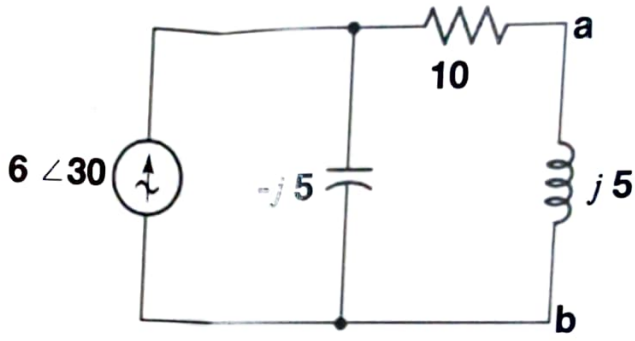
Network Signals and Systems – Final Exam

Date: 1st December 2023
Maximum Marks: 100

- Read the questions carefully & answer to the point. Show all steps & details where required.
- No electronic devices, phone/calculator allowed.
- Please underline the main point & box the final answer.
  Plagiarism, use of unfair means will result in zero marks.

Problem 1 [38 Marks]

Figure 1

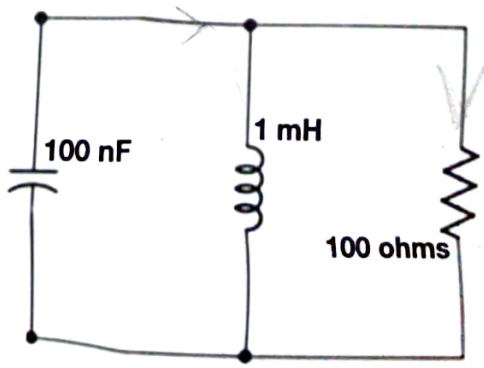


For Figure 1,

1) What is the steady state (a) equivalent impedance, (b) open circuit voltage, (c) short circuit current between points a and b ; (d) current flowing in the circuit. Show your calculations. [4*4].
2) What is the angular frequency if L=1 H [2]? Is there any frequency for which the system is purely resistive [1] ?
3) What is the average power absorbed by resistor, inductor & capacitor. Show your calculations. [3*3]
4) What is the Apparent power supplied by the source. Show all steps [4].
5) Define Power factor [2]. What is the power factor for the source [3].

Problem 2: [20 Marks]

Figure 2



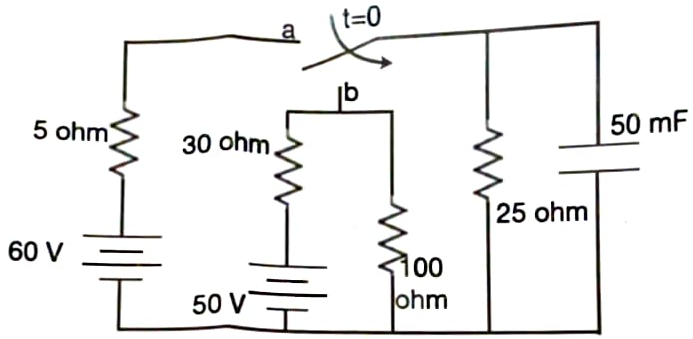
$t = 0 \quad V_c = 10V \quad I_L = 1mA$

For circuit in figure 2,

1) What is the resonant frequency (ω) & the expected circuit response [5]?. What will be the behaviour of current with time [5]? Assume zero initial conditions.
2) What should be the angular frequency if you want the system to settle fast? What is such a circuit called? [5]
3) What happens if R=0 ohms? What will be the current value? What happens to energy? What kind of circuit this is? [5]

Problem 3 [20 Marks]

Figure 3



For figure 3, what is (a) value of capacitor voltage for t>0 [10] and (b) current through the 100 ohm resistor for t>0 [10]. Show all the steps.

Problem 4 [12 Marks]

Input to an LTI system is given to be an exponential decay signal, i.e., $x(t) = e^{-\alpha t}u(t), \alpha > 0$, starting at $t = 0$. The output of this system is also observed to be an exponential decay signal but with a different decay rate, i.e., $y(t) = e^{-\beta t}u(t), \beta \neq \alpha$, and β is any real number. Use Laplace transform analysis to answer the questions below.

1) [4] Find the transfer function of this system and its ROC.
2) [4] Find the time domain impulse response of this system.
3) [2] For what range of values of α and β is this system causal?
4) [2] For what range of values of α and β is this system stable?

Problem 5 [10 Marks]

Consider a series RC circuit with resistor R and capacitance C. A variable voltage source $V_{in}(t)$ is connected to this circuit at $t = 0$.

1) [2] Find the transfer function $H(s)$ of this system with V_{in} as input and voltage across the capacitor V_c as the output.
2) [8] The input voltage source is set to 1 Volt for the first second and then increased to 2 Volts. Using Laplace transform analysis and properties, find the voltage across the capacitor from time $t = 0$ onwards and sketch it.