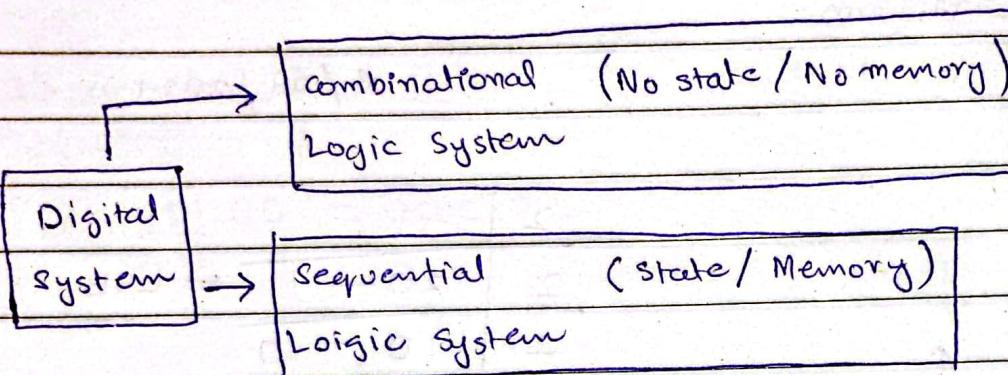
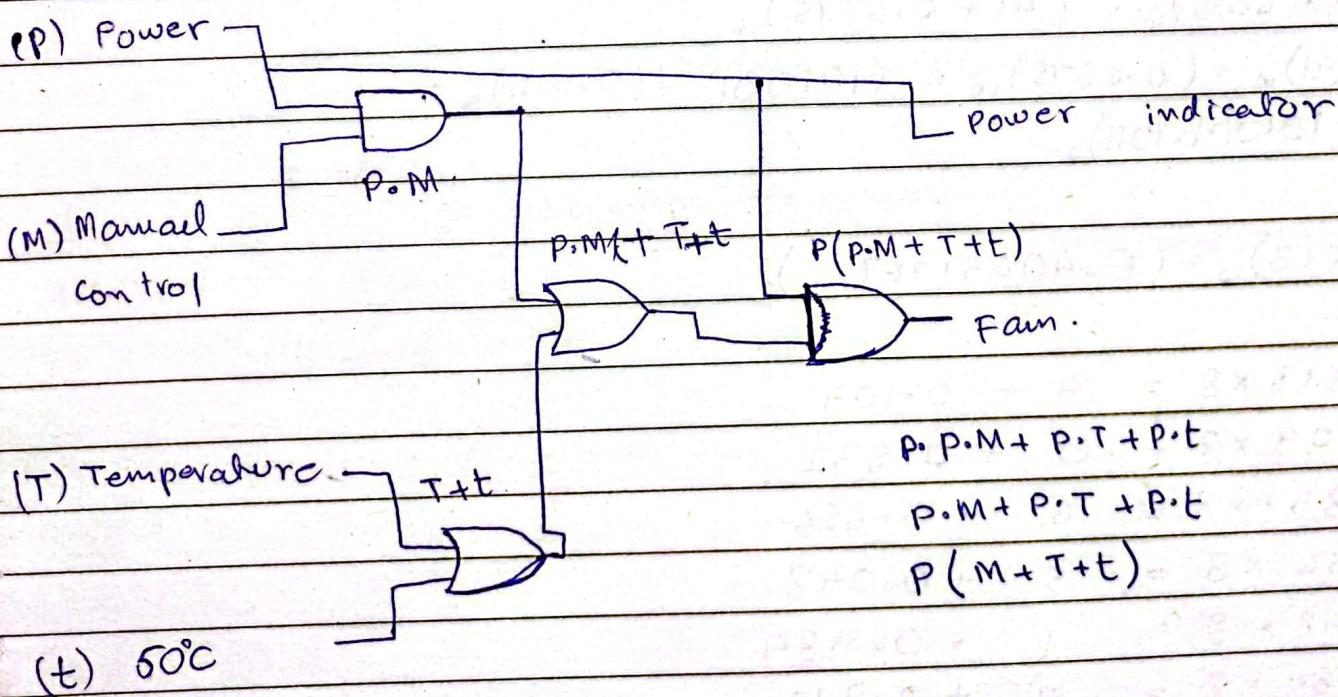
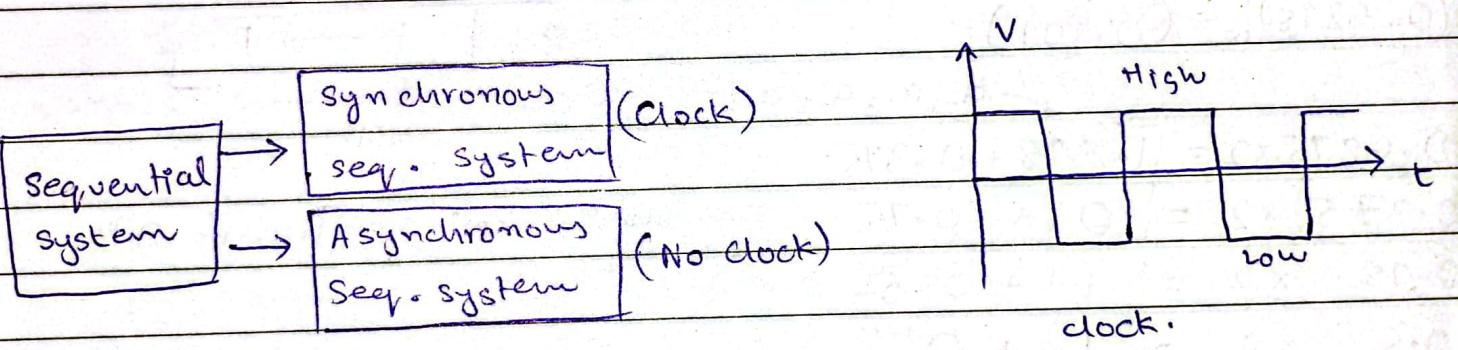


Date: 30/08/2021



1/09/2021



... $a_4 a_3 a_2 a_1 a_0$ \swarrow Radix Point $a_{-1} a_{-2} a_{-3} \dots$

$$\dots + a_4 10^4 + a_3 10^3 + a_2 10^2 + a_1 10^1 + a_0 10^0 + a_{-1} 10^{-1}$$

$$+ a_{-2} 10^{-2} + a_{-3} 10^{-3} + \dots$$

$a_i \swarrow$ weight of the digit.
In decimal its 10^2

Date: 3/09/2021

Decimal number system

= Base or radix 10.

Apollo computer used Octal Number system in their Space Mission.

