

# **Spectro-X 4**

# **User Manual**

**Program version 4.0**



## **Thank you for purchasing the Spectro-X 4 spectrum analysis toolkit.**

**Spectro-X 4 is a powerful toolkit for graphically displaying and analyzing captured RF signals, capable of producing rich, detailed video spectrograms of very large captures. Users can offload captured data from X-COM's IQ capture systems onto the X-COM SigAnalyst workstation with Spectro-X 4 for precise data analysis. Search functions give the user the ability to find hidden signals and classify unknown signals.**

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# Getting Started

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Spectro-X brings a unique array of post-processing tools to the user. This manual explains how to get the most from this program.

## Installation Location

The default installation location is C:\Program Files\X-COM\Spectro-X 4. The data files may reside anywhere. Temporary files and settings are stored in the location C:\Users\UserName\AppData\Roaming\X-COM\Spectro-X 4, where UserName is the current user's user name on the computer.

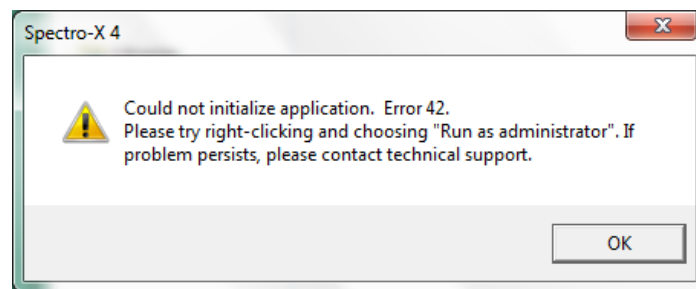
## Starting Spectro-X

Spectro-X can be accessed through the Windows Start menu under X-COM | Spectro-X 4.

## Activating

Before Spectro-X can be used, it must be activated. When the program starts for the first time, a dialog is presented which allows for Spectro-X to be run as a 30 day trial, or to be activated. Activation involves calling or e-mailing X-COM with two numbers generated during activation. X-COM uses these two numbers to generate an activation code which is entered in the appropriate location in the activation window.

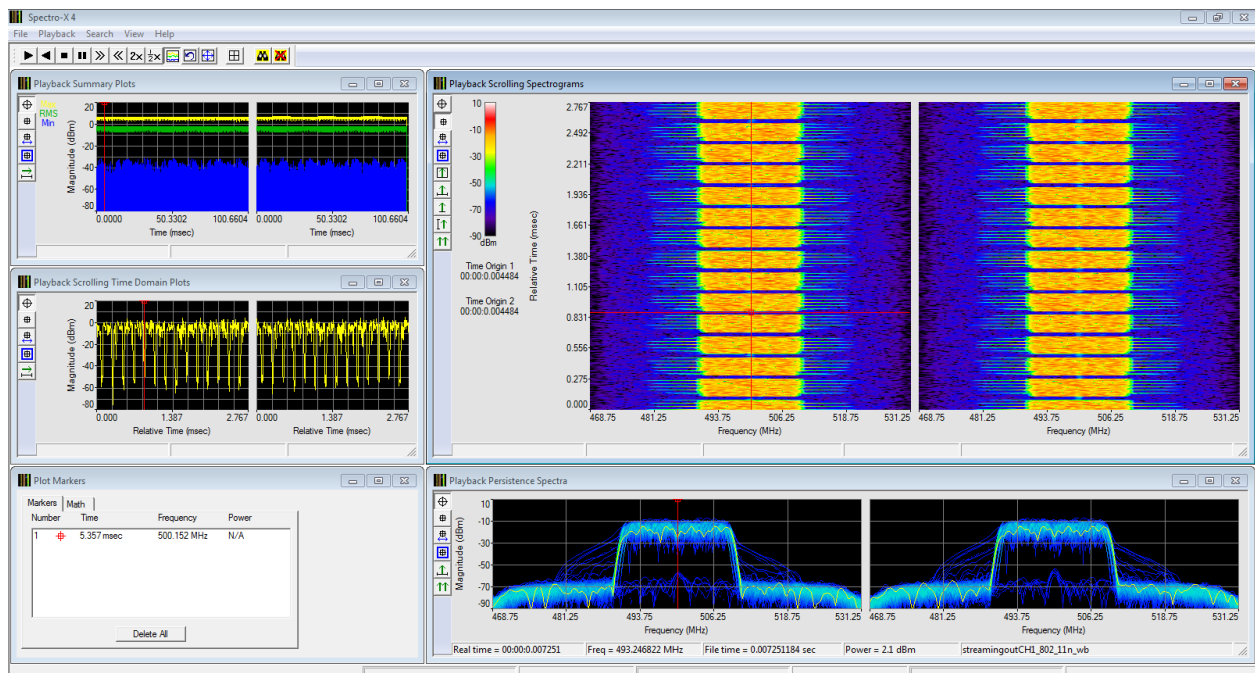
The license manager can sometimes conflict with Windows User Account Control settings. When this happens, a dialog box like this can appear.



To remedy this situation, first, make sure that the current user account has administrator privilege. Second, Windows User Account control must be turned off during the activation process. To do this, use the Control Panel item "User Accounts" and click on "Change User Account Control settings". Put the slider all the way to the bottom of the scale to "Never Notify". Click the "OK" button. When the activation process is complete, the User Account Control setting can be returned to its previous level.

## General Layout

The Spectro-X user interface consists of several elements that should be familiar to Windows users. At the top is a drop down menu with menus labeled “File”, “Playback”, “Search”, “View”, and “Help”. Each of these menus will be covered in a section of this manual. Below the menu is a tool bar which is used to control playback and search. The playback plots are divided into several windows titled “Playback Summary Plots”, “Playback Scrolling Time Domain Plots”, “Playback Scrolling Spectrograms” and “Playback Persistence Spectra”. On the left are the 2D plots, so called because the data being displayed is two-dimensional. On the right are the 3D plots which use color to display a third dimension. The window in the lower left contains information about markers which have been placed on the plots.

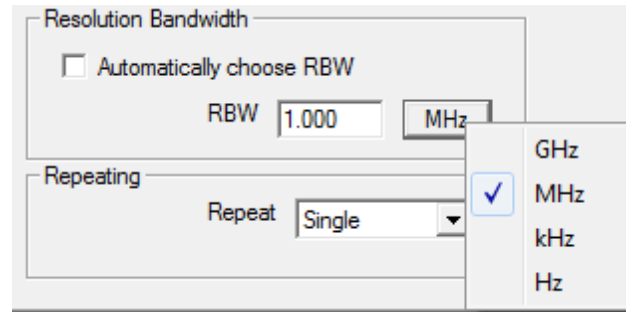
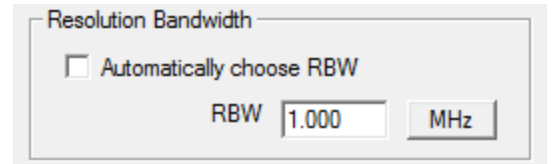


## Entering Values

Data for time and frequency values are typically entered in dialog boxes. Spectro-X allows for easy entering of values and the units for those values. As an example, consider the resolution bandwidth part of the Common tab of the Playback Control dialog.

A value for the resolution bandwidth can be entered by clicking in the text box and typing in a value. When the “Hz” button is clicked, a menu of possible units is presented. The appropriate unit can be chosen from the menu.

An alternate method for entering the unit is to type a suffix on the text. For example, to enter a value of 1 MHz, type “1m” in the text box. The “m” will not appear, but will be used to immediately set the units button to MHz. The letter “m” or “M” can be used to indicate MHz; the case is not important.



The table below shows letters and the units value that they select.

Letter	Units Value
S or s	seconds
M or m	milliseconds
U or u	microseconds
N or n	nanoseconds
P or p	picoseconds
H or h	Hertz
K or k	kilo Hertz
M or m	mega Hertz
G or g	giga Hertz

# Files

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## File Menu

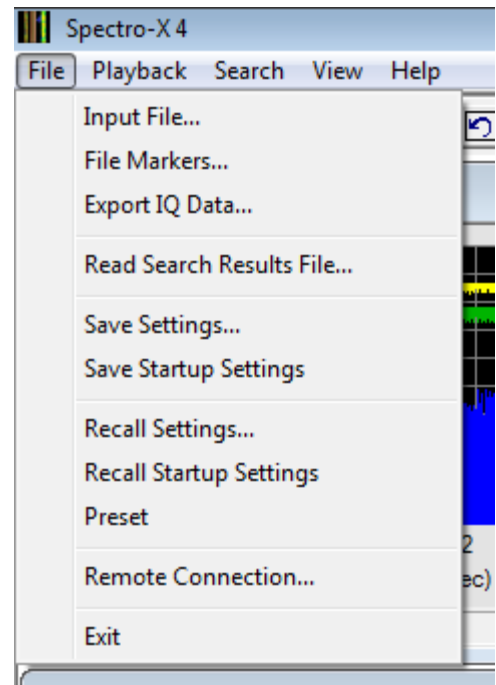
Various operations related to files are available on the file menu. The file menu allows the user to access dialogs which select the input files. It also allows access to a dialog for viewing the markers in a xiq file and a dialog for exporting the current input data in various file formats.

The file menu also allows the user to read in a search results file.

Saving and recalling of the program state is accessible through the file menu.

Remote connections to the program can be controlled using a dialog access through this menu. More information on this topic is available in the section on Remote Connections.

Finally, the user can exit the program through this menu.



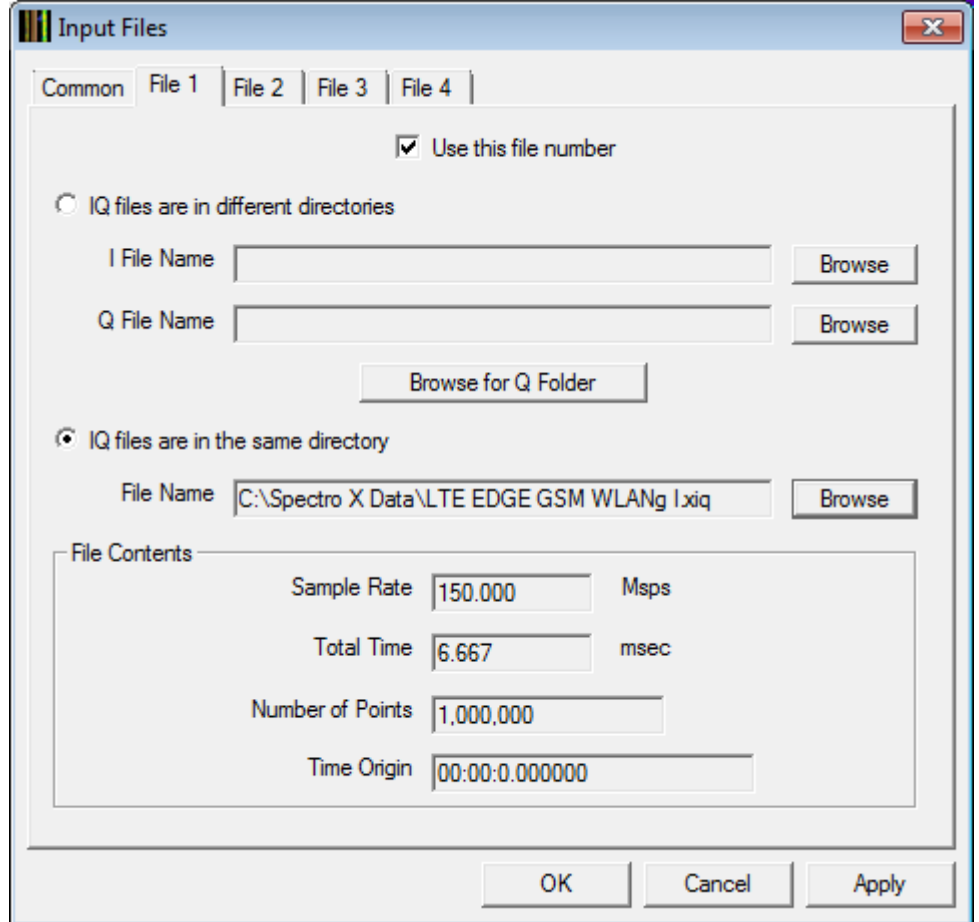


## Input File Dialog

The Input File Dialog is available from the “**File | Input File...**” menu choice.

There is a tab for each input file and a tab for settings which are common for all the files.

On the individual file tabs, there are two different methods that are used to specify the location of the input files. If the input data will be coming from xiq files, then the input files can either be in the same or in different directories. These two options are chosen using the radio buttons. If the input data is not coming from an xiq file pair, the “IQ files are in the same directory” button should be chosen.



The three “Browse” buttons can be used to select input files. Note that for xiq files not in the same directory, the “Browse for Q Folder” button can be used to select just the directory for the Q file, but not the actual Q file. The name for the Q file will be generated automatically in the selected Q directory. For xiq file pairs in the same directory, either the I or Q file can be chosen.

The file’s sample rate, total playback time, number of points, and time origin are automatically populated.

The checkbox at the top of the page can be used to turn the file on or off during playback.

The settings for the current file tab can be accepted by hitting the “Apply” button. It is not necessary to apply the settings for each file tab, as hitting the “OK” button will apply the settings to all file tabs and close the dialog.

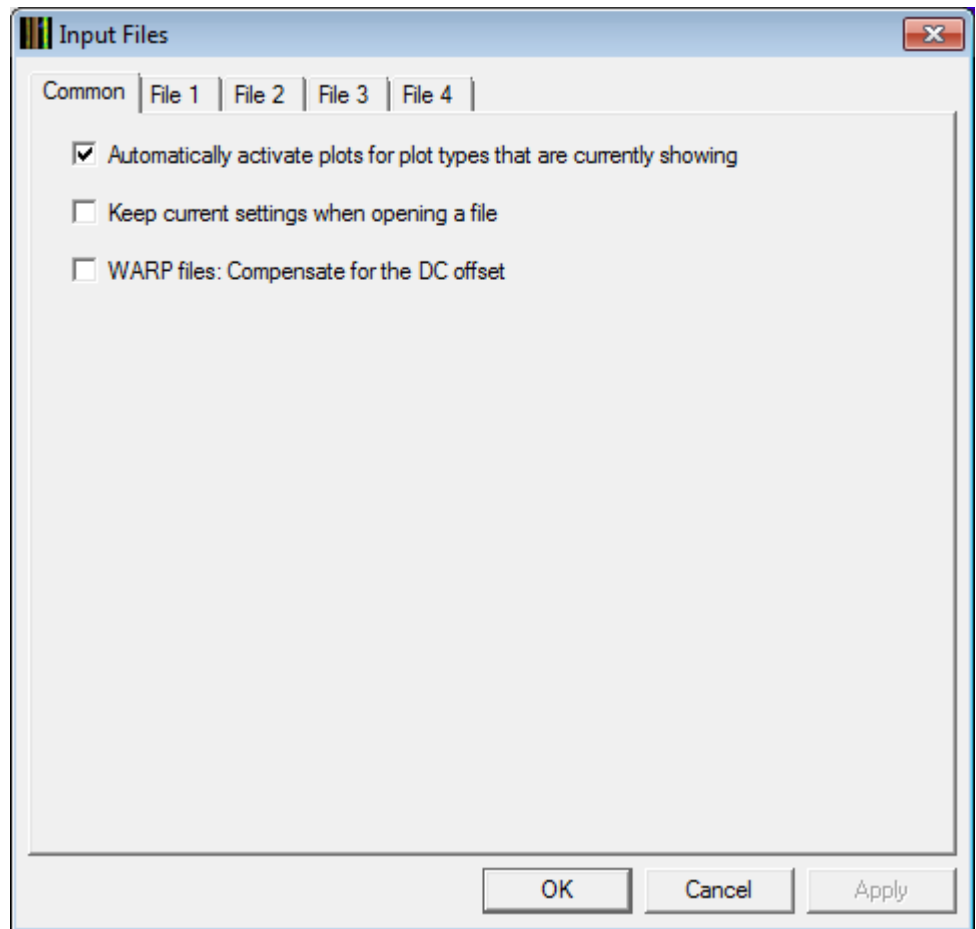
The Common tab has settings which are applied to all of the input files.

As a convenience, plots will be created for each input file, if the “Automatically activate plots for plot types that are currently showing” box is checked. Checking this box creates plots when the number of input files changes. If the box is not checked, plots will not be created for each file when the Input Files dialog closes. Plots can always be created using the Playback Active Plots dialog.

The default behavior for Spectro-X is to reset all playback settings to automatic mode when a new file is selected. If the settings are right the way they are, and should not be set to automatic when a new file is selected, then check the “Keep current settings when opening a file” check box.

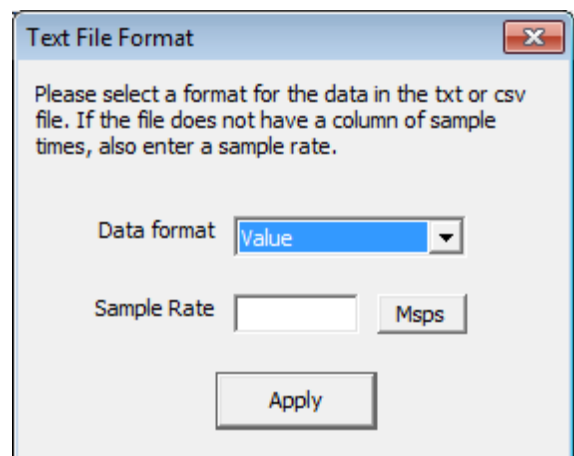
If the input files are WARP files, then the DC offset can be automatically removed by checking the “WARP files: Compensate for the DC offset” box.

