EEG 808 Electronic Devices, Modelling and Circuit Simulation

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Tutorial 1

Question 1

An Si *npn* transistor at 300 K has an area of 1 mm^2, base width of 1.0 μm, and doping of $N_{de} = 10^{18}$ cm^{-3}, N_{ab} = 1017 cm^{-3}, $N_{dc} = 10^{16}$ cm^{-3}. The minority carrier lifetimes are $\tau_E = 10^{-7} = \tau_B$; $\tau_C = 10^{-6}$ s. Calculate the collector current in the active mode for (a) V_{BE} = 0.5 V, (b) I_E = 2.5 mA, and (c) I_B = 5 μA. The base diffusion coefficient is D_b = 20 cm^2s^{-1}.

Question 2

An *npn* silicon transistor is operated in the inverse active mode (i.e., collector-base is forward biased and emitter base is reverse biased). The doping concentrations are $N_{de} = 10^{18}$ cm^{-3}; $N_{ab} = 10^{17}$ cm^{-3}, and $N_{dc} = 10^{16}$ cm^{-3}. The voltages are V_{BE} = −2 V, V_{BC} = 0.6 V. Calculate and plot the minority carrier distribution in the device. Also calculate the current in the collector and the emitter. The device parameters are: W_b = 1.0 μm, $\tau_E = \tau_B = \tau_C = 10^{-7}$s, D_b = 20 cm^2s^{-1}, D_e =10 cm^2s^{-1}, D_c = 25 cm^2s^{-1}, A = 1 mm^2.

Question 3

The V_{CE}(sat) of an *npn* transistor decreases as the base current increases for a fixed collector current. In the Ebers-Moll model, assume α_F = 0.995, α_R = 0.1, and I_C = 1.0 mA. At 300 K, at what base current is the V_{CE}(sat) value equal to (a) 0.2 V, (b) 0.1 V?

Question 4

Consider a npn Si-BJT at 300 K with the following parameters:

Nde = 10^{18} cm^{-3}
Nab = 10^{17} cm^{-3}
Ndc =10^{16} cm^{-3}
Db = 30.0 cm^2s^{-1}
Lb = 10.0μm
Wb = 1.0μm
De = 10cm^2s^{-1}
Le = 10.0μm
emitter thickness = 1.0 μm
device area =4.0 × 10^{-6} cm

(a) Calculate the emitter efficiency and gain β when the EBJ is forward biased at 1.0 V and the BCJ is reverse biased at 5.0 V. (b) Calculate the output conductance of the device defined by