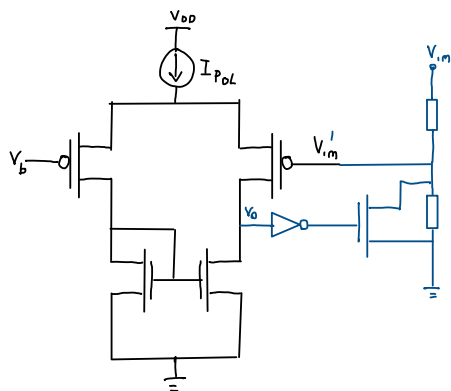


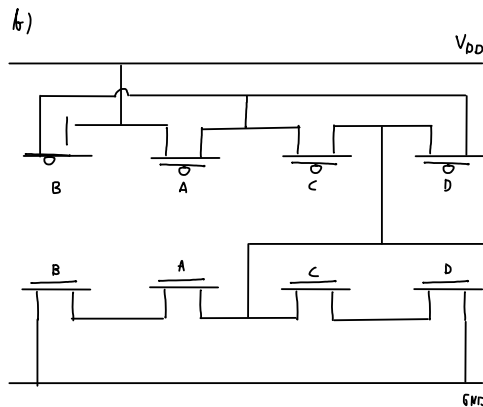
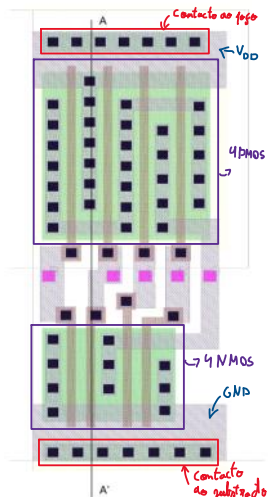
1. a) b)



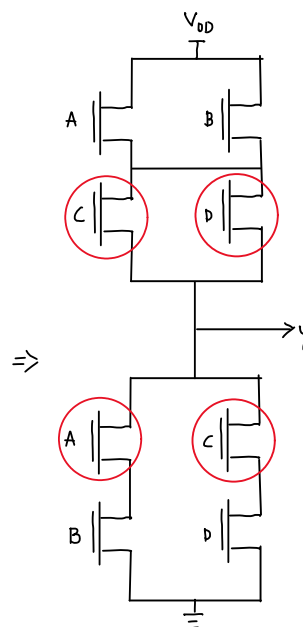
$$c) \Delta V_{th} \approx \frac{A V_{th}}{\sqrt{W \cdot L}} = 3 \text{ mV} //$$

$$V_{os} = V_{f-M_{ox}} = 3 \text{ mV}$$

2. a)



$$c) g = \overline{C \cdot D + A \cdot B}$$

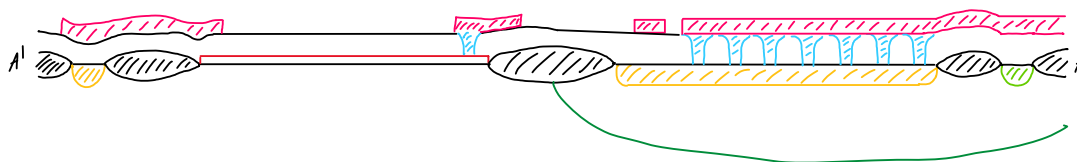


Efeito de corpo

d)

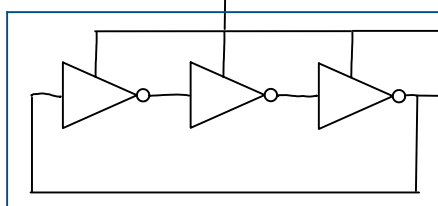
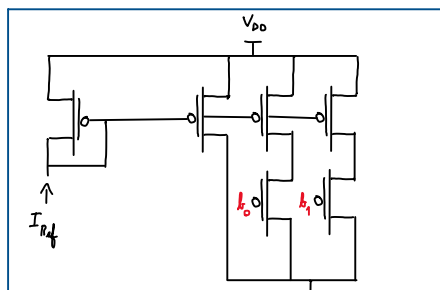
O efeito de corpo é o aumento da tensão de *threshold* com o aumento da tensão da *source* para o *bulk*. Este efeito dá-se nos transístores indicados.

e)

