

Stimscope: A Virtual Instrument for Neurophysiology in the Teaching Lab

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Stimscope Interface

Frequency Histogram Generator

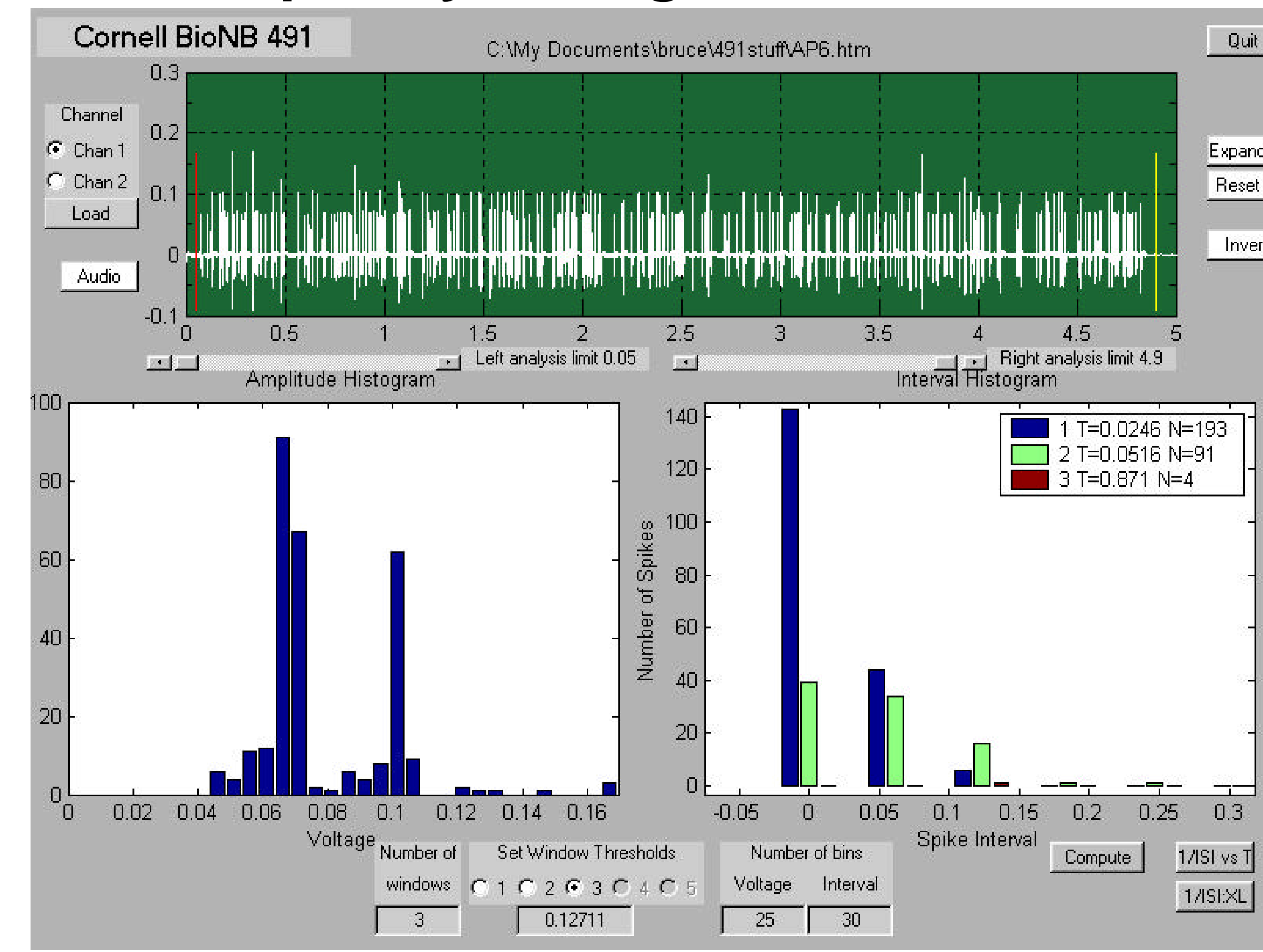
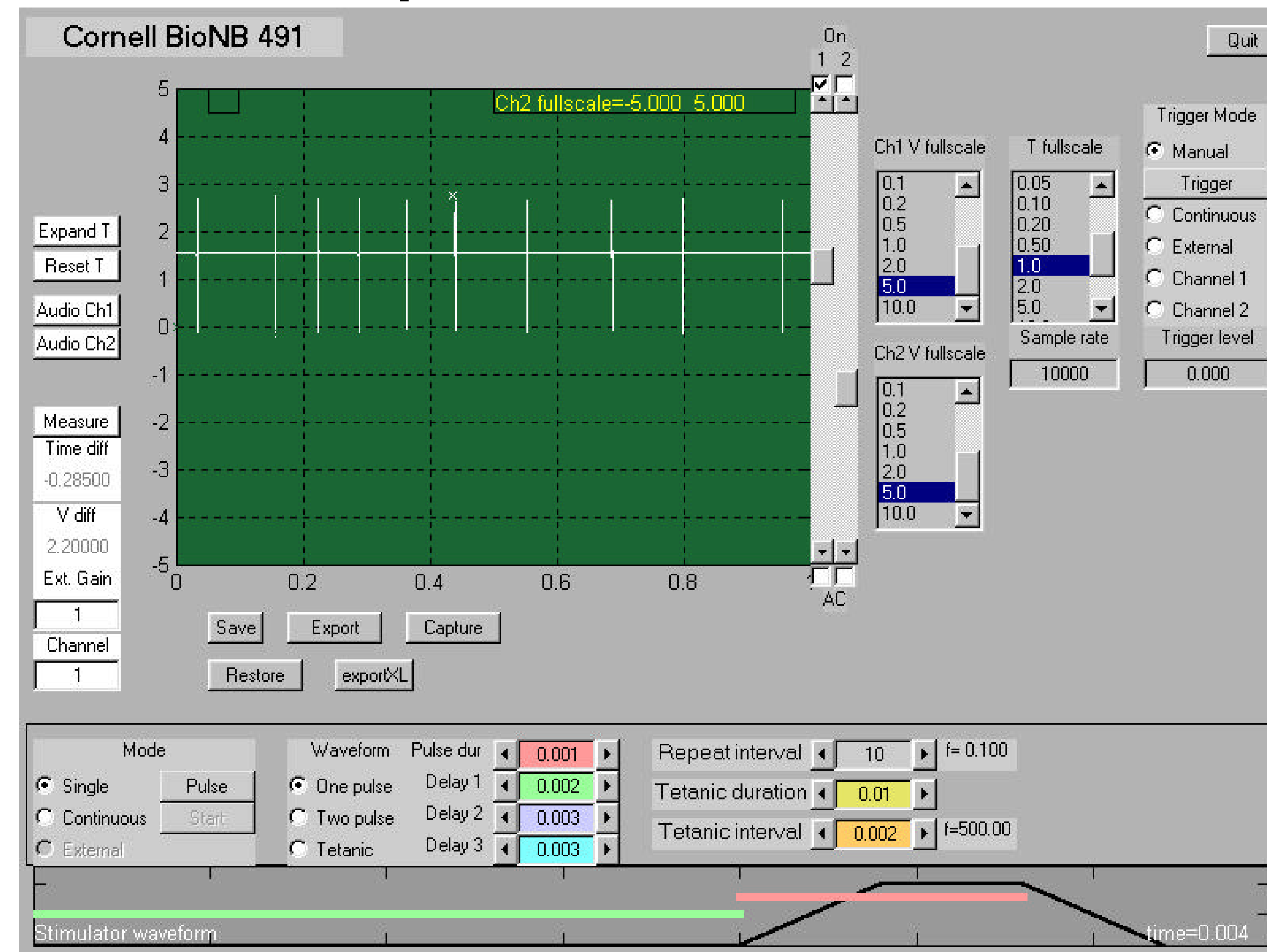
Introduction

