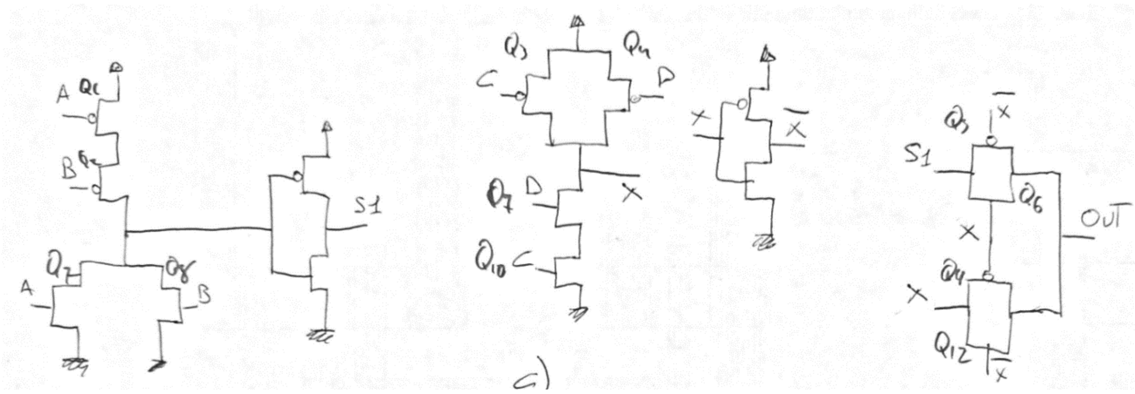
Problema 1

a)

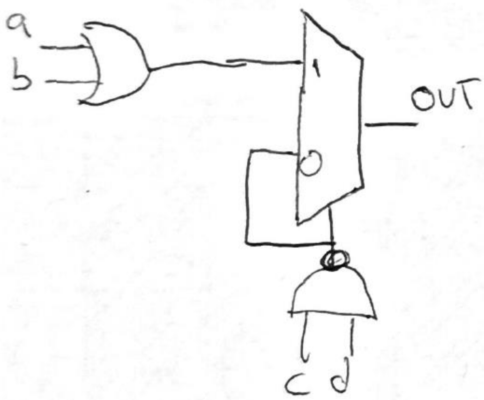


b)

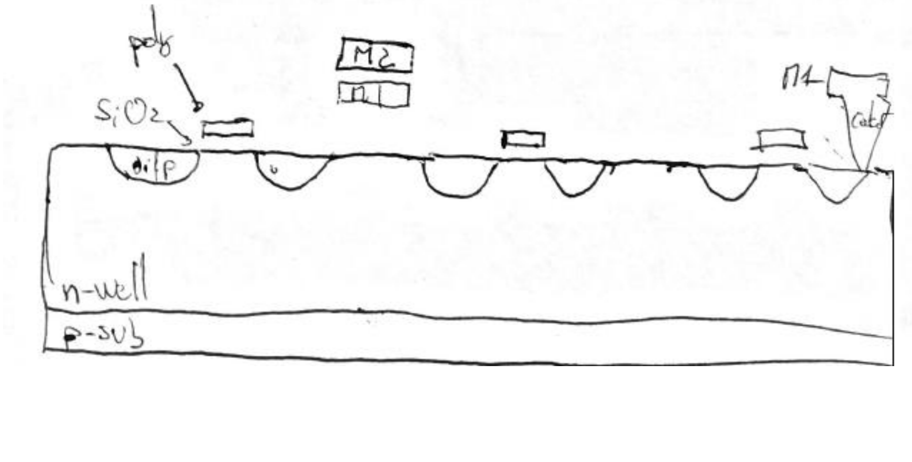
ABCD	Q_1	Q_2	Q_3	Q_4	Q_5	Q_6	Q_7	Q_8	Q_9	Q_{10}	Q_{11}	Q_{12}
0101	ON	off	ON	off	ON	ON	off	ON	ON	off	off	off
1011	off	ON	off	off	off	off	ON	off	ON	ON	ON	ON

c)

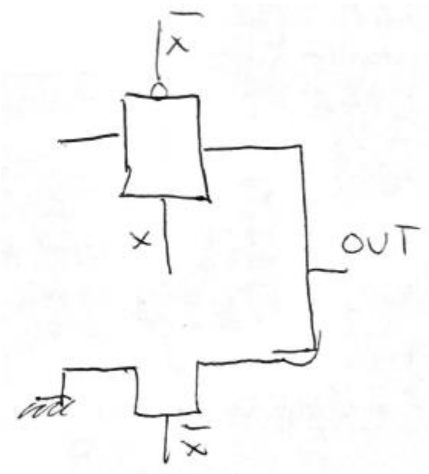
$$OUT = (a+b)\cdot\left(\overline{c\cdot d}\right)$$



d)



e)



Al tener una de las entradas del multiplexor conectada a un ‘0’ lógico, se podría sustituir por un transistor de paso de tipo N que transmiten los ceros sin degradación.

