

EE 236: Experiment 4

I/V Characteristics of Solar Cell

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1 Aim

To find I/V characteristics of a Solar Cell corresponding to varying illuminations of light applied to it, to plot its power curve, and also to find its fill factor.

2 Prelab Simulations

2.1 NGSPICE Code for IV Characteristics of Solar Cell

```
.include 'solar_cell.txt'

*Jatin Kumar
*22B3922
*Plot IV Characteristics of Solar Cell

v1 0 1 dc
x1 1 2 solar_cell
vsolar 2 3 dc 0
r1 3 0 100

.dc v1 -2 2 0.01

.control

run
```

```

let id = i(vsolar)
let vd = {v(1) - v(2)}
plot id vs vd
.endc
.end

```

2.2 NGSPICE Code for finding V_{OC} , I_{SC} , I_{MP} , V_{MP}

```

.include 'solar_cell.txt'

*Jatin Kumar
*22B3922
*Find Fill Factor

x1 1 2 solar_cell
vsolar 3 1 dc 0
r1 2 3 100

.dc r1 0.001 10k 0.1

.control

run
let power = {i(vsolar)*(v(1) - v(2))}
let id = i(vsolar)
let vd = {v(1) - v(2)}
plot id vs vd power vs vd
.endc
.end

```

2.3 Simulation Results

- I/V Characteristics for Solar Cell in Dark (Illumination Current of 0 mA)

