

Introduction to Digital Circuits 1

Types of Digital Circuits:

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

Types of Adders

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

$$0 + 0 = 0, 0 + 1 = 1, 1 + 0 = 1 \text{ and } 1 + 1 = \boxed{1} \boxed{0}$$

carry
 ↗
 ↘
 sum

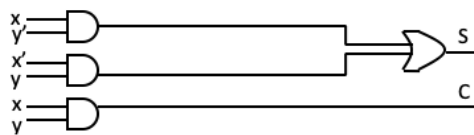
- The higher significant bit of this result is called a *carry*
- The lower significant digit is *sum*

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

$$S = x'y + xy' \quad (\text{from the truth table})$$

$$C = xy \quad (\text{from the truth table})$$

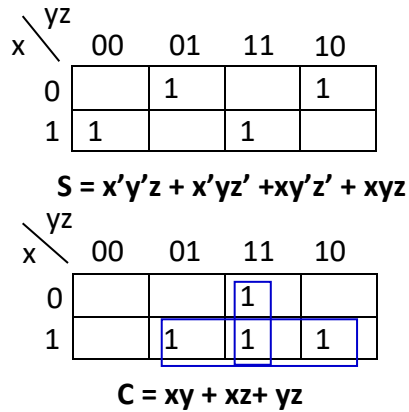
x	y	C	S
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0



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

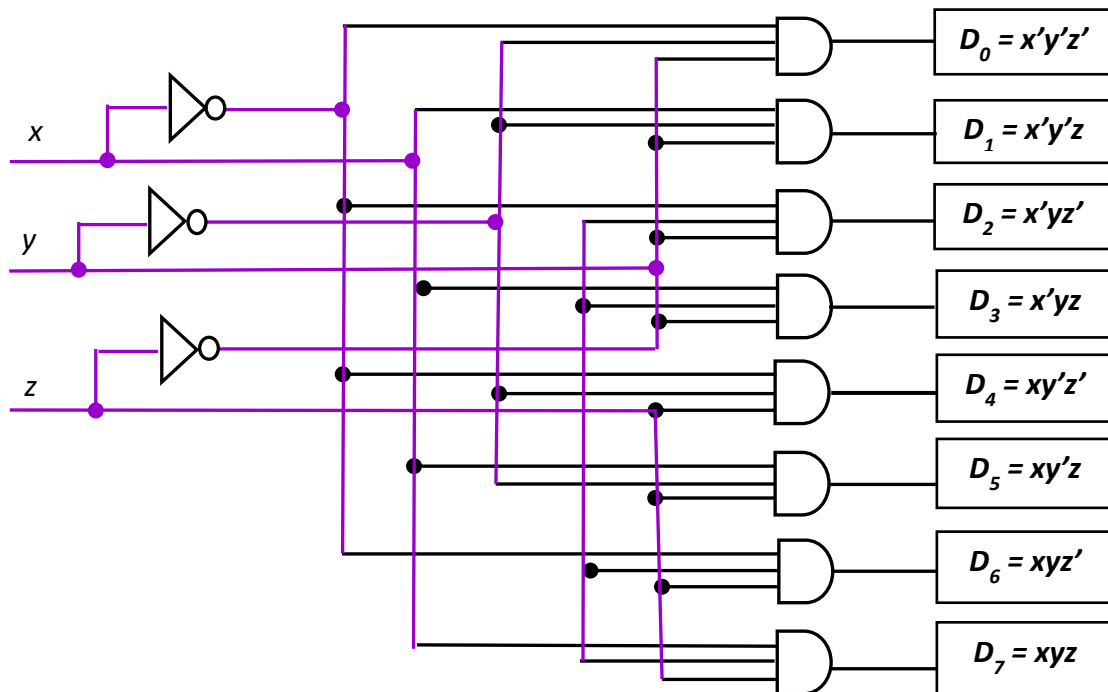
- Two of the inputs are x and y, representing the two significant bits to be added.
- The third input z is carry from the previous lower significant position.
- Two output are sum(S) and carry(C).
- the truth table and map for full adder:

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



Decoder:

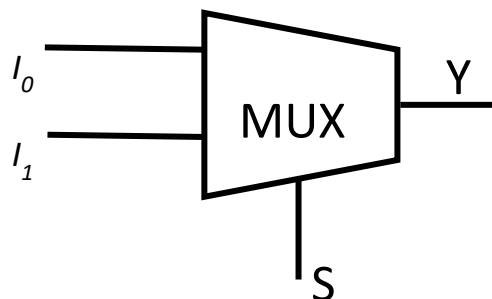
- Converts binary information from n input lines to a maximum of 2^n unique output lines.
- As an example consider the 3-to-8 line decoder circuit below:



- 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:

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

$F = x'y' + x'z'$

4. Draw the logic diagram:

