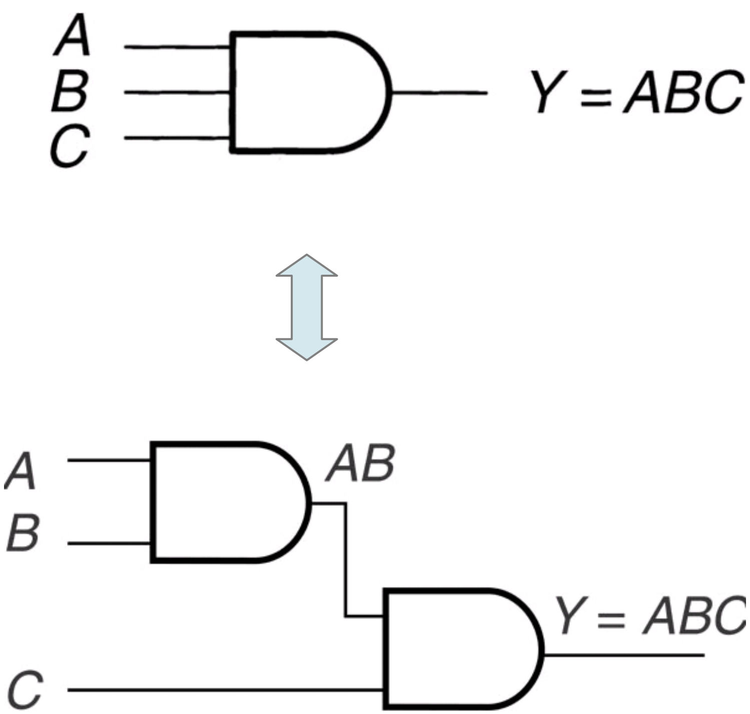
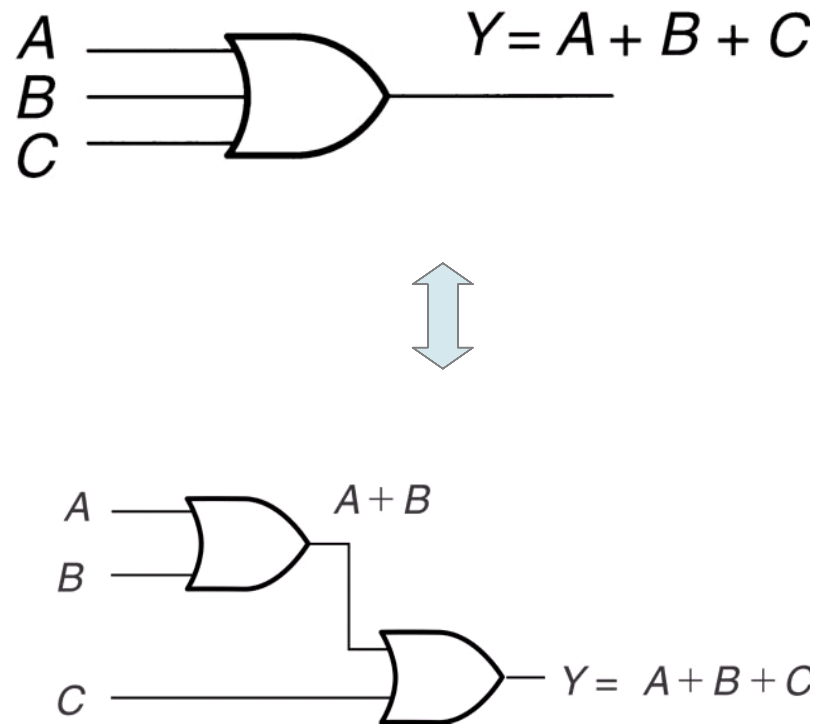


Class 4
Combinational Logic

Three-Input AND and OR







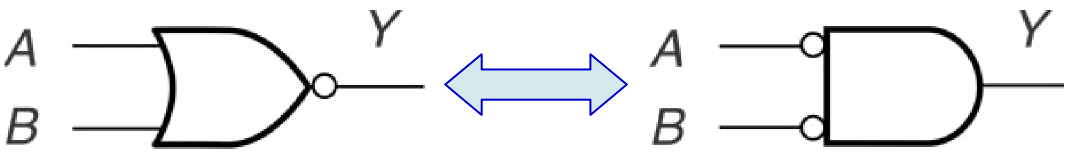
DeMorgan's Theorems

- Break the line and change the sign

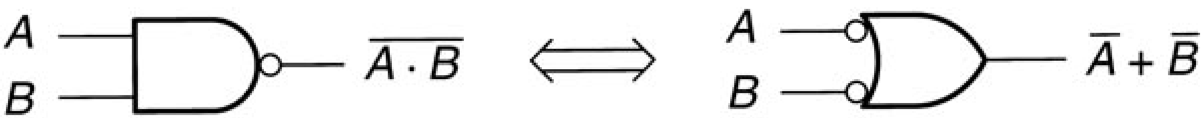
$$\overline{A\cdot B} = \overline{A} + \overline{B}$$

