Solar PV System Precise by Using P&O for Maximum Output

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Abstract: Global energy requirement is increasing exponentially. This amplify in demand causes fear pertaining to the international energy crisis and allied green pressure. The key of these issues is seen in renewable power sources. Solar energy is measured single of the main sources of renewable power, obtainable in great quantity and also without charge of price. Solar photovoltaic (PV) cells are damaged to change solar power into tolerant electrical power. These solar PV cells show nonlinear quality and offer very short competence. consequently, it becomes important to take out upper limit power starting solar PV cells by means of maximum power point tracking (MPPT). Perturb and observe (P&O) is one of such MPPT schemes. The behaviour of MPPT schemes under continually changing atmospheric conditions is critical. It leads to two conditions, i.e., rapid change in solar irradiation and partial shading due to clouds, etc. Also, the behaviour of MPPT schemes under changed load condition becomes significant to analyze. This article aims to address the issue of the conventional P&O MPPT scheme under increase solar irradiation condition and its behaviour under changed load condition. The modified MPPT scheme is implemented in the control circuit of a DC–DC converter. The simulation study is done using MATLAB/ simulation. The results of the MPPT scheme are compared with existing schemes. The modified MPPT scheme works fast and gives improved results under change of solar irradiation. Furthermore, the steady state oscillations are also reduced.

Key words: PV cell, MPPT, boost converter

1 Introduction

Solitary of the key anxiety in the power division is the day-to-day escalating power order but the unavailability of adequate assets to gather the power requires by means of the conventional energy sources. Demand has improved for renewable sources of energy to be engaged along with straight systems to meet the power demand. [4]Renewable sources similar to wind power and solar power are the best power sources which are creature utilized in this consider. The unbroken use of vestige fuels has caused the fossil fuel place to be compact and has really affect the background depleting the biosphere and cumulatively count to comprehensive warming. [3]

Solar power is amply to be had that has finished it potential to harvest it and exploit it right. [1].Solar life can be a impartial generating unit depending on the obtainability of a grid close. Thus, it can be worn to energy rural areas where the accessibility of grids is incredibly little.

2 Modelling of Solar Cell

A PV module is obtained by connecting solar cells in parallel and series. Considering only a single solar cell; it can be demonstrated by applying a current source, a diode and two resistors. This is single diode model and also two diodes are accessible, in this single diode model is considered.

The matching circuit of solo diode classical of a solar cell shown in fig no 1.[2].

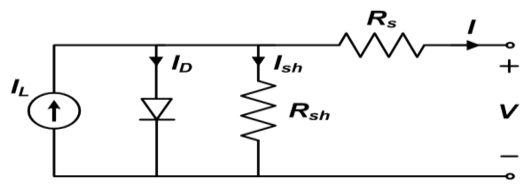

Figure 1: Single diode model of a solar cell.

Here we considered current source, diode and resistance. The shunt confrontation (Rsh) in parallel is very high, has a small effect and can be neglected.

The I-V characteristics of the PV cell path can be sets by the following equations.

The current through diode is given by:

$$I_D = I_O[\exp\left(\frac{q*(V+IR_S)}{KT}\right) - 1 \text{ .... } (1)$$

While, the solar cell output current:

$$I = I_L - I_D - Ish \text{ ....}(2)$$

$$I = I_L - I_O\left[\exp\left(\frac{q*(V+IR_S)}{KT}\right) - 1\right] - \left(\frac{V+IR_S}{R_{sh}}\right) \text{ .... } (3)$$

Where as

I: Solar cell current (A)

I_L: Light generated current (A)

I_O: Diode saturation current (A)

q: Electron charge (1.6×10-19 C)

K: Boltzman constant (1.38×10-23 J/K)

T: Cell temperature in Kelvin (K)

V: solar cell output voltage (V)

Rs: Solar cell series resistance (Ω)

Rsh: Solar cell shunt resistance (Ω)

The I-V characteristics of a solar cell shown in the Fig. 2.

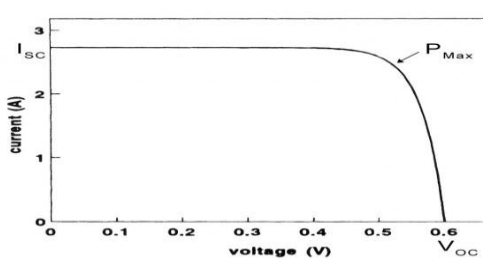

Figure 2: I-V characteristics of a solar cell

When the voltage and the current description are multiplied and the P-V characteristics as shown in Figure 3.[4] The point indicated as MPP is the point at which the panel power output is maximum.

