ENVIRONMENTAL IMPACT ON SOLAR PHOTOVOLTAIC MODULE AND ITS DETAIL ANALYSIS FOR DIFFERENT VARYING PARAMETERS

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Abstract: With rapid use of Solar Photovoltaic (PV) cell under different environmental conditions is utilized to mitigate sort of power fall in micro grid. For better Solar cell concert, various parasitic resistance are used to improved output power and further energy efficient under different conditions like weather temperature irradiation. This paper presents a comparatively study on dip daylight hour with respect to average daylight hour of an annual weather condition under different environmental. In this paper , the objective is focused on power and fill factor which is affected by parasitic (shunt) resistance depends on open circuit voltage (V_{OC}) and short circuit (I_{SC}) current with the help of MATLAB/SIMULINK model.

Keywords: Solar PV cell, shunt resistance, irradiation, Fill factor, Month, MATLAB/SIMULINK.

I. INTRODUCTION

Photovoltaic (PV) systems have become popular, its annual growth rate is increasing in recent years and also emerging as an alternative pure energy sources due to its numerous advantages features like maintenance free, pollution free and reliable. On the other hand the conventional energy like the fossil fuels are rapidly destroying, oil prices are rising and our environment is badly affected and contaminated. Photovoltaic effect, which converts solar energy to electrical energy directly without harming the environment, can be considered the most essential and the most sustainable resource because solar energy is widely available and completely free of cost. The stipulation of solar energy has substantially increased by 20%-25% in recent past 20 years. The popularity of PV system is increasing for its features like economic in scaling, increasing in efficiency and improved in manufacturing technology. Research works are being held to improve efficiency, cost and reliability. PV mathematical simulation models are required in order to analyze the performance of the newly developed system. Simple mathematical model of PV modules have been proposed. Besides that, some indirect method by using soft-computing, have been discussed in literatures. But those are complicated and required lots of mathematical computation.

In this paper, a simple compact mathematical modeling of PV module has been simulated using MATLAB/SIMULINK and details analysis have been made in order to observe its characteristics like voltage-current (V~I) and power-voltage (P~V) for different varying parameters such as irradiances, temperatures and shunt resistance. Along with that, 12 months (January-February) PV characteristics comparison between average daylight hour and pick daylight hour of a city (Dhanbad) has been explained and their characteristics curves are shown.

II. EQUIVALENT CIRCUIT OF PV MODULE

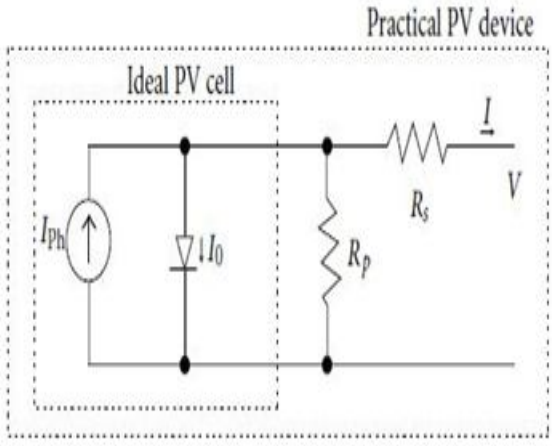


Fig. 1. equivalent circuit of PV cell

A PV module is consists of many solar cell which are connected in series and parallel. Reason for this series and parallel connection is to obtain desired voltage and current. Each solar cell is represented by single p-n junction diode.

When energy exceeding a certain threshold value (band gap energy) is applied to a valence electron, the bonds are broken and the electron is free to move around in a new energy band called the conduction band where it can conduct electricity through the material. Thus, the free electrons in the conduction band are separated from the valence band by the band gap. This energy needed to free the electron can be supplied by photons, which are particles of light. When the solar cell is exposed to sunlight, photons hit valence electrons, breaking the bonds and forcing

them to the conduction band. PV cell are connected in larger numbers called PV module which are further grouped in series parallel connection to form PV arrays. Following are the basic equations. These equations are taken from the basic theory of photovoltaic. These equations are represent the I-V characteristics of PV module.

