

Pro Audio White Space Finder

Introduction

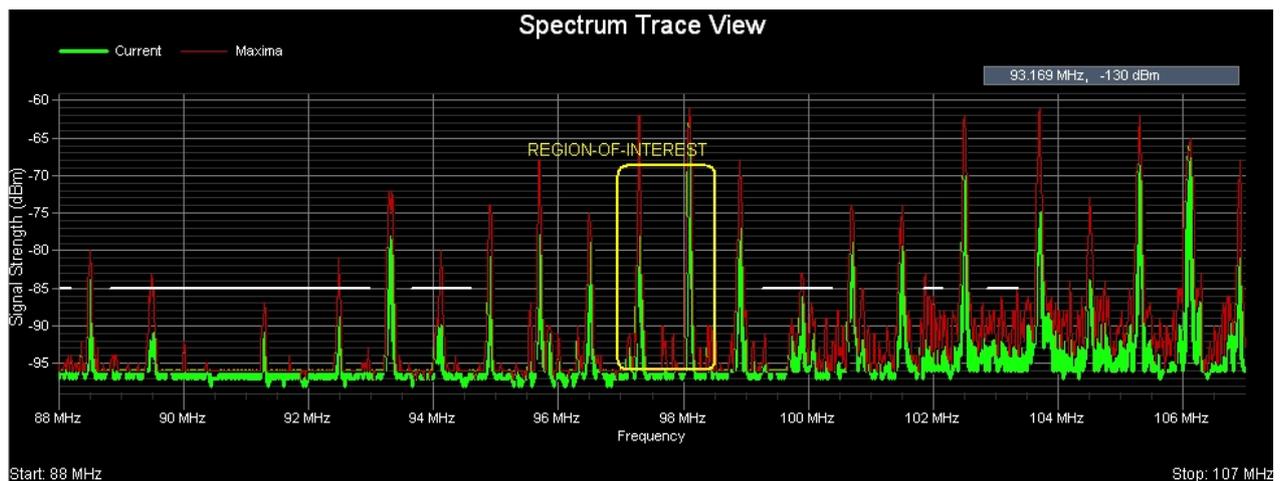
Welcome to **Pro Audio White Space Finder** (PAWS4400) -- a new, PC-based RF spectrum analyzer specifically designed for the professional wireless audio and video industries. The new analyzer is the industry's first, PC-based RF spectrum analyzer to offer spectrum analysis, intermodulation analysis and automatic charting of open white space (open RF frequency) for use with wireless microphones, in-ear monitors, remote control, security, access control, etc -- all built into a single tool. The unique features extend beyond the bounds of traditional RF analyzers. Though **Pro Audio White Space Finder** is well suited for wireless professional audio production and AV integration, it is also the perfect tool for general commercial and industrial RF work. It supports frequency ranges 500 KHz through 4400 MHz. Below are a few of **Pro Audio White Space Finder's** more unique features and functions:

- [Intermodulation Analysis](#)
- [White Space & Intermod-Compatible Frequencies](#)
- [Monitored Frequencies](#)
- [Region-Of-Interest \(ROI\) Trace View](#)
- 3-Dimensional [Waterfall History](#) View
- [Topographic Trace](#) View
- [Delta Trace View](#)
- Easy-to-use [Control Panel](#) for settings adjustments
- Highly sensitive and stable [Signal Hound](#)™ RF spectrum analyzer receiver

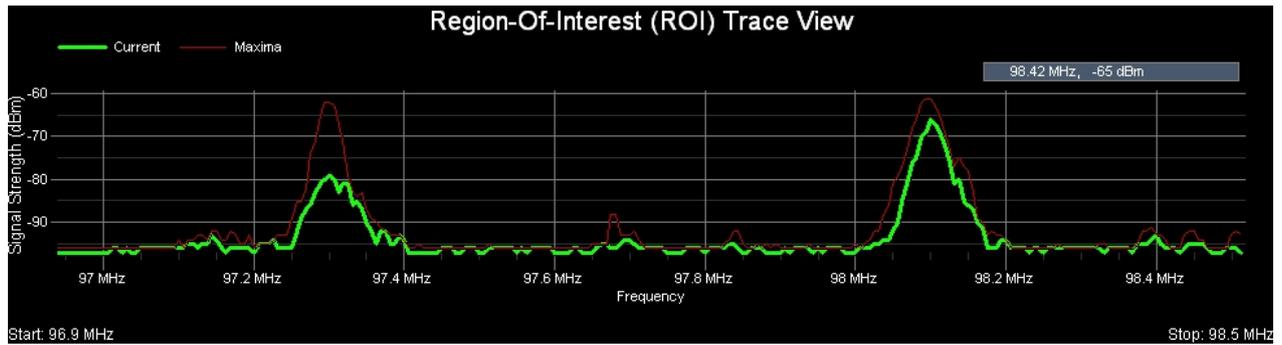
Main View



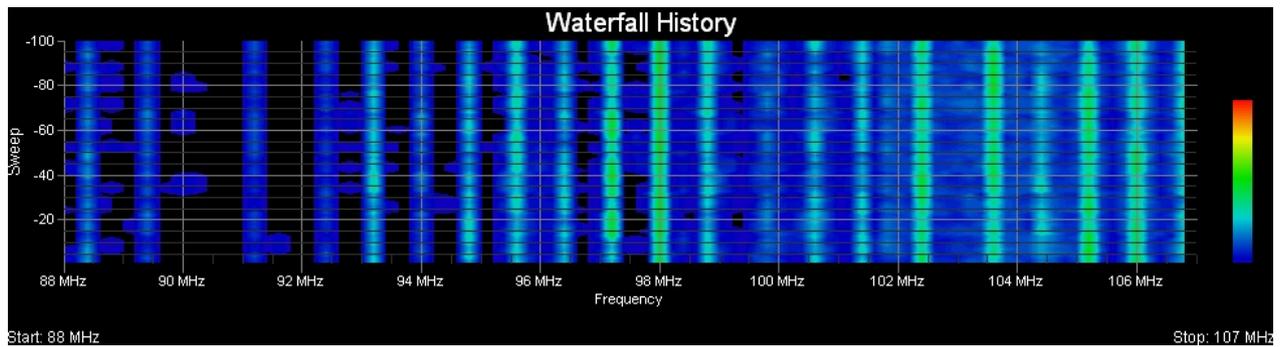
Spectrum Trace View



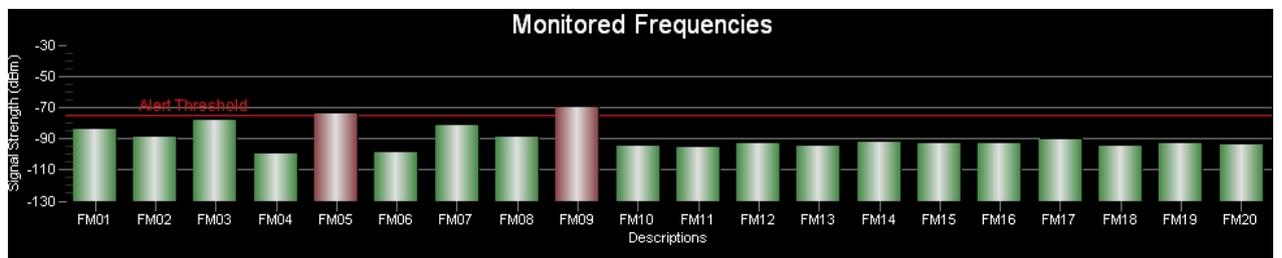
Region-Of-Interest Trace View



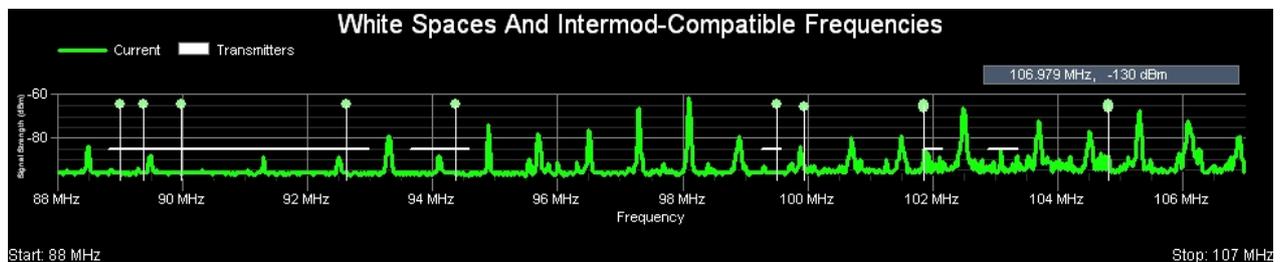
Waterfall History View



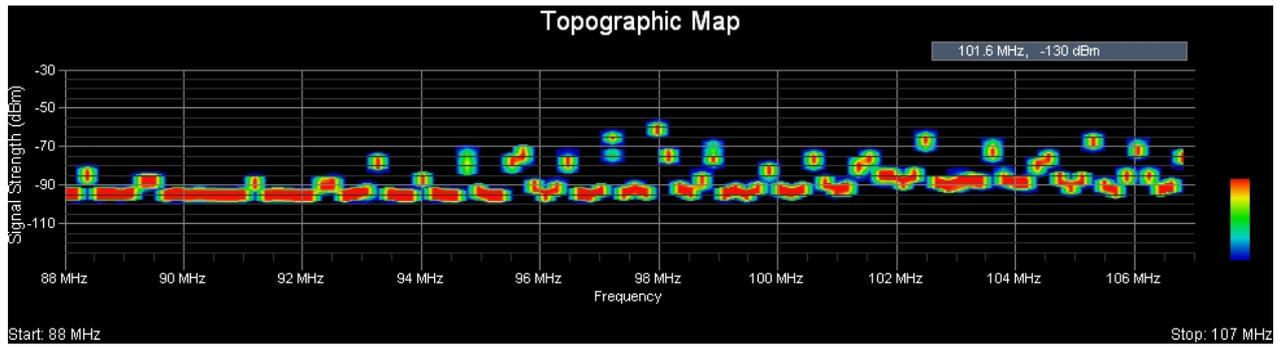
Monitored Frequencies



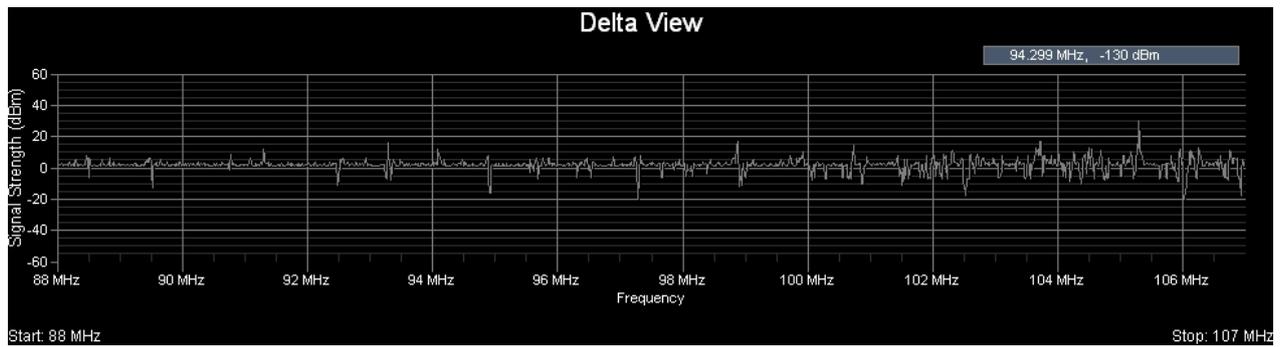
White Spaces and Intermod-Compatible Frequencies



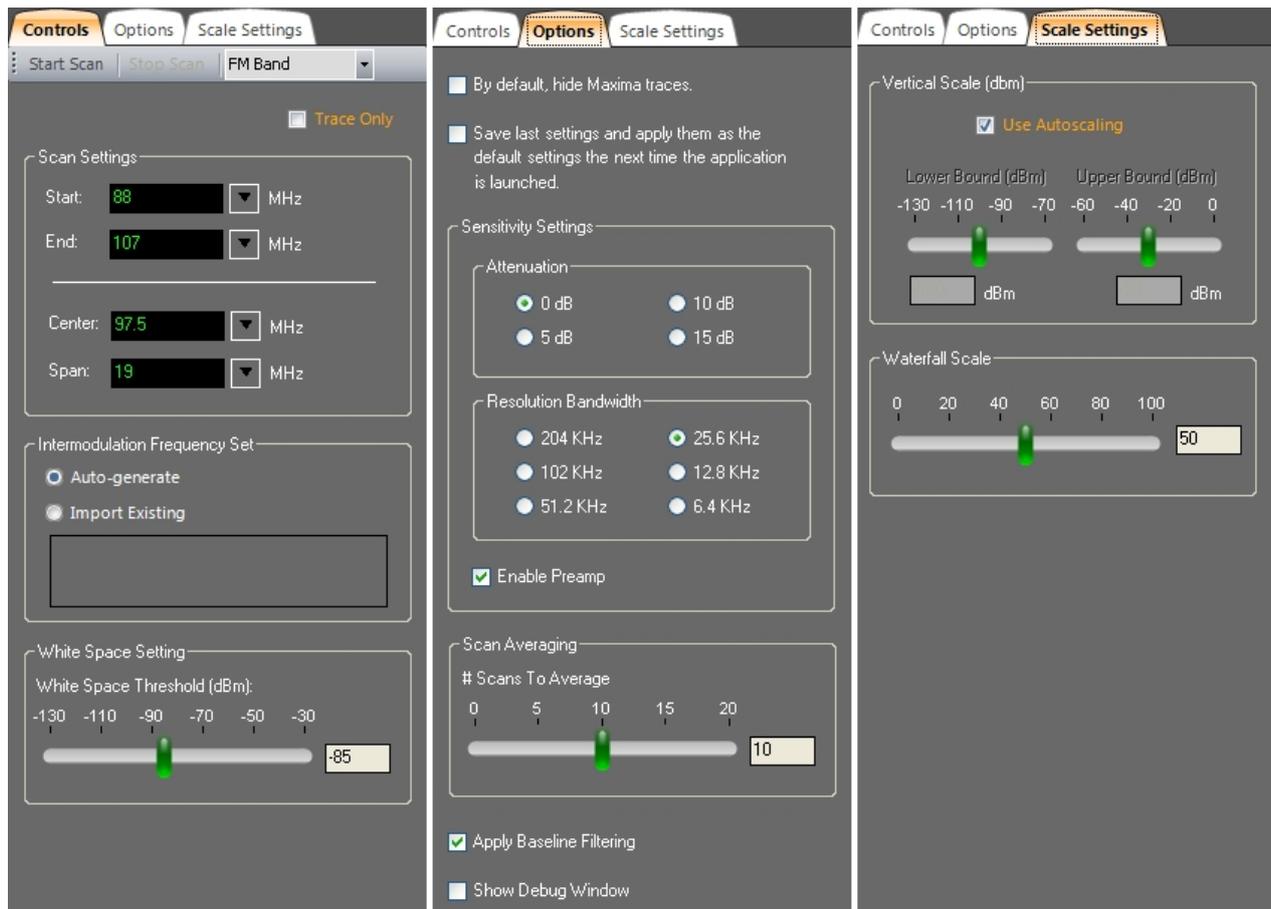
Topographic Map



Delta Trace View



Control Panel



Signal Hound™ is a trademark of Test Equipment Plus.

Installation

Suggested System and Hardware Requirements:

- PC running Windows XP Professional (SP3), Windows Vista, Windows 7 (32- or 64-bit)
- Microsoft .NET Framework version 3.5 (or later)
- An available USB port for interfacing with the Signal Hound™ RF spectrum analyzer
- CPU: Intel Pentium 4, 1.2 GHz or faster
- Memory: 2048 MB or greater
- Hard Drive: 1000 MB free space or greater
- Video: 32 MB video RAM
- Display resolution: 1280x1024 or greater

Installing and Launching the Pro Audio White Space Finder Application

1) Before beginning the installation it will be necessary to download the latest version of **Pro Audio White Space Finder** from our website -- <http://rationalwaves.com/wireless-diagnostic-tools/downloads/>.

2) You will need administrative privileges in order to install the application software on your computer. Please login to an account on your computer that includes 'Administrator' rights before proceeding with the installation.

3) Run the **Pro Audio White Space Finder** setup program and follow the prompts for installing the application. Be sure to review the License Agreement as you progress through the installation procedure. When the Setup Wizard has completed then click the 'Finish' button. By default the application is installed under in the folder '\Program Files \RationalWaves\WhiteSpaceFinder and a desktop icon is created (labeled 'White Space Finder').

