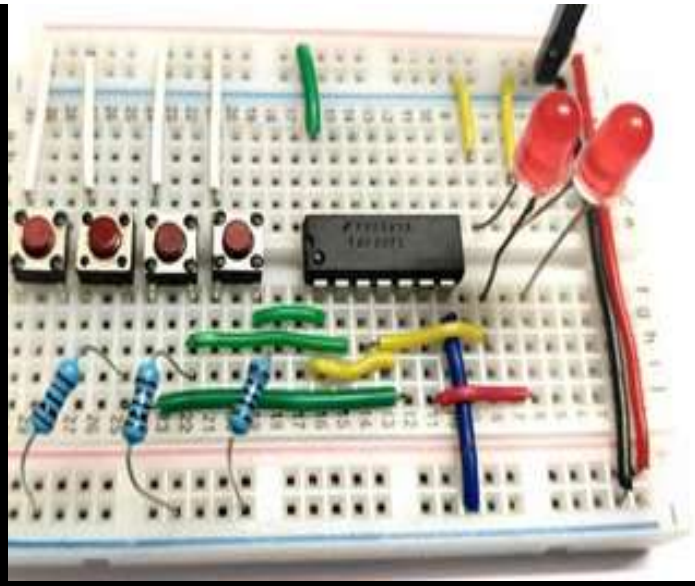
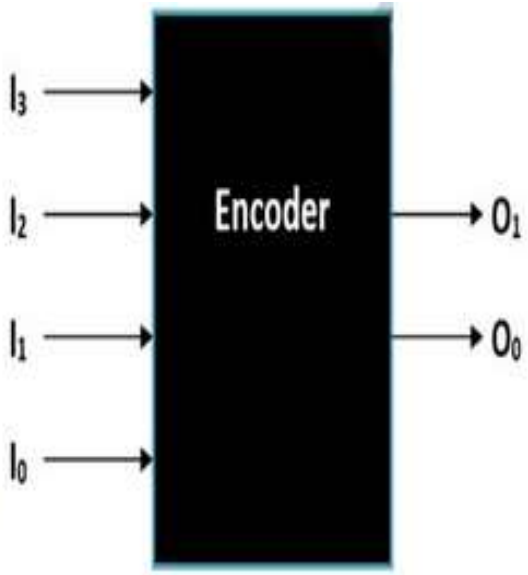
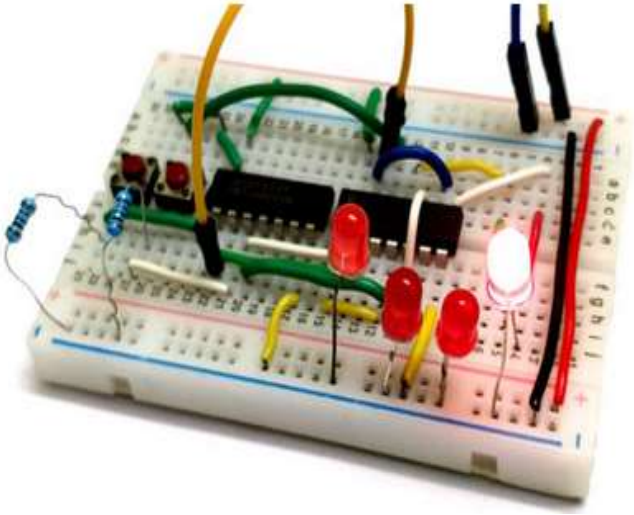
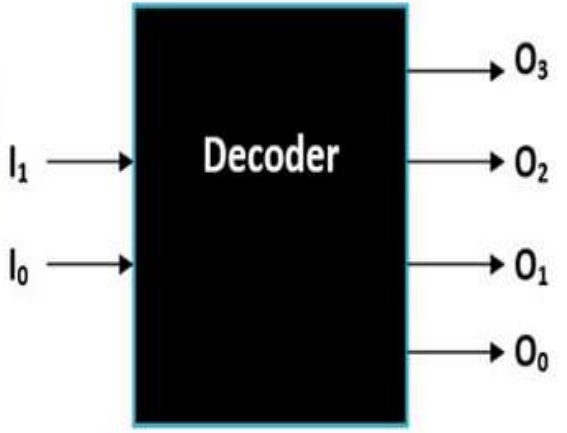
Encoders And Decoders

