Lab 2: Resistors and Diodes

Experiment 1: Diode-Connected Transistor Characteristics

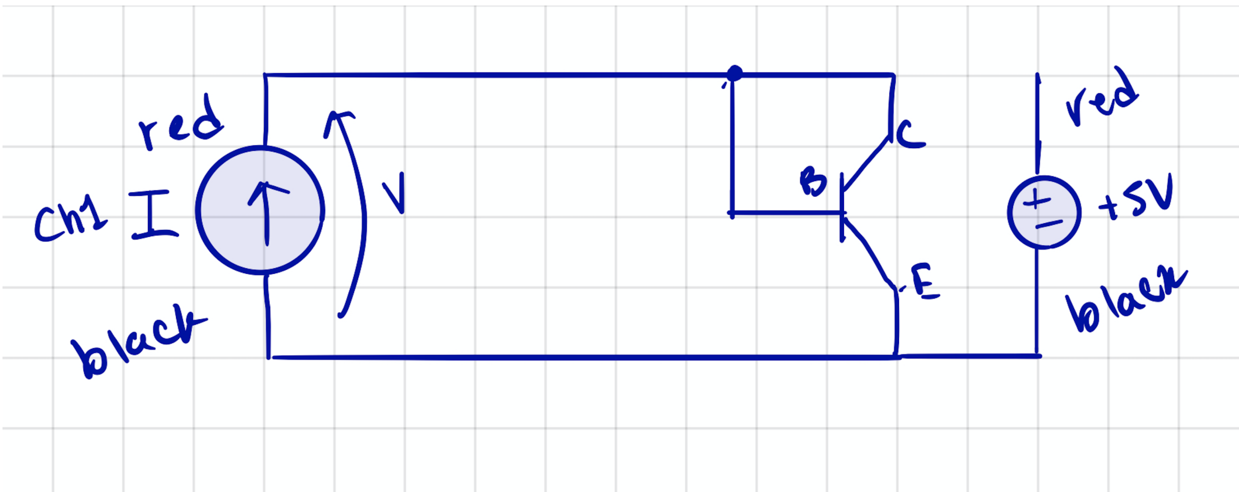

Figure 1: This describes the experimental lay out when we forced a current through the diode connected transistor and measured the voltages.

To create the diode connected transistor, we connected the top and middle pins of the transistor together. Then, we used channel 1 to force a current through this diode connected transistor and also measure the voltage across it. We used the black lead of the 5V channel in order to create the ground. We logarithmically swept the current output from channel one from 1 nA to 10 mA.

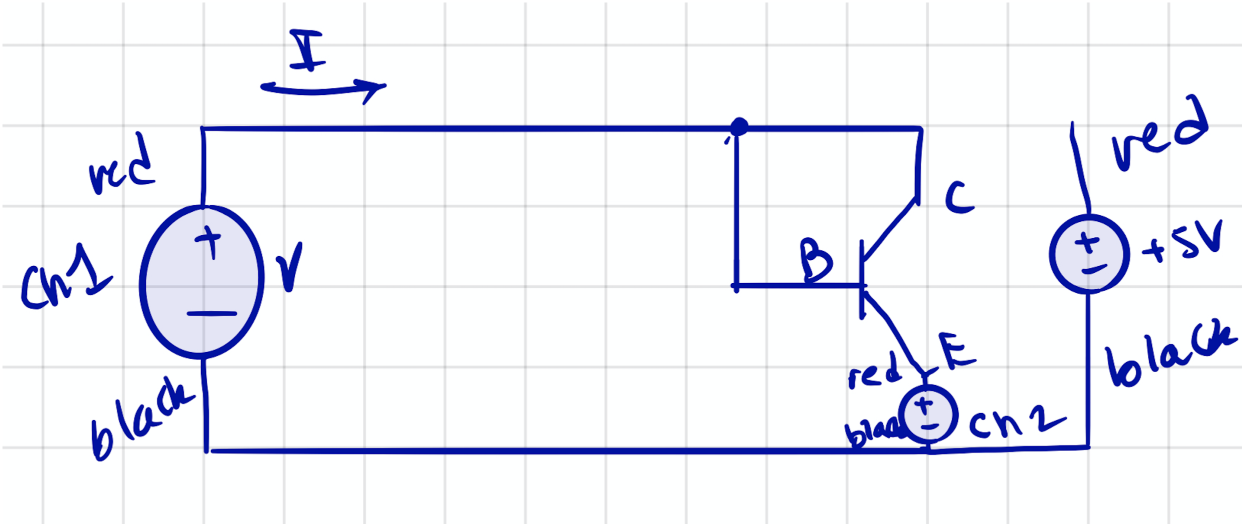

Figure 2: This describes the experimental lay out when we forced a voltage across the diode connected transistor and recorded the current.

We used the same diode connected transistor and used channel 1 to force a voltage across it. Then, we placed channel 2 in series with it to measure the current. Again, we used the black lead of the 5V channel in order to create ground.

We found that there weren't any substantial differences between the voltage current characteristic and the current voltage characteristic. If there were any differences it could be due to measurement noise and parasitic impedance/capaticance.

We then plotted the current-voltage characteristic and fit an exponential curve to it.

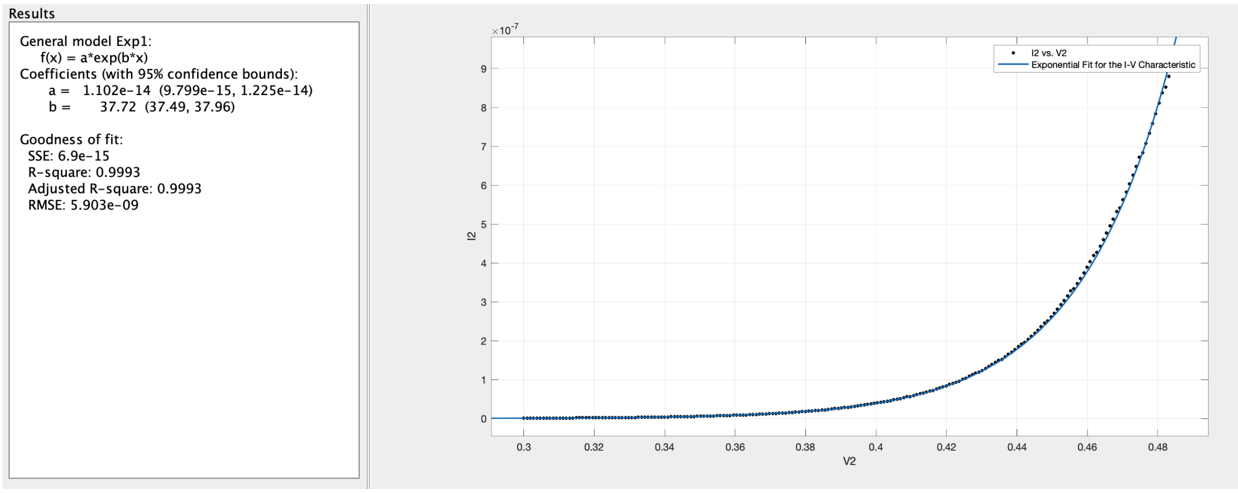

Figure 3: The fitting of an exponential plot to the current voltage characteristic when we force a voltage across it and measure the current.

