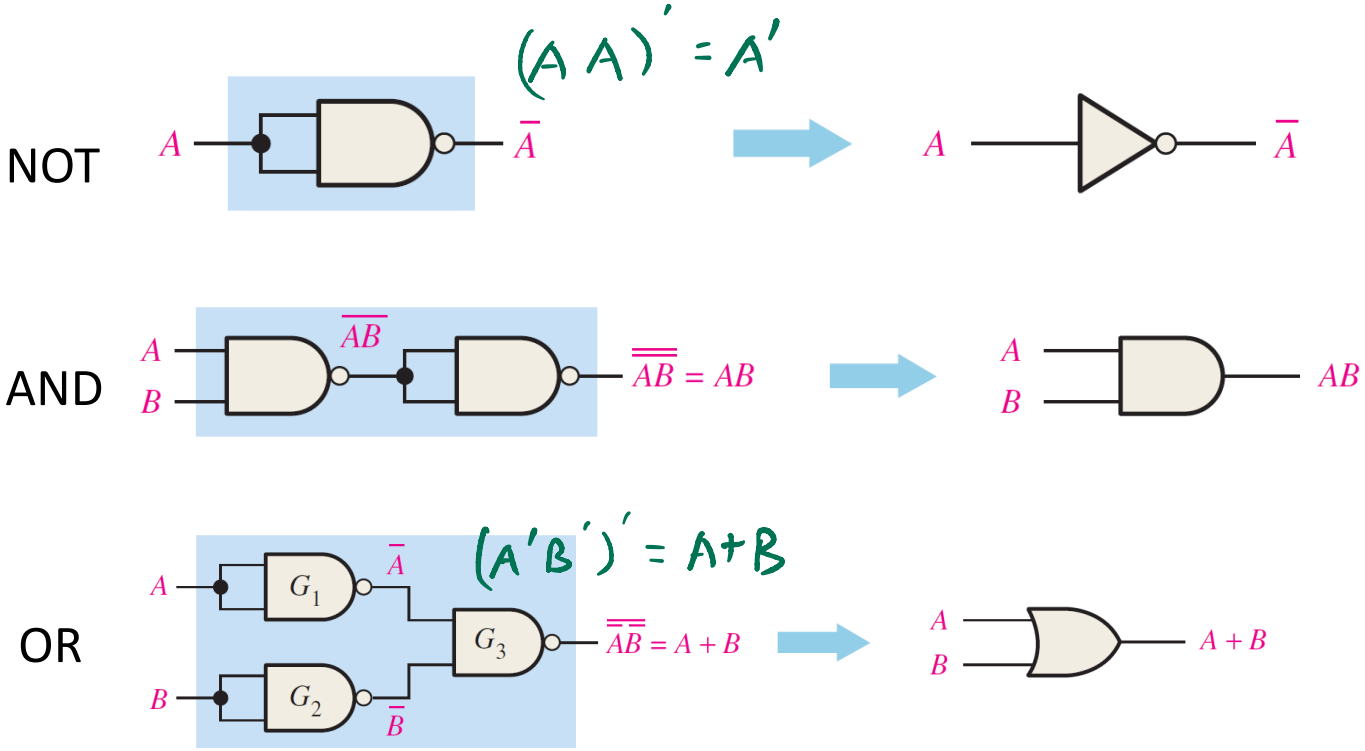
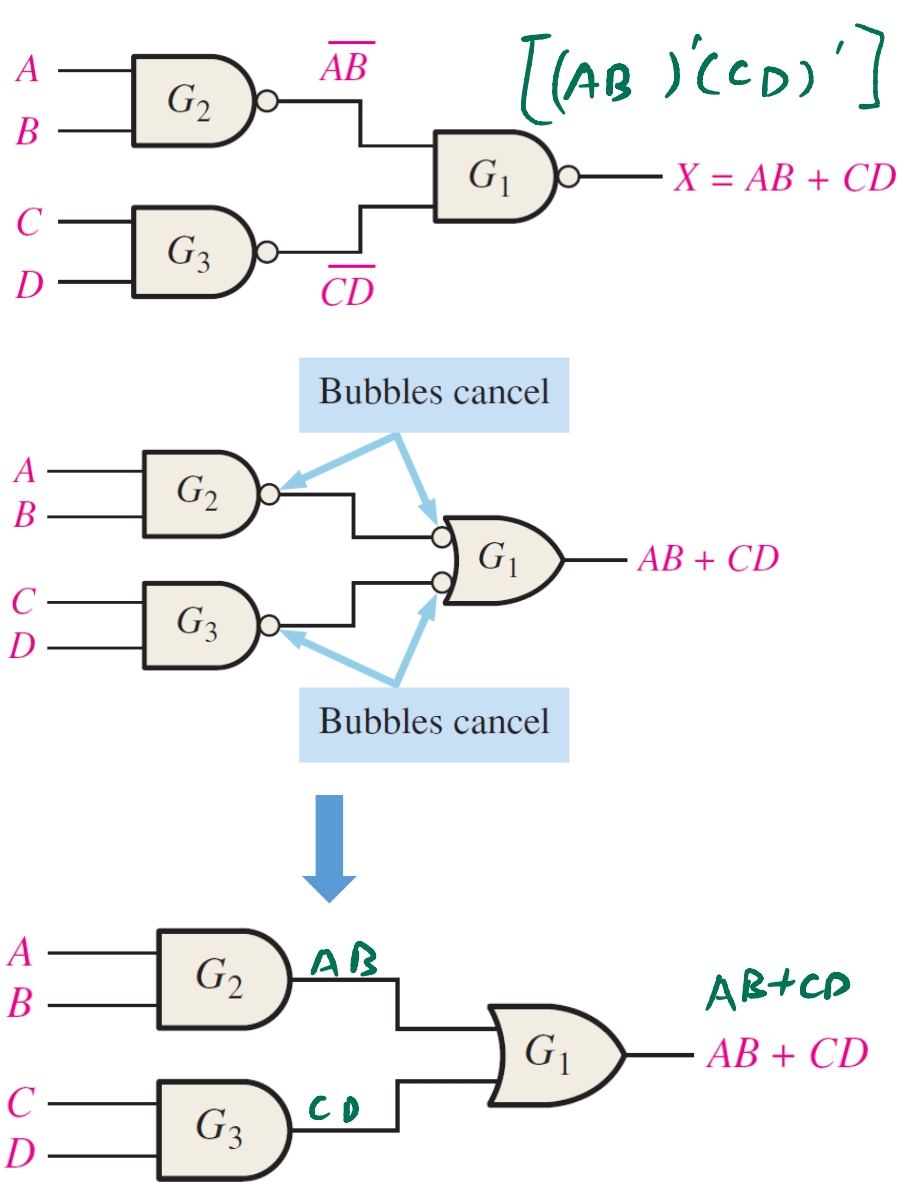
Universality of NAND gate



