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Improve Performance of MPPT Photovoltaic System by PID Controller

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Abstract :- **Maximum power point trackers are efficient enough to enhance an efficiency of the photovoltaic system. So many methodologies have been proposed up to this date to achieve maximum power. PV modules are capable of generating maximum power under diverse atmospheric conditions. The base paper [12] proposed an MPPT (Maximum Power Point Tracking) algorithm that based on fuzzy logic for a solar system. The solar panel is analyzed and then simulated by using SIMULINK or MATLAB. The PV system is bound to DC-DC BUCK BOOST converter. The MPP (Maximum Power Point) is an operating point where Solar panel used to generate maximum power. In order to gain maximum efficiency and the power, it is required that entire system should operate at MPP. The MPP of PV panel maintains similar on changing by changing cell temperature and solar irradiance. So to achieve maximum power with PV system, the MPPT algorithms are put into the operation. In this paper, we are enhancing voltage, current and power performance of solar output. Hence, further, the application of PID controller helps to enhance performance that we are going to implement. PID controller is efficient enough to enhance solar output power performance.**

Keywords: *PV Modeling, PID controller, Buck-Boost Converter, Fuzzy Logic, MPPT.*

I. INTRODUCTION

The use of renewable energy source is increasing day by day. The reason behind this is the exhaustion and consumption of massive fossil fuel. The Photovoltaic array is one of the renewable energy sources that used in so many applications like battery charging, water pumping, PV systems (grid connected) and hybrid vehicles. As PV used to deliver maximum power to load, there finds an optimum operation point. The optimum operating point used to change with cell temperature and solar irradiation. Hence, online tracking of MPP (maximum power point) of PV array becomes an important part of any successful PV system. The diversity of MPPT (maximum power point tracking) method has developed. The particular method varies in the implementation of cost, convergence speed, needed sensors number, sensed parameters and complexity. [1] The algorithm which has used here has two major parts (a) maximum power computation and (b) direct power control (power drawn from PV). Then the maximum power is calculated online by utilizing a modified P&O (perturb and observe) algorithm. The calculated power has then evaluated with an instantaneous PV power, and the error in between reference power (maximum) and actual power (activates ON/ OFF controller) with the hysteresis band so that to drive a buck chopper. Hence, an instantaneous power is sustain between tolerance bands, where power extracted from PV.

A. PV Equivalent Circuit

The solar cell is made up of semiconductor P-N junction. When exposed to light DC is produced in it. There find variation in generated current because of the solar irradiance. The standard equivalent PV cell circuit is below. In addition to that basic equation which describes V-I characteristics for PV model is also given below.

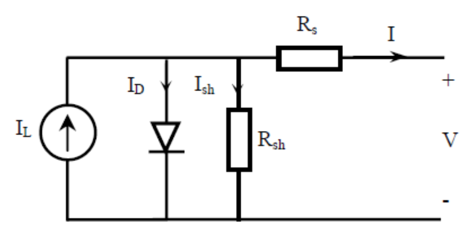

Figure 1:- Equivalent circuit of PV solar cell

$$I = I_L - I_0 \left(e^{\frac{q(V+IR_s)}{kT}} - 1\right) - \frac{V + IR_s}{R_{sh}} \quad \text{... ... (1)}$$

Where,

I: cell current (A),

I_L: light generated current (A),

I_o: diode saturation current,

q: charge of electron [1.6x10-19 (coulomb)],

K: Boltzmann constant (j/K),

T: cell temperature (K),

Rs: series resistance (ohms),

R_{sh}: shunt resistance (ohms),

V: cell output voltage (V).

B. Commonly Used MPPT Techniques

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The problem is to find voltage VMPP and current IMPP that is believed by MPPT technique. In this particular section, most typical MPPT methods are presented in order.

C. Fractional Open-Circuit Voltage

The Certain method depends on an observation in which the ratio in between array voltage (at the maximum power VMPP) to OC (open circuit) voltage VOC is constant.

$$V_{MPP} \sim k_1 V_{OC} \qquad ....(2)$$

The factor k1 is in between 0.71 & 0.78. After getting k1 VMPP is calculated by periodically measuring VOC. The implementation of such method is cheap and straightforward. The tracking efficiency of it is relatively small because of the use of incorrect values of constant k1 in the calculation of VMMP.