The coefficient a is the saturation current, Is. Therefore, Is is 1.102e-14 A.

The coefficient b is 1/thermal voltage. This is equal to 0.0265 V.

As you can see, the R-squared value is 0.9993.

These values actually make a lot of sense as we know that the thermal voltage is actually around 0.025 V. 1/0.025 is equal to 40 which is really similar to the b that we found, although in the 6% error bound.

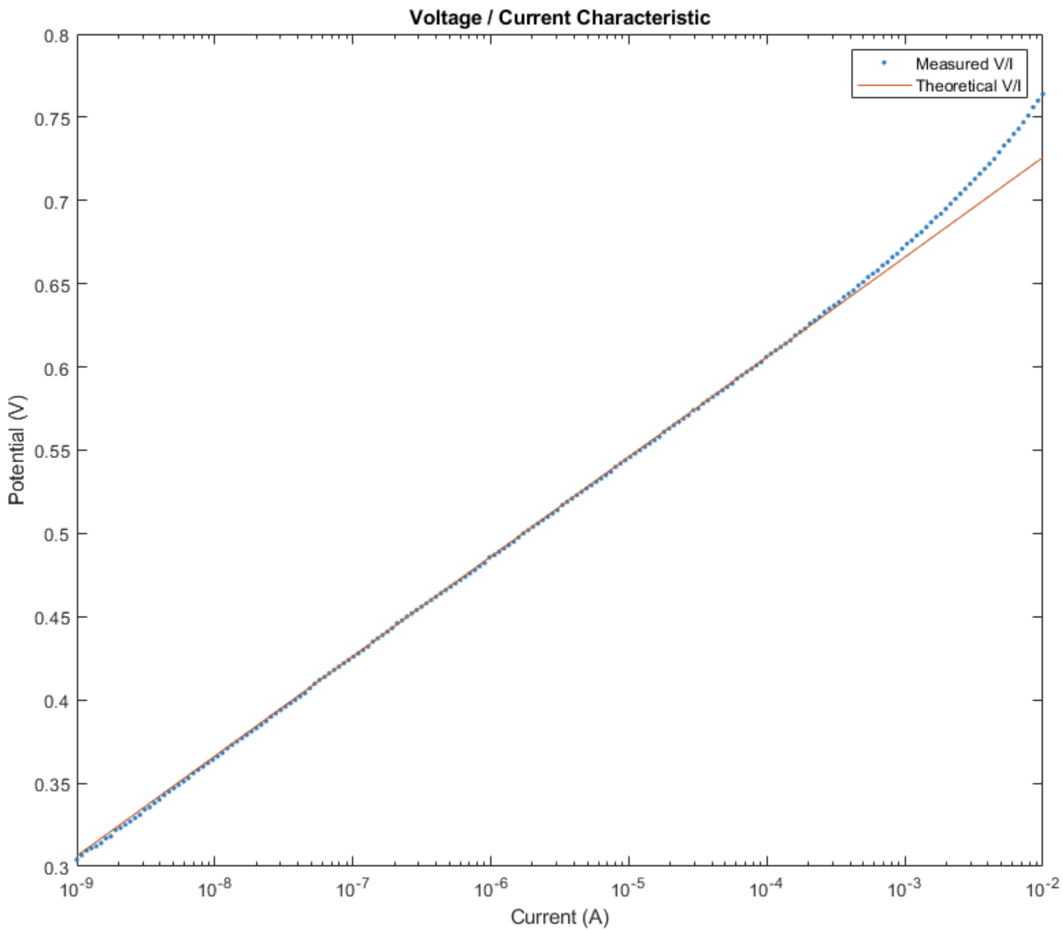

Figure 4: This is the same voltage-current characteristic plotted on the a semilogx plot. The fit of the exponential plot can be seen here more visually as well.

In figure 4, we can see that the theoretical current voltage characteristic of this diode connected transistor is indeed very similar to the current voltage characteristic that we measured.

