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UPSC ENGINEERING SERVICES EXAMINATION

Electronics & Telecommunication Engineering

Test-2 : Signals and Systems + Microprocessors and Microcontroller [All topics]
Network Theory-1 + Control Systems-1 [Part Syllabus]

Name : ....

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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.
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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	189

Signature of Evaluator ....

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2. Do not write anything other than the actual answers to the questions anywhere inside your QCAB.
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Section A : Signals and Systems + Microprocessors and Microcontroller

Q.1 (a) Suppose the following facts are given about the signal $x(t)$ with Laplace transform $X(s)$:

1. $x(t)$ is real and even.
2. $X(s)$ has four poles and no zeros in the finite s-plane.
3. $X(s)$ has a pole at $s = \frac{1}{2}e^{j\frac{\pi}{4}}$.
4. $\int_{-\infty}^{\infty} x(t)dt = 4$

Determine $X(s)$.

[10 marks]

Sol ① x(t) is real,

Poles = 4 ; Z = 0 ;

$s_1 = \frac{1}{2}e^{j\frac{\pi}{4}}$; $s_2 = s_1^* = \frac{1}{2}e^{-j\frac{\pi}{4}}$

$s_3 = 2e^{j\frac{\pi}{4}}$, $s_4 = 2e^{-j\frac{\pi}{4}}$.

$$X(s) = X(s) = \frac{K}{(s+p_1)(s+p_2)(s+p_3)(s+p_4)}$$

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

$$= \frac{K}{\left(s^2 - \frac{j}{2}\right)\left(s^2 - 2j\right)}$$

$$\boxed{X(s) = \frac{K}{s^4+1}}$$

$x(0) = \int_0^\infty x(t)\,dt = 4$;

$X(s)\big|_{s=0} = \frac{k}{1} = 4$; $\boxed{k=4}$

$$\boxed{X(s) = \frac{4}{(s^4+1)}}$$

7

Q.1 (b) Describe the following instructions of 8085 microprocessor:
(i) SBI (ii) SHLD (iii) RRC (iv) SPHL (v) DAD
[10 marks]

(b) (i) SBI :- It is describe the Subtraction immediate data. It will be used in immediate addressing mode :

(ii) SHLD :- It is shift HL pair and DE pair Content in the instruction.

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(iii) RRC. It Shows Rotate Right Carry.

Ex: RRC: 04H

→ $\boxed{0000\ 0100}$ = 04H

RRC ⇒ . $\boxed{0000\ 0010}$ = 02H. } ⇒ div they can be used.

(iv) SPHL :- It will be interchange SP (Stack point) and HL pair Content.

(i) DAD: Decimal adjust Accumulator:

It will be used in BCD number

Eg: DAD A; (A) = 1AH   0001 1010

→ 110

20H ← 0010 0000

Q.1 (c) Let $g_1(t) = \{[\cos(\omega_0 t)]x(t)\} * h(t)$ and $g_2(t) = \{[\sin(\omega_0 t)]x(t)\} * h(t)$, where $x(t) = \sum_{k=-\infty}^{\infty} a_k e^{jk100t}$ is a real-valued periodic signal and h(t) is the impulse response of a stable LTI sytem.

Specify a value for ω_0 and any necessary constraints on $H(j\omega)$ to ensure that

$$g_1(t) = \text{Re}\{a_5\} \text{ and } g_2(t) = \text{Im}\{a_5\}$$

[10 marks]

$g_1(t) = \frac{e^{j\omega_0 t} + e^{-j\omega_0 t}}{2}$; $g_2(t) = \frac{e^{j\omega_0 t} - e^{-j\omega_0 t}}{2j}$

$a_0 = \frac{1}{2}$; $a_{-1} = \frac{1}{2}$; $a_1 = -\frac{1}{2j}$, $a_1 = \frac{1}{2j}$

$x(t) \longrightarrow a_k$:

$x(t) = \sum_{k=-\infty}^{\infty} a_k e^{jk\omega_0 t}$; $\boxed{\omega_0 = 100}$;

4

$a_5 = \frac{e^{j5\omega_0 t} + e^{-j5\omega_0 t}}{2}$;

$\text{Re}\{a_5\} = \frac{1}{2}$; $\text{Img}\{a_5\} = \frac{1}{2}$.

Q.1 (d) Design the control word to configure the ports of 8255 (programmable peripheral interface) chip in mode 0, with port B and port C upper (PC_U) as inputs and port A and port C lower (PC_L) as outputs.

[10 marks]

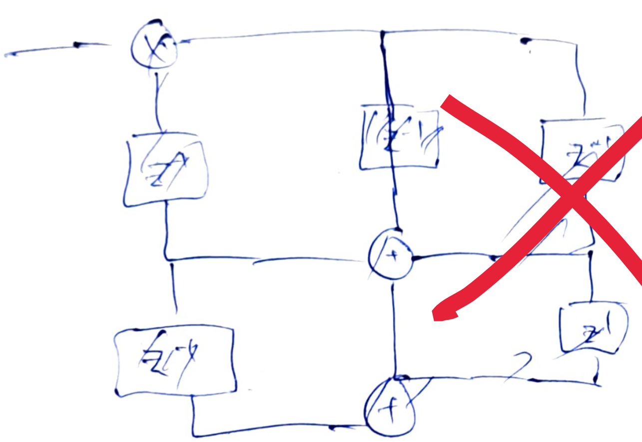
Q.1 (e) Consider the following transfer function of an IIR filter:

$$H(z) = \frac{0.28z^2 + 0.319z + 0.04}{0.5z^3 + 0.3z^2 + 0.17z - 0.2}$$

Realize this filter using direct form-I and direct form-II structures.

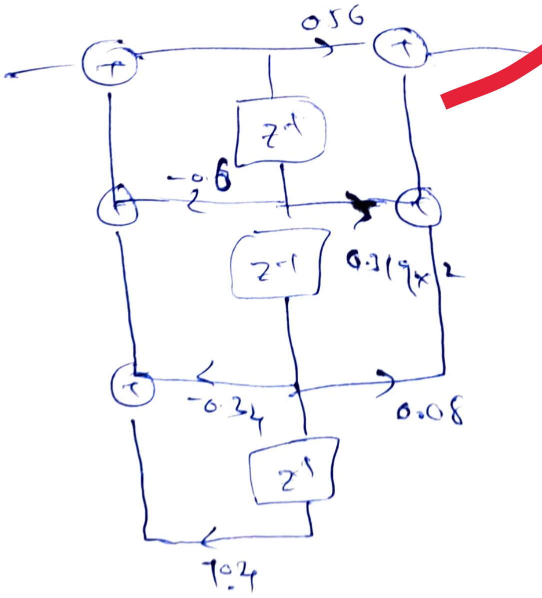
[10 marks]

D-I :



$H(z) = \frac{0.28 + 0.319z^{-1} + 0.04z^{-2}}{0.5 + 0.3z^{-1} + 0.17z^{-2} - 0.2z^{-3}} = \frac{0.28 + 0.319z^{-1} + 0.04z^{-2}}{0.5\left(1 - \frac{(-0.3z^{-1} + 0.17z^{-2} + 0.2z^{-3})}{0.5}\right)}$

D-II :



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D-II

Q.1 (f) It is required to move a block of 16-byte long data string from offset 4000 H to offset 5000 H. Write assembly language program to accomplish the above task for both 8085 and 8086 microprocessors. Assume that the block size is 10 and segment addresses are pre-initialized in case of 8086 microprocessor.

