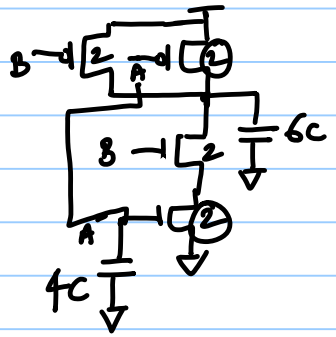
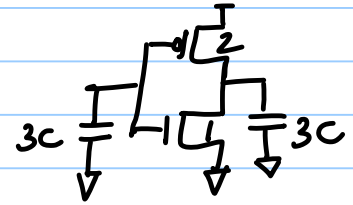
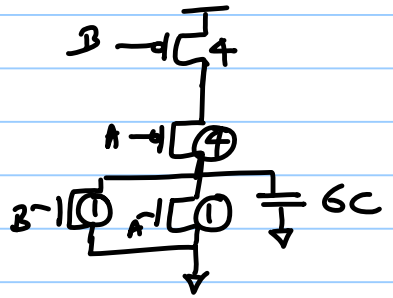
27/09/2019

# EE5311

## MODULE-4 - COMB CKTS




$g = \frac{4}{3}$ (LOGICAL EFFORT)

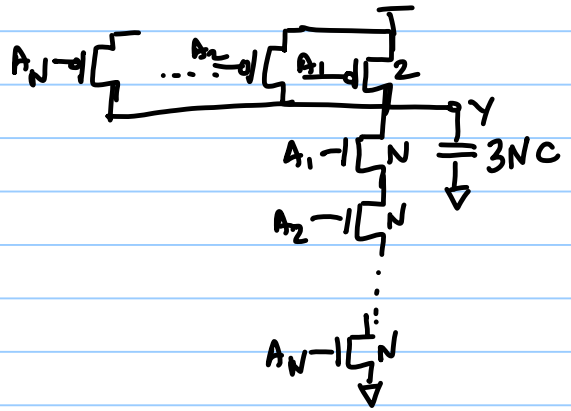
$p = \frac{6C}{3C} = 2$ (PARASITIC EFFORT)

$C_A = C_B = 5C$

$g_A = g_B = 5C/3C = 5/3$

$p = 6C/3C = 2$

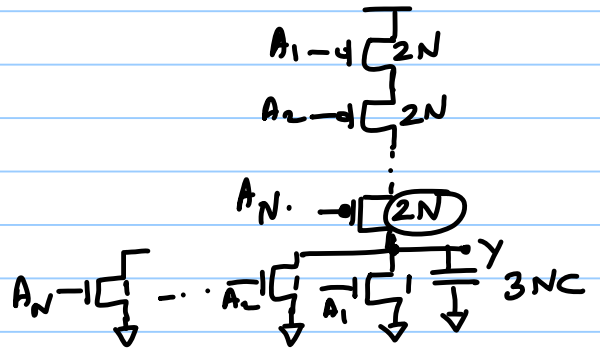
N input NAND & NOR.




$C_{A_K} = (N+2)C$

$\therefore \quad g_{A_K} = \frac{(N+2)C}{3C} = \left(\frac{N+2}{3}\right)$

$p = \frac{3NC}{3C} = N$



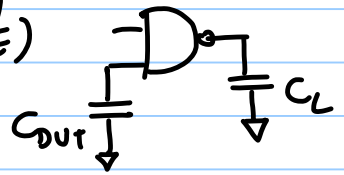

$C_{A_K} = (2N+1)C$

$g_{A_K} = \frac{(2N+1)C}{3C} = \frac{(2N+1)}{3}$

$p = \frac{3NC}{3C} = N$

$$delay = \left(\frac{C_L}{C_{OUT}}\right)\cdot\left(\frac{C_{UNIT}}{C_{INV}}\right) + p$$

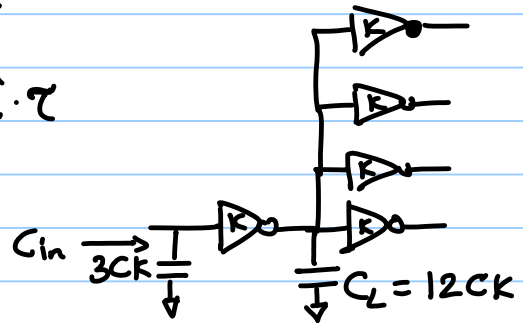
$h$ (E·E) $\quad$ $g$ (L·E) $\quad$ $p$ (P·E)



