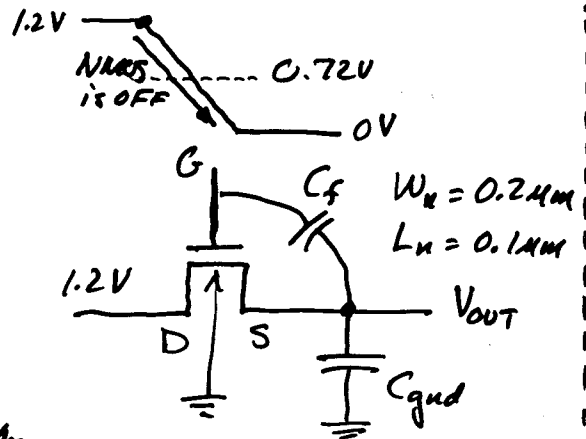


Example

In the circuit shown with the input at 1.2V, what is the initial value of the output when the clock is at 1.2V?

Estimate the final value after the clock goes low. Assume 0.13  $\mu\text{m}$  technology.  $\epsilon_{\text{ox}} = 3.9 \times 10^{-14} \text{ F/cm}^2$

Solution

Need to find  $V_{TN}$ .

$$\left. \begin{array}{l} 1.) V_{TN} = 0.4 + 0.2 \sqrt{0.88 + V_{out}} - 0.2 \sqrt{0.88} \\ 2.) V_{out} = 1.2 - V_{TN} \end{array} \right\} \begin{array}{l} \text{Solve} \\ \text{iteratively} \\ \text{to get } V_{TN} \\ = 0.483V \end{array}$$

$$\therefore V_{out}(\text{initial}) = 1.2 - 0.483V = \underline{\underline{0.72V}}$$

Final value = ?

$$C_f = C_{ox} L_D W_n = (1.6 \times 10^{-6} \frac{\text{F}}{\text{cm}^2}) (10 \times 10^{-7}) (0.2 \times 10^{-4}) = 0.032 \text{ fF}$$

$L_D = 10^{-9} \mu\text{m}$

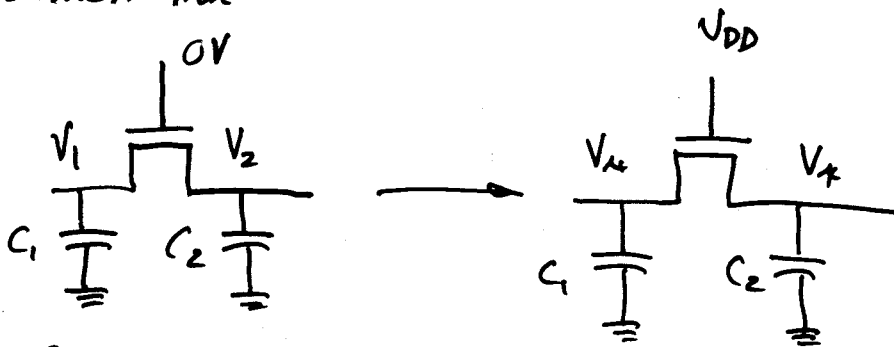
$$C_{gd} = C_{eff} \times W = 1 \frac{\text{fF}}{\mu\text{m}} (0.2 \mu\text{m}) = 0.2 \text{ fF}$$

$$\therefore V_{out}(\text{final}) = 0.72 - V_{DD} \left( \frac{\frac{1}{C_{gd}}}{\frac{1}{C_{gd}} + \frac{1}{C_f}} \right) = 0.72 - 1.2 \left( \frac{C_f}{C_f + C_{gd}} \right)$$

$$V_{out}(\text{final}) = 0.72 - 1.2 \left( \frac{0.032}{0.232} \right) = 0.72 - 0.166 \approx \underline{\underline{0.55V}}$$

Charge Sharing

Illustration-



$$Q_{\text{total}} = C_1 V_1 + C_2 V_2$$

$$Q_{\text{total}} = V_x (C_1 + C_2)$$

With charge conservation -

$$C_1 V_1 + C_2 V_2 = V_x (C_1 + C_2) \Rightarrow V_x = \frac{C_1 V_1 + C_2 V_2}{C_1 + C_2}$$

Examples

Compute the charge sharing effects for the following cases using 0.13um technology.

a.)  $C_1 = 100\text{fF}$ ,  $C_2 = 20\text{fF}$ ,  $V_1 = 0$ , and  $V_2 = 1.2\text{V}$

$$V_x = \frac{100\text{fF} \cdot 0 + 20\text{fF} \cdot 1.2\text{V}}{120\text{fF}} = 0.2\text{V}$$

b.)  $C_1 = 20\text{fF}$ ,  $C_2 = 20\text{fF}$ ,  $V_1 = 0$ ,  $V_2 = 1.2\text{V}$

$$V_x = \frac{20\text{fF} \cdot 0 + 20\text{fF} \cdot 1.2}{40\text{fF}} = 0.6\text{V}$$

c.)  $C_1 = 20\text{fF}$ ,  $C_2 = 100\text{fF}$ ,  $V_1 = 0$ , and  $V_2 = 1.2\text{V}$