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

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

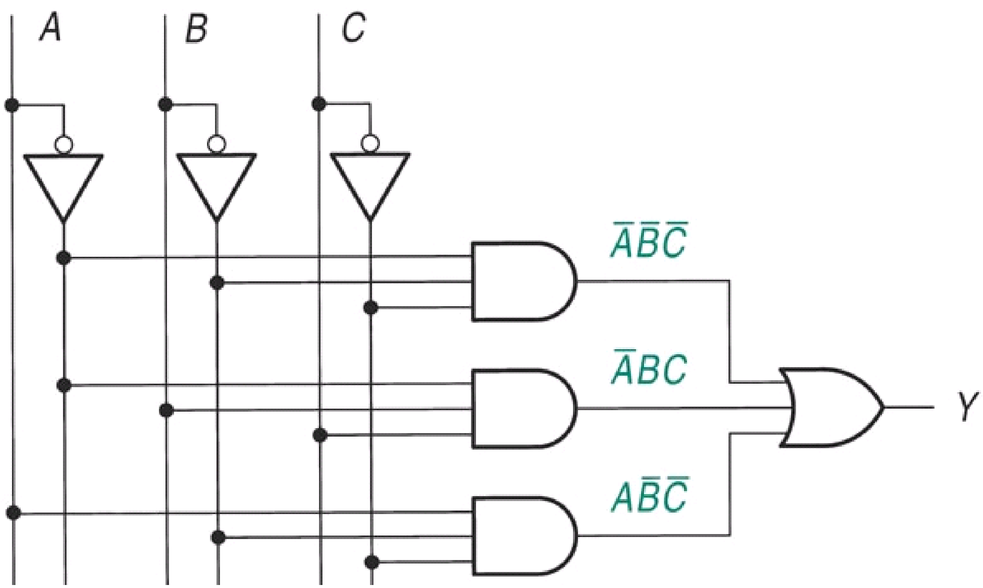


$\overline{A+B}$ $\overline{A}\cdot\overline{B}$



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

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

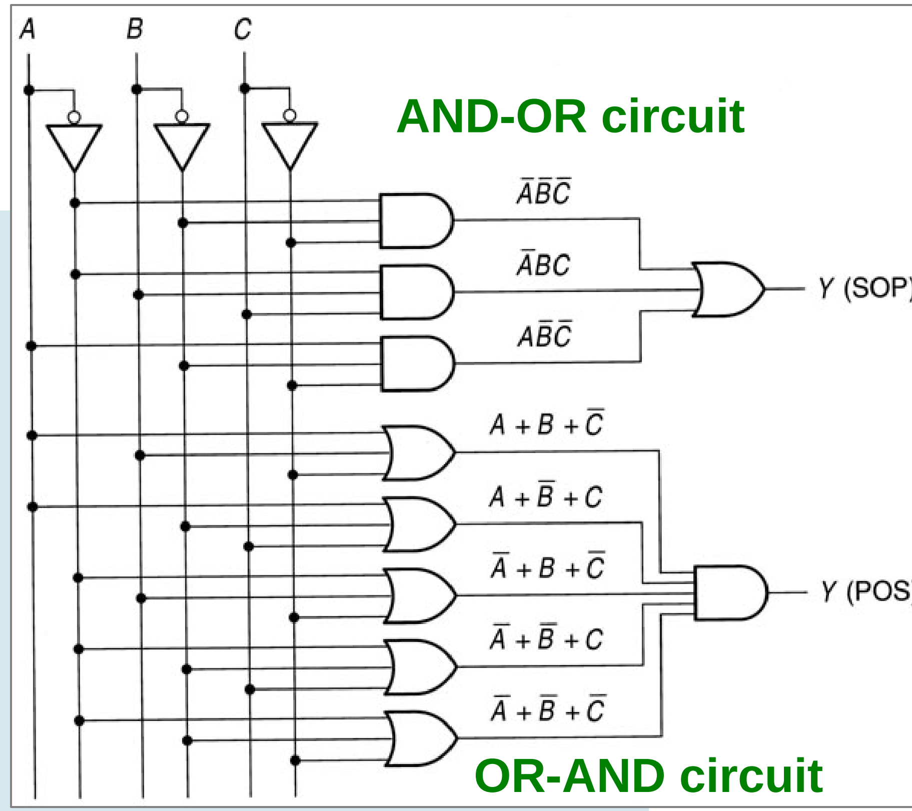
Truth table



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

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

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

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

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

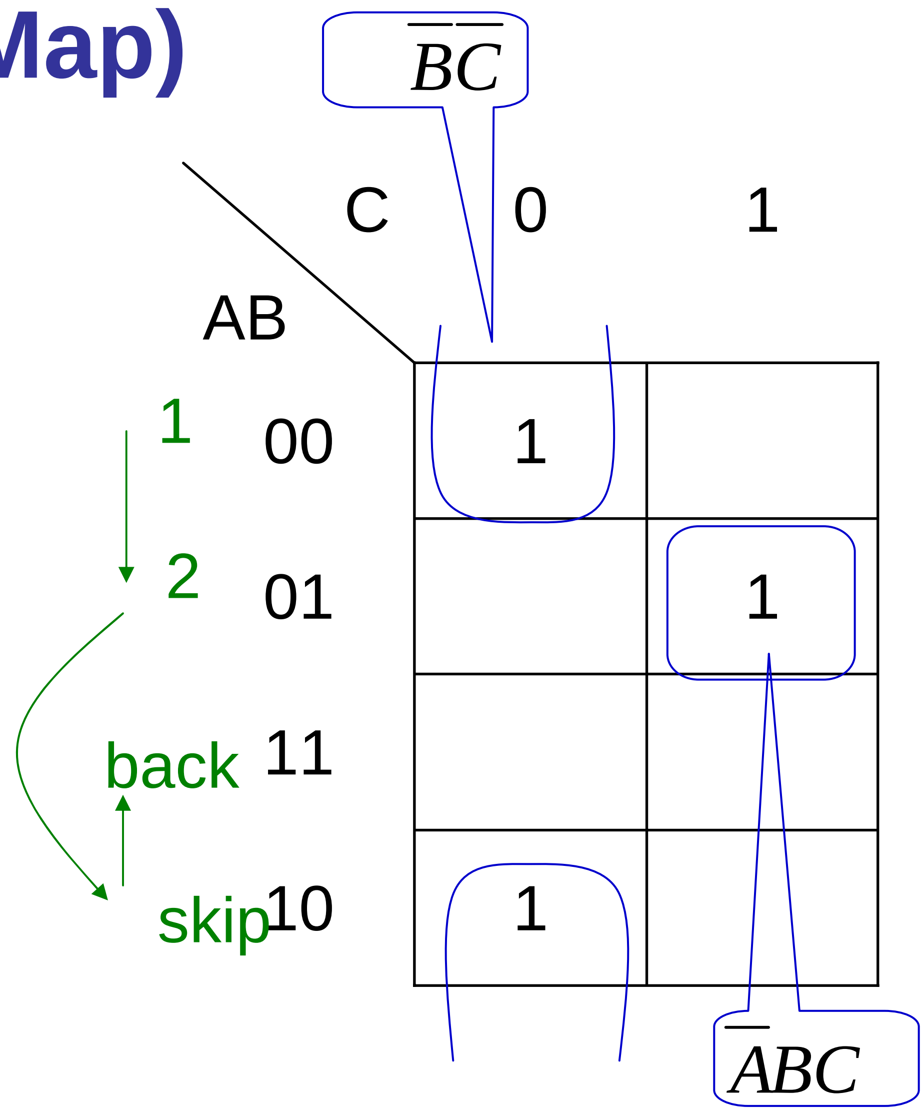
$$Y = \overline{\overline{A}\,\overline{B}C} \cdot \overline{\overline{A}B\overline{C}} \cdot \overline{A\overline{B}C} \cdot \overline{AB\overline{C}} \cdot \overline{ABC}$$

