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ESE 2020 : Mains Test Series

UPSC ENGINEERING SERVICES EXAMINATION

Electronics & Telecommunication Engineering

Test-2: Network Theory + Microprocessors and Microcontroller (All Topics)
Digital Circuits-1 + Control Systems-1 (Part Syllabus)

Name : ....

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Student's Signature

Instructions for Candidates

1. Do furnish the appropriate details in the answer sheet (viz. Name & Roll No).
2. Answer must be written in English only.
3. Use only black/blue pen.
4. The space limit for every part of the question is specified in this Question Cum Answer Booklet. Candidate should write the answer in the space provided.
5. Any page or portion of the page left blank in the Question Cum Answer Booklet must be clearly struck off.
6. Last two pages of this booklet are provided for rough work. Strike off these two pages after completion of the examination.

FOR OFFICE USE

Question No.	Marks Obtained
Section-A	
Q.1	
Q.2	
Q.3	
Q.4	
Section-B	
Q.5	
Q.6	
Q.7	
Q.8	
Total Marks Obtained	248

Signature of Evaluator ....

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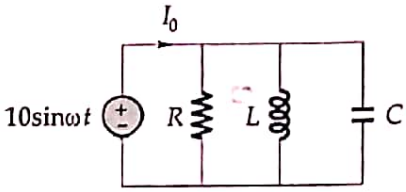
Section A : Network Theory + Microprocessors and Microcontroller

Q.1 (a) In the parallel RLC circuit shown below, let $R = 8\ k\Omega$, $L = 0.2$ mH and $C = 8\ \mu$F.



(i) Calculate resonance frequency ω_0, quality factor Q and bandwidth B.

(ii) Find half-power frequencies ω_1 and ω_2.

(iii) Determine the power dissipated at resonance frequency ω_0, half-power frequencies ω_1 and ω_2.

[12 marks]

Sol.

(i) For parallel R-L-C circuit, resonance frequency ω_0 is given as.

$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{0.2\times10^{-3}\times8\times10^{-6}}}$$

$$\boxed{\omega_0 = 25\times10^{3}\ \text{rad/sec}}\ \text{Ans}$$

also

$$B.\omega = \frac{1}{RC} = \frac{1}{8\times10^{3}\times8\times10^{-6}}$$

$$\boxed{B.\omega = 15.625\ \text{rad/s}}\ \text{Ans}$$

and

$$Q = \frac{\omega_0}{B\omega} = \frac{25\times10^{3}}{15.625}$$

$$\boxed{Q = 1600}\ \text{Ans}$$

(ii) As $Q \geq 10$, so half power frequencies ω_1 & ω_2 are given as

$$\omega_1 = \omega_0 - \frac{B}{2} =$$

$$\omega_1 = 25\times1000 - \frac{15.625}{2}$$

$$\boxed{\omega_1 = 24992.18 \text{ rad/sec}}$$ Ans.

and $\omega_2 = \omega_0 + \frac{B}{2} = 25000 + \frac{15.625}{2}$

$$\boxed{\omega_2 = 25007.81 \text{ rad/sec}}$$ Ans.

(iii) $I_0 = \frac{10 \sin \omega t}{8 \, k\Omega}$

$I_0 = 1.25 \sin \omega t \text{ mA}$

$|I_0| = 1.25 \text{ mA}.$

at ω_0 power dissipated

$P_{\omega_0} = \frac{1}{2} |I_0|^2 \cdot R$

$= \frac{1}{2} |1.25 \text{ mA}|^2 \times 8 \, k\Omega$

$$\boxed{P_{\omega_0} = 6.25 \text{ mW}}$$ Answer.

• At half power ω_1, ω_2, $I_0' = \frac{I_0}{\sqrt{2}}$.

$P_{\omega_1} = \frac{1}{2} |I_0'|^2 \cdot R$

$= \frac{1}{2} \times \frac{|I_0|^2}{2} \times R$

$P_{\omega_1} = \frac{P_{\omega_0}}{2}$

$P_{\omega_1} = \frac{6.25}{2} \text{ mW}$

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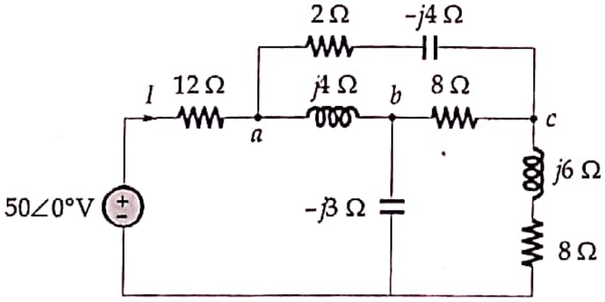
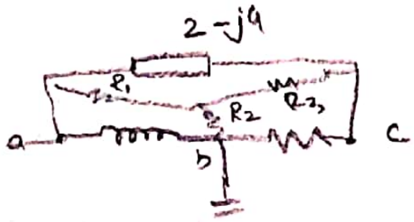
$P_{\omega_1} = 3.125 \text{ mW}$

$$\boxed{P_{\omega_2} = P_{\omega_1} = 3.125 \text{ mW}}$$ Ans

Q.1 (b) Find current *I* in the circuit shown below:



[12 marks]



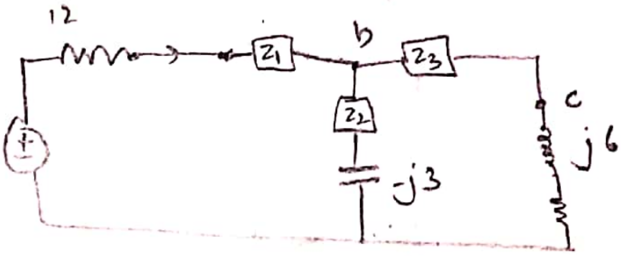
$$Z_1 = \frac{(2-j4)j4}{2-\cancel{4j}+\cancel{4j}+8} = \frac{(2-j4)j4}{10} = \frac{16+8j}{10}$$

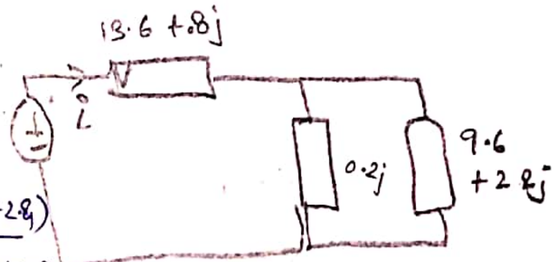
$$Z_2 = \frac{j4\cdot 8}{10} = \frac{32j}{10} \qquad Z_3 = \frac{(2-j4)\,8}{10}$$

$$Z_3 = \frac{16-32j}{10}$$

redraw given circuit

- $j6 + 8 + \frac{16}{10} - \frac{32j}{10} = \frac{48}{5} + 2.8j$
- $\frac{32j}{10} - j3 = 0.2j$
- $\frac{16+8j}{10} + 12$
  $= 13.6 + 0.8j$





Total impedance

$$Z = (13.6 + .8j) + \left(\frac{0.2j \times (9.6+2.8)}{9.6+2.8j+0.2j}\right)$$

$$Z = (13.6 + 0.8j) + \frac{-0.56 + 1.92j}{9.6 + 3j}$$

~~Zeq~~ using calculator we get

$z = 13.603 + 0.9988j$

current $\dot{i} = \dfrac{50\angle 0^\circ V}{13.603 + 0.9988j}$

$\dot{i} = \dfrac{50\angle 0^\circ}{13.6404\angle 4.199^\circ}$

$\boxed{\dot{i} = 3.66\angle -4.2^\circ A}$ Ans.

