LAB ASSIGNMENT 4&5

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LabTask-1:

Aim:

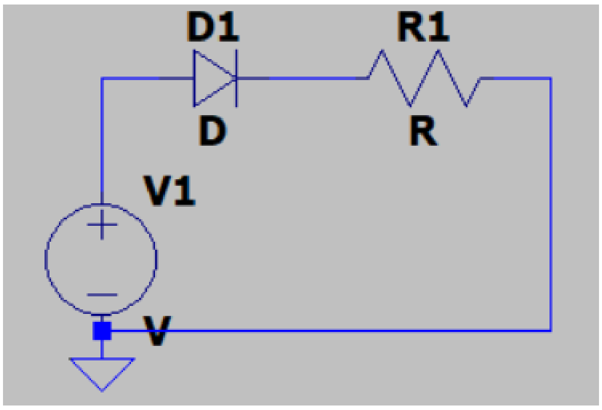
To understand I-V characteristics of diode using 100Ω ,1kΩ and 10kΩ resistors in series one by one.

Apparatus:

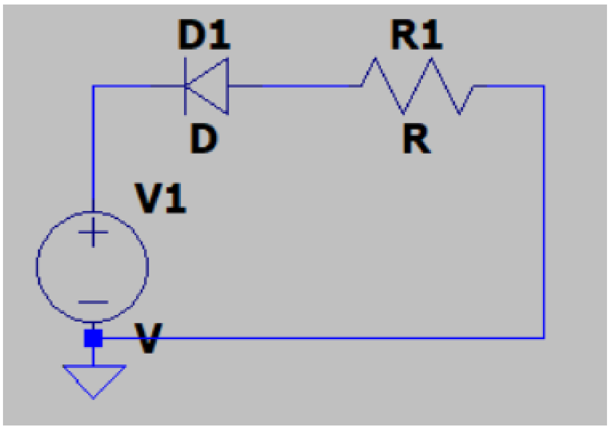
1. Power supply.
2. IN4007 diodes.
3. 100Ω, 1kΩ and 10kΩ resistors.
4. Multimeter.

Experiment:

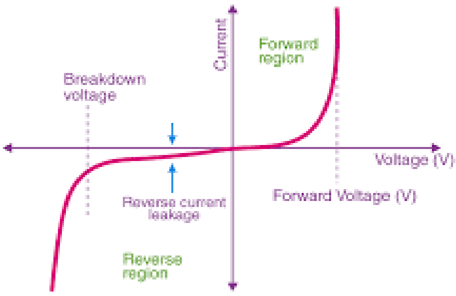
1. Build a forward bias circuit using diode and resistor. We know that diode allows current to flow through it when it is in forward bias since beyond cut-in voltage diode acts as open circuit.



2. Build a reverse bias circuit using diode and resistor. We know that diode doesnot allow or allow very low current to flow through it when it is in reverse bias. We can get reverse bias circuit just by reversing the terminal of diode or power supply. Current flown in reverse bias is measured in reverse bias. The width of depletion region increases, there by the diode offer high resistance and acts as closed circuit.



3. Use multimeter to measure the voltage across the diode and resistance and to measure current in the circuit.
   General V-I characteristics of diode are:



Obersered reading for some voltages:

For 100Ω:

1)0.8V

2)4V

For 1kΩ:

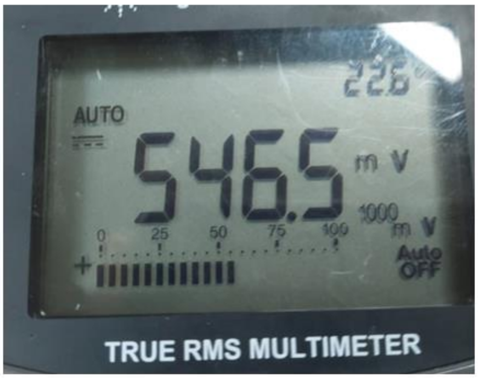
1)2V:

2)5V:

For 10kΩ:

1)2V

2)5V



Observations:

1. 100Ω:

   Forward Bias

Applied vol	Voltage resistor	Voltage diode	Current(mA)
0	0	0.008	0
0.2	0	0.24	0

0.5	0.0384	0.5415	0.1931
0.8	0.182	0.6154	1.89
1	0.3643	0.6521	3.66
1.2	0.565	0.6657	5.5
1.6	0.9263	0.6878	10
1.8	1.166	0.6963	11.35
2	1.381	0.7018	13.76
2.4	1.71	0.7156	17.5
2.8	2.106	0.7244	21.41
3	2.34	0.728	23.55
3.8	3.09	0.741	31.72
4	3.329	0.7442	34.18
4.2	3.5	0.7451	35.97
4.6	3.875	0.75	40
4.8	4.08	0.7515	42.14
5	4.265	0.7528	44.03
5.5	4.745	0.755	47.45
6	5.323	0.762	55.14

2. 100Ω:
   Reverse Bias

Applied vol	Voltage resistor	Voltage diode	Current(mA)
-6	-0.0013	-5.265	-0.0139
-5.5	-0.001	-4.88	-0.0095
-5	-0.0006	-4.471	-0.0063
-4.5	-0.00046	-3.98	-0.0041
-4.2	-0.00036	-3.744	-0.0033
-3.8	-0.00024	-3.39	-0.0022
-3.5	-0.00013	-3.12	-0.0014
-3	-0.00012	-2.662	-0.0008
-2.8	0	-2.682	-0.00065
-2.5	0	-2.266	-0.00044
-2.2	0	-2.081	-0.00031
-2	0	-1.778	-0.00025
-1.8	0	-1.72	-0.00015
-1.5	0	-1.352	0
-1.2	0	-1.148	0
-1	0	-0.891	0
-0.8	0	-0.748	0
-0.5	0	-0.47	0
-0.2	0	-0.19	0
0	0	0.008	0

