EC5.101 Network, Signals & Systems Final Exam
Feb 2023

Part 1: Signals & Systems

Instructions:

a) There are *5 questions* for a total of *40 marks.*

b) Mention any additional assumptions you make that is not given in the question.

c) Write your answers neatly and clearly show the steps used to arrive at the solutions.

1. [12 marks] An LTI system with input $x(t)$ and output $y(t)$ can be described as

$$\frac{d^2y(t)}{dt^2} - \frac{dy(t)}{dt} - 6y(t) = x(t).$$

(a) [4] Find the transfer function $H(s)$ for this system and sketch the pole-zero plot.

(b) [4] Find and sketch the impulse response of this system if it is known to be stable.

(c) [2] Can this system be simultaneously stable and causal? Explain.

(d) [2] Using $H(s)$, find the output of this system when the input is $\cos(t)$.

2. [6 marks] Find the Laplace transform and the corresponding ROC for the following signal:

$$x(t) = \sum_{k=0}^{\infty} \delta(t - kt_0), \quad t_0 > 0.$$

3. [6 marks] A system with input signal $x(t)$ and output signal $y(t)$ is given by

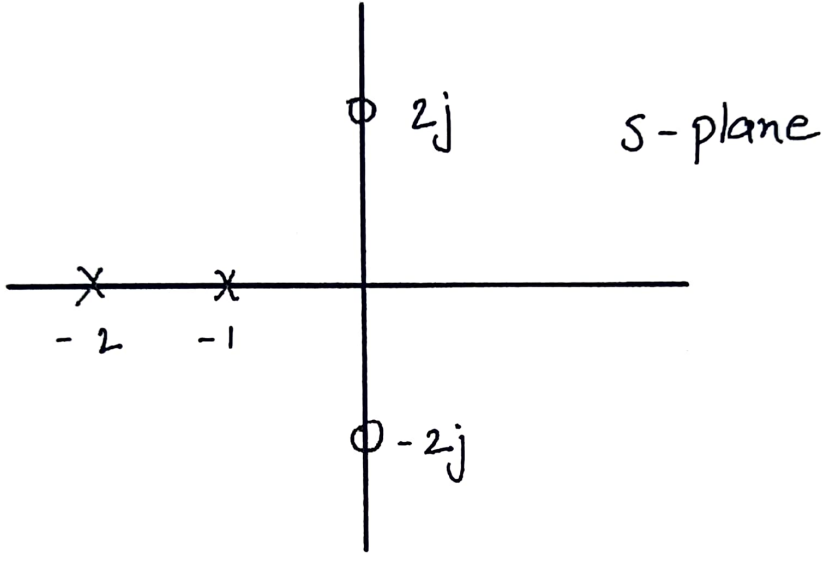
$$y(t) = \int_{\tau=0}^{t} x(\tau)d\tau, \quad \forall t \in \mathbb{R}.$$

(a) [2] If the input signal has even symmetry, show that the output signal has odd symmetry.

(b) [4] Investigate whether this system is an LTI system.

4. [6 marks] It is known that convolution of the signals $x_1(t)$, $x_2(t)$, and $x_3(t)$ is given by the signal $y(t) = x_1(t) * x_2(t) * x_3(t)$. For some real constant $a \in \mathbb{R}$, using Laplace transform and its properties (or otherwise), express the convolution $x_1(at) * x_2(at) * x_3(at)$ in terms of $y(t)$ and a.

5. [10 marks] Pole-zero plot of the transfer function of a system is shown below.



(a) [2] If the transfer function is known to be of the rational form, write down its expression.

(b) [2] How many distinct systems can have the above transfer function? Identify their ROC.

(c) [3] For each system, comment on their stability and causality. Justify.

(d) [3] It is observed that if $\sin(\alpha t)$ is given as input to the causal system with above transfer function, the output is 0. Find α.

Part 2: Circuits & Network Theory

Read instructions and questions carefully before attempting.

- This section is for 60 marks and has 4 problems.
- Show all steps & calculations neatly. Marks will be deducted for untidy work.
- Underline or box your final answers.
- Using any unfair means (plagiarism, copying/cheating, electronic communication) to answer the questions will results in awarding of 0 (zero) points.
- Cell phones, calculators should be kept outside the class room

1 For circuit shown in figure 1, switch is flipped from location A to B at t=0. Obtain an expression for i_L, V_L, V_R, and V_c. [12 points]

