SYLLABUS

CIRCUITS AND SYSTEMS (EEC-213/EEC-208)

Applicable from the Academic Session 2021-22

Marking Scheme:

1. Teachers Continuous Evaluation: 25 marks
2. Term end Theory Examinations: 75 marks

Instructions for paper setter:

1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory add cover the entire syllabus. This question should be objective, single line answers or short answer type question of total 15 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall havel a marks weightage of 15.

UNIT I

Signals, Classification of Signals, Systems, Classification of Systems, Linear Time Invariant (LTI) Systems; Laplace Transform, z-Transform, Fourier Series and Transform (Continuous and Discrete) and their properties. Laplace Transform and Continuous Time LTI systems, z-Transform and Discrete Time LTI systems, Fourier analysis of signals and systems, State Space Analysis. **[T1]**

UNIT II

System modeling in terms of differential equations and transient response of R, L, C, series and parallel circuits for impulse, step, ramp, sinusoidal and exponential signals by classical method and using Laplace transform. **[T2]**

UNIT III

AC Circuits: Circuits containing Capacitors and Inductors, Transient Response, Alternating Current and Voltages, Phasors, Impedances and Admittance, Mesh Analysis, Loop Analysis, Nodal Analysis, Thevenin's and Norton's Theorem, Y - D and D-Y Transformation, Bridge Circuits. Resonant Circuits, Complex Frequency and Network Function, Two port Networks. Passive Filters. **[T3]**

UNIT IV

Graph theory: Concept of tree, tie set matrix, cut set matrix and application to solve electric networks-Two port networks - Introduction of two port parameters and their interconversion, interconnection of two 2-port networks, open circuit and short circuit impedances and ABCD constants, relation between image impedances and short circuit and open circuit impedances. Network functions, their properties and concept of transform impedance, Hurwitz polynomial. **[T2]**

SYLLABUS
(ACADEMIC SESSION 2014-15)

CIRCUIT & SYSTEMS (ETEE-207)

Maximum Marks: 7

INSTRUCTIONS TO PAPER SETTERS

1. Question No. 1 should be compulsory and cover the entire syllabus. This questio should have objective or short answer type questions. It should be of 25 marks.

2. Apart from Question No. 1, the rest of the paper shall consist of four units as per th syllabus. Every unit should have two questions. However, the student may be asked to attemp only 1 question from each unit. Each question should be 12.5 marks.

UNIT-I

Introduction to signals, their classification and types, different types of systems, LTI systen and their properties, periodic waveforms and signal synthesis, properties and applications Laplace transform of complex waveform.

[T1,T2][No. of Hours: 1

UNIT-II

System modeling in terms of differential equations and transient response of R, L, C, seri and parallel circuits for impulse, step, ramp, sinusoidal and exponential signals by classic method and using Laplace transform.

[T1,T2][No. of Hours: 1

UNIT-III

Graph theory: concept of tree, tie set matrix, cut set matrix and application to solve elect networks.

Two port networks – Introduction of two port parameters and their interconversi interconnection of two 2-port networks, open circuit and short circuit impedances and AB constants relation between image impedances and short circuit and open circuit impedanc Network functions, their properties and concept of transform impedance, Hurwitz polynom

[T1,T2][No. of Hours:

UNIT-IV

Positive real function and synthesis of LC, RC, RL Networks in Foster's I and II, Cauer's II forms, Introduction of passive filter and their classification, frequency response, characteri impedance of low pass, high pass, Band Pass and Band reject prototype section.

[T1,T2][No. of Hours:

NEW TOPICS ADDED FROM ACADEMIC SESSION (2021-22)

Q.1 State and explain Norton theorem. **(IPU-2014)**

Ans. Statement: "Any two terminal, linear, bilateral network can be replaced by an equivalent circuit conisting of a current source parallel with the resistance (impedance) seen from that terminals. The equivalent current source, I_N is the short circuit between the terminals and equivalent resistance, R_N, is the ratio of the open circuit voltage to the short circuit current at these terminals."

Explaination:

– Consider a netwoek of fig (a)

– Short circuit terminals AB: T to find out short circuited current

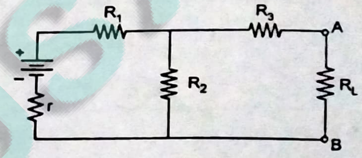


fig. (a)

I_{sc} (By replacing reistance R_L with a zero resistance thick wire) fig (b)

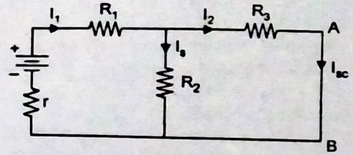


Fig. (b)

– Equivalent resistance of the fig. (c) network, $R_N = ((R_1 + r) \parallel R_2) + R_3$

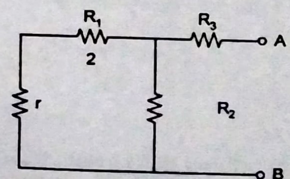


Fig. (c)

– Nortons equivalent circuit will be as per fig (*d*)

$$I_L = \frac{I_{sc} R_N}{R_N + R_L}$$

(applying current dimension in fig. (*d*)

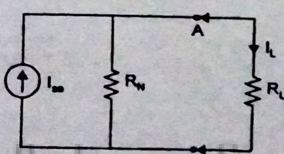
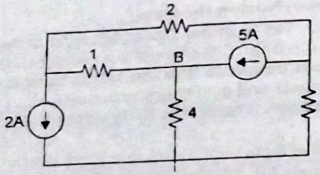
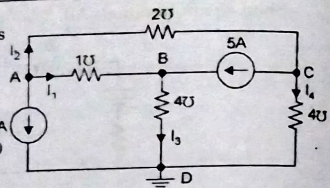


Fig. (d)

Q.2 Using the nodal analysis, find the different branch current in the circuit of figure shown. All Branch conductances are in Siemens. (6)(IPU-2014)



Ans. At node A, apply KCL/nodal analysis



$$2 + I_1 + I_2 = 0$$
$$\Rightarrow 2 + (V_A - V_B)1 + (V_A - V_C)2 = 0$$
$$\Rightarrow 2 + V_A - V_B + 2V_A - 2V_C = 0$$
$$\Rightarrow 2 + 3V_A - V_B - 2V_C = 0$$
$$\Rightarrow 3V_A - V_B - 2V_C = -2 \quad ...(1)$$

at node B, apply KCL/nodal analysis

$$I_1 + 5 = I_3$$
$$\Rightarrow (V_A - V_B)1 + 5 = V_B.4$$
$$\Rightarrow V_A - V_B + 5 = 4V_B$$
$$\Rightarrow V_A - V_B - 4V_B = -5$$
$$\Rightarrow V_A - 5V_B = -5 \quad (2)$$

at node C, apply KCL/nodal analysis

$$I_2 = 5 + I_4$$
$$\Rightarrow (V_A - V_C)2 = 5 + V_C.4$$
$$\Rightarrow 2V_A - 2V_C = 5 + 4V_C$$
$$\Rightarrow 2V_A - 2V_C - 4V_C = 5$$
$$\Rightarrow 2V_A - 6V_C = 5 \quad (3)$$

we solve equation (1), (2) & equation (3), then we get

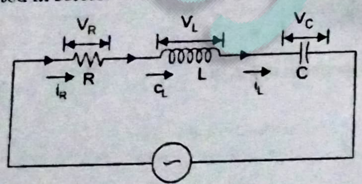
$$V_A = -5/4,\ V_B = 3/4,\ V_C = -5/4$$

$$I_1 = (V_A - V_B)1 = \left(-\frac{5}{4} - \frac{3}{4}\right)1 = \frac{-8}{4} = -2 \text{ Amp.} \quad I_3 = V_B 4 = \frac{3}{4} \times 4 = 3 \text{ amp}$$

$$I_2 = (V_A - V_C)2 = \left(-\frac{5}{4} - \left(-\frac{5}{4}\right)\right)2 = 0 \text{ Amp}; \quad I_4 = 4V_c = 4 \times \left(-\frac{5}{4}\right) = -5 \text{ amp Ans.}$$

Q.3 Discuss resonance the Series RLC circuits. How the resonant frequency is calculate. Give graphical representation of resonance. (IPU-2014)

Ans. Consider an ac circuit containing a resistance R, an inductance L and capacitance C connected in series. as shown in figure.



Impedance of the circuit

$$Z = \sqrt{R^2 + (x_L - x_c)^2} = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega c}\right)^2}$$

if for some frequency of applied voltage $x_L = x_c$ in magnitude then

(*i*) Net reactance is zero ie. $X = 0$ (*ii*) Impedance of the circuit $Z = R$

(*iii*) The current flowing through the circuit is maximum and in phase with the applied voltage. The magnitude of the current will be equal to V/R.

(*iv*) $\cos\phi = 1$

(*iv*) $I x_L = I x_c$

when the above condition exists, the circuit is said to be in resonace and the frequency at which it occurs is known as resonant frequency.

If resonant frequency is denoted by f_r

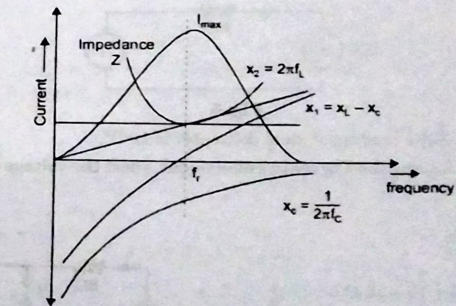
If, then

$$x_L = \omega L = 2\pi f_r L \qquad x_c = \frac{1}{2\pi f_r c}$$

$$x_L = x_c \Rightarrow \qquad 2\pi f_r L = \frac{1}{2\pi f_r c}$$

$$\Rightarrow \qquad f_r = \frac{1}{2\pi\sqrt{Lc}} \Rightarrow \omega_r = \frac{1}{\sqrt{Lc}}$$

graphical representation of resonance.



→ The circuit can be made resonant in two different ways namely,

(*i*) by varying L& C paramerer at a constant supply or frequency.

(*ii*) by varying the supply frequency & with Parameters L and C constant.

→ In the above graphical representation, Resistance R is independent of supply frequency, therefore, remains constant. It has been represented by a straight line. i.e. parallel to the X-axis.

$$\rightarrow \qquad x_L = \omega_L$$
$$\Rightarrow \qquad x_L = 2\pi f_r L$$
$$\Rightarrow \qquad f_r \propto x_L$$

Due $x_L \propto f_r$, so it is represented by a straight line passing through the origin. and it lies on the first quadrant. Similary

$$x_c = \frac{1}{2\pi f_r c}$$

$$x_c \propto (1/f_r).$$

→ So x_c inversely proprtional to the resonant frequency and it is represented by a rectangular hyperbola. It lies in the fourth quadrant.

→ The net reactance is the difference of inductive reactance x_L and capacitive reactance x_c and the curve drawn between the net reactance $(x_L - x_C)$ and frequency will be a hyperbola. The frequency at which the reactance curve crosses the frequency axis is called the resonant frequency. (f_r)

→ The impedance of the circuit, Z being equal to $\sqrt{R^2 + (x_L - x_c)^2}$ is minimum at resmant frequncy f_r.

→ At frequencies lower than resonant frequency f_r the impedance Z is large and capacitive as $x_C > x_L$ and the power factor is leading. and at frequencies higher than resonant frequency f_r, the impedance Z is large but $x_L > x_C$ and power factor is lagging. The power factor has the maximum value of unity at resonant frequency.

Q.4 (i) For a circuit shown in Fig. A, the reading of ideal voltmeter is.....

(ii) For a network in Fig. B, if we find the Thevenin's Equivalent Circuit at terminal X & Y then Thevenin's Voltage will be **(IPU-2015)**

Ans. (i)

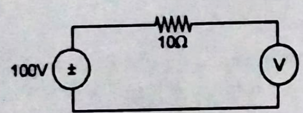


Fig. A

From the Fig. A the reading of ideal voltmeter is 100V.

Ans. (*ii*) For finding the Thevenin's equivalent, short the voltage source and open current source.

Now, $i_4 = \frac{V_0}{10}$

$R_{xy} = 5 + 10 = 15\,\Omega$

$6\,i_4 - 2V_o = 0$

$\frac{6V_0}{10} - 2V_0 = 0$

$6V_0 - 20\,V_0 = 0$

$\boxed{V_o = 0}$

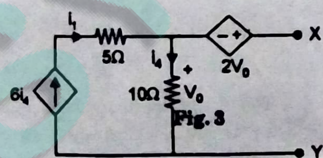


Fig. B

Because there is no independent source.

Q.5 For a series RL circuit shown in Fig A. Draw a phasor diagram showing all the electrical quantities (Voltage and Current) marked in the circuit. Also write the impedance of circuit in j notation. **(IPU-2015)**

Ans.

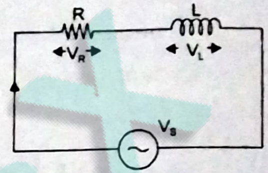
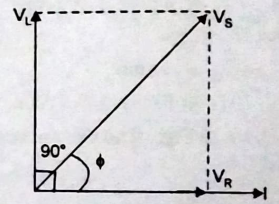


Fig. A

From the above circuit

$$V_s = \sqrt{V_R^2 + V_L^2} \quad ...(1)$$

Phasor diagram of RL circuit



and impedance of RL circuit is given by

$$\boxed{Z = R + jX_L} \quad ...(2)$$

Q.6 For a network shown in Fig. A, find all the marked mesh currents. **(IPU-2015)**

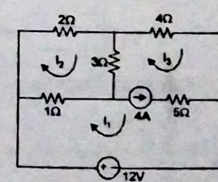


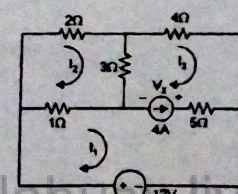
Fig. A

Ans

I_1 = ?

I_2 = ?

I_3 = ?



(Applying Mesh Analysis)

$$12 + V_z = 6I_1 - I_2 - 5I_3 \quad ...(1)$$
$$0 = -I_1 + 6I_2 - 3I_3 \quad ...(2)$$
$$-V_z = -5I_1 - 3I_2 + 12I_3 \quad ...(3)$$

Adding equation (1) to (3), we get

$$12 = I_1 - 4I_2 + 7I_3 \quad ...(4)$$

• The relation between the source current and mesh currents is given by

$$I_s = I_1 - I_3$$
$$4 = I_1 - I_3 \quad ...(5)$$

→ Now from equation (3), (4), (5) the value of I_1, I_2 and I_3 can be obtained.

→ Multiply equation (3) by 2, equation (4) by 3, and adding the results to eliminate I_2.

We get

$$I_1 + 15I_3 = 36 \quad ...(6)$$
$$I_1 - I_3 = 4 \quad ...(7)$$

• From above equation $I_1 = 6$ Amp, $I_3 = 2$ Amp

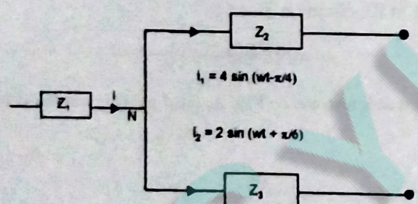
Put the value in equation (3), we get

$$I_2 = 2 \text{ Amp}$$

So, $I_1 = 6$ Amp, $I_2 = 2$ Amp, $I_3 = 2$ Amp **Ans.**

Q.7 For a network shown in Fig., find the current 'I' entering the node 'N'. Express 'I' in polar form. (IPU-2015)

Ans.



• From the above, 'I' is the phasor sum of currents

i.e. $I = i_1 + i_2$ ...(1)

• $I = 4 \sin (\omega t - \pi/4) + 2 \sin (\omega t + \pi/6)$

$$= 4 \sin \omega t . \cos \frac{\pi}{4} - 4 \cos \omega t \sin \frac{\pi}{4} + 2 \sin \omega t \cos \pi/6 + 2 \cos \omega t \sin \pi/6$$

$$= \frac{4}{\sqrt{2}} \sin \omega t - \frac{4}{\sqrt{2}} \cos \omega t + 2 . \frac{\sqrt{3}}{2} + 2 . \frac{1}{2} \cos \omega t$$

$$I = 4.560 \sin \omega t - 1.828 \cos \omega t \quad ...(2)$$

Standard form of equation is. $i = I_m \sin (\omega t + \alpha)$

$$i = (I_m \cos \alpha) \sin \omega t + (I_m \sin \alpha) \cos \omega t \quad ...(3)$$

By comparing, we find, $I_m \cos \alpha = 4.560$

$$I_m \sin \alpha = 1.828$$

• Squaring and adding these quantities we get

$$I_m^2 \cos^2 \alpha + I_m^2 \sin^2 \alpha = (4.560)^2 + (-1.828)^2$$
$$I_m^2 (\cos^2 \alpha + \sin^2 \alpha) = 20.79 + 3.34$$
$$I_m^2 = 24.13$$
$$\Rightarrow \quad I_m = 4.91 \text{ Amp.}$$
$$\Rightarrow \quad \frac{I_m \sin a}{I_m \cos a} = \frac{-1.828}{4.560} \Rightarrow \tan \alpha = -0.400$$
$$\boxed{a = -21.8^\circ}$$

⇒ Now standard current equation – $i = I_m \sin (\omega t + \alpha)$

⇒ $i = 4.91 \sin (\omega t - 21.8^\circ)$ **Ans.**

Q.8 Find the current through R_L in the network shown in Fig.A using Norton Theorem. (IPU-2015)

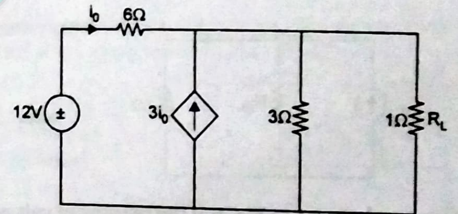
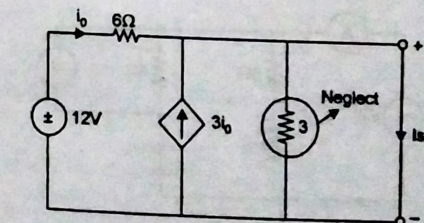


Fig.A

Ans. First remove R_L and short terminals



$$I_{sc} = 3i_0 + i_0 = 4i_0$$

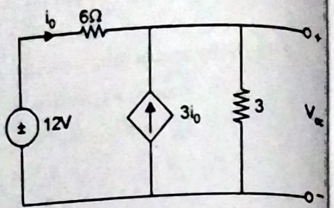
But

$$i_0 = \frac{12}{6} = 2 \text{ Amp}$$
$$I_{sc} = 4 \times 2 = 8 \text{ Amp}$$

$$\boxed{I_{sc} = I_N = 8\text{ Amp}}$$

⇒

Now open the terminals



Nodal Analysis

$$i_o + 3i_o - \frac{V_{oc}}{3} = 0$$

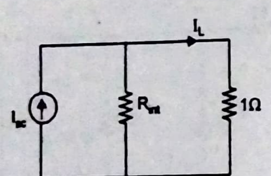
$$\Rightarrow \quad 4i_o = \frac{V_{oc}}{3}$$

$$= 0$$

$$\Rightarrow \quad 4\left[\frac{12-V_{oc}}{8-\frac{8V_{oc}}{3}}\right] - \frac{V_{oc}}{3} = 0$$

$$\boxed{V_{oc} = 8V}$$

Now $\quad R_{in} = \frac{V_{oc}}{Isc} = \frac{8}{8} = 1W$



Ans.

Q.9 For a AC network shown in Fig. A, if the reading of voltmeter (indicating RMS value) is 60V then find the reading of Ammeter. Note Ammeter is also indicating the RMS value. **(IPU-2015)**

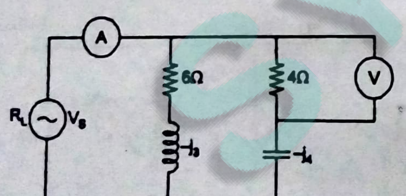


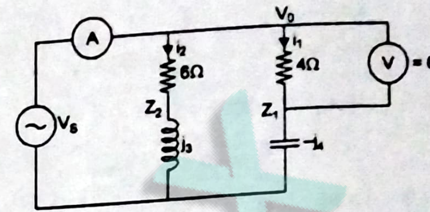
Fig. A

Ans. V =60V (rms) Ammeter reading ; $\quad i_1 = 60/4 = 15$ Amp

$$Z_1 = (4 - j_4)\; Z_2 = (6 + j_3)$$

$$V_0 \Rightarrow 15(4 - j_4)$$

$$V_1 = (60 - j\,60)\text{ volt}$$



Now $\quad \boxed{i_2 = \frac{V_1}{Z_2}}$

Because in parallel voltage is same so it directly appears to Z_2.

$$i_2 = \frac{60 - j60}{6 + j_3} = (10 - j20)$$

Now

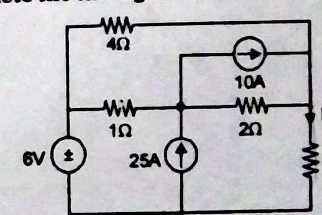
$$i = i_1 + i_2 = (15 + j0) + (10 - j\,20)$$

$$i = (25 - j20)\text{ Amp}$$

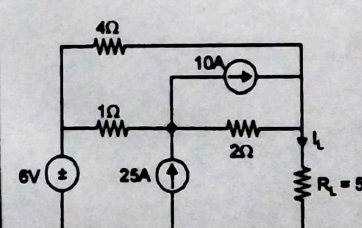
Now Ammeter reads $\boxed{i = 25\text{Amp}}$ **Ans.**

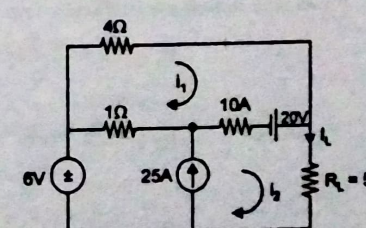
Q.10. For a network shown in Fig. A, if R_L is load resistance & I_L is current flowing through it then complete the table given below. **(IPU-2015)**

S.No.	R_L	I_L
1		5 Ohm
2		10 Ohm
3		15 Ohm



Ans.





$$\Rightarrow \quad 4i_1 + 20 + 10(i_1 - i_2) + 1(i_1 - i_2) = 0$$

$$\Rightarrow \quad 15\,i_1 - 11i_2 = -20 \qquad ...(1)$$

$$i_2 - i_1 + 10(i_2 - i_1) - 20 + 5\,i_2 = 0$$

$$-11\,i_1 + 16\,i_2 = 20 \qquad ...(2)$$

$$15i_1 - 11i_2 = -20 \times 16$$
$$11i_1 - 16i_2 = -20 \times 11$$

$$\Rightarrow \quad 240i_1 - 121i_1 = -320 + 220$$

$$119\, i_1 = -100$$

$$\boxed{i_1 = -0.840 \text{ Amp.}}$$

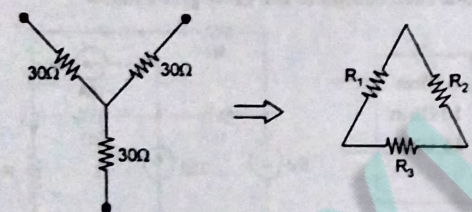
$$-(15 \times 0.840) = 11\, i_2 = -20$$
$$-12.6 - 11\, i_2 = -20$$
$$-11\, i_2 = -20 + 12.6$$
$$-11\, i_2 = -7.4$$

$$\boxed{i_2 = 0.672}$$

$$\boxed{I_1 = I_2 = 0.672 \text{ Amp}}$$

Q.11 A star connection contains three equal resistances of 30 ohm. Find the resistances of the equivalent Delta connection. **(IPU-2015)**

Ans.



From star to delta transformation:

$$R_1 = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_1} = \frac{(30 \times 30) + (30 \times 30) + (30 \times 30)}{30}$$
$$= 90\ \Omega$$

$$R_2 = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_2} = \frac{(30 \times 30) + (30 \times 30) + (30 \times 30)}{30}$$
$$= 90\ \Omega$$

$$R_3 = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_3} = \frac{(30 \times 30) + (30 \times 30) + (30 \times 30)}{30}$$
$$= 90\ \Omega$$

$$\Rightarrow \quad \boxed{R_1 = R_2 = R_3 = 90\text{W}} \text{ Ans.}$$

Q. 12. Give statements of Thevenin's and Norton's theorem. **(IPU-2015)**

Ans. Thevenin's Theorem: Thevenin's theorem states that any two-terminal, linear bilateral dc network can be replaced by an equivalent circuit consisting of a voltage source, E_{Th} (or V_{Th}) and a series resistor, R_{Th} as shown in Fig. 1.

Here, V_{Th} is voltage across two terminals (load terminals). It is also known as V_{oc} (open circuit voltage). R_{Th} is internal resistance of the network as viewed back into the open circuited network from terminals a and b with all voltage sources replaced by their internal resistance (if any) and current sources by infinite resistance.

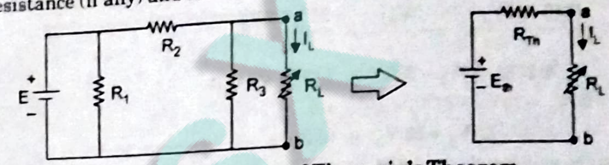


Fig. 1. Illustration of Thevenin's Theorem

Norton's Theorem: Norton Theorem states that any two-terminal linear bilateral dc network can be replaced by an equivalent circuit consisting of a current source, I_N (or I_{sc}) and a parallel resistor, R_N as shown in Fig.

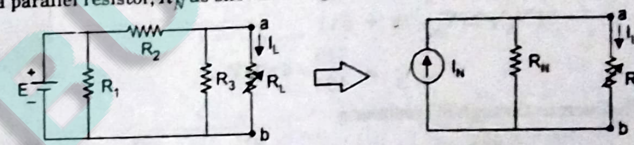
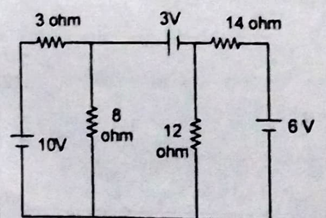


Fig. 2. Illustration of Norton's Theorem

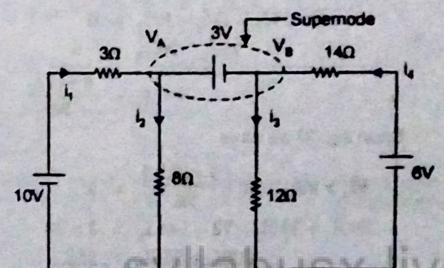
Here, I_N is the constant current equal to the current which would flow in a short-circuit placed across the terminals a and b. R_N is internal resistance of the network as viewed back into the open circuited network from terminals a and b with all voltage sources replaced by their internal resistance (if any) and current sources by infinite resistance.

Q. 13 For the circuit shown in fig. Find current across 8 ohm resistor by nodal analysis OR by mesh analysis. **(IPU-2015)**



Ans. By Nodal Analysis:

From the given circuit, it is clear that it is the case of super node.



Let the direction of current in different branches be i_1, i_2, i_3 and i_4 as shown in the modified circuit diagram.

