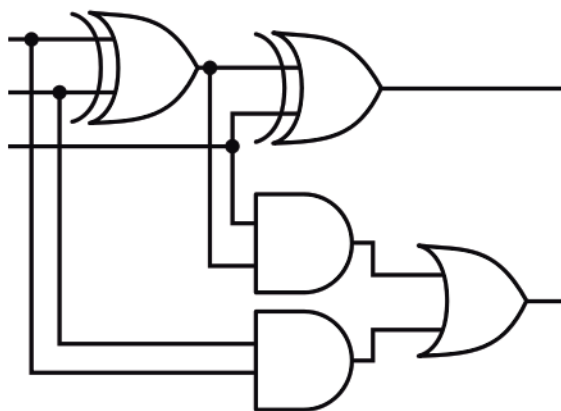




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**COMPUTER SCIENCE &
INFORMATION TECHNOLOGY**

DIGITAL LOGIC

Volume-1 : Study Material with Classroom Practice Questions

Digital Logic

(Solutions for Vol-1_Classroom Practice Questions)

1. Number Systems

01. Ans: (d)

Sol: $135_x + 144_x = 323_x$

$$(1 \times x^2 + 3 \times x^1 + 5 \times x^0) + (1 \times x^2 + 4 \times x^1 + 4 \times x^0) = 3x^2 + 2x^1 + 3x^0$$

$$\Rightarrow x^2 + 3x + 5 + x^2 + 4x + 4 = 3x^2 + 2x + 3$$

$$x^2 - 5x - 6 = 0$$

$$(x-6)(x+1) = 0 \quad (\text{Base cannot be negative})$$

Hence $x = 6$.

(OR)

As per the given number x must be greater than 5. Let consider $x = 6$

$$(135)_6 = (59)_{10}$$

$$(144)_6 = (64)_{10}$$

$$(323)_6 = (123)_{10}$$

$$(59)_{10} + (64)_{10} = (123)_{10}$$

So that $x = 6$

02. Ans: (a)

Sol: 8-bit representation of

$$+127_{10} = 01111111_{(2)}$$

1's complement representation of

$$-127 = 10000000.$$

2's complement representation of

$$-127 = 10000001.$$

No. of 1's in 2's complement of

$$-127 = m = 2$$

No. of 1's in 1's complement of

$$-127 = n = 1$$

$$\therefore m:n = 2:1$$

03. Ans: (c)

Sol: In 2's complement representation the sign bit can be extended towards left any number of times without changing the value. In given number the sign bit is 'X₃', hence it can be extended left any number of times.

04. Ans: (c)

Sol: Binary representation of $+(539)_{10}$:

2	539	
2	269	-1
2	134	-1
2	67	-0
2	33	-1
2	16	-1
2	8	-0
2	4	-0
2	2	-0
1		-0

$$(+539)_{10} = (10000 \ 11 \ 0 \ 11)_2 = (00100 \ 0011011)_2$$

$$2'S \text{ complement} \rightarrow 110111100101$$

$$\text{Hexadecimal equivalent} \rightarrow (DE5)_H$$

05. Ans: 5

Sol: Symbols used in this equation are 0,1,2,3.

Hence base or radix can be 4 or higher

$$(312)_x = (20)_x (13.1)_x$$

$$3x^2 + 1x + 2x^0 = (2x+0)(x+3x^0+x^{-1})$$

$$3x^2 + x + 2 = (2x) \left(x + 3 + \frac{1}{x} \right)$$

$$3x^2 + x + 2 = 2x^2 + 6x + 2$$

$$x^2 - 5x = 0 \Rightarrow x(x-5) = 0$$

$$x = 0(\text{or}) x = 5$$

$$x \text{ must be } x > 3, \text{ So } x = 5$$



06. Ans: 3 possible solutions

Sol: $123_5 = x8_y$

$$1 \times 5^2 + 2 \times 5^1 + 3 \times 5^0 = x.y^1 + 8 \times y^0$$

$$25 + 10 + 3 = xy + 8$$

$$\therefore xy = 30$$

Possible solutions:

i. $x = 1, y = 30$

ii. $x = 2, y = 15$

iii. $x = 3, y = 10$

3 possible solutions

07. Ans: 1

Sol: The range (or) distinct values

For 2's complement $\Rightarrow -(2^{n-1})$ to $+(2^{n-1}-1)$

For sign magnitude

$$\Rightarrow -(2^{n-1}-1) \text{ to } +(2^{n-1}-1)$$

Let $n = 2 \Rightarrow$ in 2's complement

$$-(2^{2-1}) \text{ to } +(2^{2-1}-1)$$

$$-2 \text{ to } +1 \Rightarrow -2, -1, 0, +1 \Rightarrow x = 4$$

$$n = 2 \text{ in sign magnitude} \Rightarrow -1 \text{ to } +1 \Rightarrow y = 3$$

$$x - y = 1$$

2. Logic Gates & Boolean Algebra

01. Ans: (b)

Sol: Truth table of XOR

A	B	o/p
0	0	0
0	1	1
1	0	1
1	1	0

Stage 1:

Given one i/p = 1 Always.

1	X	o/p
1	0	1
1	1	0

For First XOR gate o/p = $\bar{X}$

Stage 2:

$\bar{X}$	X	o/p
0	1	1
1	0	1

For second XOR gate o/p = 1.

Similarly for third XOR gate o/p = $\bar{X}$ & for fourth o/p = 1

For Even number of XOR gates o/p = 1

For 20 XOR gates cascaded o/p = 1.

02. Ans: (b)

Sol:

v = 0					v = 1				
w,x	$\bar{w}\bar{x}$	$\bar{w}x$	$w\bar{x}$	wx	w,x	$\bar{w}\bar{x}$	$\bar{w}x$	$w\bar{x}$	wx
y,z	00	01	11	10	y,z	00	01	11	10
$\bar{y}z = 00$		1	1		$\bar{y}z = 00$		1	1	
$\bar{y}z = 01$	1	1	1	1	$\bar{y}z = 01$	1	1	1	1
$yz = 11$		1	1		$yz = 11$		1	1	
$\bar{y}z = 10$		1	1		$\bar{y}z = 10$		1	1	

03. Ans: (c)

Sol: $f = f_1 f_2 + f_3$



04. Ans: (c)

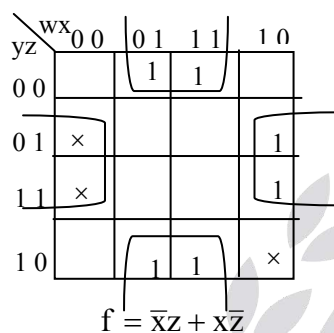
Sol: Let $x_1 = x_2 = x_3 = x_4$

For all cases option A, B, D not satisfy.

3. K-Maps

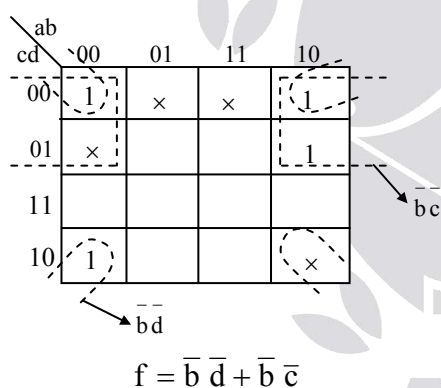
01. Ans: (b)

Sol:



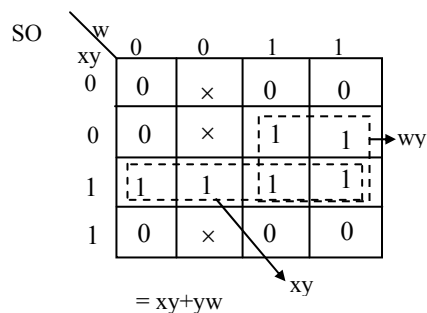
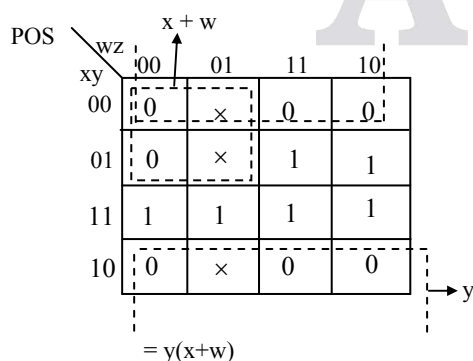
02. Ans: (b)

Sol:



03.

Sol:



SOP: $x y + y w$

POS: $y(x + w)$

04. Ans: (a)

Sol: For n-variable Boolean expression,

Maximum number of minterms = 2^n

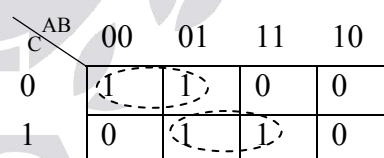
Maximum number of implicants = 2^n

Maximum number of Essential prime

$$\begin{aligned} \text{implicants} &= \frac{2^n}{2} \\ &= 2^{n-1} \end{aligned}$$

05. Ans: (c)

Sol:



06. Ans: 1

Sol: After minimization = $(\bar{A} + \bar{B} + \bar{C} + \bar{D})$
 $= ABCD$

∴ only one minterm.



07. Ans: 3

Sol: $\bar{w}\bar{z} + \bar{w}xy + \bar{x}yz$

	yz	00	01	11	10
wx	00	1			1
	01	1	1		1
	11				
	10				1

4. Combinational Circuits

01. Ans: (d)

Sol: Let the output of first MUX is "F₁"

$$F_1 = AI_0 + AI_1$$

Where A is selection line, I₀, I₁ = MUX Inputs

$$F_1 = \bar{S}_1 \cdot W + S_1 \cdot \bar{W} = S_1 \oplus W$$

Output of second MUX is

$$F = \bar{A} \cdot I_0 + A \cdot I_1$$

$$F = \bar{S}_2 \cdot F_1 + S_2 \cdot \bar{F}_1$$

$$F = S_2 \oplus F_1$$

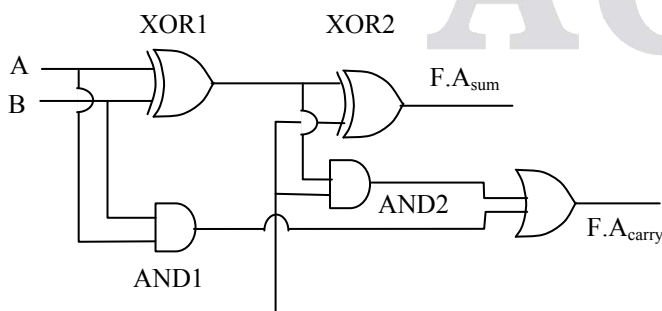
$$\text{But } F_1 = S_1 \oplus W$$

$$F = S_2 \oplus S_1 \oplus W$$

$$\text{i.e., } F = W \oplus S_1 \oplus S_2$$

02. Ans: 19.2

Sol: F.A using H.A



$$t_{\text{AND}} = 1.2\mu\text{s}; t_{\text{OR}} = 1.2\mu\text{sec}$$

$$\text{XOR} = 2 \times 1.2 = 2.4\mu\text{sec}$$

$$\begin{aligned} \text{Time for addition} &= \text{XOR1} + \text{XOR2} = 2.4 + 2.4 \\ &= 4.8\mu\text{sec} \end{aligned}$$

$$\begin{aligned} \text{Time for carry} &= \text{XOR1} + \text{AND2} + \text{OR} \\ &= 2.4 + 1.2 + 1.2 = 4.8\mu\text{sec} \end{aligned}$$

