EE236: Experiment 4

Sheel F. Shah, 19D070052

February 19, 2022

Overview of the experiment

0.1 Aim of the experiment

The aim of this experiment was to understand the workings of solar cells as temperature varies. We also look at the effect of R_s and R_{sh} on the characteristics of the solar cell.

0.2 Report Pattern

Instead of following the template, I have split the report into sections based on the questions/simulations. Each section is based on one question/simulation, and all associated details are in that section only.

1 IV characteristics of solar cell

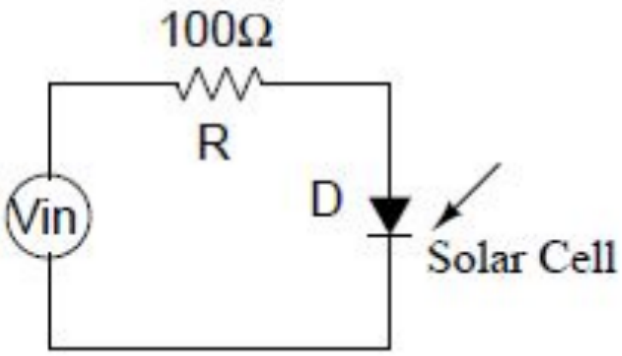

Figure 1: Circuit used

Netlist used:

```
19D070052 Sheel Shah Solar IV
.include Solar_Cell.txt

v_dc 1 0

r1 1 21 100
x1 21 31 solar_cell IL_val = 0e-3
v_dummy1 31 0 0
.dc v_dc 0.01 2 0.01 temp 35 75 10

* start control
.control
set color0 = rgb:f/f/e
set color1 = rgb:1/1/1

run

plot i(v_dummy1) vs v(21)-v(31), 1m vs v(21)-v(31), 5m vs v(21)-v(31)
```

```
* end control
.endc

.end
```

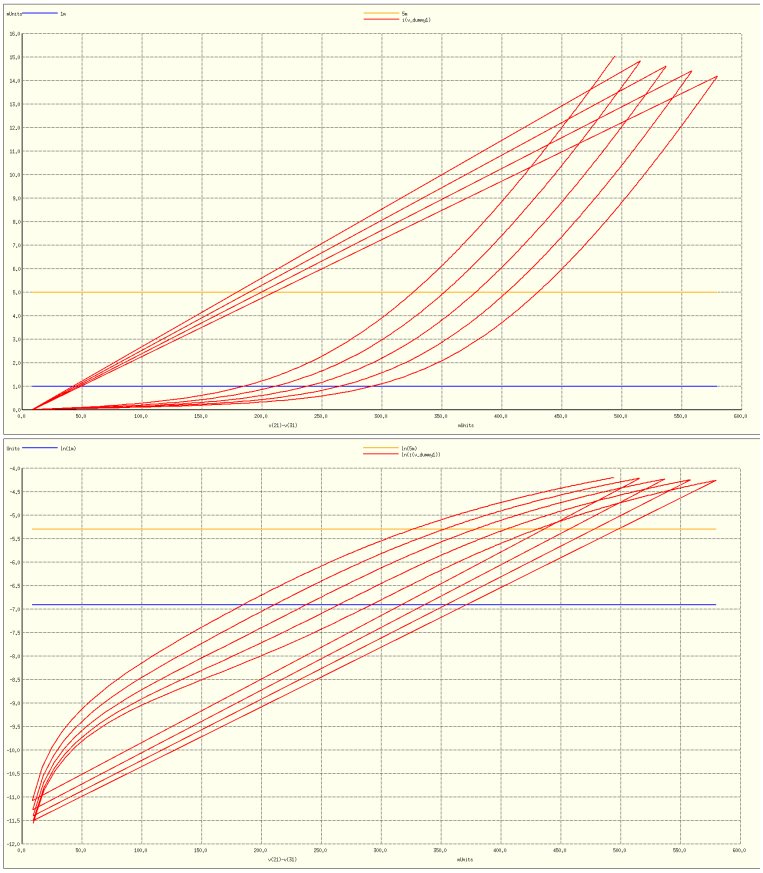

Figure 2: IV Characteristics and ln I vs V plot

Ideality factor calculation:
Step 1 was to calculate the slope of ln I vs V plot.
Step 2 was to calculate $\eta = 1/(slope * V_T)$

