EE236: Experiment No. 4
Temperature dependance of Solar Cell Characteristics

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1 Overview of the experiment

1.1 Aim of the experiment

Aim of this experiment is to analyze the forward bias I-V and C-V characteristics of Solar Cell in twisted conditions. We have to vary the temperatures and find Ideality factors at certain points.
To analyze the effects of Series Resistance (R_s) and Shunt Resistance (R_{sh}) on the Lighted I-V Characteristics of Solar Cell.

1.2 Methods

Firstly, I read and understood the background material to understand the temperature dependence. Then, I used the netlists from the previous lab for plotting the I-V Characteristics of Solar Cell at different temperatures namely, 35^0C, 45^0C, 55^0C, 65^0C and 75^0C. Then, I calculated η for low forward bias (1mA) and for high forward bias (5mA) at all the temperatures.
After that, I simulated the lighted I-V Characteristics of Solar Cell for all the given temperatures and R varying from 1 Ω to 500 Ω to find V_{oc}, I_{sc} and Fill Factor (FF).
Finally, I varied the Series Resistance (R_s) and Shunt Resistance (R_{sh}) of the Solar Cell to find V_{oc}, I_{sc} and Fill Factor (FF).

2 Design

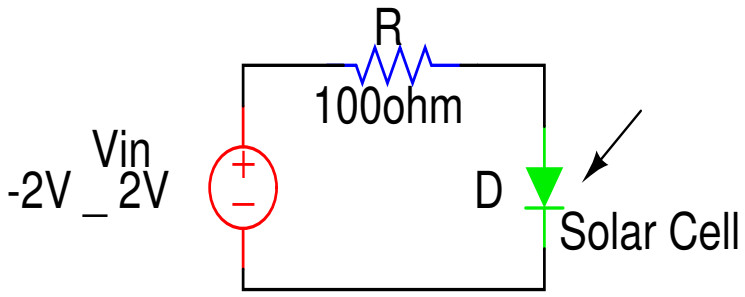

Fig 1. : I-V Characteristics of Solar Cell

The circuit in Fig. 1 is for the I-V characteristics simulation of Solar Cell. I did DC analysis for input voltage from -2V to 2V. The Solar Cell is forward biased. I simulated the circuit for 5 different values of temperatures.

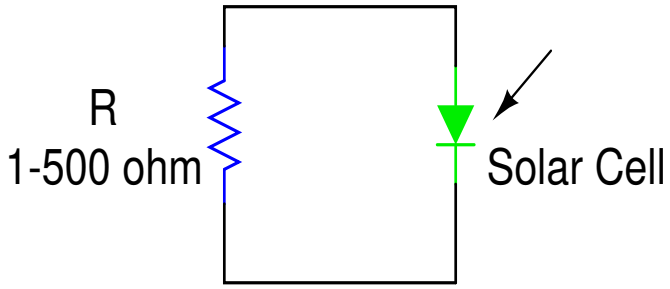

Fig 2. : I-V Characteristics of Solar Cell as a power source

This circuit represents I-V Characteristics of Solar Cell as a power source. I did a DC analysis for resistance from 1 Ω to 500 Ω. Then, I measured the I-V characteristics of the circuit for 8mA light generated current.
V_{OC} is the rightmost point on the I-V curve whereas I_{SC} is the leftmost point on the curve. Lastly, I plotted P-V graph and calculated the Fill Factor using the following formula.
And varied the Series Resistance (R_s) and Shunt Resistance (R_{sh}) of the Solar Cell to find V_{oc}, I_{sc} and Fill Factor (FF).

$$\text{Fill Factor (FF)} = I_{MP} * V_{MP}/(I_{SC} * V_{OC}) \tag{1}$$

[where, V_{MP} is the voltage at which the power P reaches maximum and I_{MP} the current at the maximum power point.]