Problema 2

a) $t_{pi} = \ln 2 \cdot R_{eq} \cdot C_g \qquad R_{eq} = R_S \frac{L}{W} \qquad C_g = C_{ox} L W$

$R_{eq_1} = R_S \frac{L_1}{W_1} = R_S \frac{L}{aW} \qquad C_{g_2} = C_{ox} \cdot L_2 W_2 = C_{ox} \cdot L \cdot bW$

$t_p = \ln 2 \cdot R_S \frac{L}{aW} \cdot C_{ox} \cdot L \cdot bW =$

$= \frac{b}{a} \ln \cdot R_S \frac{L}{W} \cdot C_{ox} L W = \frac{b}{a} \ln 2 \cdot R_{eq} \cdot C_g = \boxed{\frac{b}{a} t_{pi} = t_p}$

b) $C_L = \alpha^n C_g \Rightarrow n = \frac{\ln (C_L/C_g)}{\ln \alpha} = \frac{\ln 300}{\ln e} = 5'7 \simeq \boxed{6 = n}$

$t_{pmin} \Rightarrow \alpha = e$

$\alpha = \sqrt[n]{C_L/C_g} = \sqrt[6]{300} = \boxed{2'59 = \alpha}$

$t_p = n \alpha t_{pi} = 6 \cdot 2'59 \cdot t_{pi} = \boxed{15'54 t_{pi} = t_p}$

$A_o = \frac{\alpha^n - 1}{\alpha - 1} A_o = \boxed{189'22 A_o = A}$

$(n = 5 \Rightarrow \alpha = 3'13 \Rightarrow t_{pi} = 15'64 t_{pi})$ X

$L_n = L_p = 2\lambda$

1er inv: $W_{n_1} = 6\lambda \qquad W_{p_1} = 15\lambda$

2° inv: $W_{n_2} = 3'13 \cdot 6\lambda = 18'78\lambda \simeq 19\lambda$

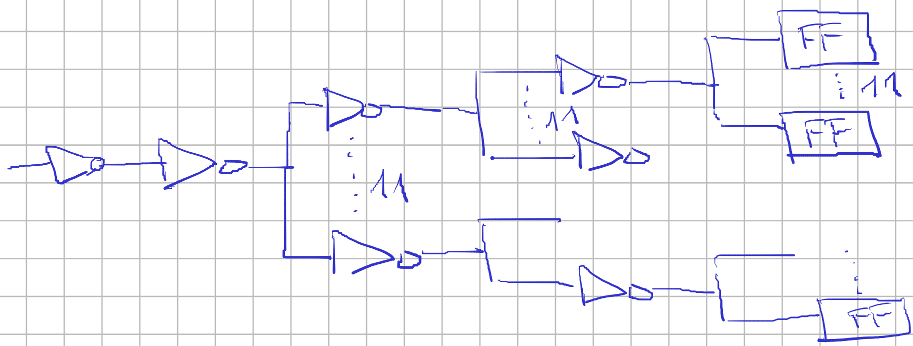
$W_{p_2} = 3'13 \cdot 15\lambda = 46'95\lambda \simeq 47\lambda$

