AKTU B.Tech II-Year

GATEWAY CLASSES

EC & EC Allied

DSD : Digital System Design

Unit-2 Lec-4

Gateway Classes



Today's target

- Comparators
- Decoders
- PYQ

Avinash Sir

UNIT-2 : Combinational circuits:

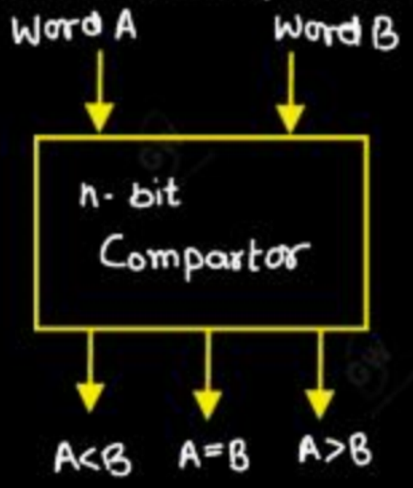
- Analysis and Design of combinational circuits
- MSI devices like comparators, multiplexers, demultiplexers, encoder, decoder,
- circuit realization using Multiplexers and decoders, half and full adders, subtractors, serial and parallel adders, BCD adder, barrel shifter and ALU.

Gateway Classes

Comparators

A comparator is a combinational circuit that compares two binary numbers (A and B) and determines their relative magnitudes, i.e., whether:

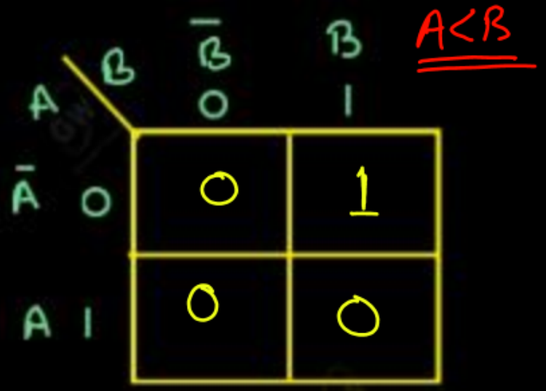
$$A = B, \quad A > B, \quad A < B$$



Basic 1-bit Comparator

For two 1-bit inputs A and B: Truth Table

INPUT		OUTPUT		
A	B	Y1 = A < B	Y2 = A = B	Y3 = A > B
0	0	0	1	0
0	1	1	0	0
1	0	0	0	1
1	1	0	1	0

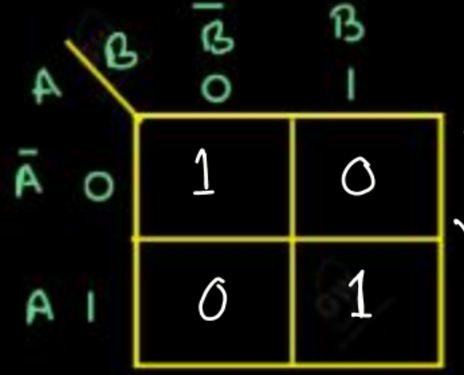


$Y_1 = A<B = \bar{A}B$



$Y_3 = A>B = A\bar{B}$

$Y_2 = (A=B)$



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

$Y = A \odot B$

