Design and Analysis of P&O algorithm based MPPT solar system in PSIM

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Abstract

Conventional solar panels suffer with non-identical losses (resistive losses, diode leakage, loss of material properties etc.). To overcome these unwanted phenomena, a solar maximum power point tracking (MPPT) algorithm has been introduced. In this paper, the algorithms used for tracking the sun (or the solar maximum power point tracking algorithm) has been introduced & a brief description of the basic & easiest algorithm i.e., the P&O Algorithm using PSIM software has been provided to give a clear view about the concept & implementation of MPPT.

Keywords: Photovoltaic, MPPT, P&O, PSIM.

1. Introduction

To serve the growing demand for electricity in this world; dependency on conventional energy is not enough it has been proved years ago. Now, scientists and engineers are focusing on how to integrate the output of non-conventional energies and as the most reliable non-conventional energy source is the sun, hence; it is very important to look for the technologies for the development of solar power.

The temperature at the sun's surface is 5500 ºC (approx).
The temperature of the core of the sun is several million degree Celsius.
The radiation from sun is 384*10^24w,i.e; 3.84*10^26w.
The radius of the sun's orbit is 0.7 million km.
The radius of earth's orbit is 6371 km.
Power emitted by the sun is 384 YW.
Hence; the intensity of the Sun's radiation at earth's orbit is
= [3.84*10^26/4*3.14*(1.49*10^11)^2]W/m^2.
=1377 W/m^2.
Area of earth's disc is = [3.14*(6.371*10^6)^2] = 1.27*10^14 m^2.
Hence; power receive from sun by earth is = (1.27 *10^14*1377) = 1.755*10^17 w/s.

Hence, power received from the sun by earth each year is = 5.5 million exe joules.

When a solar panel is permanently mounted at a fixed place at a certain angel, it gets only as many photon particles as it falls on it, but the sun's position in the earth's sky is not fixed, hence; the panel doesn't get the same amount of power throughout the day. This is

where the need for MPPT comes from. Using this technique, we can rotate the solar panel to the direction of the sun accordingly to track the maximum power throughout the day.

MPPTs are most effective to overcome certain unwanted conditions-

1. Cold weather conditions (cloudy and hazy days) which prevents the sunlight and hence; decreases the PV module's output.
2. MPPT also can extract more current to charge the battery when the battery is deeply discharged.
3. To implement MPPT successfully, firstly it is needed to know about the algorithms associated with it.

2. Methodology and Implementation of MPPT Algorithm

The world's energy usage is 500 exajoules/year and the amount of energy reaches the earth's surface during the day time is 5.5 million exajoules/year, this implies that we can receive 500 exajoules from sun by only 0.79 hrs, but, unfortunately we are till now able to capture and utilize only 10-15% of total incoming solar radiation.

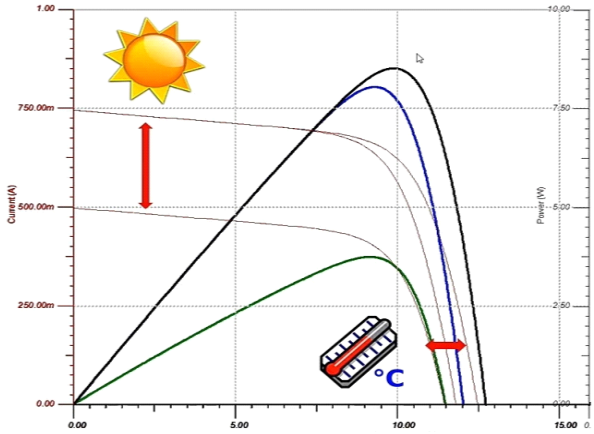

Figure 1. P-V curve of Conventional P&O MPPT

If we carefully observe this curve, it's been clearly seen that with rise of temperature and with rotation of sun, the PV efficiency is varying. When the temperature is high and the sun is above the PV module, the module's capturing more amount of energy and the efficiency is decreasing in proportional to the sun set and temperature drop.

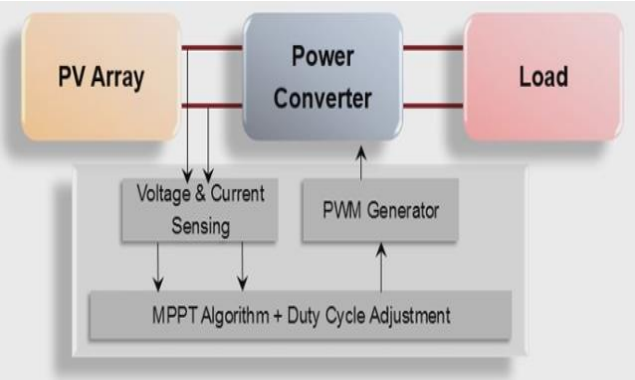

Figure 2. Block diagram for the understanding and implementation of the P&O algorithm

Fig. 2 represents the basic block diagram for the understanding and implementation of the P & O algorithm. Here the figure represents the tracking system for the measurement of current and voltage to find out the power output of the PV panel. The solar panel is absorbing the maximum photon emission and the DC\DC converter is supplying the desired power supply to the load and the maximum power tracking is being controlled by the voltage current sensing unit which is controlled by the MPPT algorithm.

