Kalpa Publications in Engineering
Volume 1, 2017, Pages 152–158
ICRISET2017. International Conference on Research and Innovations in Science, Engineering &Technology. Selected Papers in Engineering

The Performance Of Solar Pv Array Using Different MPPT Techniques

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Abstract

This paper gives the review of the modelling of solar photovoltaic (PV) array using the basic diode equations and comparison of various Maximum Power point Tracking (MPPT) techniques used for the tracking of maximum power available on the output side of PV array. The PV modelling as well as MPPT algorithms along with a DC-DC boost converter connected to a resistive load for standalone photovoltaic system are simulated and analysed in MATLAB/Simulink.

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1 Introduction

With the advancement of technology, day by day fossil fuels are depleting and they are on the verge of extinction. Solar energy is one of the energy resource which is readily available on earth. It creates no pollution as well as maintenance requirement is also minimal. PV cell/panel/array is used for the conversion of solar energy directly into electricity. The power-voltage (P-V) characteristics of PV panel is non linear in nature so power is not maximum when voltage and currents are maximum [1], [3], [4].

The maximum power is obtained at the peak point of P-V and I-V curve. The power from this extracted using the maximum power point tracking (MPPT) algorithms. The maximum power available depends on the two main factors i.e. irradiance and temperature. As the irradiance increases, the maximum power (Pmax) increases and vice-versa. In case of temperature, with increase in temperature, Pmax decreases and vice-versa. Hence maximum power keeps on fluctuating due to continuous variation in irradiance and temperature. This tracking of Pmax is done by MPPT algorithms [5].

This review paper has presented the various MPPT algorithms which control the duty cycle of the DC-DC boost converter and hence change the voltage accordingly and follow the point of maximum power. Some of the commonly used MPPT algorithms are Perturb & Observe (P&O), Incremental

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Conductance (INC), Fractional Open Circuit Voltage (FOCV) and Fractional Short Circuit Current (FSCC) [3], [5].

2 Modelling Of Solar PV Cell

The solar modules or solar panels are made of building block called solar cell or photovoltaic (PV) cell. A PV cell is made up of semiconductor material which converts the light fallen onto its surface directly into electricity. The power generated by a single cell is very small, so it cannot be used in most of the practical applications. To use it efficiently, several PV cells are connected in series or parallel or in both series-parallel configurations, called PV modules to get higher amount of power [1], [3]. The equivalent model of solar PV device is represented in Fig. 1

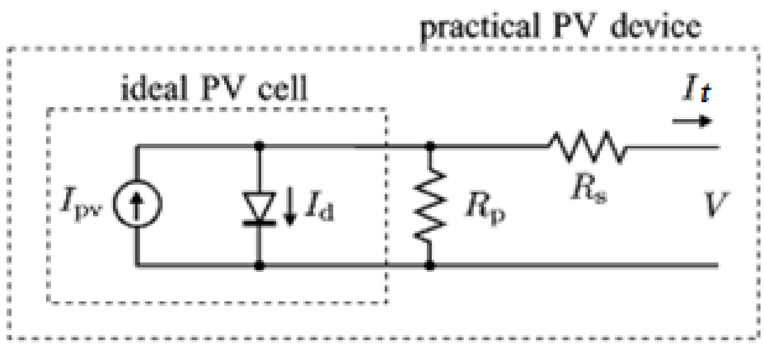

Figure 1: Equivalent model of a solar PV device **[1]**

The basic governing equations for a one solar PV cell are written as [1]:

$$\boldsymbol{It = Ipv - Io\left(\exp\left(\frac{Vd}{niVt}\right) - 1\right)} \quad (1)$$

$$Id = Io\,(exp(\frac{Va}{niVt\,h)}) - 1) \quad (2)$$

where,

Ip is the current produced by the incident light
Id is the schokley diode current
Io is the current due to reverse saturation or leakage current
Va is the voltage present across the diode
Vth is the thermal voltage of diode which is equal to kT/q
q is the charge of the electron
k is the Boltzmann constant
T is the temperature of the PN junction in Kelvin
ni gives the ideality factor of diode

As shown in Fig. 1. there are two resistances Rs and Rp used for representing the practical PV device.