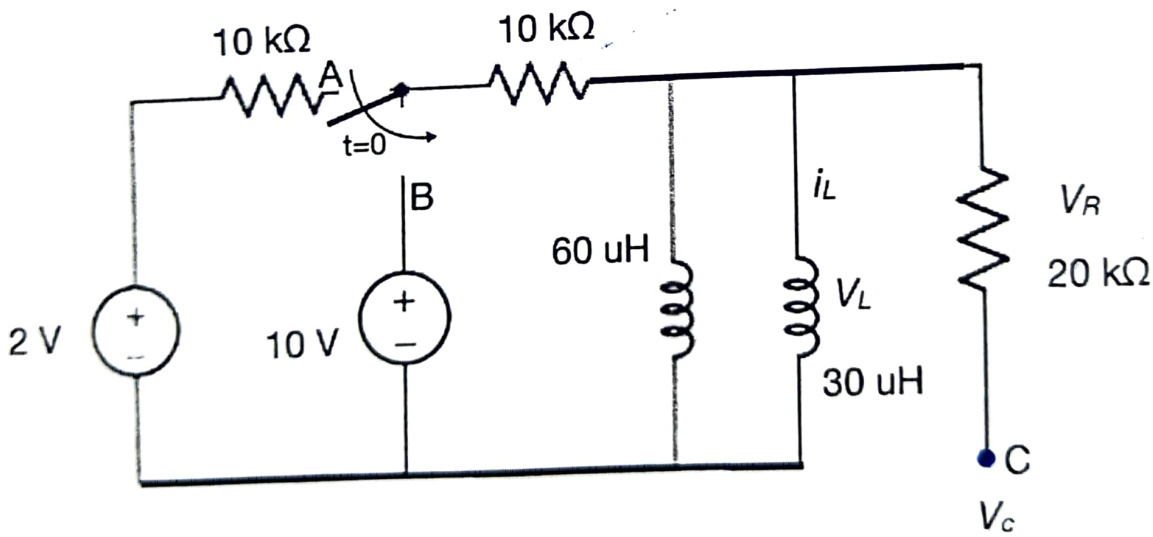


Figure 1 (Problem 1)

2

(A) What are three different types of responses that you are expect from RLC circuit stimulated with a DC voltage or current ? What are the main characteristics of each response type & under what conditions is each observed ? [8 points]

(B) For figure 2, Find capacitor voltage for t<0 and t>0. [8 points]

(C) For what value of C will get a response of other two type [4 points].

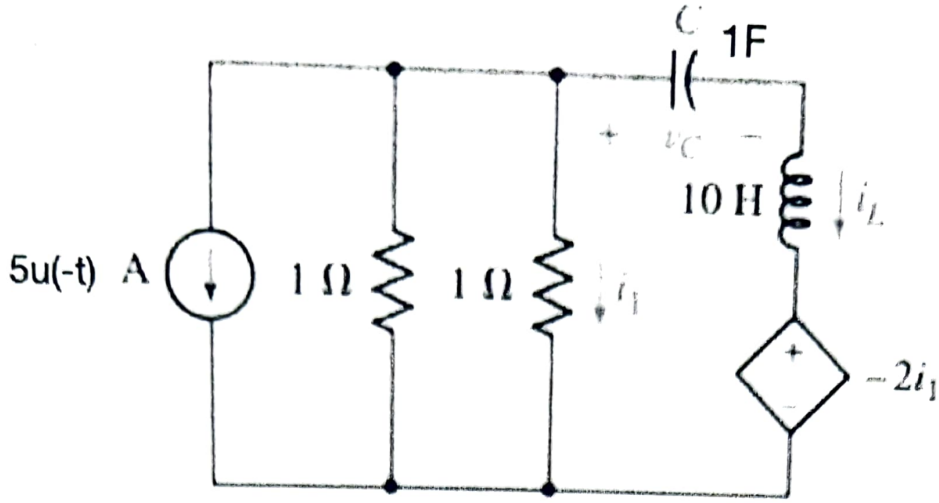


Figure 2
(Problem 2B)

3

(A) For an RC series circuit connected to an AC voltage source $V_m \cos \omega t$, derive the capacitor steady state voltage. Convert voltage to complex/ phasor, write the differential equation, apply solution and compare. Which two parameters have changed ? [8]

(B) For inductor, will current lead or lag? Show. How about for capacitor? [4]

(C) Find the voltage across the capacitor and inductor in the circuit in figure 3. Choose any appropriate method. Give each step clearly. Calculate the power supplied by the source. [8]

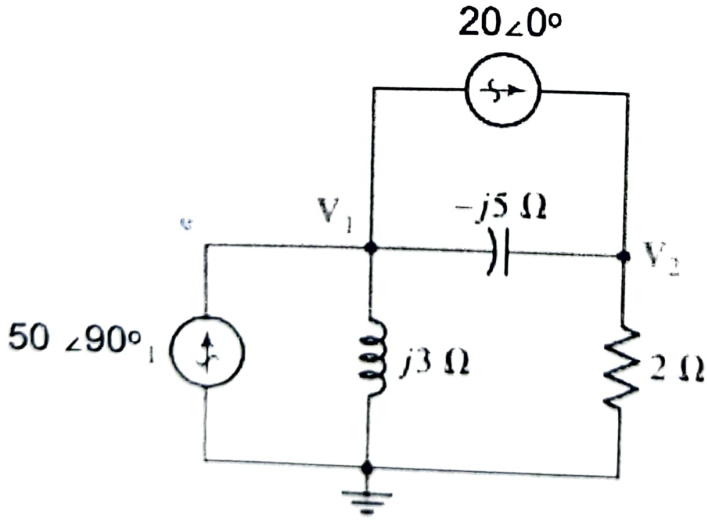


Figure 3
(Problem 3C)

4.

(A) What is meaning of RMS value, effective value, apparent power & Power factor. [5]

(B) Load of 1.5+j2 is supplied power from 60 V power supply. What is the power take up by the load? What will be the change in PF if the load doubles? Suggest a simple way to make the power factor =0. 85 [3]