EG-EE445

1. An inverter has a measured delay of 2ns.

   a- If five identical delays are connected in series as shown in Figure 1, what is the delay from a to b?

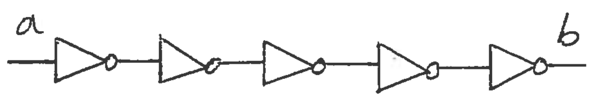

Figure 1

   b- If the a and b are connected together as shown in Figure 2 such that the voltage at a will now oscillate like a clock,

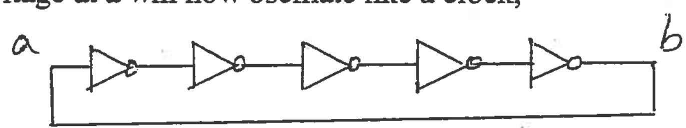

Figure 2

   (i) what is the period of oscillation?

   (ii) What is the frequency of oscillation?

2. A step input from 0 V to 1.2 V is applied to the RC circuit of Figure 3. Calculate the time required for the voltage across the capacitor to: a) reach 0.6 V, b) reach 1.2 V, c) go from 10% to 90% of 1.2 V?

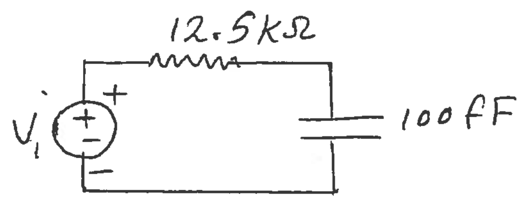

Figure 3

3. The uniform areal density of defects for a CMOS fabrication process is 0.0063 mm^{-2}. Estimate the yield for 9x12 mm chips.

4. The uniform areal density of defects for a CMOS fabrication process is 0.0014 mm^{-2}. Estimate the maximum economically viable chip size.

5. When a type of integrated circuit is tested at 200°C, 10% of the circuits fail within 1000 h with V_{DD} =1.65 V. Estimate the 10% lifetime at 175°C and 1.65 V supply voltage, assuming E_a = 1.0 eV. Repeat for 100°C.

EE445 homework 1 - Solutions

Q1 - a) delay (a-b) = 5 x 2nsec = 10nsec

b) part (i) - $f = \dfrac{1}{m(t_{PHL}+t_{PLH})}$

$t_p = \dfrac{t_{PHL}+t_{PLH}}{2} \Rightarrow f = \dfrac{1}{m \times 2t_p}$

$m = 5 \Rightarrow f = \dfrac{1}{10t_p} = \dfrac{1}{10 \times 2nsec} = \dfrac{1}{20nsec}$

$\therefore T = 20\,nsec$

part (ii): $f = \dfrac{1}{20nsec} = 50\,MHz$

Q2 -

a) $V_0 = V(1-e^{-t/RC}) = 1.2\,(1-e^{-t/(12.5\times10^3 \times 100\times10^{-15})})$

$\therefore V_0 = 1.2\,(1-e^{-8\times10^8 t})$

if $V_0 = 0.6\,V \Rightarrow 0.6 = 1.2\,(1-e^{-8\times10^8 t_1})$

$\therefore t_1 = 0.866\,nsec$

b) for $V_0 = 1.2 \Rightarrow t = \infty$

c) $\begin{cases} 1-e^{-8\times10^8 t'} = 0.1 \Rightarrow e^{-8\times10^8 t'} = 0.9 \\ 1-e^{-8\times10^8 t''} = 0.9 \Rightarrow e^{-8\times10^8 t''} = 0.1 \end{cases}$

$\therefore e^{-8\times10^8 (t'-t'')} = 9 \Rightarrow (t''-t') = t_r = \dfrac{\ln 9}{8\times10^8} = 2.7$

Q3

$$Y = \exp(-D_o A) = \exp\{-(9mm)(12mm)(0.0063mm^{-2})\} = 50\%$$

Q4

$$Y = e^{-D_o A} \geqslant 0.95$$

$$\therefore A \leqslant \frac{-\ln(0.95)}{D_o} = \frac{0.051}{0.0014mm^{-2}}$$

$$\therefore A \leqslant 36mm^2 = 0.36cm^2$$

Q5

At 200°C, the acceleration factor with respect to 100°C is:

$$A_{200} = \exp\left\{\frac{1eV}{8.7\times10^{-5}eV/K}\left(\frac{1}{100+273} - \frac{1}{200+273}\right)\right\} = 675$$

At 175°C, the acceleration factor with respect to 100°C is:

$$A_{175} = \exp\left[\frac{1eV}{8.7\times10^{-5}eV/K}\left(\frac{1}{100+273} - \frac{1}{175+273}\right)\right] = 174$$

$\therefore$ The lifetime at 100°C is

$A_{200}(675) = 675{,}000$ hrs

$\therefore$ The lifetime at 175°C is: $675000/174 = 3900$ hrs