EE230: Homework 2.
Plotting and Data Representation

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1 Overview of the experiment

1.1 Aim of the experiment

To plot the $log_e(I)$ vs V curve for a pn junction diode and to visually evaluate the parameter n from the plot.

1.2 Methods

We know that the pn junction diode is characterised by the following equation

$$I = I_0(e^{\frac{qV}{nkT}} - 1) \tag{1}$$

Where I_0 is the reverse saturation current, V is the voltage, q is the elementary charge, k is the boltzmann constant, T is temperature. For the values of V given in the lab handout $V >> \frac{kT}{q}$ hence $e^{\frac{qV}{nkT}} >> 1$

Thus $I \approx I_0 e^{\frac{qV}{nkT}}$, $log_e(I) = log_e(I_0) + \frac{qV}{nkT}$. Thus the slope (m) of the graph for the linear region is $\frac{q}{nkT}$. Thus we can get the value of n as

$$n = \frac{(\frac{\Delta X}{\Delta Y}) \cdot q}{kT} \tag{2}$$

Thus two points $(x_1, y_1), (x_2, y_2)$ can be chosen from the plot where the behaviour is linear and the value of the slope m = $\frac{\Delta Y}{\Delta X}$ can be found and using equation (2) the value of n can be approximated.

2 Simulation results

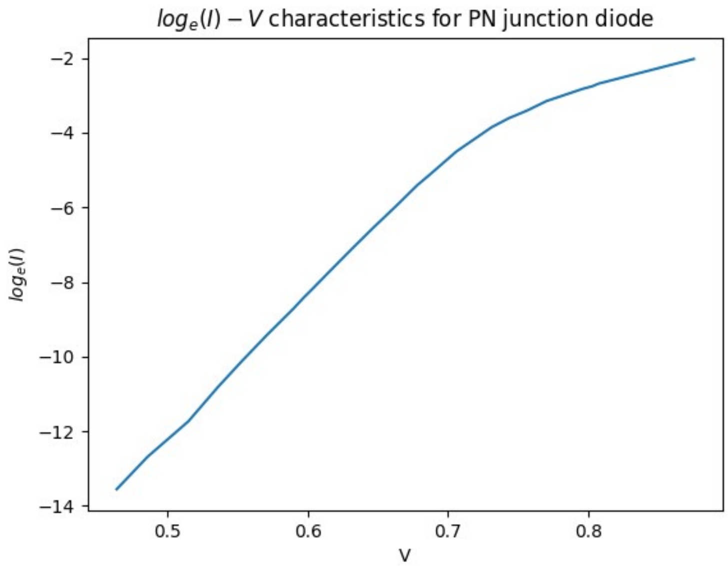
2.1 Code snippet

The python script `pn_junction.py` was used to plot the $log_e(I)$ vs V curves and then approximate the value of n using equation (2) is as follows.
The V-I values for the pn junction were stored in `pn_readings.txt`.

```
import matplotlib.pyplot as plt
import numpy as np

filename = "pn_readings.txt"
with open(filename,'r') as t:
    values = t.readlines()
    values = [(i[0:-1].split()) for i in values]
    x_values = np.array([float(i[0]) for i in values])
    y_values = np.log(np.array([float(i[1]) for i in values]))

x1 = 0.604
x2 = 0.632
y1 = np.log(2.85E-04)
y2 = np.log(8.30E-04)

m = (y2-y1)/(x2-x1)
k = 1.38E-23
q = 1.6E-19
T = 300

n = q/(k*T*m)
print(n)

plt.xlabel("V")
plt.ylabel("$log_{e}(I)$")
plt.title("$log_{e}(I)-V$ characteristics for PN junction diode")
plt.plot(x_values,y_values)
plt.show()
```

2.2 Simulation results

The $log_e(I)$ vs V curve that was returned by the script was as follows



It was observed that the $log_e(I)$ vs V plot was nearly linear visually for $0.5 \leq V \leq 0.75$. Thus from the dataset (0.604, $log_e(2.85E-04)$) and (0.632, $log_e(8.30E-04)$) were chosen as $(x_1, y_1), (x_2, y_2)$ and thus the value of n obtained using equation (2) was $\mathbf{n = 1.0123}$.

3 Experimental results

The value of n which was found using the visual linear approximation method was $\mathbf{n = 1.0123}$.

The actual value of n obtained using the same two datapoints and eq (1) after solving the complicated transcedental equation is $\mathbf{n = 1.0075}$.

Thus we conclude that the visual method approximates the value of n very well and leads to very minimal error. Thus the parameter n can be visually evaluted using the method given in 1.2