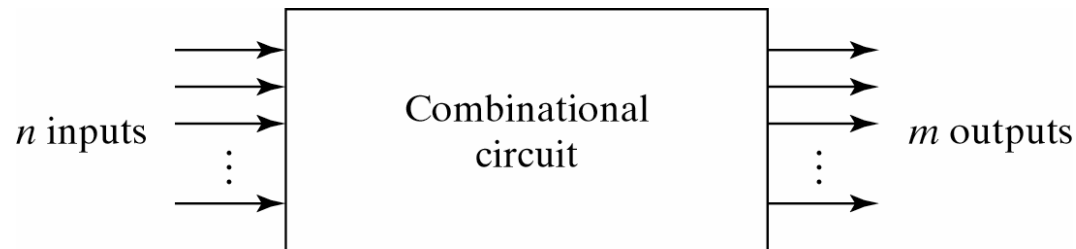


Combinational Circuits

- Logic circuits are either combinational or sequential.
 - Combinational logic circuits consist of logic gates whose outputs at any time are determined from the present combination of the inputs.
 - Sequential circuits consist of memory elements and logic gates.



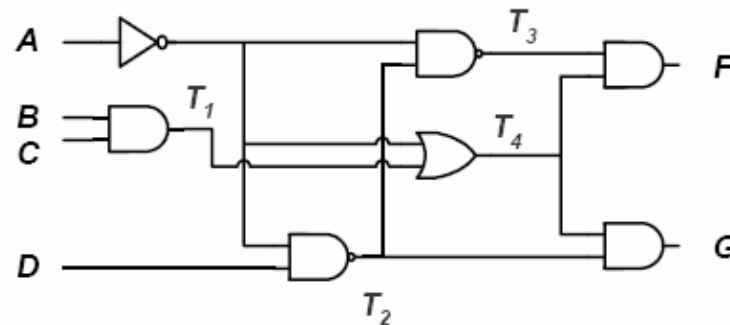
A block Diagram of Combinational Circuit

Analysis Procedure

1. Obtain Boolean expression from logic diagram
 - a. Label all gate outputs that are a function of input variables. Obtain Boolean function for each gate.
 - b. Label all gate outputs that are a function of input variables and previously labeled gates. Obtain Boolean function for each of these gates.
 - c. Repeat step (b) until the outputs of the circuit are obtained.
2. Obtain the truth table from the logic diagram
 - a. Prepare the truth table for n input variables and 2^n input combinations.
 - b. Label all gate outputs that are a function of input variables. Fill in the truth table for these outputs.
 - c. Label all gate outputs that are functions of input variables and previously labeled gates. Fill in the truth table columns for these outputs.
 - d. Repeat step (c) until the columns for all the outputs are obtained.

Example 1

- Determine the Boolean functions for the outputs F and G as a function of the four inputs A, B, C, and D.



$$T_1 = BC$$

$$T_2 = (A'D)' = A + D'$$

$$T_3 = (A'T_2)' = A + T_2' = A + A'D = A + D$$

$$T_4 = A' + T_1 = A' + BC$$

$$\begin{aligned} F = T_3T_4 &= (A + D)(A' + BC) = AA' + ABC + A'D + BCD \\ &= ABC + A'D + BCD = ABC + A'D \end{aligned}$$

$$\begin{aligned} G = T_2T_4 &= (A + D')(A' + BC) = AA' + ABC + A'D' + BCD' \\ &= ABC + A'D' + BCD' = ABC + A'D' \end{aligned}$$

- Analyze the previous logic circuit by establishing the truth table for F and G.

[illegible]

Design Procedure

- **Describe the problem (i.e., the problem statement).**
- **Determine the available number of input variables and required output variables.**
- **Assign letter symbols to the input and output variables.**
- **Derive the truth table that defines the required relationships between inputs and outputs.**
- **Obtain the simplified Boolean function for each output.**
- **Draw the logic diagram.**

Design of a Code Converter

- Design a combinational logic circuit that will convert from a BCD code to Excess-3 code.
- Design:
 - 4 inputs : A, B, C, and D
 - 4 outputs: w, x, y, and z
- Truth Table:

Inputs (BCD Code)				Outputs(Excess-3)			
A	B	C	D	w	x	y	z
0	0	0	0	0	0	1	1
0	0	0	1	0	1	0	0
0	0	1	0	0	1	0	1
0	0	1	1	0	1	1	0
0	1	0	0	0	1	1	1
0	1	0	1	1	0	0	0
0	1	1	0	1	0	0	1
0	1	1	1	1	0	1	0
1	0	0	0	1	0	1	1
1	0	0	1	1	1	0	0

- The six unused combinations are considered don't care conditions. These correspond to 10, 11, 12, 13, 14, and 15.
- Simplification of the output functions is made using Karnaugh maps and making use of the don't care conditions.

Design of a Code Converter (cont.)

A B C D					
		00	01	11	10
00				X	1
01			1	X	1
11			1	X	X
10			1	X	X

$$w = A + BC + BD$$

A B C D					
		00	01	11	10
00			1	X	
01		1		X	1
11		1		X	X
10		1		X	X

$$x = B'C + B'D + BC'D'$$

A B C D					
		00	01	11	10
00		1	1	X	1
01				X	
11		1	1	X	X
10				X	X

$$y = CD + C'D'$$

A B C D					
		00	01	11	10
00		1	1	X	1
01				X	
11				X	X
10		1	1	X	X

$$z = D'$$

A two level logic diagram can be obtained directly from the logic expressions.