2.1 Photocurrent

Photocurrent is exists due to photons which are move in light in the form of energy packets. These photons are responsible for generation of current.
Photocurrent is proportional to solar insolation and is also depend on temperature.

$$I_{Ph} = [I_{SC} + K_I(T - T_R)\lambda] \quad .....(1)$$

Where I_{Ph} is photon generated current at standard test condition (AM=1.5, 25℃, 1sun=1000W/m^2) , T is actual temperature (kelvin),T_R is reference temperature (kelvin) , K_I is short circuit current temperature coefficient(0.0017A/K) and λ is insolation in W/m^2,I_{SC} is module short circuit current

2.2 Module reverse saturation current

Module reverse saturation current $I_{rs}$is proportional to module short circuit current I_{SC} but it also depend on various factors.

$$I_{rs} = \frac{I_{SC}}{[\exp(\frac{qV_{OC}}{N_S kAT})-1]} \quad .....(2)$$

Where V_{OC} is module open circuit voltage, N_s is number of solar cell connected in series, q is an electron charge ($1.6 * 10^{-19}$C) , A is ideality factor and k is Boltzmann constant($1.3805*10^{-23}$ J/K)

2.3 Module saturation current[10]

Module saturation current$I_o$is varies with the cell temperature and this is given by

$$I_o = I_{rs}\left[\frac{T}{T_r}\right]^3 \exp\left[\frac{q*E_g}{Ak}\left\{\frac{1}{T_r} - \frac{1}{T}\right\}\right] \quad .....(3)$$

Where E_g is band gap energy of the semiconductor material.

2.4 Module output current

Output current of PV module of single diode model is given by

$$I_L = N_P * I_{Ph} - N_P * I_o\left[\exp\left\{\frac{q*(V_L+I_L R_s)}{N_S AKT}\right\} - 1\right] - V_L + (I_L R_s)/R_{sh} \quad .....(4)$$

Where $N_P$parallel connection of PV cells is, $V_L$is open circuit voltage, R_s is equivalent series resistance and R_{sh} is equivalent parallel resistance

In above equation R_{sh} has great effect. When the value of R_{sh} is very small then open dcircuit voltage and fill factor is reduced so the value of R_{sh} is sufficiently large hence neglected to simplify the model equation , so equation (4) can be written as

$$I_L = N_P * I_{Ph} - N_P * I_o\left[\exp\left\{\frac{q*(V_L+I_L R_s)}{N_S AKT}\right\} - 1\right] \quad .....(5)$$

III. VARIATION OF DIFFERENT PARAMETERS

3.1 constant temperature (25℃) with different irradiation

Figure 2 and 3 shows V-I and V-P characteristics with different irradiation (1000W/m^2, 800W/m^2, 600W/m^2, 400W/m^2) with constant temperature (25℃)

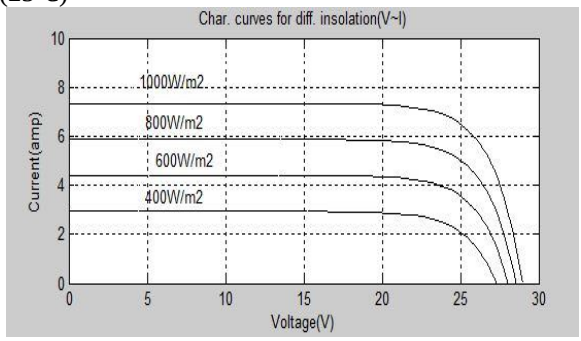


Fig 2 V~I Curves for different irradiation at constant temperature

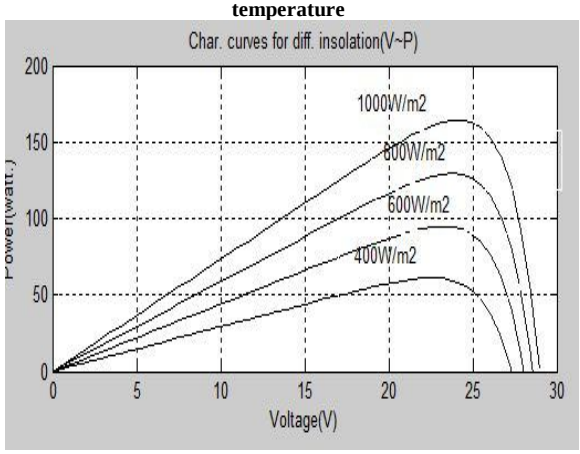


Fig. 3. V~P Curves for different irradiation at constant temperature

3.2 Constant irradiation(1000W/m^2)with different temperature

In this case, temperature is taken as variable (65℃, 45℃, 35℃, 25℃) and irradiation is taken as constant with value 1000W/m^2.