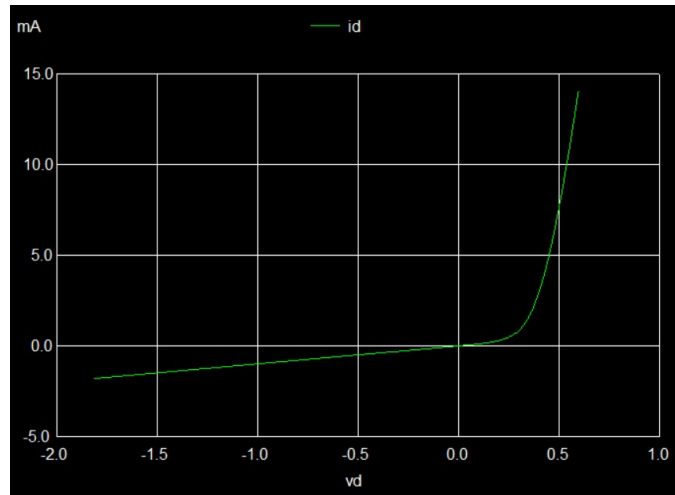


Figure 1: Dark I-V

- I/V Characteristics for Illumination Current of 8 mA

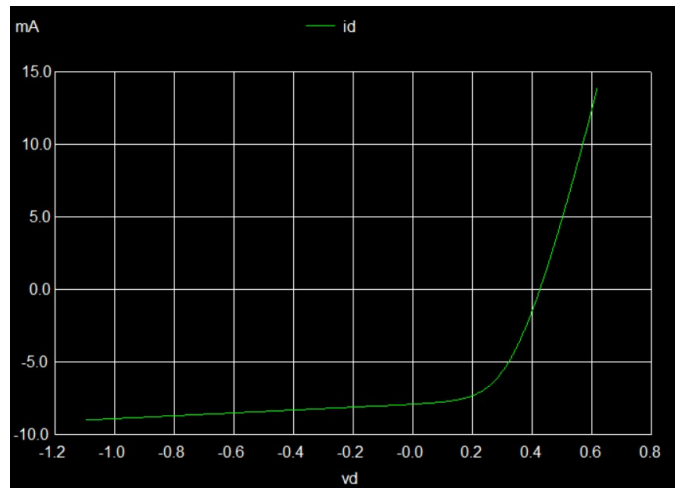


Figure 2: 8mA I-V

- I/V Characteristics for Illumination Current of 10 mA

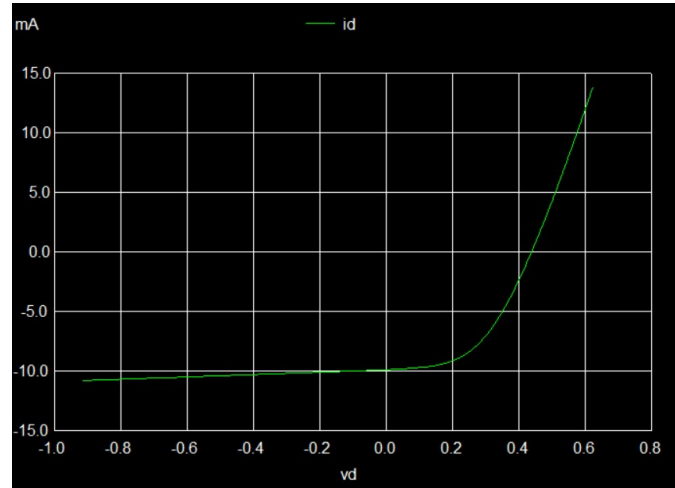


Figure 3: 10mA I-V

- Power Curve and IV Characteristics for Cell as Power Source for 8 mA

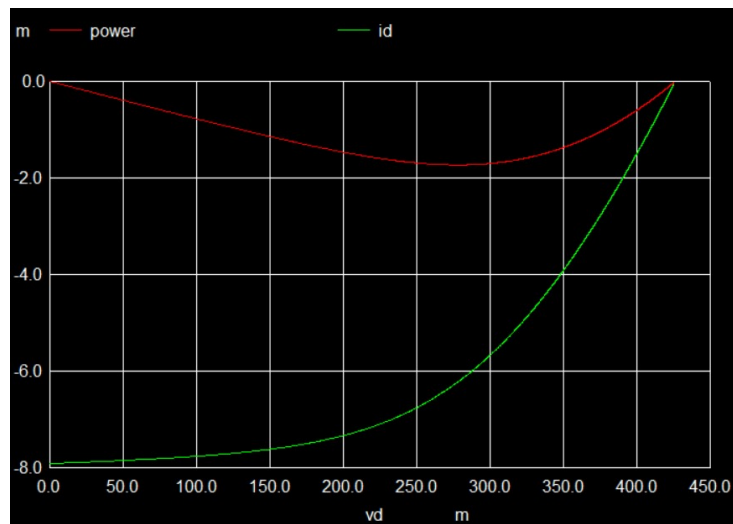


Figure 4: Power 8mA

- Power Curve and IV Characteristics for Cell as Power Source for 10 mA

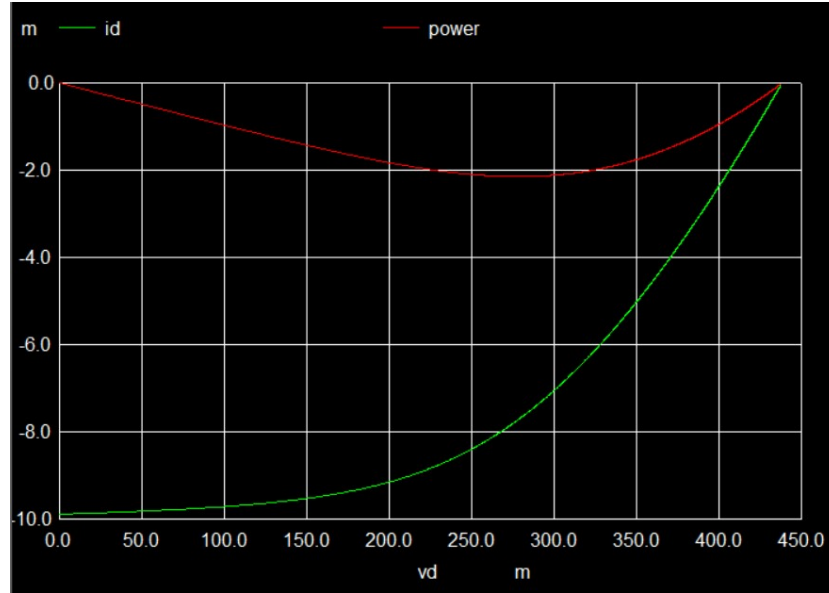


Figure 5: Power 10mA

From the two above two power curves, we obtain the following values shown in the bottom table and hence can evaluate the value of Fill Factor.