3 Simulation results

3.1 Code snippets

3.1.1 I-V Characteristics of Solar Cell for different temperatures :

```
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*EE236 | Lab 4
*I-V Characteristics of Solar Cell
*Including Solar cell model file
.include Solar_Cell.txt
*Netlist
Vin In GND dc 0.01 ;Input
Vx 1 2 dc 0 ;Dummy voltage source
R1 In 1 100 ;Resistor
X1 2 GND solar_cell IL_val=0e-3 ;IL = 0A
*.temp 35 ;Temperature
*.temp 45 ;Temperature
*.temp 55 ;Temperature
*.temp 65 ;Temperature
.temp 75 ;Temperature
*DC Analysis
.dc Vin -2 2 0.01
.control
run
set color0 = white
set color1 = black
set color2 = blue
set color3 = red
set xbrushwidth = 2
plot I(Vx) vs V(2) ;Id vs Vd plot
.endc
.end
```

3.1.2 Lighted I-V Characteristics of Solar Cell for different temperatures :

```
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*EE236 | Lab 4
*Lighted I-V Characteristics
*Including Solar cell model file
```
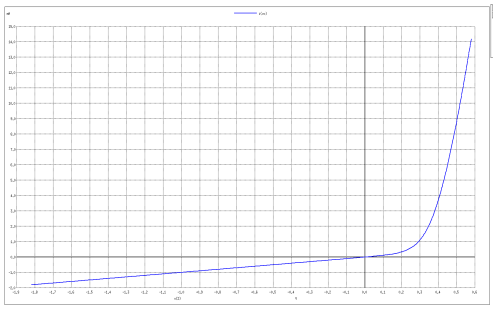

```
.include Solar_Cell.txt
*Netlist
Vx 1 2 dc 0
R1 0 1 100
X1 2 0 solar_cell IL_val=8e-3 ;IL = 8mA
*.temp 35 ;Temperature
*.temp 45 ;Temperature
*.temp 55 ;Temperature
*.temp 65 ;Temperature
.temp 75 ;Temperature
*DC Analysis
.dc R1 1 500 0.01
.control
run
set color0 = white
set color1 = black
set color2 = blue
set color3 = red
set xbrushwidth = 2
plot I(Vx) vs V(2)
plot V(1)*I(Vx) vs V(2)
.endc
.end
```

3.2 Simulation results



I-V Characteristics of Solar Cell at
Fig. 3 : T = 35^0C

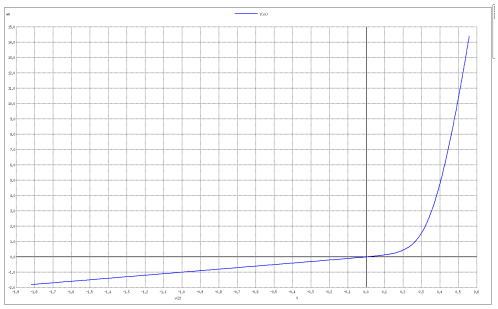
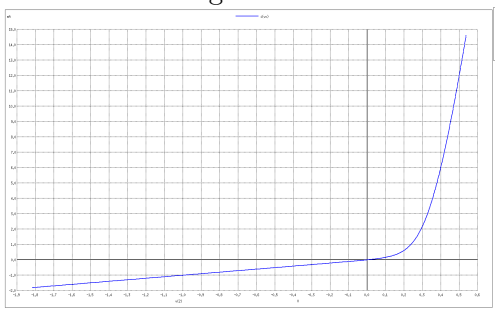


