

Massachusetts Institute of Technology
Department of Electrical Engineering and Computer Science
6.012 Microelectronic Devices and Circuits
Homework #2

Problem 1

Fill in the values for the maximum electric field, built in voltage, and depletion region width for the following pn junctions. Assume thermal equilibrium.

$N_d \text{ cm}^{-3}$	$N_a \text{ cm}^{-3}$	$x_{no} \text{ nm}$	$x_{po} \text{ nm}$	$E_o \text{ kV/cm}$	$\phi_B \text{ mV}$
10^{15}	10^{15}				
10^{16}	10^{17}				
10^{16}	10^{18}				

Problem 2 Howe and Sodini – P3.6

Problem 3 Howe and Sodini – P3.8

Problem 4

Voltage controlled oscillators are used in most RF circuits to select a particular frequency to receive. They are made with tank circuits where the inductor value is fixed and the capacitor value is controllable by changing the voltage. Pn junction diodes are often used for these circuits as the variable capacitor. Consider a pn junction with p-side doping $N_a = 10^{14} \text{ cm}^{-3}$ and n-side doping $N_d = 10^{16} \text{ cm}^{-3}$. Use the approximation that the junction is one-sided.

- a) What is the thermal equilibrium depletion region width?
- b) What is the reverse bias needed to increase the depletion width to $3 \mu\text{m}$?
- c) If the maximum electric field allowable in the junction is $E_{max} = 7 \times 10^4 \text{ V/cm}$, what is the maximum depletion width? What is the bias voltage corresponding to the maximum depletion width?
- d) Given an inductance of 5 nH , calculate the area of the diode to make the resonant frequency $\frac{1}{2\pi\sqrt{LC}} = 1 \text{ GHz}$, when the voltage across the diode is 0 V .
- e) Plot the range of frequencies that can be tuned with the range of tuning voltages from 0 V to the maximum voltage calculated in (c).

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