[10 marks]

Q.2 (a) Find the Fourier transform for the following signals:

(i) $x_1(t) = e^{-|t|}\cos(2t)$

(ii) $x_2(t) = \dfrac{\sin(2\pi t)}{\pi(t-1)}$

(iii) $x_3(t) = \begin{cases} t^2 \; ; \; 0 < t < 1 \\ 0 \; ; \; \text{otherwise} \end{cases}$

(iv) $x_4(t) = (1 - |t|)u(t+1)u(1-t)$

[20 marks]

Sol

① $x_1(t) = \underset{x(t)}{e^{-|t|}}\ \underset{h(t)}{\cos 2t}$

$x_1 = x(t) \cdot h(t) = (X(\omega) * H(\omega))\frac{1}{2\pi}$

$X(\omega) = F\{e^{-a|t|}\} = \frac{2a}{a^2+\omega^2}$

$= \{e^{-|t|}\} = \frac{2}{1+\omega^2}$

$h(t) = \cos 2t$

$h(\omega) = \pi(\delta(\omega-2) + \delta(\omega+2)]$

$H(\omega) = \pi[\delta(\omega-2) + \delta(\omega+2)]$

$x_1(\omega) = \frac{1}{2\cancel{\pi}}\left[\cancel{2\pi}\left(\frac{1}{1+\omega^2}\right) * [\delta(\omega-2) + \delta(\omega+2]\right]$

$= [\delta(\omega-2) + \delta(\omega+2)] * \frac{1}{1+\omega^2}$

$= \frac{1}{5}\delta(\omega-2) + \frac{1}{5}\delta(\omega+2)$

$\boxed{x_1(\omega) = \frac{1}{5}[\delta(\omega-2) + \delta(\omega+2)}$

(g)

$$x_2(t) = \frac{\sin 2\pi t}{\pi(t-1)}$$

$t-1 = t'$

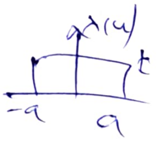
$t = t'-1$

$$x_2(t') = \frac{\sin 2\pi(t'-1)}{\pi t'} = \frac{\sin 2\pi(t'-1)}{\pi t'}$$

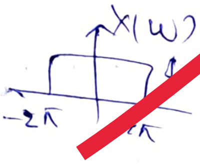
$$= \frac{\sin(2\pi t - 2\pi)}{\pi t} = \frac{-\sin(360-2\pi t)}{\pi t}$$

$$x_2(t) = \frac{\sin 2\pi t}{\pi t} \quad (\sin(360-\theta^\circ = -\sin\theta^\circ)$$

$$\frac{\sin at}{\pi t} \longrightarrow$$



$$\frac{\sin 2\pi t}{\pi t} \longrightarrow$$



$$X(\omega) \Rightarrow \Rightarrow \text{rect}\left(\frac{\omega}{4\pi}\right)$$

(h)

$$x_3 = \{ t^2 \quad 0<t<1$$

$$X(\omega) = \int_{-\infty}^{\infty} x(t) e^{-j\omega t} dt$$

$$X_3(\omega) = \int_0^1 t^2 e^{-j\omega t} dt$$

$$\Rightarrow \int t^2 e^{-j\omega t}$$

$$= t^2 \frac{e^{-j\omega t}}{-j\omega}\Big|_0^1 - \int 2t \frac{e^{-j\omega t}}{\omega^2}$$

$$= t^2 \frac{e^{-j\omega t}}{-j\omega}\Big|_0^1 - \frac{2}{\omega^2}\left[t\frac{e^{-j\omega t}}{-j\omega} - \frac{e^{-j\omega t}}{\omega^2}\right]\Big|_0^1$$

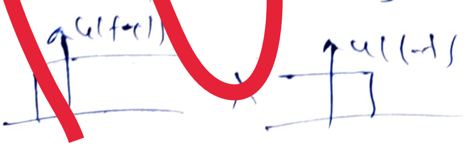
$$= \frac{e^{-j\omega}}{-j\omega} - \frac{2}{\omega^2}\left[\frac{e^{-j\omega}}{-j\omega} - \frac{e^{-j\omega}}{\omega^2} + \frac{1}{\omega^2}\right].$$

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

① k_4 $(1-(t+1))\,u(t+1)\,u(1-t) = [1-(t+1)]\,[u(t - u(t-1)]$

$x_1(t) = (1-(t+1))\,u(t+1) - u(t+1) - t\,u(t+1)$

$x_2(t) = u(1-t) = -\frac{1}{s^2}$



$\Rightarrow u(t+1) - u(t-1)$

$=$

$$|X_1(s)| =$$

$$A\,\mathrm{rect}\left(\frac{t}{T}\right) = ([1-(t+1)]\,u(t) - u(t+1)) = X(s) \Rightarrow \boxed{1\,Sa^2\left(\frac{\omega T}{2}\right)}$$

Q.2 (b) Explain the following Data Transfer Schemes:

(i) Programmed data transfer schemes.

(ii) DMA data transfer scheme.

[20 marks]

Sol: (ii) DMA:

⇒ It is used to transfer the Data directly from the i/p (or) o/p to without interfering (or) interrupt u/p. The huge amount of Data is transferred blw the o/p of device to seq m/m controller.

⇒ There are 3-techniq (or) types: modes)

(i) Short Burst mode

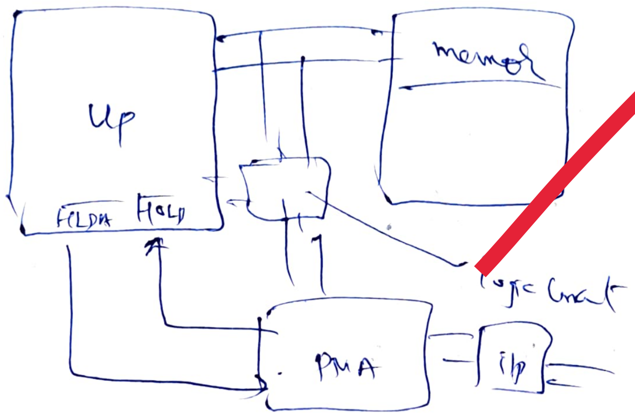
(ii) Cycle Stealing technique

(iii) interleaved technique

(i) Short Burst: The once the start the cpu' for its operation it will flow the until it ends.

(ii) Cycle Stealing Mode: In the bunch of tehnique it will be transferred to huge data

(1i) interleaved technique : when the µP programmer perform internal operation, : In that time it will be executed. : HOLD , HLDA are the pins for the DMA: control operation to perform on up.



