EE236: Electronic Devices Lab
Lab 3: Diode IV Characterization

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1 Aim of the experiment

- To study the forward and reverse bias I/V characteristics of a Photodiode.
- To measure the response of the Photodiode for different lights and different intensities. (4 LEDs are provided, along with their current vs intensity data)
- To use the Photodiode as an optical signal sensor in combination with an Infra-red LED.

2 Theory

Photodiode: A photodiode is a light-sensitive semiconductor diode i.e it produces current when it absorbs photons. Under dark conditions, a photodiode behaves like a regular P-N junction diode. But when photons are incident on it, the I-V curve shifts downwards, increasing the reverse current. Hence, a photodiode is operated in reverse bias (because different types of incident light will give different reverse currents). A photodiode can be used as an optical sensor.

Infra-red LEDs: Infra-red LEDs are just regular LEDs with wavelength ranges between 800 nm and 980 nm. Hence it falls outside the visible light range. Since the light emitted by IR LEDs are not visible to the human eye, they are used in applications such as remote control, motion sensing, security cameras, etc.

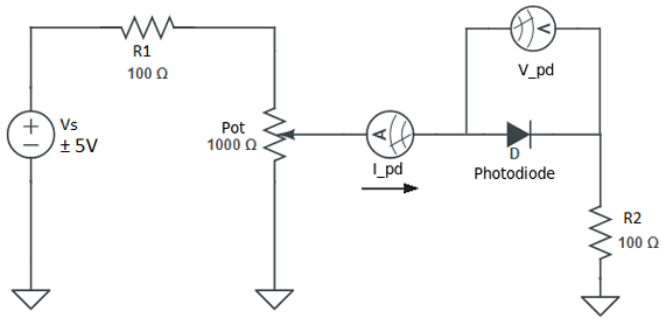
3 Design

3.1 Components used

- Photodiode
- LEDs (Infra-red, Red, Green, Blue)
- Resistors- 100Ω (×2), 1kΩ (×1)
- Potentiometer- 1kΩ, 500Ω
- Black cone
- Breadboard, connecting wires

3.2 Part 1: Dark I-V Characteristics of Photodiode

3.2.1 Circuit



3.2.2 Results and Inferences

Voltage (V)	**Current (A)**	**log(abs(Id))**
-4.55	-0.06	-2.81
-3.58	-0.05	-2.99
-3.08	-0.04	-3.22
-2.03	-0.03	-3.51
-1.29	-0.02	-3.91
-0.6	-0.01	-4.61
0.28	0.02	-3.91
0.38	0.12	-2.12
0.45	0.46	-0.78
0.5	1.23	0.21
0.52	1.68	0.52
0.54	2.06	0.72
0.58	3.26	1.18
0.6	4	1.39
0.63	5.49	1.70
0.66	7.19	1.97
0.71	11.06	2.40
0.76	15.71	2.75
0.78	18.84	2.94