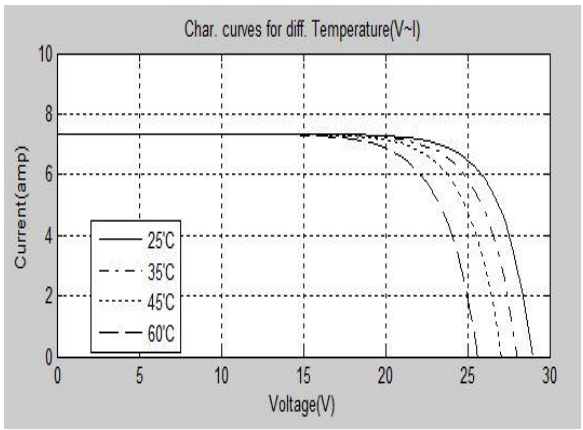


Fig .4. V~I Curves for different temperature at constant irradiation

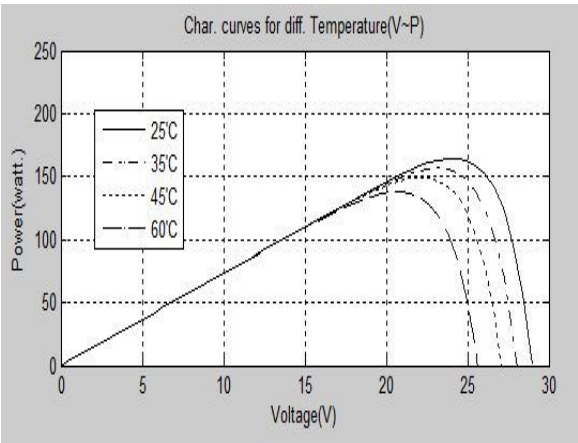


Fig. 5. V~P Curves for different temperature at constant irradiation

3.3 Variation of shunt resistance

For variation of shunt resistance (parasitic resistance) we use single solar cell. Here we consider cell temperature is 25ºC and insolation is 1000 W/m2. we know that value of shunt resistance should be large because at large value of shunt resistance, pv cell current and voltage is increases so accordingly output power is increases and fill factor improves. Fill factor is the measure of squareness of I-V characteristic of solar cell and it is always less than one. [8] At low value of shunt resistance fill factor & output power is reduces. These results can be seen in table 1.

Table 1: Effect of shunt resistance on performance parameters of a solar cell

Rsh (Ω)	Isc(A)	Voc (V)	Pmax (W)	Fill factor	% loss	
					Pmax	FF
200	3.8	0.59	1.38	0.626	_	_
40	3.75	0.57	1.27	0.594	8	5
20	3.7	0.54	0.66	0.330	52	47
10	3.6	0.37	0.38	0.285	72	54
5	3.5	0.19	0.18	0.270	86	68

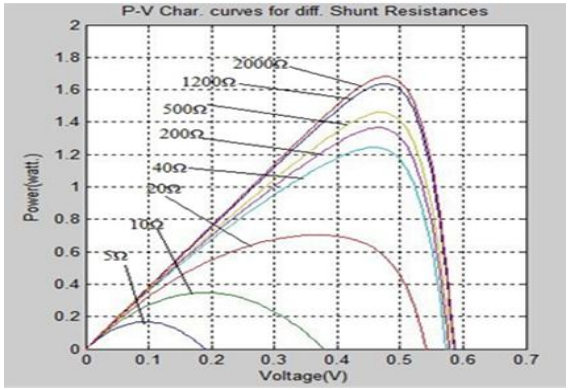


Fig.6. V~P characteristic curve for different shunt resistance

Fig.6. P-V characteristic curve for different shunt resistance is drawn by MATLAB program. Various value of shunt resistances are 5Ω, 10Ω, 20Ω, 40Ω, 200Ω, 500Ω, 1200Ω, 2000Ω Figure 6 shows that changing the shunt resistance value, changes the output power fastly but voltage varies slowly. The overall impact of reducing the shunt resistance value is it reduces the maximum power point. By the figure 6 we see that by increasing the value of shunt resistance, voltage is increasing but it constant after some higher value of shunt resistance.

