EE53053 – Signals, Systems and Signal Processing
Assignment 2 (30% of the overall course grade)
Release: 07/11/2022. Due: 11/11/2022 before 2359 hours

- This assignment is worth 30% of your overall course grade.
- Use the MS WORD equivalent of justified text format, single-line spacing, 12 pt Calibri font and 2 cm margin all over.
- Solutions must not exceed 15 A4 sides excluding the Appendix.
- Submit typed answers. Handwritten / scanned solutions will not be graded.
- For full credit, show all the intermediate steps and relevant work. Only reporting the answers will result in an automatic penalty of 80% of the overall grade.
- Include the full, well-commented code for each of the three problems in the Appendix under headings: Code for Problem 1, Code for Problem 2 and Code for Problem 3. Do not embed pieces of code in the main document.
- Generate all figures using code (no hand-drawn plots). Use appropriate legends and labels for each figure. Size figures consistently.
- A single PDF file must be uploaded on MyAberdeen via the relevant link. The file should be named FirstNameInitialLastName_sub2.pdf. Thus, John Doe's submission will be JDoe_sub2.pdf.

Problem 1: Consider the circuit given in Figure Q1 with zero initial conditions.

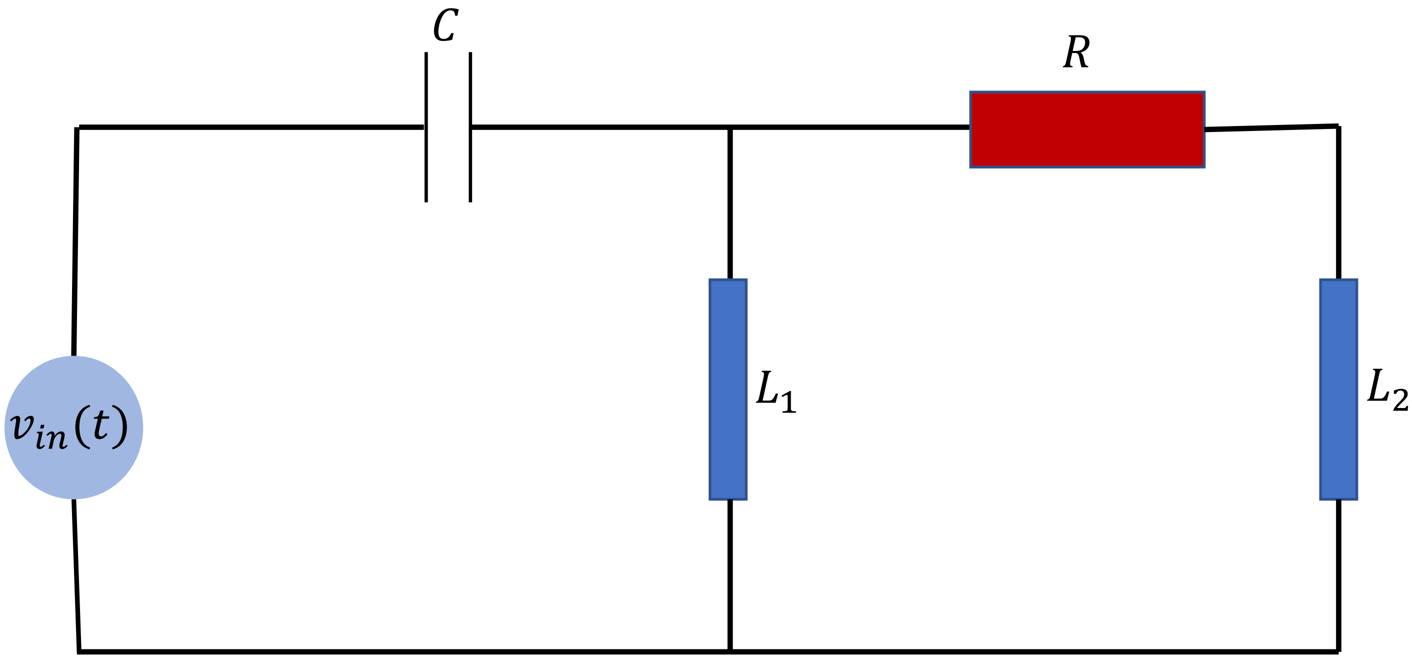

Figure Q1

i. Derive the parametric transfer-function of this circuit that relates input $v_{in}(t)$ and current flowing through the resistance R.

ii. If the circuit parameters are as follows:
- $R = 80\ \Omega$
- $C = 280 \times 10^{-5}\ F$
- $L_1 = 0.01\ H$
- $L_2 = 0.02\ H$

Determine the poles and zeros of the system and state if the system if stable and minimum phase. Plot the pole-zero plot of the system ➔ **Figure 1. ii.**

iii. If $v_{in}(t)$ is a unit step, use the Final Value theorem to determine the steady-state current $i_R(t)$, flowing through the resistor R. Plot the current flowing through the resistor for time $[0, 5]$ s to confirm ➔ **Figure 1. iii.**

iv. It is claimed that if $v_{in}(t) = \sin(60\pi t)$, the resulting current flowing through the resistor will be $i_R(t) = 0.5107 \sin(60\pi t + 1.7836)$. Confirm if this is true and explain why / why not, using any analysis you think appropriate and relevant time- and frequency-domain plots ➔ **Figures 1. iv. a** and **1. iv. b.**

[10 marks each = 40 marks total]

Problem 2: A continuous-time system has the following transfer-function:

$$H(s) = \frac{\gamma}{s^2 + \alpha s + \beta}$$

where γ, α and β are system parameters.

i. Derive the difference equation that captures the dynamics of this system when sampled at T seconds.

ii. Derive the parametric transfer function of the difference equation you obtained in Problem 2. i. and compute the equivalent numeric transfer functions if the system parameters are: $\gamma = 100$, $\alpha = 0.2$ and $\beta = 100$; for:
   a. $T = 0.01$ s → H_1
   b. $T = 0.001$ s → H_2
   c. $T = 0.0001$ s → H_3

iii. Superimpose the Magnitude Response plots for $H(s)$, H_1, H_2 and H_3 on the same plot between [0.1 Hz, 100 kHz] with a resolution of 0.1 Hz and comment on the similarities, differences, and any other aspects giving clear reasons for each ➔ **Figure 2. iii**.

iv. Derive the impulse response expression for H_3 and compute the values explicitly for $n = [1001,\ 10001,\ 50001,\ 100001,\ 600001]$. Show how well these values match with the impulse response of $H(s)$ by plotting both the impulse responses ➔ **Figure 2. iv**.

[10 marks each = 40 marks total]

Problem 3: Write a well-commented code and generate:

i. A discrete-time version of the continuous-time signal

$$x(t) = 2\sin(20\pi t) + 1.5\sin(2000\pi t) - 3\cos(5000\pi t)$$

sampled at 20 kHz, for a duration of 1 second.

ii. Design of a system transfer function $H(s)$, that reduces the power of the highest frequency component in the signal $x(t)$, by exactly 50%. Explain your design with relevant reasoning.

iii. A Bode plot of the designed system transfer function for up to two decades beyond the highest frequency component in $x(t)$, with dB, Hz, and degree units for relevant quantities / axes ➔**Figure 3. iii**.

iv. Time and Frequency-domain plots of the signal/s to demonstrate that your system performs as expected ➔ **Figure 3. iv. a,** and **3. iv. b.**

[5 marks each = 20 marks total]

Good Luck!

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