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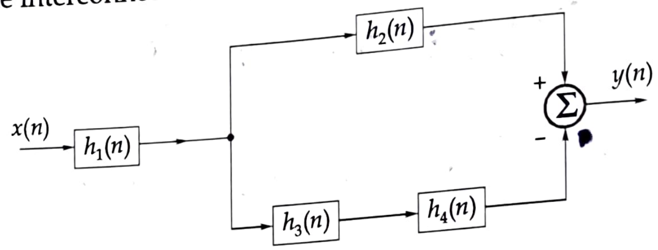
Q.2 (c) Consider the interconnection of LTI systems shown in the figure below:



$$h_1(n) = \left\{\underset{\uparrow}{\frac{1}{2}}, \frac{1}{4}, \frac{1}{2}\right\},\ h_2(n) = h_3(n) = (n+1)\,u(n) \text{ and } h_4(n) = \delta(n-2)$$

Determine the response of the system, if $x(n) = \delta(n+2) + 3\delta(n-1) - 4\delta(n-3)$. Assume that the system is initially relaxed.

[20 marks]

$h_3(n) * h_4(n) = (n+1)\,u(n) * \delta(n-2)$

$= (n-2+1)\,u(n-2)$.

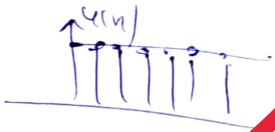
$h_3(n) * h_4(n) = (n+1)\,u(n-2)$

$h_2(n) + h_3(n) = (n+1)\,u(n-2) + (n+1)\,u(n)$

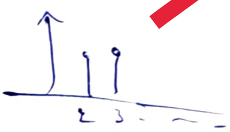
$h_2(n) + h_3(n) = (n+1)\,[u(n) + u(n-2)]$

–

$u(n) =$



$u(n-2) =$



$\boxed{u(n) - u(n-2) = \delta(n) + \delta(n-1)}$

$h_2(n) + h_3(n) + h_4(n) = (n+1)\,(\delta(n) + \delta(n+1))$

$h_5(n) = (n+1)\,\delta(n) + (n+1)\,\delta(n+1)$ —①

$y(n) = h_c(n) * h_5(n)$

$y(n) \Rightarrow \left[\frac{1}{2}\delta(n) + \frac{1}{4}\delta(n-1) + \frac{1}{2}\delta(n-2)\right] * \left\{(n+1)\,\delta(n) + (n+1)\,\delta(n-1)\right\}$

$\Rightarrow \frac{(n+1)}{2}\delta(n) + \frac{(n+1)}{2}\delta(n+1) + \frac{(n+1)\,\delta(n-1)}{4} + \frac{(n+1)}{2}\delta(n-2)$

$+ \frac{1}{4}(n+1)\,\delta(n) + \frac{(n+1)}{2}\delta(n-1)$

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

$y(n) = x(n) * h(n):$

$\Rightarrow \{8\,\delta(n+2) + 3\,\delta(n-1) - 4\,\delta(n-3)\} * h(n)$

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

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

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

2

Q.3 (a) Consider a list of 50 numbers is stored in memory, starting at 6000 H in an 8085 microprocessor system. Write an assembly language program to find number of negative, zero and positive numbers from this list and store these results in memory locations 7000 H, 7001 H and 7002 H respectively.

[20 marks]

Do not write in this margin

Q.3 (b) Determine the z-transform for the following sequences. Sketch the pole-zero plot and indicate the ROC.

(i) $\left(\frac{1}{2}\right)^n \{u[n]-u[n-10]\}$

(ii) $7\left(\frac{1}{3}\right)^n \cos\left[\frac{2\pi n}{6}+\frac{\pi}{4}\right]u[n]$

[20 marks]

Q.3 (c) **(i)** Consider a signal $m(t) = \cos \omega_0 t$, where $\omega_0 = 2\pi f_0$. Illustrate the effect of undersampling of $m(t)$ for a sampling rate of $f_s = \frac{3}{2} f_0$.

(ii) Explain briefly three 8085 microprocessor instructions, which use stack memory for their execution.

[10 + 10 marks]

Q.4 (a) **(i)** Write an 8085 assembly language program to convert a 2-digit BCD number stored at memory address 2200 H into its binary equivalent number and store the result in a memory location 2300 H.

(ii) Write an 8051 assembly language program to convert a given 8-bit binary number into its Gray Code equivalent. Explain with an example.

[14 + 6 marks]

Q.4 (b) Let $x_1(t)$ represent the input to an LTI system, where $x_1(t) = \sum_{k=-\infty}^{\infty} \alpha^{|k|} e^{jk\frac{\pi}{4}t}$ for $0 < \alpha < 1$.

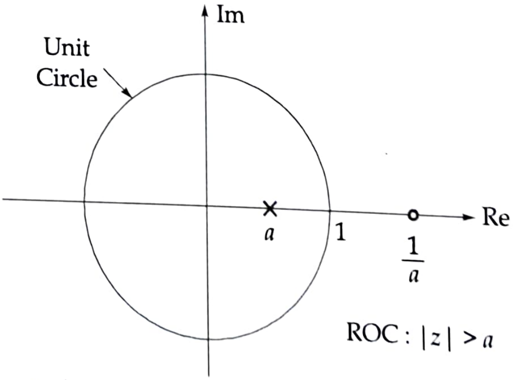
The frequency response of the system is

$$H(j\omega) = \begin{cases} 1 \ ; & |\omega| < W \\ 0 \ ; & \text{otherwise} \end{cases}$$

What is the minimum value of W so that the average energy in the output signal will be at least 90% of that in the input signal?

[20 marks]

Q.4 (c) **(i)** A discrete time system with the pole-zero pattern shown below is referred to as a first order all-pass system, since the magnitude of the frequency response is constant regardless of frequency.



Show that $\left|H(e^{j\omega})\right|$ is constant.

(ii) What is BSR mode in 8255?

Write the BSR control words for the following cases:

1. PC_0 to be set
2. PC_7 to be reset
3. PC_1 to be set
4. PC_7 to be set

[10 + 10 marks]

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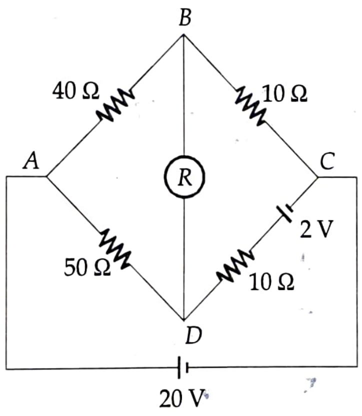
Section B : Network Theory-1 + Control Systems-1

Q.5 (a) In the circuit shown below:



Determine the current through R = 18 Ω using Thevenin's theorem.

[10 marks]

Sol.