6/09/2021

$$\begin{array}{r} 8 | 153 \\ 8 | 19 \quad \underline{-1} \\ 8 | 2 \quad \underline{-3} \quad \uparrow \end{array}$$

$$\begin{array}{r} 2 | 41 \\ 2 | 20 \quad \underline{-1} \quad \leftarrow \text{LSB} \\ 2 | 10 \quad \underline{-0} \\ 2 | 5 \quad \underline{-0} \\ 2 | 2 \quad \underline{-1} \\ 2 | 1 \quad \underline{-1} \quad \uparrow \quad \text{MSB} \end{array}$$

$$(0.6875)_{10} = (0.1011)_2$$

$$0.6875 \times 2 = 1.0 \quad \swarrow \quad a_{-1} a_{-2} a_{-3} a_{-4}$$

$$0.375 \times 2 = 0 + 0.75$$

Most/Least significant Bit

$$0.75 \times 2 = 1 + 0.5$$

$$0.5 \times 2 = 1 + 0$$

$$(41.6875)_{10} = (41 + 0.6875)_{10}$$

$$= (41)_{10} + (0.6875)_{10} = (101001)_2 + (0.1011)_2$$

$$= (101001.1011)_2$$

$$(0.513)_{10} = (0.40651767\dots)_8$$

$$0.513 \times 8 = 4 + 0.104$$

$$0.104 \times 8 = 0 + 0.832$$

$$0.832 \times 8 = 6 + 0.656$$

$$0.656 \times 8 = 5 + 0.248$$

$$0.248 \times 8 = 1 + 0.984$$

$$0.984 \times 8 = 7 + 0.872$$

$$0.872 \times 8 = 6 + 0.975$$

$$0.975 \times 8 = 7 + 0.808$$

Radix complement

r 's complement.

$$r^n - N ; n = \lfloor \log_r (N) \rfloor$$

2 's complement.

$$\frac{1101100}{0010} = 0010100$$

Date: 8/09/2021

Diminished Radix Complement.

$(r-1)$'s complement.

$$(r^n - 1) - (N) \quad r$$

$$n = \lfloor \log_r (N) \rfloor$$

+ 9

- 9

| | | |
|---------------------|-----------|-----------|
| sign magnitude | 0000 1001 | 1000 1001 |
| sign-1's complement | 0000 1001 | 1111 0110 |
| sign-2's complement | 0000 1001 | 1111 0111 |

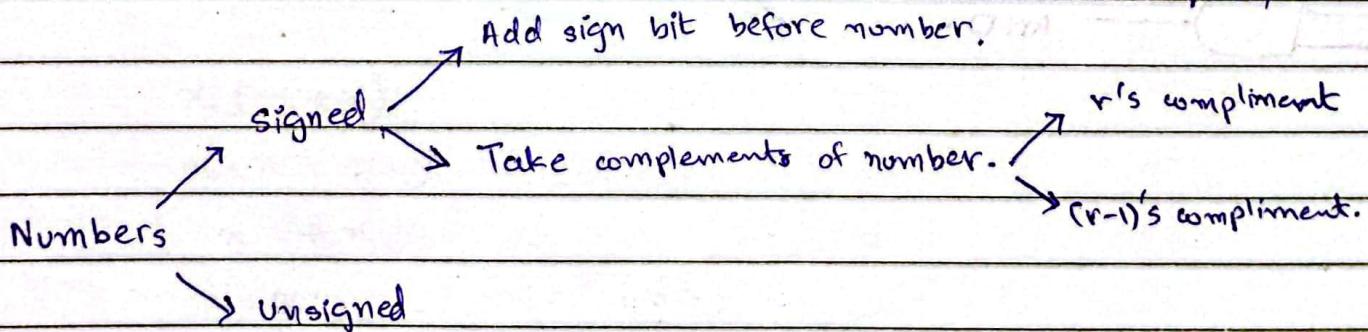
n -bit number.

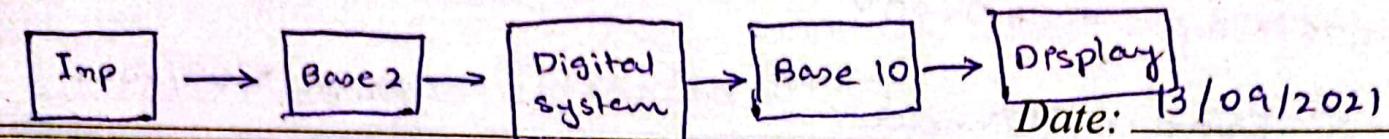
$$\text{sign magnitude} \quad -2^{n-1} + 1 \leq x \leq 2^{n-1} - 1$$

$$\text{sign-1's complement} \quad -2^{n-1} + 1 \leq x \leq 2^{n-1} - 1$$

$$\text{sign 2's complement} \quad -2^{n-1} \leq x \leq 2^{n-1} - 1$$

10/09/2021





Base 10

$$170 = 0001\ 0111\ 0000 \text{ (BCD)}$$

BCDs are not binary numbers.

They are encoded in terms of

0s and 1s but they aren't binary.

15/09/2021

Error Detection code

Error correction code.

Logic devices

Fixed function

(ASIC)

Programmable

(PLDS)

Field

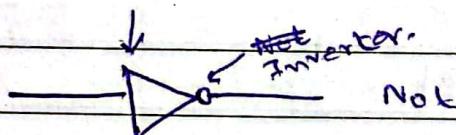
Programmable. Mask

(FPGA)

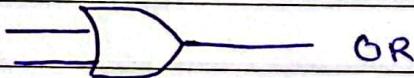
Programmable

(MPC7A, OTP)

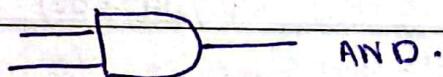
Buffer



17/09/2021



OR



AND.

Theorem 1(b)

$$x \cdot x^3 = x \cdot x^2 + x \cdot x' \quad (5b)$$

$$x \cdot (x + x') \quad (4a)$$

$$x \cdot 1 \quad (5a)$$

$$x \quad (2b)$$

Date: _____

Theorem 2(b)

$$x \cdot 0$$

$$x \cdot x \cdot x' \quad (5b)$$

$$x \cdot x' \quad (1b)$$

$$0 \quad (5b)$$

Theorem 6(a)

$$1 \cdot x + x \cdot y$$

$$x(1+y) \quad (4a)$$

$$x \cdot 1 \quad \text{Th. (2a)}$$

$$x \quad (2b)$$

Theorem 6(b)

$$x(x+y)$$

$$x \cdot x + x \cdot y$$

$$x + x \cdot y$$

$$x \quad (6a)$$

Date: _____

$$xy + x'z + yz = xy + x'z$$

Proof: -

$$\begin{aligned} & xy + x \cdot x' + x'z + yz \\ & xy + x'(x+z) + yz \\ & xy + (x \cdot x' + x'z + yz) \\ & xy + yz + x \cdot x' + x' \cdot z \\ & y \cdot (x+z) + x' \cdot (x+z) \\ & (y+x')(x+z) \end{aligned}$$

$$\begin{aligned} & xy + x'z + yz \\ & xy + x'z + yz(x+x') \\ & xy + x'z + xyz + x'yz \\ & xy(1+z) + x'z(1+y) \\ & xy + x'z \end{aligned}$$

$$\begin{aligned} F_1 &= x'yz + x'y'z \\ F_1' &= (x'yz + x'y'z)' \\ &= (x'yz)' \cdot (x'y'z)' \\ &= (x''+y'+z')(x''+y''+z') \\ F_1' &= (x+y'+z')(x+y+z') \end{aligned}$$

$$A \cdot (B+C) = AB + AC \Leftrightarrow A+BC = (A+B)(A+C)$$

Duality Principle.

Date: _____

$$f_1 = x'y'z + xy'z' + xyz$$

$$f_1' = (x'y'z)' \cdot (xy'z')' + (xyz)'$$

$$f_1' = (x+y+z')(x'+y'+z)(x'+y'+z')$$

~~$$x'z(x+y+z')$$~~

$$F_1 = x'y'z' + x'y'z$$

$$F_1' = (x'y'z')' \cdot (x'y'z)'$$

$$F_1' = (x''+y'+z'')(x''+y''+z')$$

$$F_1' = (x+y'+z)(x+y+z')$$

27/09/2021

$$F_3 = AB + C(D+E)$$

non-standard form

$$F_3 = AB + CD + CE$$

standard form.

