Physics 15c Fall 1992 Laboratory 2

FOURIER SERIES AND FOURIER TRANSFORM LAB

There are three parts to this lab. Do the first one first and either of the other two second and the remaining one third.

1. Make wave forms using sine waves. Derive the fourier coefficients of a periodic square wave, triangular wave and delta function or sharp pulse. Then construct this waveform using the box of sine waves provided. Use the oscilloscope to check the results. You can construct other waveforms that you might think of.
Do you know what is in the box which you are using?
Do you know how you might make a function generator in general?

2. Frequency analyser . Use a function generator and the frequency analyser to analyse the square, and triangular waveforms. Does this agree with what you found in part 1. The Fourier spectrum can be viewed using the linear or logarithmic scale. Check t his out. What is the definition of decibels and why do we use it to describe sounds for instance.

3. Use a FAST FOURIER TRANSFORM chip to process function generator waveforms and human sounds. There is an amplifier you can use to digitise sounds. The computer displays for you both the input signal and the Fourier transform. See the attached sheet of intsructions. Compare the signals on the oscilloscope with the computer. Does the computer digitiser work perfectly? Vary the sampling rate and see what happens to the signal. Look at the Fourier spectrum of various wave forms and sounds. You can record sounds and transfer them to floop disk and look at them on another setup in the lab. Can you see the effect of aliasing??

DIGITIZATION AND FOURIER ANALYSIS LAB

This lab consists of two parts. First we will digitally record (digitize) sound and other waveforms. Then we will analyze the frequency content of these waveforms (Fourier analysis).

1. Digitization

We will use a microphone and an amplifier to convert sound waves into a varying voltage. A circuit called an analog-to-digital converter measures this voltage and converts it into a number which the computer stores in its memory. This process is called "sampling." The sampling rate specifies how many samples are taken per second, and is usually specified in kilohertz. A CD player, for example, uses a sampling rate of 44.1 kHz, or 44,100 samples per second.

There are two considerations when deciding what sampling rate to use. If the sampling rate is too high, our storage medium will fill up too quickly. However, if the sampling rate is too low a form of distortion called "aliasing" occurs. In fact, the sampling rate must be *at least twice the highest frequency* we wish to record. Any frequency greater than half the sampling rate shows up as a lower, aliased frequency. For example, if the input frequency is between half the sampling rate and the sampling rate, then upon playback we will hear an "alias" signal at the frequency given by the following formula:

$$\text{alias frequency} = \text{sampling rate} - \text{input frequency} .$$

2. Fourier Analysis

The principle of Fourier Analysis is that any waveform is made up of pure tones (sine waves) of various frequencies and amplitudes. You can use the FFT SPECTROGRAM desk accessory (found under the Atari symbol at the top left corner of the screen, just to the left of "File") to analyze any waveform you have SAVE'ed with the Digisound program. The program displays a spectrogram of frequency content *versus* time. The darker the spectrogram at a given frequency and time, the greater the amplitude of that frequency at that time. To identify what sounds go with what part of the spectrogram, use the mouse to select any region you want played back.

A second desk accessory, FFT SPECTRUM, performs a discrete fourier transform using the first 128 samples stored in any .snd file you specify. It produces a bar graph showing energy *versus* frequency. The horizontal scale goes from 0 Hz to one-half the sampling rate.

Print out your best Fourier analysis by holding down the **Alternate** key and pressing the **Help** key (this prints whatever is on the screen, and takes about 6 minutes). Mark the important features on your graph and hand it in to your lab instructor.

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