

4.10

P.3

(4.41)

CMOS inverter  
matched MOSFETs

$$V_t = 1V$$

Find  $V_{IL}$ ,  $V_{IH}$ ,  $NM$ when  $V_{DD} = 5V$ 

$$V_{IL} = \frac{1}{8}(3V_{DD} + 2V_t)$$

$$= \frac{1}{8}(3 \times 5 + (2)(1))$$

$$V_{IL} = 2.125V$$

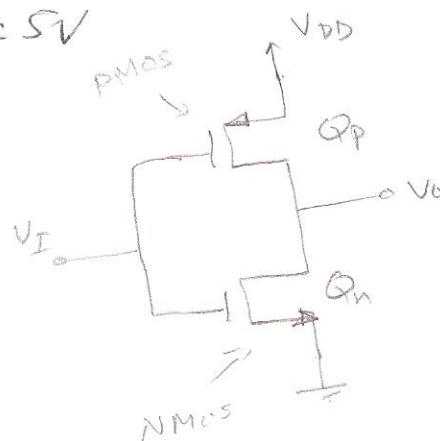
$$V_{IH} = \frac{1}{8}(5V_{DD} + 2V_t)$$

$$= \frac{1}{8}(5 \times 5 - (2)(1))$$

$$V_{IH} = 2.875V$$

$$NM_L = NM_H = \frac{1}{8}(3V_{DD} + 2V_t)$$

$$NM = 2.125V$$

P.4

CMOS inverter

$$V_{DD} = 5V$$

4.45

$$\left(\frac{W}{L}\right)_n = \frac{10}{5}$$

$$\left(\frac{W}{L}\right)_p = \frac{20}{5}$$

$$V_{tn} = |V_{tp}| = 1V$$

$$\mu_n C_{ox} = 2\mu_p C_{ox} = 20 \mu A/V^2$$

$$C_L = 0.1 pF$$

total effective load capacitance

Find

$$t_{PHL}, t_{PLH}, t_p$$

$$\text{Since } V_t \approx 0.2V_{DD}$$

$$\Rightarrow t_{PHL} = \frac{1.6C}{k'_n \left(\frac{W}{L}\right)_n V_{DD}}$$

$$= \frac{(1.6)(0.1 \times 10^{-12})}{2 \times 10^{-6} \times 2 \times 5} = 0.8 \times 10^{-9} \text{ Sec}$$

(4)

$$t_{PLH} \approx \frac{1.6C}{k'_p \left(\frac{W}{L}\right)_p V_{DD}}$$

$$= \frac{1.6 \times 0.1 \times 10^{-12}}{10 \times 10^{-6} \times 4 \times 5}$$

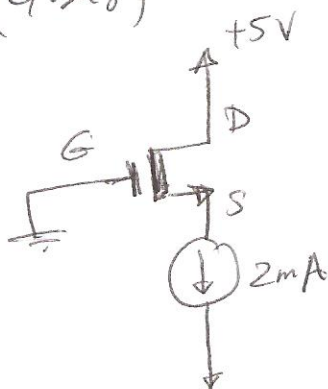
$$t_{PLH} = 0.8 \text{ nsec}$$

$$t_p = \frac{t_{PHL} + t_{PLH}}{2}$$
$$= \frac{0.8 \times 10^{-9} + 0.8 \times 10^{-9}}{2}$$

$$t_p = 0.8 \times 10^{-9} \text{ sec}$$

propagation delay

P.4 (4.48)



D-MOSFET

$$k'_n \frac{W}{L} = 4 \text{ mA/V}^2$$

$$V_t = -2 \text{ V}$$

$$I_{DSS} ?$$

$$I_{DSS} = \frac{1}{2} k'_n \frac{W}{L} V_t^2$$
$$= \frac{1}{2} (4 \times 10^{-3}) (4)$$

(drain current in saturation with  $V_{GS}=0$ )

$$I_{DSS} = 8 \text{ mA}$$

Find  $V_s = ?$  in saturation

$$V_{GS} = \sqrt{\frac{2I_D}{k'_n \frac{W}{L}}} - V_t$$

$$= \sqrt{\frac{2 \times 2 \times 10^{-3}}{4 \times 10^{-3}}} - 2 = -1 \text{ V}$$

$$\Rightarrow V_s = 1 \text{ V}$$