Extracting Maximum Power from Photovoltaic System using MPPT Techniques

Ms Gulrez Aslam Bodhle
(gul24oct@yahoo.co.in)
Student of Power Plant Engineering & Energy Management
Master of Engineering (Electrical),
SESGOIFE, DIKSAL

Prof. Gopal Chaudhari
(M.E. Electrical)
(Assi. Prof. Electronics Engineering
YTIET, Bhivpuri Road, Karjat,
Mumbai University)

Prof. Sharvari Sane
(M. Tech Electrical)
(H.O.D. Electrical Engineering
SESGOIFE, DIKSAL, Karjat,
Mumbai University)

Abstract — In this paper for control of photo-voltaic power by utilization of a boost converter using Maximum Power Point Tracking (MPPT) control mechanism is presented. The MPPT is responsible for extracting the maximum possible power from the photo-voltaic and feed it to the load via the boost converter which steps up the voltage to required magnitude. The main aim will be to The main aim will be to extract maximum power from the photo-voltaic so its necessary to continuously track maximum power point of the photo-voltaic module. The MPPT basically works on an algorithm.

The algorithms are usually written in m files of MATLAB and utilized in simulation.

Keywords: *Boost Converter, MPPT, solar cell.*

*****

1. Introduction

Conventional energy sources are unable to meet the increasing demand for energy worldwide. So, alternative energy sources like sunlight, wind and biomass come into picture. In that context, photo-voltaic energy is a source of interesting energy; it is renewable, inexhaustible and non-polluting, and it is used as energy sources in various applications[10] . But because of its high cost and low efficiency, energy contribution is less than other energy sources.

The main purpose of this paper presents a brief introduction to its functioning and behavior of pv device and its basic equations and it's followed by the mathematical modelling of pv array and MPPT technique. And in the unique point P-V and I-V characteristics which photo-voltaic system operates at maximum efficiency. So this point called maximum power point (MPP). The maximum power point trackers (MPPT) are used to maintain the MPP. So it minimized the overall cost and maximizes the array efficiency. MPPT typically regulates the terminal voltage of the panel and the MPPT control to extract maximum power from the PV array becomes indispensable in the PV generation system. The output characteristics are of PV module depends on

The solar Isolation.
The cell Temperature and
The Output Voltage of PV Module.
Mathematical modelling of the solar array (module) here is done mainly for obtaining the performance characteristics. The performance characteristics of PV module mainly depend on the operating conditions, they also depend on solar array design quality.

The output quantities (Voltage, current and power) vary as a function of irradiation, temperature and load current. The effects of these three variations are considered in the modeling, so that any change in the temperature and solar irradiation levels should not adversely affect the PV module output

Maximum Power Point Tracking, frequently referred to as MPPT, is an electronic system that operates the Photo-voltaic (PV) modules in a manner that allows the modules to produce all the power they are capable of.

MPPT is not a mechanical tracking system that "physically moves "the modules to make them point more directly at the sun. MPPT is a fully electronic system that varies the electrical operating point of the modules so that the modules are able to deliver maximum available power.Therefore MPPT techniques are needed to maintain the PV array's operating at its MPPT. Many MPPT algorithm are there to obtain the maximum power point of PV cell as listed below

- Perturb and observation method
- Incremental conduction method
- Fractional open circuit voltage method
- Fractional short circuit current method
- Fuzzy logic method

2. Basic Block Diagram

The basic block diagram is as shown in figure 1.It consists of Solar panel, DC-DC power converter, MPPT controller, Load.

Initially voltage and current from the solar panel is sensed by using voltage and current sensor. These voltage and current values can be input to the MPPT controller. Later these values can be proceed according into the MPPT algorithm used to track the maximum power point of solar panel. The output of MPPT block is used as input to DC-DC converter which may be voltage parameter or duty cycle. DC-DC converter helps in maintaining the operating voltage at the maximum power point. By varying the duty cycle of DC-DC converter. Usually Buck, Boost, Buck- Boost configuration is used according to requirement. In this paper Boost converter is used to step up the operating voltage at the maximum power point. DC-DC power converter is connected between the solar panel and load. The heart of the model is the MPPT block which helps in finding the maximum operating point of solar panel. This can be done by using MPPT algorithms. Which in turn gives gating signal to Boost converter which maintains the operating voltage at the maximum operating point irrespective of solar irradiance and temperature.

