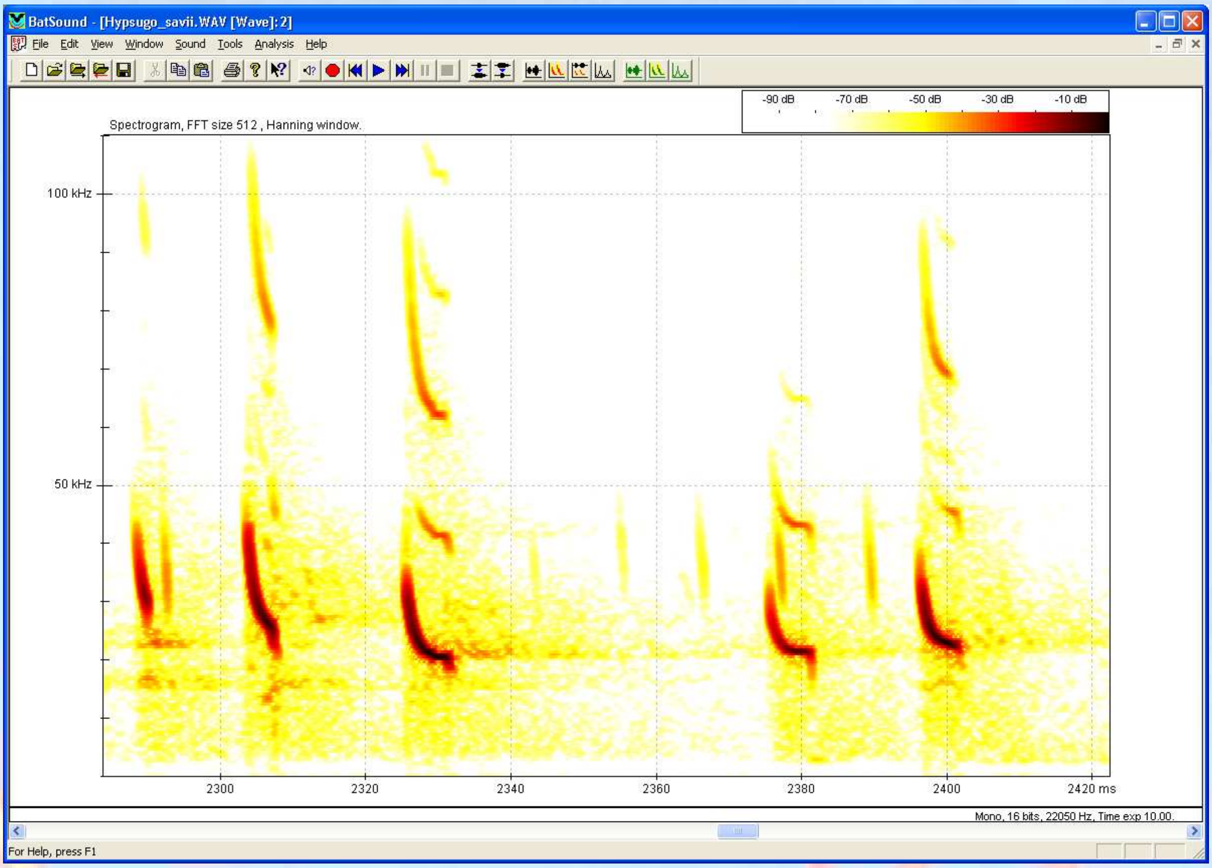
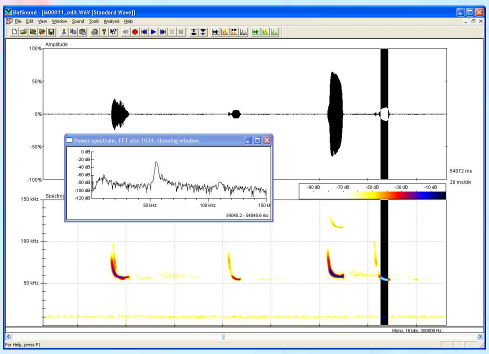
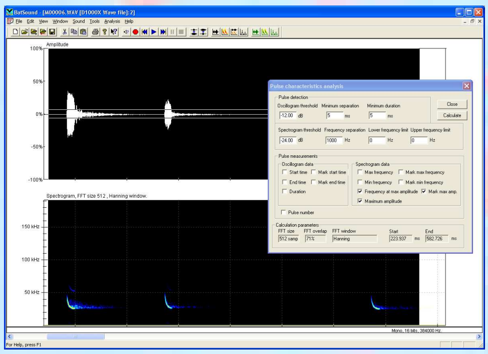
BatSound®

Real-time spectrogram sound analysis software

Version 4.4







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Version 4.4, November 2016

1. Introduction

Welcome to the world of advanced sound analysis!

With BatSound you can record, play back, edit and analyze sound on your computer. The advanced recording feature allows simultaneous storage of the sound on the hard disk and real-time display of the spectrogram and/or oscillogram of the signal.

For the analysis of bat calls, time expanded recordings or recordings made with a high-speed recorder (such as the D500X or D1000X detectors) should be used in order to take full advantage of BatSound. Recordings made from a heterodyne bat detector are usually not suitable for sound analysis.

Some of the BatSound features are:

- Real-time spectrogram
- Direct hard disk recording of signals
- Power spectrum
- Pulse Interval analysis
- Pulse Length analysis
- Sound editor including advanced time domain filtering
- Uses standard sound card for sound input/output
- Virtual bat detector mode
- Sound-activated, automatic recording mode
- Automatic calculation of important pulse characteristics (duration, min/max frequency etc.)

On the BatSound program CD (or other storage media), you will find the file readme.txt, containing the latest information and changes not yet available at the time of printing of this manual. Pettersson Elektronik's web page, www.batsound.com, may also provide more recent information about the software.

2. Getting Started

System requirements

The minimum system requirements for BatSound are:

- An Intel/AMD 1 GHz computer or better
- RAM: 1 GB minimum (more may be required depending on the Windows version)
- A Windows compatible sound card
- >10 GB free hard disk space
- Windows 7, Windows 8 or Windows 10 operating system
- Microsoft Visual C++ 2015 Redistributable (x86). If it is not already installed on your computer, it can be downloaded from:

  https://www.microsoft.com/en-us/download/details.aspx?id=48145

  If you have a 64 bits Windows version, Microsoft Visual C++ 2015 Redistributable (x64) also must be installed on your computer.

The speed of the computer, its hard disk and graphics card affect the performance of the program. The real-time spectrogram display requires high system performance, as does the virtual bat detector .

Checking the sound card

A Windows compatible sound card is required for input of sound into BatSound. The sound card has to be installed and configured before you run BatSound. Please refer to the instructions accompanying your sound card and computer for information on how to install and configure the sound card.

The sound card and related software is not a part of the BatSound package. Please refer any questions regarding the sound card and any software accompanying this to the sound card manufacturer or distributor!

If you have not already used the sound card, you may want to perform the following tests to verify that the sound card is working as it should:

- Use the software included with the sound card to make sure you can record and play sound without problems. If necessary use the appropriate software (e.g. the Volume Control in Windows) to adjust the recording and playback levels. Please note that this software is *not a part of BatSound*, so you should refer to the documentation of your sound card and/or Windows for information about this.
- Use the Media Player application (included in Windows, and described in the Windows documentation) to play sound.

3. Installing the Software

To install BatSound, insert the BatSound Installation CD into the appropriate drive in your system. The installation process should start automatically within a few seconds. If it does not start automatically, please locate the file *Batsound4Setup.msi* on the CD, using Windows Explorer, and doubleclick on the file name to start the installation program. Follow the instructions on the screen to finish the installation.

Please note that the serial number/license code that you enter during the installation is case sensitive. It must be entered exactly as printed on the serial number label on the inner back cover of this manual. Entering the wrong serial number will result in an error message when the program is launched. If this happens, please re-install the software.

If you have received the software as a download link, the serial number/license code has been supplied separately. Please make sure to save this code for any future use.

4. Testing the program

After installation of the software, you should perform a few simple tests to verify it is working properly.

Load a sound file

The first step is to load a sound file. The file BATDEMO1.WAV was copied into your BatSound/Examples folder (directory) during installation. Choose Open from the File menu and then double-click BATDEMO1 in the file list. Make sure the selected File format is includes *.wav files and that “Open as: Automatic detection” is chosen.

After loading, the oscillogram (amplitude versus time) and spectrogram (frequency and amplitude versus time) of the opened file is displayed on the screen. If you choose the Spectrogram (oscillogram) command from the Analysis menu, only the spectrogram (oscillogram) of the signal will be shown instead.

Once you have loaded the file, you can also listen to it. Choose Play sound from the Sound menu to play the sound file through the sound card. If you wish to listen to a sound file containing a "high-speed recording" (i.e. an ultrasonic recording made with a high sampling frequency), you should use the "Play Speed" feature to reduce the play speed and obtain a time expanded playback.

Make a recording

Connect a suitable sound source to one of the inputs of your sound card (e.g. a tape recorder to the LINE input). Make sure the Windows Volume Control* is adjusted to make recording possible on the input you have chosen.

Choose New Recording from the File menu and then Record from the Sound menu to start recording. By default, the oscillogram and/or spectrogram of the signal are displayed at the same time it is recorded. The Recording status dialog box will appear on the screen. You can move this box to the desired part of the screen. Make sure the “Real time graphics” box is checked or the signal will not be displayed while the recording is made.

The recording continues until you interrupt it by clicking the Stop button in the Recording status dialog box. Click Exit to exit the Recording status dialog box.

If the above exercises were successful, then the software and hardware are most probably set up correctly.

NOTE: For information on command shortcuts, please refer to Chapter 9 of this manual.

* The name of this Windows utility may be different on your system.

5. Tutorial

In this tutorial, you will be familiarized with the most common functions in BatSound. The tutorial does not cover all functions in BatSound. For detailed information, please refer to chapters 6-9.

Using the Help function

The help function is a convenient way to find answers to your questions about BatSound if you don't have the manual available. Choose Help from the Help menu to open a pdf file of this manual.

Opening a sound file - controlling the window

To get something to analyze, first open the sound file BATDEMO1.WAV (choose Open from the File menu). The signal is displayed in the active window as an oscillogram and/or a spectrogram, depending on which selection you make in the Analysis menu (Oscillogram, Spectrogram or Combined). You can change the appearance of the diagrams in many ways, and we will now take a look at some of these.

The **main window** consists of the following:

- The graphics area, where the different diagrams are drawn
- The title bar
- The menu bar
- The toolbar
- The scrollbar
- The status bar

You can choose to **hide/show the toolbar and status bar** in the View menu. A check mark next to a menu item means that the item will be displayed on the screen. Although it is often an advantage to have access to both the toolbar and status bar, hiding one or both will make the graphics area larger, which can be desired particularly if you are using a small screen.

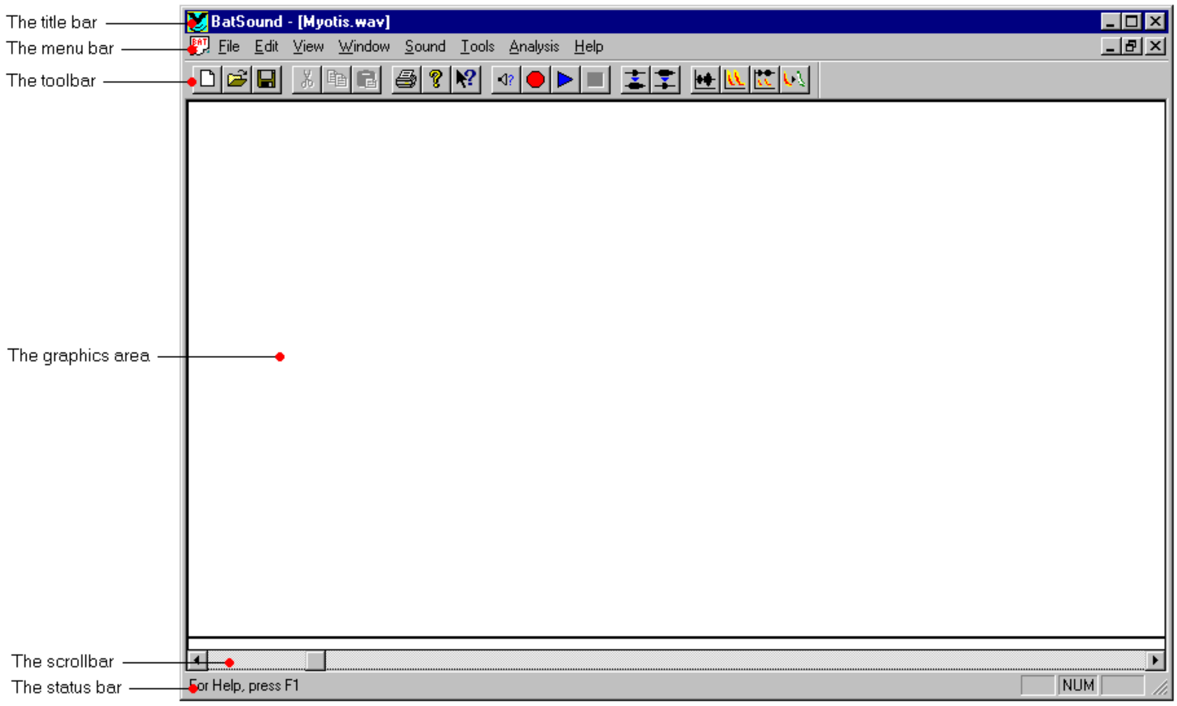


Figure 1. The BatSound main window.

The **scrollbar** at the bottom of the window can be used to scroll through the sound file. Clicking on the arrows (or pressing Ctrl + Left/Right Arrow) results in scrolling in small steps, while clicking on the bar to the left or right of the position indicator gives scrolling in larger steps.

Sometimes you may want to take a closer look at a small portion of the signal. Use the **zoom** function to achieve this. First, select the part of the signal you wish to expand. If the Marking Cursor type is used, position the marker at the beginning of the desired zoom interval, press the left mouse button down and move the marker (mouse) to the end position of the zoom interval, then release the button. The selected interval is now shown in inverse colors. Then choose Zoom In from the Tools menu to accomplish the zooming, or click the Zoom In button on the toolbar.

If the Measurement Cursor type is used, it is possible to zoom along both axes in the oscillogram as well as the spectrogram.

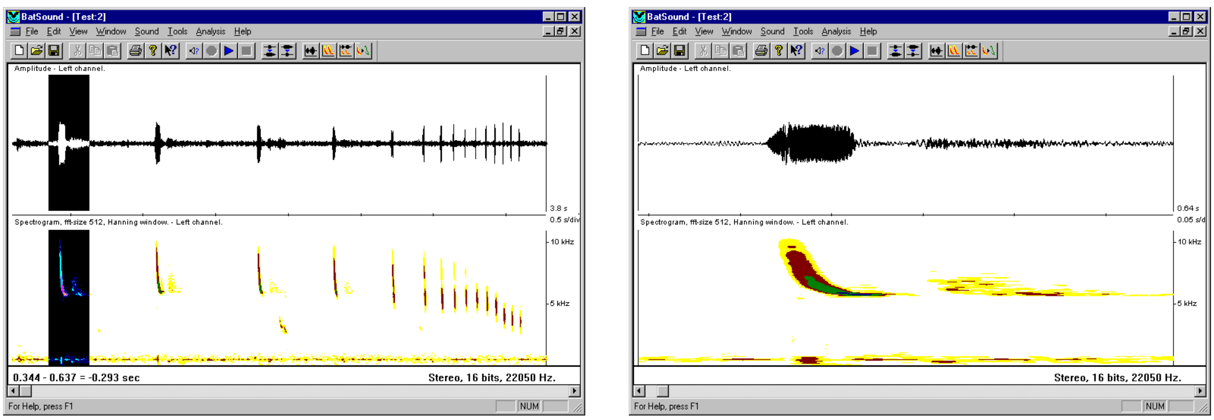


Figure 2. Zooming. The selected section (left) determines which part to zoom.

Changing the size of the window can be made in two ways.

1. Click the Maximize icon on the menu bar, which makes the sound file window as large as possible.
2. Use the mouse to drag the size bar at the lower right corner or the edges of the window to the desired size.

Comparing different signals or analysis results is easy in BatSound, since it is possible to **have many windows open at the same time**. To try this, open another sound file (e.g. BATDEMO2.WAV). When first displayed, this new signal will occupy the entire graphics area. In order to show more than one window, choose Cascade or Tile from the Window menu.

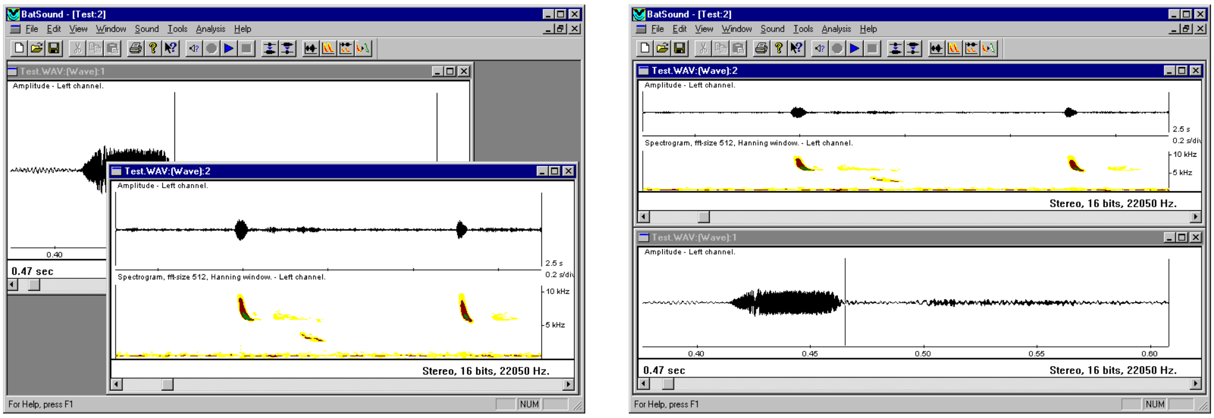


Figure 3. Displaying multiple windows. Cascade mode (left), Tile mode (right).

Playing sound

To **play a sound,** simply click the Play button in the toolbar or choose Play Sound from the Sound menu. This will cause the sound file in the active window to be played. If you have selected a section of the sound file prior to choosing Play Sound, only the selected section will be played. Otherwise, the file will be played from the current cursor position and to the end of the file. It is always possible to interrupt the playback by clicking the Stop button in the toolbar or choosing Stop Play Sound from the Sound menu.

Please note that it is possible to unintentionally make a very narrow selection (the marked interval may then look almost like the vertical cursor). The following commands may then give unexpected results, e.g. choosing Play Sound will cause an extremely small portion of the sound file to be played.

Recording sound - The real-time spectrogram

To make a new **recording of a sound**, first choose New from the File menu, which will open a new, empty window. You may want to adjust the recording parameters (sound format and display settings) before starting the recording, but if you are satisfied with the current parameter settings, all you have to do to start recording is to click the Record button in the toolbar or choose Record Sound from the Sound menu.

An automatic recording mode is also available, in which the program starts recording as soon as there is sound present (like a voice activated tape recorder). To use this mode, use the “Automatic Recording” command in the Sound menu. Please refer to chapter 9 for more detailed information.

The **sound format** (bit depth, stereo/mono, sampling frequency) is selected through the Sound Format command in the Sound menu. The selected parameters only apply to new recordings. Recordings already made, of course retain the above sound parameters. The sampling frequency, however, can be changed in an existing sound file. This should be done only in very special cases and only by experienced users.

The **time expansion** factor can also be changed in the Sound Format dialog. Normally a time expansion factor of 1 is used. However, when time expanded signals are analyzed, the time expansion factor is used to automatically adjust time and frequency values on the axes. This parameter may be changed even after a recording has been made.

Comments to describe the sound file can also be entered in the Sound Format dialog. These comments will be stored in the file, *provided it is saved in one of the BatSound File Formats*.

The **Spectrogram settings – default** command (Analysis menu) allows you to change the time axis scale and to set the spectrogram parameters for all spectrogram to come. To change the settings in an existing spectrogram, use the Spectrogram settings command in the “right mouse button” menu. In the **Oscillogram settings** dialog (Analysis menu) a few oscillogram parameters can be changed.