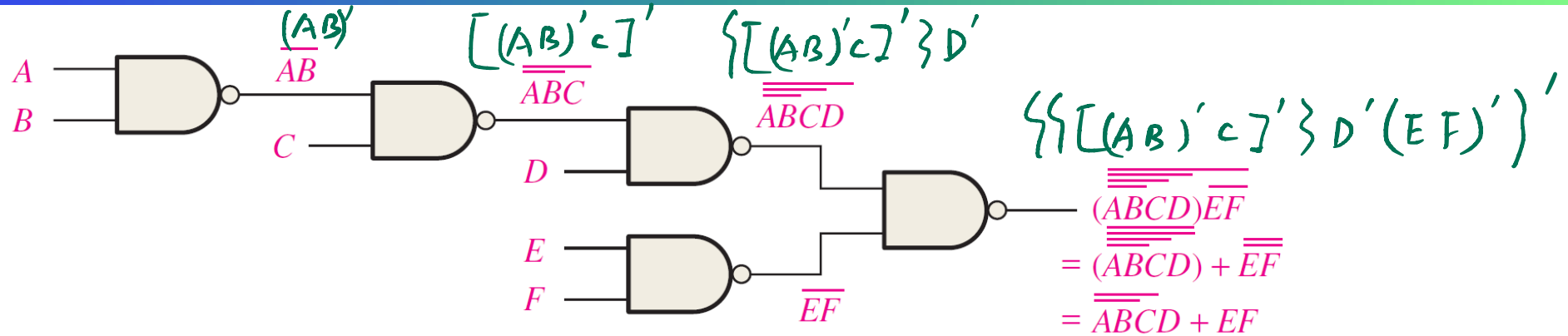
- The universality means that it can be used as an inverter, AND, OR, and NOR operations.
- The three basic logic gates, AND, OR and NOT, can be used to build any combinational logic circuit.

