University of Mumbai
Examination 2021 under Cluster 06
(Lead College: Vidyavardhini's College of Engg Tech)

Examination for Direct Second Year Students Commencing from 10th April 2021

Program: **Electronics Engineering**

Curriculum Scheme: Rev 2019

Examination: SE Semester III (For DSE Students)

Course Code: ELC304 and Course Name: Electrical Network Analysis and Synthesis

Time: 2 hour Max. Marks: 80

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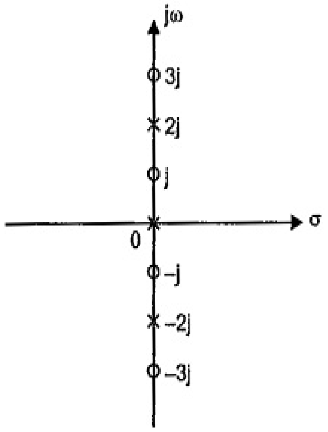
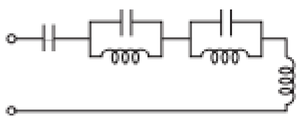
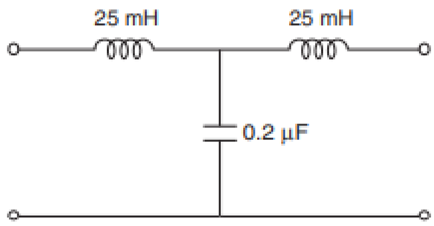
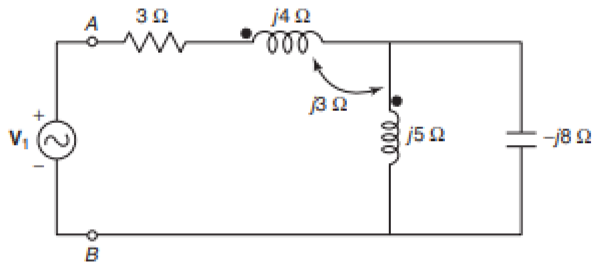
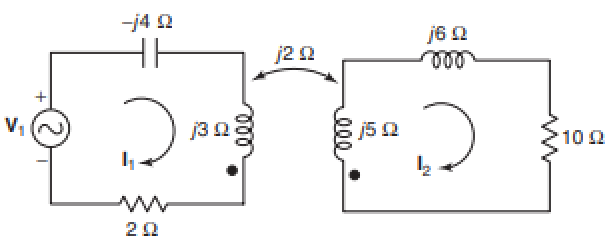
Q1.	**Choose the correct option for following questions. All the Questions are compulsory and carry equal marks**
1.	-----------------between coils is defined as fraction of magnetic flux produced by the current in one coil that links the other
Option A:	Coefficient of Coupling
Option B:	Self Inductance
Option C:	Mutual Inductance
Option D:	Self Coupling
2.	The combined inductance of two coils connected in series is 0.6 H or 0.1 H depending on relative directions of currents in the two coils. If one of the coils has a self-inductance of 0.2 H, find (a) mutual inductance, and (b) coefficient of coupling.
Option A:	(a)M=0.105H , (b) K= 0.62
Option B:	(a)M=0.125H , (b) K= 0.72
Option C:	(a)M=0.115H , (b) K= 0.72
Option D:	(a)M=0.125H , (b) K= 0.62
3.	Which notation of instant implies that the unchanged condition of network is about to change?
Option A:	$t\ (0)^{+}$
Option B:	$t(0)_{-}$
Option C:	t^{*}
Option D:	$t^{\hat{}}$
4.	What does 'σ' indicate in the equation of complex frequency variable s = σ + jω while defining the Laplace transform?
Option A:	Attenuation constant
Option B:	Damping factor