For 1kΩ:

1. Forward Bias

Applied vol	Voltage resistor	Voltage diode	Current(mA)

0	0	0	0
0.2	0	0.1986	0
0.5	0.0625	0.4376	0.0562
0.8	0.2967	0.5051	0.2701
1	0.4873	0.5346	0.3705
1.2	0.6517	0.5477	0.6165
1.6	1.036	0.5687	0.9779
1.8	1.233	0.5766	1.18
2	1.411	0.5831	1.41
2.4	1.783	0.5938	1.83
2.8	2.202	0.6039	2.25
3	2.405	0.6083	2.4
3.4	2.777	0.6148	2.81
3.8	3.259	0.6224	3.18
4	3.44	0.6246	3.41
4.2	3.595	0.6267	3.6
4.6	4.016	0.6392	4
4.8	4.193	0.6408	4.21
5	4.402	0.6421	4.4
5.5	4.804	0.6483	4.804
6	5.397	0.6502	5.39

2. Reverse bias:

Applied vol	Voltage resistor	Voltage diode	Current(mA)
-6	-0.0033	-5.463	-0.005
-5.5	-0.0025	-4.911	-0.00424
-5	-0.0016	-4.521	-0.0037
-4.5	-0.0009	-4.008	-0.003
-4	-0.0005	-3.629	-0.00221
-3.5	-0.0003	-3.122	-0.0015
-3	-0.0001	-2.753	-0.0009
-2.5	0	-2.34	-0.0004
-2	0	-1.826	-0.0001
-1.5	0	-1.408	0
-1	0	-0.9671	0
-0.5	0	-0.4982	0
0	0	0	0

For 100kΩ:

1. Forward Bias

Applied vol	Voltage resistor	Voltage diode	Current(mA)
0	0	0	0
0.2	0.0032	0.2635	0.0029
0.5	0.1336	0.4012	0.0145
0.8	0.3577	0.4371	0.0364
1	0.5605	0.4564	0.0597
1.2	0.8073	0.4692	0.0741
1.6	1.129	0.4833	0.1126

1.8	1.3	0.4897	0.1357
2	1.515	0.4966	0.1554
2.4	1.9	0.5073	0.1926
2.8	2.34	0.5154	0.2328
3	2.48	0.5199	0.2591
3.4	2.87	0.526	0.2925
3.8	3.296	0.5318	0.3325
4	3.51	0.5352	0.3508
4.2	3.71	0.5378	0.3723
4.6	4.04	0.5427	0.418
4.8	4.24	0.5446	0.43
5	4.451	0.5465	0.4503
5.5	4.91	0.5501	0.4863
6	5.432	0.5568	0.5538

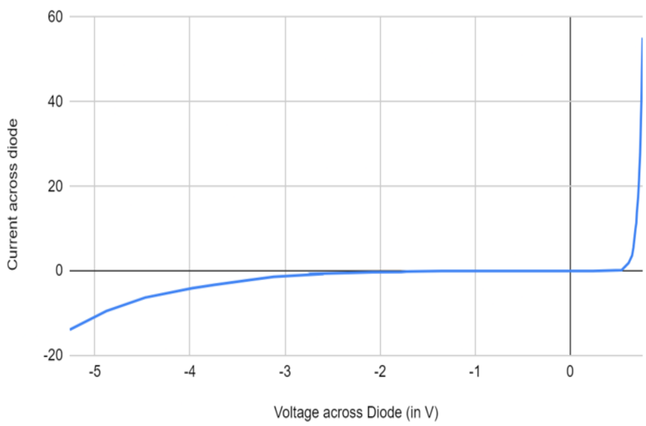
2. Reverse bias:

Applied vol	Voltage resistor	Voltage diode	Current(mA)
-6	-0.0071	-5.733	-0.00518
-5.5	-0.0054	-5.156	-0.00354
-5	-0.0034	-4.747	-0.00235
-4.5	-0.002	-4.21	-0.00153
-4	-0.0011	-3.81	-0.00112
-3.5	-0.000645	-3.278	-0.00052
-3	-0.000215	-2.89	-0.0003
-2.5	0	-2.457	-0.00016
-2	0	-1.92	-0.00009
-1.5	0	-1.478	0
-1	0	-1.015	0
-0.5	0	-0.523	0
0	0	0	0

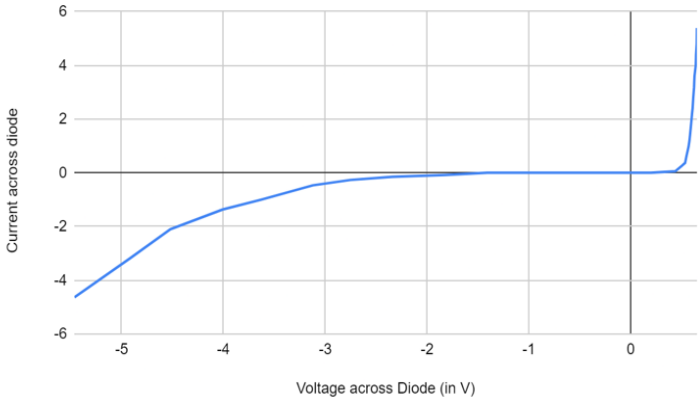
Graphs:

Right side of Y-axis is forward bias graph and left side is reverse bias graph:

