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Maximum Power Harvesting of Solar Energy by using Novel Control of DC-DC Converter

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***Abstract*: -- Nowadays the energy crises are due to the limited fossil fuel on the earth. Solar energy is the continuous source of renewable energy. Solar energy has main advantages is that clean, maintenance free and space limited area compare to the other type of renewable energy which can be space consuming. One of the methods to improve the efficiency of the photovoltaic system by using intermediate power processor which changes the current and voltage levels such that maximum power can be extracted. In this project, we analyze the design and simulation of the electrical operation of a photovoltaic (PV) system. Photovoltaic energy is used as a renewable energy system. Photovoltaic (PV) cells are used to generate dc voltages and given to DC-DC converter. Designing of converter gives constant output. DC-DC converter used Buck type of converter. The converter output is given to battery. Buck converter gives the constant output which controlled by PWM controller and feedback control system. A maximum power point tracking (MPPT) algorithm technique is used to track the peak power to maximize the produced energy. This algorithm will identify the suitable duty cycle ratio in which buck converter should operate to the maximum point. The MPPT algorithm is important in increasing the efficiency of the system.**

***Keywords:* — Component; formatting; style; styling; insert (key words).**

I. INTRODUCTION

As we all know that, Non-Renewable energy source are depleting day by day it is necessary to used maximum renewable energy as much as possible. The increasing demand for electricity and decreasing rate of the stored energy is the main cause for choosing the renewable energy. As non renewable energy source cause various harmful effect to the atmosphere .But in renewable energy source there is not such effect on atmosphere renewable energy source are clean, maintenance-free and also renewable energy are exists in large quantity in our nature out of all renewable energy source solar energy are available anywhere in large quantity. But it is clearly seen that it is necessary to reduce manufacturing cost and increase the efficiency of solar energy conversion system. Because of performance of the PV module not desirable. Now it is main concern to improve the efficiency of this technology. Although solar charge available throughout the day its irradiation varies from morning to evening with changing climatic condition. Because of this limitation it's necessary to use intermediate power processor which gives maximum desirable output with respective to the change in input. A dc-dc converter act as an intermediate power processor between the load and the PV module which transfer maximum power from solar PV panel to the connected load. MPPT is a technique which tracks this peak power and convey it to load at all time. MPPT in a basically dc-dc converter whose duty cycle is adjusted for drawing the amount of current so that the system operates in maximum power point. In MPPT commonly used technique is the P&O algorithm. The P&O algorithm perturbs the operating point of the PV module by increasing or decreasing a control parameter by a small amount and measuring the PV array output before and after the perturbation. If the power increases, the algorithm continuous to perturb the system in the same direction; otherwise the system is perturbed in the opposite direction. As shown in block diagram, system is consists of a PV panel, controller circuit, buck converter and a battery. It is equipped with analog to digital converters and PWM controller. A/D converter used to convert signal coming from current and voltage sensors.

II. BASIC CHARACTERISTICS OF PV MODULE

A. Circuit Configuration

A solar cell is an electronic device which directly convert sunlight into electricity. solar irradiation falls on solar cell produces both current and voltage to generate electric power. Figure 1 shows widely used single diode equivalent circuit model to represent the characteristics of PV panel for analyzing and simulation of PV system. The model represent photovoltaic panel as a current source Iph in shunt with single diode and resistor Rsh as well as series resistor Rs.

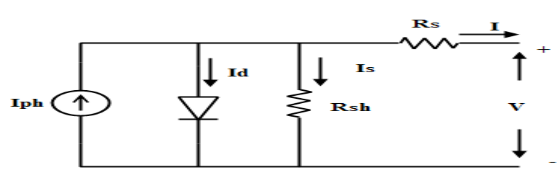

Fig.1. Equivalent circuit of solar cell

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The output current from the Photovoltaic module is
$I=Iph-Id$ (1)

$Id=I_0(e_q\, v_d/K_T-1)$ (2)

Substituting equation (2) in (1)
We get,

$I=I_{ph}-I_0(e^{qVd/KT}-1)$ (3)

But, Voltage across Diode (Vd)

$V_d=(V+IR_s)/N$ (4)

Substituting equation (4) in (3)

$I=I_{ph}-I_0(e^{q(V+IRs)/NKT}-1)$ (5)

Where,
I is the Output Voltage of PV module,
Id is the Diode current,
I0 is the reverse saturation current of cell,
V is the output voltage of the cell,
q stands for electron charge (1.602 ×10-19C),
K is the Boltzman constant.(1.38×10-23 J/K),
N is the no. of diode in series to form single diode model And T is the junction temperature in Kelvin.