Gateway Classes

Basic 1-bit Comparator

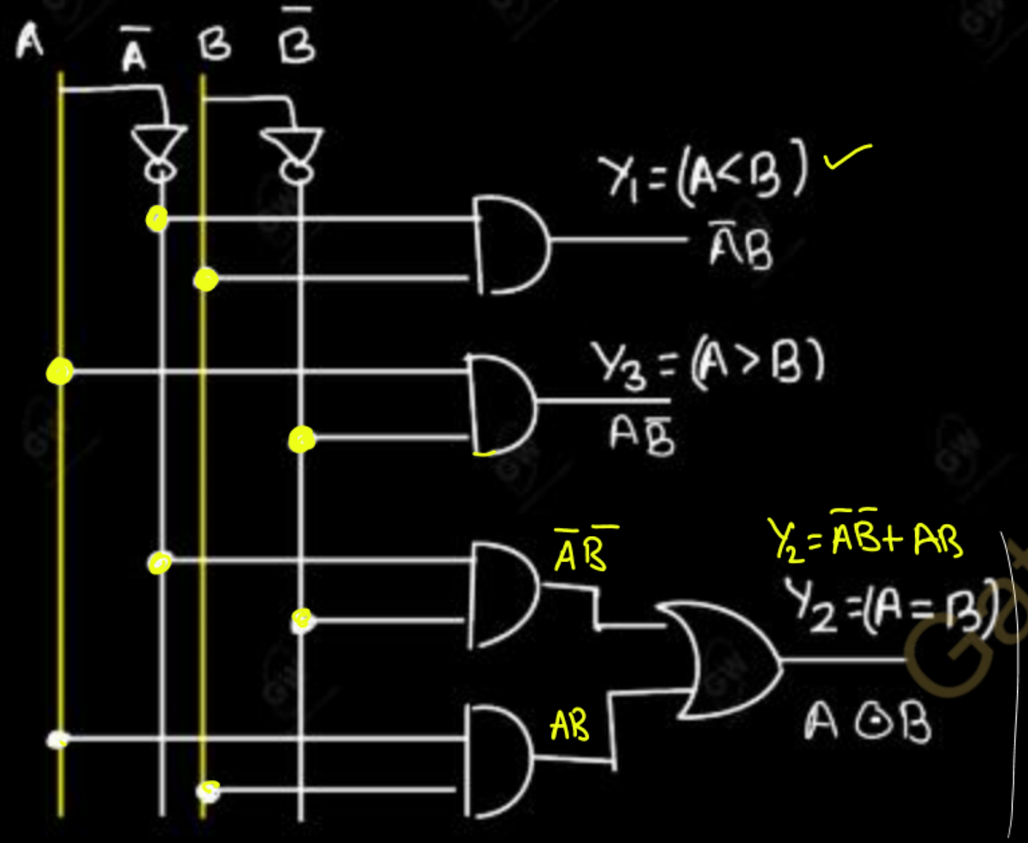
$Y_1 = (A < B) = \bar{A}B$

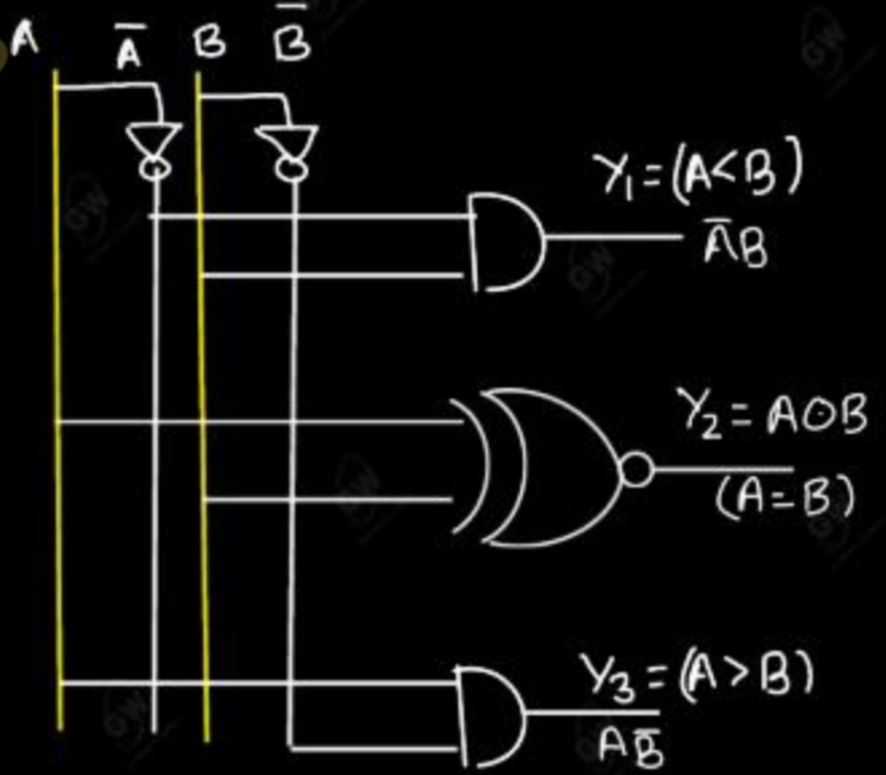
$Y_2 = (A = B) = A \odot B = \bar{A}\bar{B} + AB$

$Y_3 = (A > B) = A\bar{B}$

Realize using Ex-NOR Gate

Circuit Realization





Gateway Classes

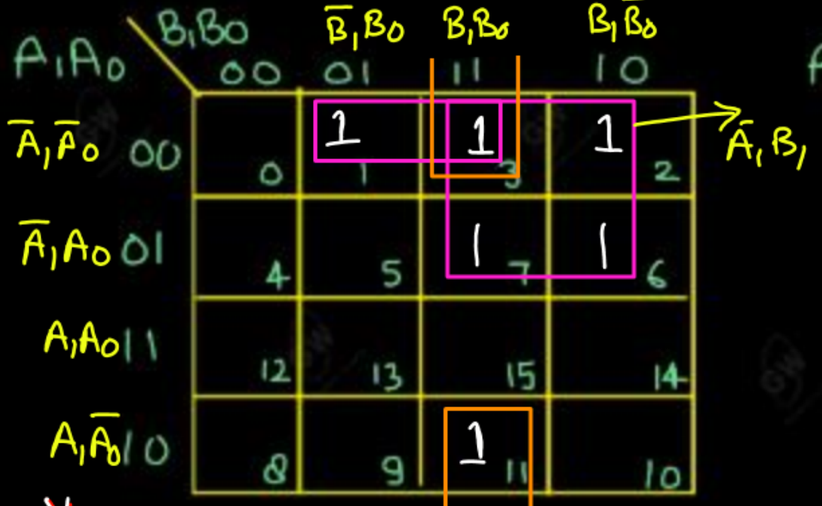
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Basic 2-bit Comparator