By nodal analysis, we have

$$i_1 + i_4 = i_2 + i_3$$

$$\frac{10 - V_A}{3} + \frac{6 - V_B}{14} = \frac{V_A}{8} + \frac{V_B}{12}$$

$$\frac{(140 - 14V_A + 18 - 3V_B)}{3 \times 14} = \frac{3V_A + 2V_B}{24}$$

$$4(158 - 14V_A - 3V_B) = 7(3V_A + 2V_B)$$

$$632 - 56V_A - 12V_B - 21V_A - 14V_B = 0$$

$$77V_A + 26V_B = 632$$

From the super node, we have

$$V_A - V_B = 3$$

$$V_B = V_A - 3$$

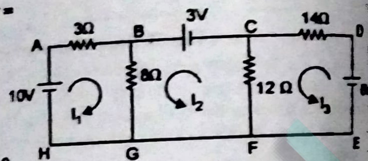
$$77V_A + 26(V_A - 3) = 632$$

$$77V_A + 26V_A - 78 = 632$$

$$V_A = \frac{710}{103} = 6.893\,V$$

∴ The current through 8Ω resistor =

$$i_2 = \frac{V_A}{8} = \frac{6.893}{8} = 0.862\text{ A}$$



By Mesh Analysis

From loop ABGH, we get

$$10 - 3I_1 - 8(I_1 + I_2) = 0$$

$$10 - 3I_1 - 8I_1 - 8I_2 = 0$$

$$11I_1 + 8I_2 = 10$$

From loop, BCFG, we get

$$3 - 8(I_1 + I_2) - 12(I_2 - I_3) = 0$$

$$3 - 8I_1 - 8I_2 - 12I_2 + 12I_3 = 0$$

$$8I_1 + 20I_2 - 12I_3 = 3$$

From loop CFDE, we get

$$6 - 14I_3 + 12(I_2 - I_3) = 0$$

$$6 - 14I_3 + 12I_2 - 12I_3 = 0$$

$$12I_2 - 26I_3 = -6$$

$$\Rightarrow \quad I_3 = \frac{6 + 12I_2}{26}$$

From eq. (2) we have

$$8I_1 + 20I_2 - 12\left(\frac{6 + 12I_2}{26}\right) = 3$$

$$208I_1 + 520I_2 - 72 - 144I_2 = 3 \times 26$$

$$208I_1 + 376I_2 = 150$$

From eq. (1) we have $\quad I_2 = \frac{10 - 11I_1}{8}$

From eq. (4) we have

$$208I_1 + 376\left(\frac{10 - 11I_1}{8}\right) = 150$$

$$208I_1 + 47(10 - 11I_1) = 150$$

$$208I_1 + 470 - 517I_1 = 150$$

$$309I_1 = 320$$

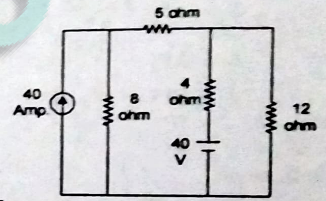
$$\boxed{I_1 = 1.035A}$$

$$\Rightarrow \quad I_2 = \frac{10 - 11 \times 1.035}{8} \Rightarrow \boxed{I_2 = -0.173A}$$

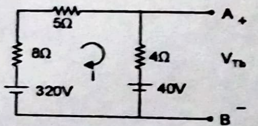
∴ Current though 8Ω resistor = $I_1 + I_2$

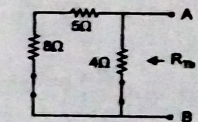
$$= 1.035 - 0.173 = 0.862\text{ A}$$

Q. 14 Draw equivalent Thevenin's circuit for Network shown in fig. Take 12 Ohm as load resistance. (IPU-2018)



Ans. By Thevenin's Theorem





$$R_{Th} = (5 + 8) \,||\, 4 = 13 \,||\, 4 = \frac{13 \times 4}{17} = \frac{52}{17}\Omega$$

$$320 - 8I - 5I - 4I - 40 = 0$$

$$17I = 280$$

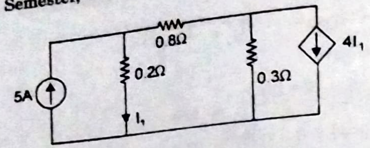
$$I = \frac{280}{17} = 16.47A$$

$$\Rightarrow \quad 40 + 4I - V_{Th} = 0$$

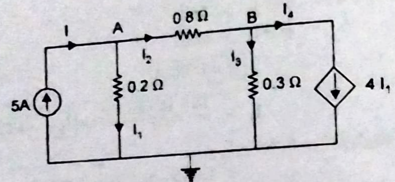
$$V_{Th} = 40 + 4 \times 16.47 = 105.88\text{ V}$$

$$\therefore \quad I_L = \frac{V_{Th}}{R_{Th} + R_L} = \frac{105.88}{12 + \frac{52}{17}} = 7.03\text{ A}$$

Q. 15 Find the voltage across the 0.8 Ω resistor using nodal analysis for circuit shown in Fig. (IPU-2018)



Ans.



Applying KCL at node A, we get $I = I_1 + I_2$

$$5 = \frac{V_A}{0.2} + \frac{V_A - V_B}{0.8}$$

$$5 = 5V_A + \frac{5}{4}(V_A - V_B)$$

$$20 = 20V_A + 5V_A - 5V_B$$

$$25V_A - 5V_B = 20$$

$$5V_A - V_B = 4 \quad ...(1)$$

Applying KCl at node B, we get

$$I_2 = I_3 + I_4$$

$$\frac{V_A - V_B}{0.8} = \frac{V_B}{0.3} + 4I_1$$

$$\frac{5}{4}(V_A - V_B) = \frac{10}{3}V_B + \frac{4V_A}{0.2}$$

$$\frac{5}{4}(V_A - V_B) = \frac{10V_B}{3} + 20V_A$$

$$15(V_. - V_n) = 4(10V_B + 60V_A)$$

$$15V_A - 15V_B = 40V_B + 240V_A$$

$$225V_A = -55V_B$$

$$V_A = -\frac{55}{225}V_B = -\frac{11}{45}V_B \quad ...(2$$

From eq (1) and (2), we get $V_B = 5V_A - 4$

$$\Rightarrow \quad V_A = -\frac{4}{45}(5V_A - 4)$$

$$45V_A = -55V_A + 44$$

$$100V_A = 44$$

$$V_A = \frac{44}{100}V \Rightarrow \boxed{V_A = 0.44\ V}$$

$$\Rightarrow \quad V_B = 5 \times 0.44 - 4$$

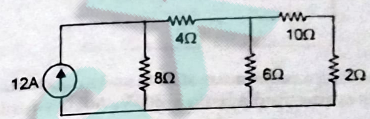
$$\boxed{V_B = -1.80\ V}$$

$\therefore$ Voltage across

$$0.8\ \Omega = V_A - V_B$$

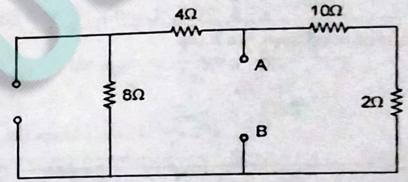
$$= 0.44 - (-1.80) = 2.24\ V$$

Q. 16 Find current in 6 Ω resistor using Norton's theorem for Fig. shown below. **(IPU-2018)**



Ans. Here $R_L = 6\Omega$

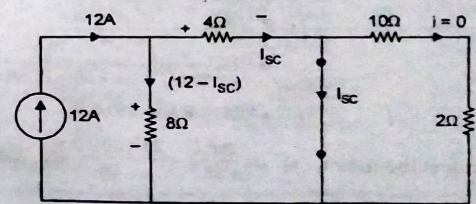
Rearranging the network for Norton's Resistance, R_N



$$\therefore \quad R_N = (4 + 8) \| (10 + 2)$$

$$= 12 \| 12 = \frac{12 \times 12}{24} = 6\Omega$$

Rearranging the network for Norton's current, I_N (in I_{sc})



Applying KVL in a loop, we get

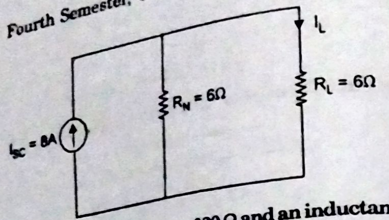
$$8(12 - I_{sc}) - 4I_{sc} = 0$$

$$96 - 8I_{sc} - 4I_{sc} = 0$$

$$I_{sc} = \frac{96}{12} = 8A$$

The Norton's Equivalent Circuit is shown as

$$\therefore I_L = \frac{R_N}{R_N + R_L} \times I_{Sc} = \frac{6}{6+6} \times 8 = 4A$$



Q.17 A circuit having a resistance of 20 Ω and an inductance of 0.8H and a va... capacitor in series is connected across a 200V, 50Hz supply. Calculate:
(i) The capacitance to give resonance.
(ii) The voltage across the inductor and the capacitor
(iii) The Q factor of the circuit (IPU-...)

Ans. Given,

$$R = 20\Omega;\ L = 0.8\ H;\ V = 200\ V;\ f = 50\ Hz$$

(i) Under Resonant condition, we have

$$X_L = X_C$$

$$2\pi f L = \frac{1}{2\pi fc}$$

$$C = \frac{1}{(2\pi f)^2 L} = \frac{1}{(2\pi \times 50)^2 \times 0.8} = 12.66\ \mu F$$

(ii) At resonance, current through the circuit,

$$I = \frac{V}{R} = \frac{200}{20} = 10A$$

$$\therefore\quad V_L = IX_L = I \times 2\pi f_r L = 10 \times 2\pi \times 50 \times 0.8$$

$$= 2513.27\ V \approx 2514\ V$$

$$\Rightarrow\quad V_C = IX_C$$

$$= I \times \frac{1}{2\pi f_r C} = \frac{10}{2\pi \times 50 \times 12.66 \times 10^{-6}}$$

$$= 2514.3\ V \approx 2514\ V$$

(iii) Q-factor of the circuit,

$$Q = \frac{2\pi f_r L}{R} = \frac{2\pi \times 50 \times 0.8}{20} = 12.57$$

Q.18 Derive $f_0 = 1/(2\pi\sqrt{LC})\dfrac{\sqrt{R^2 - L/C}}{R_1^2 - L/C}$ for a parallel resonant circ... R_1 is the resistance in series with the inductor and R_1 is the resistance ... with the capacitor. (IPU-...)

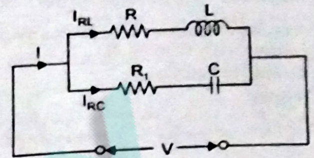
Ans. When an inductive reactance and a capacitive reactance are connected ... as shown in fig. condition may reach under which parallel or current resonance ...

– For parallel resonance–

Reactive component of RL branch = Reactive component of RC branch

i.e.

$$I_{RL} \sin\phi_{RL} = I_{Rc} \sin\phi_{RC}$$



– From fig.

$$I_{RL} = \frac{V}{\sqrt{R^2 + (\omega_r L)^2}}$$

and

$$\sin\phi_{RL} = \frac{X_L}{Z_{RL}} = \frac{\omega_r L}{\sqrt{R^2 + (\omega_r L)^2}}$$

and

$$I_{RC} = \frac{V}{Z_{Rc}} = \frac{V}{\sqrt{R_1^2 + \left(\frac{1}{\omega_r C}\right)^2}}$$

and

$$\sin\phi_{RC} = \frac{X_C}{Z_{Rc}} = \frac{1/\omega_r C}{R_1^2 + \left(\frac{1}{\omega_r C}\right)^2}$$

From equations (2) and (3) in (1) we get-

$$\frac{V}{\sqrt{R^2 + (\omega_r L)^2}} \times \frac{\omega_r L}{\sqrt{R_2 + (\omega_r L)^2}} = \frac{V}{\sqrt{R_1^2 + \left(\frac{1}{\omega_r C}\right)^2}} \times \frac{1/\omega_r C}{\sqrt{R_1^2 + \left(\frac{1}{\omega_r C}\right)^2}}$$

or

$$\frac{\omega_r L}{R^2 + (\omega_r L)^2} = \frac{1/\omega_r C}{R^2 + (1/\omega_r C)^2}$$

or

$$\frac{\omega_r L}{R^2 + \omega_r^2 L^2} = \frac{\omega_r C}{\omega_r^2 R_1^2 C^2 + 1}$$

or

$$L(\omega_r^2 R_1^2 C^2 + 1) = C(R^2 + \omega_r^2 L^2)$$

or

$$\omega_r^2 LC(R_1^2 C - L) = CR^2 - L$$

or

$$\omega_r = \frac{1}{\sqrt{LC}}\sqrt{\frac{CR^2 - 1}{CR_1^2 - 1}}$$

Resonant Frequency

$$f_r = \frac{1}{2\pi}\omega_r$$

or

$$f_r = \frac{1}{2\pi\sqrt{LC}}\sqrt{\frac{CR^2 - L}{CR_1^2 - L}}$$

Q.19 State thevenin theorem. Find thevenin equivalent voltage and thevenin equivalent resistance in fig. (A) & draw Norton equivalent circuit? (IPU-2016)

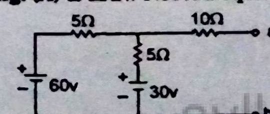
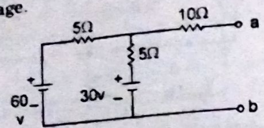


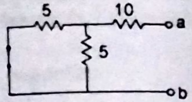
Fig. A.

Ans. A linear two-terminal circuit can be replaced by an equivalent circuit consisting of voltage source V_{TH} is series with resistor R_{TH}.

Where R_{TH} = Equivalent Resistance

V_{TH} = Equivalent Voltage.





$$R_{ab} = R_{TH} \Rightarrow$$

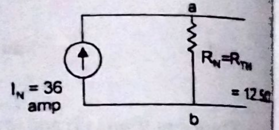
$$R_{ab} = R_{TH} = (5 \| 5) + 10 = 12.5\ \Omega$$

For V_{TH}

$= 5i + 5i + 30 = 60$

$10i = 30$

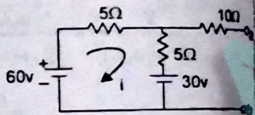
$\boxed{i = 3\,amp}$



$V_{ab} = V_{TH} = 10 \times 0 + 5.i + 30$

$= 0 + 5 \times 3 + 30$

$\boxed{V_{ab} = V_{TH} = 45V}$



For Norton's Equivalent

$$\Rightarrow \quad I_N = \frac{V_{TH}}{R_{TH}} = \frac{45}{12.5} = 36\,amp \text{ Ans.}$$

Q.20 Find the equivalent resistance across AB in the Fig. 1, all the resistances are equal and 5 ohm. **(IPU-2016)**

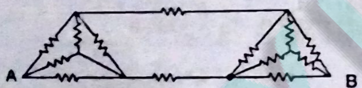
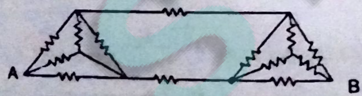
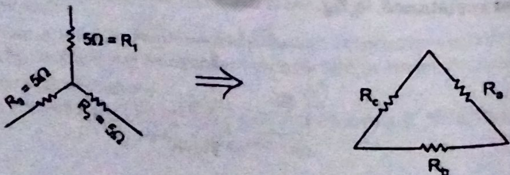


Fig. 1.

Ans. Each resistance value = 5Ω



Converting from star to delta



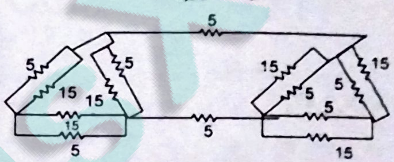
$$\Rightarrow \quad R_a = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_3}$$

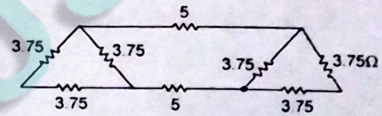
$$\Rightarrow \quad = \frac{5 \times 5 + 5 \times 5 + 5 \times 5}{5} = \frac{75}{5} = 15\Omega$$

$$R_b = 15\Omega,\ R_c = 15\Omega$$

Now

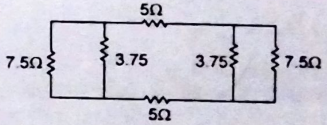
$$15 \| 15 \Rightarrow \frac{15 \times \cancel{5}}{2\cancel{0}4} = \frac{15}{4} = 3.75\Omega$$





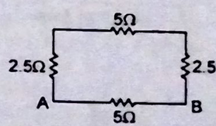
$\Rightarrow 3.75 + 3.75 = 7.50\ \Omega$

$\Rightarrow$



$$\Rightarrow \quad 7.5 \| 3.75 \Rightarrow \frac{7.5 \times 3.75}{7.5 + 3.75} = \frac{28.125}{11.25} = 2.5\Omega$$

Now



$$\Rightarrow \quad R_{AB} = 2.5 + 2.5 + 5 + 5 = 15\Omega \text{ Ans.}$$

Q.21. Find the current through, 2 ohm resistor using nodal analysis and Thevenin's theorem for the circuit shown in fig A. **(IPU-2016)**

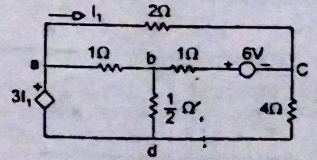
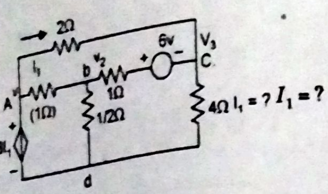


Fig.A

Ans.



Nodal Analysis $V_1 = 3I_1$

$$\Rightarrow \quad \frac{V_2-V_1}{1}+\frac{V_2-6-V_3}{1}+\frac{2V_2}{1} = 0$$

$$4V_2-V_1-V_3 = 6$$

$$\frac{V_1-V_3}{2} = I_1$$

Now,

$$2I_1 = V_1-V_3$$

$$\Rightarrow \quad V_1 = \frac{3(V_1-V_3)}{2}$$

$$\boxed{3V_3 = V_1}$$

$\Rightarrow$

$$\Rightarrow \quad \frac{V_3}{4}+\frac{V_3+6-V_2}{1}+\frac{V_3-V_1}{2} = 0$$

$$V_3+4V_3+24-4V_2+2V_3-2V_1 = 0$$

$$7V_3-6V_2 = 24$$

After solving

$$V_1 = 99 \text{ volt}, V_3 = 33 \text{ volt}$$

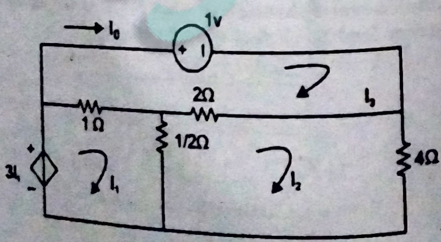
$$I_1 = \frac{V_1-V_3}{2} = \frac{99-33}{2} = \frac{66}{2}$$

$\boxed{I_1 = 33\ Amp}$ **Ans.**

Thevenin's Equivalent–

For R_{TH}

$$R_{TH} = \frac{1}{I_0}$$



$$3I_1+(I_1-I_3)+\frac{1}{2}(I_1-I_2) = 0$$

$$\Rightarrow \quad 4I_1-I_3+\frac{1}{2}I_1-\frac{1}{2}I_2 = 0$$

$$\Rightarrow \quad 3.5\,I_1-0.5\,I_2-I_3 = 0 \qquad ...(1)$$

$$2(I_2-I_3)+4I_2+1/2\,(I_2-I_1) = 0$$

$$2I_2-2I_3+4I_2+0.5\,I_2-0.5\,I_1 = 0$$

$$\Rightarrow \quad -0.5I_1+6.5\,I_2-2I_3 = 0$$

$$0.5I_1-6.5I_2+2I_3 = 0 \qquad ...(2)$$

$$(I_3-I_1)+1+2\,(I_3-I_2) = 0$$

$$\Rightarrow \quad I_3-I_1+1+2I_3-2I_2 = 0$$

$$\Rightarrow \quad -I_1-2I_2+3I_3 = -1$$

$$I_1+2I_2-3I_3 = 1 \qquad ...(3)$$

$$I_1 = 0.166 \text{ Amp}$$

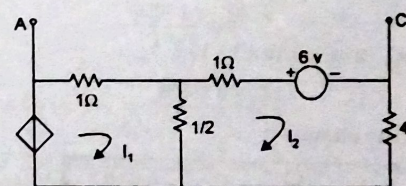
$$I_2 = 0.166 \text{ Amp}$$

$$\boxed{I_3 = -0.5} \text{ Amp}$$

$$R_{TH} = \frac{1}{0.5} = 2\Omega$$

$$\boxed{R_{TH} = 2\Omega}$$

for $V_{TH} = V_{oc}$



$$\Rightarrow \quad I_1+1/2\,(I_1-I_2) = 0$$

$$0.5I_1-0.5\,I_2 = 0 \qquad ...(1)$$

$$I_2+6+4I_2+1/2\,(I_2-I_1) = 0 \quad I_1 = 1 \text{ amp.}$$

$$I_2+6+4I_2+1/2\,I_2-0.5\,I_1 = 0 \quad I_2 = -1 \text{ amp}$$

$$-0.5I_1+5.5\,I_2 = -6 \qquad ...(2)$$

$$V_{oc} = V_{TH}$$

$$\Rightarrow \quad 1\times I_1+1I_2+6$$

$$= \cancel{1}-\cancel{1}+6$$

$$= 6V$$

$\boxed{V_{TH} = 6V}$ **Ans.**

UNIT-II

Q.22 In the circuit shown in Fig. A, I_s = cos 1000 t. Determine the frequency domain circuit and determine the phasors I_1 and I_2. Draw the phasor diagram for V_1, V_2, V_3 and V_4 in the same figure. (IPU-2016)

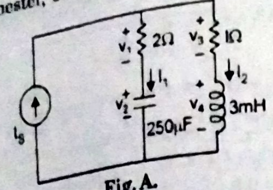


Fig. A.

Ans.
Comparing with reference equation–

$I_s = \cos 1000\,t$

$I_s = \cos \omega t \Rightarrow \omega = 1000$

$= 2\pi f = 1000$

$$f = \frac{1000}{2\pi}$$

$$\boxed{f = 159.15\ Hz}$$

Now

$$C = 250\,\mu F, X_c = \frac{1}{2\pi f c}$$

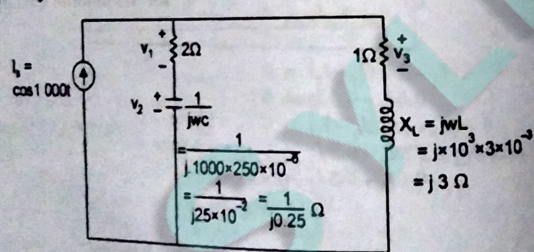
$$= \frac{1}{2\pi \times 159.15 \times 250 \times 10^{-6}}$$

$$= \boxed{X_C = 4.00\Omega}$$

$L = 3mH\ X_L = 2\pi f l = 2\pi \times 159.15 \times 3 \times 10^{-3}$

$$\boxed{X_L = 0.333\Omega}$$

Frequency domain circuit



$$\Rightarrow \quad Z_{eq} = Z_1 \,||\, Z_2$$

$$= \left(2 + \frac{1}{j\omega c}\right) || (1 + j\omega L)$$

$$= \frac{\left(2 + \frac{1}{j0.25}\right) \times (1 + j3)}{\left(2 + \frac{1}{j0.25}\right) + (1 + j3)} = \frac{(2 - j4)(1 + j3)}{(2 - j4) + (1 + j3)}$$

$$Z_{eq} = \frac{(14 + j2)}{(3 - j)} = (4 + j2)\Omega$$

$$V_{eq} = I_m \times Z_{eq} = 1 \times (4 + j2),\ \boxed{I_m = 1}$$

$$= (4 + j2)\ \text{volt}$$

$\Rightarrow$ Now

$$I_1 = \frac{V_{eq}}{Z_1} = \frac{(4 + j2)}{(2 - j4)} = 1\angle 90^\circ$$

$$I_2 = \frac{V_{eq}}{Z_2} = \frac{(4 + j2)}{(1 + j3)} = 1.414\angle -45^\circ\ amp$$

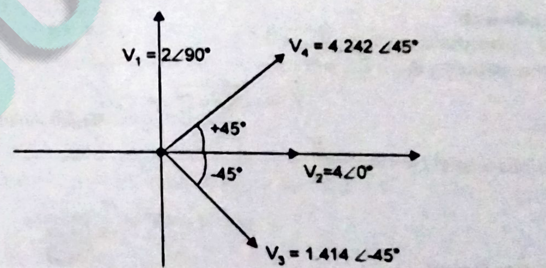
$$V_1 = I_1 \times 2 = 1\angle 90^\circ \times 2 = 2\angle 90^\circ$$

$$V_2 = I_1 \times (-j4) = 1\angle 90^\circ \times (j4) = 4\angle 0^\circ$$

$$V_3 = I_2 \times 1 = 1.414\ \angle -45^\circ \times 1 = 1.414\angle -45^\circ$$

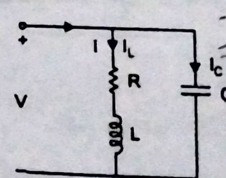
$$V_4 = I_2 \times j3 = 1.414\angle -45^\circ \times j3 = 4.242\angle 45^\circ$$

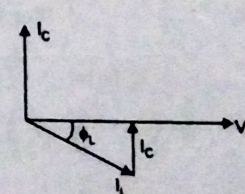
Phasor diagram



Q.23. For a parallel RLC circuit define resonant frequency, damped resonant frequency and Q. Obtain exact expressions for half power frequencies in terms of resonant frequency and Q. (IPU-2016)

Ans. Parallel Resonant





$\Rightarrow$ **The admittance of the circuit is**

$$Y = j\omega c + \frac{1}{R + j\omega L} = j\omega c + \frac{R - j\omega L}{R^2 - \omega^2 L^2}$$

$$\frac{R}{R^2 + \omega^2 L^2} + j\omega\left(C - \frac{L}{R^2 + \omega^2 L^2}\right)$$

At resonance the j term is zero, and $\omega = \omega_0$,

$$\Rightarrow \quad C - \frac{L}{R^2 + \omega_0^2 L^2} = 0$$

$$\Rightarrow \quad R^2 + \omega_0^2 L^2 = \frac{L}{C}$$

$$\Rightarrow \quad \omega_0^2 L^2 = \frac{L}{C} - R^2 \Rightarrow \boxed{\omega_0 = \sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}}\ \text{rad/sec}$$

$$\Rightarrow$$

Resonant frequency in Hz

$$\boxed{f_0 = \frac{\omega_0}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}}\ \text{rad/sec}$$

if 'R' is small than

$$\boxed{F_0 = \frac{1}{2\pi}\sqrt{\frac{1}{LC}}}\ \text{Hz}$$

Bandwidth

At f_1, susceptance $= B_{L1} - B_{CL} = G$

f_2, susceptance, $B_{C2} - B_{L2} = G$

$$Y = \sqrt{(G^2 + B^2)} = \sqrt{2}G$$

and phase angle $\phi = \tan^{-1}\frac{B}{G}$

$$= \tan^{-1} 1 = 45° \text{ or } \frac{\pi}{4} \text{ radian.}$$

Quality factor

$$\text{Q-factor} = \frac{\text{Circulating current between L and C}}{\text{Line current}}$$

$$I_C = 2\pi f_r CV$$

line current,

$$I = \frac{V}{L/CR} = VcR/L$$

$$\text{Q-factor} = \frac{I_C}{I} = \frac{2\pi f L}{R}$$

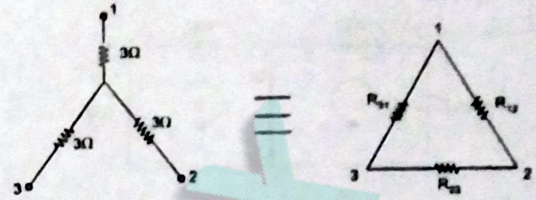
$$f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC}}$$

$$\text{Q-factor} = 2\pi \times \frac{1}{2\pi}\sqrt{\frac{1}{LC}} \times \frac{L}{R}$$

$$\boxed{Q = \frac{1}{R}\sqrt{\frac{L}{C}}}\ \text{Ans.}$$

Q.24. Three equal resistance of 3 ohm are connected in star. What is the resistance in one of the arms in an equivalent delta circuit? (IPU-...)