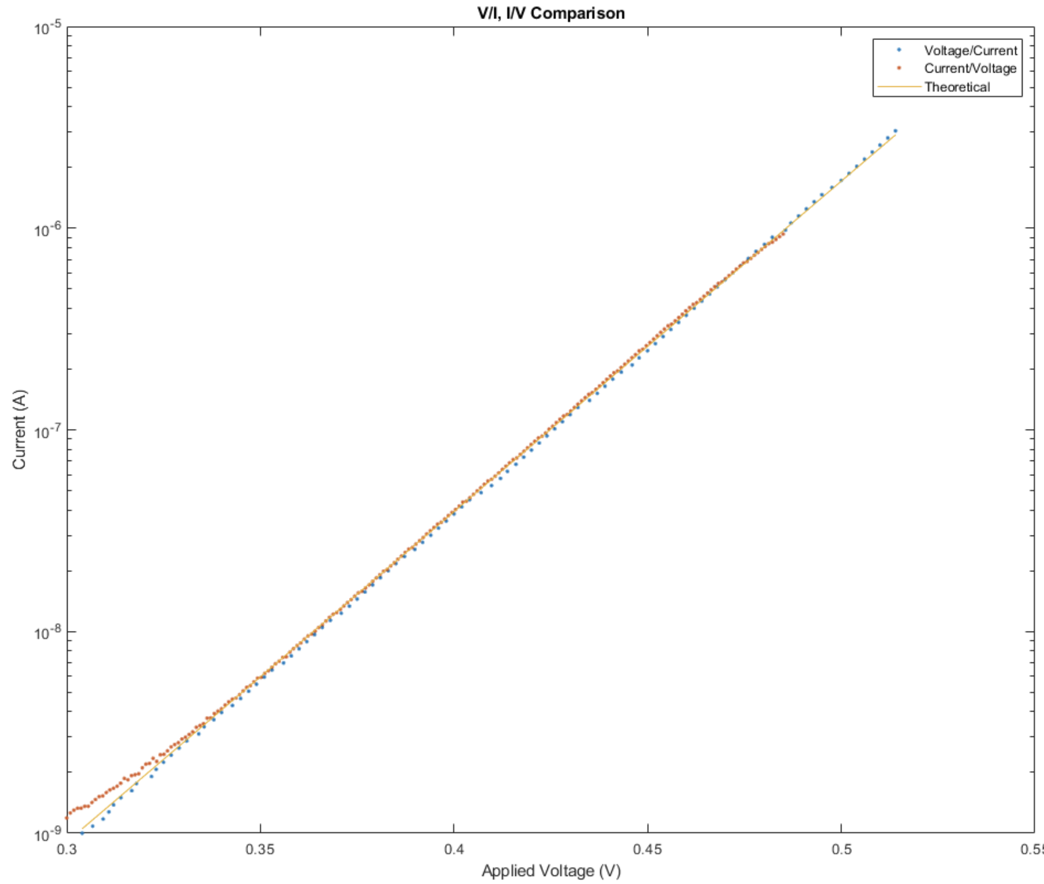

Figure 5: A comparison of the V-I and I-V characteristics of this circuit along with a theoretical projection of them.

In figure 5, we can see how the current voltage and voltage current characteristics do not vary much from each other, as they should not. In addition to this, the theoretical fit for both fo them is fairly linear.

Next, we plotted the measured incremental resistance. To find the theoretical incremental resistance against this we solved for the equation below.

$$V = ln(\frac{I}{1.102e-14A}) \cdot 0.0265V$$

Where 1.102e-14 A is the saturation current and 0.0265 V is the thermal voltage.

Then, we took the derivative of this with respect to current to find the theoretical incremental resistance.

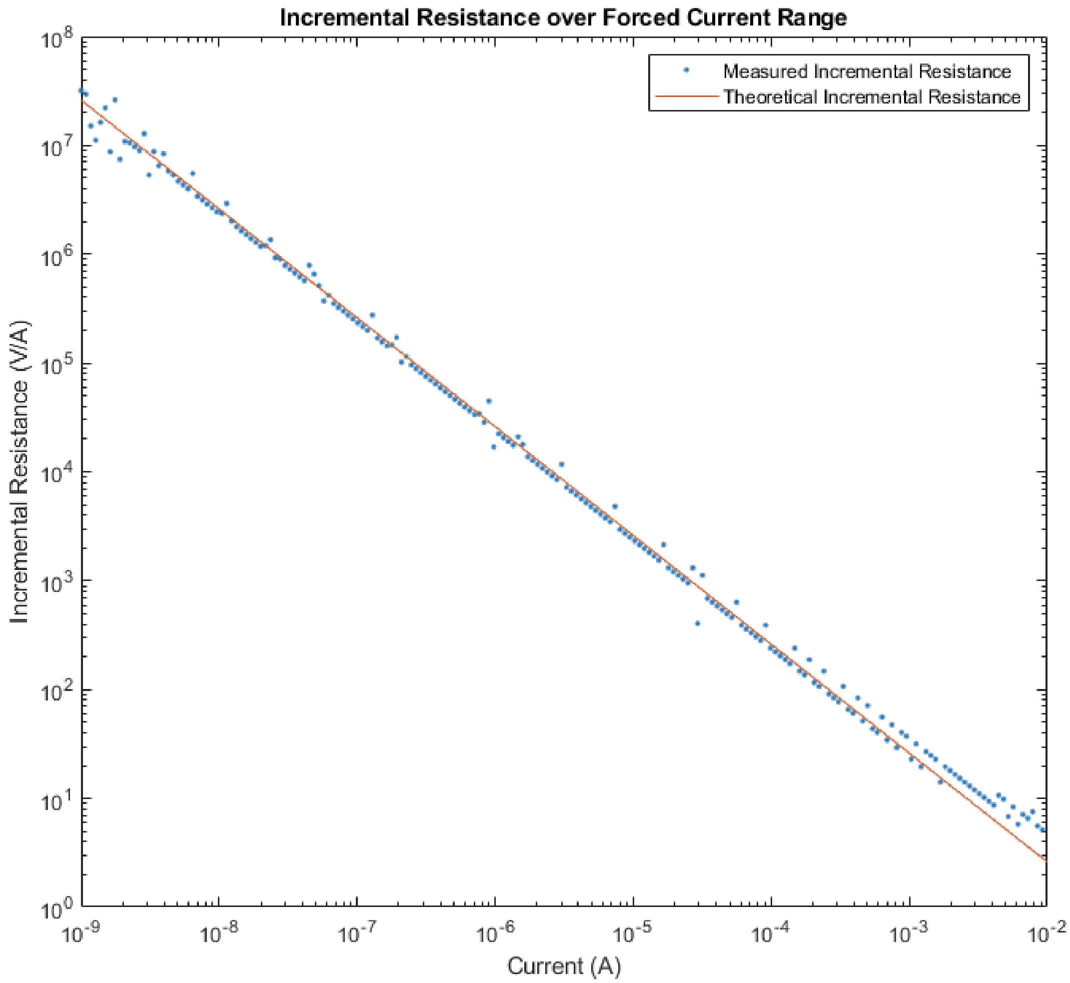

Figure 6: This is a log-log plot showing the incremental resistance and the theoretical incremental resistance.

The measured incremental resistance and theoretical incremental resistance match each other pretty closely. Any differences in the fit can be attributed to the use of a breadboard and electromagnetic interference.

