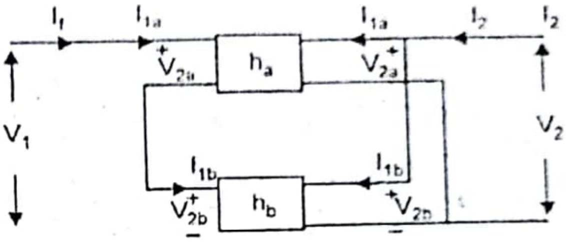
Important Question

Q.1. Find the overall parameter for series-parallel connection.

Ans. Series Parallel Connection: Two part networks are said to be connected in series parallel if the input ports are connected in series while the output port are connected in parallel as shown below:



$$V_1 = V_{1a} + V_{1b}$$
$$I_1 = I_{1a} = I_{1b}$$
$$V_2 = V_{2a} = V_{2b}$$
$$I_2 = I_{2a} + I_{2b}$$

for network 1 $$\begin{bmatrix} V_{1a} \\ V_{2a} \end{bmatrix} = \begin{bmatrix} h_{11a} & h_{12a} \\ h_{21a} & h_{22a} \end{bmatrix} \begin{bmatrix} I_{1a} \\ V_{2a} \end{bmatrix}$$

for Network 2 $$\begin{bmatrix} V_{1b} \\ I_{2b} \end{bmatrix} = \begin{bmatrix} h_{11b} & h_{12b} \\ h_{21b} & h_{22b} \end{bmatrix} \begin{bmatrix} I_{1b} \\ V_{2b} \end{bmatrix}$$

Now $$\begin{bmatrix} V_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} h_{1b} & h_{12b} \\ h_{2b} & h_{22b} \end{bmatrix} \begin{bmatrix} I_{1b} \\ I_{2b} \end{bmatrix}$$

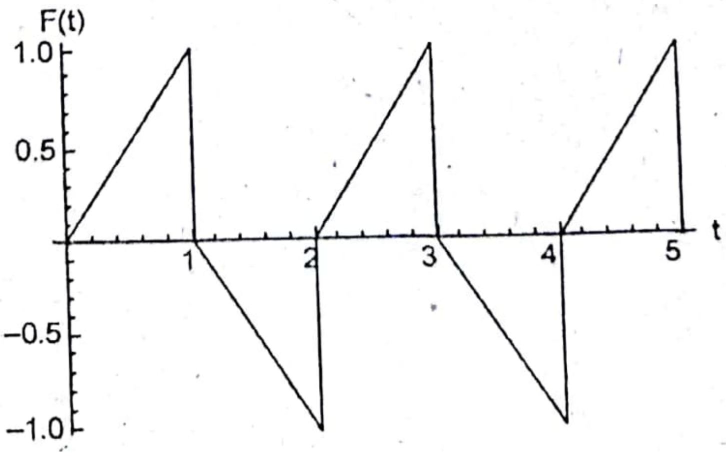
$$\begin{bmatrix} V_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} h_{a1a+h11b} & h_{12a+12b} \\ h_{21a+h21b} & h_{22a+22b} \end{bmatrix} \begin{bmatrix} I_1 \\ V_2 \end{bmatrix}$$

As we know $$\begin{bmatrix} V_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12a+12b} \\ h_{21} & h_{22a+22b} \end{bmatrix} \begin{bmatrix} I_1 \\ V_2 \end{bmatrix}$$

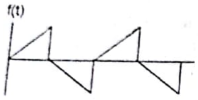
Now on comparing we get

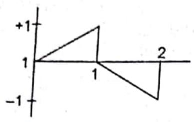
$$h_{11} = h_{11a} + h_{11b}$$
$$h_{12} = h_{12a} + h_{12b}$$
$$h_{21} = h_{21a} + h_{21b}$$
$$h_{22} = h_{22a} + h_{22b}$$

Q.2. Find the Laplace of the periodic waveform as shown in Fig.



Ans.





$$f(t) = t[u(t) - u(t-1)] + (-t+1)[u(t-1) - u(t-2)]$$
$$= tu(t) - tu(t-1) - tu(t-1) + u(t-1)$$
$$+ tu(t-2) - u(t-2)$$
$$= tu(t) - 2tu(t-1) + u(t-1) + tu(t-2) - u(t-2)$$

On taking LT

$$= \frac{1}{s^2} - 2e^{-s}\lambda[t+1] + \frac{e^{-s}}{s} + e - 2s$$

$$\lambda[t+2] - \frac{e^{-2s}}{s}$$

$$F'(s) = \frac{1}{s^2} - 2e^{-s}\left[\frac{1}{s^2} + \frac{1}{s}\right] + \frac{e^{-s}}{s} + e^{-2s}\left[\frac{1}{s^2} + \frac{2}{s}\right]\frac{e^{-2s}}{s}$$

As we know for the LT of a periodic function we multiply the term $\frac{1}{1-e^{-TS}}$ to the LT the single period of the function.

$$F(s) = \frac{1}{1-e^{-2s}} F'(s)$$

FIRST TERM EXAMINATION
THIRD SEMESTER (B. TECH) ETEE-207
CIRCUIT & SYSTEMS-2013

Time : 1½ hrs. **M.M. : 30**

Note: ***Quetion number 1 is compulsory and attempt any two from the rest.***

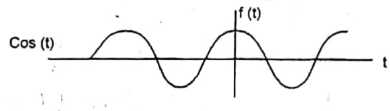
Q.1. (a) Define even signal and odd signal with examples. **(2)**

Ans. Even Signal:

if $f(-t) = f(t)$

Then signal is known as even signal.

e.g: cos (t)

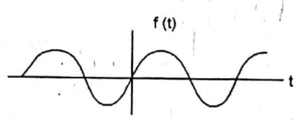


odd signal

If $f(-t) = -f(t)$

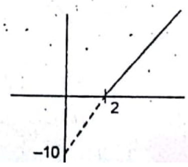
then signal is known as odd signal

e.g.; sin (t)



Q.1. (b) Draw the waveform of (i) $f(t) = 5(t-2)\,U(t-2)$, (ii) $f(t) = V_m \sin\omega\left(t - \frac{T}{2}\right)U\left(t - \frac{T}{2}\right)$. **(2)**

Ans. (*i*) $f(t) = 5(t-2)\,u(t-2)$



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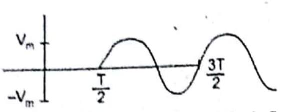


Q.1. (c) Define step, ramp, impulse signal and their Laplace transform. (2)

Ans. Step signal $\begin{cases} A & t \geq 0 \\ 0 & t < 0 \end{cases}$

Step signal $\xrightarrow{LT} \dfrac{A}{S}$

Ramp signal $r(t) = \begin{cases} At & t \geq 0 \\ 0 & t < 0 \end{cases}$

$$r(t) \xrightarrow{LT} \frac{A}{S^2}$$

Impulse signal $\delta(t) = \begin{cases} 1 & t = 0 \\ 0 & 0w \end{cases}$

$\delta(t) \to 1$

Q.1. (d) What do you mean by transient response and steady state response of and electrical circuit? (2)

Ans. The value of current and voltage during transient time are known as transent response.

The value of current and voltage after transient time are known as steady state response.

Q.1. (e) Define graph, tree, twigs, and links. (4)

Ans. Graph: A graph is defined as a collection of nodes and branches. It shows the geometrical interconnection of the elements of a network.

Tree: Is defined as any set of branches in the original graph that is just sufficient to connect all the nodes this number is $(n-1)$.

Twigs: The branch of the tree is known as twigs $n_t = n - 1$.

Link: The branches of the graph which are not in tree form the co-tree complement of the tree.

$$n_l = b - n_t = b - n + 1$$

where
n = total no. of branch in the tree
n_t = no. of twigs
n_l = no. of links

Q.2. (a) Synthesize the waveform using gate signal as shown in Fig. 1.

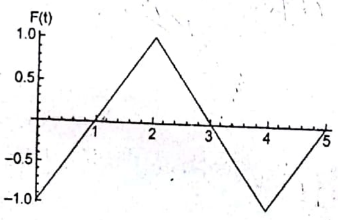


Fig. 1

Ans.
$$x(t) = (t-1)\,[u(t) - u(t-2)] + (-t+3)\,[u(t-2) - u(t-4)] + (t-5)\,[u(t-4) - u(t-5)]$$

Q.2. (b) Find the Laplace of the periodic waveform as shown in Fig. 2. (3)

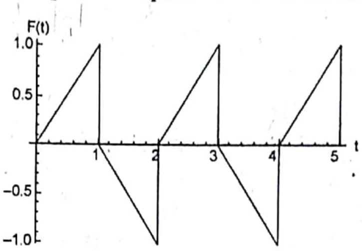


Fig. 2

Ans.2.(b) Refer Q. No. 2 ; Important question page 119

Q.2. (c) Find the initial values of inductor and capacitor as shown in figure 3. (3)

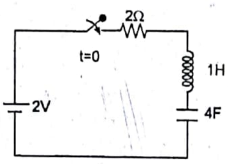


Fig. 3

Ans. $t = 0^+$

Capacitor behave as a short circuit & inductor behave as open circuit.

$$V_C = 0$$
$$V_L = 2V$$

Q.3. (a) For R-L circuit, when switch was closed at $t = 0$, (steady state) = 10 cos (ωt – 60°). The supply voltage is having a value v = 80 cos (wt). Find $i(t)$ in fig. 4.

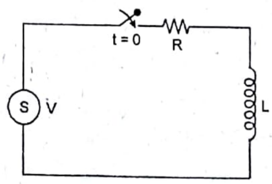


Fig. 4

Ans. $V = iR + L\dfrac{di}{dt}$

$$\frac{di}{dt}+\frac{iR}{L} = \frac{V}{L}$$

$$CF = Ae^{-\frac{R}{L}t}$$

$$PI = \frac{80\cos wt}{D+\frac{R}{L}}$$

$$= \frac{80\cos wt}{D^2-\left(\frac{R}{L}\right)^2}\left(D-\frac{R}{L}\right)$$

$$= \frac{(80\cos wt)\left(D-\frac{R}{L}\right)}{-w^2-\left(\frac{R}{L}\right)^2}$$

$$= \frac{1}{-\left(w^2+\left(\frac{R}{L}\right)^2\right)}\left(D-\frac{R}{L}\right)80\cos wt$$

$$= \frac{1}{-\left(w^2+\left(\frac{R}{L}\right)^2\right)}\left\{-80w\sin wt-\frac{R}{L}80\cos wt\right.$$

$$= \frac{1}{-\left(w^2+\left(\frac{R}{L}\right)^2\right)}\left\{-80w\sin wt-\frac{R}{L}80\cos wt\right\}$$

$$i(t) = CF+PI$$

$$i(t) = Ae^{-\frac{R}{L}t}-\frac{1}{\left\{w^2+\left(\frac{R}{L}\right)^2\right\}}\left\{-80w\sin wt-\frac{R}{L}80\cos wt\right\}$$

at $t = 0, i = 10\cos(wt-60)$

Putting this value in $i(t)$

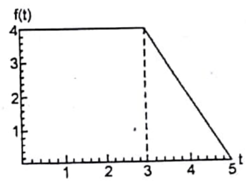
We get
$$A = 10\cos(wt-60)-\frac{80R}{\left(w^2+\left(\frac{R}{L}\right)^2\right)L}$$

Putting the value of A in equation of $i(t)$.

We get final $i(t)$.

$$i(t) = \left\{10\cos(wt-60)-\frac{80R}{\left(w^2+\left(\frac{R}{L}\right)^2\right)z}\right\}e^{-\frac{R}{L}t}$$
$$-\frac{1}{\left\{w^2+\left(\frac{R}{L}\right)^2\right\}}-80w\sin wt-\frac{R80}{L}\cos wt$$

Q.3. (b) Determine the Laplace transform of the following waveform as shown in figure 5.



Ans.
$$f(t) = \{u(t)-u(t-3)\}+(-t+5)\{u(t-3)-u(t-5)\}$$

$$u(t)\to\frac{1}{S}$$

$$u(t-3)\to\frac{e^{-3s}}{S}$$

$$-(t-3)\,u(t-3)+2u\,(t-3)+(t-5)\,u\,(t-5)$$

$$-\frac{e^{-3S}}{s^2}+2\frac{e^{-3s}}{s}+\frac{e^{-5s}}{s^2}$$

$$F(s) = \frac{1}{s}-\frac{e^{-3s}}{s}-\frac{e^{-3s}}{s^2}+\frac{2e^{-3s}}{s}-\frac{e^{-5s}}{s^2}$$

Q.3. (c) Find the value of $F(0)$ and $f(\alpha)$ for $\frac{7s+1}{s(s+2)}$.

Ans. Using Initial Value Theorem

$$F(0) = \lim_{s\to\infty} sF(s)$$

$$= \lim_{s\to\infty}\frac{\cancel{s}(7s+1)}{\cancel{s}(s+2)} = \lim_{s\to\infty}\frac{7+\frac{1}{s}}{1+\frac{2}{s}} = 7$$

F(∞) final value theorem

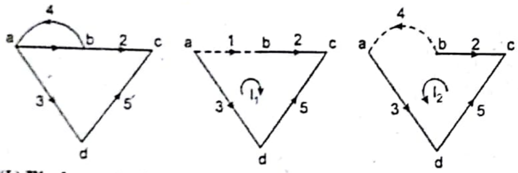
$$F(\infty) = \lim_{s\to 0} sF(s)$$

$$= \lim_{s\to 0}\frac{s(7s+1)}{s(s+2)} = \frac{1}{2}$$

Q.4. (a) For the given the complete incidence matrix form the graph. (3)

$$A_c = \begin{array}{c|ccccc|} & 1 & 2 & 3 & 4 & 5 \\ a & 1 & 0 & 1 & -1 & 0 \\ b & -1 & 1 & 0 & 1 & 0 \\ c & 0 & -1 & 0 & 0 & -1 \\ d & 0 & 0 & -1 & 0 & 1 \end{array}$$

Ans.



Q.4. (b) Find out the fundamental tie-set matrix $[B_f]$ considering twigs as (3, 5, 2). (4)

Ans. $B_f =$

	Branch	1	2	3	4	5
	l_1	1	1	−1	0	−1
loop	l_2	0	−1	1	1	1

Q.4. (c) Write the properties of complete incidence matrix. (3)

Ans. Properties of complete incidence matrix:

(i) Sum of the entries in any column is zero.

(ii) The rank of a complete incidence matrix of a connected graph is $n-1$.

(iii) The determinant of a complete incidence matrix is always zero.

Q.4. (d) State super position theorem with its limitations.

Ans. Super position theorem: In an active linear network containing several source (including dependent sources). The overall response in any branch in the network equals the algebraic sum of the responses of each individual source considered separately with all other sources made in operative, *i.e.*, replaced by their internal resistance or impedance.

Limitations:

(i) Not applicable to ckt consisting of only dependent sources

(ii) Not applicable to the ckt consisting of non linear elements like duode, transistor etc.

(iii) Not applicable for calculation of power

(iv) Not useful to the circuits consisting of less than two independent sources.

SECOND TERM EXAMINATION
THIRD SEMESTER (B. TECH) ETEE-207
CIRCUIT & SYSTEMS-2013

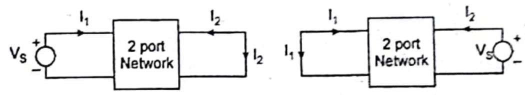
Time : $1^1/_2$ hrs. **M.M. : 30**

Note: ***Quetion number 1 is compulsory and attempt any two from the rest.***

Q.1. (a) Find the condition of Reciprocity for Y parameter. (2)

Ans.

$$I_1 = Y_{11}V_1 + Y_{12}V_2$$
$$I_2 = Y_{21}V_1 + Y_{22}V_2$$
$$V_1 = V_s, I_1 = I_1, V_2 = 0, I_2 = -I_2'$$



Putting this value in above eqn. we get

$$I_2' = -Y_{21}V_s$$
$$V_2 = V_s, I_2 = I_2, V_1 = 0, I_1 = -I_1$$

Putting the value in above eqn. we get

$$I_1' = -Y_{12}V_s$$

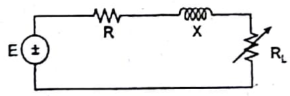
Now comparing I_2' & I_1'

$$Y_{12} = Y_{21}$$

Q.1. (b) Find the overall parameter for series-parallel connection. (2)

Ans.1. (b) Refer Q. No.1 ; Important Question page 119

Q.1. (c) Derive the condition for maximum power transfer for the circuit given in Fig. 1. (2)



Ans.1. (c) Refer Q. No.4(c) ; Second term 2013

Q.1. (d) State the Superposition Theorem. (2)

Ans.1. (d) Refer Q. No.4(d) ; First term 2013

Q.1. (e) Draw equivalent circuit of inverse transmission parameter. (2)

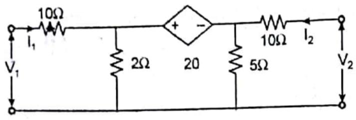
Ans. $(V_2, I_2) = f(V_1 - I_1)$

$$\begin{bmatrix} V_2 \\ I_2 \end{bmatrix} = \begin{bmatrix} A' & B' \\ C' & D' \end{bmatrix} \begin{bmatrix} V_1 \\ -I_1 \end{bmatrix}$$

$$V_2 = A'V_1 + B'(-I_1)$$

$$I_2 = C'V_1' + D'(-I_1)$$

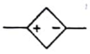
Q.2. (a) Find out the Y parameters for the network given in fig. 2. **(5)**



Ans.

$$V_1 = Y_{11}I_1 + Y_{12}I_2$$
$$V_2 = Y_{21}I_1 + Y_{22}I_2$$

Note: There is some mistake in this Question



Represent dependent source but here it does not depend on any parameter

Q.2. (b) Derive the relationship for the conversion of Y parameter to invers h parameter; and find the inverse hybrid parameter. **(3)**

Ans.

$$V_1 = h_{11}I_1 + h_{12}V_2 \quad ...(1)$$
$$I_2 = h_{21}I_1 + h_{22}V_2 \quad ...(2)$$

Rewriting equation (1) we get

$$I_1 = \frac{1}{h_{11}}V_1 - \frac{h_{12}}{h_{11}}V_2 \quad ...(3)$$

$$Y_{11} = \frac{1}{h_{11}} \quad Y_{12} = -\frac{h_{12}}{h_{11}}$$

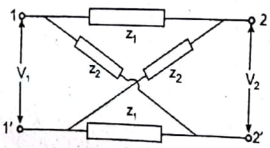
Putting the value of I_1 in equation 2

$$I_2 = h_{21}\left[\frac{1}{h_{11}}V_1 - \frac{h_{12}}{h_{11}}V_2\right] + h_{22}V_2 \qquad Y_{21} = \frac{h_{21}}{h_{11}}$$

$$Y_{22} = \frac{\Delta h}{h_{11}}$$

$$I_2 = \frac{h_{21}}{h_{11}}V_1 + \frac{\Delta h}{h_{11}}V_2$$

Q.3. (a) Show that $Z_{12} = Z_{21}$ for the network given in fig. 3. **(5)**



Ans. This is a symatrical circuit So

$$Z_{12} = Z_{21}$$

Applying KVL at loop *abd*, *bdc*, *abdc*

$$V_1 = Z_1 I' + Z_2(I' + I_2) \quad ...(1)$$
$$V_2 = Z_2(I' + I_2) + Z_1(I' + I_2 - I_1) \quad ...(2)$$
$$Z_1 I' + Z_2(I)(I' + I_2) + Z_1(I' + I_2 - I_1) - Z_2(I_1 - I') = 0 \quad ...(3)$$
$$I' = \frac{I_1 - I_2}{2} \quad ...(4)$$

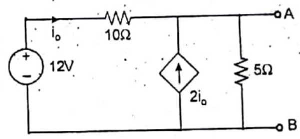
Putting the value of I' in equation (1) and (2) we get

$$V_1 = \underbrace{\frac{Z_1 - Z_2}{2}}_{Z_{11}} I_1 + \underbrace{\frac{Z_2 - Z_1}{2}}_{Z_{12}} I_2$$

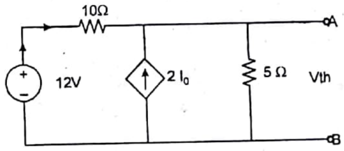
$$V_2 = \underbrace{\frac{Z_2 - Z_1}{2}}_{Z21} I_1 + \underbrace{\frac{Z_1 + Z_2}{2}}_{Z_{22}} I_2$$

Here $\quad Z_{12} = Z_{21}$

Q.3. (b) Determine the Thevenin's equivalent circuit across AB in fig. 4. **(5)**

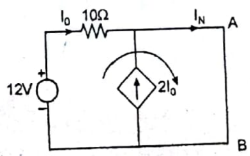


Ans.



for I_N short AB

$$10\,I_0 = 12$$
$$I_0 = \frac{12}{10} = 1.2A$$
$$I_N = I_0 + 2I_0 = 3I = 3 \times 1.2 = 3.6A$$
$$10I_0 + 5 \times 3\,I_0 = 12$$



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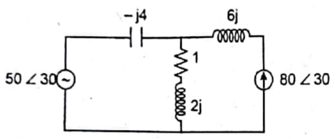
$$V_0 = \frac{12}{25}$$

$$V_{th} = 5\times\frac{12}{25} = \frac{12}{5} = 2.4$$

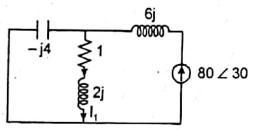
$$R_{th} = \frac{2.4}{1.2} = 2\Omega$$

Q.4. (a) Using Superposition theorem, find the voltage across (1 + 2j) impedance in network as shown in fig. 5. (5)

Ans.



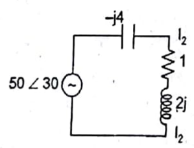
Case 1 : Short Voltage Source



Applying current diviion rule current L_1

$$I_1 = \frac{-j4}{1+2j-4j}I = \frac{-j4}{1-j2}80\angle -30$$

Case 2 : Open the current source

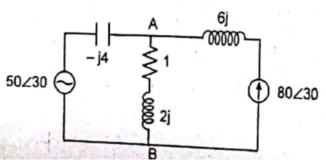


$$I_2 = \frac{50\angle 30}{1+2j-4j} = \frac{50\angle 30}{1-2j}$$

Total Current $\quad I = I_1 + I_2$

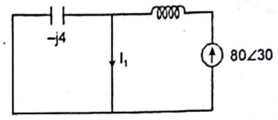
$$V = I(1+2j)$$

Q.4. (b) Determine the Norton's equivalent impedance between point A and B. Draw Norton's equivalent circuit shown in fig. 5. (5)



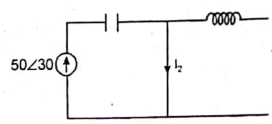
Ans.

Case 1 : Short voltage source



$$I_1 = 80\angle -30$$

Case 2 :



$$I_2 = \frac{50\angle 30}{-4j}$$

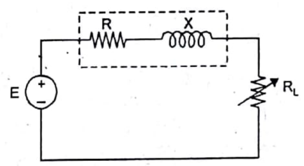
$$I_N = 80L - 30 + \frac{50\angle 30}{-4j}$$

$$V_{th} = 50\angle 30 - (-j4\times 80\angle 30)$$

Q.4. (c)

Find the condition for maximum power transfer for the circuit fig. 1(c).

Ans.



$$I = \frac{E}{R + jx + R_L}$$

Power $\quad P = I^2 R_L = \left(\frac{E}{R + jx + R_1}\right)^2 R_L$

$$\left.\begin{matrix} X = 0 \\ R_L = R \end{matrix}\right\} \text{Condition for maximum power transfer}$$

END TERM EXAMINATION
THIRD SEMESTER (B. TECH) ETEE-207
CIRCUIT & SYSTEMS-2013

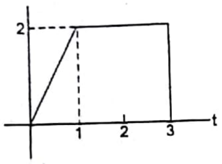
M.M. : 75

Time : 3 hrs.

Note: ***Attempt any five questions including Q.no. 1 which is compulsory.***

Q.1. (a) Draw the waveform of the signal $V(t) = 2t\, u(t) - 2(t-1)\, u(t-1) - 2\, u(t-3)$. **(5)**

Ans. $2t\, u(t) - 2\,(t-1)\, u\,(t-1) - 2\, u(t-3)$



Q.1. (b) The transfer function of a network is given by $\dfrac{V(s)}{I(s)} = \dfrac{(s+3)}{(s+2)(s+4)}$. For a unit step input, find the steady state value of $v(t)$. **(5)**

Ans. If $I(s)$ is input thin

$$V(s) = \frac{(s+3)}{(s+2)(s+4)} \times I(s)$$

Input is $U(t)$

if $$I(s) = \frac{1}{s}$$

$$V(s) = \frac{(s+3)}{(s+2)(s+4)s}$$

$$V(s) = \frac{A}{s} + \frac{B}{s+2} + \frac{C}{s+4}$$

$$A = \frac{(s+3)}{(s+2)(s+4)\cancel{s}} \times \cancel{s}\Big|_{s=0} = \frac{3}{8}$$

$$B = \frac{s+3}{(s\cancel{+}2)(s+4)s} \times (s\cancel{+}2)\Big|_{s=-2}$$

$$= \frac{1}{-2\times 2} = -\frac{1}{4}$$

$$C = \frac{s+3}{(s+2)\cancel{(s+4)}_s} \times \cancel{(s+4)}\Big|_{s=-4}$$

$$= \frac{-1}{-2\times -4} = -\frac{1}{8}$$

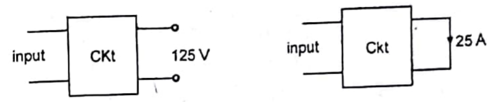
$$V(s) = \frac{3}{85} + \left\{-\frac{1}{4(s+2)}\right\} - \frac{1}{8}\left(\frac{1}{s+4}\right)$$

taking ILT

$$V(t) = \frac{3}{8}u(t) - \frac{1}{4}e^{-2t}u(t) - \frac{1}{8}e^{-4t}u(t)$$

Q.1. (c) In a two terminal network, the open circuit voltage at the load terminal is 125V and th short circuit at the same terminal gives 25A current. Determine the value of maximum power transfer which can take place at the load terminal. **(5)**

Ans.



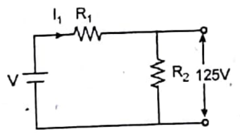


Fig. 1

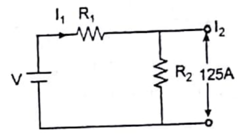


Fig. 2

$$I_1 = \frac{V}{R_1 + R_2} \quad V_{out} = \frac{V}{R_1 + R_2} \times R_2 = 125 \qquad ...(1)$$

for fig. 2

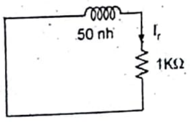
$$I_2 = \frac{V}{R_1} = 25 \qquad ...(2)$$

From equation 1 & 2

$$\frac{\dfrac{\cancel{V}R_2}{R_1 + R_2}}{\dfrac{\cancel{V}}{R_1}} = \frac{125}{25} \rightarrow \frac{R_1 R_2}{R_1 + R_2} = 5$$

For maximum power transfer.

Q.1. (d) Find the current i_r, through the 1kΩ resister of Fig. 1 at t = 1nsec, If i_r (0⁺)=6A. **(5)**



Ans.
$$L\frac{dI_r}{dt} + I_r R = 0$$

$$50\times 10^{-9}\frac{dI_r}{dt} + I_r\, 1\times 10^{3} = 0$$

$$\frac{dI_r}{dt} + \frac{1}{50}\times 10^{12} I_r = 0$$

$$\frac{dI_r}{dt} + 10^{10} I_r = 0$$

$$I_r = Ae^{-10^{10}t} \qquad ...(1)$$

at $$t = 0, I_r = 6A$$

$$A = 6$$

Putting this value in equation 1.

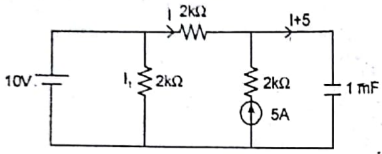
$$I_r = 6e^{-10^{10}t}$$

at $$t = 1 \times 10^{-n}\ s$$

$$I_r = 6 \times e^{-10^{10} \times 10^{-9}}$$

$$= 6e^{-1} = \frac{6}{e}$$

Q.1. (e) Obtain the time constant for the network shown in Fig. 2. **(5)**



Ans.