V_{Th} :

open Circuit the R_L ;

And find V_{Th} across the R_L

Apply KVL in loop

$50I + 40I + 10I - 2 + 10I = 0$

$110I = 2$

$\boxed{I = \frac{2}{110}}$

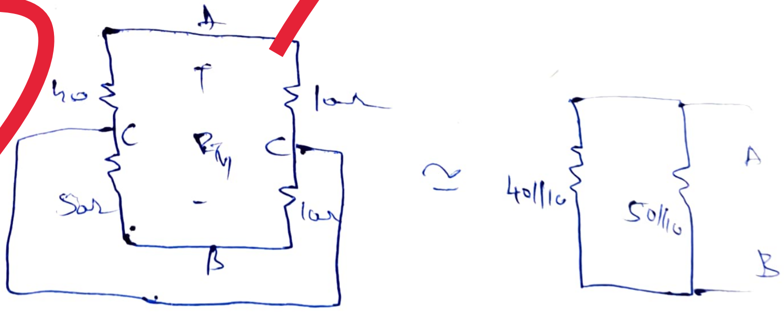
Apply : KVL in

$40I_2 + 50I_1 \pm V_{Th}$

$V_{Th} = 90I = 90 \times \frac{2}{110}$

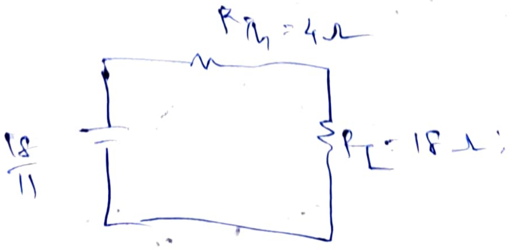
$\boxed{V_{Th} = \frac{189}{119} = \frac{18}{11}}$

R_{Th}:



$R_{Th} = 8 || 8.3 = 4\,\Omega$

Eg.

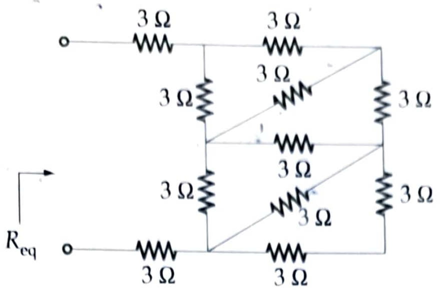


$I_L = \frac{V_{Th}}{R_L + R_{Th}} = \frac{1.63}{22\Omega}$

$I_L = 0.0743$

$\boxed{I_L = 7[illegible]3\ mA}$

Q.5 (b) For the circuit shown below, find the equivalent resistance, R_{eq}

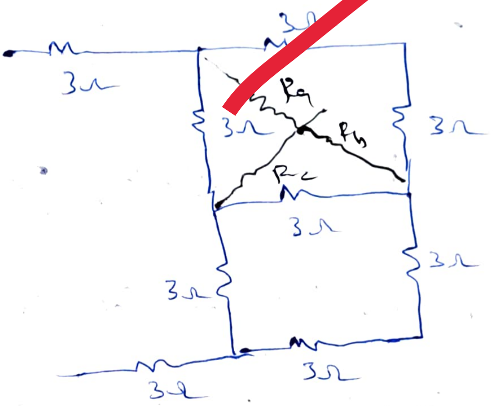


[10 marks]

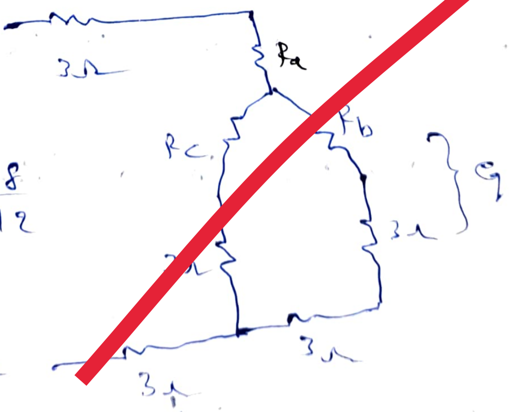
Sol:

The balance bridge is applied above;

So; 3Ω Resistance are neglected.



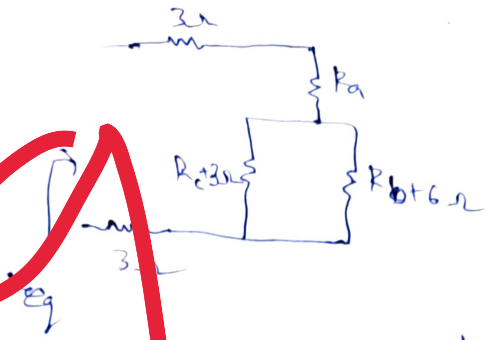
Apply Star and Δ transformation



$$R_a = \frac{3\times6}{3+3+6} = \frac{18}{12}$$

$$R_b = \frac{3\times6}{3+3+6} = \frac{18}{12}$$

$$R_c = \frac{3\times3}{12} = \frac{9}{12}$$



$R' = R_a + 3\Omega = 3.75\Omega$

$R'' = R_b + 6\Omega = 7.5$

$R' || R'' = 1.07$

$R_{eq} = 3 + 3 + R_a + R' || R'' = 3 + \ldots + 1.07$

$\boxed{R_{eq} = 8.57\Omega}$

Q.5 (c) What are Gain Margin and Phase Margin? Discuss briefly about their importance in design of control system.

[10 marks]

Sol:

Gain Margin: The amount of gain can be added so that the system become stable's. It indicate the gain of control system. If the Gain is 0 dB, -ve dB it becomes unstable in -ve feedback.

Phase Margin: The amount of phase shift in the designed control system, if the phase shift become zero. It will help us to stable gain of the system.

G.M: $GM = 20 \log\left(\frac{1}{\frac{K}{G(s)H(s)}}\right)$

P.M: $PM = 180 + \angle GH(j\omega)$

Q.5 (d) Determine the range of real valued system constant K for which the system with following characteristic equation is stable.

$$s^4 + Ks^3 + 2s^2 + (K+1)s + 10 = 0$$

[10 marks]

Sol. Stability Can be Calculated using R-H Criteria

R-H Criteria:

$$\begin{array}{c|ccc} s^4 & 1 & 2 & 10 \\ s^3 & K & K+1 & \\ s^2 & \frac{2K-(K+1)}{K} & 10 & \\ s^1 & K+1 & \longrightarrow & \boxed{K>-1} \\ s^0 & 10 & & \end{array}$$

s^2,

$$\left(\frac{2K-K+1}{K}\right)s^2 + 10 = 0 > 0$$

$$\left(\frac{K-1}{K}\right)s^2 + 10 = 0, > 0$$

$$K-1 \geq K$$

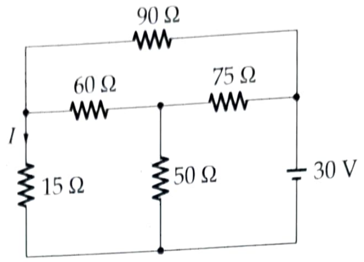
~~$2/K \geq 1$~~

$K=0$: It will be infinity

So: $K>1$; The System stable

8

Q.5 (e) State reciprocity theorem and verify it with respect to 30 V source and current I in the network given below:



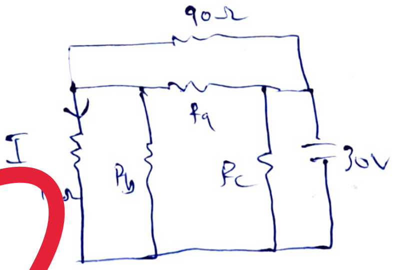
[10 marks]

Sol.

Reciprocity: The interchange of Source and Excitation of the Nlw, the Nlw it will become Same the ratio of Source and Excitation.

$$\therefore \boxed{\frac{V}{I} = \frac{I}{V}}$$

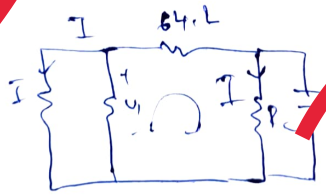
Nlw.



