

# Real-Time Spectrogram<sup>™</sup>

## User Guide

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Engineering Design

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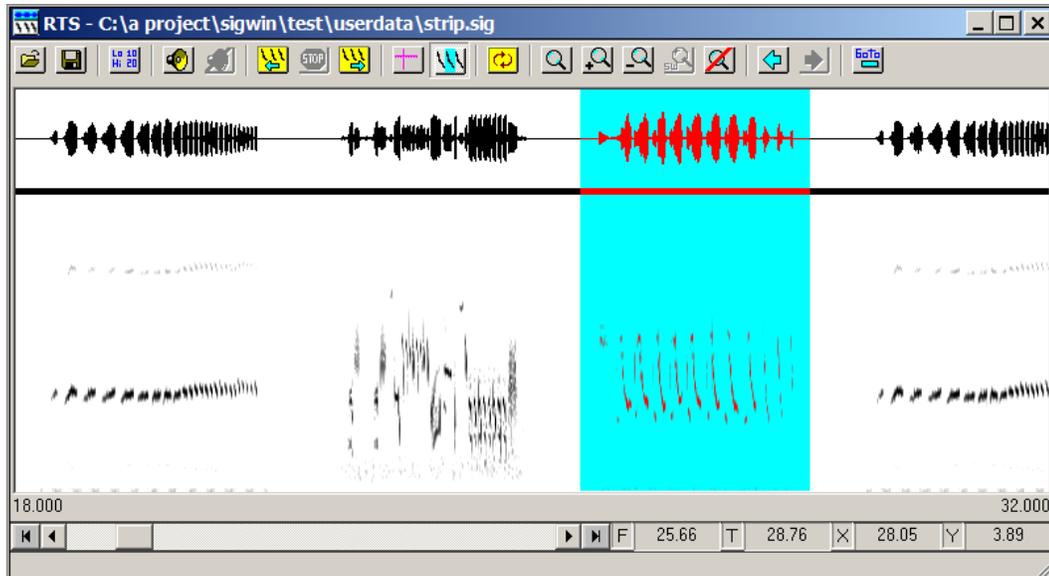
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## 1. Introduction

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The **Real-Time Spectrogram™ (RTS™)** displays the time-aligned spectrogram and waveform of a continuous sound file. The RTS can efficiently review large amounts of acoustic data, while measuring, extracting, and storing sound parameters and signal segments directly from the screen.

RTS is designed to view, measure, and edit digital sound files. While the earlier RTS for DOS required continuous access to the source tape and repeated playing and pausing, RTS for Windows can digitize an entire data tape unattended (see "Data Input"), then scroll rapidly through the sound file at between **10 and 100 times real-time** (depending on event density). A 45-minute sound tape can be reviewed in less than 5 minutes!

RTS runs within SIGNAL™, so signal segments can be transferred directly to SIGNAL buffers for immediate analysis, or saved to disk as SIGNAL, Wave or AIFF format sound files. Measured sound parameters can be stored in the SIGNAL logfile.

**Note: RTS 4 does not have built-in analog I/O, unlike the earlier RTS for DOS.** You cannot play a sound tape directly into RTS 4 and watch it scroll by. Instead, you digitize the tape, then scroll the digitized sound file. However, you can play sounds on the display (limited to audio frequencies) through the system card. Real-time scrolling acquisition and playback of "live" audio will be available in a **future** version of RTS.

## 2. Installing the RTS

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The RTS is part of SIGNAL and is automatically installed when you install SIGNAL. To confirm the installation, verify that the RTS menu item (I/O | Real-Time Spectrogram) on the

SIGNAL menu) and toolbar button ( button on the SIGNAL toolbar) are enabled. If these items are grayed out, select Tools | License Info on the SIGNAL menu and confirm that RTS is listed under Licensed Modules. If not, contact Engineering Design to upgrade your license.

## 3. Launching the RTS

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To launch the RTS, start SIGNAL, then do any of the following:

- Select I/O | Real-Time Spectrogram on the SIGNAL menu
- Click the  button on the SIGNAL toolbar
- Enter the **RTS** command in the SIGNAL console window
- Select "Display in RTS window" in the SIGNAL graph dialog (Graphics|Graph on the menu)

The RTS opens in its own window on top of SIGNAL, which can be resized and dragged anywhere on the screen. RTS saves its window position between sessions and will automatically open to its previous position.

## 4. RTS Help

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The SIGNAL/RTS help system includes a chapter on the RTS. To open this, click the Help button on either the SIGNAL or RTS toolbar.



Open the SIGNAL/RTS help system.

## 5. RTS Commands

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RTS commands are presented on the RTS toolbar and/or the RTS context menu. These are described here.

### RTS Toolbar

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The **RTS toolbar** presents a set of command buttons at the top of the RTS window. These are summarized here, and explained in detail in other sections of this guide. Some toolbar buttons (such as Zoom and Play) refer to the selected signal segment, while others (such as Open Sound File, Change Settings, or Scroll Forward) refer to the RTS program or screen.

-  Close sound file
-  Open sound file
-  Save current selection to a sound file
-  Change RTS program settings
-  Start recording [Future]
-  Stop recording [Future]
-  Play current selection
-  Stop playback
-  Scroll screen backward in time
-  Stop scrolling
-  Scroll screen forward in time
-  Activate crosshair cursor
-  Activate drag highlight
-  Zoom to the current selection
-  Zoom current screen by 2X (magnify)
-  Zoom current screen by 1/2X (un-magnify)
-  Restore global screen width (from Settings)
-  Display entire source signal
-  Display previous screen



Display next screen



Display specified time range in source file



Refresh display



Open Help system

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## RTS Context Menus

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RTS commands are also presented in **context menus**, which are displayed by R-clicking when the **crosshair cursor** or **drag highlight** is active. There is some overlap between toolbar and menu commands. Menu commands are summarized here, and explained in detail in other sections of this guide.

Most menu commands (such as Zoom, Play, or Save to Sound File) refer to the currently selected signal segment, or the entire screen if no segment is selected. "Selecting a Signal Segment" summarizes the techniques and rules for selecting signals.

### Crosshair cursor menu

From X	F
To X	T
Clear From/To	C
Bookmark ▶	
Zoom	Enter
Previous	Bksp
Next	Ctrl+Bksp
Play	P
Save to Buffer	B
Save to Sound File	S
Save x,y to Logfile	L
Save x,y to UVARs	U

Set FROM time limit

Set TO time limit

Reset FROM/TO time limits

Open Bookmark menu

Display (zoom) signal within current FROM/TO limits

Redraw previous zoom display

Redraw next zoom display

Play selected segment

Save selected segment to buffer

Save selected segment to sound file

Save current x,y value to log file

Save current x,y value to UVARs

### Drag highlight menu

Zoom	Enter
Previous	Bksp
Next	Ctrl+Bksp
Clear Highlight	C
Play	P
Save to Buffer	B
Save to Sound File	S
Save x,y to Logfile	L

Display (zoom) highlighted signal segment  
 Redraw previous zoom display  
 Redraw next zoom display  
 Remove signal highlight

Play selected segment

Save selected segment to buffer  
 Save selected segment to sound file

Save current x,y value to log file

## 6. Data Input

### Viewing Sound Data in the RTS

RTS 4 is designed for viewing digital sound files. It does not have built-in analog I/O, unlike earlier RTS versions. You cannot play a sound tape directly into RTS 4 and watch it scroll by. Instead, you digitize the entire tape unattended, then scroll through the digitized sound file much faster than real time, which is much more efficient. Mechanical tape playing and pausing is replaced by navigating on-screen through the sound file. Real-time scrolling acquisition and playback of "live" audio will be available in a **future** version of RTS.

To review a sound data tape in the RTS, follow these steps:

1. Digitize the entire tape unattended into a sound file using one of the Engineering Design direct-to-disk analog I/O programs. These programs support all the major analog I/O hardware manufacturers, and are called **CBDisk™**, **DartDisk™**, **DTDisk™**, **NIDisk™**, and **WaveDisk™**, after their respective manufacturers.
2. Open the sound file in the RTS for review, measurement, and editing.

Note that a simpler approach, particularly in lab environments, is to bypass the tape recorder entirely and record the original data directly to a sound file using one of the above programs, i.e., use the computer as a digital tape recorder. Then the sound file is immediately ready for review and analysis in the RTS.

## Opening a Sound File

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To open a sound file, click the **Open File** button on the RTS toolbar. If no path is specified, Open File will search the DATAIN path in SIGNAL. The filename is displayed in the title bar of the RTS window.

## Closing a Sound File

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To close a sound file, click the **Close File** button on the RTS toolbar.

## Sound File Display Conventions

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The RTS will accept files in the SIGNAL, Wave, AIFF, and BLB sound file formats.

SIGNAL sound files may be floating point or integer, and may have a non-0 time origin. The displayed voltage amplitude of SIGNAL integer time files is determined by their stored conversion factor, which by default is 32768 bits / 10 Volts. This matches the default A/D converter range (-10.00000, +9.99969) Volts to the 16-bit integer range (-32768, +32767). For example, a data value of 3277 will be displayed as 1.0 Volts. Floating point SIGNAL files are stored as voltages, so no conversion is necessary.

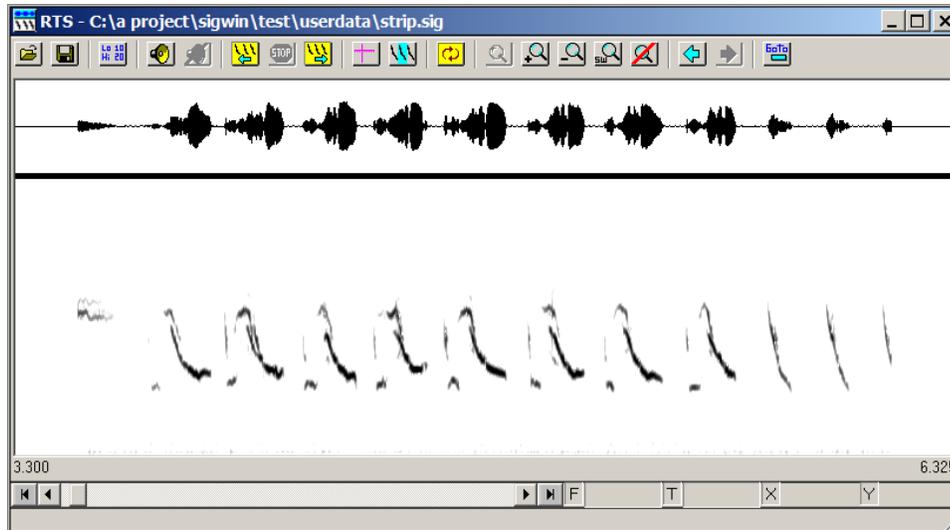
Wave and AIFF files contain no internal conversion factor, and are displayed with an assumed conversion factor of 32768 bits / 3 Volts. This matches the nominal range of the PC sound card ( $\pm 3$  Volts) to the 16-bit integer range. For example, a data value of 10923 will be displayed as 1.0 Volts.

The displayed voltage amplitude of BLB files is determined by their stored conversion factor, which by default is 32768 bits / 10 Volts.