Illumination Current (mA)	V_{MP} (V)	I_{MP} (mA)	V_{OC} (V)	I_{SC} (mA)
10	0.28	-7.64	0.44	-10
8	0.277	-6.23	0.43	-8

Table 1: Fill Factor Evaluation

Thus the values of fill factors can be obtained using this equation:

$$\text{Fill Factor} = \frac{V_{MP} \times I_{MP}}{V_{OC} \times I_{SC}}$$

Thus, the **fill factor** for illuminations of **8 mA** is **0.486** and **10 mA** is **0.501**.

3 Lab Experiment

3.1 Circuits Used

- Circuit To Obtain IV Characteristics

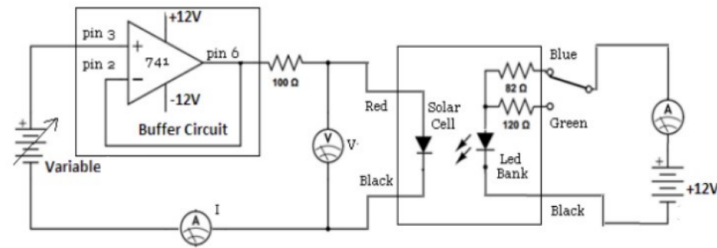


Figure 6: Circuit to Obtain IV Characteristics

- Circuit for Solar Cell as Power Source and Power Curve

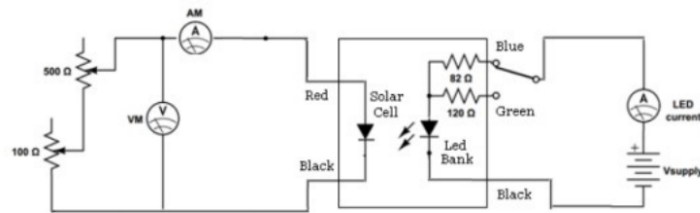


Figure 7: Circuit for Solar Cell as Power Source and Power Curve

- Circuit to find V_{OC} and I_{SC}

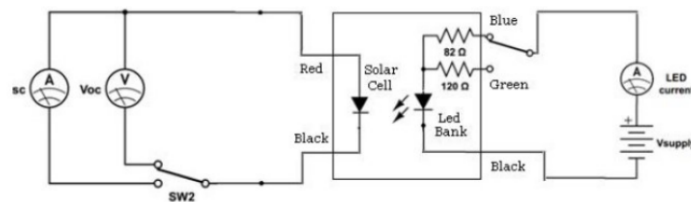


Figure 8: Circuit to find V_{OC} and I_{SC}

3.2 Observations and Plots Obtained

3.2.1 Part 1(a): Values Obtained for Dark I-V Characteristics

Vsupply	I_D (mA)	V_D
-2.0	-0.99	-2.20
-1.9	-0.96	-2.17
-1.7	-0.76	-1.95
-1.3	-0.26	-1.27
-1.2	-0.46	-1.59
-0.8	-0.30	-1.25
-0.5	-0.16	-0.97
0.5	1.60	0.33
1.0	5.05	0.41
1.1	6.15	0.41
1.5	9.44	0.44
1.6	10.63	0.45
2.0	13.53	0.45

