Premier University, Chittagong

EEE-2201: Digital Electronics and Pulse Technique

Analysis & Synthesis of Digital Logic Circuits

Dr. Sampad Ghosh

Associate Professor

Department of Electrical and Electronic Engineering

Faculty of Electrical and Computer Engineering

Chittagong University of Engineering and Technology (CUET)

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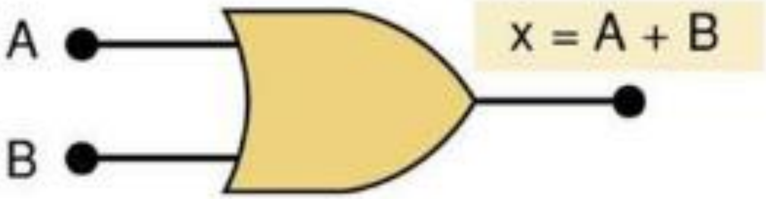
Topics	Reference
Analysis & synthesis of digital logic circuits	
Basic logic functions OR gates, AND gates, NOR gates, Describing logic circuits algebraically, Evaluating logic circuit outputs, Implementing circuits from Boolean expressions, NOR gates & NAND gates	*Tocci*

OR and AND Gates

Truth table and circuit symbol for a 2-input OR and AND gate

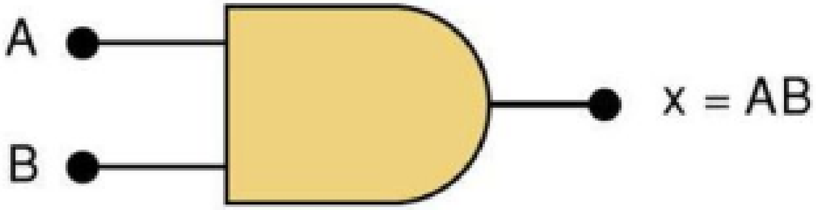
OR

A	B	x = A + B
0	0	0
0	1	1
1	0	1
1	1	1



OR Gate

A	B	x = A · B
0	0	0
0	1	0
1	0	0
1	1	1



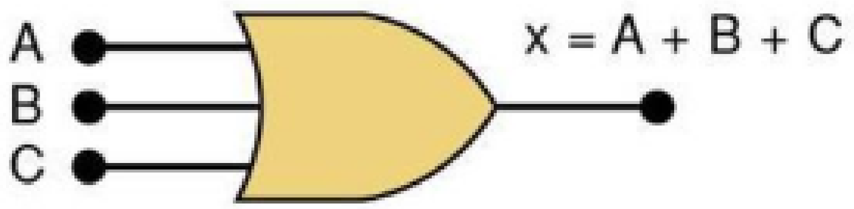
AND gate

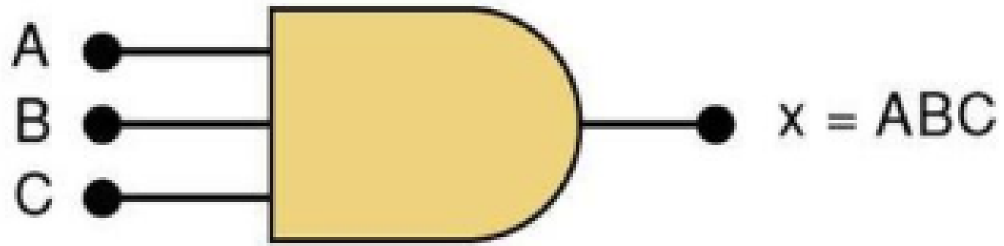
OR and AND Gates...

