I-V Characteristics of Solar Cell

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1 Overview of the experiment

1.1 Aim of the experiment

To measure the I-V characteristics in forward and reverse bias of the solar cell in the dark and light conditions under two different illuminations. To examine the use of a solar cell as a power source, by measuring the current and voltage across it. Also, measuring the power generated by a solar cell when used in the above operation, by measurement of open-circuit voltage and short-circuit current across the cell.

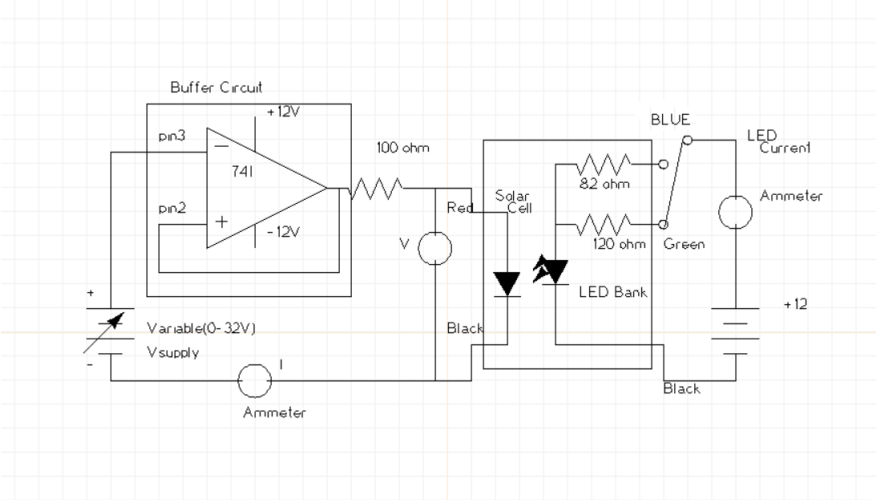
1.2 Methods

In the first part of the experiment, the solar cell was placed in a circuit, and voltage across it was varied. The I-V characteristics was then measured for 3 conditions,i.e., dark, low-light and high-light. LEDs were used inside the black box to generate light.
In the next part, the cell was placed under pre-determined conditions of light, and the current and voltage generated by the solar cell were measured.
In the last part, we place the cell in a similar setup as before, and measured the open-circuit voltage and short-circuit current across it.

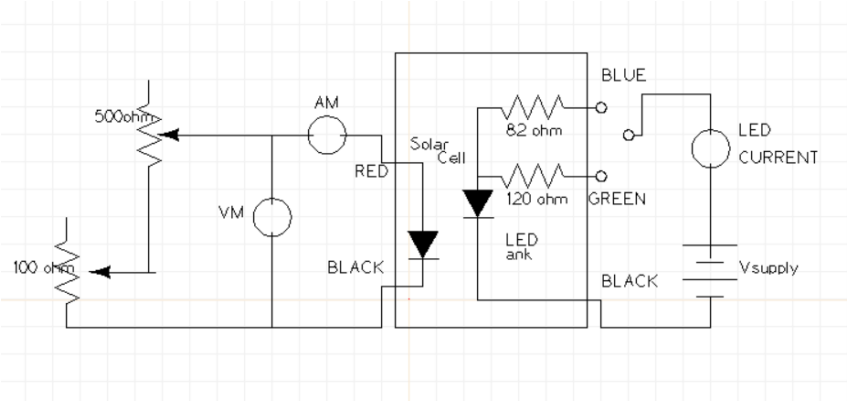
2 Design

2.1 Part 1: Measurement of I-V characteristics

To vary the illumination of LEDs, current through them was varied.