Table 2: Dark I-V Characteristics

IV Characteristics Obtained for Solar Cell in Dark

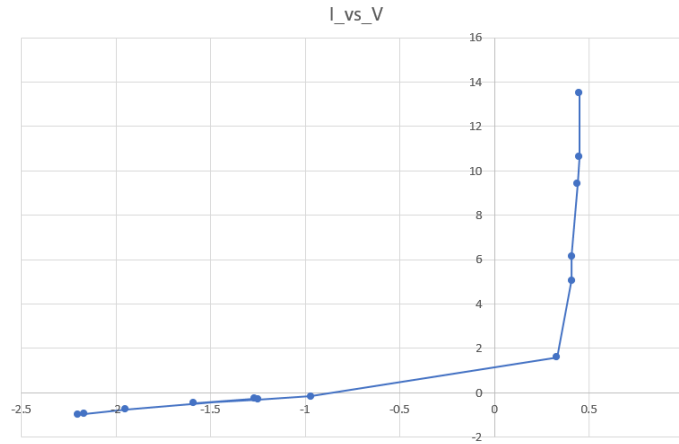


Figure 9: Dark I-V

3.2.2 Part 1(b):

- For Illumination 1 (Connected to “Green”)

Vsupply	I_D (mA)	V_D
-2.0	-6.64	-1.28
-1.8	-6.50	-1.02
-1.5	-6.37	-0.80
-1.0	-6.15	-0.32
-0.8	-6.10	-0.15
-0.5	-5.95	0.13
-0.3	-5.50	0.29
-0.1	-4.60	0.36
0.0	-3.45	0.40
0.3	-1.90	0.42
0.5	0.86	0.45
0.8	3.20	0.46
1.0	4.50	0.47
1.5	9.10	0.49
1.8	11.50	0.50
2.0	13.40	0.50

Table 3: I-V Characteristics for Illumination 1 (Green)

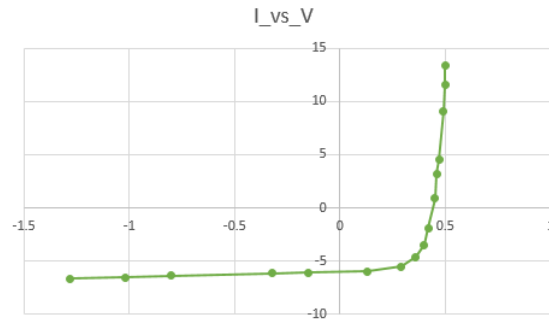


Figure 10: IV Characteristics Obtained for Illumination 1 (Green)

- For Illumination 2 (Connected to “Blue”)

Vsupply	I_D (mA)	V_D
-2.0	-8.79	-1.05
-1.8	-8.70	-0.88
-1.5	-8.50	-0.55
-1.0	-8.33	-0.06
-0.8	-8.25	0.08
-0.5	-7.70	0.28
-0.3	-6.63	0.37
-0.1	-4.60	0.41
0.0	-3.70	0.42
0.3	-1.80	0.44
0.5	0.41	0.46
0.8	3.07	0.47
1.0	4.80	0.48
1.5	9.32	0.49
1.8	12.15	0.50
2.0	13.60	0.50

Table 4: I-V Characteristics for Illumination 2 (Blue)

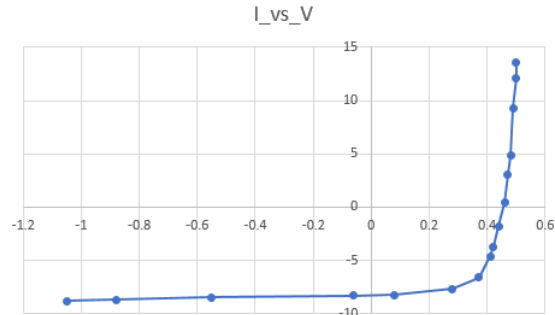


Figure 11: IV Characteristics Obtained for Illumination 2 (Blue)

3.2.3 Part 2: For Illumination 1 (Connected to “Green”)

The value of current flowing through the LED bank to illuminate the solar cell was measured as 44.3 mA.

