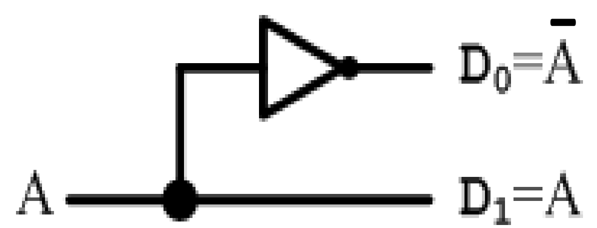
Continue - Application of Combinational Logic Circuit / DECODER- ENCODER & Bit Converters

First Class

Decoder

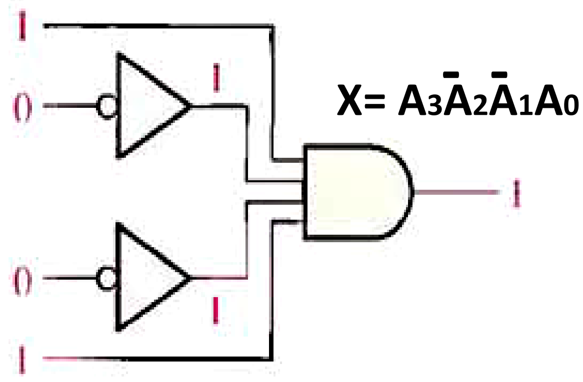
- **Decoder** – Is a digital circuit that detects the presence of a specified combination of bits (code) on its input and indicates the presence of that code by a specified output level.
- **Decoding** – Is the conversion of an *n*-bit input code to an *m*-bit output code with $n \leq m \leq 2^n$ such that each valid code word produces a unique output code
- Circuits that perform decoding are called ***decoders***
- This a 1-to-2 Line decoder – exactly one of the output lines will be active.

A	D_0	D_1
0	1	0
1	0	1



Decoder

Example: Determine the logic required to decode the binary Number **1001** by producing a High level on the output



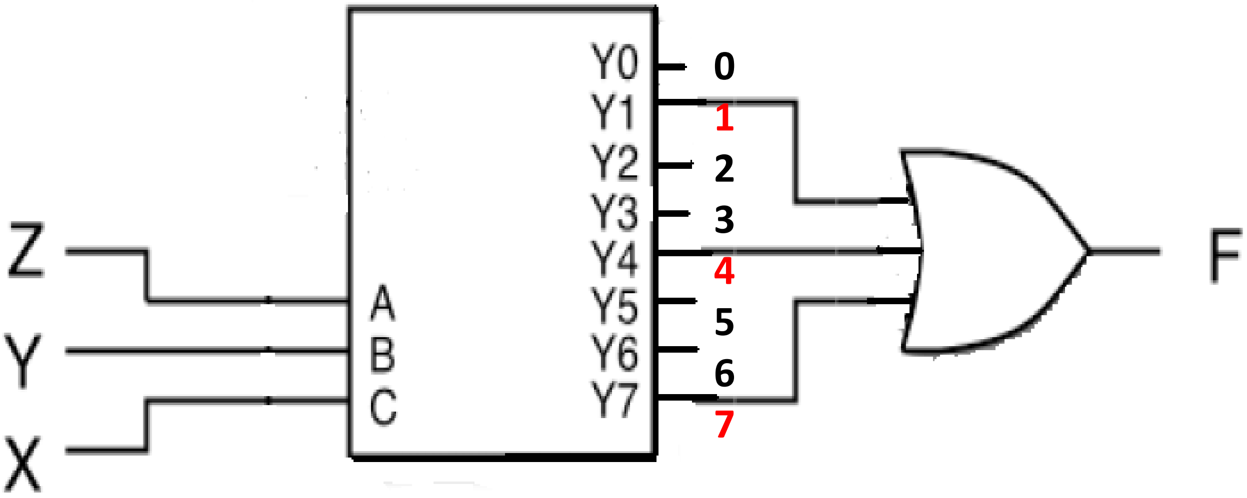
Solution: You must be sure that all of the inputs to the AND gate are HIGH when the binary number 1001 occurs,

$$\mathbf{X = A_3\bar{A}_2\bar{A}_1A_0}$$

Decoder

- **Example**: Realize F (X,Y,Z) = Σ (1, 4, 7) with a decoder

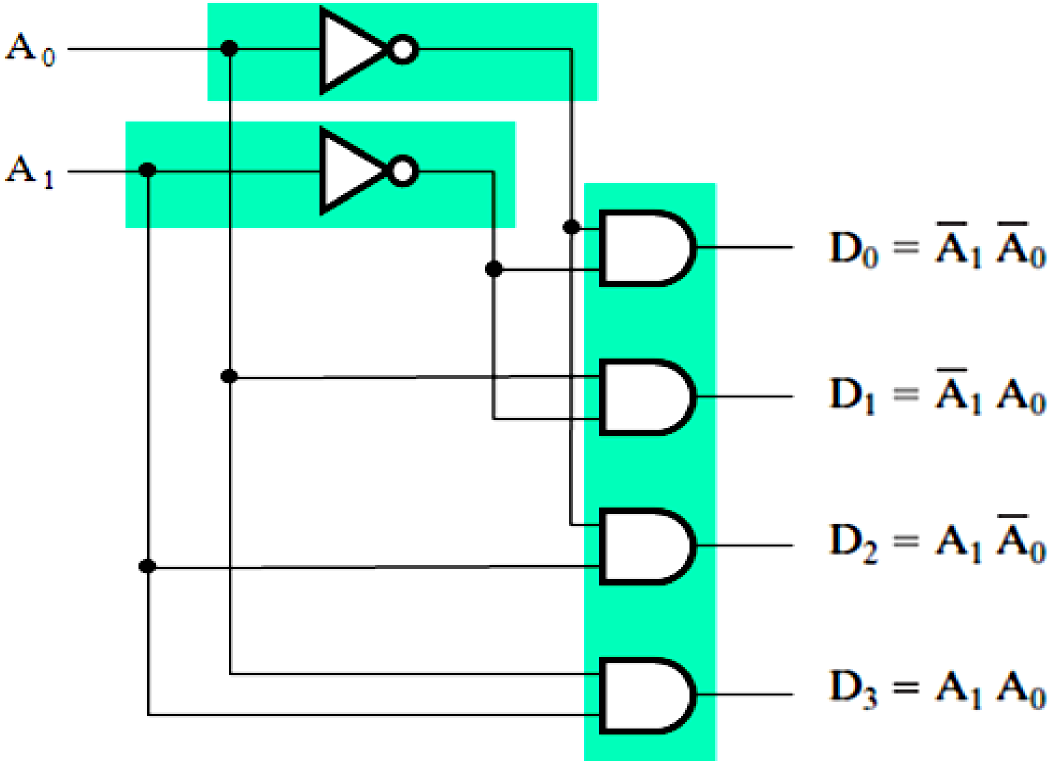
Solution: 1, 4, 7 means the three outputs obtained from eight output.