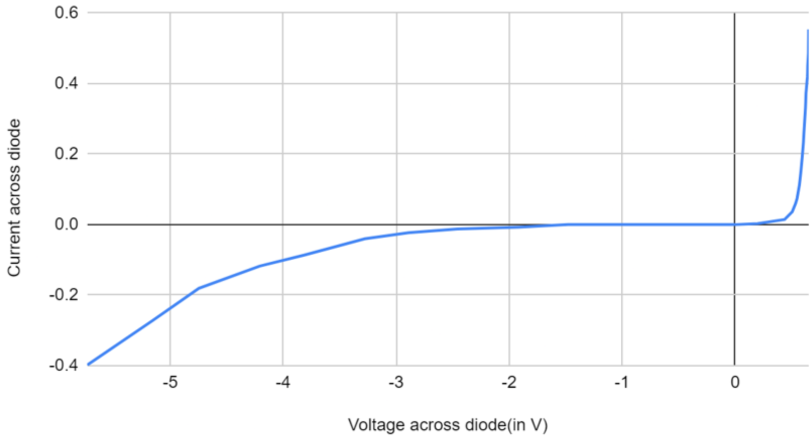
100Ω:



Graph for 1kΩ:



Graph for 100kΩ:



X-axis value in Volts.

+Y-axis value in milli amperes

-Y-axis value in micro amperes

Conclusion:

In reverse bias, the small valued resistors come in handy to measure low current. We need to increase precision of measurements by taking less error multimeter which can measure micro readings. From data sheet of IN4007, the reverse bias withstand voltage is around 1000V.

Lab-Task-2:

Aim:

Rectifying a sinusoidal and triangular wave of v=5V and frequency 12kHz with full-wave bridge rectifier and its filter circuit.

Apparatus:

1. Oscilloscope
2. Function generator

3. Diodes IN4007.
4. Load resistance 470Ω.
5. Capcitor 10nF.

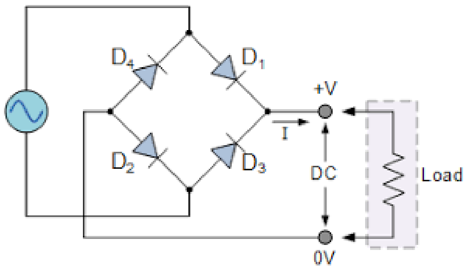
Here, Frequency = 10kHz

Max. amplitude=5V

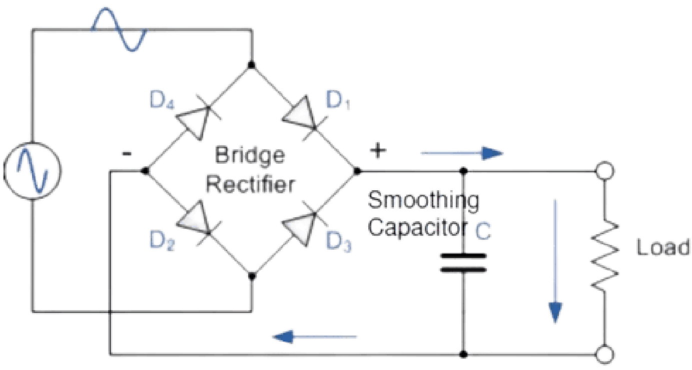
Vpp=10V

Experiment:

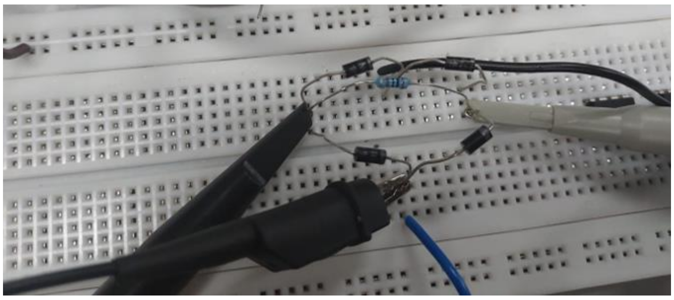
1. Construct a circuit like below.



2. In the above circuit for an sinusoidal wave, the positive half-wave will pass through D1 and D2(forward bias) and becomes voltage at 1st terminal across load.The negative half wave will pass through D3 and D4(forward bias) and becomes voltage 2nd terminal across load. So, V(1st terminal) – V(2nd terminal) gives rectified full wave.
3. We add capacitor parallel to the load to smoothen the ripples in the AC curve. Since capacitore is used to store energy.

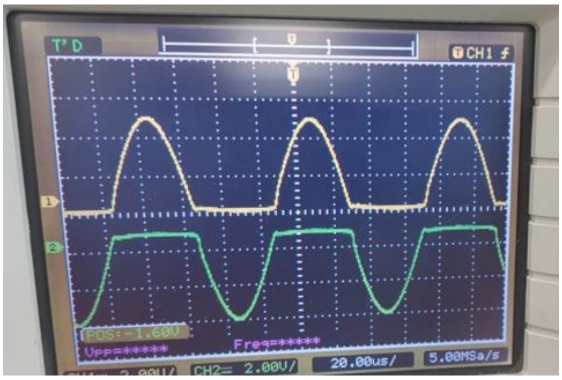


Circuit:



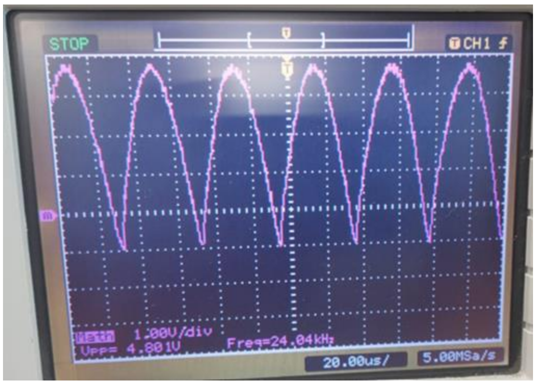
Sinisoidal wave:

Terminal voltages across load:



Use “MATH” mode with “1-2” option to get full rectified wave.