As part of our effort to make inexpensive, user friendly, and flexible physiology lab instrumentation, we created Stimscope, written in Matlab, to closely simulate the appearance and function of a traditional oscilloscope and physiological stimulator in one combined interface. *The simulated instruments record and produce actual voltages for experimentation.*

We used Matlab for this instrument because it easily generates graphic user interfaces, acquires data in real time, and provides extensive, easy-to-use analysis and plotting.

The virtual oscilloscope accepts two channel input from either the Windows sound device or a National Instruments DAQ board. Each channel has independent amplification, gain calibration, audio channel, and measurement capabilities. Traces can be saved, loaded for printing and analysis at different time scales, and exported to graphics, analysis, and spreadsheet software. For example, we also wrote a frequency histogram generator to compute a multi-windowed spike-interval histogram from stored data.

The virtual stimulator produces output from the sound device or DAQ board to control a stimulus isolation unit. Stimulus control includes pulse duration, delay, and frequency for single pulses, twin pulses with varying intervals, and tetanic stimuli.



Conclusions

Stimscope has been extensively tested and shaped by undergraduates in a semester-long physiology lab course based on the Crawdad CD. This version of Stimscope is available at www.crawdad.cornell.edu.

The 15 students who used the software for a semester were very valuable in providing feedback. Students liked the final product. The instructors found the software user friendly and were convinced that it could replace a physical oscilloscope.

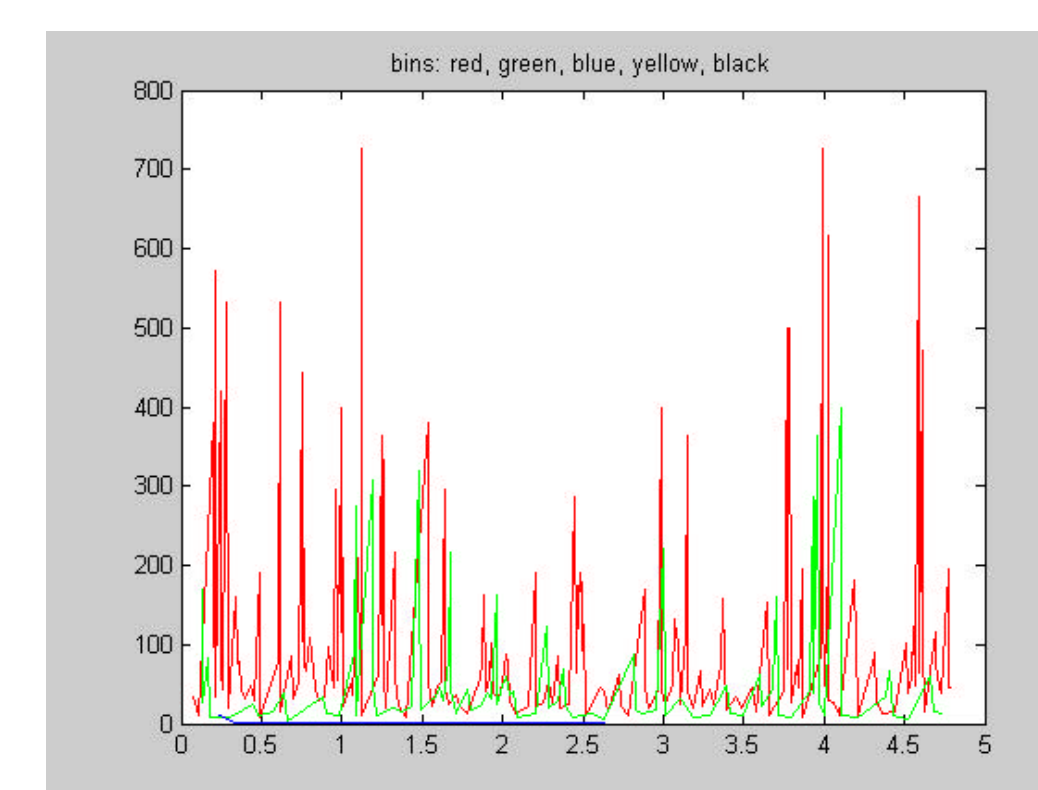
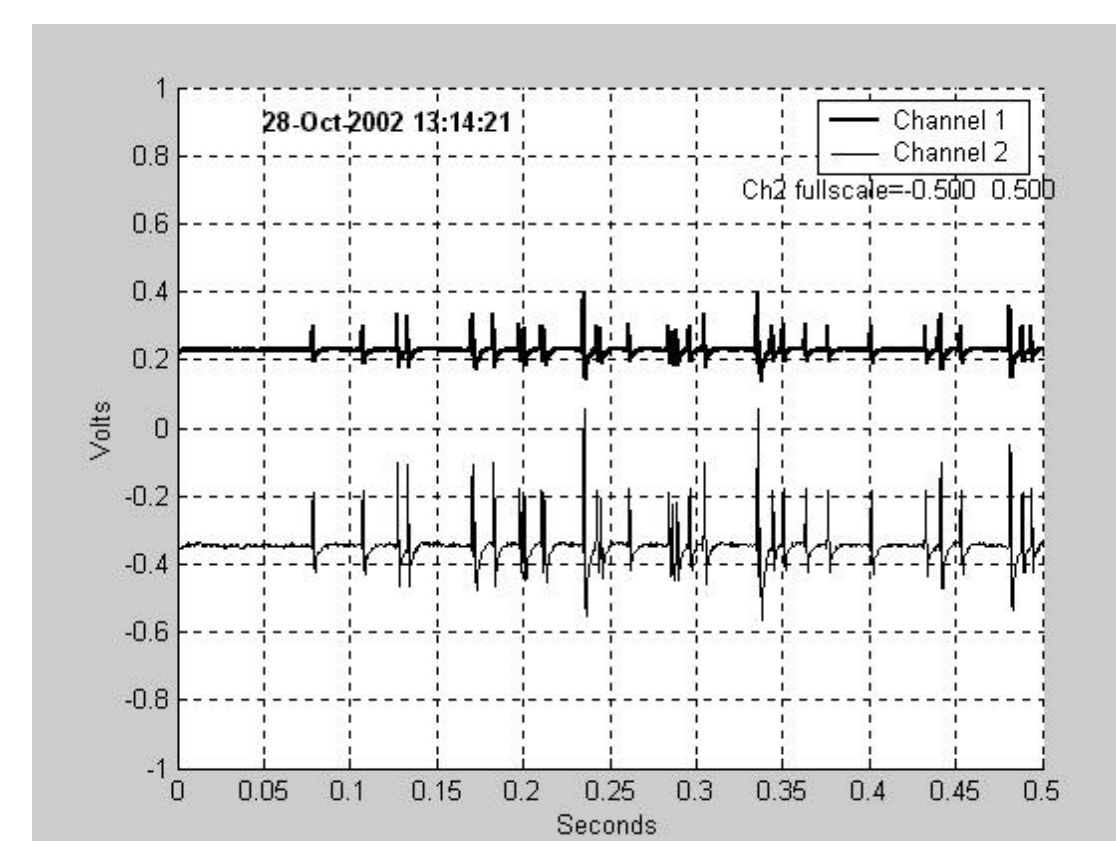
The next step is to rewrite the interface as a native windows application so that the Matlab base is not required. This new version will use custom electronics at the input to enable winsound to be used directly for extracellular recording.

