Analysis Procedure

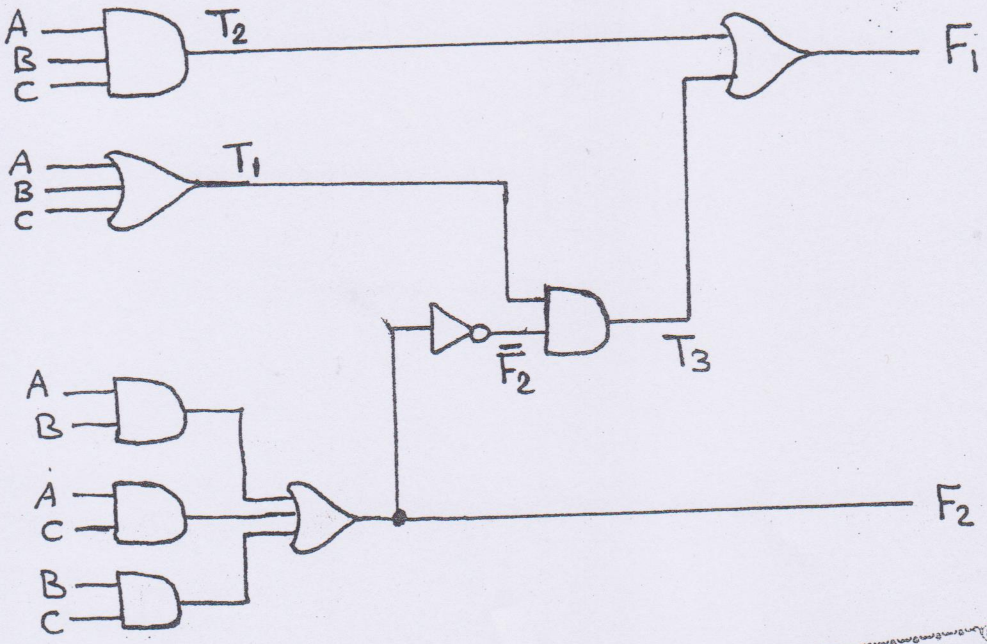
The analysis of a combinational circuit requires that we determine the function that the circuit implements. This starts with a given logic diagram and culminates with a set of Boolean functions, a truth table, or a possible explanation of the circuit operation.

The first step in the analysis is to make sure that the given circuit is combinational and not sequential. The diagram of a combinational circuit has logic gates with no feedback paths or memory elements. A feedback path is a connection from the output of one gate to the input of a second gate that forms part of the input to the first gate.

To obtain the output Boolean functions from a logic diagram, proceed as follows:

1. Label all gate outputs that are a function of input variables with arbitrary symbols. Determine the Boolean functions for each gate output.
2. Label the gates that are a function of input variables and previously labeled gates with other arbitrary symbols. Find the Boolean functions for these gates.
3. Repeat the process outlined in step 2 until the outputs of the circuit are obtained.
4. By repeated substitution of previously defined functions, obtain the output Boolean functions in terms of input variables.

ex: Analys the following Combinational circuit:



$$F_2 = AB + AC + BC$$

$$T_1 = A + B + C$$

$$T_2 = ABC$$

$$T_3 = \bar{F}_2 T_1$$

$$F_1 = T_3 + T_2$$

$$F_1 = \bar{F}_2 T_1 + T_2 = \overline{(AB + AC + BC)}(A+B+C) + ABC$$

$$= (\bar{A}+\bar{B})(\bar{A}+\bar{C})(\bar{B}+\bar{C})(A+B+C) + ABC$$

$$= (\bar{A}+\bar{B}\bar{C})(A\bar{B}+A\bar{C}+B\bar{C}+\bar{B}C) + ABC$$

$$F_1 = \bar{A}B\bar{C} + \bar{A}\bar{B}C + A\bar{B}\bar{C} + ABC$$

The derivation of the truth table for the circuit is a straight-forward process once the output Boolean functions are known. To obtain the truth table directly from the logic diagram without going through the derivations of the Boolean functions, proceed as follows:

1- Determin the number of input variables in the circuit. For n inputs, from the 2^n possible input combinations and list the binary numbers from 0 to 2^n-1 in a table.

2- Label the outputs of selected gates with arbitrary symbols.

3- Obtain the truth table for the outputs of those gates that are a function of the input variables only.

4- Proceed to obtain the truth table for the outputs of those gates that are a function of Previously defined values until the columns for all outputs are determined.

A	B	C	F_2	$\overline{F_2}$	T_1	T_2	T_3	F_1
0	0	0	0	1	0	0	0	0
0	0	1	0	1	1	0	1	1
0	1	0	0	1	1	0	1	1
0	1	1	1	0	1	0	0	0
1	0	0	0	1	1	0	1	1
1	0	1	1	0	1	0	0	0
1	1	0	1	0	1	0	0	0
1	1	1	1	0	1	1	0	1

Inspection of the truth table combinations for A, B, C, F_1, and F_2 shows that it is identical to the truth table of the FULL ADDER givenin the next section, for x, y, z, S, and C, respectively.

Design Procedure

The design of combinational circuits starts from the specification of the problem and culminates in a logic circuit diagram or a set of Boolean functions from which the logic diagram can be obtained. The procedure involves the following steps:

1- From the specifications of the circuit, determine the required number of inputs and outputs and assign a symbol to each.
2- Derive the truth table that defines the required relationship between inputs and outputs.
3- Obtain the simplified Boolean functions for each output as a function of the input variables.
4- Draw the logic diagram and verify the correctness of the design.

