Digital Oscilloscope 2.1
Display and Analysis of Waveform Patterns

1. Welcome to Digital Oscilloscope

This software oscilloscope enables you to use your Macintosh as an oscilloscope and as a frequency meter. To run this application, you need sound input hardware and an appropriate sound driver, Systems Software 7.0 or later, and one megabyte of RAM. Version 2.1 supports two-channel sound input, 16-bit amplitude resolution, and color traces.

Digital Oscilloscope 2.1 is freeware. If you are using this software you should not forget to give me a feedback about your use of the program. Send your comments, suggestions, and bug reports to:

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1.1 Introduction

Oscilloscopes and frequency meters are some commonly used instruments in electronic engineering. If you intend to use such instruments in the audible spectrum, there is a good reason to consider using your Macintosh together with this application.

Oscilloscopes permit a visual examination of electrical phenomena. Usually, they display the amplitude of a signal as a function of time. An important feature common to all oscilloscopes is the triggering mechanism. The trigger is used to determine at what time the display of the signal has to start. The triggering feature is especially useful for the examination of periodic electrical phenomena, which take place too fast for the eye to follow. In addition, the oscilloscope may be used to study any variable that can be converted into electrical potentials.

For periodic phenomena, the number of cycles that occur over a given time period is of major interest. This is the primary use of the frequency meter.

1.2 Requirements

Every Macintosh that is equipped with sound input hardware and an associated driver will be able to run this application. Digital Oscilloscope requires Systems Software 7.0 or later. A math coprocessor is not required.

Unless your Macintosh doesn't have a built-in microphone or CD player, you need to plug in an external source (e. g., a wave generator, a tape recorder) to the microphone or line jack. Make sure that the sound source provides the appropriate input level.

1.3 Installation

If you have already used a previous version of Digital Oscilloscope, you should first throw the old preferences file in the trash. Digital Oscilloscope puts a new preferences file into the system's preferences folder in order to save your settings. The required memory partition of one megabyte is enough to use the oscilloscope, the frequency meter, and to hold a couple of screen shots. To start just double-click the application.

1.4 Known Problems

Users of Powerbooks with built-in microphones may encounter the problem that the hard disk repeatedly spins up and down. Spinning down the hard disc is a system feature probably intended to prevent the internal microphone from picking up disc noise. The only way to go around this problem so far is to attach an external source *before* you start the oscilloscope.

Changing the color depth from the Monitor Control Panel may cause the oscilloscope to draw incorrectly. To avoid this, close the oscilloscope window before you change the monitor settings.

2 Getting started

After starting-up, select **Input Device** from the **Options** menu. The dialog presents a list of all available sound input devices. Depending on the sound driver you are using and the capabilities of your sound input device, an **Options** dialog will be available.

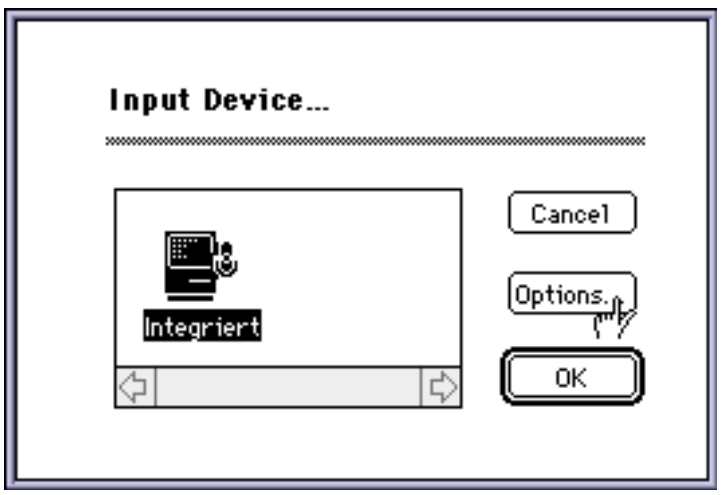

Figure 1 Selecting the input device

After you have selected a sound input device, choose **Calibration** from the **Options** menu. This setting tells the oscilloscope which voltage corresponds to the maximum peak-to-peak input signal. If you do not know this value, just leave the default untouched. Note that this value does not change the level of the signal in any way. Depending on the machine you are running the maximum peak-to-peak input voltage may be as little as 4 millivolts, or as high as 2 volts.