TABLE I. Specification of PV Module

SPECIFICATION	VALUE
Rated Power	70 W
Open circuit Voltage(Voc)	>21V
Short Circuit current(Isc)	3.33A
Maximum Voltage(Vm)	17.5V
Maximum Current(Im)	4A

Output characteristics of PV module

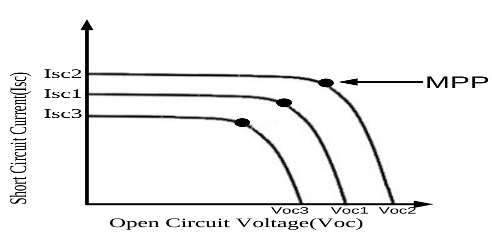

Fig.2. Characteristics of PV module

The I-V Characteristics of a PV system for different irradiances as shown in fig.2&3 from the study we see that both power and current level increase with increased level of irradiation at constant temperature on the other hand voltage remain relatively constant for different Irradiation.

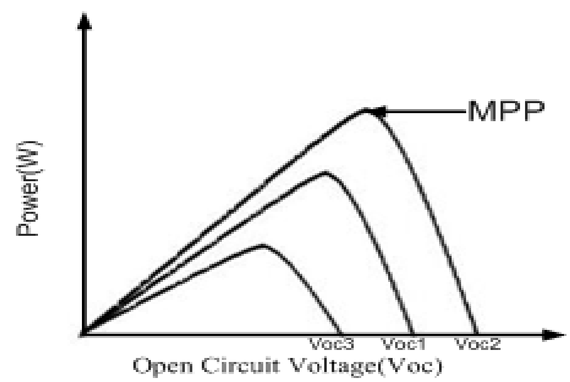

Fig.3. P-V characteristics of PV module

C. Analysis of voltage variation with respect to time of PV Module.

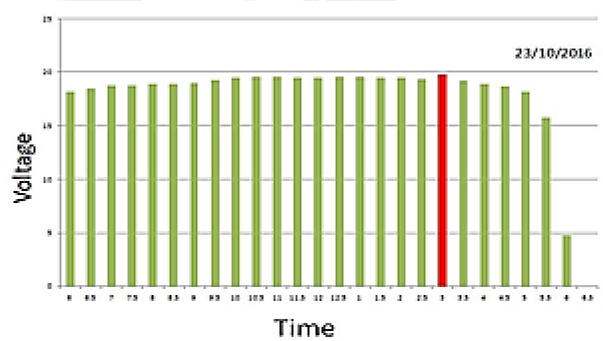

Fig.4. Voltage vs time variation of PV module

The above data is taken at the Campus of DMIETR, Wardha in the month of October and randomly on 23 octomber 2017 data is shown in figure 4. As seen from figure 4, the maximum open circuit voltage of the PV panel is approximately around 3 pm and the minimum open circuit voltage is around 6 pm morning. But the variation of the minimum and maximum is found to only 2.2 V during harvesting of the solar energy from PV.

III. DC-DC BUCK CONVERTER

The dc-dc buck converter converts a higher dc input voltage to lower dc output voltage. The basic buck converter structure is shown figure 5. It consist of controlled switch s, an uncontrolled switch diode D, an inductor L, an capacitor C, and a load resistance R.

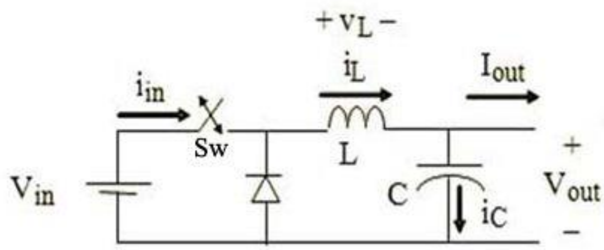

Fig. 1. Buck converter circuit

In a buck converter, the duty cycle (D), i.e., the ratio of "ON" time to Total time period is given as

$$D=\frac{V_{out}}{V_{in}}$$

Where,
Vin and VO are the input and output voltage of the buck converter.
Equations for the selection of Inductor,

$$L=\frac{V_{out}\times(V_{in}-V_{out})}{\Delta I_L\times f_s\times V_{in}}$$

Equations for the selection of Capacitor,

$$C_{OUT}=\frac{\Delta I_L}{8\times f_s\times \Delta V_{out}}$$

Here, Switching frequency denoted by fs; ΔI_L is the inductor current ripple and ΔV_{out} is output voltage ripple.

