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SIMULATION AND ANALYSIS OF MATHEMATICAL MODEL OF PV MODULE

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Abstract **– The primary aim of the present work is to assess the performance of photovoltaic module. The paper presents the development of a MATLAB/SIMULINK model for the solar PV cell. The simulation of photovoltaic model for obtaining the performance characteristic has also been carried out in this paper. The developed the is the simulated and validated experimentally solar panel . the experimental results obtained , exhibited a good agreement with the simulated data.**

Keywords**— Photovoltaic module, simulink, matlab**

I. INTRODUCTION

In last few years, global warming have become important issue on international agenda. Green houses gas emission; demanding to be reduced by developed countries. The production of energy based on fossil full is declining therefore clean energy source production is increasing for future development. As requirement and need of energy is increasing around the world. Important issue is growing an alternative energy resource.

Standalone PV systems are used to provide electricity to the isolated users or loads remote as of the electricity grid and hard to feed as of poorly accessible areas. In this technique it is compulsory to store energy produced by PV system with battery to feed the load at night or when sun is not present.
Grid connected PV system are parallel connected to public grid and design to input energy produced into same as becoming power plant. They are used to condense the energy requirements of building for public use.

The PV module gives the output directly proportional to the irradiance and temperature by using photoelectric effect. If there is partial shading on array then that is tracked and studied my MPPT block using technique to extract the MPP.

II. STAGES OF PV ARRAY

There are three stages of a PV array:-

- Power generation
- Power conversion and conditioning
- Power distribution

Figure1-1 BLOCK DIAGRAM OF A GRID

The power is generated by modelling of PV array. The power is controlled by MPPT controller and maximised using BOOST converter. This DC output voltage is converted to AC voltage using inverter and directly supplied to the load.

III. PHOTOVOLTAIC ARRAY

When a two or more modules are connected in series or parallel they form a Photovoltaic array. The power produced by single module is not enough to meet the requirements of the load. Many PV module are connected in series to obtain large output voltages and in parallel in

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order to achieve the large output currents. In rural areas these arrays are directly used for agricultural purposes and can be used to directly generate electricity for household purposes.

IV. PV CELL

A photovoltaic cell is a semiconductor gadget whose p-n intersections are presented to daylight. It is comprised of a few distinct sorts of semiconductor gadgets. Si PV cells are for the most part utilized in light of the fact that they are the stand out whose creation is monetarily possible in huge scale. Fig 2 delineates the physical structure of a PV cell.

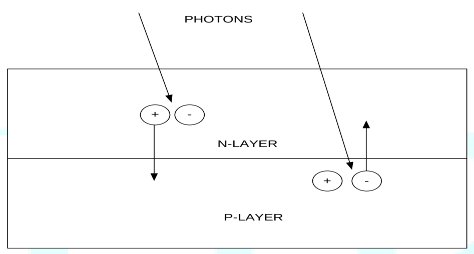


Fig 2. Physical structure of solar cell

PV cell chips away at the rule of photoelectric impact. At the point when daylight hits the surface of the matter, electrons gets catapulted from the conduction band and some bit of the sun oriented energy is consumed by the semiconductor. The electrons from the valence band hops to the conduction band when the energy of the photons is more noteworthy than the band crevice vitality of the PV cell. Photons with energy not exactly the band gap energy are pointless and create no current and voltage.

Photons energy more prominent than the band hole energy are utilized to produce power. These electron gap sets are made in the district of the semiconductor. These electrons are allowed to move in the heading by the activity of the electric field introduce in the PV cells. These electrons embody current and can be utilized for outside utilization. These voltage and current produces indebted force

V. EQUIVALENT CIRCUIT OF SOLAR CELL

The electrical model of solar cell can be represented in the Fig 2:

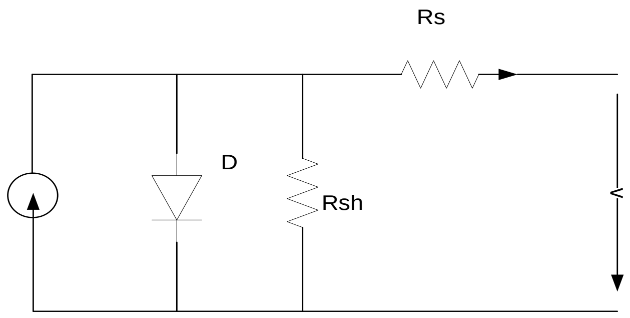


Fig – 3 Equivalent circuit of a solar cell

The voltage-current equation is expressed as:

$$I = I_L - I_D \left(e^{\frac{q(V-IR_S)}{AKT}} - 1 \right) - \frac{V-IR_S}{R_{SH}} \quad [1]$$

Where I is output current, Vis the O/P voltage, Io is the dark saturation current, q is charge of an electron, A is diode quality (idealistic) factor, K is Boltzmann constant, T is absolute Temperature, R_s is series resistance, R_{sh} is shunt resistance of the solar cell, R_s represent existing by contact and bulk semiconductor material of solar cell. Origin of R_{sh} is difficult to explain (related to non ideal nature of p-n junction). In ideal case: R_s would be zero & R_{sh} would be infinity.