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Q.1 (c) Write a program for an 8085 microprocessor to calculate the sum of series of number. The length of series is stored in the memory location 1100H and the sequence is stored starting from location 2100H. Assume the sum to be 8-bit number without any carry and store the result in location 3200H.

[12 marks]

```
LDA 1100H
MOV C, A
MOV B, 0000H
MOV H, 2100H
MOV A, H
ADD B
```

1100 ↓ C ← sum

LDA 1100H → Load location 1100H

MOV C, A → initialise counter

MOV A, 00H → A = 00 (sum = 0)

LXI H, 2100H → Load location of data

LOOP : ADD M   M+A → adding data

INX H → increment pointer

DCR C → decrement counter

JNZ LOOP → condition

~~MOV B, A~~

~~SOTA~~ STA 3200H → store result ~~in~~ at 3200H location

HLT

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Q.1 (d) Write a program for 8051 microcontroller to find the sum of 5 BCD data items that are stored in RAM locations starting from 40H.

[12 marks]

```
       MOV R0, #40H  — initialise location 40H
       MOV R1, #05H → counter 5 BCD
       MOV A, #00H  → clear A
       MOV R2, A    → 00 to R2.
loop1: ADD A, @R0
       DAA A
       JNC loop2
       INC R2
Loop2: INC R0
       JNZ loop1
       HLT.
```

BCD → ADD/ 8085 → DAA

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Q.1 (e) The reduced incidence matrix of an oriented graph is given as:

$$\begin{bmatrix} 0 & -1 & 1 & 0 & 0 \\ 0 & 0 & -1 & -1 & -1 \\ -1 & 0 & 0 & 0 & 1 \end{bmatrix}$$

(i) Draw its graph.

(ii) How many trees are possible for this graph?

[12 marks]

Sol.

(i)

Branch

node ↓

reduced →

$$\begin{bmatrix} 0 & -1 & 1 & 0 & 0 \\ 0 & 0 & -1 & -1 & -1 \\ -1 & 0 & 0 & 0 & 1 \end{bmatrix}$$

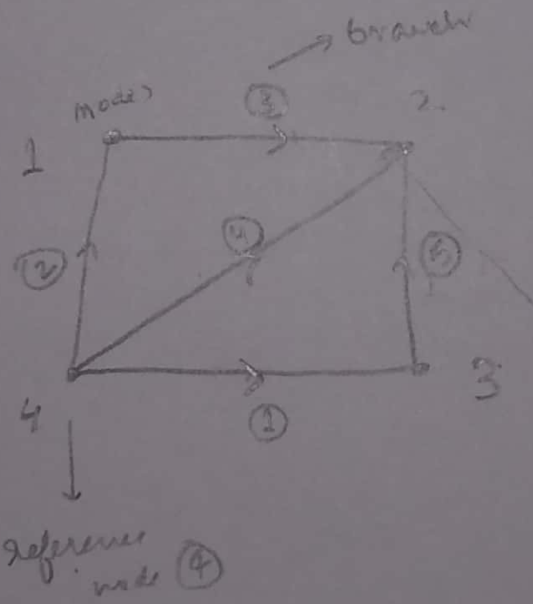
full non reduced incidence matrix

B

$$\begin{array}{c|ccccc} & 1 & 2 & 3 & 4 & 5 \\ \hline \text{node } 1 & 0 & -1 & 1 & 0 & 0 \\ 2 & 0 & 0 & -1 & -1 & -1 \\ 3 & -1 & 0 & 0 & 0 & 1 \\ 4 & +1 & +1 & 0 & +1 & 0 \end{array}$$

$+1 \longrightarrow$

$-1 \longleftarrow$



(graph)

(ii) $\text{Tree} = \det(A \cdot A^T) = \begin{bmatrix} 0 & -1 & 1 & 0 & 0 \\ 0 & 0 & -1 & -1 & -1 \\ -1 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 & 0 & -1 \\ -1 & 0 & 0 \\ 1 & -1 & 0 \\ 0 & -1 & 0 \\ 0 & -1 & 1 \end{bmatrix}$

$\text{Tree} = \det \begin{bmatrix} 2 & -1 & 0 \\ -1 & 3 & -1 \\ 0 & -1 & 2 \end{bmatrix}$

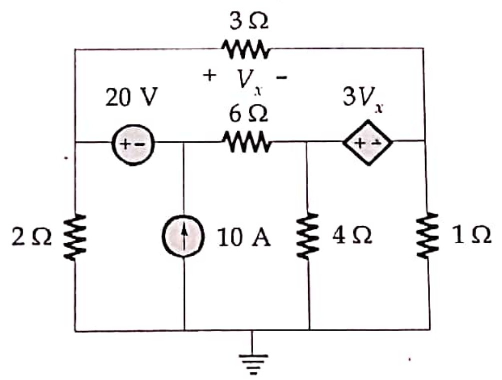
$\text{Tree} = 2(6-1) + 1(-2-0) + 0(\quad)$

$\text{Tree} = 10 - 2$

$\boxed{\text{Total nos of tree} = 8}$ Answer

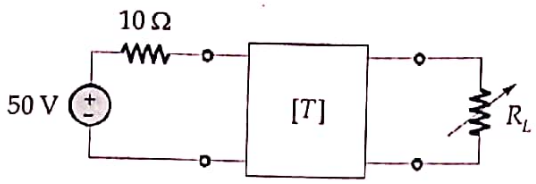
11

Q.2 (a) Find the node voltages in the circuit shown below:



[20 marks]

Q.4 (a) The ABCD parameters of the two-port network in figure are $\begin{bmatrix} 4 & 20\,\Omega \\ 0.1S & 2 \end{bmatrix}$



The output port is connected to a variable load for maximum power transfer. Find R_L and the maximum power transferred.

[20 marks]

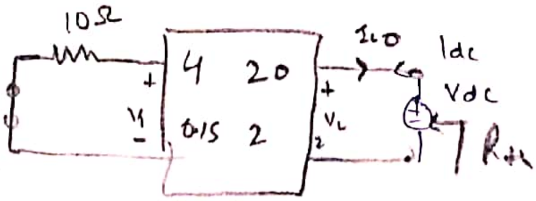
Sol.