Experiment 2: Characteristics of a Resistor and Diode in Series

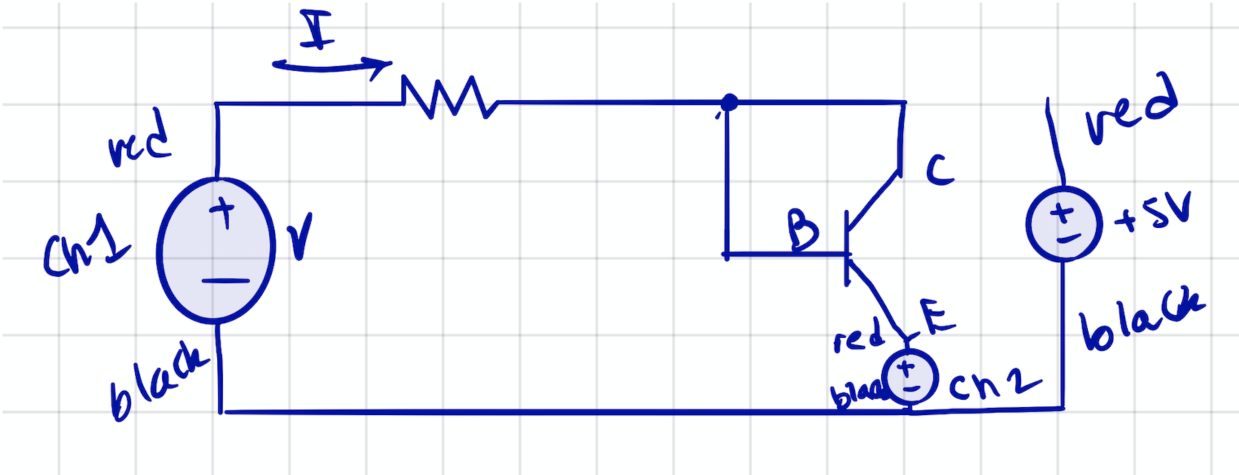

Figure 7: This schematic describes the experiment set up with the resistor in series with a diode connected transistor.

For this experiment, we placed a resistor in series with the diode connected transistor. We tested three different values for this resistor: 301 ohms, 3.01 kOhms, and 30.1 kOhms. We provided a voltage to the circuit using channel one and measured the current using channel 2 in series with the diode connected transistor. We used the black lead of the 5V in order to maintain the ground.

This circuit does behave qualitatively as we expected on the prelab assignment, especially in the sense of the Von and Ion calculations that we will do later.

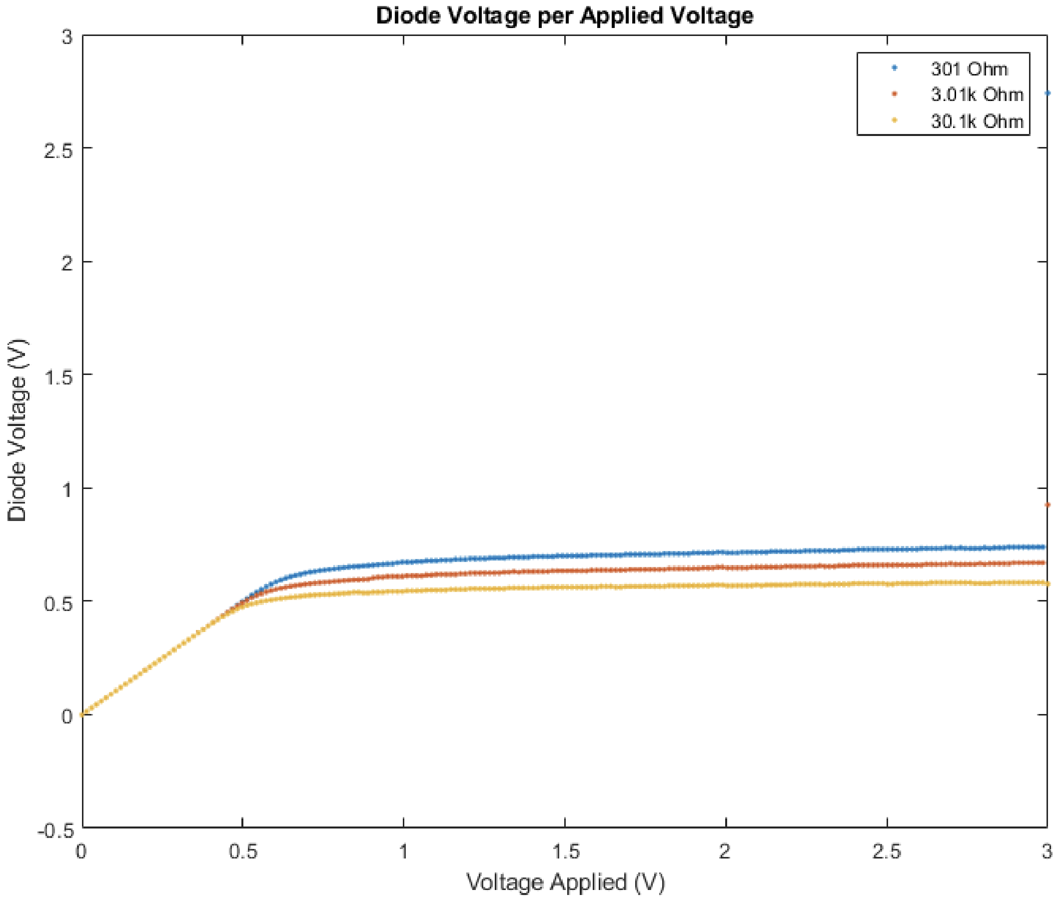

Figure 8: This is a plot of the voltage across the diode-connected transistor as a function of the applied input voltage for all of the resistors that we used.

