Ilkogretim Online - Elementary Education Online, 2021; Vol 20 (Issue 1): pp. 4942-4954
http://ilkogretim-online.org
doi: 10.17051/ilkonline.2021.01.528

Perturb And Observation Based Mppt Control Of Solar Pv System Using Boost Converter

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Abstract

The model is used for observing and studying the performance of photovoltaic system in nonideal conditions that causes multiple maximum power points (MPPs) on the power-voltage (PV) characteristics curve. a typical solar generation system consists of a solar array and a DC/DC converter. Making the output of the solar array maximum does not certainly result in the maximum DC/DC converter output. Therefore, it is suggested that the PV array and the DC/DC converter should be considered as one system to maximize the overall system output. Since the efficiency of PV-panel is low, advanced power electronics converter are employed to improve the overall system efficiency. The solar panel is modeled and analyzed in MATLAB/SIMULINK. To get the maximum efficiency and maximum power the entire system must be linked with MPPT technique. Perturb and Distribution algorithm is used to obtain MPPT. Boost DC-DC converter is used for matching load impedance with PV arrays.

Keywords: Solar PV, MPPT, Boost DC-DC Converter

Introduction

Photovoltaic (PV) cell is a source of renewable energy. It generates electricity with the help of sunrays. It is pollution free process. Using this process type of power generation method is comparatively costly these days. The generation of power using PV cell depends on weather conditions. Power electronics device can extract suitably high power from the PV arrays to keep overall output power per unit cost as low as possible. In general, the output power of PVarray that depends upon environment condition, sunrays falling on PV array, the output energy may change every time; and the current voltage characteristics of PV arrays is highly nonlinear. Solar panel is the fundamental transducer; it is an energy conversion component of photovoltaic (PV) systems. It has used in various applications, such as aerospace industries, electric vehicles, power generation, communication equipments, etc[1-6]

It is well known that a solar PV has I-V and P-V characteristics as shown in Fig. 1. The power P generated by the PV is the function of its output voltage V_{PV} and current I_{PV}, i.e. $P(V_{PV}, I_{PV}) = V_{PV} \times I_{PV}$ - (1)

Fig 1. I-V characteristics

Due to the nonlinear relationship between V_{PV} and I_{PV} of PV panels, the output power of a PV panel has a maximum value Pmax at certain point (Vmp, Imp) which is called maximum power point (MPP). To obtain the maximum output from PV arrays, various maximum power point tracking (MPPT) methods have been developed. Most of these methods use various Perturb and Observe (P&O) algorithms to track the MPP of the solar array. However, to store the generated energy in a battery bank or transmit the energy to power gird, the output of a PV array needs tobe converted into a suitable DC voltage by using a DC/DC converter. Making the output power of the PV array $P(V_{PV}, I_{PV})$ maximum does not certainly result in the maximum output from the DC/DC converter because the efficiency of the DC/DC converter will affect the overall output of the system.

Practically, the power supplied by the panels depends on several extrinsic factors, such as temperature, insolation (incident solar radiation) level and load condition. Thus, its electrical power output generally increases linearly with the increase in irradiation where as decreases with ambient temperature. However, by using maximum power point tracking (MPPT), the photovoltaic system's power transfer efficiency and reliability can be improved significantly, as it can continuously maintain the operating point of the solar panel at the peak point, pertaining to that irradiation and temperature and so on as shown in Fig.2

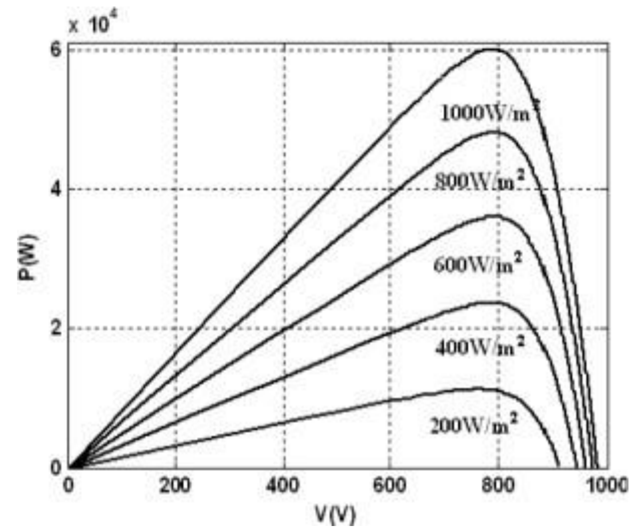

Fig.2: Power-Voltage characteristics of PV for different irradiance levels.

