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Improve efficiency of Photovoltaic (PV) system based by PID controller

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Abstract -The output powers of photovoltaic (PV) cells system are depending of the two variable factors which is the solar irradiances and cell temperature. A method to utilize effectively the PV cells is known as maximum power point tracking (MPP) method by using PID. This paper presents controllers to control the MPPT which is conventional proportional integral derivative (PID). A circuit based MATLAB/SIMULINK model for a PV cells the IV curves of photovoltaic-panel as for changes on cell parameters and environmental parameters (irradiance & temperature).We are improving the PV system results of peak power and maximum voltage by used PID controller According to results, PID controller is shown better performance compare to other MPPT algorithms.

Key_words: Photovoltaic (PV) system, Maximum power point (MPP) tracking, DC/DC converter,solar cell system.

1. INTRODUCTION

Increasing energy demand to population growth, industrial expansion and technology development, has led to exploring alternative energy sources for energy generation. Environmental issues with the concerns on greenhouse effects, global warming, depletion of natural reserves like natural gas, fossil fuels, coal, etc. is motivating research to invest in technology that can generate energy from renewable energy sources.

Renewable energy is energy generate from the renewable natural resources, such as wind, solar radiation, rainfall tides, geothermal heat etc. The PV solar energy is direct way to convert, solar radiation into electricity and is based on the Photovoltaic effect.

PV system technology has the following advantages 1) No pollution , it does not produce carbon dioxide, 2)No mechanical moving parts, no noise, direct conversion of solar radiation into electricity and Disadvantages 1) solar energy is somewhat more expensive to produce than conventional sources of energy due in part to the cost of manufacturing PV cell devices and in part to the conversion efficiencies of the equipment 2) solar power is a variable energy source, with energy production dependent on the sun.

A solar PV cell generates DC current from the sunlight. The output current of a solar array depends on the ambient temperature, solar insolation, the size and configuration of the PV array.

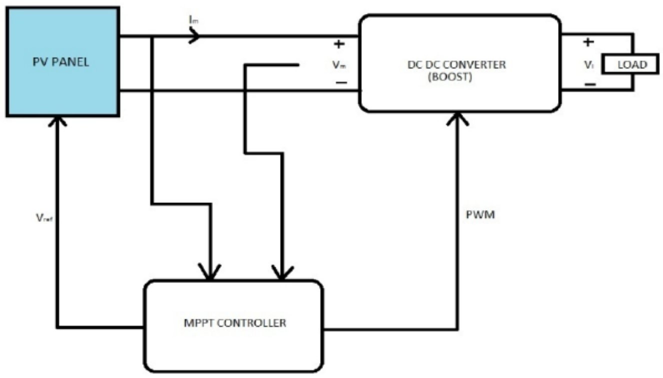

Figure.1. Block Diagram of PV Model

1.1. PV modules modeling

A photovoltaic PV cell can be represent by an equivalent circuit, shown in Fig.1.The PV cell characteristics can be obtained using by standard equations . For simulation an entire PV system array the model of a photovoltaic PV module is developed first. The each PV system module considered in this paper. The PV cells connected in series is providing an open circuit voltage (V_{oc}) and a short circuit current (I_{sc}).

Diode PV cell is shown in Figure.2 Equation-4 shows output current-voltage characteristic of a ideal PV cell in a single diode model.

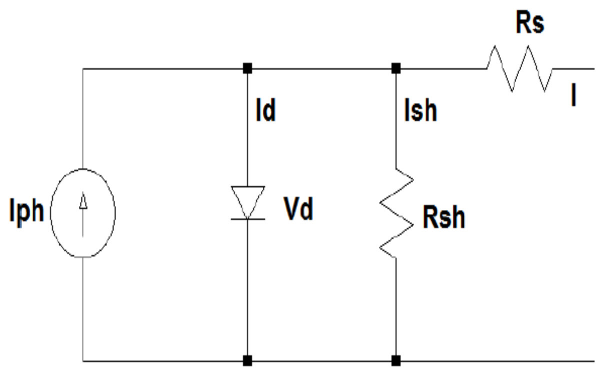

Figure.2. Solar cell equivalent circuit

The equation is solved by designing a program in MATLAB, taking into account the number of solar cells which has the photovoltaic panel.

