LAB 6.1

NPN I-V Characteristics

(See Sections 6.1–6.2, p. 352 of Sedra/Smith)

OBJECTIVES:

To study NPN transistor I-V curves by:

- Simulating a transistor to investigate the collector current vs. base-to-emitter voltage and collector-to-emitter voltage.
- Implementing a circuit and taking measurements of the I_C vs. V_{BE} and I_C vs. V_{CE} curves.
- Extracting values of β and V_A.

MATERIALS:

- Laboratory setup, including breadboard
- 1 NPN transistor (e.g., NTE2321)
- Several wires

PART 1: SIMULATION

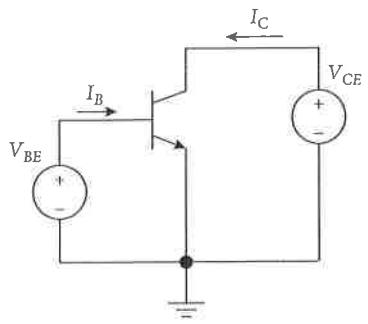

FIGURE L6.1: Transistor measurement circuit.

Consider the circuit in Figure L6.1. Enter the circuit into your simulator's schematic editor, applying DC voltage supplies to the base and collector of the transistor.

I_C vs. V_{BE}

While setting V_{CE} to a constant value of 5 V, sweep the base voltage from 0 V to 0.8 V in increments of 0.1 V. Plot a curve of I_C vs. V_{BE}. At what value of V_{BE} does

current begin to conduct? What are the values of I_B and I_C when $V_{BE} = 0.7$ V? Based on these numbers, what is your estimate of β?

I_C vs. V_{CE}

For three values of V_{BE} (0.6 V, 0.7 V, and 0.8 V), sweep the collector voltage from 0 V to 2 V in increments of 0.1 V. Plot the curves for I_C vs. V_{CE} onto a single graph, clearly indicating the value of V_{GS} next to each curve.

PART 2: MEASUREMENTS

Assemble the circuit from Figure L6.1, using a power supply to generate the DC voltages.

I_C vs. V_{BE}

While setting V_{CE} to a constant value of 5 V, sweep the base voltage from 0 V to 0.8 V in increments of 0.1 V, and measure the collector current using the power supply. (Note: not all power supplies allow you to accurately measure current; if this is the case for your lab setup, you may place a small resistor in series with the collector and measure the voltage drop across the resistor) Plot a curve of I_C vs. V_{BE}. At what value of V_{BE} does the current turn on? Using small resistors placed in series with the base and collector terminals, measure I_B and I_C for $V_{BE} = 0.7$ V? Based on these numbers, what is your estimate of β?

I_C vs. V_{CE}

For three values of V_{BE} (0.6 V, 0.7 V, and 0.8 V), sweep the V_{CE} from 0 V to 1 V in increments of 0.1 V, and measure the collector current using the power supply. Plot the curves for I_C vs. V_{CE} onto a single graph, clearly indicating the value of V_{BE} next to each curve.

PART 3: POST-MEASUREMENT EXERCISE

Simulation vs. measurement

What are the main differences between your simulated and measured curves? Can you explain the differences?

Early voltage, V_A

Based on your simulated I_C vs. V_{CE} curves for an active transistor, extract the Early voltage V_A. Does V_A change significantly for each value of V_{BE}? What is the average value of V_A?

PART 4 [OPTIONAL]: EXTRA EXPLORATION

If you have access to a semiconductor parameter analyzer, generate the I_C vs. V_{CE} curves using the analyzer. How do they compare to the curves you generated in Part 3? Re-extract values of β and V_A.