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UPSC ENGINEERING SERVICES EXAMINATION

Electrical Engineering

Test-2 : Systems and Signal Processing + Microprocessors [All topics] Electrical Circuits-1 + Control Systems-1 [Part Syllabus]

Name :

Roll No :

Test Centres			Student's Signature
Delhi ☑	Bhopal ☐	Jaipur ☐	
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Instructions for Candidates

1. Do furnish the appropriate details in the answer sheet (viz. Name & Roll No).
2. There are Eight questions divided in TWO sections.
3. Candidate has to attempt FIVE questions in all in English only.
4. Question no. 1 and 5 are compulsory and out of the remaining THREE are to be attempted choosing at least ONE question from each section.
5. Use only black/blue pen.
6. 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.
7. Any page or portion of the page left blank in the Question Cum Answer Booklet must be clearly struck off.
8. There are few rough work sheets at the end of this booklet. Strike off these pages after completion of the examination.

FOR OFFICE USE

Question No.	Marks Obtained
Section-A	
Q.1	52
Q.2	52
Q.3	51
Q.4	
Section-B	
Q.5	55
Q.6	54
Q.7	
Q.8	
Total Marks Obtained	264

Signature of Evaluator: Sourabh kumar

Cross Checked by: ....

IMPORTANT INSTRUCTIONS

CANDIDATES SHOULD READ THE UNDERMENTIONED INSTRUCTIONS CAREFULLY. VIOLATION OF ANY OF THE INSTRUCTIONS MAY LEAD TO PENALTY.

DONT'S

1. Do not write your name or registration number anywhere inside this Question-cum-Answer Booklet (QCAB).
2. Do not write anything other than the actual answers to the questions anywhere inside your QCAB.
3. Do not tear off any leaves from your QCAB, if you find any page missing do not fail to notify the supervisor/invigilator.
4. Do not leave behind your QCAB on your table unattended, it should be handed over to the invigilator after conclusion of the exam.

DO'S

1. Read the Instructions on the cover page and strictly follow them.
2. Write your registration number and other particulars, in the space provided on the cover of QCAB.
3. Write legibly and neatly.
4. For rough notes or calculation, the last two blank pages of this booklet should be used. The rough notes should be crossed through afterwards.
5. If you wish to cancel any work, draw your pen through it or write "Cancelled" across it, otherwise it may be evaluated.
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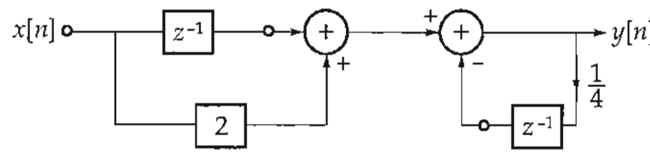
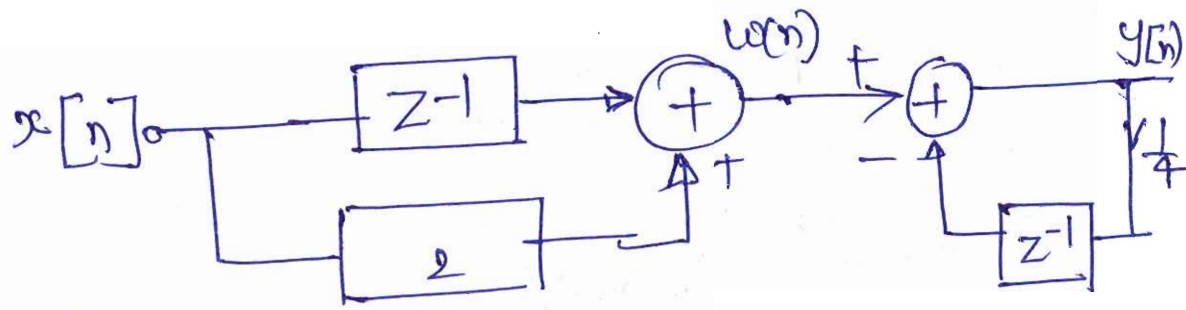
Section A : Systems and Signal Processing + Microprocessors

Q.1 (a) Consider the system shown in figure below :



Determine the impulse response of the system?

[12 marks]



we have,

$$W(z) = (z^{-1} + 2)\, X(z)$$

or $\quad w(n) = x(n-1) + 2x(n) \quad \longleftarrow (1)$

$\left\{ \text{we know} \quad x(n) \Leftrightarrow X(z) \right.$

$\left. \qquad\qquad x(n-n_0) \Leftrightarrow z^{-n_0} X(z) \right\}$

Similarly,

$$Y(z) = \frac{1}{4} z^{-1} Y(z) + W(z)$$

$\Downarrow$ IZT

$$y(n) = \frac{1}{4} y(n-1) + w(n)$$

using eq(1)

$$y(n) = \frac{1}{4} y(n-1) + x(n-1) + 2x(n)$$

Taking ZT,

$$Y(z) = \frac{1}{4} z^{-1} Y(z) + z^{-1} X(z) + 2X(z)$$

$$\frac{Y(z)}{X(z)} = \frac{2 + z^{-1}}{1 - \frac{1}{4} z^{-1}}$$

$$H(z) = \frac{2}{1 - \frac{1}{4} z^{-1}} + \frac{z^{-1}}{1 - \frac{1}{4} z^{-1}}$$

using the result, $\left\{ a^n u(n) \overset{ZT}{\Longleftrightarrow} \frac{1}{1 - a z^{-1}} \right\}$

$$h(n) = 2 \left(\frac{1}{4}\right)^n u(n) + \left(\frac{1}{4}\right)^{n-1} u(n-1)$$

Thus impulse response is

$$h(n) = 2 \left(\frac{1}{4}\right)^n u(n) + \left(\frac{1}{4}\right)^{n-1} u(n-1)$$

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Q.1 (b) Find $x(n)$ by using convolution for

$$X(z) = \frac{1}{\left(1-\frac{1}{2}z^{-1}\right)\left(1+\frac{1}{4}z^{-1}\right)}$$

[12 marks]

Let $X(z) = X_1(z)\, X_2(z)$

$$\frac{1}{\left(1-\frac{1}{2}z^{-1}\right)} \quad \frac{1}{\left(1+\frac{1}{4}z^{-1}\right)}$$

Convolution property states

$$x_1(n) * x_2(n) \xleftrightarrow[ZT]{} X_1(z)\, X_2(z)$$

For $\frac{1}{1-\frac{1}{2}z^{-1}} \xleftrightarrow[IZT]{} x_1(n) = \left(\frac{1}{2}\right)^n u(n)$

For $\frac{1}{1+\frac{1}{4}z^{-1}} \xleftrightarrow[IZT]{} x_2(n) = \left(-\frac{1}{4}\right)^n u(n)$

Definition of convolution is.

$$x(n) = x_1(n) * x_2(n)$$

$$= \sum_{k=-\infty}^{\infty} x_1(k)\, x_2(n-k)$$

$$= \sum_{k=-\infty}^{\infty} \left(\frac{1}{2}\right)^k u(k) \left(-\frac{1}{4}\right)^{n-k} u(n-k)$$

$$= \sum_{k=0}^{\infty} \left(\frac{1}{2}\right)^k \left(-\frac{1}{4}\right)^{-k} \left(-\frac{1}{4}\right)^n u(n-k)$$

$$= \sum_{k=0}^{\infty} (-2)^{k} \left(-\frac{1}{4}\right)^{n} u(n-k)$$

$$= \begin{cases} 0 & n < 0 \\ \left(-\frac{1}{4}\right)^{n} \sum_{k=0}^{\infty} (-2)^{k} & n \geq 0 \end{cases}$$

$$= \left[\left(-\frac{1}{4}\right)^{n} \frac{1-(-2)^{n+1}}{1-(-2)}\right] u(n)$$

$$= \left[\frac{\left(-\frac{1}{4}\right)^{n} - \left(-\frac{1}{4}\right)^{n} (-2)(-2)^{n}}{3}\right] u(n)$$

$$= \left[\frac{\left(-\frac{1}{4}\right)^{n} + 2\left(\frac{1}{2}\right)^{n}}{3}\right] u(n)$$

$$= \frac{\left(-\frac{1}{4}\right)^{n}}{3} u(n) + \frac{2}{3}\left(\frac{1}{2}\right)^{n} u(n)$$

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Good Approach

Do not write in this margin

Q.1 (c) Find the Inverse DFT of the sequence $Y(K) = \{1, 0, 1, 0\}$.

[12 marks]

Using the definition,

$$y(n) = \frac{1}{N} \sum_{K=0}^{N-1} Y(K) e^{j\frac{2\pi}{N}Kn}$$

$$= \frac{1}{4} \sum_{K=0}^{3} Y(K) e^{j\frac{\pi}{2}Kn} \quad [N=4]$$

$$= \frac{Y(0) + \cancel{Y(1) e^{j\frac{\pi}{2}n}} + Y(2) e^{j\pi n} + \cancel{Y(3) e^{j\frac{3\pi}{2}n}}}{4}$$

where $Y(1) = Y(3) = 0$ and $Y(0) = Y(2) = 1$

$$= \frac{1 + e^{j\pi n}}{4}$$

$$= \frac{1 + (-1)^n}{4} \quad \left[e^{j\pi} = -1\right]$$

$$y(n) = \begin{cases} \frac{1 + (-1)}{4} = 0 & n :- \text{odd} \\ \frac{1+1}{4} = \frac{1}{2} & n - \text{even} \end{cases}$$

Do not write in this margin

$y(0) = y(2) = 0.5$ n — even

$y(1) = y(3) = 0$ n — Odd

Thus $y(n) = \{0.5, 0, 0.5, 0\}$

Alternatively

$$y(n) = \frac{1}{4}\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & j & -1 & -j \\ 1 & -1 & 1 & -1 \\ 1 & -j & -1 & j \end{bmatrix}\begin{bmatrix} 1 \\ 0 \\ 1 \\ 0 \end{bmatrix}$$

$$= \frac{1}{4}\begin{bmatrix} 2 \\ 0 \\ 2 \\ 0 \end{bmatrix}$$

$$= \begin{bmatrix} 0.5 \\ 0 \\ 0.5 \\ 0 \end{bmatrix}$$

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Q.1 (d) Consider an analog filter whose transfer function is :

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

Find $H(z)$ by using bilinear transformation. (Assume $T = 1$ sec).