D. Fractional Short-Circuit Current

The IMPP, that is, current at maximum power point is linearly related to I_{sc}, that is, short circuit current of PV array. By considering this method gives output.

$$I_{MPP} \approx k_2 I_{SC} \qquad \ldots\ldots(3)$$

Similarly, in fractional voltage method, the term value k2 is not constant. It gives the value in between 0.78 & 0.92. The tracking efficiency and method accuracy depend on the accuracy of periodic measurement of I_{sc} (short circuit current) a k2.

E. Perturb And Observe (P&O)

In this method, MPPT-algorithm is based on the calculation of two factors.
(a) PV output power
(b) power change by PV voltage and current sampling.

The tracker operates on solar array voltage where the voltage is increment or decrement periodically. If perturbation increases or decreases in PV output power, then consequent perturbation is produced in same opposite direction. Therefore, the duty cycle of dc chopper gets changed and repeat until the MPP (maximum power point) . Entire system oscillates around MPP. The step size minimization of perturbation can reduce oscillation. However, small sizes of step reduce the speed of MPPT. Hence to solve a certain problem, application of variable perturbation size needed to get reduced toward MPP. As well P&O technique can fail under the quick change in atmospheric conditions. The numbers of research activities have been taken to enhance conventional P&O and hill-climbing methods. The [4] proposes the 3Point Weight Comparison P&O method. The method that compares actual power point for two earlier points the judgment is made regarding the sign of perturbation. The [5] suggests 2 stage algorithm. The algorithms offer fast tracking in 1st stage & finer tracking in 2nd stage.

F. Incremental Conductance

The given method depends on the principle of PV array power slope. At MPP the PV array power curve is zero.

(dP/dV) = 0. Since (P = VI), it yields:

$\Delta I/\Delta V = - I/V$, at MPP (4.a)
$\Delta I/\Delta V > - I/V$, left of MPP
$\Delta I/\Delta V < - I/V$, right of MPP

The instantaneous conductance I/V and incremental conductance ΔI/ΔV assist in tracking MPP. This is done through by making the comparison between them. Certain algorithm increases or decreases the voltage of array reference until equation condition 4.a get satisfied. And when we reached to maximum power, the PV array operation maintained at the certain point. The method needs high sampling rates as well as fast power slope calculations.

G. MPPT Method

Lots of MPPT methodologies is used to find PV voltage and current at MPP (maximum power point), that is, VMPP and IMPP respectively. The suggested algorithm neither tracks IMPP nor VMPP. It tracks power PMAX only. The PMAX extracted from PV.

On the off chance that actual power is very much controlled inside the tolerance band of hysteresis controller, the fractional tracking is succeeded, and PMAX may be expanded to more prominent value. In any case, if the power controller neglects to track PMAX, this implies that registered PMAX is greater than maximum power PV. In this manner, a decrement occurs in calculated PMAX.

It should be done until PACT and PMAX mistake get restricted according to lower and upper limit. Algorithm sets calculated PMAX (maximum power) to starting value. It should be zero or any other value. The PV current and voltage are measured. At that point, an instantaneous value of the PV power PACT gets calculated.

The error amongst PACT and PMAX is input to the ON/OFF controller with the hysteresis band. The controller output is utilized to drive Buck Chopper power transistor like PACT-tracks PMAX.

Up to this time, maximum real power is not tracked. Hence we need to check error in between PACT and PMAX to point out maximum power. On the off chance that error is lower than a specific upper limit (0.5 Watt), this implies that the Power drawn from PV is inside a suitable value so that we may increase PMAX by a specific step-size. This new PMAX value is put away and used to limit actual PV power to point out this new esteem. At that point, the calculation is rehashed once more. At the point when the error amongst PACT and PMAX surpass the existing upper limit. That means that PV cannot deliver PMAX value. Consequently, we need to decrease PMAX by specific step-size (nearly 0.5 Watt).

