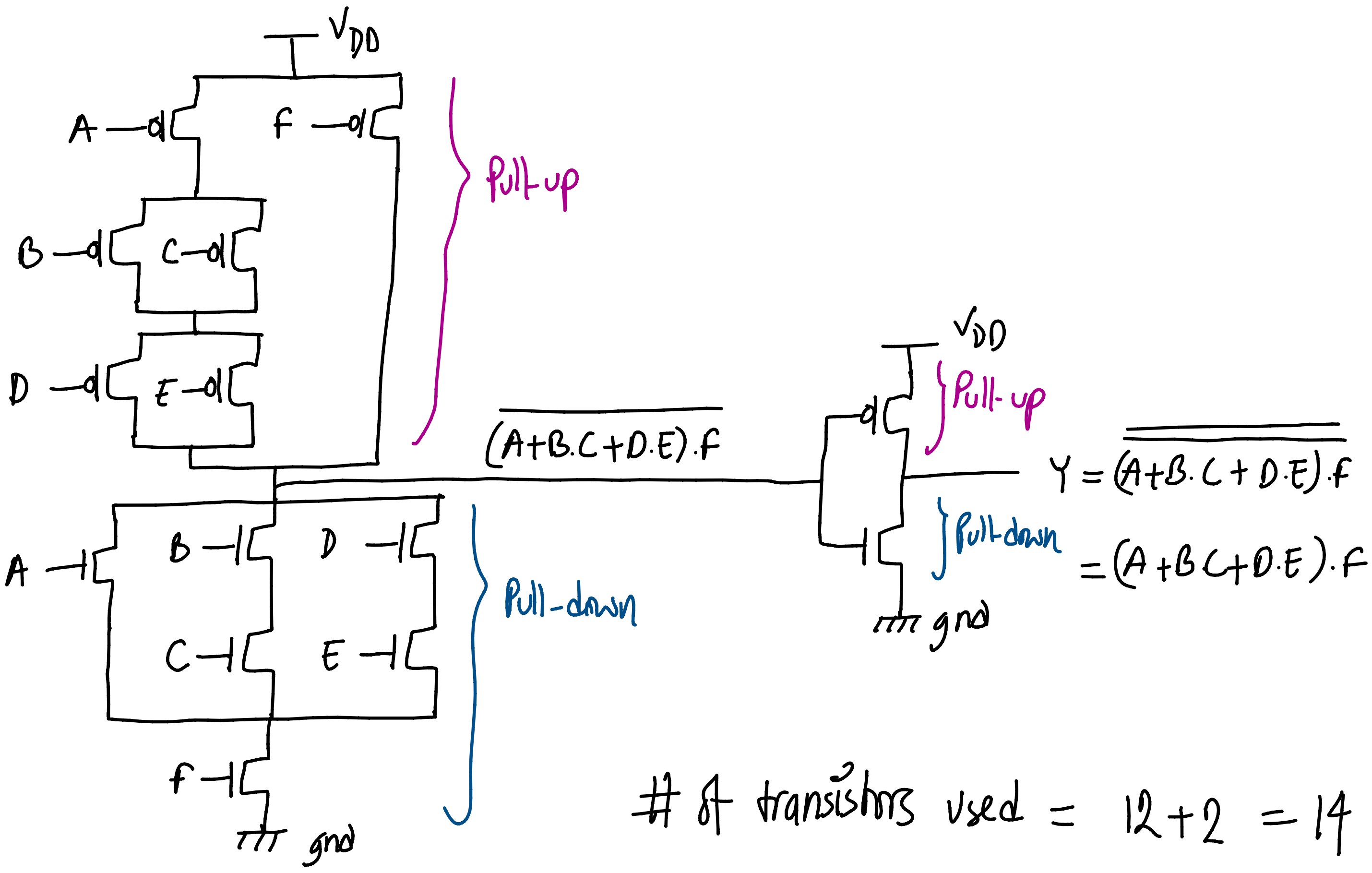
Quiz 1 Solution

Tuesday, November 16, 2021 12:23 PM

Slot 1

1. Design a CMOS compound gate that implements the following function:
   $$Y = (A + B.C + D.E).F$$
   where A, B, C, D, E, F are inputs and Y is the output. Clearly mark the pull-up & pull-down network. How many transistors have you used in your design? **[7+2+1]**
2. Design a positive-edge-triggered D flip-flop using CMOS transmission gates and inverters. Briefly describe how it works. **[7+3]**