[12 marks]

Bilinear transformation is defined as,

$$s = \frac{2}{T}\left(\frac{1-z^{-1}}{1+z^{-1}}\right)$$

$$= 2\left(\frac{1-z^{-1}}{1+z^{-1}}\right) \quad [T = 1 \text{ sec})$$

Replacing $s \longrightarrow 2\left(\frac{1-z^{-1}}{1+z^{-1}}\right)$

we get,

$$H(z) = \frac{2}{\left[2\left(\frac{1-z^{-1}}{1+z^{-1}}\right)+1\right]\left[2\left(\frac{1-z^{-1}}{1+z^{-1}}\right)+2\right]}$$

$$= \frac{2(1+z^{-1})^2}{\left[2(1-z^{-1}) + 1+z^{-1}\right]\left[2(1-z^{-1}) + 2(1+z^{-1})\right]}$$

$$= \frac{2(1+z^{-1})^2}{(3-z^{-1})(4)}$$

$$= \frac{1+2z^{-1}+z^{-2}}{2(3-z^{-1})}$$

$$= \frac{z^2+2z+1}{2(3z^2-z)}$$

Thus $H(z)$ for filter is,

$$H(z) = \frac{z^2+2z+1}{2(3z^2-z)}$$

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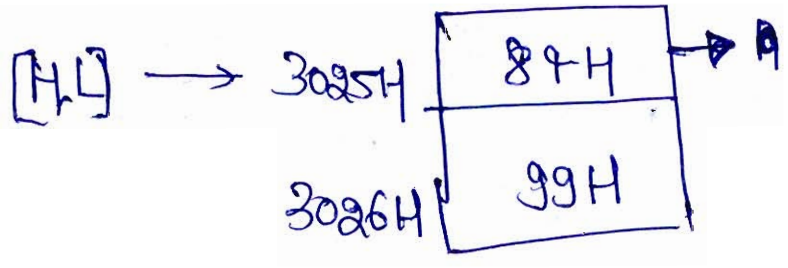
Good Approach

Q.1 (e) Write a program in 8085 microprocessor to find the smallest of the two numbers stored at memory location 3025H and 3026H and store the result in the memory location 3027H.

3025H	84H
3026H	99H

[12 marks]



The program is,

LXI H, 3025H; : [H,L] has address for operand 1.

MOV A, M; store in accumulator

INX H; [H,L] points to operand 2

CMP M;

JNC Store [A] is greater than or equal to [M]

STA 3027H [A] is less

Store: MOV A, M Swap the smaller no of Acc.

STA 3027H Store result

HLT End

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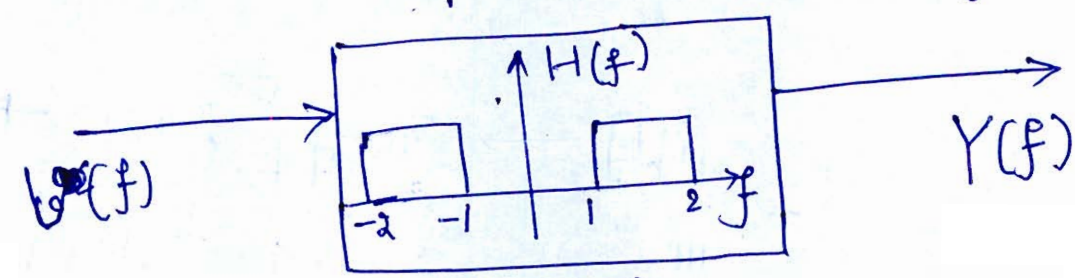
Q.2 (a) The one-sided exponential pulse (i.e., $v(t) = 0$ for $t < 0$), $v(t) = 4e^{-3t}u(t)$ V is applied to the input of an ideal bandpass filter. If the filter passband is defined by $1 < |f| < 2$ Hz, calculate the percentage of output energy w.r.t. to input energy.

[20 marks]

Consider the low pass filter block diagram:-



f in (Hz)

The input is,

$$v(t) = 4e^{-3t}u(t) \text{ V}$$

$$\Rightarrow V(f) = \frac{4}{3 + j2\pi f}$$

The energy of input is,

$$E_v = \int_{-\infty}^{\infty} |v(t)|^2 dt$$

$$= \int_{0}^{\infty} \left|4e^{-3t}\right|^2 dt$$

$$= 16 \left. \frac{e^{-6t}}{-6} \right|_0^{\infty}$$

$$= \frac{8}{3}$$

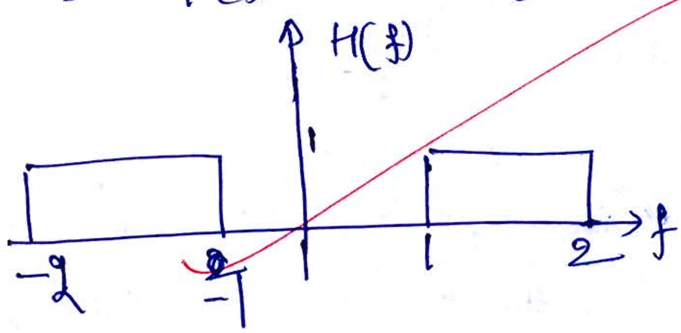
using convolution property,

$$Y(f) = H(f)V(f)$$

Parseval' Energy relation states,

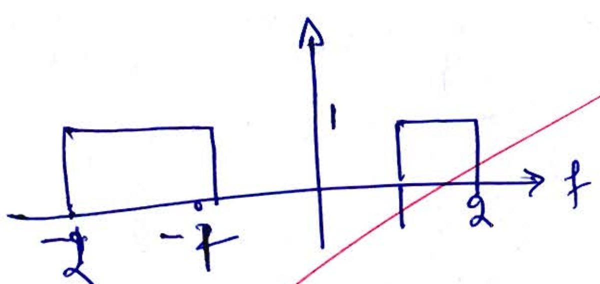
$$E_y = \int_{-\infty}^{\infty} |y(t)|^2 dt = \int_{-\infty}^{\infty} |Y(f)|^2 df$$

where, $Y(f) = H(f) \times \cancel{X}(f)$ V



$\times$ $\cancel{X}$ V(f)

$$|Y(f)| = |H(f)| \times |V(f)|$$



$$\times \frac{4}{\sqrt{9+4\pi^2 f^2}}$$

$$= \begin{cases} \dfrac{4}{\sqrt{9+4\pi^2 f^2}} & -2 \le f \le 1 \\[2ex] \dfrac{4}{\sqrt{9+4\pi^2 f^2}} & 1 \le f \le 2 \end{cases}$$

The energy of output is,

$$E_y = \int_{-\infty}^{\infty} |Y(f)|^2 df$$

$$= 2\left[\int_1^2 \frac{16}{9 + 4\pi^2 f^2}\right]$$

$$= 2\left[\int_1^2 \frac{\frac{16}{4\pi^2}}{\frac{9}{4\pi^2} + f^2}\right]$$

$$= 2 \times \frac{16}{4\pi^2} \times \frac{1}{\sqrt{\frac{9}{4\pi^2}}}\left[\tan^{-1}\left(\frac{f}{\sqrt{\frac{9}{4\pi^2}}}\right)\right]_1^2$$

$$= 2 \times \frac{16}{4\pi^2} \times \frac{1}{\frac{3}{2\pi}}\left(\tan^{-1}\left(\frac{2}{3/2\pi}\right) - \tan^{-1}\left(\frac{1}{3/2\pi}\right)\right)$$

$$= 0.3584$$

% of output energy w.r.t input

$$= \frac{0.3584}{8/3} \times 100$$

$$= 13.44\ \%$$

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Good Approach

Q.2 (b) Consider an ideal low pass filter with frequency response,

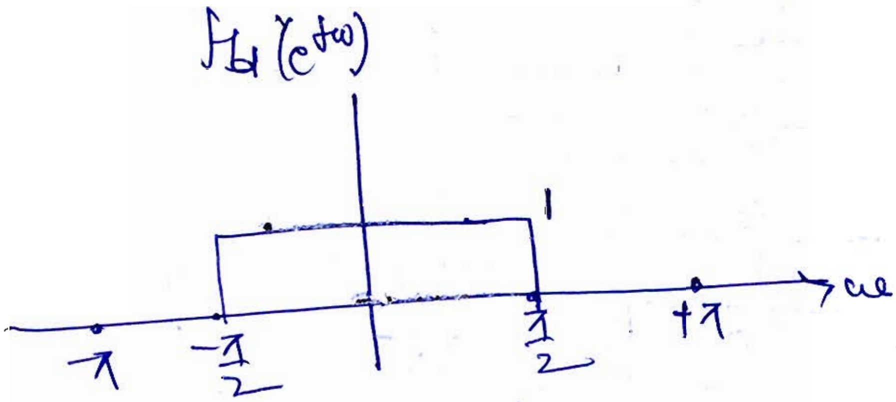
$$H_d(e^{j\omega}) = 1 \qquad \text{for } \frac{-\pi}{2} \le \omega \le \frac{\pi}{2}$$

$$= 0 \qquad \text{for } \frac{\pi}{2} \le |\omega| \le \pi$$

(i) Find the value of $h(n)$ for all coefficients of length $N = 11$.

(ii) Find the transfer function of the filter, i.e., $H(z)$. **[12 + 8 = 20 marks]**

(i)



The impulse response is,

$$h_d(n) = \frac{1}{2\pi}\left[\int_{-\pi}^{\pi} H_d(e^{j\omega})\, e^{j\omega n}\, d\omega\right]$$

$$= \frac{1}{2\pi}\left[\int_{-\pi/2}^{\pi/2} e^{j\omega n}\, d\omega\right]$$

$$= \frac{e^{j\frac{\pi}{2}n} - e^{-j\frac{\pi}{2}n}}{j2\pi n}$$

$$= \frac{j2\sin\frac{\pi}{2}n}{j2\pi n}$$

$$= \frac{\sin\left(\frac{\pi}{2}n\right)}{\pi n}$$

For filter of length 11,

The range of n : $-5 \le n \le 5$

n	$h_d(n) = \frac{\sin(\frac{\pi}{2}n)}{\pi n}$
-5	0.0636
-4	0
-3	-0.1061
-2	0
-1	0.3183
0	0.5
1	0.3183
2	0
3	-0.1061
4	0
5	0.0636

Delaying hd(n) by 5 sampes we get,

$$h_d(n) = \{\underset{\uparrow}{0.0636}, 0, -0.1061, 0, 0.3183, 0.5, 0.3183, 0, -0.1061, 0, 0.0636\}$$

Do not write in this margin

(11) To find $H(z)$:-

Using defenetion, $H(z) = \sum_{n=-\infty}^{\infty} h(n) z^{-n}$

$H(z) = 0.0636 + 0z^{-1} - 0.1061z^{-2} + 0z^{-3} + 0.3183z^{-4} + 0.5z^{-5} + 0.3183z^{-6} + 0z^{-7} - 0.1061z^{-8} + 0z^{-9} + 0.0636z^{-10}$

$= 0.0636 - 0.1061(z^{-2} + z^{-8}) + 0.3183(z^{-4} + z^{-6}) + 0.5z^{-5}$

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Incomplete solution

Q.2 (c) (i) Let at the memory location 4020 H, the instruction MOV B, A with opcode 47H is stored while the accumulator content is 05H. Draw the timing diagram showing the execution of this instruction in 8085 microprocessor.

