Mathematical Model of PV Cell Module in Matlab

[1]K.Sivamahalaxmi, [2]K.Lavanya, [3]Karimella Vikram
[1,2]Dept. of H & S, TKR Engineering College, India
[3]Dept. of ECE, TKR Engineering College, Meerpet, Saroor Nagar, Hyderabad, Telangana, India

Abstract
The physical modeling of the system is not that much efficient so the analysis is done through the mathematical modeling approach. In this paper mathematical analysis is done for the single diode model. Single diode model is employed to investigate the I-V and P-V characteristics of 46 W module . The effect of irradiation and temperature is also considered. The analysis is done in MATLAB/ SIMULINK environment. This mathematical analysis approach is a very flexible to change the Parameters of the system.

Keywords
Solar Energy, Photo Voltaic Effect, MATLAB/SIMULINK, Characteristics of PV cell.

PV Cell Modelling
For computer simulation of a physical system modeling should be done .It includes all the physical elements &ll the parameters influencing the system. In this dealing the physical system is converted to computer codes and aracteristics are plotted. To describe the behavior of the physical PV cell, the PV model is chosen by the researchers. Most commonly used model is a single diode model

I. 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, photovoltaic 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. It is therefore essential to have effective and flexible models, to enable you to perform easy manipulation of certain data (irradiance and temperature) investigate how to get its performance as maximum as possible. The use of these simple models provides sufficient accuracy to analyze the behavior of the solar cell and have proven to be effective in most cases. Solar cells convert solar energy into electrical energy. This phenomenon occurs in materials which have the property of capture photon and emit electrons. The main material used in the photovoltaic industry is silicon. For the better understanding of the PV module the mathematical model is continuously updated. The output characteristics are of PV module depends on

- The solar Isolation.
- The cell Temperature and
- The Output Voltage of PV Module.

It is necessary to model the PV module for the design and simulation of Maximum power point tracking for PV system applications because it has non-linear characteristics. 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) very 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. The Photo voltaic analysis model proposed in this paper is circuitry based model to be used with simulink. Here module is modelled and P-V & I-V characteristics are plotted for different irradiation (1000W/ m2, 600W/m2, 200W/m2) and for different temperatures (250 C, 500C and 750 Introduction

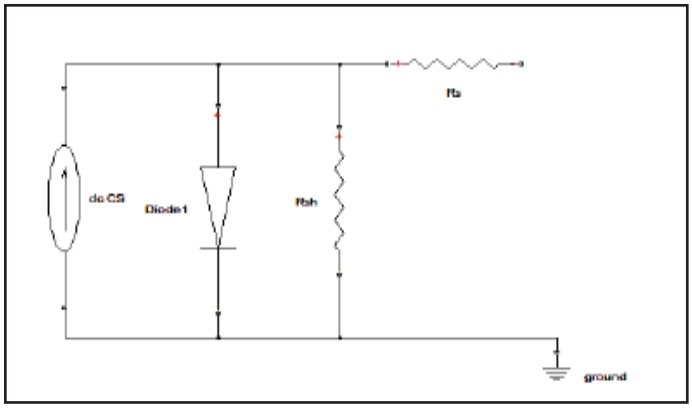

Fig. 1: Solar Cell Model

Electron-hole pairs are created, when light falls at the junction and it provides an electrical current flow across thejunction of constant rate. Then net current is calculated by considering difference between the normal current and lightgenerated current. The internal series Resistance Rs is in series with the junction. It is mostly d

II. Principle and Opreration 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].

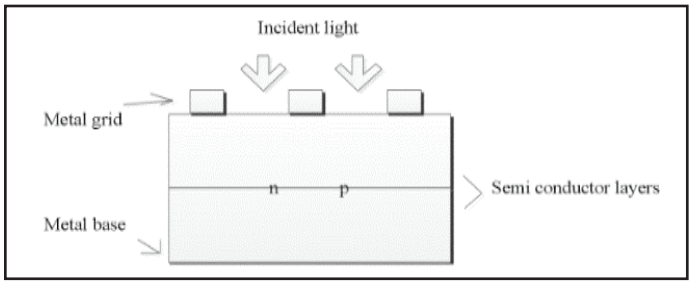

Fig. 2: Physical Structure of PV Cell

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 withenergy 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 junctionor a useful load depending on the junctioncharacteristics 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 carriesdepends 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.