Spectro-X will accept X-COM IQ captures in either xiq or the newer xdat formats, X-COM WARP files, Tektronix tiq files, Agilent bin files, ASCII text files (with a txt extension) and ASCII text files in comma separated value format (with a csv extension).



If a file with an extension of txt or csv is selected, when the Apply button is pressed, an additional dialog opens. The Text File Format dialog is used to supply additional information about the format of the data in the file. For txt files, the data is in columns with some sort of whitespace character between the columns. For csv files, the data is in columns with a comma separating the values.

Spectro-X supports four formats for the data in the file. The table below lists the four formats in the



“Data format” list of the dialog and the associated columns of data in the file. If the “Value” or “I Q” formats are chosen, then the sample rate must be supplied using the “Sample Rate” text box.

Spectro-X reads data from the txt or csv file according to the chosen file format. If a line of data does not parse into expected data values, then it is skipped. Thus, text headers for the columns are permissible, as Spectro-X will simply skip them as a non-data line.

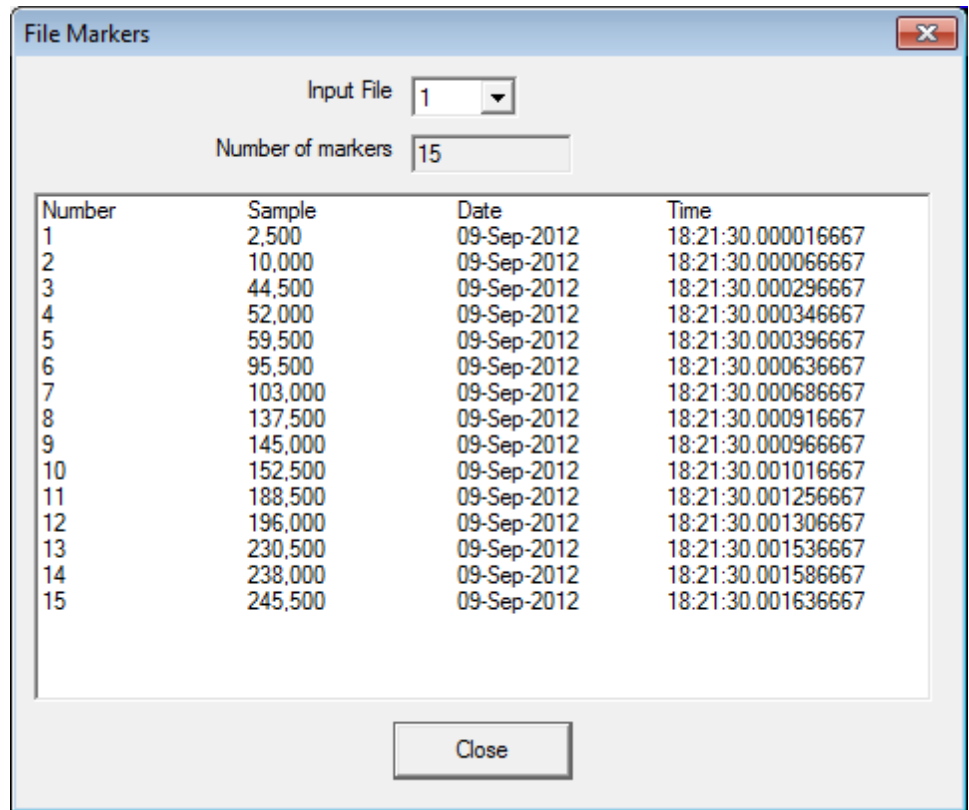
Data Format	Column 1	Column 2	Column 3
Value	Sample value		
I Q	I sample value	Q sample value	
Time Value	Sample time	Sample value	
Time I Q	Sample time	I sample value	Q sample value

In general, txt and csv files are much slower to read and much larger in size than files with one of the binary formats. While it may be convenient to be able to read ASCII files, one of the binary formats is strongly suggested for large data files.

## File Markers Dialog

XIQ and WARP files can contain markers which mark significant points in the input file. The Markers dialog can be used to view the markers and to set the playback start and stop times using the markers. Access this dialog using the “**File | Markers...**” menu choice.

The markers in the current input file are listed. The first marker in an XIQ file is used to set the time origin for the data.



Left clicking an item in the list brings up a context menu. Further clicking in the context menu sets that marker as either the playback start or stop time.

Clicking “Close” closes the dialog.

## Export IQ Data Dialog

It is possible to export the input file data in another format using the Export IQ Data dialog. This dialog is accessed using the “**File | Export IQ Data...**” menu choice.

The input file whose data will be exported is selected using the Input File list. Use the “Browse” button to open a standard Windows save file dialog. The file extension determines what type of file will be created. The currently supported export types are xiq, tiq, mat and txt.

The Agilent 89600 VSA software uses a particular format for txt and mat files. If the exported data will be used with the Agilent software, then check the

“Use Agilent file format for txt and mat files” check box. If that box is not checked, a more general version of those file types will be written.

The binary data format for xiq and Tektronix tiq files can sometimes be less than optimal when converting between file formats. To avoid this problem, check the “Maximize the dynamic range...” box. This setting only affects xiq and tiq output files. Selecting this option uses the full dynamic range of the binary data, but requires a two-pass process which doubles the processing time.

If the “All time” checkbox is checked, the entire input file will be exported. If the entire input file is not desired, a time range can be selected using the “Start” and “Stop” text boxes.

Export IQ Data to a File

Input File 1

Output File  Browse

Options

Use Agilent file format for txt and mat files

Maximize the dynamic range of xiq and tiq output files

Time Limits

All time

This time range

Start 0 psec

Stop 1.000000000 sec

Processing

Apply a frequency shift of 0.0 MHz

Decimate by

Apply a filter Passband 5%

Output sample rate 150.000 Msp

Output passband (< +/-)

Output stopband (> +/-)

Start Export Stop Export Close

The items in the “Processing” box are optional processing steps which can be applied to the input data before it is exported to the selected file.

The “Apply a frequency shift” check box and associated text box and units button can be used to apply a frequency shift to the data. The “Decimate by” check box and associated text box can be used to enter a factor which will be used to reduce the sample rate. The “Apply a filter” check box and list can be used to apply various lowpass filters to the data. The output sample rate, passband and stopband are useful to understand the effect of the chosen settings.

The “Processing” items can be used for IQ demodulation of a signal on a carrier during export of the data. The processing steps are performed as frequency shift, then decimation, then filtering.

To begin an export, click the “Start Export” button. To stop an export operation, click the “Stop Export” button. To cancel without exporting, click the “Close” button.

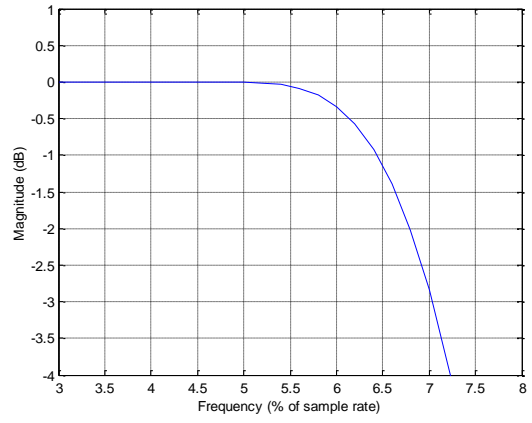
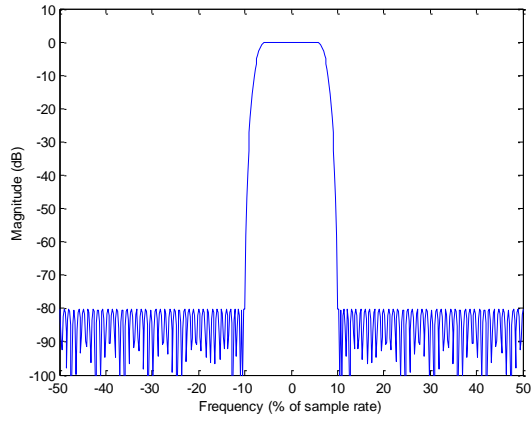
### Export IQ Data Filters

The filters which can optionally be applied during export of the data are implemented as digital FIR filters. The passband has less than 0.001 dB ripple, while the stopband has at least 80 dB of attenuation. The stopband begins at a frequency which is 2x the highest frequency in the passband.

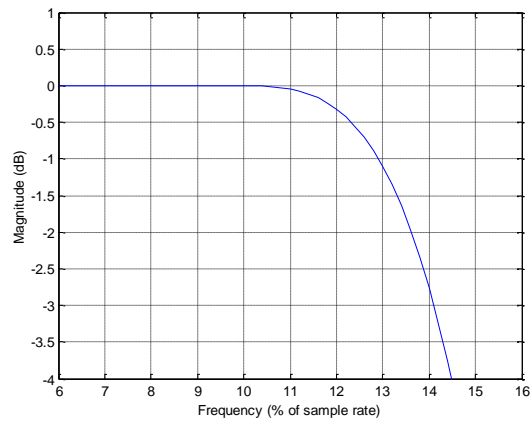
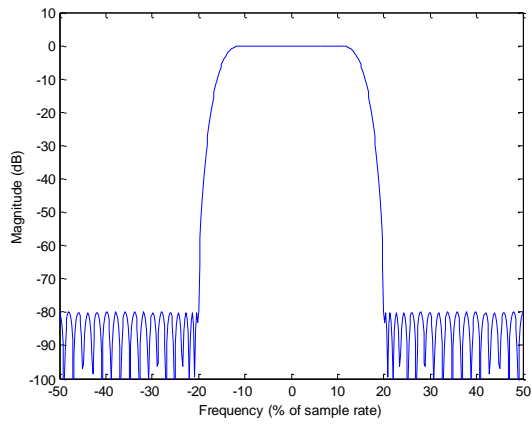
All of the filters are lowpass filters. Because the filters are applied to both I and Q, the plots below show them in both negative and positive frequencies, in order to show their effects on frequencies both below and above the center frequency. Plotting the filter transfer function like this makes them appear to be bandpass filters, but they are actually lowpass filters. The plots below show the magnitude of the filter transfer function versus a frequency scale related to the sample rate. A close-up view of the corner of the passband is also shown.

Export IQ Data Filter Specifications

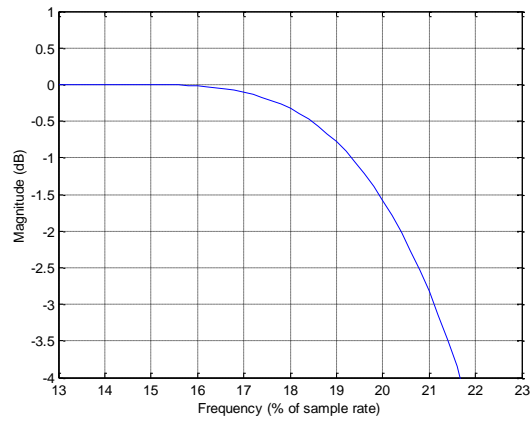
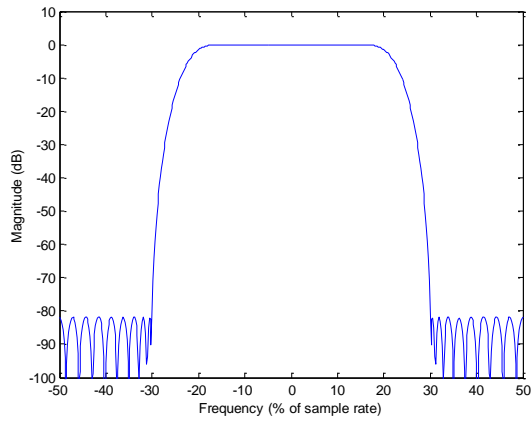
Filter Name	Passband	Stopband
Passband 5%	$-0.05f_s \leq f \leq +0.05f_s$	$f \leq -0.1f_s$ and $f \geq +0.1f_s$
Passband 10%	$-0.1f_s \leq f \leq +0.1f_s$	$f \leq -0.2f_s$ and $f \geq +0.2f_s$
Passband 15%	$-0.15f_s \leq f \leq +0.15f_s$	$f \leq -0.3f_s$ and $f \geq +0.3f_s$
Passband 20%	$-0.2f_s \leq f \leq +0.2f_s$	$f \leq -0.4f_s$ and $f \geq +0.4f_s$



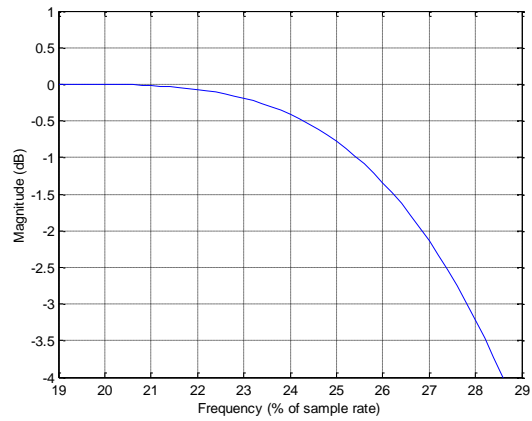
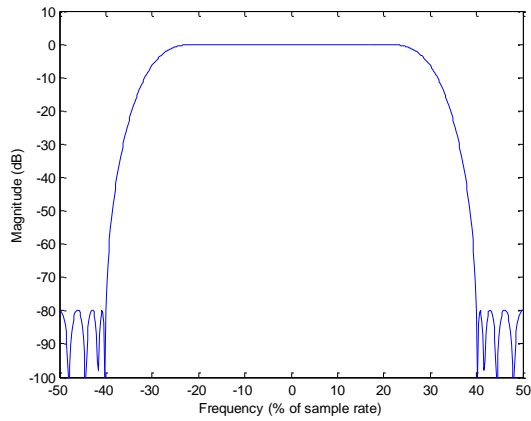
Passband 5% Filter Response



Passband 10% Filter Response



Passband 15% Filter Response



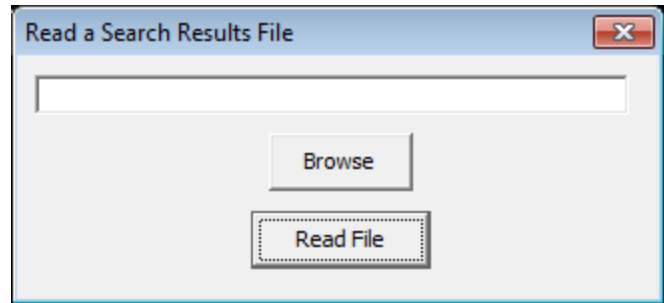
Passband 20% Filter Response



## Reading a Search Results File

Spectro-X can save search results to files. Those results can be read back from a file using the “Read a Search Results File” dialog. This dialog is accessed using the **“File | Read Search Results File...”** menu choice.

Use the “Browse” button to select the file from which the results will be read. Press the “Read File” button to read the file and display the results in the Search Results dialog. To close the dialog without reading the file, just close the dialog.



## Saving and Recalling Settings

The File menu has five items related to saving and recalling the settings for Spectro-X. To save all of the current settings, select **“File | Save Settings...”** This brings up a dialog box for creating a file name. The file will be saved with a “.config” extension. If the **“File | Save Startup Settings”** menu choice is chosen, the current settings will be used as program settings each time Spectro-X starts up.

To recall settings from a file, choose **“File | Recall Settings...”** That choice opens a file dialog which can be used to select the settings file. To recall the settings used at start up, choose **“File | Recall Startup Settings”**. Finally, to put the program in a factory default configuration, choose **“File | Preset”**.

# Playback

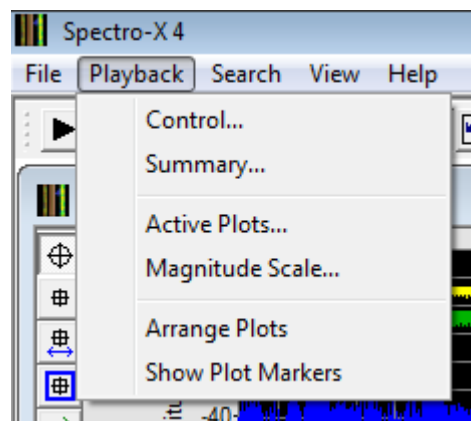
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Playback is controlled by items found in the “Playback” menu and by some items on the Control Bar. This section discusses those items, as well as the plots which are used to display the playback representations of the data.

## Playback Menu

The Playback menu contains items which are used for controlling the playback, for saving plots periodically during the playback, for selecting which plots are visible and for controlling the layout of plots.

The “**Control...**”, “**Summary...**”, “**Active Plots...**” and “**Magnitude Scale...**” menu choices will be discussed next as those choices all lead to specific dialogs. Before proceeding to the description of those dialogs, the last two items in the menu will be discussed.



