Faculty of Engineering

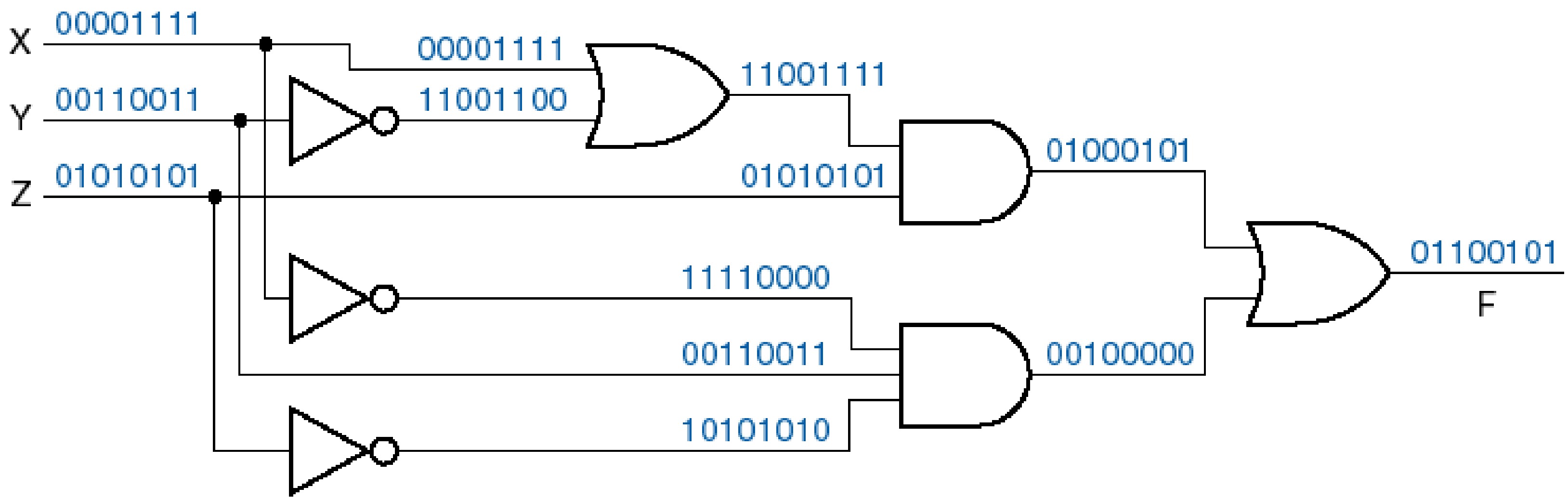
CSE115: Digital Design

Lecture 6:
Combinational Circuit Analysis

Suggested Reading

- Section 4.2

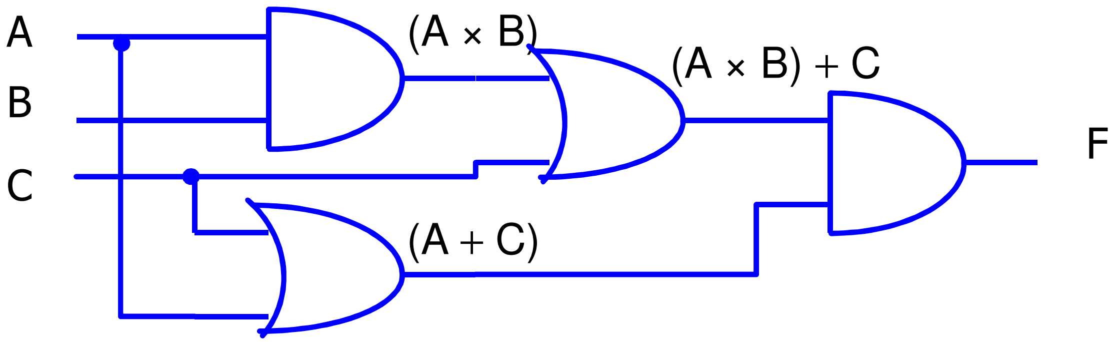
Combinational Circuit Analysis



Logic Circuit → Logic Function → Truth Table

Example 1:

Logic Circuit → Logic Function → Truth Table



$F = (A + C) \times ((A \times B) + C)$

A	B	C	AB	AB+C	A+C	**F**
0	0	0	0	0	0	**0**
0	0	1	0	1	1	**1**
0	1	0	0	0	0	**0**
0	1	1	0	1	1	**1**
1	0	0	0	0	1	**0**
1	0	1	0	1	1	**1**
1	1	0	1	1	1	**1**
1	1	1	1	1	1	**1**

Example 1:

Logic Function Simplification

$$F = (A + C) \times ((A \times B) + C)$$

$$= A \times (A \times B + C) + C \times (A \times B + C)$$

$$= A \times A \times B + A \times C + C \times A \times B + C \times C$$

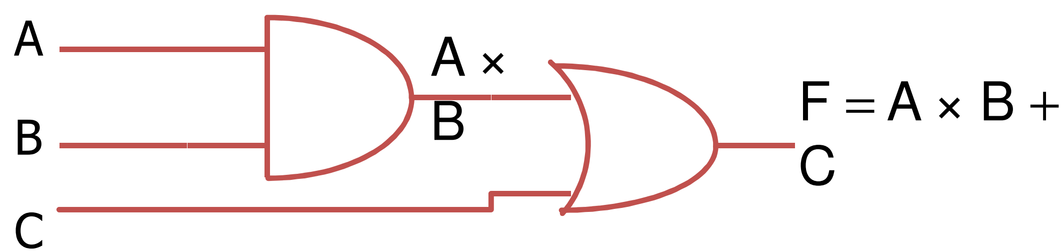
$$= A \times B \ + A \times C + A \times B \times C + C$$

$$= (A \times B + A \times B \times C) + (A \times C + C)$$

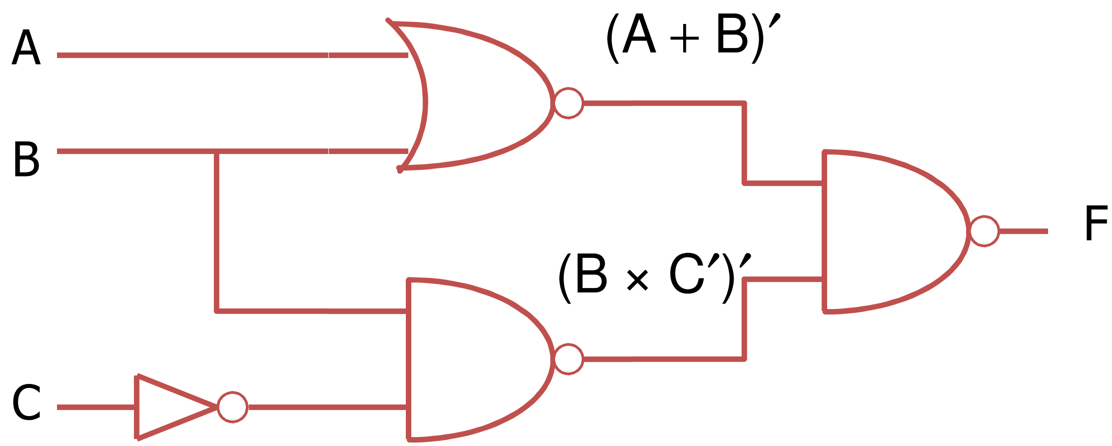
$$= A \times B \times (1 + C) + ((A + 1) \times C)$$

$$= A \times B + C$$

Same function, different circuit



Example 2:



$$F = [(A + B)' \times (B \times C')']'$$

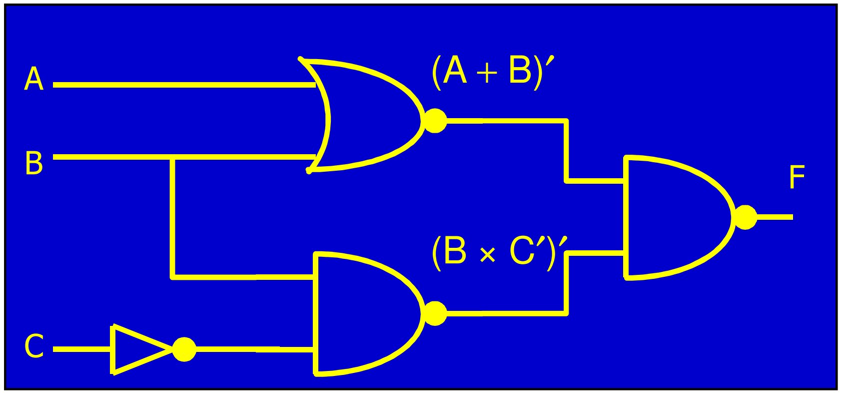
A	B	C	F
0	0	0	**0**
0	0	1	**0**
0	1	0	**1**
0	1	1	**1**
1	0	0	**1**
1	0	1	**1**
1	1	0	**1**
1	1	1	**1**

