# Analysis of Impact of Variation of Parameters on the Power of Solar Module

Anu Khandelwal,
M.Tech student and Vandana Khanna,
Senior Assistant Professor
ITM University, Gurgaon-122017, India

*Abstract*- **A MATLAB based study of solar module has been presented in this paper. There are many parameters which can affect the power of solar cells such as solar irradiation, series and shunt resistances, saturation currents, temperature etc. The observations are taken by varying parameters with different patterns. To observe their effect with temperature and irradiance, the average values are varied according to the meteorological data of city New Delhi taken monthly from the year 2000 to 2012 and then accordingly power is observed for each case.**

*Keywords— Solar cell, solar module, parameters, MATLAB, power*

## 1. INTRODUCTION

With the problem of increasing energy crisis the experiments and research in the field of renewable energy has become the primary focus for all. The renewable energy consists of areas like wind energy, solar energy, water etc [1]. The solar energy is eco friendly and green. It is infinitely available to us and easy to access and use. In today's era of conventional energy sources, the solar energy is going to be a suitable substitute [2].

Due to these reasons, the photovoltaic cells came into existence. The photovoltaic cells convert solar energy into electrical energy for us to use. They work on the principle of photovoltaic effect [3]. A basic unit of solar cell can generate voltage up to 0.5V. But this small amount of voltage is not much of use for us. So, to get higher voltage these solar cells can be connected into series in the order of 24 or 36 cells [4]. This series connection is known as solar module. A solar module can give us voltage up to 12-18V. By connecting no. of modules according to our need solar panels are made which can be mounted anywhere and can be used for domestic and commercial purpose [5].

The practical experiments on solar cells are not an easy task. So, the simulations are done to test and observe the variations. There are many parameters which can affect the efficiency of solar cells such as solar irradiation, series and shunt resistances, temperature etc. Various simulation software are available but MATLAB has been used in this work [6]. MATLAB consists of solar cell unit, power sources and other models which are needed to design a solar cell module. The observations are taken by varying parameters with different patterns. To observe their effect with temperature and irradiance, the values are varied according to the meteorological data of city New Delhi and then accordingly power is observed for each case [7].

## 2. SOLAR CELL MODEL

As a solar cell behaves differently in different conditions therefore an equivalent model of cell is used for simulation. A solar cell behaves as a current source in ideal case. To observe the variation in parameters of solar cell the I-V characteristics are to be studied. I-V characteristics can be obtained using two types of models: Single cell and Double cell model.
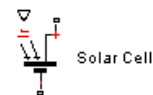


Fig. 2.1: Symbol of solar cell

The two diode model of solar cell is as shown below in fig. 2.2. It consists of two diodes D1 and D2. Two resistances are used, one series resistance Rs, taken as 0.001 ohm in ideal case and other shunt resistance Rsh, taken as 100 ohm in ideal case.

$I_{ph}$ is the photo generated current which can be represented as current source and it is proportional to light as input as shown in eq. (1).
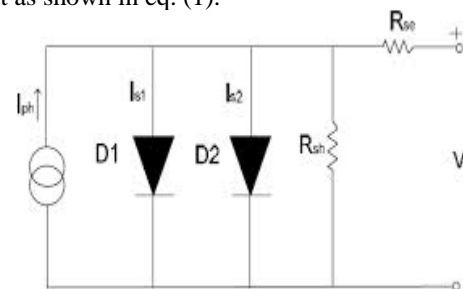


Fig. 2.2 Two diode solar cell model

The output current I is :

$$I = I_L - I_{01}[e^{V+IRs/a_1 V_{t1}} - 1] - I_{02}[e^{V+IRs/a_{2V t2}} - 1] - (V + IRs/R_p)$$

(1)

Where,

$$I_L = I_{L0} \times I_{r0}/I_r$$

(2)

k- Boltzmann constant,
q- charge of an electron,
Ir- irradiance in W/m2,
T- Measurement temperature value,
N- diode ideality factor,
V- voltage across the electrical ports,
Is- diode reverse saturation current,
Ipho- photo generated current for standard irradiance Iro,
I-Output current of cell

