**Introduction:**

Oscillogoat is an advanced digital oscilloscope with data processing capability. It is designed to be used anywhere an audio frequency signal is found. This application can also be used extensively to study AC (alternating current) electronics as well as transistor circuits and operational amplifiers. Electronics theory is much better learned when the actual circuits are built and tested. This storage oscilloscope is designed to be affordable. But is also advanced enoght to be used in professionals. Oscillogoat was built to be used in a variety of situations including physics and electro-physiology labs. One of the first uses of this program was to remove baseline currents and identify individual ion channel currents in cardiac cell recordings.

There are four buffers that will store up to 10000 32 bit real numbers each. The program fills these buffers with data from the analog to digital converter that resides on the sound card. The program then allows real time display of the data is one of five modes. These modes are 1, single channel. 2, Dual channel. 3, X-Y mode. 4, Color spectrogram. 5. Spectrum magnitude and phase. The program then allows for processing and display of each buffer independently. The buffers can also be played back through the computers speakers.

The data produced by this program is compatible with Microsoft Excel as well as Lotus and a number of text based programs and editors. The graphs (including spectrogram) can be edited and/or printed in both color and black and white using Microsoft Word or Image Forge by Cursor Arts. Image Forge has a free fully functional trial download version. See

http://www.cursorarts.com/ca.download.html. Oscillogoat will store the data on a disk using compressed RL1 type files or it will use standard text files PRN type (same as TXT type). The data produced by Oscillogoat can also be used by Mathematica and Matlab. The data can also be converted to any of over seventy-five other types using Omniformat, a free program. See http://www.omniformat.com.

The current version of Oscillogoat works with Creative Sounblaster 16 (SB 16) and compatible soundcards. These are the ISA type cards found in many computers. To find out what kind of sound card is in any given computer, in windows, go to control panel; system; device manager;sound, video and game controllers. To find out if your system is ISA compatible in order to add a SB 16 compatible sound card, go to control panel; system; device manager; system devices and see if ISA hardware is on the host computer.

The program uses the line in input WITH THE VOLUME AS SET BY THE MIXER PROGRAM THAT COMES WITH YOUR COMPUTER SET TO MAXIMUM. This gives a full scale range of -0.5 to 0.5 volts. The mic input can be used with the proper pre-amp gain entered. The gain of the mic channels can be determined with a simple voltage source. The gain of the mic channels can then be typed in to Oscillogoat for permanent use. The gain of any other preamplifier can also be programmed.

**F1 Scope function:** This is the real-time data display and spectrogram. The full-scale voltage of the scope is from -0.5 to 0.5 volts. If a pre-amplifier is used, simply set the channel gain to the gain of the

pre-amplifier using the f9 setup function. The channel one (left channel) and the channel two (right channel) gain can be set separately by the F9 setup function. The dual trace and X-Y mode use second (righr) channel.

**Keys for all scope functions:**

'g' or 'G' (graph type) causes the program to go from single trace to dual trace to x-y mode to spectrogram to spectrum and then back again to single trace. Single trace is the left input (channel 1) of the sound card. Dual trace puts the left channel (channel 1) on the upper trace and the left channel (channel 2) on the trace. In X-Y mode the left channel (channel 1) is the X-axis. the right channel (channel 2) is the Y-axis. All modes will run from 5000 to 44000 samples per second. Use the setup function (F9) to set the starting sample rate and many other initial values.

The following keys pressed will cause the the assosiated functions to be prerformed when in scope mode.

'r' or 'R' sets the sample rate. Acceptable rates are 5000 to 44000 samples per second.

's' or 'S' toggles multi-trace vs. single shot. Any key will, in conjunction with the proper trigger, start a trace in single-shot mode. In multi-trace mode, each trace only requires the trigger to be applied. Free run mode can be selected and no trigger is needed.

'i' or 'I', 'e' or 'E' and 'f' or 'F' control the trigger modes.

'i' or 'I' is for internal trigger. In this mode, the trigger comes from the left channel (channel 1). The trigger value is a level from zero to 255. The value of 127 is the default and this corresponds to a zero voltage input from the AC coupled sound card.

