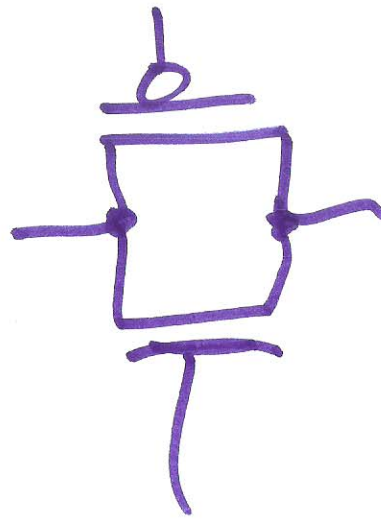


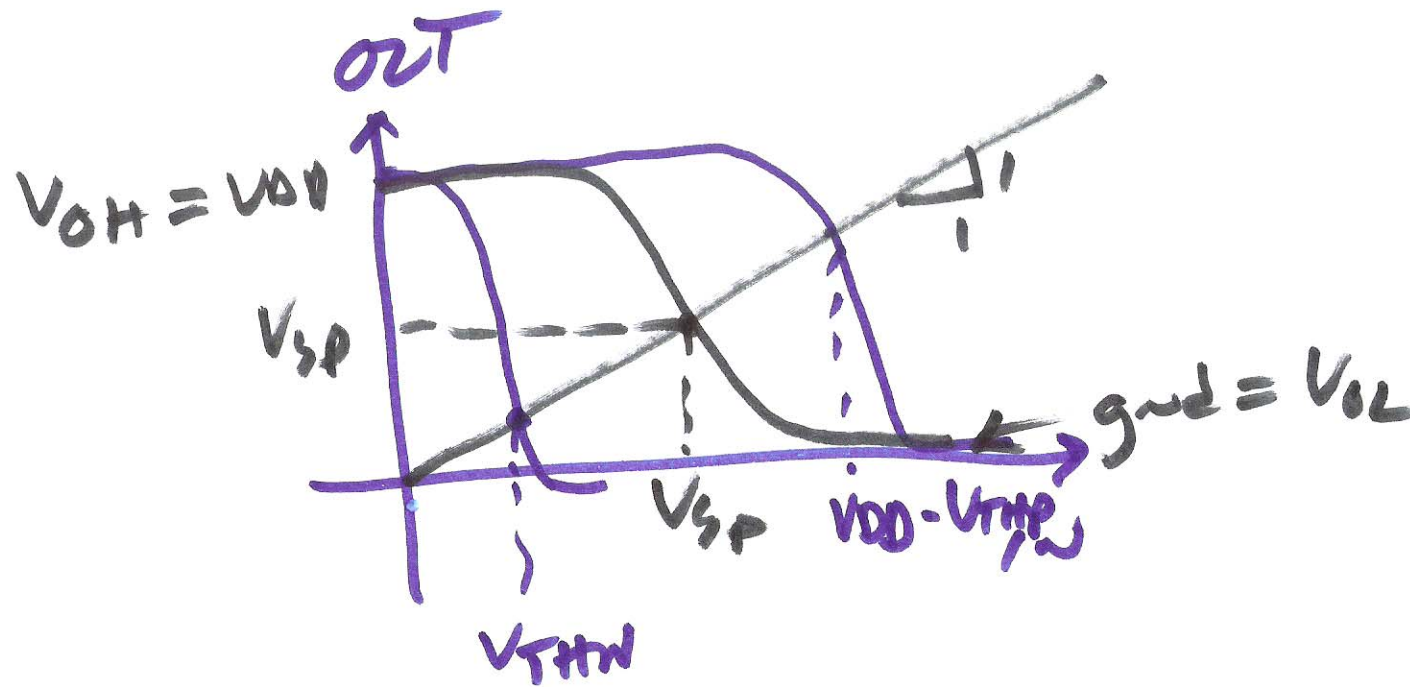
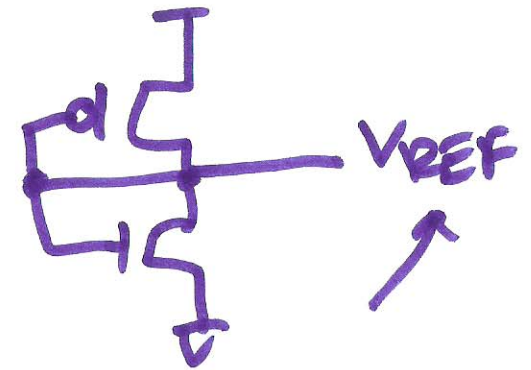
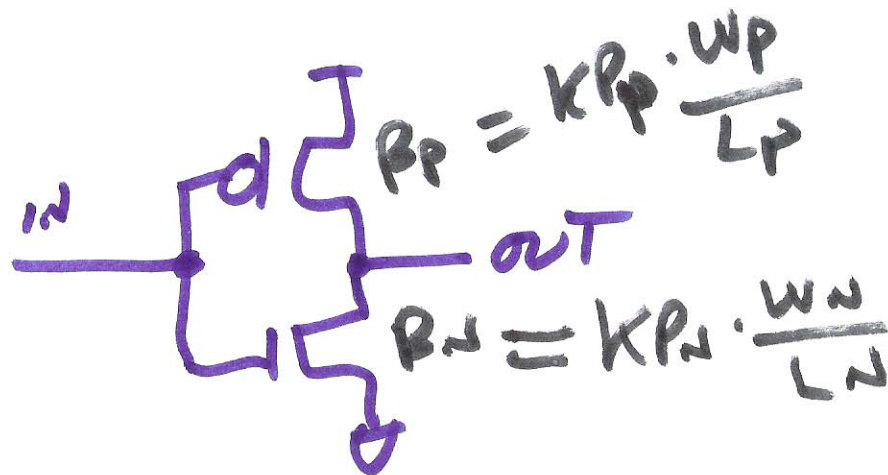
EE 421 ECG 621
CMOS Digital IC Design
Lecture 20
NOV. 6, 2013

