COMPLEX CMOS GATES

Example: $F = \overline{(A+B)\cdot C}$

1) De Morgan's Law

$\overline{(a+b)} = \bar{a}\cdot\bar{b}$

$\overline{a\cdot b} = \bar{a}+\bar{b}$

Duality

$a+b \Leftrightarrow a\cdot b$

$(a+b)\cdot c \Leftrightarrow a\cdot b+c$

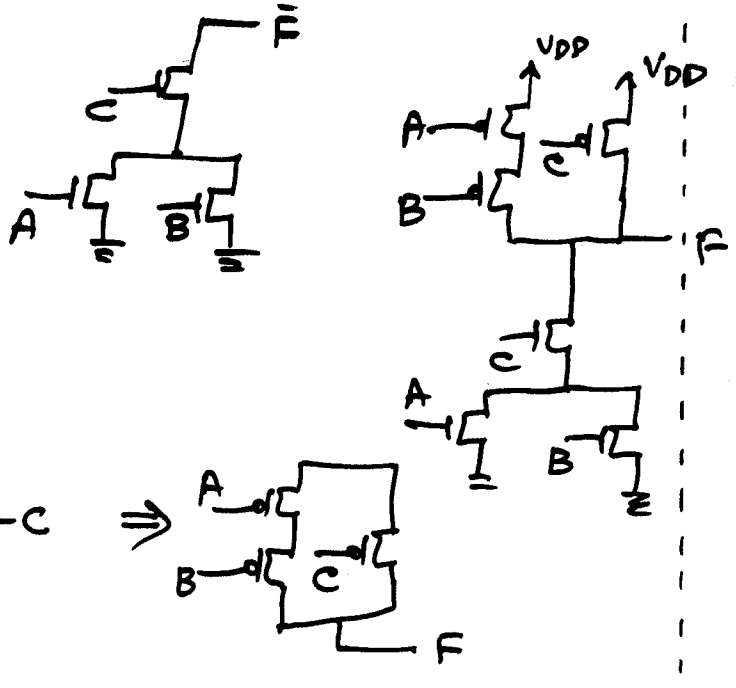
2) AND in CMOS → series NMOS, parallel PMOS

OR → parallel NMOS, series PMOS

3) Since NMOS act to pull F low, implement $\bar{F}$.

4) " PMOS act to pull F high, " F but with inverted inputs

$F = \overline{(A+B)\cdot C} \rightarrow \bar{F} = (A+B)\cdot C$

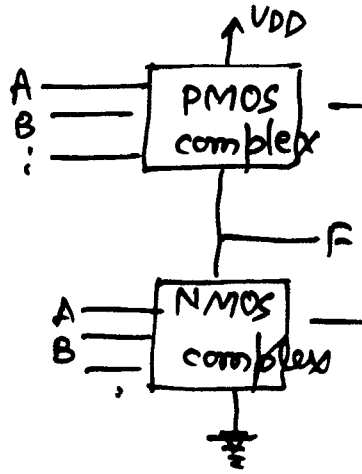


$F = \overline{(A+B)\cdot C} = \bar{A}\cdot\bar{B}+\bar{C}$

$= \overline{(A+B)}+\bar{C}$

$F = \bar{\bar{A}}\cdot\bar{\bar{B}}+\bar{\bar{C}} = A\cdot B+C \Rightarrow$

Generalized complex gate synthesis



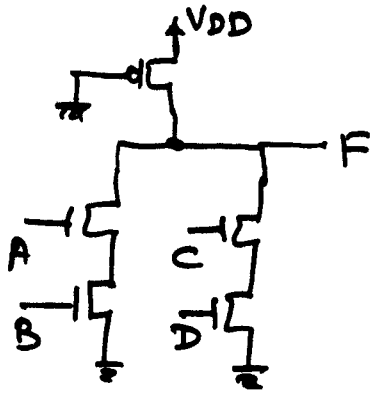
→ implement F with inverted inputs

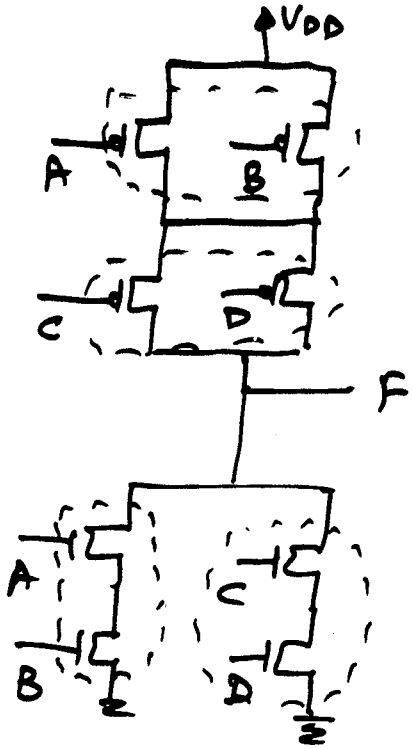
→ implement $\bar{F}$.