Table 1: Voltage, Current, and log(abs(Id)) values

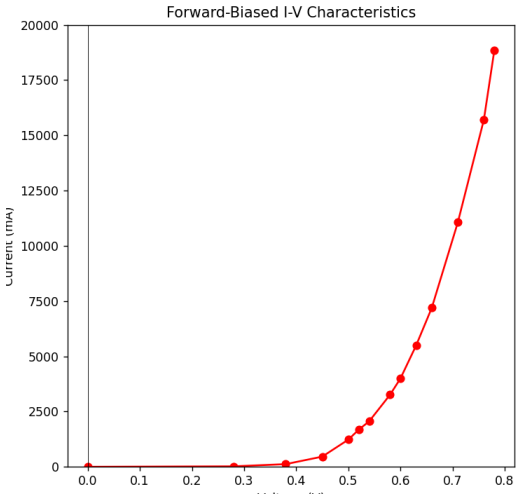


Figure 1: Forward-biased I-V characteristics

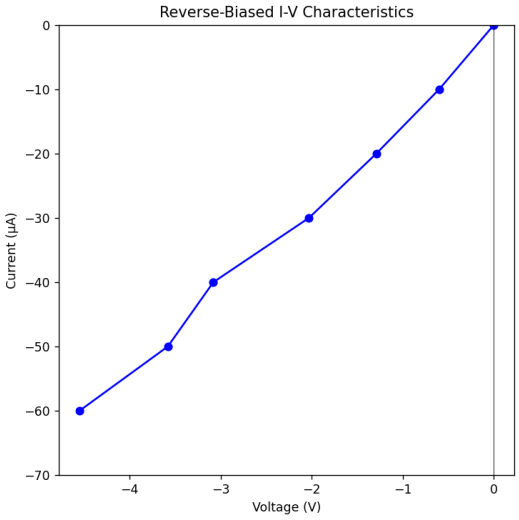


Figure 2: Reverse-biased I-V characteristics

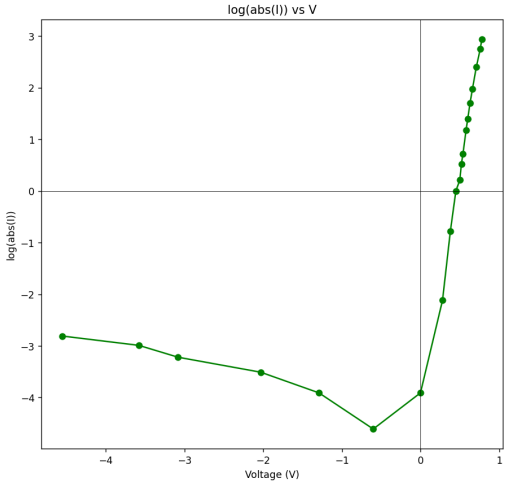
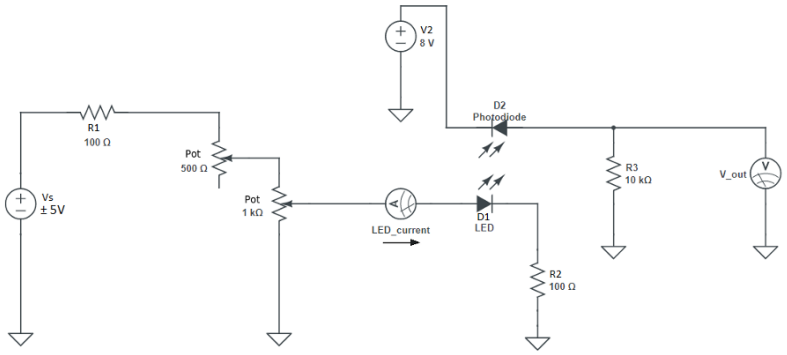


Figure 3: log(I) vs V

The ideality factor (η) can be calculated from the slope of the $ln(I_D)$ vs V_D curve and comes out to be 2.30

3.3 Part 2 : Photodiode response to lights of different intensities and wavelengths

3.3.1 Circuit



3.3.2 Results and Inferences

Current (A)	Voltage (V)	Intensity (lm)	Efficiency (%)
0.301	2.6	1000	8.637873754
0.416	4.3	1500	10.33653846
0.572	4.9	2000	8.566433566

Table 2: Blue LED Data

Current (A)	Voltage (V)	Intensity (lm)	Efficiency (%)
0.188	3.0	1000	15.95744681
0.294	3.7	1500	12.58503401
0.371	4.5	2000	12.12938005

Table 3: Green LED Data

Current (A)	Voltage (V)	Intensity (lm)	Efficiency (%)
2.0	6.9	1000	3.45
3.0	10.3	1500	3.433333333
4.0	13.7	2000	3.425

Table 4: Red LED Data

Current (A)	Voltage (V)	Intensity (lm)	Efficiency (%)
4.51	55.2	1000	12.23946785
5.17	64.9	1500	12.55319149
6.28	81.5	2000	12.97770701