[14 marks]

Consider :- MOV B, A
4020 H :-

one ~~opc~~ byte instruction

Memory

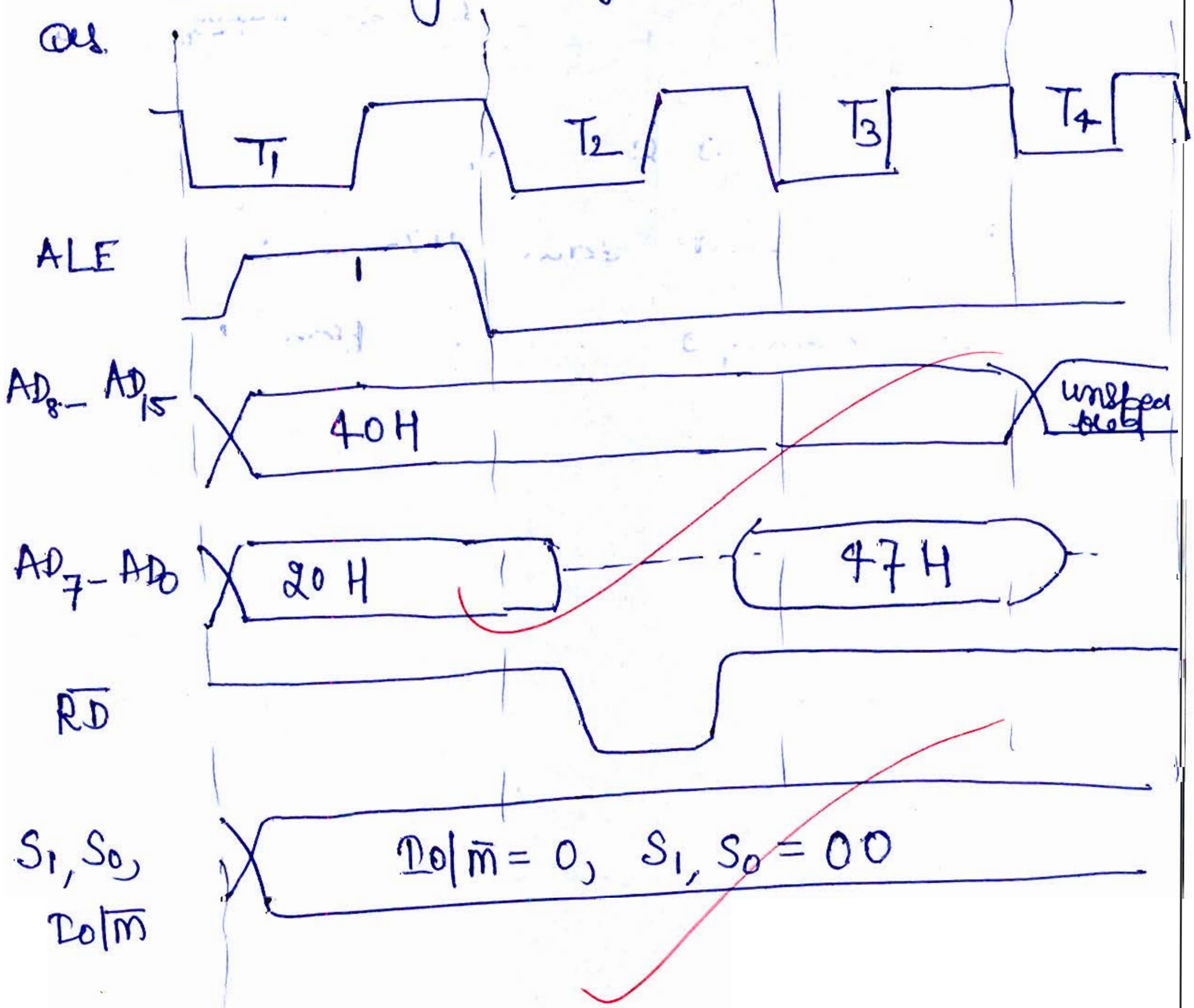
4020H | 47H

Function :- B ← A

Machine cycles — Opcode fetch

No of T-states — 4

MOV B, A timing diagram can be drawn as.



MOV B, A is a one-byte instruction having only one machine cycle namely opcode fetch machine cycle.

In T_1 cycle, the address bus has address 4020 H. In T_2 cycle RD is activated to read the opcode of instruction stored at 4020H.

The lower order address bus is demultiplexed for data reading by lowering ALE to 0. The transfer of content of A to register B is immediately done since internal registers are fast.

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Q.2 (c) (ii) Define addressing modes of microprocessor system. State and explain addressing mode supported by 8085 microprocessor.

[6 marks]

Addressing mode is a way by which operands are specefied in an enstruction.

For example mov B, A

Addressing mode:- Register

In 8085 μp, there are 5 addressing mode

(i) Register addressing mode:- Operands are in the registers.

Eg.- mov B, A

(ii) Direct addressing mode:- The memory address of operand is specified. ex.- LDA 2000 H

(iii) Indirect addressing mode:- The address of operand is pointed by internal registers. mov A, M

(iv) Immediate addressing mode:- The operand itself is provided.

MVI A, 20 H

(v) Implied addressing mode- operations which by default assume Acc. is operand. eg.- RAL

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Q.3 (a) **(i)** Determine whether each of the following systems are linear, time invariant and static :

(a) $y(t) = x(\cos 3t)$

(b) $y(t) = (t^2 - 1)x(t)$

[6 + 6 = 12 marks]

(a) $y(t) = x(\cos 3t)$

A linear system must obey principle of superposition and principle of homogenity.

Superposition :-

$x_1(t) \longrightarrow \boxed{T} \xrightarrow{y_1(t)} x_1(\cos 3t)$

$x_2(t) \longrightarrow \boxed{T} \xrightarrow{y_2(t)} x_2(\cos 3t)$

$x_1(t) + x_2(t) \longrightarrow \boxed{T} \xrightarrow{y_n(t)} x_1(\cos 3t) + x_2(\cos 3t)$

$y_n(t) = y_1(t) + y_2(t)$ (true)

Homogenity :- $x_1(t) \longrightarrow \boxed{T} \longrightarrow y(t) = x(\cos 3t)$

$Kx(t) \longrightarrow \boxed{T} \longrightarrow y_n(t) = Kx(\cos 3t)$

$\Rightarrow y_n(t) = K\,y(t)$ (obey)

System (a) is linear.

System (a) is time-variant as delayed input $x(t-\tau)$ produces $x(\cos 3t - \tau)$ which is not equal to delayed output $x(\cos 3(t-\tau))$.

System (a) is dynamic since, as ~~o~~ output

$\underline{y(1)} = x(3\times) = \underbrace{x(-1)}_{past}$

depends on past inputs.

(b)

$y(t) = (t^2-1)\,x(t)$

Linearity :–

$y_1(t) + y_2(t) = y_n(t)$

$\Rightarrow (t^2-1)\,x_1(t) + (t^2-1)\,x_2(t) = (t^2-1)\left[x_1(t) + x_2(t)\right]$ (true)

Similarly homogenity also holds.

System is linear.

System is time variant as

$x(t-\tau) \longrightarrow \boxed{T} \longrightarrow y(t) = (t^2-1)\,x(t-\tau)$

$y_d(t) = \left((t-\tau)^2 - 1\right)x(t-\tau)$

$y(t) \neq y_d(t)$ [time-variant]

System is static, since y(t) depends x(t) or present o/p depends on present i/p only.

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Good Approach

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Q.3 (a) (ii) Compute $x_1(n) * x_2(n)$ using matrix approach, if $x_1(n) = \delta(n) + \delta(n-1) - \delta(n-2) - \delta(n-3)$ and $x_2(n) = \delta(n) - \delta(n-2) + \delta(n-4)$. (Assume $N = 5$). (* represents circular convolution).

[8 marks]

We have,

$$x_1(n) = \delta(n) + \delta(n-1) - \delta(n-2) - \delta(n-3)$$

$$= \left[\underset{\uparrow}{1}, 1, -1, -1, 0\right]$$

Similarly,

$$x_2(n) = \left[\underset{\uparrow}{1}, 0, -1, 0, 1\right]$$

The matrix convolution of $x_1(n)$ and $x_2(n)$ can be found by the following multiplication

$$x_1(n) * x_2(n) = \begin{bmatrix} 1 & 1 & -1 & -1 & 0 \end{bmatrix} \begin{bmatrix} 1 & 0 & -1 & 0 & 1 \\ 1 & 1 & 0 & -1 & 0 \\ 0 & 1 & 1 & 0 & -1 \\ -1 & 0 & 1 & 1 & 0 \\ 0 & -1 & 0 & 1 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 3 & 0 & -3 & -2 & 2 \end{bmatrix}$$

verifying:—

$$y(n) = x_1(n) * x_2(n) = \sum_{k=0}^{4} x_1(k)\, x_2(n-k)$$

$$= \cancel{x_1(0)}^{1} x_2(n) + \cancel{x_1(1)}^{1} x_2(n-1) + \cancel{x_1(2)}^{-1} x_2(n-2)$$

$$+ \cancel{x_1(3)}^{-1} x_2(n-3) + x_1(4)\, x_2(n-4)$$

$$= x_2(n) + x_2(n-1) - x_2(n-2) - x_2(n-3)$$

$$y(0) = x_2(0) + x_2(-1) - x_2(-2) - x_2(-3)$$

$$= x_2(0) + x_2(4) - x_2(3) - x_2(2)$$

$$= 1 + 1 - (-1) - 0$$

$$= 3$$

$$y(1) = x_2(1) + x_2(0) - x_2(-1) - x_2(-2)$$

$$= x_2(1) + x_2(0) - x_2(4) - x_2(3)$$

$$= 0 + 1 - 1 - 0 = 0$$

we can verify further.

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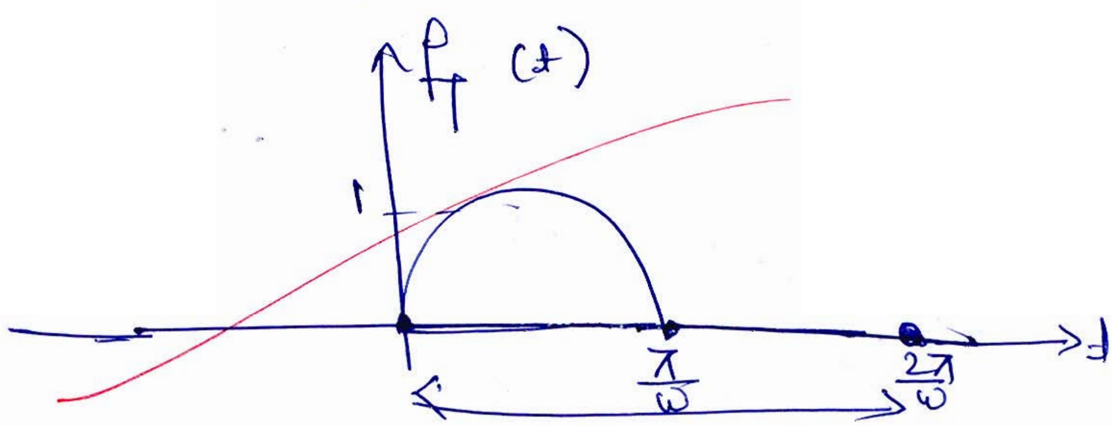
Q.3 (b) (i) Consider the continuous time signal

$$f(t) = \begin{cases} \sin \omega t; & 0 < t < \dfrac{\pi}{\omega} \\ 0; & \dfrac{\pi}{\omega} < t < \dfrac{2\pi}{\omega} \end{cases}$$

Also, $f\left(t + \dfrac{2\pi}{\omega}\right) = f(t)$, then find the Laplace transform of $f(t)$.

