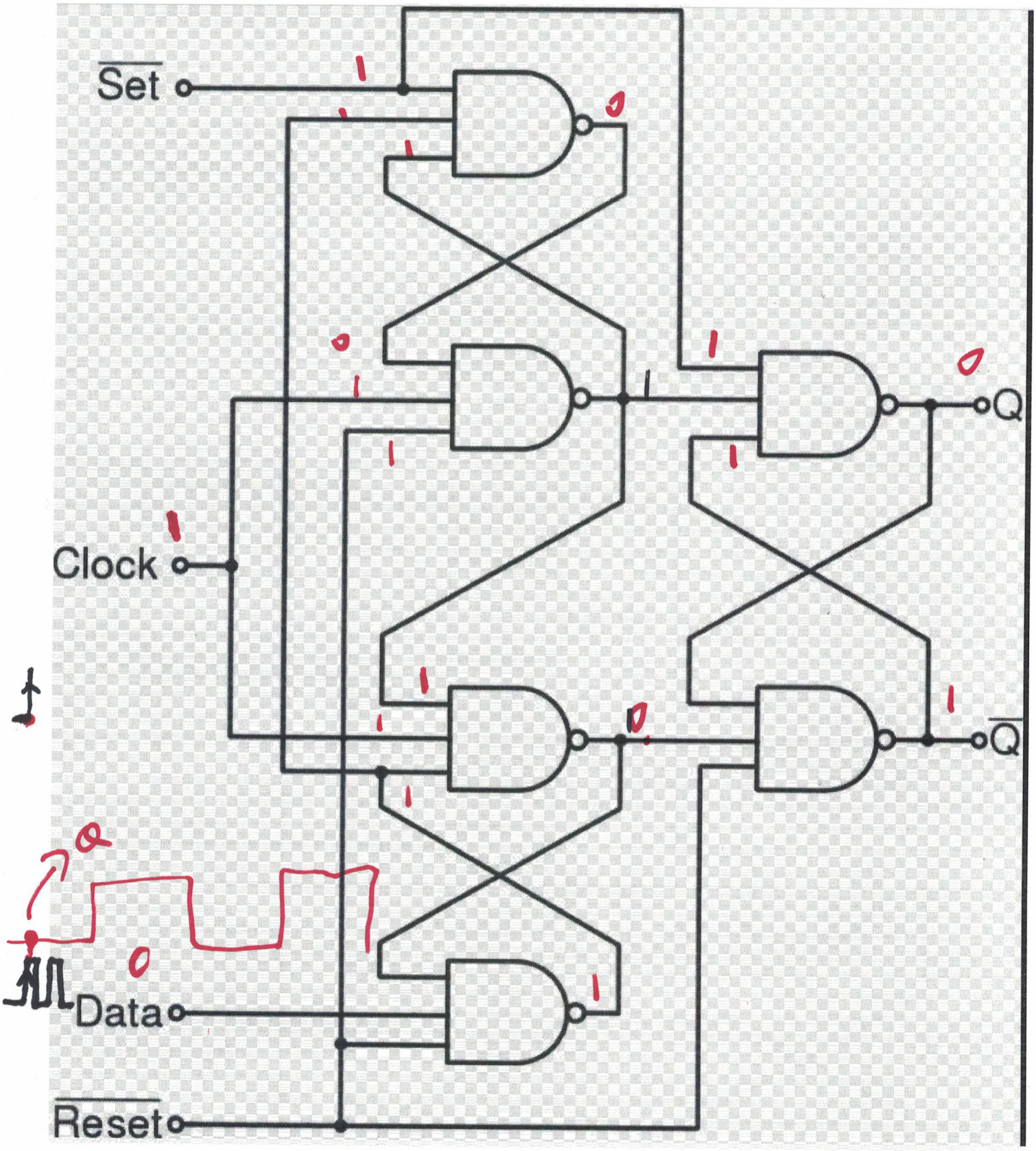
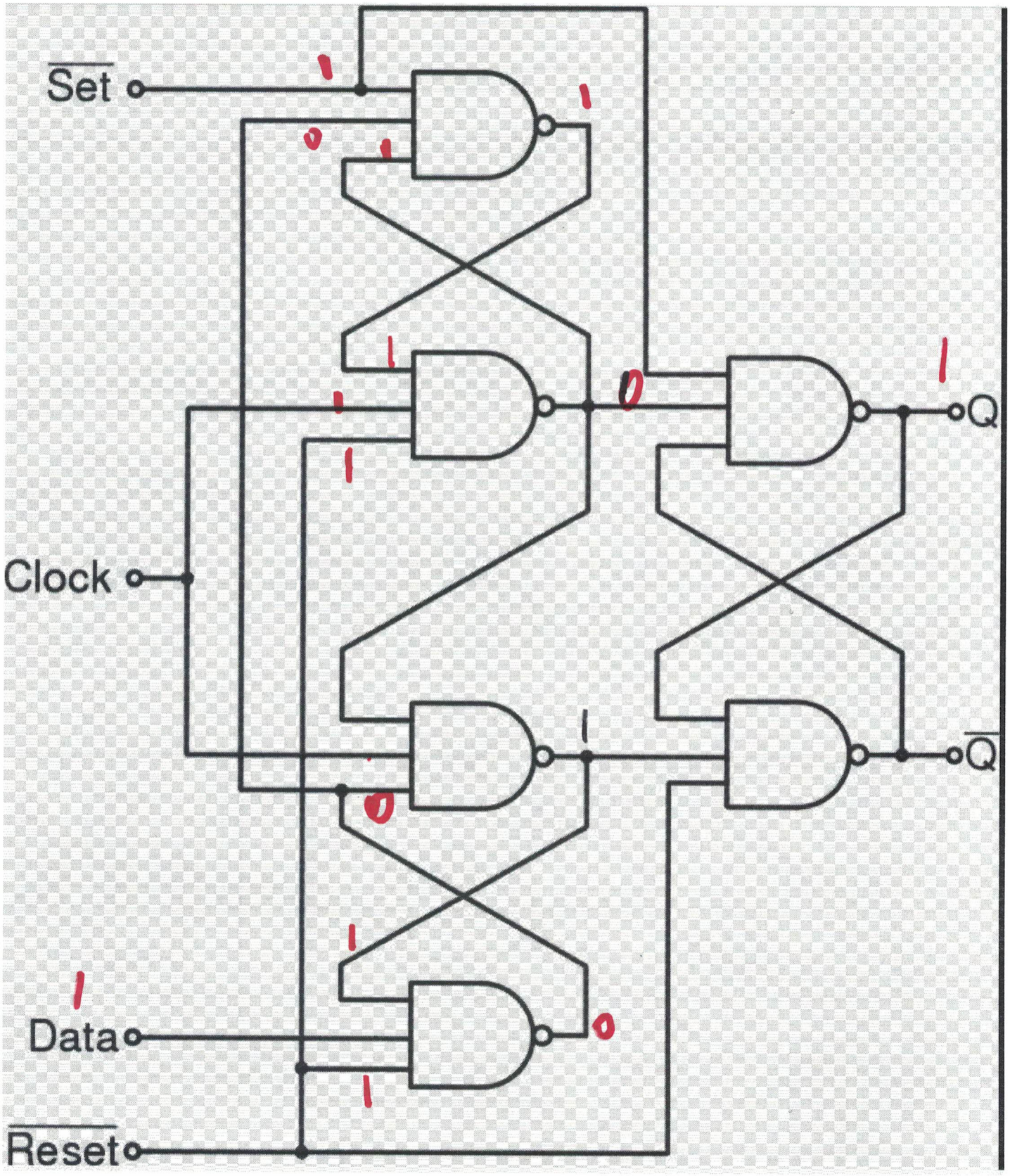
rising edge triggered, synchronous DFF



