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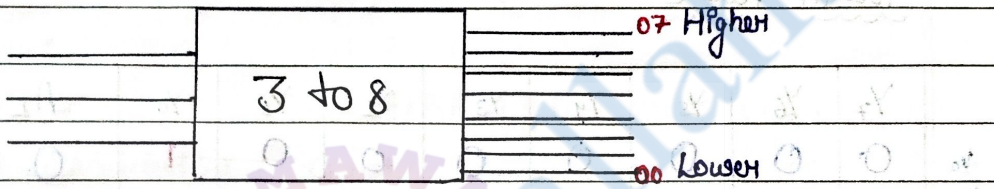
Unit ⇨ 5

Encoders and decoders

Encoders

$2^n = n$ ∴ 3 is input and 8 is output

$2^3 = 8$

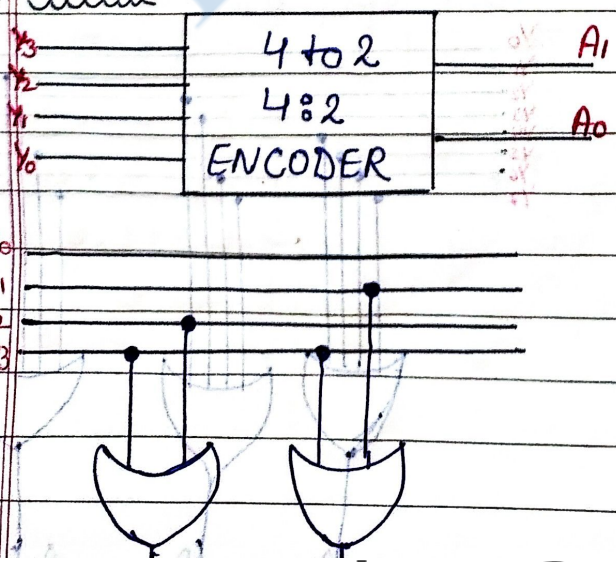


→ An encoder is a combinational circuit that perform the reverse operation of DECODERs. It has maximum of 2^n input lines and (n) output lines. It will products a binary code equivalent to the input, which is active high. Therefore the ENCODER, ENCODE 2^n input line with in small n bits. It is optional to represent the enable signal in ENCODERS.

$2^n =$

Example :~

1) 4 to 2



Y_3	Y_2	Y_1	Y_0	A_1	A_0
0	0	0	1	0	0
0	0	1	0	0	1
0	1	0	0	1	0
1	0	0	0	1	1

$A_0 = Y_1 + Y_3$

$A_1 = Y_2 + Y_3$

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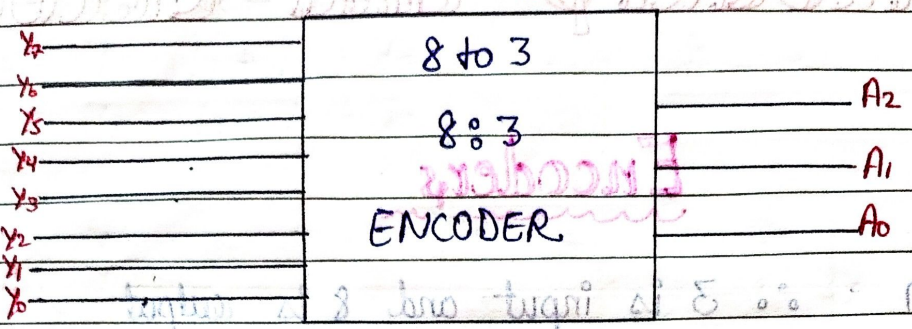
2.) 8 to 3 (Octal to Binary encoder)

