Abstract—Nowadays, solar harvesting is more popular. As the popularity becomes higher, the material quality and solar tracking methods are more improved. There are several factors affecting the solar system. Major influence on solar cell, intensity of source radiation and storage techniques. The materials used in solar cell manufacturing limit the efficiency of solar cell. This makes it particularly difficult to make considerable improvements in the performance of the cell, and hence restricts the efficiency of the overall collection process. Therefore, the most attainable maximum power point tracking method of improving the performance of solar power collection is to increase the mean intensity of radiation received from the source used. The purpose of the tracking system controls elevation and orientation angles of solar panels such that the panels always maintain perpendicular to the sunlight. The measured variables of our automatic system were compared with those of a fixed angle PV system. As a result of the experiment, the voltage generated by the proposed tracking device has an overall increase of about 28.11% more than the fixed angle PV system. There are three major approaches for maximizing power extraction in medium and large scale systems. They are sun tracking, maximum power point (MPP) tracking or both.

Key words: Dual Axis, Solar Tracking, Power Point Tracking

I. INTRODUCTION

Climate change one of society’s most inevitable challenges. Engineering efforts to address these challenges have largely focused on development and refinement of mechanical, electrical and material technologies that generate and store renewable energy, such as solar arrays, wind turbines and fuel cells. In recent years, growing attention has been drawn to computational methods, such as control theory, artificial intelligence and operations research that are essential for the energy efficient and reliable operation of these systems. The uses of alternative sources such as solar energy are becoming more widespread. To make solar energy more viable, the efficiency of solar array systems must be maximized. A feasible approach to maximizing the efficiency of solar array system is solar tracking. Proposed in this report is a system that controls the movement of a solar array so that it is constantly aligned towards the direction of the sun. Solar modules are devices that cleanly convert sunlight into electricity and offer a practical solution to the problem of power generation in remote areas. The solar tracker designed and constructed in this project offers a reliable and affordable method of aligning a solar module with the sun in order to maximize its energy output. Automatic Sun Tracking System is a hybrid hardware/software prototype, which automatically provides best alignment of solar panel with the sun, to get maximum output (electricity).

II. DESIGN OF SUN TRACKING SYSTEM:

A. Structure Design – Rotate and Tilt

Rotate and Tilt structure is chosen for a smoother movement on dynamic search system. This structure is friendly to the base motor. It does not stress the first level structure through unnecessary load torque from the structure above it. This design involves first rotating the PV panel to the desired direction and then tilting it to the desired tilt angle in order to get maximum irradiance. Rotate and tilt system has a rotational structure at the base platform and the tilting structure at the second level. To make sure the structure is stable and the load torque is constant for the rotational motor, the center of gravity of tilting structure is aligned at the rotating center. Figure 1 shows the idea and implementation of rotate and tilts system.

Fig. 1: Rotate and tilt Mechanism Structure

B. PV cell as a sensor

In this sun tracking system, small polycrystalline PV cells are used as the sensors to determine the solar irradiance. The very important electrical characteristic of the solar panel used is the short circuit current, ISC. ISC increases with the increase in the irradiance. To put it more accurate, ISC is proportional to the irradiance in the cosine function of the angle between a normal to the collector face and the
incoming solar beam radiation. Figure 2 illustrates the angle described above.

![Incidence angle](image)

Fig. 2: The incidence angle, $\Theta$ between normal to the collector face and incoming solar beam radiation [4] Isc $\propto$ Solar radiation $\times$ cos $\Theta$

Solar cell can hence be tilted around while short circuit current is being measured. The maximum current will indicate the best insolation when the incident angle is zero degree.