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

standard form

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

↓

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

canonical form.

$$F = \sum (1, 4, 5, 6, 7)$$

~~$$F = A + B$$~~

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

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

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

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

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

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

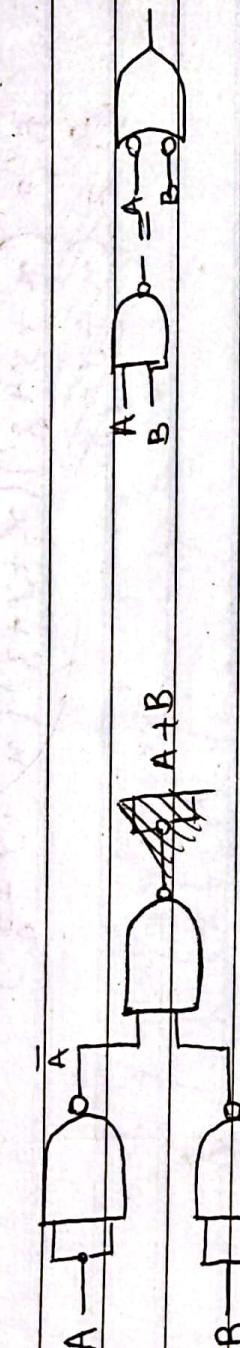
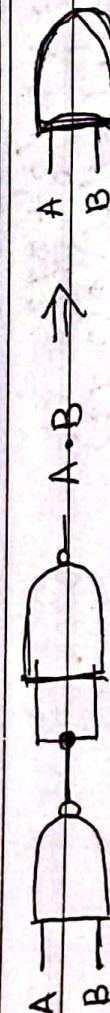
$$F = (\bar{x}+y+z)(\bar{x}+y+\bar{z})(x+y+\bar{z})(x+\bar{y}+z)(\bar{x}+y+\bar{z})$$

$$F = \prod (0, 2, 4, 5)$$

NAND gate is Universal Gate. we can use it everywhere.

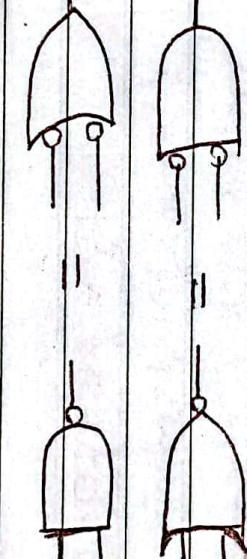
$$A \rightarrow \overline{D} \rightarrow \overline{A} \Rightarrow A \rightarrow \overline{D} \rightarrow \overline{A}$$

Date: _____

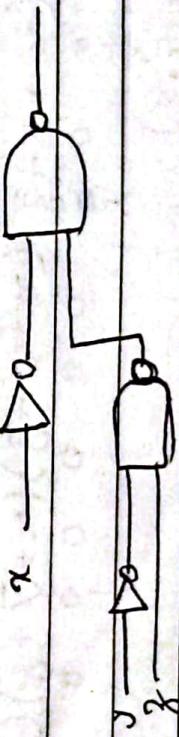
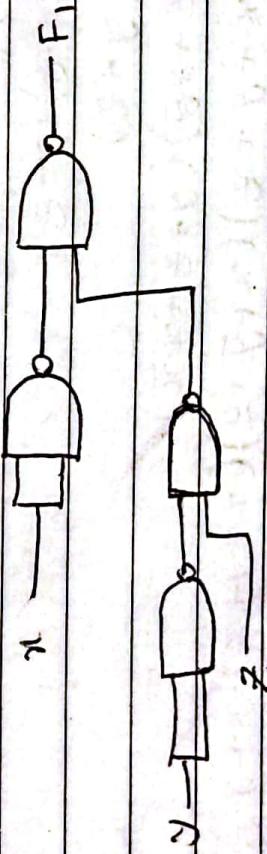
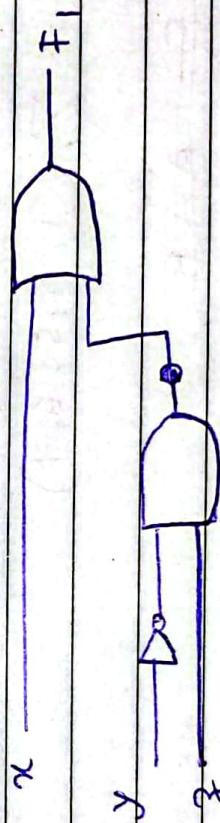


NOR gate is also universal gate.

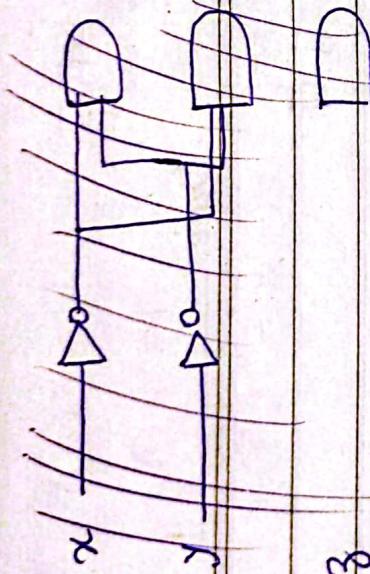
29/09/2021.



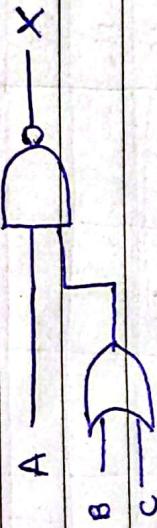
$$F_1 = x + y'z$$



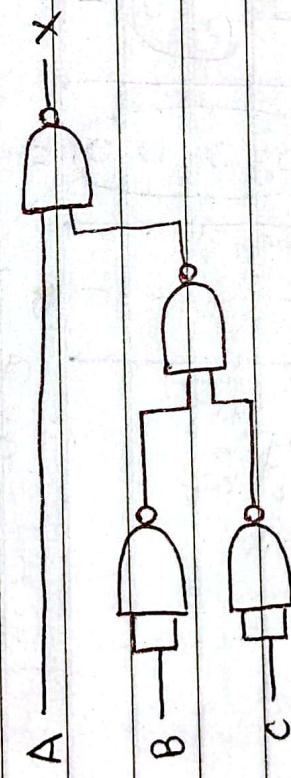
Date: _____



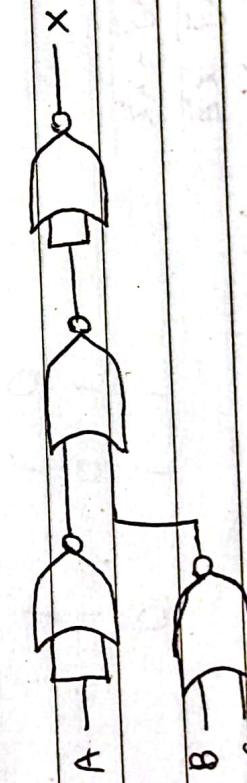
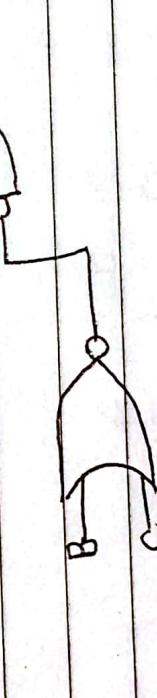
3



a) $A \rightarrow X$



b) $A \rightarrow X$



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

Date: _____

| AB | CD | 00 | 01 | 11 | 10 | |
|----|----|----|----|----|----|-------------------------------------|
| 00 | | 1 | 1 | | 1 | $\rightarrow \bar{B}\bar{D}$ |
| 01 | | | | | 1 | $\rightarrow \bar{A}C\bar{D}$ |
| 11 | | | | | | |
| 10 | | 1 | 1 | 1 | 1 | $\rightarrow \bar{A}\bar{B}\bar{C}$ |
| | | | | | | |