[12 marks]

Since f(t) is periodic out of which one period is



we can write, $T = 2\pi/\omega$

$$f(t) = f_T(t) + f_T(t-T) + f_T(t-2T) + \cdots$$

assuming f(t) is right sided signal

using time shifting property,

$$F(s) = F_T(s) + e^{-Ts} F_T(s) + e^{-2Ts} F_T(s)$$

$$= \frac{F_T(s)}{1 - e^{-Ts}}$$

where $F_T(s) = \int_0^{\pi/\omega} \sin \omega t \, e^{-st} \, dt$

$$= \left[\frac{e^{-st}}{s^2+\omega^2} \left(-s \sin\omega t - \omega \cos\omega t \right) \right]_0^{\pi/\omega}$$

$$= \frac{e^{-\frac{s\pi}{\omega}}}{s^2+\omega^2} \cdot \left(-\omega \cos\pi \right) - \frac{1}{s^2+\omega^2} \left(-\omega \right)$$

$$= \frac{\omega \left(1 - e^{-\frac{s\pi}{\omega}} \right)}{s^2+\omega^2}$$

Thus $F(s) = \dfrac{F_T(s)}{1 - e^{-\frac{2s\pi}{\omega}}}$

$$= \frac{\omega \left(1 - e^{-\frac{s\pi}{\omega}} \right)}{(s^2+\omega^2)\left(1 - e^{-\frac{2s\pi}{\omega}} \right)}$$

$$= \frac{\omega}{(s^2+\omega^2)\left(1 + e^{-\frac{s\pi}{\omega}} \right)}$$

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Good Approach

Q.3 (b) (ii) Find $x(n)$ by using convolution property of z-transform for

$$X(z) = \frac{1}{1-\frac{1}{4}z^{-1}-\frac{1}{8}z^{-2}}$$

[8 marks]

$$X(z) = \frac{1}{1-\frac{1}{4}z^{-1}-\frac{1}{8}z^{-2}}$$

$$= \frac{1}{\left(1-\frac{1}{2}z^{-1}\right)\left(1+\frac{1}{4}z^{-1}\right)}$$

According to convolution property,

$$\underbrace{x_1(n) * x_2(n)}_{x(n)} \overset{ZT}{\Longleftrightarrow} \underbrace{X_1(z)}_{\frac{1}{1-\frac{1}{2}z^{-1}}} \underbrace{X_2(z)}_{\frac{1}{1+\frac{1}{4}z^{-1}}}$$

$$\frac{1}{1-\frac{1}{2}z^{-1}} \overset{IZT}{\Longleftrightarrow} x_1(n) = \left(\frac{1}{2}\right)^n u(n)$$

$$\frac{1}{1+\frac{1}{4}z^{-1}} \overset{IZT}{\Longleftrightarrow} x_2(n) = \left(\frac{-1}{4}\right)^n u(n)$$

using convolution,

$$x(n) = \left(\frac{1}{2}\right)^n u(n) * \left(\frac{-1}{4}\right)^n u(n)$$

$$= \sum_{K=-\infty}^{\infty} \left(\frac{1}{2}\right)^K u(K) \left(\frac{-1}{4}\right)^{n-K} u(n-K)$$

$$= \sum_{k=0}^{\infty} \left(\frac{1}{2}\right)^{k} \left(-\frac{1}{4}\right)^{-k} \left(-\frac{1}{4}\right)^{n} u(n-k)$$

$$= \sum_{k=0}^{\infty} \left(-2\right)^{k} \left(-\frac{1}{4}\right)^{n} u(n-k)$$

$$= \begin{cases} 0 & n < 0 \\ \sum_{k=0}^{n} \left(-2\right)^{k} \left(-\frac{1}{4}\right)^{n} & n \geq 0 \end{cases}$$

$$= \begin{cases} 0 & n < 0 \\ \left(-\frac{1}{4}\right)^{n} \dfrac{1-\left(-2\right)^{n+1}}{1-\left(-2\right)} & n \geq 0 \end{cases}$$

Try to avoid

8

$$= \begin{cases} 0 & n < 0 \\ \left(-\frac{1}{4}\right)^{n} \cdot \dfrac{1-\left(-2\right)^{n+1}}{3} & n \geq 0 \end{cases}$$

$$\begin{cases} 0 & n < 0 \\ \dfrac{\left(-\frac{1}{4}\right)^{n} - \left(-\frac{1}{4}\right)^{n}\left(-2\right)^{n+1}}{3} & n \geq 0 \end{cases} = \frac{\left(-\frac{1}{4}\right)^{n} u(n)}{3} + \frac{2\left(\frac{1}{2}\right)^{n}}{3}$$

$=$

Q.3 (c) (i) Calculate the time delay in the 8085 assembly language program given below. The system has a clock period of 0.5 μs.

```
        MVI   B, 00H
NEXT  : DCR   B
        MVI   C, 11H
DELAY : DCR   C
        JNZ   DELAY
        MOV   A, B
        OUT   PORT
        HLT
```

[10 marks]

Consider the table,

Ins.	T-State	no of execu.	Total T State
MVI B,00 H	7	1	7
DCR B	4	1	4
MVI C, 11H	7	1	7
DCR C	4	17	68
JNZ	10	16	160
	7	1	7
MOV A,B	4	1	4
OUT PORT	7	1	1
HLT	5	1	5

Total T Stat Σ = ~~263~~ T

For a clock period of ~~0.5 μsec~~

or $T = 0.5\ \mu sec$,

Total delay in $\mu sec = 263T$

$= 263 \times 0.5$

$= 131.5\ \mu sec.$

The instruction flow is,

```
      MVI  B, 004
NEXT: DCR  B
DELAY: MVI C, 11H
      DCR  C
      JNZ  DELAY
      MOV  A, B
      OUT  PORT
      HLT
```

5

Do not write in this margin

Q.3 (c) (ii) Consider the cascade of the following two systems S_1 and S_2 as shown in figure.

$$x(n) \longrightarrow \boxed{S_1} \xrightarrow{w(n)} \boxed{S_2} \longrightarrow y(n)$$

where, System, S_1 : Causal LTI with the difference equation as below:

$$w(n) = \frac{1}{2}w(n-1) + x(n)$$

System, S_2 : Causal LTI with the difference equation as below:

$$y(n) = \alpha y(n-1) + \beta w(n)$$

If the difference equation relating $x(n)$ and $y(n)$ is

$$y(n) = \frac{-1}{8}y(n-2) + \frac{3}{4}y(n-1) + x(n)$$

Determine α and β. **[10 marks]**

In DTFT domain or frequency domain

$$X(e^{j\Omega}) \longrightarrow \underset{H_1(e^{j\Omega})}{\boxed{S_1}} \xrightarrow{W(e^{j\Omega})} \underset{H_2(e^{j\Omega})}{\boxed{S_2}} \longrightarrow Y(e^{j\Omega})$$

we have for S_1

$$w(n) = \frac{1}{2} w(n-1) + x(n)$$

Taking DTFT

$$W(e^{j\Omega}) = \frac{1}{2} e^{-j\Omega} W(e^{j\Omega}) + X(e^{j\Omega})$$

Thus, $$H_1(e^{j\Omega}) = \frac{W(e^{j\Omega})}{X(e^{j\Omega})} = \frac{1}{1 - \frac{1}{2}e^{-j\Omega}}$$

Similarly for S_2:-

$$y(n) = \alpha y(n-1) + \beta w(n)$$

$$H_2(e^{j\Omega}) = \frac{Y(e^{j\Omega})}{W(e^{j\Omega})} = \frac{\beta}{1 - \alpha e^{-j\Omega}}$$

For the Cascaded system

$$x(n) \longrightarrow \boxed{H(e^{j\Omega})} \longrightarrow y(n)$$

$$y(n) = -\frac{1}{8}\, y(n-2) + \frac{3}{4}\, y(n-1) + x(n)$$

$$Y(e^{j\Omega}) = -\frac{1}{8} e^{-j2\Omega}\, Y(e^{j\Omega}) + \frac{3}{4} e^{-j\Omega}\, Y(e^{j\Omega}) + X(e^{j\Omega})$$

$$H(e^{j\Omega}) = \frac{1}{1 + \frac{1}{8} e^{-j2\Omega} \cancel{+} - \frac{3}{4} e^{-j\Omega}}$$

$$\Rightarrow H_1(e^{j\Omega})\, H_2(e^{j\Omega}) = \frac{1}{1 - \frac{3}{4} e^{-j\Omega} + \frac{1}{8} e^{-j2\Omega}}$$

$$\Rightarrow \frac{1}{1 - \frac{1}{2} e^{-j\Omega}} \cdot \frac{\beta}{1 - \alpha e^{-j\Omega}} = \frac{1}{1 - \frac{3}{4} e^{-j\Omega} + \frac{1}{8} e^{-j2\Omega}}$$

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$$\Rightarrow \frac{\beta}{1 - \left(\frac{1}{2} + \alpha\right) e^{-j\Omega} + \frac{\alpha}{2} e^{-j2\Omega}} = \frac{1}{1 - \frac{3}{4} e^{-j\Omega} + \frac{1}{8} e^{-j2\Omega}}$$

Good Approach

Comparing

$$\frac{1}{2} + \alpha = \frac{3}{4} \Longrightarrow \boxed{\alpha = \frac{1}{4} \text{ and } \beta = 1}$$

$$\frac{\alpha}{2} = \frac{1}{8}$$

Q.4 (a) (i) Draw direct form-I and direct form-II block diagram for the given transfer function.

$$H(z) = \frac{z^2 - 2z + 4}{\left(z - \frac{1}{2}\right)(2z^2 + z + 1)}$$

(ii) Draw the cascade-form block diagram for the given transfer function using minimum delay elements.

$$H(z) = \frac{z - 1}{(4z^3 + 2z^2 + 2z + 3)}$$

[12 + 8 marks]

Q.4 (b) (i) Multiply the 8-bit unsigned number in memory location 4480H by the 8-bit unsigned number in memory location 4481H.

By shift-add routine method and the store the 8 least significant bits of the result in memory location 5500H and 8 most significant bits in memory location 5501H. Write comments in selected instruction.

[14 marks]

Q.4 (b) **(ii)** The following diagnostic routine can be used to troubleshoot the interfacing circuit of an input port :

Instruction	Byte	T-states	Machine Cycle M_1 M_2 M_3
START : IN24H	2	10(4, 3, 3)	
JMP START	3	10(4, 3, 3)	

1. Identify the machine cycles.
2. If the system clock is 6 MHz, calculate the time required to execute the routine.

[6 marks]

Q.4 (c) (i) Explain the mathematical function that is performed by the following instructions of 8085 processor and find the status of PSW at the end of the program.

