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Design of PV Module for Green Building Installation

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Abstract : This paper represents an simple and easy technique of designing the photovoltaic arrays by using MATLAB simulink. The equation of the model is represented. This design is very much useful for power electronics designers in needy of an straightforward and effective way to simulate the model. Useful for installation for green building and household works. Many are are now willing to installing on the roof tops.

Keywords: Renewable energy, photovoltaic(PV) system, green building, array.

I. INTRODUCTION

India lies in a region of temperature climate of the world where major part of land gets sufficient amount of sunlight minimum of more than 8 hours daily. The amount of heat received is more than or equivalent to 200 MW/sq.km. Now a days the world is in need of more energy as the population is increasing so the use of energy. So to battle the needy the preachers and technologists are eyeing to renewable energy sources. Solar is the sustainable source to generate electricity. Solar photovoltaic (PV) system converts the direct sunlight to electrical energy. The photovoltaic (PV) or solar cells are basically semiconductor devices which convert to direct sunlight to direct current (DC) to alternating current(AC). Maximum of the energy dawned from the sun appears in the form of light is a short wave radiation. When this radiation collides a solid or liquid, it is consumed and altered into heat energy. This heat energy is altered into mechanical energy or awful work. Solar energy is freely and sufficiently available, environmentally very clean, lifespan is more and pollution free.[6].

II. PHOTOVOLTAIC (PV) SYSTEM

Photovoltaic (PV) is an effective technology producing electricity from sunlight radiation with the help of solar cells enclosed in a panel called PV modules consisting of 34 or 72 PV cells generating a DC voltage depending on solar radiation and temperature the voltage differs between 23 V to 45 V and maximal power of 160 W. A PV cell generates 0.5 V Dc so the cells are arranged in series for high voltage or in parallel for high current forming a PV module to aim required output. When a number of modules are connected all together to produce sufficient amount of energy for the requirement at home and business are called array. It can be also used to give power to several number of electric boards, to charge batteries , motors, etc. PV systems are becoming more common and familiar. The fig1 shows the PV system.[6],[7].

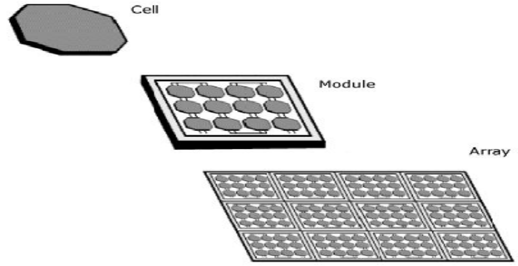

Fig1. Photovoltaic system.

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III. GREEN BUILDING

Green building is an environmental friendly sustainable building. It is constructed or designed so as to minimise the outside environmental impact. Its main aim is to reduce the usage energy. Main strategies of designing the green building is to reduce the consumption of water and energy. It saves money, gives better comfort, environment remains healthier for people living in the area. Seeing the wide diversity that is existing in the building typology over India, many interests and problems range from marking low cost to high cost, low energy buildings to high energy buildings through different profit groups and climatic regions of the country. The green building performs environmental friendly structures that lowers their environment encounter. This field turns into more important as the natural resources are not wasted and the energy is developed to increase. The green building method is expanding and the capacity of the building design interest of economy, comfort, benefits and stamina. These buildings are high conduct structures that get to certain secure standards for decreasing natural resources utilization. Human beings are seriously participating in this field of concept of 'cure' and 'prevention'. The Green Building concept is increasing rapidly across all over world. The fig.2 showing the concept of a roof mounted of PV arrays.[4],[5].

Fig 2. a roof mounted PV array.

IV. MODELING OF PV ARRAYS

Photovoltaic cells are also known as direct solar power device as they convert the direct light to electricity. Without environmental impact it can develop direct current electricity. As the PV cell is made up of semiconductor devices, the PV system costs low maintenance due to the free moving parts, constant and less operation. The output characteristics of PV module depends on temperature of cell, on the solar isolation and voltage output.