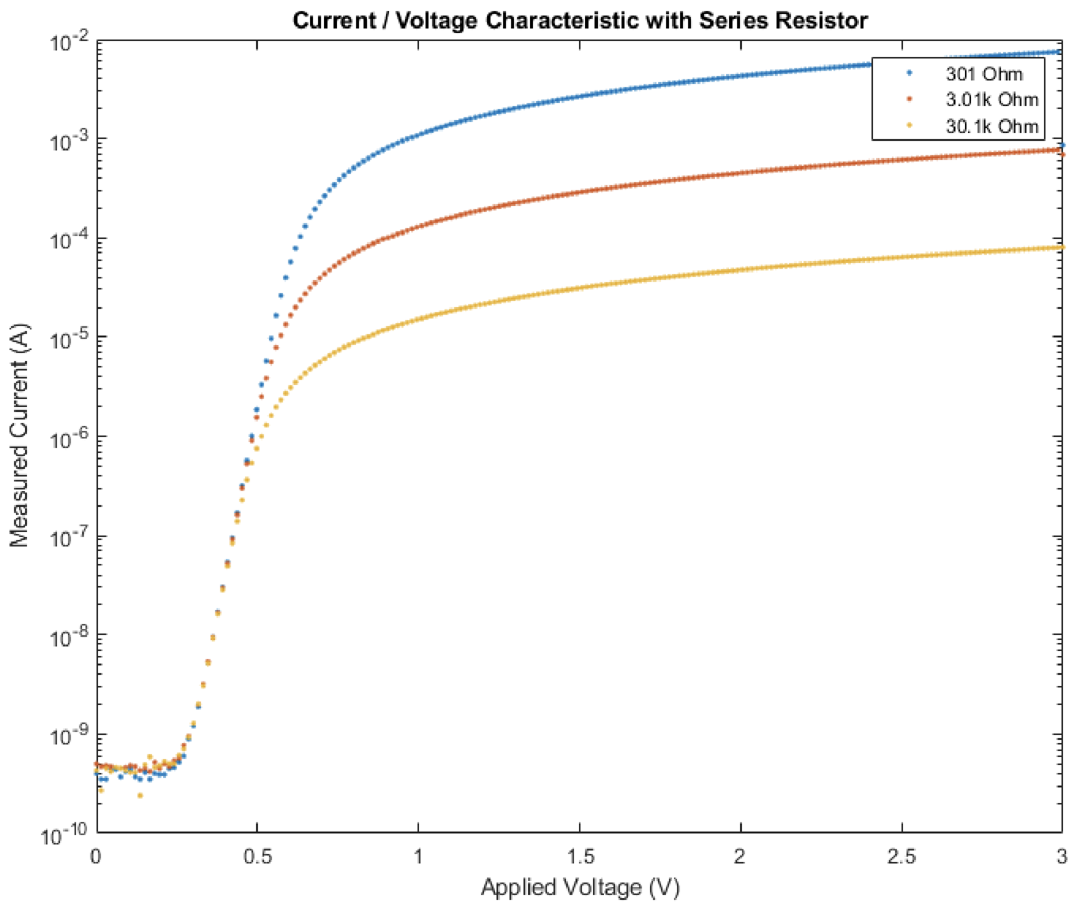

Figure 9: This is a plot of the the measured current flowing into the circuit as a function of the applied input voltage.

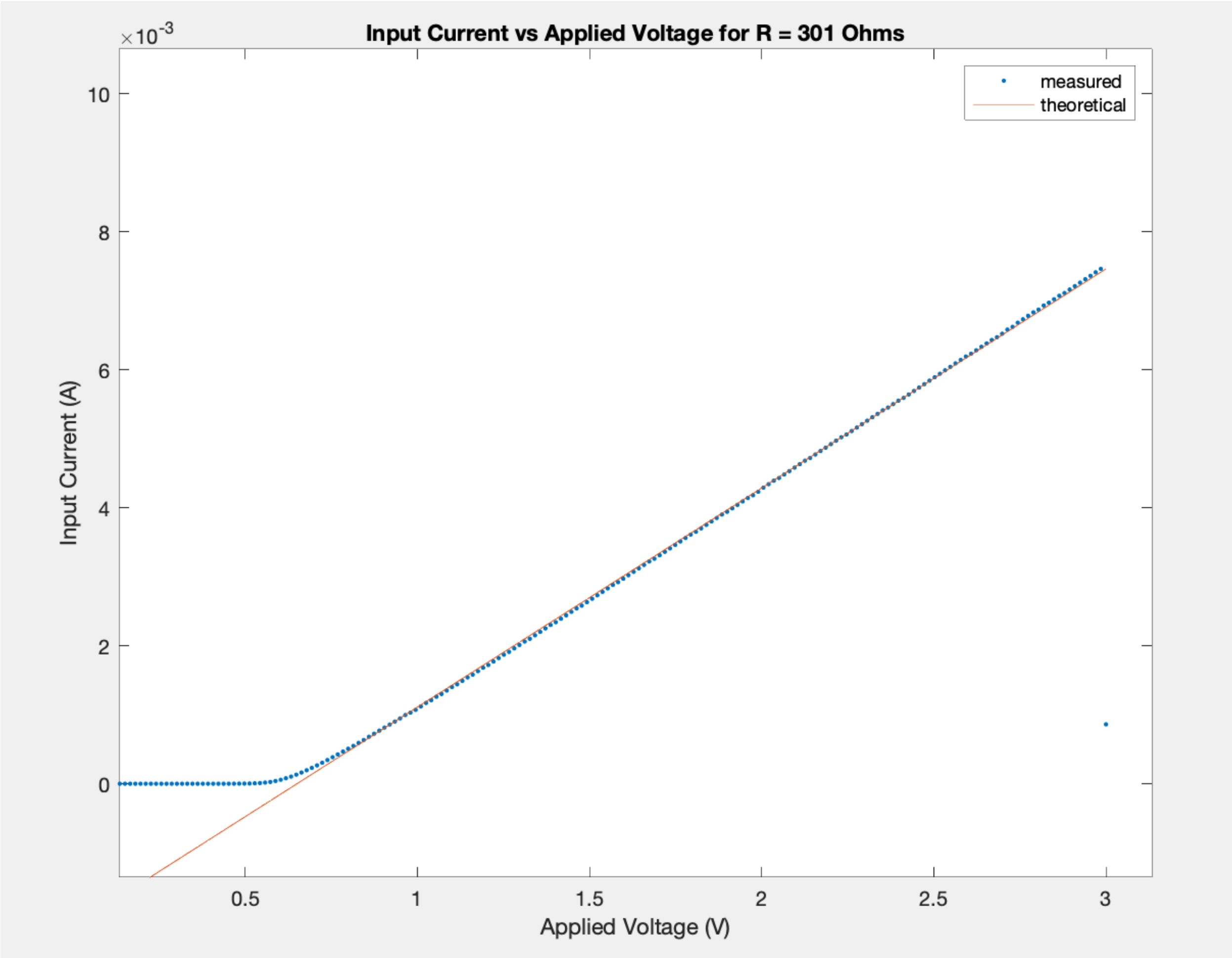

Figure 10: LInear fit of input current vs applied input voltage for the circuit with a resistor of 301 Ohms

