III-Sem (BEC302 - DIGITAL SYSTEM DESIGN)

AKTU : Syllabus

Unit-I

Logic simplification and combinational logic design: Number Systems, Binary arithmetic, signed magnitude representation, Binary codes, code conversion, review of Boolean algebra and Demorgans theorem, SOP & POS forms, Canonical forms, Karnaugh maps up to 5 variables, tabulation method.

Unit-II

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 7455 9612 84

III-Sem (BEC302 - DIGITAL SYSTEM DESIGN)

AKTU : Syllabus

Unit-III

Sequential logic design: Building blocks like S-R, JK and Master-Slave JK FF, D FF, T FF, edge triggered FF, Flip flop conversion, Applications of Flip Flops: ripple and synchronous counters, Ring counter, Johnson counter, shift registers: SISO, SIPO, PISO, PIPO, Bidirectional shift register, Universal shift register; Finite state machines: Mealy and Moore machines, State diagrams, state reduction, Analysis of clocked sequential circuits, Design of clocked sequential circuits

Gateway Classes: 1455 9612 84

III-Sem (BEC302 - DIGITAL SYSTEM DESIGN)

AKTU : Syllabus

Unit-IV

Logic families and semiconductor memories: TTL NAND gate, specifications, noise margin, propagation delay, fan-in, fan-out, tristate TTL, ECL, CMOS families and their interfacing, memory elements, concept of programmable logic devices like FPGA, logic implementation using programmable devices.

Gateway Classes: 7255 9612 84

III-Sem (BEC302 - DIGITAL SYSTEM DESIGN)

AKTU : Syllabus

Unit-V

Digital-to-Analog converters (DAC): Specifications of DACs, Weighted resistor, R□2R ladder, Analog-to-digital converters (ADC): Specifications of ADCs, principle of ADC, switched capacitor circuits: Basic concept, practical configurations, ADC etc. ADC Types: dual slope, successive approximation, counting type, flash etc.

Gateway Classes : 7455 9612 84

DIGITAL SYSTEM DESIGN

UNIT 1 : LOGIC SIMPLIFICATION AND COMBINATIONAL LOGIC DESIGN

AKTU Syllabus

Logic simplification and combinational logic design: Number Systems, Binary arithmetic, signed magnitude representation, Binary codes, code conversion, review of Boolean algebra and Demorgans theorem, SOP & POS forms, Canonical forms, Karnaugh maps up to 5 variables, tabulation method.

Gateway Classes 7455 961294

DIGITAL SYSTEM DESIGN

UNIT 1 : LOGIC SIMPLIFICATION AND COMBINATIONAL LOGIC DESIGN

Today's Target

- NUMBER SYSTEM ✓
- ITS TRANSFORMATION ✓
- DPP ✓

Gateway Classes : 7455 9012 84

Digital Systems are useful in:

- Communication
- Business Transaction
- Traffic Control
- Spacecraft Guidance
- Medical Treatment etc

Gateway Classes : 7455 9612 84

Advantage of Digital System

- Generality
- Flexible
- Can perform variety of task
- Range over wide spectrum of applications
- Ability to represent and manipulate discrete elements of information.

Gateway Classes : 7455 9612 84

WHAT ARE DIGITAL SYSTEMS?

- Any system which takes digital inputs – process this data – gives digital outputs are digital systems.
- Signals represented in the form of 1's and 0's are called as digital signals.
- This is a form of encoding of signals.
- Group of bits = binary codes

Gateway Classes : 7455 961284

Number Systems:

- ✓ Decimal (Base: 10)
  - Symbols: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
- ✓ Binary (Base 2)
  - Symbols: 0, 1
- ✓ Octal (Base 8)
  - Symbols: 0, 1, 2, 3, 4, 5, 6, 7
- ✓ Hexadecimal (Base 16)
  - Symbols: 0, 1, 2, ---- 9, A, B, C, D, E, F
- ✓ Excess-3 →
- ✓ Gray ✓
- ✓ BCD ✓

Gateway Classes : 7455 9612 84

Binary Number System:

- Uses two symbols 0, 1
- Base or radix = 2
- 1 nibble = 4 bits
- 1 byte = 8 bits
- 1Kbits (kilo) = 2^{10} = 1024 bits
- 1Mbits (mega) = 2^{20} = 1024 x 1024 bits
- 1Gbits (giga) = 2^{30} = 1024 x 1024 x 1024 bits
- 1 Tbits (tera) = 2^{40}

0/1 = Bit

0110

10100100

Gateway Classes : 7455 9612 84

➢Numeric systems :

> we use daily is the decimal system,

> this system is not convenient for machines

> the information is handled codified in the shape of on or off bits

> necessity of knowing the positional calculation

> allow us to express a number in any base where we need it.

Radix number systems :

➢base of a number system or radix

➢ defines the range of values that a digit may have.

Gateway Classes : 7455 9612 84

Conversion: Decimal To Binary

- **Successive division by 2:**

$(68)_{10} = (\quad)_2 = (1000100)_2$

2	68	0
2	34	0
2	17	1
2	8	0
2	4	0
2	2	0
2	1	1
	0,	

Gateway Classes : 7455 9612 84

Example 2 : Decimal Number Conversion

$(0.683)_{10} = (0.1010\ldots)_2$

$0.683 \times 2 = 1.366$ → 1

$0.366 \times 2 = 0.732$ → 0

$0.732 \times 2 = 1.464$ → 1

$0.464 \times 2 = 0.928$ → 0

Gateway Classes : 7455 9612 84

$(62.34)_{10} = (111110.0101)_2$

2	62	0
2	31	1
2	15	1
2	7	1
2	3	1
2	1	1
	0	

$0.34 \times 2 = 0.68$ — 0

$0.68 \times 2 = 1.36$ — 1

$0.36 \times 2 = 0.72$ — 0

$0.72 \times 2 = 1.44$ — 1

Gateway Classes : 7455 962 84

HOME WORK

1) Convert $(2532)_{10}$ to binary

2) Convert $(0.528)_{10}$ to binary

3) Convert $((1685.29)_{10}$ to binary

4) Convert $(1546)_{10}$ to $(\text{-- })_2$

5) Convert$(0.445)_{10}$ to $(\text{-- })_2$

6) Convert$(1.5629)_{10}$ to $(\text{-- })_2$

Gateway Classes : 7455 9612 84

DIGITAL SYSTEM DESIGN

UNIT 1 : LOGIC SIMPLIFICATION AND COMBINATIONAL LOGIC DESIGN

Today's Target

Conversion of

- Binary number to Decimal
- Decimal to octal
- Binary to Octal
- DPP

Gateway Classes : 7455 961 284

Binary To Decimal Conversion

- The decimal number is equal to the sum of binary digits (d_n) times their power of 2 (2^n):

$$\text{decimal} = d_0\times2^0 + d_1\times2^1 + d_2\times2^2 + \dots$$

MSB LSB

1 0 1 1

$1\times2^3 + 0\times2^2 + 1\times2^1 + 1\times2^0$

$8 + 0 + 2 + 1$

$= (11)_{10}$

1 0 1 0 1 1

$1\times2^5 + 0\times2^4 + 1\times2^3 + 0\times2^2 + 1\times2^1 + 1\times2^0$

$32 + 0 + 8 + 0 + 2 + 1$

$= (43)_{10}$

Gateway Classes : 7455961284

Example: Find the decimal value of 111001_2

$$(0.111001)_2$$

$$= 0 + 1 \times 2^{-1} + 1 \times 2^{-2} + 1 \times 2^{-3} + 0 \times 2^{-4} + 0 \times 2^{-5} + 1 \times 2^{-6}$$

$$= 0 + \frac{1}{2} + \frac{1}{4} + \frac{1}{8} + 0 + 0 + \frac{1}{64}$$

$$= 0.5 + 0.25 + 0.125 + 0 + 0 +$$

$$= (\quad)_{10}$$

Gateway Classes: 7455 96 3 84

Binary with decimal point

$(1101.101)_2 = (\ )_{10}$

$1\times2^3 + 1\times2^2 + 0\times2^1 + 1\times2^0 + 1\times2^{-1} + 0\times2^{-2} + 1\times2^{-3}$

$8 + 4 + 0 + 1 + 0.5 + 0 + 0.125$

$13 + 0.625$

$= (13.625)_{10}$

Gateway Classes : 7455 9612 84

Decimal To Octal

- **Convert decimal number 210 into octal number.**

$(210)_{10} \longrightarrow (1262)_8$

8	210	2
8	26	6
8	10	2
8	1	1
	0	

Gateway Classes : 7455 9612 84

Conversion of Decimal Fraction Number in Octal Number

$(0.12)_{10} = (\quad)_8 = (0.07514)_8$

$0.12 \times 8 = 0.96 \rightarrow 0$

$0.96 \times 8 = 7.68 \rightarrow 7$

$0.68 \times 8 = 5.24 \rightarrow 5$

$0.24 \times 8 = 1.92 \rightarrow 1$

Gateway Classes : 7455 961284

$$(10.56)_{10} = (12.436)_8$$

8	10	2
8	1	1
	0	

$0.56 \times 8 = 4.48$ → 4

$0.48 \times 8 = 3.84$ → 3

$0.84 \times 8 = 6.72$ → 6

Gateway Classes : 7455 961 284

Binary To Octal Conversion

There are two methods:

1) Binary to Decimal to Octal
2) Grouping

Gateway Classes : 7455 9612 84

Convert binary number 10010110 into octal number.

Method-I

$$1\ 0\ 0\ 1\ 0\ 1\ 1\ 0$$

$$1\times2^{7}+0+0+1\times2^{4}+0\times2^{3}+1\times2^{2}+1\times2^{1}+0\times2^{0}$$

$$128+16+4+2+0$$

$$(150)_{10}$$

8	150	6
8	18	2
8	2	2
	0	

$$= (226)_8$$

$$(10010110)_2 \rightarrow (226)_8$$

Gateway Classes : 7455961284

Convert binary number 10010110 into octal number.

Method-II

$$\underline{\underline{(}}\,101\,100\,101\,.\,100\,100\,010\,\underline{\underline{)_2}}$$

$$5\quad 4\quad 5\,.\,4\quad 4\quad 2$$

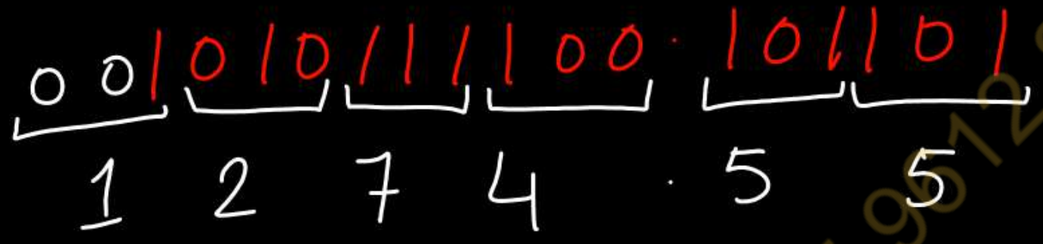
$$(10110010\,1.100100010)_2$$

$$=(545.442)_8$$

0 →	0 0 0
1 →	0 0 1
2 →	0 1 0 ✓
3 →	0 1 1
4 →	1 0 0 ✓
5 →	1 0 1 ✓
6 →	1 1 0
7 →	1 1 1

Gateway Classes 7455 964 284

Convert binary number 1010111100.101101 into octal number.



$$= (1274.55)_8$$

Gateway Classes : 7455 9512 84

DPP :Lec-2

Convert :

a) $(1011010.10110)_2 = (\ )_{10}$

b) $(1011010)_2 = (\ )_{10}$

c) $(0.10110)_2 = (\ )_{10}$

d) $(421)_{10} = (\ )_8$

e) $(125.68)_{10} = (\ )_8$

f) $(1011010)_2 = (\ )_8$

g) $(10111010.10110)_2 = (\ )_8$

Gateway Classes : 7455 9612 84

GATEWAY CLASSES

ANY DOUBT????

Gateway Classes 7455 9612 84

DIGITAL SYSTEM DESIGN

UNIT 1 : LOGIC SIMPLIFICATION AND COMBINATIONAL LOGIC DESIGN

Today's Target

- Conversion of Decimal number to Hexa Decimal Number
- Hexa Decimal to Decimal conversion
- Binary to Hexa Decimal Conversion
- DPP

Gateway Classes: 7455 961 284

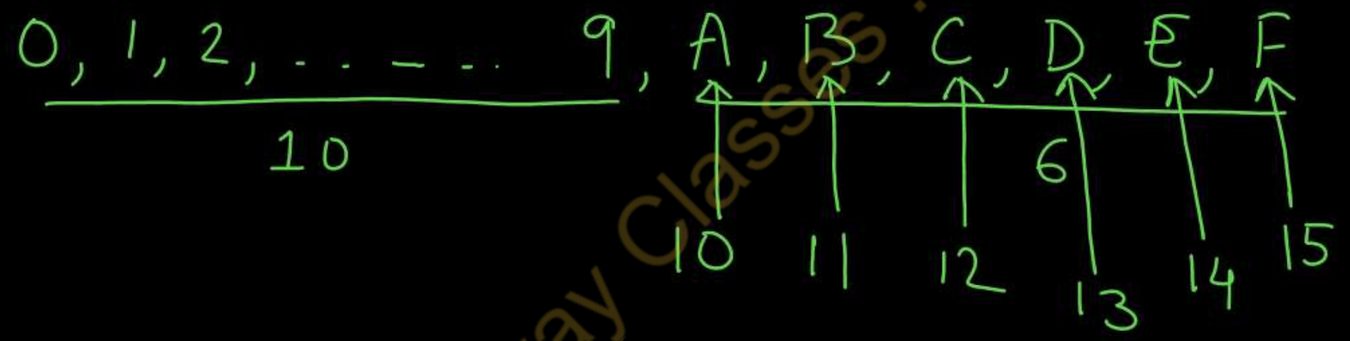
Decimal to Hexadecimal Conversion:

6 10

1) Divide the decimal by 16 until the result is 15 or less.

2) Take the whole number (before the decimal point) and look up the corresponding hex value in the hex-decimal comparison list above (e.g. 10 = A, 15 = F).

3) Take the remainder (after the decimal point) and multiply by 16.



Gateway Classes : 7455 9612 84

Example: Find the Hex equivalent of decimal number 3509

$(3509)_{10} = (\quad)_H = (\quad)_{16}$

16	3509	5
16	219	11 → B
16	13	13 → D
	0	

↑

A	B	C	D	E	F
10	11	12	13	14	15

$(3509)_{10} = (DB5)_{16}$

Gateway Classes : 7455 9612 84

Fractional Decimal to Hex Conversion

$(0.1204)_{10} \rightarrow (\quad)_H$

$0.1204 \times 16 \rightarrow 1.9264$ → 1

$0.9264 \times 16 \rightarrow 14.8224$ → 14 ← E

$0.8224 \times 16 \rightarrow 13.1584$ → 13 ← D

$0.1584 \times 16 \rightarrow 2.5344$ → 2

$(0.1204)_{10} \rightarrow (1ED2)_{16}$

Gateway Classes : 7455 9612 84

Whole & Fractional Decimal number to Hex Conversion

$(148.62)_{10} \longrightarrow (\quad)_H$

16	148	4
16	9	9
	0	

$0.62 \times 16 = 9.92$

$0.92 \times 16 = 14.72$

$0.72 \times 16 = 11.52$

$0.52 \times 16 = 8.32$

9
14 → E
11 → B
8

$(148.62)_{10} \rightarrow (94.9EB8)_H$

Gateway Classes 7455 0612 84

Hexadecimal To Decimal Conversion:

$(AE73)_{16} = (\ )_{10}$



$10 \times 16^3 + 14 \times 16^2 + 7 \times 16^1 + 3 \times 16^0$

$= 10 \times 4096 + 14 \times 256 + 7 \times 16 + 3 \times 1$

$= 40960 + 3584 + 112 + 3$

$= (44659)_{10}$

Gateway Classes : 7455 9612 84

Fractional Hex Number to Decimal Conversion

$(11A \cdot 35B)_{16} \rightarrow (\quad)_{10}$

$1 \times 16^2 + 1 \times 16^1 + 10 \times 16^0 + 3 \times 16^{-1} + 5 \times 16^{-2} + 11 \times 16^{-3}$

$= 256 + 16 + 10 + 0.1875 + 0.01953 + 0.002685$

$= (282.2097)_{10}$

Gateway Classes : 7455 9612 84

Binary to Hex Conversion

$$(\quad)_2 = (\quad)_{10} = (\quad)_H$$

$$\underbrace{0101}_{5}\ \underbrace{0110}_{6}\ \underbrace{1000}_{8}\ \underbrace{1101}_{D}.\ \underbrace{1100}_{C}\ \underbrace{1010}_{A}$$

$$= (568D \cdot CA)_H$$

0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
10	1010
11	1011
12	1100
13	1101
14	1110
15	1111

Gateway Classes : 7455961284

DPP

Convert

1) $(15287)_{10}=(\ )_H$
2) $(0.1236)_{10}=(\ )_H$
3) $(1764.286)_{10}=(\ )_H$
4) $(1A6D5)_H=(\ )_{10}$
5) $(1ECB.25)_{10}=(\ )_H$
6) $(1011001101010.10101111)_2=(\ )_H$

Gateway Classes : 7455 9612 84

UNIT 1 : LOGIC SIMPLIFICATION AND COMBINATIONAL LOGIC DESIGN

Today's Target

- BINARY ARITHMATIC OPERATIONS
- Binary Addition, Subtraction, Multiplication, Division
- DPP

Gateway Classes : 7456961284

BINARY ARITHMATIC OPERATIONS

- Binary Addition
- Binary Subtraction
- Binary Multiplication
- Binary Division

Gateway Classes : 7455 9612 84

Binary Addition

A	B	S	Carry
0	0	0	
0	1	1	
1	0	1	
1	1	0	1
1	1	1	1

```
  1 1 1
  1 0 1 1 0
+ 0 1 1 1 1
-------------
1 0 0 1 0 1
```

Result = 100101

Gateway Classes : 7455961284

Binary Subtraction

$0 - 0 = 0$

$1 - 0 = 1$

$1 - 1 = 0$

$0 - 1 = 1$ | 1 = Borrow

$$\begin{array}{r} {\scriptstyle 1} \\ 217 \\ -\ 9 \\ \hline \end{array}$$

Ex:

$$\begin{array}{r} {\scriptstyle 0\ \ 0\ \ 1\ \ 1} \\ 1\,0\,1\,1\,0 \\ -\ 0\,1\,0\,0\,1 \\ \hline 0\,1\,1\,0\,0\,1\,1 \end{array}$$

Gateway Classes : 7455 961284

Binary Multiplication

$0 \times 0 = 0$

$0 \times 1 = 0$

$1 \times 0 = 0$

$1 \times 1 = 1$

$$
\begin{array}{r}
123 \\
\times\ 52 \\
\hline
246 \\
+615X \\
\hline
6396
\end{array}
$$

$$
\begin{array}{r}
10110110 \\
\times\ \ \ \ 0110 \\
\hline
10000000 \\
1\ 0\ 1\ 1\ 0\ 1\ 0\ X \\
1\ 0\ 1\ 1\ 0\ 1\ 0\ X\ X \\
+\ 0\ 0\ 0\ 0\ 0\ 0\ X\ X\ X \\
\hline
100001100
\end{array}
$$