The “**Arrange Plots**” menu choice attempts to distribute the plots using the available screen space. The 2D plots are given the left 1/3 of the screen space. The 3D plots are given the right 2/3 of the screen. The 2D plots are distributed vertically with equal space given to each plot. The 3D plots distribute vertically according to the number of time points in the scrolling spectrogram and the number of power points in the persistence spectrum.

The “**Show Plot Markers**” menu choice makes the plot marker window visible.

## Playback Control Dialog

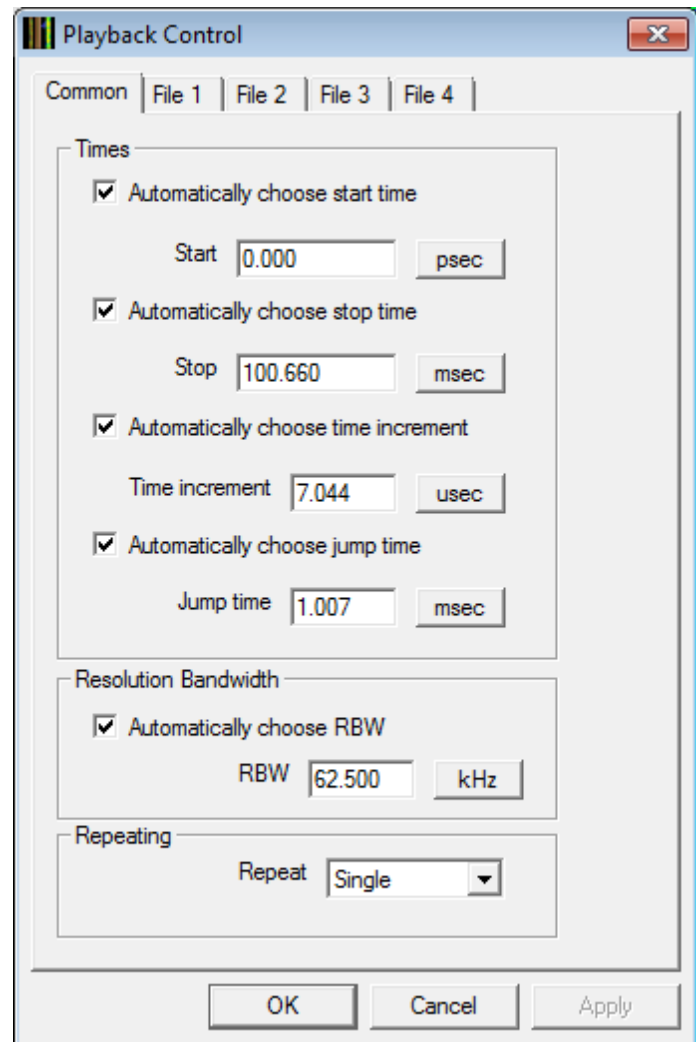
The menu choice “**Playback | Control...**” brings up the playback control dialog. There is a tab for the common settings for playback and tabs for the settings which are unique to each file. Much of the playback behavior is controlled using this dialog. Most of the settings have a check box which allows for automatic choices of the various parameters. For many signals and input files, the automatic choices will be acceptable. However, it may be necessary to alter the default choices. There is no need to uncheck the various check boxes, as entering a value for a setting will un-check the associated box.

The “Times” parameters control the parts of the input data which will be played. If the “Automatically choose start time” and “Automatically choose stop time” boxes are checked, the entire file will be played. To select a portion of the file, enter values into the “Start” or “Stop” boxes.

The time increment is the amount of time that playback steps from one set of data to the next. Playback retrieves a part of the input data, processes it and displays it on the various plots. The next part of the input data will be the time increment further along in the input data. For the value of 7.044 microsec above, the beginning of the next set of data will be 7.044 microsec later than the beginning of the current data. It should be noted that the time step can cause data to overlap, or not, depending on the choice of resolution bandwidth.

The “Jump time” is the time that the retrieval of data from the input file will jump, forward or backward, when the Jump Forward or Jump Backward buttons on the toolbar are pushed. The default value for the jump is 1% of the file length.

The “Resolution Bandwidth” parameter controls the RBW which will be used to compute the frequency domain views of the data. If the default choice is not correct for the input data, a value can be entered using the “RBW” parameter. A smaller value for RBW gives



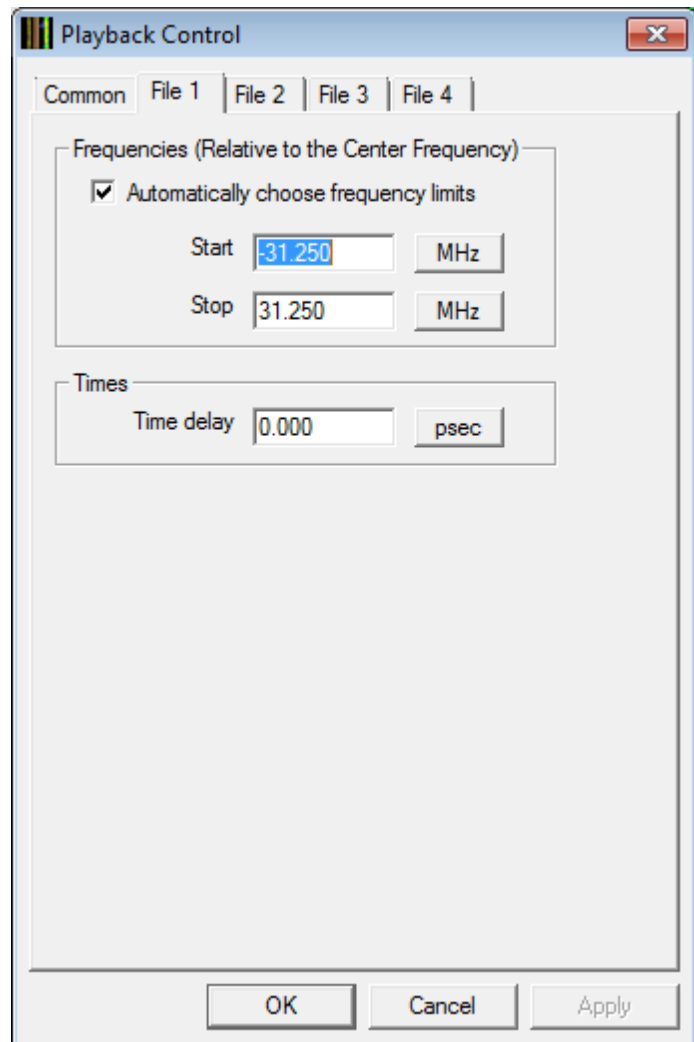
more detail in frequency. A larger value of RBW gives less detail in frequency, but more detail in time.

The “Repeating” parameter controls what happens when a playback is complete. “Single” means that the playback will stop after playing the input data once. “Continuous” means that the playback will go back to the beginning of the input data and continue playing.

Each file has settings which can be used for only that file. These settings are accessed on the individual file tabs.

The “Frequencies” parameters control the generation of frequency domain views of the input data. These settings affect the scrolling spectrogram and the persistence spectrum. The default frequency range is set by parameters in the input file which specify the valid frequency range for the data. The actual frequency range can be set using the “Start” and “Stop” parameters.

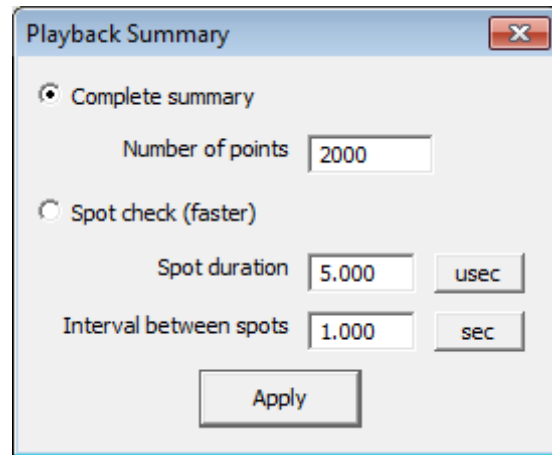
The “Time delay” parameter can be used to adjust the time alignment of the files during playback. Note that this only adjusts the apparent time of one file compared to another during playback. All markers and time displays show the actual time of the file and do not take into account the time delay value.



## Playback Summary Dialog

The menu choice “**Playback | Summary...**” brings up the Playback Summary dialog. This dialog is used to control the settings for the summary type of playback. Summary is a quick way to see an overview of the contents of the input files. The summary is in the form of min, max and RMS values.

There are two methods which can be used to generate a summary view of the input files: complete and spot check.



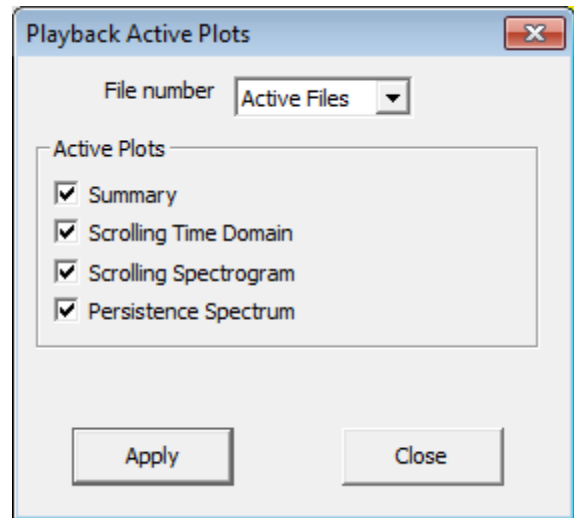
A complete summary looks at every input point in the input files and generates max, min and RMS values. The number of points is how many points there will be in the resulting summary plots. This method is thorough in that it processes every input data point in the files. However, due to its rigorous nature, it can be slower than desired.

A faster, but less rigorous method is spot check. This method does not summarize the entire file contents in a fixed number of points, but rather does spot checks on the file contents. The spot duration and interval between spots, as well as the file length determine how many summary points are generated. This method does not rigorously include every input data point in the summary, only those in the spot duration. The interval between spots and the file length determine the number of points. This method is generally faster than the complete summary, even if the resulting number of output points is greater.

## Active Plots Dialog

The menu choice “**Playback | Active Plots...**” brings up the Active Plots dialog. This dialog is used to select which plots will be displayed during playback.

The list at the top controls how the settings in the checkboxes will be applied to the input files when the “Apply” button is clicked. The choices are “Active Files”, the number of each input file and “All Files”. The selection of this list will determine which files the settings in the checkboxes will be applied to.



There are four plot playback plot types: Summary, Scrolling Time Domain, Scrolling Spectrogram and Persistence Spectrum. A check means that this plot type will be shown.

Press the “Apply” button to accept the settings in the dialog. The dialog does not automatically close when the Apply button is pressed because there may be other plots which should be activated rather than just those selected in the File Number list.

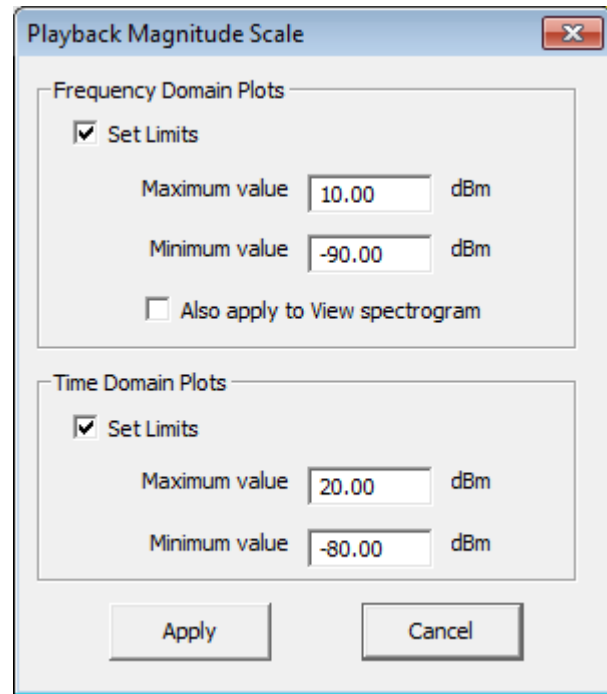
Clicking the “Close” button closes the dialog without making any changes, or any further changes beyond those that may have already been made.

## Magnitude Scale Dialog

The menu choice “**Playback | Magnitude Scale...**” brings up the Playback Magnitude Scale dialog. This dialog is a convenient way to set one set of limits for all of the magnitude scales for playback plots.

The “Frequency Domain Plots” section sets limits for all playback plots which have a frequency horizontal scale. Limits values entered here will set the power scale for all those plots to the entered limits.

The “Time Domain Plots” section sets limits for all playback plots which have a time horizontal scale.



The reason that frequency domain plots and time domain plots are handled separately is that the resolution bandwidth (RBW) can affect the power values in frequency domain plots.

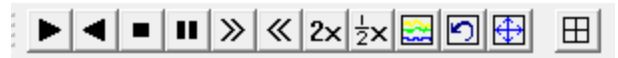
Press the “Apply” button to accept the settings in the dialog. Press the “Cancel” button, or simply close the window to ignore any changes that have been made.

Changes made to the scale values of an individual plot after the settings in this dialog have been applied, override the settings made with this dialog. This allows an individual plot to have different limits which display some aspect of signal behavior more fully. The Playback Magnitude Scale dialog is merely a convenient means to set all the frequency or time domain plot scale to the same values, without having to set each plot individually.



## Playback Control Bar

Playback is controlled by the Playback Control Bar.



The **Play Forward**, **Play Reverse**, **Stop**, and **Pause** buttons function like a normal video player.

The **Jump Forward** and **Jump Backward** buttons change the current playback time by adding (jump forward) or subtracting (jump backward) the amount of time specified by the “Jump time” parameter in the Playback Control dialog, to the current playback time.

**Double Speed** makes the signal display twice as fast, and **Half Speed** makes it display half as fast. These buttons multiply the time increment parameter in the Playback Control dialog box by either 2 or  $\frac{1}{2}$ . They do not change the rate at which processing occurs.













**Summary On** turns on summary mode during playback.

**Undo Limits Selection** undoes settings of time or frequency or time-frequency limits for playback which have been applied by using playback tools on the playback plots. The last 10 settings can be undone.

**Set to Auto Limits** goes back to default settings for the time and frequency limits for playback. This button does not affect magnitude scales, only time and frequency limits.

**Arrange Plots** will align the open plots in a manner to best fit the viewing area. This functionality is identical to selecting the menu choice “**Playback | Arrange Plots**”. The plots will be arranged on the main window, wherever the main window lies.

### Playback Toolbar buttons

Button Name	Image	Function
Play Forward		Plays the data in a forward direction
Play Reverse		Plays the data in a reverse direction
Stop		Stops playing
Pause		Pauses the playing
Jump Forward		Moves the playback time forward
Jump Backward		Moves the playback time backward
Double Speed		Doubles the time increment value
Half Speed		Halves the time increment value
Summary On		Puts playback in a mode which generates summary plots only
Undo Limits Selection		Undoes selections of time, frequency or time-frequency limits
Set to Auto Limits		Sets time and frequency limits to default values
Arrange Plots		Distributes the plots on the screen

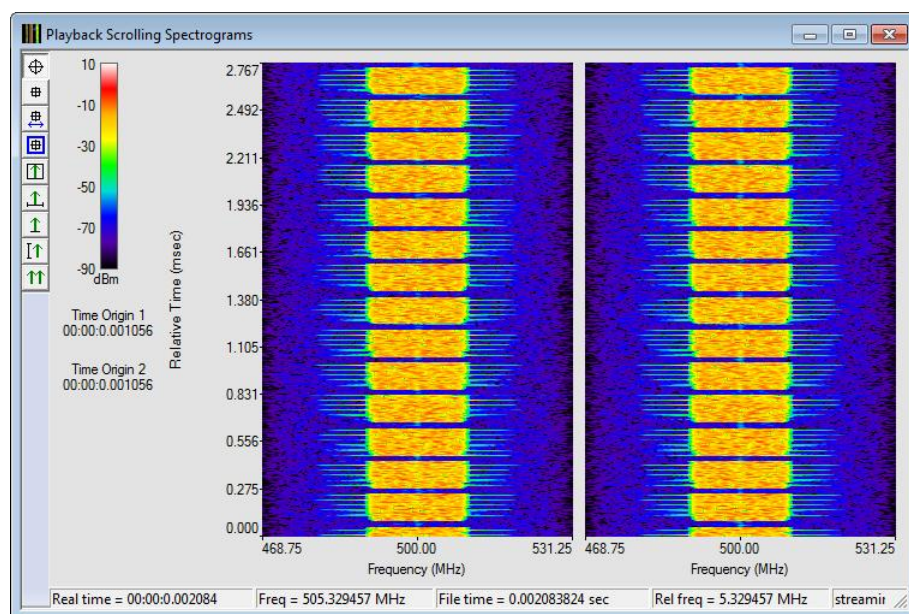
# Playback 3D Plots

There are two types of 3D plots: the Playback Spectrogram and the Playback Persistence Spectrum.

