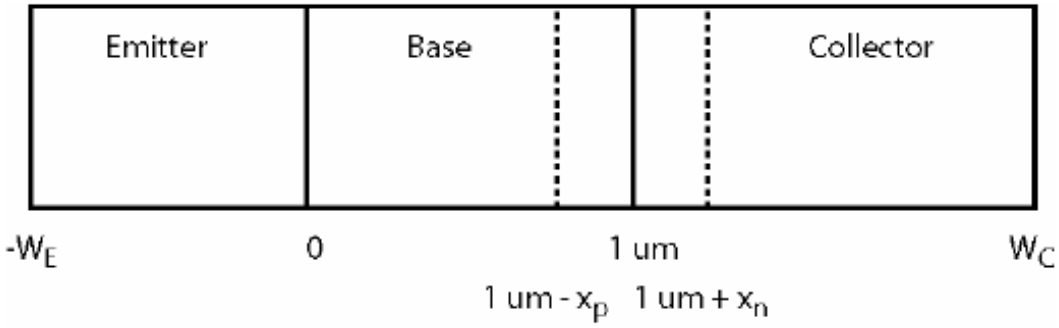
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Electrical Engineering and Computer Science

6.012 Microelectronic Devices and Circuits
Homework #6

Problem 1

You are given an npn bipolar transistor which has uniform doping concentrations $N_{dE} = 10^{19}$ cm^{-3} $N_{aB} = 10^{17}$ cm^{-3} $N_{dC} = 10^{16}$ cm^{-3}. Assume the base width is 1 μm from the B-E junction to the B-C junction. The area of the emitter and collector is 10^{-6} cm^2, $\mu_n = 1000$ cm^2/V-sec, $\mu_p = 500$ cm^2/V-sec. Ignore the depletion region width of forward biased junctions.



a) Given $V_{BE} = 0.66$V and $V_{BC} = -3$V sketch the minority carrier concentration vs. x in all three regions of the device.

b) Calculate x_n and x_p at the base-collector junction.

c) Find the emitter width W_E such that $\beta_F = 200$.

d) Find the collector width W_C such that $\beta_R = 5$.

e) Calculate I_S

Problem 2

You are given the npn transistor with the parameters and operating point from Problem 1 above, with the additional information that $V_{an} = 20V$.

a) Find the transconductance, g_m

b) Find the input resistance, r_π

c) Find the output resistance r_o

d) What is the minority electron storage Q_{NB}?

e) Find C_π

f) At what frequency does $|1/j\omega C_\pi| = r_\pi$?

Problem 3

Silicon-Germanium bipolar transistors were developed in the late 1980's to improve the current gain β_F over that of conventional silicon transistors. When the emitter is made of this material we can assume that the intrinsic carrier concentration in the emitter is reduced to10^9 cm^{-3}. This transistor is biased in the forward active region and has a collector current $I_C = 100\mu A$. Use the same dimensions and doping concentrations as Problem 1 for this problem.

a) Calculate the new V_{BE} such that $I_C = 10\mu A$
b) Find the forward active current gain, β_F.
c) Determine the base doping level that will yield the same value of β_F as the transistor would have if its emitter were silicon instead of SiGe?

Problem 4

Howe and Sodini P7.6

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Spring 2009