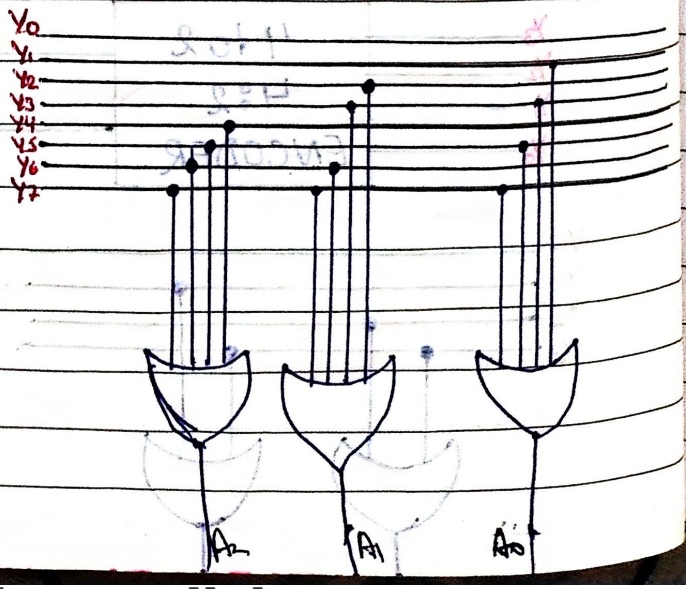


Truth table

	Y_7	Y_6	Y_5	Y_4	Y_3	Y_2	Y_1	Y_0	A_2	A_1	A_0
Y_0	0	0	0	0	0	0	0	1	0	0	0
Y_1	0	0	0	0	0	0	1	0	0	0	1
Y_2	0	0	0	0	0	1	0	0	0	1	0
Y_3	0	0	0	0	1	0	0	0	0	1	1
Y_4	0	0	0	1	0	0	0	0	1	0	0
Y_5	0	0	1	0	0	0	0	0	1	0	1
Y_6	0	1	0	0	0	0	0	0	1	1	0
Y_7	1	0	0	0	0	0	0	0	1	1	1

(Octal to Binary Encoder)

$$A_0 = Y_1 + Y_3 + Y_5 + Y_7$$
$$A_1 = Y_2 + Y_3 + Y_6 + Y_7$$
$$A_2 = Y_4 + Y_5 + Y_6 + Y_7$$



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* It is well known that a binary to octal decoder (3-to-8 decoder) accep : s a 3-bit input code and activities one of eight output lines corresponding to that code. An octal-to-binary encoder perform the opposite function, it accepts eight inputs and produces a 3-bit output code corresponding to the activated input.

~~3.~~) Decimal-to-BCD Encoder (10 – 4)

A decimal-to-BCD encoder is one with ten iputs corresponding to ten decimal digits (0 to 9) and four outputs (A, B, C, D) representing the BCD value of input decimal digit.

* Truth table

Y_9	Y_8	Y_7	Y_6	Y_5	Y_4	Y_3	Y_2	Y_1	Y_0	A	B	C	D
0	0	0	0	0	0	0	0	0	1	0	0	0	0
0	0	0	0	0	0	0	0	1	0	0	0	0	1
0	0	0	0	0	0	0	1	0	0	0	0	1	0
0	0	0	0	0	0	1	0	0	0	0	0	1	1
0	0	0	0	0	1	0	0	0	0	0	1	0	0
0	0	0	0	1	0	0	0	0	0	0	1	0	1
0	0	0	1	0	0	0	0	0	0	0	1	1	0
0	0	1	0	0	0	0	0	0	0	0	1	1	1
0	1	0	0	0	0	0	0	0	0	1	0	0	0
1	0	0	0	0	0	0	0	0	0	1	0	0	1

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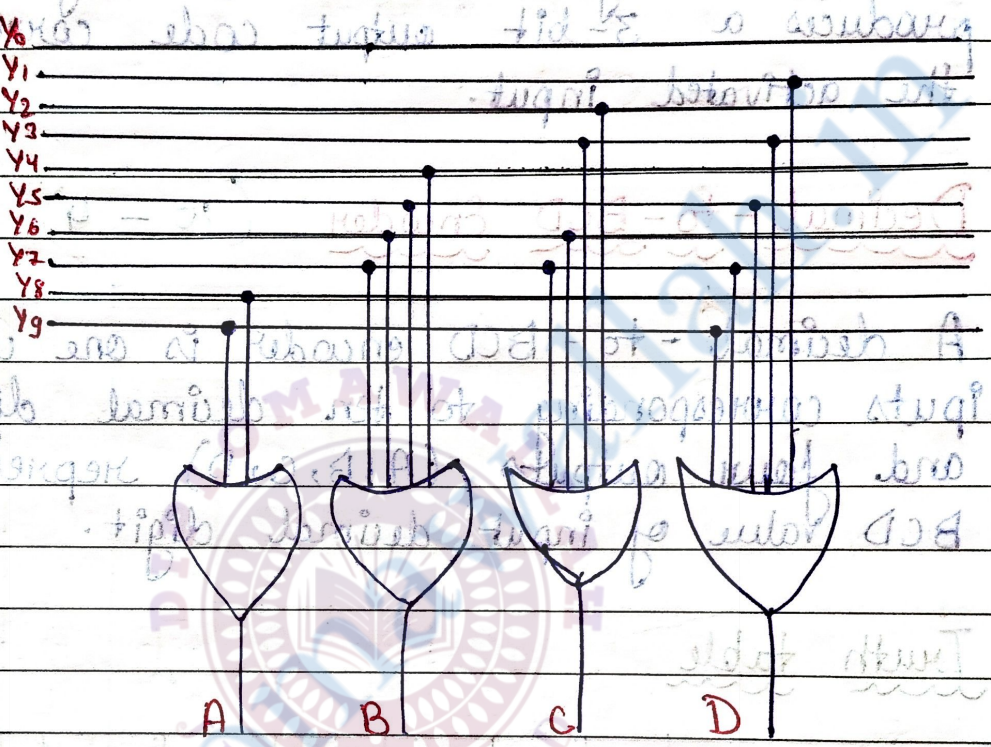
$A = Y_8 + Y_9$
$B = Y_4 + Y_5 + Y_6 + Y_7$
$C = Y_2 + Y_3 + Y_6 + Y_7$
$D = Y_1 + Y_3 + Y_5 + Y_7 + Y_9$