IV. BLOCK DIAGRAM

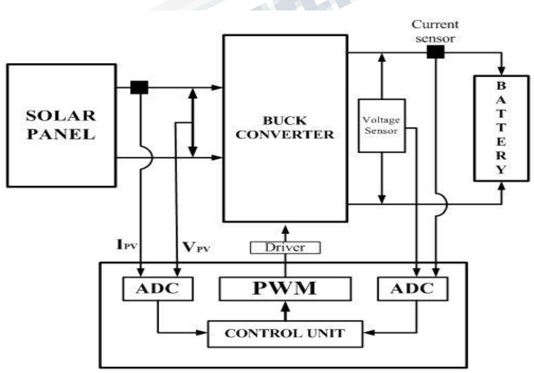

Fig. 6. Block diagram of complete PV system

In the block diagram of the proposed converter the main part is the buck converter, basically it is the dc-dc converter used to step down the input voltage at the output stage and output voltage is controlled by pwm technique.

V. SIMULINK MODEL OF COMPLETE SYSTEM

The solar panel is designed using matlab shown in figure 7 With 36 solar cell connected in series according to the power requirement and its voltage, current and power are measure under various weather condition.

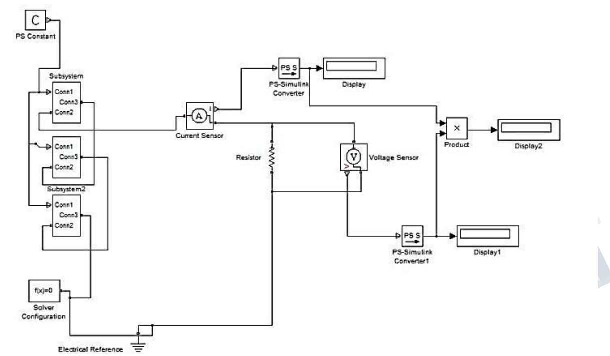

Fig.7. Simulink model of Solar Panel

Similarly, the buck converter is also designed by using matlab in order to transfer maximum power from solar panel to the load as shown as

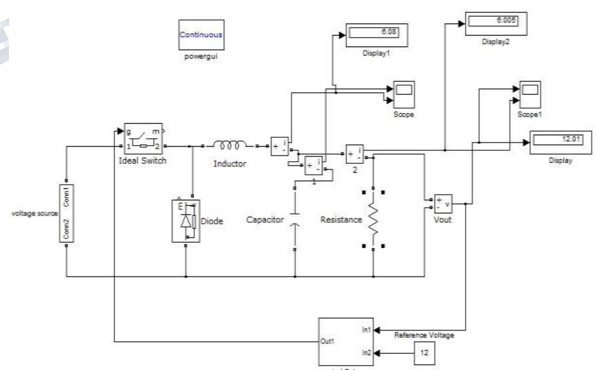

Fig.8. Simulink model of Close loop Buck Converter

TABLE II. Buck converter specification

Specification	Value

Input voltage	17.5 V DC
Output voltage	12 V DC
Switching frequency	50 kHz
Duty cycle	70 %
Inductance	47µH
Capacitance	220 µF

Required output of buck converter as shown in below figure 9 of input 17.5V dc.

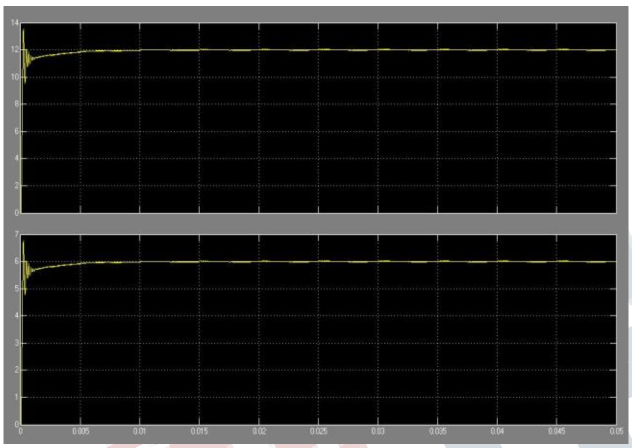

Fig. 9. Output result of close loop buck converter

VI. MPPT TECHNIQUE

There are many methods used for maximum power point tracking these method are 1. Perturb and Observe method 2.Incremental Conductance method 3.Parasitic Capacitance method 4.Constant Voltage method 5. Constant Current method.

A. Perturb and Observe method:

In this method very less number of sensors are utilized [5] and [6]. The operating voltage is sampled and the algorithm changes the operating voltage in the required direction and samples$dP\ dV$. If dP/dV is positive, then the algorithm increases the voltage value towards the MPP until $dP/\ dV$is negative. This iteration is continued until the algorithm finally reaches the MPP. This algorithm is not suitable when the variation in the solar irradiation is high. The voltage never actually reaches an exact value but perturbs around the maximum power point (MPP).

B. Incremental Conductance method

This method uses the PV array's incremental conductance $dI\ dV$to compute the sign of dP/dV. When $dI\ dV$is equal and opposite to the value of I/V (where dP/dV=0) the algorithm knows that the maximum power point is reached and thus it terminates and returns the corresponding value of operating voltage for MPP. This method tracks rapidly changing irradiation conditions more accurately than P&O method. One complexity in this method is that it requires many sensors to operate and hence is economically less effective [5] and [6].