Maximum power transfered when load is equal to its ~~theve~~ thevenine resistence equivalen and

$$\text{Power} = \frac{V_{th}^2}{4R_{th}}.$$

- For R_{th} $(R_L = R_{th})$

$V = 0;$



from given ABCD parameter,

$$\left.\begin{aligned} V_1 &= 4V_2 - 20 I_2 \\ I_1 &= 0.1V_2 - 2 I_2 \end{aligned}\right] \longrightarrow (A)$$

from figure, $V_1 = -10 I_1$

$V_2 = V_{dc}$, $I_2 = -I_{dc}$.

$\therefore$ we get

$$-10 I_1 = 4V_{dc} + 20 I_{dc} \quad \text{— (i)}$$

$$I_1 = 0.1 V_{dc} + 2 I_{dc} \quad \text{— (ii)}$$

or

$$-10 I_1 = 4 V_{dc} + 20 I_{dc}$$

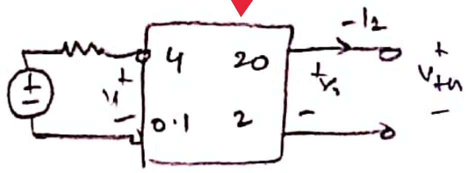
$$10 I_1 = 1 V_{dc} + 20 I_{dc}.$$

$$0 = 5 V_{dc} + 40 I_{dc}$$

$$\therefore \quad \frac{V_{dc}}{I_{dc}} = 8\Omega \Rightarrow R_{th}$$

$$\boxed{R_L = R_{th} = 8\,\Omega} \text{ Ans.}$$

for V_{th}.



~~the~~ $V_2 = V_{th}$

$I_2 = 0.$

from ABCD parameter, equation A;

$$V_1 = 4V_{th}$$

$$I_1 = 0.1V_{th}.$$

also from figure,

$$50 = 10I_1 + V_1$$

$$\therefore \quad 50 = 10(0.1V_{th}) + 4V_{th}.$$

$$1V_{th} + 4V_{th} = 50$$

$$\boxed{V_{th} = 10\text{ V}}$$

Power transferred $P_{max} = \dfrac{V_{th}^2}{4R_{th}} = \dfrac{10^2}{4\times 8}$

$$\boxed{P_{max} = 3.125\text{ W}} \text{ Answer.}$$

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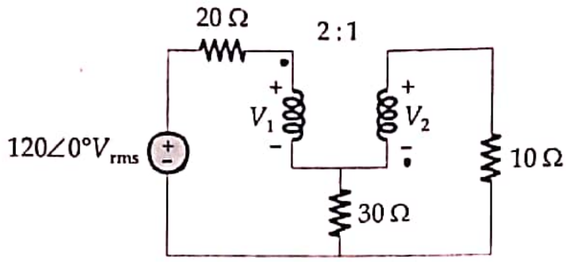
Q.4 (b) Calculate the power supplied to the 10 Ω resistor in the ideal transformer circuit of figure shown below:

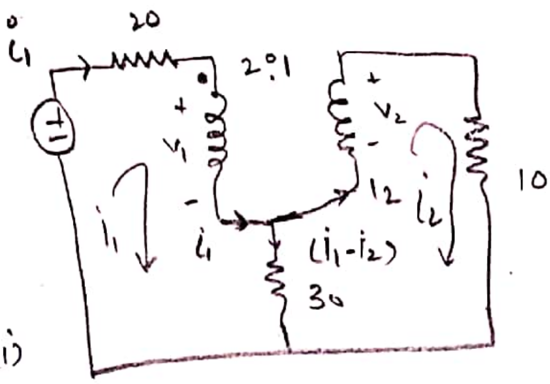


[20 marks]

Sol

Applying KVL in loop 1.

$$-120\angle 0° + 20i_1 + V_1 + 30i_1 - 30i_2 = 0$$



$$50i_1 - 30i_2 + V_1 = 120 \quad -(i)$$

Applying KVL ~~co~~ in loop 2

$$-V_2 + 10i_2 + 30i_2 - 30i_1 = 0$$

$$40i_2 - 30i_1 = V_2 \quad -(ii)$$

and

$$-\frac{V_1}{V_2} = \frac{2}{1}$$

$V_1 = -2V_2$ putting V_2 from (ii)

$$V_1 = -80i_2 + 60i_1$$

$\Rightarrow$ or

$$120 - 50i_1 + 30i_2 = -80i_2 + 60i_1$$

$$\cancel{120 = -30i_1 + 30i_2}$$

$$\cancel{i_2 = i_1 = 4}$$

$$120 = 110i_1 - 110i_2$$

$$\dot{i}_1 - \dot{i}_2 = \frac{12}{11}$$ also $$-\frac{I_1}{I_2} = \frac{1}{2} \text{ or } I_2 = -2I_1 \text{ or } I_1 = -\frac{I_2}{2}$$

$$\therefore \quad -\frac{\dot{i}_2}{2} - \dot{i}_2 = \frac{12}{11}$$

$$-\frac{3\dot{i}_2}{2} = \frac{12}{11} \Rightarrow \boxed{\dot{i}_2 = -0.7272 \text{ A}}$$

Power supplied to 10 Ω resistor is

$$P = (-0.7272)^2 \cdot 10$$

18

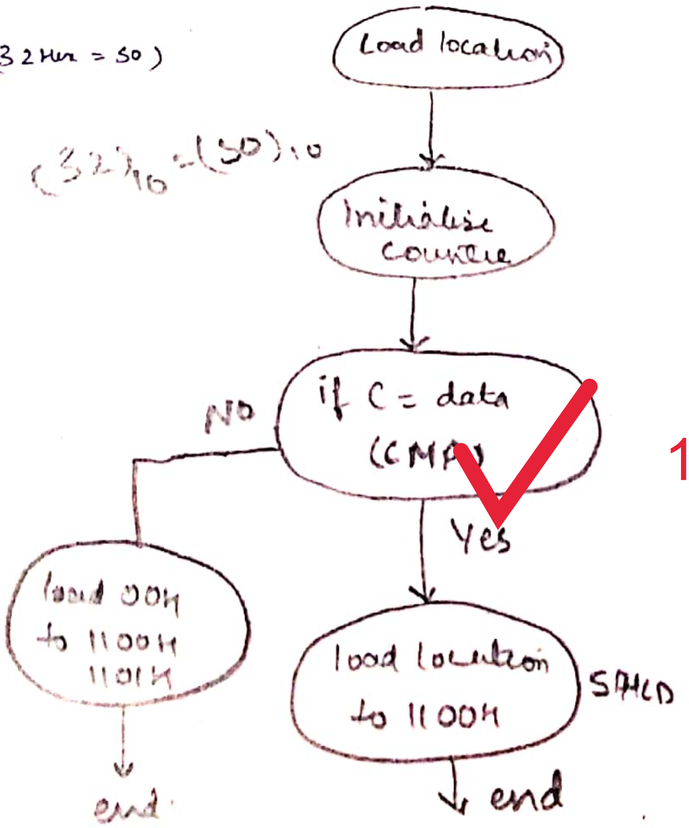
$$\boxed{P = 5.29 \text{ W}}$$ Answer

Q.4 (c) Given is the list of 50 different numbers which are stored in consecutive memory location starting from 1000H. Write a program to search the given byte which is stored in the register 'C'. If the byte is found, then store the location of the byte in memory location 1100H and 1101H. If the byte is not found then store the value 00H at 1100H and 1101H and also draw the flow chart for the given program which is to be written for 8085 microprocessor.

