AKTU B.Tech II-Year

GATEWAY CLASSES

EC & EC Allied

DSD : Digital System Design

Unit-2 Lec-2

Gateway Classes



Today's target

- Types of Subtractors
- PYQ

Avinash Sir

AKTU : *DIGITAL SYSTEM DESIGN (BEC-302)* Syllabus

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

Subtractor

A subtractor is a combinational circuit that performs the arithmetic subtraction of two binary numbers.

Just like adders, there are two basic types:

- Half Subtractor
- Full Subtractor

Gateway Classes

Half Subtractor (HS)

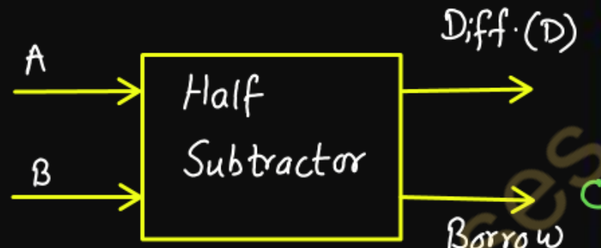
A half subtractor is a combinational circuit with two inputs and two outputs that subtracts one binary digit from another.

Inputs: A (minuend), B (subtrahend)

Outputs: Difference (D) Borrow (Bo)

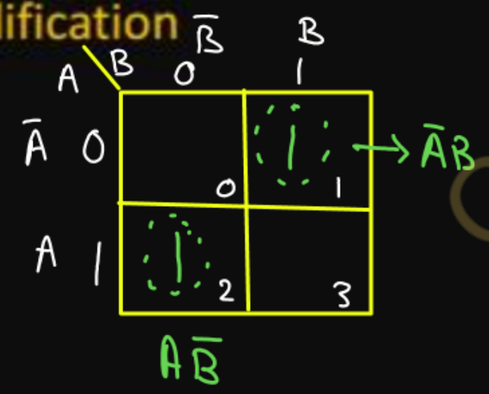
Difference $D = A\bar{B} + \bar{A}B = A \oplus B$

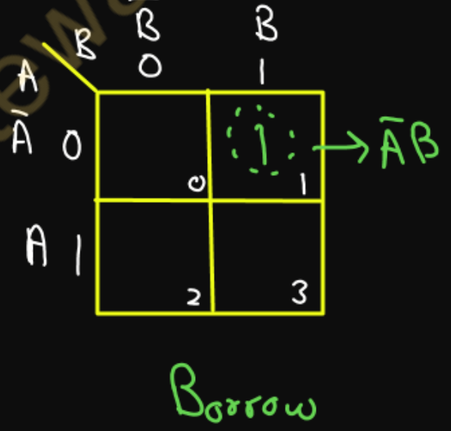
Borrow $B_o = \bar{A}B$



	INPUTS		OUTPUTS	
	A	B	Difference (D)	Borrow (B_0)
0	0	0	0	0
1	0	1	1	1
2	1	0	1	0
3	1	1	0	0

➤ K Map Simplification





Gateway Classes

Limitation of Half Subtractor

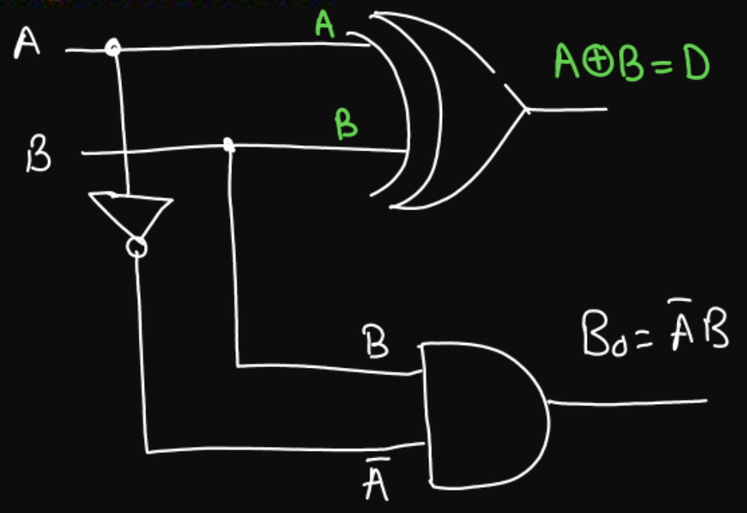
Half Subtractor does not consider a borrow from the previous stage → cannot be used alone for multi-bit subtraction.