Truth table and circuit symbol for a 3-input OR and AND gate

A	B	C	x = A + B + C
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

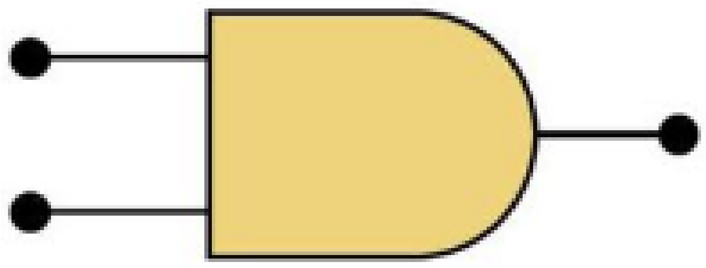
A	B	C	x = ABC
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1





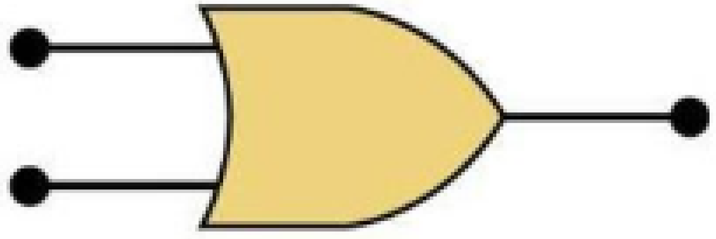
AND / OR

- The AND symbol on a logic-circuit diagram tells you output will go HIGH only when **all inputs** are HIGH.



Input **Output**

- The OR symbol means the output will go HIGH when **any input** is HIGH.

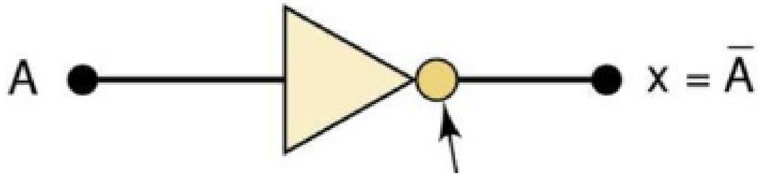


NOT Operation with NOT Gates

- Boolean expression for NOT operation
  - $\mathbf{x = A' = \bar{A}}$ - *read as x equals "NOT A" or "inverse of A" or "complement of A"*
- The NOT gate is an electronic circuit that produces an inverted version of the input at its output.
  - More commonly called an *Inverter*.

Truth table and circuit symbol for NOT gate

A	$x = \bar{A}$
0	1
1	0



Presence of small circle always denotes inversion

Boolean operations

- Summarized rules for OR, AND and NOT.

OR	AND	NOT
$0 + 0 = 0$	$0 \cdot 0 = 0$	$\overline{0} = 1$
$0 + 1 = 1$	$0 \cdot 1 = 0$	$\overline{1} = 0$
$1 + 0 = 1$	$1 \cdot 0 = 0$	
$1 + 1 = 1$	$1 \cdot 1 = 1$	

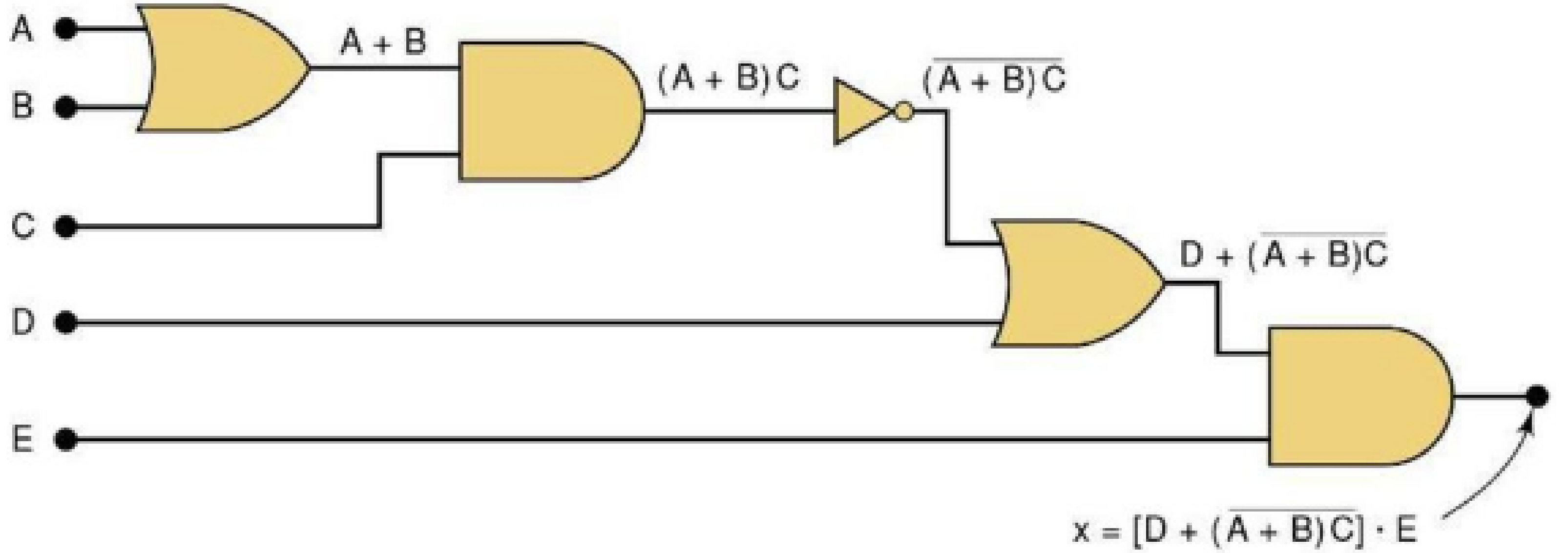
- These three basic Boolean operations can describe any logic circuit.

