Electronics Lab 08: Load Lines

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I. THEORY

We connected a 5 Volt power source across the base and emitter of a 2222 transistor in series with a resistor. The resistor served to limit and control the current through the transistor as we analyzed it. Varying the resistor was our means to vary the current going into the base and out of the emitter. Since this is simply a PN junction, Shockley's equation, $i_d \approx I_s e^{\frac{V_D}{V_T}}$, to help analyze our data.

Now if we solve Shockley's Equation for V_D we get the following.

$$V_D = \ln\left(\frac{i_D}{I_s}\right) nV_T \tag{1}$$

$$V_D = nV_T(\ln i_D - \ln Is) \tag{2}$$

Taking this a step further to get it into a linear $y = mx + b$ form we see the following.

$$\ln i_D = \frac{1}{nV_T} V_D + \ln I_s \tag{3}$$

This clearly shows us a linear relationship with a slope of $\frac{1}{nVt}$, and a y intercept of $\ln I_s$. We can compare this without collected data once it is properly fit a linear trend.

II. DATA

The collected data was then graphed with error bars as seen below. Layering the i_D in a natural log allows our $V_D vs i_D$ graph to actually have a linear relationship.

A trendline, $y = 30.631x - 22.25$, was then made to fit the data from which we can extrapolate some valuable data, notably the y intercept and the slope.

If we take our extrapolated y intercept of -22.25 and set it equal to our theoretical intercept of $\ln I_s$ we can solve for the saturation current, (I_s), of our transistor.

$$\ln I_s = -22.25 \tag{4}$$

$$I_s = e^{-22.25} = 2.1724 * 10^{-10} mA \tag{5}$$

A saturation current of $2.1724 * 10^{-13}$ milliAmps is within our range of reasonable numbers.

We can also use our slope of 30.631 to solve for V_T if we assume our value of n. In this case let's assume $n = 1$.

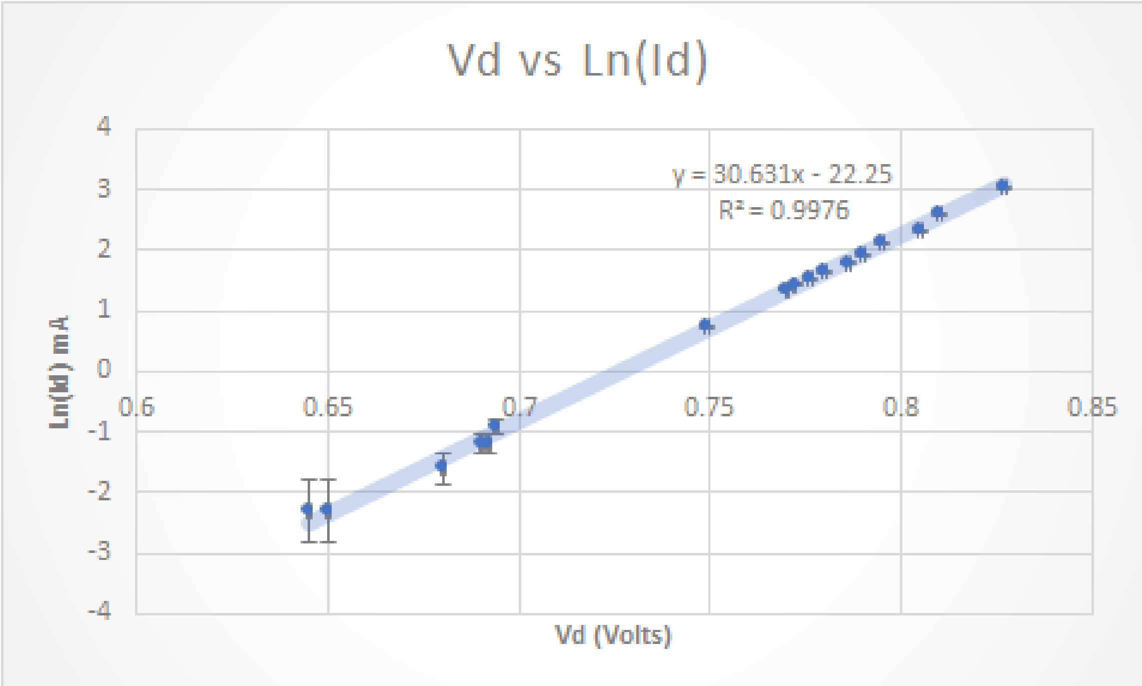

FIG. 1. Collected Data Graphed in Excel

$$\frac{1}{nV_T} = 30.631 \tag{6}$$

$$V_T = 0.032647 \tag{7}$$

While 32.647 milliVolts isn't outside of our range of possibilities, it seems a tad high to me. 26mV is already a higher estimation for V_T at room temperature. We could instead measure the temperature to directly find V_T which could then be used to find n itself. If we do this we find n to be ≈ 1.2821 when we assume a V_T of 26mV.

Since we were able to solve for the saturation current, assuming we know V_T we could alternatively use Shockley's equation to solve for n.