Lab 3 – instantaneous spectrum

1. Simulate a 400 sample signal containing 200 samples of a sinusoid with $\theta_1 = 0.24\pi$ (for $n = 0 \ldots 199$) and 200 samples of a sinusoid with $\theta_2 = 0.72\pi$ (for $n = 200 \ldots 399$).

   (a) Plot the signal. Plot its amplitude spectrum (with boxcar window) using log scale, limit the plot at -40 dB.

   (b) Plot the amplitude spectrum computed with Hamming window. Can you tell anything about the properties of signal vs. time from this spectrum?

   (c) Compute FFT with sliding window:
   `[X,f,n] = swifft(x,g,n, 'noplot'); % compute...`
   `swifft(x,g,n,X); % display...` where

   n - vector of window starting points (`1:400`); don't use more than 500 points if you want to display a movie

   g - a window (`hamming(100)`)

   x - the signal

   f - frequency vector for plotting

   X - table of instantaneous spectra

   Press space to see the movie.

   (d) Display a 3-D plot of instantaneous spectra X (compute them with `n=1:10:400`)
   `mesh(abs(X))` or `mesh(20*log10(abs(X)))`
   Identify the frequency and time axes, understand how they are scaled.

   (e) Plot the spectrogram `spectrogram(X,f,n)`, computed with `n=1:400`. Note the transitions between segments with different frequencies.

2. Repeat 1c and 1e for shorter window. Note the differences.

3. Plot the spectrogram of an LFM (linear frequency modulation) signal from the generator: pull the "sweep width" handle to switch the modulation on, see the signal on the oscilloscope, choose the frequencies and sweep width to obtain a nice plot of $N = 1024$ samples; for gathering the data use `y=getdata(N,1,Ts)` command. (Hint: set "width" about 3 o'clock, "speed" about 10 o'clock).

4. Experiment to see the properties of different window lengths (at least 2) and window types (2-4, maybe including Kaiser with different β). Sketch some results, describe all. Try to understand signal components visible on the spectrogram.

5. *Repeat the two previous experiments with modulated triangle wave. (sketch only the most important picture)*

6. Plot the spectrogram of a voice signal from the microphone: use the preamplifier (middle row on an A/D input card; adjust the amplification with a red switch and black knob to have A/D input inside ±5V range), gather 8000 samples, think before choosing f_s. Try to see some features of different sounds. Try to match a good window to signal properties.

7. *Plot the result of filtering an item 1 signal with a lowpass filter with pre-modulation:* ***`stft_lp(signal,window,frequency)`*** *choose filter frequency equal to center frequency of an FFT bin with or without the sine component; compare the result to a section of a spectrogram. Find the stft_lp.m definition file, try to understand its inner working.*

Note: `swifft` is not a standard Matlab function. It has been written for this lab.

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