Applying kLl

$$10 = 2000I + \frac{1}{C}\int (I+5)dt$$

On differentiating we get

$$0 = 2000\frac{dI}{dt} + 1000(I+5)$$

$$\frac{2dI}{dt} + I + 5 = 0$$

$$\frac{dI}{dt} + \frac{I}{2} = -\frac{5}{2}$$

$$CF = Ae^{-\frac{1}{2}t}$$

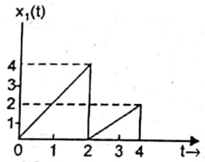
$$PI = -5$$

$$I = Ae^{-\frac{1}{2}t} - 5$$

Time constant

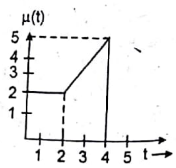
$$T = 2\ \text{sec}$$

Q.2. (a) Write the equation for the waveforms shown in Fig. 3(a) & (b) **(6)**



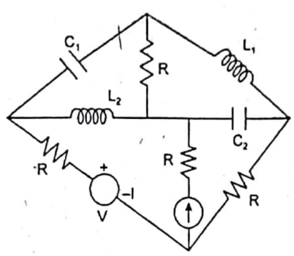
Ans. $x_1(t) = 2t\,[u(t) - u(t-2)] + t - 2\,[u(t-2) - u\,(t-4)]$

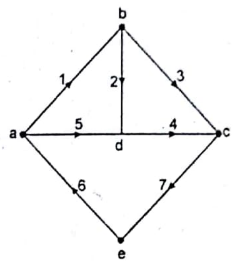
$$x_2(t) = [u(t) - u(t-2)] + \left[\frac{3}{2}t - 1\right][u(t-2) - u(t-4)]$$



Q.2. (b) Draw the directed graph and obtain the incidence matrix for the network shown in Fig. 4. **(6.5)**

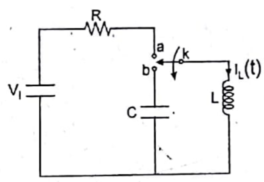
Ans.





	1	2	3	4	5	6	7
a	1	0	0	0	1	–1	0
b	–1	1	1	0	0	0	0
c	0	0	–1	–1	0	0	1
d	0	–1	0	1	–1	0	0
e	0	0	0	0	0	1	–1

Q.3. (a) The switch k (Fig. 5) is the steady state position a for $-\infty < t < 0$. At $t = 0$, it is connected to position b. Find the expression for current $i_L(t)$, for $t > 0$. **(6)**



Ans. at $$t = (0^-)$$

Inductor work as short circuit

$$L = \frac{V_1}{R}$$ [Inductor work as short circuit]

at $$t = 0^+$$

$$\frac{1}{c}\int_0^t i(t) + L\frac{di(t)}{dt} = 0 \qquad (1)$$

taking LT of equation (1)

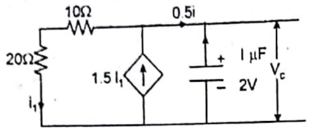
$$\frac{1}{cs}I(s) + L\left[sI(s) - b_L(0^+)\right] = 0$$

$$\left(\frac{1}{Cs + Ls}\right)I(s) = L\frac{v_1}{R}$$

$$I(s) = \frac{LV_1/R}{(1+LCs^2)/Cs} = \frac{V_1}{R}\left(\frac{s}{s^2 + \frac{1}{LC}}\right)$$

$$i(t) = \frac{V_1}{R}\cos\left(\frac{t}{\sqrt{LC}}\right)u(t)$$

Q.3. (b) Find expressions for $v_c(t)$ for $t > 0$ if $V_c(0^+)$=2V. **(6.5)**



Ans.
$$C\frac{dv}{dt} = \frac{V_c}{30} + 1.5\frac{V_c}{30}$$

$$C\frac{dv}{dt} = \frac{V_c}{30} + \frac{V_c}{20}$$

$$C\frac{dv}{dt} = \frac{5\cancel{0}}{30\times 2\cancel{0}}V_c = \frac{5}{60}V_c$$

$$C_sV(s) - 2 = \frac{5}{60}V_cS$$

$$V_s\left(sC - \frac{5}{60}\right) = 2 \Rightarrow V_s(s) = \frac{2}{Sc - \frac{5}{60}}$$

$$V(s) = \frac{2}{1\times 10^{-6}s - \frac{5}{60}}$$

$$= \frac{2}{10^{-6}\left(s - \frac{5}{60\times 10^{-6}}\right)}$$

$$= 2\times 10^{6}\frac{1}{\left(s - \frac{5}{6\times 10^{-5}}\right)}$$

$$= 2\times 10^{6} e^{\left\{\frac{5}{6\times 10^{-5}}\right\}t}$$

Q.4. (a) For a unit step input, find the forced and natural responses of the system described by

$$\frac{d^2y(t)}{dt^2} + 6\frac{dy(t)}{dt} + 2y(t) = 3\frac{dx(t)}{dt} + 9x(t),$$

the initial conditions of the system are $y(0^+)$=1 and $y'(0^+)$ = 2. **(6.5)**

Ans. $\frac{d^2y(t)}{dt^2} + 6\frac{dy(t)}{dt} + 2y(t) = 3\frac{dx(t)}{dt} + 9x(t)$

$$s^2Y(s) - sy(0) - y'(0) + 6sY(s) - 6y(0) + 2y(s)$$

$$= 3\left[sX(s) - x(0^+)\right] + 9X(s)$$

$$s^2Y(s) - s - 2 + 6sY(s) - 6 + 2Y(s) = 3sX(s) + 9X(s)$$

given $x(t) = u(t)$

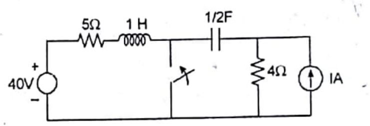
$$X(s) = \frac{1}{s}$$

$$Y(s)[s^2 + 6s + 2] = 3\cancel{s}\times\frac{1}{\cancel{s}} + \frac{9}{s} + s + 8$$

$$= \frac{s^2 + 11s + 9}{s}$$

$$Y(s) = \frac{s^2 + 11s + 9}{s(s^2 + 6s + 2)}$$

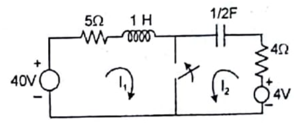
Q.4. (b) The circuit shown in Fig. 7 achieved steady state before switching and at t = 0 the switch k is closed. Determine the expression for the current $i(t)$. **(6)**



Ans.
Applying KVL in loop 1

$$40 = 5i + L\frac{di}{dt} \qquad L = 1H$$

$$40 = 5i + \frac{di}{dt}$$



$$CF = Ae^{-5t} \quad PI = \frac{40}{5} = 8$$

$$i_1 = Ae^{-5t} + 8$$

at $t = 0 \; i = 0$

Putting this value in above eqn.

$$A = -8$$

$$i_1 = -8e^{-5t} + 8$$

Applying KVL in loop 2

$$\frac{40}{(36+4)} = \frac{1}{C}\int i_2dt + i_2 4$$

On differentiating we get

$$0 = \frac{1}{C}i_2 + 4\frac{di_2}{dt} \quad C = \frac{1}{2}$$

$$2i_2 + 4\frac{di_2}{dt} = 0$$

$$\frac{di_2}{dt} + \frac{1}{2}i_2 = 0$$

$$i_2 = Be^{-\frac{1}{2}t}$$

at $t = 0$
$$i_2 = \frac{40}{4}$$

$$= 10$$

Putting the value in above eqn.

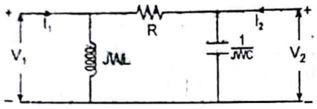
We get $\quad B = 10$

$$i_2 = 10e^{-\frac{1}{2}t}$$

$$i = i_1 + i_2$$

$$= -8e^{-4t} + 8 + 10e^{-\frac{1}{2}t}$$

Q.5. (a) Determine the T-parameters for the netework shown in Fig. (6)



Ans. Apply KCL at node (B)

$$I_2 = V_2\, jwc + \frac{v_2 - v_1}{R}$$

$$V_1 = (1 + jwcR)v_2 + R(-I_2)$$

Applying KCl at node (A)

$$I_1 = \frac{v_1}{jwL} + \frac{v_1 - v_2}{R}$$

$$I_1 = v_1\left(\frac{1}{jwL} + \frac{1}{R}\right) - \frac{v_2}{R}$$

P)utting the value of v1 in above eqn.

$$I_1 = \frac{R + jwL}{jwRL}\{(1 + jwcR)V_2 - RI_2\} - \frac{V_2}{R}$$

$$= V_2\left\{\frac{(R + jwL)(1 + jweR)}{jwRL} - \frac{1}{R}\right\} - R\frac{+jwL}{jwRL}$$

$$A = 1 + jwCR$$

$$B = R$$

$$C = \frac{C}{L}\left\{jwL + R + \frac{1}{jwc}\right\}$$

$$D = 1 + \frac{R}{jwL}$$

Q.5. (b) Determine the relationship for conversion of Y parameter to h-parameter. Find the conditions for symmetry in terms of *h* parameters.(6.5)

Ans.

$$V_1 = h_{11}I_1 + h_{12}V_2 \qquad (1)$$

$$I_2 = h_{21}I_1 + h_{22}V_2 \qquad (2)$$

$$I_1 = \frac{1}{h_{11}}v_1 - \frac{h_{12}}{h_{11}}v_2$$

$$Y_{11} = \frac{1}{h_{11}} \quad y_{12} = -\frac{h_{12}}{h_{11}}$$

Putting the value of I_1 in equation (2)

$$I_2 = h_{21}\left[\frac{1}{h_{11}}v_1 + \frac{\Delta h}{h_{11}}v_2\right] + h_{22}v_2$$

$$= \frac{h_{21}}{h_{11}}v_1 + \frac{\Delta h}{h_{11}}v_2$$

$$Y_{21} = \frac{h_{21}}{h_{11}} \quad y_{22} = \frac{\Delta h}{h_{11}}$$

Condition for symetry

Case 1
$$V_1 = V_s\, I_1 = I_1\, I_2 = 0\ V_2 = V_2$$
$$V_s = h_{11}I_1 + h_{12}v_2$$
$$0 = h_{21}I_1 + h_{22}v_2$$
$$\frac{V_s}{L_1} = \frac{h_{11}h_{22} - h_{12}h_{21}}{h_{22}}$$

Case II
$$V_2 = V_2\, I_2 = I_2\, I_1 = 0\ V_1 = V_1$$
$$V_1 = h_{12}V_s$$
$$I_2 = h_{22}V_s \text{ or } \frac{V_s}{I_2} = \frac{1}{h_{22}}$$

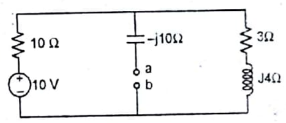
On equating both we get

$$h_{11}h_{22} - h_{12}h_{21} = 1$$
$$\Delta h = 1$$

Q.6. (a) A voltage source V_1 whose internal impedance is $R_1 + jX_1$ delivers power to a load R_2, where R_2 is variable. Find the value of R_2 at which the power deliverd to the load is a maximum. (5)

Ans.6.(a) Out of syllabus

Q.6. (b) State Norton's theorem. Obtain the Thevenin's and Norton' equivalent of the netweork across the terminal AB as shown in Fig. 9. (all element values are in ohm). (7.5)



Ans. Vth is voltage across $(3 + j4)\Omega$

$$V_{th} = \frac{10}{3 + j4 + 10}(3 + j4)$$

$$= 3.67\ \underline{|36°}\ V$$

$$Z_{th} = [10\|(3 + j4)] + (-j10)$$

$$= \frac{(3 + j4)10}{10 + 3 + j4} - j10$$

$$= 8.38\angle -69.3°\Omega$$

$$I_n = \frac{V_{th}}{Z_{th}} = \frac{3.67\ \underline{|36°}}{8.38\ \underline{|-69.3°}}$$

$$= .438\ \underline{|105.30}$$

$$Zth = Z_N$$

Q.7. (a) Test whether the polynomial $F(s) = 4s^4 + 2s^3 + 5s^2 + 3s + 2$ is Hurwitz or not. (4)

Ans. $4s^4 + 2s^3 + 5s^2 + 3s + 2$

$$M(s) = 4s^4 + 5s^2 + 2$$
$$N(s) = 25^3 + 3s$$

$$2s^3 + 36\overline{)\,4s^4 + 5s^2 + 2\,}(2s$$
$$\pm 4s^4 \pm 6s^2$$
$$s^2 + 2\overline{)\,2s^3 + 3s + 2\,}(-2s$$
$$\mp 2s^3 \mp 4s$$
$$7s\overline{)\,-s^2 + 2\,}\left(-\frac{1}{7}s\right.$$
$$-s^2$$
$$+$$
$$2\overline{)\,7s\,}\left(\frac{7}{2}s\right.$$
$$7s$$
$$\times$$

–ve coefficient.
Not Hurwitz.

Q.7. (b) For the LC driving point impedance function $Z_D(s) = \dfrac{(s^2+1)(s^2+16)}{s(s^2+4)}$ synthesize in Foster-I and Caur-I form. (8.5)

Ans.
$$Z_D = \frac{(s^2+1)(s^2+16)}{s(s^2+4)} = \frac{s^4+17s^2+16}{s^3+4s}$$

Faster-I

$$s^3 + 4s\overline{)\,s^4 + 17s^2 + 16\,}(s$$
$$\underline{-s^4 \pm 4s^2}$$
$$13s^2 + 16$$

$$= s + \frac{13s^2+16}{s^3+4s} = s + \frac{13s^2+16}{s(s^2+4)}$$

$$= s + \frac{A}{s} + \frac{Bs+c}{s^2+4}$$

$$Bs^2 + As^2 = 13s^2$$

$$A = \left.\frac{13s^2+16}{\cancel{s}(s^2+4)}\cancel{s}\right|_{s=0}$$

$$= 4$$
$$B = 9$$
$$C = 0$$

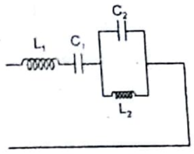
$$s + \frac{4}{s} + \frac{9s}{s^2+4}$$

$$LS \quad \frac{1}{CS} \quad \frac{\frac{1}{c}s}{s^2+\frac{1}{L}}$$

$$L_1 = 1 \quad C_2 = \frac{1}{9}$$

$$C_1 = \frac{1}{4} \quad L_2C_2 = \frac{1}{4}$$

$$L_2 = \frac{9}{4}$$



Cauer-II

$$s^3 + 4s\overline{)\,s^4 + 17s^2 + 16\,}(s \to z_1$$
$$-s^4 \pm 4s^2$$
$$13s^2 + 16\overline{)\,s^3 + 4s\,}\left(\frac{1}{13}s \leftrightarrow y_1\right.$$
$$-s^3 \pm \frac{16}{13}s$$
$$\frac{36}{13}s\overline{)\,13s^2 + 16\,}\left(\frac{169}{36}s\right.$$
$$-13s^2$$
$$16\overline{)\,\frac{36}{13}s\,}($$

$$16\overline{)\,\frac{36}{13}s\,}\left(\frac{36}{13\times 16}s \to y_2\right.$$
$$\frac{36}{13}$$
$$\times$$

$$s \to z_1$$
$$z = L_1 s$$
$$L_1 = 1$$

$$\frac{1}{13}s \to y_1$$

$$c_1 s$$

$$c_1 = \frac{1}{13}$$

$$\frac{169}{36}s \to z_2$$

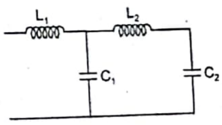
$$L_2 s$$

$$L_2 = \frac{169}{36}$$

$$\frac{36}{13\times 16}s \to y^2$$

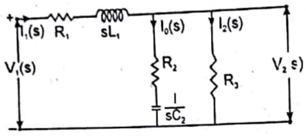
$$C_2 s$$

$$C_2 = \frac{36}{13\times 16}$$



For New Syllabus Circuit & System

Q. For the circuit shown in figure. Determine the network transfer function.



Ans. The network equation are

$$V_2(s) = R_3 I_2(s)$$

$$= \left(R_2 + \frac{1}{sC_2}\right) I_0(s) \qquad \text{...(1)}$$

or

$$I_0(s) = \frac{V_2(s)}{R_2 + \dfrac{1}{sC_2}} \qquad \text{...(2)}$$

$$I_1(s) = I_2(s) + I_0(s)$$

$$V_1(s) = V_2(s) + (R_1 + sL_1) I_1(s)$$

Transfer impedance function,

$$Z_{21}(s) = \frac{V_2(s)}{I_1(s)}$$

$$V_2(s) = \left(R_2 + \frac{1}{sC_2}\right) I_0(s)$$

$$I_1(s) = I_2(s) + I_0(s) = I_0(s)\left[\frac{I_2(s)}{I_0(s)} + 1\right]$$

$$= I_0(s)\left[\frac{R_2}{R_3} + \frac{1}{sC_2R_3} + 1\right] \qquad \text{[From Equation (1)]}$$

$$\therefore \quad Z_{21}(s) = \frac{R_3(sC_2R_2 + 1)}{C_2(R_2 + R_3)s + 1}$$

(*ii*) Transfer admittance function,

$$Y_{21}(s) = \frac{I_2(s)}{V_1(s)}$$

$$V_1(s) = V_2(s) + (R_1 + sL_1) I_1(s)$$

$$= R_3 I_2(s) + (R_1 + sL_1)[I_2(s) + I_0(s)] \qquad \text{[From Equations (1) and (3)]}$$

$$= I_2(s)\left[R_3 + (R_1 + sL_1) + (R_1 + sL_1)\left(\frac{R_3}{R_2 + \dfrac{1}{sC_2}}\right)\right]$$

$$= I_2(s)\left[\frac{(R_3 + R_1 + sL_1)(sC_2R_2 + 1) + (R_1 + sL_1).R_3.sC_2}{(sC_2R_2 + 1)}\right]$$

$$\therefore \quad Y_{21}(s) = \frac{sC_2R_2 + 1}{L_1C_2(R_2 + R_3)s^2 + \left[C_2(R_1R_2 + R_2R_3 + R_3R_1) + L_1\right]s + (R_1 + R_3)}$$

(*iii*) Voltage transfer function,

$$G_{21}(s) = \frac{V_2(s)}{V_1(s)} = \frac{V_2(s)}{I_1(s)} \cdot \frac{I_2(s)}{V_1(s)} \cdot \frac{I_1(s)}{I_2(s)} = Z_{21}(s).Y_{21}(s).\frac{I_1(s)}{I_2(s)}$$

$$I_1(s) = I_2(s) + I_0(s) = I_2(s)\left[1 + \frac{I_0(s)}{I_2(s)}\right]$$

$$= I_2(s)\left[1 + \frac{R_3}{R_2 + \dfrac{1}{sC_2}}\right] = I_2(s)\left[\frac{[(aR_2C_2 + 1)] + sC_2R_3}{(sR_2C_2 + 1)}\right]$$

$$\frac{I_1(s)}{I_2(s)} = \frac{C_2(R_2 + R_3)s + 1}{sR_2C_2 + 1}$$

$$\therefore \quad G_{21}(s) = \frac{R_3(sC_2R_2 + 1)}{L_2C_2(R_2 + R_3)s^2 + \left[C_2(R_1R_2 + R_2R_3 + R_3R_1) + L_1\right]s + (R_1 + R_3)}$$

(*iv*) Current transfer function,

$$\alpha_{21}(s) = \frac{I_2(s)}{I_1(s)} = \frac{sR_2C_2 + 1}{C_2(R_2 + R_3)s + 1}$$

Q. Find the open circuit driving point impedance at terminals 1-1' of the ladder work shown in figure below.

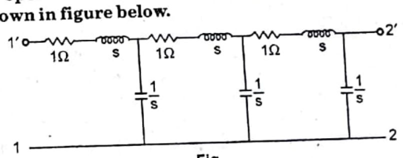


Fig.

Ans. From figure

$$Z_1(s) = s + 1, Y_2(s) = s, Z_3(s) = s + 1, Y_4 = s, Z_5 = s + 1, Y_6 = 2.$$

Therefore,

$$Z_{11}(s) = Z_1 + \cfrac{1}{Y_2 + \cfrac{1}{Z_3 + \cfrac{1}{Y_4 + \cfrac{1}{Z_5 + \cfrac{1}{Y_6}}}}}$$

$$= (s+1) + \cfrac{1}{s + \cfrac{1}{(s+1) + \cfrac{1}{s + \cfrac{1}{(s+1) + \cfrac{1}{s}}}}}$$

$$= (s+1)+\cfrac{1}{s+\cfrac{1}{(s+1)+\cfrac{1}{s+\cfrac{s}{s^2+s+1}}}}$$

$$= (s+1)+\cfrac{1}{s+\cfrac{1}{(s+1)+\cfrac{s^2+s+1}{s^3+s^2+2s}}}$$

$$= \frac{s^6+6s^5+11s^4+13s^3+10s^2+5s+1}{s^5+5s^4+5s^3+3s^2+3s}$$

Q. Write necessary conditions for

(a) Driving Point Immittance Functions and

(b) Transfer functions

Ans. (a) **Necessary Conditions for Driving Point Immittance Function (with common factors in $N(s)$ and $D(s)$ cancelled):**

1. The coefficients in the polynomials $N(s)$ and $D(s)$ must be real and positive.
2. Poles and zeros must be conjugate if imaginary or complex.
3. The real part of all poles and zeros must be negative or zero, if the real part is zero, then that pole or zero must be simple, i.e. all the roots of $N(s) = 0$ and $D(s) = 0$ lie on the left half of s-plane and simple roots may lie on the imaginary or jw-axis.
4. The polynomials $N(s)$ and $D(s)$ may not have missing terms between those of highest and lowest degrees, unless all even or all odd terms are missing.
5. The highest degree of $N(s)$ and $D(s)$ may differ by either zero or one only.
6. The lowest degree of $N(s)$ and $D(s)$ may differ by either zero or one only.

(b) **Necessary Conditions for Transfer Fucntions (with common factors in N(s) and D(s) cancelled)**

1. The coefficients in the polynomials $N(s)$ and $D(s)$ of $T = N/D$ must be real and those for $D(s)$ must be positive.
2. Poles and zeroes must be conjugate if imaginary or complex.
3. The real part of poles must be negative or zero, if the real part is zero, then that pole must be simple. This includes the origin.
4. The polynomial $D(s)$ may not have any missing term between that of highest and lowest, degrees, unless all even or all odd terms are missing.
5. The polynomial N(s) may have terms missing, and some of the coefficients may be negative.
6. The degree of N(s) may be as small as zero independent of the degree of D(s).
7. (a) for G and α : The maximum degree of N(s) is equal to the degree of D(s).
   (b) For Z and Y : The maximum degree of N(s) is equal to the degree of D(s) plus one.

THIRD SEMESTER (B.TECH)
FIRST TERM EXAMINATION [2014]
CIRCUITS AND SYSTEMS [ETEE-207]

Time : 1.30 hrs. **M.M. : 30**

Note: *Attempt Question no. 1. which is compulsory and any two more questions from remaining. There is step-marking and use of scientific calculator (non-programmable) is permitted. Assume missing data, if any.*

Q.1. (a) Clearly distinguish between Transient Analysis and Steady State Analysis. Under what interval of time, as a multiple of Time Constant of the series R-L. or series R-C circuit, can we approximate the values of $v(t)$ or $i(t)$ as its steady state value? Why? **(4)**

Ans. The value of voltage and current during the transient peirod are known as transient response.

The values of voltage and current after the transient has died out are known as the steady state response *

4 time constant.

Q.1. (b) An LTI system has an impulse response $h(t)$ for which the Laplace Transform is

$H(s) = 1/(s + 1)$: Re(s) > – 1. Determine the step response for the same LTI system assuming it to be initially relaxed. **(2)**

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

On taking Inverse LT we get

$$h(t) = e^{-t}u(t)$$

If input is $u(t)$ then $U(s) = \frac{1}{s}$

$$y(s) = \frac{1}{s+1}\times\frac{1}{s} = \frac{1}{s} - \frac{1}{s+1}$$

on taking LT

$$y(t) = u(t) - e^{-t}u(t)$$

Q.1. (c) What is the rate of change of current at $t = 0+$ in a coil of resistance 20 Ω and inductance of 0.8 H when connected to a 200 V DC supply? Determine its value using classical method. **[2]**

Ans.
$$V = R\,i(t) + L\frac{d\,i(t)}{dt}$$

$$20 = 20\,i(t) + 0.8\frac{d\,i(t)}{dt}$$

$$\frac{d\,i(t)}{dt} + 25\,i(t) = 250$$

$$\text{C.F.} = Ke^{-25t}$$

$$P.I. = \frac{250\,e^{0t}}{D+25} = \frac{250}{25} = 10$$

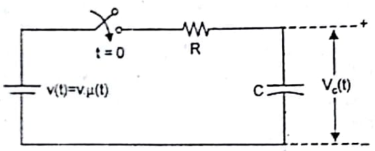
$$i(t) = K e^{-25t} + 10$$

at $t = 0^{+}\; i = 0 =$

$$0 = K + 10 \Rightarrow k = -10$$

$$i(t) = 10(1 - e^{-25t})$$

Q.1. (*d*) Derive an expression for $Vc(t)$ for the circuit given below for $t > 0$, assuming zero initial condition. (2)



Ans.
$$V = R\,i(t) + \frac{1}{c}\int i(t)\,dt$$

On taking LT

$$\frac{V}{s} = R\,I(s) + \frac{1}{c}\,I(s)$$

$$I(s) = \frac{V}{S\left(R + \frac{1}{CS}\right)} = \frac{CV}{RCS+1} = \frac{V}{R}\times\frac{1}{\left(S + \frac{1}{CR}\right)}$$

On taking ILT we get $i(t) = \frac{V}{R}e^{-t/RC}$

$$V_c(t) = \frac{1}{C}\int \frac{V}{R}e^{-t/RC}\,dt$$

$$= \frac{1}{C}\times\frac{V}{R}\times e^{-t/RC} = Ve^{-t/RC}$$

Q.1. (*e*) Solve the differential equation, with $y(0) = 0.5$ & $y(0) = 0$

$$\frac{d^2y(t)}{dt^2} + 9\frac{dy(t)}{dt} + 20\,y(t) = 1$$

Ans.
$$\frac{d^2y(t)}{dt^2} + 9\frac{dy(t)}{dt} + 20y(t) = 1$$

On taking LT

$$s^2y(s) - s\,y(0^+) - y(0) + 9\,[sY(s) - y(0^+)] + 20\,Y(s) = \frac{1}{5}$$

$$s^2\,Y(s) - .5S + 9\,sy(s) - 4.5 + 20\,Y(s) = \frac{1}{5}$$

$$Y(s)\,[s^2 + 9s + 20] = \frac{1}{s} + .5s + 4.5$$

$$Y(s) = \frac{.5S^2 + 4.5S + 1}{s(s^2 + 9s + 20)} = \frac{(s^2 + 9s + 2)}{2S(s^2 + 9s + 20)}$$

on taking ILT, we get $y(t)$

Other method to solve

$$CF = D^2 + 9D + 20$$
$$CF = Ae^{-5t} + Be^{-4t}$$
$$= D^2 + 5D + 4D + 20$$
$$(D+5)(D+4)$$
$$D = 5, 4$$

for
$$\text{P I}\;\frac{1\,e^{0t}}{D^2 + 9D + 20} = \frac{1}{20}$$

$$Y(t) = Ae^{-5t} + Be^{-4t} + \frac{1}{20}$$

at $t = 0$, $Y(0) = .5\,A + B = .45$

on differentiating $y(t) = -5\,A\,e^{-5t} + e^{-4t}\,Br - 4$

at $t = 0\;y'(0) = 0$

$$-5A - 4B = 0$$

$$5A = -4B \Rightarrow A = \frac{-4B}{5}$$

$$-\frac{4B}{5} + B = .45$$

$\Rightarrow$
$$B = 2.25$$
$$A = -1.8$$

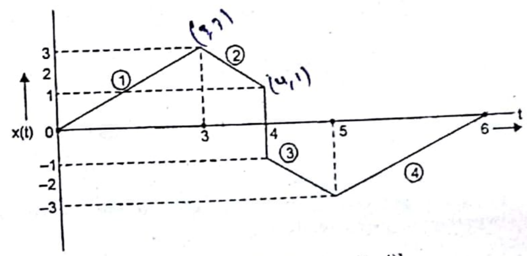
$$y(t) = -1.8\,e^{-5t} + 2.25\,e^{-4t} + \frac{1}{20}$$

Q.2. (*a*) Let $x(t)$ and $y(t)$ be periodic signals with fundamental periods T_1 and T_2 respectively. Under what conditions is the sum $[x(t) + y(t)]$ periodic, and what shall be the fundamental period of the signal, if it is periodic. (2)

Ans. if $\frac{T_1}{T_2}$ is a rational number

T_2 is the Fundamental period

Q.2. (*b*) Synthesize the given waveform using step, ramp signals only: (4)



Ans. $y(t) = t[u(t) - u(t-3)] + (-2t+4)\,[u(t-3) - u(t-4)]$
$+ (-2t+7)\,[u(t-u) - u(t-5)] + (t-8)\,[u(t-5) - u(t-8)]$

Q.2. (c) Determine $x(t)$ for the following conditions if $X(s)$ is given by $X(s)$, $\frac{1}{(s+1)(s+2)}$ when

(i) $x(t)$ is right-rided.