Let $A = A1\ A0$ and $B = B1\ B0$

Truth table

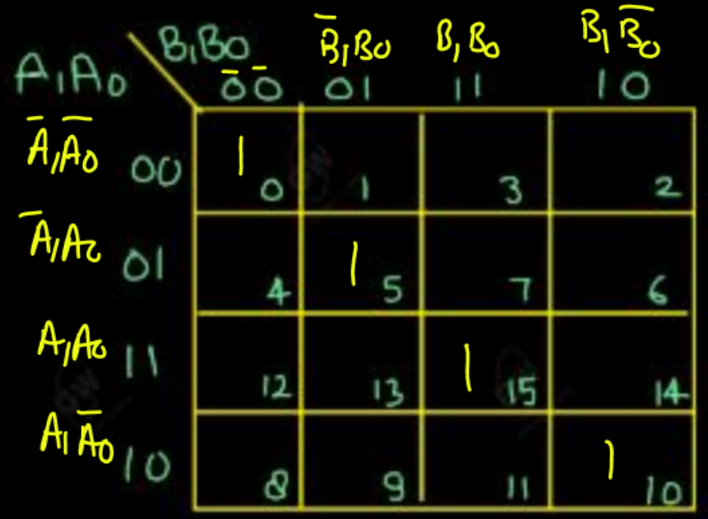
	Input A1	Input A0	Input B1	Input B0	output A < B	output A = B	output A > B
0	0	0	0	0	0	1	0
1	0	0	0	1	1	0	0
2	0	0	1	0	1	0	0
3	0	0	1	1	1	0	0
4	0	1	0	0	0	0	1
5	0	1	0	1	0	1	0
6	0	1	1	0	1	0	0
7	0	1	1	1	1	0	0
8	1	0	0	0	0	0	1
9	1	0	0	1	0	0	1
10	1	0	1	0	0	1	0
11	1	0	1	1	1	0	0
12	1	1	0	0	0	0	1
13	1	1	0	1	0	0	1
14	1	1	1	0	0	0	1
15	1	1	1	1	0	1	0



$Y_1 = A<B = \bar{A}_1B_1 + \bar{A}_1\bar{A}_0B_0 + \bar{A}_0B_1B_0$



$Y_3 = A>B = A_1\bar{B}_1 + A_0\bar{B}_1\bar{B}_0 + A_1A_0\bar{B}_0$



$Y_2 = (A=B) = \bar{A}_1\bar{A}_0\bar{B}_1\bar{B}_0 + \bar{A}_1A_0\bar{B}_1B_0 + A_1A_0B_1B_0 + A_1\bar{A}_0B_1\bar{B}_0$

$= \bar{A}_1\bar{B}_1(\bar{A}_0\bar{B}_0 + A_0B_0) + A_1B_1(A_0B_0 + \bar{A}_0\bar{B}_0)$