Fig. 4 : T = 45^0C



I-V Characteristics of Solar Cell at
Fig. 5 : T = 55^0C

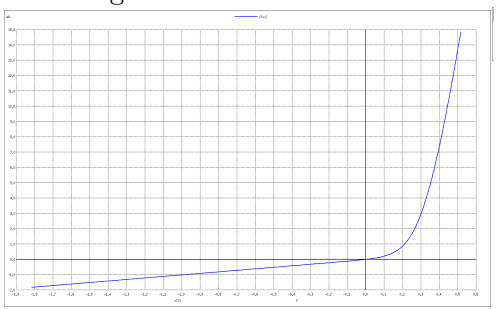


Fig. 6 : T = 65^0C

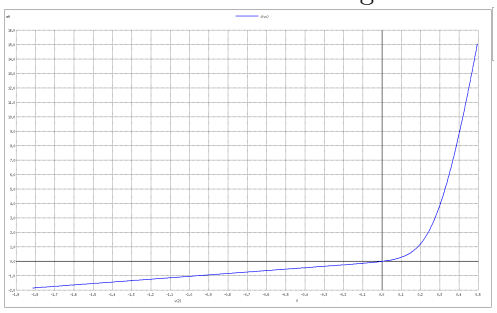
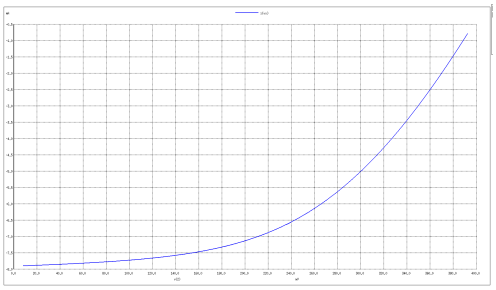


Fig. 7 : I-V Characteristics of Solar Cell at T = 75^0C

Temp	V_D (I_D=1mA)	V_D (I_D=2mA)	V_D (I_D=5mA)	η (I_D=1mA)	η (I_D=5mA)
35^0C	0.2924V	0.3484V	0.4333V	3.0586	3.9024
45^0C	0.2651V	0.3227V	0.4075V	2.3042	3.5949
55^0C	0.2393V	0.2924V	0.3803V	2.6493	4.1112
65^0C	0.2106V	0.2667V	0.3530V	3.7922	3.7197
75^0C	0.1826V	0.2405V	0.3289V	2.5982	3.6942



Lighted I-V Characteristics of Solar Cell at T = 35^0C

Fig. 8 : I_D vs V_D

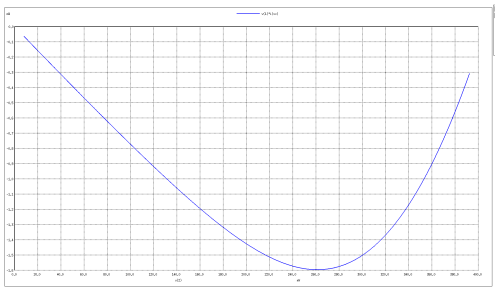
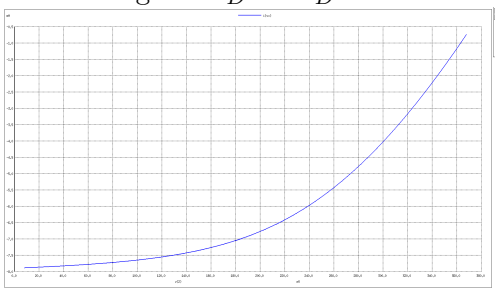


Fig. 9 : P_R vs V_D



Lighted I-V Characteristics of Solar Cell at T = 45^0C

Fig. 10 : I_D vs V_D

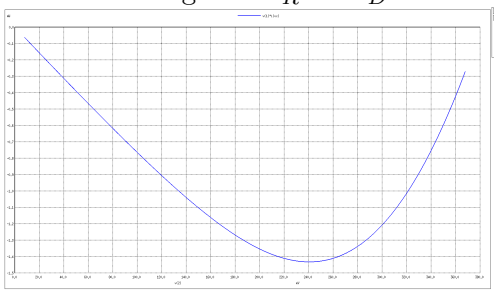
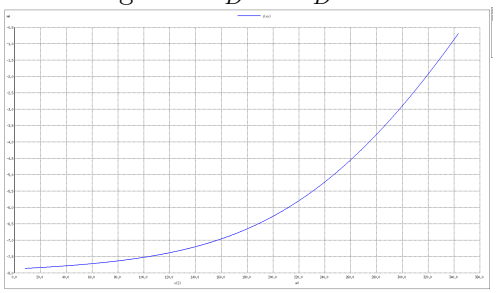


