Performance Analysis of Maximum Power Point Tracker (MPPT) for Photovoltaic Systems

Sanjay Charaya, Assistant Professor, Department of Electrical Engineering, Ch. Devi Lal State Institute of Engineering and Technology, PanniwalaMota, Sirsa, Haryana (India)

***Abstract*:** Maximum Power Point Tracker (MPPT) is a good tool to optimize the efficiency of photovoltaic system. As we know that V-I characteristic of PV cell comes to be non-linear curve. On this curve certain points are having the maximum power drawn from PV array to the load. These points are called maximum power points. The locus of these points is called the maximum power line. A Buck-Boost type DC-DC converter is used to construct the MPPT. A control algorithm with Pulse Width Modulation is applied to control the duty cycle of DC-DC converter.

***Keywords*: Maximum Power Point Tracker (MPPT), Pulse Width Modulation, Solar array, Buck-Boost type DC-DC Converter.**

I. INTRODUCTION:

It is very clear to us that the requirement of energy is increasing day by day. It is also expected that in coming years there may be an energy crisis in our society. The energy sources which are being used conventionally are polluting and harmful to our environment. But in turn Non-conventional energy sources may play a pivotal role to generate power without polluting our environment. At the same time the operational cost of the Non-conventional energy system is very small or negligible.

Out of all Non-conventional energy sources, solar energy is one of the purest and clean forms of energy we receive on earth, without any environmental degradation. The global energy needs can be met through the use of solar energy, since it is abundant in nature and is freely accessible energy source at no cost. To draw power from solar energy, photovoltaic comes in to light. Photovoltaic is the technology by which solar radiation or sunlight can be directly converted into electricity or power.

This paper discusses the performance of a MPPT in terms of their maximum power collecting capacity from PV system and delivering to the load side. To track the maximum power point of the Photovoltaic cell, a control algorithm based on Perturbation and Observation (P&O) method is being used. A DC-DC converter is used to construct the real time MPPT. An algorithm utilizing the Pulse Width Modulation technique is implemented to control duty cycle of the DC-DC converter.

II. PV CELL CHARACTERISTICS:

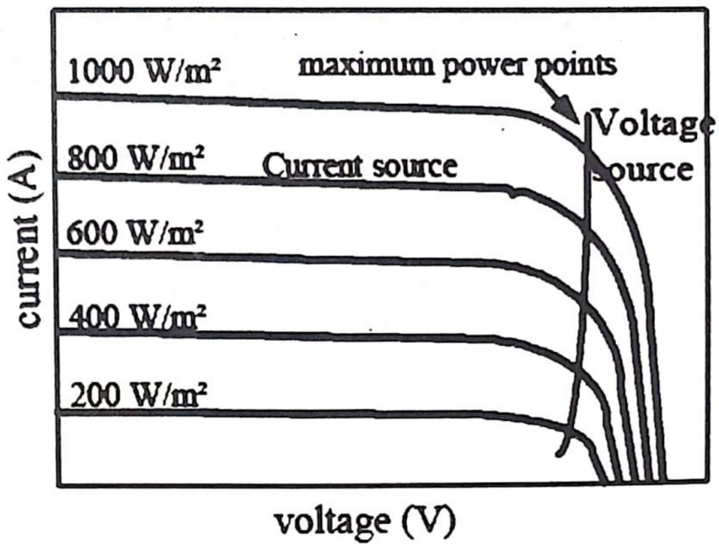

Figure-1: Maximum Power Point (MPP) changes with Irradiance levels (I-V Curves)

A PV cell is having non-linear Current (I)-Voltage (V) characteristics as shown in the figure-1 above. Power (P)-Voltage (V) characteristics are also non-linear as shown in the following figure-2;

