Improve Efficiency Solar Cells Using PID Controller

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Abstract
The photovoltaic cell (PV) converts the solar radiation into electric energy and the current coming out of the photovoltaic cell is of the direct current type. The external power of the PV system depends on solar radiation (G) and cell temperature (T). The method of using photovoltaic cells (PV) is efficiently known by the method of tracking the maximum power points (MPPT) using the PID console. This paper introduces MPPT controllers and is a traditional Relative Integration derivative (PID). The work to simulation and modeling to PV cell by MATLAB program. The results show the relationship of curve IV and V-P of the PV panel, as is the case with changes in cell parameters and environmental parameters (radiation and temperature). Optimize PV results for maximum power and maximum voltage using the PID controller used. According to the results, observe the best PID control if compared with other MPPT algorithms.

Key words: Photovoltaic cells (PV), Maximum power point (MPPT) tracking, Proportional Integration Derivative (PID), solar radiation (G) and temperature (T).

1. INTRODUCTION

Increased energy demand for population growth, industrial expansion, and technology development has led to the exploration of alternative energy sources for power generation. Environmental issues related to fears of the effects of global warming and global warming and the depletion of natural reserves such as fossil fuels, coal, natural gas, etc. stimulate research on investing in technology that can generate energy from renewable or alternative energy sources [1].

The sustainable power source (SPS) is the vitality created from inexhaustible regular assets, for example, sun based radiation, wind, geothermal, tsunamis, and so forth from characteristic sources.
Sunlight based PV is a technique that is legitimately changed over to sun-powered radiation into electrical vitality and relies upon the photoelectric impact [2].

PV system has during the operation some the following pros (it does not produce noise mean these quiet system, it does not produce any gas, direct conversion of solar radiation into electricity, no environment pollution and no have mechanical moving parts).

In addition, from cons PV system (the initial expensive cost to produce power from solar cells and power production is a variable dependent on the sun and weather case during the day) [3]

The PV cell produces a direct current from the sunlight. The external current from PV cells depends on the temperature, solar radiation and size of the PV array.

![Figure 1. Block Diagram of PV Model](image)

Figure 1. represents the components of the solar system, which consists of a solar panel, which is connected to a charge controller, that regulates the charging of batteries, so that it cuts off the power from the batteries if they reach a certain level of charging (does not reach 100%), and this method maintains the integrity of the batteries [4].

In addition, the controller adjusts the power produced from the PV cells to allow the batteries to take the necessary voltage and current. However, improve the performance of solar panels by making use of maximum energy, then connected to a battery system that will been used to store energy generated from solar panels after passing through the charge controller and then connect it with loads that work on DC power [5].

In addition, for purpose get AC from the PV system must install an inverter in system with connection after the batteries stage is required to transformer the power from DC to AC.

2. PV cells modeling

The PV cell can represent by an identical circuit, which appeared in Fig.2. The proportional circuit of a PV cell at most involves a current source correlated in corresponding with a diode and two resistors shunt and series to show up the losses [2-6].
Thence, the PV cell attributes can be gotten utilizing standard conditions. For reproduction, a whole PV framework cluster the model of a photovoltaic PV module is grown first. The PV cells correlated with the regulator are giving a short out current (Isc) and open-circuit voltage (Voc). When used Kirchhoff law to the equivalent circuit will be getting on the maximum output current characteristic of an ideal PV cell in a single diode model as shown in equation (5) [7].

![Solar cell equivalent circuit](image)

\[ I_{ph} = \frac{G}{G_{ref}} [I_{sc} + K_i (T - T_{ref})] \]

\[ I_a = I_s \left( \frac{\exp(\frac{q}{N k T} (V + I R_s)) - 1}{\exp(\frac{q}{N k T} (V + I R_s))} \right) \]

\[ I_{sh} = \frac{V + I R_s}{R_{sh}} \]

\[ I_{pv} = I_{ph} - I_{sh} \left[ \exp(q \frac{V + I R_s}{N k T}) - 1 \right] \]

**3. Boost (DC/DC) Converter**

The boost converter is also known as the increment converter. It can be used in situations where the output voltage is more than the input voltage, mainly like work is a versatile buck converter. Practical applications using a boost type transformer are shown in network systems [2-7].

\[ \mu = \frac{V_o}{V_i} = \frac{T}{T_{off}} = \frac{1}{1-D} \]

Where \( T_{off} \) is the duration that the switch is not active, \( D \) is a duty ratio, \( T \) is the time.
There are two different modes from through them it operation works a boost converter. The converter is based on close and opens the switch [8].