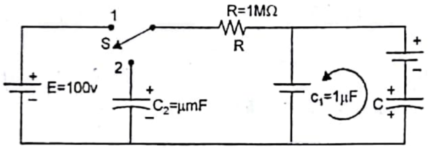
(ii) $x(t)$ is two-sided with ROC lying in between –1 and –2. **(4)**

Ans.
$$X(s) = \frac{1}{(S+1)(S+2)} = \frac{1}{S+1} - \frac{1}{S+2}$$

(1) $$x(t) = e^{-t}u(t) - e^{-2t}u(t)$$

(2) $$x(t) = -e^{-t}u(t) - e^{-2t}u(t)$$

Q.3. (a) In the circuit of the figure below, switch S has been in position 1 for a long time:



(i) Find the complete solution for the current in the circuit when S is put to position 2.

(ii) How long does it takes in seconds for the transient to disappear? (current to decay within 1%)

(iii) Determine the voltage which appears across each capacitor at steady state. **(5)**

Ans.
$$V_c(0^-) = 1000\ V$$

$$1000 = R\,i(t) + \frac{1}{c_2}\int i(t)\,dt + \frac{1}{c_1}\int i(t)\,dt$$

on differentiating above equation we get

$$R\frac{di(t)}{dt} + \frac{1}{c_2}i(t) + \frac{1}{c_1}i(t) = 0$$

$$10^6\frac{di(t)}{dt} + \frac{2}{10^{-6}}i(t) = 0$$

$$\frac{di(t)}{dt} + 2i(t) = 0 \Rightarrow i(t) = A\,e^{-2t}$$

at
$$t = 0^+\ i(0^+) = \frac{-1000}{10^6} = -10^{-3}$$

$$A = -10^{-3}$$

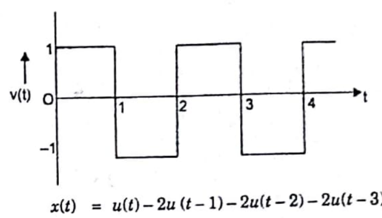
$$i(t) = -10^{-3}e^{-2t}$$

Q.3. (b) Define Time Constant of an RL and RC circuit. Why there are no transients in purely resistive circuits? **(2)**

Ans. In RL circuit time constant $= \frac{L}{R}$

In RC circuit $= RC$

Q.3. (c) For the given square wave, determine the Laplace transform, using its properties: **(3)**



Ans.
$$x(t) = u(t) - 2u(t-1) - 2u(t-2) - 2u(t-3)$$

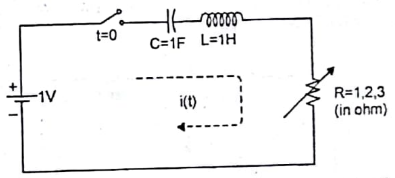
on taking LT

$$x(s) = \frac{1}{s} - 2\frac{e^{-s}}{s} - 2\frac{e^{-2s}}{s} - 2\frac{e^{-3s}}{s} + \ldots$$

$$= \frac{1}{s} - \frac{2}{s}(e^{-s} + e^{-2s} + e^{-3s} \ldots \infty)$$

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

Q.4. (a) A series R-L-C circuit having a pure Inducto having Inductance 1 H and a pure Capacitor having Capacitance 1F is connected with a variable resistor which can take three values: 1 Ω, 2Ω and 3Ω.



Determine $i(t)$ for $t > 0$ in each of the three cases, indicating the nature of response. (Assume all initial conditions to be zero) **(6)**

Ans.
$$L\frac{di(t)}{dt} + Ri(t) + \frac{1}{c}\int i(t)\,dt = 1$$

On differentiating above equation we get

$$L\frac{d^2i(t)}{dt^2} + R\frac{di(t)}{dt} + \frac{1}{c}i(t) = 0$$

$$\frac{d^2i(t)}{dt^2} + \frac{R}{L}\frac{di(t)}{dt} + \frac{1}{LC}i(t) = 0$$

$$D^2 + \frac{R}{L}D + \frac{1}{LC} = 0$$

if
$$R = 1, L = 1, C = 1$$

$$D^2 + D + 1 = 0$$

$$D = \frac{-1-i\sqrt{3}}{2}, \frac{-1+j\sqrt{3}}{2}$$

$$i(t) = Ae^{-\left(\frac{1-j\sqrt{3}}{2}\right)t} + Be^{-\left(\frac{1+j\sqrt{3}}{2}\right)t}$$

at $t = 0\; i = 0$

$A + B = 0$

if $R = 2$

$p^2 + 2p + 1 = 0$

$p = -1, -1.$

$i(t) = Ae^{-t} + Bte^{-t}$

at $t = 0\; i = 0$

$A = 0$

if $R = 3$

$p^2 + 3p + 1 = 0$

$D = b^2 - 4ac$

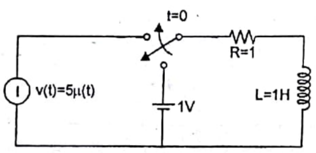
$$P = \frac{5-3+\sqrt{5}}{2} = \frac{3-\sqrt{5}}{2}$$

$$i(t) = Ae^{-\left(\frac{3-\sqrt{5}}{2}\right)t} + Be^{-\left(\frac{-3+\sqrt{5}}{2}\right)t}$$

at $t = 0\; i = 0$

$A + B = 0$

Q.4. (*b*) The switch *S* is moved from the position 1 to position 2 at $t = 0$, when a 5 V DC is impressed to the R-L circuit. At what time does the voltage across Inductor become hall of the voltage impressed? (4)



Ans. $i(0^-) = iA$

(because inductor behave as short circuit)

$$5u(t) = 1\,i(t) + L\frac{d\,i(t)}{dt}$$

$$\frac{d\,i(t)}{dt} + i(t) = 5u(t)$$

$$\text{C.f} = Ae^{-t}$$

$$PI = \frac{5}{D+1} = 5$$

$i(t) = 5 + Ae^{-t}$

at $t = 0 \quad i = 1A$

$1 = 5 + A \quad A = -4$

$i(t) = 5 - 4e^{-t}$

THIRD SEMESTER (B.TECH)
SECOND TERM EXAMINATION [2014]
CIRCUITS AND SYSTEMS [ETEE-207]

Time : 1.30 hrs. **M.M. : 30**

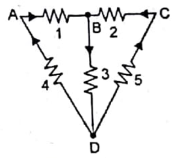
Note: *Attempt Question no. 1. which is compulsory and any two more questions from remaining. There is step-marking and use of scientific calculator (non-programmable) is permitted. Assume missing data, if any.*

Q.1. (*a*) Give an expression for the transient response of an initially relaxed purely inductive circuit having an inductance or 1 H when subjected to an input $v(t) = 2$ cost.

Ans.
$$i(t) = \frac{1}{L}\int V(t)\,dt$$

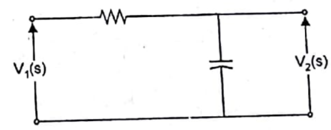
$$i(t) = \frac{1}{1}\int 2\cos t\,dt = 2\sin t$$

Q.1. (*b*) Define node and branch of an oriented graph. Draw any electrical circuit without using Inductor and Capacitor which represents the following graph with *A, B, C, D* as nodes and 1 to 5 as branches.

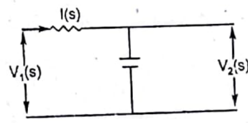


Ans. The components in a circuit is replaced by line segments called branch. Two or more branches meet at apoint is called node.

Q.1. (c) Determine V2(s)/V1(s) for the given R-C circuit, where *R* is in ohm and *C* is in Farad.



Ans.



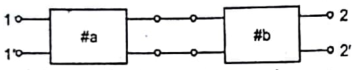
$$V_1(s) = I(s)\,R + I(s) \times \frac{1}{cs}$$

$$I(s) = \frac{V_1(s)}{R + \frac{1}{cs}}$$

$$V_2(s) = I(s) \times \frac{1}{cs} = \frac{V_1(s)}{R + \frac{1}{cs}} \times \frac{1}{cs}$$

$$\frac{V_2(s)}{V_1(s)} = \frac{1/cs}{R + 1/cs} = \frac{1}{1 + Rcs}$$

Q.1. (*d*) Two networks '*a*' and '*b*' are connected in cascade as shown below. If $[T_a']$ and $[T_b']$ are their inverse transmission parameters, derive for $[T']$ the overall value for cascaded network.



Ans. For the cascaded network, *T*-parameters are given as:

$$[T] = [T_a][T_b]$$

For the inverse parameters,

$$[T'] = [[T_a][T_b]]'$$

By using matrix property

$$[AB]^{-1} = [B^{-1}A^{-1}]$$
$$T = [T_a][T_b]$$

Q.1. (*e*) Check whether the polynomial $F(s) = s^3 + 4s^2 + 2s + 8$ is Hurwitz or not. **(5 × 2 = 10)**

Ans. $s^3 + 4s^2 + 2s + 8$

$$\text{odd port} = s^3 + 2s$$
$$\text{even port} = 4s^2 + 8$$

$$4s^2 + 8)\, s^3 + 2s \,(1/9\, s$$
$$\underline{s^3 + 2s}$$
$$0$$

$$F(s) = s^3 + 2s\left(1 + \frac{4}{s}\right)$$

From above. equation we can say $\left(1 + \frac{4}{s}\right)$ is hurwitz

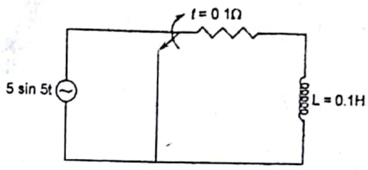
Now check for $s^3 + 2s$

$$s(s^2 + 2) = s(s + i\sqrt{2})(s - i\sqrt{2}) \text{ is hurwitz}$$

So $F(s)$ is hurwitz

Q.2. (*a*) Obtain the current for $t > 0$, if an *AC* voltage $v = 5 \sin 5t$ is applied when the switch '*k*' is moved from position 1 to 2 at $t = 0$.

Ans.



$$5 \sin 5t = I(t) \times R + L\frac{dI(t)}{dt}$$

$$= I(t) + .1\frac{dI(t)}{dt}$$

$$\frac{dI(t)}{dt} + 10\, I(t) = 50 \sin 5t$$

for

$$CF = D + 10 = 0$$
$$D = -10$$
$$CF = Ae^{-10t}$$

$$PI = \frac{50 \sin 5t\,(D - 10)}{(D + 10)(D - 10)}$$

$$= \frac{(D - 10)(50 \sin 5t)}{D^2 - 10^2}$$

$$= \frac{D(50 \sin 5t) - 500 \sin 5t}{-25 - 100}$$

$$= \frac{5 \times 50 \cos 5t}{-75} + \frac{500}{75}\sin 5t$$

$$E(t) = CF + PI$$

$$= A\,e^{-10t} - \frac{10}{3}\cos 5t + \frac{20}{3}\sin 5t$$

at $t = 0$ $i = 0$ (inductor behave as open circuit)

$$0 = A - \frac{10}{3}$$

$$\Rightarrow \quad A = \frac{10}{3}$$

$$I(t) = \frac{10}{3}e^{-10t} - \frac{10}{3}\cos 5t + \frac{20}{3}\sin 5t$$

Q.2. (*b*) The following equation give the voltage *V*1 and *V*2 at the two ports of a two port network:

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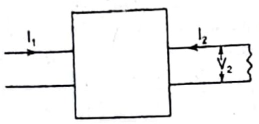
$$V_1 = 5I_1 + 6I_2 \quad ...(1)$$
$$V_2 = 2I_1 + I_2 \quad ...(2)$$

A load resistor of 5 ohm is connected across port 2. Calculate the input impedance. **(5)**

Ans.

$$\left.\begin{aligned} V &= 5I_1 + 6I_2 \quad ...(1) \\ V_2 &= 2I_1 + I_2 \quad ...(2) \end{aligned}\right\} \text{given}$$

$$V_2 = -5I_2 \text{ from fig.}$$



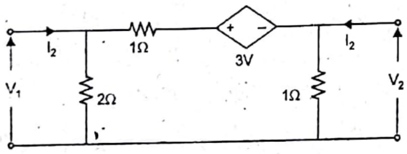
on putting this value in equation (2)

$$-5I_2 = 2I_1 + I_2$$
$$-6I_2 = 2I_1 \Rightarrow I_1 = -3I_2$$

Putting the value of I_2 in equation (1)

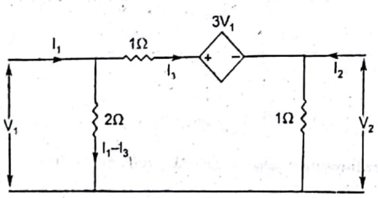
$$V_1 = 5I_1 + 6 \times -\left(\frac{I_1}{3}\right)$$
$$V_1 = 5I_1 - 2I_1$$
$$\boxed{Z_{in} = \frac{V_1}{I_1} = 3}$$

Q.3. (a) Determine the Z parameters for the following network shown in figure below:



State whether it is reciprocal, symmetrical or not. **(5)**

Ans.



$$V_1 = 2(I_1 - I_3) \quad ...(1)$$
$$I_3 + 3V_1 - 2(I_1 - I_3) - (I_2 + I_3) = 0$$
$$4I_3 - 2I_1 + I_2 + 3V_1 = 0 \quad ...(2)$$
$$V_2 = I_2 + I_3 \quad ...(3)$$

from equation (1), (2) and (3)

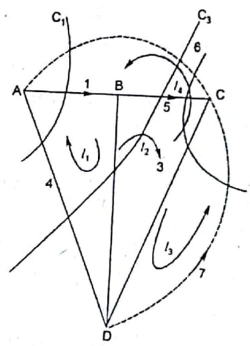
$$V_1 = 2I_1 - 2\left(\frac{I_1}{2} - \frac{I_2}{4} - \frac{3V_1}{4}\right)$$
$$V_1 = 2I_1 - I_2 \quad ...(4)$$
$$V_2 = I_2 + \frac{1}{4}(2I_1 - I_2 - 3V_1)$$
$$V = 2I_1 + \frac{3}{2}I_2 \quad ...(5)$$

from equation 4 and 5

$$Z = \begin{bmatrix} -2 & -1 \\ 2 & 3/2 \end{bmatrix}$$

Q.3. (b) Determine the Incidence Matrix, Cut-set Matrix and Tie-Se matrix, assuming (1, 2, 3) as set of twigs and (4, 5, 6, 7) as set of links, for the given oriented graph. **(5)**

Ans.



Incident matrix

$$A = \begin{array}{c|ccccccc|} & 1 & 2 & 3 & 4 & 5 & 6 & 7 \\ A & 1 & 0 & 0 & -1 & 0 & -1 & 0 \\ B & -1 & 1 & 0 & 0 & 1 & 0 & 0 \\ C & 0 & 0 & -1 & 0 & -1 & 1 & -1 \\ D & 0 & -1 & 1 & 1 & 0 & 0 & 1 \end{array}$$

Cut set matrix

$$\begin{array}{c|cccccc|c} & 1 & 2 & 3 & 4 & 5 & 6 & 7 \\ c_1 & 1 & 0 & 0 & -1 & 0 & -1 & 0 \\ c_2 & 0 & 0 & 1 & 0 & 1 & -1 & 0 \\ c_3 & 0 & 1 & 0 & -1 & 1 & -1 & 0 \end{array}$$

Tie set

$$\begin{array}{c|ccccccc|} & 1 & 2 & 3 & 4 & 5 & 6 & 7 \\ l_1 & 1 & 0 & 0 & -1 & 0 & -1 & 0 \\ l_2 & -1 & 1 & 0 & 0 & 1 & 0 & 0 \\ l_3 & 0 & 0 & -1 & 0 & -1 & 1 & -1 \\ l_4 & 0 & -1 & 1 & 1 & 0 & 0 & 1 \end{array}$$

Q.4. (a) The driving point impedances of a one port reactive network is given by

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

Obtain Foster's I OR Foster's II form of realization. Draw the circuit. **(5)**

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

Ans.

On partial fraction

$$\frac{A_1 s}{s^2+1} + \frac{A_2 s}{s^2+16}$$

$$A_1 = \left.\frac{4s(s^2+4)}{(s-1j)(s^2+16)}\right|_{s=-j} = .8$$

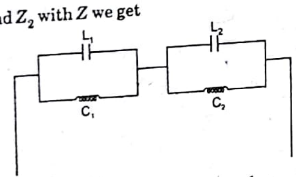
$$A_2 = \left.\frac{4s(s^2+4)}{(s^2+1)(s-4j)}\right|_{s=-4j} = 3.2$$

$$Z = \underbrace{\frac{.8S}{s^2+1}}_{z_1} + \underbrace{\frac{3.2.S}{s^2+16}}_{z_2}$$

for faster I

$$Z(s) = \frac{\frac{1}{e}s}{s^2+\frac{1}{Lc}}$$

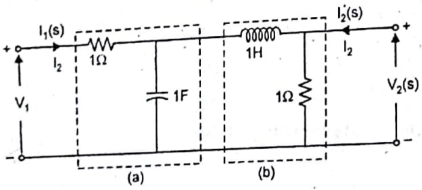
on comparing Z_1 and Z_2 with Z we get



$$L_1 = .8 \quad c_1 = \frac{1}{0.8} \qquad \frac{1}{LC} = 16$$

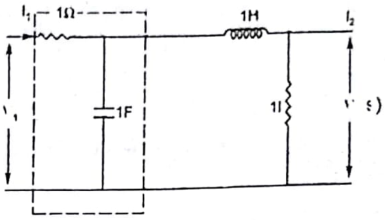
$$L_2 = .2\, c_2 = \frac{1}{3.2} \qquad L = \frac{1}{16\times C} = \frac{3.2}{16} = .2$$

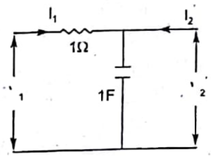
Q.4. (b) Obtain the Transmission parameters for the network shown below, using properties of inter-connection or otherwise. Check for reciprocity condition. **(5)**



Ans.

$$V_1 = AV_2 + B(-I_2)$$
$$I_1 = CV_2 + D(-I_2)$$





$$V_1 = I_1 + (I_1+I_2)\frac{1}{s}$$

$$= I_1\left(1+\frac{1}{s}\right) + I_2'/s \qquad ...(1)$$

$$V_2 = \frac{(I_2^1+I_1)}{s}$$

$$I_1 = SV_2 - I_2' \qquad ...(2)$$

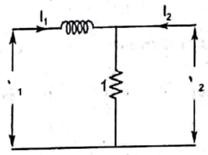
Putting the value of I_1 and in equation (1)

$$V_1 = (SV_2 - I_2')\left(1+\frac{1}{s}\right) + I_2'(s)$$

$$= S\left(1+\frac{1}{s}\right)V_2 + I_2'\left(s-1-\frac{1}{s}\right)$$

$$= (S+1)V_2 + I_2' - 1 \qquad ...(3)$$

From equation (3) and (2)



$$Ia = \begin{bmatrix}(s+1) & +1\\ s & 1\end{bmatrix}$$

$$V_1 = SI_1 + (I_1+I_2) \qquad ...(1)$$
$$V_2 = (I_2+I_1)$$
$$I_1 = V_2 - I_2 \qquad ...(2)$$
$$V_1 = (S+1)(V_2-I_2) + I_2$$
$$= (S+1)V_2 + I_2(1-S-1)$$
$$= (S+1)V_2 - I_2 S$$

$$T_b = \begin{bmatrix}s+1 & -s\\ 1 & -1\end{bmatrix}$$

$$T = T_a T_b = \begin{bmatrix}s^2+2s+2 & s^2+s+1\\ s^2+s+1 & s^2+1\end{bmatrix}$$

THIRD SEMESTER (B.TECH)
END TERM EXAMINATION [2014]
CIRCUITS AND SYSTEMS [ETEE-207]

M.M.:

Time : 3 hrs.

Note: *Attempt any five questions including Q.No. 1 which is compulsory. Assume missing data if any.*

Q.1. (a) Show that voltage across a capacitor & current through an inductor cannot change instantaneously.

Ans. For Modulator

$$L_1(t) = \frac{1}{L}\int_{-\infty} v_l dt$$

$$L_2 = (0-)\, t = 0_-$$

$$L_2(0_+ \quad t = 0_+$$

therefore $\quad t = 0_+$

$$i_L(0_+) = \frac{1}{L}\int_{-\infty}^{0+} V_L dt$$

$$= i_L(0) + \frac{T}{L}\int_{0^-}^{0+} V_L dt$$

Interval 0_- to 0_+ is almost zero.

So $\quad \frac{1}{L}\int_{0-}^{0+} V_L dt = 0$

$$i_L(0_+) = i_L(0-)$$

Similarly for Capacitor

$$V(0-) = V(0_+)$$

This shows the voltage across a capacitor is constant & current across enductor constant for instantenous change

Q.1. (b) A resistor of 10 Ω has a current $i = 6 \sin 500\,\pi t$. Find the instantaneous voltage, power & energy over one cycle.

Ans. Instantaneous voltage $= IR = 60 \sin 500\,\pi t$

$$\text{Power} = I_{rms}^2 R$$

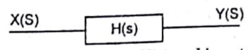
$$= \left(\frac{6}{\sqrt{2}}\right)^2 \times 10 = \frac{360}{2} \times 10 = 1800 \text{ W}$$

$$E = PT$$

$$= p \times \frac{1}{f} = 1800 \times \frac{1}{250} = 72$$

Q.1. (c) Show that the output of an LTI system in simply its impulse response convolved with the excitation.

Ans.



Let a LTI system with transfer function $H(s)$ and input $X(s)$

Then output of the system is

$$y(s) = H(s) \times (s)$$

Applying convolution theorem

$$H(s)X(s) \xrightarrow{ILT} h(t) \times x(t)$$

Q.1. (d) State significance of impulse, unit step, ramp & exponential signals why are they used?

Ans. Impulse $\quad \delta(t) = \begin{cases} 1 & t = 0 \\ 0 & o\omega \end{cases}$

Unit step $\quad u(t) = \begin{cases} t & t \geq 0 \\ 0 & ow \end{cases}$

ramp $r(t) = \begin{cases} t & \geq 0 \\ 0 & 0w \end{cases}$

exponential function $= \begin{cases} e^{at} & t \geq 0 \\ 0 & 0w \end{cases}$

These all basic signal is use to know the basic input response of the system.

Q.1. (e) Check the system $y(t) = x(t) \cos \omega_0 t$ for time invariance $y(t) = Ax(t) + B$ for linearity. **(3 × 5 = 15)**

Ans. $\quad y(t) = x(t) \cos w_0 t$

1st to Apply Shifted input $x(t-T)$ then output is

$$x(t-T) \cos w_0 t$$

and time shifted output is

$$c(t-T) \cos w_0(t-T)$$

both are not equal so system is time variant

$$y(t) = A\,x(t) + B$$

for input $x_1(t) \to y_1(t)$

$$y_1(t) = Ax_2(t) + B$$

for input $\quad ax_1(t) + b\,x_2(t)$

$$y(t) = A[(ax_1(t) + b\,x_1(t)] + B$$

for input $x_2(t) \to y_2(t)$

$$y_2(t) = Ax_2(t) + B$$

linear combination of output

$a(Ax_1(t) + B) + b(Ax_2(t) + B)$

$$y(t) = Aa\,x_1(t) + aB + bA\,x_2(t) + Bb$$

$$y(t) \neq y'(t)$$

So system is non linear.

Q.2. (a) A 2 element series circuit has an average power 940 W & power factor 0.707 lagging. Determine the circuits elements if the expressed voltage is $v = 99 \sin(6000\,t + 30°)$ V.

Ans. (RL) An ac circuit in which the current lags behind the voltage is said to have a lagging power factor. (RC) An ac amount in which current leads the voltage is said to have a leading power factor.

Lagging power factor mean current lags behind voltage means RL circuit.

$$\cos\phi = .707$$
$$\phi = 45°$$
$$\text{Power} = VI\cos\phi$$
$$940 = 99 \times I \times .707$$
$$I = \frac{940}{99 \times .707} = 13.42$$
$$I = 13.42 \sin(6000\,t + 30 - 45)$$
$$= 13.42 \sin(6000t - 15)$$

Q.2. (b) Derive the "Q" for a parallel RLC circuit. (10)

Ans. θ = factor for parallel RLC

$$\text{Let } V = V_m \sin wt$$

$$\text{current through } i_L = \frac{V_m \sin(\omega_0 t - 90)}{XL_0}$$

inductor where $w_0 = \dfrac{1}{\sqrt{LC}}$

Instenteneous energy in circuit is

$$w(t) = \frac{1}{2} L\, i_L^2 + \frac{1}{2} C v^2$$
$$= \frac{1}{2} C V_m^2$$

Average power loss in circuit is

$$P = \frac{V^2}{R} = \frac{(V_m/\sqrt{2})^2}{R} = \frac{V_m^2}{2R}$$

Energy loss per cycle

$$P\frac{2\pi}{\omega_0} = \frac{\pi Vm^2}{\omega_0 R}$$

Quality factor $Q_{OP} = \dfrac{2\pi\,(\text{maximum energy store in ckt})}{(\text{total energy loss frequency})}$

$$= \frac{2\pi \frac{1}{2} C V_m^2}{\pi V^2/\omega_0 R}$$

$$\boxed{Q_{OP} = \omega_0 C R}$$

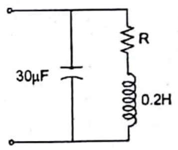
Q.3. (a) Find the rms value of $v = (10 + 14.4\cos\omega t + 3.55 \sin 3\,\omega t)$ V. (5)

Ans. $V^2 = \dfrac{1}{2\pi}\displaystyle\int_0^{2\pi} v^2 dt = \dfrac{1}{2\pi}\int (10 + 14.4\cos\omega t + 3.55\sin 3.\omega t)^2 dt$

$$V_{rms}^2 = \left(10^2 + \frac{(14.4)^2}{2} + \frac{(3.55)^2}{2}\right)$$

$$V_{rms} = \sqrt{10^2 + \frac{(14.4)^2}{2} + \frac{(3.55)^2}{2}}$$

Q.3. (b) Compare the resonant frequency of the circuit shown for $R = 0$ & $R = 50\,\Omega$.



LC parallel tank circuit.

Ans.

if $R = 0$

$$Y = j\omega c + \frac{1}{j\omega L}$$
$$Y = j\omega c - j\frac{1}{\omega L}$$

for resonance $Im(y) = 0$

$$\omega c - \frac{1}{\omega L} = 0$$
$$\omega c = \frac{1}{\omega L} \Rightarrow \omega^2 = \frac{1}{LC} \quad \Rightarrow \omega = \frac{1}{\sqrt{LC}}$$

If $R = 50$

$$Y = j\omega c + \frac{1}{R + j\omega L} : j\omega c + \frac{R - j\omega L}{R^2 + \omega^2 L^2}$$
$$Y = \frac{R}{R^2 + \omega^2 L^2} - j\omega\left(C - \frac{L}{R^2 + \omega^2 L^2}\right)$$
$$Im(y) = 0$$
$$j\omega\left(C - \frac{L}{R^2 + \omega^2 L^2}\right) = 0$$

$$C = \frac{L}{R^2+\omega^2L^2}$$

$$\omega^2L^2C = L - CR^2$$

$$\omega^2 = \frac{L-CR^2}{L^2C} \Rightarrow \omega = \sqrt{\frac{L-CR^2}{L^2C}}$$

Putting the value of R L & C

$$\omega = \sqrt{\frac{.2-30\times10^{-6}\times2500}{(.2)^2\times3\times10^{-6}}}$$

Q.4. (a) A CT function has $H(s) = \frac{1}{s+5}$. If it is excited by a sinusoidal input $x(t) = 10\cos 200\,\pi t$. Find the steady state output function amplitude and frequency of the output waveform.