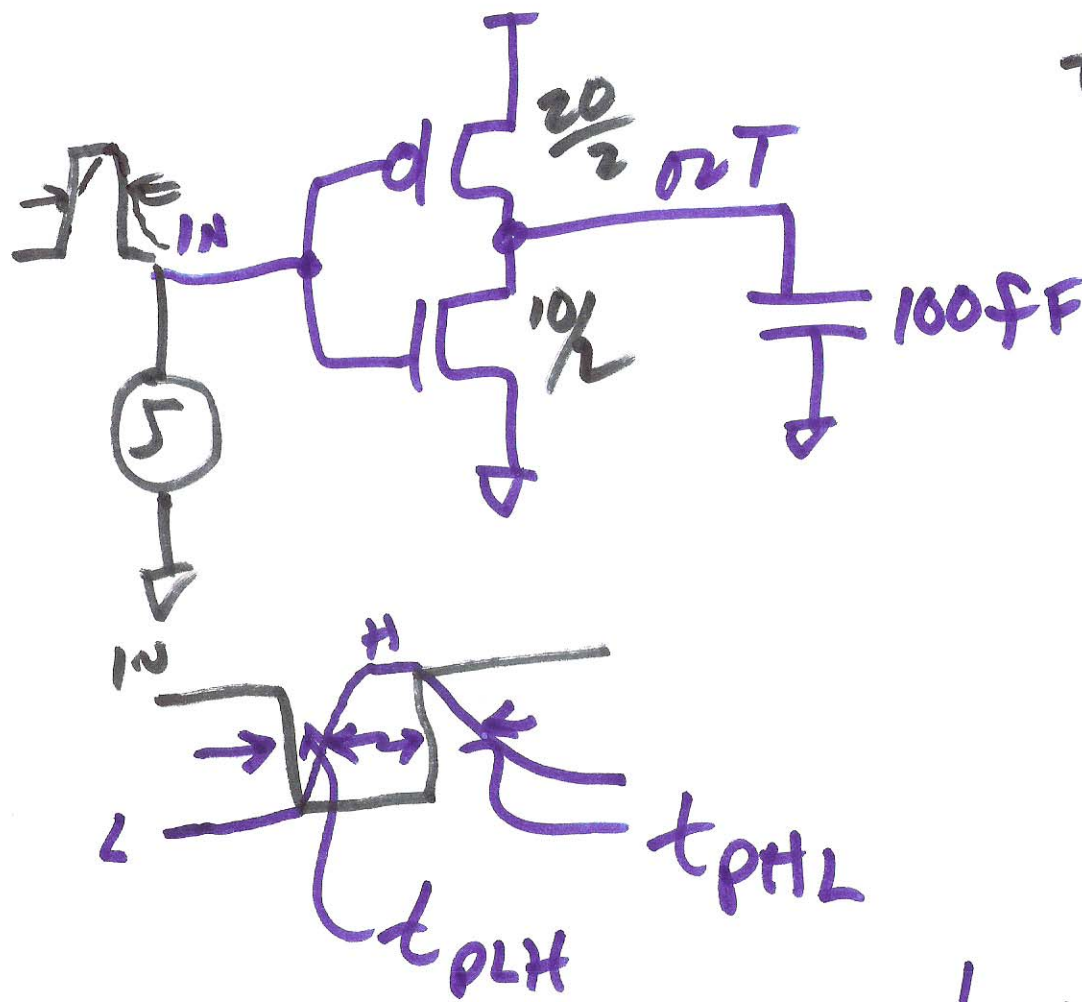


vdd



gnd





$$t_{PLH} = 0.7 R_p \cdot 100fF$$

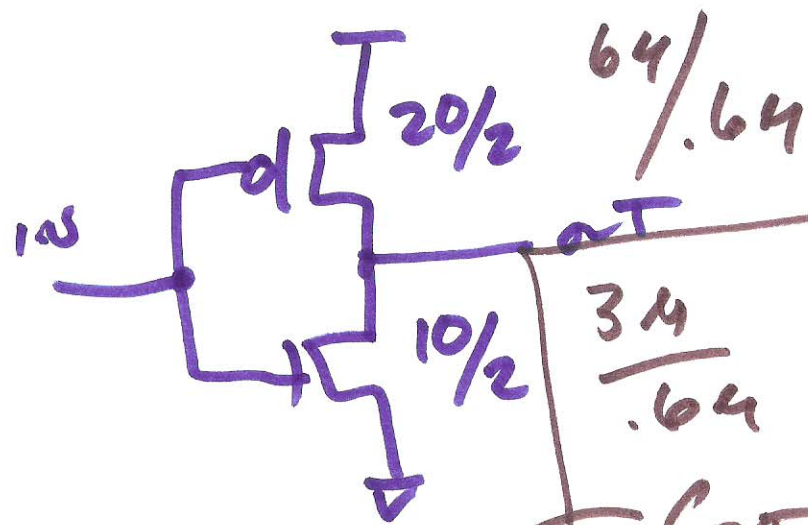
$$t_{PHL} = 0.7 \cdot R_n \cdot 100fF$$

$$R_n = R_n' \cdot \frac{L}{W} = 20K \cdot \frac{2}{10} = \underline{\underline{4K}}$$