For more information about the real-time spectrogram, please refer to chapter 6, "The real-time spectrogram".

If a sound file is already displayed in the active window, you may also continue recording to this file. Simply click the Record button (or Record Sound in the Sound menu) to start recording. The new recording will be appended to the existing file, using the same sound format as this.

Analysis ***Please refer to Appendix A for more detailed information on the different analysis types!***

- The Power Spectrum

The Power Spectrum shows the frequency contents of the signal as signal power versus frequency. The power (Y-axis) is here given in dB relative the maximum level (0 dB). A linear power scale can also be chosen. The Power Spectrum is calculated via the FFT (Fast Fourier Transform). Choose Power Spectrum Settings to enter new parameters (FFT size, FFT window and scaling) if desired.

The power spectrum is calculated over a limited portion of the signal, so first you should select the time interval for the calculation. This can be done in two ways:

1. Mark the starting point of the interval over which you wish to calculate the power spectrum. The FFT size given under Power Spectrum Settings determines the length of the interval, which is shown in inverse colors.

2. Mark the desired time interval over which you wish to calculate the power spectrum. A number of FFTs are calculated over this interval, and then averaged before being displayed. A small overlap between successive FFTs will be used to fit the FFTs into the desired time interval.

Then choose Power Spectrum from the Analysis menu. An example of a power spectrum is given below.

By clicking the right mouse button somewhere in the Power Spectrum window, a menu is invoked from which you may choose the command Settings. This will open the Power Spectrum Settings dialog box, where you can change the settings for the Power Spectrum currently shown in the window. To select the default settings for a Power Spectrum (i.e. the settings used for all new Power Spectrum analyses), you should use the Power Spectrum Settings command *in the Analysis menu* (please refer to the Commands Overview section of this manual for more information on the settings).
The "right mouse button" menu in the Power Spectrum also allows you to print the Power Spectrum or to copy it to the clipboard.

It is also possible to display the power spectrum in the **continuous update mode**, meaning that the power spectrum is continuously updated as the power spectrum settings are changed. E.g. if you mark a new interval in the oscillogram or spectrogram (to indicate where the power spectrum should be calculated), the power spectrum will immediately be computed and displayed for the new interval.

This is particularly useful for examining how the power spectrum changes while scrolling through a spectrogram (use the arrow keys to move the cursor through the spectrogram). Note that the actual interval over which the power spectrum is calculated is always shown.

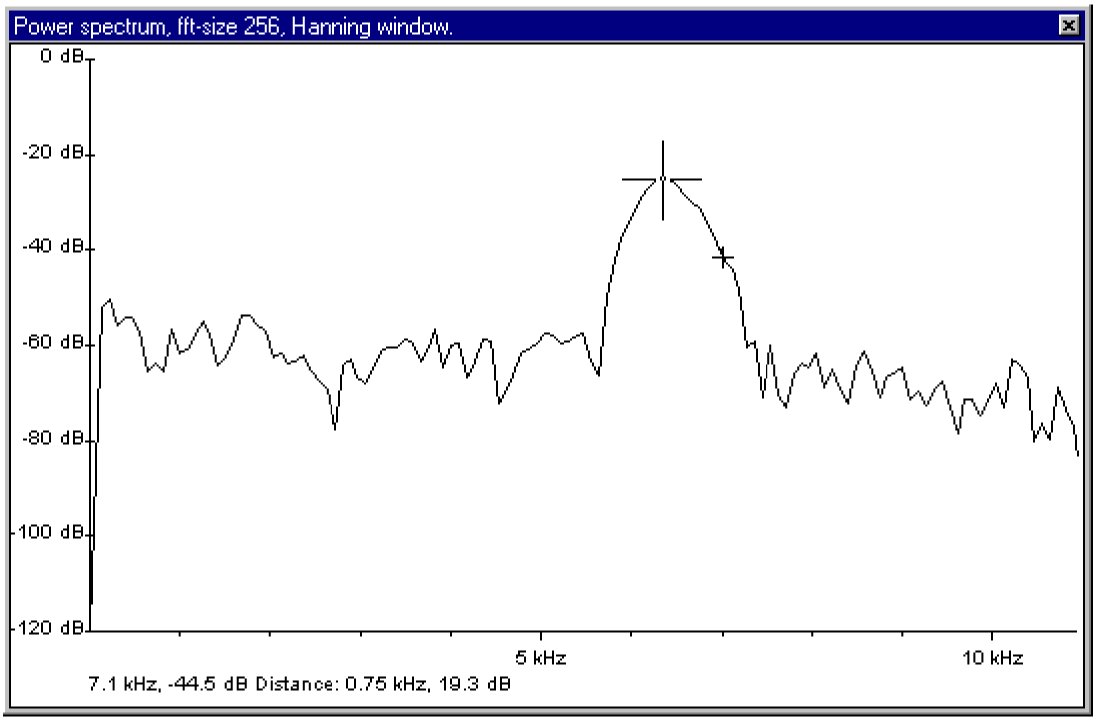


Figure 4. A power spectrum (power vs. frequency).

- The Spectrogram

The spectrogram basically consists of a large number of power spectra, calculated one after the other along the signal. That way the spectrogram is able to show how the power spectrum of the signal changes over time. In order to represent this 3-dimensional information (power and frequency vs. time) in a 2-dimensional diagram the power has been coded into different colors or different shades of gray.

In the Spectrogram Settings dialog box, the FFT size and FFT Window can be chosen, just like in the Power Spectrum settings dialog box. For the spectrogram some additional parameters may be entered; the overlap between FFTs, the way the power is mapped into different colors and the time scale for each window.

To calculate a spectrogram, adjust the settings if necessary and make sure the active window contains an oscillogram (or spectrogram) of the signal you want to analyze. Then choose Spectrogram from the Analysis menu or click the Spectrogram button in the toolbar.

If the resulting spectrogram is too weak (only visible where the signal is strongest) or if the noise shows too much, you may need to adjust the Amplitude Threshold in the Spectrogram Settings dialog box. This can also be made by holding the Shift key and clicking the arrows to the left and right of the color bar in the diagram window. Clicking the arrows without holding the Shift key will affect both the Amplitude Threshold and Contrast.

An example of a spectrogram is given below.

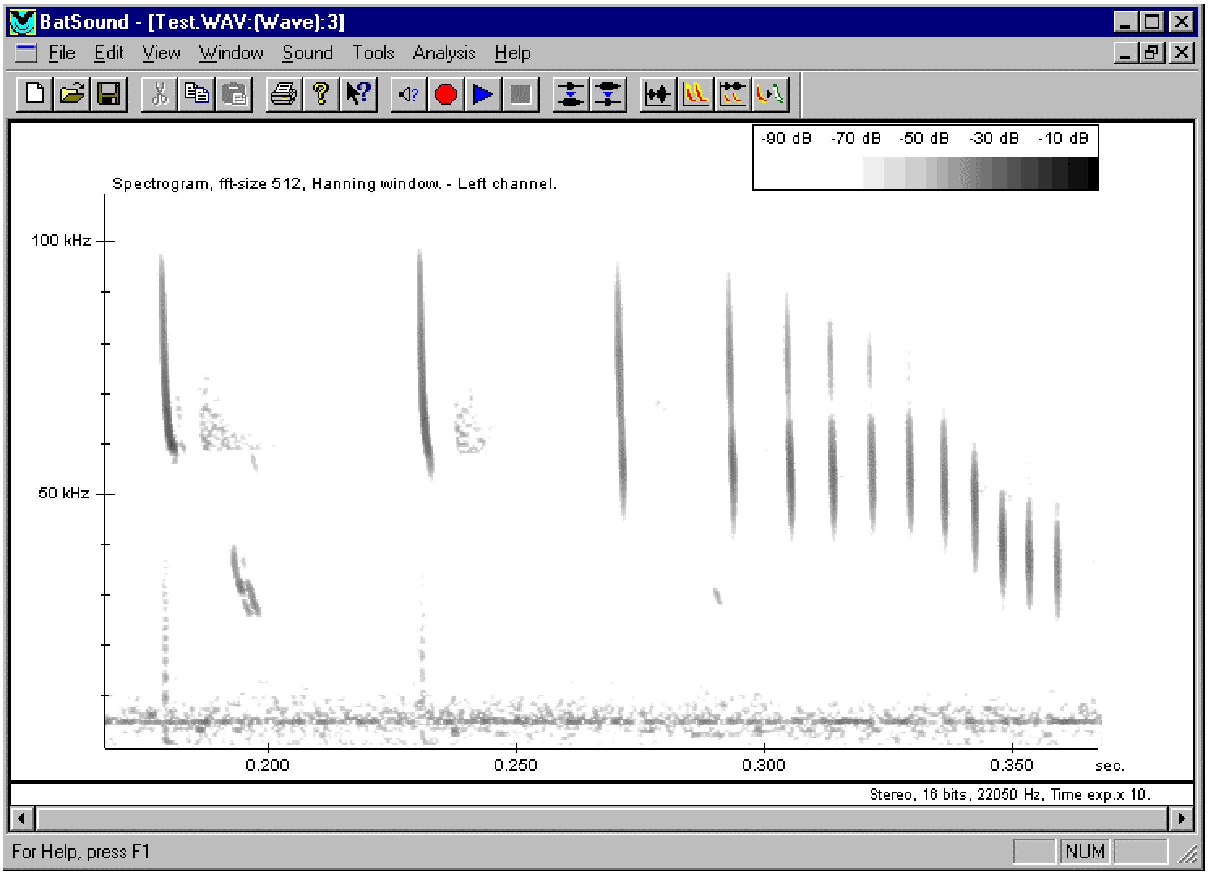


Figure 5. A spectrogram (frequency and power vs. time).

- The Pulse Interval and Pulse Length Analyses

These two analysis types both result in a histogram showing the distribution of the time intervals between successive pulses and pulse lengths respectively.

To make this analysis, make sure the active window contains an oscillogram of the signal you want to analyze. When you choose Pulse Length/Interval Analysis from the Analysis menu, two horizontal cursors appear in the oscillogram. Using the mouse, adjust the cursors slightly above the noise floor and check that the cursors intersects all pulses you want to include in the analysis (only pulses exceeding the cursor level will be counted).

In the Pulse Interval/Pulse Length Settings dialog box you should enter values for the Detection Delay Time, Histogram Start/End time and Histogram bar width (please refer to the Pulse Interval/Pulse Length Settings command description in the command section of this manual). If "Automatic Calculation…" is checked, all parameters expect the Detection Delay Time will be calculated automatically and any values manually entered will be disregarded.

“Right mouse button” menus

Clicking the right mouse button in a diagram will invoke a menu with a number of commands often used in that type of analysis. Using this menu rather than the main menus gives you quicker access to these commands.

In a few cases, the commands in the right mouse button menu have no counterpart in the main menus or work in a slightly different fashion. For more detailed information on the commands in the right mouse button menu, please refer to the section on the respective analysis type in chapter 9 of this manual.

Editing the signal

There are many ways you can edit the sound files. In this section only a few of these are mentioned. In all cases, only the selected portion of the signal will be edited.

If the signal you have recorded is too weak, you may wish to amplify it. Choose Adjust Volume from the Edit menu and enter a suitable factor (200% means that the amplitude will become twice the original amplitude). Please note that for optimum sound quality, you should try to adjust the *recording volume* so the resulting recording level is appropriate instead of adjusting the volume by editing the sound file.

The signal may have been disturbed by noise or other signals. If so, it may be possible to reduce the disturbance by applying time domain filtering of the signal. The filter removes or attenuates certain signal frequencies, according to the selections you make.’

Exporting analysis data

Sometimes you may wish to export the numerical results from the analyses to other programs, e.g. to perform statistical analysis in a spreadsheet program. The following types of information can be exported:

Power Spectrum data. Use the “Copy Ascii” command in the “right mouse button” menu of the Power Spectrum to copy the numerical values making up the diagram to the Windows clipboard. The same data can also be written directly to a text file by using the “Ascii File Export” command from the right mouse button menu. Please refer to the Power Spectrum Command section in chapter 10 for more information.

Pulse Interval/Pulse Length Analysis data. Use the “Copy Ascii” command in the “right mouse button” menu of the Pulse Interval/Pulse Length diagram to copy the numerical values making up the diagram to the Windows clipboard. Please refer to the Pulse Interval/Pulse Length Analysis Command section in chapter 10 for more information.

Oscillogram data. Use the “Copy Ascii” command in the “right mouse button” menu of the Oscillogram to copy the numerical values making up the diagram to the Windows clipboard. Please refer to the Oscillogram Command section in chapter 10 for more information.

Mark Distances data. Use the “Copy” button in the “Mark Distances” dialog box (Tools menu) to copy the data from the Mark Distances table to the Windows clipboard.

Pulse Characteristics data. Use the “Copy” button in the “Pulse Characteristics” dialog box to copy the data from the Pulse Characteristics table to the Windows clipboard.

NOTE: To open the “right mouse button” menu, position the cursor anywhere in the diagram and click the right mouse button.

6. The Real-time Spectrogram

The real-time spectrogram mode with simultaneous hard disk recording of the signal is a very useful operating mode of BatSound. Using this mode, you are able to visually follow the signal by looking at the spectrogram and/or oscillogram running over the screen and at the same time, the signal is stored on the hard disk. This means that you, after interrupting the recording, can scroll through selected parts of the sound file again and, if desired, make a more detailed analysis of the interesting parts.

The spectrogram of a signal is displayed in real time each time a recording is made (Record command in the Sound menu), provided that the current window is set up for displaying spectrograms (click the Spectrogram button in the toolbar to set up the window to display spectrograms).

The main sound file type in BatSound is the commonly used Wave file. Also the different BatSound file formats are based on Wave files. The BatSound wave formats, however, also contain additional information about the recording. The table below shows the resulting file sizes for some different formats and recording lengths.

Format	**Approximate file size in MB**			**Maximum signal frequency (appr.)**
	10 sec. recording	**30 sec. recording**	**60 sec. recording**	**kHz**
44.1 kHz, 16 bits, mono	0.88	2.6	5.2	20
44.1 kHz, 16 bits, stereo	1.76	5.2	10.5	20
96 kHz, 16 bits, mono	1.9	5.7	11.5	45
192 kHz, 16 bits, mono	3.8	11.5	23	90
384 kHz*, 16 bits, mono	7.7	23	46.1	180

* Recording at this sampling frequency is not possible with all Windows versions.

Please note that the real-time spectrogram mode uses a great deal of the computer's system resources; the signal has to be sampled and the samples copied to the file on the hard disk, a large number of FFTs have to be computed, coded and finally sent to the screen as a spectrogram. Some factors affecting the success of this are:

The processor speed
The access time of the hard disk
The speed of the graphics card

If the overall performance of the system is not sufficient, the display of the spectrogram may be delayed and if the memory buffers are exhausted, finally some signal samples may be lost.

How do I know when there is a problem?

If you notice the drawing speed of the progressing oscillogram/spectrogram becomes lower and that the sound from the loudspeaker and the signal drawn on the screen are not synchronized, then the system has problems coping with all of its tasks.

If you hear "clicks" in the recorded sounds when you replay them, then some samples were probably lost. This too is a sign of insufficient system resources.

What can be done to increase system performance?

The first thing you should check is the setting of the "Threshold" in the Spectrogram Settings dialog box. The amplitude Threshold determines the level of the weakest signal to be displayed in the spectrogram. If this is set too low, all weak parts of the signal and much of the noise will be shown in the spectrogram, resulting in a slower display (drawing graphics on the screen is a time consuming task for the computer!).

So, try to set the Threshold to a higher level if possible (remember that you can always return to the signal when the recording has been stopped, to make a more detailed analysis with any analysis settings you might choose). This will make the display more rapid.

Using a smaller FFT size and/or smaller overlap (see the Spectrogram settings command) will also make the display of the spectrogram faster. Setting Overlap to Automatic is usually the best choice in order to reduce the system load.

Using a smaller window to display, the waveforms during recording will make the display faster.

Using "Mono" instead of "Stereo" if possible will decrease the load on the system.

Using a lower sampling frequency if possible will decrease the load on the system.

You should make sure no other applications are running at the same time as BatSound, particularly applications trying to access the hard disk or write to the screen.

The speed of the hard disk can be gradually decreased, as the disk is filled and the files are being fragmented. There are many utility programs that can be used to defragment a hard disk, one of which is the Windows utility Defrag.

Finally, you could try to fine-tune the performance of the computer by running the SETUP utility (usually available by hitting a special key during system boot-up). The way to do this depends on your hardware, so please refer to the User’s Manual of your computer for information about this.

7. The Virtual Bat Detector Mode

In the Virtual Bat Detector mode, time expanded (or high-speed recorded) sounds are replayed at their original speed, as heard through a heterodyne bat detector. In order to understand this mode, some basic knowledge about heterodyne detectors is required. The Virtual Bat Detector mode will only work with mono sound files.

Heterodyne bat detectors

A heterodyne bat detector is a narrowband detector meaning that only a limited portion of the entire ultrasonic frequency range is converted into audible sounds at each time. A *tuning control* is used to select the center frequency of the range to make audible. Let us assume the width of this range is about 10 kHz (which may be considered a "normal" bandwidth). If the tuning control is set to 30 kHz, this means that the range 25 to 35 kHz will be made audible. The frequency of the converted signal equals the difference between the original ultrasonic frequency and the tuned frequency, so if the ultrasound has a frequency of 29 kHz, the resulting audible frequency will be 1 kHz at a tuned frequency of 30 kHz. Obviously, the same result will be obtained for an original frequency of 31 kHz.

The heterodyne technique has several advantages; it gives a relatively cheap design, it offers high sensitivity and it enables the user to, at least roughly, determine the frequency of the ultrasound. The resultant audible sound also has tonal qualities, like "ticks" and "smacks", telling the user more about the type of call. A constant frequency (CF) pulse gives a smacking sound, while a frequency modulated (FM) sweep pulse results in a ticking sound. An FM sweep pulse, leveling out to a CF portion will give a ticking sound when the detector is tuned to the frequency range of the sweep, but a smacking sound if tuned to near the frequency of the CF portion. Hence, it is important to tune the detector properly in each situation, in order to extract as much information as possible about the signal.

The Virtual Bat Detector principle

Given the large number of bat species, each using a number of different types of calls, it should come as no surprise that it usually takes quite some time to learn how to identify the different species with a bat detector. The main idea with the Virtual Bat Detector is to facilitate this learning process. The Virtual Bat Detector emulates a heterodyne bat detector using time expanded or high-speed recorded sound files. An on screen tuning control is available which may be adjusted while the sound file is being played - just like a real bat detector! An important advantage with the Virtual Bat Detector is that the spectrogram of the signal is displayed while it is being replayed, with the tuned frequency clearly shown both graphically (as a horizontal bar) and with digits. This makes it very easy to understand the connection between the spectrogram and the different sounds heard in a heterodyne detector, at different frequency settings.

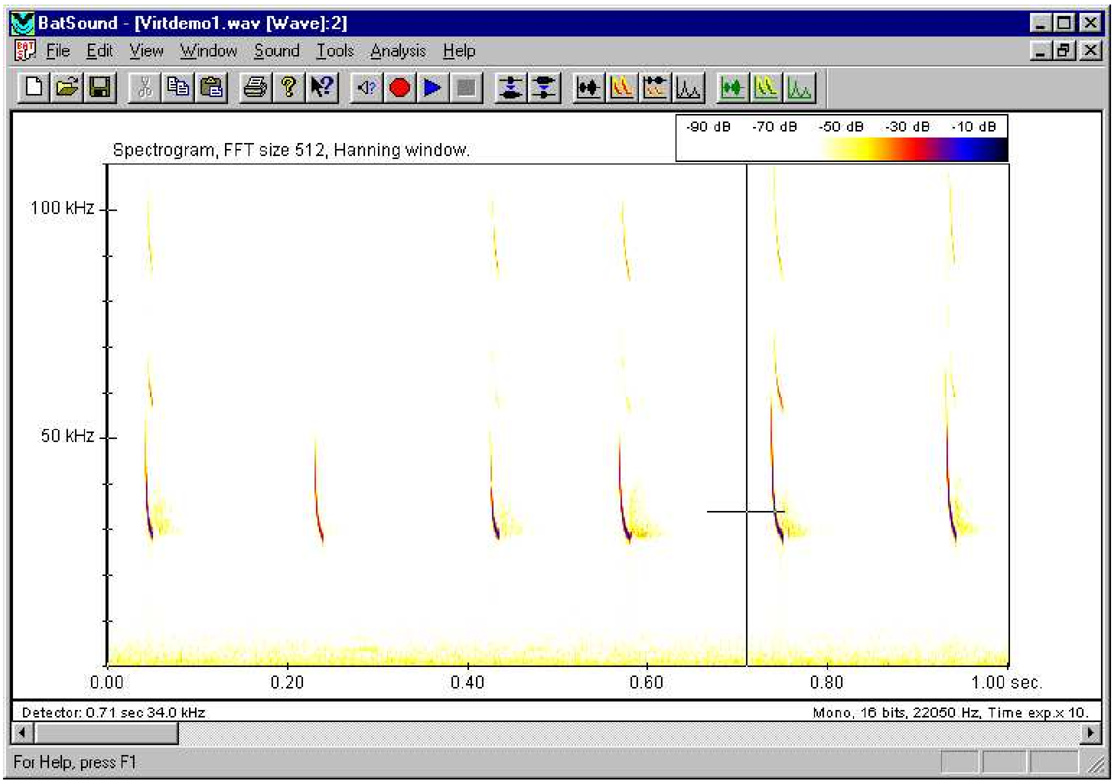


Figure 6. The Virtual Bat Detector replay screen. The tuned frequency is displayed in the lower left corner and also indicated with the horizontal bar.

