Introduction

Greetings, fellow spectrum traveler.

The RF Explorer RackPRO (hereafter referred to as "RackPRO") has the advanced features of more expensive spectrum analyzers, but is designed to be intuitive and easy to use. There's no need to read large user manuals to get up to speed on the techniques you need to manage and monitor complex spectrum.

> Looking for Clear Waves software documentation?
> Please visit http://www.rfvenue.com/clearwaves
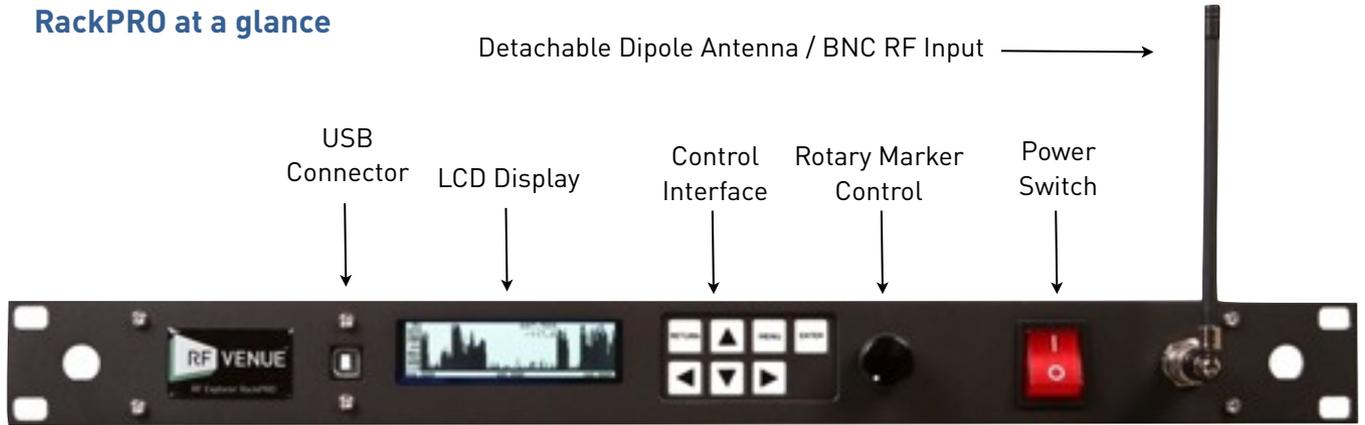> for a link to the online Clear Waves manual.

For instance, you do not need to adjust resolution bandwidth (RBW) every time you select a different frequency span. Actually, you don't even need to know what resolution bandwidth is! You can begin using the RackPRO with little to no knowledge of the scientific principles required to use more complicated analyzers and progress through the RackPRO's features at your own pace - returning to this manual and our growing library of online tutorials at your convenience.

We welcome your questions and feedback to make this manual as useful as possible. Please contribute with ideas, suggestions, and comments via email to orders@RFVenue.com.

Happy signal hunting,

RF Venue, Inc.

RackPRO at a glance

Detachable Dipole Antenna / BNC RF Input ⟶

USB Connector LCD Display Control Interface Rotary Marker Control Power Switch

## Spectrum Analyzer Mode - Main Screen

Upon startup, RackPRO goes to Spectrum Analyzer mode automatically.

The X axis represents frequency in MHZ and the Y axis represents actual received power (amplitude) in dBm or dBuV.

The main screen automatically displays a small marker with a triangle shape. This triangle indicates the peak amplitude found in the current frequency span, being the first text line the frequency in MHZ and the second line the amplitude at that particular point. The marker can be moved manually to display the amplitudes of other frequencies throughout the range using the wheel (more on this in the Configuration Menu).

