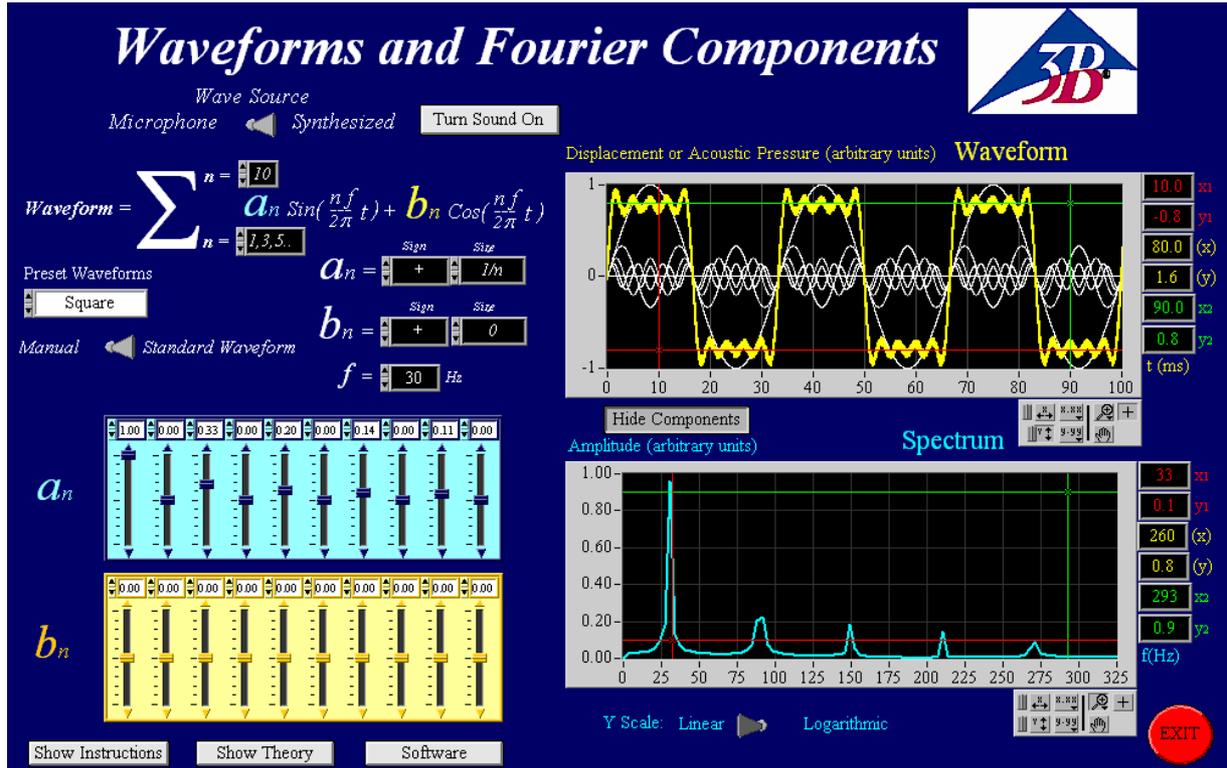


Fourier Software 1012587

Instruction Manual

06/11 MEC



1. Description

The program allows you to create, visualize and hear synthetic waveforms from either preset types or free hand by adjusting each component manually.

It also permits you to analyze the spectrum of audio inputs recorded with a microphone using the sound card built into the computer.

Most computers have a sound card capable of sampling up to 44100 Hz. This means that in principle sounds with frequencies up to 22050 Hz can be analyzed. In practice the limit may be well below this (more typically ~18000 Hz).

The sound cards of different computers have different accuracies. For this reason the producer does not offer any guarantee as to the traceability of measurements made with this software. It is intended only as an educational resource.

The "Fourier Analysis" or "Spectral Analysis" of real waveforms enables scientists and engineers to find out the frequency components that are present in any particular waveform.

A summary of the instructions are included in the program, and are displayed by pressing the button:

Show Instructions

2. System requirements

- Windows XP or higher;
- 512 MB RAM or higher;
- 128 MB Graphic card or higher;
- 16 bit Sound card or higher;
- Computer links: Microphone input; Line out

3. Operation

To run the software only double click on the file: "Fourier Analysis Large Final.exe" or "Fourier Analysis Small Final.exe".

The user needs administration rights on his computer to use the software.

3.1 Producing synthesized waveforms

The software has two main modes of operation which are controlled using the Wave Source toggle switch shown below.



