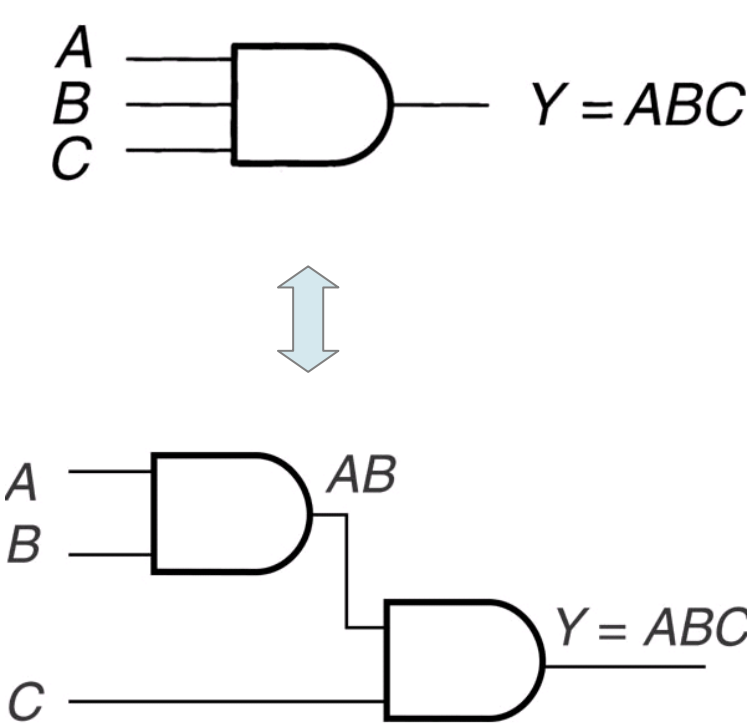
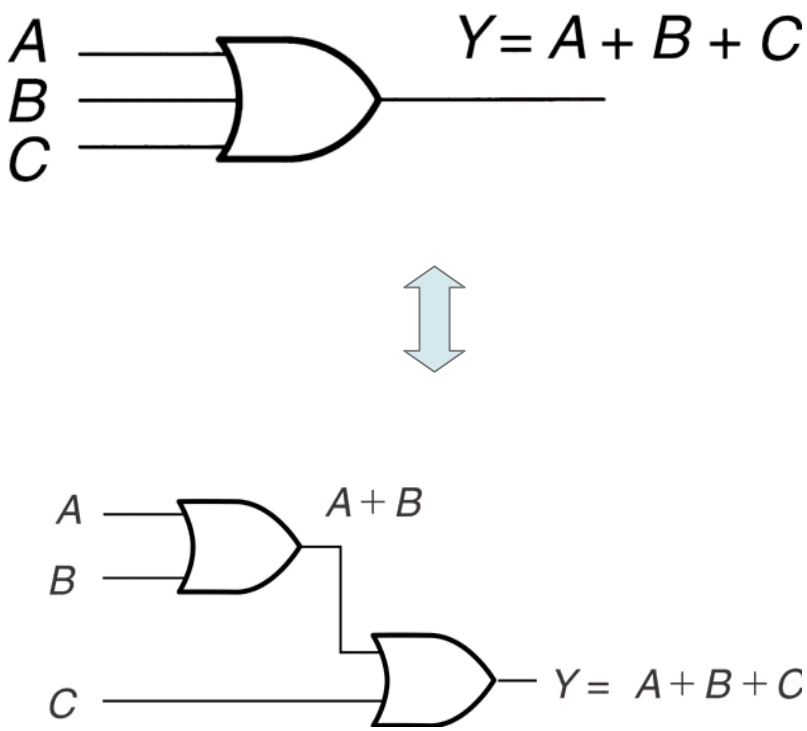