DEEPA MATHEWS









ENCODERS & DECODERS

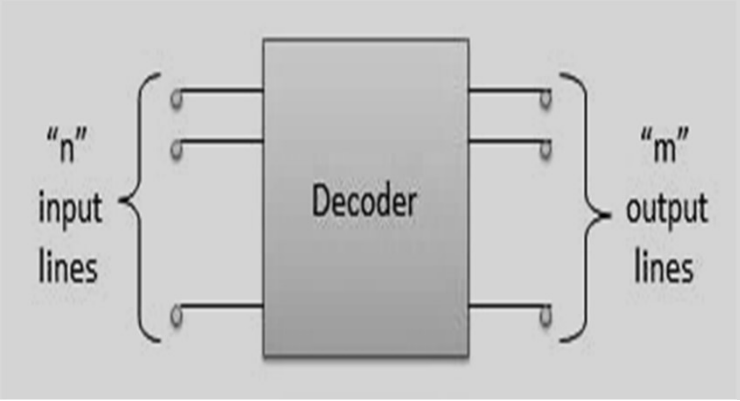
- **Encoders and Decoders** are the combinational logic circuits which are used to **convert data from one form to another form**.
- Binary code of N digits can be used to store 2^N distinct elements of coded information. This is what encoders and decoders are used for.
- **Encoders** convert 2^N lines of input into a code of N bits and **Decoders** decode the N bits into 2^N lines.
- Encoders converts familiar numbers or symbols into coded format and decoders decodes the coded information. These are frequently used in communication system such as telecommunication, networking, etc. to transfer data from one end to the other end.

ENCODERS & DECODERS - APPLICATIONS

- Speed synchronization of multiple motors in industries.
- War field flying robot with a night vision flying camera.
- Robotic vehicle with the metal detector.
- RF based home automation system.
- Automatic health monitoring systems.

DECODERS

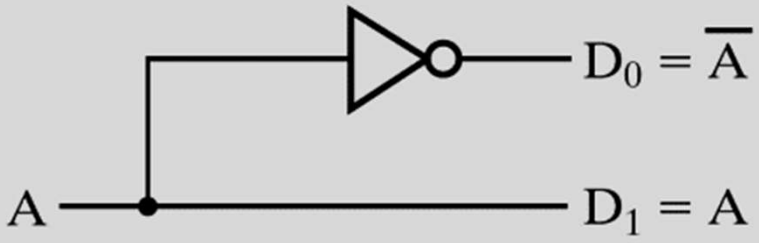
- A decoder **has n inputs and 2^n outputs**
- It is also called as *n-to-m* decoder, where $m \leq 2^n$
- A decoder selects **one of 2^n** outputs by decoding the **binary value** on the **n** inputs.
- Exactly **one output** will be active for each combination of the inputs.
- The decoder generates all of the minterms of the **n** input variables.
- Two types:
  - Active **High** Decoder
  - Active **Low** Decoder



1 TO 2 LINE DECODER

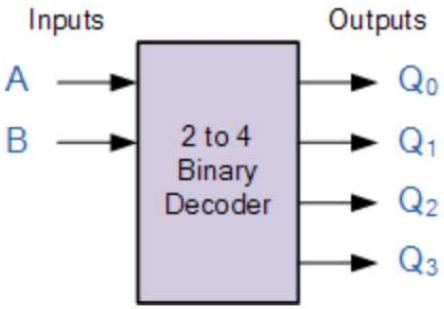
- The **smallest** possible decoder
- The 1-to-2 binary decoder consists of 1-input (A) and 2-outputs (Do & D1)
- Works like an inverter (*NOT-gate*)

A	D_0	D_1
0	1	0
1	0	1



2 TO 4 LINE DECODER (ACTIVE HIGH)

- 2 inputs – A,B and 4 Outputs -Q_0, Q_1, Q_2, Q_3.
- Truth table explains the operations of a decoder. It shows that each output is 1 for only a specific combination of inputs.



