saket

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ESE 2024 : Mains Test Series

UPSC ENGINEERING SERVICES EXAMINATION

Electronics & Telecommunication Engineering

Test-3 : Analog and Digital Communication Systems [All topics]

Signals and Systems-1 + Microprocessors and Microcontroller [Part Syllabus]

Network Theory-2 + Control Systems-2 [Part Syllabus]

Name :

Roll No :

Test Centres				**Student's Signature**
Delhi ☐	Bhopal ☐	Jaipur ☐	Pune ☐	
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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	38
Q.2	
Q.3	19
Q.4	
Section-B	
Q.5	28
Q.6	50
Q.7	
Q.8	38
Total Marks Obtained	173

Good.

Signature of Evaluator: A

Cross Checked by

1. Avoid calculations mistakes
2. You can do much better

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.
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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.
6. Handover your QCAB personally to the invigilator before leaving the examination hall.

Section A : Analog and Digital Communication Systems

Q.1 (a) With the help of frequency spectrum and the graphical representation of wave specify the difference between Amplitude Modulation and Linear addition of modulating signal and carrier signal. (Assume the modulating and carrier signal to be sinusoidal)

[12 marks]

Sol: Amplitude modulation

In this amplitude of the carrier varied with the msg signal.

$m(t) \rightarrow \Sigma \rightarrow$ BPF $\rightarrow$ O/P

$\uparrow c(t)$

$c(t) \Rightarrow A_c \cos \omega_c t$

$m(t) \rightarrow A_m \sin \omega_m t$ or $A_m \cos \omega_m t$

$S_{AM}(t) \Rightarrow A_c[1 + K_a m(t)] \cos \omega_c t$

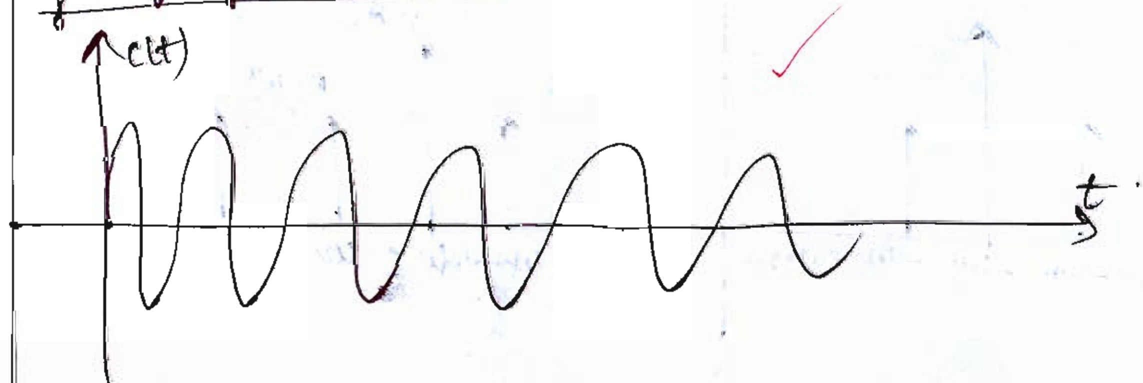
where default $K_a = \frac{1}{A_c}$

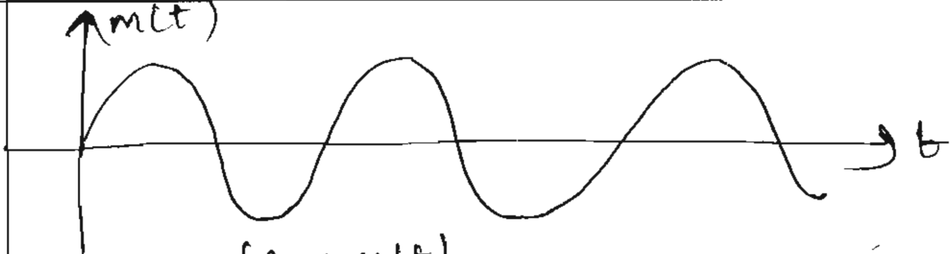
μ (modulation Index) $= K_a |m(t)|_{max}$.

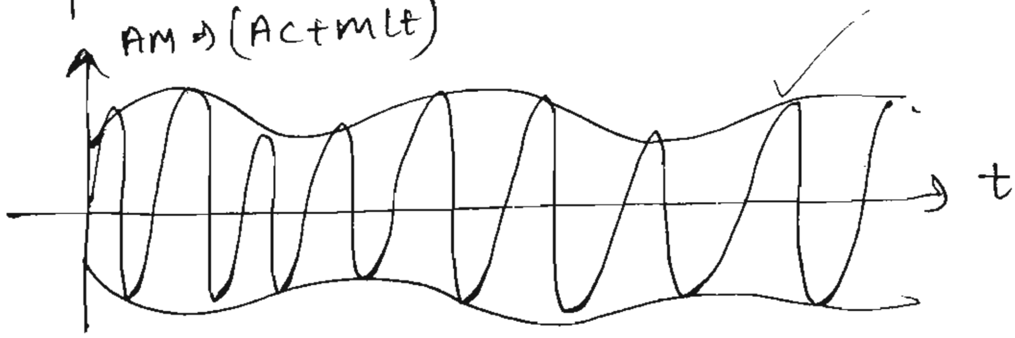
So, $[A_c + m(t)] \cos \omega_c t$.

linear added AM sig.

freq Spectrum







where the original freq spectrum

$A_c \cos \omega_c t\,[1 + K_a m(t)]$

7

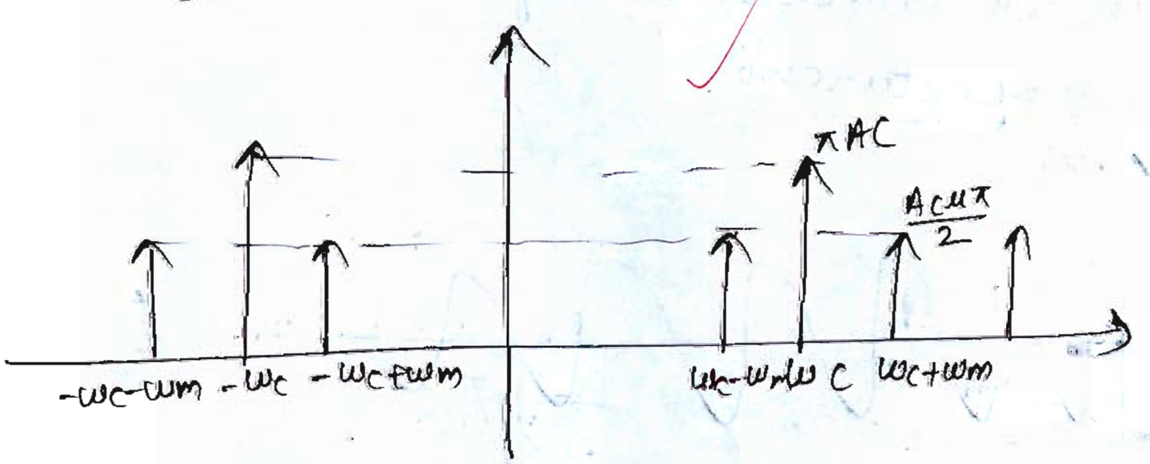
$\Rightarrow S_{AM}(t) \Rightarrow A_c \cos \omega_c t + \frac{A_c \mu}{2} \cos(\omega_c + \omega_m)t$

$+ \frac{A_c \mu}{2} \cos(\omega_c - \omega_m)t$

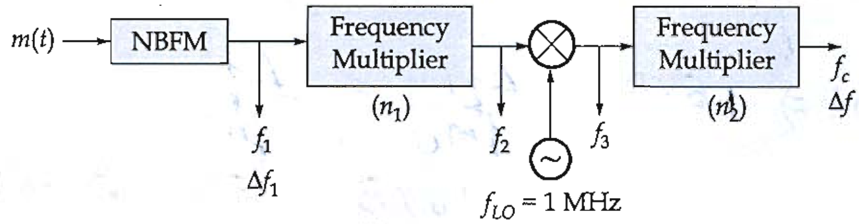
$\Rightarrow \pi A_c[\delta(\omega + \omega_c) + \delta(\omega - \omega_c)]$

$+ \frac{A_c \mu}{2}\pi[\delta(\omega - (\omega_c + \omega_m)] + \delta(\omega + (\omega_c + \omega_m)]$

$+ \frac{A_c \mu \pi}{2}[\delta(\omega - (\omega_c - \omega_m)] + \delta[\omega + (\omega_c - \omega_m)]$



Q.1 (b) Consider the block diagram of an Armstrong FM transmitter shown in the figure below:



It is given that f_1 = 175 kHz, n_1 = 16, n_2 = 32, Δf_1 = 50 Hz; then calculate

(i) The maximum frequency deviation Δf of the output FM signal.

(ii) The frequency f_3.

(iii) The possible values of carrier frequency f_c.

[12 marks]

sol- i) $f_c = f_3 n_2$

$$\boxed{\frac{\Delta f}{f_m} = \beta}$$

$f_2 = n_1 f_1$

$f_2 = 16 \times 175 \times 10^3$

$f_2 = 2800 \times 10^3$ Hz

for up conversion

$f_2 + f_{LO} = f_3$

$(2.8 + 1)10^6 = f_3$

$$\boxed{f_3 = 3.8\ \text{MHz}}$$

$\beta_1 = \frac{\Delta f_1}{f_1}$

$\Delta f = k_f\, m|_{max}$

β

$f_c = 3.8 \times 10^6 \times 32$

$$\boxed{f_c = 121.6\ \text{MHz}}$$

for down conversion

$f_2 - f_{LO} = f_3$

$(2.8 - 1) \times 10^6 = f_3$

$$\boxed{f_3 = 1.8\ \text{MHz}}$$

$f_c = n_2 f_3$

$f_c = 32 \times 1.8 \times 10^6$

$$\boxed{f_c = 57.6\ \text{MHz}}$$

$\beta_1 = \frac{\Delta f_1}{f_m}$

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$\beta_{final} \Rightarrow 16 \times 32 \left[\frac{\Delta f_1}{f_{m_1}}\right] = \frac{\Delta f}{f_m}$

$\Delta f = 16 \times 32 \times 50 \Rightarrow \underline{25.6\ KHz}$

Q.1 (c) The carrier $c(t) = A\cos 2\pi 10^6 t$ is angle modulated (PM or FM) by the sinusoidal signal $m(t)$. The modulation index β for frequency modulated signal and for phase modulated signal are 4.5 and 9 respectively. Also, using Carson's rule, the bandwidth for phase modulated and frequency modulated signals are 8.250 kHz and 15 kHz respectively. (Assume deviation constants are $K_p = 3$ rad/V and K_f Hz/V)

(i) Determine $m(t)$ and K_f.

