AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
i-CREDIT HOURS ENGINEERING PROGRAMS
COMPUTER ENGINEERING AND SOFTWARE SYSTEMS PROGRAM

ECE 251 : Signals and Systems Fundamentals
Course Project Description
Fall 2024

1 Objectives:

- Become familiar with Matlab / GNU-Octave.
- Use Matlab / GNU-Octave to deal with signals in time and frequency domain.
- Use Matlab / GNU-Octave to design Butterworth band-pass filters.

2 Steps:

1. (4%) Generate the signal $x(t)$ defined as follows:

$$x(t) = \cos(2\pi f_1 t) + \cos(2\pi f_2 t) + \cos(2\pi f_3 t) + \cos(2\pi f_4 t)$$

where $f_1 = 500$ Hz, $f_2 = 1000$ Hz, $f_3 = 1500$ Hz, and $f_4 = 2000$ Hz.

2. (4%) Store the generated signal $x(t)$ as an audio file with extension (*.wav)
3. (4%) Plot the signal $x(t)$ versus time t.
4. (4%) Compute the energy of the signal $x(t)$.
5. (4%) Compute the frequency spectrum $X(f)$ of this signal.
6. (4%) Plot the magnitude of $X(f)$ in the frequency range $-f_s/2 \leqslant f \leqslant f_s/2$, where f_s is the sampling frequency.
7. (4%) Compute the Energy of the signal $x(t)$ from its frequency spectrum $X(f)$, and hence you can verify Parseval's theorem.
8. (4%) Design a Butterworth low-pass filter with filter order 20 and cut-off frequency of 1.25 kHz.
9. (4%) Plot the magnitude and phase response of the Butterworth LPF you've designed.
10. (4%) Apply the signal $x(t)$ to this Butterworth LPF and let's denote the output signal as $y_1(t)$.
11. (4%) Store the generated signal $y_1(t)$ as an audio file with extension (*.wav)
12. (4%) Plot the signal $y_1(t)$ versus time t.
13. (4%) Compute the energy of the signal $y_1(t)$.
14. (4%) Compute the frequency spectrum $Y_1(f)$ of this signal.
15. (4%) Plot the magnitude of $Y_1(f)$ in the frequency range $-f_s/2 \leqslant f \leqslant f_s/2$.

16. (4%) Compute the Energy of the signal $y_1(t)$ from its frequency spectrum $Y_1(f)$, and hence you can verify Parseval's theorem.
17. (4%) Design a Butterworth high-pass filter with filter order 20 and cut-off frequency of 1.25 kHz.
18. (4%) Plot the magnitude and phase response of the Butterworth HPF you've designed.
19. (4%) Apply the signal $x(t)$ to this Butterworth HPF and let's denote the output signal as $y_2(t)$.
20. (4%) Store the generated signal $y_2(t)$ as an audio file with extension (*.wav)
21. (4%) Plot the signal $y_2(t)$ versus time t.
22. (4%) Compute the energy of the signal $y_2(t)$.
23. (4%) Compute the frequency spectrum $Y_2(f)$ of this signal.
24. (4%) Plot the magnitude of $Y_2(f)$ in the frequency range $-f_s/2 \leqslant f \leqslant f_s/2$.
25. (4%) Compute the Energy of the signal $y_2(t)$ from its frequency spectrum $Y_2(f)$, and hence you can verify Parseval's theorem.

3 Useful Matlab / GNU-Octave Commands:

1. buttord, butter
2. zp2sos, sosfilt
3. freqz
4. fft, fftshift
5. audioread, audiowrite

1. Each **group of 4/5 students** should work together and submit one report.
2. Please prepare one compressed file that includes the following items:
   (a) Your Matlab / GNU-Octave codes (*.m files).
   (b) A report (pdf files Only) that includes your output waveform, the energy values to be computed, plots of the filtered signal, etc.
   (c) In your report make sure to clearly indicate the contribution of each member of the group.
   (d) The audio files generated by your code.
3. Project will be submitted via the course page on LMS on before 11 : 59 PM on December 27^{th} 2024.

Good Luck