## Playback Spectrogram

The playback spectrogram provides a scrolling view of signals with both time and frequency information. The horizontal scale is frequency. The vertical scale is time. The colors represent the magnitude of the input signal at a particular time and at a particular frequency.

The horizontal frequency scale can be displayed as relative to the center frequency of the acquired data, or as an absolute scale. The scales in the spectrograms shown here are absolute scales. The frequency scale is controlled by two playback parameters: the start frequency and the stop frequency. These parameters can be found on the individual file tabs of the Playback Control dialog. The start and stop frequencies set the minimum and maximum limits of the plot.



The vertical scale is time relative to a time origin. The time origin comes from the input file. The time origin value displayed on the plot is the time of the data being displayed at the bottom of the plot.

It should be noted that the time scale has the earlier value at the bottom and the later value at the top. This was chosen so that this plot would agree with all the other plots in the system, in that minimum horizontal scale – minimum vertical scale location on the plot is in the lower left corner. Some spectrogram implementations that the user may encounter in other equipment put minimum time at the top of the plot.

The time scale of the plot is controlled by the time step increment. This parameter can be found on the Common tab of the Playback Control dialog. The time step increment controls the amount of time that is stepped from the creation of one horizontal line, to the creation of the next horizontal line.

In the top left corner of the window is the color scale which is being used to create the spectrogram.

Along the bottom of the window is a status bar which displays time and frequency values when some of the toolbar tools are selected and the cursor is over a plot.

## Spectrogram Context Menu

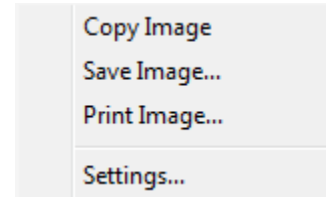
Right-clicking anywhere in the playback spectrogram brings up a context menu.

**Copy Image** – Copies the image of the plot to the clipboard

**Save Image...** – Saves image as a bitmap, JPEG, GIF, or PNG file

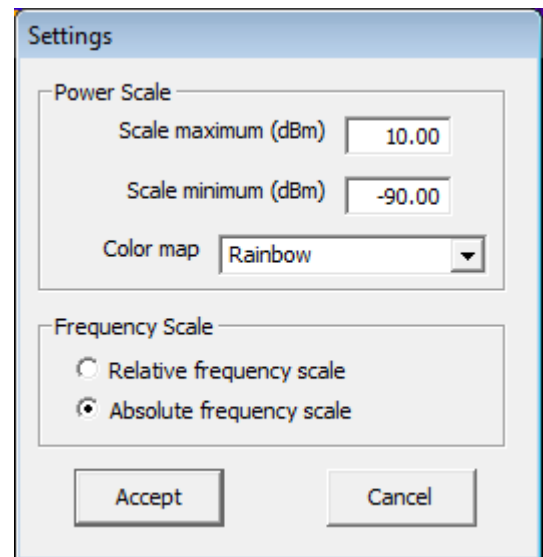
**Print Image...** – Sends the image of the plot directly to a printer

**Settings...** – Brings up a dialog for adjusting some properties for the spectrogram



## Spectrogram Settings Dialog

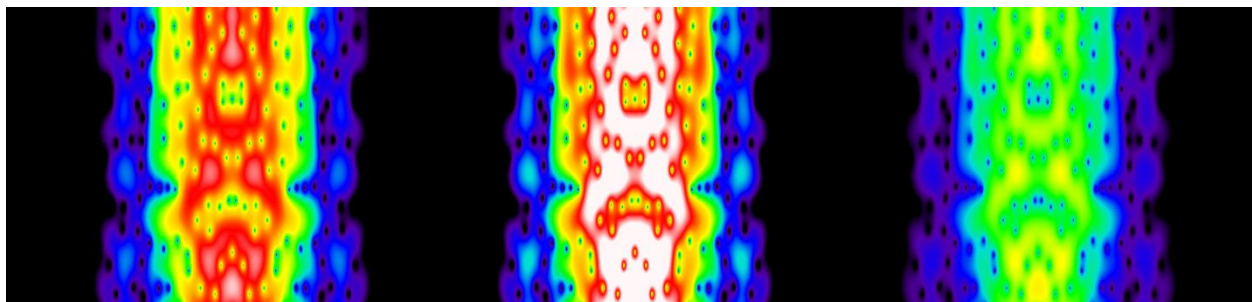
Clicking on Settings... in the context menu brings up the Settings dialog. The limits of the power scale can be adjusted using the controls in the "Power Scale" section. The frequency scale can be set to display frequencies relative to the center frequency of the acquisition or as absolute frequencies using the radio button in the "Frequency Scale" section.



## Setting the Spectrogram Color Scale

Changing the color scale can dramatically change the appearance of the playback spectrogram. For the best detail in analyzing the entire viewing portion's power resolution, the scale needs to be set so that the maximum color level faintly begins to show in the signal (white, if the rainbow color scale is selected).

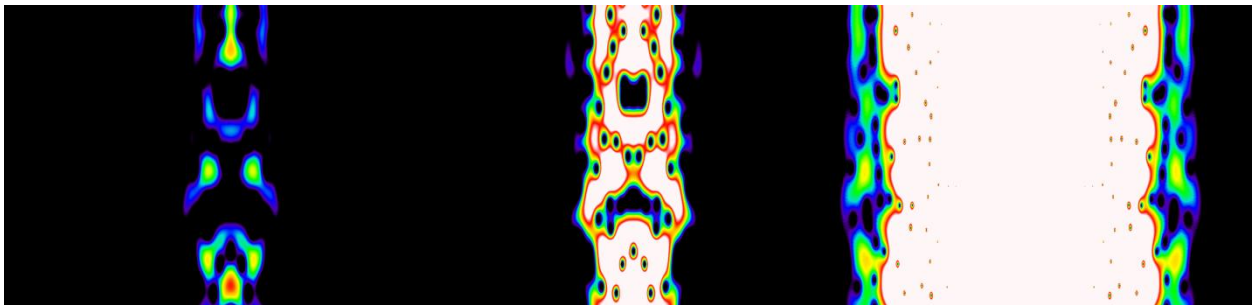
This ensures that no signal level is far above the color scale. In the figure below, the image on the left has a good choice for the maximum power level for the color scale. The image in the center has the maximum power level set too low. The image on the right has the power



level set too high.

Setting the minimum limit is dependent on how much signal-to-noise ratio the viewer would like to see, and the minimum power level of interest. Setting the minimum level very low may reveal previously unknown, low-level signals, but it may also introduce unnecessary noise into the viewing plot.

If extreme resolution for a particular region of power is required, the levels may be set so that the maximum level and the minimum level span a fairly small range. The figure below shows the same signal viewed as above, but with the power levels set in 10 dBm ranges. The image on the left emphasizes the highest powers, while that on the right emphasizes the lowest powers.






## Spectrogram Toolbar

Along the left edge of the window is a toolbar with various tools which can be applied to the spectrogram plots. These tools determine what action will be taken when a mouse click or a click and drag operation occurs in a plot.

Spectrogram Toolbar buttons

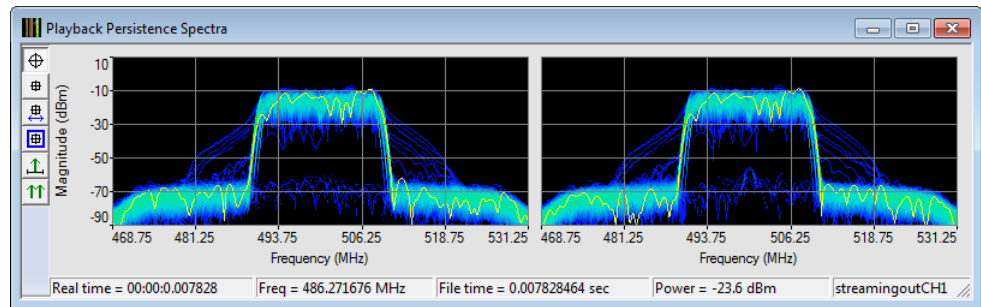
Button Name	Image	Function
Value Tool		Displays the location of the cursor in the status bar
Place a Marker		Allows placement of a marker with a mouse click
Move an Existing Marker		Moves the location of a marker
Marker Properties		A mouse click on a marker brings up the Marker Properties dialog
Play with Time and Frequency Limits		Initiates a playback with limits in both time and frequency
Play Starting Here with Frequency Limits		Initiates a playback starting at a point in time, with limits to the frequency scale

Play Starting Here		Initiates a playback starting at a point in time
Play with Time Limits		Initiates a playback with limits in time
Apply Frequency Limits to All Files		Apply the frequency limits of one of the tools above to all of the files, not just the file it was chosen on

The Apply Frequency Limits to All Files tool is a modifier to some of the other tools. It means that the frequency limits chosen on one of the plots should be used on all of the plots. Press it to engage it as a modifier. Press it again to release it and disable it as a modifier.

## Playback Persistence Spectrum

The playback persistence spectrum displays the playback signal in the frequency domain. The vertical scale is magnitude in dBm and the horizontal



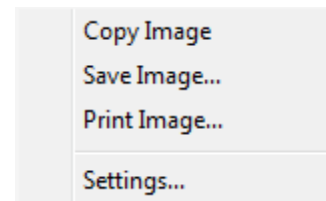
scale is relative frequency. The color scaling of the image functions as an indication of how much time the spectrum occupies a power level for a given frequency. The brighter the color, the longer the spectrum has spent at that power level for that frequency. The rate at which the colors fade can be adjusted.

The horizontal scale is frequency relative to a frequency origin. This scale is identical to that of the playback spectrogram. The control of the scale is also the same as that for the spectrogram.

## Persistence Spectrum Context Menu

Right-clicking anywhere in the persistence spectrum brings up a context menu.

- Copy Image** – Copies the image of the plot to the clipboard
- Save Image...** – Saves image as a bitmap, JPEG, GIF, or PNG file
- Print Image...** – Sends the image of the plot directly to a printer
- Settings...** – Brings up a dialog controlling persistence



## Persistence Spectrum Settings Dialog

The persistence spectrum settings dialog is used to set various parameters controlling the display of the persistence spectrum plots.

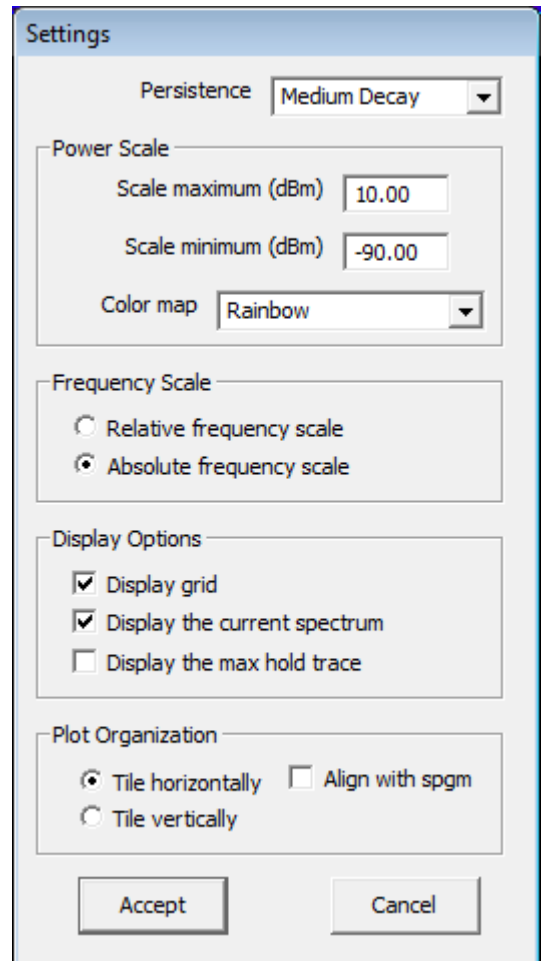
The type of persistence can be chosen using the list at the top of the dialog. The values for persistence and their effects on the plot will be described in the next section.

The power scale limits are controlled by the “Scale maximum (dBm)” and “Scale minimum (dBm)” parameters. The color scale can be changed using the “Color map” list.

The frequency scale can be set to display frequencies relative to the center frequency of the acquisition or as absolute frequencies using the radio button in the “Frequency Scale” section.

There are several optional aspects of the display of the plots. The horizontal and vertical grid can be displayed or not. The current spectrum can be overlaid on the plots. Finally, a max hold trace can be displayed.

The persistence spectrum plots can be displayed side-by-side (tile horizontally) or stacked one on top of the other (tile vertically). When the plots are tiled horizontally, the “Align with spgm” checkbox chooses the same alignment criteria as the scrolling spectrogram plots. This makes it easy to align a persistence spectrum plot precisely underneath the associated scrolling spectrogram.



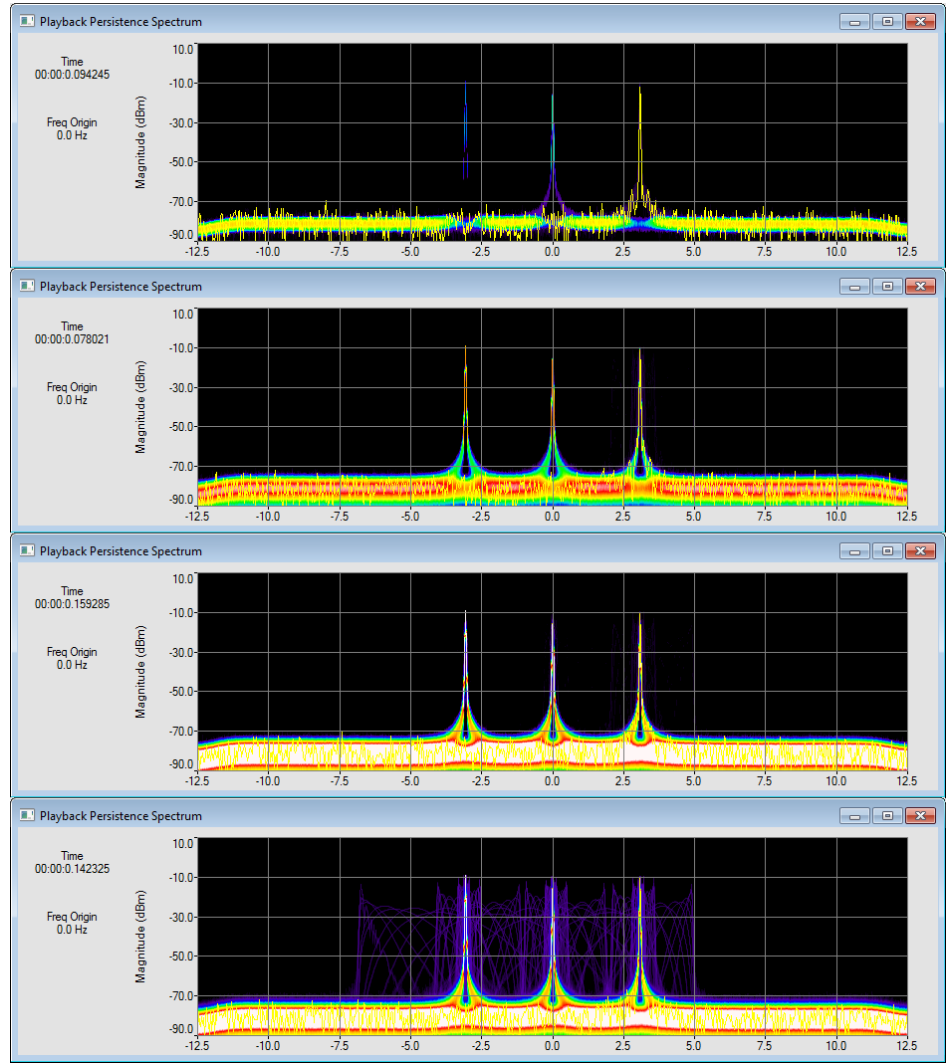


## Setting the Persistence

Persistence controls how fast or slow the image dies in time. The persistence has four possible settings:

- 1) Fast Decay
- 2) Medium Decay
- 3) Slow Decay
- 4) Infinite



The figure shows fast decay at the top, slow decay next to the top, medium decay next to the bottom and infinite persistence at the bottom.







## Persistence Spectrum Toolbar

Along the left edge of the window is a toolbar with various tools which can be applied to the persistence plots. These tools determine what action will be taken when a mouse click or a click and drag operation occurs in a plot.