$$R_p = \underline{\underline{4K}}$$

$$280ps$$

$$t_{PHL} = t_{PLH} = \underline{\underline{280ps}}$$



$$t_{PLH} = 0.7 R_D \cdot (C_L + 13.5 \text{ ff})$$

$$t_{PHL} = 0.7 R_N \cdot (C_L + 13.5 \text{ ff})$$

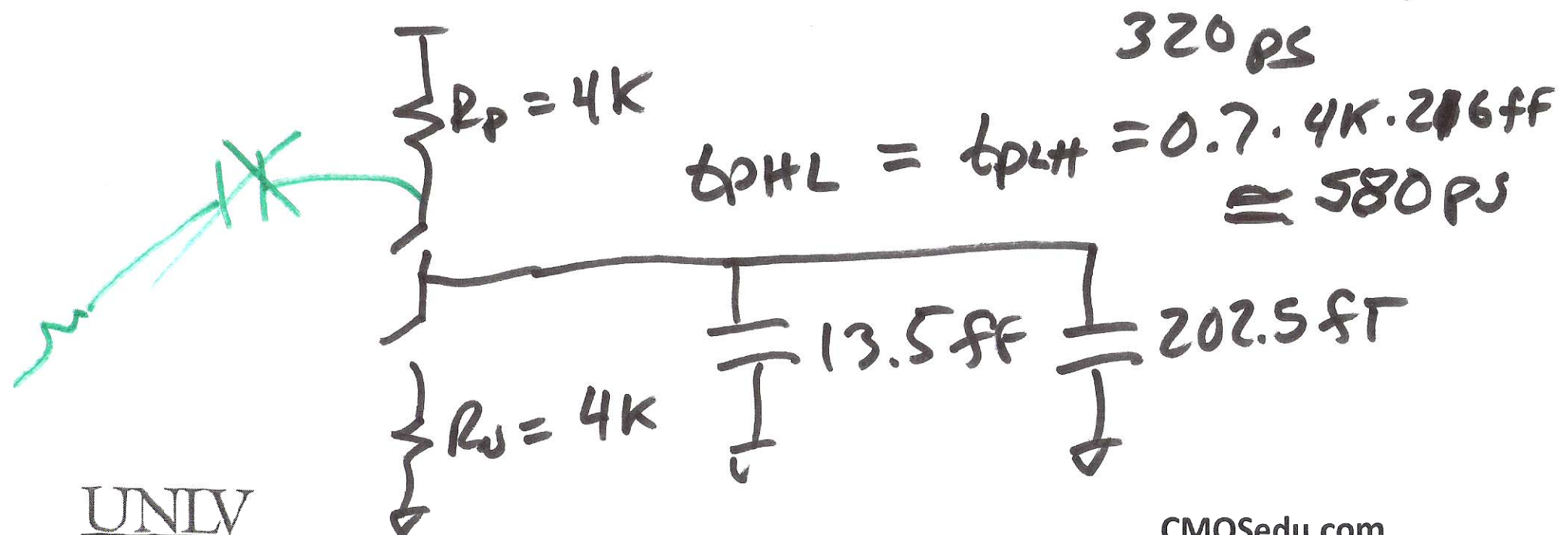
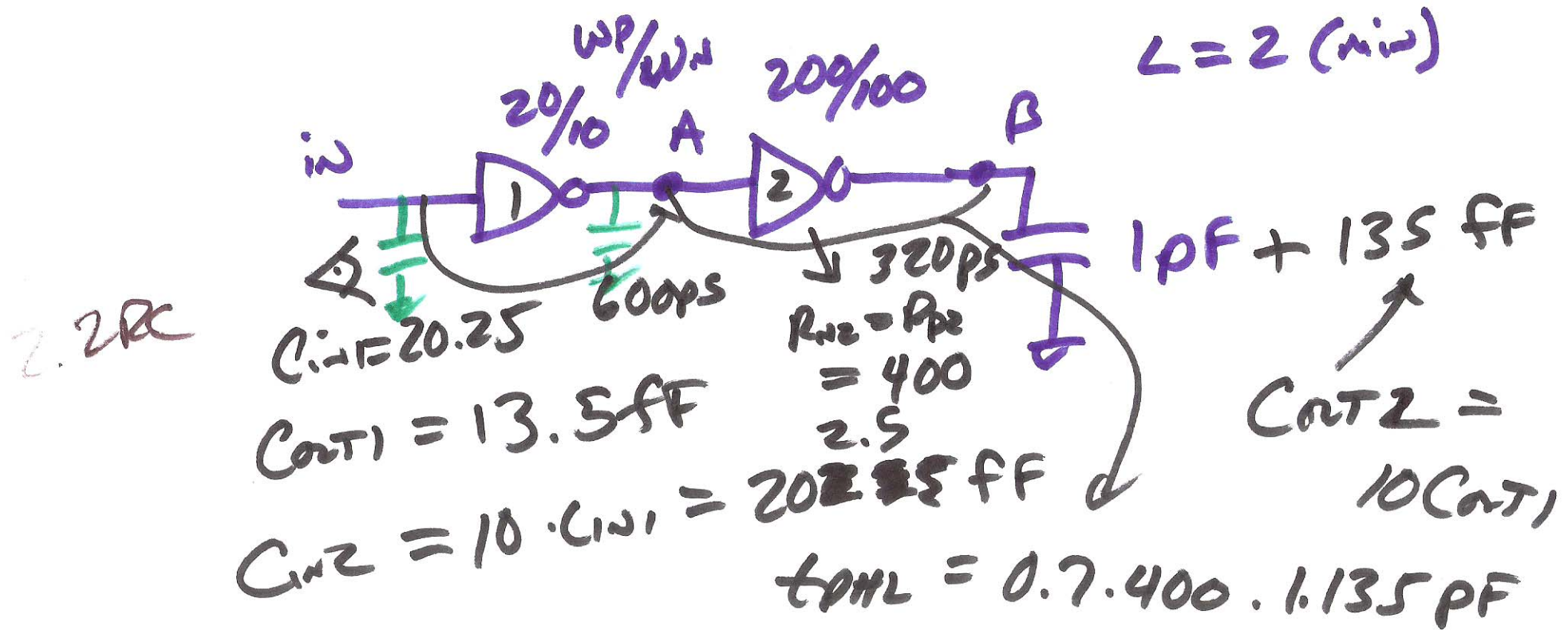
$$C_{out} = C_{ox} W_N L_N + C_{ox} W_P L_P = \frac{2}{3} C_{in} = 13.5 \text{ ff}$$

$$C_{in} = \frac{3}{2} C_{ox} \cdot W_N L_N + \frac{3}{2} C_{ox} \cdot W_P L_P = 1.5 \cdot 2.5 \text{ ff} \left(\frac{1.8 \mu\text{m}^2 + 3.6 \mu\text{m}^2}{\mu\text{m}^2} \right)$$

