

ECSE-2210 Microelectronics Technology
Homework 6 – Solution

Reading list: Chapters 7, 8 and 14 (pages 301-318, 327-338 and 477 - 487).

1. An abrupt, one-sided p⁺-n junction has the following characteristics on the n-side.
N-side:

$$N_D = 4 \times 10^{16} \text{ cm}^{-3}$$

$$D_n = 25 \text{ cm}^2/\text{s}; D_p = 10 \text{ cm}^2/\text{s}$$

$$\tau_p = \tau_n = 10^{-7} \text{ s}$$

$$\text{Area } A = 1 \text{ cm}^2$$

Answer the following:

- a. The diode is biased in the forward direction such that the forward voltage $V_A = 0.6 \text{ V}$. Calculate the low-frequency diffusion capacitance, and the low frequency conductance of the diode. Draw the equivalent circuit of the diode at low frequency.

First calculate the saturation current, I_0 , and hence I , using equation 6.29 and 6.30.

For a p⁺-n diode, we can neglect the saturation current caused by the p-side electrons since the minority carrier concentration in p-side will be very small compared to the minority carrier concentration in n-side.

Therefore, $I_0 = qA (D_p \times p_n)/L_p$

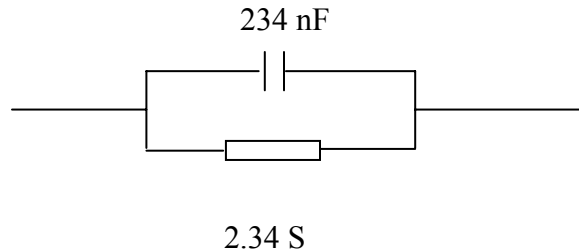
$$I_0 = 1.6 \times 10^{-19} \text{ C} \times 1 \text{ cm}^2 \times (10 \text{ cm}^2/\text{s} \times 2500 \text{ cm}^{-3}) / (10^{-3} \text{ cm}) = 4 \times 10^{-12} \text{ A}$$

[with $L_p = (D_p \times \tau_p)^{1/2}$]

$$I = I_0 \exp(0.6/0.0256) = 0.06 \text{ A.}$$

$$\text{So, } G_0 = qI/kT = 2.34 \text{ S}$$

$$C_d = qI\tau_p/kT = 234 \text{ nF.}$$

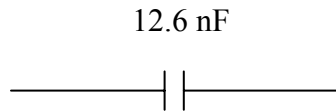


- b. The diode is biased in reverse such that the applied voltage $|V_A| = 20$ V. Calculate the reverse bias capacitance (Hint: you can neglect V_{bi}). Draw the equivalent circuit, assuming an ideal diode. Explain briefly how the circuit will change if we start considering the non-ideal behavior of the diode.

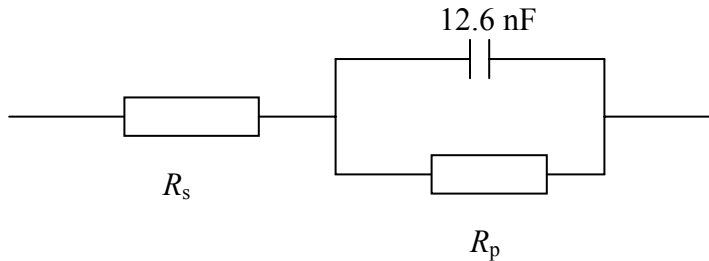
First find the depletion layer width:

$$W = [(2\epsilon)/qN_D |V_A|]^{1/2} = 0.79 \times 10^{-4} \text{ cm} \rightarrow C = \epsilon/W = 12.6 \text{ nF}.$$

Reverse bias conductance is zero under reverse bias (for an ideal diode)



You have to add a parallel resistance across the capacitor above to account for the g-r current in the depletion layer (This accounts for the fact that the reverse bias current is voltage dependent). Also, you have to add a series resistance to account for the parasitic contact resistances, as well the resistance of the neutral regions.



2.) Refer to exercise 7.2. in the textbook.