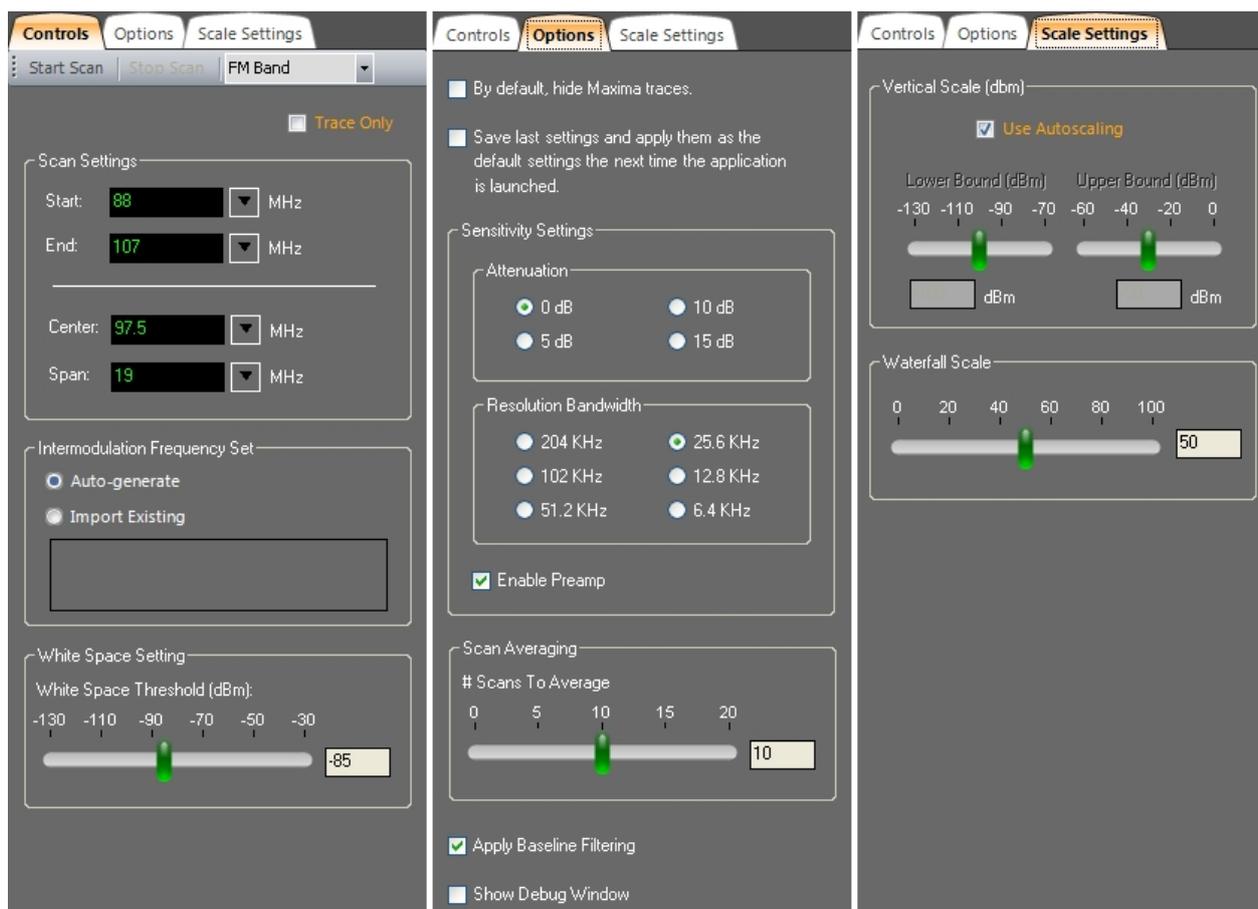


4) Attach the Signal Hound spectrum analyzer to your PC using the USB-to-PC connection cable that shipped with the product.

5) The first time the application is launched you will be prompted to register the application. If you have not yet purchased a Registration Code or if you do not have a Signal Hound RF spectrum analyzer then you can still run the application in 'Demo Mode'. In 'Demo Mode' the application is fully functional but uses simulated data. If you do have a Registration Code then you can enter it at this time by selecting 'Enter Registration Code'. The Registration Code is 20 hexadecimal digits -- i.e. 5 groups of 4 hexadecimal digits separated by hyphens (e.g. 4254-6B62-544A-4835-3339). When you enter the Registration Code it is not necessary to include the hyphens.



Control Panel



When the application first launches, the main charting window appears along with the Control Panel. The Control Panel includes important settings and is used to configure the software and spectrum analyzer. The settings include:

- Start / Stop Scan

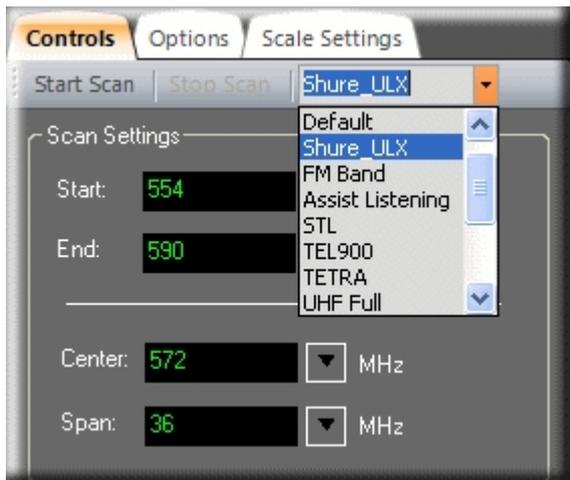
- Built-in Profiles
- 'Trace Only' mode
- Scan Settings
- Default Frequency Set
- Sensitivity Settings
- Scan Averaging
- Scale Settings

Start / Stop Scan



Pro Audio White Space Finder employs a wide-band RF spectrum analyzer that scans the frequency range specified by the user. Scanning is controlled by the 'Start Scan' and 'Stop Scan' buttons. Scanning repeats continuously until the 'Stop Scan' button is pressed. The frequency range that is scanned is defined by the 'Start' and 'End' frequency settings (see below).

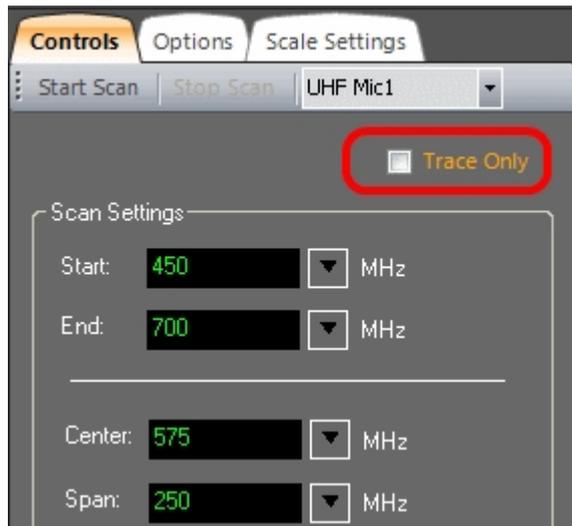
Built-in Profiles



The **Pro Audio White Space Finder** application comes pre-configured with 'Built-in Profiles'. These profiles control many important parameters, including the following: Start and End frequencies, Region-Of-Interest (ROI), sensitivity, scaling, and the [Monitored Frequencies](#) settings. The application also supports [User-defined Profiles](#). When you select one of the built-in profiles from this drop-down list then those settings are immediately applied throughout the application and will be in effect the next time the 'Start Scan' button is pressed. In general, the built-in profiles use default settings and differ only in their Start and End frequencies.

As a side note, the built-in profiles can not be accessed while the analyzer is actively scanning. That is, if the analyzer is scanning and you wish to use a built-in profile then it is necessary to first press the 'Stop Scan' button.

Trace Only (mode)



On those occasions when you only wish to capture spectrum traces and are not interested in performing intermodulation analysis, then you can save time by selecting the 'Trace Only' checkbox. When 'Trace Only' mode is selected then the Spectrum Trace view expands to full screen and the other diagnostic charts are not available. Also, Intermodulation Analysis is not available during 'Trace Only' mode.

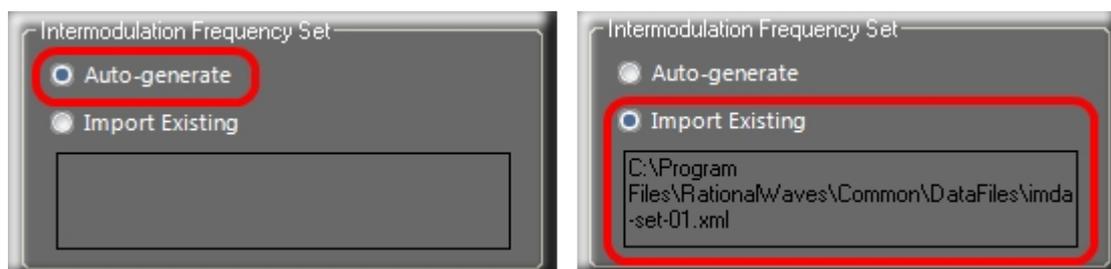
Scan Settings



The most important parameters are the Start and End frequencies, which are set here. The Start and End frequencies can be set explicitly or implicitly, if you prefer, by setting the Center frequency and the Span. They are always specified in units of megahertz (MHz). Supported frequencies are 500 KHz through 4400 MHz.

As a side note, the scan settings can not be accessed while the analyzer is actively scanning. That is, if the analyzer is scanning and you wish to change the frequency range then it is necessary to first press the 'Stop Scan' button.

Intermodulation Frequency Set



Intermodulation interference is rarely desirable in wireless communication systems -- particularly in radio or audio processing. Furthermore, it is not something that is readily measurable and avoidable (e.g. using an RF spectrum analyzer). However, the physical basis for IMD is well understood and the mathematical formulas used to describe it are relatively simple -- so, computational methods can be applied to generate frequency sets that are free of intermodulation interference and which mitigate its effect. If you are interested in learning more details about intermodulation distortion there are many articles and references available on the Internet. For a good explanation we refer you to the following article: [Intermodulation Performance and Measurement of Intermodulation Components](#).

A 'Frequency Set' is a set of computed frequencies that are related in a very important way -- they are intermodulation-compatible. That is, their intermodulation products do not interfere with the frequencies in the set. **Pro Audio White Space Finder** provides two ways for you to introduce a Frequency Set that will be applied for real-time intermodulation analysis -- 'Auto-generate' and 'Import Existing'.

Auto-generate: When the 'Start Scan' button is pressed then the application will compute a frequency set for the specified frequency range that tests for two-transmitter, 3rd-order intermodulation products (2Tx3rds). This takes only a few seconds and is performed prior to the first scan. With each scan the '[Whitespaces And Intermod-Compatible Frequencies](#)' chart is updated. Taking into account both white space regions and the computed frequency set, the chart displays those channels that are both free of RF interference and intermodulation distortion. These are the channels you would then assign to your wireless transmitters.

Import Existing: If you have previously created a frequency set using **Pro Audio White Space Finder** or **Intermod Assist** and saved it in an XML-formated file, then you can import that file. In this case, the application takes into account the white space regions and the imported frequency set when computing the best channels. Again, with each scan, the '[Whitespaces And Intermod-Compatible Frequencies](#)' chart is updated and displays those channels that are both free of RF interference and intermodulation distortion.

White Space Setting



The 'White Space Threshold' slider controls the threshold signal strength (in dBm) below which is considered 'White Space'. When you adjust this control you'll also see the horizontal, white line in the Spectrum Trace view move up and down accordingly. Along those frequency spans where the white line is solid and not interrupted by a peak, then this would be considered a White Space region. It is completely up to the user as to what is an appropriate threshold for this control -- it depends greatly on the environment you are working in and what level of signal transmissions you feel can be safely ignored. Those frequencies whose signal strength amplitudes exceed the threshold are considered off-limits and are locked-out -- that is, they will not be considered as candidates for a frequency set.

The results from determining the White Space regions are used for locating open frequency space in crowded RF environments and applied to computing the best frequencies and spacing for setting-up multiple transmitters -- as shown in the '[Whitespaces And Intermod-Compatible Frequencies](#)' view. This is most helpful when frequency coordination and RF interference are factors that need to be taken into consideration when selecting which frequencies or channels to assign to wireless transmitters.

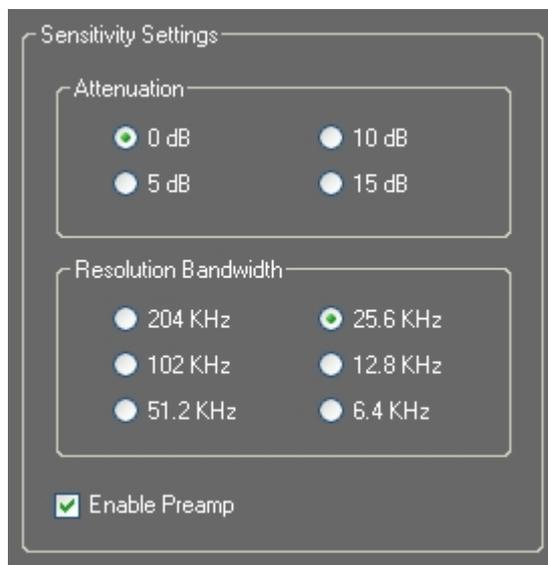
By default, hide Maxima traces

Selecting this CheckBox causes the Maxima traces to be hidden by default in the Spectrum and Region-Of-Interest (ROI) Trace views. The Maxima traces can be re-enabled from the popup menu that is accessed by right-clicking on either the Spectrum or ROI Trace views.

Save last settings and apply them as the default settings the next time the application is launched

When this CheckBox is selected then the next time the application is launched it will remember your last settings and apply them to the new session.

Sensitivity Settings



We recommend you leave the sensitivity settings at their default values: 0 dBm Attenuation, Resolution Bandwidth of 25.6 KHz and Preamp enabled.

Attenuation:

The internal electronic attenuator may be set to 0, 5, 10 or 15 dB. A Local Oscillator signal may be observed at the RF input port, often found 10.7 MHz above the RF frequency being scanned. Typically, this level will not interfere with your measurements. If you are connecting to an antenna and suspect LO feedthrough is a problem, then this can be mitigated by setting the attenuator to 15 dB. This will typically reduce your LO leakage to less than 2 nanowatts for all frequencies below 1 GHz -- but at the expense of sensitivity.

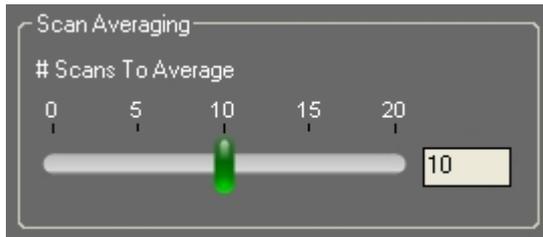
Resolution Bandwidth:

Resolution Bandwidth (RBW) controls the frequency resolution of the frequency axis -- that is, the smallest distance that can be resolved between two adjacent peaks. In FFT-based analyzers (such as the Signal Hound spectrum analyzer) the FFT and its associated windowing parameters determine the frequency resolution or resolution bandwidth. As you lower the RBW to improve frequency resolution the sweep time increases because the FFT spectrum analyzer is performing a longer data acquisition and larger FFT calculation.

Preamp:

A preamplifier was designed into the Signal Hound spectrum analyzer to reduce the displayed average noise level.

Scan Averaging

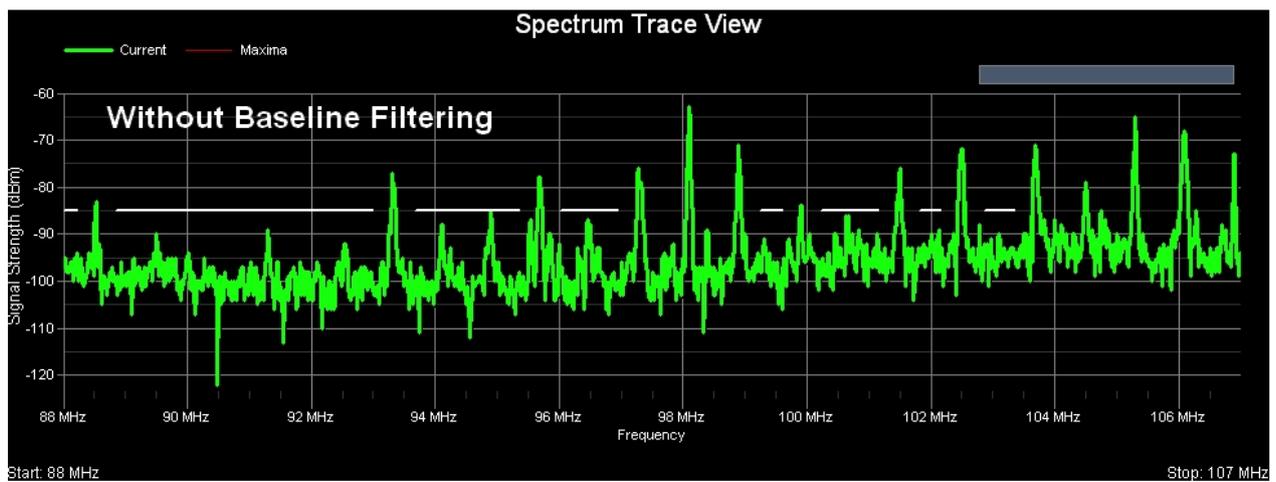
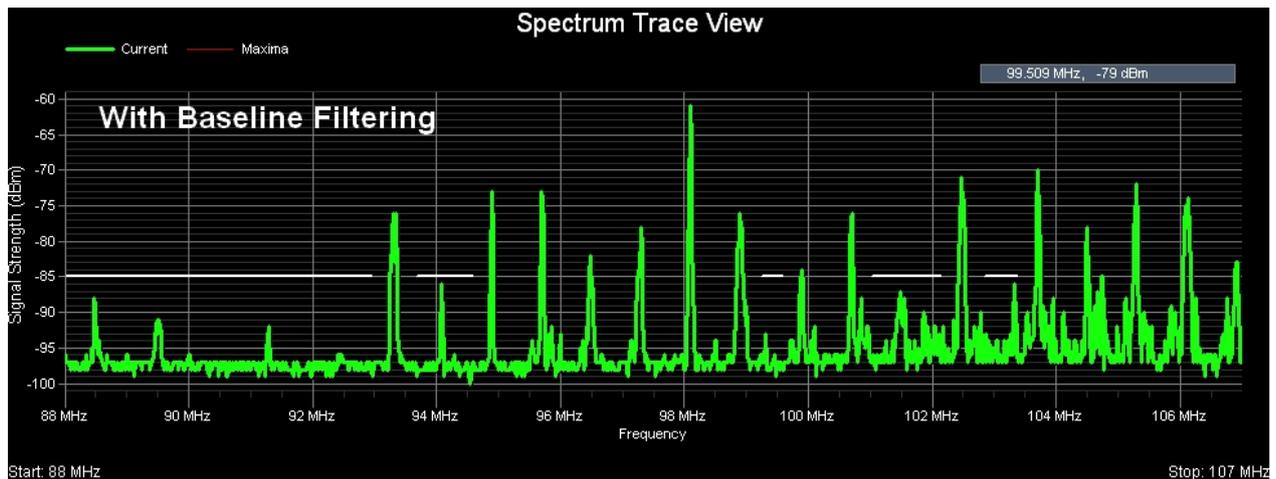


Scan averaging (also referred to as video averaging) accumulates and averages scans over time. RF signals can fluctuate quite a bit from one scan to another, and scan averaging helps to eliminate some of the noise and enhance the pattern of the true signals. One downside to using scan averaging is that in an unstable RF environment where signals are spontaneously appearing or disappearing, then these changes could be slow to appear in the diagnostic views. To disable scan averaging, set the number of scans to average to '0'.