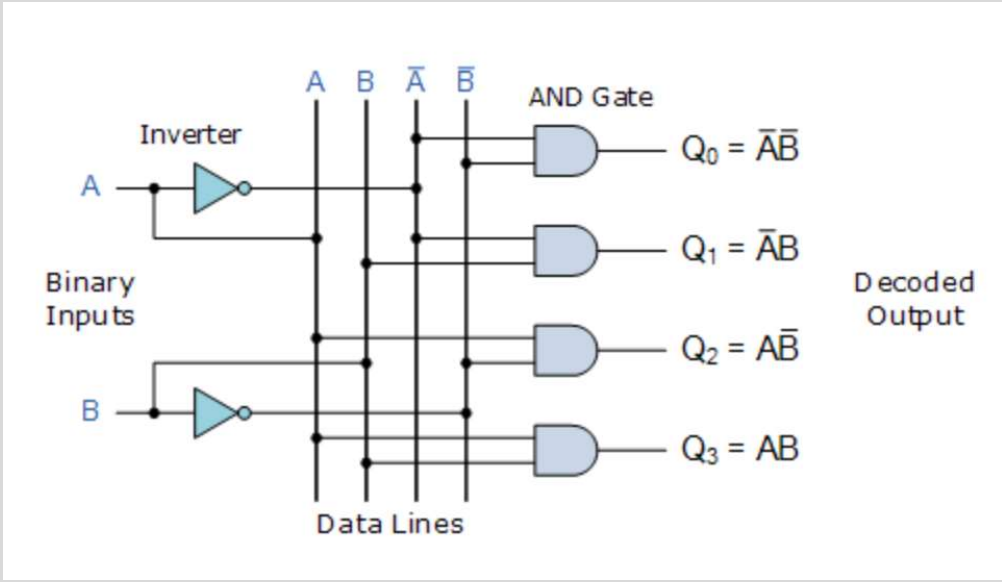
Truth Table

A	B	Q_0	Q_1	Q_2	Q_3
0	0	1	0	0	0
0	1	0	1	0	0
1	0	0	0	1	0
1	1	0	0	0	1

Maxterms:

Q0 = A'B', Q1 = A'B

Q2 = AB' , Q3 = AB

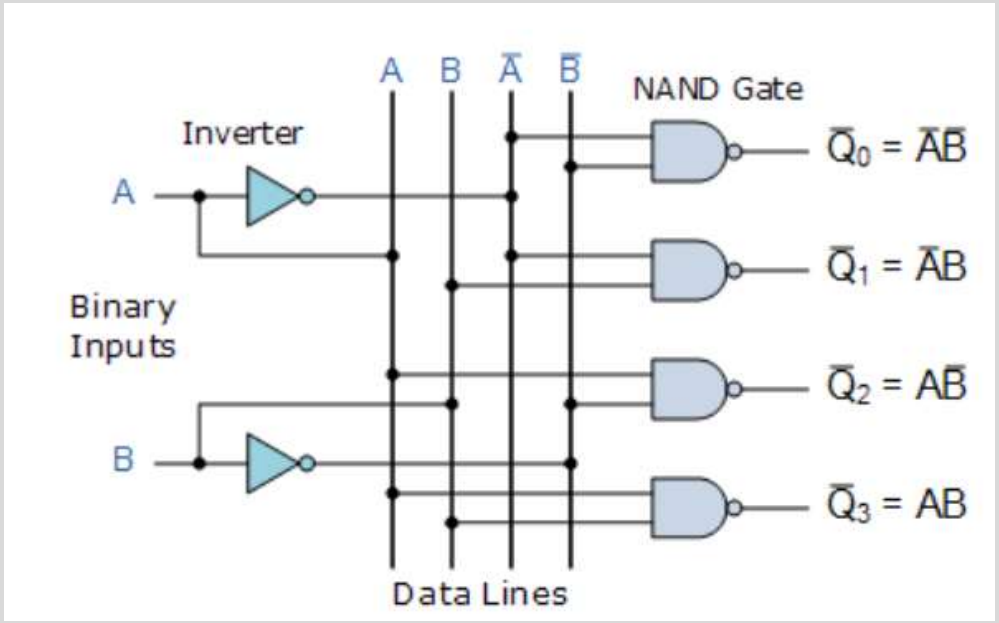


2 TO 4 LINE DECODER (ACTIVE LOW)

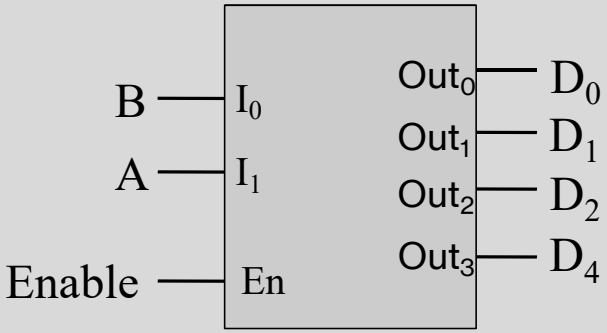
- Truth table explains the operations of a ACTIVE=LOW decoder. It shows that each output is 0 (active low) for only a specific combination of inputs.

