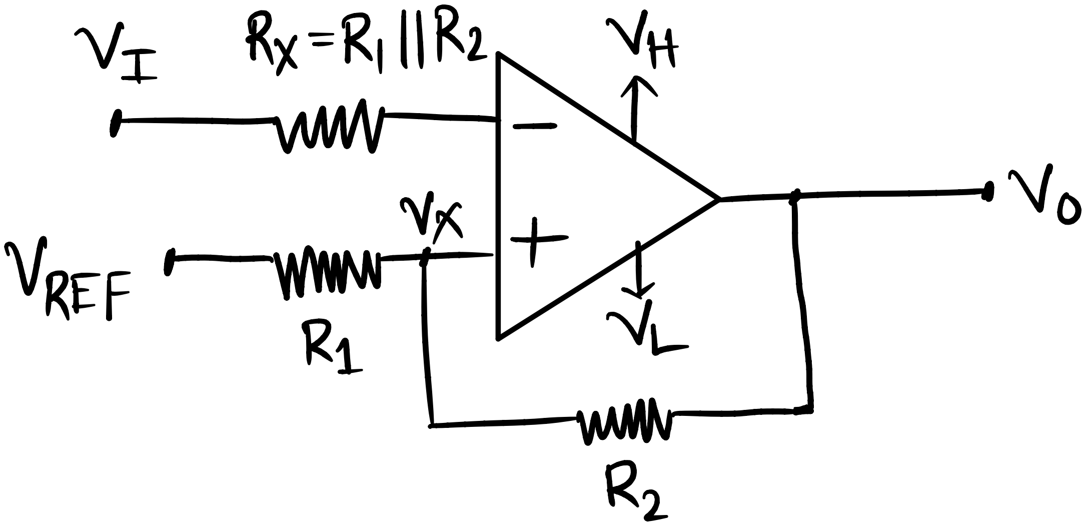
1.



Specification: $V_{REF} = 4V$, $V_H = 10V$, $V_L = -5V$

$R_1 = 3k\Omega$, $R_2 = 6k\Omega$

Question: What type of Schmitt Trigger is this?

Determine R_X, V_{TH}, V_{TL},

Hysteresis width, Draw VTC (V_o vs V_{in})

