EE218: LINEAR SYSTEMS II LABORATORY
Missouri University of Science & Technology

LAB 4: SPECTRUM OF VOICE AND DATA SIGNALS

Aim: In this lab you will investigate the time-domain signal and frequency domain spectrums of voice and data signals.

Required Background:

- Sampling theorem.
- Spectrum of periodic and a-periodic power signals.
- Digital logic, binary operations.

Introduction: In the previous labs you looked at the spectrum of periodic signals and white noise. Now we are going to look at signals that are a little more typical in signal processing and communications problems. The first few items below have you investigating the spectrum of a voice signal (in particular, your voice), and the next set of questions is for a digital data signal that may be produced by a computer, cell phone, and similar devices.

Procedure:

Part I:

1. Connect a microphone to the mic input of the sound card in the PC. Have one person sing into the microphone. It is best if this singing is kept very simple, such as a single vowel sound like aaaaaaaaah, ooooooooo, eeeeeeeeeeee. Record these sounds, and determine the fundamental frequency of the person’s voice.

2. How many significant harmonics can you see in the person’s voice signal recorded above?

3. Which sound produces the fewest harmonics? What sound produces the most harmonics?

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4. Can you make sounds that are not periodic? If so, what sounds are they and what do their spectra look like?

5. What is the highest and lowest fundamental frequencies each person in your lab group can generate?

6. The fundamental frequency of a person's voice will change as they speak. If you want to measure the frequency of their voice during normal conversation, you will need to do so using as short a sample of their speech as possible. How many msec of data do you typically need to reliably determine the frequency of their voice?

7. Find a segment of a .wav file that has a single instrument playing a single note. Determine the fundamental frequency and the number of significant harmonics in the signal.

Part II:

8. Build a 15 bit circular shift register which you can load with random data of your choice, then set it to loop through the data continuously. To do this, you may wish to use some TTL logic chips, such as 74LS164, 8-bit, serial in / parallel out shift registers. Obtain a couple of these chips from the lab TA, and build up the shift register on a prototype board. Use a lab oscillator to clock the shift register, so you can easily change the clock frequency. When laying out the circuit, make it easy to change the initial 16 bits you program into the shift register. Verify your shift register is working properly by loading it with the pattern 1111 0000 1010 1010 and slowly shifting it out. Look at the output signal on an oscilloscope, and verify the pattern is correct.

9. Load the shift register with the pattern 1111 0000 1111 0000 and clock the circular shift register at 3kHz. Look at the signal on a spectrum analyzer. Verify the harmonics are at the right frequency and have the correct amplitude.

10. Load the shift register with the pattern 0101 0011 0111 0110 and clock it out at 3 kHz. Verify the harmonics are at the correct amplitudes and frequencies. It will be a bit tedious to calculate the harmonics by hand, so you may wish to generate this signal in Matlab and use the FFT routine to calculate the theoretical amplitudes.

11. Suppose someone put an unknown pattern into the shift register, and only allowed you to look at the output signal as it is displayed on a spectrum analyzer. Could you determine anything about the clock frequency or the data pattern?

For Your Report:

- Parts 1-5: To answer most of these questions you will have to plot the amplitude spectrum of your recordings. You don't have to include the amplitude spectrum of EVERY recording (this would be a lot of plots) but do include enough plots and description to make it clear how you used the plots to answer the questions.

- Parts 6: To answer this question grab a "segment" of recorded speech and see how short the segment has to be before it looks like a single frequency. Repeat this process for several segments to see what the average length should be.

- Part 7: Include the time domain plot and amplitude spectrum of your WAV file.

- Part 8-10: The most important item to include for your report is a comparison of the measured amplitude spectrum and the theoretical amplitude spectrum. With plot the two amplitude spectrums in the same figure to show that they match, or use percent difference calculations. The easiest way to get the theoretical amplitude spectrum is to simulate the data sequences in Matlab.