The main screen has a number of additional indicators:
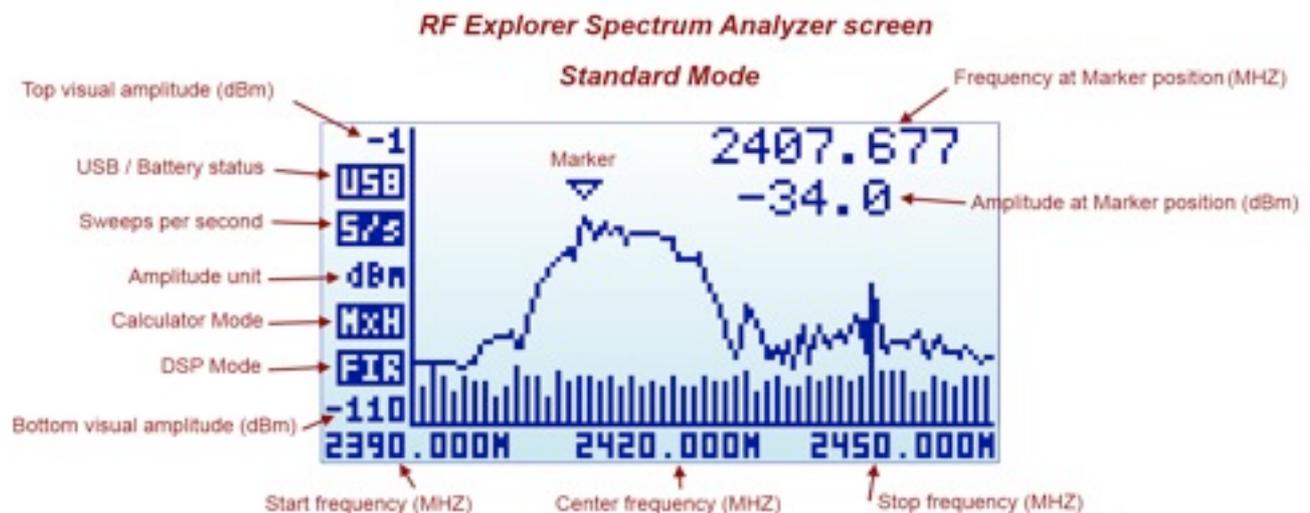
The available indicators are:

- **Sweeps per second**: this is an approximate value of the number of full screen sweeps happening every second. In the example above, there are 5 sweeps per second or, in equivalent terms, one sweep every 200ms.

- **Calculator mode**: this indicator may have different values as specified by the Calculator mode in the frequency menu.

- **DSP mode**: this indicator shows the actual value being used by the Analyzer. The *DSP:Auto* is the recommended setting in the Frequency Menu so RackPRO will select the best possible option as per below:

  - **FST**: Fast mode. This is the standard mode available.

- **Marker**: There are different operational modes for the marker, see Configuration Menu.

The analyzer screen can be turned into advanced mode using the [Return] key:

RF Explorer Spectrum Analyzer screen
Advanced Mode
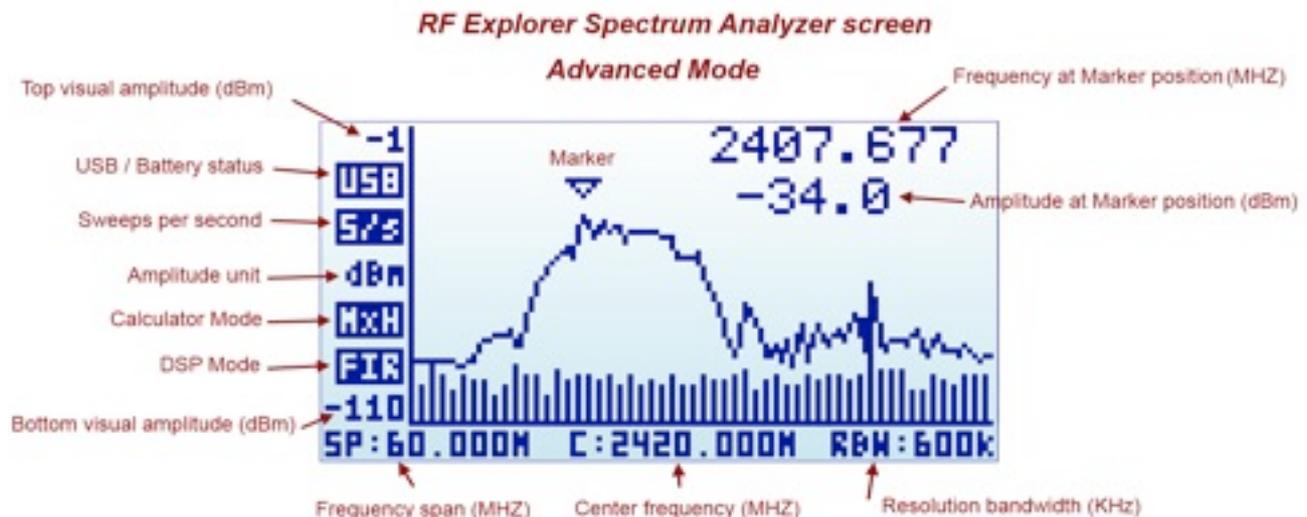
Note the frequency axis indicators changes at the bottom. More details about this screen mode in section *Analyzer screen*.