Solution: This is inverting Schmitt Trigger

$$R_X^{-1} = R_1^{-1} + R_2^{-1}$$

$$\Rightarrow R_X^{-1} = (3k\Omega)^{-1} + (6k\Omega)^{-1}$$

$$\Rightarrow R_X = 2\,k\Omega$$

$$V_{TH} = V_{REF}\frac{R_2}{R_1+R_2} + V_H\frac{R_1}{R_1+R_2}$$

$$= 4\frac{6}{3+6} + 10\frac{3}{3+6}$$

$$= 6\ V$$

$$V_{TL} = V_{REF}\frac{R_2}{R_1+R_2} + V_L\frac{R_1}{R_1+R_2}$$

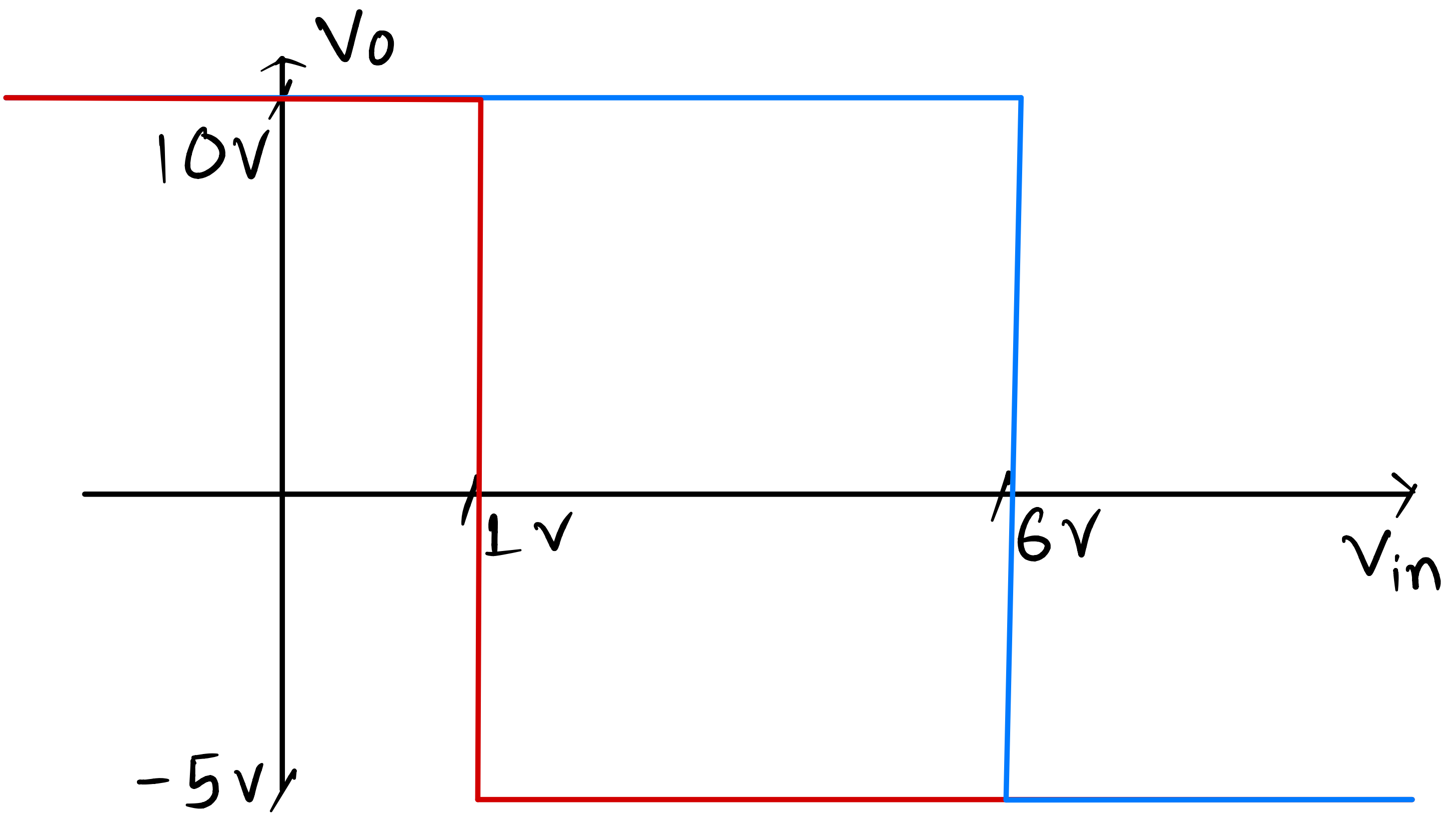
$$= 4\frac{6}{3+6} + (-5)\frac{3}{3+6}$$

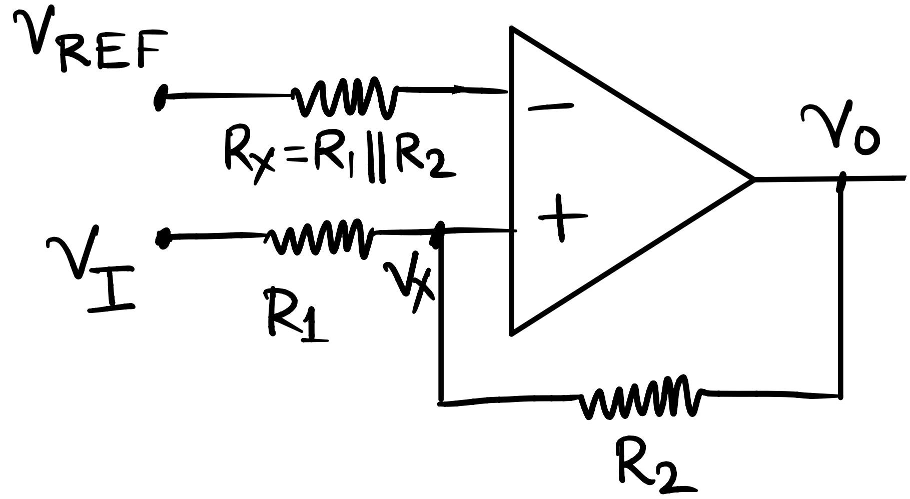
$$= 1\ V$$

$$\text{Hysteresis width} = V_{TH} - V_{TL}$$

$$= 6 - 1$$

$$= 5\ V$$



2. 