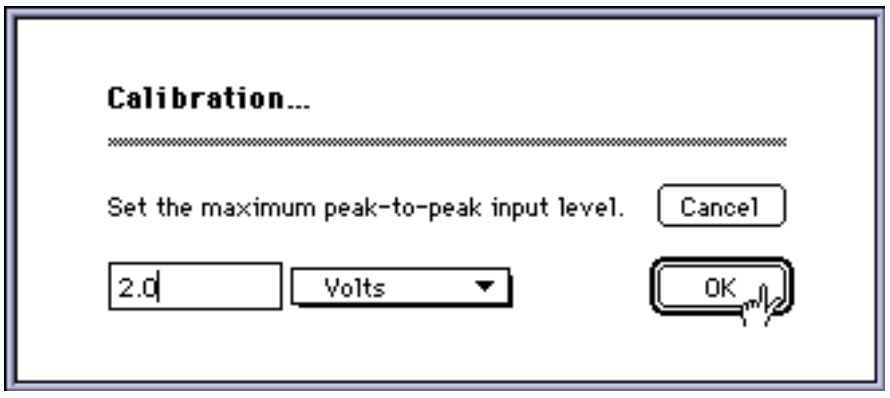

Figure 2 Calibration of the input signal

You can adjust the play-through volume with the slider in the volume dialog. Choose **Volume** from the **Options** menu.

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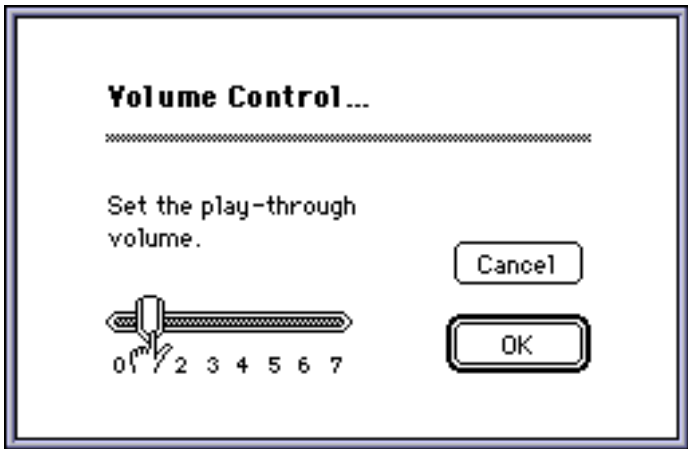

Figure 3 Adjusting the play-through volume

Now choose **Oscilloscope** or **Frequency Meter** from the **Tools** menu.

3 The Oscilloscope

After having chosen **Oscilloscope** from the **Tools** menu, the oscilloscope window should look something like the figure below. You probably won't find out that the screen shows a small sequence from one of Haydn's piano trios.