(ii) Write the expression of modulated signal for both phase and frequency modulated signal.

(iii) If the amplitude of $m(t)$ is decreased by a factor of two, then calculate the new modulation index for both the modulation schemes.

[12 marks]

Sol:

$c(t) = A\cos(2\pi \times 10^6 t)$

$\beta_f = 4.5 \qquad \beta_p = 9$

$(B.W)_{PM} = 8.250\ KHz \qquad (B.W)_{FM} = 15\ KHz$.

$K_p = 3\ rad/V \qquad K_f$

$S_{FM}(t) = A_c \cos\left(2\pi f_c t + 2\pi K_f \int_{-\infty}^{t} m(t)\,dt\right)$

$\Rightarrow A_c \cos(2\pi f_c t + \beta \sin \omega_m t)$

$\beta_f = \frac{\Delta f}{f_m}$

$(B.W)_{FM} = (\beta_f + 1) 2 f_m$

$15 \times 10^3 = (4.5 + 1) 2 f_m$

$f_m = \frac{15 \times 10^3}{11} \Rightarrow \underline{f_m = 1.36\ KHz}$

$$\beta_f = \frac{\Delta f}{f_m}$$

$$4.5 \times 1.86 \times 10^3 = \Delta f.$$

$$\Delta f = 6.12 \times 10^3 \quad \text{— (i)}$$

for PM $\quad S_{PM}(t) = A_c \cos[2\pi f_c t + k_p m(t)]$

$$k_p m(t)|_{max} = \beta$$

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$$\cancel{\beta_p = \Delta f}$$

$$(\beta_p + 1) 2 f_m = 8.250 \times 10^3$$

$$f_m = \frac{8.250 \times 10^3}{20}$$

$$\boxed{f_m \Rightarrow 412.5 \text{ Hz}}$$

$$\beta = \frac{\Delta f}{f_m} \qquad \Delta f = \frac{1}{2\pi} \cancel{\frac{d}{dt}} K_p A_m \cancel{2\pi} f_m$$

$$\frac{9 \times 4\cancel{12.5}}{} = K_p A_m \cancel{f_m}$$

$$A_m = \frac{9}{3}$$

$$\boxed{A_m = 3}$$

$$\Delta f_{FM} \Rightarrow \frac{1}{2\pi} \frac{d}{dt} (2\pi k_f m(t))$$

$$k_f A_m.$$

$$\text{(i)} \quad K_f \times 3 = 6.12 \times 10^3$$

$$\boxed{K_f = 2.04 \times 10^3}$$

for PM. $\quad A_c \cos[2\pi \times 10^6 t + 9 \cos(2\pi \times 412.5) t].$

for FM $\quad A_c \cos[2\pi \times 10^6 t + 4.5 \sin(2\pi \times 1.86 \times 10^3 t)].$

Q.1 (d) Compare the performance of an uncoded data transmission system with the performance of a coded system using the (7, 4) Hamming code with $d_{min} = 3$, when applied to the transmission of a binary source with rate $R = 10^4$ bits/sec. The channel is assumed to be an additive White Gaussian noise channel, the received power is 1 μW and the noise power spectral density is $\frac{N_0}{2} = 10^{-11}$ W/Hz. The modulation scheme is binary PSK. Consider $Q(3.16) = 7.86 \times 10^{-4}$ and $Q(4.14) = 1.73 \times 10^{-5}$.

[12 marks]

Sol^n

PSK

$$P_e \Rightarrow Q\left(\sqrt{\frac{d_{min}^2}{2N_0}}\right).$$

$P \Rightarrow A_c^2$

$S = \frac{E}{T_1}$

$\frac{A_c^2}{2} = 10^{-6}$

$$P_e = Q\left(\sqrt{\frac{4E_b}{2N_0}}\right)$$

$$P_e = Q\left(\sqrt{\frac{2E_b}{2N_0}}\right)$$

6

$$\Rightarrow Q\left(\sqrt{\frac{A_c^2 T_b}{N_0}}\right)$$

$$Q\left(\sqrt{\frac{2\times10^{-6}}{2\times10^{-11}\times10^{4}}}\right)$$

$$Q\left(\sqrt{10^{-6}\times10^{7}}\right)$$

$$\Rightarrow Q\left(\sqrt{3.16}\right)$$

$$P_e = 7.86\times10^{-4}$$

PSK when $d_{min} = 3$

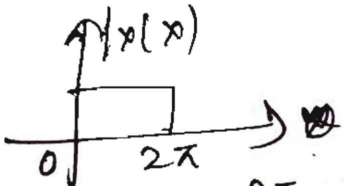
$$P_e \Rightarrow Q\left(\sqrt{\frac{9}{2\times2\times10^{-11}}}\right).$$

$$\Rightarrow Q\left(\sqrt{2.25\times10^{11}}\right)$$

Q.1 (e) Two random variables X and Y are related to another random variable θ, as $X = \sin\theta$ and $Y = \cos\theta$. If θ is uniformly distributed in the range $[0, 2\pi]$, then prove that X and Y are orthogonal, uncorrelated but not independent.

[12 marks]

soln $X = \sin\theta \qquad Y = \cos\theta$



$$R_X(x) = \int_0^{2\pi} \frac{1}{2\pi} \sin\theta \sin(\theta+\phi)\, d\theta$$

$$\Rightarrow \frac{1}{4\pi}\int_0^{2\pi} \sin(2\theta+\phi) + \sin\phi \, d\theta$$

$$\Rightarrow \frac{1}{4\pi}[2\pi]\sin\phi$$

$$\Rightarrow \frac{\sin\phi}{2}$$

$$R_Y[Y] = \int_0^{2\pi}\frac{1}{2\pi}\cos\theta\cos(\theta+\phi)\, d\theta$$

$$\Rightarrow \frac{1}{4\pi}\int_0^{2\pi}\cos(2\theta+\phi) + \cos\phi \, d\phi$$

$$\Rightarrow \frac{\cos\phi}{2}$$

$R_x[x] = \frac{\sin\phi}{2}$ $\quad R_y[y] = \frac{\cos\phi}{2}$

$E[x] = \int_0^{2\pi} \frac{1}{2\pi} \sin\theta \, d\theta$

$\Rightarrow \frac{1}{2\pi}\left[-\cos\theta\right]_0^{2\pi} \Rightarrow \frac{1}{2\pi}\left[-\cos 2\pi + 1\right]$

$\Rightarrow 0$

$E[Y] = \int_0^{2\pi} \frac{1}{2\pi} \cos\theta \, d\theta$

$\Rightarrow \frac{1}{2\pi}\left[\sin\theta\right]_0^{2\pi} = 0$

9

$E[x] = E[Y] = 0$

~~$cov[x\,Y] = E[x]\,E[Y] - E[Y]\,E$~~

$cov[xY] = E[xY] - E[x]\,E[y]$

<u>for orthogonal sig.</u>

$R_x[x] = \frac{\sin\phi}{2}$ $\quad R_y[Y] = \cos\phi$

Revise communication

both are orthogonal

~~X~~ & Y are dependent sig.

but uncorreleded

both have $E[x] = E[Y] = 0$

and independent so, $cov[x,y] = 0$

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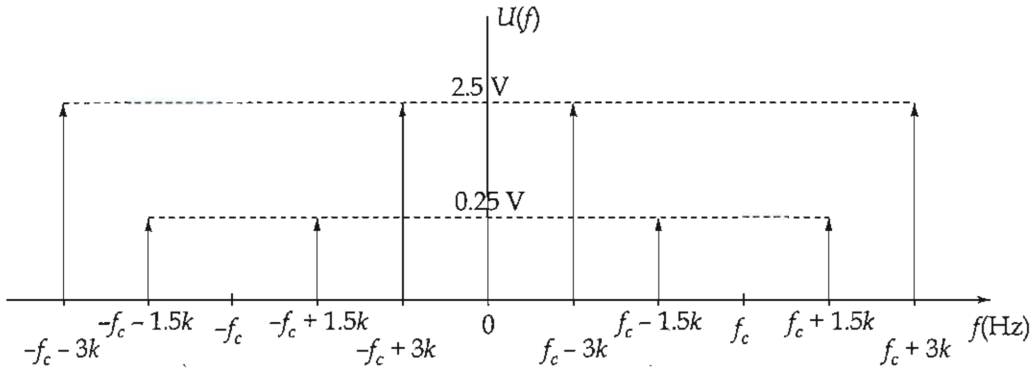
Q.2 (a) The spectrum of a Amplitude modulated signal, $U(f)$ is depicted below:



(Assume Amplitude of carrier signal, $A_C = 10$ volt)

(i) Write the expression for the AM signal $u(t)$ in time domain.. Also, determine the message signal, $m(t)$ and carrier signal, $c(t)$.

(ii) Identity the AM modulation scheme used from the given spectrum and mention some advantages of the scheme used over double side band full carrier (DSB-FC) AM modulation scheme. Also, calculate the % of power saved in the above modulation scheme as compared to DSB-FC.

(iii) Determine the power in each of the frequency components.

(iv) With the help of total power dissipated, calculate the modulation index. Also calculate the bandwidth of the modulated signal.

[7 + 5 + 3 + 5 marks]

Do not write in this margin

Q.2 (b) **(i)** The pulse rate in a DM system is 56,000 per sec. The input signal is $5 \cos(2\pi \times 1000t) + 2 \cos(2\pi \times 2000t)$ V, with t in sec. Find the minimum value of step size which will avoid slope overload distortion. What would be disadvantages of choosing a value of step-size which is larger than the minimum?

(ii) **1.** Generate the CRC code for the data word 1110. The divisor polynomial is $p^3 + p + 1$.

2. Also, mention the advantage of cyclic codes.

[10 + 10 marks]

Q.2 (c) Discuss briefly the following parameters which are used to describe an AM receiver:

(i) Selectivity **(ii)** Sensitivity

(iii) Dynamic range **(iv)** Fidelity

[20 marks]

Q.3 (a) (i) In a picture transmission, there are about 2.5×10^6 picture elements per frame. For good reproduction, 12 brightness levels are necessary. Assume all levels are equally likely to occur. Determine the channel bandwidth, without coding to transmit one picture frame every three minutes. (Assume the SNR over the channel to be 30 dB)

(ii) 1. What do you understand by source coding? What is the purpose of the channel encoder and channel decoder?

2. Also, explain the purpose of the digital modulator and digital demodulator.

[10 + 10 marks]

Sol. 3) a) i) pictures Transmission / frame

$\Rightarrow 2.5 \times 10^6$

equally likely they occurs

So, entropy of 12 levels that occur likely

$H(X) \Rightarrow \log_2 12 \Rightarrow 3.58$ ~~picture / fram~~

$C \geq B \log_2 \left(1 + \frac{S}{N}\right)$.