Ans.

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

$$x(t) = 10\cos 200\,\pi t$$

$$X(s) = \frac{10\times s}{s^2+(200\pi)^2}$$

$$y(s) = \frac{1}{s+5}\times\frac{10s}{s^2+(200\pi)^2} \Rightarrow \frac{A}{s+5}+\frac{B}{s+200\pi j}+\frac{c}{s-200j}$$

$$A = \left.\frac{10s}{s^2+(200\pi)^2}\right|_{s=-5} = \frac{-50}{25+200^2\pi^2}$$

$$B = \left.\frac{10s}{(s+5)(s-200\pi)}\right|_{s=200\pi j}$$

$$C = \left.\frac{10s}{(s+5)(s+200j)}\right|_{s=-200\pi j}$$

Steady state output $s \to 0$ or $t \to \infty$

Apply final value theorem

$$\lim_{s\to0} sy(s) = \lim_{s\to0}\frac{10s^2}{(s+5)(s^2+(200\pi)^2)} = 0$$

Q.4. (b) A CTS is described by $\ddot{y}+3\dot{y}+2y = 3r$. Find.

(i) Transfer function $H(s)$.

(ii) Impulse response $h(t)$.

(iii) Step response

(iv) Frequency response

(v) Block diagram representation of this system.

Ans. (i) $\dot{y}+3\dot{y}+2y = 3r$

taking LT

$$s^2y(s)+3s\,y(s)+2\,y(s) = 3\,R(s)$$

$$H\frac{y(s)}{R(s)} = \frac{3}{s^2+3s+2} = \frac{3}{(s+1)(s+2)}$$

(ii) $\frac{A}{S+1}+\frac{B}{S+2} \Rightarrow A = 3\;B = -3$

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

on taking iLT

$$h(t) = 3e^{-t}-3e^{-2t}$$

(iii) $y(s) = H(s)\times(s)$

For unit step input $x(t) = u(t)$

$$x(s) = \frac{1}{s}$$

$$= \frac{3}{(s+1)(s+2)}\times\frac{1}{s} = \frac{3}{s(s+1)(s+2)}$$

$$\frac{A}{s}+\frac{B}{s+1}+\frac{C}{s+2}$$

$$A = \left.\frac{3}{(s+1)(s+2)}\right|_{s=0} = \frac{3}{2}$$

$$B = \left.\frac{3}{s(s+2)}\right|_{s=-1} = \frac{3}{-1(-1+2)} = -3$$

$$C = \left.\frac{3}{s(s+1)}\right|_{s=-2} = 3/2$$

$$y(s) = \frac{3}{2}\times\frac{1}{s}-\frac{3}{3+1}+\frac{3}{2}\frac{1}{s+2}$$

$$y(t) = \frac{3}{2}\,u(t)-3e^{-t}+\frac{3}{2}e^{-2t}$$

(iv) $\frac{3}{(s+1)(s+2)}$ putting $s = jw$

$$H(jw) = \frac{3}{(jw+1)(jw+2)} \Rightarrow \frac{3}{-w^2+3jw+2} = \frac{3}{(2-\omega^2)+3j\omega}$$

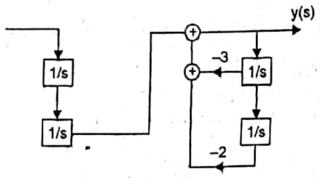
on rationalizing $\frac{3\{(2-\omega^2)-3\,j\omega)\}}{(2-\omega^2)^2+(3\omega)^2} = \frac{3(2-\omega^2)-9j\omega}{4+\omega^4+3\omega^2}$

(v) $\frac{3}{s^2+3s+2}$

$$\frac{\frac{3}{s^2}}{1+\frac{3}{s}+\frac{2}{s^2}} = \frac{y(s)}{x(s)}$$

$$\frac{3}{s^2}x(s) = y(s)+\frac{3}{s}x(s)+\frac{2}{s^2}y(s)$$

$$y(s) = \frac{3}{s^2}x(s)-\frac{3}{s}y(s)-\frac{2}{s^2}y(s)$$



Q.5. (a) Given $F(S) = \frac{2s+5}{(s+2)(s+5)}$. Find $f(t)$ if the ROC is

***(i)* $s > -2$**
***(ii)* $-5 < s < -2$**
***(iii)* $s < -5$**

Ans. (a) $F(s)\ \frac{2s+5}{(s+2)(s+5)}$

$$= \frac{A}{s+2}+\frac{B}{s+5}$$

$$A = \left.\frac{2s+5}{s+5}\right|_{s=-2} = \frac{-4+5}{-2+5} = \frac{1}{3}$$

$$B = \left.\frac{2s+5}{5+2}\right|_{s=-5}\ \frac{-10+5}{-5+2} - \frac{5}{3}$$

$$F(s) = \frac{1}{3}\frac{1}{s+2}+\frac{5}{3}\frac{1}{s+5}$$

1. If ROC $s > -2$

$\frac{1}{2}e^{-2t}u(t)+\frac{5}{3}e^{-5t}$

(ii)

$-5 < s < -2$

$$\frac{1}{2}e^{-2t}u(-t)+\frac{5}{3}e^{-5t}u(t)$$

(iii) $s < -5$

$$\frac{1}{2}e^{-2t}u(t)+\frac{5}{3}e^{-5t}u(-t)$$

Q.5. (b) Show that $LT\ [f(t) = s.F(s) - f(0)$.

Ans. if $\quad L(f(t)) = F(s)$

then $\quad L\left[\frac{df(t)}{dt}\right] = SF(s)-f(0^-)$

Proof $\quad L\left[\frac{d}{dt}f(t)\right] = \int_0^{\infty}\frac{df(t)}{dt}e^{-st}dt$

on integrating by parts

$$u = e^{-st} \text{ and } dv = d\,f(t)$$
$$du = -se^{-st} \text{ and } v = f(t)$$

$$\int u\,dv = vu - \int v\,du$$

$$= e^{-st}f(t)\Big|_0^{\infty} - \int_0^{\infty} f(t)(-se^{-st})dt$$

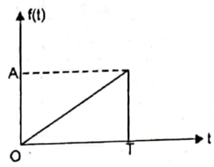
$$= e^{-st}f(t)\Big|_0^{\infty} + s\int_0^{\infty} f(t)e^{-st}dt$$

$$= -f(0^-)+sF(s)$$

$$L\left[\frac{d\,f(t)}{dt}\right] = sF(s)-x(0^-)$$

Q.5. (c) Find Laplace transform (LT) of the saw tooth wave form shown in figure:

Ans.



$$f(t) = \frac{A}{T}t[u(t)-u(t-T)]$$

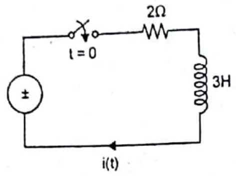
$$= \frac{A}{T}+u(t)-\frac{A}{T}u(t-T)$$

$$= \frac{A}{T}tu(t)-\frac{A}{T}[(t-T)-u(t-T)+Tu(t-T)]$$

on taking LT

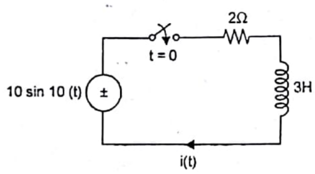
$$FS = \frac{A}{T}\frac{1}{s^2}-\frac{A}{T}\left[\frac{e^{-TS}}{s^2}+T\,e^{-TS}\right]$$

Q.6. (a) Switch is closed at $t = 0$. Find $i(t)$ for $t \geq 0$ using Laplace transform. (8)



Ans. $\quad$ At $t = 0$

$$i = \frac{10 \sin 10(0)}{2}$$



Apply KVL $\quad 10 \sin 10\,t = 2\,i(t) + 3\frac{d\,i(t)}{dt}$

$$\text{taking }(LT) = \frac{10 \times 10}{s^2 + 10^2} = 2\,I(s) + 3\,s\,I(s)$$

$$I(S) = \frac{100}{s^2+100} \times \frac{1}{(2+3s)} \Rightarrow \frac{A}{3S+2} + \frac{B}{(S+10i)} + \frac{C}{(S-10j)}$$

$$A = \left.\frac{100}{s^2+100}\right|_{s=\frac{-2}{3}} = \frac{100}{\frac{4}{9}+100} = \frac{900}{904}$$

$$B = \left.\frac{100}{(2+3s)(s-10j)}\right|_{s=-10j} = \frac{100}{(2-30j)(-20j)}$$

$$= \frac{5}{(-2j-30)}$$

$$C = \left.\frac{100}{(2+3s)(s+10j)}\right|_{s=10j} = \frac{100}{(2+30j)(20j)} = \frac{5}{(2j-30)}$$

$$1(s) = \frac{900}{904 \times 3\left(s+\frac{2}{3}\right)} + \frac{5}{(-2j-30)}\frac{1}{s+10j} + \frac{s}{(2j-30)}\frac{1}{(s-10j)}$$

$$= \frac{300}{904}e^{-\frac{2}{3}t} + \frac{5}{(-2j-30)}e^{-j^{10}t} + \frac{5}{(2j-30)}e^{j10t}$$

Q.6. (b) Find the transient steady state response of a causal system having $h(t) = e^{-t}$ & $x(t) = 10 \sin 4t\, u(t)$. (7)

Ans.
$$h(t) = e^{-t}$$
$$x(t) = 10 \sin 4t\, u(t)$$

taking LT

$$H(s) = \frac{1}{s+1}\, x(s) = \frac{10 \times 4}{s+j^2}$$

$$y(s) = \frac{1}{s+1} \times \frac{40}{s^2+4^2}$$

$$= \frac{A}{s+1} + \frac{B}{s+j4} + \frac{C}{s-j^4}$$

$$A = \left.\frac{40}{s^2+4^2}\right|_{s=-1} = \frac{40}{17}$$

$$B = \left.\frac{40}{(s+1)(s-4j)}\right|_{s=-4j} = \frac{40}{(-4j+1)(-8j)} = \frac{5}{(-4-j)}$$

$$C = \left.\frac{40}{(s+1)(s+4j)}\right|_{s=4j} = \frac{40}{(4j+1)(8j)} = \frac{5}{(-4+j)}$$

$$y(s) = \frac{40}{17}\frac{1}{s+1} + \frac{5}{(-4-j)}\frac{1}{(s+j4)} + \frac{5}{(-4+j)}\frac{1}{(s-j4)}$$

$$= \frac{40}{17}e^{-t} + \frac{5}{(-4-j)}e^{-j4t} + \frac{5}{(-4+j)}e^{+j4t}$$

Q.7. (a) What are ABCD parameters? Show that AD-BC = 1 for a bilateral network. (7)

Ans. In terms of T-parameters

$$V_1 = AV_2 + B(-I_2)$$
$$I_1 = CV_2 + D(-I_2)$$

Fig. (b); $\quad V_1 = V_s, I_1, V_2 = 0, I_2 = -I'_2.$

$$I'_2 = \frac{V_s}{B}$$

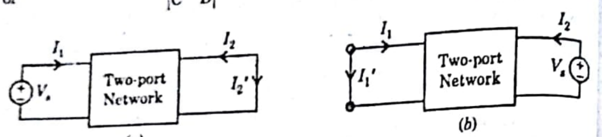
As in figure (b); $\quad V_2 = V_s, I_2 = I_2, V_1 = 0, I_1 = -I'_1$

$$I'_1 = V_s\left(\frac{AD-BC}{B}\right)$$

Above discussion leads to the condition of reciprocity,

$$AD - BC = 1 \text{ or } \Delta T = 1$$

or
$$\begin{vmatrix} A & B \\ C & D \end{vmatrix} = 1$$



Q.7. (b) Show that $Z_{11} = Z_{22}$ for a symmetric network & $Z_{12} = Z_{21}$ for a reciprocal network.

Ans. In terms of Z-parameters.

As in (a); $V_1 = V_2, I_1 = I_1 I_2 = 0, V_2 = V_2$.

$$V_s = Z_{11} I_1$$

$$\left.\frac{V_s}{I_1}\right|_{I_2=0} = Z_{11}$$

As in figure 8.14 (b); $V_2 = V_s, I_2 = I_2, I_1 = 0, V_1 = V_1$.

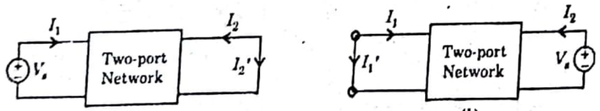
$$V_s = Z_{22} I_2$$

$$\left.\frac{V_s}{I_2}\right|_{I_1=0} = Z_{22}$$

from the definition of symmetry,

$$\left.\frac{V_s}{I_1}\right|_{I_2=0} = \left.\frac{V_s}{I_2}\right|_{I_1=0} \text{ leads to}$$

$$Z_{11} = Z_{22}$$



In terms of Z-parameters

$$V_1 = Z_{11} I_1 + Z_{12} I_2$$
$$V_2 = Z_{21} I_1 + Z_{22} I_2$$

As in figure (a): $V_1 = V_s, I_1 = I_1, V_2 = 0, I_2 = -I_2'$

Therefore, $V_s = Z_{11} I_1 - Z_{12} I_2'$

and $0 = Z_{21} I_1 - Z_{22} I_2'$

Hence $$I_2' = \frac{V_s Z_{21}}{Z_{11} Z_{22} - Z_{21} Z_{12}}$$

As in figure 8.13 (b); $V_2 = V_s, I_2 = I_2, V_1 = 0, I_1 = -I_1'$.

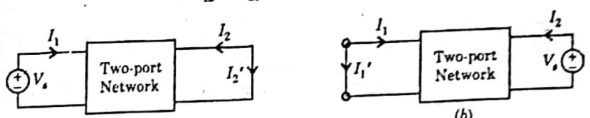
Therefore, $0 = -Z_{11} I_1' + Z_{12} I_2$

and $V_s = -Z_{21} I_1' + Z_{22} I_2$

Hence $$I_1' = \frac{V_s Z_{12}}{Z_{11} Z_{22} - Z_{21} Z_{12}}$$

Comparing I_2' and I_1', we get

$$Z_{12} = Z_{21}$$



Q.8. (a) List the difference between tree & cotree. What is meant by the terms Tie set & Cut set? (3)

Ans. The concept of a tree is now introduced. Consider a connected graph G with n nodes and b branches. A tree is defined as a connected graph which has no closed path. Alternatively, a tree graph is a connected graph in which there is a unique path between every pair of nodes. A tree is an important concept in linear graph theory.

A tree is defined as any set of branches in the original graph that is just sufficient to connect all the nodes. This number (of branches) is $n - 1$.

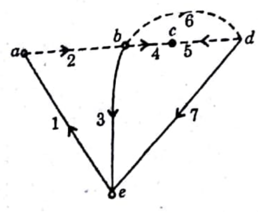
For a given graph it is possible to draw numerous trees. The tree branches are $(n - 1)$, which are called twigs. The remaining branches are called links. The branches of the graph which are not in the tree form the co-tree or complement of the tree. Link is any branch belonging to the co-tree. It is obvious that for each tree there exists a particular co-tree corresponding to that particular tree.

A graph, is then, the union of tree and its co-tree. This decomposition of a graph into tree and co-tree or its branches into twigs and links is not unique.

Number of twigs; $nt = n - 1$

Number of links; $nl = b - nt = b - n + 1$

A tree and its co-tree of graph.



——— twings ; branch of tree [1, 3, 4, 7]

- - - - - links branch of co-tree [2, 5, 6]

branches (b) = 7
nodes (n) = 5
twings (t) = 4
links (l) = 3

Fig. Tree and co-tree of the oriented linear graph

The tree of a graph has the following properties.

1. In a tree, there exists one and only one path between any pair of nodes.

2. Every connected graph has at least one tree.

3. A connected subgraph of a connected graph is a tree if there exist all the nodes the graph.

4. Each tree has $(n-1)$ branches

5. The rank of a tree is $(n-1)$; this is also the rank of the graph to which tr belongs.

Q.8. (b) List the necessary & sufficient condition for +ve real function. (6

Ans. The necessary and sufficient conditions for a rational function $T(s)$ with re coefficients to be *p.r.* are:

Condition (1): $T(s)$ must have no poles in the right half of s-plane, *i.e.*, Denominat $D(s)$ of $T(s)$ has a factor of the type $s^2 + a$; where a is positive real constant, imagina axis ($j\omega$-axis) with real and positive residues. This condition is tested by making partial fraction expansion of $T(s)$ and checking whether the residues of the poles on th $j\omega$-axis are positive and real.

Condition (3): $Re[T(j\omega)] \geq 0$, for all ω

or $A(\omega^2) \equiv M_1(j\omega).M_2(j\omega) - N_1(j\omega).N_2(j\omega) \geq 0$; for all ωw

Q.8. (c) Realize $F(s) = \dfrac{(s+2)(s+5)}{s(s+4)(s+6)}$ using Foster-1 & Foster-II representatio (6

Ans. Foster – I form: Since we know that the residues of poles of $Z_{R-L}(s)$ are rea and negative. So determine the residues of

$\dfrac{Z(s)}{s}$ as:

$$\frac{Z(s)}{s} = \frac{(s+2)(s+5)}{(s+1)(s+4)}$$

$$s^2+5s+4 \,\big)\, s^2+7s+10 \,\big(\, 1$$
$$\underline{s^2+5s+4}$$
$$2s+6$$

$$= 1 + \frac{2s+6}{(s+1)(s+4)}$$

Using partial fraction expansion.

$$\frac{Z(s)}{s} = 1 + \frac{\frac{4}{3}}{s+1} + \frac{\frac{2}{3}}{s+4}$$

or, $$Z(s) = s + \frac{\frac{4}{3}s}{s+1} + \frac{\frac{2}{3}s}{s+4}$$

Therefore, synthesized networks is shown in figure (*a*)

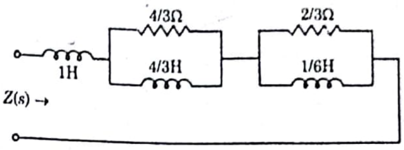


Fig. (*a*)

Foster-II form: $$Y(s) = \frac{(s+1)(s+4)}{s(s+2)(s+5)}$$

Using partial fraction expansion, we have

$$Y(s) = \frac{\frac{2}{5}}{s} + \frac{\frac{1}{3}}{s+2} + \frac{\frac{4}{15}}{s+5}$$

Therefore, synthesized network is shown in figure (*b*).

(*b*) Cauer-I form:

$$Z(s) = \frac{s^3+7s^2+10s}{s^2+5s+4}$$

As found in previous example.

$$Z_1 = s, Y_2 = \frac{1}{2}$$

$$Z_3 = s, Y_4 = 1, Z_5 = \frac{1}{2}s$$

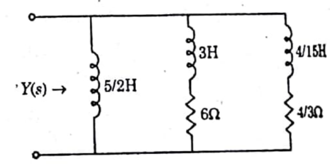


Fig. (*b*)

Therefore, the synthesized network shown in figure (c).

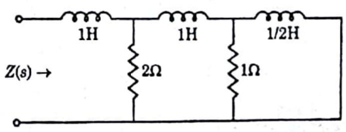


Fig. (c).

Caure-II form:

$$Z(s) = \frac{s^3+7s^2+10s}{s^2+5s+4} = \frac{10s+7s^2+s^3}{4+5s+s^2}$$

or
$$Y(s) = \frac{4+5s+s^2}{10s+7s^2+s^3}$$

As found in previous example,

$$Y_1 = \frac{2}{5s}, Z_2 = \frac{50}{11}, Y_3 = \frac{121}{235s}, Z_4 = \frac{2209}{44}, Y_5 = \frac{4}{47s}$$

Therefore, the synthesized network is shown in figure (*d*).

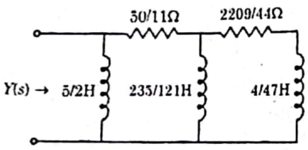


Fig. (*d*)

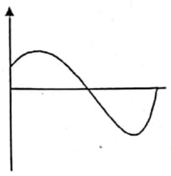
FIRST TERM EXAMINATION [SEPT. 2015]
THIRD SEMESTER [B.TECH]
CIRCUIT AND SYSTEMS

Time. 1.30 Hours **M.M. : 30**

***Note:** Question No.1 is compulsory and attempt any two from the rest.*

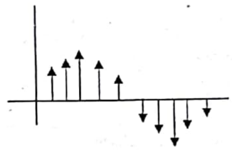
Q.1. (*i*) What are Continuous - time and Discrete-time Signals? (10 × 1 = 0)

Ans. Signal which has value for all Instant of time is called continous time signal and represented by $x(t)$ Eg:



$$x(t) = \sin t$$

Signal which has value for some particular Instant of time is known as discret time signal $x[n]$



Q.1. (*ii*) What is a Gate Signal?

Ans. Gate Signal

$$g_{t_0 t_1}(t) = \begin{cases} 1 & t_0 < t < t < \\ 0 & 0.w \end{cases} = u(t-t_o) - u(t-t_1)$$

Q.1. (*iii*) What is a Linear System?

Ans. If $x_1(t)$ is a input of a signal and $y_1(t)$ is the output corresponding to input $x_1(t)$ and $y_2(t)$ is the output corresponding ot input $x_2(t)$ and output corresponding to linear combination of $x_1(t)$ and $x_2(t)$ is equal to the linear combination of $y_1(t)$ and $y_2(t)$ then system is known as linear system

Q.1. (*iv*) What are Singularity Functions?

Ans.
$$\text{sign}(t) = \begin{cases} 1 & t \geq o \\ -1 & t < o \end{cases}$$

Q.1. (*v*) What do you understand by Waveform Synthesis?

Ans. To express any diterministic signal into mathematical expression is known as waveform synthesis.

Q.1. (*vi*) Define the Time Constant of a series R-L Circuit.

Ans.
$$T = \frac{L}{R}$$

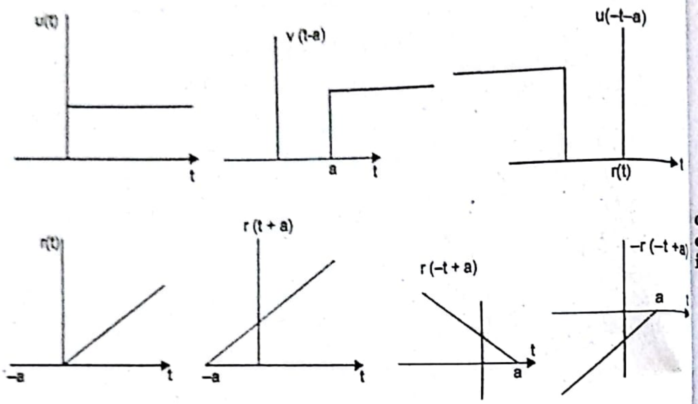
Q.1. (*vii*) What are the advantages of Laplace Transform technique?

Ans. (*i*) The homegenous equation and the particular integral of the solution are obtained in one operation.

(*ii*) It converts the integro-differential equation onto an algebric equation in S

Q.1. (viii) Represent the following functions by suitable Waveforms:
$u(-t-a)$ and $-r(-t+a)$

Ans.



Q.1. (ix) What are Single Energy and Double Energy Transients?

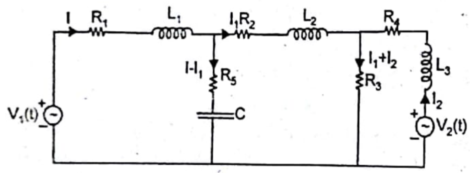
Ans. If the systems contain only resistance Induction or capacitance for C than system is known as single energy transient. If the system contain L and C both then system is known as deouble energy transient.

Q.1. (x) Write down the expression for the current in an initially relaxed series R–C Circuit energized by a Step voltage.

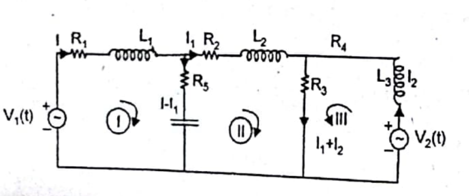
Ans.

$$i(t) = \frac{1}{R} e^{-\frac{1}{\tau}/R_C}$$

Q.2. (a) Write down the Integro-Differential Equations for the electrical circuit shown in Fig (1) using KVL. (5)



Ans.



On Applying KVL is loop I

$$V_1(t) = IR_1 + L_1\frac{dI}{dt} + (I - I_1)R_5 + \frac{1}{c}\int (I - I_1)dt$$

on Applying KVL is loop II

$$I_1R_2 + L_2\frac{dI_1}{dt} + (I_1 + I_2)R_3 = (I - I_1)R_5 + \frac{1}{c}\int (I - I_1)dt$$

On Applying KVL is loop III

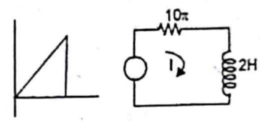
$$V_2(t) = L_3\frac{dI_3}{dt} + I_2R_4 + (I_1 + I_2)R_3$$

Q.2. (b) A series circuit consisting of a resistance of 10 Ω and an inductance of 2H is energized with a ramp function of 5 occuring at t = 5 seconds. Find the current i(t) for any time t ≤ 0 seconds, assuming the initial current through the inductance to be zero. (5)

Ans.

$$t\{u(t) - u(t-5)\}$$

Applying KVL



$$t\{u(t) - u(t-5)\} = 10I + 2\frac{dI}{dt}$$

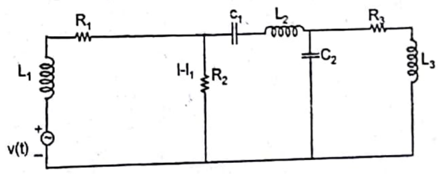
taking L.T

$$=10\,I(s) + 2S\,I(s) = \frac{1}{S^2} - LT\{(t-5)u(t-5) + 5u(t-5)\}$$

$$\frac{1}{s^2} - \frac{e^{-5s}}{s^2} - \frac{5e^{-5s}}{s} = I(s)(10 + 2s)$$

$$I(s) = \frac{1 - e^{-5s} - 5se^{-5s}}{s^2(10 + 2s)}$$

Q.3. (a) Frame the performance equations in time domain for the electrical circuit shown in Fig (2) using KCL.



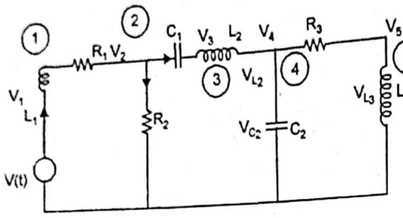
Ans.

Applying KCl at node 1.

$$\frac{1}{L_1}\int \{V(t) - V_1(t)\} = \frac{V_1 - V_2}{R_1}$$

Applying KCl at node 2

$$\frac{V_1 - V_2}{R_1} = \frac{V_2}{R_2} + C_1\frac{d(V_2 - V_3)}{dt}$$



Applying KCl al node 3

$$C_1\frac{d(V_2-V_3)}{dt} = \frac{1}{L_2}\int(V_3-V_4)dt$$

AL node 4

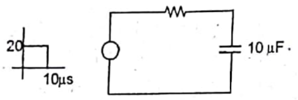
$$\frac{1}{L_2}\int(V_3-V_4)dt = C_2\frac{dV_4}{dt}+\frac{V_4-V_5}{R_3}$$

At node 5

$$\frac{V_4-V_5}{R_3} = \frac{1}{L_3}\int V_5 dt$$

Q.3. (*b*) A voltage pulse of 20 volts magnitude and 10 μs duration is applied to a series R-C Circuit. Determine the current in the circuit. Assume that the circuit is initially relaxed. The value of R-10 Ω and C = 10 μF. (5)

Ans.