- *Synthesized* sets the computer to produce the waveforms.
- *Microphone* sets the computer to record waveforms through the microphone input.

3.2 Producing standard synthesized waveforms

Standard preset wave forms or manual ones can be selected using the vertical toggle switch shown below.



- *Standard Waveforms* enables you to select from 5 different types of waves by clicking inside the fields shown in the table.
- *Manual* enables you to create your own waveforms by adjusting the amplitudes and frequencies.

	Triangular wave
	Square wave
	Positive going sawtooth
	Negative going sawtooth
	AC rectified

In order to obtain a perfect representation of the waveforms selected it is necessary to use an infinite number of higher harmonics. This software is restricted to a maximum of 10. The number of components to be included in the series can be set by typing a number in the black "n =" box at the top of the Σ shown below (displaying number 8).

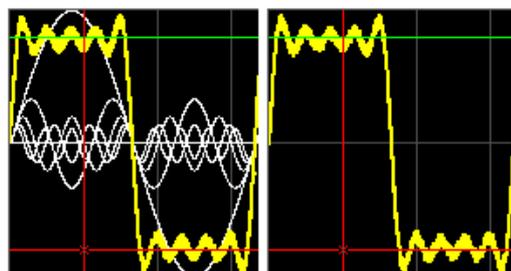
$$\text{Waveform} = \sum_{n=1,3,5}^{n=8} a_n \sin\left(\frac{nf}{2\pi}t\right) + b_n \cos\left(\frac{nf}{2\pi}t\right)$$

The black "n =" box at the bottom of the Σ is set automatically by the type of preset waveform being displayed. Some waveforms use all the harmonics others only use the odd harmonics.

Pressing the *Show/Hide Components* button displayed below lets you show or hide the individual wave components.



The components are shown in white, and the resultant waveform is displayed in yellow:



Pressing the *Turn Sound On/Off* button makes the program output the resultant wave to the audio output of the computer.



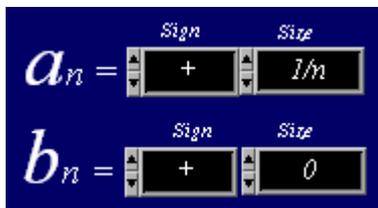
The *Volume* knob will appear or disappear depending on whether the sound is turned on or off.



Change the number in the "*f* =" box shown below to change the fundamental frequency of the series.



The magnitudes and signs of the *a* and *b* coefficients of the Sine and Cosines are shown in the fields below. In some cases they are not used so the amplitude is shown as zero.



3.3 Producing manual synthesized waveforms

Toggle the "*Standard Waveforms/Manual*" switch to Manual in order to take manual control over the amplitudes of the components.

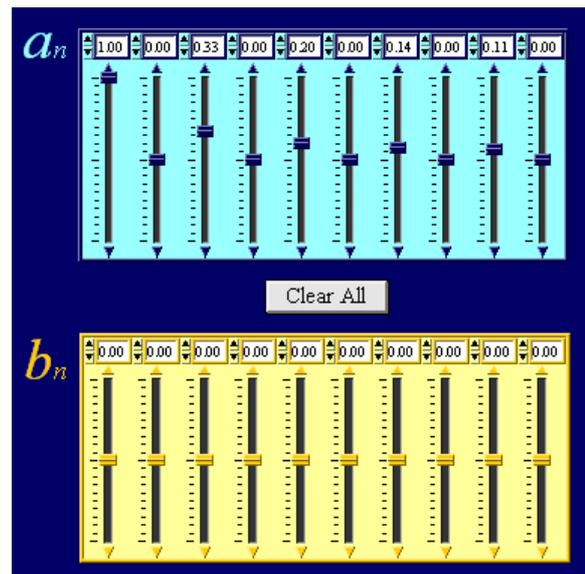


Choose how you want to control the components of your synthesized waveform, using either Sines and Cosines or Sines and Phases (in units of π radians):



The display below shows what the software displays when Sines and Cosines are selected. In this case the synthesized wave was a square wave which uses only the odd multiples of the fundamental Sine and does not use Cosines at all (notice all Cosine amplitudes are set to zero).

Press the "*Clear All*" button to set all the amplitudes to zero and start again. The number of sliders shown depend on the number of components requested in the black "*n* =" box at the top of the Σ .



