ECE 251 : Signals & Systems
Matlab / GNU-Octave Project
(5 Marks)

Spring 2019

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 low-pass and high-pass filters.

2 Steps:

Use Matlab / GNU-Octave to perform the following steps:

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

19. Apply the signal $x(t)$ to this Butterworth HPF and let's denote the output signal as $y_2(t)$.
20. Store the generated signal $y_2(t)$ as an audio file with extension (*.wav)
21. Plot the signal $y_2(t)$ versus time t.
22. Compute the energy of the signal $y_2(t)$.
23. Compute the frequency spectrum $Y_2(f)$ of this signal.
24. Plot the magnitude of $Y_2(f)$ in the frequency range $-f_s/2 \leqslant f \leqslant f_s/2$.
25. 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. freqz
2. filter
3. butter
4. fft, fftshift
5. audioread, audiowrite

4 Notes:

1. Each **group of 5 students** should work together and submit one report **before the Midnight of June 24th, 2019**.
2. Please prepare one compressed file that includes the following items:
   (a) Your Matlab / GNU-Octave codes (*.m files).
   (b) A report (word or pdf file) that includes your output waveform, the energy values to be computed, etc.
   (c) The audio files generated by your code.
3. Please send the compressed file to the following email address `signals.systems2019@gmail.com`
4. The email subject line should be: "Spring 2019 - ECE 251 - Matlab Project".

Good Luck