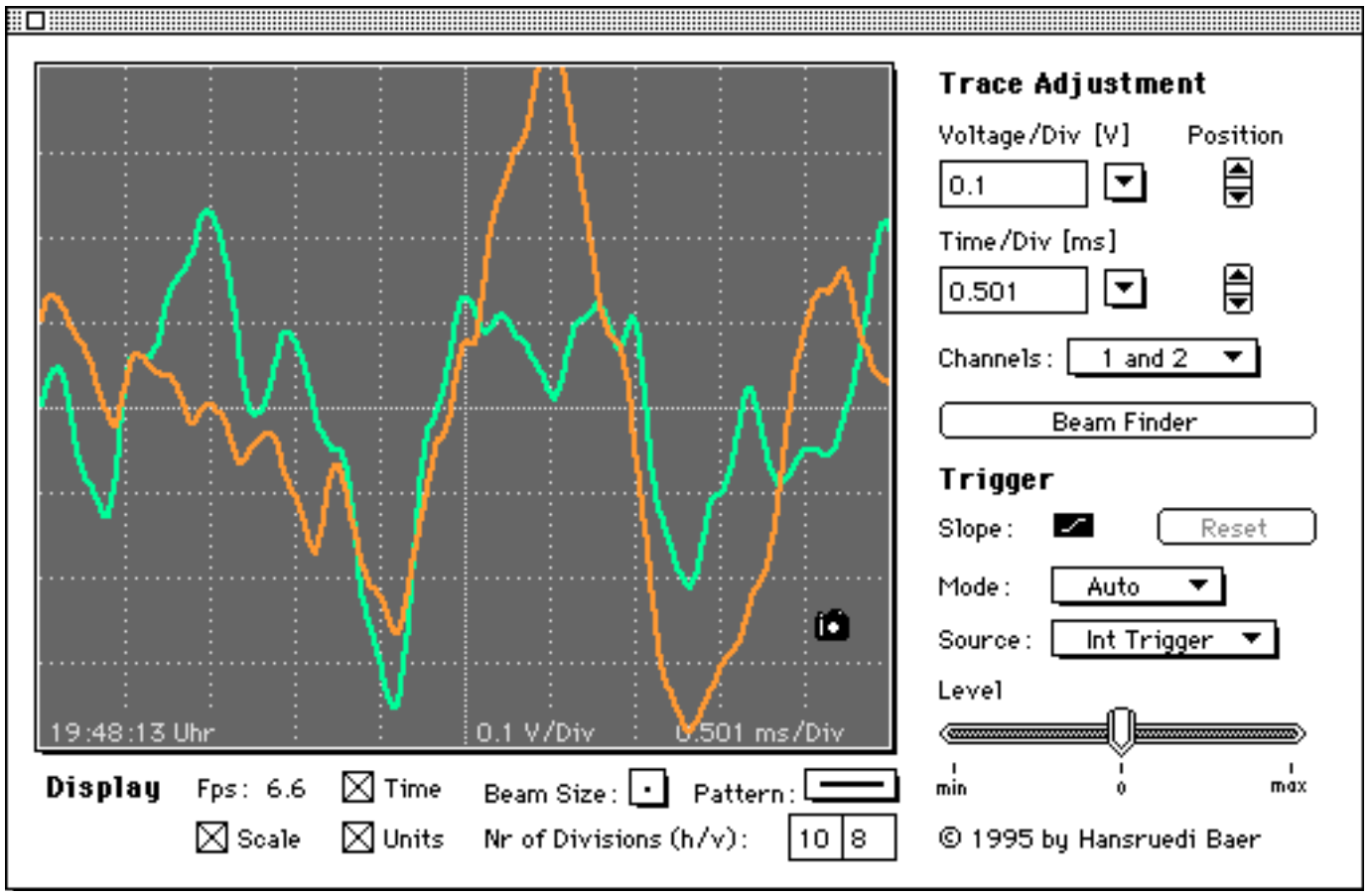

Figure 4 The oscilloscope window

If you do not see any trace, choose **Auto** from the **Mode** pop-up menu, choose a channel from the **Channels** pop-up menu, and push the **Beam Finder** button. Additionally, check the color settings (menu item **Colors...** in the **Options** menu). If your trace is just a straight line, there is apparently no input signal. The next section describes the features of the oscilloscope in details.

3.1 Trace Adjustment

3.1.1 Voltage per Division

You can set the voltage per division. This feature enables you to scale the amplitude of the trace and it facilitates reading the voltage of a signal on the screen. Keep in mind that the amplitude of the trace depends on the calibration and scale settings. The value for the voltage per division must be between 0.001 and 10,000. The pop-up menu provides some useful values.

3.1.2 Time per Division

You can set the time per division in milliseconds. This feature scales the trace along the time axis. You will also be able to estimate the duration of a signal or its frequency. The value for the time per division must be between 0.01 and 100 milliseconds. Be aware that when using large values for time per division, you are likely to get an alias of the original signal that shows a lower frequency.

3.1.3 Position

Use the position button to change the position of the trace. For one-channel sound input devices, the second button will be disabled. The position button comprises three functions: moving the trace up or down, or centre it on the screen. To speed up scrolling, hold down the shift key.
If you have a two-channel input device, the position buttons will be enabled according to the channels settings. You can display two traces simultaneously and position the traces independently.

3.1.4 Channels

If your sound input device supports two channels, you can trace two signals simultaneously, or you can mix the channels. For one-channel devices only channel 1 will be available. Note that adding or subtracting channels may cause an overflow. In this case you have to lower the input level.

3.1.5 Beam Finder

The beam finder helps you find the trace and reasonably scale it on the screen. This feature is especially useful if the beam is off the screen. The beam finder affects the parameters for the voltage per division, the time per division, and the position. The trace will be scaled so that you will see about 3 to 4 cycles with an amplitude of about 75% of the screen height. Hold down the shift key to retain the current position.

3.2 Trigger

The trigger determines the start of the trace on the screen. It prevents periodic signals from shifting on the screen, or it can retain certain signals. The trigger can be manipulated in a number of ways, as will be shown in the following sections.

3.2.1 Slope

The triggering slope determines if the trace starts on the increasing or decreasing edge of the signal. Push the slope button to change between positive and negative slope.

3.2.2 Mode

You can set the trigger mode to auto, normal, or single. In **Auto** mode, the trace will be drawn, even if there is no trigger signal. If you select **Normal** mode, the trace is only drawn if a trigger signal can be detected. **Single** mode is restricted to a single trace. You have to push the **Reset** button to get a new trace. If you don't get any

trace, you have to change the trigger level with the slider or increase the level of the input signal.