## 7. RTS Display

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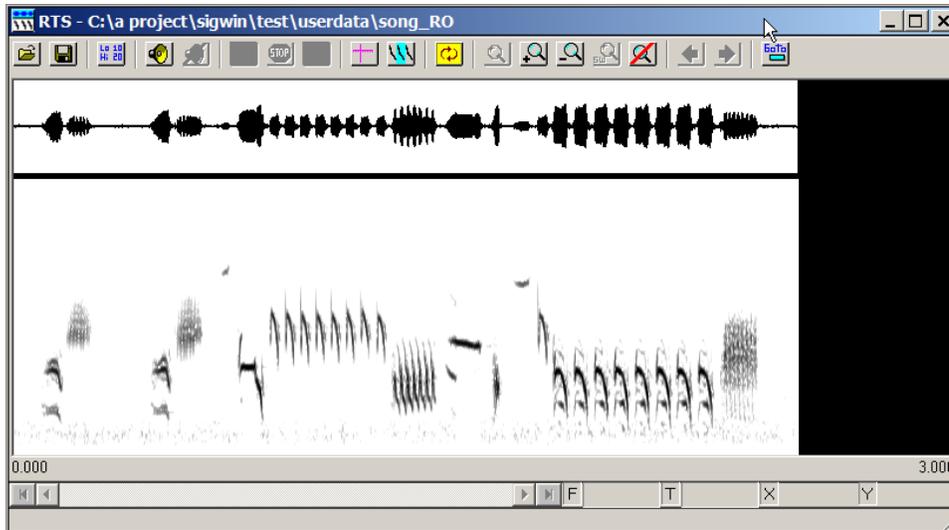
The RTS display consists of a time-aligned waveform and spectrogram. RTS 4 supports one data channel. Display settings such as screen width, frequency range, dynamic range, and spectral resolution can all be varied – see "Settings" below.



## Screen Width

Screen width can be set to between 2 and 3600 seconds (= 1 hour). Large screen widths are useful for efficiently viewing long sound files, particular those with sparse events. Maximum practical screen width is limited by the pixel width of the RTS window and the time duration of the events of interest. Pixel width can be increased by a wider RTS window and higher resolution screen. Max practical screen width occurs when the gap between successive FFT's exceeds the shortest events of interest, causing these events to "fall between the transforms" on the spectrogram display. See "Spectrogram properties" for detailed discussion. The waveform display is not subject to this limitation because it represents the value of every data point within the screen range, i.e., it has no mathematical gaps at any screen width.

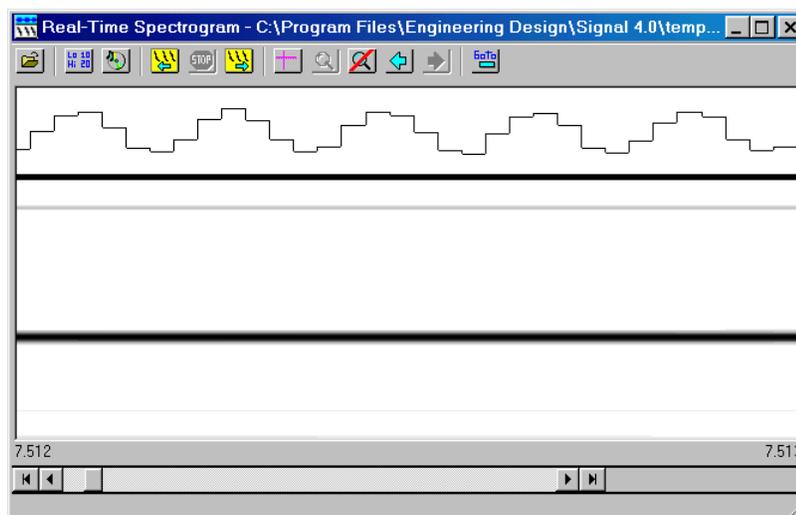
When the sound file is shorter than the screen width setting, the RTS draws the signal to the scale of the requested screen width, then blacks out the remainder. For example, in the following figure, signal duration is 2.5 secs and screen width is 3.0 secs. Note that in this case, a signal segment can be selected using the highlight tool (see "Drag-Selecting a Signal Segment") but **not** with the crosshair cursor ( see "Crosshair Cursor").



## Waveform Properties

The waveform display is calibrated in Volts, based on the known or assumed voltage conversion ratio (bits/Volt) of the digitizer. This ratio is either read from the file header (SIGNAL and BLB files) or calculated from the bit-width of the sample values (e.g., 16 bits) and an assumed converter range of 10 Volts. The user can adjust the voltage range of the display to accommodate different signal levels.

At very high time zoom (the figure shows a 1-msec time segment), the waveform display becomes blocky or "stair-step" in appearance. Each step represents one sample point in the input signal. This display differs from SIGNAL, which at high time zoom "connects the dots" by drawing straight lines between each sample point for a smoother display. The RTS can't look forward in time to do this, but both displays provide the same information.



## Spectrogram Properties

The RTS spectrogram display consists of successive Fourier transforms (FFT's), one FFT per pixel column. Thus if the RTS window is 1000 pixels wide, the spectrogram will contain 1000 FFT's. The spectrogram is recalculated every time the screen is redrawn, so FFT overlap (see below) is always maximal for the current screen width.

The appearance of the spectrogram display is controlled by a number of mathematical relationships. These are described here.

### Frequency and time resolution

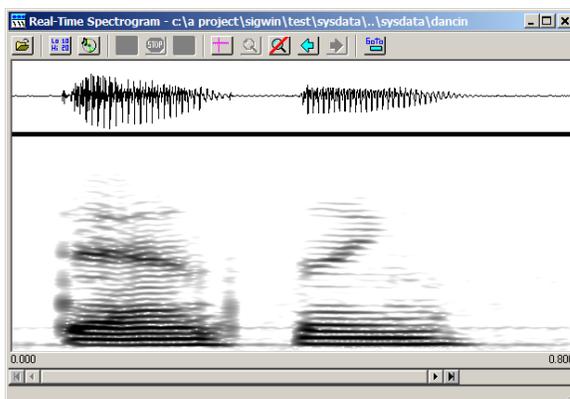
The **frequency resolution** and **time resolution** of a spectrogram characterize its degree of spectral and temporal definition. Digital spectrogram resolution is determined by the time duration of the sliding Fourier transform window. If  $T$  is the duration of this window in seconds, then

$$\begin{aligned} \text{Time resolution} &= T && [\text{ sec }] \\ \text{Frequency resolution} &= 1 / T && [\text{ Hz }] \end{aligned}$$

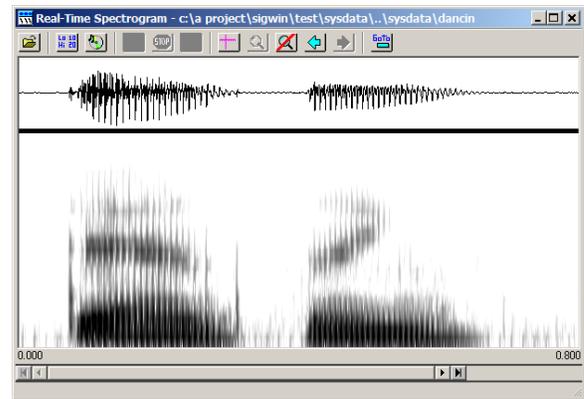
and

$$\begin{aligned} T_{\text{res}} &= \text{FFT-length} / (\text{sample rate}) && [\text{ sec }] \\ F_{\text{res}} &= (\text{sample rate}) / \text{FFT-length} && [\text{ Hz }] \end{aligned}$$

Fine frequency resolution (small  $F_{\text{res}}$ ) reveals spectral detail while blurring the exact location of these features in time. Conversely, fine time resolution (small  $T_{\text{res}}$ ) reveals temporal detail while blurring spectral features. The figure shows two spectrograms of a human speech signal at narrowband (24 Hz) and wideband (195 Hz) resolutions. Optimal resolution depends on the temporal-spectral character of the signal and the relative importance of temporal and spectral features in the analysis.



**F-res = 24 Hz, T-res = 41.0 msec**



**F-res = 195 Hz, T-res = 5.1 msec**

The Display settings page provides three controls for resolution. When the user adjusts Transform length, the RTS automatically calculates and displays the new frequency and time resolution.

**Transform length** is the FFT length in points. Together with the signal's sample rate, it determines the frequency and time resolution. It is restricted to powers of 2.

**Frequency resolution** in Hz = (sample rate) / (transform length). Smaller values reveal finer frequency detail and coarser time features.

**Time resolution** in seconds = (transform length) / (sample rate) = 1 / (frequency resolution). Smaller values reveal finer time detail and coarser frequency features.

**Update from file header:** The frequency and time resolution calculation is based on the current sound file's sample rate. To use some other rate in the calculation, click the "Update from file header" button to read the sample rate from another sound file.

### **Time Granularity and Transform Overlap**

In a digital spectrogram, the finite number of time steps (FFT's) can produce a time granularity in the computed spectrogram. This granularity can be characterized either by the interval between the start of successive transforms or by the percentage overlap of successive transforms. When screen width is small, successive FFT's may overlap significantly, but when screen width is large, there may be significant gaps between successive FFT's (negative overlap). When these gaps exceed the duration of events of interest, events can fall between FFT's and be omitted from the display entirely.

The user cannot directly adjust the number of transforms. That is determined by the pixel width of the RTS window, since the RTS always computes one FFT per pixel column. Widening the RTS window increases the number of FFT's, which increases transform overlap and produces a more time-detailed spectrogram.

The Display settings page reports **Transform overlap**, which is the percentage overlap between successive FFT's.  $Overlap = 100 * [1 - (transform\ interval) / (transform\ duration)]$ , where transform duration in seconds = (sample rate in Hz) / (transform length in points). **Negative overlap** indicates that successive FFT's are non-time-contiguous, which is common with large screen-widths. For example, an overlap of 50% indicates that each FFT begins one half FFT length after its predecessor, while an overlap of -100% means there is a gap of one FFT length between successive FFT windows. Greater overlap produces a more time-detailed spectrogram, although overlap > 50% provides little improvement. The tolerable amount of negative overlap depends on the level of time detail in the signal, and the amount of detail required in the spectrogram.

### **Spectrogram Gain and Range**

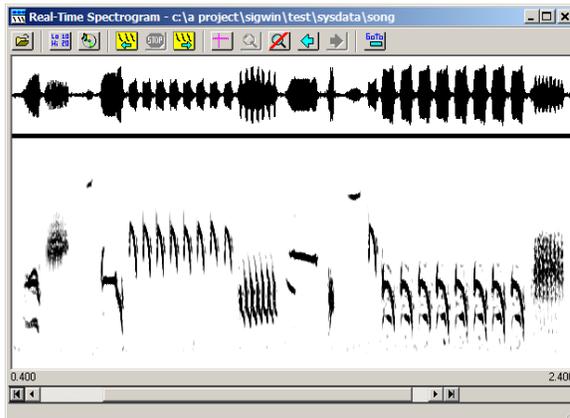
Spectrogram gain and range are adjusted in the Display settings page. These two parameters should be adjusted jointly to display the desired signal features. Following are guidelines and examples.

**Spectrogram range** is the intensity range (in dB) represented between the lightest and darkest grey levels. The calculated spectrogram is mapped to this range such that for a grey-level display, all levels above this range are drawn black (saturated) and levels below this range are drawn white (omitted).

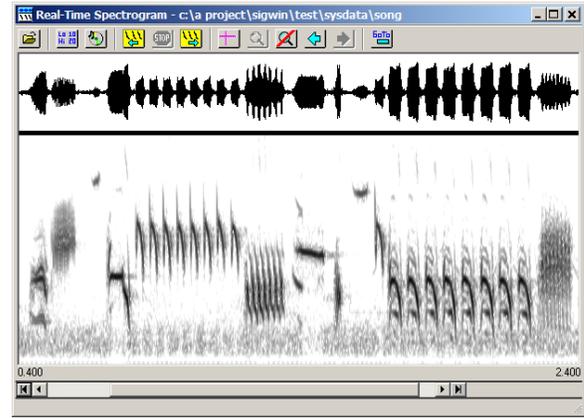
Increasing spectrogram range displays low-level and high-level detail simultaneously, but may also display low-level noise, obscuring the spectrogram. A small range produces clean

spectrograms, but can saturate high-level sound features (drive them to black) and omit low-level ones.