H. System Modeling

The system of PV power is demonstrated by utilizing Power System Block, which set under the Matlab. The MPPT algorithm is demonstrated by utilizing the blocks of Simulink. The calculated maximum power PMAX and PV power PACT are planned together. The PV-current was 3 A that is comparing to the irradiance of the 1 kW/m2.As clarified before; the PMAX is begun from an initial value (0) and is expanded progressively. As indicated by the outcomes, processed PMAX is 51.5W, while theoretical value was 54W, so, 95% tracking efficiency. In the meantime, the algorithm of direct power control keeps actual power at 51.5 that limited in between the upper & lower limit of + 0.1W.

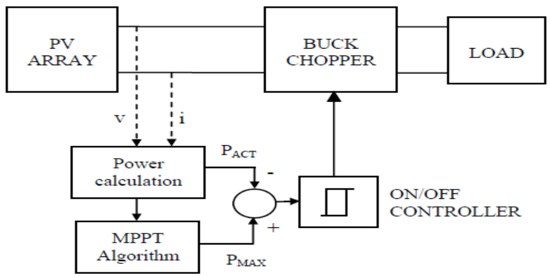

Figure 2: - Block diagram of the PV system under investigation

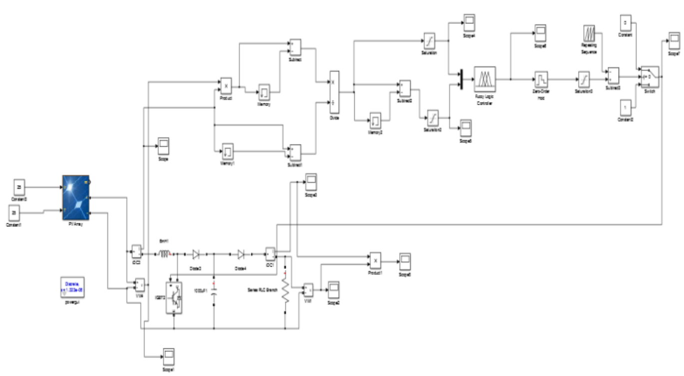

Figure 3:- Solar design circuit by Fuzzy Logic controller

II. PROBLEM STATEMENT

Maximum power point trackers are so important to improve the efficiency of photovoltaic systems. Many methods have been proposed to achieve the maximum power that the PV modules are capable of producing under different atmospheric conditions. In this research , we are improving the performance of the output solar voltage , current and power . In the previous paper they are working for the fuzzy logic for show the Voltage , current and Power .For Fuzzy Logic controller voltage is 315 V , current is $3.15 * 10^{-3}$ Amp and power is 1 W. We will apply proposed methodology for improve the voltage , current and power from the given values .

III. PROPOSED METHODOLOGY

In the industrial control system commonly used PID (proportional integral derivative) controller is a type of control loop feedback mechanism. The PID controller used for calculating error value. The error value is the difference between desired set point and measured process variable. The controller tries to reduce error by controlling variables like a damper; the power supplied to a heating element, the power supplied to the new value (determined by a weighted sum) and control valve position. The new value determined by weighted sum is calculated by:

$$u(t) = K_P e(t) + K_i \int_0^t e(t)dt + K_d \frac{de(t)}{dy} \qquad \ldots\ldots\ldots(3)$$

Where,

Kp, Ki & Kd: All are the positive coefficients for a proportional term, integral term, and derivative terms, respectively. Sometimes they denote as P, I and D.

The PID controllers, when utilized alone. It gives the poor execution, when the gain of PID loop reduced, so that, a CS (control system) doesn't overshoot. It oscillates and hunts about a value of control set-point. They likewise experience the issues within the sight of non-linearity, may exchange off the regulation VS response time. Don't respond to the behavior of changing process conduct and have the lag in response to a large number of disturbances.