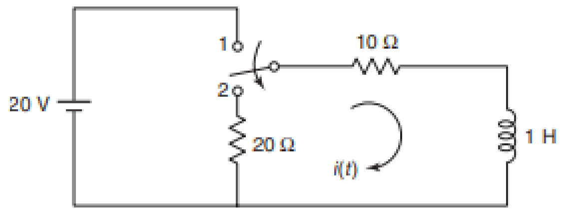
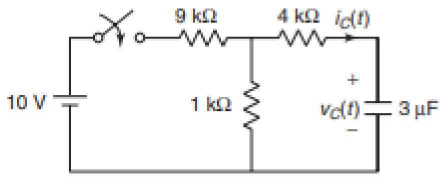
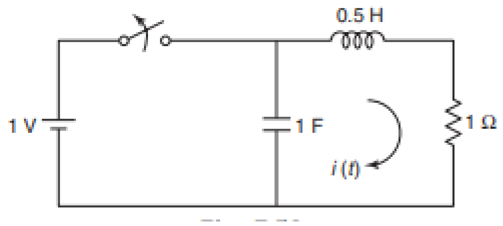
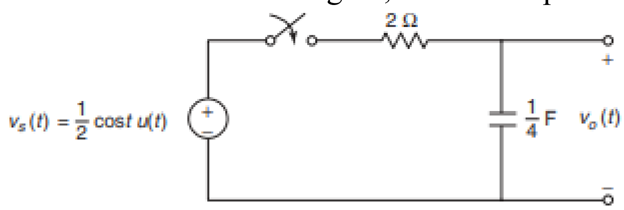
Option C:	Propagation constant
Option D:	Phase constant
5.	Consider a function f(t) that satisfies the differential equation given below. What equation will be generated by taking Laplace transform and replacing the terms $f(0^-)$ & $f'(0^-)$ by zero? $[d^2 f(t) / dt^2] + 5 [df(t) / dt] + 6 f(t) = 10$
Option A:	$[S^2 F(s) + 5s F(s) + 6 F(s)] = 10/s$
Option B:	$[S^2 F(s) + 5s F(s) – 6 F(s)] = 10/s$
Option C:	$[S^2 F(s) – 5s F(s) + 6 F(s)] = 10/s$
Option D:	$[S^2 F(s) – 5s F(s) – 6 F(s)] = 10/s$
6.	What is an ideal value of network function at poles?
Option A:	Zero
Option B:	Nonzero
Option C:	Infinity
Option D:	Unity
7.	The realization of driving point immitance functions of networks can be done by any of the forms which are not used from following
Option A:	Foster I
Option B:	Foster II
Option C:	Cauer I
Option D:	Curier II
8.	Which among the following represents the precise condition of reciprocity for transmission parameters?
Option A:	AD-BC=0
Option B:	AC-BD=1
Option C:	AD-BC=1
Option D:	BC-AD=1
9.	The relation between Z_{OT}, Z_{oc}, Z_{sc} is?
Option A:	$Z_{OT}=\sqrt{Z_{oc}Z_{sc}}$
Option B:	$Z_{oc}=\sqrt{(Z_{OT} Z_{sc})}$
Option C:	$Z_{sc}=\sqrt{(Z_{OT} Z_{oc})}$
Option D:	$Z_{oc}=\sqrt{(Z_{OT} Z_{oc})}$
10.	In determining Hybrid parameters, among V_1, V_2, I_1, I_2, which of the following

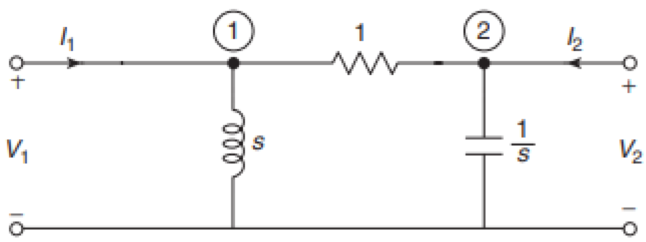
	are dependent variables?
Option A:	V_1 and V_2
Option B:	I_1 and I_2
Option C:	V_1 and I_2
Option D:	I_1 and V_2
11.	The Laplace transform of a unit-ramp function starting at t = a is
Option A:	$\frac{1}{(s+a)^2}$
Option B:	$\frac{e^{-as}}{(s+a)^2}$
Option C:	$\frac{e^{-as}}{s^2}$
Option D:	$\frac{a}{s^2}$
12.	 Fig. 7.4 Above pole zero diagram indicates which function
Option A:	RC
Option B:	LC
Option C:	RL
Option D:	RLC
13.	A system is represented by the transfer function 10 / (S+2)(s+1), The dc gain of this system is
Option A:	1
Option B:	5
Option C:	10
Option D:	2
14.	The transfer function of a low-pass RC network is