In the following example, the first figure was drawn with a low Range value and produces a "silhouette" spectrogram with few amplitude features, while the second was drawn with a high Range value and reveals a wide range of amplitude detail, but also more noise.



**Range = 10 dB, Gain = 0 dB**

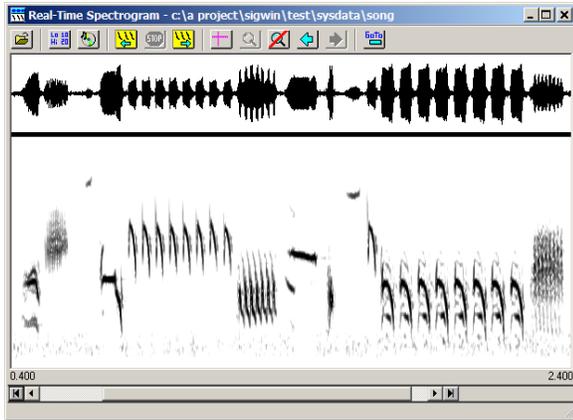


**Range = 50 dB, Gain = -20 dB**

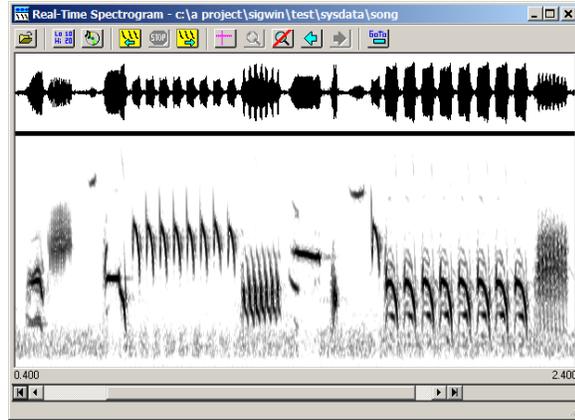
**Spectrogram gain** is the gain applied to the calculated spectrogram before mapping it to the requested range. Increasing gain increases the darkness of the display. This reveals low-level sound features, but can also display low-level noise, obscuring the spectrogram, and can saturate high-level features. Reducing gain eliminates low-level noise but may also omit low-level sound features.

By RTS convention, increasing the Range parameter **lowers the lower cutoff** of the displayed intensity range, i.e., reveals more low-level detail without changing the upper cutoff. This ensures that changing Range will not saturate the display, because the upper cutoff is not changed. To maintain the same lower cutoff (amount of low-level detail), **reduce gain by the amount of the range increase**. See the following example. Conversely, after decreasing Range (which raises the range cutoff), increase gain by the same amount to maintain a constant level of low-level detail.

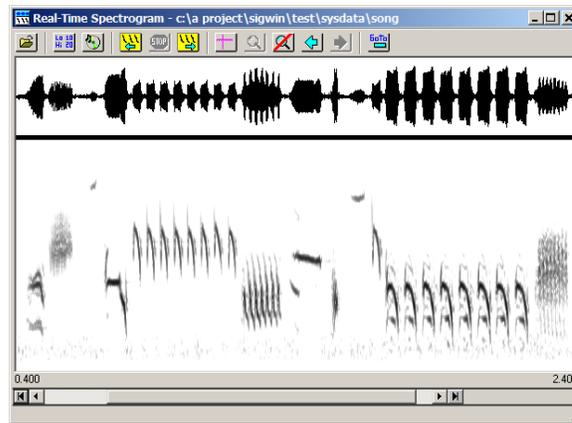
In the following example, the first figure is the reference. In the second, range is increased, revealing more detail but increasing background noise. In the third, gain is reduced by the amount that range was increased, returning background noise to its original level. The third spectrogram is not as dark overall because its energy is spread over a wider range of greys.



Range = 25 dB, Gain = -10 dB



Range = 35 dB, Gain = -10 dB



Range = 35 dB, Gain = -20 dB

### **Frequency Range**

The lower and upper frequency limits of the spectrogram display can be adjusted on the Display settings page.

**Min frequency** sets the lower frequency limit of the spectrogram display.

**Max frequency** sets the upper frequency limit of the spectrogram display. It is limited to (sample rate) / 2.

### **Spectrogram Palette**

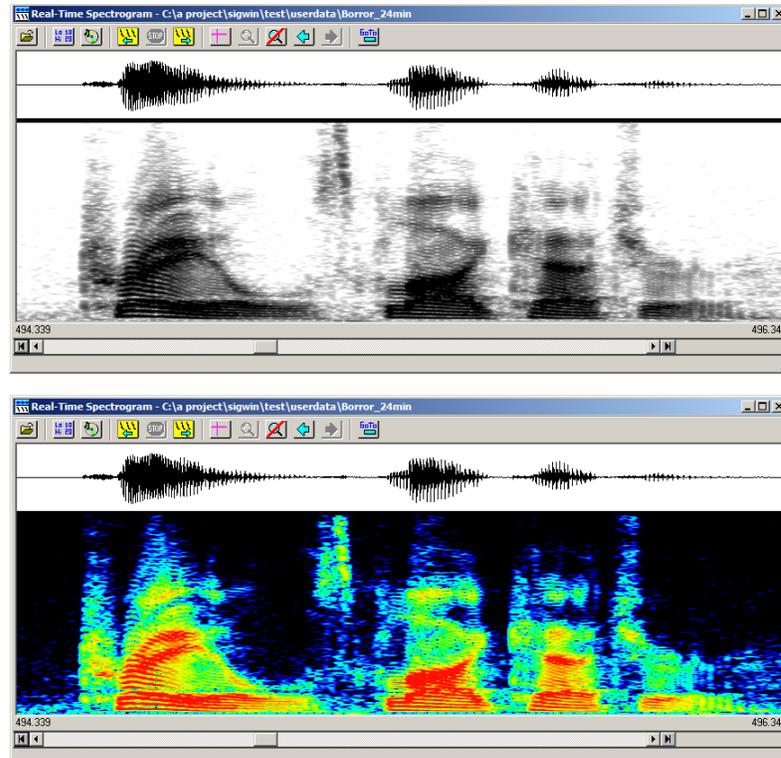
Spectrograms can be displayed in grey-scale or color. **Note** that intensity is mapped logarithmically to grey or color shades. I.e., the intensity range in dB is divided equally among the number of shades, so that each grey or color represents an intensity band of

$$\text{Range} / (\text{no. shades}) \quad [\text{dB}]$$

**Grey-scale** draws the spectrogram in 256 shades of grey, ranging from white (lowest intensity) to black (highest intensity).

**Rainbow** draws the spectrogram in 256 colors, ranging from black (lowest intensity) through blue, green, yellow, to red (highest intensity).

The figure shows a human speech sound in grey-scale and rainbow displays.



## Refreshing the Display



The **Refresh Screen** button recalculates and redraws the RTS display, in case the the display is unexpectedly corrupted.

## 8. Navigating the Screen

The RTS uses a viewer model similar to word processors: the screen is a viewport on a larger document, which is navigated in a variety of ways: paging through successive pages, scrolling by single columns, dragging the scrollbar thumb button, jumping to the beginning or end of document, or going to a numerically specified location. The RTS screen can also be scrolled continuously forward and backward. As with word processors, many of these actions are provided through both a scrollbar and keyboard shortcuts.

## Scrollbar

---

The RTS scrollbar contains a thumb button, left and right column scroll buttons, and buttons to jump to the beginning and end of the source file:



The scrollbar supports these actions:

- **Left scroll** and **right scroll** buttons scroll the screen one column either direction.
- Clicking in the **page left** or **page right** areas between scroll button and thumb button jumps the screen backward (earlier in time) or forward, respectively, by the current screen width.
- Dragging the **thumb button** jumps to any location within the file. The numerical location of the thumb is continuously updated during the drag, but the screen display is not redrawn (because the spectrogram can't be redrawn that fast).
- **Goto begin** and **goto end** buttons jump to the beginning and end of the source file, respectively.

## Keyboard shortcuts

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The following keystrokes provide shortcuts for the specified scrollbar buttons:

- **Ctrl+Home** and **Ctrl+End** mirror the **goto begin** and **goto end** buttons.
- **PageUp** and **PageDown** mirror the **page left** and **page right** buttons, moving the screen backward (earlier in time) or forward by the current screen width.
- **Left arrow** and **right arrow** mirror the **left scroll** and **right scroll** buttons, moving the screen one column earlier or later.

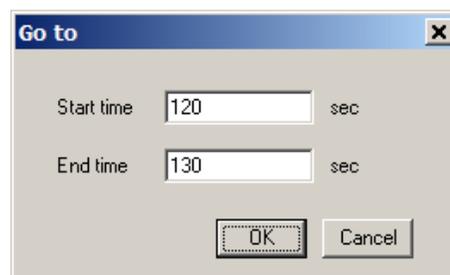
Note that page-wise operations (page-up and page-down) move the screen by the current screen width. This allows the user to browse the source file at the current magnification.

## Goto

---



The **Goto** button displays a numerically specified time range in the source file:



This range can be specified in one of two ways:

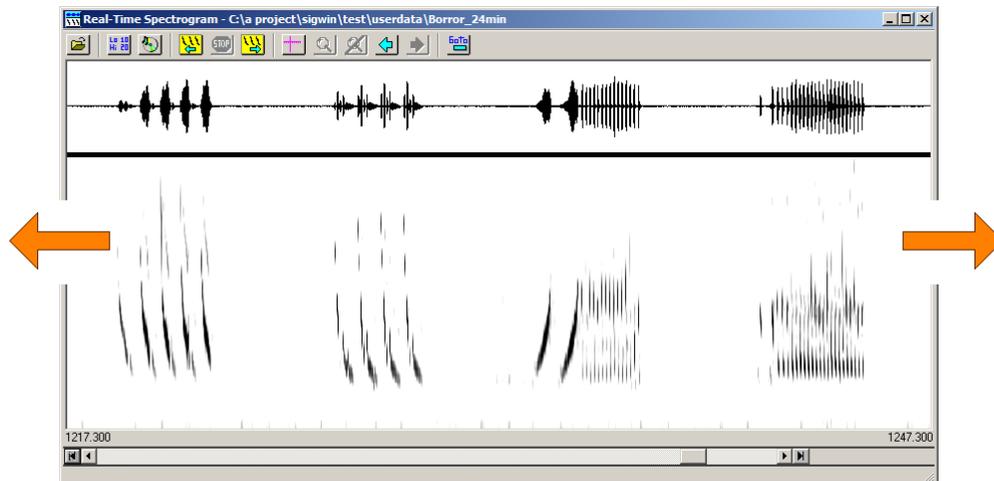
1. If both start and end are specified, the RTS will display that range.
2. If only start is specified, the display segment will begin at the start value and extend for the global screen width setting.

The target signal range is added to the zoom stack (see "Zooming the Screen"), so the user can return to it, like a zoomed segment.

## 9. Forward and Backward Scroll



The RTS screen can be scrolled rapidly forward and backward. The model is a tape player transport. The RTS provides **Scroll Forward**, **Scroll Backward**, and **Stop Scroll** buttons, and the user can click between them to jockey the screen.



