Improve Performance of PV System by PID Controller

1Nishant Kumar, 2Nitin Sharma

Abstract

Power from solar panel is affected by isolation and temperature variation which can be minimized by MPPT system. To extract maximum power from solar system, perturb and observe technique of PID controller is used. A PV system require proper battery charge controller to balance the power flow from PV system to battery and load such that photovoltaic power is utilized effectively. A circuit based simulation model for a PV-cell for assessing the IV trademark curves of photovoltaic-panel as for changes on environmental parameters (irradiance & temperature) and cell parameters (ideality factor & parasitic resistance). We are improving the results of peak power and voltage by use PID controller. Maximum power and maximum voltage is increasing from the base system.

Keywords: MPPT, Shockley diode, photovoltaic (PV), MATLAB/Simulink, irradiance, IV and PV Curves.

Introduction

Renewable energy is energy generated from natural resources such as sunlight, wind, rain, tides and geothermal heat which are renewable (naturally replenished). Renewable energy technologies range from solar power, wind power, hydroelectricity/micro hydro, and biomass and bio fuels for transportation.

Renewable energy is energy that is generated from natural processes that are continuously replenished. This includes sunlight, geothermal heat, wind, tides, water, and various forms of biomass. This energy cannot be exhausted and is constantly renewed.

Alternative energy is a term used for an energy source that is an alternative to using fossil fuels. Generally, it indicates energies that are non-traditional and have low environmental impact. The term alternative is used to contrast with fossil fuels according to some sources. By most definitions alternative energy doesn't harm the environment, a distinction which separates it from renewable energy which may or may not have significant environmental impact.

Renewable energy is generally defined as energy that comes from resources which are naturally replenished on a human timescale such as sunlight, wind, rain, tides, waves and geothermal heat. Renewable energy replaces conventional fuels in four distinct areas: electricity generation, hot water/ space heating, motor fuels, and rural (off-grid) energy services. Based on REN21’s 2014 report, renewable contributed 19 percent to our energy consumption and 22 percent to our electricity generation in 2012 and 2013, respectively. Both, modern renewable, such as hydro, wind, solar and bio fuels, as well as traditional biomass, contributed in about equal parts to the global energy supply. Worldwide investments in renewable technologies amounted to more than US$ 214 billion in 2013, with countries like China and the United States heavily investing in wind, hydro, solar and bio fuels.

Renewable energy resources exist over wide geographical areas, in contrast to other energy sources, which are concentrated in a limited number of countries. Rapid deployment of renewable energy and energy efficiency is resulting in significant energy security, climate change mitigation, and economic benefits. In international public opinion surveys there is strong support for promoting renewable sources such as solar power and wind power. At the national level, at least 30 nations around the world already have renewable energy contributing more than 20 percent of energy supply. National renewable energy markets are projected to continue to grow strongly in the coming decade and beyond. While many renewable energy projects are large-scale, renewable technologies are also suited to rural and remote
areas and developing countries, where energy is often crucial in human development. United Nations’ Secretary-General Ban Ki-moon has said that renewable energy has the ability to lift the poorest nations to new levels of prosperity.

Solar Energy

Solar energy is radiant light and heat from the sun harnessed using a range of ever-evolving technologies such as solar heating, solar photovoltaic, solar thermal energy, solar architecture and artificial photosynthesis. [1][2]

It is an important source of renewable energy and its technologies are broadly characterized as either passive solar or active solar depending on the way they capture and distribute solar energy or convert it into solar power. Active solar techniques include the use of photovoltaic systems, concentrated solar power and solar water heating to harness the energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light dispersing properties, and designing spaces that naturally circulate air.

In 2011, the International Energy Agency said that “the development of affordable, inexhaustible and clean solar energy technologies will have huge longer-term benefits. It will increase countries’ energy security through reliance on an indigenous, inexhaustible and mostly import-independent resource, enhance sustainability, reduce pollution, lower the costs of mitigating global warming, and keep fossil fuel prices lower than otherwise. These advantages are global. Hence the additional costs of the incentives for early deployment should be considered learning investments; they must be wisely spent and need to be widely shared”.[1]

Solar Cell or Photovoltaic Cell

Solar cells, also called photovoltaic (PV) cells by scientists, convert sunlight directly into electricity. PV gets its name from the process of converting light (photons) to electricity (voltage), which is called the PV effect. The PV effect was discovered in 1954, when scientists at Bell Telephone discovered that silicon (an element found in sand) created an electric charge when exposed to sunlight. Soon solar cells were being used to power space satellites and smaller items like calculators and watches. Today, thousands of people power their homes and businesses with individual solar PV systems. Utility companies are also using PV technology for large power stations. Solar panels used to power homes and businesses are typically made from solar cells combined into modules that hold about 40 cells. A typical home will use about 10 to 20 solar panels to power the home. The panels are mounted at a fixed angle facing south, or they can be mounted on a tracking device that follows the sun, allowing them to capture the most sunlight. Many solar panels combined together to create one system is called a solar array. For large electric utility or industrial applications, hundreds of solar arrays are interconnected to form a large utility-scale PV system.

