Example: Another CMOS Logic Gate Synthesis

Now let's design a gate that realizes this Boolean algebraic expression:

$$Y = \left(\overline{A} + \overline{B}\right)C$$

Step 1: *Design PDN*

First, let's rewrite Boolean expression as $\overline{Y} = f(A,B,C)$:

$$Y = \left(\overline{A} + \overline{B}\right)C$$

$$\overline{Y} = \overline{\left(\overline{A} + \overline{B}\right)C}$$

$$\overline{Y} = \left(\overline{\overline{A} + \overline{B}}\right) + \overline{C}$$

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

Q: *Yikes! We cannot write this expression explicitly in terms of* ***uncomplemented*** *inputs A, B, and C ! The input C appears as* $\overline{C}$ *in the expression. What do we do* ***now?***

A: An easy problem to solve! We can essentially make a substitution of variables:

$$C' = \overline{C}$$

And thus:

$$\overline{Y} = AB + C'$$

Therefore, the inputs to this logic gate should be A, B, and C' (i.e, A, B, and the complement of C).

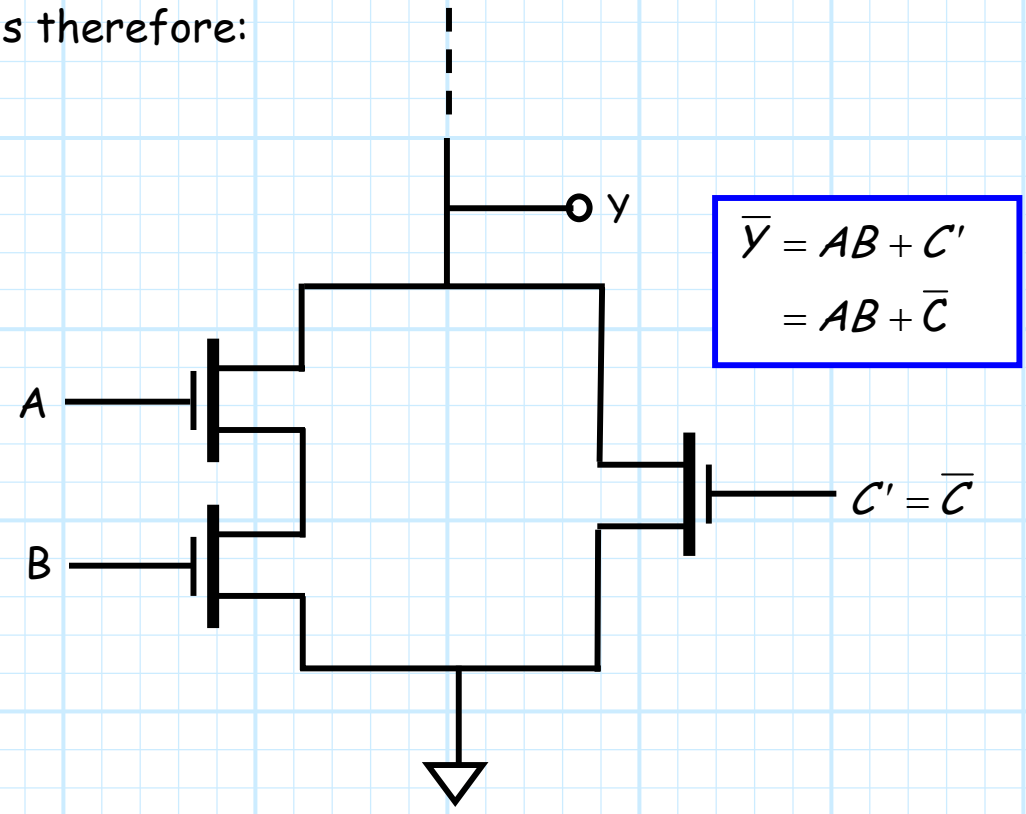
Note that this Boolean expression "says" that:

"The ouput is low if either,A AND B are both high, OR C' is **high**"

Of course another way of "saying" this is:

"The output is low if either A AND B are both high, OR C is **low**"

The PDN is therefore:



Step 2: *Design the PUN*

Note we have as similar problem as before—the expression for Y **cannot** explicitly be written in terms of complemented inputs $\overline{A}$, $\overline{B}$, and $\overline{C}$:

$$Y = \left(\overline{A} + \overline{B}\right)C$$

Note we can again solve this problem by using the same substitution of variable C:

$$C' = \overline{C}$$
$$\overline{C'} = C$$

Therefore:

$$Y = \left(\overline{A} + \overline{B}\right)\overline{C'}$$
$$= \left(\overline{A} + \overline{B}\right)C$$