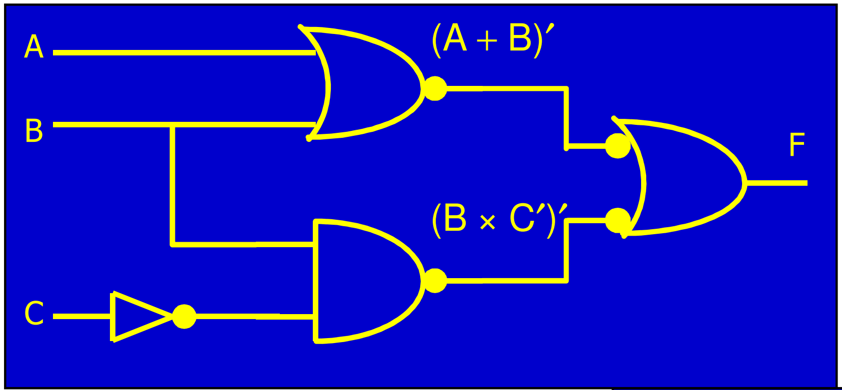
$$F_{A,B,C} = \Sigma\ (2,3,4,5,6,7)$$

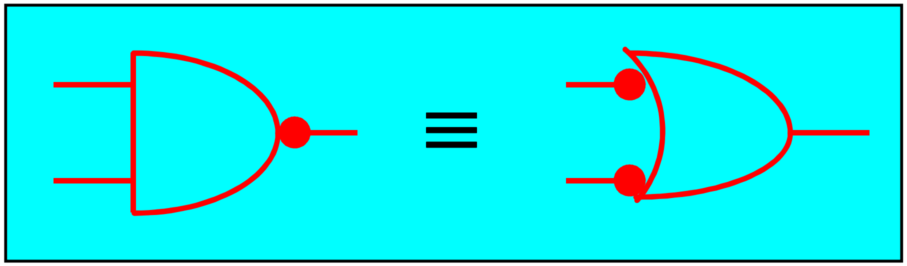
OR

$$F_{A,B,C} = \Pi\ (0,1)$$

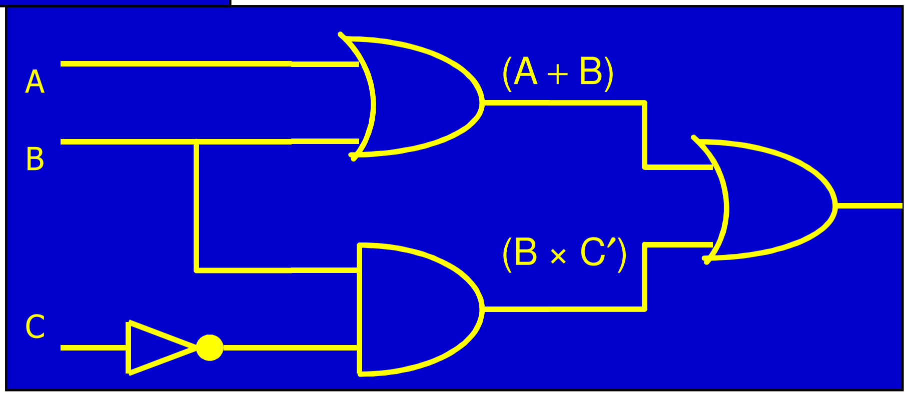
Example 2 (Contd.):







$$F = A + B + B \times C'$$



Example 2 (Contd.):

$F = [(A + B)' \times (B \times C')']'$

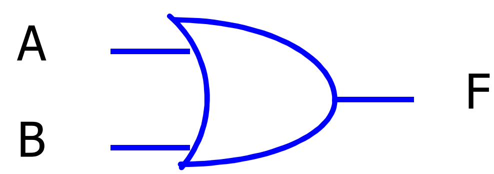
$= (A + B)'' + (B \times C')''$ using Demorgan's theorem