Scrolling provides an efficient way to review long and/or sparse source files. If **screen width** is the duration of data displayed on the screen and **scroll time** is the physical time required to scroll one screen width, then the ratio of these two (screen width / scroll time) represents the review rate relative to real-time. For example, on one sparse data set, a screen width of 300 seconds was scrolled in 3 seconds, for a review rate of **100 times real-time!**

Scroll time is adjusted in the I/O settings page. For a given processor and video speed, and selected FFT length, screen width, and screen size, there is a minimum scroll time, beyond which the RTS cannot scroll any faster. If you request a scroll time shorter than this, the RTS will scroll at its maximum speed. No warning is issued. To always scroll as quickly as possible, set Scroll time to 0.

## 10. Crosshair Cursor

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The RTS provides a full screen cross-hair cursor spanning the spectrogram and waveform display. To display the cursor, click the **Cursor** button on the toolbar. The cursor is used to 1) obtain on-screen x,y measurements of sound features and 2) delimit signal segments for magnification, playback, and editing via commands on the cursor menu.

### Cursor movement

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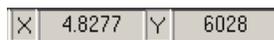
The cursor can be moved via the mouse or keyboard. Keyboard shortcuts are:

- **Left arrow** and **right arrow** provide fine movement.
- **Shift+left arrow** and **shift+right arrow** provide accelerated movement.
- **Home** and **End** jump to the screen left and right, respectively.

### Cursor x,y readout

---

The RTS reports the current x,y cursor location in either the spectrogram or waveform via two boxes labeled "X" and "Y" next to the scrollbar. Readout units for the X coordinate are in seconds, and units for the Y coordinate are in Volts (waveform display) or Hz (spectrogram display). The readout is updated continuously as the cursor moves.



Readout numerical resolution scales automatically with graph range, becoming finer as that range decreases and coarser as it increases. Technically, a 1-pixel cursor movement will always register in the least significant decimal place. This ensures that the readout will not be cluttered with excess decimal places, nor will it fail to respond to cursor movement, no matter how great or small the zoom.

### Selecting a signal segment using From X and To X

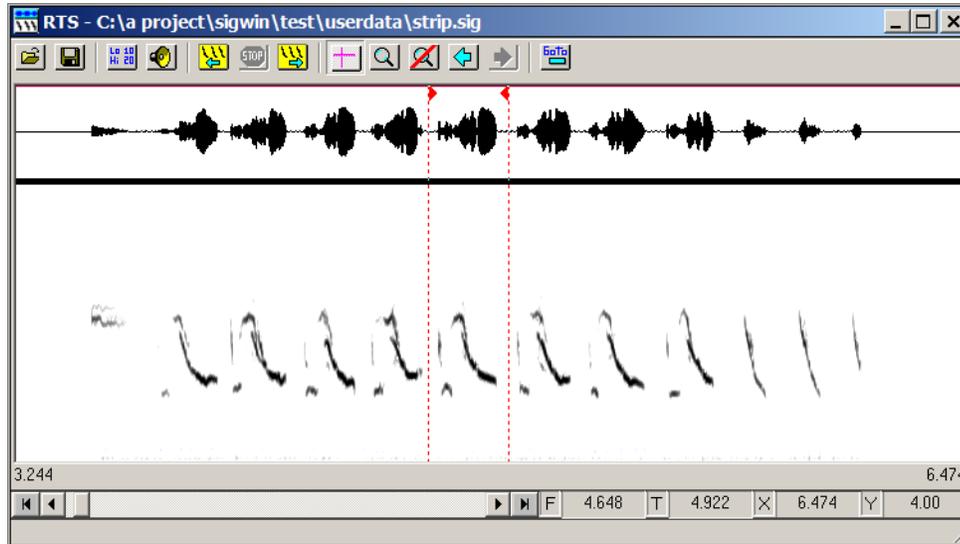
---

The cursor is used to delimit signal segments for magnification, playback, and editing, via commands on the cursor menu. To delimit a segment:

1. Move the cursor to the beginning of the desired segment, R-click for the cursor menu, and select **From X**. Or just position the cursor and hit F.
2. Move the cursor to the end beginning of the desired segment, R-click for the cursor menu, and select **To X**. Or just position the cursor and hit T.
3. To clear From and To markers, select **Clear From/To** from the cursor menu or just hit C.

**Note:** RTS sometimes fails to recognize keyboard shortcuts. The cause has not been determined.

From and To locations are indicated by dashed vertical red lines with inward pointing arrowheads to distinguish From and To . The figure shows From and To markers at 4.648 and 4.922 seconds, respectively.



From/To limits can be retained depending on user preference. See "Selecting a Signal Segment" for details.

## From-X / To-X readout

The RTS reports the current From-X and To-X values in two boxes labeled "F" and "T" next to the scrollbar. Readout is in seconds.



As with the cursor X,Y readout, resolution scales automatically with graph range, becoming finer as that range decreases and coarser as it increases.

## Cursor context menu

When the cursor is active, you can R-click for a menu of commands, many of which refer to the current From-X / To-X interval. These commands are discussed in detail elsewhere in this guide.

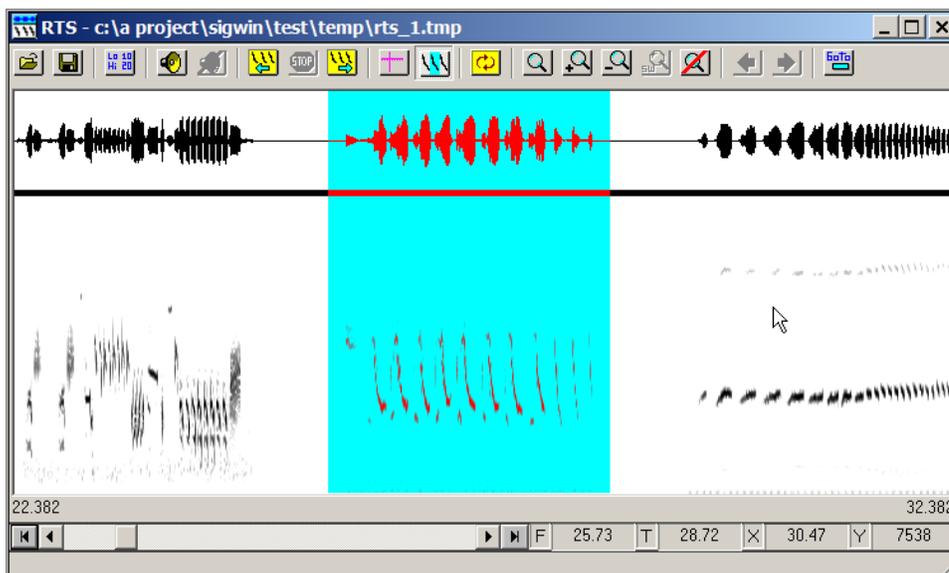
From X	F
To X	T
Clear From/To	C
Bookmark	
Zoom	Enter
Previous	Bksp
Next	Ctrl+Bksp
Play	P
Save to Buffer	B
Save to Sound File	S
Save x,y to Logfile	L
Save x,y to UVARs	U

- Set FROM time limit
- Set TO time limit
- Reset FROM/TO time limits
- Open Bookmark menu
- Display (zoom) signal within current FROM/TO limits
- Redraw previous zoom display
- Redraw next zoom display
- Play selected segment
- Stop playback
- Save selected segment to buffer
- Save selected segment to sound file
- Save current x,y value to log file
- Save current x,y value to UVARs

## 11. Drag-Selecting a Signal Segment



Many RTS operations – such as Zoom, Play, and Save to Sound File – are performed on a selected signal segment. A segment can be selected in several ways (see "Selecting a Signal Segment"). RTS allows you to drag-select a signal. To do this, click the drag-highlight button, then L-click and drag in either direction across the segment of interest. The RTS will highlight the selected segment in light blue while you are dragging. The selection can then be used in commands such as Zoom, Play, and Save. The figure shows a signal selection between 25.73 and 28.72 seconds, as indicated in the F/T readout (see "Drag selection readout" below).



The signal selection is retained, whether or not the highlight is visible, until explicitly cleared by the user (via the drag highlight context menu) or until a new sound file is opened. The drag highlight tool may be activated and removed without altering the selection.

Signal selection bounds are saved and restored with each screen on the zoom stack. See the example in "Zooming the Screen".

## Mouse location readout

---

While drag-selecting, the RTS reports the current x location of the mouse in the box labeled "X" next to the scrollbar.

X	28.72	Y	
---	-------	---	--

After drag-selecting (see the above figure), the RTS reports the current x,y location of the mouse in the boxes labeled "X" and "Y" next to the scrollbar.

X	35.47	Y	7538
---	-------	---	------

Readout units for the X coordinate are in seconds, and units for the Y coordinate are in Volts (waveform display) or Hz (spectrogram display). The readout is updated continuously as the mouse moves. Readout numerical resolution scales automatically with graph range, becoming finer as that range decreases and coarser as it increases. Technically, a 1-pixel mouse movement will always register in the least significant decimal place. This ensures that the readout will not be cluttered with excess decimal places, nor will it fail to respond to cursor movement, no matter how great or small the zoom.

## Drag selection readout

---

After drag-selecting a signal segment, the RTS reports the segment's begin and end times in the boxes labeled "F" and "T" (From and To) next to the scrollbar. Readout is in seconds.

F	25.73	T	28.72
---	-------	---	-------

As with the X,Y readout, resolution scales automatically with graph range, becoming finer as that range decreases and coarser as it increases.

## Drag highlight context menu

---

When the drag highlight is active, you can R-click for a menu of commands, many of which refer to the currently highlighted signal segment. These commands are discussed in detail elsewhere in this guide.

Zoom	Enter
Previous	Bksp
Next	Ctrl+Bksp
Clear Highlight	C
Play	P
Stop Play	
Save to Buffer	B
Save to Sound File	S
Save x,y to Logfile	L

Display (zoom) highlighted signal segment  
Redraw previous zoom display  
Redraw next zoom display  
Remove signal highlight

Play selected segment  
Stop playback

Save selected segment to buffer  
Save selected segment to sound file

Save current x,y value to log file

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## 12. Bookmarks

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Bookmarks allow the user to delimit a segment of any length for display and later file storage. They are used to locate widely spaced start and end points with maximum accuracy. The current RTS supports one set of bookmark start/end limits, but a **future** RTS may support an unlimited number of bookmarks, to allow the user to index the events in an entire sound file – see below.

Bookmark operations are available from the Bookmark menu, which is accessed from the Cursor menu. Keyboard shortcuts are as shown in the menu.

Start	Ctrl+F
End	Ctrl+T
Clear	Ctrl+C
Display	Ctrl+D

Set bookmark start time  
Set bookmark end time  
Clear bookmark time limits

Display bookmarked signal

---

### Setting a bookmark

---

The cursor is used to delimit signal segments for magnification, playback, and editing, via commands on the cursor menu. To delimit a segment:

1. Move the cursor to the start point of the desired segment, R-click for the cursor menu, select **Bookmark** to open the Bookmark menu, then select **Start**. Or just position the cursor and hit ctrl+F.
2. Move the cursor to the desired end point of the desired segment and select **End** from the Bookmark menu. Or just position the cursor and hit ctrl+T.
3. To clear both bookmarks, select **Clear** from the bookmark menu, or just hit ctrl+C.