3.2.3 Level

The trigger level determines the signal level that triggers the trace. You can set the trigger level with the level slider.

3.2.4 Source

For one-channel sound input devices only internal trigger or no trigger can be used. **Internal Trigger** creates a trigger signal from the signal itself. If your sound input device supports multiple channel and you choose **External Trigger**, you must provide a trigger signal in the other channel. Also, you can use the second channel as **External Sweep**. Thus, you will be able to create x-y-plots and draw Lissajous figures.[1]

3.3 Display

You can manipulate the oscilloscope's screen in a number of ways. You can draw a scale on the screen and set the number of vertical and horizontal divisions. The number must be between 2 and 40 for horizontal, and between 2 and 32 for vertical divisions. The time stamp and the voltage and time per division at the bottom of the screen are particularly useful if you save the screen for later analysis. Beam size and pattern are the counterparts of focus and intensity on traditional oscilloscopes. Watch the value for the number of frames per second (fps). You will notice that this value depends on various settings such as time per division, beam size, pattern, and also the settings of the color depth of the monitor. See section 3.5 for setting the oscilloscope's screen colors.

3.4 Saving Documents

When you move the cursor over the oscilloscope's screen, you will notice that the cursor's shape changes to a camera symbol. Clicking on the screen will copy the screen's image and paste it into a new window. You can write the saved screen to a file by using the **Save** or **Save As** command. You can also use the clipboard to import the screen pictures or amplitude tables into a graphics program or a text editor.

There are three kind of documents, Digital Oscilloscope can produce. Choose **Output Options** from the **Options** menu to select the kind of document you want.

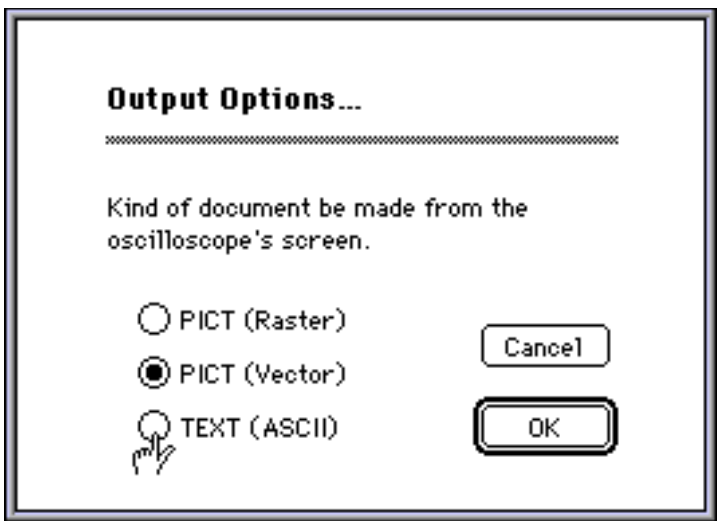

Figure 5 The output options dialog

PICT (Bitmap) produces a bitmap of the oscilloscope's screen. If you want to edit the oscillogram in a drawing program later, choose PICT (Vector). This is also the most compact representation. TEXT (ASCII) creates a table of the amplitude values of the input signal. By the way, the amplitude values in the ASCII output reflect the setting of the calibration.

3.5 Setting Colors

[1] 1. This feature is still in an experimental stage and may possibly lead to unpredictable results.

Choose **Colors…** from the menu **Options** to change the color settings of the oscilloscope's screen. You can change the color of the traces for each channel, the color of the scale, the date and units information,

and the screen itself. To change the colors, click into the color box. The system's color wheel will then be presented.

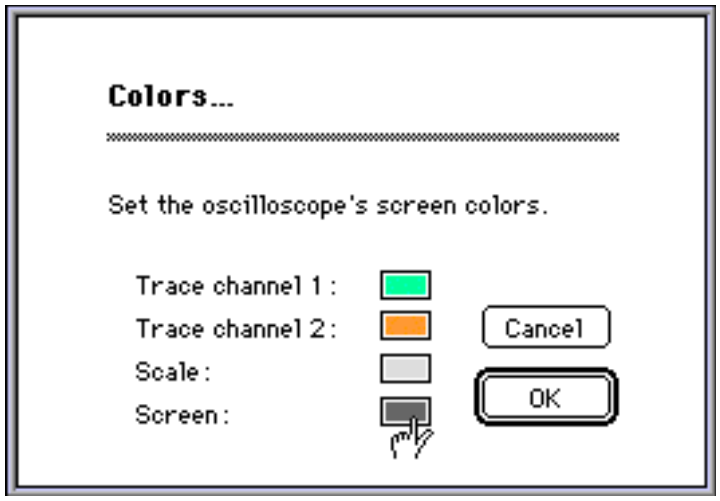

Figure 6 The color settings dialog

The oscilloscope will use the monitor's color depth. Working with 24-bit color depth will need considerably more memory, and the speed will possibly slow down. Also, pictures saved as pixel maps will use the monitor's color depth. To retain the colors for pictures created on black-and-white monitors use the *Vector Mode* from the **Output Options.**

