EEE140 Digital Electronics I
Lecture #5

- Combinational Logic Analysis -

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What will be covered in this topic?

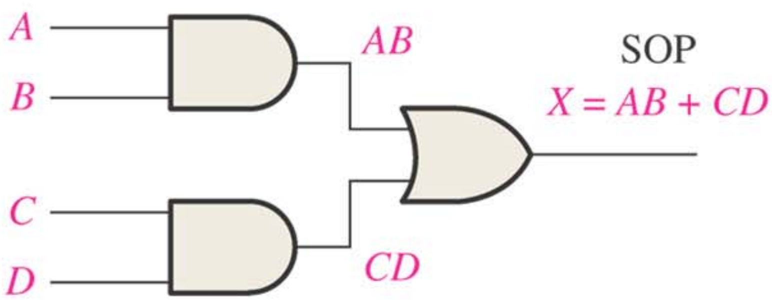
- 5-1 Basic Combinational Logic Circuits
- 5-2 Implementing Combinational Logic
- 5-3 The Universal Property of NAND and NOR Gates
- 5-4 Combinational Logic Using NAND and NOR Gates
- 5-5 Logic Circuit Operation With Pulse Waveform Inputs
- 5-6 Combinational Logic with VHDL
- 5-7 Troubleshooting

Introduction

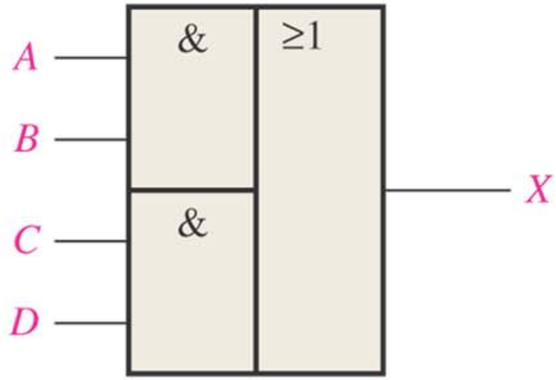
- So far we have learnt about logic circuits as independent circuit. From this chapter we will learn about logic gates which have been connected together to produce a specified output for certain specified combinations of input variables, with no storage involved – the resulting circuit is in the category of *combinational logic*
- Important sections to know:
  - SOP and POS expressions

5-1 Basic Combinational Logic Circuits

- AND-OR logic (remember SOP to get a clearer image of this)
  - Details on this type of logic are given below. We need to know the symbol and how it is used/described



(a) Logic diagram (ANSI standard distinctive shape symbols)

