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Modeling and Analysis of Environmental Impact on Solar PV Using MATLAB/Simulink

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Abstract
Abstract—Globally, the requirement of energy demand increased every year due to rapid growth of population and industrialization. Traditional fossil fuels are harms the environment, since it emitting CO and CO2 during extraction of heat energy. Hence, renewable energy resources are play a noteworthy part in generation of electrical energy. Renewable energy resources are namely, wind, solar, tidal et. Among them, the generation of electrical energy from solar PV technology has been increased in globally. Which is due to availability of solar energy is omnipresent. In this article solar cell characteristics has been modelling by MATLAB/Simulink block set. At first, a single solar cell has been modelling. Subsequently, PV array used to build a model. Both model is used to learning effect of temperature, irradiance on output of solar cells. This has been assessed through PV and IV physiognomies of solar cell. From the simulation found, depends of sun irradiation the yield potential of solar cell has been varied.

Keywords: *Solar PV, Irradiance, Temperature, Shading Effect*

I. INTRODUCTION

Energy harnessing rate from solar technology had increased year by year which is due to technology development as well cost of solar PV panel rapidly decreased. Globally, a survey found that annual potential of solar energy is 13843611 Twh. This is more five times higher than world energy consumption. Perhaps, total installed capacity of solar photovoltaic power plant is 75 gigawatt (GW) which very less compared to available capacity Due to negative impact of fossil fuels, solar is the best option for developing countries. Around the world, country wise installed capacity of solar PV technology at the end of 2018 as shown in Fig 1. We consider more than 7900 MW installed capacity. It shows china occupy first place with the total installed capacity of 176,100 MW whereas fifth place for India. At present, total installed capacity of solar PV in India is 31.101 GW. From the above study shows a huge opportunity is available for study and analyses the solar PV technology [1] - [3].

Solar PV panels are generating electrical energy from photovoltaic effect. That means when light is fall on the photo diode it emits electrical energy, the photo means light and voltaic refers to voltage. Such photo effect also possible solid liquid and gasses but the conversion efficiency is high in case of semiconducting materials. Numerous materials are used to develop solar cell perhaps crystalline materials popular used to make a solar cell. Around the world, above 90% of solar PV cell are made by using crystalline materials. At the incident of adequate sun 4 mm diameter of solar cell can produced 1 W of Direct Current respectively[3],[4].

Now days, three types of solar PV panels are popular used such as polycrystalline, monocrystalline

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and thin film. The another name of polycrystalline is multi crystalline. The principle of harnessing electrical energy is unique in all panels however each technology has unique feature before purchasing PV panel a buyer must know significance of panels respectively. The monocrystalline panels are made by single crystal of silicon whereas silicon fragment melted

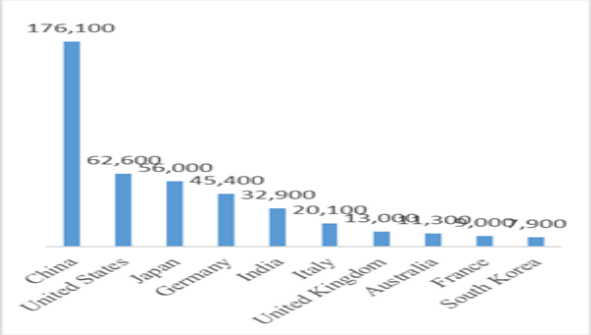

Fig 1.Countrywise PV installed in 2018

Together for making polycrystalline. The third type has been made by deposition of semiconductor materials on a class, substrate etc. Popularly following materials are used for making polycrystalline solar cell namely cadmium telluride (CdTe), copper indium gallium diselenide (CIGS), and amorphous thin-film silicon (a-Si, TF-Si) [5],[6].

The efficiency of monocrystalline panel is 15-20% since its made by high grade of silicon materials, lesser space is required for producing high power. Nevertheless, it has high cost and temperature depended. But, polycrystalline solar PV panels cost is low and wastage of silicon material significantly lower that of mono. Also, temperature depended is quite low. But efficiency is lower and its occupy more space since which is made by lesser quality materials. Third, thin film manufacturing process quit simple that of others. Shading and temperature effect is low. Moreover, the efficiency of solar PV panel has very low.

Fig 2. Polycrystalline Solar PV

A solar cell is referring to a single cell while module is make by single solar cells are connected together. Basically, per module either 36, 60 or 72 cells are used to build a module. Number of modules are series connected for making solar PV array[7],[8]. For an example poly crystalline solar PV panel is shown in Fig 2.

The manuscript has five section in section 1, we dealt the necessity of solar PV and how much of solar PV based power plants are installed, types of solar PV, in section 2 a discussion has been made on photovoltaic effect on solar PV has been briefly explained. While, in section 3, equivalent circuit solar PV cell and its output equation has been presented, section four shows the MATLAB results which are clearly explained the correlation between solar PV output and environmental factor under single cell and solar array. Finally, key finding has been concluded in conclusion section.

