

# EE236: Lab 4

## I-V Characteristics of Solar Cell

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### 1 Aim of the experiment

1. To measure the I-V characteristics in forward and reverse bias of the solar cell in the dark.
2. To measure the current-voltage characteristics for two different levels of illumination  $I_1$  and  $I_2$ .
3. To measure the I-V characteristics for solar cell as power source.
4. To measure  $V_{OC}$  and  $I_{SC}$  at different illumination levels.

### 2 Design & Working

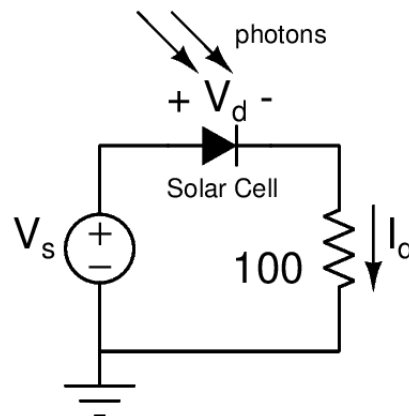


Fig. Solar Cell I-V circuit

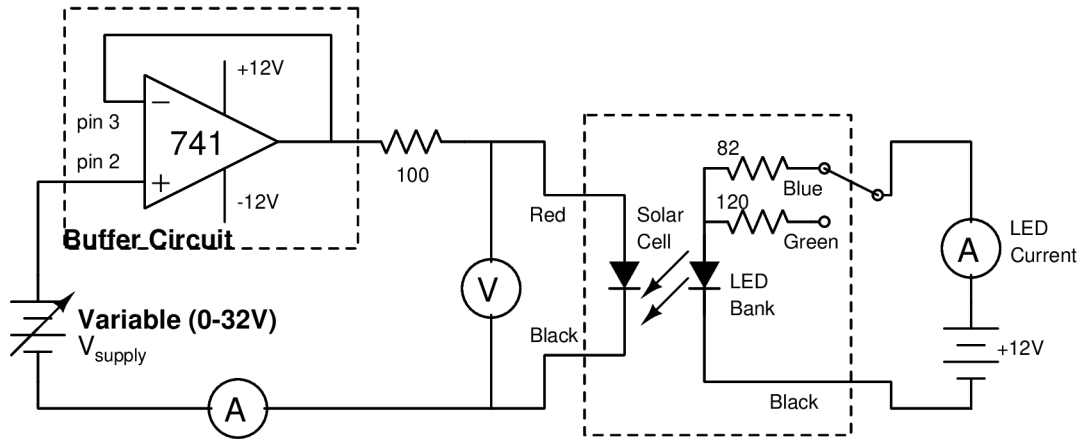


Fig. Circuit to measure I-V Characteristics

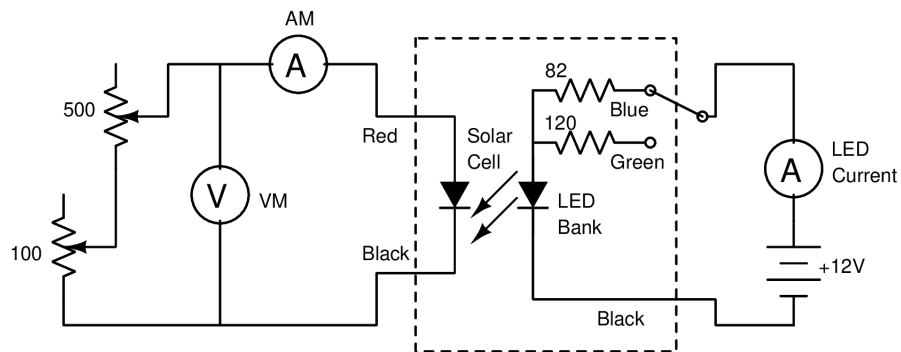


Fig. Solar Cell as Power Source

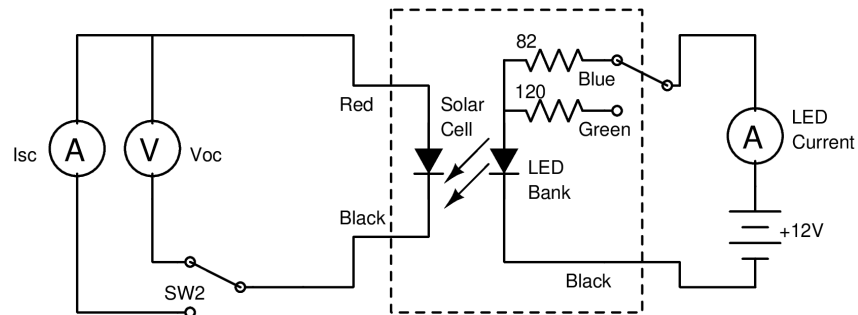


Fig. Circuit to measure  $V_{OC}$  and  $I_{SC}$  at different illumination levels

## 3 Simulation

### 3.1 Code Snippet

Solar Cell I-V Characteristics

```
* Including Solar cell subcircuit
.include Solar_Cell.txt
* Circuit connections