MPPT consists of two units DC –DC Converter and MPP algorithm. Normally DC-DC converter offers constant source of power for change in line or load condition but it can alsobe used to track unique point by MPPT algorithm.

In practice, there are two possible tracking methods for solar power extraction, i.e medium and large scale PV systems. These are either sun tracking or maximum power point (MPP) tracking or both. A use of MPP tracking is now a day is very popular because of economic reasons and fast operation. The purpose of DC-DC converter is to operate at maximum PV voltage / power based on defined algorithm.

Implementation

i) Diagram Of Proposed MPPT control method

Fig 3 shows the block diagram of the system

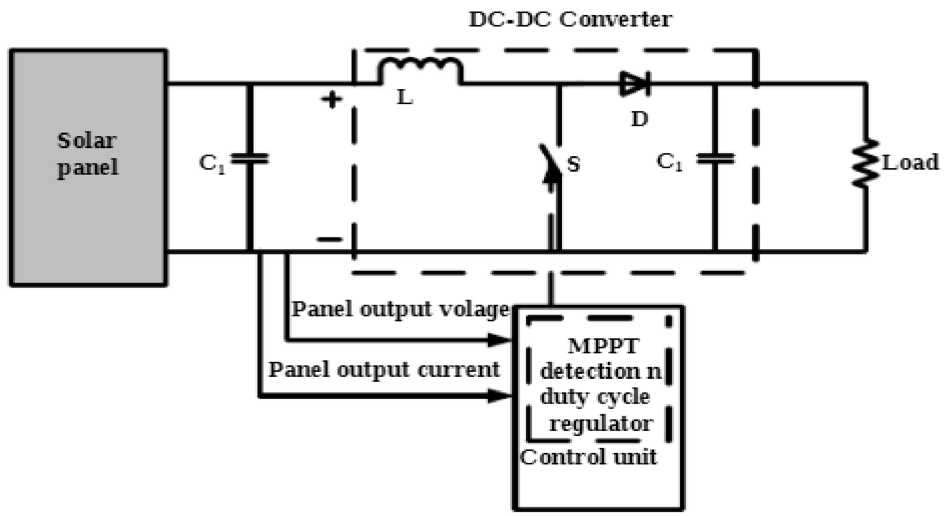

Fig 3 Block diagram of the system

ii) Boost converter

Fig 4. Boost converter

A boost converter as in fig 4 is one of the simplest types of switch mode converter. As the name suggests, it takes an input voltage and boosts or increases it. All it consists of is an inductor, a semiconductor switch (these days it's a MOSFET, since you can get really nice ones these days), a diode and a capacitor. Also needed is a source of a periodic square wave. This can be something as simple as a 555 timer or even a dedicated SMPS IC like the famous MC34063A IC.

The biggest advantage boost converters offer is their high efficiency – some of them can even go up to 99%! In other words, 99% of the input energy is converted to useful output energy, only 1% is wasted.

Boost Converter Operation

There is yet another way of thinking about the operation of a boost converter.We know that theenergy stored in an inductor is given by:

$$\frac{1}{2} \times L \times I^2$$

Where L is the inductance of the coil and I is the maximum peak current.

So some energy is stored in the inductor from the input and same is transferred to the output though at a higher voltage (power is conserved, obviously). This happens many thousands of times a second (depending on the oscillator frequency) and so the energy adds up in every cycle so you get a nice measurable and useful energy output, for example 10 Joules every second, i.e. 10 watts.As the equation tells us, the energy stored in the inductor is proportional to the inductance and also to the square of the peak current.

To increase output power our first thoughts might be to increase the size of the inductor. If we make the inductance larger, the maximum peak current that can be achieved in a given time decreases, or the time taken to reach that current increases (remember the basic equation V/L = dI/dt), so the overall output energy does not increase by a significant amount!

However, since energy is proportional to the square of the maximum current, increasing the current will lead to a larger increase in output energy. So choosing the inductor is a fine balance between inductance and peak current.

