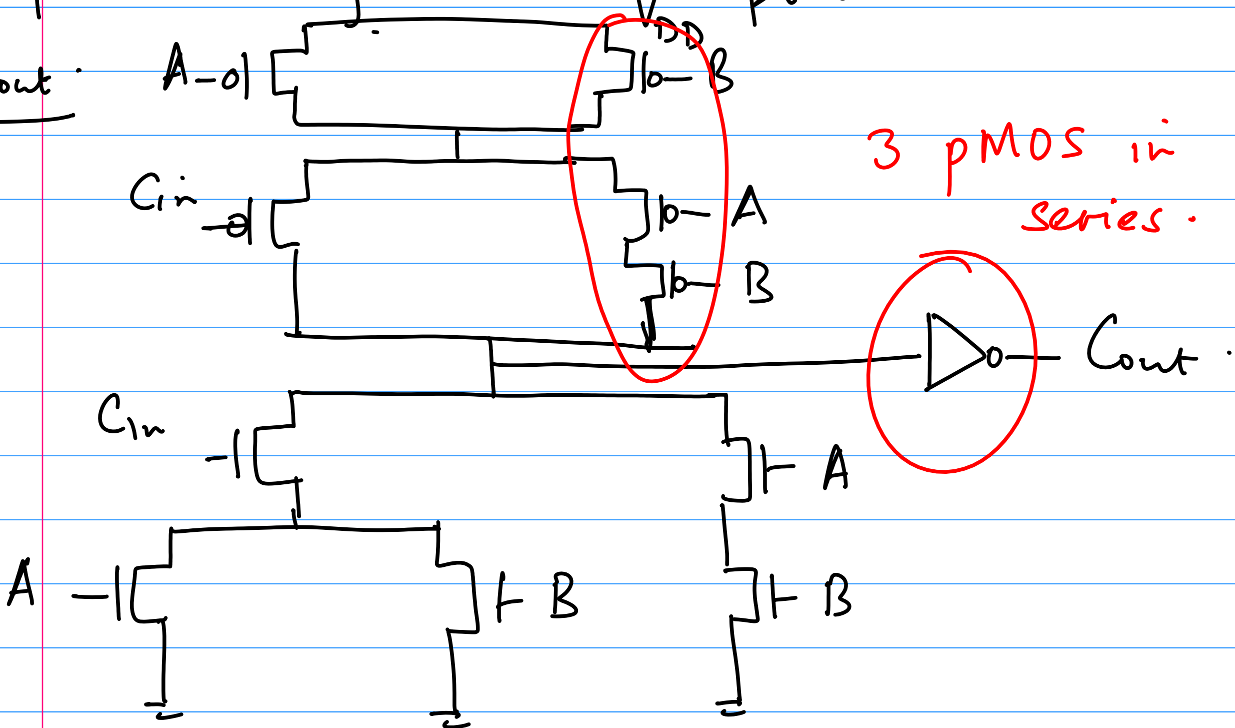
Adder Inputs : A, B, Cin

FA.

$$S(A, B, C_{in}) = A \oplus B \oplus C_{in}$$
$$C_{out}(A, B, C_{in}) = AB + BC_{in} + AC_{in}$$

Complementary CMOS implementation:

Cout:



Sum: $A \oplus B \oplus C_{in} = \bar{A}\bar{B}C_{in} + \cdots$
$= \Sigma(1, 2, 4, 7)$

3 transistors in series

4 pMOS transistors in series in the PUN.

24 transistors for Sum &
12 " " Cout.

1. Minimise no of transistors
2. Reduce the number of pMOS transistors in series in the PUN.

Boolean expressions

$$S(A, B, C_{in}) = \sum(1, 2, 4, 7)$$

$$\overline{S}(A, B, C_{in}) = \sum(0, 3, 5, 6)$$

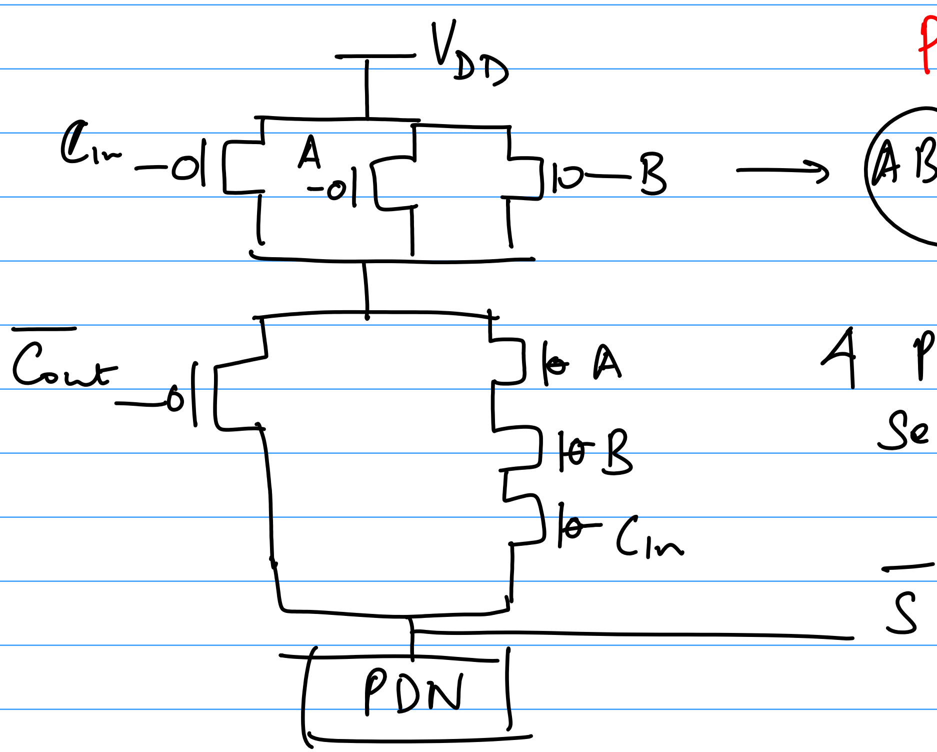
$$C_{out}(A, B, C_{in}) = \sum(3, 5, 6, 7)$$

