Complex Amplitude Modulation: Exercises

DSP Lab (ECE-UY 4163 / ECE-GY 6183)

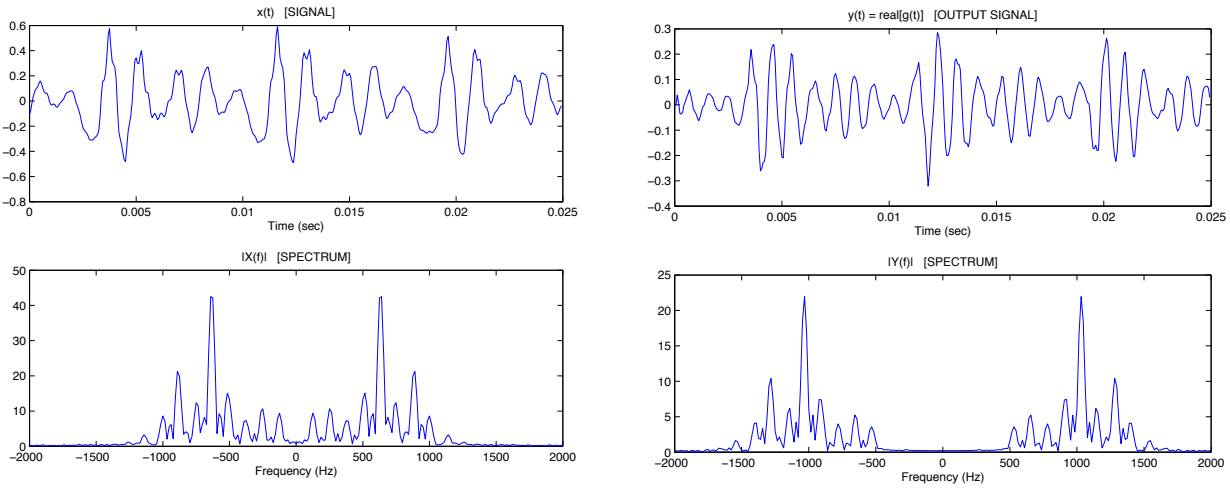
2023

In a previous exercise we implemented the amplitude modulation (AM) affect for real-time speech modification. This method computes the output signal as

$$y(t) = x(t)\,\cos(2\pi f_1 t). \tag{1}$$

In the AM effect, each frequency in the input signal is shifted to two different frequencies in the output signal. This leads the spectrum of the signal to overlap itself.

To shift the frequencies in a signal to higher frequencies, without leading to spectral overlap, we can use a complex form of amplitude modulation. The complex AM effect is illustrated in the figure below. This effect is implemented in the provided Matlab programs, but the provided programs do not implement it for real-time processing.



Exercises

1. Run the Matlab program for the complex AM effect using a recording of your own speech as the input signal.

2. Implement the complex AM effect using Python and Pyaudio. For the input signal use the same wave file as in the provided Matlab programs. Verify that your Python program produces the same output signal as the Matlab program does.

3. Implement the complex AM effect in Python with PyAudio. Your program should take the microphone signal as input and produce an output audio signal (on speakers or headphones). Compare the sound

with real-valued AM in equation (1) which was implemented earlier in the course. To avoid feedback and to hear the signals clearly, it is recommended to use headphones or earbuds.

4. Implement the complex AM effect in Python with PyAudio. Your program should acquire the microphone signal as the input signal. Your program should play the output signal to the output audio device (e.g., headphones) in real time (at the same time as the input signal). Simultaneously, your program should plot the input and output signals, and their Fourier transforms, using the animate and FFT functions (in Matplotlib and Numpy). To avoid feedback and to hear the signals clearly, you should use headphones or earbuds. SUBMIT

   Prepare a screen recording (as an MP4 file) of the figure window showing the real-time plots. The audio track of your screen recording should be only the output speech signal (not the input signal). In your screen recording, you should say sentences in your own voice. The effect of the AM effect should be clear in the screen recording. An example screen recording is provided.

   To submit:

   (a) A brief screen recording (an mp4 file, not larger than 8 MB).

   (b) Submit your python program as a py file.

   (c) Comments in a pdf file. Your comment file should include a screenshot of your figure window illustrating the AM effect.