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Subject: Digital Logic Design
Midterm-Assignment
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DIGITAL LOGIC & DESIGN

Midterm-Assignment

Date: ....

Q.1: Convert each of the following

(a) $45.25_{10} = (?)_2$

Given:

45.25_{10}

Required:

Convert 45.25_{10} to binary number system.

Sol

Using Repeated division for 45.

2	45	
2	22	1
2	11	0
2	5	1
2	2	1
2	1	0

$(45)_{10} = (101101)_2$

Now for frictional part we use repeated multiplication method.

$\Rightarrow \quad 0.25 \times 2 = 0.50 \rightarrow 0$

$\Rightarrow \quad 0.50 \times 2 = 1.00 \rightarrow 1$

hence

$$45.25_{(10)} = (101101.01)_2$$

$\therefore$ Answer

Date:

(b) $10000000.1010_2 = (?)_{10}$

Given:

$10000000.1010_{(2)}$

Required:

To convert the given binary number into decimal number system.

Sol

Using weighted notation

$(1 \times 2^{7}) + (1 \times 2^{-1}) + (1 \times 2^{-3})$

$\Rightarrow (1 \times 128) + (0.5) + (0.125)$

$\Rightarrow 128.625_{(10)}$ Answer

(c) $4D7F_{(16)} = (?)_{10}$

Given: $4D7F_{(16)}$

Required: Convert the given Hex number into decimal number system.

Sol

Using weighted notation.

$(4\times16^3)+(13\times16^2)+(7\times16^1)+(15\times16^0)$

$\Rightarrow (4\times4096)+(13\times256)+(7\times16)+(15\times1)$

$\Rightarrow 16384+3328+112+15$

$\Rightarrow (19839)_{10}$ Answer

Date: ....

(d) $128_{(10)} = (?)_{16}$

Given:

$128_{(10)}$

Required:

Hex equivalent of the given Decimal number.

Sol Using Repeated division by 16.

$$\begin{array}{r|rr} 16 & 128 & \\ 16 & 8 & 0 \\ & & \end{array}$$

hence

$128_{(10)} = (80)_{16}$ Answer

(e) $3A6F_{(16)} = (?)_2$

Given:

$3A6F_{(16)}$

Required:

To Convert the given hex number into binary number System

Sol

Using Hex – Binary table to convert $3A6F_{(16)}$ to Binary.

3	A	6	F
0011	1010	0110	1111

hence

$3A6F_{(16)} = 11101001101111_{(2)}$ Answer.

(f) $1100001111100101_{(2)} = (?)_{16}$

Given

$1100001111100101_{(2)}$

Required

Hex equivalent of given binary number

Sol

Using Groups of four.

1100	0011	1110	0101
C	3	E	5

hence

$1100001111100101_{(2)} = C3E5_{(16)}$ Answer

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(g) $6173_{(8)} = (?)_{10}$

Given:

$6173_{(8)}$

Required:

Decimal Equivalent of $6173_{(8)}$

Sol

Using weighted notation

$(6\times8^3)+(1\times8^2)+(7\times8^1)+(3\times8^0)$

$\Rightarrow (6\times512)+(1\times64)+(7\times8)+(3\times1)$

$\Rightarrow (3072)+(64)+(56)+(3)$

$\Rightarrow (3195)_{(10)}$

hence

$61783_{(8)} = 3195_{(10)}$ Answer.

(h) $169_{(10)} = (?)_8$

Given:

$169_{(10)}$

Required:

Octal Equivalent of $169_{(10)}$

Sol

using Repeated division by 8

8	169	
8	21	1
8	2	5

here $169_{(10)} = (251)_8$ Answer

(i) $2A7D_{(16)} = (?)_8$

Given:

$2A7D_{(16)}$

Required:

Octal Equivalent of $2A7D_{(16)}$

Sol

First Convert $2A7D_{(16)}$ to Binary number using groups of Four. (Table)

2	A	7	D
0010	1010	0111	1101

Now, Convert the obtained binary number into octal number using groups of 3.

Date: ....

= 000 010 101 001 111 101

0 2 5 1 7 5

hence

$2A7D_{(16)} = 25175_{(8)}$ Answer.

(j) $11111111_{(2)} = \pm(?)_{10}$

Given:

$(11111111)_2$

Required:

Decimal equivalent of given signed Binary no.

Sol

Using 2's Complement

$$\begin{array}{rl} 11111111 & \\ \hline 00000000 & \text{1's Complement} \\ + \quad\quad\quad\quad 1 & \text{2's Complement} \\ \hline 00000001 & \end{array}$$

$(1 \times 2^0) = 1_{(10)}$ Answer.

(k) $-12_{(10)} = (?)_2$

Given:

$-12_{(10)}$

Required:

Binary equivalent of $-12_{(10)}$

Sol

First find Binary equivalent of $12_{(10)}$ using repeated division by 2.

2	12	
2	6	0
2	3	0
2	1	1

$12_{(10)} = 1100_{(2)} \Rightarrow 00001100_{(2)}$.