Vs 1 0 dc 20
X1 1 2 solar_cell
R1 2 dummy 100
Vdummy dummy 0 dc 0
* Performing DC analysis
.dc Vs -2 2 0.01
.control
run
* Plot settings
set color0 = white
set color1 = black
set color2 = red
* I-V Plot
plot i(Vdummy), (i(Vdummy)*v(1,2)) vs v(1,2)
* Measuring cutin voltage (1mA)
meas dc cutin find v(1,2) when i(Vdummy) = 1m
* Measuring Isc and Vsc
meas dc Isc find i(Vdummy) when v(1,2) = 0
meas dc Voc find v(1,2) when i(Vdummy) = 0
* Measuring Im and Vm
let derivout = deriv(v(1,2)*i(Vdummy))
meas dc Im find i(Vdummy) when derivout = 0
meas dc Vm find v(1,2) when derivout = 0
* Measuring FF
let FF = (Im*Vm)/(Isc*Voc)
print FF
.endc
.end
```

### 3.2 Simulation Results

Given below is the plot for  $I_D$  vs  $V_D$  waveform for the Solar Cell with no light (0 mA current through the LEDs):

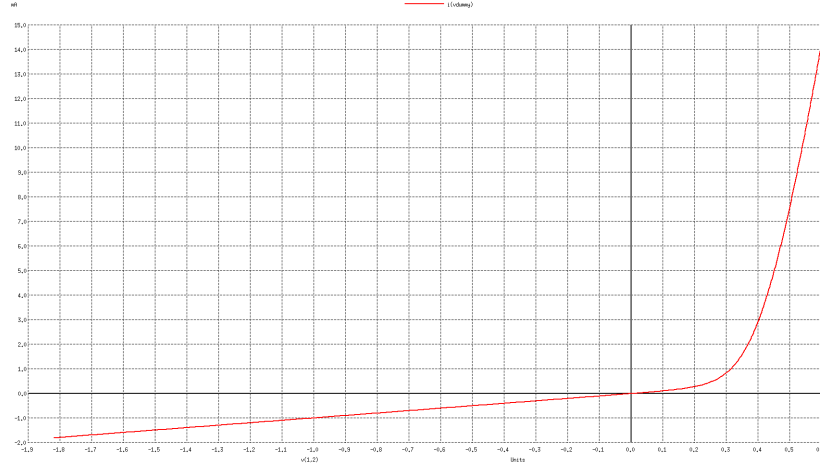


Fig. I-V Characteristics for the Solar Cell with no light

Given below is the plot for  $I_D$  vs  $V_D$  and Power waveforms for the Solar Cell with Illumination 1 (8 mA current through the LEDs):