2.2 Part:-2 Solar cell as power source

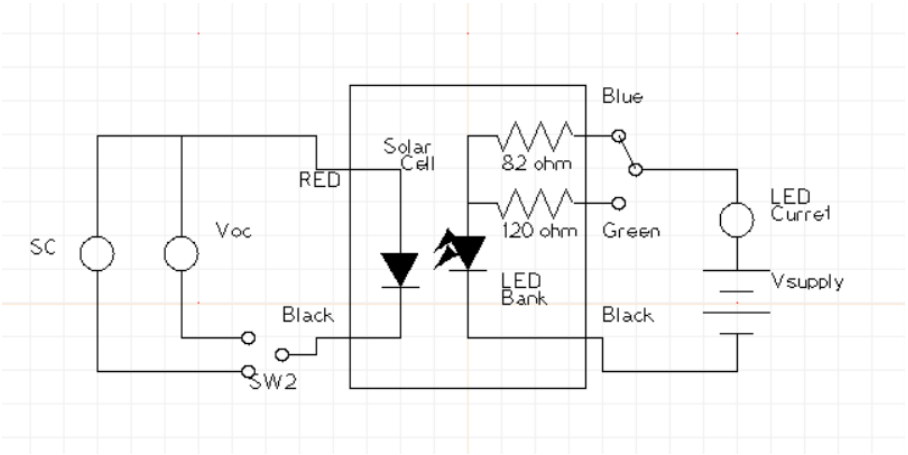


Above circuit is used to find the variation of solar cell as power source by changing the load resistance using two potentiometers of 500Ω and 100Ω. Found the values of current and voltage from ammeter and voltmeter from open circuit voltage V_{oc} to short circuit current I_{sc} and plotted the power graph also.

Fill Factor of Solar Cell was calculated using:-

Fill Factor = $\frac{I_{MP}V_{MP}}{I_{sc}V_{oc}}$

2.3 Part:-3 Measurement of V_{oc} and I_{sc} at different illumination levels



In this part we had to measure variation of open circuit voltage V_{oc} and short circuit current I_{sc} for different values of LED current by changing supply voltage to Blue LED from $10mA$ to $50mA$ in steps of $10mA$.

3 Simulation results

3.1 PreLab Ngspice code

3.1.1 Dark light

```
*solar cell under dark condition
.include Solar_Cell.txt
Vin 1 0 0
x1 1 2 solar_cell
vdiode 2 3 0
r 3 0 100
.dc Vin -2 2 0.0001
.control
run
let V_ = v(1)-v(2)
let power = (v(1)-v(2))*i(vdiode)
plot i(vdiode) vs v(1)-v(2)    power vs v(1)-v(2)
.endc
.end
```

3.1.2 Light illumination of 8mA

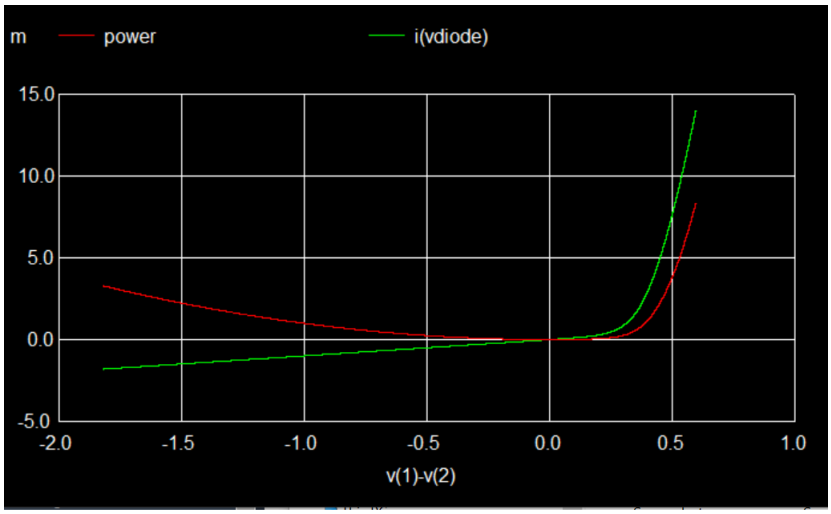
```
*solar cell for illumination 8mA
.include Solar_Cell_8.txt
```

```
Vin 1 0 0
x1 1 2 solar_cell
vdummy 2 3 0
r 3 0 100
.dc Vin -2 2 0.0001
.control
run
let V_ = v(1)-v(2)
let power = (v(1)-v(2))*i(vdummy)
let dybydx=deriv(power)
plot i(vdummy) vs v(1)-v(2)    power vs v(1)-v(2)
meas dc isc find i(vdummy) WHEN V_=0
meas dc voc find V_ WHEN i(vdummy)=0
meas dc imp FIND i(vdummy) WHEN dybydx=0 cross=1
meas dc Vmp FIND V_ WHEN dybydx=0 cross=1
let fill_factor = imp*Vmp/(isc*vsc)
print fill_factor
.endc
.end
```