Now taking 2's Complement of obtained number.

$$
\begin{array}{rl}
0\,0\,0\,0\,1\,1\,0\,0 & \\
\hline
1\,1\,1\,1\,0\,0\,1\,1 & \text{1's Complement} \\
+ \qquad\qquad\quad 1 & \text{2's Complemt.} \\
\hline
1\,1\,1\,1\,0\,1\,0\,0 &
\end{array}
$$

hence

$-12_{(10)} = 11110100_{(2)}$ Answer.

Date: ....

(l) 198 = (?) BCD

Given:

$198_{(10)}$

Required:

Convert the given decimal number to binary codded decimal

Sol

Using Deci-BCD table

1	9	8
0001	1001	1000

hence

$198_{(10)} = 000110011000$ BCD

(m) 100001110000 BCD = $(?)_{10}$

Given:

100001110000 BCD

Required:

Decimal equivalent of the given BCD number.

Sol

Using BCD-Decimal table

1000	0111	0000
8	7	0

hence 100001110000 Bcd = $870_{(10)}$ Answer.

(n) $1001010_{(2)}$ = (?) Gray.

Given:

$1001010_{(2)}$

Required:

Gray equivalent of $1001010_{(2)}$

Sol

$$\begin{array}{ccccccc} 1 \rightarrow & +0 \rightarrow & +0 \rightarrow & +1 \rightarrow & +0 \rightarrow & +1 \rightarrow & +0 \\ \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\ 1 & 1 & 0 & 1 & 1 & 1 & 1 \end{array}$$

hence

$1001010_{(2)}$ = 1101111 gray Answer

Date: ....

(O) 10101111 grey = (?)$_2$

Given:

10101111 grey

Required:

Binary Equivalent of 10101111 grey

Sol

1	0	1	0	1	1	1	1
↓	↓	↓	↓	↓	↓	↓	↓
1	1	0	0	1	0	1	0

hence

10101111 grey = $11001010_{(2)}$

(P) 0100 0001 = (?) ASCII

Given:

$01000001_{(2)}$

Required:

ASCII Equivalent of $01000001_{(2)}$

Sol

using ASCII table

$(1 \times 2^6) + (1 \times 2^0)$

$(1 \times 64) + (1 \times 1)$

$64 + 1$

$\Rightarrow 65_{(10)}$

Darsi Notes

$65_{10} = (A)$ ASCII character. Answer

(Q) 111000 = (?111000) Even parity.

Given:

$111000_{(2)}$

Required:

Attach Even parity bit to (111000)

Sol

Since there has to be even amount of 1's in an even parity number, we add 1 to the given number

1111000 => $1111000_{(2)}$ Answer

Date: ....

Q2: Calculate each of the following.

(a) $01111111_{(2)} - 00000111_{(2)}$

Sol

Taking 2's Complement on

$$
\begin{array}{r l}
\underline{00000111} & \\
11111000 & \text{1's Complement} \\
+ \qquad\qquad\quad \underline{1} & \text{2's Complement} \\
11111001 &
\end{array}
$$

Now

$$
\begin{array}{r}
1\,1\,1\,1\,1\,1\,1\,1 \\
{}^{1}0\,1\,1\,1\,1\,1\,1\,1 \\
+\ 1\,1\,1\,1\,1\,0\,0\,1 \\
\hline
1\,0\,1\,1\,1\,1\,0\,0\,0
\end{array}
$$

$\uparrow$

Discarded bit

hence $01111000_{(2)}$ Answer

(b) $01101010_{(2)} \times 11110001_{(2)}$

Sol

Using 2's Complement:

```
  1 1 1 1 0 0 0 1
  ---------------
  0 0 0 0 1 1 1 0     1's Complement
                + 1   2's Complement
  ---------------
  0 0 0 0 1 1 1 1
```

Now

```
                      0 0 0 0 1 1 1 1
                      0 1 1 0 1 0 1 0
                      ---------------
                      0 0 0 0 0 0 0 0
                    0 0 0 0 1 1 1 1 x
                  0 0 0 0 0 0 0 0 x x
                0 0 0 0 1 1 1 1 x x x
              0 0 0 0 0 0 0 0 x x x x
            0 0 0 0 1 1 1 1 x x x x x
          0 0 0 0 1 1 1 1 x x x x x x
        0 0 0 0 0 0 0 0 x x x x x x x
  -----------------------------------
  0 0 0 0 1 1 0 0 0 1 1 0 1 1 0
```

hence $11000110110_{(2)}$ Ans

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(C) $10001000_2 \div 00100010_2$

Sol

Quotient = 00000000

Now Subtracting deviser from divident using 2's Complement.

$$\begin{array}{r} 10001000 \\ +\ 11011110 \\ \hline \text{Discard} \leftarrow 1\,01100110 \end{array}$$

$$\begin{array}{rl} 00100010 & \\ 11011101 & \text{1's Com} \\ 1 & \text{2's Com} \\ \hline 11011110 & \end{array}$$

Adding 1 to Quotient.
= 00000001

Subtracting deviser from 1st partial remainder using 2's Comp.

$$\begin{array}{r} 01100110 \\ +\ 11011110 \\ \hline \text{Discard} \leftarrow 1\,01000100 \end{array}$$