20 [u(t) – u(t–10)]

Applying KVL

$$20\,[u(t)-u(t-10\ \mu s)] = I\times 10+\frac{1}{10\mu F}\int 1dt$$

taking LT

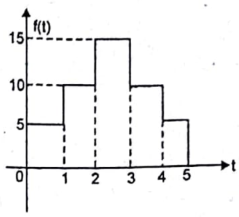
$$20\left\{\frac{1}{s}-\frac{e^{-10s}}{s}\right\} = 10I(s)+10^5\frac{I(s)}{s}$$

$$I(s) = \frac{20(1-e^{-10s})}{10s+10^5}$$

$$= \frac{2\left(1-e^{-10s}\right)}{s+10^4}$$

$$= 2e^{-10^4 t}-2e^{-10^4(t-10)}$$

Q.4. (*a*) Synthesize the following function into its component signals and hence find the mathematical equation for it. (5)

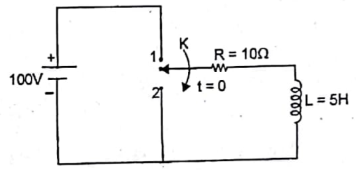


Ans. $f(t) = 5\,(u(t)-u(t-1)) + 10\,[u(t-1)-u(t-2)] + 15\,[u(t-2)-u(t-3)] + 10\,[u(t-3)-u(t-4)] + 5\,[u(t-4)-u(t-5)]$

Q.4. (*b*) The Switch in the circuit shown in Fig (3) is kept in position-1 for a sufficiently long time so that the Steady State Conditons are attained by the circuit. The switch 'K' is moved to position-2 at t = 0 sec. Obtain an expression for the circuit for any time, t ≥ 0. Use Leplace transform Method. (5)

Ans. When *K* at position 1 and steady state reach inductor behave as short circuit

$$L = \frac{V}{R}=\frac{100}{10}=10A$$



when *K* at 2

$$5\frac{dI}{dt}+I\times 10 = 0$$

$$\frac{dI}{dt}+2I = 0$$

$$I = Ae^{-2t}$$

at $t = 0$

$i = 10\,A$

Putting this values en above equation $10 = Ae^{0}$

$$I = 10\,e^{-2t} \rightarrow A = 10$$

$$I = 10\,e^{-2t}$$

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SECOND TERM EXAMINATION [NOV. 2015] THIRD SEMESTER [B.TECH] CIRCUITS AND SYSTEMS

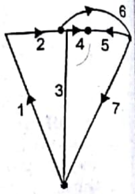
M.M.:

Time. 1.30 Hours

Note: Question No.1 is compulsory and attempt any two from the rest. **(10×1 = 1**

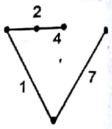
Q.1. (i) What is an Oriented Graph? Explain with an example.

Ans. In a graph each branch carrier an arrow to indicate its orientation of graph is known as oriented graph.



Q.1. (ii) With reference to an Oreinted Network Graph define (i) Tree an (ii)Co-tree

Ans. If three is this the 1,2,4,7 is twing and 3, 5, 6 is the co turg and 3, 5, 6 is the co tree or link



Q.1. (iii) What is a Tie-set Schedule?

Ans. Loop which contain only one link are independent are called basic or fundamental loops or tie sets.

Q.1. (iv) Define h-Parameters for a two-port network.

Ans.

$$V_1 = h_{11}I_1 + h_{12}V_2$$
$$I_2 = h_{21}I_1 + h_{22}V_2$$

$$h_{11} = \frac{V_1}{V_2}\bigg|_{V_2=0} \qquad h_{21} = \frac{V_2}{V_1}\bigg|_{V_2=0} \qquad h_{12} = \frac{I_1}{V_2}\bigg|_{I_1=0} \qquad h_{22} = \frac{I_2}{V_2}\bigg|_{I_1=0}$$

Q.1. (v) Define the Network Functions of a Single Port Network.

Ans. In single port network Network function is Impedance and transform admittance

$$Z(s) = \frac{V(s)}{I(s)} \qquad Y(s) = \frac{I(s)}{V(s)}$$

Q.1. (vi) Write down the relationships between the Z-parameters and Y-parameters.

Ans.

$$Z_{11} = \frac{\Delta h}{h_{22}} \qquad Z_{12} = \frac{h_{12}}{h_{22}}$$

$$Z_{21} = \frac{-h_{21}}{h_{22}} \qquad Z_{22} = \frac{1}{h_{22}}$$

where $\Delta h = h_{11}h_{22} - h_{12}h_{21}$

Q.1. (vii) What is the difference between the network analysis and network synthesis?

Ans. To Analysis any circuit is network analysis or to know all prameter of circuit is called network analysis.

Q.1. (viii) What are Hurwitz polynomials?

Ans. Hurwitz polynomial: Polynomial whose all roots lies in left side of imaginary axis.

Q.1. (ix) What do you mean by a Positive Real Function?

Ans. A Transfer function $T(s) = \frac{N(s)}{D(s)}$ is prf if

(1) T(s) is real for all real value of s

(2) D(s) is Hurwitz polynomial

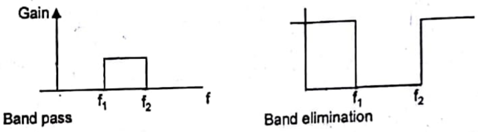
(3) T(S) may have pole on Jw axis

(4) Real part of T(s) is greater than or equal to zero for the real part of s is greater than or equal to zero

Q.1. (x) What are Band pass and Band Elimination Filters?

Ans. A filter which pass a cirtain range frequency and reject other all frequency is called Band pass filter.

→ A filter which pass a cirtain range of frequency is known as Bend elimination filter.



Q.2. (a) For the network Graph shown in Fig.1, identify the tie-sets and write the tie-set schedule on the basis of current variables. **(5)**

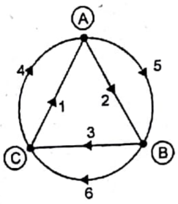
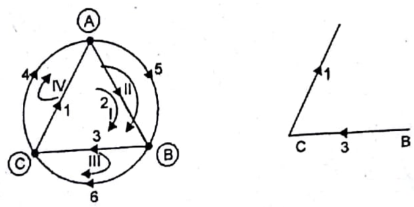


Fig. 1

Ans.



	1	2	3	4	5	6
*loop*1	1	1	1	0	0	0
*loop*2	1	0	1	0	1	0
*loop*3	0	0	−1	0	0	1
*loop*4	−1	0	0	1	0	0

Q.2. (*b*) Determine the Y-Parameters of the two-Port network shown Fig.2.

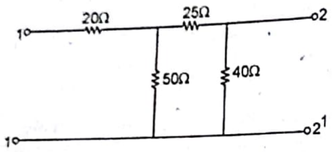
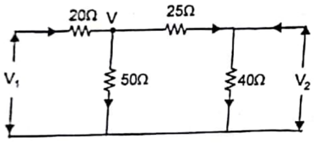


Fig. 2

Ans.



$$\frac{V_1 - V}{20} = \frac{V}{50} + \frac{V - V_2}{25}$$

$$I_1 = \frac{V}{50} + \frac{V - V_2}{25}$$

$$I_2 = \frac{V_2 - V}{25} + \frac{V_2}{40}$$

$$I_1 = \frac{V_1 - V}{20} \Rightarrow -20I_1 + V_1 = V$$

$$I_1 = \frac{V_1 - 20I_1}{50} + \frac{V_1 - 20I_1 - V_2}{25}$$

$$I_1 + \frac{20I_1}{50} + \frac{20I_1}{25} = \frac{V_1}{50} + \frac{V_1 - V_2}{25}$$

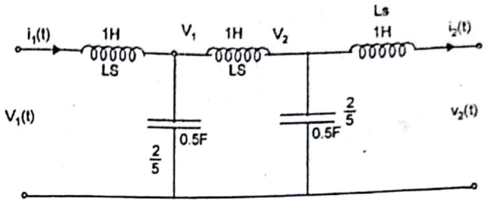
$$\frac{110I_1}{50} = \frac{3V_1}{50} - \frac{V_2}{25}$$

$$I_1 = \frac{3V_1}{110} - \frac{V_2}{55}$$

Putting the value of I_1 in equation (3)

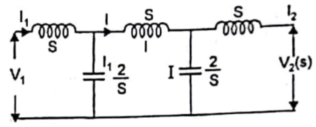
$$I_2 = V_2\left(\frac{1}{25} + \frac{1}{40}\right) - \frac{1}{25}\left(\frac{20V_2}{55} - \frac{60V_1}{110}\right)$$

Q.3. (*a*) Find G_{21} (S) for the circuit shown in Fig.3. **(5)**



(Fig.3)

Ans.



$$G_{21}(s) = \frac{V_2(s)}{V_1(s)} \text{ at } I_2 = 0$$

$$Z_{eq}(s) = \frac{\left(s + \frac{2}{s}\right)\frac{2}{s}}{\left(s + \frac{2}{s} + \frac{2}{s}\right)} + s$$

$$= \frac{\frac{2(s^2+2)}{s^2}}{\frac{s^2+4}{s}} + s$$

$$= \frac{2(s^2+2)}{s(s^2+4)} + s = \frac{2s^2+4+s^4+4s^2}{s(s^2+4)}$$

$$I_1 = \frac{V_1}{\frac{s^4+6s^2+4}{s(s^2+4)}} = \frac{s(s^2+4)}{s^4+6s^2+4}V_1$$

$$I = \frac{\frac{2}{s}\times I_1}{\left(s+\frac{4}{s}\right)} = \frac{\frac{2}{s}\left(\frac{s(s^2+4)}{(s^4+6s^2+4)}\right)V_1}{\left(s+\frac{4}{s}\right)}$$

$$V_2 = \frac{2}{s}\times I = \frac{2}{s}\times\frac{2}{s}\frac{\left(\frac{s(s^2+4)}{s^4+6s^2+4}\right)}{(s+4/s)}V_1$$

$$\frac{V_2}{V_1} = \frac{4(s^2+4)}{(s^4+6s^2+4)(s^2+4)}$$

Q.3. (b) Test the polynomial $Q(S) = S^6 + 2S^5 + 6S^4 + 10S^3 + 9S^2 + 8S + 4$ for Hurwitz property.

Ans. $S^6 + 2S^5 + 6S^4 + 10S^3 + 9S^2 + 8S + 4$

$$2S^5 + 10S^3 + 8S \,\big)\, S^6 + 6S^4 + 9S^2 + 4 \,\big(\, \frac{1}{2}S$$
$$-S^6 + 5S^4 + \pm 4S^2$$
$$S^4 + 5S^2 + 4 \,\big)\, 2S^5 + 10S^3 + 8S \,\big(\, 2S$$
$$2S^5 + 10S^3 + 8S$$
$$\times$$

$$2S^5 + S^4 + 5S^2 + 4 + 10S^3 + 8S$$
$$(2S + 1)(S^4 + 5S^2 + 4)$$
$$(2S + 1) \text{ is hurtwitz}$$

$$4S^3 + 10S \,\big)\, S^4 + 5S^2 + 4 \,\big(\, \frac{4}{10}s$$
$$-S^4 \pm \frac{10}{4}S^2$$
$$\frac{5}{2}S^2 + 4 \,\big)\, 4S^3 + 10S \,\big(\, \frac{8}{5}S$$
$$-4S^3 + \frac{32}{5}S$$
$$\frac{18}{5}S \,\big)\, \frac{5}{2}S^2 + 4 \,\big(\, \frac{25}{36}$$
$$\frac{5}{2}S^2$$
$$4 \,\big)\, \frac{18}{5}s \,\big(\, \frac{20}{18}$$
$$15S$$
$$\times$$

all coefficent is the Positive So function is hurwitz.

Q.4. (a) Realize the following driving point impedance function (i) as a first Foster Form and (ii) as a Second Foster of LC Networks. (5)

$$Z(s) = \frac{S^3 + 4S}{2S^4 + 20S^2 + 18}$$

Ans. From the pole zero diagram

$$Z(s) = \frac{K(s^2+1)(s^2+9)}{s(s^2+4)}$$

By putting $Z(-2) = \frac{130}{16} = \frac{K.5.13}{-2.8}$ gives $K = 2$

Therefore, $$Z(s) = \frac{2(s^2+1)(s^2+9)}{s(s^2+4)}$$

(a) Foster -I Form:

$$S^3 + 4S \,\big)\, 2S^4 + 20S^2 + 18 \,\big(\, 2S$$
$$2S^4 + 8S^2$$
$$12S^2 + 18$$

$$Z(s) = 2s + \frac{12s^2 + 18}{s(s^2+4)}$$

Using partial fraction expansion,

$$\frac{12s^2+18}{s(s^2+4)} = \frac{A}{s} + \frac{Bs+C}{s^2+4}$$

$$A = 9/2, C = 0 \text{ and } B = \frac{15}{2}$$

Therefore,

$$Z(s) = 2s + \frac{\frac{9}{2}}{s} + \frac{\frac{15}{2}s}{s^2+4}$$

We then obtain the synthesized network in figure 1(a).

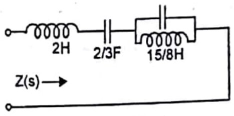


Fig. 1.(a)

Foster-II form:

$$Y(s) = \frac{s(s^2+4)}{2(s^2+1)(s^2+9)}$$

Using partial fraction expansion,

$$\frac{s(s^2+4)}{2(s^2+1)(s^2+9)} = \frac{1}{2}\left[\frac{As+B}{s^2+1} + \frac{Cs+D}{s^2+9}\right]$$

$$A = \frac{3}{8}, B = D = 0, C = \frac{5}{8}$$

Therefore,

$$Y(s) = \frac{1}{2}\left[\frac{\frac{3}{8}s}{s^2+1} + \frac{\frac{5}{8}s}{s^2+9}\right]$$

$$= \frac{\frac{3}{16}s}{s^2+1} + \frac{\frac{5}{16}s}{s^2+9}$$

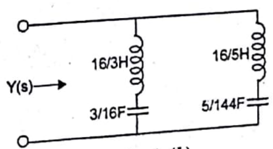


Fig. 1. (b)

Hence, synthesized network is shown in figure 1 (*b*).

(*b*) Cauer-I form:

$$Z(\bar{s}) = \frac{2(s^2+1)(s^2+9)}{s(s^2+4)} = \frac{2s^4+20s^2+18}{s^3+4s}$$

The continued fraction expansion is

$$s^3+4s\,\big)\,2s^4+20s^2+18\,\big(\,2s \leftrightarrow Z_1$$
$$\underline{2s^4+8s^2}$$
$$12s^2+18\,\big)\,s^3+4s\,\big(\,\tfrac{1}{12}s \leftrightarrow Y_2$$
$$\underline{s3+\tfrac{3}{2}s}$$
$$\tfrac{5}{2}\,\big)\,12s^2+18\,\big(\,\tfrac{2}{5}\times 12s = \tfrac{24}{5}s \leftrightarrow Z_3$$
$$\underline{12s^2}$$
$$18\,\big)\,\tfrac{5}{2}s\,\big(\,\tfrac{1}{18}\,\tfrac{1}{18}s = \tfrac{1}{18}s \leftrightarrow Y_4$$
$$\underline{\tfrac{5}{2}s}$$
$$\times$$

Therefore, the final synthesized network is shown in figure 1. (*c*).

Cauer-II form:

$$Z(s) = \frac{2s^4+20s^2+18}{s^3+4s}$$

$$= \frac{18+20s^2+2s^4}{4s+s^3}$$

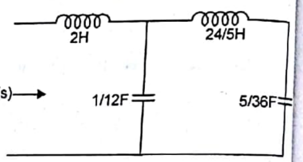


Fig. 1(*c*)

The Continued fraction expansion is

$$4s+s3\,\big)\,18+20s^2+2s^4\,\big(\,\tfrac{18}{4s} = \tfrac{9}{2s} \leftrightarrow Z_1$$
$$\underline{18+\tfrac{9}{2}s^2}$$
$$\tfrac{31}{2}s^2+2s^4\,\big)\,4s+s^3\,\big(\,\tfrac{2}{31}\cdot\tfrac{4}{S} = \tfrac{8}{31S} \leftrightarrow Y_2$$
$$\underline{4s\tfrac{16}{13}s^3}$$
$$\tfrac{15}{31}s^3\,\big)\,\tfrac{31}{2}s^2+2s^4\,\big(\,\tfrac{31}{15}\cdot\tfrac{31}{2s} = \tfrac{961}{30s} \leftrightarrow Z_3$$
$$\underline{\tfrac{31}{2}s^2}$$
$$2s^4\,\big)\,\tfrac{15}{31}s^2\,\big(\,\tfrac{1}{2}\cdot\tfrac{15}{31s} = \tfrac{15}{62s} \leftrightarrow Y_4$$
$$\underline{\tfrac{15}{31}s^3}$$
$$\times$$

Therefore, the final synthesized network is shown in figure 1 (*d*).

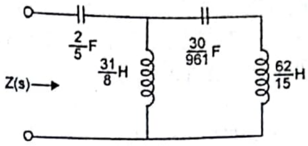
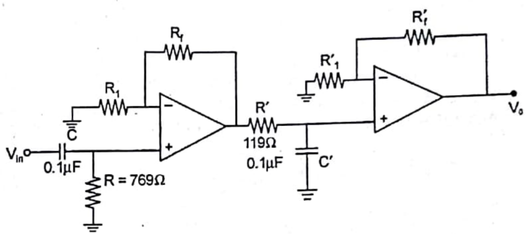


Fig. 1 (*d*)

Q.4. (*b*) Design a Band Pass Filter having a Design impedance of 400 Ω and cut 0 off frequencies of 2 KHz and 8khZ.

Ans.



Given that f = 2 KHz for HPF

and f = 8KHz for LPF

we know that

$$f = \frac{1}{2\pi RC}$$

Let C = 0.1μF then

$$2\times10^3 = \frac{1}{2\pi\times R\times 0.1\mu F}$$

$$\therefore \quad R = \frac{1}{2\times3.14\times2\times10^3\times0.1\times10^{-6}} = 796\Omega$$

Aslo

$$8\text{KHz} = \frac{1}{2\pi RC}$$

$$\therefore \quad R = \frac{1}{2\times3.14\times8\times10^3\times0.1\times10^{-6}}$$

$$R = 199\ \Omega$$

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END TERM EXAMINATION [DEC. 2015]
THIRD SEMESTER [B. TECH]
CIRCUIT AND SYSTEM

Time: 3 Hrs. **MM : 75**

Note: *Attempt any five question including Q no.1. which is compulsory. Select one question from each unit.*

Q.1. (a) Determine the following systems are LT1, causal or not. **(5)**

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

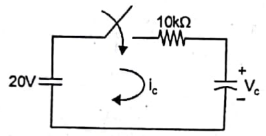
(ii) $y(n) = \sum_{k=n_0}^{n+n_0} x(k)$

Ans. $y(t) = t^2x(t-1)$

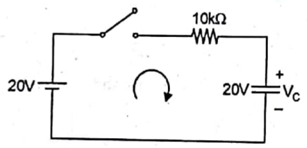
(i) Present output depends on only past input so system is causal.

(ii) Present output depends on past and future input so system is non causal.

Q.1. (b) The switch in the following circuit is closed at $t = 0$, determine the equations for capacitor voltage and current. Compute v_c and i_c at $t = 50$ ms. **(5)**



Ans.



$$20 = 10^4 I + \frac{1}{C}\int I\,dt$$

On differentiating we get

$$\frac{1}{C}I + 10^4\frac{dI}{dt} = 0$$

$$\frac{dI}{dt} + \frac{1}{10^4C}I = 0$$

$$I = Ae^{\frac{t}{10^4c}} \quad \text{...(1)}$$

at $\quad t = 0 \quad I = \frac{20}{10^4} = 2\times10^{-3}A$

$$V = \frac{1}{C}\int I\,dt = \frac{1}{C}\int Ae^{-t/10^4C}dt \quad \text{...(2)}$$

Putting the value of initial condition we get

$$A = 2\times10^{-3}A$$

$$I = 2\times10^{-3}e^{\frac{-t}{10^4C}}$$

Q.1. (c) Find Laplace transform of $\frac{1}{4}t\sin(2t)\,u(t)$. **(5)**

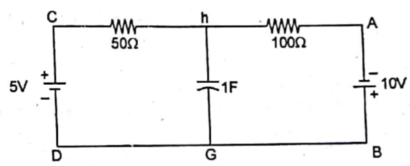
Ans. LT $\sin 2t \to \frac{2}{s^2+2^2}$

Applying differentiation property we get

$$\text{LT of } t\sin 2t \to -\frac{d\left(\frac{2}{s^2+2^2}\right)}{ds} = \frac{2s\times2}{(s^2+4)^2} = \frac{4s}{(s^2+4)^2}$$

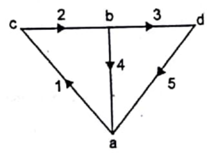
So LT of $\frac{1}{4}t\ \sin 2t = \frac{s}{(s^2+4)^2}$.

Q.1. (d) For the following circuit draw directed graph and write incidence matrix. **(5)**



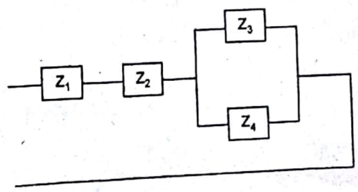
Ans.

	1	2	3	4	5
a	1	0	0	−1	−1
b	0	−1	1	1	0
c	−1	1	0	0	0
d	0	0	−1	0	1



Q.1. (e) Write down Foster I, II and Caur I, II forms of circuit synthesis. **(5)**

Ans. Foster I.



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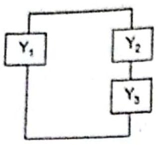
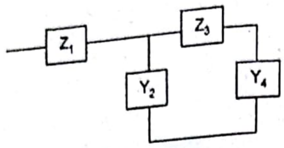


Foster II



Cauer I and II

UNIT-I

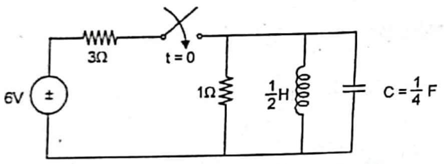
Q.2. (a) Find E_∞ for the signal $x(t) = \delta(t+2) - \delta(t-2)$. **(6)**

Ans. $x(t) = \delta(t+2) - \delta(t-2)$

$$E = \int |x(t)|^2\, dt = \int_{-\infty}^{\infty} (\delta^2(2t+2) + \delta^2(t-2) - 2\delta(t+2)(\delta-2)dt = 1 + 1 = 2$$

Q.2. (b) Switch of the following circuit is opened at $t = 0$ after a long time. Write expression for $v(t)$ at $t > 0$. **(6.5)**

Ans.



$t < 0$ inductor work as short circuit and capacitor as open circuit then current through conductor is $I = \frac{6}{3} = 2A$ and

$$c\frac{dV_c}{dt} = \frac{1}{L}\int V_c dt + \frac{v_c}{1}$$

$$\frac{1}{4}\frac{dv_c}{dt} = 2\int v_c\, dt + v_c$$

On differentiating the above eqn.

$$\frac{1}{4}\frac{d^2v_c}{dt} = 2v_c + \frac{dv_c}{dt}$$

$$\frac{d^2v_c}{dt} - 4\frac{dv_c}{dt} - 8v_c = 0$$

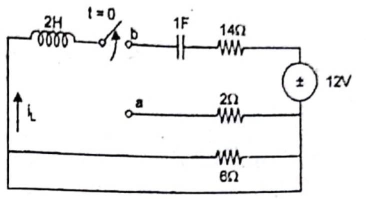
$$v_c = Ae^{-(2+2\sqrt{3})t} + Be^{-(2-2\sqrt{3})t}$$

$$\alpha, \beta = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

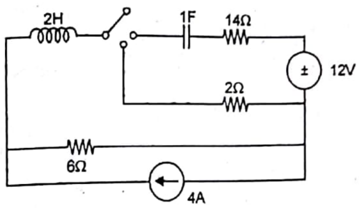
$$= \frac{4 \pm \sqrt{16 - 4 \times 1 \times -8}}{2}$$

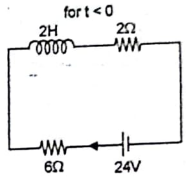
$$= \frac{4 \pm \sqrt{48}}{2} = 2(1 \pm \sqrt{3}).$$

Q.3. For the following circuit switch is moved from position (a) to (b) at $t = 0$. Then find $i_1(t)$ for $t > 0$. **(12.5)**



Ans.





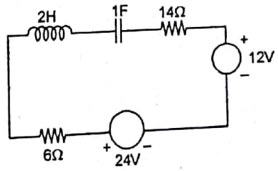
Inductor work as short circuit

$$I = \frac{24}{8} = 3A$$

Applying KVL

$$24 - 12 = 20I + 2\frac{dI}{dt} + \frac{1}{1}\int I\, dt$$

$$12 = 20I + 2\frac{dI}{dt} + \int I\, dt$$



On differentiating both side we get

$$2\frac{d^2I}{dt^2} + 20\frac{dI}{dt} + I = 0$$

$$\frac{d^2I}{dt^2} + 10\frac{dI}{dt} + .5I = 0$$

$$I = Ae^{-0.36t} + Be^{-9.97t}$$

$$\alpha, \beta = \frac{-10+\sqrt{100-4\times 5}}{2}$$

$$= \frac{-10\pm\sqrt{98}}{2} = -5\pm\frac{7}{2}\sqrt{2} = .036\ -9.97$$

UNIT-II

Q.4. Consider the following circuits, the two switches are closed simultaneously at $t = 0$. The voltage on capacitor C_1 and C_2 before the switched are closed are 1 and 2V respectively. **(12.5)**

(a) Find the currents $i_1(t)$ and $i_2(t)$.

Ans. Applying KVL in Loop 1

$$4 = (I_1+I_2)2+\int I_1\, dt$$

$$2 = (I_1+I_2)2+\int I_2 dt$$

Applying LT on both equation we get

$$\frac{4}{s} = 2I_1(s)+\frac{I_1(s)}{s}+2I_2(s)$$

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

or

$$\left[I_1(s)\left(2+\frac{1}{5}\right)+2\,I_2(s)=\frac{4}{s}\right]\times 2$$

$$\left[I_1(s)\,2\pm\left(2+\frac{1}{s}\right)I_2(s)=\frac{2}{s}\right]\left(2+\frac{1}{s}\right)$$

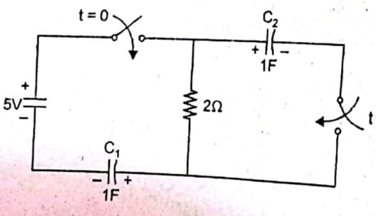
$$\left[4-\left(2+\frac{1}{s}\right)^2\right]I_2(s) = \frac{8}{s}-\frac{4}{s}-\frac{2}{s^2}$$

$$I_2(s) = \frac{\frac{4s-2}{s^2}}{4-4-\frac{2}{s}-\frac{1}{s^2}} = \frac{\frac{12\,s+2}{s^2}}{\frac{8s^2+2s+1}{s^2}} = \frac{12s+2}{8s^2+2s+1}$$

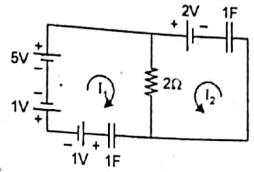
$$= \frac{2(s-1)}{-(2s+1)}$$

$$I_1(s) = \frac{8}{5}+$$

Q.4. (b) Find capacitor voltages at $t = 0$.



Ans.