Evaluating Logic Circuit Outputs

- Rules for evaluating a Boolean expression:
  - Perform all inversions of single terms.
  - Perform all operations within parenthesis.
  - Perform AND operation before an OR operation unless parenthesis indicate otherwise.
  - If an expression has a bar over it, perform operations inside the expression, and then invert the result.

A=B=0, C=D=E=1,

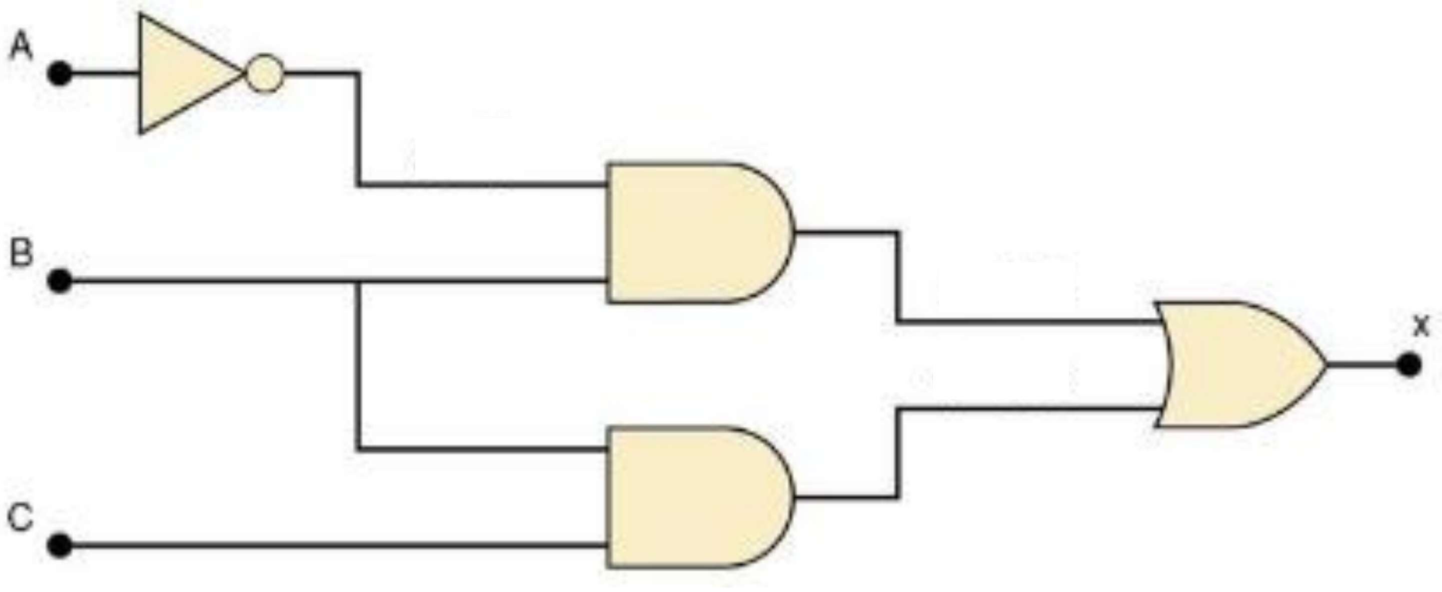
$$
\begin{aligned}
x &= [D + \overline{(A + B)C}] \cdot E \\
&= [1 + \overline{(0 + 0) \cdot 1}] \cdot 1 \\
&= [1 + \overline{0 \cdot 1}] \cdot 1 \\
&= [1 + \overline{0}] \cdot 1 \\
&= [1 + 1] \cdot 1 \\
&= 1 \cdot 1 \\
&= 1
\end{aligned}
$$