$= (A_1B_1 + \bar{A}_1\bar{B}_1)(A_0B_0 + \bar{A}_0\bar{B}_0)$

$Y_2 = (A_1 \odot B_1)(A_0 \odot B_0)$

Gateway Classes

Basic 2-bit Comparator

Circuit Realization

For $A<B$

$$\bar{A}_1\bar{A}_0B_0 + \bar{A}_1B_1 + \bar{A}_0B_1B_0 = Y_1$$

For $A>B$

$$A_0\bar{B}_1\bar{B}_0 + A_1A_0\bar{B}_0 + A_1\bar{B}_1 = Y_3$$

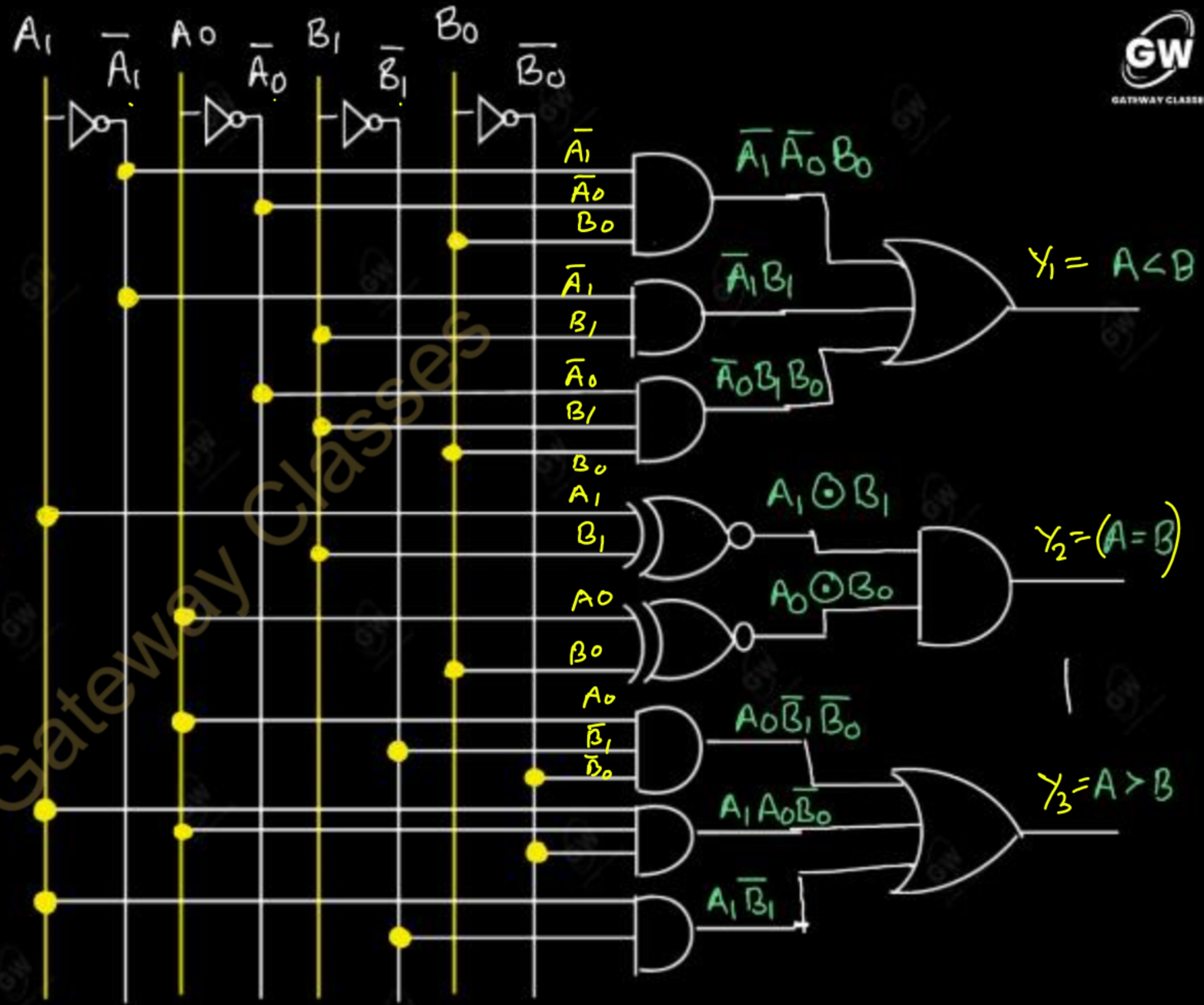
For $A=B$

$$\bar{A}_1\bar{A}_0\bar{B}_1\bar{B}_0 + \bar{A}_1A_0\bar{B}_1B_0 + A_1A_0B_1B_0 + A_1\bar{A}_0B_1\bar{B}_0$$

$$= \bar{A}_0\bar{B}_0(\bar{A}_1\bar{B}_1 + A_1B_1) + A_0B_0(\bar{A}_1\bar{B}_1 + A_1B_1)$$

$$= (\bar{A}_1\bar{B}_1 + A_1B_1)(\bar{A}_0\bar{B}_0 + A_0B_0)$$

$$= (A_1 \odot B_1).(A_0 \odot B_0) = Y_2$$



Gateway Classes

n-bit Comparator

For larger numbers (like 4-bit or 8-bit), the same principle applies:

- Compare MSB first, then proceed bit by bit if equal.
- Usually implemented using cascaded 1-bit comparators.

IC 7485 is a common 4-bit magnitude comparator that provides outputs for $A>B$, $A=B$, and $A<B$.

Applications of Comparators

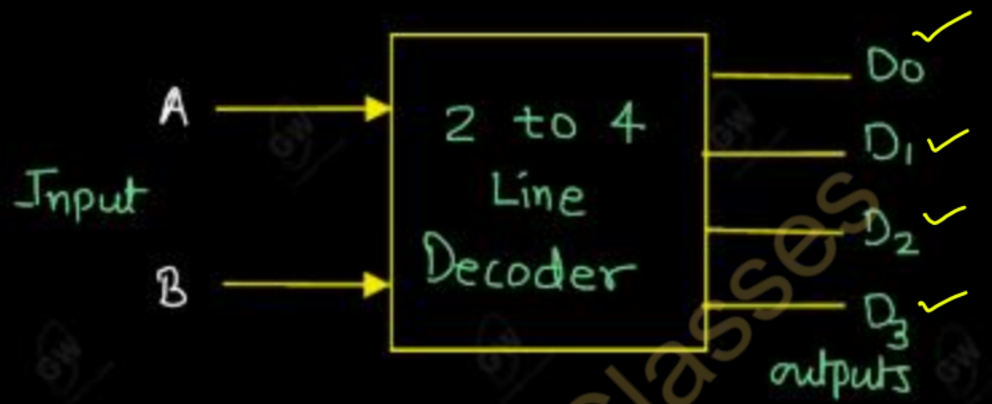
- Digital sorting (ordering numbers).
- Searching in digital systems.
- Used in ALUs to check conditions (equal, less, greater).
- Input matching in memory systems.