$V_{C1} = 5$ volt

$V_{C2} = 0$

Q.5. (a) For the LTI system described by the following differential equation determine system function $H(s)$. **(6.5)**

$$y''(t) + y'(t) - 2y(t) = x(t)$$

Ans.

$$y''(t)+y'(t)-2y(t) = x(t)$$

Taking LT

$$s^2\,Y(s)+s\,Y(s)-2\,Y(s) = X(s)$$

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

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

Q.5. (b) Find Inverse Laplace transform of **(6)**

$$X(s) = \frac{2+2s\,e^{-2s}+4\,e^{-4s}}{s^2+4s+3} \qquad Re\,S > -1$$

Ans. $X(s) = \frac{2+2se^{-2s}+4e^{-4s}}{s^2+4s+3} = \frac{2}{s^2+4s+3}+\frac{2s\,e^{-2s}}{s^2+4s+3}+\frac{4\,e^{-4s}}{s^2+4s+3}$

LT of

$$\frac{2}{(s+3)(s+1)} = \frac{A}{s+3}+\frac{B}{s+1}$$

$$A = \frac{2}{(s+3)(s+1)}(s+3)\Big|_{s=-3} = \frac{2}{-2} = -1$$

$$B = \frac{2}{(s+3)(s+1)}(s+1)\Big|_{s=-1} = 1$$

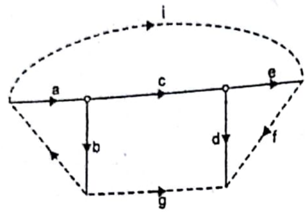
$$X(s) = \frac{-1}{s+3}+\frac{1}{s+1}+\frac{-se^{-2s}}{s+3}+\frac{se^{-2s}}{s+1}-\frac{2e^{-4s}}{s+3}+\frac{2e^{-4s}}{s+1}$$

taking ILT

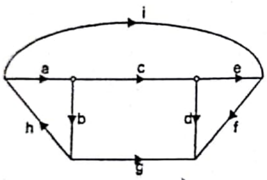
$$r(t) = -e^{-3t}+e^{-t}-e^{-3(t)}$$

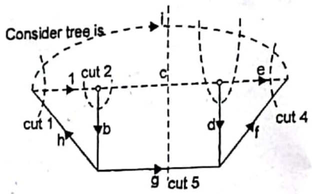
UNIT-III

Q.6. Determine the fundamental cut set and fundamental loop matrix for the following graph. Where solid lines are twigs and dotted lines are links. **(12.5)**



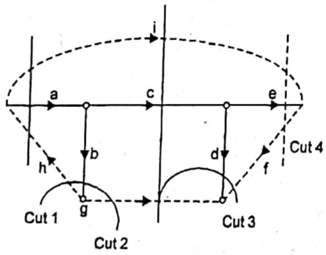
Ans.





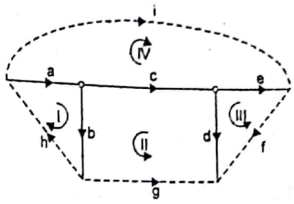
Twig are h, b, g, d, f
Link are a, c, e, i

	a	b	c	d	e	f	g	h	i
cut 1	–1	0	0	0	0	0	0	1	–1
cut 2	–1	1	1	0	0	0	0	0	0
cut 3	0	0	–1	1	1	0	0	0	0
cut 4	0	0	0	0	1	1	0	0	1
cut 5	0	0	1	0	0	0	1	0	1



Fundamental cutset Matrix

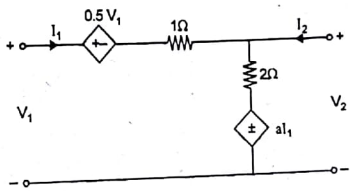
	a	b	c	d	e	f	g	h	i
cut 1	1	0	0	0	0	0	0	–1	1
cut 2	0	1	0	0	0	0	–1	–1	0
cut 3	0	0	0	1	0	–1	1	0	0
cut 4	0	0	0	0	1	1	0	0	1
cut 5	0	0	1	0	0	0	1	0	1



Fundamental loop matrix

	a	b	c	d	e	f	g	h	i
loop 1	1	1	0	0	00	0	0	1	0
loop 2	0	1	–1	–1	0	0	1	0	0
loop 3	0	0	0	1	–1	1	0	0	0
loop 4	–1	0	–1	0	–1	0	0	0	1

Q.7. (*a*) For what value of a is the following circuit reciprocal. **(6)**



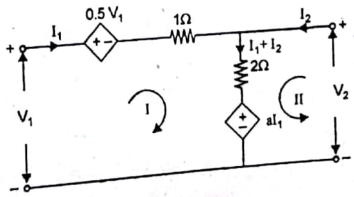
Ans.

On applying KVL in loop I

$$V_1 - 0.5V_1 - aI_1 = I_1 + 2(I_1 + I_2)$$

$$.5V_1 = (3+a)I_1 + 2I_2$$

$$V_1 = (6+2a)I_1 + 4I_2 \qquad \text{...(1)}$$



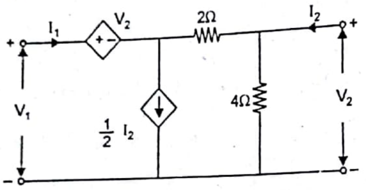
Applying KVL in loop 2

$$V_2 = 2(I_1+I_2)+aI_1$$
$$V_2 = (2+a)I_1+2I_2$$
$$z_{11} = (6+2a) \quad z_{12}=4$$
$$z_{21} = 2+a \quad z_{22}=2$$

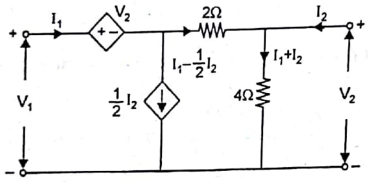
for Reciprocity

$$z_{12} = z_{21}$$
$$2+a = 4 \Rightarrow a=2$$

Q.7. (b) Find h parameters of the following circuit.



Ans.



$$V_1-V_2 = 2\left(I_1-\frac{1}{2}I_2\right)+4\left(I_1+\frac{I_2}{2}\right)$$
$$V_2 = 4\left(I_1+\frac{I_2}{2}\right)$$
$$V_1-V_2 = 6I_1+I_2$$
$$V_2 = 4I_1+2I_2$$
$$V_1 = h_{11}I_1+h_{12}V_2$$
$$I_2 = h_{21}I_1+h_{22}V_2$$

Putting the value of I_2 from equation 2 to equation 1.

$$V_1-V_2 = 6I_1+\frac{V_2}{2}-2I_1$$
$$V_1 = 4I_1+\frac{3}{2}V_2$$
$$I_2 = \frac{-4I_1}{2}+\frac{V_2}{2}$$
$$h_{11} = 4 \quad h_{21}=-2$$
$$h_{12} = \frac{3}{2} \quad h_{22} = \frac{1}{2}$$

UNIT–IV

Q.8. (a) What are the properties of Hurwitz Polynomial. (6)

Ans. Properties of Hurwtiz Polynomial.

Hurwitz polynomial $P(s)$ have the following properties:

(i) If the polynomial $P(s)$ can be written as

$$P(s) = a_n s^n + a_{n-1}s^{n-1} + \ldots + a_1 s + a_0$$

Then, All the coefficients a_i must be positive. A corollary is that between the highest order term in s and the lowest order term, none of the coefficients may be zero unless the polynomial is even or odd. In other words, $a_{n-1}, a_{n-2}, \ldots, a_2, a_1$ must not be zero if the polynomial is neither even nor odd.

(ii) Both the odd and even parts of a Hurwitz polynomial $P(s)$ have roots on the $j\omega$–axis only. If we denote the even part of $P(s)$ as $M(s)$ and the odd part as $N(s)$, so that

$$P(s) = M(s)+N(s) \ldots$$

then $M(s)$ and $N(s)$ both have roots on the $j\omega$-axis only.

(iii) As a result of property (ii), if $P(s)$ is either even or odd, all its roots are on the $j\omega$-axis (including origin).

(iv) The continued fraction expansion of the ratio ($\psi(s)$ of the odd to even parts ($N(s)/M(s)$) or the even to odd parts ($M(s)/N(s)$) of a Hurwitz polynomial yields all positive quotient terms. As,

$$\psi(s) = \frac{N(s)}{M(s)} \text{ or } \frac{M(s)}{N(s)} = q_1 s + \cfrac{1}{q_2 s + \cfrac{1}{\ddots + \cfrac{1}{q_n s}}}$$

Where the quotients $q_1, q_2 \ldots, q_n$ must be positive if the polynomial $P(s) = M(s) + N(s)$ is Hurwitz.

(v) If $P(s)$ is Hurwitz polynomial and $W(s)$ is a multiplicative factor. Then $P_1(s) = P(s).\,W(s)$ is also Hurwitz polynomial, if $W(s)$ is Hurwitz polynomial.

(vi) In case the polynomial is either only even or only odd, it is not possible to obtain the continued fraction expansion in such cases, the polynomial $P(s)$ is Hurwitz if the ratio of $P(s)$ and its derivative $P'(s)$ gives a continued fraction expansion.

Q.8. (b) $F(s) = \dfrac{s^2+4s+3}{s^2+6s+8}$ check whether the function is positive real or not. (6.5)

Ans.

$$F(s) = \frac{s^2+4s+3}{s^2+6s+8} = \frac{(s+3)(s+1)}{(s+2)(s+4)} = \frac{N(s)}{D(s)}$$

1. All pole of the $D(s)$ Lies on the –ve side of real axis.
2. No any pale on imaginary axis.
3. $$M_1M_2 - N_1N_2 \geq 0 \text{ for all value of } \omega$$

$$M_1 = s^2+3 \quad M_2 = s^2+8$$
$$N_1 = 4s \quad N_2 = 6s$$

$$(s^2+3)(s^2+8) - 4s\,.\,6s = s^4 - 13s^2 + 24$$

Putting $s \to j\omega$

$$= \omega^4 + 13\,\omega^2 + 24$$

this is always +ve for any value of ω

So function is P.R.F

Q.9. Realize $Z(s) = \dfrac{s^2+2s+2}{s^2+s+1}$ by cauer–I form.

Ans.

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

$$\begin{array}{l}
s^2+s+1\,\big)\,s^2+2s+2\,\big(\,1 \leftrightarrow z_1 \\
\qquad\quad \underline{s^2+s+1} \\
\qquad\qquad s+1\,\big)\,s^2+s+1\,\big(\,s \leftrightarrow y_2 \\
\qquad\qquad\qquad \underline{s^2+s} \\
\qquad\qquad\qquad\qquad 1\,\big)\,s+1\,\big(\,s \leftrightarrow z_3 \\
\qquad\qquad\qquad\qquad\qquad \underline{s} \\
\qquad\qquad\qquad\qquad\qquad 1\,\big)\,1\,\big(\,s \leftrightarrow y_4 \\
\qquad\qquad\qquad\qquad\qquad\quad \underline{1} \\
\qquad\qquad\qquad\qquad\qquad\quad \times
\end{array}$$

MID TERM EXAMINATION [SEPT. 2016]
THIRD SEMESTER [B.TECH]
CIRCUITS AND SYSTEMS [ETEE-207]

Time : 1½ Hrs. **M.M. : 30**

Note: *Answer any three questions. All questions carry equal marks.*

Q.1. (a) Define a signal and also describe the different types of the signals. (4)

Ans. A signal may be considered to be a function of time that represents a physical variable of interest associated with a system.

Types of Signal

1. Continuous time signal
2. Discrete time signal

On the basis of symmetry

1. Even signal
2. Odd signal

On the basis of periodicity

1. Periodic signal
2. Non periodic signal

On the basis of power and energy

1. Power signal
2. Energy signal

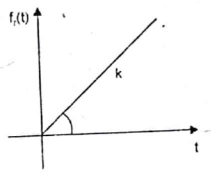
Basic Signal

1. Step Signal: $f_s(t)$ is defined by

$$f_s(t) = \begin{cases} 0; & t<0 \\ K; & t>0 \end{cases}$$

where K is the amplitude of step signal

2. Ramp Signal: $f_r(t)$ is defined by



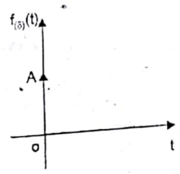
$$f_r(t) = \begin{cases} 0\ ; & t<0 \\ Kt\ ; & t\ge 0 \end{cases}$$

K is the slope of ramp signal.

3. Impulse Signal: $f_\delta(t)$ is defined by

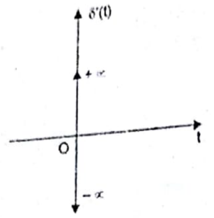
$$f_\delta(t) = \begin{cases} 0\ ; & t\ne 0 \\ A\ ; & t\ge 0 \end{cases}$$

where A is the area of impulse signal.



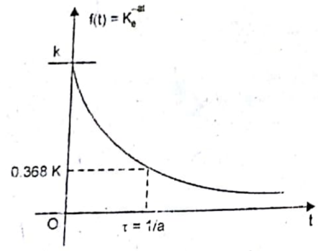
Other Basic Signals

1. Unit Doublet Signal: It a unit impulse signal $\delta(t)$ is differentiated w.r.t. to t, we get



$$\delta'(t) = \frac{d}{dt}[(\delta t)] = +\propto \text{ and } -\propto ; t = O$$
$$= O ; \quad t \neq 0$$

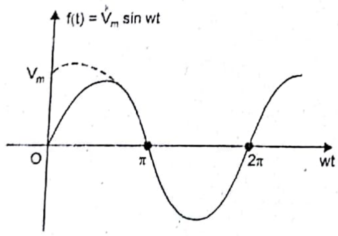
2. Exponential Signal



$$f(t) = \begin{cases} O & ; t \leq O \\ K_e^{-at} & ; t \geq O \end{cases}$$

where a and k are real constants.

3. Sinusoidal Signal



$$f(t) = \begin{cases} O & ; t < 0 \\ V_m \sin wt & ; t \geq O \end{cases}$$

Q.1. (b) Draw the waveform of the signal represented by the mathematic equation $V(t) = 2tu(t) - 2(t-1)\,u(t-1) - 2u(t-3)$ and find its Laplace Transformation.

Ans. $V(t) = 2tu(t) - 2(t-1)\,u(t-1) - 2u(t-3)$

$$= 2[tu(t) - (t-1)\,u(t-1) - u(t-3)]$$

If $0 < t < 1$

Only $\quad u(t) = 1$ and $u(t-1) = u(t-3) = 0$

Then $\quad V(t) = 2t$

If $\quad 1 < t < 3$

$u(t) = u(t-1) = 1$ and $u(t-3) = 0$

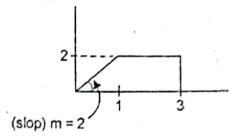
$V(t) = 2t - 2t + 2 = 2$

When $\quad t > 3$

$u(t) = u(t-1) = u(t-3) = 1$

$V(t) = 2t - 2t + 2 - 2 = 0$

The final wave.



Q.2. (a) What is LTI System and describe its properties in detail? (6)

Ans. LTI Systems

A system is instantaneous (or memoryless or zero memory or without memory) if its output at any time depends only on the value of the input at the same time, otherwise dynamic *i.e.*, a dynamic system or system with memory is one whose output depends on past or future values of the input or past values of output in addition to the present input.

A without memory continuous-time LTI system has the form

$$y(t) = Kx(t) \quad \text{(where } K \text{ is any constant)}$$

Its impulse response

$$h(t) = K\delta(t)$$

Similarly, the form of a without memory discrete-time LTI system and its corresponding impulse response we $y[n] = Kx[n]$ and $h[n] = K\delta[n]$, respectively.

Note that if $k = 1$, then these systems become identity systems, with outputs equal to the inputs and with unit impulse responses equal to the unit impulse signals, *i.e.*,

$$h(t) = 0; \text{ for } t \neq 0 \text{ and } h[n] = 0; \text{ for } n \neq 0$$

In this case, the convolution integral and sum formulas imply that

$$x(t) = x(t) * \delta(t) \text{ and } x[n] = x[n] * \delta[n]$$

If an LTI system has an impulse response $h(t)$ or $h[n]$ that is not identically zero for $t \neq 0$ or $n \neq 0$, respectively, then the system is with memory or dynamic.

2. Causality of LTI Systems: A system is causal or non-anticipative if the output of the system at any time depends only on values of the input at the present time and in the past otherwise non-causal *i.e.*, a non-causal system is the system whose output depends (or anticipate) future values of the input.

A continuous-time LTI system to be causal, output $y(t)$ must not depend on input $x(\tau)$ for $\tau > t$. This results

$$h(t) = 0 \quad \text{for} \quad t < 0$$

Similarly, for a causal discrete-time LTI system the output $y[n]$ depends on input $x[k]$ for $k < n$. This results $h[n] = 0$ for $n < 0$.

That is the impulse response of a causal LTI system must be zero before the impulse occurs.

More generally, causality for an LTI system is equivalent to the condition of initial rest. And the system output is

$$y(t) = \int_{-\infty}^{t} x(\tau)h(t-\tau)\,d\tau \quad \text{or} \quad y[n] = \sum_{k=-\infty}^{n} x[k]\,h[n-k]$$

In other words, the causality of an LTI system is equivalent to its impulse response being a causal signal.

3. Invertibility of LTI Systems: A system is invertible only if an inverse system exists that, when cascaded with the original system, yields an output equal to the input to the first system. Here, if an LTI system is invertible, then it has an LTI inverse.

If we have an LTI system with impulse response $h(t)$ or $h[n]$, then inverse system with impulse response $g(t)$ or $g[n]$, must satisfy

$$h(t) * g(t) = \delta(t)$$

or $$h[n] * g[n] = \delta[n]$$

4. Stability of LTI Systems: An LTI system is said to stable if the impulse response is absolutely integrable in case of continuous-time or absolutely summable in case of discrete-time systems, *i.e.*,

$$\int_{-\infty}^{\infty} |h(\tau)|d\tau < \infty \quad \text{or} \quad \sum_{k=-\infty}^{\infty} |h[k]|$$

More general, an LTI system is said to be stable if the impulse response approaches zero as $t \to \infty$ or $n \to \infty$ for continuous-time or discrete-time system, respectively.

5. Commutative Property: The output of an LTI system with impulse response $h(t)$ or $h[n]$ to input $x(t)$ or $x[n]$ is equal to the output of the system with impulse response $x(t)$ or $x[n]$ to input $h(t)$ or $h[n]$, *i.e.*,

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

or $$y[n] = x[n] * h[n] = h[n] * x[n]$$

This leads to $$y(t) = \int_{-\infty}^{\infty} x(\tau)\,h(t-\tau)\,d\tau = \int_{-\infty}^{\infty} x(t-\tau)\,h(\tau)\,d\tau$$

or $$y[n] = \sum_{k=-\infty}^{\infty} x[k]\,h[n-k] = \sum_{k=-\infty}^{\infty} x[n-k]\,h[k]$$

which may at times be easier to evaluate then equation.

6. Distributive Property: The output of an LTI system with impulse response $h_1(t) + h_2(t)$ or $h_1[n] + h_2[n]$ to input $x(t)$ or $x[n]$ is equal to the sum of the output of system with impulse response $h_1(t)$ or $h_1[n]$ to input $x(t)$ or $x[n]$ and system with impulse response $h_2(t)$ or $h_2[n]$ to input $x(t)$ or $x[n]$, *i.e.*,

$$y(t) = x(t) * [h_1(t) + h_2(t)] = x(t) * h_1(t) + x(t) * h_2(t)$$

or $$y[n] = x[n] * [h_1[n] + h_2[n]] = x[n] * h_1[n] + x[n] * h_2[n]$$

The distributive property is useful when two or more systems are connected in parallel.

Also, as a consequence of both commutative and distributive properties, we have

$$y(t) = [x_1(t) + x_2(t)] * h(t) = x_1(t) * h(t) + x_2(t) * h(t)$$

or $$y[n] = [x_1[n] + x_2[n]] * h[n] = x_1[n] * h[n] + x_2[n] * h[n]$$

Which simply state that the response of an LTI system to the sum of two inputs must equal the sum of the responses to these inputs individually.

7. Associative Property: The output of an LTI system with impulse response $[h_1(t) + h_2(t)]$ or $[h_1[n] + h_2[n]]$ to input $x(t)$ or $x[n]$ is equal to the output of the system with impulse response $h_2(t)$ or $h_2[n]$ to input $[x(t) * h_1(t)]$ or $x_1[n] * h_1[n]]$, *i.e.*,

$$y(t) = x(t) * [h_1(t) * h_2(t)] = [x(t) * h_1(t)] * h_2(t)$$

or $$y[n] = x[n] * [h_1[n] + h_2[n]] = [x[n] * h_1[n]] * h_2[n]$$

The associative property is useful when two or more systems are connected in series or in cascade.

Also, as a consequence of this property, we can say that the overall system response does not depend upon the order of the systems in the series or in cascade.

Q.2. (b) Find the Laplace Transform of the following functions: (4)

(i) e^{at} **sin** (wt) ***(ii)*** $10u(t-1) - \delta(t-2) - 5\delta(t-3)$.

Ans. Laplace Transform

(i) e^{at} **(sin** wt**)**

As we know the LT of $\sin wt = \dfrac{w}{s^2 + w^2}$

Property

$$e^{at}\sin wt \xrightarrow{LT} \frac{w}{(s-a)^2 - w^2} \qquad \begin{bmatrix} f(t) \xrightarrow{LT} F(s) \\ e^{at} f(t) \longrightarrow F(s-a) \end{bmatrix}$$

(ii) $f(t) = 10u(t-1) - \delta(t-2) - 5\delta(t-3)$

Property

$$u(t-1) \xrightarrow{LT} \frac{e^{-s}}{s} \qquad \begin{bmatrix} f(t) \longrightarrow F(s) \\ f(t-a) \longrightarrow e^{-aS}F(s) \end{bmatrix}$$

$$\delta(t-2) \xrightarrow{LT} e^{-2s}$$

$$\delta(t-3) \xrightarrow{LT} e^{-3s}$$

$$f(t) \xrightarrow{LT} 10\frac{e^{-s}}{s} - e^{-2s} - 5e^{-3s}$$

Q.3. (a) Write the mathematical equation for the waveform shown in Fig. using Signal Synthesis Concept and find its Laplace Transformation. (4)

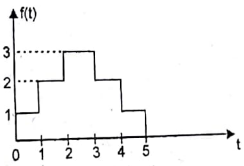
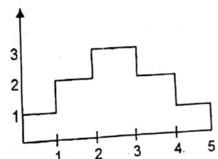


Fig. 1.

Ans.



$$f(t) = u(t) + u(t-1) + u(t-2) - u(t-3) - u(t-4) - u(t-5)$$

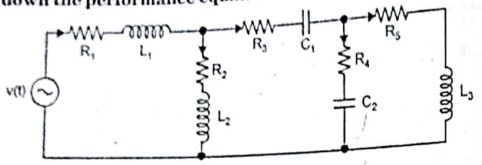
$$f(t) \xrightarrow{LT} \frac{1}{s} + \frac{e^{-s}}{s} + \frac{e^{-2s}}{s} - \frac{e^{-3s}}{s} - \frac{e^{-4s}}{s} - \frac{e^{-5s}}{s}$$

As we know $u(t) \xrightarrow{LT} \dfrac{1}{s}$

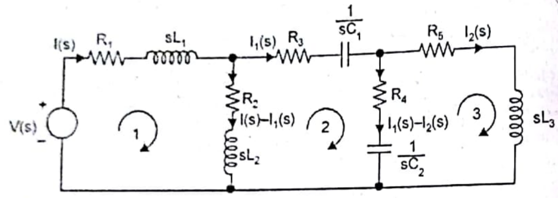
$$f(t-a) \longrightarrow e^{-as}F(s)$$

So $u(t-a) \longrightarrow \frac{e^{-as}}{s}$

Q.3. (b) Draw the s-domain equivalent circuit for the circuit shown in Fig. 2 and write down the performance equations using KVL. (6)



Ans.



Applying KVL in loop 1, 2 and 3

In loop 1: $V(s) = R_1 I + sL_1 I + (R_2 + sL_2)(I - I_1)$

In loop 2: $(R_2 + L_2 s)(I - I_1) = \left(R_3 + \frac{1}{sC_1}\right)I_1 + \left(R_4 + \frac{1}{C_2 s}\right)(I_1 - I_2)$

In loop 3: $\left(R_4 + \frac{1}{sC_2}\right)(I_1 - I_2) = (R_5 + sL_3)I_2.$

Q.4. (a) Obtain an expression for the current in the indctor for any time $t \geq 0$, in the circuit shown in Fig. 3 using Laplace Transformation. Assume the circuit to be initially relaxed. (5)

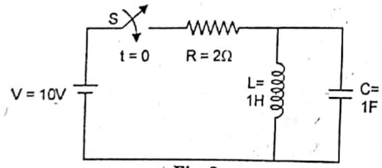
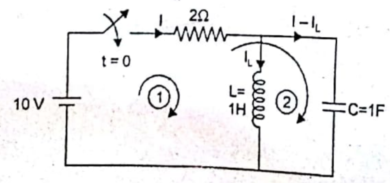


Fig. 3

Ans.



Applying KVL in loop 1 and 2

$$10 = 2I + 1\frac{dI_L}{dt} \quad ...(1)$$

Taking LT:

$$\frac{10}{s} = 2I(s) + sI_L(s)\, I_L(O^+)$$

$$\frac{10}{s} = 2I + sI_L \quad ...(1a)$$

$$10 = 2I + \frac{1}{C}\int(I - I_L)\,dt \quad ...(2)$$

Taking LT:

$$\frac{10}{s} = 2I + \frac{I - I_L}{s}$$

$$\frac{10}{s} = \left(2 + \frac{1}{s}\right)I - \frac{I_L}{s} \quad ...(2a)$$

$$= \left(sI_L + 2I = \frac{10}{s}\right) \times \left(2 + \frac{1}{s}\right)$$

$$\left(\frac{-I_L}{+\ s} \frac{+}{-} \left(2 + \frac{1}{s}\right)I + \frac{10}{-\ s}\right) \times 2$$

$$\left[\left(2 + \frac{1}{s}\right)s + \frac{2}{s}\right]I_L = \frac{20}{s} + \frac{10}{s^2} - \frac{20}{s}$$

$$\left(2S + 1 - \frac{2}{s}\right)I_L = \frac{10}{s^2}$$

$$I_L = \frac{10}{s(2s^2 + s + 2)}.$$

Q.4. (b) Determine the current $i(t)$ in the circuit shown in Fig. 4 using Laplace Transformation. (5)

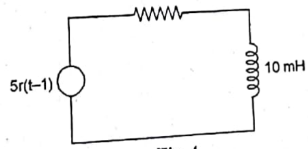
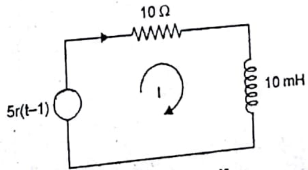


Fig. 4

Ans.



$$5r(t-1) = 10I + 10 \times 10^{-3}\frac{dI}{dt}$$

Taking LT: $\dfrac{5e^{-S}}{s^2} = 10I(s) + 10^{-2}sI(s)$

$$\Rightarrow \quad I(s) = \frac{5e^{-s}}{s^2(10^{-2}s+10)} = \frac{500e^{-s}}{s^2(s+1000)}$$

Now ILT: $\dfrac{1}{s^2(s+1000)} = \dfrac{A}{s} + \dfrac{B}{s^2} + \dfrac{C}{s+1000}$

$$B = \frac{1}{1000} \qquad C = \frac{1}{10^6}$$

$$\frac{1}{s^2(s+1000)} \xrightarrow{\text{LT}} Au(t) + Btu(t) + Ce^{-1000t}$$

Finally: $\dfrac{500e^{-s}}{s^2(s+1000)} \xrightarrow{\text{LT}} 500\,Au(t-1) + 500B(t-1)\,u(t-1) + 500C\,e^{-1000(t-1)}$

Put the value of A, B, C, we get I.

END TERM EXAMINATION [DEC. 2016]
THIRD SEMESTER [B.TECH]
CIRCUIT AND SYSTEM [ETEC-207]

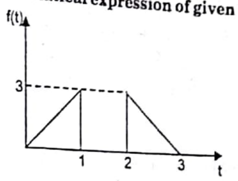
Time : 3 Hrs. **M.M. : 75**

Note: *Attempt any five questions including Q. no. 1 which is compulsory. Select one question from each unit. Assume suitable missing data if any.*

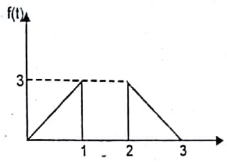
Q.1. (a) What is LTI system and describe their properties in brief. **(5×5=25)**

Ans. Refer Q.2. (a) Mid Term Examination 2016.

Q.1. (b) Write the mathematical expression of given waveform.

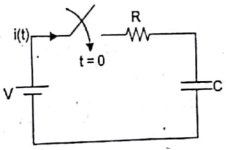


Ans.

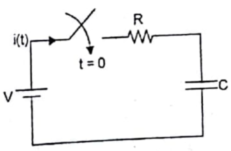


$$f(t) = 3t[u(t) - u(t-1)] + (9-3t)\,[u(t-2) - u(t-3)]$$

Q.1. (c) Find the current $i(t)$ in the given network using Laplace technique.