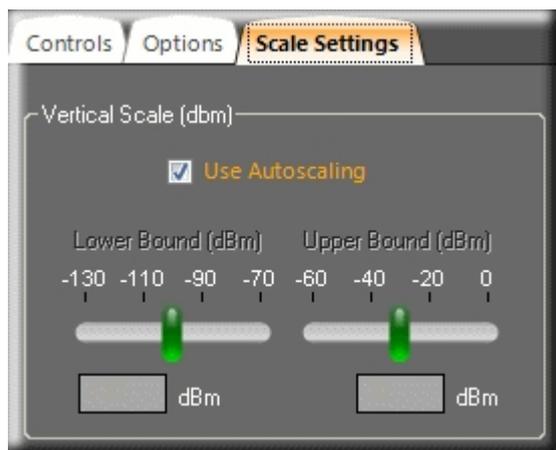
Baseline Filter

Apply Baseline Filtering

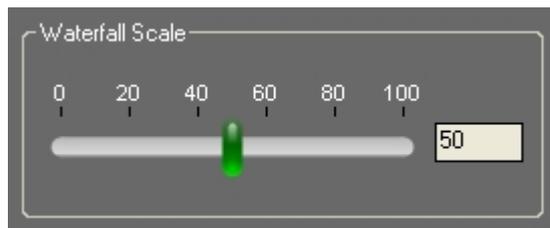
The raw data acquired during a spectrum scan can be very "spikey" -- making it difficult to identify a baseline for the spectrum trace. By default a baseline filtering algorithm (implemented in software) is applied to the raw data. Below are examples of traces with and without baseline filtering enabled.



Scale Settings

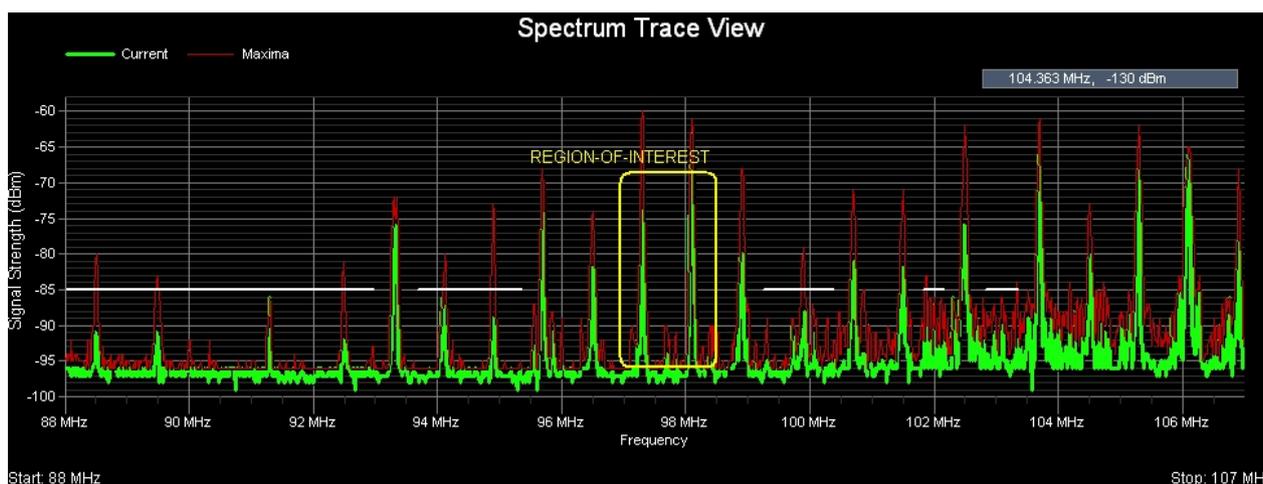


Two types of scaling can be applied to spectrum traces -- autoscaling (the default) and manual scaling. When autoscaling is selected then manual scaling is disabled. When manual scaling is used, the slider controls the lower and upper boundaries (in dBm) of the Spectrum, ROI, Topographic and White Spaces views. The auto and manual scaling controls can be used to "zoom" the trace views and enhance their clarity. This has no effect on data acquisition or intermodulation analysis -- only on how the data is displayed.



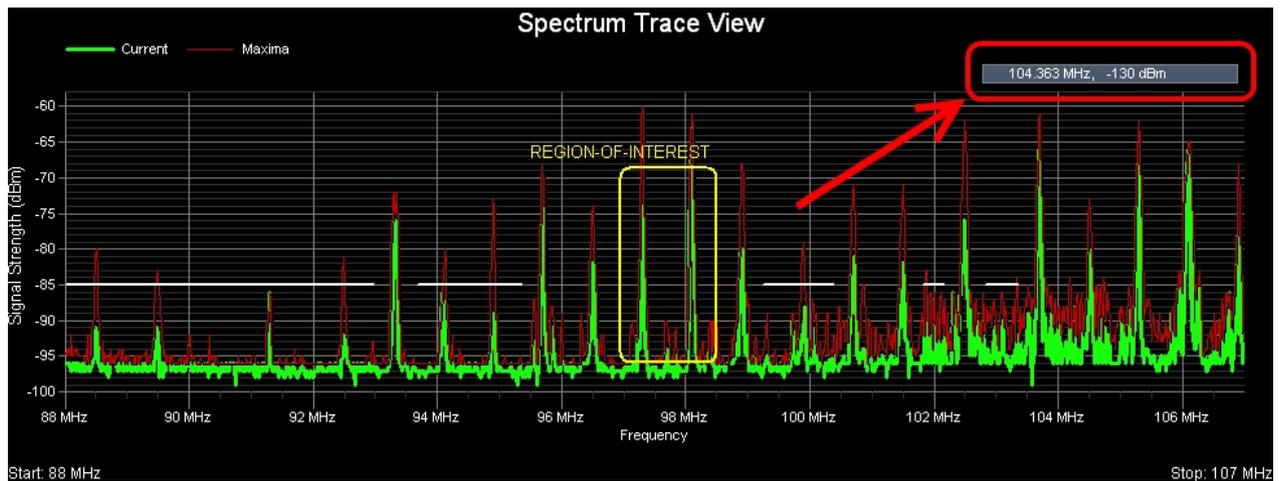
The 'Waterfall Scale' slider control applies only to the 'Waterfall History' view. This control can be used to rescale and remap the signal strengths to better spread them across the range of colors that are used (see legend to the right of the Waterfall History view). This is useful when all the signal strengths are large and the Waterfall view appears mostly red or when all the signal strengths are low and the Waterfall view appears mostly blue. For the best visual effect, ideally you'd like the peaks (strong signals) to appear red and the valleys (weak signals) to appear blue. But sometimes even the valleys have large signal strength values or the peaks have low signal strength values. This control is useful in remapping the color legend to better make use of the colors and how they are spread across the peaks and valleys of the signal strength values.

Spectrum Trace View

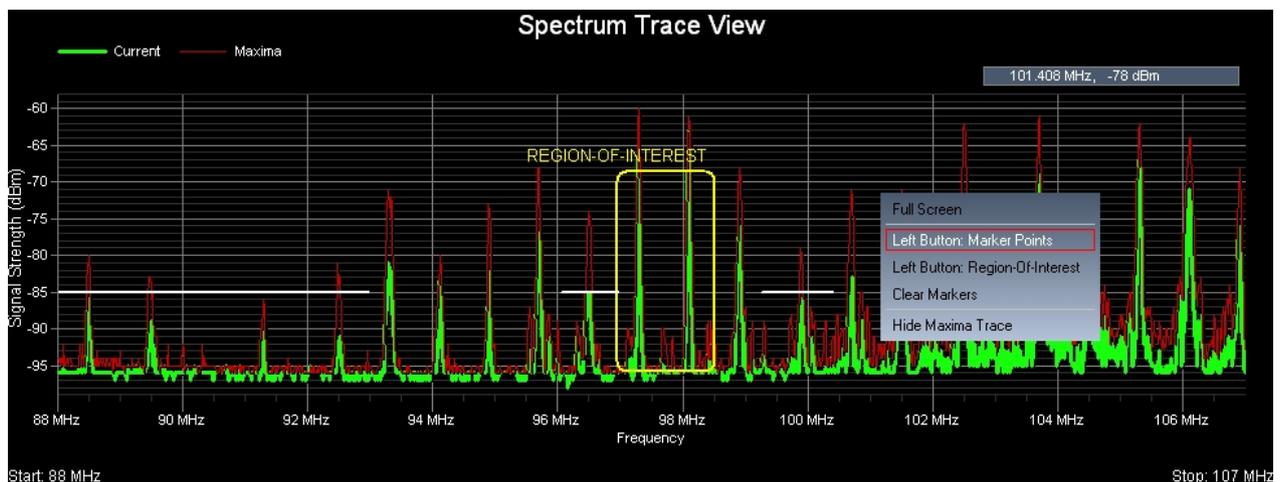


Pro Audio White Space Finder continuously scans and samples the signal strength (dBm) of frequencies in the range the user has specified. In the 'Spectrum Trace' view the signal strength data (in dBm) is displayed as a function of frequency.

By default 2 traces are displayed -- **Current** (green) and **Maxima** (red). The **Current** trace displays the signal strength data from the most recent scan. The **Maxima** trace displays the maximum signal strength for each frequency since the scan session was begun.



In the upper-right-hand corner of the view there is a small rectangle that displays the current [x,y] grid coordinates in MHz and dBm. As you move the mouse cursor around the chart then these coordinates are continuously updated.



When you right-click the mouse button then a popup menu appears with several choices you can select from:

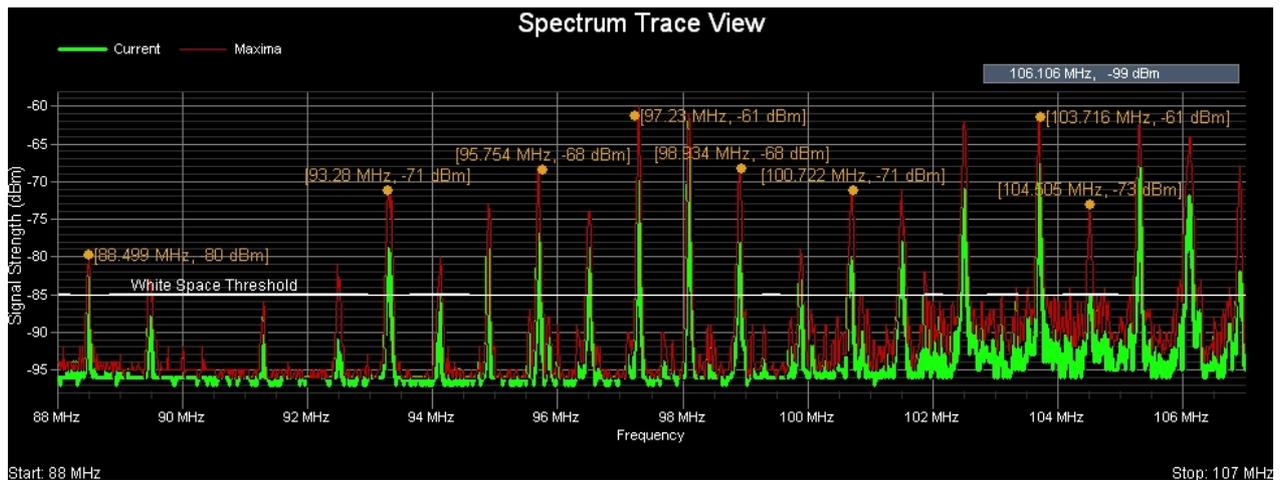
- Full Screen view
- Left Button used for creating Marker points or 'Hot Spots'
- Left Button used for specifying a Region-Of-Interest (ROI)
- Clear Markers and ROI outline from the display
- Hide Maxima Trace

These choices will be discussed further below...

Full Screen view

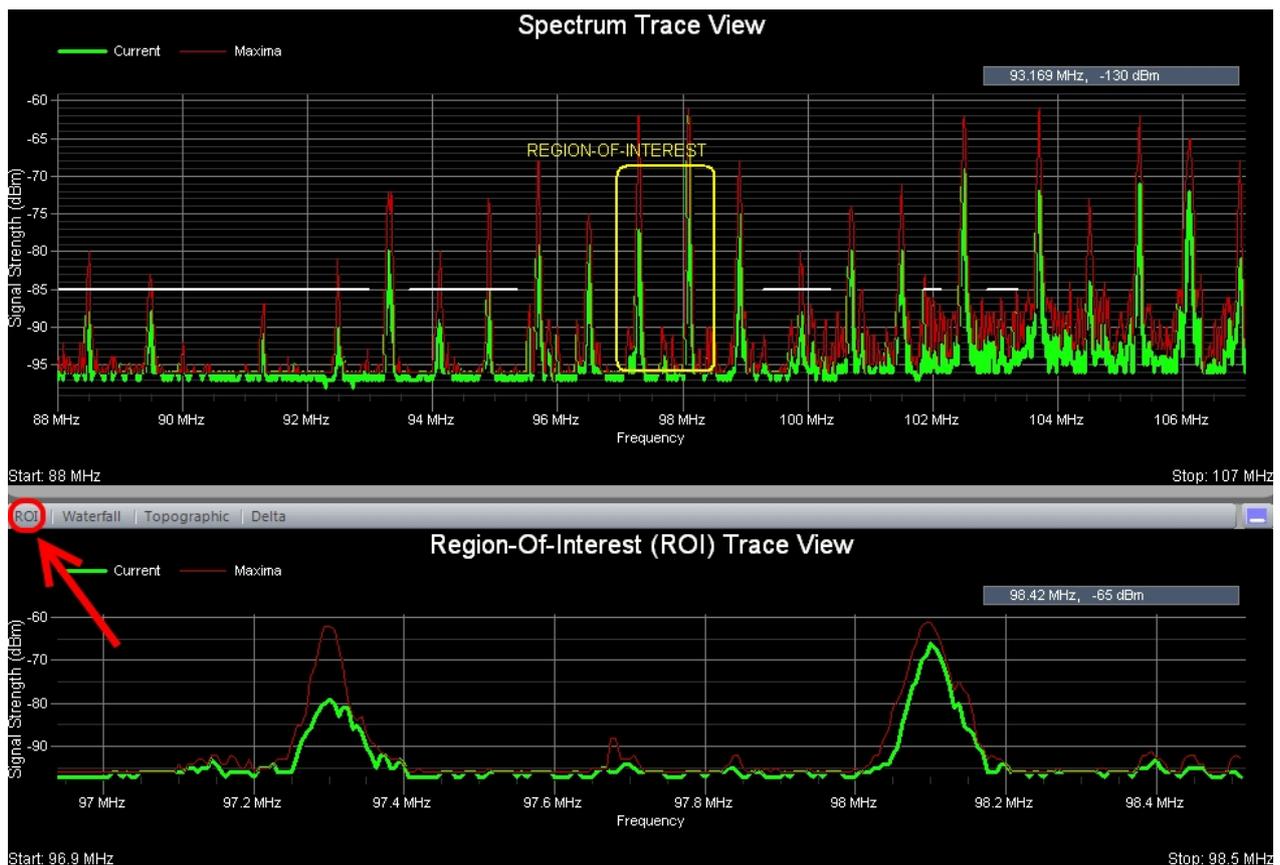
When you select 'Full Screen' from the popup menu then the Spectrum Trace view will enlarge and fill the entire screen and the two, lower display windows will become minimized. To restore the Spectrum Trace view to its original dimensions then again access the popup menu by right-clicking the mouse and this time select 'Restore Screen'.

Left Button used for creating Marker points or 'Hot Spots'



When you select 'Left Button: Marker Points' from the popup menu then subsequent left-clicks create Marker points or 'Hot Spots' that display the corresponding frequency (in MHz) and signal strength (in dBm) for the location in the grid that you just clicked on.

Left Button used for specifying a Region-Of-Interest (ROI)



When you select 'Left Button: Region-Of-Interest' from the popup menu then by pressing and dragging the left mouse button you can outline a Region-Of-Interest or ROI. When **Pro Audio White Space Finder** first launches 3 views are displayed -- the middle one is the 'Region-Of-Interest (ROI) Trace' view. And it is this view that will show the trace information for the ROI that you just defined.

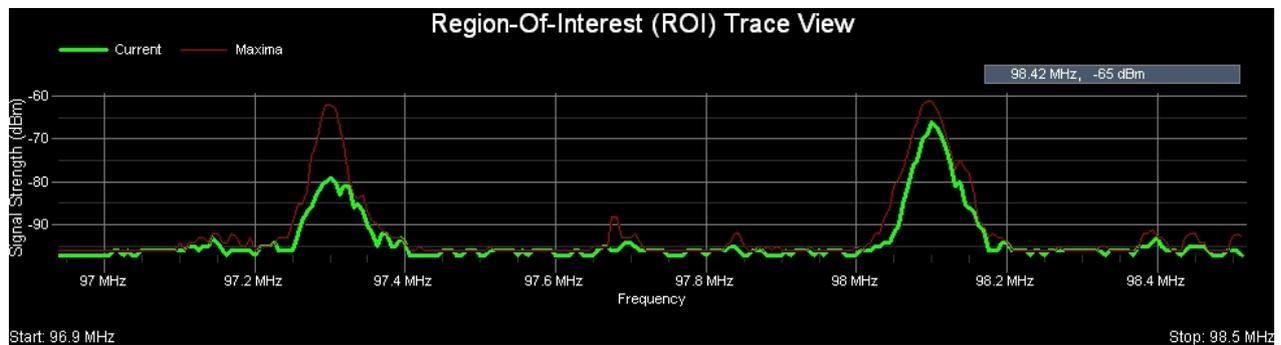
Clear Markers and ROI outline from the display

If the 'Spectrum Trace' view becomes too cluttered with Markers and the ROI outline, then these can be removed from the display by selecting 'Clear Markers' from the popup menu.