Temp.	$V_d(I_d = 1mA)$	$V_d(I_d = 2mA)$	$V_d(I_d = 5mA)$	$\eta(I_d = 1mA)$	$\eta(I_d = 5mA)$
35	0.29	0.35	0.43	2.98	4.42
45	0.26	0.32	0.40	2.91	4.29
55	0.24	0.29	0.38	2.86	4.11
65	0.21	0.27	0.35	2.79	4.02
75	0.18	0.24	0.33	2.64	3.88

Table 1: Table 1

2 I_{SC} and V_{OC} measurement, and fill factor calculation

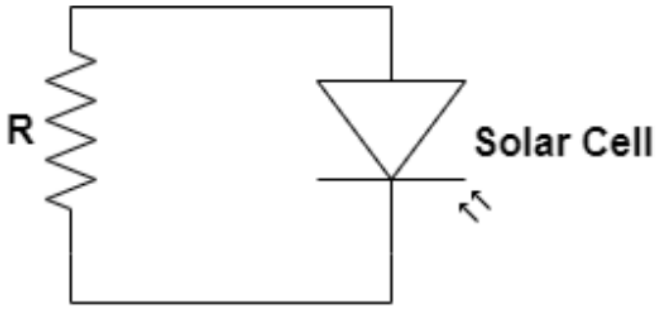

Figure 3: Circuit used

```
19D070052 Sheel Shah Solar IV
.include Solar_Cell.txt

r2 0 22 100
x2 22 32 solar_cell IL_val = 8e-3
v_dummy2 0 32 0

* start control
.control
set color0 = rgb:f/f/e
set color1 = rgb:1/1/1

run

dc r2 1 500 1 temp 35 75 10
let i1 = i(v_dummy2)
let v1 = v(22)-v(32)
let p1 = i1*v1
```

```
plot dc1.i1 vs dc1.v1
plot dc1.p1 vs dc1.v1

** values: 35 to 75
** i_sc = 7.89m, 7.88m, 7.86m, 7.82m, 7.76m
** v_oc = 392m, 368m, 343m, 319m, 294m
** p_mp = 1.60m, 1.43m, 1.28m, 1.13m, 0.98m
** ff = 0.517, 0.493, 0.475, 0.453, 0.430
* end control
.endc

.end
```

All measured values are mentioned in the code
I_{sc}, V_{oc} and fill factor, all decrease linearly with temperature

