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Different Methods for Modeling PV Panels: An Overview

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Abstract- The paper presents the simulation of solar photovoltaic module in different methods using MATLAB/ Simulink. The I-V & P-V characteristics are obtained. The maximum power point tracking (MPPT) algorithm, which is based on the incremental conductance method, is described. Also, the points indicating module voltage Vmp and current Imp at maximum power Pmax are obtained.

Keywords— Photovoltaic modules, MPPT, Incremental conductance Method

I. INTRODUCTION

Solar power refers to the energy created when solar radiation is converted into heat (thermal processes) or electricity (electric processes).Solar energy describes several energy creation techniques that use the sun's radiation. It has been used in traditional construction for centuries though in developed countries interest has fluctuated with the price of fossil fuel. The traditional use of solar energy as passive heating has influenced the design of homes and public buildings in many parts of the world: the most efficient dwellings historically have been designed, in the northern latitudes, with large windows facing south and small windows in the walls oriented toward the north. This simple building technique has for centuries reduced the need for other sources of energy to generate heat. The industrial growth and economic prosperity of the West during the 20th century caused a massive abandonment of this type of construction and a simultaneous increase in the use of electricity and fuel to moderate home temperatures. The 21st century could signal a return to this type of passive energy use. Solar energy is used in several different applications:

1) To generate electricity through photovoltaic or solar electric panels. The latter convert heat into electricity.
2) To use directly the heat generated: water and building heating, and cooking. The last option is particularly useful in regions of poor countries without traditional power sources.
3) In the desalination of marine water for its use in everything from agricultural to industry.
4) With the sun, the processes of distillation, evaporation, and photosynthesis all occur naturally. Many craft and industrial processes depend on this application of solar radiation.
5) The strength and radiation of the sun varies according to time of day, latitude, atmospheric conditions -which limit it (i.e. "global dimming" is the negative effect of pollution on the strength of the sun's rays) - as well as, the position and inclination of the earth with respect to the sun.

Solar radiation can be used directly or indirectly. Direct radiation originates directly from the solar focus, without intermediary reflectors nor refractors, though it can be reflected and concentrated for use. It can't be controlled, though it can be used as a passive system, for example, in the orientation and characteristics of a building with respect to the sun.

II.PV PANELS

A solar panel is a set of solar photovoltaic modules electrically connect- ed and mounted on a supporting structure. A photovoltaic module is a packaged, connected assembly of solar cells. The solar module can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications. Each module is rated by its DC output power under standard test conditions (STC), and typically ranges from 100 to 320 watts. The efficiency of a module determines the area of a module given the same rated output - an 8% efficient 230 watt module will have twice the area of a 16% efficient 230 watt module. A single solar module can produce only a limited amount of power; most installations contain multiple modules. A photovoltaic system typically includes a panel or an array of solar modules, an inverter, and sometimes a battery and/or solar tracker and inter- connection wiring.

III.DIFFERENT METHODS FOR MODELING PV PANELS

A solar cell is basically a p-n junction fabricated in a thin wafer of semiconductor. The electromagnetic radiation of solar energy can be directly converted to electricity through photo voltaic effect. Being exposed to the sunlight, photons with energy greater than the band-gap energy of the semiconductor creates some electron-hole pairs proportional to the incident irradiation. The equivalent circuit of a PV cell is as shown in Figure 1[1] [2][3].

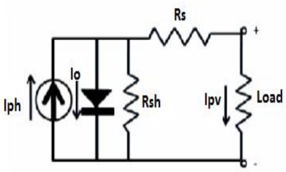


Fig 1. PV cell modelled as diode circuit

The current source Iph represents the cell photocurrent. Rsh and Rs are the intrinsic shunt and series resistances of the cell, respectively. Usually the value of Rsh is very large and that of Rs is very small, hence they may be neglected to simplify the analysis. PV cells are grouped in larger units called PV modules which are further interconnected in a parallel-series configuration to form PV arrays. The photovoltaic panel can be modelled mathematically as given in equations.