However ideal situation is not possible or manufactured the performance of semiconductor can be improved by minimizing the effect of resistance. As to simplify the model [10] effect of shunt resistance is not considered and neglected.

A PV panel is collected of many solar cells. In PV panel the solar cells are connected in series and parallel so as to get the required output current and voltage of PV panel & high enough to fulfil the requirement of the equipment.Taking into consideration the simplification model of solar cell as shown in Fig – 3.2.

$$I = n_P I_L - n_P I_D \left(e^{\frac{q(V-IR_S)}{AKTn_S}} - 1 \right)$$

n_p & n_s are number of solar cell in parallel & series respectively.

The practical PV device has a series resistance R_S whose influence is stronger when the device operates in voltage source region and for current source region parallel resistance is used. R_S resistance is sum of several resistance. It depends on the contact resistance of metal base with p semiconductor layer,resistance of p-n junction bodies,the contact resistance of the n layer with top layer of the n layer with top grid and the resistance of grid[2]. R_P resistance exists due to the leakage current of the p-n junction. Fig 4 shows the equivalent circuit of the practical PV device including the series and parallel resistance.

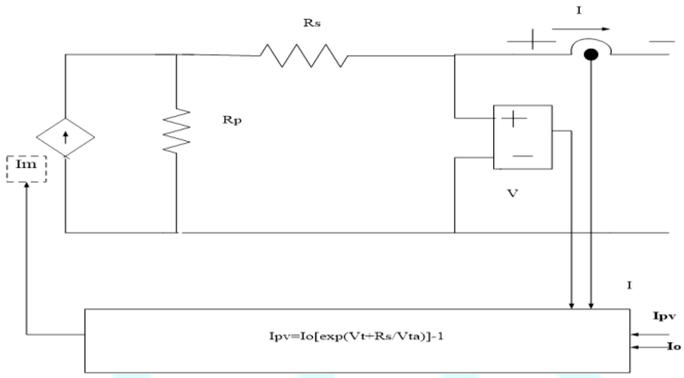


Figure 4 EQUIVALENT CIRCUIT OF PV ARRAY WITH CURRENT EQUATION

Generally R_P is high and R_S is low. The I-V characteristics of a practical PV device is given as fig 5.

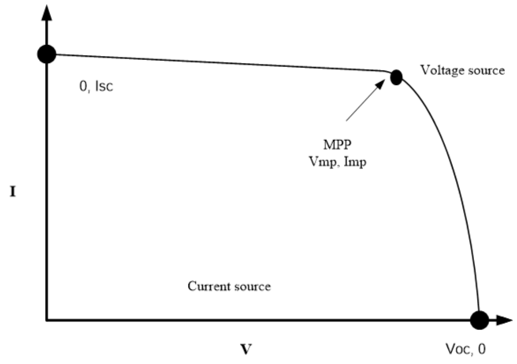


Figure 5 CHARACTERISTICS I-V CURVE OF A PRACTICAL PV DEVICE

The above curve represents the I-V characteristics of a practical PV device which shows three points:open circuit (V_{sc},0).short circuit (0,I_{sc}),MPP (V_{mp},I_{mp})

According to circuit in fig 3 kirchhoff's law is applied to present the photovoltaic current.

$$I_m = I_{PV} - I_d(N_{ss} * N_{PP})\text{..................}[1]$$

$$I_m = I_{PV}N_{PP} - I_O N_{PP}[\exp\left(\frac{\frac{q(V+IR_S N_{PP})}{N_{SS}}}{a*k*T*N_S}\right) - 1].[2]$$

Where,

I_{PV} is the light generated current by incident light

, I_O is the reverse saturation current,

k is Boltzmann's constant($1.38*10^{-19}$J/K),

T ,the temperature of the p-n junction,

a is the ideality factor.

The photocurrent depends on the solar irradiation and cell temperature is given as

$$I_{pv} = (I_{pvn} + K_I(T - T_n))\frac{G}{G_n} \quad \text{.........}[3]$$

Where,

K_I is the temperature coefficient of cells short circuit current

, T_n is the cells nominal temperature ,

I_{pvn} is the light generated current at nominal temperature(25 & 1000w/m2).

$$I_O = \frac{I_{scn}+K_I dT}{\exp(V_{ocn}+K_V dT)/aV_t)-1} \ldots\ldots\ldots\ldots [4]$$

where

V_t = the thermal voltage of the connected cell at nominal temperature[4].