Persistence Toolbar buttons

Button Name	Image	Function
Value Tool		Displays the location of the cursor in the status bar
Place a Marker		Allows placement of a marker with a mouse click

Move an Existing Marker		Moves the location of a marker
Marker Properties		A mouse click on a marker brings up the Marker Properties dialog
Play with Frequency Limits		Initiates a playback with limits to the frequency scale
Apply Frequency Limits to All Files		Apply the frequency limits of one of the tools above to all of the files, not just the file it was chosen on

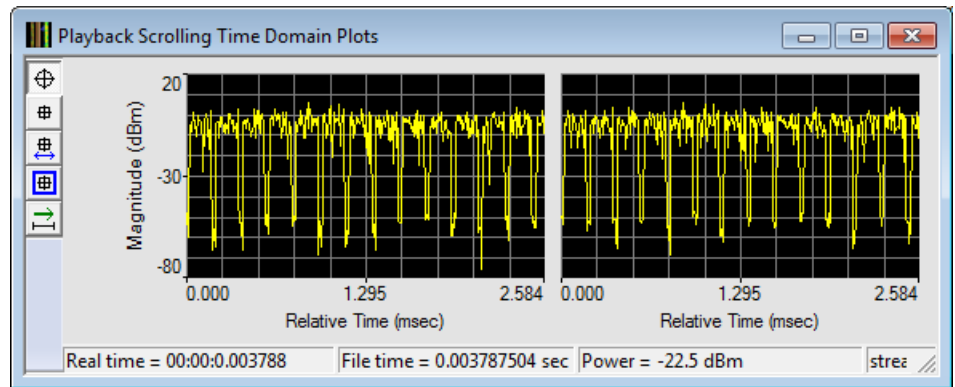
The Apply Frequency Limits to All Files tool is a modifier to the Play with Frequency Limits tools. It means that the frequency limits chosen on one of the plots should be used on all of the plots. Press it to engage it as a modifier. Press it again to release it and disable it as a modifier.

# Playback 2D Plots

There are two types of 2D plots: the Playback Scrolling Time Domain plots and the Playback Summary plots.

## Playback Scrolling Time Domain Plot

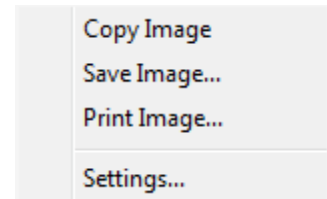
The Playback Scrolling Time Domain plots display signal power versus time. The time scale is the same as that in the scrolling spectrogram plot. As with the 3D plots, this plot has a status bar, a context menu, a settings dialog and a toolbar.



## Persistence Spectrum Context Menu

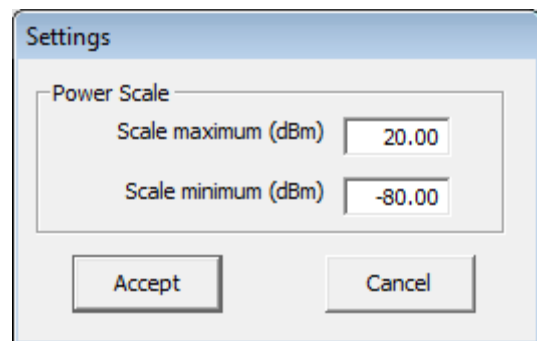
Right-clicking anywhere in the scrolling time domain plot brings up a context menu.

- Copy Image** – Copies the image of the plot to the clipboard
- Save Image...** – Saves image as a bitmap, JPEG, GIF, or PNG file
- Print Image...** – Sends the image of the plot directly to a printer
- Settings...** – Brings up a dialog controlling the magnitude scale



## Scrolling Time Domain Settings Dialog






The scrolling time domain settings dialog is used to set the limits of the vertical power scale.



## Scrolling Time Domain Toolbar

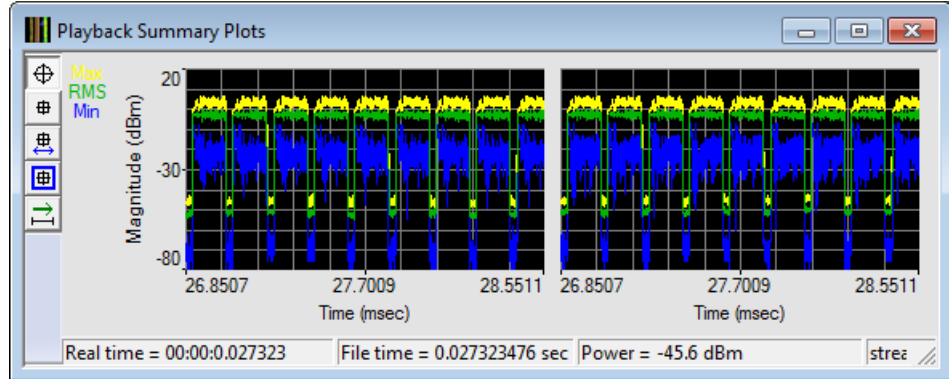
Along the left edge of the window is a toolbar with various tools which can be applied to the scrolling time domain plots. These tools determine what action will be taken when a mouse click or a click and drag operation occurs in a plot.

Persistence Toolbar buttons

Button Name	Image	Function
Value Tool		Displays the location of the cursor in the status bar
Place a Marker		Allows placement of a marker with a mouse click
Move an Existing Marker		Moves the location of a marker
Marker Properties		A mouse click on a marker brings up the Marker Properties dialog
Play with Time Limits		Initiates a playback with limits in time

## Playback Summary Plot

The Playback Summary plots display signal power versus time. This plot helps give an overview of the signal content of large sections of data. There are 3 traces plotted, the maximum, RMS and minimum data values. As with the 3D plots and the scrolling time domain plot, this plot has a status bar, a context menu, a settings dialog and a toolbar.



## Summary Context Menu

Right-clicking anywhere in the scrolling time domain plot brings up a context menu.

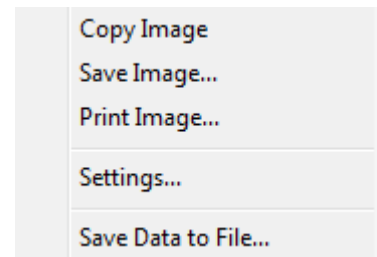
**Copy Image** – Copies the image of the plot to the clipboard

**Save Image...** – Saves image as a bitmap, JPEG, GIF, or PNG file

**Print Image...** – Sends the image of the plot directly to a printer

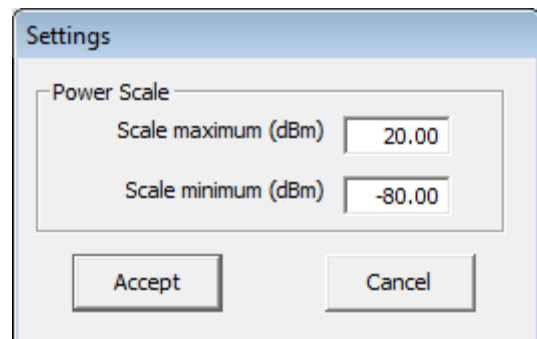
**Settings...** – Brings up a dialog controlling the magnitude scale

**Save Data to File...** – Brings up a dialog which allows for saving of the min, max and RMS data to a text file



## Summary Settings Dialog






The summary settings dialog is used to set the limits of the vertical power scale.



## Summary Toolbar

Along the left edge of the window is a toolbar with various tools which can be applied to the scrolling time domain plots. These tools determine what action will be taken when a mouse click or a click and drag operation occurs in a plot.

### Persistence Toolbar buttons

Button Name	Image	Function
Value Tool		Displays the location of the cursor in the status bar
Place a Marker		Allows placement of a marker with a mouse click
Move an Existing Marker		Moves the location of a marker
Marker Properties		A mouse click on a marker brings up the Marker Properties dialog
Play with Time Limits		Initiates a playback with limits in time

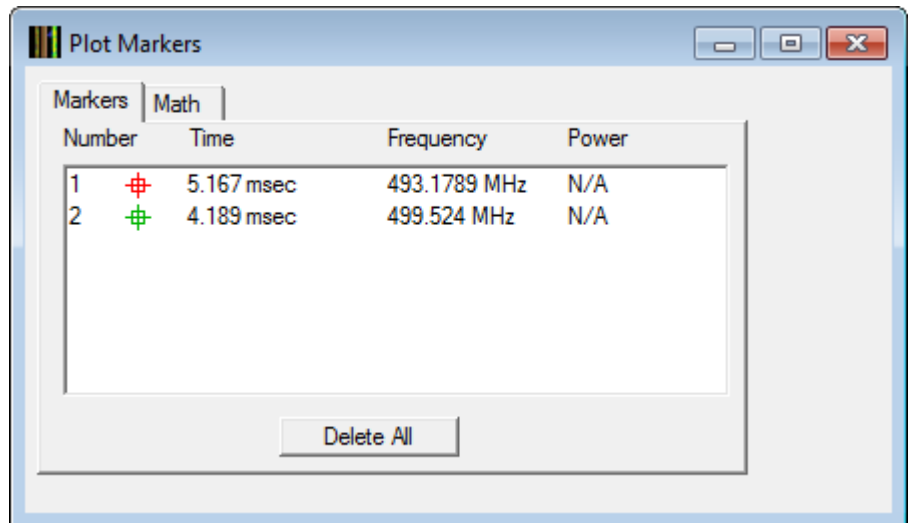
# Plot Markers

As described in the section on playback 3D and 2D plots, Spectro-X 4 has the ability to place markers on all plots. Once placed, the markers are displayed in the plot markers window.

Plot markers in Spectro-X are location markers (as opposed to trace markers). Location markers mark a location on a plot with respect to the horizontal and vertical axes.

The three principal

dimensions of plots used to display data in Spectro-X are time, frequency and power. A plot marker placed on a plot has the same two dimensions as the horizontal and vertical axes of the plot that it was placed on.



The plot markers window has two tabs: Markers and Math.

## Plot Markers: Markers Tab

The current markers are displayed on the markers tab. Left clicking with the mouse on a marker brings up a context menu which presents options for that marker.

**Enabled** – Enable or Disable a marker without deleting it

**Delete** – Delete the marker

**Set Properties...** – Bring up the Marker Properties dialog

**Use as Math : First** – Use as the first marker number on the Math tab

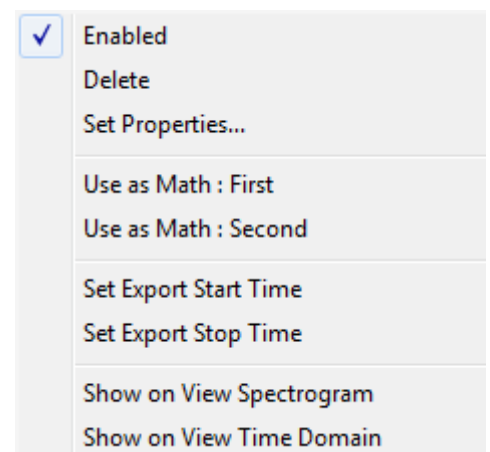
**Use as Math : Second** – Use as the second marker number on the Math tab

**Set Export Start Time** – Use the marker time as the start time when exporting IQ data to a file

**Set Export Stop Time** – Use the marker time as the stop time when exporting IQ data to a file

**Show on View Spectrogram** – Bring up the View Spectrogram window, showing the data at the marker time

**Show on View Time Domain** – Bring up the View Time Domain window, showing the data at the marker time



## Plot Marker Properties Dialog

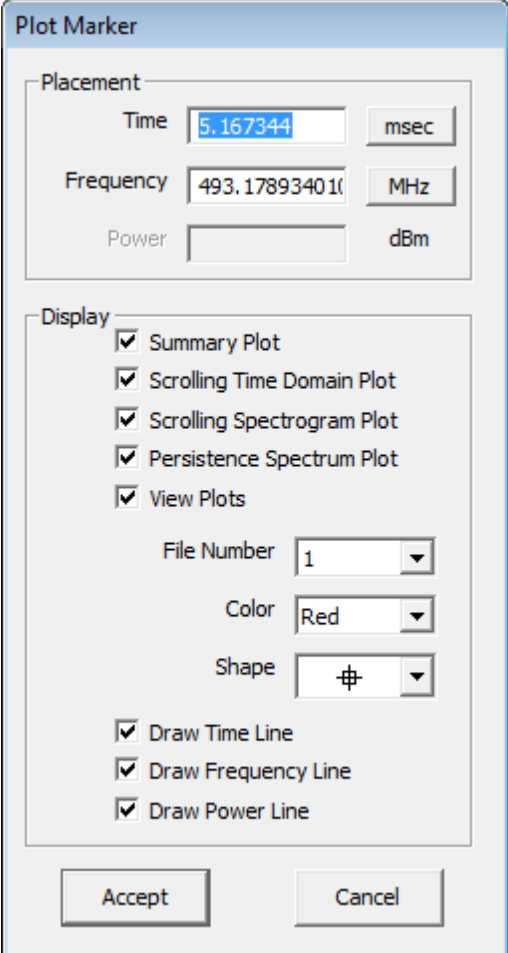
The Plot Marker Properties dialog can be used to control the location and display of a marker.

The items in the “Placement” section are used to fine tune the time, frequency or power value which define the location of the marker.

The items in the “Display” section control how a marker is displayed. The checkboxes at the top control which type of plot the marker is displayed on. The “File Number” list allows the marker to be displayed on just one file number, or on the plots for all file numbers. The “Color” and “Shape” lists control the appearance of the marker. The three checkboxes at the bottom control the display of line extensions from the actual plot location.

Clicking “Accept” accepts the values of the settings for the various items and closes the dialog. Clicking “Cancel” closes the dialog without making any changes.

Although the operation of this dialog is described in relation to a selection on the plot marker list in the Plot Marker window, this dialog can also be invoked using the marker properties tool on the toolbar for each plot window.



The screenshot shows the "Plot Marker" dialog box with the following settings:

- Placement section:**
  - Time: 5.167344 msec
  - Frequency: 493.17893401 MHz
  - Power: (empty) dBm
- Display section:**
  - Summary Plot
  - Scrolling Time Domain Plot
  - Scrolling Spectrogram Plot
  - Persistence Spectrum Plot
  - View Plots
  - File Number: 1
  - Color: Red
  - Shape: (crosshair icon)
  - Draw Time Line
  - Draw Frequency Line
  - Draw Power Line

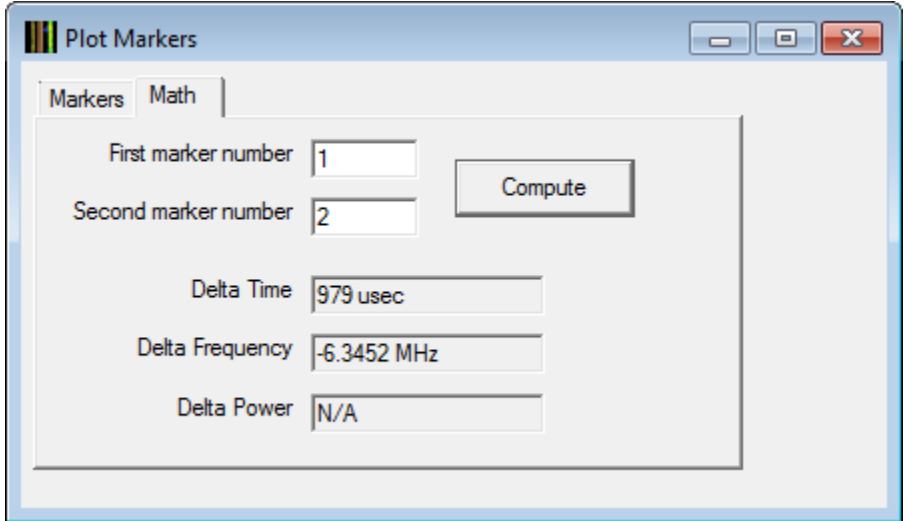
Buttons: "Accept" and "Cancel"



## Plot Markers: Math Tab

The Math tab can be used to perform simple marker calculations.

Enter a value for the first and second marker numbers and click the “Compute” button to compute the time, frequency and power difference between the chosen markers. The difference is computed as the values from the first marker number minus the values from the second marker number.



# Search

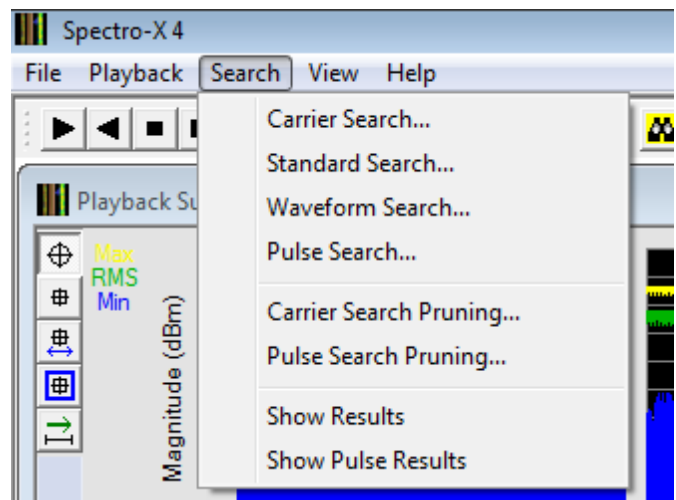
---

The Search menu allows access to dialog boxes which control the various types of searches available in Spectro-X. The three types of search will be discussed in this section.

The results of searching are displayed in the Search Results window. If that window is inadvertently closed, it can be opened again using the **“Search | Show Results”** menu choice.

Spectro-X has the ability to remove (or “prune”) results from a previous carrier or pulse search that was stored in a file or from the next carrier or pulse search operation. The **“Search | Carrier Search Pruning...”** and **“Search | Pulse Search Pruning...”** menu choices can be used to bring up dialog boxes that implement this functionality.

Before proceeding to explain the search functionality, one item should be noted. Only one type of search is active at a time. The currently active search type is that search whose dialog box was closed most recently using the “Accept” button. Thus, if the Carrier Search dialog was the last one closed using the “Accept” button in that dialog, then the current search type is carrier search.