Hide Maxima Trace

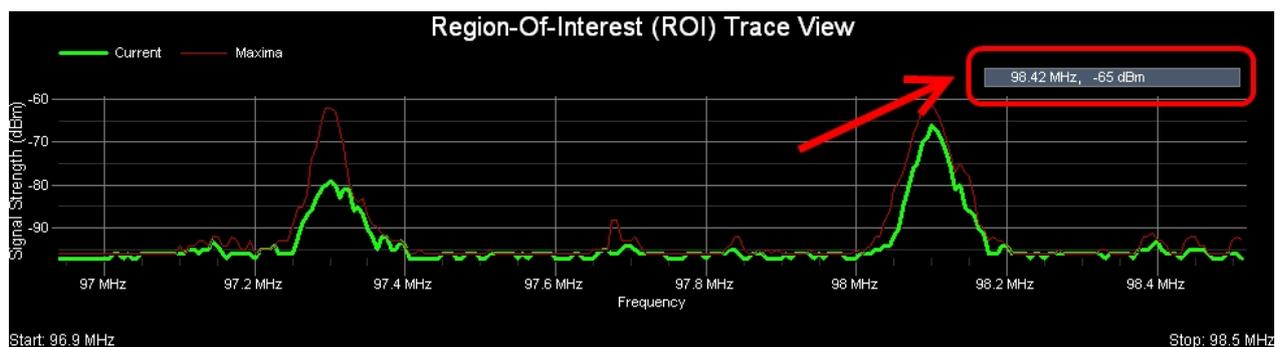
When you select this option from the popup menu then the Maxima trace is no longer displayed. If the Maxima trace is currently hidden and you wish to display it again, then from the popup menu select 'Show Maxima Trace' and it will once again be displayed in the view.

Region Of Interest Trace View

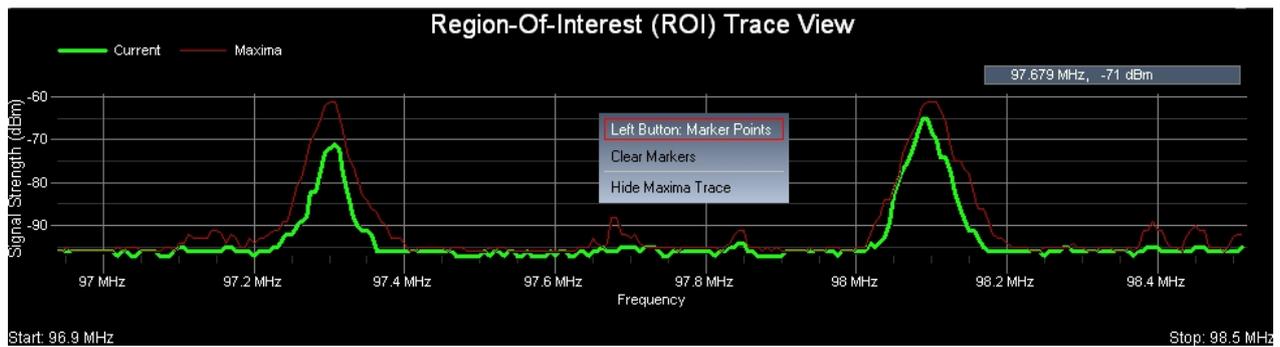


Pro Audio White Space Finder continuously scans and samples the signal strength (dBm) of frequencies in the range the user has specified. In the 'Region-Of-Interest (ROI) Trace' view the signal strength data (in dBm) is displayed as a function of frequency.

By default 2 traces are displayed -- **Current** (green) and **Maxima** (red). The **Current** trace displays the signal strength data from the most recent scan. The **Maxima** trace displays the maximum signal strength for each frequency since the scan session was begun.



In the upper-right-hand corner of the view there is a small rectangle that displays the current [x,y] grid coordinates in MHz and dBm. As you move the mouse cursor around the chart then these coordinates are continuously updated.

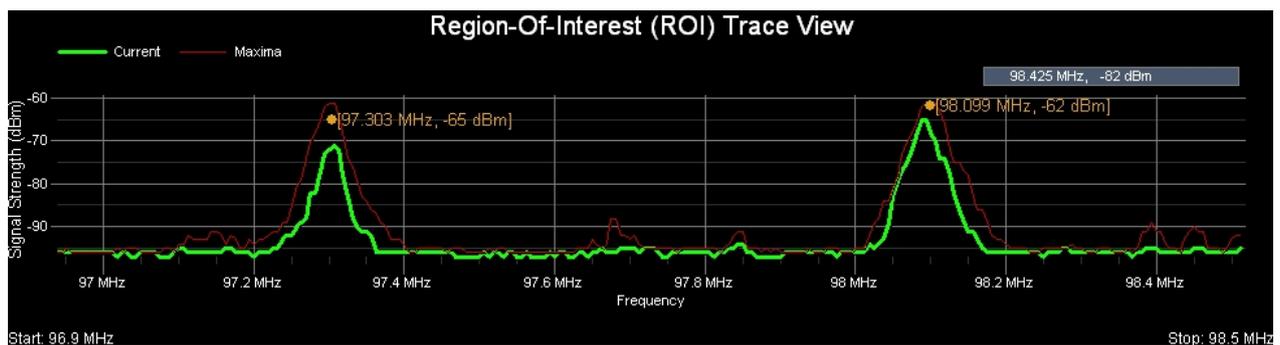


When you right-click the mouse button then a popup menu appears with several choices you can select from:

- Left Button used for creating Marker points or 'Hot Spots'
- Clear Marker from the display
- Hide Maxima Trace

These choices will be discussed further below...

Left Button used for creating Marker points or 'Hot Spots'



When you select 'Left Button: Marker Points' from the popup menu then subsequent left-clicks create Marker points or 'Hot Spots' that display the corresponding frequency (in MHz) and signal strength (in dBm) for the location in the grid that you just clicked on.

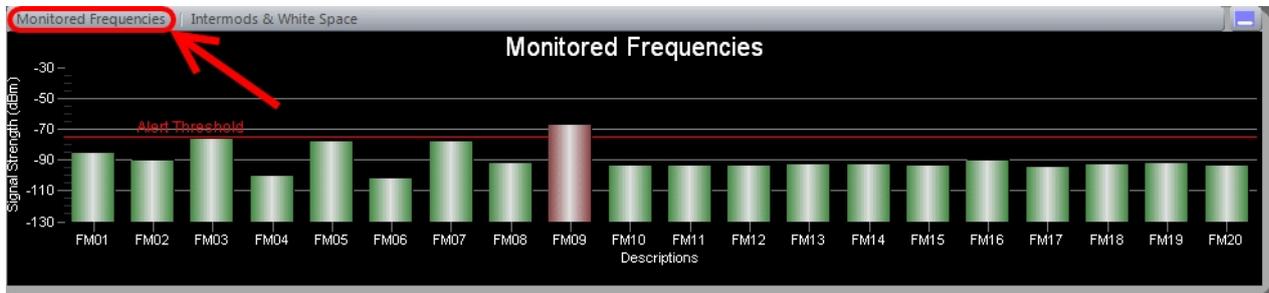
Clear Markers and ROI outline from the display

If the 'Region-Of-Interest' view becomes too cluttered with Markers, then these can be removed from the display by selecting 'Clear Markers' from the popup menu.

Hide Maxima Trace

When you select this option from the popup menu then the Maxima trace is no longer displayed. If the Maxima trace is currently hidden and you wish to display it again, then from the popup menu select 'Show Maxima Trace' and it will once again be included in the view.

Monitored Frequencies



This feature allows you to monitor any 20 frequencies within the the frequency range supported by your receiver. Furthermore, you can specify an 'Alert Threshold' -- such that if the signal strength of an interfering transmitter were to rise above this threshold then the corresponding bar for that frequency turns red (otherwise it appears green). The purpose of this feature is to alert you in the event the ambient RF energy, measured at specific frequencies, were to rise above a threshold value -- thereby posing a risk to using a specific frequency as one of the channels you assign to an audio transmitter.

Checked	Freq	Value	Unit	Description
<input checked="" type="checkbox"/>	Freq 1:	89.475	MHz	DEF01
<input checked="" type="checkbox"/>	Freq 2:	91.192	MHz	DEF02
<input checked="" type="checkbox"/>	Freq 3:	93.29	MHz	DEF03
<input checked="" type="checkbox"/>	Freq 4:	93.761	MHz	DEF04
<input checked="" type="checkbox"/>	Freq 5:	95.669	MHz	DEF05
<input checked="" type="checkbox"/>	Freq 6:	96.928	MHz	DEF06
<input checked="" type="checkbox"/>	Freq 7:	101.481	MHz	DEF07
<input checked="" type="checkbox"/>	Freq 8:	103.21	MHz	DEF08
<input checked="" type="checkbox"/>	Freq 9:	105.309	MHz	DEF09
<input checked="" type="checkbox"/>	Freq 10:	2412	MHz	DEF10
<input checked="" type="checkbox"/>	Freq 11:	2417	MHz	DEF11
<input checked="" type="checkbox"/>	Freq 12:	2422	MHz	DEF12
<input checked="" type="checkbox"/>	Freq 13:	2427	MHz	DEF13
<input checked="" type="checkbox"/>	Freq 14:	2432	MHz	DEF14
<input checked="" type="checkbox"/>	Freq 15:	2437	MHz	DEF15
<input checked="" type="checkbox"/>	Freq 16:	2442	MHz	DEF16
<input checked="" type="checkbox"/>	Freq 17:	2447	MHz	DEF17
<input checked="" type="checkbox"/>	Freq 18:	2452	MHz	DEF18
<input checked="" type="checkbox"/>	Freq 19:	2457	MHz	DEF19
<input checked="" type="checkbox"/>	Freq 20:	2462	MHz	DEF20

Alert Threshold (dBm): Bar turns RED if signal strength falls below this level...

Slider: -130, -110, -90, -70, -50, -30. Value: -75

Buttons: OK, Cancel

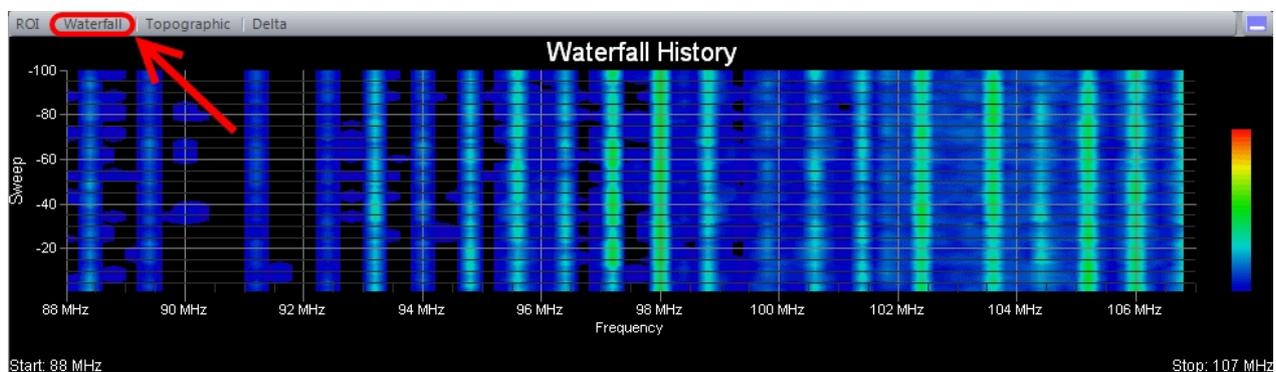
To specify the frequencies you wish to monitor select **Tools / Monitored Frequencies** from the main menu. The 'Monitored Frequencies' DialogBox will then appear. From here you can enter up to 20 frequencies to monitor along with a short description. The short description will be used to identify the frequency bar in the Monitored Frequencies view.

Adjacent to each frequency is a check box -- if a check appears in the check box then that frequency will be monitored -- otherwise, if unchecked, then it will be ignored.

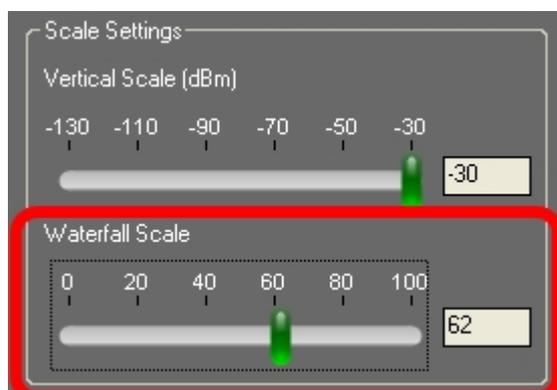
This DialogBox also provides a slider control for setting the 'Alert Threshold'. If the signal strength of a monitored frequency falls below this threshold then its corresponding bar will appear red in color (otherwise, it is green).

As a side note, the 'Monitored Frequencies' DialogBox can not be accessed while the receiver is actively scanning. That is, if the receiver is scanning and you wish to change these frequencies then it is necessary to first press the 'Stop Scan' button.

Waterfall History



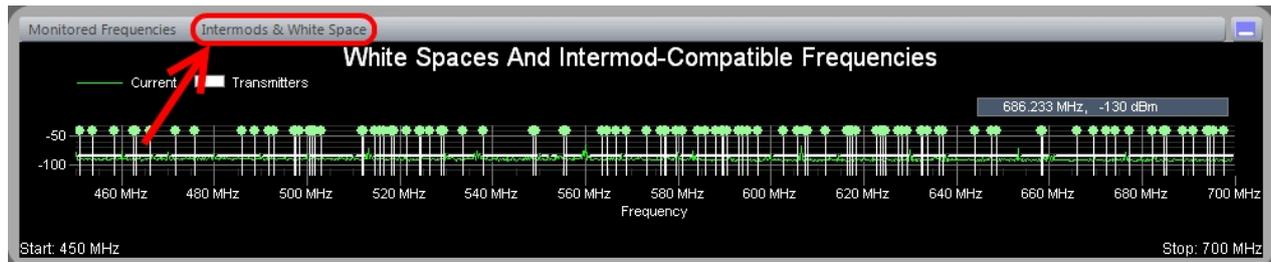
The 'Waterfall History' view is also known as a "heatmap" graph. It is a 3-dimensional representation of the data, where the X-axis is the frequency scale, the Y-axis is a time scale, and the "Z-axis" is the color scale. Each horizontal line in the Waterfall chart displays the signal strength (as a color) as a function of frequency as measured over the time period of one scan. That is, with each scan (or sweep) a new row is added at the bottom of the Waterfall chart. The color legend to the right shows that stronger signals will appear red and weaker signals will appear blue.



On the [Control Panel](#) there is a group of settings with the heading 'Scale Settings'. Within that group of settings there is a 'Waterfall Scale' slider control that applies only to the 'Waterfall History' view. This control can be used to rescale the signal strengths to better spread them across the range of colors that are used. This is useful when all the signal strengths are large and the Waterfall appears mostly red or when all the signal

strengths are low and the Waterfall appears mostly blue. For the best visual effect, ideally you'd like the peaks (strong signals) to appear red and the valleys (weak signals) to appear blue. But sometimes even the valleys have large signal strength values or the peaks have low signal strength values. This control is useful in remapping the color legend to better make use of the colors and how they are spread across the peaks and valleys of the signal strength values.

Whitespaces And Intermod-Compatible Frequencies



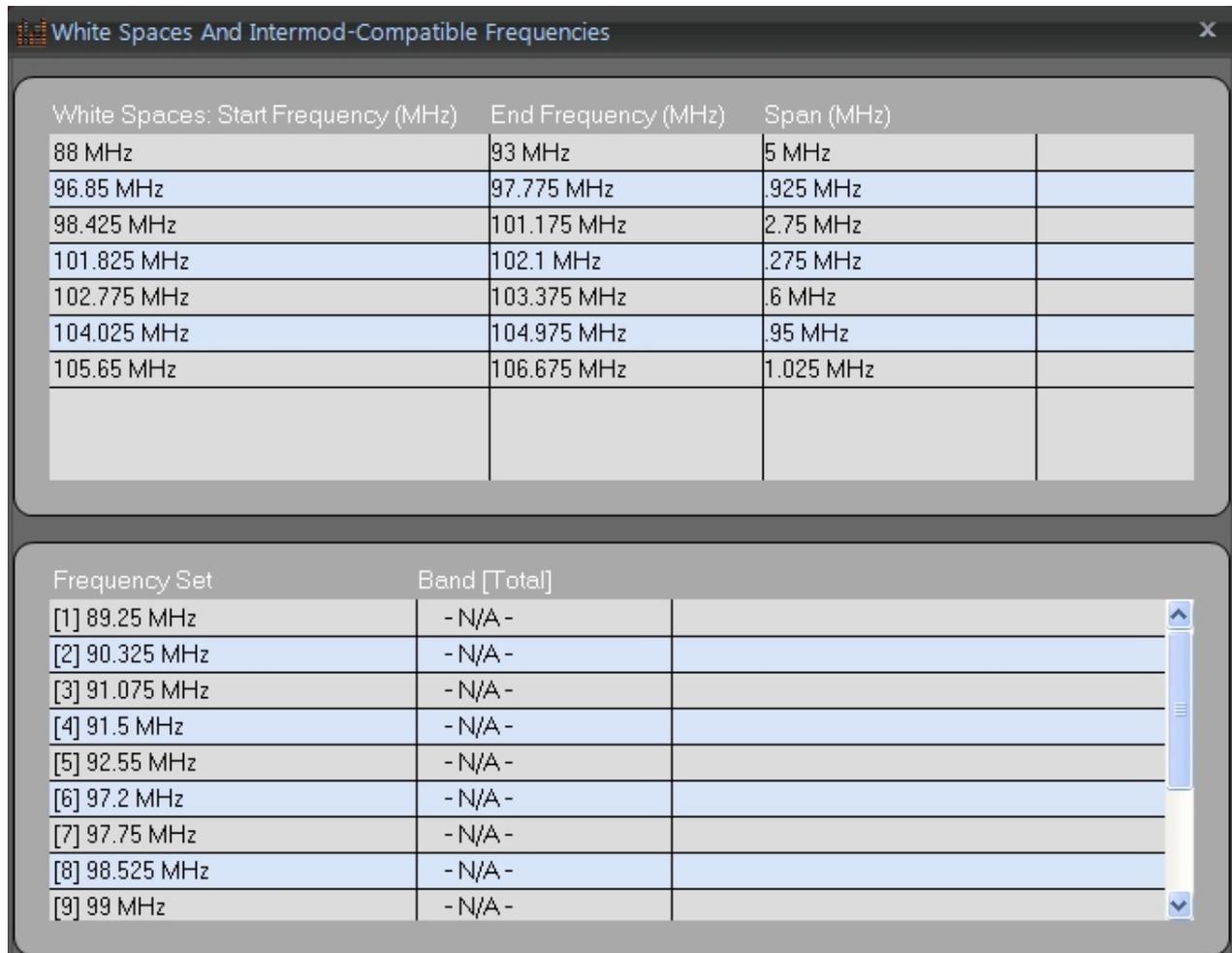
This is one of the more powerful features of **Pro Audio White Space Finder** -- it is used for locating open frequency space in crowded RF environments **PLUS** frequency coordination -- that is, assigning channels that are both free of RF interference and intermodulation distortion. In the [Control Panel](#) a user specifies a signal strength to be used as the 'White Space Threshold' -- frequencies that fall below this threshold are considered open and available and will be included in the intermodulation analysis.