Option A:	$(RCs)\,(1+RCs)$
Option B:	$\frac{RCs}{1+RCs}$
Option C:	$\frac{1}{1+RCs}$
Option D:	$\frac{s}{1+RCs}$
15.	The input ports of two networks are connected in series and the output ports are connected in parallel ,then resultant h-parameter matrix is the ---------- of h-parameter matrices of each individual two-port network
Option A:	Substraction
Option B:	Division
Option C:	Multiplication
Option D:	Sum
16.	For a two-port network to be reciprocal
Option A:	z11 = z22
Option B:	y21 = y12
Option C:	h21 = h12
Option D:	AD - BC = 0
17.	The number of roots of $s^3 + 5s^2 + 7s + 3 = 0$ in the right half of s-plane is
Option A:	Zero
Option B:	One
Option C:	Two
Option D:	Three
18.	The circuit shown in Fig. is 
Option A:	Cauer I form
Option B:	Cauer II form
Option C:	Foster I form
Option D:	Foster II form
19.	From below functions which is positive real function
Option A:	$F(s) = \frac{s^3 + 5s}{s^4 + 2s^2 + 1}$
Option B:	$F(s) = \frac{s^2 + s + 6}{s^2 + s + 1}$

Option C:	$F(s) = \dfrac{s^2+4}{s^3+3s^2+3s+1}$
Option D:	$F(s) = \dfrac{s^3+6s^2+7s+3}{s^2+2s+1}$
20.	Find the nominal impedance, cut-off frequency for the network shown in fig. 
Option A:	nominal impedance=500, cut-off frequency=3.18Khz
Option B:	nominal impedance=600, cut-off frequency=3.18Khz
Option C:	nominal impedance=500, cut-off frequency=2.16Khz
Option D:	nominal impedance=600, cut-off frequency=2.16Khz

Q2 (20 Marks)	**Solve any Four out of Six (5 marks each)**
A	For the coupled circuit shown in Figure, find input impedance at terminals A and B. 
B	*Find the conductively coupled equivalent circuit for the network shown in Fig.* 
C	In the network shown in Figure, the switch is changed from the position 1 to the position 2 at t = 0, steady condition having reached before switching. Find the values of I, di/dt, d^2i/dt^2 at t=0+

	
D	In the network shown in Figure, the switch closes at t = 0. The capacitor is initially uncharged. Find v_c (t) and i_c (t) 
E	In the network shown in Figure, the switch is opened at t = 0. Steady-state condition is achieved before t = 0. Find i(t) 
F	For the network shown in Figure, find the response vo (t). 

Q3 (20 Marks)	
Q.3 A	**Solve any Two (5 marks each)**
i.	Write short note on Different types of filter
ii.	Determine the transmission parameters for the network shown in Fig. 
iii.	Write derivation for Condition for Reciprocity
Q.3 B	**Solve any One (10 marks each)**
i.	a) Prove that polynomial $P(s) = s^4 + s^3 + 2s^2 + 3s + 2$ is not Hurwitz.

	b) Test whether the polynomial $P(s) = s^8 + 5s^6 + 2s^4 + 3s^2 + 1$ is Hurwitz by Routh array
ii.	Realise Foster I & Cauer I forms of the following RC impedance function $Z(s) = \frac{s+4}{(s+2)(s+6)}$

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Q1:

Question Number	Correct Option (Enter either 'A' or 'B' or 'C' or 'D')
Q1.	A
Q2.	B
Q3.	B
Q4	A
Q5	A
Q6	C
Q7	D
Q8.	C
Q9.	A
Q10.	C
Q11.	C
Q12.	B
Q13.	B
Q14.	C
Q15.	D
Q16.	B
Q17.	A
Q18.	C
Q19.	D
Q20.	A

Important steps and final answer for the questions involving numerical example

Q2(A):

Solution The equivalent circuit in terms of dependent sources is shown in Fig. 4.52.