Given, Hysteresis width $= 14\ V$, $R_x = 3.5\ k\Omega$

Case 1 : $V_{REF} = 2\ V$ and V_I is very low (large negative voltage), $V_x = 2\ V$

Case 2 : $V_{REF} = 4\ V$ and V_I is very high (large positive voltage), $V_x = 25\ V$

Question : What type of Schmitt Trigger is this? Find R_1 and R_2, V_H and V_L

<u>Solution</u> : This is a non-inverting Schmitt Trigger

Hysteresis width

$$\Rightarrow V_{TH} - V_{TL} = \left(-\frac{R_1}{R_2}\right)V_L - \left(-\frac{R_1}{R_2}\right)V_H$$

$$\Rightarrow 14 = (V_L - V_H)\left(-\frac{R_1}{R_2}\right)$$

We know,

$$V_{TH} = V_{REF}\left(\frac{R_1+R_2}{R_2}\right) + \left(-\frac{R_1}{R_2}\right)V_L$$

$$V_{TL} = V_{REF}\left(\frac{R_1+R_2}{R_2}\right) + \left(-\frac{R_1}{R_2}\right)V_H$$

Case 1: $25 = 4\,\frac{R_1+R_2}{R_2} + \left(-\frac{R_1}{R_2}\right)V_L \quad \cdots \text{(i)}$

Case 2: $2 = 2\,\frac{R_1+R_2}{R_2} + \left(-\frac{R_1}{R_2}\right)V_H \quad \cdots \text{(ii)}$

$\text{(i)} - \text{(ii)} \Rightarrow 23 = 2\,\frac{R_1+R_2}{R_2} + (V_L - V_H)\left(-\frac{R_1}{R_2}\right)$

$$\Rightarrow \frac{23-14}{2} = \frac{R_1+R_2}{R_2}$$

$$\Rightarrow 4.5 = \frac{R_1+R_2}{R_2}$$

$$\Rightarrow 3.5 = \frac{R_1}{R_2}$$

$$\Rightarrow R_1 = 3.5 R_2$$

$$= 7\text{ k}\Omega$$

$$\frac{1}{R_X} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{3.5\text{ k}} = \frac{1}{3.5R_2} + \frac{1}{R_2}$$