$I_{ph} = (G/G_{ref}) [I_{sc} + Ki (T-25)]$ (1)

$Ir = I_{rT1} (Ta/Tref1)^3 \times e^{[-b(\frac{1}{Tref}-\frac{1}{T})]}$ (2)

$Ir_{-T1} = I_{SCT1}/(\frac{Voc}{e^{AVt1}})$ (3)

$I_{pv} = I_{ph} - I_r[\exp\{q (V_{pv}+I_{pv}Ra)/AkT\}-1]-(V_{pv}+IR_a)/Rsh$ (4)

The diode voltage is Vg equal to 1.2 V for crystalline silicon < 1.7 V for amorphous silicon. Where b= Vg*q/ (A*k)

PV system is gives the output Voltage & Current that will be vary with the change in solar temperature and sun Irradiation. Hence to get constant voltage at the load duty cycle of the DC-DC converter should change with change in PV system voltage. In order to get constant voltage at the load MPPT Controller are design that can control the duty cycle of DC-DC converter.1.2.

1.2. Boost (DC/DC) Converter

The boost converter is also known as the step-up converter. It can be used in the cases where the output voltage more than the input voltage, essentially the functioning like are versed buck converter. The practical applications which use a boost type converter appear in grid systems.

$$\mu = \frac{Vo}{Vi} = T/T_{off} = \frac{1}{1-D} \quad 1.2$$

Where T_{off} is the duration that the switch is not active, D is a duty ratio, T is the time period.

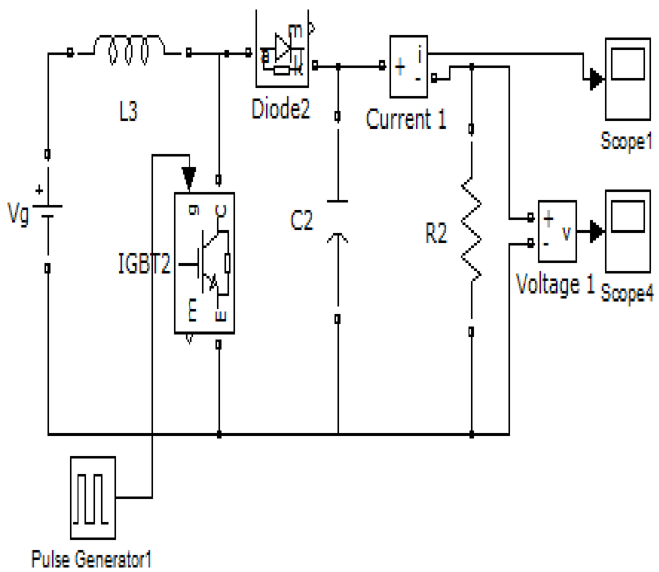

Figure.3. Boost converter

There are two different modes of operation works a boost converter. The converter are based on close and open the switch.The first mode when the switch is closed known as charging mode, second mode when the switch is opened known as discharging mode.

2. MPPT Algorithms

The MPPT (maximum Power point) is a greater frequency DC/DC converters .They take the DC input from solar panels change to higher frequency AC & convert it back down to different DC current & voltage to exactly matched to system of the batteries. MPPT' operating at higher audio frequencies usually in 30- 80 KHz range. The advantage of greater frequency circuits that we can be designed with higher efficiency & small components .

The conventional controller is charging discharge battery, it simply connected the modules directly to the battery. This forces the modules system to operate at battery voltage, typically is not the ideal.The main principle of incremental conductance method is that the derivative of the output power (P), in terms of voltage (V), at the peak power points equal to zero (dP/dV = 0). Therefore, from the equation P=I.V, the following equation is obtain;

$$\frac{dP}{dV} = V\frac{dI}{dV} + I = 0 \quad (\text{at the MPP}) \quad 2.1$$

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

$$\frac{\Delta I}{\Delta V} = -\frac{I}{V} \quad 2.2$$

Equation (2.2) means that, at the MPP, the opposite of the instantaneous conductance of PV array system on the left side of the equation equals to the incremental conductance on the right hand side. Thus, the derivative of the points should be greater than zero on the left of the MPP while, less than zero on the right side:

If $\frac{dP}{dV} = 0 \left(\frac{dI}{dV} = -\frac{I}{V}\right)$, then MPP is reached. 2.3

If $\frac{dP}{dV} < 0 \left(\frac{dI}{dV} < -\frac{I}{V}\right)$, then decrease Vref. 2.4

If $\frac{dP}{dV} > 0 \left(\frac{dI}{dV} > -\frac{I}{V}\right)$, then increase Vref. 2.5

3. PID controller

A PID (proportional-integral-derivative) controller is a control loop feedback mechanism. Feedback mechanism mainly used in industrial control systems. The PID controller attempts to correct the error between a desired setpoint & a measured process variable by calculating & then output of a corrective action that can adjust the process according. As the PID controller involves calculation three different (separate) parameters, Proportional(P), Derivative(D) and the Integral (I) values. The Proportional (P) value is determing the reaction to current error, the Derivative (D) value is determing reaction based on the rate at which the error has been changed and the Integral (I) value determines the reaction based on the sum of the recent errors. The add this three actions are used to adjusting the process via a control elements. We are using PID controller for improve the performance of the voltage and peak power. PID controller gain change the value of the output will change But after a fixed gain the value cannot be change.

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

Figure.5. PID controller

Table.1 : PID controller gain values

PID Controller	P	I	D
Gain value	1.5	0.2	0.0

4. Result & analysis

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

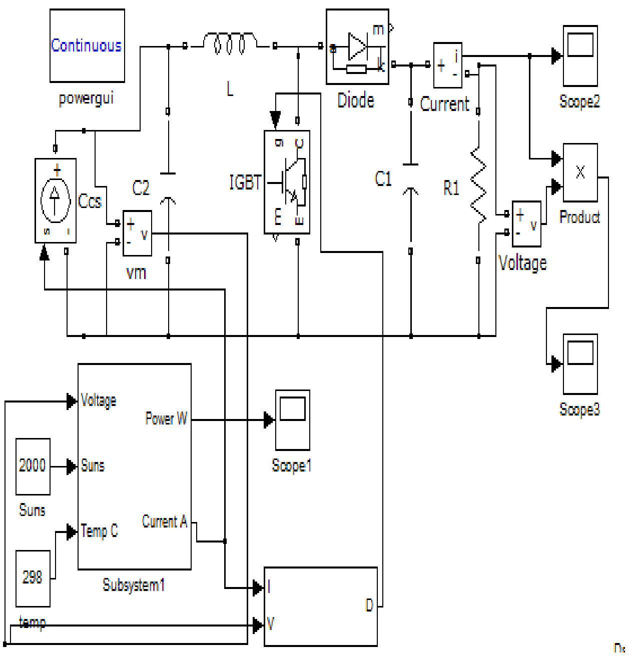

Figure.6. the solar modeled of PV system with inverter

Table.2: PV cells Specification

Electric parameter	PV Cell
Maximum power P_{max}	66.45 W
Maximum voltage(open circuit)	110.4 V
Maximum current (short circuit output)	1.66 A
Temp. coeff.short circuit current	(.065+.015)%C

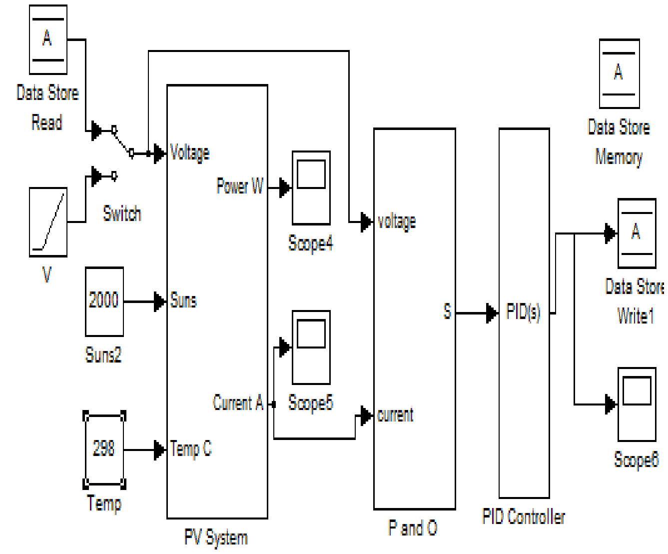

Figure.7. The proposed PID controller for PV module

Result for PV system without PID controller

Form the figure.8 we can see that peak current (I) is going up to 1.661 A, when we don't apply any controller. The current can be improve by apply the PID controller.