**Note:** RTS sometimes fails to recognize keyboard shortcuts. The cause has not been determined.

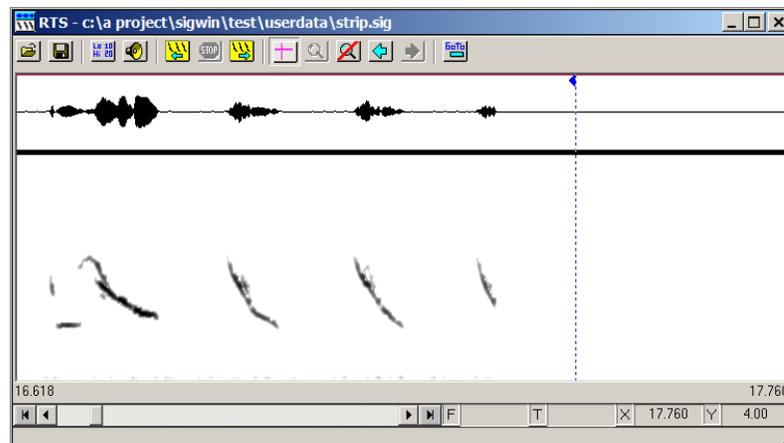
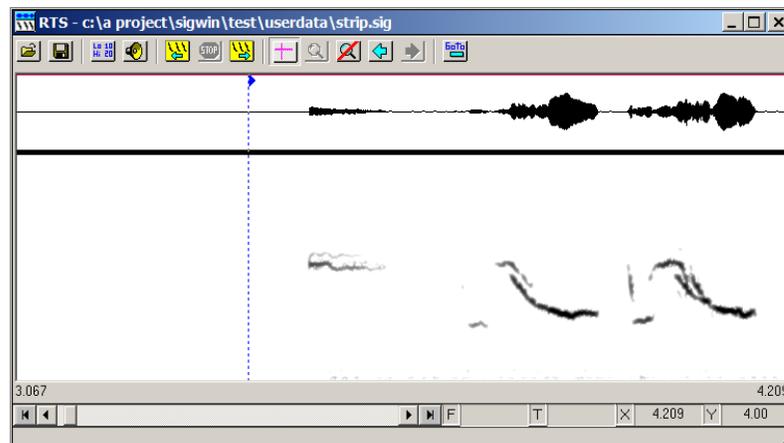
Bookmark locations are indicated by dashed vertical blue lines with inward pointing arrowheads to distinguish Start and End . Bookmark values are retained until altered or

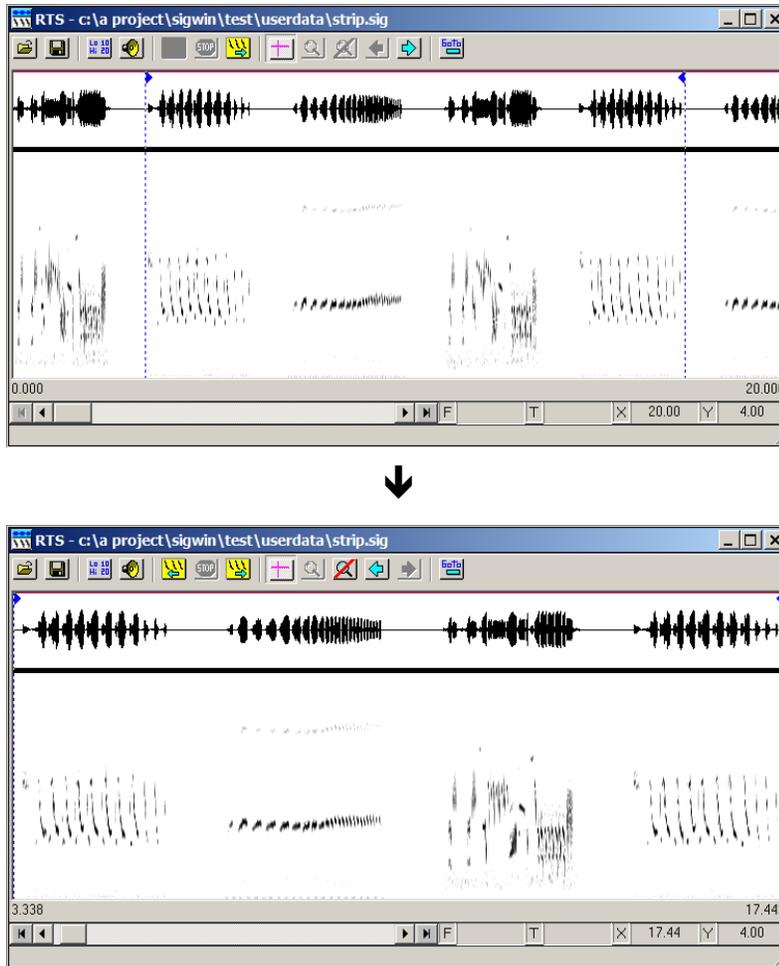
cleared by the user or until a new sound file is opened. The cursor may be activated and removed without altering bookmarks.

## Using bookmarks

Bookmarks are similar to From/To limits, but they are independent of them. Thus From/To can be used to zoom to the desired start and end points with great accuracy and set those locations as a bookmark. This cannot be done with From/To alone. Following are typical steps in bookmarking a signal:

1. Use From/To to zoom around the desired start point. Locate the cursor at the desired start point and set a Start bookmark (top).
2. Similarly, use From/To to zoom around the desired end point and set an End bookmark (upper middle).
3. If desired, click the Unzoom button to view the previous screen (lower middle).
4. Select Display from the Bookmark menu to view the bookmarked segment (bottom).





After the bookmarked signal is displayed, it can be played, saved to a buffer or sound file, etc., using the commands in the cursor menu.

## Bookmarks in the Future

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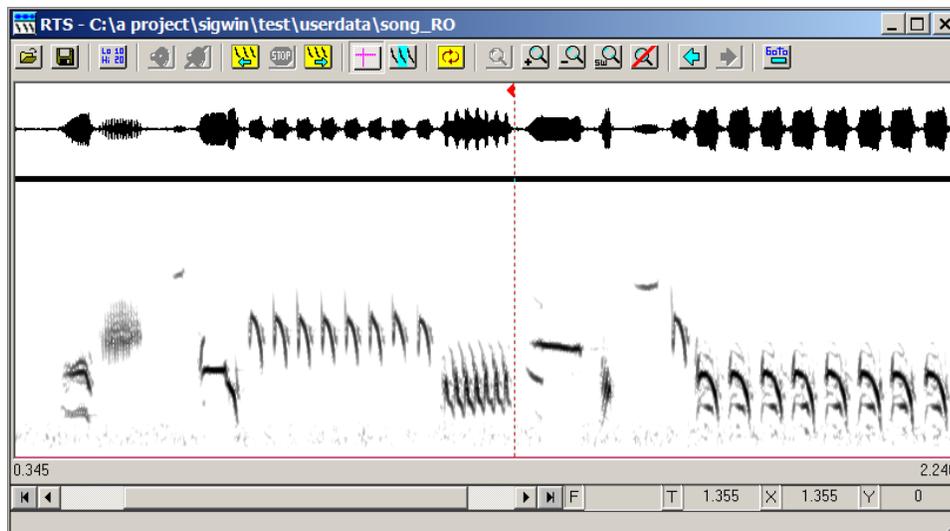
A **future** RTS may support an unlimited number of bookmarks, allowing the user to catalog and index an entire sound file. Individual bookmarks can be annotated with ID or demographic info, and the bookmark ensemble can be collected in a **bookmark file**. This file can be exported to a spreadsheet or statistical program for statistical analysis. Or it can be imported into SIGNAL to perform automated data analysis on the entire sound file simply by stepping through the bookmarks.

## 13. Selecting a Signal Segment

Many RTS operations – including Zoom, Play, and Save to Sound File – are performed on the currently selected signal segment. This segment can be specified in two ways:

- Activate the crosshair cursor, then delimit the desired segment with From and/or To markers, as described in "Crosshair Cursor".
- Activate the drag highlight, then drag the mouse across the desired segment to select it, as described in "Drag-Selecting a Signal Segment".

With the crosshair cursor, if either From or To is not set, that limit defaults to the corresponding edge of the visible screen. If neither limit is set (cursor or drag highlight), the selection defaults to the visible screen. In the following figure, no From limit is set, so the selection extends from the left screen edge ( $t = 0.345$  secs) to the To marker at  $t = 1.355$  secs.



### Retaining From/To Limits

From/To limits can be retained depending on user preference. If **Retain From/To** on the General-I/O settings page is selected, From/To limits are retained until altered or cleared by the user, even when scrolled or paged offscreen or when the cursor or highlight is deactivated. If **Retain From/To** is not selected, From/To limits are cleared when From/To limits are scrolled or paged offscreen and when the cursor or highlight is deactivated.

From/To limits are always cleared when a new sound file is opened.

From/To limits are always saved and restored with each screen on the zoom stack. See the example in "Zooming the Screen".

## 14. Zooming the Screen

---



Any segment on the RTS screen can be magnified or "zoomed" **in the horizontal direction** for closer examination. Delimit the desired time segment as described in "Selecting a Signal Segment". Then click the **Zoom** button, or select Zoom on the cursor menu, or hit the Enter key.

**Note:** the current RTS has no cursor-based vertical zoom. To zoom the vertical axis, adjust the frequency range from the Settings screen.



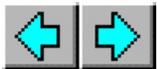
Alternately, you can zoom the RTS screen by 2 times (2X) about its horizontal midpoint by clicking the "magnifier +" button. To unzoom by 2 times (1/2X), click the "magnifier -" button.



The **Restore Screen Width** button clears the zoom stack and restores the global screen width (from the Settings screen). This command also appears on the cursor menu and has keyboard shortcut Ctrl+Enter.



The **Full Signal** button clears the zoom stack and displays the entire source signal. Long sound files (30 minutes or more) may take some time before drawing starts.

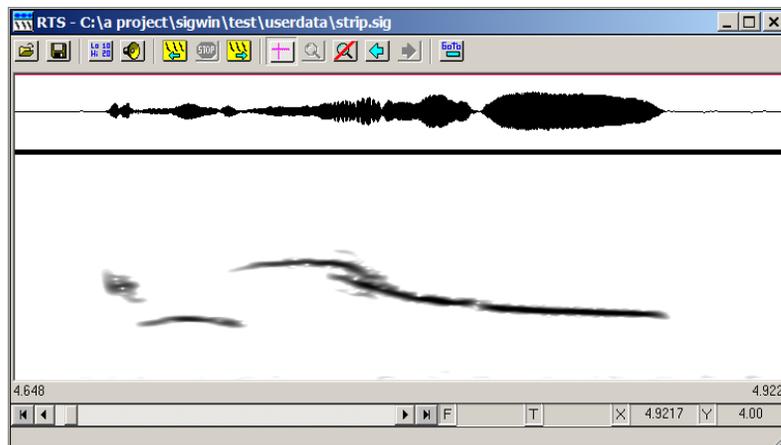
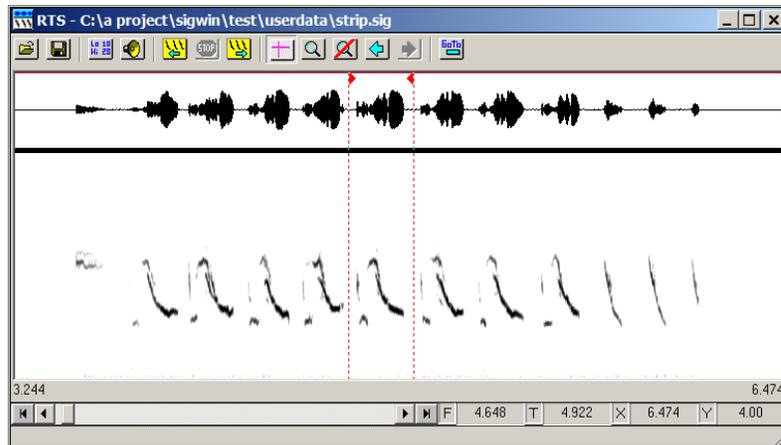
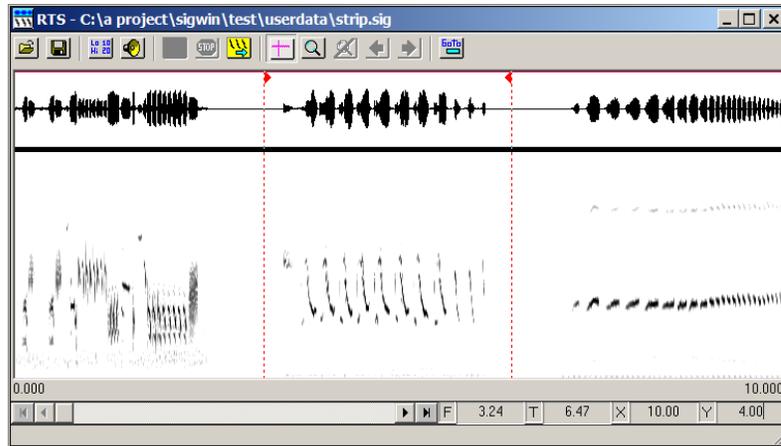


The RTS remembers successive screens as you zoom into a signal segment. You can navigate up and down this "zoom stack" using the **Previous** and **Next** buttons, like a browser. This allows the user, for example, to zoom to a feature of interest, then return to the original screen display. Previous and Next also appear on the cursor menu and have keyboard shortcuts Bksp and Ctrl+Bksp, respectively.