Mode 1

$$v_L = L\frac{di_L}{dt} = V_S$$

Where

$$L\frac{I_L}{T_{ON}} = V_s$$

v_L = Inductor Voltage

$$\Delta I_L = \frac{V_S}{L} kT$$

V_S = Input Voltage

where, $k = \frac{T_{ON}}{T}$, $T_{ON} = kT$

$$\frac{di_L}{dt} = \frac{\Delta I}{T_{ON}} = \frac{I_{max} - I_{min}}{T_{ON}}$$

$$\Delta I = \frac{V_S kT}{L} \qquad kT = \frac{\Delta I L}{V_S}$$

Mode 2

$$v_L = V_S - V_O = -L\frac{di_L}{dt}$$

$$-L\left(\frac{\Delta I}{T_{OFF}}\right) = V_S - V_O$$

$$L\frac{\Delta I}{(1-k)T} = V_O - V_S$$

$$\text{where, } T_{OFF} = T - T_{ON} \Rightarrow T_{OFF} = (1-k)T$$

$$\Delta I = \frac{(V_O - V_S)(1-k)T}{L} \qquad (1-k)T = \frac{\Delta I L}{V_O - V_S}$$

$$\frac{V_S kT}{L} = \frac{(V_O - V_S)(1-k)T}{L}$$

$$V_S kT = (V_O - V_S)(1-k)T$$

$$V_S (kT + (1-k)T) = V_O (1-k)T$$

$$V_S(T) = V_O(1-k)T$$

$$V_O = \frac{V_S}{1-k}$$

This equation gives the average output voltage of boost converter. The design equations for Land C are given below

$$L = V_S \frac{k}{f\,\Delta I} \qquad C = \frac{I_O k}{f\,\Delta v}$$

iii) MPPT Algorithm

PERTURB AND OBSERVATION MPPT ALGORITHM

In perturb and observation as depicted in fig 5, a perturbation in voltage results when the load point is far away from the MPP point due to changing environmental conditions. This perturbation results in changes of the power in the solar module. The perturbation extends itselfin the same orientation as long as the power increases. When the maximum power is reached, atthe next instance of time, the power decreases progressively and the direction is reversed. The algorithm oscillates at the steady state around the maximum point. To keep the variation in power small, the size of the perturbation is kept made small. In this technique the operating point oscillates about the MPP point but does not coincides to MPP point and this problem is more pronounced under non uniform conditions. The basic principle of operation is that at MPP, the gradient of P-V curve vanishes. From the gradient, it is possible to obtain a corresponding location of this load point. The change in power with respect to the change in voltage is defined as the gradient. Fig 6 depicts the flow chart of P&O algorithm

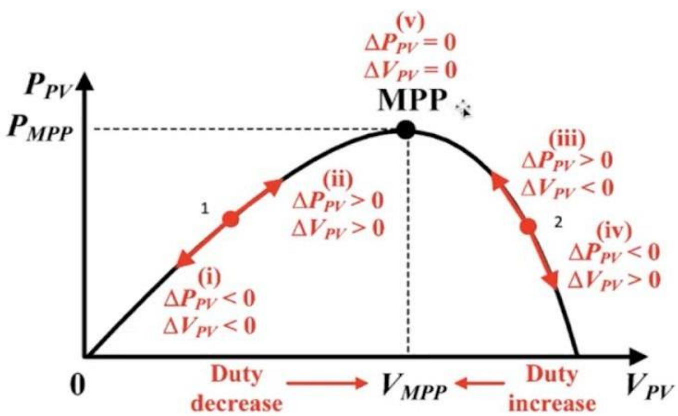

Fig 5 Perturb and Observation

$\frac{dP}{dV}$ ▯ 0 at MPP

$\frac{dP}{dV}$ ▯ 0 at the left of MPP

$\frac{dP}{dV}$ □ 0 at the left of MPP

Fig 6 Flow chart of P&O algorithm

Simulation Circuit

Simulation of the system is done in MATLAB; the solar PV system is simulated with boost converter and P&O algorithm for MPPT control. The solar array with 5 parallel strings, it has a maximum power of 1000W at $1kW/m^2$. The V-I and P-V characteristics are shown in Fig 7