K_V = the voltage coefficient.

In this study, a general PV model is implemented using MATLAB/SIMULINK. In this model inputs are the solar irradiation and temperature and outputs are photovoltaic voltage and current.

The Parameters used in modelling of PV array are shown in table1

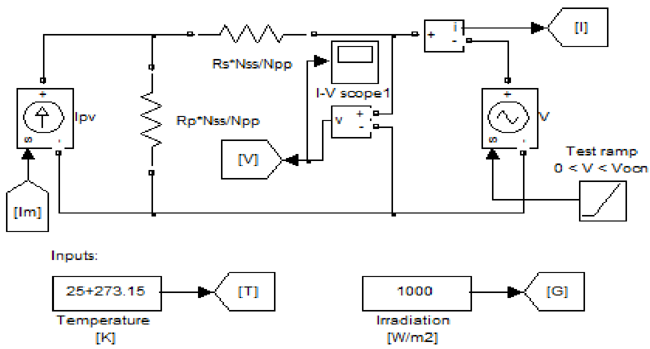
PARAMETER	VALUE
G	1000
I_{MP}	7.61 amp
I_{SC}	8.21amp
K_I	0.0032
K_V	-0.1230
N_{PP}	2
N_S	54
N_{SS}	15
P_{MAX}	200.143W
T	298K
V_{OCN}	32.9V
V_{MP}	26.3V

Table1

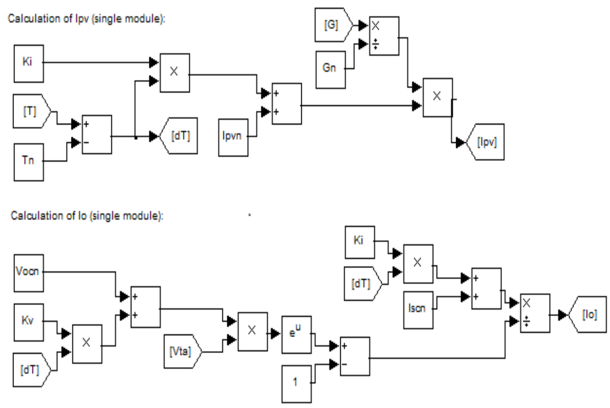
This chapter summarises the implementation of PV Array by using the mathematical modelling. It also explains the construction of PV cell into PV module to form a PV array. The modelling of PV array is done by using MATLAB/SIMULINK.

VI. SIMULATION RESULTS AND DISCUSSION

The performance analysis is done using simulated results which are found using MATLAB.



Calculation of I_{pv} and I_o :



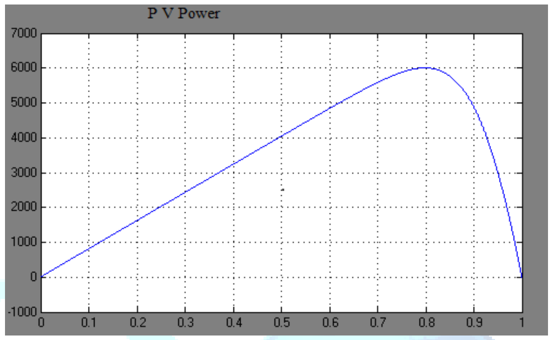
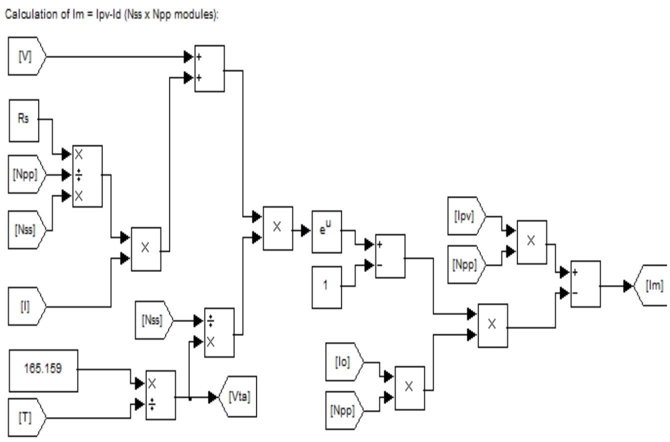


