Modelling Of PV Cells Using Matlab/Simulink

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Abstract— **Energy is the prime mover of economic growth and is vital to the sustenance of a modern economy. One of the major concerns in the power sector is the day-to-day increasing power demand but the unavailability of enough resources to meet the power demand using the covenantal energy sources. Renewable sources like wind energy and solar energy are the prime energy sources which are being unlined in this regard. The cernuous use of fossil fuels has caused the fossil fuel deposit to be reduced and has rascally affected the environment depleting the biosphere and cumulavely adding to global warming. Solar energy is abundantly available that has made it possible to harvest it and utilize it properly**

I.   INTRODUCTION

1. History of PV Cells

Photovoltaic technology in reality goes back over 160 years. The basic science was first came upon in 1839 but the pace of advancement really hastened in two major drives in the 20th Century. Bell Laboratories, discovered silicon had photoelectric attributes and quickly developed Si solar cells, achieving 6% efficiency and former satellites were the elemental use for these first solar cells.

II. DESCRIPTION OF PV CELL

Solar cell is basically a p-n junction fabricated in a thin wafer or layer of semiconductor. These are made up of semiconductor materials like silicon etc. A thin semiconductor wafer is specially treated to form an electric field, positive on a side and negative on the other.
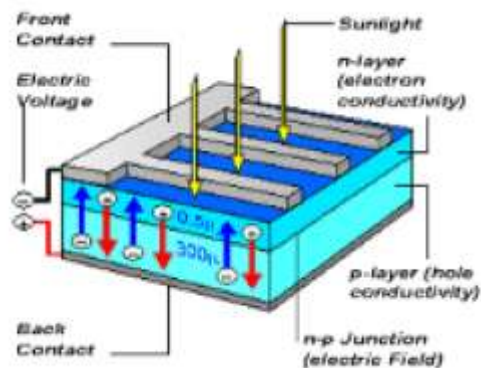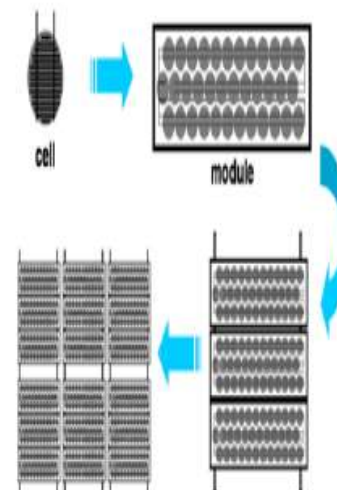

Fig. 1 Solar cell

A photovoltaic system uses one or more solar modules or panels to convert solar energy to electrical energy. Basically, its components include solar panels, mechanical and electrical connections and means of modifying the electrical output we get. When sunlight hits the cell, the photons are absorbed by the semiconductor atoms, freeing electrons from the negative layer. This free electron finds its path through an external circuit toward the positive layer resulting in an electric current from the positive layer to the negative one.

2.1 Photovoltaic module& array

Several PV cells are connected in series (for high voltage) and in parallel for (for high current) to form a PV module. A PV array is a group of several PV modules which are electrically connected in series and parallel circuits to generate the required current and voltage.

Fig.2 Cell and Array of PV cell structure

III. WORKING PRINCIPLE

An array of solar cells converts solar energy into a usable amount of direct current (DC) electricity.
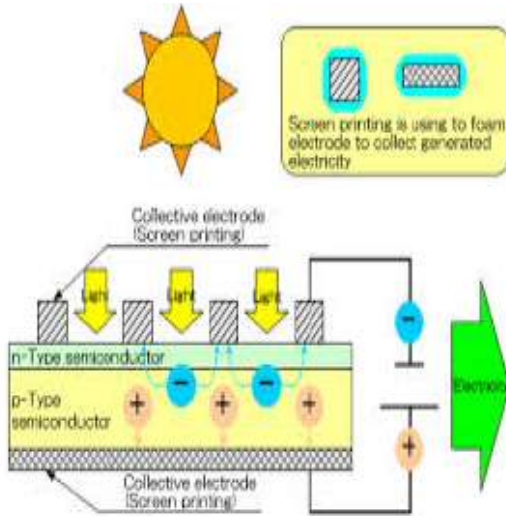
Fig.3 Solar cell working

The operation of solar cells may be described from a PN junction where there are diffusion currents and direct currents for the direct and reverse polarization, respectively. Usually, the cells operate in reverse direction so that the current direct is desirable. When the PN junction is exposed to light, photons with energy greater than the gap of energy are absorbed, causing the emergence of electron-hole pairs. These carriers are separated under the influence of electric fields within the junction, creating a current that is proportional to the incidence of solar irradiation.

IV CHARACTERISTICS OF PV CELL

The characteristics of solar cells depend upon irradiance and temperature. The typical I-V and P-V characteristics short of the fundamental parameters related to solar cell are

1. Short circuit current (Isc)
2. Open circuit voltage (Voc)
3. Maximum power point (MPP,
4. Efficiency of solar cell and
5. Fill factor.