Ex: Convert the binary Coded Decimal (BCD) to the excess-3 code for the decimal digits.

Input BCD				Output			
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

AB \ CD	00	01	11	10
00	1			1
01	1			1
11	X	X	X	X
10	1		X	X

$Z = \bar{D}$

AB \ CD	00	01	11	10
00	1		1	
01	1		1	
11	X	X	X	X
10	1		X	X

$Y = CD + \bar{C}\bar{D}$

AB \ CD	00	01	11	10
00		1	1	1
01	1			
11	X	X	X	X
10		1	X	X

$X = \bar{B}C + \bar{B}D + B\bar{C}\bar{D}$

AB \ CD	00	01	11	10
00				
01		1	1	1
11	X	X	X	X
10	1	1	X	X

$W = A + BC + BD$

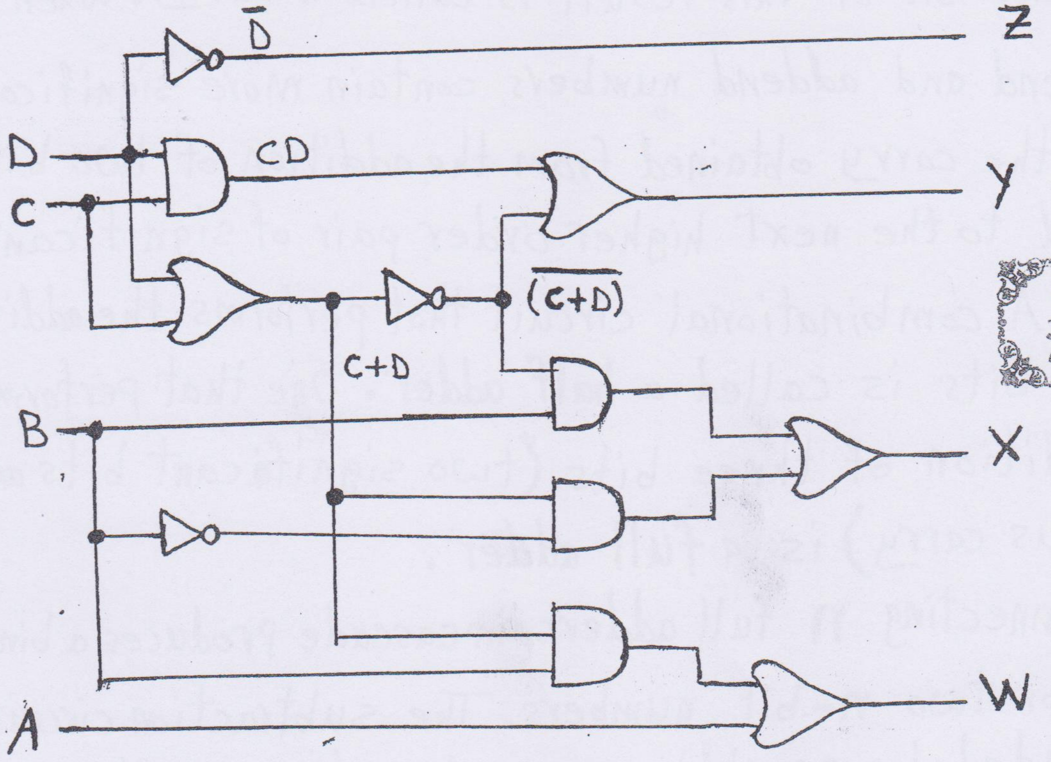
$Z = \bar{D}$

$Y = CD + \bar{C}\bar{D} = CD + \overline{(C+D)}$

$X = \bar{B}C + \bar{B}D + B\bar{C}\bar{D} = \bar{B}(C+D) + B\bar{C}\bar{D}$

$\quad = \bar{B}(C+D) + B\overline{(C+D)}$

$W = A + BC + BD = A + B(C+D)$



Binary Adder – Subtractor

Digital Computers perform a variety of information processing tasks. Among the functions encountered are the various arithmetic operations. The most basic arithmetic operation is the addition of two binary digits. This simple addition consists of four possible elementary operations:

$0 + 0 = 0$

$0 + 1 = 1$

$1 + 0 = 1$

$1 + 1 = 10$

The first three operations produce a sum of one digit, but when both augend and addend bits are equal to 1, the binary sum consists of two digits. The higher significant bit of this result is called a carry. When the augend and addend numbers contain more significant digits, the carry obtained from the addition of two bits is added to the next higher order pair of significant bits. A combinational circuit that performs the addition of two bits is called a **half adder**. One that performs the addition of three bits (two significant bits and a previous carry) is a **full adder**.

Connecting **n** full adders in cascade produces a binary adder for two **n**-bit numbers. The subtraction circuit is included by providing a complementing circuit.

Half Adder (HA)

This circuit needs two binary inputs and two binary outputs. The input variables designate the augend and addend bits; the output variables produce the sum and carry. We assign symbols x and y to the two inputs and S (for Sum) and C (for carry) to the outputs.

x	y	C	S
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0

$$S = \bar{x}y + x\bar{y} = x \oplus y$$

$$C = xy$$