### Using the Zoom Stack

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In the following example, the user delimits the event between 3.24 and 6.47 (top) and clicks  to display that interval (middle). He then delimits the subsegment between 4.648 and 4.922 and clicks  to zoom again (bottom). There are now three displays on the zoom stack, and  can be used to navigate up and down the stack. From/To limits are saved with each screen on the stack and restored when that screen is displayed, so the user can navigate back and forth between an event and subsegments without re-entering From/To limits, as shown in the figures below.



## 15. Playing a Signal Segment

### Play

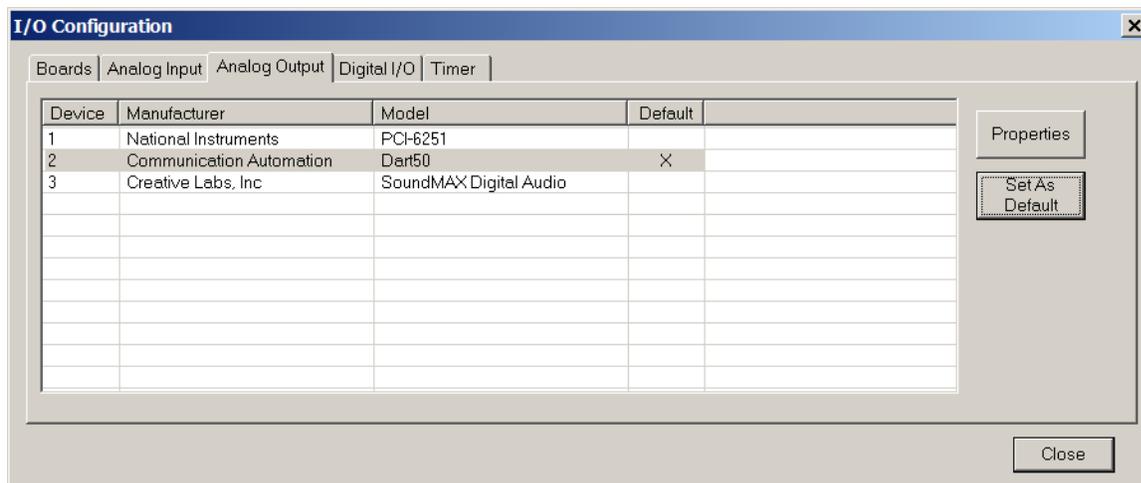


The RTS can play a screen selection of any length. To perform a playback, delimit the desired segment as described in "Selecting a Signal Segment", then click the Play button on the toolbar, or R-click and select Play from the cursor menu, or hit the P key.

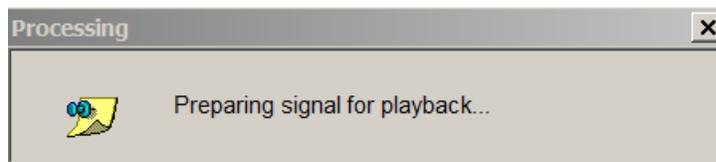
The RTS can play the selection through either the system sound chip (the default) or an installed SIGNAL I/O device. This is determined by setting the SIGNAL **PLAYDEV** (Playback Device) parameter to WIN (Windows sound chip) or SIGIO, respectively.

When playing through the system sound chip, RTS resamples the signal to 44.1 kHz before playback. This places some limits on playback. Signals are limited to approximately 20 kHz bandwidth and due to resampling space constraints, playback length is limited to a few million sample points.

When playing through an installed SIGNAL I/O device, you can select the device via I/O | Configure | Output on the SIGNAL menu. Select the desired device, then click Set As Default. In this case, the signal will not be resampled; the RTS will select the device's closest available sample rate.



Since long signals can take some time to prepare for playback, the RTS may display the following screen before playback:



## Stop Play

---

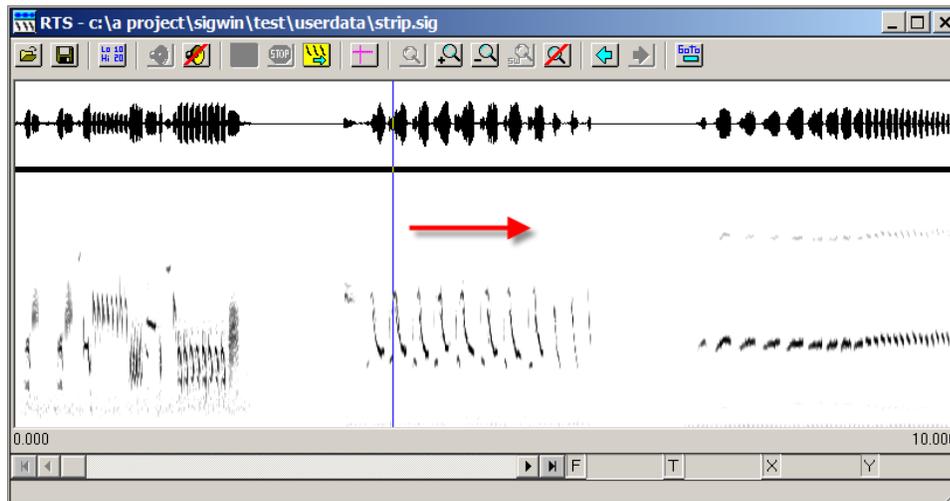


To stop playback, click the Stop Play button.

## Playback Wiper

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Playback is accompanied by a playback wiper (blue vertical line) that moves continuously across the screen in synchronization with the sound, to help relate the displayed waveform or spectrogram to the auditory signal.



## 16. Storing Sound Files and Sound Parameters

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The RTS can store data in several forms:

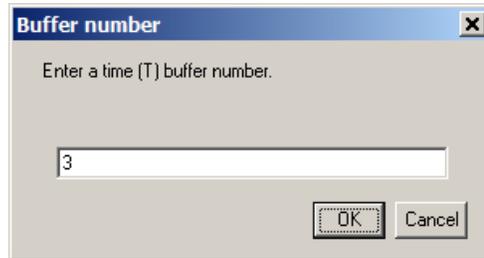
- Signal segments can be transferred to SIGNAL buffers for detailed analysis.
- Signal segments can be stored as sound files in SIGNAL, Wave or AIFF format.
- x,y screen measurements can be stored in the SIGNAL logfile.

### Transferring a Signal Segment to a SIGNAL Buffer

---

To transfer a signal segment to a SIGNAL buffer, delimit the desired segment as described in "Selecting a Signal Segment", then R-click for the cursor menu and select **Save to Buffer**, or hit the B key. The RTS will request the destination buffer number, then transfer the buffer and display it in the SIGNAL graph window.

The user can switch freely between RTS and SIGNAL, selecting segments in the RTS, exporting them to SIGNAL buffers, and analyzing them in SIGNAL. See the screenshot in "RTS Screen" for an example.

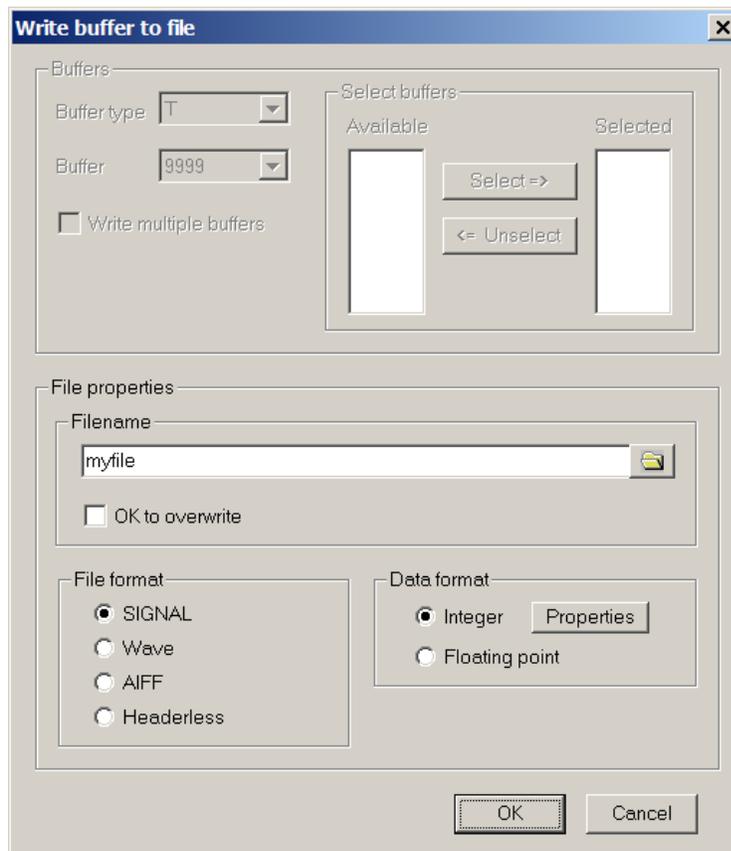


## Saving a Screen Segment as a Sound File

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To save a segment as a sound file, delimit the desired segment as described in "Selecting a Signal Segment", then R-click for the cursor menu and select **Save to Sound File**, or hit the S key. Provide the filename, sound file format, and data format. Sound files can be saved in SIGNAL, Wave, or AIFF format.



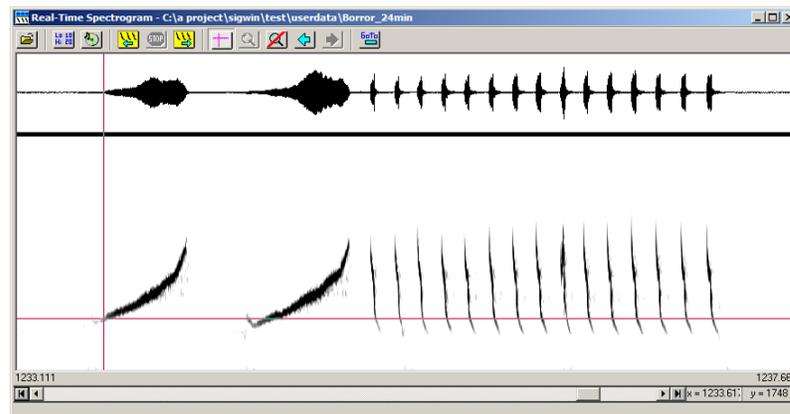
## Time origin

When signal segments are exported from the RTS as SIGNAL buffers or SIGNAL-format sound files, the stored segment can optionally retain its time location in the original source file. Thus a segment located at 146.2 seconds in the source file will be stored with a time origin of 146.2 rather than 0. This facilitates analysis of inter-event intervals and other temporal sequence characteristics. **Note:** this option only exists with SIGNAL-format sound files because Wave and AIFF sound files do not store time origin. Time origin is set in the I/O settings page. The default sets the time origin of all exported segments to 0.