9

$\frac{2.5 \times 10^6 \times 3.58}{180} \geq B \log_2 (1 + 10^3)$

$49722.22 \geq B \log_2 1001$ ∴ 1 picture frame every 3 min

1 3 min
1 min → 60 sec
Rb ⇒ bit/sec
180 sec

$B \leq 4.988$ KHz

$\underline{B \approx 5 \text{ KHZ}}$

Good

ii) 1) source coding

In case of source coding we provide different length code according to the prob of occurrance of bits.

If the bits have high probability then code associated with it will be less and if it have occurace of prob low then code associated with it is very large.

- different length coding will be used
  - shannon fano
  - huffman code.

- channel encoder :- channel encoder is used to encode the sampled Analog value in to digitally transmitted bits so it is easier to process them.

- channel decoder It work reverse of encoder it transmit or change the digitally pulse back to original and transfer them to the receiver side.

2) digital modulator

modulation is a process of addition

of different pulses works on diff freq and transmit them one together.

6

Digital demodulator

It's a way of segregating the original msg sig pulses transmitted at the Transmitter side work opposite to the modulator

Q.3 (b) An angle modulated signal with carrier frequency of 1 MHz is described by the equation:

$$S_{EM}(t) = 5\cos(\omega_c t + 20\sin 1000\pi t + 10\sin 2000\pi t)$$

Then, calculate

(i) The power of the modulated signal

(ii) The maximum frequency deviation Δf.

(iii) The maximum phase deviation $\Delta\phi$.

(iv) The bandwidth of $S_{EM}(t)$.

(v) Modulation index 'β'.

[20 marks]

Sol:- Power of modulated sig.

$$P_t = P_c\left[1+\frac{\mu^2}{2}\right].$$

1

$A_c = 5$ $\quad \frac{A_c \mu}{2} = 20$

$A_c \mu = 40$

$\mu =$

Incomplete

B : x T

$$\left[\begin{array}{cccc|ccc} 0 & 0 & 0 & 1 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 0 & 1 & 1 & 1 \\ 1 & 0 & 0 & 0 & 1 & 0 & 1 \end{array}\right]$$

Q.3 (c) The parity check matrix of a (7, 4) linear block code is given as

$$H = \left[\begin{array}{ccc|cccc} 1 & 0 & 0 & 1 & 0 & 1 & 1 \\ 0 & 1 & 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 & 1 \end{array}\right]$$

(i) Find the generator matrix G for this code.

(ii) Determine all possible code words corresponding to the generator matrix.

(iii) Determine the minimum distance of the code word.

(iv) Check whether [0 1 0 0 0 1 1] is a valid codeword or not.

[4 + 8 + 4 + 4 marks]

Soln:

$$P^T_k : I$$

$$G = \left[\begin{array}{ccc|cccc} 1 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 & 0 & 0 & 1 \end{array}\right]$$

3

Incomplete

Q.4 (a) A single-tone LSB-SSB modulated signal is generated using the phase-shift method of SSB generation. However, the narrow-band carrier phase-shift network cause a phase error '$\in$' between the input phase and quadrature phase carrier. Assume message signal as $\cos(\omega_m t)$ and carrier signal as $\cos(\omega_c t)$.

(i) Draw the block diagram for the generation of LSB-SSB signal for the above case.

(ii) Find the expression for the output SSB signal with the above given conditions and sketch the frequency spectrum.

(iii) Obtain the expression for the ratio of the power in the desired to undesired sideband as a function of $\in$.

(iv) Calculate the ratio of desired to undesired power, if phase error $\in$ is 15°.

[20 marks]

Q.4 (b) In a DSB-SC system, the carrier frequency is 600 kHz and the modulating signal $m(t)$ has a uniform PSD band limited to 5 kHz. The modulated signal is transmitted over a distortionless channel having a noise with PSD, $S_n(\omega) = \frac{1}{\omega^2 + a^2}$ where $a = 10^6\pi$. Assume the useful signal power at the receiver input is 1 μW. The received signal is band pass-filtered, multiplied by $2\cos\omega_c t$ and then low pass filtered to obtain the output $s_0(t) + n_0(t)$. Determine the output SNR.

[20 marks]

Q.4 (c) A binary channel has the following noise characteristics:

$$P(Y/X) = \begin{bmatrix} \frac{2}{3} & \frac{1}{3} \\ \frac{1}{3} & \frac{2}{3} \end{bmatrix}$$

(i) If the input symbols are transmitted with probabilities $\frac{3}{4}$ and $\frac{1}{4}$ respectively, calculate $H(X)$, $H(Y)$, $H(X, Y)$, $H\left(\frac{Y}{X}\right)$, $H(X \mid Y)$ and $I(X, Y)$.

(ii) Find the channel capacity, efficiency and redundancy of the channel.

[20 marks]

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Section B : Signals and Systems-1 + Microprocessors and Microcontroller-1 + Network Theory-2 + Control Systems-2

Q.5 (a) (i) The open loop transfer function of a system is given by $G(s) = \frac{5}{s(s+2)}$. It is desired to locate the pole of this transfer function at –6 and $-2 \pm j3$ by using a suitable PID controller. Determine the suitable gains needed for PID controller to achieve the given specifications.

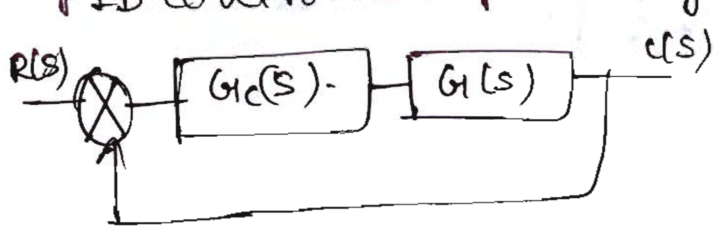
(ii) Design a PD controller so that the system having open loop transfer function $G(s)H(s) = \frac{1}{s(s+1)}$ will have phase margin of 40° at 2 rad/sec.

[6 + 6 marks]

Sol– 5) a) i) $G(s) = \frac{5}{s(s+2)}$

desired location of pole ⇒ -6 & $-2 \pm j3$

PID controller open loop gain ⇒ $K_P + K_D s + \frac{K_I}{s}$



6

Characteristic eqn $1 + G_c(s)\,G(s) = 0$

$$1 + \frac{5}{s(s+2)s}\left(K_P s + K_D s^2 + K_I\right) = 0$$

$$s^2(s+2) + 5K_P s + 5K_D s^2 + 5K_I = 0$$

$$s^3 + 2s^2 + 5K_D s^2 + 5K_P s + 5K_I = 0$$

$$s^3 + (2 + 5K_D)s^2 + 5K_P s + 5K_I = 0 \quad \text{(i)}$$

characteristic eq^n with given poles →

$$(s+a)\left[s-(-2+j3)\right]\left[s-(-2-j3)\right]=0$$

$$(s+6)\left[(s+2-j3)(s+2+j3)\right]=0$$

$$(s+6)\left[s^2+2s-\cancel{j3}s+2s+4-\cancel{6j}+\cancel{3j}s+\cancel{6j}-j^2 9\right]=0$$

$$(s+6)\left[s^2+4s+13\right]=0$$

$$s^3+6s^2+4s^2+24s+13s+78=0$$

$$s^3+10s^2+37s+78=0 \quad \text{--- (ii)}$$

Compare both the eq^{n}s → eq^n (i) & (ii)

we get,

$$5K_I = 78 \qquad \boxed{K_I = 15.6}$$

$$5K_P = 37$$

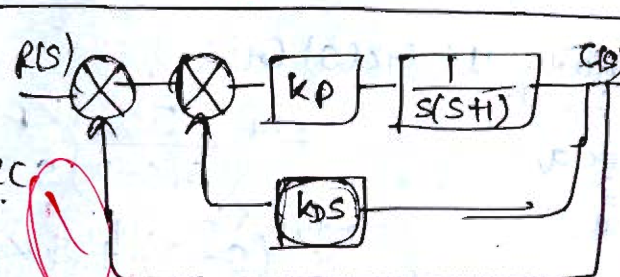
$$2+5K_D = 10$$

$$\boxed{K_P = 7.4}$$

$$\boxed{K_D = 1.6}$$

$$G_c(s) = 7.4 + 1.6s + \frac{15.6}{s}$$

ii) $G(s)H(s) = \dfrac{1}{s(s+1)}$



PM = 40° at 2 rad/sec

Inner loop →

$$\frac{\dfrac{K_P}{s(s+1)}}{1+\dfrac{K_P K_D s}{s(s+1)}} \Rightarrow \frac{K_P}{s^2+K_P K_D s+s} \Rightarrow \frac{K_P}{s(s+K_P K_D+1)}$$

Do not write in this margin

$PM = 180° + \phi = 40°$

$\phi = -140 \big|_{at\ \omega gc = 2 rad/sec}$

$\Rightarrow$ overall openloop transfer function $\Rightarrow$

$\phi = -90° - \tan^{-1}\left(\frac{\omega}{K_PK_D+1}\right)$

$-140 + 90° = -\tan^{-1}\left(\frac{\omega}{K_PK_D+1}\right)$

$\tan(50°) = \frac{\omega}{K_PK_D+1}$

$1.2K_PK_D + 1.2 = 2$

$\boxed{K_PK_D = 0.667}$

$\left|\frac{K_P}{\omega\sqrt{(1+K_PK_D)^2+\omega^2}}\right| = 1$

$K_P^2 = \omega^2\left[\omega^2 + (1+K_PK_D)^2\right]$

$K_P^2 = 4(4 + 1 + K_P^2K_D^2 + 2K_PK_D)$

$K_P^2 = 20 + 8K_PK_D + 4(K_PK_D)^2$

$4(0.667)^2 + 8(0.667) + 20 = K_P^2$

$\boxed{K_P = 5.206}$

$\boxed{K_D = 0.128}$

Q.5 (b) Write short notes on the following with respect to 8085 microprocessor:

(i) Maskable and non-maskable interrupts.

(ii) Vectored and non-vectored interrupts.

(iii) Edge triggered and level triggered interrupts.

(iv) Priority based interrupts.

[12 marks]

Sol:- i) maskable Interrupts :-

These are those Interrupts which can be dayled or ignored by the µp when it is performing any Important task or performing any other operation.

e.g: RST 7.5, RST 6.5 etc.

nonmaskable Interrupts :-

These are those Interrupts which can't be delayed by the processer even when It's performing any other task these Interrupt are always accepted.

e.g: TRAP

ii) Vectored Interrupt :-

Vectored Interrupts are those Interrupt the add are specified from the external source or we can say that they have an specified address.
e.g. RST 7.5, TRAP etc

nonvectored Interrupts

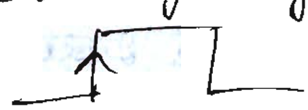
nonvectored Interrupts are those Interrupts whose address are not specified by an external device's and we can say they does not have any specific address.

e.g. INTR.

iii) Edge triggered :-

ed triggered ~~Interrupts~~ Interrupts are those Interrupts In which either they go low to high or they go high to low means either positive going or negative going.

