ECSE-2210 Microelectronics Technology
Homework 7 – 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:

   $N_D = 4 \times 10^{16}$ cm^{-3}
   $D_n = 25$cm^2/s; $D_p = 10$ cm^2/s
   $\tau_p = \tau_n = 10^{-7}$s
   Area $A = 1$ cm^2

   Answer the following:

   a. The diode is biased in the forward direction such that the forward voltage $V_A = 0.6$ 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.

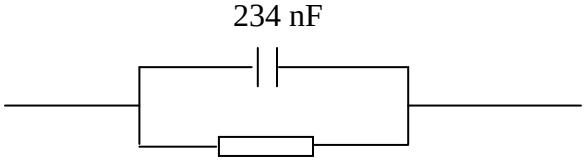
      First calculate the saturation current, I_0, and hence I, using equation 6.29 and 6.30.

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

      $I_0 = 1.6 \times 10^{-19}$ C $\times$ 1 cm^2 $\times$ (10 cm^2/s $\times$ 2500 cm^{-3})/(10^{-3} cm) $= 4 \times 10^{-12}$ A
      [with $L_p = (D_p \times \tau_p)^{1/2}$]

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

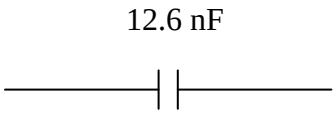
      So, $G_0 = qI/kT = 2.34$ S
      $C_d = qI\tau_p/kT = 234$ nF.

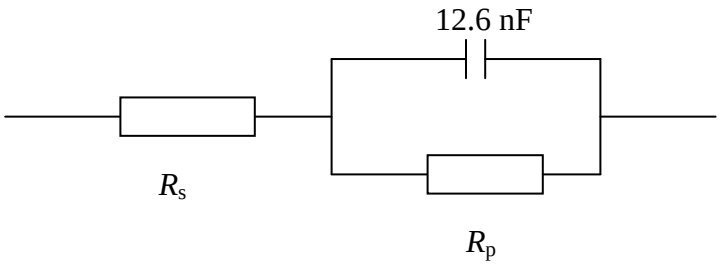
b. The diode is biased in reverse such that the applied voltage $|V_A|$ = 20 V. Calculate the reverse bias capacitance (Hint: you can neglect V_{bi}). Draw the equivalent circuit, assuming an ideal diode. Explain briefly how the circuit will change if we start considering the non-ideal behavior of the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

First find the depletion layer width:
$W = [(2\varepsilon)/qN_D\,|V_A|]^{1/2} = 0.79 \times 10^{-4}$ cm $\rightarrow$ $C = \varepsilon/W$ = 12.6 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.