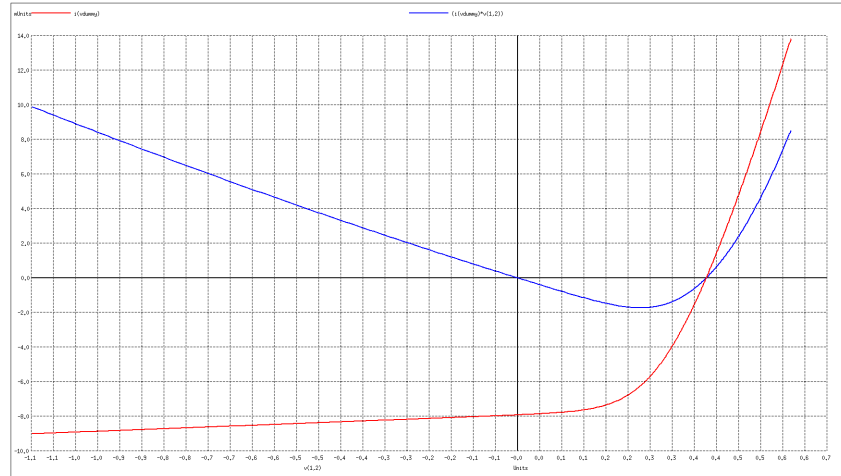


Fig. I-V Characteristics for the Solar Cell with Illumination 1

Given below is the plot for  $I_D$  vs  $V_D$  Power waveforms for the Solar Cell with Illumination 2 (10 mA current through the LEDs):

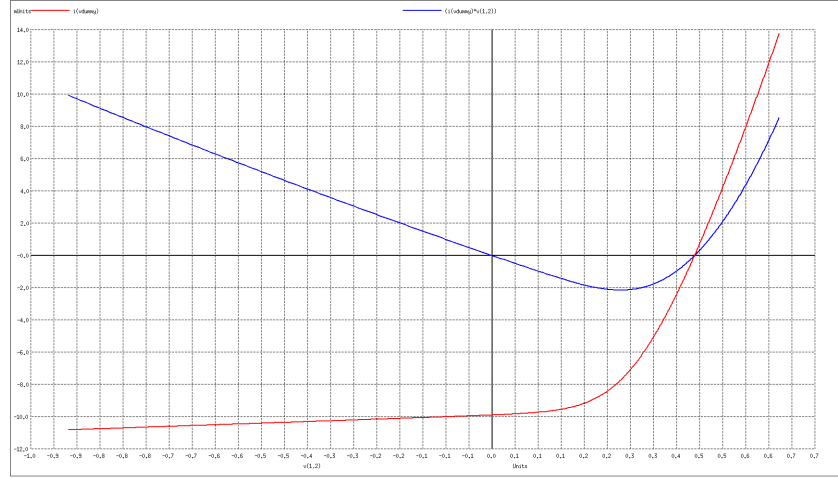


Fig. I-V Characteristics for the Solar Cell with Illumination 1

Given below are the measured readings using the above simulations for the Solar Cell at different illuminations:

	Cutin	$I_{SC}$	$V_{OC}$	$I_m$	$V_m$	FF
No Light	0.313V	-	-	-	-	-
Illumination 1	0.443V	$-7.91mA$	0.426V	$-6.22mA$	0.278V	0.513
Illumination 2	0.453V	$-9.89mA$	0.438V	$-7.71mA$	0.278V	0.495

## 4 Experimental Results

### 4.1 Part - 1

Given below are my readings for  $I_D$  and  $V_D$  for the Solar Cell under no light:

$V_D$ (in V)	$I_D$ (in mA)	$V_D$ (in V)	$I_D$ (in mA)
-2.04	-0.46	0	0
-1.93	-0.44	0.07	0
-1.83	-0.34	0.16	0.11
-1.73	-0.26	0.26	0.47
-1.61	-0.20	0.29	1.91
-1.51	-0.17	0.34	7.25
-1.41	-0.13	0.37	12.51
-1.31	-0.09	0.39	21.1
-1.21	-0.08	0.42	20.9
-1.1	-0.07	0.43	20.8
-1.0	-0.06	0.43	20.9
-0.9	-0.05	0.44	20.8
-0.8	-0.04	0.45	20.8
-0.71	-0.03	0.45	20.7
-0.61	-0.03	0.46	20.6
-0.5	-0.03	0.47	20.6
-0.41	-0.02	0.48	20.6
-0.3	-0.02	0.48	20.6
-0.21	-0.01	0.49	20.6
-0.1	-0.01	0.50	20.6

