TEST 3:-

DIGITAL & ANALOG COMMUNICATION

NETWORKTHEORY1+MICROPROCESSOR

MICROCONTROLLER1+

DIGITAL2&CONTROLSYSTEM2

1(i)(a)

Given $f(x,y) = c(x+y)$

and $0 < x < 3$, $x < y < x+2$

Value of intregral of joint probility

$$\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x,y) = 1$$

$$\Rightarrow \int_{x=0}^{3}\int_{y=x}^{x+2} [c(x+y)\, dy]\, dx = 1$$

$$\Rightarrow c\int_{x=0}^{3} [xy + y^2/2]_{y=x}^{y=x+2}\, dx = 1$$

$$\Rightarrow c\int_{x=0}^{3} [x\{x+2-x\} + \frac{(x+2)^2 - x^2}{2}]\, dx = 1$$

$$\Rightarrow c\int_{0}^{3} (2x + 2x + 2)\, dx = 1$$

$$\Rightarrow c\left[\frac{4x^2}{2} + 2x\right]_0^3 = 1$$

$$\Rightarrow c[2\{9-0\} + 2(3-0)] = 1$$

$$\Rightarrow c = \frac{1}{24}$$

(i) $P(X<1, Y<2) = \int_{-\infty}^{1}\int_{-\infty}^{2} f(x,y)\, dy\, dx$

$$= \int_{x=0}^{1}\int_{y=x}^{2} \frac{1}{24}(x+y)\, dy\, dx$$

$$= \frac{1}{24}\int_{x=0}^{1} [xy + y^2/2]_x^2\, dx$$

$$= \frac{1}{24}\int_{x=0}^{1} \left[x(2-x) + \frac{4-x^2}{2}\right] dx.$$

$$= \frac{1}{24}\left[\frac{2x^2}{2} - \frac{x^3}{3} + 2x - \frac{x^3}{6}\right]_0^1$$

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$$P(x<1, y<2) = \frac{1}{24}\left[1-\frac{1}{3}+2-\frac{1}{6}\right]$$

$$= \frac{1}{24}\,\frac{6-2+12-1}{6} = 5/48$$

$$\boxed{P(x<1, y<2) = 0.104167}$$

(ii)

$$E(x) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} x\, f(x,y)\, dy\, dx.$$

$$= \int_{x=0}^{3}\int_{y=x}^{x+2} \frac{x(x+y)}{24}\, dy\, dx$$

$$= \frac{1}{24}\int_{x=0}^{3}\left[\int_{y=x}^{x+2}(x^2+xy)\, dy\right] dx$$

$$= \frac{1}{24}\int_{x=0}^{3}\left[x^2y+\frac{xy^2}{2}\right]_{x}^{x+2} dx.$$

$$= \frac{1}{24}\int_{x=0}^{3}\left[x^2(x+2-x)+\frac{x}{2}\{(x+2)^2-x^2\}\right] dx$$

$$= \frac{1}{24}\int_{x=0}^{3}(2x^2+2x^2+2x)\, dx$$

$$= \frac{1}{24}\left[\frac{4x^3}{3}+\frac{2}{2}x^2\right]_0^3$$

$$= \frac{1}{24}\left[\frac{4}{3}\times(27-0)+(9-0)\right] = \frac{45}{24}$$

$$\boxed{E(x) = 1.875}$$

(1)(b) Given ~~At~~ $m_a = 0.7071$

(i) Total power ~~in~~ of AM signal

$$P_c\left(1+\frac{m_a^2}{2}\right) = 50\times10^3$$

$$\Rightarrow P_c = \frac{50\times10^3}{1+\frac{0.7071^2}{2}} = 40\times10^3$$

Carrier power $\boxed{P_c = 40\text{ kW}}$

(ii) Transmission efficiency

$$\eta = \frac{m_a^2}{2+m_a^2}$$

$$= \frac{0.7071^2}{2+0.7071^2} = 0.2$$

$$\boxed{\eta = 20\%}$$

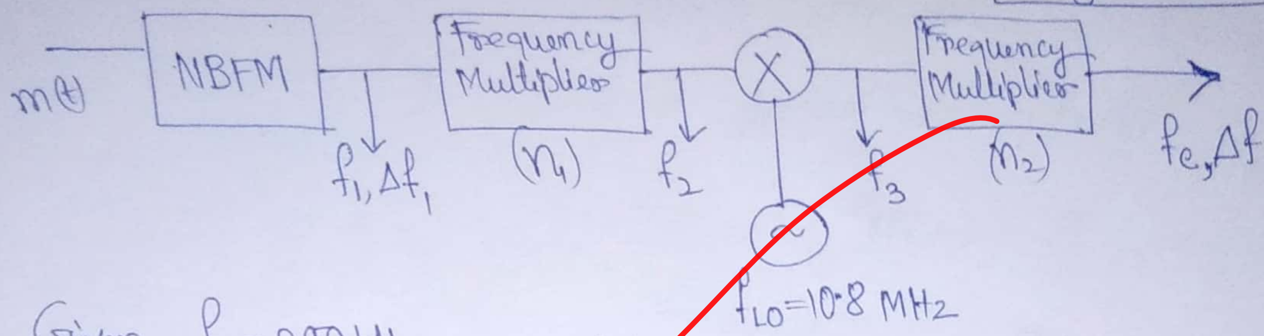
(iii) Power of Modulated signal

$$\frac{A_{max}^2}{2\times R} = 50\times10^3$$

$$\Rightarrow A_{max} = \sqrt{50\times10^3\times2\times50} = 2.236\text{ kV}$$

Peak amplitude of modulated Carrier $\boxed{A_{max} = 2.236\text{ kV}}$

(1)(c) Redrawn the given figure,



Given $f_1 = 200$ kHz, $n_1 = 64$, $n_2 = 48$, $\Delta f_1 = 25$ Hz.

(i) The maximum frequency deviation

$$\Delta f = n_1 \times n_2 \times \Delta f_1 = 64 \times 48 \times 25 \text{ Hz}$$

$$\boxed{\Delta f = 76.8 \text{ kHz}}$$

(ii) The frequency $f_2 = n_1 \times f_1 = 64 \times 200$ kHz

$$f_2 = 12.8 \text{ MHz}$$

And the frequency $f_3 = f_2 - f_{LO} = (12.8 - 10.8)$ MHz

$$\Rightarrow \boxed{f_3 = 2 \text{ MHz}}$$

(iii) The carrier frequency

$$f_c = n_2 \times f_3 = 48 \times 2 \text{ MHz}$$

$$\boxed{f_c = 96 \text{ MHz}}$$

(1)(d) Given $s(t) = \begin{cases} s_1(t) = A\sin\left(\frac{\pi t}{T}\right); & 0 \le t \le T \\ s_2(t) = 0 ; & 0 \le t \le T \end{cases}$ Page 5

~~Energy of~~ $s_1(t)$

$$E_p = \cancel{\frac{A^2}{4}T} = \int_0^T \left[A\sin\left(\frac{\pi t}{T}\right)\right]^2 dt = \frac{A^2}{2}\int_0^T \left(1 - \cos\frac{2\pi t}{T}\right) dt$$

$$= \left[\frac{A^2}{2} t - \frac{\sin\frac{2\pi t}{T}}{\frac{2\pi}{T}}\right]_0^T$$

$$E_p = \frac{A^2}{2} T$$

And Energy of $E_q = 0$.

