Free Oscilloscope Web App Using Computer Mic, Built-In Sound Library, or Your Own Files

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Abstract

We have developed an online oscilloscope program which allows users to see waveforms by utilizing their computer microphones, selecting from our library of over 30 audio files, and opening any *.mp3 or *.wav file on their computers. The oscilloscope displays real-time signals against time. The oscilloscope has been calibrated so one can make accurate frequency measurements of periodic waves to within 1%. The web app is ideal for computer projection in class.

Introduction

Class demonstrations with oscilloscopes gained popularity in the 1950s. The commercial success of mass-produced cathode-ray tubes for televisions led to the construction of oscilloscopes for projection in large classrooms. [1] Today it is common for teachers to use oscilloscope software such as the *MacScope II* [2]. Our HTML5 oscilloscope is a free web application (app) that students and teachers can access and run online [3].

Use of the oscilloscope app

An effective use of our oscilloscope is watching the waveform display in real time as the app responds to sound waves. There are three ways to display sound sources. First, one can use a

microphone to speak, sing, or make any sound in class. The oscilloscope displays the waveform as the sound is heard. There are four sensitivity settings to choose from, which adjust the vertical scale of the oscilloscope so that the waveforms fit nicely on the screen. The time scale can be changed to horizontally expand or compress the visual representation of the waves. One can also modify the refresh rate by selecting slow or fast response.

A second source of audio is our sound library of over 30 samples that can be chosen from the app's built-in sound menu. Finally, the user can open any *.mp3 or *.wav file and watch the changing waveforms as the audio file is played by the app. Watching the waveforms provides insight into the physics of sound. See figure 1 for a screenshot of a waveform produced by a flute.
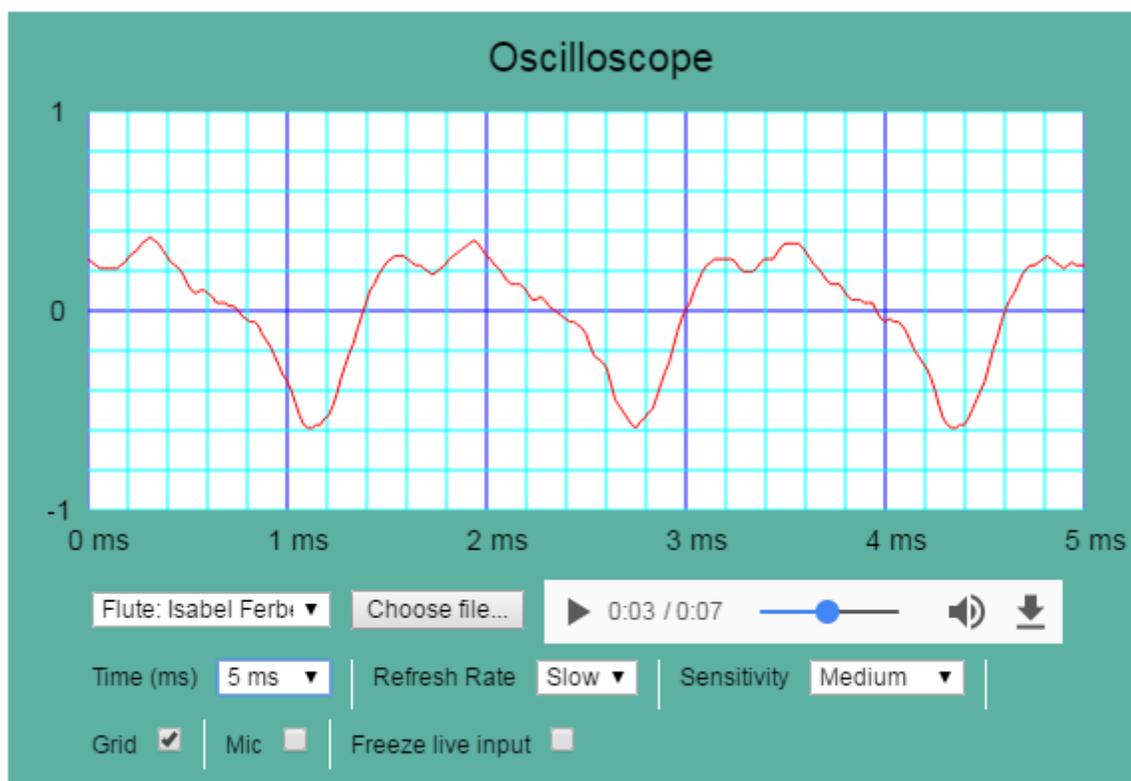

Figure 1. Screenshot of waveform produced by a flute, courtesy flautist Isabel Ferber.

