IMPLEMENTATION OF MAXIMUM POWER POINT TRACKING ALGORITHM USING RASPBERRY PI

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ABSTRACT: Renewable energy plays a vital role for the development of a country. Energy can be extracted from a number of ambient conditions like vibration, solar, thermal gradient etc. The maximum power from these systems can be extracted by using MPPT along with power converters. However, conventional maximum power point tracking (MPPT) method for solar cells, are complex and cannot be utilized due to their cost and power requirements. In proposed system the performances of DC-DC converter assisted by MPPT and the performance is characterized by and Perturb and Observe algorithm along with Raspberry Pi controller using boost converter by varying the duty cycle of the boost converter. The main advantages of P&O algorithm are simple in structure, with both stand-alone and grid-connected systems, MPP tracking can be done with very high efficiency.

Keywords: Perturb and observe algorithm, Photovoltaic, MPPT, Raspberry Pi.

1. INTRODUCTION

Renewable energy plays a vital role for the development of a country. The most important motivating factors towards the use of renewable energy sources for power generation are depletion of fossil fuel reservoirs, increased oil prices &global warming. Among the various energy sources available, solar energy is available throughout the year and highly sustainable energy system. Photovoltaic (PV) has grown steadily in recent decades as a carbon-free technology alternative. Photovoltaic(PV) technology is a major means by which to convert solar energy into electricity using semi-conductors. PV(or)solar energy has several advantages as follows (1) green & environmental friendship (2) clean & free of emissions, since it does not produce any pollution(or) harmful to nature (3) it is omnipresent & absence of fuel cost. Concentrating solar power can contribute significantly to the world’s energy supply.

MPPT is a major challenge in the use of PV systems since Current-voltage (I-V) and P-V curves are non-linear in nature. These curves depend on solar insolation and ambient temperature. As the parameters vary continuously, tracking MPP is a major problem. However, when the PV arrays in the PV power-generation system receive uniform solar insolation, there exists a single MPP in the P-V curve.

The aim of this paper is to design a fast and unconditionally stable maximum power point tracking scheme for photovoltaic generator using Perturb and observe technique.

2.PHOTOVOLTAIC MODULE

2.1 P-V Cell Model

A solar cell is a p-n junction which is made from two layers of silicon doped with a small quantity of impurity atoms: in the n-layer, atoms with one more valence electron, called donors, and in the p-layer, with one less valence electron, known as acceptors. When the two layers joined together, the free electrons of the n-layer are diffused in the p-side, leaving behind an area positively charged by the donors. Similarly, the free holes in the p-layer are diffused in the n-side, leaving behind a region negatively charged by the acceptors. Fig 1 shows photovoltaic cell representation. This creates an electrical field in the two sides that is a potential barrier to further flow. The equilibrium is reached in the junction when the electrons and holes cannot surpass that potential barrier and consequently they cannot move. This electric field pulls the electrons and holes in opposite directions as the current can flow in one way only electrons can move from the p-side to the n-side and the holes in the opposite direction.

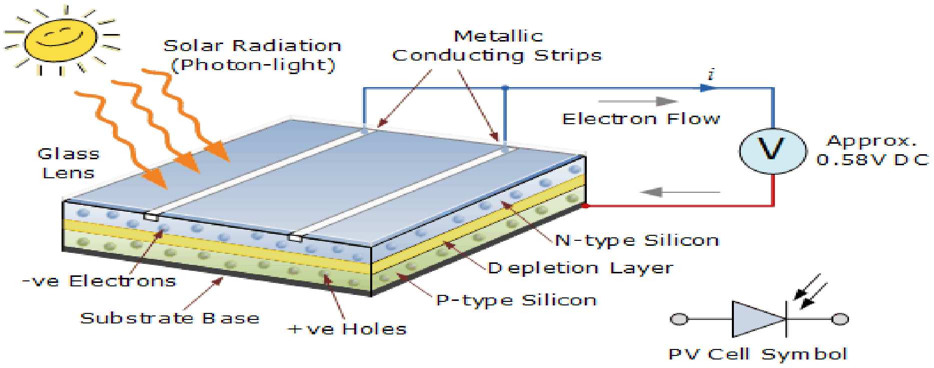

Fig 1. Photovoltaic cell

2.2 A P-V Cell Model

A simple equivalent circuit of a solar cell consists of a current source in parallel with a diode. Fig 2 shows the equivalent circuit of a PV cell.The output of the current source is directly proportional to the solar energy i.e photons which hits on the solar cell i.e photocurrent Iph.[1] When there is no sunlight, the solar cell is not an active device; it works as a diode, i.e. a p-n junction. It produces neither a current nor a voltage. When, it is allowed to connect to an external source (large voltage) it generates a current Id, called diode (D) current or dark current. The diode decides the IV characteristics of the cell.