Average bit ~~me~~ energy

$$E_b = \cancel{\frac{E_p + E_q}{2} = \frac{A^2T}{4}}$$

$$= [P(s_1)E_p + P(s_2)E_q] = 0.5 \times \frac{A^2T}{2} + 0.5 \times 0$$

$$= \frac{A^2T}{4}$$

$$d_{min}^2 = \frac{A^2T}{2} = 2E_b$$

Probability error for noise $\eta/2 = 10^{-15}$

$$P_e = Q\left(\sqrt{\frac{d_{min}^2}{2\eta}}\right) = Q\left(\sqrt{\frac{2E_b}{2\eta}}\right)$$

$$P_e = Q\left(\sqrt{\frac{E_b}{\eta}}\right) = Q\left(\sqrt{\frac{\frac{A^2T}{4}}{2\times10^{-15}}}\right)$$

$$P_e = Q\left(\sqrt{\frac{(2\times10^{-3})^2 \times 2\times10^{-6}}{4\times2\times10^{-15}}}\right) = Q(\sqrt{5})$$

$$\boxed{P_e = Q(2.236)}$$

(1)(e) Given Signal, with $A = 1v$ and $f_m = 10\,kHz$, let assume

$$m(t) = A \sin 2\pi \times 10^4 t$$

And Sampling frequency $f_s = 10 \times (\text{Nyquist rate})$

$$= 10 \times (2 \times 10^4)$$

$$= 2 \times 10^5 \text{ Hz.}$$

(i) To prevent ~~a~~ Slope Overload

$$\frac{\Delta}{T_s} \geq \left\{ \frac{d}{dt} m(t) \right\}_{max}$$

$$\Rightarrow \frac{\Delta}{T_s} \geq \left\{ \frac{d}{dt} \left[A \sin(2\pi \times 10^4 t) \right] \right\}_{max}$$

$$\Rightarrow \frac{\Delta}{T_s} \geq \left\{ A\, 2\pi \times 10^4 \left(\cos 2\pi \times 10^4 t \right) \right\}_{max}$$

$$\Rightarrow f_s \cdot \Delta \geq 2\pi \times 10^4 \qquad \left[\because A = 1v \text{ and } f_s = \frac{1}{T_s} \right]$$

$$\Rightarrow \Delta \geq \frac{2\pi \times 10^4}{2 \times 10^5}$$

$$\Rightarrow \Delta \geq 0.314 \text{ V}$$

Δ can be chosen as ~~$\Delta = 0.32\,V$~~ $\Delta = 0.31416\,V$

(ii) Signal power $S = \frac{A^2}{2} = \frac{1}{2} W$ [let the load $= 1\Omega$]

Noise Power $= \frac{\Delta^2}{12}$ [Consider the uniform distribution]

$$N = 8.22467 \times 10^{-3}\, W.$$

Corresponding $SNR = \frac{S}{N} = \frac{\frac{1}{2}}{8.22467 \times 10^{-3}} = 60.8$

$$\boxed{SNR = 17.84\,dB}$$

3) (a) (i) Given $m(t) = \text{Sinc}\, t + \text{Sinc}^2 t$

$$= \frac{\sin \pi t}{\pi t} + \frac{\sin^2 \pi t}{(\pi t)^2}$$

let assume Carrier signal

$$c(t) = A_c \cos 2\pi f_c t$$

Modulated signal,

$$s(t) = m(t) \cdot c(t)$$

$$= A_c \frac{\sin \pi t}{\pi t} \cos 2\pi f_c t + A_c \frac{\sin^2 \pi t}{\pi^2 t^2} \cos 2\pi f_c t$$

$$= \frac{A_c}{2\pi t}\left[\sin(2\pi f_c + \pi)t - \sin(2\pi f_c - \pi)t\right]$$

$$+ \frac{A_c}{2\pi^2 t^2}(1 - \cos 2\pi t)\cos 2\pi f_c t$$

$$= \frac{A_c}{2\pi t}\left[\sin(2\pi f_c + \pi t) - \sin(2\pi f_c - \pi)t\right] + \frac{A_c}{2\pi^2 t^2}\cos 2\pi f_c t$$

$$- \frac{A_c}{4\pi^2 t^2}\left[\cos(2\pi f_c + 2\pi)t + \cos(2\pi f_c - 2\pi)t\right]$$

$$= \frac{A_c}{2\pi t}\left[\sin 2\pi\left(f_c + \tfrac{1}{2}\right)t - \sin 2\pi\left(f_c - \tfrac{1}{2}\right)t\right] + \frac{A_c}{2\pi^2 t^2}\cos 2\pi f_c t.$$

$$- \frac{A_c}{4\pi^2 t^2}\left[\cos 2\pi(f_c + 1)t + \cos 2\pi(f_c - 1)t\right]$$

Maximum frequency present in $s(t)$

$$f_{max} = (f_c + 1) \text{ Hz}.$$

Minimum frequency Present in $s(t)$

$$f_{min} = (f_c - 1) \text{ Hz}.$$

Required bandwidth of the bandpass filter

$$\boxed{BW = (f_c + 1) - (f_c - 1) = 2 \text{ Hz}}$$

(3) (a) (ii) Given

$$s_{PM}(t) = A\cos(\omega_c t + k_p m(t))$$

$$f_{LO} = \sin((\omega_c - \Delta\omega)t - \phi(t))$$

Output of the multiplier

$$s'_{pm}(t) = A\cos(\omega_c t + k_p m(t)) \cdot \sin((\omega_c - \Delta\omega)t - \phi(t))$$

$$= \frac{A}{2}\sin[(\omega_c - \Delta\omega + \omega_c)t + k_p m(t) - \phi(t)]$$

$$+ \frac{A}{2}\sin[-\Delta\omega t - \phi(t) - k_p m(t)]$$

Output of the Band pass filter

$$s''(t) = -\frac{A}{2}\sin[\Delta\omega t + \phi(t) + k_p m(t)]$$

Output of the differentiator

$$s'''(t) = \frac{d}{dt}s''(t) = -\frac{A}{2}\cos[\Delta\omega t + \phi(t) + k_p m(t)] \times (\Delta\omega + \phi'(t) + k_p m'(t))$$

Output of the Envolop detector,

$$s''''(t) = \frac{A}{2}(k_p m'(t) + \Delta\omega + \phi'(t))$$

Then,

$$y(t) = \int s''''(t) = \frac{A}{2}\int(k_p m(t) + \Delta\omega t + \phi(t))\,dt.$$

$$= \frac{A}{2}[k_p m(t) + \Delta\omega t + \phi(t)]$$

Auto Correlation function of noise $\phi(t)$;

$$R_\phi(\tau) = 10^{-4}e^{-0.005|\tau|}$$

SFD of $\phi(t)$

$$S(\omega) = F[R_\phi(\tau)] = \frac{10^{-4}\times 2\times 0.005}{\omega^2 + 0.005^2} = \frac{10^{-6}}{\omega^2 + 0.005^2}$$

Noise power

$= \cancel{S} \; SFD \times \text{Bandwidth}$

$= S(\omega) \times \Delta\omega$

$$N = \frac{10^{-6}\,\Delta\omega}{\omega^2 + 0.005^2}$$

SNR at output

$$(SNR)_o = \frac{S}{N} = \frac{P_m}{\frac{10^{-6}\,\Delta\omega}{\omega^2+0.005^2}} = \left(\frac{\omega^2+0.005^2}{\Delta\omega}\right) 10^6$$

$$\boxed{SNR = \frac{\omega^2+0.005^2}{\Delta\omega}\, 10^6}$$

3 (b)

