Recitation 9  
EE 3161 – Spring 2008

1) For the silicon pnp bipolar transistor shown below, what are $\alpha_T$ and $\beta$ if we include base recombination? If $V_{EB} = 0$, at what $V_{CB}$ does the transistor reach a punchthrough condition (base region fully depleted)? How does this compare to the open base breakdown voltage? (Let $m=4$.)

![Transistor Diagram]

$p^+: N_a = 5 \times 10^{17} \text{ cm}^{-3}$

$n: N_d = 3 \times 10^{16} \text{ cm}^{-3}$

$p: N_a = 6 \times 10^{15} \text{ cm}^{-3}$

$\tau_E = \tau_B = \tau_C = 1 \mu s$

$A = 1 \text{ cm}^2$

2) We have a transistor in the common emitter configuration and:
   i.) the base recombination time, $\tau_B = 0.1 \mu s$
   ii.) the base transit time, $\tau_t = 1 \text{ ns}$
   iii.) the base current in the ‘ON’ state, $I_{B on} = 1.0 \text{ mA}$
   iv.) The collector current in saturation, $I_{C sat} = 10.0 \text{ mA}$

If we apply $I_{B on}$ to the transistor in cutoff, what is the rise time for this device? What is the switching delay for the device to switch from ‘ON’ to ‘OFF’ if we switch $I_B$ from $I_{B on}$ to 0? What about from $I_{B on}$ to $-I_{B on}$?