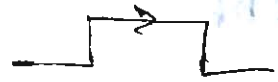
e.g. TRAP, RST 7.5



level triggered :-

those Interrupts which triggered at the high or low level only not on the transition period called as level trigg

e.g. RST 6.5 etc.



iv) Priority based Interrupts

when there are more than one Interrupts occurs in a process then the up have to select Interrupts according to the priority of those Interrupts.

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e.g. TRAP > RST7.5 > RST 6.5 > RST5.5 > INTR

Q.5 (c) Consider the following relations:

$$y(t) = x(t) * h(t) \quad ; \quad g(t) = x(3t) * h(3t)$$

Where "*" indicates the convolution. If the signal $g(t)$ can be represented as $g(t) = ay(bt)$, then determine the values of a and b without using any transform.

[12 marks]

Soln: $y(t) = x(t) * h(t)$

$Y(S) = X(S) \cdot H(S)$ (convolution property)

$g(t) = x(3t) * h(3t)$ $\quad \therefore g(t) = a\,y(bt)$

$x(at) \rightarrow \frac{1}{a} X\left(\frac{s}{a}\right)$

time scaling property

1

Incomplete

Q.5 (d) Explain all registers of 8086 Microprocessor.

[12 marks]

Sol:- Registers In 8086

i) general purpose reg

ii) Segment reg.

iii) Stack pointer.

i) general purpose register

In 8086 we can use any of the general purpose reg as an accumulator. converse of the 8085 in that only Accumulator will be used to store all the airmatic operation.

AX , BX , CX , DX

↓

Acccumulator → AH, AL

BX → Base register → BH, BL

CX → Code register

CH   CL

DX → Data register

DH   DL.

ii) Segment register

In 8086 there are 4 types of Segments register.

a) SS :- Stack segment ~~(used to access strings)~~

It is used to access the content of Stack using segment reg given.

DS :- Data Segment

It is used to access data in the particular memory location.

Code segment

It is used to access the code, written in particular location.

Extra segment

It's used to access the String written from high to low or low to high.

Do not write in this margin

Instruction pointer :- It is used to point the Instruction written on the particular point work quite similar as the PC of the 8085.

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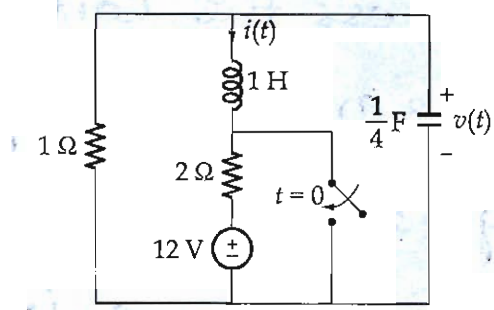
~~But~~ Base pointer :-

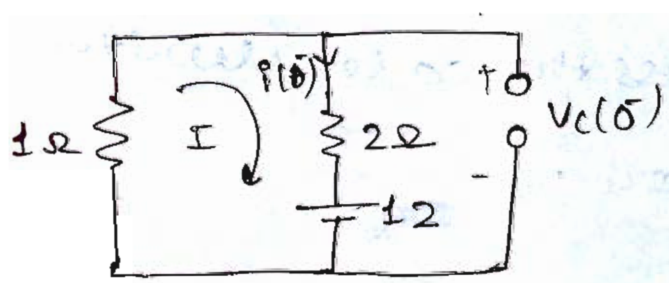
Base pointer register used to locate the base add of the given program whenwe have to calculate the EA = base add + OffsetValue

Q.5 (e) For the given circuit, find $i(t)$ and $v(t)$ for $t > 0$.



[12 marks]

Sol :- at $t=0^-$ Switch is open



$V_c(0^-) - 2i(0^-) - 12 = 0$

$V_c(0^-) = 12 + 2(-4)$

$V_c(0^-) = 12 - 8$

$\boxed{V_c(0^-) = 4\ V}$

2

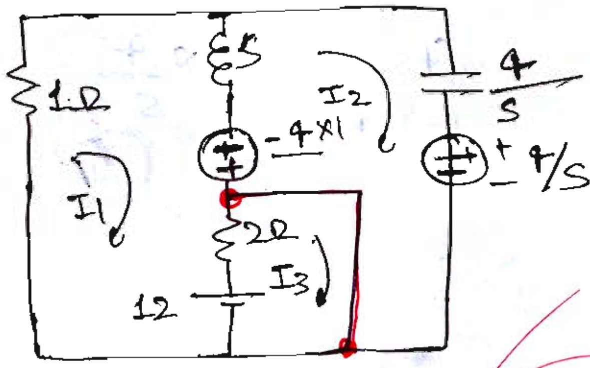
$-I - 2I - 12 = 0$

$-3I = 12$

$I = \frac{-12}{3} \Rightarrow -4A$

$\boxed{I = -4A}$

at $t=0^+$ when switch is closed (Laplace domain)



$$12-2(I_3-I_1)=0$$

$$12-2I_3+2I_1=0 \quad \text{(iii)}$$

S.C

$$-I_1-S(I_1-I_2)-4-2(I_1-I_3)-12=0 \quad \text{(i)}$$

$$-\frac{4}{S}+4-S(I_2-I_1)-\frac{4I_2}{S}=0$$

$$-\frac{4}{S}+4=S(I_2-I_1)+\frac{4}{S}I_2$$

$$4-\frac{4}{S}=\left[S+\frac{4}{S}\right]I_2-SI_1$$

$$\frac{4S-4}{S}=\frac{[S^2+4]}{S}I_2-\frac{S^2}{S}I_1$$

$$4S-4=[S^2+4]I_2-SI_1 \quad \text{(ii)}$$

calculation error

(i) $-I_1-SI_1+SI_2-16-2I_1+2I_3=0$

$$[-3-S]I_1+SI_2-16+12+2I_1=0$$

$$-4+SI_2-SI_1-I_1=0$$

$$(S+1)I_1-SI_2=-4$$

$$SI_2-(S+1)I_1=4 \quad \text{(iv)}$$

(ii) × S+1

$$(4S-4)(S+1)=(S^2+4)(S+1)I_2-S(S+1)I_1$$

$$-4S=-S^2I_2 \mp S(\cancel{S}+1)I_1$$

$(s^3+4s+\cancel{s^2}+4-\cancel{s^2})I_2$

$= 4s^2-\cancel{4s}+\cancel{4s}-4-4s$

$$\boxed{I_2 = \frac{4s^2-4s-4}{s^3+4s+4}}$$

$sI_2-(s+1)I_1 = 4$

$I_1 \left[\frac{4s^3-4s^2-4s-(s+1)(s^3+4s+4)}{s^3+4s+4}\right] = 4$

$V(t) = \frac{I_2}{sC}$

$\Rightarrow \left[\frac{4s^2-4s-4}{s^3+4s+4}\right] \times \frac{4}{s}.$

Q.6 (a) A control system is represented by the state equation given below:

$\dot{x}(t) = Ax(t)$

If the response of the system is $x(t) = \begin{bmatrix} e^{-t} \\ -2e^{-t} \end{bmatrix}$ when, $x(0) = \begin{pmatrix} 1 \\ -2 \end{pmatrix}$ and $x(t) = \begin{pmatrix} e^{-2t} \\ -e^{-2t} \end{pmatrix}$

when $x(0) = \begin{pmatrix} 1 \\ -1 \end{pmatrix}$.

Calculate the system matrix A and state transition matrix for the system.

[20 marks]

Soln -

$\dot{x}(t) = Ax(t)$

$$x_1(t) = \begin{bmatrix} \phi_{11} & \phi_{12} \\ \phi_{21} & \phi_{22} \end{bmatrix} \begin{bmatrix} x_1(0) \\ x_2(0) \end{bmatrix}$$

$$\begin{bmatrix} e^{-t} \\ -2e^{-t} \end{bmatrix} \Rightarrow \begin{bmatrix} \phi_{11} & \phi_{12} \\ \phi_{21} & \phi_{22} \end{bmatrix} \begin{bmatrix} 1 \\ -2 \end{bmatrix}$$

$e^{-t} = \phi_{11} - 2\phi_{12}$ — (i)

$-2e^{-t} = \phi_{21} - 2\phi_{22}$ — (ii)

using another condition

$$\begin{bmatrix} e^{-2t} \\ -e^{-2t} \end{bmatrix} = \begin{bmatrix} \phi_{11} & \phi_{12} \\ \phi_{21} & \phi_{22} \end{bmatrix} \begin{bmatrix} 1 \\ -1 \end{bmatrix}$$

$e^{-2t} = \phi_{11} - \phi_{12}$ — (iii)

$-e^{-2t} = \phi_{21} - \phi_{22}$ — (iv)

using eqn (i) & (iii)

$e^{-t} = \cancel{\phi_{11}} - 2\phi_{12}$

$e^{-2t} = \cancel{\phi_{11}} - \phi_{12}$

$- \quad - \quad +$

$\phi_{12} - 2\phi_{12} = e^{-t} - e^{-2t}$

$-\phi_{12} = -[e^{-t} + e^{-2t}]$

$\boxed{\phi_{12} = e^{-2t} - e^{-t}}$

(iii) $\phi_{11} - \phi_{12} = e^{-2t}$

$\phi_{11} = e^{-2t} + \phi_{12}$

$\phi_{11} = e^{-2t} + e^{-2t} - e^{-t}$

$\boxed{\phi_{11} = 2e^{-2t} - e^{-t}}$

eqn (ii) & (iv)

$-2e^{-t} = \cancel{\phi_{21}} - 2\phi_{22}$

$-e^{-2t} = \cancel{\phi_{21}} - \phi_{22}$

$+ \quad - \quad +$

$-\phi_{22} = e^{-2t} - 2e^{-t}$

$\boxed{\phi_{22} = 2e^{-t} - e^{-2t}}$

$-e^{-2t} = \phi_{21} - \phi_{22}$

$\phi_{21} = \phi_{22} - e^{-2t}$

$\phi_{21} \Rightarrow 2e^{-t} - e^{-2t} - e^{-2t}$

$\boxed{\phi_{21} = 2e^{-t} - 2e^{-2t}}$

$$\phi(t) = \begin{bmatrix} 2e^{-2t} - e^{-t} & e^{-2t} - e^{-t} \\ 2e^{-t} - 2e^{-2t} & 2e^{-t} - e^{-2t} \end{bmatrix} \Rightarrow \underline{\underline{e^{At}}}.$$

$$\phi(s) = \begin{bmatrix} \frac{2}{s+2} - \frac{1}{s+1} & \frac{1}{s+2} - \frac{1}{s+1} \\ \frac{2}{s+1} - \frac{2}{s+2} & \frac{2}{s+1} - \frac{1}{s+2} \end{bmatrix}$$

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$$\Rightarrow \begin{bmatrix} \frac{2s+2-s-2}{(s+1)(s+2)} & \frac{s+1-s-2}{(s+1)(s+2)} \\ \frac{2s+4-2s-2}{(s+1)(s+4)} & \frac{2s+4-s-1}{(s+1)(s+2)} \end{bmatrix} = \begin{bmatrix} s & -1 \\ 2 & s+3 \end{bmatrix} \frac{1}{(s+1)(s+2)}$$

$$\Rightarrow \begin{bmatrix} s+3 & 1 \\ -2 & s \end{bmatrix} \Rightarrow \begin{bmatrix} s & 0 \\ 0 & s \end{bmatrix} - \begin{bmatrix} -3 & -1 \\ 2 & 0 \end{bmatrix} \Rightarrow \underline{\underline{A = \begin{bmatrix} -3 & -1 \\ 2 & 0 \end{bmatrix}}}$$

Q.6 (b) Consider an initially relaxed causal LTI system characterized by the following difference equation:

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

(i) Find the frequency response $H(e^{j\omega})$ and the impulse response $h(n)$ of the system.