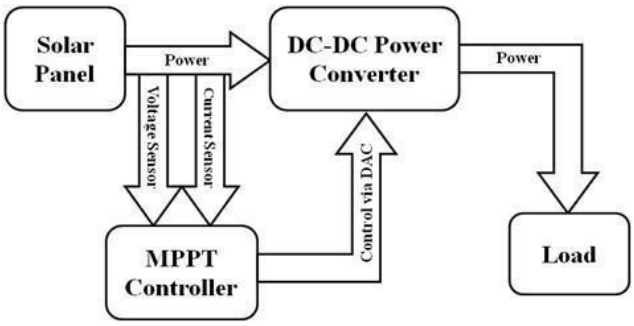

Figure 2 :Basic Block Diagram

2.1 Principle and Operation of PV Cell:-

An array/module of pv cell converts solar energy into a usable amount of DC (direct current) energy. The panels of solar made of semiconductor. Material and silicon being the most abundant (very large) used semiconductor [1].

The p-n junction exposed to light, photons with energy greater than the gap of energy are absorbed, causing the

emergence of electron-hole pairs. There carriers are separated under the influence of electric fields within the junction. Creating a current that is proportional to incidence of solar irradiation [3]. Being exposed to the sunlight, photons with energy of the semiconductor creates some electrons-hole pair proportional to the incident irradiation [4]. The light generated current is acted as a constant current source supplying the current to either the junction or a useful load depending on the junction characteristics and the value of the external load resistance. This phenomenon depends on the semiconductor material and on the wavelength of the incident light. The rate of generation of electric carries depends on the flux of incident light and the capacity of absorption of semiconductor. The capacity of absorption depends mainly on the semiconductor band gap, on the reflectance of the cell surface (that depends on the shape and treatment of the surface). The value of series resistance is very low, but the value of parallel resistance is infinity.

2.1 Mathematical Modelling of PV Cell:-

The equivalent circuit diagram of pv cell is shown below in figure. It includes a current source (I ph), diode (D), a series

resistance (R s), and shunt resistance (R sh)[2].

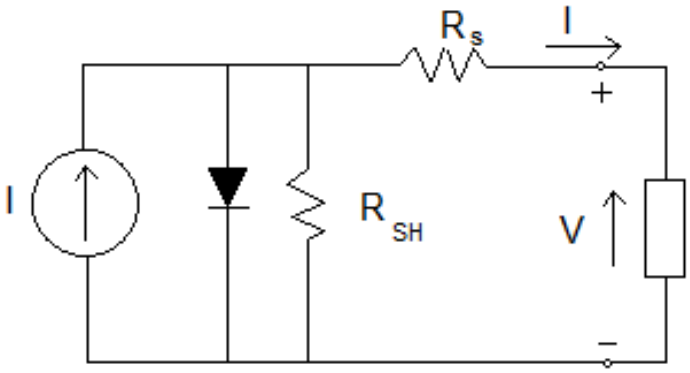

Figure 2.1 :Single Diode Model of a PV Cell

The equivalent circuit based model is mainly used for the MPPT technologies. In mathematical equations in pv cell/module used following nomenclature.