Using menus

There are several menus in RackPRO. They are organized on different screens, which you can iterate through by using the [Menu] key. If you click [Menu] button multiple times, you will visit every one of them:


Optionally, you can use the [Left] and [Right] keys to go from one screen to another.

You can exit from a menu anytime by using the [Return] key.

The first time you click on [Menu] button in a RackPRO session, Frequency Menu will open. This may change as we will see later, so every time you click on [Menu] from Spectrum Analyzer main screen, you actually re-open the last menu you were working with. In this way you save time by not having to navigate through all the menus to go the same place you were before.

Operational Mode menu

The menu display different functional modes available in your Analyzer.
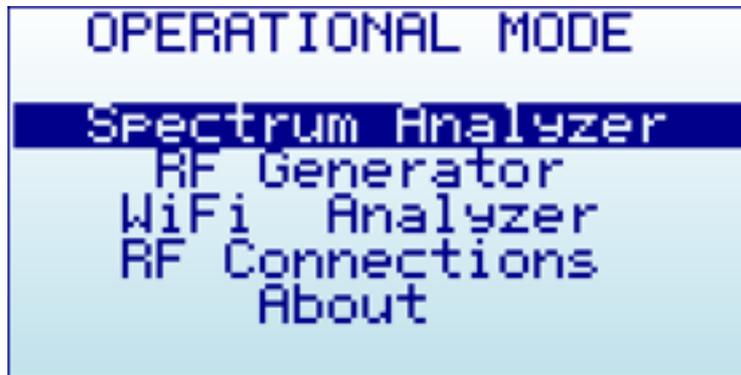
Use [Up] and [Down] arrow keys to select the desired mode and click on [Enter] to activate it immediately.

- Spectrum Analyzer mode is the default mode.

- RF Generator is not yet available on the RackPRO, it will display this message below:

- WiFi Analyzer is not available on the RackPRO.

- About displays information about installed firmware and versioning. Use any key to get out of this screen.

Frequency Menu
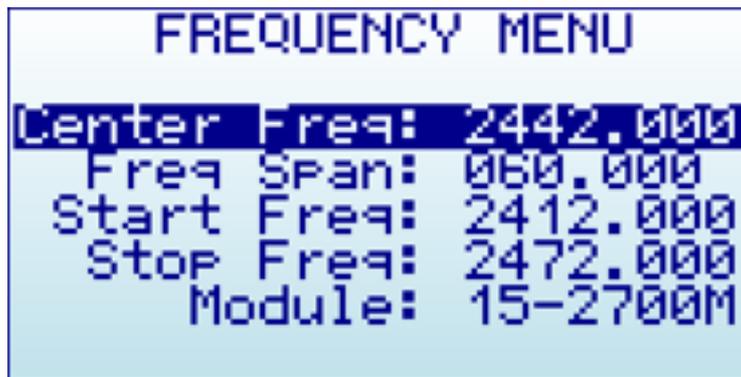
- **Center Freq**: Center frequency in MHZ

- **Freq Span**: Frequency span (or range) to display on screen in MHZ

- **Start Freq**: Lower frequency range to display on screen in MHZ

- **Stop Freq**: Higher frequency range to display on screen in MHZ

- **Module**: Active selected RF module. When an expansion module is installed, click [Enter] key to enable the module you need.