$= A + B + B \times C'$

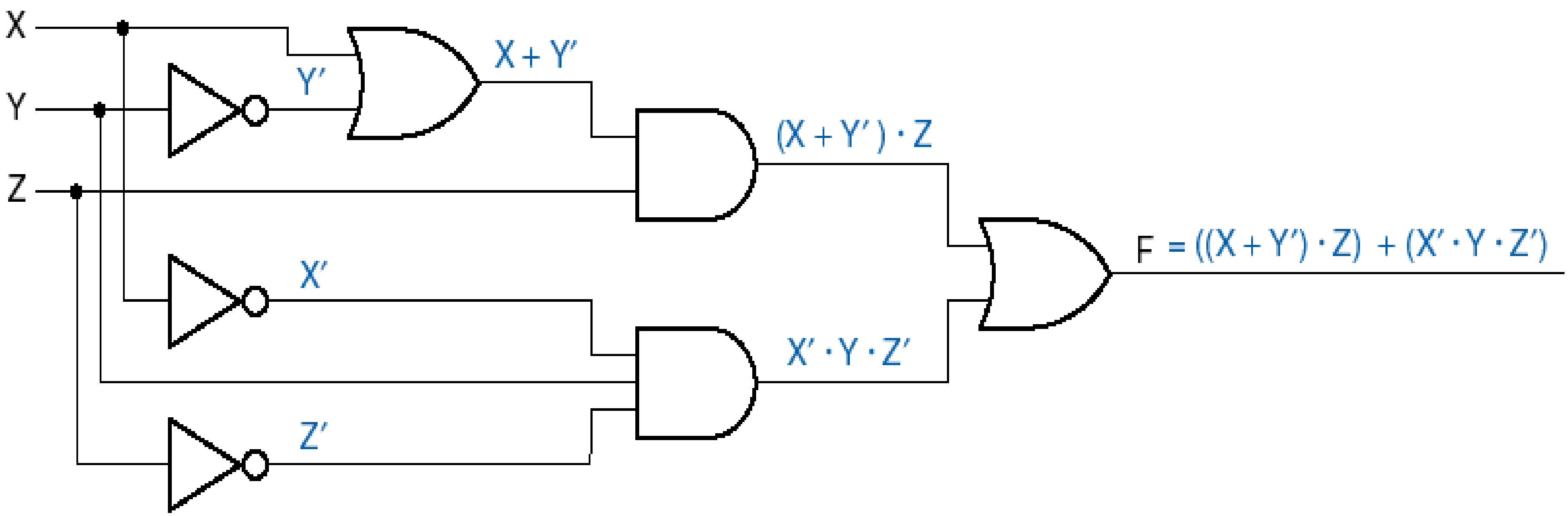
$= A + B \times (1 + C')$

$= A + B \times 1$

$= A + B$



Example 3:



(Multiply out)

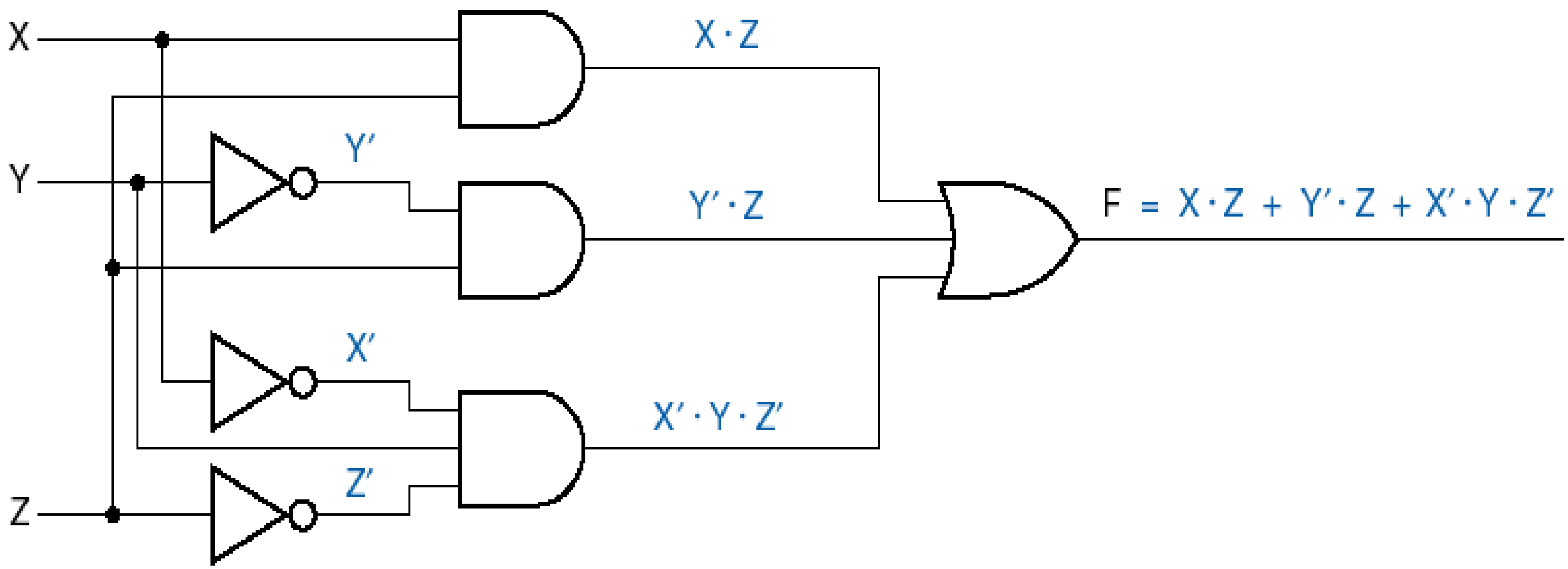
$$F = ((X + Y') \times Z) + (X' \times Y \times Z')$$

$$F = (X \times Z) + (Y' \times Z) + (X' \times Y \times Z')$$

Example 3 (Contd.):