$\boxed{1.}$



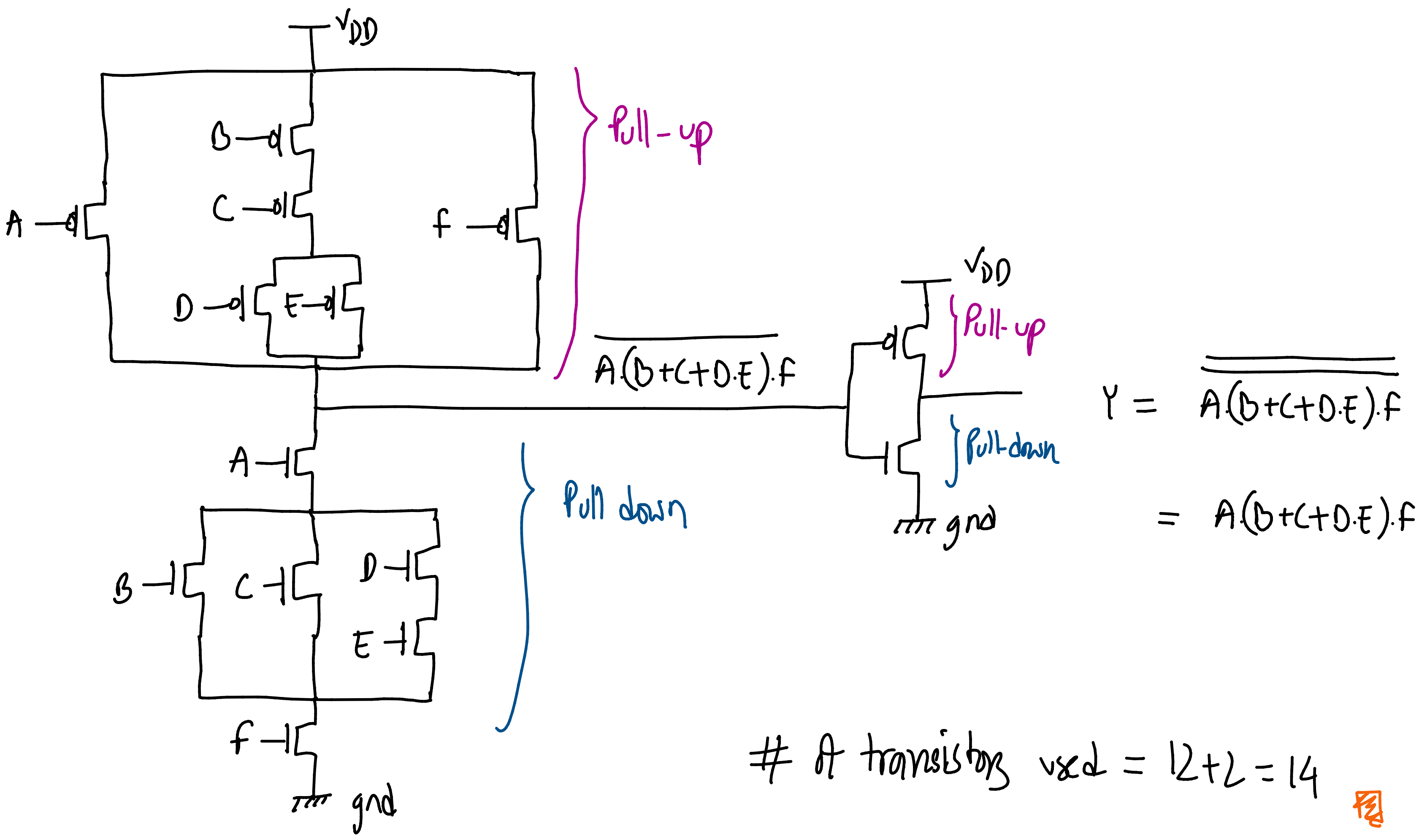
# of transistors used = 12+2 = 14

$\boxed{2.}$ Ref: Lecture: 4, Slide 17, 18. Textbook: 1.4.9.2 Flip-Flops, Page 17-18

Slot 2

1. Design a CMOS compound gate that implements the following function:
   $$Y = A.(B+C+D.E).F$$
   where A, B, C, D, E, F are inputs and Y is the output. Clearly mark the pull-up & pull-down network. How many transistors have you used in your design? **[7+2+1]**
2. Design a complete 4:1 non-inverting MUX using CMOS tristate inverters. Briefly describe how it works. **[7 +3]**

$\boxed{1.}$



# of transistors used = 12+2 = 14

$\boxed{2.}$ Ref: Lecture 4, Slide 12. Textbook: 1.4.8 Multiplexers, Page 15-16.

Makeup

Some useful logic gates are listed below:

Name	Input	Output	Equation
NOT	A	Y	$Y = \overline{A}$
AND	A, B	Y	$Y = A.B$
OR	A, B	Y	$Y = A + B$
XOR	A, B	Y	$Y = A.\overline{B} + \overline{A}.B$
XNOR	A, B	Y	$Y = \overline{A}.\overline{B} + A.B$

1. Design a circuit with output **f** and inputs **x1**, **x0**, **y1**, and **y0**. Let **X = x1x0** and **Y = y1y0** represent two 2-digit *binary* numbers. The output **f** should be **1** if the numbers represented by X and Y are equal. Otherwise, **f** should be **0**. You may use the gates from the list above. **[10]**
2. What is a transmission gate? What is a pass transistor? Briefly explain why one is superior to the other in general. **[6]**