[20 marks]

```
      LXI  H, 1000H
      MVI  B, 0032H     (32Hex = 50)
loop1 MOV  A, M
      CMP  C
      JZ   loop2
      INX  H
      DCR  B
      JNZ  loop 1
      LXI  H, 0000H
      SHLD 1100H
loop2 : SHLD 1100H
      HLT
```

$(32)_{16} = (50)_{10}$



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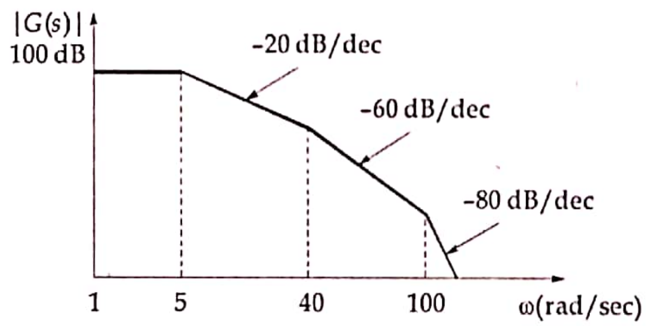
Section B : Digital Circuits-1 + Control Systems-1 [Part Syllabus]

Q.5 (a) The magnitude plot of the open loop transfer function $G(s)$ of a certain system is shown below:



(i) Determine the open loop transfer function $G(s)$.

(ii) Estimate the phase at each of the corner frequencies.

[12 marks]

(i) No initial slope so no zero or poles at zero, initial magnitude = 100 dB

$$20 \log K = 100 \text{ dB}$$

Slope change at 5 $\longrightarrow$ one pole (−20 dB)

40 $\longrightarrow$ two pole (−60 dB)

100 $\longrightarrow$ one pole (−80 dB)

$K =$ antilog 5 $\quad \underline{K = 10^5}$,

$$G(s)\cancel{H(s)} = \frac{K}{\left(\frac{s}{5}+1\right)\left(\frac{s}{40}+1\right)^2\left(\frac{s}{100}+1\right)}$$

$$G(s)\cancel{H(s)} = \frac{10^5}{\frac{(s+5)\cdot(s+40)^2(s+100)}{5\cdot 40^2\cdot 100}}$$

$$\boxed{G(s) = \frac{10^5 \cdot 8\times10^5}{(s+5)(s+40)^2(s+100)}}$$ Ans.

Angle $\angle G(j\omega) = -\tan^{-1}\frac{\omega}{5} - 2\tan\frac{\omega}{40} - \cancel{2}\tan^{-1}\frac{\omega}{100}$

At $\omega = 5$ rad $\boxed{\angle G(j\omega) = -62.11^\circ}$ $-45^\circ -$ Ans

at $\omega = 40$ $\angle G(j\omega) = -82.87 \cancel{+} - \cancel{180^\circ}\ 90^\circ - 21^\circ$

$\boxed{\angle G(j\omega) = -194.67^\circ}$ Ans

at $\omega = 100$ rad/sec $\boxed{\angle G(j\omega) = -268.53^\circ}$ Ans

12

Q.5 (b) Consider the following characteristic equation of a closed loop system

$$s^4 + 20s^3 + 224s^2 + 1240s + 2400 + K = 0$$

(i) Find the condition for stability of the system.

(ii) Determine the value of K which will cause sustained oscillations and also determine the frequency of such oscillations.

[12 marks]

Sol: (i) formulate R-H table

s^4	1	224	2400+K
s^3	20	1240	0
s^2	162	2400+K	0
s^1	A	0	0
s^0	2400+K	0	0

$$A = \frac{162\times1240 - 20(2400+K)}{162}$$

For stable system

$2400 + K > 0$

and $A > 0$ i.e $162\times1240 > 20(2400+K)$

$10044 > 2400+K$

$7644 > K$.

$\therefore$ $\boxed{-2400 < K < 7644}$ Ans.

(ii) when $A = 0$; system will have 0 coloumn i.e system will oscillate

$\therefore$ $K_{osc} = 7644$

So Auxillary Equation is

$$162s^2 + 2400 + K = 0$$

$$162s^2 + 2400 + 7644 = 0$$

$$s^2 = \frac{-10044}{162}$$

$$s = \pm j\sqrt{62}$$

frequency of oscillation is $\boxed{\sqrt{62} \text{ or } 7.874}$ rad/sec

Ans.

12

Q.5 (c) Find the following conversions

(i) Convert 423_{10} to hexadecimal.

(ii) Convert 177_{10} to its 8-bit binary equivalent.

(iii) Convert 378_{10} to 16-bit binary equivalent.

(iv) Convert $B2F_{16}$ to decimal.

(v) Convert 37_{10} to binary.

[12 marks]

(i) $(423)_{10} \rightarrow (\quad)_{16}$

16	423	7
16	26	10 → A
	1	

$= (1A7)_{16}$ Ans.

(ii) $(177)_{10} \rightarrow (\quad)_2$

2	177	1
2	88	0
2	44	0
2	22	0
2	11	1
2	5	1
2	2	0
	1	

$= (\underbrace{1011}\,\underbrace{0001})_2$

(iii) $(378)_{10} \rightarrow (\quad)_2$

$= (0000\;0001\;0111\;1010)_2$

16 bit binary Ans.

2	378	0
2	189	1
2	94	0
2	47	1
2	23	1
2	11	1
2	5	1
2	2	0
	1	

(iv) $(B2F)_{16} \rightarrow (\quad)_{10}$

$11\times16^2 + 2\times16^1 + 15\times16^0$

$= 2816 + 32 + 15 = (2863)_{10}$ Ans

(v) $(37)_{10} \rightarrow (\quad)_2$

$= (100101)_2$ Ans.

2	37	1
2	18	0
2	9	1
2	4	0
2	2	0
	1	

10

Q.5 (d) (i) Simplify the expression $Z=\overline{(\bar{A}+C)\cdot(B+\bar{D})}$ to one having only single variables inverted.

(ii) Using the *K*-map, simplify

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

[12 marks]

Sol.