New circuit, same function

$$F = (X \times Z) + (Y' \times Z) + (X' \times Y \times Z')$$



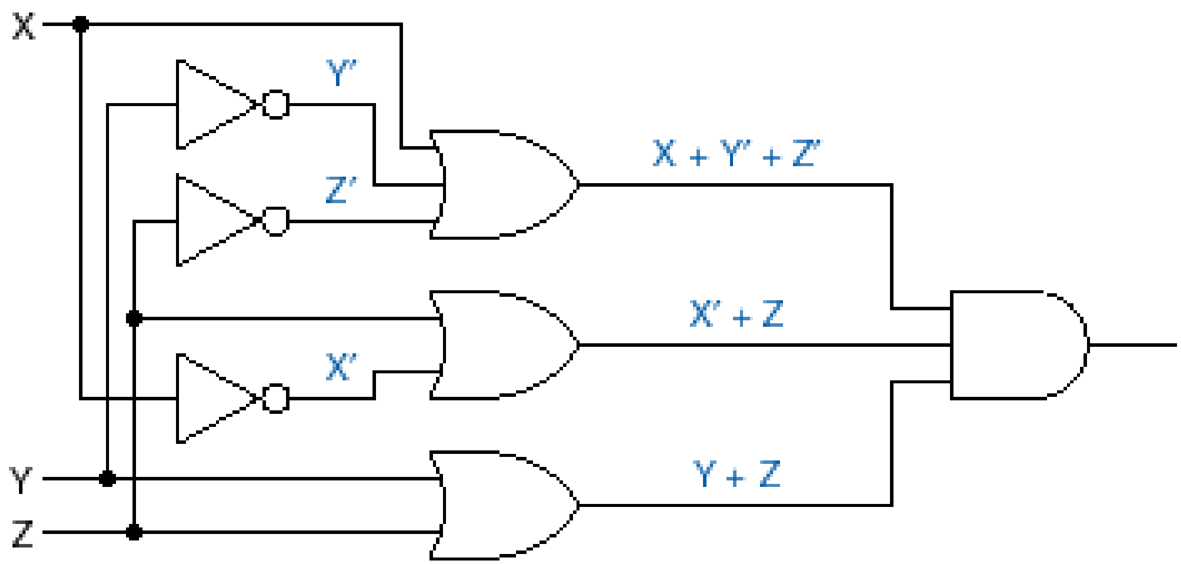
Example 3 (Contd.):

$F = ((X + Y') \cdot Z) + (X' \cdot Y \cdot Z')$ **(Add out)**

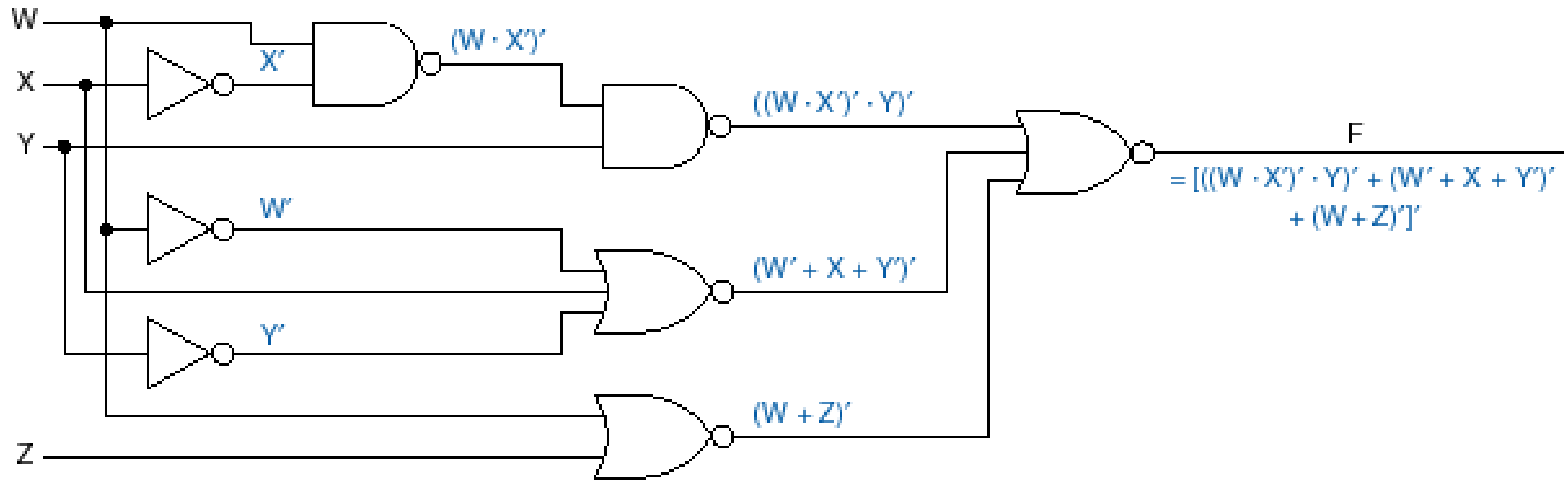
$((X + Y' + X') \cdot (X + Y' + Y) \cdot (X + Y' + Z) \cdot (Z + X') \cdot (Z + Y) \cdot (Z + Z')$