P=V*I

Differentiating w.r.t voltage yields;

$$dP/dV=(V*I)/dV \quad (5)$$

$$dP/dV = I*(dV/dV)+ V*dI/dV \quad (6)$$

$$dP/dV = I + V*dI \quad (7)$$

When the maximum power point is reached the slope $dP/dV=0$.

Thus the condition would be;

$$dP/dV=0 \quad (8)$$

$$I + V*(dI\ dV)=0 \quad (9)$$

$$dI/dV= -I\ V \quad (10)$$

C. Parasitic Capacitance method

This method is an improved version of the incremental conductance method, with the improvement being that the effect of the PV cell's parasitic union capacitance is included into the voltage calculation [5] and [6].

D. Constant Voltage method

This method which is a not so widely used method because of the losses during operation is dependent on the relation between the open circuit voltage and the maximum power point voltage. The ratio of these two voltages is generally constant for a solar cell, roughly around 0.76. Thus the open circuit voltage is obtained experimentally and the operating voltage is adjusted to 76% of this value [8].

E. Constant Current method

Similar to the constant voltage method, this method is dependent on the relation between the open circuit current and the maximum power point current. The ratio of these two currents is generally constant for a solar cell, roughly around 0.95. Thus the short circuit current is obtained experimentally and the operating current is adjusted to 95% of this value [8].

F. Proposed Control Method

Maximum power point tracking (MPPT) is the indirect technique to increase the efficiency of the PV panel. For the MPPT process, it will work continuously to make the system to operate at or around the MPP. There are many methods to track the MPP. The most common and basic method that can

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be applied to track the maximum power is the perturb and observe method (P&O method).

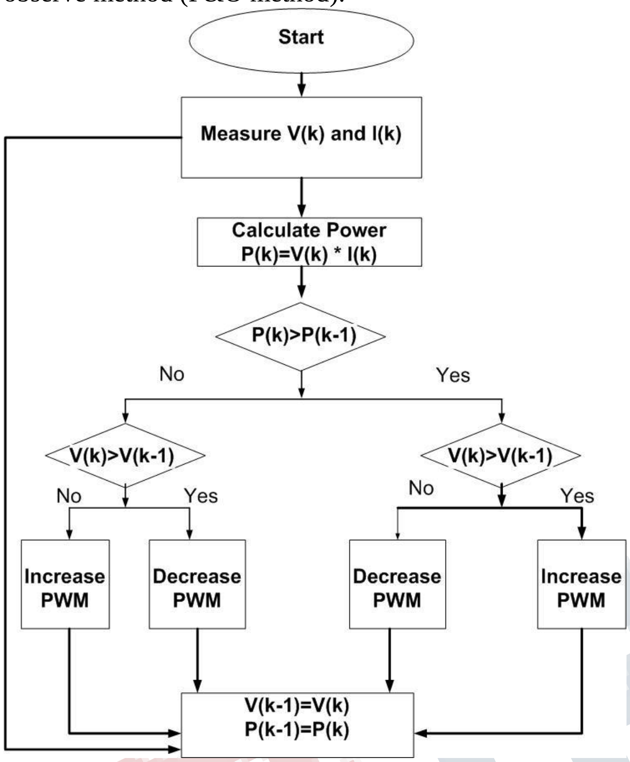

Fig. 10. P&O algorithm

A principle of the P&O method works by adjusting the duty cycle of the converter, which indirectly perturb the power output of the PV. Then, the system compares the new power to the previous power to determine the next adjustment. Let's define the difference of the PV power output as

$$dP=P(k)-P(k-1) \quad (1)$$

• If the value P(k)>P(k-1) is positive, the system will adjust voltage(increase or decrease the voltage) by adjusting the duty cycle of the converter in the same direction.

• If the value P(k)<P(k-1) is negative, the system will adjust voltage(increase or decrease the voltage) by adjusting the duty cycle of the converter in the opposite direction.

The diagram of this method is shown in figure 10 the advantage of the P&O method is a simple method for MPP determination. The P&O method can also work well at steady state, when light intensity and temperature change slowly.

VII. CONCLUSION

In this paper, an optimized MPPT technique along with buck converter is designed for solar system .our objective is to reduce the settling time of an output power by comparing output voltage with the input voltage. Also this paper provide low cost microcontroller based fast response MPPT technique. P&O algorithm is used to track maximum power point irrespective of irradiation, temperature and load condition. MPPT algorithm responds in very fast manner and its accuracy is higher that it reaches ti steady state very quickly. Hence the results obtained at different environmental condition are found to be satisfactory.

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