Vo is the output voltage, V
Io is the output current, A
Tr is the reference temperature
T is the operating temperature in Kelvin
Is=Iu is the saturation current (A)
Isc is the short circuit current
Iur is the cell reverse saturation current at a reference temperature
I is the light generated current or photon current
A=B is the ideality factor
K is the Boltzmann constant (1.3805*10 -23 J/K)
q is electron charge (1.6*10 -19 C)
Rs is the series resistance
Rsh is the shunt resistance
Ns is the number of cells connected in series
Np is the number of cells connected in parallel
Eg is the band gap energy (1.1 eV)
Ki is a cell's short circuit temperature coefficient
G is the irradiance (W/m 2)
The photocurrent mainly depends on the solar insulation and cell's working temperature, which is described as
I= [Isc + KI (T –T r)] □ ..... (ii)

Where,
Isc = Cell's short-circuit current at a 25°C and 1kw/m2
KI = Cell's short-circuit current temperature coefficient,
On the other hand, the cell's saturation current varies with the cell temperature, which is described as
Is = Iur (T/T r) 3 exp [q Eg(1/Tr - 1/T)/ kA] ....(iii)

2.2 MPPT Techniques:-

2.2.1 Perturb and Observation(P&O) :-

P&O is mostly used algorithm for MPPT. And it operated by the periodically perturbing (increasing or decreasing).It involves introducing perturbation in power operating voltage. In this algorithm if the power has increased, it keeps same direction (increase voltage) otherwise, changes its direction (decrease voltage). This process is repeated at each MPP tracking step until the MPP is reached. After reaching the MPP, the algorithm naturally oscillates around its correct value. It means power decreases then continue vary the voltage or current in the reverse direction.

Figure 2.2.1 : Flowchart of Perturb & Observation Algorithm

2.2.2 Incremental Conductance Method :-

The P&O method is not sufficient for all condition of the MPP, and it fail under continues changing environment condition. So overcome this condition we use incremental conductance method. In this method used to derivative of the current with respect to the voltage to reach the maximum power point (MPP). This maximum power should be equal to di/dv = -i/v. The variation in the voltage towards biggest or smallest value it also be affected the power value. If power increase then should continue in the same direction. If power decrease then should be reverse direction.