Gateway Classes : 7455 961284

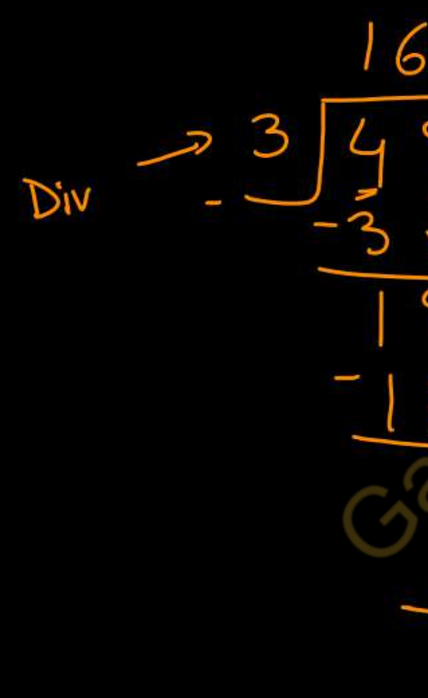
Binary Division

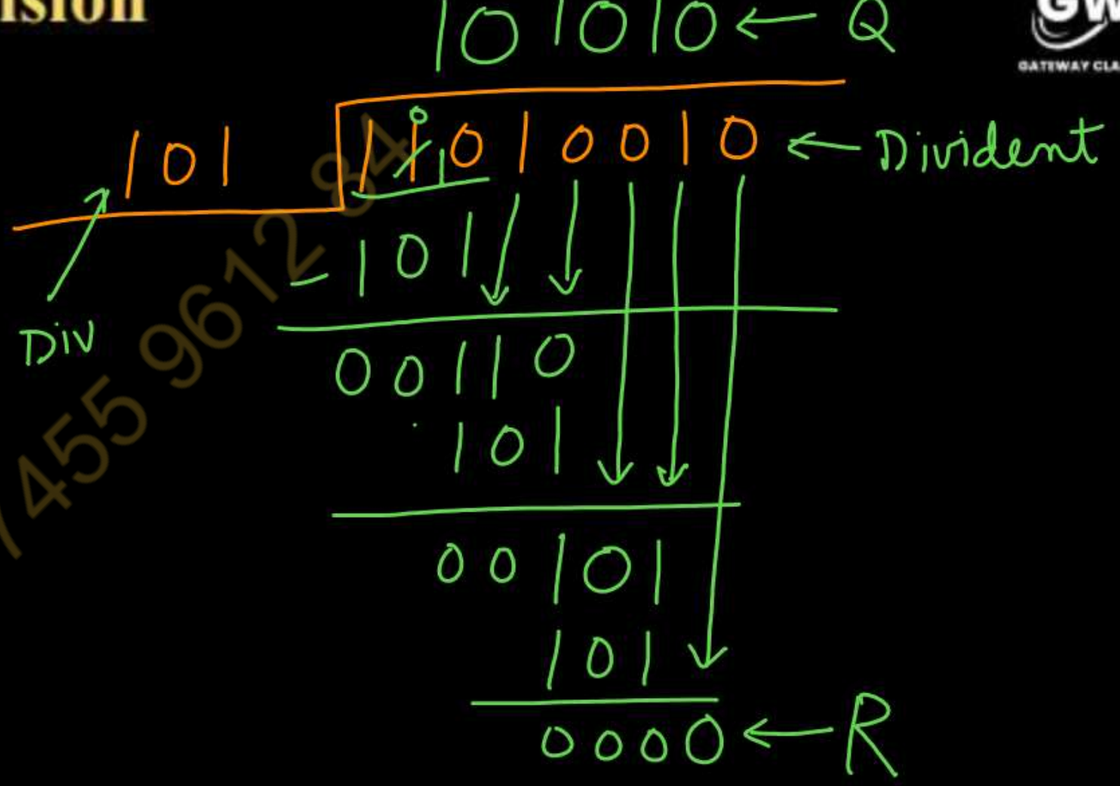
$0 \div 0 = 0$

$0 \div 1 = 0$

$1 \div 0 = ND$

$1 \div 1 = 1$





Gateway Classes : 7455 961294

$$(3\ 3)_6 \rightarrow (\quad)_{10}$$
$$+\ (4\ 5)_6 \rightarrow (\quad)_{10}$$
$$(12\ 2)_6 \qquad (\quad)_6$$

6 —	10
7 —	11
8 —	12
	13
	14
	15
	20
	21
	25

	9
1	0
1	1
1	2
1	3
	⋮
1	9
2	0

99
100

Gateway Classes · 7455 9612 84

UNIVERSITY QUESTIONS

YEAR	QUESTIONS	MARKS
22-23	Convert $(454.523)_{10}$ to an Hexadecimal number	2 marks
20-21	Convert the following: (i) Hexadecimal equivalent of decimal number 256 (ii) Decimal equivalent of $(123)_9$ (iii) $(378.93)_{10}$ to octal (iv) Convert A3BH and 2F3H into binary	10 marks
19-20	The solution to the quadratic equation $k^2 - 11k + 22 = 0$ are k=3 and k=6. What is the base of the number system?	2 marks
18-19	Determine the value of base x, if $(193)_x = (623)_8$	2 marks
17-18	What is (33)6 + (45)6	2 marks
17-18	Convert the following (i) $(562.13)_7 = (?)_{10}$ (ii) $(467.342)_8 = (?)_{10}$	2 marks

$(256)_{10} = (\quad)_H$

$(123)_9$

$1\times9^2 + 2\times9^1 + 3\times9^0 = 81 + 18 + 3$

$= (102)_{10}$

1010 0011 1011

Gateway Classes: 7455961284

$K^2 - 11K + 22 = 0 \Rightarrow (K = 3, K = 6)$

Suppose base = B

For $K = 3$

$3^2 - (1 \times B^1 + 1 \times B^0)3 + (2 \times B^1 + 2 \times B^0) = 0$

$9 - (B + 1)3 + (2B + 2) = 0$

$9 - 3B - 3 + 2B + 2 = 0$

$-B + 8 = 0$

$\boxed{B = 8}$

For $K = 6$

$6^2 - (1 \times B^1 + 1 \times B^0)6 + (2B^1 + 2B^0) = 0$

$36 - (B + 1)6 + (2B + 2) = 0$

$36 - 6B - 6 + 2B + 2 = 0$

$(15)_6$

$1 \times 6^1 + 5 \times 6^0$

$32 - 4B = 0$

$4B = 32$

$\boxed{B = 8}$

Gateway Classes : 7455961284

$(454.523)_{10} = (\quad)_{16}$

16	454	6
16	28	12=C
16	1	1
	0	

$0.523 \times 16 = 8.368$ → 8

$0.368 \times 16 = 5.888$ → 5

$0.888 \times 16 = 14.208$ → 14(E)

$(1C6.85E)_{16}$

Gateway Classes : 7455 961264

DPP

Convert :

a) $(1011)_2 + (11010)_2$

b) $(1011010)_2 - (1001001)_2$

c) $(10110)_2 \times (1010)_2$

d) $(1101101)_2 \div (1011)_2$

Gateway Classes : 7455 9612 84

DIGITAL SYSTEM DESIGN

UNIT 1 : LOGIC SIMPLIFICATION AND COMBINATIONAL LOGIC DESIGN

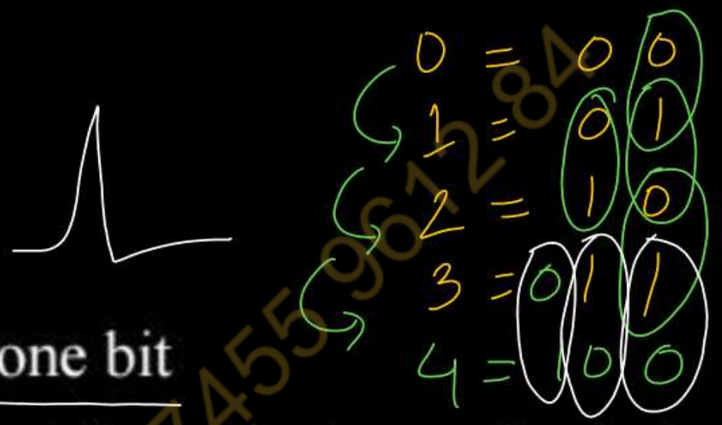
Today's Target

- Gray code
- Binary to Gray Conversion
- Gray to Binary Conversion
- Signed Magnitude Representation
- 1's Complement & 2's Complement of a number
- DPP

Gateway Classes : 7455 961284

Gray code

- The reflected binary code (RBC)
- reflected binary (RB) or Gray code
- after Frank Gray,
- two successive values differ in only one bit



- widely used to prevent spurious output from electromechanical switches
- to facilitate error correction in digital communications such as digital terrestrial television and some cable TV systems.
- Many devices indicate position by closing and opening switches. If that device uses natural binary codes, positions 3 and 4 are next to each other but all three bits of the binary representation differ:

• 3=011 & 4=100

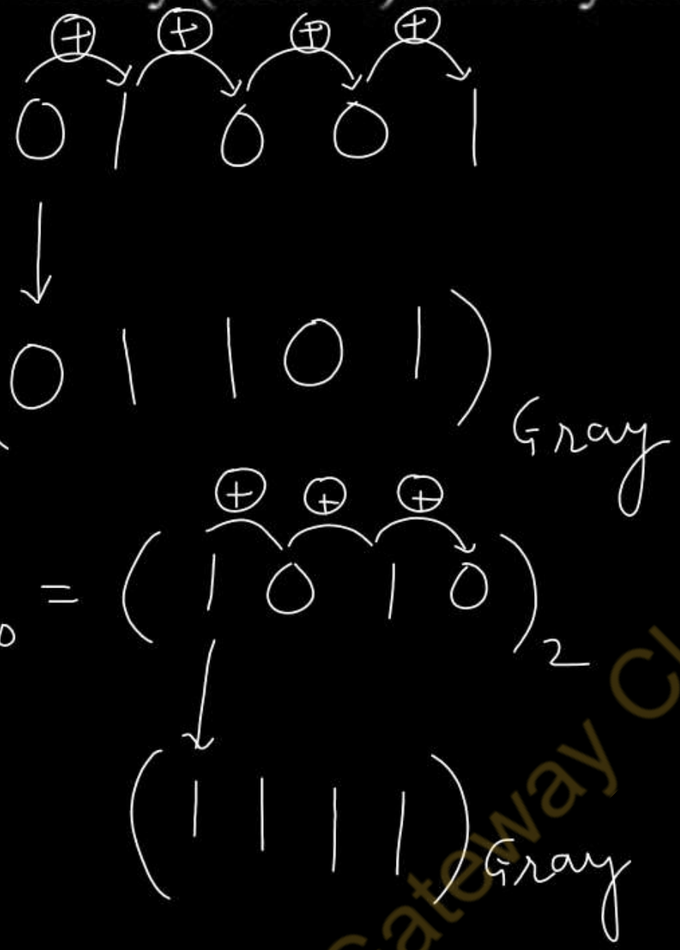
Gateway Classes : 7455961284

DECIMAL	BINARY	GRAY
0	0000	0000
1	0001	0001
2	0010	0011
3	0011	0010
4	0100	0110
5	0101	0111
6	0110	0101
7	0111	0100
8	1000	1100
9	1001	1101
10	1010	1111
11	1011	1110
12	1100	1010
13	1101	1011
14	1110	1001
15	1111	1000

GW GATEWAY CLASSES
GW GATEWAY CLASSES
Gateway Classes : 7455 9612 84

How to Convert Binary to Gray Code

- Convert binary (01001) to Gray Code



Ex- OR

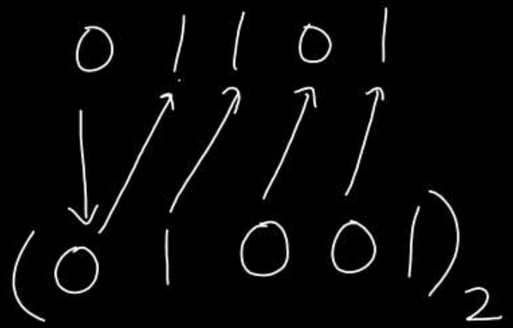
$Y = \bar{A}B + A\bar{B}$

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

Gateway Classes : 7455 9612 84

Gray to Binary Code Converter

- Convert Gray number 01101 to binary



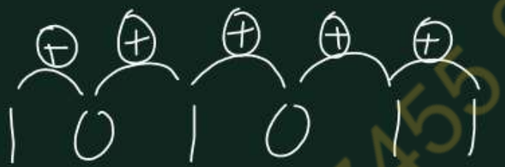


Gateway Classes : 7455961284

$(43)_{10} \Rightarrow (\quad)_{Gray}$

$(43)_{10} = (101011)_2 = (111110)_{Gray}$

2	43	1
2	21	1
2	10	0
2	5	1
2	2	0
2	1	1
	0	



$(1\ 1\ 1\ 1\ 1\ 0)$

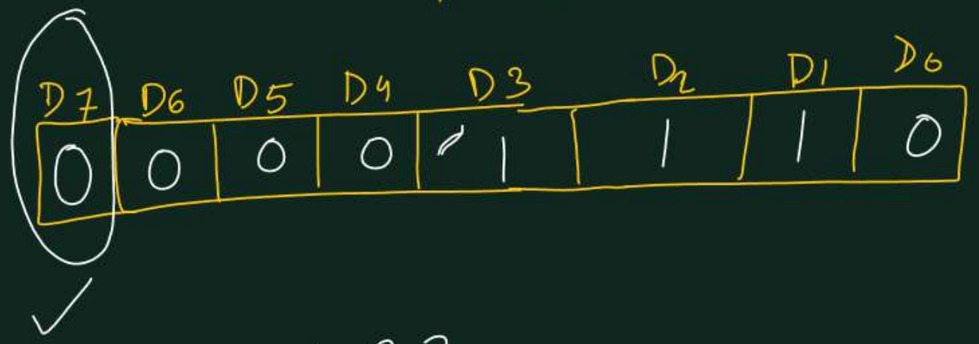
Gateway Classes : 7455 9612 84

Signed Magnitude Representation

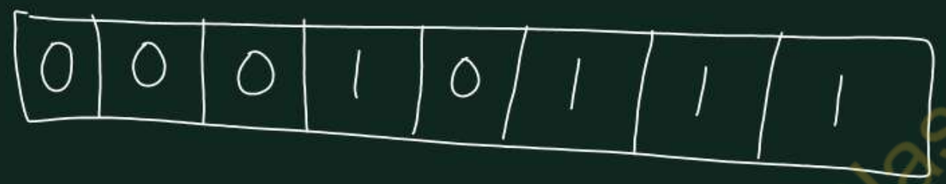
- In the signed magnitude form;
- the MSB(Most Significant Bit) is used to represent the sign
- If the sign bit is zero, the binary number is positive
- If the sign bit is one, the binary number is negative.
- The rest of the bits represent the magnitude of the given number.
- The negative number is represented by its complement form.

Gateway Classes: 7435 9612 84

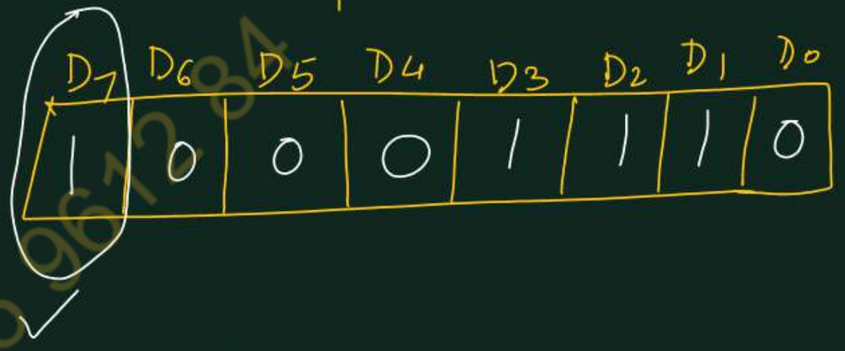
+14



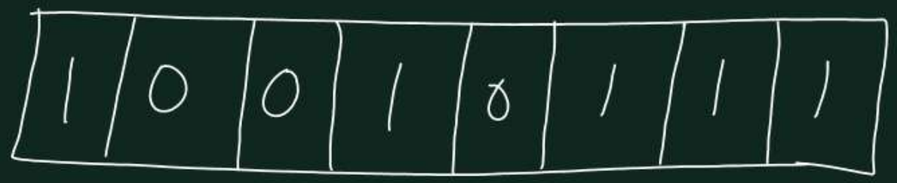
+23



-14



-23



16 8 4 2 1

23 = 1 0 1 1 1

2^4 2^3 2^2 2^1 2^0

Gateway Classes : 7455 9612 84

1's Complement & 2's Complement

- 1's complement of (-19) is:

no = 10011

1's = 01100

2's = 1's + 1

- 2's complement of (-19) is:

no = 10011

2's = 01101

1's = 01100

\+ 1

2's ⇒ 01101

2	19	1
2	9	1
2	4	0
2	2	0
2	1	1
	0	

$(19)_{10} = (10011)_2$

16	8	4	2	1
1	0	0	1	1

Gateway Classes : 7455 9612 84

no ⇒ 1 0 0 1 0 0

2's ⇒ 0 1 1 0 0

no ⇒ 1 0 0 1 0 0

1's ⇒ 0 1 1 0 1 1

\+ 1

2's ⇒ 0 1 1 0 0

Gateway Classes : 7455 9612 84

- 1's complement of 0110.100 is

1's ⇒ 1001.011

- 2's complement of 0110.100 is

2's ⇒ 1001.100

Gateway Classes : 7455 9612 84

DPP

Convert :

a) $(1011010110)_2 = (\ )_{Gray}$

b) $(1011010)_{Gray} = (\ )_2$

c) Find 1's complement of number $(-14.23)_{10}$

d) Find 2's complement of number $(-26.414)_{10}$

Results:

a) (1110111101)

b) (1101100)

c) (0001.11000)

d) (00101.10011)

Gateway Classes 7455 9612 84

UNIVERSITY QUESTIONS

YEAR	QUESTION	MARKS	ANSWER
20-21	Convert binary code (00011011) to gray code.	2 marks	(00010110)
18-19	Define cyclic codes	2 marks	First slide

Gateway Classes : 7455961284

DIGITAL SYSTEM DESIGN

UNIT 1 : LOGIC SIMPLIFICATION AND COMBINATIONAL LOGIC DESIGN

Gateway Classes : 7455 9612 84

Today's Target

- Boolean Algebra Rules
- Boolean Algebra Law
- De-Morgan's Theorem
- Simplification Numerical
- DPP
- AKTU University Question

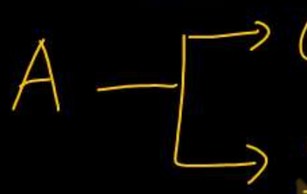
BOOLEAN ALGEBRA

- used to analyze and simplify the digital (logic) circuits
- uses only the binary numbers i.e. 0 and 1
- called as **Binary Algebra** or **logical Algebra**
- invented by **George Boole** in 1854

Gateway Classes 7455 9612 84

Rule in Boolean Algebra

- Variable used can have only two values.