The 'White Space Threshold' slider controls the threshold signal strength (in dBm) below which is considered 'White Space'. When you adjust this control you'll also see the horizontal, white line in the Spectrum Trace view move up and down accordingly. Along those frequency spans where the white line is solid and not interrupted by a peak, then this would be considered a White Space region. It is completely up to the user as to what is an appropriate threshold for this control -- it depends on the environment you are working in and what level of background RF energy you feel can be safely tolerated. As with most things, there are trade-offs. The lower (more strict) the threshold, the less white space and fewer intermod-compatible channel assignments available. The higher (more lenient) the threshold, the more white space and more intermod-compatible channel assignments will be available.

The measurements for White Space regions are used for locating open frequency space in crowded RF environments and are applied to the intermodulation analysis. The computed results show the best channel assignments for setting-up multiple transmitters -- as shown in the 'White Spaces and Intermod-Compatible Frequencies' view. These channel assignments are free of RF interference and intermodulation distortion. This is most helpful when frequency coordination and RF interference are factors that need to be taken

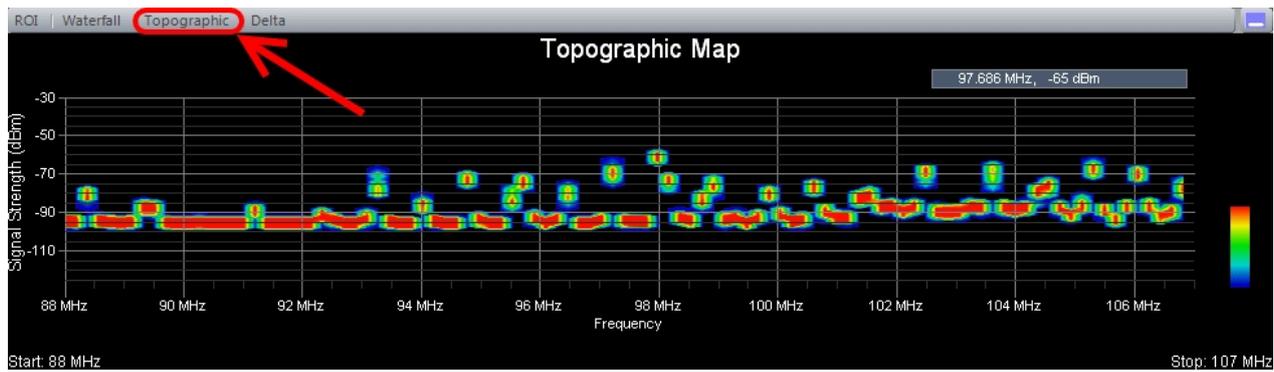
into account when selecting which frequencies or channels to use.



When you right-click the mouse button inside the 'White Spaces and Intermod-Compatible Frequencies' chart then a popup menu appears -- selecting 'More Info...' causes a DialogBox to display that lists all White Spaces and Channel Assignments (Frequency Set) in table format.

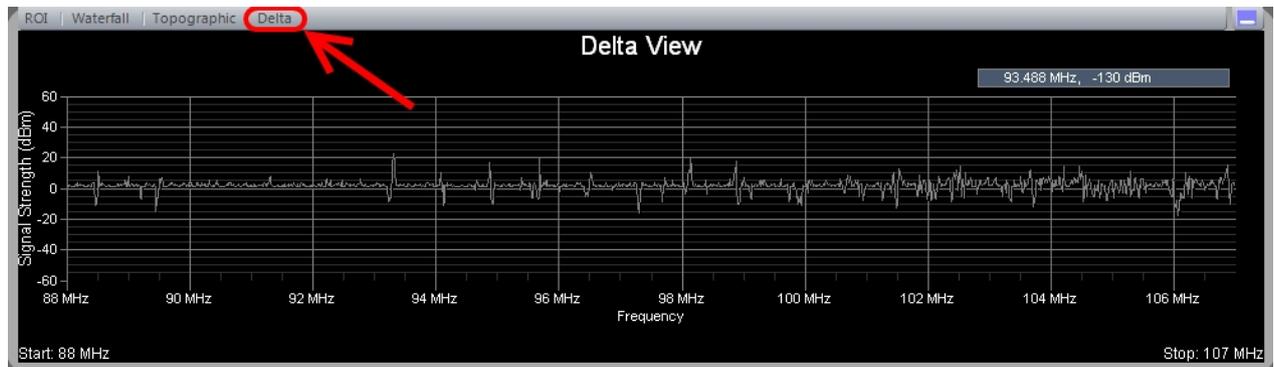
To save the frequency set to a file, from the main menu select 'File / Create Report...'. This allows you to save the Frequency Set, list of white spaces, and current charts to a PDF file.

Topographic Map



This chart shows accumulated RF energy as a function of frequency. The power of the signal strength in dBm is shown across the frequency span. A signal strength that appears with a relatively low occurrence is 'blueish' in color, whereas increasingly brighter colors are used for signal strengths that occur more frequently. Signal strengths that occur most often are 'redish' in color. Over time, this spectral view will approximate the steady-state RF energy signature of a given environment.

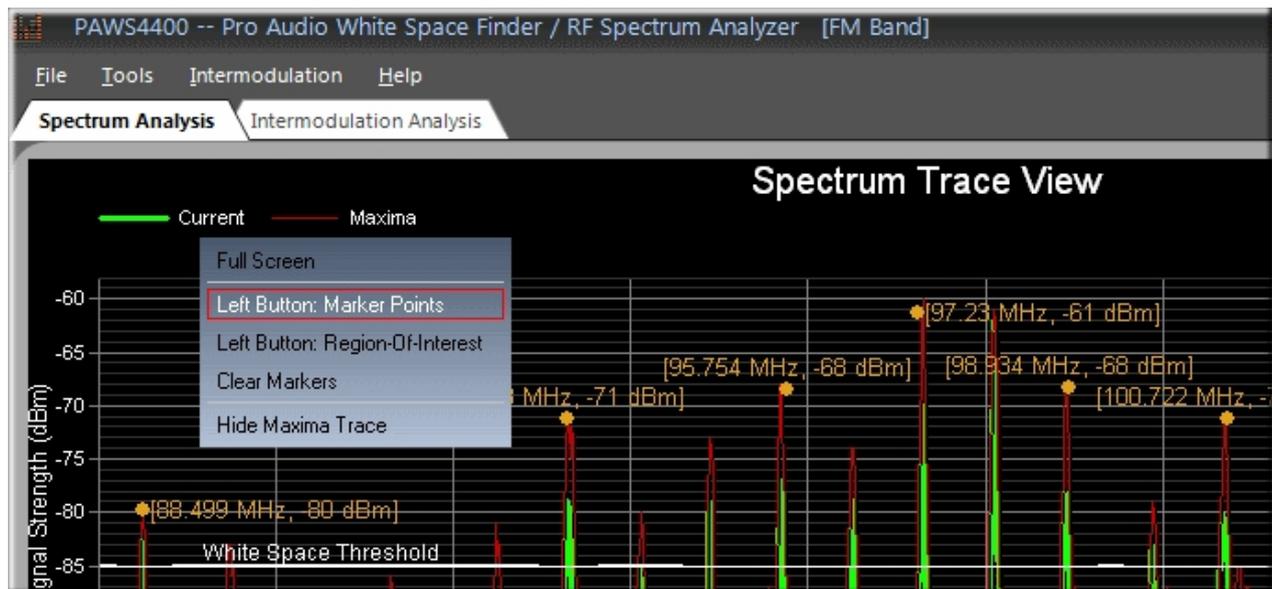
Delta Trace View



The Delta trace view can be used to view small (or large) changes in the RF spectrum over time. Here's how it works... When scanning begins the first trace is saved as a 'snapshot'. For all subsequent scans, the snapshot trace is subtracted from the current trace and the difference, i.e. 'delta', is displayed. Plotting the data in this way makes it easy to detect RF changes that occurred since the initial 'snapshot'.

Popup Menus

Popup menus are associated with several charts and are displayed by right-clicking on the chart. They provide access to additional features, as described below.



The popup menu associated with the 'Spectrum Trace' view supports the following features:

Full Screen:

When you select this option from the popup menu then the 'Spectrum Trace' view will enlarge and fill the entire screen and the two, lower display windows will become minimized. To restore the 'Spectrum Trace' view to its original dimensions then again access the popup menu by right-clicking the mouse and this time select 'Restore Screen'.

Left Button: Marker Points:

When you select this option from the popup menu then subsequent left-clicks create Marker points or 'Hot Spots' that display the corresponding frequency (in MHz) and signal strength (in dBm) for the location in the grid that you just clicked on.

Left Button: Region-Of-Interest:

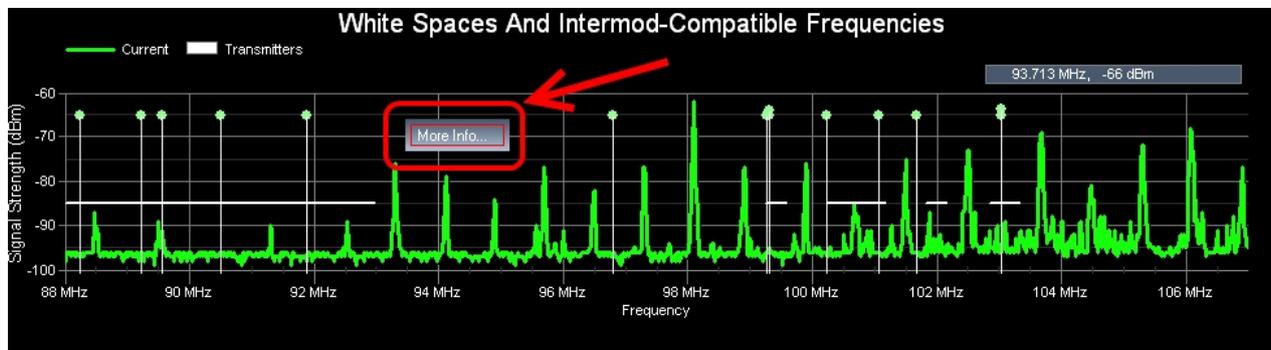
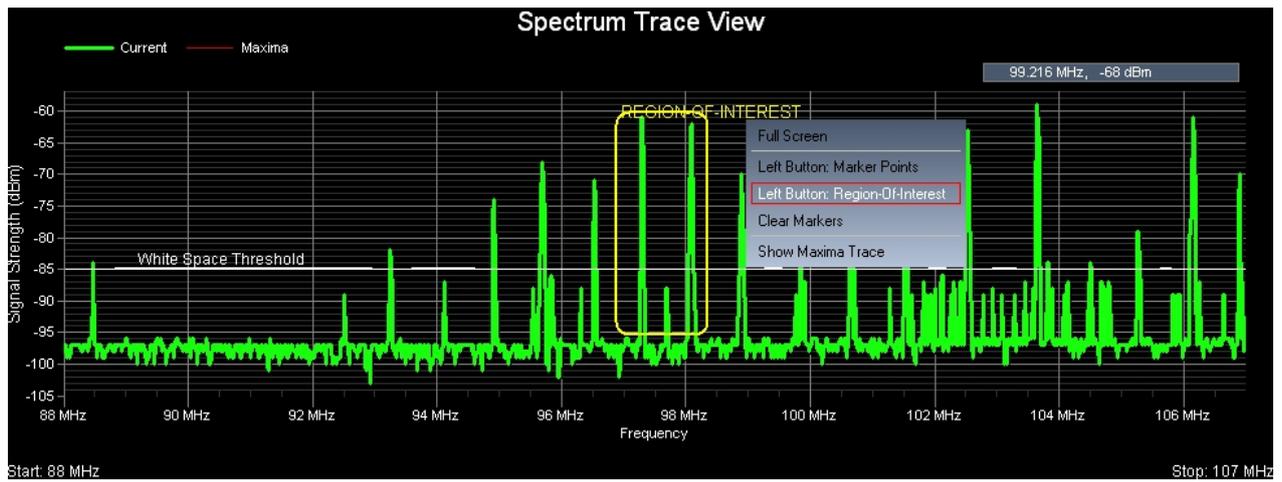
When you select this option from the popup menu then by pressing and dragging the left mouse button you can outline a Region-Of-Interest or ROI (see below). When the application first launches 3 views are displayed -- the middle one is the 'Region-Of-Interest (ROI) Trace' view. And it is this view that will show the trace information for the ROI you just specified.

Clear Markers:

If the 'Spectrum Trace' view becomes too cluttered with Markers and the ROI outline, then these can be removed from the display by selecting 'Clear Markers' from the popup menu.

Hide Maxima Trace:

When you select one of these options from the popup menu then the Maxima trace is no longer displayed. If the Maxima trace is currently hidden and you wish to display it again, then from the popup menu select 'Show Maxima Trace' and it will once again be included in the view.



The popup menu associated with the 'White Spaces And Intermod-Compatible Frequencies' view supports the following feature:

More Info: When you select 'More Info' then a table appears that displays a listing of the white space regions and a frequency set with the current channel assignments computed from the last scan.

White Spaces And Intermod-Compatible Frequencies			
White Spaces: Start Frequency (MHz)	End Frequency (MHz)	Span (MHz)	
88 MHz	92.975 MHz	4.975 MHz	
99.25 MHz	99.575 MHz	.325 MHz	
100.225 MHz	101.175 MHz	.95 MHz	
101.825 MHz	102.15 MHz	.325 MHz	
102.85 MHz	103.325 MHz	.475 MHz	

Frequency Set	Band [Total]	
[1] 88.25 MHz	- N/A -	
[2] 89.225 MHz	- N/A -	
[3] 89.55 MHz	- N/A -	
[4] 90.5 MHz	- N/A -	
[5] 91.875 MHz	- N/A -	
[6] 99.275 MHz	- N/A -	
[7] 100.225 MHz	- N/A -	
[8] 103.025 MHz	- N/A -	

Intermod Settings

2TX 3rd Order Intermods
 Near Hit: KHz

3TX 3rd Order Intermods
 Near Hit: KHz

2TX 5th Order Intermods
 Near Hit: KHz

Step Size: KHz

Ignore intermodulation products if Tx separation exceeds Max value:

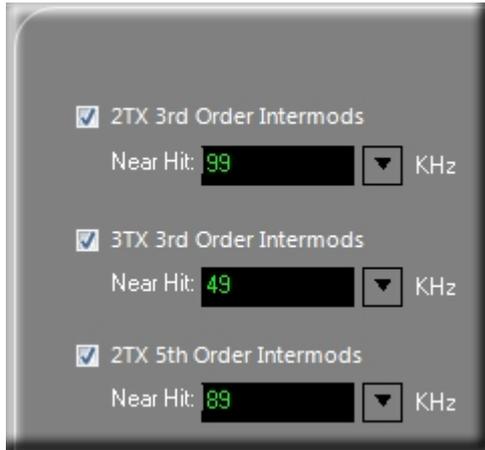
3TX 3rd Order Tx Frequencies
 Max MHz

All Transmitter Frequencies
 Max MHz

When performing intermodulation calculations there are several settings that affect the size and stringency of the resulting frequency set. These include the following:

- Intermod Stringency / Compatibility Level
- Step Size
- Ignore Certain Intermod Products

Intermod Stringency / Compatibility Level



Pro Audio White Space Finder calculates the 3 types of intermodulation products that happen to be closest to our fundamental frequencies. These are:

- Two-Transmitter, 3rd Order Components (2Tx 3rds)
- Three-Transmitter, 3rd Order Components (3Tx 3rds)
- Two-Transmitter, 5th Order Components (5Tx 5ths)

When creating an intermodulation-compatible frequency set any combination of these 3 tests can be applied in order to obtain the desired level of reliability. In fact, these three tests can be combined in different ways in order to generate frequency sets with 7 different levels of stringency:

Intermod Products That Are Tested When

The Frequency Set Is Generated

Stringency	2Tx 3rds	3Tx 3rds	2Tx 5ths
Strictest	YES	YES	YES
Strict	YES	YES	
Moderate	YES		YES
Lenient	YES		
Weak		YES	YES
Weaker		YES	
Weakest			YES

What this means is that a frequency set created under 'Strictest' conditions is guaranteed to be free of intermodulation interference caused by 2Tx 3rd, 3Tx 3rd and 2Tx 5th intermodulation products. Similarly, a frequency set created under 'Strict' conditions is guaranteed to be free of intermodulation interference caused by 2Tx 3rd and 3Tx 3rd

intermodulation products. And so on...

