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Analysis of Solar Photovoltaic panel Characteristics using MATLAB

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Abstract —A MATLAB programming for the solar PV cell, modules and array is developed and presented in this dissertation. This programming is based on the fundamental circuit equations of a solar PV cell taking into account the effects of physical and environmental parameters such as the solar radiation and cell temperature

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INDEX TERMS—-MATLAB,SOLAR CELL ,PROGRAMINGL, SOLAR RADIATION,SERIES RESISTANCE,SHUNT RESISTANCE,TEMPERATURE

1 INTRODUCTION

The development of new energy sources is continuously enhanced because of the critical situation of the chemical industrial fuels such as oil, gas and others. Thus, the renewable energy sources have become a more important contributor to the total energy consumed in the world. In fact, the demand for solar energy has increased by 20% to 25% over the past 20 years. In fact, nowadays, solar PV provides around 4800 GW. Between 2004 and 2009, grid connected PV capacity reached 21 GW and was increasing at an annual average rate of 60%. In order to get benefit from the application of PV systems, research activities are being conducted in an attempt to gain further improvement in their cost, efficiency and reliability.

Drastic changes in energy conversion system are anticipated due to shortage of conventional fuels. Fuel deposit in the world will soon deplete by the end of 2020. Fossil fuel scarcity will be maximum. The main reasons for the above are due to increasing demand for electricity, rising population, rapid advance in technology. It is worthwhile to mention here that indiscriminate use of commercial energy has lead to serious environment problems like air and water pollutions. Man, when he is embarking on use of alternate sources of energy should bear in mind, his environment. The creation of new source of perennial environmentally acceptable, low cost electrical energy as a replacement for energy from rapidly depleting resources of fossil fuels is the fundamental need for the survival of mankind. The Indian power sector is highly dependent on coal as a fuel, with 53% of the total installed capacity being coal based generation. Given the current scenario, coal consumption by the power sector is likely to reach levels of 173 Metric Tonnes by 2015. According to the Ministry of Coal, the existing coal reserves are estimated to last for another 40-45 years.

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2 INTRODUCTION TO I-V CURVES

The I-V (current-voltage) curve of a PV string (or module) describes its energy conversion capability at the existing conditions of irradiance (light level) and temperature. Conceptually, the curve represents the combinations of current and voltage at which the string could be operated or 'loaded', if the irradiance and cell temperature could be held constant. Figure 2.1 shows a typical I-V curve, the power-voltage or P-V curve that is computed from it, and key points on these curves. Referring to Figure 1, the span of the I-V curve ranges from the

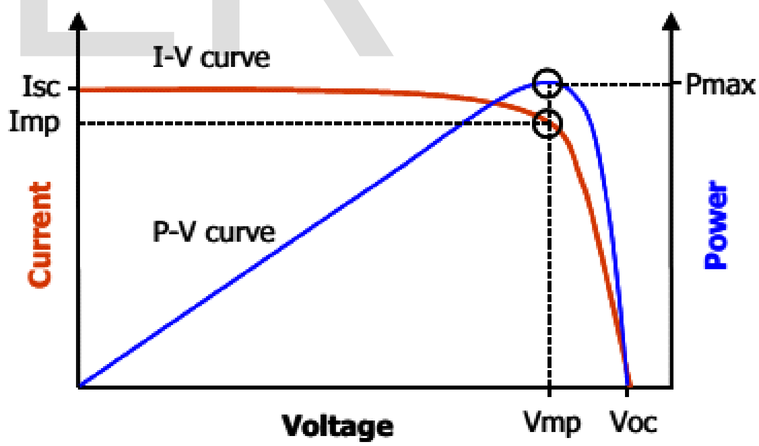

Figure 2.1 the I-V and P-V curves of a photovoltaic device

3 . EFFECTS OF SOLAR RADIATION VARIATION

Solar Radiation variation is important in characterization of photovoltaic devices. We present results of an experimental investigation of the effects of the Radiation variation on the device performance of multicrystalline silicon photovoltaic module. The investigation concentrate on the analysis of outdoor solar Radiation measurements carried out at one min intervals on clear sky days. Short circuit current and open