Fig 7 shows I-V characteristics curve for different value of shunt resistance. Different values of shunt resistance are 5Ω, 10Ω, 20Ω, 40Ω, 200Ω, 500Ω, 1200Ω, 2000Ω. By decreasing the value of shunt resistance, voltage & current is decreases but by Increasing shunt resistance value, voltage of PV cell increases fastly.

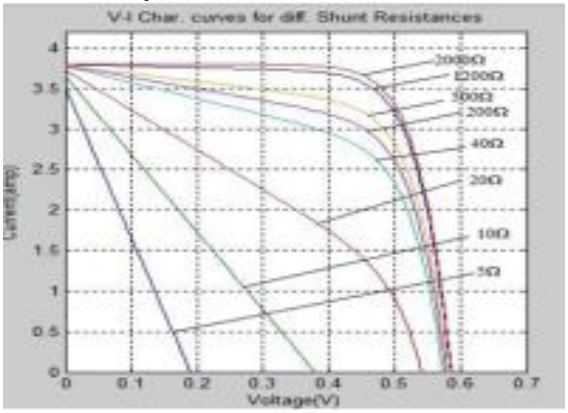


Fig.7. V~I characteristic curve for different shunt resistance

IV. DETAILS OF DATA INCLUDING TEMPERATURE AND INSOLATION FOR DHANBAD INDIA

Dhanbad Latitude °N 23.79 Longitude °E 86.45

Table 2 contains all month corresponding to their average temperature and average insolation. In table 1 we consider only 6 hour operation but in table 2 we use average daylight hour for a particular month. In table -2, March month has maximum insolation but in table 3 February month has maximum insolation. In program we simply put the value of insolation of all months with their respective temperature value. By this program we can calculate output power for any location.

TABLE 2. Temperature and insolation with 6 hours a day [9]

Month	22 year avg insolation (kWh/m2/day)	Insolation (W/m2, considers 6hours a day)	22 year avg temperature (°C)
January	5.34	890.00	18.3
February	5.96	993.33	21.9
March	6.04	1006.66	26.6
April	5.97	995.00	28.9
May	5.67	945.00	28.8
June	4.47	745.00	28.3
July	3.97	661.66	27.4
August	3.92	653.33	27.1
September	4.15	691.66	26.5
October	5.01	835.00	24.5
November	5.25	875.00	21.9
December	5.23	871.66	19.0

TABLE 3. Temperature and insolation with average daylight hour [9]

Month	22 year avg insolation (kWh/m2/day)	Average daylight hours	Insolation (W/m^2)	22year avg temperature
January	5.34	10.9	489.90	18.3
February	5.96	11.4	522.80	21.9
March	6.04	12.0	503.33	26.6
April	5.97	12.6	473.80	28.9
May	5.67	13.2	429.54	28.8
June	4.47	13.4	333.58	28.3
July	3.97	13.3	286.46	27.4
August	3.92	12.9	289.92	27.1
September	4.15	12.3	334.95	26.5
October	5.01	11.6	431.03	24.5
November	5.25	11.0	481.81	21.9
December	5.23	10.7	505.76	19.0

By comparison of figure 8 and figure 10 we see that current is decreases in figure 10 with respect to figure 8. Similarly by comparison of figure 9 and figure 11 we see that power is reduces in figure 11 with respect to figure 9. In figure 10 we see that maximum value of current is 50 % of maximum current of figure 8. For peak daylight hour maximum output power 165 watt but for average daylight hour maximum output power 80 watt i.e 50 % loss. For peak daylight March month has maximum output power and august month has lowest output power. & for average daylight hour February has maximum output power and july has lowest output power.

