EE 220/220L Circuits I (Fall 2019)
Laboratory 5 Mesh Analysis

Background

The goals of this lab are to analyze the DC operation of an npn bipolar junction transistor (BJT) in the **active** mode and experimentally verify the results for the circuit shown in Figure 1. For analysis, assume that $V_{CC} = 17.8$ V, $R_1 = 39$ kΩ, $R_2 = 5.6$ kΩ, $R_C = 680$ Ω, & $R_E = 130$ Ω with a transistor where $\beta = 190$ and $V_{BE} = 0.67$ V. Datasheet(s) with information on the Fairchild PN2222A transistors used is available on the course web page (purchased 2009-2013).

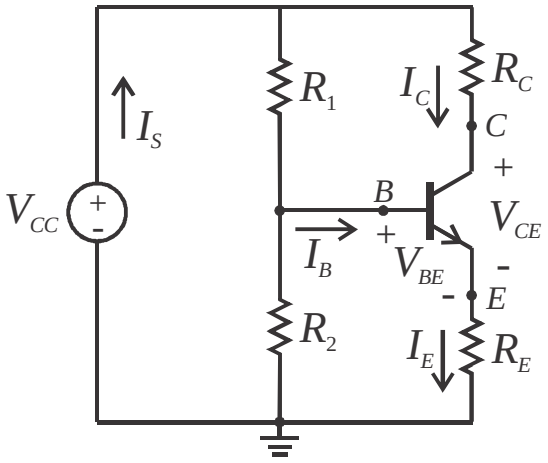

Figure 1 Transistor Circuit

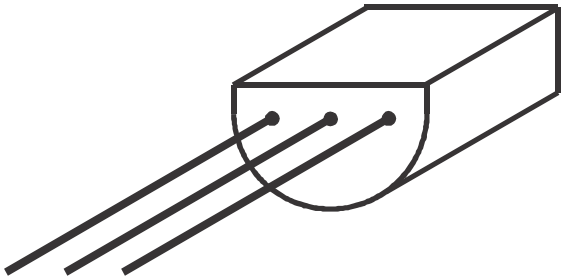

Figure 2 PN2222A Transistor TO-92 Package

Preliminary

1) Using transistor datasheet(s) (insert relevant parts in logbook), label the transistor leads in Figure 2 (e.g., *B*, *C*, & *E*). Then, insert information/graphs on absolute maximum ratings, DC current gain h_{FE} (AKA: β), and V_{BE} for the **active** (AKA: on) mode, **NOT** saturation or cut-off modes.
2) Using the equivalent circuit model for the transistor (see section 3.9 in the text), analyze the transistor circuit shown in Figure 1 using **mesh analysis** to find the mesh currents I_S, I_C, & I_E. Also, calculate the base current I_B, collector voltage V_C, emitter voltage V_E, base voltage V_B, and collector-emitter voltage V_{CE}. [Note: **Do NOT** rename variables.]
3) Using the values calculated in part 2, mark and read off the expected value of V_{BE} on the datasheet excerpts of part 1. Does the datasheet agree with the given V_{BE} value? Do the values calculated in part 2 correspond to one of the DC current gain conditions? If so, mark which one.
4) Calculate the power absorbed by each circuit component. (Hint: To find the amount of power absorbed by the transistor P_Q, calculate $|P_{source}|$ and subtract powers dissipated by the resistors.)

SHOW ALL WORK IN LOGBOOK!

5) Have the lab instructor or TA sign-off on your preliminary before you begin the experiment.

Experiment

1) Using a digital multimeter (DMM), measure and record actual value of each resistor. Also, measure β_{DMM} (AKA: h_{FE}) for the BJT using the DMM (see upper righthand corner on front).
2) Build the circuit on a breadboard. Measure and record the currents I_S, I_C, I_E, & I_B and the voltages V_{BE}, V_{CE}, V_E, V_C, V_B, & V_{CC}. [Note: Due to measurement error, it is possible to measure $I_C > I_E$.]
3) Have the lab instructor or a TA sign-off on your data before you tear down the circuit.

Analysis and Conclusions

- Use experimental data to calculate the actual $\beta_{meas} = I_C / I_B$ and power absorbed by each circuit component.
- Prepare a neat table in your logbook to compare the calculated/nominal resistor values, source voltage, voltages, currents, β (include both β_{DMM} and β_{meas} on separate lines), and powers to those measured. Put the variable name/label in first column, calculated/nominal values in second column, measured values in third column, and percent difference between the calculated/nominal and measured values in fourth column.
- Analyze the data and discuss the results. Explain differences from calculated/predicted values.
- Why might β_{DMM} be different from β_{meas}?