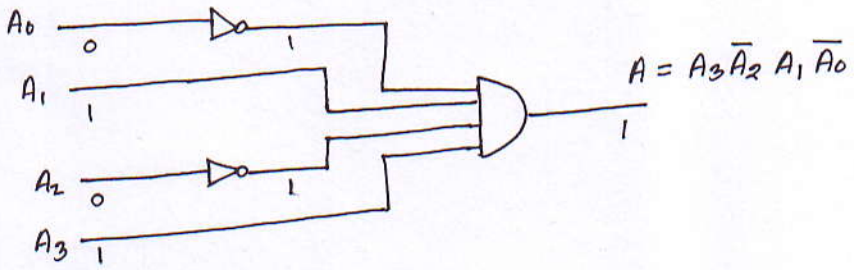
Digital Logic Design :

Lecture 12

Decoders : The basic function of a decoder is to detect the presence of a specified combination of bits (code) on its input and to indicate the presence of that code by a specified output level.

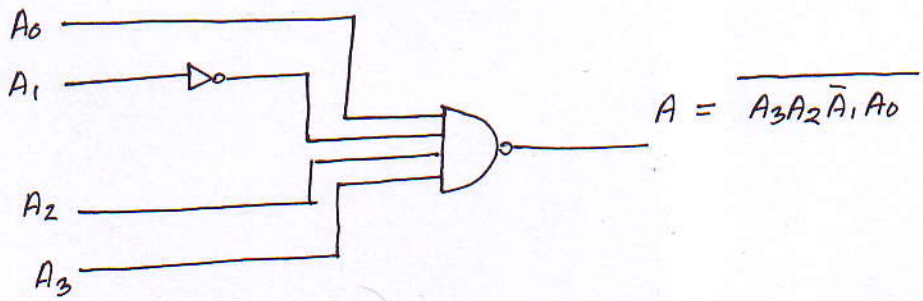
1) Determine the logic required to decode the binary number 1010 by producing a HIGH level on the output.

ans. : Decoding function : $A = A_3 \bar{A}_2 A_1 \bar{A}_0$



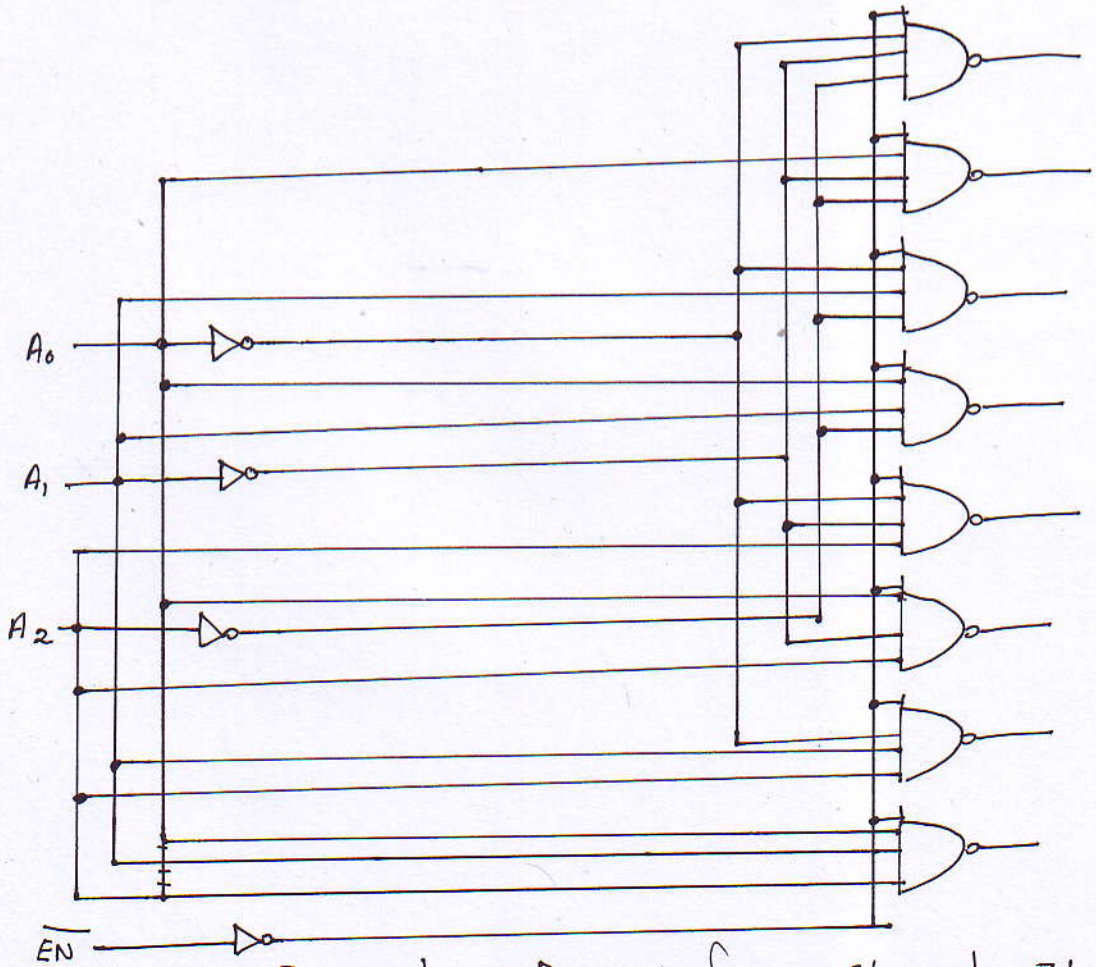
2) Determine the logic required to decode the binary number 1101 by producing an active-LOW output.