Rp is the parallel connected resistance representing current due to leakage at the borders to the ground and Rs which is series resistance represents the internally generated losses due to flow of current in the module [3]. Considering the effects of resistances the modified equation from Equation (1) becomes:

$$It = Ipv - Io\left(\exp\left(\frac{V+IRs}{niVt}\right) - 1\right) - \frac{V+IRs}{Rp} \quad (3)$$

Where V is indicating the voltage of the PV device. The type of module used for the modelling of the PV module is Kyocera KC200GT. Its datasheet is given in table 1. The Current-Voltage (I-V) and Power-Voltage (P-V) curves of this model are given in Fig.2 and Fig.3 respectively.

Impp	7.61 A
Vmpp	26.3 V
Pmax	200.143 W
Is (Short circuit current)	8.21 A
Voc (Open circuit voltage)	32.9 V
Kv (Voltage constant)	-0.1230 V/K
Ki(Current constant	0.0032 A/K
No. of series connected cells, Ns	54

Table 1: Parameters of Kyocera KC200GT [1]

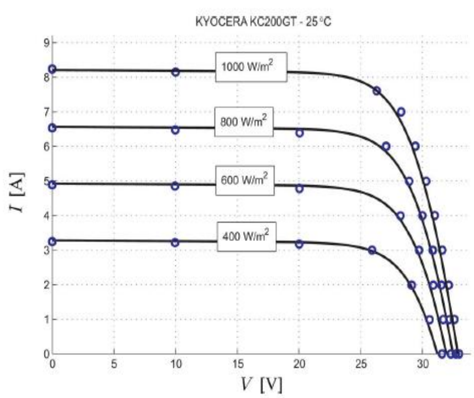

Figure 2. I-V curves of the Solar module at different irradiations [3]

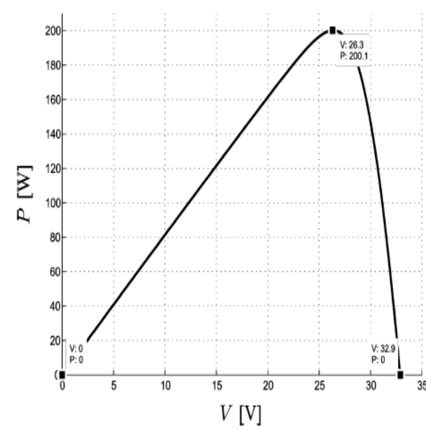

Figure 3. P-V Curve of Solar module [1]

3 MPPT Algorithms

3.1 Fractional Short Circuit Current (FSCC)

This is one of the simplest and fastest technique of detecting the MPP. It doesn’t give the exact MPP. Its principle is simple that the relationship between the current at MPP, Impp and the short circuit current, Isc is linear. Hence Impp is proportional to Isc by a factor *k*. *k* is calculated according to PV module datasheet and its value lies between 0.85-0.95 [5].

$$Impp = k\ Isc \tag{4}$$

3.2 Fractional Open Circuit Voltage (FOCV)

Similarly as FSCC, this technique also does not give the true MPP. This is easier than FSCC method. Its basic principle is that the voltage at MPP, Vmpp is proportional to the open circuit voltage, Voc by a constant *k*, whose value varies between 0.70-0.85 [2]. It is obtained from the datasheet of PV module [5].

$$Vmpp = k\ Voc \tag{5}$$

3.3 Perturb & Observe (P&O)

This is the most widely used technique. This algorithm has a simple logic of perturbing the operating point of PV device regularly by changing the controlling parameter like duty ratio measuring PV array output power before and after the perturbation [3],[5]. If power is found to be increased then algorithm will continue perturbing in the same direction. Because of this continuous perturbation in P&O algorithm, power, voltage waves fluctuate around their MPP values [3], [4].