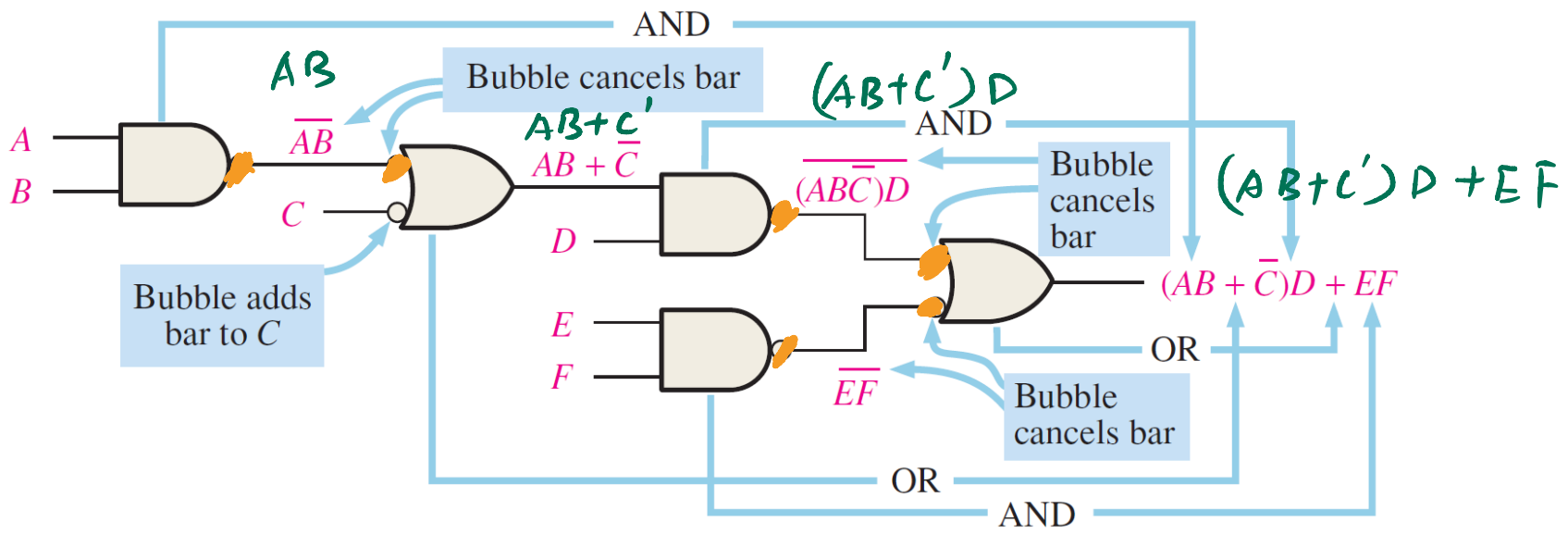
Simplify NAND logic using dual symbols



- All logic diagrams using NAND gates should be drawn with each gate represented by either a NAND or the equivalent negative-OR.
- They are known as the dual symbols.
- Ensure either bubble-to-bubble or nonbubble-to-nonbubble connection between output and input.