(i)

$$Z = \overline{(\bar{A}+C)\cdot(B+\bar{D})}$$

using demorgan theorem.

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

$$Z = \bar{\bar{A}}\cdot\bar{C} + \bar{B}\cdot\bar{\bar{D}}$$

$$Z' = \boxed{Z' = A\cdot\bar{C} + \bar{B}D}$$

$\bar{Z'} = Z$ single variable ~~uu~~ inverted

(ii)

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

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

$\bar{A}\bar{B}\bar{C}\bar{D} = 0$

$\bar{C}D = 1, 3, 5, 9, 13$

$A\bar{B}C = 8, 9, 10, 11$

$\bar{D} = 0, 2, 4, 6, 8, 10, (12, 14)$

AB \ CD	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$	1	1		1
$\bar{A}B$	1	1		1
AB	1	1		1
$A\bar{B}$	1	1	1	1

Simplified expression

~~$Y = A\bar{C} + \bar{D} + A\bar{B}$~~ Ans.

$$\boxed{Y = A\bar{B} + \bar{C} + \bar{D}}$$

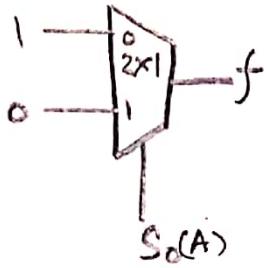
10

Q.5 (e) Implement all the basic logic gates using 2 × 1 MUX.

[12 marks]

Sol.

NOT



$f = \bar{A}$

AND

$f = A \cdot B$

OR

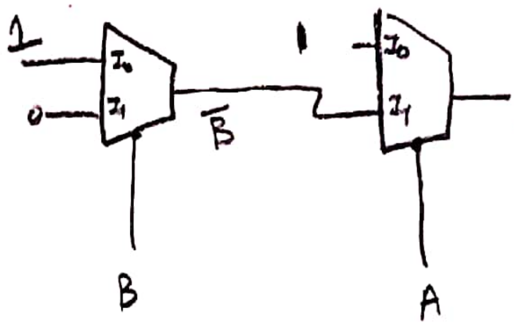
$f = \bar{A} \cdot B + A \Rightarrow (A + \bar{A})(A + B)$

$= A + B$

OR

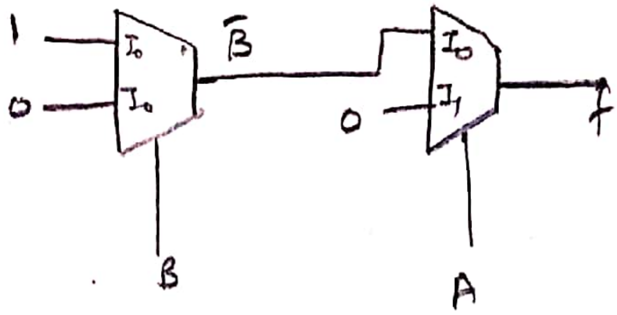
- NAND.

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



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

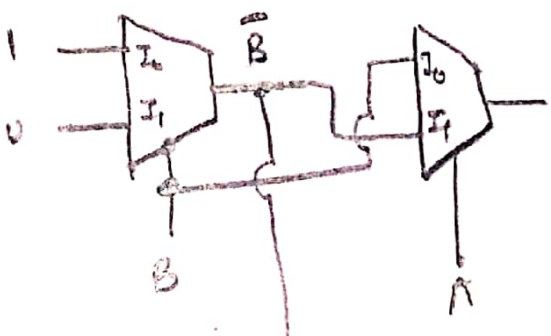
- NOR.



$f = \overline{A+B}$

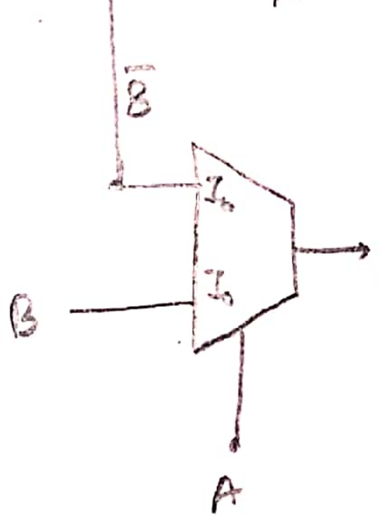
$= \bar{A} \cdot \bar{B}$

- X-OR.



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

- XNOR.



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

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Q.6 (a) (i) The open-loop transfer function of a unity feedback system is $G(s)H(s) = \dfrac{s+2}{(s+1)(s-1)}$. Comment on the stability by drawing the Nyquist plot.

[12 marks]

(ii) A feedback control system has an open loop transfer function of

$$G(s)\,H(s) = \frac{Ke^{-s}}{s(s^2+2s+1)}$$

Determine the maximum value of K for the closed loop stability by using R-H criteria.

[8 marks]

Sol^n (i)

$$G(s)\,H(s) = \frac{s+2}{(s+1)(s-1)}$$

$P = 1$

$$G(j\omega)H(j\omega) = \frac{j\omega+2}{(j\omega+1)(j\omega-1)}$$

$$|M| = \frac{\sqrt{\omega^2+4}}{\sqrt{\omega^2+1}\sqrt{\omega^2+1}}$$

$$\angle\phi = \tan^{-1}\frac{\omega}{2} - \tan^{-1}\omega + 180 + \tan^{-1}\omega$$

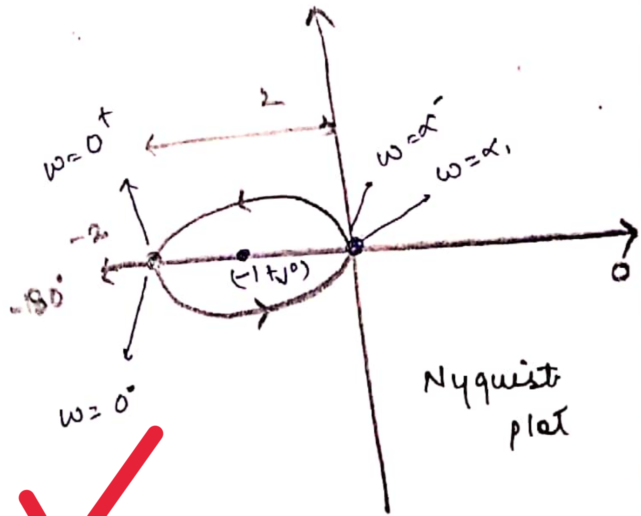
$=$

$\omega = 0$, $M = 2$, $\phi = -180°$

$\omega = \infty$; $M = 0$; $\phi = -90°$

$\omega = 0^-$, $M = 2$, $\phi = 180°$

$\omega = \infty^-$, $M = 0$, $\phi = 90°$



From figure

$N = 1$ (anticlockwise circle)

$N = P - Z$

$1 = 1 - Z$

$\boxed{Z = 0}$ $\therefore$ closed loop system will be Stable Ans.

