Introduction to Digital Circuits 1

Types of Digital Circuits:

- Combinational: consists of logic gates whose outputs are determined from the present combination of inputs.
  - Design of combinational circuit follows these procedures:
  - Sequential: consists of combinational circuits and a memory elements circuit.

Types of Adders

- Binary Adder:
  - Most basic arithmetic operation.
  - Consists of four possible operations:

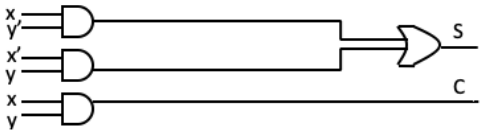
0 + 0 = 0, 0 + 1 = 1, 1 + 0 = 1 and 1 + 1 = 1 0 (carry: 1, sum: 0)

    - The higher significant bit of this result is called a *carry*
    - The lower significant digit is *sum*
- Half Adder:
  - Needs two binary inputs and produce two binary outputs.
  - The input variables are the augends and addend bits; the output variables are *sum (s)* and *carry (c).*
  - In this circuit x and y are input and S and C are the output.
  - The truth table, the Boolean function and the logic circuit for half adder:

S = x'y + xy' (from the truth table)

C = xy (from the truth table)

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



- Full Adder:
  - A combinational circuit that forms the arithmetic sum of three bits.
  - Consists of three inputs and two outputs.

- Two of the inputs are x and y, representing the two significant bits to be added.
- The third input z is carry from the previous lower significant position.
- Two output are sum(S) and carry(C).
- the truth table and map for full adder:

x	*y*	*z*	*C*	*S*
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

x \ yz	00	01	11	10
0		1		1
1	1		1	

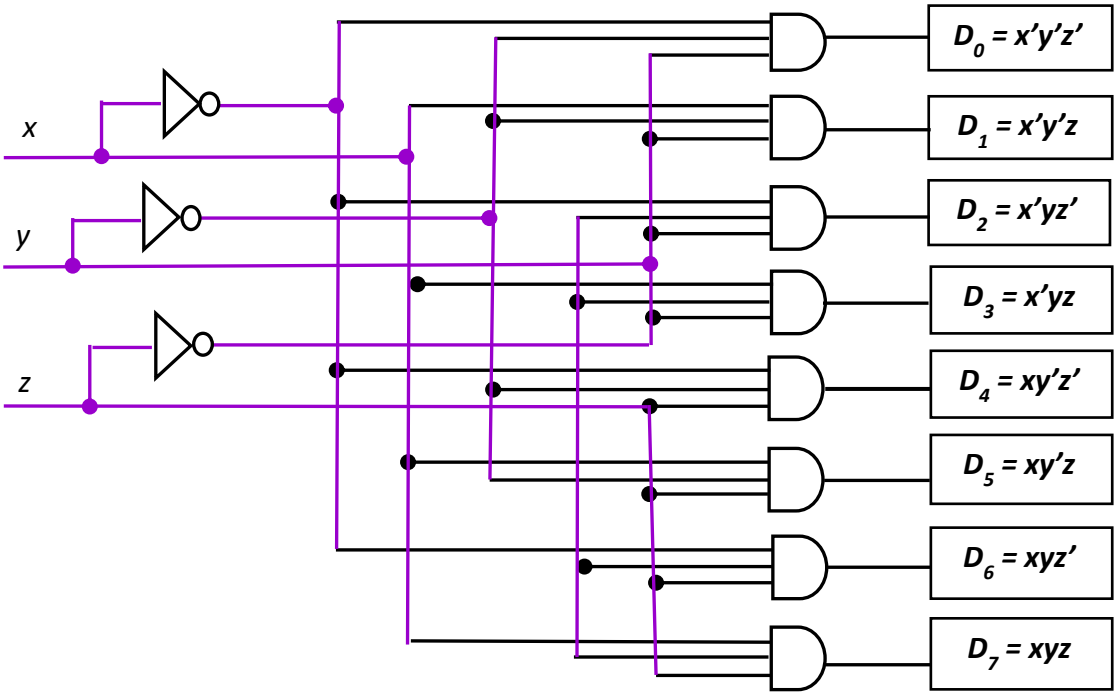
S = x'y'z + x'yz' +xy'z' + xyz

x \ yz	00	01	11	10
0			1	
1		1	1	1

C = xy + xz+ yz

Decoder:

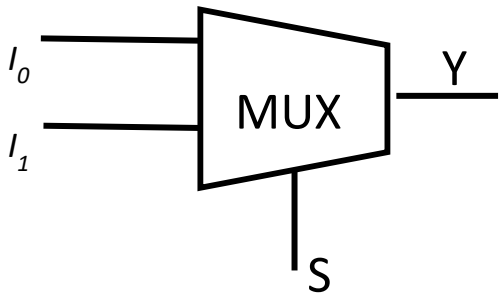
- Converts binary information from ***n*** input lines to a maximum of 2^n unique output lines.
- As an example consider the 3-to-8 line decoder circuit below:



- The three inputs are decoded into eight outputs, each representing one of the minterms of the three input variables.
- The three inverters provide the complement of inputs.
- Each one of eight AND gates represent one of the minterms.

Multiplexer

- The multiplexer is a combinational circuit that selects binary information from one of many input lines and directs it to a single output line.
- The selection of particular input line is controlled by a set of selection lines.
- Normally, there are 2^n input line and ***n*** selection lines whose combinations determine which input is selected.
- A ***2-to-1*** line multiplexer connects one of two 1-bit sources to a common destination as shown in the next slide.
- The block diagram of the circuit is also shown below.



Examples of Combinational circuits:

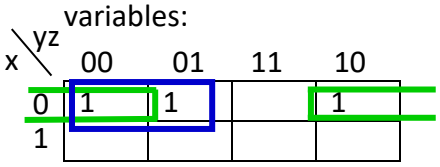
- Design a combinational circuit with three inputs and one output. The output is 1 when the binary value of the inputs is less than 3. The input is 0 otherwise.
- **Answer:**

1. In this question, we have three input (let's call them x,y,z) and one output (let's call it F):

2. Derive the truth table that defines the required relationship between inputs and outputs. (from question, it says that the output is 1 if the binary value of input is less than 3:

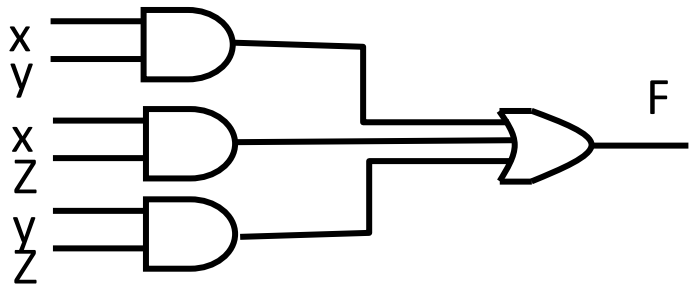
x	*y*	*Z*	*F*
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	0

3. Get simplified Boolean function for each output as a function of the input variables:



F = x'y'+ x'z'

4. Draw the logic diagram:



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