Evaluating Logic Circuit Outputs …

- The best way to analyze a circuit made up of multiple logic gates is to use a **truth table**:
  - It allows you to analyze one gate or logic combination at a time.
  - It allows you to easily double-check your work.
  - When you are done, you have a table of tremendous benefit in troubleshooting the logic circuit.

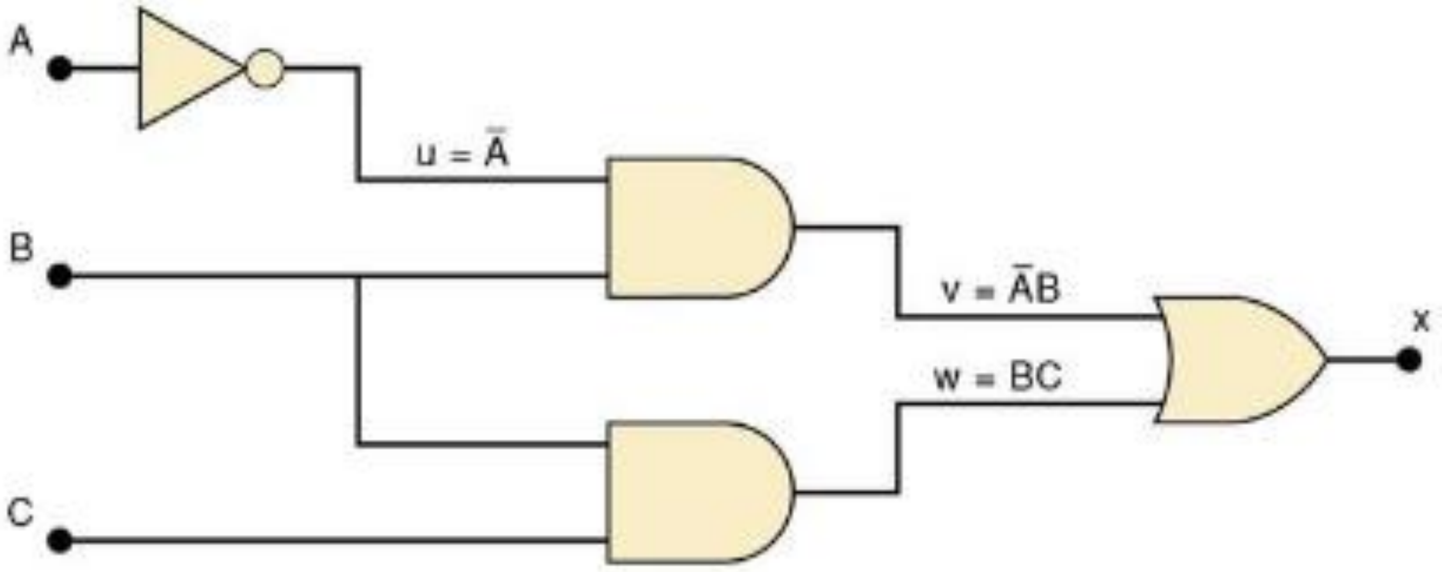
Analysis of a Logic Circuit using Truth Tables



A	B	C	u= $\overline{A}$	v= $\overline{A}B$	w= BC	x= v+w
0	0	0	1			
0	0	1	1			
0	1	0	1			
0	1	1	1			
1	0	0	0			
1	0	1	0			
1	1	0	0			
1	1	1	0			

1. The first step after listing all input combinations is to create a column in the truth table for each intermediate signal (node).