- Binary 1 = HIGH and Binary 0 = LOW.
- Complement of a variable is represented by an overbar (-)/(‘). $\bar{A} = A'$
- Thus if B = 0 then B’= 1 and if B = 1 then B’= 0.

$A + B = Y = 1$

- ORing of the variables is represented by a plus (+) sign between them. Ex- A + B
- Logical ANDing of the two or more variable is represented by a dot between them. Ex- A.B.C. or ABC.

Gateway Classes : 7455 9612 84

Boolean Laws

- There are six types of Boolean Laws.

Addition | Multiplication

1) **Commutative law:** $A+B = B+A$ | $A \cdot B = B \cdot A$

2) **Associative law:** $A(B+C) = AB+AC$

3) **Distributive law:** $A+(B+C) = (A+B)+C$ | $A \cdot (B \cdot C) = (A \cdot B) \cdot C$

4) **AND law:** $A+0 = A$, $A+1 = 1$ | $A+A = A$, $A+\bar{A} = 1$

5) **OR law:** $A \cdot 0 = 0$, $A \cdot 1 = A$ | $A \cdot A = A$, $A \cdot \bar{A} = 0$

6) **INVERSION law:** $\bar{\bar{A}} = A$

Gateway Classes: 7455 9612 84

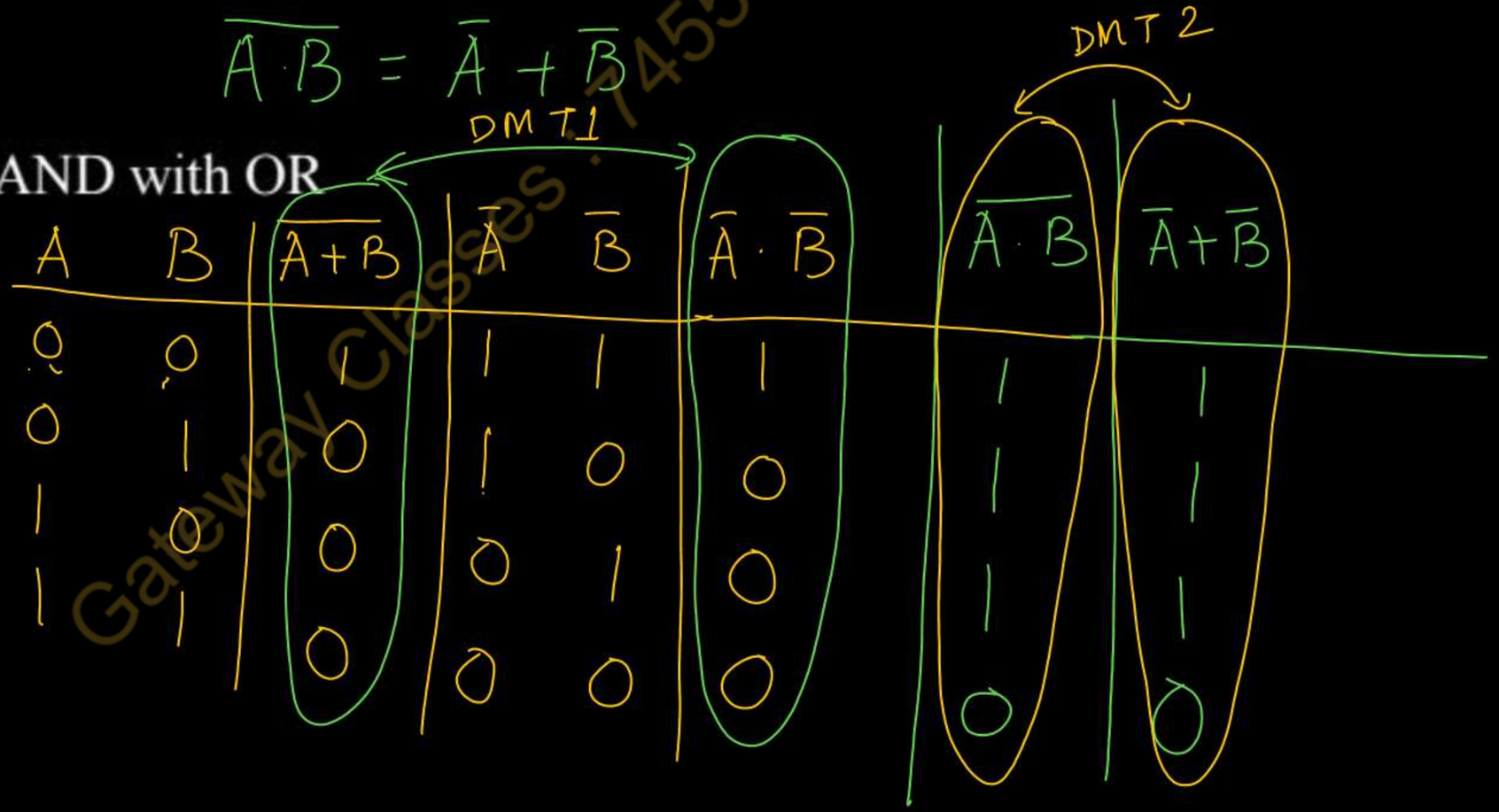
De- Morgan's Theorem

1) $(A+B)' = A'.B'$ ✓ $\quad \overline{A+B} = \bar{A} \cdot \bar{B}$

invert and replace OR with AND

2) $(A.B)' = A' + B'$ $\quad \overline{A \cdot B} = \bar{A} + \bar{B}$

invert and replace AND with OR



Gateway Classes 7455 9612 84

Using the above laws, simplify the following expression:
$(A + B)(A + C)$

$$(A+B)(A+C)$$

$$A(A+C) + B(A+C)$$

$$A \cdot A + A \cdot C + A \cdot B + B \cdot C$$

$$A + AC + AB + BC$$

$$A(1+C) + AB + BC$$

$$A + AB + BC$$

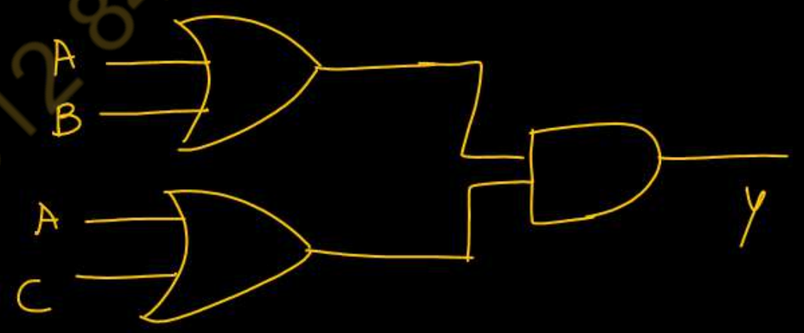
$$A(1+B) + BC$$

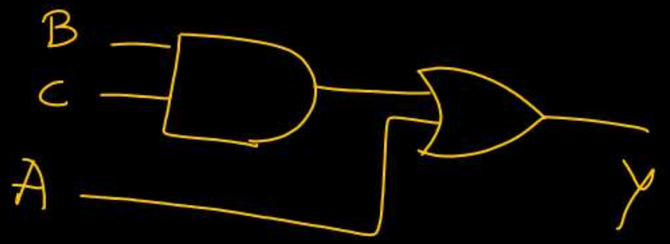
$$A + BC$$

AND Law
$A \cdot A = A$

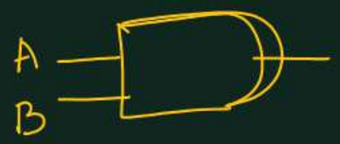
OR Law
$1 + A = 1$

AND Law
$1 \cdot A = A$





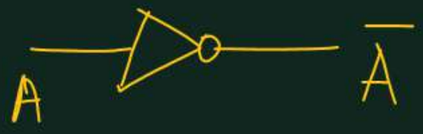
Gateway Classes : 7455 961284

AND 

$Y = A \cdot B$

OR 

$Y = A + B$

NOT 

$\bar{A}$

NAND 

$Y = \overline{A \cdot B}$

NOR 

$Y = \overline{A + B}$

Ex-OR



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

Ex-NOR



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

Gateway Classes : 7455 961284

Simplify the following expression: C + (BC)'

$C + (\overline{BC})$

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

$1 + \bar{B}$

1

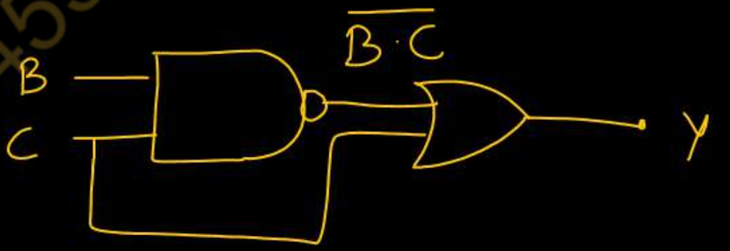
OR Law

$A + \bar{A} = 1$

$1 + A = 1$

De-Morgan's Th^m

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



$Y = 1$

Gateway Classes : 7455 9612 84

Simplify the following expression: $(AB)'(A' + B)(B' + B)$

$\overline{AB}\,(\bar{A}+B)(B+\bar{B})$

Demorgan's th^{m}

$(\bar{A}+\bar{B})(\bar{A}+B)\,1$

$(\bar{A}+\bar{B})(\bar{A}+B)$

$\bar{A}(\bar{A}+B)+\bar{B}(\bar{A}+B)$

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

$\bar{A}+\bar{A}B+\bar{A}\bar{B}+0$

$\bar{A}(1+B)+\bar{A}B$

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

$\bar{A}(1+B)$

$\bar{A}$

OR law

$A+\bar{A}=1$

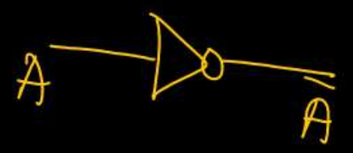
AND law

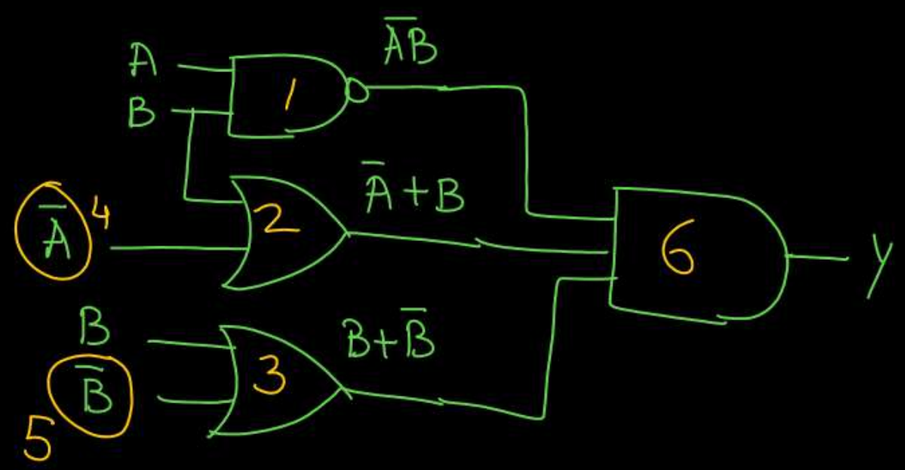
$1\cdot A=A$

AND law

$A\cdot\bar{A}=0$

$A+A=A$





Gateway Classes: 7455 961284

Simplify the following expression: (A + C)(AD + AD') + AC + C

$(A+C)(AD+A\bar{D})+AC+C$

$(A+C)(A[D+\bar{D}])+C(A+1)$

$(A+C)(A)+C$

$A\cdot A+AC+C$

$A+AC+C$

$A(1+C)+C$

$A+C$

OR law

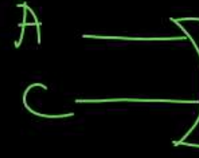
$A+1=1$

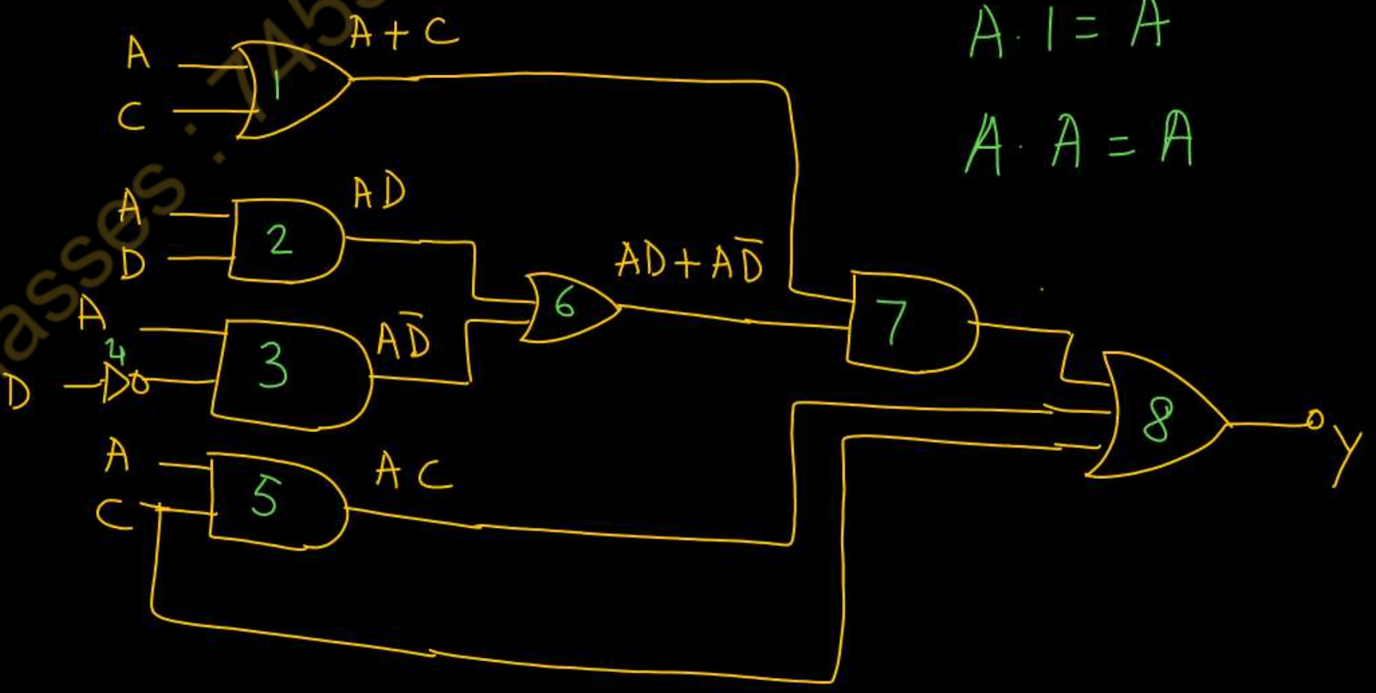
$A+\bar{A}=1$

AND law

$A\cdot 1=A$

$A\cdot A=A$





Gateway Classes : 7455 9612 84

Simplify the following expression: A'(A + B) + (B + AA)(A + B')

$$\bar{A}(A+B)+(B+AA)(A+\bar{B})$$

$$A\bar{A}+\bar{A}B+(B+A)(A+\bar{B})$$

$$0+\bar{A}B+AB+B\bar{B}+AA+A\bar{B}$$

$$\underline{\bar{A}B+AB}+0+\underline{A+A\bar{B}}$$

$$B(\bar{A}+A)+A(1+\bar{B})$$

$$B(1)+A(1)$$

$$B+A$$

Gateway Classes: 7455961284

Simplify the following expression: A + B(A + C) + AC

$$A + B(A + C) + AC$$

$$A + AB + BC + AC$$

$$A(1 + B) + BC + AC$$

$$A + BC + AC$$

$$A(1 + C) + BC$$

$$A + BC$$

Gateway Classes: 7455 9612 84

DPP

Simplify :

a) $\{(AB)' + C\}'B$

b) $AB + BC(B + C)$

c) $AB(B'C + AC)$

d) $(A + B' + C')(A + B' + C)(A + B + C')$

Results:

a) ABC'

b) $B(A + C)$

c) ABC

d) $A + (B' C')$

Gateway Classes : 7455 9612 84

UNIVERSITY QUESTIONS

YEAR	QUESTION	MARKS	ANSWER
20-21	State and Prove Demorgan's theorem	10 marks	

Gateway Classes : 7455 9612 84

DIGITAL SYSTEM DESIGN

UNIT 1 : LOGIC SIMPLIFICATION AND COMBINATIONAL LOGIC DESIGN

Today's Target

- **Binary-coded decimal**
- BCD Representation
- **BCD Addition**
- **BCD Subtraction: by 1's and by 9's complement method**
- **DPP**

Gateway Classes : 7455 96[illegible] 84

Binary-coded decimal

- **Binary-coded decimal** (**BCD**) is: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
- a class of binary encodings of decimal numbers
- each digit is represented by a fixed number of bits, usually four or eight.
- Sometimes, special bit patterns are used for a sign or other indications (e.g. error or overflow).

$+9 = 0\,1001$ $\quad -9 = 1\,1001$

Gateway Classes : 7455 9612 84

BCD Representation for Decimal Digits

dec.	BCD
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001

dec.	BCD
10	0001 0000
	1 0
11 =	0001 0001
435	0100 0011 0101
78	0111 1000

$(1001\ 0110)_{BCD} = (96)_{10}$

Gateway Classes : 7455 9612 84

BCD ARITHMATIC

- BCD Addition
- BCD Subtraction

Gateway Classes : 7455 9612 84

BCD Addition

1) At first the given number are to be added using the rule of binary.

$0 + 0 = 0$
$0 + 1 = 1$
$1 + 0 = 1$
$1 + 1 = 0$ | 1 = carry
$1 + 1 + 1 = 1$ | 1 = carry

2) Result of addition consider two cases:

- **Case 1:** the result of addition is greater than 9 or if a carry bit is present in the result which is not valid for BCD number => Add 6 whose binary equivalent is $(0110)_2$ to the result of addition.

- **Case 2:** The result of addition in is less than 9, which is valid for BCD numbers.

