ANSWER BOOK NO.: 135821 Supplementary Sheet

04 PAGES

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
MID/END TERM EXAMINATION

Name of the student ..... ECC-205 Answer Key. Programme .....

Course Code ..... Course Name .....

Date of Exam ..... Enrollment No ..... Signature of Invigilator .....

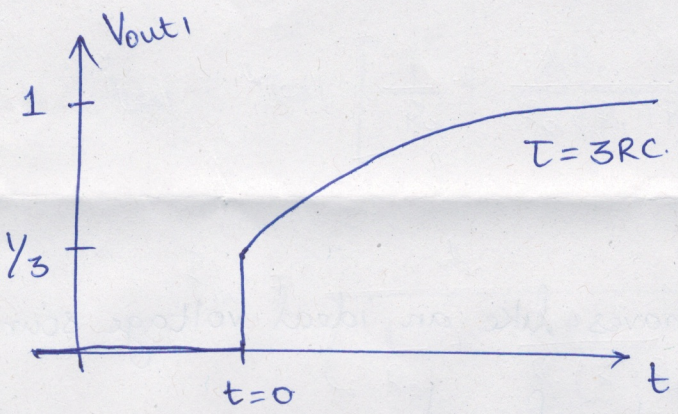
Set-B

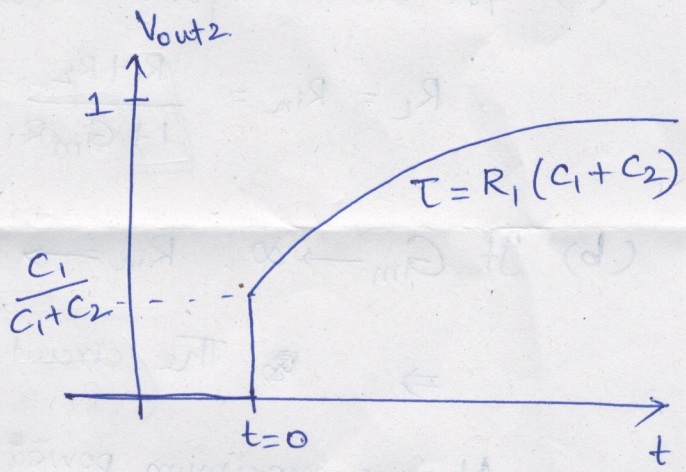
① Number of dependent variables = Order of the circuit.

C_4 & L_3 does not come in the picture for calculating order.

$\Rightarrow$ Order = 6

②





$\frac{C_1}{C_1+C_2} = \frac{1}{3} \Rightarrow 3C_1 - C_1 = C_2$

$\boxed{C_1 = C_2/2}$ — ①

$R_1(C_1+C_2) = 3RC$

$R_1\, 1.5C_2 = 3RC$

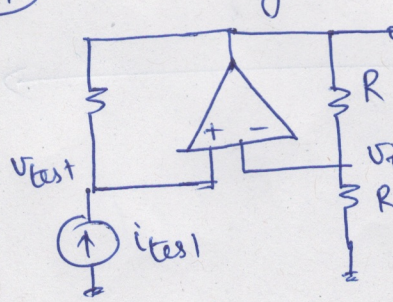
$\boxed{C_2 = C}$

$\Rightarrow \boxed{R_1 = 2R}$

$\therefore \boxed{R_1 = 2R}$

$\boxed{C_1 = C/2}$; $\boxed{C_2 = C}$

④ B is negative, A is positive.

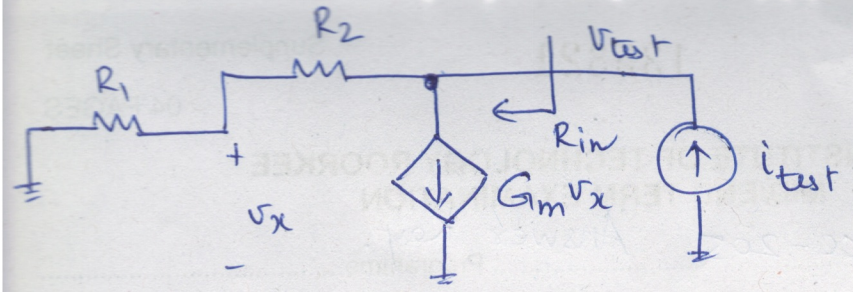


$v_0 = \frac{v_{test}}{R} \times R + v_{test} = 2v_{test}$

$i = \frac{v_{test}}{R}$

$\Rightarrow i_{test} = \frac{v_{test} - 2v_{test}}{R_1}$

$\Rightarrow \boxed{R_{in} = -R_1}$



$$i_{test} = G_m v_x + \frac{v_{test}}{R_1+R_2} = G_m \cdot \frac{v_{test} R_1}{R_1+R_2} + \frac{v_{test}}{R_1+R_2}$$

$$R_{in} = \frac{v_{test}}{i_{test}} = \frac{1 \times (R_1+R_2)}{(1+G_m R_1)}$$

for maximum power transfer.