Decoder

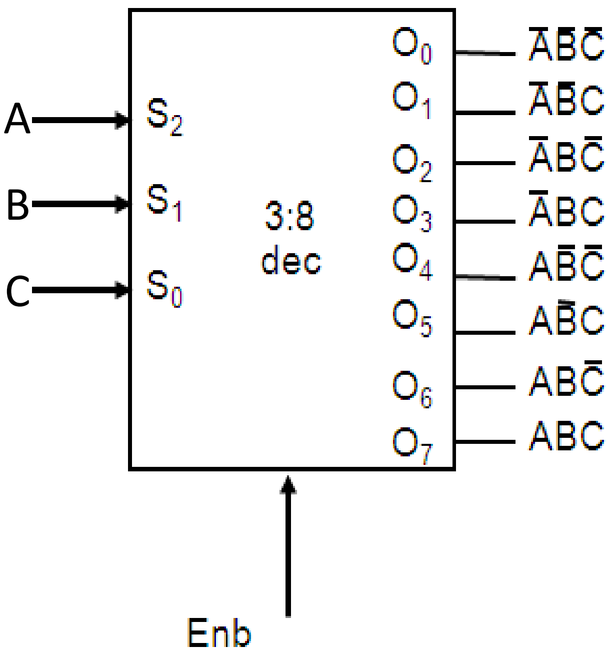
- **A 2-to-4 line decoder**

A_1	A_0	D_0	D_1	D_2	D_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



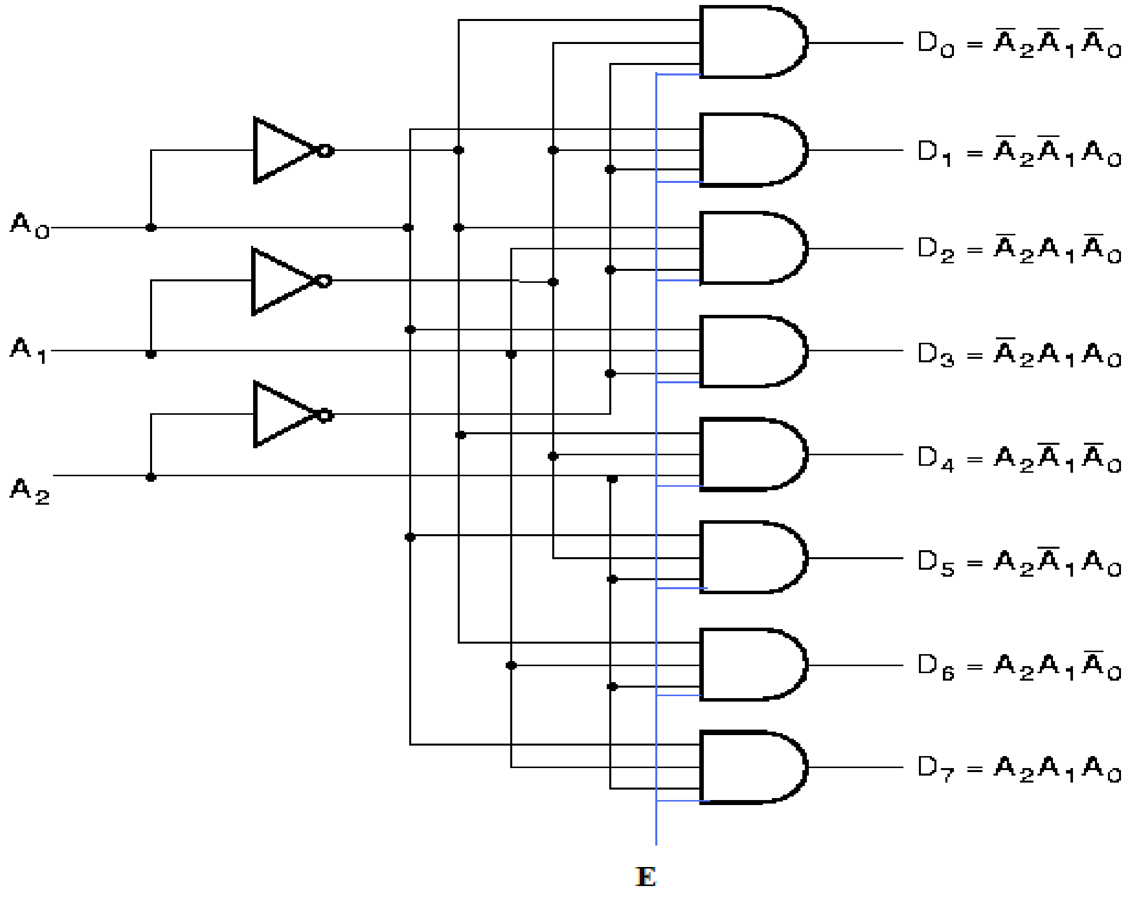
Decoder

- 2-to-4,
- 3-to-8,
- …
- n-to-2^n



Enb	A	B	C	O0	O1	O2	O3	O4	O5	O6	O7
0	x	x	x	0	0	0	0	0	0	0	0
1	0	0	0	1							
1	0	0	1		1						
1	0	1	0			1					
1	0	1	1				1				
1	1	0	0					1			
1	1	0	1						1		
1	1	1	0							1	
1	1	1	1								1

3-to-8 Decoder with Enable



Application of Decoder

- **Example**: Realize the 1 bit-binary adder circuit using decoder.

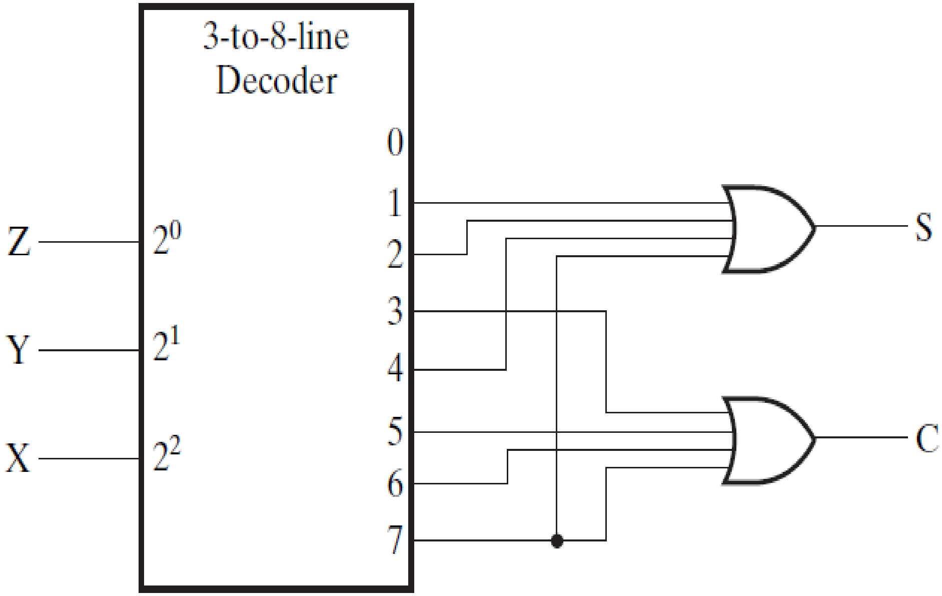
Solution: The truth table is as shown, so the output function should be:

$$S(X, Y, Z) = \sum m(1, 2, 4, 7)$$

$$C(X, Y, Z) = \sum m(3, 5, 6, 7)$$

Truth Table for 1-bit Binary 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