3.6 Limitations

Due to the given sampling rate of the sound input device, the manageable bandwidth of this oscilloscope is limited to about 10 to 20 kHz. Only alternating voltage can be displayed, since the AD-converter does normally not convert direct voltage. Additionally, the input level is limited to a relatively small range. In many cases you will probably have to connect a kind of attenuator or amplifier between the signal source and the Macintosh. Digital Oscilloscope automatically chooses the highest available sample rate and sample size.

Note that text output does not respect time scaling, that is, each sample will be printed. Large values for time per division tend to large amplitude tables. Text output will be truncated to about 1000 records. This is due to the Macintosh's TextEdit limitation.

4 The Frequency Meter

Since version 1.3.0, Digital Oscilloscope also includes a frequency meter. To open the frequency meter, choose **Frequency Meter** from the **Tools** menu. You should now see something like this:

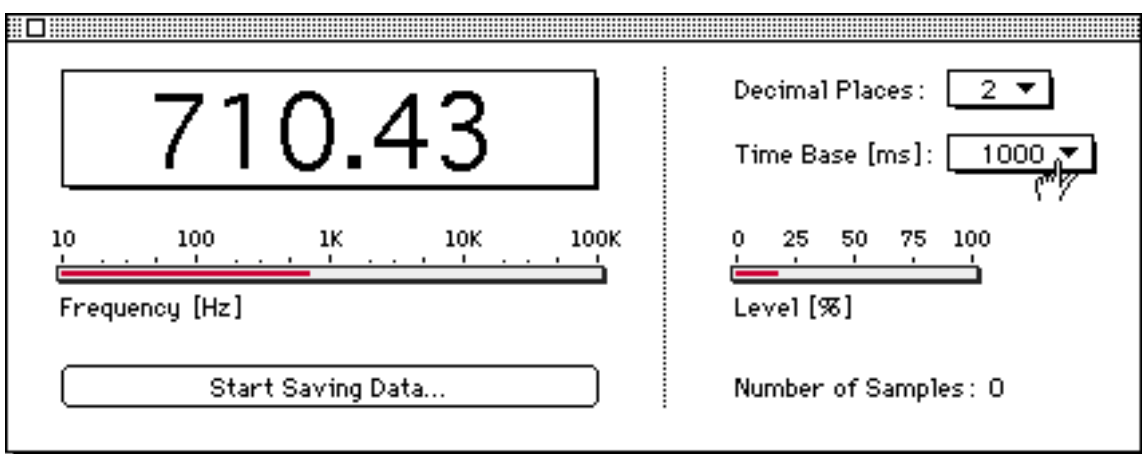

Figure 7 The frequency meter window

4.1 Time Base

The time base determines the number of milliseconds during which the number of cycles of the input signal will be evaluated. Small values lead to shorter measurement cycles, large value to better accuracy. Keep in mind that during the measuring cycle interactions are disabled. You will probably notice a slight delay on your actions, which depends on the duration of the chosen time base. You will be warned if the signal level is too low to reliably determine the frequency.

4.2 Decimal Places

You can set the number of decimal places between zero and four. This setting will affect both, the display of the current frequency and the saved output.

4.3 Saving Data

For monitoring and analyzing frequency and level of your signals over longer periods you can send the data to a file. The standard file dialog will be presented when you click on the button labelled «Start Saving Data…». The button's label changes then to «Stop Saving Data…», and the number of samples written to the file will be displayed. To stop writing to the file push the button again. The data will be written in a simple text format.

4.4 Accuracy

A proper input signal is required to guarantee a reliable measurement. The accuracy is given by the chosen time base, the sample rate, and the precision of the internal clock. Note that in case of missing or low signal level the meter shows a value of zero.

5 Acknowledgements

I'm very thankful for the many ideas, suggestions, and bug reports I got since the first publication of this program. The «About» window has kindly been created by Hans Krenn, Basel (Switzerland).

6 Disclaimer

Zurich, July 29, 1995
Hansruedi Baer