Rajshree
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MST 1 + MST 2

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Semester :- IIIrd Semester

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Digital Electronics (CER3C4)

Mid Semester Test -1

Q.1. Convert the following numbers to decimal

(i) $(12121)_3$

The decimal equivalent of this are :-

$$1\times(3^4) + 2\times(3^3) + 1\times(3^2) + 2\times(3^1) + 1\times(3^0)$$
$$81 + 54 + 9 + 6 + 1$$
$$151$$

So, $(12121)_3 = (151)_{10}$

(ii) $(198)_{12}$

The decimal equivalent of this are :-

$$1\times(12^2) + 9\times(12^1) + 8\times(12^0)$$
$$144 + 108 + 8$$
$$260$$

So, $(198)_{12} = (260)_{10}$

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(iii) $(0.342)_6$

The decimal equivalent of this are :-

$$3 \times (6^{-1}) + 4 \times (6^{-2}) + 2 \times (6^{-3})$$

$$\frac{3}{6} + \frac{4}{36} + \frac{2}{216} = \frac{1}{2} + \frac{1}{9} + \frac{1}{108}$$

$$= \frac{54 + 12 + 1}{108}$$

$$= \frac{67}{108}$$

$$= 0.620370$$

So $(0.342)_6 = (0.62037)_{10}$

(iv) $(4310)_5$

The decimal equivalent of this are :-

$$4 \times (5^3) + 3 \times (5^2) + 1 \times (5^1) + 0 \times (5^0)$$
$$4 \times 125 + 3 \times 25 + 1 \times 5 + 0$$
$$500 + 75 + 5 + 0$$
$$580$$

So, $(4310)_5 = (580)_{10}$

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(v) $(1001001.011)_2$

The decimal equivalent of this are :-

$$1\times(2^6)+0\times(2^5)+0\times(2^4)+1\times(2^3)+0\times(2^2)+0\times(2^1)+1\times(2^0)+0\times(2^{-1})+1\times(2^{-2})\cancel{+1\times2}$$
$$+1\times(2^{-3})$$

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

$$\frac{73}{1}+\frac{1}{4}+\frac{1}{8}$$

$$\frac{584+2+1}{8}$$

$$\frac{587}{8}$$

$$73.375$$

So, $(1001001.011)_2 = (73.375)_{10}$

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Q.2. Perform the subtraction using 9's and 10's complement for each.

(i) 3570 - 2100

Ans Substraction using 9's complement

Let, A = 3570, B = 2100

First we have to find out 9's complement of B

$$\begin{array}{r} 9\;9\;9\;9 \\ -\;2\;1\;0\;0 \\ \hline 7\;8\;9\;9 \end{array}$$

Now we have to add 9's complement of B to A

$$\begin{array}{rr} & 3\;5\;7\;0 \\ + & 7\;8\;9\;9 \\ \hline (\text{carry}-1) & 1\;4\;6\;9 \end{array}$$

Now we have to add the carry to the result

$$\begin{array}{r} 1\;4\;6\;9 \\ +\quad\quad\;\;1 \\ \hline 1\;4\;7\;0 \end{array}$$

Now, The answer is 1470

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Substraction using 10's complement

Let, $A = 3570$, $B = 2100$

First we have to find out 10's complement of B

$$
\begin{array}{r}
9\ 9\ 9\ 9 \\
-\ 2\ 1\ 0\ 0 \\
\hline
7\ 8\ 9\ 9 \\
+\qquad\quad 1 \\
\hline
7\ 9\ 0\ 0
\end{array}
$$

7 8 9 9 → 9's complement

7 9 0 0 → 10's complement

Now, we have to add 10's complement of B to A

$$
\begin{array}{r}
3\ 5\ 7\ 0 \\
+\ 7\ 9\ 0\ 0 \\
\hline
1\ 1\ 4\ 7\ 0
\end{array}
$$

Carry → 1

To get the answer we have to ignore this carry.

So, The answer is 1470.