Class 4
Combinational Logic

Three-Input AND and OR





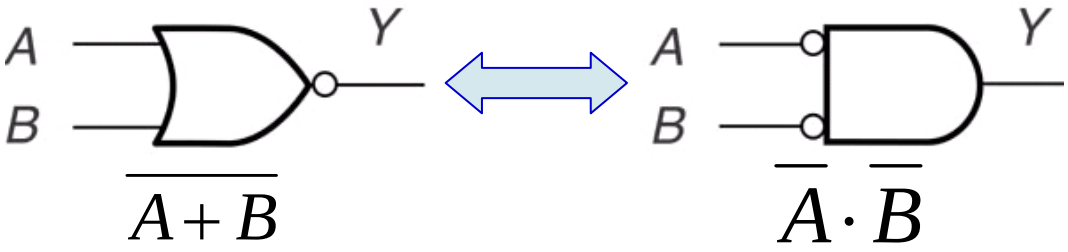
DeMorgan's Theorems

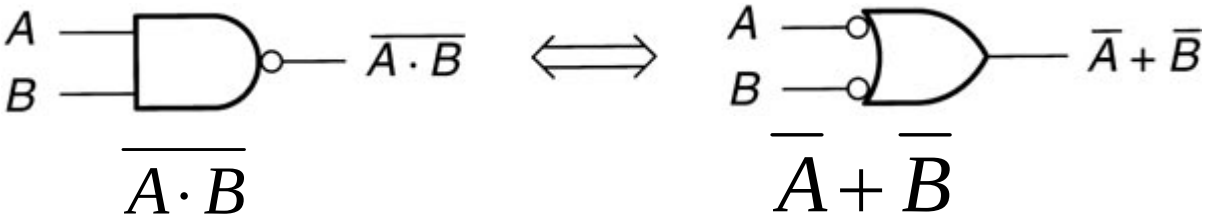
- Break the line and change the sign

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

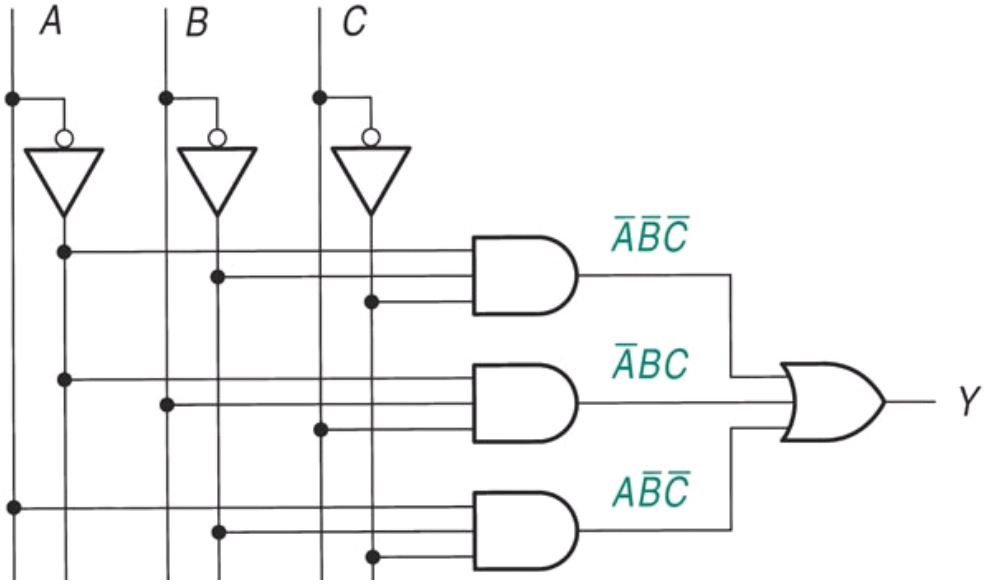
$$\overline{A + B} = \overline{A} \cdot \overline{B}$$

A	B	$\overline{A \cdot B}$	$\overline{A} + \overline{B}$	$\overline{A + B}$	$\overline{A} \cdot \overline{B}$
0	0	1	1	1	1
0	1	1	1	0	0
1	0	1	1	0	0
1	1	0	0	0	0





Boolean Expression from Logic Gate



Logic gates

A	B	C	$\bar{A}\bar{B}\bar{C}$	$\bar{A}BC$	$A\bar{B}\bar{C}$	Y
0	0	0	1	0	0	1
0	0	1	0	0	0	0
0	1	0	0	0	0	0
0	1	1	0	1	0	1
1	0	0	0	0	1	1
1	0	1	0	0	0	0
1	1	0	0	0	0	0
1	1	1	0	0	0	0

Truth table



Sum of Products (SOP) and Product of Sums (POS)

A	B	C	$\overline{A}\overline{B}\overline{C}$	$\overline{A}BC$	$A\overline{B}\overline{C}$	Y	$\overline{Y}$	Minterms	$\overline{Y}$	Maxterms
0	0	0	1	0	0	1	0	$\overline{A}\overline{B}\overline{C}$		
0	0	1	0	0	0	0	1		$\overline{A}\overline{B}C$	$A+B+\overline{C}$
0	1	0	0	0	0	0	1		$\overline{A}B\overline{C}$	$A+\overline{B}+C$
0	1	1	0	1	0	1	0	$A\overline{B}\overline{C}$		
1	0	0	0	0	1	1	0	$\overline{A}BC$		
1	0	1	0	0	0	0	1		$A\overline{B}C$	$\overline{A}+B+\overline{C}$
1	1	0	0	0	0	0	1		$AB\overline{C}$	$\overline{A}+\overline{B}+C$
1	1	1	0	0	0	0	1		ABC	$\overline{A}+\overline{B}+\overline{C}$



Sum of Products (SOP) and Product of Sums (POS) (Cont.)

(SOP) → AND then OR

$$Y = \overline{A}\overline{B}\overline{C} + \overline{A}BC + A\overline{B}\overline{C}$$

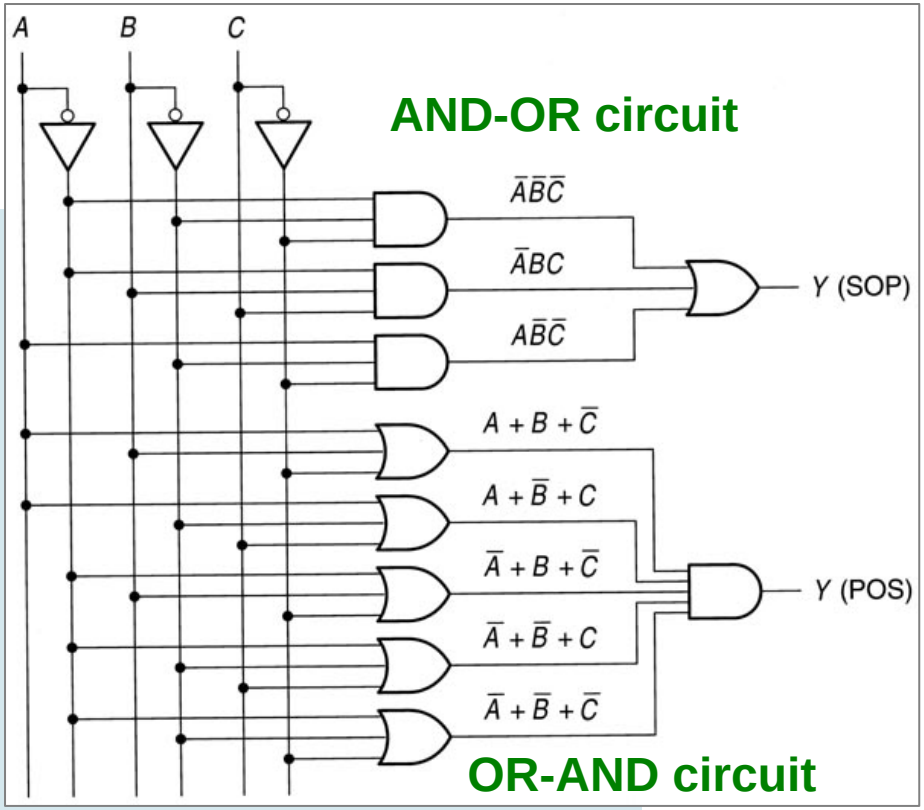
$$Y = \overline{B}\overline{C} + \overline{A}BC \text{ (reduction)}$$

$$\overline{Y} = \overline{A}\overline{B}C + \overline{A}B\overline{C} + A\overline{B}C + AB\overline{C} + ABC$$

$$\overline{\overline{Y}} = \overline{\overline{A}\overline{B}C + \overline{A}B\overline{C} + A\overline{B}C + AB\overline{C} + ABC}$$

$$Y = \overline{\overline{A}\overline{B}C} \cdot \overline{\overline{A}B\overline{C}} \cdot \overline{A\overline{B}C} \cdot \overline{AB\overline{C}} \cdot \overline{ABC}$$