1. **Without filter:**



Since its recitified full wave, the output frequency is twice the input frequency and Vpp output is half of Vpp input i.e, 24kHz and 5 V respectively.

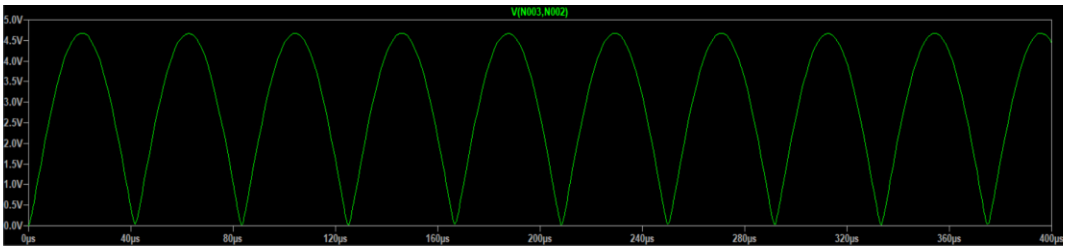
Error in output readings:

Output frequency error=$\frac{24-24.04}{24}\times 100$=0.167%

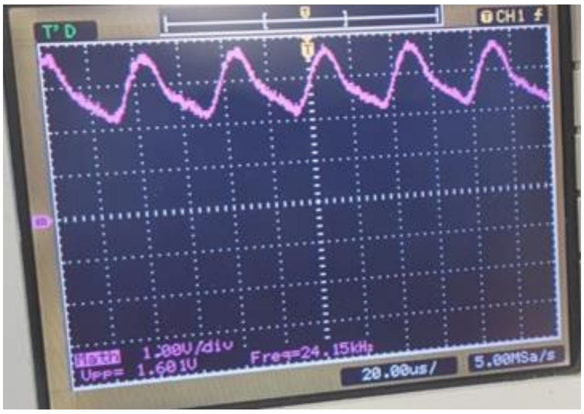
Output vpp error=$\frac{5-4.8}{5}\times 100$=4%

Error percentage is too less.

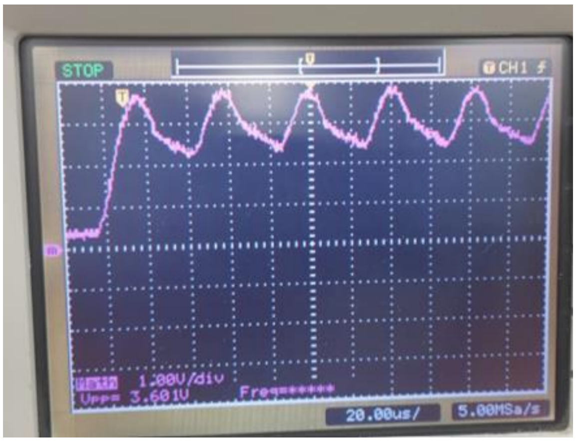
Simulation:



2. **With filter:**

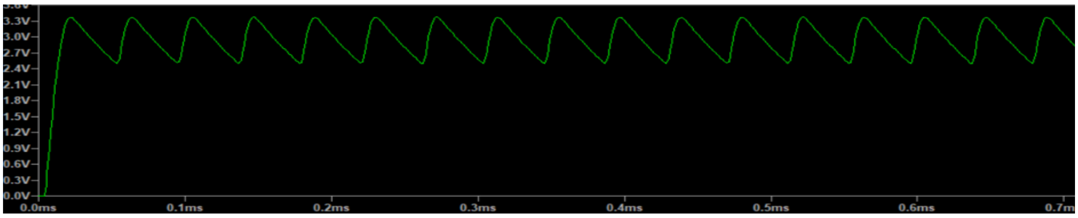


At Steady-state



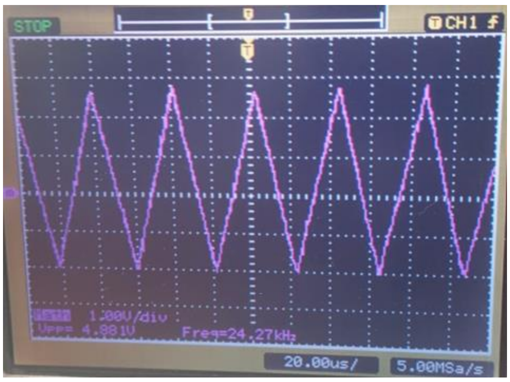
At Transient responce

Simulation:



Triangular wave:

1. **Without filter:**



Since its recitified full wave, the output frequency is twice the input frequency and Vpp output is half of Vpp input i.e, 24kHz and 5 V respectively.

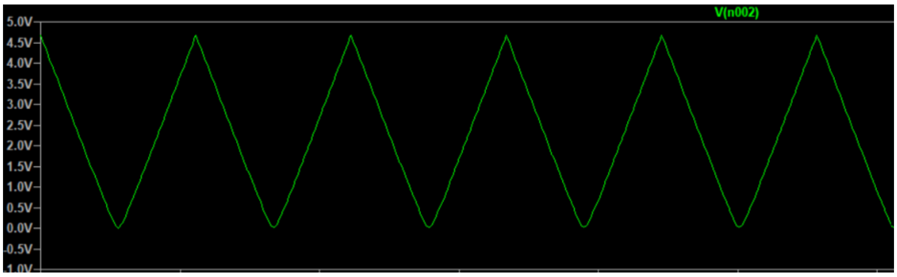
Error in output readings:

Output frequency error=$\frac{24-24.27}{24} \times 100$=1.125%

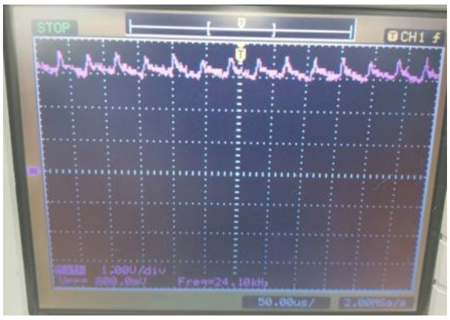
Output vpp error=$\frac{5-4.88}{5} \times 100$=0.4%

Error percentage is too less.