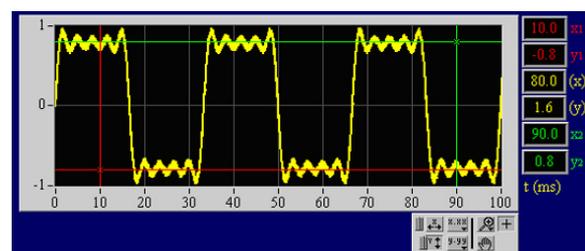
If Sine and Phase are selected instead, the *b* coefficient sliders are replaced by red Φ (phase) sliders.

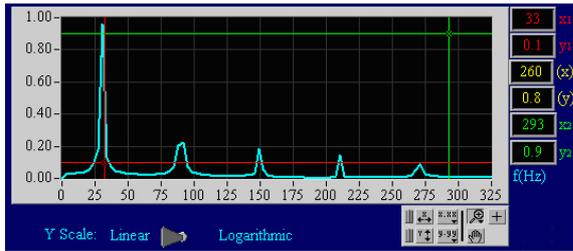


3.4 Control of the Graphs

Two graphs are displayed by the program: the Waveform (yellow) and the Spectrum (blue). A typical synthetic square wave is shown below:

Notice the palette at the bottom right hand side of the graph. This can be used extensively to control various features of the graphs that are plotted.





Note: If the location of the cursors is not clear, they are located at the margins of the plot.



It is possible to overtype the numbers at either end of the X or Y scales to change the X or Y ranges of the graphs, but the graph palette permits you to carry out a number of different actions on the graphs.

	<p>Click on the magnifying glass at the bottom right hand side of the graphs in order to zoom in to any desired area of the graphs.</p>
	<p>Click on the top left to mark a rectangular area into which you want to zoom.</p>
	<p>Click on the middle top to mark an X range into which you want to zoom.</p>
	<p>Click on the top right to mark a Y range into which you want to zoom.</p>
	<p>Click on the bottom left to undo the previous zoom operation.</p>
	<p>Click on the middle bottom and then click on a point on the graph to expand the scales centered on the point where you have clicked.</p>
	<p>Click on the bottom right and then click on a point on the graph to reduce the scales centered on the point where you have clicked.</p>

	<p>Click on this button to auto-scale in the X axis and display the full X range of the data.</p>
	<p>Click on this button to auto-scale in the Y axis and display the full Y range of the data.</p>
	<p>Click on this button to enable you to drag the graph range around in both X and Y.</p>
	<p>Click on this button to enable you to move the red and green XY cursors on the plot area of the graphs. The X and Y coordinates of the cursors are displayed on the right hand side of the graphs in red and green respectively, and the difference between the two is shown in yellow.</p>
	<p>Choosing the setting for the axes.</p>

Toggle the "Linear/Logarithmic" switch under the Spectrum graph to change the Y scaling of the spectrum graph.



The logarithmic mode enables you to notice small amplitude components in the spectrum which are often swamped in the linear scale so that they are not noticeable.

3.5 Recording and analyzing sound using a microphone

Toggle the "Wave Source" switch to microphone to record and analyze waves using the microphone input of the computer.



Ensure that a microphone is plugged in to the computer and that it is active. Check with a windows application that it is live.

The "Capture Threshold" knob allows you to set a trigger so that the recording freezes whenever the threshold is exceeded. If you want to record and analyze continuously without stopping, set the threshold to maximum.



You can also freeze the recording manually by pressing the "Freeze" button.



Press the "Reset" button in order to record again.



Change the "Recording time" (in milliseconds) by changing the number in the field shown below. Longer recording times require longer analysis time. You should set the recording time to be sufficiently long to include at least 10 complete cycles of the waveform (ideally over 100!).

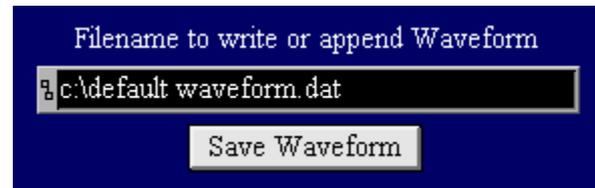


Note: The spectrum is calculated with better precision when the recording time is longer.

3.6 Saving the data

The option of saving data into text files that can be read with other software is only available when operating in the microphone mode.

To save the Waveform so that it can be studied in further detail, enter a filename in the field on the left and press the "Save Waveform" button.



To save the Spectrum so that it can be studied in further detail, enter a filename in the field on the left and press the "Save Spectrum" button.



In both cases the program will create tab-delimited text files which can then be read with other software such as Excel, Origin, etc.

Note: if the filename is not changed, the program will not over-write the previous data, but will append the new waveform or spectrum to the end of the previous file.