4. MPPT Algorithms

Maximum Power Point Tracking (MPPT) is a technique commonly used PV systems to increase maximum output power in all conditions.

Although, solar energy is mainly covered, the principle generally applies to sources of variable energy: for example, the transport of light energy and thermal heat layers.

Solar PV systems exist in many different configurations regarding their relationship to reflective systems, external networks, battery batteries, or other electrical loads. Regardless of the final destination of solar energy, the central problem that MPPT addresses is that the energy transfer efficiency of the solar cell depends on the amount of sunlight that falls on the solar panels and the electrical characteristics of the load. As the amount of sunlight varies, the load property that gives the highest power transfer efficiency changes, so the system efficiency is improved when the load characteristics are changed to keep the power transfer at the highest efficiency [9].

The control unit charges the battery according to the voltage of the battery storage system, and the control units connect directly to the power storage system (with batteries). Moreover, calculating the greatest external power from the PV cell can be defined by law \( P = IV \), where \( I \) represents the output power (P) and output voltage (V). Additional, from which derived the external power equation according to voltage and results in the equation (7), since the output power from the greatest possible is equalize derive to zero \( (dP / dV = 0) \) [10].

\[
\frac{dp}{dv} = V \frac{dt}{dv} + 1 = 0 \quad \text{(At the MPP)} \quad (7)
\]

Therefore, within a sampling period, Equation can be rewritten as:

\[
\frac{dt}{dv} = -\frac{1}{V} \quad (8)
\]
From Equation (8) represent that at the MPP, something contrary to the prompt conductance of the PV cluster framework on the left half of the condition rises to the steady conductance on the right-hand side. Henceforth, the subordinate of the focuses ought to be under zero on the correct side and more noteworthy than zero on the left of the MPP while:

If \( \frac{dl}{dv} = 0 \) (\( \frac{dl}{dv} = - \frac{1}{v} \)), then MPP is reached \hspace{1cm} (9)

If \( \frac{dl}{dv} < 0 \) (\( \frac{dl}{dv} < - \frac{1}{v} \)), then decrease \( V_{\text{ref}} \) \hspace{1cm} (10)

If \( \frac{dl}{dv} > 0 \) (\( \frac{dl}{dv} > - \frac{1}{v} \)), then increase \( V_{\text{ref}} \) \hspace{1cm} (11)

5. PID controller

The PID controller (proportional-integral-derivative) is the input circle control component. Criticism instruments predominantly utilized in mechanical control frameworks. PID the controller attempts to address the blunder between the required set point and procedure variable estimated by figuring and then the consequence of a remedial activity can be balanced activity appropriately. It additionally includes a PID controller to compute three extraordinarily (isolated) [4-11].

![Figure 4. Represent sample PID controller](image)

In figure (4) represent Parameters relative proportional (P), derivative (D) and integral (I).proportional worth (P) decides the response to for the present blunder, the subordinate worth (D) decides the response depends on the rate at which the mistake was changed and the estimation of the Integral (I) is set the response depends on of the whole of ongoing mistakes [12].

Additional, a figure (4) and figure (5) showing the output versus time, for different values of Kp (that is, Ki and Kd remain constant) in the open loop. The PV versus time, for different values of Kp (that is, Ki and Kd remain constant) in the closed loop.
Proportional limit is sometimes called amplification and causes the output value to change by an amount proportional to the current error value. A proportional response can be adjusted by multiplying the error value with a fixed adjustable value, $K_p$, also called proportional amplification [12-13].