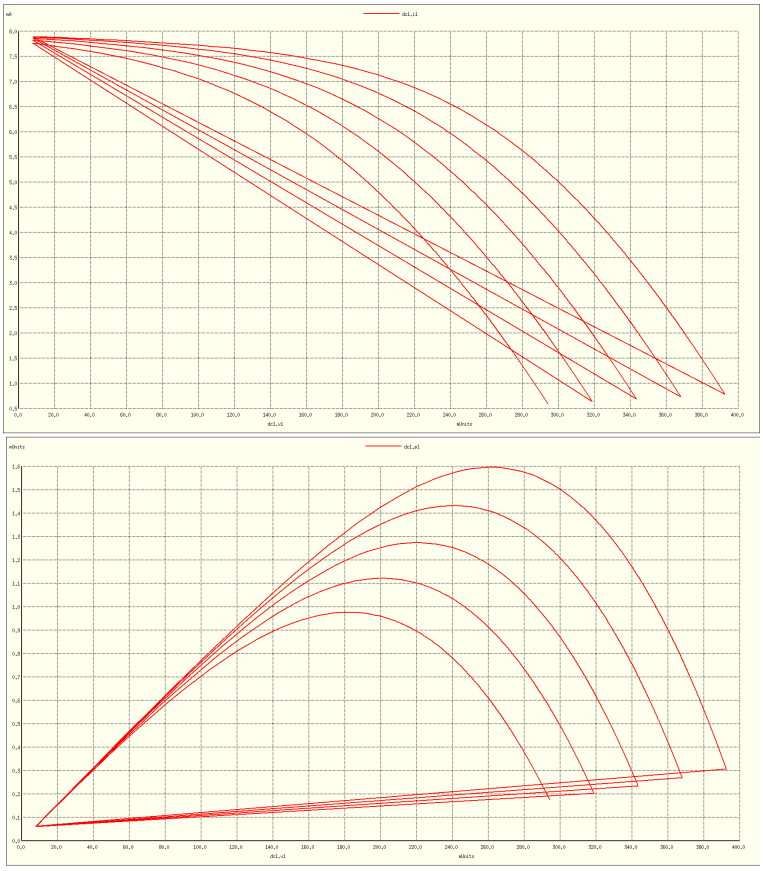

Figure 4: I vs V plot and P vs V plot

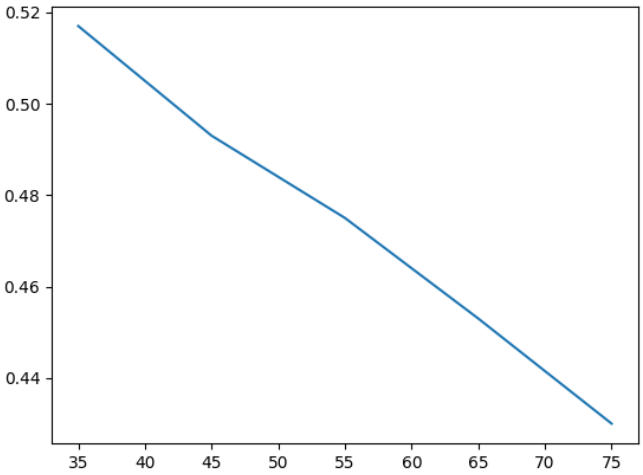

Figure 5: Fill Factor vs Temperature

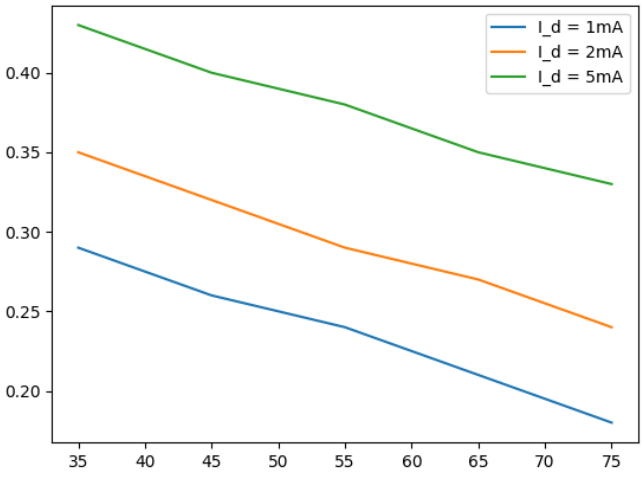

Figure 6: V_d vs Temperature

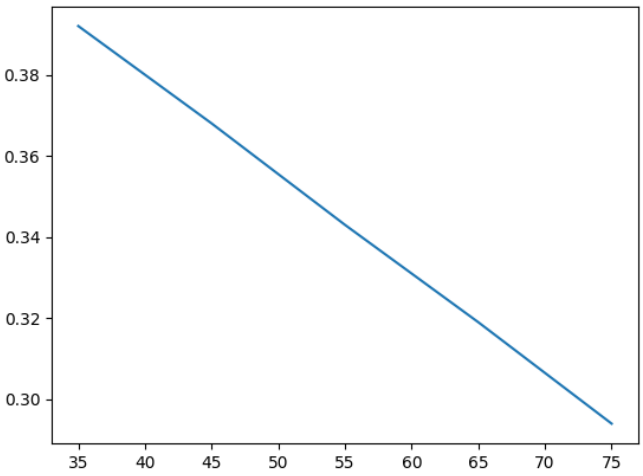

Figure 7: V_{oc} vs Temperature

3 Effect of R_S and R_{sh}

Same circuits as that of parts 1 and 2 are used.

Netlist for part A:

```
19D070052 Sheel Shah Solar IV
.include Solar_Cell.txt

v_dc 1 0

r_s1 1 21 100
x1 21 31 solar_cell IL_val = 8e-3 rsh_val = 100
v_dummy1 31 0 0

r_s2 1 22 100
x2 22 32 solar_cell IL_val = 8e-3 rsh_val = 500
v_dummy2 32 0 0

r_s3 1 23 100
x3 23 33 solar_cell IL_val = 8e-3 rsh_val = 5k
v_dummy3 33 0 0

.dc v_dc -2 2 0.01

* start control
.control
set color0 = rgb:f/f/e
set color1 = rgb:1/1/1

run

plot i(v_dummy1) vs v(21)-v(31), i(v_dummy2) vs v(22)-v(32), i(v_dummy3) vs v(23)-


* end control
.endc
```

```
.end
```