Gateway Classes 7455 961284

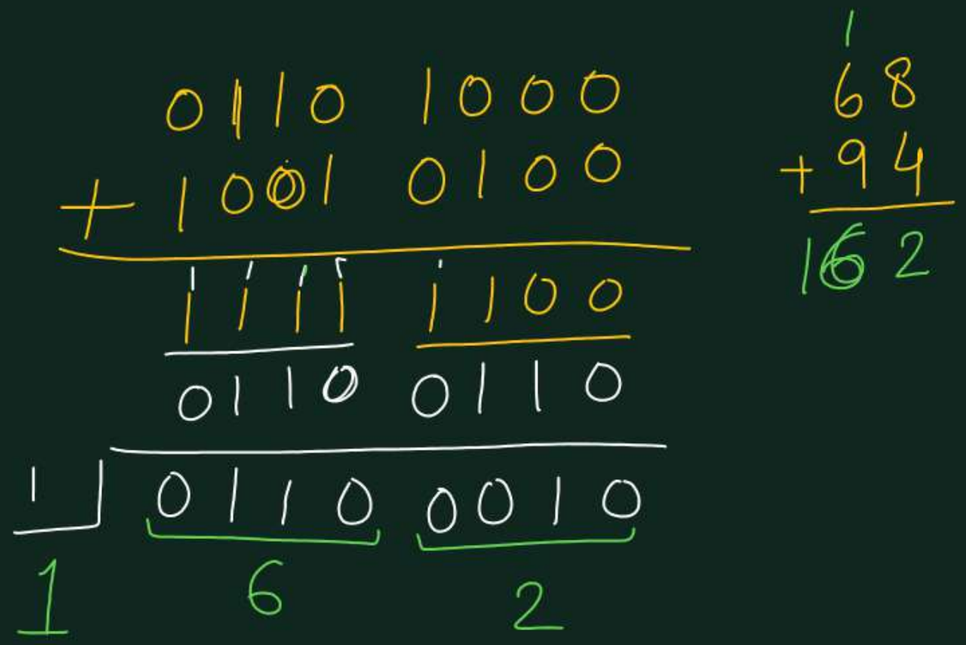
Examples: (i) 1010 + 0101
(ii) 0001 + 0101
(iii) 0001 0001 + 0010 0110

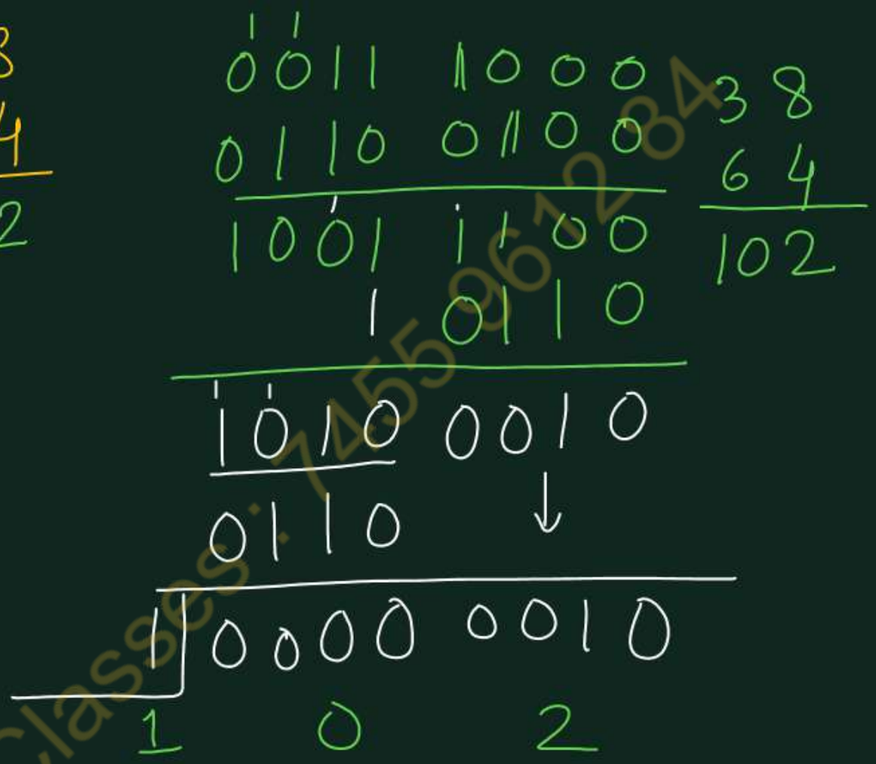
```
  1 0 1 0   = (10)
+ 0 1 0 1   = (5)
-----------
  1 1 1 1  ⇐ Invalid BCD
+ 0 1 1 0
-----------
0001 | 0 1 0 1 |
-----------
  1      5
```

```
    1
  0 0 0 1
+ 0 1 0 1
---------
  0 1 1 0  ⇐ Result
```

```
0001 0001  = 11
0010 0110  +26
-----------
 0011 0111   37
-----------
  3    7
```

Gateway Classes : 7455961284





Gateway Classes: 7455961284

BCD Subtraction

- Method of BCD Subtraction : using 1's complement method

- Method of BCD Subtraction: using 9's complement method

1's complement

$1 \rightarrow 0$

$0 \rightarrow 1$

1's ⇒ 1 1 0 1 / 0 0 1 0

9's Complement

47

$$\begin{array}{r} 99 \\ -\ 47 \\ \hline 52 \end{array}$$ ← 9's of no.

Gateway Classes : 7455961264

Example : (i) 0101 0100 0001 - 0010 0001 0110 **(ii)** $(49)_{10} - (51)_{10}$

(iii) $(57)_{10} - (78)_{10}$

```
 0101 0100 0001          541
-0010 0001 0110         -216
---------------         ----
                        325
  1  1     1     1
I: 0101 0100 0001
1's+1101 1110 1001
---------------------
! 0011 0010 1010 ⇐ Result +ve
      ⊗ 1010
---------------------
  0011 0010 0100
            1
---------------------
  0011 0010 0101
    3    2    5
```

```
0110 ⇐ 6
1010 ⇐ 2's of 6
```

```
 49   0100 1001
-51   0101 0001
---------------
      0
I:    0100 1001
1's:+ 1010 1110
---------------
X  1111 0111 ⇐ Result - ve
   0000 1000 ⇐ 1's of Result
      ⊗ 1010 ⇐ 2's of 6
---------------
   0000 0010
   -(0   2)
```

Gateway Classes : 7455 9612 84

$(57)_{10} - (78)_{10}$

$$\begin{array}{r} 0101\ \ 0111 \\ -\ 0111\ \ 1000 \\ \hline \end{array}$$

$$\begin{array}{lll} & \overset{\otimes}{0}101 & \overset{1\ \ 1}{0}111 \\ \text{I:} & \hline & \hline \\ \text{1's of II:} & +1000 & 0111 \\ \hline \end{array}$$

$$\begin{array}{r} \times\ 1101\ \ 1110 \\ \hline \end{array} \Leftarrow \text{No carry, Result -ve}$$

$$\underline{0010}\ \ \underline{0001} \Leftarrow \text{1's of Result}$$

$$-(2\ \ 1)$$

1) Take I no.
2) Add 1's of II no. (-ve no.)
3) If carry is generated, Result is +ve
   ⇒ If all digits are valid BCD ⇒ Result OK
   ⇒ If digit is invalid BCD add 2's of 6 (i.e. 1010) to invalid digit
4) If no carry → Result is -ve
   ⇒ take 1's of Result
   ⇒ Check if carry was generated from I nibble to 2 nibble
      → If carry generated → add 0110 to lower nibble
      → otherwise take result as it is.

Gateway Classes: 7455 961 784

Example : (iv) $(57)_{10} - (82)_{10}$

1's : 0 1 0 1 0 1 1 1

1's of II : +0 1 1 1 1 1 0 1

× | 1 10 1 0100 ⇐ Result -ve

0010 1011 ⇐ 1's of Result

⊗ 1010 ⇐ 2's of 6

0010 0101

$-(2 \quad 5)$

(v) $(46)_{10} - (78)_{10}$

I : 0100 0110

1's of II : + 1000 0111

| 1100 1101 ⇐ Result -ve

0011 0010 ⇐ 1's of Result

$-(3 \quad 2)$

Gateway Classes : 7455961284

BCD Subtraction: using 9's complement method

- (0101 0001) – (0010 0001)

$$\begin{array}{r} 51 \\ -21 \\ \hline \end{array}$$

$$\begin{array}{r} 99 \\ -21 \\ \hline 78 \end{array} \Leftarrow 9\text{'s of } 21$$

I : 51

9's of II : 78

$$\begin{array}{r} 129 \\ \hookrightarrow\ 1 \\ \hline 30 \end{array} \Leftarrow \text{Result +ve}$$

21 – 51

$$\begin{array}{r} 99 \\ -51 \\ \hline 48 \end{array} \Leftarrow 9\text{'s of } 51$$

I : 21

9's of II : 48

69 ⇐ Result -ve

–(30) ⇐ 9's of Result

$$\begin{array}{r} 99 \\ -69 \\ \hline 30 \end{array}$$

Gateway Classes : 7455961284

DPP

Write :

a) $(1011010.10110)_2 = (\ )_{BCD}$

b) $(247)_{10} = (\ )_{BCD}$

c) $(0.01010010)_{BCD} = (\ )_{10}$

d) $(421)_{10} + (179)_{10} = (\ )_{BCD}$

e) $(125)_{10} - (562)_{10} = (\ )_{BCD}$ using 1's and 9's complement

f) $(721)_{10} - (158)_{10} = (\ )_{BCD}$ using 1's and 9's complement

g) $(845)_{10} - (123)_{10} = (\ )_{BCD}$ using 1's and 9's complement

Gateway Classes : 7455 9612 84

UNIT 1 : LOGIC SIMPLIFICATION AND COMBINATIONAL LOGIC DESIGN

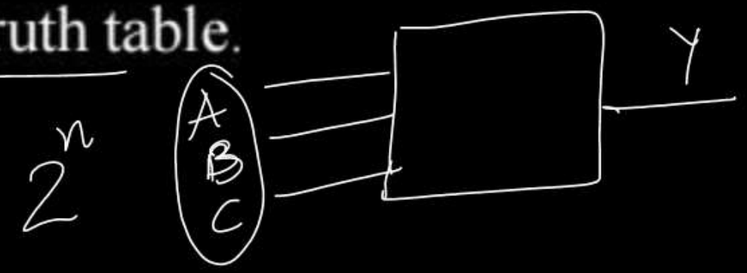
Today's Target

- Truth Table Formation
- Canonical and Standard Forms
- Truth table representing minterm and maxterm
- Express the Boolean function as standard sum of minterms.
- Express the Boolean function as standard sum of maxterms.
- DPP

Gateway Classes : 7455961284

Truth Table Formation

- A truth table represents a table having all combinations of inputs and their corresponding result.
- It is possible to convert the switching equation into a truth table.
- For example, F(A,B,C) = A + BC
- The output will be high (1) if A = 1 or BC = 1 or both are 1
- The number of rows in the truth table is 2^n where n is the number of input variables
- Here there are $2^3 = 8$ possible input combination of inputs.



Gateway Classes : 7455961284

(A+BC) INPUTS			OUTPUT
A	B	C	Y
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

Maxterms

Minterms

Gateway Classes : 7455 9612 84

Generate Truth Table for : $Y = (A' + B) + C$

A	B	C	Y
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

Gateway Classes : 7455 9612 84

CANONICAL AND STANDARD FORMS

- **Canonical Form –**
- In Boolean algebra,Boolean function can be expressed as Canonical Disjunctive Normal Form known as **minterm**
- Some are expressed as Canonical Conjunctive Normal Form known as **maxterm** .
- In Minterm, we look for the functions where the output results in "1" & perform **Sum of minterm = SOP**
- In Maxterm we look for function where the output results in "0" & perform **Product of Maxterm = POS**
- Boolean functions expressed as a sum of minterms or product of maxterms are said to be in canonical form.

Gateway Classes : 7455 961284

Canonical

- SOP (Sum of Product)
- POS (Product of Sum)

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

$(A + \bar{B}) \cdot (\bar{B} + \bar{C}) \cdot (\bar{A} + C)$

$C \quad A$

Gateway Classes 7455 9612 84

Standard Form

- In standard form Boolean function will contain all the variables in either true form or complemented form while in canonical number of variables depends on the output of SOP or POS.

- AB +BC = Canonical SOP
- ABC' + ABC + A'BC = Standard SOP
- (A+B) (B+C) = Canonical POS
- (A+B+C')(A+B+C)(A'+B+C) = Standard POS

Gateway Classes : 7455 9612 84

Truth table representing minterm and maxterm

X	Y	Z	Minterms	Maxterms
0	0	0	$m_0 = \bar{x}\bar{y}\bar{z}$	$M_0 = (x+y+z)$
0	0	1	$m_1 = \bar{x}\bar{y}z$	$M_1 = (x+y+\bar{z})$
0	1	0	$m_2 = \bar{x}y\bar{z}$	$M_2 = (x+\bar{y}+z)$
0	1	1	$m_3 = \bar{x}yz$	$M_3 = (x+\bar{y}+\bar{z})$
1	0	0	$m_4 = x\bar{y}\bar{z}$	$M_4 = (\bar{x}+y+z)$
1	0	1	$m_5 = x\bar{y}z$	$M_5 = (\bar{x}+y+\bar{z})$
1	1	0	$m_6 = xy\bar{z}$	$M_6 = (\bar{x}+\bar{y}+z)$
1	1	1	$m_7 = xyz$	$M_7 = (\bar{x}+\bar{y}+\bar{z})$

Gateway Classes : 7455961284

Example – Express the Boolean function $F = A + B'C$ as standard sum of minterms.

$B + \bar{B}$

$A + A = A$

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

$$= A \cdot 1 \cdot 1 + 1 \cdot \bar{B}C$$

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

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

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

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

$$= \Sigma m(7, 6, 5, 4, 1)$$

Gateway Classes: 7455 9612 84

Express the Boolean function F = xy + x'z as a product of maxterms

$F = xy + \bar{x}z$

$= (xy + \bar{x})(xy + z)$

$A + BC = (A+B)(A+C)$

$= (x + \bar{x})(y + \bar{x})(x + z)(y + z)$

$= (\bar{x} + y)(x + z)(y + z)$

$= (\bar{x} + y + 0)(x + 0 + z)(0 + y + z)$

$= (\bar{x} + y + z\bar{z})(x + y\bar{y} + z)(x\bar{x} + y + z)$

$= (\bar{x} + y + z)(\bar{x} + y + \bar{z})(x + y + z)(x + \bar{y} + z)(x + y + z)(\bar{x} + y + z)$

$A \cdot A = A$

$= (\bar{x} + y + z)(\bar{x} + y + \bar{z})(x + y + z)(x + \bar{y} + z)$

$= \Pi M(4, 5, 0, 2)$

Gateway Classes : 7455961284

Example –Convert F(A, B, C) = ∑m(1,4,5,6,7) to POS FORM

$$F(A,B,C) = \sum m(1,4,5,6,7)$$

$$= \pi M(0,2,3)$$

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

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

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

Gateway Classes : 7455961284

DPP

a) Generate truth table for F= xy + x'z

b) Generate truth table for Y= (a+c') (b+c)

b) Convert Boolean expression in standard form F=y'+xz'+xyz

c) Express the Boolean function F = (A+B')(B+C) as a product of maxterms

Gateway Classes : 7455 9612 84

UNIT 1 : LOGIC SIMPLIFICATION AND COMBINATIONAL LOGIC DESIGN

Today's Target

- Methods to simplify the boolean function
- 2,3,4 Variable K-Map
- Numerical Practice
- DPP
- University Questions

Gateway Classes : 7455 96 12 84

Methods to simplify the boolean function

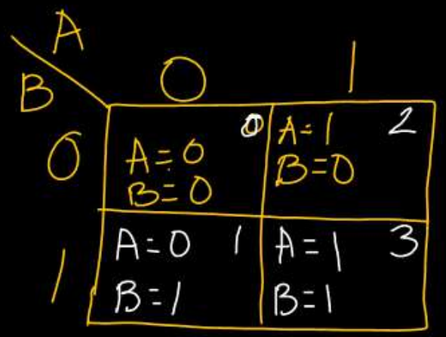
The methods used for simplifying the Boolean function are as follows –

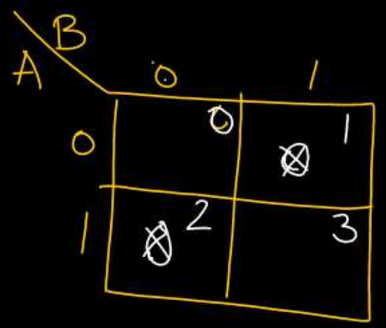
- Karnaugh-map or K-map
- NAND gate method
- Tabular method

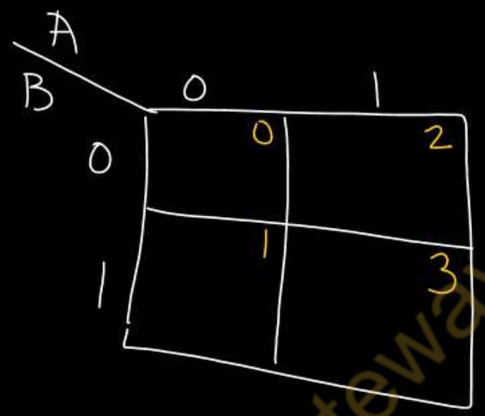
Gateway Classes : 7455 9612 84

2 Variable K-Map

- The number of cells is four, since the number of variables is two.
- **2 variable K-Map.**







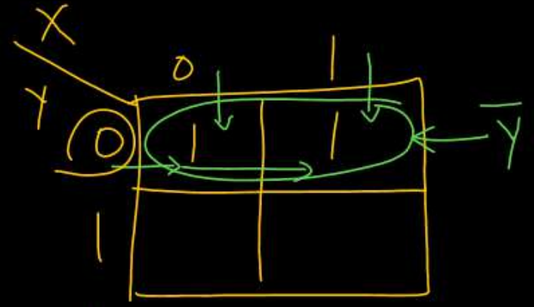


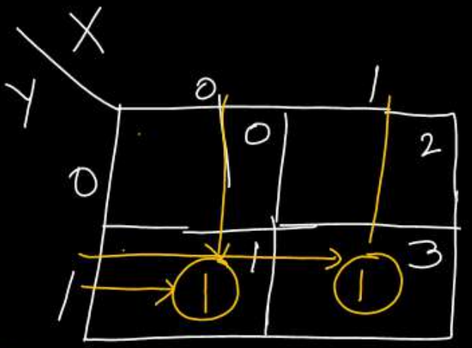
variable = 2

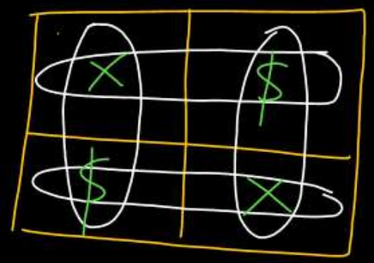
Combination = $2^n = 2^2 = 4$

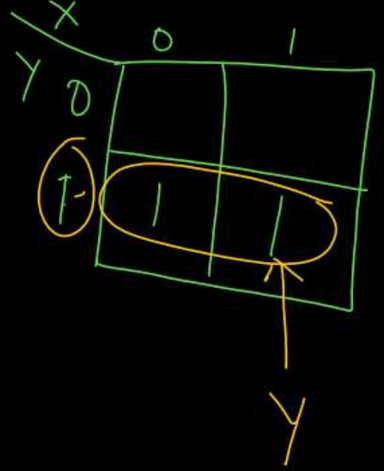
Gateway Classes : 7455961284

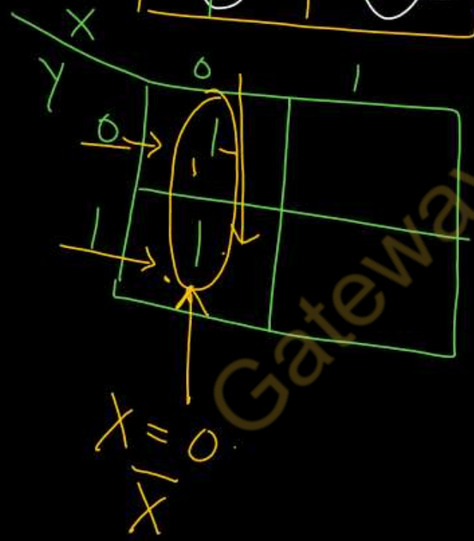
Example - X'Y+XY (SOP)