Fig. 11 : P_R vs V_D



Lighted I-V Characteristics of Solar Cell at T = 55^0C

Fig. 12 : I_D vs V_D

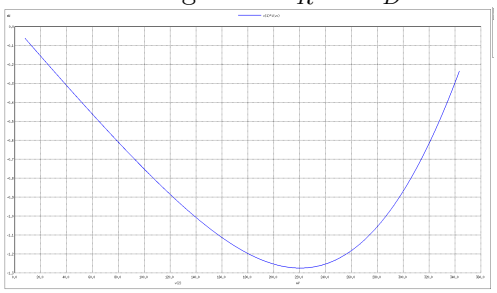
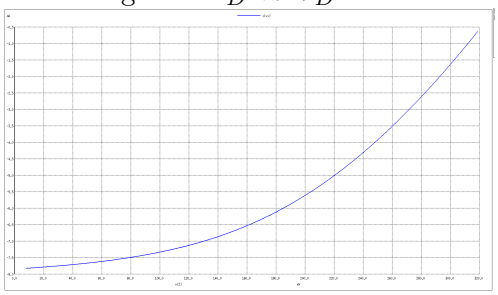


Fig. 13 : P_R vs V_D



Lighted I-V Characteristics of Solar Cell at T = 65^0C

Fig. 14 : I_D vs V_D

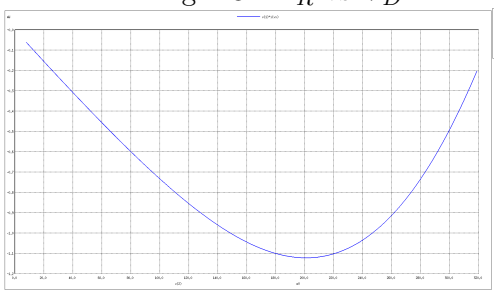


Fig. 15 : P_R vs V_D

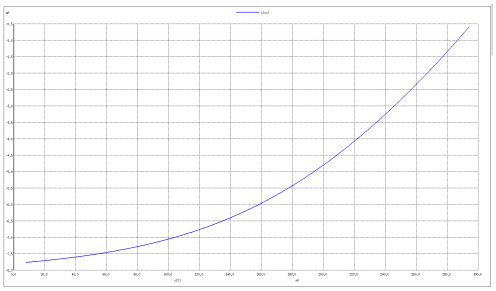


Fig. 16 : I_D vs V_D

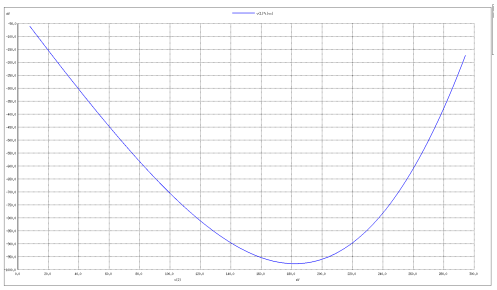


Fig. 17 : P_R vs V_D

Lighted I-V Characteristics of Solar Cell at T = 75^0C

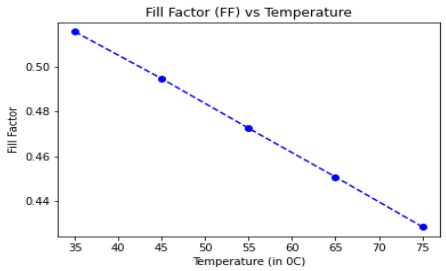


Fig. 18 : Fill Factor (FF) vs Temperature

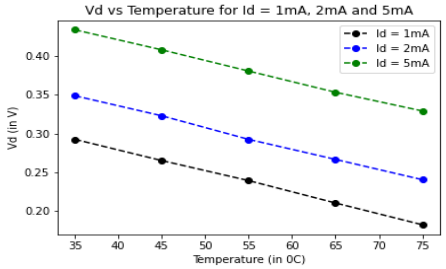


Fig. 19 : V_D vs Temperature (for I_D = 1mA, 2mA and 5mA)