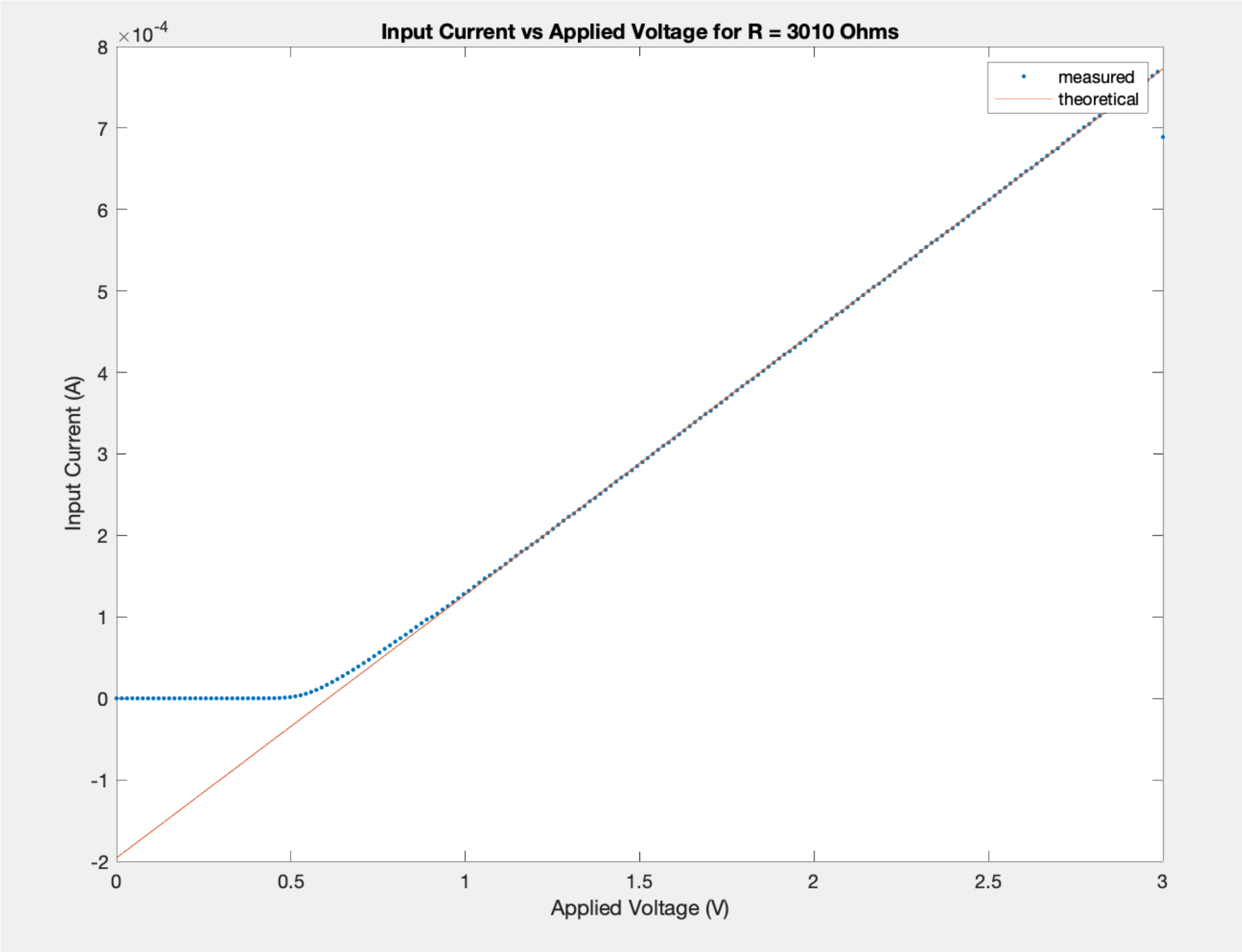

Figure 11: LInear fit of input current vs applied input voltage for the circuit with a resistor of 3010 Ohms