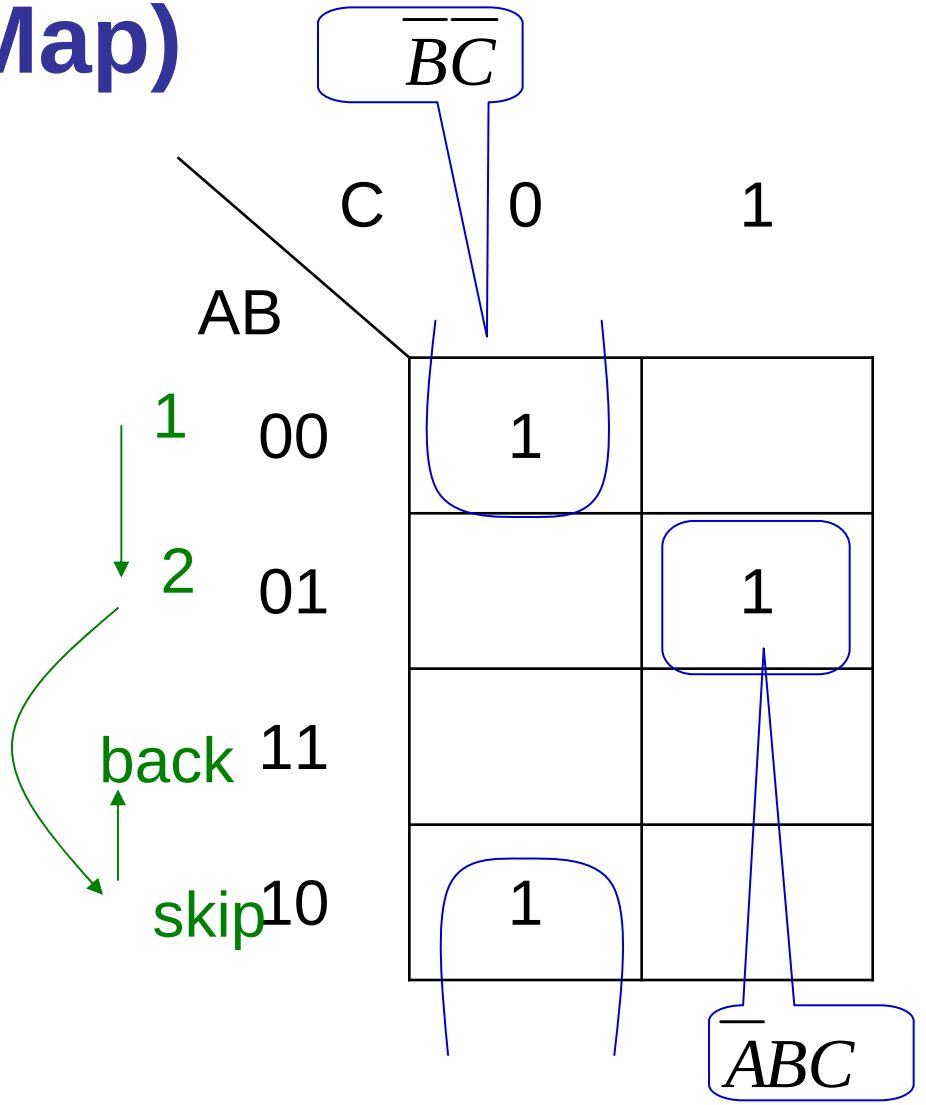
$$Y = (A + B + \overline{C}) \cdot (A + \overline{B} + C) \cdot (\overline{A} + B + \overline{C}) \cdot (\overline{A} + \overline{B} + C) \cdot (\overline{A} + \overline{B} + \overline{C})$$



(POS) → OR then AND

Karnaugh Map (K-Map)

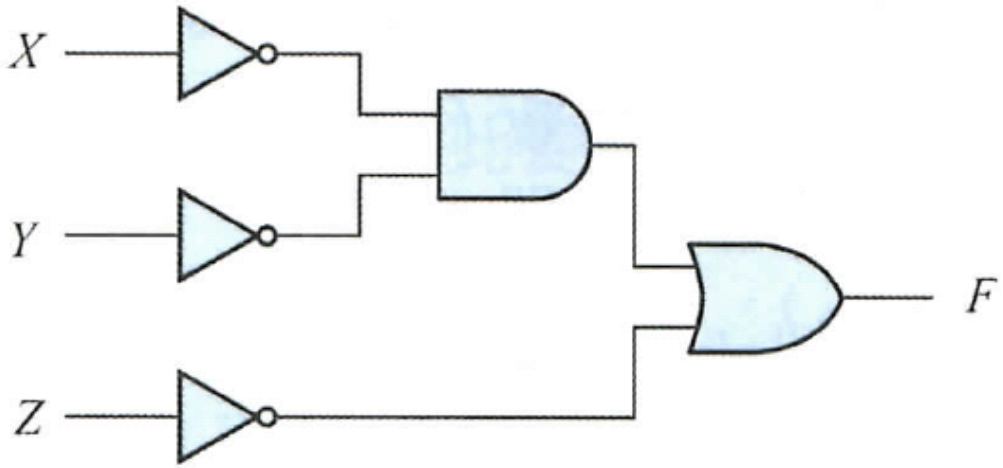
A	B	C	$\overline{A}\overline{B}\overline{C}$	$\overline{A}BC$	$A\overline{B}\overline{C}$	Y
0	0	0	1	0	0	1
0	0	1	0	0	0	0
0	1	0	0	0	0	0
0	1	1	0	1	0	1
1	0	0	0	0	1	1
1	0	1	0	0	0	0
1	1	0	0	0	0	0
1	1	1	0	0	0	0

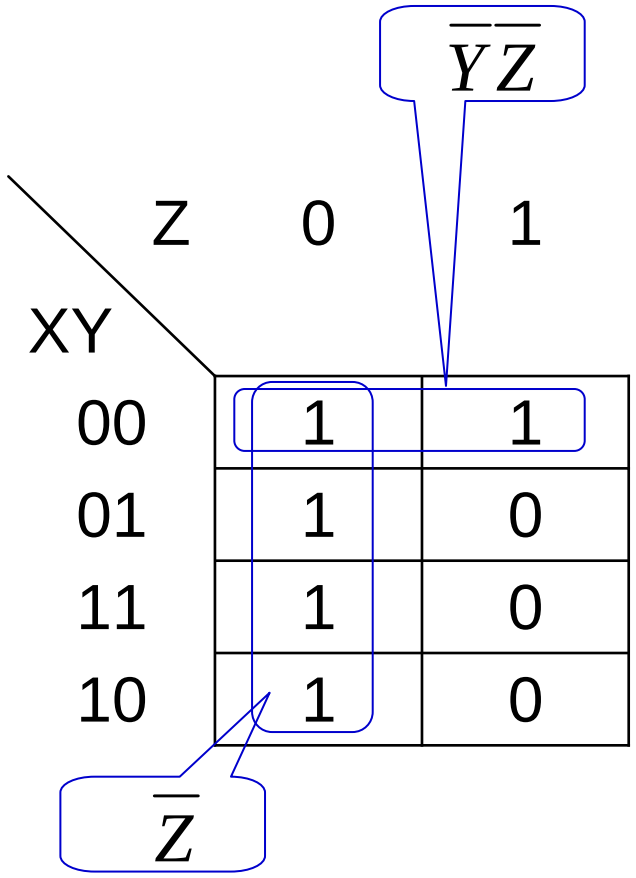


AND-OR Circuit

- Transform the Boolean expression into a simplified SOP(積之和) form.