Logic Implementation

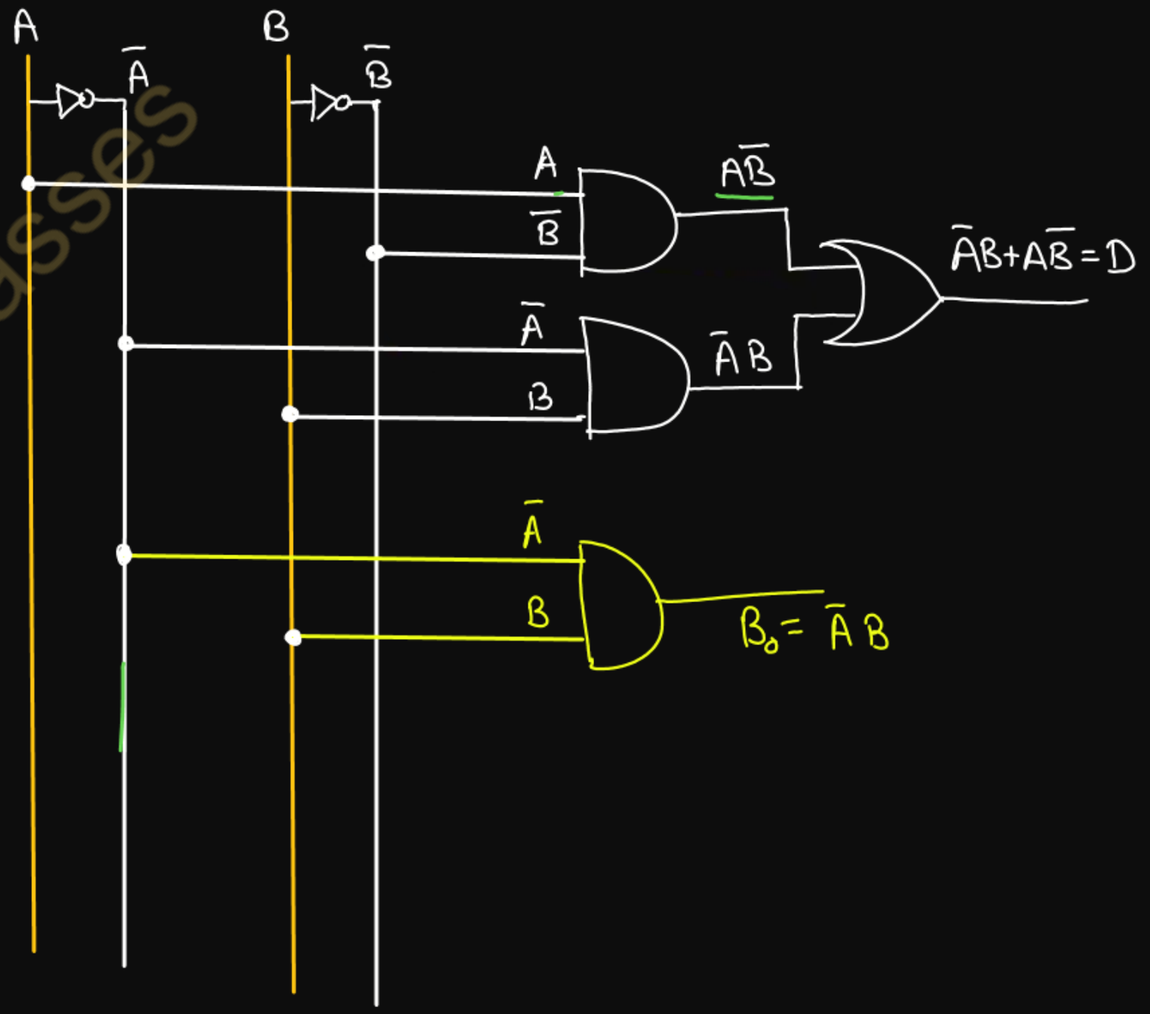
$$D = A\bar{B} + \bar{A}B = A \oplus B$$

