$x_n = W\frac{N_A}{N_A+N_D} = 0.1\,\mu m$ (+3) (+2) #

$x_p = W\frac{N_D}{N_A+N_D} = 0.1\,\mu m$ (+3) (+2) #

(c) (5%) If the cross-sectional area of the junction is 20 μm², find the magnitude of the charge stored on either side of the junction.

$A = 20\,\mu m^2 = 20\times10^{-8}\,cm^2$

$Q_j = A_j\left(\frac{N_A N_D}{N_A+N_D}\right)W = 20\times10^{-8}\times1.6\times10^{-19}\left(\frac{3\times10^{16}}{2}\right)\times0.2\times10^{-4}$ (+3)

$= 1.6\times10^{-14}\,C$ (+2) #

3. (20%) Consider an *n*-channel MOSFET with t_{ox} = 6 nm, μ_n =460 cm²/V•s, V_t = 0.5 V, and *WIL* = 10. Find the drain current in the following cases:

(a) v_{GS} =2.5Vand v_{DS} =1.0 *V*

$C_{ox} = \frac{\varepsilon_{ox}}{t_{ox}} = \frac{3.45\times10^{-11}}{6\times10^{-9}}$ (+1), $V_{ov} = V_{GS} - V_t = 2\,V$ (+1)

$k_n = \mu_n C_{ox}\frac{W}{L} = 2.645\,mA/V^2$ (+1)

$I_D = k_n\left[V_{DS}V_{ov} - \frac{1}{2}V_{DS}^2\right] = 4\,mA$ # (+1) (+1)

(b) v_{GS} =2.0Vand v_{DS} =1.5 *V*

$C_{ox} = \frac{\varepsilon_{ox}}{t_{ox}}$ (+1), $V_{ov} = V_{GS} - V_t = 1.5\,V$ (+1)

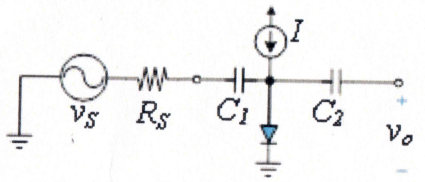
$k_n = \mu_n C_{ox}\frac{W}{L}$ (+1), $I_D = \frac{1}{2}k_n V_{ov}^2 = 3\,mA$ # (+1) (+1)

(c) v_{GS} =2.5Vand v_{DS} =0.2 *V*

$C_{ox} = \frac{\varepsilon_{ox}}{t_{ox}}$ (+1) $V_{ov} = V_{GS} - V_t = 2V$ (+1)

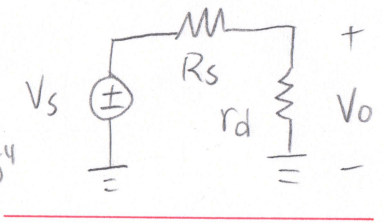
$k_n = \mu_n C_{ox}\frac{W}{L}$ (+1) $I_D = k_n\left[V_{DS}V_{ov} - \frac{1}{2}V_{DS}^2\right] = 1\,mA$ (+1) (+1) #

shown in this drawing).



(a) Use the diode small-signal model to show that the signal component of the output voltage is

$$v_o = v_s\frac{V_T}{V_T + IR_s}$$



(+5)

$r_d = \frac{V_T}{I}$ (+2)

$V_o = V_S\times\frac{r_d}{r_d + R_S} = V_S\frac{V_T/I}{V_T/I + R_S}$ (+3)

$= V_S\frac{V_T}{V_T + IR_S}$

(b) If v_S = 10 mV, find v_o for *I* = 1 mA, 0.1 mA, and 1 μA. Let *R* = *1 kΩ*. At what value of *I* does v_o become one-half of v_S?

(+2) $V_o = \frac{V_T}{V_T + R_S I} = 10\times\frac{25}{25 + 10^3 I}$

① (+1) $I = 1\,mA \rightarrow V_o = 0.24\,mV$

(+1) $I = 0.1\,mA \rightarrow V_o = 2\,mV$

(+1) $I = \mu A \rightarrow V_o = 9.6\,mV$

② (+3) $V_o = \frac{1}{2}V_S = V_S\frac{0.025}{0.025 + 10^3 I}$

V_S =10 mV

$I = 25\,\mu A$ (+2)