Module photo-current:

$$I_{ph} = [I_{scr} + K_i(T - 298)] \times \frac{\lambda}{1000} \longrightarrow (1$$

Module reverse saturation current - Irs:

$$I_{rs} = \frac{I_{scr}}{[\exp(q \times V_{oc} / NsKAT) - 1]} \longrightarrow (2 \qquad (4.2)$$

The module saturation current I vary with the cell temperature, which is given by

$$I_s = I_{rs}[\frac{T}{T_r}]^3 \exp([\frac{q \times E_{go}}{AK}][\frac{1}{T_r} - \frac{1}{T}]) \longrightarrow (3) \qquad (4.3)$$

The current output of PV module is

$$I_{pv} = N_p \times I_{ph} - N_p \times I_0[\exp\{\frac{q \times (V_{pv} I_{pv} R_s)}{NsAKT}\} - 1] \longrightarrow (4$$

Where,

V_{PV} Is output voltage of a PV module (V)

I_{PV} Is output current of a PV module (A)

T_R Is the reference temperature = 298 K

T Is the module operating temperature in Kelvin

I_{ph} Is the light generated current in a PV module

I_0 Is the PV module saturation current (A)

A Is an ideality factor = 1.6

K Is Boltzmann constant = 1.3805 × 10-23 J/K q Is Electron charge = 1.6 × 10-19 C

R_S Is the series resistance of the PV module

I_{SCR} Is the PV module short-circuit current at 25 A and 1000W/ m^2 = 2.55A

K_i Is the short-circuit current temperature co-efficient

I_{SCR} = 0.0017A / ^0c Is the PV module illumination (W/m2) = 1000W/ m^2

E_{go} Is the band gap for silicon = 1.1 eV

N_S Is the number of cells connected in

series

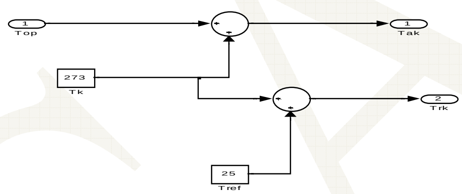
N_P Is the number of cells connected in parallel.

We can choose different methods for modelling PV panels but in all type of modelling we are using the same equations [4] [5].

MODEL 1

A Step 1

This step converts the module operating temperature given in degrees Celsius to Kelvin.



Function: To convert operating temperature-Centigrade to Kelvin
Equations:

1. T_{rk} = 273 + 25 (Ref Temp)
2. T_{ak} = 273 + Top (Operating Temp)

Fig 2. Subsystem 1

B. Step 2

This step calculates the photon current.

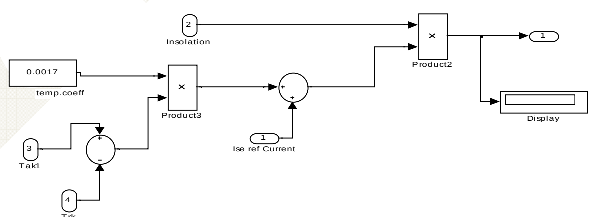


Fig 3.Subsystem 2

C. Step 3

This step calculates the reverse saturation current

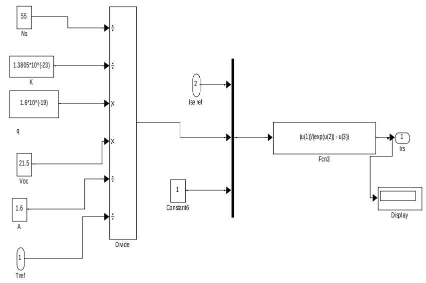


Fig 4.Subsystem 3

D. Step 4

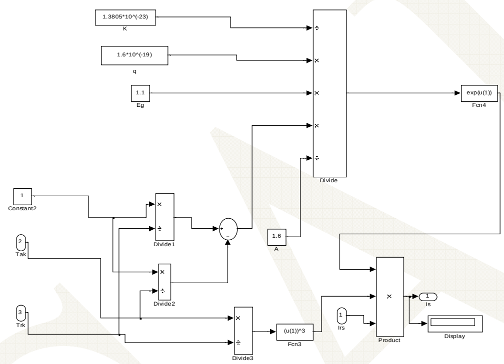


Fig 5.Subsystem 4

This step calculates the saturation current

E. Step 5

This step calculates the output current of the module.