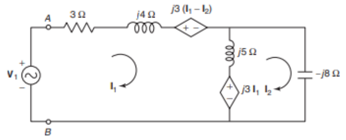


Fig. 4.52

Applying KVL to Mesh 1,

$$\mathbf{V}_1 - 3\mathbf{I}_1 - j4\mathbf{I}_1 - j3(\mathbf{I}_1 - \mathbf{I}_2) - j5(\mathbf{I}_1 - \mathbf{I}_2) - j3\mathbf{I}_1 = 0$$

$$(3 + j15)\,\mathbf{I}_1 - j8\,\mathbf{I}_2 = \mathbf{V}_1 \qquad \text{...(i)}$$

Applying KVL to Mesh 2,

$$j3\,\mathbf{I}_1 - j5(\mathbf{I}_2 - \mathbf{I}_1) + j8\,\mathbf{I}_2 = 0$$

$$j8\,\mathbf{I}_1 + j3\,\mathbf{I}_2 = 0$$

$$\mathbf{I}_2 = -\frac{j8}{j3}\mathbf{I}_1 = -2.67\,\mathbf{I}_1 \qquad \text{...(ii)}$$

Substituting Eq (ii) in Eq (i),

$$(3 + j15)\mathbf{I}_1 - j8(-2.67\,\mathbf{I}_1) = \mathbf{V}_1$$

$$(3 + j\,36.36)\,\mathbf{I}_1 = \mathbf{V}_1$$

$$\mathbf{Z}_i = \frac{\mathbf{V}_1}{\mathbf{I}_1} = (3 + j\,36.36)\,\Omega = 36.48\angle 85.28^\circ\,\Omega$$

Q2(B):

Solution The current $\mathbf{I}_1$ leaves from the dotted end and $\mathbf{I}_2$ enters from the dotted end. Hence, mutual inductance M is negative.

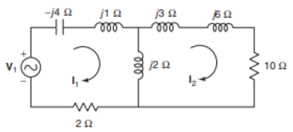
In the conductively coupled equivalent circuit,

$$\mathbf{Z}_1 = j\omega(L_1 - M) = j\omega L_1 - j\omega M = j3 - j2 = j1\,\Omega$$

$$\mathbf{Z}_2 = j\omega(L_2 - M) = j\omega L_2 - j\omega M = j5 - j2 = j3\,\Omega$$

$$\mathbf{Z}_3 = j\omega M = j2\,\Omega$$

The conductively coupled equivalent circuit is shown in Fig. 4.76.



Q2(C):

Solution At $t = 0^-$, the network attains steady-state condition. Hence, the capacitor acts as an open circuit.

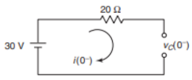


Fig. 6.26

$$v_C(0^-) = 30 \text{ V}$$
$$i(0^-) = 0$$

At $t = 0^+$, the network is shown in Fig. 6.27.
At $t = 0^+$, the capacitor acts as a voltage source of 30 V.

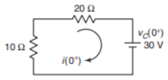


Fig. 6.27

$$v_C(0^+) = 30 \text{ V}$$
$$i(0^+) = -\frac{30}{30} = -1 \text{ A}$$

For $t > 0$, the network is shown in Fig. 6.28.
Writing the KVL equation for $t > 0$,

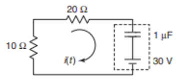


Fig. 6.28

$$-10i - 20i - \frac{1}{1\times 10^{-6}}\int_0^t i\, dt - 30 = 0 \qquad \ldots\text{(i)}$$

Differentiating Eq. (i),

$$-30\frac{di}{dt} - 10^6 i = 0 \qquad \ldots\text{(ii)}$$

At $t = 0^+$,
$$-30\frac{di}{dt}(0^+) - 10^6 i(0^+) = 0$$
$$\frac{di}{dt}(0^+) = \frac{10^6(-1)}{30} = 0.33\times 10^5 \text{ A/s}$$

At $t = 0^+$,
$$-30\frac{di}{dt}(0^+) - \frac{d^2i}{dt^2}(0^+) = 0$$
$$\frac{d^2i}{dt^2}(0^+) = 1800 \text{ A/s}^2$$

Q2(D):

Solution At $t = 0^-$, the capacitor is uncharged. Hence, it acts as a short circuit.