Ideally one would always want to use a frequency set created under 'Strictest' conditions because the frequencies within the set could be assigned to different transmitters and the level of reliability would be very high (since interference caused by intermodulation distortion would be eliminated for all intents and purposes). However, for practical purposes, it may not be possible to always create frequency sets of 'Strictest' stringency when you have many transmitters you need to assign channels to. Assuming that transmitter channels fall on 25 KHz boundaries, then for a particular frequency range (e.g. 470 MHz - 500 MHz) there are a limited number of intermodulation-free frequencies that can be computed. Furthermore, as the stringency is increased then the number of intermodulation-free frequencies that are available goes down. That is, the size of the frequency set is determined by (a) the frequency range, and (b) the intermod stringency or compatibility level.

For example -- let's take the frequency range of 470 MHz - 500 MHz and assume that transmitter channels fall on 25 KHz boundaries. The following results are approximations:

Stringency	Frequency Set Size
Strictest	16
Strict	17
Moderate	22
Lenient	32

As you can see, the number of transmitter channels you require will dictate the level of intermod stringency that can be applied in order to generate a frequency set of sufficient size to accommodate your needs. In this example, if we required 26 channel assignments then we would create a frequency set of "Lenient" stringency.

As a side note, when it comes to configuring audio equipment, at the very least your frequency set should be free of interference from 2Tx 3rd-order intermod products -- i.e. be of "Lenient" stringency or higher -- since these are the most destructive.

Near Hit Settings:

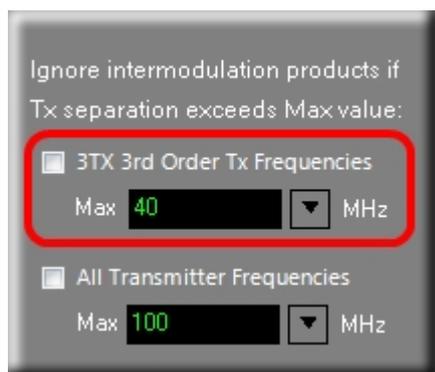
Related to 'Stringency' is the concept of 'Near Hits'. This means that in order to qualify as a compatible frequency and be a member of a frequency set a candidate frequency must not match an intermod product nor be within a specified distance of an intermod product. A 'Near Hit' setting specifies the minimum distance a candidate frequency must be from an intermod product in order to qualify as a compatible frequency. If a candidate frequency is too close to an intermod product then it is disqualified. For example, by default, intermod-compatible frequencies must be at least 99 KHz from 2Tx 3rd-order products, 49 KHz from 3Tx 3rd-order products, and 89 KHz from 2Tx 5th-order products. As the 'Near Hit' distance is increased then the frequency set becomes more stringent, but that comes at a cost -- fewer candidate frequencies will qualify as members of the frequency set and, hence, the frequency set will be smaller. We suggest you leave the 'Near Hit' settings at their default values.

Step Size

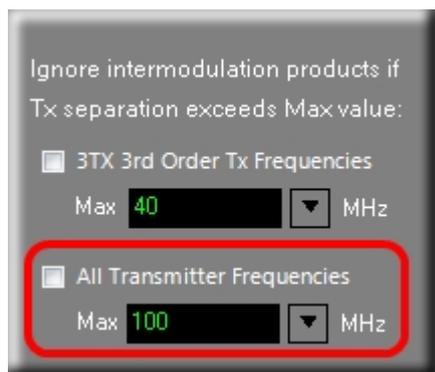


Most audio transmitters are designed to operate on channel frequencies that fall on 25 KHz boundaries -- i.e. they are "tunable" in 25 KHz steps. Given a frequency range (e.g. 470 MHz to 500 MHz) and a step-size of 25 KHz, then only frequencies within that range and which also are multiples of 25 KHz are potential candidates to be included in the frequency set that **Pro Audio White Space Finder** generates (provided they also meet the stringency requirements described above). We suggest you leave the 'Step Size' setting at its default value of 25 KHz.

Ignore Certain Intermod Products



Intermodulation products are calculated from either two transmitter frequencies (e.g. 2Tx 3rds, 2Tx 5ths) or three transmitter frequencies (3Tx 3rds). If you prefer that **Pro Audio White Space Finder** ignore 3Tx 3rd products generated by 3 frequencies where at least one of them is more than 40 MHz distant from the others, then enable this setting by checking the CheckBox. By checking the CheckBox you are telling **Pro Audio White Space Finder** to ignore certain intermodulation products, thereby **decreasing** the stringency of the frequency set.



Likewise, if you prefer that **Pro Audio White Space Finder** ignore any product where at least one of the transmitter frequencies is more than 100 MHz distant from the other(s), then enable this setting by checking the CheckBox. Again, by checking the CheckBox you are telling **Pro Audio White Space Finder** to ignore certain intermodulation products, thereby **decreasing** the stringency of the frequency set.

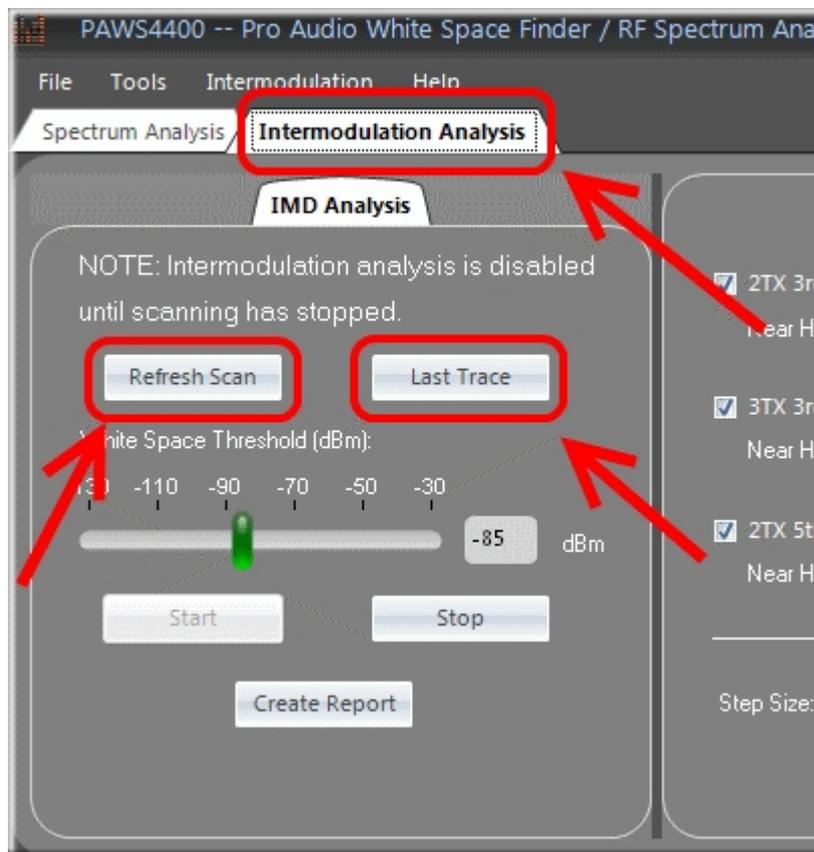
By default **Pro Audio White Space Finder** does not ignore any intermod products when generating a compatible frequency set. However, if you find yourself in a situation where you need to slightly increase the size of a frequency set, then you might consider checking one or both of these CheckBoxes. Interference from intermodulation distortion may be less

of a problem when transmitters are operating in bands that are many MHz apart from one another.

Generate Frequency Set From Spectrum Trace

Pro Audio White Space Finder allows you to generate a frequency set that takes into account interference from **both** RF interferers and intermodulation products. This is a very powerful feature -- it allows you to make channel assignments using frequencies that are free of RF interference and intermodulation distortion.

The results displayed in the 'White Spaces and Intermod-Compatible Frequencies' view are sufficient for most wireless audio installations. The frequency set that is computed in real-time is free of RF interference and the most destructive types of intermodulation distortion. However, for more demanding scenarios, it is possible to take the analysis a step further.



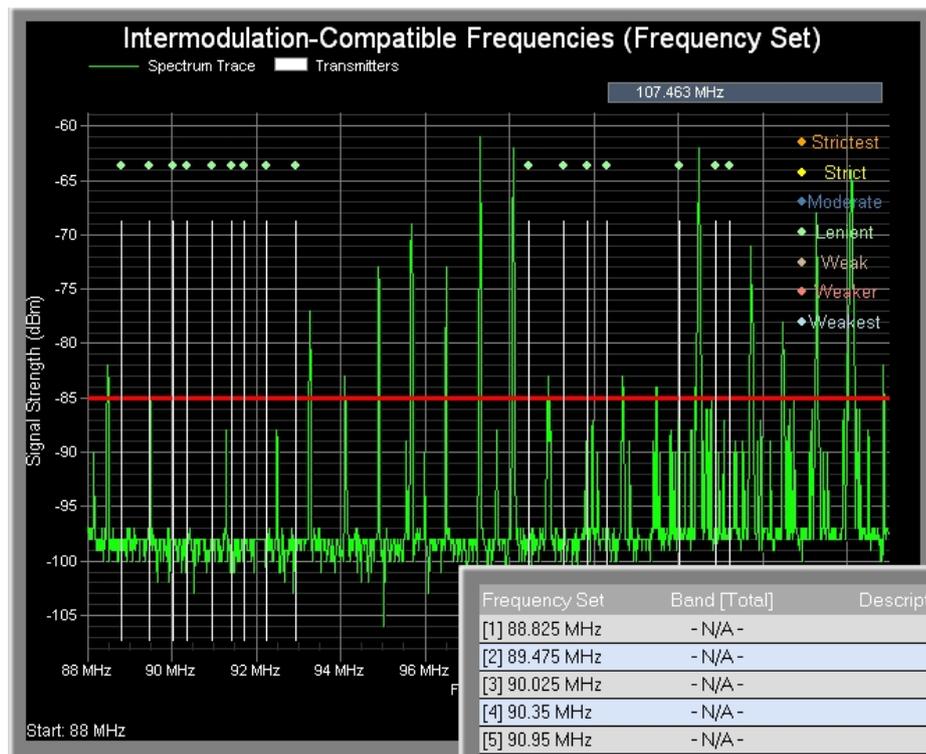
By selecting the 'Intermodulation Analysis' tab a new screen is displayed with additional settings, grid and chart. [NOTE: While scanning is in progress then this feature is disabled]. Initially the chart is blank and you'll need to fill it with a spectrum trace. You can do this by pressing the 'Last Trace' button, which will retrieve the last spectrum trace (assuming you had previously performed some scans). Alternatively, you can perform a one-time scan by pressing the 'Refresh Scan' button.



After the RF spectrum data is loaded then its trace will be displayed -- along with a horizontal, red line that indicates the "White Space Threshold". The 'White Space Threshold' slider controls the threshold signal strength (in dBm) below which is considered 'White Space' -- that is, frequencies not subject to RF interference and which should be considered potential candidates for the frequency set. When you adjust this control you'll see the horizontal, red line move up and down accordingly. Those frequencies whose signal strength amplitudes exceed the threshold are considered off-limits and are locked-out -- that is, they will not be considered as candidates for a frequency set.

In addition to adjusting the 'White Space Threshold' you should select a combination of intermod products you wish to test for from the '[Intermod Settings](#)'. The initial set of candidate frequencies from which intermod-compatible frequencies are drawn include multiples of the step-size that also fall within the "White Space" -- i.e. below the "White Space Threshold".

After the "White Space Threshold" and 'Intermod Settings' have been accounted for, press the 'Start' button to begin the computation.



When the computation has completed the intermod-compatible frequencies that compose the frequency set are listed in the 'Results' window. They are also displayed graphically -- as shown above. Here you see that the intermod-compatible frequencies (the vertical white lines) only occur within the "White Space" regions.

Reserved Frequencies

Frequency Set	Band [Total]	Description
[1] 88.2 MHz	- N/A -	Background Vocal #1
[2] 88.525 MHz	- N/A -	Background Vocal #2
[3] 89.325 MHz	- N/A -	
[4] 90.025 MHz	- N/A -	
[5] 90.35 MHz	- N/A -	Lead Vocal
[6] 90.95 MHz	- N/A -	
[7] 92 MHz	- N/A -	
[8] 92.4 MHz	- N/A -	
[9] 92.95 MHz	- N/A -	
[10] 94.075 MHz	- N/A -	
[11] 94.575 MHz	- N/A -	
[12] 96.45 MHz	- N/A -	
[13] 96.925 MHz	- N/A -	
[14] 99.4 MHz	- N/A -	
[15] 100.075 MHz	- N/A -	
[16] 102.175 MHz	- N/A -	
[17] 103.1 MHz	- N/A -	
[18] 104.125 MHz	- N/A -	
[19] 104.85 MHz	- N/A -	
[20] 105.75 MHz	- N/A -	

Enter Description or Exclude Frequency

Enter brief description for this frequency: 92 MHz

Background Vocal #3

NOTE: Adding a description has the effect of adding this frequency to the set of 'Reserved' frequencies. Each 'Reserved' frequency has the potential of reducing the reliability of the frequency set.

Exclude this frequency from IMD analyses: 92 MHz

OK Cancel

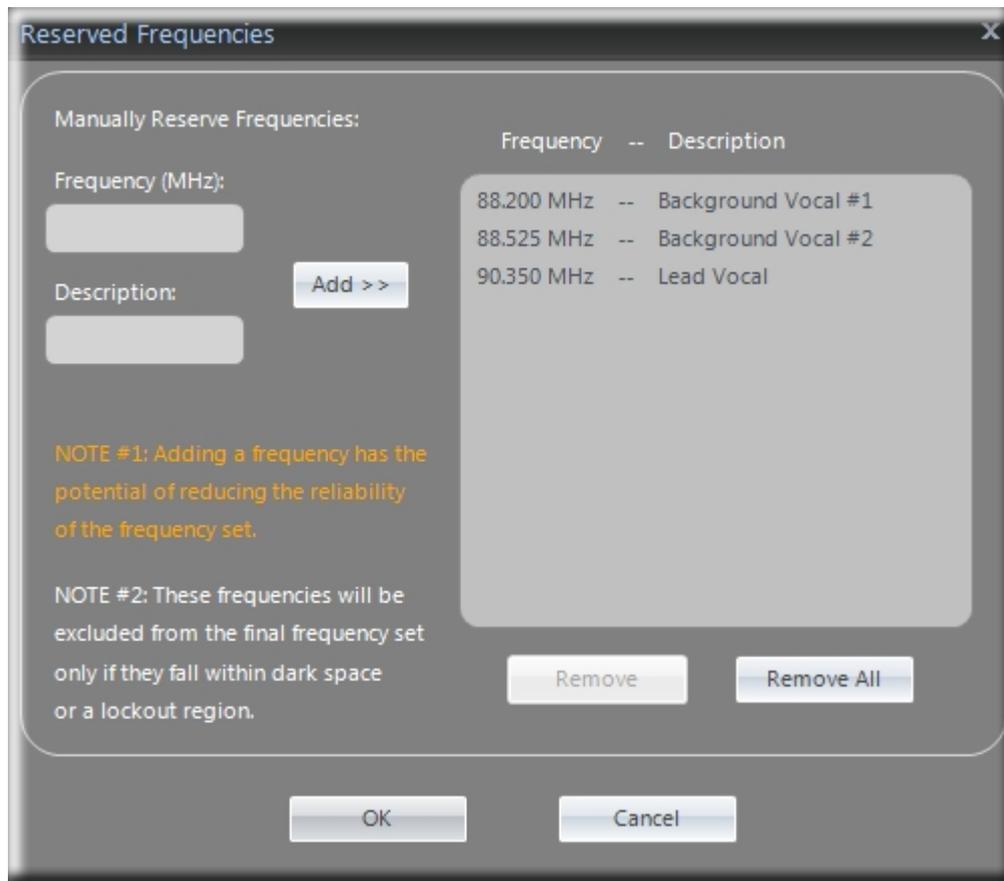
Pro Audio White Space Finder allows you to add a label or description to any frequency within the frequency set. When you left-click on a frequency in the results window then a DialogBox appears that allows you to enter some text. When you are finished then press the 'OK' button. If you choose to create a PDF report the description you just entered will also be included. Alternatively, you can use this DialogBox to exclude a frequency from all future intermodulation analyses.

Adding a description serves another important purpose -- it designates that frequency as a "**reserved**" frequency. A reserved frequency is one that will always be included in the frequency set that results from an intermodulation analysis.

Reserved frequencies provides a means for a user to enter one or more frequencies into the coordination for those instances where a particular device is considered mandatory. For example, facilities or events often have a pool of existing equipment to which channels will need to be added. Also guest systems using preconfigured channels may have to be integrated and coordinated with resident systems.

There are two ways to add Reserved frequencies -- from the main menu select

Intermodulation / Reserved Frequencies, or from the Results window left-click on a frequency and add a description (as explained above). When you use the latter method and then go to **Intermodulation / Reserved Frequencies**, you should see the frequencies have been added.