(ii) for low frequency $e^{-s} = 1 - s$

$\therefore \quad G(s)H(s) = \dfrac{K(1-s)}{s^3 + 2s^2 + s}$.

Characteristic Equation: $1 + G(s)H(s) = 0$.

$$s^3 + 2s^2 + s(1-K) + K = 0$$

$$\begin{array}{c|ccc} s^3 & 1 & 1-K & 0 \\ s^2 & 2 & K & 0 \\ s^1 & \frac{2-2K-K}{2} & 0 & 0 \\ s^0 & K & 0 & 0 \end{array}$$

For system to be stable

$K > 0$

$\dfrac{2-2K-K}{2} > 0$

$2 - 2K - K > 0$

$2 - 3K > 0$

$2 > 3K$

$1.5 > K$.

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For stability $\boxed{0 < K < 1.5}$

$\boxed{\text{maximum value of } K = 1.5}$ Ans.

Q.6 (b) (i) Implement the logic circuit that has the expression $x = \overline{AB \cdot (\overline{C+D})}$ using only NOR and NAND gates.

[8 marks]

(ii) Design an astable multivibrator using a practical MUX circuit. Calculate the minimum propagation delay that the MUX circuit should have so that the frequency of output wave is equal to 20 MHz.

[12 marks]

(i)

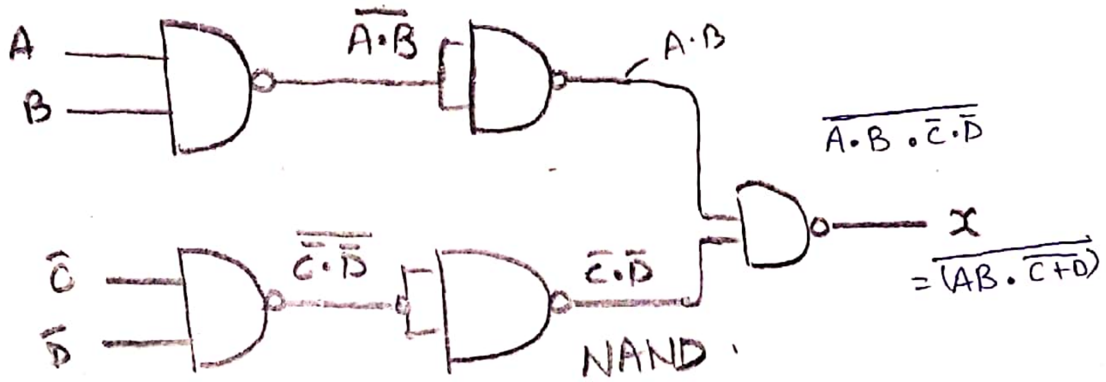
$$x = \overline{A \cdot B \cdot (\overline{C+D})}$$

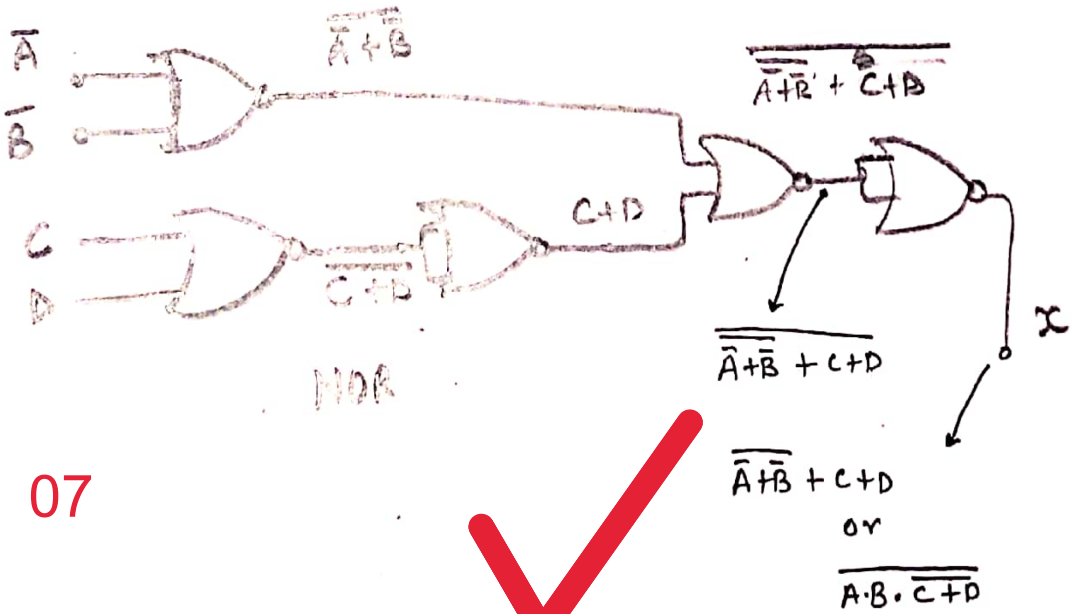
$$x = \overline{A \cdot B \cdot \bar{C} \cdot \bar{D}} \quad \text{— NAND}$$

or

$$x = \overline{\bar{A}+\bar{B} \cdot (\overline{C+D})}$$

$$x = \overline{\bar{A}+\bar{B}} + (C+D) \quad \text{— NOR.}$$





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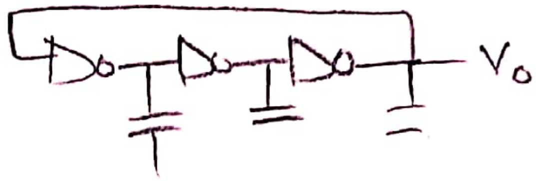
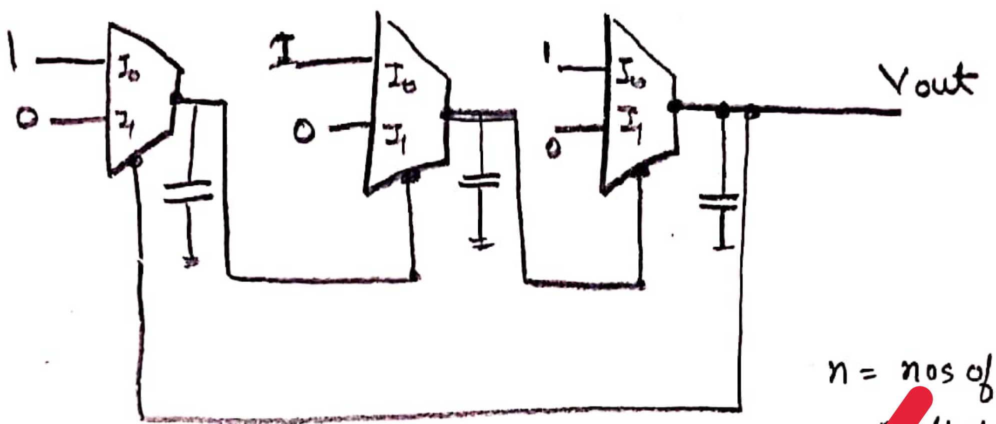
(ii)





n = nos of multiplexer used

Astable multivibrator $f = \frac{1}{2n \cdot t_p}$

$f = 20\ MHz$

$\therefore\ 20 \times 10^6 = \frac{1}{2 \times 3 \times t_p}$

$t_p = \frac{1}{2 \times 3 \times 20 \times 10^6\ Hz}$

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$\boxed{t_p = 8.33\ nsec}$ Ans.