4.1. Short circuit current (ISC)

Short Circuit Current is the current corresponds to the short circuit condition when the impedance is low and it is calculated when the voltage equals to zero.

$$I \text{ (at } V=0) = ISC \quad (1)$$

4.2 Open Circuit Voltage

Open Circuit Voltage is the voltage when the open circuit occurs and there is no current passing through the cell. The Open circuit voltage is calculated when the voltage equals to zero.

$$V \text{ (at } I=0) = Voc \quad (2)$$

The open circuit voltage can be expressed as:
$Voc=(AKTc/q)ln[Ipv/Ig]$ Open Circuit Voltage

4.3 Maximum power point

Maximum power point is the condition under which the solar cell generates its maximum power. The current and voltage in this condition are defined as Imax &Vmax. $Pmax=Voc*Isc*FF$

4.4 Fill factor

Fill factor is defined as the ratio of Pmax divided by product of Voc and Is $FF=[Pmax/Voc*Isc]$

4.5 Efficiency

Efficiency is defined as ratio of Pmax to the product of input light irradiance (E) and the solar cell surface area (Ac) $Efficiency=Pmax/E*A$

V. SOLAR RADIATION VS IRRADIATION
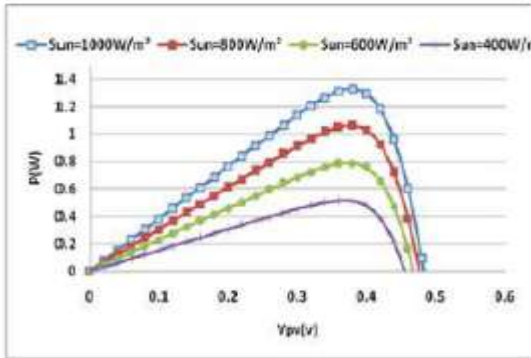
The PV cell photocurrent depends on the irradiance and the temperature according to equation
$Iph= G/Gref (Iph,ref+ \mu sc \Delta T)$

However, the voltage has a 50 mV increase as the solar radiation increased from 400

1. *W/m2 to 1000 W/m*
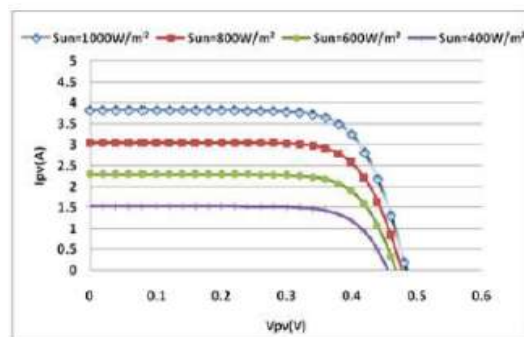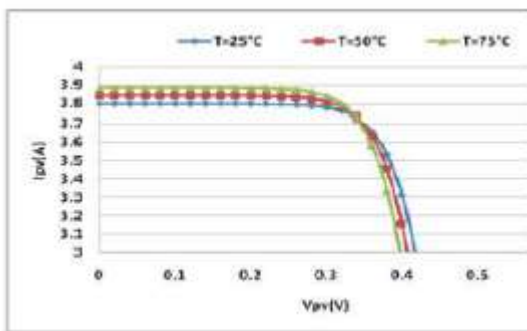

Fig 4 Voltage VS Current

Fig 5 Voltage VS Power

In general, for a given solar radiation, when the cell temperature increases, the open circuit voltage Voc drops slightly, while the short circuit current increases.

Fig 6 Voltage vs Current for different temperatures

The influence of an increase in IO is evidently seen as decreasing the open-circuit voltage Voc. Most commonly used model is a single diode model. A photovoltaic cell can be modeled as a current source PN connected in parallel with a diode.
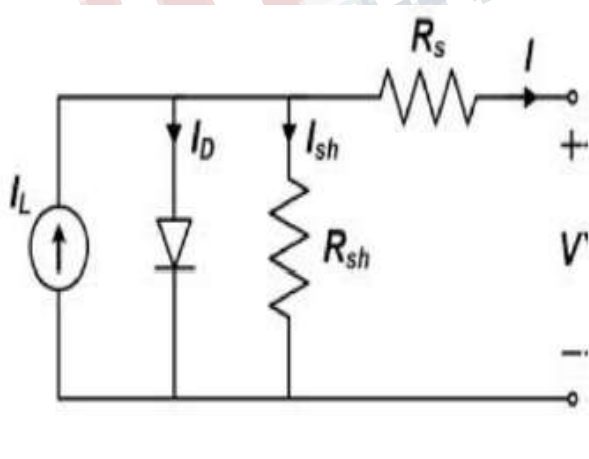
Fig 7 Equivalent diagram for solar cell

VI. EQUATIONS INVOLVED IN MODELING OF PV CELL

The single diode model does not take into account the internal losses of the current. A diode is connected in anti-parallel with the light generated current source. The output current I is obtained by Kirchhoff law.