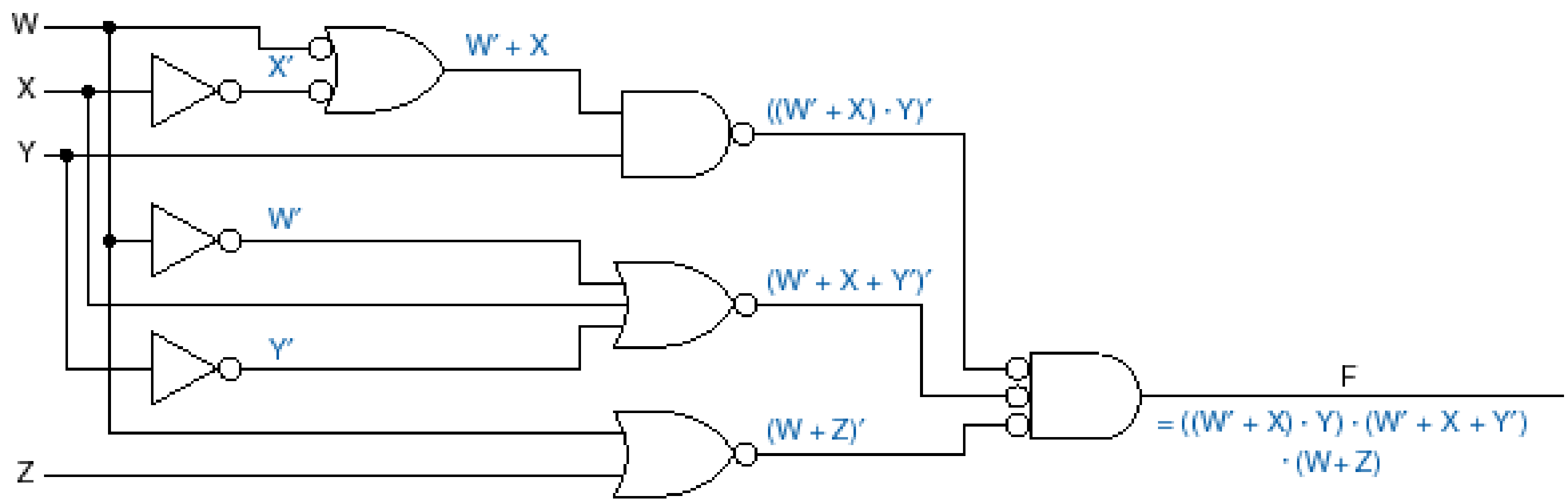
$1 \cdot 1 \cdot (X + Y' + Z) \cdot (X' + Z) \cdot (Y + Z) \cdot 1$