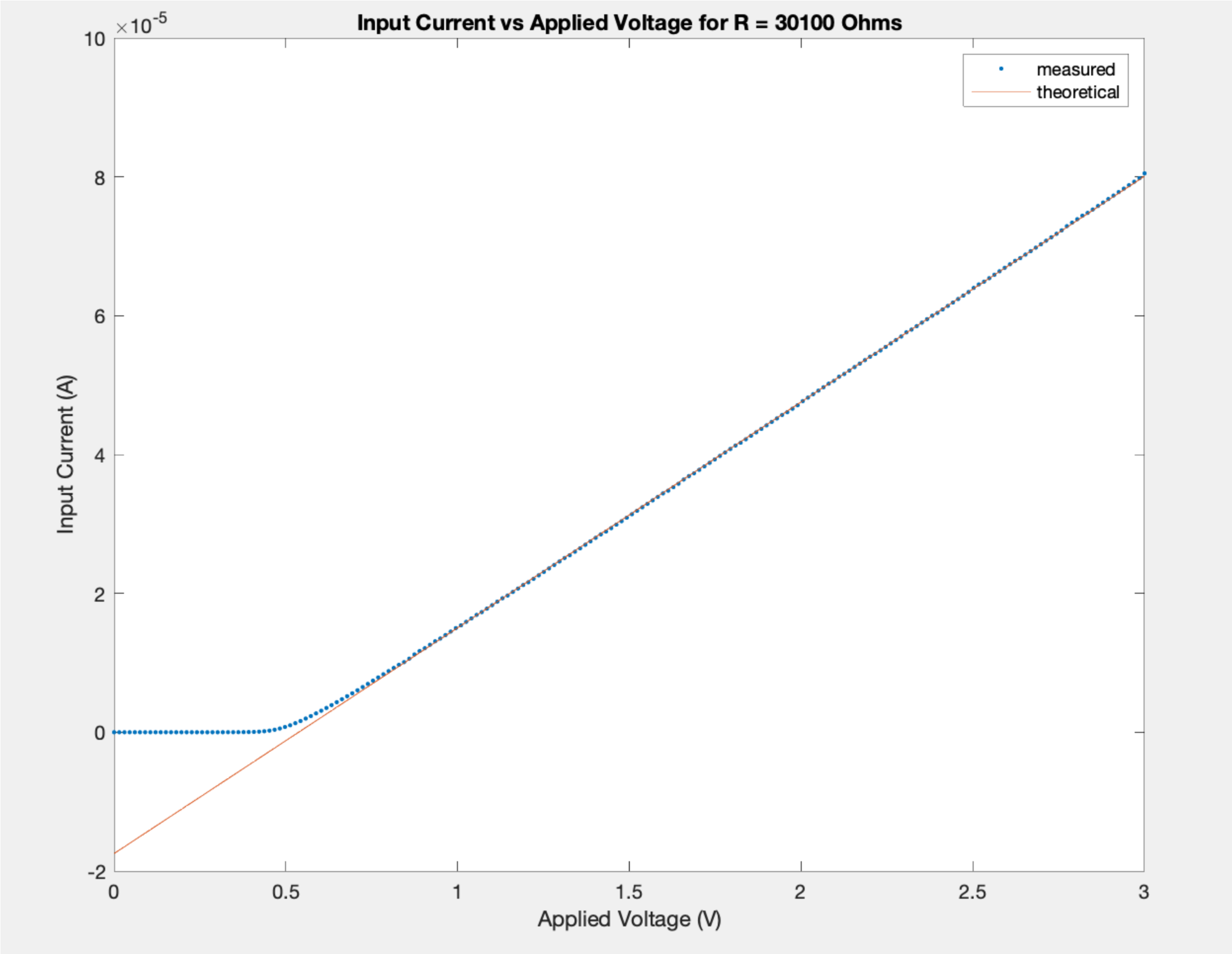

Figure 12: LInear fit of input current vs applied input voltage for the circuit with a resistor of 30100 Ohms

In order to calculate turn on current and turn on voltages, we use the following equations derived in the prelab.

$$I_{on} = \frac{U_T}{R}$$

$$V_{on} = U_T \cdot ln(\frac{U_T}{R \cdot I_S})$$

We calculated the saturation current to be 1.102e-14 A earlier. And our Ut to be 26.5 mV. These are our theoretical turn on voltages and turn on currents.

In order to find our measured turn on, we looked at the current voltage characteristic graphs. We annotated the approximate point where the graph starts to enter the linear region. This is on a semilog plot, so when the graph starts to look logarithmic, is when it would be considered linear. These points are very similar to the theoretical calculated values.

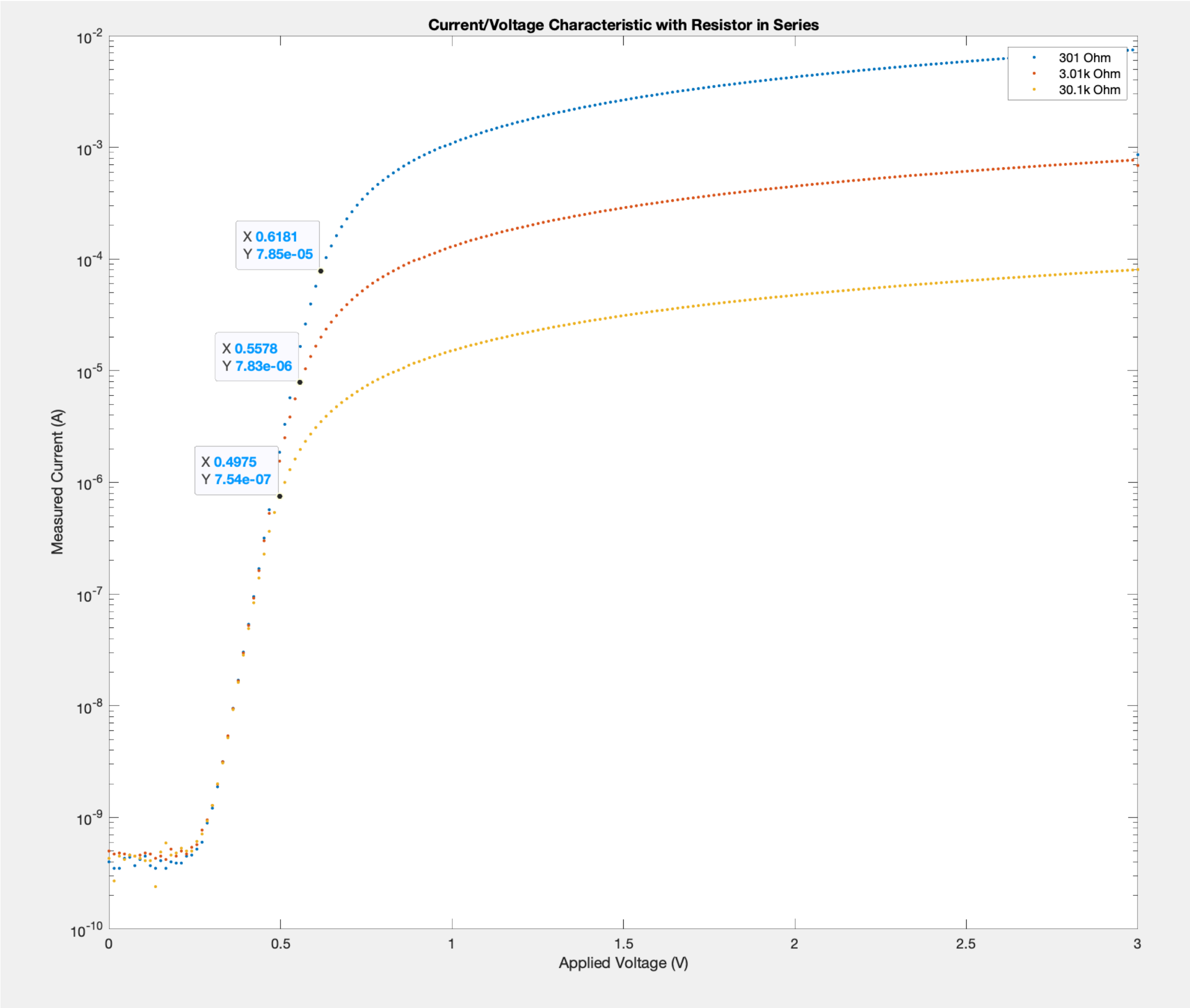

Figure 13: Current Voltage characteristics for different resistor values in series. The points where the turn on voltage and turn on current are annotated.