Scope controls:

- Channel 1 and 2 can be turned off and on by clicking the check-boxes at the upper-right corner of the trace display. Each trace can be set to AC mode by clicking the check-boxes in the lower-right corner of the trace display. Traces may be positioned vertically by using the vertical sliders to the right of the display. Vertical voltage scale can be set from .001 to 10 volts full scale with the V fullscale control, for each channel separately. Channel 1 scale is shown on the y-axis of the plot. Channel 2 scale is shown in yellow at the top of the plot.
- Horizontal time scale can be set from .001 second to 30 seconds with the T fullscale control.
- Trigger source can be set to: (1) Manual, which activates the scope Trigger button. Pressing the Trigger button will cause the scope to acquire one trace. (2) Continuous to acquire data as fast as possible. (3) External to cause the scope to acquire data when an external pulse is applied to analog input 2 with an amplitude greater than the value set in the Trigger Level control. (4) Channel-1 or Channel-2 which triggers the scope when the voltage on the respective channel is equal to the value set in the Trigger Level control.
- Sample rate (samples/second) can be set to 8000, 11000, 22000 or 44100 for the winsound device and to an arbitrary value for the NIDAQ device. Default is 10000 sample/sec.
- The Expand T control activates a cursor-based drag box. Click on the Expand T control, then click-drag-release in the scope trace display. The part of the waveform you dragged over will expand to fill the display in the horizontal direction. Voltage scaling is not affected. A scrollbar appears so that you can scroll through the entire waveform.
- Audio Ch1 and Ch2 play the traces through the sound card.
- The Measure control activates a cursor-based drag box. Click on the Measure control, then click in the scope trace display. The click sets a zero value. The difference between the zero value and current cursor position is placed in the edit fields below the control. Since each trace can have different gain, you must choose the trace. If you have an external amplifier between you experiment and the computer input, you can set the gain.
- Save stores the entire data structure of the scope on the disk using a standard dialog box. Restore reloads a saved data structure. exportXL saves the two voltage traces as an Excel datasheet, with time, trace1 and trace2 as columns.
- Capture causes the scope traces to be copied to another window, time stamped, and formatted for printing. Once a display has been captured, the standard Matlab print, export, save and edit commands may be used. For instance, you can add a title. Saving the captured image from the file menu allows you to reopen it at a later time. The image to the right is an example captured image.

