The final exam of " Introduction to Electronics" on 29.05.2020

In the final exam we have only 6 questions similar to the following:

Student's name:

Student's ID No:

1. A junction employs $N_D = 5 \times 10^{17}$ cm^{-3} and $N_A = 4 \times 10^{16}$ cm^{-3}.

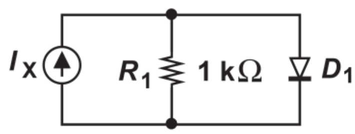
(a) Determine the majority and minority carrier concentrations on both sides.

(b) Calculate the built-in potential at T = 300 K.

(c) Determine the junction capacitance per unit area.

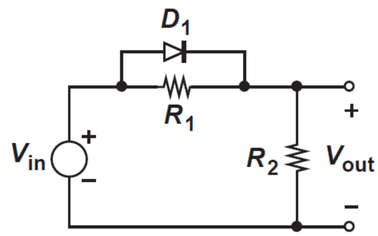
2. For what value of I_X in Fig. p1, does R_1 carry a current equal to $I_X/2$? Assume $I_S = 3 \times 10^{-16}$ A.

Fig. p1



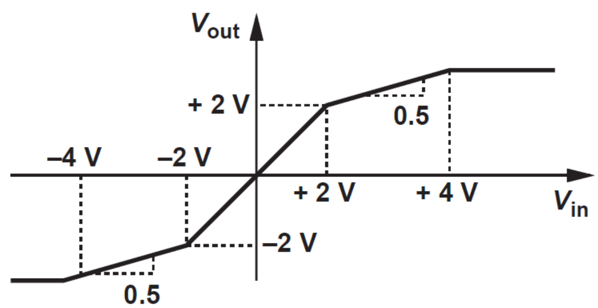
3. Plot the input/output characteristic of the circuits illustrated in Fig. p3 assuming a constant-voltage model.

Fig. p3



4. “Wave-shaping” applications require the input/output characteristic illustrated in Fig. p4. Using ideal diodes and other components, construct a circuit that provides such a characteristic. (The value of resistors is not unique).

Fig. p4



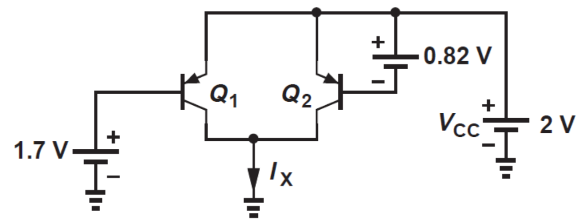
5. A fictitious bipolar transistor exhibits the following relationship between its base and collector currents:

$$I_C = aI_B^2$$

where $\boldsymbol{a}$ is a constant coefficient. Construct the small-signal model of the device if I_C is still equal to $I_S \exp(V_{BE}/V_T)$.

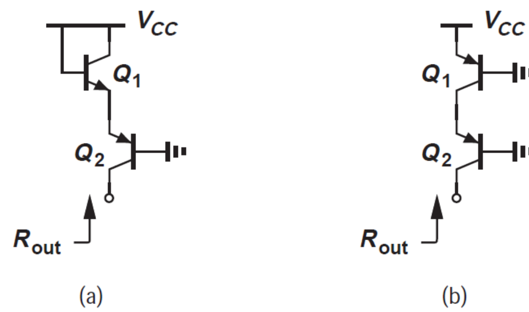
6. If $I_{S1} = 3I_{S2} = 6 \times 10^{-16}$ A, calculate I_X in Fig. p6.

Fig. p6



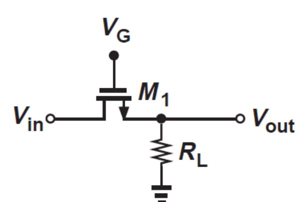
7. Using a small-signal equivalent circuit, compute the output impedances of the stages in Fig. p7 with $V_A < \infty$. Assume $\beta >> 1$.

Fig. p7



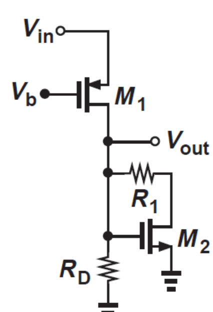
8. In the circuit of Fig. p8, M_1 serves as an electronic switch. If $V_{in} \approx 0$, determine W/L such that the circuit attenuates the signal by only 5%. Assume $V_G = 1.8$ V and $R_L = 100\ \Omega$.

Fig. p8



9. Construct the small-signal model for the circuit shown in Fig. p9 if all of the transistors operate in saturation and $\lambda \neq 0$.

Fig. p9



Wish you full success!

$\varepsilon_{Si}=\varepsilon r\ (Si) \times \varepsilon_0=11.7\times 8.85\times 10^{-12}$ F/m, k= 1.38×10^{-23} J/K, $D_n = 34\ \mathrm{cm^2/s}$, $D_p = 12\ \mathrm{cm^2/s}$,

$$I_{tot} = I_s(\exp\frac{V_F}{V_T} - 1) \qquad\qquad I_s = Aqn_i^{\ 2}(\frac{D_n}{N_A L_n} + \frac{D_p}{N_D L_p})$$

$$V_0 = \frac{kT}{q}\ln\frac{N_A N_D}{n_i^2}.$$

$$C_j = \frac{C_{j0}}{\sqrt{1 - \frac{V_R}{V_0}}}, \qquad C_{j0} = \sqrt{\frac{\epsilon_{si} q}{2}\frac{N_A N_D}{N_A + N_D}\frac{1}{V_0}}, \qquad\qquad \frac{D}{\mu} = \frac{kT}{q}.$$

$$J_{tot} = q(\mu_n n + \mu_p p)E \qquad\qquad J_{tot} = q(D_n dn/dx - D_p dp/dx)$$

$$V_R \approx \frac{V_p - V_{D,on}}{R_L}\cdot\frac{T_{in}}{C_1} \approx \frac{V_p - V_{D,on}}{R_L C_1 f_{in}},$$

$$I_p \approx C_1\omega_{in}V_p\sqrt{\frac{2V_R}{V_p}} + \frac{V_p}{R_L} \approx \frac{V_p}{R_L}(R_L C_1 \omega_{in}\sqrt{\frac{2V_R}{V_p}} + 1)$$

$$I_C = \frac{A_E q D_n n_i^2}{N_E W_B}\left(\exp\frac{V_{BE}}{V_T} - 1\right)$$

$$I_C = I_S\exp\frac{V_{BE}}{V_T}$$

$$I_S = \frac{A_E q D_n n_i^2}{N_E W_B} \qquad\qquad r_O = \frac{V_A}{I_C}$$

$$V_{TH} = V_{TH0} + \rho\left(\sqrt{2\phi_F + V_{SB}} - \sqrt{2\phi_F}\right)$$

$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}\left[2(V_{GS} - V_{TH})V_{DS} - V_{DS}^2\right]$$

$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS} - V_{TH})^2(1 + \lambda V_{DS}), \qquad\qquad r_O = \frac{1}{\lambda I_D}$$

$$R_{on} = \frac{1}{\mu_n C_{ox}\frac{W}{L}(V_{GS} - V_{TH})}.$$

$$g_m = \mu_n C_{ox}\frac{W}{L}(V_{GS} - V_{TH}) \qquad\qquad g_m = \frac{2I_D}{V_{GS} - V_{TH}} \qquad\qquad g_m = \sqrt{2\mu_n C_{ox}\frac{W}{L}I_D}$$