Ans.



$$V = IR + \frac{1}{C}\int i\,dt$$

$$\frac{V}{s} = IR + \frac{1}{C}\left[\frac{I(s)}{s} - \frac{I'(0)}{s}\right]$$

$$\frac{V}{s} = IR + \frac{I}{Cs}$$

$$\Rightarrow \quad I = \frac{V}{s\left(\frac{1}{Cs} + R\right)} = \frac{CV}{CRs+1} = \frac{V}{R}\left(\frac{1}{s + \frac{1}{RC}}\right)$$

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$$I(t) = \frac{V}{R}e^{-\frac{1}{RC}t}$$

Q.1. (d) Find T parameter in terms of g parameter.

Ans.

$$V_1 = AV_2 + B(-I_2) \quad ...(1)$$

$$I_1 = CV_2 + D(-I_2) \quad ...(2)$$

$$V_2 = \frac{1}{A}V_1 + \frac{B}{A}I_2$$

$$g_{21} = \frac{1}{A} \text{ and } g_{22} = \frac{B}{A}$$

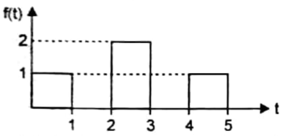
Putting the value of V_2 in equation (2)

$$I_1 = C\left[\frac{1}{A}V_1 + \frac{B}{A}I_2\right] + D(-I_2) = \frac{C}{A}V_1 + \left(\frac{BC}{A} - D\right)I_2$$

$$g_{11} = \frac{C}{A} \text{ and } g_{12} = \frac{B}{A}$$

UNIT–I

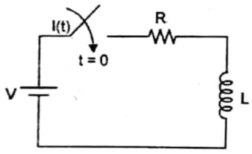
Q.2. (a) Synthesis the given waveform using gate signal. (6)



Ans. $f(t) = [u(t) - u(t-1)] + 2[u(t-2) - u(t-3)] + [u(t-4) - u(t-5)]$

$$= g^{(t)}_{(0,1)} + 2g^{(t)}_{(2,3)} + g^{(t)}_{(4,5)}$$

Q.2. (b) Find the step transient response of series RL network using differential equation method. (6.5)

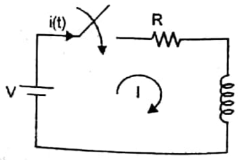


Ans.

Applying KVL $\quad V = IR + L\frac{dI}{dt} \quad \frac{dI}{dt} + \frac{R}{L}I = \frac{V}{L}$

C.F. $\quad D + \frac{R}{L} = 0$

$$I_{cf}(t) = Ae^{-\frac{R}{L}t}$$



$$\text{PI} = \left.\frac{\frac{V}{L}}{D + \frac{R}{L}}\right|_{D=0} = \frac{V}{R}$$

$$i(t) = Ae^{-\frac{R}{L}t} + \frac{V}{R}$$

at $\quad t = 0 \quad i = 0$

$$A = -\frac{V}{R}$$

$$i(t) = \frac{V}{R}\left(1 - e^{-\frac{R}{L}t}\right).$$

Q.3. (a) Define different type of test signals with their mathematical and graphical representation and Laplace. (6)

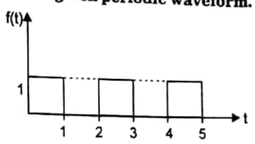
Ans. Refer Q. 1 (a) of Mid Term 2016.

Q.3. (b) Draw the waveform of given expression $f(t) = 2tu(t) - 2(t-1)\,u(t-1) - 2u(t-3)$. (6.5)

Ans. Refer Q. 1 (b) of Mid Term 2016.

UNIT–II

Q.4. (a) Find the Laplace of given periodic waveform. (6)

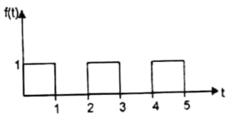


Ans.

$$f(t) = [u(t) - u(t-1)] + [u(t-2) - u(t-3)] + [u(t-4) - u(t-5)] + ...$$

Taking LT: $F(s) = \frac{1}{s} - \frac{e^{-S}}{s} + \frac{e^{-2S}}{s} - \frac{e^{-3s}}{s} + \frac{e^{-4s}}{s} - \frac{e^{-5s}}{s} + ...$

$$= \frac{1}{s}[1 - e^{-s} + e^{-2s} - e^{-3s} + e^{-4s} - e^{-5s} + ...]$$



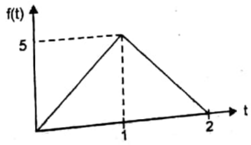
$$F(S) = \frac{1}{s} \times \frac{1}{1 + e^{-s}}.$$

Q.4. (b) Find the Laplace of given function $f(t) = 5tu(t)$. (6.5)

Ans. $\quad f(t) = 5tu(t)$

$$= 5\int_0^{\infty} te^{-st}\,dt = 5\left[\frac{te^{-st}}{-s} - \frac{1}{-s}\int_0^{\infty} e^{-st}\,dt\right]_0^{\infty} = 5\left[-\frac{e^{-st}}{s^2}\right]_0^{\infty} = \frac{5}{s^2}$$

Q.5. (a) Find the Laplace of given waveform. (6)



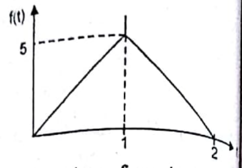
Ans.

$$f(t) = 5[t(u(t) - u(t-1)] + (2-t)[u(t-1) - u(t-2)]$$

$$f(t) = 5[tu(t) - tu(t-1) + 2u(t-1) - 2u(t-2) - tu(t-1) + tu(t-2)]$$

$$= 5[tu(t) - 2(t-1)\,u(t-1) + (t-2)\,u(t-2)]$$

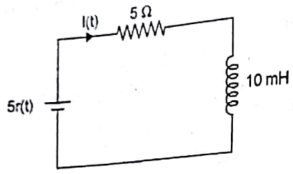
$$= 5[r(t) - 2r(t-1) + r(t-2)]$$



$$F(S) = 5\left[\frac{1}{s^2} - \frac{2e^{-s}}{s^2} + \frac{e^{-2s}}{s^2}\right]$$

$$= \frac{5}{s^2}\,[1 - 2e^{-s} + e^{-2s}].$$

Q.5. (b) Find the current in given network using laplace transform technique. (6.5)



Ans.

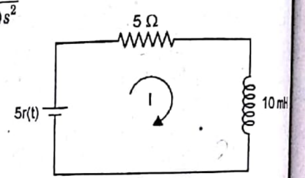
$$5r(t) = 5I + 10^{-2}\frac{dI}{dt}$$

Taking LT: $\frac{5}{s^2} = 5I + 10^{-2}sI$

$$\Rightarrow \quad I = \frac{5}{s^2(5+10^{-2}s)} = \frac{500}{(5+500)s^2}$$

$$I(s) = \frac{A}{s} + \frac{B}{s^2} + \frac{C}{s+500}$$

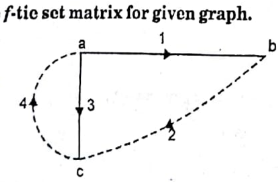
$$B = 1 \quad C = \frac{1}{500} \quad A = \text{Find}$$



$$I(t) = Au(t) + tu(t) + \frac{1}{500}e^{-500t}$$

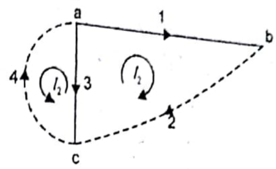
UNIT-II

Q.6. (a) Determine *f*-tie set matrix for given graph. (6

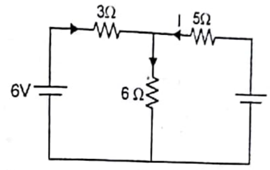


Ans.

$$B_f = \begin{array}{c} \\ 2 \\ 4 \end{array}\!\!\begin{array}{c} \begin{array}{cccc} 1 & 2 & 3 & 4 \end{array} \\ \begin{bmatrix} 1 & 1 & -1 & 0 \\ 0 & 0 & 1 & 1 \end{bmatrix} \end{array} \begin{array}{l} \\ \to \text{for loop 1} \\ \to \text{for loop 2} \end{array}$$



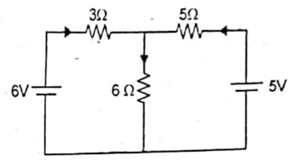
Q.6. (b) Find the current in given network using super position theorem. (6.5)



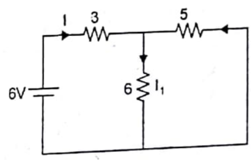
Ans. 1st consider 6 V and replace 5 V with short circuit.

$$R_{eq} = (6 \,||\, 5) + 3$$

$$= 3 + \frac{6\times 5}{6+5} = 3 + \frac{30}{11} = \frac{63}{11}$$



$$I = \frac{6}{\frac{63}{11}} = \frac{66}{63}$$



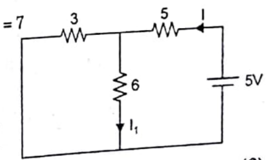
$$I_1 = \frac{5}{11}\times I$$

$$= \frac{5}{11}\times\frac{66}{63} = \frac{30}{63}$$

Consider 5 V and replace 6 V by short circuit

$$I = \frac{5}{7}$$

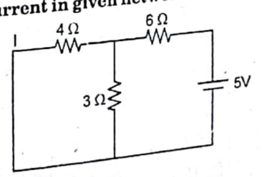
$$R_{th} = (6 \,||\, 3) + 5 = 5 + \frac{6\times 3}{9} = 7$$



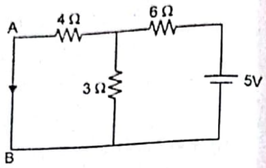
$$I_1' = \frac{3}{9}\times\frac{5}{7} = \frac{15}{63}$$

$$\text{Total } I = I_1 + I_1' = \frac{30}{63} + \frac{15}{63} = \frac{45}{63}$$ (6)

Q.7. (a) Find the current in given network using Norton's theorem.



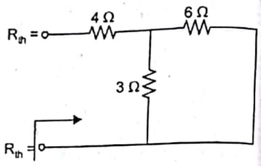
Ans.



$$\text{Total current} = \frac{5}{(4\,||\,3)+6}$$

$$= \frac{5}{\frac{12}{7}+6}$$

$$= \frac{35}{54}$$



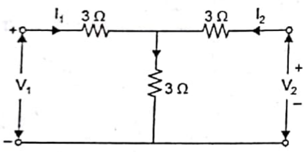
$$\text{Current through(AB)} = \frac{3}{7}\times I$$

$$I_N = \frac{3}{7}\times\frac{35}{54} = \frac{15}{54}$$

$$R_{th} = 4+(6\,||\,3)$$

$$= 4+\frac{18}{9} = 6.$$

Q.7. (*b*) Find transmission parameter of given two port network. **(6.5)**



Ans.

$$V_1 = AV_2+B(-I_2)$$

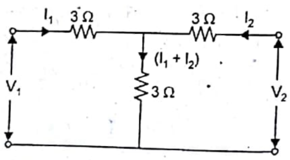
$$I_1 = CV_2+D(-I_2)$$

$$V_1 = 6I_1+3I_2 \quad \text{...(1)}$$

$$V_2 = 3I_1+6I_2 \quad \text{...(2)}$$

From equation (2),

$$I_1 = \frac{V_2}{3}-2I_2$$



Putting the value of I_1 in equation (1)

$$V_1 = 6\left(\frac{V_2}{3}-2I_2\right)+3I_2$$

$$V_1 = 2V_2-9I_2$$

On comparing, we get

$$A = 2,\ B = 9$$

$$V_2 = 3I_1+6I_2$$

$$I_1 = \frac{V_2}{3}-\frac{6I_2}{3}$$

$$I_1 = \frac{V_2}{3}-2I_2$$

On companing, we get

$$C = \frac{1}{3} \quad D = 2$$

Q.8. (*a*) Realize the function in Foster-1 and Foster-2 form. **(12.5)**

$$Z(s) = \frac{s(s+2)\,s(s+5)}{s(s+1)(s+4)}.$$

Ans.

$$Z(s) = \frac{s(s+2)\,s(s+5)}{s(s+1)(s+4)} = \frac{s(s+2)(s+5)}{(s+1)(s+4)}$$

Foster 1:

$$\frac{Z(s)}{s} = \frac{(s+2)(s+5)}{(s+1)(s+4)} = \frac{s^2+7s+10}{s^2+5s+4}$$

$$s^2+5s+4\,\overline{)\,s^2+7s+10\,}(1$$
$$\underline{s^2+5s+4}$$
$$2s+6$$

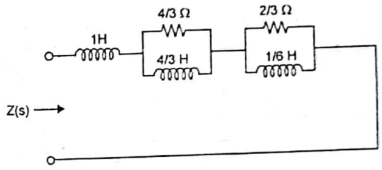
$$\frac{Z(s)}{s} = 1+\frac{2s+6}{(s+1)(s+4)}$$

Using partial fraction

$$\frac{Z(s)}{s} = 1+\frac{A}{s+1}+\frac{B}{s+4}$$

$$A = \frac{4}{3},\ B = \frac{2}{3}$$

$$Z(s) = s+\frac{\frac{4}{3}s}{s+1}+\frac{\frac{2}{3}s}{s+4}$$



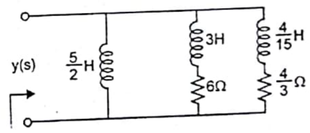
Foster II:

$$Y(s) = \frac{(s+1)(s+4)}{s(s+2)(s+5)}$$

$$Y(s) = \frac{A}{s}+\frac{B}{s+2}+\frac{C}{s+5}$$

$$A = \frac{2}{5},\ B = \frac{1}{3},\ C = \frac{4}{15}$$

$$Y(s) = \frac{\frac{2}{5}}{s}+\frac{\frac{1}{3}}{s+2}+\frac{\frac{4}{15}}{s+5}$$



Q.9. Realize the function in Caur-1 and Caur-2 form. **(12.5)**

$$Z(S) = \frac{(s+1)(s+4)}{s(s+2)(s+5)}$$

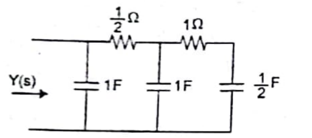
Ans.

$$Z(s) = \frac{(s+1)(s+4)}{s(s+2)(s+5)}$$

Caur-1:

$$Y(s) = \frac{s^3+7s^2+10s}{s^2+5s+4}$$

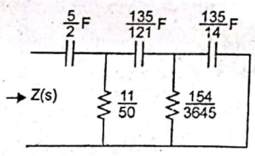
$$s^2+5s+4 \overline{)\, s^3+7s^2+10s\,}\big(\, s \longleftrightarrow Y_1$$
$$\underline{s^3+5s^2+4s}$$
$$2s^2+6s\,\overline{)\, s^2+5s+4\,}\big(\, \tfrac{1}{2} \longleftrightarrow Z_2$$
$$\underline{s^2+3s}$$
$$2s+4\,\overline{)\, 2s^2+6s\,}\big(\, s \longleftrightarrow Y_3$$
$$\underline{2s^2+4s}$$
$$2s\,\overline{)\, 2s+4\,}\big(\, 1 \longleftrightarrow Z_4$$
$$\underline{2s}$$
$$+4\,\overline{)\, 2s\,}\big(\, \tfrac{1}{2}s \longleftrightarrow Y_5$$
$$\underline{2s}$$
$$\times$$



Caur-II:

$$Z(s) = \frac{s^2+5s+4}{s^3+7s^2+10s} = \frac{4+5s+s^2}{10s+7s^2+s^3}$$

$$10s+7s^2+s^3\,\overline{)\, 4+5s+s^2\,}\big(\, \frac{4}{10s} \longleftrightarrow Z_1$$
$$\underline{4+\frac{14}{5}s+\frac{2}{5}s^2}$$
$$\frac{11}{5}s+\frac{3}{5}s^2\,\overline{)\, 10s+7s^2+s^3\,}\big(\, \frac{5}{11}.10 \longleftrightarrow Y_2$$
$$\underline{10s+\frac{30}{11}s^2}$$
$$\frac{47}{11}s^2+s^3\,\overline{)\, \frac{11}{5}s+\frac{3}{5}s^2\,}\big(\, \frac{11}{47}\times\frac{11}{5s} \longleftrightarrow Z_3$$
$$\underline{\frac{11}{5}s+\frac{121}{235}s^2}$$
$$\frac{20}{235}s^2\,\overline{)\, \frac{47}{11}s^2+s^3\,}\big(\, \frac{235}{20}\times\frac{47}{11} \longleftrightarrow Y_4$$
$$\underline{\frac{47}{11}s^2}$$
$$+s^3\,\overline{)\, \frac{20}{235}s^2\,}\big(\, \frac{20}{235s} \longleftrightarrow Z_5$$
$$\underline{\frac{20}{235}s^2}$$
$$\times$$



FIRST TERM EXAMINATION [SEPT. 2017]
THIRD SEMESTER [B.TECH]
CIRCUITS AND SYSTEMS
[ETEE-207]

Time : 1½ hrs. **M.M. : 30**

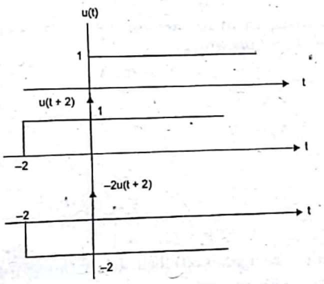
Note: *Attempt any three questions including Q.No 1 which is compulsory.*

Q.1. Attempt all of the follo wing:

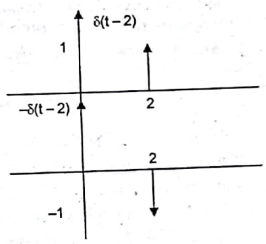
Q.1. (a) Draw the waveform of

(i) $-2u(t+2)$ (ii) $-\delta(t-2)$ (iii) $-r(t+2)$ **(2)**

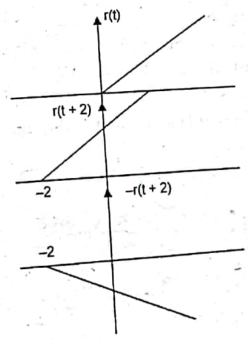
Ans. (i) $u(t)$



(ii) $-\delta(t-2)$



(iii) $-r(t+2)$



Q.1. (b) Write the equation for the waveform shown in the figure 1 using shifted step function. **(2)**

Ans.

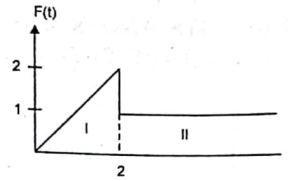


Fig. 1

Section I $t\,[u(t)-u(t-2)]$

Section II $u(t-2)$

$F(t) = t(u(t)-u(t-2)] + u(t-2)$

Q.1. (c) Prove that the impulse response of any network is inverse Laplace transform of the transfer function of that network. **(2)**

Ans. As we know the transfer function is the ratio of $Y(S)$ and $X(S)$

$$T(S) = H(S) = \frac{Y(S)}{X(S)} \quad ...(i)$$

Where $Y(S)$ is the LT of $y(t)$ *i.e.* output

and $X(S)$ is the LT of $x(t)$ *i.e.*, input

if input is $x(t) = \delta(t)$ then $X(s) = 1$

On putting this value in eqn 1 we get $H(S) = Y(S)$

On taking ILT $h(t) = y(t)$ that means if the input is $\delta(t)$ then $h(t) = y(t)$.

and Impulse response of a system is the response if input is $\delta(t)$.

Q.1. (d) What are the advantages of Laplace Transform techniques. **(2)**

Ans. Advantage of LT

1. It gives complete solution
2. Initial conditions are automatically considered in the transformed equation
3. Easy to solve differential equation using LT
4. It gives systemetic solution of differential eqn.

Q.1. (e) Find even and odd component of the signal $x(t) = e^{-2t}$ cost. **(2)**

Ans. $x(t) = e^{-2t}\cos 2t$

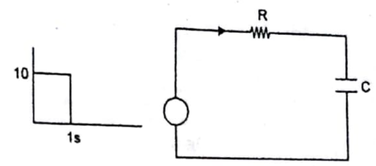
$x(-t) = e^{+2t}\cos(-2t) = e^{2t}\cos 2t$

$$x_{even}(t) = \frac{e^{-2t}\cos 2t + e^{2t}\cos 2t}{2}$$

$$x_{odd}(t) = \frac{e^{-2t}\cos 2t - e^{2t}\cos 2t}{2}$$

Q.2. (a) Find out the response $i(t)$ for $t > 0$ for the series R-C circuit excited by a pulse excitation of 10 magnitudes voltage for one second duration. Explain $i(t)$ with graph. Assuming initial conditions zero. $R = 1\Omega$, $C = 1F$. **(5)**

Ans.



$$V = iR + \frac{1}{C}\int i\,dt$$

$$10[u(t)-u(t-1)] = iR + \frac{1}{C}\int i\,dt$$

taking LT

$$\frac{10}{s} - \frac{10}{s}e^{-s} = I(s)R + \frac{1}{C}\frac{I(s)}{s}$$

$$R = 1\,\Omega \quad C = 1\,F$$

$$\frac{10}{s} - \frac{10}{s}e^{-s} = I(s)\left(1+\frac{1}{s}\right) = I(s)\left(\frac{s+1}{s}\right)$$

$$I(s) = \frac{10(1-e^{-s})}{(1+s)} = \frac{10}{s+1} - \frac{10e^{-s}}{s+1}$$

taking ILT

$$i(t) = 10\,e^{-t} - 10\,e^{-(t-1)}$$

$$= 10\,e^{-t}(1-e)$$

Q. 2. (b) Given $F(s) = \dfrac{s+1}{(s+2)(s+3)}$. Find Initial value and Final Value of the function. **(5)**

Ans. Initial Value Theorem $\lim_{s\to\infty} sF(s)$

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

$$= \lim_{s\to\infty} \frac{\cancel{s^2}\left(1+\frac{1}{s}\right)}{\cancel{s^2}\left(1+\frac{2}{s}\right)\left(1+\frac{3}{s}\right)} = \frac{1}{1\times 1} = 1$$

Final Value Theorem $= \lim_{s\to 0} sF(s)$

$$= \lim_{s\to 0} \frac{s(s+1)}{(s+2)(s+2)} = 0$$

Q.3. (a) Calculate Laplace Transform of periodic function as shown in figure 2. (5)

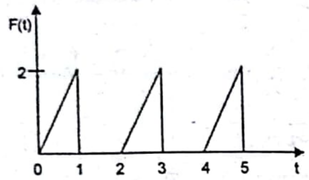
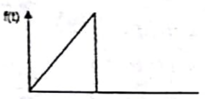


Fig. 2

Ans.



$$f(t) = t[u(t) - u(t) - 1] = t\,u(t) - tu(t-1)$$

taking LT

$$F(s) = \frac{1}{s^2} - LT[(t-1)u(t-1)] - LT[u(t-1)]$$

$$= \frac{1}{s^2} - \frac{e^{-s}}{s^2} - \frac{e^{-s}}{s}$$

$$LT \text{ of } F(t) = \frac{1}{1-e^{-2s}}\left(\frac{1}{s^2} - \frac{e^{-s}}{s^2} - \frac{e^{-s}}{s}\right)$$

Q.3. (b) In the circuit of figure 3 switch S_1 is closed at $t \infty 0$ and switch S_2 is open at $t \infty 0.2$ second. Find the expression for the transient current for two intervals. (5)

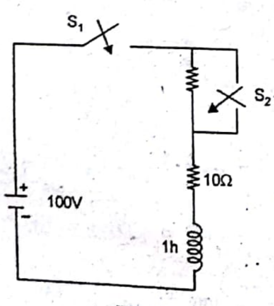
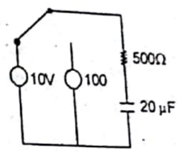


Fig. 3

Ans.



$$100 = 20\,i + L\frac{di}{dt}$$

$$100 = 20i + \frac{di}{dt}$$

$$Cf = Ae^{-20t}$$

$$PI = \frac{100}{D+20} = \frac{\cancel{100}^{5}}{\cancel{20}} = 5$$

$$i(t) = Ae^{-20t} + 5$$

at $t = 0$ $i = 0$ because inductor work as open ckt

$$A = -5$$

$$i(t) = 5(1-e^{-20t})$$

$$t = .2s \text{ at } i = 5(1-e^{-.2\times 20}) = 5(1-e^{-4})$$

When S_2 is open

$$100 = 10i + L\frac{di}{dt}$$

$$CF = Be^{-10t}$$

$$PI = \frac{100}{D+10} = 10$$

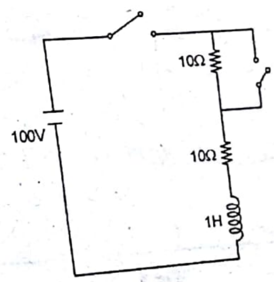
$$i(t) = Be^{-10t} + 10$$

at $t = 0,\ i = 5(1-e^{-4})$

$$5(1-e^{-4}) = B + 10 \Rightarrow B = -10 + 5 - 5e^{-4}$$

$$= -4.9$$

$$i(t) = -4.9\,e^{-10t} + 10$$



When both switch is on 1st 10 Ω is by passed

So KVL eqn is

$$100 = 10i + 1\frac{di}{dt}$$

$$CF = Ae^{-10t}$$

$$PI = \frac{100}{10} = 10$$

$$i(t) = Ae^{-10t} + 10$$

at $t = 0; i = 0$

$$0 = Ae^{-10\times 0} + 10 \Rightarrow A = -10$$

$$i(t) = 10(1 - e^{-10t})$$

at $t = .2S$

$$i = 10(1 - e^{-10\times .2})$$

$$= 10(1 - e^{-2})$$

$$= 8.64$$

When S_1 is off

then Applying on *KVL* on loop we get

$$100 = 20i + \frac{di}{dt}$$

$$CF = Be^{-20t}$$

$$PI = \frac{100}{20} = 5$$

$$i(t) = 5 + Be^{-20t}$$

at $t = 0.05 \quad i(t) = 8.64$

$$8.64 = 5 + Be^{o} \Rightarrow B = 8.64 - 5 = 3.64$$

$$i(t) = 5 + 3.64\,e^{-20t}$$

at $t = oos\ i(t) = 8.64 - 5 = 3.64$

$$i(t) = 5 + 3.64\,e^{-20t}$$

Q.4. (*a*) Find the time at which D.C. Source deliver a current of 500 Amp in below circuit as shown in figure 4 after closing the switch *K* at *t* = 0 sec. (5)

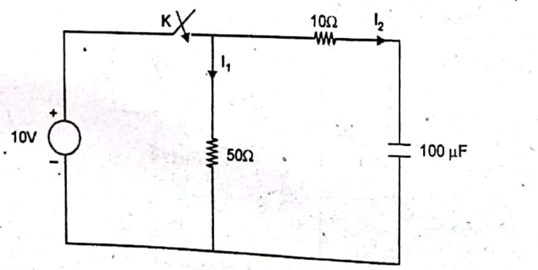


Fig. 4

Ans.

$$I_1 = \frac{10}{50} = .2\text{A} = 200 \text{ mA}$$

$$I = 500 \text{ mA}$$

$I = I_1 + I_2$

$$\Rightarrow 500 = 200 + I_2$$

$$I_2 = 300 \text{ mA}$$

$$I_2 = \frac{V}{R}e^{-t/T}$$

$$0.3 = \frac{10}{70}e^{-\frac{t}{RC}} = \frac{10}{70}e^{-\frac{t}{.007}}$$

$$-\frac{t}{0.007} = \log_e(2.1) = t = 5.2 \text{ ms.}$$

Q.4. (*b*) In the circuit of figure 5 the switch *S* is closed on position. In *t* ∞ *O* nd after one time constant is moved to position 2. Find the current before and fter moving to position 2. Assuming all initial conditions are zero. (5)

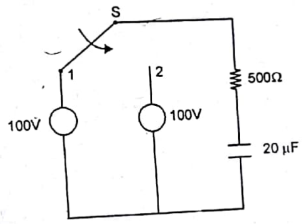


Fig. 5

Ans. Applying *KVL* $100 = 500\,i + \frac{1}{20\mu F}\int i\,dt$

On differentiating above eqn

$$0 = 500\frac{di}{dt} + \frac{1}{20\times 10^{-6}}i$$

$$\frac{di}{dt} + 100i = 0$$

$$i(t) = Ke^{-100t}$$

at $t = 0 \quad i = \frac{100}{500} = .2\text{A}$

$$K = .2$$

$$i(t) = 0.2e^{-100}t$$

time constant $T = RC = 500 \times 20 \times 10^{-6}$

$$= 10^{-2}$$

$$i(t) = 2e^{-100\times 10^{-2}} = \frac{.2}{e} = .074\,A$$

$$V_C = 100\,(1-e^{-1}) = 63.7\text{ V}$$

When switch move to position 2

$$100 = 500\,i + \frac{1}{20\times 10^{-6}}\int i\,dt$$

On differentiating we get

$$\frac{dI}{dt} + 100i = 0$$

$$i(t) = Ke^{-100t}$$

$$V = \frac{1}{C}\int i\,dt = \frac{1}{20\times 10^{-6}}\int Ke^{-100t}dt$$

$$= -\frac{K}{20\times 10^{-6}\times 100}e^{-100t}$$

$$V_C = -500\,Ke^{-100t}$$

at $t = 0\ V_C = 63.7V$

$$63.7 = 500\,Ke^{\circ} \Rightarrow K = -\frac{63.7}{500}$$

$$i(t) = -\frac{63.7}{500}e^{-100t}.$$

END TERM EXAMINATION [DEC. 2017]
THIRD SEMESTER [B.TECH]
CIRCUITS AND SYSTEMS
[ETEE-207]

Time : 3 hrs. **M.M. : 75**

Note: *Attempt any five questions including Q.No. 1 which is compulsory.*

Q.1. (*a*) What are even and odd signals? Give examples. **(2)**

Ans. If

$x(-t) = x(t)$ then signal is even

$x(-t) = -x(t)$ then signal is odd

Q.1. (*b*) What are energy and power signal? Discuss. **(2)**

Ans. A signal is power signal if Average power of a system is finite and energy is infinite.