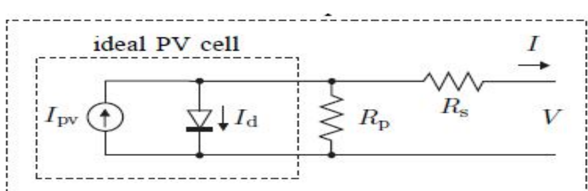

Fig 3. equivalent circuit of photovoltaic.

Solar cell is a p type - n type junction assembled in a thin wafer of semiconductor. The equivalent circuit of photovoltaic is presented in the fig 3. Ipv represents the current of photovoltaic of the array and Id is the current across the diode. Rp is equivalent parallel resistance and Rs is the equivalent series resistance. The arrays thermal voltage is denoted as Vt = Ns kT/q with a series number of cells connected. To get higher output voltage the cells are connected in series and to rise the current the cells are connected in parallel. Fig 4 shows the I-V curve and fig 5 shows the P-V curve of photovoltaic cell.[1],[2],[3].

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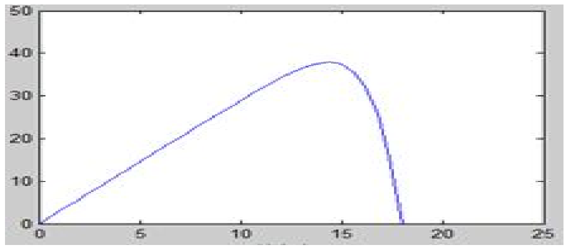

Fig 4. I-V curve of PV.

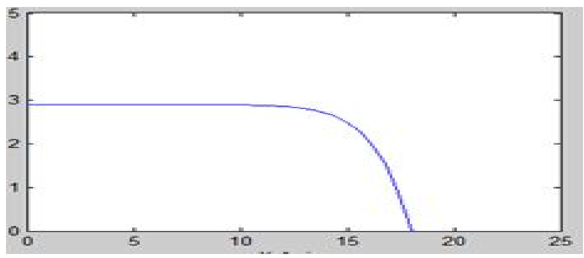

Fig 5. P-V curve

The references we are taking for modelling the module are as below;
Vpv=Voc is the voltage output (V) of a PV module,
Ipv is the photovoltaic current (A) of a PV module,
Vmp is the maximum power point voltage ,
Imp is the maximum power point current,
KV is the voltage coefficient or voltage of open-circuit ,
KI is the current coefficient or current of short-circuit ,
Pmax,e is the maximum peak output power,
Tr is the reference temperature = 298 K,
T[K] is the p n junction temperature ,
Io,Ipv is the saturation current (A) of PV module,
a is the constant ideality factor is 1.3,
Ns is the number of cells connected in series,
Np is the number of cells connected in parallel,
k = 1.3805 × 10^{-23} J/K is the Boltzman constant,
q = 1.6 × 10^{-19} C is electron charge,
Rs= 0.221 Ω is resistance in series,
Rp is the equivalent resistance in parallel ,
Eg is the band gap for silicon = 1.12 eV,
G (W/m2) is the surface irradiation,
Gn is the nominal irradiation,
I_0 is the current saturation across diode,
Data taken for modelling:

Imp	7.61 Amp
Vmp	26.2 V
P max	200.142 W
I sc	8.21 A
V oc	32.9 V
Kv	-0.1230 V/K
Ki	0.0032 A/K
Ns	54

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I mp	7.60 A
V mp	26.3 V
Io,n	$9.825.10^{-8}$ A
I pv	8.214 A
A	1.3
Rp	415.400 Ω
Rs	0.221 Ω