Given $f(x,y) = \begin{cases} \frac{3}{2}(x^2+y^2) & 0<x<1,\ 0<y<1 \\ 0 & ;\ \text{otherwise} \end{cases}$

$$E(X) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} x\, f(x,y)\, dx\,dy = \int_0^1\int_0^1 \frac{3x}{2}(x^2+y^2)\, dx\,dy$$

$$= \frac{3}{2}\int_0^1 x\left[x^2 y + \frac{y^3}{3}\right]_0^1 dx$$

$$= \frac{3}{2}\int_0^1 x\left[x^2 + \frac{1}{3}\right] dx$$

$$= \frac{3}{2}\int_0^1 \left(x^3 + \frac{x}{3}\right) dx = \frac{3}{2}\left[\frac{x^4}{4} + \frac{x^2}{6}\right]_0^1$$

$$E(X) = \frac{3}{2}\times\left[\frac{1}{4}+\frac{1}{6}\right] = \frac{3\times(3+2)}{24} = \frac{5}{8}$$

$$E(Y) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} y\, f(x,y)\, dx\,dy = \frac{3}{2}\int_0^1\int_0^1 y(x^2+y^2)\, dx\,dy$$

$$= \frac{3}{2}\int_0^1 \left[\frac{x^2y^2}{2} + \frac{y^4}{4}\right]_0^1 dx = \frac{3}{2}\int_0^1\left(\frac{x^2}{2}+\frac{1}{4}\right) dx$$

$$= \frac{3}{2}\left[\frac{x^3}{6} + \frac{x}{4}\right]_0^1 = \frac{3}{2}\times\frac{(3+2)}{2\times 6} = \cancel{\frac{8}{4}} \cdot \frac{5}{8}$$

$$E(XY) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} xy\, f(x,y)\, dx\, dy$$

$$= \frac{3}{2}\int_0^1\int_0^1 xy(x^2+y^2)\, dx\, dy = \frac{3}{2}\int_0^1 \left(\frac{x^3y^2}{2} + \frac{xy^4}{4}\right)_0^1 dx$$

$$= \frac{3}{2}\int_0^1 \left(\frac{x^3}{2} + \frac{x}{4}\right) dx = \frac{3}{2}\left[\frac{x^4}{8} + \frac{x^2}{8}\right]_0^1$$

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

$$E(X^2) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} x^2 f(x,y)\, dx\, dy = \frac{3}{2}\int_0^1\int_0^1 x^2(x^2+y^2)\, dx\, dy$$

$$= \frac{3}{2}\int_0^1 \left[x^4 y + \frac{x^2y^3}{3}\right]_0^1 dx = \frac{3}{2}\int_0^1 \left[x^4 + \frac{x^2}{3}\right] dx$$

$$= \frac{3}{2}\left[\frac{x^5}{5} + \frac{x^3}{9}\right]_0^1 = \frac{3}{2}\,\frac{(9+5)}{45} = \frac{7}{15}$$

$$E[Y^2] = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} y^2 f(x,y)\, dx\, dy = \frac{3}{2}\int_0^1\int_0^1 y^2(x^2+y^2)\, dx\, dy$$

$$= \frac{3}{2}\int_0^1 \left[\frac{x^2y^3}{3} + \frac{y^5}{5}\right]_0^1 dx = \frac{3}{2}\int_0^1 \left(\frac{x^2}{3} + \frac{1}{5}\right) dx$$

$$= \frac{3}{2}\left[\frac{x^3}{9} + \frac{x}{5}\right]_0^1 = \frac{3}{2} \times \frac{(5+9)}{45} = \frac{7}{15}$$

$$\mathrm{Cov}[x,y] = \sigma_{xy} = E(XY) - E(X)E(Y) = \frac{3}{8} - \frac{5}{8}\times\frac{5}{8}$$

$$= \frac{24-15}{8\times 8} = \frac{9}{64}$$

$$\sigma_x = \sqrt{E(x^2) - [E(x)]^2} = \sqrt{\frac{7}{15} - \left(\frac{5}{8}\right)^2} = \sqrt{\frac{73}{960}}$$

$$\sigma_y = \sqrt{E(Y^2) - [E(Y)]^2} = \sqrt{\frac{7}{15} - \left(\frac{5}{8}\right)^2} = \sqrt{\frac{73}{960}}$$

Correlation function $\rho_{xy} = \frac{\mathrm{Cov}[X,Y]}{\sigma_x \sigma_y} = \frac{\frac{9}{64}}{\sqrt{\frac{73}{960}} \times \sqrt{\frac{73}{960}}} = \frac{135}{73} = 1.8493$

$$\boxed{\rho_{xy} = 1.8493}$$

3) (C) Sampling rate $= 1.25 \times \cancel{\phi}$ (Nyquist rate)

$= 1.25 \times 2 \times 4$ kHz

$f_s = 10$ kHz

Quantization level $L = 2^n = 256 = 2^8$

Quantized bit $n = 8$

(i) Information rate $= 10 \times 8 = 80$ kbps

(ii) For n-bit quantizer, typical SNR in dB

$$1.76 + 6.02n \geq 20$$

$$\Rightarrow \quad n \geq 3.03$$

If we choose $n \cong 3$

Information rate $r = n \times f_s = 3 \times 10 = 30$ kbps

Minimum required BW $= \frac{r}{2} = \frac{30}{2} = 15$ kHz.

Corresponding output cannot be transferred with bandwidth of 10 kHz and (S/N) ratio of 20dB.

(iii) For minimum (BW) $= \frac{r}{2} = 10$ kHz

$r = 20$ kHz

Quantized bit $n = \frac{r}{f_s} = \frac{20}{10} = 2$

SNR $= 1.76 + 6.02 \times n = 13.8$ dB.

(iv) For n-bit quantizer SNR

$$1.76 + 6.02n \geq 20$$

$$\Rightarrow n \geq 3$$

$$\therefore n = 3$$

Information rate $r = nf_s = 3\times10 = 30$ kHz

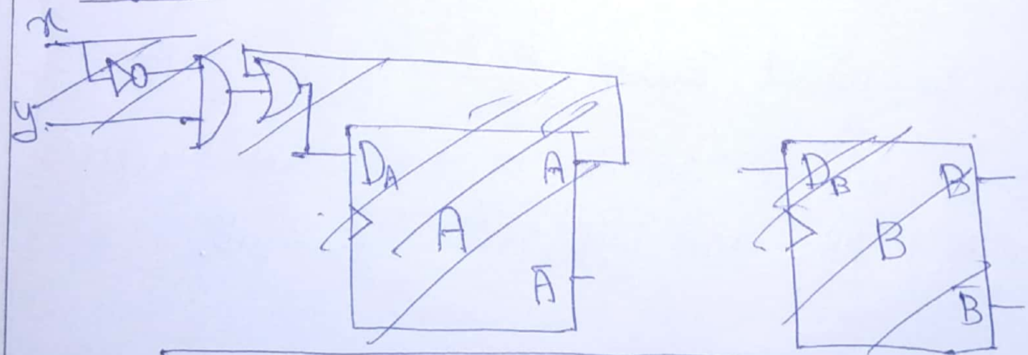
Minimum required BW $= \frac{r}{2} = 15$ kHz

