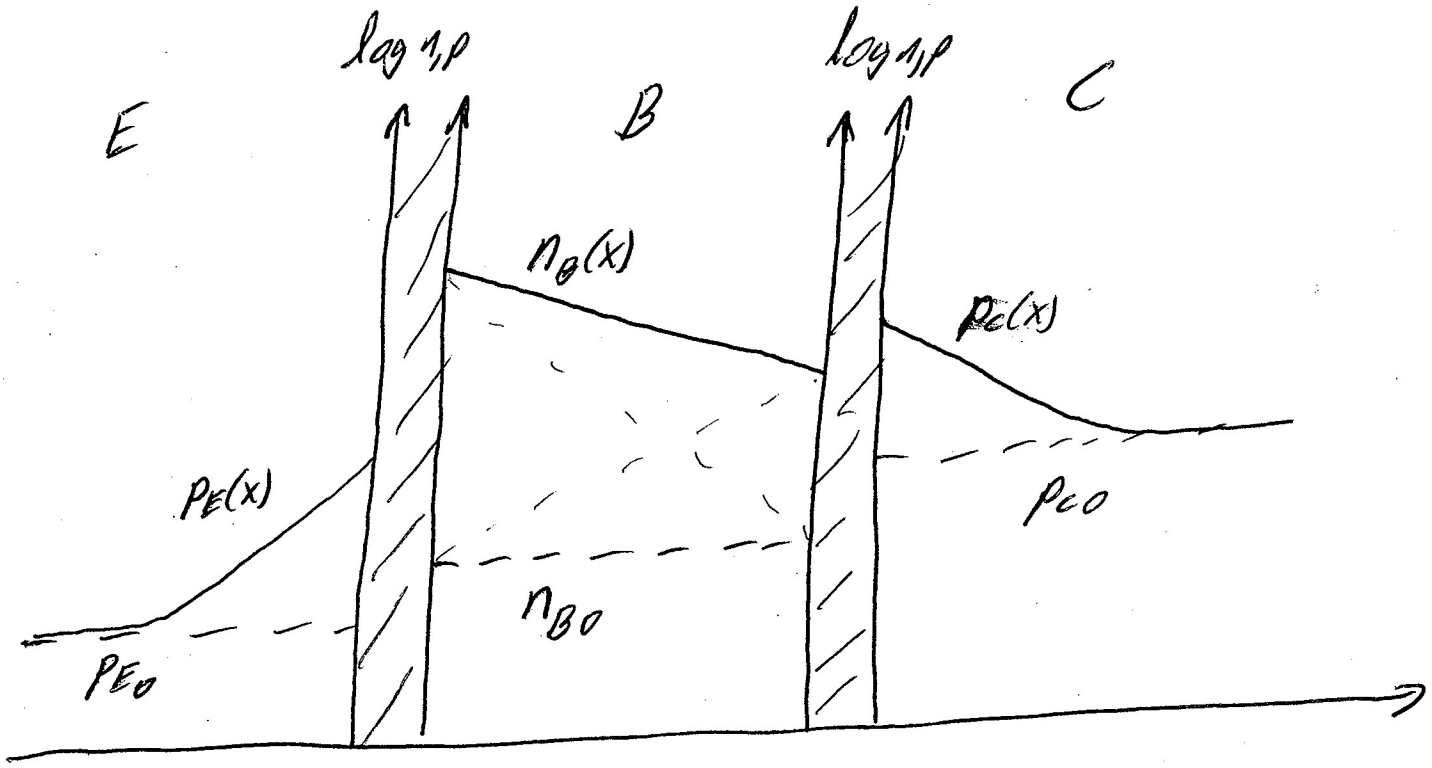
1. a.) Forward Active EB fwd. bias
CB rev. bias

b.) Cutoff both junctions rev. bias

Saturation



(2) Preliminaries

$$D_E = \frac{kT}{q}\mu_n(N_E = 5\times10^{17}) = (.026)(420\ \tfrac{cm^2}{V\text{-}s})$$

$$\underline{D_E = 10.9\ \tfrac{cm^2}{s}}$$

$$D_B = \frac{kT}{q}\mu_p(3\times10^{16}) = (.026)(350\ \tfrac{cm^2}{V\text{-}s})$$

$$\underline{D_B = 9.1\ \tfrac{cm^2}{s}}$$

$$D_C = \frac{kT}{q}\mu_n(6\times10^{15}) = (.026)(1290\ \tfrac{cm^2}{V\text{-}s})$$

$$\underline{D_C = 33.5\ \tfrac{cm^2}{s}}$$

$$\underline{L_E = \sqrt{D_E\tau_E} = 14.8\ \mu m} \qquad \underline{L_B = 13.5\ \mu m}$$

$$\underline{L_C = 58\ \mu m}$$

What is W?

$$W = W_B - x_{nE} - x_{nC}$$

$V_{EB} = .3V$

$$x_{nE} = \sqrt{\frac{2\epsilon}{q}(V_{bi} - V_a)\frac{N_a}{N_d(N_a + N_d)}}$$

$$V_{bi} = \frac{kT}{q}\ln\frac{N_aN_d}{n_i^2} = .84$$

$$\underline{x_{nE} = .15\ \mu m}$$

$V_{CB} = -3V$

$$x_{nc} = \sqrt{\frac{2\epsilon}{q}(V_{bi} - V_a)\frac{N_a}{N_d(N_a + N_d)}}$$

$$V_{bi} = \frac{kT}{q}\ln\frac{N_a N_d}{n_i^2} = .73$$

$$x_{nc} = .16\,\mu m$$

$$W = 1.6\,\mu m - .15\,\mu m - .16\,\mu m$$

$$\underline{W = 1.29\,\mu m}$$

In forward active

$$I_E \approx qn_i^2 A\left(\frac{D_E}{L_E N_E} + \frac{D_B}{W N_B}\right)e^{qV_{EB}/kT}$$

The emitter injection efficiency

$$\gamma = \frac{I_{Ep}}{I_{En} + I_{Ep}}$$

$$\gamma = \frac{\frac{D_B}{W N_B}}{\frac{D_E}{L_E N_E} + \frac{D_B}{W N_B}} = .994$$

α_T = base transport factor

$\alpha_T = 1$ in absence of base recombination

$\alpha_T = 1 - \frac{W^2}{2L_B^2}$ → with base recombination

$\alpha_T = .995$

$\beta = \frac{\alpha_T \gamma}{1 - \alpha_T \gamma} = 142$ with no base recombination

$\beta = 83$ with base recombination

Inverse active: use same W

$$\gamma = \frac{\frac{D_B}{W N_B}}{\frac{D_C}{L_C N_C} + \frac{D_B}{W N_B}} = .71$$

$\alpha_T = 1$ with no base recombination

$\beta = 2.45$

The primary reason that γ & β have changed is due to the doping differences between the emitter & collector.

Since the $N_{Ep} >> N_{Bn}$ hole current dominates the forward biased EB junction. However, since $N_{Cp} << N_{Bn}$, electron current is much more important & thus offsets the contribution due to the small size of the base.