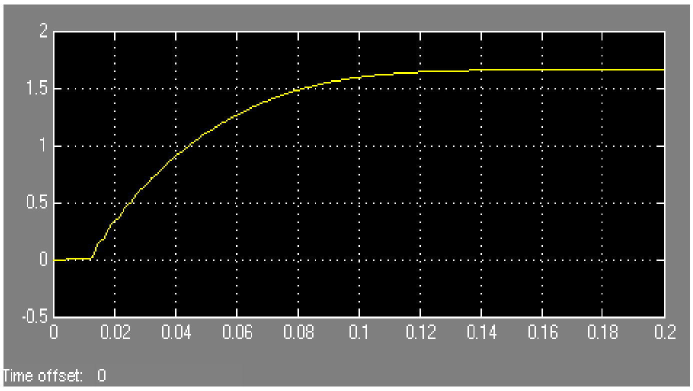

Figure.8. Current graph without any controller

Form the figure.9 we can see that peak voltage(V) is going up to 110.4 V, when we do not apply any controller. The voltage can be improve by apply the PID controller.

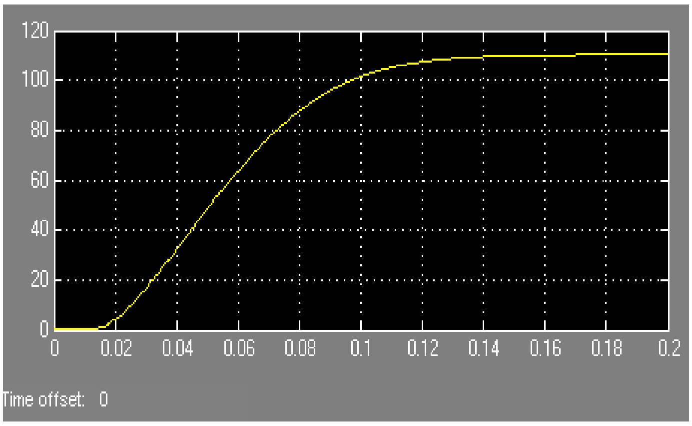

Figure.9. Voltage graph without any controller

Form the figure.10 we can see that peak power (P) is going up to 66.45 W, when we do not apply any controller. The power can be improved by apply the PID controller.

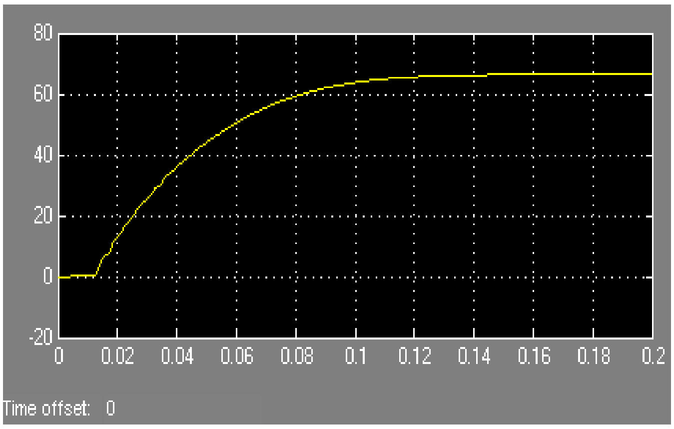

Figure.10. Power graph without any controller

Result for PV system with PID controller

Form the figure.11 we can see that peak current(I) is going up to 1.98A when we apply the PID controller. The voltage can be further improve by apply to fuzzy logic controller.