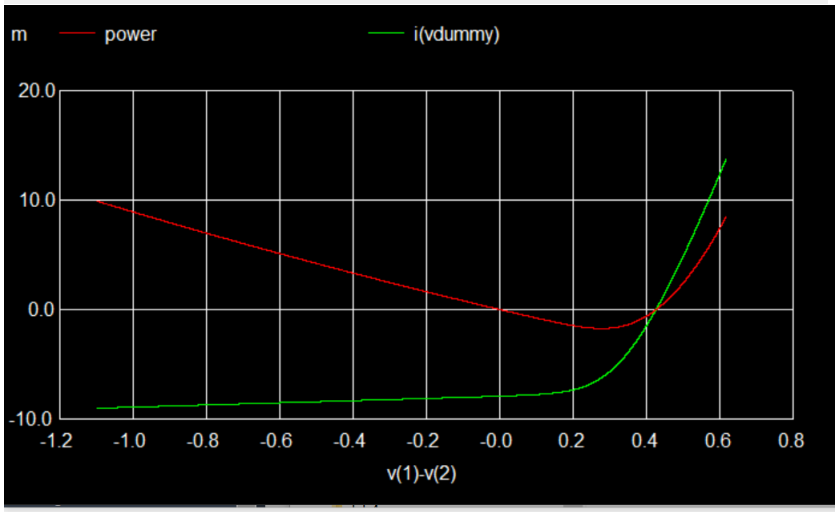
3.1.3 For light illumination of 10mA

```
*prelab of solar cell for illumination 10mA
.include Solar_Cell_10.txt
Vin 1 0 0
x1 1 2 solar_cell
vdummy 2 3 0
r 3 0 100
.dc Vin -2 2 0.0001
.control
run
let V_ = v(1)-v(2)
let power = (v(1)-v(2))*i(vdummy)
let dybydx=deriv(power)
plot i(vdummy) vs v(1)-v(2)    power vs v(1)-v(2)
meas dc isc find i(vdummy) WHEN V_=0
meas dc voc find V_ WHEN i(vdummy)=0
meas dc imp FIND i(vdummy) WHEN dybydx=0 cross=1
meas dc Vmp FIND V_ WHEN dybydx=0 cross=1
let fill_factor = imp*Vmp/(isc*vsc)
print fill_factor

.endc
.end
```

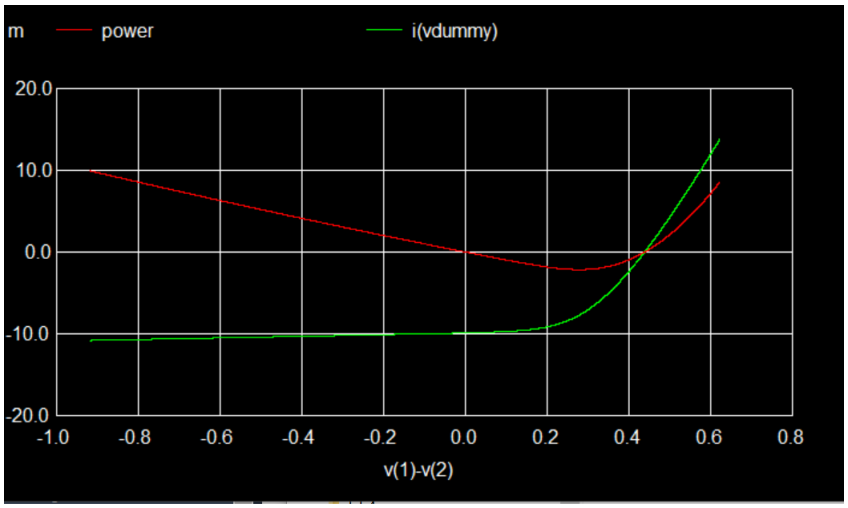
3.2 Simulation results for Dark, I_1 and I_2 respectively




```
ngspice 36
No compatibility mode selected!

Circuit: *prelab of solar cell under dark condition

Doing analysis at TEMP = 27.000000 and TNOM = 27.000000

No. of Data Rows : 40001
ngspice 10 ->
```




```
ngspice 36
Doing analysis at TEMP = 27.000000 and TNOM = 27.000000

No. of Data Rows : 40001
isc                     =  -7.913629e-03
vsc                     =  4.262215e-01
imp                     =  -6.222370e-03
vmp                     =  2.780933e-01
fill_factor = 5.130212e-01
ngspice 7 ->
```