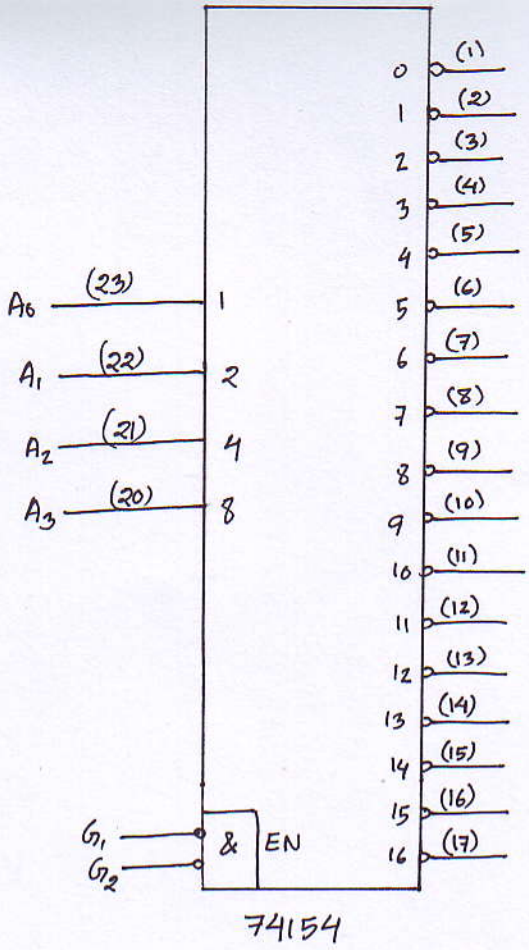
ans. : Decoding function : $A = \overline{A_3 A_2 \bar{A}_1 A_0}$