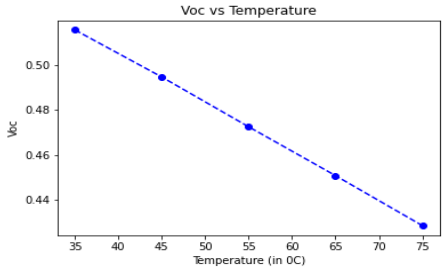
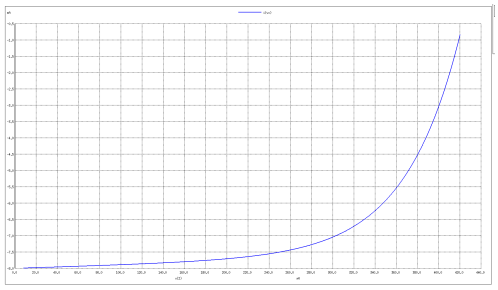
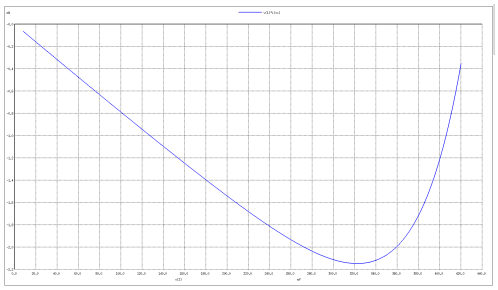


Fig. 20 : V_{oc} vs Temperature

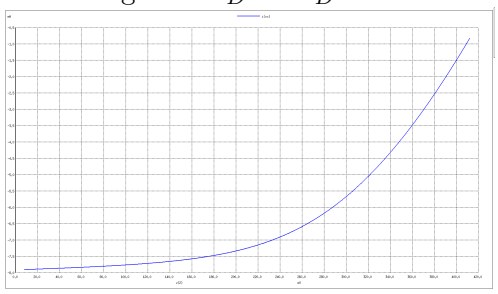
Fill Factor (FF), V_D and V_{oc} all show linear decreasing trend with Temperature. V_D increases with increase in I_D.

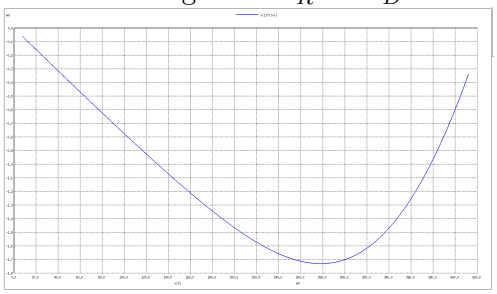




Lighted I-V Characteristics of Solar Cell at $R_s = 0\Omega$

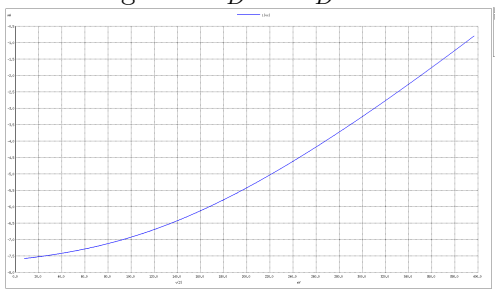
Fig. 21 : I_D vs V_D Fig. 22 : P_R vs V_D

