Fourier Series LABVIEW GUI Documentation

INTRODUCTION

The Fourier Series GUI is meant to be used as a learning tool to better understand the Fourier Series. The user is able to input the amplitude and frequency of 5 separate sine waves and sum them together. The result of this summation is plotted in real time in order for the user to see how the changes affect the resultant signal.

The user can then input the amplitude and frequency of a square, sawtooth, or triangle wave and attempt to approximate each of these waves by summing the five sine waves together. If the user is unable to obtain the correct Fourier coefficients and frequencies required for each of the five sine waves, the GUI allows for the user to auto approximate each of the waves. The correct coefficients are then displayed next to the user inputs. The user can then check the inputs with the auto-approximated coefficients.

Multiple tabs are available under the main plotting screen, the first of which displays an FFT of both the Fourier approximation and actual signal. The next tab displays a low pass filter which allows the user to change the lower cut-off frequency and see its effects on the approximated signal and its FFT. The final tab displays a band-pass filter which allows the user to see the effects of applying both a high and low cut-off frequency to the Fourier approximation.

FILES NEEDED

FourierGUI.exe
Fourier_LabVIEW_GUI.pdf
Fourier_LabVIEW_GUI_Assignment.pdf

LABVIEW VI

The LABVIEW VI created for this GUI was setup in such a way that the user could see the effect of changes made in real time. The front panel, which is the interface the user sees, can be seen in Figure 1.

The user can input the amplitude and frequency of five different sine waves, which the GUI then sums together and plots. Three separate waves can then be approximated by the user along with the option of auto-approximation by the GUI itself. The coefficient values used in the atuo-approximation can be found in Appendix A. An FFT, low-pass filter, and band-pass filter can also be applied to the summed signals by clicking through the tabs.

OPERATING THE GUI

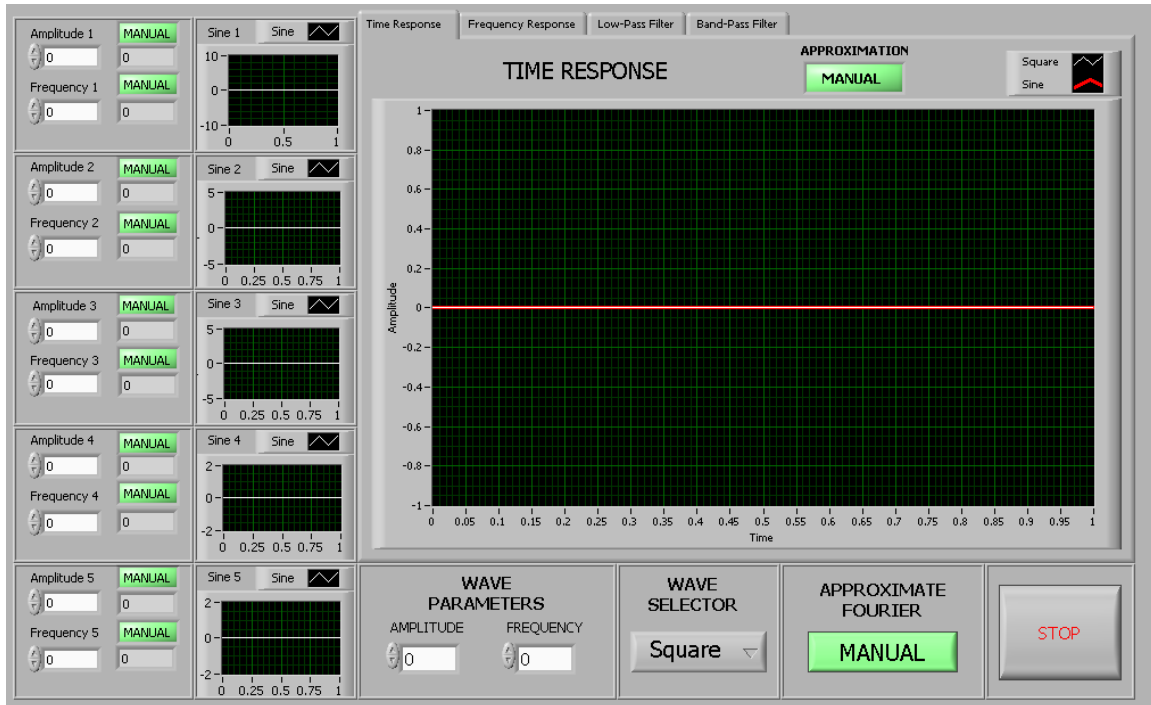When the LABVIEW GUI is initially opened it will look like Figure 3.

