

**Paper 7, TDC Part-3**  
**Chapter– 4, Combinational Logic Design**  
**Lecture - 16**

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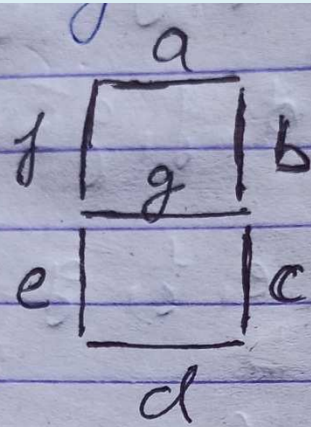
# Combinational Logic Design

BCD-to-7-Segment Decoder :-

A digital display that consists of seven LED segments is commonly used to display decimal numerals in digital systems. Most familiar examples are electronic calculators and watches where one 7-segment display device is used for displaying one numeral 0 through 9. For using this display device, the data has to be converted from some binary code to the code required for the display. Usually, the binary code used is natural BCD. Figure below shows the 7 segment display device.

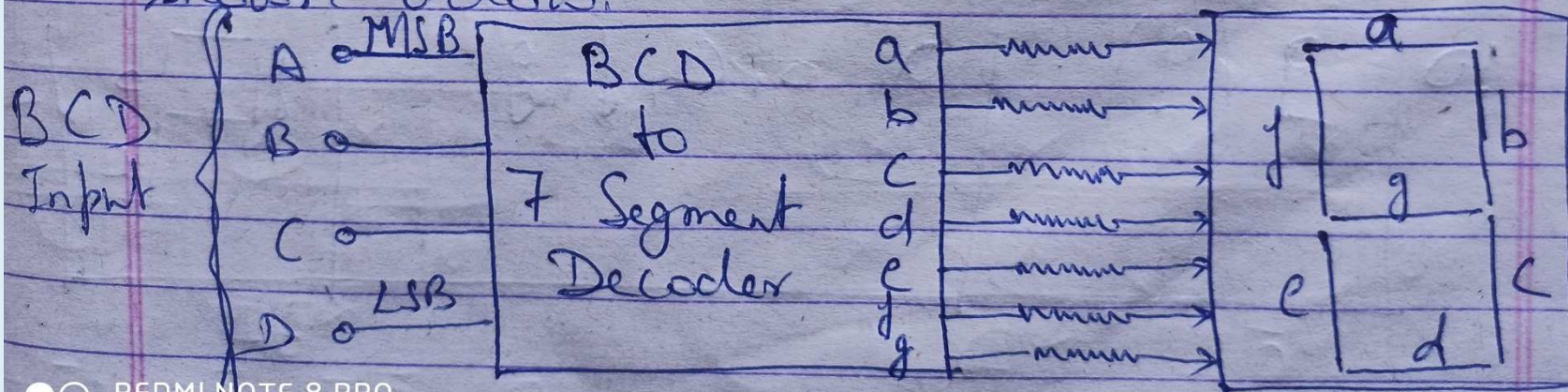


# Combinational Logic Design



The 7 segments are a, b, c, d, e, f & g

~~Table~~ The display system with connection is shown below.





# Combinational Logic Design

Table below shows the segments which must be illuminated for each of the numerals

	Numerals	Segments (Illuminated)	Display pattern
1	0	a, b, c, d, e, f	
2	1	a, b	
3	2 (2)	a, b, d, e, g	
4	3 (3)	a, b, c, d, g	
5	4	b, c, f, g	



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6	5 (	a, c, d, f, g	$\begin{array}{c c c} a & & \\ \hline f & g & \\ \hline & d & c \end{array}$
7	6 (6)	c, d, e, f, g	$\begin{array}{c c c} f & g & \\ \hline e & d & c \end{array}$
8	7 -	a, b, c	$\begin{array}{c c} a & \\ \hline & b \\ & c \end{array}$
9	8 (8)	a, b, c, d, e, f, g	$\begin{array}{c c c} a & & \\ \hline f & g & b \\ \hline e & d & c \end{array}$
10	9 (9)	a, b, c, f, g	$\begin{array}{c c c} a & & \\ \hline f & g & b \\ & & c \end{array}$



# Combinational Logic Design

Table below gives the truth table of BCD to 7-segment decoder. ABCD inputs is for the natural BCD code for numerals 0 to 9. The outputs of 7 segments displays are, a, b, c, d, e, f & g.

