Solar Cell Characteristics and Efficiency Plot

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Abstract- *As we know this era of energy generation is era of renewable energy because conventional sources like coal, oil is depleting rapidly due to excessive uses. Due to this, price of these sources also increasing day by day which is no economical for developing countries like India. Therefore we need to develop renewable energy from different sources. This project will give a practical world experience related to solar energy to students. Solar energy could be the largest source of energy generation in next 20 to 30 years. So this project will be proved helpful to the students in understand the solar energy characteristics and help them in future.*

A solar experimental kit is designed to perform plot the characteristic of a solar panel and to find thesolar panel efficiency. We have taken 3w, 6v solar panel and 100watt bulb as a source for the plot. A variable resistance of rating (0-250 ohm) is used and the characteristic is plotted. For the efficiency determination a 2.5 watt , 6v , 300 rpm DC motor has been used .

I. INTRODUCTION

The sun emits 3.89 $\times 10^{26}$watts of energy per second. Of that huge amount of energy only 1,388 watts reaches onper square meter of Earth's atmosphere and out of which even less reaches Earth's surface[1]. This solar radiation is converted into electricity by solar panel.

Thesolar panels can only generate power at certaintimes of the day. Therefore it is important to decide the time period of generation. To make sure that energy received from the sun is converted into electricity with maximum efficiency it is important to find the MPP.

II .KIT COMPONENT

a. Solar panel

Max. Power - 3 W
Max. Power Voltage - 8.97 V
Max. Power Current - 0.34 A
Open Circuit Voltage - 11.12 V
Short Circuit Current - 0.37 A
Dimension - 21.5 * 20.3 * 3.2cm

b. Variable Resistance

Range - (0 - 250 ohm)
Type - Wire wound rotary
Power rating - 5 w
Tolerance - (+/- 10) %

c. Analog Ammeter

Current Range - (0-1 A) DC
Resolution - 0.05 A

d. Analog Voltmeter

Voltage Range - (0-15 V) DC
Accuracy Class - 2.5

e. DC Motor

Type - PMDC
Rating – (2.5w,6v,300rpm)

III. DESIGN AND SETUP

The kit consists of the solar panel connected in series with the ammeter and the voltmeter connected in parallel in the circuit with the variable resistance to get the characteristic plot. The 100w bulb is used as a light source for the panel and the characteristic plot is taken .

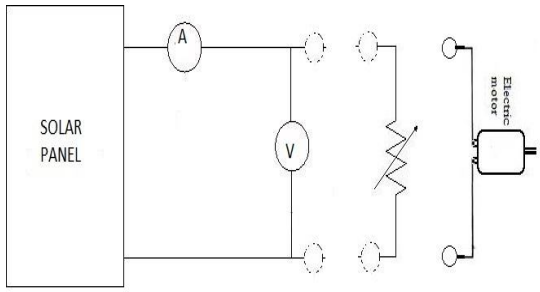

FIG 1. Experimental setup of the kit

For the efficiency test of the panel , the variable resistance is removed and DC motor is connected in the circuit as shown in the figure 1 .

Actual experimental kit is shown below. For connections, sv-7 chords are used.

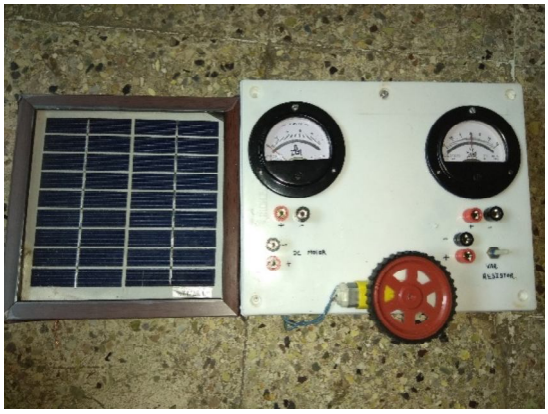

FIG 2: Actual Kit

IV. EXPERIMENTS AND RESULTS

a. Characteristics plot of solar cell

For this experiment, variable resistance is connected using chords. A 100 W bulb is used as the source. V & I values were taken for different values of resistance. Two tables of V-I characteristics were plotted by varying the distance of the lamp from panel.

Table 1- V-I readings at a distance 0.1m from panel to source

SR. NO.	Voltage (v)	Current (A)
1	0	.207
2	2	.202
3	4	.200
4	6	.194
5	8	.145
6	8.5	.120
7	9	.060
8	9.5	0

From the table 1 we can conclude that at 0 ohm variable resistance the value of voltage is 0V and current is .207A which the short circuit current . At the maximum resistance i.e 250 ohm , the value of voltage is 9.5V i.e the open circuit voltage and the current is 0A plotted for a distance of 0.1m of the panel from the lamp.