Adding 1 to Quotient.
00000010

Again

$$\begin{array}{r} 01000100 \\ +\ 11011110 \\ \hline \text{Discard} \leftarrow 1\,00100010 \end{array}$$

Adding 1 to Quotient
= 00000011

Now Again

$$
\begin{array}{r}
 1\,1\,1\,\,1\,1\,1 \\
 00100010 \\
+\ 11011110 \\
\hline
\text{Discard.} \leftarrow 1\ 00000000
\end{array}
$$

Adding 1 to Qoutient

Qoutient = 00000100 Answer

(d) $6D_{16} - 3F_{16}$

Sol Using 2's Complement on $3F_{16}$

3	F
0011	1111

$3F_{16} = 00111111.$

Taking 2's Complement

$$\begin{array}{rl} 00111111 & \\ \hline 11000000 & \text{1's. Co} \\ + \quad\quad 1 & \text{2's Co} \\ \hline 11000001 & \end{array}$$

$$\underbrace{1100}_{C} \; \underbrace{0001}_{1}$$

Now adding $6D_{16}$ and C1

$$\begin{array}{r} 6D \\ + \; C1 \\ \hline 12E \end{array}$$

$\Rightarrow$ $F = \boxed{12E}$ Ans

Date: ....

(c) 00010110 BCD to 00010101 BCD = $(?)_{10}$

Sol

$$
\begin{array}{rcc}
 & 0001 & 0110 \\
+ & 0001 & 0101 \\
\hline
 & 0010 & 1010
\end{array}
$$

→ invalid due to (>9)

Add 6 to invalid code

$$
\begin{array}{rcc}
 & 0010 & 1011 \\
 & & +0110 \\
\hline
 & 0011 & 0001
\end{array}
$$

$\underline{0011}\ \underline{0001}$ Answer

3 1

Date: ....

Q3: Apply CRC to the Data bits $1101001 1_2$ using generator code 1010_2 to produce the transmitted CRC code.

Given:

$D = 11010011_2$

$G = 1010$

$D' = 110100110000$

Required:

Transmitted CRC Code

Sol

Using modulo-2 operation

$$\frac{D'}{G} = \frac{110100110000}{1010}$$

```
110100110000          110100110100
1010                  1010
----                  ----
 1110                  1110
 1010                  1010
 ----                  ----
  1000                  1000
  1010          =>      1010
  ----                  ----
    1011                  1011
    1010                  1010
    ----                  ----
       1000                  1010
       1010                  1010
       ----                  ----
        100                    00
```

Since Remainder $\neq 0$, Remainder $= 0$

we appened that data bits with remainder end and do modulo-2 operation again.

110100110100 CRC Answer.

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Q 4: Asume that Code produced in Q3 has error occure in the most significant bit during transmission. Apply CRC to detet the error.

Given:

Recieved Data = $D' = 010100110100$

$G = 1010$

Required:

To detect the error in the transmitted CRC code.

```
010100110100
1010
1111
1010
01010
 1010
 00000110
     1010
     1100
     1010
     01101
      1010
      01110
       1010
```

