ENGR 305 – Lab #7

NPN at DC

OBJECTIVES:

To study DC biasing of an NPN bipolar transistor by:

- Completing the DC analysis of two circuits: (1) an NPN transistor that is biased in the active region and (2) an NPN transistor that is biased in the saturation region.
- Implementing the circuits in an experimental setting, taking measurements, and comparing their performance with theoretical and simulated results.
- Qualitatively seeing the impact of transistor-to-transistor variations.

MATERIALS:

- Laboratory setup, including breadboard
- 1 NPN transistor (2N3904)
- Several wires and resistors of varying sizes

PART 1: NPN IN ACTIVE MODE

Consider the circuit shown.

Design the circuit such that $I_C = 1\ mA$, $V_B = 0\ V$, and $V_C = +5V$. Use supplies of $V_+ = V_- = 15\ V$. Use $\beta = 100$.

Hand calculations

- Sketch the circuit in your lab book, clearly labeling the transistor's three terminals.
- What are I_B and I_E? Based on these numbers, what is V_E?
- You now have enough information to calculate R_E and R_C. Are the calculated values available in your kit? Can you achieve these values by combining several resistors? Comment.
- Derive the Thevenin equivalent circuit of R_1 and R_2. What values of R_1 and R_2 do you need to use to achieve $V_B = 0$? Is the problem completely specified? If not, what needs to be specified?

Prototyping and Measurement

- Assemble the circuit onto a breadboard.
- Using a digital multimeter, measure V_E, V_C, and V_B.
- Using a digital multimeter, measure all resistors to three significant figures.

Post-Measurement Exercise

- What are the measured values of V_{BE} and V_{CE}? How do they compare to your pre-lab calculations? Explain any discrepancies.
- Based on the measured values of V_C and V_E and your measured resistor values, what are the measured values of I_E, I_C and I_B based on your lab measurements?

PART 2: NPN IN SATURATION MODE

Redesign the circuit such that $I_C = 1\ mA$, $I_E = 1.2\ mA$, $V_C = +2V$, and $V_{CE} = 0.2\ V$. Use supplies of $V_+ = -V_- = 15\ V$. Note that you must use the saturation model.

Hand calculations

- Sketch the circuit in your lab book, clearly labeling the transistor's three terminals.
- Based on the specifications, calculate V_E and V_B.
- You now have enough information to calculate R_C and R_E. Are the calculated values available in your kit? Can you achieve this value by combining several resistors? Comment.
- What is β_{forced}?
- What values of R_1 and R_2 do you need to use? Is the problem completely specified?

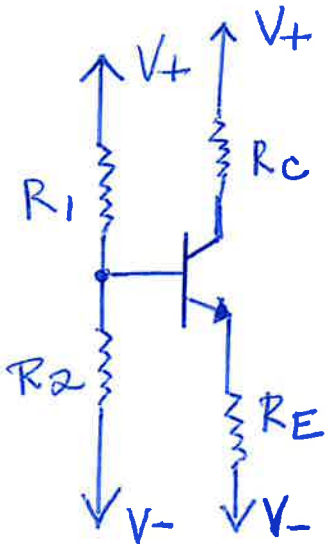
Prototyping and Measurement

- Assemble the circuit onto a breadboard.
- Using a digital multimeter, measure V_E, V_C, and V_B. Report them in your lab book.
- Using a digital multimeter, measure all resistors to three significant digits.

Post-Measurement Exercise

- What are the measured values of V_{BE} and V_{CE}? How do they compare to your pre-lab calculations? Explain any discrepancies.
- Based on the measured voltages and resistor values, what are the measured values of I_E, I_C and I_B based on your lab measurements? What is β_{forced}?

Part I and II (circuit)



Part 3: Diode-Connected NPN