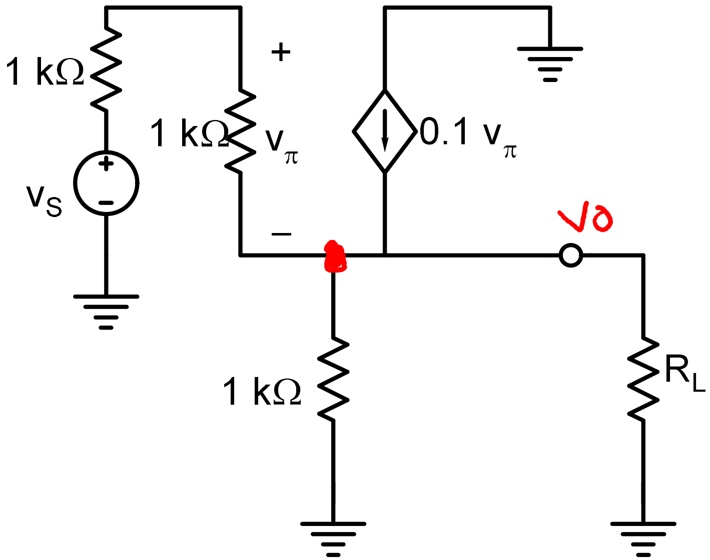
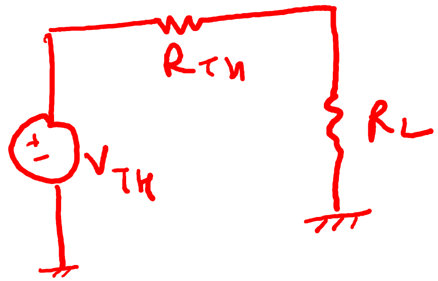
ESC201T : Introduction to Electronics

Quiz-1 (25/9/2020): solution

Q.1 Determine the value of load resistor R_L for which power dissipated in it would be maximum. Show all relevant steps of your analysis to justify your final answer.----(6 marks)



Build Thevenin's equ. ckt at Vo



Then $R_L = R_{TH}$ 2

To Find $V_{oc} = V_{TH}$

$$-\frac{V_{oc}}{1k\Omega} + 0.1 v_\pi + \frac{v_s - v_{oc}}{2k\Omega} = 0$$

2

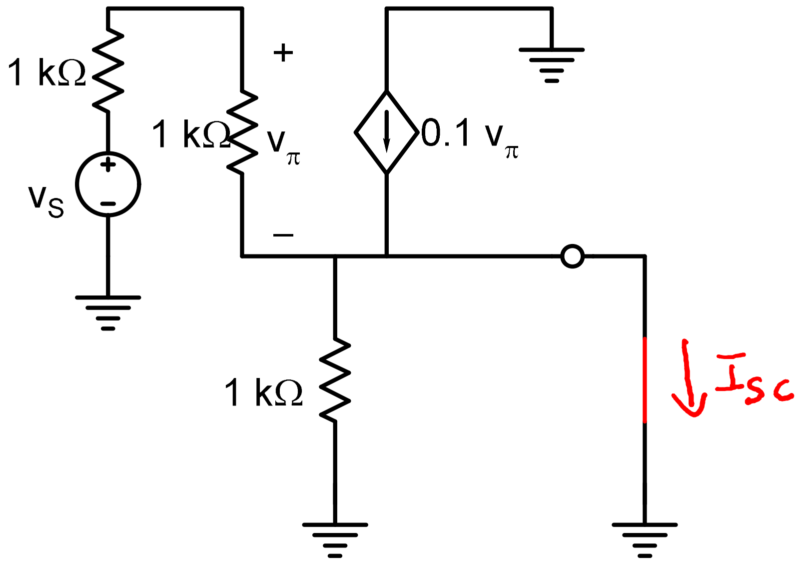
$$v_\pi = \frac{(v_s - v_{oc})}{2}$$

$$v_s\left(\frac{1}{2k} + \frac{0.1}{2}\right) = v_{oc}\left[\frac{1}{1k} + \frac{0.1}{2} + \frac{1}{2k}\right]$$

$$v_{oc} = v_s \times \frac{5.05\times 10^{-2}}{5.15\times 10^{-2}} = 0.98\, v_s$$

Grader : Praveen

To find R_{th}, find I_{sc} first.



$$I_{sc} = \frac{v_s}{2k\Omega} + 0.1\,\frac{v_s}{2}$$

$$= v_s\left[5\times10^{-4} + 5\times10^{-2}\right]$$

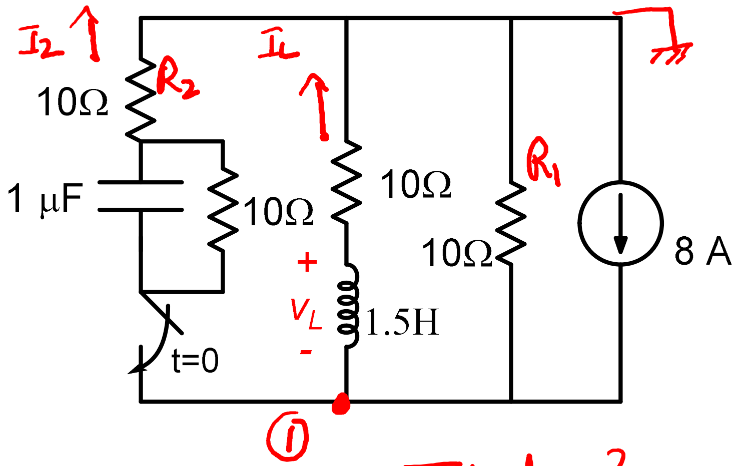
$$I_{sc} = 5.05\times10^{-2}\,v_s \quad (1)$$

$$v_{oc} = \frac{5.05\times10^{-2}\,v_s}{5.15\times10^{-2}} \quad (1)$$

$$R_{TH} = \frac{v_{oc}}{I_{sc}} = \frac{100}{5.15} = 19.4\Omega$$

So for $R_L = R_{TH} = 19.4\Omega$, P_L would be maximum

Q.2 Determine the voltage V_L across the inductor immediately after the switch is closed at t=0. Assume that switch was kept open for a time long enough for steady state to prevail. Show all relevant steps of your analysis to justify your final answer. 4



Before Switch is closed at t=0

$I_L = \frac{8}{2} = 4A.$

After Switch is closed $I_L(0^+) = 4A$ 1

That leaves 4A to distribute between R_1 and R_2. Note capacitor $V_C(0^+) = 0$ so it will act like short. 1

$\Rightarrow I_2 = 4/2 = 2A \Rightarrow V_1 = 2 \times 10 = 20V$ 1

$V_1 = 20 = -V_L + I_L \times 10 = -V_L + 40$

$\Rightarrow V_L = 20V$ 1

Grader : Anju Meghwani

ESC201T : Introduction to Electronics

Mid-Sem Exam (18/10/2020)

There are three parts A, B and C. Total marks 30

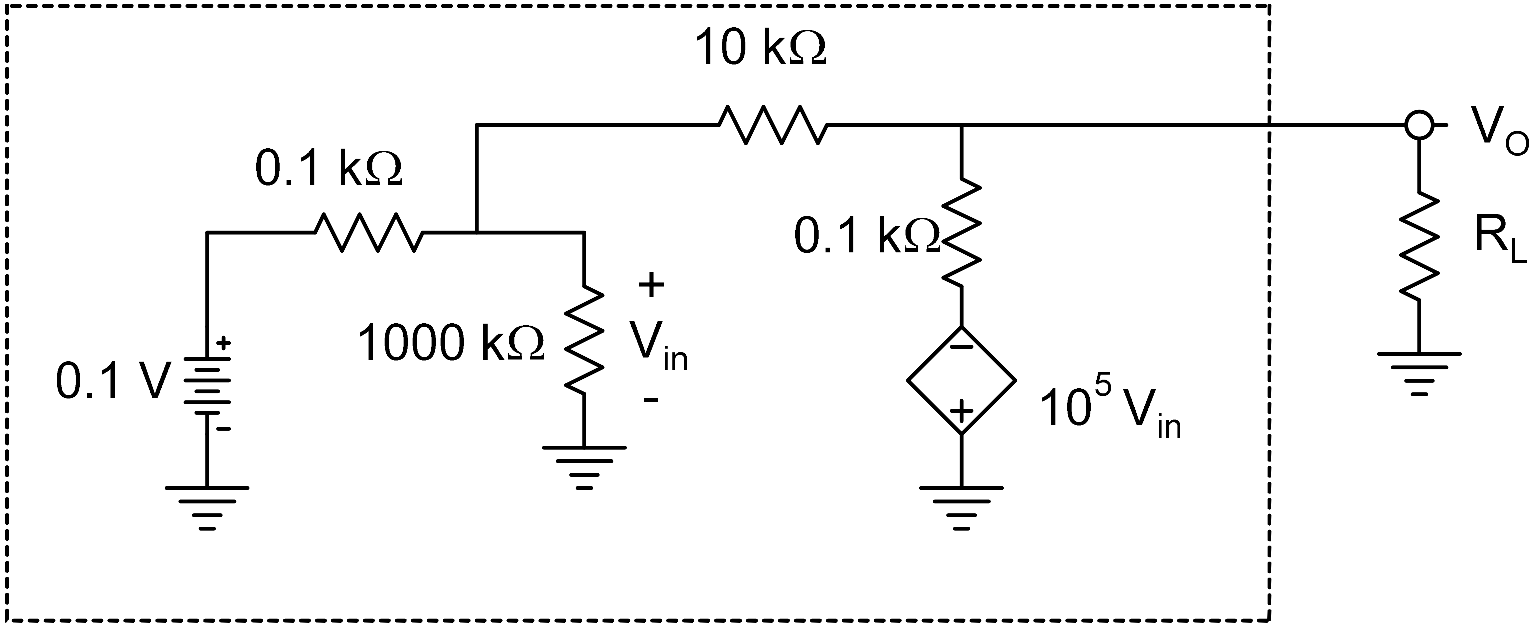
<u>Mid-Sem : Solution</u>

ESC201T : Introduction to Electronics

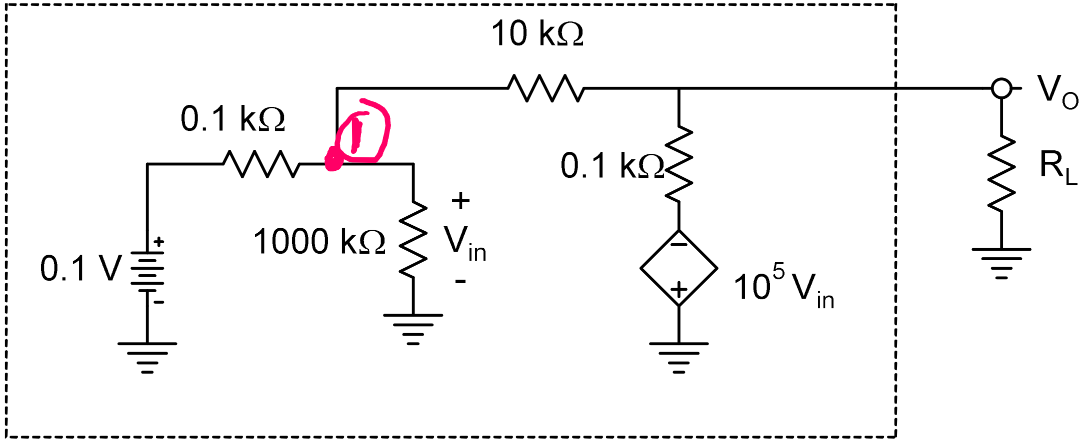
Mid-Sem Exam -partA (18/10/2020) (Note there are 2-pages)

Time : 6-6.40PM . Stop at 6.30pm and submit within time

Q.1 Determine the Thevenins equivalent (both Thevenin voltage and Thevenin resistance) for the circuit within dotted lines between the output terminal Vo and ground. Use approximations to obtain an answer that is correct to first decimal place only. Show steps of your analysis and indicate also the approximations made-----5 marks



Grader : Venkatesh



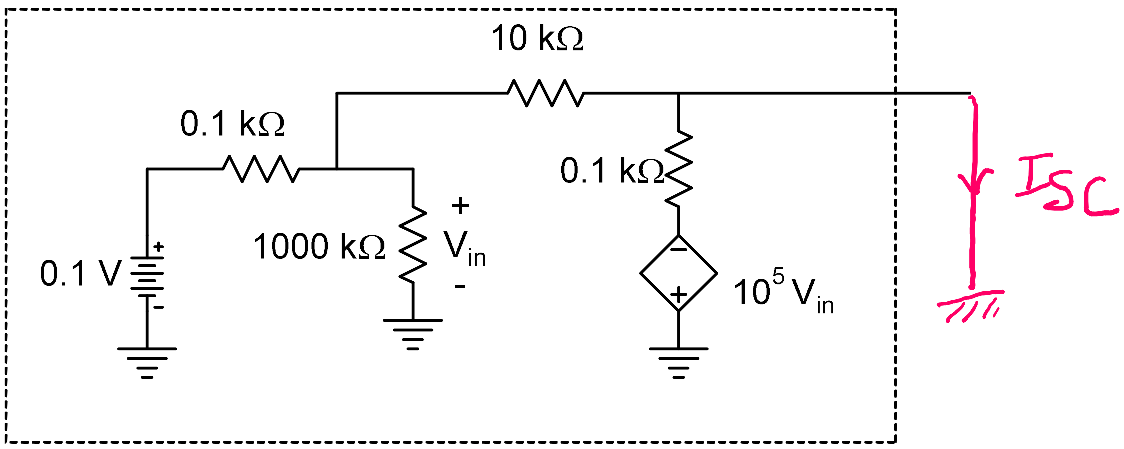
$$KCL\ at\ node 1: \quad \frac{V_{in}}{1000} + \frac{V_{in} - 0.1}{0.1} + \frac{V_{in} + 10^5 V_{in}}{10.1} = 0$$

$$\Rightarrow \frac{10^5 V_{in}}{10.1} \approx \frac{0.1}{0.1} \Rightarrow \mathrm{V_{in}} \approx 10^{-4} V$$

$$KCL\ at\ output\ node: \quad \frac{V_{OC} - V_{in}}{1000} + \frac{V_{OC} + 10^5 V_{in}}{0.1} = 0 \Rightarrow V_{OC} \approx -10^5 V_{in} = -10V$$

$$\Rightarrow \mathrm{V_{TH}} \approx -10V$$

3



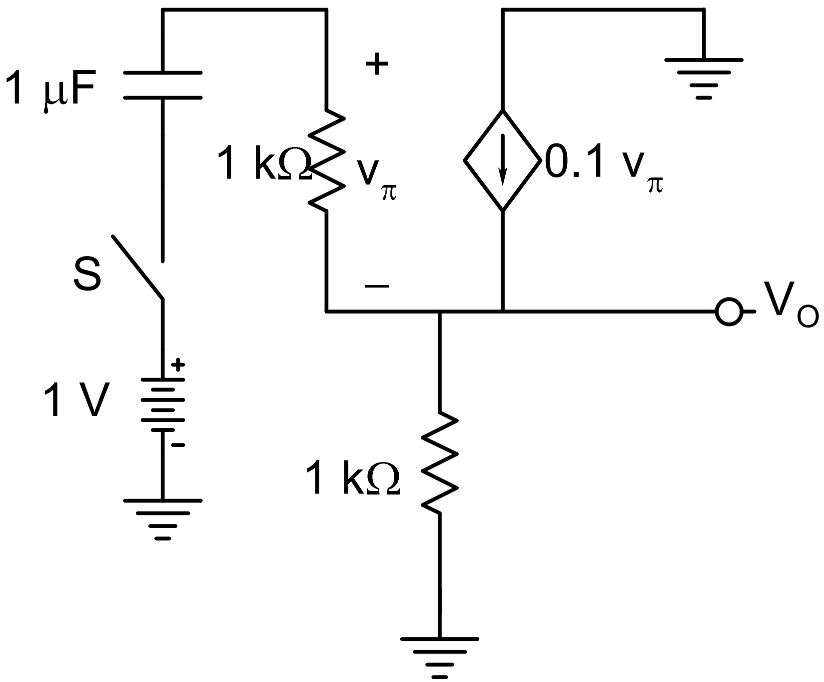
$$KCL\ at\ node1: \frac{V_{in}}{1000} + \frac{V_{in} - 0.1}{0.1} + \frac{V_{in}}{10} = 0 \Rightarrow V_{in} \approx 0.1\ V$$

$$I_{SC} = \frac{V_{in}}{10k} - \frac{10^5 V_{in}}{0.1k} = 0 \Rightarrow I_{SC} \approx -100\ A$$

$$R_{TH} = \frac{V_{OC}}{I_{SC}} = \frac{-10}{-100} = 0.1\Omega$$

2

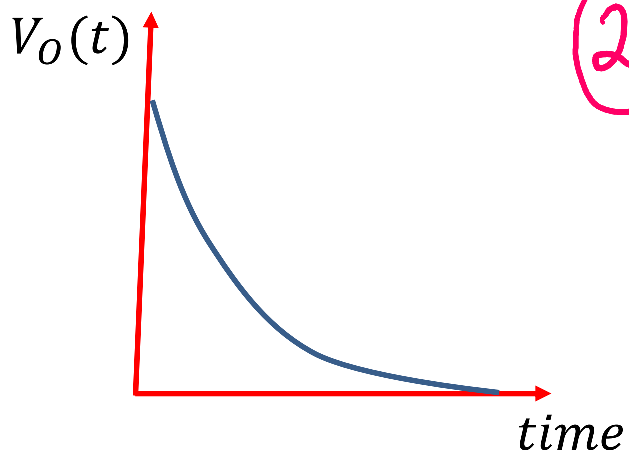
Q.2 Sketch the qualitative variation of output voltage Vo after Switch S is closed at t = 0. Before that, the switch was open for a long time for steady state condition to prevail and there was no charge on the capacitor. Determine the time constant of the circuit. Show all relevant steps------5 marks



$$At\ t = 0^+, Capacitor\ will\ act\ as\ short\ and\ 1V\ input\ will\ result\ in\ a\ non\ zero\ V_O$$

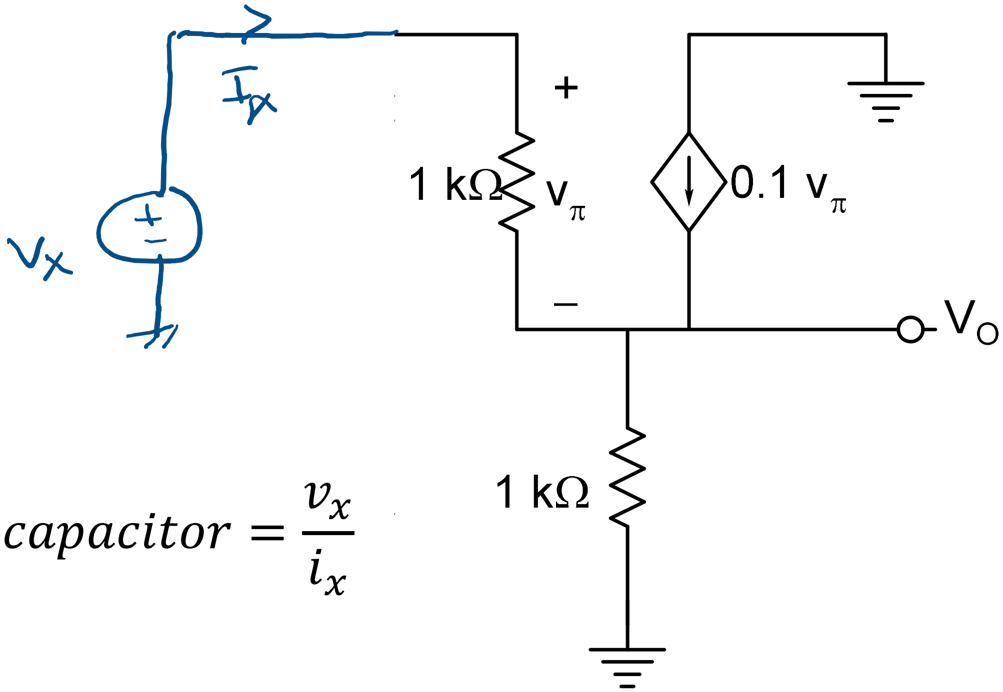
$$As\ t \to \infty, capacitor\ will\ act\ as\ open\ so\ that\ v_\pi = 0\ and\ V_O = 0$$

$Therefore:$



2

Grader : Venkatesh



$$R_{eq}\ seen\ by\ capacitor = \frac{v_x}{i_x}$$

$$V_X = I_X \times 10^3 + (I_X + 10^2 I_X) \times 10^3 = 102 \times 10^3 \times I_X$$

$$\Rightarrow R_{eq} = 102\ k\Omega$$ 2

$$\tau = R_{eq} \times C = 102 \times 10^3 \times 10^{-6} = 102ms$$ 1

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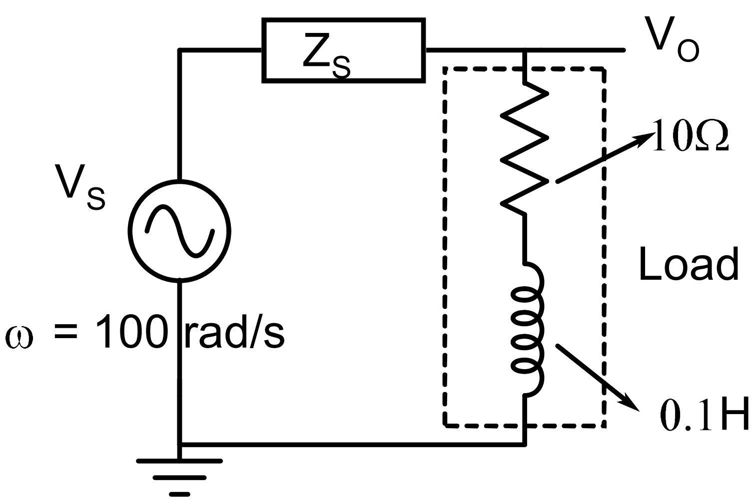
Mid-Sem Exam -partB (18/10/2020) (Note there are 3-pages)

Time : 6.40-7.20PM. Stop at 7.10pm and submit within time

Q.3 Determine optimum value of impedance Z_S such that maximum power is dissipated in Load (shown within dotted line). Implement Z_S as a suitable combination of circuit elements (resistor, capacitor or inductor). Explain your answer----3Marks



$$P_L = \frac{I^2 \times 10}{2} \Rightarrow For\ max.\, P_L, I\ should\ be\ max$$

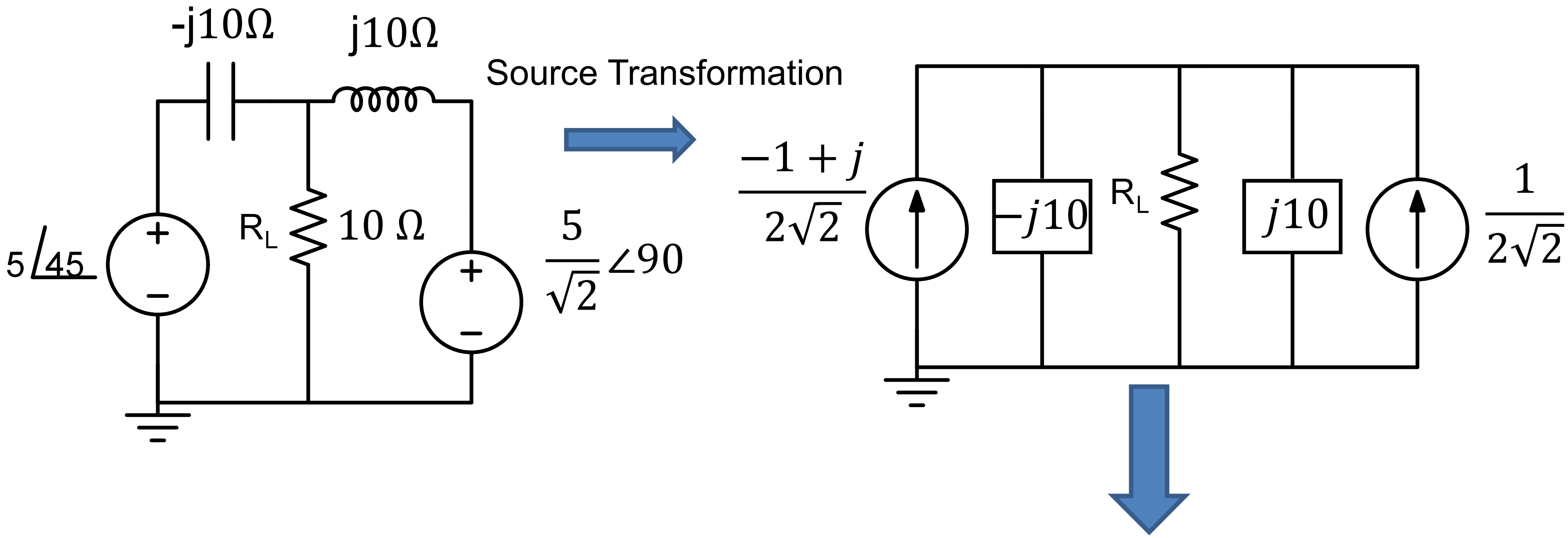
$$I = \frac{V_S}{Z_S + 10 + j10}$$

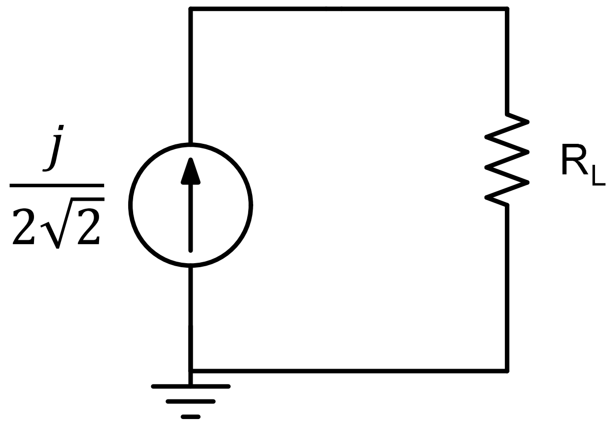
$$For\ maximum\ I \Rightarrow Z_S = 0 - j10$$ 1 1

$$Z_S = -\frac{j}{\omega C} = -j10 \Rightarrow C = 10^{-3}F$$ 1

Grader : Adrish

Q. 4 Determine the phasor current ($I_L \angle \theta_L$) in load resistor R_L. Show steps of your analysis--- 4Marks

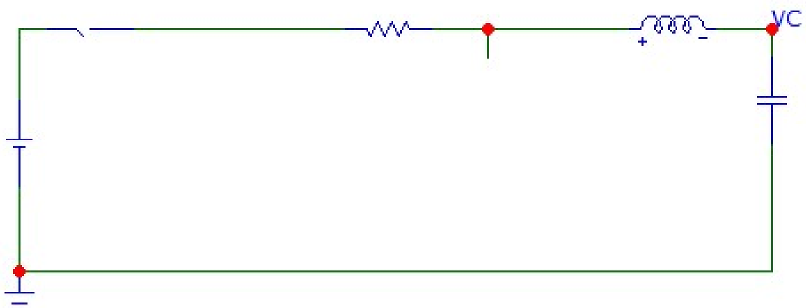


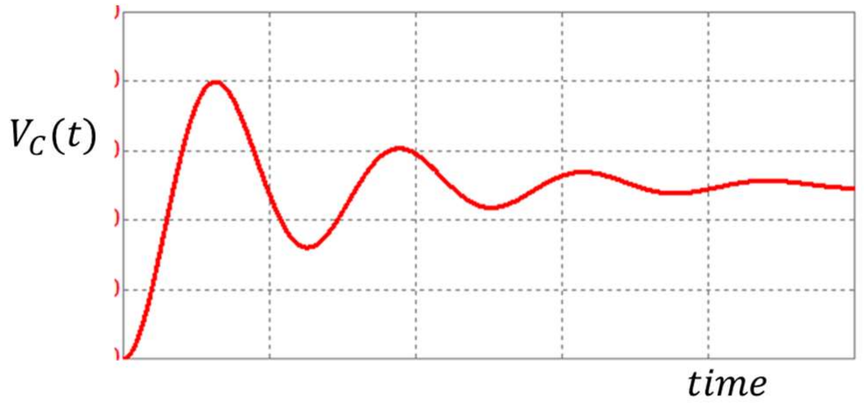


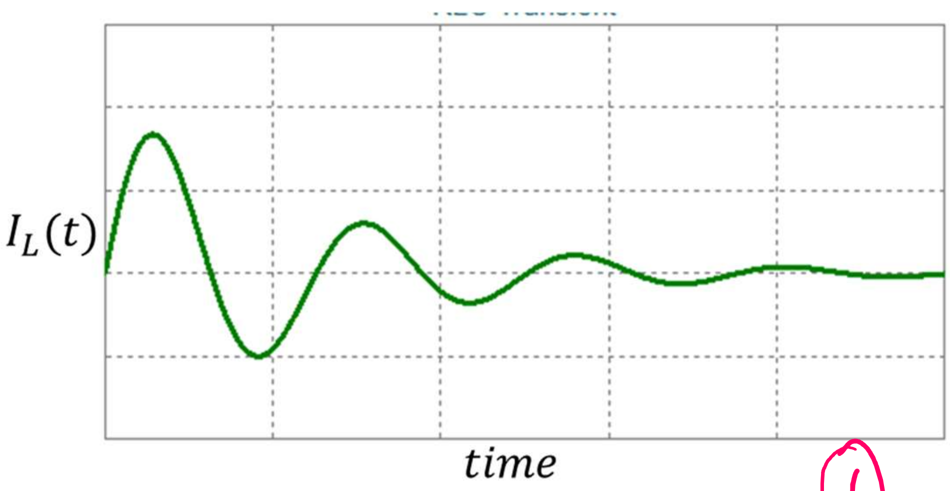
4 *Phasor Current* : $\frac{1}{2\sqrt{2}}\angle 90°$

Grader : Adrish

Q.5 Figure shows voltage across the capacitor VC as a function of time after the switch was closed in the circuit shown below. Sketch the qualitative variation of inductor current and explain whether the first peak in current will occur before or after the first peak in capacitor voltage--- 3Marks







(1)

Inductor current starts from zero, reaches a peak and after a few oscillations reduces to zero. Capacitance Peak occurs after current peak as capacitance keeps on charging till current is positive (2)

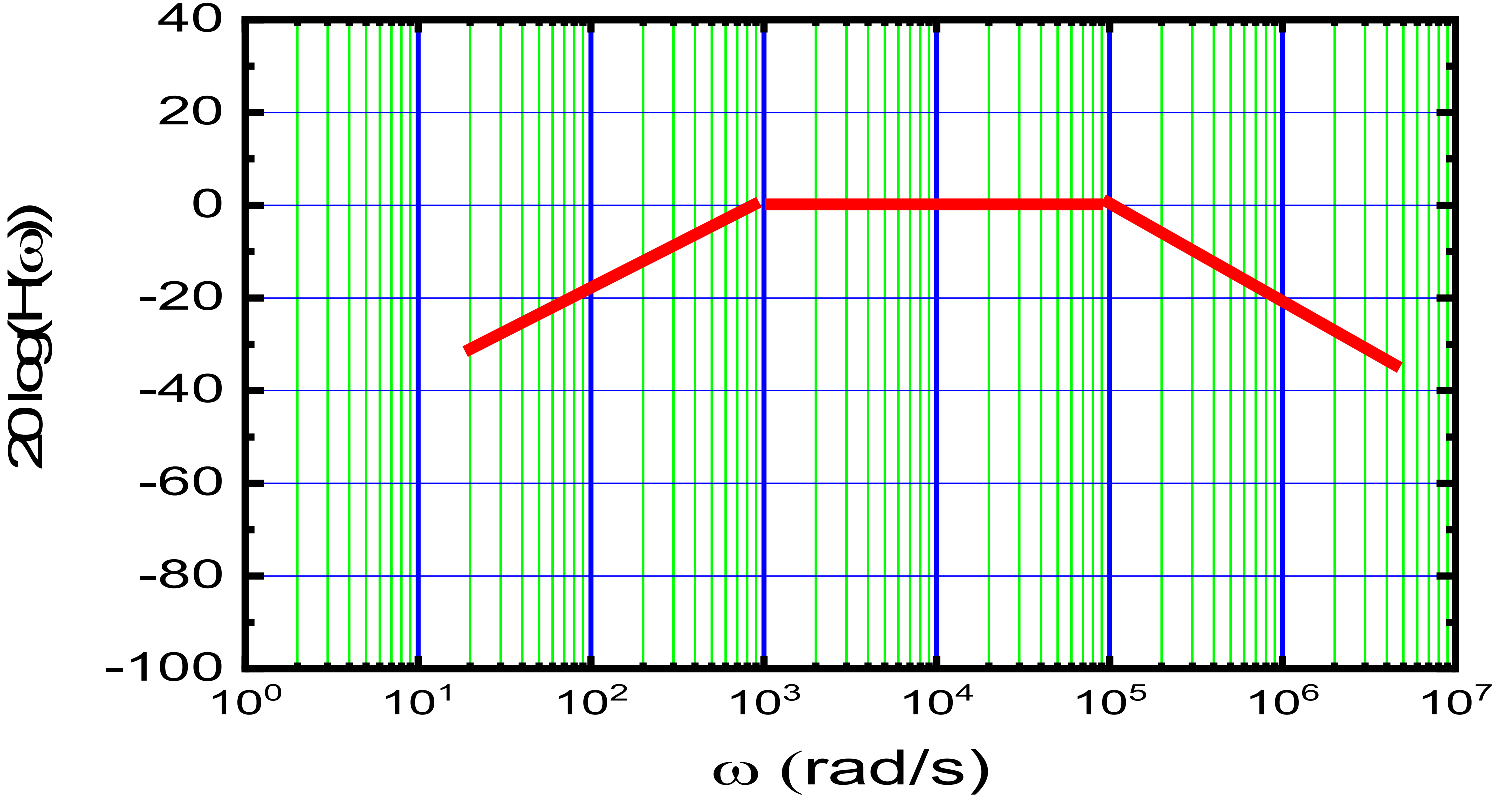
Grader : Adrish

ESC201T : Introduction to Electronics

Mid-Sem Exam -partC (18/10/2020) (Note there are 3-pages)

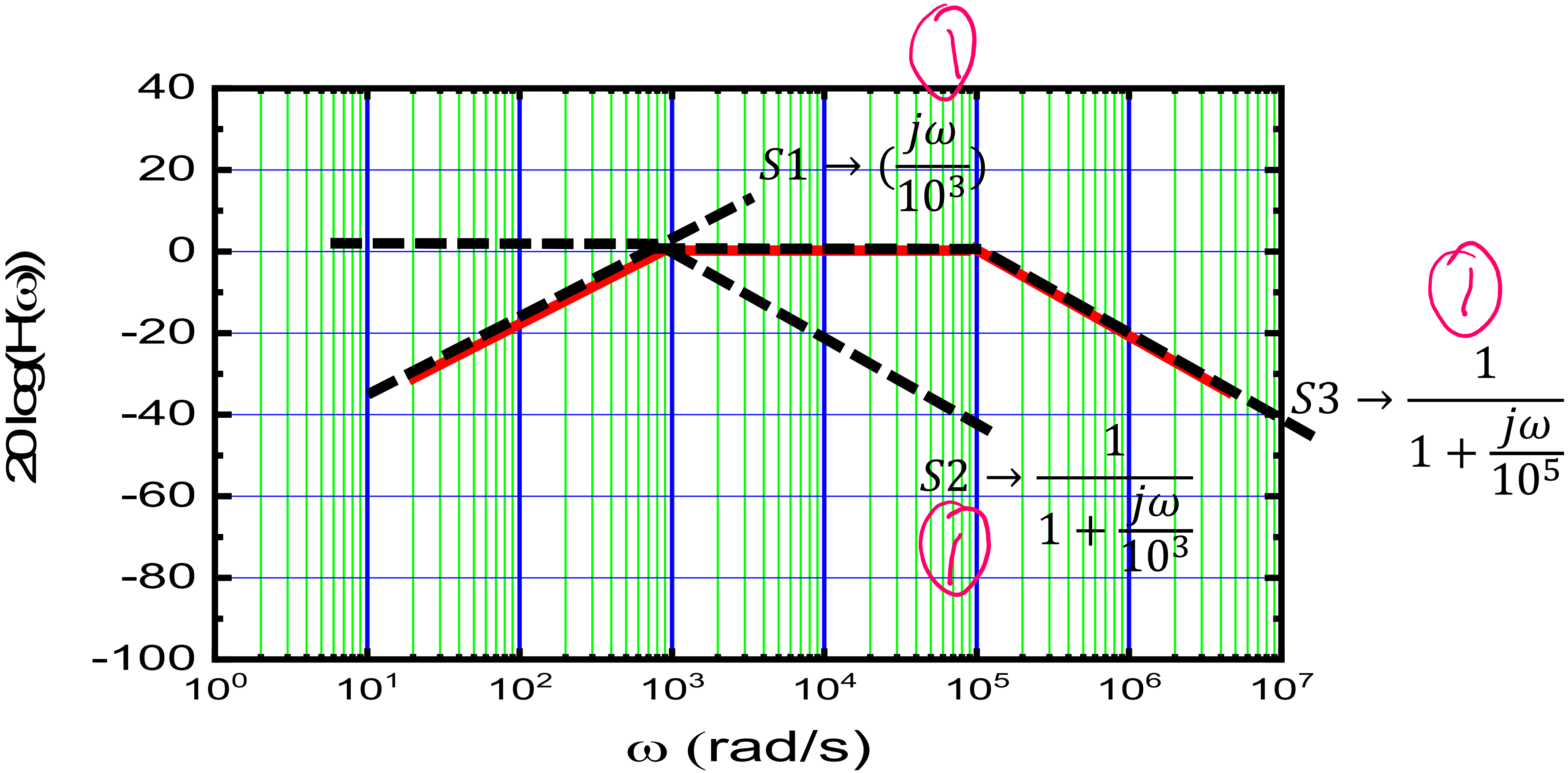
Time : 7.20-8PM. Stop at 7.50pm and submit within time

Q.6(a) Determine the simplest transfer function expression that will have the asymptotic Bode plot shown below. Give brief reasons for your answer.-----3 marks



Grader : Anju Meghwani

The Bode plot is made of following segments S1, S2 and S3



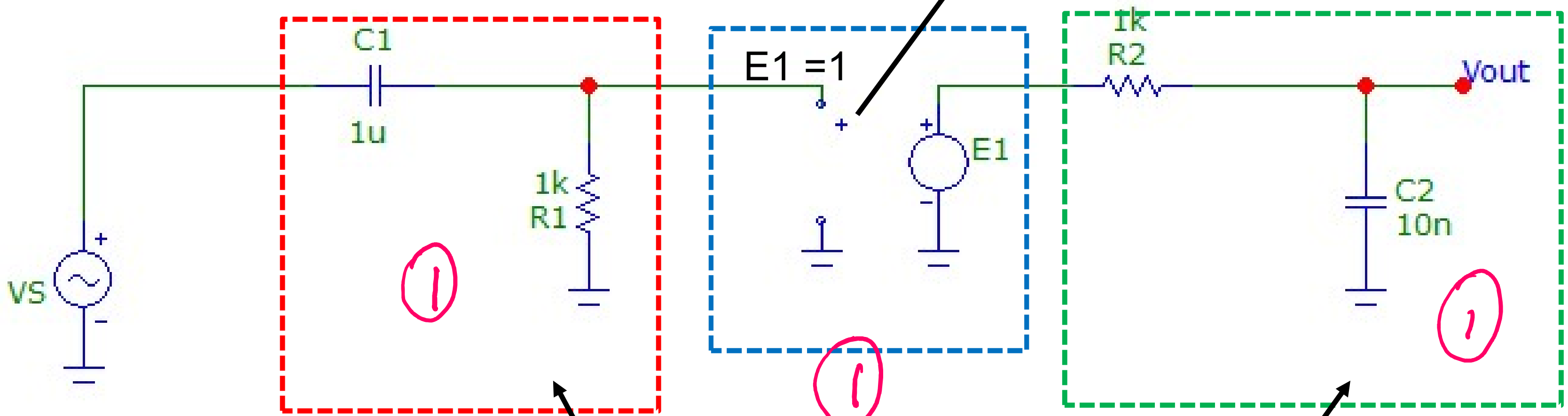
$$H(\omega) = \frac{j\omega/10^3}{(1 + (j\omega/10^3) \times (1 + (j\omega/10^5))}$$

Q.6 (b) Design a circuit to implement the transfer function obtained in part (a) assuming that you have only the following components available

1. Only two resistors , each of value 1K ohms
2. Only Two capacitors. Each one can have any independent value
3. One voltage controlled voltage source of any value (in case you require it)

Give the complete circuit diagram and values of all components. Give brief reasons for your design.------5 marks

Included for isolation, otherwise transfer function will not simply be a product



$$R_1 C_1 = 10^{-3} \Rightarrow C_1 = 1\ \mu F$$

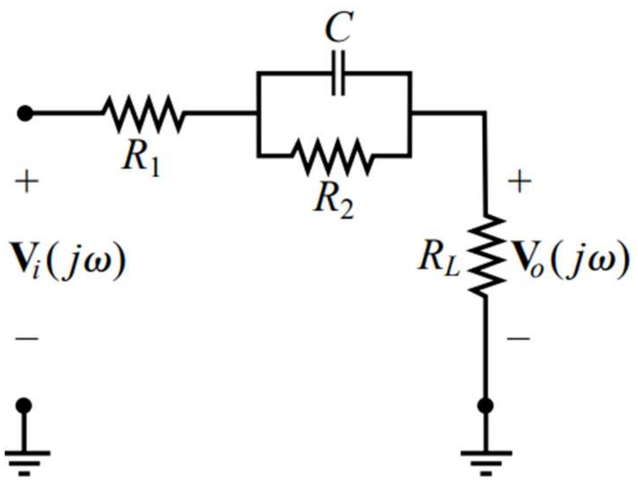
1

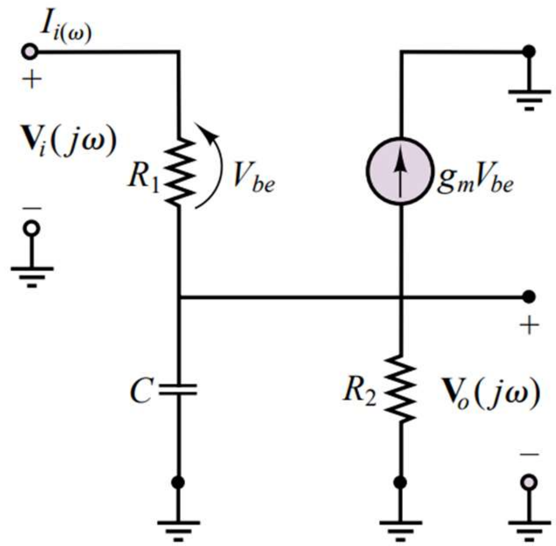
$$R_2 C_2 = 10^{-5} \Rightarrow C_2 = 10\ nF$$

1

$$H(\omega) = \boxed{\frac{(j\omega/10^3)}{1 + (j\omega/10^3)}} \times \boxed{\frac{1}{1 + (j\omega/10^5)}}$$

Q. 7 Determine the nature of filter for each one of the two circuits shown below. Give brief justification ------2 Marks





Filter-A

$$(\omega \to 0) \to V_O \to \frac{R_L}{R_1 + R_2 + R_L}$$

$$(\omega \to \infty) \to V_O \to \frac{R_L}{R_1 + R_L}$$

1

$$V(\omega \to 0) < V(\omega \to \infty) \Rightarrow High\ Pass\ Filter$$

Filter-B

$$(\omega \to 0) \to V_O \to non\ zero$$

$$(\omega \to \infty) \to V_O \to 0$$

$$\Rightarrow LowPass\ Filter$$

1

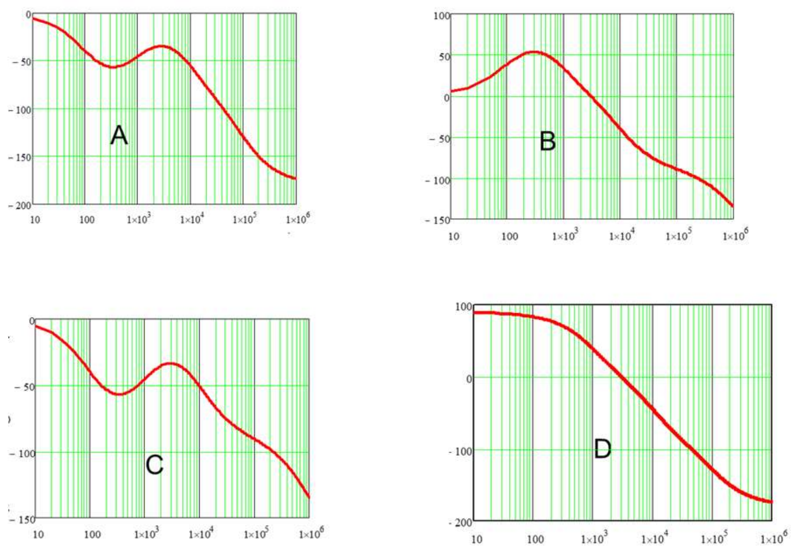
Quiz-2

ESC201T : Introduction to Electronics

Quiz-2(23/10/2020)

There are 5 questions in this quiz

Q. 1 Match the phase response to the transfer functions



① will give a phase of 90 at zero frequencies due to this term

$$H1(\omega) = \frac{\left(j \times \frac{\omega}{10^3}\right)}{\left(1 + j \times \frac{\omega}{10^3}\right)} \times \frac{1}{\left(1 + j \times \frac{\omega}{10^4}\right)} \times \frac{1}{\left(1 + j \times \frac{\omega}{10^5}\right)}$$

phase of -45 at 10^4

③ at 10^6 it will give phase ~ -90

$$H2(\omega) = \frac{\left(1 + j \times \frac{\omega}{10^3}\right)}{\left(1 + j \times \frac{\omega}{10^2}\right)} \times \frac{1}{\left(1 + j \times \frac{\omega}{10^4}\right)} \times \frac{1}{\left(1 + j \times \frac{\omega}{10^6}\right)}$$

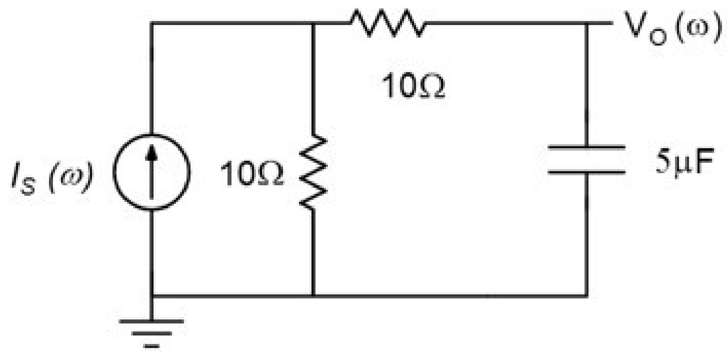
$$H3(\omega) = \frac{\left(1 + j \times \frac{\omega}{10^3}\right)}{\left(1 + j \times \frac{\omega}{10^2}\right)} \times \frac{1}{\left(1 + j \times \frac{\omega}{10^4}\right)} \times \frac{1}{\left(1 + j \times \frac{\omega}{10^5}\right)}$$

④ will give initially an increase in phase with ω

$$H4(\omega) = \left\{\frac{\left(1 + j \times \frac{\omega}{10^2}\right)}{\left(1 + j \times \frac{\omega}{10^3}\right)}\right\} \times \frac{1}{\left(1 + j \times \frac{\omega}{10^4}\right)} \times \frac{1}{\left(1 + j \times \frac{\omega}{10^5}\right)}$$

$$Ans: \underbrace{H_1 \rightarrow D}_{①}; H_2 \rightarrow C; \underbrace{H_3 \rightarrow A}_{③}; \underbrace{H_4 \rightarrow B}_{④}$$

Q.2 *For the circuit shown, the closest estimates of the magnitude of the transfer function* $\dfrac{V_O(\omega)}{I_S(\omega)}$ *at* $\omega = 10$ *and* $\omega = 10^6$ *rad/s in dB are*



Ans : +20dB, -20dB

$$V_o = I_s \times \frac{10 \times \frac{1}{j\omega c}}{10+10+\frac{1}{j\omega c}} = I_s \frac{10}{1 + j\omega c \cdot 20}$$

$$\frac{V_o}{I_s} = \frac{10}{1+j\omega c\, 20} \rightarrow \frac{10}{1+j\frac{\omega}{\omega_2}}$$

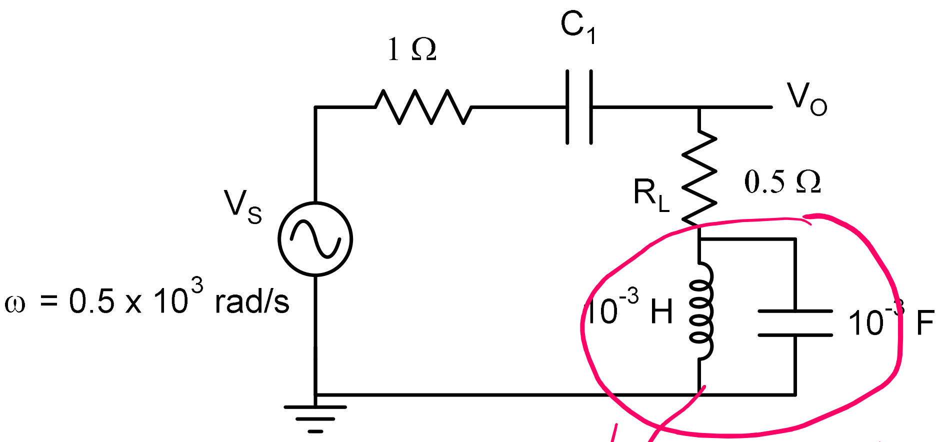
$\rightarrow$ for $\omega << \omega_2 \rightarrow 20dB$

$\rightarrow$ for $\omega >> \omega_2 \sim \frac{10\,\omega_2}{j\,10^6}$

$\rightarrow -20dB$

$$c \times 20 = 10^{-4} \rightarrow \omega_2 = 10^4$$

Q.3 The value of capacitor C_1 (in Milli-Farads) for which maximum power will be dissipated in the load resistor R_L is -------
(answer only as an integer)



Ans: 3

$$\frac{j\omega L \times \frac{1}{j\omega C}}{j\omega L + \frac{1}{j\omega C}} = \frac{L/C}{j\left(\omega L - \frac{1}{\omega C}\right)} = j\frac{2}{3}$$

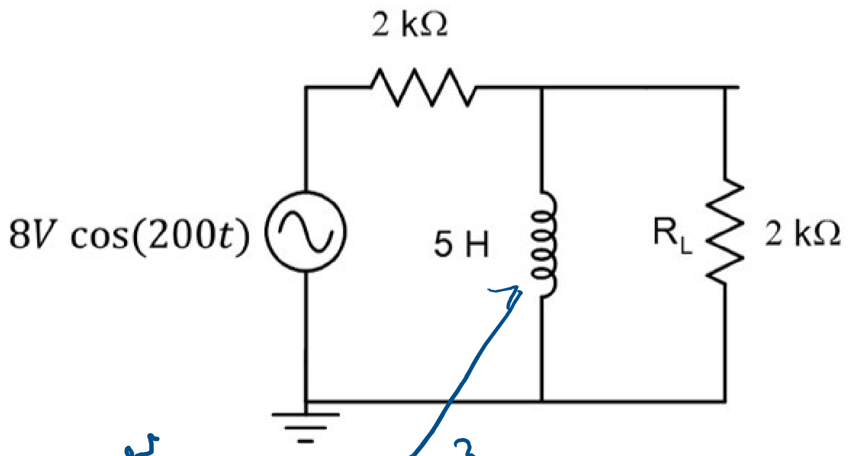
for max. power

$$\Rightarrow \frac{1}{j\omega C_1} = -j\frac{2}{3}$$

$$\Rightarrow C_1 = \frac{3}{2 \times 0.5 \times 10^3} = 3 \times 10^{-3}\ F$$

Q.4 The power dissipated in load resistor R_L (in milli-watts) is…..

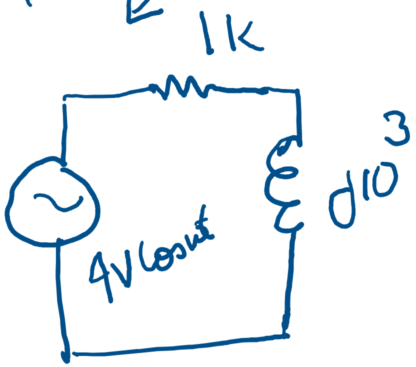
(8V refers to peak value. Give answer as an integer)



Ans: 2

$j10^3\,\Omega$

thevenin

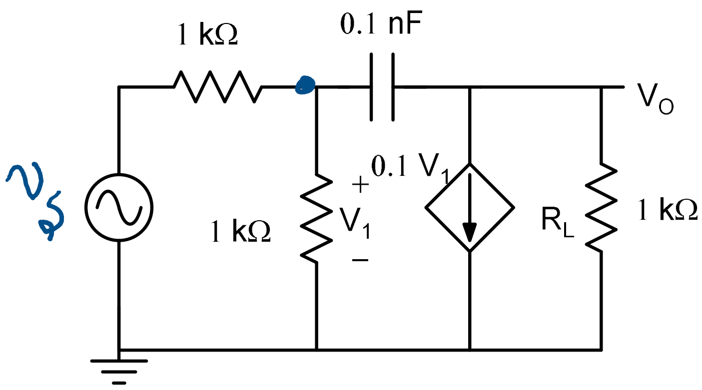


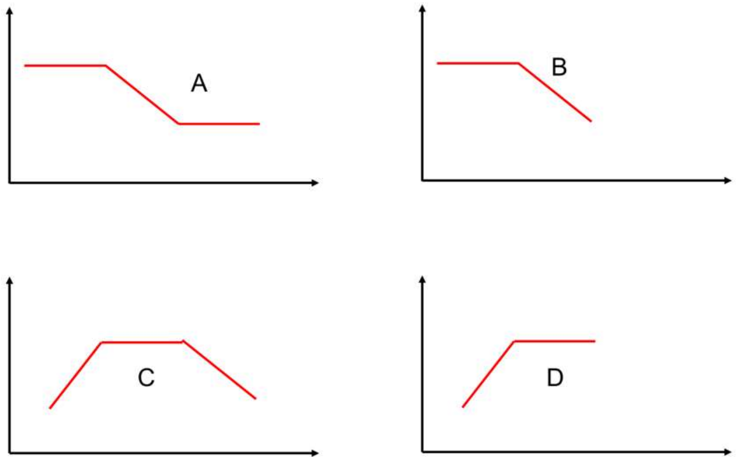
$$\rightarrow V_L = \frac{j10^3 \cdot 4}{10^3 + j10^3} = \frac{j}{1+j}$$

$$|V_L| = \frac{4}{\sqrt{2}} = |V_{R_L}|$$

$$P_L = \frac{V_{R_L}^2}{2R_L} = \frac{16}{2\times2\times2} = \underline{2W}$$

Q.5 Which graph correctly describes the frequency response (magnitude in (dB) vs frequency) of output voltage V_O of the amplifier circuit shown below.





Answer : A

At low frequencies capacitor is like open ckt

$$\frac{v_o}{v_s} = -\left(\frac{1K}{1K+1K}\right) \times 0.1 \times 10^3 = -50$$ So there is significant Gain

As f ↑ capacitor begins to short V_1 to V_o causing V_o to decrease. Eventually cap. acts like a short making $V_o \sim V_1$ and constant.

MQ

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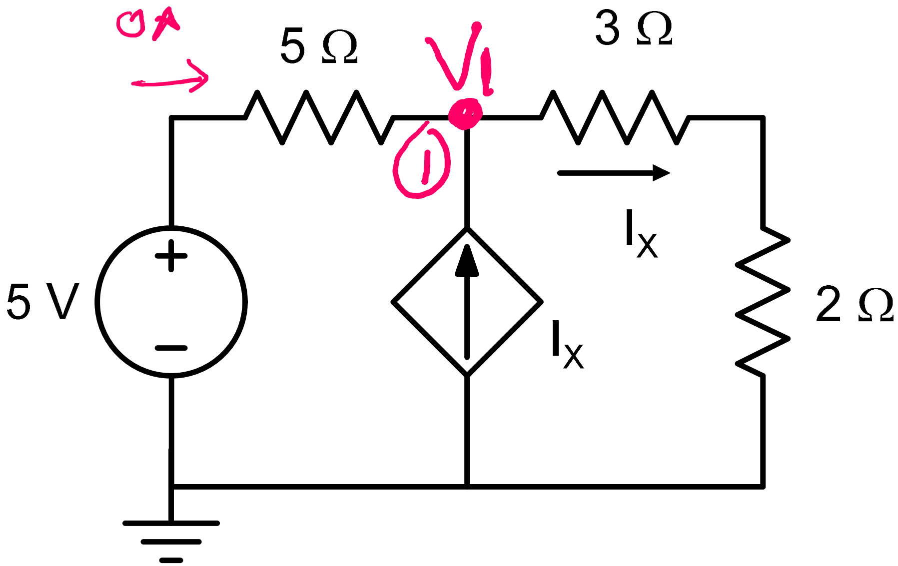
MQ1

Determine power dissipated/generated in dependent current source shown below. Write your answer along with all relevant steps on a piece of paper take a photograph and upload it on mooKIT. If that does not work, send email to your tutor. Try to send email within time... (10 Marks)



$$\frac{5-V_1}{5} + I_X - I_X = 0$$

$$\Rightarrow V_1 = 5\,V \rightarrow 5$$

$$\Rightarrow I_X = \frac{V_1}{5} = 1\,A$$

$$P_x = -V_1 \times I_x = -5W$$

3 2

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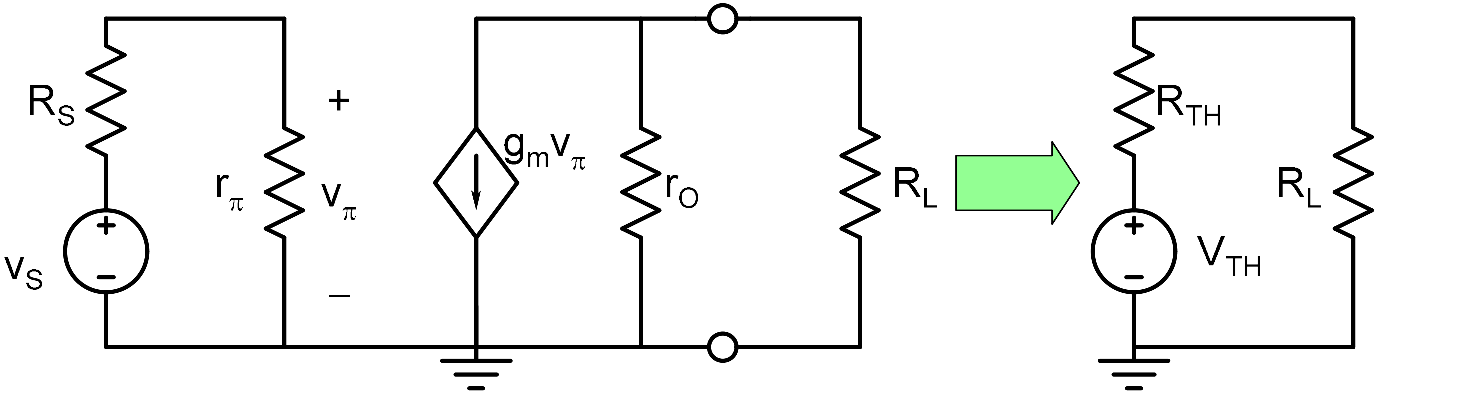
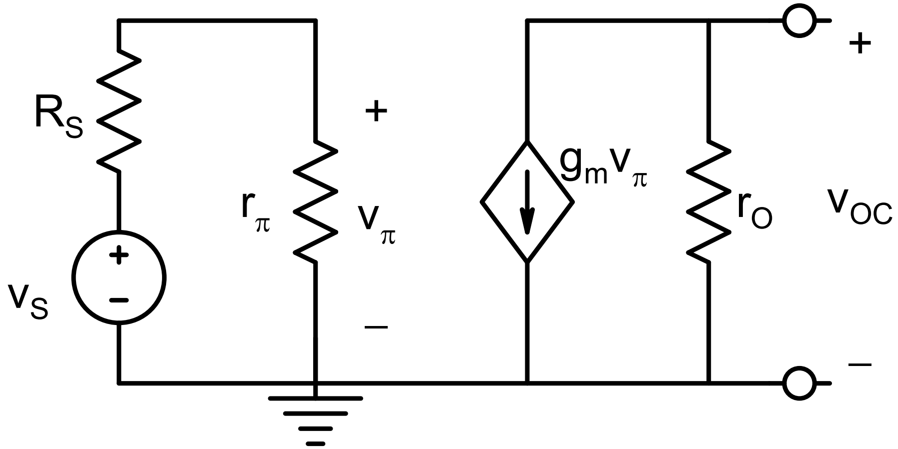
MQ2 (18/9/2020)

Q.1 Thevenin's theorem is used to carry out the circuit transformation shown below. Determine the value of Thevenin's voltage and Thevenin's resistance-----10 marks



$$v_S = 5mV; R_S = 1k\Omega; r_\pi = 1k\Omega; g_m = 0.1\Omega^{-1}; r_O = 100k\Omega; R_L = 1k\Omega$$



$$v_\pi = v_S \times \frac{r_\pi}{r_\pi + R_S}$$

$$\frac{v_{OC}}{r_O} + g_m v_\pi = 0$$

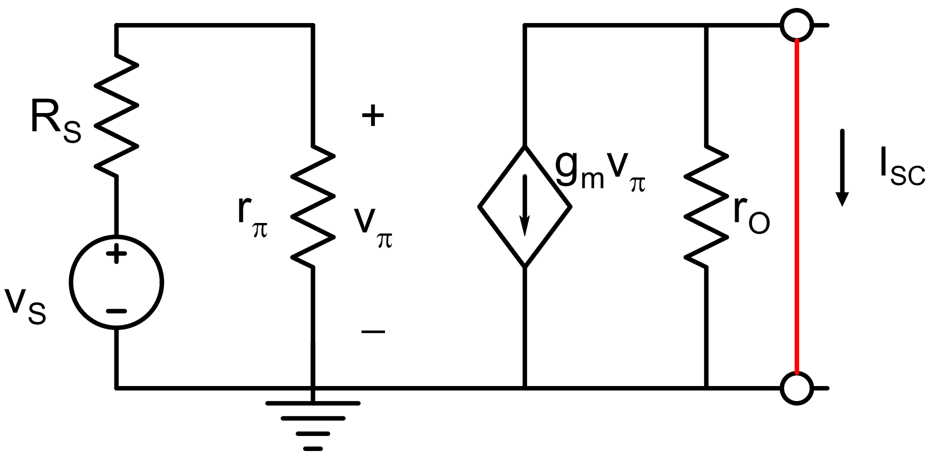
$$V_{TH} = v_{OC} = -g_m \times r_O \times \frac{r_\pi}{r_\pi + R_S} v_S$$

2 4

$$V_{TH} = -0.1 \times 10^5 \times 0.5 \times 5 \times 10^{-3} = -25V$$

6

Thevenin's resistance can be found from the circuit



$$I_{SC} = -g_m \times \frac{r_\pi}{r_\pi + R_S} \times v_S$$ 2

$$R_{TH} = \frac{v_{OC}}{I_{SC}} = r_O = 100k\Omega$$ 2

overall 4 for R-TH calculation

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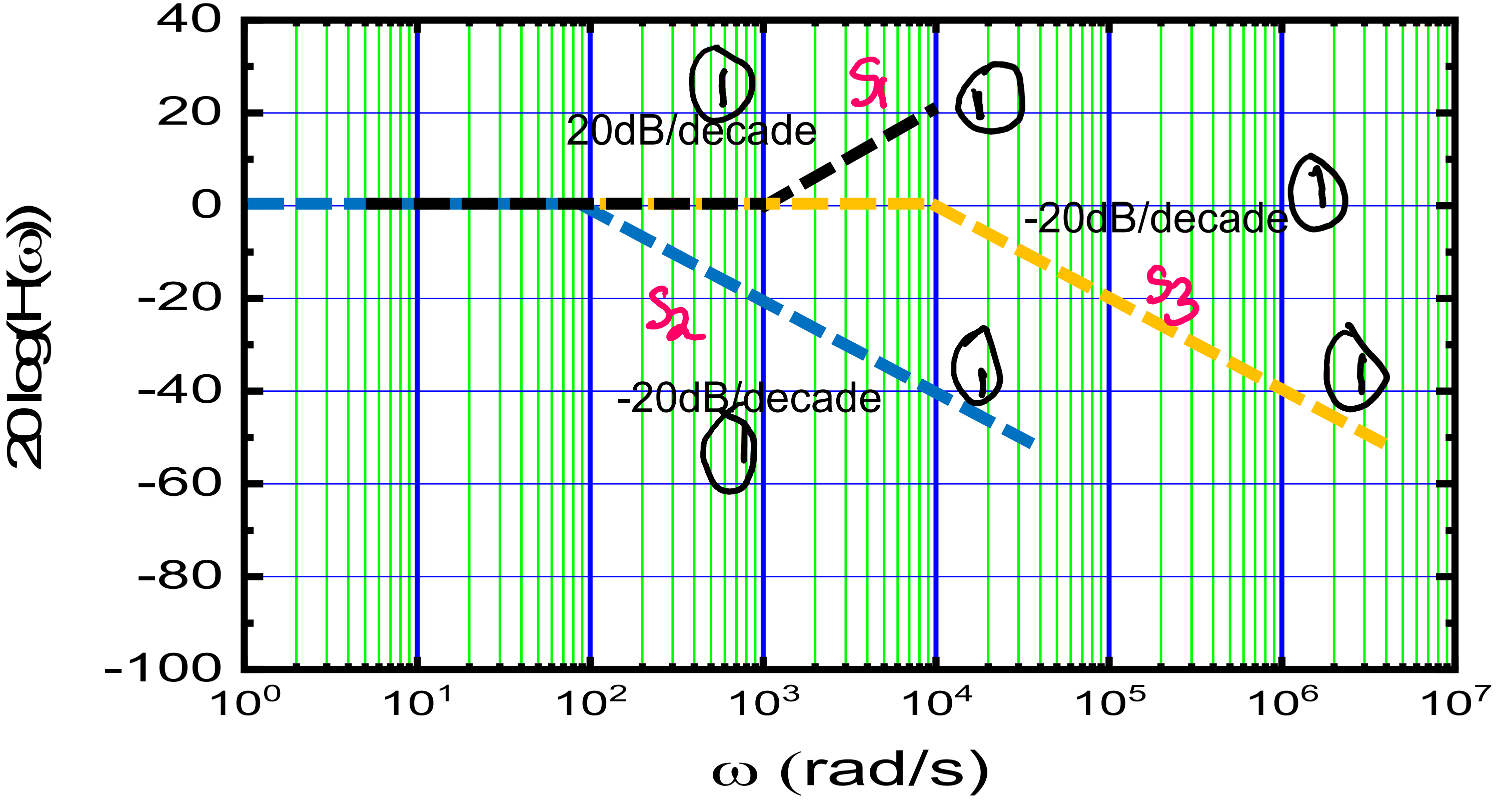
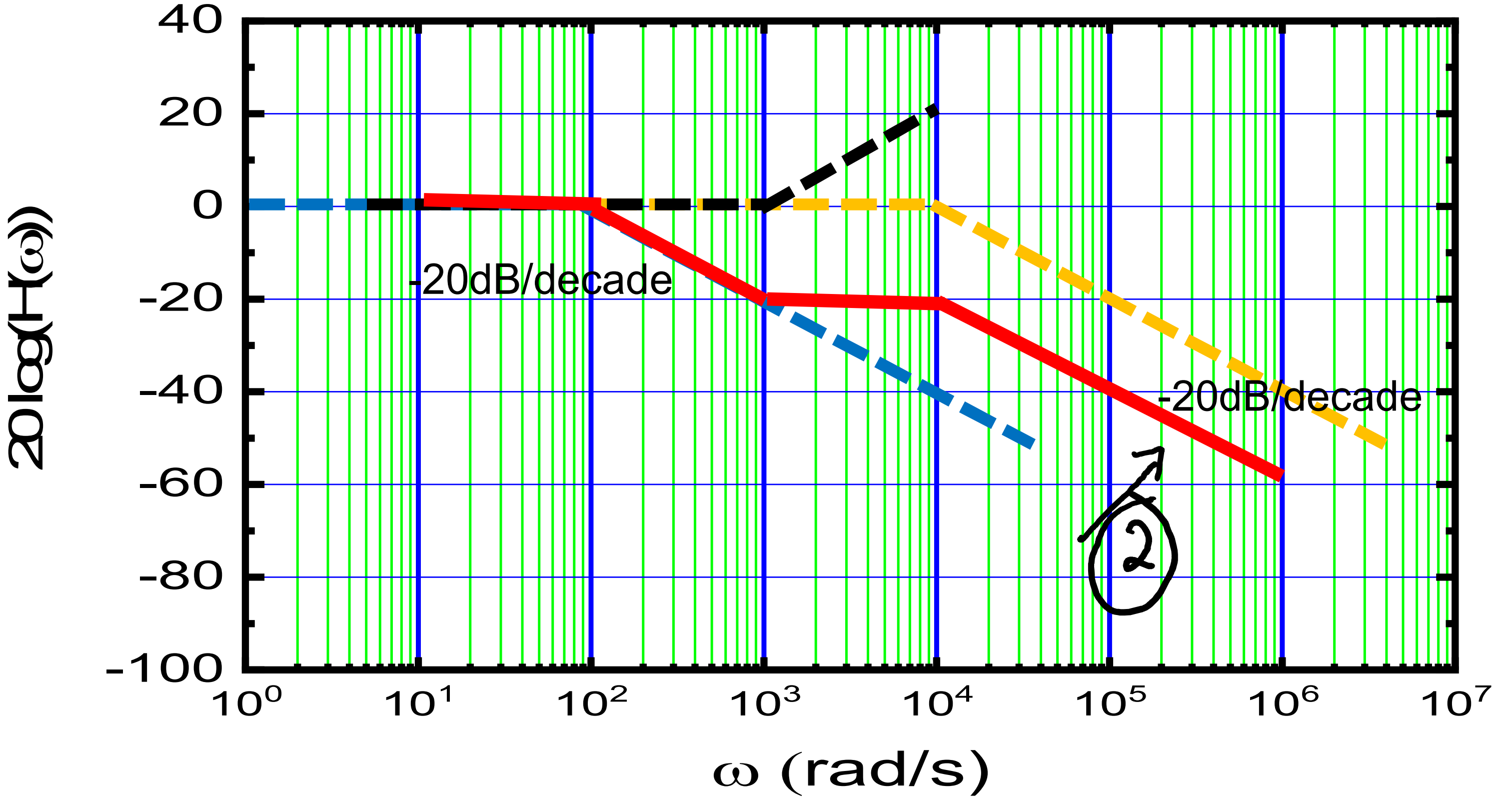
MQ3 (8/10/2020)

Q.1 Sketch the Bode plot (magnitude part) of the transfer function given below. Show all relevant details in the diagram. Using only the plot, estimate the magnitude of $H(\omega)$ (in dB) at $\omega = 5000$ *and* 10^6 rad/s ----10 marks

$$H(\omega) = \frac{\overbrace{1+j\omega/10^3}^{S1}}{\underbrace{1+\frac{j\omega}{10^2}}_{S2}} \times \frac{1}{\underbrace{1+\frac{j\omega}{10^4}}_{S3}}$$





The magnitude of $\mathrm{H}(\omega)$ (in dB) at $\omega = 5000$ $is\ -20dB\ and\ -60dB\ at 10^6$rad/s

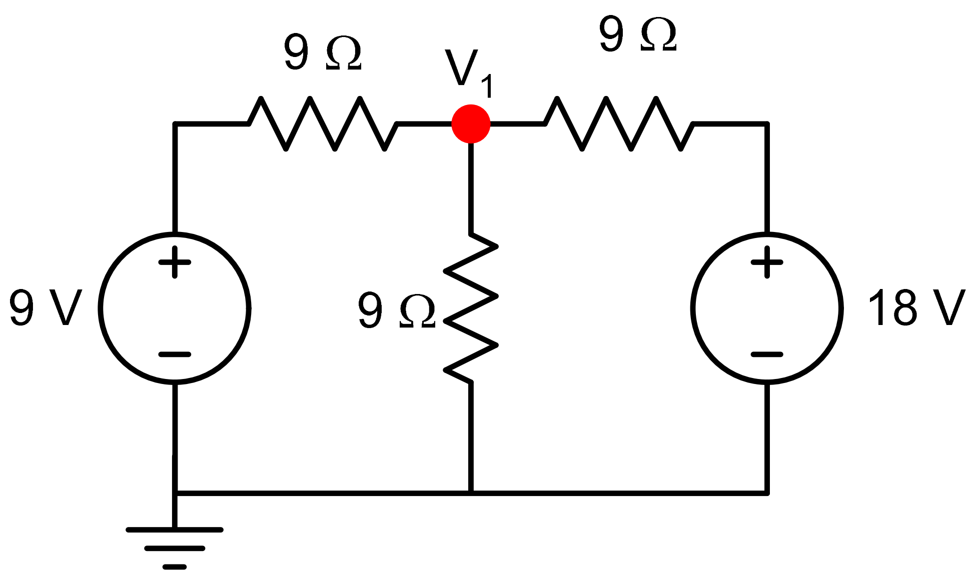
1 1

Discussion Quiz

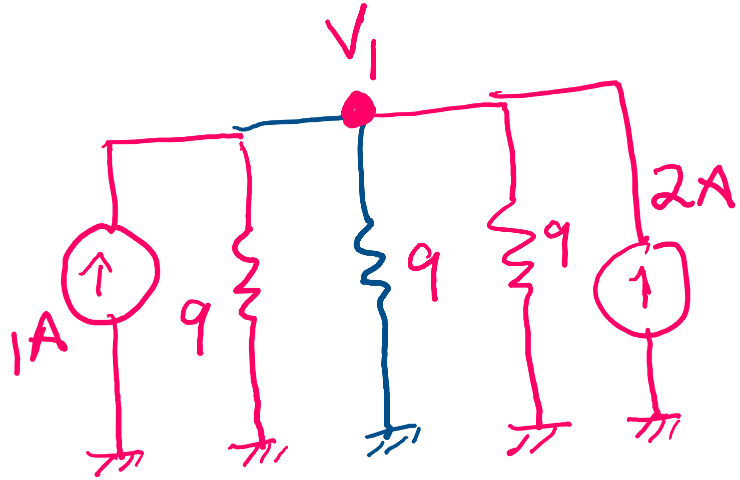
ESC201T : Introduction to Electronics

Discussion Quiz 1 (16/9/2020)

Q. Use Source transformation to determine voltage V1. Express your answer as an integer only without units.



$\Longrightarrow$



$$V_1 = (1+2) \times 3 = \underline{9V}$$

Ans : 9

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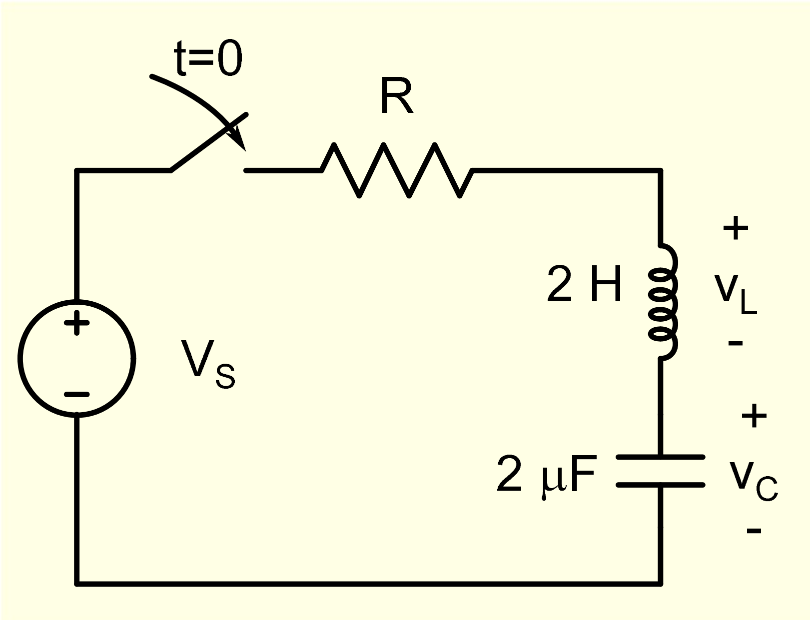
Discussion Quiz 2 (30/9/2020)

Q. Determine the value of resistance (in $k\Omega$) below which oscillations in capacitor voltage Vc in the circuit shown below will occur upon closing of the switch.
(Assume switch is open for a long time and there is zero initial charge on capacitor. Give answer only as an integer)



$$\omega_O = \frac{1}{\sqrt{L \times C}} = 500 \text{ rad/s}$$

$$Q = \frac{\omega_O L}{R} \geq 0.5$$

$$\Rightarrow R \leq 2 \times 10^3 \Omega$$

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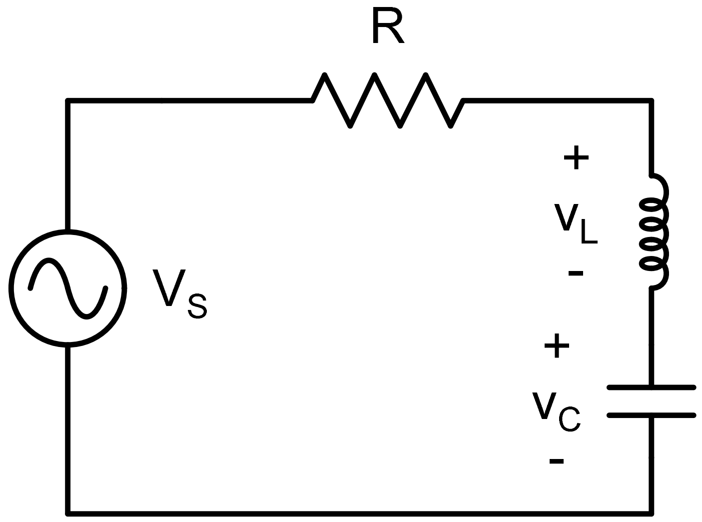
Discussion Quiz 3 (7/10/2020)

Q. Determine the maximum value of resistance (in Ω) required to obtain magnitude of capacitor voltage (v_c) larger than 100V. (Give answer only as an integer)



$$v_C = \frac{1/j\omega C}{R + \frac{1}{j\omega C} + j\omega L} \times 1$$

$$\omega = 10\pi 10^6$$

$$\omega L = 10^4 \qquad \frac{1}{\omega C} = 10^4$$

$$V_S = 1\sin(10\pi 10^6 t)$$

$$L = \frac{1}{\pi} \times 10^{-3} H$$

$$C = \frac{10}{\pi} \times 10^{-12} F$$

$$\Rightarrow v_C = \frac{1/\omega C}{R} \times 1 \geq 100$$

$$R \leq 100\Omega$$

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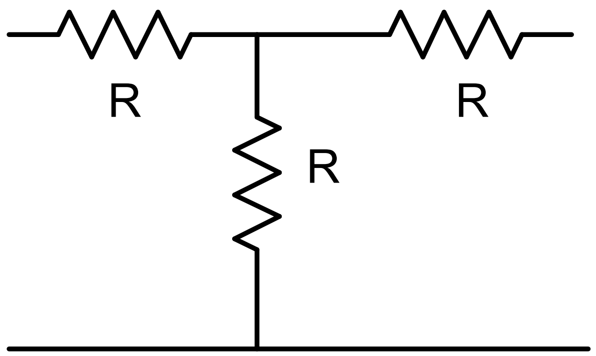
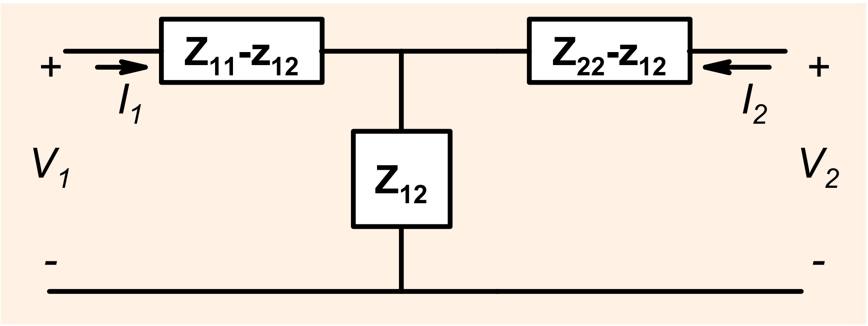
Discussion Quiz 4 (28/10/2020)

Q. Determine the Z parameters for the circuit shown. Enter integer values normalized by R and separated by commas as $\frac{z_{11}}{R}, \frac{z_{12}}{R}, \frac{z_{21}}{R}, \frac{z_{22}}{R}$

(if you determine answer as z_{11} = 5R, z_{12} = 6R, z_{21} = 7R and z_{22} = 8R then enter 5,6,7,8 as the answer)





$$z_{12} = z_{21} = R$$

$$z_{11} - z_{21} = R \Rightarrow z_{11} = 2R$$

$$z_{22} - z_{21} = R \Rightarrow z_{22} = 2R$$

Answer is 2,1,1,2

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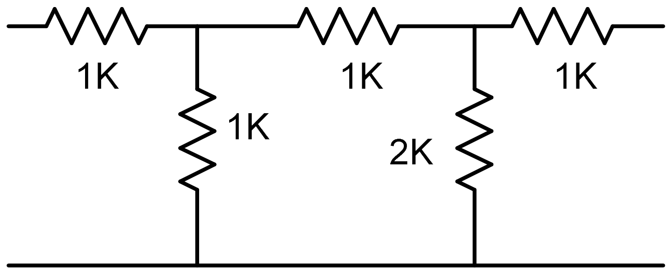
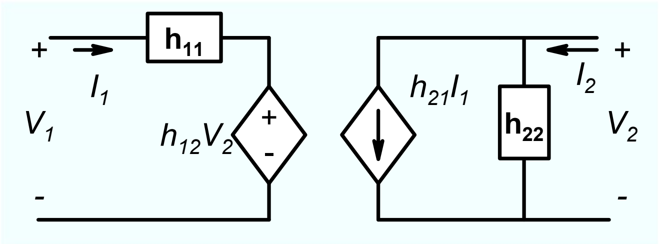
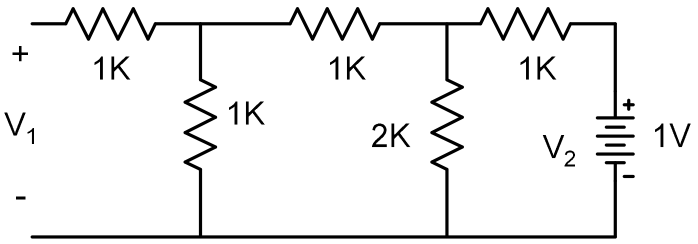
DQ4 (28/10/2020)

Q. Determine h_{12} parameter for the circuit shown. (Enter value as y.yy, as an example 0.89)





$$h_{12} = \frac{V_1}{V_2} | I_1 = 0$$



$$\frac{V_1}{V_2} = \frac{1}{2} \times \frac{1}{2} = 0.25$$

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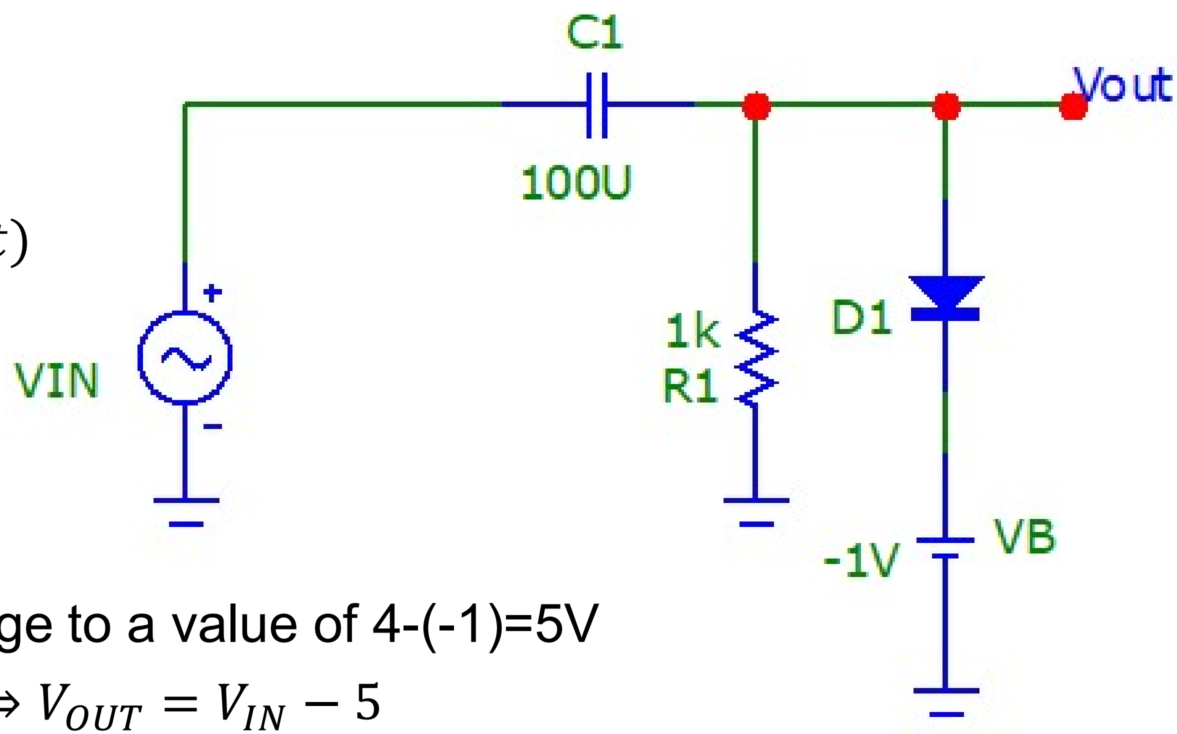
DQ5 (04/11/2020)

Q.1 Assuming that the diode is ideal (with zero voltage drop under forward bias), determine the maximum value of output voltage for the circuit shown below under sinusoidal steady state condition. 4V input refers to peak value of sinusoid.

(Enter value as an integer with sign like +5 or -6 as an example)

$$V_{IN} = 4V sin(\omega t)$$
$$f = 100Hz$$



Capacitor will charge to a value of 4-(-1)=5V

$$V_{IN} - V_{OUT} = 5 \Rightarrow V_{OUT} = V_{IN} - 5$$

$$Maximum\ value\ of\ V_{OUT} = -1V$$