Priority Encoder :-

The priority encoder is an encoder that includes the priority function. The operation of the priority encoder is such that if two or more inputs are equal to 1 at the same time, the input having the highest priority will take precedence. The truth table of a four-input priority encoder is:-

Truth table

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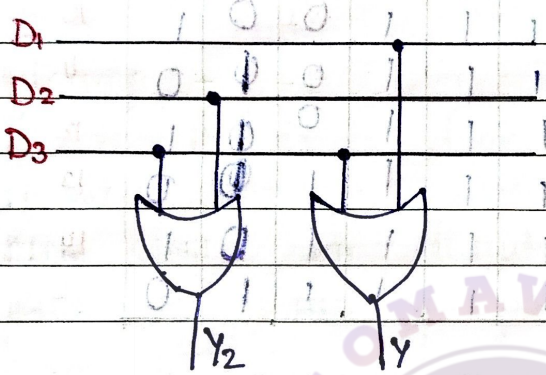
INPUT				OUTPUT		
D_0	D_1	D_2	D_3	Y_2	Y_1	Y_0
0	0	0	0	X	X	0
1	0	0	0	0	0	1
X	1	0	0	0	1	1
X	X	1	0	1	0	1
X	X	X	1	1	1	1

$Y_1 = D_1 + D_3$

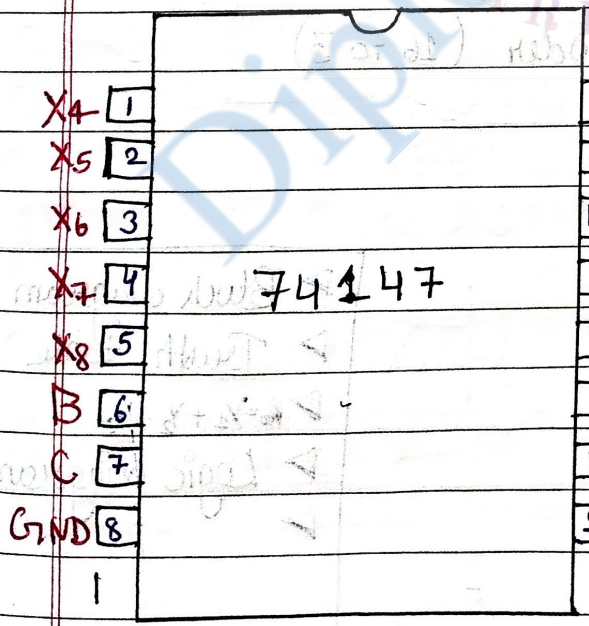
$Y_2 = D_2 + D_3$



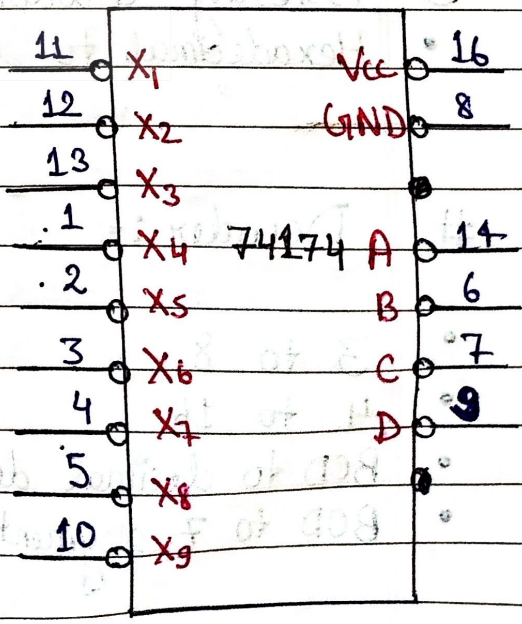
Logic diagram of Priority Encoder

* IC (Integrated Circuit)
→ IC = 16 Pin.