## Storing x,y Measurements in the SIGNAL Logfile

The RTS cursor allows the user to make x,y measurements anywhere on the spectrogram or waveform. This can be used to measure minimum and maximum frequencies, start and end times, etc. RTS does not provide differential cursor measurements, but differential quantities such as frequency range or event duration or inter-event intervals can be derived by exporting x,y coordinates to a spreadsheet and performing spreadsheet calculations.

x,y measurements can be stored in the SIGNAL logfile. To do this, position the cursor at the desired location, R-click for the cursor menu, and select **Save x,y to Logfile**. Or position the cursor and hit the L key.



No.	StartT	EndT	MinF	MaxF
1	1233.578	1234.102	1700.93	4383.18
2	1234.463	1235.044	1471.96	4481.31
3	1251.508	1251.801	1635.51	6509.35
4	1251.942	1252.241	1537.38	6672.90
5	1252.387	1252.680	1635.51	6705.61

Start time

**The logfile must be created and opened in SIGNAL before saving data from the RTS.** The SIGNAL Reference Guide describes the setup, editing, and management of logfiles. For a demo, select Help | Demos on the SIGNAL menu and run the two logfile demos.

## 17. Settings



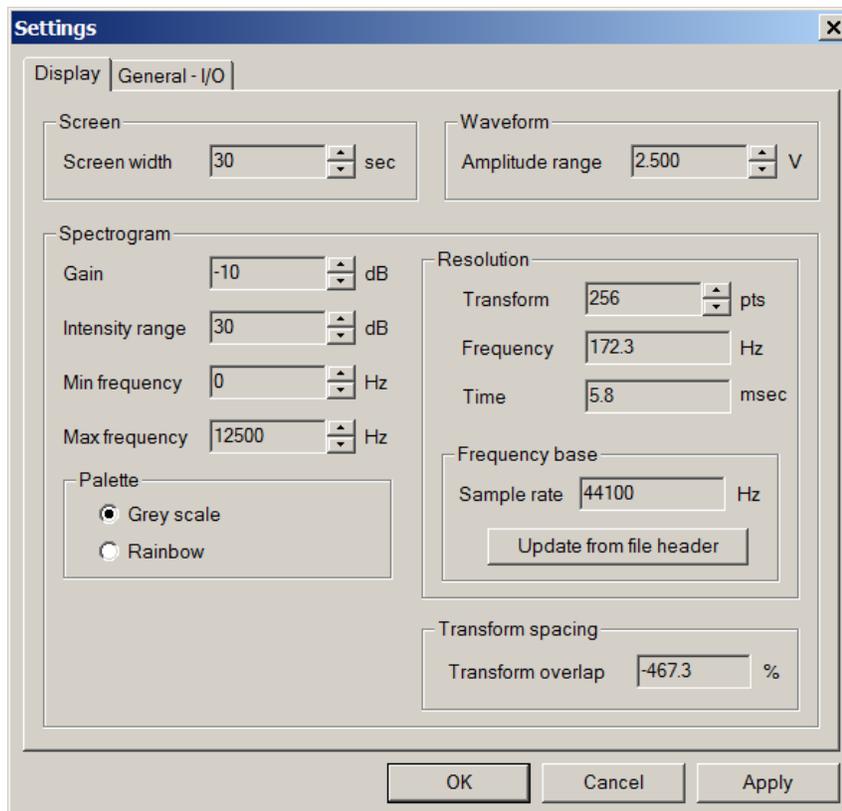
RTS settings are displayed and adjusted in two pages –**Display settings** and **General – I/O settings**. These are accessed via the **Settings** button on the RTS toolbar.

RTS settings are saved between sessions in the Windows registry, as well as the screen position of the RTS window. These settings are defined and discussed throughout this guide.

### Display settings

**Display settings** include screen width, waveform amplitude, spectrogram gain and intensity range, frequency range, color palette, and time and frequency resolution. These properties are discussed in the "RTS Display" chapter.

The RTS screen is redrawn after clicking OK or Apply to reflect screen changes. For example, to observe the effect of different frequency resolutions, position the RTS window and settings page separately on the screen, then try different resolutions and click Apply to immediately see the effect.



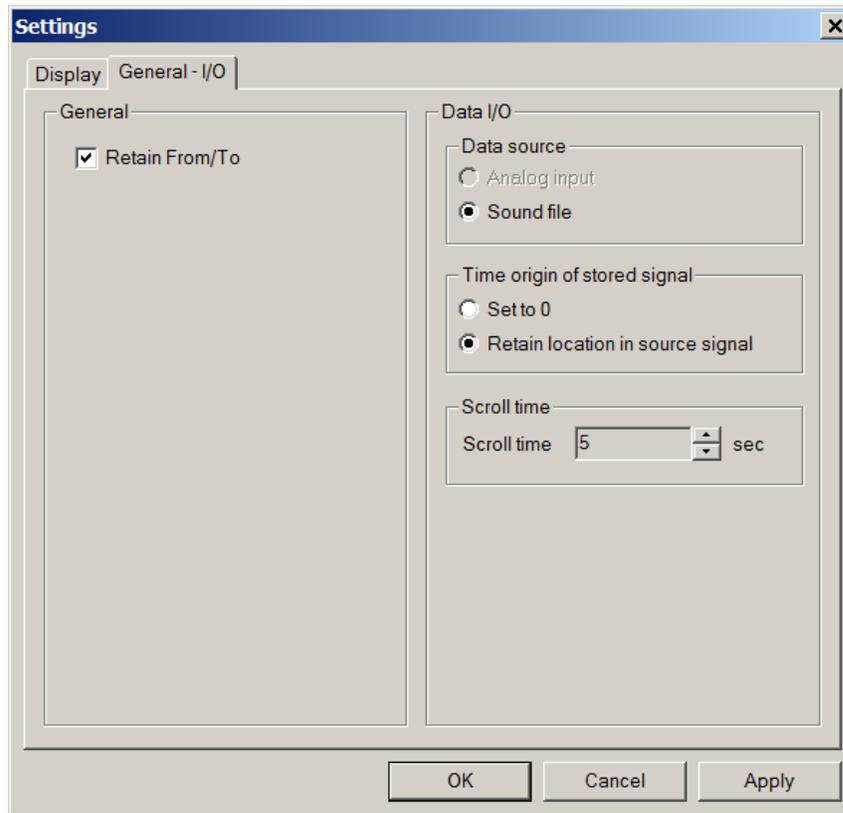
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## General and I/O Settings

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**General settings** include miscellaneous program settings, such as retaining From/To limits.

**I/O settings** control how sound data are entered into and saved by the RTS, and how that data is displayed dynamically by scrolling. Settings include data source, stored time origin, and scroll time (scroll rate). See "Storing Sound Files and Sound Parameters" for a discussion of time origin, and "Forward and Backward Scroll" for a discussion of scroll time.



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## 18. Using the RTS with SIGNAL

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SIGNAL and the RTS can exchange signals and share screen windows in multiple ways. This section describes how the programs can exchange data and how they can be used together on the screen.

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### Transferring Data from RTS to SIGNAL

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Data can be transferred from RTS to SIGNAL in several ways.

**Signal segments** can be transferred in order to perform detailed and even automated sound analysis in SIGNAL. This is done by saving them to SIGNAL buffers. Select the segment of

interest in the RTS (see "Selecting a Signal Segment"), then select "Save to Buffer" from the context menu (see "Storing Sound Files and Sound Parameters"). The figures in "Coordinating SIGNAL and RTS Windows" below illustrate this process.

**x,y coordinates** can be transferred, typically for use in SIGNAL programs. To do this, select "Save x,y to UVARs" from the RTS crosshair cursor context menu.

## **Displaying SIGNAL Data in RTS Windows**

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### **SIGNAL vs. RTS Signal Display**

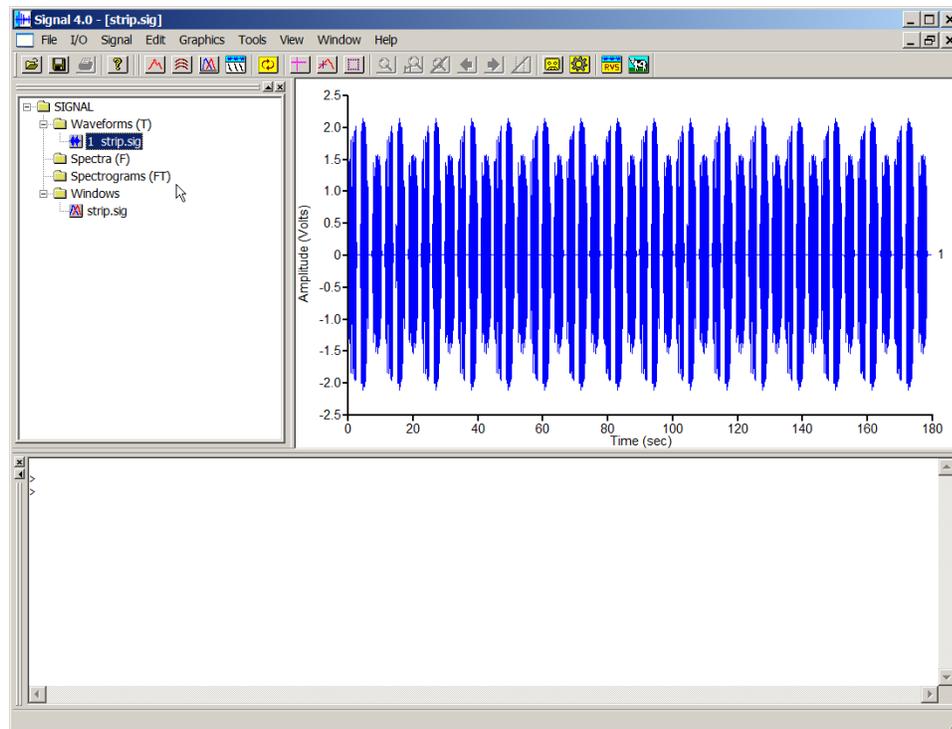
The SIGNAL graph window is designed for detailed examination, measurement, and labeling, but not for viewing long signals, because 1) the entire signal must be read into a buffer in order to view it and 2) the window cannot be scrolled to conveniently view a short segment in detail. The RTS window fills this need by providing a scrolling view of signals of any length.