Gateway Classes

Decoder

A decoder is a combinational circuit that converts binary information from 'n' input lines into a maximum of 2^n unique output lines.

A 2 to 4 Line Decoder



$D_0 = \bar{A}\bar{B}$

$D_1 = \bar{A}B$

$D_2 = A\bar{B}$

$D_3 = AB$

INPUT		OUTPUT			
A	B	D0	D1	D2	D3
0	0	1	0	0	0
0	1	0	1	0	0
1	0	0	0	1	0
1	1	0	0	0	1

Gateway Classes

Decoder

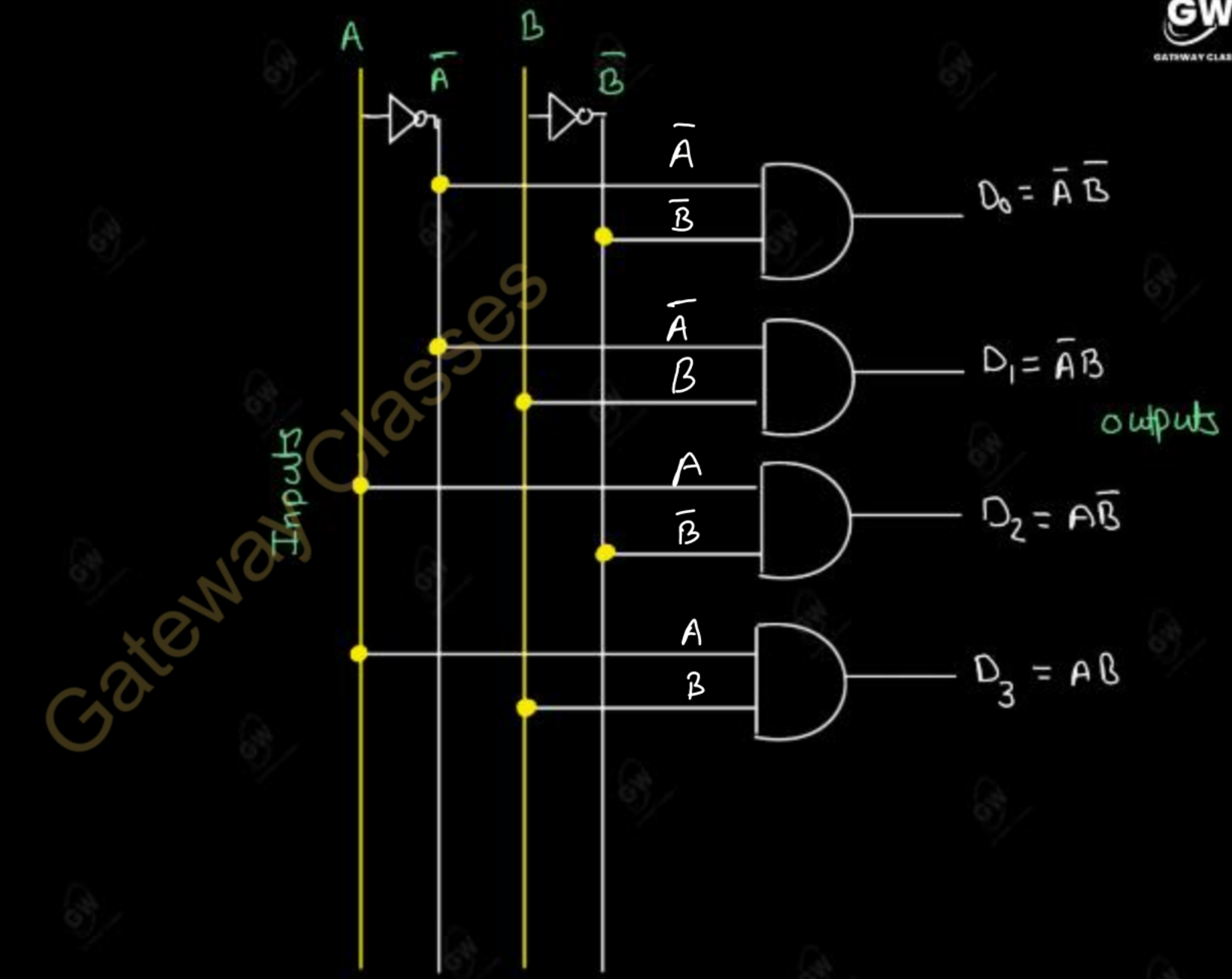
Circuit Realization

$D_0 = \bar{A}\,\bar{B}$

$D_1 = \bar{A}B$

$D_2 = A\bar{B}$

$D_3 = AB$

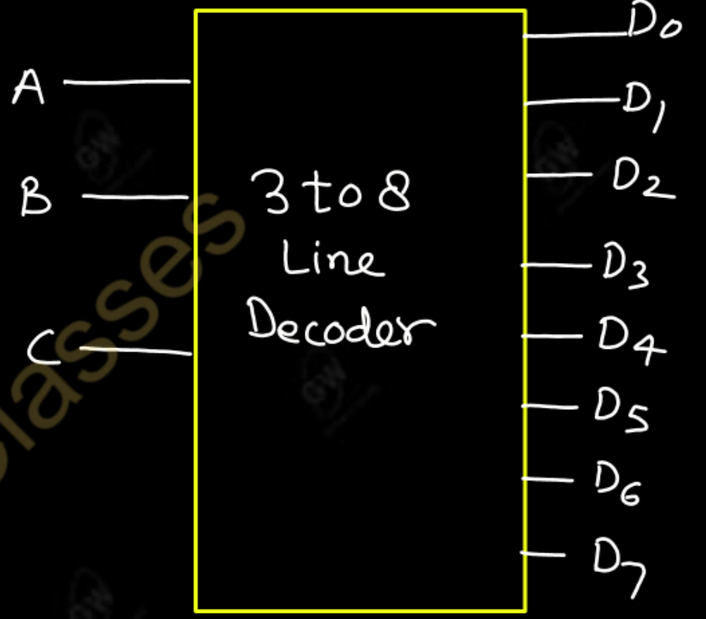


Gateway Classes

A 3 to 8 Line Decoder

$2^n = 2^3 = 8$ line

Input			output							
A	B	C	D0	D1	D2	D3	D4	D5	D6	D7
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



