Homework No. 12 – Solutions

Problem 1 – P10.1

a) *0.18µm, Al, Metal 5*
$L=20mm,\ W=0.4\mu m,\ R_{sq}=27\ m\Omega/\square$
$R_{wire}=R_{sq}\times L/W$
$R_{wire}=27\ m\Omega/\square\times 20mm\ /0.4\mu m=1.35\ K\Omega$

b) *0.13µm, Cu, Metal 8*
$L=20mm,\ W=0.4\mu m,\ R_{sq}=21\ m\Omega/\square$
$R_{wire}=R_{sq}\times L/W$
$R_{wire}=21\ m\Omega/\square\times 20mm\ /0.4\mu m=1.05\ K\Omega$

$C_{int}=0.1fF/\mu m$
$C_{wire}=C_{int}\times L$
$C_{wire}=0.1fF/\mu m\times 20mm=2pF$

$\tau = 0.38\times R_{wire}\times C_{wire}$
$\tau_{Al} = 0.38\times R_{wire}\times C_{wire} = 0.38\times 1.35\ K\Omega\times 2pF = 1.026\ ns$
$\tau_{Cu} = 0.38\times R_{wire}\times C_{wire} = 0.38\times 1.05\ K\Omega\times 2pF = 0.798\ ns$

Problem 2 – P10.3

The wire is shielded above and below so it has all the Lateral, Area and Fringing capacitance.

$T=1\mu m,\ H=0.5\mu m,\ W=0.4\mu m,\ \lambda=0.1\mu m$

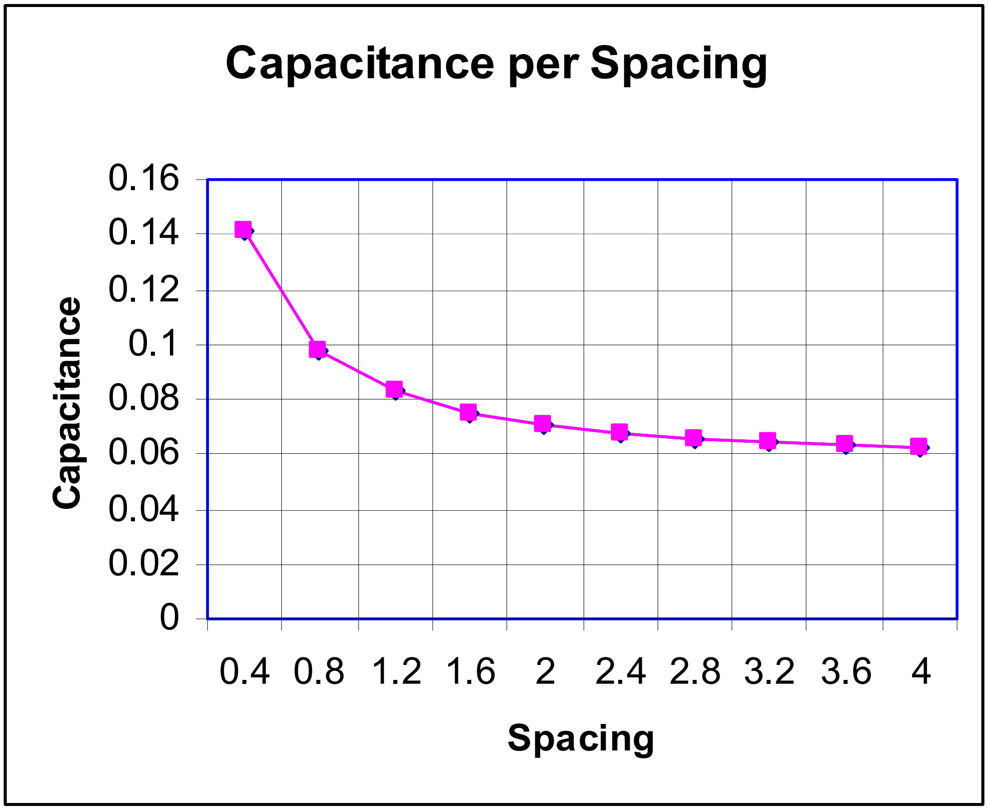
$\varepsilon_{ox}= 4\varepsilon_o= 4(\ 88.5\times 10^{-4}\ fF/\mu m) = 354\times 10^{-4}\ fF/\mu m$

$C_{Lateral}= \varepsilon_{ox}\times T/S = (354/S)\times 10^{-4}\ fF/\mu m$
$C_{Area}= \varepsilon_{ox}\times W/H = 142\times 10^{-4}\ fF/\mu m$
$C_{Fring}= \varepsilon_{ox}\times Ln(1+T/H) = 389\times 10^{-4}\ fF/\mu m$

$C_{Total}= C_{Lateral}+C_{Area}+C_{Fring}$

S: 4λ … 40λ, Step = 4λ (0.4µm … 4µm)

Problem 2 - Continued



Problem 3 – P10.8

(a) If the aggressor switches by,

$$\Delta V_A = 1.8V$$

then the peak value of noise on the victim line will be,

$$\Delta V_V = \frac{C_C \Delta V_A}{(C_{gnd} + C_C)} = \frac{(100\,fF)(1.8V)}{(60\,fF + 100\,fF)} = 1.125V$$

(b) Given that the aggressor net is switching in the opposite direction of the victim net, the loading capacitance on the victim net will be,

$$C_L = C_{gnd} + 2C_C = 60\,fF + 2(100\,fF) = 260\,fF$$

Problem 4 – P10.9

The following values are used:

Cint = 0.2 fF/um
Lint = 0.45 pH/um
Rsq = 21 mΩ/sq
Wwire = 0.4 um

Therefore,

Rint = Rsq/Wwire = (21 mΩ/sq) / (0.4 um) = 52.5 mΩ/um

The critical length is:

Lcrit = [FO4/0.38RintCint]$^{1/2}$ = [(40 ps)/(0.38 x 21 mΩ/sq x 0.2 fF/um)]$^{1/2}$ = **3.2 mm**

For inductance to be important, the wire length must fall in the following range:

$$\frac{tr}{2\sqrt{L\text{int}\, C\text{int}}} \le l \le \frac{2}{R\text{int}}\sqrt{\frac{L\text{int}}{C\text{int}}}$$

First the value of tr (rise time) must be calculated. An approximate value can be found by using HSPICE to analyze the rise time of the output of a 4X inverter being driven by a 1X inverter, while driving a 16X inverter. This value can be found to be 83 ps in 0.13 um technology. After plugging these numbers in to the inductance formulas it can be seen that the for inductance to be important, the wire length must fall in the following range:

1.8 mm < l < 4.3 mm

Therefore, the critical length lies right in the middle of this range, suggesting that when inductance is important buffer insertion should be performed to reduce the overall delay and inductive effects.