II. PHOTOVOLTAIC EFFECT

The solar cells are made by semiconducting materials. These materials have electron which is absorb photon from sun hence electron gain energy associate to the photon. It is expressed by following equation

$E=h.v$ (1)

$E=h.c/lamda$ (2)

where E is the photon energy for its frequency, ν, or its wavelength, λ. H is Planck's constant and c, the speed of light.

Basically electrical materials are classified as insulator, conductor and semiconductor respectively. The difference between each material is based on the how electron will appear. For an example, insulators offer very high resistance against current flow which is due to forbidden gap between and valance and conduction band is high. So there is no free electronics. While, in conductor, overlap between valance and conduction band. Hence, conductor has more free electrons also it has very less resistance. However, semiconductors conductivity depends on temperature, voltage, material composition etc. The gap between valance and conduction band is only

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1electron volt [9],[10].

III. Equivalent Circuit of Solar Cell

Equivalent circuit of solar PV cell is shown in figure it has a current source Isc and parallel connected diode(D) and parallel resistance(Rp) and Series resistance (Rs), respectively. The current source represents for ideal solar cell but practically solar cells never perfect, henceforth a series are parallel resistance has been included as shown in figure 3.

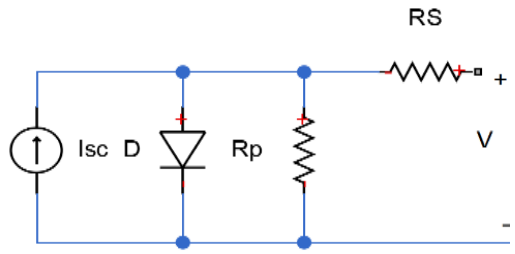

Figure 3. Single diode PV Equivalent circuit

The series resistance represents the metal contact with semiconductor, resistance of layer with semiconductor itself, resistance of metallic fingers which make front grid of solar cell. Perhaps, the parallel resistance effect due to leakage around edge of the cell, short circuit of minor steel components etc. The relation between output current, diode current as shown in blow (3) to (5) [11].

$$I_{out} = I_{SC} - ID \quad (3)$$

$$I_D = Io * (e^q k \frac{(V + IR_s)}{nKT} - 1) \quad (4)$$

$$I_{out} = I_L * (e^q k \frac{(V + IR_s)}{nKT} - 1) - \frac{(V + IR_s)}{R_p} \quad (5)$$

IV. Photovoltaic Effect

Solar PV out is intermittent hence it creates a power quality issues. Therefore, a new MPPT technique has been developed which is incorporated with the solar PV charge control. It controls the output power. Following MPPT techniques are popularly used that are Perturb & Observe, Incremental Conductance, Fractional open circuit voltage, Fuzzy Logic Control, Neural Network. Among them, the first method is a very simple method that of others. Since, only one sensor is enough to decide the perturbation therefore its cost wise cheaper. This method a controller can adjust the array voltage and measured power. Also, it takes a decision based on the present power and previous power. According to that it, it finds an optimum point. Conversely, this method not suitable for fast varying environmental condition respectively. Such a problem has been rectified by incremental conductance algorithm by this algorithm once reached the maximum point it can stop the agitation. Third method working based on the relationship between solar PV power as well as open circuit voltage respectively. While, the fuzzy logic method can have reduced the oscillation and its make an accurate location, respectively. Once compared to neural network it simple as well as implementation very easy. Since, ANN based MPPT has been required training huge data set to find the maximum power point. Therefore, above study states that, day by day a new technique has been incorporated with solar PV which is due to solar panel efficiency is very low but the installation cost is low hence it necessary to keep operation solar PV in maximum efficiency is mandatory [12]-[15].

V. Solar Cell Characteristics

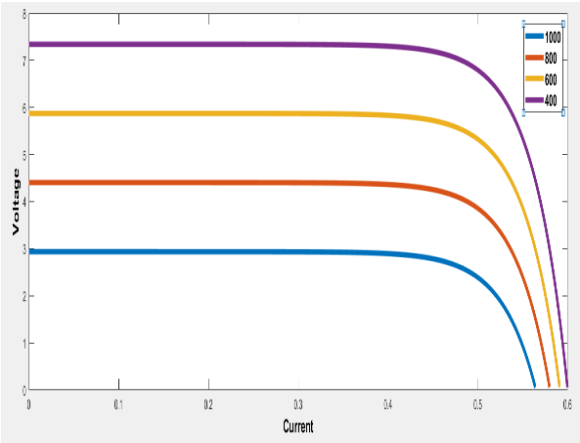

Figure 4. VI Characteristics Single Cell

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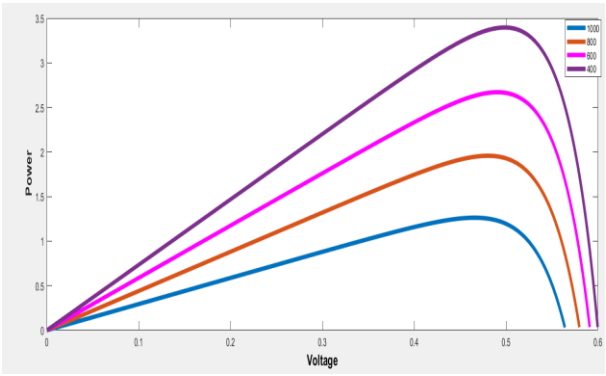