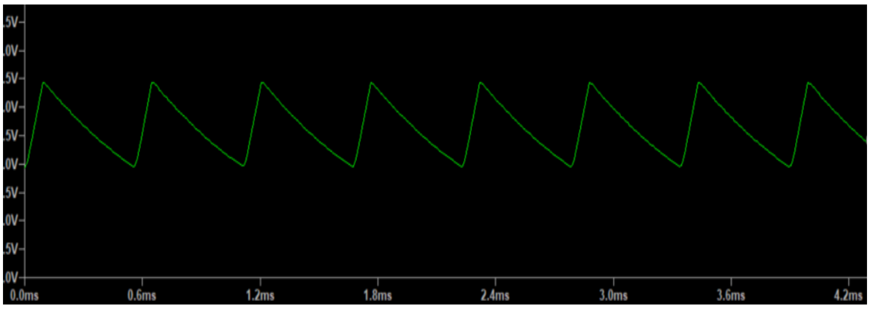
Simulation:



2. **With filter:**



Simulation:



Conclusion:

Capacitor is introduced to decrease the ripples in the ac curve and get DC voltage (smooth). Less the time period compared to time constant, more the smoothness of graph. The results can be obtained more accurately by selecting the capacitor an dresistor wisely based on time constants and time periods.

LabTask-3:

Aim:

1. Light and dark I-V characteristics of solar cell(-2V to +2V).
2. Light and dark I-V characteristics of solar cell with buffer(-2V to +2V).
3. Find V_{oc}, I_{sc}, filling factor and efficiency for light characteristics.

Apparatus:

1. Solar cell
2. Resistor 100Ω
3. Power supply.
4. Light source.
5. Multimeter.
6. Opamp(LM741).

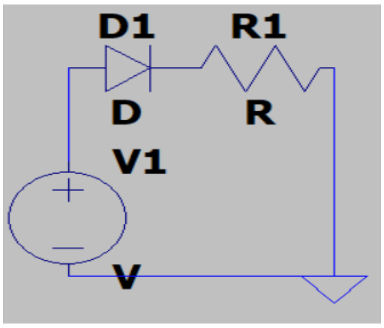
Experiment:

1. Solar cell is PN junction diode when illuminated we can observe some voltage and current in it due to electric field in conduction band charge carrier.
2. So, solar cell at dark acts as PN junction diode i.e, like IN4007.
3. When illuminated, Solar cell conducts current.
4. V_{oc} is maximum voltage drawn from solar cell when light illuminated. It is x-intercept of I-V characteristics graph.
5. I_{sc} is current when voltage across solar cell is zero. It is y-intercept of I-V characteristics graph.
6. Filling Factor determines the quality of solar cell.

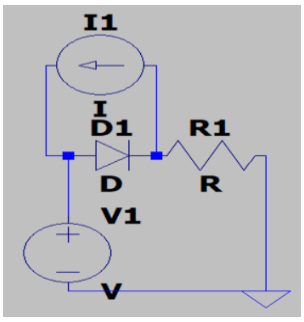
$$Filling\ Factor = \frac{P_{max}}{V_{OC}I_{SC}}$$

7. Efficiency(η)= $\frac{P_{max}}{P_{in}}$
8. From the analysis in above 3 points, the circuits(forward bias) are

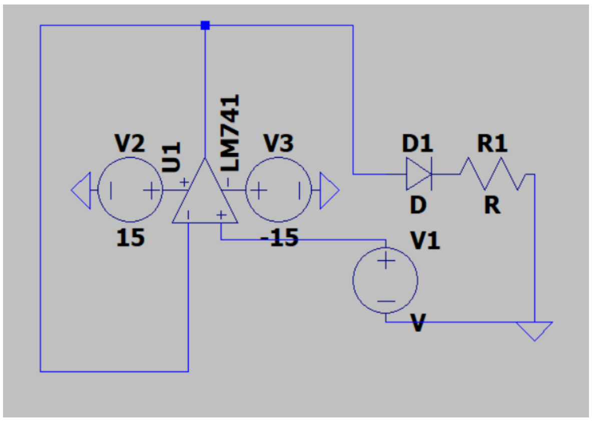
No illumination:



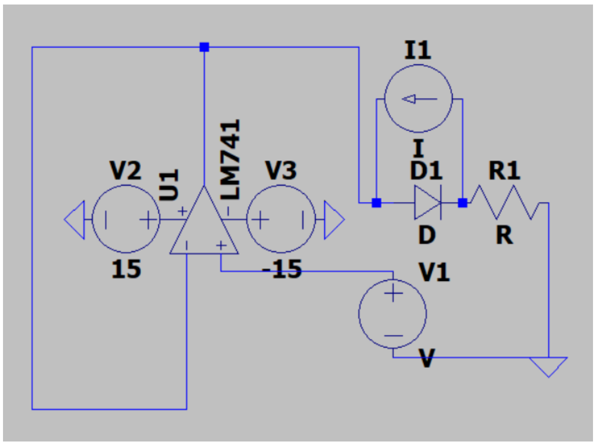
Illumination:



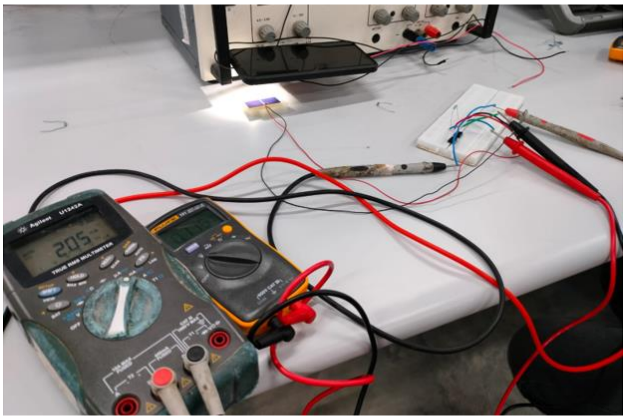
No illumination with active buffer:



Illumination with active buffer:



Circuit:

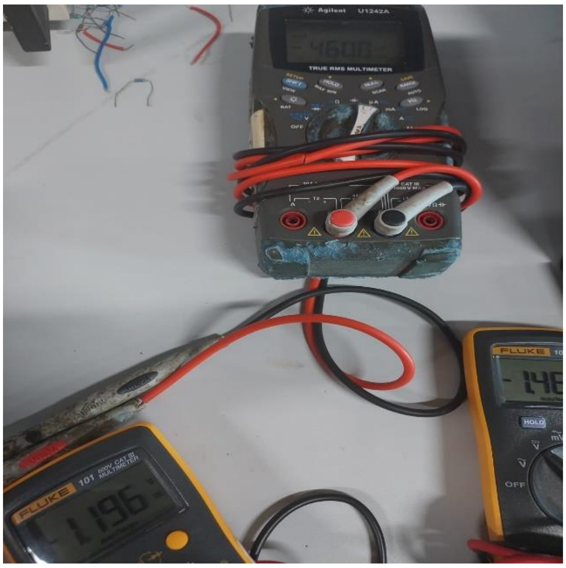


Not illuminated active buffer:

0.5V:

1V:

-1.5V:



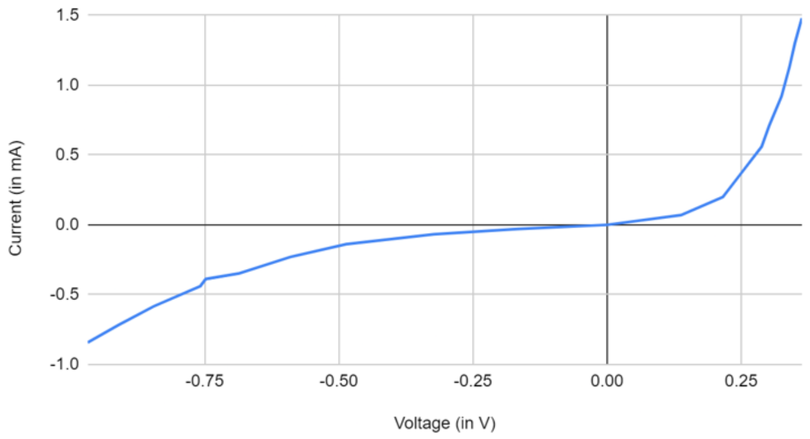
Illuminated with buffer:

0.9:

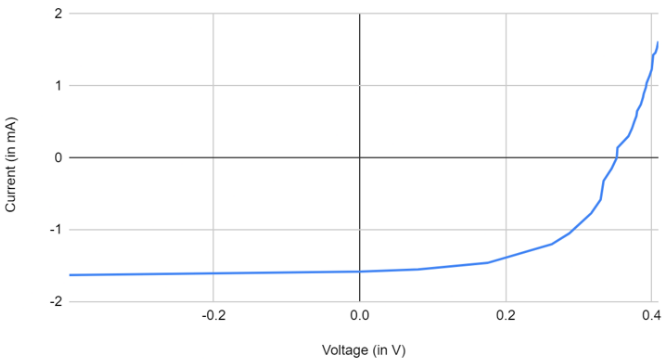
0.5V:

Observed graphs:

Not Illuminated:



Illuminated:



On analysing the graph, we have

V_{oc}(x-intercept)=0.352V

I_{Sc}(Y-intercept)=1.58mA

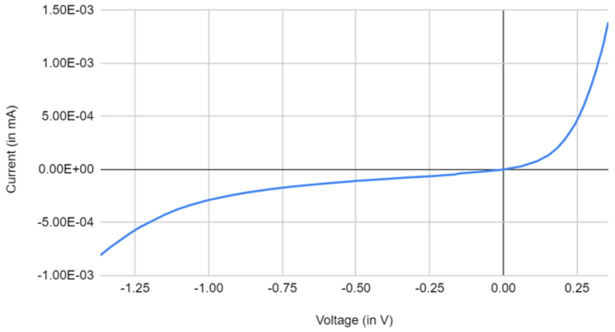
P_{max}=0.36mW

So,

$$Filling\ Factor = \frac{P_{max}}{V_{OC}I_{SC}} = \frac{0.36}{0.352 \times 1.58} = 0.647$$

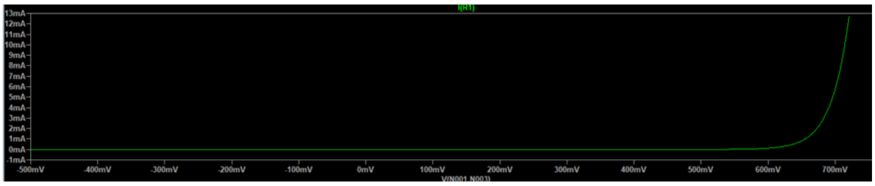
$$\eta = \frac{P_{max}}{P_{in}} = \frac{0.36}{2.365} = 0.1522$$

Not illuminated with active buffer:

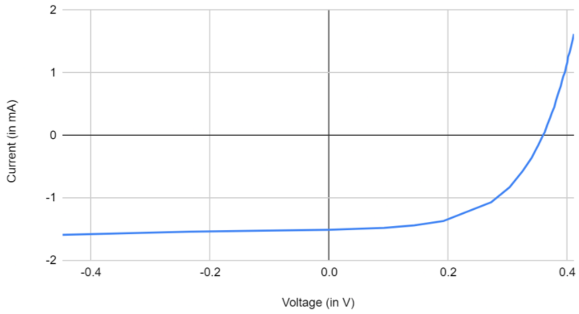


Simulation:

Resistance is 100Ω.



