Decoder

- Decoder is a combinational logic circuit with 'n' inputs and a maximum of 2^n outputs .
- One output is selected for each combination of the inputs

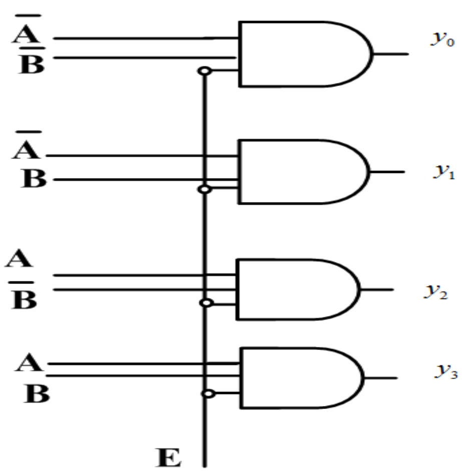
Ex:- 2 × 4 decoder

Let the inputs are A&B; outputs are y_3, y_2, y_1, y_0

A	B	y_3	y_2	y_1	y_0
0	0	0	0	0	1
0	1	0	0	1	0
1	0	0	1	0	0
1	1	1	0	0	0

$$\therefore y_0 = \overline{A}\,\overline{B}$$
$$y_1 = \overline{A}B$$
$$y_2 = A\overline{B}$$
$$y_3 = AB$$

Circuit



If E=0 ⟹ $y_3 = y_2 = y_1 = y_0 = 0$

If E=1 normal operation mentioned in the above truth table

3×8 decoder:

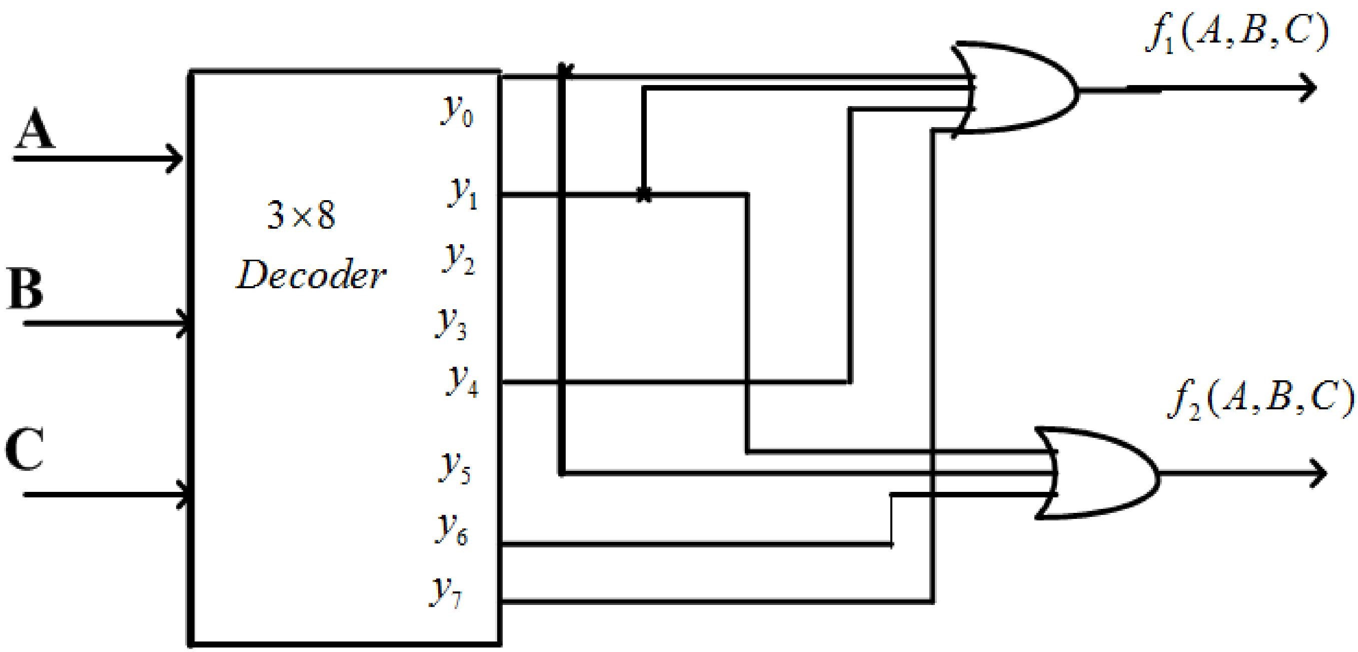
For 3×8 decoder,

$$y_0 = \overline{A}\,\overline{B}\,\overline{C} = m_0 \text{(minterm 0)}\ ; \quad \text{similarly } y_7 = ABC = m_7$$

i.e decoder generates all the minterms. Hence any Boolean function can be implemente using decoder .

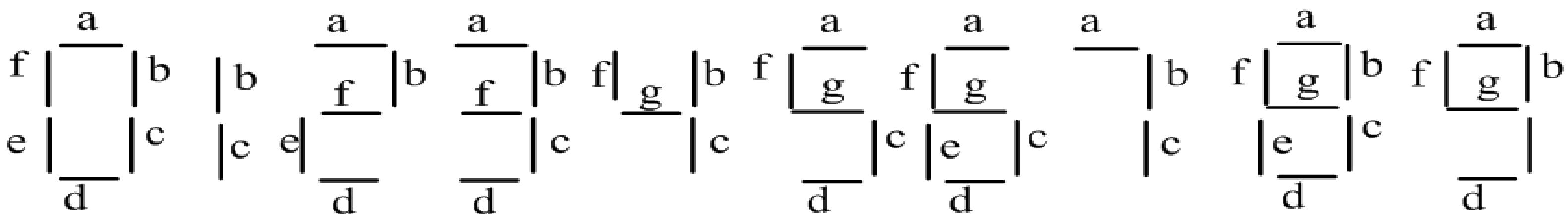
Ex:- Implement the following Boolean functions using decoder

$$f_1(A,B,C) = \sum m(0,1,4,7) \qquad f_2(A,B,C) = \sum m(1,4,6)$$



Design of BCD to 7- segment decoder

decimal	BCD input 8 4 2 1 w x y z	7-segment output a b c d e f g
0	0 0 0 0	1 1 1 1 1 1 0
1	0 0 0 1	0 1 1 0 0 0 0
2	0 0 1 0	1 1 0 1 1 0 1
3	0 0 1 1	1 1 1 1 0 1 0
4	0 1 0 0	0 1 1 0 0 1 1
5	0 1 0 1	1 0 1 1 0 1 1
6	0 1 1 0	1 0 1 1 1 1 1
7	0 1 1 1	1 1 1 0 0 0 0
8	1 0 0 0	1 1 1 1 1 1 1
9	**1 0 0 1**	**1 1 1 1 0 1 1**



$$\therefore a = \sum m(0,2,3,5,6,7,8,9) + \sum d(10,11,12,13,14,15)$$

yz \ wx	00	01	11	10
00	1		×	1
01		1	×	1
11	1	1	×	×
10	1	1	×	×

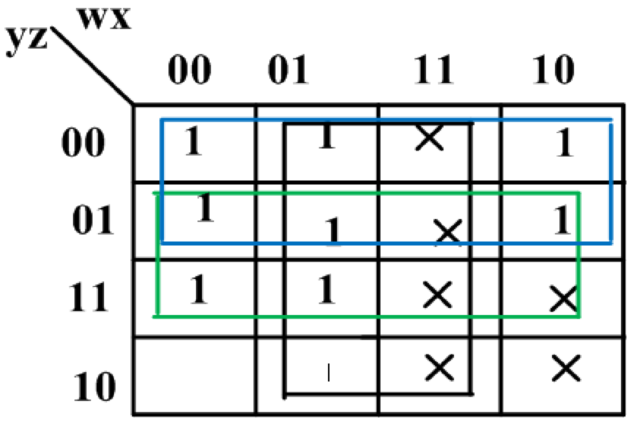
$$\therefore a = w + y + xz + \overline{x}\,\overline{z}$$

$$\therefore b = \sum m(0,1,2,3,4,7,8,9) + \sum d(10,11,12,13,14,15)$$

yz \ wx	00	01	11	10
00	1	1	×	1
01	1		×	1
11	1	1	×	×
10	1		×	×

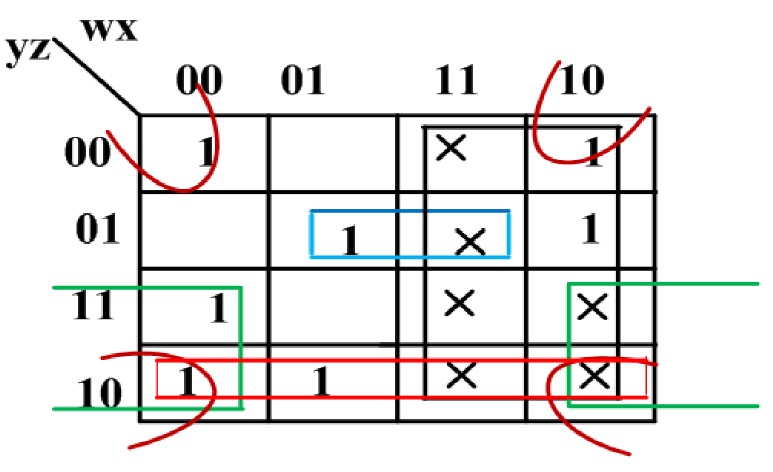
$$\therefore b = \overline{x} + \overline{y}\,\overline{z} + yz$$

$$\therefore c = \sum m(0,1,3,4,5,6,7,8,9) + \sum d(10,11,12,13,14,15)$$



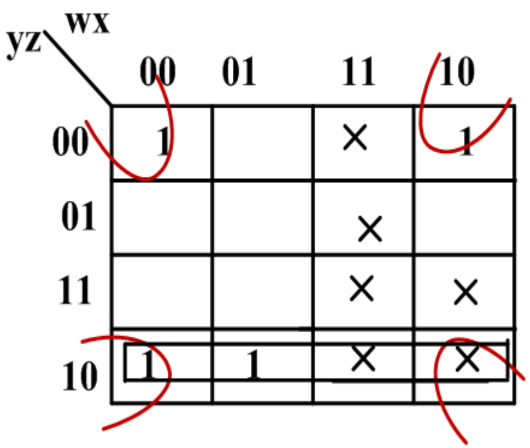
$$\therefore c = x + \overline{y} + z$$

$$\therefore d = \sum m(0,2,3,5,6,8,9) + \sum d(10,11,12,13,14,15)$$



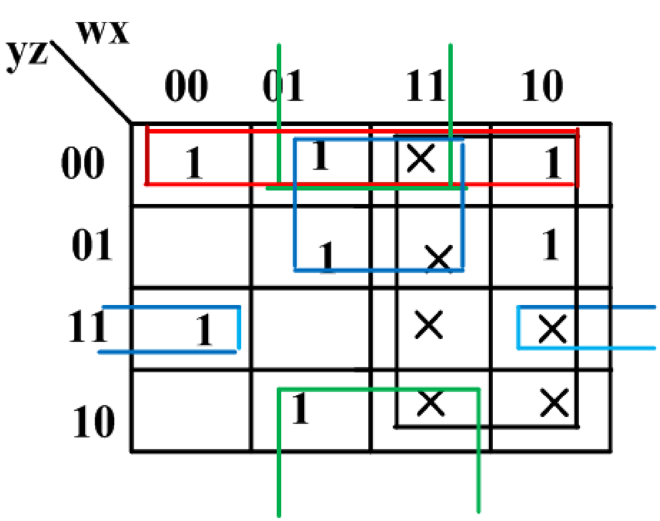
$$d = w + \overline{x}\,\overline{z} + y\overline{z} + \overline{x}y + x\overline{y}z$$

$$\therefore e = \sum m(0,2,6,8) + \sum d(10,11,12,13,14,15)$$



$$\therefore e = \bar{x}\bar{z} + y\bar{z}$$

$$\therefore f = \sum m(0,3,4,5,6,8,9) + \sum d(10,11,12,13,14,15)$$



$$\therefore f = w + x\bar{z} + x\bar{y} + \bar{y}\bar{z} + \bar{x}yz$$

$$\therefore g = \sum m(2,4,5,6,8,9) + \sum d(10,11,12,13,14,15)$$

yz \ wx	00	01	11	10
00		1	×	1
01		1	×	1
11			×	×
10	1	1	×	×

$$\therefore g = w + y\bar{z} + x\bar{y}$$

Multiplexer

- Multiplexer is a combinational circuit with 2^n inputs, n selection lines and one output.
- Depending on the status of selection lines, one of the inputs is transferred to the output.

Ex:- Let n=2 No. of inputs=4

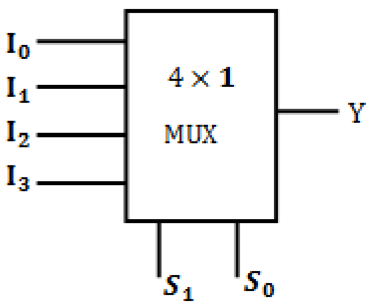
4×1 MUX contains four inputs, two selection lines and one output

Let the inputs are I_0, I_1, I_2, I_3 selection signal are S_1,and S_0 output be y

The truth table of 4*1 multiplexer (MUX) is as follows:

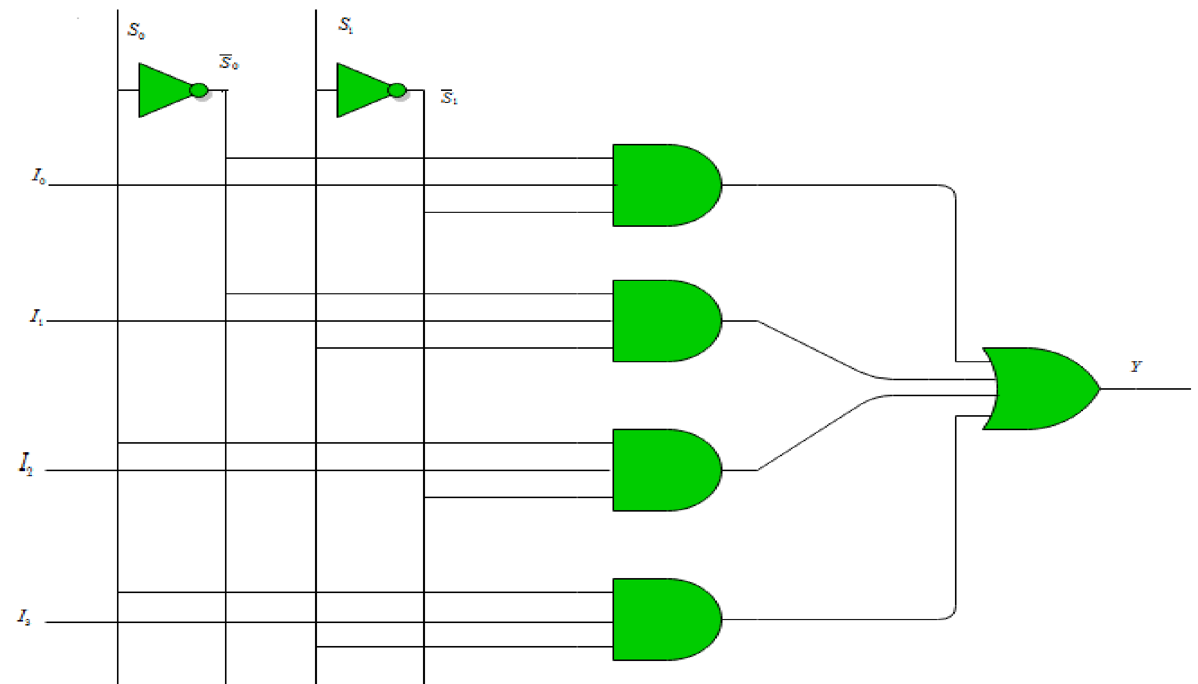
Truth table

S_1	S_0	Y
0	0	I_0
0	1	I_1
1	0	I_2
1	1	I_3



The Boolean expression for Y is

$$Y = \overline{S}_1\overline{S}_0 I_0 + \overline{S}_1 S_0 I_1 + S_1 \overline{S}_0 I_2 + S_1 S_0 I_3$$



Boolean function implementation using MUX

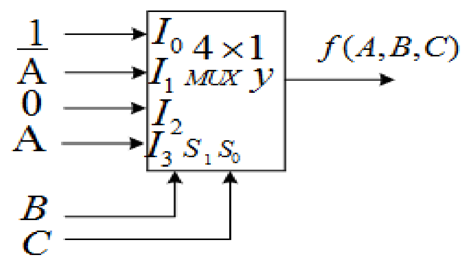
- A '*n*' variable Boolean function can be implemented using a MUX with *(n-1)* selection signal
- $2^{(n-1)} \times 1$ MUX is required

Ex:- Implement the following Boolean function using MUX $f(A,B,C) = \sum m(0,1,4,7)$

Sol:-Since the no. of variable in given Boolean function n=3 ➡ 4×1MUX is required.

- Connect last *(n-1)* variables of the given Boolean function to selection lines of MUX.

	I_0	I_1	I_2	I_3
$\bar{A}$	0	1	2	3
A	4	5	6	7
	1	$\bar{A}$	0	A



- If both the terms along the column are encircled, the corresponding input is 1.
- If both the terms along column are not encircled, the corresponding input 0
- If only upper one is encircled the correspond input is $\bar{A}$
- If only lower one is encircled .the corresponding is A

3 -bit odd parity generator

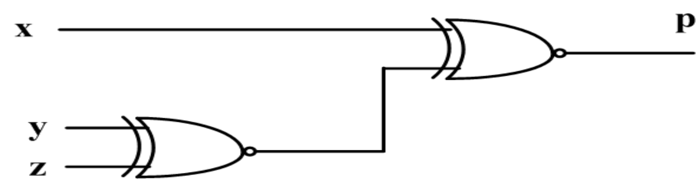
Let inputs are x, y and z, output be p

x	y	z	p
0	0	0	1
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	0

$$p = \bar{x}\bar{y}\bar{z} + \bar{x}yz + x\bar{y}z + xy\bar{z}$$

$$p = \bar{x}[\overline{y \oplus z}] + x[y \oplus z]$$

$$= \overline{x \oplus [y \oplus z]}$$



4-bit odd parity checker:-

E=1 ➡ error ; E=0 ➡ No error

x	y	z	p	E
0	0	0	0	1
0	0	0	1	0
0	0	1	0	0
0	0	1	1	1
0	1	0	0	0
0	1	0	1	1
0	1	1	0	1
0	1	1	1	0
1	0	0	0	0
1	0	0	1	1
1	0	1	0	1
1	0	1	1	0
1	1	0	0	1
1	1	0	1	0
1	1	1	0	0
1	1	1	1	1

$$\therefore E = \bar{x}\bar{y}\bar{z}\bar{p} + \bar{x}\bar{y}zp + \bar{x}y\bar{z}p + \bar{x}yz\bar{p} + z\bar{y}\bar{z}p + x\bar{y}z\bar{p} + xy\bar{z}\bar{p} + xyzp$$

$$= \bar{x}\bar{y}[\overline{z \oplus p}] + \bar{x}y[z \oplus p] + x\bar{y}[z \oplus p] + xy[\overline{z \oplus p}]$$

$$= [x \oplus y] + [z \oplus p] + [\overline{x \oplus y}] + [\overline{z \oplus p}]$$

$$= \overline{[x \oplus y] \oplus [z \oplus p]}$$