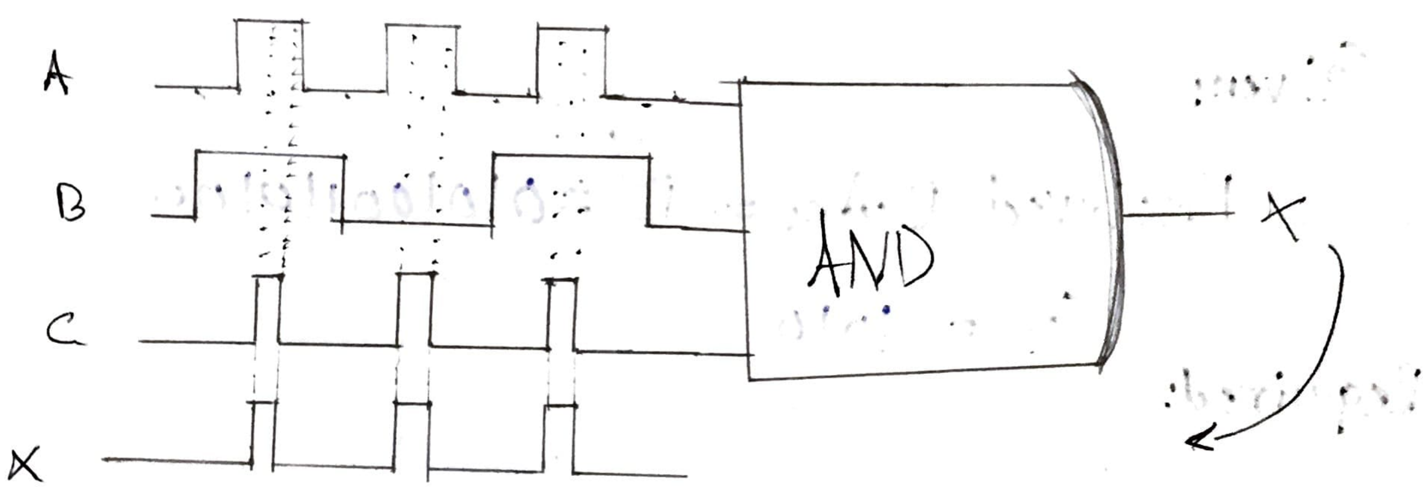
```
01000
 1010
 0010
```

Remainder $\neq 0$

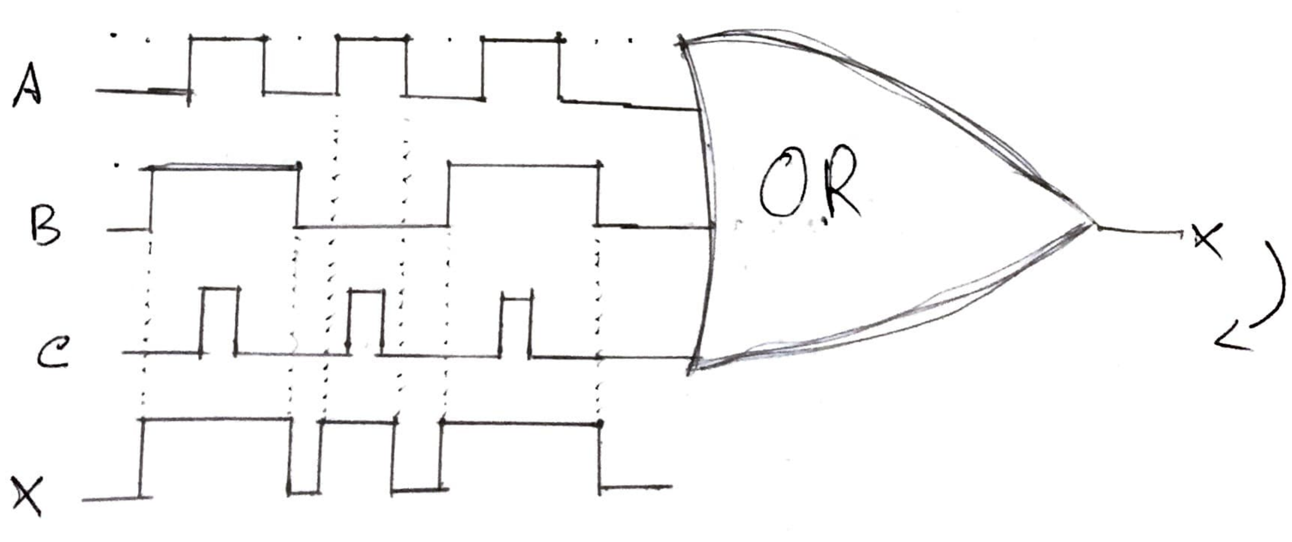
hence Error has occured.

Darsi Notes

Q5: The input waveforms in figure are applied to a 3-input AND gate. Show the output waveform with timing diagram.

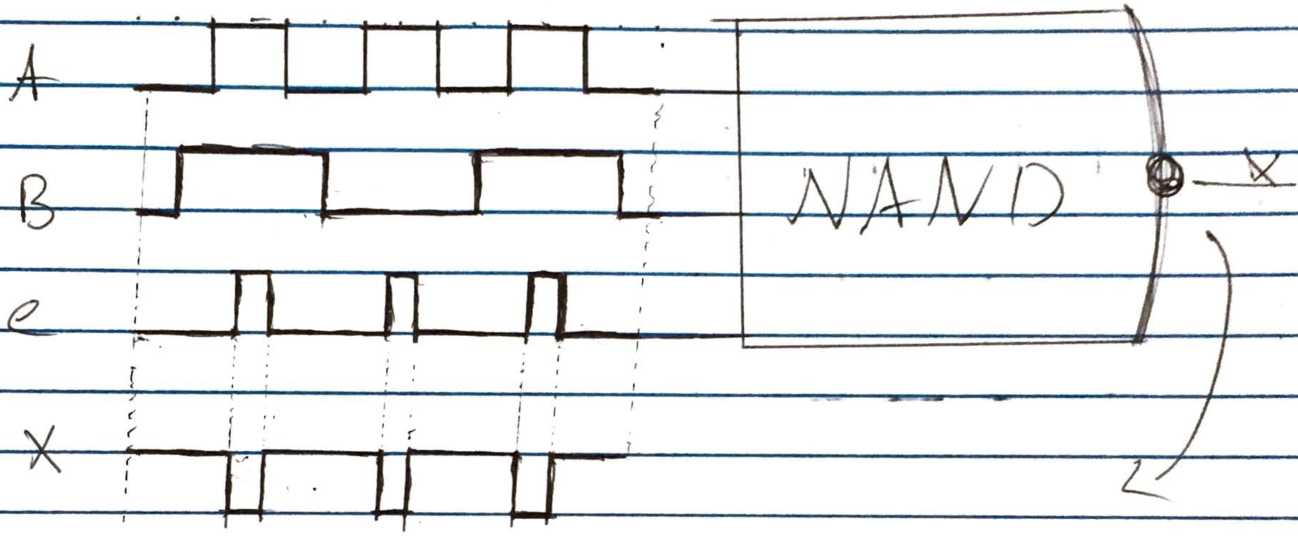


Q6: Repeat Q5 for OR gate.