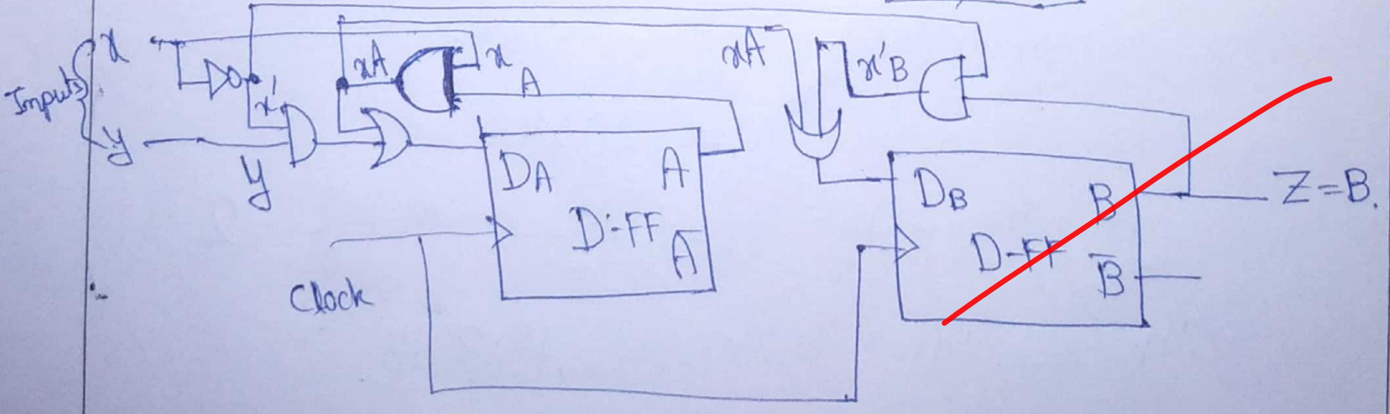
SECTION-2

(5) (a) Given $A(t+1) = x'y + xA$ $\quad Z = B.$

$$B(t+1) = x'B + xA$$

(i) Logic diagram of the circuit

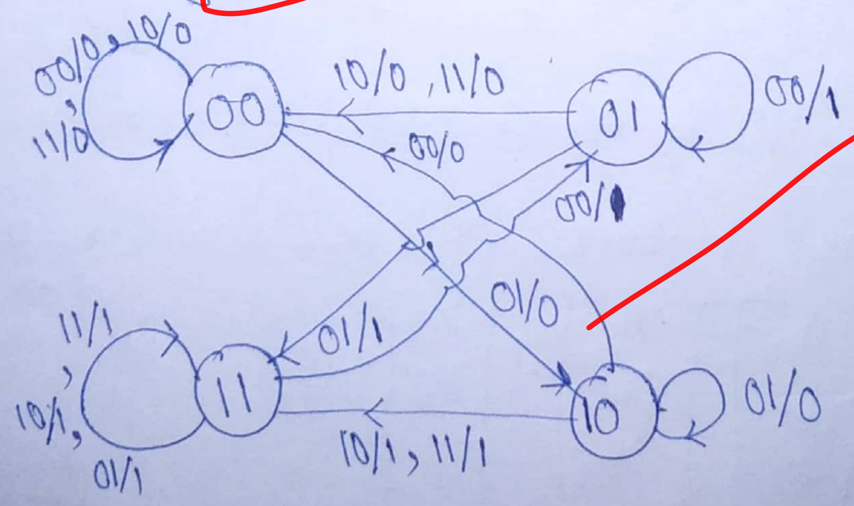




(ii) State table

Present State A	Present State B	Input X	Input Y	Excitation D_A	Excitation D_B	Next State A^+	Next State B^+	Output $Z=B$
0	0	0	0	0	0	0	0	0
0	0	0	1	1	0	1	0	0
0	0	1	0	0	0	0	0	0
0	0	1	1	0	0	0	0	0
0	1	0	0	0	1	0	1	1
0	1	0	1	1	1	1	1	1
0	1	1	0	0	0	0	0	0
0	1	1	1	0	0	0	0	0
1	0	0	0	0	0	0	0	0
1	0	0	1	1	0	1	0	0
1	0	1	0	1	1	1	1	1
1	0	1	1	1	1	1	1	1
1	1	0	0	0	1	0	1	1
1	1	0	1	1	1	1	1	1
1	1	1	0	1	1	1	1	1
1	1	1	1	1	1	1	1	1

(iii) State diagram

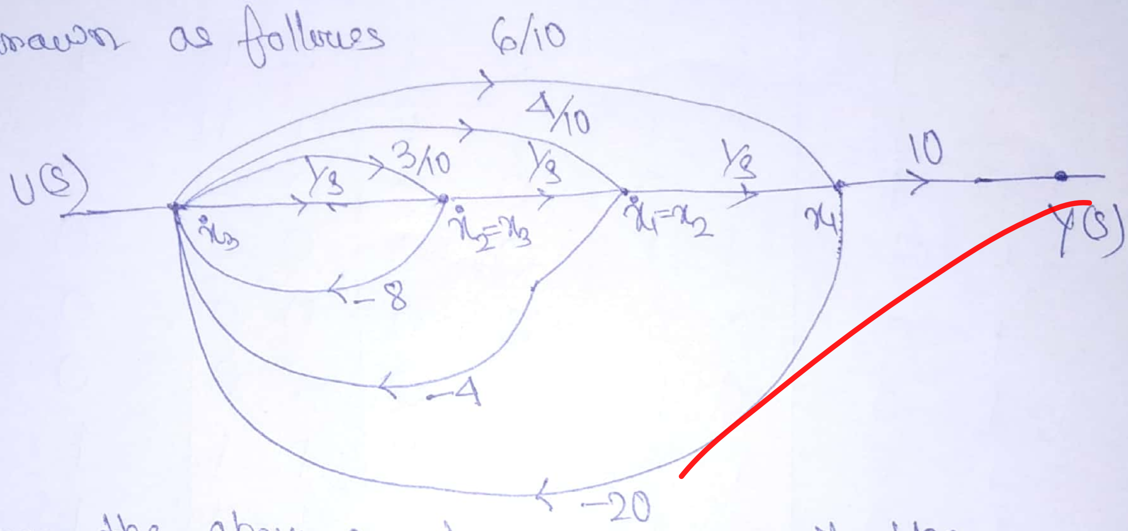


5(b) Given,

$$\frac{Y(s)}{U(s)} = \frac{6s^3+4s^2+3s+10}{s^3+8s^2+4s+20}$$

$$Y(s) = \frac{6+\frac{4}{s}+\frac{3}{s^2}+\frac{10}{s^3}}{1+\frac{8}{s}+\frac{4}{s^2}+\frac{20}{s^3}}\,U(s).$$

Signal flow graph of the above response can be drawn as follows



From the above graph we can write the state variable equation as

$$\dot{x}_1 = x_2 + \frac{4}{10}U(s)$$

$$\dot{x}_2 = x_3 + \frac{3}{10}U(s)$$

$$\dot{x}_3 = -20x_1 - 4x_2 - 8x_3 + U(s).$$

$$y(s) = 10x_1 + 6\,U(s).$$

State phase Matrix can be written as

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix} = \begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -20 & -4 & -8\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix} + \begin{bmatrix}0.4\\ 0.3\\ 1\end{bmatrix}U(s)$$

$$A = \begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -20 & -4 & -8\end{bmatrix}$$

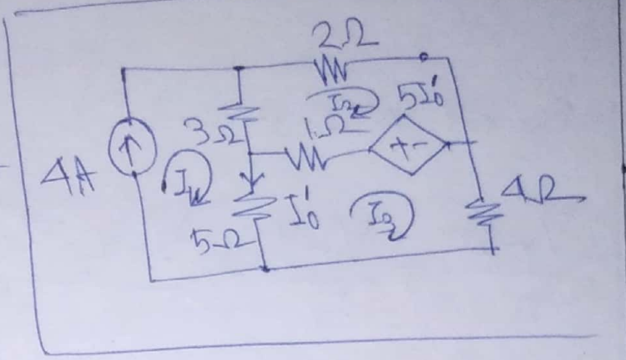
$$[Y] = \begin{bmatrix}10 & 0 & 0\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix} + [6]\,U(s)$$

$$B = \begin{bmatrix}0.4\\ 0.3\\ 1\end{bmatrix} \quad D = [6]$$

$$C = \begin{bmatrix}10 & 0 & 0\end{bmatrix}$$

(5) (c) Consider only 4A current source is acting

Apply KVL in the ~~Loop (1)~~ Loop (2) ~~Loop (3)~~ ~~of~~ we get ~~respectively~~



$$\cancel{8I_1 - 3I_2 - 5I_3}$$

$$-3I_1 + 6I_2 - I_3 = 5I_0' = 5(I_1 - I_3)$$

$[\because I_0' = (I_1 - I_3)]$

$\Rightarrow -8I_1 + 6I_2 + 4I_3 = 0$ [and $I_1 = 4A$]