## Carrier Search

Carrier Search looks for signals which resemble modulation on a carrier with a constant frequency. On a spectrogram these types of signals look like vertical stripes. Carrier search estimates the carrier frequency, the 3 dB signal bandwidth and gives the start time and duration for the signals found. Carrier search is not a good choice when looking for signals which change in frequency, such as chirp signals.

The Carrier Search dialog is accessed using the **“Search | Carrier Search...”** menu choice.

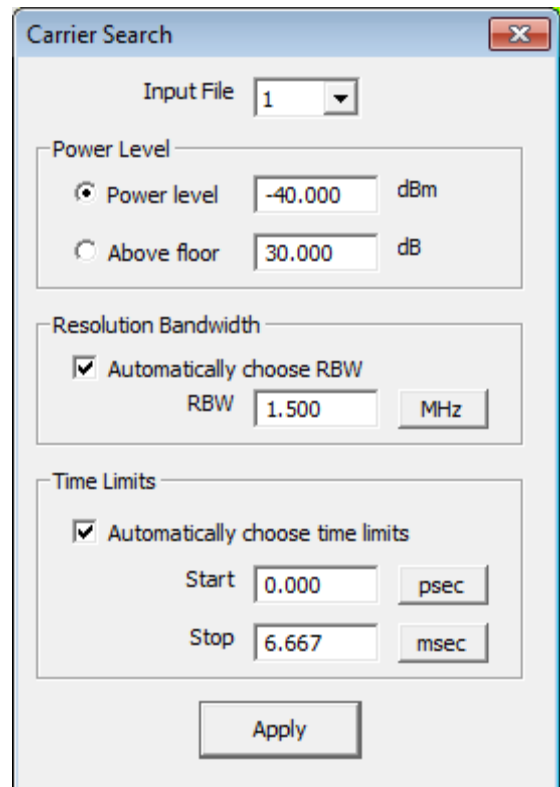
The “Input File” list at the top is used to control which of the input files the carrier search will be applied to.

The fundamental parameter controlling what defines a carrier is the power level. There are two means of entering the power level: either by absolute power level or by dB above the noise floor. This subject will be covered in more detail after the rest of the dialog box discussion.

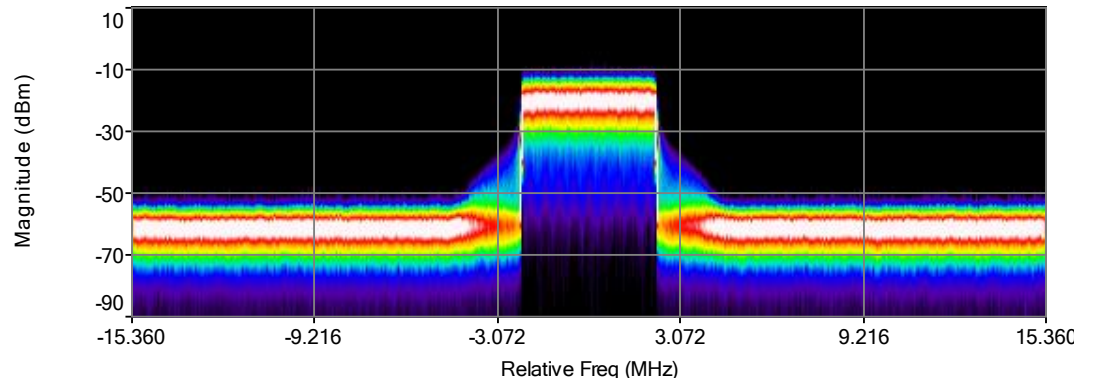
The resolution bandwidth can be controlled by entering a value into the RBW box. Because the RBW affects the resolution in frequency and the resolution in time, Spectro-X places limits on how much the RBW can vary. If an RBW is chosen outside of these limits, Spectro-X will automatically set it to a valid value and alert the user when the search starts.

The time limits section can be used to limit the search to certain parts of the input data.

Pressing the “Apply” button accepts the values in the dialog and makes carrier search the current search type. Closing the dialog discards the entered values.



As mentioned above, the fundamental parameter for controlling carrier search is the power level. As an example of how to set the power level, consider the



plot which is an LTE (4G) cell phone signal. To get a basic understanding of the power levels in the input data, the file was played back. The resulting persistence spectrum is shown. A good power level for finding carriers is one that cuts through the “stump” of the spectrum. So an absolute power level between -50 dBm and -30 dBm would be a good choice. A power level below -50 dBm could inadvertently find carriers in the noise floor. A power level above -30 dBm could separate the one carrier into several, depending on the instantaneous frequency content of the signal. A good value of absolute power for this signal is -40 dBm. By entering a value of -40 dBm for the power level, we are asking Spectro-X to find all carriers with a power level of at least -40 dBm.

The alternative method for setting the power level is a value above the noise floor. The signal shown has a noise floor around -60 dBm. A good rule of thumb to avoid the noise floor is to be 20 dB over the floor level. If the signal types are unknown in the input data, a good initial setting for the power level is 20 dB above the noise floor.

When searching for carriers, any part of the spectrum which exceeds the specified power level is a carrier. The width of the signal above the specified power level is not important with respect to finding carriers, only that the power level was exceeded.

## Standard Search

Standard search allows searches of carriers for particular wireless standards. The currently supported standards are GSM, EDGE, 802.11 a/g and LTE (4G cell phone).

The “Input File” list at the top is used to control which of the input files the standard search will be applied to.

The carrier frequency for the carrier to be searched is entered using the text box. The confidence limit allows an adjustment on how sure Spectro-X is that a signal is of a certain type. Most signal types which are well aligned in frequency will yield 99% confidence. However, slight uncertainties in the carrier frequency can lead to lower level of confidence.

Because the carrier frequency is extremely important in determining a signal type, it is possible to have Spectro-X vary the carrier around the value entered in the “Carrier Frequency”. This automated varying of the carrier frequency is called carrier stepping. To enable carrier stepping, the “Carrier stepping on” box must be checked. The “Frequency range” is the full range of adjacent frequencies which will be tried as carrier frequencies. The frequency increment is how much the carrier frequency changes from one carrier frequency to the next.

At least one of the standard types must be checked in the “Candidate Types” area. Because LTE has multiple parameters that are needed to specify it, pressing the “LTE Parameters” button brings up a dialog which allows those parameters to be set. At present, only the uplink part of LTE is available for searching.

The “Time Limits” section allows the entire input file to be searched, or just a section of time from that file.

Pressing the “Apply” button accepts the values in the dialog and sets Standard search as the current search type. Closing the window ignores the values in the dialog.

The screenshot shows the "Standard Search" dialog box with the following settings:

- Input File: 1
- Carrier Frequency: 0.000 Hz
- Confidence Limit: 90.000 %
- Carrier Stepping:  Carrier stepping on
- Frequency range: 100.000 kHz
- Frequency increment: 10.000 kHz
- Candidate Types:  GSM,  LTE,  EDGE,  802.11a/g, and an "LTE Parameters" button.
- Time Limits:  Automatically choose time limits
- Manual: Start 0.000 psec, Stop 1.000 sec
- Apply button at the bottom.

## Waveform Search

Waveform search allows for searches for particular signals that have been saved in a file.

The “Input File” list at the top is used to control which of the input files the waveform search will be applied to.

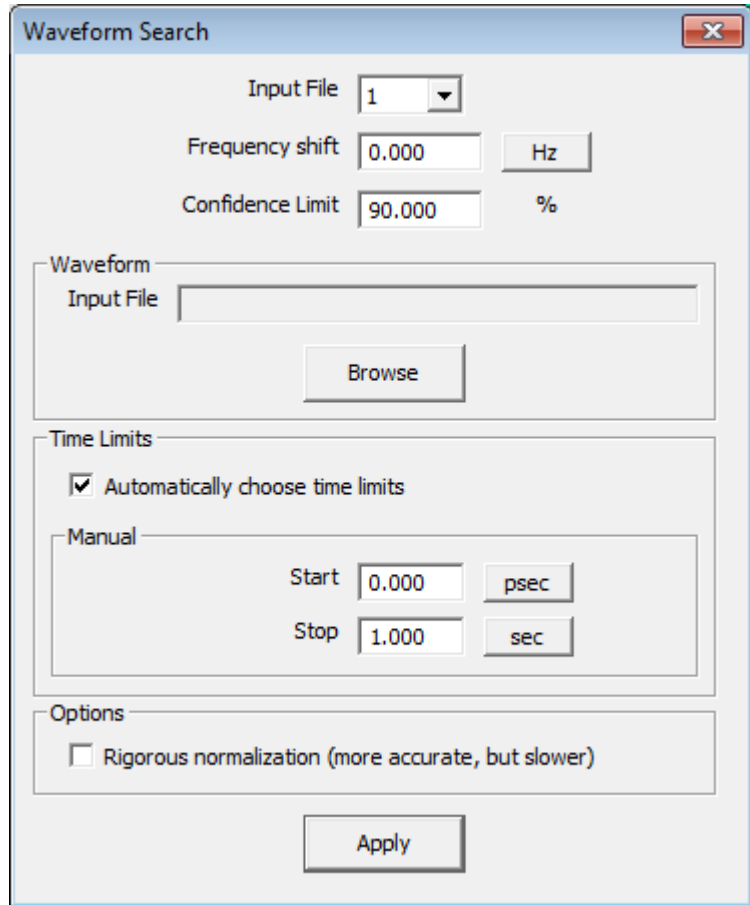
The frequency shift, if non-zero, is the amount of frequency that the input file will be shifted in order to align the frequency content in the Waveform input file with that of the input file. If the Waveform input file represents a baseband signal (center frequency of 0 Hz), then the shift frequency can be thought of as the carrier frequency in the input data which will be shifted to baseband before a comparison is made with the Waveform input file. If the Waveform input file does not represent a baseband signal, but rather a modulated carrier, then the shift frequency can be thought of as the frequency shift applied to the Waveform input file before a comparison is made with the input file.

The confidence limit allows an adjustment on how sure Spectro-X is that the signal in the waveform file has been found. Most signal types which are well aligned in frequency will yield 99% confidence. However, slight uncertainties in the carrier frequency can lead to lower levels of confidence.

The “Browse” button in the “Waveform” part of the dialog is used to select a small input file which determines what signal is being searched for.

The “Time Limits” section allows the entire input file to be searched, or just a section of time from the current input file.

One option for the calculation is how rigorous the normalization should be. By checking the “Rigorous normalization” box, the most complete method for calculating the % confidence will be used. However, because that method can be up to five times slower, leaving the box unchecked will use a faster approximate method. The result of this approximate method could be % confidence numbers which are too small. If the % confidence results seem odd, then the more rigorous method should be used.



The screenshot shows the "Waveform Search" dialog box with the following settings:

- Input File: 1
- Frequency shift: 0.000 Hz
- Confidence Limit: 90.000 %
- Waveform Input File: (empty text box)
- Browse button: (present)
- Time Limits:  Automatically choose time limits
- Manual section: Start 0.000 psec, Stop 1.000 sec
- Options:  Rigorous normalization (more accurate, but slower)
- Apply button: (present)

Pressing the “Apply” button accepts the values in the dialog and sets Waveform search as the current search type. Closing the window ignores the values in the dialog.

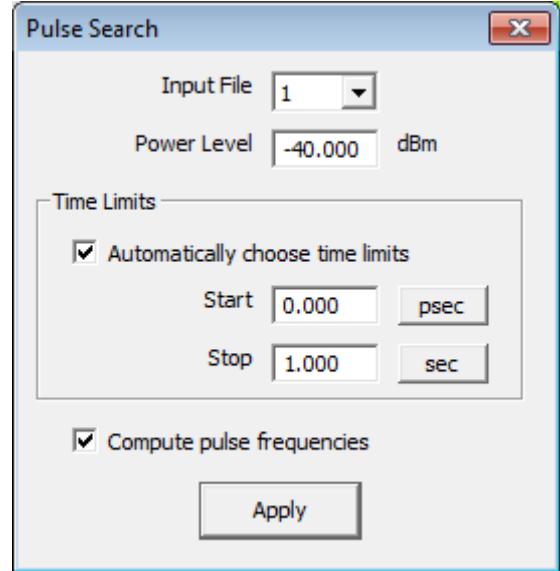
## Pulse Search

Pulse search allows for searches of input data which consists of a series of power pulses.

The “Input File” list at the top is used to control which of the input files the pulse search will be applied to.

A pulse is defined as a transition in power in the time domain from a low level to a higher level. The “Power Level” defines this transition point. It is analogous to a trigger level on an oscilloscope.

The “Time Limits” section allows the entire input file to be searched, or just a section of time from the selected input file.



In some cases it may be desired that the frequency of the pulse be determined. This is true if the instrument acquiring the data was not set at a center frequency equal to the system generating the pulses. Checking the “Compute pulse frequencies” adds a computation of frequency to the pulse search calculations. If unchecked, the pulse frequency is set to 0 in the results.

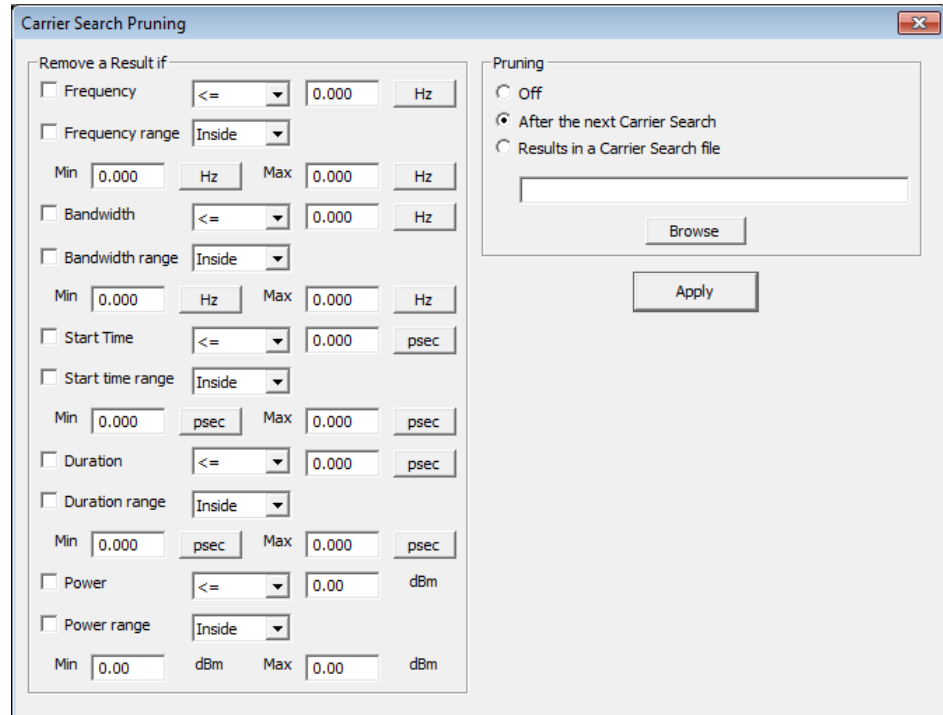
Pressing the “Apply” button accepts the values in the dialog and sets pulse search as the current search type. Closing the window ignores the values in the dialog.



## Carrier Search Pruning

Carrier Search Pruning eliminates results found by a carrier search process. The signals can be removed (pruned) by any of the fundamental results parameters of carrier frequency, bandwidth, start time, duration and carrier power.

The Carrier Search Pruning dialog is accessed using the **“Search | Carrier Search Pruning...”** menu choice.



Pruning can be turned off by selecting the “Off” button. If the “After the next Carrier Search” button is selected, then the pruning will be run after the completion of the next carrier search operation. Pruning can also be applied to carrier search results which have been saved to a file. (The file can be saved in the Search Results dialog.) This allows for multiple prunings to be tried on the same set of results without having to rerun the actual carrier search operation. This can be a significant time savings. The “Browse” button can be used to select an input file.

If the pruning is being applied to a results file, only the pruning will run the next time that the “Search Start” toolbar button is pressed. Thus, pruning a file takes precedence over performing a carrier search.

