

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

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

- (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

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

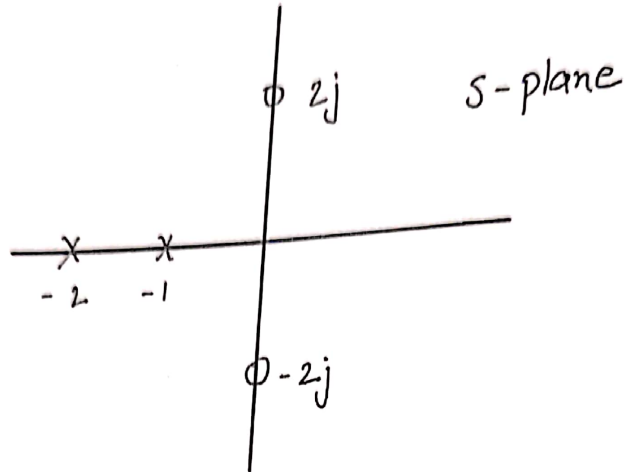
- (a) [2] If the input signal has even symmetry, show that the output signal has odd symmetry.
  - (b) [4] Investigate whether this system is an LTI system.
4. [6 marks] It is known that convolution of the signals  $x_1(t)$ ,  $x_2(t)$ , and  $x_3(t)$  is given by the signal  $y(t) = x_1(t) * x_2(t) * x_3(t)$ . 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  $a$ .

$x(at)$

$$Y'(s) = X_1(s) \cdot X_2(s) \cdot X_3(s)$$

$$1 = \frac{1}{a^3} \cdot Y(as)$$

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



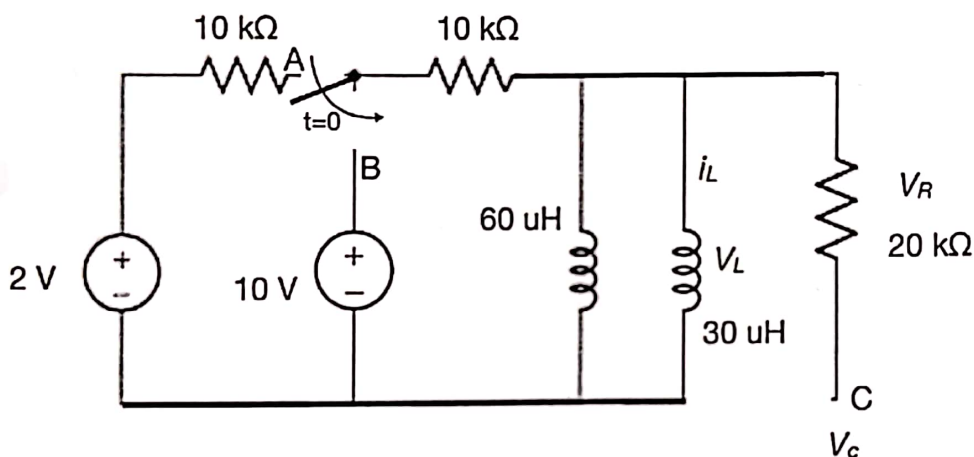
- [2] If the transfer function is known to be of the rational form, write down its expression.
- [2] How many distinct systems can have the above transfer function? Identify their ROC.
- [3] For each system, comment on their stability and causality. Justify.
- [3] It is observed that if  $\sin(\alpha t)$  is given as input to the causal system with above transfer function, the output is 0. Find  $\alpha$ .

## 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 result 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]



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].

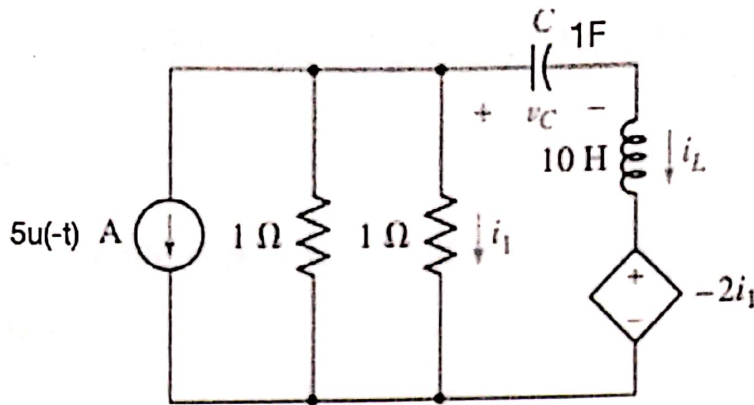


Figure 2  
(Problem 2B)



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]

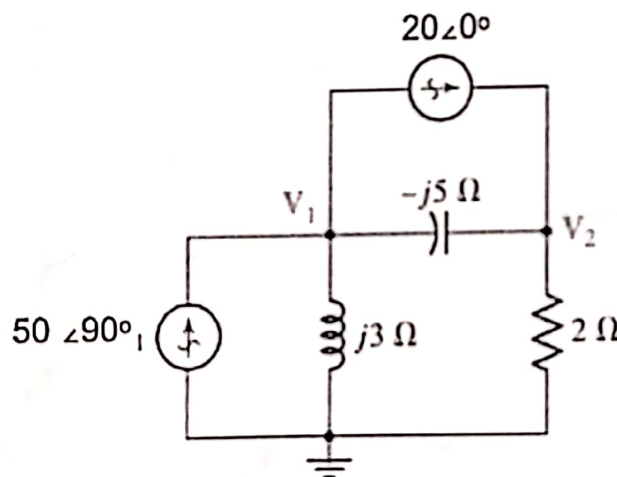


Figure 3  
(Problem 3C)

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]