$\Rightarrow 6I_2 + 4I_3 = 8 \times 4 = 32$

$\Rightarrow 3I_2 + 2I_3 = 16$ ——— (1)

By applying KVL in Loop (3) we get,

$$-5I_1 - I_2 + 10I_3 = -5I_0' = -5(I_1 - I_3)$$

$[\because I_0' = I_1 - I_3]$

$\Rightarrow -I_2 + 5I_3 = 0$

$\Rightarrow I_2 = 5I_3$ ——— (2)

From equation (1) and (2) we get,

$$3 \times 5I_3 + 2I_3 = 16$$

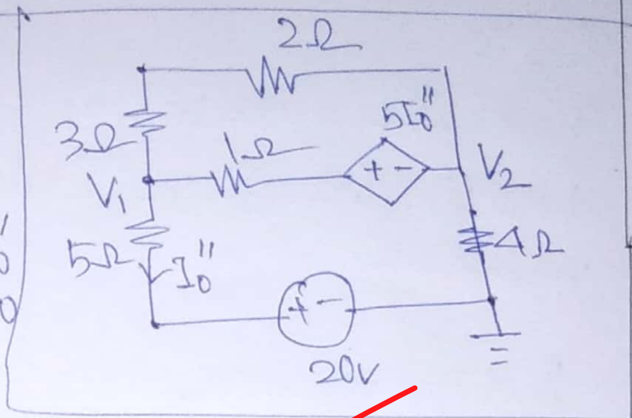
$$\Rightarrow I_3 = \frac{16}{17}.$$

Therefore $I_0' = I_1 - I_3 = 4 - \frac{16}{17} = \frac{52}{17}$

$$I_0' = 3.059\ A.$$

Scanned with CamScanner

Consider only 20V, source is acting.



By ~~KV~~ KCL at node (1)

$$\frac{V_1-20}{5} + \frac{V_1-V_2}{5} + \frac{V_1-V_2-5I_0''}{1} = 0$$

where, $I_0'' = \frac{V_1-20}{5}$

$$\Rightarrow V_1\left(\frac{1}{5}+\frac{1}{5}+1\right) - V_2\left(\frac{1}{5}+1\right) - 5\times\left(\frac{V_1-20}{5}\right) = \frac{20}{5}$$

$$\Rightarrow V_1 \frac{7}{5} - V_2 \cdot \frac{6}{5} - V_1 + 20 = 4$$

$$\Rightarrow \frac{2}{5}V_1 - \frac{6}{5}V_2 = -16$$

$$\Rightarrow 2V_1 - 6V_2 = -80 \quad \text{——— (1)}$$

By KCL at node (2) we get,

$$\frac{V_2-V_1}{5} + \frac{V_2-V_1+5I_0''}{1} + \frac{V_2}{4} = 0.$$

$$\Rightarrow V_2\left(\frac{1}{5}+1+\frac{1}{4}\right) - V_1\left(\frac{1}{5}+1\right) + 5\times\left(\frac{V_1-20}{5}\right) = 0.$$

$$\Rightarrow V_2 \frac{29}{20} - \frac{6V_1}{5} + V_1 - 20 = 0.$$

$$\Rightarrow -\frac{V_1}{5} + \frac{29V_2}{20} = 20$$

$$\Rightarrow -4V_1 + 29V_2 = 400. \quad \text{——— (2)}$$

By solving equation (1) and (2) we get,

$$V_1 = \frac{40}{17} \qquad V_2 = \frac{240}{17}$$

Current $I_0'' = \frac{V_1-20}{5} = \frac{\frac{40}{17}-20}{5} = -\frac{60}{17}$ A.

~~$I_0'' = -0.7059$ A~~ $I_0 = -\frac{60}{17}$

By using Superposition theorem

Current $I_0 = I_0' + I_0'' = \cancel{3.059 - 0.7059}$ A.

$\Rightarrow I_0 = \frac{52}{17} - \frac{60}{17} = -\frac{8}{17}$

$\Rightarrow \boxed{I_0 = -0.47059\ A}$

(5)(d) Program in 8086 to find greatest number

Memory Address	Mnemonics	Algorithm
0400 H	MOV AX, 2000 H;	
0402 H	MOV DS, AX;	Loading the data segment address
0403 H	MOV SI, 0500H;	Load the SI by the Counter offset.
0405 H	MOV CX, [SI] ;	Load the Count in C
0406 H	MOV AL, 00H;	Clearing the lower byte of accumulator
0408 H	INC SI;	Increment the pointer address.
040A H	CMP AL, [SI];	Comparing the numbers with the content of accumulator.
	~~JAE~~	
040B H	JAE 040F	If the accumulator is greater no need to exchange
040D H	MOV AL, [SI];	Accumulator is lesser and ~~data~~ greater data stored in acc.
040F H	LOOP 0408H;	Continue the process until Count CX = 0;
0411 H	MOV [0600]; AL;	Store the greater number in address of offset 0600 H
0413 H	HLT	STOP.

(5)(e) ~~Addressing Modes of in 8086 microprocessor~~

An instruction performed specific operation on specified data. The way which a operand is specified in an instruction is called addressing mode.

8086 microprocesser has 8 addressing mode. which are discussed below.

Register addressing mode:- In the mode of operation, data in ~~man~~ transferred or manupulated in between two registers

Example ADD AX, BX ; Adding data of 16 bit acc to 16 bit base reg. and storing the result in acc.

(1)(e) ~~Addressing Modes in 8086 microprocessor~~

Immediate addressing mode:-

In this addressing mode data is ~~are~~ resides in the operand itself. ~~Example~~ MOV AX, 1600H;

Rest of 6 addressing mode, in operand offset ~~of~~ address of data resides. For which ~~as~~ starting address is ~~Code~~ segment address, And offset ~~as~~ is decided by

~~OFSI~~ Offset = Displacement + Base + Index.

Memory Address = DS : Offset

Direct addressing mode

In this addressing mode, offset of operands is resides in the instruction as displacement address only.

MOV AX, [0015] ; Here 0015H is the offset of operand.

Indirect addressing mode

In this addressing mode offset of operands is resides in index or base register.

MOV AX, [SI];

Based addressing mode

In this addressing mode offset of operand is reside in base register and displace-ment address.

ADD AX, [BX+03]. Offset = BX+03H.

Indexed addressing Mode

In this addressing mode operand offset is the sum of 8 bit / 16 bit displacement and contain of index register SI/DI.

MOV AX, [SI+0018] Offset = SI+0018H.

Based Indexed addressing mode

In this addressing mode operand's offset is the sum of contain of base register (BX/BP) and Index register (SI/DS).

ADD AX, [SI+BX] > Offset = SI+BX

Relative ~~Index~~ Based Indexed addressing mode

In this addressing mode operand's offset is the sum of contain of ~~bas~~ 8 bit / 16 bit displacement address, base register (BX/BP) and index register (SI/DI)

MOV AX, [BX+SI+010A] Offset = BX+SI+010AH.

