ENGR 305 – Lab 8 (2 weeks)

PNP at DC (Formal report by group)

OBJECTIVES:

To study DC biasing of a PNP bipolar transistor by:

- Completing the DC analysis of three circuits: (1) a PNP transistor that is biased in the active region, (2) a PNP transistor that is biased in the saturation region, and (3) a diode-connected PNP transistor.
- Simulating circuits to compare the results with paper analysis.
- 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 PNP transistor (2N3906)
- Several wires and resistors of varying sizes

PART 1: PNP IN ACTIVE MODE

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

Hand calculations

- Sketch the circuit in your notes, 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 of R_1 and R_2. What values of R_1 and R_2 do you need to use to achieve $V_B = 0\ V$? Remember that $I_B \neq 0$. Is the problem completely specified?

Simulation

- Use the 2N3906 part from the pnp dropdown list.
- When you set up the simulation (Configure analysis), choose the *dc op pnt*.
- Simulate your circuit using values of $R_E, R_C, R_1\ and\ R_2$ based on your calculations.
- Report the values of $V_E, V_C, V_B, I_E, I_C\ and\ I_B$. How closely do they match your calculations? (Remember: The simulator has its own, more complex model of the real transistor, so there should be some small variations.)

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 $V_{EB}\ and\ V_{EC}$? How do they compare to your pre-lab calculations? Explain any discrepancies.
- Based on 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: PNP IN SATURATION MODE

Redesign the circuit (same circuit as Part I) such that $I_C = 1\ mA, I_E = 1.2\ mA, V_C = -2V, and\ V_{EC} = 0.2V$. Use voltage 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 $R_E\ and\ R_C$. Are the calculated values available? 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?

Simulation

- Use the 2N3906 part from the pnp dropdown list.
- When you set up the simulation (Configure analysis), choose the *dc op pnt*.
- Simulate your circuit using values of $R_E, R_C, R_1\ and\ R_2$ based on your calculations.
- Report the values of $V_E, V_C, V_B, I_E, I_C\ and\ I_B$. How closely do they match your calculations?

Prototyping and Measurement

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

Post-Measurement Exercise

- What are the measured values of $V_{EB}\ and\ V_{EC}$? 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? What is β_{forced}?

PART 3: DIODE-CONNECTED PNP

Consider the circuit for this part. Design the circuit such that $I_C = 1\ mA\ and\ R_E = 15\ k\Omega$. 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 is the operating region of the transistor? Calculate V_C.
- You now have enough information to calculate R_C. Is the calculated value available in your kit? Can you achieve this by combining resistors? Comment.

Simulation

- Simulate your circuit using the value of R_C based on your calculations.
- Report the values of $V_E, V_C, I_E, I_C\ and\ I_B$. How closely do they match your calculations?

Prototyping and Measurement

- Assemble the circuit onto a breadboard.
- Using a digital multimeter, measure $V_E\ and\ V_C$. Report the values.
- Using a digital multimeter, measure all resistors to three significant digits.

Post-Measurement Exercise

- How do the measured values 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?