for n-bit total time required

$$= (n-1) t_c + \text{Max}[t_c, t_s]$$

⇒ for 4 bit

$$(4-1) \times 4.8 + \text{Max}[4.8, 4.8]$$

$$3 \times 4.8 + 4.8 = 19.2\mu\text{sec}$$

03. Ans: 6

Sol: T = 0 → NOR → MUX 1 → MUX 2

$$2\text{ns} \quad 1.5\text{ns} \quad 1.5\text{ns}$$

$$\text{Delay} = 2\text{ns} + 1.5\text{ns} + 1.5\text{ns} = 5\text{ns}$$

T = 1 → NOT → MUX 1 → NOR → MUX 2

$$1\text{ns} \quad 1.5\text{ns} \quad 2\text{ns} \quad 1.5\text{ns}$$

$$\text{Delay} = 1\text{ns} + 1.5\text{ns} + 2\text{ns} + 1.5\text{ns} = 6\text{ns}$$

Hence, the maximum delay of the circuit is 6ns

04. Ans: -1

Sol: When all bits in 'B' register is '1', then only it gives highest delay.

∴ '-1' in 8 bit notation of 2's complement is 1111 1111

05. Ans: 195

Sol: Given $t_{\text{carry}} = 12\text{ns}$

$$t_{\text{sum}} = 15\text{ns}$$

$$n = 16 \text{ bit}$$

$$\text{Time required} = (16-1) \times 12 + \text{max}(15, 12)$$

$$15 \times 12 + 15 = 195\text{nsec.}$$



5. Sequential Circuits

01. Ans: 4

Sol: In the given first loop of states, zero has repeated 3 times. So, minimum 4 number of Flip-flops are needed.

02. Ans: (b)

Sol:

CLK	Serial in= $B \oplus C \oplus D$	A B C D
0		1 0 1 0
1	1 $\rightarrow$	1 1 0 1
2	0 $\rightarrow$	0 1 1 0
3	0 $\rightarrow$	0 0 1 1
4	0 $\rightarrow$	0 0 0 1
5	1 $\rightarrow$	1 0 0 0
6	0 $\rightarrow$	0 1 0 0
7	1 $\rightarrow$	1 0 1 0

03. Ans: (b)

Sol:

J	K	Q_n	$\bar{Q}_n$	$T = (J + Q_n)(K + \bar{Q}_n)$	Q_{n+1}
0	0	0	1	$0.1 = 0$	0 } Q_n
0	0	1	0	$1.0 = 0$	
0	1	0	1	$0.1 = 0$	0 } 0
0	1	1	0	$1.1 = 1$	
1	0	0	1	$1.1 = 1$	1 } 1
1	0	1	0	$1.0 = 0$	
1	1	0	1	$1.1 = 1$	1 } $\bar{Q}_n$
1	1	1	0	$1.1 = 1$	

J \ KQ_n	00	01	11	10
0			1	
1	1		1	1

$$T = J \bar{Q}_n + KQ_n = (J + Q_n)(K + \bar{Q}_n)$$

07. Ans: (c)

Sol: From circuit we can write

$$D = X \oplus Q$$

$$\text{but for D FF} \Rightarrow Q_{n+1} = D$$

$$Q_{n+1} = D = X \oplus Q$$

$$Q_{n+1} = \bar{X}Q + X\bar{Q}$$

[This is same as T FF output]

$$\text{T FF output } Q_{n+1} = \bar{T}Q + T\bar{Q}$$

Therefore given circuit act as T Flip-Flop

08. Ans: (d)

$$\text{Sol: } D_A = Q_B \odot Q_C ; D_B = Q_A ; D_C = Q_B$$

$$\text{Given initially } Q_A = Q_B = Q_C = 0$$

CLOCK	D_A	D_B	D_C	Q_A	Q_B	Q_C
0	-	-	-	0	0	0
1	1	0	0	1	0	0
2	1	1	0	1	1	0
3	0	1	1	0	1	1
4	1	0	1	1	0	1
5	0	1	0	0	1	0
6	0	0	1	0	0	1

The output observed at Q_A is 0110100-----