Ans.



$$R_{31} = R_{23} = R_{12} = 3 + 3 + \frac{3 \times 3}{3} = 9\,\Omega$$

Q.25 Find the Thevenin's and Norton's Equivalents for the circuit as shown in fig 1 with respect to terminals *ab*.(IPU-2017)

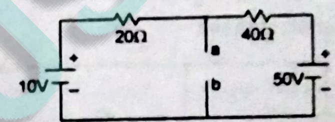


Fig 1

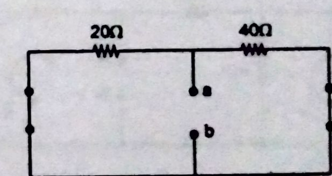
Ans. (a) Thevenin's Equivalent circuit

Step (i)

$$i = \frac{50 - 10}{20 + 40} = \frac{40}{60} = \frac{2}{3}A$$

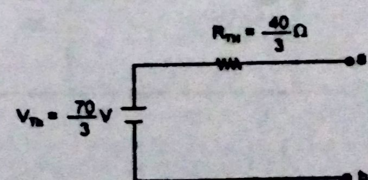
$$V_{th} = V_{ab} = 50 - 40 \times \frac{2}{3} = \frac{70}{3}V$$

Step (ii) For R_{Th}



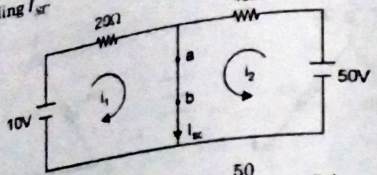
$$R_{Th} = 20\,\Omega \,||\, 40\,\Omega = \left(\frac{1}{20} + \frac{1}{40}\right)^{-1} = \frac{40}{3}\,\Omega$$

Step (iii) Thevenin equivalent circuit



(b) Norton's Equivalent circuit:

Step (i) For finding I_{SC}



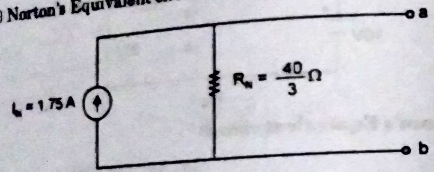
$$i_1 = \frac{10}{20} = 0.5\,\text{A};\; i_2 = \frac{50}{40} = 1.25\,\text{A}$$

$$I_{SC} = i_1 + i_2 = 0.5 + 1.25 = 1.75\,\text{A}$$

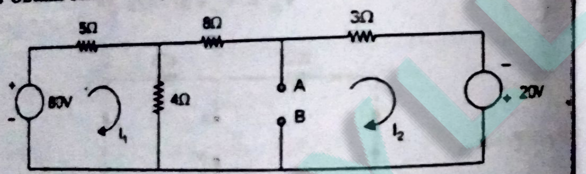
Step (ii) For finding R_N

$$R_N = R_{th} = \frac{40}{3}\,\Omega$$

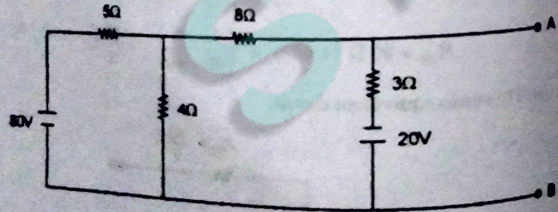
Step (iii) Norton's Equivalent circuit



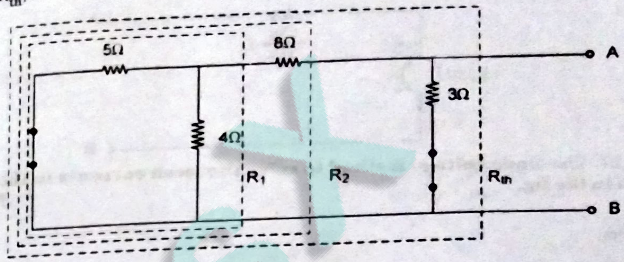
Q.26 Obtain Thevenin equivalent circuit at AB as in fig. (IPU-20...)



Ans.



for R_{th},



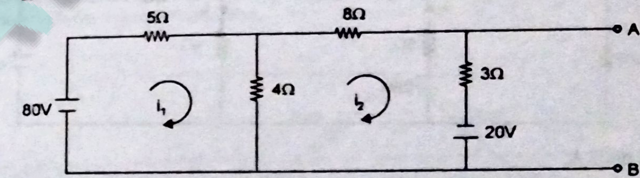
$$R_1 = 5\Omega \parallel 4\,\Omega$$

$$= \left(\frac{1}{5}+\frac{1}{4}\right)^{-1} = \frac{20}{9}\Omega$$

$$R_2 = \left(\frac{20}{9}\Omega\right) + 8\Omega = \frac{92}{9}\Omega$$

$$R_{th} = R_2 \parallel 3\Omega = \left(\frac{9}{92}+\frac{1}{3}\right)^{-1} = \frac{276}{119}\Omega$$

for V_{th},



Apply KVL,

$$80 - 5i_1 - 4(i_1 - i_2) = 0$$

$$9i_1 - 4i_2 = 80 \quad \text{...(1)}$$

$$4(i_2 - i_1) + 8i_2 + 3i_2 + 20 = 0$$

$$4i_1 - 15i_2 = 20 \quad \text{...(2)}$$

equation (2) × 9 – eq. (1) × 4

$$119\, i_2 = 140$$

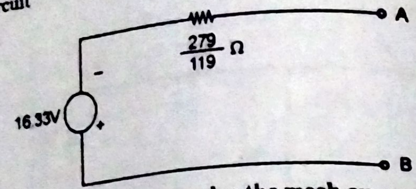
$$i_2 = \frac{140}{119}$$

$$V_{th} = 3i_2 - 20$$

$$= 3\times\frac{140}{119} - 20 = \frac{420-2380}{119} = \frac{-1960}{119}$$

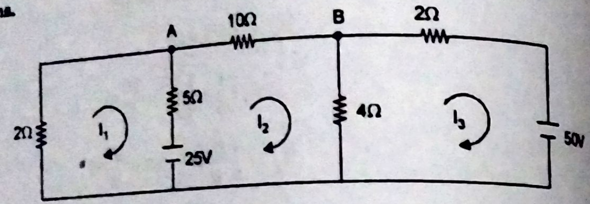
$$= -16.33\text{V}$$

Equivalent circuit

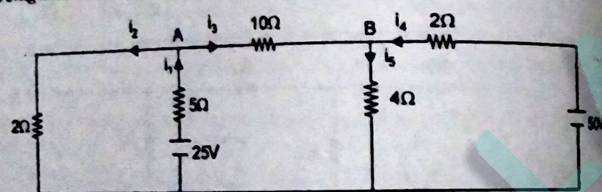


Q.27. Use node voltage method to solve the mesh currents in the network shown in the fig. (IPU

Ans.



Using Node Voltage Method,



At node A,

$$i_1 = i_2 + i_3$$

$$\frac{25 - V_A}{5} = \frac{V_A - 0}{2} + \frac{V_A - V_B}{10}$$

$$50 - 2V_A = 5V_A + V_A - V_B$$

$$8V_A - V_B = 50$$

At node B,

$$i_3 + i_4 = i_5$$

$$\frac{V_A - V_B}{10} + \frac{50 - V_B}{2} = \frac{V_B - 0}{4}$$

$$2V_A - 2V_B + 500 - 10V_B = 5V_B$$

$$2V_A - 17V_B = -500$$

equation (1) – (2) × 4

$$67V_B = 2050$$

$$V_B = \frac{2050}{67} V$$

in equation (1)

$$8V_A = 50 + \frac{2050}{67}$$

$$V_A = \frac{5400}{8 \times 67} = \frac{675}{67} V$$

$$i_2 = \frac{V_A}{2} = \frac{675}{67 \times 2} = \frac{675}{134} A$$

Current $I_1 = -i_2 = \frac{-675}{134} A$

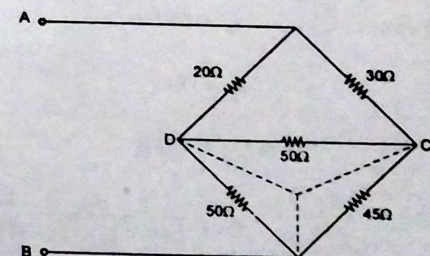
Current $I_2 = i_3 = \frac{V_A - V_B}{10} = \frac{675}{67} - \frac{2050}{67} = \frac{-1375}{67} A$

Current $I_3 = -i_4 = \frac{V_B - 50}{2}$

$$= \frac{\frac{2050}{67} - 50}{2} = -\frac{1300}{134} = \frac{-650}{67} A$$

Q.28. Find the resistance at *A-B* terminals in the electric circuit as shown using star- delta transformation. **(IPU-2018)**

Ans.

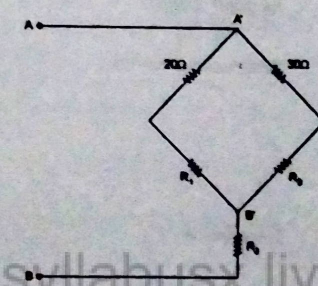


Using Star-Delta conversion

$$R_1 = \frac{50 \times 50}{50 + 50 + 45} = \frac{2500}{145} = \frac{500}{29} \Omega$$

$$R_2 = \frac{50 \times 45}{50 + 50 + 45} = \frac{2250}{145} = \frac{450}{29} \Omega$$

$$R_3 = \frac{50 \times 45}{50 + 50 + 45} = \frac{450}{29} \Omega$$



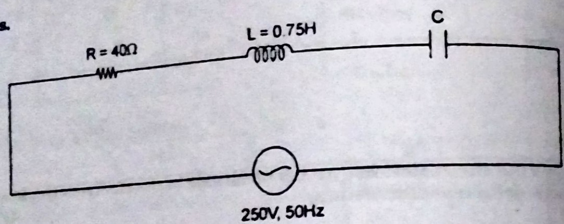
$$R_{A'B'} = \left(20 + \frac{500}{29}\right) || \left(30 + \frac{450}{29}\right)$$

$$= \left(\frac{29}{1080} + \frac{29}{1320}\right)^{-1} = \frac{120}{29}\left(\frac{1}{9} + \frac{1}{11}\right)^{-1} = \frac{594}{29}\,\Omega$$

$$R_{AB} = R_{A'B'} + \frac{450}{29} = \frac{594}{29} + \frac{450}{29} = \frac{1044}{29} = 36\Omega$$

Q.29. A coil of resistance 40 Ω and inductance 0.75 H forms port of a se... circuit for which resonant frequency is 55 Hz. If the supply is 250 V, 50 Hz... (i) Line current (ii) Power factor (iii) Power consumed (iv) Voltage acro... coil. (IPU-...

Ans.



Resonant frequency $\quad f_r = 55$ Hz

At resonance,

$$X_L = X_C$$

$$2\pi f_r L = \frac{1}{2\pi f_r C}$$

$$C = \frac{1}{(2\pi f_r)^2 L} = \frac{1}{(2\pi \times 55)^2 \times .75} = 11.1...$$

At 250V, 50Hz

Reactance of circuit,

$$X = \omega L \frac{1}{\omega C}$$

$$X = 2\pi \times 50 \times .75 - \frac{1}{2\pi \times 50 \times 11.165 \times 10^{...}}$$

$$= 235.62 - 285.1 = -49.48\ \Omega$$

Impedance

$$Z = \sqrt{R^2 + X^2} = \sqrt{40^2 + (49.48)^2}$$

$$= 63.63\ \Omega$$

(i) Line current $\quad I = \dfrac{V}{Z} = \dfrac{250}{63.63} = 3.93\text{A}$

(ii) Power factor $\quad \cos\phi = \dfrac{R}{Z} = \dfrac{40}{63.63} = .629$ (leading)

(iii) $\quad P = I^2R = (3.93)^2 \times 40 = 618$ W

(iv) $\quad V_{RL} = IZ_{R-L}$

$$= 3.93\sqrt{40^2 + (2\pi \times 50 \times .75)^2}$$

$$= 939.2\ \text{V}$$

ACCORDING TO NEW SYLLABUS (EEC 213/EEC-30

UNIT - I

Q.1 Refer to Q.1 (b) of First Term Examination 2014 (Pg. No. 1-2014).
Q.2 Refer to Q.2 (a),(b),(c) of First Term Examination 2014 (Pg. No. 3,4-20
Q.3 Refer to Q.3 (c) of First Term Examination 2014 (Pg. No. 5-2014).
Q.4 Refer to Q.1 (b),(c),(d),(e) of End Term Examination 2014 (Pg. No. 14
Q.5 Refer to Q.5 (a),(b),(c) of End Term Examination 2014 (Pg. No. 20,21-
Q.6 Refer to Q.1 (i) to (v),(viii),(ix) of First Term Exam 2015 (Pg. No. 1,2-
Q.7 Refer to Q.4 (a) of First Term Examination 2015 (Pg. No. 4-2015).
Q.8 Refer to Q.1 (a) of End Term Examination 2015 (Pg. No. 14-2015).
Q.9 Refer to Q.2 (a) of End Term Examination 2015 (Pg. No. 16-2015).
Q.10 Refer to Q.5 (a),(b) of End Term Examination 2015 (Pg. No. 19-2015
Q.11 Refer to Q.1 (a),(b) of First Term Examination 2016 (Pg. No. 1,2-20
Q.12 Refer to Q.2 (a),(b) of First Term Examination 2016 (Pg. No. 3,5-20
Q.13 Refer to Q.3 (a) of First Term Examination 2016 (Pg. No. 5-2016).
Q.14 Refer to Q.1 (b) of End Term Examination 2016 (Pg. No. 9-2016).
Q.15 Refer to Q.2 (a) of End Term Examination 2016 (Pg. No. 10-2016).
Q.16 Refer to Q.4 (a),(b) of End Term Examination 2016 (Pg. No. 11-2016
Q.17 Refer to Q.5 (a) of End Term Examination 2016 (Pg. No. 11-2016).
Q.18 Refer to Q.1 (a),(b),(c),(d),(e) of First Term Exam 2017 (Pg. No. 1,2-
Q.19 Refer to Q.2 (b) of First Term Examination 2017 (Pg. No. 3-2017).
Q.20 Refer to Q.3 (a) of First Term Examination 2017 (Pg. No. 4-2017).
Q.21 Refer to Q.1 (a),(b),(c) of End Term Examination 2017 (Pg. No. 9-20
Q.22 Refer to Q.2 (a) of End Term Examination 2017 (Pg. No. 10-2017).
Q.23 Refer to Q.3 (a),(b) of End Term Examination 2017 (Pg. No. 11,12-
Q.24 Refer to Q.4 (a),(b) of End Term Examination 2017 (Pg. No. 13,14-
Q.25 Refer to Q.5 (b) of End Term Examination 2017 (Pg. No. 16-2017).
Q.26 Refer to Q.1 (a),(b),(e) of First Term Examination 2018 (Pg. No. 1,
Q.27 Refer to Q.2 (a),(b) of First Term Examination 2018 (Pg. No. 3,4-20
Q.28 Refer to Q.4 (a) of First Term Examination 2018 (Pg. No. 7-2018).
Q.29 Refer to Q.1 (d),(e) of End Term Examination 2018 (Pg. No. 9-2018
Q.30 Refer to Q.2 (a),(b) of End Term Examination 2018 (Pg. No. 10-201
Q.31 Refer to Q.3 (a),(b) of End Term Examination 2018 (Pg. No. 11-201
Q.32 Refer to Q.4 (b) of End Term Examination 2018 (Pg. No. 12-2018)

UNIT - II

Q.1 Refer to Q.1 (c),(d),(e) of First Term Examination 2014 (Pg. No. 1-
Q.2 Refer to Q.3 (a),(b) of First Term Examination 2014 (Pg. No. 4-2014
Q.3 Refer to Q.4 (a),(b) of First Term Examination 2014 (Pg. No. 5,6-20
Q.4 Refer to Q.1 (a) of Second Term Examination 2014 (Pg. No. 7-2014
Q.5 Refer to Q.2 (a) of Second Term Examination 2014 (Pg. No. 8-2014)

Q.6 Refer to Q.1 (a) of End Term Examination 2014 (Pg. No. 14-2014).
Q.7 Refer to Q.2 (b) of End Term Examination 2014 (Pg. No. 16-2014).
Q.8 Refer to Q.3 (a),(b) of End Term Examination 2014 (Pg. No. 17-2014).
Q.9 Refer to Q.4 (a),(b) of End Term Examination 2014 (Pg. No. 18-2014).
Q.10 Refer to Q.6 (a),(b) of End Term Examination 2014 (Pg. No. 22,23-2014).
Q.11 Refer to Q.1 (vi),(vii),(x) of First Term Examination 2015 (Pg. No. 1,2-2015).
Q.12 Refer to Q.2 (a),(b) of First Term Examination 2015 (Pg. No. 2,3-2015).
Q.13 Refer to Q.3 (a),(b) of First Term Examination 2015 (Pg. No. 3,4-2015).
Q.14 Refer to Q.4 (b) of First Term Examination 2015 (Pg. No. 5-2015).
Q.15 Refer to Q.1 (b),(c) of End Term Examination 2015 (Pg. No. 14,15-2015).
Q.16 Refer to Q.2 (b) of End Term Examination 2015 (Pg. No. 16-2015).
Q.17 Refer to Q.3 of End Term Examination 2015 (Pg. No. 17-2015).
Q.18 Refer to Q.4 (a),(b) of End Term Examination 2015 (Pg. No. 18-2015).
Q.19 Refer to Q.3 (b) of First Term Examination 2016 (Pg. No. 6-2016).
Q.20 Refer to Q.4 (a),(b) of First Term Examination 2016 (Pg. No. 6,7-2016).
Q.21 Refer to Q.1 (c) of End Term Examination 2016 (Pg. No. 9-2016).
Q.22 Refer to Q.2 (b) of End Term Examination 2016 (Pg. No. 10-2016).
Q.23 Refer to Q.5 (b) of End Term Examination 2016 (Pg. No. 12-2016).
Q.24 Refer to Q.2 (a) of First Term Examination 2017 (Pg. No. 3-2017).
Q.25 Refer to Q.3 (b) of First Term Examination 2017 (Pg. No. 4-2017).
Q.26 Refer to Q.4 (a),(b) of First Term Examination 2017 (Pg. No. 6,7-2017).
Q.27 Refer to Q.2 (b) of End Term Examination 2017 (Pg. No. 10-2017).
Q.28 Refer to Q.5 (a) of End Term Examination 2017 (Pg. No. 15-2017).
Q.29 Refer to Q.1 (c) of First Term Examination 2018 (Pg. No. 3-2018).
Q.30 Refer to Q.3 (a),(b) of First Term Examination 2018 (Pg. No. 5,6-2018).
Q.31 Refer to Q.4 (b) of First Term Examination 2018 (Pg. No. 7-2018).
Q.32 Refer to Q.4 (a) of End Term Examination 2018 (Pg. No. 11-2018).
Q.33 Refer to Q.5 (a),(b) of End Term Examination 2018 (Pg. No. 12,14-2018).

UNIT - III

Q.1 Refer to Q.1 (a) of First Term Examination 2014 (Pg. No. 1-2014).
Q.2 Refer to Q.1 (c) of Second Term Examination 2014 (Pg. No. 7-2014).
Q.3 Refer to Q.1 (x) of Second Term Examination 2015 (Pg. No. 7-2015).
Q.4 Refer to Q.4 (b) of Second Term Examination 2015 (Pg. No. 13-2015).
Q.5 Refer to Q.6 (b) of End Term Examination 2016 (Pg. No. 13-2016).
Q.6 Refer to Q.7 (a) of End Term Examination 2016 (Pg. No. 14-2016).
Q.7 Refer to Q.1 (d) of End Term Examination 2017 (Pg. No. 9-2017).
Q.8 Refer to Q.9 (a),(b) of End Term Examination 2017 (Pg. No. 21,22-2017).
Q.9 Refer to Q.1 (c) of End Term Examination 2018 (Pg. No. 8-2018).
Q.10 Refer to Q.9 (a) of End Term Examination 2018 (Pg. No. 21-2018).

UNIT - IV

Q.1 Refer to Q.1 (b),(c),(e) of Second Term Examination 2014 (Pg. No. 7,8-2014).
Q.2 Refer to Q.2 (b) of First Term Examination 2014 (Pg. No. 9-2014).
Q.3 Refer to Q.3 (a),(b) of Second Term Examination 2014 (Pg. No. 10,11-2014).
Q.4 Refer to Q.4 (b) of Second Term Examination 2014 (Pg. No. 12-2014).
Q.5 Refer to Q.7 (a),(b) of End Term Examination 2014 (Pg. No. 23,24-2014).
Q.6 Refer to Q.5 (a) of End Term Examination 2014 (Pg. No. 25-2014).
Q.7 Refer to Q.1 (i) to (viii) of Second Term Examination 2015 (Pg. No. 6,7-2015).
Q.8 Refer to Q.2 (a),(b) of Second Term Examination 2015 (Pg. No. 7,8-2015).
Q.9 Refer to Q.3 (a),(b) of Second Term Examination 2015 (Pg. No. 9,10-2015).
Q.10 Refer to Q.1 (c) of End Term Examination 2015 (Pg. No. 15-2015).
Q.11 Refer to Q.6 of End Term Examination 2015 (Pg. No. 19-2015).
Q.12 Refer to Q.7 (a),(b) of End Term Examination 2015 (Pg. No. 21,22-2015).
Q.13 Refer to Q.4 (a) of End Term Examination 2015 (Pg. No. 23-2015).
Q.14 Refer to Q.1 (a) of End Term Examination 2016 (Pg. No. 10-2016).
Q.15 Refer to Q.6 (a) of End Term Examination 2016 (Pg. No. 12-2016).
Q.16 Refer to Q.7 (b) of End Term Examination 2016 (Pg. No. 14-2016).
Q.17 Refer to Q.1 (e),(f),(g) of End Term Examination 2017 (Pg. No. 9-2017).
Q.18 Refer to Q.5 (a),(b) of End Term Examination 2017 (Pg. No. 16,17-2017).
Q.19 Refer to Q.7 (a),(b) of End Term Examination 2017 (Pg. No. 18,19-2017).
Q.20 Refer to Q.1 (a) of End Term Examination 2018 (Pg. No. 8,9-2018).
Q.21 Refer to Q.6 (a),(b) of End Term Examination 2018 (Pg. No. 15,16-2018).
Q.22 Refer to Q.7 (a),(b) of End Term Examination 2018 (Pg. No. 16,17-2018).
Q.23 Refer to Q.9 (b) of End Term Examination 2018 (Pg. No. 21-2018).

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 Ω and inductance of 0.8 H when connected to a 200 V DC supply? Determine value using classical method. **(2)**

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

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

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

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

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

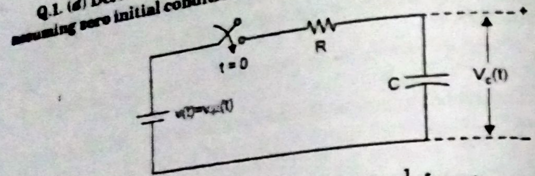
$$i(t) = K\,e^{-25t} + 10$$

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

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

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

Q.1. (d) Derive an expression for $V_C(t)$ for the circuit given below by assuming zero initial condition.



Ans.

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

On taking LT

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$\Rightarrow$

$$B = 2.25$$

$$A = -1.8$$

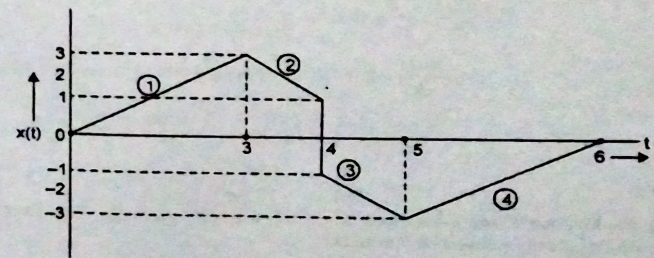
$$y(t) = -1.8\,e^{-5t} + 2.25\,e^{-4t} + \frac{1}{20}$$

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 $\frac{1}{(s+1)(s+2)}$ when

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

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

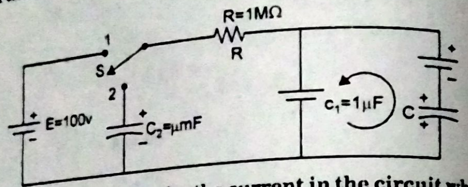
Ans.

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

(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 posi... a long time:



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

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

(iii) Determine the voltage which appears across each capacitor a... state.

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

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

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

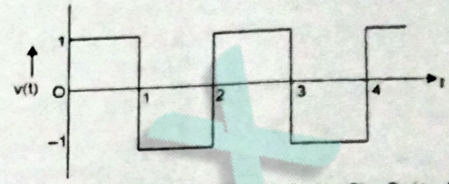
$$i(t) = -10^{-3}e^{-2t}$$

Q.3. (b) Define Time Constant of an RL and RC circuit. Why the... transients in purely resistive circuits?

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.

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

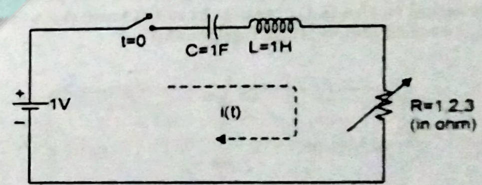
on taking LT

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

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

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

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

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

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

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

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

$$t = 0\ i = 0$$
$$A + B = 0$$
$$B = 2$$

at

$$p^2 + 2p + 1 = 0$$
$$p = -1, -1$$
$$i(t) = A e^{-t} + B t e^{-t}$$
$$t = 0\ i = 0$$
$$A = 0$$
$$B = 3$$

at

$$p^2 + 3p + 1 = 0$$
$$D = b^2 - 4ac$$

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

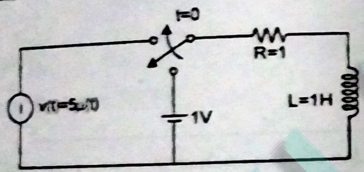
$$i(t) = A e^{-\left(\frac{3-\sqrt{5}}{2}\right)t} + B e^{-\left(\frac{-3+\sqrt{5}}{2}\right)t}$$

$$t = 0\ i = 0$$

at

$$A + B = 0$$

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



Ans. $i(0^-) = 1A$

(because inductor behave as short ci...

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

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

$$C.F = A e^{-t}$$

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

at

$$i(t) = 5 + A e^{-t}$$
$$t = 0\quad i = 1A$$
$$1 = 5 + A \quad A = -4$$
$$i(t) = 5 - 4e^{-t}$$

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

...me : 1.30 hrs. **M.M. : 30**

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

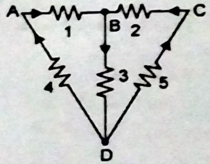
Q.1. (a) Give an expression for the transient response of an initially relaxed ...rely inductive circuit having an inductance or 1 H when subjected to an input ...) = 2 cost.

Ans.

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

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

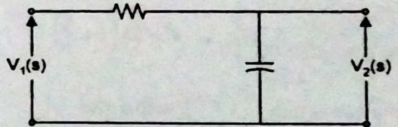
Q.1. (b) Define node and branch of an oriented graph. Draw any electrical ...cuit without using Inductor and Capacitor which represents the following ...ph with *A, B, C, D* as nodes and 1 to 5 as branches.



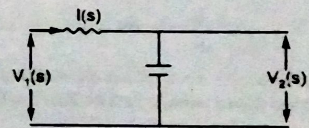
Ans. The components in a circuit is replaced by line segments called branch.

Two or more branches meet at apoint is called node.

Q.1. (c) Determine *V*2(*s*)/*V*1(*s*) for the given R-C circuit, where *R* is in ohm ... *C* is in Farad.



Ans.



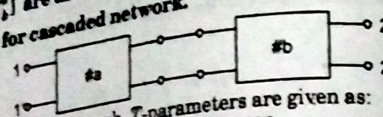
$$V_1(s) = I(s)\,R + I(s) \times \frac{1}{cs}$$

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

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

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

Q.1. (d) Two networks 'a' and 'b' are connected in cascade as shown. If $[T_a']$ and $[T_b']$ are their inverse transmission parameters, derive 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.

Ans.

