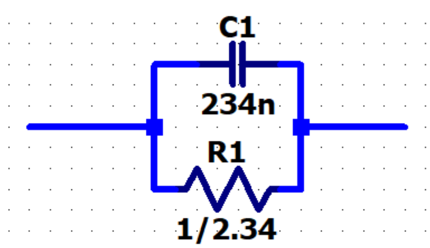
Hayden Fuller
Microelectronics HW7

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

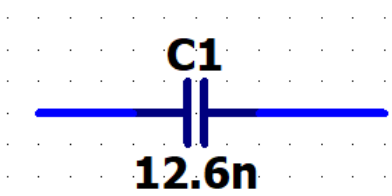
1. An abrupt, one-sided p+ -n junction has the following characteristics on the n-side.
   N-side:
   ND = 4 × 1016 cm-3
   Dn = 25cm2 /s;
   Dp = 10 cm2 /s
   τp = τn = 10-7s
   Area A = 1 cm2 Answer the following:
   a. The diode is biased in the forward direction such that the forward voltage VA = 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

$I=I_0$(e^(V_A q/kT) -1)
I_0=qA(DN ni^2/LN NA + DP ni^2/LP ND)
I_0=qA(DP ni^2/LP ND)
I_0=qA(DP pn/LP)
LP=sqrt(DP * taup)
I_0=1.6x10^-19C * 1cm^2 (10cm^2/s 2500cm^-3/10^-3cm)
I_0=1.6x10^-19 * 1 (10 2500/10^-3) C/s
I_0=4x10^-12 A
$I=I_0$(e^(.6/.0256) -1)=60mA
G=I q/kT=2.34S
C=I*taup q/kt = 234nF



   b. The diode is biased in reverse such that the applied voltage |VA| = 20 V. Calculate the reverse bias capacitance (Hint: you can neglect Vbi). 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.

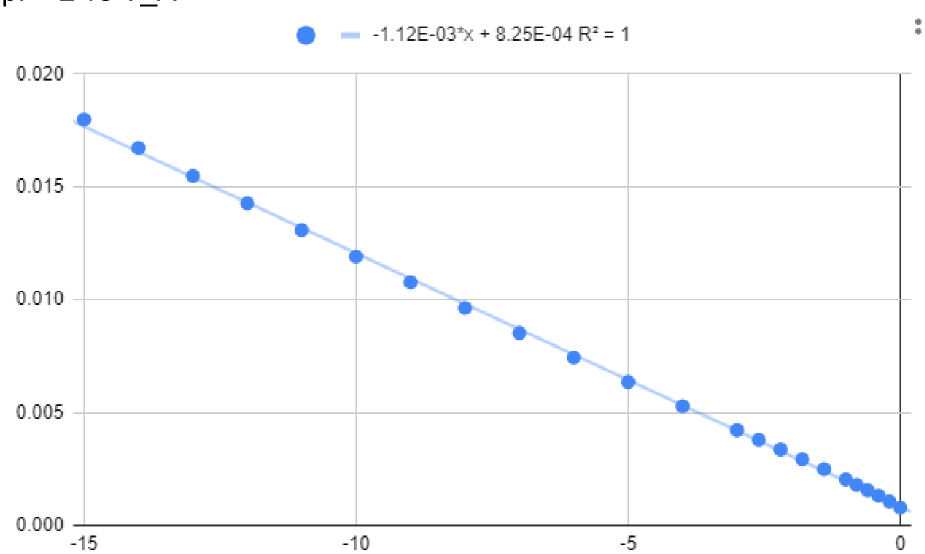
W=sqrt(2e/qND V_A)
W=0.79x10^-4
C=e/W=12.6nF



2. Problem 7.4 in text. The IN4002 is one of the popular 4000-series general-purpose diodes. CV data from an IN4002 p+ -n junction diode is listed in Table below. Before analyzing the data, subtract 3pF from each capacitance value to account for the stray capacitance shunting the encapsulated diode. Assume area of the diode is 6×10^-3 cm^2. Make a 1/C^2 -versus- V plot (as described in text) to determine the doping concentration in the lightly doped side. Also, determine the built-in voltage, Vbi from the graph.

VA (V)	C(pF)	VA (V)	C(pF)	VA (V)	C(pF)
0.0	38.709	-2.2	20.254	-9.0	12.639
-0.2	33.717	-2.6	19.248	-10.0	12.163
-0.4	30.567	-3.0	18.405	-11.0	11.746
-0.6	28.319	-4.0	16.762	-12.0	11.373
-0.8	26.598	-5.0	15.548	-13.0	11.037
-1.0	25.170	-6.0	14.599	-14.0	10.734
-1.4	23.060	-7.0	13.834	-15.0	10.458
-1.8	21.490	-8.0	13.189		

pF^-2 vs V_A



1/C^2=2/(q NB KS e0 A^2) * (Vbi-VA)

8.25x10^-4 - 1.12x10^-3 VA = Vbi 2/(q NB KS e0 A^2) - VA 2/(q NB KS e0 A^2)

1.12x10^-3 = 2/(q NB KS e0 A^2)
8.25x10^-4 = Vbi 2/(q NB KS e0 A^2)
8.25x10^-4 = Vbi 1.12x10^-3
8.25x10^-4 / 1.12x10^-3 = Vbi
Vbi = 0.7366V

1.12x10^-3 = 2/(q NB KS e0 A^2)
NB = 2/(q (1.12x10^-3) KS e0 A^2)
NB = 2/((1.6x10^-19) (1.12x10^-3x10^12) (11.8) (8.85x10^-14) (6×10^-3)^2)
NB=2.96x10^14