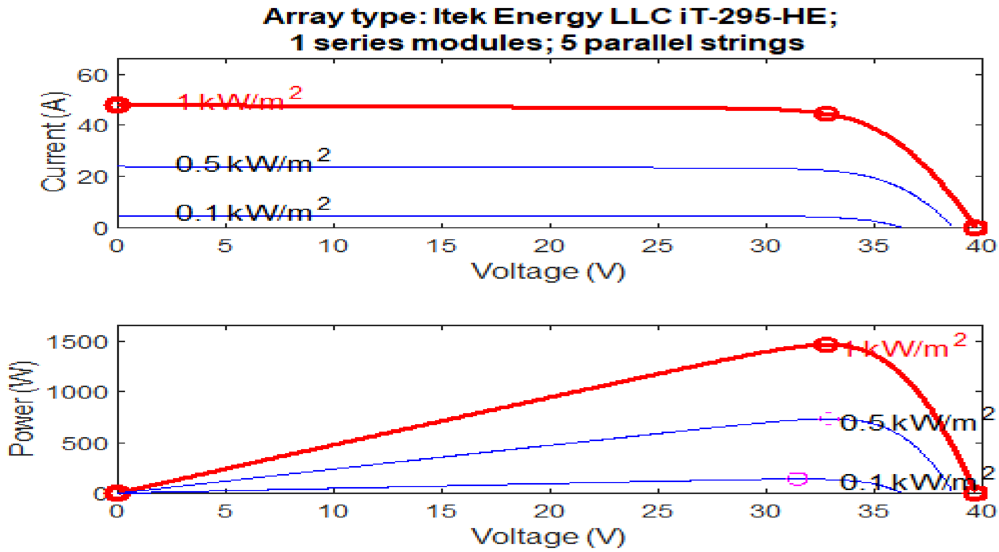

Fig 7. I-V and P-V characteristics

The simulation circuit is shown in Fig 8.

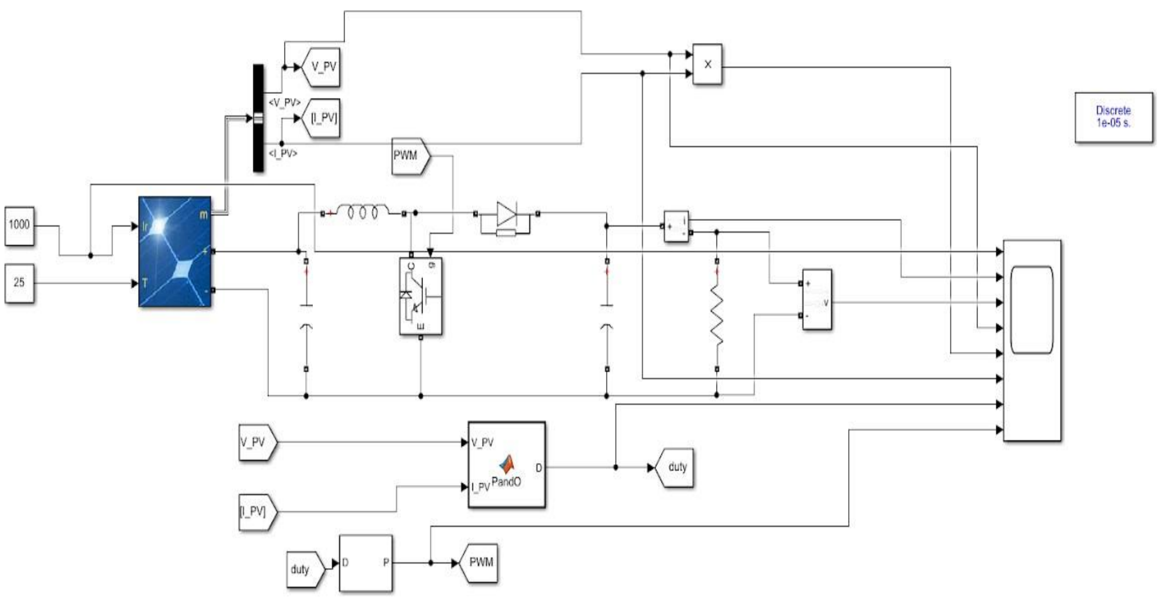

Fig 8. Simulation circuit

The simulation parameters use are given in below Table 1

Table 1; Simulation Parameters

Parameter	value
Cell irradiance	1000 w/m^2
Cell temperature	25°C
Boost converter capacitance	3300µF
Boost converter inductance	5mH
load resistance	10Ω

The simulation results obtained are shown in Fig, the results show that the MPPT algorithmwork effectively and controls the power at the maximum power.

Fig 9 Simulation Results

Conclusion

It is observed that the MPPT is indispensible in PV system to optimize the PV power at any environmental conductance. With the implementation of MPPT, PV power at low irradiance has been boosted. MPPT is more regulated than PO algorithm. From the above graph the performance of PV system with MPPT is highly affected with the varying irradiance level. It decreases the efficiency of the system when the operating point is far away from the MPP point. By giving a suitable fix operating load the Boost converter is capable to track the MPPT at different irradiations. The effect of change in irradiance has been studied and observed.

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