(a) Pinout Diagram



(b) Logic symbol



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* Truth table :-

X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	A	B	C	D		
1	1	1	1	1	1	1	1	1	0	1	1	1	16	15
X	X	X	X	X	X	X	X	0	0	1	1	0	17	16
X	X	X	X	X	X	X	0	1	0	1	1	1	18	17
X	X	X	X	X	X	0	1	1	1	0	0	0	9	8
X	X	X	X	X	0	1	1	1	1	0	0	1	10	9
X	X	X	X	0	1	1	1	1	1	0	1	0	11	10
X	X	X	0	1	1	1	1	1	1	0	1	1	12	11
X	X	0	1	1	1	1	1	1	1	1	0	0	13	12
X	0	1	1	1	1	1	1	1	1	1	0	1	14	13
0	1	1	1	1	1	1	1	1	1	1	1	0		14

Example of Encoder are :-

- 8 to 3 (octal to binary encoder)
- Decimal to - BCD encoder
- Priority encoder
- Hexadecimal to binary encoder (16 to 3)

Decoder :-

- 3 to 8
- 4 to 16
- BCD to decimal decoder
- BCD to 7 segment decoder

- ▷ Block diagram
- ▷ Truth Table
- ▷ $A_0 = Y_1 + Y_2 + Y_3$
- ▷ Logic diagram
- ▷

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Decoder

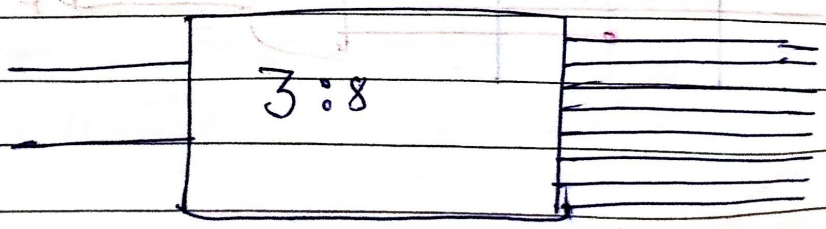
→ A decoder is similar to demultiplexer but without any data input most digital system required the decoding of data. Decoding is necessary in application such as data demultiplexing, digital display, digital to analog converters and memory addressing.

A decoder is a logic circuit that converts an n-bit binary input code into 2^n = output lines. such that each output line will be activated four only one of possible combination of inputs.

* 3 to 8 Decoder

A	B	C	D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7
0	0	0	1	0	0	0	0	0	0	0
0	0	1	0	1	0	0	0	0	0	0
0	1	0	0	0	1	0	0	0	0	0
0	1	1	0	0	0	1	0	0	0	0
1	0	0	0	0	0	0	1	0	0	0
1	0	1	0	0	0	0	0	1	0	0
1	1	0	0	0	0	0	0	0	1	0
1	1	1	0	0	0	0	0	0	0	1