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circuit voltage have been measured to describe the module electrical performance. We have shown that the shift in the solar Radiation has a negative impact on the device performance of the module. The above output includes two subsystems: one that calculates the PV cell photocurrent which depends on the radiation and the temperature. The output power of the solar PV module changes with change in direction of the sun, change in solar insolation level and change in temperature. Also there is a single maximum power point in the PV characteristics of the PV module for a particular operating condition. It is desired that the PV module operates close to this point, i.e., output of the PV module approaches near to MPP. The process of operating PV module at this condition is called as maximum power point tracking (MPPT).

Determine current and output power

I_o=Np*Iph-Np*Irs*(exp (q/ (k*T*A)*V_o/N_s)-1)

$P_o = V_o.*I_o$

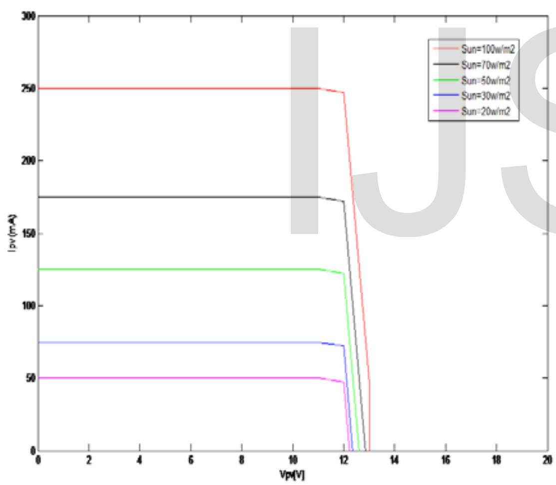

Figure 3.1 (a) I-V curves for different Rs.

4. Effect of Varying Cell Temperature

The diode reverse saturation current varies as a cubic function of the temperature and it can be expressed as:

$$I_s(T) = I_s\left(\frac{T}{T_{nom}}\right)\exp\left[\left(\frac{T}{T_{nom}} - 1\right)\frac{Eg}{NV_t}\right]$$

where Is is the diode reverse saturation current, Tnom is the nominal temperature, Eg is the band gap energy of the semiconductor and Vt is the thermal voltage. The reverse saturation current is based on equation . 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.

, the open circuit voltage Voc drops slightly, while the short circuit current increases. This behavior is validated and presented in Figure4.1