LXI H, 2050H

MVI A, 22H

INR A

STA 2050H

INR A

XRA M

HLT

[14 marks]

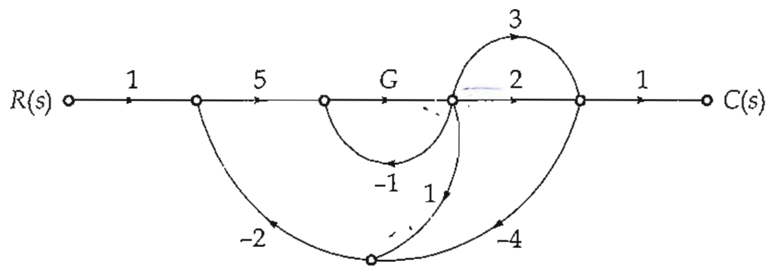
Q.4 (c) **(ii)** Explain the following in terms of direct memory access (DMA)

1. Cycle Stealing DMA
2. Interleaved DMA
3. Block Transfer DMA

[6 marks]

Section B : Electrical Circuits - 1 + Control Systems - 1

Q.5 (a) Consider the signal flow graph shown below :



Determine the value of gain G if the overall transfer function is given by $\frac{13}{17}$.

[12 marks]

For mason' gain formula,

No of forward path:-

$P_1: 1 \times 5 \times G \times 2 \times 1 = 10G$

$P_2: 1 \times 5 \times G \times 3 \times 1 = 15G$

No of loops:-

$L_1: G \times -1 = -G.$

$L_2 = 5 \times G \times 2 \times -4 \times -2 = 80G$

$L_3 = 5 \times G \times 1 \times -2 = -10G$

$L_4 = 5 \times G \times 3 \times -4 \times -2 = 120G$

No of two non-touching loops = 0 or more

using mason's gain formula,

$$\frac{C}{R} = \frac{\Sigma P_i \Delta_i}{\Delta}$$

where

$$\Delta = 1 - L_1 - L_2 - L_3 - L_4$$

$$= 1 + G - 80G + 10G - 120G$$

$$= 1 - 189G$$

$\Delta_1 = 1$ and $\Delta_2 = 1$

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$$\frac{C}{R} = \frac{10G \times 1 + 15G \times 1}{1 - 189G}$$

Good approach

$$\frac{13}{17} = \frac{25G}{1-189G}$$

$$\Rightarrow 13(1-189G) = 25G \times 17$$

$$\Rightarrow 13 - 13 \times 189G = 25G \times 17$$

$$\Rightarrow G = \frac{13}{25 \times 17 + 13 \times 189} = \frac{13}{2882} = 4.51 \times 10^{-3}$$

Do not write in this margin

Q.5 (b) Using the Routh criterion, check whether the system represented by the following characteristic equation is stable or not. Comment on the location of the roots. Determine the frequency of sustained oscillations if any.

$$s^4 + 2s^3 + 6s^2 + 8s + 8 = 0$$

[12 marks]

Forming the Routh Table

s^4	1	6	8
s^3	2	8	0
s^2	$\frac{2\times 6 - 1\times 8}{2} = 2$	8	0
s^1	0	0	0

Since s^1 row is completely zero indicating roots located symmetrically only about origin.

Auxiliary polynomial

$A(s) = 2s^2 + 8$ [using row s^2]

$\frac{dA}{ds} = 4s + 0$

Continuing the routh array

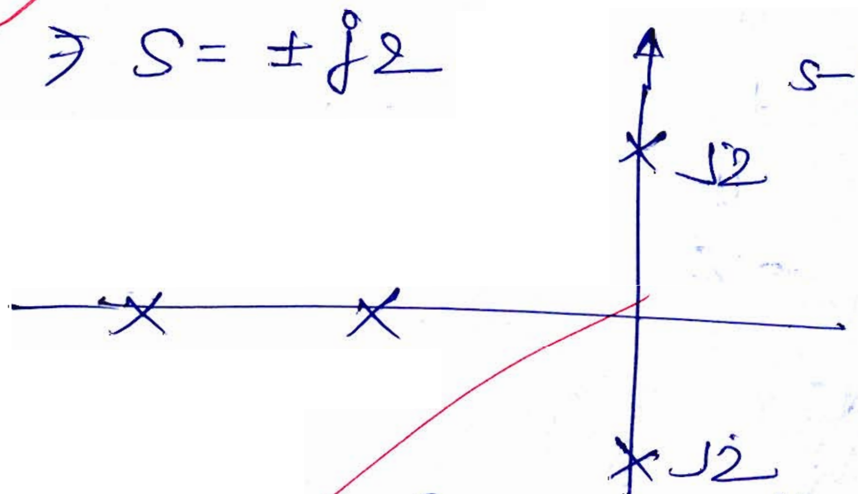
s^4	1	6	8
s^3	2	8	0
s^2	2	8	0
s^1	4	0	0
s^0	8	0	0

No change in sign so no roots lie in LHS.

For symmetrically located roots,

$2s^2 + 8 = 0$

$\Rightarrow s = \pm j2$



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Good Approach

The system is marginally stable

The frequency of oscillation $\omega = 2 \frac{rad}{sec}$.

2 roots on $j\omega$-axes and 2 roots on LHS

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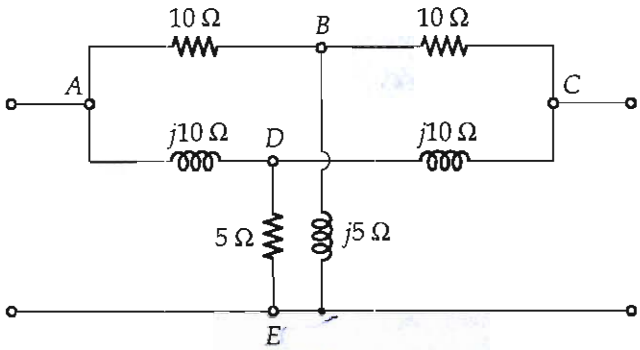
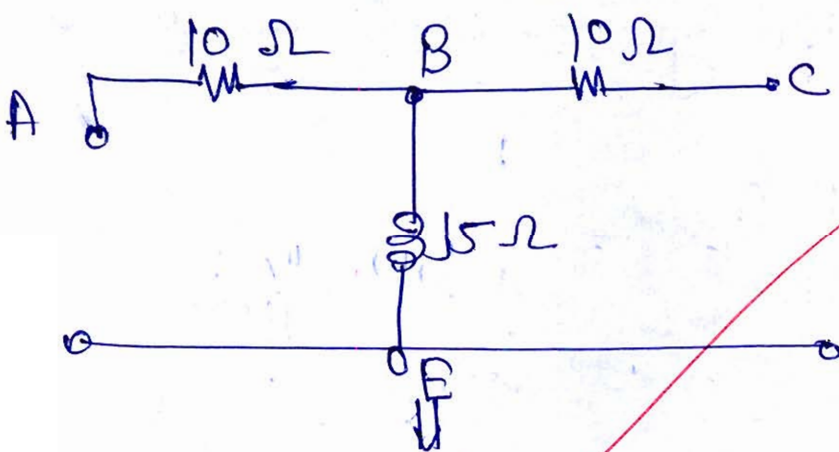
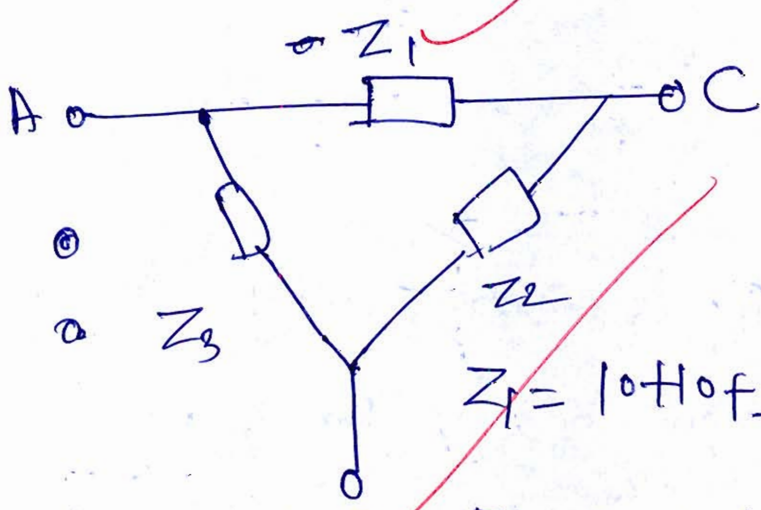
Q.5 (c) The network shown in figure consists of two star connected circuits in parallel. Obtain the single delta connected equivalent.



[12 marks]

Each Y can be converted into Δ as



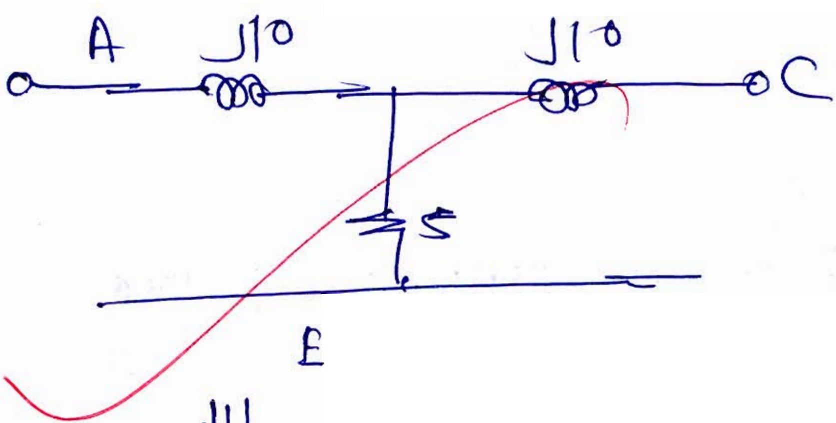


$$Z_1 = 10+10+\frac{10\times10}{j5} = 20-j20$$

$$Z_2 = 10+j5+\frac{10\times j5}{10} = 10+j10$$

$$Z_3 = 10+j5+\frac{10\times j5}{10} = 10+j10$$

For other Y network



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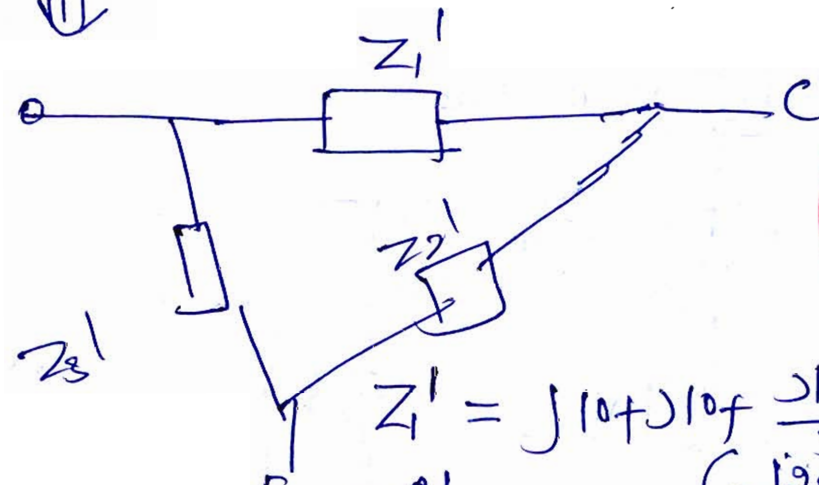