3.4 Incremental Conductance (INC)

This algorithm tracks the slope of PV curve of solar PV device. Its fundamental principle is that the PV curve of a PV array at constant temperature and irradiation level has only single MPP. At MPP, power derivative with respect to voltage (dP/dV) is equal to zero i.e. incremental conductance dIpv/dVpv equals negative of instantaneous conductance Ipv/Vpv. On the left side of MPP, positive slope is obtained and on the right side of MPP, negative slope is obtained. The incremental conductance algorithm compares dIpv/dVpv and Ipv/Vpv and decides whether to increase or decrease the control parameter [3], [6]. This technique is complex compared to others.

4 Modelling and simulation

The PV array with DC-DC boost converter is modelled and simulated in MATLAB/Simulink as shown in Fig. 6. It consists of PV array, DC-DC boost converter, resistive load and control block.

- PV Array: A PV array model is made by [1] which is used for the analysis of system. Kyocera KC200GT module is used whose specifications are shown in Table II-1.
- DC-DC Converter: This is used for stepping up the output voltage and maintaining the constant maximum power at the output. IGBT recieves duty cycle from the control block. The values of various components of converter are [3]:

  Capacitor on input side Ci = 400,Capacitor on output side Co = 10 μF,
  Inductance Li = 15mH
  Resistance on load = 80 ohms
- Control Block: Both P&O and INC techniques algorithm are fed in MPPT controller whose

output is given to PWM generator which generates duty cycle.

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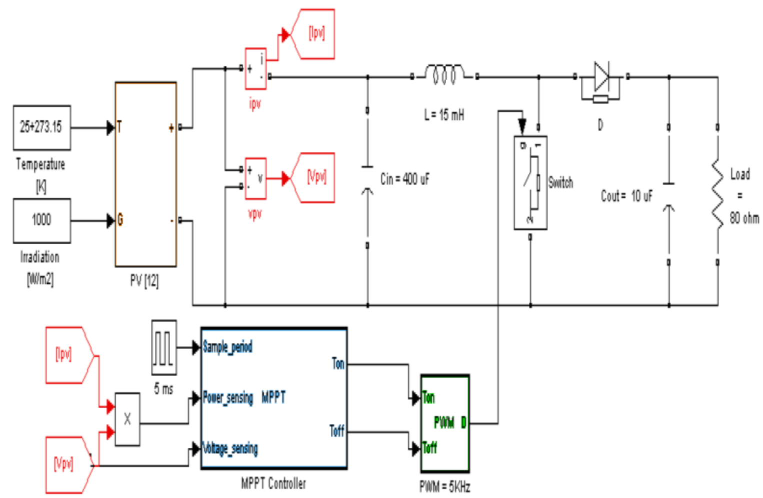

Figure 4. Simulation setup of PV system with boost converter

5 Simulation results

The performance of all the algorithms under steady state condition of 1000W/m^2 and 25ºC is observed. The voltage curve and power curves are drawn as shown in Fig. 5 and 6 respectively. Similarly the results are in dynamic conditions when the atmospheric conditions are increased at step rate of 25W/m2-1ºC per 10msec up to 800W/m2-17ºC as shown in Fig. 7 [3]. It is shown that the fluctuations in INC algorithm are less compared to P&O algorithm. However FSCC also has fewer fluctuations around MPP but FOCV and FSCC do not give the true MPP. Hence under steady conditions the performance of INC algorithm is best. It is seen that under dynamic condition, FSCC and INC algorithm provides fair results.

