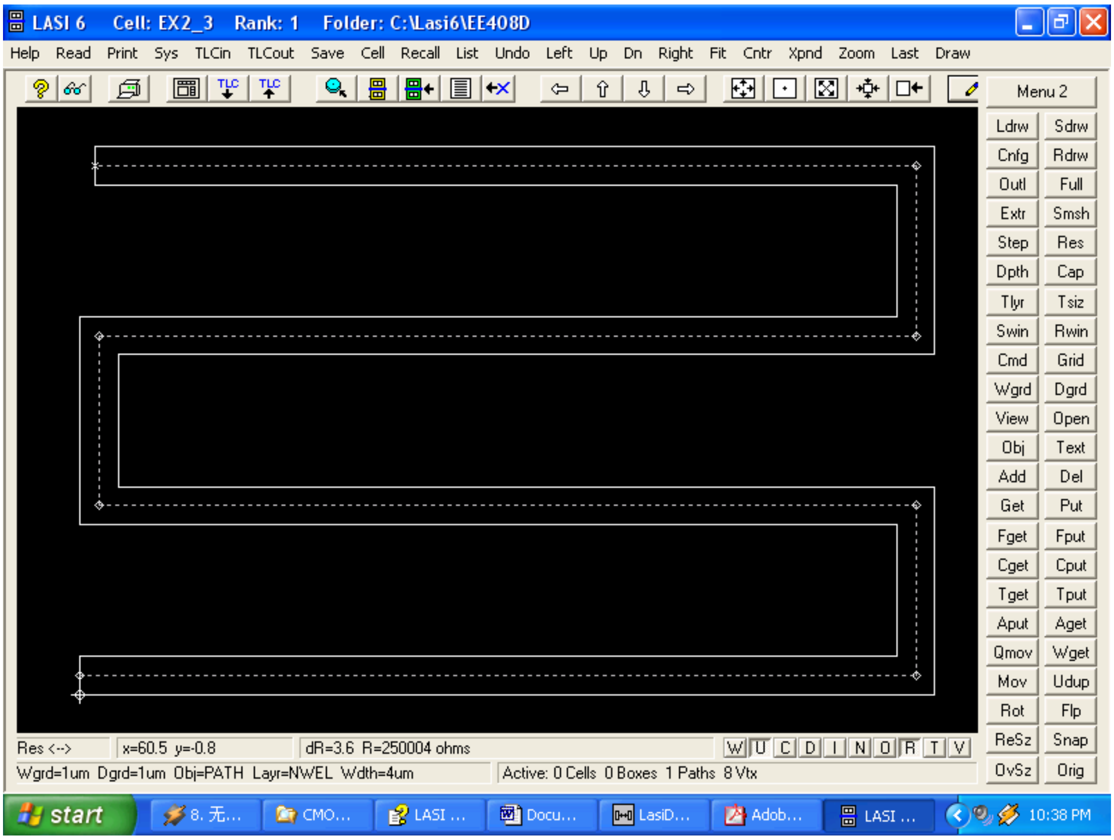
HW 2_SOLUTION

Problem 2_3



1. Draw the graph by “Path”; define the width of the path is 4um (Ws=4um) ; the maximum length of a segment is 86um (Ls=86um). Define width between horizontal line is Wg=13.87um. Notice that the maximum length of the resister is 86+4=90um<100um.

2. Also, this design has passed the LASIDRC check. (Wg=13.87um>9um, Ws=4um>3um).

3. Define SheetResistance R(square)=2.5k Ohm. As shown above, the total resistance of this resistor is R=250004Ohm=250k Ohm.

Problem 2.7.

According to Ex. 2.3,

$$C_j = C_{j0} / (1-(V_d/0.7))^{0.33} = 1.12\,pF / (1-(-1/0.7))^{0.33} = 0.8357pF$$

$$f_{3db} = 1/(2\pi RC) = 1/(2 \times \pi \times 10k \times 0.8357pF) \approx 19\ Mhz$$

Problem 2.10

For $5\mu m \times 2000\mu m$ nwell, the capacitance C is simply the product of the bottom area of the resistor with the zero-bias depletion capacitance.

$$C = 100aF \times 5^2 \times 400 = 1pF,\ \ R = 1M\Omega$$

Therefore, the delay is given by

$$t_d = 0.35RC = 0.35 \times 1pF \times 1\ M\Omega = 0.35\mu s$$

Problem 2.14.

The diode storage time is given by

$$t_s = \tau_T \bullet \ln((i_F - i_R)/(-i_R)),$$

$$i_F = V_F / R = (5\text{-}0.7)V/\ 1K\Omega = 4.3mA,\ \ i_R = V_R / R = (\text{-}5\text{-}0.7)V/\ 1K\Omega = \text{-}5.7mA$$

Therefore,

$$t_s = 5ns \times \ln(10/5.7) \approx 2.81ns$$

5. For a PN junction with uniform doping of $N_A = 10^{17}/cm^3$ and $N_D = 10^{17}/cm^3$, calculate the built-in potential, width of the depletion region, and the junction capacitance.

Ans:

Built-in Potential:

$$\phi_{bi} = V_T \ln\left(\frac{N_A N_D}{n_i^2}\right) = 0.026 \times \ln\left(\frac{10^{17} \times 10^{17}}{\left(1.45 \times 10^{10}\right)^2}\right) = 0.83V$$

Width:

$$X_d = \sqrt{\frac{2\varepsilon_s}{q}\left(\frac{1}{N_A} + \frac{1}{N_D}\right)\phi_{bi}} = \sqrt{\frac{2 \times 1.036 \times 10^{-12}}{1.6 \times 10^{-19}}\left(\frac{1}{10^{17}} + \frac{1}{10^{17}}\right) \times 0.83} = 0.147\mu m$$

Junction capacitance:

$$C_j = \frac{\varepsilon_s}{X_d} = \frac{1.036 \times 10^{-12} F/cm}{0.147\mu m} = 7.16 \times 10^{-8} F/cm^2$$