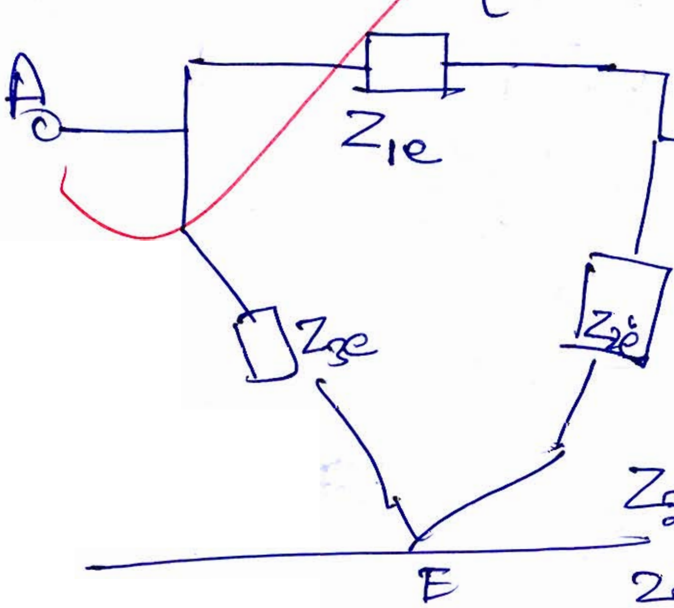
11

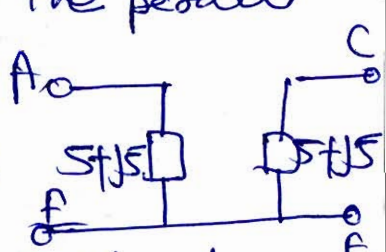
$Z_1' = j10 + j10 + \frac{j10 \times j10}{5} = (j20 - 20)\,\Omega$

$Z_2' = j10 + 5 + \frac{j10 \times 5}{j10} = j10 + 10\,\Omega$

$Z_3' = Z_2' = j10 + 10\,\Omega$

For single delta circuit of the parall





$Z_e = Z_1 \parallel Z_1'$

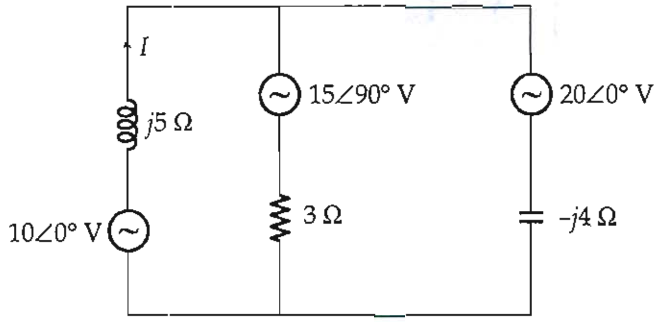
$= (20 - j20)(j20 - 20)$

$= \infty$ (open circuit)

$Z_{2e} = (10 + j10) \parallel (10 + j10) = 5 + j5$

$Z_{3e} = 5 + j5$

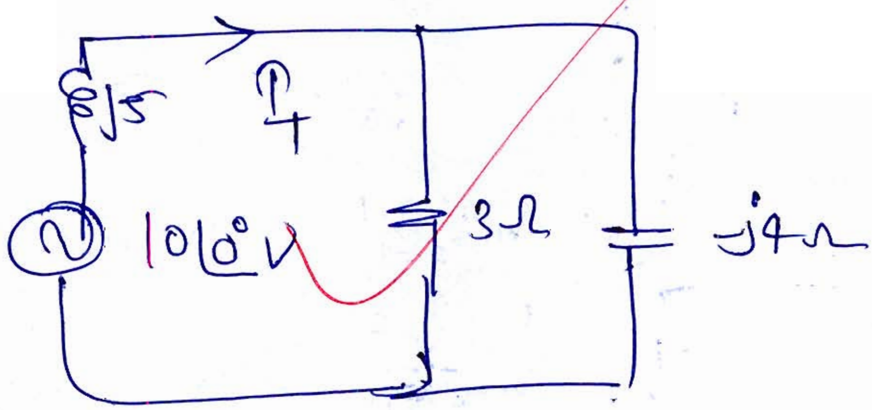
Q.5 (d) Find current I through $j5\ \Omega$ branch using superposition theorem for the netwrok shown in figure.



[12 marks]

In Superposition only one source acts at a time.

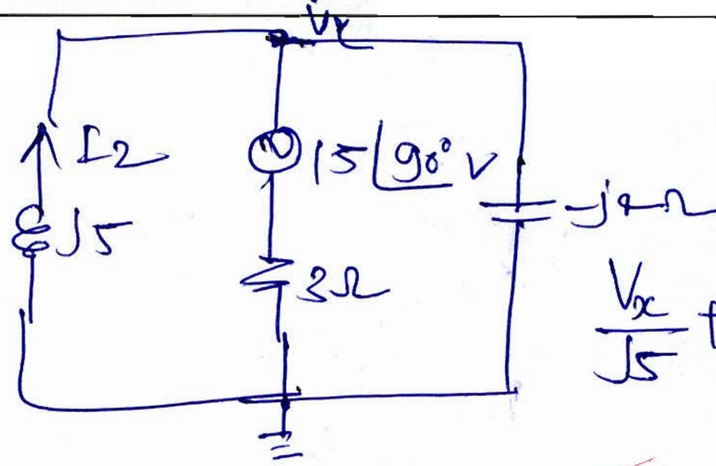
Let $10\angle 0^\circ$ V active —



$$I_1 = \frac{10\angle 0^\circ}{j5 + \left(\frac{3 \times -j4}{3 - j4}\right)}$$

$$= 2.9723\ \angle -61.66^\circ\ A$$

Let $15\angle 90^\circ$ V active :-



Applying KCL

$$\frac{V_x}{J5} + \frac{V_x - 15\angle 90^\circ}{3} + \frac{V_x}{-J4} = 0$$

$$V_x = \frac{\frac{15\angle 90^\circ}{3}}{\frac{1}{J5} + \frac{1}{3} + \frac{1}{-J4}} = 14.8390\angle 81.47^\circ \text{ V}$$

$$I_2 = -\frac{V_x}{J5} = 2.9668\angle 171.47^\circ \text{ A}$$

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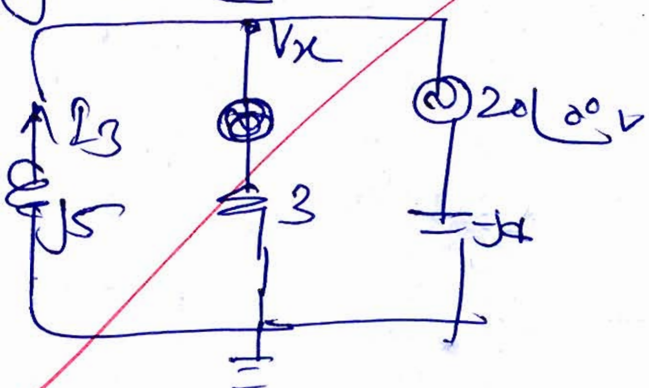
only $20\angle 0^\circ$ V active



$$V_x = \frac{\frac{20\angle 0^\circ}{-J4}}{\frac{1}{3} + \frac{1}{J5} + \frac{1}{-J4}}$$

$$= 14.834\angle 81.47^\circ$$

$$I_3 = -\frac{V_x}{J5} = 2.9668\angle 171.47^\circ \text{ V}$$

Good Approach

Thus $I = I_1 + I_2 + I_3$

$$= 2.4723\angle -61.66^\circ + 2.9668\angle 171.47^\circ + 2.9668\angle 171.47^\circ$$

$$= 4.87\angle -164.56^\circ \text{ A}$$

Q.5 (e) The open-loop transfer function of a unity feedback control system is given by

$$G(s) = \frac{K}{s(1+sT)}$$

(i) By what factor the amplifier gain K should be multiplied so that the damping ratio is increased from 0.2 to 0.8?

(ii) By what factor the time constant T should be multiplied so that the damping ratio is reduced from 0.9 to 0.3?

[12 marks]

$$\frac{C(s)}{R(s)} = \frac{G(s)}{1+G(s)} = \frac{\frac{K}{s(1+sT)}}{1+\frac{K}{s(1+sT)}} =$$

$$\frac{K}{Ts^2+s+K} = \frac{K/T}{s^2+s/T+K/T}$$

We set,

$$s^2 + 2\xi\omega_n s + \omega_n^2 = s^2 + s/T + K/T$$

$$\begin{cases} \omega_n^2 = \frac{K}{T} \Rightarrow \omega_n = \sqrt{\frac{K}{T}} \\ 2\xi\omega_n = \frac{1}{T} \Rightarrow \xi = \frac{1}{2}\sqrt{\frac{1}{TK}} \end{cases}$$

(i) Assuming K varies

$$\xi = \frac{1}{2\sqrt{TK}}$$

$$\Rightarrow K = \frac{1}{4\xi^2 T}$$

Do not write in this margin

If ξ increases, K decreas.

$$\frac{K_2}{K_1} = \left(\frac{\xi_1}{\xi_2}\right)^2 = \left(\frac{0.2}{0.8}\right)^2 = \frac{1}{16}$$

Thus when ξ increases from 0.2 to .8

$K_2 = \frac{K_1}{16}$ or K gets multplied by $\frac{1}{16}$.

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(ii) Assuming T varies:—

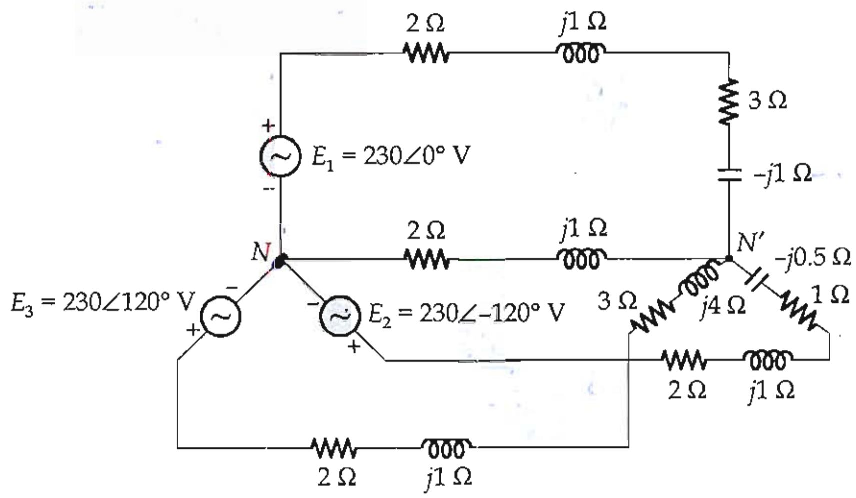
$$\xi = \frac{1}{2\sqrt{TK}} \Rightarrow T = \frac{1}{4\xi^2 K}$$

$$\Rightarrow \frac{T_2}{T_1} = \left(\frac{\xi_1}{\xi_2}\right)^2 = \left(\frac{0.9}{0.3}\right)^2 = 9$$

As ξ reduces from 0.9 to 0.3

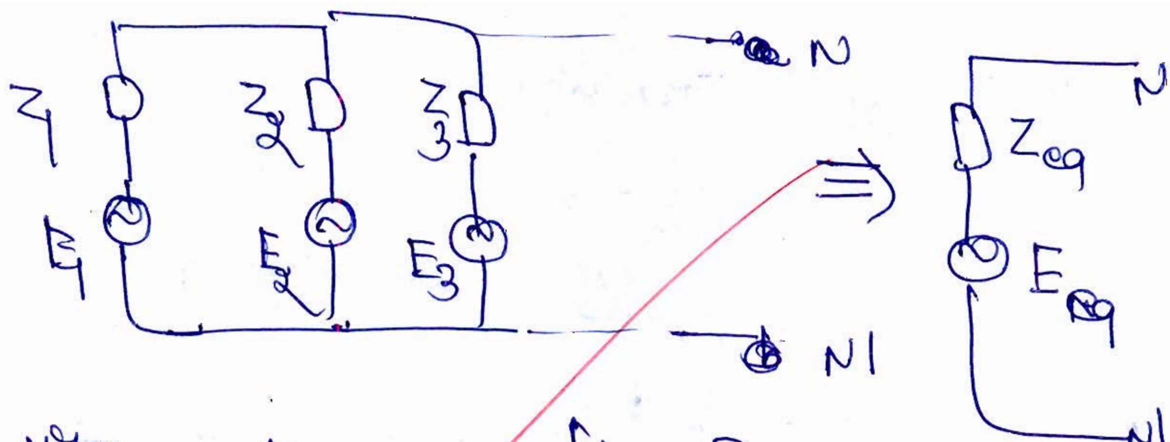
$T_2 = 9T_1$ or T should be multplied by 9.