Netlist for part B:

```
19D070052 Sheel Shah Solar IV
.include Solar_Cell.txt

r1 0 21 100
x1 21 31 solar_cell IL_val = 8e-3 rsh_val = 100
v_dummy1 0 31 0

r2 0 22 100
x2 22 32 solar_cell IL_val = 8e-3 rsh_val = 500
v_dummy2 0 32 0

r3 0 23 100
x3 23 33 solar_cell IL_val = 8e-3 rsh_val = 5k
v_dummy3 0 33 0

* start control
.control
set color0 = rgb:f/f/e
set color1 = rgb:1/1/1

run

dc r1 1 500 1
let i1 = i(v_dummy1)
let v1 = v(21)-v(31)
let p1 = i1*v1

dc r2 1 500 1
let i2 = i(v_dummy2)
let v2 = v(22)-v(32)
let p2 = i2*v2

dc r3 1 500 1
```

```
let i3 = i(v_dummy3)
let v3 = v(23)-v(33)
let p3 = i3*v3

plot dc1.i1 vs dc1.v1, dc2.i2 vs dc2.v2, dc3.i3 vs dc3.v3
plot dc1.p1 vs dc1.v1, dc2.p2 vs dc2.v2, dc3.p3 vs dc3.v3

** values(rs 0 10 30)
** i_sc = 8m, 7.9m, 7.6m
** v_oc = 0.42, 0.41, 0.39
** p_mp = 2.16m, 1.74m, 1.12m
** ff = 0.64, 0.54, 0.38

** values(rsh 100 500 5k)
** i_sc = 7.2m, 7.8m, 8m
** v_oc = 0.38, 0.41, 0.42
** p_mp = 1.11m, 1.66m, 1.80m
** ff = 0.41, 0.52, 0.54

* end control
.endc

.end
```

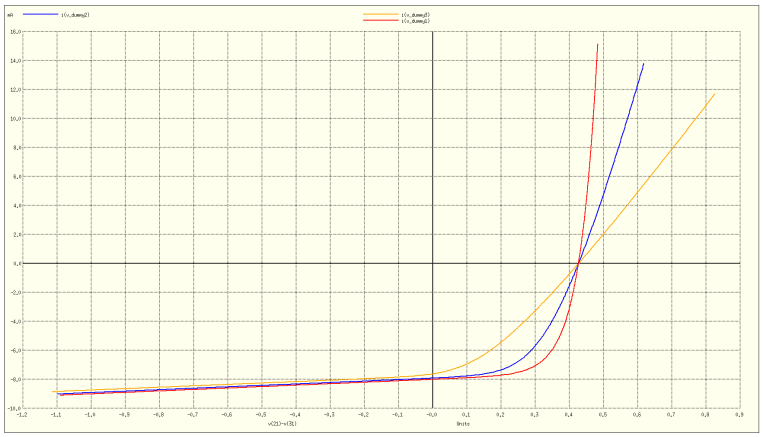

Figure 8: I vs V plot as R_s changes
The curve flattens as the series resistance increases.

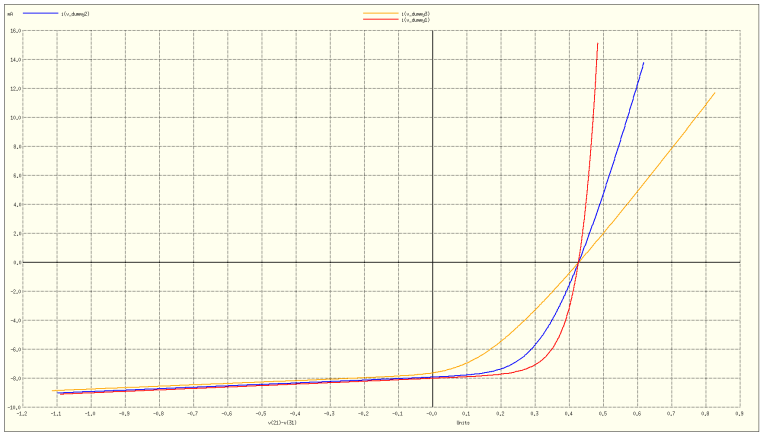

Figure 9: I vs V plot as $R_s h$ changes
The curve becomes more ideal for high shunt resistance, and I_l approaches the desired value.