3-line to 8-line decoder

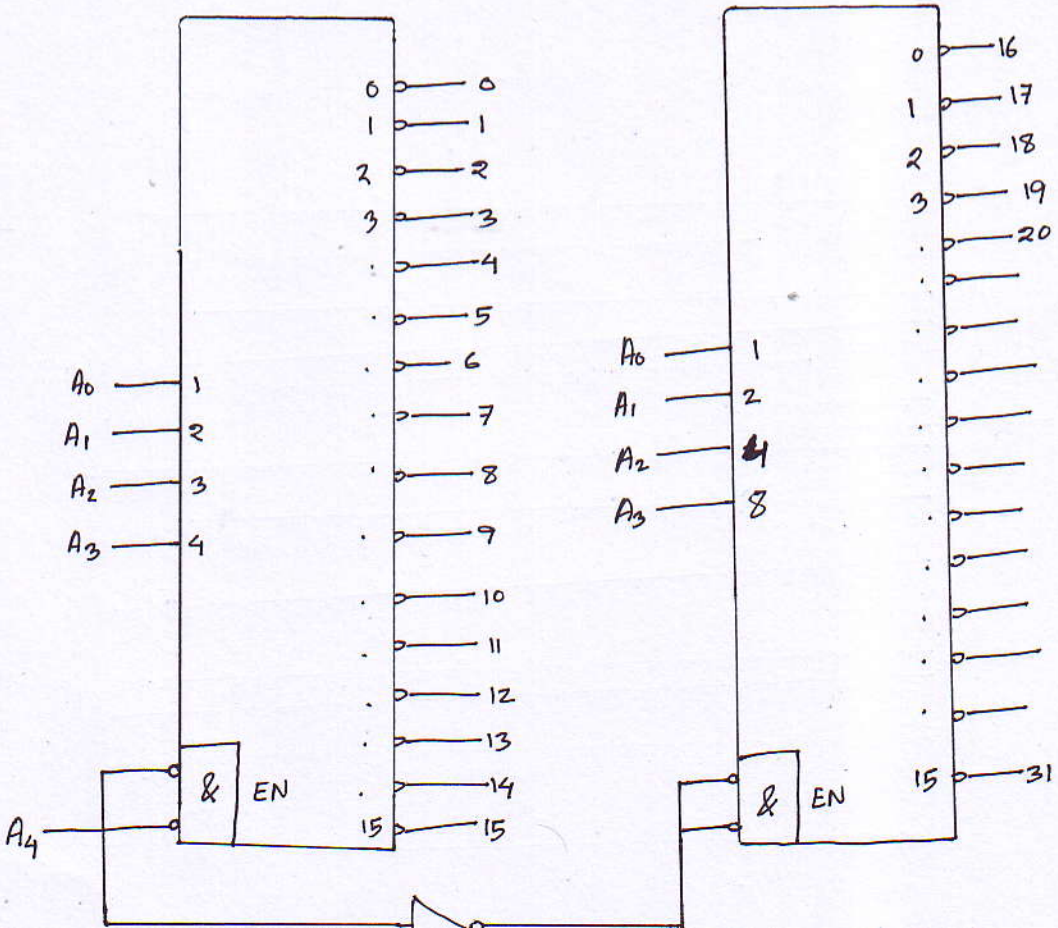
Decimal Digit	Binary Input A_2	A_1	A_0	Outputs 0	1	2	3	4	5	6	7	Decoding function
0	0	0	0	0	1	1	1	1	1	1	1	$\overline{A_2}\,\overline{A_1}\,\overline{A_0}$
1	0	0	1	1	0	1	1	1	1	1	1	$\overline{A_2}\,\overline{A_1}\,A_0$
2	0	1	0	1	1	0	1	1	1	1	1	$\overline{A_2}\,A_1\,\overline{A_0}$
3	0	1	1	1	1	1	0	1	1	1	1	$\overline{A_2}\,A_1\,A_0$
4	1	0	0	1	1	1	1	0	1	1	1	$A_2\,\overline{A_1}\,\overline{A_0}$
5	1	0	1	1	1	1	1	1	0	1	1	$A_2\,\overline{A_1}\,A_0$
6	1	1	0	1	1	1	1	1	1	0	1	$A_2\,A_1\,\overline{A_0}$
7	1	1	1	1	1	1	1	1	1	1	0	$A_2\,A_1\,A_0$





Logic symbol for the 74154 4-line to 16-line decoder

* Design a 5-bit decoder using 74154.



Encoders : An encoder accepts an active level on one of its inputs and converts it to a coded output, such as decimal to BCD.