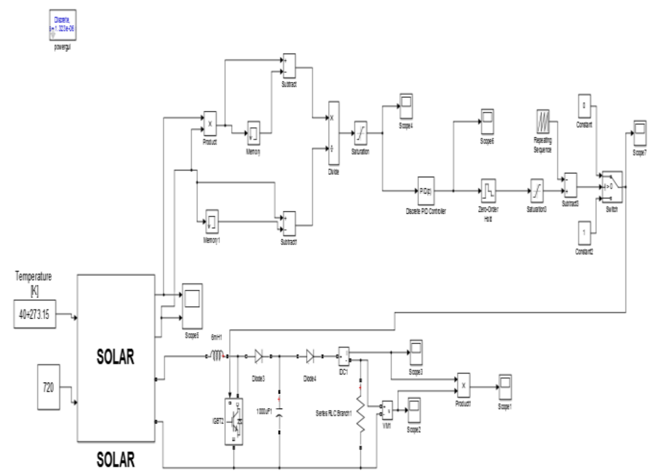

Figure 4 :- Solar design circuit for PID controller

The most critical enhancement is to incorporate forward control with the learning about the system, and by utilizing the PID just to control an error. On the other hand, PIDs can be adjusted in the minor routes, for example, by changing certain parameters, improving measurement, or cascading numerous PID-controllers. We are utilizing the PID controller for to enhance the execution of peak- power & peak-voltage. As PID-controller pick up the change in an output graph can increase. After fix gain, the value can't be modified.

PID Controller	Gain value
Proportional (P)	1.5
Integral (I)	0.1
Derivative (D)	0

Table 1 :- PID Controllers Gains

IV. RESULTS

In the previous paper , fuzzy logic was using for show the solar voltage and current with power . As we see from the results that PID controller is able to give high power with voltage and current as compare to fuzzy logic .

A. Output Power By Fuzzy Logic

As we can see from the figure 5 the power near about 1W. It is the power result by use fuzzy logic controller . As we can see from the image it is getting stable after 0.04 sec. So the stability time can also be reduce .

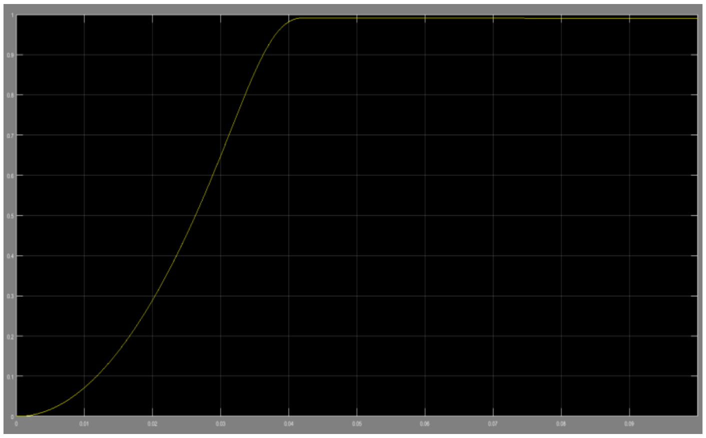

Figure 5:- Output Power for Fuzzy logic controller

B. Output Voltage By Fuzzy Logic Controller

As we can see from the figure 6 the output voltage is near to 330 V and it is getting stable after 0.04 sec. It is solar output voltage by use fuzzy logic controller .

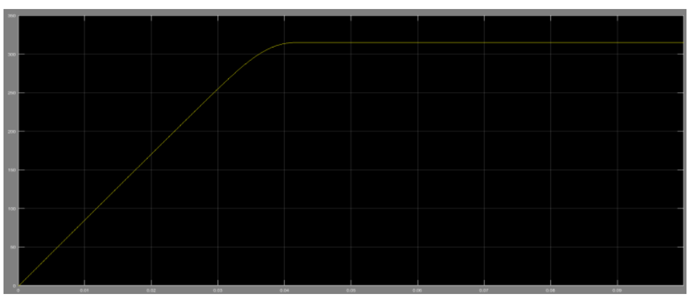

Figure 6 :- Output Voltage for Fuzzy logic

C. Output Current

As we can see from the figure 7 it is showing the solar output current graph by use Fuzzy logic controller . As we can see from the figure the output current is $3.25 * 10^{-3}$ Amp. which is getting stable after 0.04 sec .