Truth Table

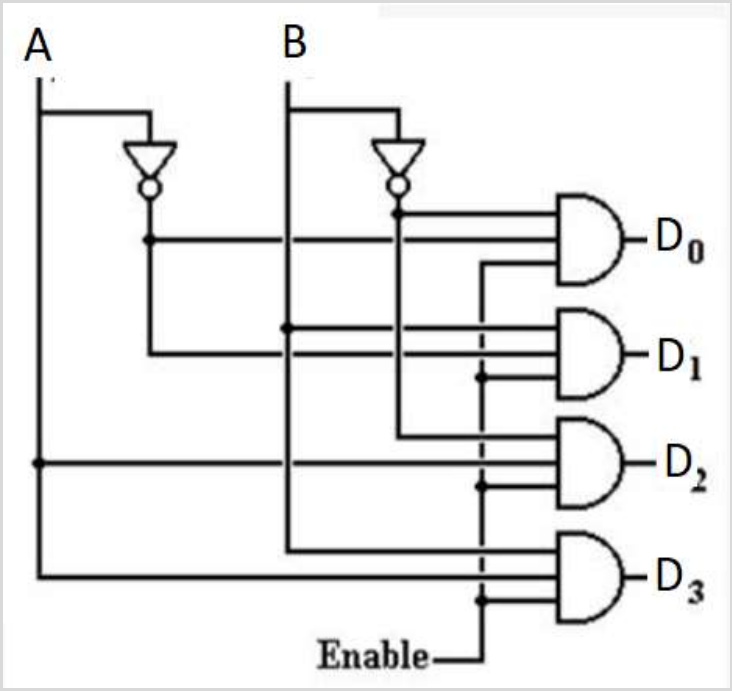
A	B	Q_0	Q_1	Q_2	Q_3
0	0	0	1	1	1
0	1	1	0	1	1
1	0	1	1	0	1
1	1	1	1	1	0



DECODER WITH ENABLE

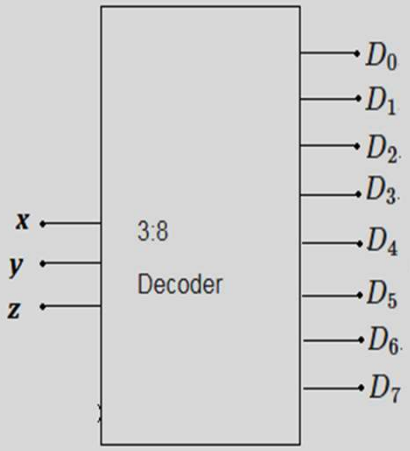


	En	A	B	D_0	D_1	D_2	D_3
enabled	1	0	0	1	0	0	0
	1	0	1	0	1	0	0
	1	1	0	0	0	1	0
	1	1	1	0	0	0	1
disabled	0	x	x	0	0	0	0