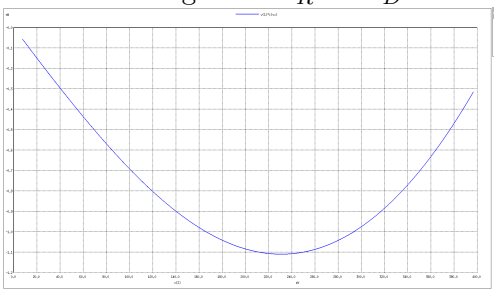




Lighted I-V Characteristics of Solar Cell at $R_s = 10\Omega$

Fig. 23 : I_D vs V_D Fig. 24 : P_R vs V_D





Lighted I-V Characteristics of Solar Cell at $R_s = 30\Omega$

Fig. 25 : I_D vs V_D Fig. 26 : P_R vs V_D

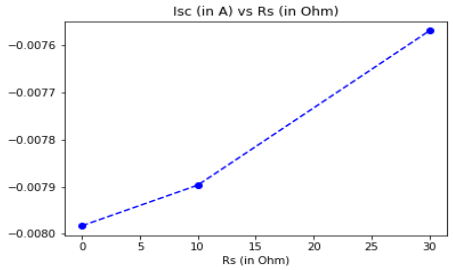


Fig. 27 : I_{sc} vs R_s

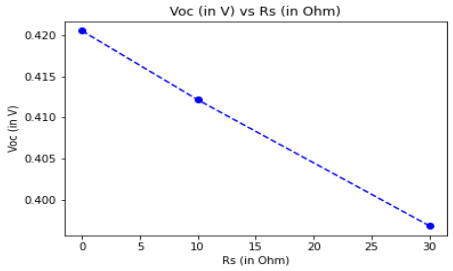


Fig. 28 : V_{oc} vs R_s

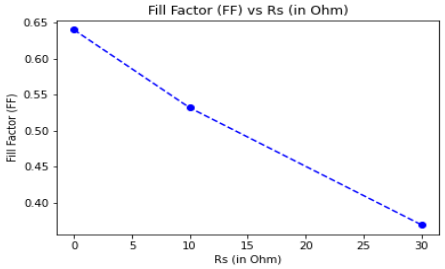
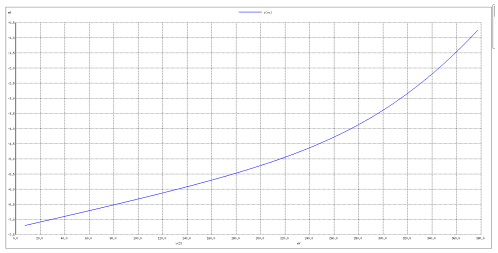


Fig. 29 : Fill Factor (FF) vs R_s

With increase in R_s, I_D vs V_D as well as P_R vs V_D curve of the Lighted I-V Characteristics of Solar Cell gets flatten. Also, Fill Factor (FF), I_{sc} (in magnitude) and V_{oc} decreases with increase in R_s.



Lighted I-V Characteristics of Solar Cell at $R_{sh} = 100\Omega$

Fig. 30 : I_D vs V_D

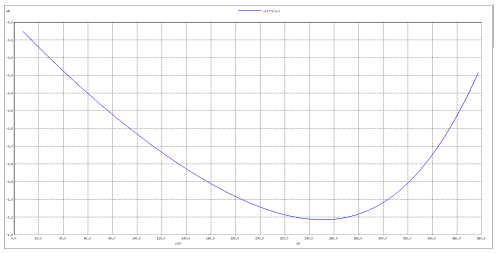
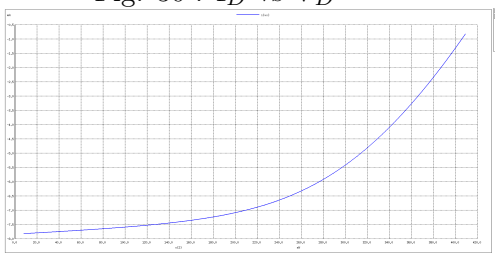