IV. RESULTS AND DISCUSSION

From figure 9 we see that march month has maximum output power for peakday light hour and in figure 4 february month has highest output power for average daylight hour. By the matlab program we can draw the charactersicts curve of solar module for any location. We can also consider some parameter by some modification in program. By the figure 6 we see that low shunt resistance reduces the voltage of cell and cell current so output power decreases i.e value of shunt resistance should be high. By the table 1 we can say that at lowest value of shunt resistance fill factor is reduces by 68 % & output power is reduces by 86%

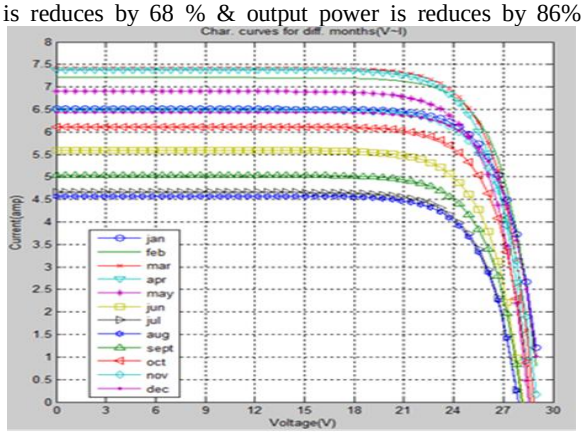


Fig.8.V-I curve for different months for peak daylight hour

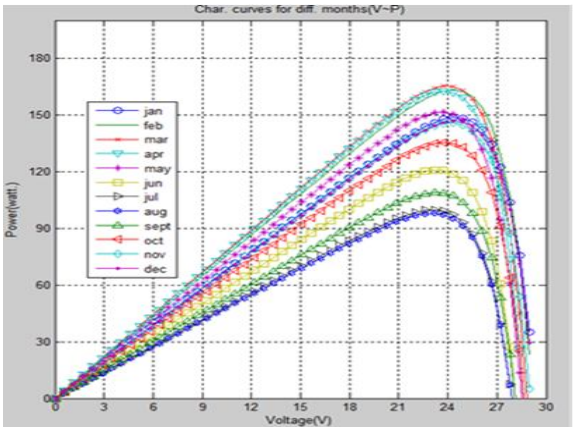


Fig.9. V-P curve for different months for peak daylight hour

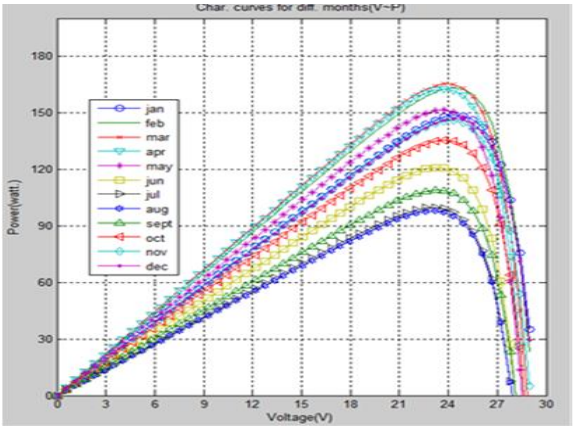


Fig.10.V-I curve for different months for average daylight hour

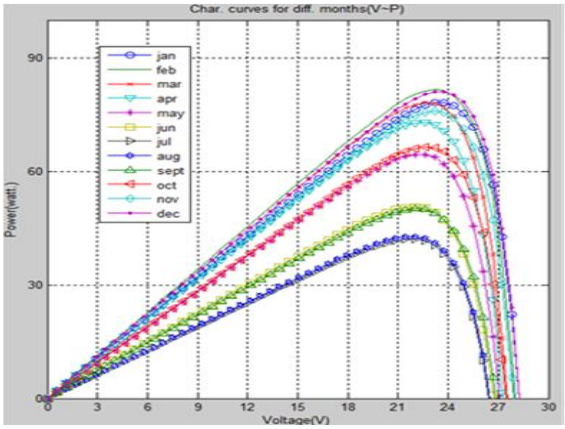


Fig.11.V-P curve for different months for average daylight hour

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