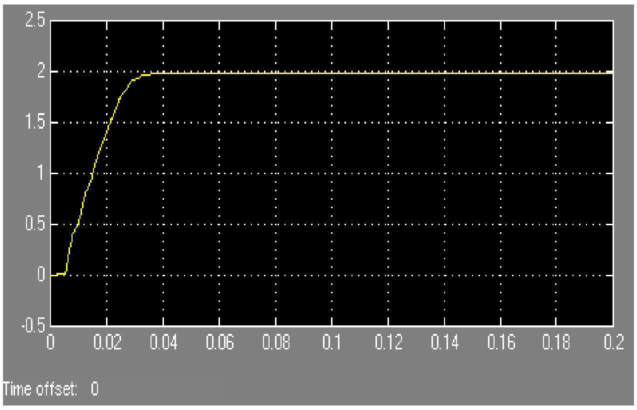

Figure.11. current graph with PID controller

Form the figure.12we can see that peak voltage(V) is going up to 157 V when we apply the PID controller. The voltage can be further improve by apply to fuzzy logic controller.

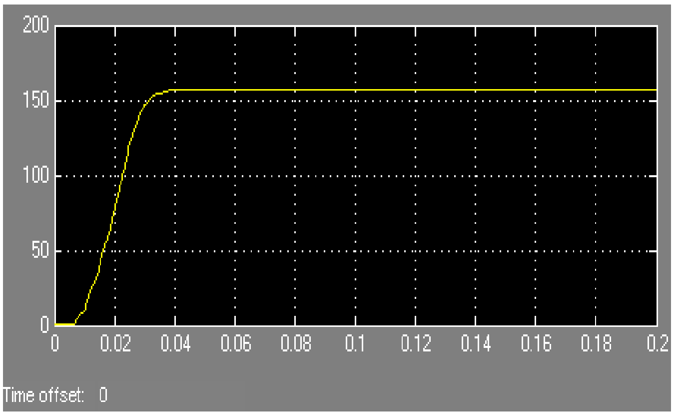

Figure.12. Voltage graph with PID controller

Form the figure.13 we can see that peak power(P) is going up to 79.24 W when we apply the PID controller. Power can be further improve by apply to fuzzy logic controller.

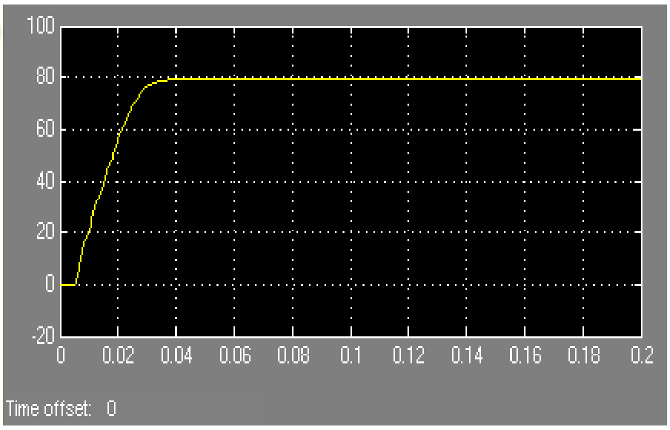

Figure.13. Power graph with PID controller

Table.3: Proposed design Output values for PV

Parameter	Calculate value (existing design)	Calculate value (proposed design)
Peak current	1.661 A	1.981 A
Peak voltage	110.4 V	157 V
Peak power	66.45 W	79.24 W

4. Conclusion

The PV cell-generate DC current from the sunlight. the solar array is generated by connecting individual solar cells system together. The output current is a solar array depends on the ambient temperature, solar insolation, the

size and configuration of the PV array. In general, the larger area PV panels will produce more energy, and smaller PV panels produce less energy. From the simulation result, the PID controller has shown the better performance than other MPPT techniques.
In the paper, we apply PID controller is improving the performance of the output power. When we do not apply PID controller the output power is getting 66.45 W. It gets improved when we apply the PID controller and getting the output power is 79.24 W. For further improve the performance of PV system we can apply Neural network which can further improved the performance of output power. After apply neural network controller the results of the current, voltages and power get improved.

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BIOGRAPHIES

Laxmi Kant Dwivedi was born in Unnao (UP), India, in 1985. He received his B.Tech degree in Electronics & instrumentation in 2010 from IET - Lucknow and M.Tech in control system (EE) in 2016 from IIT-BHU, India.