Node *u* has been filled as the complement of *A*

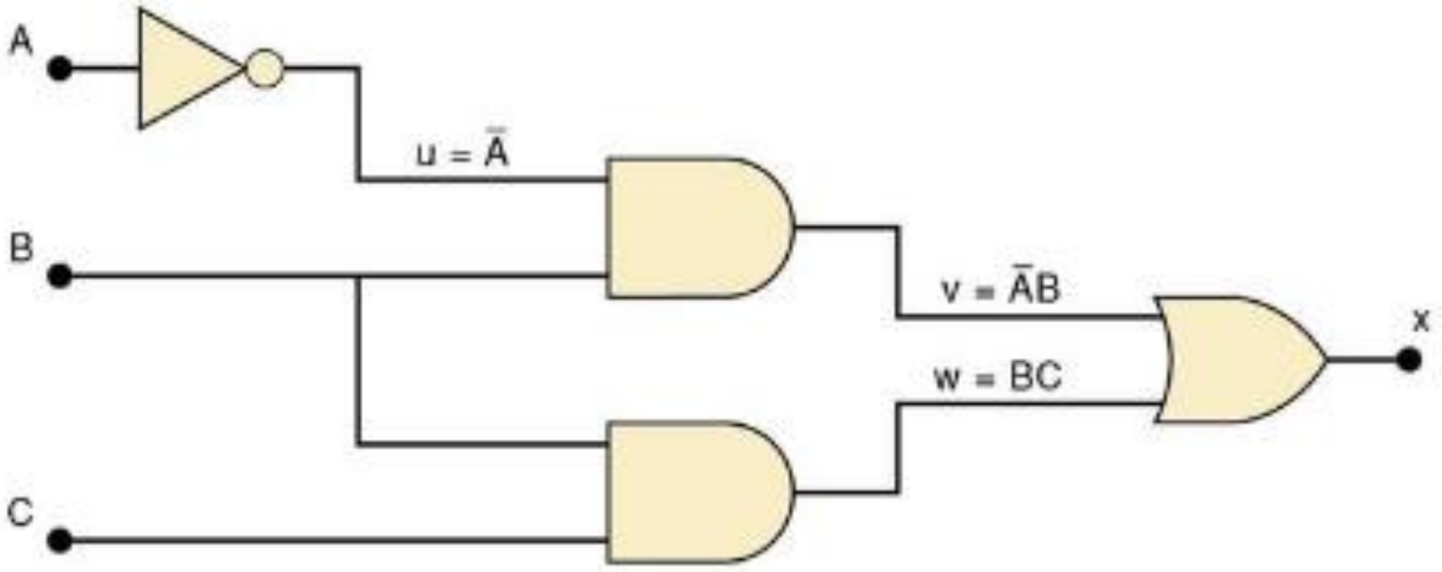


A	B	C	u= $\bar{A}$	v= $\bar{A}B$	w= BC	x= v+w
0	0	0	1	0		
0	0	1	1	0		
0	1	0	1	1		
0	1	1	1	1		
1	0	0	0	0		
1	0	1	0	0		
1	1	0	0	0		
1	1	1	0	0		

2. The next step is to fill in the values for column *v*.

Node *v* should be HIGH when *A′* (node *u*) and *B* are HIGH

Analysis of a Logic Circuit using Truth Tables...

