Concept and control techniques on the development of an autonomous solar tracker

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ABSTRACT –Since the fixed solar panel drives to inefficient for high power consumption and brought to confine the energy generating capability as it unable to capture optimum sunlight, the solar panel have to be aligned perpendicularly with the sunlight in ensuring high efficiency of solar energy system. This paper presents a development of an autonomous solar tracker which focused on the concept and control techniques. This solar tracker has been developed in order to capture optimum solar power for the electrical generation efficiency. The control techniques will drive tracks the angle and the direction of the accurate sun rays throughout the UV sensor, pyranometer.

1. INTRODUCTION

Generally, solar power is the conversion of sunlight into electricity, either directly using PV (photovoltaic), or indirectly using CSP (concentrated solar power) [1]. A photovoltaic panel is a device used take energy from the sunlight and convert that energy into electricity [2]. When the sun rays are incident on the solar cell, due to the photovoltaic effect, light energy from the sun is used to convert it to electrical energy [3]. The solar power depending on the efficiency which is directly related to the amount of solar energy captured. One of the methods to increase the efficiency of solar panel system is to employ a solar panel tracking system [4]. This employs a maximum power output (electricity) produce by the tracking system [5]. Therefore, employing a tracking panel will generate higher electricity and more efficient [6]. A solar tracker is a device that orients a payload toward the sun. In photovoltaic applications, trackers are used to minimize the angle of incidence between the incoming sunlight and a photovoltaic panel [1].

In solar trackers the panel is made to rotate in the directions with respect to sun [7]. This will tend to maximize the amount of power absorbed by PV systems. It is estimated that using a tracking system, over a fixed system, can increase the power output by 30% - 60% [4]. The solar tracker is a complete machine that fitted with solar panel and tracks the motion of the sun by ensuring optimize amount of sunlight captured. The Solar Tracker will attempt to navigate to the best angle of exposure of light from the sun [8].

Hence, this paper comprises the development of an autonomous solar tracker which focus on the concept and control techniques with the chronological drive tracker of PIC development board with MCU PIC18F8520, UV sensor-Pyranometer, and the tracker structure. From sensing device; pyranometer, the system provides a pulse width modulation (PWM) which is the technique of determining the solar panel's perfect positions. At the end of the paper a measurement of Sun' intensity is shown and analysed.

2. SOLAR TRACKER CONCEPT DESIGN

2.1 Concept design

Figure 2.1 show overview of the structure design that has been conducted for the solar tracker for the solar panel compartment, solid base to support the weight and the rotating shaft. Meanwhile, Figure 2.2 represents the back view of the solar tracker with details labeling of the devices involve in the system.

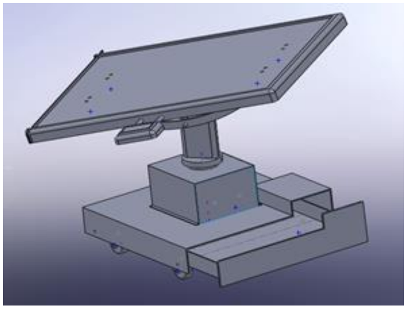

Figure 2.1 Overview of solar tracker design

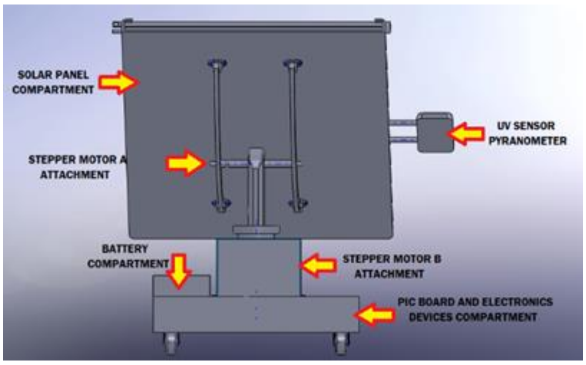

Figure 2.2Back view of solar tracker design

3. UV SENSOR – PYRANOMETER

The system is proposed by using the pyranometer (Figure 3.1) as the UV sensor to fix the functionally as sensing the sun intensity. The pyranometer has to be mounted on a horizontal surface or in the same plane as a solar heat collector or photovoltaic (PV) panel when the global irradiation on these surfaces is of interest [8]. Thus, in this solar tracker system, the pyranometer is mounted parallel with the solar panel in terms of conducting optimum energy captured.