Application of Decoder

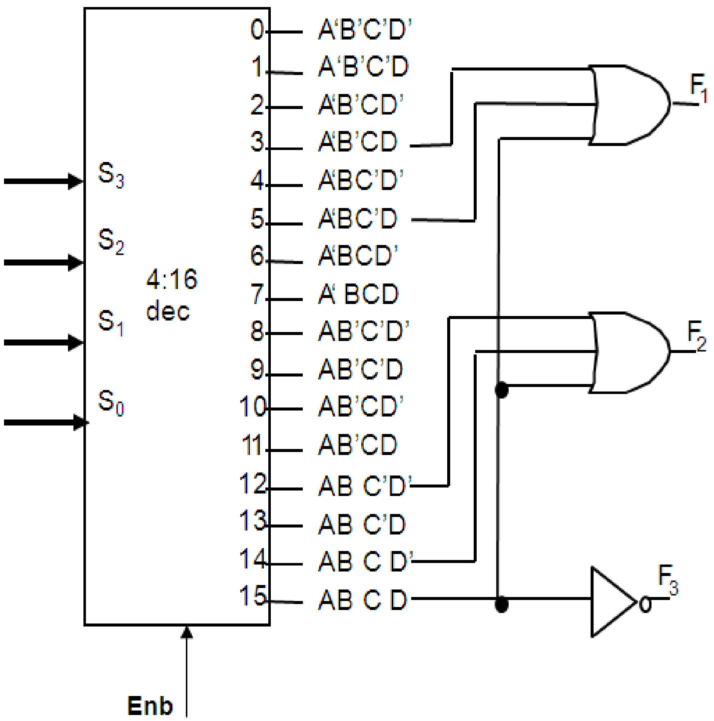
- **Implementing General Logic**

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

Example: design a circuit that can realize the output below:

F1 = A' B C' D + A' B' C D + A B C D
F2 = A B C' D' + A B C
F3 = (A' + B' + C' + D')

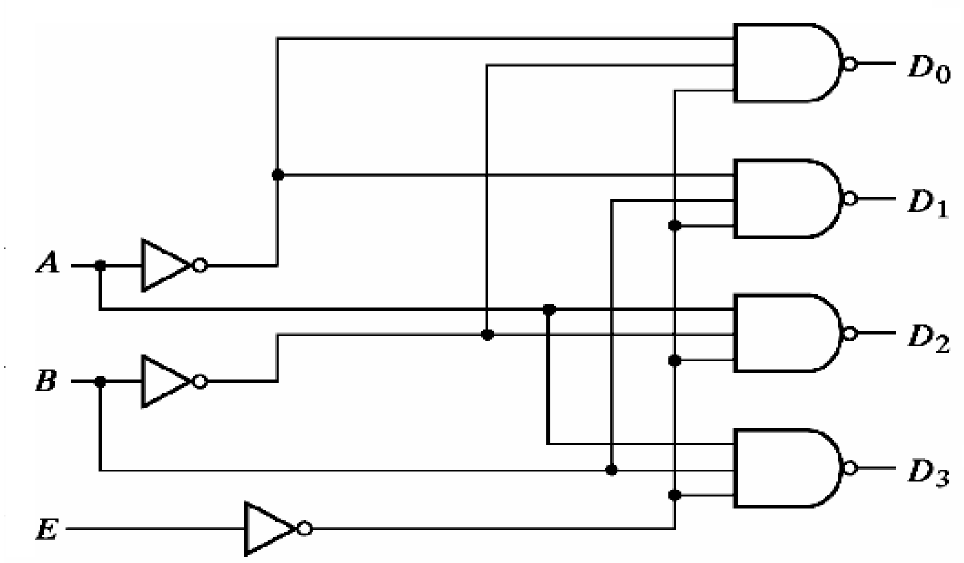
Solution:



Note: X' means $\overline{X}$

Active Low Decoder

- If an active-low output is required for each decoded number, the entire decoder can be implemented with NAND gates and inverters.
- **Example**: 2-to-4 Decoder is enabled when E=0 and an output is active if it is 0



(a) Logic diagram

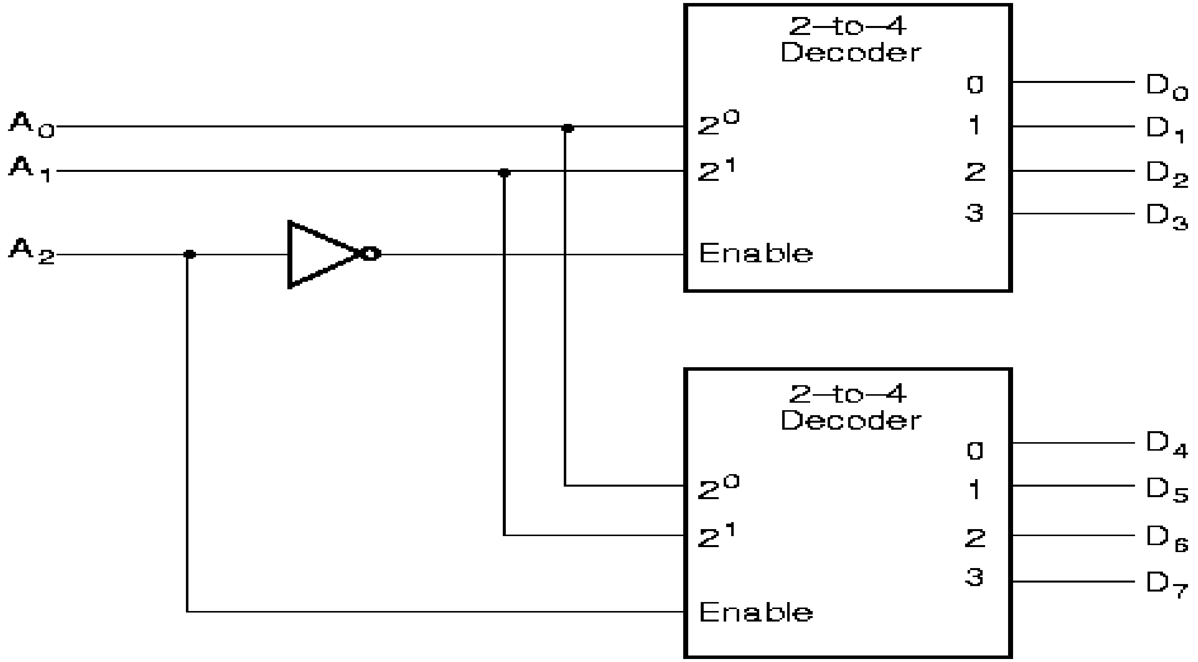
E	A	B	D_0	D_1	D_2	D_3
1	X	X	1	1	1	1
0	0	0	0	1	1	1
0	0	1	1	0	1	1
0	1	0	1	1	0	1
0	1	1	1	1	1	0

