APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Scheme for Valuation/Answer Key

Scheme of evaluation (marks in brackets) and answers of problems/key

Third Semester B.Tech Degree Examination December 2021 (2019 scheme)

Course Code: ECT205

Course Name: NETWORK THEORY

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions. Each question carries 3 marks Marks

1 Convert the current source 3A parallel to 3Ω to a voltage source 9V in series with 3Ω. (1 mark) (3)

Then the voltage across 10Ω, $V = 9 \times \frac{10}{13} = 6.92$volts (2 marks)

2 Independent and dependent voltage sources (1.5 marks) (3)

Independent and dependent current sources (1.5 marks)

3 Steps for finding the Norton resistance (2 marks) (3)

Model equivalent circuit (1 mark)

4 Theorem (1 mark) (3)

Example (2 marks)

5 Write the expression of f(t). $f(t) = \begin{cases} 2; 0 \le t \le 1 \\ 0; 1 \le t \le 2 \end{cases}$ (1 mark) (3)

As it is a periodic signal with period T=2,

$F(s) = \frac{1}{1-e^{-Ts}} \int_0^T f(t)e^{-st}dt = \frac{1}{1-e^{-2s}} \int_0^2 f(t)e^{-st}dt = \frac{2(1-e^{-s})}{s(1-e^{-2s})} = \frac{2}{s(1+e^{-s})}$(2 marks)

6 RL network (1 mark) (3)

$i(t) = \frac{[1-e^{-t\left(\frac{R}{L}\right)}]}{R}$, t>0

Derivation (2 marks)

7 Write the significance of poles and zeros each1.5marks (1.5x 2=3 marks) (3)

8 Any 3 points (3 marks) (3)

9 Define reciprocity, condition is $Z_{12} = Z_{21}$ (1.5 marks) (3)

Define symmetry, condition is $Z_{11} = Z_{22}$ (1.5 marks)

10 $Z_{11} = \frac{A}{C},\ Z_{12} = \frac{AD - BC}{C}$ (3)

$Z_{21} = \frac{1}{C}, Z_{22} = \frac{D}{C}$

(3 marks)

PART B

Answer any one full question from each module. Each question carries 14 marks

Module 1

11 (a) Consider the 2 meshes with currents I_1 and I_2. (6)

Applying KVL to mesh 1, $4I_1 - 2I_2 = 20$ (2 marks)

Applying KVL to mesh 2, $-2I_1 + 10I_2 = 80$ (2 marks)

Solving $I_1 = I_2 = 10A$ (2 marks)

(b) In the given network, there may be an ambiguity in the source .So students can give marks if they solved considering as voltage source or current source. (8)

As Current source

Consider the single node in the circuit. Let V_1 be the node voltage.

Applying KCL at that node, $\frac{V_1}{25} = 100\angle 45^0 + 200\angle 90^0$. (2 marks)

Solving $V_1 = 1767.8 + j6767.8$ (4 marks)

$I_{25} = 70.71 + j270.07$(2 mark)

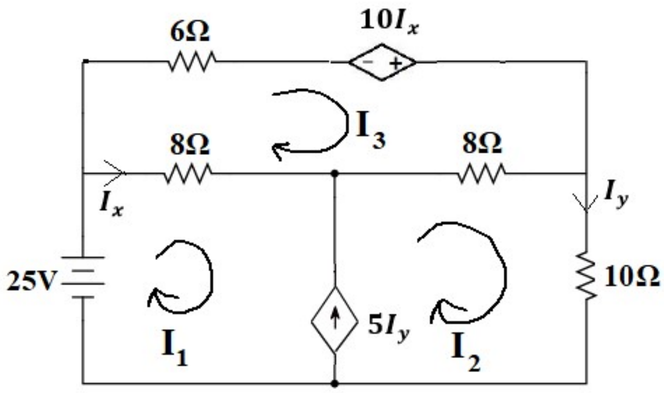
As voltage source

Consider the single node in the circuit. Let V_1 be the node voltage and apply KCL

V_1=86.69-j191.03 V (6 marks)

$I_{25} = 3.46 - j7.64\ A = 8.38\ \angle -65.58^0\ A$ (2 mark)

12 Consider 3 meshes as shown below (14)



From the figure, $I_x = I_1 - I_3$ and $I_y = I_2$

Meshes 1 and 2 form a supermesh.