Our oscilloscope can also be employed to measure frequencies of periodic waves. In order to closely examine a waveform, users can pause the sound playing from a file, or click the "Freeze live input" checkbox to obtain a still image of the sound coming through the microphone.

To measure the period of the periodic tone in figure 1, notice the places where the waveform crosses the horizontal axis. One crossing takes place at 3.0 ms. See figure 2. The same corresponding point one period later crosses the horizontal axis at 4.6 ms. The period is found by subtracting these values to arrive at $T = 4.6 \text{ ms} - 3.0 \text{ ms} = 1.6 \text{ ms}$. The corresponding frequency is $f = \dfrac{1}{T} = \dfrac{1000}{T \text{ (in ms)}} = \dfrac{1000}{1.6} = 625 \text{ Hz}$.
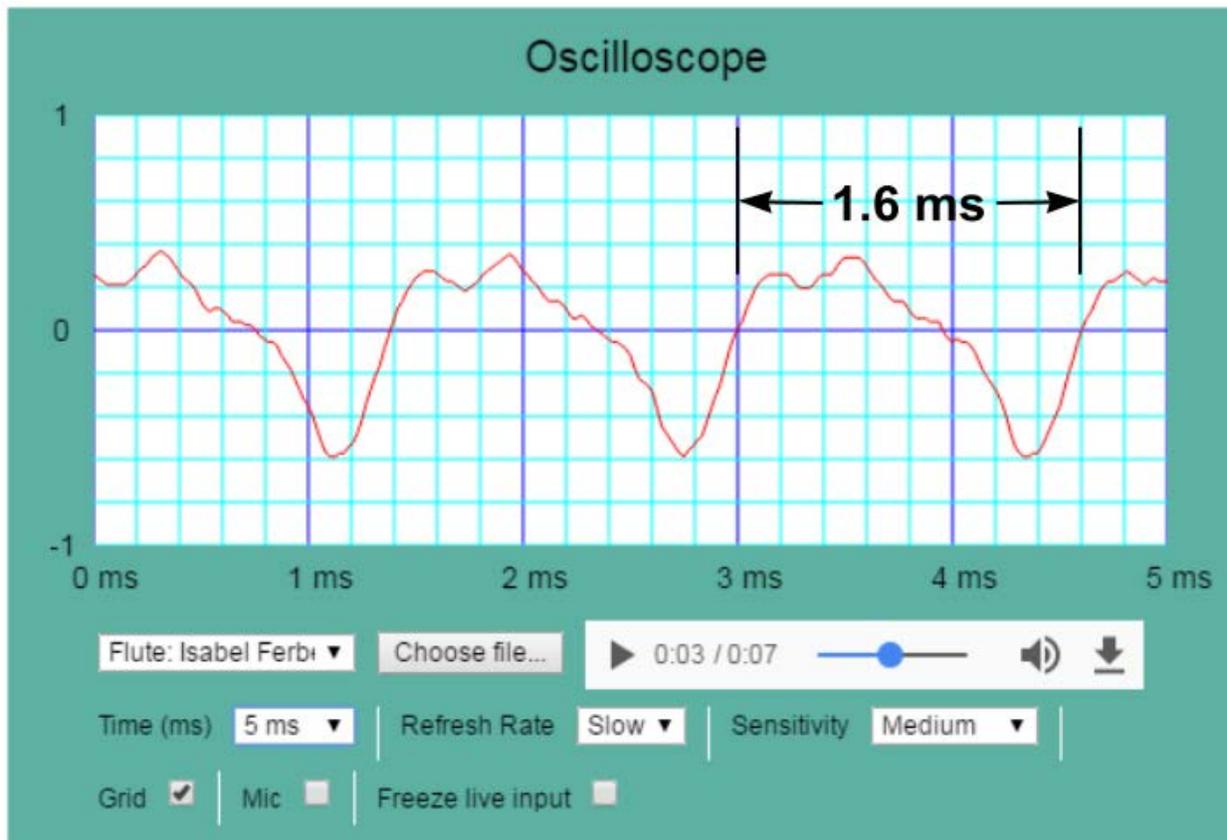

Figure 2. Measuring the period of a periodic wave on the oscilloscope.

