George Mason University

Physics 311

Data Acquisition Lab 1: Signal analysis *

Introduction

The frequency components of a square wave can be obtained by capturing the waveform and applying a Fast Fourier Transform algorithm. It is important to analyze signals because what you perceive as pure noise might have hidden frequency components, which can be considered data of your experiment.

The process of extracting the frequency components, which make up an arbitrary waveform is called **Fourier Analysis**.

In this experiment, you will use the DAQ with your VI and an oscilloscope to perform a Fourier Analysis. For this purpose, you need to update your VI.

Procedure Part 1

1. Connect the function generator directly to the oscilloscope. Set the frequency to 200 Hz and choose a sinusoidal waveform. The amplitude should be about 1V. Set the time scale so that the scope shows at least 5 cycles. Capture this waveform with open choice desktop. Copy the data and paste them into Excel.

2. Now change to a square wave but do not change anything else. Repeat the above capture procedure. This time leave three columns free between the first data set and where you paste this one.

3. In Excel, select **Data, Data Analysis, Fourier Analysis.** The instructions in this and the following section assume that the times are put in column A, and the signal voltages in column B. As input Range, enter B1:B2048, if your voltage data is in column B. (We cannot use all 2500 points from the scope because the algorithm requires that the number of points be a power of 2.) Select Output Range and enter C1:C2048.

4. What you will see next is a set of two numbers for each cell. This is because the frequency decomposition algorithm (the FFT) produces them. They can be put into the form of a magnitude and a phase. Excel's algorithm produces two components, the real and the imaginary parts of a complex number. In this experiment, we are only interested in the magnitude, so in the adjacent column, (D), enter = IMABS(C1) and copy this to the rest of the column.

5. The FFt algorithm produce frequency components over a finite set of frequencies. The lowest one is 0, corresponding to a constant level. The highest one is:

$$f_{max} = \frac{1}{2\Delta t}$$

*Partially adapted from Physics 263

6. Where Δt is the time interval between samples. In addition, the second half of the output column is associated with negative frequencies. Therefore, in this data set, there are only 1024 positive frequencies. We are only interested in the lower part of the frequency spectrum, so in the next column, compute the frequency for each component for the first 200 numbers in the magnitude column. To do this, enter 0 in cell E1. In cell E2 enter =E1+1./((A3-A2)*2048).

7. Then copy cell E2 to cells E3 to E200. This will calculate the correct frequency for the corresponding component in column D.

8. Next, repeat the above procedure for the square wave data. You do not have to construct the frequency column, because it is the same as for the sine wave. Make a graph of the FFT magnitude vs. frequency, for the first 200 points. If the sine-wave frequency is f_0 do you see peaks in the square wave spectrum at every integer multiple of f_0? If not, for what harmonics do the peaks occur?

Procedure Part 2

9. Modify your DAQ to perform an FFT with your Oscilloscope VI. Then connect the function generator to the DAQ and set the frequency to 200 Hz and the amplitude to 1V. Use your modified DAQ to perform a signal analysis in the frequency domain. Copy the graphs into your Excel spreadsheet (as pictures – use the windows snipping tool). In your lab notes, compare the calculations from Excel with the measurements you performed with the DAQ.

10. Does the DAQ oscilloscope display the same frequencies as your calculations in the Excel spreadsheet? If not, what is the error? Which method is more accurate? The DAQ one or the oscilloscope analysis?

*Partially adapted from Physics 263