

Assessment of Efficient Solar PV Array and modelling of MPPT using Matlab

Mr.Sukanta Kumar Tulo
Dept. of Electronics Engineering
Gandhi Institute of Engg& Tech, Gunupur
sukant.99t@gmail.com

Subham Singh, Neha Rani, Sumit Saurabh
Dept. of Electronics Engineering,
Gandhi Institute of Engg& Tech, Gunupur
giet13aei011@gmail.com

Abstract:- Solar radiant energy accounts for most of the usable renewable energy on Earth. Photovoltaic (PV) is a method of generating electrical power by converting solar radiation into direct current electricity using semiconductor that exhibit the photovoltaic effect. This paper presents a method of modelling and simulation of photovoltaic arrays in MATLAB. This method helps in implementation and also useful to determine the characteristic of a particular photovoltaic cell array and to study the effect of different values of solar irradiation at different temperatures concerning the performance of photovoltaic (PV) cells. This model can also be used to build a photovoltaic circuit for any photovoltaic array. All modules which form the photovoltaic system model are individually modelled and validated in Simulink.

Keywords: Modelling, Solar cell, photovoltaic array, Simulation, MATLAB/Simulink.

I. INTRODUCTION

Photovoltaic (PV) and renewable energy sources (RES) have experimented a great development in recent years, mainly because of the growing concern about climate change and the oil price increase, which has led many countries to adopt new regulations to promote this kind of energy. Photovoltaic cells are very low exploitation costs (free fuel), limited maintenance requirements, reliable, silent and easy to install. In addition, in some stand-alone applications photovoltaic cells are certainly convenient in comparison with other energy sources, especially in those places that are not accessible, which is unprofitable to install traditional power lines.

II. MODEL OF SOLAR CELL

Any photovoltaic model is based on diode behaviour, which gives to photovoltaic cell its exponential characteristic. The solar cell can be modelled with three modelling systems. The first possibility of modelling can be done with instruments which can implement any differential equation or algebraic relationship of a highly complex mathematical model. Another possibility is given by Simscape, which allows direct modelling using physical components of the electric field (resistors, capacitors, diodes) to implement exactly the same mathematical equation. A modelling system more complex than those described above is performed using SimElectronics advanced component library, which contains a block called Solar Cell.

The solar cell from MATLAB 7.10.0. (R2010a) is a solar current source, which includes solar induced current and temperature dependence.

A. Solar - induced current

Solar cell block is formed from a single solar panel as a resistance, R_s is connected in series with a parallel combination of a current source, two exponential two diodes and a parallel Resistor, R_p . The output current source I is given by equation (1):

$$I = I_{ph} - I_s \left(e^{\frac{V + I R_s}{N V_t}} - 1 \right) - I_{s2} \left(e^{\frac{V + I R_s}{N_2 V_t}} - 1 \right) - \frac{V + I R_s}{R_p} \quad \dots (1)$$

Where I_{ph} depicts solar-induced current:

$I_{ph} = I_{ph0} \cdot I_r / I_{r0}$, where I_r = irradiance in (W/m²) which fall on the surface of cell; I_{ph0} is measured solar generated current for the irradiance I_{r0} ; I_s is the saturation current of the first diode; I_{s2} is saturation current of the second diode in the model; $V_t = KT / q$ which

represents the thermal voltage, dependent on temperature of the device T , K is Boltzmann constant and q is the charge of electron; N is the quality factor (the emission coefficient for the diode) of the first diode; N_2 is the quality factor (the emission coefficient for the diode) of the second diode; V is the voltage at the terminals of the solar cell.

B. Temperature dependence

Several solar cell parameters (the solar-induced current I_{ph} , the saturation current of the first diode I_{s1} , the saturation current of the second diode I_{s2} , the series resistance R_s and the parallel resistance R_p) depend on temperature. Photovoltaic cell temperature is specified by value of the fixed circuit temperature parameter, T_{FIXED}

$$I_{ph}(t) = I_{ph} * \{1 + TIPH1 * (T - T_{meas})\} \dots(2)$$

Where, $TIPH1$ is the first temperature coefficient for I_{ph} , T_{meas} is the parameter extraction temperature.