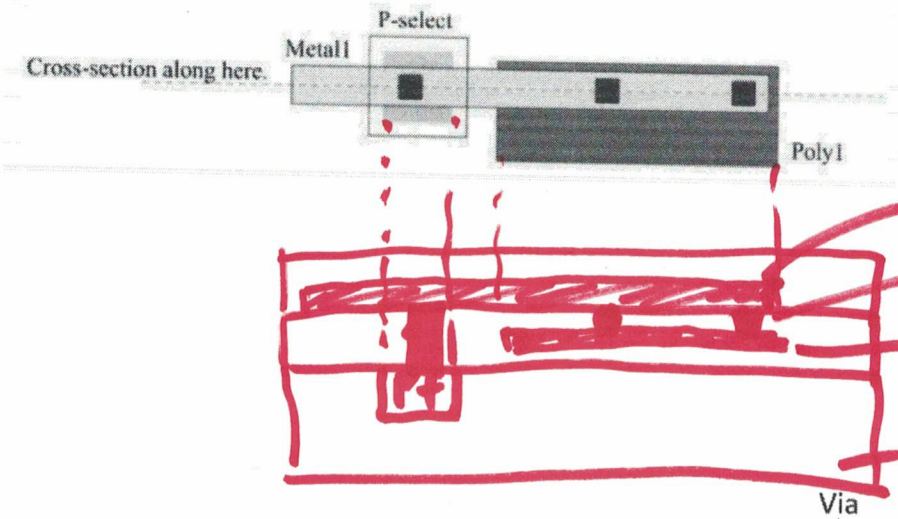

Set
Clock
Data
Reset
Q
Q

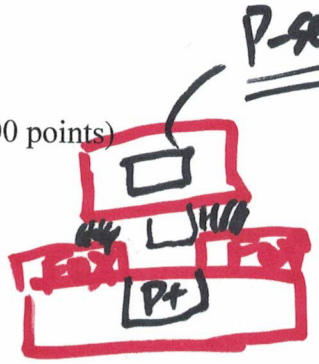
No Need to Draw Fox

ENGR338 Quiz 6

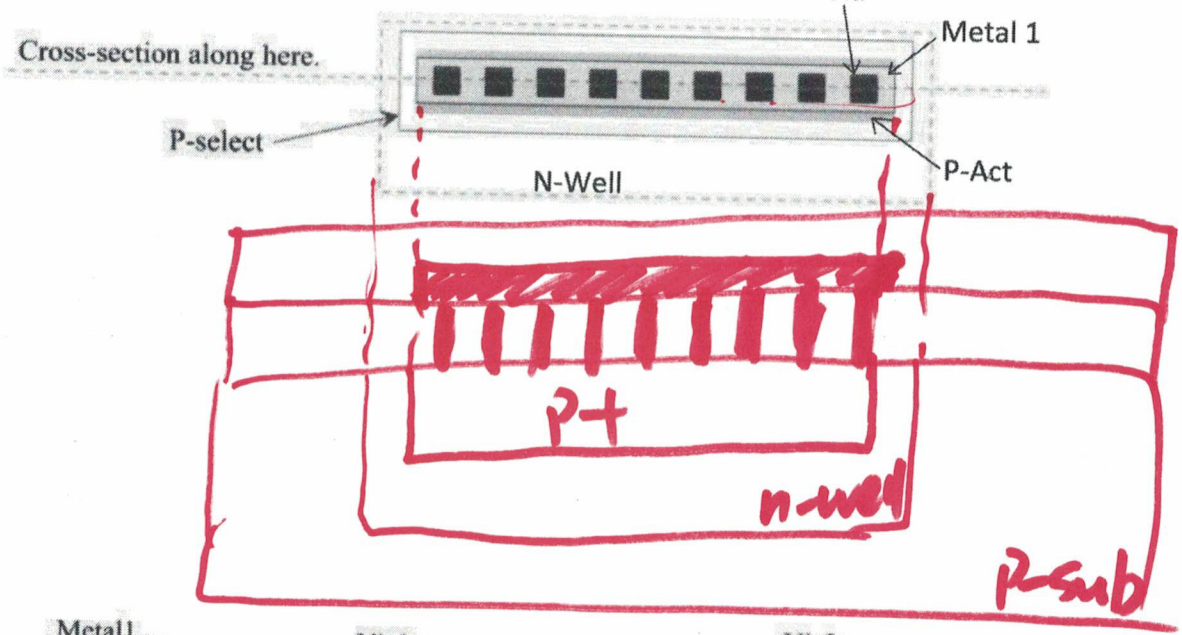
1. Sketch the cross-sectional view at the line indicated in the following figures. (100 points)

(a)