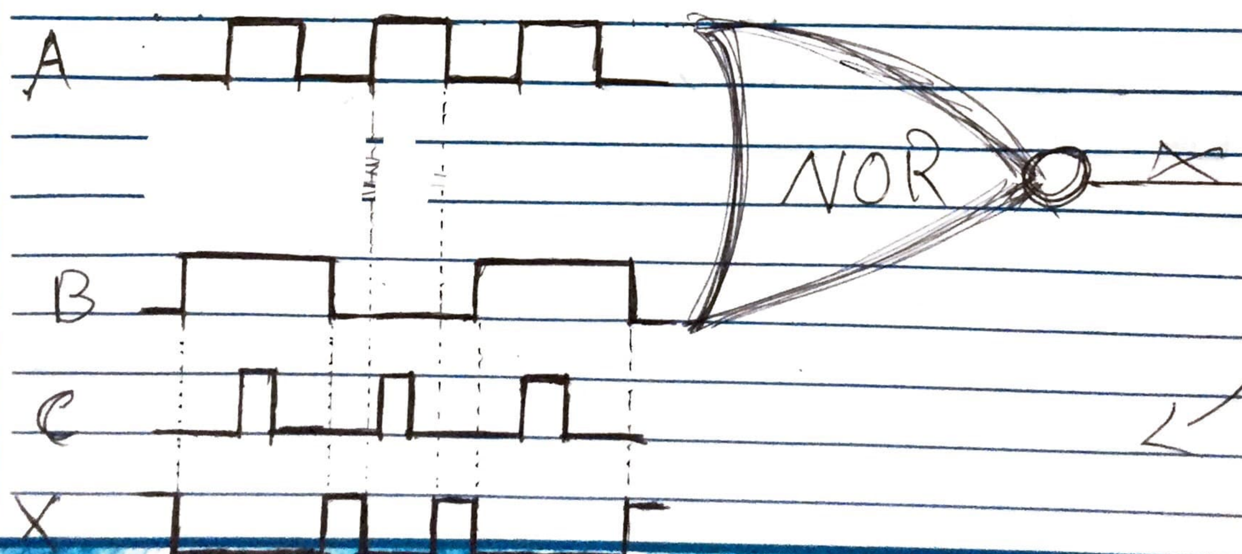


Date: ....