Truth table



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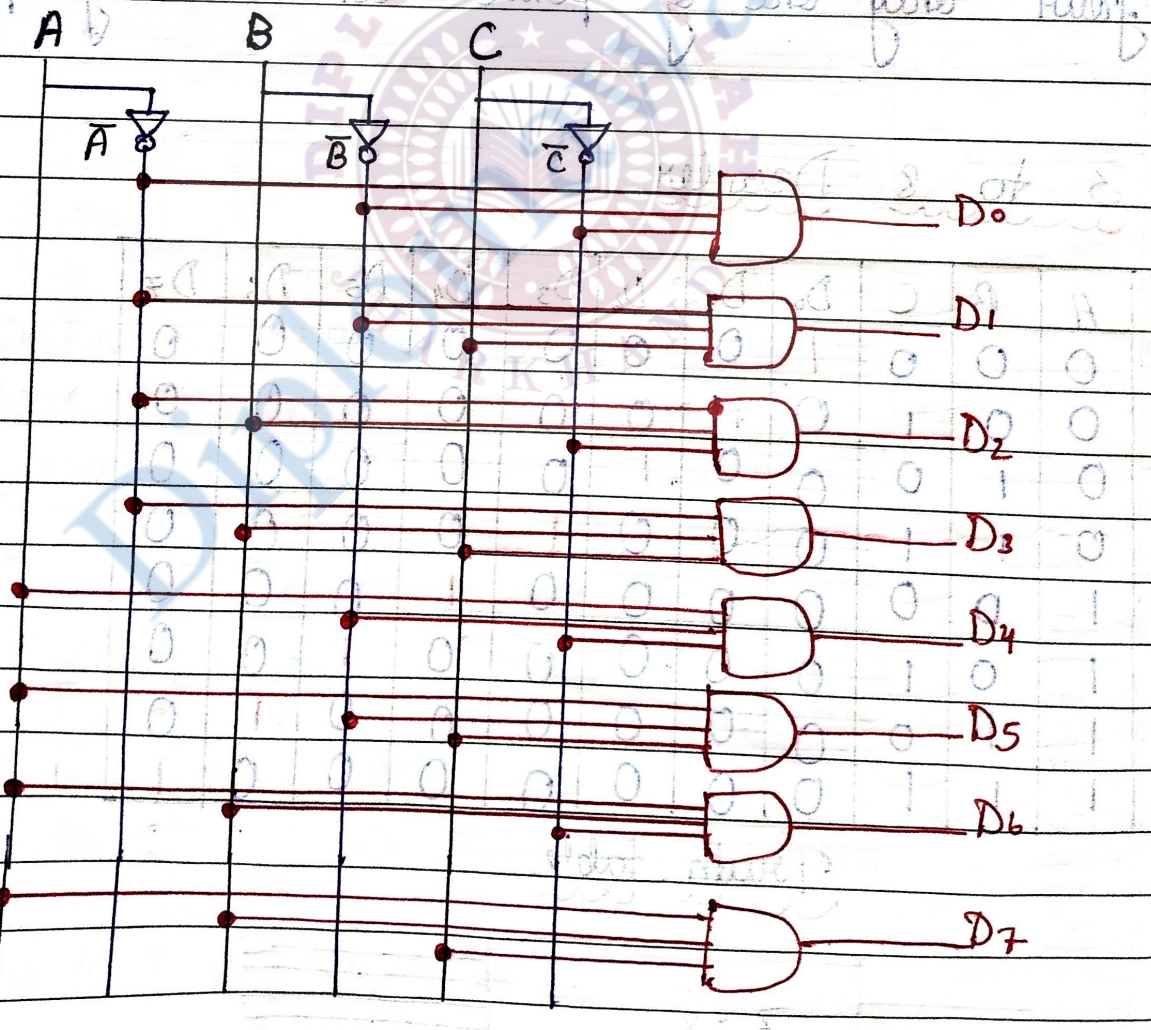
* Boolean expression :~

$D_0 = \bar{A}\bar{B}\bar{C}$
$D_1 = \bar{A}\bar{B}C$
$D_2 = \bar{A}B\bar{C}$
$D_3 = \bar{A}BC$
$D_4 = A\bar{B}\bar{C}$
$D_5 = A\bar{B}C$
$D_6 = AB\bar{C}$
$D_7 = ABC$

* Logic diagram :~



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* 4 to 16 Decoder :~

Truth table :~

A	B	C	D	D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}	D_{11}	D_{12}	D_{13}	D_{14}	D_{15}
0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
0	1	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

* Boolean Expression :~

$D_0 = \bar{A}\bar{B}\bar{C}\bar{D}$
$D_1 = \bar{A}\bar{B}\bar{C}D$
$D_2 = \bar{A}\bar{B}C\bar{D}$
$D_3 = \bar{A}\bar{B}CD$
$D_4 = \bar{A}B\bar{C}\bar{D}$
$D_5 = \bar{A}B\bar{C}D$
$D_6 = \bar{A}BC\bar{D}$
$D_7 = \bar{A}BCD$
$D_8 = A\bar{B}\bar{C}\bar{D}$
$D_9 = A\bar{B}\bar{C}D$
$D_{10} = A\bar{B}C\bar{D}$
$D_{11} = A\bar{B}CD$
$D_{12} = AB\bar{C}\bar{D}$
$D_{13} = AB\bar{C}D$
$D_{14} = ABC\bar{D}$
$D_{15} = ABCD$