$$F = \overline{Z} + \overline{X}\,\overline{Y}$$





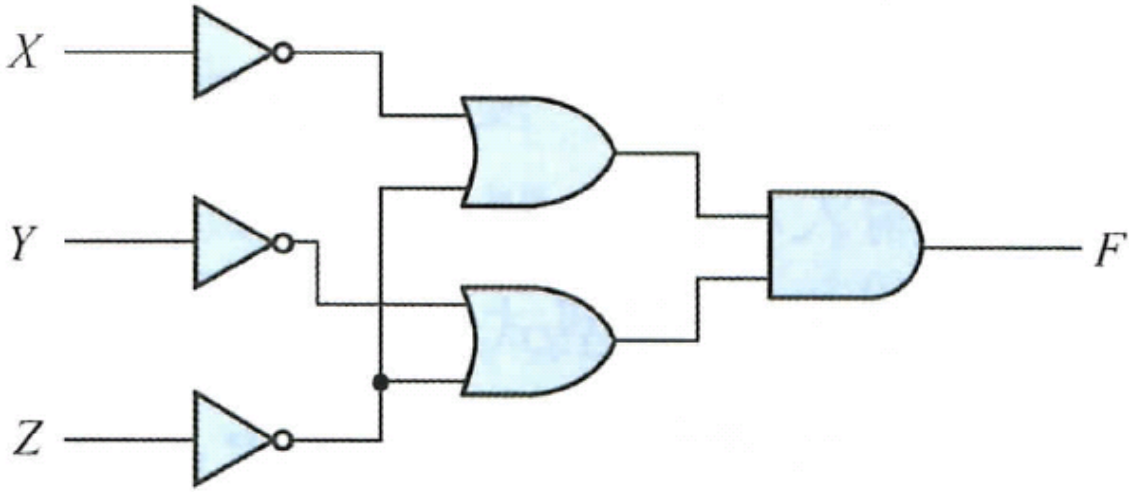


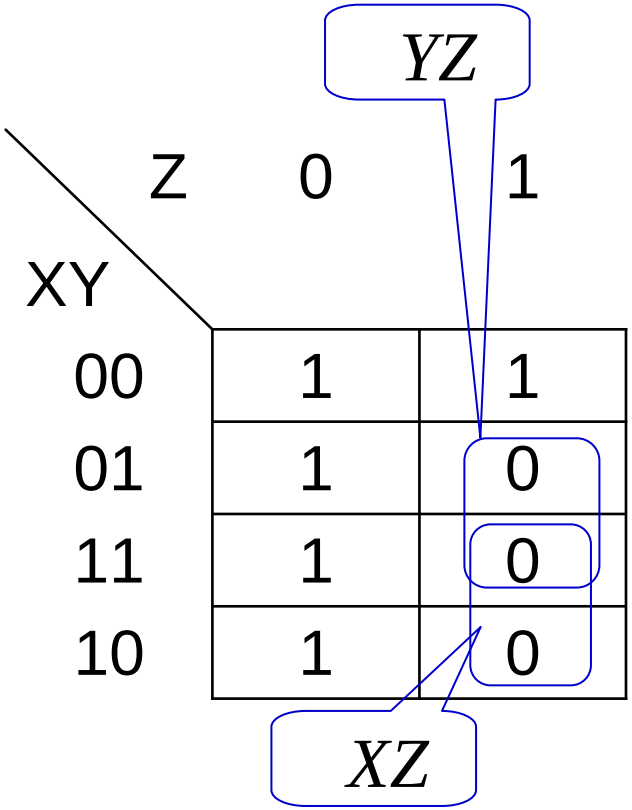
OR-AND Circuit

- Transform the Boolean function into a simplified POS (和之積) form.

$$\overline{F} = XZ + YZ$$

$$F = \overline{XZ + YZ} = \overline{XZ} \cdot \overline{YZ} = (\overline{X} + \overline{Z})(\overline{Y} + \overline{Z})$$





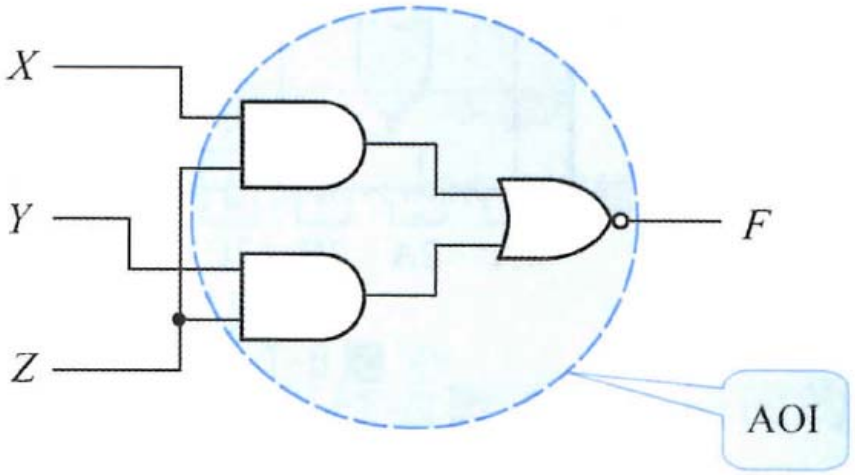


AOI (AND-OR-NOT) Circuit

- How to design an AOI circuit:
  - Derive an SOP form for ***complement F***
  - Negate the complement F to derive F