$$v_C(0^-) = 0$$
$$i_C(0^-) = 0$$

At $t = 0^+$, the network is shown in Fig. 6.130.
Since voltage across the capacitor cannot change instantaneously,

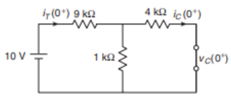


Fig. 6.130

$$v_C(0^+) = 0$$

At $t = 0^+$, $i_T(0^+) = \left[\frac{10}{9\text{ k} + (4\text{ k} \| 1\text{ k})}\right] = \frac{10}{9.8\text{ k}} = 1.02 \text{ mA}$

$$i_C(0^+) = 1.02\text{ m} \times \frac{1\text{ k}}{1\text{ k} + 4\text{ k}} = 0.204 \text{ mA}$$

For $t > 0$, the network is shown in Fig. 6.131.
For $t > 0$, representing the network to the left of the capacitor by Thevenin's equivalent network,

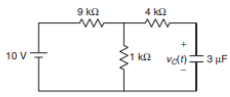


Fig. 6.131

$$V_{eq} = 10 \times \frac{1\text{ k}}{9\text{ k} + 1\text{ k}} = 1 \text{ V}$$
$$R_{eq} = (9\text{ k} \| 1\text{ k}) + 4\text{ k} = 4.9 \text{ k}\Omega$$

For $t > 0$, Thevenin's equivalent network is shown in Fig. 6.132.
Writing the KCL equation for $t > 0$,

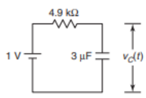


Fig. 6.132

$$3\times 10^{-6}\frac{dv_C}{dt} + \frac{v_C - 1}{4.9\times 10^3} = 0$$
$$\frac{dv_C}{dt} + 68.02\, v_C = 68.02$$

Comparing with the differential equation $\frac{dv}{dt} + Pv = Q$,

$$P = 68.02, \quad Q = 68.02$$

The solution of this differential equation is given by,

$$v_C(t) = e^{-Pt}\int Q\, e^{Pt}\, dt + k\, e^{-Pt}$$
$$= e^{-68.02t}\int 68.02\, e^{68.02t}\, dt + k\, e^{-68.02t}$$
$$= 1 + k\, e^{-68.02t}$$

At $t = 0, v_C(0) = 0$

$$0 = 1 + k$$
$$k = -1$$
$$v_C(t) = 1 - e^{-68.02t} \qquad \text{for } t > 0$$
$$i_C(t) = C\frac{dv_C}{dt}$$
$$= 3\times 10^{-6}\frac{d}{dt}(1 - e^{-68.02t})$$
$$= 3\times 10^{-6} \times 68.02 e^{-68.02t}$$
$$= 204.06\times 10^{-6} e^{-68.02t} \qquad \text{for } t > 0$$

Q2(E)

Solution At $t = 0^-$, the network is shown in Fig 7.54. At $t = 0^-$, the switch is closed and steady-state condition is achieved. Hence, the capacitor acts as an open circuit and the inductor acts as a short circuit.

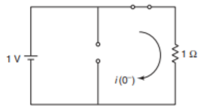


Fig. 7.54

$$v_c(0^-) = 1 \text{ V}$$
$$i(0^-) = 1 \text{ A}$$

Since current through the inductor and voltage across the capacitor cannot change instantaneously,

$$v_c(0^+) = 1 \text{ V}$$
$$i(0^+) = 1 \text{ A}$$

For $t > 0$, the transformed network is shown in Fig. 7.55.
Applying KVL to the mesh for $t > 0$,

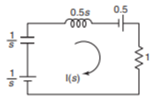


Fig. 7.55

$$\frac{1}{s} - \frac{1}{s}I(s) - 0.5s\, I(s) + 0.5 - I(s) = 0$$
$$0.5 + \frac{1}{s} = \frac{1}{s}I(s) + 0.5s\, I(s) + I(s)$$
$$I(s)\left[1 + \frac{1}{s} + 0.5s\right] = 0.5 + \frac{1}{s}$$
$$I(s) = \frac{s+2}{s^2+2s+2} = \frac{(s+1)+1}{(s+1)^2+1} = \frac{s+1}{(s+1)^2+1} + \frac{1}{(s+1)^2+1}$$

Taking the inverse Laplace transform,

$$i(t) = e^{-t}\cos t + e^{-t}\sin t \qquad \text{for } t > 0$$

Q2(F)

Solution For $t > 0$, the transformed network is shown in Fig. 7.83.