$$B_0 = \bar{A}B$$

Using Ex-OR Gate



USING BASIC GATES



Gateway Classes

Logic Implementation Half Subtractor

$\bar{A}B$ $A\bar{B}$

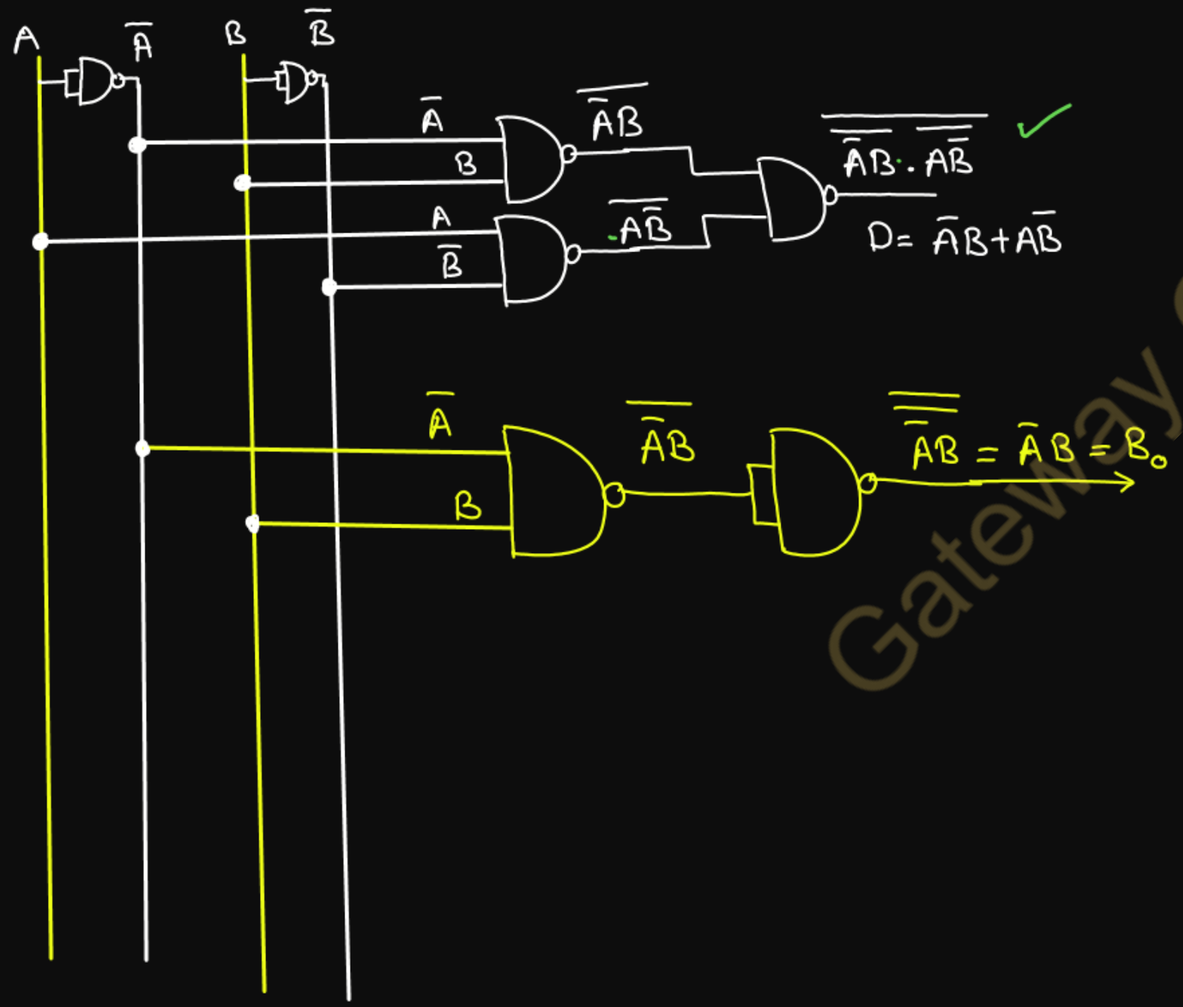
Using NAND Gate

$D = \overline{\bar{A}B + A\bar{B}}$

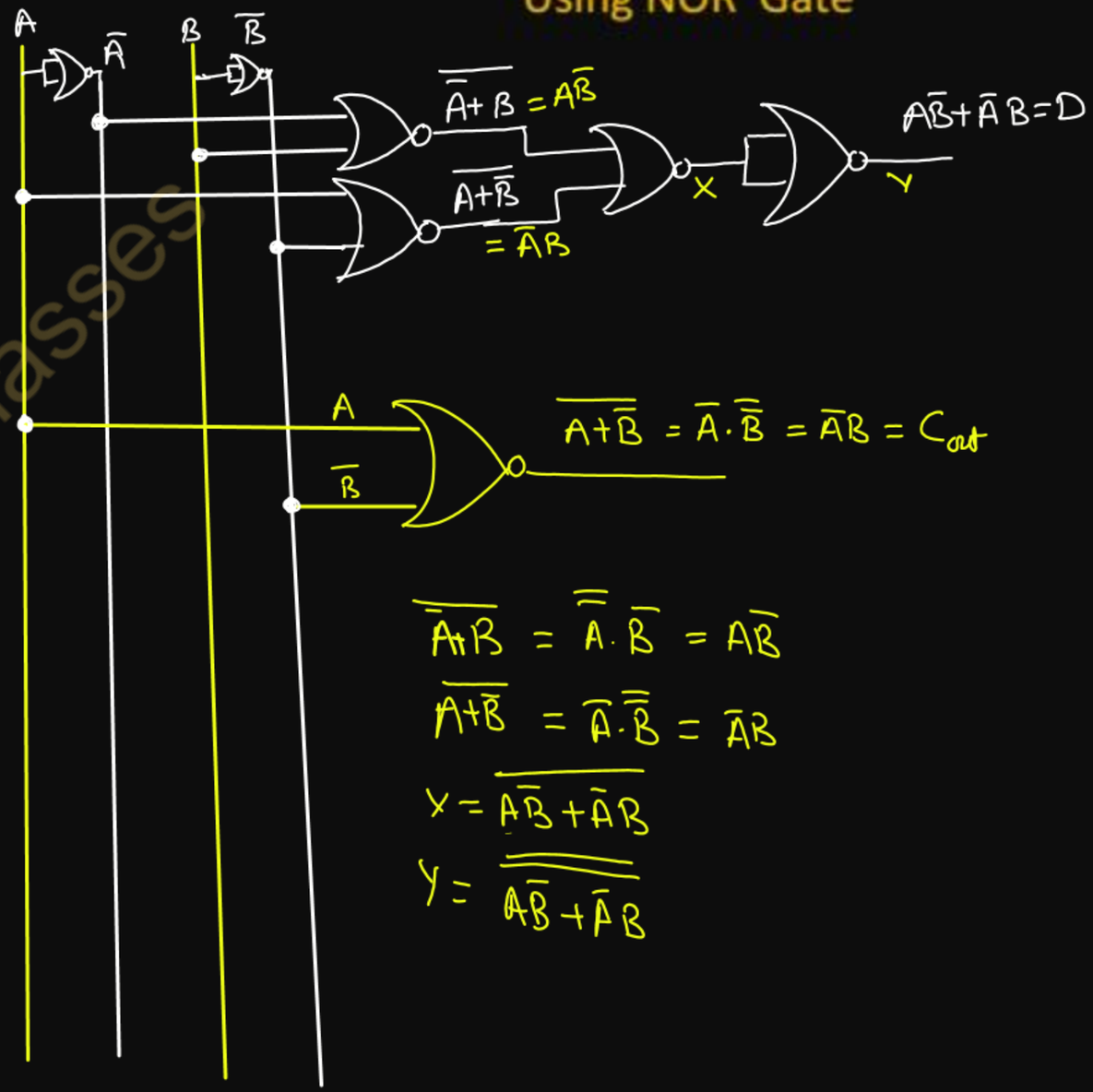
$= \overline{\bar{A}B} \cdot \overline{A\bar{B}}$ ✓