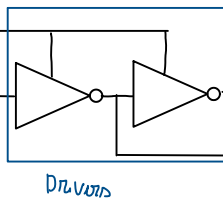


3. a)

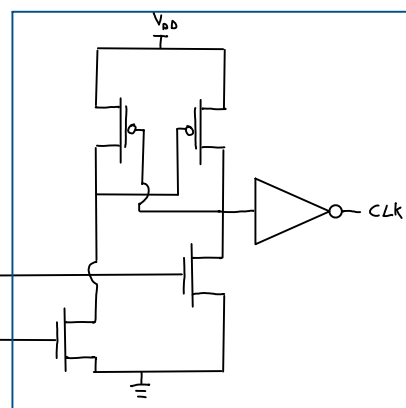
Controlo de Frequência



Divisor



Drivers



Level Converter

b) Transistores em saturação $\rightarrow V_{DD} = 200 \text{ mV}$

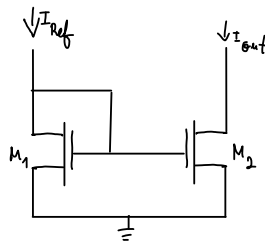
$L = 1 \mu\text{m}$ para minimizar CLM

$$I_{out} = 4 I_{Ref} \Rightarrow$$

$$I_D = \frac{\mu C_{ox}}{2} \cdot \frac{W}{L} \cdot V_{DD}^2 \Rightarrow I_{out} = \left(\frac{W}{L}\right)_{M_2} I_{Ref}$$

$$\left(\frac{W}{L}\right)_{M_2} = 4 \left(\frac{W}{L}\right)_{M_1}$$

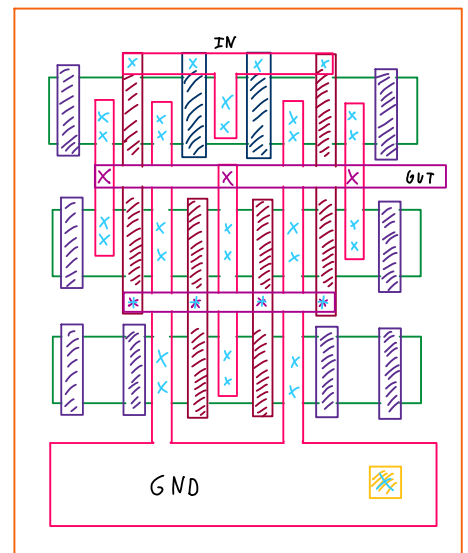
$$\left(\frac{W}{L}\right)_{M_1} = \frac{2 \cdot I_{Ref}}{\mu C_{ox}} \cdot \frac{1}{V_{DD}^2} = 0.295 \Rightarrow \left(\frac{W}{L}\right)_{M_2} = 1.176$$



Para aplicar common centroid

$N_{gates} M_1 = 2$

$N_{gates} M_2 = 8$



4) a) Este circuito permite escolher entre uma fonte de corrente NMOS ou PMOS com um bit.

M1 - M3 - M5: Espelho NMOS

M2 - M4: Espelho PMOS

M6 - M7: Switches que permitem comutar entre as fontes.

b) $M_1 - M_2 - M_3 - M_4 - M_5$: Saturação $\Rightarrow \begin{cases} V_{DD} = 200 \text{ mV} \\ L = 1 \mu\text{m} \end{cases}$

Para M_1 e M_5

$$i = C \frac{dV}{dt} \Leftrightarrow \frac{\mu C_{ox}}{2} \cdot \frac{W}{L} \cdot V_{DD}^2 = C \frac{dV}{dt} \Leftrightarrow \frac{W}{L} = \frac{2C}{\mu C_{ox}} \cdot \frac{1}{V_{DD}^2} \cdot \frac{dV}{dt}$$

Para M_2 e M_4 :

Para M_1, M_3 e

$$\left(\frac{W}{L}\right)_{M_4} = \alpha \left(\frac{W}{L}\right)_{M_1} \quad \left(\frac{W}{L}\right)_{M_3} = \beta \left(\frac{W}{L}\right)_{M_1} = \gamma \left(\frac{W}{L}\right)_{M_1}$$

$M_6 - M_7$: Switches - Dimensões mínimas

- $L = 0.35 \mu\text{m}$

- $W = 0.4 \mu\text{m}$