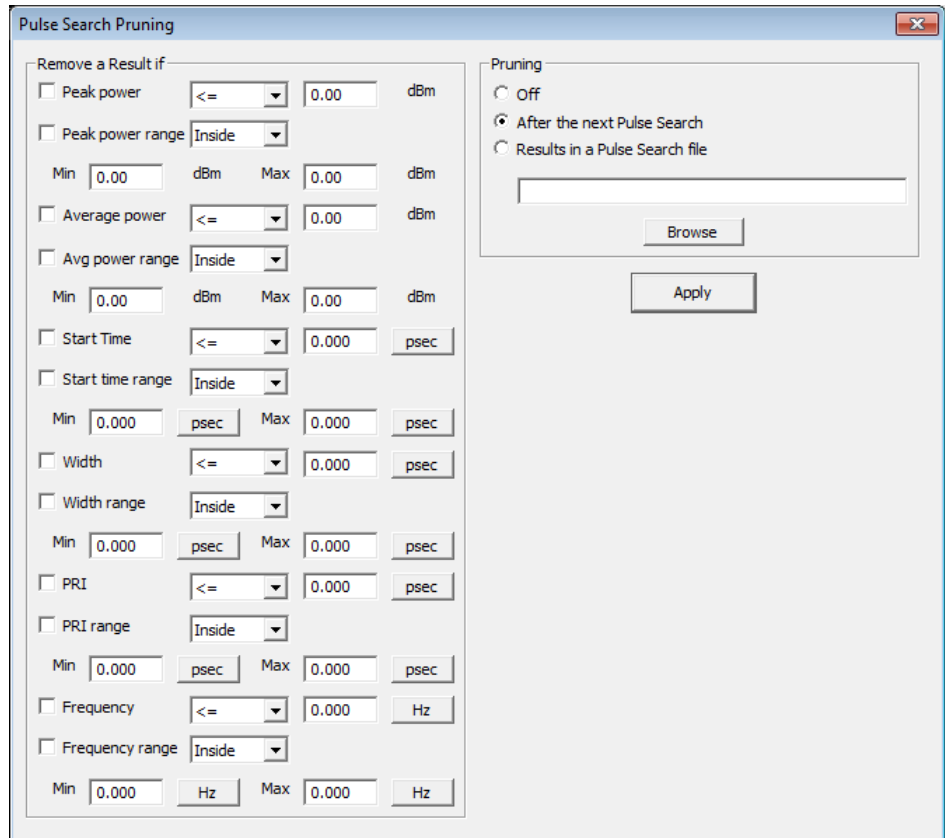
All of the parameters which control pruning define what kind of results to remove from the list of carriers. Each parameter, frequency, bandwidth, start time, duration and power, has two types of controls: a boundary value or range values. The top check box for each type of parameter enables the boundary value. The lower checkbox enables the range values. Both boundaries and ranges can be used together. Remember, what is being entered in the various criteria is a description of what to remove, not what to keep.

Pressing the “Apply” button accepts the values in the dialog. Closing the dialog discards the entered values.

## Pulse Search Pruning

Pulse Search Pruning eliminates results found by a pulse search process. The signals can be removed (pruned) by any of the fundamental results parameters of peak power, average power, start time, pulse width (duration), Pulse Repetition Interval (PRI) and frequency.

The Pulse Search Pruning dialog is accessed using the **“Search | Pulse Search Pruning...”** menu choice.




Pruning can be turned off by selecting the “Off” button. If the “After the next Pulse Search” button is selected, then the pruning will be run after the completion of the next pulse search operation. Pruning can also be applied to pulse search results which have been saved to a file. (The file can be saved in the Pulse Search Results dialog.) This allows for multiple prunings to be tried on the same set of results without having to rerun the actual pulse search operation. This can be a significant time savings. The “Browse” button can be used to select an input file.


If the pruning is being applied to a results file, only the pruning will run the next time that the “Search Start” toolbar button is pressed. Thus, pruning a file takes precedence over performing a pulse search.


All of the parameters which control pruning define what kind of results to remove from the list of carriers. Each parameter, peak power, average power, start time, pulse width, PRI and frequency, has two types of controls: a boundary value or range values. The top check box for each type of parameter enables the boundary value. The lower checkbox enables the range values. Both boundaries and ranges can be used together. Remember, what is being entered in the various criteria is a description of what to remove, not what to keep.

Pressing the “Apply” button accepts the values in the dialog. Closing the dialog discards the entered values.

## Search Control Bar

There are two buttons on the toolbar which control Search. 

The Search Start button  can be used to start a search or pruning operation.

The Search Stop button  can be used to stop a currently running search.

## Search Results

The Search Results window pops up automatically when a search begins. As results are found, they are added to the list.

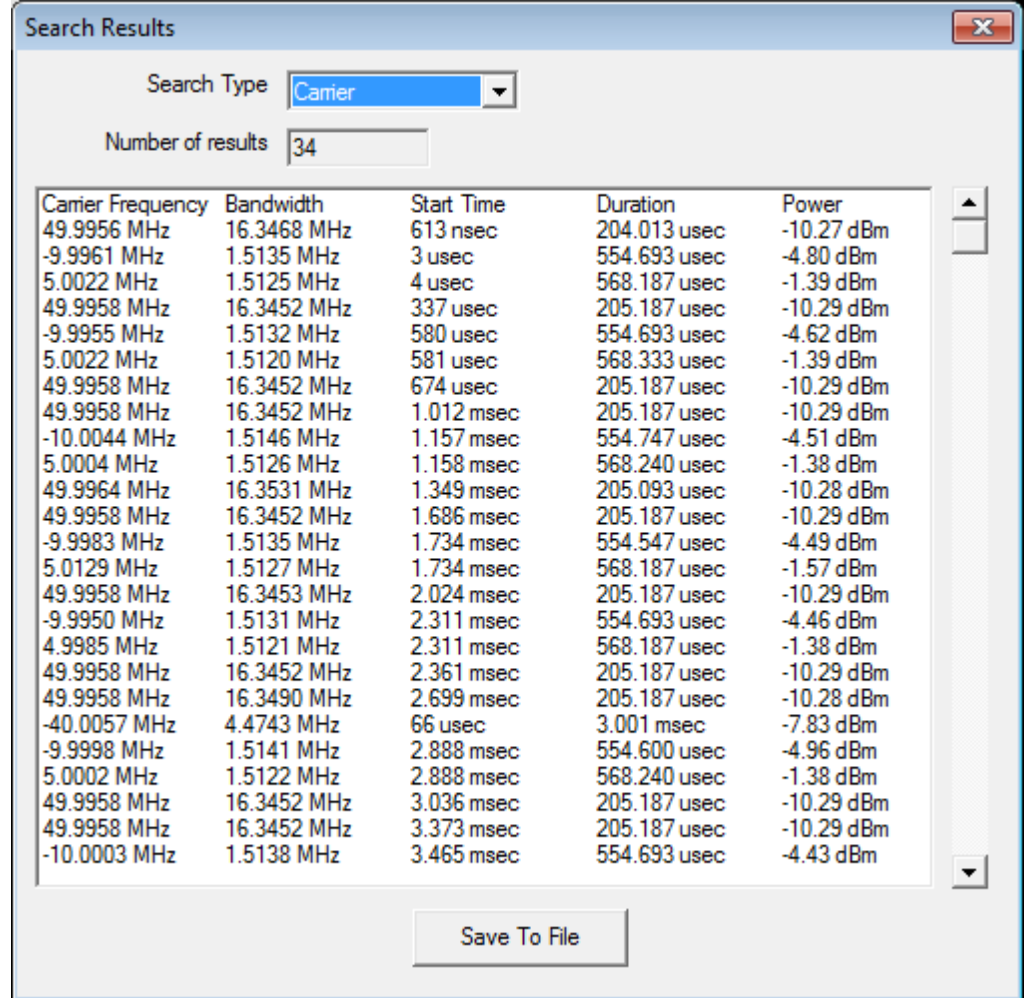
The “Search Type” list can be used to select the type of search results which are being displayed. The number of results is shown in the box.

The vertical scroll bar is enabled when there are more results than can be displayed in the list.

The results displayed in the list are temporary.

If a new search of the same type is started, the current results will be cleared. In order to save the results, use the “Save To File” button, which will bring up a standard Windows file saving dialog. Only the currently displayed results are saved.

Clicking on a result in the list will bring up the View Spectrogram displaying the input data at the start time for that result. Note that the RBW used for carrier searches will be transferred to the View Spectrogram so that the view will be the same as that used by Spectro-X in the carrier search algorithm.



Search Results

Search Type: Carrier

Number of results: 34

Carrier Frequency	Bandwidth	Start Time	Duration	Power
49.9956 MHz	16.3468 MHz	613 nsec	204.013 usec	-10.27 dBm
-9.9961 MHz	1.5135 MHz	3 usec	554.693 usec	-4.80 dBm
5.0022 MHz	1.5125 MHz	4 usec	568.187 usec	-1.39 dBm
49.9958 MHz	16.3452 MHz	337 usec	205.187 usec	-10.29 dBm
-9.9955 MHz	1.5132 MHz	580 usec	554.693 usec	-4.62 dBm
5.0022 MHz	1.5120 MHz	581 usec	568.333 usec	-1.39 dBm
49.9958 MHz	16.3452 MHz	674 usec	205.187 usec	-10.29 dBm
49.9958 MHz	16.3452 MHz	1.012 msec	205.187 usec	-10.29 dBm
-10.0044 MHz	1.5146 MHz	1.157 msec	554.747 usec	-4.51 dBm
5.0004 MHz	1.5126 MHz	1.158 msec	568.240 usec	-1.38 dBm
49.9964 MHz	16.3531 MHz	1.349 msec	205.093 usec	-10.28 dBm
49.9958 MHz	16.3452 MHz	1.686 msec	205.187 usec	-10.29 dBm
-9.9983 MHz	1.5135 MHz	1.734 msec	554.547 usec	-4.49 dBm
5.0129 MHz	1.5127 MHz	1.734 msec	568.187 usec	-1.57 dBm
49.9958 MHz	16.3453 MHz	2.024 msec	205.187 usec	-10.29 dBm
-9.9950 MHz	1.5131 MHz	2.311 msec	554.693 usec	-4.46 dBm
4.9985 MHz	1.5121 MHz	2.311 msec	568.187 usec	-1.38 dBm
49.9958 MHz	16.3452 MHz	2.361 msec	205.187 usec	-10.29 dBm
49.9958 MHz	16.3490 MHz	2.699 msec	205.187 usec	-10.28 dBm
-40.0057 MHz	4.4743 MHz	66 usec	3.001 msec	-7.83 dBm
-9.9998 MHz	1.5141 MHz	2.888 msec	554.600 usec	-4.96 dBm
5.0002 MHz	1.5122 MHz	2.888 msec	568.240 usec	-1.38 dBm
49.9958 MHz	16.3452 MHz	3.036 msec	205.187 usec	-10.29 dBm
49.9958 MHz	16.3452 MHz	3.373 msec	205.187 usec	-10.29 dBm
-10.0003 MHz	1.5138 MHz	3.465 msec	554.693 usec	-4.43 dBm

Save To File

## Pulse Search Results

The Pulse Search Results window pops up automatically when a pulse search begins. As results are found, they are added to the list.

The “Search Type” list can be used to select the type of search results which are being displayed. The number of results is shown in the box.

The vertical scroll bar is enabled when there are more results than can be displayed in the list.

The “Sort” section contains controls that can be used to sort the list above. The particular parameter to which the sorting is being applied must be chosen, as well as whether the results should be put in increasing or decreasing order for that parameter. Press “Sort” to initiate the sort. Press “Undo” to go back to the original results.

The results displayed in the list are temporary. If a new pulse search is started, the current results will be cleared. In order to save the results, use the “Save To File” button, which will bring up a standard Windows file saving dialog. Only the currently displayed results are saved.

Clicking on a result in the list will bring up the View Spectrogram displaying the input data at the start time for that result.

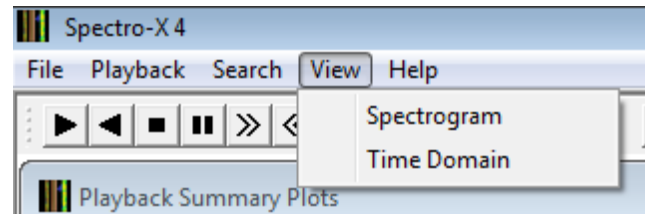
The screenshot shows a window titled "Pulse Search Results". At the top, there is a "Search Type" dropdown menu set to "Pulse" and a "Number of results" text box containing "2852". Below this is a table with the following columns: Peak Power, Avg Power, Start Time, Width, PRI, Rise Time, Fall Time, and Frequency. The table contains 20 rows of data. At the bottom of the window, there is a "Sort" section with a "Parameter" dropdown menu set to "Peak power", radio buttons for "Increasing" (selected) and "Decreasing", and buttons for "Sort", "Undo", and "Save To File".

Peak Power	Avg Power	Start Time	Width	PRI	Rise Time	Fall Time	Frequency
-33.15 dBm	-33.98 dBm	888 usec	1.000 usec	0.0 sec	10.313 nsec	12.396 nsec	-470.3125 kHz
-33.19 dBm	-33.95 dBm	1.088 msec	1000.000 nsec	200.000 usec	17.604 nsec	8.750 nsec	494.965 kHz
-33.07 dBm	-33.83 dBm	1.288 msec	986.667 nsec	200.007 usec	9.271 nsec	9.792 nsec	-7.3902 kHz
-33.21 dBm	-33.88 dBm	1.488 msec	986.667 nsec	200.000 usec	9.896 nsec	8.333 nsec	-4.9268 kHz
-33.13 dBm	-33.94 dBm	1.688 msec	986.667 nsec	200.000 usec	9.792 nsec	6.875 nsec	-5.9825 kHz
-33.23 dBm	-33.93 dBm	1.888 msec	993.333 nsec	200.000 usec	9.375 nsec	9.792 nsec	-412.472 kHz
-32.88 dBm	-33.89 dBm	2.088 msec	986.667 nsec	200.000 usec	9.375 nsec	6.458 nsec	-12.317 kHz
-33.22 dBm	-33.97 dBm	2.288 msec	993.333 nsec	199.993 usec	10.000 nsec	13.958 nsec	13.2830 kHz
-33.19 dBm	-33.88 dBm	2.488 msec	993.333 nsec	200.007 usec	10.625 nsec	8.333 nsec	-286.2836 kHz
-32.87 dBm	-33.89 dBm	2.688 msec	986.667 nsec	200.000 usec	9.583 nsec	10.417 nsec	-2.4634 kHz
-33.86 dBm	-34.71 dBm	3.888 msec	986.667 nsec	1.200 msec	10.000 nsec	10.000 nsec	-31.6723 kHz
-33.97 dBm	-34.69 dBm	4.088 msec	993.333 nsec	200.000 usec	9.167 nsec	12.917 nsec	-459.312 kHz
-33.54 dBm	-34.71 dBm	4.288 msec	986.667 nsec	200.000 usec	10.833 nsec	22.917 nsec	-25.3378 kHz
-33.66 dBm	-34.65 dBm	4.488 msec	993.333 nsec	200.000 usec	9.167 nsec	8.333 nsec	-340.464 kHz
-33.89 dBm	-34.62 dBm	4.688 msec	986.667 nsec	200.000 usec	9.583 nsec	8.750 nsec	12.6689 kHz
-34.09 dBm	-34.73 dBm	4.888 msec	986.667 nsec	200.000 usec	9.583 nsec	10.833 nsec	-3.5191 kHz
-33.86 dBm	-34.68 dBm	5.088 msec	986.667 nsec	200.000 usec	9.167 nsec	20.000 nsec	7.7421 kHz
-33.79 dBm	-34.60 dBm	5.288 msec	986.667 nsec	200.000 usec	9.583 nsec	9.583 nsec	-31.6723 kHz
-33.94 dBm	-34.66 dBm	5.488 msec	986.667 nsec	200.000 usec	10.000 nsec	10.417 nsec	-21.1149 kHz
-33.88 dBm	-34.63 dBm	5.688 msec	986.667 nsec	200.000 usec	9.167 nsec	8.333 nsec	-16.8919 kHz
-34.56 dBm	-35.42 dBm	6.888 msec	986.667 nsec	1.200 msec	10.000 nsec	12.917 nsec	-35.1914 kHz
-34.42 dBm	-35.39 dBm	7.088 msec	986.667 nsec	200.000 usec	9.512 nsec	11.484 nsec	-30.4846 kHz
-34.26 dBm	-35.32 dBm	7.288 msec	986.667 nsec	200.000 usec	9.766 nsec	6.016 nsec	-14.1206 kHz
-34.35 dBm	-35.49 dBm	7.488 msec	986.667 nsec	200.000 usec	9.062 nsec	16.875 nsec	-34.0477 kHz
-34.71 dBm	-35.41 dBm	7.688 msec	986.667 nsec	200.000 usec	9.583 nsec	8.802 nsec	14.8684 kHz

# View Spectrogram and View Time Domain

## View Menu

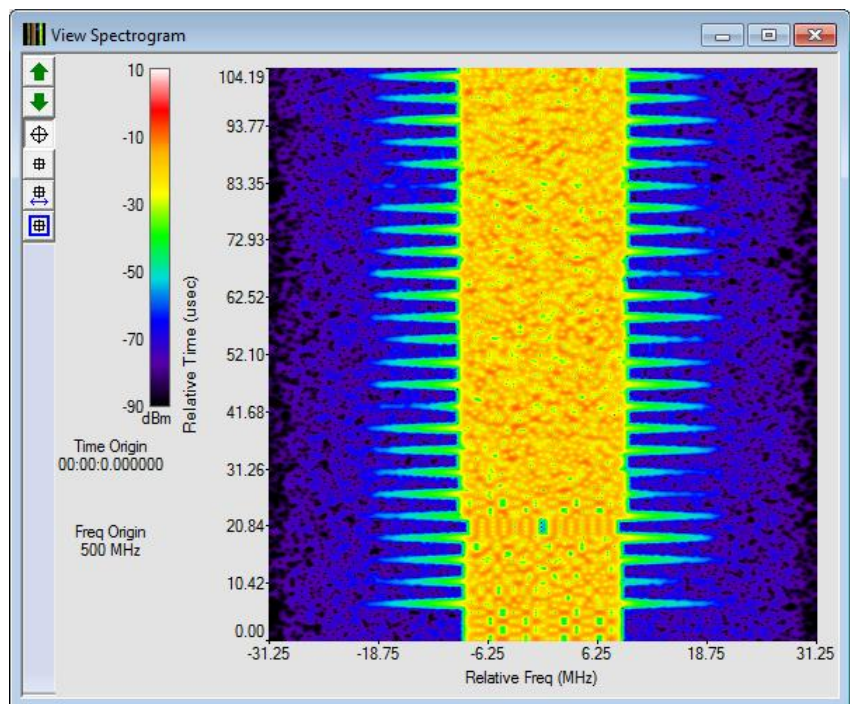
The View Spectrogram and the View Time Domain give static views of a portion of the input data. The plots are particularly useful when a very detailed investigation of signal characteristics is desired. The **“View | Spectrogram”** menu choice makes the View Spectrogram plot visible. The window also becomes visible when a result in the Search Result list is clicked. The **“View | Time Domain”** menu choice makes the View Time Domain plot visible.