Given below is the I-V based on the above observations

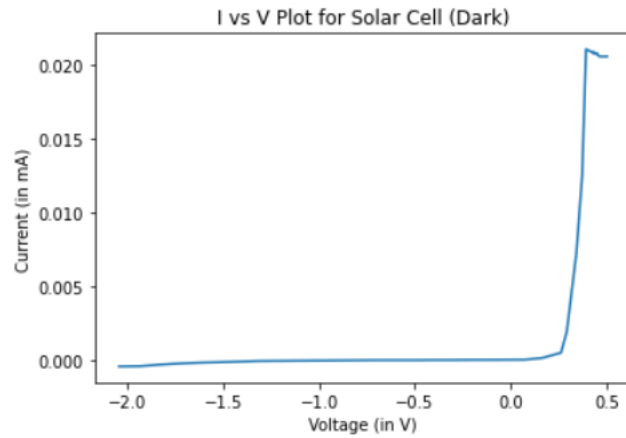


Fig. I-V Characteristics for the Solar Cell with no light

Given below are my readings for  $I_D$  and  $V_D$  for the Solar Cell with Illumination 1:

$V_D$ (in V)	$I_D$ (in mA)	$V_D$ (in V)	$I_D$ (in mA)
-1.17	-7.7	0.39	-7.5
-1.13	-7.7	0.41	-7.4
-0.99	-7.7	0.42	-7.2
-0.92	-7.7	0.43	-6.6
-0.79	-7.7	0.44	-3.0
-0.67	-7.6	0.44	2.0
-0.56	-7.6	0.45	11.1
-0.48	-7.6	0.46	21.0
-0.35	-7.5	0.46	20.9
-0.25	-7.5	0.47	20.8
-0.18	-7.5	0.47	20.8
-0.09	-7.5	0.48	20.7
0	-7.5	0.48	20.7
0.12	-7.5	0.48	20.7
0.21	-7.5	0.49	20.7
0.28	-7.5	0.49	20.7
0.32	-7.5	0.49	20.7
0.35	-7.5	0.50	20.7
0.37	-7.5	0.50	20.7
0.38	-7.5	0.51	20.7

Given below is the I-V based on the above observations

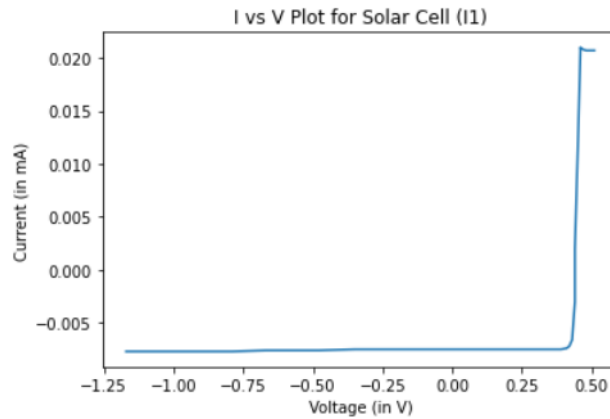


Fig. I-V Characteristics for the Solar Cell with Illumination 1

Given below are my readings for  $I_D$  and  $V_D$  for the Solar Cell with Illumination 2:

$V_D$ (in V)	$I_D$ (in mA)	$V_D$ (in V)	$I_D$ (in mA)
-0.90	-10.2	0.41	-9.9
-0.80	-10.2	0.43	-9.9
-0.70	-10.2	0.43	-9.5
-0.62	-10.2	0.44	-8.3
-0.54	-10.2	0.44	-3.4
-0.40	-10.1	0.45	1.4
-0.37	-10.1	0.45	11.0
-0.30	-10.1	0.46	21.0
-0.21	-10.1	0.47	20.8
-0.10	-10.1	0.47	20.7
-0.02	-10.1	0.47	20.7
0.08	-10.1	0.48	20.8
0.19	-10.1	0.48	20.8
0.25	-10.1	0.49	20.8
0.29	-10.1	0.49	20.8
0.32	-10.1	0.49	20.8
0.35	-10.1	0.50	20.8
0.37	-10.1	0.50	20.8
0.39	-10.1	0.50	20.8
0.40	-10.1	0.51	20.8