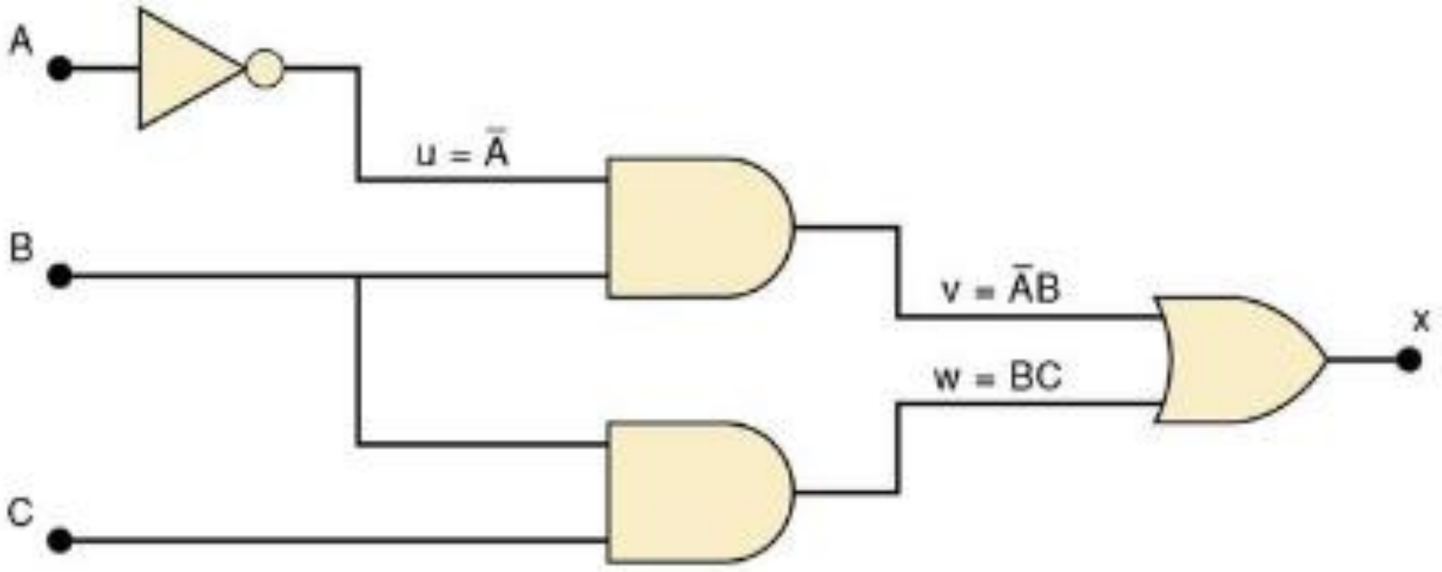


A	B	C	u= $\bar{A}$	v= $\bar{A}B$	w= BC	x= v+w
0	0	0	1	0	0	
0	0	1	1	0	0	
0	1	0	1	1	0	
0	1	1	1	1	1	
1	0	0	0	0	0	
1	0	1	0	0	0	
1	1	0	0	0	0	
1	1	1	0	0	1	

3. The third step is to predict the values at node *w* which is the logical product of *BC*.

This column is HIGH whenever B and C are HIGH

Analysis of a Logic Circuit using Truth Tables...



A	B	C	u= Ā	v= ĀB	w= BC	x= v+w
0	0	0	1	0	0	0
0	0	1	1	0	0	0
0	1	0	1	1	0	1
0	1	1	1	1	1	1
1	0	0	0	0	0	0
1	0	1	0	0	0	0
1	1	0	0	0	0	0
1	1	1	0	0	1	1