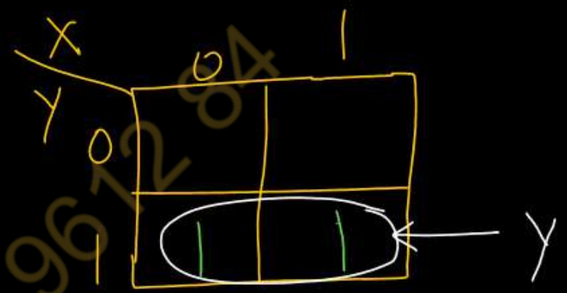












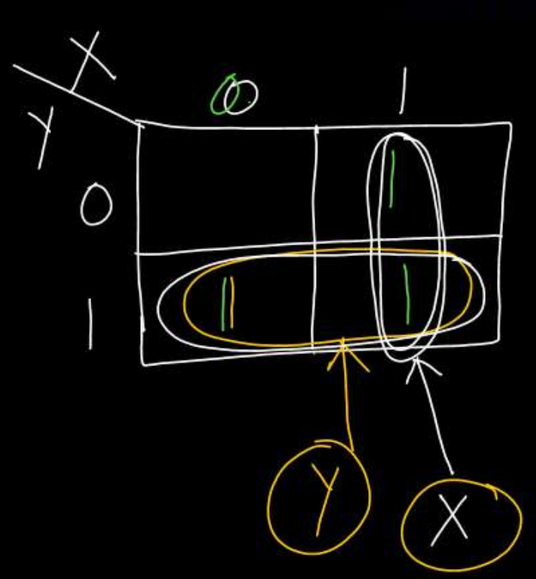
$$\bar{X}Y + XY = Y$$

$$Y(\bar{X} + X)$$

$$Y(1) = Y$$

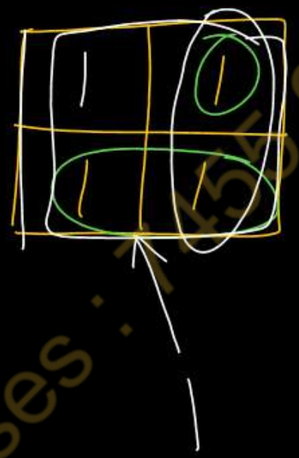
Gateway Classes : 7455 9612 84

Example - X'Y+XY+XY'



0 1 11 10

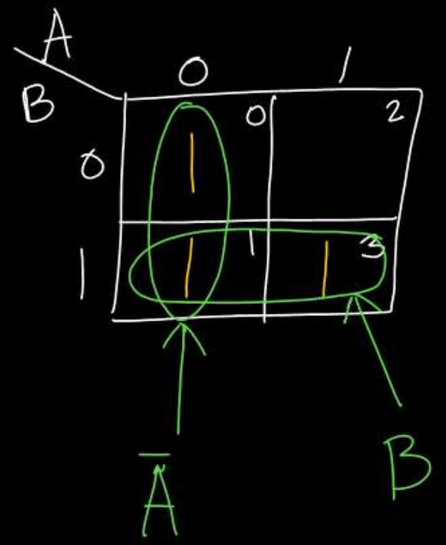
= X + Y



Gateway Classes : 7455 9612 84

Example- $f(A,B) = \sum m(0,1,3) = A'B' + A'B + AB$

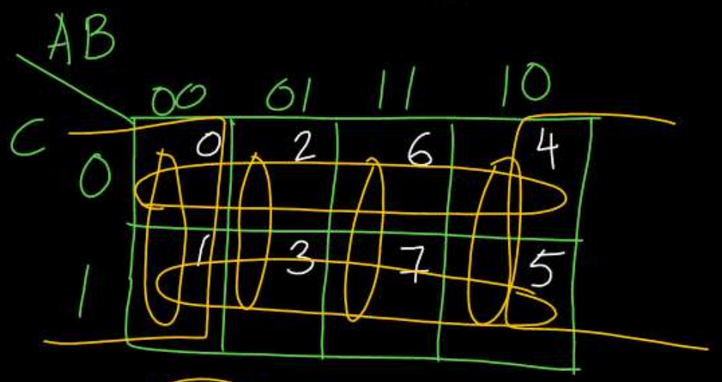
$= \bar{A} + B$

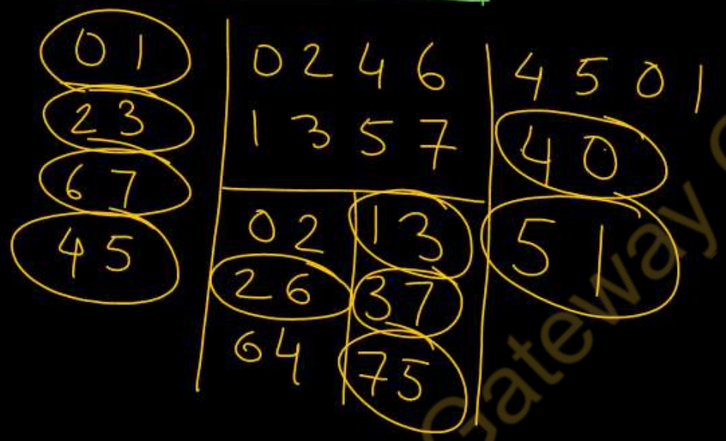


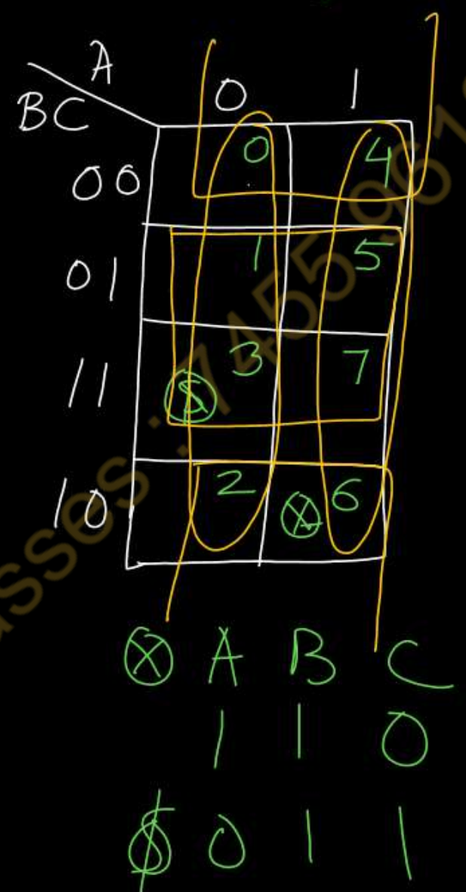
Gateway Classes : 7455 9612 84

3 Variable K-Map

- The number of cells in 3 variable K-map is eight, since the number of variables is three. 2^3
- **3 variable K-Map**





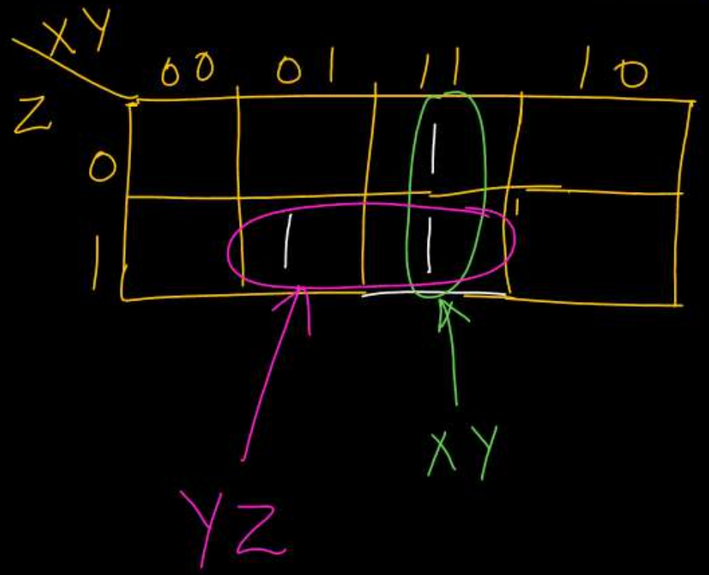


⊗ A B C
1 1 0
$ 0 1 1

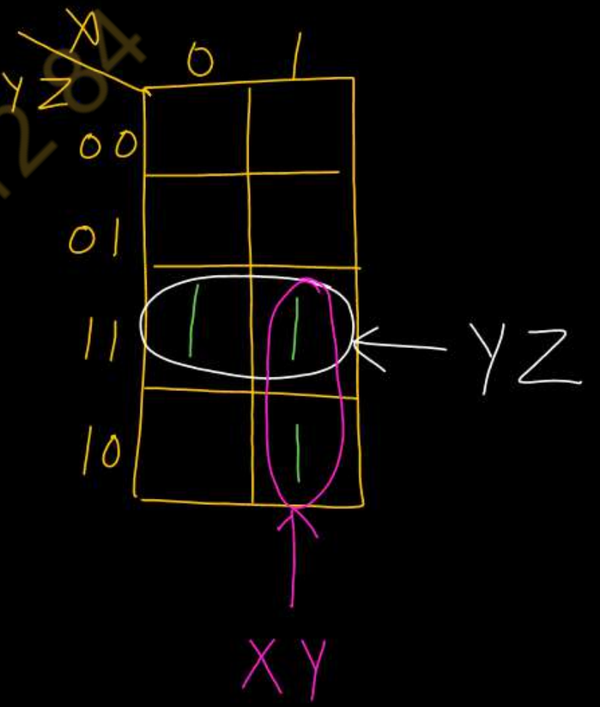
Gateway Classes: 9455 9812 84

Example- F = XYZ'+XYZ+X'YZ (SOP)

110 111 011

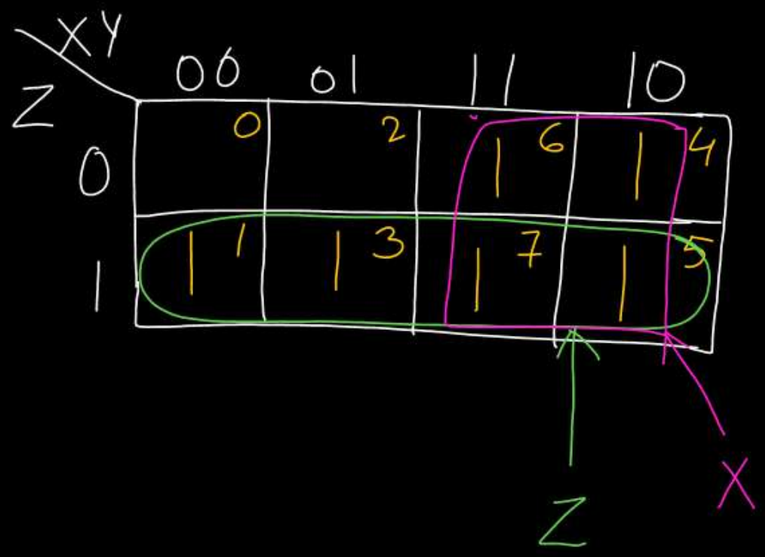


$F = XY + YZ$



Gateway Classes : 7455 961294

Example- F(X,Y,Z) = (1,3,4,5,6,7)



$F = X + Z$

Gateway Classes : 7455 9612 84

4 Variable K-Map

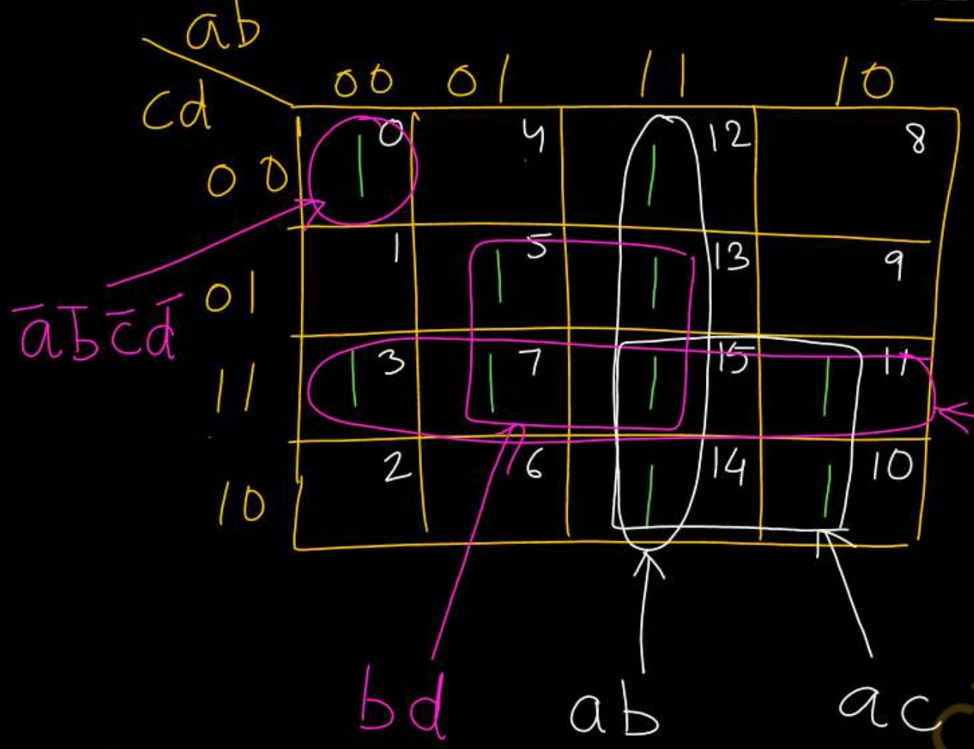
- number of cells in 4 variable K-map is sixteen $2^4 = 16$
- **4 variable K-Map.**

CD \ AB	00	01	11	10
00	0	4	12	8
01	1	5	13	9
11	3	7	15	11
10	2	6	14	10

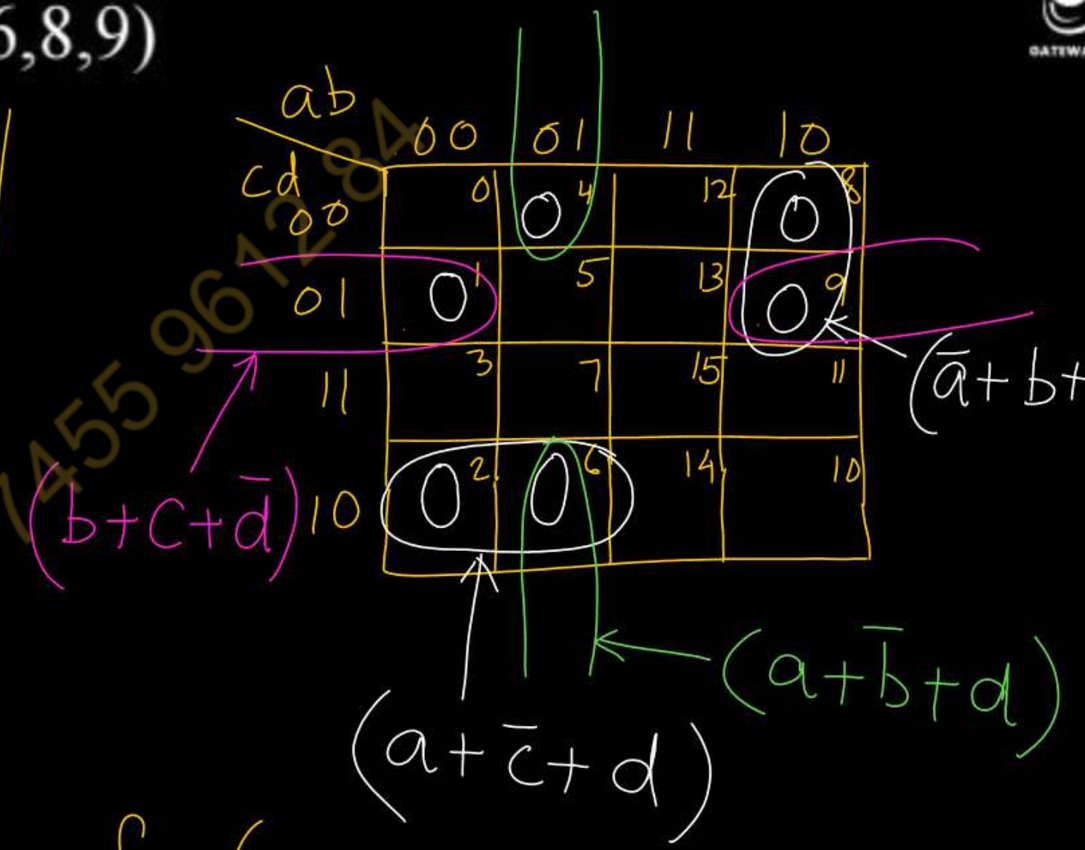
AB \ CD	00	01	11	10
00	0	1	3	2
01	4	5	7	6
11	12	13	15	14
10	8	9	11	10

Gateway Classes : 7455 95 12 84

Example-f(a,b,c,d) = $\sum m(0,3,5,7,10,11,12,13,14,15)$ = $\prod M(1,2,4,6,8,9)$