$(X + Y' + Z) \cdot (X' + Z) \cdot (Y + Z)$

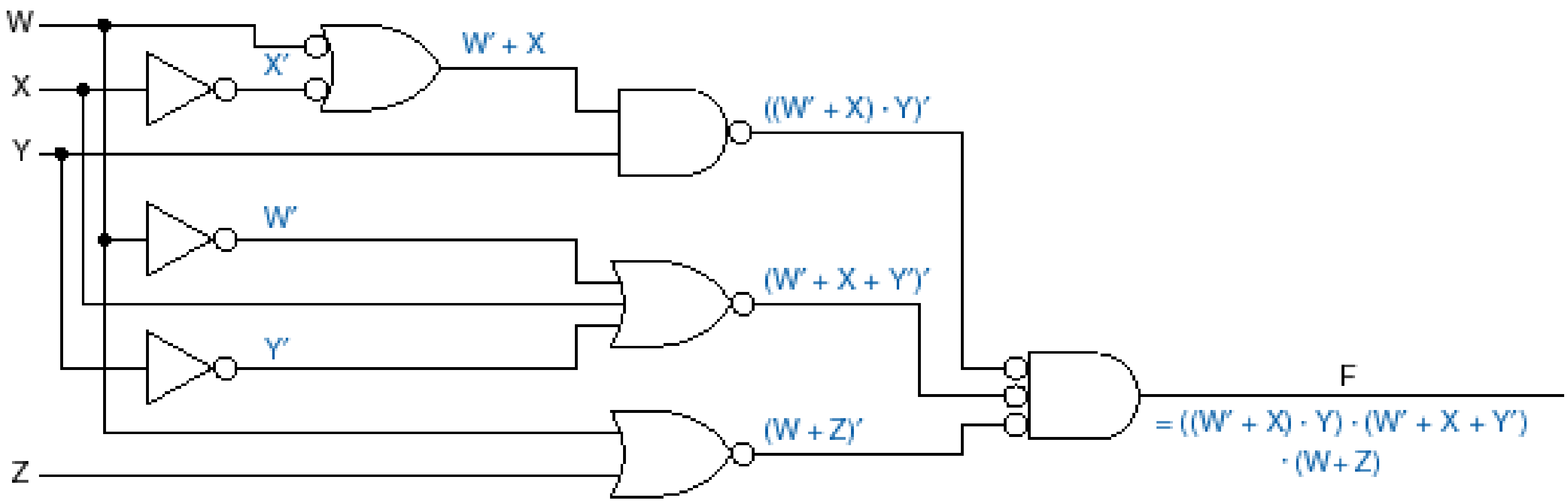


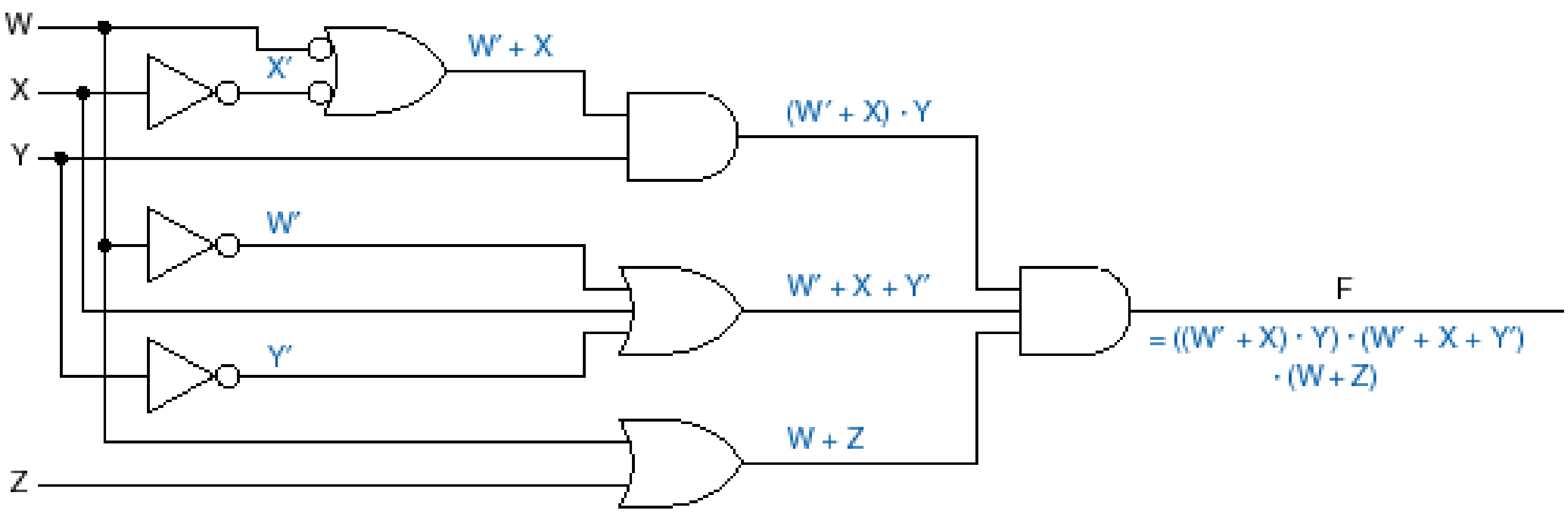
Shortcut: Symbol Substitution





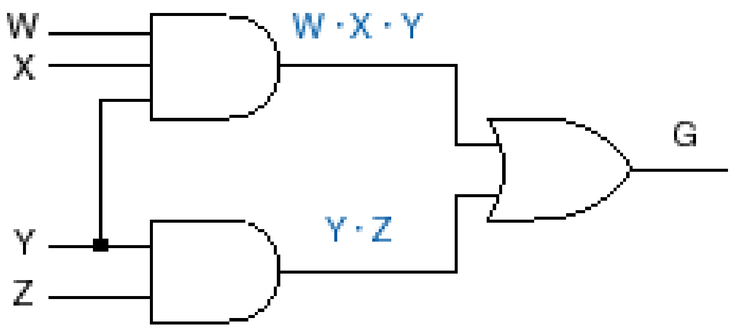
Different Circuit, Same Function

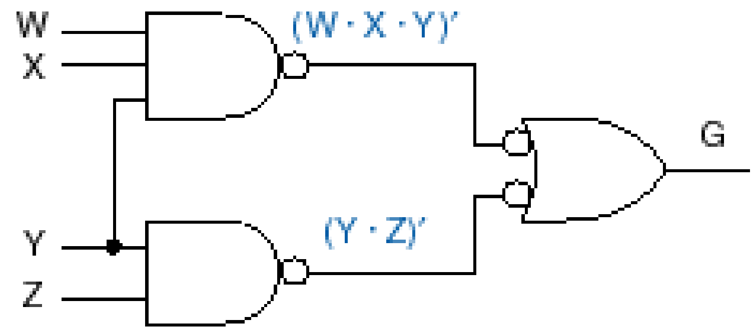


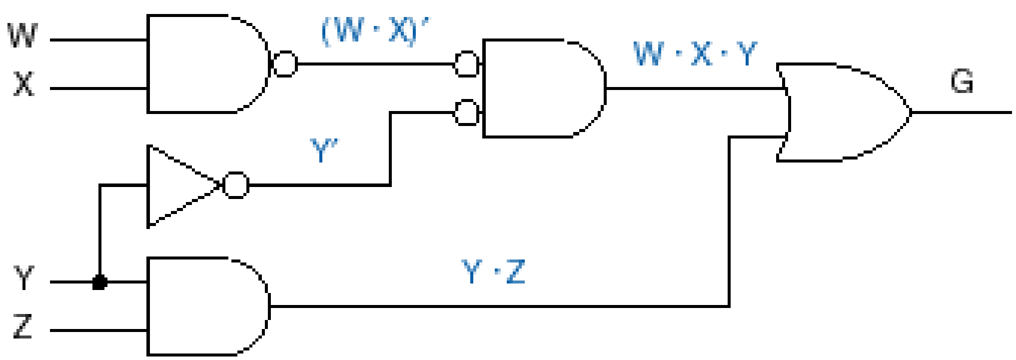


Example 4

$$G_{W,X,Y,Z} = W \cdot X \cdot Y + Y \cdot Z$$







Combinational Analysis Review

Combinational Analysis Review:

Logic Circuit → Logic Function → Truth Table

Analyze a combinational logic circuit by obtaining a formal description of its logic function