$$\overline{F} = XZ + YZ$$

$$F = \overline{XZ + YZ}$$



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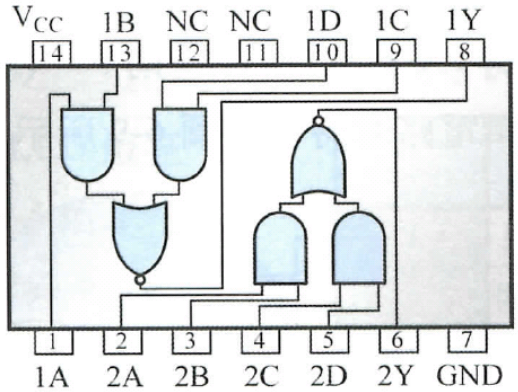
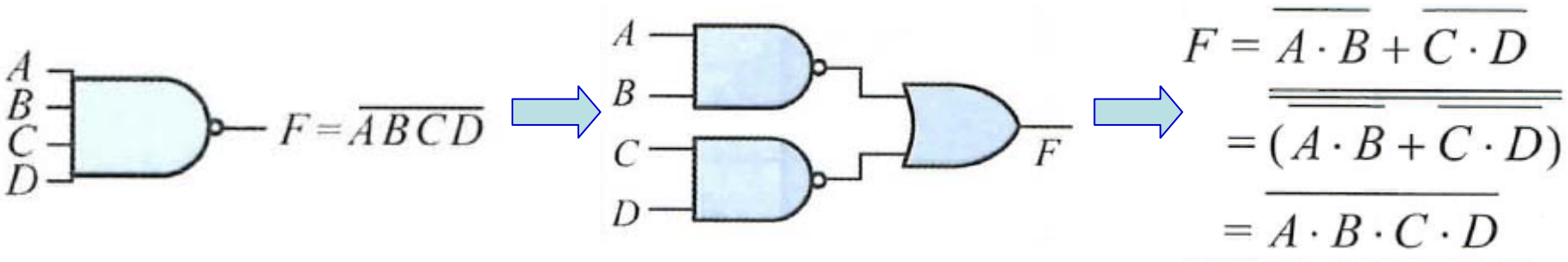