Illuminated with active buffer:



On analysing the graph, we have

V_{oc}(x-intercept)=0.359V

I_{Sc}(Y-intercept)=1.51mA

P_{max}=0.395mW

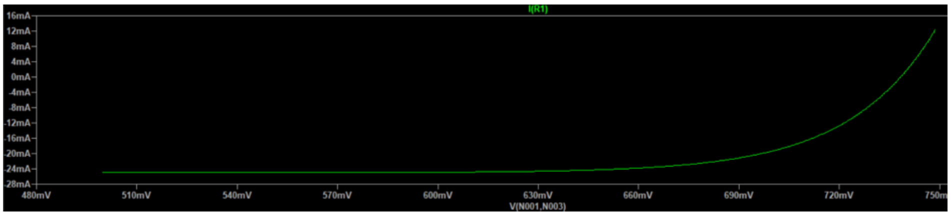
So,

$$Filling\ Factor = \frac{P_{max}}{V_{OC}I_{SC}} = \frac{0.395}{0.359 \times 1.51} = 0.728$$

$$\eta = \frac{P_{max}}{P_{in}} = \frac{0.395}{2.453} = 0.161$$

Simulation:

Resistance is 100Ω and current is 25mA.



Conclusion:

We can observe the increase in efficiency in active buffer when compare to without buffer curcuit. So, this proves us Active buffer reduces the disturbances. So, her we matched the graphs to theory correctly.

LabTask-4

Aim:

1. To tabulate the values of voltage(V_L), current(I_L) and power(P_L) across a load resistor(R_L) connected in series with illuminated solar cell. Plot the $I_L\ vs\ R_L, V_L\ vs\ R_L,$ $P_L\ vs\ R_L, I_L\ vs\ V_L\ and\ P_L\ vs\ V_L.$
2. Calculate V_{OS} , I_{SC} , filliing factor and efficiency.

Apparatus:

1. Solar cell.
2. Multimeter.
3. Power supply.
4. Different values of resistors.
5. Light source.

Experiment:

1. Connect solar cell and load resistor in series and find voltage, current, power across it and replace the present load resistance with another load resiatance.
2. I_{sc} is current when voltage across solar cell is zero. It is y-intercept of I-V characteristics graph.
3. Filling Factor determines the quality of solar cell.

$$Filling\ Factor = \frac{P_{max}}{V_{OC}I_{SC}}$$

4. Efficiency(η)= $\frac{P_{max}}{P_{in}}$

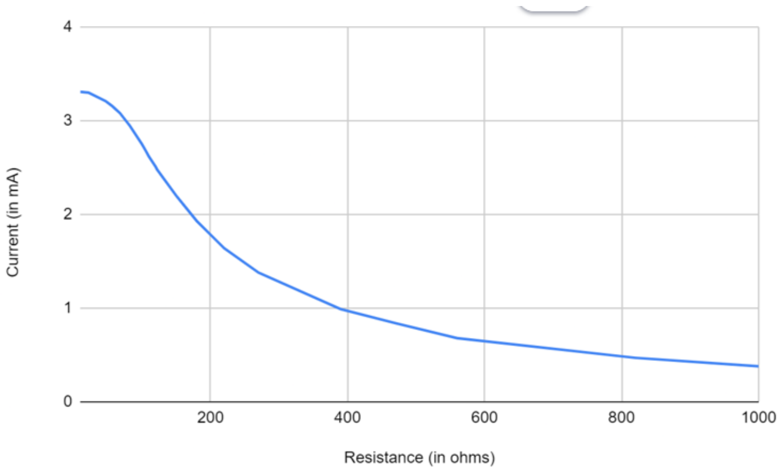
Tabulated values:

Load resistance(in ohms)	Voltage across load	Current through load (in mA)	Power (in uW)
10	34	3.3	112.54
22	73	3.3	240.9
47	152	3.21	487.92
56	178	3.16	562.48
68	212	3.08	652.96
82	242	2.95	713.9
100	278	2.75	764.5
105	285	2.685	765.22
110	291	2.62	762.42
120	302	2.51	758.02
122	304	2.48	753.92
150	332	2.2	730.4
180	348	1.93	671.64
220	361	1.64	592.04
270	373	1.38	514.74
390	387	0.99	383.13
470	395	0.84	331.8

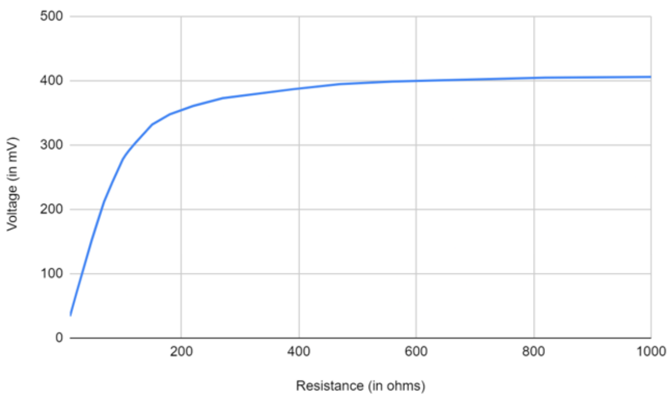
560	399	0.68	271.32
820	405	0.47	190.35
1000	406	0.38	154.28