The selected frequency band to display can be specified in two different but complementary ways:

- **Center/Span**: This is the traditional Spectrum Analyzer format all engineers are used to. You select the Center frequency at which the band will be displayed, and then a Frequency Span.

- **Start/Stop**: This alternative mode is very useful to select frequency range between two frequencies of interest, with no need to manually calculate the Center or the Span.

The valid values for Frequency and Span are defined based on operational mode.

As you edit Center/Span or Start/Stop, the other values are updated accordingly, so feel free to use the method you prefer. In general, you will use Center/Span more frequently when you know the frequency you want to look at, and probably Start/Stop when you just want to look at a larger span to see what is happening in a specific range.

To navigate through the menu, just use [Up] and [Down] keys to go to the option you want, then click on [Enter] to edit that option, [Left] or [Right] to go to the digit you want to change, and [Enter] to confirm or [Return] to cancel.

As an example, a center frequency of 430MHz with a 20MHz span:

A click on the [Menu] button will open the Frequency Menu:
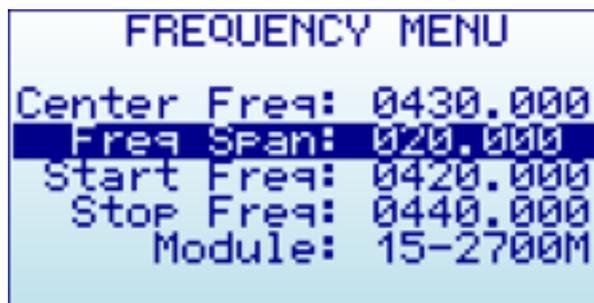
Selecting a span of 10MHz, the Start/Stop frequency changes accordingly:
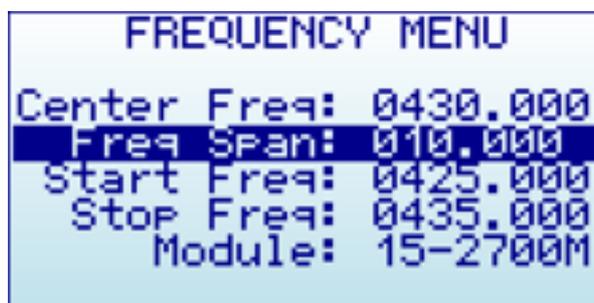
A click on [Return] button will close the menu and go back to Spectrum Analyzer main screen.

Note: *While RackPRO Spectrum Analyzer screen is enabled, the [Left] and [Right] buttons can be used to increase or decrease the Start/Stop frequency, virtually moving the visible spectrum to*

the left or the right 25% on every key press. This is helpful in order to offset the visual range without need to specify a new numeric range.
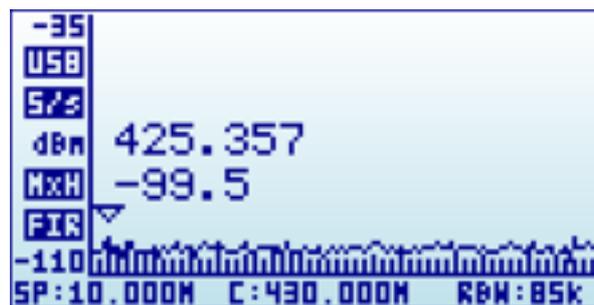
Analyzer screen in Advanced Mode

Alternatively, there is a simpler way to increase and decrease frequency span while keeping the center frequency. As this is a usual workflow, the RackPRO Spectrum Analyzer screen enables the [Return] key to switch between standard visualization mode and advanced mode.

In this screen above, the frequency reading at the bottom changed from Start/Center/Stop frequency to Span/Center/RBW. When this mode is enabled, a key press on [Left] or [Right] button will increase or decrease to double and half frequency span respectively.

As an example, to increase the span from 10MHz to 20MHz, a single click to the [Left] button is enough, no need to go back to the Frequency Menu.

Advanced: Understanding RBW

The advanced mode displays the currently selected RBW (Resolution Band Width). This is an important concept for advanced users.