Supermesh current equation is $I_2 - I_1 = 5I_y = 5I_2$ which is equivalent to

$I_1 + 4I_2 = 0$------------- (1) (2 marks)

Supermesh voltage equation is $8(I_1 - I_3) + 8(I_2 - I_3) + 10I_2 = 25$ which is equivalent to $8I_1 + 18I_2 - 16I_3 = 25$ -------------- (2) (2 marks)

Considering mesh 3, $6I_3 + 8(I_3 - I_1) + 8(I_3 - I_2) = 10I_x$ which is equivalent to $6I_3 + 8(I_3 - I_1) + 8(I_3 - I_2) = 10(I_1 - I_3)$

That is $-18I_1 - 8I_2 + 32I_3 = 0$ ------------------ (3) (2 marks)

Solving (1), (2) and (3)

$$I_1 = \frac{-50}{9} = -5.57A$$

$$I_2 = \frac{25}{18} = 1.39A$$

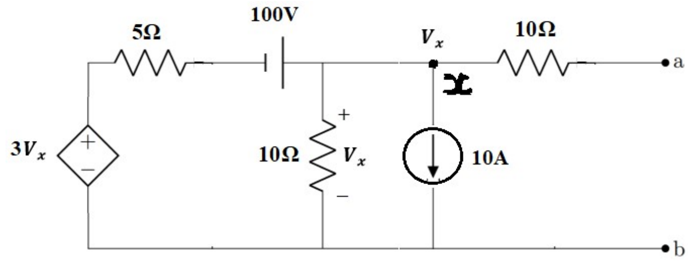
$$I_3 = \frac{-25}{9} = -2.78A$$

Solution – 6 marks

Voltage across 10Ω resistor = $10I_2 = \frac{250}{18} = 13.9V$ (2 marks)

Module 2

13 (a) Considering the node ‘x’ with node voltage V_x as shown below (8)



Applying KCL at node ‘x’

$$\frac{V_x - 100 - 3V_x}{5} + \frac{V_x}{10} + 10 = 0$$

Solving for the Thevenin voltage, $V_{th} = V_x = \frac{-100}{3}V$ (3 marks)

Short circuit the terminal a-b and considering the same node

$$\frac{V_x - 100 - 3V_x}{5} + \frac{V_x}{10} + \frac{V_x}{10} + 10 = 0$$

Solving $V_x = -50V$

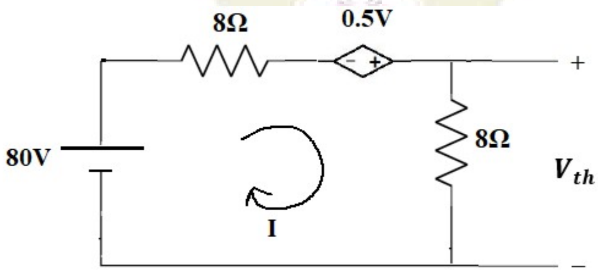
(6)

The short circuit current $I_N = \frac{-5}{10} = -5A$ (3 marks)

Therefore, Thevenn resistance, $R_{th} = \frac{V_{th}}{I_N} = \frac{20}{3} = 6.67\Omega$ (1mark)

Thevenin equivalent network (1 mark)

(b) Applying source transformation to 10A current source and 8Ω resistor.



(1 mark)

From the above figure $V = V_{th} = 8I$

Writing the mesh equation $8I + 8I - 0.5V_{th} = 80$

Solving $I = \frac{80}{12}A$

$V_{th} = 8I = 53.33\,V$(2 marks)

Short circuiting the output side for finding the short circuit current,

$I_N = \frac{80}{8} = 10A$(1 mark)

Therefore $R_{th} = \frac{V_{th}}{I_N} = 5.33\Omega$ (1 mark)

$R_L = R_{th} = 5.33\Omega$

Maximum power is given by

$P = \frac{V_{th}^2}{4R_{th}} = 133.4\,W$(1 mark)

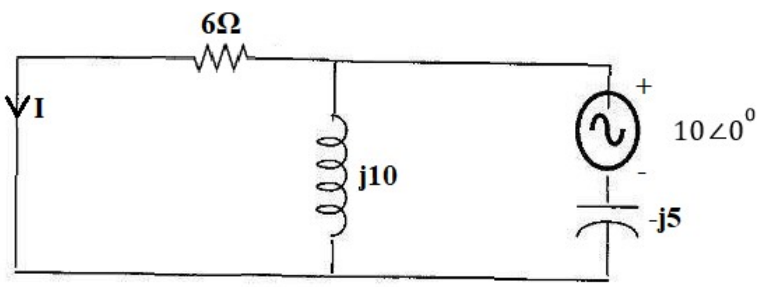
14 Retain the positions of the source $10\angle 0^0$ and the response I. Applying mesh analysis, (14)

$(6 + j10)I_1 - j10I_2 = 10\angle 0^0$------------- (1)

$-j10I_1 + j5I_2 = 0$-------------- (2)

Solving $I = I_2 = 0.8823 + j1.47\,A$ (7 marks)

Interchange the source and the response as shown below.