V_L (V)	I_L (mA)	P (mW)
0.00	6.31	0.00
0.05	6.25	0.31
0.07	6.21	0.43
0.12	6.12	0.73
0.225	5.49	1.24
0.25	5.03	1.26
0.29	4.43	1.28
0.31	3.93	1.22
0.33	3.25	1.07
0.35	2.81	0.98
0.365	2.26	0.82
0.38	1.58	0.60
0.39	1.17	0.46
0.40	0.69	0.28

Table 5: I_L vs V_L for Illumination 1 (Green)

- I_L vs V_L for Illumination 1 (Green)

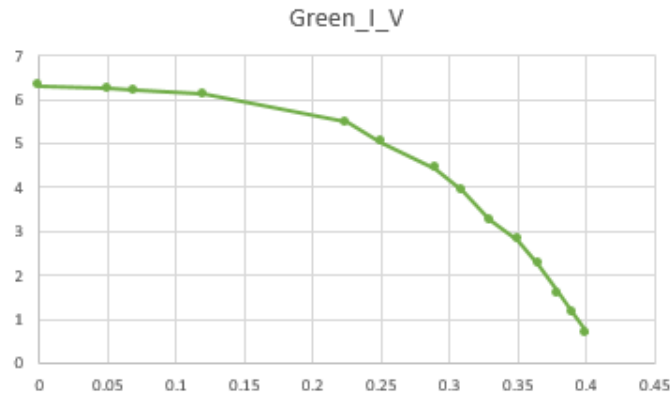


Figure 12: I_L vs V_L

- **P vs V_L for Illumination 1 (Green)**

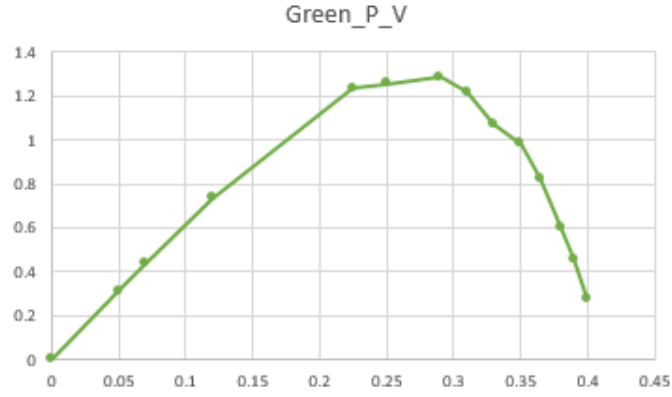


Figure 13: P vs V_L

3.2.4 Part 2: For Illumination 2 (Connected to “Blue”)

The value of current flowing through the LED bank to illuminate the solar cell was measured as 58.9 mA.

V_L (V)	I_L (mA)	P (mW)
0.00	6.31	0.00
0.01	6.25	0.06
0.05	6.26	0.31
0.16	6.00	0.96
0.22	5.56	1.22
0.27	4.85	1.31
0.35	2.92	1.02
0.38	1.60	0.61
0.40	0.75	0.30
0.41	0.69	0.28

Table 6: IL vs VL for Illumination 2 (Blue)

- IL vs VL for Illumination 2 (Blue)

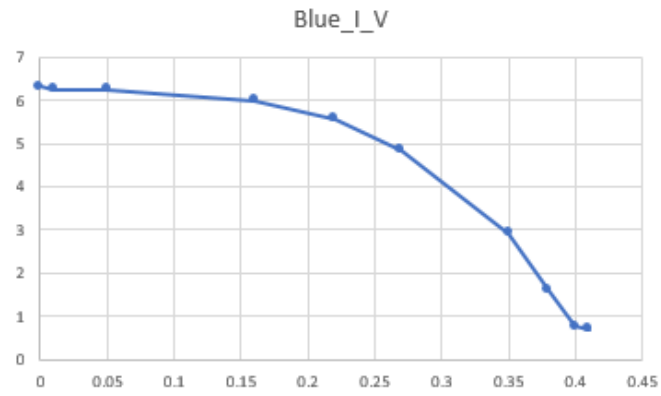


Figure 14: I_L vs V_L

- P vs VL for Illumination 2 (Blue)