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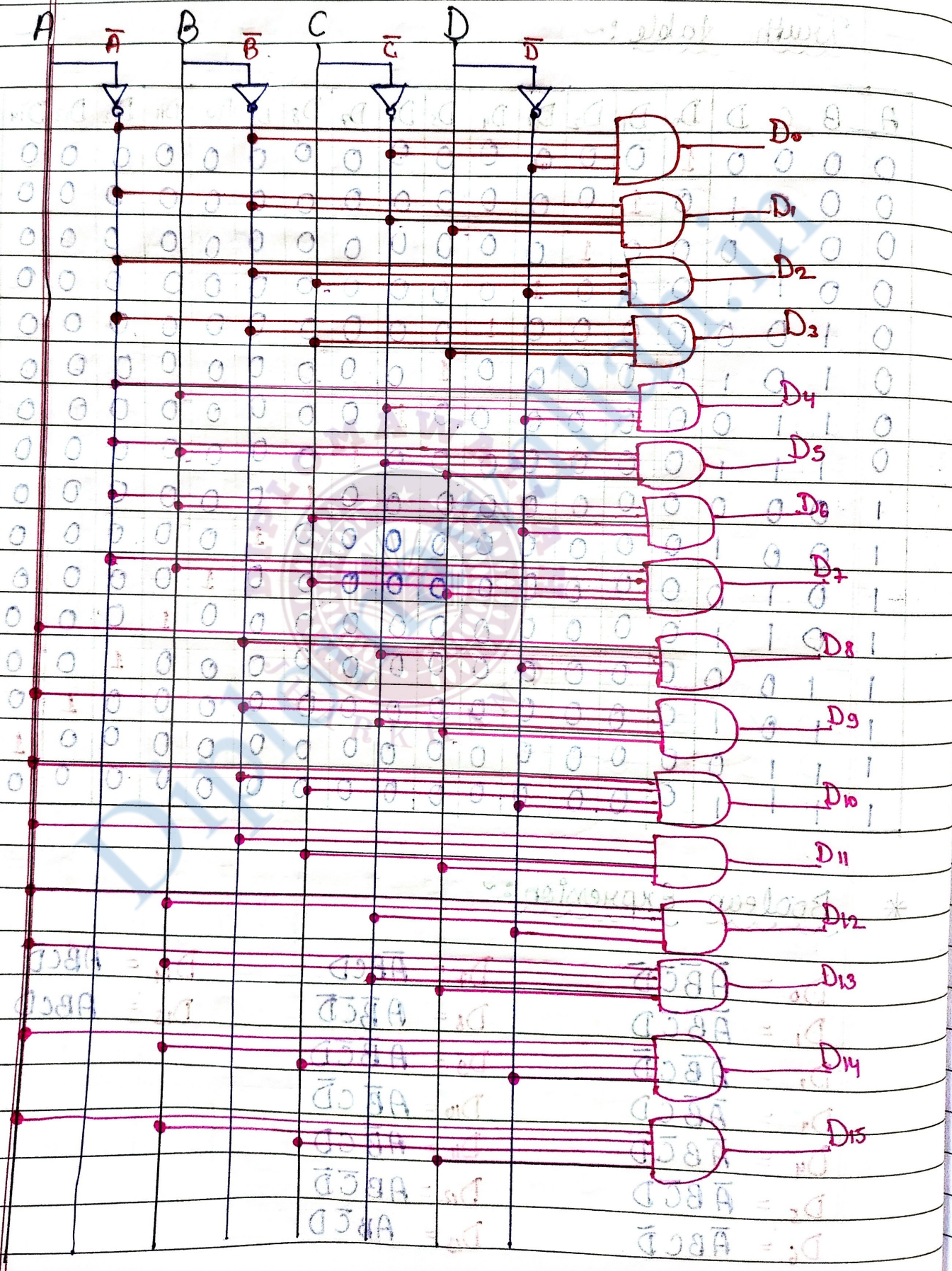
* Logic diagram :-



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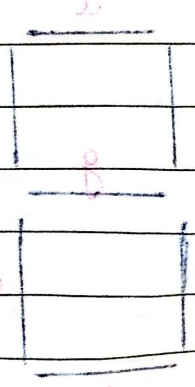
BCD to Decimal Decoder :~ (0-9)

* Truth Table :~

A	B	C	D	D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9
0	0	0	0	1	0	0	0	0	0	0	0	0	0
0	0	0	1	0	1	0	0	0	0	0	0	0	0
0	0	1	0	0	0	1	0	0	0	0	0	0	0
0	0	1	1	0	0	0	1	0	0	0	0	0	0
0	1	0	0	0	0	0	0	1	0	0	0	0	0
0	1	0	1	0	0	0	0	0	1	0	0	0	0
0	1	1	0	0	0	0	0	0	0	1	0	0	0
0	1	1	1	0	0	0	0	0	0	0	1	0	0
1	0	0	0	0	0	0	0	0	0	0	0	1	0
1	0	0	1	0	0	0	0	0	0	0	0	0	1