(ii) Find the response $y(n)$, if the input to this system is $x(n) = \left(\frac{1}{4}\right)^n u(n)$.

[20 marks]

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

$$Y(z) - \frac{3}{4}z^{-1}Y(z) + \frac{1}{8}z^{-2}Y(z) = 2X(z)$$

$$Y(z)\left[1 - \frac{3}{4}z^{-1} + \frac{z^{-2}}{8}\right] = 2X(z)$$

$$\frac{Y(z)}{X(z)} = H(z) = \frac{2}{1 - \frac{3}{4}z^{-1} + \frac{z^{-2}}{8}} \Rightarrow \frac{2}{1 - \frac{3}{4z} + \frac{1}{8z^2}}$$

$$\frac{8z^2 - 6z + 1}{8z^2}$$

$\Rightarrow H(z) = \dfrac{16z^2}{8z^2 - 6z + 1} \Rightarrow \dfrac{2z^2}{z^2 - \frac{3}{4}z + \frac{1}{8}} \Rightarrow \dfrac{2z^2}{\left(z - \frac{1}{2}\right)\left(z - \frac{1}{4}\right)}$

$\dfrac{H(z)}{z}$ replace z to $e^{j\omega}$.

we get $\Rightarrow H(e^{j\omega}) = \dfrac{2e^{2j\omega}}{e^{2j\omega} - \frac{3}{4}e^{j\omega} + \frac{1}{8}} \Rightarrow \dfrac{2e^{2j\omega}}{\left(e^{j\omega} - \frac{1}{2}\right)\left(e^{j\omega} - \frac{1}{4}\right)}$

h(n) calculated as –

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

$$2z = Az - \frac{A}{4} + Bz - \frac{B}{2}$$

$$A + B = 2$$

$$-\frac{A}{4} - \frac{B}{2} = 0$$

$$-\frac{A}{\cancel{4}_2} = \frac{B}{\cancel{2}}$$

$$\boxed{A = -2B}$$

$$A = -2(-2)$$

$$\boxed{A = 4}$$

$$-2B + B = 2 \qquad \boxed{B = -2}$$

$$-B = 2$$

9

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

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

ii) when $x(n) = \left(\frac{1}{4}\right)^n u(n)$

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

$$Y(z)\left[1 - \frac{3}{4} z^{-1} + \frac{1}{8} z^{-2}\right] = 2\left[\frac{z}{z-\frac{1}{4}}\right]$$

$$Y(z) = \frac{\frac{2z}{\left(z-\frac{1}{4}\right)}}{1 - \frac{3}{4}z^{-1} + \frac{z^{-2}}{8}}$$

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

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$$Y(z) = \frac{2z^3}{\left(z-\frac{1}{2}\right)\left(z-\frac{1}{4}\right)^2}$$

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

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

$$2z^2 = \left[z^2 + \frac{1}{16} - \frac{z}{2}\right]A + \left[z^2 - \frac{z}{2} - \frac{z}{4} + \frac{1}{8}\right]B + \left[z - \frac{1}{2}\right]C$$

calculation error

$\boxed{A + B = 2}$

$0 = -\frac{A}{2} - \frac{3}{4}B + \frac{C}{1}$

$\boxed{0 = -2A - 3B + 4C}$

$4C - 3B - 2(2-B)$

$4C - 3B - 4 + 2B$

$4C - B = 4$

$\frac{A}{16} + \frac{B}{8} - \frac{C}{2} = 0$

$\frac{A + 2B - 8C}{16} = 0$

$A + 2B - 8C = 0$

$2 - B + 2B - 8C = 0$

$2 + B - 8C = 0$

$8C - \cancel{B} = 2$

$4C - \cancel{B} = 4$

$4C = -2$

$\boxed{C = \frac{-1}{2}}$

$4C - B = 4$

$4\left(\frac{-1}{2}\right) - 4 = B$

$-2 - 4 = B$

$\boxed{B = -6}$

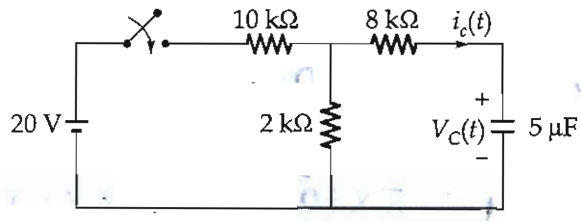
$A = 2 - B$

$A = 2 - (-6)$ $\boxed{A = 8}$

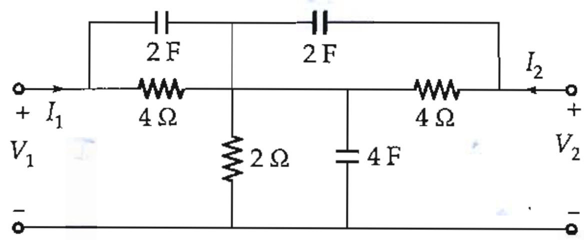
$$Y(z) = \frac{8z}{z-\frac{1}{2}} - \frac{6z}{\left(z-\frac{1}{4}\right)} - \frac{1}{2}\frac{z}{\left(z-\frac{1}{4}\right)^2}$$

$$8\left(\frac{1}{2}\right)^n u(n) - 6\left(\frac{1}{4}\right)^n u(n) - 0.125\, n\left(\frac{1}{4}\right)^n u(n)$$

Q.6 (c) (i) In the network shown in figure, the switch closes at $t = 0$. The capacitor is initially uncharged. Find $V_C(t)$ and $i_c(t)$.

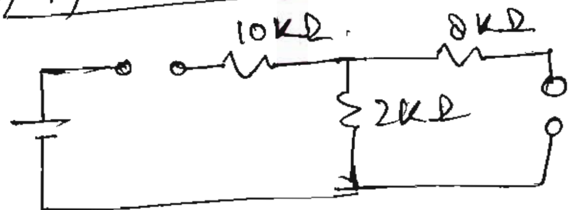


(ii) Find Y-parameters for the network shown in figure.



[10 + 10 marks]

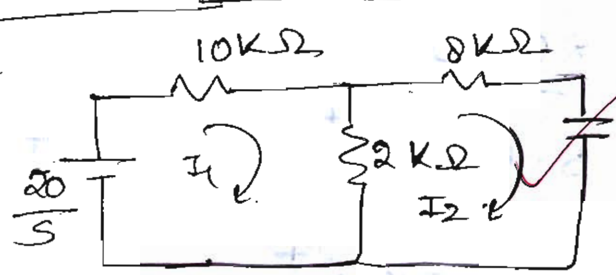
Sol:- c) i) at $t=0^-$ switch opened



$V_c(0^-)=0$ $i_c(0^-)=0$

at $t=0^+$

Laplace domain



$\frac{1}{SC} \Rightarrow \frac{10^6}{S(5)}$

In loop-1 $\frac{20}{S} - 10\times10^3 I_1 - 2\times10^3(I_1 - I_2) = 0$

$$\frac{20}{S} - 10\times10^3 I_1 - 2\times10^3 I_1 + 2\times10^3 I_2 = 0$$

$$\frac{20}{S} = 12\times10^3 I_1 - 2\times10^3 I_2 \quad \text{—(i)}$$

In loop-2 $-8\times10^3 I_2 - \frac{I_2}{SC} - 2\times10^3(I_2 - I_1) = 0$

$$-\left[10\times10^3 I_2 + \frac{I_2}{SC}\right] + 2\times10^3 I_1 = 0$$

$$\left[10\times10^3 + \frac{1}{SC}\right] I_2 = 2\times10^3 I_1$$

$$\left[\frac{S(5\times10^{-6}\times10^4)+1}{SC(2\times10^3)}\right] I_2 = I_1 \Rightarrow \frac{1 + S\times5\times10^{-2}}{\frac{S\cancel{5}\times10^{-6}\times2\times10^3}{S(10^{-2})}}$$

$$I_1 = \frac{1 + 5\times10^{-2}S}{10^{-2}S} I_2$$

$$-(i)\quad \frac{20}{S} = 12\times10^{3} I_1 - 2\times10^{3} I_2$$

$$\frac{20}{S} = \left[12\times10^{3}\left[\frac{1 + 5\times10^{-2}S}{10^{-2}S}\right] - 2\times10^{3}\right] I_2$$

$$\frac{20}{\cancel{S}} = \left[\frac{12\times10^{3} + 600S - 20S}{10^{-2}\cancel{S}}\right] I_2$$