Minimum propagation delay must be 8.33 nsec

Q.6 (c) Sketch the root-locus plot and determine the approximate damping ratio for a value of $K = 1.33$ for a control system having a forward transfer function with unity feedback, $G(s) = \frac{K(s+2)}{s^2+2s+3}$. [20 marks]

Sol:

$$G(s) = \frac{K(s+2)}{s^2+2s+3}$$

zero = $s = -2$,

pole = $s_1 = -1 \pm j\sqrt{2}$

- No of asymptate $P-Z = 2-1 = 1$.
- Angle of asymptote, $\frac{\pm(2q+1)180^\circ}{P-Z} = 180^\circ$,
- Centroid $-\sigma = \frac{(-1-1)+2}{1} = 0$.
- break point

$$K = -\frac{s^2+2s+3}{s+2}$$

$-\frac{dK}{ds} = 0$ i.e $\frac{(s+2)(2s+2)-(s^2+2s+3)\cdot 1}{(s+2)^2} = 0$

$= 2s^2+2s+4s+4-s^2-2s-3$

$\Rightarrow s^2+4s+1 = 0$

$s_1 s_2 = -3.73, -0.2679$.

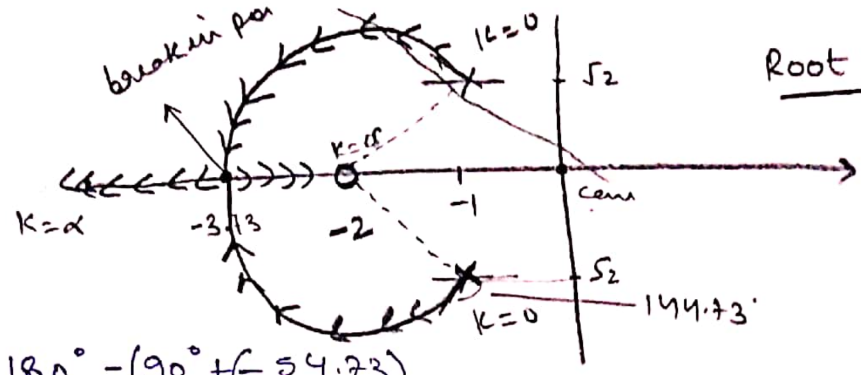
-3.73 is break ~~away~~ in point

- Angle of departure

$\angle s|_{-1+\sqrt{2}j} = \frac{(1+\sqrt{2}j)}{90^\circ \cdot 0^\circ}$

$= \tan^{-1}\frac{\sqrt{2}}{1} = -54.73^\circ$.

Root locus.



$\theta_d = 180° - (90° + (-54.73))$

$= \underline{144.73°}$ $\quad \theta_d = -144.73°$

- For $K = 1.33$, we apply magnitude condition

$$\frac{1.33\,(s+2)}{s^2+2s+3} = 1$$

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or $\quad s^2 + 0.67s + 0.34 = 0$

$$s_1 s_2 = -0.335 \pm 0.477j$$

angle condition.

$$\angle G(s)H(s)\Big|_{s=-0.335+0.477j} = \frac{k\,(1.665 + 0.477j)}{(0.665 - 0.937j)(0.665 + 1.891j)}$$

$\angle G(s)H(s) = 141.24°$ or $38.75°$

$\xi = \cos\theta = \cos 38.75$

$\boxed{\xi = 0.77}$ Ans.

Q.7 (a) In a thermal power plant, the three digital signals i.e. the steam temperature (T_s), drum level (L_D) and water flow (F_W) are used to control a particular system by a feedback signal (F) that comes from the field to the control room. A logic circuit is to be designed to generate a high feedback signal (F) whenever any one of the condition is satisfied.

C1 : All levels are at zero

C2 : Level L_D and T_s set to zero

C3 : Level F_W and T_s set to zero

C4 : Only level L_D is set to zero

C5 : All the levels are high

Find the minimum expression for the feedback signal F and construct a logic circuit using three 2 × 1 MUX only.

[20 marks]

Sol.

	T_s	L_D	F_w	F	
0	0	0	0	1	0
1	0	0	1	1	1
2	0	1	0	1	2
3	0	1	1	0	3
4	1	0	0	1	4
5	1	0	1	1	5
6	1	1	0	0	6
7	1	1	1	1	7

0 → low

1 - high

T_s \ $L_D F_W$	00	01	11	10
$\bar{T_s}$	1	1		1
T_s	1	1	1	

Minimum Expression $\boxed{F = \bar{L}_D + T_s F_W + \bar{T}_s \bar{F}_W}$

$F = \bar{L}_D + T_S \odot F_W$

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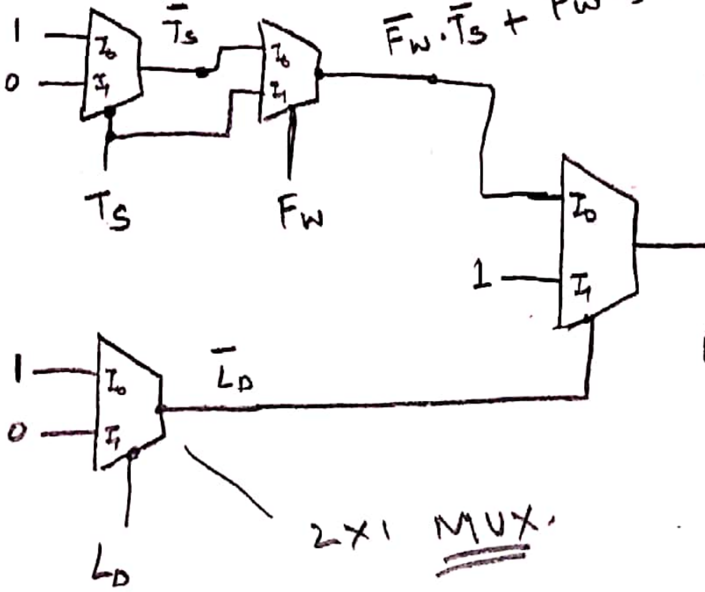
$\bar{F}_W \cdot \bar{T}_S + F_W T_S \; (T_S \odot F_W)$



$F = \bar{L}_D + (T_S \odot F_W)$

or

$F = \bar{L}_D + \bar{T}_S \bar{F}_W + T_S F_W$

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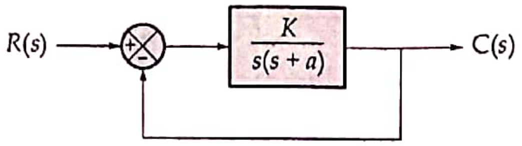
Q.7 (b) Find K and a for the feedback system shown below so that $M_r = 1.25$ and $\omega_r = 12.65$ rad/sec will be satisfied. Also determine the settling time and bandwidth.



