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+\$# **What is a Spectrum Analyzer**

What is **RF Vision** and what can it do?

What is it?

A spectrum analyzer is a laboratory instrument used to convert a signal from the **time domain** (amplitude-vs-time) to the **frequency domain** (amplitude-vs-frequency). If you are familiar with an ordinary oscilloscope you know what a time domain display looks like. A frequency domain display is known as a **spectrum**. Unless you are measuring a single tone, an oscilloscope provides little in the way of frequency information; however, a spectrum analyzer clearly shows this information

How does it work?

The program works in conjunction with Science Workshop's RF Spectrum Analyzer hardware and the sound card on your computer. Plug the Analyzer X/Y output signals into the Line-In jack on the back of the sound card. The program then uses the card to perform an "Analog-to-Digital" conversion on the signals and extract the RF Spectral data and plot it on the screen in real-time.

What can it do?

- {bmc bm0.bmp} Check your transmitter output for "spurs".
- {bmc bm1.bmp} See if the band is "open" at a glance.
- {bmc bm2.bmp} Find a quiet spot on the band.
- {bmc bm3.bmp} Monitor ALL the local repeaters SIMULTANEOUSLY!.
- {bmc bm4.bmp} Receive "on-carrier" or "sub-carrier" ATV sound.
- {bmc bm5.bmp} Examine Satellite TV signals and their sub-carriers.
- {bmc bm6.bmp} Measure the amplitude and frequency of RFI generated by your computer.
- {bmc bm7.bmp} Orient and tune antennas for maximum results across a band of frequencies.
- {bmc bm8.bmp} Sweep an area for illegal "bugs"
- {bmc bm9.bmp} Identify modulation modes such as AM, FM, SSB, FSK, PCM etc.

+\$# **Basic Operation**

The program acquires the X/Y signals from Science Workshop's RF Spectrum Analyzer hardware, extracts the spectrum information, and displays it on the screen. The program will continuously acquire new data and display the results until stopped.

Science Workshop's RF Spectrum Analyzer hardware provides X and Y outputs which are normally used by an oscilloscope. The X output contains the voltage ramp used to control the RF tuner's VCO (Voltage Controlled Oscillator). The Y output contains the signal level detected by the tuner. As the tuner's frequency is swept by the ramp signal, it produces the RF spectrum corresponding to the sweep.

The RF Vision software synchronizes with the ramp start and stop limits and extracts the corresponding RF spectrum from the Y channel. This spectrum is then displayed in one of three views:

Views

- {bmc bm10.bmp} The Spectrum view displays the amplitude of the signal versus frequency.
- {bmc bm11.bmp} The Spectrogram view displays the spectra over time. The amplitude is shown in color.
- {bmc bm12.bmp} The 3-D Surface view displays a perspective of the spectra over time.

See Also: System Requirements

+\$# **Spectrum View**

This view is a 2 dimensional plot of the spectrum. The vertical axis shows the amplitude at each frequency and is scaled in Decibels (dB). The horizontal axis shows the frequency in Megahertz (MHz).

Zoom Button

The zoom button toggles the spectrum display between Zoom In and Zoom Out modes.

Out: The entire spectrum is displayed within the available plot area.

In: The spectrum is expanded horizontally to assure that all sample values are visible. A horizontal scroll bar will appear along the lower edge of the plot to allow the user to scroll to any portion of the available spectrum.

Note:

Because there are typically many more spectrum sample values than screen pixels, some detail may be lost when Zoomed Out.

See Also: [Cursor Measurements](#), [Calibration](#), [Measurement Accuracy](#), [Performance Issues](#)

+\$# **Spectrogram View**

This view displays the spectral data over time. The frequency axis is the same scale as the [spectrum plot](#) but the Y-axis now shows time. Color is used to show the amplitude. This view is especially useful for tracking frequency changes over time. The vertical axis is scaled in seconds relative to the start of the plot.

Notes:

Due to memory considerations, the display cannot be scrolled vertically. Maximize the window to show a full screen's worth of data.

The display will automatically be cleared if one of the following parameters changes:

{bmc bm15.bmp}	Ramp Time
{bmc bm16.bmp}	Calibration Settings

The display can also be cleared by using the Clear All command under the View menu.

See Also: [Cursor Measurements](#), [Settings](#), [Measurement Accuracy](#)

+\$# 3-D Surface View

This display is a perspective view of the spectral data over time. The frequency axis is the same scale as the [2-D Spectrum plot](#), and [Spectrogram](#). The Y-axis shows time. This view is useful for better visualizing the rf spectra as it changes over time. The vertical axis scaling is in seconds relative to the start of the plot.