2.1 Perturb and Observe (P&O) Technique

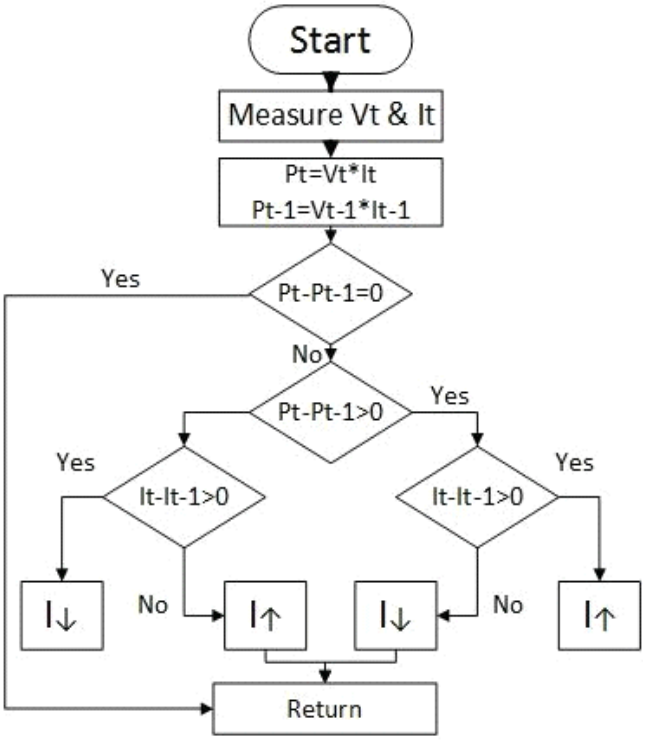

Figure 3. Flowchart of P&O algorithm

This is a conventional block diagram of P & O algorithm used for solar MPPT.

1. We first have an initial value of duty cycle “D”, we measure the duty cycle value along with the initial power present in the system at a starting time “t”.
   Power (P)= V *I.
2. Now, we change the duty cycle “D” by “delta D”.[Eg; let the first value of “D”=0.5, after applying “delta D”=0.01, the new duty cycle will be “D new”=(0.5+0.01)=0.51].
3. Now, again we measure the power & at this point, we check if the “P new” > “P”
4. Again the value of duty cycle will be increased & “P” will become “Pold” &it’s value will be updated.
5. This cycle will continue until & unless “Pnew”<”Pold”.
   At this point, the value of “D” will be deceased & again it will check if “Pnew”>” Pold”, then again “D” value will be increased & this is how the maximum point can be tracked using the P & O algorithm.

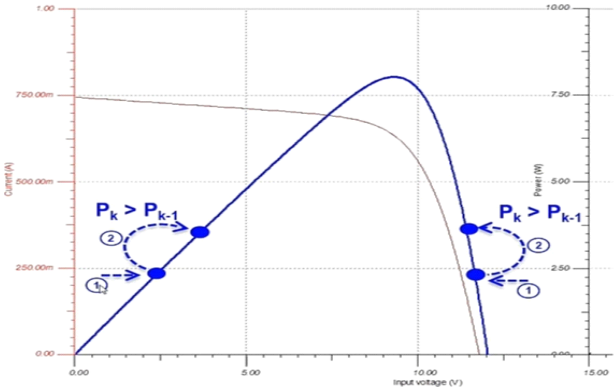

Figure 4. Flowchart of P&O algorithm

In this graph it's clearly shown how the increment or decrement of "D" is taking place.

3. DC-DC Converter Analysis Using Boost Converter

The boost converter (also known as a step up converter) is a type of SMPS (Switch Mode Power Supply) consisting of a power supply in the input & in the output, we get a power greater than the input power. Here, the transistor acts as a switch in the circuit. Other than that, this circuit consists of an inductor & a diode.