III. Characteristics of PV Cell

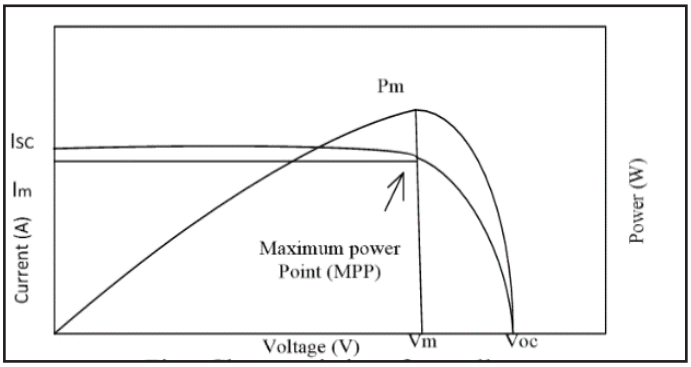

Fig. 3:

That may be increase or decrease output power due to all parameters used in pv cell like irradiation, temperature, seriesresistance, parallel resistance, ideality factor, saturation current etc. ue to the high sheetResistance of the diffused layer which is in series with the junction properties. Studies in this field indicate that exploiting Nano fluid in solar systems, offers unique advantages over conventional fluids. In this paper, the applications of nanofluids on different types of solar collectors, photovoltaic systems and solar thermoelectric are reviewed. Beside the wide range of energy conversion, the efforts done on the Energy Storage System (ESS) have been reviewed. In the field of economics, nanotech reduces manufacturing costs as a result of using a low temperature process. Research is needed for better understanding the effects from the Low pass and high pass and band pass width

IV. Mathematical Modeling of PV CELL

The equivalent circuit diagram of pv cell is shown below in figure. It includes a current source (Iph), diode (D), a seriesresistance (Rs), and shunt resistance (Rsh)[2].

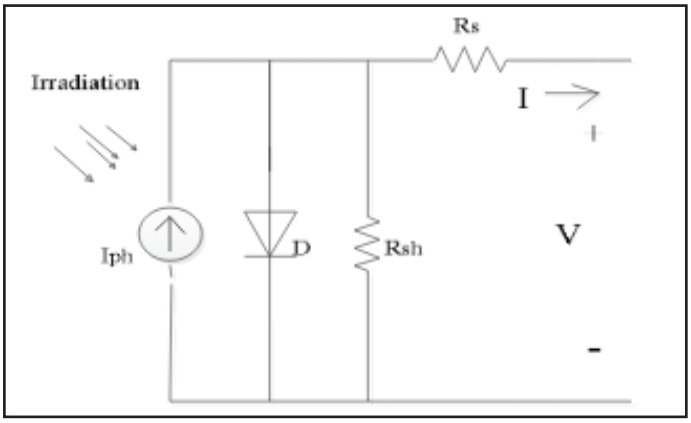

Fig. 4: Circuit Diagram of pv Cell

The equivalent circuit based model is mainly used for the MPPT technologies. In mathematical equation ns in pv cell/module used following nomenclature. Vpv is the output voltage, V Ipv is output current, A Tn is the reference temperature T is the operating temperature in Kelvin Is=Io is the saturation current (A) Isc is the short circuit current IoR is the cell reverse saturation current at a reference temperature Iph 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 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 voltage, current (V -I) characteristic equation of pv/solar cell is given by

$$I = Iph - Io\left(\exp\frac{q.(V+IRs)}{N.K.T} - 1\right) - \frac{(V+IRs)}{Rsh} \quad (1)$$

Where photon current is-

$$Iph = (Isc + Ki\,(T-Tn))\frac{G}{100} \quad (2)$$

The cell's saturation current varies with cell temperature, which is-

$$Is_{(T)} = Is\left(\frac{T}{Tn}\right)^3 * \exp\left[\frac{Eg}{Vt}\left(\frac{T}{Tn} - 1\right)\right] \quad (3)$$

Vt is called thermal voltage-

$$Vt = K.T/q \quad (4)$$

The current output of pv module is-

$$Ipv = Np*Iph - Np*Io\left[\exp\left\{\frac{q*(Vpv+I.Rs)}{Ns.A.K.T}\right\} - 1\right] \quad (5)$$

V. Maximum Power Point Tracking

MPPT is an algorithm that included in charge controllers used for extracting maximum available power from pv cell/module under certain conditions. This voltage at which pv cells/module can provide maximum power is called maximum power point (or peak power voltage)[11]. The output power depends on it radiation, temperature and it's parameters and product of voltage and current

A. Perturb and Observe (P&O) Method

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 (increasevoltage) 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.