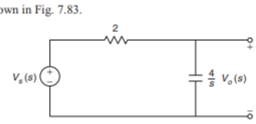


Fig. 7.83

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

By voltage-division rule,

$$V_o(s) = V_s(s) \times \frac{\frac{4}{s}}{2 + \frac{4}{s}} = \frac{2V_s(s)}{s+2} = \frac{s}{(s^2+1)(s+2)}$$

By partial-fraction expansion,

$$V_o(s) = \frac{As+B}{s^2+1} + \frac{C}{s+2}$$
$$s = (As+B)(s+2) + c(s^2+1)$$
$$s = (A+C)s^2 + (2A+B)s + (2B+C)$$

Comparing coefficient of s^2, s and s^0,

$$A + C = 0$$
$$2A + B = 1$$
$$2B + C = 0$$

Solving the equations,

$$A = 0.4, \quad B = 0.2, \quad C = -0.4$$
$$V_o(s) = \frac{0.4s+0.2}{s^2+1} - \frac{0.4}{s+2} = \frac{0.4s}{s^2+1} + \frac{0.2}{s^2+1} - \frac{0.4}{s+2}$$

Taking the inverse Laplace transform,

$$i(t) = 0.4\cos t + 0.2\sin t - 0.4e^{-2t} \qquad \text{for } t > 0$$

Q3(A1):Types of filter with explanation.

Q3(A2):

Solution
Applying KCL at Node 1,

$$I_1 = \frac{V_1}{s} + (V_1 - V_2)$$
$$- \frac{s+1}{s}V_1 - V_2 \qquad \ldots\text{(i)}$$

Applying KCL at Node 2,

$$I_2 = \frac{V_2}{\frac{1}{s}} + (V_2 - V_1)$$
$$- (s+1)\,V_2 - V_1$$
$$V_1 = (s+1)\,V_2 - I_2 \qquad \ldots\text{(ii)}$$

Substituting Eq. (ii) in Eq. (i),

$$I_1 = \frac{s+1}{s}[(s+1)V_2 - I_2] - V_2$$
$$= \left[\frac{(s+1)^2}{s} - 1\right]V_2 - \frac{s+1}{s}I_2$$
$$= \left(\frac{s^2+s+1}{s}\right)V_2 - \left(\frac{s+1}{s}\right)I_2 \qquad \text{...(iii)}$$

Comparing Eqs (ii) and (iii) with *ABCD* parameter equations,

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} s+1 & 1 \\ \frac{s^2+s+1}{s} & \frac{s+1}{s} \end{bmatrix}$$

Q3(A3):

9.5.1 Condition for Reciprocity

(a) As shown in Fig. 9.37, voltage V_s is applied at the input port and the output port is short-circuited.

i.e.,
$$V_1 = V_s$$
$$V_2 = 0$$
$$I_2' = -I_2$$

Fig. 9.37 *Network for deriving condition for reciprocity*

From the *h*-parameter equations,
$$V_s = h_{11} I_1$$
$$-I_2' = h_{21} I_1$$
$$\frac{V_s}{I_2'} = -\frac{h_{11}}{h_{21}}$$

(b) As shown in Fig. 9.38, voltage V_s is applied at the output port with the input port short-circuited.

i.e.,
$$V_1 = 0$$
$$V_2 = V_s$$
$$I_1 = -I_1'$$

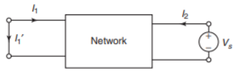


Fig. 9.38 *Network for deriving condition for reciprocity*

From the *h*-parameter equations,
$$0 = h_{11}I_1 + h_{12}V_s$$
$$h_{12}V_s = -h_{11}I_1 = h_{11}I_1'$$
$$\frac{V_s}{I_1'} = \frac{h_{11}}{h_{12}}$$

Hence, for the network to be reciprocal,
$$\frac{V_s}{I_2'} = \frac{V_s}{I_1'}$$

i.e.,
$$h_{21} = -h_{12}$$

Q3(B1-a):