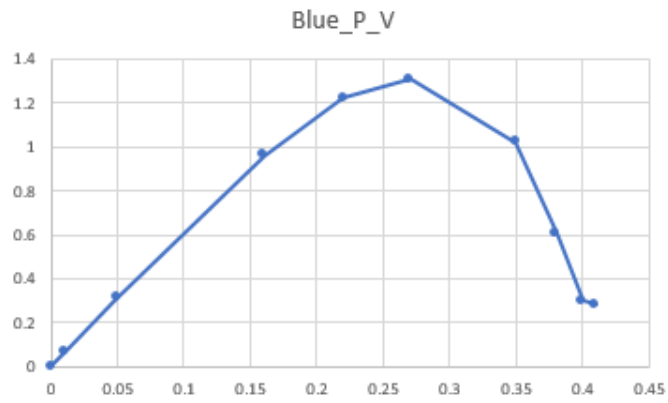


Figure 15: P vs V_L

3.2.5 Results Obtained after Calculations for Part 2

The Fill Factors were found using the following relation:

$$\text{Fill Factor} = \frac{P_{\max}}{V_{OC} \times I_{SC}}$$

Value	Illumination 1 (Green)	Illumination 2 (Blue)
$I_{\text{LED Bank}}$ (mA)	44.3	58.9
I_{SC} (mA)	5.86	8.00
V_{OC} (V)	0.45	0.50
P_{\max} (mW)	1.914	1.401
I_{MP} (mA)	4.67	6.38
V_{MP} (V)	0.30	0.30
FF	0.5312	0.4785

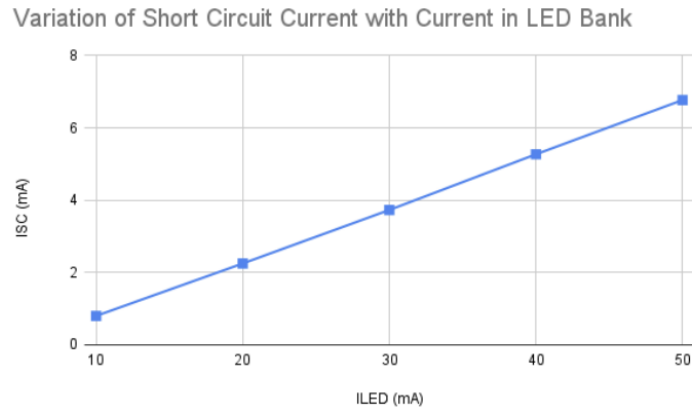
Table 7: Fill Factor Calculation

3.2.6 Part 3: Values of V_{OC} and I_{SC} for Different Illuminations

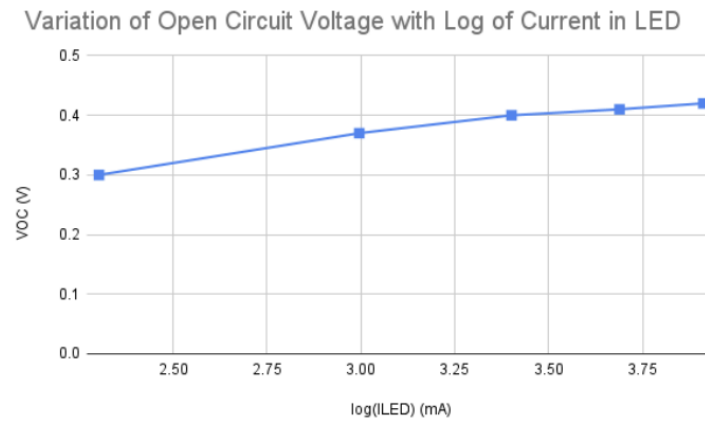
I_{LED} (mA)	I_{SC} (mA)	V_{OC} (V)
10	1.82	0.39
20	4.15	0.43
30	6.11	0.45
40	8.05	0.46
50	9.75	0.47

Table 8: V_{OC} and I_{SC} for Different Illuminations

Variation of I_{SC} with I_{LED}



Variation of V_{OC} with $\log(I_{LED})$



- We notice that both the above plots show linear behavior as we would expect.

4 Completion Status

The experiment was thoroughly conducted and successfully completed within the lab setting. All objectives were met, and the procedures were carried out as planned, yielding the expected results.