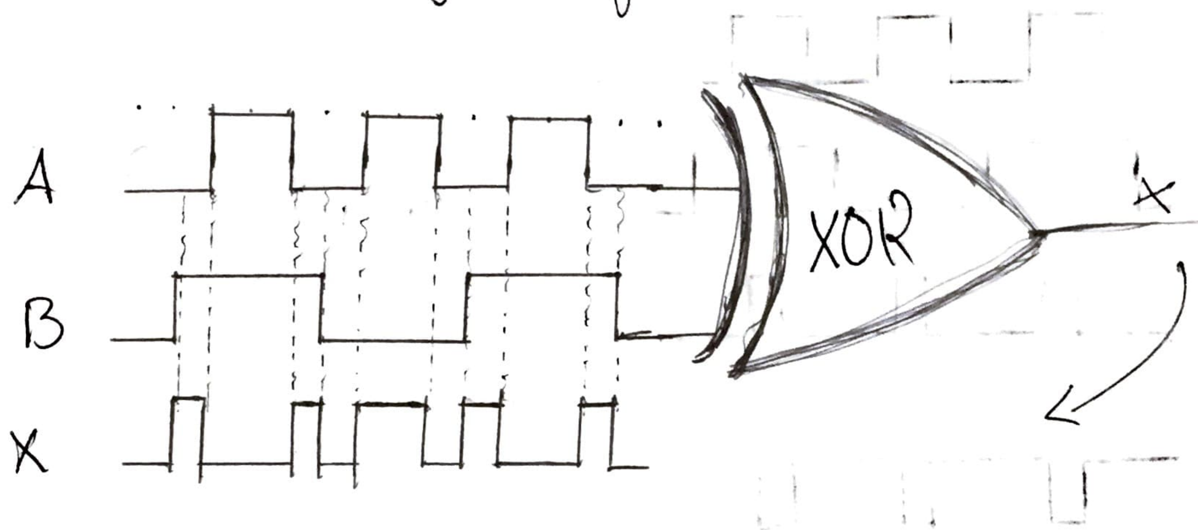
Q7: Repeat Q5, for NAND Gate



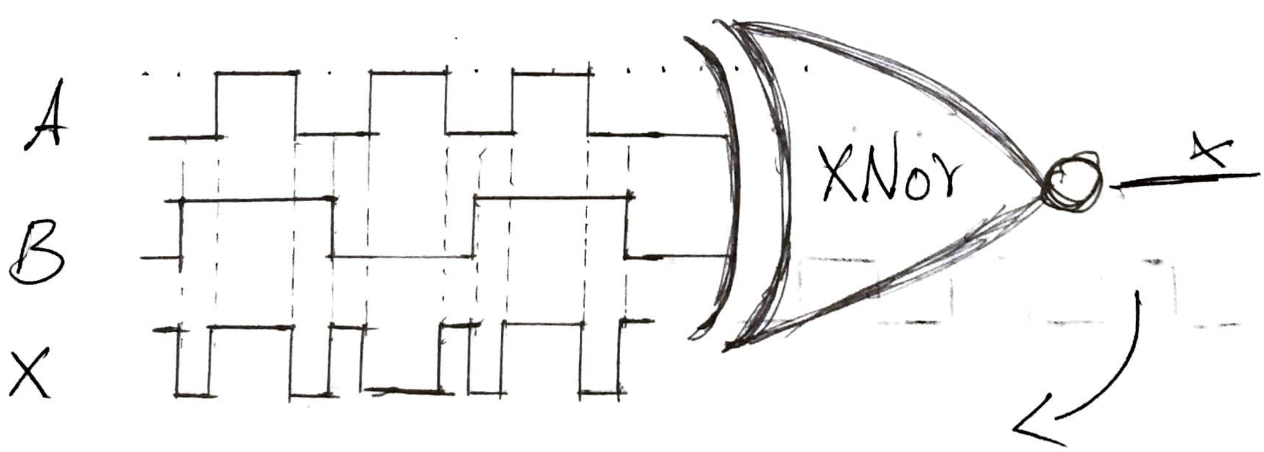
Q8: Repeat Q5 for NOR Gate



Q9: The input waveforms in figure are applied to a XOR gate, Show the output waveform with timing diagram.



Q10: Repeat Q9 for XNOR gate.



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Q11: Using boolean algebra techniques, Simplify the following expressions as much as possible.

$$A\overline{B} + A\overline{B}C + A\overline{B}CD + A\overline{B}CDE$$

Sol Using Boolean Algebra Rules,

$$\Rightarrow \underbrace{A\overline{B} + A\overline{B}C}_{(A+AB=A)} + A\overline{B}CD + A\overline{B}CDE$$

$$\Rightarrow \underbrace{A\overline{B} + A\overline{B}CD}_{A+AB=A} + A\overline{B}CDE$$

$$\Rightarrow \underbrace{A\overline{B} + A\overline{B}CDE}_{A+AB=A}$$

$(A\overline{B})$ Answer

Rough work

$A\overline{B} + A\overline{B}C$

$A\overline{B}\underbrace{(1+C)}_{A+1=1}$

$A\overline{B}(1)$

$(A\overline{B})$

Q12: Convert the following expression to Standard SoP form.

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

Sol

$\Rightarrow (C+D)(\bar{A}+D)$

$\Rightarrow C\bar{A}+D$

Domain of this SoP is ACD

$\Rightarrow$ Term $C\bar{A}$ is missing D.

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

$\Rightarrow$ Term D is missing C and A

$= D = D(A+\bar{A}) = DA + D\bar{A}$

$\Rightarrow$ Term DA and $D\bar{A}$ is missing C.

$= DA = DA(C+\bar{C}) = DAC + DA\bar{C}$

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

Joing Aall the terms

$(C\bar{A}D + C\bar{A}\bar{D} + DAC + DA\bar{C} + D\bar{A}C + D\bar{A}\bar{C})$

Answer

Converting to SoP

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

$\Rightarrow C\bar{A} + CD + D\bar{A} + \underbrace{DD}_{AA=A}$

$= C\bar{A} + CD + \underbrace{\bar{A}D + D}_{A+AB=A}$

$= C\bar{A} + \underbrace{CD + D}_{A+AB=A}$

$\Rightarrow C\bar{A} + D$

Q13: Write standard POS expression using the standard SOP expression from Q12.

Sol

POS Express

$(C\bar{A}D) + (C\bar{A}\bar{D}) + (DAC) + (DA\bar{C}) + (D\bar{A}C) + (D\bar{A}\bar{C})$

There are three variable in the domain of this expression.
Total possible combinations are $2^3 = 8$.

Combinations contained in this POS expression are

$(101) + (100) + (111) + (110) + (101) + (100)$

$\Rightarrow (101) + (100) + (111) + (110)$

Remaining combinations are:

000, 010, 011, 001

hence the POS expression is

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

Q 14: Draw a Sing Truth for both standard PoS and Standard Sop expressions obtained in Q-12 and Q 13.

A	C	D	X	POS/SOP
0	0	0	0	$(A+C+D)$
0	0	1	0	$(A+C+\bar{D})$
0	1	0	0	$(A+\bar{C}+D)$
0	1	1	0	$(A+\bar{C}+\bar{D})$
1	0	0	1	$(A\bar{C}\bar{D})$
1	0	1	1	$(A\bar{C}D)$
1	1	0	1	$(AC\bar{D})$
1	1	1	1	(ACD)

POS Expression:

$$(A+C+D)(A+\bar{C}+D)(A+\bar{C}+D)(A+C+D).$$

Sop Expression:

$$(CAD)+(C\bar{A}\bar{D})+(\bar{C}DA)+(D+\bar{C})$$

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Q15: Use karnaugh map to simplify the following expressions to a minimum SOP form

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

$$000 + 011 + 101 + 110$$

AB \ C	0	1	
00	1		$\rightarrow (\bar{A}\bar{B}\bar{C})$
01		1	$\rightarrow (\bar{A}BC)$
11	1		$\rightarrow (AB\bar{C})$
10		1	$\rightarrow (A\bar{B}C)$

$(\bar{A}\bar{B}\bar{C}) + (\bar{A}BC) + (AB\bar{C}) + (A\bar{B}C)$ is the minimum SOP.