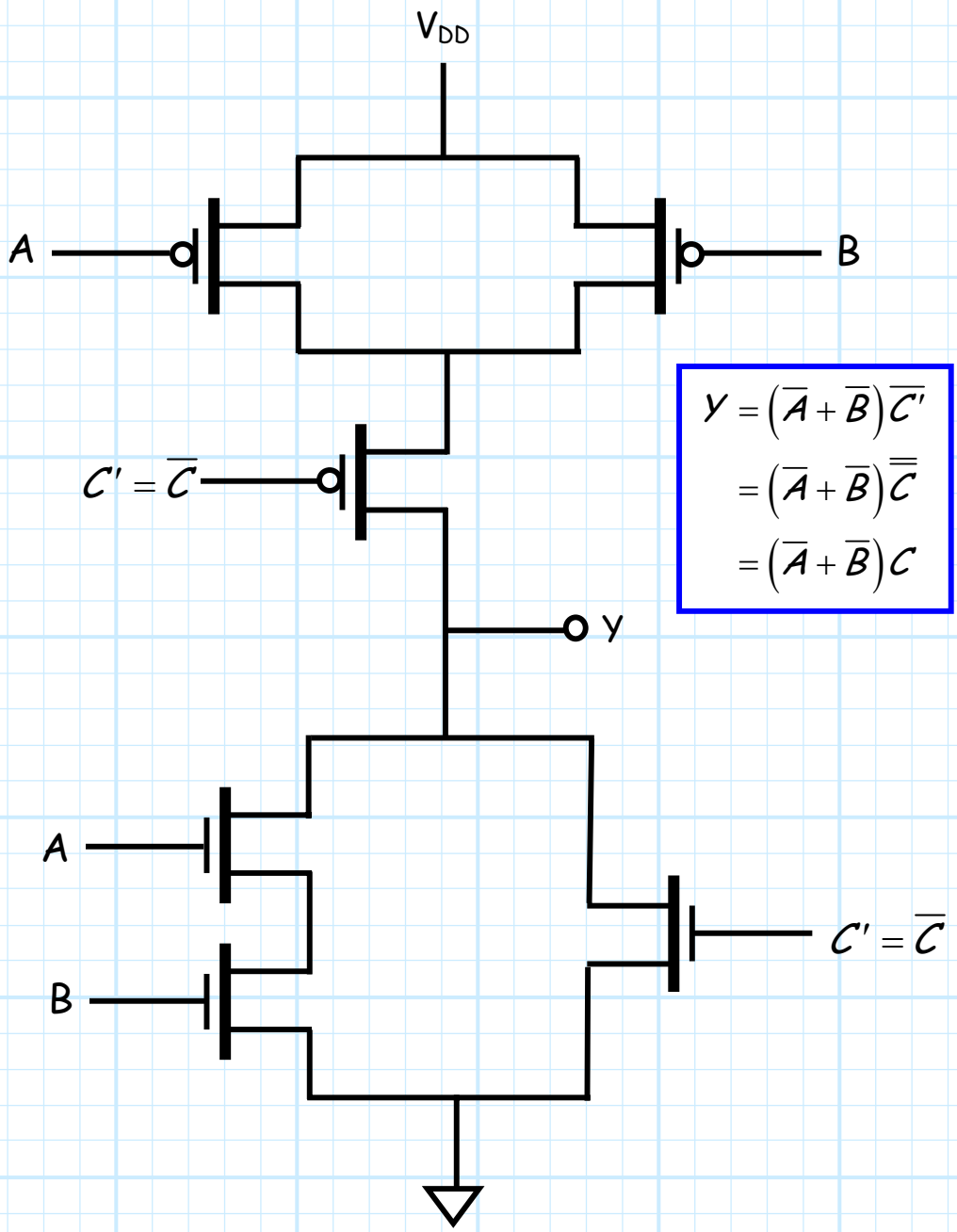
This expression "says" that:

"The output will be high if, either A OR B are low, AND C' is **low**"

Which is equivalent to saying:

"The output will be high if, either A OR B are low, AND C is **high**"

The CMOS digital logic device is therefore:



$$Y = \left(\overline{A} + \overline{B}\right)\overline{C'}$$
$$= \left(\overline{A} + \overline{B}\right)\overline{\overline{C}}$$
$$= \left(\overline{A} + \overline{B}\right)C$$