3. Describe the current trend in *MOSFET* IC design. **[4]**

digits

$\boxed{1.}$ Two 2-digit binary numbers : $X\,(= x_1\ x_0)$ & $Y\,(= y_1\ y_0)$

numbers

are equal iff $x_1 = y_1$ and $x_0 = y_0$.

Approach 1: $x_1 = y_1 \Rightarrow x_1 = 1$ & $y_1 = 1$ or, $x_1 = 0$ & $y_1 = 0$

$\Rightarrow x_1 y_1 + \overline{x_1}\,\overline{y_1}$

$x_0 = y_0 \Rightarrow x_0 = 1$ & $y_0 = 1$ or, $x_0 = 0$ & $y_0 = 0$

$\Rightarrow x_0 y_0 + \overline{x_0}\,\overline{y_0}$

$$\therefore f = (x_1 . y_1 + \overline{x_1} . \overline{y_1}) . (x_0 . y_0 + \overline{x_0} . \overline{y_0})$$

Approach 2: Using the def^n of XNOR gates : A XNOR B, $A \odot B = \overline{A} . \overline{B} + A . B$

$$f = (x_1 \odot y_1) . (x_0 \odot y_0)$$

Implement the logic function "f" using the logic gates.

$\boxed{2.}$ Ref: lecture 4, Slide 3,4. Textbook: 1.4.6 Pass Transistors & Transmission Gates between these two. transmission gates are superior because is produces both strong 1 & strong 0; whereas pass transistors can either produce only one of them.

$\boxed{3.}$ Ref: lecture 1, Slide 14.

Early MOSFET IC's were built using only pMOS or nMOS. Both pMOS & nMOS processes suffered from poor performance / higher power consumption / yield / reliability.

Current MOSFET IC's are hence built in CMOS technology.