$$\overline{C_{out}}(A, B, C_{in}) = \sum(0, 1, 2, 4)$$

$$S(A, B, C_{in}) = \overline{C_{out}}(A + B + C_{in}) + ABC_{in}$$

series transistors in PUN.

14 + 2 transistors.



→ ABC_{in}

4 pMOS in series.

$$S(A, B, C_{in}) = \Sigma(1, 2, 4, 7)$$

$$\overline{S}(A, B, C_{in}) = \Sigma(0, 3, 5, 6)$$

$$= S(\overline{A}, \overline{B}, \overline{C_{in}})$$

$$\overline{C_{out}}(A, B, C_{in}) = C_{out}(\overline{A}, \overline{B}, \overline{C_{in}})$$

$$\overline{AB + BC_{in} + AC_{in}} = \overline{A}\,\overline{B} + \overline{B}\,\overline{C_{in}} + \overline{A}\,\overline{C_{in}}$$

2 input NAND. $F = \overline{AB} \longrightarrow$ PDN

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

$\overline{C_{out}}$:

$\overline{AB + BC_{in} + AC_{in}} \longrightarrow$ PDN

3 pMOS transistors in series $\longleftarrow (\overline{A} + \overline{B})(\overline{B} + \overline{C_{in}})(\overline{A} + \overline{C_{in}}) \longrightarrow$ PUN

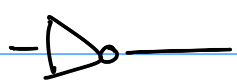
$= \overline{A}\,\overline{B} + \overline{B}\,\overline{C_{in}} + \overline{A}\,\overline{C_{in}}$

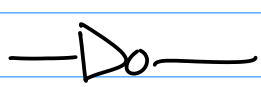
4

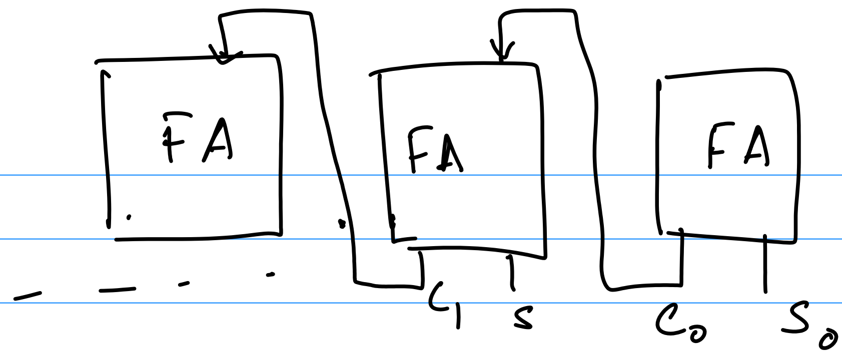
2 pMOS transistors in series.

Mirror symmetric implementation.

Do: the same for the Sum.

$\overline{S}$ 

$\overline{C_{out}}$  C_{out}

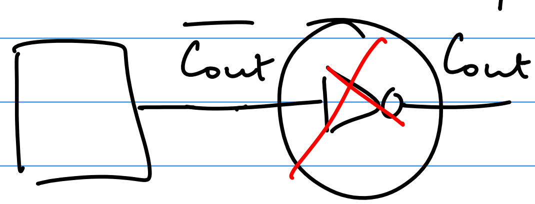


Ripple carry adder

carry path is the critical path.

'N' bit adder, $t_D = (N-1)t_{carry} + t_{sum}$.

Optimise carry path to maximise speed.



$$S(A, B, C_{in}) = ABC_{in} + \overline{C_{out}}(A+B+C_{in})$$

$$\overline{S}(A, B, C_{in}) = \overline{A}\,\overline{B}\,\overline{C_{in}} + C_{out}(\overline{A}+\overline{B}+\overline{C_{in}})$$

$$C_{out}(A, B, C_{in}) = AB + BC_{in} + AC_{in}$$

$$\overline{C_{out}}(A, B, C_{in}) = \overline{A}\,\overline{B} + \overline{B}\,\overline{C_{in}} + \overline{A}\,\overline{C_{in}}$$