Stimulator controls

- Trigger mode can be set to: (1) Single, which activates the Trigger button. (2) Continuous to produce pulses at the rate specified by the Repeat Interval control when the Start button is pushed.
- The waveform can be set to single pulse, two pulse or tetanic. In tetanic mode, the trigger continuous mode is disabled.
- All pulse delays and durations are set with a set of edit fields and left-right arrows. The stimulating waveform is drawn below the controls. The color of each time control corresponds to the color of a line on the drawing.
- In one pulse mode you can set Delay 1 (trigger to pulse) and pulse duration. In two pulse mode you can set Delay 1, Delay 2 (pulse to pulse) and pulse duration. In tetanic mode you can set Delay 1, Delay 2 (first pulse to train), Delay 3 (train to last pulse) and pulse duration. You can also set the tetanic duration which is the length of all the pulses in the train, and the interval which is the spacing of pulses within the train.
- The image above and left shows the stimulator in tetanic mode. The length of each colored line on the drawing corresponds to the setting on the similarly colored control.



Histogram Generator

- The histogram generator takes files stored by Stimscope and performs two operations on them. First it computes an amplitude histogram of all spikes, then bins the spikes by amplitude and produces a spike-interval histogram. The GUI consists of three plotting axes and their related controls. The three plots:
 - Raw data is plotted at the top. The **only control** which is active initially is the **Load** button. Use the dialog box to select a file saved from Stimscope. The test file shown contains two simulated units. The small amplitude unit fires about twice as often as the bigger unit. About 200 spikes were expected for the smaller unit and about 100 for the larger unit. The 7 larger units are summation artifacts. Once data is loaded, you can pick a channel to analyze. **Expand T** and **Reset T** buttons enable zooming and panning. Zooming is performed by click-dragging the mouse over the region of interest. Panning is performed by a slider which appears when time is expanded. The **Invert** button flips the sign input data. There are two slider controls below the raw data window. The left control sets a beginning analysis cutoff time. The right control sets an ending analysis cutoff time. The **Audio** button plays the waveform through the sound card.
 - When you click the **Compute** button, an amplitude histogram of the spikes is plotted at the lower left and a group of binned spike interval histograms are plotted at the lower right. A separate histogram is plotted for each active amplitude bin. A legend is added to the lower-right plot which gives the average ISI and number of action potentials in each active amplitude bin.
 - The number of amplitude bins chosen activates the corresponding number of **Set Window Thresholds** buttons. When a window threshold button is selected, the window's lower edge amplitude value may be set. The top edge of the highest window is the maximum amplitude spike detected.
 - If you want more resolution in either voltage or interval on either histogram, you can change the number of bars. The Matlab figure zoom control allows you to expand a portion of any plot. The lower-right plot in the example at the top of the page has been zoomed for clarity.
 - The **1/ISI vs T** button opens a separate window with a plot of 'instantaneous frequency' vs time for each of the windowed spike trains. You have to push the **Compute** button *before* you use this feature. See example to the left.
 - The **exportXL** button exports the instantaneous frequency vs time data to an Excel spreadsheet. You have to push the **Compute** button *before* you use this feature.