# EECE 2412 – Homework 5 – Fall 2016

Due: Wednesday, October 26, 2016

1) Find the hole concentration and free-electron concentration of silicon at 300K if the following doping concentrations are used during the fabrication:
   a. An acceptor concentration of $10^{16}$ cm$^{-3}$, and a donor concentration of $10^{18}$ cm$^{-3}$.
   b. An acceptor concentration of $10^{17}$ cm$^{-3}$, and a donor concentration of $10^{17}$ cm$^{-3}$.

2) Problem 4.10 on page 280 in the textbook (Allan R. Hambley, Electronics, 2$^{nd}$ edition).

3) Problem 4.34 on page 282 in the textbook.

4) Measurements of the circuit below produced the labeled voltage values. Calculate the transistor's value of β.
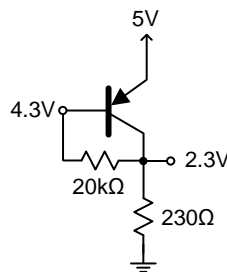


5) Setup the test circuit below in PSPICE. Notice that one of the BJT models is Qbreakn and the other one is Q2N2222.
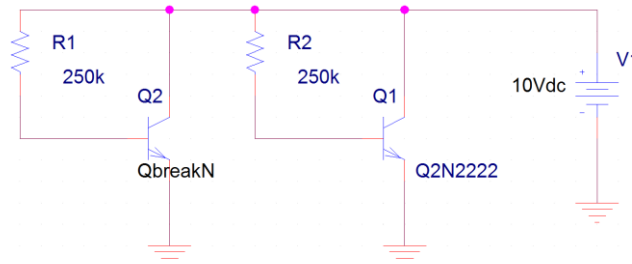


   a. Setup a DC bias point analysis and place a check mark next to "Include detailed bias point information…" in the output file options of the simulation settings (analysis) window. Run a simulation to determine the values of $I_C$ and $I_B$ for the 2N2222 transistor. Show the calculation and value of $\beta_{DC}$ for the 2N2222 transistor in your submitted assignment.
   b. Select the Qbreakn transistor in the schematic and choose "edit → PSPICE model" in the menu on the top. To specify a β value of 150, change the statement in the first line to:
      .model Qbreakn NPN BF=150
      Save the model entry and rerun the DC bias point simulation. Make sure that all voltages and currents are labeled before printing out the schematic for submission. Calculate $\beta_{DC}$ for the Qbreakn transistor and provide the value.
   c. Switch to the simulation output window (in which you usually plot results). Choose "View → output file" in the menu on the top. Scroll down to the BJT model parameters and verify that BF is 150 for the Qbreakn device. What is BF in the Q2N2222 model? Scroll down further to find the operating point information, which will be saved when the option is selected as described in part a). Notice that you can find a lot of relevant information in this list, such as $V_{BE}$, $g_m$, $f_t$, RO (= $r_{ce}$), RPI (= $r_\pi$). You can use these DC operating point and small-signal parameters when you want to perform accurate hand calculations. There are two parameters

for β in the list: BETADC represents the DC current gain, and BETAAC represents the AC current gain. What are these two parameters for the 2N2222 BJT under the simulated DC bias conditions? Print out the output file and highlight BF, BETAAC, and BETADC for the 2N2222 transistor.

d.  Find a datasheet on the internet for a 2N2222 transistor from any manufacturer. Print out the page that that reports the DC current gain (β) for the BJT. Highlight the case (value of β) that is the most appropriate estimate under the given DC bias conditions in the example circuit. Is your simulation result close to this value?