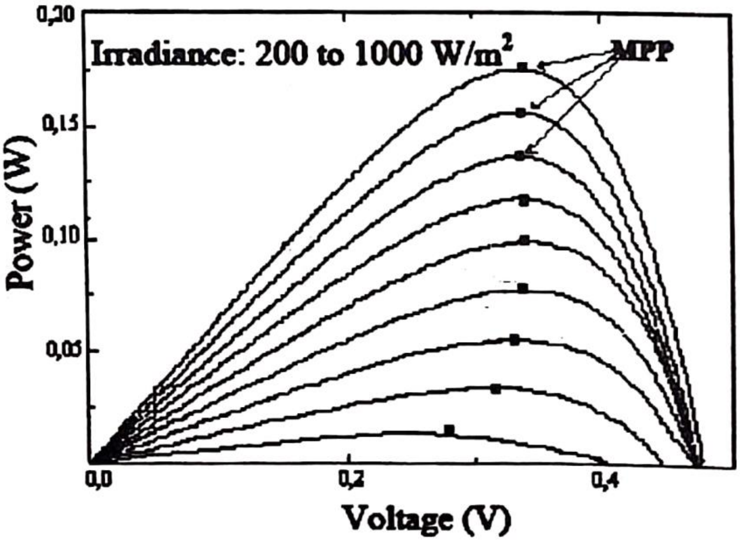

Figure-2: Maximum Power Point (MPP) changes with Irradiance levels (P-V Curves)

The maximum power points are shown on these curves, which are to be obtained by using the MPPT. Maximum power points are at the different places for different solar radiations and different instant of the day time.

III. MAXIMUM POWER POINT TRACKER (MPPT):

To construct the MPPT in real time, a Buck-Boost type DC-DC converter is used which has to be worked in continuous conduction mode. A control algorithm is also used to control the duty cycle of the converter by using pulse width modulation (PWM) technique. Here Perturbation & Observation (P & O) method is being used in control section. The circuit of MPPT is made up by using 8051 microcontroller. 8-bit Analog to Digital (A/D) converter and a Digital to Analog (D/A) converter are also used to give a complete shape to the circuit. The block diagram of PV system is shown as follows:

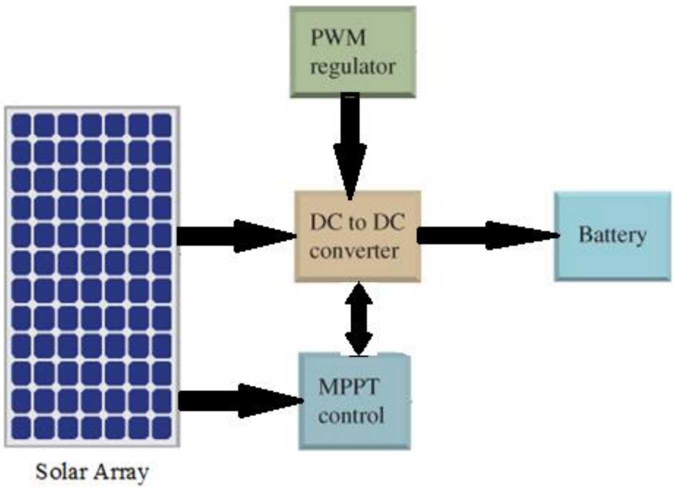

Figure-3: Block diagram of PV System

When the solar module is exposed to sunlight, the solar cells will convert sunlight into direct electricity (DC). Then the voltage generated from the solar panel will be entered into the MPPT controller before entering into the battery. But voltage and current information also goes into the microcontroller to be calculated according to the MPPT algorithm.

IV. BUCK BOOST CONVERTER:

In this paper we have used a Buck-Boost type DC-DC converter. Buck boost type power converter or often called a step-down regulator, the average output voltage (V_0), is smaller than the input voltage, (V_i). The basic buck boost converter circuit and its circuit diagram are shown in Fig.4;