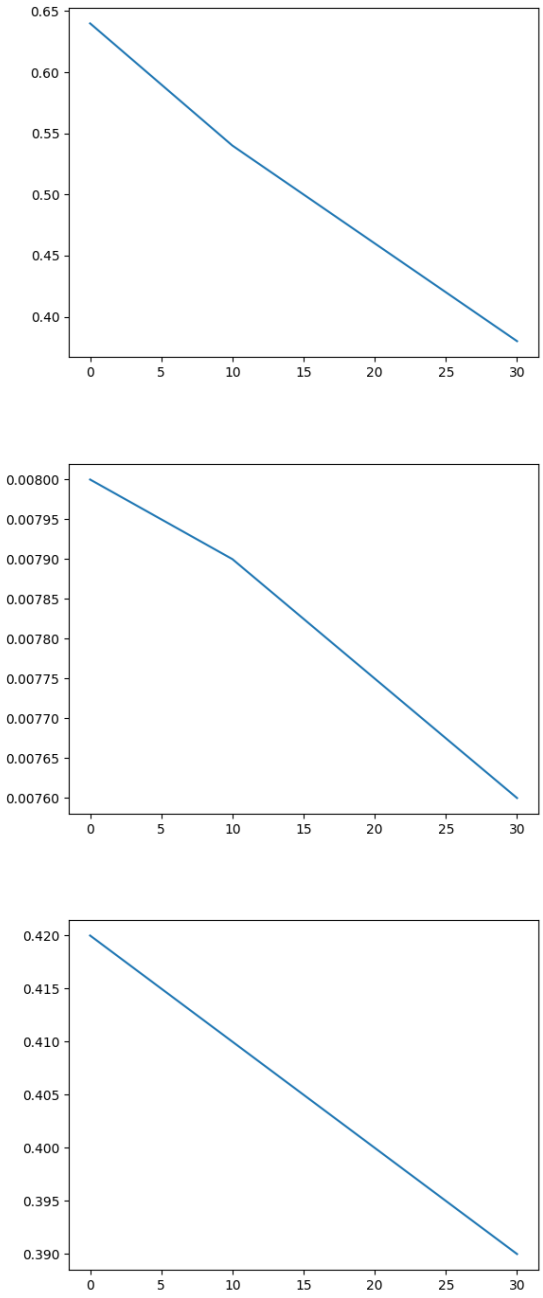

Figure 10: Fill Factor, I_{sc}, V_{oc} vs R_s, all have a decreasing trend.

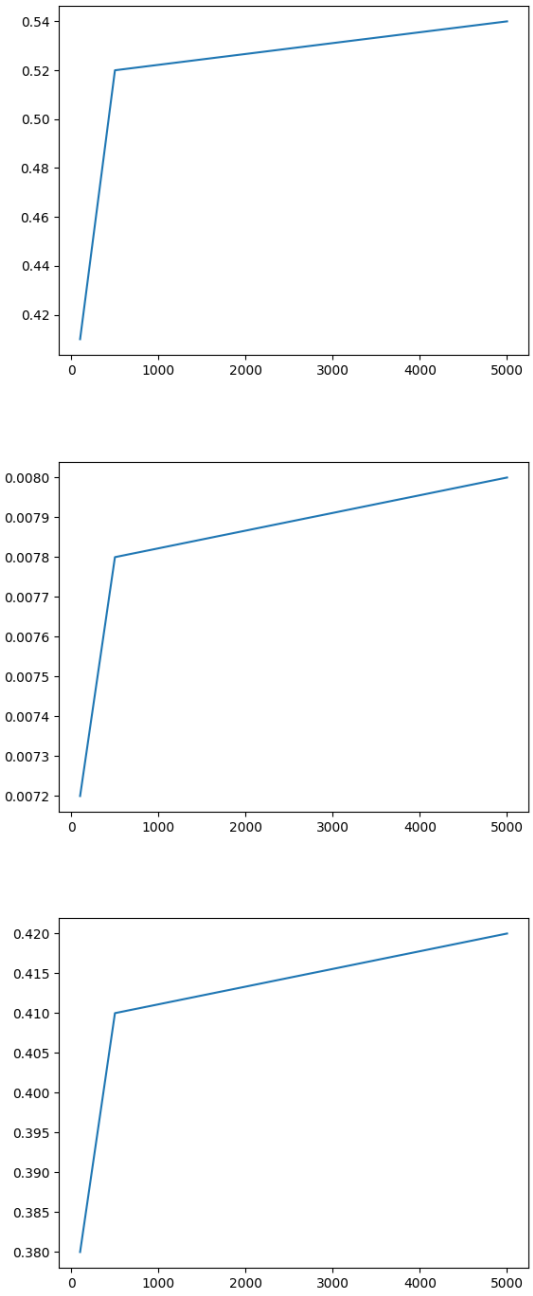

Figure 11: Fill Factor, I_{sc}, V_{oc} vs R_{sh}, all have a increasing trend.

4 Experiment completion status

I was able to complete all parts of the experiment.