Q16: Obtain the minimum POS expression from karnaugh map used in Q.15.

Sol

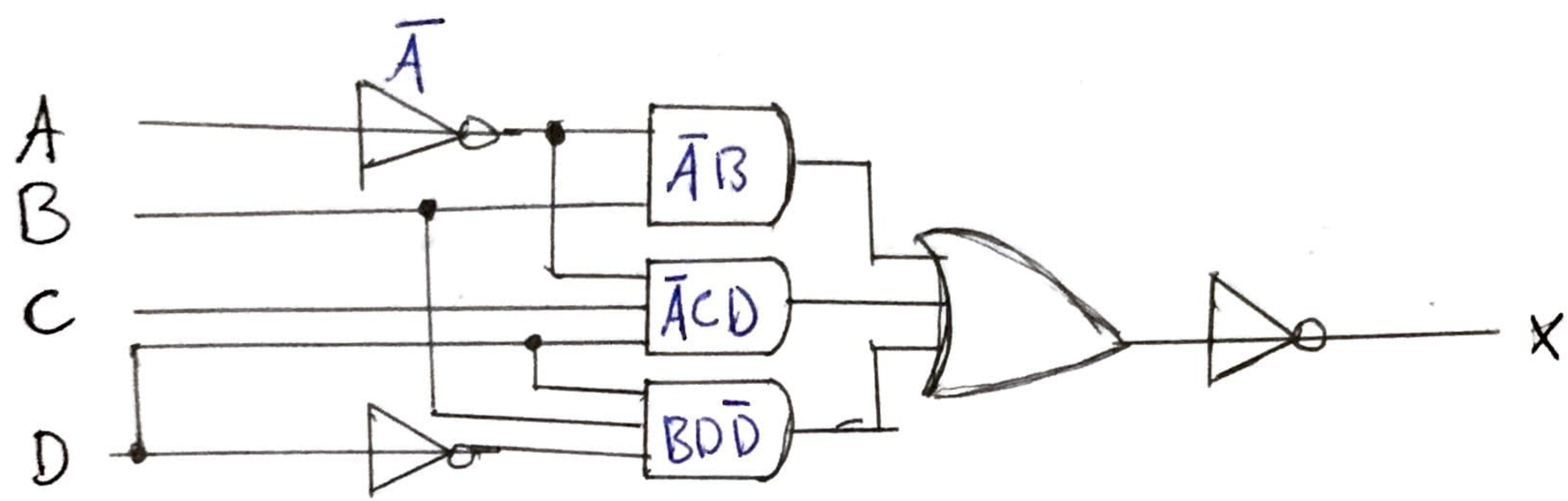
AB \ C	0	1	
00	1	0	$\rightarrow (A+B+\bar{C})$
01	0	1	$\rightarrow (A+\bar{B}+C)$
11	1	0	$\rightarrow (A+B+\bar{C})$
10	0	1	$\rightarrow (\bar{A}+B+C)$

hence

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

is the minimum POS expression.

Q17: write the output expression for the circuit in figure.