As was mentioned above, only a portion of the entire ultrasonic frequency range can be made audible at each time. This is achieved by using a filter in the heterodyne detector. It is the characteristics of this filter that determines the width of the frequency range to transform. The Virtual Bat Detector uses a filter in a similar fashion, and in order to make it as versatile as possible, the characteristics of this filter can be changed (see below).

Using the Virtual Bat Detector with time expanded recordings

Before running the Virtual Bat Detector, you should prepare one or more sound files to be played. As mentioned previously, time expanded or high-speed recorded sound files should be used. Please note that only mono sound files can be used in the Virtual Bat Detector mode. A few example sound files are supplied with BatSound, so to test this mode you can use the file "Virt1.wav". This file contains a sequence of bat calls time expanded 10 times. If the appropriate time expansion factor (accessible via the Sound Format command in the Sound menu) has not already been entered, it is advisable to do so before continuing. This will make the filter design procedure easier.

To change from the normal mode to the Virtual Bat Detector mode, select "Virtual Bat Detector" from the Sound menu. This invokes the "Start Virtual Bat Detector" dialog box.

First, the "speed factor" should be entered. If you are using the "Virt1.wav" file, you should enter 10 (i.e. the time expansion factor). Next, you should specify the filter characteristics to use. Click the "Select Filter" button to enter the filter design dialog box (see below). For maximum versatility, you may select any filter type. However, to emulate a standard heterodyne bat detector, a lowpass filter should be selected. You should leave the check box “Use the speed factor to calculate play speed” unchecked.

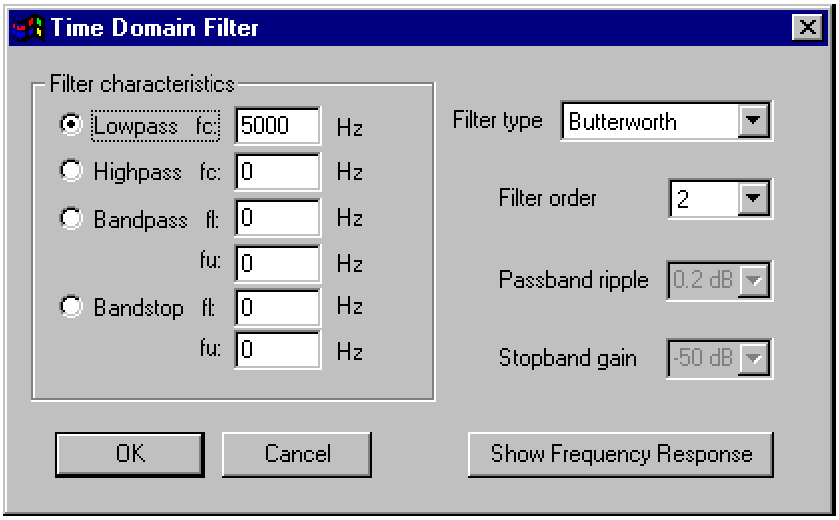


Figure 7. The filter design dialog.

If the time expansion factor has been entered as recommended above, the filter's cut-off frequency ("fc" in the dialog) should be chosen to be half of the desired bandwidth of the detector. E.g. to obtain the bandwidth from the example above (10 kHz), you should choose a cut-off frequency of 5000 Hz. *If you have not entered the appropriate time expansion factor in the Sound Format dialog box, you will have to compensate for this manually, meaning that you should choose a cut-off frequency of 5000/10 = 500 Hz instead.*

You may select any of the available filter types and filter orders. If you are uncertain of what to choose, try a 2nd order Butterworth filter. The higher filter order the sharper cut-off, but also the heavier computational burden on the computer, so particularly if the computer is not one of the faster, you should use a low order filter (e.g. 2nd order).

Now you are ready to play the sound file through the Virtual Bat Detector. Press the "Play" button in the toolbar or select "Play Sound" in the Sound menu. The file is now played at the original rate, meaning it will be replayed n times faster than when replayed in the normal mode (n = the time expansion factor = 10 in the example). The tuned frequency is indicated as a short horizontal bar and is also displayed with digits in the lower left corner of the window. Use the up and down arrow keys to change the setting of the tuning control. Under certain circumstances, there will be a delay in the tuning control's response to pressing the arrow keys. Usually this is because the computer performance is not sufficient for the selected Virtual Bat Detector parameters (filter order and speed factor). High filter orders and high-speed factors will require higher computer performance to work well.

When a sound file is replayed through the Virtual Bat Detector, the duration of the sound is shorter than if the file was replayed in the normal mode (for a speed factor of 10, the duration is one tenth). Hence you will need quite long sequences of time expanded signals. If you have problems finding sufficiently long sequences, you might want to use a few shorter sequences and paste them together to a longer sequence.

Using the Virtual Bat Detector with high-speed recordings

If the file you intend to play through the Virtual Bat Detector contains high-speed recorded sound (i.e. the sound in the file is not time expanded), most of what is said in the previous section still holds. There are, however, a few important differences.

In the Start Virtual Bat Detector dialog box you should check the box “Use the speed factor to calculate play speed” and select a speed factor that results in a “play speed” (play sampling rate) that is supported by the sound card. E.g. if the sampling rate in the sound file is 400000 Hz, you could enter a speed factor of 10 to obtain a “play speed” of 40000 Hz (which is supported by a standard sound card). Changing the speed factor will not change the time it will take to play the file, only the playback sampling rate.

What if it doesn't work?

The horizontal bar showing the tuned frequency is not visible.

A spectrogram has to be displayed in the active window in order for the tuning control to be active. Make sure you have selected this before running the Virtual Bat Detector.

The tuning control does not move when I press the arrow keys.

The computer's performance may be inadequate for the selected Virtual Bat Detector parameters (see above). Try a lower filter order and/or a lower speed factor if possible. On a sufficiently fast computer, the tuning indicator should move with no or small delay when you press the up/down arrow keys.

Exiting the Virtual Bat Detector mode

In order to exit the Virtual Bat Detector mode and return to the normal mode, open the Sound menu. As you see, the "Virtual Bat Detector" command is checked. Select the "Virtual Bat Detector" command again to uncheck this alternative.

8. *BatSound* Commands Overview

In this section, you will find a short description of all commands available in BatSound. The commands are listed according to the menu in which they occur.

File menu commands

The File menu offers the following commands:

New	Opens a new file to make a sound recording.
Open	Opens an existing document (sound file).
Open Next/Previous	Opens the next/previous sound file (in alphabetic order)
Close	Closes an opened document (sound file).
Save	Saves an opened document (sound file) using the same file name.
Save As	Saves an opened document (sound file) to a specified file name.
Save Selected Interval	Saves the selected section of the sound file to a specified file name.
Import	Imports and opens an existing document (sound file) in a non-standard format (e.g. mp3).
Export Graphics	Saves the current main diagram (oscillogram/spectrogram) to a file (e.g. bmp, jpg, tif).
File Management	Functions for managing D500X/D1000X files. Presents embedded file information and has easy copy and file rename function.
Print	Prints the diagram in the active window.
Print Preview	Displays the diagram on the screen, as it would appear printed.
Print Setup	Selects a printer and printer connection.
File properties	Displays the properties for the active sound file
Exit	Exits BatSound.

Edit menu commands

The Edit menu offers the following commands:

Undo	Reverses previous editing operation.
Cut	Deletes the selected section of the sound file and moves it to the clipboard.
Copy	Copies the selected section of the sound file and the diagram in the active window to the clipboard.
Paste	Pastes data from the clipboard into the sound file.
Select All	Selects the entire sound file.
Delete	Deletes the selected section of the sound file from the document.
Clear/silence	Replaces the selected section of the sound file with silence.
Reverse	Time-reverses the selected section of the sound file.
Adjust Volume	Changes the gain of the selected section of the sound file.
Filter	Performs time-domain filtering of the selected section of the sound file.

View menu commands

The View menu offers the following commands:

Toolbar	Shows or hides the toolbar.
Status Bar	Shows or hides the status bar.

Window menu commands

The Window menu offers the following commands, which enable you to arrange multiple views of multiple documents in the application window:

Cascade	Arranges windows in an overlapped fashion.
Tile	Arranges windows in non-overlapped tiles.
Arrange Icons	Arranges icons of closed windows.
Split	Split the active window into panes.
Window 1, 2, ...	Goes to specified window.

Sound menu commands

The Sound menu offers the following command:

Sound Devices	Displays information about the installed sound devices.
Play Sound	Plays the currently selected section of the sound file.
Move to beginning of file	Makes the cursor move to the beginning of the file.
Move to end of file	Makes the cursor move to the end of the file.
Play Speed	Selects which speed to use for playback of sounds.
Record Sound	Starts recording to the selected file, with optional display of the spectrogram and/or oscillogram in real time.
Pause Play sound	Pauses playing sound. To resume playing, select Play sound.
Stop Play sound	Stops playing sound.
Sound Format	Selects the sound format for recordings *from the regular sound card* (bit depth, stereo/mono, sampling frequency and time expansion factor). Also used to save comments in the sound file.
Automatic recording	Selects the Automatic recording mode, in which BatSound automatically starts a recording as soon as there is sound present.
Virtual Bat Detector	Selects the Virtual Bat Detector replay mode.

Tools menu commands

The Tools menu offers the following commands:

Zoom In	Zooms in on the selected section of the sound file.
Zoom Out	Changes the zoom level back one step.
Default Zoom	Restores the displayed sound file to the original zoom level.
Zoom Entire File	Adjusts the zoom level so that the entire sound file fits into the active window.
Zoom full range frequency/amplitude	Adjusts the zoom vertical zoom level so that the full frequency and amplitude range is shown
Marking cursor	Selects cursor type to allow selecting (marking) portions of the signal.
Marking cursor - stereo	Selects cursor type to allow selecting (marking) both channels of a stereo file.
Measurement cursor/Large measurement cursor	Selects cursor type to allow display of time and frequency values (absolute and relative). Also used for window zoom in oscillograms and spectrograms.
Level cursor	Selects cursor type used for pulse interval/length analysis.
Save cursor as mark	Puts a "mark" at the current cursor position.
Set active mark	Selects the active mark.
Active mark properties	Changes the properties (label, type of mark) of the active mark.
Move active mark	Enables/disables changing the position of the active mark using the arrow keys.
Mark distances	Displays a table (matrix) showing distances between the marks.
Scroll to mark	Scrolls the sound file to the selected mark.
Clear all marks	Deletes all marks.

Analysis menu commands

The Analysis menu offers the following commands:

Spectrogram	Displays the spectrogram of the signal in the current active window.
Oscillogram	Displays the oscillogram (envelope curve) of the signal in the current active window.
Zero Crossing Analysis	Displays a frequency-time plot using Zero Crossing Analysis.
Combined	Displays both the spectrogram and the oscillogram of the signal in the current active window.
Power Spectrum	Displays the power spectrum of the signal.
Pulse Interval/ Pulse Length Analysis	Displays pulse interval and pulse length diagrams of the signal.
Pulse Characteristics Analysis	Displays important pulse characteristics (min/max frequency, duration etc) in a table.
Spectrogram Settings - Default	Changes the default analysis parameters for Spectrograms.
Zero Crossing Analysis Settings - Default	Changes the default analysis parameters for Zero Crossing Analysis plots.
Oscillogram Settings - Default	Changes the default display parameters oscillograms.
Power Spectrum Settings - Default	Changes the default analysis parameters for Power Spectra.
Pulse Interval/ Pulse Length Analysis Settings - Default	Changes the default analysis parameters for Pulse Interval and Pulse Length Analysis diagrams.

Help menu commands

The Help menu offers the following commands, which provide you assistance with this application:

Help	Opens the BatSound User's Manual (as a pdf file).
Help on the web	Links to the Help page at the Pettersson web site.
Pettersson homepage	Links to the main page at the Pettersson web site.
About	Displays the version number etc. of this application.

9. *BatSound* Commands

In this section a detailed description of each command is given. The commands are listed in the same order they appear within each menu.

The File menu

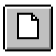
New command (File menu)

Use this command to open a new, empty sound file. Typically, you would choose this command to make a new recording or to paste data from the clipboard when you are editing files.

To start recording to the file, choose Record Sound from the Sound menu, or click on the red “Record” button in the toolbar. The oscillogram and/or spectrogram is displayed at the same time the signal is stored on the hard disk.

You can open an existing document/sound file with the Open command.

Shortcuts

Toolbar: 

Keys: CTRL+N

Open command (File menu)

Use this command to open an existing document/sound file in a new window. You can open multiple documents at once. Use the Window menu to switch among the multiple open documents. See Window 1, 2, ... command.

The default file extension is .wav and .bsnd, but other formats may be chosen in the File Open dialog box.

Shortcuts

Toolbar: 

Keys: CTRL+O

File Open dialog box

The following options allow you to specify which file to open:

File Name
Type or select the filename you want to open. This box lists files with the extension you select in the List Files of Type box.

List Files of Type
Select the type of file (extension) you want to open.

Please note that "Data files" (.dat and .raw files) do not contain any information about the sampling frequency used to make the recording, so in order to obtain the correct frequency and time in the diagrams, the sampling frequency of the sound file must be changed manually in the Sound Format dialog. All other file types already contain information about the sampling frequency and no further action is required.

Drives

Select the drive in which BatSound stores the file that you want to open.

Directories

Select the directory in which BatSound stores the file that you want to open.

Open as

Select the file format for the file you want to open. The "Automatic detection" alternative means that the program attempts to determine the file format. If you experience problems using this alternative, please use one of the other, "manual" alternatives.

The D500X/D1000X alternative is for .wav files created by the D500X/D1000X ultrasound detectors. It will retrieve the extra information in these files, such as recording date/time and GPS data (if available).

Open next/previous commands (File menu)

Use this command to open the next file in alphabetic order. This is useful if you are going through a large number of files with names in sequential order, e.g. M00001.wav, M00002.wav…

The command is only available when there is at least one file open. If there is more than one file open, it is the active file that is used to determine the next file to open.

If the active file is a non-wave file, e.g. an mp3 file, this command will import and open the next mp3 file.

Shortcuts

Toolbar:		
Keys:	N	B

Close command (File menu)

Use this command to close all windows containing the active document/sound file. Before closing an untitled document, BatSound displays the Save As dialog box and suggests that you name and save the document.

You can also close a document by using the Close icon  on the *document's* title bar or menu bar.

Save command (File menu)

Use this command to save the active document/sound file to its current name and directory. When you save a document for the first time, BatSound displays the Save As dialog box so you can name your document. If you want to change the name and directory of an existing document before you save it, choose the Save As command.

Shortcuts

Toolbar: 

Keys: CTRL+S

Save As command (File menu)

Use this command to save and name the active document/sound file. BatSound displays the Save As dialog box (see below) so you can name the file.

To save a document with its existing name and directory, use the Save command.

Save Selected Interval command (File menu)

Use this command to save and name *the selected interval* of the active document/sound file. BatSound displays the Save As dialog box (see below) so you can name the file.

Import command (File menu)

Use this command to import and open a non-wave file, e.g. an mp3 file. This command uses the codecs for various file formats that are already installed on the computer, so which file types that can be imported depends on which codecs have been installed on the computer.

After importing and opening a non-wave file, the text “converted” will appear in the title bar along with the file name.

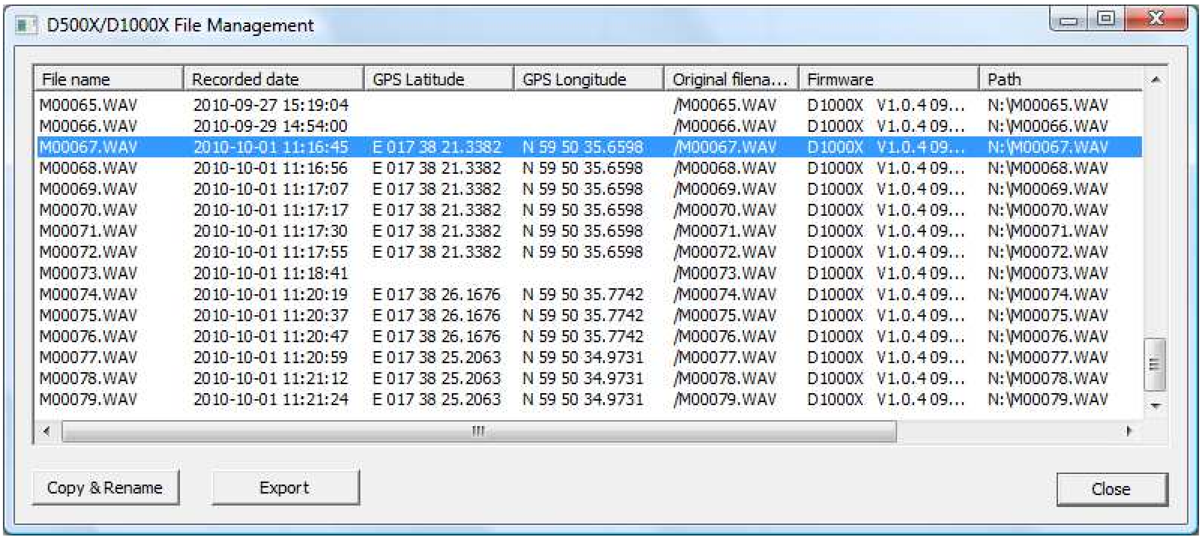
Export Graphics command (File menu)

Use this command to create a picture file with the current main diagram (oscillogram and/or spectrogram). The selectable file formats depend on which codecs are installed on the computer, but typically include bmp, jpg, gif, tif, png and emf.

D500X/D1000X File Management command (File menu)

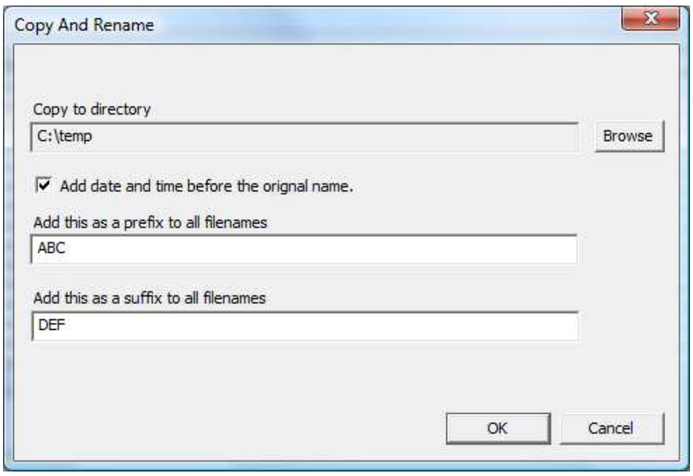
This command opens the File Management dialog box which gives a list of the D500X/D1000X ultrasound detector files in the selected folder with the embedded file information:

File name
Time and date of recording
GPS latitude and longitude (if available)
Original file name
D500X/D1000X firmware version



The information in the File Management list can be exported to a tab separated text file ("Export"). Select the desired information to export by first highlighting it. It is also possible to press Ctrl-C to copy the highlighted section to the Windows clipboard.