Solution Even part of $P(s) = m(s) = s^4 + 2s^2 + 2$

Odd part of $P(s) = n(s) = s^3 + 3s$

$$Q(s) = \frac{m(s)}{n(s)}$$

By continued fraction expansion,

$$\begin{array}{l} s^3+3s\,\big)\, s^4+2s^2+2\,\big(\, s \\ \qquad \underline{s^4+3s^2} \\ \qquad -s^2+2\,\big)\, s^3+3s\,\big(\, -s \\ \qquad\qquad \underline{s^3-2s} \\ \qquad\qquad 5s\,\big)\, -s^2+2\,\big(\, -\frac{1}{5}s \\ \qquad\qquad\quad \underline{-s^2} \\ \qquad\qquad\quad 2\,\big)\, 5s\,\big(\, \frac{5}{2}s \\ \qquad\qquad\qquad \underline{5s} \\ \qquad\qquad\qquad 0 \end{array}$$

Since two quotient terms are negative, $P(s)$ is not Hurwitz.

Q3(B1-b):

Solution The given polynomial contains even functions only.

$$P'(s) = 8s^7 + 30s^5 + 8s^3 + 6s$$

The Routh array is given by,

s^8	1	5	2	3	1
s^7	8	30	8	6	0
s^6	1.25	1	2.25	1	
s^5	23.6	−6.4	−0.4	0	
s^4	1.33	2.27	1		
s^3	−46.6	−18.14	0		
s^2	1.75	1			
s^1	8.49				
s^0	1				

Since there is a sign change in the first column of the array, the polynomial is not Hurwitz.

Q3(B2):

Solution

Cauer I Form The Cauer I form is obtained by continued fraction expansion of $Z(s)$ about the pole at infinity. In the above function, the degree of the numerator is less than the degree of the denominator which indicates presence of a zero at infinity. Hence, the admittance function $Y(s)$ has a pole at infinity.

$$Y(s) = \frac{s^2+8s+12}{s+4}$$

By continued fraction expansion,

$$\begin{array}{l} s+4\,\big)\, s^2+8s+12\,\big(\, s \leftarrow Y \\ \quad \underline{s^2+4s} \\ \quad 4s+12\,\big)\, s+4\,\big(\, \frac{1}{4} \leftarrow Z \\ \qquad \underline{s+3} \\ \qquad 1\,\big)\, 4s+12\,\big(\, 4s \leftarrow Y \\ \qquad\quad \underline{4s} \\ \qquad\quad 12\,\big)\, 1\,\big(\, \frac{1}{12} \leftarrow Z \\ \qquad\qquad \underline{1} \\ \qquad\qquad 0 \end{array}$$

The impedances are connected in series branches, whereas the admittances are connected in parallel branches. The network is shown in Fig. 10.55.

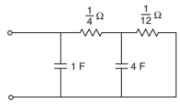


Fig. 10.55

Foster I Form The Foster I form is obtained by partial fraction expansion of $Z(s)$.

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

By partial-fraction expansion,

$$Z(s) = \frac{K_1}{s+2} + \frac{K_2}{s+6}$$

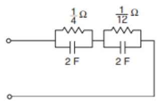
where
$$K_1 = (s+2)Z(s)\big|_{s=-2} = \frac{(-2+4)}{(-2+6)} = \frac{1}{2}$$
$$K_2 = (s+6)Z(s)\big|_{s=-6} = \frac{(-6+4)}{(-6+2)} = \frac{1}{2}$$
$$Z(s) = \frac{\frac{1}{2}}{s+2} + \frac{\frac{1}{2}}{s+6}$$

These two terms represent the impedance of a parallel *RC* circuit for which

$$Z_{RC}(s) = \frac{\frac{1}{C_i}}{s + \frac{1}{R_i C_i}}$$

By direct comparison,

$$R_1 = \frac{1}{4}\,\Omega, \quad C_1 = 2\text{ F}$$
$$R_2 = \frac{1}{12}\,\Omega, \quad C_2 = 2\text{ F}$$



The network is shown in Fig. 10.56.

Fig. 10.56