(b) Truth table

Decoder Expansion

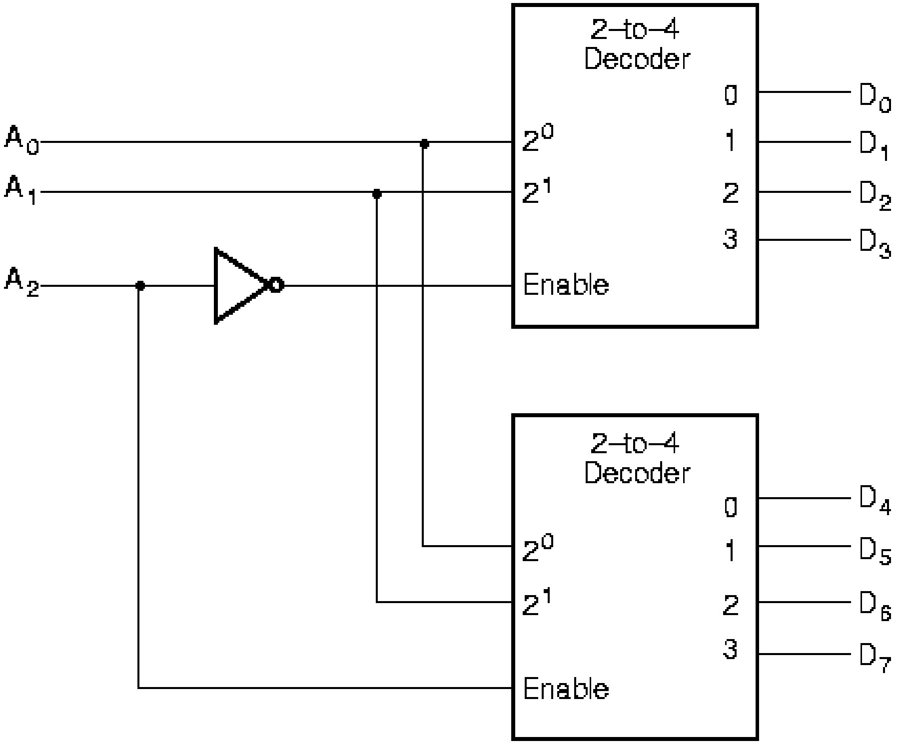
Decoder expansion

- Combine two or more small decoders with enable inputs to form a larger decoder. 3-to-8-line decoder constructed from two 2-to-4-line decoders
    - **The MSB is connected to the enable inputs**
    - **if A_2= 0, upper is enabled; if A_2=1, lower is enabled.**

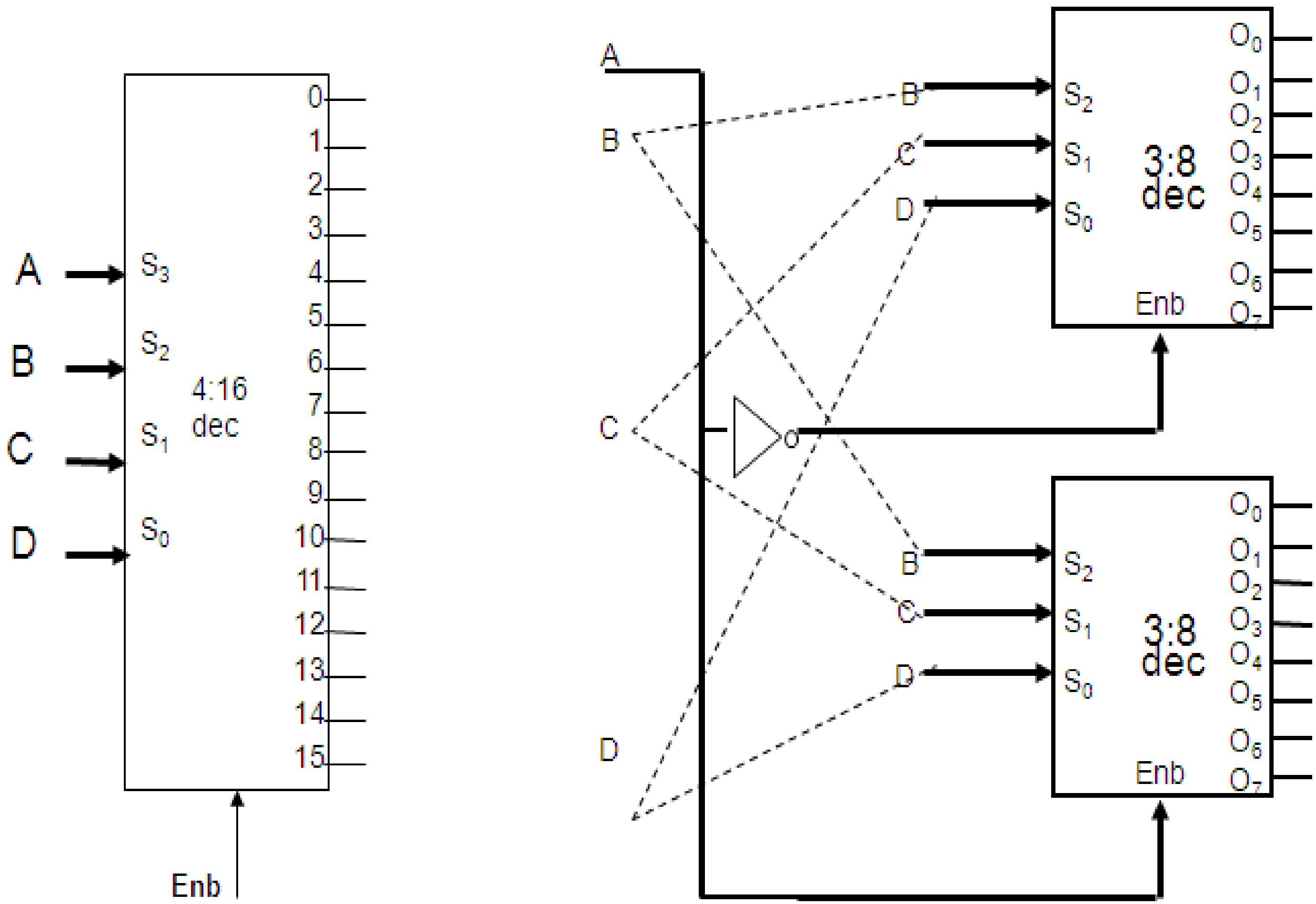


Combining Two 2-4 Decoders to Form One 3-8 Decoder Using Enable Switch

A_2	A_1	A_0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	0	0	0	0	0	0	0	0	0	1
0	0	1	0	0	0	0	0	0	1	0
0	1	0	0	0	0	0	0	1	0	0
0	1	1	0	0	0	0	1	0	0	0
1	0	0	0	0	0	1	0	0	0	0
1	0	1	0	0	1	0	0	0	0	0
1	1	0	0	1	0	0	0	0	0	0
1	1	1	1	0	0	0	0	0	0	0