$R_a = \frac{60\times75+75\times50+50\times60}{50} = 225$

$R_b = 150$

$R_c = 187.5$

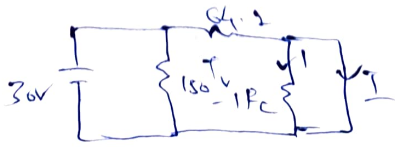


$I = \frac{30}{187.5} = 0.16$

$V_1 = 64.2\times0.16+30V = 40.272$

$$\boxed{I = \frac{40.272}{15} = 4.65\ A}$$

$\boxed{I = 4.66\ A}$



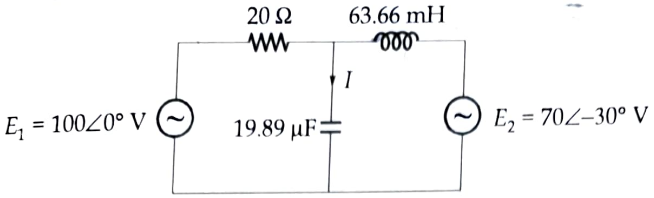
⇒ Same

$I = 0.16$

$V_1 = 30V; \ I_1 = 0.2$

$I' = \frac{0.2\times642}{64.2 * 1875} =$

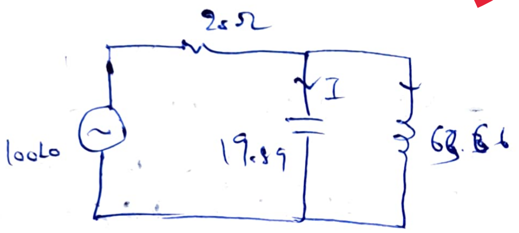
For the circuit shown in below figure, if the frequency of supply is 50 Hz, determine the current *I* flowing through the 19.89 μF capacitor using superposition theorem.



[10 marks]

S.P.T = Superposition Theorem : only one Sour act at atime

Case i. E_1 act , E_2 = S.C (Shorted)



$jX_L = j\omega L = j \times 50 \times 2\pi \times 63.66 \times 10^{-3} = j20$

$-jX_C = -jX_C = -j \frac{1}{2\pi \times 50 \times 19.89 \times 10^{-6}} = -j160$

$Z_{eq} = 20 + \frac{jX_L \cdot -jX_C}{jX_L - jX_C} = 20 + \frac{X_L X_C}{j(X_L - X_C)}$

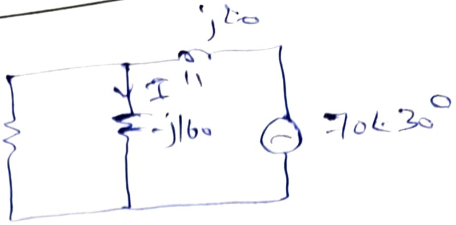
$Z_{eq} = 20 + \frac{20 \times 160 - j}{(20 - 160)} = 20 + \frac{320(4j)}{140} = 20 + 2.2j$

$I_T = \frac{100}{20 + 2.2j} = 33.63\angle -47.7$

$\boxed{I = I_T \times \frac{j20}{j20 - j160}} \Rightarrow 33.63^{\angle -47.67} \times \frac{20\angle 90}{-j(140)}$

$I' = 4.8\angle 180 - 47.7 = 4.8\angle 132.3°$

Case 1.



$Z_{eq} = +j20 - \frac{j160 \times 20}{20 - j160} = j20 - 2.46 - 19.69j$

$\boxed{Z_{eq} = -2.46 + 0.31j}$

$I_T = \frac{70 \angle -30^\circ}{2.47 \angle 172.81} = 28.34 \angle 157.19$

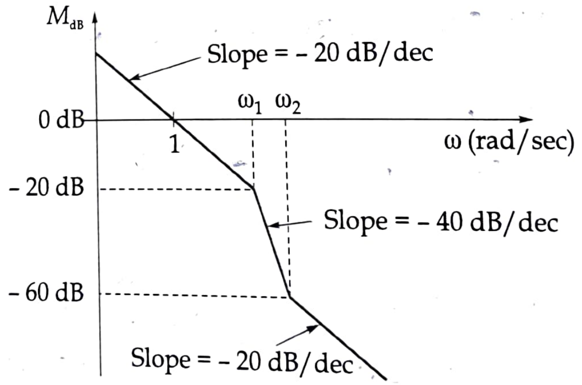
$I'' = \frac{28.34 \times 20}{20 - j160} = 28.34 \angle 157.19 \times 0.12 \angle 82.87$

$\boxed{I'' \quad 3.4 \angle 240^\circ}$

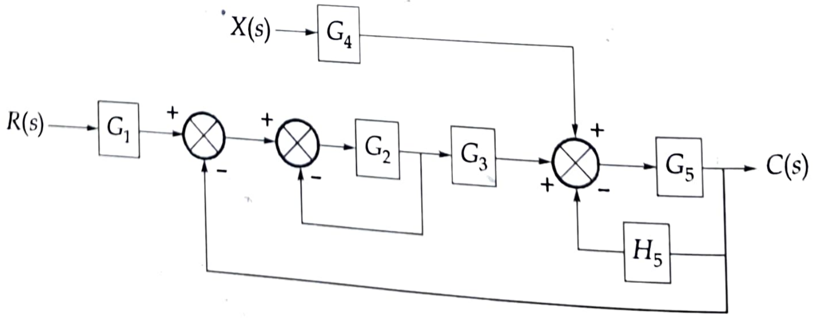
$\boxed{I = 4.95 \angle 172}$

$\therefore$ Total $= I' + I'' = 4.f \angle 132 + 3.4 \angle 240^\circ$

Q.6 (a) (i) Determine the transfer function corresponding to the following Bode plot:



(ii) Using block diagram reduction technique, find the transfer function from each input to the output C(s) for the system shown below:



[10 + 10 marks]

@ Ans

@

Transfer function $= \dfrac{K\left(1+\frac{s}{\omega_2}\right)}{s\left(1+\frac{s}{\omega_1}\right)}$

⇒ for K :