$D_0 = \bar{A}\bar{B}\bar{C}$

$D_1 = \bar{A}\bar{B}C$

$D_2 = \bar{A}B\bar{C}$

$D_3 = \bar{A}BC$

$D_4 = A\bar{B}\bar{C}$

$D_5 = A\bar{B}C$

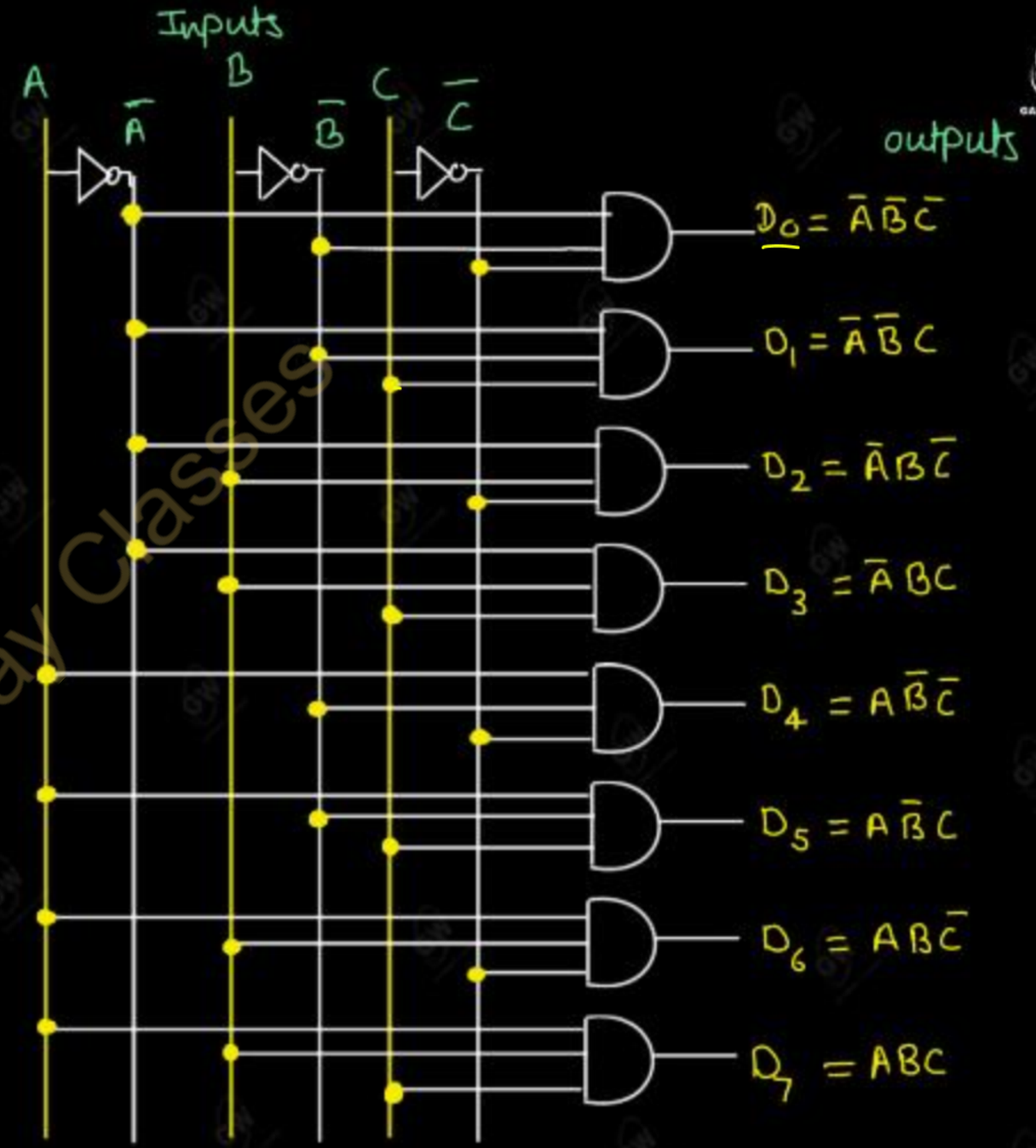
$D_6 = AB\bar{C}$

$D_7 = ABC$

Gateway Classes

A 3 to 8 Line Decoder

Circuit Realization



Gateway Classes

Design a 4 to 16 Line Decoder using 3 to 8 Line Decoder

Circuit Realization

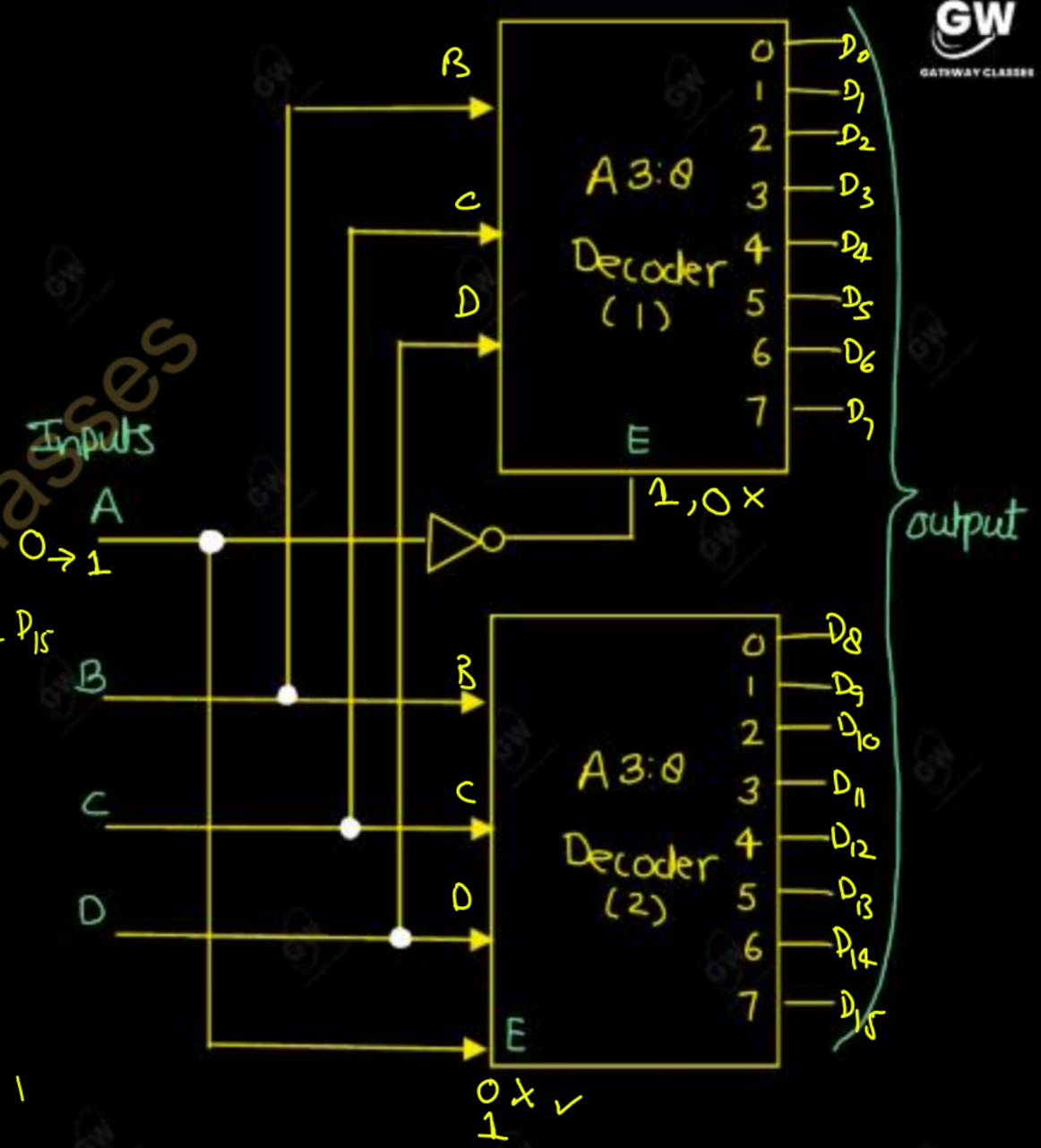
When $A3 = 0$

Decoder 1 active → generates outputs $D0$ to $D7$.