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 04, April-2015

## 3. SIMULATION AND RESULTS

The simulation for 36 cell solar module has been done in MATLAB. It consists of 36 solar cells, irradiance block for variation of irradiance, SPICE environmental parameters for variation of device temperature. The current sensor senses the current same as voltage sensor senses the voltage. The power is product of current and voltage therefore product block is used.
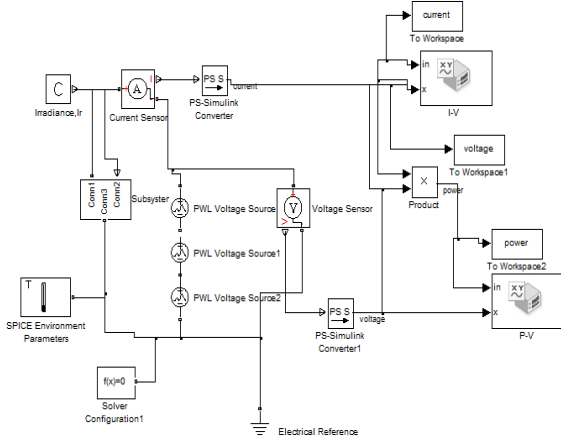
As a result, we get I-V and P-V curves.



Fig. 3.1: MATLAB model of 36 cell solar module

Fig.3.1 shows the complete MATLAB solar module for 36 cells, where 36 solar cells are shown using black box.

The fig. 3.2 shows the 36 solar cells connected in series to get a voltage of up to 18V. These solar cells can be connected into any form such as series or parallel according to the requirement.

Also, instead of 36 cells 24 solar cell modules are also being used for some applications.

The curve for I-V characteristics and P-V characteristics were obtained for this solar module by varying parameters one by one and together as well and the power for every simulation was observed.
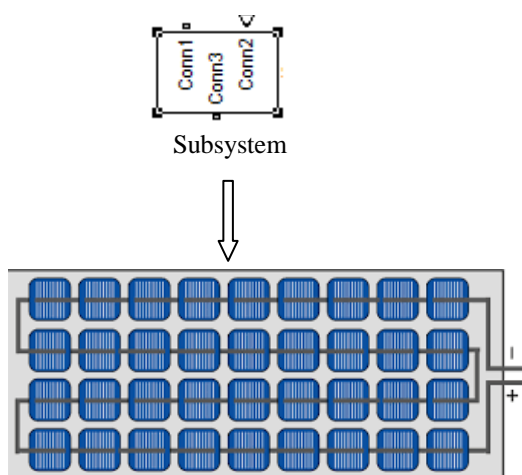


Subsystem



Fig. 3.2: 36 solar cells connected in series

A single subsystem consists of 36 solar cells connected in series.

### a. When constant values of parameters were taken

In this case, circuit temperature was taken as 25°C and standard irradiance as 1000W/m2, according to STC. Other parameters values were taken constant such as series resistance 0.02 ohm, shunt resistance 98ohm, diode saturation current 1 as 1nA, diode saturation current 2 as 10nA and Ideality factor as 1.The P-V and I-V characteristics curves are as shown in fig. 3.2 below:-
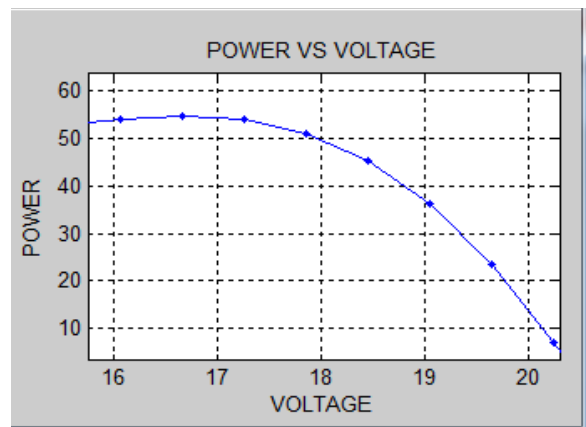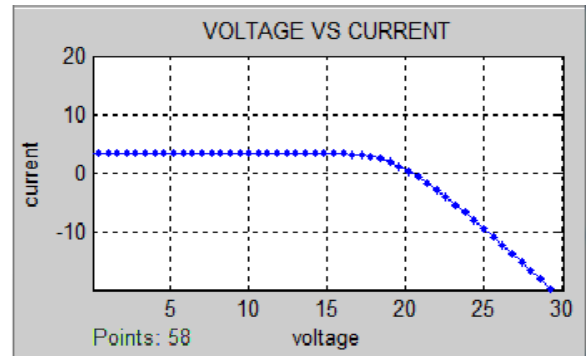


Fig. 3.2: P-V and I-V curves, when constant values of parameters are taken

The maximum power observed in this case is 55W.

### b. When all the parameters are varied one by one except irradiance and temperature

In this case, the circuit temperature and irradiance are kept constant according to STC while other parameters such as series and shunt resistance, saturation current etc are varied with a variation of 10%, give or take, one by one. The values of parameters are taken randomly. For each parameter 20 simulations are done and the average value of all the simulations is shown as result.