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

(POS) → OR then AND

Karnaugh Map (K-Map)

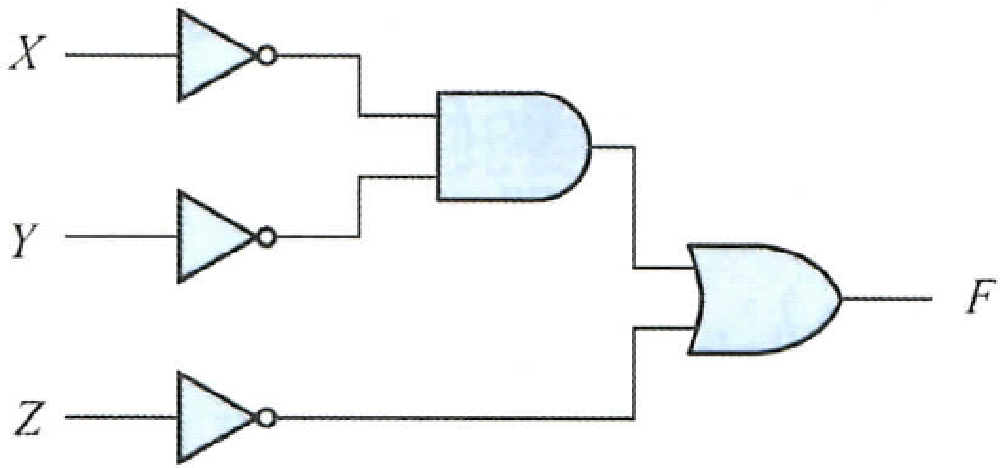
A	B	C	$\bar{A}\bar{B}\bar{C}$	$\bar{A}BC$	$A\bar{B}\bar{C}$	Y
0	0	0	1	0	0	1
0	0	1	0	0	0	0
0	1	0	0	0	0	0
0	1	1	0	1	0	1
1	0	0	0	0	1	1
1	0	1	0	0	0	0
1	1	0	0	0	0	0
1	1	1	0	0	0	0



AND-OR Circuit

- Transform the boolean expressoin into a simplified SOP form.

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



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

$\overline{Y}\,\overline{Z}$

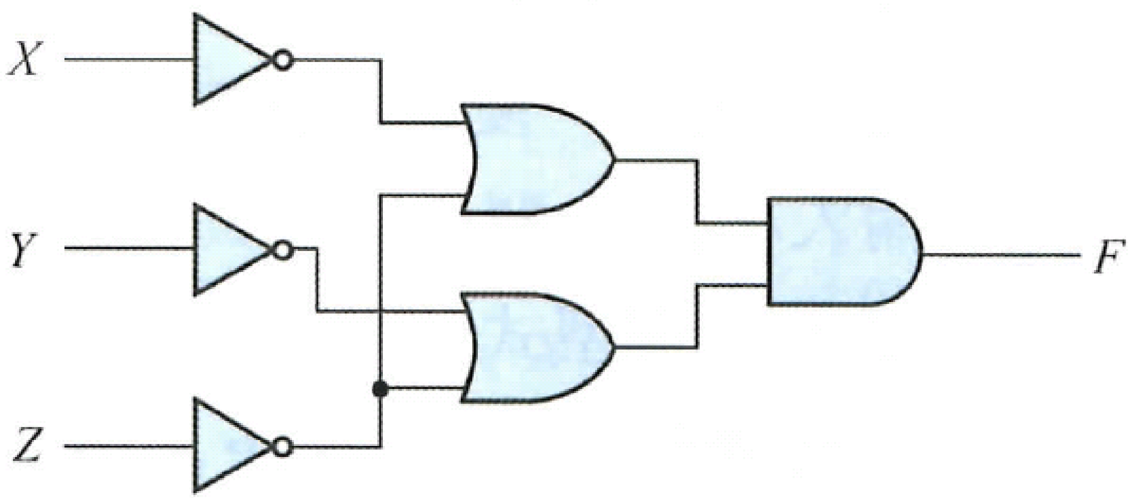
$\overline{Z}$

OR-AND Circuit

- Transform the boolean function into a simplified POS form.