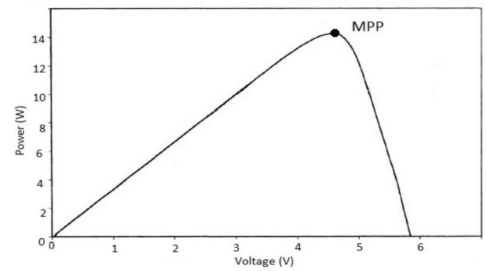

Figure 3: P-V characteristics curve of photovoltaic cell.

2.1 Effect of Variation of Solar Irradiation

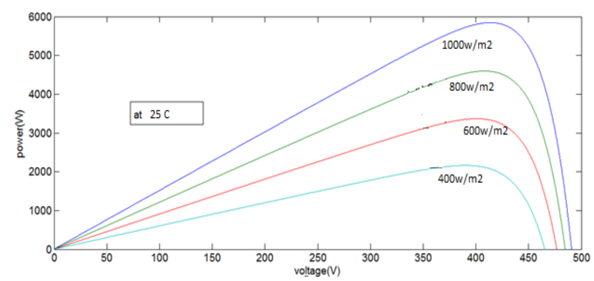

Figure 4: Variation of P-V curve with solar irradiation.

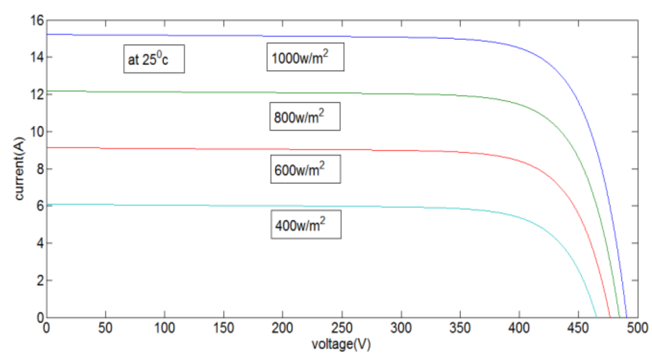

Figure 5: Variation of I-V curve with solar irradiation.

2.2 Effect of Variation of Temperature

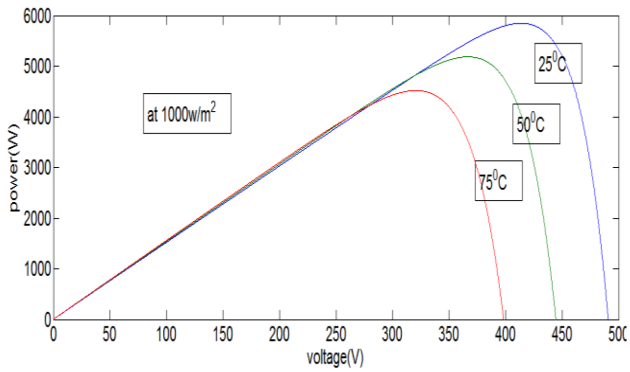

Figure 6: Variation of P-V curve with temperature

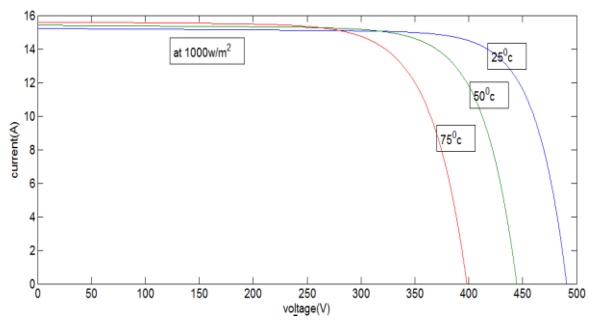

Figure 7: Variation of I-V with temperature.

3 DC-DC Converter

Converters are used to convert either from AC to DC or DC to AC. DC to DC converter uses electronic switching and transforms DC voltage from one level to other level [7].

3.1 Types of DC to DC converters

There are two types of DC to DC converters

i. DC to DC converters without isolation
ii. DC to DC converters with isolation

DC to DC converters without isolation

Some of the by and large used DC to DC converters with seclusion are

a. Buck converter
b. Boost converter
c. Buck-boost converter

The buck converter is step down converter (input voltage > output voltage) whereas Boost converter is a step-up converter (voltage > output voltage). The buck boost converter is subsequent from step up and step-down converters. The buck boost converter is operated in step up or step-down mode which is based on duty cycle of switch The Step down and step up converters are basic converter topologies based on which other converters are derived [8].

DC to DC converters with isolation:

a. Cuck converter (can be used in non-isolated mode also)
b. Fly back converter
c. Forward converter
d. Full bridge converter
e. Half bridge converter
f. Push-pull converter etc.

3.2 Boost Converter

Boost converter is used to step up input voltage and output voltage increases to a higher value, this is obtained by storing energy in inductor electromagnetic field [5].

Figure 8 illustrates the basic circuit of a Boost converter. MOSFET and bipolar transistor are worn for power switching purposes. They are selected based on switching speed, voltage, current and cost. In buck converter the positions of the components are rearranged.

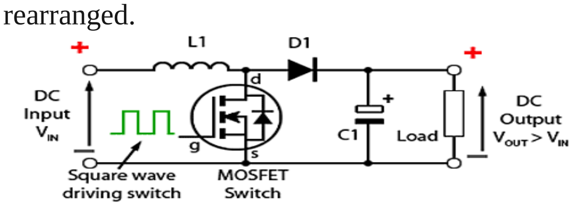

Figure 8: Basic Boost Converter Circuit

3.3 Boost converter Operation

The basic principle of boost converter is storing of energy in inductor and does not allow sudden changes in current. The output voltage of boost converter is higher than input voltage. Basic boost converter is shown in Figure 8 [5].

When the switch is blocked current streams beginning inductor in clockwise direction and polarity of left side of inductor is positive [6]. As the switch is opened impedance develops advanced and current is condensed, then the polarity will be reversed and inductor becomes negative. This results in charging the capacitor through diode at a higher voltage. If the switch is operates fast the inductor will not discharge completely in sandwiched between charging stages, the load consumes a higher voltage than input source.

Even when the switch is opened, capacitor is in parallel with load and charged to combined voltage. When switch is closed the right hand is short circuited from left hand side and capacitor supplies voltage and energy to load. The purpose of blocking diode is to prevent capacitor from discharging through switch.

The principle of a Boost converter of two different states (see figure 9(a) & (b)):

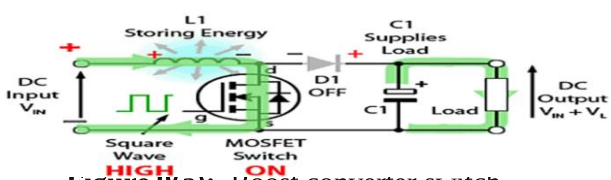

Figure 9(a): Boost converter switch (MOSFET) is closed

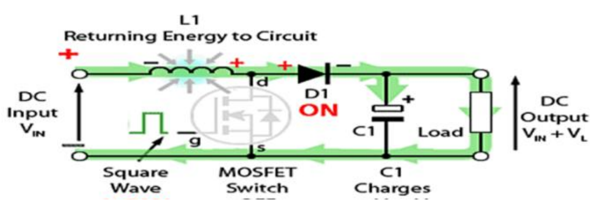

Figure 9(b): Boost converter switch (MOSFET) is opened

- in the On-state, the switch S (see figure 9(a)) is stopped, ensuing in an swell in the inductor current;
- in the Off-state, the switch is open and the only path offered to inductor current is through the flyback diode D, the capacitor C and the load Because of this capacitor transfers the energy possessed during on-state.
- The input current is the same as the inductor current as can be seen in figure 9(b). As it is not discontinuous input side of the filter are relaxed.

4 Maximum Power Point Tracking [MPPT]

4.1 An overview of Maximum Power Point Tracking

Solar panel converts 30 to 40 percent of energy into useful power and efficiency of the solar panel is low down. Highest power point tracking system is used to advance the efficiency of the solar panel.

According to Maximum Power Transfer theorem, the power production of a circuit is maximum when the Thevenin impedance of the path matches with the load impedance. Hence our crisis of tracking the maximum power point reduces to an impedance corresponding problem.

On the foundation side, a boost converter allied to a solar plate in order to enhance the output voltage so that it can be used for different applications like a motor load. By changing the duty cycle of the boost converter appropriately we can match the source impedance with that of the load impedance.

4.2 Different MPPT techniques

The techniques which are used to trace maximum power point are[9]-[13]

- Constant Voltage (CV) Method,
- Open Voltage (OV) Method,
- Temperature Methods,
- Incremental Conductance (INC) Methods,
- Perturb and Observe (P&Oa and P&Ob) Methods,
- Fuzzy Logic Method,

4.3 Hill-climbing techniques

Both P&O and INC algorithms are based on the “hill-climbing” principle, which consists of moving the operation point of the PV array in the direction in which power increases [14] and [15]. One of the most popularly used MPPT technique is Hill-climbing method as its implementation is easy and obtains good performance. [15]. The advantages of both methods are the simplicity and low computational power they need. One of the drawbacks is maximum power point oscillates during changing conditions of atmospheric conditions [7]. [15]-[17]. These drawbacks will be explained later.

4.4 Perturb and observe

Hill-climbing involves a perturbation on the duty cycle of the power converter and P&O a perturbation in the in action voltage of the DC relation among the PV array and the power converter [8]. In the case of the Hill-climbing, perturbing the duty cycle of the power converter implies modifying the voltage of the DC link between the PV array and the power converter, so both names refer to the same technique. In this method, the sign of the last perturbation and the sign of the last increment in the power are used to decide what the next perturbation should be. As can be seen in Figure 10, on the left of the MPP incrementing the voltage increases the power whereas on the right decrementing the voltage increases the power.

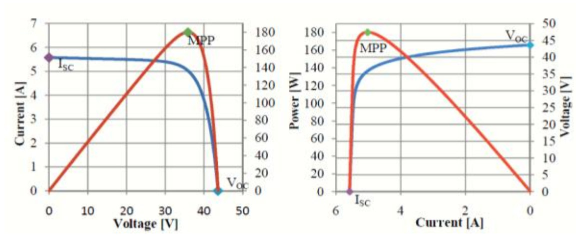

Figure 10: PV panel characteristic curves.

Perturb & Observe (P&O) is easy method. P&O only uses voltage sensor, to sense voltage of the PV array and hence easy to implement. The time complexity of this algorithm is very less but on reaching very near to the MPP it doesn't stop at the Maximum power point and keeps on perturbing in both the directions. When this happens, the algorithm has reached very near to the MPP and it can set an appropriate error limit. However, the method does not take into consideration of the rapid change of irradiation level and considers it as a change in MPP due to perturbation and ends up calculating the wrong MPP. This problem can have avoided by using incremental conductance method.

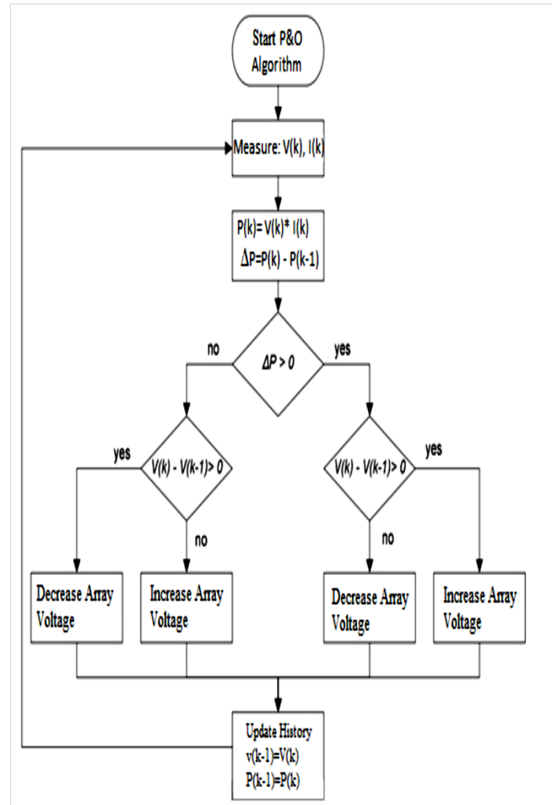

Figure 11: The flowchart of the P&O Algorithm.

5 Simulation Modelling of PV System with MPPT

5.1 Simulink Model

The below Figure 12shows the Simulink model of the PV system and the PV solar cell IV and PV characteristics are mentioned above. PV cell with different irradiations are also included.

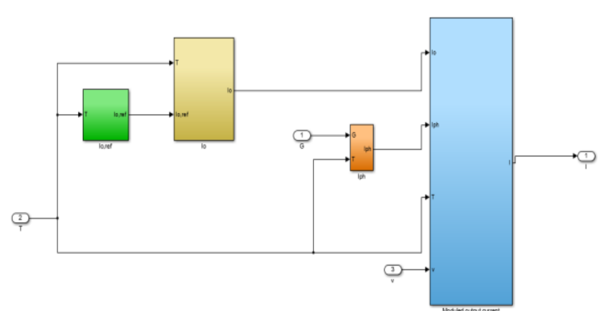

Figure 12: Simulink model of PV system.

The below Figure 13 shows the Simulink model of the P&O method of the solar PV system. It includes Boost converter for converting variable DC to fixed DC and boost the voltage. PI controller is used as controller for the MPPT method of Perturb and observe.

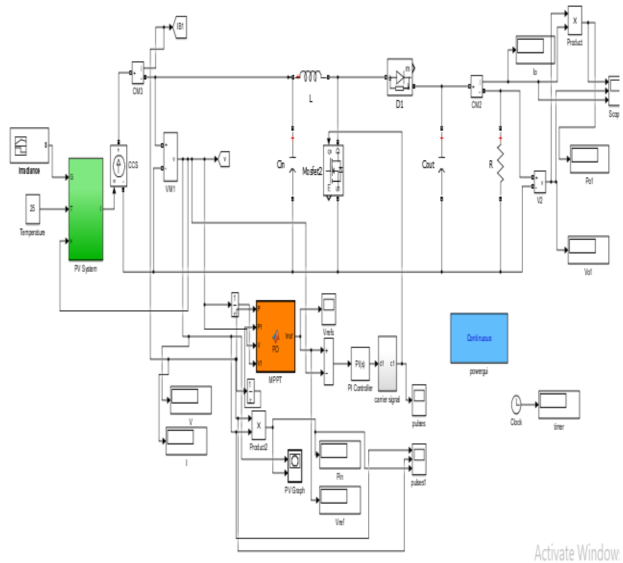

Figure 13: Simulink model of PV system with P&O method.

The below figure 14 represent the output voltage of PV cell. The curve has a transient state from 0 to 1.7 sec and it reached to steady state from 1.7 sec. as the irradiation is increased from 900w/cm^2 to 1000w/cm^2 and the magnitude of the voltage is increased. With change in irradiance the state of the system voltage from dynamic state to study state.

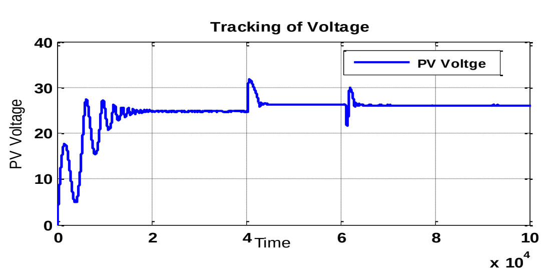

Figure 14: Result of P&O MPPT tracking of voltage.

The below figure 15 represents the solar cell output current. The current has reached the steady state at 1.8sec. As the irradiance is changed current has increased from 4sec to 6.1sec and current decreases from 6.1sec to 10sec.

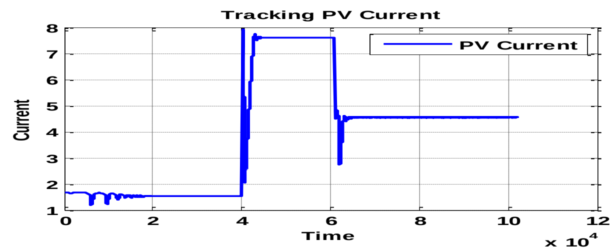

Figure 15: P&O MPPT tracking of current

The below figure16 represents the DC output power of the solar cell and the power changes from trasiant state to steady state at 1sec.. As the irradiance is increased from 4 to 6sec hence output PV power is increased.

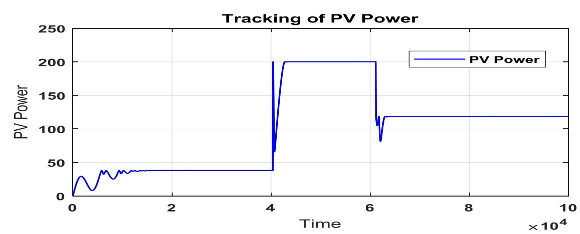

Figure 16: P&O MPPT tracking of power

6 Conclusion

In boost converter MOSFET is used as a switch and MPPT controller with P&O algorithm is given as the gate signal for MOSFET in boost converter, PI controller is used in MPPT algorithm. From solar PV cell variable dc voltage is obtained and it is stepped up with boost converter to fixed DC voltage, which is given to load

In this Maximum Power Point Tracking of a PV Arrangement uses P&O Technique and Boost Converter to get maximum output power. The P&O MPPT scheme works faster and gives improved results under changes of solar irradiation and temperature. Furthermore, the steady-state oscillations are also reduced using the P&O method.

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