ECE 132 Fall 2018

# UNIVERSITY OF CALIFORNIA, SANTA BARBARA

Department of Electrical and Computer Engineering

## Homework 5 – due December 7, 2018 by 5:00pm

1. A Si *n*-*p*-*n* BJT has emitter, base and collector doping levels of $10^{19}$ cm$^{-3}$, 5x$10^{18}$ cm$^{-3}$, and $10^{17}$ cm$^{-3}$, respectively. It is biased in the normal active mode, with a base-emitter voltage $V_{BE} = 1V$ and a collector-emitter voltage $V_{CE} = 4V$. During operation, the current through the device causes is to heat up to 400 K, such that $n_i = 10^{12}$ cm$^{-3}$, and $\varepsilon_r = 15$. Assume electron and hole mobilities of 500 and 100 cm$^2$/V-s, respectively, in the emitter, and 800 and 250 cm$^2$/V-s, respectively, in the base. Assume the minority carrier lifetimes are 1 ns everywhere. If the neutral base width is 500 nm and the neutral emitter is 3 μm wide, calculate the emitter current density $J_E$, the emitter injection efficiency $\gamma$, and the base transport factor $\alpha_T$. Qualitatively sketch the device structure showing the minority carrier concentrations in the emitter and the base, and sketch the band diagram under bias below it.

2. Problem 7.20 in Streetman.

3. For the BJT in the previous problem, calculate $\gamma$, $\alpha_T$, $\beta$, $I_E$, $I_B$, and $I_C$ for the two values of $V_{EB}$.

4. Reading Assignment: *Streetman*: Ch. 7 (sections 7.1-7.2 and 7.4-7.6)