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

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

| AB | CD | 00 | 01 | 11 | 10 | |
|----|----|----|----|----|----|---------------------------|
| 00 | | 1 | 1 | | 1 | |
| 01 | | 0 | 0 | 0 | 1 | |
| 11 | | 0 | 0 | 0 | 0 | $\rightarrow AB$ |
| 10 | | 1 | 1 | 0 | 1 | $\rightarrow \bar{A} + B$ |
| | | | | | | |

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

$$Z = \overline{xy} = \overline{yx}$$

$$x \quad y \quad z$$

$$w = \overline{xyz} = \overline{zyx}$$

$$0 \quad 0 \quad \textcircled{1}$$

$$0 \quad 1 \quad 1$$

$$1 \quad 0 \quad 1$$

$$\overline{xz} + \overline{yz}$$

$$\overline{xy} + \overline{yz}$$

$$1 \quad 1 \quad 0$$

$$\overline{xz} \overline{yz}$$

$$\overline{xy} \overline{xz}$$

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

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

$$\text{Unit load} = \frac{I_{OL}}{I_{IL}} = \frac{8.0 \text{ mA}}{0.4 \text{ mA}} = 20$$

$$xy + \bar{z}$$

$$\bar{x} + yz$$

$$P_o = V_{CC} \left(\frac{I_{CCH} + I_{CCL}}{2} \right)$$

$$x \oplus x = 0$$

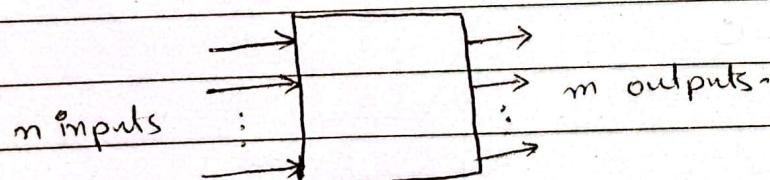
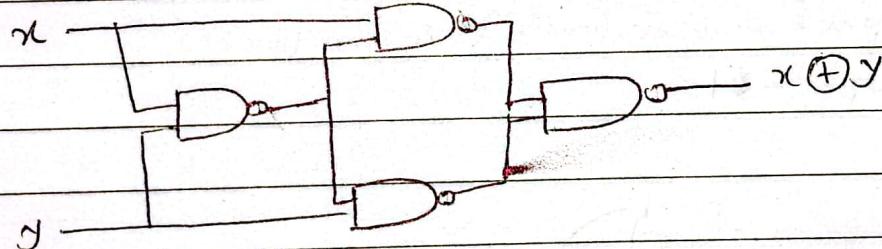
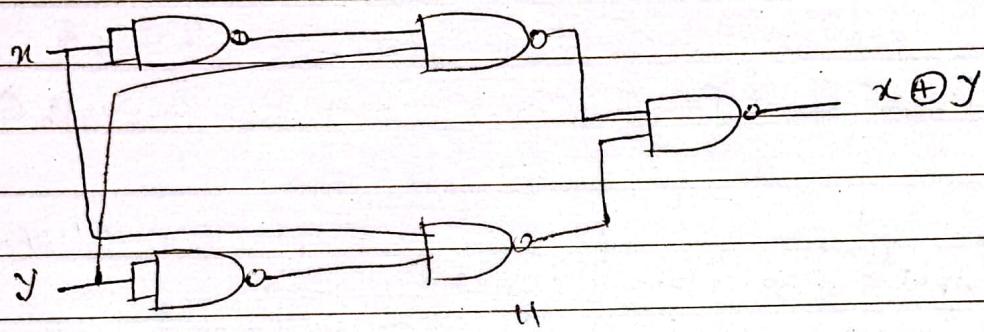
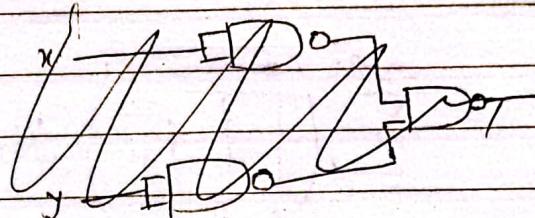
$$x \oplus y = \begin{array}{c} x \\ y \end{array} \oplus y$$

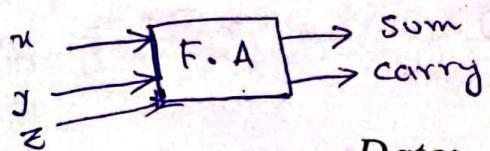
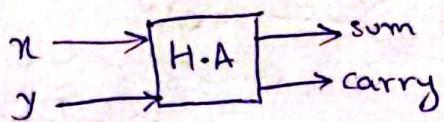
$$x \oplus u' = 1$$

Date: 13/10/2021

$$x \oplus y' = x' \oplus y = (x \oplus y)'$$

$$x \oplus 0$$





Date: _____

$$S_i = P_i \oplus C_i$$

$$C_{i+1} = G_i + P_i C_i$$

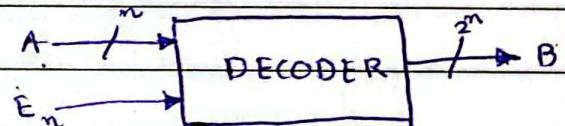
$$C_n = \sum_{i=0}^{n-1} \left(\prod_{k=0}^{n-1-i} P_k \right) (G_i \delta_{0 \neq}^i S_0^i C_0)$$

$$C_n = G_{n-1} + P_{n-1} G_{n-2} + P_{n-1} P_{n-2} G_{n-3} + \dots + P_{n-1} P_{n-2} \dots P_0 G_0$$

25/10/2021.

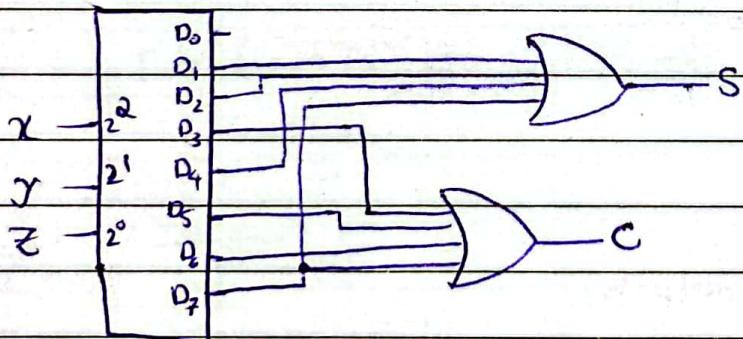
When $E_n = 1$, Output = Decoder func. } Active high.

$E_n = 0$, Output = 0

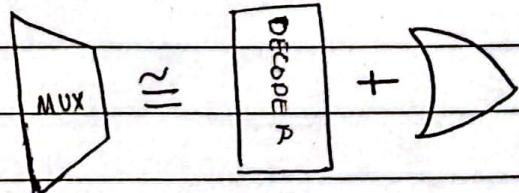
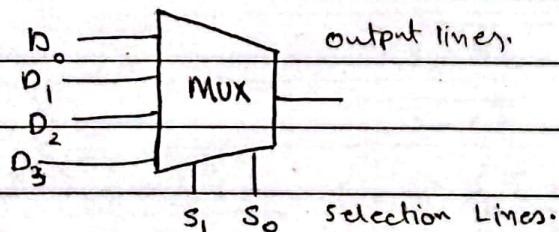


When $E_n = 0$, Output = Decoder func. } Active low.