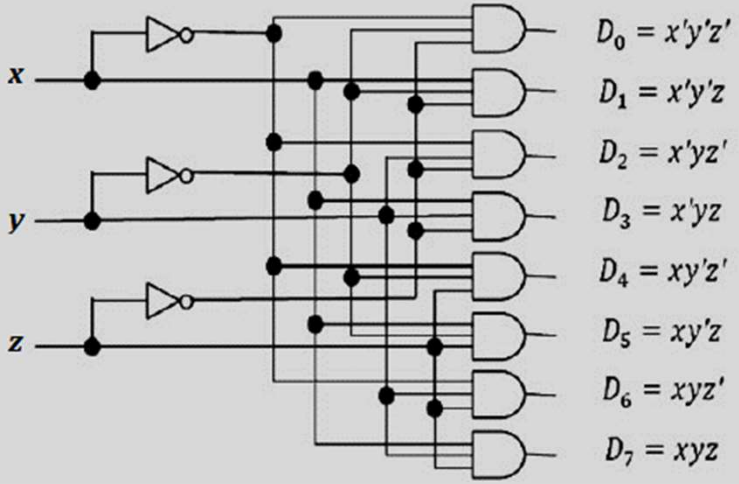


3-TO-8 LINE DECODER

- A 3 to 8 decoder has three inputs (x,y,z) and eight outputs (DO to D7).
- Based on 3 inputs, one of the 8 output is selected and so also called as **1 of 8 decoder**,
- 3 to 8 line decoder circuit is also called as **binary to an octal decoder**.
- Circuit can be implemented using three NOT gates & eight 3-input AND gates.



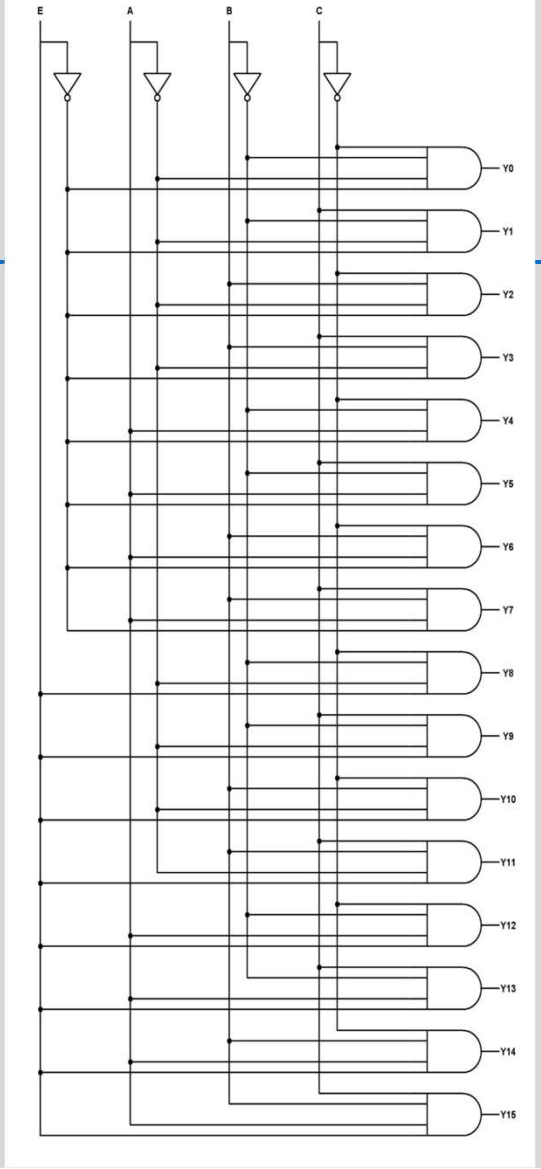
Inputs			Outputs							
x	y	z	D0	D1	D2	D3	D4	D5	D6	D7
0	0	0	1	0	0	0	0	0	0	0
0	0	1	0	1	0	0	0	0	0	0
0	1	0	0	0	1	0	0	0	0	0
0	1	1	0	0	0	1	0	0	0	0
1	0	0	0	0	0	0	1	0	0	0
1	0	1	0	0	0	0	0	1	0	0
1	1	0	0	0	0	0	0	0	1	0
1	1	1	0	0	0	0	0	0	0	1



4-TO-16 DECODER

A 4-to-16 decoder consists of 4 inputs & 16 outputs; Only one output will be high at a given time and all other outputs are low (if using minterms)

E	A	B	C	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15
0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
0	1	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1



IMPLEMENTING BOOLEAN FUNCTIONS USING DECODERS

Any combinational circuit can be constructed using decoders and OR gates!