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

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



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

YZ

XZ

AOI (AND-OR-NOT) Circuit

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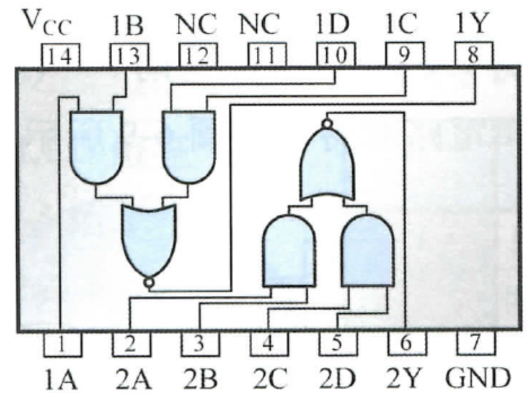
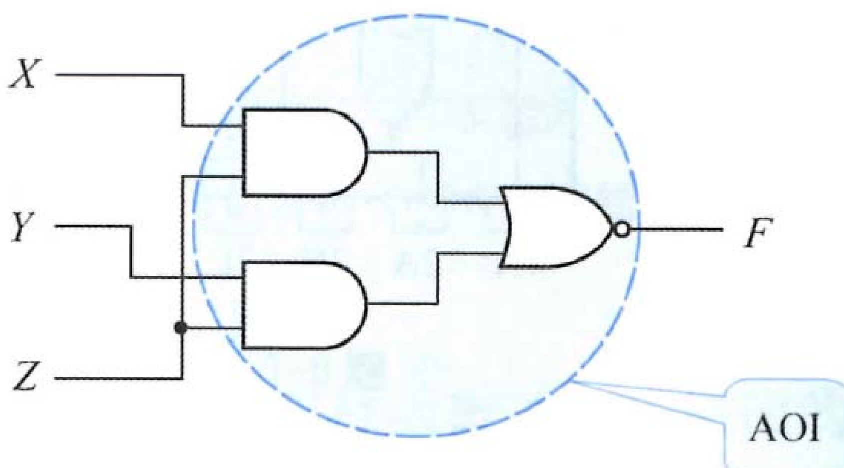


- How to design an AOI circuit:
  - Derive a SOF form for complement F
  - Negate the complement F to derive F

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

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

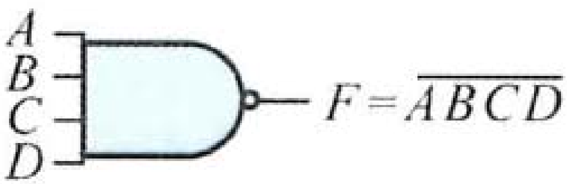


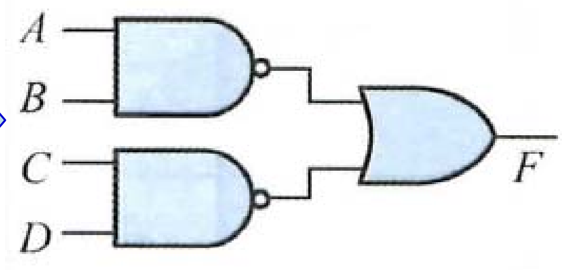
XY \ Z	0	1
00	1	1
01	1	0
11	1	0
10	1	0

YZ

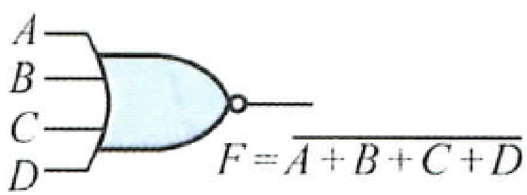
XZ

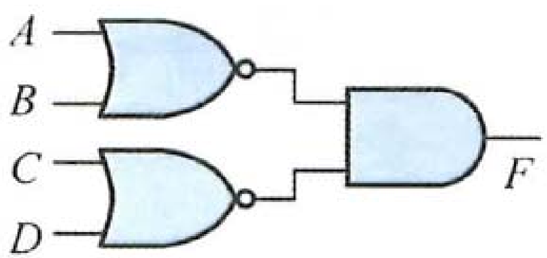
Four-Input NAND and NOR





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





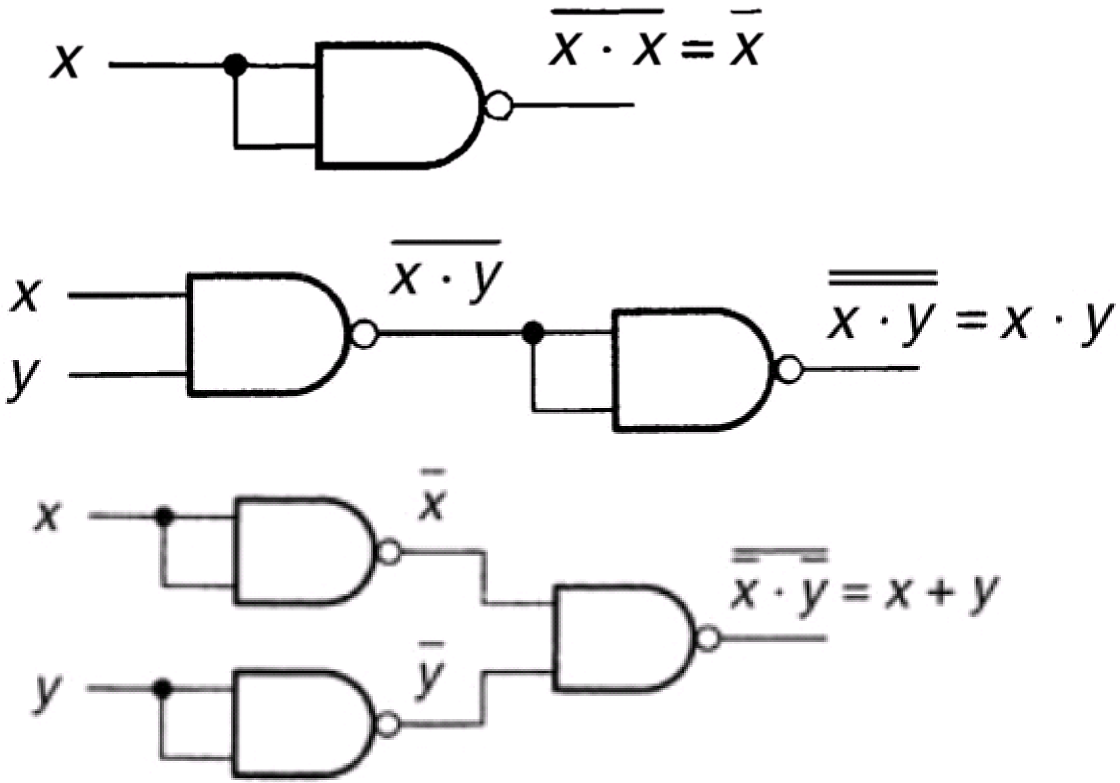
$$F = \overline{(A+B)}\cdot\overline{(C+D)}$$
$$= \overline{\overline{\overline{(A+B)}\cdot\overline{(C+D)}}}$$
$$= \overline{A+B+C+D}$$