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(ii) 20 - 1000

Ans Substraction using 9's complement

Let, A = 20 , B = 1000

First we have to find out 9's complement of B

$$\begin{array}{r} 9\ 9\ 9\ 9 \\ -\ 1\ 0\ 0\ 0 \\ \hline 8\ 9\ 9\ 9 \end{array}$$

Now we have to add 9's complement of B to A

$$\begin{array}{r} 0\ 0\ 2\ 0 \\ +\ 8\ 9\ 9\ 9 \\ \hline 9\ 0\ 1\ 9 \end{array}$$

There is no carry, Again we have to find 9's complement of the resut (9019).

$$\begin{array}{r} 9\ 9\ 9\ 9 \\ -\ 9\ 0\ 1\ 9 \\ \hline 0\ 9\ 8\ 0 \end{array}$$

We have to add (-) sign because there is no carry

So, The answer is -980

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Substraction using 10's complement

Let, A = 20 , B = 1000

First we have to find out 10's complement of B

$$\begin{array}{r} 9\,9\,9\,9 \\ -\,1\,0\,0\,0 \\ \hline 8\,9\,9\,9 \\ +\quad\;\;1 \\ \hline 9\,0\,0\,0 \end{array}$$

8999 → 9's complement

9000 → 10's complement

Now, we have to add 10's complement of B to A

$$\begin{array}{r} 0\,0\,2\,0 \\ +\,9\,0\,0\,0 \\ \hline 9\,0\,2\,0 \end{array}$$

There is no carry, Again we have to find 10's complement of the result (9020)

$$\begin{array}{r} 9\,9\,9\,9 \\ -\,9\,0\,2\,0 \\ \hline 0\,9\,7\,9 \\ +\quad\;\;1 \\ \hline 0\,9\,8\,0 \end{array}$$

0979 → 9's complement

0980 → 10's complement

We have to add (-) sign to result because there is no carry

So, The answer is -980

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Q.3. Represent decimal no 780 in BCD, Excess-3 and as a binary number.

Decimal to BCD

For converting into BCD we have to convert each digit of decimal no. into group of 4 bit binary no.

7	8	0
↓	↓	↓
0111	1000	0000

So, The answer is $(780)_{10} = (011110000000)_{BCD}$

Decimal to Excess-3

For converting into Excess-3 code, we have to perform the following operation:-

(i) We have to add 3 in each digit of decimal no.
(ii) Than we have to convert each digit of decimal no. into group of 4 bit binary no.

7	8	0
+	+	+
3	3	3
=	=	=
10	11	3
↓	↓	↓
1010	1011	0011

So, The answer is $(780)_{10} = (101010110011)_{Excess-3}$

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Decimal to Binary

2	780	0
2	390	0
2	195	1
2	97	1
2	48	0
2	24	0
2	12	0
2	6	0
2	3	1
	1	1

So, The answer is $(780)_{10} = (1100001100)_2$

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Q. 4. Express the following function in product of max terms.

(i) $F(A,B,C,D) = D(A'+B) + B'D$

$$F(A,B,C,D) = D(A'+B) + B'D$$
$$= A'D + BD + B'D$$
$$= A'(B+B')D + (A+A')BD + (A+A')B'D$$
$$= A'BD + A'B'D + ABD + A'BD + AB'D + A'B'D$$
$$= A'B(C+C')D + A'B'(C+C')D + AB(C+C')D + A'B(C+C')D + AB'(C+C')D + A'B'(C+C')D$$

$$= A'BCD + A'BC'D + A'B'CD + A'B'C'D + ABCD + ABC'D + A'BCD + A'BC'D + AB'CD + AB'C'D + A'B'CD + A'B'C'D$$

$$= A'BCD + A'BC'D + A'B'CD + A'B'C'D + ABCD + ABC'D + AB'CD + AB'C'D$$
$$= m_1 + m_3 + m_5 + m_7 + m_9 + m_{11} + m_{13} + m_{15}$$

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$$= M_2 + M_4 + M_6 + M_8 + M_{10} + M_{12} + M_{14}$$

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(ii) $F(w,x,y,z) = y'z + wxy' + wxz' + w'x'z$

$F(w,x,y,z) = y'z + wxy' + wxz' + w'x'z$

$= (x+x')y'z + wxy'(z+z') + wx(y+y')z' + w'x'(y+y')z$

$= xy'z + x'y'z + wxy'z + wxy'z' + wxyz' + wxy'z' +$
$w'x'yz + w'x'y'z$

$= (w+w')xy'z + (w+w')x'y'z + wxy'z + wxy'z' +$
$wxyz' + wxy'z' + w'x'y'z + w'x'yz$

$= wxy'z + w'xy'z + wx'y'z + w'x'y'z + wxy'z + wxy'z' +$
$wxyz' + wxy'z' + w'x'y'z + w'x'yz$