Q.6 (a) The network shown in figure represents a three phase four wire electrical power system. Use Millman's theorem to determine the potential difference between the two neutral points N and N'.



[20 marks]

According to Millaman theorem,



Where, $E_{eq} = \dfrac{\dfrac{E_1}{Z_1} + \dfrac{E_2}{Z_2} + \cdots}{\dfrac{1}{Z_1} + \dfrac{1}{Z_2} + \dfrac{1}{Z_3} \cdots}$

and $\dfrac{1}{Z_{eq}} = \dfrac{1}{Z_1} + \dfrac{1}{Z_2} + \dfrac{1}{Z_3} \cdots$

we have, 3 branches between N and N'

Where $E_1 = 230\angle 0^\circ$

$E_2 = 230\angle -120^\circ$

$E_3 = 230\angle 120^\circ$

$Z_1 = 2+j+3-j = 5\ \Omega$

$Z_2 = 2+j+1-j0.5 = 3+j0.5\ \Omega$

$Z_3 = 2+j+3+j4 = 5+j5\ \Omega$

We have,

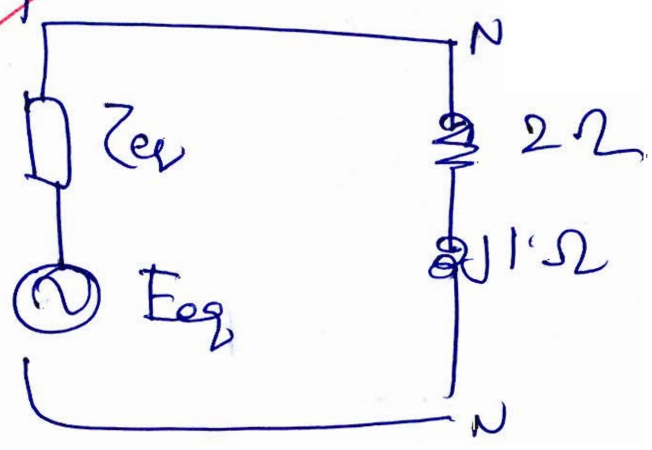
$$\frac{1}{Z_{eq}} = \frac{1}{5} + \frac{1}{3+j0.5} + \frac{1}{5+j5}$$

$$Z_{eq} = 1.555\angle 13.86^\circ\ \Omega$$

Thus,
$$E_{eq} = \frac{\dfrac{230\angle 0^\circ}{5} + \dfrac{230\angle -120}{3+j0.5} + \dfrac{230\angle 120}{5+j5}}{\dfrac{1}{5} + \dfrac{1}{3+j0.5} + \dfrac{1}{5+j5}}$$

$$= 43.083\angle -62.873^\circ\ V$$

The equivalent circuit across NN' is



using voltage division rule,

$$V_{NN1} = E_{eq} \times \frac{(2+j1)}{(2+j1) + Z_{eq}}$$

$$= 43.083 \angle -62.879^\circ \times \frac{2+j1}{(2+j1) + 1.555 \angle 13.8^\circ}$$

$$= 25.563 \angle -57.67^\circ \text{ V}$$

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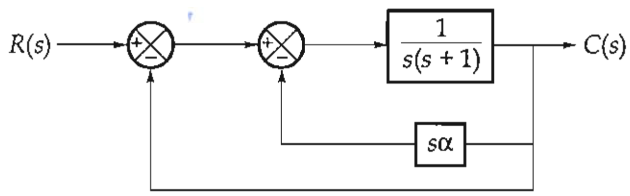
Q.6 (b) A control system is shown in the block diagram given below :



Sketch the root locus as the value of the parameter α is varied from 0 to ∞. Determine the value of α for the transient response to have critical damping.

[20 marks]

The inner loop has transfer function,

$$T_i(s) = \frac{\frac{1}{s(s+1)}}{1 + \frac{s\alpha}{s(s+1)}} = \frac{1}{s^2 + s + s\alpha}$$

$$= \frac{1}{s^2 + s + s\alpha}$$

The overall TF is

$$\frac{C(s)}{R(s)} = \frac{\frac{1}{s^2+s+s\alpha}}{1 + \frac{1}{s^2+s+s\alpha}} = \frac{1}{s^2 + s + s\alpha + 1}$$

$$q(s) = s^2 + s + 1 + s\alpha$$

$$= 1 + \left(\frac{s}{s^2+s+1}\right)\alpha$$

we get equivalent $G(s) = \frac{s}{s^2+s+1}$

No of zero, $Z = 1$ $\qquad Z = 0$

No of poles, $P = 2$ $\qquad P = -\frac{1}{2} \pm j\frac{\sqrt{3}}{2}$

$= -0.5 \pm j0.866$

Centroid :- $\frac{\Sigma p - \Sigma Z}{P - Z} = \frac{-\frac{1}{2} - \frac{1}{2} - 0}{2 - 1}$

$= -1$

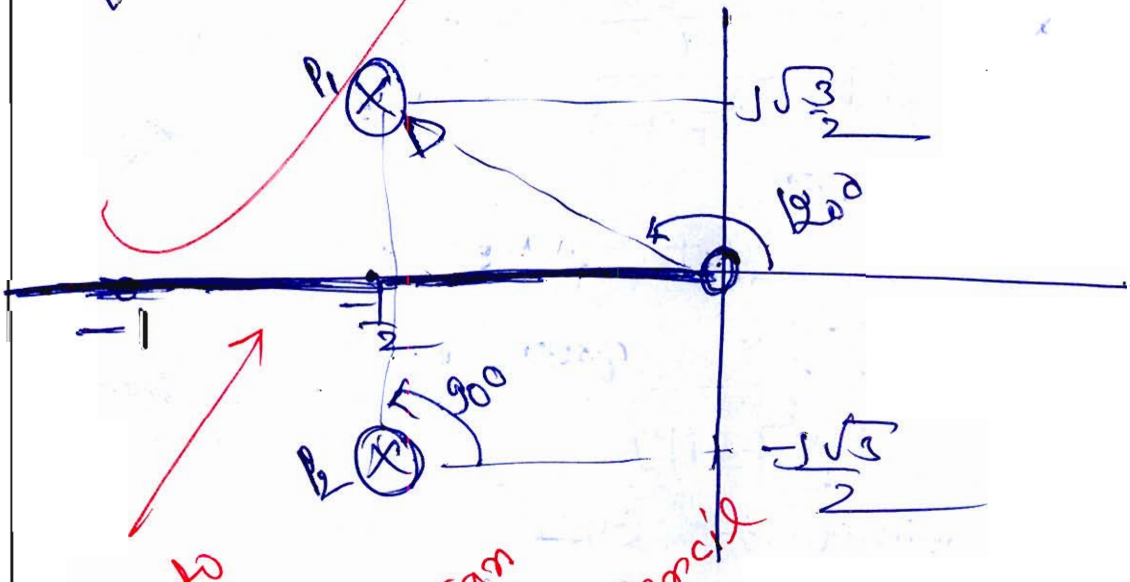
no of Asymptotes $= 1$

angle of asymptotes $= \frac{(2q+1)180^\circ}{P-Z}$

$= (2q+1)180^\circ$

$= \underline{180^\circ}$

Root locus on real axis :-



Try to avoid

you can use pencil

Angle of departure —

$$\theta_{p_1} = 180^\circ - \sum \theta_{p_2} + \sum \theta_z$$

$$= 180^\circ - 90^\circ + 120^\circ$$

$$= 210^\circ = -150^\circ$$

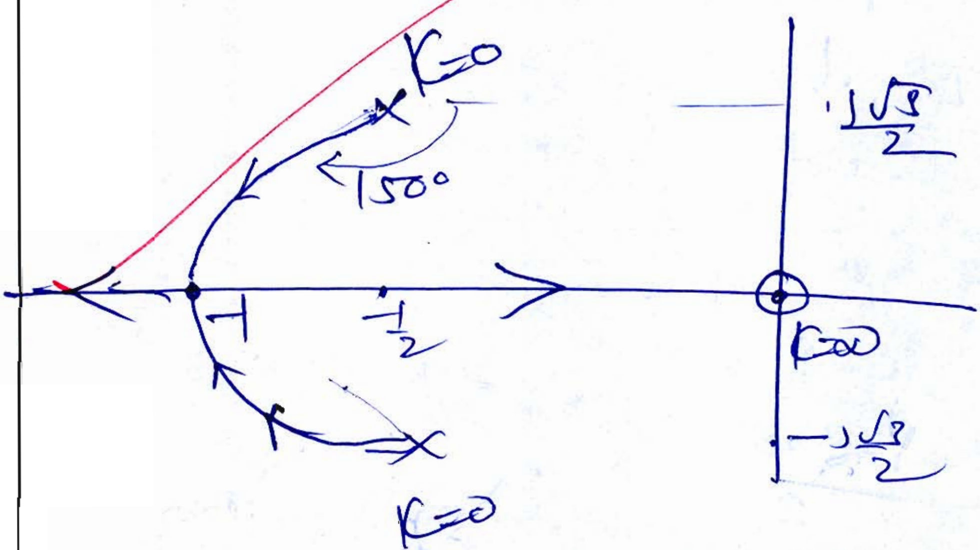
Breakaway point

$$K = -\frac{(s^2+s+1)}{s} \Rightarrow \frac{dK}{ds} = -\left[\frac{(2s+1)s - (s^2+s+1)}{s^2}\right]$$

$$\frac{dK}{ds} = 0 \Rightarrow s = -1$$

The complete root locus is,

18



For $s=-1$, the poles are repeated.
hence damping is critical.

$$K_{critical} = \left[-\frac{(s^2+s+1)}{s}\right]_{s=-1}$$

$$= 1$$

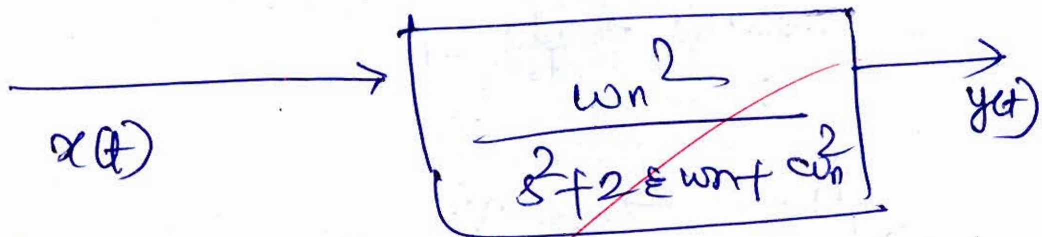
Q.6 (c) A unity feedback control system has an open-loop transfer function

$$G(s) = \frac{5}{s(s+1)}$$

Find the rise time, percentage overshoot, peak time and settling time for a step input of 10 units. Also, determine the peak overshoot.