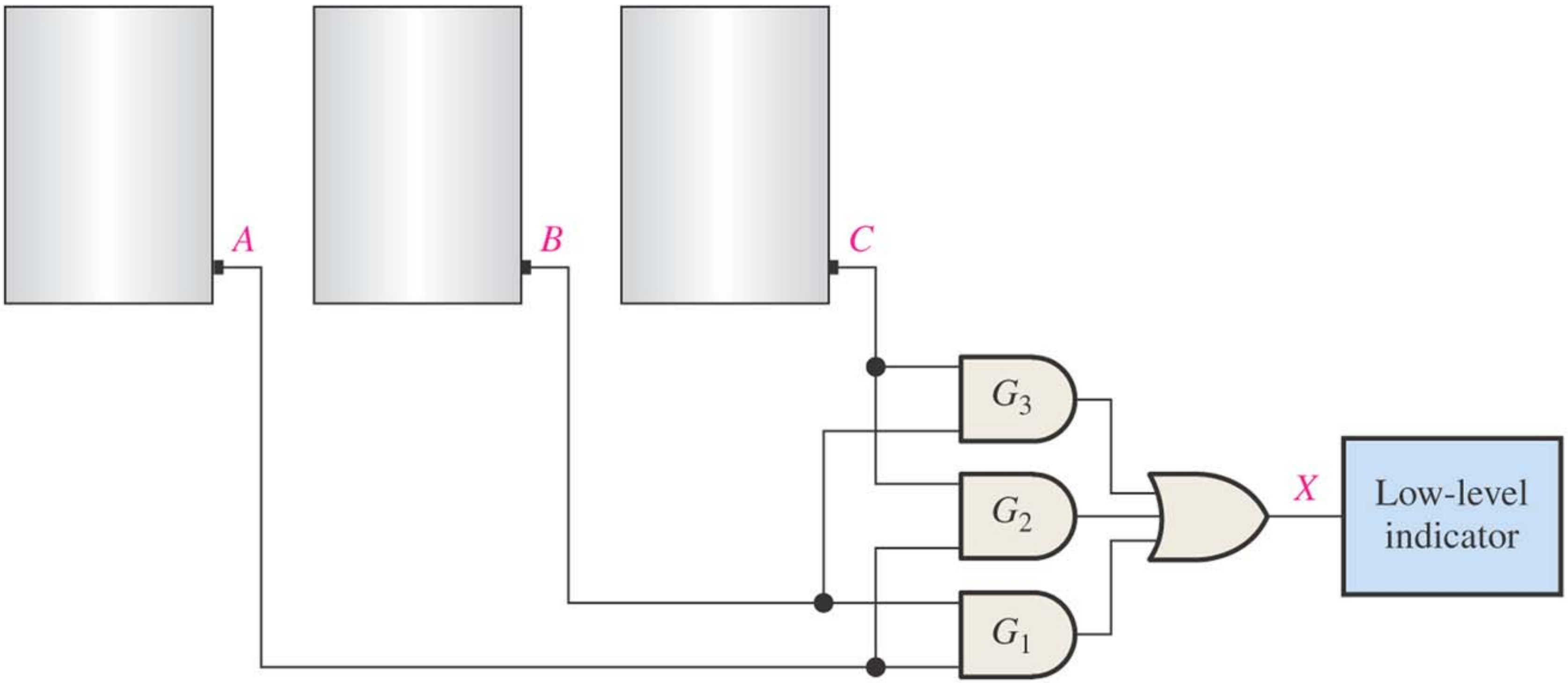


(b) ANSI standard rectangular outline symbol

How to describe the AND-OR logic?

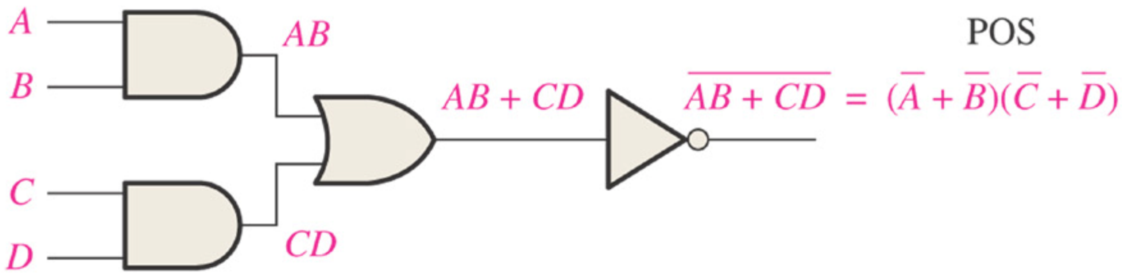
- From the figure (Figure 5-1), we may say something like this:
  - For a 4-input AND-OR logic circuit, the output X is HIGH (1) if both input A and B are HIGH(1) or both input C and input D are HIGH(1)
  - Please refer Table 5-1

Example 5-1

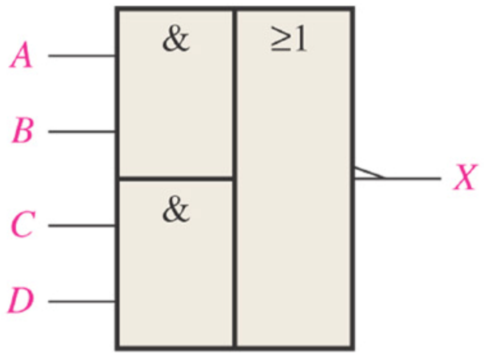


AND-OR-Invert Logic

- A complemented version of AND-OR Logic
- If AND-OR logic implements SOP, then AND-OR-Invert implements POS
- The details of this are given below:

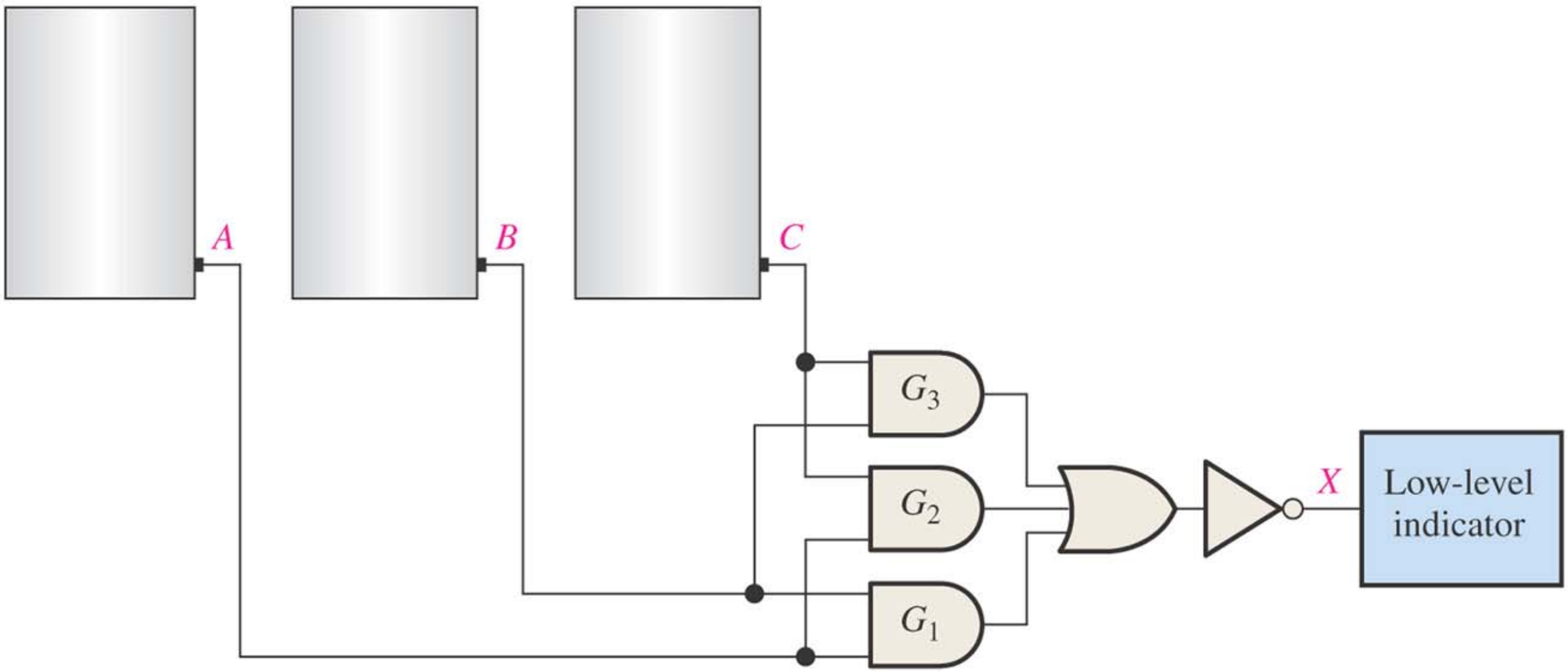


(a)