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

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

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

$$4s^2+8)\,s^3+2s\,(1/9\,s$$

$$\frac{s^3+2s}{0}$$

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

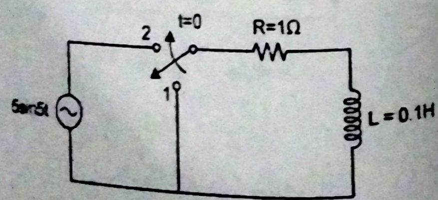
From above equation we can say $\left(1+\frac{4}{s}\right)$ is hurwitz

Now check for s^3+2s

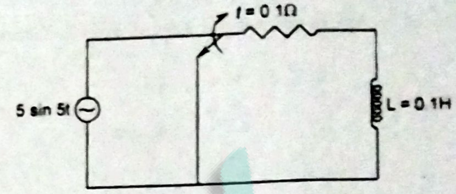
$$s(s^2+2) = s(s+i\sqrt{2})(s-i\sqrt{2}) \text{ is hurwitz}$$

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

$$CF = D+10 = 0$$

$$D = -10$$

$$CF = Ae^{-10t}$$

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

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

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

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

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

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

at

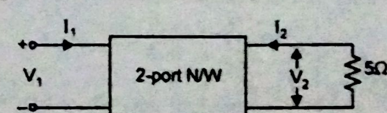
$$t = 0\; i = 0 \text{ (inductor behave as open circuit)}$$

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

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

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

Q.2. (b) The following equation give the voltage V1 and V2 at the two ports of two port network:

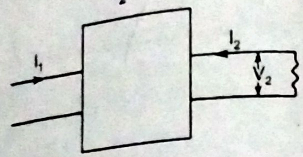


$$V_1 = 5I_1 + 6I_2$$
$$V_2 = 2I_1 + I_2$$

A load resistor of 5 ohm is connected across port 2. Calculate the impedance.

Ans.

$$V = 5I_1 + 6I_2 \quad ...(1)$$
$$V_2 = 2I_1 + I_2 \quad ...(2)$$
$$V_2 = -5I_2 \text{ from fig.}$$



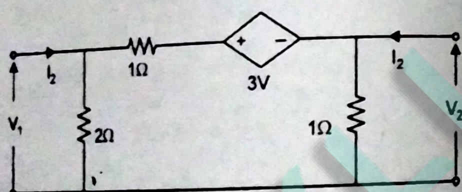
on putting this value in equation (2)

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

Putting the value of I_2 in equation (1)

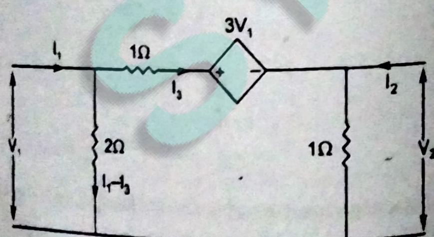
$$V_1 = 5I_1 + 6 \times -\left(\frac{I_1}{3}\right)$$
$$V_1 = 5I_1 - 2I_1$$
$$\boxed{Z_{in} = \frac{V_1}{I_1} = 3}$$

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



State whether it is reciprocal, symmetrical or not.

Ans.



$$V_1 = 2(I_1 - I_3)$$
$$I_3 + 3V_1 - 2(I_1 - I_3) - (I_2 + I_3) = 0$$
$$4I_3 - 2I_1 + I_2 + 3V_1 = 0$$
$$V_2 = I_2 + I_3$$

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

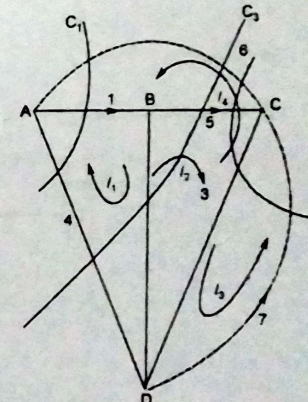
$$V_1 = 2I_1 - 2\left(\frac{I_1}{2} - \frac{I_2}{4} - \frac{3V_1}{4}\right)$$
$$V_1 = 2I_1 - I_2 \quad ...(4)$$
$$V_2 = I_2 + \frac{1}{4}(2I_1 - I_2 - 3V_1)$$
$$V = 2I_1 + \frac{3}{2}I_2 \quad ...(5)$$

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, ssuming (1, 2, 3) as set of twigs and (4, 5, 6, 7) as set of links, for the given oriented raph. (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

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

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

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

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

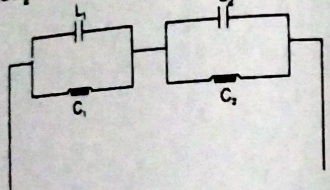
$$A_2 = \left.\frac{4s(s^2+4)}{(s^2+1)(s-4j)}\right|_{s=-4j} = 3.2$$

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

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

for faster I

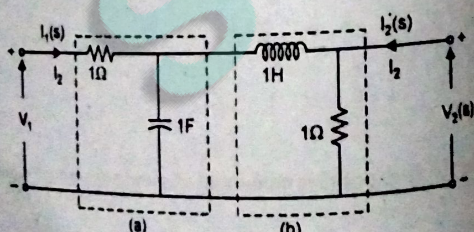
on comparing Z_1 and Z_2 with Z we get



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

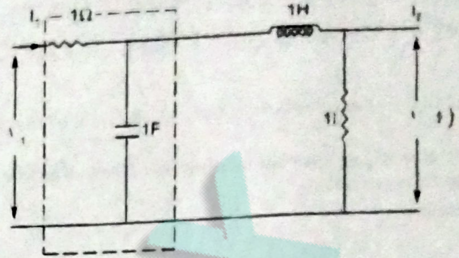
$$L_2 = .2\, c_2 = \frac{1}{3.2} \quad L = \frac{1}{16 \times C} = \frac{3.2}{16}$$

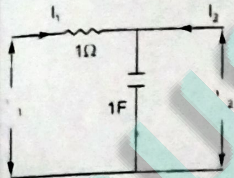
Q.4. (b) Obtain the Transmission parameters for the network shown using properties of inter-connection or otherwise. Check for reciprocity condition.



Ans.

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





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

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

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

$$I_1 = SV_2 - I_2' \quad \text{...(2)}$$

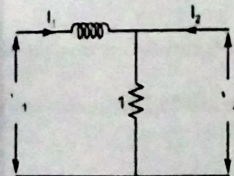
Putting the value of I_1 and in equation (1)

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

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

$$= (S+1)V_2 + I_2' - 1 \quad \text{...(3)}$$

From equation (3) and (2)



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

$$V_1 = SI_1 + (I_1 + I_2) \quad \text{...(1)}$$
$$V_2 = (I_2 + I_1)$$
$$I_1 = V_2 - I_2 \quad \text{...(2)}$$
$$V_1 = (S+1)(V_2 - I_2) + I_2$$
$$= (S+1)V_2 + I_2(1 - S - 1)$$
$$= (S+1)V_2 - I_2 S$$

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

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

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

Time : 3 hrs. M.M.

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 $= I\,R = 60 \sin 500\,\pi t$

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

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

$$E = PT$$

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

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

Ans.

$$X(S) \longrightarrow \boxed{H(s)} \longrightarrow Y(S)$$

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

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

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

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 $v = 99 \sin(6000t + 30°)$ 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

$$\cos\phi = .707$$

$$\phi = 45°$$

$$\text{Power} = VI\cos\phi$$

$$940 = 99 \times I \times .707$$

$$I = \frac{940}{99 \times .707} = 13.42$$

$$I = 13.42 \sin(6000t + 30 - 45)$$

$$= 13.42 \sin(6000t - 15)$$

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

Ans. θ = factor for parallel RLC

Let $V = V_m \sin \omega t$

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

inductor where $\omega_0 = \dfrac{1}{\sqrt{LC}}$

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

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

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

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

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

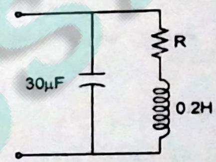
Q.3. (a) Find the rms value of $v = (10 + 14.4\cos\omega t + 3.55\sin 3\omega t)$ V. **(5)**

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 $x(t) = 10\cos 200\pi t$. Find the steady state output function amplitude frequency of the output waveform.

Ans.

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

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

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

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

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

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

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

Steady state output $s\to0$ 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) $\ddot{y}+3\dot{y}+2y = 3r$

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 $s = jw$

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

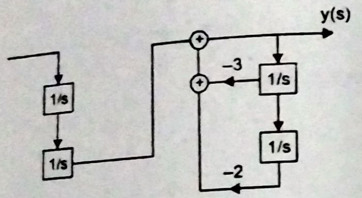
on rationalizing $\frac{3[(2-\omega^2)-3j\omega]}{(2-\omega^2)^2+(3\omega)^2} = \frac{3(2-\omega^2)-9j\omega}{4+\omega^4+3\omega^2}$

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

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

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

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



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
$$L(f(t)) = F(s)$$

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

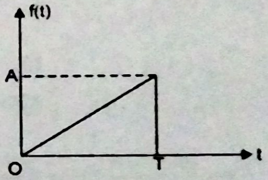
Proof
$$L\left[\frac{d}{dt}f(t)\right] = \int_0^{\infty}\frac{df(t)}{dt}e^{-st}dt$$

on integrating by parts

$$u = e^{-st} \text{ and } dv = d\,f(t)$$
$$du = -se^{-st} \text{ and } v = f(t)$$
$$\int u\,dv = vu - \int v\,du$$
$$= e^{-st}f(t)\Big|_0^{\infty} - \int_0^{\infty}f(t)(-se^{-st})dt$$
$$= e^{-st}f(t)\Big|_0^{\infty} + s\int_0^{\infty}f(t)e^{-st}dt$$
$$= -f(0^-)+s\,F(s)$$
$$L\left[\frac{d\,f(t)}{dt}\right] = sF(s)-x(0^-)$$

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

Ans.

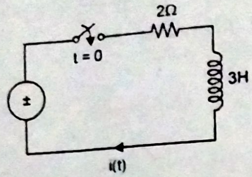


$$f(t) = \frac{A}{T}t[u(t)-u(t-T)]$$
$$= \frac{A}{T}+u(t)-\frac{A}{T}u(t-T)$$
$$= \frac{A}{T}tu(t)-\frac{A}{T}[(t-T)-u(t-T)+Tu(t-T)]$$

on taking LT

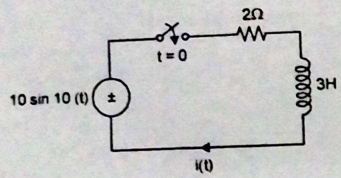
$$FS = \frac{A}{T}\frac{1}{s^2}-\frac{A}{T}\left[\frac{e^{-TS}}{s^2}+T\,e^{-TS}\right]$$

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



Ans. At $t = 0$

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



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

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

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

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

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

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

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

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

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

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); $\quad V_2 = V_s I_2 = I_2 V_1 = 0, I_1 = -I'_1$

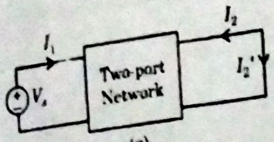
$$I'_1 = V_s\left(\frac{AD-BC}{B}\right)$$

Above discussion leads to the condition of reciprocity.

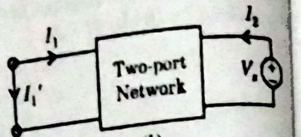
$$AD - BC = 1 \text{ or } \Delta T = 1$$

or

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



(a)



(b)

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); $V_1 = V_s, I_1 = I_1 I_2 = 0, V_2 = V_T$

$$V_s = Z_{11} I_1$$

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

As in figure 8.14 (b); $\quad V_2 = V_s, I_2 = I_T I_1 = 0, V_1 = V_T$

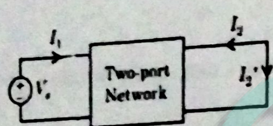
$$V_s = Z_{21} I_2$$

$$\left.\frac{V_s}{I_2}\right|_{I_1=0} = Z_{21}$$

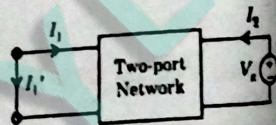
from the definition of symmetry,

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

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



(a)



(b)

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): $\quad V_1 = V_s, I_1 = I_1, V_2 = 0, I_2 = -I_2'$

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

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

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

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

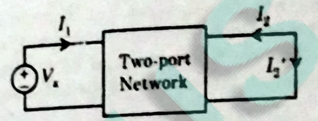
Therefore, $\quad 0 = -Z_{11} I_1' + Z_{12} I_2$

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

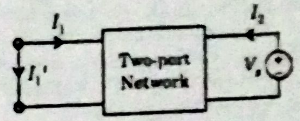
Hence $\quad I_1' = \dfrac{V_s Z_{12}}{Z_{11} Z_{22} - Z_{21} Z_{12}}$

Comparing I_2' and I_1', we get

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



(a)



(b)

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 $n - 1$.

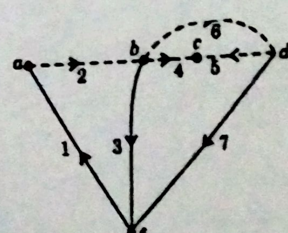
For a given graph it is possible to draw numerous trees. The tree branches are $(n - 1)$, which are called twigs. The remaining branches are called links. The branches of the graph which are not in the tree form the co-tree or complement of the tree. Link is any branch belonging to the co-tree. It is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

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

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

Condition (1): $T(s)$ must have no poles in the right half of *s*-plane, *i.e.*, Denominator $D(s)$ of $T(s)$ has a factor of the type $s^2 + a$; where a is positive real constant, imaginary 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 $j\omega$-axis are positive and real.

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

or $A(\omega^2) = M_1(j\omega).M_2(j\omega) - N_1(j\omega).N_2(j\omega) \ge 0$, for all ω

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

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

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

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

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

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

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*)

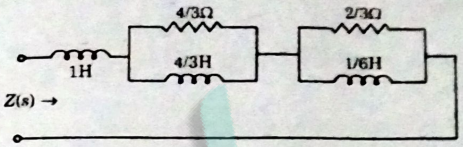


Fig. (*a*)

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.

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

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

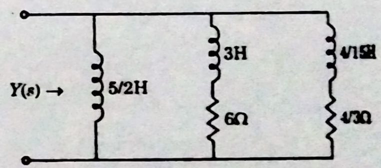


Fig. (*b*)

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

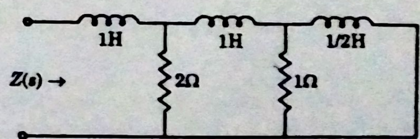


Fig. (c).

Caure-II form:

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

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

or

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*).

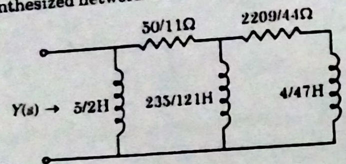


Fig. (*d*)

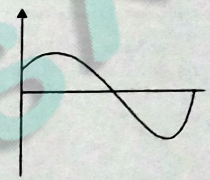
FIRST TERM EXAMINATION [SEPT. 2015]
THIRD SEMESTER [B.TECH]
CIRCUIT AND SYSTEMS

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

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

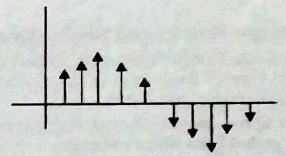
Q.1. (*i*) What are Continuous - time and Discrete-time Signals? (10 × 1 = 0)

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

$$g_{t_0t_1}(t) = \begin{cases}1 & t_0<t<t_1 \\ 0 & 0w\end{cases} = u(t-t_0) - u(t-t_1)$$

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.

$$\text{sign}(t) = \begin{cases}1 & t \geq 0 \\ -1 & t<0\end{cases}$$

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.

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

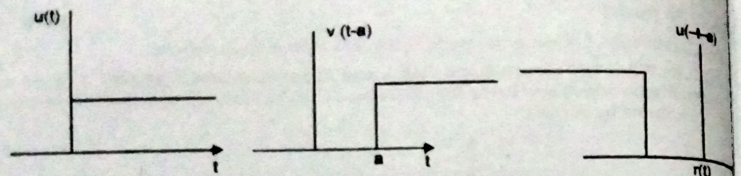
Q.1. (*vii*) What are the advantages of Laplace Transform technique?

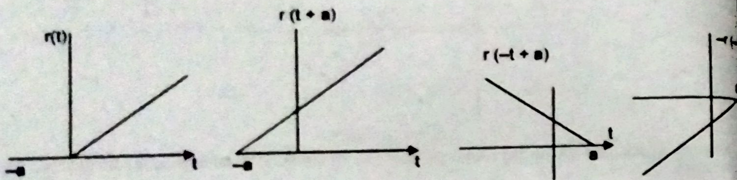
Ans. (*i*) The homegenous equation and the particular integral of the solution are obtained in one operation.

(*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?

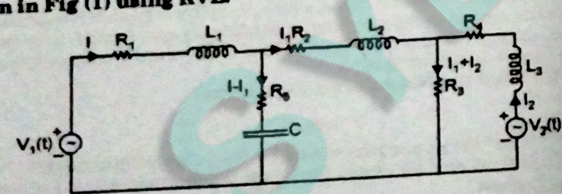
Ans. If the systems contain only resistance Induction or capacitance for C system is known as single energy transient. If the system contain L and C both system is known as deouble energy transient.

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

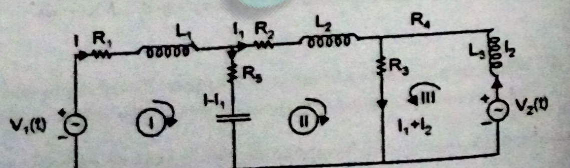
Ans.

$$i(t) = \frac{1}{R}e^{-\frac{1}{0}/R_C}$$

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



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

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

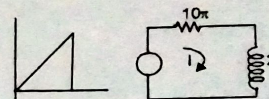
On Applying KVL is loop III

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

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

Ans.

$t[u(t) - u(t-5)]$



Applying KVL

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

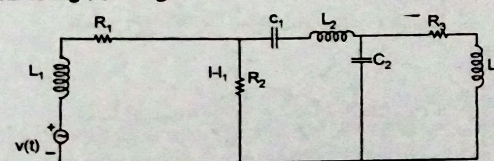
taking L.T

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

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

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

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



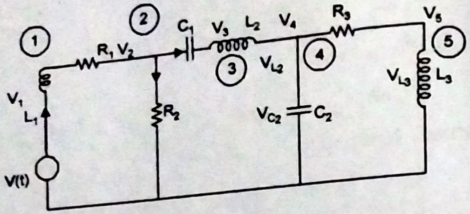
Ans.

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

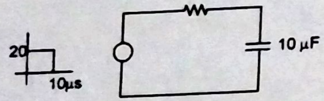
$$\frac{1}{L_2}\int (V_3 - V_4)dt = C_2\frac{dV_4}{dt} + \frac{V_4 - V_5}{R_3}$$

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 ap a series R-C Circuit. Determine the current in the circuit. Assume t circuit is initially relaxed. The value of R-10 Ω and C = 10 μF.

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

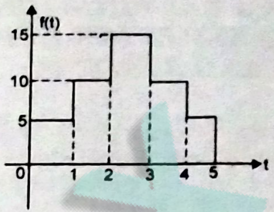
$$20\left\{\frac{1}{s} - \frac{e^{-10s}}{s}\right\} = 10I(s) + 10^5\frac{I(s)}{s}$$

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

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

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

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

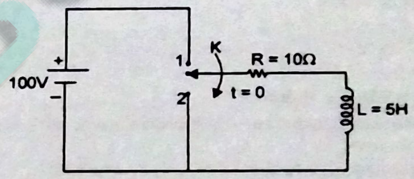


Ans. $f(t) = 5\,(u(t) - u(t-1)] + 10\,[u(t-1) - u(t-2)] + 15\,[u(t-2) - u(t-3)] + 10\,[u(t-3) - u(t-4)] + 5\,[u(t-4) - u(t-5)]$

Q.4. (*b*) The Switch in the circuit shown in Fig (3) is kept in position-1 r a sufficiently long time so that the Steady State Conditons are attained the circuit. The switch 'K' is moved to position-2 at t = 0 sec. Obtain expression for the circuit for any time, t ≥ 0. Use Leplace transform thod. (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 $10 = Ae^{0}$

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

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

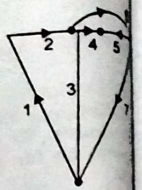
SECOND TERM EXAMINATION [NOV. 2015]
THIRD SEMESTER [B.TECH]
CIRCUITS AND SYSTEMS

Time. 1.30 Hours M.M.

Note: Question No.1 is compulsory and attempt any two from the rest. (10x1 =

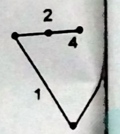
Q.1. (i) What is an Oriented Graph? Explain with an example.

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 (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 ba 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 trans 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 a 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

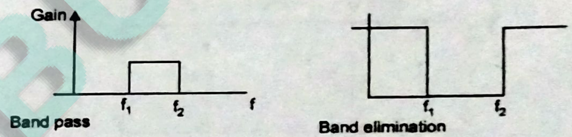
(3) T(S) may have pole on Jw axis

(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)

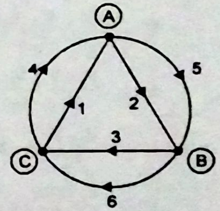
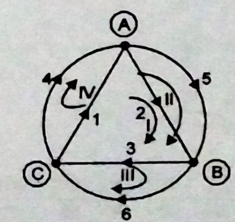
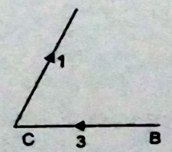


Fig. 1

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 in Fig.2.

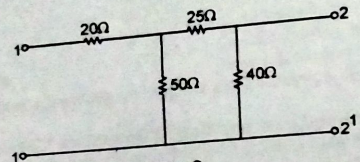
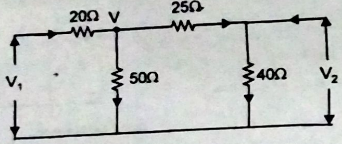


Fig. 2

Ans.



$$\frac{V_1 - V}{20} = \frac{V}{50} + \frac{V - V_2}{25}$$

$$I_1 = \frac{V}{50} + \frac{V - V_2}{25}$$

$$I_2 = \frac{V_2 - V}{25} + \frac{V_2}{40}$$

$$I_1 = \frac{V_1 - V}{20} \Rightarrow -20I_1 + V_1 = V$$

$$I_1 = \frac{V_1 - 20I_1}{50} + \frac{V_1 - 20I_1 - V_2}{25}$$

$$I_1 + \frac{20I_1}{50} + \frac{20I_1}{25} = \frac{V_1}{50} + \frac{V_1 - V_2}{25}$$

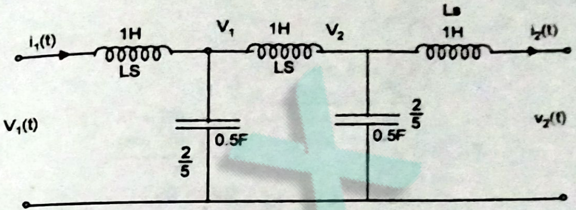
$$\frac{110I_1}{50} = \frac{3V_1}{50} - \frac{V_2}{25}$$

$$I_1 = \frac{3V_1}{110} - \frac{V_2}{55}$$

Putting the value of I_1 in equation (3)

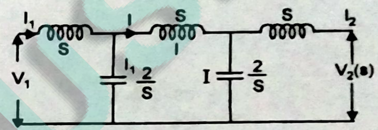
$$I_2 = V_2\left(\frac{1}{25} + \frac{1}{40}\right) - \frac{1}{25}\left(\frac{20V_2}{55} - \frac{60V_1}{110}\right)$$

Q.3. (a) Find G_{21} (S) for the circuit shown in Fig.3. **(5)**



(Fig.3)

Ans.



$$G_{21}(s) = \frac{V_2(s)}{V_1(s)} \text{ at } I_2 = 0$$

$$Z_{eq}(s) = \frac{\left(s + \frac{2}{s}\right)\frac{2}{s}}{\left(s + \frac{2}{s} + \frac{2}{s}\right)} + s$$

$$= \frac{\frac{2(s^2+2)}{\cancel{s^2}}}{\frac{s^2+4}{\cancel{s}}} + s$$

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

$$I_1 = \frac{V_1}{\frac{s^4+6s^2+4}{s(s^2+4)}} = \frac{s(s^2+4)}{s^4+6s^2+4}V_1$$

$$I = \frac{\frac{2}{s} \times I_1}{\left(s + \frac{4}{s}\right)} = \frac{\frac{2}{s}\left(\frac{s(s^2+4)}{(s^4+6s^2+4)}\right)V_1}{\left(s + \frac{4}{s}\right)}$$

$$V_2 = \frac{2}{s} \times I = \frac{2}{s} \times \frac{\frac{2}{s}\left(\frac{s(s^2+4)}{s^4+6s^2+4}\right)}{(s+4/s)}V_1$$

$$\frac{V_2}{V_1} = \frac{4(s^2+4)}{(s^4+6s^3+4)(s^2+4)}$$

Q.3. (b) Test the polynomial $Q(S) = S^6 + 2S^5 + 6S^4 + 10S^3 + 9S^2 + 8S + 4$ for Hurwitz property.

Ans. $S^6 + 2S^5 + 6S^4 + 10S^3 + 9S^2 + 8S + 4$

$$2S^5 + 10S^3 + 8S \,\big)\, S^6 + 6S^4 + 9S^2 + 4 \,\big(\, \frac{1}{2}S$$
$$\underline{-S^6 + 5S^4 + \pm 4S^2}$$
$$S^4 + 5S^2 + 4 \,\big)\, 2S^5 + 10S^3 + 8S \,\big(\, 2S$$
$$\underline{2S^5 + 10S^3 + 8S}$$
$$\times$$

$$2S^5 + S^4 + 5S^2 + 4 + 10S^3 + 8S$$
$$(2S + 1)(S^4 + 5S^2 + 4)$$
$$(2S + 1) \text{ is hurtwitz}$$

$$4S^3 + 10S \,\big)\, S^4 + 5S^2 + 4 \,\big(\, \frac{4}{10}s$$
$$\underline{-S^4 \pm \frac{10}{4}S^2}$$
$$\frac{5}{2}S^2 + 4 \,\big)\, 4S^3 + 10S \,\big(\, \frac{8}{5}S$$
$$\underline{-4S^3 + \frac{32}{5}S}$$
$$\frac{18}{5}S \,\big)\, \frac{5}{2}S^2 + 4 \,\big(\, \frac{25}{36}$$
$$\underline{\frac{5}{2}S^2}$$
$$4 \,\big)\, \frac{18}{5}s \,\big(\, \frac{20}{18}$$
$$\underline{15S}$$
$$\times$$

all coefficent is the Positive So function is hurwitz.

Q.4. (a) Realize the following driving point impedance function (i) as a Foster Form and (ii) as a Second Foster of LC Networks.

$$Z(s) = \frac{S^3 + 4S}{2S^4 + 20S^2 + 18}$$

Ans. From the pole zero diagram

$$Z(s) = \frac{K(s^2+1)(s^2+9)}{s(s^2+4)}$$

By putting

$$Z(-2) = \frac{130}{16} = \frac{K.5.13}{-2.8} \text{ gives } K = 2$$

Therefore,

$$Z(s) = \frac{2(s^2+1)(s^2+9)}{s(s^2+4)}$$

(a) Foster -I Form:

$$S^3 + 4S \,\big)\, 2S^4 + 20S^2 + 18 \,\big(\, 2S$$
$$\underline{2S^4 + 8S^2}$$
$$12S^2 + 18$$

$$Z(s) = 2s + \frac{12s^2 + 18}{s(s^2+4)}$$

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).

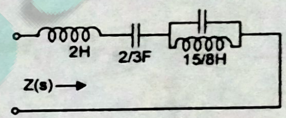


Fig. 1.(a)

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,

$$Y(s) = \frac{1}{2}\left[\frac{\frac{3}{8}s}{s^2+1} + \frac{\frac{5}{8}s}{s^2+9}\right]$$

$$= \frac{\frac{3}{16}s}{s^2+1} + \frac{\frac{5}{16}s}{s^2+9}$$

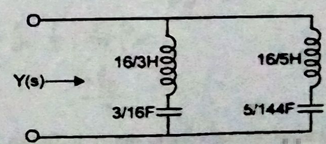


Fig. 1. (b)

Hence, synthesized network is shown in figure 1 (*b*).