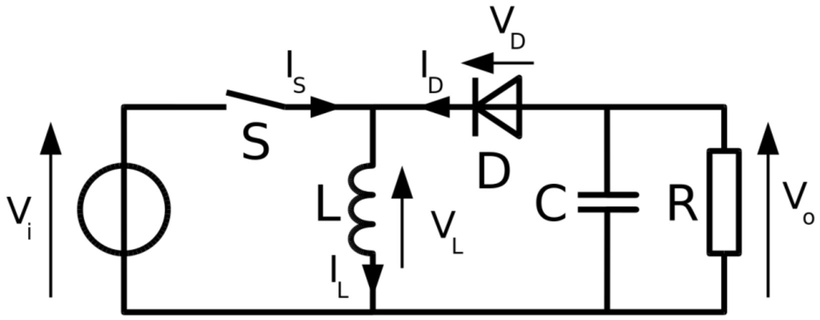

Figure-4: Buck-Boost type DC-DC converter

4.1 Principle of operation:

Figure 5, shows two operating states of the buck–boost converter i.e. on state and the off state as following:

- When the switch is turned on, the input voltage source supplies current to the inductor, and the capacitor supplies current to the resistor (output load). This results in accumulating energy in L.
- When the switch is opened, the inductor supplies current to the load via the diode D, so energy is transferred from L to C and R.

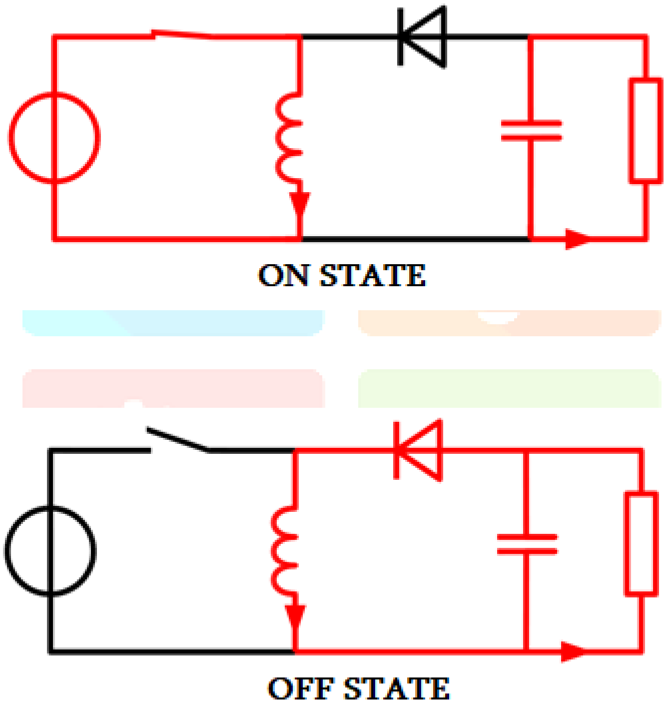

Figure-5: On state and Off state of Buck-Boost converter

V. CONTROL ALGORITHM:

To track in real time, the maximum power point of the Photovoltaic cell, an algorithm based on Perturbation & Observation (P & O) method is being used.

According to this flow chart, array voltage (V_P) and current (I_P) are measured and then output power of PV array is calculated and compared to the previous power of the PV array. If the actual power (P_{actual}) is equal to or greater than the previous measured output power ($P_{previous}$) then the control section increases the duty ratio (D) of the converter. If the P_{actual} is smaller than previous measured power ($P_{previous}$) then control section decreases the duty ratio (D) of the converter. In this way the MPPT tracks the locus of maximum power point called Maximum Power Line (MPL).The flow chart for this perturbation & observation (P & O) method is drawn as follows;

This control algorithm which uses 8051 microcontrollers, an 8-bit A/D and an 8-bit D/A converter. The Perturbation & Observation method used is very simple to use and very efficient too.