The Copy & Rename function is used to copy one or more D500X/D1000X files from the CF card to the computer's hard disk. Optionally the files can also be renamed. The Rename function can also be used to add the time and date to the original file name. A user defined prefix and/or suffix can be added to the original file name. Selecting multiple files, will create copies of all files with time/date, prefix and suffix added. This is useful to add identification information (e.g. recording location) to a group of files. As an example, if the settings showed below are applied to the file M00067.WAV above, this will result in a copy of the file to the file ABC2010-10-01_11_16_45_M00067DEF.WAV in the C:\temp folder.



File Save As dialog box

The following options allow you to specify the name and location of the file you're about to save:

File Name

Type a new filename to save a document/sound file with a different name. BatSound adds the extension you specify in the Save File As Type box. The default extension is .bsnd.

File Format

The following file formats are available:

BatSound data file (*.bsnd) - A wave format with embedded information used by BatSound, e.g. comments and certain display parameters.

BatSound file pairs (*.wav, *.bsndp) – The extra information which is embedded in the BatSound data files is here stored in a separate file with extension .bsndp and the .wav file is a standard wave file that can be read by other programs.

BatSound wave file - A wave format with embedded information used by BatSound, e.g. comments and certain display parameters. This file format is compatible with BatSound version 3 wave files.

BatSound compressed wave file - A wave format similar to BatSound wave, that does not save the “silent” portions of the signal, which in most cases gives a significant reduction in file size. When a file of this type is opened again in BatSound, silent periods are automatically inserted between the calls, to retain the original time relations.

When this format is selected, the user is prompted for the threshold level (below which the signal is not saved) and the time interval before and after the pulse where the signal still should be saved, even though it does not reach above the threshold. This avoids abruptly cutting of the pulses.

D500X/D1000X files – A wave format for files recorded with the D500X or D1000X ultrasound detectors. The format has embedded information about the recording, e.g. time/date and (for the D1000X) GPS data. It should be chosen when a D500X/D1000X file has been edited and you wish to save it without loosing this embedded information. Choosing this format will not create a D500X/D1000X type of file from a standard wave file.

Wave files – The regular wave format. BatSound can read this format as well, but no BatSound specific information will be stored in the file. Typically, this format should be used to create files to be read by other applications, not capable of reading the BatSound wave format.

Data file – Only the raw samples are stored sequentially in the file. No information about sampling frequency etc. is stored. Typically, this format should be used to create files to be read by other applications, not capable of reading wave files.

Print command (File menu)

Use this command to print a document (diagram). This command presents a Print dialog box, where you may specify the range of pages to be printed, the number of copies, the destination printer, and other printer setup options.

Note: To print other diagrams than those in the main windows, e.g. a power spectrum, position the cursor in the power spectrum window and click the right mouse button to invoke a menu with the print command.

Shortcuts

Toolbar: 

Keys: CTRL+P

Print Preview command (File menu)

Use this command to display the active document, as it would appear when printed. When you choose this command, the main window will be replaced with a print preview window in which one or two pages will be displayed in their printed format. The print preview toolbar offers you options to view either one or two pages at a time; move back and forth through the document; zoom in and out of pages; and initiate a print job.

Print Setup command (File menu)

Use this command to select a printer and a printer connection. This command presents a Print Setup dialog box, where you specify the printer and its connection.

Print Setup dialog box

The following options allow you to select the destination printer and its connection.

Printer

Select the printer you want to use. Choose the Default Printer; or choose the Specific Printer option and select one of the current installed printers shown in the box. You install printers and configure ports using the Windows Control Panel.

Orientation

Choose Portrait or Landscape.

Paper Size

Select the size of paper that the document is to be printed on.

Paper Source

Some printers offer multiple trays for different paper sources. Specify the tray here.

Options

Displays a dialog box where you can make additional choices about printing, specific to the type of printer you have selected.

Network...

Choose this button to connect to a network location, assigning it a new drive letter.

File properties

Use this command to display the properties of the active file. This information includes the file size, recording time, number of channels etc. The comments stored using the Sound Format command as well as GPS data from a D500X/D1000X file (if present) are also displayed.

1, 2, 3, 4 command (File menu)

Use the numbers and filenames listed at the bottom of the File menu to open the last four documents/sound files you closed. Choose the number that corresponds with the document you want to open.

Exit command (File menu)

Use this command to end your BatSound session. You can also use the Close command on the application Control menu. BatSound prompts you to save documents (sound files) with unsaved changes.

Shortcuts

Mouse: Click the application's close button ☒.

Keys: ALT+F4

The Edit menu

Undo/Can't Undo command (Edit menu)

Use this command to reverse the last editing action, if possible. The name of the command changes, depending on what the last action was. The Undo command changes to Can't Undo on the menu if you cannot reverse your last action.

Shortcuts

Keys: CTRL+Z or
ALT-BACKSPACE

Cut command (Edit menu)

Use this command to cut the currently selected section of the sound file and put it on the clipboard. The length of the edited sound file is shorter than it was prior to editing. This command is unavailable if there is no data currently selected.

Cutting data to the clipboard replaces the contents previously stored there.

Shortcuts

Toolbar: 

Keys: CTRL+X or
Shift + Delete

Copy command (Edit menu)

Use this command to copy the currently selected section of the sound file to the clipboard. Typically, you would use this function to edit the sound file or to create a new sound file.

This command also makes a copy of the diagram in the active window. This is done independently of the copying of the sound file and puts a copy of the diagram on the clipboard. That way the diagrams can easily be pasted into other Windows applications (word processor, desktop publishing etc.). The clipboard will contain a copy of the diagram in two different formats; the bitmap and Windows Metafile formats. The application you paste the diagram into either picks the most suitable format or gives the user the option to select which format to use.

Note that the bitmap format depends on the current graphics resolution of your system. With high resolution and many colors, the bitmaps can get very large. If so, you may find it worthwhile to reduce the number of colors prior to making the copy, or to use a graphics editor to reduce the number of colors of the picture file. The Windows clipboard editor and the application “Paint” have some basic picture file editing/conversion facilities.

Note that some applications, e.g. Word for Windows, will choose the Metafile format if available, although this sometimes may change the aspect ratio of the diagram. If you encounter this problem, choose “Paste special” from the Edit menu to get the bitmap format instead.

If there is no data currently selected, this command only makes a copy of the diagram as described above. Copying data to the clipboard replaces the contents previously stored there.

Note: To copy other diagrams than those in the main windows, e.g. a power spectrum, position the cursor in the power spectrum window and click the right mouse button to invoke a menu with the copy command.

Shortcuts

Toolbar: 

Keys: CTRL+C or
CTRL+Insert

Paste command (Edit menu)

Use this command to insert a copy of any *sounds* stored in the clipboard at the insertion point. This command is unavailable if the clipboard is empty.

Shortcuts

Toolbar: 

Keys: CTRL+V

Select All command (Edit menu)

Use this command to select the entire document/sound file. This is useful when you wish to edit the entire document/sound file.

Delete command (Edit menu)

Use this command to cut the currently selected section of the document/sound file, without putting it on the clipboard. The length of the edited sound file is shorter than it was prior to editing. This command is unavailable if there is no data currently selected.

Clear/Silence command (Edit menu)

Use this command to replace the currently selected section of the sound file with silence. The length of the sound file is the same as before using this command. This command is unavailable if there is no data currently selected.

Reverse command (Edit menu)

Use this command to time-reverse the currently selected section of the sound file. This command is unavailable if there is no data currently selected.

Adjust Volume command (Edit menu)

Use this command to increase or decrease the amplitude of the currently selected section of the sound file. This command is unavailable if there is no data currently selected.

Filter command (Edit menu)

Use this command to perform time domain filtering of the currently selected section of the sound file. Typically, you would use this command to remove or attenuate noise and other undesired artifacts of the signal. A theoretical, ideal filter would be able to completely remove certain frequencies from a signal as described below. However, all practical filters are only approximations of an ideal filter, so the desired frequencies are not completely removed but rather more or less attenuated.

If you select the Filter command, the “Time domain filter” dialog appears, in which you can select the following filter characteristics:

Lowpass Filter - removes/attenuates signals above the selected cut-off frequency (fc).
Highpass Filter - removes/attenuates signals below the selected cut-off frequency (fc).
Bandpass Filter - removes/attenuates signals below and above a selected band of frequencies (frequency limits fl and fu).
Bandstop Filter - removes/attenuates signals within a selected band of frequencies (frequency limits fl and fu).

For each of the above filters, you may also choose between **Butterworth, Chebyshev type 1 or Elliptic** filter types. For the **User defined** filter type, please see below.

The **Order** of the filter determines the filter’s selectivity. A high order filter is more effective in attenuating the desired frequencies than a low order filter. You may select filter order 2, 4, 6 or 8.

The **Passband Ripple** for Chebyshev type 1 and elliptic filters can be selected to 0.1, 0.2, 0.5, 1, 2 or 3 dB.

The maximum **Stopband gain** for the elliptic filter can be selected to -20, -30, -40, -50, -60 or -70 dB.

After entering the desired filter specifications, you may also **view the actual frequency response** of the filter you just specified. This is a very useful feature, particularly for anyone with limited experience from filter design. To display the frequency response, click on the “Show Frequency Response” button.

If the **User defined** filter type is selected, the filter order and coefficients will be read from a text file ("filter coefficient file"). This enables experienced users to design their own filters with characteristics other than the above mentioned. We suggest that users with no experience of digital filter design refrain from using the User defined filter type.

With the User defined filter type, it is possible to implement transfer functions up to an order of 12, according to the following notation:

$$H(z) = \frac{b_0+b_1z^{-1}+b_2z^{-2}+ \dots +b_nz^{-n}}{a_0+a_1z^{-1}+a_2z^{-2}+ \dots +a_nz^{-n}}$$

The filter coefficient file can be created with any text editor capable of storing the text as a text file (no formatting), such as the Windows utility Notepad. The format for the filter coefficient file is:

```
filter order (n)
a0
a1
.
.
.
an
b0
b1
.
.
.
bn
```

As an example, the filter coefficient file for a sixth order bandpass filter is:

```
6
1
0
1.7600
0
1.1829
0
0.2781
0.0181
0
-0.0543
0
0.0543
0
-0.0181
```

Please refer to APPENDIX B for more information on filter design.

The View menu

Toolbar command (View menu)

Use this command to display/hide the Toolbar, which includes buttons for some of the most common commands in BatSound, such as File Open. A check mark appears next to the menu item when the Toolbar is displayed.

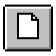
See Toolbar for help on using the toolbar.

Toolbar

The toolbar is displayed across the top of the application window, below the menu bar. The toolbar provides quick mouse access to many tools used in BatSound,

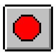
To hide or display the Toolbar, choose Toolbar from the View menu (ALT, V, T).

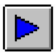
The toolbar can be repositioned using the “drag and drop” technique.

Click	To
	Open a new sound file for recording.
	Open an existing sound file. BatSound displays the Open dialog box, in which you can locate and open the desired file.
	Open the next file in the current folder in alphabetical order (relative to the active file).
	Open the previous file in the current folder in alphabetical order (relative to the active file).
	Save the active document/sound file or template with its current name. If you have not named the document, BatSound displays the Save As dialog box.
	Print the diagram in the active window.
	Cut the currently selected section of the document/sound file and put it on the clipboard.
	Copy the currently selected section of the document/sound file and put it on the clipboard.
	Insert the contents of the clipboard at the insertion point.
	Display the About dialog box.

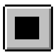
 Set the mouse pointer in Context Help mode (the pointer will change to an arrow and question mark). Click on item to display help.

 Display information on the installed Sound Device.

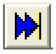
 Start recording to selected file (optional display of real-time spectrogram/oscillogram).

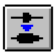
 Start playing sound from cursor position, or marked section.

 Pause playing.

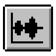
 Stop playing.

 Move cursor to beginning of file.

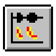
 Move cursor to end of file.

 Zoom in.

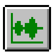
 Zoom out.

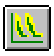
 Display oscillogram.

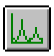
 Display spectrogram.

 Display oscillogram and spectrogram in the same window.

 Display power spectrum.

 Change default oscillogram parameter settings.

 Change default spectrogram parameter settings.

 Change default power spectrum parameter settings.

Status Bar command (View menu)

Use this command to display and hide the Status Bar, which describes the action to be executed by the selected menu item or depressed toolbar button, and keyboard latch state. A check mark appears next to the menu item when the Status Bar is displayed.

See Status Bar for help on using the status bar.

Status Bar

The status bar is displayed at the bottom of the BatSound window. To display or hide the status bar, use the Status Bar command in the View menu.

The left area of the status bar describes actions of menu items as you use the arrow keys to navigate through menus. This area similarly shows messages that describe the actions of toolbar buttons as you depress them, before releasing them. If after viewing the description of the toolbar button command you wish not to execute the command, then release the mouse button while the pointer is off the toolbar button.

The right areas of the status bar indicate which of the following keys are latched down:

Indicator	**Description**
CAP	The Caps Lock key is latched down.
NUM	The Num Lock key is latched down.
SCRL	The Scroll Lock key is latched down.

The Window menu

Cascade command (Window menu)

Use this command to arrange multiple opened windows in an overlapped fashion.

Tile command (Window menu)

Use this command to arrange multiple opened windows in a non-overlapped fashion.

Window Arrange Icons Command

Use this command to arrange the icons for minimized windows at the bottom of the main window. If there is an open document window at the bottom of the main window, then some or all of the icons may not be visible because they will be underneath this document window.

1, 2, ... command (Window menu)

BatSound displays a list of currently open document/sound file windows at the bottom of the Window menu. A check mark appears in front of the document name of the active window. Choose a document from this list to make its window active.

The Sound menu

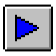
Sound Devices command (Sound menu)

Use this command to display information about the currently installed sound devices, and to select which of the available devices to use for sound playback/recording.

Play Sound command (Sound menu)

Use this command to play the currently selected section of the sound file. If nothing is selected, the sound file will be played from the current cursor position and to the end.

Shortcuts

Toolbar: 

Keys: P

Move to beginning/end of file

Use this command to move the cursor to the beginning/end of the file. This is useful to quickly scroll to the beginning or end of the file.

Shortcuts

Toolbar:  Move to beginning of file

 Move to end of file

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Play Speed command (Sound menu)

Use this command to select which speed to use for playback, 1/20, 1/10, 1/4, 1/2, 1, 2 or 4 times the original speed. Please note that using another replay speed than the original may result in a replay sampling frequency not supported by the sound card.

When high sampling frequency sound files are used, the 1/2, 1/4, 1/10 and 1/20 alternatives can be used to obtain time expansion of the high frequency sound.

Record Sound command (Sound menu)

Use this command to start recording to the selected file. As the recording is started, the Recording status dialog box appears on the screen. If the Real time graphics check box is checked, the oscillogram and/or spectrogram is displayed at the same time the signal is stored on the hard disk, using the settings in the Spectrogram Settings dialog box (see Spectrogram Settings command in the

Analysis menu). To select what to view during recording (oscillogram, spectrogram or both), click on the desired diagram type in the toolbar before starting the recording.

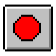
To stop/pause the recording, click the Stop button in the Recording Status dialog box. Here you can also clear the current file and start recording to a new file. To exit the current recording session, click the Exit button.

Unless a new file has been selected (New command in the File menu) the recording will be appended to the file in the current active window, using the Sound Format settings of the current file.

If the recording is made to a new file, the sampling frequency and number of bits selected with the Sound Format command (Sound menu) will be used. The default file format is BatSound Wave.

In the high-speed mode (BatSound Pro only), the Record Sound command has a different meaning. Please refer to chapter 8 for more information on this.

Shortcuts

Toolbar: 

Keys: R

Pause Play Sound command (Sound menu)

Use this command to pause playing. To resume playing, select Play Sound. The difference between the Stop Play Sound and Pause Play Sound commands is that the former resets the cursor to the beginning of the file while the latter does not.

Shortcuts

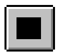
Toolbar: 

Stop Play Sound command (Sound menu)

Use this command to interrupt playing.

In the high-speed mode (BatSound Pro only), this command is also used to exit the high-speed mode. Please refer to chapter 8 for more information on this.

Shortcuts

Toolbar: 

Keys: S

Sound Format command (Sound menu)

Use this command to select the sound format to be used to make a recording.

Note: This command only affects recordings made through the regular sound card. The sampling parameters for the high-speed sampling mode are entered in the "Set Sampling Parameters" dialog.

Number of bits : 8, 16, 24 or 32

Number of channels : 1 or 2 (mono or stereo)

Sampling frequency : 11025 Hz, 22050 Hz, 44100 Hz, 48000 Hz, 96000 Hz, 192000 Hz or user defined.

Please note that if you select "user defined", not all sampling frequencies may be allowed on all sound cards, so the actual sampling frequency may differ from that you enter. Normally the sound card informs the program about the actual sampling frequency, and this will be displayed at the lower right of the screen. However, some sound cards erroneously claim to be working with the desired sampling frequency, although the actual sampling frequency may differ from this. *In such case, the program will not display the correct time and frequency information.*

Time expansion factor: A signal that is time expanded 10 times (e.g. with a bat detector) will appear to have a frequency one tenth of what it originally was. The time scale also will be 10 times longer. In order to automatically compensate for this, enter the time expansion factor (in this case: 10), and all time and frequency axes will be changed accordingly. If a time expansion factor of 1 is entered, no changes will be made to the axis scaling.

Any time expansion factor entered in the Sound Format dialog box before a new recording is made (default: 1) is stored in the sound file provided that the file was stored in "BatSound Wave" format. The time expansion factor is automatically retrieved when a file in BatSound Wave format is loaded.

In the **Comments** field of the sound format dialog, you may enter any information you find suitable to identify the recording (e.g. recording location, date and time). This information is stored in the sound file and is automatically retrieved upon loading a file, if the BatSound Wave format was used to save the file.

Which sampling frequency should I choose?

The highest possible signal frequency is roughly half the sampling frequency, so sampling with 44100 Hz makes it possible to analyze signals up to 22050 Hz, theoretically. In practice, the upper frequency limit will be less than half the sampling frequency, in this case perhaps around 20000 Hz. So, if you know the frequency content of the signal you want to analyze, you can select the sampling frequency accordingly.

Automatic recording command (Sound menu)

Selecting this command, opens the Automatic Recording dialog box from which the Automatic recording mode can be selected.

The Automatic recording mode is similar to a voice activated tape recorder – a sufficiently strong sound will make the program start recording. When the sound level is low again, the recording is stopped. The actual sound level that determines the start/stop of the recording is user selected.

The main parameter that determines when to start a recording is the sound level. When the sound level is above a certain threshold, the automatic recording system is said to be *triggered* – and the recording starts. There are two triggering modes, from the amplitude in an oscillogram or from the levels over a selected range of frequencies in a power spectrum.

When the **Oscillogram level** trigger type is selected, the system is triggered when the sound level exceeds the level entered in the **Oscillogram threshold** box. This level can be entered either as a dB value or a percentage of the full range. 0 dB corresponds to 100%, -6 dB to 50%, etc.

When the **Frequency domain level** trigger type is selected, power spectra are continuously calculated and evaluated. The system will be triggered when the power spectrum level exceeds the dB value entered in the **Power spectrum threshold** box at any frequency over the frequency range determined by the **Lower frequency limit** and **Upper frequency limit,** i.e. a frequency-selective triggering is obtained. That way, it is possible to stop the automatic recording system to from being triggered by signals outside the 'interesting' frequency range (e.g. by low-frequency noise). The FFT size, FFT overlap and FFT window has the same function as in the spectrograms. Please refer to the Spectrogram Settings command in the Analysis menu or Appendix A (The basics of signal processing) for more information about these parameters.

If the selected sound format is stereo, it is also possible to select left, right or both channels as **Trigger source**.

Once a valid trigger has been detected, the **General recording parameters** determine exactly when the recording will be started. The **Recording time before trigger** determines how long before the trigger occurred the recording should start. That way, cutting off the start of a sound pulse can be avoided. A memory buffer is used to make it possible to start recording before the trigger. In a similar way, the recording can be allowed to continue a short time after the triggering conditions are no longer valid **(Recording time after trigger).**

To avoid rapidly filling up the hard disk, the maximum recording time per file **(Max. recording time per file)**, as well as the number of recordings per session can be limited **(Max. number of recordings)**.

The **Minimum duration** determines the required length of a signal in order for a recording to start. That way, false triggering from single, short pulses can be avoided.

The recordings can be made either sequentially in a single file or each recording in a separate file. This is selected in the box **File numbering**, in which also the file name ending can be chosen (a sequential number, date and number, date and time or time). This makes it easy to determine the time each recording was made. The file beginning should be entered in the **File names – beginning** field.

In addition to this, it is also possible to automatically have marks added at the start of each recording. This is particularly useful if you are recording to a single file. This feature is enabled in the **Mark start of recording** box, where different options to display at each mark are available.

Virtual Bat Detector command (Sound menu)

Selecting this command toggles between the normal mode and the Virtual Bat Detector mode. In the Virtual Bat Detector mode, time expanded (or high-speed recorded) sounds are replayed at their original speed, as heard through a heterodyne bat detector. Please refer to chapter 7 for detailed information on the Virtual Bat Detector mode.

To exit the Virtual Bat Detector mode, select this command a second time in the Sound menu. A check mark to the left of the command indicates that the Virtual Bat detector mode is active.

Zoom In command (Tools menu)

Use this command to zoom in on a certain section of the signal. The section to be zoomed should first be selected. If no selection is made, the next higher standard zoom level will be chosen.

If you wish to zoom only along the time axis (i.e. change the time interval to be displayed), the Marking Cursor should be used.

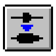
Using the Measurement Cursor enables you to select a “window” in the diagram to be zoomed (i.e. zoom along both axes). This is possible in both the oscillogram and the spectrogram.

Please note that it is possible to unintentionally make a very narrow selection (the marked interval may then look almost like the vertical cursor). The subsequent commands may then give unexpected results, e.g. choosing Zoom In will cause an extremely small portion of the sound file to be displayed.

Note: Making two or more rapid clicks on the Zoom button will change the zoom level more than one step. This can be used to inhibit the program from redrawing the diagram for each zoom level (in the case of a high-resolution spectrogram, this may take some time!).

It is also possible to manually enter figures for the time, amplitude and frequency scales in the Oscillogram Settings and Spectrogram Settings dialogs.

Shortcuts

Toolbar: 

Keys: Ctrl Up-arrow

Zoom Out command (Tools menu)

Use this command to go back to the previous zoom level.

Shortcuts

Toolbar: 

Keys: Ctrl+Down-arrow

Default Zoom command (Tools menu)

Use this command to restore the display to the original zoom level (which was used when the window was opened).

Shortcuts

Keys: Ctrl+Shift+Left-arrow

Zoom Entire File command (Tools menu)

Use this command to adjust the zoom level to show the full length of the signal.

Shortcuts

Keys: Ctrl+Shift+Down-arrow

Zoom full range frequency/amplitude (Tools menu)

Use this command to adjust the vertical zoom level so that the full frequency and amplitude range is shown in the spectrogram and oscillogram.

Marking Cursor command (Tools menu)

Use this command to select the Marking type cursor. Using this cursor type you can select (mark) desired section of the signal for editing, playing etc. In order to select a section of the sound file, position the pointer at the start point of the desired section and press the left mouse button. Hold the button down, move the pointer to the desired end position, and then release the button. The selected section will be shown in inverted colors, and the time data for the selected interval will be shown above the scrollbar.

When used to mark a section to be zoomed, the zooming action is made only along the time axis.

Please note that it is possible to unintentionally make a very narrow selection (the marked interval may then look almost like the vertical cursor). The following commands may then give unexpected results, e.g. choosing Zoom in will cause an extremely small portion of the sound file to be displayed.

Clicking the right mouse button somewhere in the active window will invoke a menu containing this command. This enables you to quickly change between the two cursor types.

Shortcuts

Keys: Ctrl+A

Marking Cursor - stereo command (Tools menu)

This command is identical to the Marking Cursor command, except that the Marking Cursor - stereo command is used to select the same time interval on both channels of a stereo file.

Measurement Cursor/Large Measurement Cursor commands (Tools menu)

Use these commands to select the Measurement type cursor. Using this cursor type the X and Y coordinates at the cursor position is displayed above the scrollbar. Clicking the left mouse button activates a second cursor while freezing the first cursor. This enables measurements of differences in X and Y coordinates. This cursor type is also used to mark a section to be zoomed along both the vertical and horizontal axes.

In order to fine tune the position of the cursor, the arrow keys on the keyboard may be used.

Clicking the right mouse button somewhere in the active window will invoke a menu containing this command. This enables you to quickly change between the two cursor types.

Shortcuts

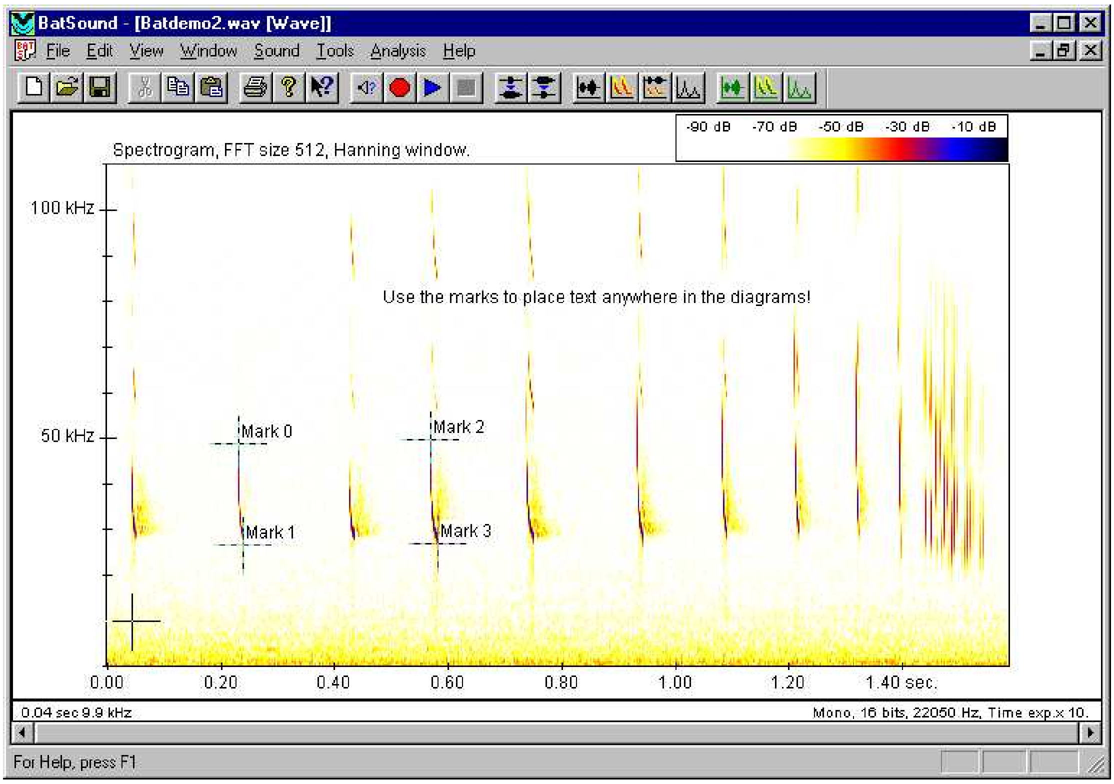
Keys: Ctrl+Shift+A (Measurement cursor)

Level Cursor command (Tools menu)

Use this command to select the Level type cursor. This cursor type is used in the Pulse Interval and Pulse Length analyses to set the threshold level in the oscillogram. Position the cursor with the mouse and click the left button to select a new level.

Save cursor as mark command (Tools menu)

Use this command to put a "mark" at the current cursor position. A mark is an object that may be located anywhere in the diagrams. It may be used to measure a number of "X-Y distances" in the diagrams, to scroll to any of the marks, or to annotate text in the diagrams.



The appearance of the mark depends on the type of cursor you used when saving the cursor as a mark.

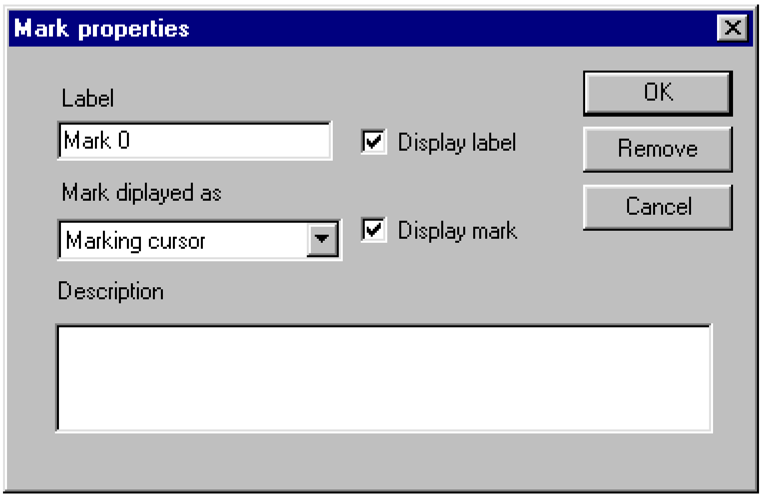
The marks are saved in the file, provided the "Wave (BatSound)" format is used.

This command is also available from the "right-hand mouse button menu".

Set active mark command (Tools menu)

Use this command to select the "active mark". Only one mark can be active at each time. The active mark may be moved and its properties may be changed.

Active mark properties command (Tools menu)



Use this command to change the properties of the active mark. The label and type of mark can be selected. It is also possible to hide the label and/or mark by unchecking the respective box. If desired, comments may be entered in the "Description" field.

Clicking the "Remove" button will erase the active mark.

Move active mark command (Tools menu)

Use this command to activate the "mark move" mode. Using the arrow keys, you may adjust the position of the active mark.

To exit this mode, select the Move active mark command a second time.

Mark distances command (Tools menu)

Use this command to display a table showing the differences between the X and Y coordinates of all marks.

Scroll to mark command (Tools menu)

Use this command to scroll to one of the available marks. This feature is particularly useful to quickly move between different parts of a long file.

Clear all marks command (Tools menu)

Use this command to delete all marks in the active sound file. Marks can be selectively deleted by selecting “Remove” in the Mark Properties dialog.

The Analysis menu

Spectrogram command (Analysis menu)

Use this command to display the spectrogram of a signal. An oscillogram or spectrogram has to be present in the active window before you choose this command. The spectrogram of the section displayed in the active window will be calculated and displayed in a new window, using the parameters given in Spectrogram Settings. If you have selected a section of the signal in the active window, the spectrogram of that section will be displayed.

Spectrogram “right mouse button menu”

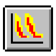
If you click the right mouse button somewhere in the Spectrogram window, a menu with a number of commonly used commands will appear. The commands are:

Cut, Copy, Paste, Save cursor as mark, Spectrogram Settings (refer to the Edit, Tools and Analysis menus for detailed information on these).

Entering new values in the Spectrogram Settings dialog *will only affect the current diagram*, as opposed to the Spectrogram Settings – Default command in the Analysis menu, which affects all Spectrograms drawn subsequently.

The cursor type (Marking cursor, Measurement cursor etc.) can also be chosen in this menu.

Shortcuts

Toolbar: 
Keys: Ctrl+Shift+S

Oscillogram command (Analysis menu)

Use this command to open a new window and display the oscillogram of the signal in the current active window.

Oscillogram “right mouse button menu”

If you click the right mouse button somewhere in the Oscillogram window, a menu with a number of commonly used commands will appear. The commands are:

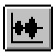
Cut, Copy, Paste, Save cursor as mark, Oscillogram Settings (refer to the Edit, Tools and Analysis menus for detailed information on these) and Copy Ascii.

The **Copy Ascii** command copies the raw sample values to the Windows clipboard, to enable exporting these to other applications.

Entering new values in the Oscillogram Settings dialog will only affect the current diagram, as opposed to the Oscillogram Settings – Default command in the Analysis menu, which affects all Oscillograms drawn subsequently.

The cursor type (Marking cursor, Measurement cursor etc.) can also be chosen in this menu.

Shortcuts

Toolbar: 
Keys: Ctrl+Shift+O

Zero Crossing Analysis command (Analysis menu)

Use this command to open a new window and display a frequency-time plot of the signal present in the active window. The Zero Crossing Analysis technique is used to obtain the diagram. The time between successive zero crossings of the sound wave is used to obtain (an average of) the time for one cycle of the signal. Taking the reciprocal of this gives the corresponding frequency.

The calculated frequency usually equals the fundamental frequency of the signal, but it is worth noting that under certain circumstances (strong harmonics), the frequency obtained from the zero crossing analysis may be one of the harmonics instead.

Regardless of which frequency is displayed (fundamental or harmonic), only one frequency can be displayed at each time, so this technique usually does not give any information on the harmonic content of the signal.

The spectrographic analysis gives results that are more reliable and is also more informative, so it is generally preferred to the zero crossing analysis.

<u>Zero Crossing Analysis "right mouse button menu"</u>

If you click the right mouse button somewhere in the Zero Crossing Analysis window, a menu with a number of commonly used commands will appear. The commands are:

Cut, Copy, Paste, Save cursor as mark, Zero Crossing Analysis Settings (refer to the Edit, Tools and Analysis menus for detailed information on these).

Entering new values in the Zero Crossing Analysis Settings dialog will only affect the current diagram, as opposed to the Zero Crossing Analysis Settings – Default command in the Analysis menu, which affects all Zero Crossing Analysis diagrams drawn subsequently.

The cursor type (Marking cursor, Measurement cursor etc.) can also be chosen in this menu.

Combined command (Analysis menu)

Use this command to open a new window and display both the oscillogram and spectrogram of a signal in the same window. See also Spectrogram command.

Shortcuts

Toolbar: 

Power Spectrum command (Analysis menu)

Use this command to display the power spectrum of the signal in the active window. The power spectrum window may be resized by dragging the size bars at the corners or edges of the window, or by clicking the maximize button in the title bar of the power spectrum window.

The power spectrum can be calculated in two ways:

1. Mark the starting point of the interval over which you wish to calculate the power spectrum. The FFT size given under Power Spectrum Settings determines the length of the interval, which is shown in inverse colors.

or

2. Mark the desired time interval over which you wish to calculate the power spectrum. A number of FFTs are calculated over this interval, and then averaged before being displayed. A small overlap between successive FFTs will be used to fit the FFTs into the desired time interval.

The time interval over which the power spectrum is calculated is displayed in the lower right corner of the diagram.

It is also possible to display the power spectrum in the **continuous update mode**, meaning that the power spectrum is continuously updated as the time interval/starting point is changed. This is particularly useful for examining how the power spectrum changes while scrolling through a spectrogram (use the arrow keys to move the cursor through the spectrogram). Note that the actual interval over which the power spectrum is calculated is always shown.

<u>Power Spectrum “right mouse button menu”</u>

If you click the right mouse button somewhere in the Power Spectrum window, a menu will appear from which you may print the diagram, copy the diagram to the clipboard or change the Power Spectrum settings of the diagram in the active Power Spectrum window.

The *Settings – current diagram command* allows you to use a different window, FFT size or power scale (please refer to Power Spectrum Settings command for more information on this). Please note that the Settings command in this menu only affects the current diagram, while the Power Spectrum Settings - Default command in the Analysis menu affects all diagrams made subsequently.

The *Copy command* will copy the Power Spectrum to the clipboard, so you can paste it into other Windows applications.

The *Copy Ascii command* copies the N/2 values in the Power Spectrum (N = FFT size) to the Windows clipboard. The values are stored as pairs of numbers (frequency and power spectrum value). This is useful to export the Power Spectrum data to e.g. a spreadsheet program.

The *Print command* will print the Power Spectrum on the printer. Please note that the Print command in the File menu will only print the oscillogram and/or spectrogram of the signal.

The *Logarithmic Scale command* is used to toggle between logarithmic (dB) and linear scale (V^2) on the vertical axis. This can also be made in the Settings dialog box (see above).

The *Continuous Update command* is used to enable/disable the continuous update mode. This can also be done in the Settings dialog box (see above).

The *Ascii File Export command* saves the N/2 (N = FFT size) values in the Power Spectrum in a text file. The values are stored as pairs of numbers (frequency and power spectrum value). See also the Copy Ascii command.

Shortcuts

Toolbar: 
Keys: Ctrl+Shift+P

Pulse Interval and Pulse Length Analysis commands (Analysis menu)

These two analysis types both result in a histogram showing the distribution of the time intervals between successive pulses (the Pulse Interval) and pulse lengths respectively.

To make this analysis, make sure the active window contains an oscillogram of the signal you want to analyze. Using the mouse, select the desired time interval for the analysis. When you choose Pulse Train Analysis from the Analysis menu, two horizontal cursors appear in the oscillogram. Using the mouse, adjust the cursors slightly above the noise floor and check that the cursors intersects all pulses you want to include in the analysis (only pulses exceeding the cursor level will be counted). The number of pulses/pulse intervals detected and the time interval over which the analysis is made will be shown in the lower right corner of the diagram.

In order to enable automated analysis of pulse length and pulse interval a so-called **Detection Delay** is used. The detection delay is used in two ways:

1. The pulse level is allowed to go below the cursor threshold for a maximum time equal to the detection delay without causing the analysis algorithm to interpret this as two separate pulses.
2. The pulse level is required to remain below the cursor threshold for at least the detection delay time (counted from the time instant it last crossed the cursor threshold) in order to qualify for a detection of the pulse end.

The Detection Delay should be chosen less than the expected pulse lengths. If too large a value is entered, the analysis algorithm will not recognize all pulses.

In the Pulse Interval/Pulse Length Settings dialog, you may also adjust the time scale for the histograms.

Pulse Interval/Pulse Length analysis "right mouse button menu"

If you click the right mouse button somewhere in the Pulse Interval/Pulse Length window, a menu will appear from which you may print the diagram, copy the diagram to the clipboard or change the Pulse Interval/Pulse Length settings of the diagram in the active Pulse Interval/Pulse Length window.

The *Settings – current diagram command* allows you to change the settings *for the current histogram*. The settings you enter in the Pulse Interval/Pulse Length Settings – Default dialog box (from the *Analysis menu*) are the default settings used for all Pulse Interval/Pulse Length analyses made subsequently.

The *Copy command* will copy the histogram to the clipboard, so you can paste it into other Windows applications.

The *Copy Ascii command* copies the histogram analysis data to the Windows clipboard. The values are stored as triplets of numbers (the time interval given as "From (ms)", "To (ms)" and the number of observations in that interval). This is useful to export the data to e.g. a spreadsheet program.

The *Print command* will print the histogram on the printer. Please note that the Print command in the File menu will only print the oscillogram and/or spectrogram of the signal.

The *Continuous Update command*, is used to enable/disable the continuous update mode. This can also be done in the Settings dialog box (see above).

The *Automatic Settings command* enables/disables this mode (see the Pulse Interval/Pulse Length Settings command).

Pulse Characteristics Analysis command (Analysis menu)

Use this command to automatically extract information on:

Pulse duration
Pulse start time
Pulse end time
Maximum frequency
Minimum frequency
Frequency at maximum amplitude
Maximum amplitude

The analysis data is displayed in a table and can also be copied to the Windows clipboard and exported to other Windows programs.

The calculation of pulse characteristics is made in two steps. First, the program searches for pulses exceeding the amplitude threshold ("Oscillogram threshold"). A certain pulse duration is also required in order for the pulse to be "accepted". When a pulse has been identified, the program continues by analyzing the spectrogram. It then starts from the loudest portion of the call and searches to the left and right of this to find the maximum and minimum frequencies etc. It is possible to allow short "gaps" in the spectrogram (in time and/or frequency).

First, the desired analysis time interval should be highlighted. Then select the Pulse Characteristics Analysis command to make the Pulse Characteristics Analysis dialog appear. The following analysis parameters can be selected:

Oscillogram threshold – Enter the desired threshold in dB. Only pulses exceeding this level will be analyzed. The corresponding level is shown in the oscillogram as horizontal lines. It is also possible to change the setting of the threshold by clicking at the desired level in the oscillogram – the dB value in the Pulse Characteristics Analysis dialog is automatically updated.

Minimum separation – In order to avoid interpreting a pulse with varying amplitude as several pulses, enter a number for the expected minimum separation between pulses in ms. If the amplitude falls below the threshold and once again reaches above the threshold before the "Minimum separation" has passed, the program will consider this to be only one pulse.

This value is also used when calculating the minimum/maximum frequency from the spectrogram to allow short gaps in time without interpreting this as two separate pulses.

Minimum duration – Enter the desired value in ms. Only pulses with a duration at least this value, will be analyzed.

Spectrogram threshold – Once a pulse fulfilling the above criteria has been found, the spectrogram is analyzed. When the algorithm searches for the minimum and maximum frequencies, the "Spectrogram threshold" value is used. Entering a value of e.g. –40 dB means that the min/max frequency will be the lowest/highest frequency where the amplitude still is above –40 dB.

Frequency separation – When searching for min/max frequency, the algorithm allows this gap in frequency and still considers it a continuous pulse. To disable this function, enter "0".

Lower/Upper frequency limit – Frequencies below/above these limits will be excluded from the analysis. Useful to avoid low- and/or high-frequency noise to affect the analysis. To disable either limit, enter "0".

Pulse measurements – Checking the respective boxes will make the corresponding parameter to be calculated and displayed in the results table.

The "Mark..." boxes are used to enable automatic positioning of marks at the respective locations in the oscillogram and spectrogram. It is recommended to enable this feature, since this makes it easy to see which start/end time, min/max frequency the program has found. For clarity, the mark labels are not visible in this case. Each mark has a label though (shown e.g. in the "Set Active Mark" list). If desired, the labels can manually be made visible in the Active Mark Properties dialog.

At the bottom of the Pulse Characteristics Analysis dialog, the "Calculation Parameters" are shown. These are taken from the Spectrogram settings of the current spectrogram. In order to avoid obtaining different FFT sizes and overlaps depending on the size of the window, it is recommended not to use the "Automatic" setting for FFT size and overlap. When manually selecting these parameters, an overlap of at least 50% is recommended.

Clicking the "Calculate" button will initiate the actual analysis and the results will be displayed in a separate window. If you wish to export these data to another Windows application (e.g. a spreadsheet program), you may do so by clicking the "Copy" button. This will copy the data into the Windows clipboard.

Before making a second analysis of the same file, it is usually advisable to delete the marks from the previous analysis using the Clear Marks button. To delete all marks, use the Clear All Marks command in the Tools menu.

Note: As with all automatic measurements, there is always a chance that the program will interpret the signal differently than if it was manually analyzed. It is recommended that you

enable the "marks positioning" feature and that you study the location of the marks after making the analysis. This will make it easy to identify any unexpected results.

Spectrogram Settings -Default command (Analysis menu)

Use this command to change the Spectrogram analysis parameters for any subsequent analyses. If you wish to change the settings only for the currently displayed spectrogram, use the "Spectrogram Settings – current diagram" command instead, available in the "Spectrogram right mouse button menu". To access this menu, position the cursor in the spectrogram area and press the right mouse button.

The parameters are:

FFT size - the number of samples used for each FFT. You may select one of the following FFT sizes:

16, 32, 64, 128, 256, 512, 1024, 2048 or Automatic.

The frequency resolution will be higher (but the time resolution lower!), the larger number of samples you choose. If you choose "Automatic", the program will select an FFT size giving a resolution that approximately corresponds to the actual screen resolution with the current window size.

FFT Window - the window type used for the FFT. You may select one of the following windows:

Rectangular, Hanning, Hamming, Parzen or Cosine.

The Hanning window is a commonly used general-purpose window. Different windows have different properties regarding *spectral leakage* and frequency resolution. For more information about this, please refer to Appendix A of this manual or the extensive selection of literature on digital signal processing.

FFT Overlap - the overlap in % of the FFT window between successive FFTs. An overlap of 50 % means that the "next" FFT will start in the middle of the interval used to calculate the "current" FFT. A large overlap increases the computation time for the spectrogram, but results in a smoother curve ("higher time resolution"). If the "Automatic" check box is checked, the program will select a suitable overlap, corresponding to the present window size and time scale. If the time scale is such that a very long portion of the signal is displayed in the window, the program will adjust the overlap to avoid long calculation times. If short pulses are present in the window in this case, some of these may be lost in the spectrogram. *To avoid this situation, manually select a sufficient overlap in such cases.*

Milliseconds per plot - determines the time scale. Enter the desired number of milliseconds to be displayed in the window.

Note: In the real-time spectrogram mode, only values between 2000 and 30000 (i.e. 2 and 30 seconds) will be accepted. The value will also be truncated to the nearest integer number of seconds.

Min and max frequency - determines the frequency scale. Enter the desired frequency range to be displayed.

Color mapping - select one of the available mappings of power spectrum levels into different colors.

Amplitude contrast - select one of the available contrast curves. This is useful to emphasize differences in the power spectra levels for certain level intervals.

This function is not active with user defined color mappings.

Threshold - adjust the level threshold in the power spectra. Portions of the power spectra below the threshold will not be displayed in the spectrogram. A weak signal requires a lower threshold, while a strong signal is likely to look best with a higher threshold.

This function is not active with user defined color mappings.

Show amplitude color bar - check this box to display a color bar in the spectrogram window, showing the actual mapping of different levels (dB) into colors.

Low level de-emphasis - check this box to change the color mapping so that the low-level portions of the spectrogram will be shown in less bright colors.

Channel to view - select which channel to view in the case of a stereo recording; left, right or both.

Grid lines – select the number of grid lines per tick mark on the vertical and horizontal axes, or no grid lines.

Values at all tick marks – check this box to obtain values at all tick marks on the frequency axis.

The frequency resolution and the time between FFTs ("time resolution") resulting from the chosen parameters are calculated and displayed, if FFT size and overlap are chosen manually.

If you want to update the active spectrogram with the new settings, click the **Apply** button before closing the dialog box. Changing the settings for the active spectrogram only can be accomplished from the "right mouse button" menu.

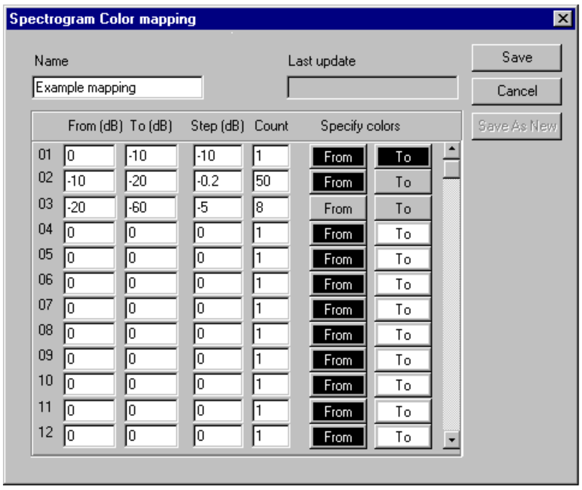
User defined color mappings

In addition to the predefined color mappings, the user can design any desired color mapping. Click the "User colors" button to enter the color mapping design mode. Choose "New" in the "User defined color mappings" dialog to open the "Spectrogram color mapping" dialog. Here you can enter the desired colors for the different dB intervals.

Each interval has its corresponding "from" and "to" color. First, choose the dB interval by entering the "From (dB)" and "To (dB)" values. Then enter the number of colors that should be used over the selected interval ("Count") or the "Step" size in dB within the interval. Obviously, these four parameters interact, and the program will automatically update the other parameters if one of them has been changed. The colors corresponding to the "From" and "To" dB values should also be chosen. Click on the "From" and "To" buttons under "Specify colors" and pick the desired colors. Repeat this procedure for any number of intervals you wish up to 64.

Example. Assume you want to design a color mapping with the following colors. For all levels from 0 dB to –10 dB, the color should be black. From –10 dB to –20 dB the color should change gradually from black to gray and from –20 to –60 dB the color should change from gray to light yellow in 5 dB steps.

Entering the values as shown below will give the desired mapping:



Note that the “Count” value for the first interval is 1, to ensure that only one color is used there. The “Step” value for the second interval was chosen to 0.2 dB to give a smooth transition between the two colors (black and gray).

To save the color mapping, enter a name (“Example mapping” in the example) and click “Save”. After saving it, this color mapping will be available as one of the alternatives under Amplitude Color Mapping in the Spectrogram Settings dialog.

Shortcut

Toolbar: 

Oscillogram Settings - Default command (Analysis menu)

Use this command to change the Oscillogram display parameters for any oscillograms to be shown.

These parameters are:

Milliseconds per plot - determines the time scale. Enter the desired number of milliseconds to be displayed in the window.

Note: In the real-time spectrogram mode, only values between 2000 and 30000 (i.e. 2 and 30 seconds) will be accepted. The value will also be truncated to the nearest integer number of seconds.

Channel to view - select which channel to view in the case of a stereo recording, left, right or both.

Min and Max Amplitude - determines the amplitude scale. Enter numbers between –100 and 100 (%).

Line between samples – Check this box if you wish to have lines drawn between successive samples (improves appearance of the oscillogram at high zoom levels).

Grid lines – select the number of grid lines per tick mark on the vertical and horizontal axes, or no grid lines.

If you want to update the active diagram with the new settings, click the **Apply** button before closing the dialog box. Changing the settings for the active diagram only can be accomplished from the "right mouse button" menu.

Zero Crossing Analysis Settings - Default command (Analysis menu)

Use this command to change the Zero Crossing Analysis parameters for any subsequent analyses.

The parameters are:

Milliseconds per plot - determines the time scale. Enter the desired number of milliseconds to be displayed in the window.

Channel to view - select which channel to view in the case of a stereo recording, left, right or both.

Number of samples in zero crossing analysis – determines the averaging time of the analysis. The smaller number the shorter the averaging time and hence the better the time resolution. The larger number the longer the averaging time and the smoother the diagram.

Detection threshold – determines the amplitude threshold in percent of full scale for the analysis. The frequency calculation is made only for portions of the signal exceeding the threshold.

Line between values – check this box if you wish to have lines drawn between successive frequency values.

Grid lines – select the number of grid lines per tick mark on the vertical and horizontal axes, or no grid lines.

If you want to update the active diagram with the new settings, click the **Apply** button before closing the dialog box. Changing the settings for the active diagram only can be accomplished from the "right mouse button" menu.

Power Spectrum Settings - Default command (Analysis menu)

Use this command to adjust the Power Spectrum analysis parameters for any subsequent analyses.

The parameters are:

FFT size - the number of samples used for each FFT. You may select one of the following FFT sizes:

16, 32, 64, 128, 256, 512, 1024, 2048, 4096, 8192, 16384 or Automatic.

The frequency resolution will be higher, the larger number of samples you choose. The choice "Automatic" will result in a variable FFT size, depending on the size of the window.

FFT Window - the window type used for the FFT. You may select one of the following windows:

Rectangular, Hanning, Hamming, Parzen or Cosine.

The Hanning window is a commonly used general-purpose window for stationary signals. However, for signals of limited duration (such as bat calls), the rectangular window usually is a better choice if the FFT size can be chosen to make one FFT exactly cover the limited duration signal. For more information on this, please refer to Appendix A of this manual or the extensive selection of literature on digital signal processing.

FFT Overlap. The interval for calculating an FFT can be determined either by the FFT size only (by just clicking at the desired start point in the spectrogram or oscillogram) or by highlighting a (longer) time interval and then selecting the Power Spectrum command. In the latter case, a number of FFTs will be calculated along the marked time interval and then averaged. The FFT Overlap in percent can be selected in the settings dialog. An overlap of 50% means that the "next" FFT will start at the time corresponding to the middle of the current FFT. Usually, a larger overlap gives a better result. An overlap value between 0 and 98% can be entered.

The actual FFT calculation interval depends on both the FFT size and the FFT overlap and obviously, if a certain time interval is marked for the calculation of the FFTs, it may be impossible to obtain exactly this time interval with the selected FFT size and FFT overlap. If the Justify overlap box is unchecked, a slightly different calculation interval will be used (than the interval that is actually marked). On the other hand, if the Justify overlap box is checked, the overlap will be adjusted instead, and the calculation interval will be exactly the one marked on the screen. The actual FFT overlap is then displayed in the FFT title bar. In both cases, using a large overlap gives a smaller deviation from the desired calculation interval and overlap, respectively.

Min level, Max level - determines the scaling of the vertical axis, i.e. the level span in dB or V^2 to be shown.

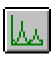
Min freq, Max freq - determines the scaling of the horizontal axis, i.e. the frequency span to be displayed.

Continuous update - check this box to activate the continuous update mode. In this mode, the power spectrum will instantaneously follow any changes made to the cursor position in the oscillogram (or spectrogram).

Logarithmic scale - check this box to activate logarithmic power scale (dB). Leaving the box unchecked gives a linear power scale (V^2).

Note: The Power Spectrum Settings dialog box can also be reached from the Power Spectrum window, by clicking the right mouse button and then selecting "Settings - Current diagram" from the menu. This is useful if you want to make changes to the settings of the analysis you just made. ***Changes of the power spectrum settings made from the "right mouse button menu" only apply to that particular power spectrum, while changes made through the Power Spectrum Settings - Default command in the Analysis menu are the default values that apply to all power spectra made subsequently.***

Shortcuts

Toolbar: 

Pulse Interval/Pulse Length Settings - Default command (Analysis menu)

Use this command to change the Pulse Interval/Pulse Length analysis parameters for any subsequent analyses.

The parameters you can adjust are:

Detection Delay Time - The detection delay is used in two ways:

1. The pulse level is allowed to go below the cursor threshold for a maximum time equal to the detection delay without causing the analysis algorithm to interpret this as two separate pulses.

2. The pulse level is required to remain below the cursor threshold for at least the detection delay time (counted from the time instant it last crossed the cursor threshold) in order to qualify for a detection of the pulse end.

The Detection Delay should be chosen less than the expected pulse lengths. If too large a value is entered, the analysis algorithm will not recognize all pulses.

Histogram start time - the start value in seconds for the time scale of the respective histogram.

Histogram end time - the end value in seconds for the time scale of the respective histogram.

Numbers of histogram bars - determines the width of each bar.

Detection Threshold - the threshold you set with the horizontal cursors, expressed in % of the maximum signal amplitude. You may change this either by entering a new value here or by changing the cursor level.

All parameters except the Detection Delay Time can also be calculated automatically if the “Automatic Calculation…” box is checked. The program then attempts to select suitable values depending on the actual signal and to adapt the time scale so that all bars in the histogram will be displayed.

Checking the “Continuous Update” box will cause the histogram to be updated immediately upon making any change in the selected interval of the signal.

Note: The Pulse Interval/Pulse Length Analysis Settings dialog box can also be reached from the Pulse Interval/Pulse Length window, by clicking the right mouse button and then selecting “Settings - Current diagram” from the menu. This is useful if you want to make changes to the settings of the analysis you just made. ***Changes of the Pulse Interval/Pulse Length Analysis settings made from the “right mouse button menu” only apply to that particular Pulse Interval/Pulse Length diagram, while changes made through the Pulse Interval/Pulse Length Analysis Settings – Default command in the Analysis menu are the default values that apply to all Pulse Interval/Pulse Length diagrams made subsequently.***

The Help menu

Help command (Help menu)

Use this command to open the BatSound User’s Manual as a pdf file.

Help on the Web (Help menu)

Use this command to open the Help page at the Pettersson web site in your browser.

Pettersson Homepage (Help menu)

Use this command to open the main page at the Pettersson web site in your browser.

About command (Help menu)

Use this command to display the copyright notice and version number of your copy of BatSound.

Context Help command

Use the Context Help command to obtain help on some portion of BatSound. When you choose the Toolbar's Context Help button, the mouse pointer will change to an arrow and question mark. Then click somewhere in the BatSound window, such as another Toolbar button. The Help topic will be shown for the item you clicked.

Note: Context Help is not available for all items.

Shortcut

Keys: SHIFT+F1

Miscellaneous

Title Bar

The title bar is located along the top of a window. It contains the name of the application and document.

To move the window, drag the title bar. Note: You can also move dialog boxes by dragging their title bars.

A title bar may contain the following elements:

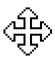
- Application Control-menu button
- Document Control-menu button
- Maximize button
- Minimize button
- Name of the application
- Name of the document
- Close button

Scroll bars

Displayed at the right and bottom edges of the document window. The scroll boxes inside the scroll bars indicate your vertical and horizontal location in the document. You can use the mouse to scroll to other parts of the document.

Size command (Control menu)

Use this command to display a four-headed arrow so you can size the active window with the arrow keys.



After the pointer changes to the four-headed arrow:

1. Press one of the DIRECTION keys (left, right, up, or down arrow key) to move the pointer to the border you want to move.
2. Press a DIRECTION key to move the border.
3. Press ENTER when the window is the size you want.

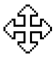
Note: This command is unavailable if you maximize the window.

Shortcut

Mouse: Drag the size bars at the corners or edges of the window.

Move command (Control menu)

Use this command to display a four-headed arrow so you can move the active window or dialog box with the arrow keys.



Note: This command is unavailable if you maximize the window.

Shortcut

Keys: CTRL+F7

Minimize command (application Control menu)

Use this command to reduce the BatSound window to an icon.

Shortcut

Mouse: Click the minimize icon on the title bar.
Keys: ALT+F9

Maximize command (Control menu)

Use this command to enlarge the active window to fill the available space.

Shortcut

Mouse: Click the maximize icon on the title bar; or double-click the title bar.
Keys: CTRL+F10 enlarges a document window.

Next Window command (document Control menu)

Use this command to switch to the next open document window. BatSound determines which window is next according to the order in which you opened the windows.

Shortcut

Keys: CTRL+F6

Close command (Control menus)

Use this command to close the active window or dialog box.

Clicking the Close icon or double-clicking a Control-menu box is the same as choosing the Close command.

Note: If you have multiple windows open for a single document, the Close command on the document Control menu closes only one window at a time. You can close all windows at once with the Close command on the File menu.

Shortcuts

Keys: CTRL+F4 closes a document window
ALT+F4 closes the BatSound window or dialog box

Restore command (Control menu)

Use this command to return the active window to its size and position before you chose the Maximize or Minimize command.

Switch to command (application Control menu)

Use this command to display a list of all open applications. Use this "Task List" to switch to or close an application on the list.

Shortcut

Keys: CTRL+ESC

Dialog Box Options

When you choose the Switch To command, you will be presented with a dialog box with the following options:

Task List
Select the application you want to switch to or close.

Switch To
Makes the selected application active.

End Task
Closes the selected application.

Cancel
Closes the Task List box.

Cascade
Arranges open applications so they overlap and you can see each title bar. This option does not affect applications reduced to icons.

Tile
Arranges open applications into windows that do not overlap. This option does not affect applications reduced to icons.

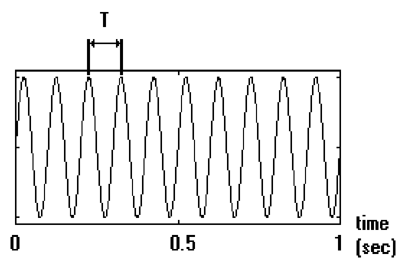
Arrange Icons
Arranges the icons of all minimized applications across the bottom of the screen.

APPENDIX A

The basics of signal processing

Acoustic signals

Sound can be defined as a wave motion, usually in air. A ***periodic signal*** theoretically consists of an infinite number of identical sequences, each sequence comprising one ***period*** of the signal. Signals with a finite number of identical sequences are generally referred to as periodic as well. The ***frequency*** of the signal is measured in Hertz (Hz), and tells us how many identical sequences or cycles there are per second. In the diagram below, a periodic signal is shown. The period is T = 0.1 sec., corresponding to a frequency of 10 Hz (=1/T).

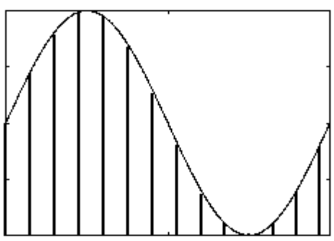


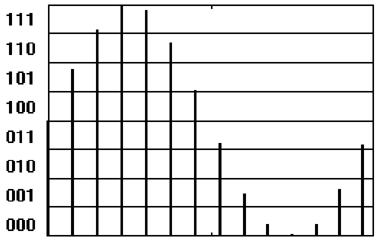
In order to convert the motion of air particles into an electric signal, a ***microphone*** is used. For ultrasonic frequencies, special ultrasound microphones are required. An ***ultrasound detector*** (bat detector) can also be used to transform the ultrasonic frequency into an audible frequency. This makes it possible to store the transformed signals on an audio frequency cassette tape recorder.

Getting the signal into the computer - sampling

In the early days of signal processing, dedicated instruments were used to perform the different types of analyses, e.g. an oscilloscope to display the oscillogram and a spectrum analyzer to produce signal spectra. Such instruments certainly still exist and in many situations are the best alternative. However, with the very powerful computers available today, it is also possible to use a combination of software and hardware (computer + data acquisition board) to obtain a very cost-effective “all-in-one” instrument.

Most signals are originally analog, i.e. they are defined for all time values and can be assigned any amplitude value. A digital device such as a computer requires digital data, so the analog signal first has to be ***sampled*** and then ***quantized***. The amplitude of the analog signal is sampled at the sampling instants, and the obtained samples are then assigned to one of the quantization levels (see below).





Resulting binary coded samples: 100, 101, 111, 111, 111, 110, 101, 011, 001, 000, 000, 000, 001, 011

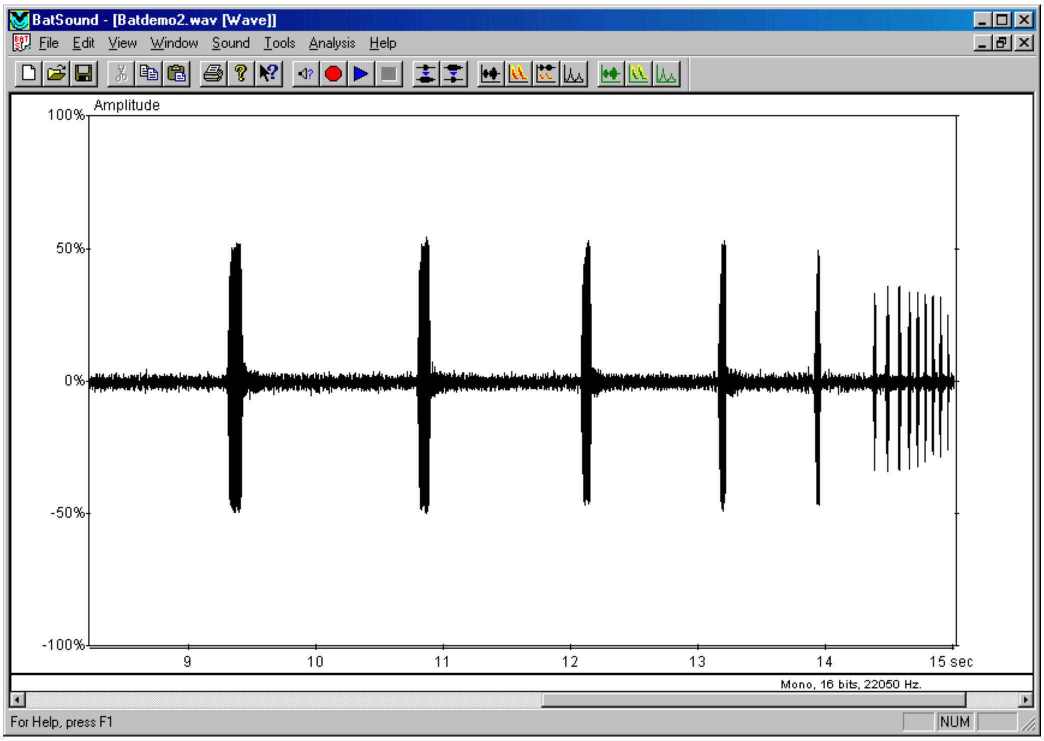
Clearly, the resemblance between the original and the sampled signal is improved if samples are taken closer to each other. However, taking many samples per time unit increases the computational burden as well as the storage requirements, so some compromise has to be made. The so called ***sampling theorem*** states that the minimum sampling frequency (number of samples per second) is twice the highest signal frequency. This means that a signal containing frequencies between 20 Hz and 20 kHz has to be sampled at a rate of at least 40000 samples per second (a sampling frequency of 40 kHz). This is the lowest sampling frequency allowed. In practice, the sampling frequency is always chosen a little higher than this.

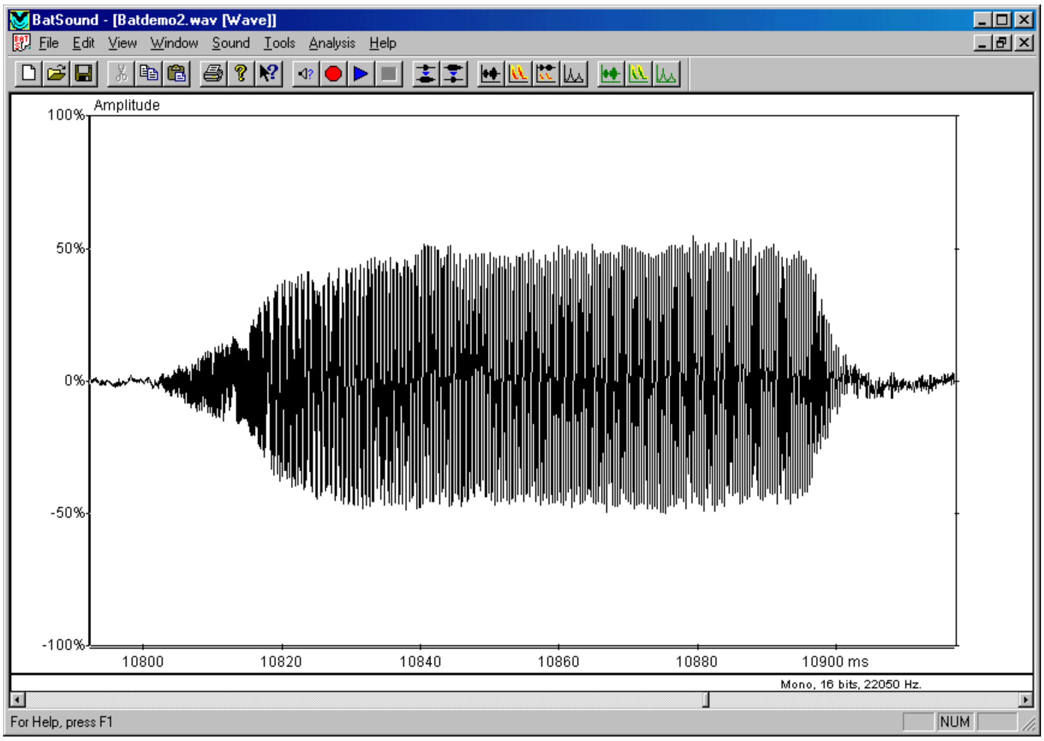
If too low a sampling frequency is used, ***aliasing*** will occur. Aliasing means that the frequency of the sampled signal will be lower than that of the original signal, so obviously this will not give a true picture of the original signal. Consequently, it is a good idea to always make sure that the signal does not contain any frequencies above half the sampling frequency. This can be attained by low-pass filtering the signal prior to the sampling. Many data acquisition boards and sound cards have such an ***anti-aliasing filter*** built-in, which automatically adapts the cut-off frequency according to the chosen sampling frequency.

The quantization process also affects the quality of the digitized signal, but in a different way. From the illustration above it should be clear that the original amplitude values are rounded off as the samples are quantized. This introduces an amplitude error, which can be perceived as an increase in the noise level. The maximum error is smaller the smaller the quantization interval is used. Since the quantization interval is determined by the number of binary digits (bits) used to represent each sample, the noise added by the quantization process will be smaller the more bits are used (i.e. 16 bits gives less noise than 8 bits).

The oscillogram

Signals can be analyzed in many ways. The most fundamental is to display the variations in voltage (sound pressure) versus time, which is often referred to as an ***oscillogram***. Two examples from BatSound are shown below. The first shows a portion of a bat call sequence, while the second shows an expanded view of one of the pulses.





A visual inspection of the oscillogram reveals some basic properties of the signal such as ***signal shape***, ***time for one period*** and, in the case of pulse-shaped signals, ***pulse length*** and ***time between pulses*** (pulse interval).

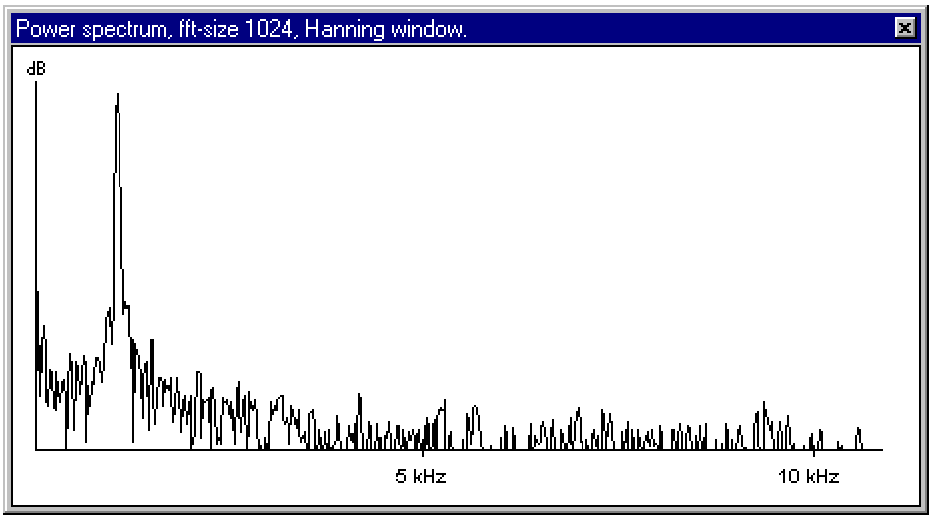
The time for one period of the signal is usually measured by calculating the time between successive zero-crossings of the signal. Taking the reciprocal of that time gives the frequency corresponding to that particular period, which in most cases corresponds to the ***fundamental frequency*** of the signal.

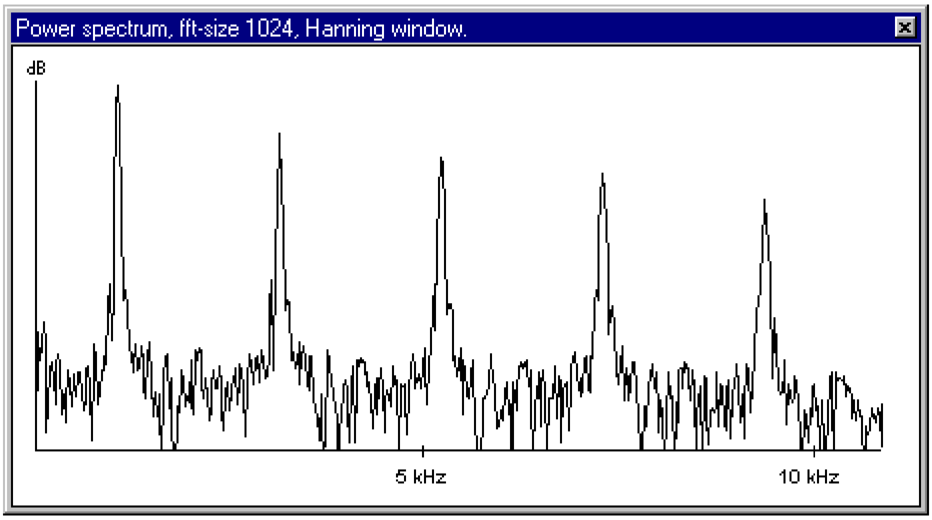
The power spectrum

A complex signal, as opposed to a pure sine wave, consists of more than one frequency. The spectrum of a signal gives information about how much and with which phase each frequency contributes to the signal. Usually the phase information is less interesting, so instead the ***magnitude of the spectrum*** is displayed (amplitude versus frequency). Alternatively, the signal power versus frequency can be displayed. In that case, we get a ***power spectrum***.

The most common method to calculate the spectrum of a digitized signal is the Fast Fourier Transform (***FFT***). This algorithm is computationally more efficient than a direct calculation of the spectrum.

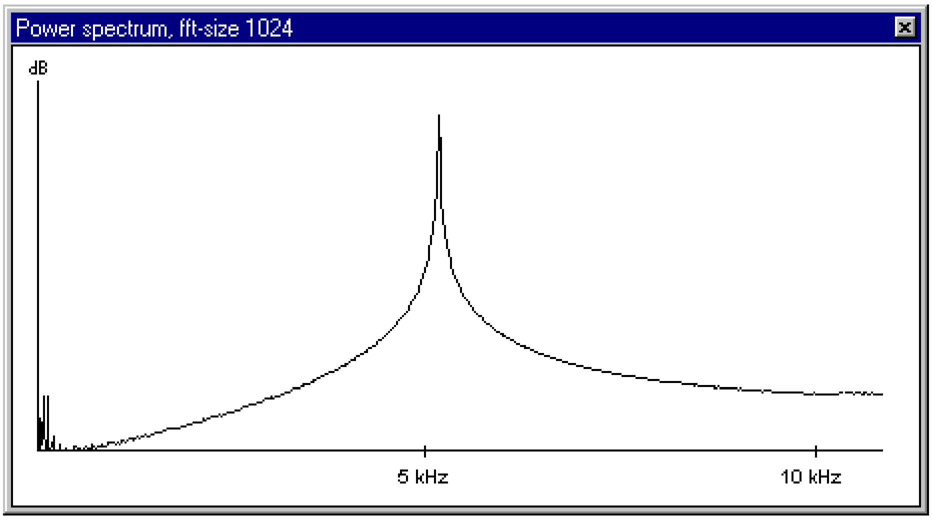
Below a few power spectra are shown, illustrating the terms ***fundamental frequency*** and ***harmonics***. The upper diagram shows the power spectrum of a sine wave, consisting of one single frequency, in accordance with the theory. The power spectrum of a square wave is shown in the lower diagram. Notice the fundamental frequency component at about 1 kHz and the harmonics at about 3, 5, 7 and 9 kHz (a symmetric square wave only has odd harmonics).

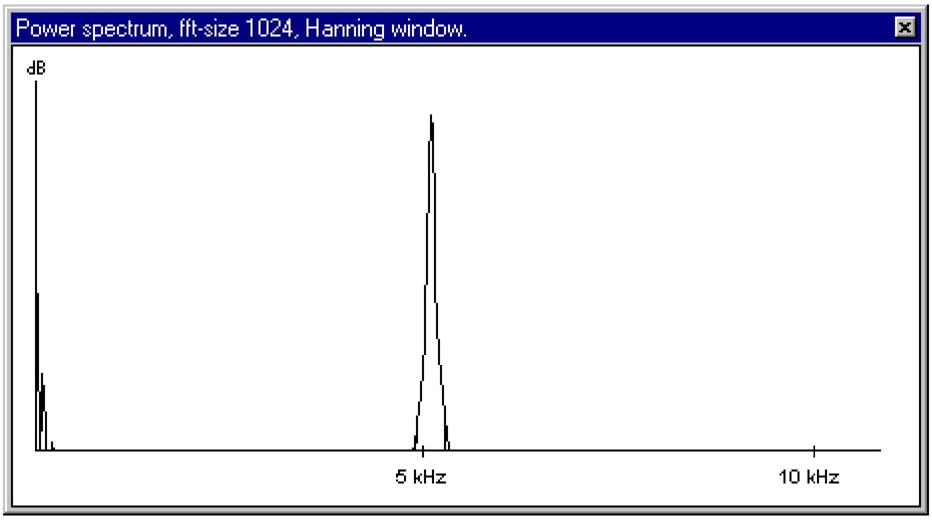




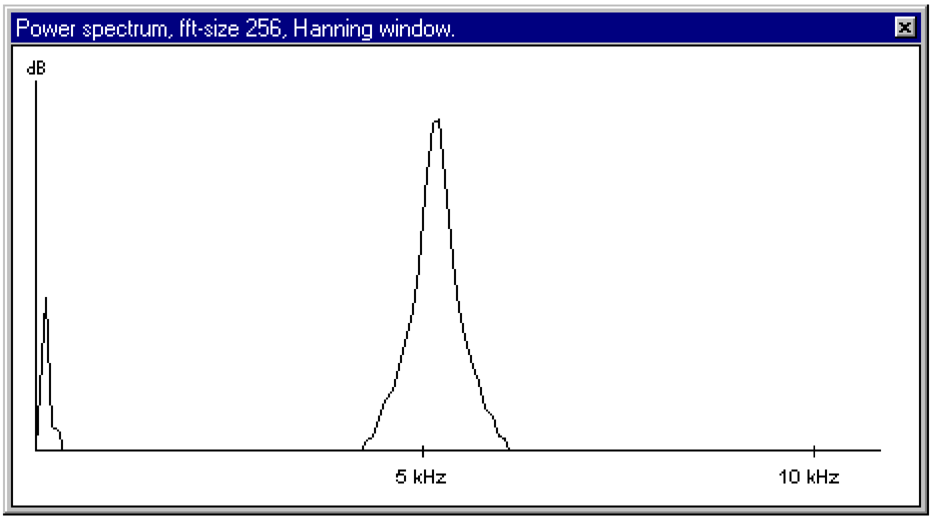
The width of each peak is determined by the length of the time interval used to calculate the spectrum (the size or length of the FFT) and the ***time window*** used. If we simply cut a portion of the signal and use that to calculate the FFT, we say that a ***rectangular window*** is used. If we instead use a ***Hanning window***, then samples at the beginning and end of the selected interval will get a lower amplitude than they originally had. Although it might seem that such a modification of the signal would result in an error in the representation of the signal, it turns out that this generally improves the appearance of the spectrum. There are a number of other windows too, but the Hanning window is generally considered a good all-round window. Below are two power spectra of the same signal (a sine wave at about 5 kHz) showing the difference between rectangular and Hanning windows. Notice the ***spectral leakage*** in the rectangular window case (the ideally very narrow peak is spread over a wide range of frequencies). The spectral leakage makes the detection of any other, weak frequency component impossible, and should thus be minimized. With a Hanning window, the situation is much improved.

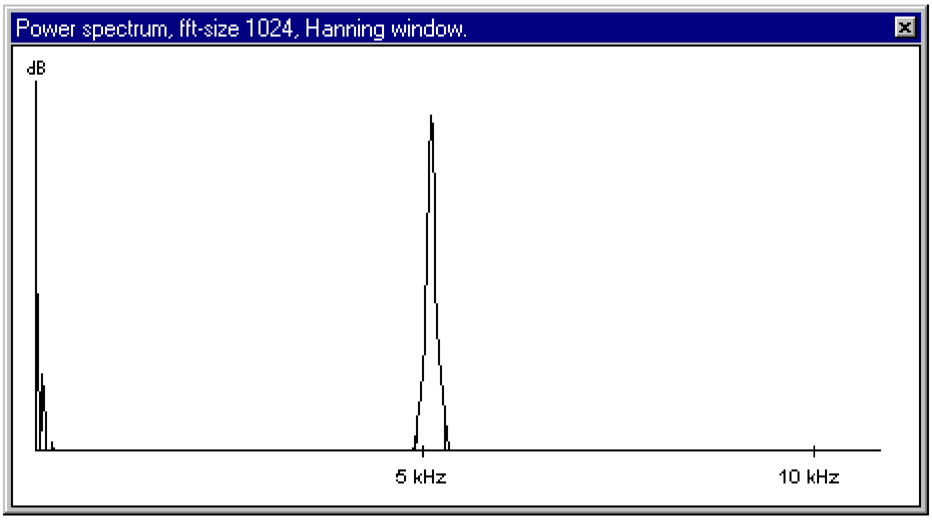
Please note that what is said above is true for stationary, periodic signals (e.g. sinusoids), but does not necessarily have to be true for other signal types. In particular, for signals of limited duration (e.g. bat calls), the rectangular window is often the best choice. Provided the signal amplitude is small at the beginning and end of the interval over which a single power spectrum is calculated, the spectral leakage is also small and the rectangular window should be used. This is usually the case when the power spectrum for an entire pulse is calculated.





As mentioned above, the size of the FFT affects the resolution (i.e. the ability to resolve closely located frequency components). The longer the FFT, the higher the frequency resolution. The diagrams below show power spectra for the same signal, but with different FFT size. The most common FFT algorithms assume the size (number of samples) to be 2^N, where N is an integer, corresponding to possible FFT lengths of 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024 etc.