0d
1d
d1
d0

(7) (a) (i) Excitation table for JK-flip-flop.

Present State Q_1	Present State Q_0	Input X	Next State Q_1^+	Next State Q_0^+	Excitation J_1	Excitation K_1	Excitation J_0	Excitation K_0
0	0	0	1	0	1	d	0	d
0	0	1	0	0	0	d	0	d
0	1	0	1	1	1	d	d	0
0	1	1	0	1	0	d	d	0
1	0	0	0	1	d	1	1	d
1	0	1	1	0	d	0	0	d
1	1	0	0	0	d	1	d	1
1	1	1	1	1	d	0	d	0

Minimization using K-Map.

For J_1

$Q_1 \backslash Q_0X$	00	01	11	10
0	1			1
1	d	d	d	d

$J_1 = \overline{X}$

For K_1

$Q_1 \backslash Q_0X$	00	01	11	10
0	d	d	d	d
1	1			1

$K_1 = \overline{X}$

For J_0

$Q_1 \backslash Q_0X$	00	01	11	10
0			d	d
1	1		d	d

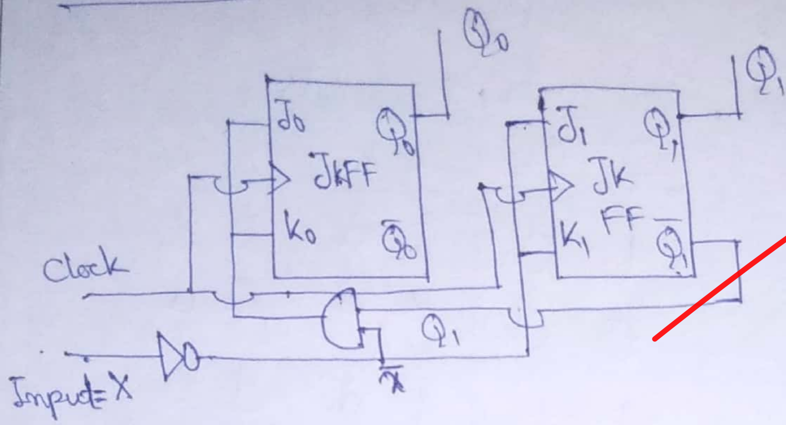
$J_0 = Q_1\overline{X}$

For K_0

$Q_1 \backslash Q_0X$	00	01	11	10
0	d	d		
1	d	d		1

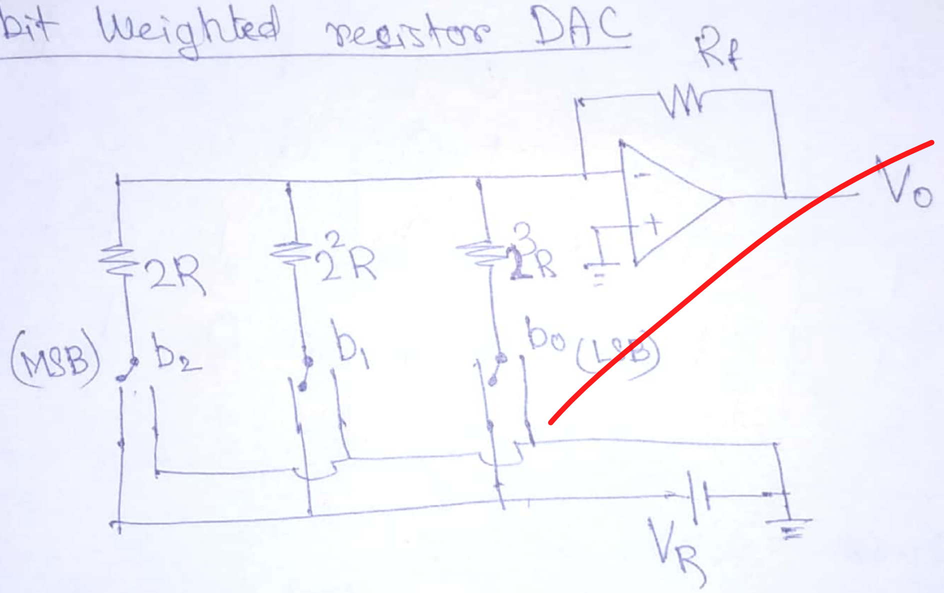
$K_0 = Q_1\overline{X}$

Implementation



(7) (a) (ii)

3-bit Weighted resistor DAC



Above diagram is a 3-bit Weighted resistor DAC. The ~~ed~~ expression of output can be derived by using Superposition theorem.

When only switch $b_0 = 1$ and $b_2 = b_1 = 0$.

$$V_0' = -\frac{R_f}{2^3R} b_0 V_R$$

When only switch $b_1 = 1$ and $b_0 = b_2 = 0$.

$$V_0'' = -\frac{R_f}{2^2R} b_1 V_R$$

When only switch $b_2 = 1$ and $b_0 = b_1 = 0$.

$$V_0''' = -\frac{R_f}{2R} b_2 V_R$$

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By using Super position theorem,

$$V_0 = V_0' + V_0'' + V_0'''$$

$$\Rightarrow \boxed{V_0 = -\frac{R_f}{R} \cdot V_R \left[\frac{b_2}{2} + \frac{b_1}{2^2} + \frac{b_0}{2^3} \right]}$$

(7)(b) Let transfer function of the lead compensator

$$G_c(s) = \frac{(T_1 a s + 1)}{(T_1 s + 1)}$$

[where, $a > 1$]

Given System, desire,

$$M_p = 20\%$$

$$\Rightarrow e^{\frac{-\pi \zeta}{\sqrt{1-\zeta^2}}} = 0.2$$

$$\Rightarrow \zeta = \sqrt{\frac{(\ln 0.2)^2}{\pi^2 + (\ln 0.2)^2}} = 0.456$$

Peak time $t_p = \frac{\pi}{\omega_n \sqrt{1-\zeta^2}} = 0.1$

$$\Rightarrow \omega_n = \frac{\pi}{0.1\sqrt{1-0.456^2}} = 35.3 \text{ rad/sec}$$

For the given system, Forward transfer function

$$G(s) = \frac{100K}{s(s+100)(s+36)} \times \frac{(T_1 a s + 1)}{(T_1 s + 1)}.$$

$$K_v = \lim_{s \to 0} s\, G(s).$$

$$\Rightarrow 40 = \lim_{s \to 0} s \cdot \frac{100k}{s(s+100)(s+36)} \times \frac{(T_1 a s + 1)}{(T_1 s + 1)}$$

$$\Rightarrow 40 = 100k$$

$$\Rightarrow \boxed{K = 0.4}$$

For the lead Compensator

$$\omega_{max} = \frac{1}{\sqrt{T_1 a \times T_1}} = 40$$

$$\Rightarrow \frac{1}{T_1\sqrt{a}} = 40$$

$$\Rightarrow T_1 = \frac{1}{40\sqrt{a}} \quad \text{——— (1)}$$

~~Overall trans~~
~~Characteristics equation o~~

Part of charecteristics equation for $\omega_n = 35.3$ rad/sec and $\zeta = 0.456$

$$s^2 + 2\zeta\omega_n s + \omega_n^2$$

$$\Rightarrow = (s^2 + 16s + 1246) \quad \text{——— (2)}$$

Characteristics equation of the closeloop system

$$1 + G(s) \times G_c(s) = 0.$$

$$\Rightarrow 1 + \frac{100 \times 0.4}{s(s+36)(s+100)} \times \frac{(T_1 a s+1)}{(T_1 s+1)} = 0$$