$E_n = 1$, Output = 0



Input lines

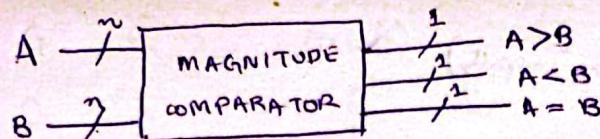


$$0 \ 0 \rightarrow D_0$$

$$0 \ 1 \rightarrow D_1$$

$$1 \ 0 \rightarrow D_2$$

$$1 \ 1 \rightarrow D_3$$



Date: _____

• Check each bit.

• If A is high at any place B is low, $A > B$.

• for $A < B$ its converse.



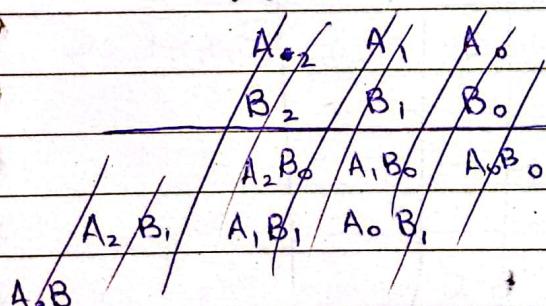
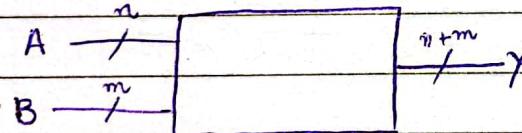
$$A_n > B_n := A_{n-1} B'_{n-1} + x_{n-1} A_{n-2} B'_{n-2}$$

$$A_n < B_n := A'_{n-1} B_{n-1} + x_{n-1} A'_{n-2} B_{n-2}$$

$$A_n > B_n = \sum_{i=0}^{n-1} \left(\prod_{k=1}^i x_k \right) A'_{n-i-1} B'_{n-i-1}$$

$$A_n < B_n = \sum_{i=0}^{n-1} \left(\prod_{k=1}^i x_k \right) A'_{n-i-1} B_{n-i-1}$$

3/11/2021



Next State = f (Present State, Input)

a) Output = f (State)

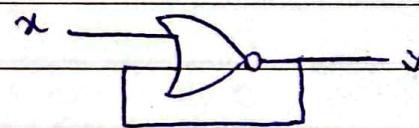
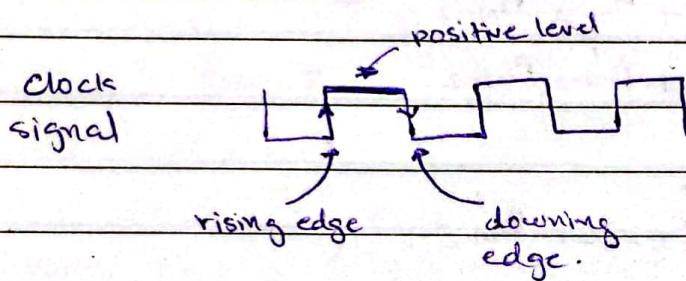
Moore Machine Date: _____

b) Output = f (State, Input) Mealy Machine

Memory
element

Latch
Level sensitive
devices

Flip - Flop
Edge - sensitive
device

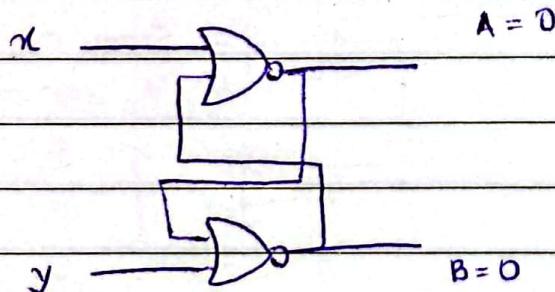


$x = 0, y = 1, 0, 1, 0, \dots$

| A | B | $\overline{A \oplus B}$ |
|---|---|-------------------------|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |

$$\overline{x+1} = 0$$

$$\overline{x+0} = \overline{x}$$



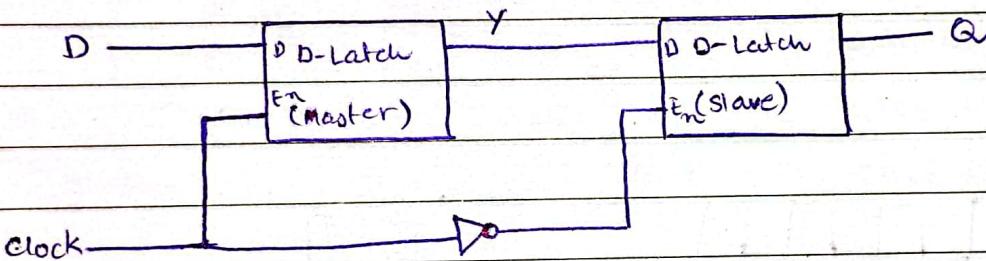
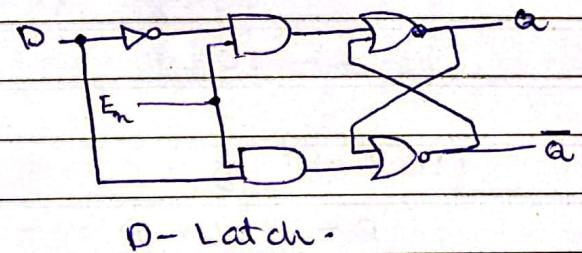
| $\overline{0}$ | \overline{x} | \overline{y} | A | B |
|----------------|----------------|----------------|----------|------------|
| 1 | 1 | 0 | 0,0,0,.. | 0,1,1,1,.. |
| 1 | 0 | 0 | 0,0,0,.. | 0,1,1,1,.. |
| 0 | 1 | 1 | 0,0,0,.. | 0,1,1,1,.. |
| 0 | 0 | 1 | 0,0,0,.. | 0,1,1,1,.. |

| | $x=R$ | $y=S$ | $A=Q$ | $B=Q'$ | |
|---|-------|-------|-------|--------|----------------------|
| 0 | 1 | 0 | 0 | 1 | \rightarrow RESET |
| 1 | 0 | 0 | 0 | 1 | \rightarrow Memory |
| 2 | 0 | 1 | 1 | 0 | \rightarrow SET |
| 3 | 0 | 0 | 1 | 0 | \rightarrow Memory |
| 4 | 1 | 1 | 0 | 0 | forbidden state |
| 5 | 1 | 1 | 0 | 0 | |

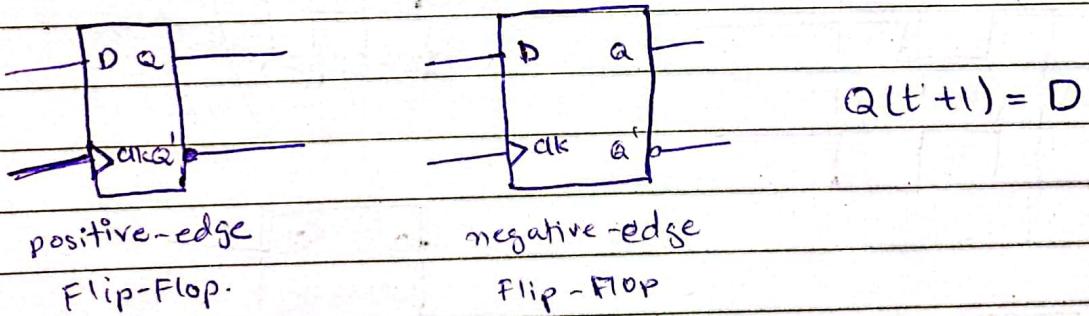
| S | R | $Q(t+1)$ |
|---|---|----------|
| 0 | 1 | 0 |
| 1 | 0 | 1 |
| 0 | 0 | $Q(t)$ |
| 1 | 1 | X |