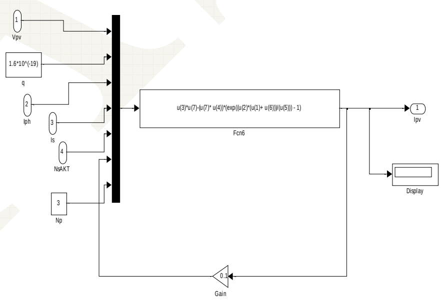


Fig 6.Subsystem 5

F. Step 6

All above six models are interconnected as given in Figure

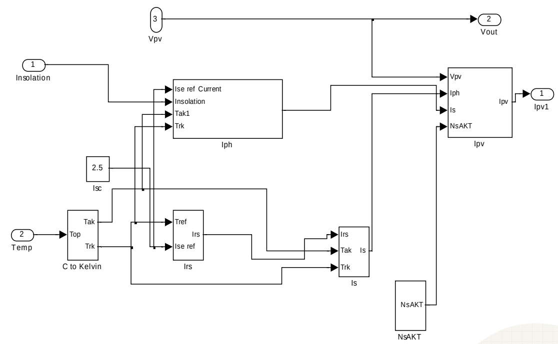


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Fig 7.Subsystem 6

MODEL 2

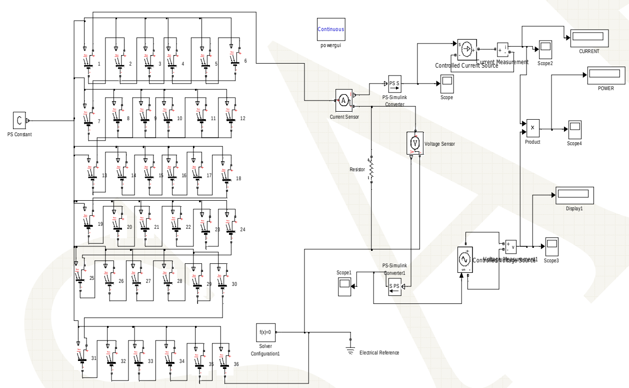

Fig 8. PV panel modelling –method 2

Solar cells are available in MATLAB. So we can model solar panel by connecting number of solar cells in series to get desired output.

MODEL 3

Here we are utilising the same equations as above for modelling the PV panel. [6][7].

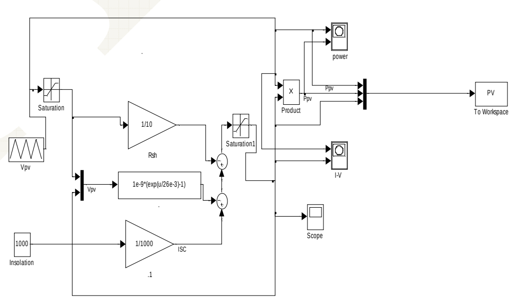

Fig 9. PV panel modelling –Method 3

IV.SIMULATION RESULTS

PV cell can be modelled as a current source in parallel with a diode. Power which depends upon irradiation and temperature. When irradiation increases power will also be increase .Also power will decrease when temperature increases. Figure shows the PV characteristics of the panel.

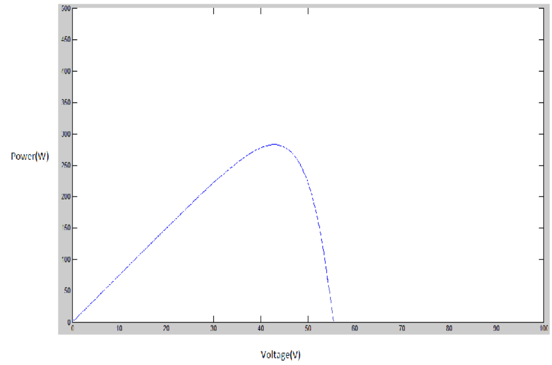

Fig 10.PV characteristics

When there is no light present to generate any current, the PV cell behaves like a diode. As the intensity of incident light increases, current is generated by the PV cell, as illustrated in Figure10.

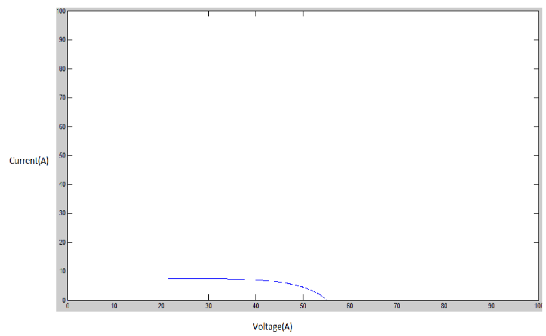

Fig 11. I V characteristics

The output voltage from solar panel is shown in figure12.We are giving this voltage output to the converter input.

V. CONCLUSION

Here the paper explains different methods for modelling PV panel and it can be said that MATLAB is a very good tool for getting proper simulation outputs. By using suitable maximum power point tracking algorithms it is possible to track the maximum power point.

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