$= wxyz' + w'xyz' + wx'y'z + w'x'y'z + wxy'z + wxy'z'$
$+ wxyz' + wxy'z' + w'x'yz + w'x'y'z$

$= wxy'z + w'xy'z + wx'y'z + w'x'y'z + wxy'z' + wxyz' +$
$w'x'yz$

$= m_1 + m_3 + m_5 + m_9 + m_{12} + m_{13} + m_{14}$

$= M_0 + M_2 + M_4 + M_6 + M_7 + M_8 + M_{10} + M_{11} + M_{15}$

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Q.5. Write Duality theorem, DeMorgan's law and Absorption theorem in Boolean Algebra

Duality Theorem

The theorem states that the dual of the Boolean function is obtained by interchanging the logical AND operator with logical OR operator and zeros with ones. For every Boolean function, there will be a corresponding Dual function.

Group 1	Group 2
$X+0=X$	$X\cdot 1=X$
$X+1=1$	$X\cdot 0=0$
$X+X=X$	$X\cdot X=X$
$X+X'=1$	$X\cdot X'=0$
$X+Y=Y+X$	$X\cdot Y=Y\cdot X$
$X+Y+Z=X+Y+Z$	$X\cdot Y\cdot Z=X\cdot Y\cdot Z$
$X\cdot(Y+Z)=(X\cdot Y)+(X\cdot Z)$	$X+(Y\cdot Z)=(X+Y)\cdot(X+Z)$

DeMorgan's Theorem

DeMorgan's has suggested two theorems which are extremly useful in Boolean Algebra. The two theorems are discussed below.

(i) First Theorem

The complement of the sum of two or more variables is equal to the product of the complement of the variables. In other

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words, a NOR gate is equivalent to bubbles AND gate.

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

A	B	A+B	$\bar{A}$	$\bar{B}$	$\overline{A+B}$	$\bar{A}\cdot\bar{B}$
0	0	0	1	1	1	1
0	1	1	1	0	0	0
1	0	1	0	1	0	0
1	1	1	0	0	0	0

(ii) Second Theorem

The complement of the product of two or more variables is equal to the sum of the complements of the variables. In other words, a NAND gate is equivalent to a bubbled OR gate.

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

A	B	A·B	$\overline{A\cdot B}$	$\bar{A}$	$\bar{B}$	$\bar{A}+\bar{B}$
0	0	0	1	1	1	1
0	1	0	1	1	0	1
1	0	0	1	0	1	1
1	1	1	0	0	0	0

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Absorption Theorem

We know that, in OR function of any one is input is logic 1, output is logic 1. Therefore we have an important relationship : $A+1=1$.

The two rules are :-

(i) $A + AB = A$
(ii) $A(A+B) = A$

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Mid Semester Test - 2

Q.1. Design BCD to gray code converter for decimal numbers. Determine all the Boolean expressions and draw logic diagram also.

Decimal	~~Gray Code~~ BCD				Gray Code			
	A	B	C	D	W	X	Y	Z
0	0	0	0	0	0	0	0	0
1	0	0	0	1	0	0	0	1
2	0	0	1	0	0	0	1	1
3	0	0	1	1	0	0	1	0
4	0	1	0	0	0	1	1	0
5	0	1	0	1	0	1	1	1
6	0	1	1	0	0	1	0	1
7	0	1	1	1	0	1	0	0
8	1	0	0	0	1	1	0	0
9	1	0	0	1	1	1	0	1
10	D	D	D	D	1	1	1	1
11	D	D	D	D	1	1	1	0
12	D	D	D	D	1	0	1	0
13	D	D	D	D	1	0	1	1
14	D	D	D	D	1	0	0	1
15	D	D	D	D	1	0	0	0

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Karnaugh Map for W :

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

Minimal Expression for W : $W = A$

Karnaugh Map for X

AB \ CD	00	01	11	10
00	$_{0}$	$_{1}$	$_{3}$	$_{2}$
01	1_{4}	1_{5}	1_{7}	1_{6}
11	[illegible] $_{12}$	[illegible] $_{13}$	[illegible] $_{15}$	[illegible] $_{14}$
10	1_{8}	1_{9}	1_{11}	1_{10}