[20 marks]

Sol'

$$\frac{C(s)}{R(s)} = \frac{K}{s^2 + as + K}$$

on comparing with standard 2nd order equation

$$2\xi\omega_n = a$$
$$\omega_n^2 = K$$

Now $M_r = 1.25$

also $$M_r = \frac{1}{2\xi\sqrt{1-\xi^2}}$$

$$\frac{1}{2\xi\sqrt{1-\xi^2}} = 1.25$$ we get $\boxed{\xi = 0.447}$

also $$\omega_r = \omega_n\sqrt{1-2\xi^2}$$

$$12.65 = \omega_n\sqrt{1 - 2\times 0.447^2}$$

$$\boxed{\omega_n = 16.33 \text{ rad/sec}}$$

$\therefore$ $$K = \omega_n^2 = 16.33^2$$

$$\boxed{K = 266.66 \approx 267}$$ Ans.

$$a = 2\xi\omega_n = 2\times 0.447\times 16.33$$

$$\boxed{a = 14.61}$$ Ans.

- Settling time $= \dfrac{4}{\xi \omega_n}$

$$t_s = \frac{4}{0.447 \times 16.33}$$

$$\boxed{\begin{array}{l} t_s = 0.548 \text{ sec } (2\% \text{ criterion}) \\ t_s = 0.4109 \text{ sec } (5\% \text{ criterion}) \end{array}}$$

Ans.

- Bandwidth $= \omega_n \sqrt{1 - 2\xi^2 + \sqrt{2 - 4\xi^2 + 4\xi^4}}$

$$\boxed{B.W = 21.705 \text{ rad/sec}}$$ Ans.

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Q.7 (c) (i) Define various voltage and current parameters that are measured for the analysis of logic IC families. (NM), Ion/Ini → 34 **[8 marks]**

(ii) Simplify the following Boolean expression without using *K*-map and implement them using two level NAND gate only. (Assuming that are the multi-input NAND gate).

1. $F = A\bar{B} + ABD + AB\bar{D} + \bar{A}\bar{C}\bar{D} + \bar{A}B\bar{C}$

2. $F = BD + BC\bar{D} + A\bar{B}\bar{C}D$

[12 marks]

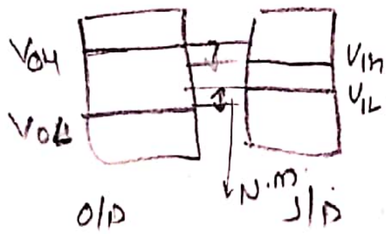
(i) Voltage parameter:

(i) V_{OH}: it is minimum voltage level required at output of gate for logic 1.

(ii) V_{OL}: it is maximum voltage level required at output of gate for logic 0.

(iii) V_{IH}: it is min. voltage level required at input of gate for logic 1

(iv) V_{OIL}: it is maximum voltage level required at input of gate for logic 0.



<u>Current parameter</u>

I_{IH} and I_{IL}: Current flow into the input when logic is high (I_{IH}) and low (I_{IL})

I_{OH} and I_{OL}: It is current flow from output when logic is high (I_{OH}) and low (I_{OL}).

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(ii)

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

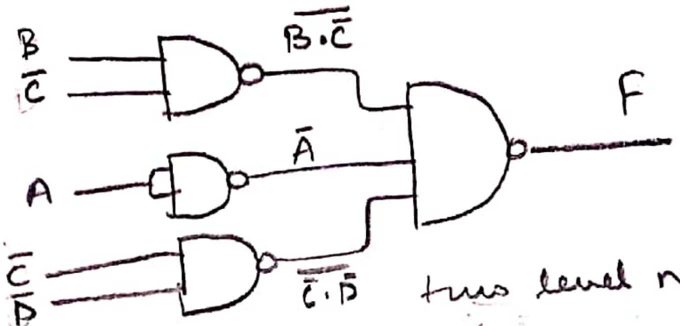
$f = A\bar{B} + AB + \cancel{\bar{A}\bar{C}} \; \bar{A}\bar{C}\bar{D} + \bar{A}B\bar{C}$

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

$f = \underset{\bar{x}}{A} + \underset{y}{\bar{A}}(\underbrace{\bar{C}\bar{D} + B\bar{C}}_{z})$

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

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



two level nand

$f = BD + BC\bar{D} + A\bar{B}\bar{C}D + \cancel{\bar{B}\bar{D}} \rightarrow 0$

~~$f = BD + BC\bar{D} + D(A\bar{B}\bar{C} + \bar{D})$~~

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

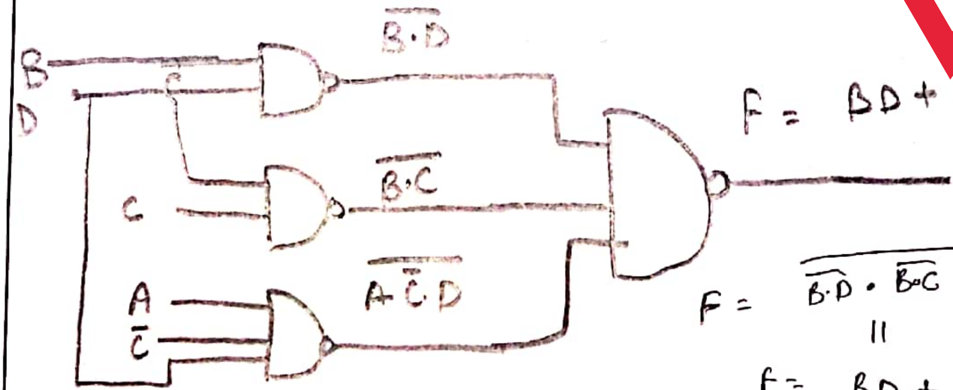
$BD + BC$

$A\bar{C}D$

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

$f = BD + A\bar{C}D + BC\bar{D} \Rightarrow B(D + C\bar{D}) + A\bar{C}D$

$\boxed{f = BD + BC + A\bar{C}D}$



$F = BD + BC + A\bar{C}D$

$F = \overline{\overline{B \cdot D} \cdot \overline{B \cdot C} \cdot \overline{A\bar{C}D}}$

$\parallel$

$f = BD + BC + A\bar{C}D$

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