Lab 8 - BJT DC Performance

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1 Introduction and Theory

In this lab we are analyzing the performance of a BJT transistor when supplied with DC voltages. Our goal is to find the I-V curve that is produced. Fig. 1 shows the circuit that we are building in this lab. We are going to control the voltages V_{BE} and V_{CE} to analyze the performance of the device.
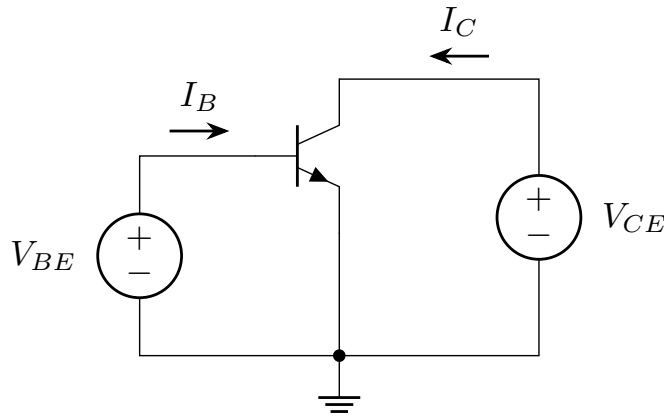

Figure 1: The BJT circuit we use in this lab.

2 Simulation

I_C **vs** V_{BE}

After building the circuit in the Multisim, we selected the DC sweep measurement mode on the voltage source V_{BE}. V_{CE} is held constant at 5 V. Sweeping V_{BE} from 0 to 0.8 volts and measuring the current I_C resulted in the graph shown in Fig. 2.

Calculating β is straight forward. We calculated $\beta = I_C/I_B$ at $V_{BE} = 0.7$ V. The result is $\beta = 161.207$.

I_C **vs** V_{CE}

For this simulation, we measured the current I_C in response to a DC sweep of V_{CE} after setting the voltage V_{BE} to 3 different voltages, as shown in Fig. 3. As you can see, with V_{BE} set to just 0.6 V, the device was never activated and current would never flow through I_C. However, when V_{BE} was set to a higher voltage, it activates the device and allows the current to flow.
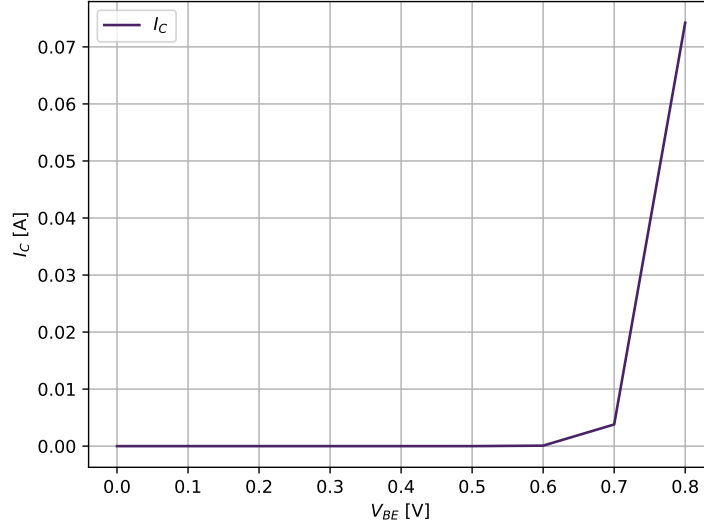
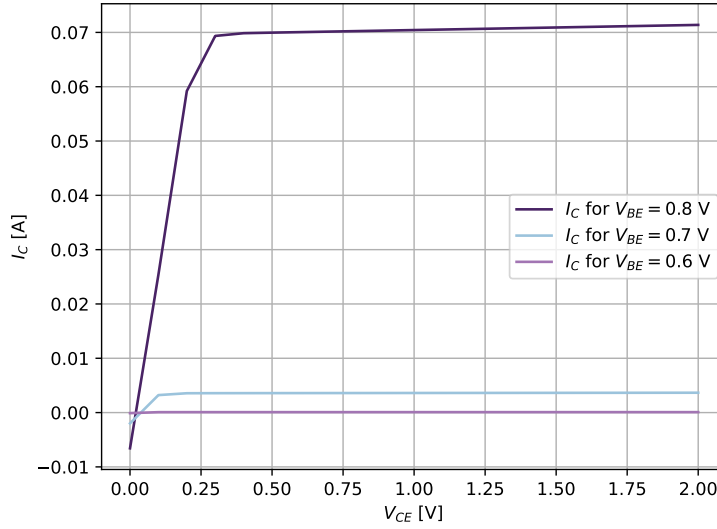Figure 2: I_C vs V_{BE} simulation results.