9

$$\frac{20\times10^{-2}}{12\times10^{3} + 580S} = I_2$$

$$I_2 = \frac{3.45\times10^{-4}}{S + 20.69}$$

$$\boxed{I_2 = I_c(t) = 3.45\times10^{-4} e^{-20.69t}\ A}$$

$$V_c(S) = \frac{I}{SC} \Rightarrow \frac{3.45\times10^{-4}}{S(S+20.69)(5\times10^{-6})}$$

$$\Rightarrow \frac{69}{S(S+20.69)} = \frac{A}{S} + \frac{B}{S+20.69}$$

$$69 = AS + 20.69A + BS$$

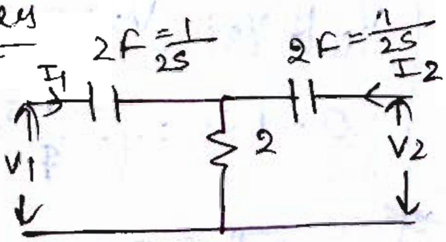
$$A + B = 0 \quad \boxed{A = -B}$$

$$\left\{\begin{array}{l} A = 3.33 \\ B = -3.33 \end{array}\right\}$$

$$\boxed{V_c(t) = 3.33\left[1 - e^{-20.69t}\right] V}$$

(ii) Y parameters

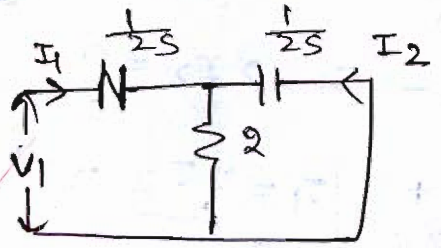
N/w - 1



$I_1 = Y_{11}V_1 + Y_{12}V_2$

$I_2 = Y_{21}V_1 + Y_{22}V_2$

Y_{11} & Y_{21} $V_2 = 0$



$$0 - \frac{I_2}{2S} - 2(I_1 + I_2) = 0$$

$$\frac{-I_2}{2S} = 2I_1 + 2I_2$$

$$\frac{-I_2}{2S} - 2I_2 = 2I_1$$

$$-\left[\frac{1+4S}{2S}\right] I_2 = 2I_1 \quad \text{(i)}$$

$$V_1 = -\left[\frac{1+4S}{2S}\right]\left[\frac{1+4S}{4S}\right] I_2 + 2I_2$$

$$V_1 = \left[\frac{-(1+4S)^2 + 16S^2}{8S^2}\right] I_2$$

$$V_1 = \left[\frac{-[1+16S^2+8S]+16S^2}{8S^2}\right] I_2$$

$$V_1 = \frac{-(1+8S)}{8S^2} I_2$$

$$Y_{21} = \frac{I_2}{V_1}\Big|_{V_2=0} \Rightarrow \boxed{\frac{-8S^2}{1+8S} = Y_{21}}$$

$$Y_{11} = \frac{I_1}{V_1}\Big|_{V_2=0}$$

for Y_{12} & Y_{22} $V_1 = 0$

$$V_1 - \frac{I_1}{2S} - 2(I_1 + I_2) = 0$$

$$V_1 = \left(\frac{1}{2S} + 2\right) I_1 + 2I_2$$

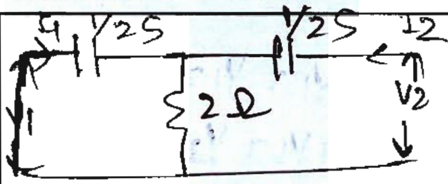
$$\cancel{V_1 = \left[\frac{1+4S}{2S}\right]\left[\frac{1+4S}{4S}\right] I_2}$$

$$V_1 = \frac{1+4S}{2S} I_1 + 2\left[\frac{4S}{1+4S}\right]$$

$$V_1 = \frac{(1+4S)^2 - 16S^2}{2S(1+4S)} I_1$$

$$\frac{2S+8S^2}{1+16S^2+8S-16S^2} = \frac{I_1}{V_1}$$

$$\boxed{\frac{2S+8S^2}{1+8S} = Y_{11}}$$



$$0 - \frac{I_1}{2s} - 2(I_1 + I_2) = 0$$

$$-\frac{I_1}{2s} - 2I_1 - 2I_2 = 0$$

$$-\left[\frac{1+4s}{2s}\right] I_1 = 2I_2 \quad (1)$$

$$V_2 - \frac{I_2}{2s} - 2(I_1 + I_2) = 0$$

$$V_2 = \frac{I_2}{2s} + 2(I_1 + I_2)$$

$$V_2 = 2I_1 + \frac{1+4s}{2s} I_2$$

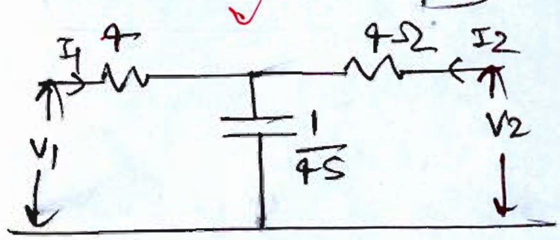
$$V_2 = -2\left[\frac{4s}{1+4s}\right] + \left[\frac{1+4s}{2s}\right] I_2$$

$$V_2 = \left[\frac{-16s^2 + 1 + 8s + 16s^2}{2s(1+4s)}\right] I_2$$

$$\frac{2s + 8s^2}{1+8s} = \frac{I_2}{V_2} = Y_{22}$$

$$Y_1 = \begin{bmatrix} \frac{2s+8s^2}{1+8s} & \frac{-8s^2}{1+8s} \\ \frac{-8s^2}{1+8s} & \frac{2s+8s^2}{1+8s} \end{bmatrix}$$

$Y_2 \Rightarrow$



Y_{11} & Y_{21} $\quad \underline{V_2 = 0}$

$$0 - 4I_2 - \left(\frac{I_1 + I_2}{4s}\right) = 0$$

$$-4I_2 - \frac{I_2}{4s} = \frac{I_1}{4s}$$

$$\frac{I_1}{4s} = -\left[\frac{16s+1}{4s}\right] I_2$$

$$I_1 = -(16s+1) I_2$$

7

$$V_1 - 4I_1 - \frac{(I_1 + I_2)}{4s} = 0$$

$$V_1 = 4I_1 + \frac{(I_1 + I_2)}{4s}$$

$$\cancel{V_1} = 4\left[\cancel{-16s-1}\right] + \cancel{1}$$

$$V_1 = \left[\frac{16s+1}{4s}\right] I_1 + \frac{I_2}{4s}$$

$$V_1 = \left[\left(\frac{16s+1}{4s}\right)^2 + \frac{1}{4s}\right] I_2$$

$$V_1 = \frac{1 - [1 + 256s^2 + 32s]}{4s}$$

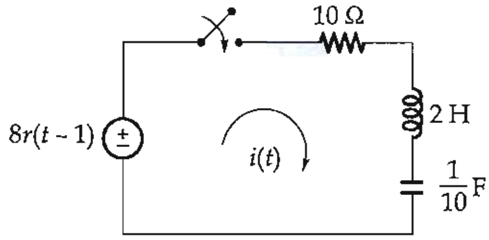
$$\frac{4s}{-[256s^2 + 32s]} = \frac{I_2}{V_1}$$

$$\boxed{Y_{21} = \frac{-1}{64s + 8}}$$

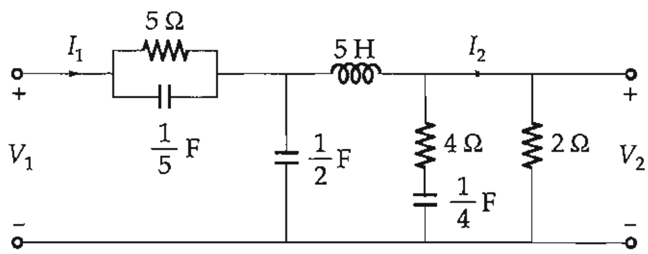
$$Y = \begin{bmatrix} \frac{8s^2 + 4s + 1/8}{1+8s} & \frac{-\frac{1}{8} - 8s^2}{1+8s} \\ \frac{-\frac{1}{8} - 8s^2}{1+8s} & \frac{8s^2 + 4s + 1/8}{1+8s} \end{bmatrix}$$

4

Q.7 (a) **(i)** For the network shown, determine the current $i(t)$ when the switch is closed at $t = 0$ with zero initial conditions.



(ii) Determine the voltage ratio $\frac{V_2}{V_1}$, current ratio $\frac{I_2}{I_1}$, transfer impedance $\frac{V_2}{I_1}$ and driving point impedance $\frac{V_1}{I_1}$ for the network shown in figure.



[5 + 15 marks]

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Q.7 (b) (i) The Fourier transform of the signal $x(t)$ is given by,

$$X(\omega) = \frac{d}{d\omega}\left[4\sin(4\omega)\frac{\sin(\omega/4)}{\omega}\right]$$

By using the properties of Fourier transform, determine and plot the signal $x(t)$.

(ii) Given that $x(t)$ has the Fourier transform $X(\omega)$. Express the Fourier transform of the following signals in terms of $X(\omega)$:

$$x_1(t) = x(1-t) + x(-1-t)$$

$$x_2(t) = x(3t-6)$$

$$x_3(t) = \frac{d^2}{dt^2}x(t-1)$$

[10 + 10 marks]

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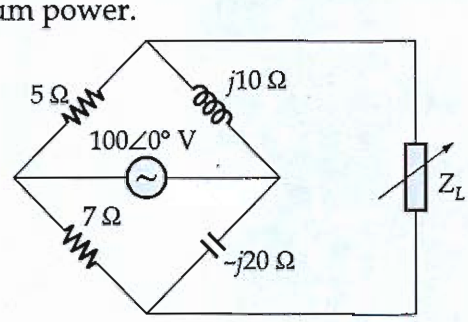
Do not write in this margin

Q.7 (c) A control system has a transfer function given by $G(s) = \dfrac{s+3}{(s+1)(s+2)^2}$. Using the method of parallel decomposition, draw the state diagram with minimum number of integrators. Also obtain the state model.

[20 marks]

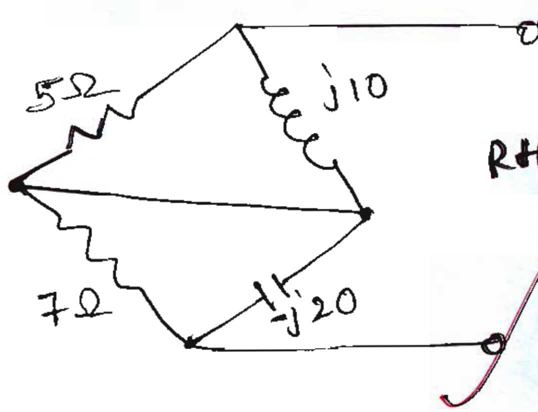
Q.8 (a) Find the value of Z_L for maximum power transfer in the network shown and also, calculate the maximum power.