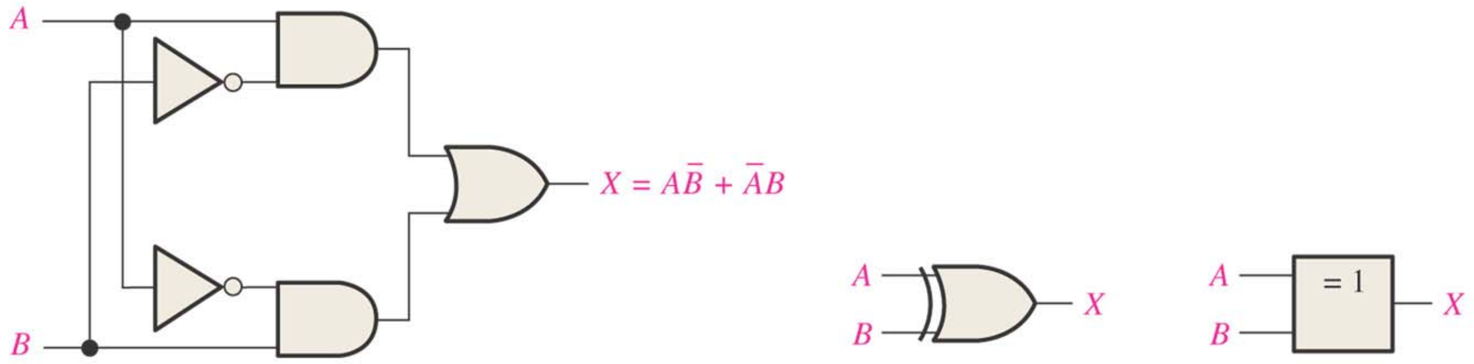
(b)

Example 5-2



Exclusive-OR Logic

- This type of logic is actually a combination of 2 ANDs, 1 OR and 2 inverters



(a) Logic diagram

(b) ANSI distinctive shape symbol

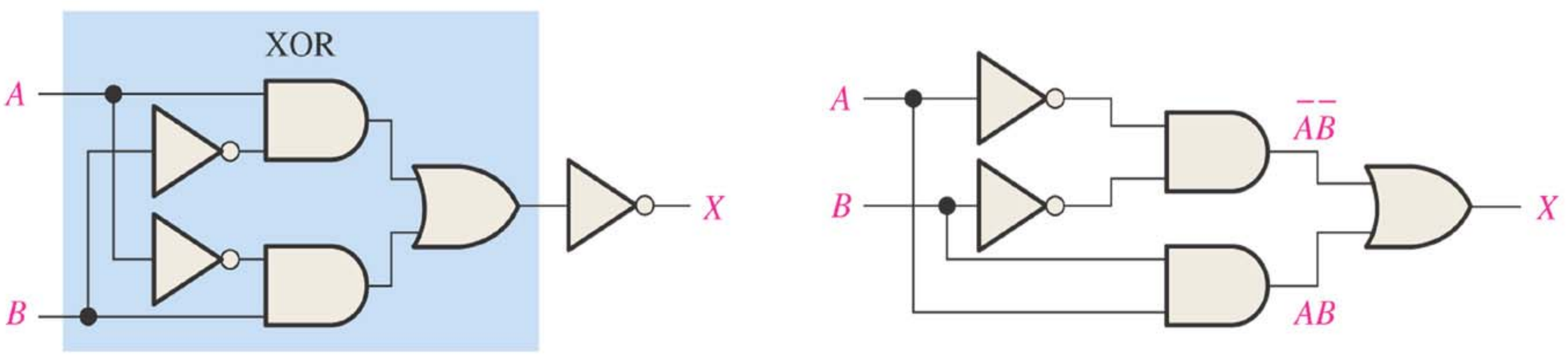
(c) ANSI rectangular outline symbol

- The output expression is $X = A\bar{B} + \bar{A}B$
- Using the special operator symbol for XOR