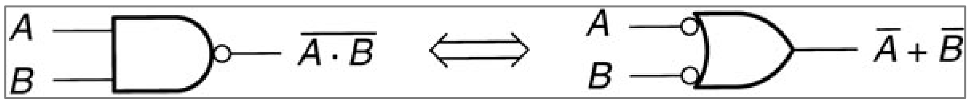
ALL NAND

NOT

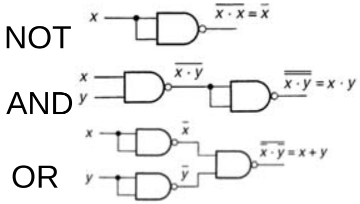
AND

OR

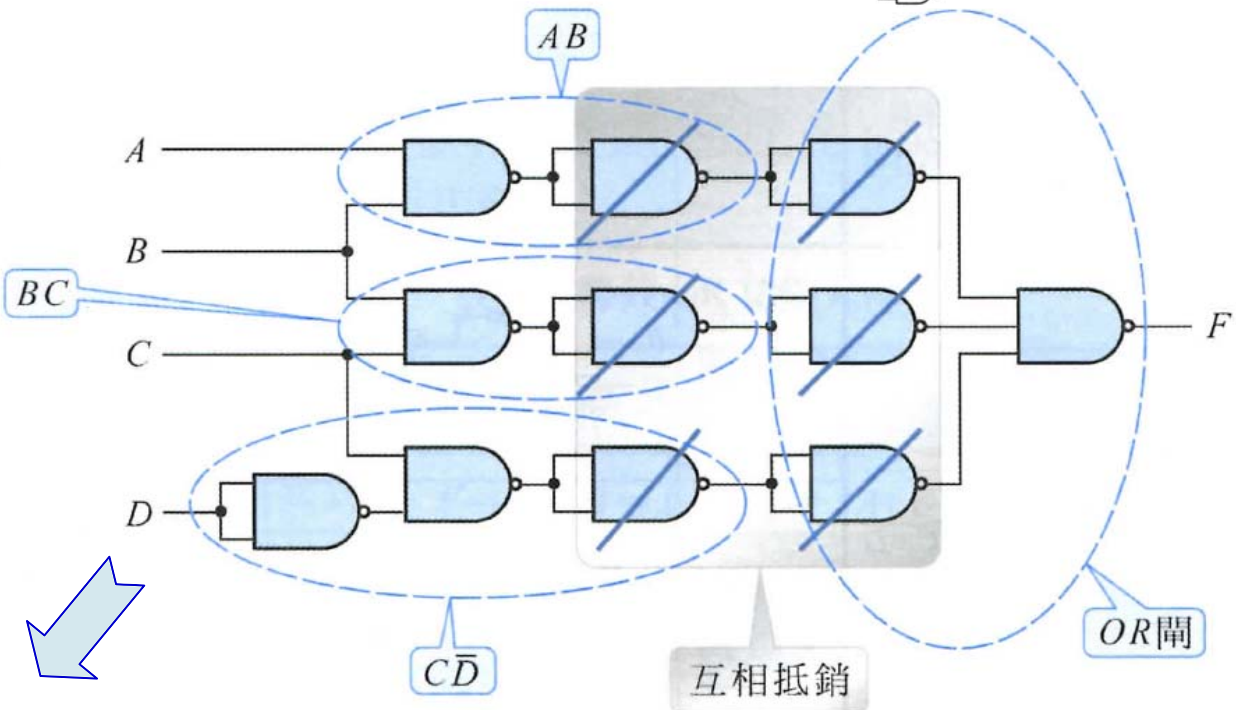


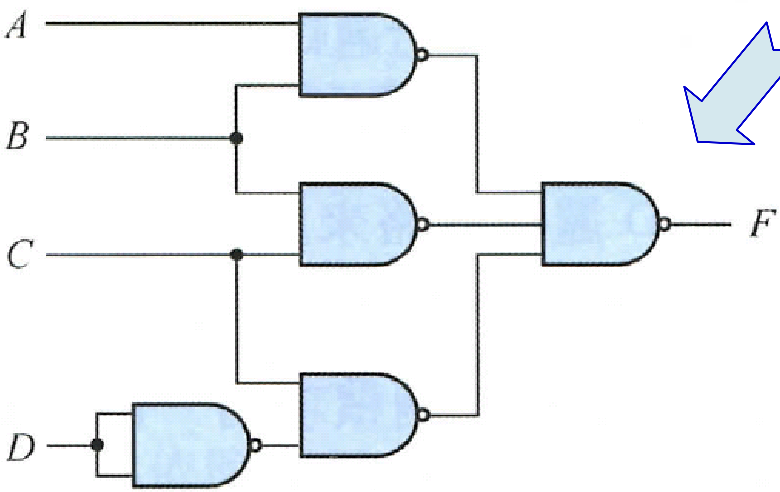


An Example of All NAND



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