$B_o = \overline{\bar{A}B} = \overline{\bar{A} + B}$

$= \overline{A + \bar{B}}$



Using NOR Gate



$\overline{\bar{A} + B} = \bar{A} \cdot \bar{B} = A\bar{B}$

$\overline{A + \bar{B}} = \bar{A} \cdot \bar{B} = \bar{A}B$

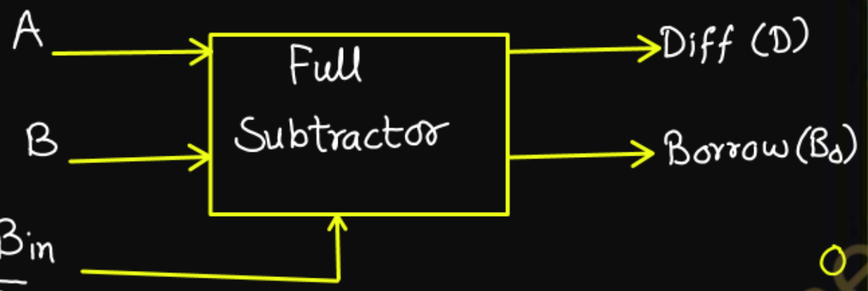
$X = \overline{A\bar{B} + \bar{A}B}$

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

Gateway Classes

Full Subtractor

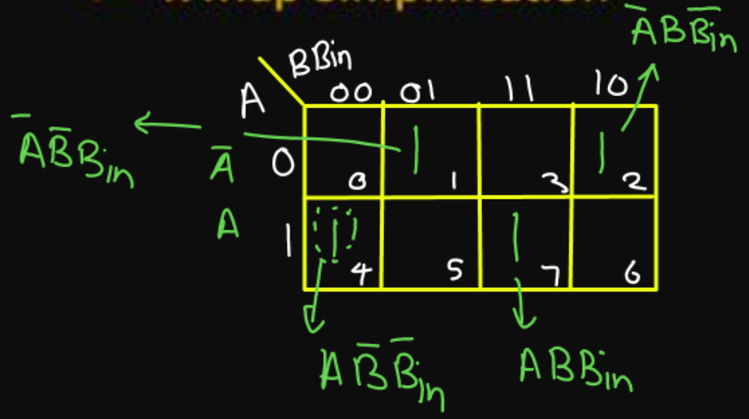
- A full subtractor subtracts three inputs: A (minuend), B (subtrahend), and a borrow-in (Bin) from the previous stage.