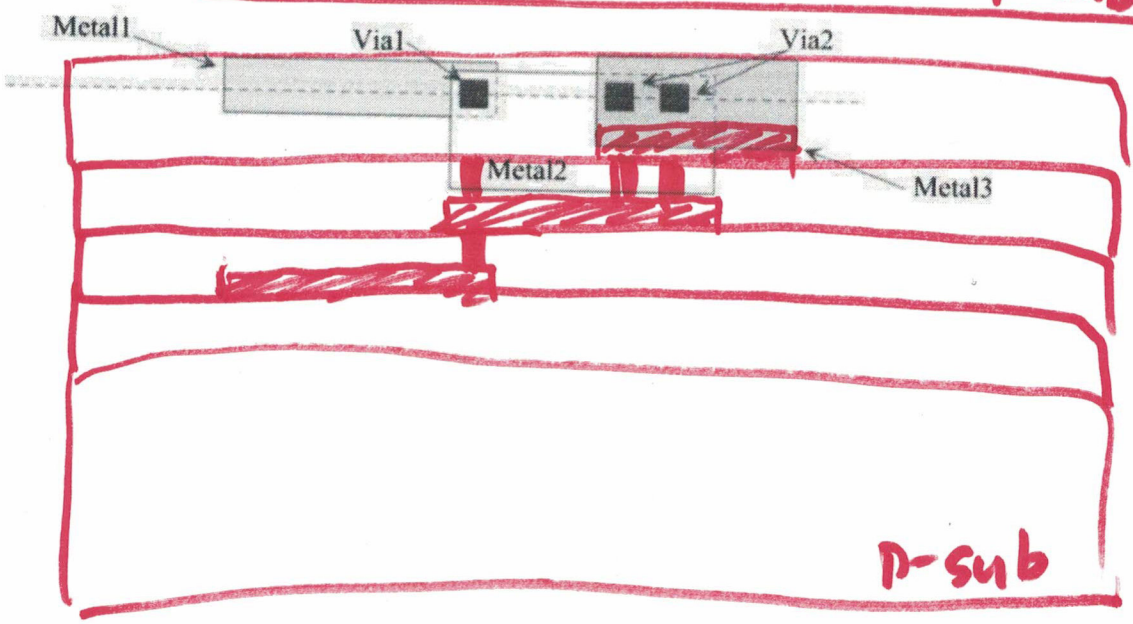


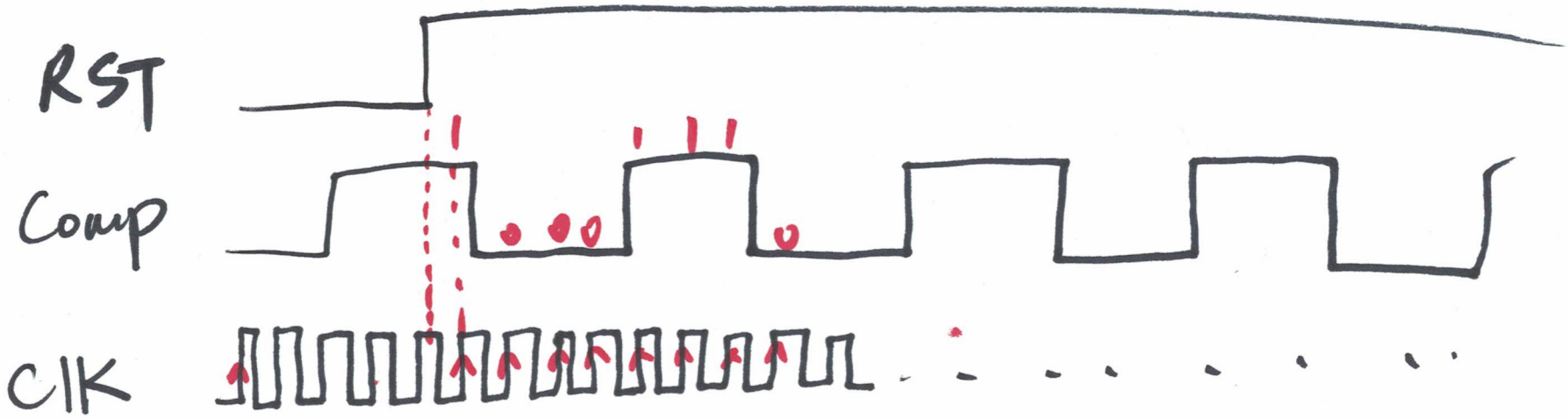


(b)



(c)