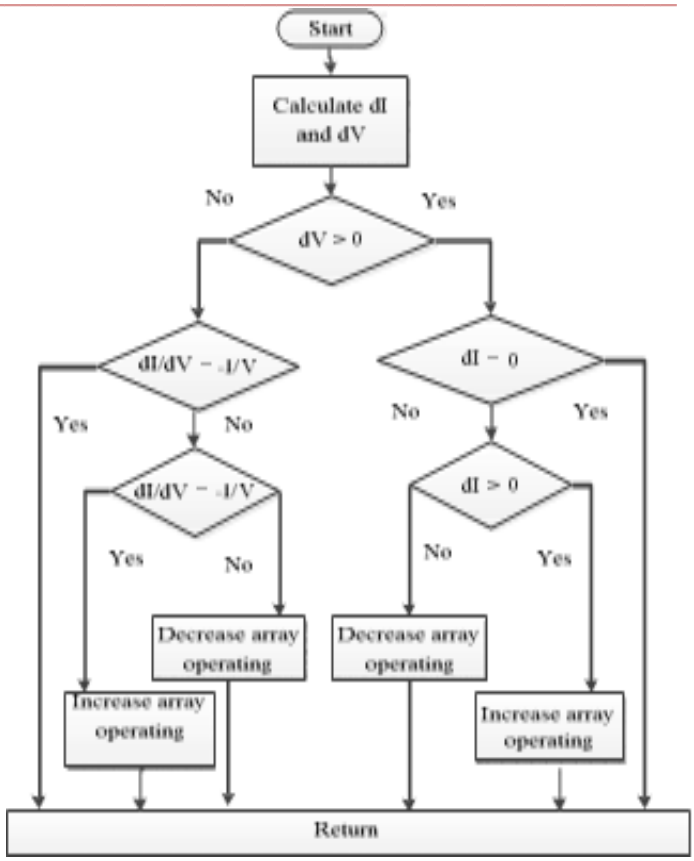

Figure 2.2.2 : Flowchart of Incremental Conductance Method

3 CONCLUSION:-

A pv model based on the mathematical equation of solar cell can be developed using MATLAB/Simulink model. In pv array works only part of the I-V characteristic near the working point maximum voltage and current. The photo-voltaic system works most of time with maximum efficiency. The behavior of the pv cell changes by varrying the parameters like resistance, sun irradiation, temperature, and parameter of the diode value are considered as input and the I-V and P-V characteristics are considered as output. Increasing temperature yields decreasing power and voltage and increasing sun irradiation the current and voltage and also power will be increased. Parallel resistance, no significant effect or (little effect) on the I-V and P-V curve if change of resistance has a very low effect on power. In the paper two techniques (P&O, incremental conductance method) used to maximize the output power. By analyzing the current with the help of mathematical model it has very convenient justified, required parameters by changing the value.

References :-

[1] Subarto kumar ghosh, Mohamamad hansanuzzaman shawon, Ashifur rahman, Rifat Abdullah, "Modeling of PV Array and Analysis of Different Parameters", International journal of Advancements in Research & Technology,volume 2, Issue 5, May 2013.

[2] Rasool Feiz Kerendian, Shima Nemati, Javad Ebrahimi and Arash Zeynalzadeh, "Evaluation and Simulation of Solar Cells by Using Matlab", International Journal of Machatronics, Electrical and Computer Technology, vol. 4(10) pp. 138-145, jan 2014.

[3] S.Sheik Mohammed, "Modeling and Simulation of Photovoltaic module using MATLAB/Simulink", International Journal of Chemical and Environmental Engineering, volume 2, No. 5, Oct 2011.

[4] N.Pandiarajan and Ranganath Muthu, "Mathematical Modeling of Photovoltaic Module with Simulink", International Conference on Electrical Energy Systems(ICEES), pp. 314-319 Jan 2011.

[5] Tarak Salmi, Mounir Bouzguenda, Adel Gastli, Ahmed Masmoudi, "MATLAB/Simulink Based Modeling of Solar Photovoltaic Cell", International Journal of Renewable Energy Reserch, vol. 2, No. 2, pp. 213-217, 2012.

[6] Savita Nema, R.K.Nema, Gayatri Agnihotri, "Matlab/simulink based study of photovoltaic cells/modules/array and their experimental verification", International Journal of Energy and Environment, volume 1, Issue 3, pp. 487-500, 2010.

[7] J. Surya Kumari and Ch. Sai Babu, "Mathematical Modeling and Simulation of Photovoltaic Cell using Matlab-Simulink Environment", International Journal of Electrical and Computer Engineering (IJECE), vol. 2, No. 1, pp. 26-34, Feb 2012.

[8] Sohan Lal, Rohtash Dhiman, Mr.S.K.Sinha, "Analysis Different MPPT Techniques for Photovoltaic System", International Journal of Engineering and Innovative Technology (IJEIT), volume 2, Issue 6, Dec 2012.

[9] M. Abdulkadir, A. S. Samosir, A. H. M. Yatim "Modeling and Simulation of a Solar Photovoltaic System, ItsDynamics and Transient Characteristics in LABVIEW" International Journal of Power Electronics and Drive System (IJPEDS)Vol. 3, No. 2, June 2013, pp. 185~192 ISSN: 2088-8694

[10] Feiz Kerendian Rasool and Pazouki Samaneh, "Photovoltaic Device Modeling and Effect of its Parameters", Research Journal of Recent Sciences, vol. 2(4), pp. 59-64, April 2013.

[11] P.Sudeepika, G.Md. Gayaz Khan, "Analysis Of Mathematical Model Of PV Cell Module in Matlab/Simulink Environment", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 3, Issue 3, pp. 7823-7829, Mar 2014.

[12] Ms.Salabha Anna George, Ms.Fossy Mary Chacko, "Comparison of Different Control Methods for Integrated System of MPPT Powered PV Module and STATCOM", International Conference on Renewable Energy and Sustainable Energy(ICRESE),pp. 207-212, 2013.