Minimal Expression for X : $A + B$

Karnaugh Map for Y

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

Minimal Expression for Y : $BC' + B'C$

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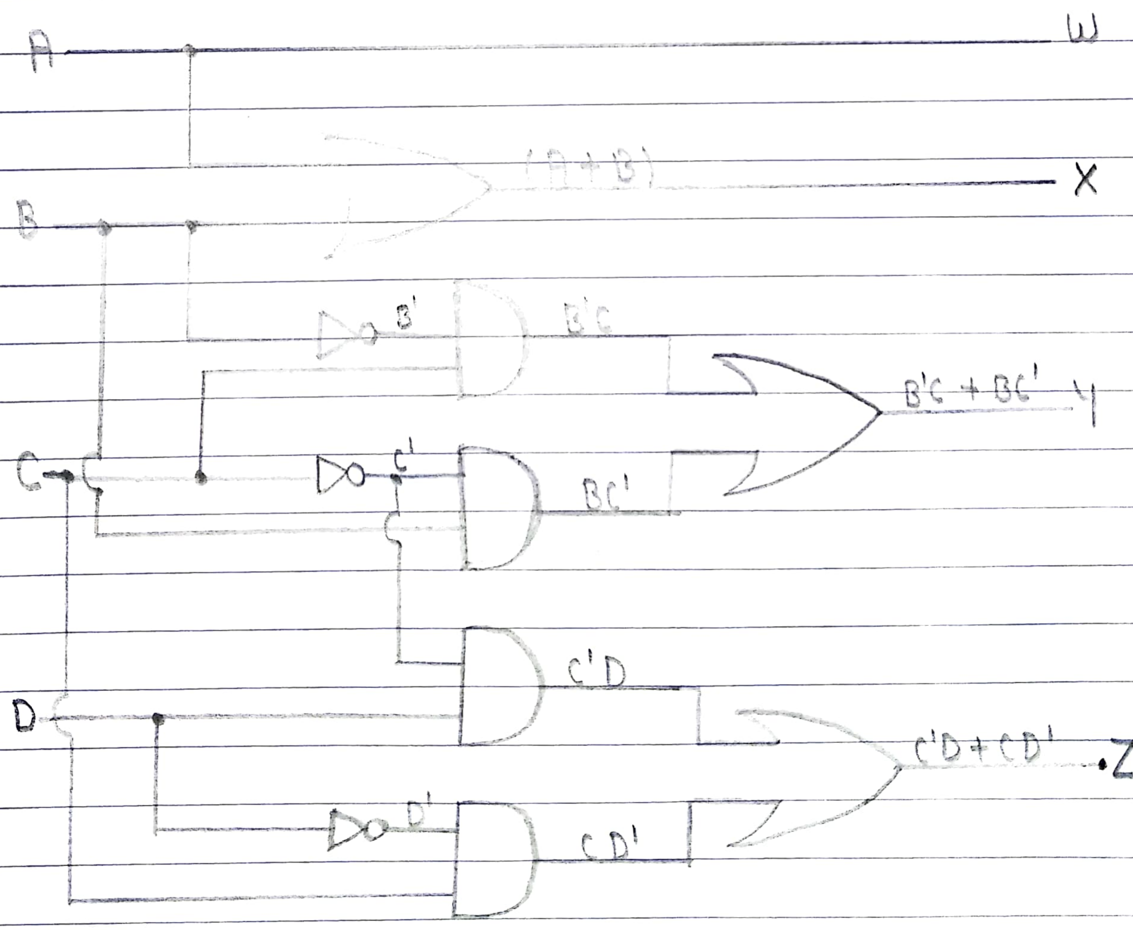
Karnaugh Map for Z

	00	01	11	10
00	0	1 (1)	3	1 (2)
01	4	1 (5)	7	1 (6)
11	12	1 (13)	15	1 (14)
10	8	1 (9)	11	1 (10)

Minimal Expression for Z : $C'D + CD'$

Logic Diagram



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Q.2. Implement a full subtractor using two half subtractor and OR gates.