$$X = A \oplus B$$

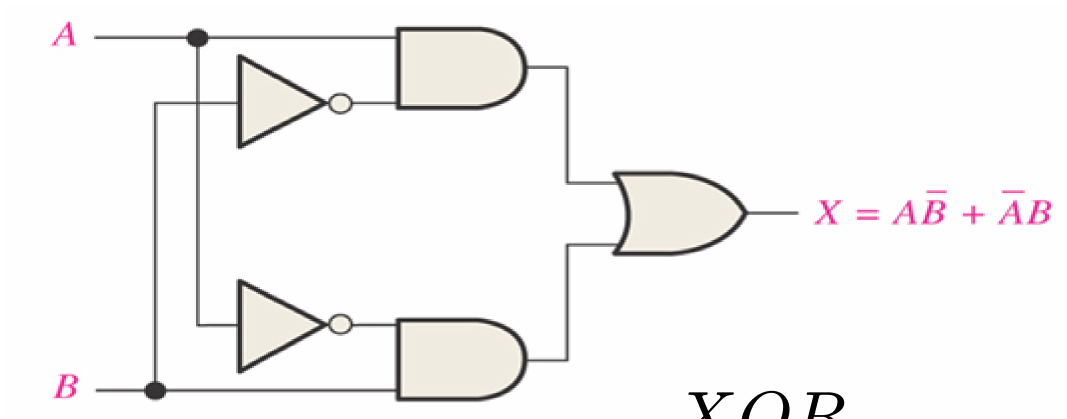
Exclusive-NOR Logic

- This is the complement of XOR. A combination of 2 ANDs, 1 OR and 2 inverters (*__Notice that the quantity of logic gates is the same__*)
- Usually written as XNOR
- The details:

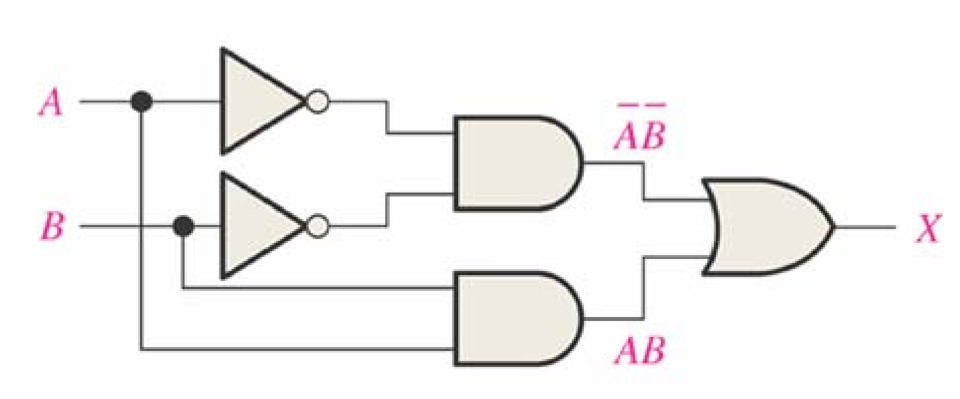


(a) $X = \overline{A\bar{B} + \bar{A}B}$ (b) $X = \bar{A}\bar{B} + AB$

XOR and XNOR logic circuits



XOR



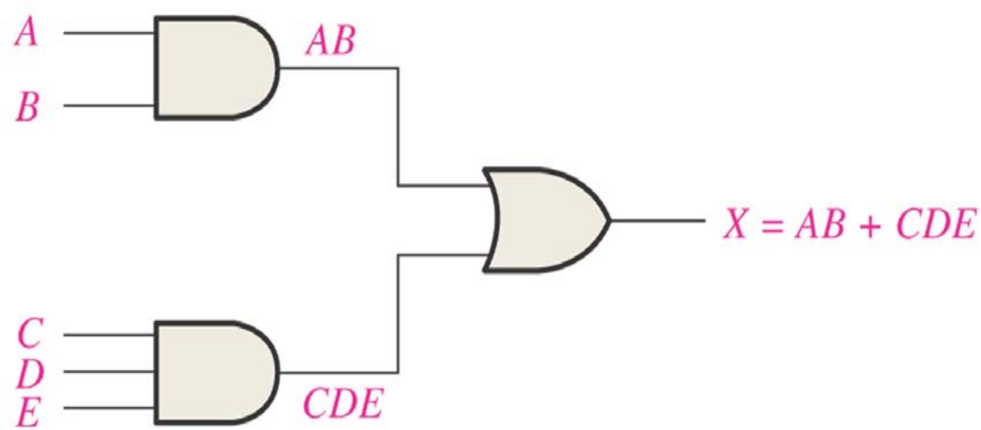
XNOR

5-2 Implementing Combinational Logic

- From a Boolean Expression to a Logic Circuit
  - Examine the expression given. In our book, the two terms are summed after being multiplied

$$X = AB + CDE$$

  - The logic circuit is

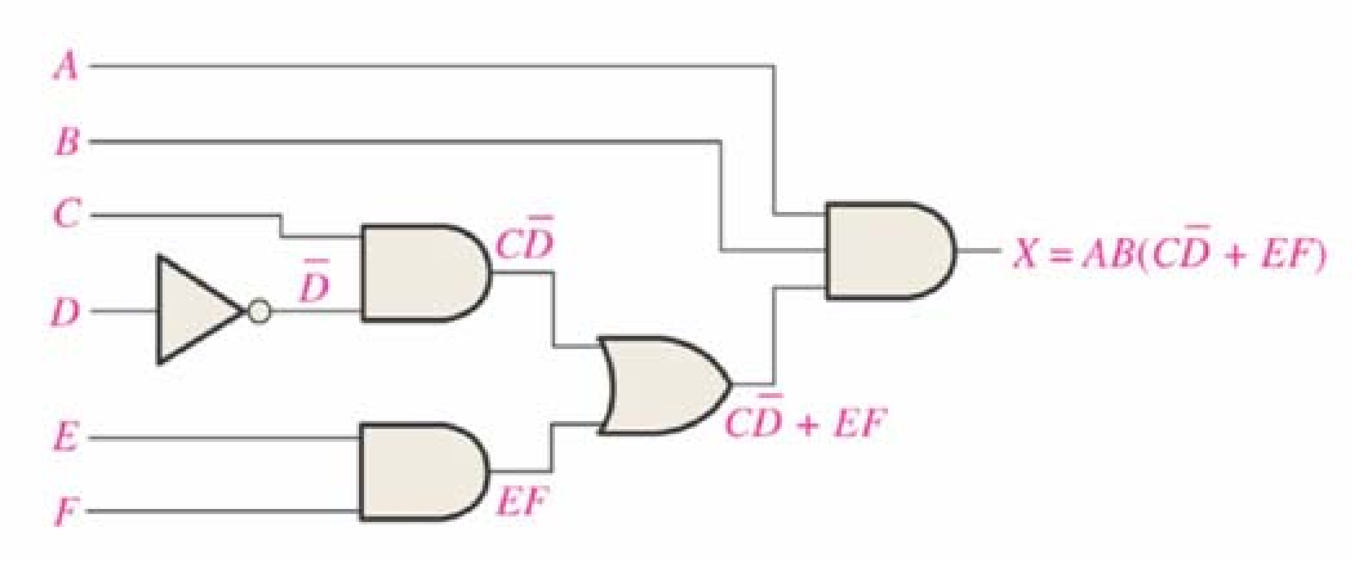


5-2 Implementing Combinational Logic (Cnt'd 1)