Mag at $\omega = 20\log K - 20\log(\omega)$

$0 = 20\log K - 20\log 1$

$\boxed{K = 10^0 = 1}$

Slope : $\dfrac{y_2 - y_1}{\log\omega_1 - \log 1} = -20$

$\dfrac{-20 - 0}{\log(\omega_1)} = -20$

$\log\omega_1 = 1$

$\boxed{\omega_1 = 10}$ rad/sec

$\dfrac{-60 + 20}{\log\left(\frac{\omega_2}{\omega_1}\right)} = -40$

$\log\left(\frac{\omega_2}{\omega_1}\right) = 1$

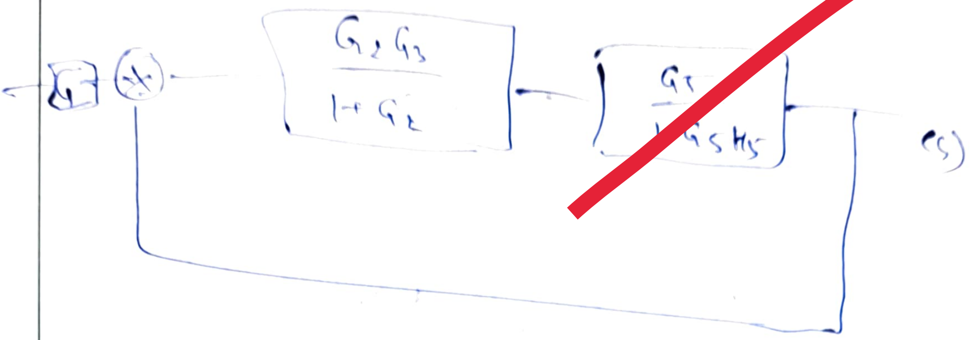
$\frac{\omega_2}{\omega_1} = 10$

$\omega_2 = 10\omega_1 = 100$ rad/sec

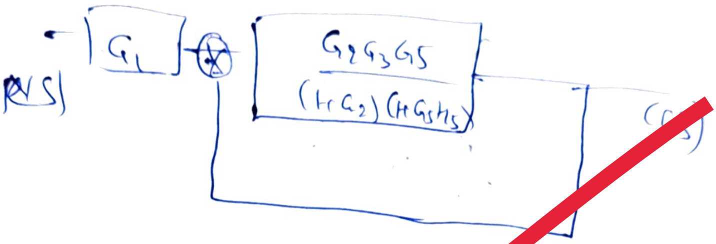
9

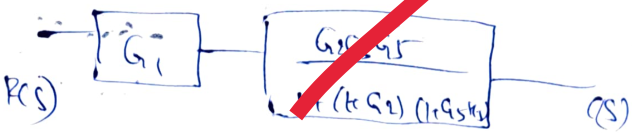
∴ $\boxed{T/F = \dfrac{C(s)}{R(s)} = \dfrac{1\left(1+\frac{s}{100}\right)}{s\left(1+\frac{s}{10}\right)}}$

(b) Case 1. $X(s) = 0$; $R(s) \to$ act ; $T(s) = \frac{C(s)}{R(s)}$



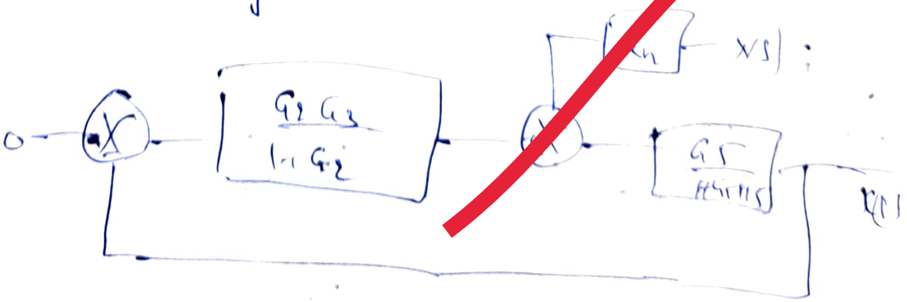
Case 1 :

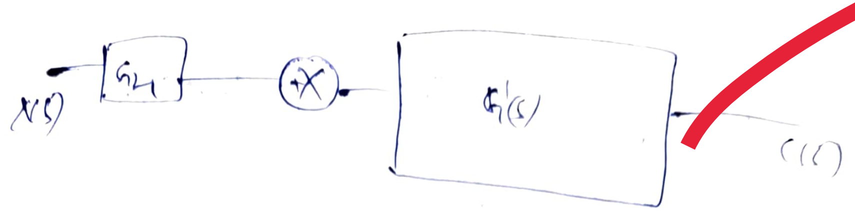




$$\boxed{T(s) = \frac{C(s)}{R(s)} = \frac{G_1G_2G_3G_5}{1+(1+G_2)(1+G_5H_5)}}$$

Case 2 : $X(s) \to$ acting ; $R(s) = 0$;





$$G'(s) = \frac{\frac{G_5}{1+G_5H_5}}{1+\frac{G_2G_3}{1+G_2}\cdot\frac{G_5}{1+G_5H_5}} = \frac{G_5(1+G_2)}{(1+G_2)(1+G_5H_5)+G_2G_3G_5}$$

$$\frac{C(s)}{X(s)} = \frac{G_4G_5(1+G_2)}{(1+G_2)(1+G_5H_5)+G_2G_3H_5}$$

Q.6 (b) The characteristic equation of a closed loop system is given by,

$$s^6 + s^5 - 2s^4 - 3s^3 - 7s^2 - 4s - 4 = 0$$

Determine the stability of the system using Routh stability criterion. While formulating Routh table, if any difficulty arise, then show two different methods to overcome the difficulty and also determine all the roots of the characteristic equation.

[20 marks]

Sol

R-H:

s^6	1	−2	−7	−4	
s^5	1	−3	−4		
s^4	1	−3	−4		
s^3	$\overset{4}{\cancel{0}}$	$\overset{-6}{\cancel{0}}$	0		← row of zero's occur:
s^2	$-\frac{3}{2}$	−4			take Auxiliary Eq:
s^1	16.6	0			
s^0	−4				

$s^4 - 3s^2 - 4 = 0$

$4s^3 - 6s = 0$

$\cancel{x^2 - 3x} - 4 = 0$ $\boxed{x = s^2}$

$x = 4, -1$

no of sign changes in the above ~~two~~ 2.

3

are two : ~~Two~~ RHS:

$s^4 - 3s^2 - 4 = 0$

$x^2 - 3x - 4 = 0$

$x = -1, 4$

$\boxed{s = \pm j}$ ← Imaginary axis.

$s = 4$

$s^2 = 4$

$\boxed{s = \pm 2}$

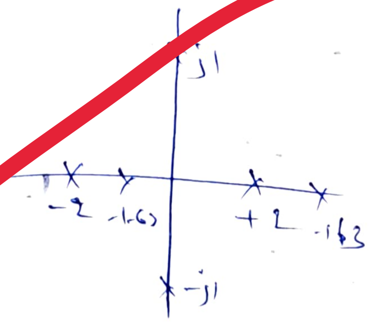
Roots; $s_{1,2} = \pm j$ $s_{3,4} = \pm 2j$

$-1.5s^2 = 4$

$s^2 = \frac{4}{-1.5}$

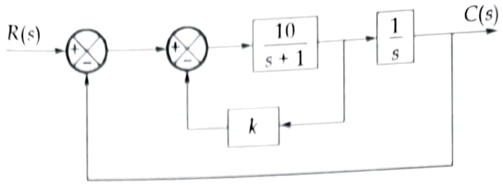
$s^2 = -2.66$

$\boxed{s_{1,2} = \pm 1.63}$



14

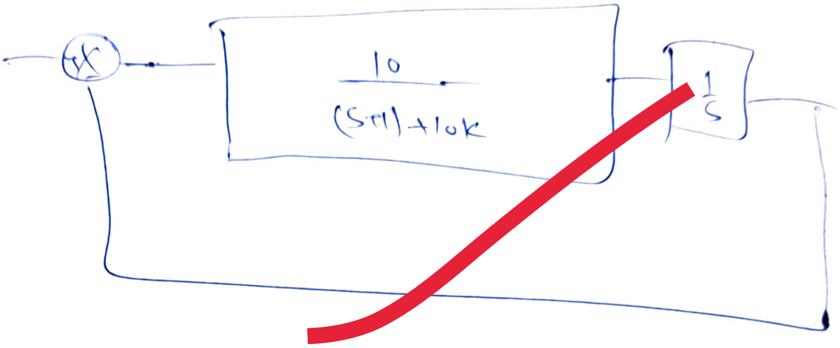
Q.6 (c) Consider the system shown below:



Sketch the root loci of the system as the gain k varies from zero to infinity. Determine the value of k such that the closed loop poles have the damping ratio $\xi = 0.7$.