* Boolean Expression :~

$D_0 = \bar{A}\bar{B}\bar{C}\bar{D}$
$D_1 = \bar{A}\bar{B}\bar{C}D$
$D_2 = \bar{A}\bar{B}C\bar{D}$
$D_3 = \bar{A}\bar{B}CD$
$D_4 = \bar{A}B\bar{C}\bar{D}$
$D_5 = \bar{A}B\bar{C}D$
$D_6 = \bar{A}BC\bar{D}$
$D_7 = \bar{A}BCD$
$D_8 = A\bar{B}\bar{C}\bar{D}$
$D_9 = A\bar{B}\bar{C}D$



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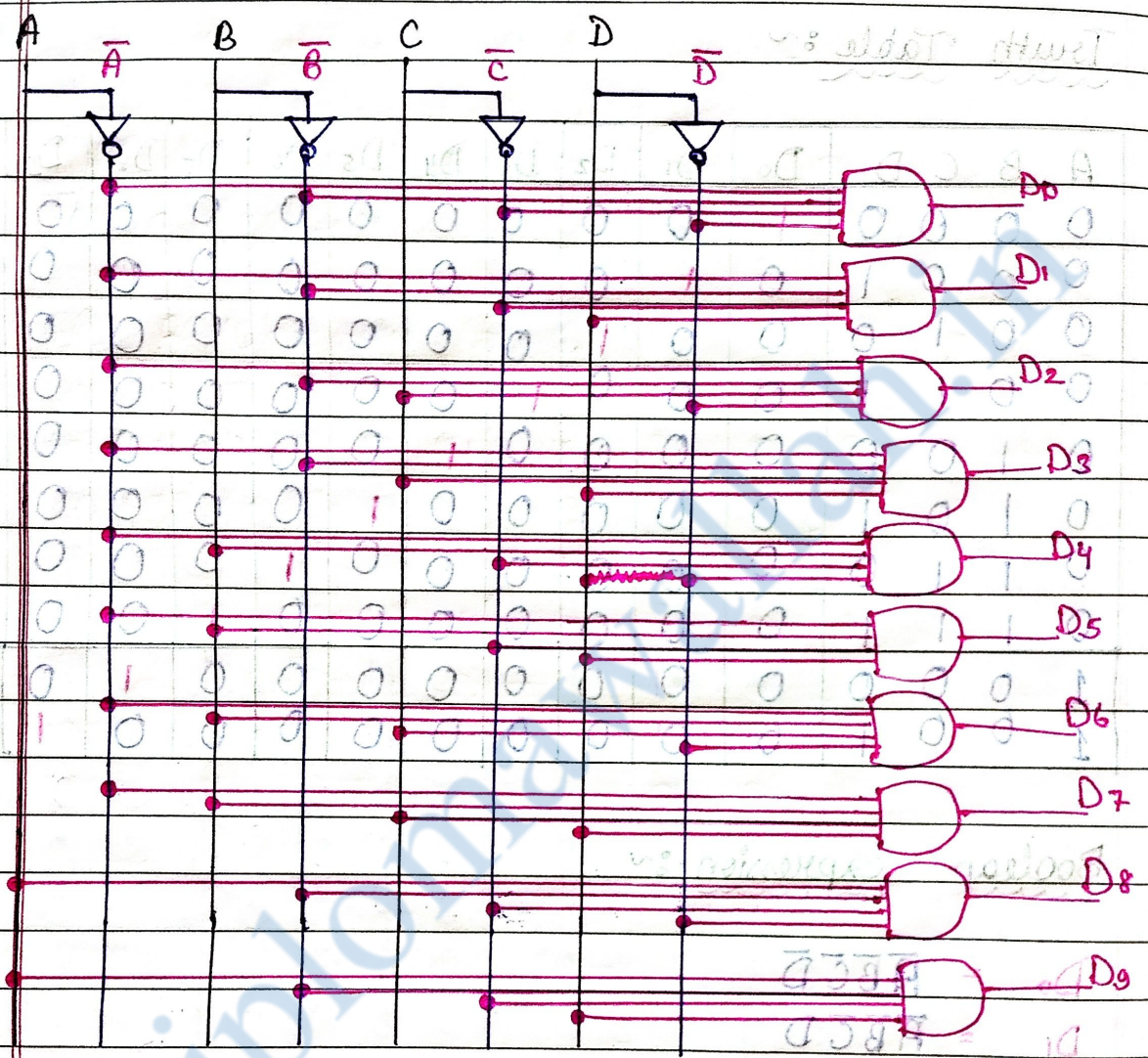
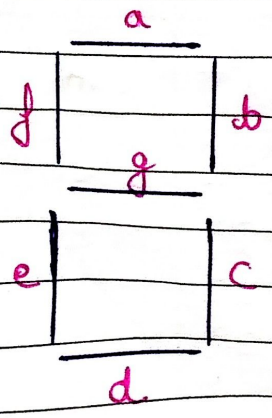
* Logic diagram :~