[15 marks]

Sol^n^ Apply thevenin's theorem,

Rth calculated by S.C the voltage source



$$R_{th} \Rightarrow 5 \,||\, 10j + 7 \,||\, -j20$$

$$\Rightarrow \frac{5 \times 10j}{5+10j} + \frac{7 \times -j20}{7-j20}$$

$$\Rightarrow \frac{[50j][5-10j]}{(5+10j)(5-10j)} + \frac{-140j}{7-j20}$$

$$\Rightarrow \frac{250j+500}{125} + \frac{(-140j)(7+j20)}{(7-j20)(7+j20)}$$

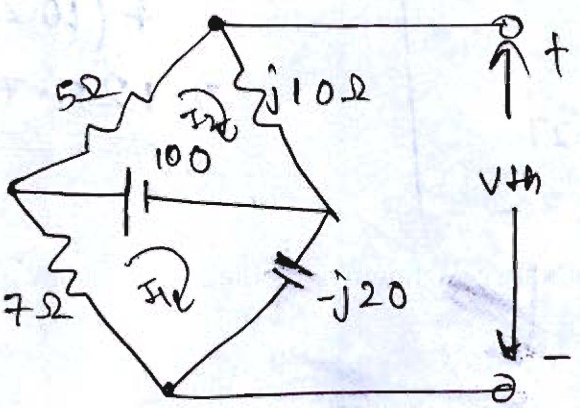
$\Rightarrow 4+2j + \left[\dfrac{-980j - j^2 2800}{49+400}\right]$

$\Rightarrow 4+2j + 6.23 - 2.18j$

$\Rightarrow 10.23 - 0.18j$

$\Rightarrow 10.23\angle -1^\circ$

Vth



$-100 + 20j\,I_1 - 7I_1 = 0$

$(20j - 7)\,I_1 = 100$ —(i)

$-10j\,I_2 + 100 - 5I_2 = 0$

$100 = (5+10j)\,I_2$ —(ii)

$V_{th} - j10\,I_2 + j20\,I_1 = 0$

$V_{th} = j10\left[\dfrac{100}{5+10j}\right] - j20\left[\dfrac{100}{20j-7}\right]$

$V_{th} = \dfrac{1000j}{5+10j} - \dfrac{2000j}{20j-7}$

$V_{th} = 80+40j - [89.08 - 31.18j]$

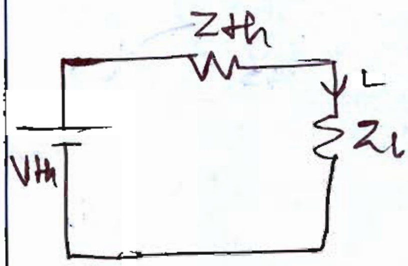
$V_{th} \Rightarrow -9.08 + 71.18j \Rightarrow 71.74\angle 97.27$

14

Good

for max power Transfer $Z_L = Z_{th}^*$

$Z_L = 10.23 + 0.18j$



$$I_L = \frac{V_{th}}{Z_{th} + Z_L}$$

$$\Rightarrow \frac{71.74\angle 97.27}{10.23 \times 2}$$

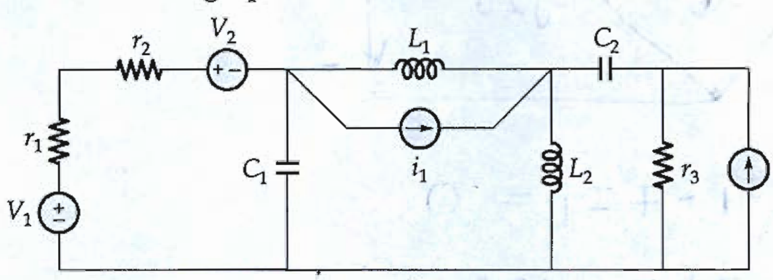
$\boxed{I_L \Rightarrow 3.506\angle 97.27 A}$

$$P_{max} \Rightarrow \frac{V_{th}^2}{4R_L}$$

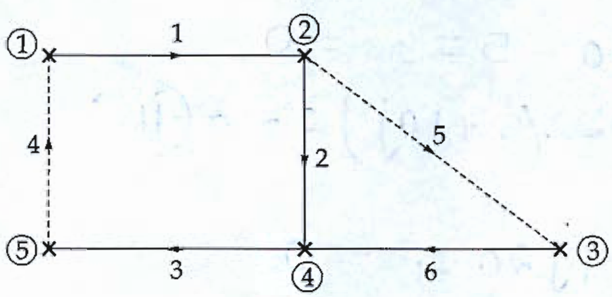
$$\Rightarrow \frac{(71.74)^2}{4(10.23)}$$

$$\Rightarrow 125.77 \omega$$

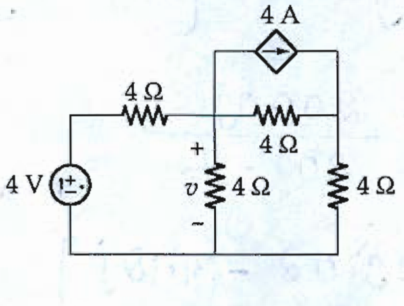
Q.8 (b) (i) Draw the oriented graph of network shown and obtain the incidence matrix.



(ii) Obtain the cutset matrix for the graph shown below:

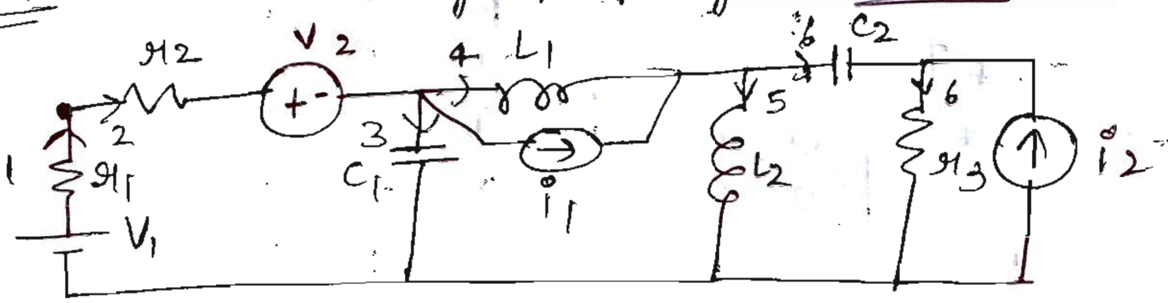


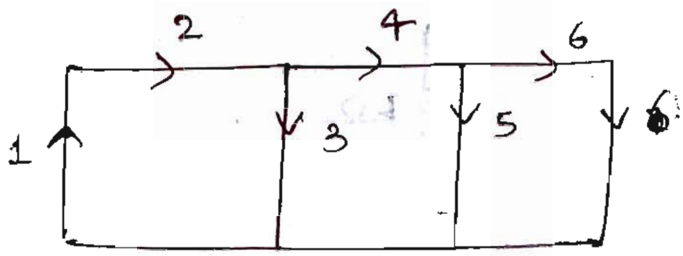
(iii) For the network shown in figure, write down the f-cutset matrix, obtain the KCL equilibrium equations in matrix form and calculate v.

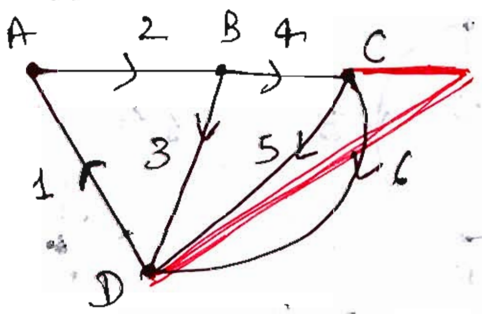


[5 + 5 + 15 marks]

8)b) i) orientented graph for given n/w



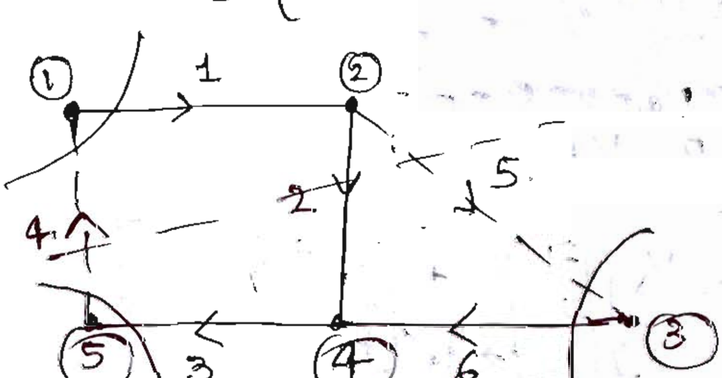




Incidence matrix

$$[A_a] = \begin{array}{c} \\ A \\ B \\ C \\ D \end{array} \begin{array}{c} \begin{matrix} 1 & 2 & 3 & 4 & 5 & 6 \end{matrix} \\ \begin{bmatrix} -1 & 1 & 0 & 0 & 0 & 0 \\ 0 & -1 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & -1 & 1 & 1 \\ 1 & 0 & -1 & 0 & -1 & -1 \end{bmatrix} \end{array}$$

8)b) iii)



node = 5

cut set = n − 1

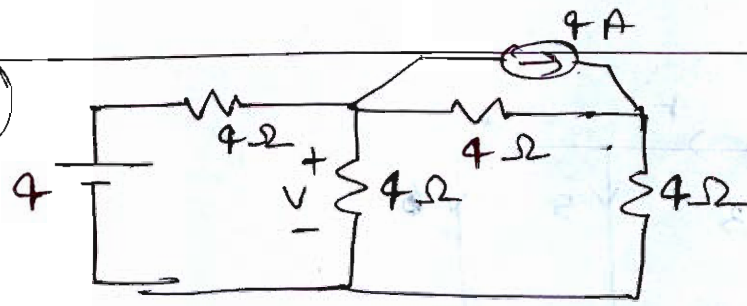
⇒ 4

cutset matrix

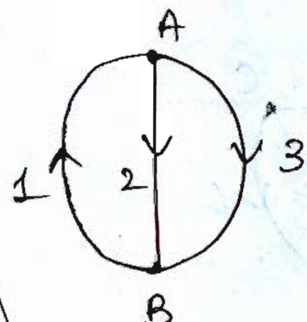
$$[C]= \begin{array}{c} \\ [1,4] \\ [3,4] \\ [5,6] \\ [2,4,5] \end{array} \begin{array}{c} \begin{array}{cccccc} 1 & 2 & 3 & 4 & 5 & 6 \end{array} \\ \begin{bmatrix} 1 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 1 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 1 \\ 0 & 1 & 0 & -1 & 1 & 0 \end{bmatrix} \end{array}$$

