Logical Design Lectures

Produced By Dr. Faris Llwaah

June 21, 2021

Lecture 5 – Combinational circuits

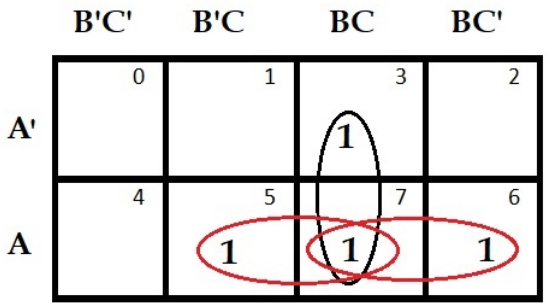
- Combinational circuit consists of input variables, logic gates, and output variables. the logic gates accept the input and generate the signals which are given to outputs. Both input and output signals represented by "0" or "1".

Example:

Design a combinational circuit with three variables that will produce a logic 1 output when more than one input variable is at logic 1.

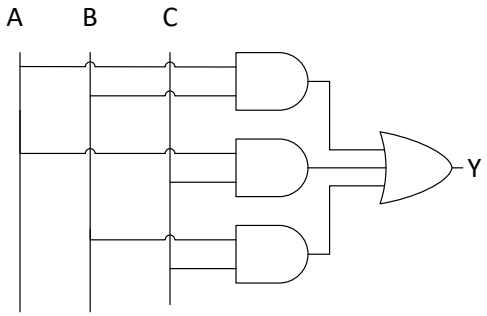
A	B	C	Y
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

$$Y = \overline{A}BC + A\overline{B}C + AB\overline{C} + ABC$$



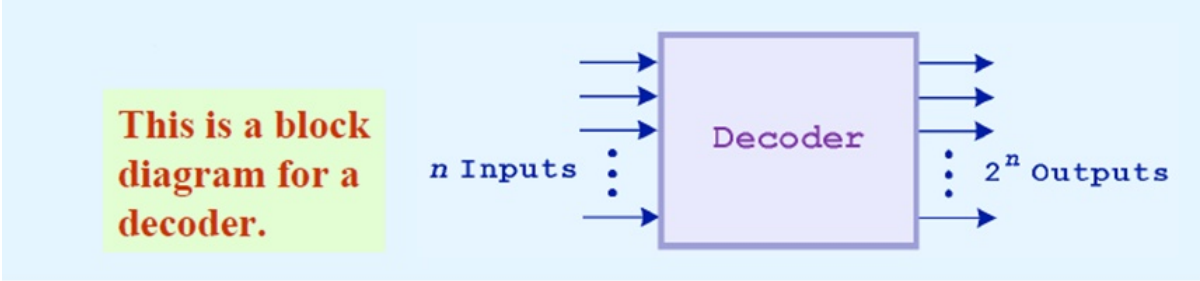
- After simplification as follows:

$$Y = AC + AB + BC$$

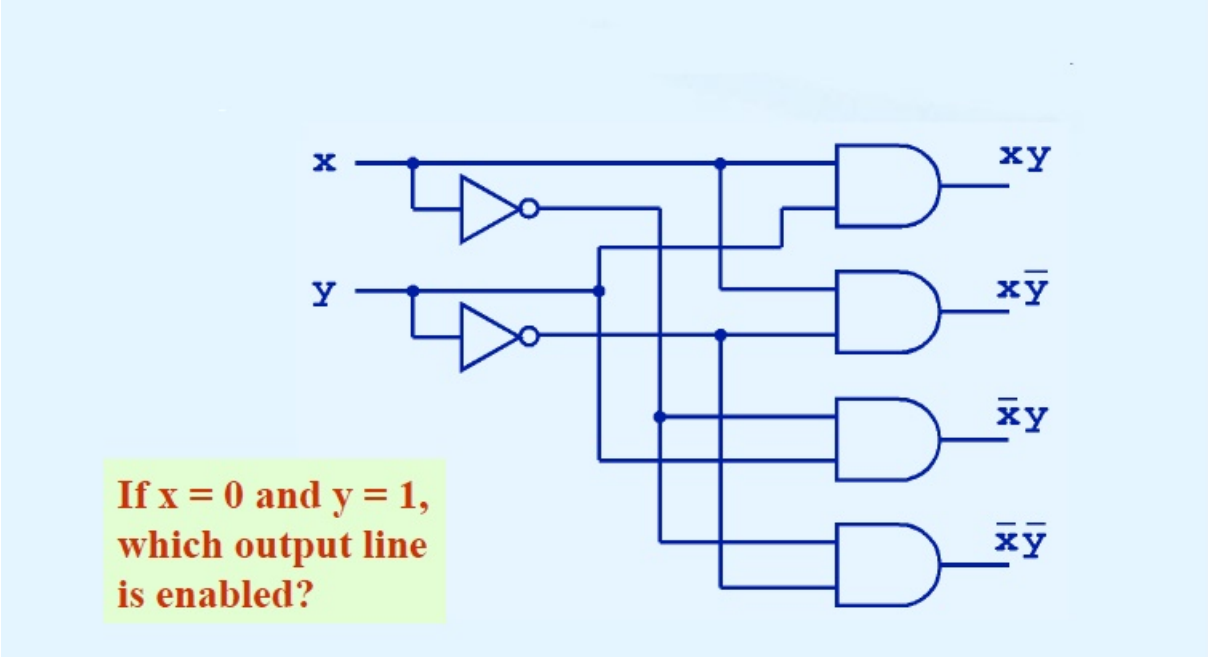


■ Decoder

- Decoders are another important types of combinational circuit.
- Among other things, they are useful in selecting a memory location according a binary value place on the address lines of a memory bus.
- Address decoders with N inputs can select any of power 2 locations.



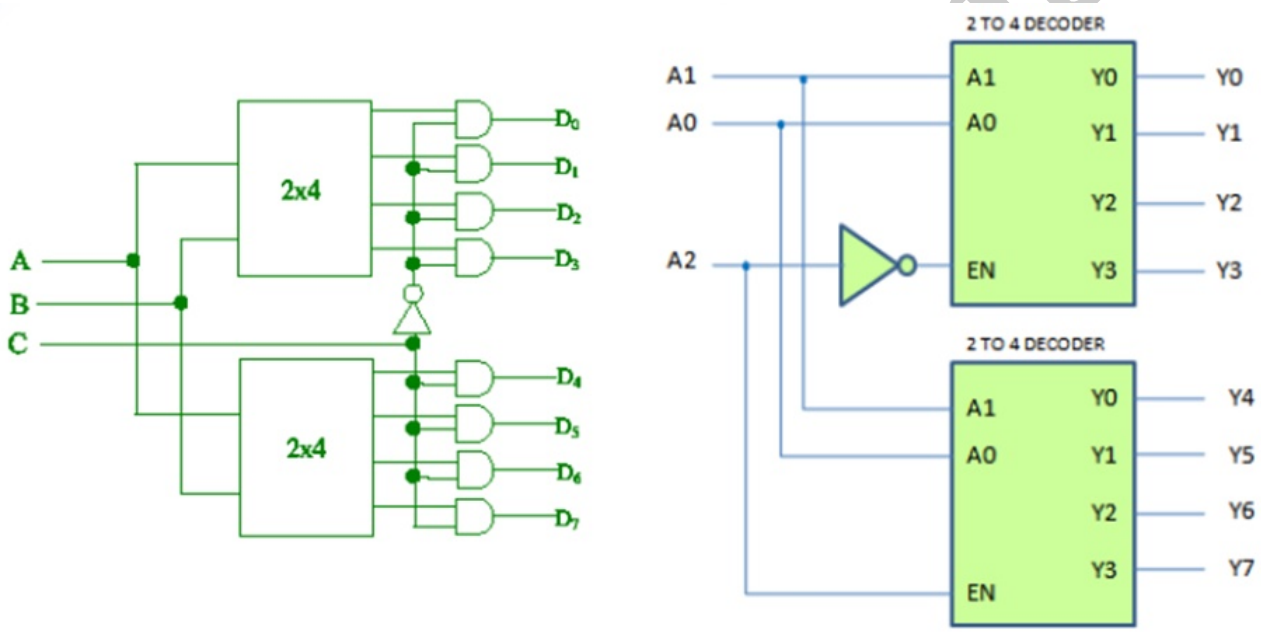
- This is what a 2-to-4 decoder logic circuit looks like on the side as follows:



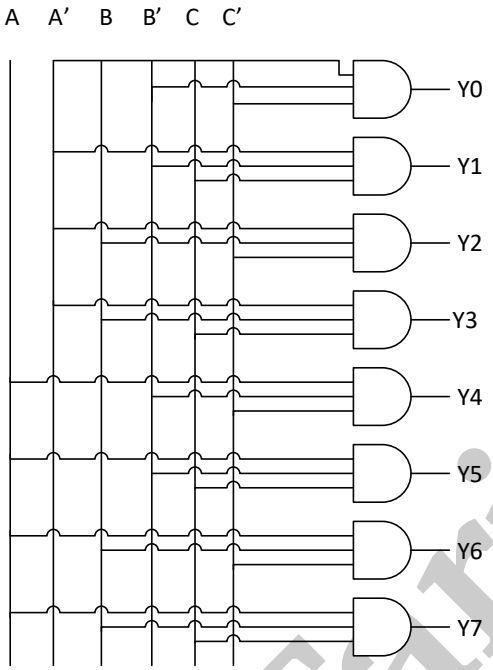
X	Y	XY	X $\overline{y}$	$\overline{x}$ Y	$\overline{x}$ $\overline{y}$
0	0	0	0	0	1
0	1	0	0	1	0
1	0	0	1	0	0
1	1	1	0	0	0

Exercise:

Build a 3-to-8 decoders using 2-to-4 decoders.



A	B	C	Y7	Y6	Y5	Y4	Y3	Y2	Y1	Y0
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



Exercise 1:

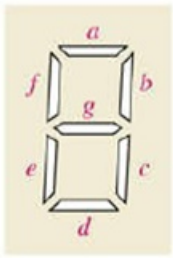
Build a 4-to-16 line decoder

Exercise 2:

Build a 4-to-10 line decoder (BCD-to-Decimal)

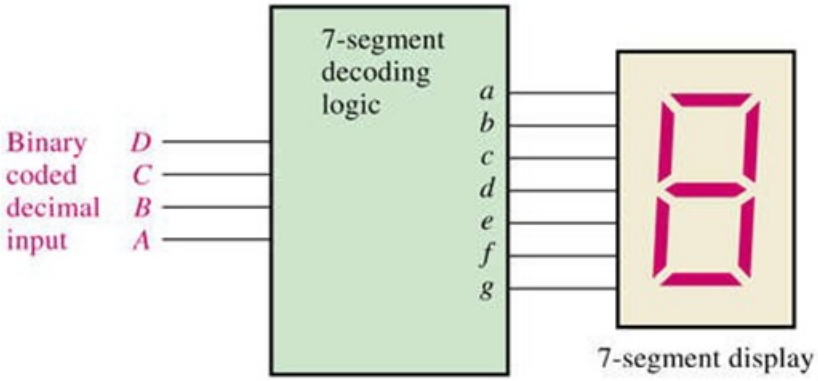
■ BCD - to - Seven Segment Decoder

Seven segment display format showing arrangement of segments in Figure (a). By energising certain combinations of those segments each of the 10 decimal digits be produced by Figure (b).



(a)

(b)