BCD to 7 Segment Decoder :~



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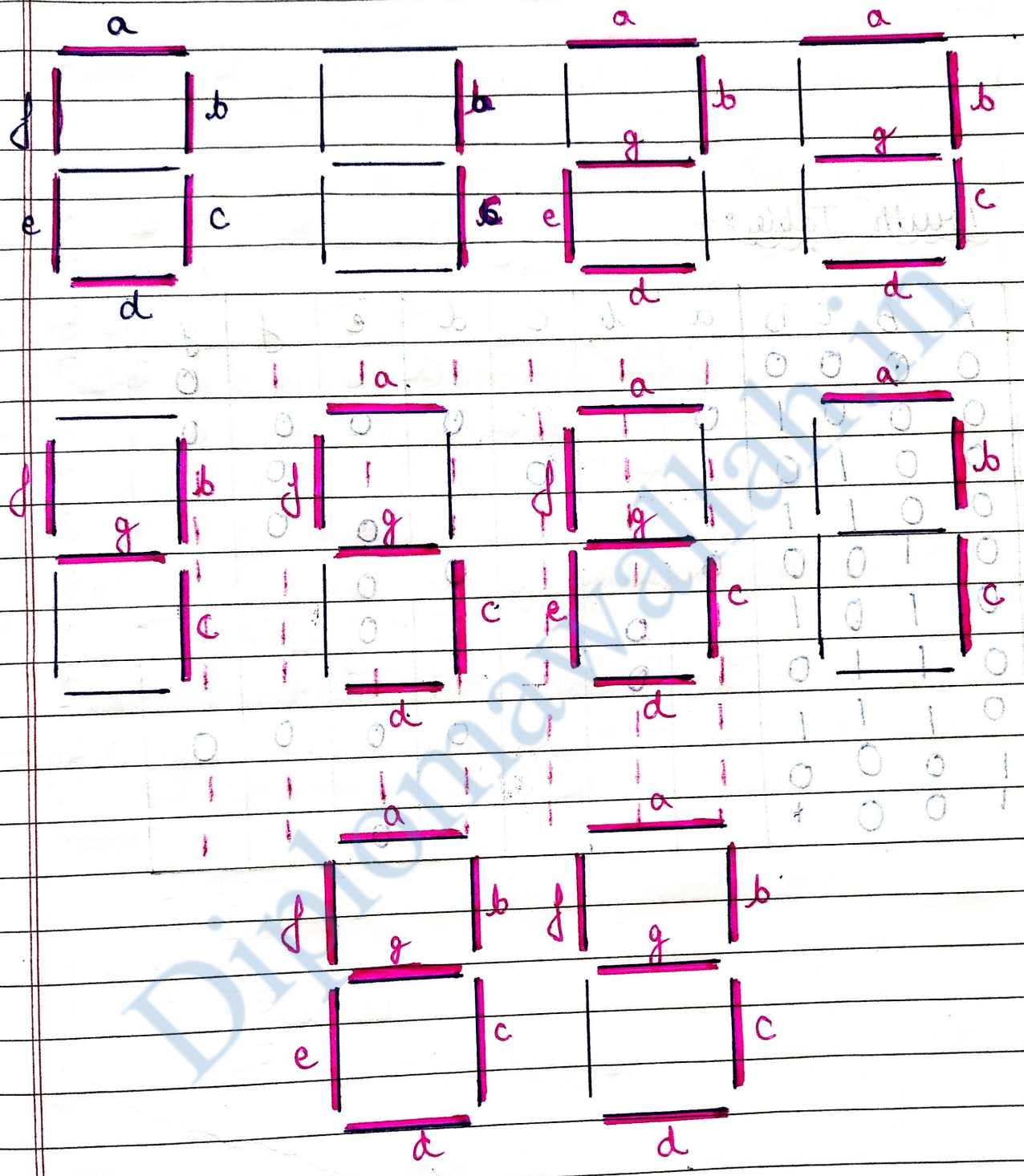

* Truth Table :-

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	1	0	1	1