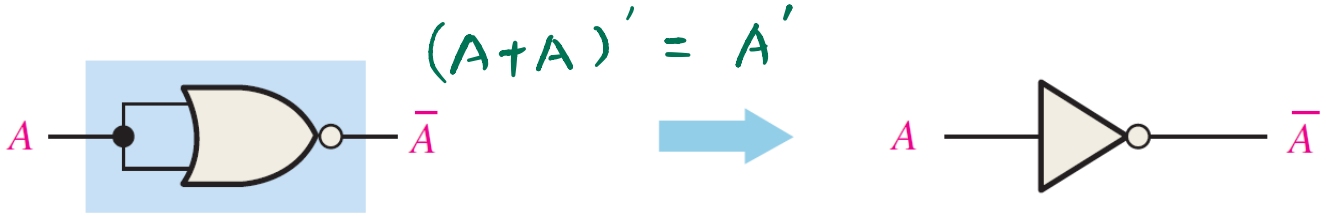
Simplify NAND logic using dual symbols





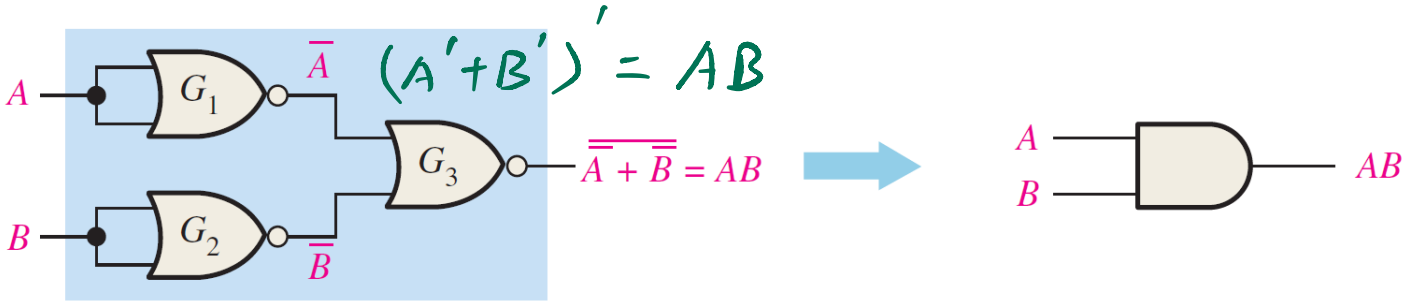
Universality of NOR gate

NOT

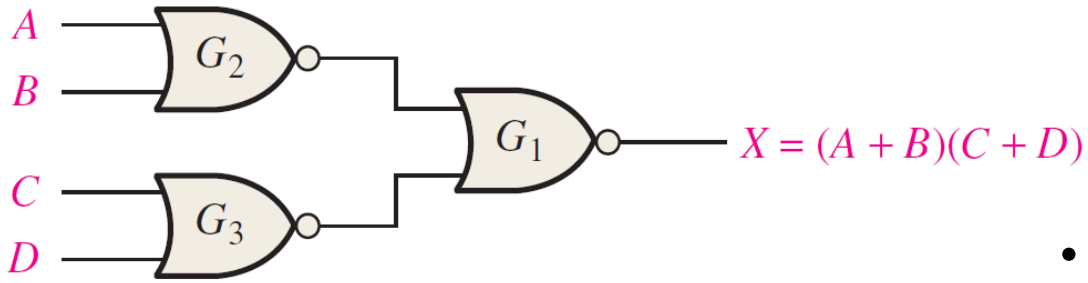


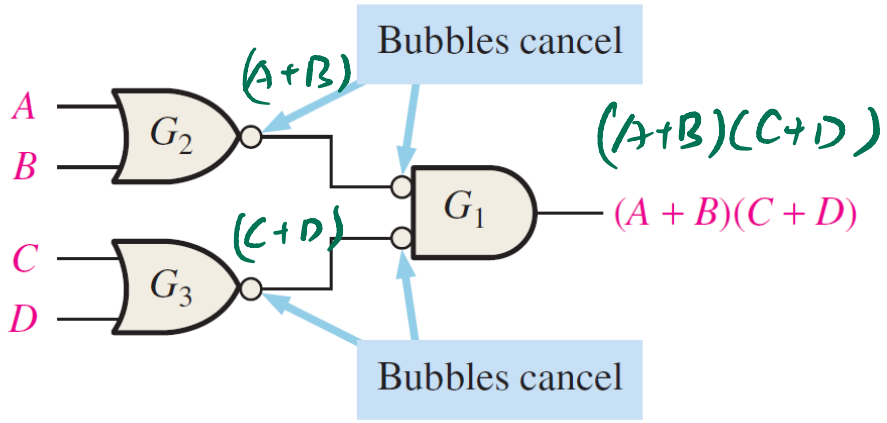