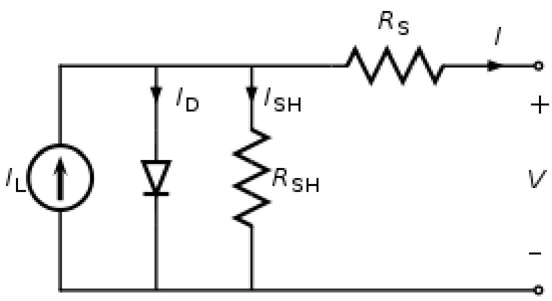

Fig 2 Circuit diagram of a PV cell

Considering the following parameters: a) Temperature dependence of the diode reserved saturation current Is. b) Temperature dependence of the photo current Iph. c) Series resistance Rs (internal losses due to the current flow) which gives a more accurate shape between the maximum power point and the open circuit voltage. d)Shunt resistance Rsh , in parallel with the diode, this corresponds to the leakage current to the ground.

Equations which define the model of a PV cell are given below

$$V_t = \text{kTop/q} \tag{1}$$

$$Voc = \frac{Iph}{Is} \tag{2}$$

$$\text{Id}= \left[e\,\frac{V+IRs}{nVtCNs} - 1\right] \text{Is Np} \tag{3}$$

$$Is = IRs\left(\frac{Top}{TRef}\right)^3 e(\frac{qEg}{nk}\left(\frac{1}{Top} - \frac{1}{Tref}\right)) \tag{4}$$

$$\text{Ish} = \frac{V+IRs}{Rp} \tag{5}$$

$$Iph = Gk[Isc + K\text{I}(Top - T\text{Ref})] \tag{6}$$

$$I = Iph\ Np - Id - Ish \tag{7}$$

3. DC-DC Converter

The solar panel is not connected directly to a load, the DC-DC converter is need to be connected between the solar panel and the load to tracking the maximum power point. Fig 3 shows the schematic diagram of Boost converter. Many power converters are available for this purpose. In the paper, BOOST converter is proposed to enhance the output voltage and efficiency.

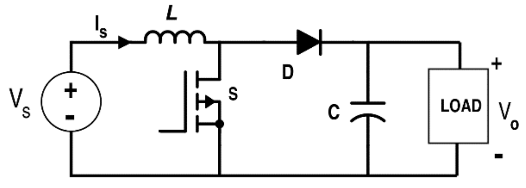

Fig 3 Schematic diagram of Boost converter

4. Perturb and Observe Algorithm

Perturb and Observe (P and O) algorithm are most widely used, especially for low-cost implementations. The MPP changes as a consequence of the variation of the irradiance level and temperature.

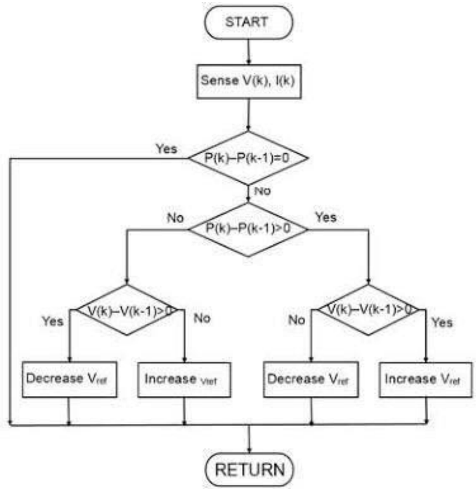

Fig 4 Flow chart of Perturb and Observe Algorithm

It is essential to ensure that the PV system always operates at the MPP in order to maximize the power harvesting in that prevailing environmental conditions. [3] This compares the power measured in the previous cycle with the power of the current cycle to determine the next perturbation direction. If the power increases due to the perturbation then the perturbation will remain in the same direction. If the operating point exceeds the peak power and deviate to the right side of the P-V characteristic curve, the power at the next instant will decrease. Thus, the direction of the perturbation reverses. As the steady-state is reached, the active point oscillates around the peak power as the MPP will perturb continuously. The flow chart required for P&O MPPT module (subsystem) is shown in Fig. 4. .The electrical characteristics data of solar module is given below.