Implement a full adder circuit with a decoder and two OR gates

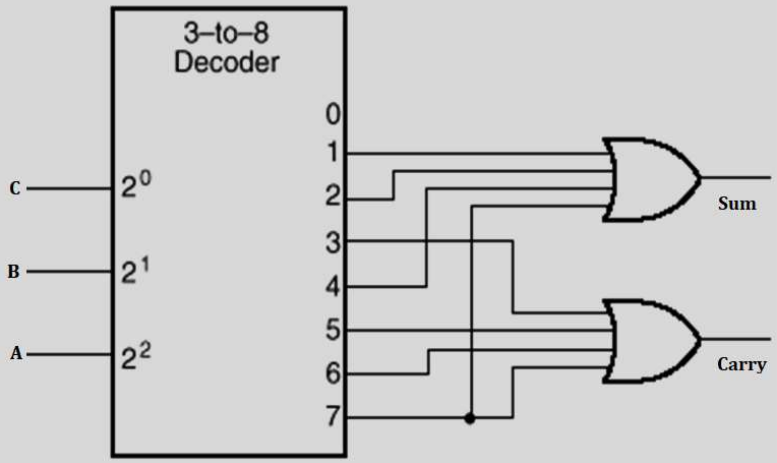
Full adder equations:

- Sum = Σm(1,2,4,7)
- Carry = Σm(3, 5, 6, 7)

A	B	Cin	Sum	Co
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

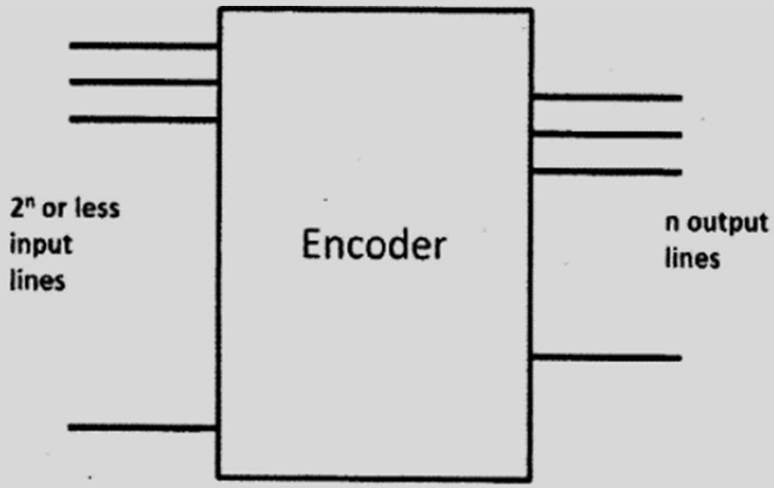
Since there are 3 inputs and a total of 8 minterms,

we need a **3-to-8 decoder**.



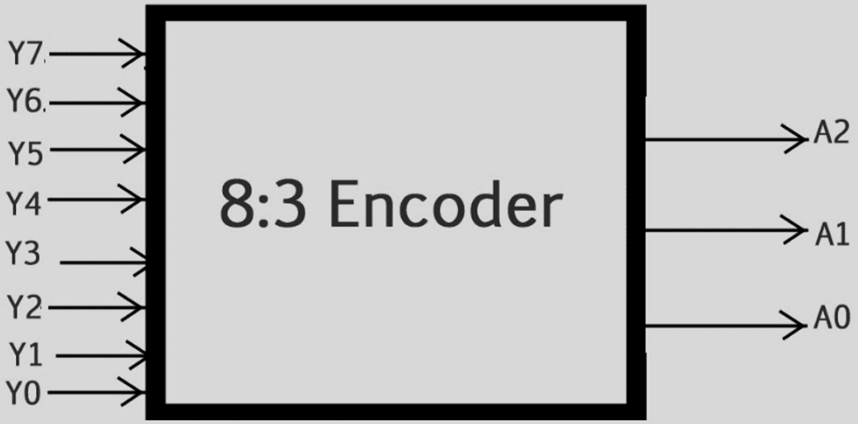
ENCODERS

- An encoder is a device which converts familiar numbers or symbols into coded format.
- **An encoder has 2^N inputs and N outputs**
- An encoder has a number of input lines, only one of which is activated at a given time, and produces an N-bit output code depending on which input is activated.
- An encoder performs the **inverse operation** of a decoder.



OCTAL-TO-BINARY ENCODER (8-TO-3 ENCODER)

It accepts 8 input lines & produces a 3-bit output code corresponding to activated input.