Date: _____

| E_m | D | $Q(t+1)$ |
|-------|---|-----------|
| 0 | X | $Q(t)$ |
| 1 | 1 | 1 (set) |
| 1 | 0 | 0 (Reset) |

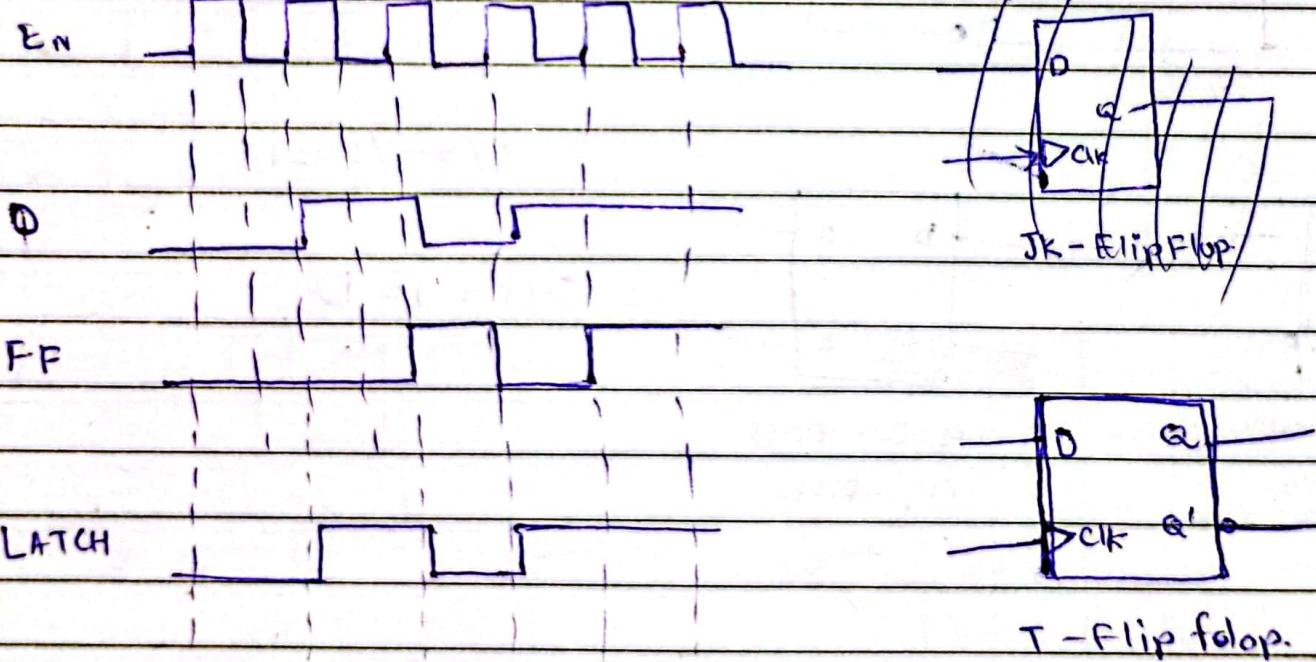


5/01/2021



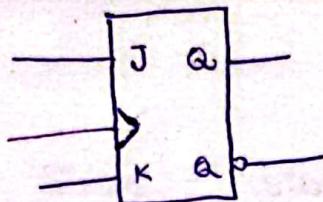
Date: _____

8/11/2021



| T | Q(t+1) |
|---|--------|
| 0 | Q(t) |
| 1 | Q'(t) |

$$\begin{aligned} Q(t+1) &= T' Q(t) + Q'(t) T \\ &= T \oplus Q(t) \end{aligned}$$



JK - FlipFlop -

Date: 8/18/2021

| J | K | <u>$Q(t+1)$</u> |
|---|---|----------------------------|
| 0 | 0 | $Q(t)$ |
| 0 | 1 | 0 |
| 1 | 0 | 1 |
| 1 | 1 | $Q'(t)$ |

| $J'K'Q + JK' + JKQ'$ | | | | | |
|----------------------|---|---|----|----|----|
| 0 | X | X | 00 | 01 | 11 |
| 0 | 0 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 0 | 0 | 0 | 0 | 0 |

$$J'K'Q + J(K' + KQ')$$

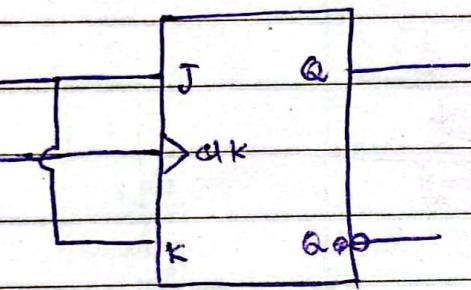
$$J'K'Q + J(K' + Q')$$

$$J'K'Q + JK' + JQ'$$

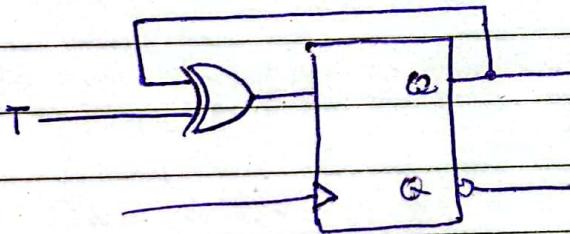
$$(J'Q + J)K' + JQ'$$

$$(J + Q)K' + JQ'$$

$$JK' + QK' + JQ'$$



T-FlipFlop by JK-FlipFlop. $Q(t+1) = JQ' + K'Q$



1. Find Input equations

10/11/2021

2. State equations.

3. State table and state diagram.

Circuit diagram \rightarrow Input Equations

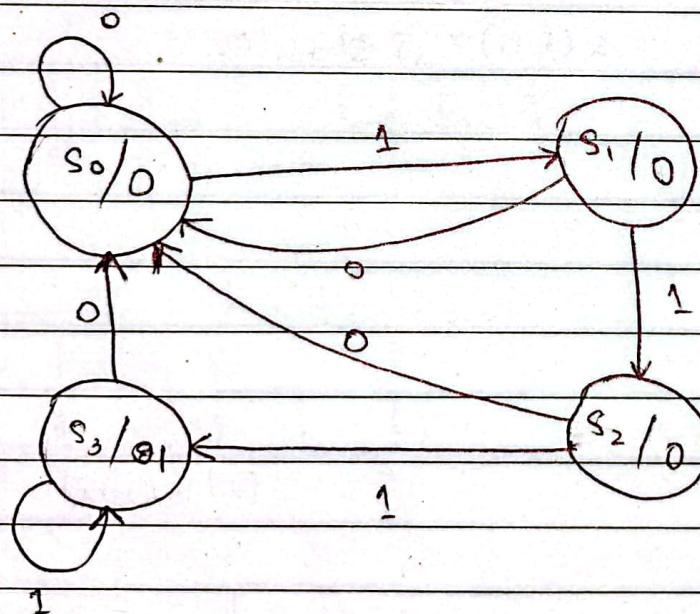
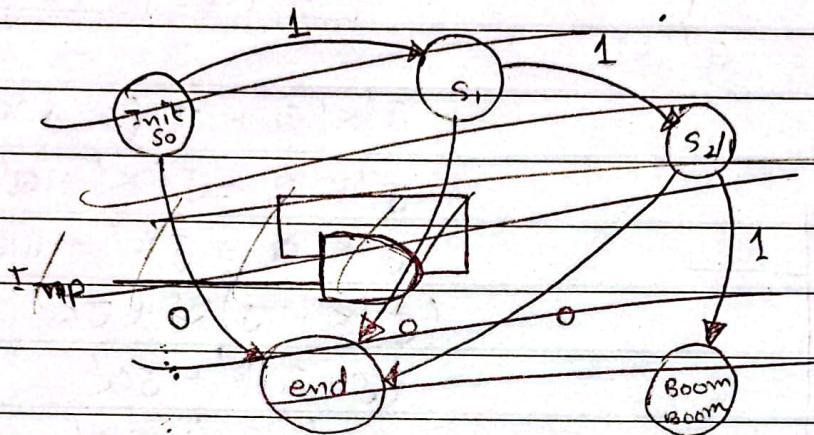