'e' or 'E' is for external trigger mode. The external trigger is a signal that is applied to the serial port. To cause a simple external trigger the pin 8 of the 9-pin serial connector must go momentarily to 12V with respect to ground (pin 5). Alternatively pin 8 may contact pin 4, thus momentarily applying the 12 volt signal.

'f' or 'F' is the free run mode. In this mode, no trigger is needed to cause a trace to be made.

With internal and external triggering, hitting any key will bypass the trigger one time. This prevents possible lock up and allows for troubleshooting in cases when the proper trigger signal is not being properly applied.

'b' or 'B' sets the buffer size. Simply enter the desired buffer size. For FFT functions which include the spectrogram and spectrum analyzer , the buffer size, which is the FFT length should be a multiple of two for proper operation. The program will automatically set the blocklength to a proper value.

'a' or 'A' toggles the auto scale function. In the single trace mode,

dual trace mode, and spectrum analyzer mode the Y axis (channel one) is automatically set to properly display the data. In X-Y mode the X-axis is also automatically scaled.

'x' or 'X' returns Oscillogoat to the main menu.

Arrow Keys control the X and Y-axis of of all modes  The arrow keys cause the appropriate doubling or halfing of an axis.

**The following are spectrogram sub-functions:**

'c' or'C' controls the cunk size that the spectrogram input data is broken into.  The chunk size is the fft lenght of the spectogram and determines the frequency resolution of the spectrogram.

'w' or 'W' allows the selection of the windowing function.
Zero is for no window, 1 is for a hamming window, 2 is for a hanning window.

't' or 'T' allows for the selection of threshold method.
1, is for unity. 2, is for 1/n  3, is for 1/log(n).

The 'p' or 'P' toggle controls the whetheror not the phase portion of the spectrogram will be plotted.

**F2 Draw function:** Plots data in a buffer.
When prompted, enter the buffer to be displayed.  If the data is from

the oscilloscope function, buffer one will contain the last buffer that was input from the sound card. Buffer two will contain the second to last data set. Buffer three, if used, will contain the third from last data set and buffer four, if used, will contain the fourth from last data set. A red box will then be displayed on the screen. The box determines which quadrants on the screen that the graph will be displayed on. Use the arrow keys to manipulate the red box, then press enter to display the data.

**F3 Zoom function:** Zooms in on data graphed by the F2 Draw function.
TO ZOOM, THE DATA FROM THE SCOPE FUNCTION MUST FIRST BE REDRAWN WITH THE F2, DRAW FUNCTION.
Use the arrow keys move the red box to select the plotted graph that will be zoomed in on. Press enter. Use the left and right arrow keys to move the red, left, region select line. Ctrl. arrow moves the region select line by ten points. Alt. arrow moves the region select by one hundred points. To shift between the right and left region select lines, press F1. If one region select line crosses the other, the software will still zoom in on the data correctly. When the desired region is selected, press 'q' or 'Q' to draw the data. This zoom function does not affect data in the buffer so that the original data can be re-drawn using the F2 Draw function.

**F4 Process function:** Go to the processing sub-function.
For all of these processes, the resulting data my be plotted using the F2 draw function. Any of the other program functions may also be done on the resulting processed buffer, allowing for multiple processing.
F1 Return: Return to the main menu.
F2 Differentiate. Calculates the derivative dy/dt of a buffer's data.

The derivative is the slope or tangent of the wave at any given point.

**F3 Average:** Calculates the average of the data.

If the whole buffer is to be average press 't' or 'T'. The average of the whole buffer will then be displayed. Hit any key to remove the displayed average and return to the main menu. If it is not whished to average the whole buffer press 'f' or 'F'. If a region of a displayed wave is to be averaged press 't' or 'T' when prompted. Use the arrow keys to select which displayed wave is to have a region averaged. Use the arrow keys to move the red lines to select the region to be averaged. The F1 key determines whether the right or left region select line is to be moved. Hit 'q' or 'Q' to display the result. Hit any key to remove the displayed average and return to the main menu.