Outputs of a combinational logic circuit depends only on its current inputs (not on history)

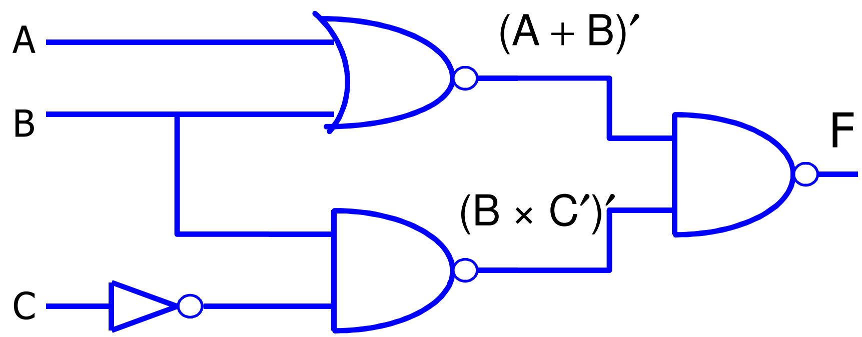
Kinds of combinational analysis:

–exhaustive (truth table)

–algebraic (expressions)

Example:

I)



II)

$$F = [(A + B)' \times (B \times C')']'$$

III)

	A	B	C	F
0	0	0	0	**0**
1	0	0	1	**0**
2	0	1	0	**1**
3	0	1	1	**1**
4	1	0	0	**1**
5	1	0	1	**1**
6	1	1	0	**1**
7	1	1	1	**1**

IV)

$$F_{A,B,C} = \Sigma\ (2,3,4,5,6,7)$$

$$F = A'BC' + A'BC + AB'C' + AB'C + ABC' + ABC$$

V)

$$F_{A,B,C} = \Pi\ (0,1)$$

$$F = (A+B+C)(A+B+C')$$

VI)