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State equation



Explanation: \leftarrow State Diagram \leftarrow State Transition Table



| Present state | Input | Next state | Output |
|----------------|-------|----------------|--------|
| S ₀ | 0 | S ₀ | 0 |
| | 1 | S ₁ | 0 |
| S ₁ | 0 | S ₀ | 0 |
| | 1 | S ₂ | 0 |
| S ₂ | 0 | S ₀ | 0 |
| | 1 | S ₃ | 0 |
| S ₃ | 0 | S ₀ | 1 |
| | 1 | S ₃ | 1 |

Binary values

BCD

Excess

One-Hot - \downarrow

Date: _____

$$S_0 = 0001$$

$$S_1 = 0010$$

$$S_2 = 0100$$

$$S_3 = 1000$$

| Present State A(t) B(t) | Input X | Next State A(t+1) B(t+1) | Output Y | D _A | D _B |
|-------------------------------|------------|--------------------------------|-------------|----------------|----------------|
| 00 | 0 | 00 | 0 | 0 | 0 |
| 00 | 1 | 01 | 0 | 0 | 1 |
| 01 | 0 | 00 | 0 | 0 | 0 |
| 01 | 1 | 10 | 0 | 0 | 0 |
| 10 | 0 | 00 | 0 | 0 | 0 |
| 10 | 1 | 11 | 0 | 1 | 1 |
| 11 | 0 | 00 | 1 | 0 | 0 |
| 11 | 1 | 11 | 1 | 1 | 1 |

Assuming using D flip-flop

$$D_A = A'B'X + AB'X + ABX$$

$$D_A = (A'B + AB' + AB)X$$

$$D_A = (A'B + A(B' + B))X$$

$$D_A = (A'B + A)X$$

$$D_A = (A + B)X$$

$$D_B = A'B'X + AB'X + ABX$$

$$D_B = (A'B' + AB' + AB)X$$

$$D_B = ((A' + A)B' + AB)X$$

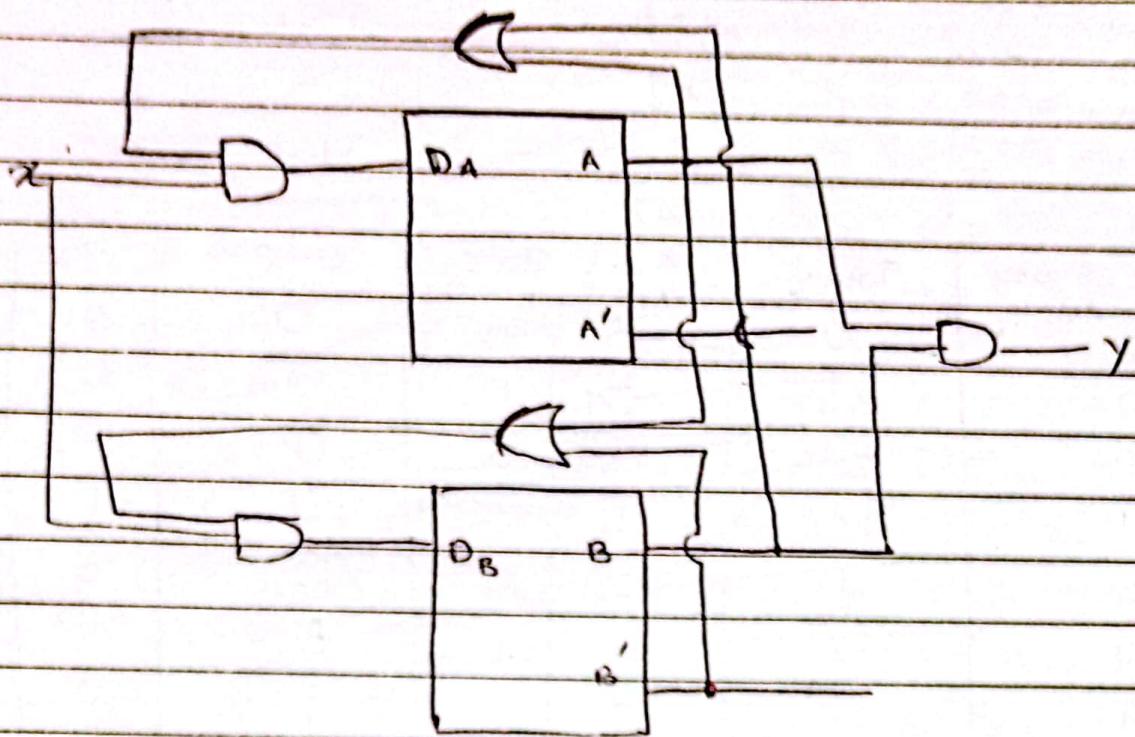
$$D_B = (B' + AB)X$$

$$D_B = (A + B')X$$

$$Y = ABX' + ABX$$

$$Y = AB$$

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| A | B | X | A(t+1) | B(t+1) | Y | T _A | T _B | J _A | K _A | J _B | K _B |
|---|---|---|--------|--------|---|----------------|----------------|----------------|----------------|----------------|----------------|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | x | 0 | x |
| 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | x | 1 | x |
| 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | x | x | 1 |
| 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | x | x | 1 |
| 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | x | 1 | 0 | x |
| 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | x | 0 | 1 | x |
| 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | x | 1 | x | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | x | 0 | x | 0 |

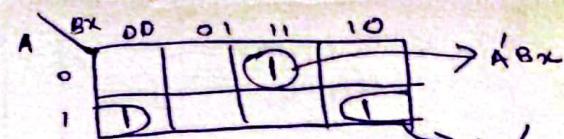
Excitation Table.

| Q(t) | Q(t+1) | T |
|------|--------|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

$$T = Q(t) \oplus Q(t+1)$$

$$T_A(A, B, x) = \sum (3, 4, 6)$$

$$T_B(A, B, x) = \sum (1, 2, 3, 5, 6)$$



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$$T_A = A'Bx + Ax'$$

$$T_B = A'x + B \oplus x$$

$$Q(t) \quad Q(t+1) \quad J \quad K \quad J_A = Bx \quad K_A = x'$$

$$0 \quad 0 \quad 0 \quad x$$

$$0 \quad 1 \quad 1 \quad x \quad J_B = x \quad K_B = (Ax)'$$

$$1 \quad 0 \quad x \quad 1$$

$$1 \quad 1 \quad x \quad 0$$

State Reduction.

