

Simulation of Parameters of Solar Photovoltaic Panels using Lab VIEW

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Abstract - In this paper, a solar panel is simulated using LabVIEW software. Four number of solar cells are connected in parallel. Each solar cell is made of silicon and simulation is performed under different solar radiations. The output current and power are obtained for varying voltage. It has been observed the outputs improve significantly with the increase in number of solar cells. Hence, the given network can be considered as beneficial compared to the existing models available in literature. Numerical results along with discussions are presented. The simulation results are verified with another software.

Key Words: solar cell; solar panel; LabVIEW; photo-current; dark current component.

1. INTRODUCTION

Solar power is gaining popularity throughout the world. Governments all around the world keep introducing new programs which aim at popularizing solar power in their respective economies [1]. The popularity of solar power can be attributed to the fact that it is a clean and abundant source of energy, which can serve as a viable alternative to fossil fuels in the future. One of the most popular ways to harness solar power is using an array of solar cells. A solar cell or photovoltaic cell is an electrical device that converts the energy of light directly into electricity by employing photovoltaic effect.

The “photovoltaic effect” is the basic physical process through which a solar cell converts sunlight into electricity. This effect is the process in which two dissimilar materials in close contact produce an electrical voltage when struck by light or other radiant energy. Light striking crystals such as silicon or germanium diodes exhibit this property the best and are economically viable which is why they are used as photovoltaic cells.

However, before actually designing a solar panel, it is required to have basic idea about its output waveforms due to application of various inputs. Hence, they are simulated before being actually implemented in hardware to ensure correct wiring and understanding of the circuit. Solar panels can be simulated in a large number of software, the most popular being the MATLAB software [2]-[4]. However, in this work, we have used LabVIEW to simulate our solar panel since it is user friendly, easy to understand and efficient. The main aim of this paper is to simulate a solar panel using

LabVIEW software. The solar panel consists of four silicon solar cells. The solar cells are connected in parallel to each other to get maximum current output. The input for this network is taken as current whereas outputs are voltage and power. The paper is organized as the following. The Section II discusses the basic theory and problem formulation of the work. The simulation model is given in Section III. The results and discussions are given in the following section. Finally, the paper is concluded with Section V.

2. PROBLEM FORMULATION

The pictorial view of a simple solar cell is shown in Fig. 1.

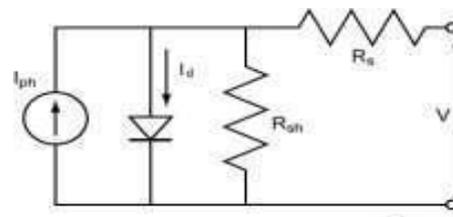


Fig-1: Connection diagram of a typical solar panel.

When light is incident on the photo-diode, a photo-current I_{ph} is produced. This current is split into two, one is the current I_D drawn by the diode itself and the other is current I which flows into the external circuit. Hence, I_{ph} is expressed as a current source. The current I is the current available to us and is used to power other appliances, circuits and devices. Thus,

$$I = I_{ph} - I_D \tag{1}$$

In an ideal circuit, the shunt resistor R_{sh} and series resistance R_s in Fig. 1 would not exist. They are internal parasitic resistances which reduce power dissipation.

Thus, R_{sh} would be infinite and R_s would be zero in an ideal circuit. Hence, the ideal circuit equation can be given as

$$I_D = I_{OC} \left(e^{\frac{qV}{kT}} - 1 \right) - I \tag{2}$$

where I_{OC} is the saturation or dark current of the diode, q is the electron charge, V is the measured cell voltage, K is the Boltzmann constant and T is the temperature.

However, for a non-ideal diode, an ideality factor n , shunt resistance R_{sh} and series resistance R_s have to be considered. The range of R_{sh} is considered as 10 to 1000 of Mega ohms [5]. Shunt resistance is used to determine the noise current in the photo-diode with no bias (photovoltaic mode). For best photo-diode performance, the highest shunt resistance is desired.

The series resistance R_s of a photo-diode arises from the resistance of the contacts and the resistance of the undepleted silicon. It is given as

$$R_s = \frac{P}{A} + R_c \quad (3)$$

where W_s is the thickness of the substrate, W_d is the width of the depleted region, A is the diffused area of the junction, P is the resistivity of the substrate and R_c is the contact resistance. The series resistance is used to determine the linearity of the photo-diode in photovoltaic mode with no bias, $V=0$. Although an ideal photo-diode should have no series resistance, typical values ranging from 10 to 1000 ohms are measured [5]. Hence, the equation of a non-ideal diode can be given as [5]

$$I = I_{ph} - I_{oc} \cdot e^{-\frac{(V + IR_s)}{nKT}} - \frac{(V + IR_s)}{R_{sh}} \quad (4)$$

with n being ideality factor.