Notes:

Due to memory considerations, the display cannot be scrolled vertically. Maximize the window to show a full screen's worth of data.

The display will automatically be cleared if one of the following parameters changes:

{bmc bm17.bmp}	Ramp Time
{bmc bm18.bmp}	Calibration Values

The display can also be cleared by using the Clear All command under the View menu.

See Also: [Cursor Measurements](#), [Calibration](#), [Measurement Accuracy](#), [Performance Issues](#)

\$# Ramp Channel Selection

Science Workshop's RF Spectrum Analyzer hardware provides X and Y outputs where the X output contains the voltage ramp used to control the RF tuner's VCO (Voltage Controlled Oscillator). The Y output contains the RF Spectrum signal level detected by the tuner.

Select which sound card channel contains the ramp signal. The opposite channel is assumed to contain the RF spectrum signal.

\$#Setting the Ramp Time

The ramp signal contains a sample of the voltage used to drive the VCO (Voltage Controlled Oscillator) for the RF Analyzer hardware. The software uses the ramp signal to synchronize with the resulting RF spectrum signal produced by your analyzer.

It is vital that the ramp time be accurately entered so that the program can correctly synchronize with the spectrum signal. Enter the correct value in milliseconds or push the "Synchronize" button to have the program measure the ramp time for you.

Pressing the Synchronize button causes the program to acquire a short sample of the ramp signal and measure the time between two adjacent ramp edges. Either a rising or falling edge will suffice.

Note:

If the ramp time is changed, the calibration values must be updated.

+\$# **Settings**

The Settings dialog box contains the following options:

- {bmc bm19.bmp} Ramp Channel Selection
- {bmc bm20.bmp} Ramp Time & Synchronization
- {bmc bm21.bmp} Averaging Block Size

Calibration

Calibrating the display involves setting the parameters which govern the frequency and amplitude axis labeling. In addition, these parameters are used when making cursor measurements.

Make sure the Enable Calibration check box is enabled.

Frequency Axis Calibration:

In order to calibrate the frequency axis, you must have either the optional center frequency readout from Science Workshop, or any suitable RF signal generator.

Procedure using Science Workshop's center frequency readout:

1. Use the center frequency control knob on the Analyzer Hardware to align the signal of interest with the yellow vertical center line of the spectrum display (if zoomed in, center the thumb control on the scroll bar).
2. Record the center frequency readout.
3. Slew the center frequency control so that this same signal is now aligned with the nearest vertical grid line. Again record the center frequency readout.
4. Open the Calibration dialog box and enter the first value in the Center Frequency edit control.
5. Enter the difference between the value and the second readouts in the Resolution edit control.

Procedure using an RF signal generator:

1. Set the signal generator output frequency so the reference signal is centered on the yellow vertical center line of the spectrum display.
2. Record the signal generator frequency.
3. Adjust the signal generator output frequency so the reference signal is aligned with the nearest vertical grid line. Again record the signal generator frequency.
4. Open the Calibration dialog box and enter the first value in the Center Frequency edit control.
5. Enter the difference between the first and second frequencies in the Resolution edit control.

Amplitude Axis Calibration:

In order to calibrate the amplitude axis, you must have a method of generating a reference signal level such as a RF signal generator.

Procedure using an RF signal generator:

1. Set the signal generator output frequency so the reference signal is visible anywhere within the spectrum plot.
2. Increase the signal level such that the reference signal aligns with the top of the plot.
3. Record the amplitude level.
4. Decrease the signal level such that the reference signal now aligns with the first

- horizontal grid line.
5. Again record the signal level.
 6. Open the Calibration dialog box and enter the first value in the Maximum Power edit control.
 7. Enter the difference between the first and second levels in the Resolution edit control.

Note: For a relative power measurement, enter Zero for the Maximum Power value and the difference between any two adjacent horizontal grid lines in the Resolution edit control. A simple attenuator can also be used to determine the grid line resolution.

\$# Averaging Block Size

This determines how many RF spectrum traces are averaged together to compute a moving average. For instance, if the averaging block size is set to 4, the spectrum currently displayed is an average of the previous 4 traces.

Averaging will effectively reduce the noise level. If the signal you are measuring is rapidly changing in frequency, a low averaging block size should be used. Use a high block size to "dig" out a steady state signal buried in a noisy background.

Setting the averaging size to "infinite" causes the program to average successive spectral traces continuously. Stopping and restarting the processor will reset the average.

Setting the block size to 1 will effectively disable averaging.

Note:

The averaging block size can be modified while processing by using the "Avg" control on the toolbar.