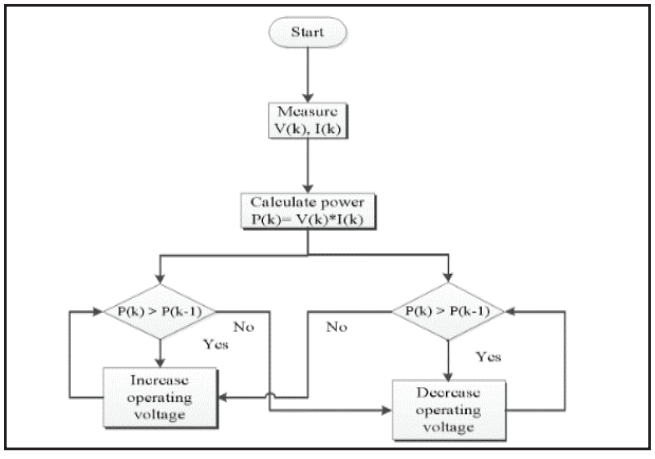

Fig. 5: Flow Chart for P&O Method

Incremental Conductance Method

The P&O method is not sufficient for all condition of the MPP, and it fail under continues changing environmentcondition. Soovercome 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

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

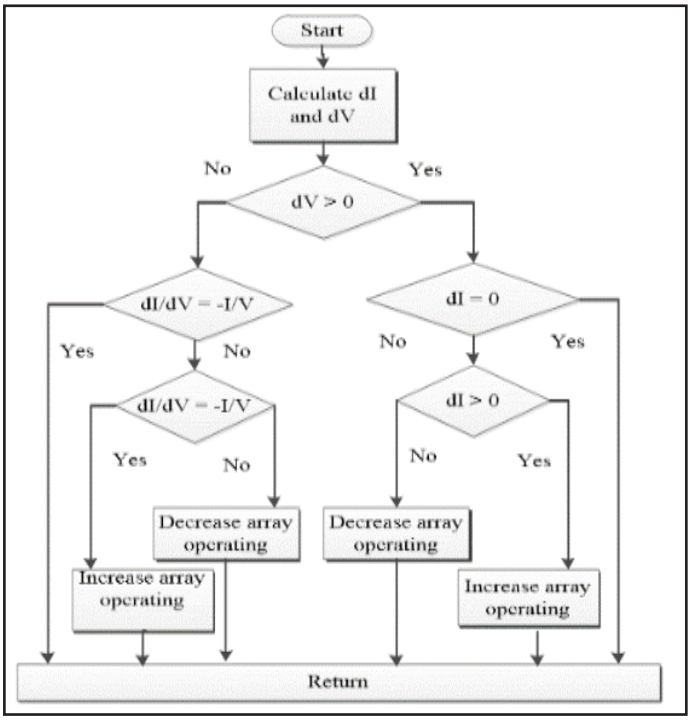

Fig. 6: Flow Chart of Interemental Condutance Method

VI. Simulink PV Model

The blocks of the model are developed using MATLAB/Simulink based on mathematical equations [5]. The photovoltaic model and circuits that can be used in simulation of power conversion for its applications and shows the different conditions related to physical and environmental to estimate the electrical behavior of the pv cell [9] The simulation model of photo current (Iph) as shown in below-