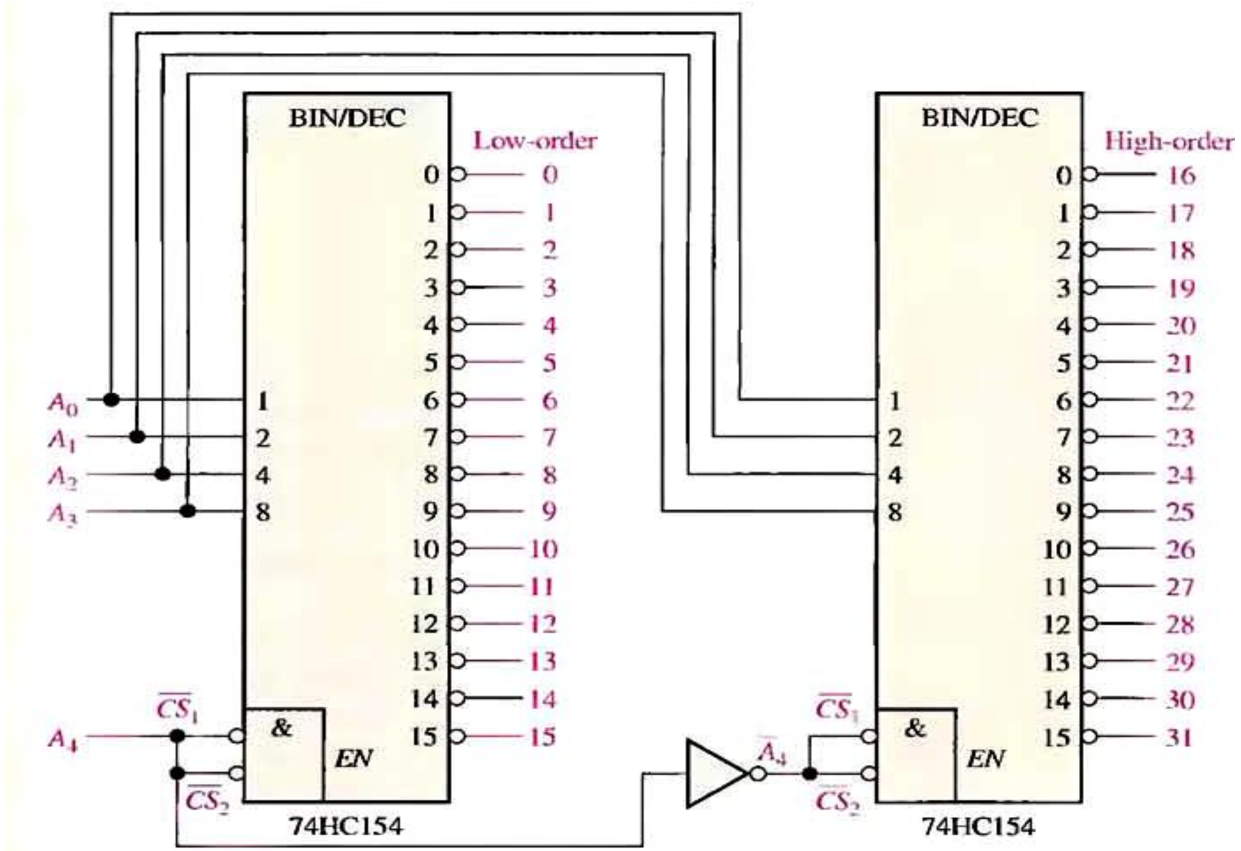


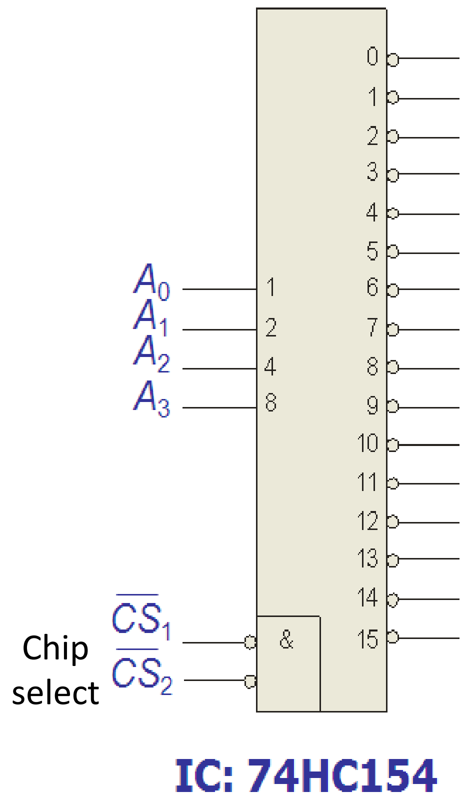
Combining Two 3-8 Decoders to Form One 4-16 Decoder Using Enable Switch