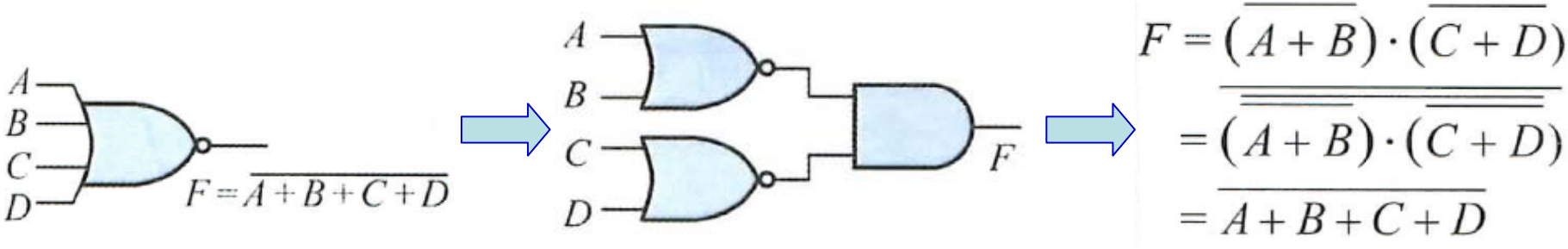
XY \ Z	0	1
00	1	1
01	1	0
11	1	0
10	1	0

YZ XZ



Four-Input NAND and NOR

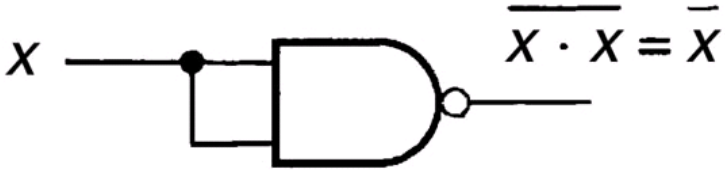




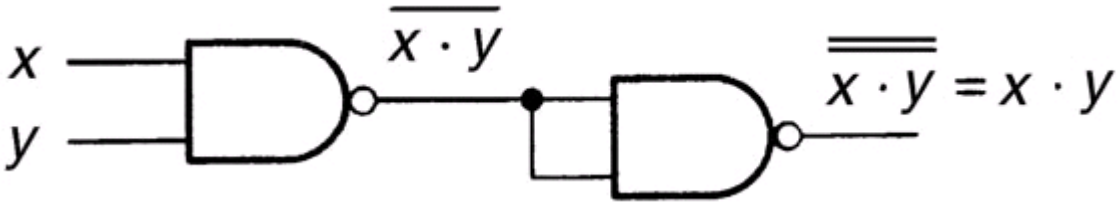


ALL NAND

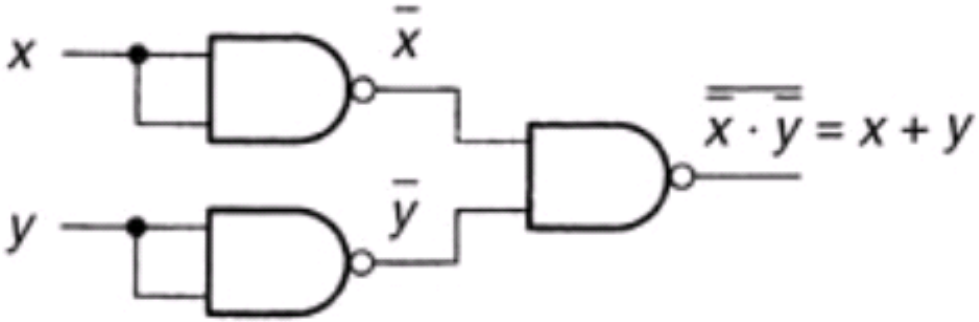
NOT

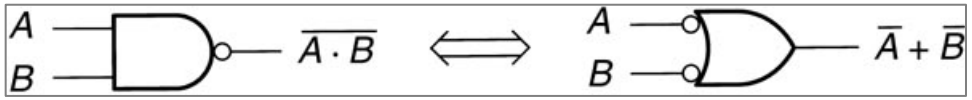


AND



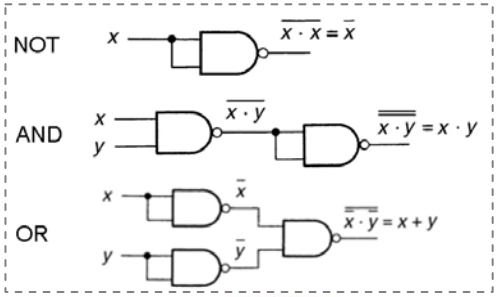
OR



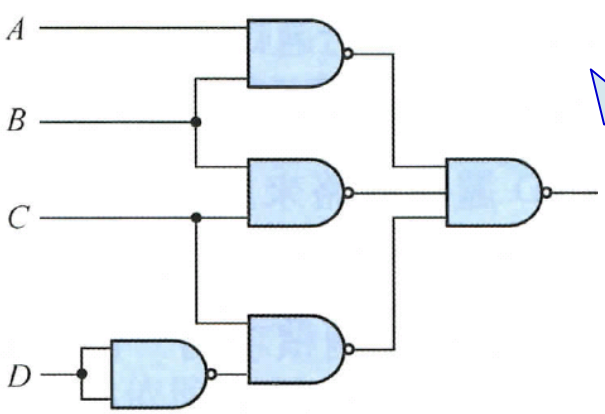


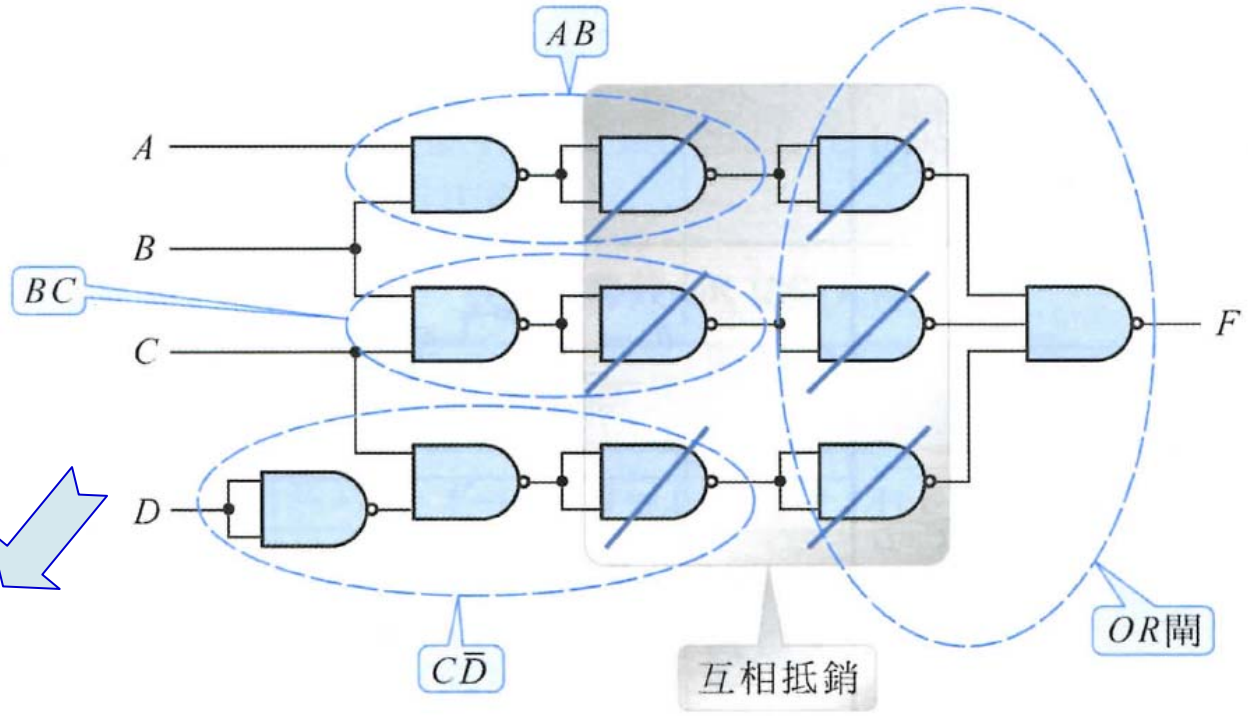


An Example of All NAND



Design an AND-OR circuit in the SOP form so as to derive a simplified circuit.



