timilsina, L. Kurdgelashvili, and P. A. Narbel, "A Review of Solar Energy Markets, Economics and Policies," 2011.

[8] J. Jr. Dimaculangan, R. W. S. Canta, L. J. B. Cosico, and J. K. S. Viterbo, "Design and Development of a Solar-Powered Lighting System Using Motion Sensing Detection," 2015.