Obtained graphs:

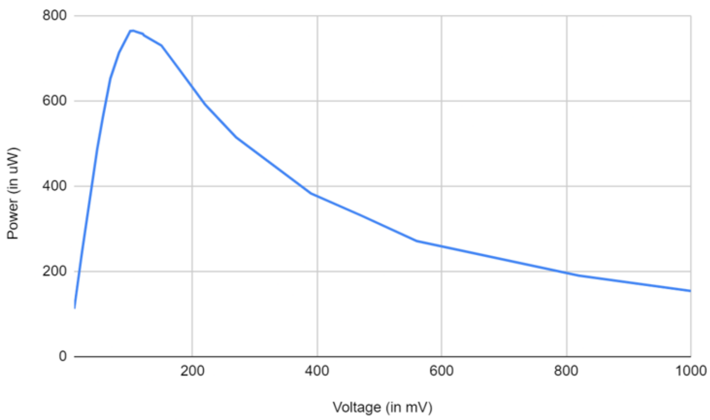
1. $I_L\ vs\ R_L$:



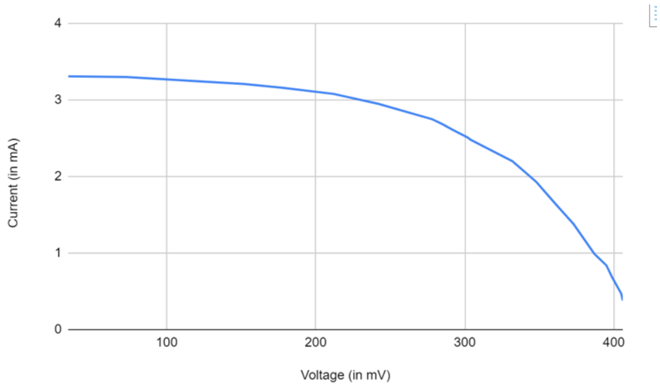
2. $V_L\ vs\ R_L$:



3. $P_L\ vs\ R_L$:



4. $I_L\ vs\ V_L$:



On analysing the graph.

V_{oc}(x-intercept)=411mV

I_{Sc}(Y-intercept)=3.36mA

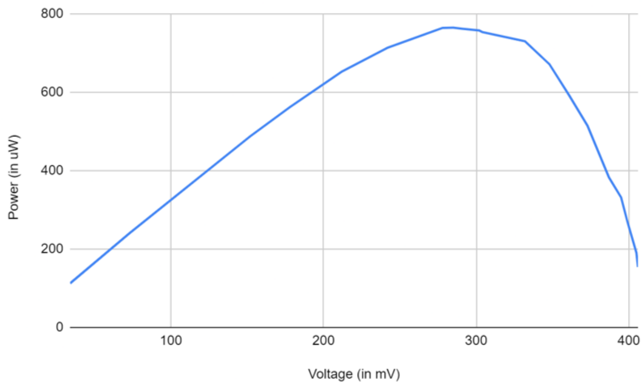
P_{max}=0.76522mW

So,

$$Filling\ Factor = \frac{P_{max}}{V_{OC}I_{SC}} = \frac{0.76522}{0.411 \times 3.36} = 0.554$$

$$\eta = \frac{P_{max}}{P_{in}} = \frac{0.76522}{3.5758} = 0.214$$

5. $P_L\ vs\ V_L$:



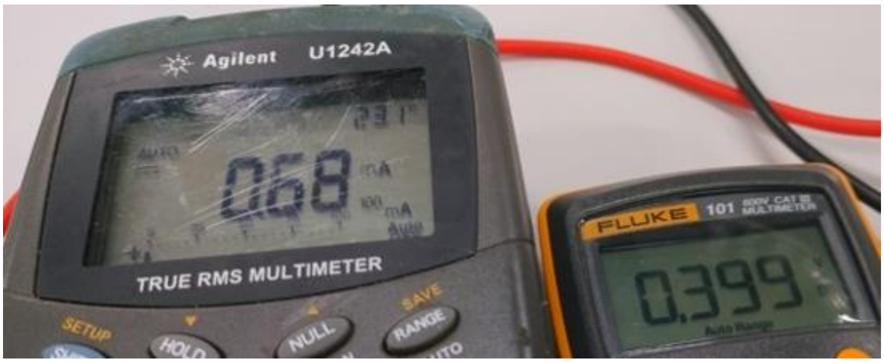
Maximum power I.e, P_{max}=0.76522mW obtained at R_L=105Ω, $V_L = 285mV$ and $I_L = 2.685mA$.

Observed values:

10Ω:

100Ω:

560Ω:



Questions:

1. Calculating number of solar cells needed to power home
   Power shown in meter=813.3W/day
   Number of solar cell needed=813.3/0.76522=1062832
2. Calculating number of solar cells needed for car to go from home to airport:
   Power will be 7kW.
   Number of solar cells needed=8000/0.76522=10454510
3. Challenges faced in realizing photovoltaics to fullfill daily needs are
   1. They need solar energy or light energy continuously that it becomes unuseful at cloudy days.
   2. We can use energy storage system but it costs more money.
   3. They are expensive.
   4. We have to place them wisely so that we can get efficiency else power generated is less.

5. They are big and bulky.

Conclusion:

We can use max power to full our needs. And the above results are improved by taking exact value of resistance to calculate maximum power.