INPUTS								OUTPUTS		
Y7	Y6	Y5	Y4	Y3	Y2	Y1	Y0	A2	A1	A0
0	0	0	0	0	0	0	1	0	0	0
0	0	0	0	0	0	1	0	0	0	1
0	0	0	0	0	1	0	0	0	1	0
0	0	0	0	1	0	0	0	0	1	1
0	0	0	1	0	0	0	0	1	0	0
0	0	1	0	0	0	0	0	1	0	1
0	1	0	0	0	0	0	0	1	1	0
1	0	0	0	0	0	0	0	1	1	1

$A2 = Y7 + Y6 + Y5 + Y4$

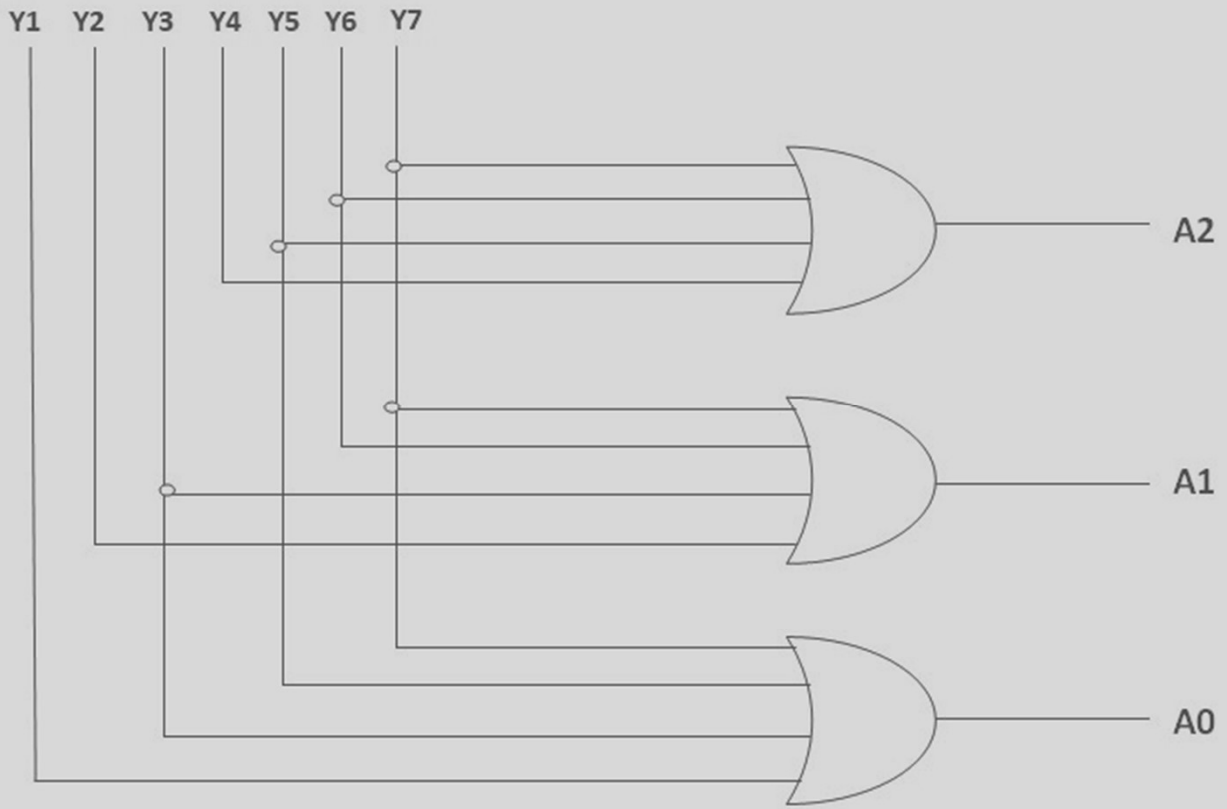
$A1 = Y7 + Y6 + Y3 + Y2$

$A0 = Y7 + Y5 + Y3 + Y1$

Y0 is not present in any of the expression. So Y0 is a don't care

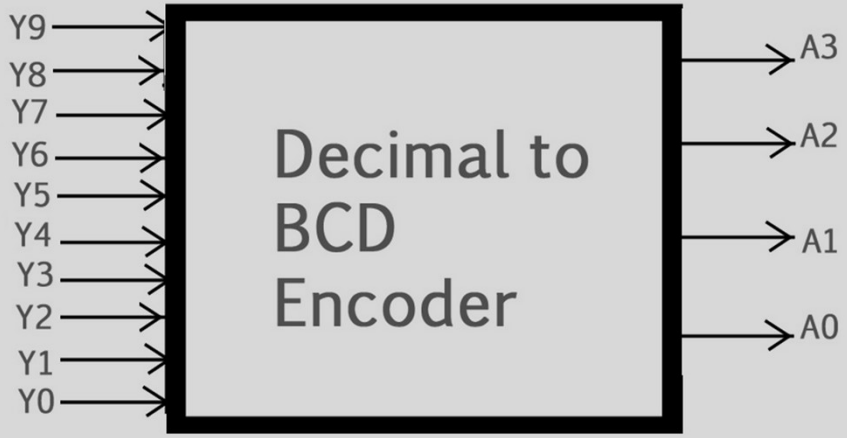
Octal-to-Binary Encoder (8-to-3 Encoder)