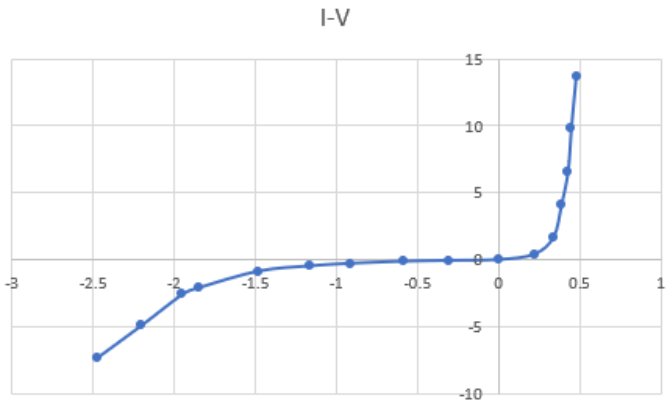
ngspice 36

```
Doing analysis at TEMP = 27.000000 and TNOM = 27.000000


No. of Data Rows : 40001
isc                =  -9.889574e-03
vsc                =  4.382731e-01
imp                =  -7.715012e-03
vmp                =  2.783805e-01
fill_factor = 4.955107e-01
ngspice 9 ->
```

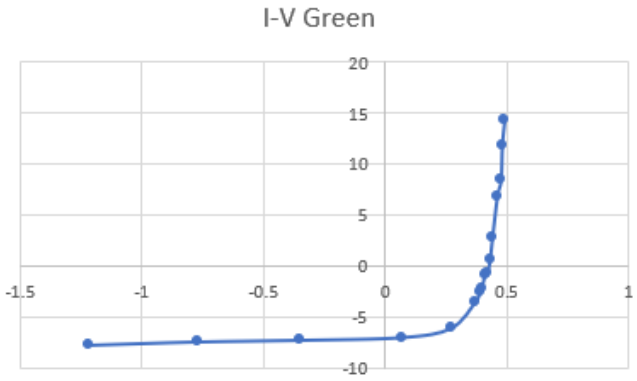
4 Experimental results

4.1 Experimental graph obtained from values taken in lab

4.1.1 Dark condition



4.1.2 Under I_1 illumination



4.1.3 Under I_2 illumination

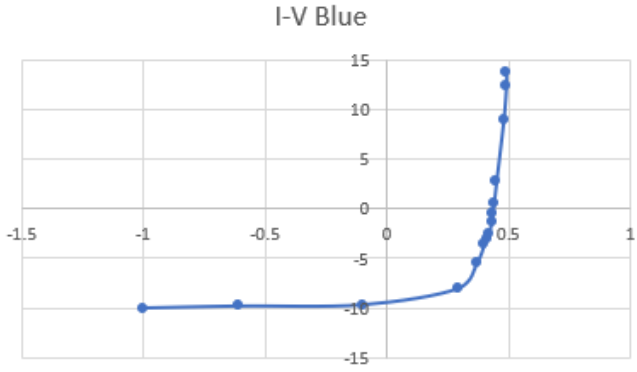


Table 1: $I_{MP}, V_{MP}, I_{sc}, V_{oc}$ values

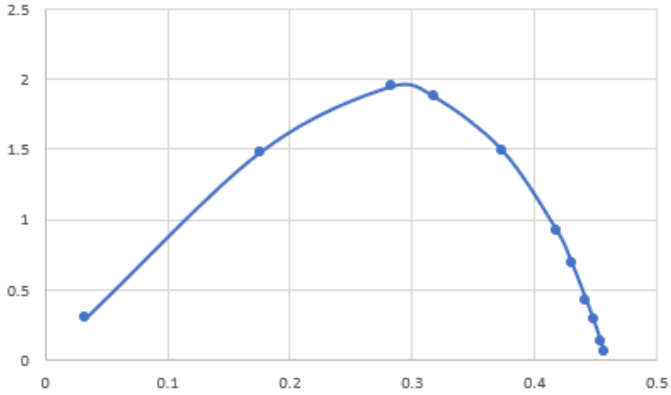
Illumination	I_{MP}	V_{MP}	I_{sc}	V_{oc}
$I_1 = 8mA$ simulation	-6.23mA	$0.27V$	$-7.88mA$	$0.43V$
$I_1 = 8mA$ **experimental**	$-6.27mA$	$0.31V$	-10.87	$0.45V$
$I_1 = 10mA$ simulation	$-7.72mA$	$0.29V$	$-9.86mA$	$0.44V$
$I_1 = 10mA$ **experimental**	$-8.45mA$	$0.30V$	$-10.86mA$	0.46