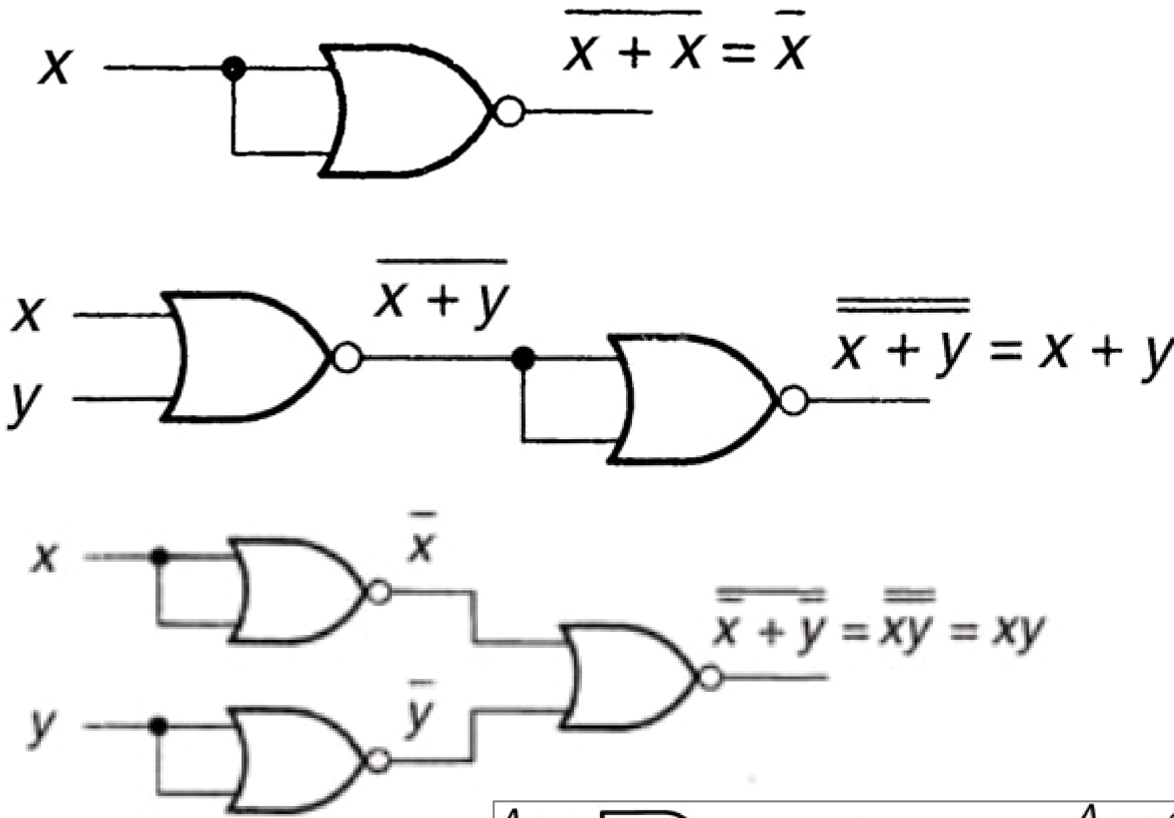
$$F = AB + BC + C\overline{D}$$

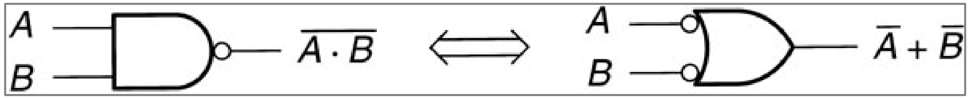
All NOR

NOT

OR

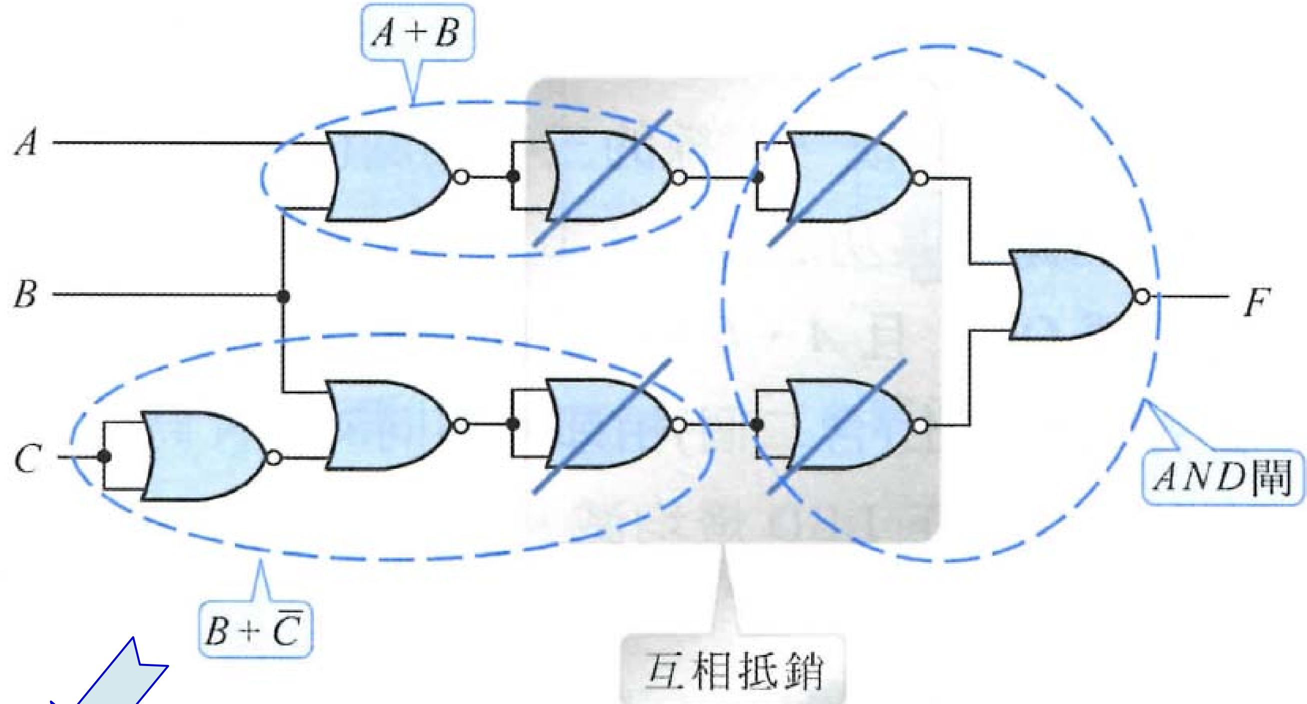
AND

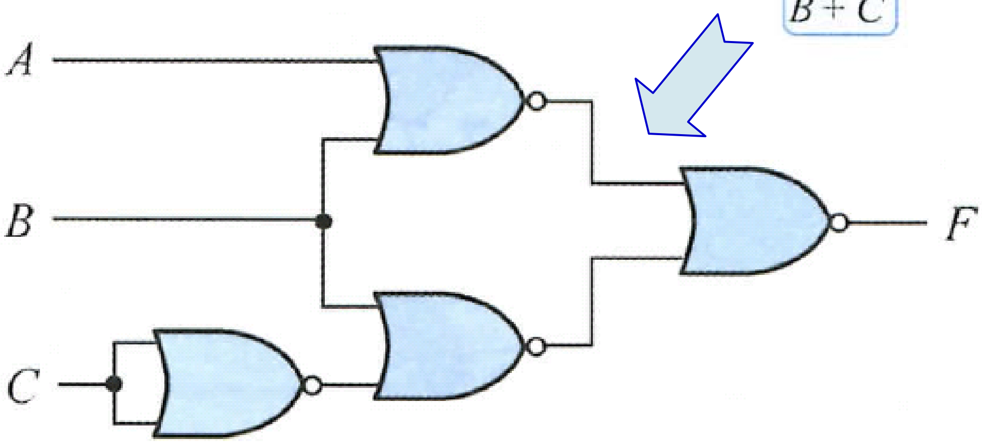




An Example of All NOR

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