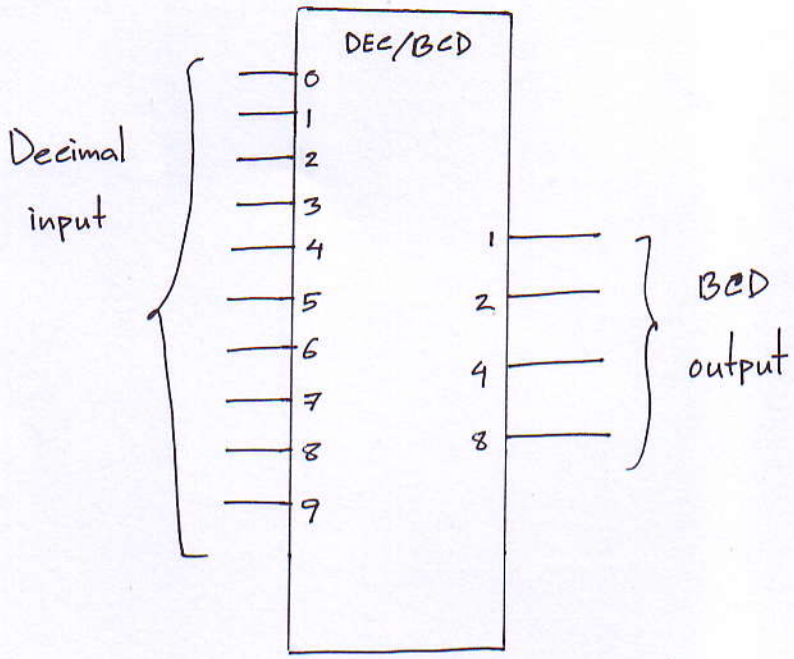


Fig : Logic symbol for a decimal to BCD encoder.

Decimal Digits	BCD code A_3	A_2	A_1	A_0
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

$A_0 = 1+3+5+7+9$

$A_1 = 2+3+6+7$

$A_2 = 4+5+6+7$

$A_4 = 8+9$

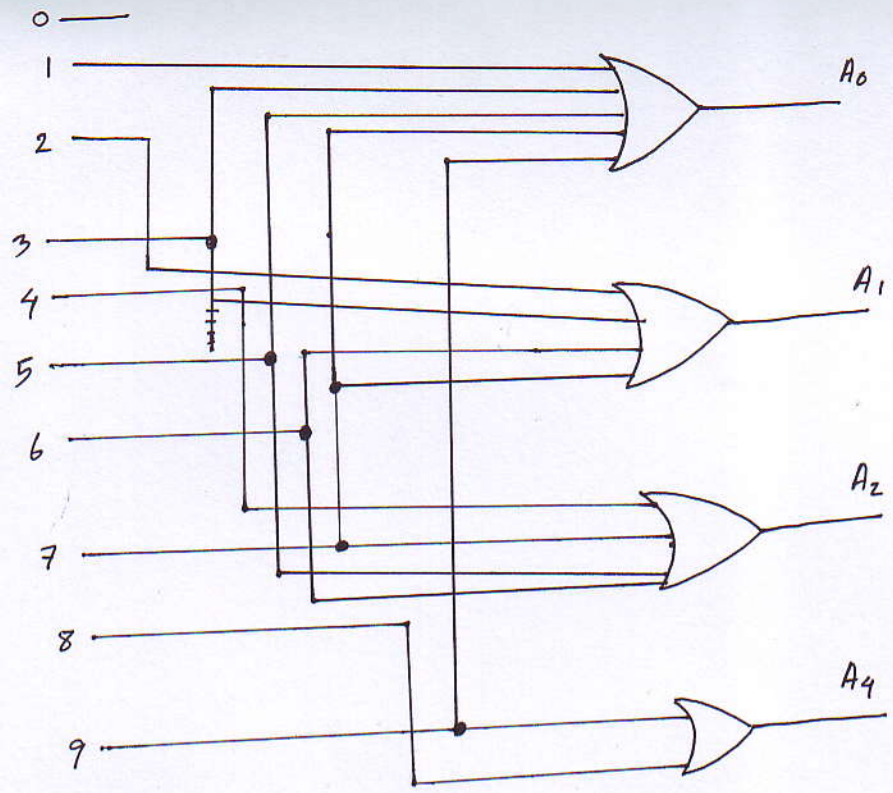


Fig : Logic diagram for a decimal to BCD encoder.

The Decimal to BCD priority encoder :

Let priority is given to the higher order digits.

Requirements to activate A_0

1) A_0 is HIGH if 1 is HIGH and 2, 4, 6, 8 low,

A_0 " " " 3 " " " 4, 6, 8 " ,

A_0 " " " 5 " " " 6, 8 " ,

A_0 " " " 7 " " " 8 " ,

A_0 " " " 9 " " .

$$\therefore A_0 = 1.\bar{2}.\bar{4}.\bar{6}.\bar{8} + 3.\bar{4}.\bar{6}.\bar{8} + 5.\bar{6}.\bar{8} + 7.\bar{8} + 9$$

Logic equation for A_1

2) A_1 is HIGH if 2 is HIGH and 4,5,8,9 LOW,
A_1 is HIGH if 3 is HIGH and 4,5,8,9 LOW,
A_1 is HIGH if 6 is HIGH and 8,9 LOW,
A_1 is HIGH if 7 is HIGH and 8,9 LOW.