The photovoltaic panel can be modelled mathematically as given in equations below ;

$$I = Ipv - I0 \left[\exp\left(\frac{V+Rs\,I}{Vt\,a}\right) - 1\right] - \frac{V+Rs\,I}{Rp} \quad (1)$$

where Ipv is the photovoltaic current (A) and Io are the current saturation of diode and Vt is the photovoltaic array thermal voltage,

$$Vt = NskT/\,q \quad (2)$$

The light-generated current (Ipv) of the elementary cells

$$Ipv = (Ipv,n + KI\Delta T)\,\frac{G}{Gn} \quad (3)$$

Io is the current at saturation passing across the diode and it is build upon on the temperature. Where Io can be conveyed by,

$$Io = Io,n \left(\frac{Tn}{T}\right)^3 \exp\left[\frac{qE_g}{ak}\left(\frac{1}{Tn} - \frac{1}{T}\right)\right] \quad (4)$$

where denoting the bandgap energy i.e, Eg ≈ 1.12 eV of the semiconductor. Io,n is the nominal saturation current :

$$Io,n = {Isc,n}\Big/{\exp\left(\frac{Voc,n}{aVt,n}\right)} \;\; -1 \quad (5)$$

where the thermal voltage is Vt,n of Ns the number of cells connected in series at the Tn is the nominal temperature of photovoltaic. The expression of the photovoltaic model expressed earlier can be enhanced assuming the equation (4) is replaced by:

$$Io = \frac{Isc,n+KI\Delta T}{\exp\left(\frac{Voc,n+KV\Delta T}{aVt}\right)-1} \quad (6)$$

and Ipv,n is epressed as;

$$Ipv,n = \frac{Rp+Rs}{RP}\,Isc,n \quad (7)$$

Eq. (7) uses the resistances Rs and Rp to determine Ipv ≠Isc.

From the figure 6 to figure 10 the MATLAB modelling of the photovoltaic system is presented in detail below.

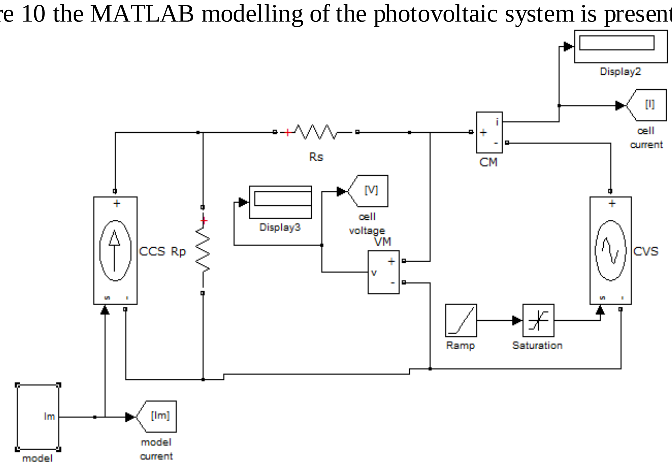

Fig 6. Module of PV simulink.

The main module of PV array is shown in fig 6 representing the circuit diagram of PV in fig 3 with single current source and two resistors Rp and Rs here the parallel resistance can be neglected. The fig 7 is subsystem of module is

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developed by employing in equation 1 according to it then module is designed working with sim power system block set.

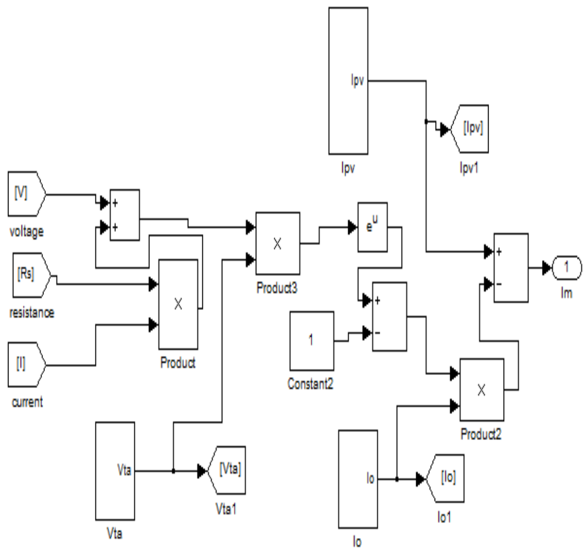

Fig 7. Subsystem of PV.