[20 marks]

For Secondord order System.



$$t_p = \frac{\pi}{\omega_d}$$

$$t_r = \frac{\pi - \cos^{-1}\xi}{\omega_d}$$

$$M_p = e^{\frac{-\pi\xi}{\sqrt{1-\xi^2}}}$$

$$t_s = \begin{cases} \frac{4}{\xi\omega_n} & 2\% \text{ Criteria} \\ \frac{3}{\xi\omega_n} & 5\% \text{ criterion} \end{cases}$$

The closed loop transfer functiones

$$\frac{Y(s)}{X(s)} = \frac{G}{1+G} = \frac{\frac{5}{s(s+1)}}{1+\frac{5}{s(s+1)}}$$

$$= \frac{5}{s^2 + s + 5}$$

Comparing with $\frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$

$$\begin{cases} \omega_n^2 = 5 \\ 2\zeta\omega_n = 1 \end{cases} \Rightarrow \omega_n = 2.236 \text{ rad/sec}$$

$$\zeta = 0.2236$$

$\omega_d = \omega_n\sqrt{1-\zeta^2}$

Rise time $t_r = \frac{\pi - \cos^{-1}\zeta}{\omega_d}$

$$= \frac{\pi - \cos^{-1}\zeta}{\omega_n\sqrt{1-\zeta^2}}$$

$$= \frac{\pi - \cos^{-1} 0.2236}{2.236\sqrt{1-0.2236^2}}$$

$$= 0.8242 \text{ sec}$$

% overshoot, $M_p = e^{-\left(\frac{\pi\zeta}{\sqrt{1-\zeta^2}}\right)} \times 100$

$$= e^{-\left(\frac{\pi \times 0.2236}{\sqrt{1-0.2236^2}}\right)} \times 100$$

$$= 48.64\%$$

Peak time, $t_p = \frac{\pi}{\omega_d}$

$$= \frac{\pi}{\omega_n \sqrt{1-\xi^2}}$$

$$= \frac{\pi}{2.236 \times \sqrt{1-0.2236^2}}$$

$$= 1.4945 \text{ sec}$$

Settling time,

$$t_s = \begin{cases} \frac{4}{\xi \omega_n} & (2\%) \\ \frac{3}{\xi \omega_n} & (5\%) \end{cases}$$

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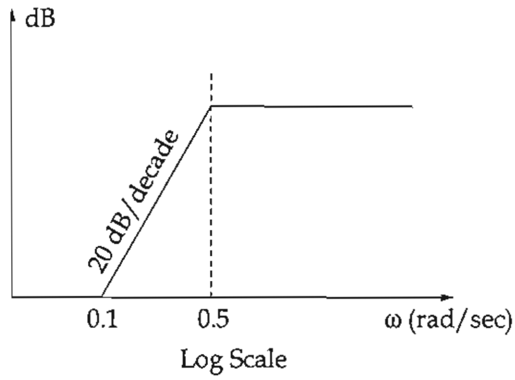
$$= \begin{cases} \frac{4}{2.236 \times 0.2236} & (2\%) \\ \frac{3}{2.236 \times 0.2236} & (5\%) \end{cases}$$

$$= \begin{cases} 8 \text{ sec} & (2\%) \\ 6 \text{ sec} & (5\%) \end{cases}$$

Good Approach

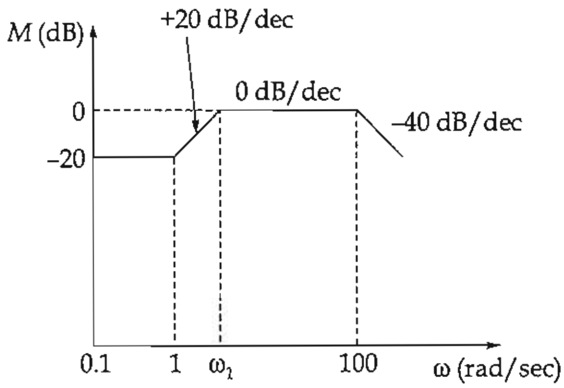
Q.7 (a) (i) The approximate Bode magnitude plot of a lead network with its pole and zero on the left half of the s-plane is shown in the following figure :



Find the frequency at which the phase angle of the network is maximum (in rad/sec).

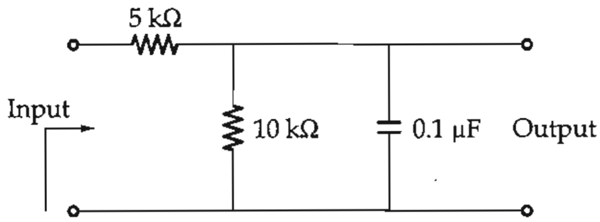
[10 marks]

Q.7 (a) **(ii)** Obtain the open loop transfer function for a system with unity feedback whose bode plot is shown below :



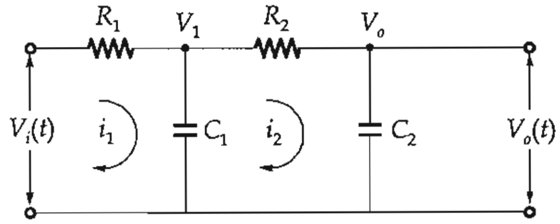
[10 marks]

Q.7 (b) (i) Draw the asymptotic magnitude and phase plot on the system shown below :



[10 marks]

Q.7 (b) (ii) Draw the block diagram for the circuit given in figure below :



[10 marks]

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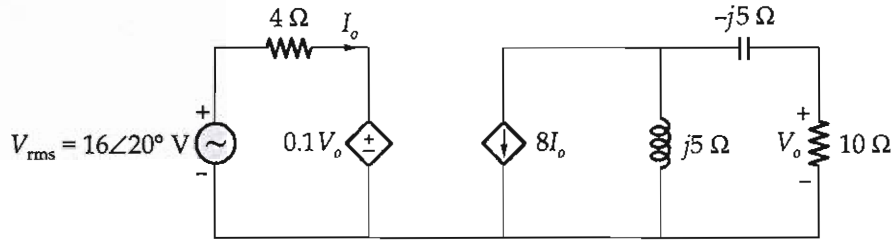
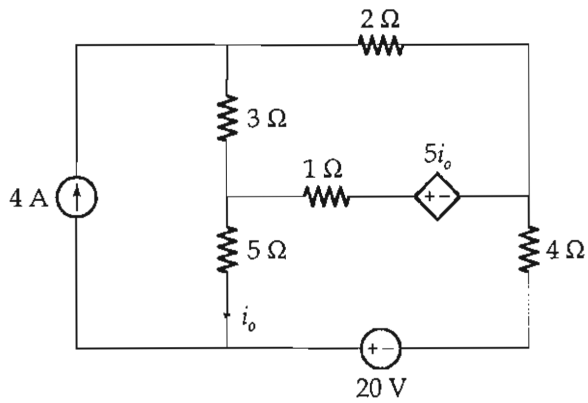
Q.7 (c) (i) For the circuit shown below, find the average power absorbed by the 10 Ω resistor



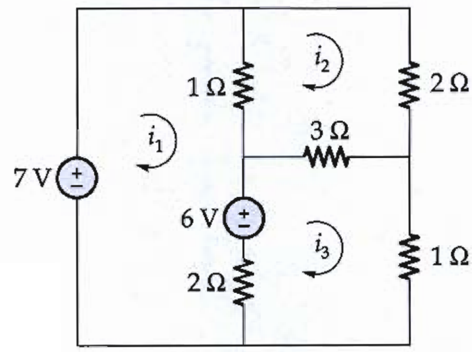
[10 marks]

Q.7 (c) **(ii)** Find the current i_o using super position theorem in the circuit shown below :

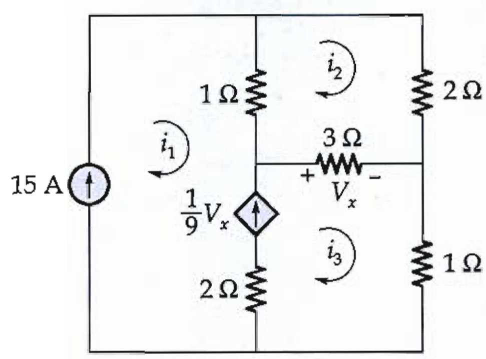


[10 marks]

Q.8 (a) **(i)** Use mesh analysis to determine mesh currents in the circuit



(ii) Use mesh analysis to determine mesh currents in the circuit



[10 + 10 = 20 marks]

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Q.8 (b) **(i)** The open-loop transfer function of a unity negative feedback system is given by

$$G(s) = \frac{K(s+1)^2}{(s+2)^2}$$

Without drawing root locus diagram, prove that the root locus (for $K > 0$) of the system lies on a circle.

(ii) The response of a feedback system to a unit step input is

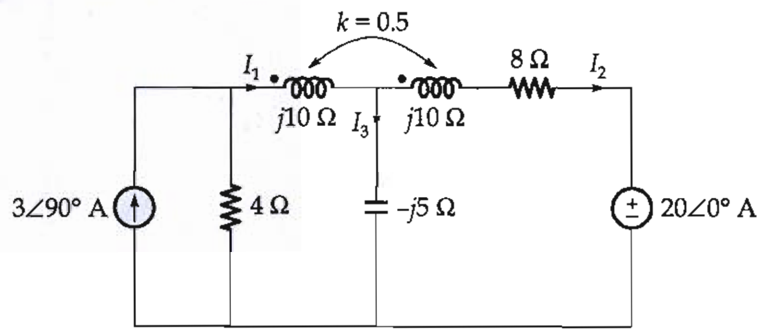
$$C(t) = 1 + 0.2e^{-60t} - 1.2e^{-10t}.$$

(a) Obtain the expression for the closed loop transfer function.

(b) Determine the undamped natural frequency and damping ratio of the system.

[10 + 10 = 20 marks]

Q.8 (c) Determine the current I_1, I_2 and I_3 in the circuit shown. Take $\omega = 1000$ rad/sec.



[20 marks]

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OOOO

Space for Rough Work

Space for Rough Work