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R = 301 Ohms
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measured: Ion = 7.85e-05v
theoretical: Ion = 8.80e-5 A

measured: Von = 0.6181 V
theoretical: Von = 0.604 V

R = 3010 Ohms
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measured: Ion = 7.83e-06
theoretical: Ion = 8.80e-6 A

measured: Von = 0.5578 V
theoretical: Von = 0.543 V

R = 30100 Ohms
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measured: Ion = 7.54e-07
theoretical: Ion = 8.80e-7 A

measured: Von = 0.4975
theoretical: Von = 0.482 V
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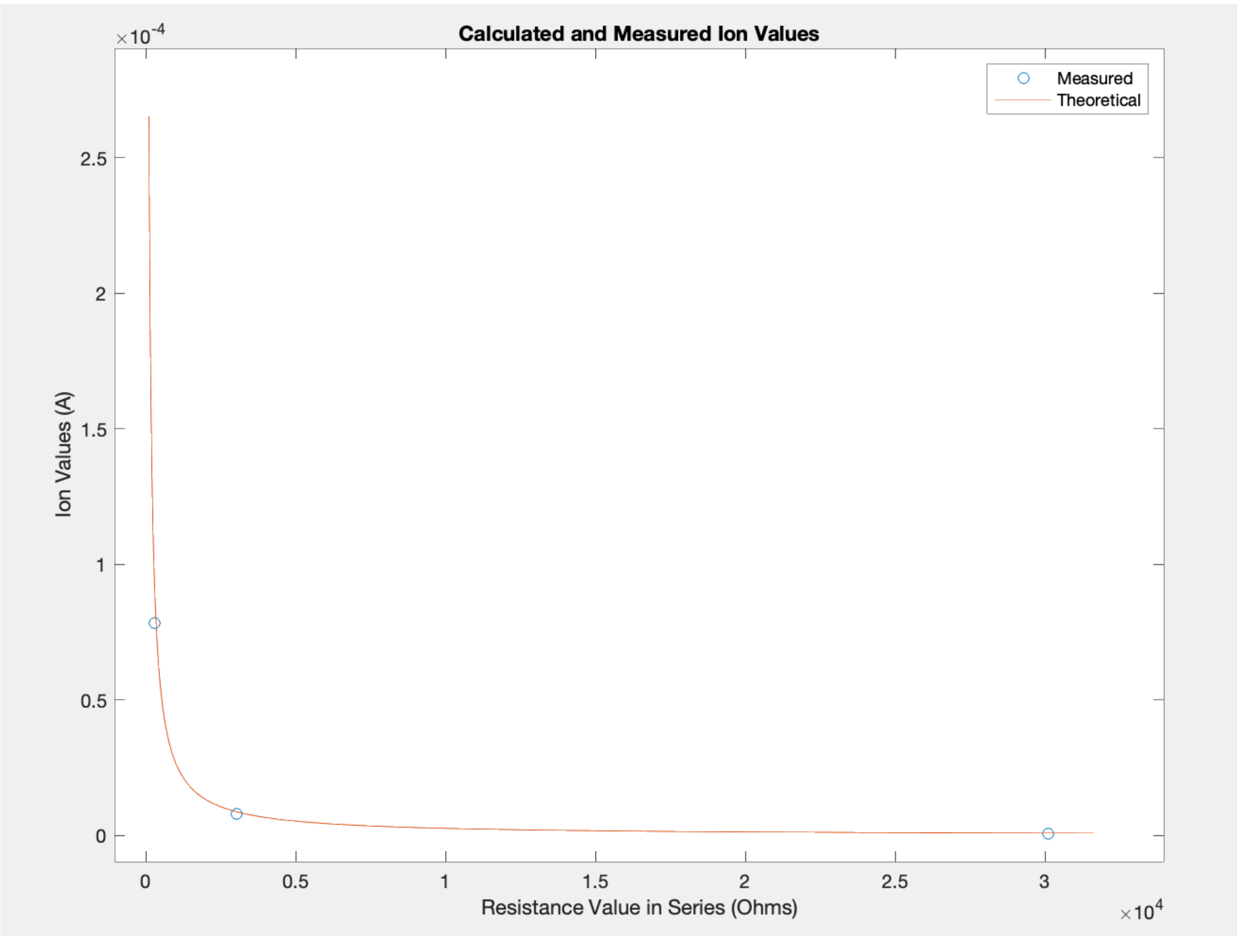

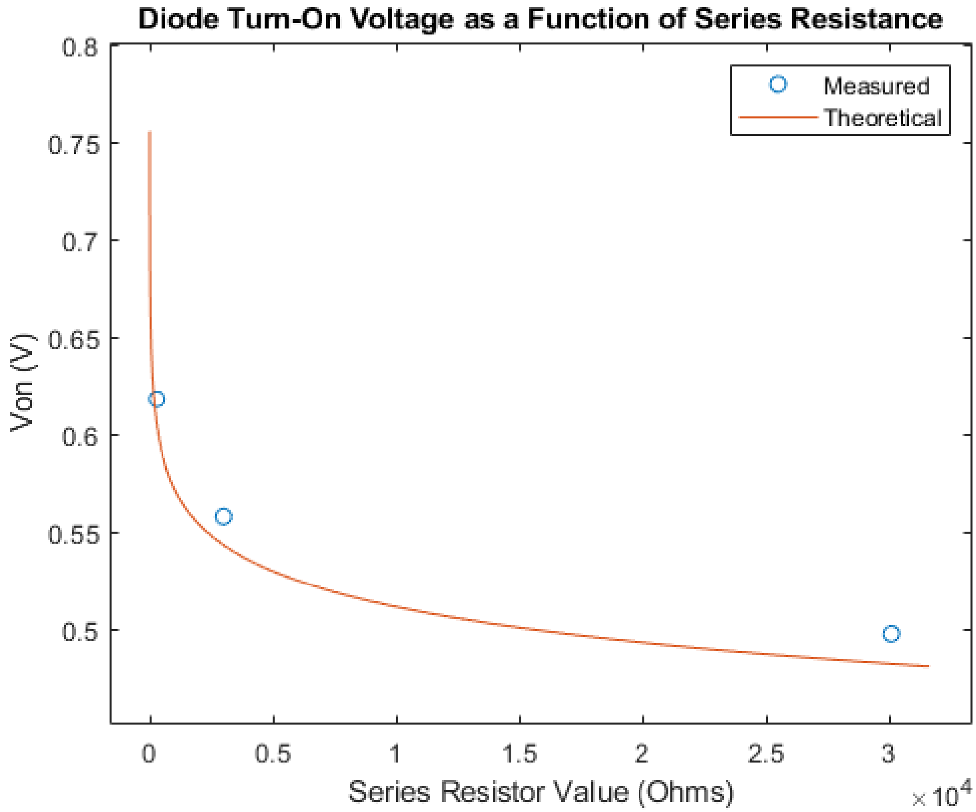

Yes, the Von and Ion graphs to follow the theoretical models as derived in the prelab very well. The Von didn't follow the theoretical model exactly as expected. This could be because the exact point that we chose was not the correct one and we could have been unconsciously fitting for one variable more than the other. It still follows the same trend as described by the equation.