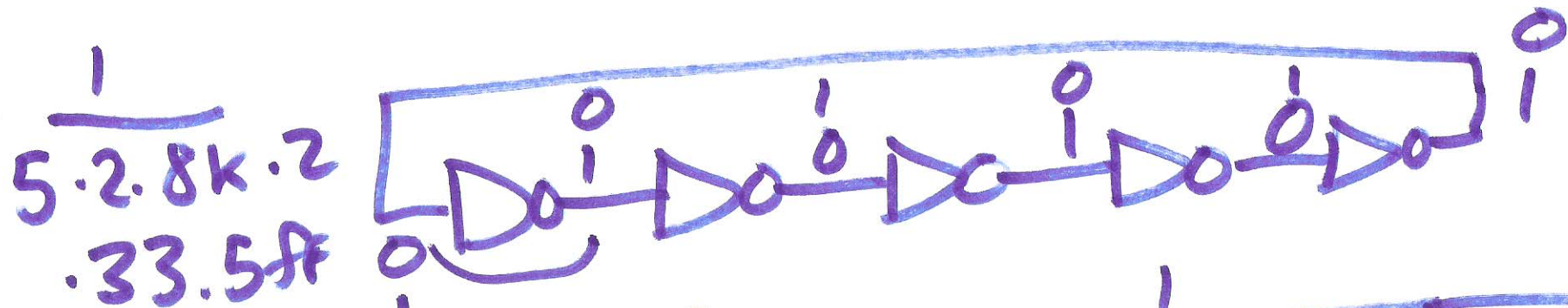
$$t_{PHL} = t_{PLH} =$$

$$0.7 \cdot 4 \text{ k} \cdot 23.5 \text{ ff} = 1.5 \cdot 2.5 \cdot 5.4 \text{ ff} = 20.25 \text{ ff}$$

$$= 70 \text{ ps}$$



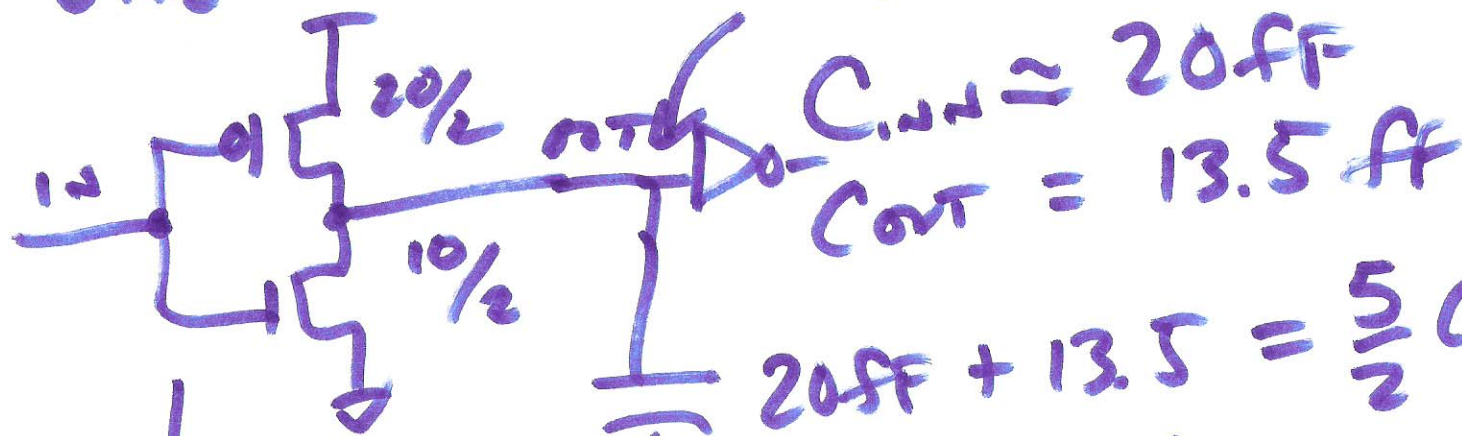
Ring Oscillator



$$f_{osc} = \frac{1}{N \cdot (t_{pHL} + t_{pLH})}$$

33.5f

$$= 1.066 \text{ GHz}$$



$$f_{osc} = \frac{1}{5 \cdot 0.7 \cdot 4k(33.5) \cdot \frac{1}{2}}$$

$$20fF + 13.5 = \frac{5}{2} C_{ox} \cdot (V_{NLD} + V_{PLP})$$