Physics 338 Advanced Physics Laboratory

Fourier Analysis

Informal Report Due: **Friday, November 22, 2024**

Safety

There are no unusual safety hazards in this experiment.

1 Introduction

Fourier Analysis provides an important window into understanding a wide variety of phenomena. In this experiment, you will become familiar with a powerful tool for Fourier Analysis, the Stanford Research Systems SR770 Fourier Analyzer, as well as the TeachSpin Fourier Modules accessory. In a subsequent experiment, you will use these tools to study a particular system in greater depth.

Since the primary purpose of this experiment is to become familiar with the apparatus, the actual report you submit will be quite brief. You should work through the parts of the instruction manual as indicated, but you only need to turn in the items specifically discussed below. However, in your notebook, you should feel free to add any additional notes you might find useful for your future experiments.

The detailed instruction manuals for this experiment are available in the lab and through the course web site.

2 Theory

The theory of Fourier Analysis was covered in Phys 218. You should refer to Chapter 8 in Ref. [1] for details. The general definitions and notation used in this experiment are defined in **Chapter 0: Overview** of the experiment manual.

3 Experiment

3.1 Chapter 1: Learning to use the SR770

Read through Chapter 1 of the experiment manual and do the suggested measurements. Specifically, for input sine, square, and triangle waves of approximately 10 kHz, record the locations and amplitudes of the main peaks in the Fourier spectrum, and compare those with the expected values. You may present your results in either table or graphical form.

3.2 Chapter 2: Learning to use the SR770's internal waveform source

Read through Chapter 2 of the experiment manual and do the suggested measurements. The "single" button on the oscilloscope is useful for looking at the superposition signal.

Specifically, do the following:

3.2.1 Uncertainty

Consider the expression on pg. 2-5:

$$\text{(frequency resolution achievable)} \cdot \text{(acquisition time required)} \geq \text{a number.} \qquad (1)$$

1. Use the default BMH window and find the frequency resolution achievable and the acquisition time required to resolve signals of 50 and 51 kHz. (The precise definition of "resolved" is up to you. Pick something sensible, document your criterion, and stick with it.)
2. Repeat for frequencies of 50.0 and 50.3 kHz.
3. Repeat for frequencies of 10 and 10.1 kHz. (This will also help illustrate whether the absolute frequency matters, or just the difference.)
4. Tabulate your results. Is Eq. 1 followed, at least approximately?

3.2.2 Windowing

Perform the "spectral leakage" test described in the "Amplitude measurement" section starting on page 2-9. Specifically, set the frequency span to 100 kHz so that the bin width is 250 Hz. Look at input signals of 50.000 kHz, 50.125 kHz, and 50.250 kHz, and record what happens qualitatively to the peak amplitudes, peak widths, and background signal level. You are just looking for qualitative changes here. Repeat this test for each of the four window choices offered by the SR770. Give a *brief* qualitative summary of your observations.

3.3 Chapter 3: Modulated Waveforms — Amplitude Modulation

Read through Chapter 3 of the experiment manual and do the suggested activities. Specifically, do the following:

1. Build the amplitude modulator described on pages 3-1 and 3-2, and draw a block diagram of what you have built. (A hand sketch attached to your final report is fine.) A block diagram is not merely a picture of the wiring used. It should be a logical diagram showing the flow of signals. Check with me if you have any questions.

2. Set up the oscilloscope as described on the top of pg. 3-3 and sketch (or save) the resulting waveform. Does it match the expected shape?
3. Connect your amplitude modulated signal to the input of the SR770. What do you observe for a simple sine wave "program" signal?
4. Now change the program signal to a square wave. How does the signal reported by the SR770 change?

References

[1] Walter Fox Smith. *Waves and Oscillations: A Prelude to Quantum Mechanics.* Oxford University Press, 2010.