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

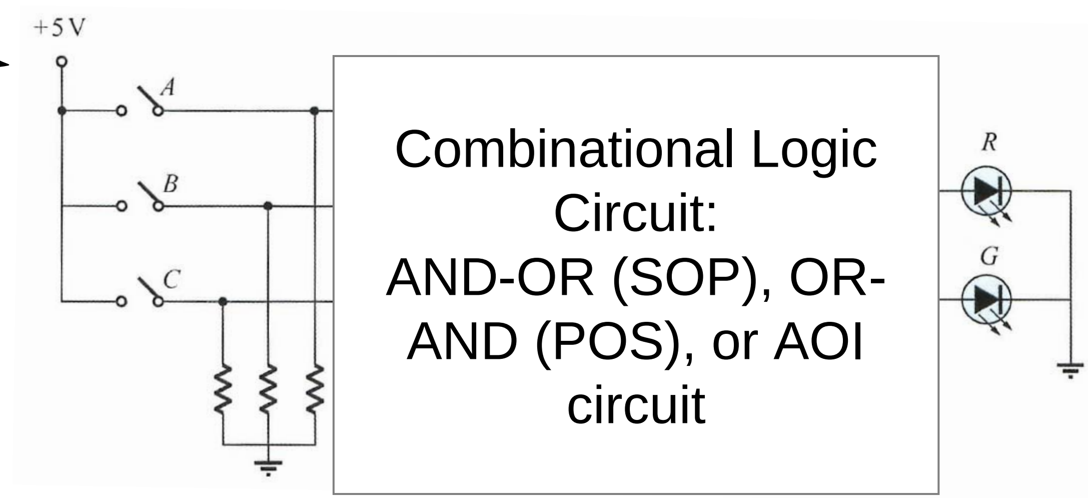


Lab 4 – Part 1

- 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.

Report 4 – Part 1

- 標明第幾個實驗並寫報告 (填寫組員姓名、學號) – 格式不限
  - 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。
  - 實驗心得。