The power value for each parameter variation is tabulated in table 3.1 below:-

| Variation of parameters | Power (W) |
|---|---|
| Variation in series resistance | 53 |
| Variation in shunt resistance | 55 |
| Variation in saturation current(IO1) | 48 |
| Variation in saturation current(IO2) | 57 |

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Table 3.1: Power values with variation of parameters by 10% and simulated at STC

It can be observed from the above values that the variation of even a single parameter affect the power of solar module.

c. *When all the parameters are varied simultaneously except temperature and irradiance*

In this case, all the parameters are varied simultaneously while temperature and irradiance are kept constant.
The I-V and P-V characteristics curves are as shown in fig. 3.3 below:-
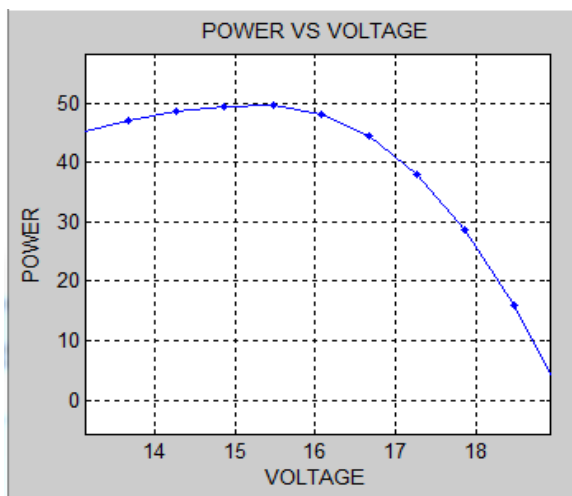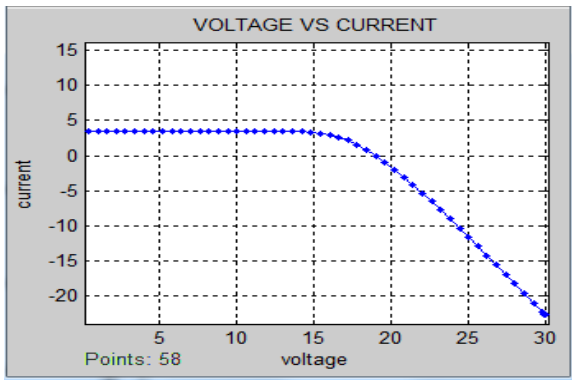


Fig. 3.3: I-V and P-V curve when all the parameters are varied simultaneously except temperature and irradiance

The maximum power in this case is 50 W.

d. *When all the parameters are varied,*
(a) With variation in temperature,

In this case, all the parameters mentioned in last case are varied with variation in temperature but irradiance is kept constant. The temperature values are taken from meteorological data of city New Delhi i.e. monthly lowest and highest temperature of the city and the corresponding values of power are observed [7].

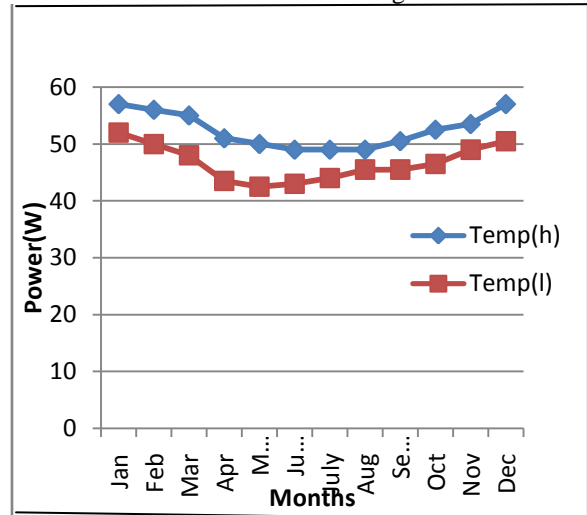The values are as shown below in Fig 3.4:-



Fig. 3.4: Power values with variation in temperature, when all the parameters are varied

As it can be seen from the Fig.3.4 above, that as the temperature increases the power decreases. It happens because as the temperature increases, the current increases but voltage decreases. This decrement in voltage is faster than increment in current and so the overall power of the cell decreases.