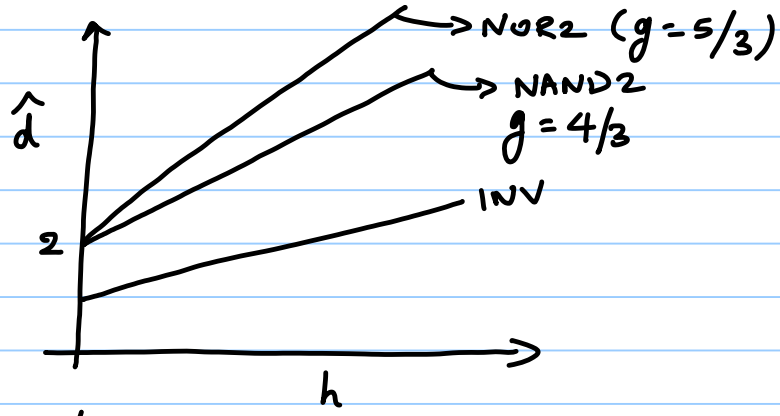

$$\hat{d} = gh + p \quad \text{(NORM. DELAY)}$$

$$\tau = 3RC$$

$$d = \hat{d}\cdot\tau$$

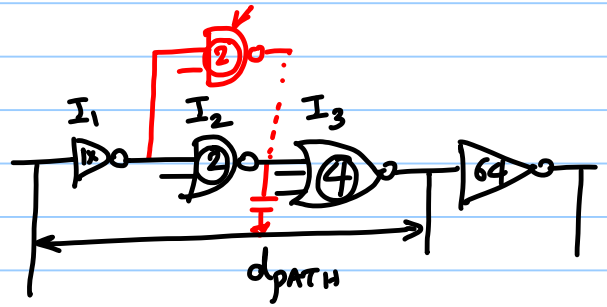



$h = 12KC/3KC = 4$




$h = C_L/C_{in} = 12C/3C = 4$

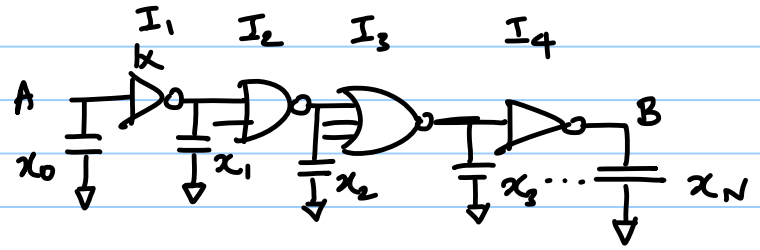
FO4 DELAY = $(gh+p)\tau = (1\times4+1)\tau = 5\tau$




$d_{PATH} = \sum d_i$

| | $I_1$ | $I_2$ | $I_3$ |
|---|---|---|---|
| $C_{in}$ | 3C | 8C | 28C |
| $C_L$ | (8C+8C) | 28C | 192C |
| h | (8/3) | (7/2) | (48/7) |
| g | 1 | 4/3 | 7/3 |
| p | 1 | 2 | 3 |
| d (gh+p) | (11/3) | (20/3) | 19 |

# PATH DELAY OPTIMIZATION




MINIMIZE DELAY B/W A & B.

Let $x_k \rightarrow$ Input cap of gate $(k+1)$

$$d_i = g_i h_i + p_i$$

$$h_1 = x_1 / x_0.$$

$$h_k = (x_k / x_{k-1})$$

$$d = \sum g_k h_k + p_k.$$

$$= \sum g_k h_k + \underbrace{\sum p_k}_{\text{Constant number} = P = \text{PATH PARASITIC EFFORT}}$$

$$\min \left( \sum_{k=1}^{N} g_k \left( \frac{x_k}{x_{k-1}} \right) \right)$$

$$F = \prod_{k=1}^{N} g_k h_k. = \underbrace{\prod_{k=1}^{N} g_k}_{G} \cdot \underbrace{\prod_{k=1}^{N} h_k}_{H} \rightarrow \frac{x_1}{x_0} \cdot \frac{x_2}{x_1} \cdot \frac{x_3}{x_2} \cdots \frac{x_N}{x_{N-1}}$$

$$= \frac{x_N}{x_0}$$

Let $f_k = g_k \cdot h_k$. Min $\sum f_k$. $\prod f_k = \text{Const}$

$$\frac{\sum f_k}{N} \geq \left(\prod f_k\right)^{1/N}$$

A.M $\geq$ G.M