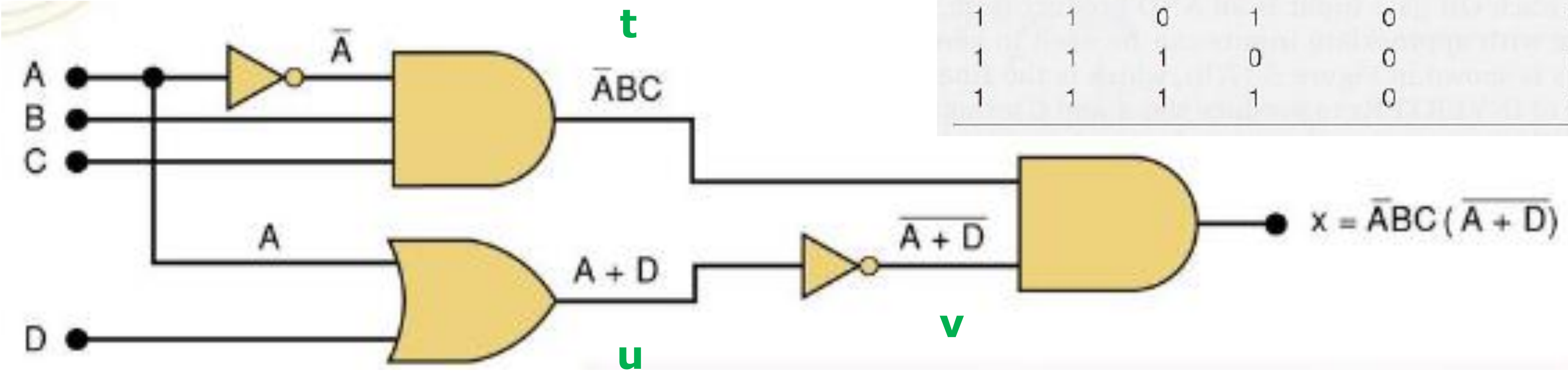
4. The final step is to logically combine columns *v* and *w* to predict the output *x*.

The *x* output will be HIGH when *v* or *w* is HIGH

Evaluating Logic Circuit Outputs

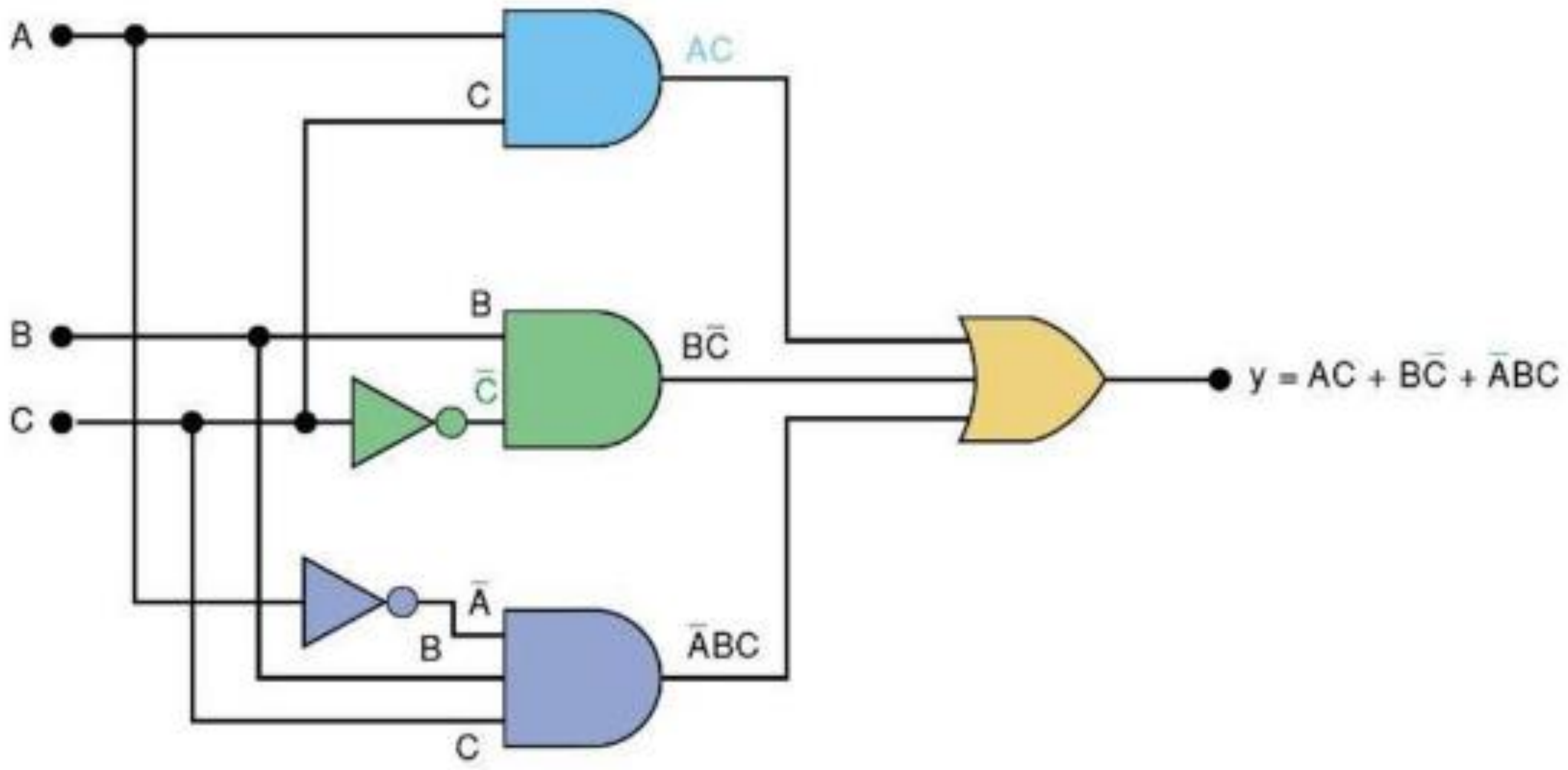
- *t*=1, when A=0, and B=C=1
- *u*=1, when A=1 or D=1
- *v*=u’
- *x*=1, when t=1 and v=1

