E1314 - Communications Systems – I
Course Project (Spring 2025)

Instructions:

- **The deadline (no extensions) of project delivery is: Tue. May 20'th, 2025 at 11:59 pm.**
- You must work **individually on this project**. You will be asked separately about the code and results.
- You may seek help on this assignment from the TA or course instructor. You may not consult anyone else, including other classmates. Any code copying, downloading code snippets from the Internet, or other academic integrity violations will result in a grade of zero on the project and, most likely, further disciplinary action.

Part I:

1- Using Matlab, record a short voice segment on your PC, between 5 and 10 seconds. Use a sampling frequency of 48 ksps.

2- Obtain the signal spectrum

3- Plot the signal in the time and frequency domains.

4- Filter the recorded signal to suppress energy beyond 3.4 kHz. Plot the signal in time and frequency domain. Playback the signal and see if you can tell the difference.

5- Try smaller cutoff frequencies and report the cutoff frequency after which the signal becomes unintelligible.

6- Now record a segment of speech where you pronounce the sounds: f, s, b, d, n, and m in isolation. Repeat steps 4 and 5 above and see if you can distinguish the fricatives (f,s), the plosives or stops: (b,d), and the nasals: (n,m) at the different cut-off frequencies. Report your results.

7- Use the bandlimited signal to modulate a 48 KHz carrier using DSB-LC modulation with a modulation index of 0.8. Plot the modulated signal and its spectrum.

8- Use an envelope detector or rectifier detector to recover the message. Playback the demodulated signal.

9- You will note that the recovered signal is of a lower amplitude than the recorded signal. Compute the energy of the recorded and demodulated signals. Then multiply the demodulated signal by an appropriate factor so that it has the same energy as the recorded signal. Make sure to remove any DC component in the demodulated signal before scaling.

10- Plot the demodulated signal in both domains.

Part II:

1- Use the bandlimited signal from part I to modulate a 48 KHz carrier using DSB-SC modulation. Plot the modulated signal and its spectrum.

2- Use the coherent detector to recover the message. Playback the recovered signal.

3- Plot the demodulated signal in both domains.

4- Now, add several values of frequency offset to the Rx LO. Playback the recovered signal using the different frequency offsets and report your observation.

5- Using the same bandlimited message signal from Part I, apply SSB-SC modulation instead of DSB-SC. Plot the modulated signal in both domains. You may use hilbert().
6- Demodulate the signal coherently. Playback the recovered signal.
7- Plot the demodulated signal in both domains.
8- Add several values of frequency offset to the Rx LO. Playback the recovered signal using the different frequency offsets and report your observation.

<u>Part III:</u>

1- Using the bandlimited message signal from Part I, apply FM modulation using a 48 KHz carrier. Use a deviation ratio β of 3 and 5. Plot the modulated signal and its spectrum for both cases.
2- Use the direct method to recover the message. Playback the recovered signal.
3- Now, generate an FM signal for a sinusoidal tone at 3 kHz.
4- Plot the modulated signal and its spectrum for various values of beta.

<u>Part IV:</u>

It examines the performance of FM in noise.

1- Add Gaussian noise to the FM signal of part III. Experiment with different noise levels. Report on whether you can tell the difference in output SNR, i.e. signal quality, for the two values of β.
2- Increase the deviation ratio, without changing the baseband SNR, until the FM demodulation breaks down. This is known as the threshold effect. Report the value of β at which this occurs.

General Hints:

- For the modulated signals, you will need to upsample the message signal. You may use the function interp1().
- For lowpass filtering, you may use fir1(),filter(),butter(), or the filter design toolbox.
- For integration, you may use cumsum(), and for differentiation you may use diff().
- For the time-domain plots of modulated signals, you may plot a segment of the signal for more clarity.
- For obtaining the spectrum, use fft() and fftshift().

Deliverables and Guidelines:

1. Mark your plots clearly. Include **axis labels**, **title**, legend,… etc.
2. For each part, all time domain signals should be plotted in the same figure, and all frequency domain signals should be plotted in a separate figure. Use subplot (). Hence, the output from your Matlab code is two figures for each part. Make the zero-frequency in the middle of the spectrum plot.
3. Comment your code reasonably.
4. Hand in a **HARD COPY REPORT** including all the above points (1-3) of your program listing, plots(s) and comments.
5. Deliver a **SOFT COPY** of your program and any needed files to run it (all zipped together) with comments about these needed files. This should be sent to the TA e-mail. The subject of the e-mail should be: E1314 Project-*partnumber – your name*.