$\therefore A_1 = (2+3)\,\bar{4}.\bar{5}.\bar{8}.\bar{9} + (6+7)\,\bar{8}.\bar{9}$

Logic equation for A_2

3) A_2 is HIGH if 4 is HIGH and 8,9 LOW,
A_2 " " " 5 " " " 8,9 ",
A_2 " " " 6 " " " 8,9 ",
A_2 " " " 7 " " " 8,9 ".

$\therefore A_2 = (4+5+6+7)\,\bar{8}.\bar{9}$

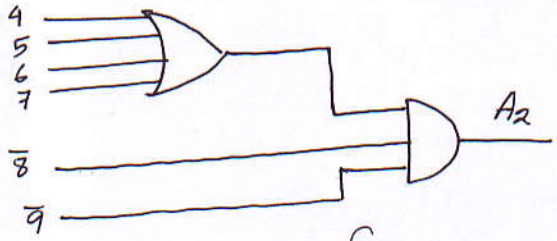


Fig: Logic for A_2

4) A_3 is HIGH if 8 or 9 is HIGH,

$\therefore A_3 = 8+9$

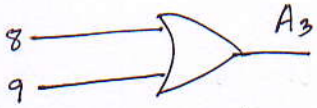


Fig: Logic for A_3

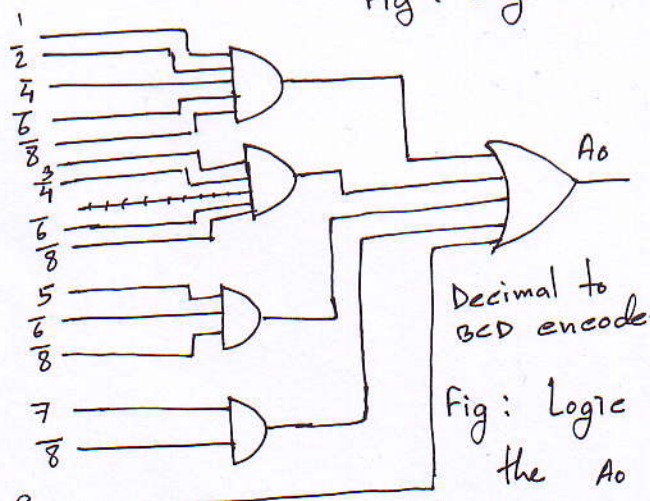


Fig: Logic for the A_0 output

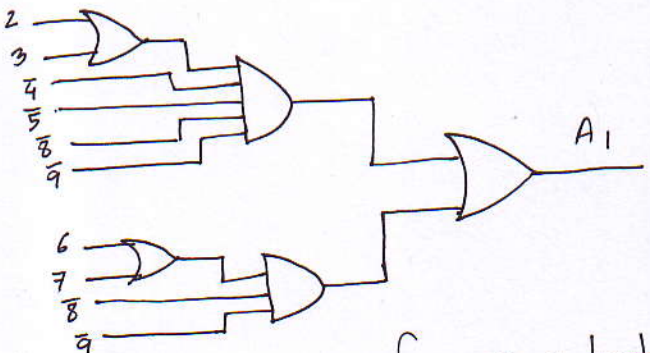
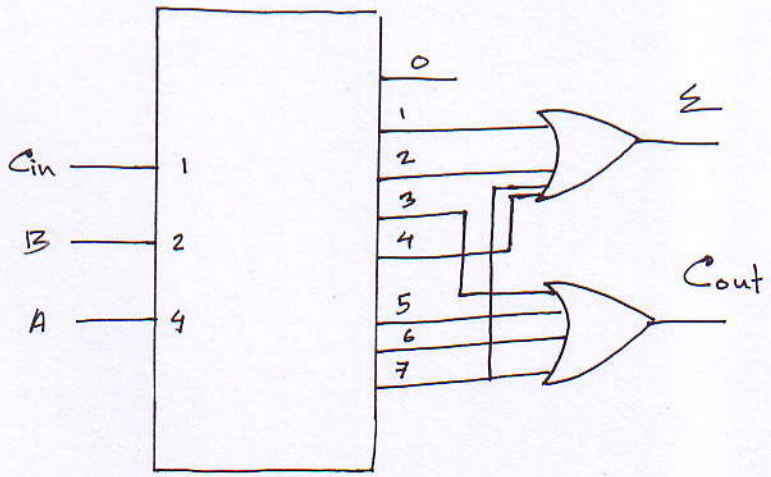


Fig: Logic for A_1 output of a decimal to BCD encoder

Implement a full Adder using a 3bit Decoder and other necessary gates.