A	B	C	D	$t = \overline{A}BC$	$u = A + D$	$v = \overline{A + D}$	$x = tv$
0	0	0	0	0	0	1	0
0	0	0	1	0	1	0	0
0	0	1	0	0	0	1	0
0	0	1	1	0	1	0	0
0	1	0	0	0	0	1	0
0	1	0	1	0	1	0	0
0	1	1	0	1	0	1	1
0	1	1	1	1	1	0	0
1	0	0	0	0	1	0	0
1	0	0	1	0	1	0	0
1	0	1	0	0	1	0	0
1	0	1	1	0	1	0	0
1	1	0	0	0	1	0	0
1	1	0	1	0	1	0	0
1	1	1	0	0	1	0	0
1	1	1	1	0	1	0	0



Implementing Circuits from Boolean Expressions

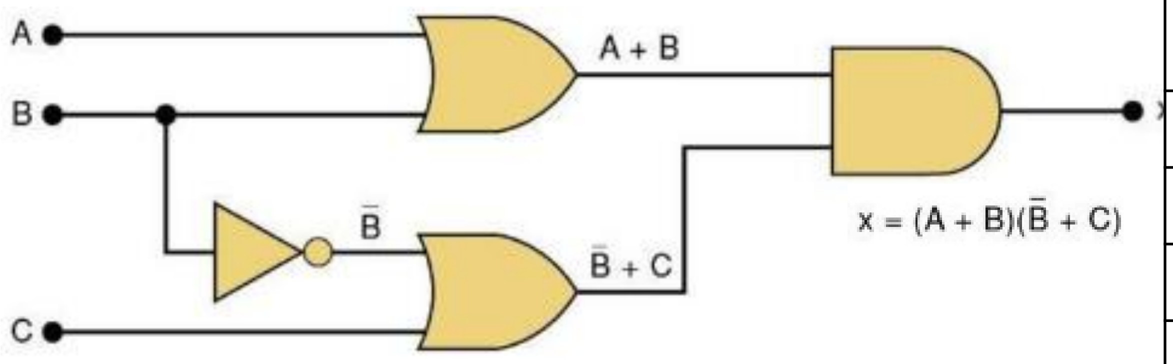
- Example: Construct a circuit whose output is **y=AC+BC′+A′BC**.
  - 3-input OR required with inputs equal AC, BC′, A′BC
  - Each OR gate input is an AND product term
  - and so on…



Implementing Circuits from Boolean Expressions …

- Test: Circuit diagram to implement x=(A+B)(B′+C). Also construct the truth table.

2 marks



A	B	C	u=B′	v=A+B	w=u+C	x=v.w
0	0	0	1	0	1	0
0	0	1	1	0	1	0
0	1	0	0	1	0	0
0	1	1	0	1	1	1
1	0	0	1	1	1	1
1	0	1	1	1	1	1
1	1	0	0	1	0	0
1	1	1	0	1	1	1