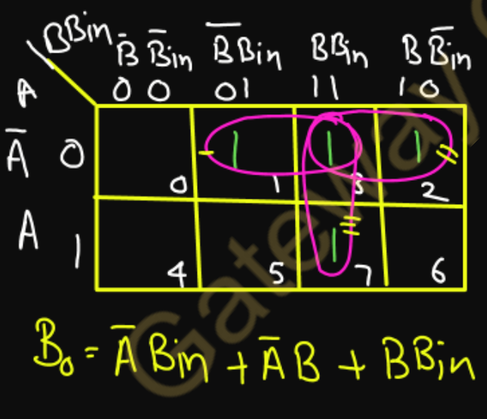


$$D = \bar{A}\bar{B}B_{in} + \bar{A}B\bar{B}_{in} + A\bar{B}\bar{B}_{in} + ABB_{in} = A \oplus B \oplus C_{in}$$

$$B_0 = \bar{A}B_{in} + \bar{A}B + BB_{in}$$

- K Map Simplification





A − B − Bin

	INPUTS			OUTPUTS	
	A	B	B_{in}	Difference (D)	Borrow (B_0)
0	0	0	0	0	0
1	0	0	1	1	1
2	0	1	0	1	1
3	0	1	1	0	1
4	1	0	0	1	0
5	1	0	1	0	0
6	1	1	0	0	0
7	1	1	1	1	1

