

**EE53053 – Signals, Systems and Signal Processing**  
**Assignment 2 (30% of the overall course grade)**  
**Due 22/11/2021 before 12 noon**

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- 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 MATLAB 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 MATLAB. Use appropriate legends and labels for each figure. To ensure that the figures are sized properly, follow the procedure given below:
    - On the figure window go → File → Export Setup. Then set:
      - Size = 14 (width), 12 (height), units centimetres. And tick Expand axes to fill figure.
      - Fonts → Use fixed font size → 12, Custom name → Times New Roman
      - Lines → Use fixed line width → 1.5
    - Then hit Apply to Figure
    - Then Export and save as .fig file.
    - Then insert this figure (not the file) into your WORD doc. Once included in the Word document, do not resize. If you are using LaTeX, export as eps or pdf and then include in your document.
  - Attach a signed Plagiarism Sheet with your submission. Failing to do so or adhere to plagiarism rules as set by the University will lead to appropriate penalties.
  - 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.
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**Problem 1:** Consider an RLC circuit whose differential equation from voltage input to charge output can be written as:  $\ddot{y}(t) + 10\dot{y}(t) + 1500y(t) = 1000x(t)$ . Provide a well-commented MATLAB code and complete the following tasks:

- i. Generate a Bode plot of the system from 1 Hz to 100 Hz with a resolution of 0.1 Hz. Magnitude responses are plotted in dB vs Hz and Phase responses in degrees vs Hz. Clearly annotate the resonant frequency on the magnitude response plot and the phase at this frequency in the phase response plot using MATLAB Data tips → **Figure 1.i**.
- ii. Compute the poles and zeros of this system by computing the appropriate roots and plot the Pole-Zero Map of the system in MATLAB to verify → **Figure 1.ii**.
- iii. If this circuit is given the following inputs:
  - a. 1 V step at 1 second for a period of 9 seconds (subfigure 1.iii.a)
  - b. 10 rad/s,  $2 V_{pk-pk}$  sine wave input for 10 seconds (subfigure 1.iii.b)
  - c. 38.4 rad/s,  $2 V_{pk-pk}$  sine wave input for 10 seconds (subfigure 1.iii.c)
  - d. 100 rad/s,  $2 V_{pk-pk}$  sine wave input for 10 seconds (subfigure 1.iii.d)
 Plot the four input-output pairs in the same figure → **Figure 1.iii**. Explain the output obtained based on the system's frequency response.
- iv. Briefly explain what you see in the figures and how it aligns with the underlying theory. Finally, comment on what you learned via this exercise.

**[10 marks each = 40 marks total]**

**Problem 2:** Write a well-commented MATLAB code to generate:

- i. A discrete-time version of the continuous-time signal
 
$$x(t) = 2 \sin(50\pi t) + 1.5 \sin(2500\pi t) - 3 \cos(6000\pi t)$$
 sampled at 20 kHz, for a duration of 1 second. Call it  $x[n]$ .
- ii. A plot of the signal for two full periods → **Figure 2.ii**.
- iii. A plot of the amplitude spectrum of the signal (dB vs Hz) → **Figure 2.iii**.
- iv. The design of a Butterworth filter that:
  - a. Reduces the amplitude of the 3 kHz component in  $x(t)$  by at least 50 dB. while not reducing the amplitude of the 1.25 kHz component by more than 2 dB.
  - b. Plot the magnitude response of the designed filter clearly showing the design parameters → **Figure 2.iv.c**
  - c. Plot the pole-zero map of the designed filter → **Figure 2.iv.d**
  - d. Give details of your filter (order, poles, zeros, stability etc)
- v. A plot that superimposes the amplitude spectrum of the filtered signal (name it  $x_f(t)$  or  $x_f[n]$ ), over the one plotted in **Figure 2.iii**
- vi. From everything done in Problem 2 (i – v), derive the mathematical expression for the filtered signal ( $x_f(t)$  or  $x_f[n]$ ) as a combination of sine waves with appropriate amplitudes and phases.

**[10 marks each = 60 marks total]**

**Built-in MATLAB functions / commands that you might find useful:**

abs, real, imag, filt, lsim, filter, tf, tfdata, freqresp, fft, c2d, bode, bodeplot, pole, zero, pzmap, axis, xlabel, ylabel, legend, figure, subplot, log10, max, min, grid, sin, cos, step, impulse, linspace.

**Good Luck!**

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