Abstract— This paper explains the operation of the Maximum Power Point Tracking (MPPT) system which harnesses the maximum possible power from available sunlight through photovoltaic system. The aim of this research is to develop a system using cost effective components that can be used in simple domestic application to charge a load. The MPPT system uses the Perturb and Observe (P&O) algorithm as a method to compute and regulate power derived. The proposed method was evaluated to observe the voltage and current output and the results are presented. The strengths of the system were identified.

Keywords— Maximum Power Point Tracking (MPPT), solar energy, renewable energy, photovoltaic (PV) systems, solar charging system

1. Introduction

The search for an alternative and potential source to replace the exhaustive resources such as crude oil is a continuous effort. One of the identified and preferred renewable resources is solar energy. Photovoltaic (PV), cells are devices that convert the solar energy of into direct current (DC) electric energy [1]. The mechanism of PV cells is based on semiconductor principles, that when light strikes the silicon surface its electrons are released, to generate an electric current. The power generated by the PV cells depends on irradiance, temperature, and cloud conditions. The power generated at each instance has a Maximum Power Point (MPP) which is never constant over time. MPPT should be used to track its changes. An MPPT tracks the highest current level in these conditions at a particular power rating level available and directs it to load [2]. In this paper, the MPPT is applied to simple charging application to demonstrate the effectiveness of the system to supply the load with more current.

2. Methodology

This is a quantitative study. The MPPT is used to bridge the PV array and the load to be charged, under sunlight. The MPPT’s embedded algorithm computes the available power MPP and draws maximum current to charge the load. The reading is taken from solar panels with power rating of 130W under variable weather conditions.

2.1 System Design and Modeling

This section describes the typical layout of the system. The MPPT controller consists of voltage and current sensor which calculate the voltage at which the module is able to produce maximum power. The Current sensor determines the current that can be drawn at identified MPP[3].

A high efficiency DC-to-DC power converter converts voltage level at the PV module to the microcontroller and battery. A microcontroller is integrated circuit to read voltage and current signals from the sensors and the MPPT system samples the output of the PV cells using a voltage and current sensor and affects the proper resistance by microcontroller to obtain maximum current from available voltage level.

Fig. 1[6] shows the block and flow diagram of the MPPT system implemented using sensors and microcontroller.

The design implements the Perturb and Observe (P&O) method which is convenient for its simplicity and lesser time delay. The P&O algorithm increases the operating voltage until the power and current level begin to decrease as shown in Fig. 2. When MPP drops, the voltage is decreased to get back towards the MPP [4].

2.2 Data Collection and Testing

The PV module is placed outdoors under direct sunlight during varying weather conditions. A constant is used by measuring the output of the PV module without MPPT implementation versus the PV module using MPPT system. This test commenced when the system was completely built, from 27th April to 16th May 2013 during the daylight hours from 8 am to 5 pm for a total of 9 hours.

A multimeter is used to measure the voltage across the MPPT module and towards the load (battery). The embedded current sensing circuit paved a way for the highest detected current to flow towards the load. The battery’s remainder voltage capacity is measured from time to time to prove the charging of the load via PV and MPPT.

This test is carried by connecting one set of solar panel to load without MPPT and another similar set but consisting of the MPPT. The readings gathered will illustrate the actual efficiency of the MPPT system.
3. Results

The performance of the PV module with rating 12 Watts to charge the given load is tested using one set with MPPT system and another without. The testing is carried out for two light intensity conditions namely sunny and cloudy. The results obtained are tabulated in Fig. 2 and Table 1.

Fig. 3 shows the graph of voltage levels of the PV system without MPPT implementation for sunny conditions.

![Fig. 3 Voltage of PV Module with Respect to Sunny Condition at Different Daylight Hours without MPPT Implementation](image)

Table 1 tabulates the reading obtained for the PV module’s output voltage level with the implementation of MPPT.

<table>
<thead>
<tr>
<th>Daytime Hours, a.m.</th>
<th>Weather Condition</th>
<th>Voltage (V)</th>
<th>Current (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sunny</td>
<td>16</td>
<td>0.625</td>
</tr>
<tr>
<td></td>
<td>Cloudy</td>
<td>16</td>
<td>0.47</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 p.m</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 p.m</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 p.m</td>
<td>15</td>
</tr>
</tbody>
</table>

4. Discussion

The availability of sunlight enables the strongest reaction of irradiance between semiconductor materials in PV cell to generate free moving electrons, therefore higher current [5]. However, the highest efficiency of the MPPT is during early midday (11 a.m) when voltage levels are high and the panel is not heated up. The P&O algorithm can convert the voltage level to a lower one to obtain a higher current level at the power produced by the PV cell.

It is shown through comparison that the voltage level in the MPPT system is adjusted to a lower one so that more current is drawn to charge the load. The controller detects the MPP at a given time, then increases the voltage until the MPP is observed to decrease. Then the controller responds by decreasing the voltage level to re-obtain the MPP with the maximum current level. The given power rating of the solar panel is 12 W.

The MPP can be evaluated by using the power formula, \( P = V \times I \) [5]

Based on Table 1 at 12 p.m it is observed that the voltage level is given as 16 V. To obtain the power in Watts, the current obtained is multiplied with the voltage.

\[
P = V \times I = 16 \text{ V} \times 0.7 \text{ A} = 11.2 \text{ W}
\]

Thus, the MPP at 12 p.m is 11.2 W which is close to the PV module power rating of 12 W.

5. Conclusion

Renewable energy sources, like solar energy, are suitable for residential and industrial applications. MPPT could increase the energy delivery by up to 24% on a solar day and in increase of 25% on cloudy days. The MPPT can regulate occurrence of battery overcharge protection, saving the cost of maintenance.

The future work proposed for this project details in programming an algorithm that combines the P&O algorithm and Incremental Conductance to detect rapid changes in light intensity. One could also integrate the use of Pulse Width Modulation PWM or fuzzy logic control to determine the state of weather and use a higher clock speed microcontroller such as 120MHz to decrease time delay computation.

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References