Figure 3: I_C vs V_{CE} simulation results.

3 Results

After simulating the performance of the device, we built the circuit to measure and compare the results.

I_C vs V_{BE}

Similar to the simulation, we swept V_{BE} from 0 to 0.8 V, while keeping V_{CE} at a constant 5 V. Fig. 4 shows the results, and they look very similar to the simulation results.

Calculating β was similar to the simulation calculation. We found that $\beta = 18.3$ mA/398 µA $= 45.98$.

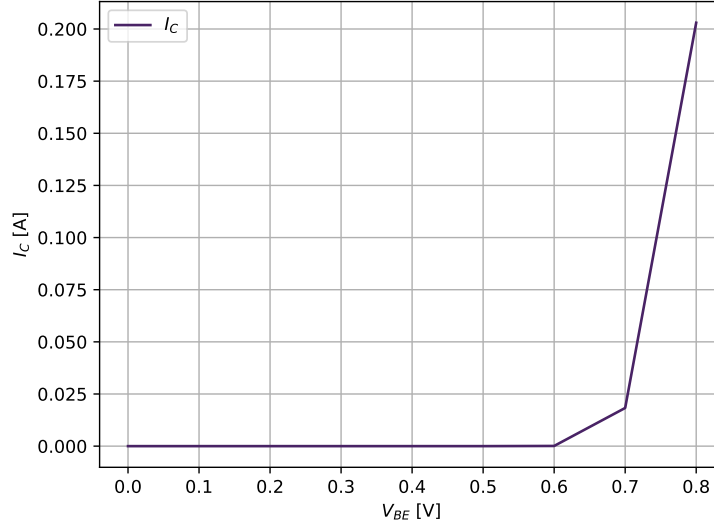Figure 4: I_C vs V_{BE} measurement results.

I_C **vs** V_{CE}

Lastly, we swept V_{CE} after setting V_{BE} to each 0.6, 0.7, and 0.8 V. The resulting graph is shown in Fig. 5.
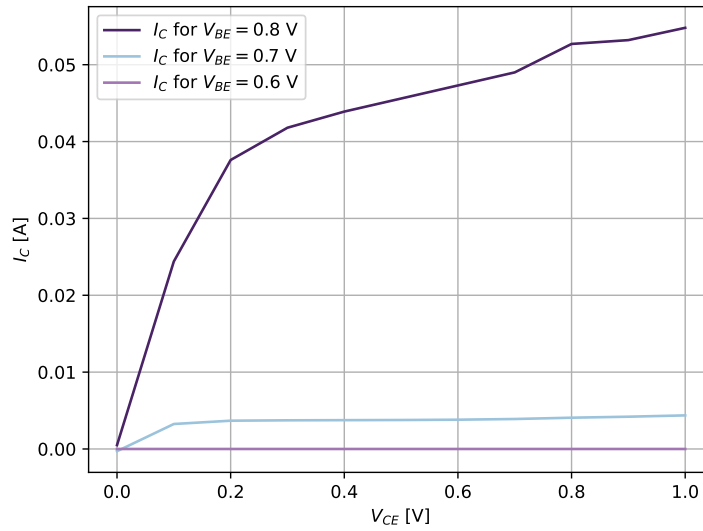

Figure 5: I_C vs V_{CE} measurement results.

4   Post-Measurement Exercise

The main difference between the simulation and measurement results is that the current was much higher in our measurements as compared to the simulation. Compare Figs. 2 and 4 and see that at $V_{BE} = 0.8$ V, the current through the BJT is at ≈ 200 mA in the real circuit and only ≈ 70 mA in the simulation. Such a high current did cause the BJT to heat up considerably.

With high temperatures at that voltage, the I_C vs V_{CE} graph seemed affected in the real circuit. The current wasn't ever able to settle when we were measuring it, and it never appeared to truly reach active region, but the current did stop increasing exponentially.

Early Voltage

Calculating the Early Voltage from the simulation was a matter of calculating the slope from the simulation curves once they reach active region and finding the point where I_C would equal 0 A. The average Early Voltage that we calculated from the simulation was found to be -65.5 V.

The Early Voltage was not calculated for $V_{BE} = 0.6$ V, because the voltage was always zero and it never reached the active region of operation.

The difference between the remaining two V_A calculations was 15.4 V, so while they were within the same order of magnitude, they weren't necessarily the exact same value.