Figure 1: LABVIEW GUI

All of the values are initially set to default values, including the cut-off frequencies of each of the filters located on the separate tabs. The sine waves, one of which is shown in Figure 4, can be altered by the user and are then summed by the GUI and plotted.
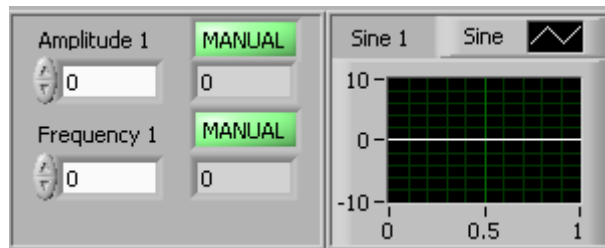

Figure 2: 1 of 5 Sine wave Inputs

The amplitude and frequency values can either be typed directly into the left-hand box or adjusted by clicked the up and down arrows. The box to the right is used as an amplitude verification, when the auto-approximation is in use, it acts as a comparison between the input value and the value that should have been input.

Fourier Approximation

This GUI is set-up to approximate either a square, sawtooth, or triangle wave. Figure 5 shows the selector as well as the amplitude and frequency input for these sample signals.
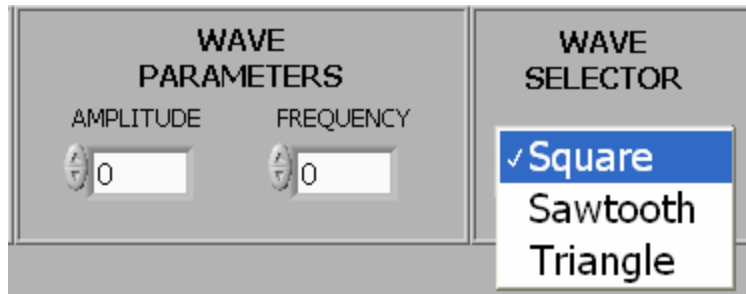
Figure 3: Wave Parameters and Selector

The wave parameters allow for the amplitude and frequency to be input by the user for either of the three sample signals.

The user can then input an amplitude and frequency for the sample wave and attempt to determine the coefficients required for the five summed sine waves in order to approximate each of the sample signals. If the user is having trouble obtaining the correct coefficients, the auto-approximation button, seen in Figure 5, can be utilized.

Figure 4: Auto-Approximation Switch

Regardless of which sample wave is selected and what parameters have been selected for that wave, the GUI will automatically approximate the sample using five sine waves. It will then output the correct coefficients needed in the box to the right of the sine wave input, as seen in Figure 3. Figure 6 shows the GUI auto-approximating a square wave of amplitude 1 and frequency 1.
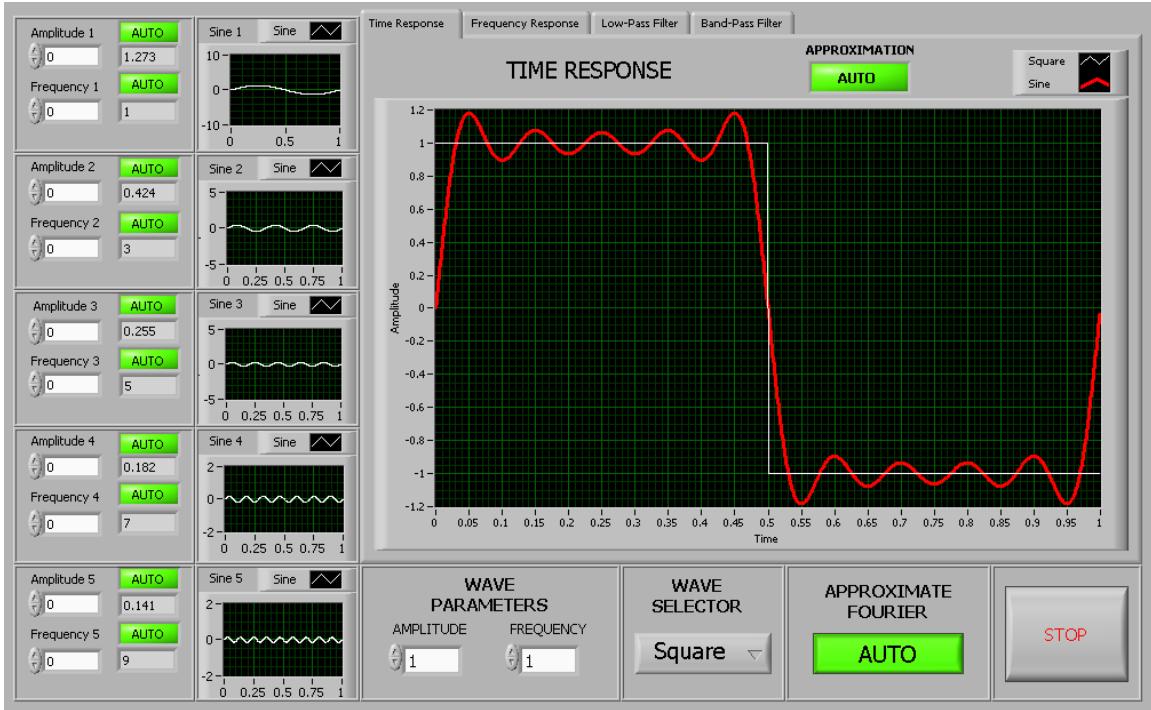
Figure 5: LABVIEW GUI Square Wave Approximation