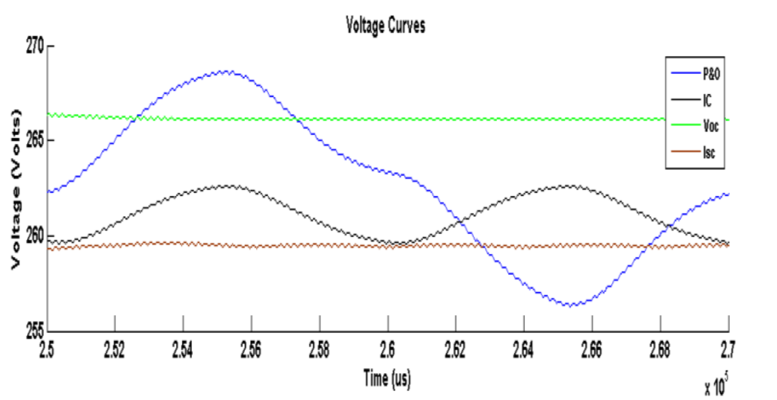

Figure 5. Voltage curve under steady state condition [3]

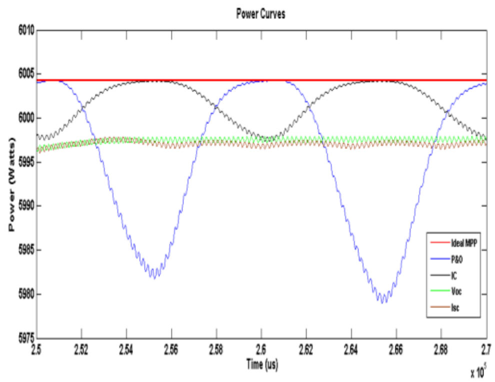

Figure 6. Power curve under steady state condition [3]

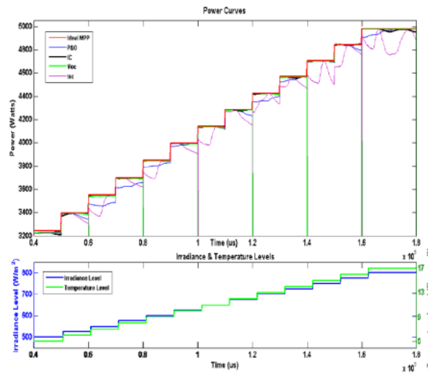

Figure 7. Power curve under dynamic condition [3]

6 Conclusion

The In this paper modelling of PV module and comparison of four MPPT techniques i.e. FOCV, FSCC, P&O and INC is done. It is observed that INC is the best technique under steady state conditions. FSCC and FOCV are the easiest to imply techniques. INC is a complicated technique but offers good result under varying weather conditions. Also FSCC and FOCV don't provide true MPP while P&O and INC are satisfied in this aspect. The fluctuations around MPP are observed more in P&O and FOCV techniques. All the four techniques are modelled and simulated in MATLAB/Simulink.

References

M. G. Villalva, J. R. Gazoli et al., (2009) "*Comprehensive approach to modelling and simulation of photovoltaic arrays*," Power Electronics, IEEE Transactions on, vol. 24, no. 5, pp. 1198–1208.

JM.A.Elgendy,B.Zahawi, and D.J.Atkinson,(2010, Oct.)"*Comparison of directly connected and constant voltage controlled photovoltaic pumping systems*," IEEE Trans. Sustain. Energy, vol. 1, no. 3, pp. 184–192.

Ali.F.Murtaza et.al., (2013)"*Comparative Anlaysis of Maximum Power Point Tracking Techniques,*" IEEE, vol. 12, pp. 83-88.

Soubhagya Kumar Dash et al.,(2014, May) " *Comparative Analysis of MPP for Solar PV Application using MATLAB/simulink*," vol.14.

T. Esram and P.L. Chapman,(2007) "*Comparison of photovoltaic array maximum power point tracking techniques*," Energy conversion, IEEE transactions on, vol. 22, no. 2, pp. 439–449.

M. A. Elgendy, B. Zahawi, and D. J. Atkinson,(2012, Jan.) "*Assessment of Incremental Conductance MPPT algorithm implementation techniques for PV pumping applications*," IEEE Trans. Sustain. Energy, vol. 3, no. 1, pp. 21–33.