Fig. 31 : P_R vs V_D



Lighted I-V Characteristics of Solar Cell at $R_{sh} = 500\Omega$

Fig. 32 : I_D vs V_D

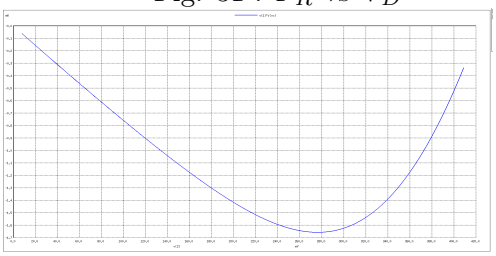
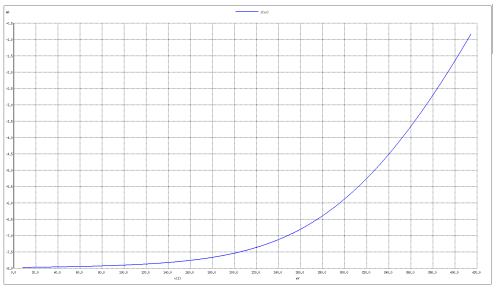
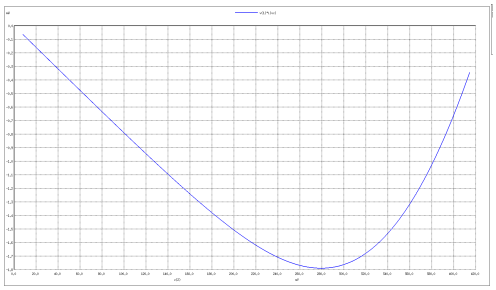


Fig. 33 : P_R vs V_D





Lighted I-V Characteristics of Solar Cell at $R_{sh} = 5000\Omega$

Fig. 34 : I_D vs V_D

Fig. 35 : P_R vs V_D

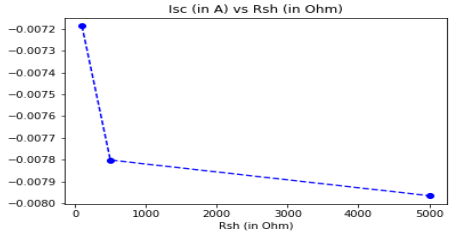


Fig. 36 : I_{sc} vs R_{sh}

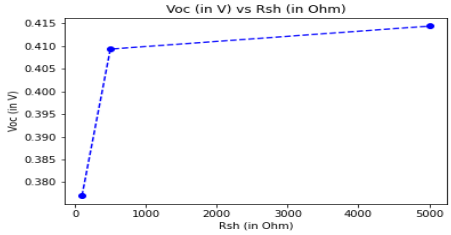


Fig. 37 : V_{oc} vs R_{sh}

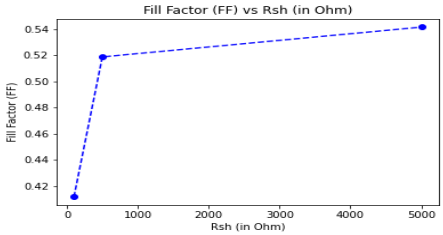


Fig. 38 : Fill Factor (FF) vs R_{sh}

Effect of R_{sh} is completely inverse as compared to R_s. With decrease in R_sh, I_D vs V_D as well as P_R vs V_D curve of the Lighted I-V Characteristics of Solar Cell gets flatten. Also, Fill Factor (FF), I_{sc} (in magnitude) and V_{oc} increases with increase in R_{sh}.

4 Experimental results

This section is not applicable for this experiment.

5 Experiment completion status

I have completed all sections as well as exercises in this lab.

6 Questions for reflection

This section is not applicable for this experiment.

■