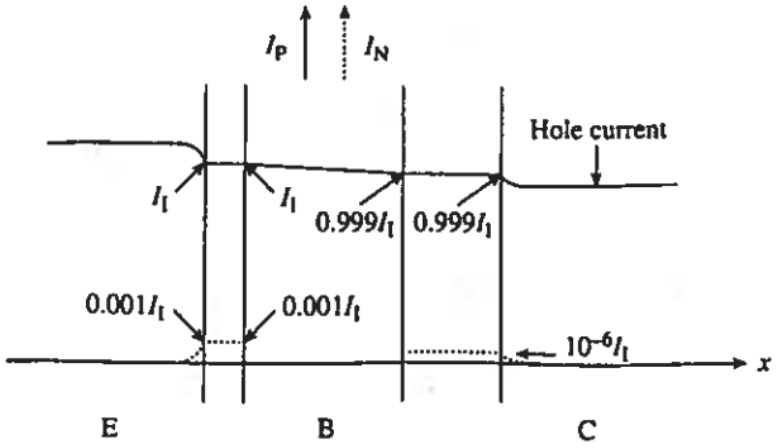
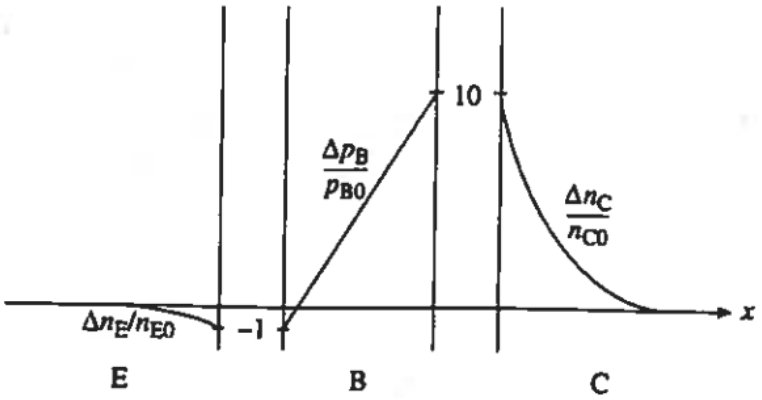
Notice: The assignments are open-book and everyone is free to discuss homework with each other. But the homework you submit must be your own.
Please finish the homework before the deadline, then convert it into a PDF document, and finally submit it through the ISPACE system. The home work should be written in English.

Assignments-3-BJT

1. A Si NPN BJT with $N_E=10^{18}$ cm^{-3}, $N_B=10^{16}$ cm^{-3}, $N_C=10^{15}$ cm^{-3}, and $W_B=2$ μm is maintained under equilibrium conditions at room temperature.
   (1) Sketch the energy band diagram for the device, properly positioning the Fermi level in the three regions.
   (2) Sketch the electrostatic potential (setting V=0 in the emitter region), the electric field, and the charge density as a function of position inside the BJT.
   (3) Calculate the net potential difference between the collector and emitter V_{CE}.
   (4) Determine the quasi-neutral width of the base.
   (5) Calculate the maximum magnitude of the electric fields in the E-B and C-B depletion regions.
2. Given a NPN BJT where I_{En}=100 μA, I_{Ep}=1 μA, I_{Cn}=99 μA, and I_{Cp}=0.1 μA, calculate:
   (1) α_T;
   (2) γ;
   (3) I_E, I_C, I_B;
   (4) α_{DC} and β_{DC};
   (5) I_{CB0} and I_{CE0};
   (6) If I_{Cn} is increased to a value closer to 100 μA while all other current components remain fixed. What effect does the I_{Cn} increase have on β_{DC}? Explain your answer.
   (7) If I_{Ep} is increased while all other current components remain fixed. What effect does the I_{Ep} increase have on β_{DC}? Explain your answer.
3. The electron and hole currents inside a PNP BJT biased in the forward active mode are plotted in the following figure. All the currents are referenced to I_1, which is the hole current injected into the base. Determine:
   (1) γ;
   (2) α_T;
   (3) β_{DC};
   (4) I_B;
   (5) For the given transistor, is the R-G current arising from the depletion regions negligible as assumed in the ideal transistor analysis? Explain your answer.



4. The $\Delta n_E/n_{E0}$, $\Delta p_B/p_{B0}$, and $\Delta n_C/n_{C0}$ distributions in the quasi-neutral regions of a PNP BJT are as sketched in the following figure. Determine:
   (1) The polarity of V_{EB};
   (2) The polarity of V_{CB};
   (3) The magnitude of V_{CB};
   (4) The working mode of this PNP BJT.



5. Two Si NPN BJTs, #1 and #2, are identical except $W_{B1}>W_{B2}$. Besides, $N_E>>N_B>N_C$, and $W<<L_B$ in both transistors. Under the same forward active mode, which BJT will exhibit:
   (1) the larger emitter efficiency γ? Explain your answer.
   (2) the larger base transport factor α_T? Explain your answer.
   (3) the larger β_{DC}? Explain your answer.
   (4) the greater sensitivity to base width modulation effect? Explain your answer.
   (5) the larger punch-through voltage? Explain your answer.
   If the maximum output current is assumed to be limited by carrier multiplication and avalanching, which BJT will exhibit:
   (6) the larger V_{CB0}? Explain your answer.
   (7) the larger V_{CE0}? Explain your answer.

6. A Si PNP BJT with each region uniformly doped. The excess minority distribution in each region is shown in the following figure (the depletion regions are not shown). The R-G current in depletion regions are negligible. D_E=30 cm^2/s, D_B=10 cm^2/s, N_E=10^{18} cm^{-3}, A_E=10^{-5} cm^2.

(1) Which mode does this BJT work at? Explain your answer.

(2) Determine the N_C.

(3) Determine the stored minority charges in base region Q_B.

(4) Determine the I_E.

(5) If the base width modulation effect is negligible, determine the β_{DC} when this BJT works at the forward active mode.