Applying mesh analysis,

$(6 + j10)I_1 - j10I_2 = 0$-------------- (3)

$-j10I_1 + j5I_2 = 10\angle 0^0$----------------- (4)

Solving $I = I_1 = 0.8823 + j1.47\,A$ (7 marks)

Module 3

15 (a) Initial value theorem statement (1 mark) (8)

LHS = RHS = 0 (3 marks)

Final value theorem statement (1 mark)

LHS = RHS = 0 (3 marks)

(b) Circuit with ramp input in time domain (1 mark) (6)

Transformed circuit in frequency domain (1 mark)

Mesh equation in Laplace domain (2 mark)

Out of syllabus. Full Marks can be given if the student try to solve Mesh equation in Laplace domain.

Time domain response solution (2 marks)

16 Draw the transformed circuit in Laplace domain (2 marks) (14)

Consider the mesh. Write the mesh equation as shown below

$$(2s+6)I(s) = \frac{200}{s^2+100}$$

$$I(s) = \frac{200}{(s^2+100)(s+3)}$$

Solve for $I(s)$. (2 marks)

Represent $I(s)$ using partial fraction expansion method.

A=0.92, B=-0.92, C=2.75

$I(s) = 0.917\left(\frac{1}{s+3}\right) - 0.917\left(\frac{s}{s^2+100}\right) + 0.275\left(\frac{10}{s^2+100}\right)$(8 marks)

Take the inverse to get $i(t)$

$i(t) = 0.917e^{-3t} - 0.917cos10t + 0.275sin10t$(2 marks)

Module 4

17 Draw the pole zero diagram (4 marks) (14)

Write V(s) in partial fraction format

$V(s) = \frac{A}{s} + \frac{B}{s+1} + \frac{C}{s+4}$(1 mark)

Find the phasor from all zeros from that pole to other poles

$$A = \frac{3\angle{-180^0} * 5\angle{-180^0}}{1\angle{-180^0} * 4\angle{-180^0}} = \frac{15}{4}\angle 0^0 = \frac{15}{4}$$

$$B = \frac{2\angle{-180^0} * 4\angle{-180^0}}{1\angle 0^0 * 3\angle{-180^0}} = \frac{8}{3}\angle{-180^0} = \frac{-8}{3}$$

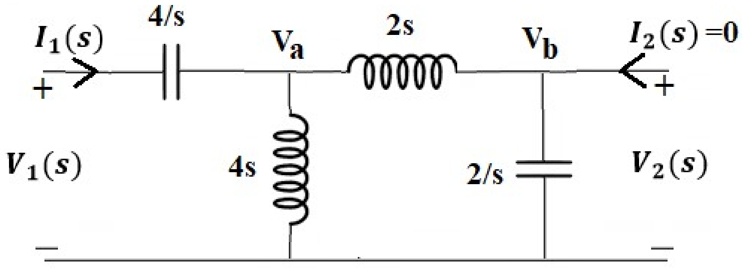
$$C = \frac{1\angle 0^0 * 1\angle{-180^0}}{3\angle 0^0 * 4\angle 0^0} = \frac{1}{12}\angle{-180^0} = \frac{-1}{12}$$

(2 marks each)

Substitute the values of A, B and C in the expression of V(s) and take the inverse.

$v(t) = \frac{15}{4} - \frac{8}{3}e^{-t} - \frac{1}{12}e^{-4t}$(3 marks)

18 Given that $I_2(s) = 0$. Transformed circuit is given by (14)



(2 marks)

Therefore, let the node voltages be V_a and V_b, from the figure $V_b = V_2$

Let the current through the 2s be I_b. Then $I_b = \frac{V_2}{2/s} = \frac{sV_2}{2}$

$$V_a = 2sI_b + V_2 = (s^2+1)V_2$$

$$I_1 = I_b + \frac{V_a}{4s} = \left(\frac{3s^2+1}{4s}\right)V_2$$

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

Solving, voltage gain transfer function is given by

$$\frac{V_1}{V_2} = \frac{s^4+4s^2+1}{s^2}$$

(6 marks)

$$V_1 = \frac{4}{s}I_1 + V_a = V_1 = \frac{4}{s}I_1 + (s^2+1)V_2 = \frac{4}{s}I_1 + (s^2+1)V_2$$