Frequency Spectrum

The user can also look at the frequency content of the signals by clicking on the TAB entitled "FFT – Original and Approximation". Figure 7 shows the frequency spectrum plot of the square wave with an amplitude and frequency of 1 and its Fourier approximation, as seen in Figure 6.
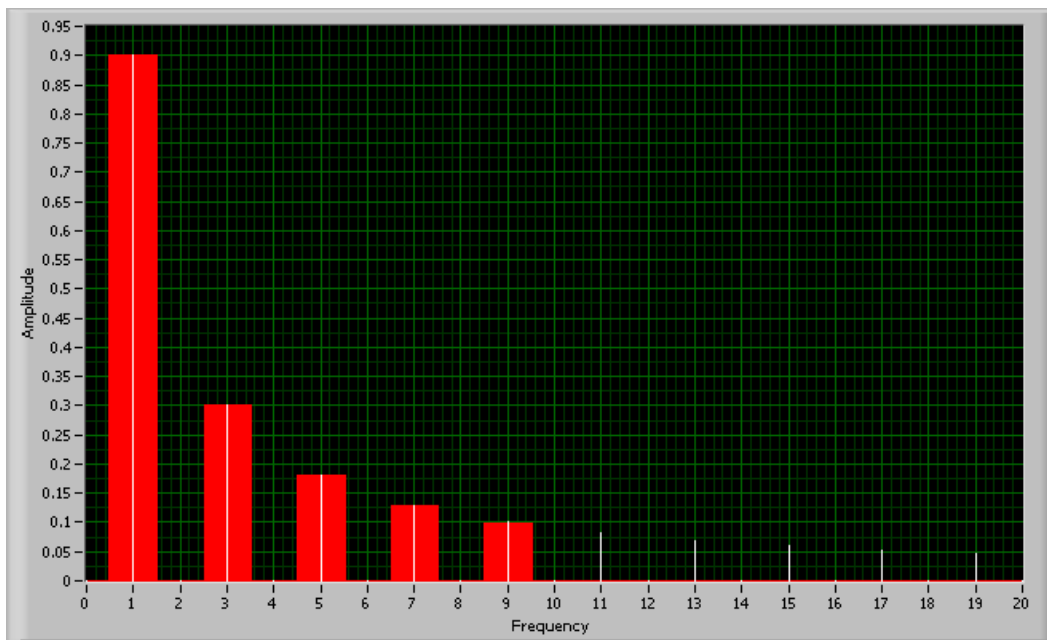

Figure 6: FFT of Original and Approximated Signal

Note that in Figure 7 only the first five frequencies match between the approximation and the actual wave. This is due to the fact that only five sine waves were used in the approximation.

Filtering

The user also has the ability to view the effects of two different filters on the Fourier approximated signals. The first of these filters, a low-pass filter, allows the user to decrease the lower cut-off frequency and watch as the contribution of each sine wave is taken out of the summed signal. The low pass filter effects on the square wave can be seen in Figure 8.
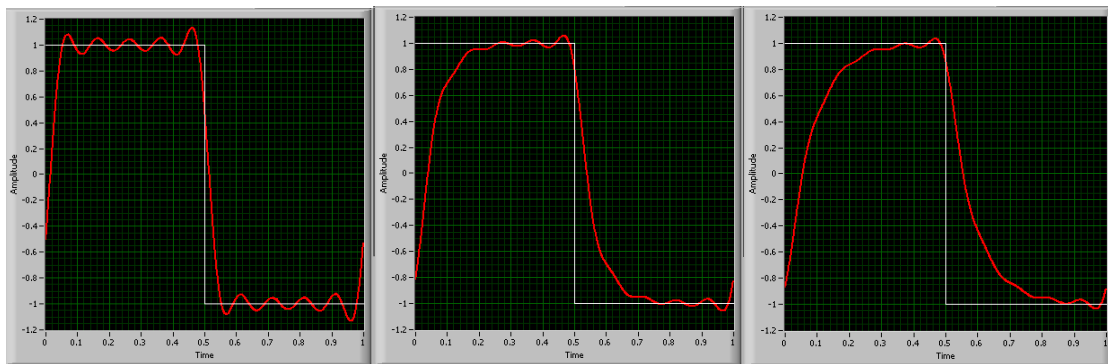