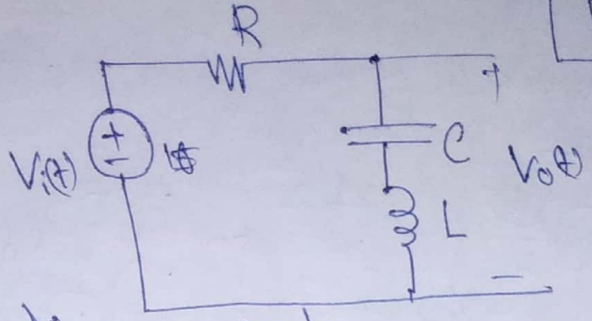
$$\Rightarrow s(s+36)(s+100)(T_1 s+1) + 40(T_1 a s+1) = 0.$$

$$\Rightarrow (s^3 + 136s^2 + 3600s)(T_1 s+1) + (40T_1 a s + 40) = 0.$$

$$\Rightarrow T_1 s^4 + (136 + 3600T_1)s^2 + (1 + 136T_1)s^3 + 3600s + 40T_1 a s + 40 = 0.$$

$$\Rightarrow s^4 + (136 + 1/T_1)s^3 + \left(3600 + \frac{136}{T_1}\right)s^2 + \left(40a + \frac{3600}{T_1}\right)s + \frac{40}{T_1} = 0$$

(7)(c) (i) Given filter



By using voltage division rule,

$$V_o(t) = \frac{(j\omega L - j/\omega C)}{(R + j\omega L - \frac{j}{\omega C})} V_i(t)$$

At $f = 200\text{ Hz}$, output is equal to zero (As it is reject the 200 Hz input).

therefore $$\frac{j\omega_0 L - j/\omega_0 C}{R + j\omega_0 L - j/\omega_0 C} = 0$$

$$\Rightarrow \omega_0 = \frac{1}{\sqrt{LC}}$$

$$\Rightarrow C = \frac{1}{\omega_0^2 L} = \left(\frac{1}{2\pi \times 200}\right)^2 \frac{1}{L} \quad \text{--- (1)}$$

And Bandwidth $$BW = \frac{R}{L} = \frac{150}{L} = 2\pi \times 100.$$

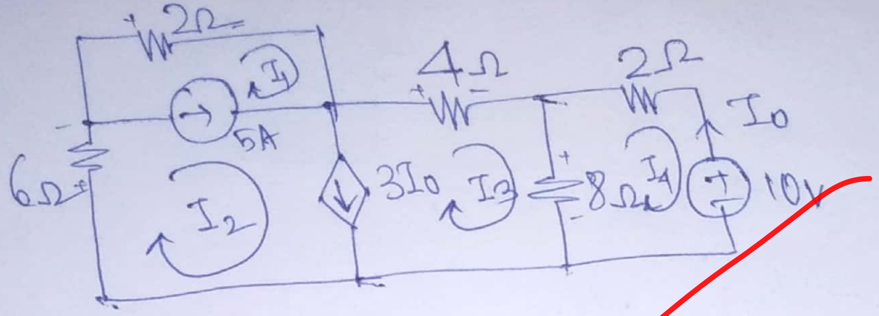
$$\Rightarrow \boxed{L = \frac{150}{2\pi \times 100} = 0.2387\text{ H}}$$

From equation (1), we get,

$$C = \frac{1}{(2\pi \times 200)^2 \times 0.2387}$$

$$\boxed{C = 2.6526\ \mu F}$$

(7) (c) (ii) ~~For the~~ Given network



Mesh equations,

For loop 1 ~~&~~ and loop 2 and loop (3) (Super Mesh)

$$2I_1 + 6I_2 + 12I_3 - 8I_4 = 0 \quad \text{——— (1)}$$

$$I_1 - I_2 = -5 \quad \text{——— (2)}$$

$$I_2 - I_3 = 3I_0 = 3(-I_4)$$

$$\Rightarrow \quad I_2 - I_3 + 3I_4 = 0 \quad \text{——— (3)}$$

For Loop 4

$$-8I_3 + 10I_4 = -10 \quad \text{——— (4)}$$

From eqn (2) Substituting $I_2 = I_1 + 5$ in equation (1), (3) and (4) we get,

$$8I_1 + 12I_3 - 8I_4 = -30 \quad \text{——— (5)}$$

$$I_1 - I_3 + 3I_4 = -5 \quad \text{——— (6)}$$

$$-8I_3 + 10I_4 = -10 \quad \text{——— (7)}$$

By solving equation (5), (6) and (7) we get,

$$\boxed{I_1 = -7.5A}, \quad I_3 = 3.928, \quad \boxed{I_4 = 2.143A}$$

(8) (a)

Mnemonics	Algorithm
LXI H 4200H;	Loading address pointer of Count in HL register pair
MOV B, M;	Loading the Count1 in reg. B
START: LXI H 4201H;	Loading the address pointer of number in HL pair
~~MOV C, M~~;	
~~INX H~~ ;	
~~MOV A,M~~;	
LDA 4200H;	Loading the ~~address~~ Count 2 in accumulator.
MOV C,A;	MOV the Count in accumulator
BACK: MOV A,M;	Get the number in ~~Co~~ accumulator
INX H;	Increment the pointer
CMP M;	Compare the number with next number
JNC SKIP;	If the next number is smaller don't interchange
JNZ SKIP;	If the next number is equal don't interchange
MOV D,M;	If the next number is greater, Interchange 2 numbers.
MOV M,A;	
DCX H;	
MOV M,D;	
INX H;	
SKIP: DCR C;	Decrement the Counter2
JNZ BACK;	If not zero, repeat
DCR B;	Decrement the Counter1
JNZ START	If not zero, repeat
HLT	STOP.

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(8) (b) (i)

$\ddot{y} + 3\dot{y}(t) + 2y(t) = u(t)$

Taking Laplace transform we get;

$$[s^2 Y(s) - s y(0) - y'(0)] + 3[s Y(s) - y(0)] + 2Y(s) = \frac{1}{s}$$

$$\Rightarrow (s^2+3s+2)Y(s) = \frac{1}{s} + (s+3)y(0) + y'(0).$$

$$\Rightarrow Y(s) = \frac{\frac{1}{s} + (s+3)\alpha + \beta}{(s+2)(s+1)}$$

$$\Rightarrow Y(s) = \frac{(s^2+3s)\alpha + \beta s + 1}{s(s+1)(s+2)}$$

$$= \frac{1}{1\times 2}\frac{1}{s} + \frac{[1+(-3)]\alpha - \beta + 1}{(-1)\times(-1+2)}\frac{1}{(s+1)} + \frac{(4-6)\alpha - 2\beta + 1}{(-2)(-2+1)}\frac{1}{(s+2)}$$

$$Y(s) = \frac{1}{2}\frac{1}{s} + \frac{-2\alpha-\beta+1}{(-1)}\frac{1}{s+1} + \frac{-2\alpha-2\beta+1}{2}\frac{1}{(s+2)}$$

Taking inverse Laplace transform,

$$y(t) = \left[\frac{1}{2} + (2\alpha+\beta-1)e^{-t} - \frac{(2\alpha+2\beta-1)}{2}e^{-2t}\right]u(t).$$

(ii) Given $A = \begin{bmatrix} -2 & 1 & 0 \\ 0 & -2 & 1 \\ 0 & 0 & -2 \end{bmatrix}$

$$\phi(s) = [Is - A]^{-1}$$

$$= \left[\begin{bmatrix} s & 0 & 0 \\ 0 & s & 0 \\ 0 & 0 & s \end{bmatrix} - \begin{bmatrix} -2 & 1 & 0 \\ 0 & -2 & 1 \\ 0 & 0 & -2 \end{bmatrix}\right]^{-1}$$

$$= \begin{bmatrix} s+2 & -1 & 0 \\ 0 & s+2 & -1 \\ 0 & 0 & (s+2) \end{bmatrix}^{-1}$$