Figure 3.1 UV Sensor – Pyranometer

4. CONTROL TECHNIQUES OF THE SOLAR TRACKER

In this system, the solar tracker movements are controlled by using two 12VDC stepper motors. Both the stepper motors rotate and drives 15^{o} per step as shown in Figure 4.1. The stepper motor for horizontal rotation (X-axis) capable to carried out 16kg of load meanwhile the stepper motor for vertical rotation (Y-axis) capable to handle load of 10kg. The Y-axis able to rotate from one end to the other end within 300^{o} (minus 30^{0} from each end to avoid clash with the structure base) meanwhile the X-axis rotates fully 360^{0}. The details explanation on the both rotations is shown on Figure 4.2.

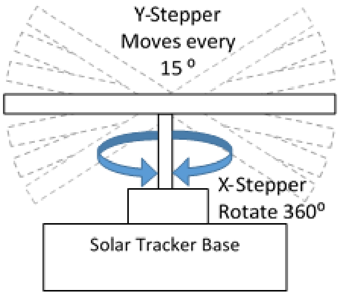

Figure 4.1 Y- axis and X-axis angular rotation

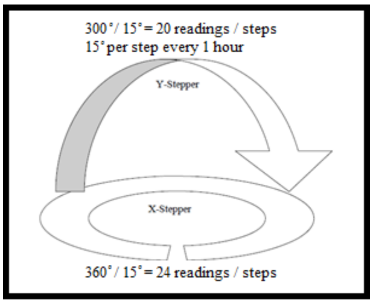

Figure 4.2 Sun Tracking position

The solar tracker that has been developed involves mechanism with several devices, components and circuitries as shown in Figure 4.3. As shown in Figure 4.4 (flow step of stepper motor rotation), the system starts with calibration process (initialization) where measurement will be conducted by the UV sensor. Several measurements will be carried out and taken in order to identify the highest value of the solar energy captured. The measurements will be manipulating in the microcontroller PIC18F8250.

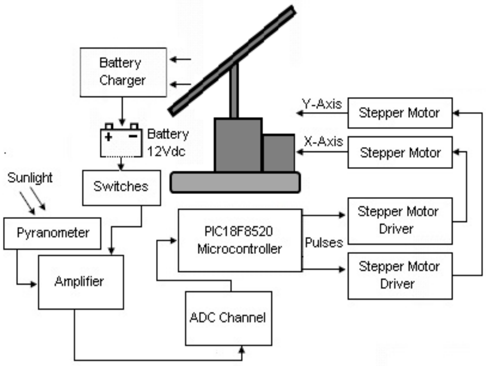

Figure 4.3 Solar tracker system block diagram

By this the microcontroller will be analyzed in order to allocate the solar panel to the right position perpendicular directly to the optimum sunlight. The microcontroller will have instructed the stepper motor to be rotating to the highest value obtained.

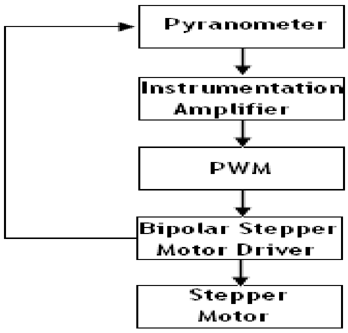

Figure 4.4 Flow of the stepper motor rotation

5. RESULTS AND DISCUSSION

Based on Figure 5.1, experiments have been conducted to obtain data on the functionality of the UV sensor- pyranometer. The experiments carried out to collect data on the output of the pyranometer. All the experiments were held on several days starting from 7.00 am to 6.30 pm. Figure 4 shows the graph of average pyranometer output voltage obtained during the experiments.

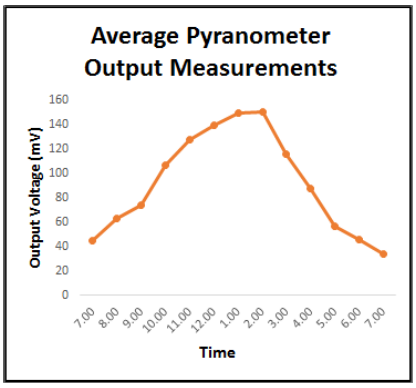

Figure 5.1 Average results of pyranometer output

These results proved that the position of the pyranometer in the system influence the solar energy captured where the pyranometer is positioned parallel with solar panel.

6. SUMMARY

In this globalizations era, solar energy is necessary as a renewable energy which able to be converted to electrical energy. Thus, the solar tracker with autonomous features is highly required in capturing maximizes solar energy. This project presented the concept and control techniques of an intelligent solar tracker with the sensing device of UV sensor-pyranometer which interfaced with an embedded processor of PIC18F8520. This solar tracker system capable to capture and absorbed optimum solar energy that sufficient to be converted to electrical energy. As despite many designs have been held and conducted, the performance and results of capturing the maximum solar energy through solar tracker still needs further improvement.

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