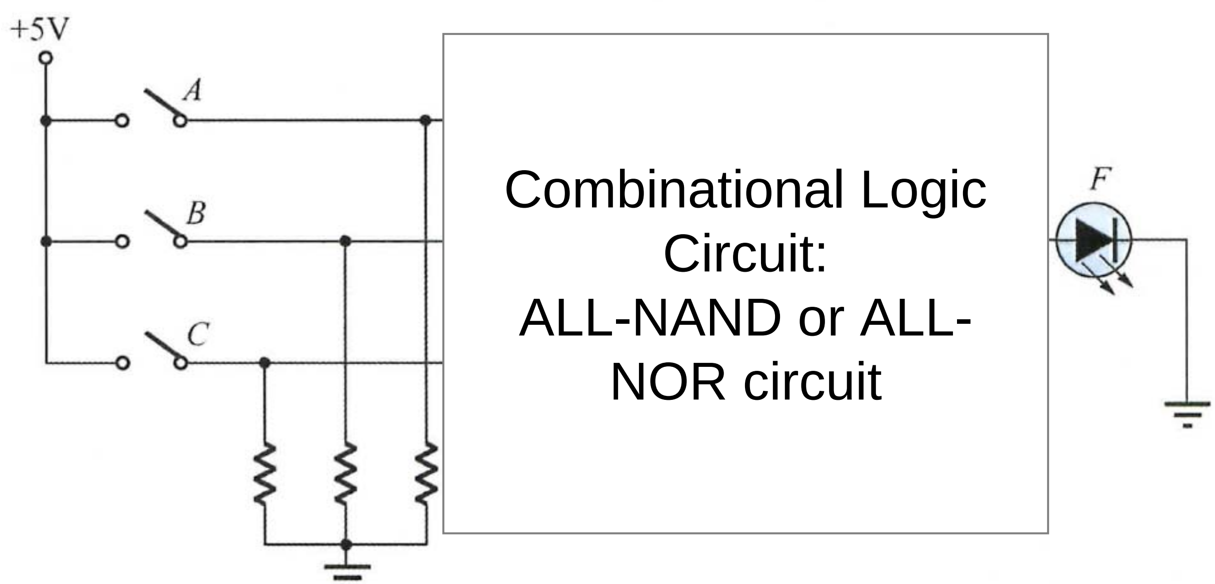


Lab 4 – Part 2

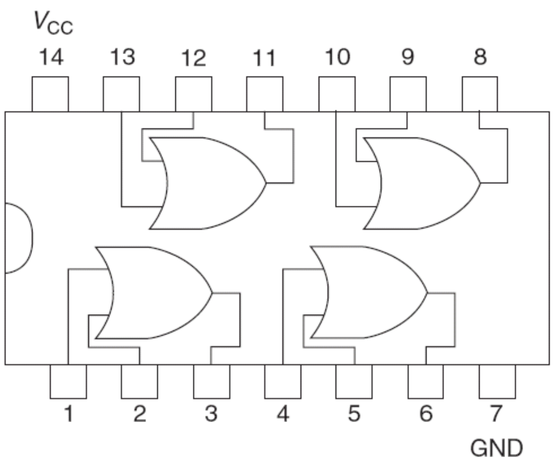
- Design a combinational circuit to solve the following question:
  - There are three switches (A, B, and C) and one LED.
  - When the power is on,
    - The LED is on when any two or more adjacent switches are on at the same time (i.e., A B on, B C on, A B C on).
    - Otherwise, the LED is off.

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。
- 實驗心得。



Chip Logic Circuit



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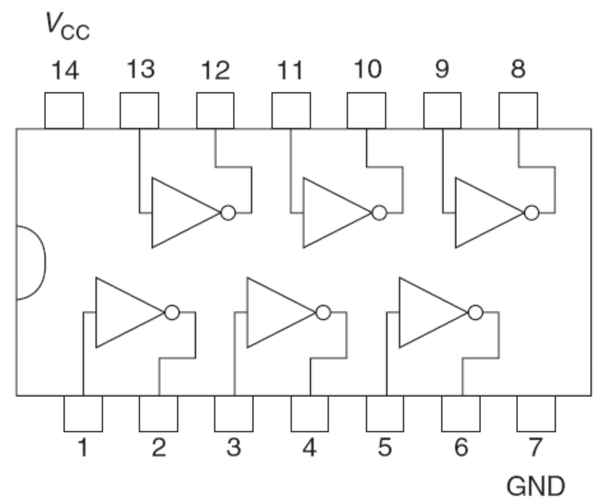

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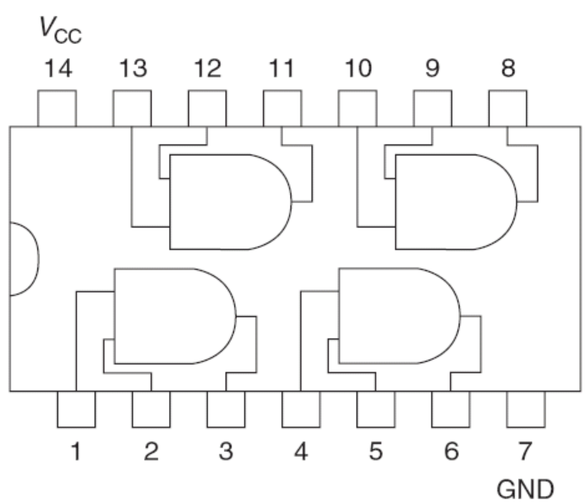

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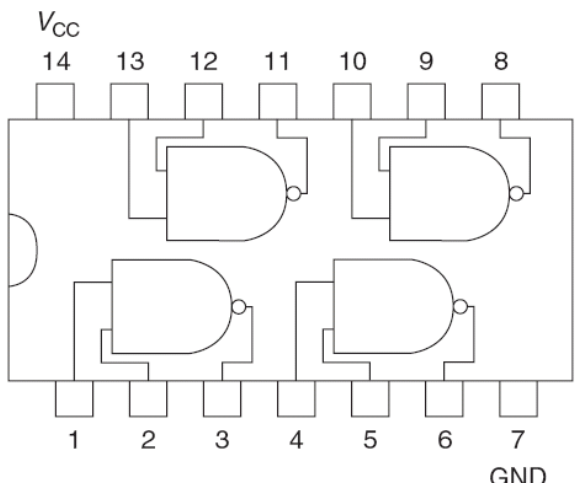
Chip Logic Circuit (Cont.)



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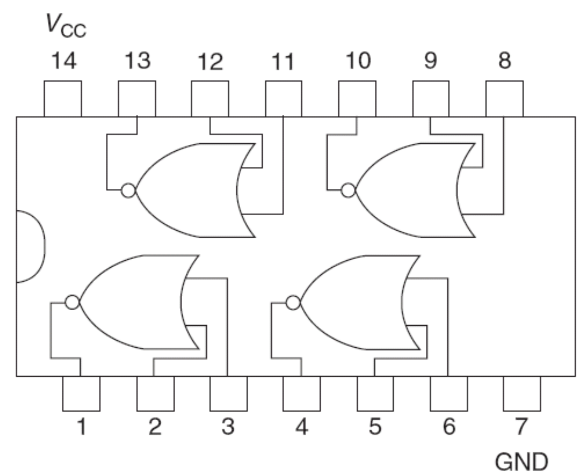

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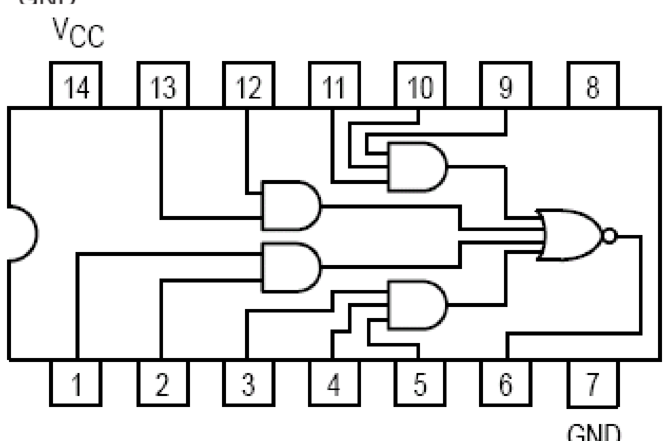

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