Full - Adder Truth table :

A	B	Cin	Σ	Cout
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



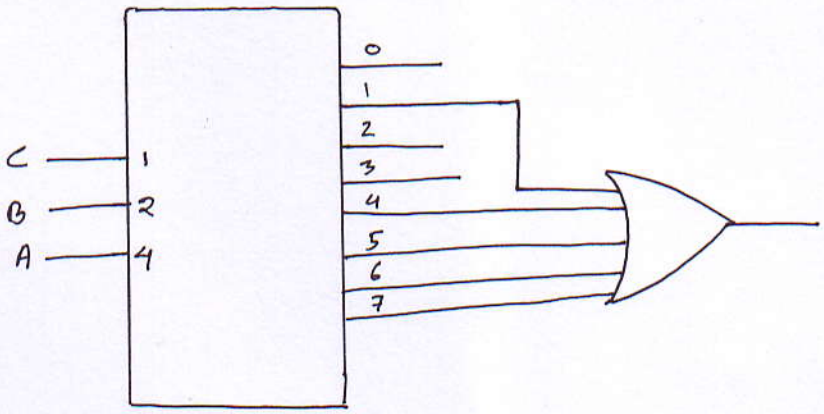
* Implement the logic function using a 3-bit and other necessary gate,

$$F(A,B,C) = A + \bar{B}C$$

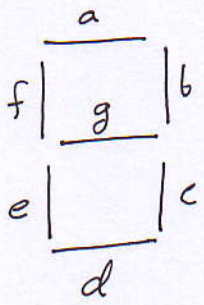
$$= AB + A\bar{B} + A\bar{B}C + \bar{A}\bar{B}C$$

$$= AB\bar{C} + ABC + A\bar{B}C + A\bar{B}\bar{C} + A\bar{B}C + \bar{A}\bar{B}C$$

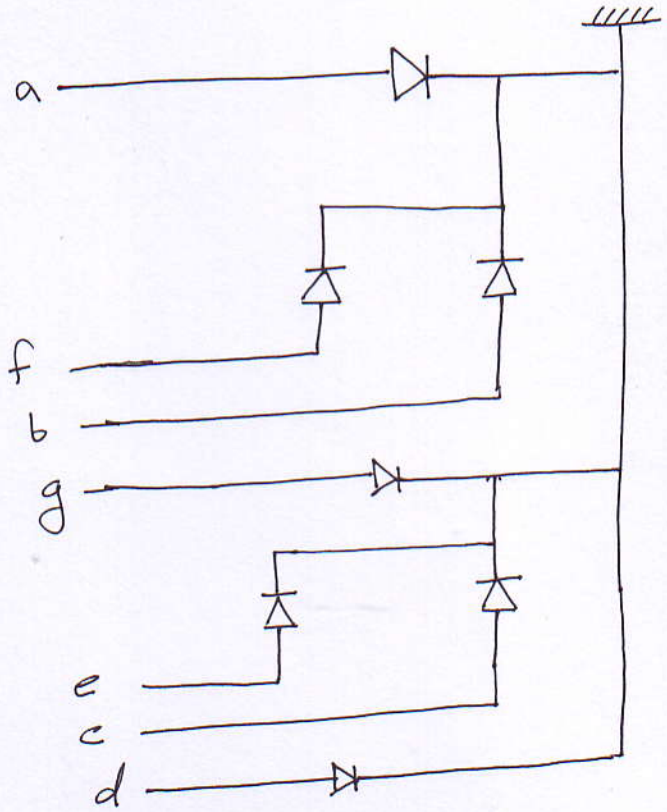
$$= \underset{110}{AB\bar{C}} + \underset{111}{ABC} + \underset{101}{A\bar{B}C} + \underset{100}{A\bar{B}\bar{C}} + \underset{001}{\bar{A}\bar{B}C}$$



BCD to 7 segment decoder/driver :