Gateway Classes

$$D = \bar{A}\bar{B}Bin + \bar{A}B\bar{Bin} + A\bar{B}\bar{Bin} + ABBin$$

$$D = Bin(\bar{A}\bar{B} + AB) + \bar{Bin}(\bar{A}B + A\bar{B})$$

$\bar{A}\bar{B} + AB$: X-NOR → $\bar{X}$

$\bar{A}B + A\bar{B}$: X-OR → X

$$\overline{A \odot B} = A \oplus B$$

$$X = \bar{A}B + A\bar{B} = A \oplus B$$

$$D = Bin\,\bar{X} + \bar{Bin} \cdot X$$

$$D = X \oplus Bin$$

$$D = A \oplus B \oplus Bin$$

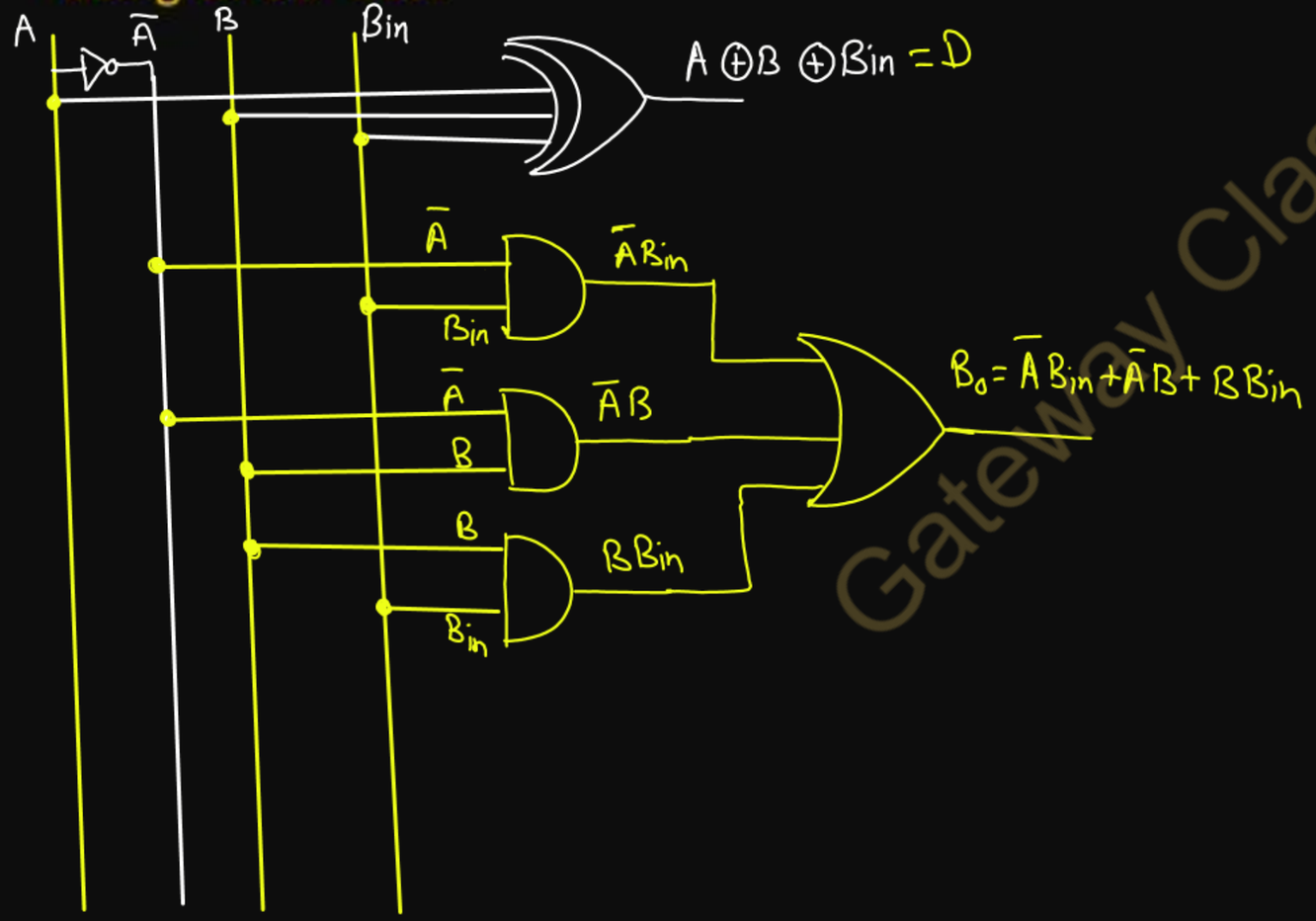
Gateway Classes

Logic Implementation

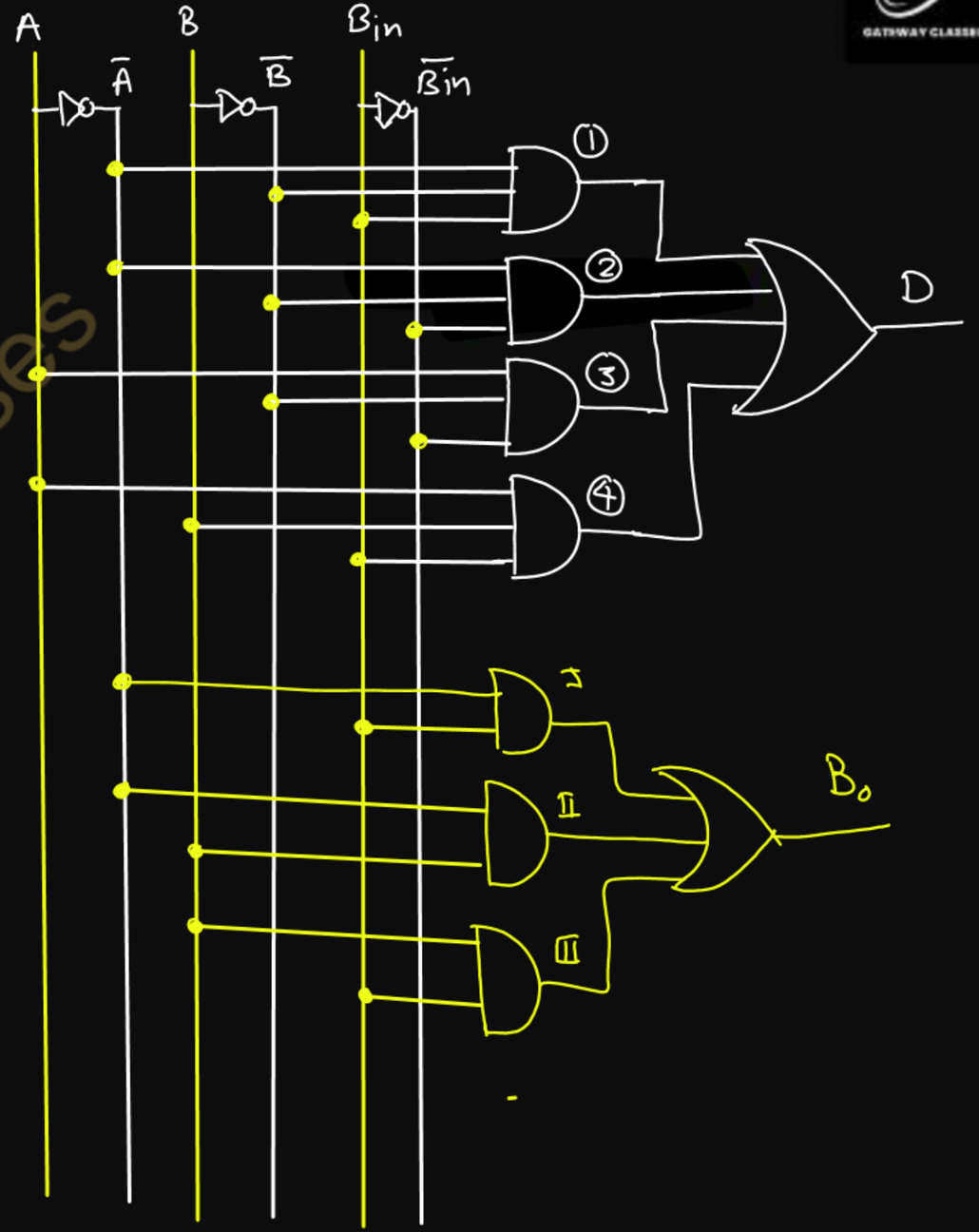
$$D = \underset{①}{\bar{A}\bar{B}B_{in}} + \underset{②}{\bar{A}B\bar{B}_{in}} + \underset{③}{A\bar{B}\bar{B}_{in}} + \underset{④}{AB B_{in}} = A \oplus B \oplus B_{in}$$

$$B_0 = \underset{I}{\bar{A}B_{in}} + \underset{II}{\bar{A}B} + \underset{III}{B B_{in}}$$