Table 5: Infrared LED Data

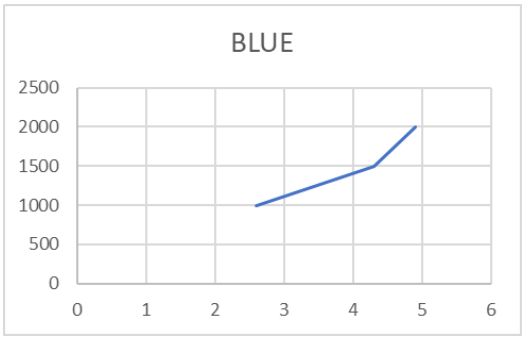


Figure 4: V vs intensity for blue LED

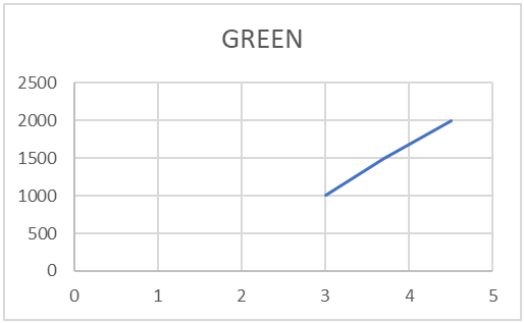


Figure 5: V vs intensity for green LED

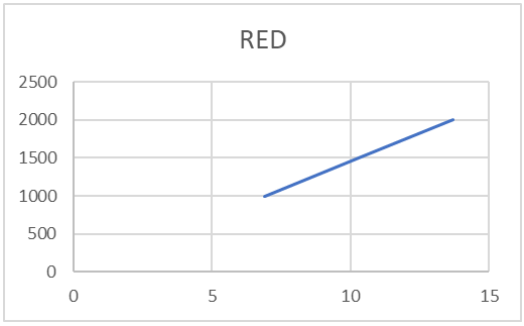


Figure 6: V vs intensity for red LED

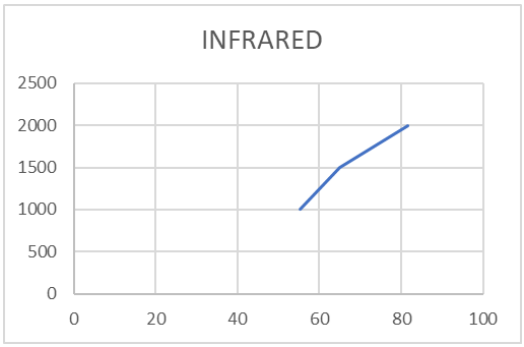


Figure 7: V vs intensity for infra-red LED

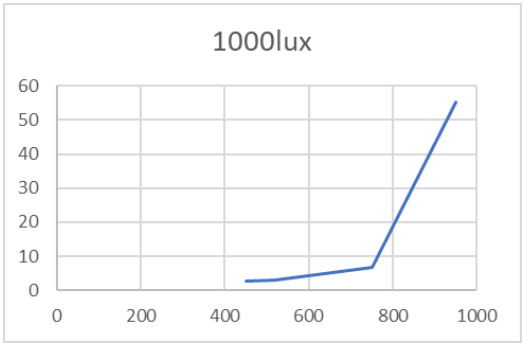


Figure 8: V vs wavelength for 1000 lux

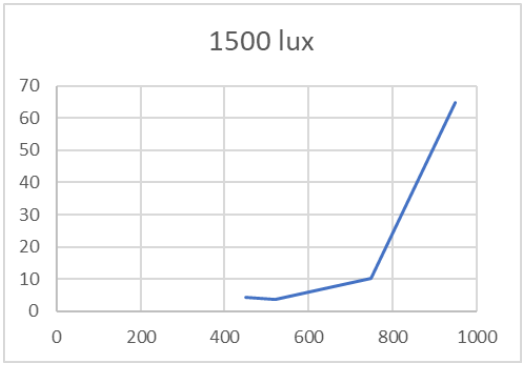


Figure 9: V vs wavelength for 1500 lux

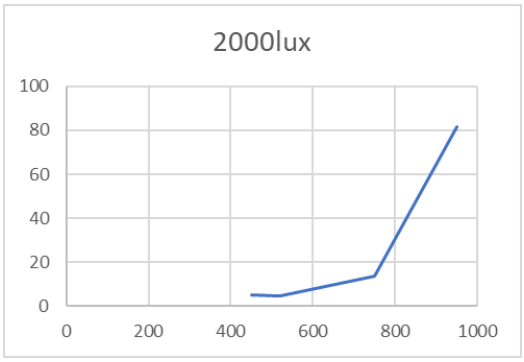


Figure 10: V vs wavelength for 2000 lux

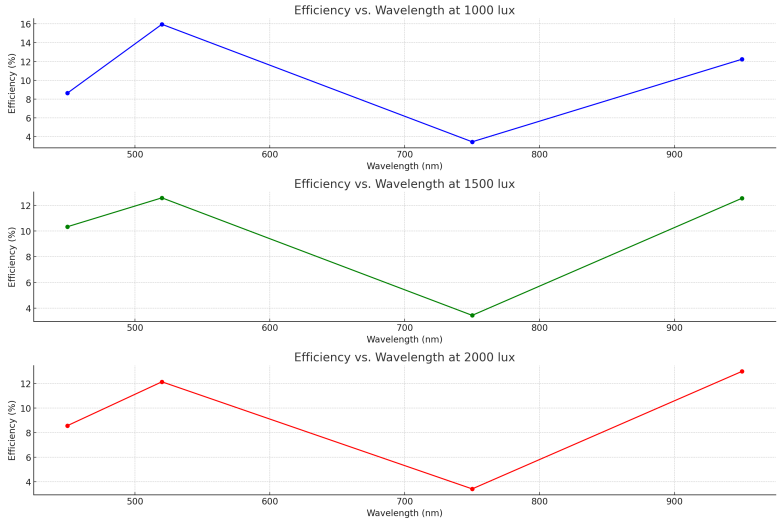
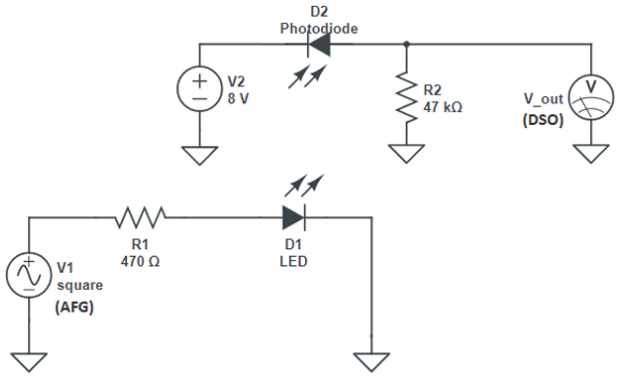