(*b*) Cauer-I form:

$$Z(s) = \frac{2(s^2+1)(s^2+9)}{s(s^2+4)} = \frac{2s^4+20s^2+18}{s^3+4s}$$

The continued fraction expansion is

$$s^3+4s\,)\,2s^4+20s^2+18\,(\,2s \leftrightarrow Z_1$$
$$\underline{2s^4+8s^2}$$
$$12s^2+18\,)\,s^3+4s\,(\,\frac{1}{12}s \leftrightarrow Y_2$$
$$\underline{s3+\frac{3}{2}s}$$
$$\frac{5}{2}s\,)\,12s^2+18\,(\,\frac{2}{5}\times 12s = \frac{24}{5}s \leftrightarrow Z_3$$
$$\underline{12s^2}$$
$$18\,)\,\frac{5}{2}s\,(\,\frac{1}{18}\cdot\frac{1}{18}s = \frac{1}{18}s \leftrightarrow Y_4$$
$$\underline{\frac{5}{2}s}$$
$$\times$$

Therefore, the final synthesized network is shown in figure 1. (*c*).

Cauer-II form:

$$Z(s) = \frac{2s^4+20s^2+18}{s^3+4s}$$

$$= \frac{18+20s^2+2s^4}{4s+s^3}$$

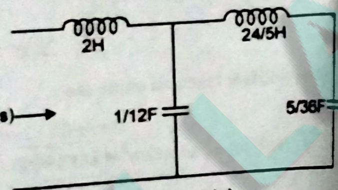


Fig. 1(*c*)

The Continued fraction expansion is

$$4s+s3\,)\,18+20s^2+2s^4\,(\,\frac{18}{4s} = \frac{9}{2s} \leftrightarrow Z_1$$
$$\underline{18+\frac{9}{2}s^2}$$
$$\frac{31}{2}s^2+2s^4\,)\,4s+s^3\,(\,\frac{2}{31}\cdot\frac{4}{5} = \frac{8}{31S} \leftrightarrow Y_2$$
$$\underline{4s\frac{16}{13}s^3}$$
$$\frac{15}{31}s^3\,)\,\frac{31}{2}s^2+2s^4\,(\,\frac{31}{15}\cdot\frac{31}{2s} = \frac{961}{30s} \leftrightarrow Z_3$$
$$\underline{\frac{31}{2}s^2}$$
$$2s^4\,)\,\frac{15}{31}s^3\,(\,\frac{1}{2}\cdot\frac{15}{31s} = \frac{15}{62s} \leftrightarrow Y_4$$
$$\underline{\frac{15}{31}s^3}$$
$$\times$$

... synthesized network is shown in figure 1 (*d*).

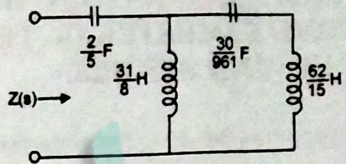
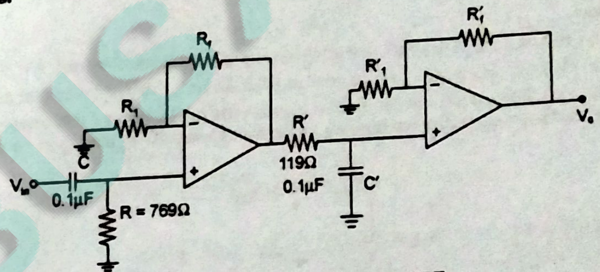


Fig. 1 (*d*)

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

$$2\times 10^3 = \frac{1}{2\pi \times R \times 0.1\mu F}$$

$$\therefore \quad R = \frac{1}{2\times 3.14\times 2\times 10^3\times 0.1\times 10^{-6}} = 796\Omega$$

Aslo

$$8\text{KHz} = \frac{1}{2\pi RC}$$

$$\therefore \quad R = \frac{1}{2\times 3.14\times 8\times 10^3\times 0.1\times 10^{-6}}$$

$$R = 199\ \Omega$$

END TERM EXAMINATION [DEC. 2015]
THIRD SEMESTER [B. TECH]
CIRCUIT AND SYSTEM

Time: 3 Hrs. **MM : 7**

Note: *Attempt any five question including Q no. 1. which is compulsory. Select one ques from each unit.*

Q.1. (a) Determine the following systems are LT1, causal or not.

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

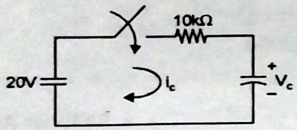
(ii) $y(n) = \sum_{k=n_0}^{n+n_0} x(k)$

Ans.
$$y(t) = t^2 x(t-1)$$

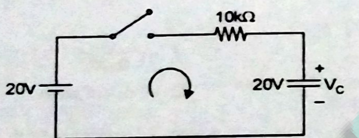
(i) Present output depends on only past input so system is causal.

(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 equations for capacitor voltage and current. Compute v_c and i_c at $t = 50$ ms.



Ans.



$$20 = 10^4 I + \frac{1}{C}\int I\,dt$$

On differentiating we get

$$\frac{1}{C}I + 10^4\frac{dI}{dt} = 0$$

$$\frac{dI}{dt} + \frac{1}{10^4 C}I = 0$$

$$I = Ae^{\frac{t}{10^4 c}}$$

at
$$t = 0 \quad I = \frac{20}{10^4} = 2\times10^{-3}A$$

$$V = \frac{1}{C}\int I\,dt = \frac{1}{C}\int Ae^{-t/10^4 C}dt$$

Putting the value of initial condition we get

$$A = 2\times10^{-3}A$$

$$I = 2\times10^{-3}e^{\frac{-t}{10^4 C}}$$

Q.1. (c) Find Laplace transform of $\frac{1}{4}t\sin(2t)\,u(t)$. **(5)**

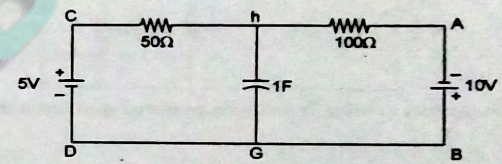
Ans. LT $\sin 2t \rightarrow \dfrac{2}{s^2+2^2}$

Applying differentiation property we get

$$\text{LT of } t\sin 2t \rightarrow -\frac{d\left(\frac{2}{s^2+2^2}\right)}{ds} = \frac{2s\times2}{(s^2+4)^2} = \frac{4s}{(s^2+4)^2}$$

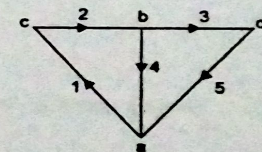
$$\text{So LT of } \frac{1}{4}t\,\sin 2t = \frac{s}{(s^2+4)^2}.$$

Q.1. (d) For the following circuit draw directed graph and write incidence matrix. **(5)**



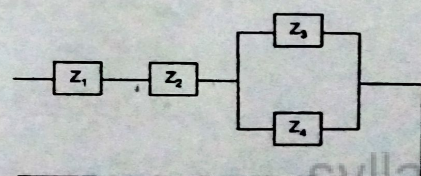
Ans.

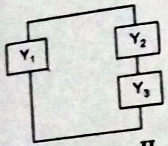
	1	2	3	4	5
a	1	0	0	–1	–1
b	0	–1	1	1	0
c	–1	1	0	0	0
d	0	0	–1	0	1



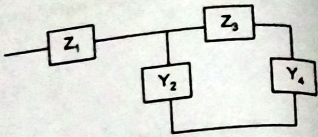
Q.1. (e) Write down Foster I, II and Caur I, II forms of circuit synthesis. **(5)**

Ans. Foster I.





Foster II



Cauer I and II

UNIT-I

Q.2. (a) Find E_∞ for the signal $x(t) = \delta(t+2) - \delta(t-2)$.

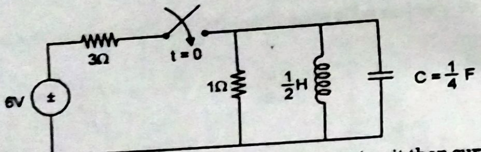
Ans.

$$x(t) = \delta(t+2) - \delta(t-2)$$

$$E = \int |x(t)|^2\, dt = \int_{-\infty}^{\infty} (\delta^2(2t+2) + \delta^2(t-2) - 2\delta(t+2)(\delta-2)dt = 1+1 = 2$$

Q.2. (b) Switch of the following circuit is opened at $t = 0$ after a long Write expression for $v(t)$ at $t > 0$.

Ans.



$t < 0$ inductor work as short circuit and capacitor as open circuit then current t 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.

$$\frac{1}{4}\frac{d^2v_c}{dt} = 2\,v_c + \frac{dv_c}{dt}$$

$$\frac{d^2v_c}{dt} - 4\frac{dv_c}{dt} - 8\,v_c = 0$$

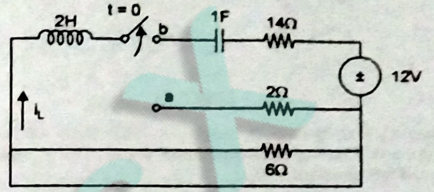
$$v_c = Ae^{-(2+2\sqrt{3})t} + Be^{-(2-2\sqrt{3})t}$$

$$\alpha, \beta = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

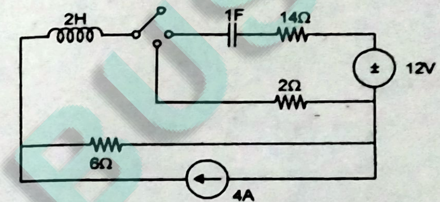
$$= \frac{4 \pm \sqrt{16 - 4\times 1 \times -8}}{2}$$

$$= \frac{4 \pm \sqrt{48}}{2} = 2(1 \pm \sqrt{3}).$$

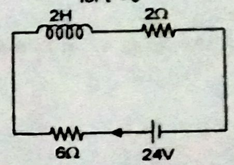
Q.3. For the following circuit switch is moved from position (a) to (b) at $t = 0$. Then find $i_1(t)$ for $t > 0$. (12.5)



Ans.



for t < 0



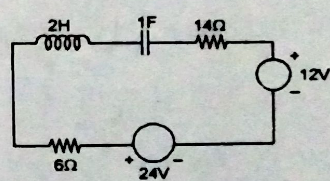
Inductor work as short circuit

$$I = \frac{24}{8} = 3\,A$$

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

$$2\frac{d^2I}{dt^2} + 20\frac{dI}{dt} + I = 0$$

$$\frac{d^2I}{dt^2} + 10\frac{dI}{dt} + .5I = 0$$

$$I = A\,e^{-0.05t} + B\,e^{-9.97t}$$

$$\alpha, \beta = \frac{-10 + \sqrt{100 - 4 \times 5}}{2}$$

$$= \frac{-10 \pm \sqrt{98}}{2} = -5 \pm \frac{7}{2}\sqrt{2} = .036 \;\; -9.97$$

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 switches are closed are 1 and 2V respectively. **(12...**

(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

$$\frac{4}{s} = 2I_1(s) + \frac{I_1(s)}{s} + 2I_2(s)$$

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

$$\left[I_1(s)\left(2 + \frac{1}{5}\right) + 2\,I_2(s) = \frac{4}{s}\right] \times 2$$

or

$$\left[I_1(s)\,2 \pm \left(2 + \frac{1}{s}\right) I_2(s) = \frac{2}{s}\right]\left(2 + \frac{1}{s}\right)$$

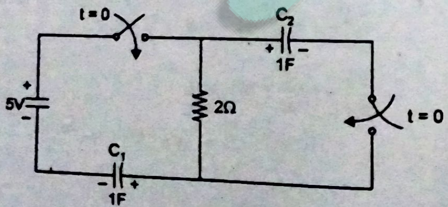
$$\left[4 - \left(2 + \frac{1}{s}\right)^2\right] I_2(s) = \frac{8}{s} - \frac{4}{s} - \frac{2}{s^2}$$

$$I_2(s) = \frac{\frac{4s-2}{s^2}}{4 - 4 - \frac{2}{s} - \frac{1}{s^2}} = \frac{\frac{12\,s+2}{s^2}}{\frac{8s^2 + 2s + 1}{s^2}} = \frac{12s+2}{8s^2 + 2s + \ldots}$$

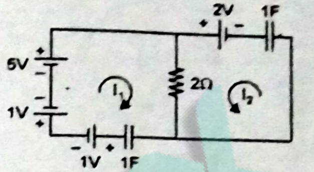
$$= \frac{2(s-1)}{-(2s+1)}$$

$$I_1(s) = \frac{8}{5} +$$

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

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

$$A = \frac{2}{(s+3)(s+1)}(s+3)\Big|_{s=-3} = \frac{2}{-2} = -1$$

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

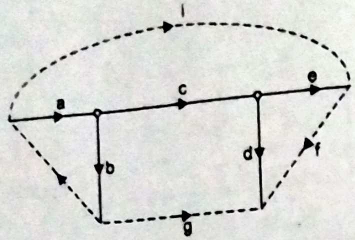
$$X(s) = \frac{-1}{s+3} + \frac{1}{s+1} + \frac{-se^{-2s}}{s+3} + \frac{se^{-2s}}{s+1} - \frac{2e^{-4s}}{s+3} + \frac{2e^{-4s}}{s+1}$$

taking ILT

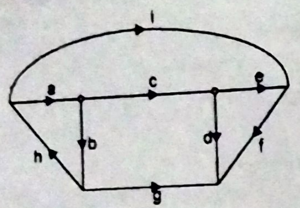
$$r(t) = -e^{-3t} + e^{-t} - e^{-3(t)}$$

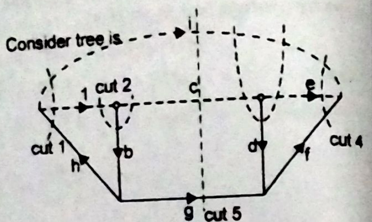
UNIT-III

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.

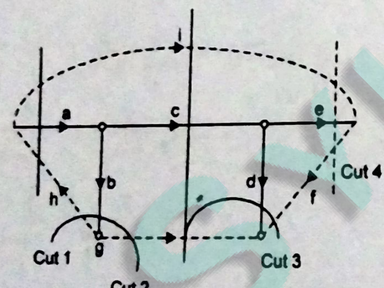




Twig are h, b, g, d, f

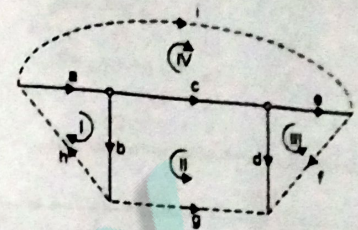
Link are a, c, e, i

	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

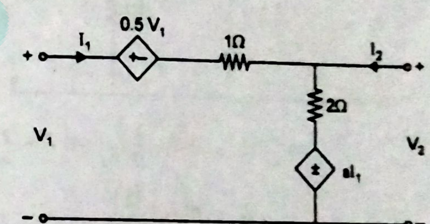
	a	b	c	d	e	f	g	h	i
cut 1	1	0	0	0	0	0	0	–1	1
cut 2	0	1	0	0	0	0	–1	–1	0
cut 3	0	0	0	1	0	–1	1	0	0
cut 4	0	0	0	0	1	1	0	0	1
cut 5	0	0	1	0	0	0	1	0	1



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)**



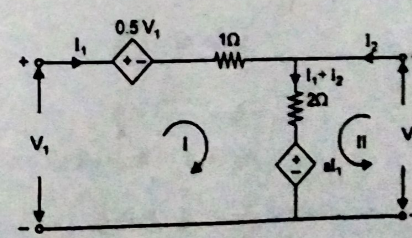
Ans.

On applying KVL in loop *I*

$$V_1 - 0.5V_1 - aI_1 = I_1 + 2(I_1 + I_2)$$

$$.5\,V_1 = (3 + a)\,I_1 + 2\,I_2$$

$$V_1 = (6 + 2a)\,I_1 + 4\,I_2 \quad \text{...(1)}$$



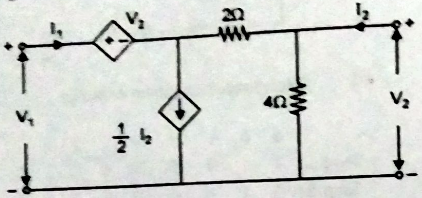
Applying KVL in loop 2

$$V_2 = 2(I_1+I_2)+aI_1$$
$$V_2 = (2+a)I_1+2I_2$$
$$z_{11} = (6+2s) \quad z_{12} = 4$$
$$z_{21} = 2+a \quad z_{22} = 2$$

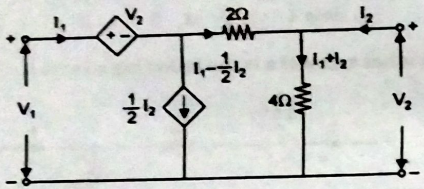
for Reciprocity

$$z_{12} = z_{21}$$
$$2+a = 4 \Rightarrow a = 2$$

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.

$$V_1-V_2 = 6I_1+\frac{V_2}{2}-2I_1$$
$$V_1 = 4I_1+\frac{3}{2}V_2$$
$$I_2 = \frac{-4I_1}{2}+\frac{V_2}{2}$$
$$h_{11} = 4 \qquad h_{21} = -2$$
$$h_{12} = \frac{3}{2} \quad h_{22} = \frac{1}{2}$$

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 $s \rightarrow j\omega$

$$= \omega^4 + 13\,\omega^2 + 24$$

this is alwags +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.

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

$s^2 + s + 1 \,)\, s^2 + 2s + 2 \,(\, 1 \leftrightarrow Z_1$

$\quad\; \underline{s^2 + s + 1}$

$\qquad s + 1 \,)\, s^2 + s + 1 \,(\, s \leftrightarrow Y_2$

$\qquad\qquad \underline{s^2 + s}$

$\qquad\qquad\quad 1 \,)\, s + 1 \,(\, s \leftrightarrow Z_3$

$\qquad\qquad\qquad \underline{s}$

$\qquad\qquad\qquad 1 \,)\, 1 \,(\, s \leftrightarrow Y_4$

$\qquad\qquad\qquad\quad \underline{1}$

$\qquad\qquad\qquad\quad X$

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 symmatry

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

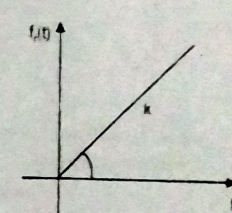
1. Step Signal: $f_s(t)$ is defined by

$$f_s(t) = \begin{cases} O; t < O \\ K; t > O \end{cases}$$

where K is the amplitude of step signal

2. Ramp Signal: $f_r(t)$ is defined by

$$f_r(t) = \begin{cases} O \;;\; t < O \\ Kt \;;\; t \geq O \end{cases}$$

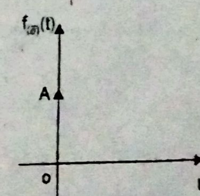


K is the slope of ramp signal.

3. Impulse Signal: $f_\delta(t)$ is defined by

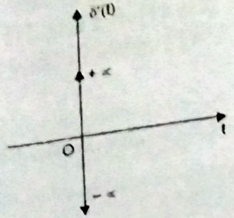
$$f_\delta(t) = \begin{cases} O \;;\; t \neq O \\ A \;;\; t \geq O \end{cases}$$

where A is the area of impulse signal.



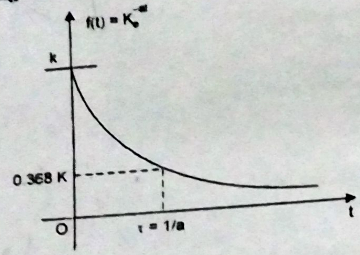
Other Basic Signals

1. Unit Doublet Signal: It a unit impulse signal $\delta(t)$ is differentiated with respect t, we get



$$\delta'(t) = \frac{d}{dt}[(\delta t)] = +\infty \text{ and } -\infty; \; t = O$$
$$= O; \quad t \neq 0$$

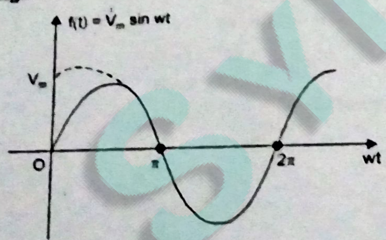
2. Exponential Signal



$$f(t) = \begin{cases} O & ; \; t \le O \\ K_e^{-at} & ; \; t \ge O \end{cases}$$

where a and k are real constants.

3. Sinusoidal Signal



$$f(t) = \begin{cases} O & ; \; t < 0 \\ V_m \sin wt & ; \; t \ge O \end{cases}$$

Q.1. (b) Draw the waveform of the signal represented by the mathe equation $V(t) = 2tu(t) - 2(t-1)\,u(t-1) - 2u(t-3)$ and find its L 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 $u(t) = 1$ and $u(t-1) = u(t-3) = 0$

Then $V(t) = 2t$

If $1 < t < 3$

$u(t) = u(t-1) = 1$ and $u(t-3) = 0$

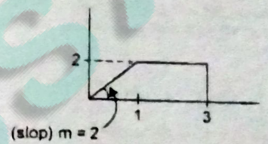
$V(t) = 2t - 2t + 2 = 2$

When $t > 3$

$u(t) = u(t-1) = u(t-3) = 1$

$V(t) = 2t - 2t + 2 - 2 = 0$

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

$$y(t) = K\,x(t) \qquad \text{(where } K \text{ is any constant)}$$

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) $e^{at} \sin(\omega t)$ (ii) $10u(t-1) - \delta(t-2) - 5\delta(t-3)$.

Ans. Laplace Transform

(i) $e^{at}(\sin \omega t)$

As we know the LT of $\sin \omega t = \dfrac{\omega}{s^2 + \omega^2}$

$$e^{at} \sin \omega t \xrightarrow{LT} \frac{\omega}{(s-a)^2 - \omega^2}$$

Property

$$\begin{bmatrix} f(t) \xrightarrow{LT} F(s) \\ e^{at} f(t) \longrightarrow F(s-a) \end{bmatrix}$$

(ii) $f(t) = 10u(t-1) - \delta(t-2) - 5\delta(t-3)$

$$u(t-1) \xrightarrow{LT} \frac{e^{-s}}{s}$$

Property

$$\begin{bmatrix} f(t) \longrightarrow F(s) \\ f(t-a) \longrightarrow e^{-as} F(s) \end{bmatrix}$$

$$\delta(t-2) \xrightarrow{LT} e^{-2s}$$

$$\delta(t-3) \xrightarrow{LT} e^{-3s},$$

$$f(t) \xrightarrow{LT} 10\frac{e^{-s}}{s} - e^{-2s} - 5e^{-3s}$$

Q.3. (a) Write the mathematical equation for the waveform shown in Fig. using Signal Synthesis Concept and find its Laplace Transformation. (4)

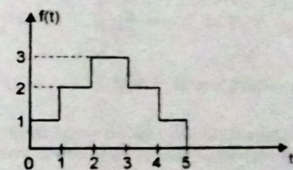
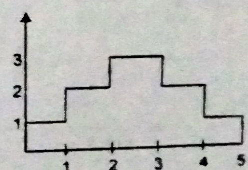


Fig. 1.

Ans.



$$f(t) = u(t) + u(t-1) + u(t-2) - u(t-3) - u(t-4) - u(t-5)$$

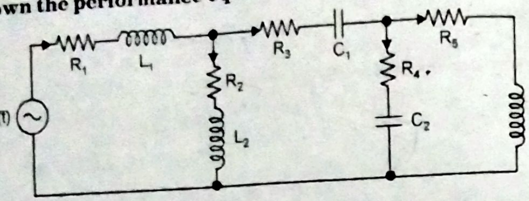
$$f(t) \xrightarrow{LT} \frac{1}{s} + \frac{e^{-s}}{s} + \frac{e^{-2s}}{s} - \frac{e^{-3s}}{s} - \frac{e^{-4s}}{s} - \frac{e^{-5s}}{s}$$

As we know $u(t) \xrightarrow{LT} \dfrac{1}{s}$

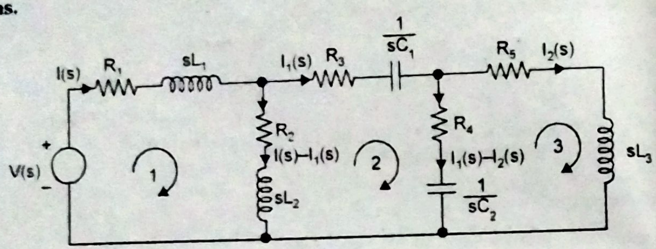
$$f(t-a) \longrightarrow e^{-as} F(s)$$

So $\quad u(t-a) \longrightarrow \frac{e^{-as}}{s}$

Q.3. (b) Draw the s-domain equivalent circuit for the circuit shown in Fig. and write down the performance equations using KVL.



Ans.



Applying KVL in loop 1, 2 and 3

In loop 1: $\quad V(s) = R_1 I + sL_1 I + (R_2 + sL_2)(I - I_1)$

In loop 2: $\quad (R_2 + L_2 s)(I - I_1) = \left(R_3 + \frac{1}{sC_1}\right)I_1 + \left(R_4 + \frac{1}{C_2 s}\right)(I_1 - I_2)$

In loop 3: $\quad \left(R_4 + \frac{1}{sC_2}\right)(I_1 - I_2) = (R_5 + sL_3)I_2.$

Q.4. (a) Obtain an expression for the current in the indctor for any time > 0, in the circuit shown in Fig. 3 using Laplace Transformation. Assume circuit to be initially relaxed.

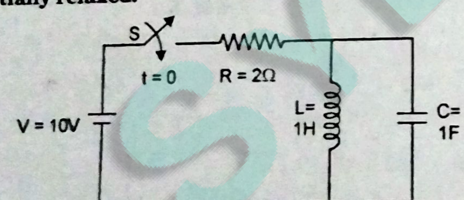
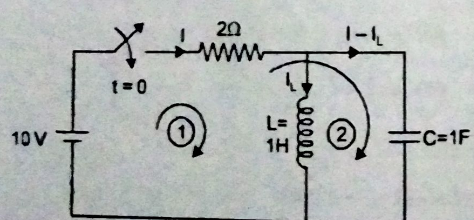


Fig. 3

Ans.



Applying KVL in loop 1 and 2

$$10 = 2I + 1\frac{dI_L}{dt}$$

Taking LT: $$\frac{10}{s} = 2I(s) + sI_L(s) I_L(0^+) \quad ...(1)$$

$$\frac{10}{s} = 2I + sI_L$$

$$10 = 2I + \frac{1}{C}\int (I - I_L)dt \quad ...(1a)$$

Taking LT: $$\frac{10}{s} = 2I + \frac{I - I_L}{s} \quad ...(2)$$

$$\frac{10}{s} = \left(2 + \frac{1}{s}\right)I - \frac{I_L}{s} \quad ...(2a)$$

$$= \left(sI_L + 2I = \frac{10}{s}\right) \times \left(2 + \frac{1}{s}\right)$$

$$\left(\frac{-I_L}{s} + \left(2 + \frac{1}{s}\right)I + \frac{10}{s}\right) \times 2$$

$$\left[\left(2 + \frac{1}{s}\right)s + \frac{2}{s}\right]I_L = \frac{20}{s} + \frac{10}{s^2} - \frac{20}{s}$$

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

$$I_L = \frac{10}{s(2s^2 + s + 2)}$$

Q.4. (b) Determine the current $i(t)$ in the circuit shown in Fig. 4 using Laplace Transformation. **(5)**

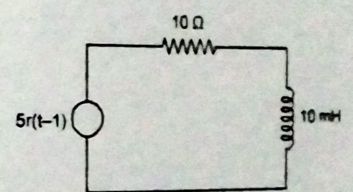
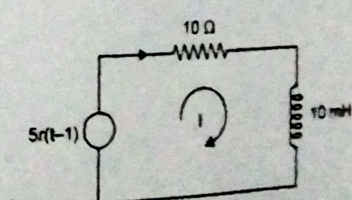


Fig. 4

Ans.



$$5r(t-1) = 10I + 10 \times 10^{-3}\frac{dI}{dt}$$

Taking LT $\quad \frac{5e^{-s}}{s^2} = 10I(s) + 10^{-2}sI(s)$

$$\Rightarrow \quad I(s) = \frac{5e^{-s}}{s^2(10^{-2}s+10)} = \frac{500e^{-s}}{s^2(s+1000)}$$

Now ILT: $\quad \frac{1}{s^2(s+1000)} = \frac{A}{s} + \frac{B}{s^2} + \frac{C}{s+1000}$

$$B = \frac{1}{1000} \qquad C = \frac{1}{10^6}$$

$$\frac{1}{s^2(s+1000)} \xrightarrow{LT} Au(t) + Btu(t) + Ce^{-1000t}$$

Finally: $\quad \frac{500e^{-s}}{s^2(s+1000)} \xrightarrow{LT} 500Au(t-1) + 500B(t-1)u(t-1) + 500C\,e^{-1000}$

Put the value of A, B, C, we get I.

