Homework # 5

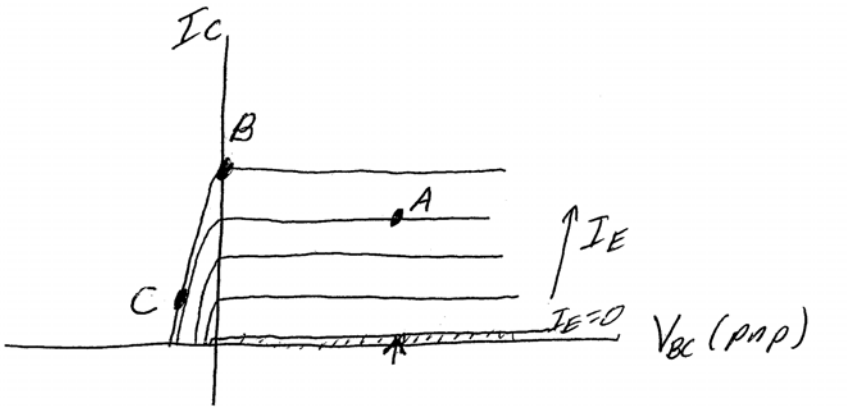
EE 3161 - Spring 2008

Due Friday, April 11 in class

1) Problem 10.4 of Pierret. Also, resketch the energy band diagram for each of the four possible bias modes.

2) Problem 11.2 of Pierret.

3) The I-V characteristics for a pnp transistor in the common base configuration are shown below. At each of the operating points A, B, and C, sketch the minority carrier concentrations in the base vs. *x*. (Assume W << L_p.) Be sure to include the equilibrium concentration as a reference.



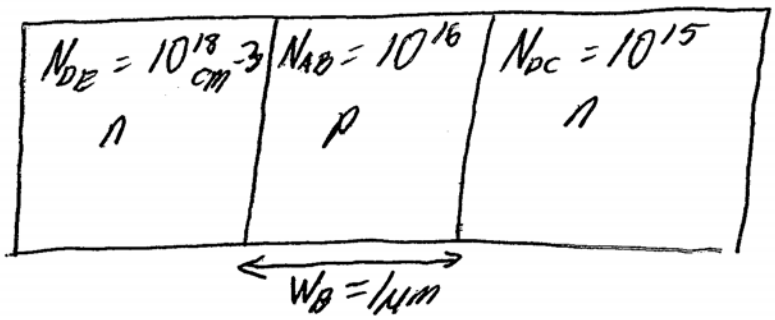
4) A npn silicon BJT is drawn below. (τ_n and τ_p = 1μs.)

a) What is the effective base width?

b) What are I_{Ep}, I_{En}, I_{Cp}, and I_{Cn} for V_{BE} = 0.5V and V_{BC} = -5V?

c) Including base recombination, what are the emitter injection efficiency, base transport factor, and β at the same voltages?

d) If the length of the emitter was reduced to 0.3μm, how would the equation for I_{Ep} change? Would this increase or decrease β?



continued on next page

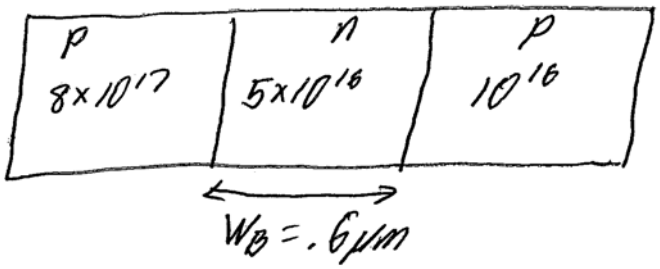
5) Consider the bipolar transistor below. The width of the n-region is 0.6 microns (depletion regions have not been included in this width). The area of the transistor is $1cm^2$.

a) For $V_{EB} = 0.5V$ and $V_{EB} = 0.8V$, plot $\log(I_C)$ vs. V_{EC} for $V_{EC} < 0$ (assume I_C is ideal; ignore base width modulation, i.e. use V_{bi} to calculate W).

b) For the conditions in part a), but now including base recombination, and assuming that $V_{EC} < -1V$, what is I_B?

c) For the case $V_{EB} = 0.8V$, and now taking base width modulation into account, replot I_C vs. V_{EC}. What is the Early voltage? (Let $V_{EC} < -1V$.)

d) Let $V_{EB} = 0.5V$. At what VEC does punchthrough (base totally depleted) occur?



6) [*Problem 1, midterm exam #2, spring 2007*]

Consider the silicon BJT in the diagram below, biased as shown. The total cross-sectional area of the device is $2mm^2$ and the base width is 3μm. Note that the top is split into two regions, each $1mm^2$ in area. The recombination times in all regions of the device are 0.1μs.

a) Sketch a band diagram for the device for $V_x = -0.5V$ and $V_z = 5V$. Calculate the position of E_f where relevant. Is the band diagram relevant for both of the top sections?

b) Write expressions for the currents I_x and I_z. Drop terms that are unimportant, but be sure to state what you are doing. Calculate I_z numerically.

c) What are the emitter injection efficiency, base transport factor, and beta?

d) If the device is used as a digital switch, estimate the rise time if I_z is the same as calculated previously and the base current is 5% of that.

e) Near what V_z does transistor breakdown current become a significant contribution to (e.g. 10% of) I_z? Is it ever a significant contribution to the base current? Why or why not?