Using Ex-OR Gate



Using Basic Gates



Gateway Classes

Logic Implementation

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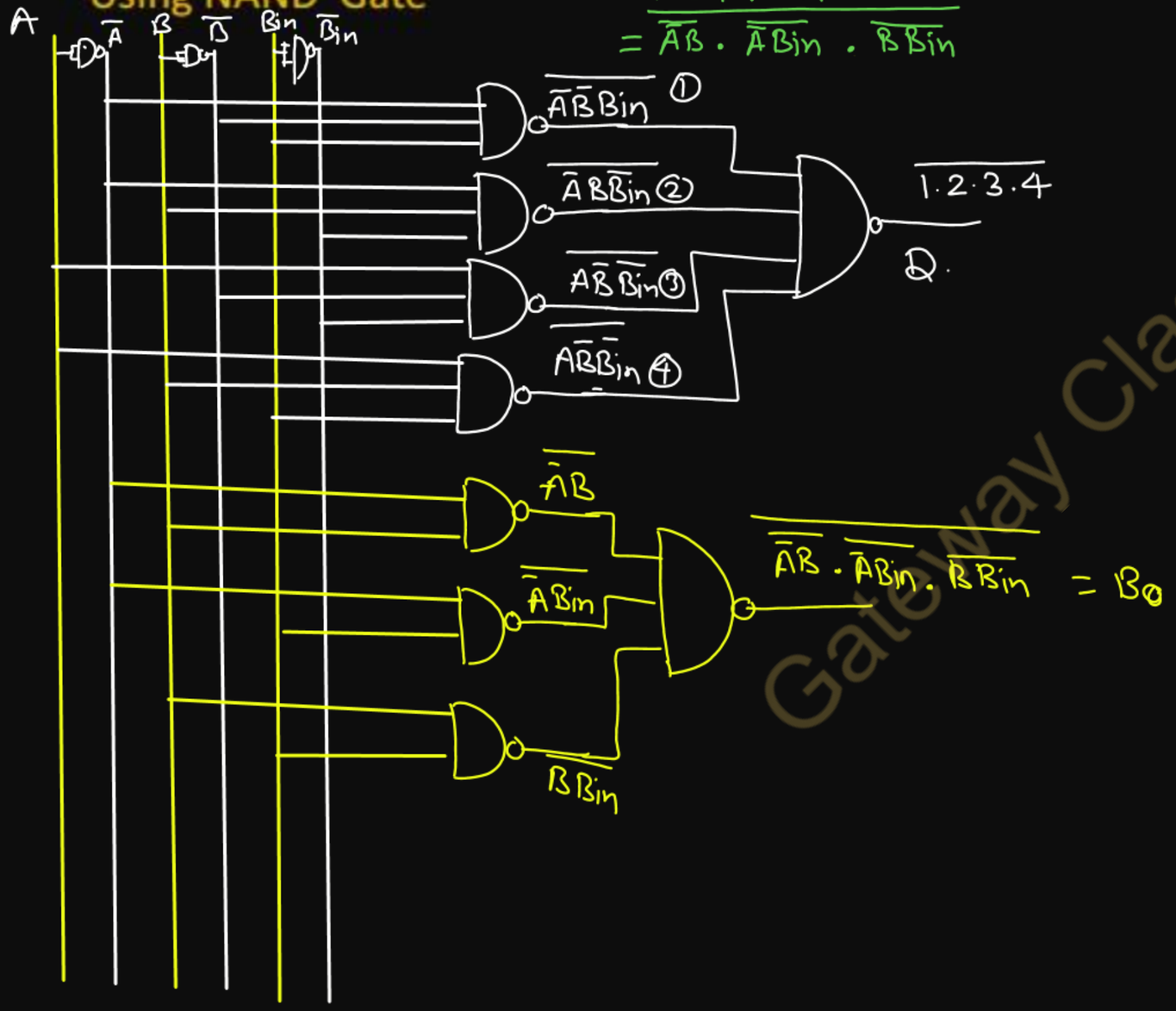
$$D = \overline{\bar{A}\bar{B}Bin + \bar{A}B\bar{Bin} + A\bar{B}\bar{Bin} + ABBin}$$

$$D = \overline{\bar{A}\bar{B}Bin} \cdot \overline{\bar{A}B\bar{Bin}} \cdot \overline{A\bar{B}\bar{Bin}} \cdot \overline{ABBin}$$