Ex. 5.3

$F = \overline{AB+CD}$ as a single-stage CMOS and Pseudo-NMOS

$\bar{F} = A \cdot B + C \cdot D$





$f = \overline{A \cdot B + C D}$

$F = \overline{\bar{A} \cdot \bar{B} + \bar{C} \cdot \bar{D}}$

$= (A+B) \cdot (C+D)$

Ex. XOR gate

$F_{XOR} = a\cdot\bar{b} + \bar{a}\cdot b$

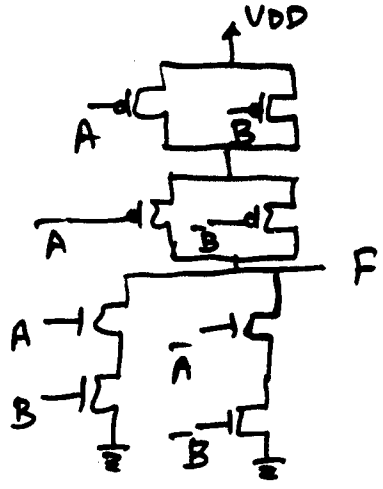
$\bar{F}_{XOR} = \overline{a\cdot\bar{b} + \bar{a}\cdot b}$

$= \overline{(a\cdot\bar{b})}\cdot\overline{(\bar{a}\cdot b)}$

$= (\bar{a}+b)\cdot(a+\bar{b})$

$= \underbrace{\bar{a}\cdot a}_{=0} + a\cdot b + \bar{a}\cdot\bar{b} + \underbrace{b\cdot\bar{b}}_{=0}$

$\bar{F}_{XOR} = a\cdot b + \bar{a}\cdot\bar{b}$

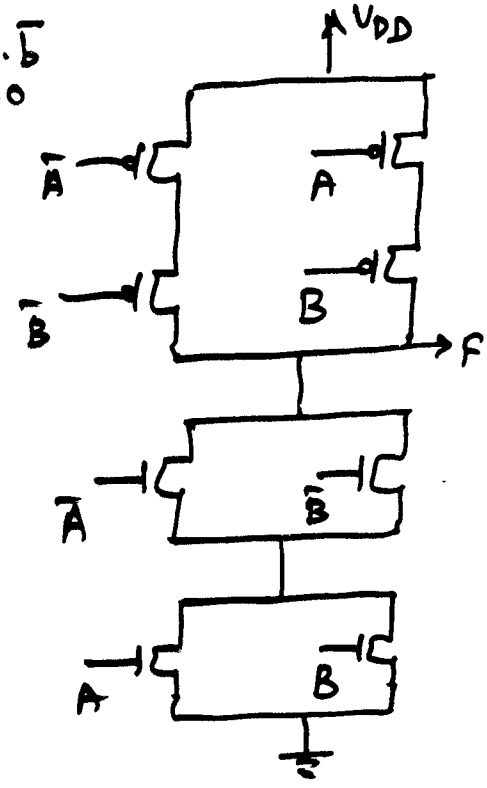


XNOR gate

$F_{XNOR} = ab + \bar{a}\cdot\bar{b}$

$F_{XNOR} = \bar{a}\cdot\bar{b} + \bar{\bar{a}}\cdot\bar{\bar{b}}$

$= \bar{a}\cdot\bar{b} + a\cdot b$



$\bar{F} = (A+B)\cdot(\bar{A}+\bar{B})$

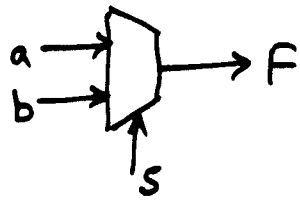
$F = \overline{(A+B)\cdot(\bar{A}+\bar{B})}$

$= \overline{(A+B)} + \overline{(\bar{A}+\bar{B})}$

$= \bar{A}\cdot\bar{B} + A\cdot B$

Ex. Multiplexer

$F = a \cdot s + b \cdot \bar{s}$



$\bar{F} = \overline{(a \cdot s + b \cdot \bar{s})}$

$= \overline{(a \cdot s)} \cdot \overline{(b \cdot \bar{s})}$

$F = \bar{a} \cdot \bar{s} + \bar{b} \cdot s$ → PMOS