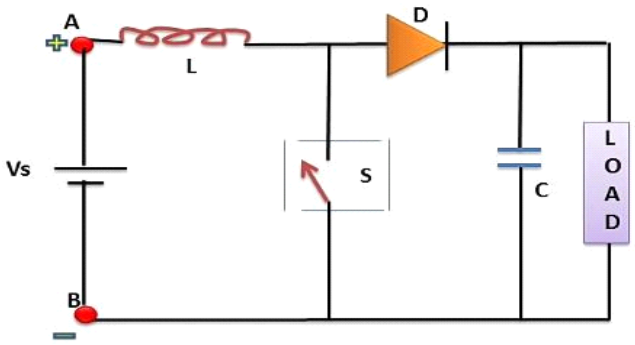

Figure 5. Boost Converter

In the circuit, when the switch is on, current is flowing through the switch via inductor & back to the supply. When the switch is off, current can no longer flow through the inductor through the switch, because of the collapse of magnetic field in the inductor, which creates a high voltage spike, current starts to flow through the rest of the circuit, i.e; through the diode & it gets stored in the capacitor & because of the presence of diode, current can't flow backward through the diode & therefore, results in stepping up the voltage.

4. Simulation and Experimental Results

Here, we have used PSIM software to implement the P & O algorithm. The circuit consists of a PV module, a boost converter, P & O algorithm & load.

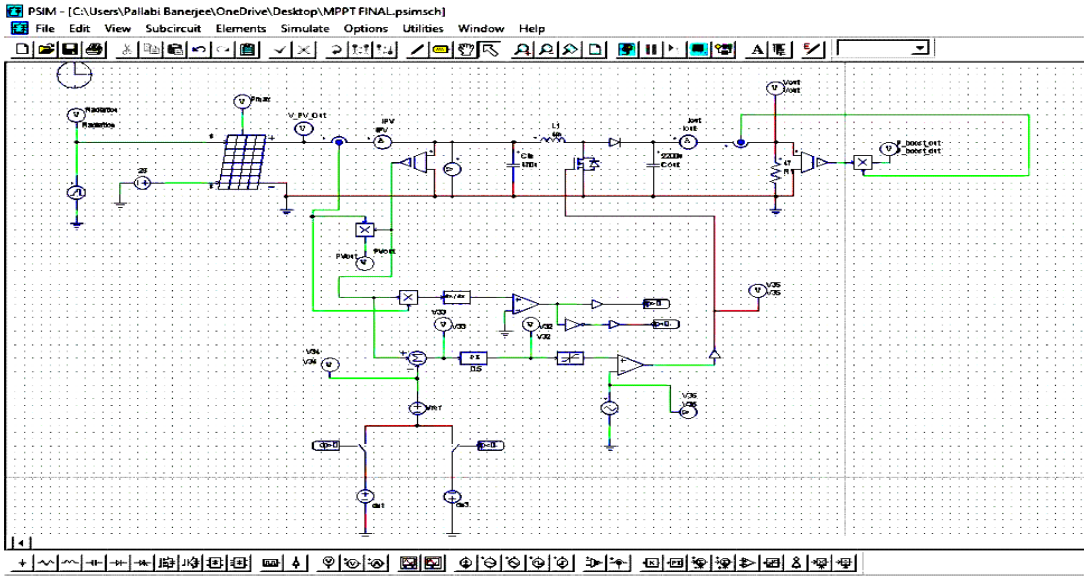

Figure 6. P&O Simulation Circuit by PSIM Software

The above simulation is the solar MPPT using P & O algorithm representation & implementation using PSIM software. Here the PV module is connected with the load via a boost converter & the MPPT tracking is being taken care off by using P & O algorithm. The algorithm will track the MPPT & the boost converter will help to give an output power greater than the input power. Now, the main motto of this implementation is to design an algorithm which will trap the maximum solar energy throughout the day, in spite of bad weather or any other natural obstacle introduction; the output should remain constant.