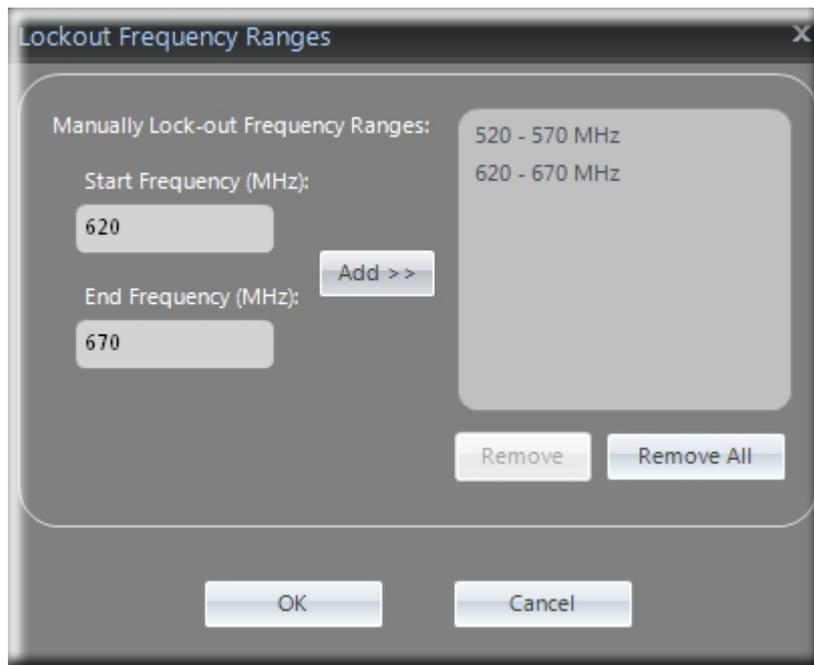


To copy, cut or paste a description, select a frequency in the results window and right-click. If a description is 'cut', then the corresponding frequency will be removed from the reserved frequencies. Similarly, if a description is 'pasted', then the corresponding frequency will be added as a reserved frequency.

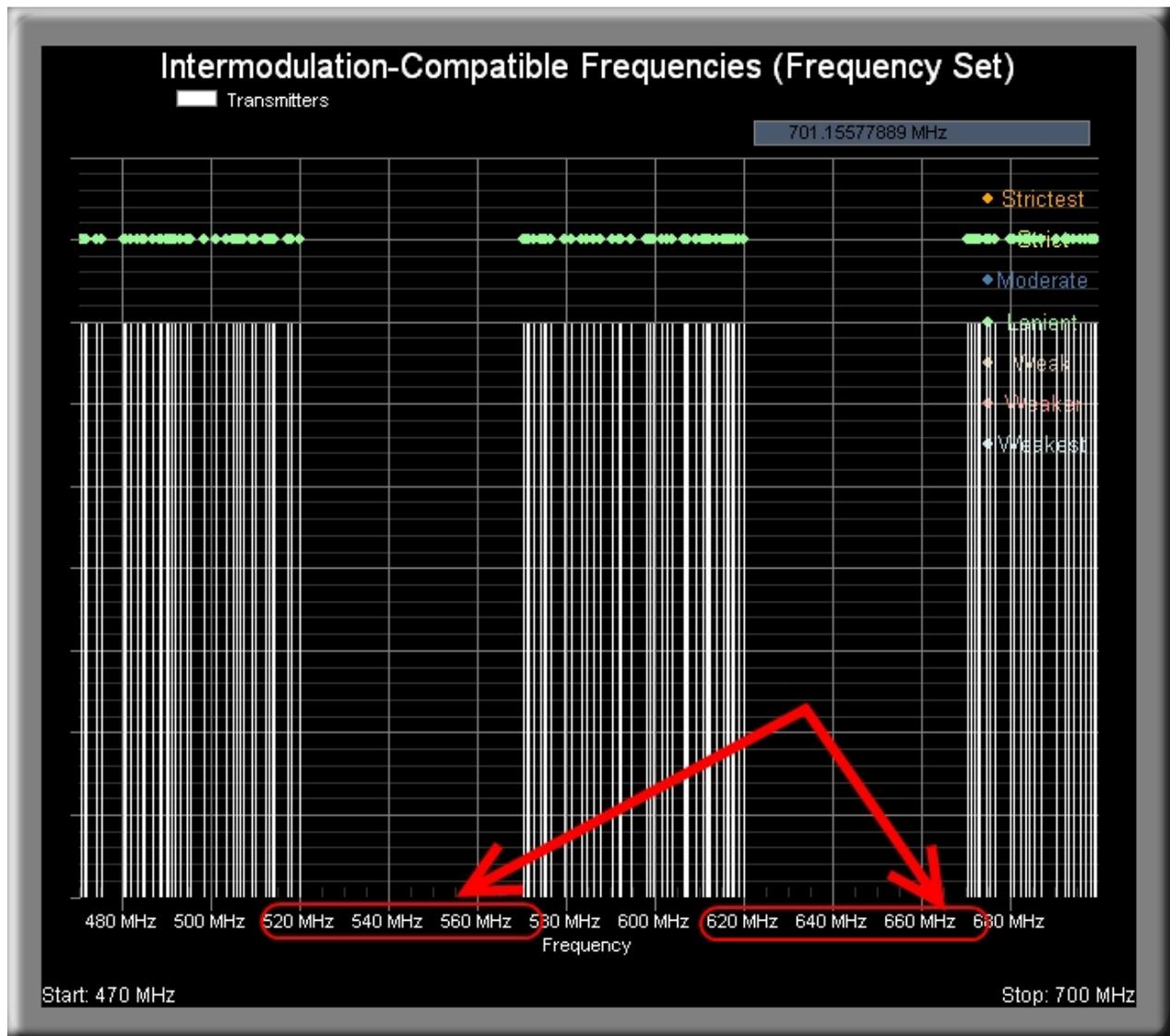
Frequency Set	Band [Total]	Description
[1] 88.2 MHz	- N/A -	Background Vocal #1
[2] 88.525 MHz	- N/A -	Background Vocal #2
[3] 89.325 MHz	- N/A -	
[4] 90.025 MHz	- N/A -	
[5] 90.35 MHz	- N/A -	Lead Vocal
[6] 90.95 MHz	- N/A -	
[7] 92 MHz	- N/A -	
[8] 92.4 MHz	- N/A -	
[9] 92.95 MHz	- N/A -	
[10] 94.075 MHz	- N/A -	
[11] 94.575 MHz	- N/A -	
[12] 96.45 MHz	- N/A -	
[13] 96.925 MHz	- N/A -	
[14] 99.4 MHz	- N/A -	
[15] 100.075 MHz	- N/A -	
[16] 102.175 MHz	- N/A -	
[17] 103.1 MHz	- N/A -	
[18] 104.125 MHz	- N/A -	
[19] 104.85 MHz	- N/A -	
[20] 105.75 MHz	- N/A -	

- Copy Description
- Cut Description
- Paste Description

Manually Lockout Frequency Ranges

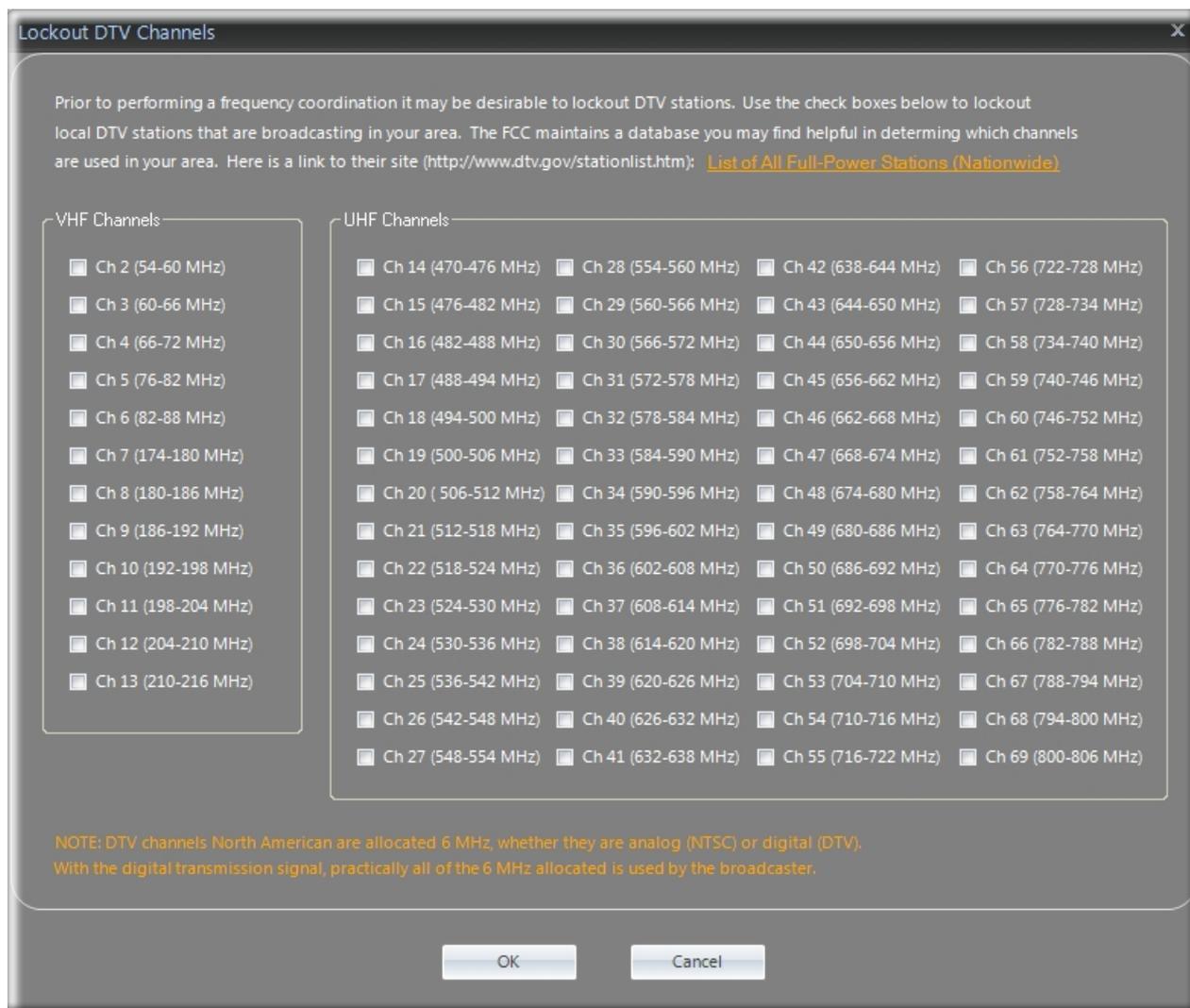


Pro Audio White Space Finder's lockout feature allows you to manually lockout frequency ranges of your choosing. Frequencies within the locked-out regions are removed from consideration as potential candidates for a frequency set. This feature is accessed from the main menu by selecting **Intermodulation / Lockout Frequency Ranges**. When the 'Lockout Frequencies' dialogbox appears enter 'Start' and 'End' frequencies, in MHz, and press the 'Add' button. The frequency range you just entered will be added to a growing list of frequencies that will be excluded from the frequency set.



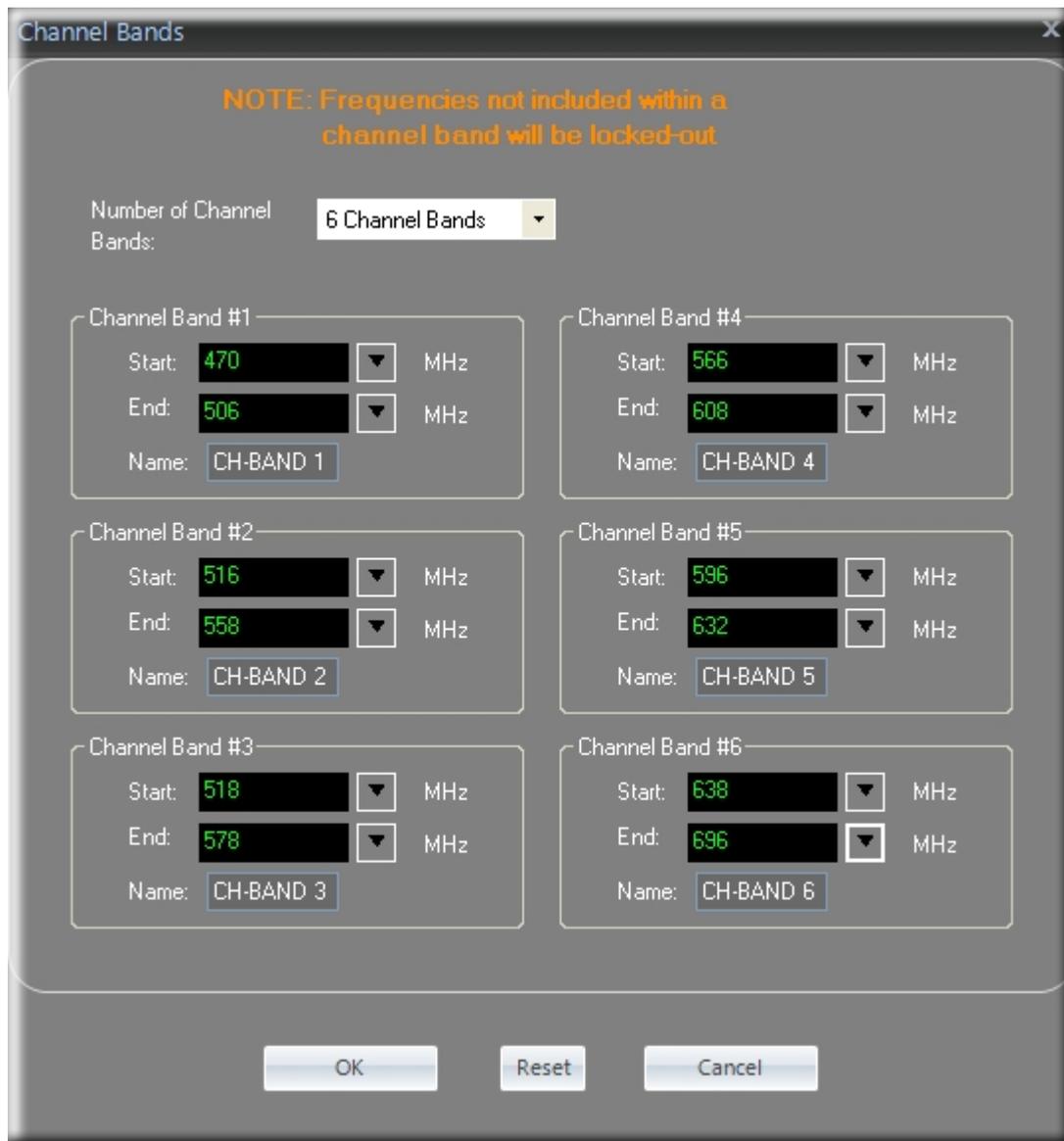
The frequency set shown above was generated with two regions locked-out: 520 - 570 MHz and 620 - 670 MHz. As you can see, the resultant frequency set does not include any frequencies from those regions.

Lockout DTV Channels

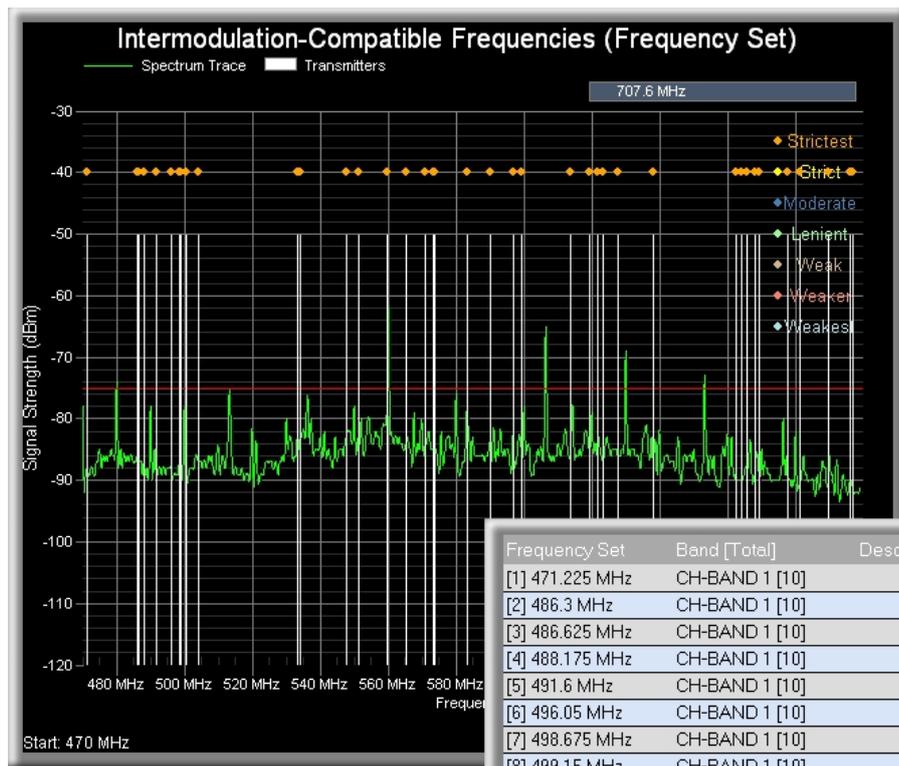


Pro Audio White Space Finder's intermodulation analysis allows you to manually lockout DTV channels of your choosing. This feature is accessed from the main menu by selecting **Intermodulation / Lockout DTV Channels**. For channels you select their corresponding frequency range is locked-out of the intermodulation analysis -- that is, frequencies within locked-out regions are removed from consideration as potential candidates of a frequency set.

Channel Bands



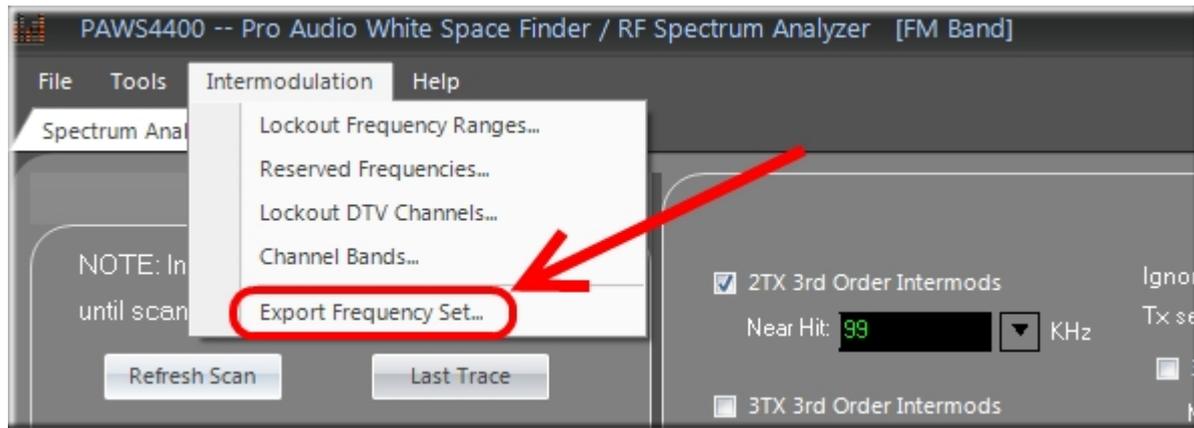
Pro Audio White Space Finder's 'Channel Bands' feature allows you to organize the frequencies within a frequency set into different groups based on their frequency ranges. This feature is accessed from the main menu by selecting **Intermodulation / Channel Bands**. Often it is the case where audio engineers are working with a variety of different wireless audio equipment that operate in different frequency ranges. However, because the equipment operates within close geographical proximity then one frequency set is applied when configuring the frequency coordination and assigning channels to transmitters. In addition to setting the Start/End frequency for each band, you can also assign a short name or label. If you wish, channel bands may overlap one another -- in which case certain frequencies may belong to more than one channel band. It is important to note that frequencies not included within a channel band will be locked-out of the intermodulation analysis.