END TERM EXAMINATION [DEC. 2016]
THIRD SEMESTER [B.TECH]
CIRCUIT AND SYSTEM [ETEC-207]

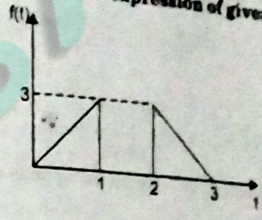
Time : 3 Hrs. **M.M. : 75**

Note: *Attempt any five questions including Q. no. 1 which is compulsory. Select one question from each unit. Assume suitable missing data if any.*

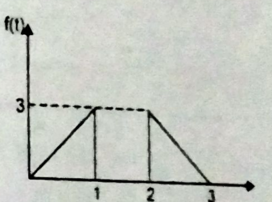
Q.1. (a) What is LTI system and describe their properties in brief. **(5×5=25)**

Ans. Refer Q.2. (a) Mid Term Examination 2016.

Q.1. (b) Write the mathematical expression of given waveform.

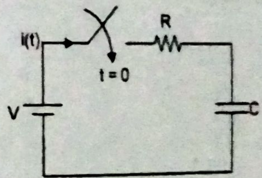


Ans.

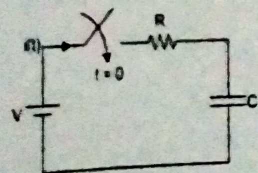


$$f(t) = 3t[u(t) - u(t-1)] + (9-3t)[u(t-2) - u(t-3)]$$

Q.1. (c) Find the current $i(t)$ in the given network using Laplace technique.



Ans.



$$V = IR + \frac{1}{C}\int i\,dt$$

$$\frac{V}{s} = IR + \frac{1}{C}\left[\frac{I(s)}{s} - \frac{I'(0)}{s}\right]$$

$$\frac{V}{s} = IR + \frac{I}{Cs}$$

$$\Rightarrow \quad I = \frac{V}{s\left(\frac{1}{Cs}+R\right)} = \frac{CV}{CRs+1} = \frac{V}{R}\left(\frac{1}{s+\frac{1}{RC}}\right)$$

$$I(t) = \frac{V}{R}e^{-\frac{1}{RC}t}$$

...(1)

...(2)

Q.1. (d) Find T parameter in terms of g parameter.

Ans.

$$V_1 = AV_2 + B(-I_2)$$

$$I_1 = CV_2 + D(-I_2)$$

$$V_2 = \frac{1}{A}V_1 + \frac{B}{A}I_2$$

$$g_{21} = \frac{1}{A} \text{ and } g_{22} = \frac{B}{A}$$

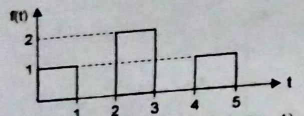
Putting the value of V_2 in equation (2)

$$I_1 = C\left[\frac{1}{A}V_1 + \frac{B}{A}I_2\right] + D(-I_2) = \frac{C}{A}V_1 + \left(\frac{BC}{A} - D\right)I_2$$

$$g_{11} = \frac{C}{A} \text{ and } g_{12} = \frac{B}{A}$$

UNIT-I

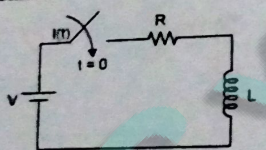
Q.2. (a) Synthesis the given waveform using gate signal.



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)



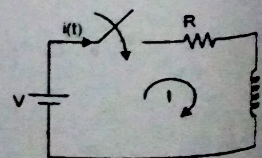
Ans.

Applying KVL $\quad V = IR + L\frac{dI}{dt} \quad \frac{dI}{dt} + \frac{R}{L}I = \frac{V}{L}$

C.F. $\quad D + \frac{R}{L} = 0$

$$I_c(t) = Ae^{-\frac{R}{L}t}$$

$$\text{PI} = \left.\frac{\frac{V}{L}}{D + \frac{R}{L}}\right|_{D=0} = \frac{V}{R}$$



$$i(t) = Ae^{-\frac{R}{L}t} + \frac{V}{R}$$

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)

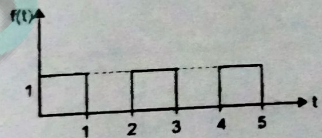
Ans. Refer Q. 1 (*a*) of Mid Term 2016.

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)

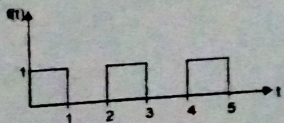


Ans.

$$f(t) = [u(t) - u(t-1)] + [u(t-2) - u(t-3)] + [u(t-4) - u(t-5)] + \ldots$$

$$\text{Taking LT: } F(s) = \frac{1}{s} - \frac{e^{-S}}{s} + \frac{e^{-2S}}{s} - \frac{e^{-3s}}{s} + \frac{e^{-4s}}{s} - \frac{e^{-5s}}{s} + \ldots$$

$$= \frac{1}{s}[1 - e^{-s} + e^{-2s} - e^{-3s} + e^{-4s} - e^{-5s} + \ldots]$$



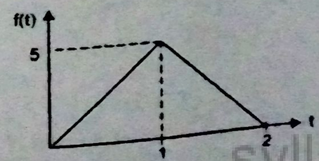
$$F(S) = \frac{1}{s} \times \frac{1}{1 + e^{-s}}.$$

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)



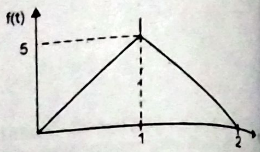
Ans.

$$f(t) = 5[t(u(t) - u(t-1))] + (2-t)\,[u(t-1) - u(t-2)]$$

$$f(t) = 5[tu(t) - tu(t-1) + 2u(t-1) - 2u(t-2) - tu(t-1) + tu(t-2)]$$

$$= 5[tu(t) - 2(t-1)\,u(t-1) + (t-2)\,u(t-2)]$$

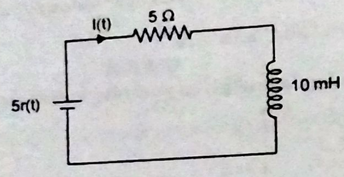
$$= 5[r(t) - 2r(t-1) + r(t-2)]$$



$$F(S) = 5\left[\frac{1}{s^2} - \frac{2e^{-s}}{s^2} + \frac{e^{-2s}}{s^2}\right]$$

$$= \frac{5}{s^2}\,[1 - 2e^{-s} + e^{-2s}].$$

Q.5. (b) Find the current in given network using laplace transform technique. (6.5)

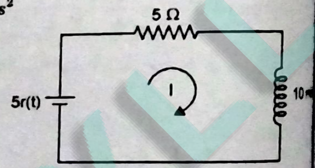


Ans.

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

Taking LT: $\frac{5}{s^2} = 5I + 10^{-2}\,sI$

$$\Rightarrow \quad I = \frac{5}{s^2(5 + 10^{-2}s)} = \frac{500}{(5+500)s^2}$$



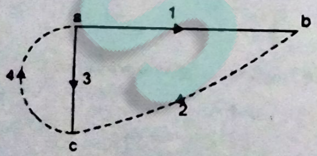
$$I(s) = \frac{A}{s} + \frac{B}{s^2} + \frac{C}{s+500}$$

$$B = 1 \quad C = \frac{1}{500} \quad A = \text{Find}$$

$$I(t) = Au(t) + tu(t) + \frac{1}{500}e^{-500t}$$

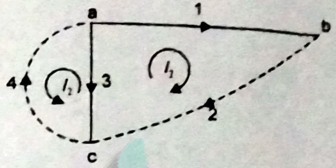
UNIT-II

Q.6. (a) Determine f-tie set matrix for given graph.

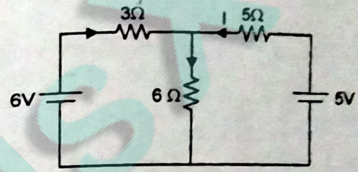


Ans.

$$B_f = \begin{array}{c} \\ 2 \\ 4 \end{array}\begin{array}{c} \begin{array}{cccc} 1 & 2 & 3 & 4 \end{array} \\ \begin{bmatrix} 1 & 1 & -1 & 0 \\ 0 & 0 & 1 & 1 \end{bmatrix} \end{array}\begin{array}{l} \\ \rightarrow \text{for loop 1} \\ \rightarrow \text{for loop 2} \end{array}$$



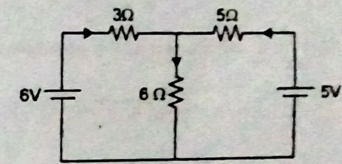
Q.6. (b) Find the current in given network using super position theorem. (6.5)



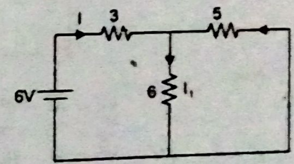
Ans. 1st consider 6 V and replace 5 V with short circuit.

$$R_{eq} = (6 \,||\, 5) + 3$$

$$= 3 + \frac{6 \times 5}{6+5} = 3 + \frac{30}{11} = \frac{63}{11}$$



$$I = \frac{6}{\frac{63}{11}} = \frac{66}{63}$$



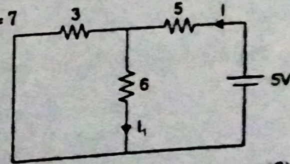
$$I_1 = \frac{5}{11} \times I$$

$$= \frac{5}{11} \times \frac{66}{63} = \frac{30}{63}$$

Consider 5 V and replace 6 V by short circuit

$$I = \frac{5}{7}$$

$$R_{th} = (6 \,||\, 3) + 5 = 5 + \frac{6 \times 3}{9} = 7$$

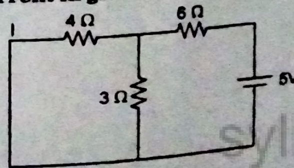


$$I_1' = \frac{3}{9} \times \frac{5}{7} = \frac{15}{63}$$

$$\text{Total } I = I_1 + I_1' = \frac{30}{63} + \frac{15}{63} = \frac{45}{63}$$

(6)

Q.7. (a) Find the current in given network using Norton's theorem.

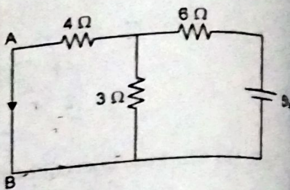


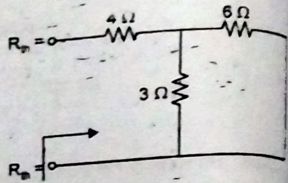
Ans.

$$\text{Total current} = \frac{5}{(4||3)+6}$$

$$= \frac{5}{\frac{12}{7}+6}$$

$$= \frac{35}{54}$$





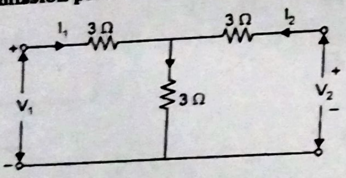
$$\text{Current through(AB)} = \frac{3}{7} \times I$$

$$I_N = \frac{3}{7} \times \frac{35}{54} = \frac{15}{54}$$

$$R_{th} = 4 + (6||3)$$

$$= 4 + \frac{18}{9} = 6.$$

Q.7. (b) Find transmission parameter of given two port network. (6.5)



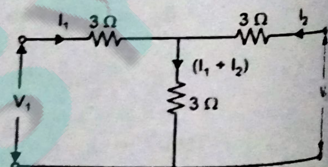
Ans.

$$V_1 = AV_2 + B(-I_2)$$
$$I_1 = CV_2 + D(-I_2)$$
$$V_1 = 6I_1 + 3I_2 \quad ...(1)$$
$$V_2 = 3I_1 + 6I_2 \quad ...(2)$$

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:

$$\frac{Z(s)}{s} = \frac{(s+2)(s+5)}{(s+1)(s+4)} = \frac{s^2+7s+10}{s^2+5s+4}$$

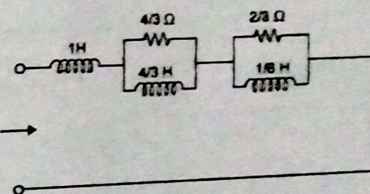
$$s^2+5s+4 \,)\, s^2+7s+10 \,(\, 1$$
$$\underline{s^2+5s+4}$$
$$2s+6$$

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

Using partial fraction

$$\frac{Z(s)}{s} = 1 + \frac{A}{s+1} + \frac{B}{s+4}$$

$$A = \frac{4}{3}, \; B = \frac{2}{3}$$

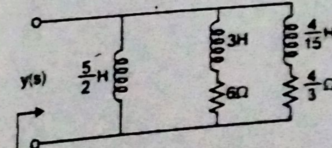


$$Z(s) = s + \frac{\frac{4}{3}s}{s+1} + \frac{\frac{2}{3}s}{s+4}$$

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:

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

$s^2+5s+4 \,\overline{)\, s^3+7s^2+10s\,}\, \left(s \longleftrightarrow Y_1 \right.$

$\underline{s^3+5s^2+4s}$

$2s^2+6s \,)\, s^2+5s+4 \left(\frac{1}{2} \longleftrightarrow Z_2 \right.$

$\underline{s^2+3s}$

$2s+4 \,)\, 2s^2+6s \left(s \longleftrightarrow Y_3 \right.$

$\underline{2s^2+4s}$

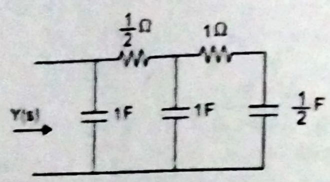
$2s \,)\, 2s+4 \left(1 \longleftrightarrow Z_4 \right.$

$\underline{2s}$

$4 \,)\, 2s \left(\frac{1}{2}s \longleftrightarrow Y_5 \right.$

$\underline{2s}$

×



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

$10s+7s^2+s^3 \,)\, 4+5s+s^2 \left(\frac{4}{10s} \longleftrightarrow Z_1 \right.$

$\underline{4+\frac{14}{5}s+\frac{2}{5}s^2}$

$\frac{11}{5}s+\frac{3}{5}s^2 \,)\, 10s+7s^2+s^3 \left(\frac{5}{11}\cdot 10 \longleftrightarrow Y_2 \right.$

$\underline{10s+\frac{30}{11}s^2}$

$\frac{47}{11}s^2+s^3 \,)\, \frac{11}{5}s+\frac{3}{5}s^2 \left(\frac{11}{47}\times\frac{11}{5s} \longleftrightarrow Z_3 \right.$

$\underline{\frac{11}{5}s+\frac{121}{235}s^2}$

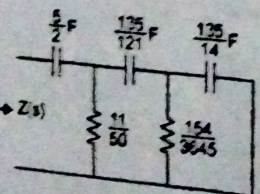
$\frac{20}{235}s^2 \,)\, \frac{47}{11}s^2+s^3 \left(\frac{235}{20}\times\frac{47}{11} \longleftrightarrow Y_4 \right.$

$\underline{\frac{47}{11}s^2}$

$+s^3 \,)\, \frac{20}{235}s^2 \left(\frac{20}{235s} \longleftrightarrow Z_5 \right.$

$\underline{\frac{20}{235}s^2}$

×



FIRST TERM EXAMINATION [SEPT. 2017]
THIRD SEMESTER [B.TECH]
CIRCUITS AND SYSTEMS
[ETEE-207]

Time: 1½ hrs. **M.M.: 30**

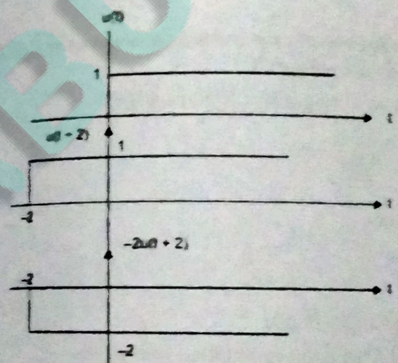
Note: *Attempt any three questions including Q.No 1 which is compulsory.*

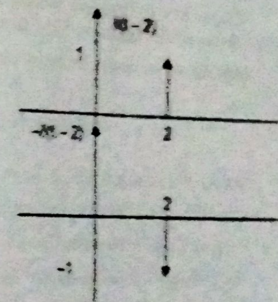
Q.1. Attempt all of the following:

Q.1. (a) Draw the waveform of

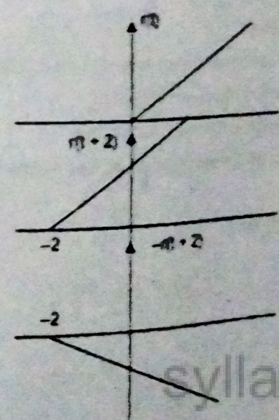
(i) $-2u(t+2)$ (ii) $-\delta(t-2)$ (iii) $-r(t+2)$ (3)

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.

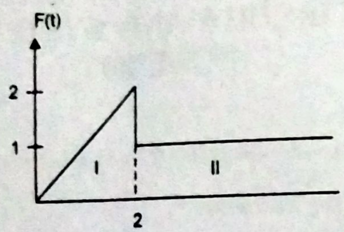


Fig. 1

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)

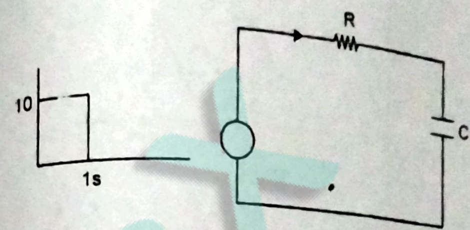
Ans. $x(t) = e^{-2t}\cos 2t$

$x(-t) = e^{+2t}\cos(-2t) = e^{2t}\cos 2t$

$$x_{even}(t) = \frac{e^{-2t}\cos 2t + e^{2t}\cos 2t}{2}$$

$$x_{odd}(t) = \frac{e^{-2t}\cos 2t - e^{2t}\cos 2t}{2}$$

Q.2. (a) Find out the response $i(t)$ for $t > 0$ for the series R-C circuit excited by excitation of 10 magnitudes voltage for one second duration. Explain with graph. Assuming initial conditions zero. R = 1Ω, C = 1F. (5)



$$V = iR + \frac{1}{C}\int i\,dt$$

$$10[u(t)-u(t-1)] = iR + \frac{1}{C}\int i\,dt$$

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 fig.

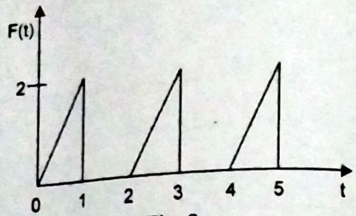
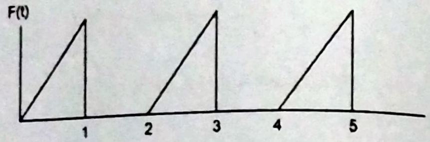
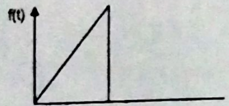


Fig. 2

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 open at $t \infty 0.2$ second. Find the expression for the transient current for intervals.

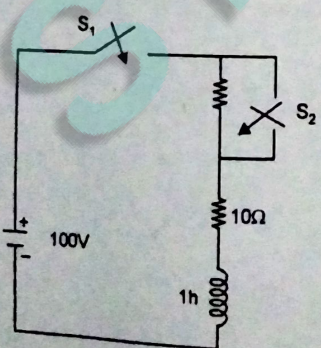
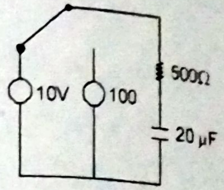


Fig. 3



$$100 = 20\,i + L\frac{di}{dt}$$

$$100 = 20i + \frac{di}{dt}$$

$$Cf = Ae^{-20t}$$

$$PI = \frac{100}{D+20} = \frac{\cancel{100}^{5}}{\cancel{20}} = 5$$

$$i(t) = Ae^{-20t} + 5$$

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

$$100 = 10i + L\frac{di}{dt}$$

$$CF = Be^{-10t}$$

$$PI = \frac{100}{D+10} = 10$$

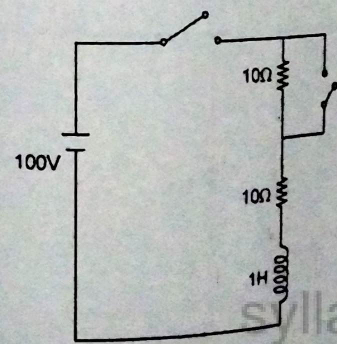
$$i(t) = Be^{-10t} + 10$$

$$t = 0,\ i = 5(1 - e^{-4})$$

$$5(1 - e^{-4}) = B + 10 \Rightarrow B = -10 + 5 - 5e^{-4}$$

$$= -4.9$$

$$i(t) = -4.9e^{-10t} + 10$$



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 $t = 0.05 \; i(t) = 8.64$

$$8.64 = 5 + Be^{o} \Rightarrow B = 8.64 - 5 = 3.64$$

$$i(t) = 5 + 3.64\,e^{-20t}$$

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 A in below circuit as shown in figure 4 after closing the switch *K* at *t* = 0 sec.

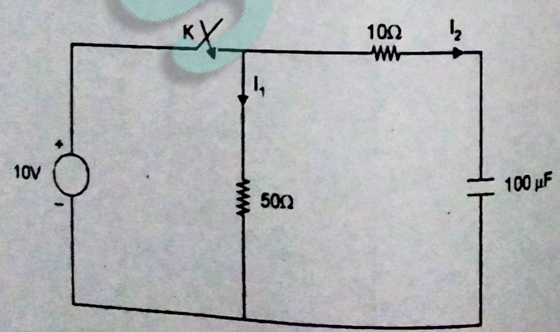


Fig. 4

Ans.

$I = I_1 + I_2$

$$I_1 = \frac{10}{50} = .2A = 200\text{ mA}$$

$$I = 500\text{ mA}$$

$$\Rightarrow 500 = 200 + I_2$$

$$I_2 = 300\text{ mA}$$

$$I_2 = \frac{V}{R}e^{-t/T}$$

$$0.3 = \frac{10}{70}e^{-\frac{t}{RC}} = \frac{10}{70}e^{-\frac{t}{.007}}$$

$$-\frac{t}{0.007} = \log_e(2.1) = t = 5.2\text{ ms.}$$

Q.4. (*b*) In the circuit of figure 5 the switch *S* is closed on position. In *t* = 0 and after one time constant is moved to position 2. Find the current before and after moving to position 2. Assuming all initial conditions are zero. (5)

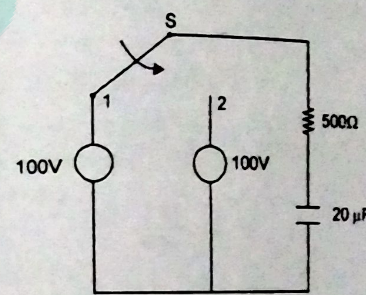


Fig. 5

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 $t = 0 \quad i = \frac{100}{500} = .2A$

$$K = .2$$

$$i(t) = 0.2e^{-100t}$$

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

$$100 = 500i + \frac{1}{20\times 10^{-6}}\int i\,dt$$

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 $t = 0\ V_C = 63.7V$

$$63.7 = 500\,K e^{\circ} \Rightarrow K = -\frac{63.7}{500}$$

$$i(t) = -\frac{63.7}{500}e^{-100t}$$

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.