The flautist was playing an E^b in the octave above middle C at the instant. This note is often referred to as E^b_5. The note being played can be verified by looking at the time 0:03 s displayed by the audio player for our 7-second flute library file (refer to either figure 1 or figure 2). One can go to a keyboard and play the phrase with the flautist. In this way, the note played at 0:03 s will be found to be E^b_5, which has a frequency equal to 622 Hz.[1] This independent method to arrive at the frequency indicates excellent agreement with our measured value of 625 Hz using our oscilloscope. The experimental error is only 0.5%.

Waveform fidelity of the oscilloscope

Depending on the combination of your computer's operating system and your chosen browser, you may recognize subtle waveform differences for certain types of waves. See figures 3a and 3b for the variation of a square-wave display on a Mac and a PC, both using the Chrome browser.

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[1] The desired note is 6 semitones above concert A = 440 Hz. Multiplying 440 by the twelfth root of 2 a total of six times gets you to the desired note at 622 Hz. Or, a teacher can look up the frequencies for the note on the keyboard online or in a reference book.
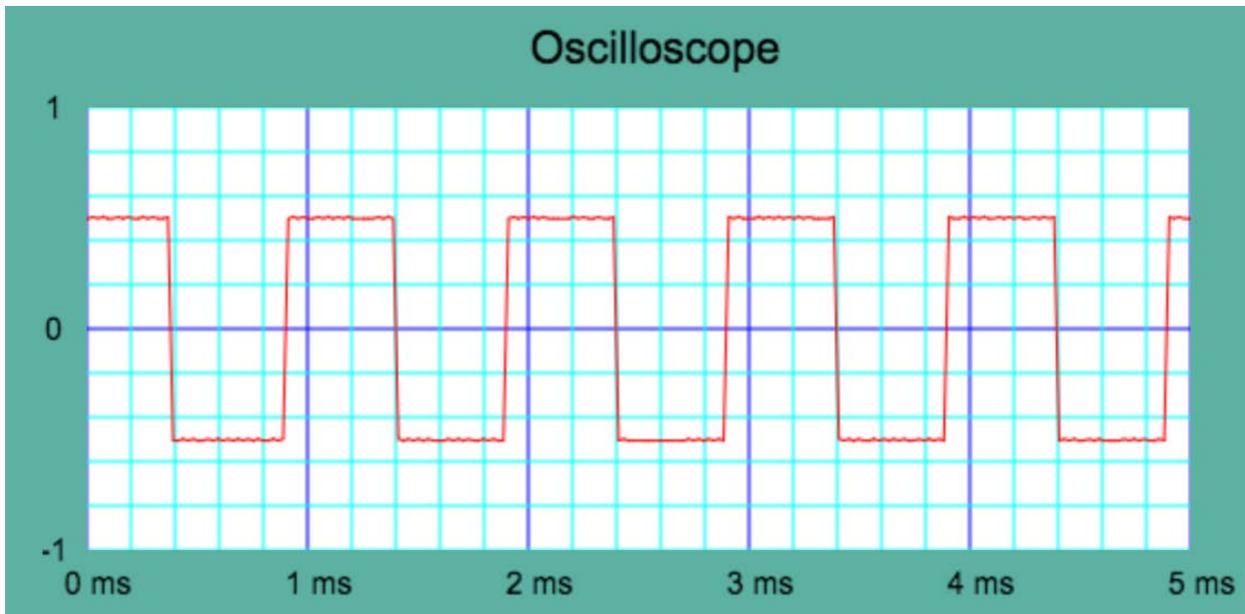
Figure 3a. A 1000-Hz square wave on the Mac with Google Chrome. Note that this rendition is better than what is displayed on the PC seen in figure 3b.
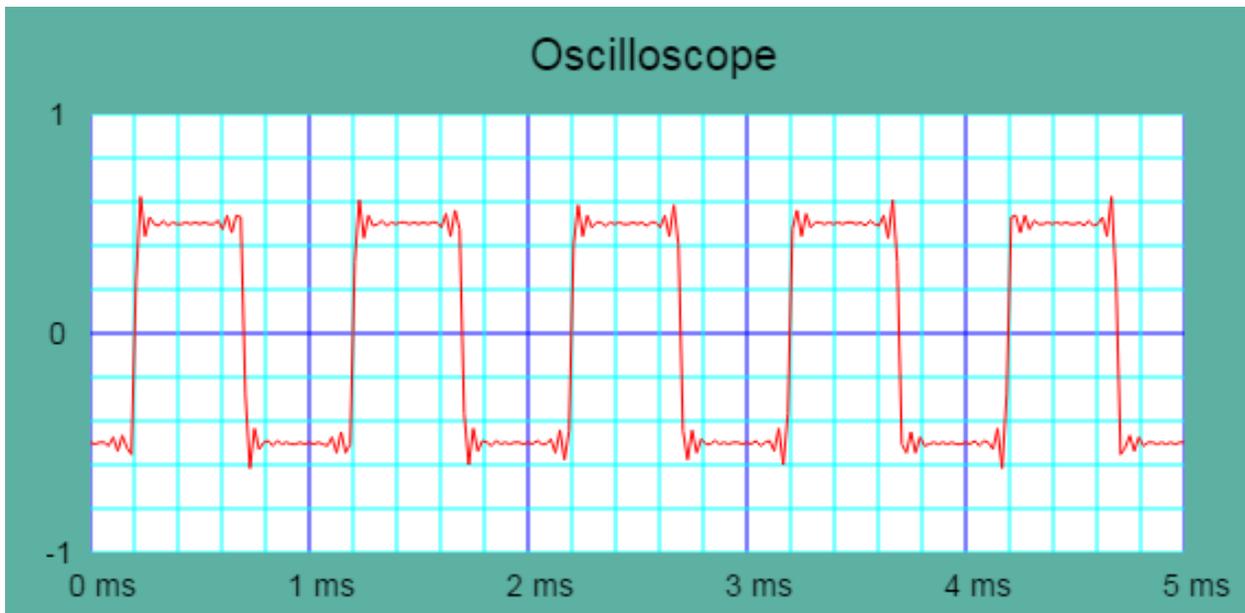