Figure 5. PV Characteristics of Single cell

Figure 4 shows the relation between voltage and current. The output of solar PV fully depends on irradiance. When irradiance is high, the output of solar PV is high and vise-versa. At 1000W/m^2,25 °C, the developed model has been generating above 7.34 V as shown in figure 4. Subsequently, we reduced the irradiation from 1000W/m^2 to 800W/m^2 at this condition generated output voltage is 5.96V which infers that there is direct relationship between voltage and current. The figure 6 shows the relation between voltage and power. At 1000 W/m^2, solar irradiation and 25°C temperature, the simulation model has been generate maximum power subsequently we reduced solar irradiation 800,600 and 400 W/m^2. This implies that, output power of solar PV cell has been gradually decreased with the irradiations, respectively.

The figure 6 shows the relation between voltage and power. At 1000 W/m^2 solar irradiation and 25°C temperature, the simulation model has been generate maximum power subsequently we reduced solar irradiation 800,600 and 400 W/m2. This implies that, output power of solar PV cell has been gradually decreased with the irradiations, respectively.

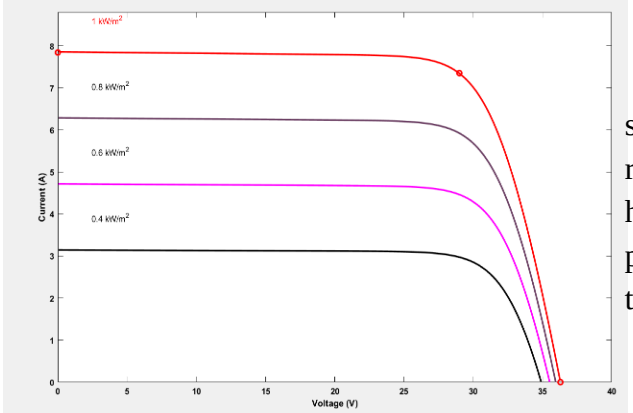

Figure 6. VI characteristics of Solar Array

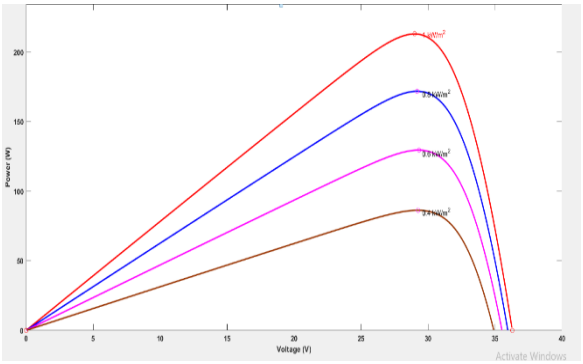

Figure 7. PV characteristics of Solar Array

As shown above figure 7 and 8 is also shows the relation between voltage and current. It is obtained from solar PV array which has 40 parallel string and 10 Series-connected modules per string. Solar string is referring to a set of series connected solar cell or module is called as string. The number of cell per module is 50 respectively. At standard temperature we vary the irradiations. At the instant of 100W/m2 , simulated model has been generating 1 kW/m2 and 0.8 kW/m^2 for 800 W/m^2 , 0.6 kW/m^2 for 600 and 0.4 kW/m2 for 400. The generating power is referring to maximum power.

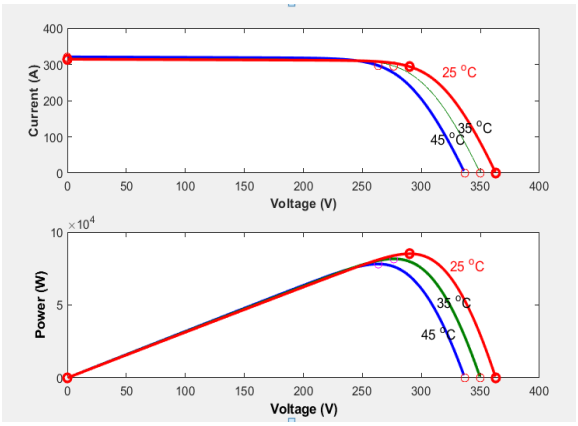

Figure 8. Relation between solar PV and Temperature

As shown in figure 8 it showes the relation between solar PV output current, voltage and power respectively. At 25 °C the output power of PV array is high whereas at 45°C it low. It infers that, PV panel performance depends on photo intensity not for temperature.

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VI. CONCLUSION

In this manuscript single solar cell and solar array has been modelling in a MATLAB / Simulink block set for analysis environmental effects on solar PV characteristics. From the simulation found that, the output power of solar PV is high at the instant of high irradiance and vise-versa. Furthermore, single solar cell and solar PV arrays characteristics such as power versus voltage, current versus voltage is appears unique pattern. However, the magnitude only significantly varied. Also, developed model great high power at 25°C when increases temperature the output of solar PV gradually decreased with a temperature rise which is evident that solar PV sensitive with temperature rise.

VII. REFERNCE

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