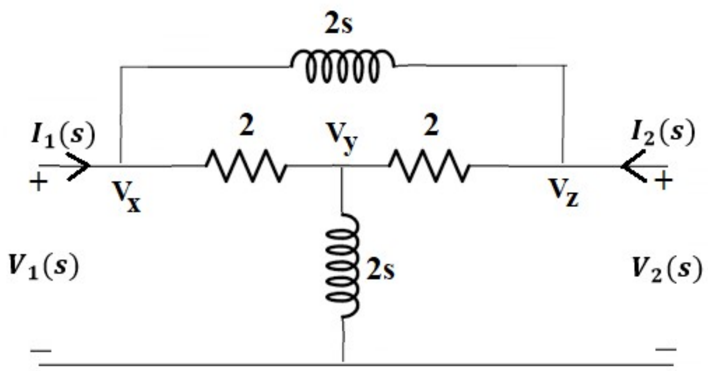
Solving, driving point impedance is given by

$$\frac{V_1}{I_1} = \frac{4(s^4+4s^2+1)}{s(3s^2+1)}$$

(6 marks)

Module 5

19 (14)



Let the node voltages be V_x, V_y and V_z.

$$V_x = V_1$$
$$V_z = V_2$$

Node equations are

$$\frac{V_x - V_y}{2} + \frac{V_x - V_z}{2s} = I_1$$
$$\frac{V_y - V_x}{2} + \frac{V_y - V_z}{2} + \frac{V_y}{2s} = 0$$
$$\frac{V_z - V_y}{2} + \frac{V_z - V_x}{2s} = I_2$$

(6 marks)

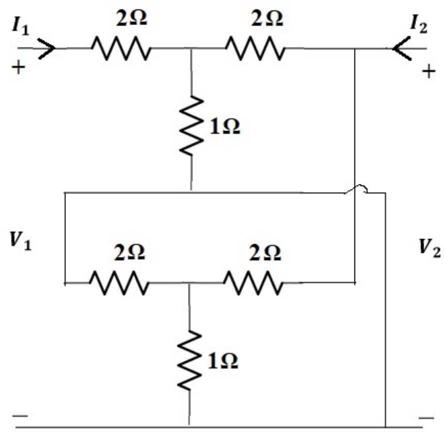
Solving the above 3 expressions,

$$I_1 = \left(\frac{s^2 + 3s + 1}{4s^2 + 2s}\right)V_1 - \left(\frac{s^2 + 2s + 1}{4s^2 + 2s}\right)V_2$$
$$I_2 = -\left(\frac{s^2 + 2s + 1}{4s^2 + 2s}\right)V_1 + \left(\frac{s^2 + 3s + 1}{4s^2 + 2s}\right)V_2$$

$Y_{11}=\frac{s^2+3s+1}{4s^2+2s}$ $Y_{12}=-\frac{s^2+2s+1}{4s^2+2s}$ $Y_{21}=-\frac{s^2+2s+1}{4s^2+2s}$ $Y_{22}=\frac{s^2+3s+1}{4s^2+2s}$(8 marks)

20 Out of syllabus.Full marks can be given if the student try to solve using Z or Y or h-parameters. (14)

2 sessions are connected in series parallel combination. Resultant network is given by



(4 marks)

Consider the single circuit in question.

Mesh 1 equation is given by

$$V_1 = 3I_1 + I_2$$

Mesh 2 equation is given by

$$V_2 = I_1 + 3I_2$$

Solving

$$I_2 = \frac{-I_1 + V_2}{3}$$

$$V_1 = \frac{8I_1 + V_2}{3} \text{(6 marks)}$$

Therefore h-parameters are given by

$$h' = \begin{bmatrix} -1/3 & 1/3 \\ 8/3 & 1/3 \end{bmatrix}$$

Similarly, the h-parameter of the second will be same as above.

$h'' = \begin{bmatrix} -1/3 & 1/3 \\ 8/3 & 1/3 \end{bmatrix}$(2 marks)

Combined parameter values are

$h = h' + h'' = \begin{bmatrix} -2/3 & 2/3 \\ 16/3 & 2/3 \end{bmatrix}$(2 marks)