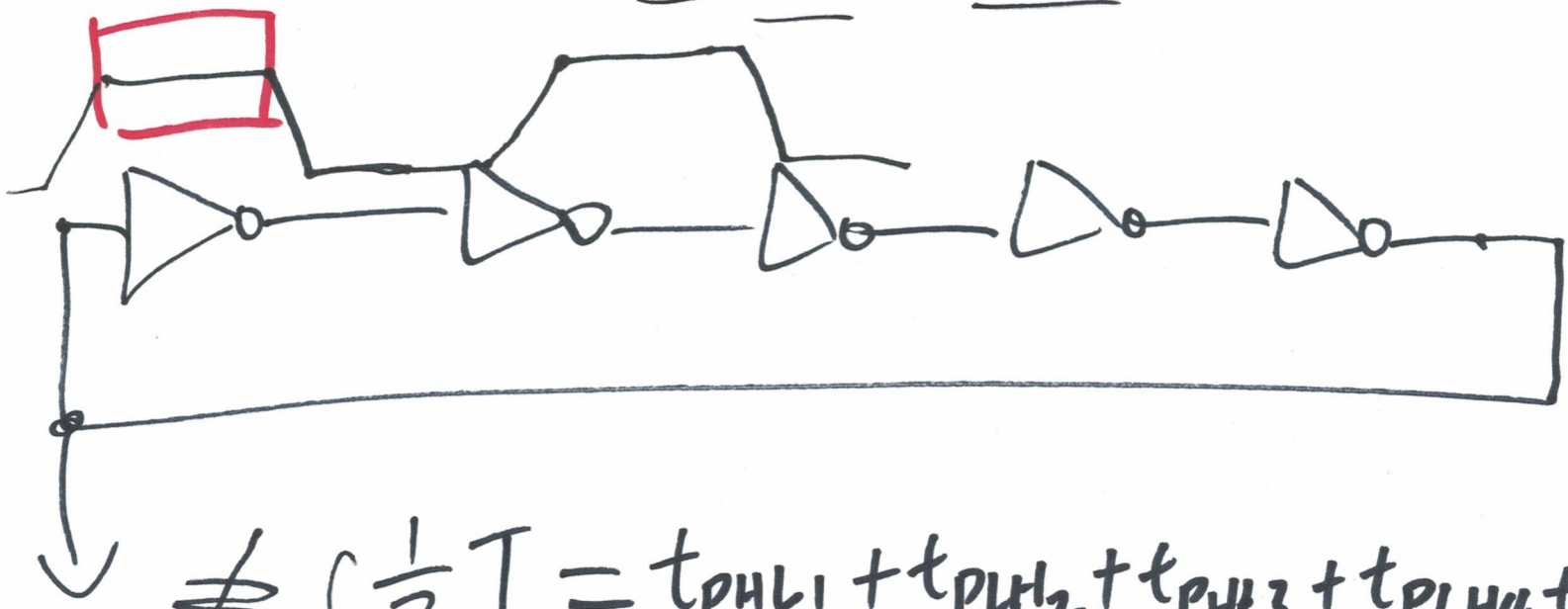


Comp = 1000 1110

The Ring Oscillator

The odd number of inverters forms a closed loop is called a ring oscillator

$$f_{osc} = \frac{1}{n(t_{PHL} + t_{PLH})}$$

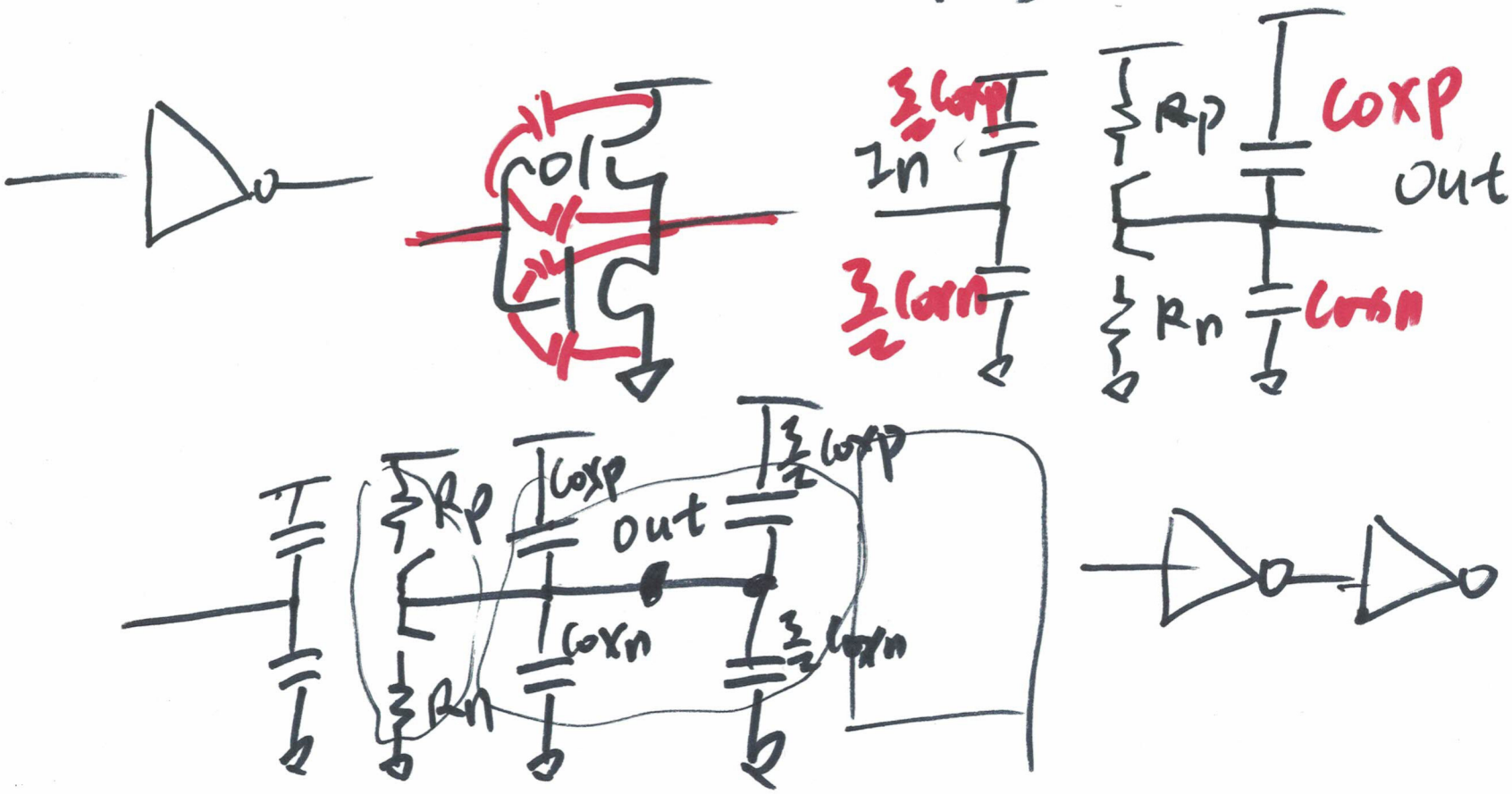


$$\nexists \begin{cases} \frac{1}{2}T = t_{PHL1} + t_{PLH2} + t_{PHL3} + t_{PLH4} + t_{PHL5} \\ \frac{1}{2}T = t_{PLH1} + t_{PHL2} + t_{PLH3} + t_{PHL4} + t_{PLH5} \end{cases}$$

$$\frac{1}{2}T + \frac{1}{2}T = T = 5 \cdot t_{pHL} + 5 \cdot t_{pLH}$$

$$= 5\,(t_{pHL} + t_{pLH})$$

$$f = \frac{1}{T} = \frac{1}{5\,(t_{pHL} + t_{pLH})}$$



$$C_{tot} = (C_{oxp} + C_{oxn}) + \frac{3}{2}(C_{oxp} + C_{oxn})$$

$$= \frac{5}{2}(C_{oxp} + C_{oxn})$$

$$t_{pHL} + t_{pLH} = 0.7(R_n + R_p) C_{tot}$$