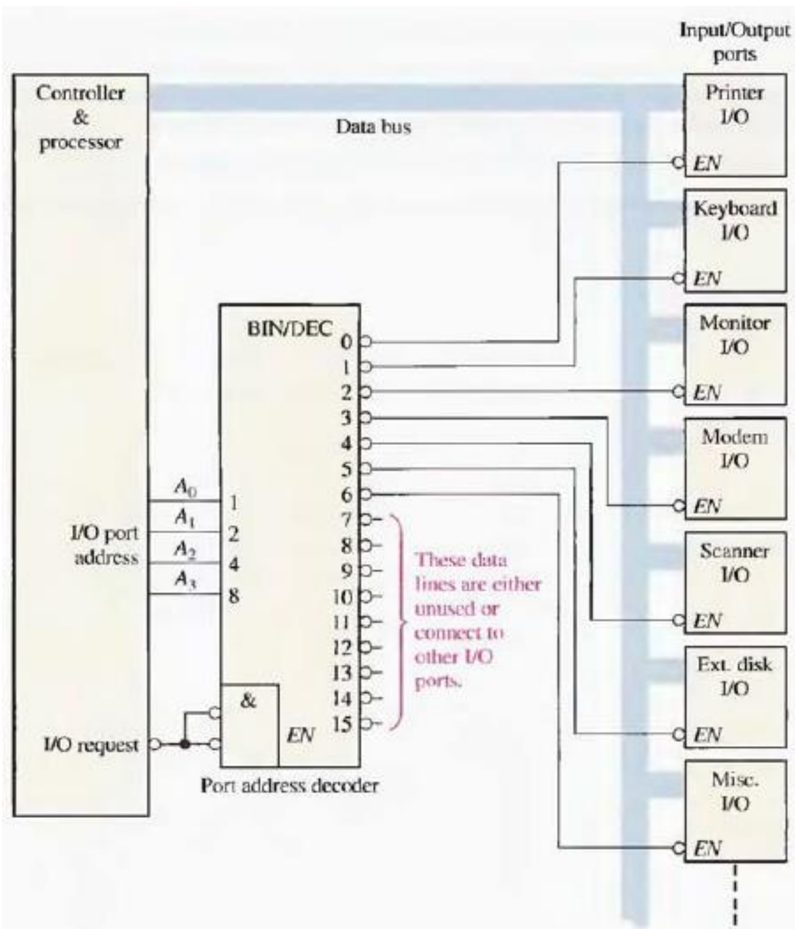
74HC154 Integrated Circuit

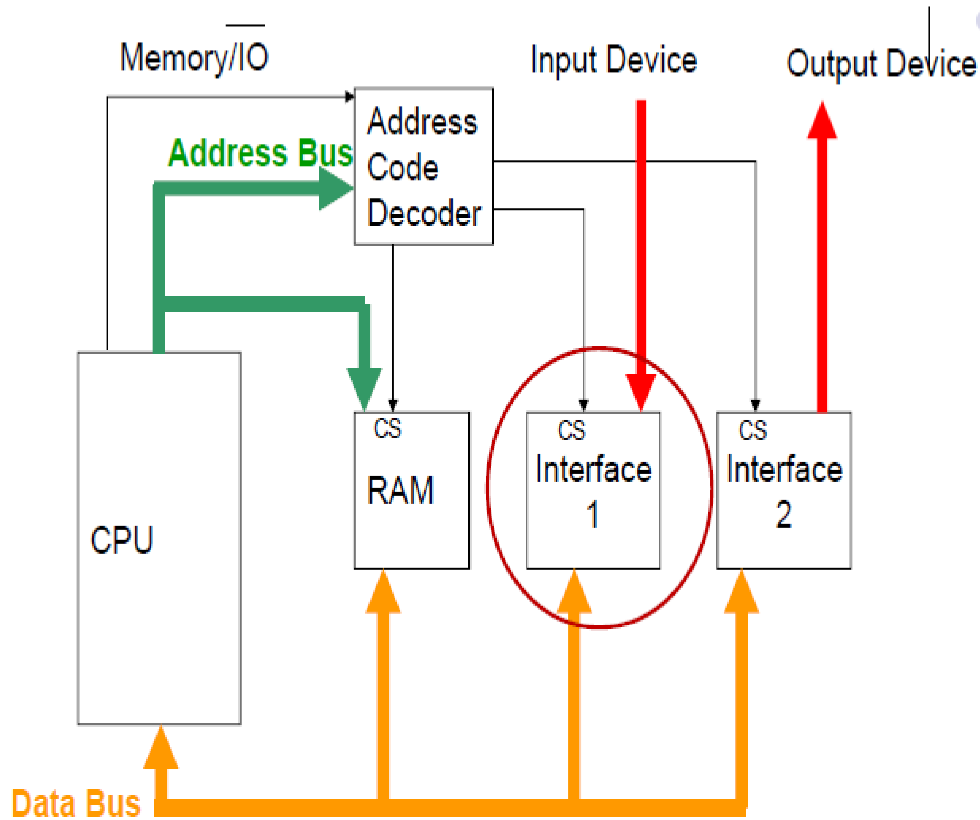
- **Example**: A certain application requires that a 5-bit number be decoded. Use a 74HC154 IC decoders to implement the logic.
- Solution: Since this IC handle only 4-bits, two decoder must be used.





Application of Decoder in Computer





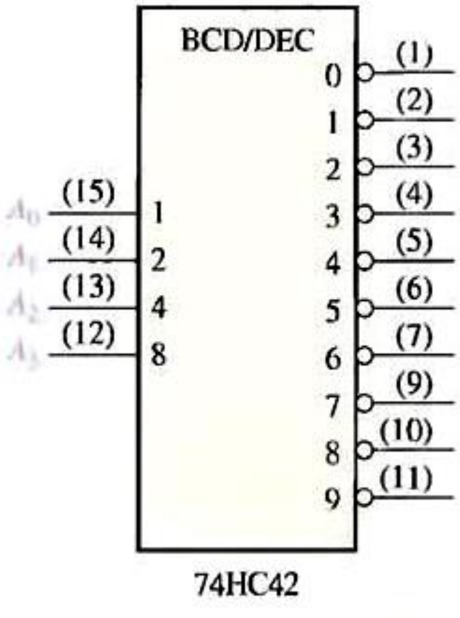
The BCD to Decimal Decoder

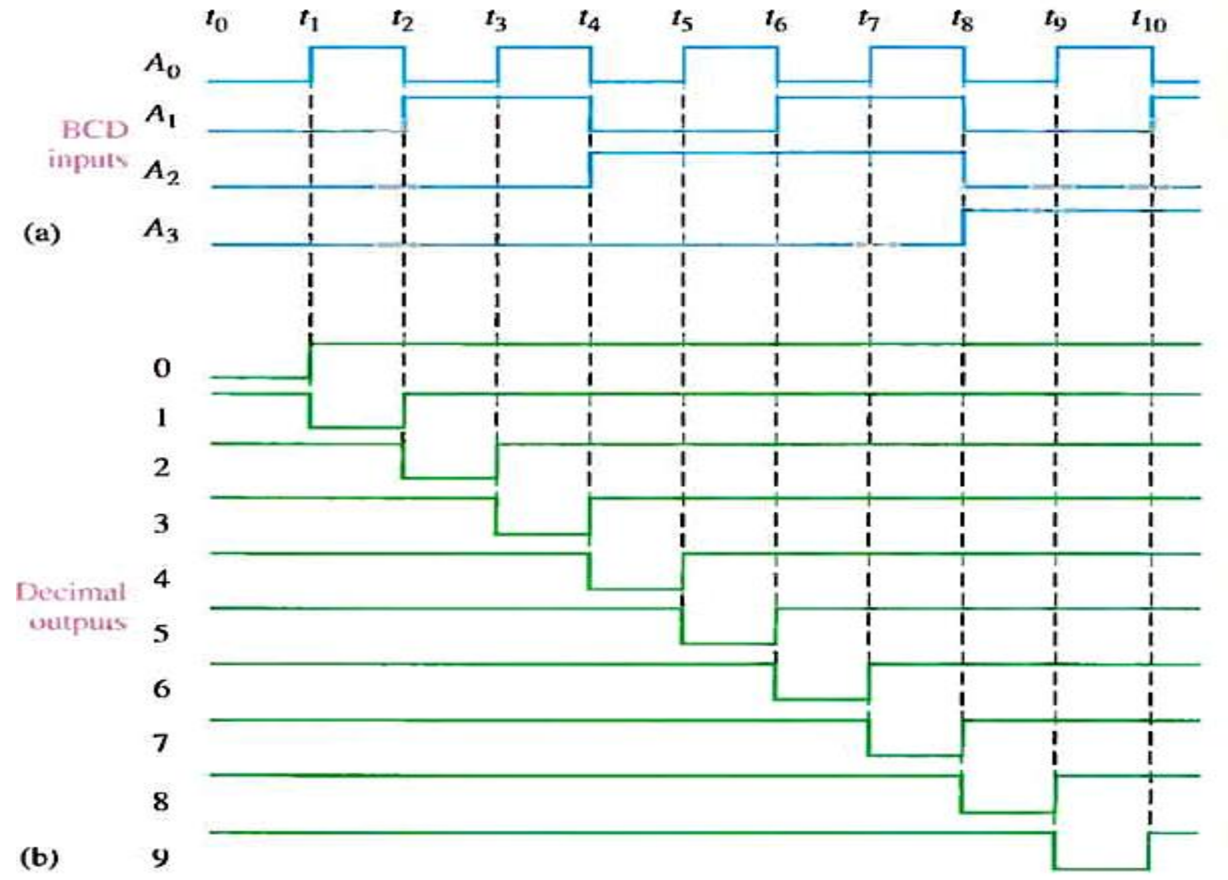
- It convert each BCD (8421 code) into one-to-ten possible decimal digit indications. It is called 4-to-10 line decoder or a 1-to-10 decoder.