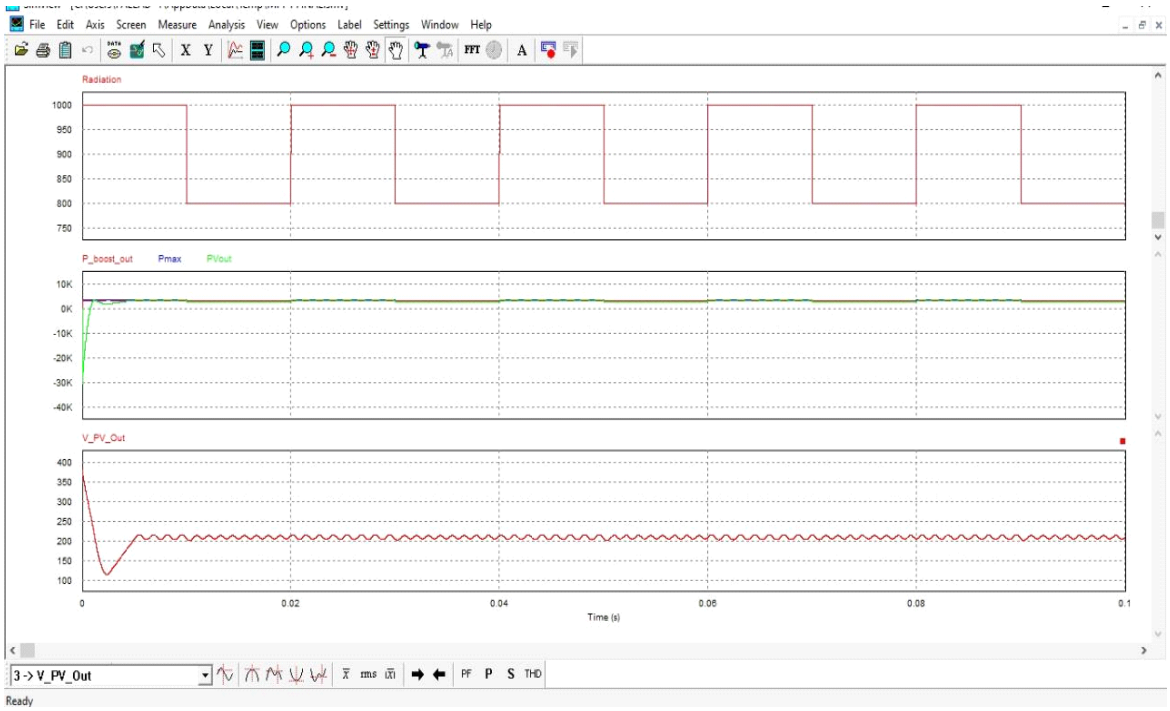

Figure 7. P&O Simulation Circuit Output Results

In this simulation, first we connected a sine wave source to the PV panel & measured the PVmax output. Then, we changed the source, which is indicating change of temperature & again measured the output.

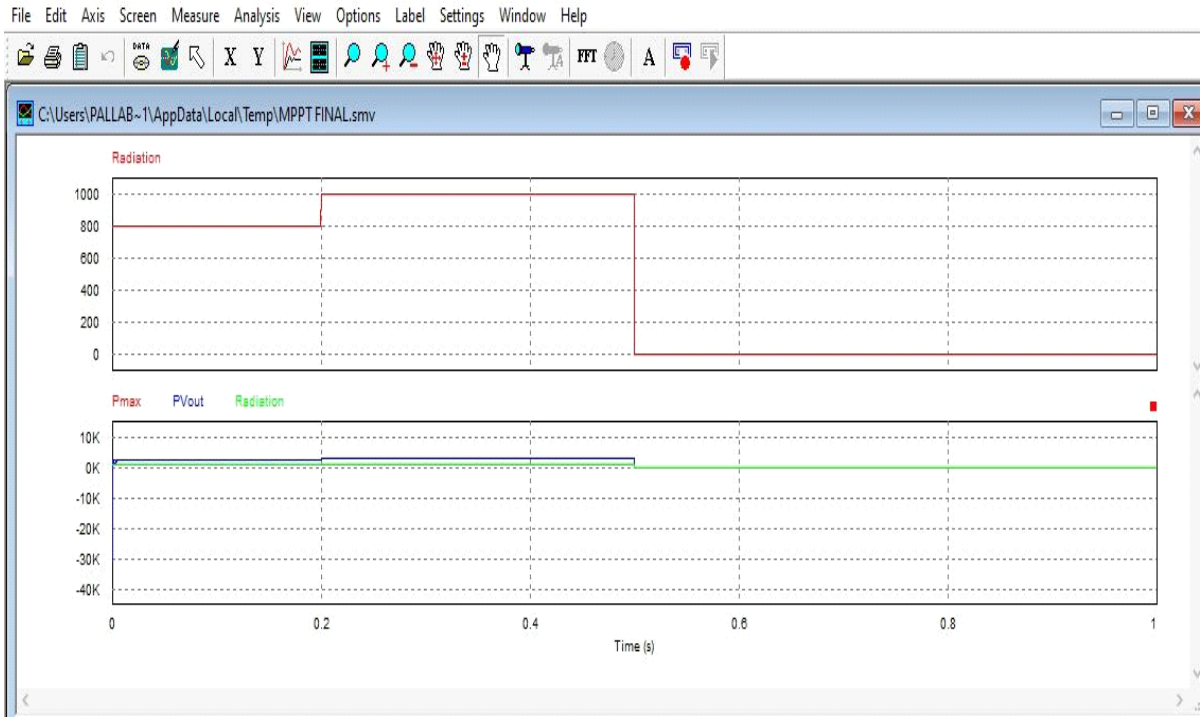

Figure 8. PV Panel & Measured the PVmax output Results

In both the cases we can clearly see that the output is remaining constant. Hence we can clearly see that the P & O algorithm has been successfully implemented.

5. Conclusion

In this paper, the working principle & simulation implementation of Solar MPPT with P & O algorithm is discussed. It is shown how the output of PV module can be increased with the help of P & O technique. Therefore, in this paper we have discussed the way we can reduce & eventually replace the use of conventional power with the help of proper & efficient implementation of non-conventional power.

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