Common Cathode Display → Active high

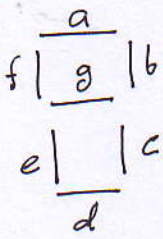


To display 4 the input code is

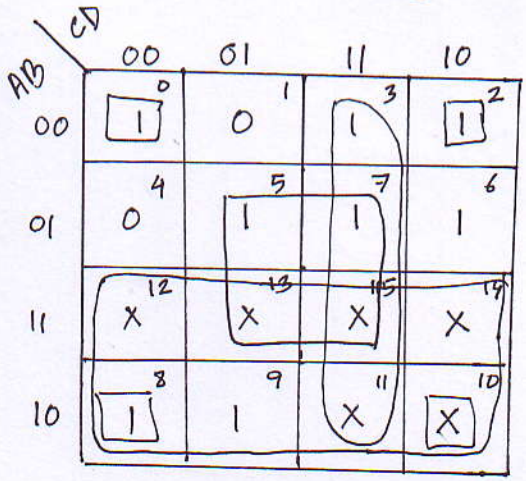
a	b	c	d	e	f	g
0	1	1	0	0	1	1

Truth table for BCD to 7-segment decoder:

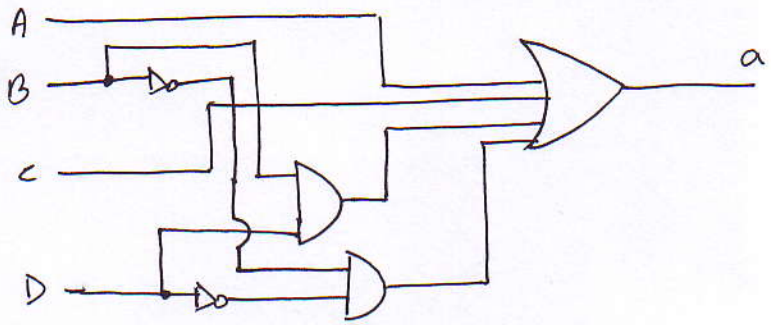
Decimal	BCD inputs A	B	C	D	Outputs a	b	c	d	e	f	g
0	0	0	0	0	1	1	1	1	1	1	0
1	0	0	0	1	0	1	1	0	0	0	0
2	0	0	1	0	1	1	0	1	1	0	1
3	0	0	1	1	1	1	1	1	0	0	1
4	0	1	0	0	0	1	1	0	0	1	1
5	0	1	0	1	1	0	1	1	0	1	1
6	0	1	1	0	1	0	1	1	1	1	1
7	0	1	1	1	1	1	1	0	0	0	0
8	1	0	0	0	1	1	1	1	1	1	1
9	1	0	0	1	1	1	1	1	0	1	1

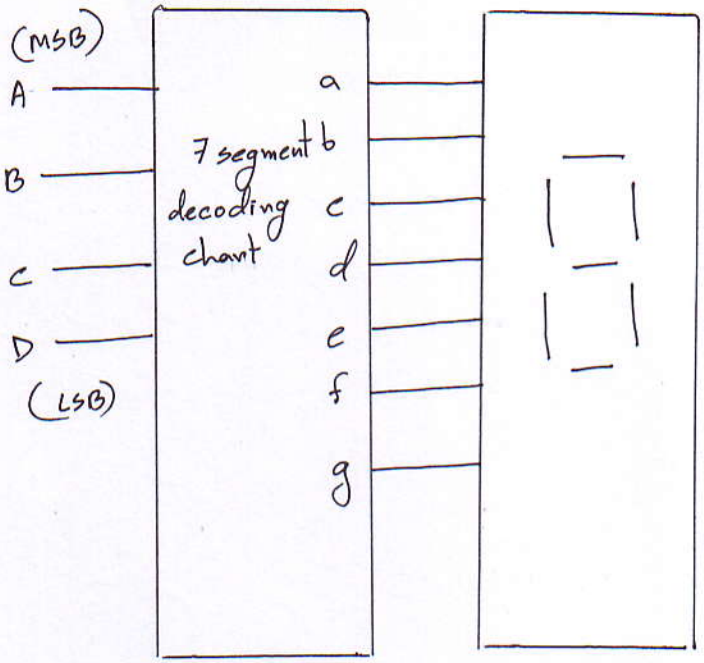


K-map for segment a,



∴ Logic for segment 'a' = $A + C + BD + \overline{B}\overline{D}$





7 segment display cc arrangement.