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% ECE 313 Linear Systems & Signals - Prof. Brian L. Evans
% Fall 2026 Tuneup #7

% Copy this file into a Matlab script window, add your code and answers
% to the questions as Matlab comments, hit "Publish", and upload the
% resulting PDF file to this page for the tune-up assignment.  Please do
% not submit a link to a file but instead upload the file
% itself.   Late penalty: 2 points per minute late.

% Audio sampling rate
fs = 8000;
Ts = 1 / fs;

% Signal duration
tmax = 3;
t = 0 : Ts : tmax;

% Spectrogram parameters
blockSize = 1024;
overlap = blockSize/2;

% Generate a chirp signal over the fourth octave
% on the Western scale (260 to 520 Hz).  This is
% the baseband signal.
f0 = 260;
fmax = 520;
fstep = (fmax-f0)/tmax;
angle = 2*pi*f0*t + pi*fstep*t.^2;
y = cos(angle);

% (a) Modulate using a sinusoidal signal at 1040 Hz
fc = 1040;
ymod = y .* cos(2*pi*fc*t);

% (b) Demodulate back to baseband
%     Step 1 - Modulate using the same carrier freq.
ymodmod = ymod .* cos(2*pi*fc*t);
% QUESTION: What do you hear?
% ANSWER: I hear two chirps.  One is increasing in frequency
% vs. time and other is decreasing in frequency vs. time.

%     Step 2 - Lowpass filter to remove high frequency
%              components centered at +/- 2 fc
%
% QUESTION: What's the maximum length for the FIR
% averaging filter you can use to pass the fourth
% octave frequencies 260 to 520 Hz? Use this value
% for FIRlength.
% ANSWER: From the handout on designing averaging
% FIR filters, https://tinyurl.com/2kebt29a,
% FIRLength = fs / fpass = 8000 Hz / 520 Hz
% rounded down to an integer, which gives 15.
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%
% Multiply the baseband signal by 2 to compensate for
% the loss of a factor of 2 due to modulating twice.
fpass = 520;
FIRlength = floor(fs/fpass);
averageFilterCoeffs = ones(1, FIRlength)/FIRlength;
ybaseband = filter(averageFilterCoeffs, 1, ymodmod);
ybaseband = 2 * ybaseband;
% QUESTION: What do you hear?
% ANSWER: I hear two chirps. The lower-frequency chirp is
% increasing in frequency vs. time (the message signal) and
% the higher-frequency chirp is decreasing in frequency vs.
% time (not the message signal but a high-frequency replica
% of the negative frequencies in the message signal that
% were attenuated by the lowpass filter).

% Plot spectrogram and playback each signal
figure;
spectrogram(y, blockSize, overlap, blockSize, fs, "yaxis", "centered");
title('Spectrogram for baseband signal');
sound(y, fs);
pause(tmax+1);

figure;
spectrogram(ymod, blockSize, overlap, blockSize, fs, "yaxis", "centered");
title('Spectrogram for modulated signal');
sound(ymod, fs);
pause(tmax+1);

figure;
spectrogram(ymodmod, blockSize, overlap, blockSize, fs, "yaxis", "centered");
title('Spectrogram for baseband signal modulated twice');
sound(ymodmod, fs);
pause(tmax+1);

figure;
spectrogram(ybaseband, blockSize, overlap, blockSize, fs, "yaxis",
"centered");
title('Spectrogram for recovered baseband signal');
sound(ybaseband, fs);
pause(tmax+1);
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