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

$$I_2 = h_{21}I_1 + h_{22}V_2$$

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

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)**

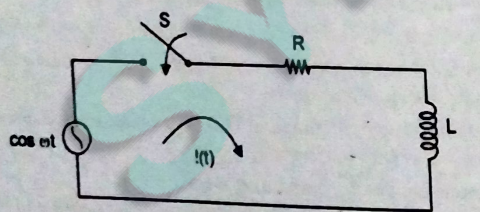


Fig. 1

Ans.

$$\cos \omega t = IR + L\frac{dI}{dt}$$

$$\frac{1}{L}\cos \omega t = \frac{R}{L}I + \frac{dI}{dt}$$

$$D + \frac{R}{L} = 0 \Rightarrow D = -\frac{R}{L}$$

$$CF = e^{-R/L\,t}$$

$$PI = \frac{1}{L}\frac{\cos \omega t}{\left(D + \frac{R}{L}\right)}\frac{(D - R/L)}{\left(D - \frac{R}{L}\right)}$$

$$= \frac{1}{L}\frac{D\cos \omega t - \frac{R}{L}\cos \omega t}{D^2 - \left(\frac{R}{L}\right)^2}$$

$$= \frac{1}{L} \times \frac{1}{-\omega^2 - \left(\frac{R}{L}\right)^2}\left[-\omega \sin \omega t + \frac{R}{L}\cos \omega t\right]$$

$$i(t) = Ae^{\frac{-R}{t}t} - \frac{1}{L\left(\omega^2 + \frac{R_2}{L^2}\right)}\left[-\omega \sin \omega t + \frac{R}{L}\cos \omega t\right]$$

Initially inductor work as open circuit. So at $t = 0$ $i = 0$

$$0 = A - \frac{R}{L}\frac{1}{L\left(\omega^2 + \frac{R^2}{L^2}\right)} \Rightarrow A - \frac{R}{L^2\omega^2 + R^2} = 0$$

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

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

$$\frac{A}{s}+\frac{B}{s+3}+\frac{C}{s+1}+\frac{D}{(s+1)^2}+\frac{Ps}{s^2+s+1}$$

$$A=\frac{s^2+2s+3}{\cancel{s}(s+1)^2(s+3)(s^2+s+1)}\times \cancel{s}\Bigg|_{s=0}=\frac{3}{3}=1$$

$$B=\frac{s^2+2s+3}{s(s+1)^2\cancel{(s+3)}(s^2+s+1)}\times \cancel{s+3}\Bigg|_{s=-3}=\frac{9-6+3}{-3\times 4\times(9-3+1)}=\frac{6}{-12\times 7}=-\frac{1}{14}$$

$$D=\frac{s^2+2s+3}{s\cancel{(s+1)}^2(s+3)(s^2+s+1)}\times\cancel{(s+1)^2}\Bigg|_{s=-1}=\frac{2}{-1\times 2\times 1}=-1$$

C and also find P

$$\boxed{\begin{aligned}&\frac{Ps}{s^2+s+1}\\ &=P\frac{s}{s^2+2\frac{1}{2}s+\left(\frac{1}{2}\right)^2+\frac{5}{4}}\\ &=\frac{P\left(s+\frac{1}{2}\right)}{\left(s+\frac{1}{2}\right)^2+\frac{5}{4}}-P\frac{e\frac{1}{2}}{\left(s+\frac{1}{2}\right)^2+\frac{5}{4}}\\ &=P\left[e^{-\frac{1}{2}t}\cos\frac{\sqrt5}{2}t-\frac{1}{2}e^{-\frac{1}{2}t}\sin\frac{\sqrt5}{2}t\right]\end{aligned}}$$

$$\frac{1}{s}+-\frac{1}{14(s+3)}+\frac{-1}{(s+1)^2}+\frac{C}{s+1}+\frac{Ps}{s^2+s+1}$$

$$u(t)-\frac{1}{14}e^{-3t}-te^{-t}+ce^{-t}+P\left[e^{-\frac{1}{2}t}\cos\frac{\sqrt5}{2}t-\frac{1}{2}e^{-\frac{1}{2}t}\sin\frac{\sqrt5}{2}t\right]$$

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

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

$$H(j\omega)=\frac{Y(j\omega)}{X(j\omega)}=\frac{1-j\omega}{1+\frac{1}{2}j\omega}$$

$$=\frac{2(1-j\omega)\times(2-j\omega)}{(2+j\omega)\times(2-j\omega)}$$

$$=\frac{2\{2-3j\omega-\omega^2\}}{4+\omega^2}=\frac{2(2-\omega^2)}{4+\omega^2}-\frac{6j\omega}{4+\omega^2}$$

$$|H(j\omega)|=\sqrt{\left(\frac{2(2-\omega)^2}{4+\omega^2}\right)^2+\left(\frac{6j\omega}{4+\omega^2}\right)^2}=\frac{1}{(4+\omega)^2}\sqrt{4(4+\omega^4-4\omega^2)+36j^2\omega^2}$$

$$=\frac{1}{4+\omega^2}\sqrt{16+4\omega^4-16\omega^2-36\omega^2}=\frac{4}{4+\omega^2}\sqrt{4+\omega^4-13\omega^2}$$

$$\angle H(j\omega)=\tan^{-1}\frac{-6\omega}{2(2-\omega^2)}=\tan^{-1}\left(\frac{-3\omega}{2-\omega^2}\right)$$

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)**

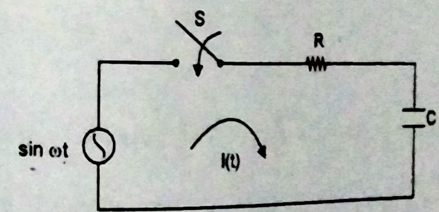


Fig. 2

Ans.

$$IR+\frac{1}{C}\int i\,dt=\sin\omega t$$

$$R\frac{di}{dt}+\frac{i}{c}=\omega\cos\omega t$$

$$\frac{di}{dt}+\frac{i}{RC}=\frac{\omega}{R}\cos\omega t$$

$$D+\frac{1}{RC}=0\Rightarrow D=-\frac{1}{RC}$$

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

$$PI = \frac{\frac{\omega}{R}\cos\omega t\left(D-\frac{1}{RC}\right)}{\left(D+\frac{1}{RC}\right)\left(D-\frac{1}{RC}\right)} = \frac{\omega}{R}\frac{\left[D(\cos\omega t)-\frac{1}{C}\cos\omega t\right]}{D^2-\left(\frac{1}{RC}\right)^2}$$

$$\frac{\frac{\omega}{R}\left[-\omega\sin\omega t-\frac{1}{RC}\cos\omega t\right]}{-\omega^2-\left(\frac{1}{RC}\right)^2}$$

$$= \frac{\left(\frac{\omega^2}{R}\sin\omega t+\frac{\omega}{R^2C}\cos\omega t\right)}{\omega^2+\left(\frac{1}{RC}\right)^2}$$

$$i(t) = Ae^{-\frac{1}{RC}t}+\frac{\omega}{R\left[\omega^2+\left(\frac{1}{RC}\right)^2\right]}\times\left[\omega\sin\omega t+\frac{1}{RC}\cos\omega t\right]$$

Q. 4. (b) Find the laplace transform of the triangular pulse shown. **(6)**

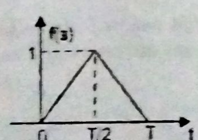


Fig. 3

Ans.
$$f(t) = \frac{2}{T}t\left[u(t)-u\left(t-\frac{T}{2}\right)\right]+2\left(1-\frac{t}{T}\right)\left[u\left(t-\frac{T}{2}\right)-4(t-T)\right]$$

$$= \frac{2}{T}\left[tu(t)-tu\left(t-\frac{T}{2}\right)\right]+\frac{2}{T}(T-t)\left[4\left(t-\frac{T}{2}\right)-u(t-T)\right]$$

$$tu(t)\to\frac{1}{s^2}$$

$$tu\left(t-\frac{T}{2}\right) = \left(t-\frac{T}{2}\right)u\left(t-\frac{T}{2}\right)+\frac{T}{2}u(t-T/2)$$

$$\xrightarrow{LT}\frac{e^{-\frac{T}{2}s}}{s^2}+\frac{T}{2}\frac{e^{-T/2s}}{s}$$

$$(t-T)u(t-T)\to\frac{e^{-Ts}}{s^2}$$

$$(t-T)u\left(t-\frac{T}{2}\right)$$

$$\left(t-\frac{T}{2}\right)u\left(t-\frac{T}{2}\right)-\frac{T}{2}u\left(t-\frac{T}{2}\right)$$

$$\frac{e^{-T/2s}}{s^2}-\frac{T}{2}\frac{e^{-1/2s}}{s}$$

$$f(t)\xrightarrow{LT}\frac{2}{T}\left[\frac{1}{s^2}-\frac{e^{-T/2s}}{s^2}-\frac{T}{2}\frac{e^{-T/2s}}{s}\right]$$

$$-\frac{2}{T}\left[\frac{e^{-T/2s}}{s}-\frac{T}{2}\frac{e^{-T/2s}}{s}-\frac{e^{-Ts}}{s^2}\right]$$

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 2A. Using Laplace Transform determine the current $I(t)$. Also draw the s-domain representation of the circuit. **(6.5)**

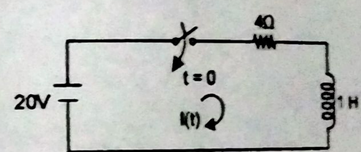


Fig. 4

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

$$x(t) \rightarrow X(s)$$

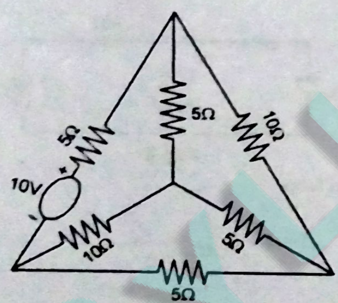
$$L[x(t)] = X(s)$$

and

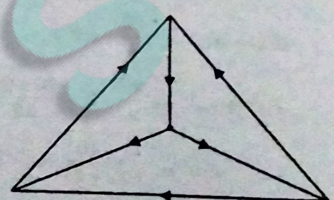
$$L^{-1}[X(s)] = x(t)$$

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)

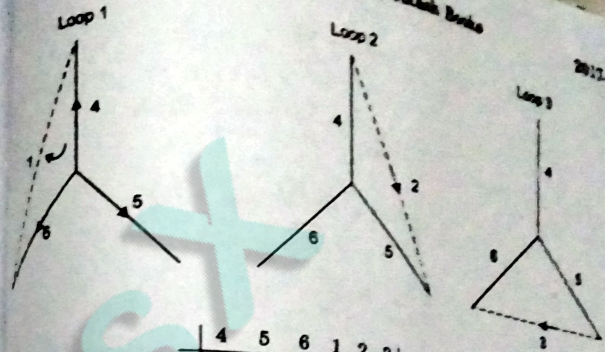


Ans.



Oriented graph of the given circuit.

We select tree (4, 5, 6) and link (1, 2, 3)



$$B_f = \begin{array}{c|cccccc} & 4 & 5 & 6 & 1 & 2 & 3 \\ \hline 1 & -1 & 0 & 1 & 1 & 0 & 0 \\ 2 & 1 & -1 & 0 & 0 & 1 & 0 \\ 3 & 0 & 1 & -1 & 0 & 0 & 1 \end{array}$$

$$Z_b = \begin{vmatrix} 5 & 0 & 0 & 0 & 0 & 0 \\ 0 & 10 & 0 & 0 & 0 & 0 \\ 0 & 0 & 5 & 0 & 0 & 0 \\ 0 & 0 & 0 & 5 & 0 & 0 \\ 0 & 0 & 0 & 0 & 5 & 0 \\ 0 & 0 & 0 & 0 & 0 & 10 \end{vmatrix}$$

$$Z_l = B_f Z_b B_f^T \quad \& \quad V_l = Z_l T_l$$

$$I_b = [B_f]^T I_l - I_S$$

$$B_f Z_b = \begin{bmatrix} -5 & 0 & 5 & 5 & 0 & 0 \\ 5 & -10 & 0 & 0 & 5 & 0 \\ 0 & 10 & -5 & 0 & 0 & 10 \end{bmatrix}$$

$$B_f Z_b B_f^T = \begin{bmatrix} -5 & 0 & 5 & 5 & 0 & 0 \\ 5 & -10 & 0 & 0 & 5 & 0 \\ 0 & 10 & -5 & 0 & 0 & 10 \end{bmatrix} \begin{bmatrix} -1 & 1 & 0 \\ 0 & -1 & 1 \\ 1 & 0 & -1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Q.4. (b) Find the transmission parameter in terms if y and z parameters. (6)

Ans.

$$V_1 = Z_{11}I_1 + Z_{12}I_2$$

$$V_2 = Z_{21}I_1 + Z_{22}I_2$$

$$I_1 = \frac{1}{Z_{21}}V_2 + \frac{Z_{22}}{Z_{21}}(-I_2)$$

$$C = \frac{1}{Z_{21}} \text{ and } D = \frac{Z_{22}}{Z_{21}}$$

$$V_1 = Z_{11}\left[\frac{1}{Z_{21}}V_2 + \frac{Z_{22}}{Z_{21}}\right](-I_2)\Bigg] + Z_{12} I_2$$

$$= \frac{(Z_{11})}{Z_{21}}V_2 + \left(\frac{Z_{11}Z_{22}}{Z_{21}} - Z_{12}\right)(-I_2)$$

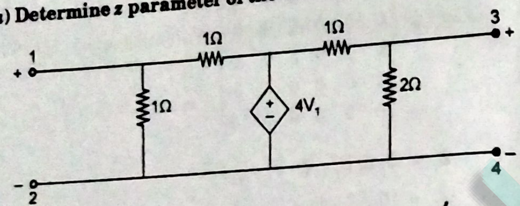
$$A = \left(\frac{Z_{11}}{Z_{21}}\right) \quad B = \frac{\Delta Z}{Z_{21}}$$

Similarly

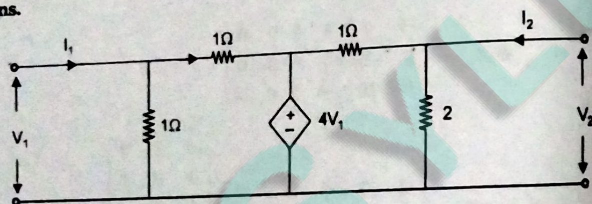
$$A = -\frac{Y_{22}}{Y_{21}} \quad B = -\frac{1}{y_{21}}$$

$$C = -\frac{\Delta Y}{Y_{21}} \quad D = -\frac{Y_{11}}{Y_{21}}$$

Q.7. (a) Determine z parameter of the networks shown.



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.

$$Z(s) = \frac{8(s^2+1)(s^2+3)}{s(s^2+2)(s^2+4)}$$

$$\frac{A_0}{s} + \frac{2A_1 s}{s^2+2} + \frac{2A_2 s}{s^2+4}$$

$$A_0 = \left.\frac{8(s^2+1)(s^2+3)}{(s^2+2)(s^2+4)}\right|_{s=0} = 3$$

$$A_1 = \left.\frac{8(s^2+1)(s^2+3)}{(s^2-j\sqrt{2})(s^2+4)}\right|_{s=-j\sqrt{2}} = 1$$

$$A_2 = \left.\frac{8(s^2+1)(s^2+3)}{s(s^2+2)(s-j\sqrt{2})}\right|_{s=-j2}$$

$$\frac{3}{5}+\frac{2s}{s^2+2}+\frac{3s}{s^2+4}$$

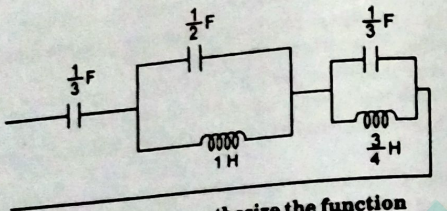
$$C_o = \frac{1}{3}F$$

$$C_1 = \frac{1}{2\times 1} = \frac{1}{2}F$$

$$L_1 = \frac{2}{(\sqrt{2})^2} = 1H$$

$$C_2 = \frac{1}{2\times 1.5} = \frac{1}{3}$$

$$L_2 = \frac{2\times 1.5}{4} = \frac{3}{4}H$$



Q. 8. (b) Using the foster II form synthesize the function

$$Y(s) = \frac{s(s^2+4)(s^2+6)}{(s^2+3)(s^2+5)}.$$

Ans. Foster *II*

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

$$= \frac{2B_1 s}{s^2+1}+\frac{2B_2 s}{s^2+3}+C_3$$

$$B_1 = \frac{1}{8}\left.\frac{s(s^2+2)(s^2+4)}{(s-1)(s^2+3)}\right|_{s=-j1} = \frac{3}{32}$$

$$B_2 = \frac{1}{8}\left.\frac{(s^2+2)(s^2+4)}{(s^2+1)(s-1\sqrt{3})}\right|_{S=-j\sqrt{3}} = \frac{1}{32}$$

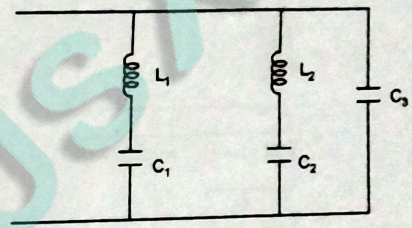
$$L_1 = \frac{1}{2}\times\frac{32}{3} = \frac{16}{3}$$

$$L_2 = \frac{1}{2}\times 32 = 16\ H$$

$$C_1 = \frac{2\times\frac{3}{32}}{1} = \frac{3}{16}F$$

$$C_2 = \frac{2\times\frac{1}{32}}{3} = \frac{1}{48}F$$

$$C_3 = \frac{1}{8}F$$



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

$$f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{50\times10^{-3}\times130\times10^{-9}}}$$

$$= 1.97\times10^3$$

$$Q = \frac{W_r L}{R} = \frac{\frac{1}{\sqrt{LC}}\times L}{R} = \frac{\sqrt{L/C}}{R} = \frac{\sqrt{\frac{50\times10^{-3}}{130\times10^{-9}}}}{80}$$

$$\frac{620}{80} = 7.75$$

$$BW = \frac{f_r}{Q} = \frac{1.97\times10^3}{7.75} = 254.2$$

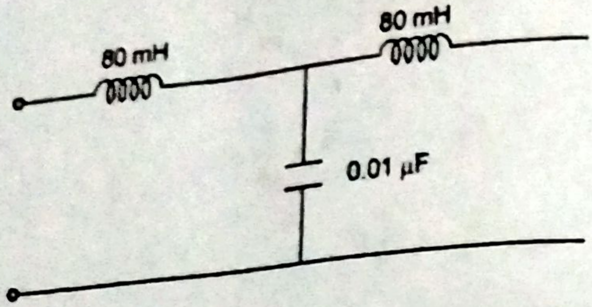
$$f_1 = f_r - \frac{BW}{2} = 1970-147$$

$$= 1823$$

$$f_2 = f_r + \frac{BW}{2} = 1970+147$$

$$= 2117$$

Q. 9. (b) For the T-section find cutoff frequency and nominal characteristics impedance R_o. **(6)**



Ans.

$$W_C = \sqrt{\frac{4}{LC}}$$

$$= \sqrt{\frac{4}{80 \times 2 \times 10^{-3} \times 0.01 \times 10^{-6}}}$$

$$= \sqrt{\frac{4}{1.6 \times 10^{-9}}}$$

$$= 50000 = 50 \text{ KHz}$$

$$R_o = \sqrt{\frac{L}{C}} = \sqrt{\frac{160 \times 10^{-3+1}}{.1 \times 10^{-6-2}}} = 4 \times 10^3$$

$$= 4000$$

$$Z_{OT} = R_O \sqrt{1 - \left(\frac{f_e}{f_c}\right)^2}$$

FIRST TERM EXAMINATION [SEP. 2018]
THIRD SEMESTER [B.TECH]
CIRCUITS AND SYSTEMS [ETEE-207]

Time : 1½ hrs. M.M. : 30

Note: Q. No. 1 is compulsory. Attempt any two more Questions from the rest.

Q.1. (a) What are even and odd signals? Explain with example. **(2)**

Ans.

$$f(-x) = f(x) \quad \text{even signal}$$
$$f(-x) = -f(x) \quad \text{odd signal}$$
$$f(x) = \cos x \text{ is a even signal}$$
$$f(x) = \sin x \text{ is a odd signal}$$

Q. 1. (b) What is LTI system. Describe its properties. **(2)**

Ans. LTI – Linear time invariant

1. 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

$$y(t) = K\,x(t) \qquad \text{(where } K \text{ is any constant)}$$

Its impulse response $\quad h(t) = K\,\delta(t)$

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. 1. (c) What is the rate of change of current at $t = 0^+$ in a coil of resistance 10 ohms and Inductance of 0.5 H, when connected to a 100 V d.c. supply. (2)

Ans.

$$L\frac{dI}{dt} + IR = 100$$

at $t = 0^+ \quad I = 0$

$$L\frac{dI}{dt} = 100 \Rightarrow \frac{dI}{dt} = \frac{1000}{5} = 200$$

Q. 1. (d) Find the Laplace Transform of the following functions: (2)

(i) $e^{-at} \cos \omega t$ (ii) $10U(t) - \delta(t) - 5\delta(t-4)$

Ans. (i) $e^{-at} \cos \omega t$

$$\cos \omega t \to \frac{s}{s^2 + \omega^2}$$

$$e^{-at} \cos \omega t \to \frac{s+a}{(s+a)^2 + \omega^2}$$

(ii) $10U(t) - \delta(t) - 5\delta(t-4)$

$$U(t) \to \frac{1}{s}$$

$$\delta(t) \to 1$$

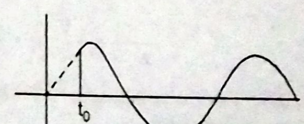
$$\delta(t-4) \to e^{-4s}$$

LT of this function is

$$\frac{10}{s} - 1 - 5e^{-4s}$$

Q. 1. (e) What are Singularity functions? If $f(t) = \sin\omega t$, then draw the signal $f(t)*u(t-t_0)$ (2)

Ans. $\sin \omega t\, 4\, (t - t_0)$



Singularity function

1. Unit step
2. Sgn (t)
3. Ramp function
4. Impulse

Q. 2. (a) Synthesize the given waveform (fig. 1. and fig. 2) and find its Laplace Transform. (6)

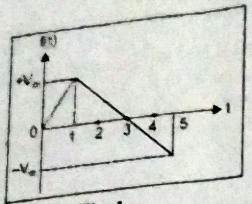


Fig. 1.

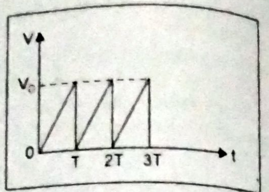


Fig. 2.

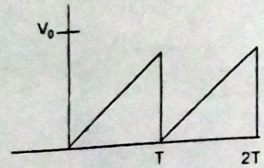
Ans.

$$f(t) = V_m t[u(t) - u(t-1)] + \frac{-V_m}{2}(t-3)[u(t-1) - u(t-5)]$$

$$= V_m t u(t) - \frac{3}{2}V_m(t-1)u(t-1) + \frac{V_m}{2}(t-5)u(t-5) + V_m u(t-5)$$

taking LT

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



$$V_1(t) = \frac{V_0}{T}t[u(t) - u(t-T)]$$

$$= \frac{V_0}{T}tu(t) - \frac{V_0}{T}(t-T)u(t-T) - V_0u(t-T)$$

taking LT

$$= \frac{V_0}{T}\left[\frac{1}{s^2} - \frac{e^{-Ts}}{s^2}\right] - V_0\frac{e^{-Ts}}{s}$$

LT of a periodic signal with period T is

$$\frac{1}{1-e^{-Ts}}\left[\frac{V_0}{T}\frac{1}{s^2} - \frac{V_0}{T}\frac{e^{-Ts}}{s^2} - \frac{V_0 e^{-Ts}}{s}\right]$$

Q. 2. (b) Without finding the inverse Laplace Transform of F(S), find initial and final values of following functions. **(4)**

(a) $F(s) = \dfrac{s^2+5s+7}{s^2+3s+2}$ **(b)** $F(s) = \dfrac{5s^3-1600}{s(s^3+18s^2+90s+800)}$

Ans. (a) $f(0^+) = \lim_{s\to\infty} sF(s) = \dfrac{s(s^2+5s+7)}{s^2+3s+2} = \infty$

$$f(\infty) = \lim_{s\to 0} sF(s) = \frac{s(s^2+5s+7)}{s^2+3s+2} = 0$$

(b)

$$f(0^+) = \lim_{s\to\infty} sF(s) = \lim_{s\to\infty}\frac{5s^3-1600}{s^3+18s^2+90s+800}$$

$$= \lim_{s\to\infty}\frac{5-\frac{1600}{s^3}}{1+\frac{18}{s}+\frac{90}{s^2}+\frac{800}{s^3}} = 5$$

$$f(\infty) = \lim_{s\to\infty} sF(s) = \lim_{s\to 0}\frac{5s^3-1600}{s^3+18s^2+90s+800} = -2$$

Q. 3. (a) Write down the Integro-Differential equation for the electric circuit shown in fig. 3. using KVL. also draw the s-domain equivalent circuit. **(5)**

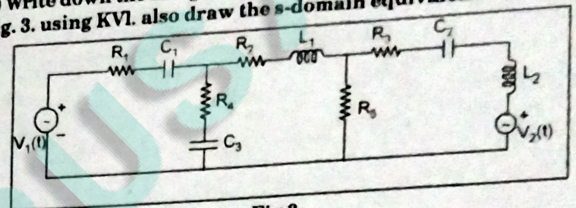
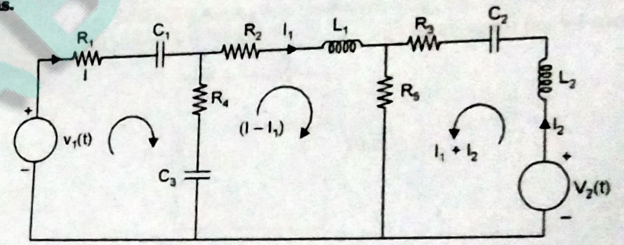


Fig.3.

Ans.

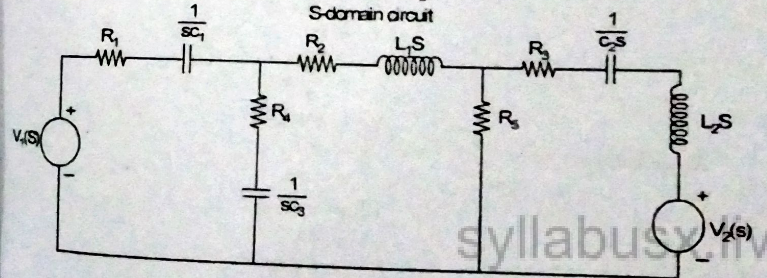


$$V_1(t) = IR_1 + \frac{1}{C_1}\int I dt + (I - I_1)R_4 + \frac{1}{C_3}\int (I - I_1)\, dt$$

$$R_2I_1 + L_1\frac{dI_1}{dt} + (I_1 + I_2)R_5 - \frac{1}{C_3}\int(I - I_1)\,dt - R_4(I - I_1)$$

$$V_2(t) = L_2\frac{dI_2}{dt} + \frac{1}{C_2}\int I_2\,dt + I_2R_3 + (I_1 + I_2)R_5$$

S-domain circuit



Q.3. (b) Find i(t) for t>0 in the circuit of fig. 4. switch is opened at t=0.

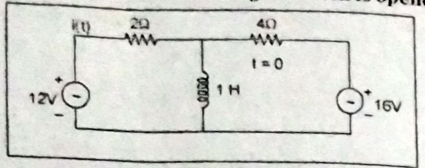
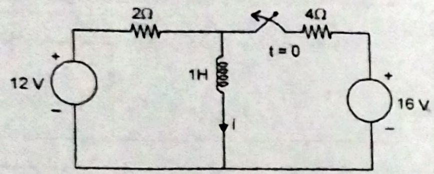


Fig. 4.

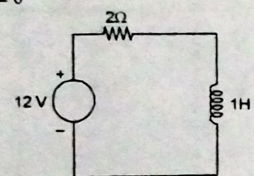
Ans.



$$t = 0^- \text{ inductor behave as short circuit}$$

So, at $t = 0$ $i = 4 + 6 = 10$ A

When switch is open at $t = 0$



$$12 = I \times 2 + L\frac{dI}{dt}$$

$$12 = 2I + \frac{dI}{dt} \qquad [L = 1 \text{ H}]$$

Auxilary equation $D + 2 = 0 \Rightarrow D = -2$

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

$$PI = \frac{12}{D+2}$$

at $D = 0$

$$= \frac{12}{2} = 6$$

$$I(t) = 6 + Ae^{-2t}$$

As we know at $t = 0$

$$I = 10 \text{ A}$$

$$10 = 6 + Ae^{o}$$

$$A = 4A$$

$$I(t) = 6 + 4e^{-2t}$$

Q.4. (a) Synthesize the given wave form (Fig. 5) using standard signals. (5)

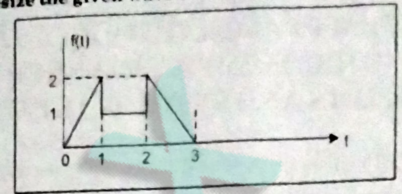
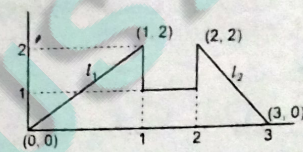


Fig. 5.

Ans.

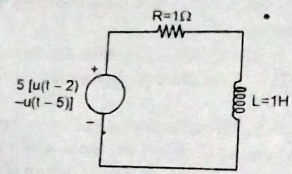


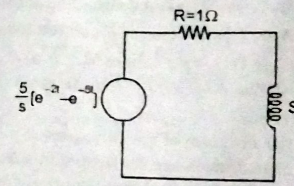
$l_1 = 2t$
$l_2 = -2t + 6$

$$f(t) = 2t[u(t) - u(t-1)] + [u(t-1) - u(t-2)] + (-2t + 6)[u(t-2) - u(t-3)]$$

Q.4. (b) A voltage pulse of magnitude 5V and duration of 3 seconds extending from t = 2 to t = 5 is applied to a series R-L circuit having R=1 ohm and L=2 henry. Find i(t). initially inductor is de-energized. (5)

Ans.





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

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

$$I(s) = 5\left[\frac{1}{s} - \frac{1}{s+1}\right](e^{-2s} - e^{-5s})$$

taking inverse LT

$$I(t) = 5[[u(t-2) - u(t-5)] - [e^{-(t+2)} - e^{-(t+5)}]]$$

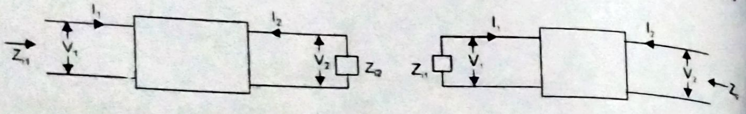
END TERM EXAMINATION [NOV-DEC 2018]
THIRD SEMESTER [B.TECH]
CIRCUITS AND SYSTEMS [ETEE-207]

Time : 3 hrs. **M.M. : 75**

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

Q.1. (a) Write short on Image Impedance. (5)

Ans. In two port network if the impedance at input port with impedance z_{i2} connected across output port be z_{i1} as shown in fig. and the impedance at output port with impedance z_{i1} connected to input port be z_{i2} as shown in fig. below.



$$Z_{i1} = \frac{V_1}{I_1}$$

$$Z_{i2} = \frac{V_2}{I_2}$$

Q. 1. (b) What are the characteristics of positive real function (prf). (5)

Ans. Properties of Positive Real Function (p.r.f.)

(i) If T(s) is p.r., then $1/_{T(s)}$ is also p.r. This property implies that if a driving point impedance Z(s) is p.r., then its reciprocal $(1/_{Z(s)})$, the driving point admittance Y(s), is also p.r.