Seven-Segment LED driver

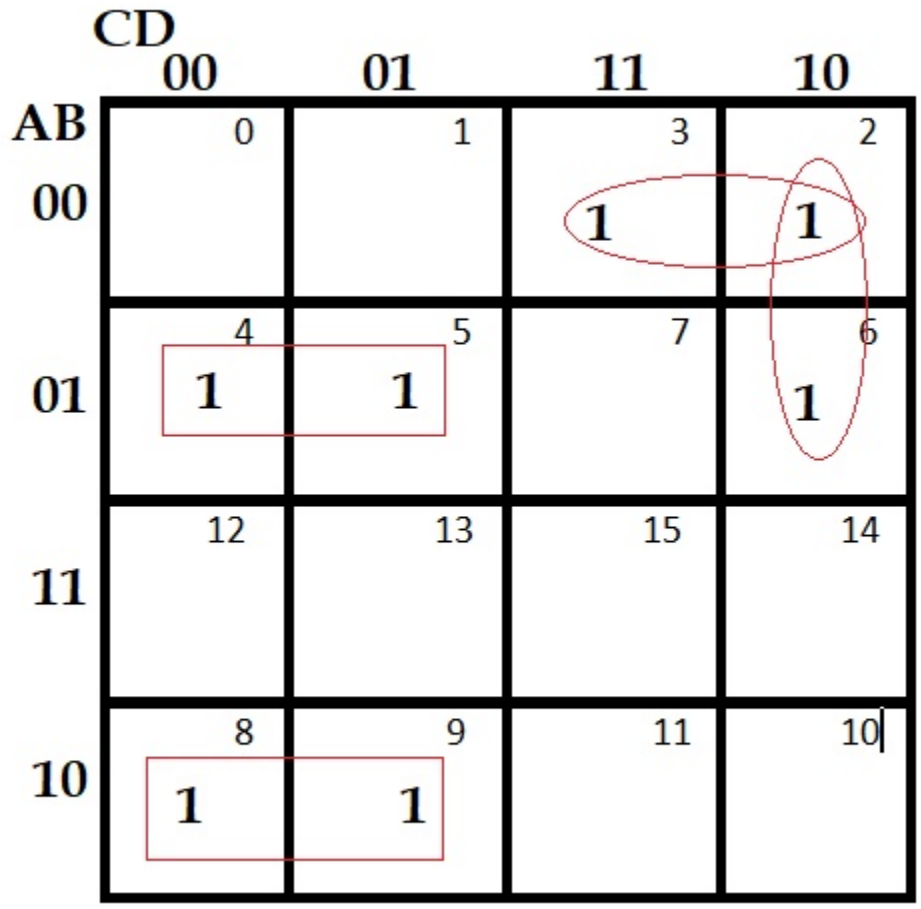
- We have designed a logic circuit that implements a seven segment decoder as follows:

A	B	C	D	a	b	c	d	e	f	g
0	0	0	0	1	1	1	1	1	1	0
0	0	0	1	0	1	1	0	0	0	0
0	0	1	0	1	1	0	1	1	0	1
0	0	1	1	1	1	1	1	0	0	1
0	1	0	0	0	1	1	0	0	1	1
0	1	0	1	1	0	1	1	0	1	1
0	1	1	0	1	0	1	1	1	1	1
0	1	1	1	1	1	1	0	0	0	0
1	0	0	0	1	1	1	1	1	1	1
1	0	0	1	1	1	1	0	0	1	1

(c)

$g = m(2, 3, 4, 5, 6, 8, 9)$

$= \overline{A}\,\overline{B}C\overline{D} + \overline{A}\,\overline{B}CD + \overline{A}B\overline{C}\,\overline{D} + \overline{A}B\overline{C}D + \overline{A}BC\overline{D} + A\overline{B}\,\overline{C}\,\overline{D} + A\overline{B}\,\overline{C}D$



$$= \overline{A}\,\overline{B}C + \overline{A}C\overline{D} + \overline{A}B\overline{C} + A\overline{B}\,\overline{C}$$