## View Spectrogram

The view spectrogram plot can be used to get a close up view of signal behavior. It is very similar to the scrolling spectrogram used for displaying the signal during playback, but it is static (non-scrolling). It can be moved forward and backward in time using buttons on the toolbar.

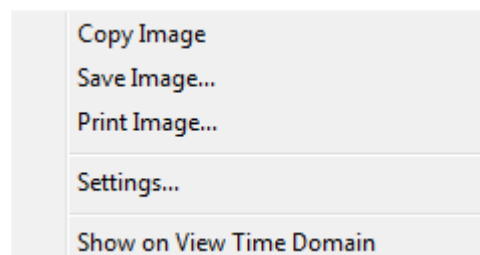
As with the playback plots, the view spectrogram plot has a context menu, a settings dialog and a toolbar.



## View Spectrogram Context Menu

Right-clicking anywhere in the view spectrogram plot brings up a context menu.

**Copy Image** – Copies the image of the plot to the clipboard





**Save Image...** – Saves image as a bitmap, JPEG, GIF, or PNG file

**Print Image...** – Sends the image of the plot directly to a printer

**Settings...** – Brings up a dialog for setting various parameters which control the computation and display of the View Spectrogram

**Show on View Time Domain** – Displays the data on the view time domain plot

## View Spectrogram Settings Dialog

The view spectrogram settings can be adjusted by right clicking on the view spectrogram and choosing “Settings...”

The “Input File” list is used to choose which input file is being displayed.

The “Frequencies” section controls the horizontal scale. The limits can be automatically chosen or manually entered. The frequencies are relative to the center frequency of the data in the file.

Resolution bandwidth adjusts the RBW used to render the image.

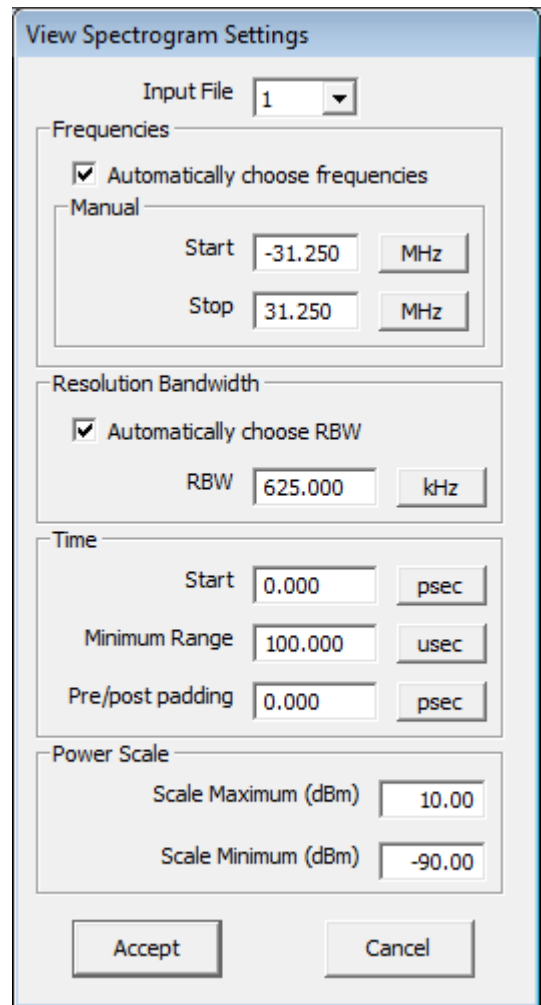
The “Time” section controls the vertical scale. The start time and amount of time (the range) can be set. Due to the finite sample rate of the data, the amount of time that can be displayed in the vertical size of the plot, is not completely flexible. Thus, the time range is the minimum amount of time that will be displayed. The “Pre/post padding” is an amount of time that is added before and after the data in order to give a view of the context of the signal which is being displayed. This value can be zero.

The “Power Scale” section adjusts the range which the color scale spans in terms of power.







The “Accept” button accepts the settings in the dialog. Pressing “Cancel” disregards the changes in the dialog and closes it.

## View Spectrogram Toolbar

Along the left edge of the window is a toolbar with various tools which can be applied to the view spectrogram plot. These tools determine what action will be taken when a mouse click or a click and drag operation occurs in a plot.



### View Spectrogram Toolbar buttons

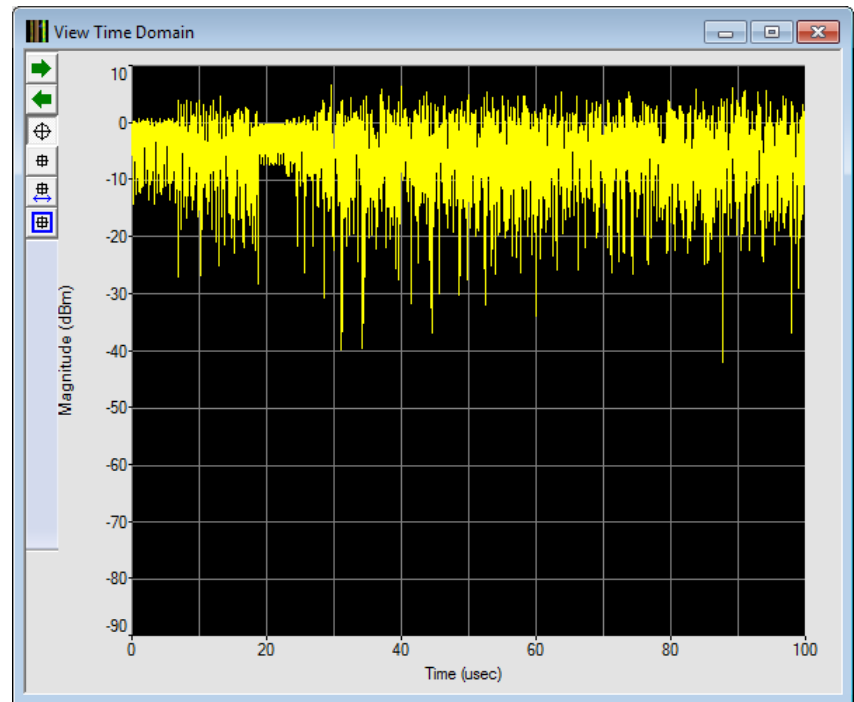
Button Name	Image	Function
Move Forward in Time		Moves the start time forward by the time range and displays the plot
Move Backward in Time		Moves the start time backward by the time range and displays the plot
Value Tool		Displays the location and data value of a mouse click in the plot
Place a Marker		Allows placement of a marker with a mouse click
Move an Existing Marker		Moves the location of a marker
Marker Properties		A mouse click on a marker brings up the Marker Properties dialog



## View Time Domain

The view time domain plot can also be used to get a close up view of signal behavior. It can be moved forward and backward in time using buttons on the toolbar.

As with the view spectrogram plot, the view time domain plot has a context menu, a settings dialog and a toolbar.



## View Time Domain Context Menu

Right-clicking anywhere in the view time domain plot brings up a context menu.

**Copy Image** – Copies the image of the plot to the clipboard

**Save Image...** – Saves image as a bitmap, JPEG, GIF, or PNG file

**Print Image...** – Sends the image of the plot directly to a printer

**Log Mag vs Time** – Displays the data in log magnitude format (dBm)

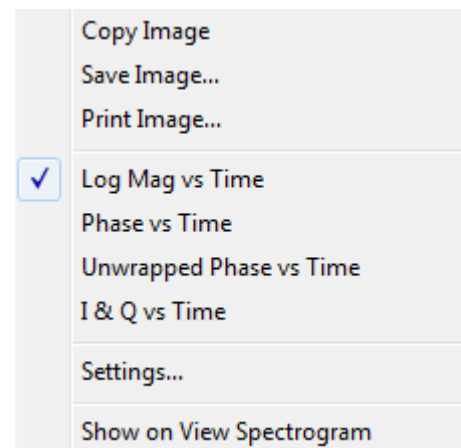
**Phase vs Time** – Displays the data in phase format

**Unwrapped Phase vs Time** – Displays the data in phase format with the phase wraps eliminated

**I & Q vs Time** – Displays the data as two traces: I vs time and Q vs time

**Settings...** – Brings up a dialog for setting various parameters which control the computation and display of the view time domain plot

**Show on View Spectrogram** – Displays the data on the view spectrogram plot



## View Time Domain Settings Dialog

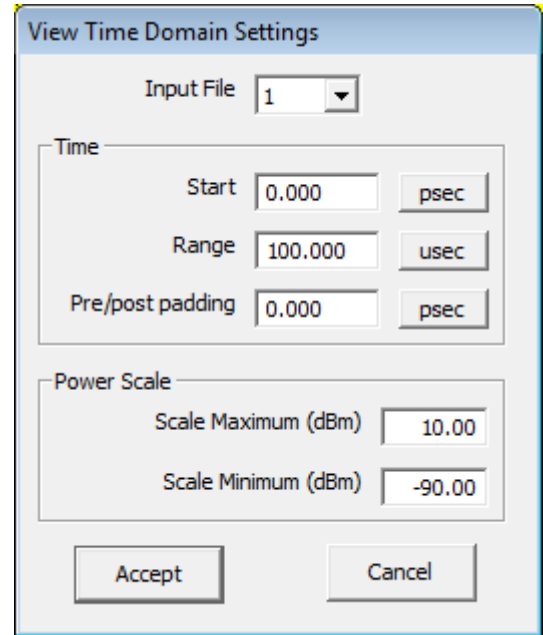
The view time domain settings can be adjusted by right clicking on the plot and choosing “Settings...”

The “Input File” list is used to choose which input file is being displayed.

The “Time” section controls the horizontal scale. The start time and amount of time (the range) can be set. The “Pre/post padding” is an amount of time that is added before and after the data in order to give a view of the context of the signal which is being displayed. This value can be zero.

The “Power Scale” section adjusts the range which the color scale spans in terms of power.

The “Accept” button accepts the settings in the dialog. Pressing “Cancel” disregards the changes in the dialog and closes it.



## View Time Domain Toolbar

Along the left edge of the window is a toolbar with various tools which can be applied to the view time domain plot. These tools determine what action will be taken when a mouse click or a click and drag operation occurs in a plot.

View Time Domain Toolbar buttons

Button Name	Image	Function
Move Forward in Time		Moves the start time forward by the time range and displays the plot
Move Backward in Time		Moves the start time backward by the time range and displays the plot
Value Tool		Displays the location of a mouse click in the plot
Place a Marker		Allows placement of a marker with a mouse click
Move an Existing Marker		Moves the location of a marker
Marker Properties		A mouse click on a marker brings up the Marker Properties dialog

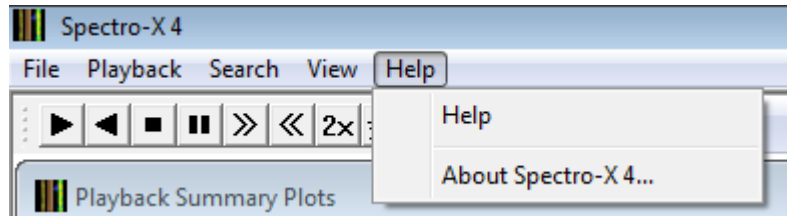
# Help

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## Help Menu

The Help menu has two items.

“**Help | Help**” can be used to display this document describing Spectro-X 4.



“**Help | About Spectro-X 4...**” displays a dialog box which shows the current version of the software which is running.



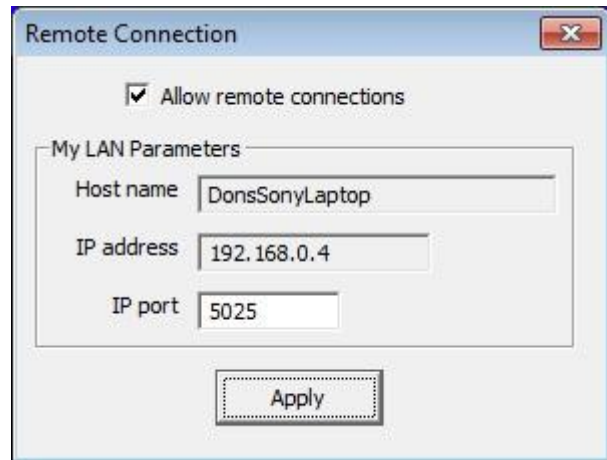
# Remote Connections

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The remote connection dialog is available using the **“File | Remote Connection...”** menu choice. This dialog is used to allow remote connections to control Spectro-X.

To allow remote connections, check the **“Allow remote connections”** check box.

The **“Host name”** and **“IP address”** boxes are merely informational. They contain information that the remote client will use to connect to this instance of Spectro-X. The **“IP port”** number text box defaults to 5025, which the SCPI over LAN IP port number assigned for this type of interaction. However, that port number can be changed if a firewall is not allowing access on this IP port number.



Press **“Apply”** to use the selections, or just close the dialog to cancel.

Telnet is not the preferred means for controlling Spectro-X remotely, but it works fairly well. (Telnet is not usually enabled on Windows computers, so you need to do it using the control panel for Programs and Features. Click on the **“Turn Windows features on or off”** to get to a list of features. Make sure that the **“Telnet Client”** box is checked.) At a command line prompt type **“telnet”** to get into telnet. Type **“open localhost 5025”** to connect to Spectro-X. If you are on a remote computer, use the host name or IP address for the Spectro-X computer.

Type **“help;”** to get a list of commands. Type **“Remote:Close;”** to terminate the remote session. Note that this is not a terminal server, so if you make a typing error, backspacing will not delete the mis-typing. You are better off just typing **‘;** to terminate the command and re-typing the command.

All commands must be terminated with either a **‘;** or a newline character (**‘\n’**). Commands are not case sensitive.

Here is the current list of commands:

Command	Action
<b>Remote:Close;</b>	Close connection
<b>Playback:File = &lt;file name&gt;;</b>	Set input file name
<b>Playback:Play;</b>	Start playback
<b>Playback:Stop;</b>	Stop playback
<b>Playback:Pause;</b>	Pause playback
<b>Playback:Resume;</b>	Resume playback after pause
<b>Playback:Double;</b>	Double the time step increment
<b>Playback:Half;</b>	Halve the time step increment
<b>Playback:Start time = &lt;start time in seconds&gt;;</b>	Set start time
<b>Playback:Stop time = &lt;stop time in seconds&gt;;</b>	Set stop time
<b>System:Save file = &lt;file name&gt;;</b>	Save settings to a file
<b>System:Recall file = &lt;file name&gt;;</b>	Recall settings from a file
<b>Search:Start;</b>	Start the current search
<b>Search:Stop;</b>	Stop the current search

<b>Search:Done?;</b>	Is search done query Response: 1 = yes, 0 = no
<b>SearchResult:Carrier:Save file = &lt;file name&gt;;</b>	Save carrier search results to a file
<b>SearchResult:Waveform:Save file = &lt;file name&gt;;</b>	Save waveform search results to a file
<b>SearchResult:Standard:Save file = &lt;file name&gt;;</b>	Save standard search results to a file
<b>SearchResult:Pruning:Save file = &lt;file name&gt;;</b>	Save pruned carrier search results to a file

# Appendices

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## Appendix A Agilent Matlab File Format

The data exported from Spectro-X in Agilent Matlab format is compatible with the 89600 VSA software. The variable sizes and names were chosen for compatibility with that product. The table below gives the variables created when a file is opened in Matlab.

Variable Name	Matrix Size	Data Type	Description
XDelta	1x1	double	1 / sample rate
Y	Nx1	single complex	Real part = I, Imag part = Q N is the number of input points

## Appendix B Matlab File Format

The data exported from Spectro-X in Matlab format is designed to make it easy to import the data and apply custom post-processing. The table below gives the variables created when a file is opened in Matlab.

Variable Name	Matrix Size	Data Type	Description
SampleRate	1x1	double	Sample rate in samples/sec
NumSamples	1x1	double	The number of samples
IQData	NumSamplesx1	single complex	Real part = I, Imag part = Q