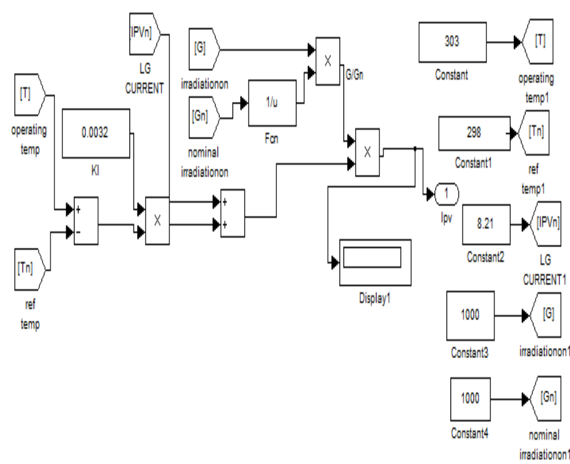

Fig 8. Subsystem of I pv.

Photovoltaic current i.e. Ipv or is light-generated current of elementary cells is designed by implementing equation 3. where Ipv,n [A] defines the nominal current at generated light normally at 30 ◦C and $1000W/m^2$, $\Delta T = T+(- Tn)$. where T is the absolute temperature and Tn is the temperatures at nominal value i.e, [K], $G(W/m^2)$ is the surface irradiation and Gn is the irradiation at nominal value.

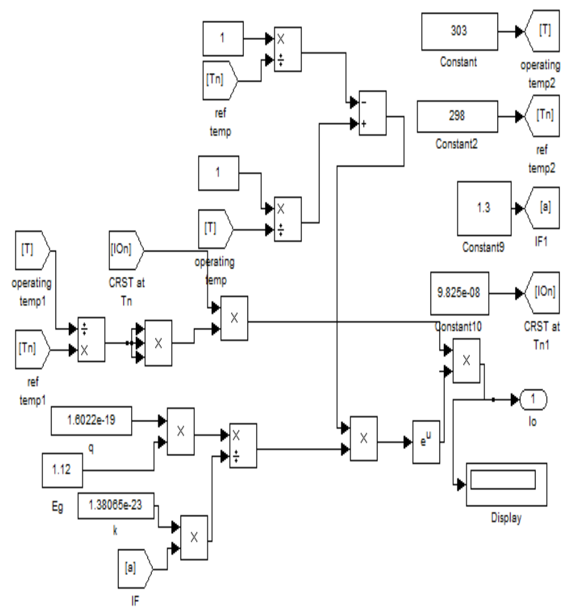

Fig 9. Subsystem of Io.

The current at saturation passing across the diode and it is build upon on the temperature is Io. In equation 4and 6. Io is conveyed to it the blocks are designed. Ideality factor a is 1.3.

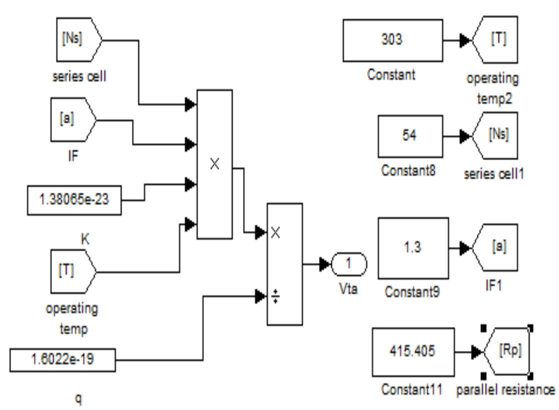

Fig 10. Subsystem of Vta.

The photovoltaic array thermal voltage denoted as Vta is designed from equation 2. Ns is the number of cells connected in series, k is the Boltzman constant, q is electron charge. Step by step modelling of photovoltaic array is modelled by MATLAB is done above.

V. CONCLUSION

This paper presents the photovoltaic model using MATLAB/simulink. It is a simple model easy to calculate the current and voltage. It can be interfaced directly with any power electronics. An inverter can be interfaced directly to it. The Green Building installation of photovoltaic and for roof top installation it can be used to generate the power for commercial use.

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