Figure 7: Low-Pass Filter Effects

The other filter that can be applied is a band-pass. This filter allows the user to select individual wave frequencies by bringing the lower cut-off just below the desired frequency and the higher cut-off just above. The band-pass filter effects on the square wave can be seen in Figure 9 for a frequency of 3.
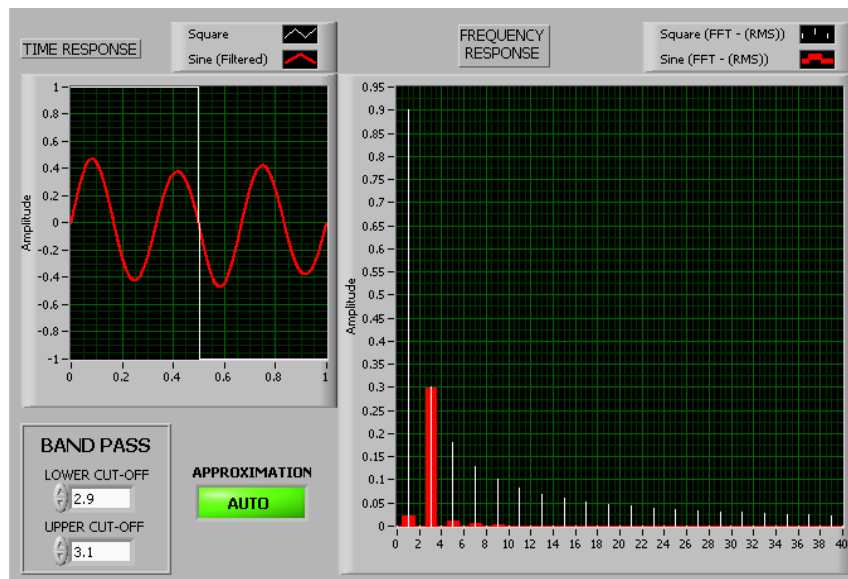

Figure 8: Band-Pass Filter Effects

Table A-1 shows the method for calculating the Fourier Coefficients using auto-approximation.

<p align="center">**Table A-1: Fourier Coefficient Determination**</p>

Wave	Amplitude	Frequency	Sine Wave	Amplitude	Frequency (Hz)
Square	x_o	f_o	1	$\dfrac{4 \cdot x_o}{\pi \cdot 1}$	$f_o \cdot 1$
			2	$\dfrac{4 \cdot x_o}{\pi \cdot 3}$	$f_o \cdot 3$
			3	$\dfrac{4 \cdot x_o}{\pi \cdot 5}$	$f_o \cdot 5$
			4	$\dfrac{4 \cdot x_o}{\pi \cdot 7}$	$f_o \cdot 7$
			5	$\dfrac{4 \cdot x_o}{\pi \cdot 9}$	$f_o \cdot 9$
Sawtooth	x_o	f_o	1	$\dfrac{x_o}{\pi \cdot 1}$	$f_o \cdot 1$
			2	$\dfrac{x_o}{\pi \cdot 2}$	$f_o \cdot 2$
			3	$\dfrac{x_o}{\pi \cdot 3}$	$f_o \cdot 3$
			4	$\dfrac{x_o}{\pi \cdot 4}$	$f_o \cdot 4$
			5	$\dfrac{x_o}{\pi \cdot 5}$	$f_o \cdot 5$
Triangle	x_o	f_o	1	$\dfrac{4 \cdot x_o}{\pi^2 \cdot 1^2}$	$f_o \cdot 1$
			2	$\dfrac{4 \cdot x_o}{\pi^2 \cdot 3^2}$	$f_o \cdot 3$
			3	$\dfrac{4 \cdot x_o}{\pi^2 \cdot 5^2}$	$f_o \cdot 5$
			4	$\dfrac{4 \cdot x_o}{\pi^2 \cdot 7^2}$	$f_o \cdot 7$
			5	$\dfrac{4 \cdot x_o}{\pi^2 \cdot 9^2}$	$f_o \cdot 9$

x_o and f_o correspond to the user-defined input amplitude and natural frequency of the signal.