III. MODEL OF PHOTOVOLTAIC ARRAY

A. Model for plotting the characteristics of PV module

In the model (Fig. 1) shows a PV cell array which is connected to a variable resistor. This resistor has an input ramp which just varies resistance linearly in closed circuit till it reaches the 30th steps.

PV ARRAY SIMULINK MODEL

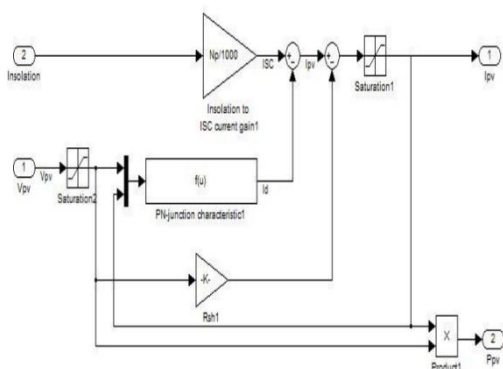


Fig1: SIMULINK model of photovoltaic array

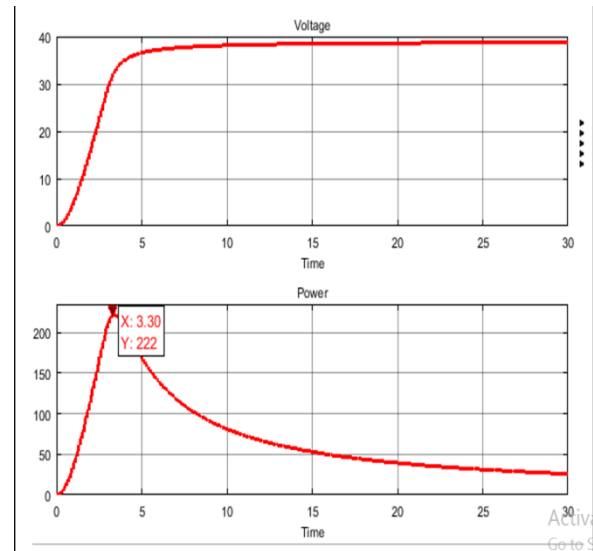


Fig2: Voltage & Power curve for PV Module.

The characteristics of V-I and V-P of the photovoltaic array is given in Fig. 3 and Fig. 4. The V-I curve represents the standard behaviour of the photovoltaic cell and photovoltaic array respectively. In the middle of this characteristic is the maximum power point(MPP). This point is very critical for this kind of system for maximum power extraction from the photovoltaic array. Result that the main objective is to try operating around of this maximum point in order to make the photovoltaic cells to work at maximum efficiency.

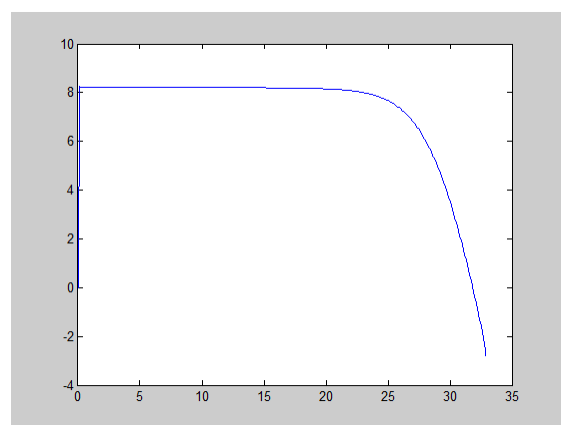


Fig3: The V-I characteristics of photovoltaic array

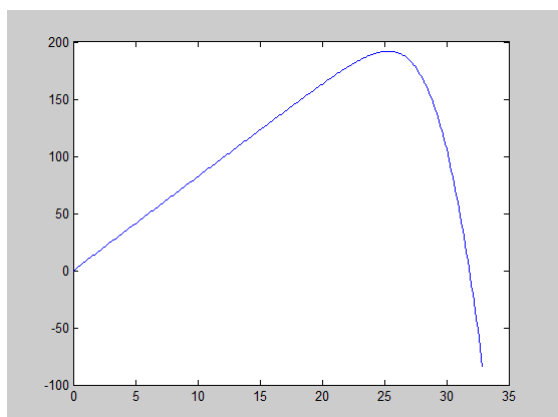


Fig4: The V-P characteristics of the photovoltaic array.