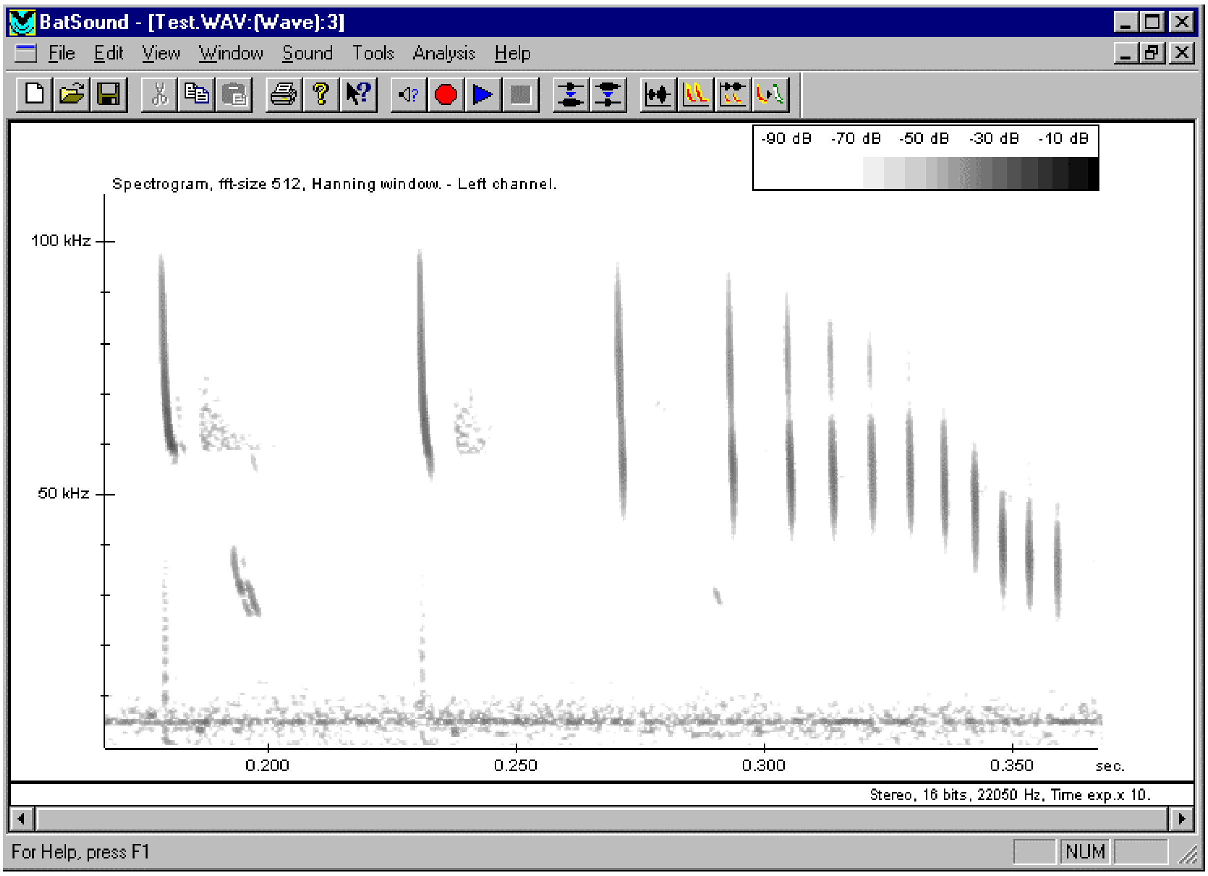


The spectrogram

As outlined in the section about the power spectrum, you have to select a limited time interval over which the spectrum is calculated. This of course means that the power spectrum cannot give any information about how the spectral content of the signal varies over time. In many applications, such information is highly useful though, and one way to obtain it is to calculate a large number of power spectra along the signal, and display this in a suitable form.

One possible way to display it is to use a so-called waterfall diagram, which is a pseudo-3-d diagram.

Another way is to display the information as a spectrogram, which simply is a frequency versus time diagram, where the power (or amplitude) is coded as different shades of gray or different colors. The spectrogram thus provides quite extensive information about the signal, much more than a zero-crossing analysis of the same signal would provide.



The parameters determining the appearance of the spectrogram include FFT size, window selection and overlap between successive FFTs. An overlap of 0% means that the “next” FFT will start right where the “current” ended, An overlap of 50% means that the next FFT will start in the middle of the time interval used to calculate the current FFT, etc. Usually it is also possible to adjust the “power-to-color” mapping.

Zero-crossing analysis

Zero-crossing analysis can be used to obtain a diagram similar to a spectrogram. It is less informative though, e.g. it only shows the predominant frequency component (usually the fundamental frequency), and does not give any information on amplitude or power.

The time between successive zero-crossings of the signal is used to calculate the period of the signal. Taking the reciprocal of this gives the frequency corresponding to that period. Usually the result is averaged over several cycles of the signal, in order to obtain a smoother curve.

Time domain analysis

Various types of analysis can also be made in the time domain, i.e. using the oscillogram as a base. Bioacoustic signals (and bat sounds in particular) often consist of a series of pulses. The distribution of these pulses can provide some useful information. E.g. the time difference between successive pulses and the individual pulse lengths can be measured and displayed (usually in a bar graph).

APPENDIX B

Filters

Electronic filters are commonly used e.g. to remove undesired frequencies from a signal. This can be used to reduce the influence of noise or other disturbances in a signal or to separate two or more signals previously combined. A signal may have been “contaminated” by 50-(60-) Hz hum from the mains. A filter, which removes this particular frequency, leaving all other frequencies unaffected, will restore the signal.

There are many ways to classify filters, one common is to look at the frequency response (selectivity) of the filter. A filter can have a lowpass, highpass, bandpass or bandstop response (there are also allpass filters, but these are beyond the scope of this overview). Each name indicates the influence of the filter on a band of frequencies, e.g. a lowpass filter would pass low frequencies while high frequencies would be significantly attenuated.

The filter characteristics available in BatSound are:

Lowpass Filter - removes/attenuates signals above the selected cut-off frequency.
Highpass Filter - removes/attenuates signals below the selected cut-off frequency.
Bandpass Filter - removes/attenuates signals below and above a selected band of frequencies.
Bandstop Filter - removes/attenuates signals within a selected band of frequencies.

Some commonly used terms to describe filters:

Passband - The frequency range which ideally should pass signals with no attenuation.
Stopband - The frequency range that ideally should attenuate signals completely.
Transition band - The frequency range between the passband and the stopband. The narrower the transition band, the more selective filter.

For each of the above filters, except the notch filter, you may also choose between **Butterworth, Chebyshev (type 1) or Elliptic** filter types. For experienced users, the **User Defined** filter type is also available. Please refer to chapter 10 (Filter command) for information on this.

The **Order** of the filter determines the filter’s selectivity. A high order filter is more effective than a low order filter, in that the transition band is narrower. You may select filter order 2, 4, 6 or 8.

Butterworth Filters

A Butterworth filter has a maximally flat frequency response in the passband. This filter type is a common general-purpose filter.

Chebyshev Filters

A Chebyshev type 1 filter has a frequency response, which ripples throughout the passband. Commonly this filter type is characterized according to the amount of ripple in the passband (e.g., a “1 dB ripple Chebyshev filter” has a gain variation of 1 dB in the passband). The advantage of allowing a certain ripple in the passband is that this considerably improves the sharpness of the transition between the passband and the stopband. This means that a filter with given selectivity requirements can be realized with a lower order using a Chebyshev filter compared to using a Butterworth filter.

In BatSound, the following values for the passband ripple can be chosen: 0.1, 0.2, 0.5, 1, 2 or 3 dB.

Allowing only a very modest ripple (0.1 or 0.2 dB) will decrease the transition band significantly compared with the Butterworth filter.

Elliptic Filters

While the Chebyshev filters had ripple in the passband, the elliptic filters (or *Cauer filters*) exhibit ripple in both the passband and the stopband. This results in an even narrower transition band. The amount of ripple in the passband is specified just like the Chebyshev filter, while the amount of ripple in the stopband usually is specified as the “maximum stopband gain” (or “minimum stopband attenuation”). Selecting a maximum stopband gain of e.g. -40 dB, ensures that the attenuation in the stopband is *at least* 40 dB relative to the gain in the passband.

In BatSound, the following values for the passband ripple can be chosen: 0.1, 0.2, 0.5, 1, 2 or 3 dB, and for the maximum stopband gain: -20, -30, -40, -50, -60 or -70 dB.

For the technically interested user, the Butterworth, Chebyshev and Elliptic filter types are realized by first designing an analog filter prototype of the respective type and then applying the bilinear transformation to obtain the digital filter which is then implemented in the software.

APPENDIX C

Troubleshooting

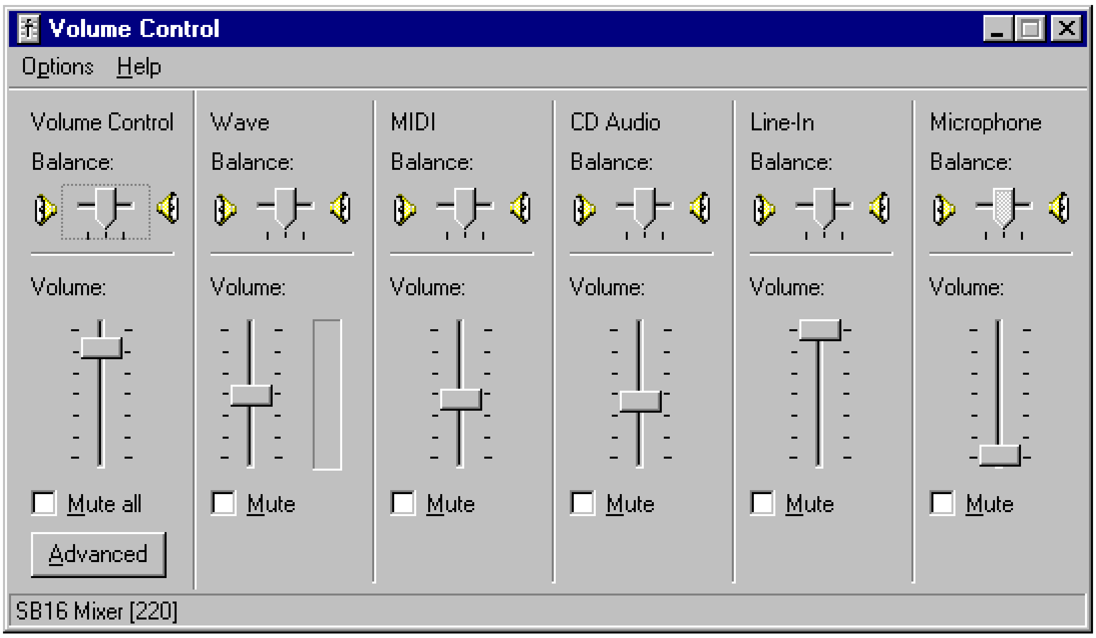
This section provides some tips and strategies for some of the most common problems you might encounter.

Problem
There is no sound when I choose the Play Sound command.

Cause/solution
1. Check the cables and connections in your system. Are the loudspeakers connected to the “Speakers” output jack?

2. Does the sound file you are trying to play really contain any sound? Load another sound file or play the sound file using another application (e.g. the Windows Media Player).

3. Check the volume control and input channel selector settings of the sound card. There may be a knob on the sound card that controls the output level to the speakers. In addition to this, it is also possible to adjust playback and recording levels using the “volume control” utility that often comes with the sound card. Enabling/disabling of the input channels is usually also possible. The Windows Volume Control offers similar options. You can access the Windows Volume Control either by double-clicking the loudspeaker symbol to the right in the Windows task bar or by choosing *Programs - Accessories - Multimedia - Volume Control* from the Start menu. The figure below shows suitable settings to enable playing sound. Make sure that both the Wave and the Volume Control are set to a level high enough.



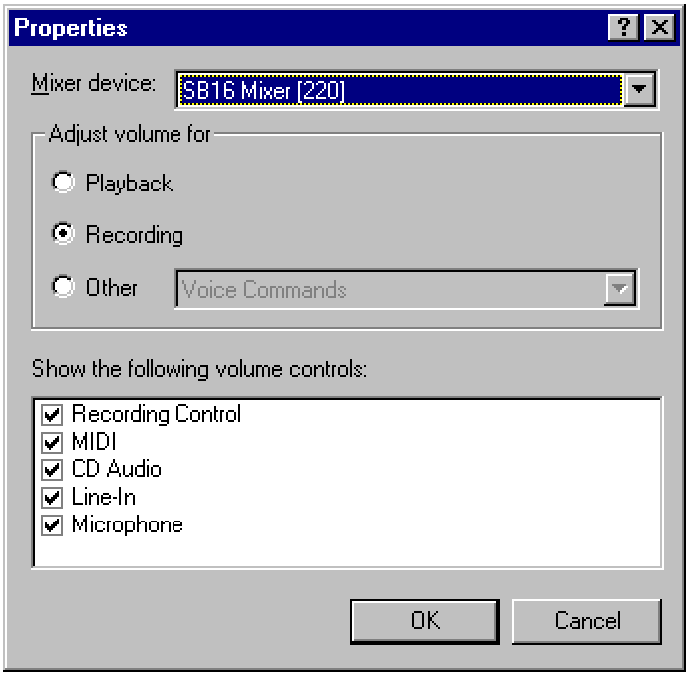
Note: With certain sound cards you will have to use the sound card’s “volume control” utility software rather than the Windows Volume Control to change the recording/playback settings.

Problem
The recordings I make don’t contain any sounds.

Cause/solution
1. Check the cables and connectors in your system. Is the cable from your sound source (e.g. tape recorder) connected to the appropriate input of the sound card (connecting a microphone to the line input will result in very weak recordings)?

2. Check the volume control and input channel selector settings of the sound card. There may be a knob on the sound card that controls the output level to the speakers. In addition to this, it is also possible to adjust playback and recording levels using the “volume control” utility that often comes with the sound card. Enabling/disabling of the input channels is usually also possible.

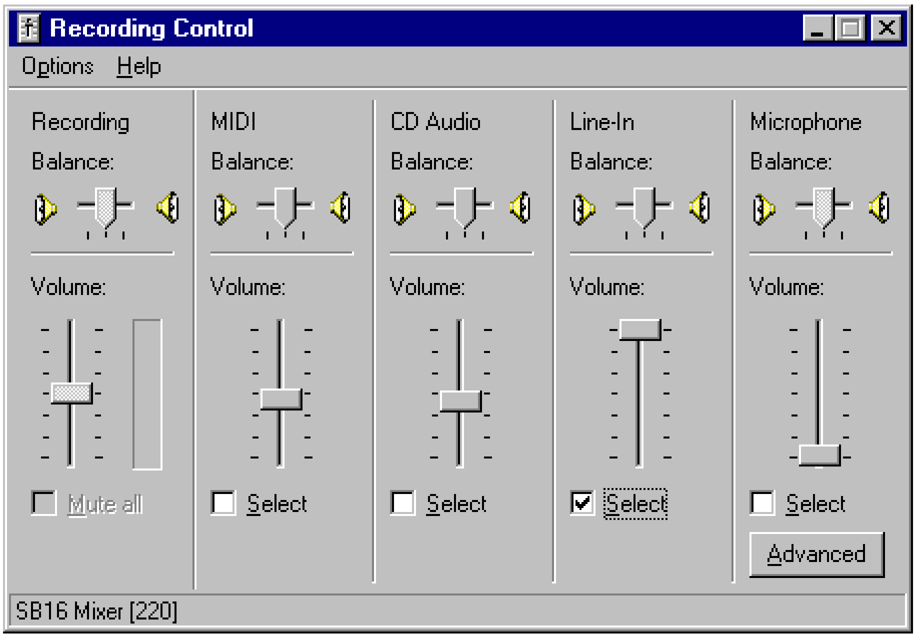
The Windows Volume Control offers similar options. You can access the Windows “Volume Control” (the name may be different on your system) either by double-clicking the loudspeaker symbol to the right in the Windows task bar or by choosing *Programs - Accessories - Multimedia - Volume Control* from the Start menu. If you use the Windows Volume Control, please note that there are separate sets of controls for recording and playback. Normally the playback controls are displayed automatically when you start the Volume Control. To show the recording controls instead, start the Volume Control and choose Properties from the Options menu, and check “Recording” in the “Adjust volume for” box:



Problem
When I try to launch BatSound I get the error message “Error in installation data”.

Cause/solution
Most likely this is because the installation code (serial number) was entered incorrectly during the installation. Please re-install BatSound and make sure the code is entered exactly as printed on the label in the User’s Manual. The code is case sensitive.

The figure below shows suitable settings to enable recording sound through the LINE input (which normally should be used). Checking the “Select” box is important!



The “Line-In” control can also be shown in the “playback” volume control (see above), so you may change the volume for the recordings there as well. The “select” check box is only present in the “Recording Control” though.

3. If you make a “mono” recording, some sound cards use only the left channel (or mixes both channels). Change the recording mode to “stereo” and view both channels to check if this is the cause of the problem. If so, use the “stereo” mode, but choose to view only the desired channel (see the Spectrogram settings command).

Note: With certain sound cards, you will have to use the sound card’s “volume control” utility software rather than the Windows Volume Control to change the recording/playback settings.

Problem
There is severe distortion in the recordings I make.

Cause/solution
Make sure that the sound level from your sound source fits the input of the sound card. E.g. connecting the output of a tape recorder to the microphone input of the sound card is likely to result in a distorted sound. Connect the tape recorder to the LINE input instead, or use an attenuator to lower the signal level before connecting it to the microphone input.

Problem
There are dropouts or clicks during playback of sounds recorded with BatSound.

Cause/Solution
1. The system performance is not sufficient for recording with the parameters and sound format you have chosen. Try to make a recording with only oscillogram display. If this plays back OK, then the system performance is the problem. Refer to the Real-time spectrogram section for more information.

2. There could possibly be a hardware conflict (IRQ, DMA or address) between the sound card and other devices installed in your system. Please refer to the Windows Help for information on how to resolve hardware conflicts.

Problem
When I choose the Zoom In command the zoom level suddenly gets very large (i.e. a very small portion of the signal is stretched out over the window).

Cause/Solution
You may unintentionally have marked a very narrow section of the signal (the marked section may then look almost like the vertical cursor). The following commands may then give unexpected results, e.g. choosing Zoom In will cause an extremely small portion of the sound file to be displayed.

If a power spectrum window is displayed, the time interval over which this is calculated will be automatically marked in the oscillogram/spectrogram. Choosing the Zoom In command will cause this interval to be zoomed.

Problem
There are no shades of gray/colors when I print out a diagram.

Cause/Solution
Make sure the printer is configured properly. Most printers have different operation modes selectable in the printer's Properties dialog box.

Please make sure you are using the latest printer drivers. Most printer manufacturers make new printer drivers available to download from their web sites.

Problem
When I try to print or copy a Power Spectrum, a Pulse Interval or a Pulse Length diagram I get the oscillogram (or spectrogram) instead.

Cause/Solution
The print command in the File menu and the Copy command in the Edit menu work on the main window only (containing the oscillogram and/or spectrogram). To print or copy diagrams from the other windows, use the Print or Copy command in the "right mouse button menu" of the respective window. To invoke this menu, position the mouse arrow anywhere in the Power Spectrum, Pulse Interval or Pulse Length diagram and then click the right mouse button.

Problem
I only get empty histograms when I make a Pulse Interval or Pulse Length analysis.

Cause/Solution
The Pulse Interval/Pulse Length parameter settings may have been inappropriately chosen.
Check that:

- The time scale covers the time range of interest for your analysis.
- The detection threshold is not set too high.
- The detection delay time is not too long for the signal you are analyzing.

Please refer to the Commands section of this manual for more information on the use of the Pulse Interval/Pulse Length parameter settings.

Problem
Marking the signal with the mouse does not work in both directions.

Cause/Solution
The current cursor type has to be “Measurement cursor” to enable marking of the signal in both directions. The cursor type is chosen in the Tools menu.

Problem
When I play a sound file in the Virtual Bat Detector mode, the tuned frequency does not change (or changes with a delay) as I press the arrow keys.

Cause/Solution
The computer's performance may be inadequate for the selected Virtual Bat Detector parameters (see above). Try a lower filter order and/or a lower speed factor if possible. On a sufficiently fast computer, the tuning indicator should move with no or small delay when you press the up/down arrow keys.

Problem
In the Virtual Bat Detector mode, the horizontal bar showing the tuned frequency is not visible.

Cause/solution
A spectrogram has to be displayed in the active window in order for the tuning control to be active. Make sure you have selected this before running the Virtual Bat Detector.

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