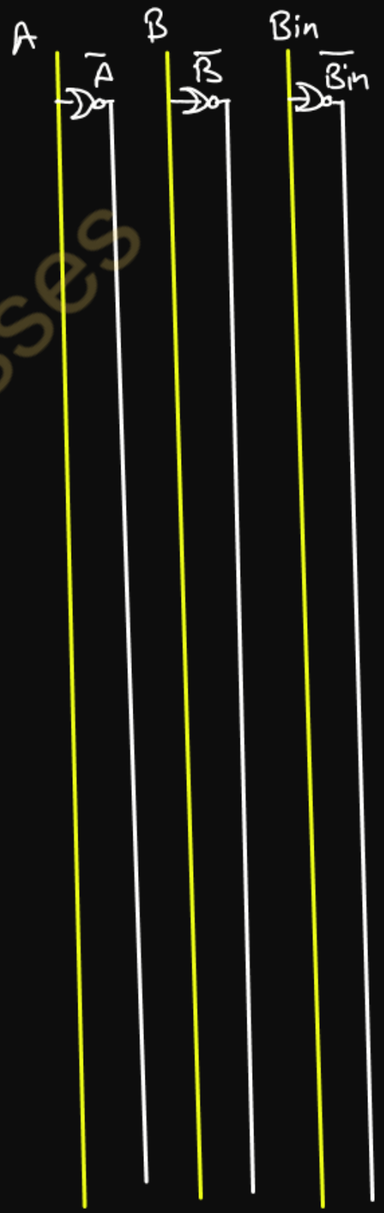
$$B_0 = \overline{\bar{A}B + \bar{A}Bin + B\bar{Bin}}$$

$$= \overline{\bar{A}B} \cdot \overline{\bar{A}Bin} \cdot \overline{B\bar{Bin}}$$

Using NAND Gate



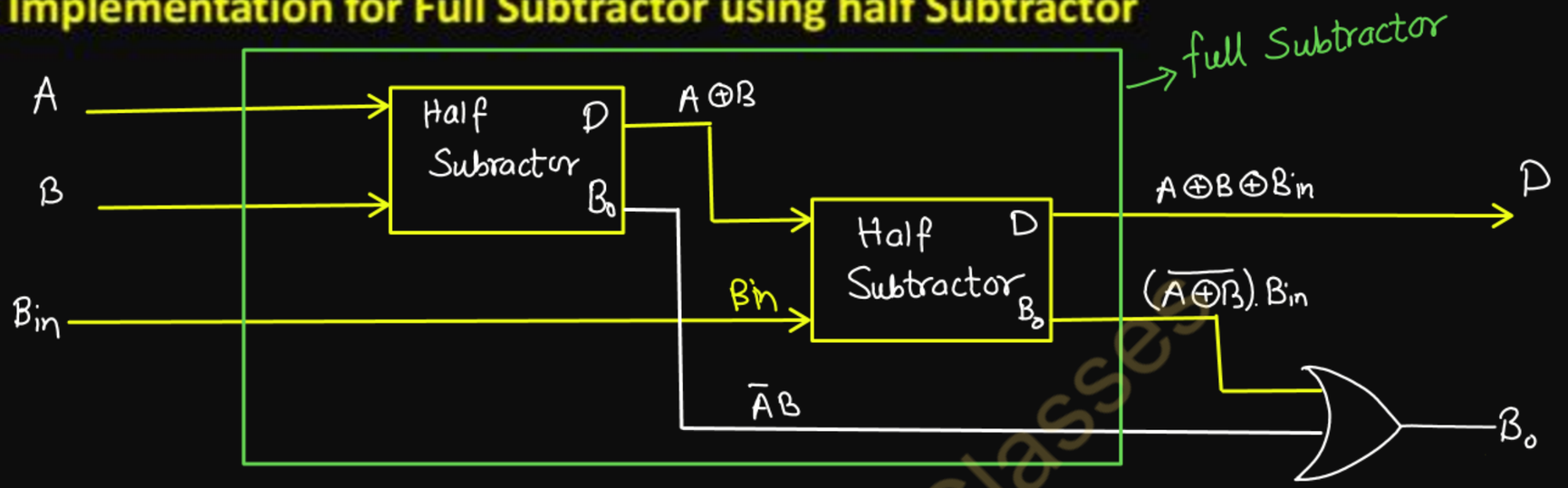
Using NOR Gate



"Do Yourself"

Gateway Classes

Logic Implementation for Full Subtractor using half Subtractor



For Borrow

$1 + B_{in} = 1$

$= \left(\overline{A \oplus B}\right) \cdot B_{in} + \bar{A}B$

$= (A \odot B) B_{in} + \bar{A}B$

$= (\bar{A}\bar{B} + AB) B_{in} + \bar{A}B$

$= \bar{A}\bar{B}B_{in} + ABB_{in} + \bar{A}B(1 + B_{in})$

$= \bar{A}\bar{B}B_{in} + ABB_{in} + \bar{A}B + \bar{A}BB_{in}$

$= BB_{in}(A + \bar{A}) + \bar{A}\bar{B}B_{in} + \bar{A}B$ ($A + \bar{A} = 1$)

$= BB_{in} + \bar{A}\bar{B}B_{in} + \bar{A}B(1 + B_{in})$

$= BB_{in} + \bar{A}\bar{B}B_{in} + \bar{A}B + \bar{A}BB_{in}$

$= BB_{in} + \bar{A}B_{in}(\bar{B} + B) + \bar{A}B$ ($\bar{B} + B = 1$)

$\boxed{B_o = BB_{in} + \bar{A}B_{in} + \bar{A}B}$

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Thank You

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