[20 marks]

Sol =



$$\frac{C(s)}{R(s)} = \frac{10}{s(s+1)+10ks+10}$$

$q(s) =$

$$s^2+s+10ks+10=0$$

$$s^2+s+10ks+10=0$$

$$1+\frac{10ks}{s^2+s+10}=0$$

$$G(s)H(s) = \frac{10ks}{s^2+s+10}$$

∴ Zeros = 0 ;

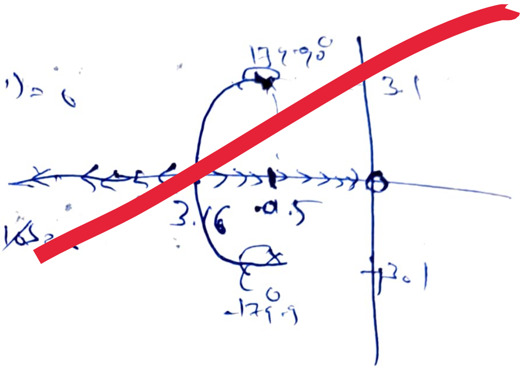
Poles = $-0.5 \pm 3.1j$

Poles = $P_{1,2} = -0.5 \pm 3.1j$

Zeros = $Z = 0$

Centroid = $\frac{\Sigma p - \Sigma z}{p - z} = \frac{-1-0}{1} = -1$

$\frac{dK}{ds} = (s^2+s+10)10 - 10s(2s+1) = 0$



$10s^2 + \cancel{10s} + 100 - 20s^2 - \cancel{10s}$

$-10s^2 = -100$

$s^2 = 10$

$\boxed{s = \pm\sqrt{10}} = 3.16$

$\phi_D = 180 - (\phi)$

$\phi = 9\cancel{0} - (\cancel{9}0 + \tan(\frac{3.1}{0.5}))$

$\phi = -0.1$

$\phi_D = 180 - 0.1 = 179.9$

$\boxed{\phi_D = \pm(179.9)}$

$q(s) = s^2 + s(1+10K) + 10 = 0;$

$\xi = 0.7; \quad 2\xi\omega_n = 1+10K; \quad \omega_n^2 = 10$

$\omega_n = \sqrt{10};$

19

$2\times 0.7\times\sqrt{10} = 1+10K;$

$10K = 1.4\times\sqrt{10} - 1$

$$K = \frac{1.4\sqrt{10}-1}{10} = 0.34$$

$\boxed{K = 0.34}$

Q.7 (a) The open-loop transfer function of a system with unity negative feedback is given by,

$$G(s) = \frac{(s+1)(s+2)}{s^3(s+10)(s+20)}$$

Draw the polar plot of the system by showing all the salient points.

[20 marks]

Sol

$1 + G(s)H(s) = s^3(s+10)(s+20) + K(s+1)(s+2) = 0;$

$s^3(s^2+30s+200) + K(s^2+3s+2) = 0;$

$s^5 + 30s^4 + 200s^3 + Ks^2 + 3sK + 2K = 0$

GM: $\omega_{gc} = |G(s)| = 1;$

$$\frac{K\sqrt{\omega^2+1}\sqrt{\omega^2+4}}{-j\omega^3\sqrt{\omega^2+100}\sqrt{\omega^2+400}} = 1$$

$K(\sqrt{\omega^2+1})(\sqrt{\omega^2+4}) = \omega^3\sqrt{\omega^2+10}\sqrt{\omega^2+400}$

$(\omega^2+1)(\omega^2+4) = \omega^6(\omega^2+10)(\omega^2+400)$

$\underline{\omega_{pc}} \div$

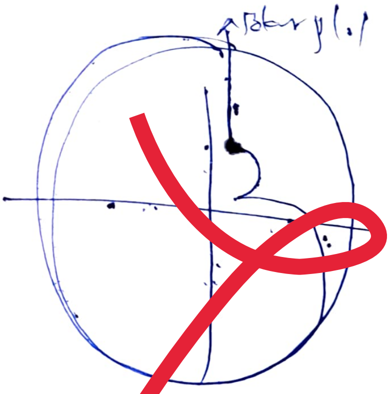
$\omega_{pc} = \angle GH = -180^\circ$

$\tan^{-1}(\frac{\omega}{1}) + \tan^{-1}(\frac{\omega}{2}) - 270^\circ - \tan^{-1}(\frac{\omega}{10}) - \tan^{-1}(\frac{\omega}{20}) = 180$

$\tan^{-1}(\frac{\omega}{1}) + \tan^{-1}(\frac{\omega}{2}) - \tan^{-1}(\frac{\omega}{10}) + \tan^{-1}(\frac{\omega}{20}) = 90^\circ$

$\Rightarrow$

$GH(j\omega) \Rightarrow \dfrac{(j\omega+1)(j\omega+2)}{j\omega^3(j\omega+10)(j\omega+20)}$

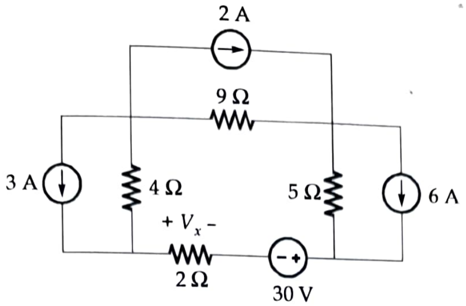


$j \times \dfrac{2-\omega^2+3j\omega}{j \cdot j\omega^3[200-\omega^2+30j\omega)}$

$\Rightarrow \dfrac{(2-\omega^2)j - 3\omega}{\omega^3(200-\omega^2+30j\omega)} \times \dfrac{\omega^3(200-\omega^2)+30j\omega^4}{\omega^3}$

Type = 3 ; Order = 5

Q.7 (b) Consider the circuit shown in the figure below:



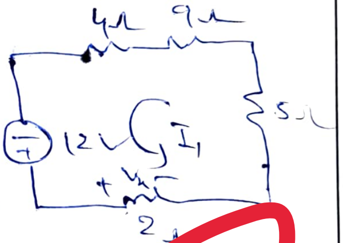
(i) Find the voltage V_x using superposition theorem.

(ii) Check the result obtained in part (i) using source transformation technique.