Table 2: Fill factor under illumination I_1 and I_2

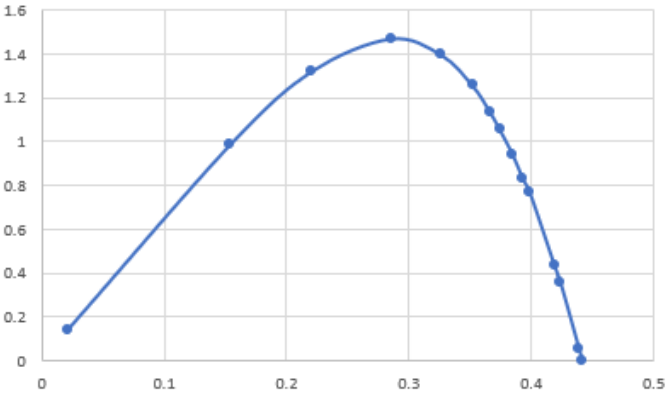
Illumination	Exp. fillfactor	simulation fillfactor
$I_1 = 8mA$	0.397	0.496
$I_2 = 10mA$	0.507	0.516

4.2 Part-2 : Solar cell as power source

4.2.1 Under I_1 illumination

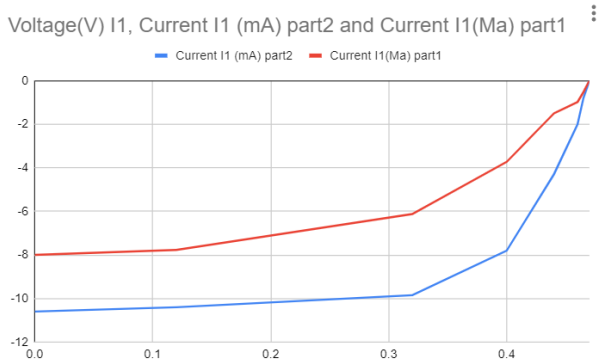


4.2.2 Under I_2 illumination

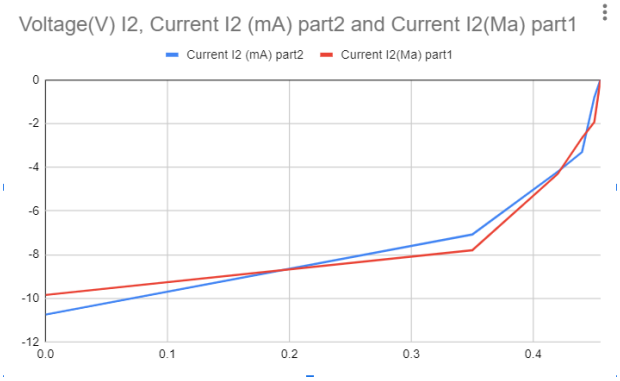


4.2.3 Superimposing the readings of part 1 and part 2

- For I_1 illumination

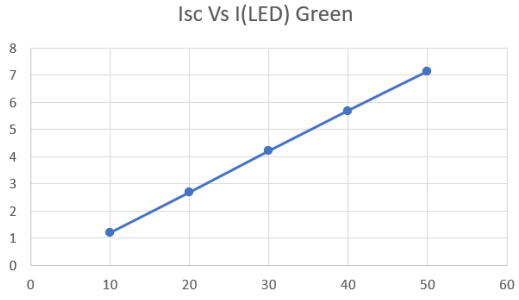


- For I_2 illumination

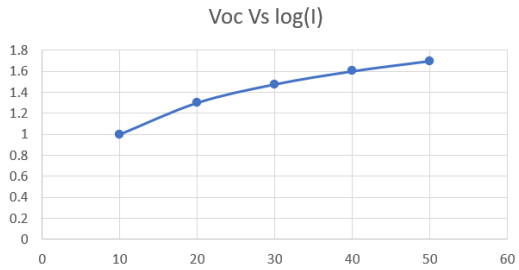


4.3 Part:-3 Measurement of V_{oc} and I_{sc} at different illumination levels for BLUE terminal illumination

- I_{sc} vs I_{LED}



- V_{oc} vs $log(I_{LED})$



5 Experiment completion status

I have completed all the parts of the experiments in the report and did all the calculation which were told to do in the experiment.