DECIMAL DIGIT	BCD CODE				DECODING FUNCTION
	A_3	A_2	A_1	A_0	
0	0	0	0	0	$\overline{A}_3\overline{A}_2\overline{A}_1\overline{A}_0$
1	0	0	0	1	$\overline{A}_3\overline{A}_2\overline{A}_1A_0$
2	0	0	1	0	$\overline{A}_3\overline{A}_2A_1\overline{A}_0$
3	0	0	1	1	$\overline{A}_3\overline{A}_2A_1A_0$
4	0	1	0	0	$\overline{A}_3A_2\overline{A}_1\overline{A}_0$
5	0	1	0	1	$\overline{A}_3A_2\overline{A}_1A_0$
6	0	1	1	0	$\overline{A}_3A_2A_1\overline{A}_0$
7	0	1	1	1	$\overline{A}_3A_2A_1A_0$
8	1	0	0	0	$A_3\overline{A}_2\overline{A}_1\overline{A}_0$
9	1	0	0	1	$A_3\overline{A}_2\overline{A}_1A_0$

The BCD to Decimal Decoder

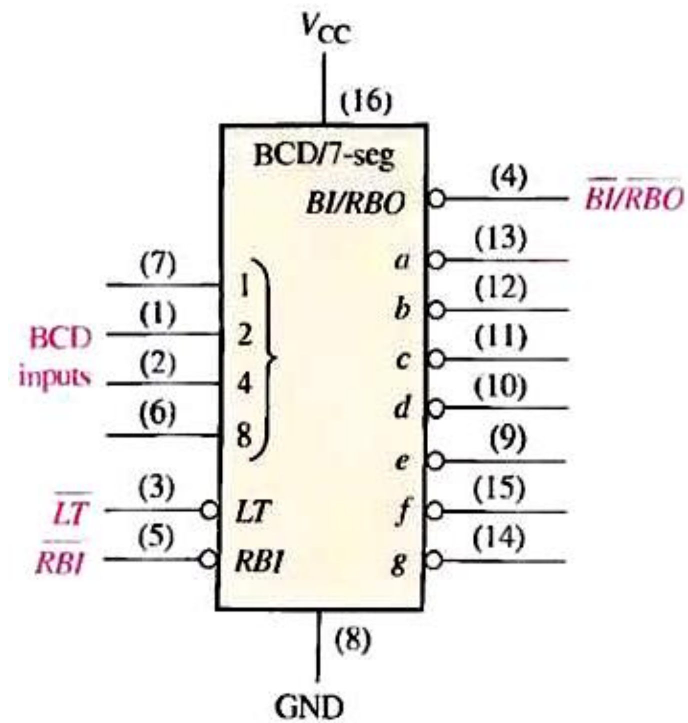
- Example: the 74HC42 is an IC BCD-to-decimal decoder. If the input waveforms as in Fig. are applied to the IC inputs, show the output waveforms.





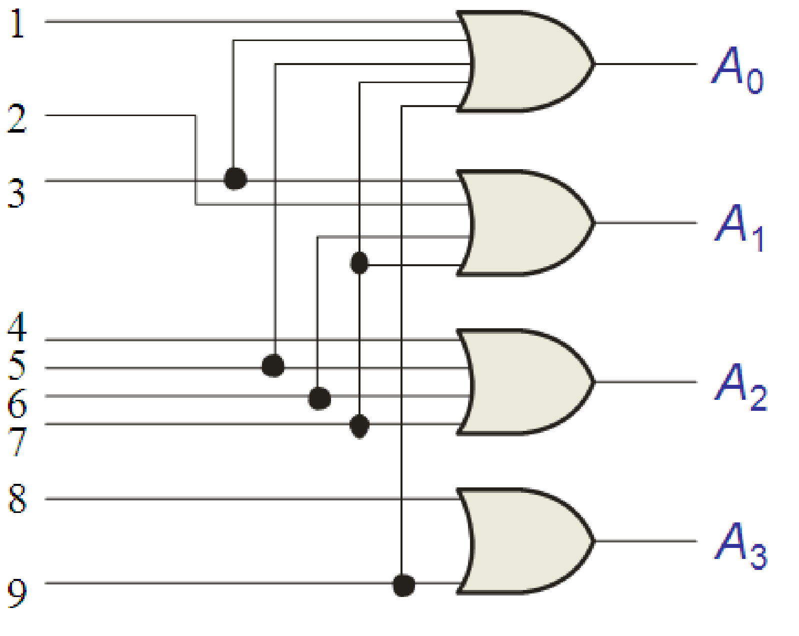
The BCD to 7-Segment Decoder

- This decoder accept the BCD code on its input and provides outputs to drive 7-segment display devices to produce a decimal readout.
- As an example, the 74LS47 . LT (Lamp Test), RBI (Ripple Blanking Input), BI/RBO (Blanking Input/ Ripple Blanking Output). All output are non-active (HIGH) if (0000) is on inputs and if RBI is low. This causes the display to be blank and produces a LOW RBO.



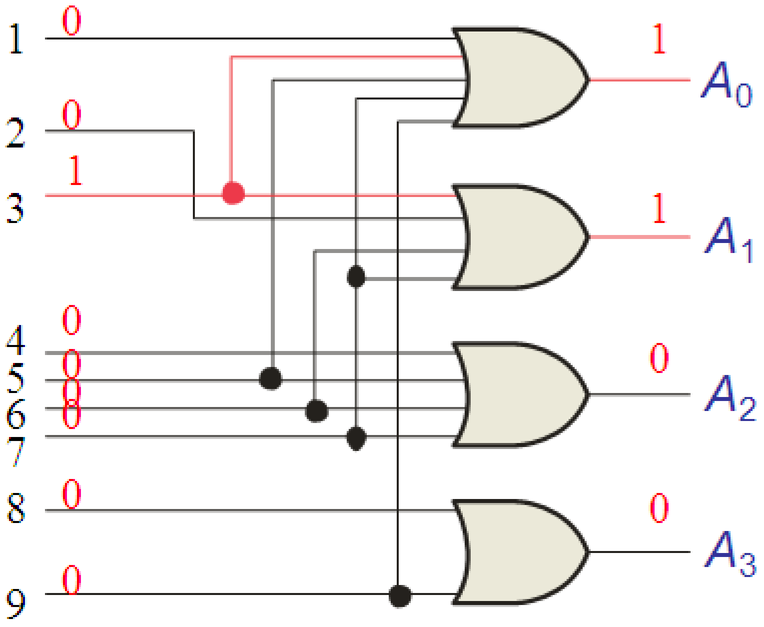
Encoder

- An encoder is a combinational logic cct. that essentially performs a reverse decoder function. It is accepts an active logic level on one of its inputs representing a digit, such as a decimal or octal digits, and converts it to a coded output, such as BCD or binary.
- IC: 74HC147 16-to-4 encoder (decimal-to-BCD)
- IC: 74F148 8-to-3 encoder