Figure 3b. A 1000-Hz square wave on a PC with Google Chrome. Note that this PC has trouble with the higher-frequency components of the square wave, essentially filtering out higher harmonics. The Mac (figure 3a) does a better job reproducing the square wave.

The Mac used to produce figure 3a is excellent at rendering a 1000-Hz square wave, while the PC in figure 3b introduces ripples. When one passes a square wave through a low-pass

filter in a lab situation, higher frequency harmonics get filtered out, which results in outputs similar to figure 3b. It appears that our PC-and-browser combination has difficulty registering the higher-frequency components of the square wave. Such deviations could be due to the audio processing in the sound card, operating system, or browser. We expect that technology improvements in the future will resolve such artifacts. Google Chrome, at the writing of this paper, runs the web app very well.

Conclusion

This paper makes available an HTML5 online oscilloscope for teachers and students. The oscilloscope is calibrated so that users can typically measure frequencies of periodic waves to within 1%. We recommend that the app be run online [3] since we keep our version updated based on the latest quirks of browsers. However, the source files are available for download if anyone wants to see the code. Any noncommercial use is allowed.

We provide a short video abstract [4] which describes the app and includes video footage from which several of our library audio files were extracted. The oscilloscope display is superimposed over the associated video so one can see the video that accompanies the sounds. We hope teachers and students will have fun in class making their own sounds and watching the waveforms in real time using our oscilloscope app.

References

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Authors

Edward Ball received his Master of Physics from Durham University, UK. He currently works as a web developer and enjoys creating browser-based interactive demonstrations, particularly those featuring sound and waves. These demos can be accessed at his Academo website (academo.org).

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