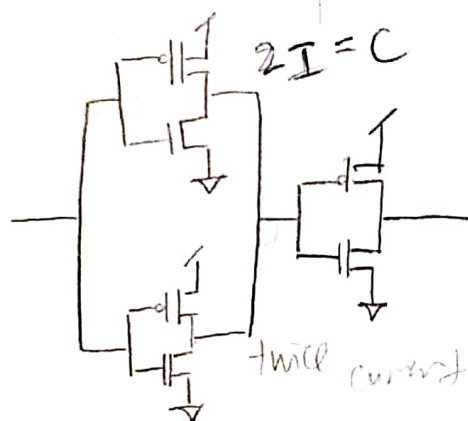


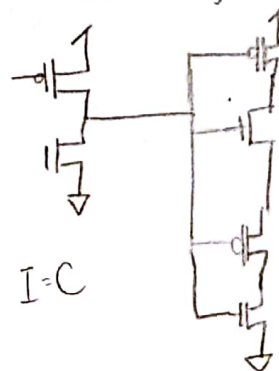
1. a) Circuit 1



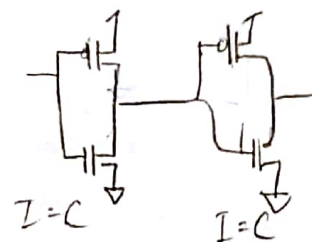
$$\tau = 2 \times N \times t_p$$

less cap is faster

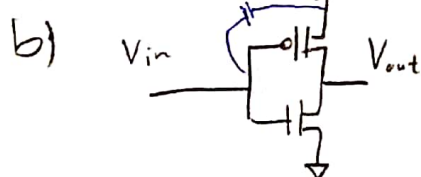
Circuit 2  $2I=C$



Circuit 3



1. a) Circuit 1 fastest  
Circuit 2 middle speed  
Circuit 3 slowest



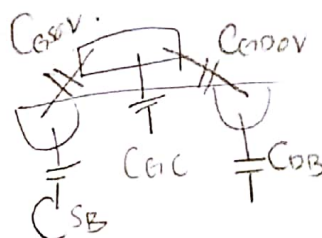
Circuit 4

c) capacitance on NMOS gate

$$C_{ox} = \epsilon_0 \cdot \frac{\epsilon_r}{t_{ox}}$$

$$= (8.854 \times 10^{-12} \text{ F/m}) \left( \frac{3.9}{8 \times 10^{-9}} \right)$$

$$C_{ox} = 0.00432$$



$$C = \frac{1}{2} C_{GSovP} + C_{GCP} + \frac{1}{2} C_{GDovP} \text{ gate} + C_{GSovN} + C_{GCN} + \frac{1}{2} C_{GDovN}$$

$$C_{GC} + C_{GSov} + C_{GDov} = C_{ox} \cdot W_N \cdot L_N + C_{Gso} \cdot W_N + C_{Gdo} \cdot W_N$$

$$= (0.00432)(0.3 \times 10^{-6} \text{ m})(100 \times 10^{-6} \text{ m})$$

$$+ (3.4 \times 10^{-10})(0.3 \times 10^{-6} \text{ m})$$

$$+ (3.4 \times 10^{-10})(0.3 \times 10^{-6} \text{ m})$$

$$\text{Cap on NMOS gate} = 1.298 \times 10^{-13} \text{ F}$$

$$\text{PMOS gate } C_{GC} + C_{GSov} + C_{GDov} = C_{ox} \cdot W_P \cdot L_P + C_{Gso} \cdot W_P + C_{Gdo} \cdot W_P$$

$$= (0.00432)(2 \times 10^{-6} \text{ m})(100 \times 10^{-6} \text{ m})$$

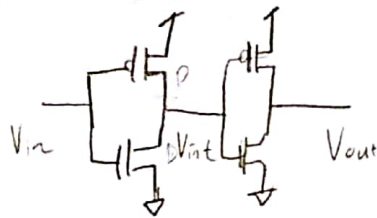
$$+ (5.3752 \times 10^{-11})(2 \times 10^{-6})$$

$$+ (5.3752 \times 10^{-11})(2 \times 10^{-6})$$

$$\text{Cap on PMOS gate} = 8.6421 \times 10^{-13} \text{ F}$$

$$V_{in} \text{ cap} = C_P + C_N = 9.939 \times 10^{-13} \text{ F}$$

1. d)



$$C = \left[ C_{GSOVP} + C_{GCP} + 2C_{GDOVP} + C_{GSOVN} + C_{GCN} + 2C_{GDOVN} \right] = C_{partC}$$

$$+ C_{GDOVP} + C_{DBP}$$

$$+ C_{GDOVN} + C_{DBN}$$

e)  $C = C_{partC} + (C_{ox} W_P L_P + C_{DBP} \cdot W_P) + (C_{ox} W_N L_N + C_{DBN} \cdot W_N)$

e)  $= C_{partC} + (0.00432)(2 \times 10^{-6} \text{m})(100 \times 10^{-6} \text{m}) + (3.365 \times 10^{-10}) \times (2 \times 10^{-6})$

$$+ (0.00432)(0.3 \times 10^{-6} \text{m})(100 \times 10^{-6} \text{m}) + (5.75 \times 10^{-10})(0.3 \times 10^{-6})$$

$$= 1.988 \times 10^{-12} \text{F}$$

f) Area (M2) 116 aF/ $\mu\text{m}^2$

20 $\mu\text{m}$  = L

2 $\mu\text{m}$  = W

$$C = \text{Area} \times C_{\text{per unit area}}$$

$$= (20 \mu\text{m})(2 \mu\text{m})(116 \text{ aF}/\mu\text{m}^2)$$

$$\boxed{C = 4640 \text{ aF}}$$

2h)  $T = 2 \times N \times t_P$  ;  $t_P = \frac{t_r + t_f}{2}$

$$= 2 \times 17 \times \left( \frac{(0.05 + 0.12) \times 10^{-9}}{2} \right)$$

$$= 2.89 \times 10^{-9} \text{sec}$$