$$R_L = R_{in} = \frac{R_1+R_2}{1+G_m R_1}$$

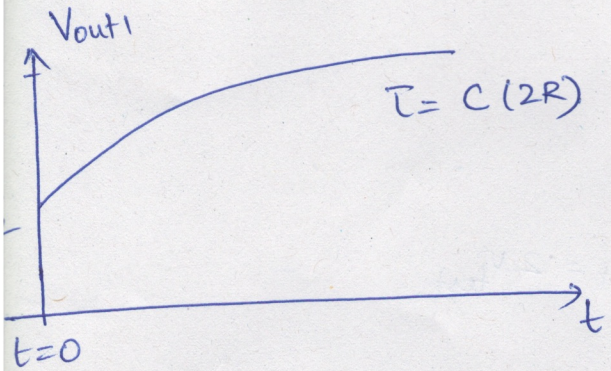
if $G_m \longrightarrow \infty$, $R_{in} \longrightarrow 0$

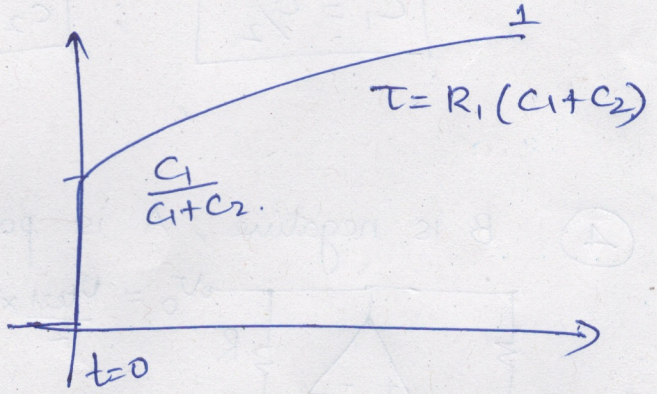
$\Rightarrow$ The circuit behaves like an ideal voltage source.

Always maximum power is transferred.

-A

Order = 7



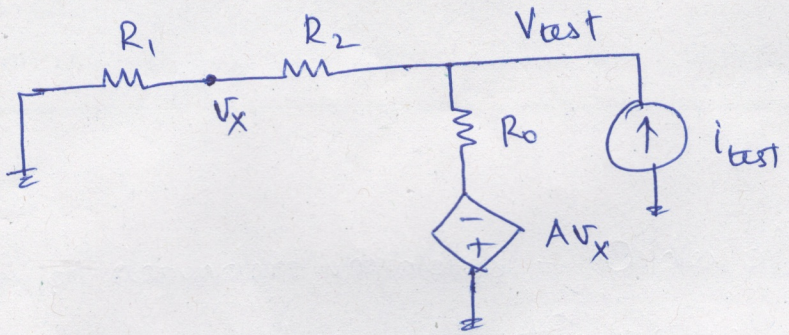


$\therefore$ $C_1 = C_2$ $\Rightarrow$ $R_1 = R$

(4) A is negative, B is positive.

$\therefore R_{in} = -R_1$ (same as before).

(5)



$$\therefore \quad v_x = v_{test} \cdot \frac{R_1}{R_1+R_2} \qquad i_{test} = \frac{V_{test} + A R_1 \frac{V_{test}}{R_1+R_2}}{R_o} + \frac{V_{test}}{R_1+R_2}$$

$$i_{test} = V_{test} \left[\frac{1}{R_o} + \frac{AR_1}{R_o(R_1+R_2)} + \frac{1}{R_1+R_2} \right]$$

$$R_{in} = \frac{1}{\left(\frac{1}{R_o} + \frac{AR_1}{R_o(R_1+R_2)} + \frac{1}{R_1+R_2} \right)}$$

(a) $R_L = R_{in}$

(b) $A \to \infty$, $R_{in} \to 0$

Always max power is transferred!

IIT Roorkee: Mid Term Exam, July - Nov 2024
ECC - 205 Network Theory (Set-B)

Time : 1.5 hours **Maximum marks : 50**

QUESTION - 1 (10 MARKS)

As discussed in class, the order of the circuit is the order of the differential equation relating the output and input of the circuit. I had also asked you (in class) to think about the relation between order and the various components of a circuit. This question deals with that thought. Fig. 1 shows a high order circuit with multiple resistors (R), capacitors (C) and inductors (L). Find the order of the circuit.

① Observation that capacitor voltages & inductor currents are unknowns → 3 marks

② C_4 & L_3 do not form part of unknowns → 3 marks

③ Order ⇒ 6
↳ 4 marks

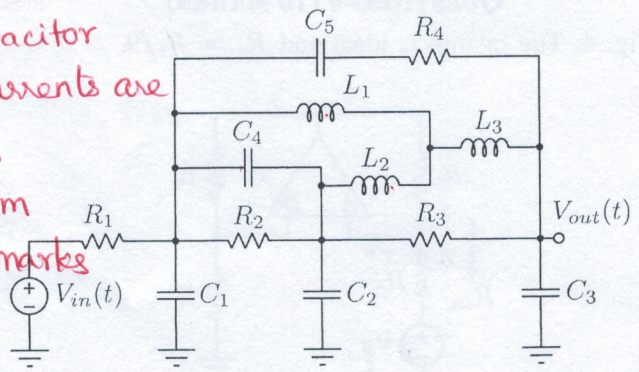


Fig. 1. Figure for question - 1

QUESTION - 2 (10 MARKS)

Consider the circuits shown in Fig. 2(a) and Fig. 2(b). The input is a unit step signal for both the circuits. Assume zero initial conditions in the capacitors.

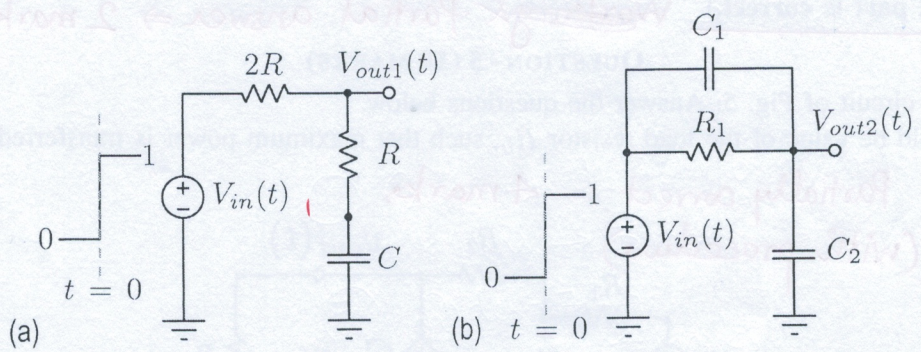


Fig. 2. Figure for question - 2

- Sketch the output voltage, $V_{out1}(t)$ as a function of time. What is the time constant of the circuit? **(5 marks)** correct o/p voltage → 3 marks, correct time constant → 2 marks
- Fig. 2(b) is another circuit, whose output is $V_{out2}(t)$. Can V_{out2} be made to have the same response (with time) as V_{out1}? If yes, then what are the values of R_1, C_1 and C_2 to achieve the same? If not, then justify your claim. **(5 marks)**

* Observing that (b) can give the same o/p as V_{out1} & its shape correct :- 2 marks

* Correct R_1 → 1 mark, C_1 → 1 mark, C_2 → 1 mark.

(Laplace domain)

Correct Telegen equation $\sum V_k(s)\hat{I}(s) = 0 = \sum \hat{V}_k(s) I_k(s)$ ⇒ 5 marks

QUESTION - 3 (10 MARKS)

The network N contains only resistors, capacitors and inductors. Assume the initial conditions are zero for all the components in the network.

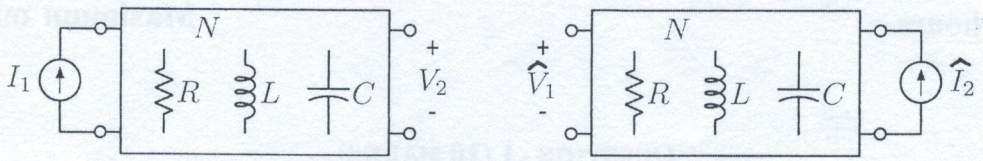


Fig. 3. Figure for question - 3

Can you prove that the network is reciprocal (i.e) $V_2/I_1 = \hat{V}_1/\hat{I}_2$? *[Hint : Follow the steps of the proof of reciprocity theorem in the Laplace domain.]*

QUESTION - 4 (10 MARKS)

Consider the circuit of Fig. 4. The opamp is ideal and $R_s = R_1/9$.

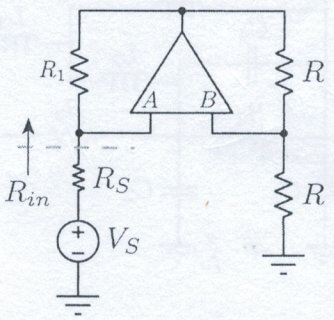


Fig. 4. Figure for question - 4

- Determine the signs of the opamp for negative feedback. **(5 marks)** *[Hint: Calculate the loop gain by breaking the loop at the output of the opamp.]* B is -ve & A is +ve ⇒ 5 marks.
- Determine R_{in}, the resistance seen by the current source I_{in}. **(5 marks. Credit will be given only if the first part is correct.)** ~~Working~~ Partial answer ⇒ 2 marks, full answer 5 marks.

QUESTION - 5 (10 MARKS)

Consider the circuit of Fig. 5. Answer the questions below.

- What should be value of the load resistor R_L, such that maximum power is transferred to the load? **(7 marks)** Partially correct :- 4 marks (with procedure)

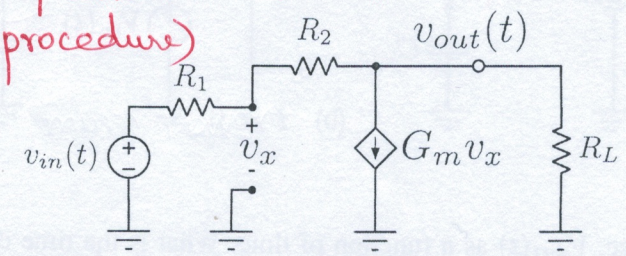


Fig. 5. Figure for question - 5

- If G_m tends to infinity, what is the optimum load R_L, such that maximum power is transferred? Explain your result intuitively. **(3 marks)**

Circuit approaches an ideal voltage source & maximum power is always transferred → 3 marks.

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ECC - 205 Network Theory (Set-A)

Time : 1.5 hours **Maximum marks : 50**

QUESTION - 1 (10 MARKS)

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1) Observation that capacitor voltages & inductor currents are unknowns → 3 marks
2) C_4 & L_4 do not form part of unknowns → 3 marks
3) Order = 7 → 4 marks

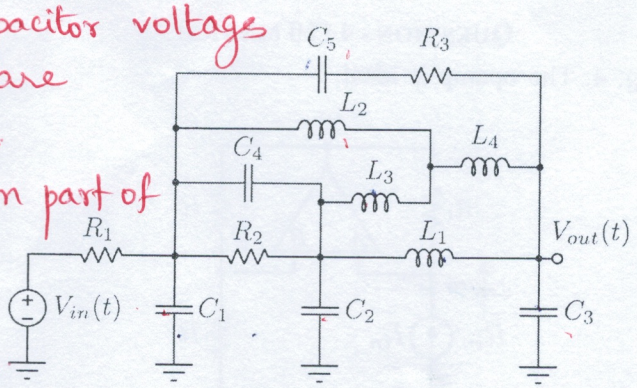


Fig. 1. Figure for question - 1

QUESTION - 2 (10 MARKS)

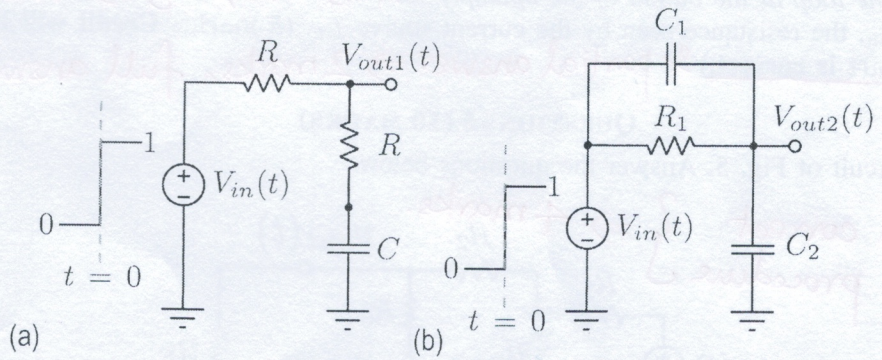


Fig. 2. Figure for question - 2

Consider the circuits shown in Fig. 2(a) and Fig. 2(b). The input is a unit step signal for both the circuits. Assume zero initial conditions in the capacitors.

- Sketch the output voltage, $V_{out1}(t)$ as a function of time. What is the time constant of the circuit? **(5 marks)** 2.5
- Fig. 2(b) is another circuit, whose output is $\boldsymbol{V_{out2}}(t)$. Can $\boldsymbol{V_{out2}}$ be made to have the same response (with time) as $\boldsymbol{V_{out1}}$? If yes, then what are the values of R_1, C_1 and C_2 to achieve the same? If not, then justify your claim. **(5 marks)** 2.5

→ Correct o/p voltage → 3 marks, correct time constant → 2 marks
→ * Observing that (b) can give the same o/p as V_{out1} & its shape is correct :- 2 marks
* Correct R_1 → 1 mark, C_1 → 1 mark, C_2 → 1 mark.

(Laplace domain)

Correct Tellegen equation $\sum V_k(s)\hat{I}_k(s) = \sum \hat{V}_k(s) I_k(s) = 0$

QUESTION - 3 (10 MARKS)

Consider the network N shown in Fig. 3. It contains only resistors, capacitors and inductors. Assume the initial conditions are zero for all the components in the network. Can you show that the network is reciprocal (i.e) $V_2/I_1 = \hat{V}_1/\hat{I}_2$? *[Hint : Follow the steps of the proof of reciprocity theorem in the Laplace domain.]*

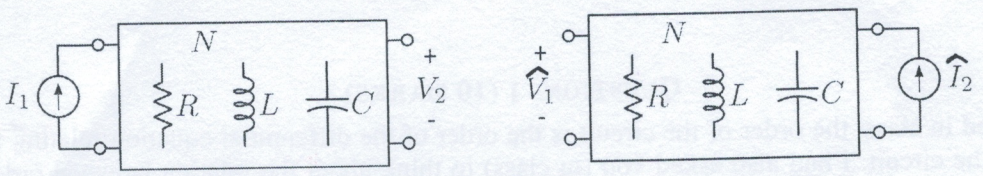
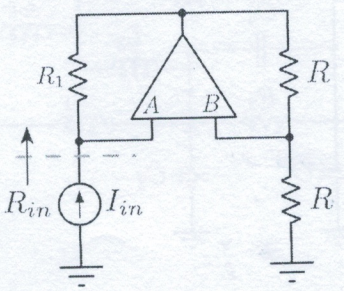


Fig. 3. Figure for question - 3

QUESTION - 4 (10 MARKS)

Consider the circuit of Fig. 4. The opamp is ideal.



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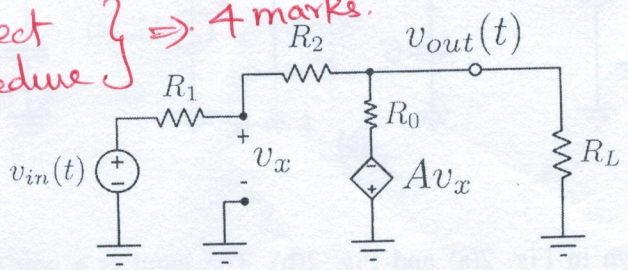
- Determine the signs of the opamp for negative feedback. **(5 marks)** *[Hint: Calculate the loop gain by breaking the loop at the output of the opamp.]* A is -ve & B is +ve ⇒ 5 marks
- Determine R_{in}, the resistance seen by the current source I_{in}. **(5 marks. Credit will be given only if the first part is correct.)** & partial answer ⇒ 2 marks. full answer ⇒ 5 marks.

QUESTION - 5 (10 MARKS)

Consider the circuit of Fig. 5. Answer the questions below.

Partial correct } ⇒ 4 marks.
with procedure }



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- What should be value of the load resistor R_L, such that maximum power is transferred to the load? **(7 marks)**
- If the gain of the VCVS, A, tends to infinity, what is the optimum load R_L, such that maximum power is transferred? Explain your result intuitively. **(3 marks)**

Circuit approaches an ideal voltages source & maximum power is always transferred → 3 marks.