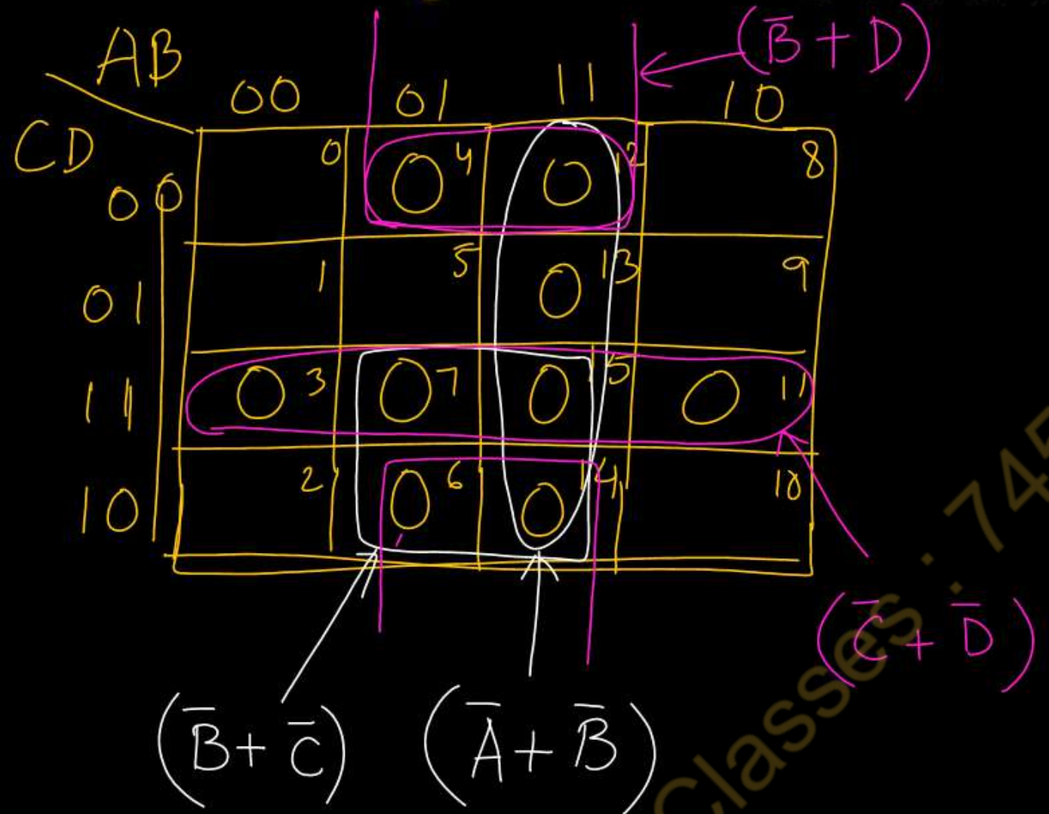
$$f = bd + ab + ac + cd + \bar{a}\bar{b}\bar{c}\bar{d}$$



$$f = (b+c+\bar{d})(a+\bar{c}+d)(a+\bar{b}+d)(\bar{a}+b+c)$$

Gateway Classes : 7455 961 284

Example: $F = \Pi M(3,4,6,7,11,12,13,14,15) \Rightarrow POS$



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

Gateway Classes : 7455 9612 84

DPP

a) Example : Minimize the following Boolean function using sum of products (SOP): $f(a,b,c,d) = \sum \bullet m(3,7,11,12,13,14,15)$

b) Simplify the expression $F(A,B,C,D) = ACD + A'B + D'$ by K map

c) Simplify the logic function using K-map $F(A,B,C,D) = \Sigma m(0,1,8,9,11,15)$

Gateway Classes 7455 9612 84

UNIVERSITY QUESTIONS

YEAR	QUESTION	MARKS	ANSWER
21-22	Simplify the expression F(A,B,C) =AB+BC+A' by K map	2 marks	A'+B
21-22	Minimize the following Boolean function F(A,B,C,D)= Σm(0,3,4,5,7,9,13,14,15)	10 marks	BD+A'C'D'+ A'CD+AC'D+ ABC
20-21	Simplify using K map to obtain a minimum POS expression: (A'+B'+C+D)(A+B'+C+D)(A+B+C'+D') (A'+B+C'+D') (A+B+C'+D)	10 marks	(B'+C+D) (A+B+C') (B+C'+D)

Gateway Classes . 7455 9612 84

UNIT 1 : LOGIC SIMPLIFICATION AND COMBINATIONAL LOGIC DESIGN

Today's Target

- Don't Care Conditions
- 5,6 Variable K-Map
- Numerical Practice
- DPP
- University Questions

Gateway Classes : 7455 96[illegible] 84

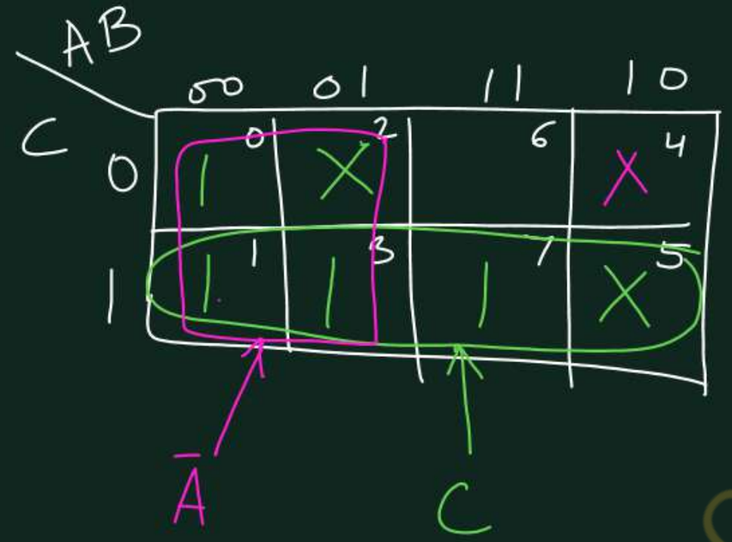
Don't Care (Incompletely Specified) Conditions

- Some times, not all values of a function are defined
- Some input conditions will never occur
- We don't care what the output is for that input condition
- In these cases, we can choose the output to be either 0 or 1, whichever simplifies the circuit.

Gateway Classes: 7455 9612 84

$F = \Sigma m(0,1,3,7) + d(2,5)$

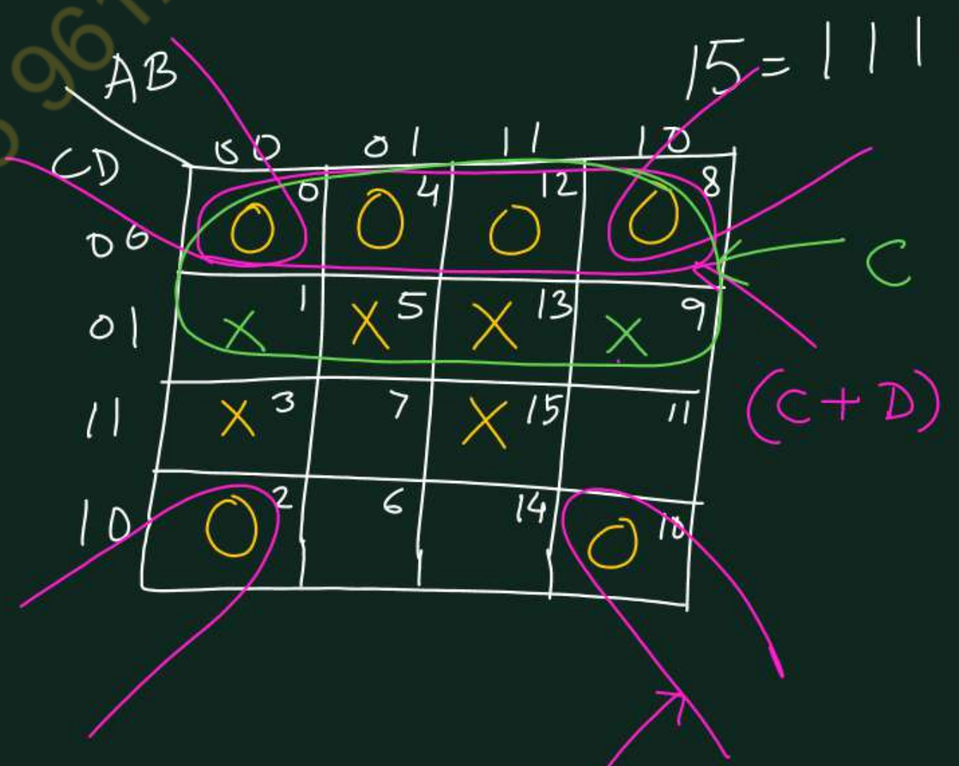
$7 = 1\,1\,1$



$F = \bar{A} + C$

$F = \Pi M(0,2,4,8,10,12) + d(3,5,13,15)$

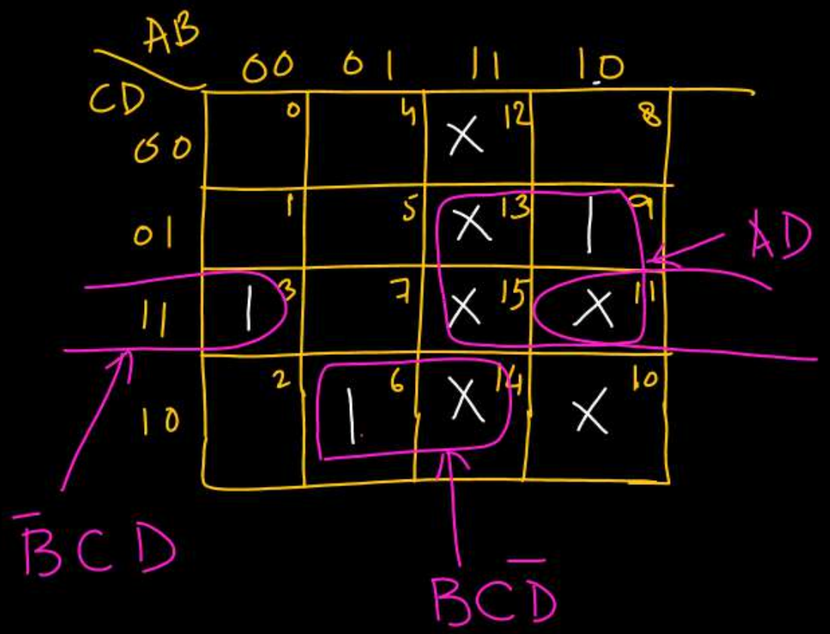
$15 = 1\,1\,1\,1$



$F = (B+D)(C+D)(B+D)$

Gateway Classes : 7455 9612 84

Example: A circuit is to have an output of 1 if a binary coded decimal (BCD) digit is a multiple of 3



$$F = \Pi M(0, 1, 2, 4, 5, 7, 8) + d(10, 11, 12, 13, 14, 15)$$

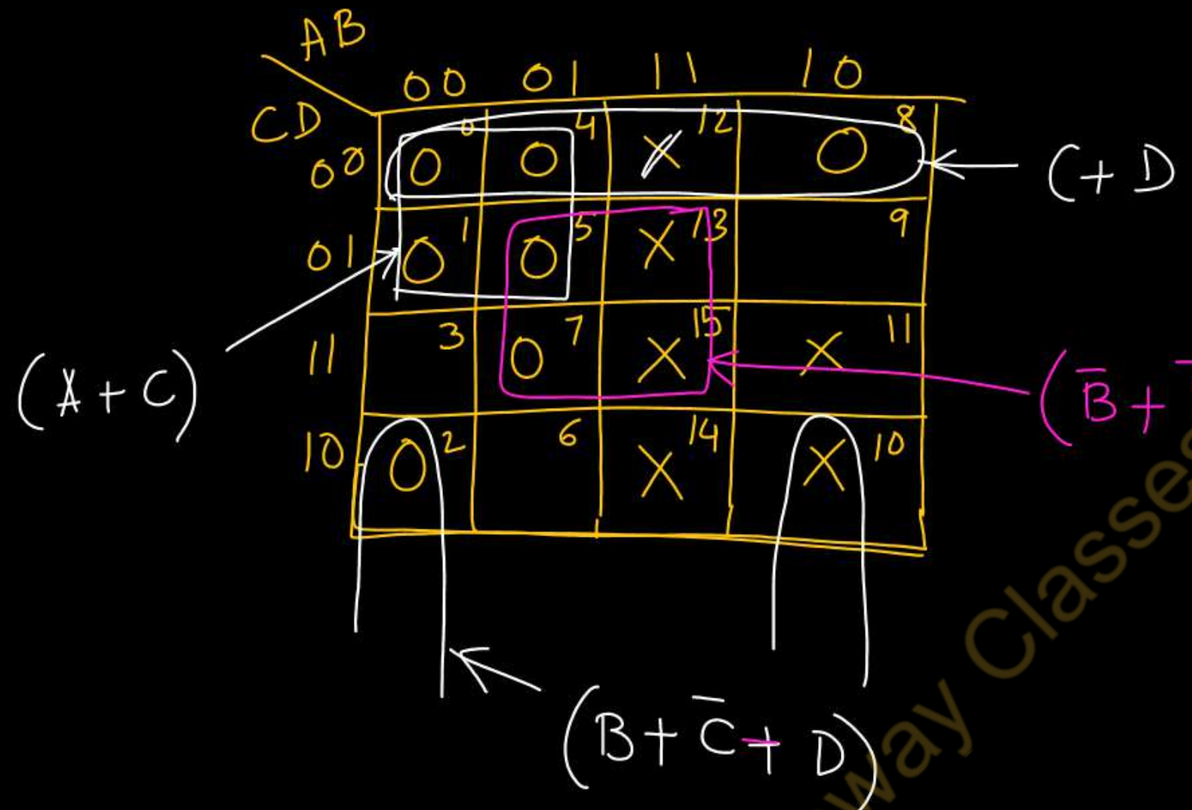
A	B	C	D	Y
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	1
0	1	0	0	1
0	1	0	1	0
0	1	1	0	1
0	1	1	1	0
1	0	0	0	0
1	0	0	1	1
1	0	1	0	X
1	0	1	1	X
1	1	0	0	X
1	1	0	1	X
1	1	1	0	X
1	1	1	1	X

$$F = AD + BC\bar{D} + \bar{B}C\bar{D}$$
$$= AD + C(B\bar{D} + \bar{B}D)$$
$$= AD + C(B \oplus D)$$

GatewayClasses : 7455 961264

Product of sums:

$F = \Pi M(0, 1, 2, 4, 5, 7, 8) + d(10, 11, 12, 13, 14, 15)$



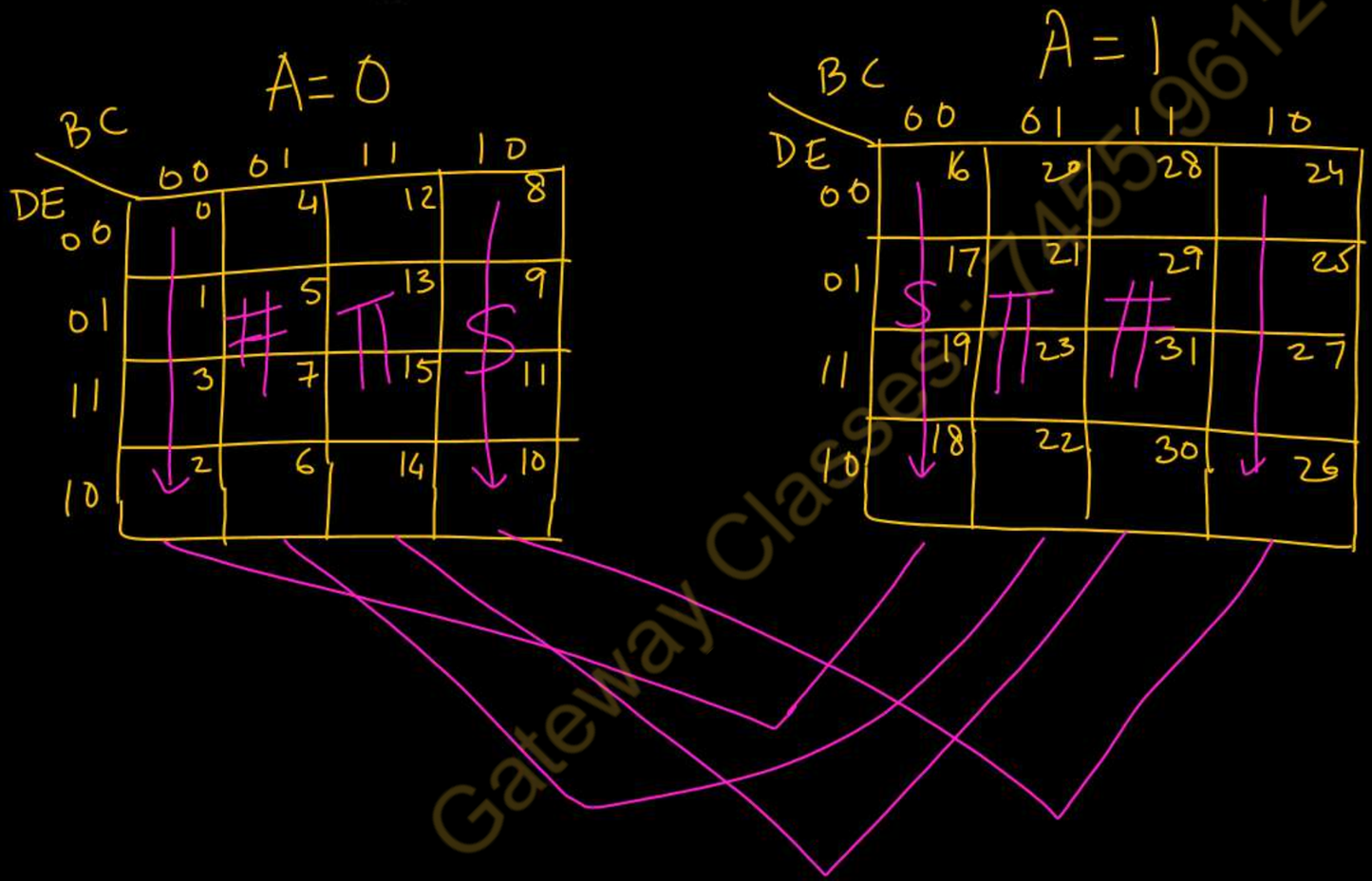
$F = (C+D)(\bar{B}+\bar{D})(B+\bar{C}+D)$

$(A+C)$

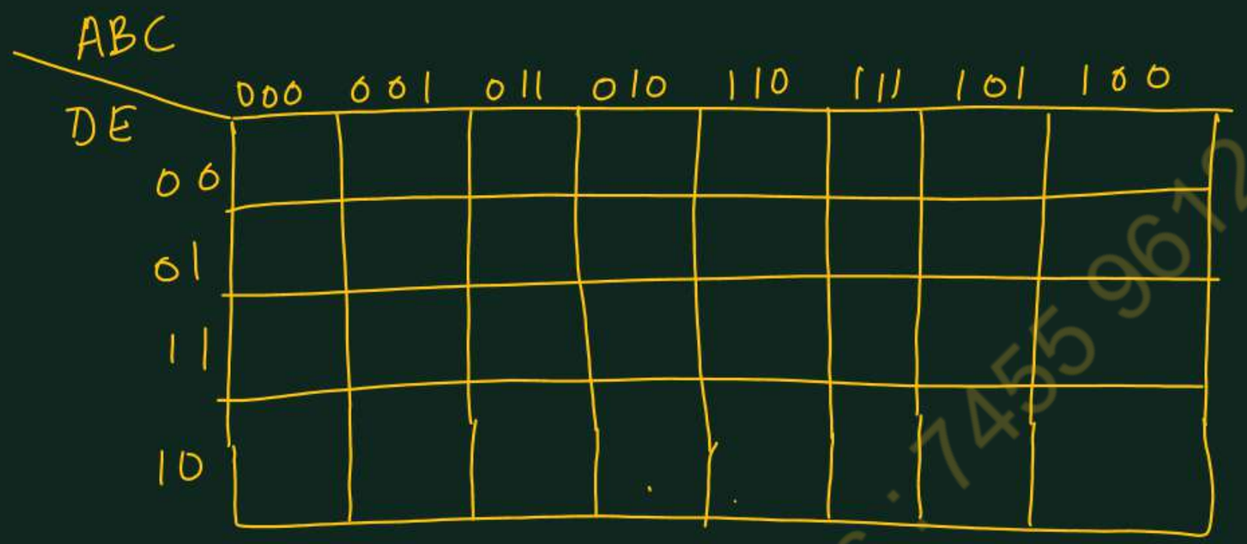
Gateway Classes: 7455 96 12 84

5 Variable K-Map

- The number of cells in 5 variable K-map is thirty-two $2^5 = 32$
- **5 variable K-Map**.