The RBW references the internal filter used to discriminate the bandwidth of each sweep step. In the RackPRO's user interface, each measurement dot represents a range of frequencies, and there are exactly 112 steps on each sweep. As an example, in a 10MHz span, each of the 112 measurement steps represents 10MHz/112=0.089MHz or, in other words, 89KHz.

The range of frequencies represented on each sweep step is a level of uncertainty; screen resolution is limited to that RBW. With a resolution of 89KHz on screen (for a 10MHz span), the best accuracy expected is exactly that value. In other words, a frequency reading of 430.100MHz on screen may mean a range of +/-44.5KHz each side, as the filter will not discriminate further than that for a 10MHz span.

In addition to that, RBW has an important impact on the sensitivity of the Spectrum Analyzer. The wider the filter bandwidth, the higher the spectral noise and therefore the lower the sensitivity. This is visible by an increasing noise floor as the RBW is larger, and lower noise floor as the RBW is narrower. Based on this, the narrowest RBW would look like the better choice for all measurements but as you get a narrower RBW you also decrease the scan speed notably, due to the slower nature of narrow filter as well as the need to measure more sweep points to cover the full span.

To put it simply: selecting the best combination of RBW, scan speed and sensitivity requires significant experience. In most Spectrum Analyzers, operator needs to fully understand and select RBW for each measurement, this being one of the most challenging aspects of proper Spectrum Analyzer usage.

Fortunately, this is not the case with RackPRO: The design of the internal DSP includes sophisticated internal tables and algorithms to make the best possible choice at all times automatically. No user intervention is required to get the best compromise between scan speed, noise floor and sensitivity every time.

In all cases, the internal RBW can be checked anytime on the advanced screen mode.

Attenuator Menu
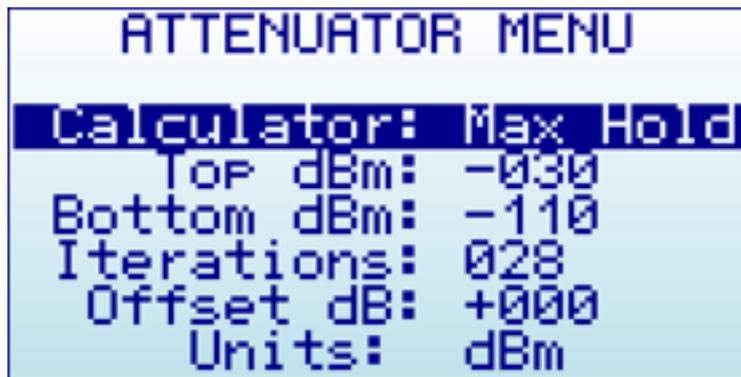
- **Calculator**: internal DSP calculator mode.

- **Top dBm**: Visual max amplitude on screen.

- **Bottom dBm**: Visual min amplitude on screen.

- **Iterations**: Internal DSP calculator iterations.

- **Offset dB**: external dB attenuation or gain value to compensate for external devices, such as attenuators or amplifiers.

- **Units**: dBm or dBuV.

RackPRO automatically handles the internal pre-amplifier and attenuator in order to provide the best possible dynamic range with no need of manual selection. The selected top and bottom dBm are visual limits, not real internal limits.

The internal DSP optionally performs advanced calculations in order to configure the analyzer for the required measurement:

- **Calculator** offers multiple modes to display data, to change mode click on [Enter] key:

    o **Max**: Peak values are used from the last sweep Iterations (see menu option at the bottom). This is the standard mode you will want to use to detect rapidly changing DSS signals or find for worst case channel occupancy.

    o **Max Hold**: Capture all activity in the band including the Max signal envelope mode with vector graphics and real-time activity with vertical bars. Use this mode anytime you want to detect activity for a long period of time. As this is a cumulative mode, while on Spectrum Analyzer screen you can clear the spectrum anytime with the RETURN button.

- **Average**: Arithmetic media average is calculated over the last sweep Iterations. This is the best possible choice to remove unwanted white noise from screen, particularly useful in constant wave (CW) and channel signals display.