Traditional solar cells are made from silicon, are usually flat-plate, and generally are the most efficient. Second-generation solar cells are called thin-film solar cells because they are made from amorphous silicon or no silicon materials such as cadmium telluride. Thin film solar cells use layers of semiconductor materials only a few micrometers thick. Because of their flexibility, thin film solar cells can double as rooftop shingles and tiles, building facades, or the glazing for skylights.

Third-generation solar cells are being made from a variety of new materials besides silicon, including solar inks using conventional printing press technologies, solar dyes, and conductive plastics. Some new solar cells use plastic lenses or mirrors to concentrate sunlight onto a very small piece of high efficiency PV material. The PV material is more expensive, but because so little is needed, these systems are becoming cost effective for use by utilities and industry. However, because the lenses must be pointed at the sun, the use of concentrating collectors is limited to the sunniest parts of the country.

Solar Inverter

A solar inverter, or PV inverter, converts the variable direct current (DC) output of a photovoltaic (PV) solar panel into a utility frequency alternating current (AC) that can be fed into a commercial electrical grid or used by a local, off-grid electrical network. It is a critical BOS-component in a photovoltaic system, allowing the use of ordinary AC-powered equipment. Solar inverters have special functions adapted for use with
photovoltaic arrays, including maximum power point tracking and anti-islanding protection.

Problem Statement

In the base paper design the simple PV cell is using to get power output. When we don't apply any controller then the power output is 190 W. For the voltage graph output voltage is 310 V when we don't apply any controller. Output current is near about 0.62 A. We can further improve the performance of the system. The power is too low as compare to PID controller power.

Table 1: Existing design model output

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Calculated values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak power (Pmpp)</td>
<td>190 W</td>
</tr>
<tr>
<td>Peak Voltage (Vmpp)</td>
<td>310V</td>
</tr>
<tr>
<td>Peak current</td>
<td>0.62 A</td>
</tr>
</tbody>
</table>

Proposed Methodology

A proportional– integral– derivative controller (PID controller) is a control loop feedback mechanism (controller) commonly used in industrial control systems. A PID controller continuously calculates an error value as the difference between a measured process variable and a desired set point.

We are using PID controller for improve the performance of the peak power and peak voltage. As the PID controller gain change the value of the output graph will increase. But after a fix gain the value cannot be change.

Table 2: PID controller gain values

<table>
<thead>
<tr>
<th>PID Controller</th>
<th>Gain value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportional (P)</td>
<td>1.5</td>
</tr>
<tr>
<td>Integral (I)</td>
<td>0.1</td>
</tr>
<tr>
<td>Derivative (D)</td>
<td>0</td>
</tr>
</tbody>
</table>

Results

The value of the peak power and peak voltage are getting increase by control the gain of PID. Results are showing the difference in between existing and proposed design. For improve the performance, PID controller is using.

![Figure 1: PV cell Design model](image1.png)

Results For Without PID Controller

Power Graph

Form the power graph we can see that peak power is going up to 190 W when we don't apply any controller. The peak power can be further improve by apply PID controller.

![Figure 2: Power graph for without any controller](image2.png)

Voltage Graph

Form the voltage graph we can see that peak voltage is going up to 310 V when we don't apply any controller. The peak voltage can be further improve by apply PID controller.

![Figure 3: Voltage graph for without any controller](image3.png)
Current Graph

Form the current graph we can see that peak current is going up to 0.62 A when we don't apply any controller. The peak current can be further improve by apply PID controller.

Results For With PID Controller

Power Graph

Form the power graph we can see that peak power is going up to 350 W when we apply PID controller. The peak power can be further improve by apply fuzzy logic controller.

Voltage Graph

Form the voltage graph we can see that peak voltage is going up to 410 V when we apply PID controller. The peak voltage can be further improve by apply fuzzy logic controller.

I. Conclusion

This paper presents an overview of the PID methods and their difficulty of tracking, in the fast changing environmental conditions. Solar energy is one of the forms of renewable energy source and it brings benefits to the residential that uses it as their alternative power supply. In order to increases the efficiency of system during rapid changing environmental conditions system will adapt some fuzzy logic methods. This paper presents a review on PID methods for variable environmental conditions (i.e. variable temperature and irradiation level). Apart from all the methods, an open circuit and slope detection tracking technique is found to be an efficient technique with respect to tracking speed.
and accuracy. This technique can avoid the unnecessary amount of power loss and therefore maintaining the power efficiency.

In this paper, we apply PID controller for improve the performance of the output power system. When we don't apply PID controller output voltage is getting 190 W. It gets improve when we apply PID controller. It is getting output power is 350 W when we apply PID controller.

For further improve the performance we can apply Neural network which can further improve the performance of the output power. After apply the neural network controller the results of the voltages, current and power get improved.

References


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Author's details
1M.Tech Scholar, JaganNath University, Jaipur, Rajasthan, India
2Assistant Professor, JaganNath University, Jaipur, Rajasthan, India

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