A signal is energy signal if total energy of the signal is finite and power is zero.

Q.1. (c) What is the relation between unit step function and ramp function? **(4)**

Ans.

$$r(t) = t[u(t)]$$

$$u(t) \xrightarrow{\int} r(t)$$

Q.1. (*d*) Give the classification of filters. **(4)**

Ans. Classification of filter:

1. Low pass filter
2. High pass filter
3. Band pass filter
4. Band stop filter

Q.1. (*e*) What are the characteristics of Hurwitz polynomial? Discuss. **(4)**

Ans. 1. The coefficients of the s terms must be +ve.

2. Both odd and even part of the polynomial have roots on the imaginery axis.

3. The continued fraction expansion of the ratio of even to odd parts of hurwitz polynomial gives all *+ve* quotient terms.

4. If $P(s)$ is a Hurwitz polynomial and $W(S)$ is a even multiplicative factor the $P_1(s) = W(S)\,P(S)$ is also a Hurwitz polynomial.

Q.1. (*f*) Define tree, twigs, links and loop. **(4)**

Ans. Tree: It is an inter connected open set of branches which include all the nodes of the given graph. In a Tree of the graph there cannot be any closed loop.

Twig : The branch involved in tree is known as Twig.

Link: It is that branch of graph that does not belongs to the particular tree.

Loop: This is closed contour selected in a graph.

Q.1. (*g*) Write a short note on h-parameters. **(5)**

Ans.

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

$$I_2 = h_{21}I_1 + h_{22}V_2$$

$$h_{11} = \left.\frac{V_1}{V_2}\right|_{V_1=0} \qquad h_{21} = \left.\frac{V_2}{V_1}\right|_{V_2=0} \qquad h_{12} = \left.\frac{I_1}{V_2}\right|_{I_1=0} \qquad h_{22} = \left.\frac{I_2}{V_2}\right|_{I_1=0}$$

Q.2. (a) Determine whether the system described by the differential equation $\frac{dy(t)}{dt} + y(t) + 4 = x(t)$ is linear. **(6)**

Ans.
$$\frac{dy(t)}{dt} + y(t) + 4 = x(t)$$

Let a input $x_1(t)$ and corresponding output is $y_1(t)$.

$$\frac{dy_1(t)}{dt} + y_1(t) + 4 = x_1(t)$$

Similarly Input $x_2(t)$ and output $y_2(t)$.

$$\frac{dy_2(t)}{dt} + y_2(t) + 4 = x_2(t)$$

Linear combination of them

$$a\frac{dy_1(t)}{dt} + ay_1(t) + 4a + b\frac{dy_2(t)}{dt} + by_2(t) + 4b = ax_1(t) + bx_2(t)$$

$\frac{d}{dt}[ay_1(t) + by_2(t)] + [ay_1(t) + b\,y_2(t)] + 4[a+b] = ax_1(t) + bx_2(t)$ is not in the linear combination

So system is non linear.

Q.2. (b) A Cosine wave $\cos\omega t$ is applied as input to the series RL circuit as shown in fig-1. Find the resultant current $I(t)$ if the switch "S" in closed at $t = 0$. **(6.5)**

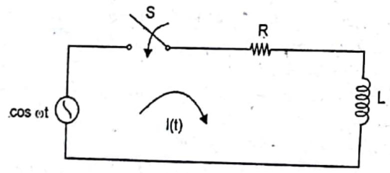


Fig. 1

Ans.
$$\cos\omega t = IR + L\frac{dI}{dt}$$

$$\frac{1}{L}\cos\omega t = \frac{R}{L}I + \frac{dI}{dt}$$

$$D + \frac{R}{L} = 0 \Rightarrow D = -\frac{R}{L}$$

$$CF = e^{-\frac{R}{L}t}$$

$$PI = \frac{1}{L}\frac{\cos\omega t}{\left(D + \frac{R}{L}\right)}\frac{(D - R/L)}{\left(D - \frac{R}{L}\right)}$$

$$= \frac{1}{L}\frac{D\cos\omega t - \frac{R}{L}\cos\omega t}{D^2 - \left(\frac{R}{L}\right)^2}$$

$$= \frac{1}{L} \times \frac{1}{-\omega^2 - \left(\frac{R}{L}\right)^2}\left[-\omega\sin\omega t + \frac{R}{L}\cos\omega t\right]$$

$$i(t) = Ae^{\frac{-R}{L}t} - \frac{1}{L\left(\omega^2 + \frac{R_2}{L^2}\right)}\left[-\omega\sin\omega t + \frac{R}{L}\cos\omega t\right]$$

Initially inductor work as open circuit. So at $t = 0 \quad i = 0$

$$0 = A - \frac{R}{L}\frac{1}{L\left(\omega^2 + \frac{R^2}{L^2}\right)} \Rightarrow A - \frac{R}{L^2\omega^2 + R^2} = 0$$

$$A = \frac{R}{L^2\omega^2 + R^2}$$

Q.3. (a) A system has a transfer function given by $H(s) = \frac{1}{(s+1)(s^2+s+1)}$. Find the response of the system when the excitation is $x(t) = (1 + e^{-3t} - e^{-t})u(t)$. **(6.5)**

Ans.
$$x(t) = (1 + e^{-3t} - e^{-t})\,u(t)$$

taking LT

$$X(s) = \frac{1}{s} + \frac{1}{s+3} - \frac{1}{s+1} = \frac{s^2 + 4s + 3 + \cancel{s^2} + s - \cancel{s^2} - 3s}{s(s+3)(s+1)}$$

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

$$Y(s) = \frac{1}{(s+1)(s^2+s+1)} \times \frac{s^2 + 2s + 3}{s(s+3)(s+1)}$$

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

Using partial fraction we can write it

$$\frac{A}{s}+\frac{B}{s+3}+\frac{C}{s+1}+\frac{D}{(s+1)^2}+\frac{Ps}{s^2+s+1}$$

$$A=\frac{s^2+2s+3}{\cancel{s}(s+1)^2(s+3)(s^2+s+1)}\times\cancel{s}\Big|_{s=0}=\frac{3}{3}=1$$

$$B=\frac{s^2+2s+3}{s(s+1)^2\cancel{(s+3)}(s^2+s+1)}\times\cancel{s+3}\Big|_{s=-3}=\frac{9-6+3}{-3\times4\times(9-3+1)}=\frac{6}{-12\times7}=-\frac{1}{14}$$

$$D=\frac{s^2+2s+3}{s\cancel{(s+1)}^2(s+3)(s^2+s+1)}\times\cancel{(s+1)^2}\Big|_{s=-1}=\frac{2}{-1\times2\times1}=-1$$

C and also find P

$$\boxed{\begin{aligned}&\frac{Ps}{s^2+s+1}\\&=P\frac{s}{s^2+2\frac{1}{2}s+\left(\frac{1}{2}\right)^2+\frac{5}{4}}\\&=\frac{P\left(s+\frac{1}{2}\right)}{\left(s+\frac{1}{2}\right)^2+\frac{5}{4}}-P\frac{e\frac{1}{2}}{\left(s+\frac{1}{2}\right)^2+\frac{5}{4}}\\&=P\left[e^{-\frac{1}{2}t}\cos\frac{\sqrt{5}}{2}t-\frac{1}{2}e^{-\frac{1}{2}t}\sin\frac{\sqrt{5}}{2}t\right]\end{aligned}}$$

$$\frac{1}{s}+-\frac{1}{14(s+3)}+\frac{-1}{(s+1)^2}+\frac{C}{s+1}+\frac{Ps}{s^2+s+1}$$

$$u(t)-\frac{1}{14}e^{-3t}-t\,e^{-t}+c\,e^{-t}+P\left[e^{-\frac{1}{2}t}\cos\frac{\sqrt{5}}{2}t-\frac{1}{2}e^{-\frac{1}{2}t}\sin\frac{\sqrt{5}}{2}t\right]$$

Q.3. (b) Determine the frequency response, magnitude response, and phase response and time delay of the system given by $y(n)+\frac{1}{2}y(n-1)=x(n)-x(n-1)$. **(6)**

Ans. $Y(n)+\frac{1}{2}y(n-1)=x[n]-x[n-1]$

Taking FT

$$Y(jw)+\frac{1}{2}(jw)Y(jw)=X(jw)-jw\,X(jw)$$

$$H(jw)=\frac{Y(jw)}{X(jw)}=\frac{1-jw}{1+\frac{1}{2}jw}$$

$$=\frac{2(1-jw)\times(2-jw)}{(2+jw)\times(2-jw)}$$

$$=\frac{2\{2-3jw-w^2\}}{4+w^2}=\frac{2(2-w^2)}{4+w^2}-\frac{6jw}{4+w^2}$$

$$|H(jw)|=\sqrt{\left(\frac{2(2-w)^2}{4+w^2}\right)^2+\left(\frac{6jw}{4+w^2}\right)^2}=\frac{1}{(4+w)^2}\sqrt{4(4+w^4-4w^2)+36j^2w^2}$$

$$=\frac{1}{4+w^2}\sqrt{16+4w^4-16w^2-36w^2}=\frac{4}{4+w^2}\sqrt{4+w^4-13w^2}$$

$$\angle H(jw)=\tan^{-1}\frac{-6w}{2(2-w^2)}=\tan^{-1}\left(\frac{-3w}{2-w^2}\right)$$

Q.4. (a) A sine wave Sin ωt is applied as the input to the series RC circuit shown in fig.2. Find the resultant current $i(t)$ if switch S is closed at $t=0$. **(6.5)**

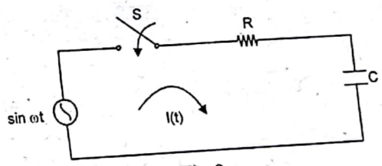


Fig. 2

Ans.

$$IR+\frac{1}{C}\int i\,dt=\sin\omega t$$

$$R\frac{di}{dt}+\frac{i}{c}=w\cos\omega t$$

$$\frac{di}{dt}+\frac{i}{RC}=\frac{\omega}{R}\cos\omega t$$

$$D+\frac{1}{RC}=0\Rightarrow D=-\frac{1}{RC}$$

$$CF = A\,e^{-\frac{1}{Rc}t}$$

$$PI = \frac{\frac{\omega}{R}\cos\omega t\left(D-\frac{1}{RC}\right)}{\left(D+\frac{1}{RC}\right)\left(D-\frac{1}{RC}\right)} = \frac{\omega}{R}\frac{\left[D(\cos\omega t)-\frac{1}{C}\cos\omega t\right]}{D^2-\left(\frac{1}{RC}\right)^2}$$

$$\frac{\frac{\omega}{R}\left[-\omega\sin\omega t-\frac{1}{RC}\cos\omega t\right]}{-\omega^2-\left(\frac{1}{RC}\right)^2}$$

$$= \frac{\left(\frac{\omega}{R}^2\sin\omega t+\frac{\omega}{R^2C}^2\cos\omega t\right)}{\omega^2+\left(\frac{1}{RC}\right)^2}$$

$$i(t) = A\,e^{-\frac{1}{RC}t} + \frac{\omega}{R\left[\omega^2+\left(\frac{1}{RC}\right)^2\right]}\times\left[\omega\sin\omega t+\frac{1}{RC}\cos\omega t\right]$$

Q. 4. (b) Find the laplace transform of the triangular pulse shown. **(6)**

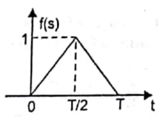


Fig. 3

Ans. $$f(t) = \frac{2}{T}t\left[u(t)-u\left(t-\frac{T}{2}\right)\right]+2\left(1-\frac{t}{T}\right)\left[u\left(t-\frac{T}{2}\right)-4(t-T)\right]$$

$$= \frac{2}{T}\left[t\,u(t)-t\,u\left(t-\frac{T}{2}\right)\right]+\frac{2}{T}(T-t)\left[4\left(t-\frac{T}{2}\right)-u(t-T)\right]$$

$$t\,u(t) \to \frac{1}{s^2}$$

$$t\,u\left(t-\frac{T}{2}\right) = \left(t-\frac{T}{2}\right)u\left(t-\frac{T}{2}\right)+\frac{T}{2}u(t-T/2)$$

$$\xrightarrow{LT} \frac{e^{-\frac{T}{2}s}}{s^2}+\frac{T}{2}\frac{e^{-T/2s}}{s}$$

$$(t-T)\,u\,(t-T) \to \frac{e^{-Ts}}{s^2}$$

$$(t-T)\,u(t-\frac{T}{2})$$

$$\left(t-\frac{T}{2}\right)u\left(t-\frac{T}{2}\right)-\frac{T}{2}u\left(t-\frac{T}{2}\right)$$

$$\Rightarrow \quad \frac{e^{-T/2\,s}}{s^2}-\frac{T}{2}\frac{e^{-1/2s}}{s}$$

$$f(t)\xrightarrow{LT}\frac{2}{T}\left[\frac{1}{s^2}-\frac{e^{-sT/2}}{s^2}-\frac{T}{2}\frac{e^{-sT/2}}{s}\right]$$

$$-\frac{2}{T}\left[\frac{e^{-T/2s}}{s}-\frac{T}{2}\frac{e^{-T/2}}{s}-\frac{e^{-sT}}{s^2}\right]$$

Q.5.(a) Consider *R-L* circuit with $R = 4\Omega$ $L = 1H$ excited by 20 *V* dc source as shown in fig 4. Assume the initial value of current in inductor is 2*A*. Using Laplace Transform determine the current *I*(*t*). Also draw the s-domain representation of the circuit. **(6.5)**

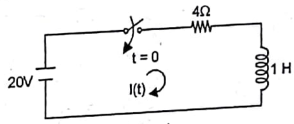


Fig. 4

Ans. Applying KVL in loop

$$I\times 4+1\frac{dI}{dt} = 20$$

taking LT we get

$$4I(s)+sI(s)-i(0^+) = \frac{20}{s}$$

$$4I(s)+sI(s) = \frac{20}{s}+i(0^+)$$

$$I(s)\,(4+s) = \frac{20}{s}+2 = \frac{20+2s}{20}$$

$$I(s) = \frac{s+10}{10(s+4)} = \frac{1}{10}\frac{s+4+6}{s+4} \quad \text{given } i(0) = 2A$$

$$= \frac{1}{10}\left[1+\frac{6}{s+4}\right]$$

taking *ILT*

$$L(t) = \frac{1}{10}\delta(t) + \frac{6}{10}e^{-4t}$$

Q. 5. (b) State and explain the laplace transform and its inverse transform. (6)

Ans. LT is a mathematical tool which transform a time domain signal into frequency (s) domain signal.

$$X(s) = \int_{-\infty}^{\infty} x(t)e^{-st}\,dt$$

Inverse LT is just inverse process of laplace transform

$$X(t) = \frac{1}{2\pi}\int X(s)\,e^{+1st}\,ds$$

To represent the laplace and inverse transform we use following notation

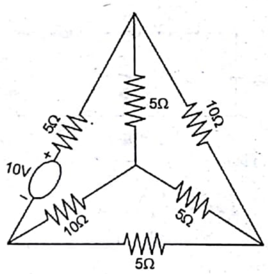
$$x(t) \to X(s)$$

$$L[x(t)] = X(s)$$

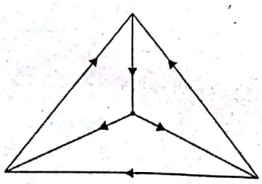
and $$L^{-1}[X(s)] = x(t)$$

Where $X(s)$ is Laplace transform of $x(t)$ and $x(t)$ is inverse laplace transform of $X(s)$.

Q.6. (a) For the network shown write the tieset matrix and determine the loop current and branch currents. (6.5)

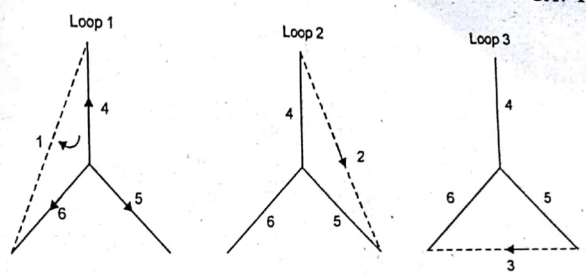


Ans.



Oriented graph of the given circuit.

We select tree (4, 5, 6) and link (1, 2, 3)



$$B_f = \begin{array}{c|cccccc} & 4 & 5 & 6 & 1 & 2 & 3 \\ \hline 1 & -1 & 0 & 1 & 1 & 0 & 0 \\ 2 & 1 & -1 & 0 & 0 & 1 & 0 \\ 3 & 0 & 1 & -1 & 0 & 0 & 1 \end{array}$$

$$Z_b = \begin{vmatrix} 5 & 0 & 0 & 0 & 0 & 0 \\ 0 & 10 & 0 & 0 & 0 & 0 \\ 0 & 0 & 5 & 0 & 0 & 0 \\ 0 & 0 & 0 & 5 & 0 & 0 \\ 0 & 0 & 0 & 0 & 5 & 0 \\ 0 & 0 & 0 & 0 & 0 & 10 \end{vmatrix}$$

$$Z_i = B_f Z_b B_f^T \quad \& \quad V_i = Z_i T_l$$

$$I_b = [B_f]^T I_l - I_S$$

$$B_f Z_b = \begin{bmatrix} -5 & 0 & 5 & 5 & 0 & 0 \\ 5 & -10 & 0 & 0 & 5 & 0 \\ 0 & 10 & -5 & 0 & 0 & 10 \end{bmatrix}$$

$$B_f Z_b B_f^T = \begin{bmatrix} -5 & 0 & 5 & 5 & 0 & 0 \\ 5 & -10 & 0 & 0 & 5 & 0 \\ 0 & 10 & -5 & 0 & 0 & 10 \end{bmatrix} \begin{bmatrix} -1 & 1 & 0 \\ 0 & -1 & 1 \\ 1 & 0 & -1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Q.6. (b) Find the transmission parameter in terms if y and z parameters. (6)

Ans.

$$V_1 = Z_{11}I_1 + Z_{12}I_2$$

$$V_2 = Z_{21}I_1 + Z_{22}I_2$$

$$I_1 = \frac{1}{Z_{21}}V_2 + \frac{Z_{22}}{Z_{21}}(-I_2)$$

$$C = \frac{1}{Z_{21}} \text{ and } D = \frac{Z_{22}}{Z_{21}}$$

$$V_1 = Z_{11}\left[\frac{1}{Z_{21}}V_2 + \frac{Z_{22}}{Z_{21}}\right](-I_2)\Big] + Z_{12}I_2$$

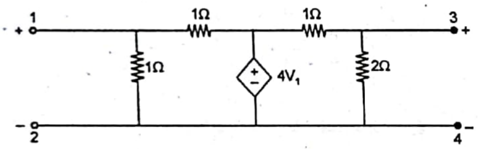
$$= \frac{(Z_{11})}{Z_{21}}V_2 + \left(\frac{Z_{11}Z_{22}}{Z_{21}} - Z_{12}\right)(-I_2)$$

$$A = \left(\frac{Z_{11}}{Z_{21}}\right) \quad B = \frac{\Delta Z}{Z_{21}}$$

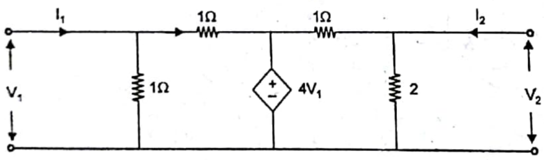
Similarly $$A = -\frac{Y_{22}}{Y_{21}} \quad B = -\frac{1}{y_{21}}$$

$$C = -\frac{\Delta Y}{Y_{21}} \quad D = -\frac{Y_{11}}{Y_{21}}$$

Q.7. (a) Determine z parameter of the networks shown. **(6.5)**



Ans.



$$I_1 = \frac{V_1}{1} + \frac{V_1 - 4V_1}{1}$$

$$I_2 = \frac{V_2}{2} + \frac{V_2 - 4V_1}{1}$$

$$I_1 = -2V_1 \Rightarrow V_1 = -\frac{I_1}{2}$$

$$I_2 = -4V_1 + \frac{3V_2}{2}$$

Putting the value of V_1 in above equation

$$\frac{3}{2}V_2 = I_2 - \frac{4I_1}{2}$$

$$V_2 = -\frac{2}{3} \times \frac{4}{2}I_1 + \frac{2}{3}I_2$$

$$V_2 = \frac{-4}{3}I_1 + \frac{2}{3}I_2$$

$$Z_{11} = -\frac{1}{2} \quad Z_{12} = 0$$

$$Z_{21} = \frac{-4}{3} \quad Z_{22} = \frac{2}{3}$$

Q.7. (b) Discuss the necessary conditions for transfer functions. **(6)**

Ans.

1. The coefficients in the polynomials N(s) and $D(s)$ of $T = N/D$ must be real and those for $D(s)$ must be positive.

2. Poles and zeroes must be conjugate if imaginary or complex.

3. The real part of poles must be negative or zero, if the real part is zero, then that pole must be simple. This includes the origin.

4. The polynomial $D(s)$ may not have any missing term between that of highest and lowest, degrees, unless all even or all odd terms are missing.

5. The polynomial N(s) may have terms missing, and some of the coefficients may be negative.

6. The degree of N(s) may be as small as zero independent of the degree of D(s).

7. (a) for G and a : The maximum degree of N(s) is equal to the degree of D(s). (b) For Z and Y : The maximum degree of N(s) is equal to the degree of D(s) plus one.

Q.8. (a) Using the foster I Form synthesize the impedence function. **(6.5)**

$$z(s) = \frac{8(s^2+1)(s^2+3)}{S(s^2+2)(s^2+4)}$$

Ans.

$$Z(s) = \frac{8(s^2+1)(s^2+3)}{s(s^2+2)(s^2+4)}$$

$$\frac{A_0}{s} + \frac{2A_1 s}{s^2+2} + \frac{2A_2 s}{s^2+4}$$

$$A_0 = \left.\frac{8(s^2+1)(s^2+3)}{(s^2+2)(s^2+4)}\right|_{s=0} = 3$$

$$A_1 = \left.\frac{8(s^2+1)(s^2+3)}{(s^2-j\sqrt{2})(s^2+4)}\right|_{s=-j\sqrt{2}} = 1$$

$$A_2 = \left.\frac{8(s^2+1)(s^2+3)}{s(s^2+2)(s-j\sqrt{2})}\right|_{s=-j2}$$

$$\frac{3}{5}+\frac{2s}{s^2+2}+\frac{3s}{s^2+4}$$

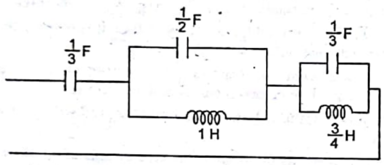
$$C_o = \frac{1}{3}F$$

$$C_1 = \frac{1}{2\times 1}=\frac{1}{2}F$$

$$L_1 = \frac{2}{(\sqrt{2})^2}=1H$$

$$C_2 = \frac{1}{2\times 1.5}=\frac{1}{3}$$

$$L_2 = \frac{2\times 1.5}{4}=\frac{3}{4}H$$



Q. 8. (b) Using the foster II form synthesize the function **(6)**

$$Y(s) = \frac{s(s^2+4)(s^2+6)}{(s^2+3)(s^2+5)},$$

Ans. Foster *II*

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

$$= \frac{2B_1 s}{s^2+1}+\frac{2B_2 s}{s^2+3}+C_3$$

$$B_1 = \frac{1}{8}\left.\frac{s(s^2+2)(s^2+4)}{(s-1)(s^2+3)}\right|_{s=-j1} = \frac{3}{32}$$

$$B_2 = \frac{1}{8}\left.\frac{(s^2+2)(s^2+4)}{(s^2+1)(s-1\sqrt{3})}\right|_{S=-j\sqrt{3}} = \frac{1}{32}$$

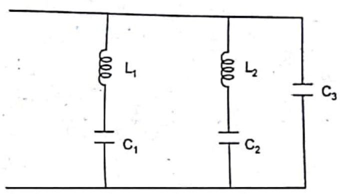
$$L_1 = \frac{1}{2}\times\frac{32}{3}=\frac{16}{3}$$

$$L_2 = \frac{1}{2}\times 32 = 16\ H$$

$$C_1 = \frac{2\times\frac{3}{32}}{1}=\frac{3}{16}F$$

$$C_2 = \frac{2\times\frac{1}{32}}{3}=\frac{1}{48}F$$

$$C_3 = \frac{1}{8}F$$



Q.9. (a) A series LCR type band pass filter has L = 50 mH C = 130 nF and RF = 80Ω. **(6.5)**

Determine

***(i)* frequency of resonance**

***(ii)* bandwidth**

***(iii)* cutoff frequency**

Ans. (*a*) For *RLC* Band pass filter

$$f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{50\times10^{-3}\times130\times10^{-9}}}$$

$$= 1.97\times10^3$$

$$Q = \frac{W_r L}{R} = \frac{\frac{1}{\sqrt{LC}}\times L}{R} = \frac{\sqrt{L/C}}{R} = \frac{\sqrt{\frac{50\times10^{-3}}{130\times10^{-9}}}}{80}$$

$$\frac{620}{80} = 7.75$$

$$BW = \frac{f_r}{Q} = \frac{1.97\times10^3}{7.75} = 254.2$$

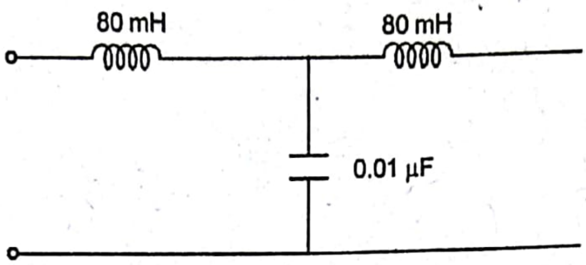
$$f_1 = f_r - \frac{BW}{2} = 1970-147$$

$$= 1823$$

$$f_2 = f_r + \frac{BW}{2} = 1970+147$$

$$= 2117$$

Q. 9. (b) For the T-section find cutoff frequency and nominal characteristics impedance R_o. **(6)**



Ans.

$$W_C = \sqrt{\frac{4}{LC}}$$

$$= \sqrt{\frac{4}{80 \times 2 \times 10^{-3} \times 0.01 \times 10^{-6}}}$$

$$= \sqrt{\frac{4}{1.6 \times 10^{-9}}}$$

$$= 50000 = 50 \text{ KHz}$$

$$R_o = \sqrt{\frac{L}{C}} = \sqrt{\frac{160 \times 10^{-3+1}}{.1 \times 10^{-6-2}}} = 4 \times 10^3$$

$$= 4000$$

$$Z_{OT} = R_O \sqrt{1 - \left(\frac{f_e}{f_c}\right)^2}$$