FIG 6 P-V CHARACTERISTICS OF PV ARRAY WITH CONSTANT IRRADIANCE AND TEMPERATURE



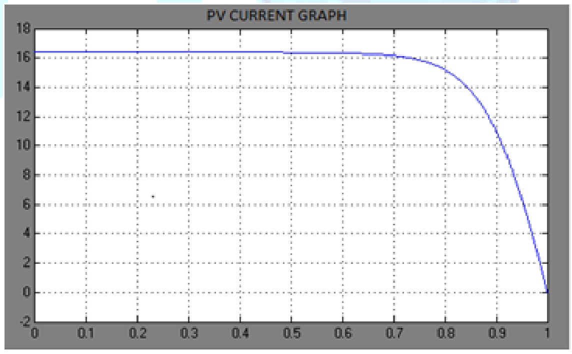


FIGURE 7 I-V CHARACTERISTICS OF PV ARRAY WITH CONSTANT TEMPERATURE AND IRRADIANCE

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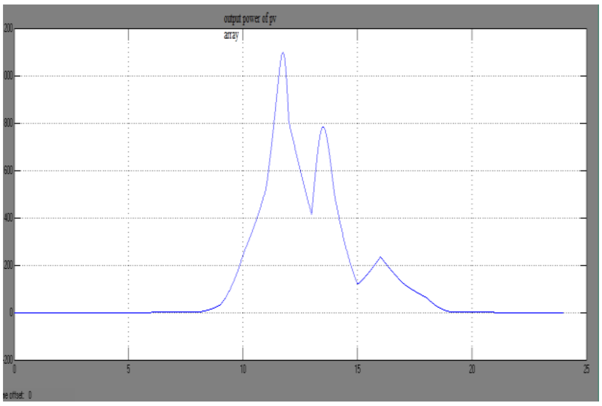

Fig 8 total output power of solar array

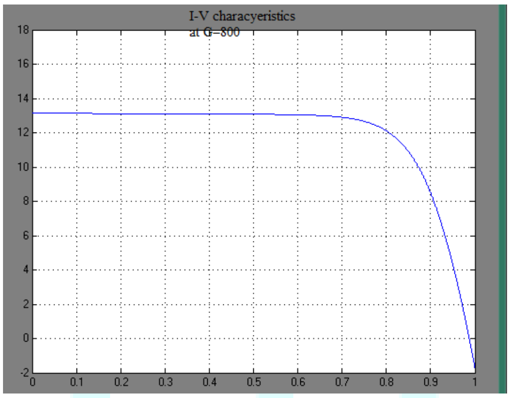

Fig 9 I-V characteristics with G=800kW/m^2

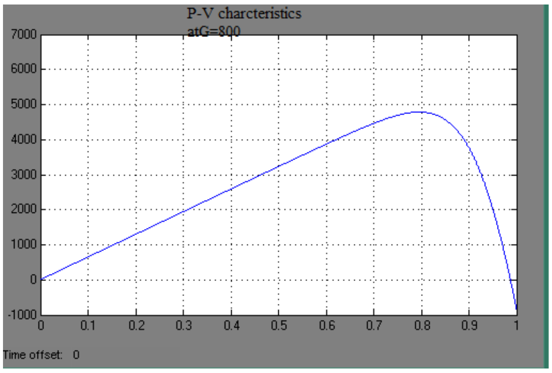

Fig 10 P-V characteristics with G=800kW/m^2

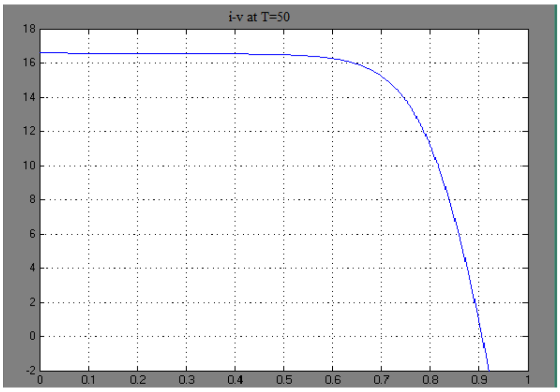

Fig 11 I-v characteristics at T=50

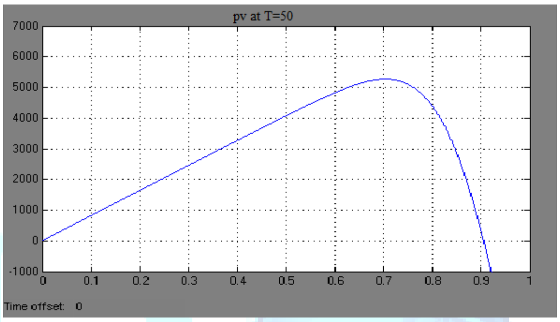

Fig 12 P-V characteristics at T=50

VII. CONCLUSION

It was found from fig 6 to fig 12 that with decreased solar irradiance, there is a decrease in both the maximum power output and short circuit current. On the other hand that with an increase in the cell temperature the maximum power output decreases while the short circuit current increases and shows the solar irradiance and cell temperature profiles used in the model.

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