I = Iph − Io[exp(V+I.RS/a)-1] −(V+I.RS/RP) Where, Io = reverse saturation current a = modified ideality factor =NS.A.k.TC/q = NS.A.VT

- ❖ V is the voltage imposed on the diode.
- ❖ VTc = 26 mV at 300 K for silisium cell
- ❖ Tc is the actual cell temperature (K)
- ❖ k Boltzmann constant $1.381 * 10^{-23}$ J/K
- ❖ q is electron charge ($1.602* 10^{-19}$ C).
- ❖ VT is called the thermal voltage because of its exclusive dependence of temperature.

The photo current (Iph) depends on both irradiance and temperature. Iph = G/Gref (Iph,ref + μsc ΔT) Where, G = Irradiance (W/m2) Gref = Irradiance at STC =1000 W/m2 Δ T = Tc − Tc,ref (Tc,ref = 298k) μsc = co-efficient of temperature of short circuit current (A/k). The reverse saturation current is given by Io =D TC 3 e (-qEg/A KTc) Where Eg = material band gap energy (ev) D = diode diffusion factor

VII. MATLAB BASED PV MODEL

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. This allows solving many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time it would take to write a program in a scalar non-interactive language such as C or FORTRAN. Simulink is a so ware package for modeling, simulating, and analyzing dynamical systems. It supports linear and nonlinear systems, modeled in continuous time, sampled time, or a hybrid of the two. For modeling, Simulink provides a graphical user interface (GUI) for building models as block diagrams, using click-and-drag mouse operations.
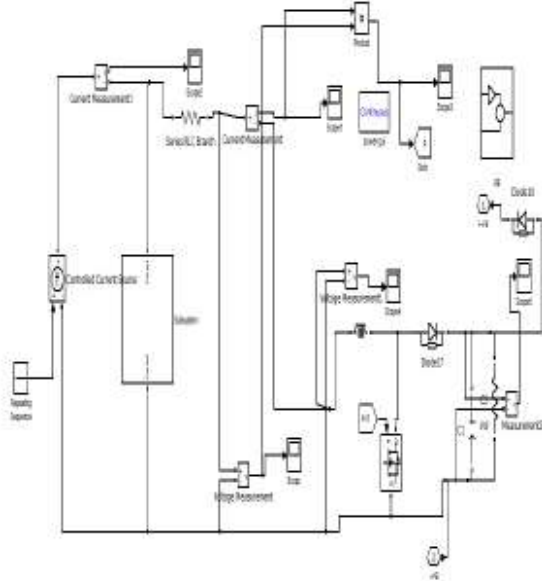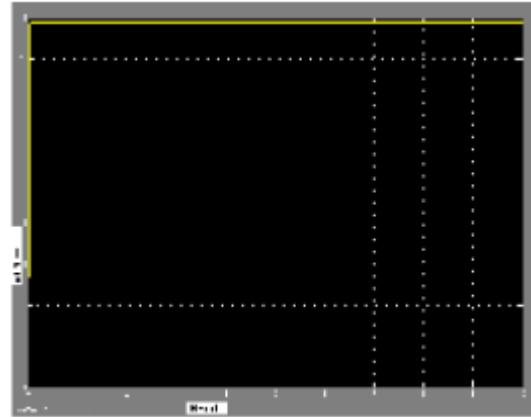
Fig 8 Simulation Circuit diagram

VIII SIMULATION RESULTS
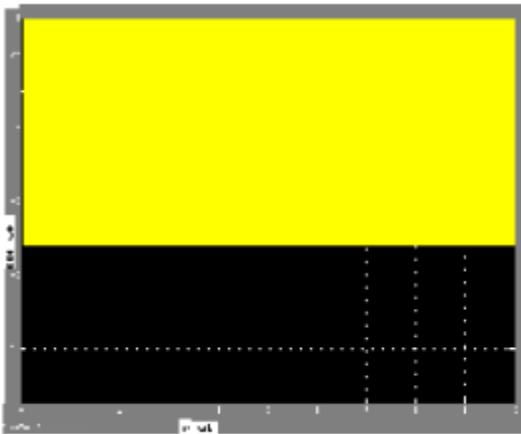
Fig .23 Graph represents Current Vs Time results

Fig .24 Graph represents Voltage Vs Time results

IX CONCLUSION

A generalized PV model which is representative of the all PV cell, module, and array has been developed with Matlab/Simulink and been verified with a PV cell .The proposed model takes sunlight irradiance and cell temperature as input parameters and outputs the I-V and P-V characteristics under various conditions.

REFERENCES

1. Pearce,Joshua (2002). "Photovoltaic's-A path to sustainable future"

2. Palz,Wolfgang(2013). Solar /power for the world". About the Author... This document prepared by Srikala. Murali Krishna doing M.Tech on Power electronic and Drives in Swetha institute of technology and science.