$$X = \overline{(\bar{A}B) + (\bar{A}CD) + (BD\bar{D})}$$

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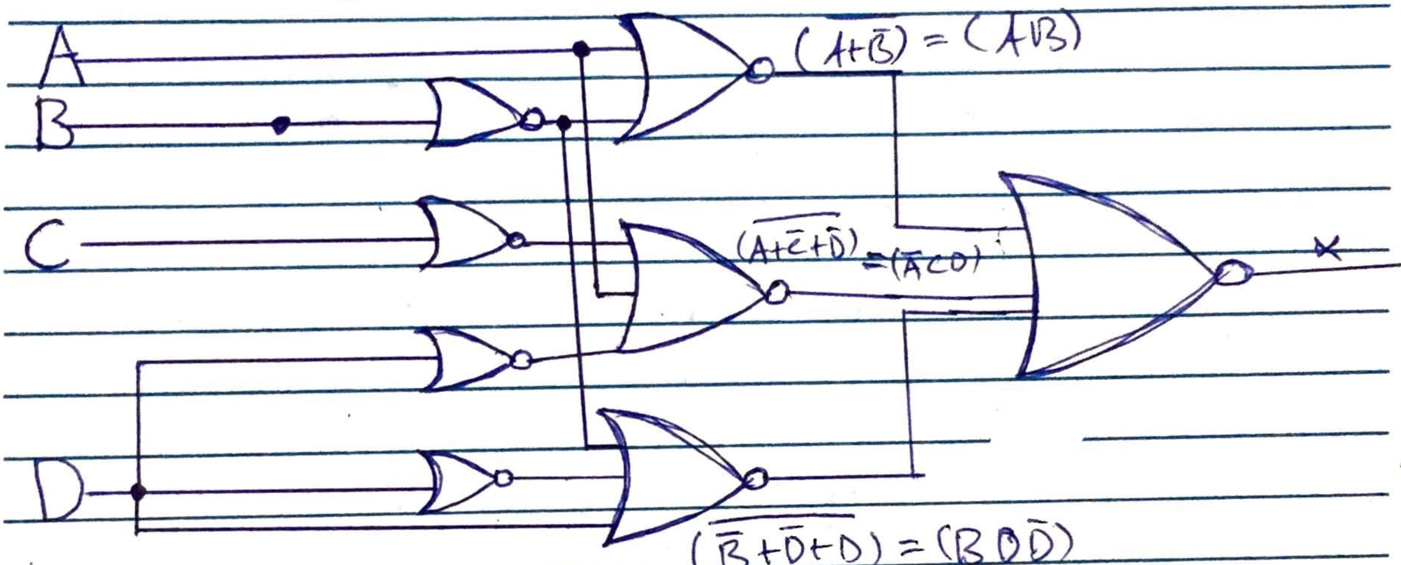
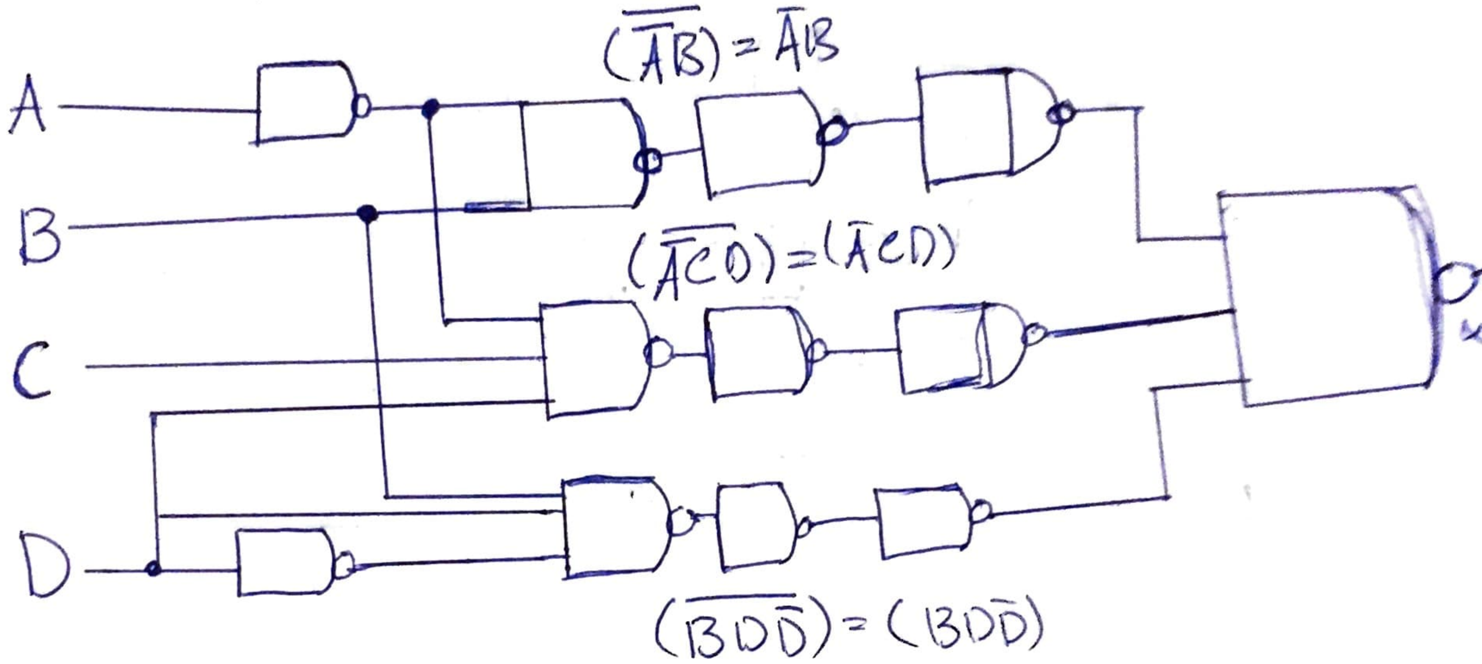
Q18: Implement the logic circuit in Q17 using NOR Gates.



$$X = \overline{(\overline{A+\overline{B}})+(\overline{A+\overline{C}+\overline{D}})+(\overline{\overline{B}+\overline{B}+D})}$$

$$\Rightarrow \overline{(\overline{A}B)+(\overline{A}CD)+(BD\overline{D})}$$

Q 19: Implement the logic circuit in Q 17 with only NAND Gates.



$$X = \overline{(\overline{\overline{A}B})(\overline{\overline{A}CD})(\overline{BD\overline{D}})}$$

By De morgan's theorem

$$X = \overline{(\overline{A}B) + (\overline{A}CD) + (BD\overline{D})}$$

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Q20: Implement a logic circuit for the truth table in table (1)

<u>Sol</u> Obtained expression from truth table is

$(\bar{A}\bar{B}C\bar{D})+(\bar{A}\bar{B}CD)+(\bar{A}B\bar{C}\bar{D})+(A\bar{B}\bar{C}\bar{D})+(A\bar{B}\bar{C}D)+(A\bar{B}C\bar{D})+(A\bar{B}CD)+(ABCD)$

By reducing the expression using boolean laws and rules we get

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