A diagram of the value of the change in error and output with time in the open-loop due to different values of $K_i$ (that is, $K_p$ and $K_d$ remain constant) is called the integral limit sometimes because of its ability to remove the residual error which the proportional limit cannot cancel. The reason can be understood by looking at the open loop where we see that the integrative limit continues to change up or down in proportion to the amount of error with and does not stop over time unless the error is zero. In practice, the integrative limit stops when it reaches the saturation stage, which is the maximum power of the operational output. The integrative limit has a stable, adjustable tuning process ($K_i$) [8-15].

Thus, the differential term ($K_d$) is sometimes called the rate, because it appears only when there is a change in the error value with respect to time and is directly proportional to the rate of this change. The differential limit improves sometimes in the control process, but it is affected greatly by the noise and can cause instability in the system. For this reason, the differential limit is used only rarely and with extreme caution in industry [16].

Therefore, at that point include these three methodology are utilized to adjust the procedure over control. We utilize the PID controller to improve voltage execution and pinnacle power. PID changing the deal with the yield worth will change yet after fixed addition, the worth cannot be change [12-17].

$$u(t)=K_p \, e(t) + K_i \int e(t) \, dt + K_d \frac{d}{dt} e(t)$$

**Figure 5.** PID controller

Where ($K_p$, $K_i$ and $K_d$) all are the positive coefficients for a proportional term, integral term, and derivative terms on respectively. Usually they denote as P, I and D. in this study was gain values P,I and D equal 1.5 , 0.2 and 0.0 respectively.

### 6. Result and Analysis

PV system Maximum output values of voltage, current and power are increased and improved based by controlling the PID control. The difference will show the results between the current design and the proposed design. Therefore, this improves the performance of PV cells back to using PID control.

In addition, The electrical parameters of the PV cell each from $P_{max}$, $V_{max}$ and $I_{max}$ are equal to 66.45 W, 110.4 V and 1.66 A respectively.
6.1 Results from the PV model without using the PID controller

Form the figure (8) we can see that maximum output current (I) from PVs cell is going up to 1.661 A, this current value was without any controller. The current can be improved when using the PID controller.
Figure 8. Output current from PV cell without PID controller.

From the figure (9) we can see that maximum output voltage (V) from PVs cell is going up to 110.4 V, this voltage value was without any controller. The voltage can be improved when using the PID controller.

Figure 9. Output voltage from PV cell without PID controller

From the figure (10) we can see that maximum output power (Pmax) from PVs cell is going up to 66.45 W, this power value was without any controller. The power can be improved when using the PID controller.
6.2 Results from the PV model with using the PID controller

From the figure(11), we can see that maximum output current (I) from PVs cell is going up to 1.98A, this current value was with using PID controller.

Figure 11. Output current from PV cell with PID controller.
Form the figure (12) we can see that maximum output voltage (V) from PVs cell is going up to 157 V, this voltage value was with using PID controller.

![Figure 12. Output voltage from PV cell with PID controller.](image1)

Form the figure (13) we can see that maximum output power (Pmax) from PVs cell is going up to 79.24 W, this power value was with using PID controller.

![Figure 13. Output power from PV cell with PID controller.](image2)
7. Conclusion

The PV cell generates direct current from the sun's rays. This current, as well as voltages, are affected by the change of solar radiation and the temperature surrounding the cell. Thus, the output design power of the cell will be affected. In addition, it was the size solar cell's main play in the composition of the PV array. Generally, smaller PV panels will produce less power, and larger PV panels will produce more power. As a result of simulation modeling, the PID controller showed better performance in optimizing the maximum values of current, voltage and power solar panels.

In the study, the PID controller was used to improve the performance of the output power from the PV cell. When we do not use a PID controller, the results output from PV cell for the maximum value for power and voltage and current are (66.45W, 110.4V, 1.66A) respectively. When using the PID controller, showed a clear improvement in the performance of the PV cell, for the output of the maximum value the power, voltage and current of the cell (79.24W, 157V, 1.98 A) respectively.

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