CMPE 314: Principles of Electronic Circuits

Dr. Yan

Lab 04 Report

Transistor Characteristics

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1. Objective

Construct a transistor circuit and measure basic transistor characteristics.

2. Equipment

a. Resistors; 1 × 2.2 kΩ, 1 × 220 kΩ
b. Transistor; 1 × 2N3904 NPN
c. DC power supply, digital multi-meter(s), breadboard

3. Background

A bipolar junction transistor (BJT) is a three-terminal electronic device constructed of doped semiconductor material and may be used in amplifying or switching applications. The BJT consists of two very closely spaced PN-junctions (diodes) - the base-emitter junction and the base-collector junction. Under typical operating conditions (forward active mode), the base-emitter junction is forward biased while the base-collector junction is reverse biased. A BJT in the forward active mode can be thought of as a current controlled current source.

4. Procedures

4.1 Part A. Forward Active Mode I-V Characteristics

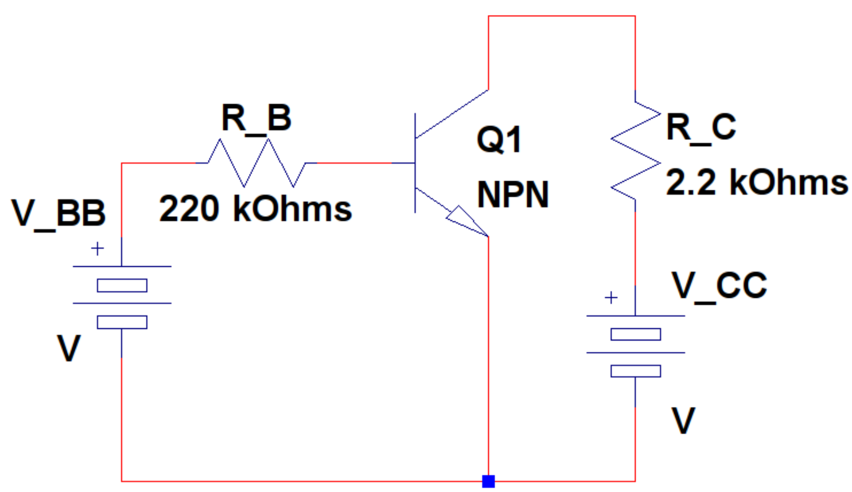

Figure 1: Common Emitter Circuit with an NPN Transistor

a. Use the NPN transistor to construct the circuit from Figure 1.
b. Increase the DC voltage V_{BB} from 0 V to 3 V with step of 0.5 V. For each V_{BB} step, increase V_{CC} from 0 V to 10 V with step of 0.25 V for $V_{CC} \leq 2\ V$ and with step of 1 V for $V_{BB} > 2\ V$. Record the corresponding voltage V_{CE} and V_{BE} for each VCC input. Calculate corresponding I_B and I_C.
c. Plot all the I_C vs V_{CE} curves for a given I_B on the same plot, which is called collector characteristic curves. Find the DC forward current gain β_F.

4.2 Part B. DC Analysis

a. Set $V_{CC} = 10\ V$, and vary V_{BB} from 1 V to 4 V, with step of 0.5 V. Measure I_C and V_{CE}.

b. Plot the I_C vs V_{CE} loadline on the same plot with the I-V characteristics curves got in Part (A). Plot the theoretical I_C vs V_{CE} loadline on the same plot. Identify the cutoff, saturation, and forward active regions on the plots.

4.3 Part C. PSPICE Simulation

a. Use PSPICE to simulate Part (A) and Part (B).

5. Results

The circuit from Figure 1 was constructed and the outputs V_{BB} and V_{CC} were recorded. I_C was computed with the relationship $I_C = \frac{V_{CC}-V_{CE}}{R_C}$ and I_B through $I_B = \frac{V_{BB}}{R_B}$. The DC current gain β_F was computed by taking the ratio of the average of I_C to the average of I_C, $\beta_F = \frac{I_C}{I_B}$, which yielded $\beta_F = \frac{8.37\times10^{-3}}{6.82\times10^{-6}} = 122.70$ as the gain.

The V_{CE} was plotted against I_C, along with the cutoff, saturation and forward active regions indicated as shown below:

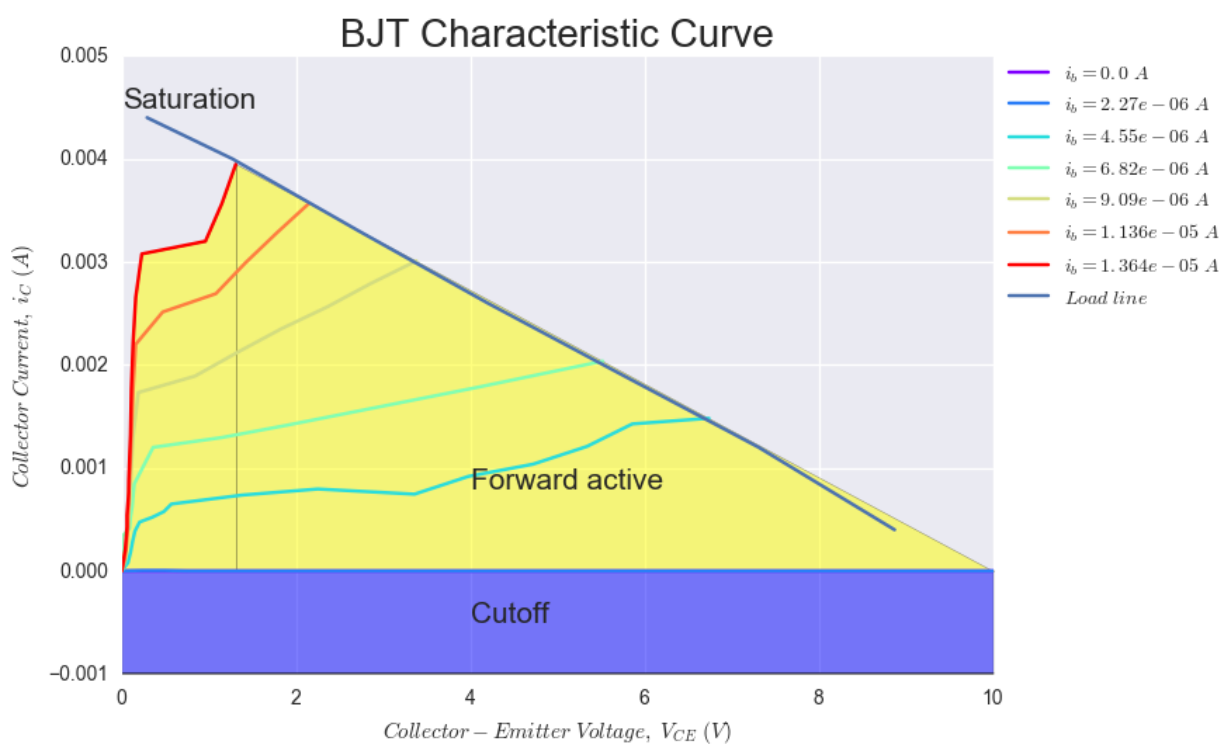

Figure 2: I-V Characteristic Curves of the Transistor Used in the Circuit Constructed from Figure 1

The transistor circuit was constructed on PSPICE, and the outputs V_{CE} and I_C were dumped and plotted to create the following transistor characteristics curve plot.

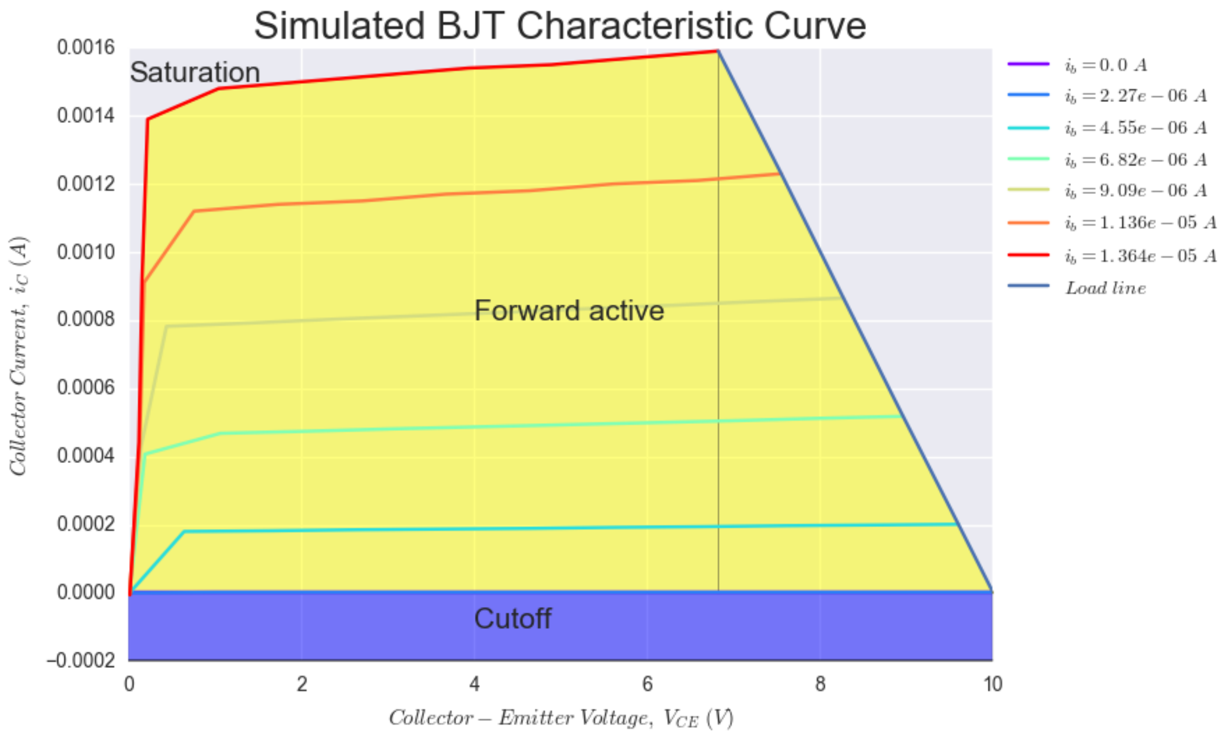

Figure 3: I-V Characteristic Curves of the Transistor Simulated on PSPICE

6. Conclusion

The I-V characteristics curves plotted from the experiment have a large error from the one plotted from the simulated circuit on PSPICE. The I_C of the curves from the measured data appear to be significantly larger than the simulated plot, and the V_{CE} seem to starting losing its data points after V_{CC} exceeds a certain threshold. The discrepancy of the plots might have been caused from inaccurate measurements of the very sensitive components used in the construction of the circuit.