+\$# **Keyboard Shortcuts**

The toolbar contains icons for controlling the processor. Each icon's label has one of the letters underlined. Pressing the <Alt> key and the underlined letter will perform the same action as a button press.

In the same way, keyboard shortcuts are available for each menu item. Pressing the <Alt> key and the underlined letter in the menu and sub-menu item will allow quick access to the commands. For instance pressing <Alt> <V> followed by <Alt> <S> will toggle the Spectrum view.

There are several standard shortcut keys for all MDI (Multiple Document Interface) applications which are worth noting:

{bmc bm22.bmp}	<Ctrl> <F6> Cycles through each view.
{bmc bm23.bmp}	<Ctrl> <F4> Close the active view.

The horizontal scroll bar can be controlled by the keyboard as well as with the mouse. Click once on the scroll bar to give it the "focus". The following keys can then be used.

Right and Left arrow keys

The arrow keys cause the spectra display to scroll right or left one line at a time.

PageUp and PageDown

The PageUp and PageDown keys cause the spectra display to scroll right or left by 1/8 of the full spectra width.

Home and End

Home causes the spectra display to scroll fully to the left; End causes the spectra to scroll to the highest possible frequency.

Note:

Processing will automatically stop when any menu item other than **View** or **Window** is selected.

+\$# **Markers**

Markers are used to highlight specific frequencies of interest. Calibration must be Enabled for Markers to show on the screen.

The selected frequencies are marked differently depending upon the view:

- | | |
|----------------|--|
| {bmc bm24.bmp} | <u>Spectrum</u> - full scale vertical line in light blue. |
| {bmc bm25.bmp} | <u>Spectrogram</u> - red marks are shown along the bottom edge of the display. |
| {bmc bm26.bmp} | <u>3-D Surface</u> view - a red band is displayed at the marked frequency. |

Note:

The line marked may not be the exact marker frequency but it will be the closest possible frequency.

+#K **Device Options**

This allows you to select a specific sound card if more than one is installed in your system. In addition, the Sampling Precision (8 or 16 bit) can be selected.

16 bit precision is recommended if your sound card supports it. The program will automatically use the highest possible sampling rate supported by your sound card.

Notes:

{bmc bm27.bmp}

16 bit cards can be used in 8 bit mode.

{bmc bm28.bmp}

sampling precision.

If you have an 8 bit card you will be unable to select 16 bit

+\$#K **Measurement Accuracy**

Frequency Accuracy:

The frequency accuracy depends directly on the accuracy of the frequency calibration settings and the ramp time entered by the user. In addition, non-linearities in the ramp signal driving the VCO will reduce the frequency accuracy accordingly.

Amplitude Accuracy:

The Amplitude accuracy depends directly on the accuracy of the amplitude calibration settings entered by the user. Many sound cards also provide control over the input level via a software utility. The amplitude values are valid only at the input level setting when the calibration measurement was made. In addition, the amplitude linearity of the RF Spectrum Analyzer hardware is not guaranteed.

+\$# **Printing the results**

The program allows you to print one View at a time. Make the view you wish to print the active window by clicking anywhere in the plot. Size the view to display the information you wish to print; only the displayed data will be printed. Select <Print> from the menu, change any printer options and click OK.

Notes:

- {bmc bm29.bmp} For best results when printing the color Spectrogram on a monochrome printer, reduce the **intensity** on the options dialog under the Print Setup dialog box (not all printers support this feature).
- {bmc bm30.bmp} For printing the 3-D Surface plot on a monochrome printer, you may wish to turn off **dithering** on the options dialog under the Print Setup dialog box (not all printers support this feature).
- {bmc bm31.bmp} Color printers are supported.
- {bmc bm32.bmp} Pen Plotters are not supported for the Spectrogram and 3-D Surface plots

Cursor Measurements

Cursor Measurements are only available when Calibration has been Enabled.

Left Mouse Button:

Pressing the left mouse button anywhere within the plot region will display horizontal and vertical measurement boxes containing the values of the X and Y positions pointed to.

Right Mouse Button:

Pressing and holding the right mouse button anywhere within the plot region and **dragging** will display horizontal and vertical measurement boxes containing the **differential** values of the X and Y positions relative to the starting point. This is very useful for measuring the difference between two signals.

Note:

It is recommended that you "Stop" the Analyzer while using these mouse actions. There are no corresponding keyboard commands.

The 3-D Surface plot can be deceptive; you must measure along the base of the plot to determine the frequency. Aligning with the top of a peak will skew the measurement to the left because of the perspective orientation of the display.