OR

AND



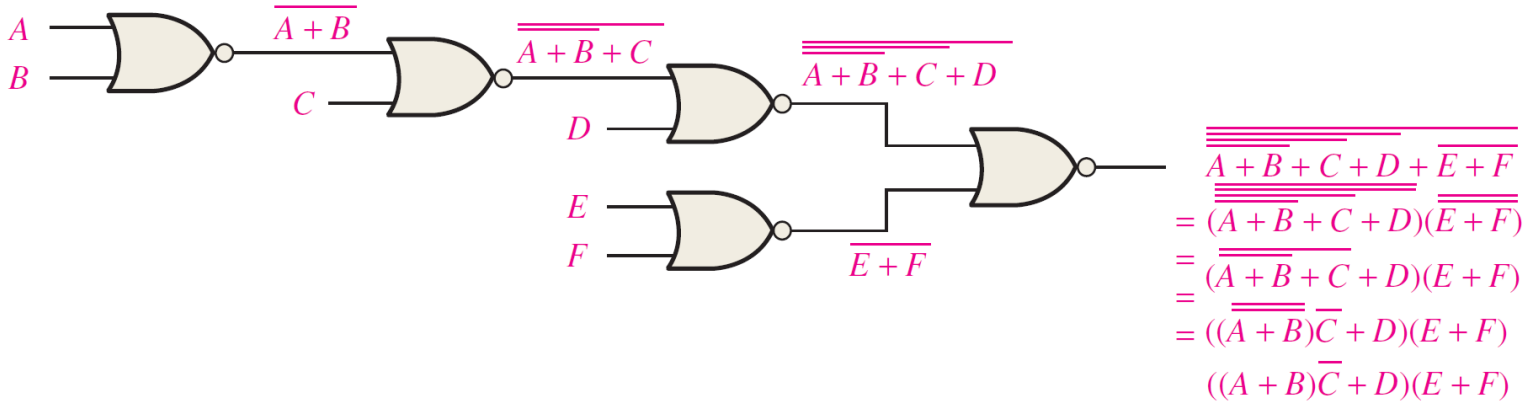
Simplify NOR logic using dual symbols

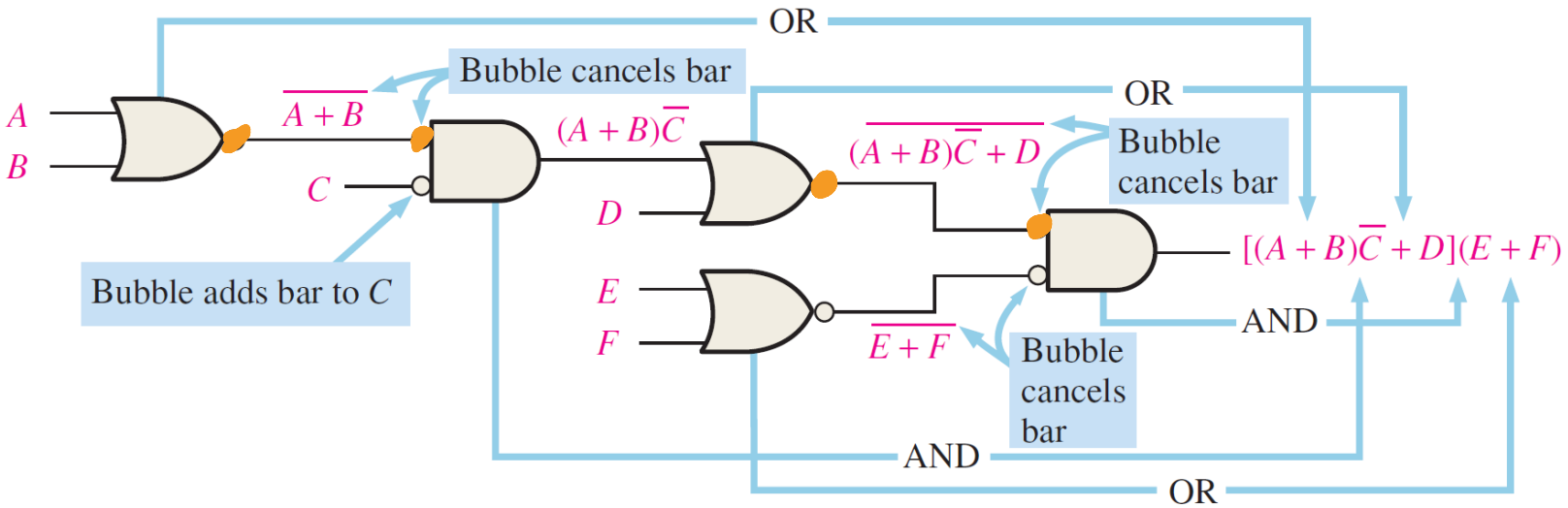


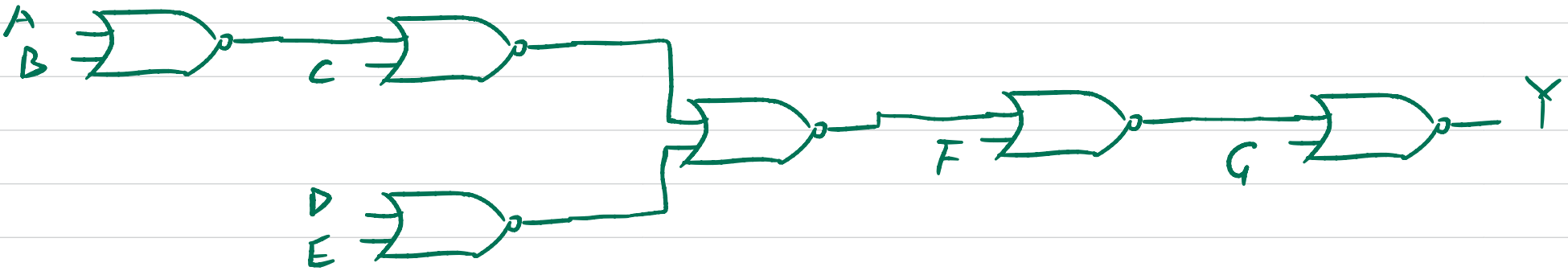


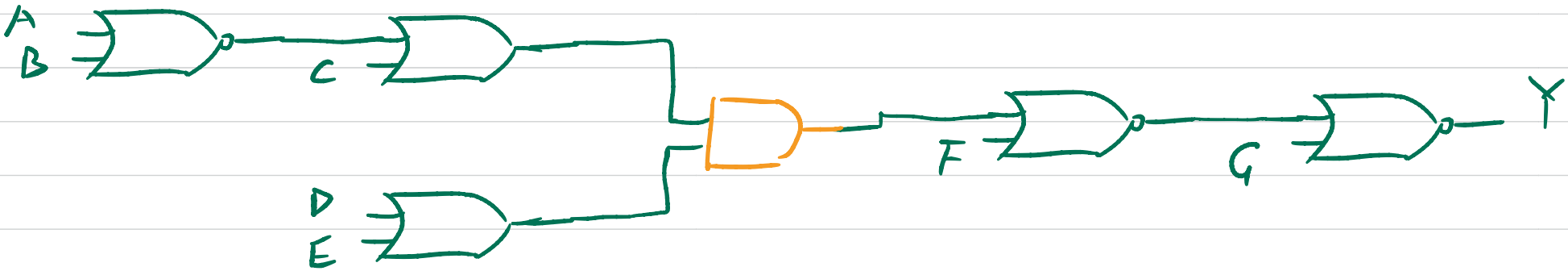
- All logic diagrams using NOR gates should be drawn with each gate represented by either a NOR or the equivalent negative-AND symbol.
- Ensure either bubble-tobubble or nonbubble-to-nonbubble connection between output and input.