3.SIMULATION

To simulate the solar panel on LabVIEW, we have used the following steps and also shown by the Flowchart in Fig.

- First, we will input the parameters by creating a control type constant for I_{ph} and I_{oc} .
- Create numerical constant of value 1.6×10^{-19} for q . Create control type constants for n and T and multiply them. Now create a constant of value 91.38×10^{-23} for K . Multiply it with output of nT . We get nKT . Divide it by q .
- Divide I_{ph} by I_{oc} . Increment it by 1. Now pass this expression through a log function box. We get $\log_e((I_{ph}/I_{oc})+1)$.
- Multiply the above two expressions to get V_{oc} [5].
- Next, we insert a "for" loop which will start with $j=1$ and increment each time the loop is completed till it reaches 100. Inside the loop

we will implement the $V=jV_{oc}/100$ to divide the V_{oc} into 100 divisions. Now, we implement the Eq. 4.

- Next, create control type constants for R_s and R_{sh} . Multiply R_s with I . Add it to the V and multiply with q . We get $q(V+I.R_s)$. Divide it by nKT . Decrement it by 1, pass the resulting expression through an exponential function. Multiply this final expression with I_{oc} . We get

$$I_{oc} \cdot e^{-\frac{(V + IR_s)}{nKT}} - 1$$

- Now divide $(V+I.R_s)$ by R_{sh} . Subtract this from the above expression. We get ID . Subtract ID from I_{ph} . We finally get current I . Now multiply I and V . This product is the power P .
- Hence, we create a control type constant which will denote the number of solar cells. We multiply this value with all the parameters: I , V and P .
- We now feed the output of these three products into three arrays each of one-dimension. The values of each of the arrays of voltage, current and power are fed into three separate files for storage. The circuit is now complete.
- Select the values and plot the P - V graph and I - V graph by inputting the values in MATLAB. Following these steps, the simulation circuit can be drawn and given in Fig. 3.

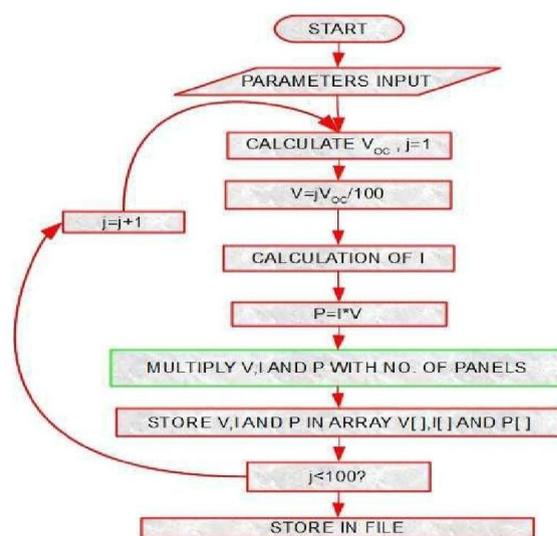


Fig -2: Flowchart of the Simulation Model solar panel made up of four solar cells. The parameters,

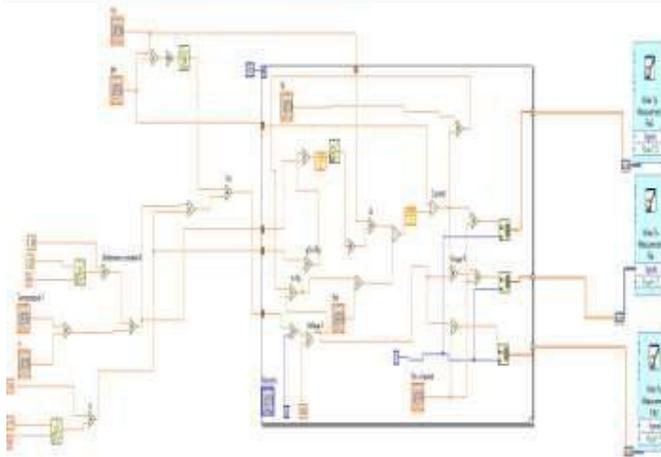


Fig -3: Block diagram of the LabVIEW model

4. RESULTS AND DISCUSSION

Our circuit is now complete. We shall now input some values as an example to show simulation and check our circuit. After simulation, we shall follow steps 13, 14 and the outputs are obtained. The following parameters are given as inputs in the LabVIEW circuit [6], [7]: $T = 298\text{ K}$, $n = 2.8$, $IOC = 0.0008\text{ A}$, $I_{ph} = 2.5\text{ A}$, $R_s = 0.02\text{ ohm}$, $R_{sh} = 2000\text{ ohm}$, number of panels is taken as four. After simulation, the following results are obtained