(b) With variation in irradiance,
In this case, all the parameters with irradiance are varied except temperature. The irradiance values are taken from meteorological data of city New Delhi i.e. monthly irradiance value of the city and corresponding power is observed [7].
The observations are tabulated in table 3.3 as below:-

Table 3.2: Power values with variation of irradiance, when all the parameters are varied too

| Month | Irradiance (W/ m2) | Power(W) |
|---|---|---|
| January | 344 | 35 |
| February | 466 | 50 |
| March | 605 | 60 |
| April | 686 | 67 |
| May | 704 | 70 |
| June | 631 | 62 |
| July | 537 | 53 |
| August | 525 | 52 |
| September | 533 | 53 |
| October | 496 | 51 |
| November | 390 | 40 |
| December | 326 | 33 |

E. *When all parameters are varied simultaneously with temperature and irradiance*

In this case, all the parameters such as series and shunt resistance, saturation currents are varied and also temperature and irradiance monthly values were varied according to the data of city New Delhi [7].The power observed are as tabulated below:-

Table 3.3: Power values with variation of both temperature and
irradiance, when all the parameters are varied

| Month | Irradiance (W/ m2) | Low Temp (°C) | Power (W) |
|---|---|---|---|
| January | 344 | 8 | 29 |
| February | 466 | 11 | 53 |
| March | 605 | 16 | 66 |
| April | 686 | 21 | 72.5 |
| May | 704 | 26 | 72.5 |
| June | 631 | 28 | 64 |
| July | 537 | 27 | 55.5 |
| August | 525 | 27 | 54 |
| September | 533 | 25 | 55.5 |
| October | 496 | 19 | 53.5 |
| November | 390 | 13 | 44 |
| December | 326 | 8 | 37.5 |

| Month | Irradiance (W/ m2) | High Temp (°C) | Power (W) |
|---|---|---|---|
| January | 344 | 20 | 34 |
| February | 466 | 50 | 43 |
| March | 605 | 30 | 61 |
| April | 686 | 37 | 66 |
| May | 704 | 40 | 65 |
| June | 631 | 38 | 61 |
| July | 537 | 35 | 53 |
| August | 525 | 34 | 52 |
| September | 533 | 34 | 53 |
| October | 496 | 33 | 50 |
| November | 390 | 28 | 40 |
| December | 326 | 23 | 35 |

Two graphs shown in Fig. 3.4 are for example and
depicts (a) for the month of February (b) for the month
of May.
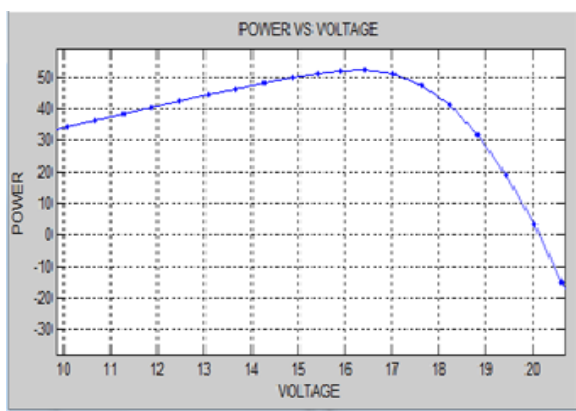


(a)
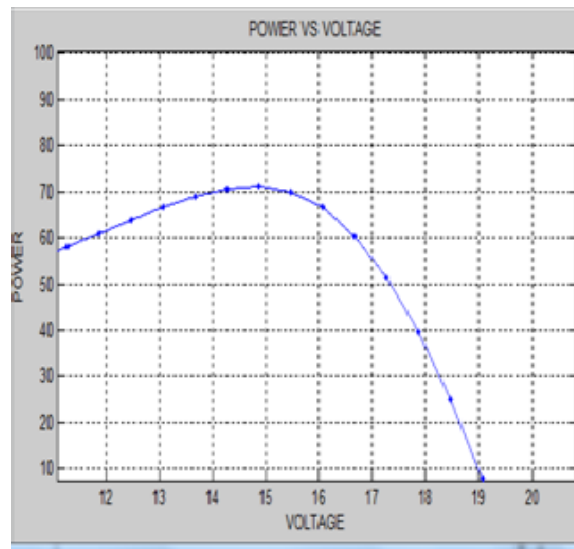


(b)

Fig. 3.5: The P-V curves show power of (a) 53W (b) 72.5 W

If we look at fig. 3.5, we see that in above curve (a),
irradiance is 466W/m2 while temperature is 11°C and
power is 53W. In curve (b), with 704W/m2 irradiance and
26°C temperature, power is 72.5W.
If we compare it with fig. 3.1, we can observe that even
with slight variation in irradiance and temperature, there is
large variation in power.

## 4. CONCLUSION

The solar module with 36 cells has been simulated in
MATLAB. It can be observed from the results that the
variation in parameters of solar cell with environmental
factors such as irradiance and power shows high variation in
power as well. So, it can be concluded that to increase the
power of the module, these parameters should be taken care
of. They can behave differently in different environmental
conditions.

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