3er inv: $W_{n_3} = 3'13^2 \cdot 6\lambda = 58'78\lambda \simeq 59\lambda$

$W_{p_3} = 3'13^2 \cdot 15\lambda = 146'95\lambda \simeq 147\lambda$

c) * 3 etapas: $F^3 = 1200 \Rightarrow F = \sqrt[3]{1200} = 10'62$

3 etapas, fanout = 11 $\quad 11^3 = 1331$



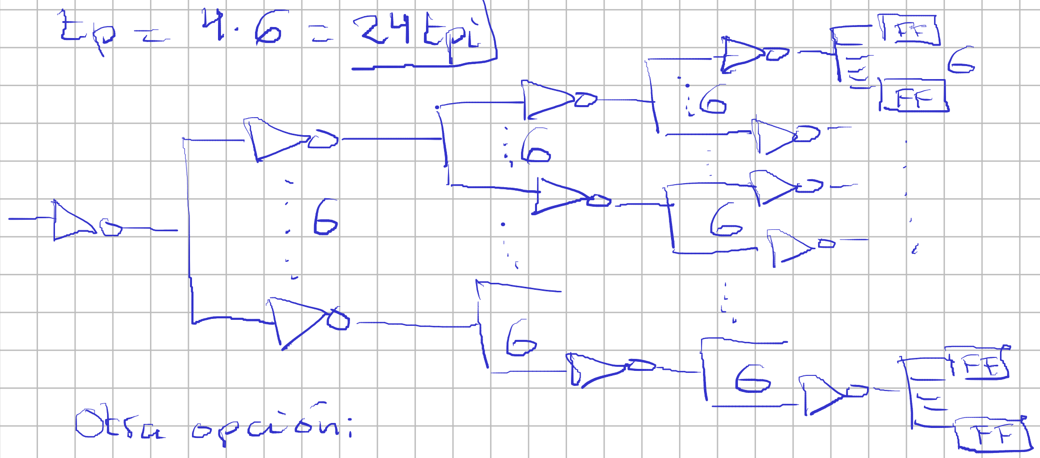
Se puede $10 \times 10 \times 12 = 1200$

$t_p = (1 + 10 + 10 + 12)\, t_{pi} = \boxed{33 t_{pi}}$

* 4 etapas: $F = \sqrt[4]{1200} = 5'88$

4 etapas, fanout = 6 $\Rightarrow 6^4 = 1296$ (sobran 96)

$t_p = 4 \cdot 6 = \underline{24 t_{pi}}$



Otra opción:

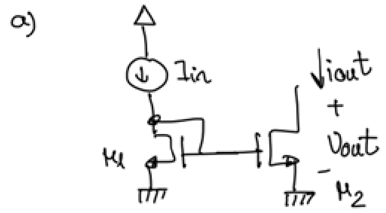
$1200 = 2^4 \cdot 3 \cdot 5^2 = 5 \cdot 5 \cdot 6 \cdot 8$

$t_p = (5 + 5 + 6 + 8)\, t_{pi} = 24 t_{pi}$. Mejor, mismo retraso, no sobran ramas

Problema 3

Ex.

a)



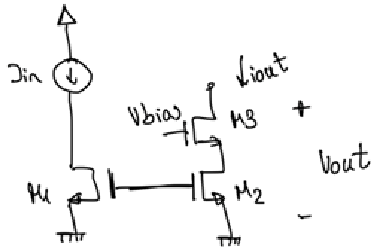
$$\frac{(W/L)_{M2}}{(W/L)_{M1}} = \frac{100\mu A}{20\mu A} = 5; \quad \left(\frac{W}{L}\right)_{M2} = 5 \cdot \left(\frac{W}{L}\right)_{M1} = 5 \cdot 10 = 50.$$

$$\hookrightarrow \boxed{\begin{array}{l} L = 100\,nm \\ W = 5\,\mu m \end{array}}$$

b) $r_{out} = \frac{1}{\lambda i_{out}} = \frac{1}{0.6 \cdot 100 \cdot 10^{-6}} = 16.67\,k\Omega.$

c) Less channel modulation $\Rightarrow \lambda\downarrow \Rightarrow r_{out}$.

d)



$$R_{out} = g_{m3}\, r_{o3}\, r_{o2}$$

$$g_{m3} = \sqrt{2 \cdot \mu_n C_{ox} \left(\frac{W}{L}\right)_3 I_{D3}} = \sqrt{2 \cdot 100 \cdot 20 \cdot 100} = 632\,\mu A/V.$$

$$r_{o3} = \frac{1}{\lambda I_{D3}} = \frac{1}{0.6 \cdot 100 \cdot 10^{-6}} = 16.67\,k\Omega.$$

$$r_{o2} = r_{o3} = 16.67\,k\Omega.$$

$$R_{out} = 175\,k\Omega.$$

e) $|A_v| = \left|\frac{V_{out}}{V_{in}}\right| = g_{m3} \cdot r_{out}$

$$g_{m3} = \sqrt{2 \mu_p C_{ox} \left(\frac{W}{L}\right) I_{D3}} = \sqrt{2 \cdot 50 \cdot 20 \cdot 100} = 447.21\,\mu A/V$$

$$r_{out} = r_{o3} \| r_{o2} = \frac{16.67}{2} = 8.3\,k\Omega.$$

$$|A_v| = 3.71\,V/V.$$