MODEL	**USP20**
Maximum Power (Pmax)	18W
Open Circuit Voltage(Voc)	21.5V
Maximum Power Point Voltage (Vmpp)	17.1V
Short Circuit Current(Isc)	1.30A
Maximum Power Point Current (Impp)	1.17A
Cell Size(mm)	24 × 156
No of cells	36
Tolerance	±10%

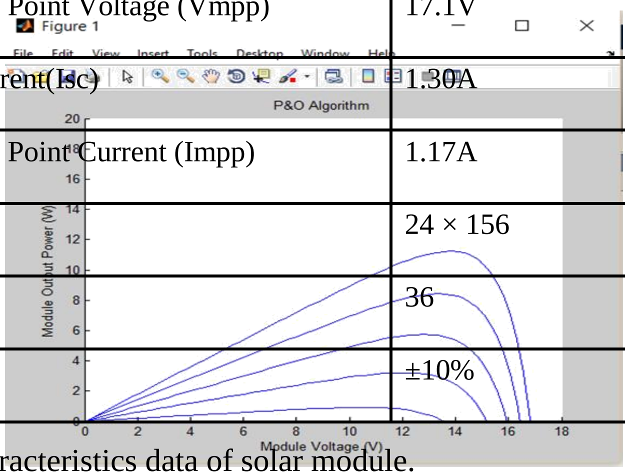

Table 1 Electrical characteristics data of solar module.

5. Simulink Model of Perturb and observe algorithm

Perturb and observe algorithm is implemented in the MATLAB environment for observation and the following results are obtained. Fig 5 shows the P-V characteristics of the P-V module.

Fig 5 P-V characteristics of P&O Algorithm

Fig 6 explains the V-I characteristics of P&O Algorithm which is also shown below.

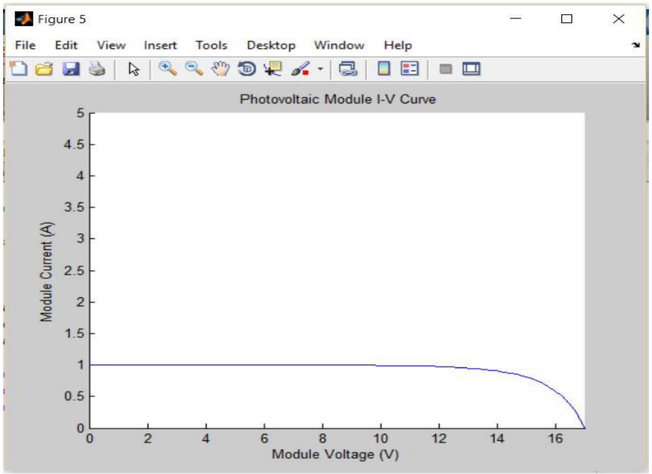

Fig 6 V-I characteristics of P&O algorithm

6.Hardware implementation of P&O algorithm

In the hardware part, the circuit is designed to step-up DC-to-DC voltage. The circuit included parts of Boost components such as controllable switch(IRF840), inductor and capacitor, ADC, Raspberry Pi, MOSFET Driver and other basic components. In order to maintain output voltage, controller will be operated in feedback circuit.[5] When the duty cycle is in ON state, diode become as reversed biased and the inductor will deliver current and switch conducts inductor current. The current through the inductor increase, as the source voltage would be greater. The simulation was run with the switch on MPPT mode. This included the MPPT block in the circuit and duty cycle D as calculated by the P&O algorithm. Under the same irradiation conditions, the P-V panel continued to generate around 16W power. Thus, increasing the conversion efficiency of the photovoltaic system as a whole. Fig 7 shows the overall experimental set-up.

Fig 7 Overall experimental set-up

7. Result and conclusion

Using the above specified Perturb and Observe algorithm, under uniform solar insolation, the given input voltage is boosted up along with the P&O logic and outputs are verified. The P&O algorithm is programmed in Python language. The python program is performed in Raspberry Pi in Raspbian environment.

Fig 8 Boosted output voltage.

The above shown Fig explains that the given input voltage is 7V where the output is 18V. The same procedure is followed throughout and the desired results are obtained.

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