$A2 = Y7 + Y6 + Y5 + Y4$
$A1 = Y7 + Y6 + Y3 + Y2$
$A0 = Y7 + Y5 + Y3 + Y1$



DECIMAL TO BCD ENCODER

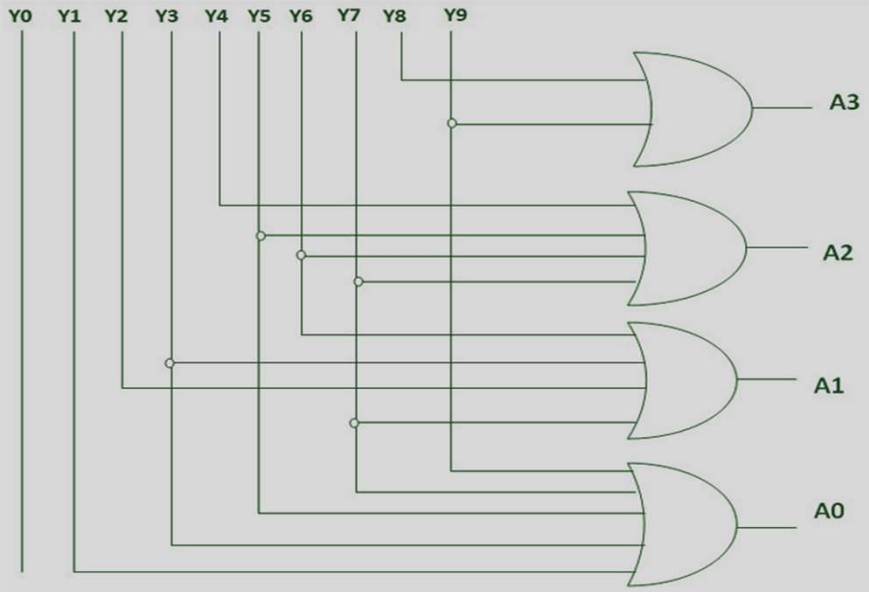
- The decimal to binary encoder usually consists of **10 input lines** and **4 output lines**.
- Each input line corresponds to the each decimal digit and 4 outputs correspond to the BCD code. This encoder accepts the decoded decimal data as an input and encodes it to the BCD output which is available on the output lines.



DECIMAL TO BCD ENCODER

INPUTS										OUTPUTS			
Y9	Y8	Y7	Y6	Y5	Y4	Y3	Y2	Y1	Y0	A3	A2	A1	A0
0	0	0	0	0	0	0	0	0	1	0	0	0	0
0	0	0	0	0	0	0	0	1	0	0	0	0	1
0	0	0	0	0	0	0	1	0	0	0	0	1	0
0	0	0	0	0	0	1	0	0	0	0	0	1	1
0	0	0	0	0	1	0	0	0	0	0	1	0	0
0	0	0	0	1	0	0	0	0	0	0	1	0	1
0	0	0	1	0	0	0	0	0	0	0	1	1	0
0	0	1	0	0	0	0	0	0	0	0	1	1	1
0	1	0	0	0	0	0	0	0	0	1	0	0	0
1	0	0	0	0	0	0	0	0	0	1	0	0	1

A3 = Y9 + Y8
A2 = Y7 + Y6 + Y5 +Y4
A1 = Y7 + Y6 + Y3 +Y2
A0 = Y9 + Y7 +Y5 +Y3 + Y1



ENCODERS

Drawbacks of Normal Encoders –

1. There is an ambiguity, when all outputs of encoder are equal to zero.
2. If more than one input is active High, then the encoder produces an output, which may not be the correct code.

To overcome these difficulties, priorities are assigned to each input of encoder