From Fig. 4, it is observed that as the voltage is increased, the current is maintained at 10 A and after a certain value of voltage, i.e. approximately 1.5V, the current starts decreasing and goes to zero. The relation between power and voltage is shown in Fig. 5. The power increases linearly with voltage and after approximately 1.8V, it starts decreasing and settles at $P = 0$

In [5], almost same technique is used to simulate another solar cell. However, in that paper only one solar cell was used. Hence, the generated power and current was small. In our work, it has been shown that the current and power can be improved with more cells connected in parallel and better utilization of the renewable energy can be done

It may be noted that we have taken practical values for a such as temperature and n can be changed depending on the environment. The resistances, R_s and R_{sh} can be replaced depending on availability. The current I_{ph} is dependent on solar intensity and IOC will change depending on the components of the diode. Although the number of solar cells can be increased to improve the outputs, but some optimization technique can be used to limit the number of solar cells to obtain the desired output. This will be our future scope of study

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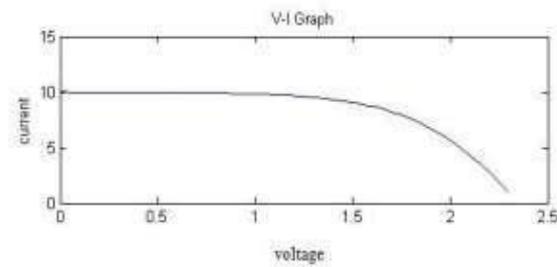


Fig -4: The output I-V characteristics

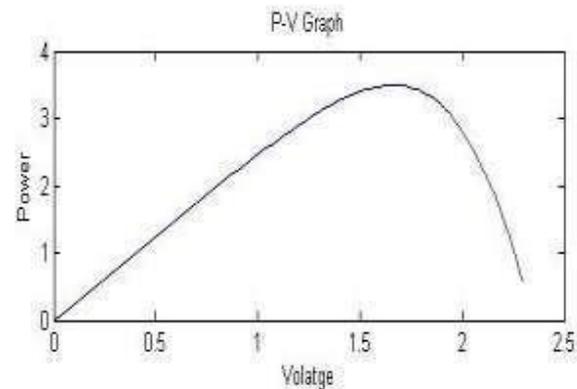


Fig -5: The output I-V characteristics.

5. CONCLUSIONS

In this paper, we simulated a solar panel made of four solar cells at a temperature of 298 K and with an ideality factor of 2.8. The advantage of this circuit is that we can change the values of the parameters to simulate solar panels made up of different number of solar cells at different conditions up to a suitable limit. We also obtain a suitable range of values for current and power which can later be optimized using MPPT (maximum power point tracking system) to increase efficiency. Hence, we obtain an efficient system which can use solar energy

6. ACKNOWLEDGEMENT

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REFERENCES

- [1] S. P. Sindhu, V. Nehra, S. Luthra, "Recognition and prioritization of challenges in growth of solar energy using analytical hierarchy process: Indian outlook", *Energy*, vol. 100, pp. 332-348, 2016
- [2] J. Walker, Geoff, "Evaluating MPPT converter topologies using a matlab PV model", *Aust. J. Electr. Electron. Eng.*, vol. 21, no. 1, 2001.
- [3] H. Atlas, M. Sharaf, "A fuzzy logic power tracking controller for a photovoltaic energy conversion scheme", *Electr. Power Syst. Res.*, vol 25, pp. 227-238, 1992.
- [4] H. Belliaa, R. Youcefb, M. Fatimab, "A detailed modeling of photovoltaic module using MATLAB NRIAG Journal of Astronomy and Geophysics, vol. 3 no. 1, pp. 53-61, 2014
- [5] G. Yang, M. Chen, "LabVIEW Based Simulation System for the Output Characteristics of PV Cells and the Influence of Internal Resistance on It", *ICIE '09*
- [6] Proceedings of the 2009 WASE International Conference on Information Engineering, vol. 1, pp. 391-394, 2009
- [7] <http://www.pveducation.org/pvcdrom/solar-cell-operation/open-circuit-voltage>
- [8] <http://www.ni.com/white-paper/7230/en/>.