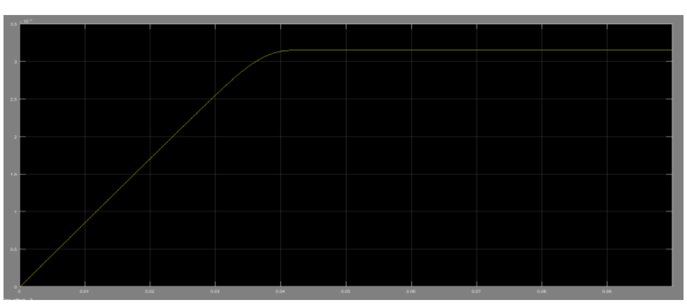

Figure 7 :- Current Graph for Design solar

D. Solar Output Voltage

Figure 8 is showing the solar output voltage which is also getting stable after 0.04 sec . The solar output voltage is 313 V which is get increase as we apply PID or Fuzzy Logic controller .

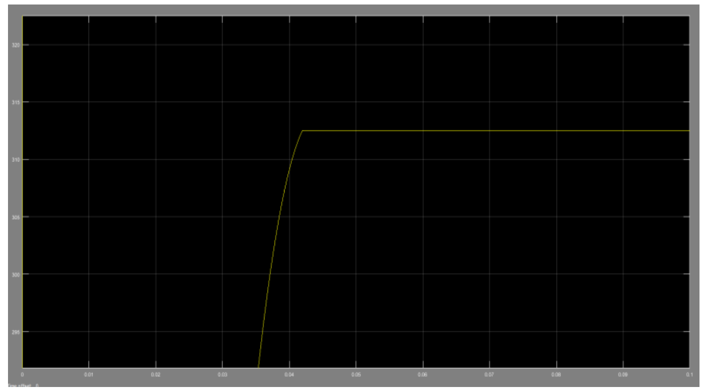

Figure 8:- Solar Output Voltage

E. Output Power By PID Controller

As we can see from the figure 9 the power near about 4 W. The Solar output power get increase after apply PID controller . As we can see from the fig 5.1 the output power is 1W for fuzzy logic controller after apply PID controller it is get increase up to 3 W . The output power by PID controller also get stable faster than fuzzy logic controller . Fuzzy logic controller output voltage was getting stable after 0.04 sec but by PID controller it is just get stable 0.02 sec .

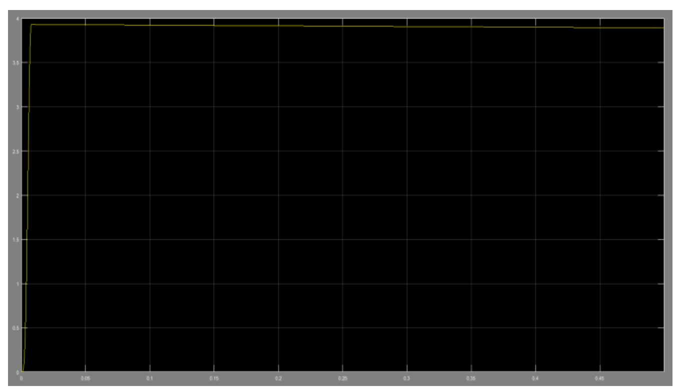

Figure 9 :- Power Graph for Design solar

F. Output Current By PID Controller

As we can see from the figure 10 , the output current is $6.2683 * 10^{-3}$ Amp. It is getting stable fast as compare to fuzzy logic controller. In the fuzzy logic controller system get stable after 0.04 sec but by PID controller it is getting stable at 0.02 sec. Stability and output current get increase by PID controller .