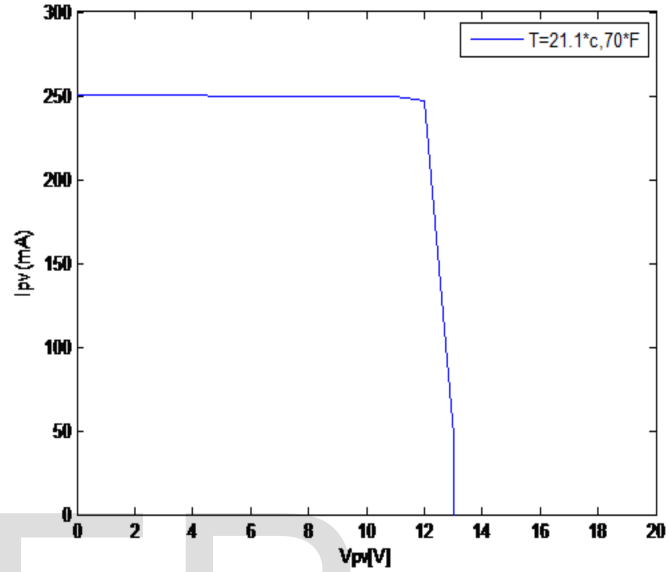

Figure 4.1 (a) I-V curves for different cell temperatures

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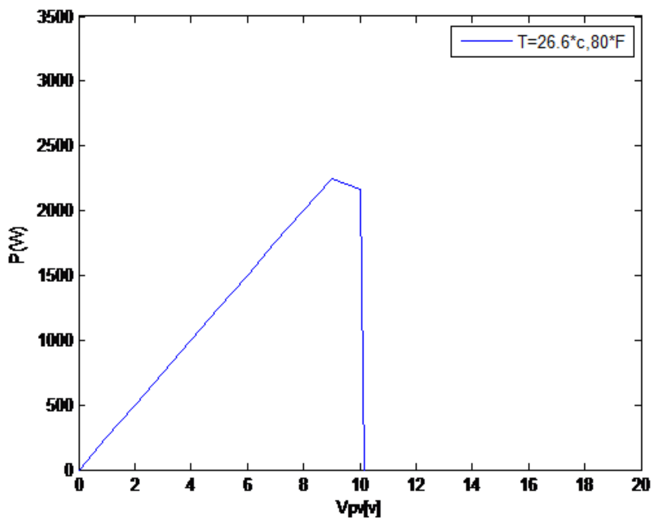

Figure 4.1 (b) P-V curves for different cell temperatures

Determine current and output Power

I_o=Np*Iph-Np*Irs*(exp (q/ (k*T*A)*V_o/N_s)-1)

$P_o = V_o.*I_o$

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5.. EFFECT OF VARYING RS

The series resistance of the PV cell is low, and in some cases, it can be neglected. However, to render the programming suitable for any given PV cell, it is possible to vary this resistance and predict the influence of its variation on the PV cell outputs. As seen in Figure 5.1 and 4.9. The variation of Rs affects the slope angle of the I-V curves resulting in a deviation of the maximum power point.

Determine current and output power

I_o=Np*Iph-Np*Irs*(exp (q/ (k*T*A)*V_o/N_s)-1)

I_{o1}=Np*Iph-Np*Irs*(exp (q/ (k*T*A)*V_o/(N_s+1))-1)

I_{o2}=Np*Iph-Np*Irs*(exp (q/ (k*T*A)*V_o/(N_s+2))-1)

P_o =V_o.*I_0

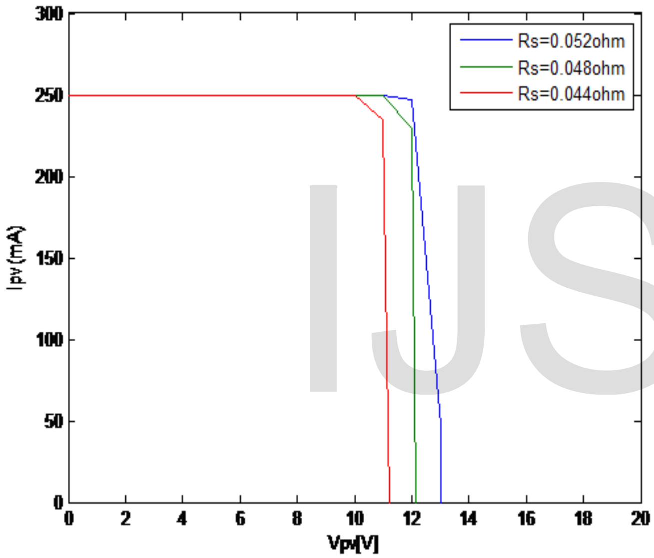

Figure 5.1 I-V curves for different Rs.

Figure 5.1 (a) Setup of the PVL-1241 solar laminate panel in Summer at temperature 39˚C.

Figure 5.1 (b) Setup of the PVL-1241 solar laminate panel in winter at temperature 15˚C

6.EXPERIMENTAL RESULTS AND VALIDATION

In order to validate the Mat lab programming, The PV test bench of Figure 5.1 a,b. was investigated. It consists of a rheostat, a daystar-meter to measure the solar radiation, two digital multi-meters and a solar panel that has the key specifications listed in Table 5.1.