(ii) The sum of p.r. functions is p.r. from an immittance stand point, we see that if two impedances are connected in series or two admittances are connected in parallel, the resultant impedance or admittance is p.r. (Note that the difference of two p.r. functions is not necessarily p.r.).

(iii) The poles and zeros of p.r.f cannot have positive real parts, i.e., they cannot be in the right half of the s-plane. In addition to this, only simple poles with real positive residues can exist on the jω-axis.

(iv) The poles and zeros of a p.r.f. are real or occur in conjugate pairs.

(v) The highest powers of the numerator N(s) and denominator D(s) polynomial may differ atmost by unity. This condition prohibits multiple poles or zeros at s = ∞.

(vi) The lowest power of D(s) and N(s) polynomials may differe by atmost unity. This condition prevents the possibility of multiple poles or zeros at s = 0.

Q. 1. (c) Write short note on types of filters with their characteristics graph. (5)

Ans. Low Pass Filters: These filters reject all frequencies above cut-off frequency f_C. The attenuation characteristic of an ideal LP filter is shown in figure 1(a). Thus the pass band or transmission band for the LP filter is the frequency range 0 to f_C and the stop band or attenuation band is the frequency range above f_C

High Pass Filters: These filters reject all frequencies below cut-off frequency f_C. Thus the pass band and stop band of the HP filter are the frequency range above f_C and below f_C respectively. The attenuation characteristic of a HP filter is shown in figure. 1. (b)

Band Pass Filters: These filters allow transmission of frequencies between two designated cut off frequencies and reject all other frequencies. As shown in figure 1. (c), a band pass filter has two cut-off frequencies and will have the pass band $f_{C2} - f_{C1}$. f_{C1} is called as the lower cut-off frequency while f_{C2} is called the upper cut-off frequency.

Band Stop or Band Elimination Filters: These filters pass all frequencies lying outside a certain range, while it attenuates all frequencies between the two frequencies f_{C1} and f_{C2}. The characteristic of an ideal band stop filter is shown in figure 1. (d).

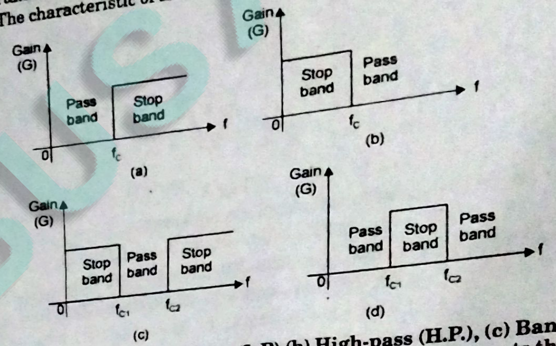


Fig. 1. Ideal response of (a) Low-pass (L.P) (b) High-pass (H.P.), (c) Band-Pass (B.P.) and (d) Band stop (B.S.) filters, Here $G = V_0/V_i$ represents the gain of the filter and attenuation is inverse of the gain of the filter

Q. 1. (d) Explain mathematically convolution in time domain for Laplace Transform. (5)

Ans. Convolution in time domain equivalent to multiplication in laplace transform.

$$x(t) \times h(t) = \int_0^t x(\tau)h(t-\tau)d\tau = X(s).H(s)$$

Q. 1. (e) Synthesize the following waveform as shown in fig. 1. Using gate function. (5)

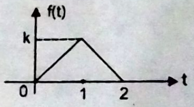


Fig.1

Ans. eqn of line 1 $\quad y = kt$

$y = m + c$

at (1, k) $\quad k = m + c$

at (2, 0)

$0 = 2m + c$

$-k = -m \pm c$

$-k = m$

$c = -2\,m$

$$= -2 \cdot 4 = 2k$$

From eq. [illegible]

[illegible]

taking LT

[illegible]

Q. 2. (a) Synthesize the following waveform as shown in fig. 2. (6.5)

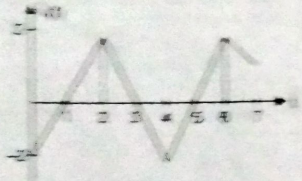


Fig. 2

Ans. 2. (a) Using gate functions, we can represent as

$$v(t) = (2t-2)[U(t) - U(t-2)] + (-2t+6)[U(t-2) - U(t-4)] + (2t-10)[U(t-4) - U(t-6)] + \dots$$

$$= (2t-2)U(t) + (-2t+2-2t+6)U(t-2) + (2t-6+2t-10)U(t-4) + \dots$$

$$= (2t-2)U(t) + (-4t+8)U(t-2) + (4t-16)U(t-4) + \dots$$

$$= 2(t-1)U(t) - 4(t-2)U(t-2) + 4(t-4)U(t-4) + \dots$$

Q. 2. (b) Calculate the Laplace Transform of the periodic waveform as shown in fig. 2. (6)

Ans. 2. (b) Using theorem for periodic functions

(i)

$$f(t) = (2t-2)[U(t) - U(t-2)] + (-2t+6)[U(t-2) - U(t-4)]$$

$$= 2tU(t) - 2U(t) - (2t-2+2t-6)U(t-2) + (2t-6)U(t-4)$$

$$= 2tU(t) - 2U(t) - 4(t-2)U(t-2) + 2(t-4)U(t-4) + 2U(t-4)$$

$$F(s) = \mathcal{L}f(t) = \frac{2}{s^2} - \frac{2}{s} - 4\frac{e^{-2s}}{s^2} + 2\frac{e^{-4s}}{s^2} + \frac{2e^{-4s}}{s}$$

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

Since Time period, T = 4, Therefore,

$$F(s) = \frac{1}{1-e^{-4s}} F_1(s) = \frac{2}{s^2}\left(\frac{1-e^{-2s}}{1+e^{-2s}}\right) - \frac{2}{s} = \frac{2}{s}\left[\left(\frac{1}{s}\right)\tanh s - 1\right]$$

(ii)

$$v(t) = 1\,G_{0,1}(t) + (-2)\,G_{1,2}(t)$$

$$= [U(t) - U(t-1)] - 2[U(t-1) - U(t-2)]$$

$$= U(t) - 3U(t-1) + 2U(t-2)$$

$$V_1(s) = \frac{1}{s}(1 - 3e^{-s} + 2e^{-2s}) = \frac{1}{s}(1 - e^{-s})(1 - 2e^{-s})$$

Since Time period, T = 2, therefore

$$V(s) = \frac{1}{1-e^{-2s}} V_1(s) = \frac{1}{1-e^{-2s}} \cdot \frac{1}{s}(1-e^{-s})(1-2e^{-s}) = \frac{1}{s}\left(\frac{1-2e^{-s}}{1+e^{-s}}\right)$$

Alternative ways:

$$f(t) = U(t) - 3U(t-1) + 3U(t-2) - 3U(t-3) + \dots$$

Q. 3. (a) Find the Laplace Transform of the given function. f(t) = $e^{-a(t-b)}$ u(t−b). (6)

Ans.

$$f(t) = e^{-a(t-b)}u(t-b)$$

$$= e^{-at}\,e^{ab}\,u(t-b)$$

$$= e^{ab}\,e^{-at}\,u(t-b)$$

$$e^{-at}u(t) \to \frac{1}{s+a}$$

Applying time shifting theorem

$$e^{-a(t-b)}u(t-b) = \frac{e^{-bs}}{s+a}$$

Q. 3. (b) Determine whether or not each of the following signals is periodic. If a signal is periodic, specify its fundamental period.

(i) $x_1(t) = e^{j7\pi t}$ (ii) $x_2(t) = e^{j(10\pi t - 12)}$ (6)

Ans. (i) $e^{j7\pi t}$

$$7\pi N = 2\pi$$

$$N = \frac{2}{7}$$

So it is a periodic signal with period = 2

(ii) [illegible]

[illegible] is not periodic

Q. 4. (a) The charge 'q' in an electric circuit is given by (6)

$d^2q(t)/dt^2 + 6\,dq(t)/dt + 25q(t) = 150$

If all initial conditions are zero, determine the current through the circuit. (6)

Ans.

$$\frac{d^2q(t)}{dt^2} + 6\frac{dq(t)}{dt} + 25q(t) = 150$$

Taking LT taking all initial condition zero

$$s^2Q(s) + 6sQ(s) + 25\,Q(s) = \frac{150}{s}$$

$$Q(s) = \frac{150}{s(s^2+6s+25)}$$

$$\int \frac{\cancel{150}^{50}}{\cancel{8}} e^{-4t}\cos 3t\,dt$$

$$Q = 50\int e^{-4t}\cos 3t\,dt$$

Taking LT LT of $\frac{1}{(s^2+8s+25)}$

$$\frac{1}{3}\times\frac{3}{(s+4)^2+3^2} \rightarrow \frac{1}{3}\cos 3t.e^{-4t}$$

Q. 4. (b) In the given networks as shown in fig.3. find the current. **(6.5)**

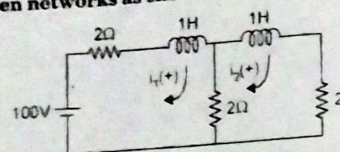


Fig. 3.

Ans. Applying KVL,

Loop 1:

$$100 = 2i_1(t) + 1.\frac{di_1(t)}{dt} + 2[i_1(t) - i_2(t)]$$

Taking Laplace transform, with $i_1(0^+) = 0$

$$\frac{100}{s} = 2I_1(s) + sI_1(s) + 2[I_1(s) - I_2(s)]$$

or

$$\frac{100}{s} = (4+s)I_1(s) - 2I_2(s) \quad ...(1)$$

Loop 2: $2[i_2(t) - i_1(t)] + 1.\frac{di_2(t)}{dt} + 2i_2(t) = 0$

Taking Laplace transform, with $i_2(0^+) = 0$

$$2[I_2(s) - I_1(s)] + sI_2(s) + 2I_2(s) = 0$$

$$(4+s)I_2(s) = 2I_1(s) \quad ...(2)$$

From equation (2), putting the value of $I_1(s)$ in equation (1), we have

$$\frac{100}{s} = \left[(4+s).\frac{(4+s)}{2} - 2\right]I_2(s)$$

$$I_2(s) = \frac{200}{s(s^2+8s+12)} = \frac{200}{s(s+2)(s+6)}$$

Using partial fraction expansion

$$I_2(s) = \frac{50/3}{s} - \frac{25}{s+2} + \frac{25/3}{s+6}$$

Therefore,

$$i_2(t) = £^{-1}[I_2(s)] = \left[\frac{50}{3} - 25e^{-2t} + \frac{25}{3}e^{-6t}\right]U(t)A$$

Q. 5. (a) Find the value of current in series R-L-C circuit with unit step response for over damped, critically damped, and under damped conditions. **(6.5)**

Ans. Application of KVL in the series RLC circuit $t = 0^+$ after the switch is closed, leads to the following differential equation

$$iR + L\frac{di}{dt} + \frac{1}{C}\int i\,dt = V_0 \text{ (Fig a)}$$

By differentiation,

$$L\frac{d^2i}{dt^2} + R\frac{di}{dt} + \frac{i}{C} = 0$$

or,

$$\left(p^2 + \frac{R}{L}p + \frac{1}{LC}\right)i = 0 \quad ...(1)$$

Equation (1) is a second order, linear homogenous differential equation. The characteristic equation then becomes

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

where the coefficients are constant. The roots of the characteristic equation then become

$$p_1, p_2 = \frac{-R/L \pm \sqrt{(R/L)^2 - 4/LC}}{2}$$

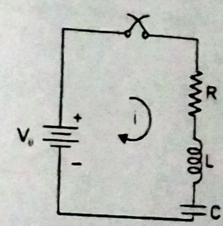


Fig. a. Series RLC circuit.

Let $\alpha = (-R/2L)$

and $\beta = \sqrt{(R/2L)^2 - \frac{1}{LC}}$

Hence, $p_1 = \alpha + \beta$

$p_2 = \alpha - \beta$

Also, the solution of differential equation 1 becomes

$$i = C_1 e^{p_1 t} + c_2 C^{p_2 t} \quad ...(2)$$

C_1 and C_2 being the constants.

Case 1. When $\left(\frac{R}{2L}\right)^2 > \frac{1}{LC}$

The time β is positive real quantity. Hence, the roots p_1 and p_2 are real but unequal.

$$p_1 = \alpha + \beta;\ p_2 = \alpha - \beta$$

$$i = C_1 e^{(\alpha+\beta)t} + C_2 e^{(\alpha-\beta)t}$$

$$= e^{\alpha t}(C_1 e^{\beta t} + C_2 e^{-\beta t})$$

The current response is over-damped fig. (b)

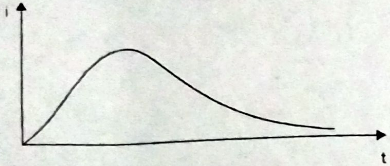


Fig. (b). Current over domping

Case 2. When $\left(\frac{R}{2L}\right)^2 < \frac{1}{LC}$

This time β is imaginary and then the roots p_1 and p_2 are complex conjugates

$$p_1 = \alpha + j\beta;\ p_2 = \alpha - j\beta$$

and

$$\begin{aligned} i &= C_1 e^{(\alpha + j\beta)t} + C_2 e^{(\alpha - j\beta)t} \\ &= e^{\alpha t}(C_1 e^{j\beta t} + C_2 e^{-j\beta t}) \\ &= e^{\alpha t}[C_1 \cos(\beta t) + C_2 \sin(\beta t)) \end{aligned}$$

Thus the current solution is underdamped (or oscillatory) Fig. c.

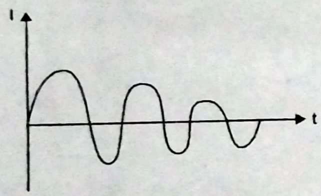


Fig. (c) Current oscillation

Case 3. When $\left(\frac{R}{2L}\right)^2 = \frac{1}{LC}$

This time β is zero.

Hence, roots p_1 and p_2 are real and equal.

$$\begin{aligned} p_1 &= p_2 = \alpha \quad \text{and} \quad i = C_1 e^{\alpha t} + C_2 t e^{\alpha t} \\ &= e^{\alpha t}(C_1 + C_2 t) \end{aligned}$$

The current response is then a critically damped one Fig.(d).

Fig. (d). Critical damping of current.

Q. 5. (b) In parallel circuit as shown in fig. 4. Calculate the branch current. **(6)**

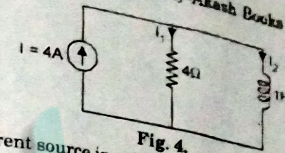


Fig. 4.

Ans. Convert the current source in voltage source.

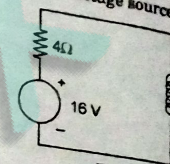


Fig.

Applying KVL

$$\begin{aligned} 16 &= I \times 4 + L\frac{dI}{dt} \\ 16 &= 4I + \frac{dI}{dt} \\ CF &= Ae^{-4t} \\ PI &= \frac{16}{D+4} = \frac{16}{4} = 4 \\ I &= 4 + Ae^{-4t} \\ t &= 0;\ I = 0 \\ A &= -4 \\ I(t) &= 4(1 - e^{-4t}) \end{aligned}$$

Q. 6. (a) Determine transmission (or ABCD) parameters of a T-network as shown in fig.5, considering three sections assuming connected in cascade manner. **(8)**

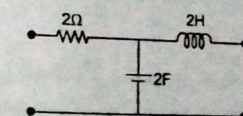
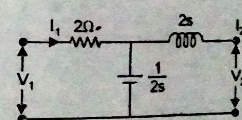


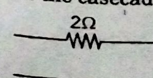
Fig. 5.

Ans.

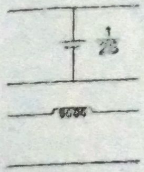


$$\begin{aligned} V_1 &= AV_2 - BI_2 \\ I_1 &= CV_2 - DI_2 \end{aligned}$$

This is the casecade combination of three network.



$$T_a = \begin{bmatrix} 1 & 2 \\ 0 & 1 \end{bmatrix}$$



$$T_b = \begin{bmatrix} 1 & 0 \\ 2s & 1 \end{bmatrix}$$

$$T_c = \begin{bmatrix} 1 & 2s \\ 0 & 1 \end{bmatrix}$$

For the combination

$$T = T_a \times T_b \times T_c$$

$$= \begin{bmatrix} 4s+1 & 2(4s^2+s+1) \\ 2s & 4s^2+1 \end{bmatrix}$$

Q. 6. (b) Find the relationship between Z-parameters in terms of h-parameters. **(4.5)**

Ans. Z-parameters in terms of h-parameters

The h-parameter are

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

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

Rewriting the equation (1), i.e.,

$$V_2 = -\frac{h_{21}}{h_{11}} I_1 + \frac{1}{h_{22}} I_2$$

Comparing with equation

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

Again from equation (1)

$$V_1 = h_{11} I_1 + h_{12}\left[-\frac{h_{21}}{h_{22}} I_1 + \frac{1}{h_{22}} I_2\right] = \left[h_{11} - \frac{h_{21}h_{12}}{h_{22}}\right] I_1 + \frac{h_{12}}{h_{22}} I_2$$

Comparing with equation

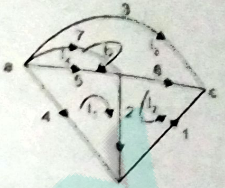
$$Z_{11} = \frac{\Delta h}{h_{22}} \text{ and } Z_{12} = \frac{h_{12}}{h_{22}}$$

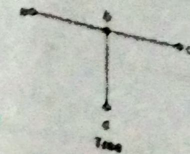
Q. 7. (a) The reduced incidence matrix of a graph is given. Draw the graph and its tree and obtain fundamental loop matrix and cut-set matrix. **(8)**

$$[A] = \begin{bmatrix} 0 & 0 & 1 & 1 & 1 & 0 & -1 \\ 0 & 1 & 0 & 0 & -1 & 1 & 1 \\ -1 & 0 & -1 & 0 & 0 & -1 & 0 \end{bmatrix}$$

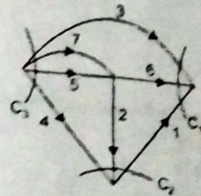
Ans. Complete matrix is

$$\begin{array}{c} \\ a \\ b \\ c \\ d \end{array} \begin{bmatrix} 1 & 2 & 3 & 4 & 5 & 6 & 7 \\ 0 & 0 & 1 & 1 & 1 & 0 & -1 \\ 0 & 1 & 0 & 0 & -1 & 1 & 1 \\ -1 & 0 & -1 & 0 & 0 & -1 & 0 \\ 1 & -1 & 0 & -1 & 0 & 0 & 0 \end{bmatrix}$$





$$f\text{loop matrix} = \begin{array}{c} \\ l_1 \\ l_2 \\ l_3 \\ l_4 \end{array} \begin{bmatrix} 1 & 2 & 3 & 4 & 5 & 6 & 7 \\ 0 & 1 & 0 & 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 1 & 0 & -1 & -1 & 0 \\ 0 & 0 & 0 & 0 & -1 & 0 & 1 \end{bmatrix}$$



$$f\text{cut set matrix} = \begin{array}{c} \\ C_1 \\ C_2 \\ C_3 \end{array} \begin{bmatrix} 1 & 2 & 3 & 4 & 5 & 6 & 7 \\ 1 & 0 & 1 & 0 & 0 & 1 & 0 \\ -1 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 1 & 0 & 1 \end{bmatrix}$$

Q. 7. (b) Check whether the given polynomial is Hurwitz or not. **(4.5)**

$P(s) = s^3 + 2s^2 + 3s + 6$

Ans. Condition(1): is satisfied (since all a are positive).

Condition (2): Even and odd parts of P(s) are

$$M(s) = 2s^2 + 6$$

$$N(s) = s^3 + 3s$$

So, continued fraction expansion of $\psi(s) = \frac{N(s)}{M(s)}$ is given as

$$2s^2+6 \,\big)\, s^3 + 3s \,\big(\, \tfrac{1}{2}s$$

$$\underline{s^3 + 3s}$$

$$\times$$

We see that the division has been terminated abruptly (suddenly) by a common factor $s^3 + 3s$. Thus

$$P(s) = (s^3+3s)\left(1+\frac{2}{s}\right) = W(s).P_1(s)$$

We know that the term $P_1(s) = \left(1+\frac{2}{s}\right)$ is Hurwitz. Now check for

$$W(s) = s^3+3s = s(s^2+3) = s\left(s+j\sqrt{3}\right)\left(s-j\sqrt{3}\right) \text{ is Hurwitz}$$

Alternatively, since W(s) is an odd function, therefore the continued fraction expansion of $\psi'(s) = W(s)/_{W'(s)}$ is given as

$$\begin{array}{l} 3s^2+3 \,\big)\, s^3+3s \,\big(\, \frac{1}{3}s \\ \qquad\quad \underline{s^3+s} \\ \qquad\quad 2s \,\big)\, 3s^2+3 \,\big(\, \frac{3}{2}s \\ \qquad\qquad\quad \underline{3s^2} \\ \qquad\qquad\quad 3 \,\big)\, 2s \,\big(\, \frac{2}{3}s \\ \qquad\qquad\qquad\quad \underline{2s} \\ \qquad\qquad\qquad\quad \times \end{array}$$

Q. 8. An Impedance function for one port network is given by, (12.5)
Z(S) = 2* (S² + 1) (S² + 9)/S* (S² + 4)
Synthesize the network in
(i) Foster's – I form
(ii) Foster's – II form
(iii) Cauer's – I form

Ans. (i) Foster – I Form

$$\begin{array}{l} s^3+4s \,\big)\, 2s^4+20s^2+18 \,\big(\, 2s \\ \qquad\qquad \underline{2s^4+8s^2} \\ \qquad\qquad\quad 12s^2+18 \end{array}$$

$$Z(s) = 2s+\frac{12s^2+18}{s(s^2+4)}$$

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 8.(a)

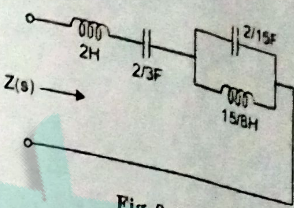


Fig. 8. (a)

(ii) 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,

$$Y(s) = \frac{1}{2}\left[\frac{\frac{3}{8}s}{s^2+1}+\frac{\frac{5}{8}s}{s^2+9}\right]$$

$$= \frac{\frac{3}{16}s}{s^2+1}+\frac{\frac{5}{16}s}{s^2+9}$$

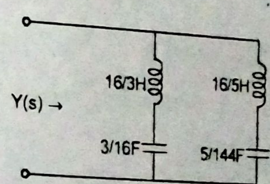


Fig. 8.(b)

Hence, synthesized network is shown in figure 8. (b).

(iii) Cauer – I from

$$Z(s) = \frac{2(s^2+1)(s^2+9)}{s(s^2+4)} = \frac{2s^4+20s^2+18}{s^3+4s}$$

The continued fraction expansion is

$$s^3+4s \overline{)\,2s^4+20s^2+18\,}\left(2s \leftrightarrow Z_1\right.$$
$$2s^4+8s^2$$
$$12s^2+18 \overline{)\,s^3+4s\,}\left(\frac{1}{12}s \leftrightarrow Y_2\right.$$
$$s^3+\frac{3}{2}s$$
$$\frac{5}{2}s \overline{)\,12s^2+18\,}\left(\frac{2}{5}\times 12s = \frac{24}{5}s \leftrightarrow Z_3\right.$$
$$12s^2$$
$$18 \overline{)\,\frac{5}{2}s\,}\left(\frac{1}{18}\cdot\frac{5}{2}s = \frac{5}{36}s \leftrightarrow Y_4\right.$$
$$\frac{5}{2}s$$
$$\times$$

Therefore, the final synthesized network is shown in figure 8. (c)

Cauer– II form:

$$Z(s) = \frac{2s^4+20s^2+18}{s^3+4s}$$

$$= \frac{18+20s^2+2s^4}{4s+s^3}$$

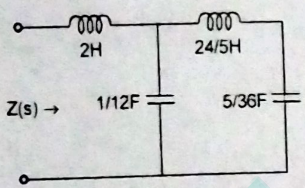


Fig.8. (c)

The continued fraction expansion is

$$4s+s^3 \overline{)\,18+20s^2+2s^4\,}\left(\frac{18}{4s} = \frac{19}{4s} \leftrightarrow Z_1\right.$$
$$18+\frac{9}{2}s^2$$
$$\frac{31}{2}s^2+2s^4 \overline{)\,4s+s^3\,}\left(\frac{2}{31}\cdot\frac{4}{s} = \frac{8}{31s} \leftrightarrow Y_2\right.$$
$$4s+\frac{16}{31}s^3$$
$$\frac{15}{31}s^3 \overline{)\,\frac{31}{2}s^2+2s^4\,}\left(\frac{31}{15}\cdot\frac{31}{2s} = \frac{961}{30s} \leftrightarrow Z_3\right.$$
$$\frac{31}{2}s^2$$
$$2s^4 \overline{)\,\frac{15}{31}s^3\,}\left(\frac{1}{2}\cdot\frac{15}{31s} = \frac{15}{62s} \leftrightarrow Y_4\right.$$
$$\frac{15}{31}s^3$$
$$\times$$

Therefore, the final synthesized network is shown in figure 8 (d)

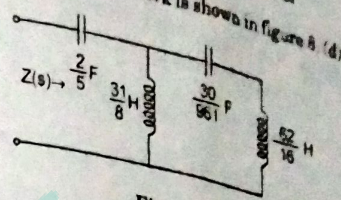


Fig.8. (d)

Q. 9. (a) Determine the cut-off frequency for the HPF as shown in fig.6 and fig. 7. **(8)**

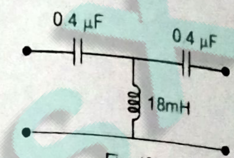


Fig. (6)

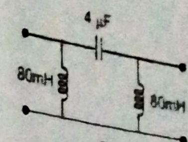


Fig (7)

Ans. (a) For the T-network

Given $2C = 0.4\ \mu F$ and $L = 18$ mH

$$K = \sqrt{\frac{L}{C}} = \sqrt{\frac{18\times10^{-3}}{0.2\times10^{-6}}} = 300\,\Omega$$

Cut-off frequency; $f_C = \dfrac{1}{4\pi\sqrt{LC}} = \dfrac{K}{4\pi L} = \dfrac{300}{4\times3.141\times18\times10^{-3}} = 1326$ Hz

or $f_C = \dfrac{1}{4\pi KC} = \dfrac{1}{4\times3.141\times300\times0.2\times10^{-6}} = 1326$ Hz

(b) For the π-network

Given $2L = 80$ mH and $C = 4\mu F$

Cut-off frequency; $f_C = \dfrac{1}{4\pi\sqrt{LC}} = \dfrac{1}{4\times3.141\times\sqrt{40\times10^{-3}\times4\times10^{-6}}} = 198.94$ Hz

Q. 9. (b) Check whether the given polynomial is Hurwitz or not.
Z(s) = (2s² + 5) s* (s² + 1) is positive real function (prf) or not. **(4.5)**

Ans. Condition (1) $D(s) = s^3+s$, then $D'(s) = 3s^2+1$

$$3s^2+1 \overline{)\,s^3+s\,}\left(\frac{1}{3}s\right.$$
$$s^3+\frac{1}{3}s$$
$$\frac{2}{3}s \overline{)\,3s^2+1\,}\left(\frac{3}{2}\cdot 3s = \frac{9}{2}s\right.$$
$$3s^2$$
$$1 \overline{)\,\frac{2}{3}s\,}\left(\frac{2}{3}s\right.$$
$$\frac{2}{3}s$$
$$\times$$

Therefore, $D(s)$ is Hurwitz polynomial

Condition (2): We find that $Z(s)$ has a pair of poles $s = \pm j1$

The partial fraction expansion of $Z(s)$ is

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

which shows that the residue of the poles at $s = \pm j1$ is negative.

Therefore, $Z(s)$ is not p.r.f.