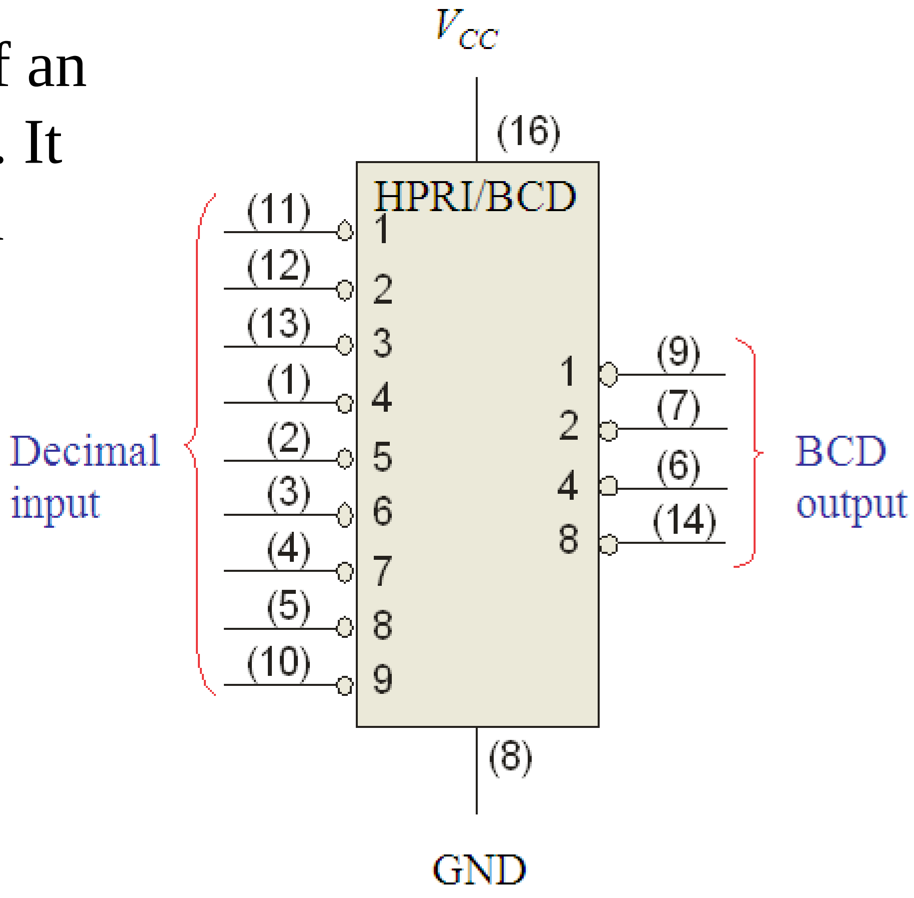
Encoder

Show how the decimal-to-BCD encoder converts the decimal number 3 into a BCD 0011.



Encoder

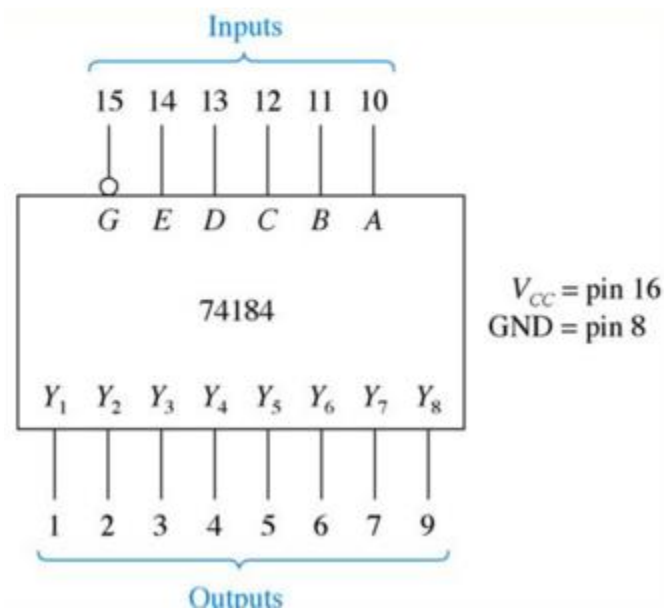
The 74HC147 is an example of an IC encoder (Decimal-to-BCD). It has ten active-LOW inputs and converts the active input to an active-LOW BCD output.



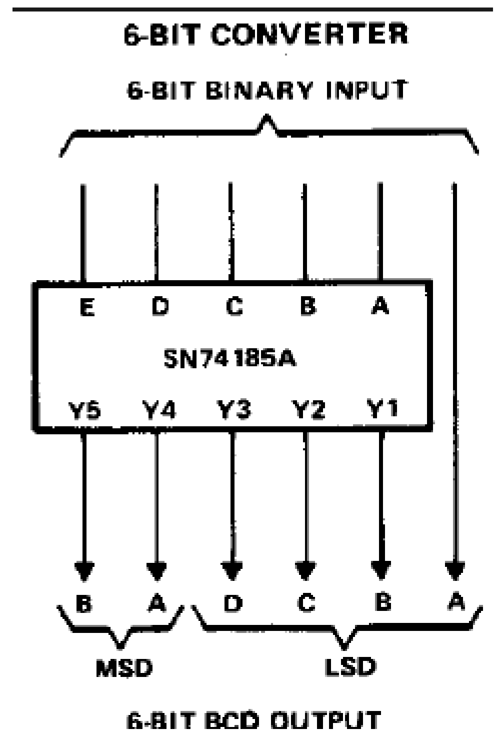
74HC147

Code Converters

- BCD-to-Binary Conversion
- IC: 74184

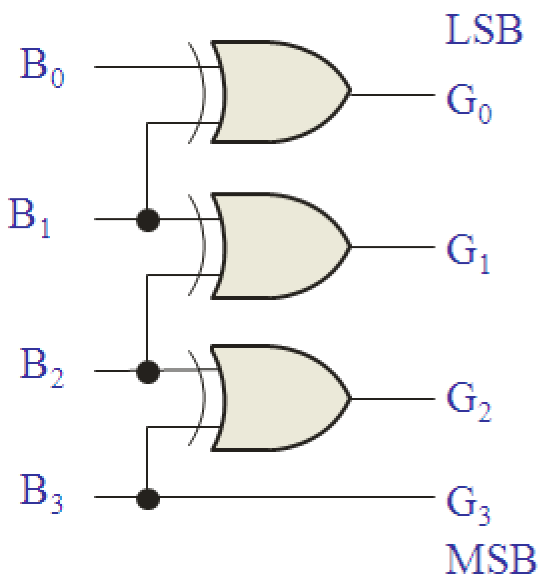


- Binary-to-BCD Conversion
- IC: 74185



Code Converters

- BIN-to-Gray



- Gray-to-BIN