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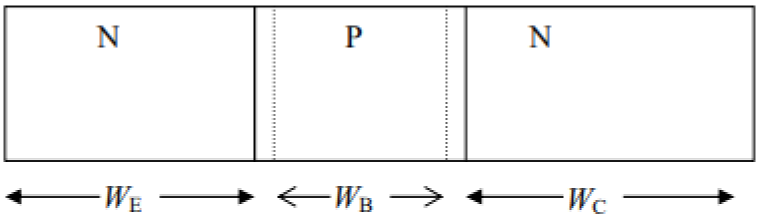
Microelectronics HW8

Reading List: Chapter 10, Chapter 11 (pages 389 - 403)
Consider an npn transistor with doping concentration and dimensions shown below. Answer the following questions.
Area A = 1 cm2



	Emitter	Base	Collector
Doping conc. (cm-3)	5×1018	1016	5×1018
W (μm)	10	2	10
Lifetimes (s)	10-9	10-7	10-9
Elect. mobility (cm2 /Vs)	120	1000	120
Hole mobility (cm2 /Vs)	75	300	75

A. a. If VBC = 0, and IC = 1 mA, what is value of VBE?

IC=q A DB nB0 / WB * e^(VBE q/kT)
DB=mu_nB kT/q = 25.9 cm^2/s
nB0=10^20 / 10^16 = 10^4 cm^-3
VBE=0.398

B. b. With the transistor biased as in (a), what is the component of the base current due to recombination in the base region?

IBR=q A WB / 2 TB * nB0 e^(VBE q/kT) = 7.54x10^-6 A

C. c. With the transistor biased as in (a), what is the component of the base current due to injection of holes into the emitter region?

IBE=q A DE / LE * pE0 e^(VBE q/kT)
DE=75 * .0259 = 1.94 cm^2/s
pE0=10^20/(5x10^18)=20cm^-3
LE=1.94 10^-9=4.4x10^-5
IBE=0.664uA

D. d. What is the value of the emitter injection efficiency, γ?

IEN=IC+IBR=10^-3 + 7.54x10^-6
IEP=IBE=0.664x10^-6
gamma=IEN/(IEN+IEP)=0.9993

E. e. What is the value of the base transport factor, αT?

alphaT=IC/(IC+IBR)=10^-3/(10^-3+7.54x10^-6)0.9925

F. f. What is the value of the common emitter current gain, βdc?

beta_dc=IC/IB=10^-3/(7.54x10^-6+0.664x10^-6)=121

G. g. If VBE is held constant at the value found in (a), and the collector-to-base voltage is increased so as to reduce the width of the neutral base region, WB, to 10-4 cm, what is the common emitter current gain, βdc now? Note that this is called “base width modulation” (also called “Early effect”) which is common in narrow base-width transistors.

IBR=q A WB / 2 TB * nB0 e^(VBE q/kT) = .5 * 7.54x10^-6 A = 3.77x10^-6 A

IC up to 2mA

beta_dc=2x10^-3/(0.664*10^-6+3.77x10^-6)=451