Example:

Estimate the fosc of a 11-stage ring oscillator.

NMOS: $R_n = 3.4K$, $C_{oxn} = 0.625fF$

PMOS: $R_p = 3.4K$, $C_{oxp} = 1.25fF$

$$C_{tot} = \frac{5}{2}(C_{oxn} + C_{oxp}) = \frac{5}{2}(0.625f + 1.25f)$$

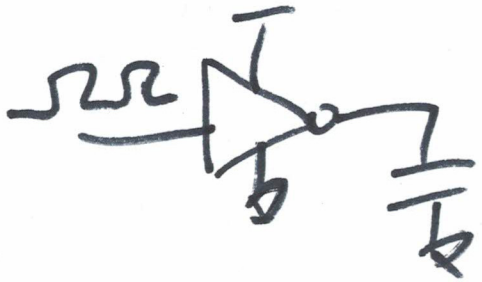
$$= 4.7f$$

$$t_{pLH} + t_{pHL} = 0.7(3.4K + 3.4K) \times 4.7f = 22ps$$

$$f_{OSC} = \frac{1}{n(t_{PHL} + t_{PLH})} = \frac{1}{11 \cdot 22ps}$$

$$= 4.16\,GHz$$

Dynamic Power Dissipation



$$I_{avg} = \frac{Q_{tot}}{t} = \frac{V_{dd} \cdot C_{tot}}{t}$$

$$P_{avg} = V_{dd} \cdot I_{avg}$$

$$= \frac{V_{dd}^2 \cdot C_{tot}}{t}$$

$$= V_{dd}^2 \cdot C_{tot} \cdot f_{clk}$$

Power dissipation is a function of:

clk frequency, power supply, load Capacitance