ESC201A EndSem Part 1

SAMYAK SINGHANIA

TOTAL POINTS

14.5 / 19

QUESTION 1

Q1 9 pts

1.1 1(a) 4 / 4

✓ **+ 4 pts** *Completely Correct*

+ 0 pts Completely Incorrect

+ 0 pts Not Attempted

+ 0 pts Copied

+ 2 pts Thevenin voltage calculated correctly

+ 2 pts Thevenin resistance calculated correctly

1.2 1(b) 0 / 3

+ 3 pts Completely Correct

✓ **+ 0 pts** *Completely Incorrect*

+ 0 pts Not Attempted

+ 1.5 pts Equivalent circuit at t=0+ correctly found

+ 0 pts Copied

+ 1.5 pts V correctly found

1.3 1(c) 2 / 2

✓ **+ 2 pts** *Completely Correct*

+ 0 pts Completely Incorrect

+ 0 pts Not Attempted

+ 0 pts Copied

+ 1 pts Circuit behavior at low & high freq correctly identified

+ 1 pts Nature of filter correctly identified

QUESTION 2

Q2 10 pts

2.1 2(a) 2.5 / 4

+ 4 pts Completely Correct

+ 0 pts Completely Incorrect

+ 0 pts Not Attempted

+ 0 pts Copied

+ 2 pts Circuit Simplified Correctly

✓ **+ 1 pts** *Resonance condition identified with correct reasoning*

+ 1 pts Frequency found correctly

+ 1.5 *Point adjustment*

2.2 2(b) 6 / 6

✓ **+ 6 pts** *Completely Correct*

+ 0 pts Completely Incorrect

+ 0 pts Not Attempted

+ 0 pts Copied

+ 1 pts Circuit Schematic drawn correctly

+ 1.5 pts Transformer turns ratio calculated correctly

+ 1 pts Capacitance calculated correctly

+ 1.5 pts Diode peak current calculated correctly

+ 1 pts Peak Inverse Voltage calculated correctly

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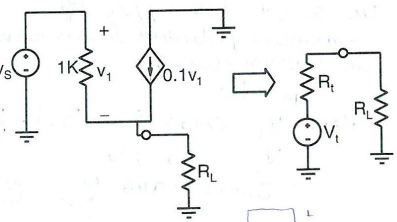
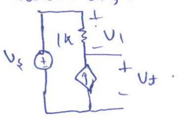
1 (a). Use Thevenin's theorem to carry out the circuit transformation shown below and determine the value of Thevenin's voltage (V_t) and resistance (R_t). [4]



Calculating Thevenin voltage V_t.



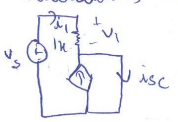
$\therefore V_s = V_1 + V_t$

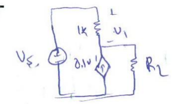
$V_1 = -0.1 V_1 \times 1K$

$\Rightarrow V_1 = 0$

$\therefore V_t = V_s$

Calculating i_{sc}





Now, $V_s = 1K \cdot i_1$

$V_1 = V_s$

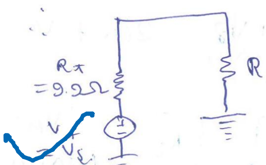
$\therefore i_1 = V_s \times 10^{-3}$

$i_{sc} = 0.1 V_1 + i_1$

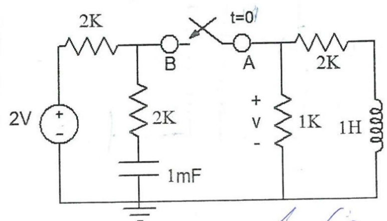
$= 0.1 V_s + V_s \times 0.001$

$= 0.101 V_s$

$\therefore R_{th} = \frac{V_t}{i_{sc}} = \frac{V_s}{0.101 V_s} = 9.9\,\Omega$



1 (b). For the circuit shown, determine the voltage V across the 1K resistor immediately after switch is closed at t=0 . Assume that the circuit had enough time to reach steady state prior to closing of switch. [3]

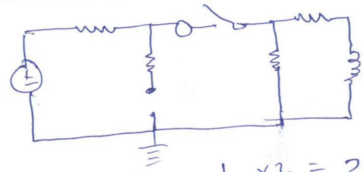


$\because$ Steady state

$\therefore$ Capacitance will act like open.

~~$\frac{2}{3} + 2 = \frac{8}{3}$~~

~~$\frac{2}{8} \times 3 = \frac{3}{4}$~~



$i_L(t=0^-) = 0$

$\Rightarrow i_L(t=0^+) = 0$

$\because$ Current cannot change across inductor instantly.

$\therefore V$ at $t=0^+ = \frac{1}{2+1} \times 2 = \frac{2}{3}$ V. immediately after the switch is closed at t=0

~~R_L across inductor $= 2 + \frac{2}{3} = \frac{8}{3}\,\Omega$~~

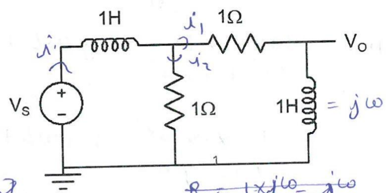
~~$i_L(t=\infty) = \frac{1}{3} \times \frac{3}{4} = \frac{1}{4}$ A.~~

~~$\therefore i_L(t) = i(\infty) + (i(0) - i(\infty)) e^{-\frac{R_{th} t}{L}} = \frac{1}{4}\left(1 - e^{-\frac{8}{3}t}\right)$~~

~~$\therefore V = 2 i_L + L\frac{di}{dt} = \frac{1}{4}\left(1 - e^{-\frac{8}{3}t}\right) + \frac{1}{4} \times \frac{8}{3} \times e^{-\frac{8}{3}t}$~~

~~$V(t) = \frac{1}{4} + \left(\frac{2}{3} - \frac{1}{4}\right) e^{-\frac{8}{3}t}$~~

1(c). Determine the nature of the filter (low pass/high pass/band pass/band stop) shown below using qualitative arguments. [2]



~~$V_s = i j\omega + i\left(1 \| (1 + j\omega)\right)$~~

~~$V_s = i\left[j\omega + \frac{1 + j\omega}{2 + j\omega}\right]$~~

~~$V_s = i\left[\frac{2j\omega - \omega^2 + 1 + j\omega}{2 + j\omega}\right]$~~

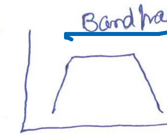
~~$R = \frac{1 \times j\omega}{1 + j\omega} = \frac{j\omega}{1 + j\omega}$~~

If ω is low; ~~current~~ impedance of inductor is low. thus current passes through $V_o = 0$

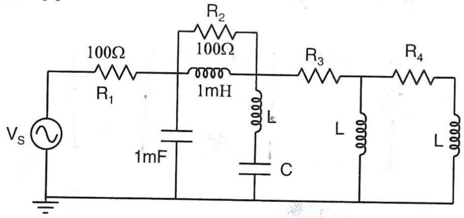
If ω is high; inductor acts like open, the $V_o = 0$, $\because$ the first inductor breaks the circuit.

$\therefore$ The nature of the filter is band pass

Band pass



2(a). The power dissipated in resistors R_3 and R_4 in the circuit shown below was measured to be zero and power measured in resistors R_1 and R_2 was measured to be equal. Using sinusoidal steady state analysis estimate the frequency of the input signal. [4]

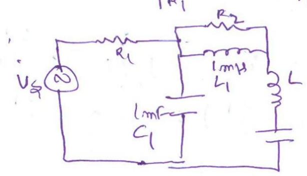


Power dissipated in R_3 & R_4 = 0.

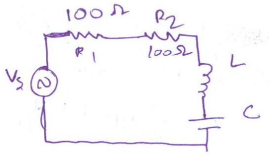
∴ $i_{rms}|_{R_3} = 0$

$i_{rms}|_{R_4} = 0$

Also, $i_{rms}|_{R_1} = i_{rms}|_{R_2}$.



⇒



Angular frequency be ω.

$$\therefore \left(\frac{R_2\, j\omega L_1}{j\omega L + R_2} + j\omega L + \frac{1}{j\omega C}\right) \Big\| \frac{1}{j\omega C_1} = R_2 + j\omega L + \frac{1}{j\omega C}$$

Now,
$$\frac{\left(\frac{100 \times j\omega 10^{-3}}{100 + j\omega 10^{-3}} + j\omega L + \frac{1}{j\omega C}\right)\frac{1}{j\omega 10^{-3}}}{\frac{100 \times j\omega 10^{-3}}{100 + j\omega 10^{-3}} + j\omega L + \frac{1}{j\omega C} + \frac{1}{j\omega 10^{-3}}} = 100 + j\omega L + \frac{1}{j\omega C}$$

$$\Rightarrow \cancel{\frac{100}{100 + j\omega 10^{-3}}} + \cancel{\frac{L}{10^{-3}}} - \cancel{\frac{1}{\omega^2 10^{-3}}}$$

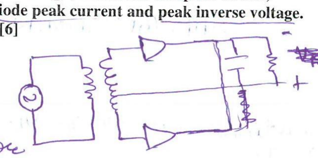
$$\omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{10^{-3} 10^{-3}}} = 10^3$$

∴ frequency $= \frac{10^3}{2\pi}$ Hz

2(b). Design a full wave rectifier based power supply circuit that will supply -10V to a load of 1000Ω with magnitude of ripple voltage less than 0.2V. As part of the design, sketch the complete circuit, determine transformer turns ratio, value of capacitance, diode peak current and peak inverse voltage. Assume that input is 220V rms with a frequency of 50Hz. [6]

$R_L = 1000\,\Omega$.

$f = 50$ Hz.



We can get −10V supply by measuring potential across resistor in reverse direction

∴ $V_M = 10$

Here $V_1 = 220 \times \sqrt{2} = 311.12$ V

$V_2 = 10.7$ V.

∴ Turns ratio $\frac{N_1}{N_2/2} = \frac{V_1}{V_2} \Rightarrow \frac{N_1}{N_2} = \frac{155.56}{10.7} = 14.5383$

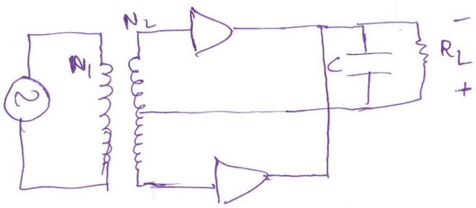
$V_r = \frac{V_M}{2 f R_L C} < 0.2V$ ∴ $\Rightarrow \frac{10}{2 \times 50 \times 1000 \times 0.2} < C$

∴ $C > \frac{5 \times 10}{10^5} \Rightarrow C > 5 \times 10^{-4}$ ∴ $C = 500\,\mu F$

Peak diode current $i_{D\,max} = \frac{V_M}{R_L}\left[1 + \pi\sqrt{\frac{2V_M}{V_r}}\right]$

$= \frac{10}{1000}\left[1 + \pi \times 10\right] = 0.324$ A.

Peak inverse voltage $= 2V_M + V_r = 20.7$ V.



∵ $V_M = 10$ V

Measured voltage across $R_L = -10$ V