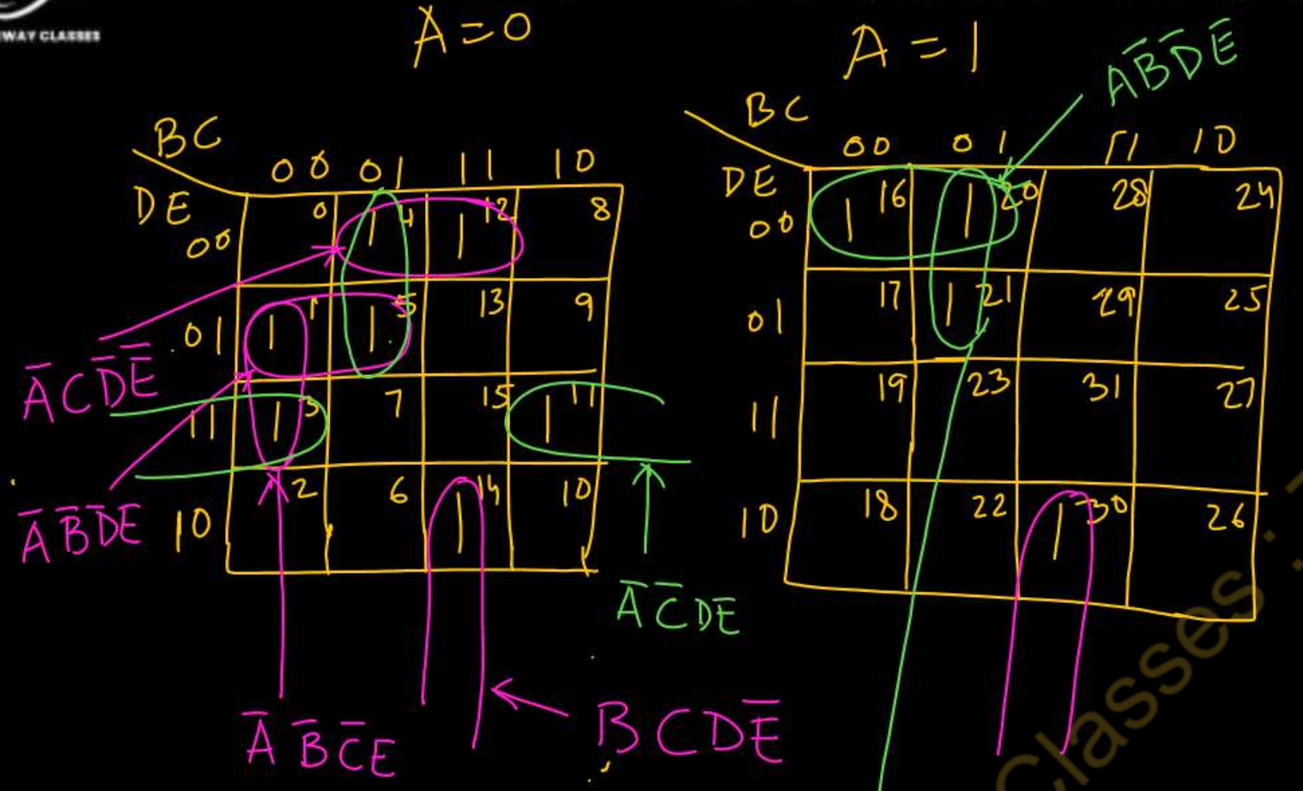


Gateway Classes: 7455961284

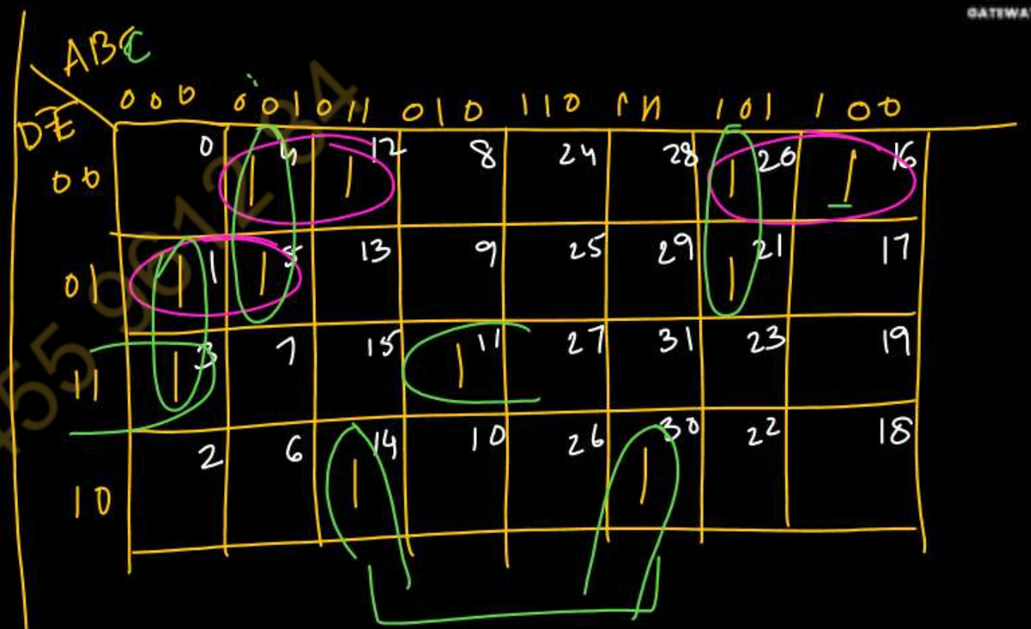


Gateway Classes : 7455 9612 84

Example: $Y(A,B,C,D,E) = \sum m(1,3,4,5,11,12,14,16,20,21,30)$



$$\bar{F} = \underset{①}{\bar{A}C\bar{D}\bar{E}} + \underset{②}{\bar{A}\bar{B}\bar{D}\bar{E}} + \underset{③}{\bar{A}\bar{B}\bar{C}E} + \underset{④}{B\bar{C}\bar{D}} + \underset{⑤}{BC\bar{D}\bar{E}} + \underset{⑥}{\bar{A}\bar{C}DE} + A\bar{B}\bar{D}\bar{E}$$



$$F = \underset{⑤}{\bar{B}C\bar{D}} + \underset{②}{A\bar{B}\bar{D}\bar{E}} + \underset{①}{\bar{A}C\bar{D}\bar{E}} + \underset{③}{\bar{A}\bar{B}\bar{C}E} + \underset{⑥}{\bar{A}\bar{C}DE} + \underset{④}{BC\bar{D}\bar{E}}$$

Gateway Classes : 7455 6612 24

6 Variable K-Map

$2^6 = 64$

AB = 00

CD \ EF	00	01	11	10
00	0	4	12	8
01	1	5	13	9
11	3	7	15	11
10	2	6	14	10

AB = 01

16	20	28	24	
17	21	29	25	
19	23	31	27	
18	22	30	26	

AB = 11

48	52	60	56	
49	53	61	57	
51	55	63	59	
50	54	62	58	

AB = 10

32	36	44	40	
33	37	45	41	
35	39	47	43	
34	38	46	42	

ABC \ DEF	000	001	011	010	110	111	101	100
000	0	8	24	16	48	56	40	32
001	1	9	25	17	49	57	41	33
011	3	11	27	19	51	59	43	35
010	2	10	26	18	50	58	42	34
110	6	14	30	22	54	62	46	38
111	7	15	31	23	55	63	47	39
101	5	13	29	21	53	61	45	37
100	4	12	28	20	52	60	44	36

Gateway Classes : +91 96128 84

DPP

a) Minimize: $y = \Sigma m(0,1,2,3,5,6,7,8,14,15) + d(4,11,13)$

b) Minimize the logic function: $F(A,B,C,D,E) = \Sigma m(8,9,10,11,13,15, 16,18,21, 24,25,26, 27,30,31)$

Gateway Classes : 7455 9612 84

UNIVERSITY QUESTIONS

YEAR	QUESTION	MARKS	ANSWER
22-23	Simplify the logic function using K-map $Y = \Sigma m (0, 2, 3, 4, 6, 7, 9, 11,16,18,19,20,22,23,25,27)$	10 marks	
19-20	Simplify the logic expression using K map $F(A,B,C,D,E,F) = \Sigma m(0,5,7,8,9,12,13,23,24,25, 28,29, 37, 40,42,44,46,55,56,57,60,61)$	10 marks	

Gateway Classes 7455 9612 84

DIGITAL SYSTEM DESIGN

UNIT 1 : LOGIC SIMPLIFICATION AND COMBINATIONAL LOGIC DESIGN

Today's Target

- Tabulation Method
- Numerical Practice
- DPP
- University Questions

Gateway Classes : 7455 9612 84

Tabulation Method

STEP 1:

- Convert Minterm List to Prime Implicant List

STEP 2:

- Choose All Essential Prime Implicants
- If all minterms are covered, stop

STEP 3:

- Formulate the Reduced Cover Table

Gateway Classes : 7455 96 12 84

EXAMPLE: $f^{on} = \{m_0, m_1, m_2, m_3, m_5, m_8, m_{10}, m_{11}, m_{13}, m_{15}\}$
$= \sum (0, 1, 2, 3, 5, 8, 10, 11, 13, 15)$

m_0	0 0 0 0
m_1	0 0 0 1
m_2	0 0 1 0
m_3	0 0 1 1
m_5	0 1 0 1
m_8	1 0 0 0
m_{10}	1 0 1 0
m_{11}	1 0 1 1
m_{13}	1 1 0 1
m_{15}	1 1 1 1

G_1	m_0	0 0 0 0	✓
G_2	m_1	0 0 0 1	✓
	m_2	0 0 1 0	✓
	m_8	1 0 0 0	✓
G_3	m_3	0 0 1 1	✓
	m_5	0 1 0 1	✓
	m_{10}	1 0 1 0	✓
G_4	m_{11}	1 0 1 1	✓
	m_{13}	1 1 0 1	✓
G_5	m_{15}	1 1 1 1	✓

0,1	0 0 0 –	✓
0,2	0 0 – 0	✓
0,8	– 0 0 0	✓
1,3	0 0 – 1	✓
1,5	0 – 0 1	(PI)
2,3	0 0 1 –	✓
2,10	– 0 1 0	✓
8,10	1 0 – 0	✓
3,11	– 0 1 1	✓
5,13	– 1 0 1	(PI)
10,11	1 0 1 –	✓
11,15	1 – 1 1	(PI)
13,15	1 1 – 1	(PI)

A B C D

0,1,2,3	0 0 – – (EPI)
0,2,8,10	– 0 – 0 (EPI)
2,3,10,11	– 0 1 – (EPI)

	0	1	2	3	5	8	10	11	13	15
$\bar{A}\bar{B}$	X	X	X	X						
$\bar{B}\bar{D}$	X		X			X	X			
$\bar{B}C$			X	X			X	X		
$\bar{A}\bar{C}D$		X			X					
$B\bar{C}D$					X				X	
ACD								X		X
$A\bar{B}D$									X	X
	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

$$f = \bar{B}\bar{D} + \bar{A}\bar{B} + B\bar{C}D + ACD$$

Gateway Classes : 7455 9c12 84

Simplify the following expression using Tabulation Method

$$F(A,B,C,D) = \sum m(0,4,8,10,12,13,15) + d(1,2)$$

m_0	0 0 0 0
m_4	0 1 0 0
m_8	1 0 0 0
m_{10}	1 0 1 0
m_{12}	1 1 0 0
m_{13}	1 1 0 1
m_{15}	1 1 1 1
d_1	0 0 0 1
d_2	0 0 1 0

G_1	m_0	0000 ✓	0,4	0 _ 0 0 ✓
			0,8	_ 0 0 0 ✓
G_2	m_4	0100 ✓	0,1	0 0 0 _ (PI)
	m_8	1000 ✓	0,2	0 0 _ 0 ✓
	d_1	0001 ✓		
	d_2	0010 ✓	4,12	_ 1 0 0 ✓
			8,10	1 0 _ 0 ✓
G_3	m_{10}	1010 ✓	8,12	1 _ 0 0 ✓
	m_{12}	1100 ✓	2,10	_ 0 1 0 ✓
G_4	m_{13}	1101 ✓	12,13	1 1 0 _ (PI)
G_5	m_{15}	1111	13,15	1 1 _ 1 (PI)

	A	B	C	D	
0,4,8,12	_	_	0	0	(EPI)
0,8,2,10	_	0	_	0	(EPI)

	m							d	
	0	4	8	10	12	13	15	1	2
$\bar{C}\bar{D}$	X	(X)	X		X				
$\bar{B}\bar{D}$	X		X	(X)					X
$\bar{A}\bar{B}\bar{C}$	X							X	
$AB\bar{C}$					X	X			
$A\bar{B}D$						X	(X)		
	✓	✓	✓	✓	✓	✓	✓		✓

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

Gateway Classes 7455 9612 84

$F = \Sigma m(0, 8, 12, 15, 21, 26, 30, 31)$

	16	8	4	2	1
	A	B	C	D	E
m_0	0	0	0	0	0
m_8	0	1	0	0	0
m_{12}	0	1	1	0	0
m_{15}	0	1	1	1	1
m_{21}	1	0	1	0	1
m_{26}	1	1	0	1	0
m_{30}	1	1	1	1	0
m_{31}	1	1	1	1	1

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DPP

a) Minimize the following Boolean function using Tabulation Method:

$F(A,B,C,D) = \sum m(0,1,2,3,4,6,7,11,12,15)$

b) Simplify the expression $F(A,B,C,D,E) = \sum m(8,9,10,11,13,15,16,18, 21,24, 25,26,27,30,31)$

c) Simplify the logic function using Quine Mc Cluskey method

$F(A,B,C,D) = \Sigma m(0,1,2,3,11,12,14,15)$

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UNIVERSITY QUESTIONS

YEAR	QUESTION	MARKS	ANSWER
22-23	Minimize y = Σm(0,1,2,3,5,6,7,8,14,15) + d(4,11,13) using tabular method.	10 marks	Y= A' +BC + B'C'D'
19-20	Minimize the logic function using Quine-McCluskey Method $F(A, B,C,D,E)= \Sigma m(8,9,10,11,13,15, 16, 18,21,24,25,26,27,30,31)$	10 marks	F=BC'+ABD+ AC'E' + A'BE + AB'CD'E
18-19	Minimize the following using Quine-McCluskey meth0d: F(A,B, C, D)= Σm(0,1, 9,15, 24, 29, 30) + d(8,11, 31)	10 marks	F= A'B'C'D' + A'BDE + A'BC'E + BC'D'E' + ABCE + ABCD

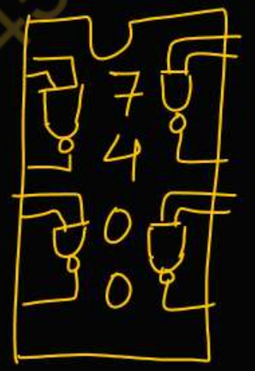
Gateway Classes 7455 961 284

DIGITAL SYSTEM DESIGN

UNIT 1 : LOGIC SIMPLIFICATION AND COMBINATIONAL LOGIC DESIGN

Today's Target

- NAND GATE IMPLEMENTATION
- Numerical Practice
- DPP
- University Questions

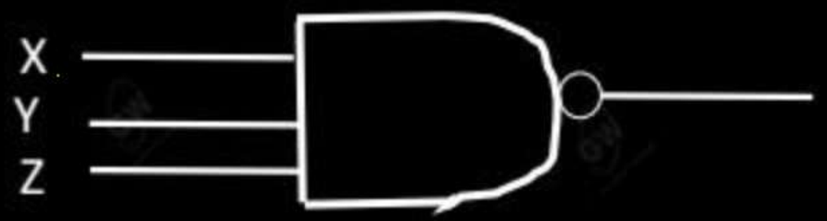


Gateway Classes : 7455 9612 84

NAND GATE IMPLEMENTATION OF CIRCUIT

- NAND gate is a universal gate
- Function should be in SOP form
- Obtain simplified Boolean function in terms of Boolean operators and then convert the function to NAND logic.
- Implement the function with AND & OR gates.
- Replace AND with NAND gate.
- Replace OR gate by invert OR (NAND) gate.
- Two bubbles on same line denote double complement & both can be removed.

Gateway Classes : 7455 9612 84



$\overline{XYZ}$

$(\bar{x}+\bar{y}+\bar{z})$



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

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

Gateway Classes : 7455 9612 84

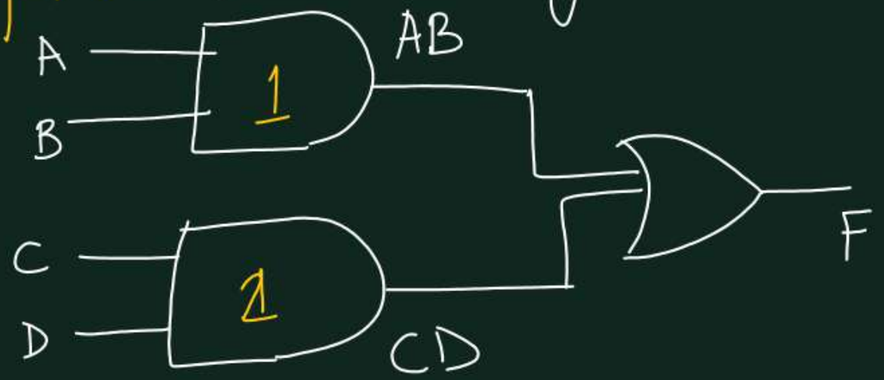
Example: F = AB + CD Implement using NAND gates only.

- Step 1: Implement using Basic gates.
- Step 2: Convert AND to NAND and OR to invert OR.
- Step 3: Replace invert OR by NAND gate.