17/11/2021.

- Output of states should be same.
- Next state should be same/equivalent by Implication.

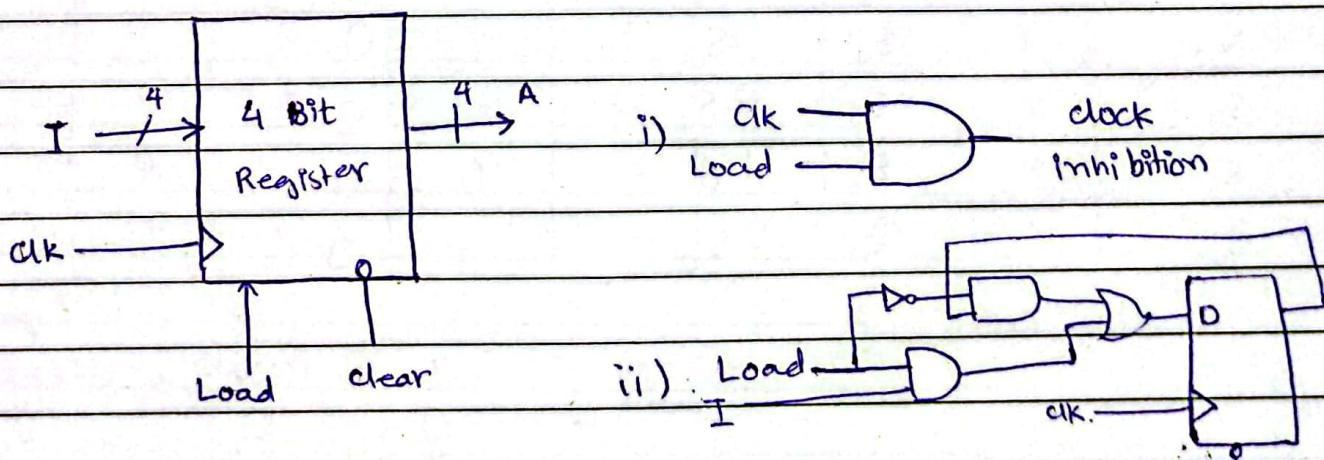
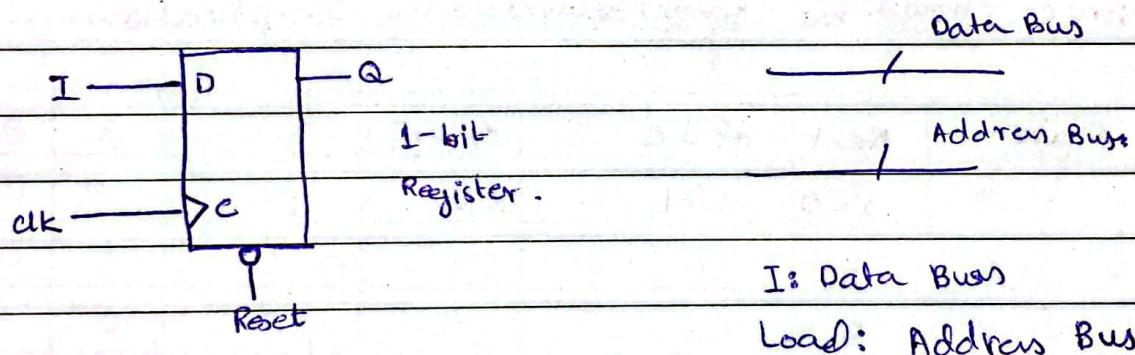
| Present State | Next state | | Output | |
|---------------|------------|-------|--------|-------|
| | $x=0$ | $x=1$ | $x=0$ | $x=1$ |
| s_0 | s_1 | s_2 | 0 | 0 |
| s_1 | s_3 | s_4 | 0 | 0 |
| s_2 | s_5 | s_6 | 0 | 0 |
| s_3 | s_0 | s_0 | 0 | 0 |
| s_4 | s_0 | s_0 | 1 | 0 |
| s_5 | s_0 | s_0 | 0 | 0 |
| s_6 | s_0 | s_0 | 1 | 0 |

Date: _____

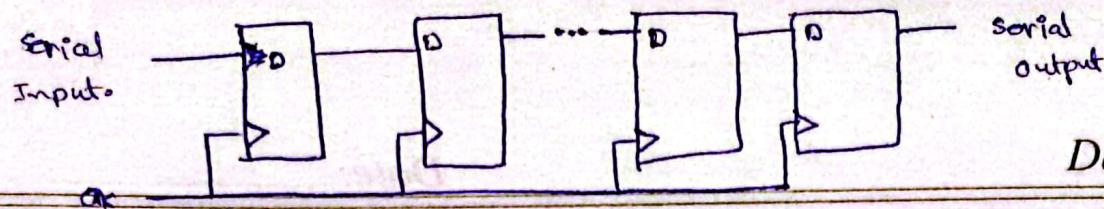
| | S_0 | S_1 | S_2 | S_3 | S_4 | S_5 | S_6 | |
|-------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|-------|-------|------------------|
| S_0 | | | | | X | X | | $S_3 \equiv S_5$ |
| S_1 | $S_1 - S_3$ $S_2 - S_4$ | | | | X | X | | $S_4 \equiv S_6$ |
| S_2 | $S_1 - S_5$ $S_2 - S_6$ | $S_3 - S_5$ $S_4 - S_6$ | | | X | X | | $S_2 \equiv S_1$ |
| S_3 | $S_1 - S_0$ $S_2 - S_0$ | $S_3 - S_0$ $S_4 - S_0$ | $S_5 - S_0$ $S_6 - S_0$ | | X | X | | |
| S_4 | X | X | X | X | | X | | |
| S_5 | $S_1 - S_0$ $S_2 - S_0$ | $S_3 - S_0$ $S_4 - S_0$ | $S_5 - S_0$ $S_6 - S_0$ | $S_0 - S_0$ $S_5 - S_0$ | X | | X | |
| S_6 | X | X | X | X | $S_0 - S_0$ $S_0 - S_0$ | X | | |

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Registers.

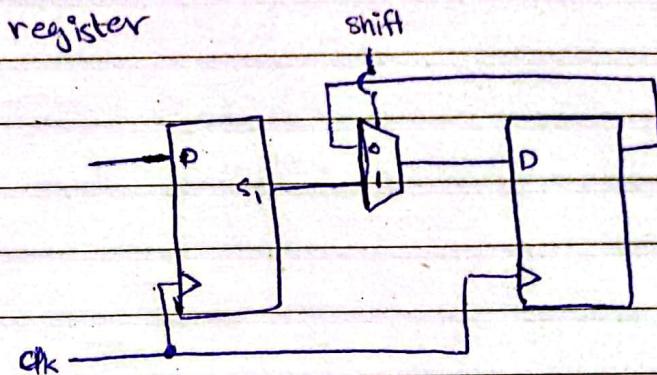
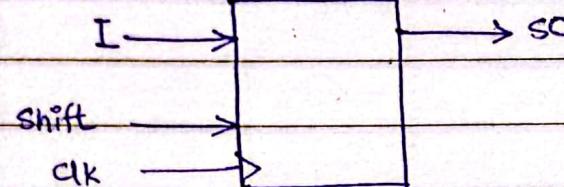


Load = 1 \Rightarrow set the values.
Load = 0 \Rightarrow do nothing.



Date: _____

n-bit shift register



- All FSMs, Synchronous Sequential Logic circuit have a common signal. It can be other than ~~the~~ clock.