**F4 Algebraic:** Ads, subtracts, multiplies or divides buffer point by point with another buffer or buffer with constant.

Select which operation is to be done (add, subtract, multiply or divide) using the 't' or 'T' and 'f' or 'F' keys. Select buffer to buffer or constant to buffer mode using the 't' or 'T' and 'f' or 'F' keys. If a buffer with buffer process is selected, the data must be in buffer one and two. The results are stored in buffer one. If a buffer is processed with a constant, enter the constant and then select which buffer is to be processed with the constant. The result will be in the buffer with the original data.

**F5 Condense:** Condenses the data by a certain number of points.

This function is implemented to cut down on the amount of data that is generated. Enter which buffer is to be condensed. Then enter how many points the data is to be condensed by. The result will have only every n'th point in the buffer. If the value is ten, every tenth point will be stored in the resulting buffer.

**F7 Limit:** Clips the signal above or below a certain threshold.
Enter the threshold to be used. Enter the buffer to be limited.
Indicate whether the function will limit above or below the threshold.
If this function limits below, the result is much like a full wave
rectifier circuit. If the function limits above, the result contains
all points whose absolute value is above a certain threshold remaining
the same. The data with the absolute value below the threshold is
set to plus or minus the threshold. The limit above function was used
in the baseline removal and filtering of cardiac single ion channel
currents.
F6: Integrate.
Simply enter the number of the buffer that is to be integrated.

**F5 FFT:** Calculates the fast Fourier transform of the data.
Enter the buffer number that is going to be FFT'd. Determine whether
or not a forward or reverse transform is to be computed. A forward
FFT converts from time to frequency. A reverse FFT converts from
frequency to time. If the transform is forward, a window can be
implemented. A window is one form of spectral smoothing of the
data so that the sudden start of data at the beginning of the
buffer and the sudden end of data at the end of the buffer do not cause
erroneous results. The type of window, Hamming, Hanning, or none
is determined by the setup function.

**F6 Store:** Stores data to a disk.
Indicate whether an entire buffer or a displayed graph's data is to be
stored using the 't' anf 'f' keys. If a whole buffer is to be stored,
type in the buffer number. If a displayed wave is to be stored, use
the Draw (F2) and Zoom (F3) functions to first display the data to

be stored. Use the arrow keys to select which displayed graph is to be stored. Hit enter when the red box is arround the desired graph. For displayed wave or buffer store, next type in the file name the data will be stored in. Make sure the disk and directory is specified along with the file name and proper extension as is for DOS convention. For example a:\data\current.rl1 will write on the floppy disk in directory 'data' the file CURRENT.rl1. The file extension is RL1 for compressed data files and PRN is for text files. PRN files can be used in Microsoft Excel, Lotus and a number of other text based programs and editors. Mathamatica and Matlab can also use these text files. USE THE F9 SETUP FUNCTION TO DETERMINE WHAT KIND OF FILE IS BEING WORKED WITH, RL1 OR PRN. Use the DOS directory function to display the existing data files. To get a listing of text (PRN) files, for example, type 'DIR *.PRN' at the DOS prompt.

**F7 Retrieve:** Loads data from a disk into the program buffer. Enter the file name. Make sure the file name has the proper DOS format including the .RL1 or .PRN extension. USE THE F9 SETUP FUNCTION TO DETERMINE WHAT KIND OF FILE IS BEING WORKED WITH, RL1 OR PRN. Use the DOS directory function to display the existing data files. To get a listing of compressed data (RL1) files, for example, type 'DIR *.RL1' at the DOS prompt.

**F8 Reverse:** Causes a negative image to be displayed for proper printing in conjunction with Microsoft Word or Cursor Arts Image Forge. The F8 key toggles between the positive and negative images. If this were not done, small white dots would be plotted on a black background. This does not produce very clear images and uses up the black ink cartridge. See 'Oscillogoat use with other programs',

at the end of the instructions, to learn how to print a display.

**F9 Setup:** Sets program values for use by Oscillogoat.
Starting sample rate tells the scope function what rate the analog
to digital converter should start sampling at. Acceptable rates
are from 5000 to 44000 samples per second.