- **Normal**: No calculation is done, just raw data as result of the realtime sweep.

- **Overwrite**: Useful to track unlimited activity in the band. Darker areas will point to high activity signal. You can clear the spectrum anytime with the RETURN button.

- **Iterations**: The number of sweep data iterations to perform calculations on. It goes from 1 to 28. As an example, a value of 5 with Calculator: Average means the DSP will use 5 complete accumulated sweeps to average data.

Note: Selecting a higher or lower Top dBm value is a very frequent workflow, as you typically want to zoom in or out based on signal power being measured. The RackPRO Spectrum Analyzer main screen offers two keyboard shortcuts: [Up] and [Down] arrow keys can be used to increase or decrease Top dBm respectively by 5dBm each time. This shortcut, together with [Left] and [Right] for moving Center Frequency or Span as described before, are very convenient to make configuration changes real-time with no need to visit the Menu.

Configuration Menu

- **Backlight**: Several levels of display backlight. RackPRO's screen has good visibility indoor and outdoor, including direct sunlight. The level of backlight should be the appropriate for each condition, and you may want to limit backlight brightness to preserve battery capacity.

- **Contrast**: There are 10 different display contrast levels to choose from.

- **USB Bauds**: Default is 500Kbps, which is also the recommended setting. In the rare case you experience a problem when connecting with the PC, you may want to change this to 2400bps slower speed. However, this is not recommended as the connection will be really slow, so do this only if there is a good reason to. The port speed in the RackPRO and PC Client settings must match to properly establish a connection.

- **Draw mode**: Vectors is the standard mode, and Fill can be specified if additional contrast is required by filling the area behind the signal.

- **Marker**: There are three different modes available for the Marker on the Spectrum Analyzer screen:

  - **Peak**: The marker will automatically detect the peak value on screen.

  - **Manual**: The marker can be manually moved anywhere on screen by using [Left] and [Right] buttons. When this mode is selected, the standard functions to move Center Frequency or Span are disabled.

  - **None**: The marker is not displayed.

- **DSP**: The DSP (Digital Signal Processor) can be configured in different ways in order to select the best possible choice of noise reduction, image rejection and scan speed.

  - **Auto**: This is the recommended option for all users. When Auto mode is enabled, the internal configuration tables will select the best possible

algorithm. The Spectrum Analyzer screen will display a FIR (Filter) or FST (Fast) mode to indicate the actual DSP mode being used.

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Protecting your instrument from damage

RackPRO is a very sensitive device. It can detect signals as low as -120dBm, which is 10E-12mW or 9nA over a 50ohm load.

This extreme sensitivity comes at the price of fragility; your device needs careful handling and protection in order to run for many years.

Most RF technicians know the RF instruments have to be protected in order to survive the high Electro Magnetic (EM) fields that may be in the environment.

Expensive instruments like $50,000 full sized Spectrum Analyzers and Signal Analyzers come with a long list of handling procedures the operator must observe in order to limit any chance of damage.

The first and most obvious precaution is to make sure the input RF power is not beyond the acceptable levels of the instrument.

The RackPRO is well protected up to +30dBm (1Watt) input power, which is plenty to play safe in many environments.

However, there are certain scenarios that must be avoided. These include proximity to microwave ovens and high power transmission sites - like cell and broadcast towers.

What may not be obvious to all users is that harmful exposure is possible **any RF frequency band, even if the RackPRO is powered off**.

As an example, the RackPRO has a frequency range of 240-960MHz - and will not detect a microwave oven (2.4GHz) on the screen, but can be very well damaged by it. Similarly, a strong 2 meter HAM or FM high power transmit station won't be detected, but still induces enough RF power to kill the RF circuitry with ease. And that doesn't depend on RackPRO being ON or OFF because the antenna will receive that powerful signal and will inject it into the spectrum analyzer, with serious risk of damage.

Specifications

FCC and CE regulations

RackPRO is a Test and Measurement device, and therefore compatible with US FCC regulation 47 CFR Part 15.103(c).

RackPRO is certified for CE compliance under regulations EN/IEC61236 and EN/IEC61000.

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