Table 2- V-I readings at a distance 0.15m from panel to source

SR. NO.	Voltage (v)	Current (A)
1	0	.14
2	2	.135
3	4	.129
4	6	.122
5	7.5	.09
6	8	.06
7	8.5	.03
8	9	0

From the table 2 we can conclude that at 0 ohm variable resistance the value of voltage is 0V and current is .14A which the short circuit current . At the maximum resistance i.e 250 ohm , the value of voltage is 9V i.e the open circuit voltage and the current is 0A plotted for a distance of 0.1m of the panel from the lamp.

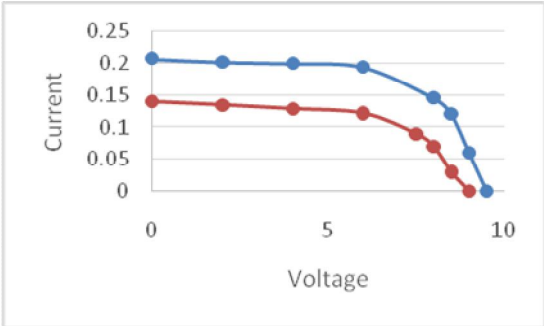

Fig 3. Shows the plot of V-I characteristics of table 1 & table 2

Blue colour graph plot for table 1 & orange colour for table 2.

From the plot MPP and FF are to be deduced which are given below.

Maximum Power Point (MPP) :- . The MPP is defined as the knee point or the point of the interaction of the graph of the plot of V vs I graph.

Tthe current and voltage at the maximum power point are designated as V_m and I_m . For a load, the maximum power point is varying with the variation in temperature, insolation, and shading. As solar power isrelatively expensive, we should operate solar panels at their maximum power point conditions.[2][3]

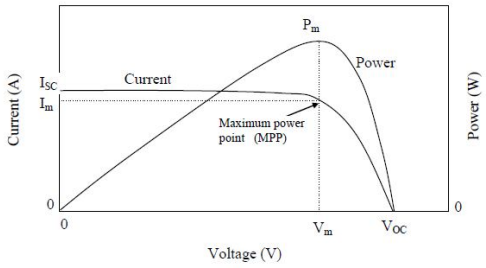

Fig 4: V-I graph showing MPP

From the V-I characteristics plot of the table 1 , the MPP at the point V = 7.1V and I = 0.172A .
Similarly, for the table 2 plot , MPP at the point V = 6.8 V and I = 0.11 A .

Fill factor :

The Fill Factor is described as the measure of the goodness or the aptness of the solar panel which is defined as the ratio of the practical values to the theoretical [2]. Fill factor is also representedin percentage.

$$FF = \frac{Vm.Im}{Voc.Isc}$$

For table 1 plot,

V_m= 7.1v I_m= 0.172A
V_{OC}=9.5v I_{SC} = 0.207A

FF = 0.62

For table 2 plot,

V_m = 6.8v I_m= 0.11A
V_{OC}=9v I_{SC} = 0.14A

FF = 0.59

b. Solar Cell Efficiency

Efficiency of a solar panel is measured by dividing panel output from the incident light input.

$$\eta = \frac{P}{E \times A} \times 100$$

Solar cell power output iscalculated by multiplying the output current and voltage of the cell:

$$P = V \times I$$

In this experimental setup, 100 Watt desk lamp is usedas the source to solar panel . In general 100 W light bulb at a distance of 0.15meter is E=350 watt per meter square .This value is going to be used as the value of irradiance in further efficiency calculations. A permanent magnet DC motor is used as constant load to the solar panel for the experiment.

Table 3: Variation of motor current and voltage w.r.t angle

Angle(Degree)	Voltage(v)	Current(A)
0	7.5	0.158
30	8	0.17
45	5	0.168

For Efficiency Calculation,

E = 350W/m^2
A= 21.5 ×20.3 × 10^{-4} cm^2
At angle 0°,
η = 7.75 %
At angle 30°,
η =8.90 %
At angle 45°,
η =5.49 %

V. CONCLUSION

This paper discusses about the characteristic plot of a solar panel and the efficiency of the PV panel. The characteristic graph provides the maximum power point of the panel at a given distance of the panel from the source.

MPP is the point of maximum power obtained for the solar panel so it is preferable to operate thesolar panel at MPP.

The efficiency calculation is done at a fixed load with the same irradiance. Maximum efficiency for the setup is obtained at an angle of 30 degree. In general, we can conclude that the maximum efficiency of a solar cell is obtained at an angel between 30 – 40 degree.

Therefore, before selecting any solar panel for commercial or residential purposes MPP and FF of the panel should be known before hand so the load demand is fulfilled by the solar panel.

REFERENCES

[1] Gilbert M. Masters, "Renewable and Efficient Electric Power System," Wiley, 2004
[2] Michael J Morgan, Greg Jakovidis and Ian McLeod (1994) An experiment to measure theI-V characteristics , Department of Physics, Monash University, Victoria 3168, Australia
[3] Bloomfield, Louis A. How things work: the physics of everyday life, 4. Ed., 2008