Half Subtractor

Truth Table

A	B	Difference	Borrow
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

Difference

A\B	0	1
0		1
1	1	

Boolean → $\bar{A}B + A\bar{B}$

$A \oplus B$

Borrow

A\B	0	1
0		1
1		

Boolean → $\bar{A}B$

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Full Subtractor

Truth Table

A	B	C	Difference	Borrow
0	0	0	0	0
0	0	1	1	1
0	1	0	1	1
0	1	1	0	1
1	0	0	1	0
1	0	1	0	0
1	1	0	0	0
1	1	1	1	1

Difference

A\BC	00	01	11	10
0		1		1
1	1		1	

Boolean :- $AB'C' + A'B'C + ABC + A'BC'$

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

$C(A'B' + AB)' + C'(A \oplus B)$

$C(A \oplus B)' + C'(A \oplus B)$

$C \oplus (A \oplus B)$

Borrow

A\BC	00	01	11	10
0		1	1	1
1			1	

Boolean :- $A'B'C + A'BC + A'BC' + ABC$

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

$C(A \oplus B)' + A'B$

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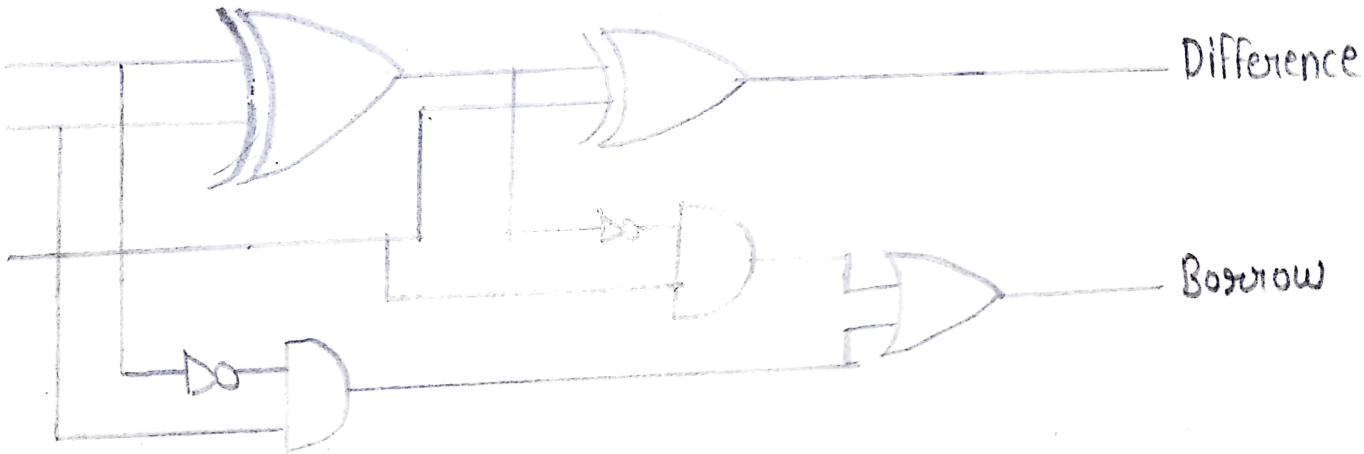
Circuit Diagram



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Q.3. Simplify the Boolean function using tabulation method

$F(A,B,C,D) = \Sigma(0,1,2,5,8,9,10)$

Ans

	A	B	C	D
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
8	1	0	0	0
5	0	1	0	1
9	1	0	0	1
10	1	0	1	0

Comparing Different Groups -

	A	B	C	D
(0,1)	0	0	0	_
(0,2)	0	0	_	0
(0,8)	_	0	0	0
(1,5)	0	_	0	1
(1,9)	_	0	0	1
(2,10)	_	0	1	0
(8,9)	1	0	0	_
(8,10)	1	0	_	0

(0,1,8,9)	_	0	0	_
(0,2,8,10)	_	0	_	0
(0,8,1,9)	_	0	0	_
(0,8,2,10)	_	0	_	0
(1,5)	0	_	0	1

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	0	1	2	5	8	9	10
(0,1,8,9)	X	X			X	X	
(0,2,8,10)	X		X		X		X
(1,5)		X		X			

	A	B	C	D
(0,1,8,9)		B'	C'	
(0,2,8,10)		B'		D'
(1,5)	A'		C'	D

$$F = B'C' + B'D' + A'C'D$$

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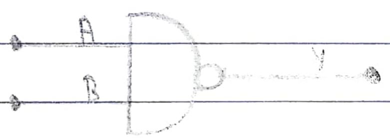
Q.4. Explain NAND and NOR implementation using one example for each.

NAND and NOR are universal logic gates which means any boolean logic can be implemented using this gates, i.e, only NAND gate or only NOR gate.