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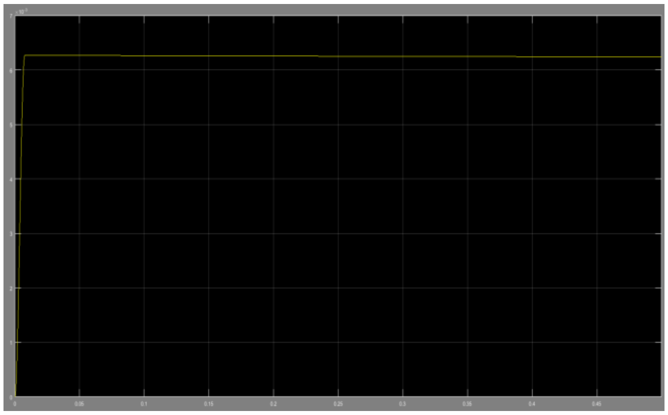

Figure 10:- Output Current graph by PID controller

G. Output Voltage By PID Controller

As we can see from the figure 11 the output voltage is showing for the PID controller . The output voltage is 626.5 V by use PID controller and it is getting stable after 0.02 sec. As compare to fuzzy logic based solar output voltage , PID based Solar output voltage is getting stable fast.

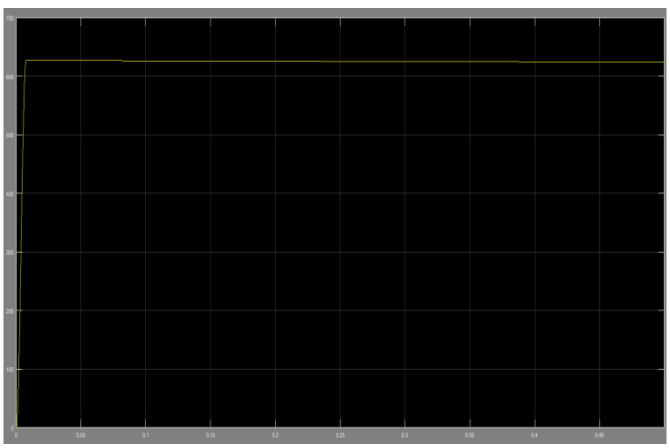

Figure 11 :- Output Solar Voltage by PID controller

H. Output Solar Voltage

As we can see from the figure 12 ,solar output voltage is 314.75 V. It is constant from the starting . It is the output without use any controller .

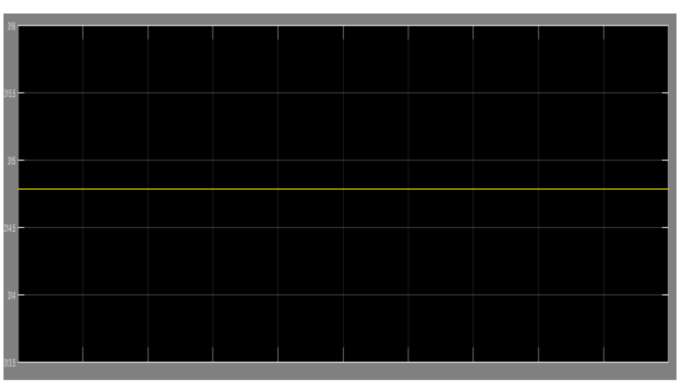

Figure 12:- Solar Output Power

	Solar Output Power	Solar Output Current	Solar Output Voltage
Fuzzy Logic Controller	1 W	$3.15 * 10^{-3}$ Amp	315 V
PID Controller	3.929 W	$6.2683 * 10^{-3}$ Amp	627 V

Table 2 :- Comparison Table

V. CONCLUSION AND FUTURE SCOPE

A. Conclusion

Paper represents the summary of PID techniques and their difficulty during tracking, in changing environmental conditions. The solar energy is the renewable source. It is beneficial for the residential who uses it as their alternate power supply. The system gets familiar with some of the fuzzy logic methodology to improve system efficiency during the changing environmental conditions. This thesis represents the summary of PID techniques for the changing environmental conditions, that is, irradiation level and variable temperature. And by considering all the methods, OC (open circuit) and slope detection tracking technique is an effective way w. r. to tracking accuracy and speed. The Certain method avoids needless amount power loss and hence maintaining the power efficiency. In the thesis, we have applied PID controller for to enhance the performance of power output system.

B. Future Scope

For the future perspective, to increase the performance of the system, we can use Neural Network. The Neural network further enhances the performance of output power. After applying the neural network controller, the performance result of power, voltage and current get improved.

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