IV. MPPT ALGORITHM

This algorithm is mainly used to obtain maximum power from solar array based on variation in irradiance and temperature. There are many types of MPPT algorithm but mainly 2 types of MPPT algorithms are used and they are as follows:

- a) Perturb and Observe (P&O)
- b) Incremental Conductance Method

A. Perturb and Observe(P&O) method

In this algorithm there is a slight perturbation introduced in the system. Due to this perturbation, the power of the module alters. If the power enhances due to the perturbation, then the perturbation is carried on in that direction. After the maximum power is attained, the power at the next instant decrements and hence the perturbation reverses.

The algorithm takes the values of current and voltage from the solar photovoltaic module. Power is computed from the assessed voltage and current. The values of voltage and power at k^{th} instant are put in.

- Disadvantages of Perturb & Observe algorithm

There are times where the irradiation changes quickly in that case the Maximum Power Point

also moves on the right hand side of the curve. The algorithm takes it as a change due to perturbation and in the next iteration it changes the direction of perturbation and hence goes away from the MPP.

However, in this algorithm we use only a single sensor, the voltage sensor, to sense the solar array voltage and so the cost of implementation is less and hence easy to use.

B. Incremental Conductance Method

Incremental conductance method uses two voltage and current sensors to sense the output voltage and current of the PV array. At MPP the slope of the PV curve is 0.

$$(dP/dV)_{MPP} = d(VI)/dV$$

$$0 = I + V dI/dV_{MPP}$$

$$(dI/dV)_{MPP} = -I/V$$

The left hand side is the instantaneous conductance of the solar panel. When this instantaneous conductance is equal to the conductance of the solar energy then MPP is reached.

At this point we are sensing both the voltage and current simultaneously. Hence the error due to change in irradiance is removed. As we go down the list of algorithms the complexity and the cost of implementation goes on increasing which may be suitable for a highly designed and elaborated system. This is the reason that Perturb and Observe and Incremental Conductance method are the most widely used algorithm.

V. CONCLUSIONS

This work describe a new implementation of solar cell by using MATLAB/Simulink of photovoltaic arrays and modelling using experimental data. To build photovoltaic panel the Solar Cell block is used and the power produced by a photovoltaic array is affected by changing the irradiance. The implemented model was validated through simulation. From the simulation result it shows

that the proposed method is efficient in terms of modelling of the functioning of the photovoltaic system.

REFERENCES

- [1] Bevrani, H., Ghosh, A., Ledwich, G.: 'Renewable energy sources and frequency regulation: survey and new perspectives', IET Rnew.PowerGener., 2010, 4, (5), pp. 438–457
- [2] ABB, Technical Application Papers No.10 Photovoltaic plants
- [3] www.mathworks.com, Osorio, C., Recorded Webinar- Model-Based Design for Solar Power Systems.
- [4] *** www.mathworks.com, Help - Solar Cell Blocks.
- [5] Messenger, R.A., Ventre, J., Photovoltaic Systems Engineering, CRC Press LLC, 2000.
- [6] Gow, J.A., Manning, C.D., Development of a Photovoltaic Array Model for Use in Power Electronics Simulation Studies, IEE Proceedings of Electric Power Applications, Vol. 146, No.2, March 1999, pp. 193-200.
- [7] Villalva, M.G., Gazoli, J.R., Filho, E.R., Comprehensive Approach to Modeling and Simulation of Photovoltaic Arrays, IEEE Transactions on Power Electronics, Vol. 24 No. 5 May, 2009, pp. 1198 -1208 About the authors Eng. Ioan-
- [8] Pavan Kumar, A.V.; Parimi, A.M.; Uma Rao, K., "Performance Analysis of a Two-Diode model of PV cell for PV based generation in MATLAB," in Advanced Communication Control and Computing technologies(ICACCCT),2014International Conference on , vol., no., pp.68-72, 8-10 May 2014.