Homework 4 Solutions

1a. $S = \frac{130nm}{32nm} = 4.0625$.

Area scales by $1/S^2 = 0.06059$

$A_{new} = 0.06059 \times A_{old} = 0.06059 \times 0.2\mu m^2 = 0.01212\mu m^2$.

b. Capacitance scales by $1/S = 0.2462$.

$C_{new} = 1/S \times C_{old} = 0.2462 \times 50ff = 12.31fF$.

c. τ scales by $1/S = 0.2462$

$\tau_{new} = 1/S \times \tau_{old} = 0.2462 \times 20ps = 4.92ps$.

d. R is constant in Denard scaling $\Rightarrow R_{new} = R_{old} = 0.1\Omega$.

2a. Prob(all NAND2 are good) $= (1-0.000001)^{350,000} = 74.1\%$.

Prob(all INV are good) $= (1-0.00000003)^{1,000,000} = 74.1\%$

Prob(all AOI22 are good) $= (1-0.00000045)^{200,000} = 40.7\%$

Prob(all NOR2 are good) $= (1-0.00001)^{200,000} = 13.5\%$

Yield $= \Pi$ Prob $= 3.02\%$.

b. Prob(NAND2) $= (1-0.000001)^{150,000} = 86.1\%$

Prob(INV) $= (1-0.00000003)^{500,000} = 86.1\%$

Prob(AOI22) $= (1-0.00000045)^{100,000} = 63.8\%$

Prob(NOR2) $= (1-0.00001)^{100,000} = 36.8\%$

Yield $= 17.4\%$

c. Prob(NAND2) $= (1-0.000001)^{100,000} = 90.5\%$

Prob(INV) $= (1-0.00000003)^{333,333} = 90.5\%$

Prob(AOI22) $= (1-0.00000045)^{66,667} = 74.1\%$

Prob(NOR2) $= (1-0.00001)^{66,667} = 51.3\%$

Yield $= 31.1\%$.

3a. Using Poisson's model.

$Yield = e^{-AD} = e^{-2mm^2 \times 1/2mm^2} = e^{-1} = 36.8\%$

b. $Yield = e^{-1mm^2 \times 1/2mm^2} = e^{-1/2} = 60.65\%$.

c. $Yield = e^{-0.5mm^2 \times 1/2mm^2} = e^{-1/4} = 77.88\%$.

d.

a. $Yield = e^{-2mm^2 \cdot 1/1mm^2} = e^{-2} = 13.53\%$

b. $Yield = e^{-1mm^2 \times 1/1mm^2} = e^{-1} = 36.8\%$.

c. $Yield = e^{-0.5mm^2 \times 1/1mm^2} = e^{-0.5} = 60.65\%$.

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4. Inverter variance = (standard deviation)^2 = $(1ps)^2 = 1ps^2$

Expected delay of ring oscillator has a mean of $11 \times 10ps = 110ps$.

Ring Oscillator also has a variance of $11 \times 1ps^2 = 11ps^2$

$\Rightarrow$ RO standard deviation = $\sqrt{11ps^2} = 3.317ps$.

From table 7.9, Maximum of 100 ROs will have a mean of $110ps + (2.5 \times 3.22ps)$

$= 118ps$.

and standard deviation = $0.43 \times 3.22ps$

$= 1.38ps$

a. Period = $2 \times 118ps = 236ps$ (Positive & negative edge).

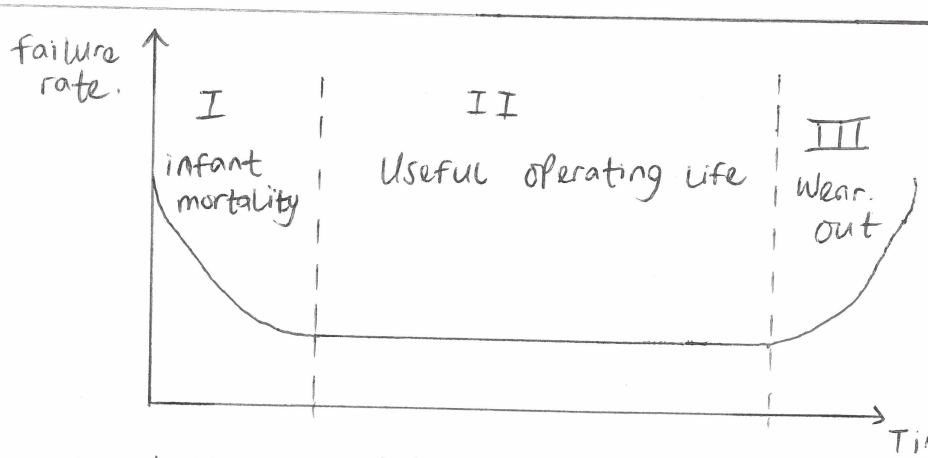
frequency = $1/236ps = 4.24 GHz$.

b. 99.7% is $\mu + 3\sigma$ (mean + [3 x standard deviation]) $\Rightarrow$ Delay = $118 + (3 \times 1.38)$

$= 122ps$.

Period = $2 \times 122 = 244ps \Rightarrow f = 1/244ps = 4.10 GHz$.

5.



Chips are most likely to fail really early or have a long life. A good idea to weed out chips that will fail early is to stress chips during testing.