Frequency Set	Band [Total]	Description
[1] 471.225 MHz	CH-BAND 1 [10]	
[2] 486.3 MHz	CH-BAND 1 [10]	
[3] 486.625 MHz	CH-BAND 1 [10]	
[4] 488.175 MHz	CH-BAND 1 [10]	
[5] 491.6 MHz	CH-BAND 1 [10]	
[6] 496.05 MHz	CH-BAND 1 [10]	
[7] 498.675 MHz	CH-BAND 1 [10]	
[8] 499.15 MHz	CH-BAND 1 [10]	
[9] 500.625 MHz	CH-BAND 1 [10]	
[10] 504.175 MHz	CH-BAND 1 [10]	
[11] 533.375 MHz	CH-BAND 2 [4]	
	CH-BAND 3 [9]	
[12] 534.325 MHz	CH-BAND 2 [4]	
	CH-BAND 3 [9]	
[13] 547.85 MHz	CH-BAND 2 [4]	
	CH-BAND 3 [9]	
[14] 551.475 MHz	CH-BAND 2 [4]	
	CH-BAND 3 [9]	
[15] 559.65 MHz	CH-BAND 3 [9]	
[16] 565.2 MHz	CH-BAND 3 [9]	
[17] 571.05 MHz	CH-BAND 3 [9]	
	CH-BAND 4 [7]	
[18] 573.425 MHz	CH-BAND 3 [9]	
	CH-BAND 4 [7]	
[19] 573.8 MHz	CH-BAND 3 [9]	
	CH-BAND 4 [7]	

In the example above we've divided our frequency range (470 to 700 MHz) into 6 channel bands. Under the 'Band' column is listed the channel band's label that each frequency belongs to. Also, the number in brackets is the total number of frequencies that fall within that channel band. As seen above, the frequency 533.375 MHz falls within two channel bands -- "CH-BAND2" and "CH-BAND3". "CH-BAND2" includes a total of 4 frequencies and "CH-BAND3" includes a total of 9 frequencies. Just to be clear, all channel bands (and frequencies) belong to the same frequency set -- hence, frequencies in different channel bands are still intermod-compatible.

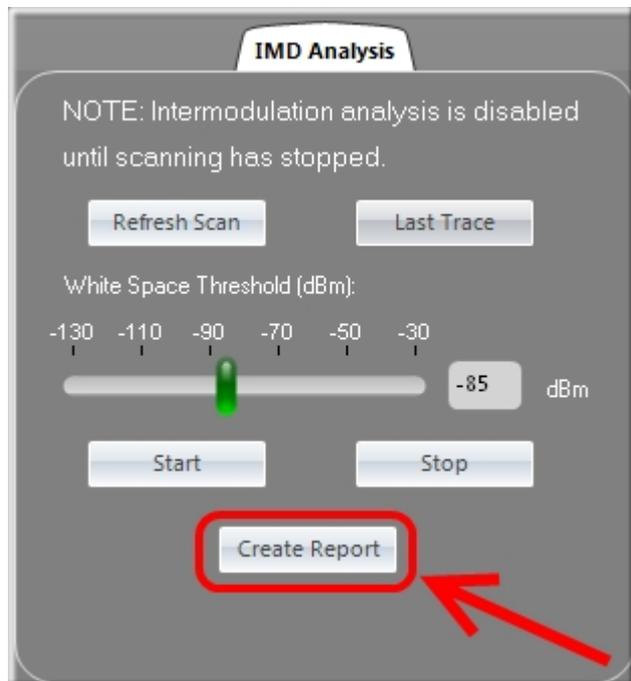
Export Frequency Set



Pro Audio White Space Finder has the ability to export the frequency set data (i.e. the list of frequencies in the 'Results' window) in XML format that is recognized by both **Pro Audio White Space Finder** and **Intermod Assist**. This is useful if you wish to use the results as input data to another program, such as **Intermod Assist**, for the purpose of performing additional analyses. An exported frequency set can also be imported into **Pro Audio White Space Finder** and used as the frequency set that is applied during real-time intermodulation analysis. For more information you can learn more in the '[Controls](#)' section of the Control Panel.

You can access the Export feature from the main menu by selecting **Intermodulation / Export Frequency Set**.

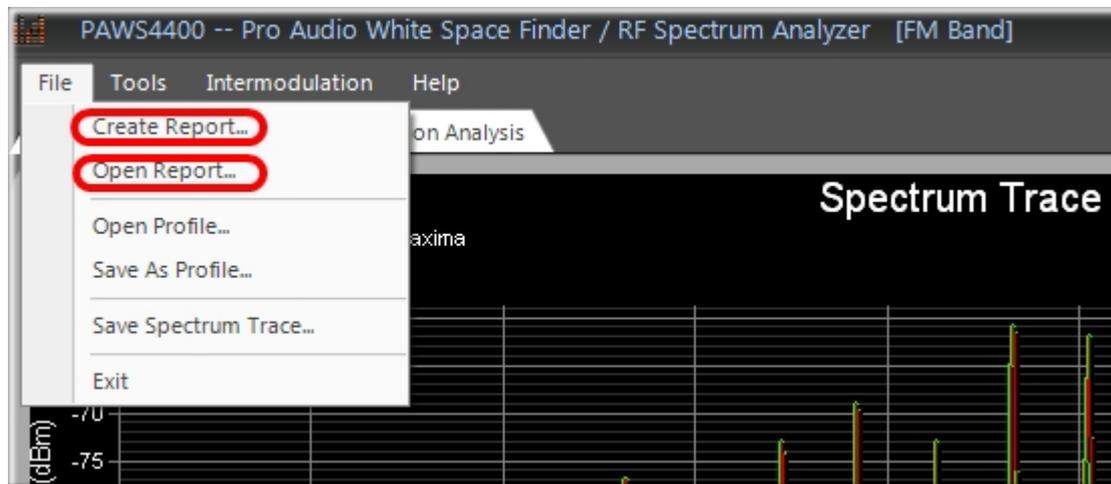
Create Report



The 'Intermodulation Analysis' section has its own report generation capability that is separate from the rest of the application and different than the one accessed from the main menu. Press the 'Create Report' button and you will be prompted for a folder and filename in which to save a report file. An Adobe PDF-formatted file will be created that includes the graphical chart depicting the members of the frequency set, along with a listing of the

frequencies and their labels (taken from the 'Results' window). At the same time, Adobe Reader will be launched so you can verify the contents of the report you've just created. Also, by selecting **File / Open Report...** from the main menu you can open and view Adobe PDF-formatted reports you've created (or any other PDF file).

Creating Reports

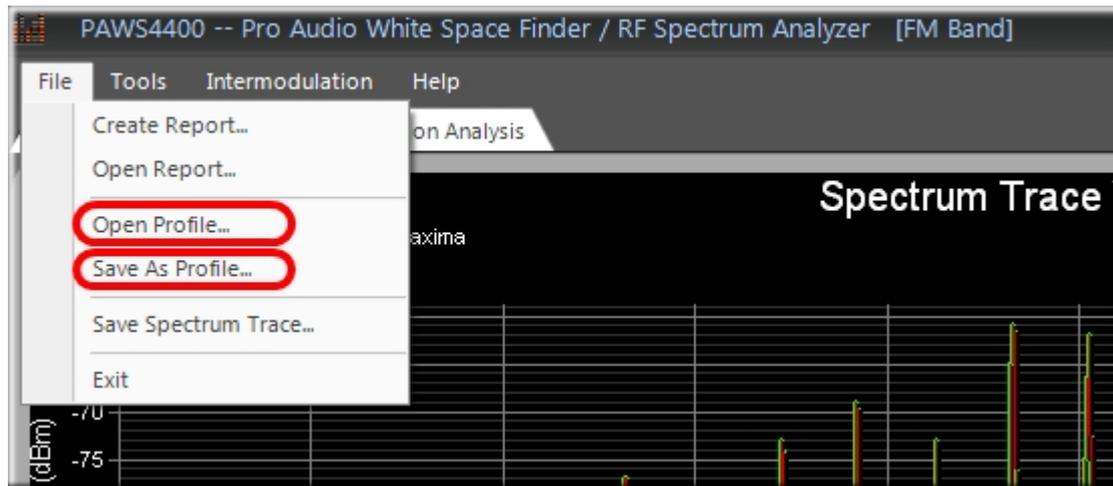


Pro Audio White Space Finder has an easy-to-use report generation capability. Select **File / Create Report** from the main menu and you will be prompted for a folder and filename in which to save a report file. An Adobe PDF-formatted file will be created that includes all charts. At the same time, Adobe Reader will be launched so you can verify the contents of the report you just created. Also, by selecting **File / Open Report** from the main menu you can open and view Adobe PDF formatted reports you've created (or any other PDF file).

User Defined Profiles

Pro Audio White Space Finder supports two types of profiles -- pre-configured or built-in (discussed in the [Control Panel](#) section) and user-defined. The difference is that user-defined profiles are created by you and stored as files that can later be loaded into the application. Profiles control many important parameters, including the following: Start and End frequencies, [Monitored Frequencies](#) settings and transmitter signal bandwidth and spacing. When you load a user-defined profile then these settings are immediately applied throughout the application and will be in effect the next time the 'Start Scan' button is pressed.

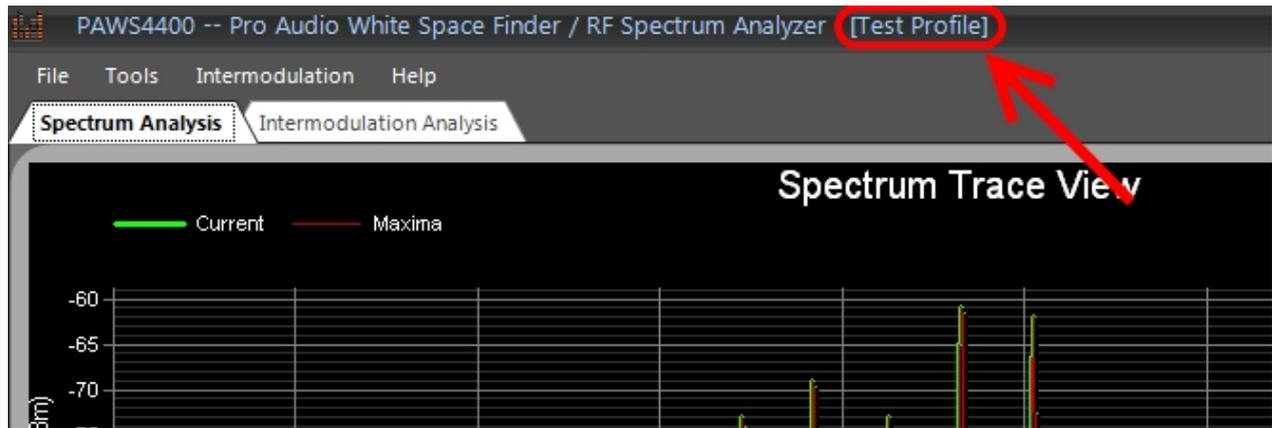
As a side note, the user-defined profiles can not be accessed while the receiver is actively scanning. That is, if the receiver is scanning and you wish to use apply a user-defined profile then it is necessary to first press the 'Stop Scan' button.



To save the current settings as a new, user-defined profile then select **File / Save As Profile** from the main menu. A 'Save Current Settings As A Profile' DialogBox will open and you can specify a filename and location of your choice. The default location is the 'Profiles' folder one level below the **Pro Audio White Space Finder's** installation directory and the default file extension is *.wsf (for **White Space Finder Profile**). After specifying a filename and location you will then be asked for a short description for this profile (see below) that will appear in the Control Panel's title bar.

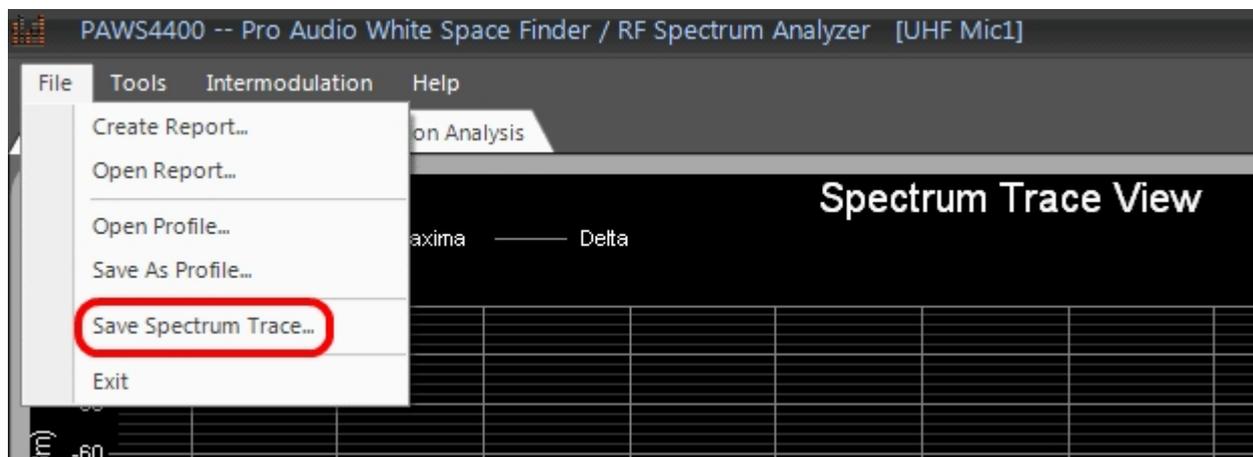


When a user-defined profile is currently in use then the description that you entered (above) is used in the application's title bar (see below). This is your visual cue as to which user-defined profile was last saved or opened.



To open a user-defined profile that you had previously created, select **File / Open Profile** from the main menu. A 'Select White Space Finder Profile' DialogBox will open and you can navigate to the folder where the profile was last saved. Select the desired profile (as you would when opening a file in any other type of application) and press the 'Open' button. The settings stored in the profile will then be immediately applied throughout the application and will be in effect the next time the 'Start Scan' button is pressed. Also, the application's title bar will change to reflect the description of the newly applied profile (see above).

Save Spectrum Trace



Spectrum traces created by **Pro Audio White Space Finder** can be saved to file and used by other programs -- e.g. [Intermod Assist](#) can use these traces to define white space regions when performing intermodulation analysis.

To save the current spectrum trace to an XML data file then select **File / Save Spectrum Trace** from the main menu. A 'Save Spectrum Trace To PAWS4400 Format' DialogBox will open and you can specify a filename and location of your choice. The default location is the 'DataFiles' folder under '\Program Files\RationalWaves\Common'.

Hardware Specifications

Specifications for the Signal Hound™ spectrum analyzer (taken from <http://signalhound.com/spec.htm>):

Signal Hound®

Abbreviated Specifications

Frequency

Frequency Range: 1Hz to 4.4GHz (RF Preamp Off); 500KHz to 4.4GHz (RF Preamp On)
Internal Frequency Reference Accuracy: ± 1 ppm
Counter Accuracy: 1Hz + timebase error
Resolution Bandwidth: 0.1Hz to 250KHz and 5MHz

Amplitude (RBW ≤ 100 KHz)

Range: +10dBm to Displayed Average Noise Level (DANL)
Absolute Accuracy: ± 1.5 dB (0dBm to DANL); ± 2.0 dB (+10dBm to >0dBm)
Displayed Average Noise Level: (dBm/Hz with 0dB input attenuation)

Frequency	RF Preamp Off	RF Preamp On
10Hz	-124 dBm	NA
100Hz to 10KHz	-135 dBm	NA
10KHz to 500KHz	-142 dBm	NA
500KHz to 10MHz	-142 dBm	-153 dBm
10MHz to 100MHz	-148 dBm	-161 dBm
100MHz to 1GHz	-144 dBm	-158 dBm
1GHz to 2.6GHz	-139 dBm	-151 dBm
2.6GHz to 3.3GHz	-135 dBm	-151 dBm
3.3GHz to 4.4GHz	-128 dBm	-134 dBm



Measuring Receiver

Operating Frequency 150KHz to 4.4GHz
FM Accuracy $\pm 1\%$ typical
AM Accuracy $\pm 1\%$ typical
Synchronous Level Detector ± 0.25 dBc ([+0dBm to -125dBm, 150KHz to 1GHz]
and [+0dBm to -115dBm, 1GHz to 4.4GHz])

Calibration Interval: 1-year

Operating Temperature

0°C to +70°C (Standard); -40°C to +85°C (Option-1)

Optional Accessories (not included)

- 1) 20dB Fixed Attenuator, Mini Circuits Part # VAT-20+
- 2) DC Block, Mini Circuits Part # BLK-89+
- 3) SMA(m) to BNC(f) Adapter, Mini Circuits part# SM-BF50+
- 4) 3GHz RF Probe, p/n P-20A (made by Auburn Technology, www.auburntec.com, phone 316-529-4520)

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Contact Us

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