NAND Gate

Definition :- NAND gate (NOT + AND), hence its operation is just opposite as AND. It has two or more input but only one output signal is there

Symbol :-



Boolean Equation :-

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

Truth Table

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

Example :-

Let there be a function f :-

$\cancel{F = xy' + x'y' + z}$ $F = AB + CD$

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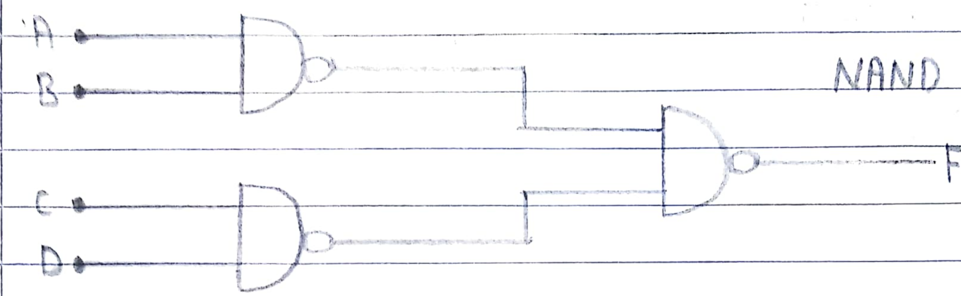
NAND Implementation



NOR Gate

Definition :- NOR gate (NOT + OR), hence it's operation is just opposite to OR gate. A NOR gate has two or more input signals but only one output signal.

Symbol :-

Boolean Equation

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

Truth Table

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

Example :-

Let there be a function F

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

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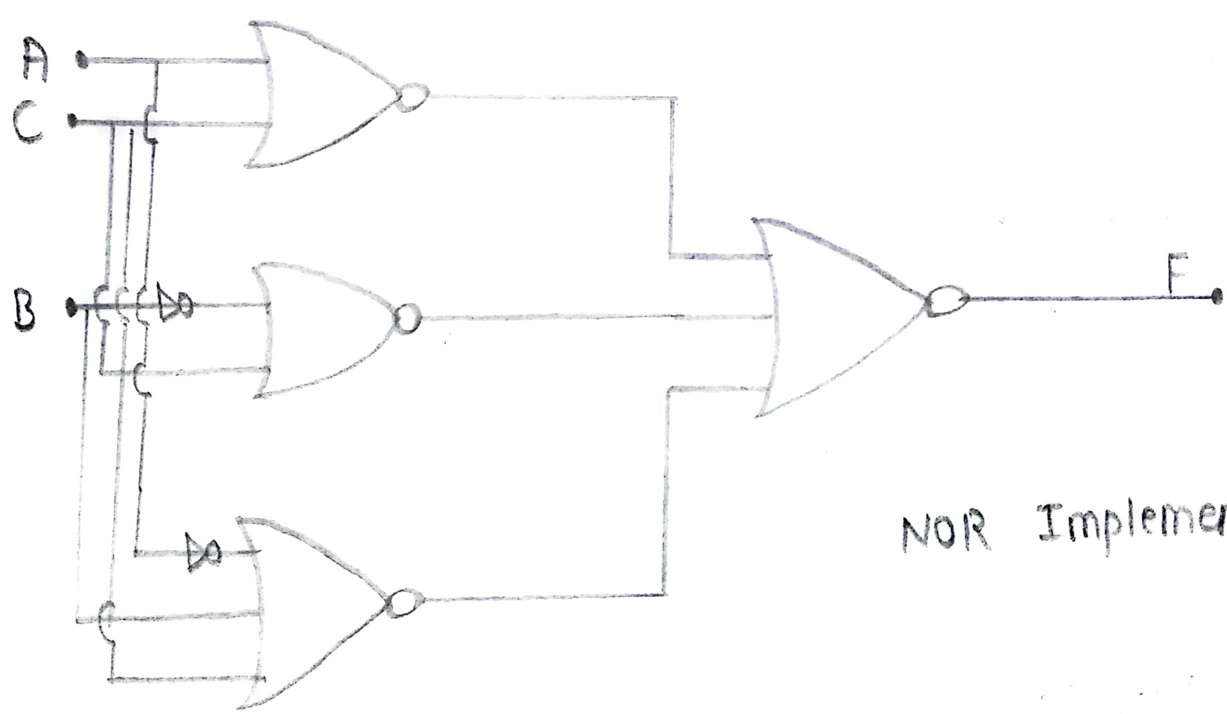

NOR Implementation

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Q.5. What is decoder? Explain 4X16 decoder with proper logic diagram.