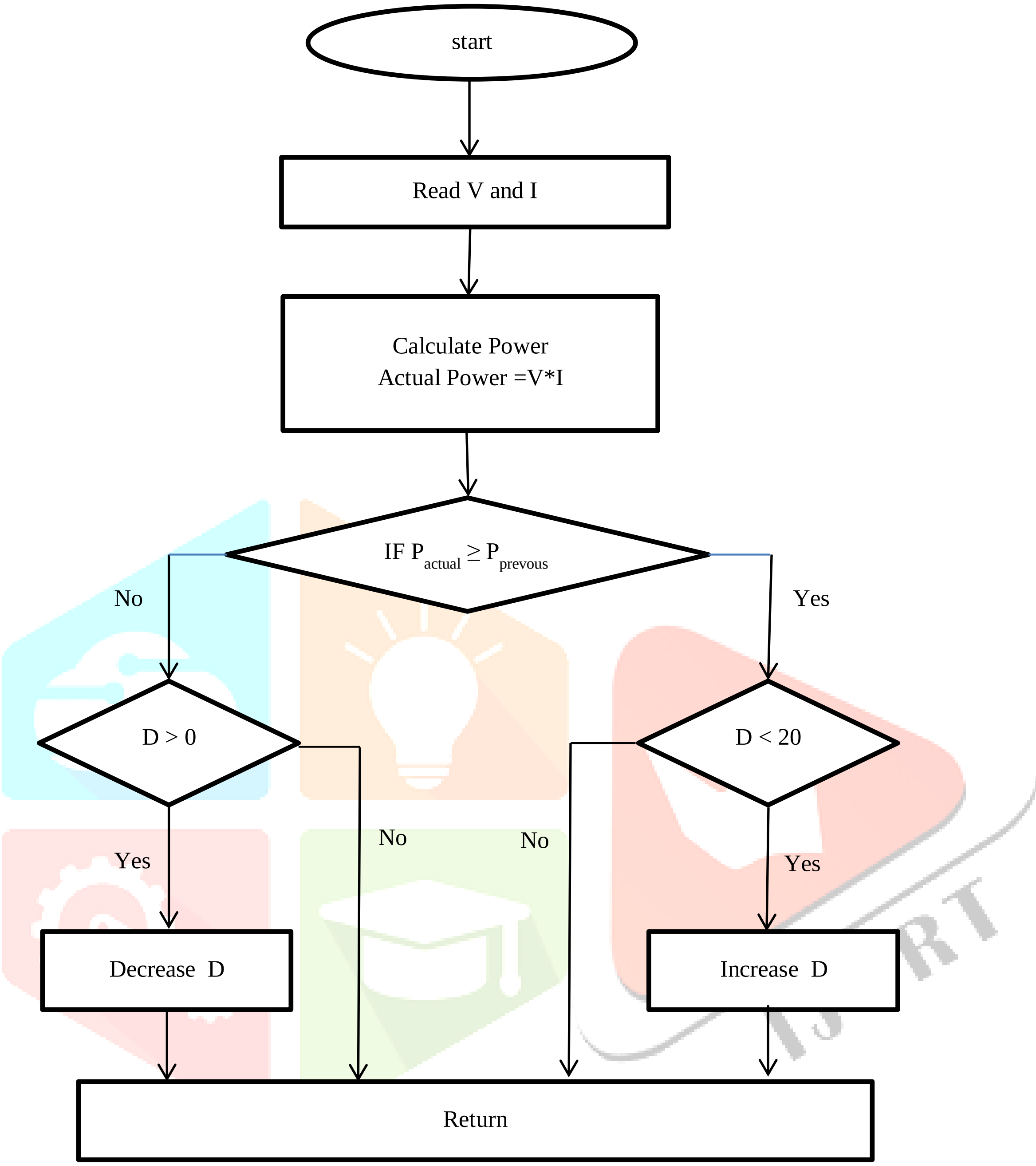

Figure-6: Flow chart based on perturbation & observation (P & O) method

VI. SCOPE FOR FUTURE WORK:

By using latest technologies like fuzzy logic controllers and Artificial Neural Networks (ANN's) MPPT can be further modified to have smarter and faster power electronic system.

In future, MPPT may be constructed in built in the photovoltaic cell by using advanced technologies like Nano Technology and UISI technology.

VII. CONCLUSION:

Experimental results on this type of MPPT system shows that MPPT play a very important part to increase the efficiency of the system by 25-30 % of what we getting now which is approximated as 15-18% for typical PV cell or solar cell.

By using MPPT without increasing the no. of PV modules the generation capacity of the solar photovoltaic (SPV) power plant can be increased.

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