Given below is the I-V based on the above observations

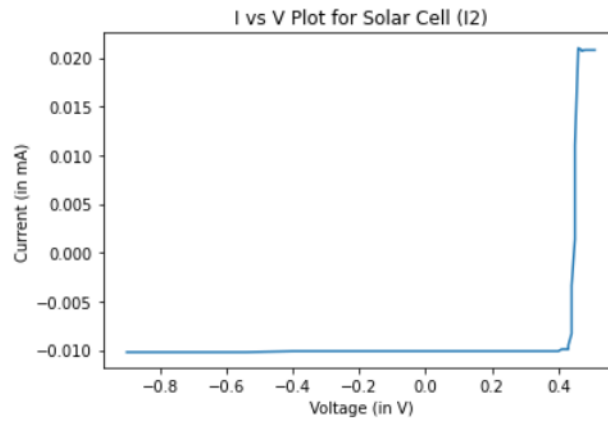


Fig. I-V Characteristics for the Solar Cell with Illumination 2



## 4.2 Part - 2

Given below are my readings for  $I_L$  and  $V_L$  for the Solar Cell with Illumination 1:

$V_L$ (in V)	$I_L$ (in mA)
0.01	-8.5
0.12	-8.3
0.19	-8.1
0.29	-7.3
0.41	-3.6
0.43	-1.6
0.44	-0.8

Given below is the I-V based on the above observations

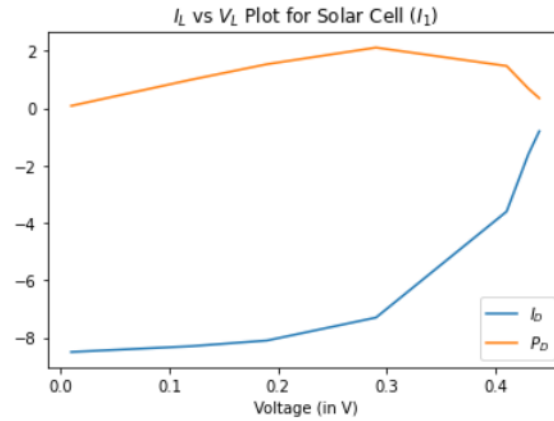


Fig. I-V Characteristics for the Solar Cell with Illumination 1

Given below are my readings for  $I_L$  and  $V_L$  for the Solar Cell with Illumination 2:

$V_L$ (in V)	$I_L$ (in mA)
0.01	-11.1
0.11	-10.9
0.19	-10.4
0.30	-9.4
0.39	-7.2
0.43	-4.2
0.44	-3.7
0.44	-3.1
0.45	-2.0
0.45	-1.5
0.45	-0.8

Given below is the I-V based on the above observations

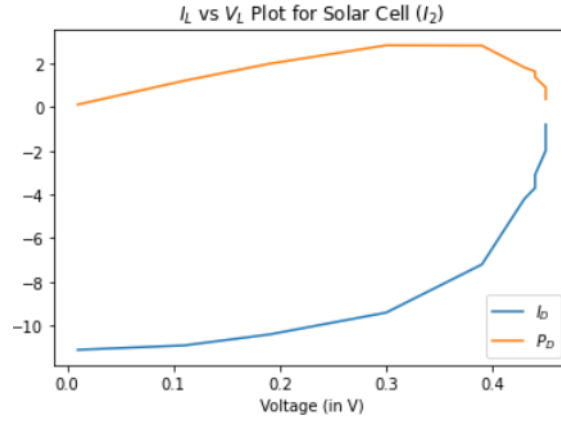


Fig. I-V Characteristics for the Solar Cell with Illumination 2

The fill factor can be calculated using the formula given below:

$$FF = \frac{I_M \times V_M}{I_{SC} \times V_{OC}} \quad (1)$$

Given below are the measured readings using the above readings for the Solar Cell at different illuminations:

	$I_{SC}$	$V_{OC}$	$I_m$	$V_m$	FF
Illumination 1	$-8.5mA$	$0.44V$	$-7.3mA$	$0.29V$	0.566
Illumination 2	$-11.1mA$	$0.45V$	$-9.4mA$	$0.30V$	0.565

### 4.3 Part - 3

Given below are my readings for  $I_{SC}$  and  $V_{OC}$  for the Solar Cell with Illumination 1 and varying  $I_{LED}$ :

$I_{LED}$ (in mA)	$V_{OC}$ (in V)	$I_{SC}$ (in mA)
10	0.39	1.97
20	0.41	3.56
30	0.43	5.92
40	0.44	7.95
50	0.45	9.52

Given below is the  $I_{SC}$  vs  $I_{LED}$  plot for Illumination 1 based on the above observations:

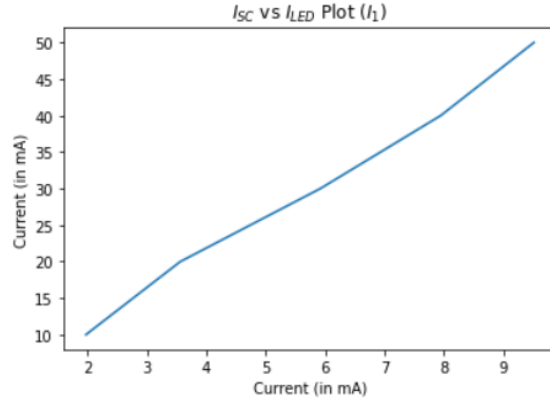


Fig.  $I_{SC}$  -  $I_{LED}$  Plot for the Solar Cell with Illumination 1

Given below is the  $V_{OC}$  vs  $\log(I_{LED})$  plot based on the above observations:

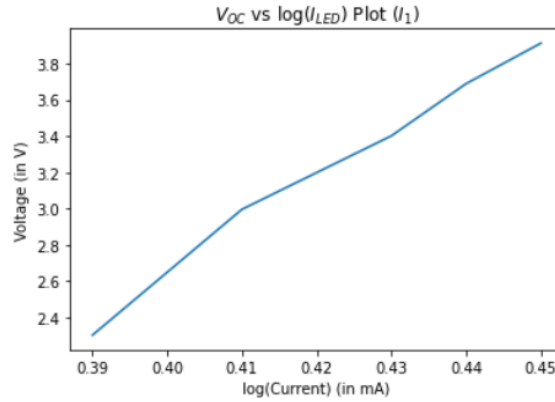


Fig.  $V_{OC}$  -  $\log(I_{LED})$  Plot for the Solar Cell with Illumination 1

Given below are my readings for  $I_{SC}$  and  $V_{OC}$  for the Solar Cell with Illumination 2 and varying  $I_{LED}$ :

$I_{LED}$ (in mA)	$V_{OC}$ (in V)	$I_{SC}$ (in mA)
10	0.39	2.39
20	0.41	4.05
30	0.43	5.69
40	0.44	7.86
50	0.46	9.55

Given below is the  $I_{SC}$  vs  $I_{LED}$  plot for Illumination 2 based on the above observations:

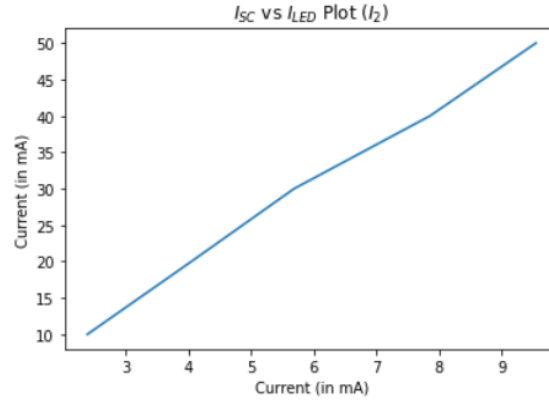


Fig.  $I_{SC}$  -  $I_{LED}$  Plot for the Solar Cell with Illumination 2

Given below is the  $V_{OC}$  vs  $\log(I_{LED})$  plot based on the above observations:

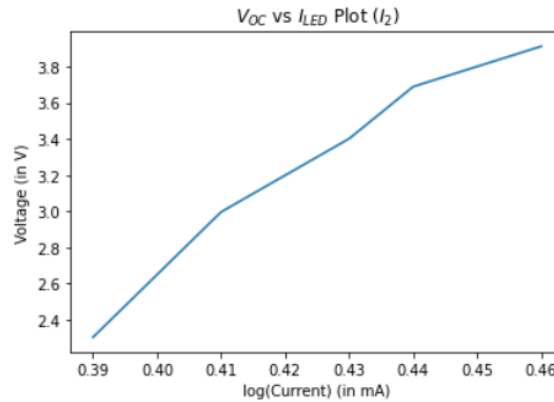


Fig.  $V_{OC}$  -  $\log(I_{LED})$  Plot for the Solar Cell with Illumination 2