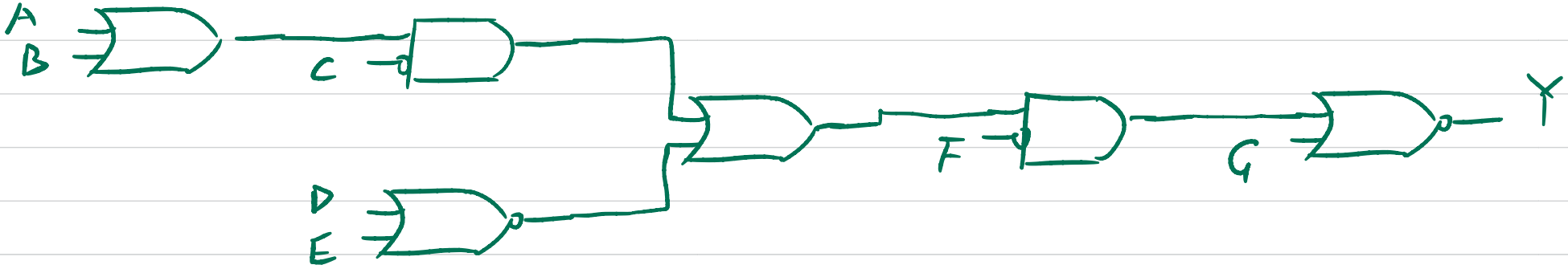
Simplify NOR logic using dual symbols





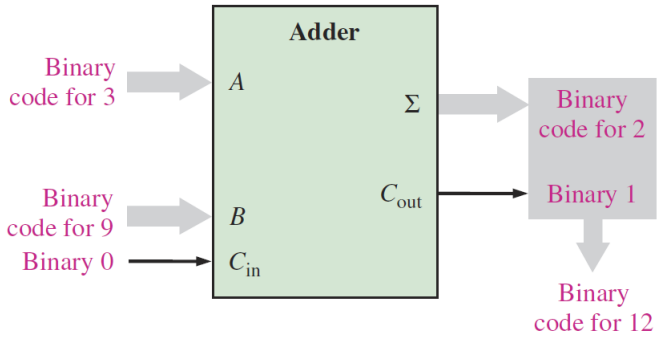

A
B
C
D
E
F
G
Y

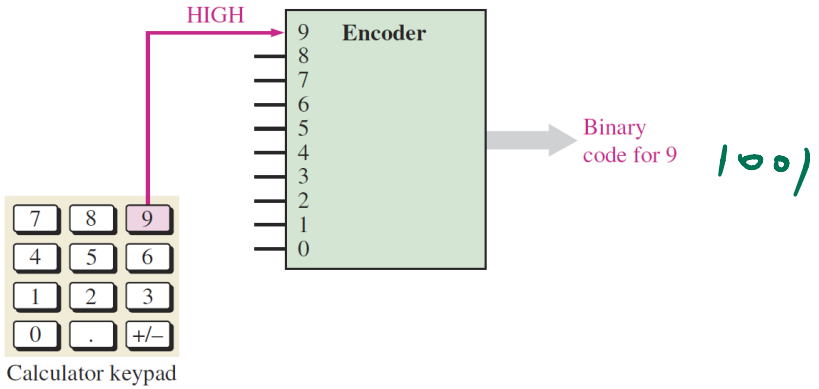

A
B
C
D
E
F
G
Y

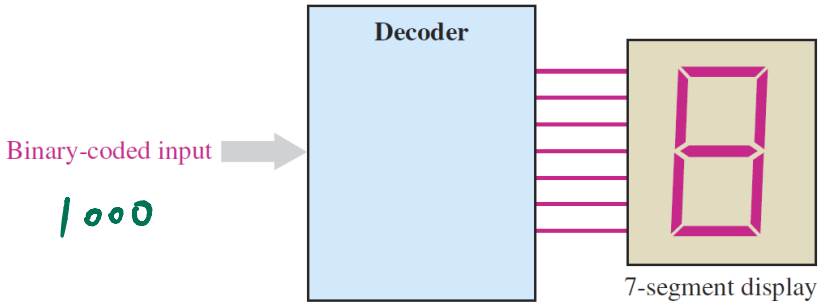

A
B
C
D
E
F
G
Y

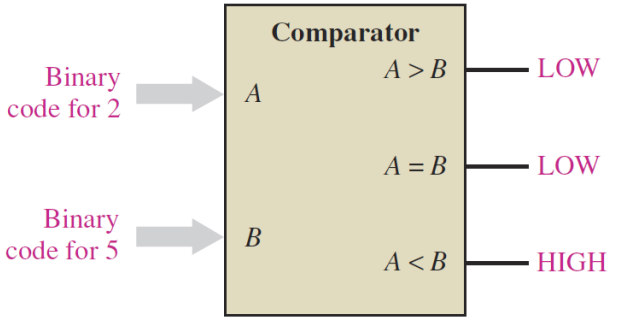
Combinational Logic

- The output only dependent on the present input









Design Combinational Logic

一、逻辑抽象

- 分析因果关系，确定输入/输出变量
- 定义逻辑状态的含意（赋值）
- 列出真值表

二、写出函数式

三、选定器件类型

四、根据所选器件：对逻辑式化简（用门）
变换（用MSI）
或进行相应的描述（PLD）

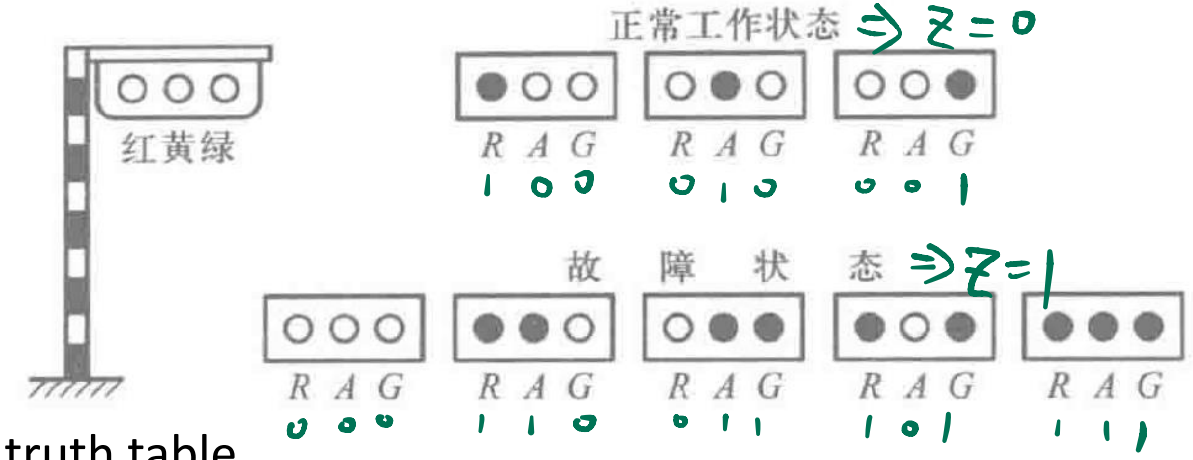
五、画出逻辑电路图，或下载到PLD

六、工艺设计

Design Example

Use NAND Gate

- Logic abstraction