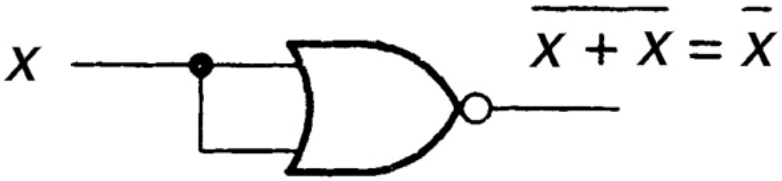


$$F = AB + BC + C\overline{D}$$

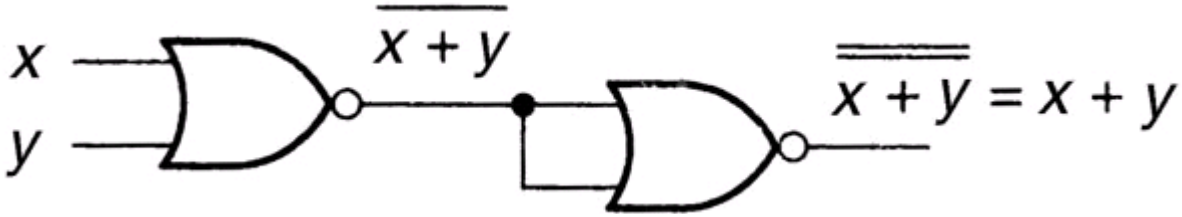


All NOR

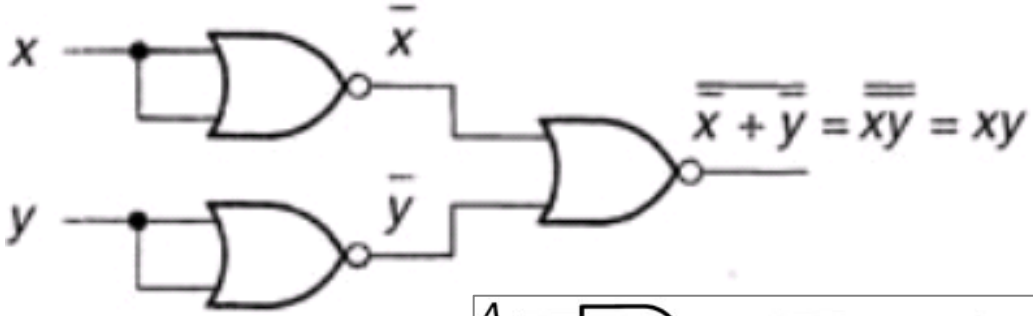
NOT

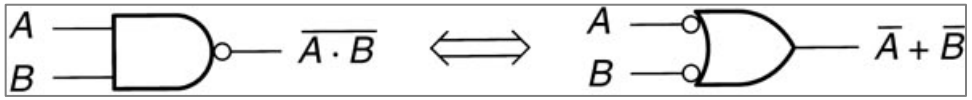


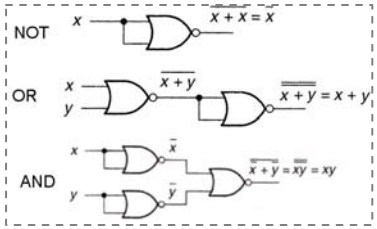
OR



AND

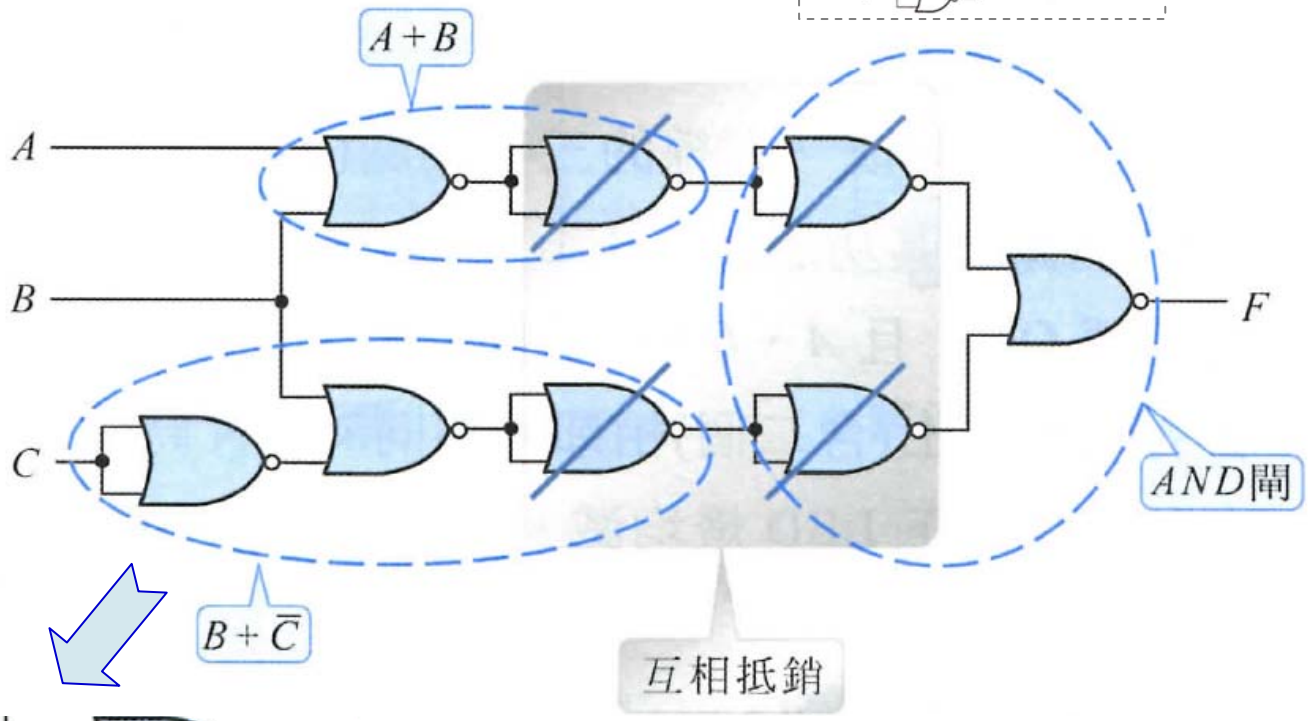


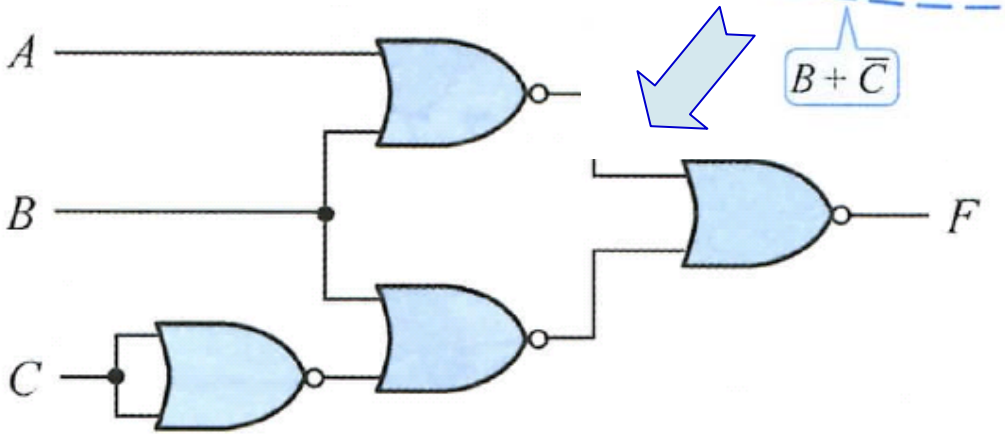




An Example of All NOR

Design an OR-AND circuit in the POS form so as to derive a simplified circuit.





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



Lab 4 – Part 1

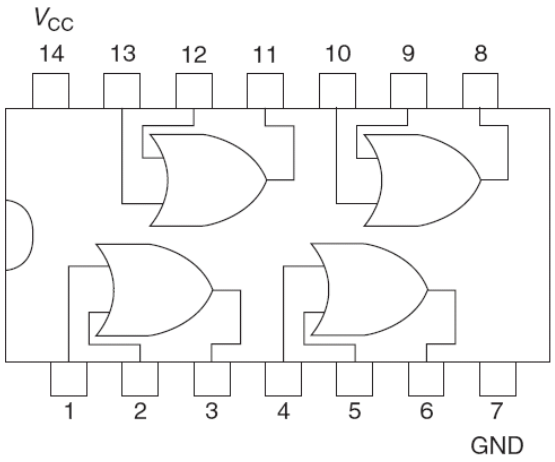
- Design a combinational circuit to solve the following question:
  - There are three switches (A, B, and C), one green LED, and one red LED.
  - When the power is on,
    - The red LED is off and the green LED is on when none or one of the switches is on.
    - The red LED is on and the green LED is off when two or three switches are on.

Lab 4 – Part 2

- Design a combinational circuit to solve the following question:
  - There are three switches (A, B, and C) and one LED.
  - When the power is on,
    - The LED is on when any two or more adjacent switches are on at the same time (i.e., A B on, B C on, A B C on).
    - Otherwise, the LED is off.