The MPP can also be determined from the short-circuit current of the panel (ISC), because IMPP is linearly related to it under varying atmospheric conditions.

$$I_{MPP} = k_{ISC}$$

Similar to fractional open circuit voltage, the constant must be determined for each type of system. Determining ISC is more challenging, because doing so from time to time not only increases power loss and heat dissipation, but also requires an additional switch and current sensor. Obviously, this increases component count and cost. The simplest implementations do not require microcontrollers, but for better accuracy and to solve problems related to partial shading, more processing power is necessary to sweep the panel current from 0 to ISC, and memorize the output voltage profile. The maximum power point voltage has a linear dependency on the open circuit voltage VOC under different irradiance and temperature conditions. Computing the MPP (Maximum Power Point) comes down to:

$$V_{MPP} = k_{V}V_{OC}$$

The constant $k$ depends on the type and configuration of the photovoltaic panel. The open circuit voltage must be measured and the MPP determined in some way for different ambient conditions. Usually, the system disconnects the load periodically to measure VOC and calculate the operating voltage. This method has some clear disadvantages, temporary loss of power being an obvious one. An alternate method would be to use one or more monitoring cells, but they also need to be chosen and placed very carefully to reflect the true open circuit voltage of the system. Although this method is quite simple and robust and does not require a microcontroller, the constant only allows a crude approximation of the MPP. Other algorithms will significantly increase the top power drawn from the same PV installation.

C. Operating principle and working Algorithm

The proposed dual axis sun tracking system can tracked the sun in two axes- horizontal and vertical. The first motor will rotate the solar panel to track the sun in the horizontal axis. Once it has established the correct direction of the sun, it will start tracking in the vertical axis to get the best tilt angle. The working principle of the tracking system is based on the P & O MPPT of solar cell used under the correct conditions. In short, the system will take a step in unidirectional and sense the change in the voltage of the solar cell. If a negative response is obtained from the feedback of the sensor, the system will turn around and move in the same direction until it reaches the maximum point. If any fluctuation detect by ADC then motor step is taken and there is a delay set. So after some time motor start stepping as per ADC signal. Small minimum change in intensity is required before a further step is taken. Besides the algorithm, searching conditions need to be specified to anticipate the changing environment condition such as movement of cloud over the sun which causes a variation in the intensity of solar irradiance. Without these searching conditions, the sun tracking system will be searching nonstop to react to the changing intensity. The conditions of interest are as follow:

1) Search trigger and its frequency

The system can scan whenever there is a specified change in the solar intensity. This condition can be used in the indoor experiment where the light intensity can be closely controlled. However, in the unpredictable outdoor environment, this condition could not be applied because the fluctuation in solar intensity due to moving cloud is prevalent. Therefore, to tackle this problem, a periodical search is more appropriate. Since the movement of the sun could be estimated about 15 degree is equal to an hour, an appropriate user predefined search cycle of 5, 10, 15 minutes can be chosen to track the sun pretty accurately.

2) Condition for searching

With the predetermined searching cycle, the system still needs another condition for starting the search. This
D. Sun tracking system results

The first part will analyse the power generated by the solar cells with and without dynamic tracking system.

1) Experiments Conditions

<table>
<thead>
<tr>
<th>Type</th>
<th>Dynamic Tracking System</th>
<th>No tracking system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load</td>
<td>13.6Ω</td>
<td>13.6Ω</td>
</tr>
<tr>
<td>Average Voltage</td>
<td>10.796</td>
<td>8.427</td>
</tr>
<tr>
<td>Average Current</td>
<td>65.558</td>
<td>34.488</td>
</tr>
<tr>
<td>Average Power</td>
<td>0.872865</td>
<td>0.362676</td>
</tr>
<tr>
<td>Improvement</td>
<td>51.0189</td>
<td>N.A.</td>
</tr>
</tbody>
</table>

The effectiveness and reliability of the P & O MPPT as sensors are verified by experimental results. For a comparison, a static PV cell and a PV cell with a dynamic tracking system are tested under the same condition. The measured power conversions of the cells are the basis for performance comparison. The effectiveness of the system was tested under winter conditions.

III. Conclusion

In this paper, an intelligent solar tracking system based on embedded microcontroller PIC16F877A is present and implemented. This solar tracking system consists of Voltage divider circuit as a voltage sensor, embedded controller, control mechanism and solar tracking equipment. The P & O MPPT technique is used for sun position is introduced briefly in order to trace the movement of the sun. The hardware structure of the intelligent solar tracking system based on PIC16F877A microcontroller is introduced in detail. Meanwhile, P & O MPPT control strategy and the software code for DC motor is described. This proposed solar tracking system can improve the photoelectric conversion efficiency of the solar cell array with high accuracy.

REFERENCES