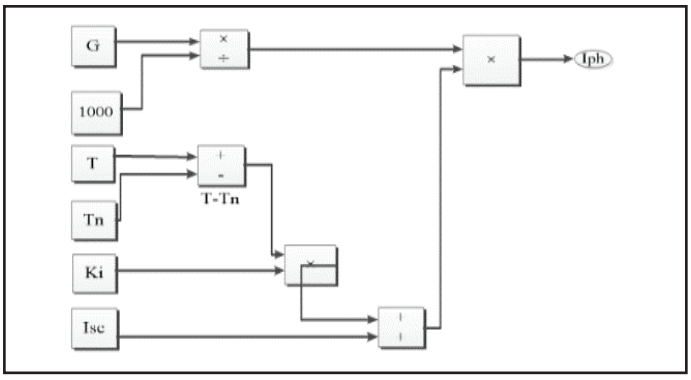

Fig. 7: Simulation Model of Calculation of Iph

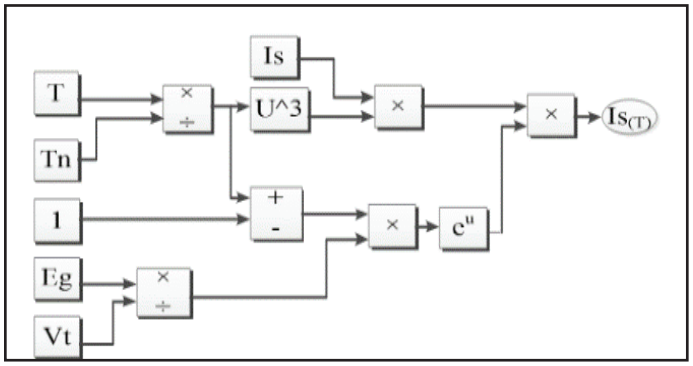

Fig. 8: Simulink Model of Reverse Saturation Current

VII. Conclusion

A pv model based on the mathematical equation of solar cell is 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 photovoltaic system works most of time with maximum efficiency. The behavior of the pv cell in electrical changes in the varies parameters like resistance, sun irradiation, temperature, and parameter of the diode are value considered as input and the I-V and P-V characteristics are considered to 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. Soremoving it to have a simple model, and increasing the series resistance results in the decreasing the power, increasingthe diode ideality factor power is increased, while and increasing the amount of reverse saturation current power will reduce. 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] Choi SUS. Enhancing thermal conductivity of fluids with nanoparticles. In: Siginer DA, Wang HP, (Eds.), Developments and applications of non-New-tonian Flows, FED-vol. 231/ MD-vol. 66. ASME Publications; 1995, p. 99e105.

[2] Mahmoodi M, Hashemi SM. Numerical study of natural convection of a nanofluid in C-shaped enclosures. Int J ThermSci2012;55:76–89.

[3] KeshavarzMoraveji M, Haddad SMH, Darabi M. Modeling of forced convective heat transfer of a non-Newtonian nanofluid in the horizontal tubeunder constant heat flux with computational fluid dynamics. Int CommunHeat Mass Transf2012; 39:995–9.

[4] Ghadimi A, Saidur R, HSC Metselaar. A review of nanofluid stability proper-ties and characterization in stationary conditions. Int J Heat Mass Transf2011; 54:4051–68.

[5] Roy G, Gherasim I, Nadeau F, Poitras G, Nguyen CT. Heat transfer performance and hydrodynamic behavior of turbulent nanofluid radial flows. Int JThermSci2012; 58:120–9.

[6] Subartokumarghosh, Mohamamad hansanuzza-manshawon, Ashifurrahman, Rifat Abdullah, "Modeling of PV Array and Analysis of Different Parameters", International journal of Advancements in Research &Technology, volume 2, Issue 5, May 2013.

[7] RasoolFeizKerendian, Shima Nemati, Javad Ebrahimi and Arash Zeynalzadeh, "Evaluation and Simulation of Solar Cells by UsingMatlab",International Journal of Machatronics, Electrical and Computer Technology, vol. 4(10) pp. 138-145, jan 2014.
[8] 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.
[9] N.Pandiarajan and Ranganath Muthu, "Mathematical Modeling of Photovoltaic Module with Simulink", International Conference onElectrical Energy Systems(ICEES), pp. 314-319 Jan 2011.
[10] TarakSalmi, MounirBouzguenda, Adel Gastli, AhmedMasmoudi, "MATLAB/Simulink Based Modeling of Solar Photovoltaic Cell", International Journal of Renewable Energy Reserch, vol. 2, No. 2, pp. 213-217, 2012.
[11] Savita Nema, R.K.Nema, GayatriAgnihotri, "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.

Smt. K.Sivamahalaxmi is working as a Asst. Professor in TKR Engineering College (H&SDept). She has published many papers and conducted workshops on this paper. Her research intrest area are Physics, (Solidstate Physics)

Smt.K.Lavanya is working as a Asst. Professor in TKREC (H&S Dept.) She has published many papers. Intrest subjects are Physics (electronics).

K.Vikram is working as a Professor in TKR Engineering College Hyderabad, India. He has published and presented good number of Technical papers in National and International Conferences. His main research interest areas are Software Engineering, Data Mining, and Networks. Image Processing