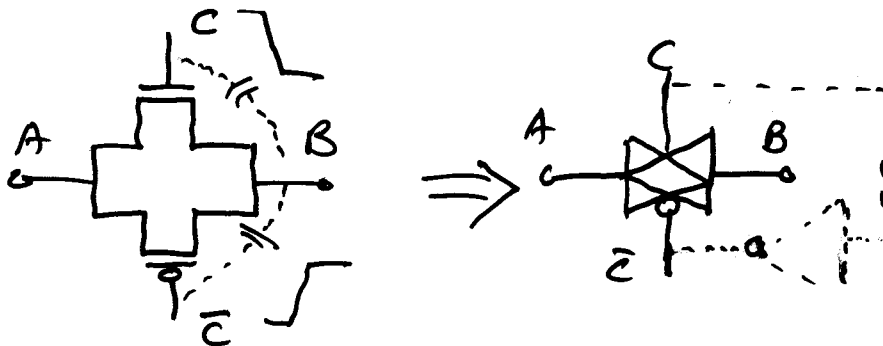
$$V_x = \frac{20\text{fF} \cdot 0 + 100\text{fF} \cdot 1.2}{120\text{fF}} = 1\text{V} \rightarrow \text{Conflict}$$

Note:  $V_x(\text{max}) = V_{\text{DD}} - V_{\text{TN}} = 0.8\text{V}$

### Other Sources of Charge Loss in the MOS switch

- 1.) Leakage currents from the BD & BS reverse biased pn junction.
- 2.) Noise injection
  - a.) Electrostatic or electromagnetic coupling
  - b.) Hot carrier (impact ionization)
  - c.)  $\alpha$ -particles

### CMOS Transmissin Gates



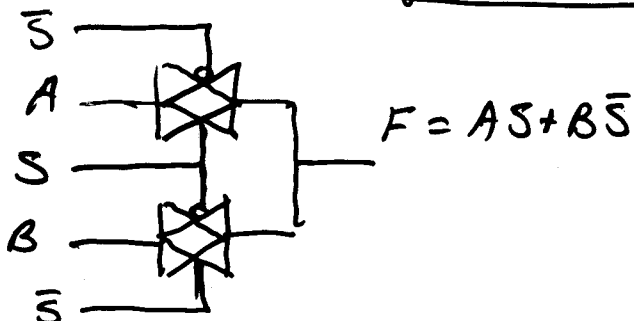
#### Advantages -

- Can transmit a high or low (wide dynamic range)
- Some cancellation in clock feed through
- Lower on resistance

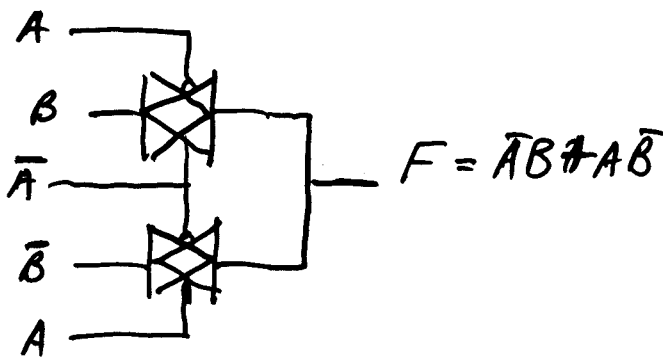
#### Disadvantages -

- Requires more transistors and more area
- Complementary clock

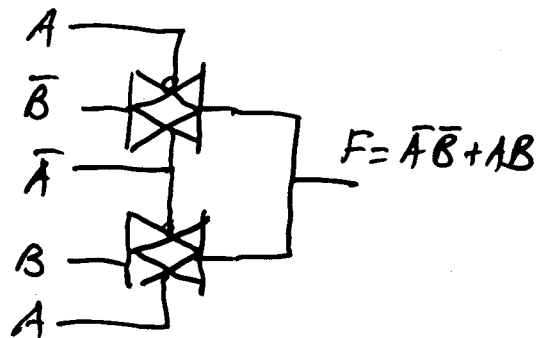
### Multiplexers using CMOS Transmissin Gates



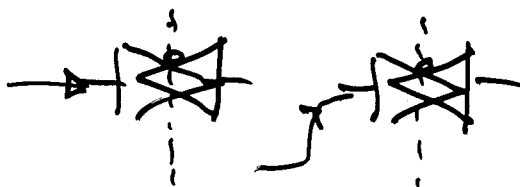
XOR Gate -



XNOR Gate -



Multiple level multiplexers



Comparing single level with multiple level -

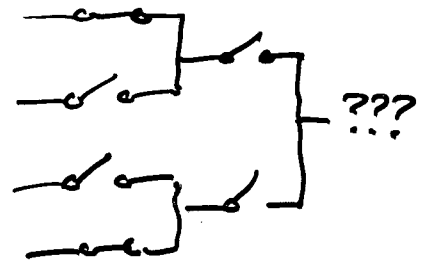
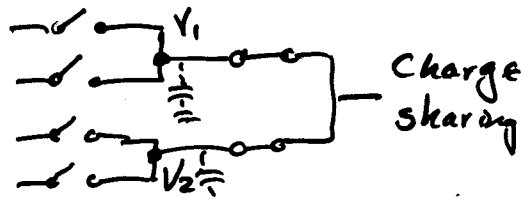
Multilevel has less control signal => Less inverters

Output Conflicts -

1.) Two defined path conflict

2.) No defined paths (Hi Z state)

3.) Charge sharing



Next is the implementation of Logic functions using the transmission gate.