Truth Table of BCD to 7 Segment Decoder

Decimal Digit Displayed	Inputs				Outputs						
	A	B	C	D	a	b	c	d	e	f	g
0	0	0	0	0	1	1	1	1	1	1	0
1	0	0	0	1	1	1	0	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	0	0	1	1	1	1	1



# Combinational Logic Design

5	0	1	0	1	1	0	1	1	0	1	1
6	0	1	1	0	0	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	0	0	1	1
x	1	0	1	0	x	x	x	x	x	x	x
x	1	0	1	1	x	x	x	x	x	x	x
x	1	1	0	0	x	x	x	x	x	x	x
x	1	1	0	1	x	x	x	x	x	x	x
x	1	1	1	0	x	x	x	x	x	x	x
x	1	1	1	1	x	x	x	x	x	x	x

After 9 it will be don't care terms so the outputs are have represented by don't care condition.

Now to find the expression of for each output segment a, b, c, d, e, f & g we need 7 ~~8~~



# Combinational Logic Design

K-maps, i.e. for each segment K-map is plotted

~~K-Map for output A~~  $\rightarrow$

As there are 4 inputs lines (A, B, C & D) so 16 entries are possible so each K-Map is of 16 cells i.e. 4 variable K-map.

K-Map for A

AB \ CD	00	01	11	10
00	1		1	1
01		1	1	
11	x	x	x	x
10	1	1	x	x

BD  $\leftarrow$  (points to row 11)  
 $\bar{B} \leftarrow$  (points to row 00)  
 $\bar{C} \bar{D} \leftarrow$  (points to cell 00,00)  
 $\bar{C} D \leftarrow$  (points to cell 00,01)  
 $C \bar{D} \leftarrow$  (points to cell 00,10)  
 $CD \leftarrow$  (points to cell 00,11)

K-Map for B

AB \ CD	00	01	11	10
00	1	1	1	1
01	1		1	
11	x	x	x	x
10	1	1	x	x

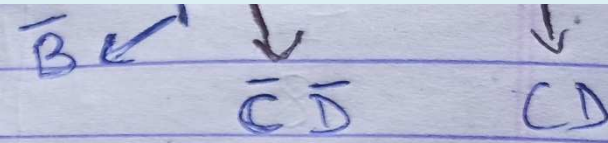
$\bar{B} \leftarrow$  (points to row 00)  
 $\bar{C} \bar{D} \leftarrow$  (points to cell 00,00)  
 $\bar{C} D \leftarrow$  (points to cell 00,01)  
 $C \bar{D} \leftarrow$  (points to cell 00,10)  
 $CD \leftarrow$  (points to cell 00,11)



# Combinational Logic Design



$$a = A + \bar{B}\bar{D} + BD + CD$$



$$b = \bar{B} + \bar{C}\bar{D} + CD$$

K-Map for C

AB \ CD	00	01	11	10
00	1	1	1	
01	1	1	1	1
11	x	x	x	x
10	1	1	x	x

Groupings for C: A vertical group of four 1s (00, 01, 11, 10 for CD=00 and 01) is labeled  $\bar{C}$ . A horizontal group of four 1s (00, 01, 11, 10 for AB=00 and 01) is labeled  $D$ . A group of four 1s (00, 01, 11, 10 for AB=00 and 01, CD=00 and 01) is labeled  $B$ .

$$C = B + \bar{C} + D$$

K-Map for D

AB \ CD	00	01	11	10
00	1	x	1	1
01		1		
11	x	x	x	x
10	1		x	x

Groupings for D: A group of four 1s (00, 01, 11, 10 for AB=00 and 01, CD=00 and 01) is labeled  $\bar{B}\bar{D}$ . A group of four 1s (00, 01, 11, 10 for AB=00 and 01, CD=00 and 01) is labeled  $\bar{B}C$ . A group of four 1s (00, 01, 11, 10 for AB=00 and 01, CD=00 and 01) is labeled  $C\bar{D}$ . A group of four 1s (00, 01, 11, 10 for AB=00 and 01, CD=00 and 01) is labeled  $B\bar{C}D$ .

$$d = \bar{B}\bar{D} + \bar{B}C + C\bar{D} + B\bar{C}D$$



# Combinational Logic Design

To be continued

Refer book- Modern Digital Electronics by RP Jain.

**Thank You**