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$$\phi(s) = \frac{\begin{bmatrix} (s+2)^2 & 0 & 0 \\ 0 & (s+2)^2 & 0 \\ 1 & (s+2) & (s+2)^2 \end{bmatrix}^T}{(s+2)^3}$$

$$\Rightarrow \phi(s) = \frac{\begin{bmatrix} (s+2)^2 & 0 & 1 \\ 0 & (s+2)^2 & (s+2) \\ 0 & 0 & (s+2)^2 \end{bmatrix}}{(s+2)^3}$$

$$\phi(s) = \begin{bmatrix} \frac{1}{s+2} & 0 & \frac{1}{(s+2)^3} \\ 0 & \frac{1}{s+2} & \frac{1}{(s+2)^2} \\ 0 & 0 & \frac{1}{s+2} \end{bmatrix}$$

State transition matrix

$$\phi(t) = \begin{bmatrix} e^{-2t} & 0 & \frac{t^2}{2}e^{-2t} \\ 0 & e^{-2t} & te^{-2t} \\ 0 & 0 & e^{-2t} \end{bmatrix}$$

(8)(b)(iii) State transition matrix

For a standard state ~~variables~~. equation for two variable,

$$\dot{X} = AX + BU$$

$$Y = CX + DU$$

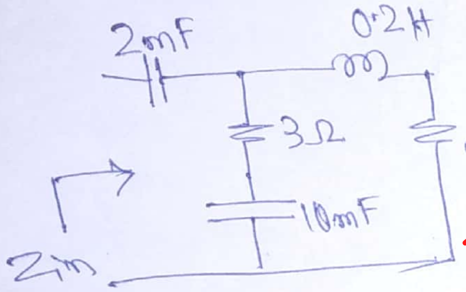
Then the state transition matrix denoted by

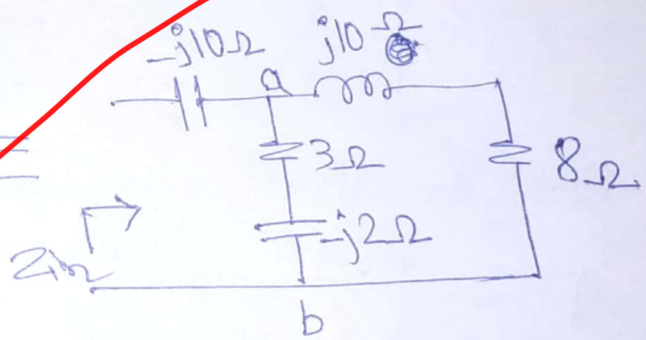
$$\phi(t) = L^{-1}\{[sI - A]^{-1}\}$$

Properties of state transition matrix

- $\phi(0) = e^{A\times 0} = I$ (Identity Matrix)
- $\phi^{-1}(t) = \phi(-t)$
- $\phi(t_1+t_2) = \phi(t_1)\cdot\phi(t_2)$
- $[\phi(t)]^n = \cancel{n\,\phi(t)}\ \phi(nt)$.
- $\phi(t_2-t_1)\cdot\phi(t_1-t_0) = \phi(t_2-t_0)$.

(8)(C)(i) Given circuit , Given $w = 50$ rad/sec





Impedence across ab

$$Z_{ab} = (3-j2)\,||\,(8+j10) = 3.395\angle -18.37^\circ$$

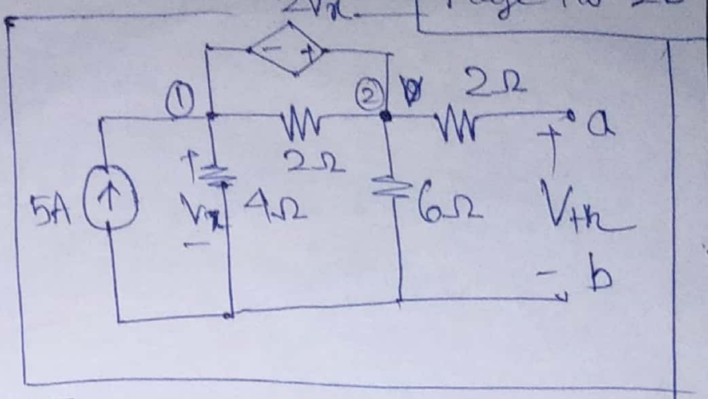
And

$$Z_{in} = -j10 + Z_{ab}$$

$$= -j10 + 3.395\angle -18.37^\circ$$

$$\boxed{Z_{in} = 3.22 - j11.07}$$

8) (C) (ii)



By applying KCL at Supernode (1)-(2) we get

$$\frac{V_x}{4} + \cancel{\frac{V_x - V_{th}}{2}} + \frac{V_{th}}{6} = 5$$

$$\Rightarrow V_x = 4\left(5 - \frac{V_{th}}{6}\right)$$

$$\Rightarrow V_x = 20 - \frac{2}{3}V_{th} \quad \text{——— (1)}$$

And by KVL in supernode (1)-(2).

$$V_{th} - V_x = 2V_x$$

$$\Rightarrow V_{th} = 3V_x = 3\left(20 - \tfrac{2}{3}V_{th}\right)$$

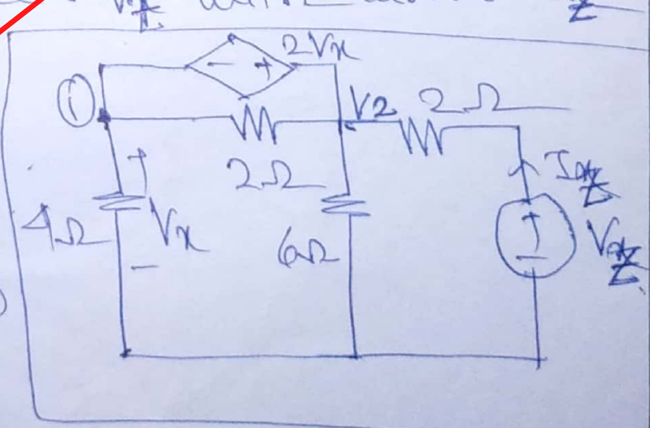
$$\left[\because V_x = 20 - \tfrac{2}{3}V_{th}\right]$$

$$\Rightarrow V_{th} = 60 - 2V_{th}$$

$$\Rightarrow V_{th} = 20\,V$$

Find Rth

To find Rth dissable the 5A current ~~source~~ source and replaced by opened circuit and connect a voltage source V_z with current I_z across 'ab'.



Node (1) and (2) constitute a super node,

KCL at super node (1)-(2)

$$\frac{V_x}{4} + \frac{V_2}{6} + \frac{V_2 - V_z}{2} = 0$$

$$3V_x + 2V_2 + 6V_2 - 6V_z = 0$$

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$$8V_2 = 6V_Z - 3V_x \quad \text{——— (1)}$$

By KVL in super node,

$$V_2 - V_x = 2V_x$$

$$\Rightarrow \quad V_2 = 3V_x \quad \text{——— (2)}$$

And also,

$$I_Z = \frac{V_Z - V_2}{2}$$

$$\Rightarrow \quad 2I_Z = V_Z - 3V_x \quad \text{——— (3)}$$

From equation (1), (2) and (3) we get,

$$2I_Z = V_Z - 3 \times \frac{6V_Z}{27}$$

$$\Rightarrow \quad \frac{V_Z}{I_Z} = 6\ \Omega.$$

Therefore Thevenin's Equivalent circuit.