Decoder

Decoder is a combinational logic circuit with some inputs (n) and many outputs (2^n). A particular output may be high or low depending upon values of input signals. Decoder detects a particular code.
The output of decoder is minimum terms of n input available lines, when enabled.

A 4x16 decoder is a higher-order decoder.
Number of inputs = 4
Number of outputs = $2^4 = 16$

It is obtained from adding either two 3x8 decoder circuits or three 2x4 decoder circuits.

3x8 Decoder circuits are combined. One enable pin acts as a input for both the decoder. Enable pin is high at one 3x8 decoder and low for the other.

When, w=0, top decoder is enabled and the other is disabled. Bottom decoder's outputs are all 0's top 8 outputs generate 0000 to 0111.

When, w=1, bottom decoder is enabled and the other is disabled. Top decoder's outputs are all 0's. Bottom 8 outputs generate 1000 to 1111

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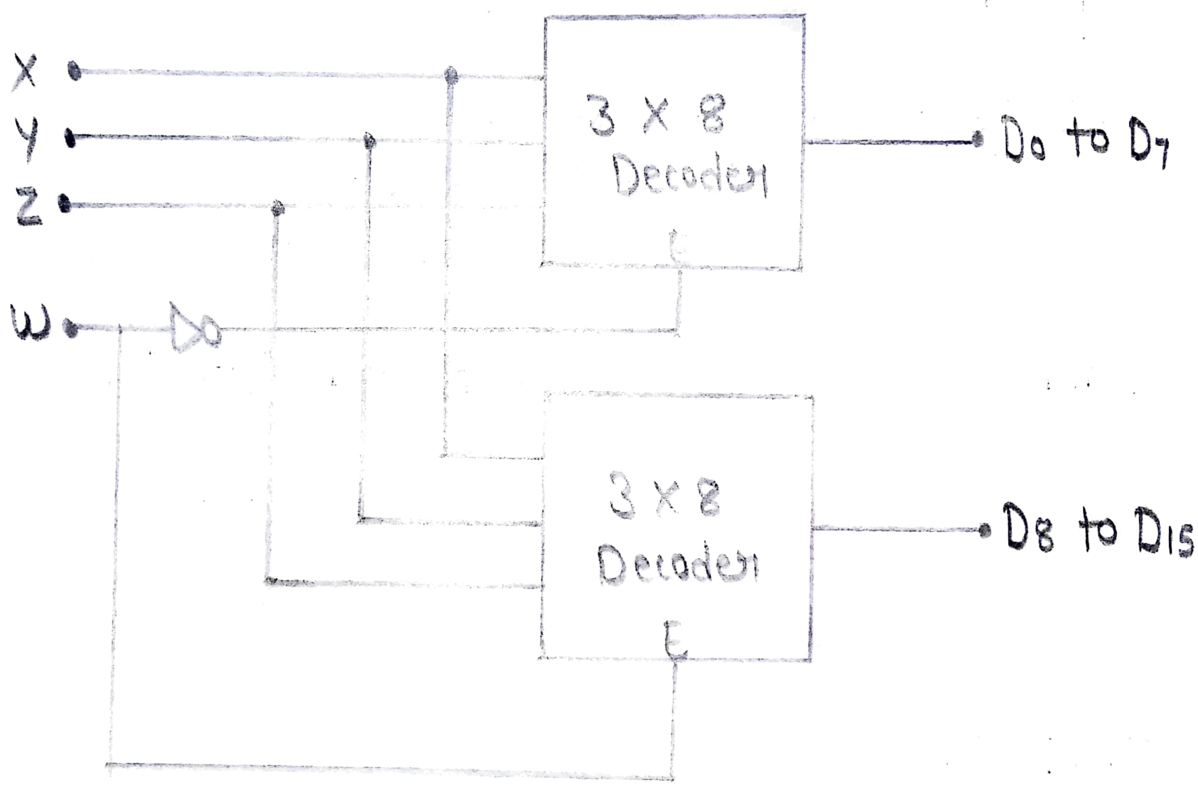
4X16 Decoder Logic Diagram



Do to D7 are higher light minterms.
D8 to D15 are lower light minterms.