$$\Rightarrow R_2 = \frac{3.5\text{k}}{3.5} + 1$$

$$\Rightarrow R_2 = 2\text{ k}\Omega$$

(i) $$25 = 4\,\frac{R_1 + R_2}{R_2} + \left(-\frac{R_1}{R_2}\right) v_L$$

$$\Rightarrow 25 = 4\,\frac{7+2}{2} + \left(-\frac{7}{2}\right) v_L$$

$$\Rightarrow v_L = (25 - 18)\left(-\frac{2}{7}\right)$$

$$= -2\,V$$

(ii) $$2 = 2\,\frac{R_1 + R_2}{R_2} + \left(-\frac{R_1}{R_2}\right) v_H$$

$$\Rightarrow 2 = 2\,\frac{7+2}{2} + \left(-\frac{7}{2}\right) v_H$$

$$\Rightarrow v_H = (2-9)\left(-\frac{2}{7}\right)$$

$$= +2\,V$$

3. Implement the boolean function

$Y = \overline{AB} + C$ with CMOS Logic

Solution: $Z = \overline{Y} = \overline{\overline{AB}+C}$

Pull down

$\overline{Z} = \overline{\overline{\overline{AB}+C}}$

$\overline{Z} = \overline{AB}+C$

$= \overline{A}+\overline{B}+C$

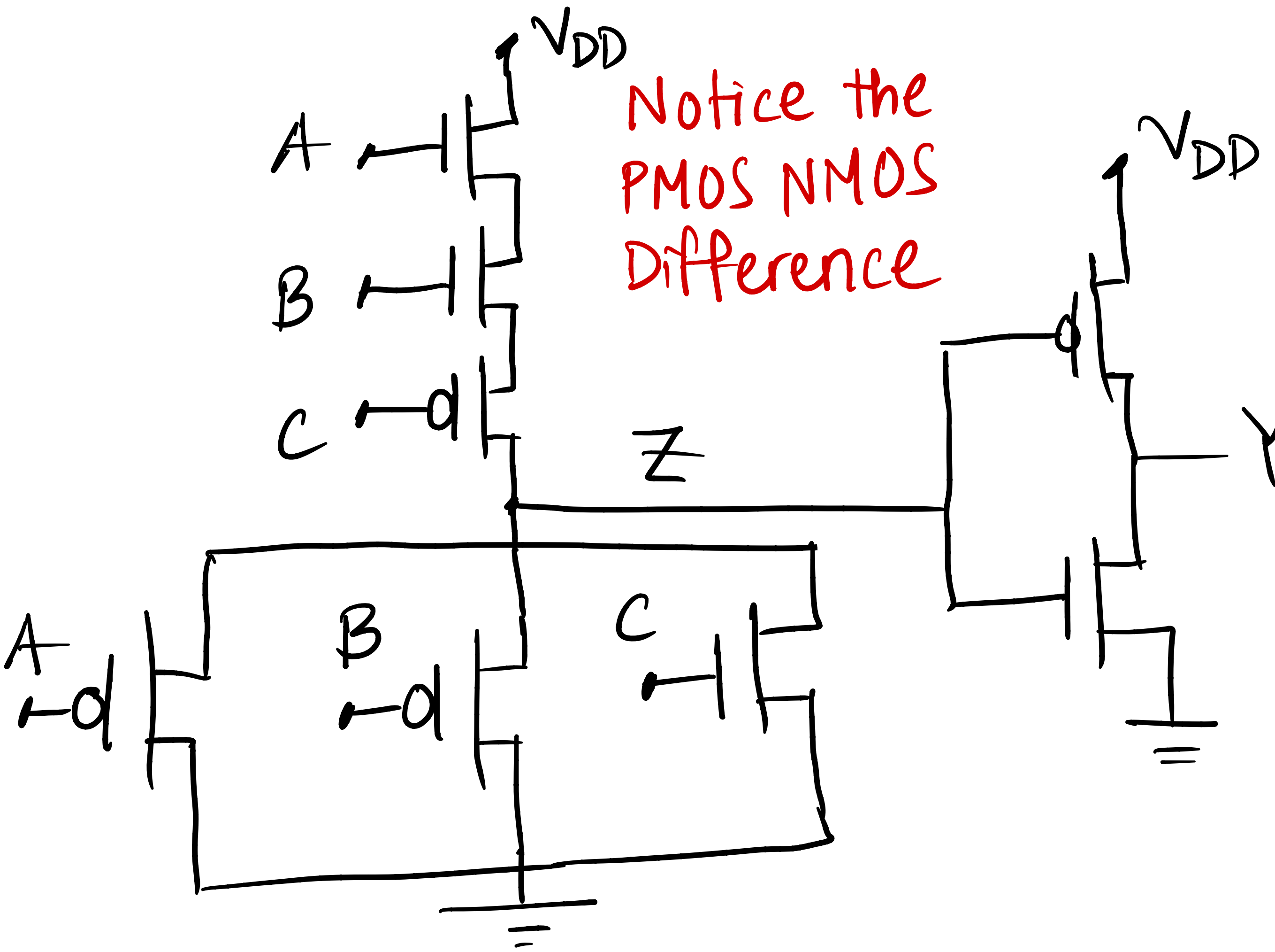
Pull up

$Z = \overline{\overline{AB}+C}$

$= \overline{\overline{AB}} \cdot \overline{C}$

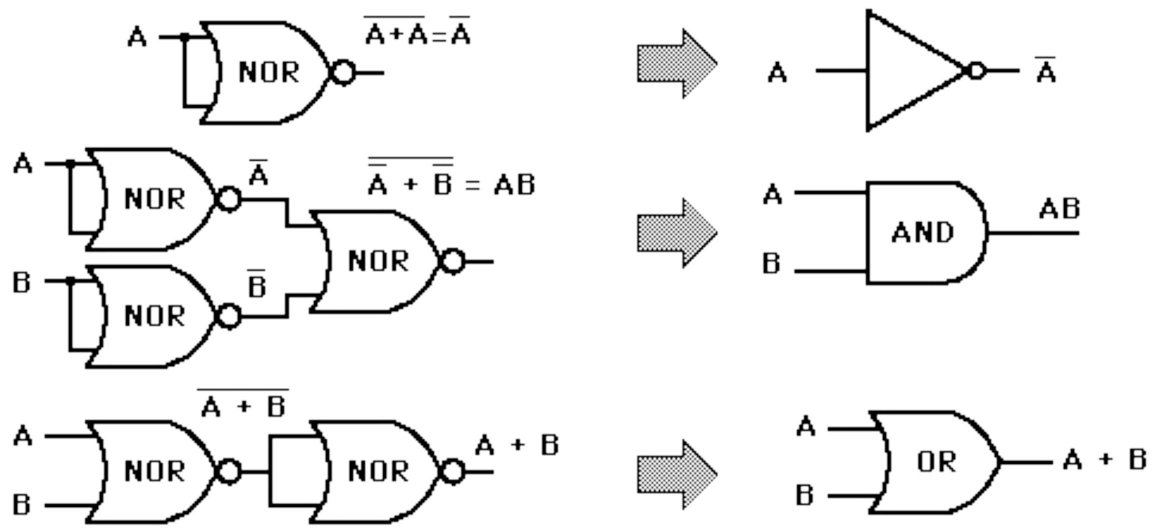
$= AB \cdot \overline{C}$

Individual input with bars are PMOS and without bars are NMOS



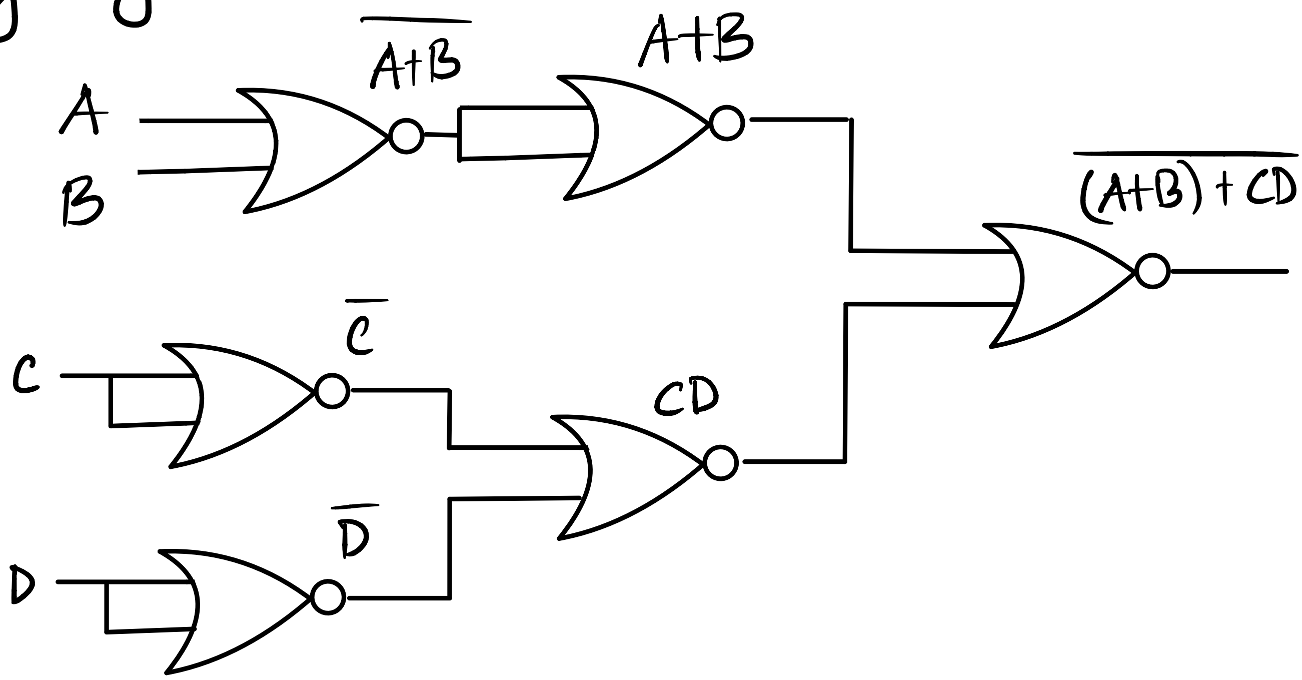
4. Implement $Y=\overline{(A+B)+CD}$ using NOR Mosfet logic circuit

We know, NOR gate is a universal gate. We can implement AND, OR, NOT using just NOR gate



$Y=\overline{(A+B)+CD}$

Logic gate form:



Circuit form: