EE240: Circuits I

ASSIGNMENT 5

Due Date: 06 Dec 2019

- Submissions will only be accepted on A4 sized papers.
- Write your name and roll number clearly at the top of the assignment.
- You are required to show working where necessary; answers will not be graded if working is not shown.
- The assignment is worth **100** marks, you are advised to start early as it is long.
- Feel free to contact the instructor or teaching assistants if you have any questions.
- Any instance of plagiarism will be **severely** dealt with; such cases would be subjected to **disciplinary action** in accordance with university rules and regulations.

Problem 1 (10 marks)

Determine $v(t)$for $t > 0$ in the following circuit.

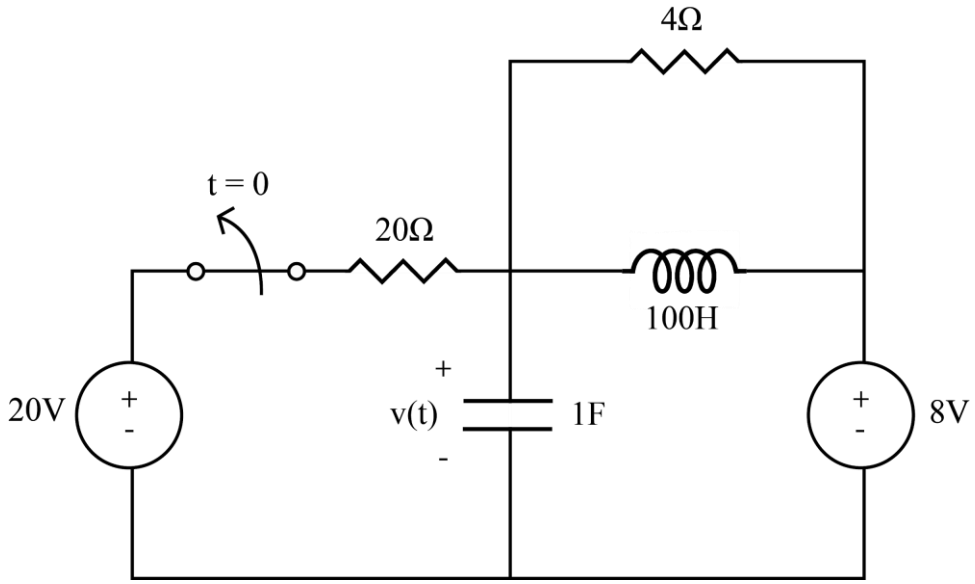


Figure 1

Problem 2 (15 marks)

Derive an expression for $i(t)$for $t > 0$ in the circuit given below.

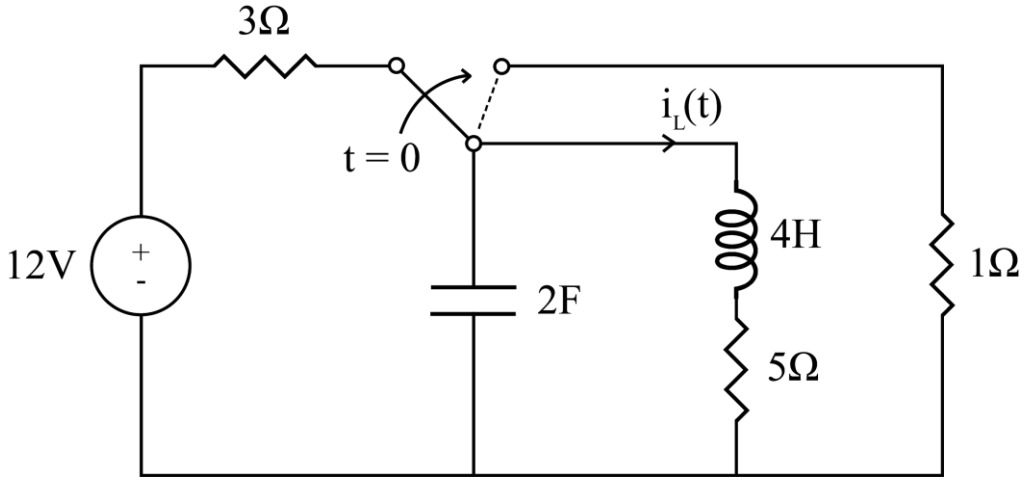


Figure 2

Problem 3 (15 marks)

Determine $i(t)$for $t > 0$ in the network shown below.

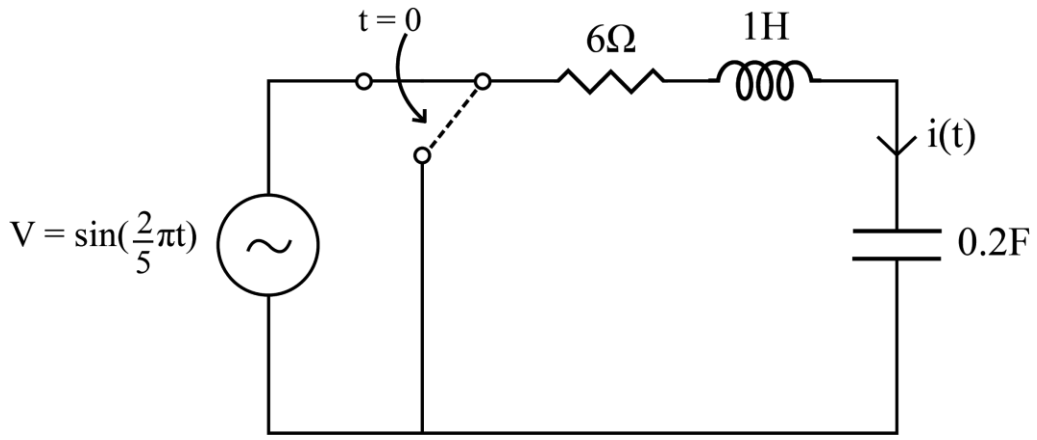


Figure 3

Problem 4 (10 marks)

The following network shows a combination of capacitors and resistors connected to a sinusoidal voltage source. Determine *i(t)* for t > 0.

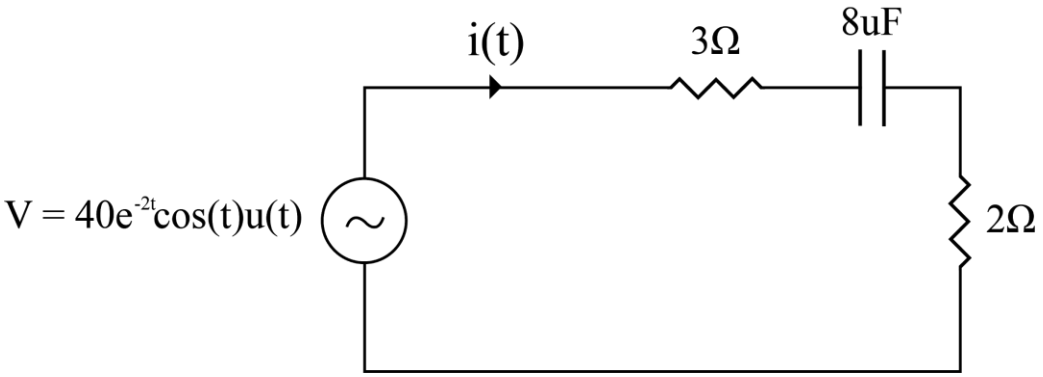


Figure 4

Problem 5 (10 marks)

A parallel RLC circuit has the following component values: R = 2kΩ, L = 250mH, and C = 10nF.

(a) **[2 marks]** Formulate the characteristic equation for the voltage response of the circuit and calculate its roots.

(b) **[2 marks]** Determine whether the voltage response is underdamped, critically damped, or overdamped.

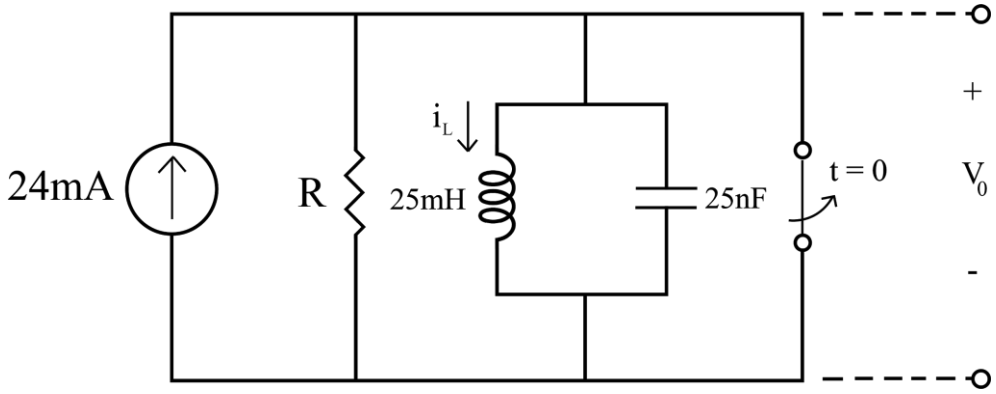
(c) **[2 marks]** Find the value of the resistor (in ohms) for which the system will have a damped frequency of 12k rad/s.

(d) **[2 marks]** Formulate the characteristic equation for the voltage response with the resistance value from part (c) and calculate its roots.

(e) **[2 marks]** Find the value of the resistor (in ohms) for which the voltage response will become critically damped.

Problem 6 (15 marks)

You are given the parallel RLC circuit shown in the figure below.



The initial energy stored in the circuit is zero. At time t = 0, a DC current source is applied to the circuit as shown.

(a) **[5 marks]** Suppose that the resistor has a value of 400Ω. Find the following:

(i) $i_L(0)$

(ii) $di_L(0^+)/dt$

(iii) Roots of the characteristic equation

(iv) Mathematical expression for $i_L(t)$ for $t \geq 0$. Sketch the graph on a plot ranging from 0 to 220μs (time axis).

(b) **[4 marks]** Suppose that the value of the resistor has been changed to 625Ω. Find the expression for $i_L(t)$ for $t \geq 0$. Sketch its graph on the same plot from part (a)(iv).

(c) **[4 marks]** Suppose that the value of the resistor has been changed yet again to 500Ω. Find the expression for $i_L(t)$ for $t \geq 0$ and plot its graph on the same plot from part (a)(iv).

(d) **[2 marks]** Looking at the plots of $i_L(t)$ for $t \geq 0$ for the three resistor values: 400Ω, 625Ω, and 500Ω, identify the time it takes for each plot to reach 90% of its final output value. Based on your observations, which value of R (ohms) creates a system design that puts a premium on reaching 90% of its final output value in the shortest time?

Note: You may use Matlab to plot your graphs

Problem 7 (10 marks)

Solve the differential equations given below:

(a) **[6 marks]**

$d^2i/dt^2 + 6\,(di/dt) + 8i = 5\cos(7t)$

where $i(0^+) = 3.94$ and $di(0^+)/dt = -9.57$

(b) **[4 marks]**

$d^3i/dt^3 + 10(d^2i/dt^2) + 31(di/dt) + 30i = 0$

where $i(0^+) = 5$, $di(0^+)/dt = -6$, and $d^2i(0^+)/dt^2 = 30$

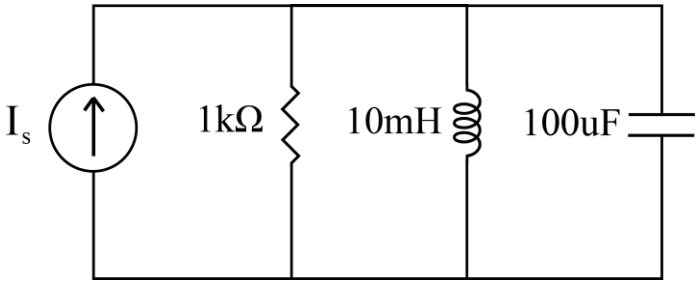
Problem 8 (5 marks)

Given the following parallel RLC circuit powered by a current source, compute its:

(a) **[2 marks]** Resonant Frequency

(b) **[2 marks]** Bandwidth

(c) **[1 mark]** Quality Factor



Problem 9 (10 marks)

The current flowing through a series RLC circuit is given by:

$$i(t) = Xe^{-4t} - 25.5e^{-6t} - 2.5e^{-2t} + 30e^{-5t}$$

where *X* is an unknown constant, the voltage source is given by:

$$V_s(t) = (5e^{-2t} + 3e^{-5t})u(t)$$

Where $u(t)$ is the unit step function. The inductance is given by $L = 0.5$H.

(a) [**4 marks**] Find the corresponding values of R and C and draw the circuit.

(b) [**4 marks**] Determine the value of X.

(c) [**2 marks**] Derive an expression for voltage across inductor $v_L(t)$ and find $v_L(1)$, i.e. inductor voltage at $t = 1$s.