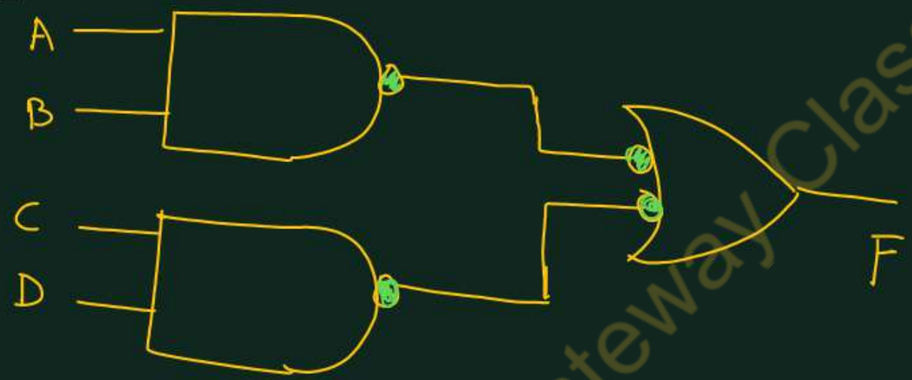
Gateway Classes : 7455 9612 84

$F = AB + CD$

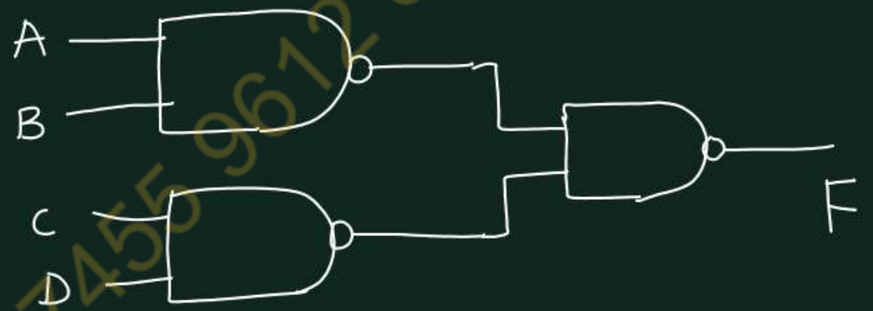
Step 1: Implement using basic Gates



Step 2: AND → NAND & OR → Invert OR



Step 3: Invert OR → NAND



Gateway Classes : 7455 9612 84

Example: F = (A+B) (A+C) Implement using NAND gates only.

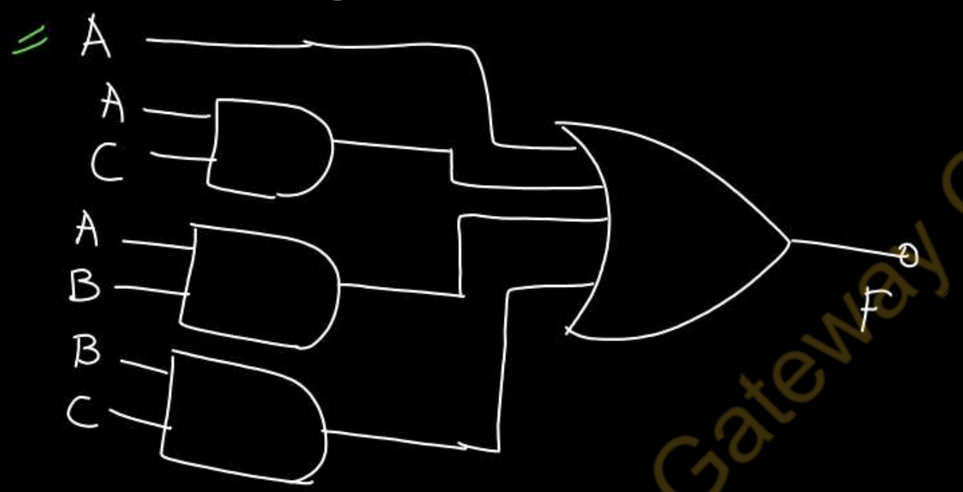
$F = (A+B)(A+C)$

$= A(A+C) + B(A+C)$

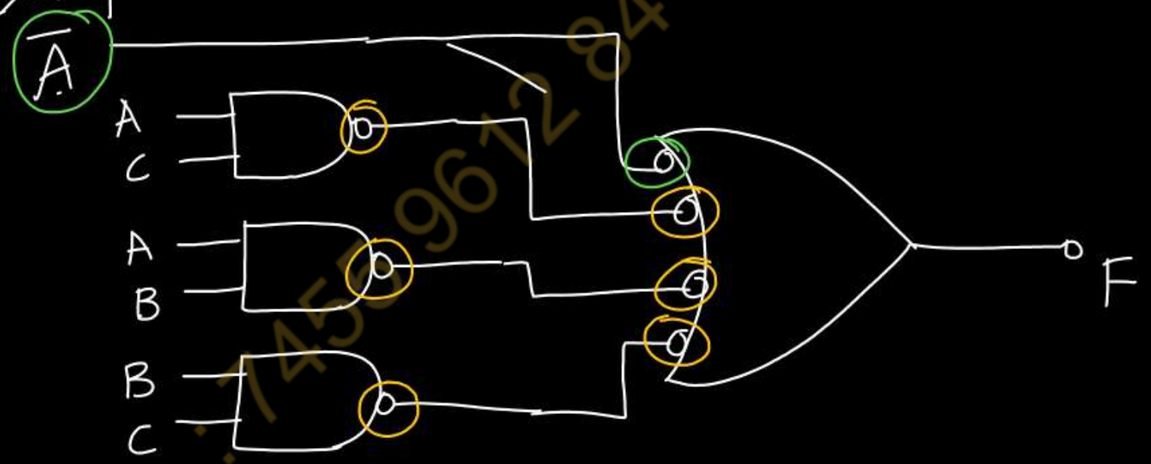
$= A \cdot A + A \cdot C + B \cdot A + B \cdot C$

$= A + AC + AB + BC$

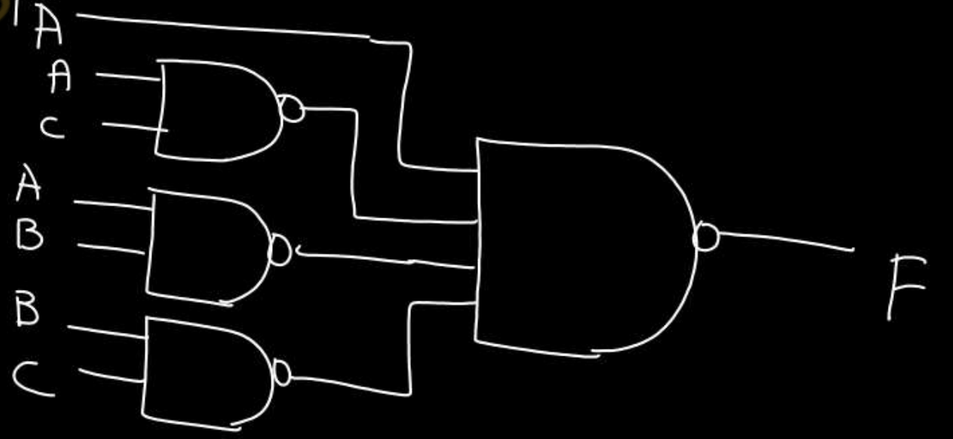
step 1: Using Basic Gates



step 2:



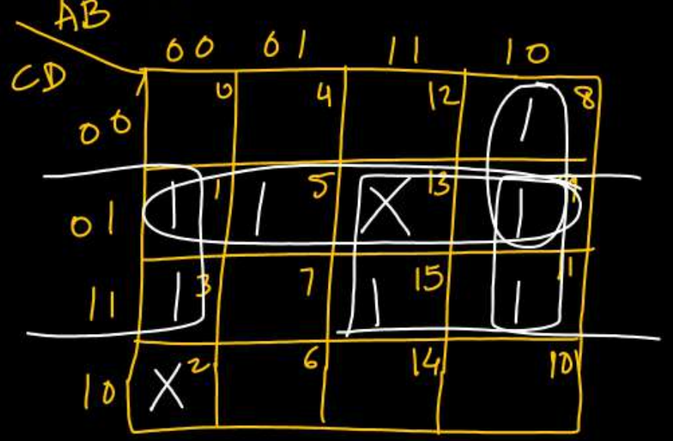
step 3:



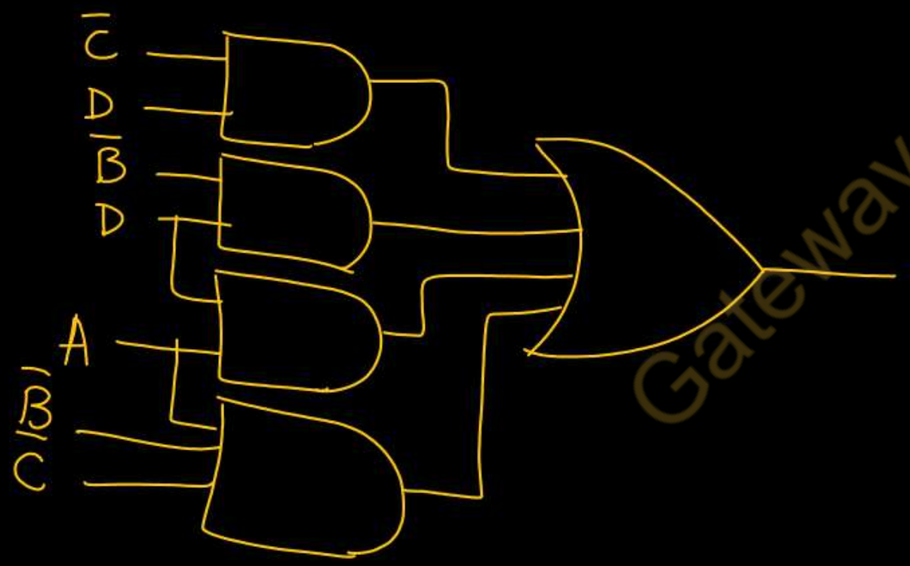
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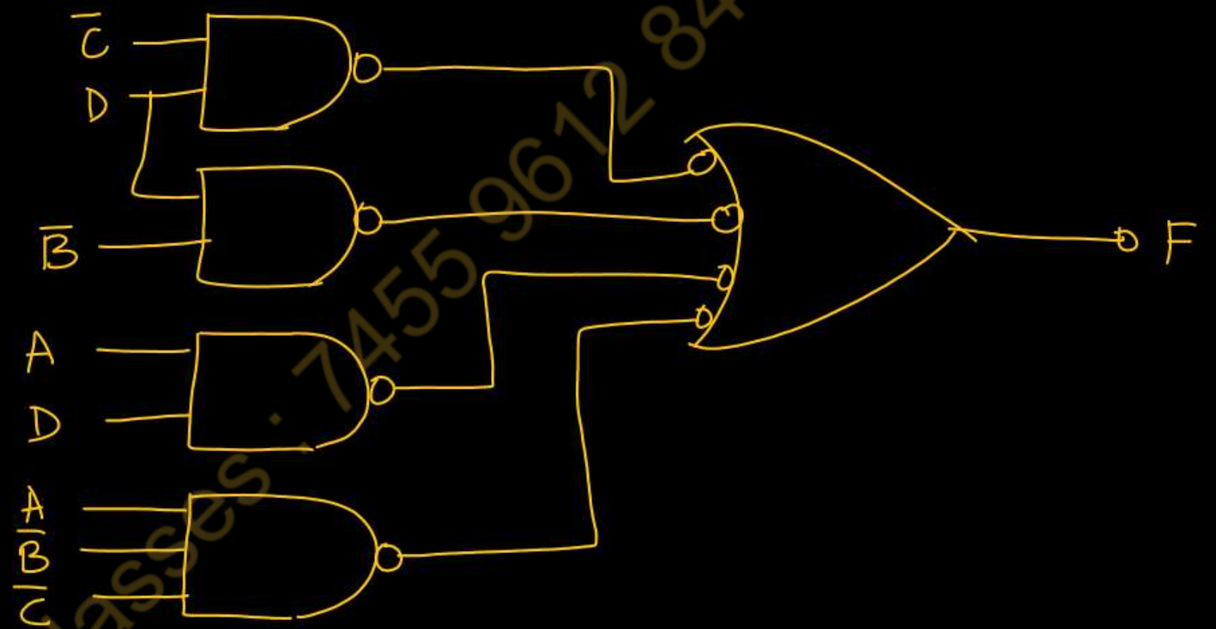
Example: $F = \Sigma m(1,3,5,8,9,11,15) + d(2,13)$

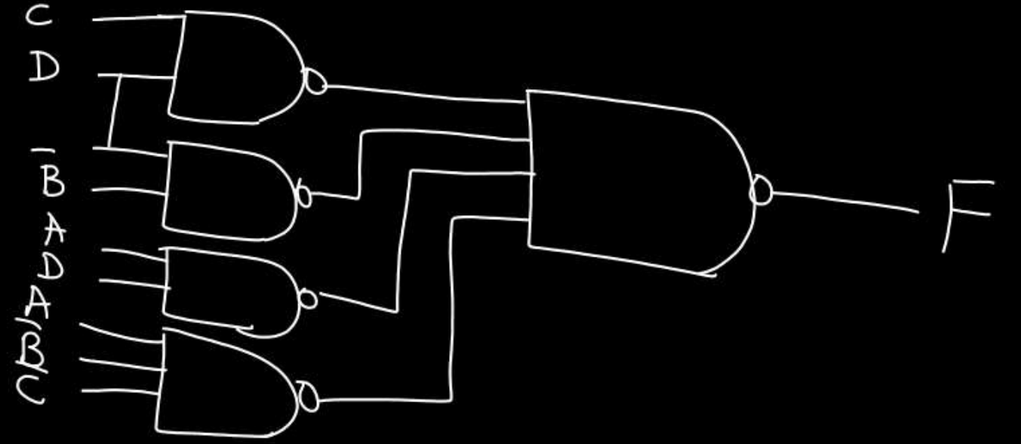
Implement using NAND gates only.



$$F = \bar{C}D + \bar{B}D + AD + A\bar{B}\bar{C}$$



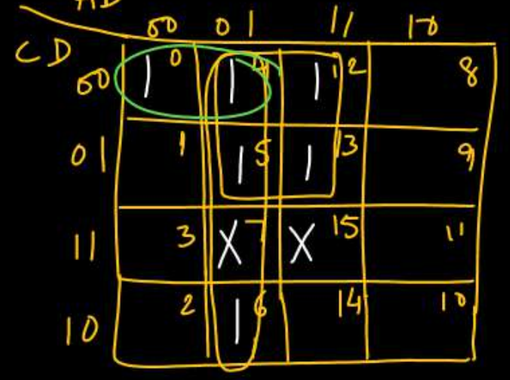




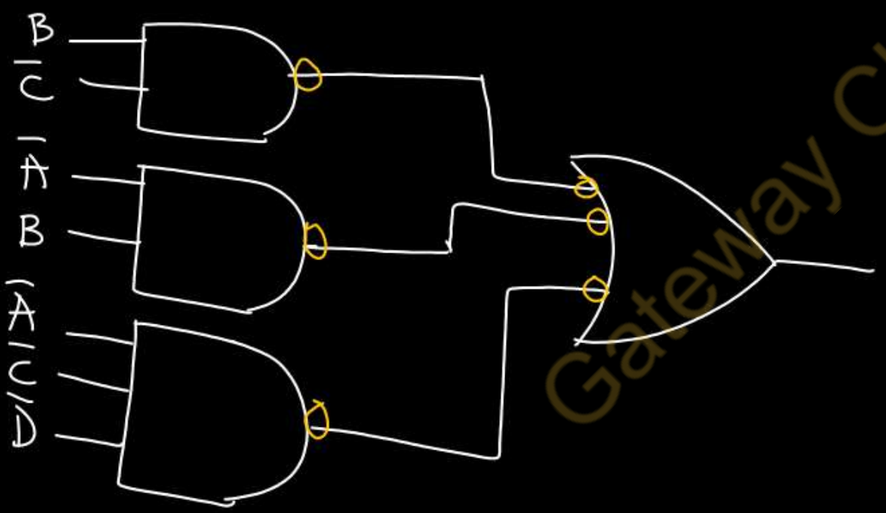
Gateway Classes : 7455 9612 84

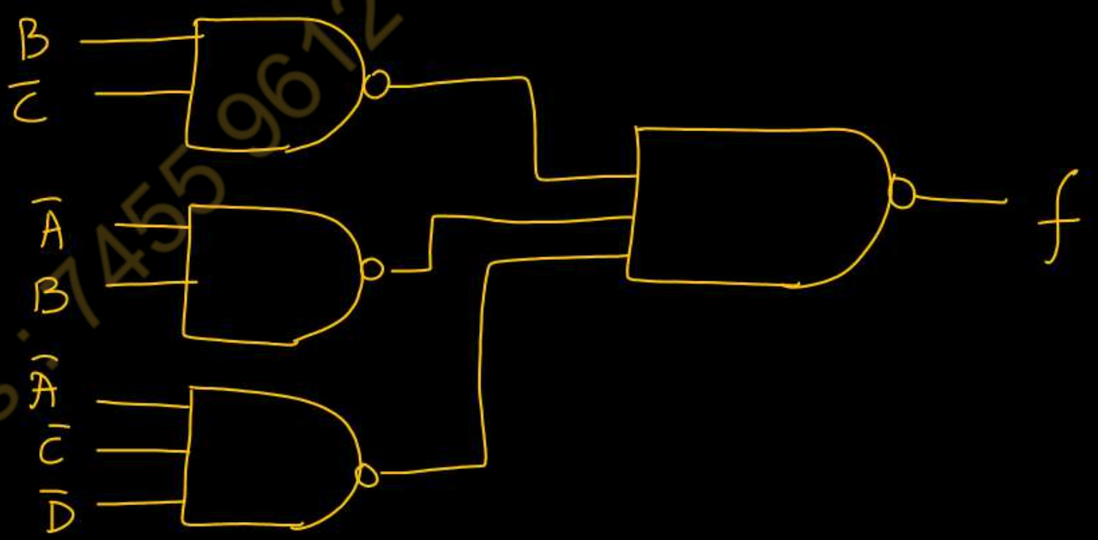
Example: f(A,B,C,D) = πM(1,2,3,8,9,10,11,14) . d(7,15)
Implement using NAND gates only.

$f(A,B,C,D) = \Sigma m(0,4,5,6,12,13) + d(7,15)$



$f = B\bar{C} + \bar{A}B + \bar{A}\,\bar{C}\,\bar{D}$





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DPP

Implement using NAND gates only:

a) $Y = \Sigma m(0,1,3,7,11,15) + d(8,9,13)$

b) $F = AB + AC' + BC$

c) $F = \pi M(6,9,11,13,14,17,20,25,28,29,30)$

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UNIVERSITY QUESTIONS

YEAR	QUESTION	MARKS	ANSWER
22-23	Give the general procedure for converting a multilevel AND-OR diagram into an all NAND diagram. Implement the following Boolean function with NAND gates only. $F(x, y, z) = \Sigma m(1,2,3,4,5,7)$	10 marks	F= z+x'y + xy'
17-18	Implement the Expression Y = ABC' + BD + E using Nand gate only.	2 marks	

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