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Table 5.1 Electrical specifications for the test panel

Solar Panel Macro Series Model No.: PVL-1241 Mfg/Year : 2013	
Type of Cell	Thin Film
Size of Panel(mm)	193*185*21 mm
Weight per Piece	500 gm.
Maximum power	3 W
Current at Pmax	250 m A
Short circuit current	125 m A
Voltage at Pmax	6 V
Open circuit voltage	13 V
No. of cell in series	18
No. of cell in Parallel	02
Power Output tolerance (%)	+/-3%
Frame materiel (Corner etc.)	Aluminum
Standard test condition	100w/m²,70⁰F

The Matlab programming was evaluated for the PVL-1241 solar panel. The results are shown in Figure 5.2. On the other hand, the experimental results for a solar radiation of 100 W/m2 are shown in Figure 5.3.The I-V and P-V programming and experimental results show a good agreement in terms of short circuit current, open circuit voltage and maximum power. In this study, the Matlab programming not only helps to predict the behavior of any PV cell under different physical and environmental conditions, also it can be considered a smart tool to extract the internal parameters of any solar PV cell including the ideal factor, series and shunt resistance. Some of these parameters are not always provided by the manufactures.

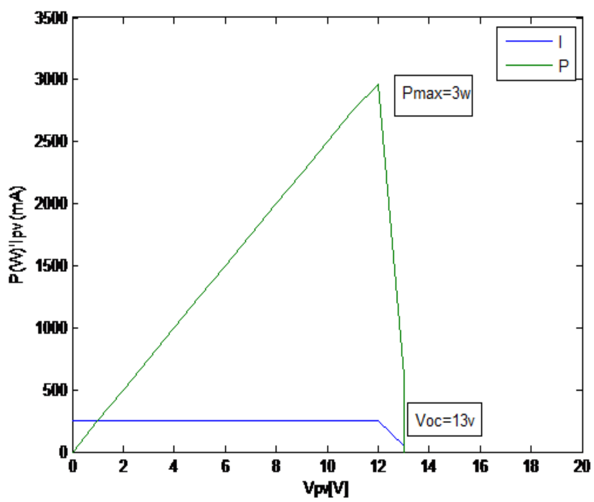

Figure 5.2 MATLAB programming results

6. CONCLUSION AND FUTURE SCOPE

A MATLAB programming for the solar PV cell, modules and array is developed and presented in this dissertation. This programming is based on the fundamental circuit equations of a solar PV cell taking into account the effects of physical and environmental parameters such as the solar radiation and cell temperature. The module programming is simulated and validated experimentally using the high efficient PVL-1241 solar laminate panel. As a result of the study, one can benefit from this programming as a photovoltaic generator in the framework of the Sim-Power-System, Matlab tool box in the field of solar PV power conversion systems. In addition, such a program would provide a tool to predict the behavior of any solar PV cell, module and array under climate and physical parameters changes. In this study, the Matlab programming not only helps to predict the behavior of any PV cell under different physical and environmental conditions, also it can be considered a smart tool to extract the internal parameters of any solar PV cell including the ideal factor, series and shunt resistance.

Objectives:

- Analysis of solar photovoltaic panel characteristic using matlab.
- Our second objective is to draw the v-i characteristics and p-i characteristics also show the variation in open circuit voltage and short circuit current.
- Comparison with actual data provided by manufactures of photovoltaic cell.

Future Scope:

The proposed PV programming takes sunlight irradiance and cell temperature as input parameters and outputs the I-V and P-V characteristics under various conditions. The maximum power point data extracted from Matlab are slightly different from actual panel data. These programming can be used to combine with wind generators and the PRMFCs to produce complex hybrid electricity generation systems to boost the Grid power supply they introduce multiple peaks in P-V characteristics.

The proposed programming is expected to serve as the basis model for carrying out study by the researchers in the field of PV modeling.

In future maltab programming are very helpful to design a new hardware of solar PV panel. In manufacturing industry matlab programming is very beneficial to design large size solar pv panel at low cost. At starting initial cost of pv panel is very high and less efficiency so less used but in future coal, diesel and petrol price are very high and produce pollution and noise. Solar panel is noiseless, pollution free, life long and less maintenance required.

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