Starting buffer size is the starting size of the buffers the program uses.
The buffer size should be a multiple of two for correct functioning of the F5 FFT function
as well as the internal FFT used in the spectrum analyzer application.
The resolution in the FFT is equal to the 1/2 the sample rate divided by
the buffer size.

Channel one pre-amplifier gain is the gain of channel one. (The left
channel). This value is the gain that any pre-amplifier gives to the
data. If an amplifier has a gain of ten million, simply set this value
to 10000000 and the data will be properly displayed. Remember that the
final input to the analog to digital converter should be in the range of
-0.5 to 0.5 volts. Channel one gain is used for the single trace mode and
for the upper plot in the dual trace mode and the Y-axis of the X-Y mode
trace. Channel one gain is also used by the spectrogram sub-
function.

Channel two pre-amplifier gain is the gain of channel two. See the
above paragraph on channel one pre-amplifier gain. Channel two
pre-amp gain is used for the lower trace in dual trace mode and
for the X axis on the X-Y trace mode.

Spectrogram chunk size is the size that the data is broken into
in the spectrogram sub-function. This value determines the time
resolution of the spectrogram. For example if sample rate is set to
10000 samples per second and chunk length is 32, the resolution of
the display will be one half of ten thousand divided by 32.
The chunk size should be a power of two and will be forced to a power
of two by the program.

Number of x-axis ticks is the number of ticks and corresponding x-axis
labels that are drawn on all graphs throughout this program.

Number of y-axis ticks is the number of ticks and corresponding y-axis
labels that are drawn on all graphs throughout this program.

RL1 file or PRN file determines whether or not compressed data (RL1)
files are used or if text (PRN) files are used. RL1 files were added
to cut down on the amount of data that is stored to disk. PRN files
are text files that can be used with a number of text based programs.
and editors.

Grids will be drawn specifies whether or not grids are drawn on graphs
throughout this program.

Axis label is the label that is put on the x or y axis of the plots.
The x-axis label also has sample rate added to the text.
The y-axis label is sometimes changed to reflect the origin of the
data. If the data was input from a file, the file name will be shown.
If the buffer is the result of a buffer-to-buffer process this will
be reflected.

Number of arrays is the number of buffers the application uses. Two or four. The program in general uses four buffers unless there is not enough memory. If the program determines there is not enough memory, it will try to use two buffers.

IRQ number is the interrupt number. It is usually 5. To find out what IRQ number to use enter DOS and type 'SET'. Look at the BLASTER line. The number next to the letter 'I' is the IRQ number.

DMA number is the direct memory access number. It is also usually 5. To find out what number to use enter DOS and type 'SET'. Look at the BLASTER line. The number next to the letter 'H' is the DMA number.

Graphics mode. This is a number that the graphics subsystem uses. It is usually 6 but can be 4 on some machines. If this number is correct, the first menu will be displayed correctly along the bottom of the screen shortly after start up.

Store as permanent defaults. This is a true or false value that will send the default file to the current directory if true. If False is selected the just typed in values will be used for the current program session only.

**F10 Play:** Plays back buffers to the speaker.
Enter which buffer is to be played. If zero is selected, all four buffers will be played. Buffer four will be played first and buffer one will be played last. Enter the percent volume to be played back.

**F11 Exit:** Exits the program and returns control to DOS.

**Oscillogoat use with other programs:**

To use the data from this program with other text based program such as Excel or Lotus or a text editor, the data must be stored as text (PRN) type. This is true as well when Mathematica or Matlab use the data.
Use the F9 setup function to make sure that PRN type has been selected.
Use the DOS command 'DIR *.PRN' to locate the text files in the current directory.
To print the data displayed with Oscillogoat, hit the print screen to send the entire screen to the paste buffer. Press Alt-space or Alt-enter to get to a windows environment. Start the desired editing program such as Word or Image Forge. Select edit-paste. The graph will then be placed in in the program for editing or printing. See the specific editor instructions for more things that can be done with Oscillogoat's output.

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