### **RTS Command**

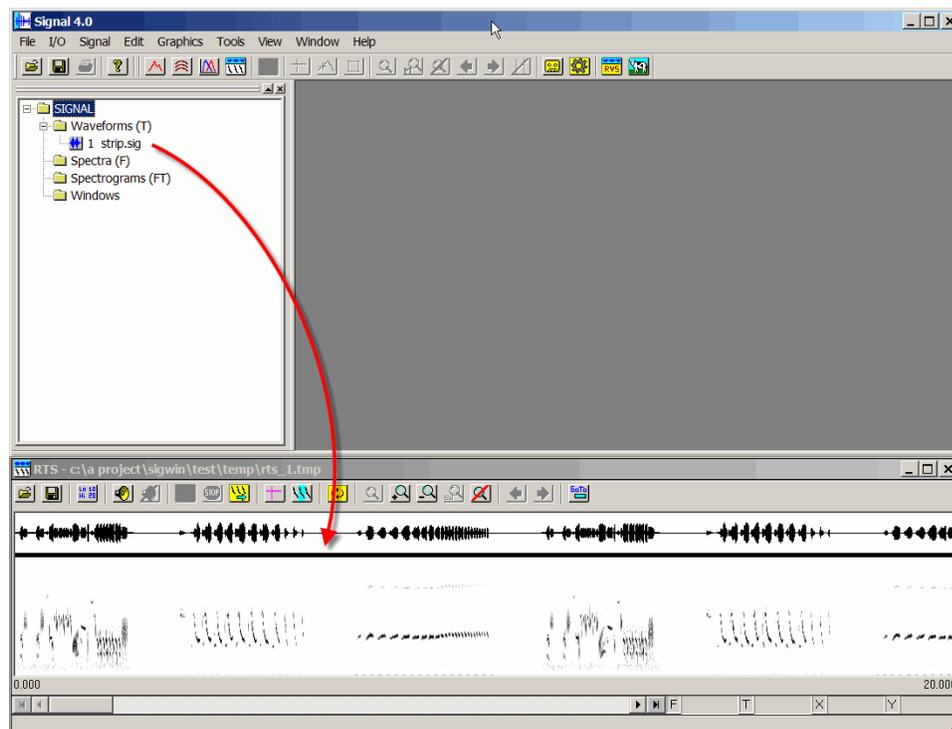
The **RTS** command in SIGNAL allows the user to display any number of SIGNAL buffers in RTS windows. Each buffer launches a new RTS window. For example, the user can display short signal segments in SIGNAL windows for detailed analysis and long signals (buffers or files) in an RTS window with scrolling. See the **SIGNAL Reference Guide** for details on the RTS command.

RTS windows can be displayed as floating windows, anywhere on the screen, or in place of the SIGNAL graph window. RTS window location can be specified by RTS command flags, by the RTSLOC parameter or set in Tools|Preferences. Again, see the **SIGNAL Reference Guide** for details.

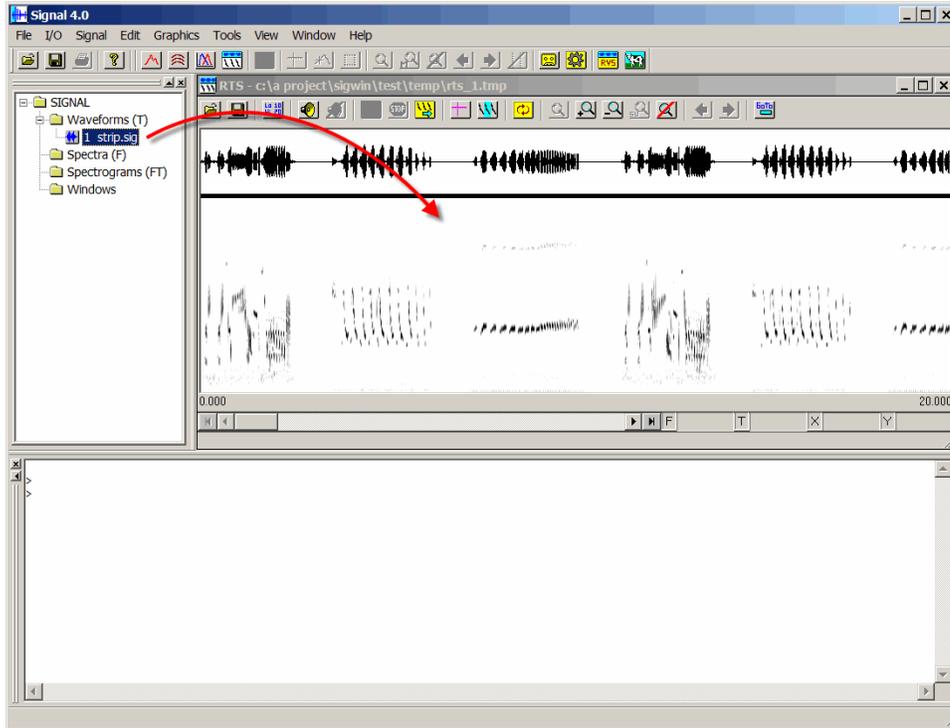
In the following, SIGNAL displays a 180-sec signal in the SIGNAL graph window. Because SIGNAL displays the entire buffer, time resolution is poor.



Here SIGNAL displays the same signal in a floating RTS window at the bottom. Time resolution is improved because the RTS displays the first 20 seconds with the rest available through scrolling.



Alternately, SIGNAL buffers can be displayed in an RTS window located in the SIGNAL graph window. This leaves the SIGNAL console window open for command entry.

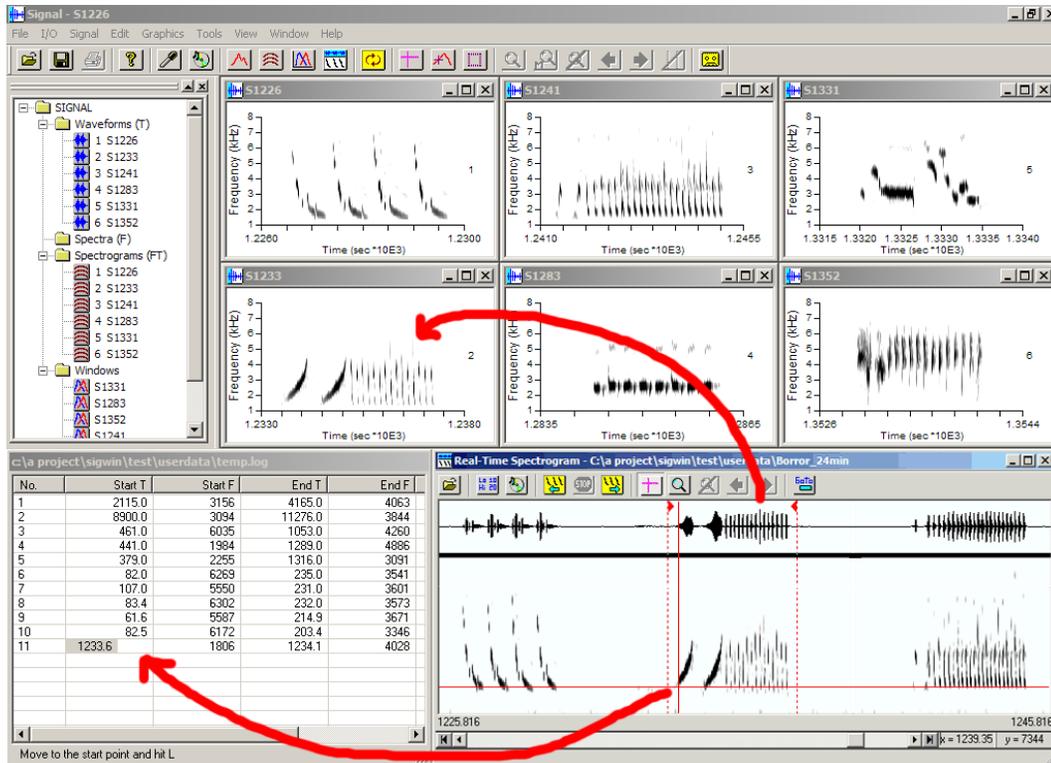


## **Coordinating RTS and SIGNAL Windows**

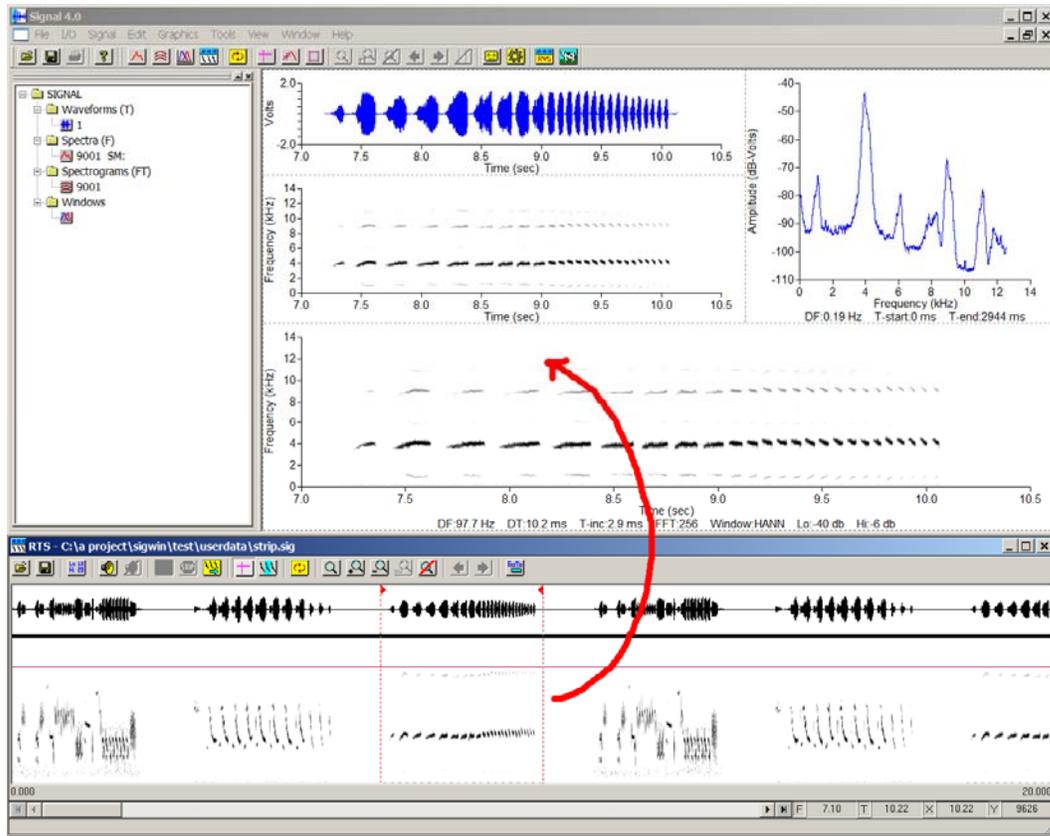
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The RTS window can be located at various places on the screen relative to SIGNAL, to facilitate different tasks.

For example, you can size the RTS window, SIGNAL graph window and SIGNAL logfile so that all three are visible at once, to simultaneously view the source file in the RTS, transfer edited signal segments from RTS to SIGNAL, and store measured parameters from RTS to the SIGNAL logfile. In the following figure, the signal segment between 1233 and 1238 seconds has been delimited and saved to SIGNAL buffer 2 (top red arrow) and on-screen frequency-time measurements (Start T, Start F, etc.) have been stored in a log file (bottom red arrow).



As another example, you can stretch the RTS window to moderate height and full screen width and locate it at the bottom of the screen, then use it as a "strip" file viewer to extract segments into SIGNAL for detailed measurement and analysis. In the following figure, the signal segment between 7.10 and 10.22 seconds has been delimited and saved to SIGNAL buffer 1, then displayed as a spectrogram with zoom windows in order to make detailed power spectrum measurements.



## 19. Operating Hints

Following are operating hints for the RTS.

1. To increase the scroll rate for the single-column left or right scroll buttons on the scrollbar (see "Navigating the Screen"), go to Control Panel | Mouse | Activities in Windows 95/98x or Control Panel | Mouse | Activities in Windows 2000/XP and set Double-Click Speed as high as possible. This sets the repetition rate when a mouse button is held down.