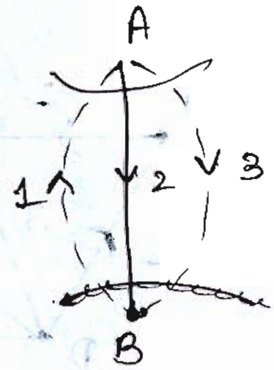
3

111



Graph





$$[C] \Rightarrow A[1,2,3] \begin{array}{c} \begin{array}{ccc} 1 & 2 & 3 \end{array} \\ \begin{bmatrix} -1 & 1 & 1 \end{bmatrix} \end{array}$$

$$[C] = \begin{bmatrix} -1 & 1 & 1 \end{bmatrix}$$

$$[Y_L][V_L] = [C][I_S] - [C][Y_B][V_S]$$

$$[Y_L] = [C][Y_B][C^T]$$

$$\Rightarrow \underset{1\times 3}{\begin{bmatrix} -1 & 1 & 1 \end{bmatrix}} \underset{3\times 3}{\begin{bmatrix} 1/4 & 0 & 0 \\ 0 & 1/4 & 0 \\ 0 & 0 & 1/8 \end{bmatrix}} \begin{bmatrix} -1 \\ 1 \\ 1 \end{bmatrix}$$

$$\Rightarrow \underset{1\times 3}{\begin{bmatrix} -1/4 & 1/4 & 1/8 \end{bmatrix}} \underset{3\times 1}{\begin{bmatrix} -1 \\ 1 \\ 1 \end{bmatrix}} \Rightarrow \begin{bmatrix} \frac{1}{4} + \frac{1}{4} + \frac{1}{8} \end{bmatrix}$$

$$\Rightarrow \frac{5}{8}$$

$$\left[\frac{5}{8}\right][V] = \begin{bmatrix}-1 & 1 & 1\end{bmatrix}\begin{bmatrix}0\\0\\-4\end{bmatrix} - \begin{bmatrix}\frac{-1}{4} & \frac{1}{4} & \frac{1}{8}\end{bmatrix}\begin{bmatrix}4\\0\\0\end{bmatrix}$$

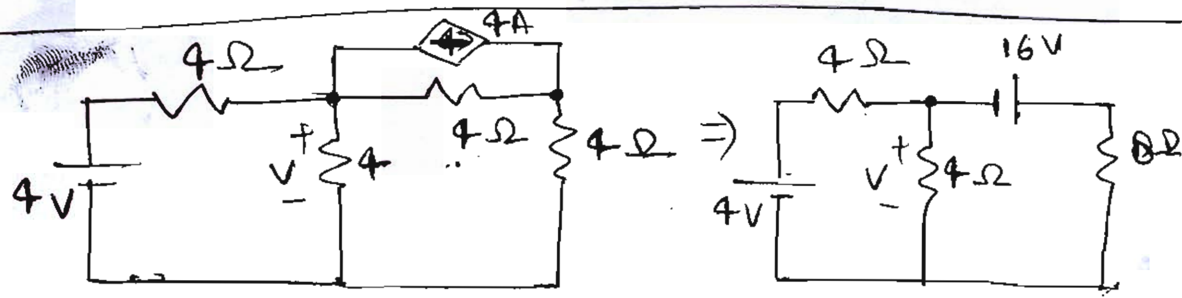
$$\frac{5}{8}V = -4 - [-1]$$

$$\frac{5}{8}V = -4+1$$

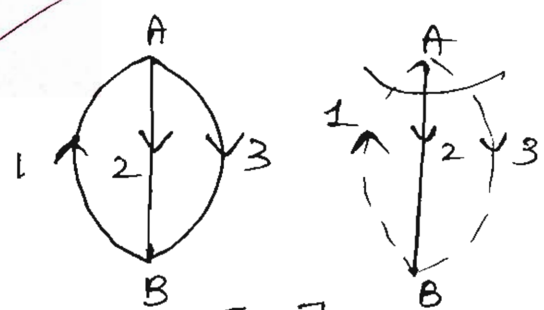
$$\frac{5V}{8} = -3$$

$$V = \frac{-24}{5}$$

$$\boxed{V = -4.8}$$



Graph



$$[C] = \begin{bmatrix}-1 & 1 & 1\end{bmatrix}$$

$$[Y_L][V_L] = [C][I_s] - [C][Y_B][V_s]$$

$$[Y_L] \Rightarrow [C][Y_B][C^T]$$

$$\Rightarrow \begin{bmatrix}-1 & 1 & 1\end{bmatrix}\begin{bmatrix}1/4 & 0 & 0\\0 & 1/4 & 0\\0 & 0 & 1/8\end{bmatrix}\begin{bmatrix}-1\\1\\1\end{bmatrix}$$

$$\Rightarrow \begin{bmatrix}-1/4 & \frac{1}{4} & \frac{1}{8}\end{bmatrix}\begin{bmatrix}-1\\1\\1\end{bmatrix} \Rightarrow \left[\frac{1}{4}+\frac{1}{4}+\frac{1}{8}\right] \Rightarrow \frac{5}{8}$$

$$\left[\frac{5}{8}\right][V] = \begin{bmatrix}-1 & 1 & 1\end{bmatrix}\begin{bmatrix}0\\0\\0\end{bmatrix} - \begin{bmatrix}\frac{-1}{4} & \frac{1}{4} & \frac{1}{8}\end{bmatrix}_{1\times 3}\begin{bmatrix}4\\0\\16\end{bmatrix}_{3\times 1}$$

$$\left[\frac{5}{8}\right][V] = 0 - \left[-1+2\right]$$

$$V = \frac{-8}{5}$$

$$\boxed{V = -1.6\ v}$$

Try to show some steps

12

8 (c) (i) Write an 8085 assembly language program to store the content of its flag register in the memory location 3000 H.

(ii) Write an 8085 assembly language program to clear 150 consecutive bytes starting from memory location 2400 H.

(iii) Describe the following instructions of 8085 microprocessor:
1. SBI 2. SHLD 3. RAR 4. SPHL 5. DAD

[5 + 5 + 10 marks]

Sol

Soln 8) c) i) Program ~~to the~~ store the content of its flag reg in the mem location 3000H.

PSW

A	Flag

~~POP PSW~~;

Push PSW.

LXI H;

POP H;

MOV A, L;

STA 3000H;

HLT

ii) clear 150 consecutive bytes starting from memory location 2400H.

```
      LXI H, 2400H;
      MVI C, 150H;  → 96H
      MVI A, 00;
Start; CLR;
      INX H;
      DCR C;
      JNZ start;
      HLT
```

2

8)c)iii) 1) SBI :- Substract Immidiate with borrow

It is of 2 byte Instruction.

Imediate addressing mode.

all flag affected.

7T States (2MC cycle used)

2) SHLD :- Store HL pair direct

3 byte Instruction.

16 T States (5MC cycle)

no flag affected.

Direct addressing mode

3) RAR :- Rotate right with carry.

1byte Instruction

4T States (1MC)

no flag affected only CY

Impllied add modes.

4) SPHL :- Top of stack in HL reg pair.

1 byte Instruction.

6 T States

reg add mode.

no flags affected.

Do not write in this margin

5) DAD → double Addition with rp
rp ← rp + [0001]
1 byte questions.
10 T states.
only cy not affected
reg addressing mode.

7

$$4s^3 - 4s^2 - 4s - \left[\begin{array}{l} s^4 + s^3 + 4s^2 + 4s \\ + 4s + 4 \end{array}\right]$$

$$\frac{4s^3 - 4s^2 - 4s - s^4 - s^3 - 4s^2 - 8s - 4]}{s^3 + 4s + 4}$$

$-I_1 + i(t) + I_2$

$$\left[\frac{-s^4 + 3s^3 - 8s^2 - 12s - 4}{s^3 + 4s + 4}\right] I_1 = 4$$

$i(t) = I_1 - I_2$

$$I_1 = \frac{4s^3 + 16s + 16}{-(s^4 - 3s^3 + 8s^2 + 12s + 4}$$

$$I_1 \Rightarrow \frac{-4s^3 - 16s + 16}{s^4 - 3s^3 + 8s^2 + 12s + 4} \quad \frac{-4s^2 - 4s - 4}{s^3 + 4s + 4}$$

$$v(t) = \frac{I_2}{sC} \Rightarrow \frac{4}{s}\left[\frac{4s^2 - 4s - 4}{s^3 + 4s + 4}\right].$$

$$\Downarrow$$

$s + 0.847$

Space for Rough Work

$Y_{11} = [$

$V_1 - 4I_1 - \frac{(I_1 + I_2)}{4s} = 0$

$V_1 = 4I_1 + \frac{I_1}{4s} + \frac{I_2}{4s}$

$V_1 = \left[\frac{16s+1}{4s}\right] I_1 + \frac{I_2}{4s}$

$V_1 = \left[\frac{16s+1}{4s}\right] I_1 + \frac{1}{4s}\left(\frac{1}{16s+1}\right) I_1$

$\frac{(16s+1)}{4s} - \frac{1}{(16s+1)4s}$

$\frac{(16s+1)^2 - 1}{(16s+1)4s}$

$\frac{256s^2 \cancel{+1} + 32s \cancel{-1}}{(16s+1)(4s)} I_1$

$\frac{I_1}{V_1} = \frac{\cancel{(4s)}(16s+1)}{256s^2+32s}$.

$\boxed{Y_{11} = \frac{16s+1}{64s+8}}$

$\frac{16s+1}{64s+8} + \frac{2s+8s^2}{1+8s}$.

$\frac{\frac{16s+1}{8} + 2s+8s^2}{1+8s}$.

$\frac{2s + \frac{1}{8} + 2s + 8s^2}{1+8s}$.

$\left[\frac{4s + 8s^2 + 0.125}{1+8s}\right]$

-8

$Y_{12} \Rightarrow Y_{21} =$

$\frac{-1}{64s+8} - \frac{8s^2}{1+8s}$

$\frac{-1/8 - 8s^2}{1+8s}$.

Space for Rough Work

$$-14\times10^3 j - 4\times10^4 j^2$$

$$\frac{4\times10^4 - 14\times10^3 j}{449}$$

$$\frac{(2\times10^3 j)(-7-20j)}{(-7-20j)(20j-7)}$$

$$-\cancel{140}j - 400j^2 + 49 + \cancel{140}j$$

$$449$$

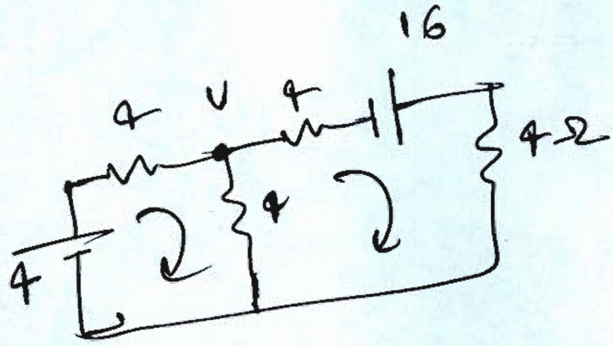
$$\frac{10^3 j\,[5-10j]}{25+\cancel{50j}-\cancel{50j}-100j^2}$$

$$\frac{5\times10^3 j - 10^4 j^2}{125}$$

$$\Rightarrow \frac{5\times10^3 j + 10^4}{125}$$

$$\Rightarrow 80 + 40j$$

Space for Rough Work



$$\frac{V-4}{4} + \frac{V}{4} + \frac{V+16}{8}$$

$$\frac{2V}{4} + \frac{V}{8} = 1-2$$

$$\frac{4V+V}{8} \Rightarrow -1$$

$$5V = -8$$

$$V = \frac{-8}{5}$$

$$V = -1.6$$