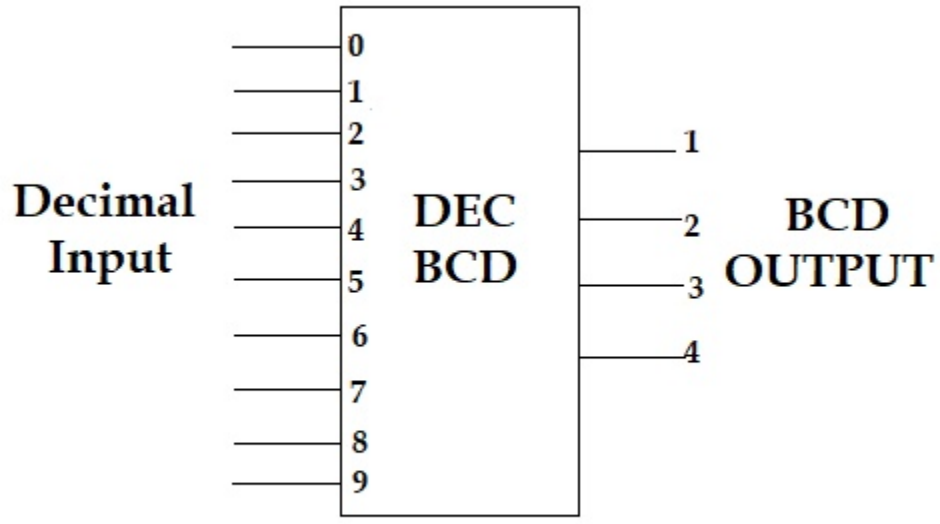
■ Encoder

- The Encoder converts information, such as decimal number or Octal digits into a coded output such as binary or BCD.

- The encoder is a combinational logic circuit that perform a "reverse" decoding function.

- Encoder can also be devised to encode various symbols and alphabetic characters.

- The process of converting from familiar symbols or numbers to a coded format is called Encoding.

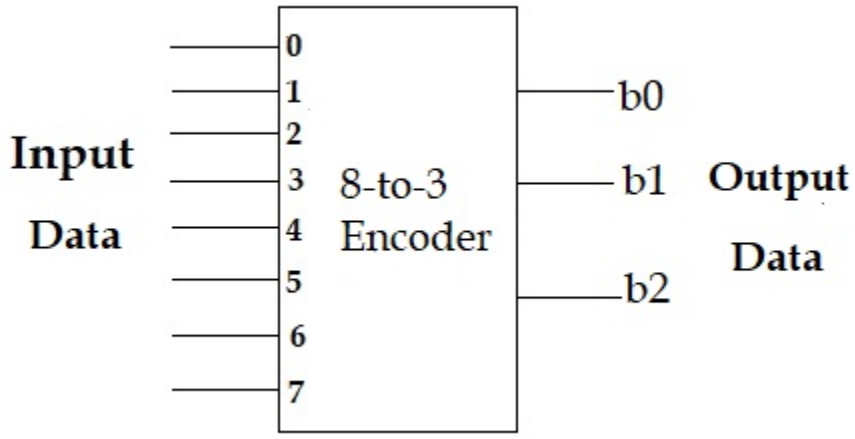


10 Line to 4 Line Encoder

- This type of encoder has 10 inputs (one for each decimal digit) and four outputs corresponding to BCD code.

Example:

Design 8-to-3 line Encoder, this is a simple and basic encoder. It has 8 inputs and 3 outputs it is also called as "Octal to Binary Encode".

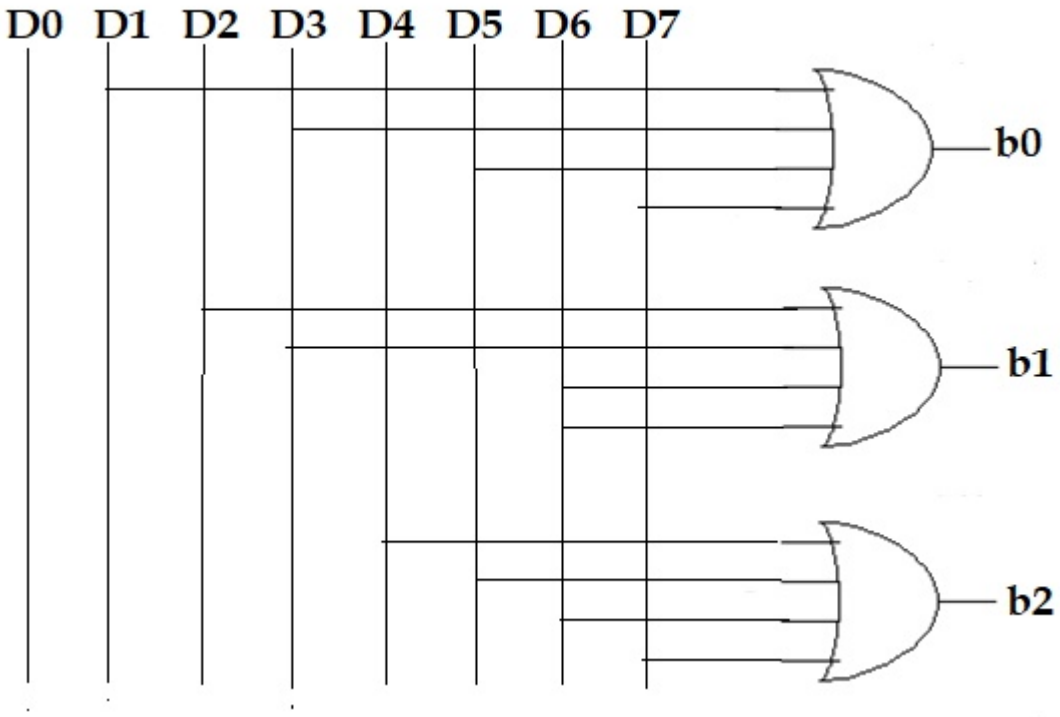


D0	D1	D2	D3	D4	D5	D6	D7	b2	b1	b0
1	0	0	0	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0	0	0	1
0	0	1	0	0	0	0	0	0	1	0
0	0	0	1	0	0	0	0	0	1	1
0	0	0	0	1	0	0	0	1	0	0
0	0	0	0	0	1	0	0	1	0	1
0	0	0	0	0	0	1	0	1	1	0
0	0	0	0	0	0	0	1	1	1	1

$b_0 = D_1 + D_3 + D_5 + D_7$

$b_1 = D_2 + D_3 + D_6 + D_7$

$b_2 = D_4 + D_5 + D_6 + D_7$



Example:

Design a decimal to BCD Encoder.

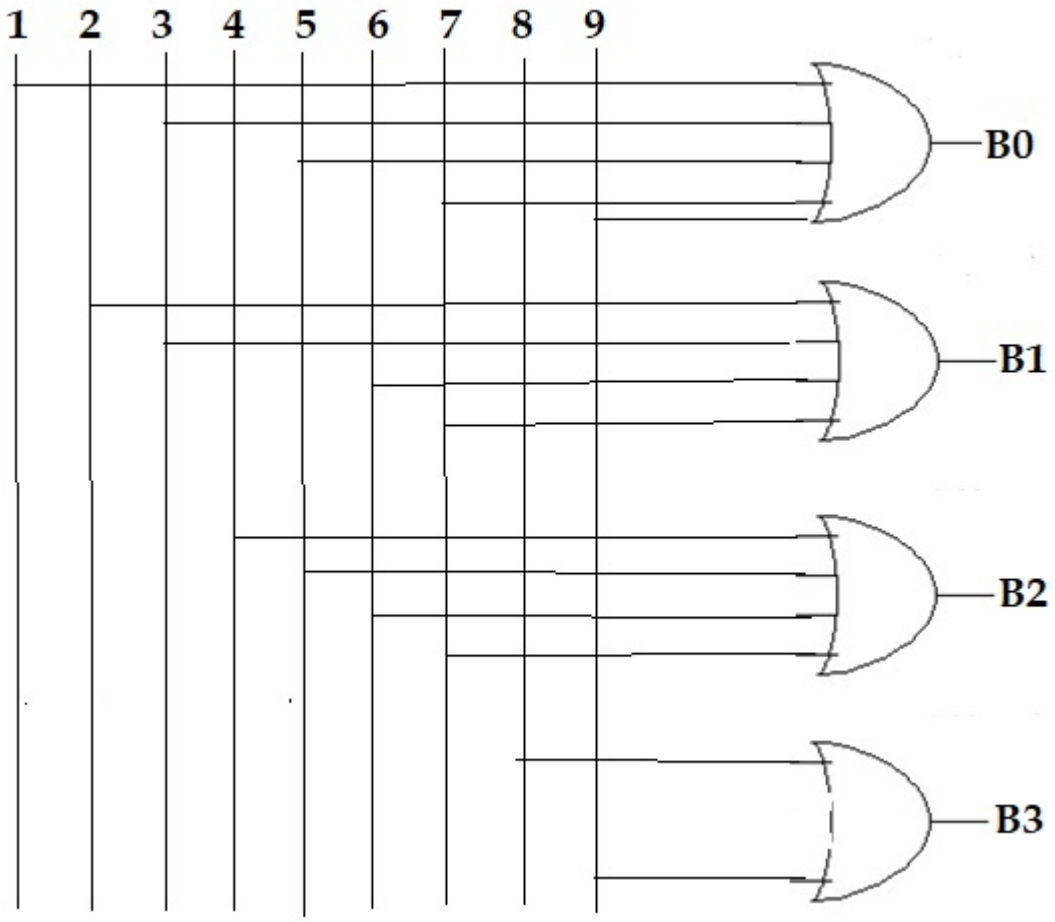
$B0 = 1 + 3 + 5 + 7 + 9$

Decimal	B3	B2	B1	B0
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1

$B1 = 2 + 3 + 6 + 7$

$B2 = 4 + 5 + 6 + 7$

$B3 = 8 + 9$



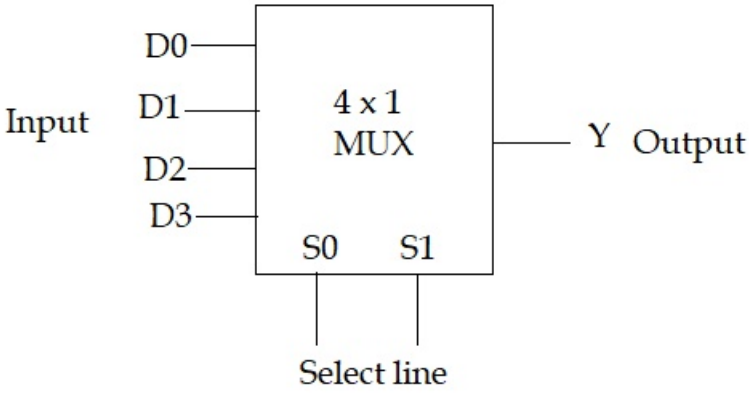
The above circuit is a decimal to BCD Encoder

- The 0 digit input is not needed because

  the BCD output are all low when there are no high inputs

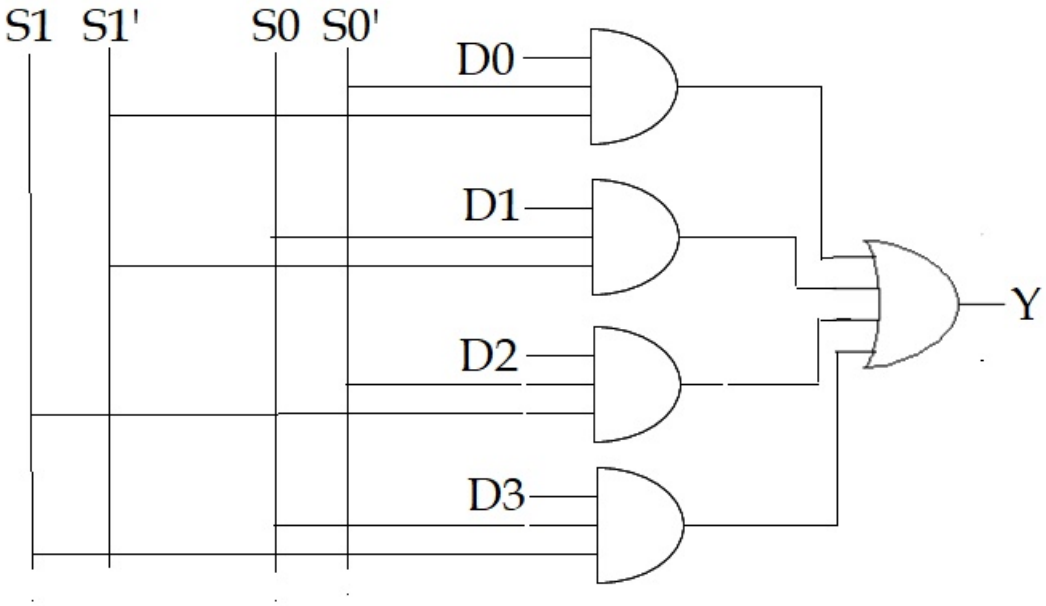
■ Multiplexers

- Multiplexer is a digital switch. It allows digital information from several sources to be routed only into a single output line.
- Digital multiplexer is a combinational circuit that selects binary information of a particular input line controlled by a set of selection lines.
- Multiplexer is called "Data selector"
- Multiplexer is " Many to one "



Logic Symbol of Multiplexer

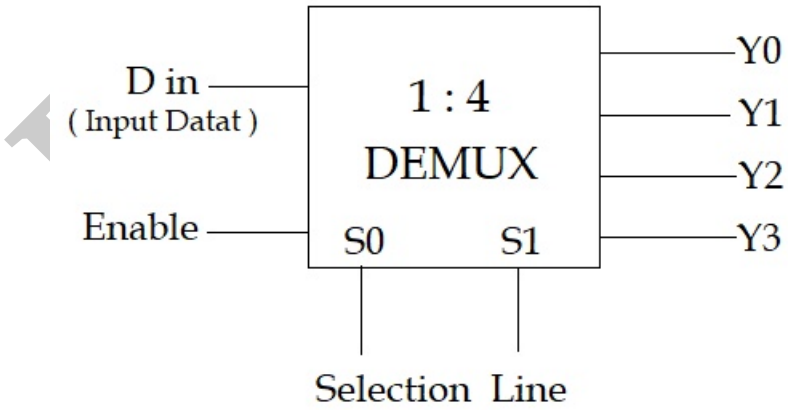
Select Line		Output
S1	S0	Y
0	0	D0
0	1	D1
1	0	D2
1	1	D3



Logic digram of 4 X 1 Multiplexer

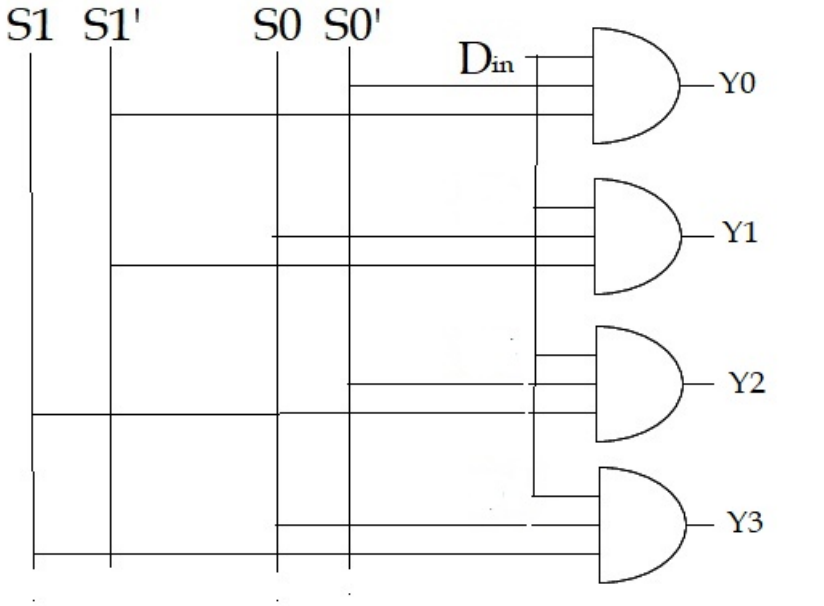
■ Demultiplexers.

- Demultiplexer is a combinational circuit that performs a reverse multiplexer function. The demultiplexer is a logic circuit that receives information on a single line and transmits this information on one of 2^n possible output lines.



1- Subtract $(46)_{10}$ *from* $(28)_{10}$ using 2's complement.

Enable	Select Line		Input	Output			
En	S1	S0	Din	Y0	Y1	Y2	Y3
0	X	X	X	0	0	0	0
1	0	0	0	0	0	0	0
1	0	0	1	1	0	0	0
1	0	1	0	0	0	0	0
1	0	1	1	0	1	0	0
1	1	0	0	0	0	0	0
1	1	0	1	0	0	1	0
1	1	1	0	0	0	0	0
1	1	1	1	0	0	0	1



Logic digram of 1 : 4 Demultiplexer