+\$# **Setting up the Analyzer**

Setup the hardware:

Install the sound card and driver (refer to instructions included with your hardware) and connect the RF spectrum analyzer hardware X/Y outputs to the Line-In jack on the rear edge of the sound card. A stereo sound card is required.

Ramp Settings:

Prior to making a measurement, you need to specify the ramp time. Go to the Settings dialog box by selecting the <Settings> command under the <Options> menu item. If you know the current ramp time enter the value directly. Alternately, press the "Synchronize" button to have the software measure the ramp time directly from the signal itself.

Calibration setup:

If your system includes equipment to allow the frequencies and amplitudes of the signals to be determined, you can optionally specify these values in the Calibration dialog box. The plot axis will then be labeled and the mouse measurements will be enabled.

Open any of the views you wish to display

Each view can be opened and closed by toggling the corresponding menu item. A check mark will appear next to any open view. Views can be opened and closed even when the processor is running but in the case of the 3-D Surface and Spectrogram views, the contents are erased once closed.

Start the analyzer

Click <Run> on the toolbar or use the associated accelerator keys <alt> <R> to start the processor. The displays will then begin updating.

Stop the analyzer and make a measurement

Click <Stop> on the toolbar or use the associated accelerator keys <alt> <S> to stop the processor. Use the mouse to point to a feature of interest on one of the views and press the left mouse button. Measurement boxes will appear which contain the corresponding plot values. Calibration must be enabled for cursor measurements to work. (See Cursor Measurements for more information)

See also: Basic Operation, What is a Spectrum Analyzer?, Calibration, Printing

+\$# **System Requirements**

Comuter Hardware requirements:

{bmc bm35.bmp}	IBM PC or compatible with 80386 CPU or higher.
{bmc bm36.bmp}	2 MB RAM minimum.
{bmc bm37.bmp}	VGA monitor capable of a minimum of 16 colors.
{bmc bm38.bmp}	Hard Disk with 1MB free space.
{bmc bm39.bmp}	Math co-processor recommended but not required.
{bmc bm40.bmp}	Windows compatible Stereo sound card: 16 bit card recommended.
{bmc bm41.bmp}	Mouse or other pointing device.

Software requirements:

{bmc bm42.bmp}	Microsoft Windows Version 3.1 or higher.
{bmc bm43.bmp}	Sound Card drivers (supplied with Sound Card)

External Hardware Requirements:

{bmc bm44.bmp}	<u>Science Workshop's</u> RF Spectrum Analyzer
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+\$# **Status Bar**

The status bar is located along the bottom edge of the application. It contains the status of several key parameters. The left-most label contains the current processing status (i.e. "Running...").

The Ramp size in samples and Sampling Rate shown just to the right of the processor status. The ramp size is determined by the ramp time and the sampling rate. The program will automatically use the highest possible sampling rate supported by your sound card.

The "Peak" label contains the frequency of the strongest tone. This label is constantly updated with the current value if calibration has been enabled.

+\$#**Toolbar**

The toolbar contains icon buttons for Run, Stop, etc. In addition it contains controls for adjusting the and averaging block size on the fly.

List of Tools:

Run	Start the processor
Stop	Stop the processor
Avg	Adjust the <u>averaging block size</u>

See also: Basic Operation, Keyboard Shortcuts

\$#Technical Support

Please feel free to call or write.

Before calling, make sure that your sound board is properly installed and that the correct sound driver is installed. A good test to determine if your sound card is working is to run the "Sound Recorder" utility provided with Windows 3.1 in the Accessories group. Also, take a moment to view the "README.TXT" file for additional instructions.

For software technical questions please contact:

Pioneer Hill Software
24460 Mason Rd.
Poulsbo, WA 98370
voice/fax: (206) 697-3472

For RF Spectrum Analyzer hardware technical questions please contact:

Science Workshop
P.O. Box 310
Bethpage, NY 11714
voice: (516) 731-7628
fax: (516) 753-6680

\$# Science Workshop

P.O. Box 310

Bethpage, NY 11714

voice (516) 731-7628

fax: (516) 753-6680

Murray Barlowe (WA2PZO)

+\$#K **Processing Speed**

The update speed is affected by many factors. Foremost among these is the Ramp Time. Select a lower ramp time for faster performance but with reduced resolution.

Video speed is another factor. The more views that are displayed, the greater the demands placed on the video subsystem. The Spectrum plot is the fastest.

The 3-D Surface and Spectrogram views are significantly slower than the Spectrum view. You may want to close these views if you are not using them. Alternatively they will run slightly faster if minimized to an icon along the bottom of the display.