- Let's try to do this

$$X = AB(C\bar{D} + EF)$$

- What will we get is something like this

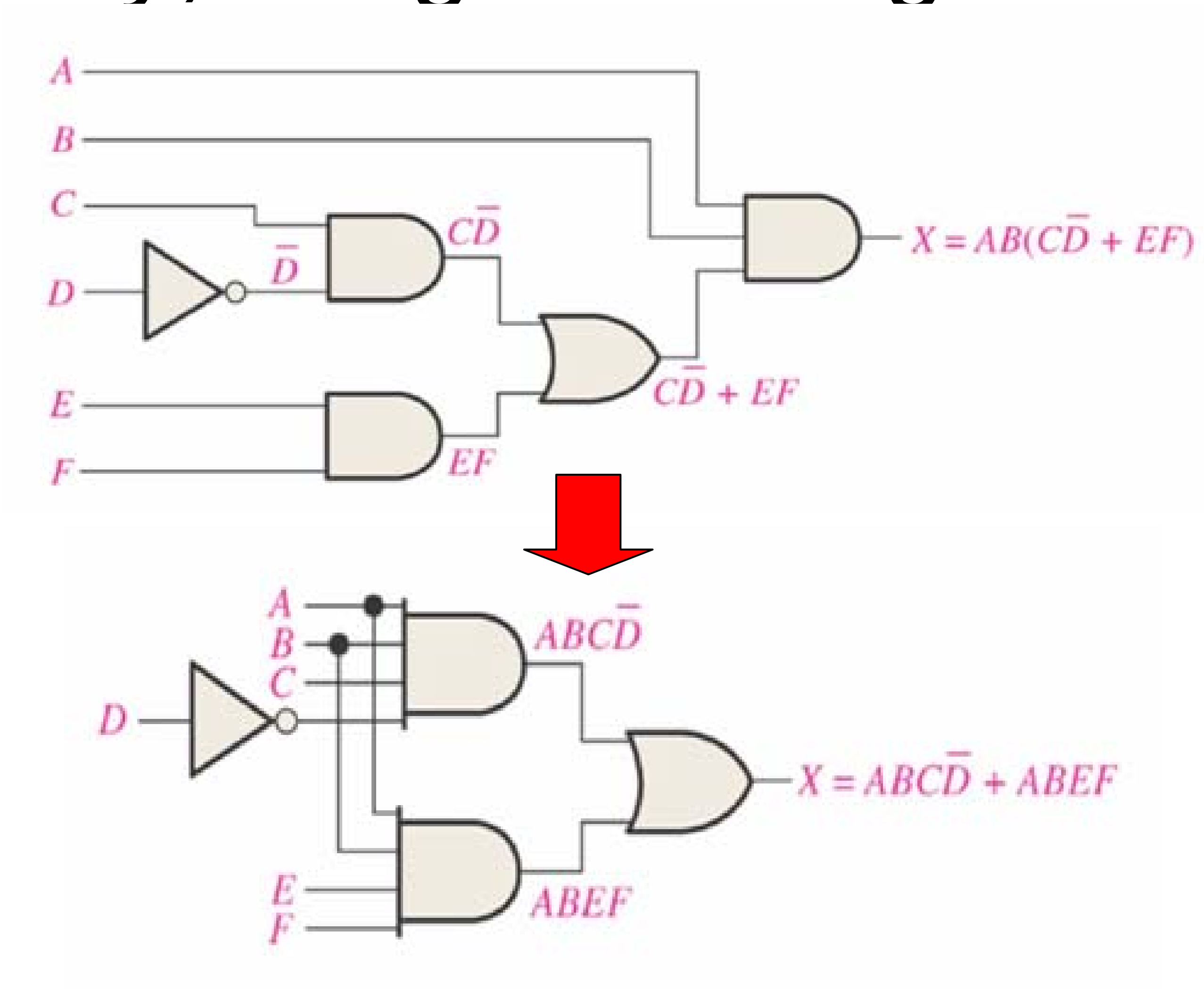


5-2 Implementing Combinational Logic (Cnt'd 2)

- Problem: propagation delay from the input to the output
- Remedy: usually, we will reduce the expression to SOP form (in the book example, we straight away get the SOP form from the given expression)

$$
\begin{aligned}
X &= AB(C\bar{D} + EF) \\
&= ABC\bar{D} + ABEF
\end{aligned}
$$

Finally, we get this logic circuit



$$X = ABC\bar{D} + ABEF$$