When $A3 = 1$

Decoder 2 active → generates outputs $D8$ to $D15$.

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	1		1														
0	0	1	0			1													
0	0	1	1				1												
0	1	0	0					1											
0	1	0	1						1										
0	1	1	0							1									
0	1	1	1								1								
1	0	0	0									1							
1	0	0	1										1						
1	0	1	0											1					
1	0	1	1												1				
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1	1	1	1																1

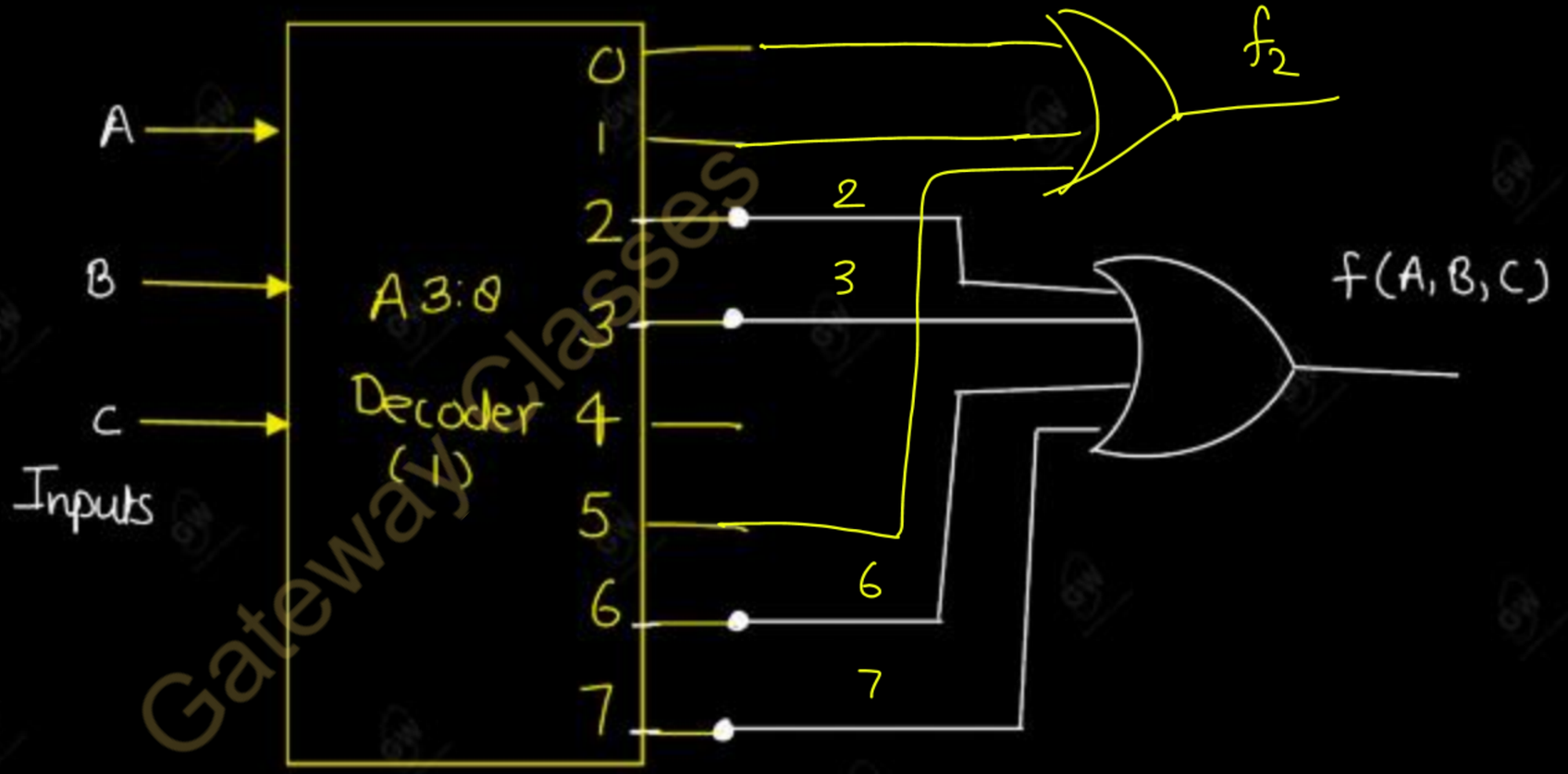


Gateway Classes

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Implement f (A,B,C) = m (2,3,6,7) using 3 to 8 line decoder

m (2,3,6,7)



Gateway Classes

Applications of Decoders

- Memory Address Decoding → Selecting memory location in RAM/ROM.
- Instruction Decoding → In CPUs, to decode machine instructions.
- 7-Segment Display Decoder → Converts binary-coded input to display digits.
- Demultiplexing → Used to connect one input line to one of many output lines.
- Digital communication systems.

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