Chip Logic Circuit



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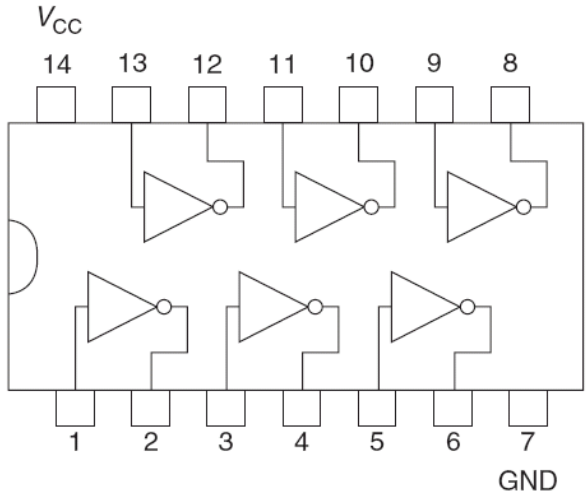
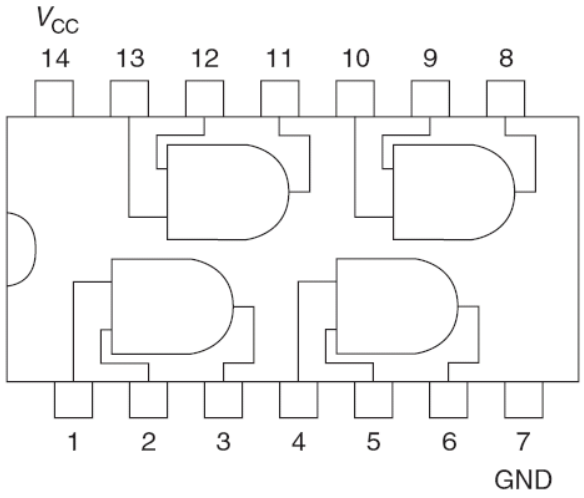


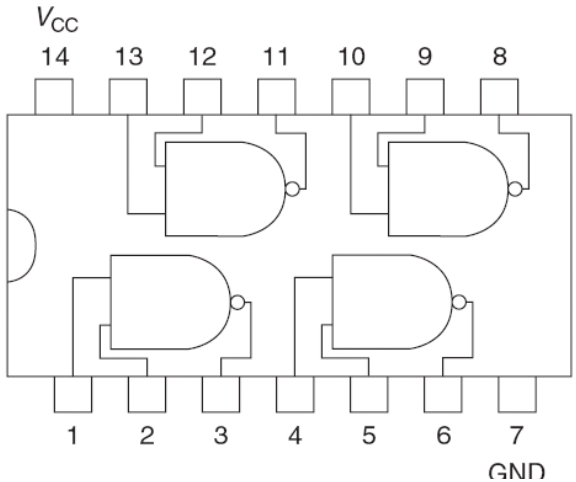
74LS04



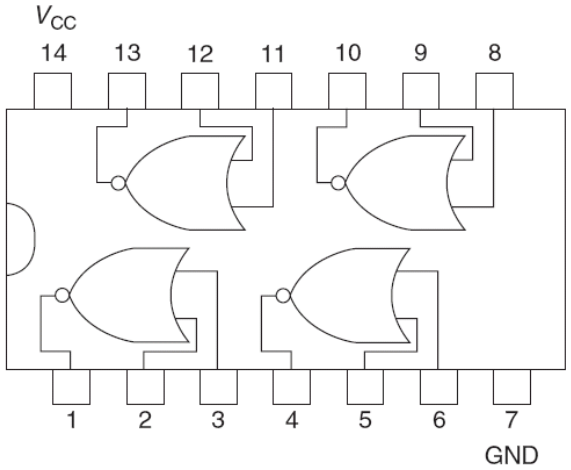
74LS08



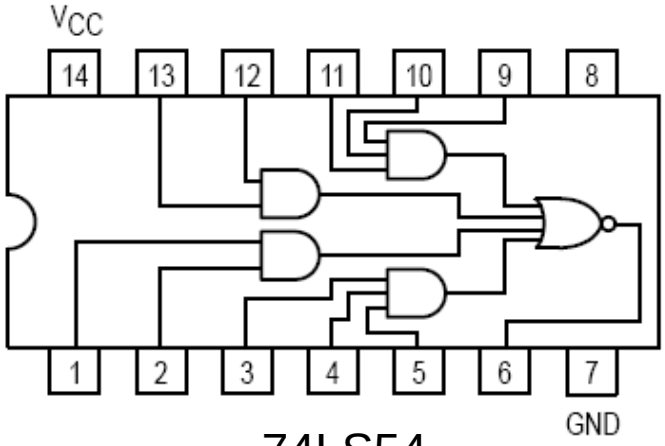
Chip Logic Circuit (Cont.)



74LS00



74LS02

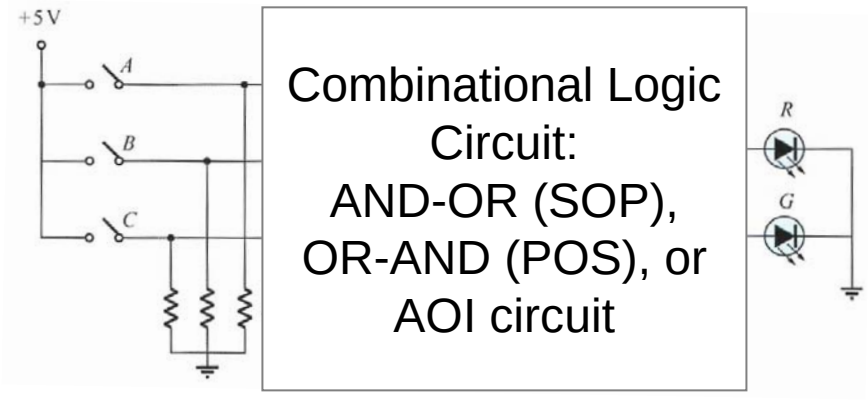


74LS54



Report 4 – Part 1

- 班級：　　姓名：　　學號：
- 使用AND-OR (SOP)、OR-AND (POS)或AOI電路解決 Part 1 的問題並完成下圖中電路 (並標出所使用的IC編號，及導出邏輯線路的過程)。
- 說明所採用的電路及採用的原因。





Report 4 – Part 2

- 使用ALL-NAND 或 ALL-NOR電路解決 Part 2 的問題並完成下圖中電路 (並標出所使用的IC編號，及導出邏輯線路的過程)。

- 說明所採用的電路及採用的原因。