[15 + 5 marks]

Sol ① Superposition: only one Independent Source at time

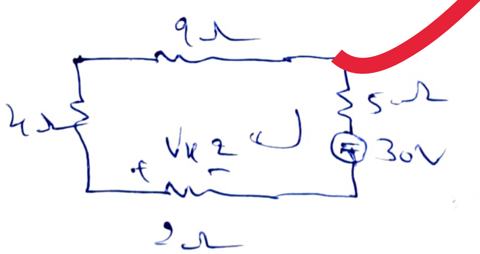
Case i: 3A acting alone:



$20 I = 12V$

$\boxed{I = \frac{3}{5} V}$, $\boxed{V_{x_1} = 2 \times \frac{3}{5} = \frac{6}{5} = 1.2V}$

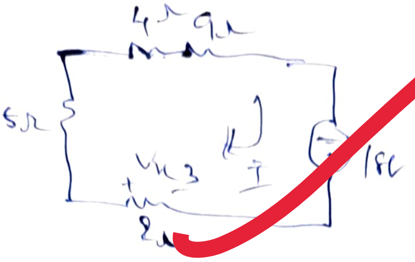
(ii)



$I = \frac{30}{20} = \frac{3}{2}$; $V_{x_2} = -2 \times \frac{3}{2} = -3V$

$\boxed{V_{x_2} = -3V}$

Case iii.



$I = \frac{18}{20} = \frac{9}{10}$

$\boxed{V_{x_3} = -\frac{9}{10} \times 2 = -1.8V}$

Case iv.

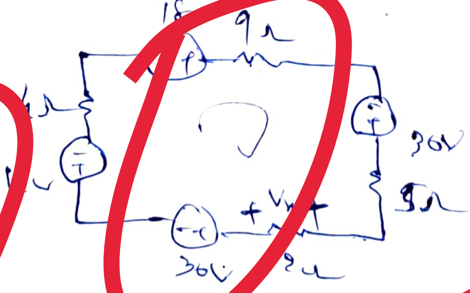
$I = \frac{30}{20} = \frac{3}{2}$

$\boxed{V_{x_4} = 2 \times \frac{3}{2} = +3V}$

∴ SPT = $V_x = V_{x_1} + V_{x_2} + V_{x_3} + V_{x_4} = 1.2 + 1.8 - [illegible] + 3$ (+1.8)

$\boxed{V_x = -0.6\,V}$ ← (I)

(ii) S.T:



$-18 - \cancel{30} + \cancel{30} + 12 + 20I = 0$

$I = \frac{+6}{20} = +\frac{3}{10}$!

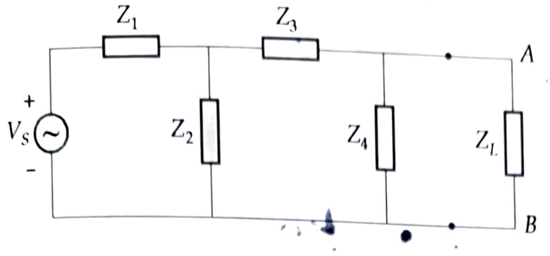
Verified.

$V_x = -\frac{6}{10} = -0.6$

$\boxed{V_x = -0.6}\,V$ ← (II)

20

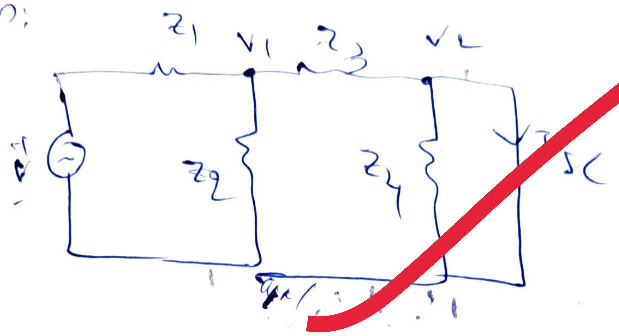
Q.7 (c) Find the current through Z_L in the network shown in figure below, using Norton's theorem.



$Z_1 = 1 + j3\ \Omega$
$Z_2 = 2 + j3\ \Omega$
$Z_3 = 3 + j2\ \Omega$
$Z_4 = 1 + j2\ \Omega$
$Z_L = 1 - j3\ \Omega$
$V_S = 40 + j0\ \Omega$

[20 marks]

Norton:



Apply : KCL : Nodal At V_1 ; V_2 :

$$\frac{V_1 - V_s}{Z_1} + \frac{V_1}{Z_2} + \frac{V_1 - V_2}{Z_3} = 0;$$

$$\frac{V_1 - 40}{1+3j} + \frac{V_1}{2+3j} + \frac{V_1 - V_2}{3+j} = 0;$$

$\boxed{V_2 = 0}$ – S.C

$$V_1\left[\frac{1}{1+3j} + \frac{1}{2+3j} + \frac{1}{3+j2}\right] + V_2\frac{-1}{3+j2} = \frac{40}{3j+1} \quad — ①$$

0.

w.r.t. :

$$\frac{V_2 - V_1}{Z_3} + \frac{V_2}{Z_4} = -I_{sc}$$

$$\boxed{I_{sc} = \frac{V_1}{Z_3}} : \quad — ②$$

$$V_1\left[\frac{1}{1+3j}+\frac{1}{2+3j}+\frac{1}{3+j2}\right] = \frac{40}{3j+1}$$

$$V_1\left[0.838\angle -54.7\right]. = \frac{40}{3j+1}$$

$$V_1 = \frac{12.64\angle -71.56}{0.838\angle -54.7}$$

$$\boxed{V_1 = 15\angle -16.8}$$

8

$$I_{sc} = \frac{15\angle -16.86^\circ}{3+j2} =$$

$$\boxed{I_{sc} = 4.16\angle -50.55}$$

I_s = Short Circuit current $\boxed{= 4.16\angle -50.55}$ A

Q.8 (a) Sketch the Nyquist plot for a unity negative feedback control system with open loop transfer function $G(s) = \dfrac{Ks^3}{(s+1)(s+2)}$ and determine the stability condition.

[20 marks]

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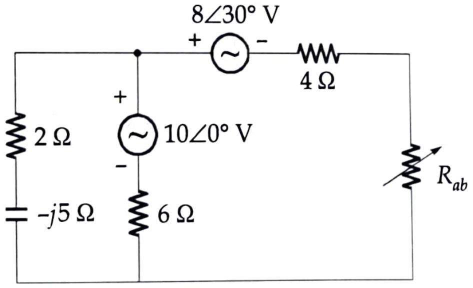
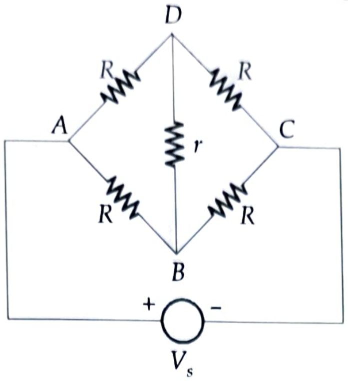
Q.8 (b) In the network shown in figure, determine the variation of current in R_{ab} when it is varied from 2 Ω to 10 Ω.



[20 marks]

Q.8 (c) By use of compensation theorem, find the voltage across BD in the bridge circuit shown in below figure when resistor in the branch BC is changed from R to $(R + \Delta R)$.



[20 marks]

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