Figure 11: Efficiency vs wavelength for each intensity

Therefore, evidently, green LED is the most efficient.

3.4 Part 3 : Application of photodiode as optical signal sensor

3.4.1 Circuit



3.4.2 Results and Inferences

Parameter	Value
Output Voltage	60 mV
Rise Time	7.897 µs
Fall Time	8.63 µs

Table 6: Measured parameters for the circuit

On changing the frequency, we get these waveforms:

Figure 12: 1 kHz

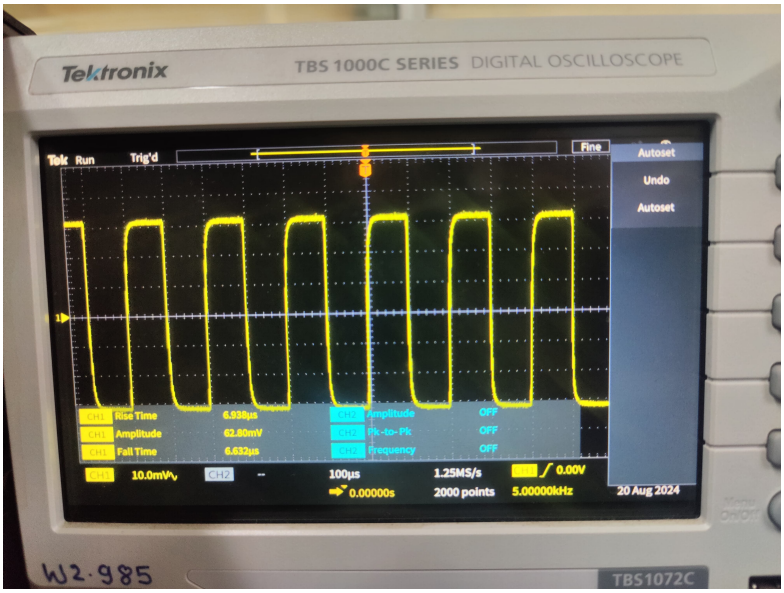


Figure 13: 5 kHz

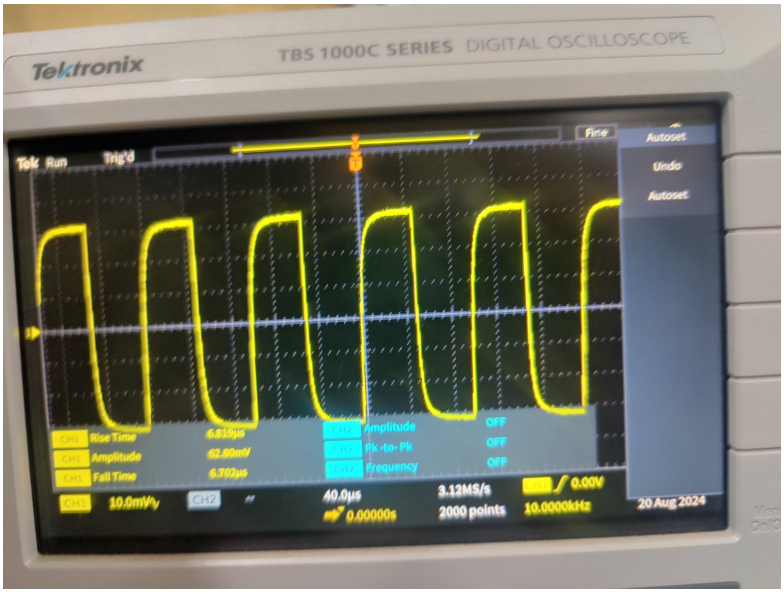


Figure 14: 10 kHz

Figure 15: 20 kHz

As evident, we start deviating from the square waveform at about 20 kHz.