- List the truth table

R	A	G	Z
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

$Z = R'A'G' + R'AG + RA'G + RAG' + RAG$

$Z' = R'A'G + R'AG' + RA'G'$

Design Example

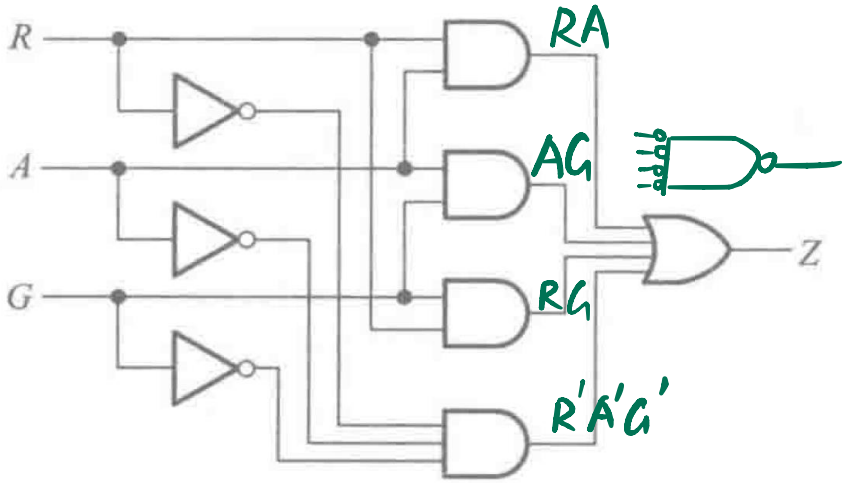
- Get the Boolean expression

$$Z = R'A'G' + R'AG + RA'G + RAG' + RAG$$

- Simplify the Boolean expression

$$Z = R'A'G' + RA + RG + AG$$

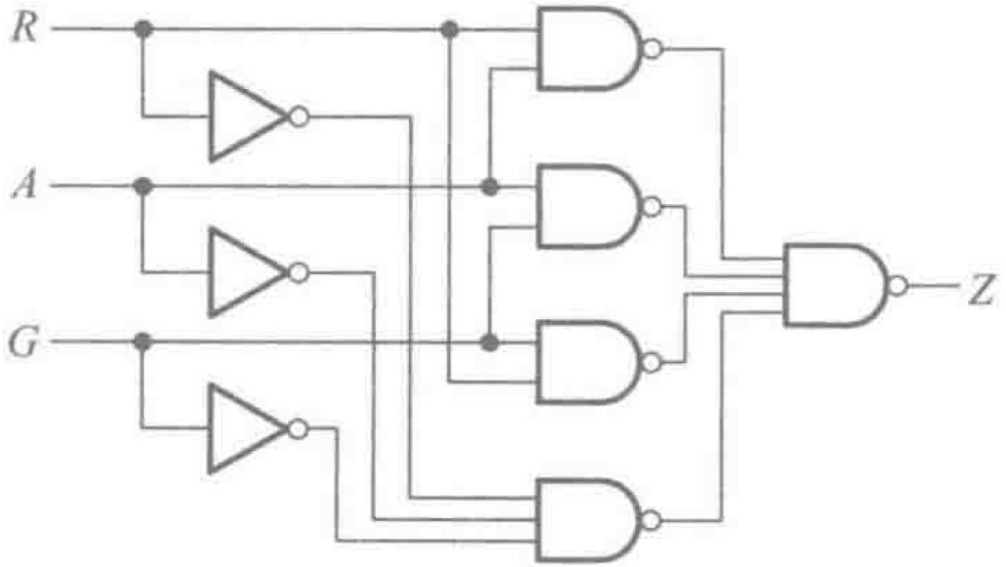
- Draw the circuit



Design Example

- If only NAND is available, the circuit need to be modified

$$Z = ((R'A'G'+RA+RG+AG)')'$$
$$= ((R'A'G')'(RA)'(RG)'(AG)')'$$



Reading materials

- Chapter 5 of Floyd book
- Chapter 4 of 阎石 book