



# Spike™ Spectrum Analyzer Software User Manual

# **Spike™ Spectrum Analyzer Software User Manual**

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# 1 Overview

This document outlines the operation and functionality of the Signal Hound Spike™ spectrum analyzer software. Spike™ is compatible with Signal Hound's line of spectrum analyzers and tracking generators which include,

- SM series – SM200A / SM200B / SM200C / SM435B / SM435C
- SP series – SP145



- BB series - BB60A / BB60C / BB60D
- SA series - SA44 / SA44B / SA124A / SA124B
- TG series - TG44 / TG124
  - A TG series device can only be interfaced when a compatible spectrum analyzer is connected in the Spike software.

This document will guide users through the setup and operation of the software. Users can use this document to learn what types of measurements the software is capable of, how to perform these measurements, and how to configure the software.

## 1.1 WHAT'S NEW

With Version 3.0, the software has been rebranded Spike. The software now supports all Signal Hound spectrum analyzers and tracking generators. Some older versions of the SA44 and SA124 require a firmware update to work with Spike.

## 1.2 SOFTWARE UPDATES

The latest version of the Spike software is always available at [www.signalhound.com/Spike](http://www.signalhound.com/Spike). As of Spike Version 3.0.10, the software will also alert a user when a newer version of the software is available. This alert will appear in the status bar as well as on the Help->About Spike dialog. The software will provide a link to where the latest version can be downloaded.

# 2 Preparation

## 2.1 SYSTEM REQUIREMENTS

### Supported Operating Systems\*

- Windows 10/11 64-bit (recommended)
- Windows 7/8 32/64-bit (minimum)\*\*
- Ubuntu 18.04/20.04 64-bit (SM, SP, and BB devices only)

### Minimum System Requirements

- Processor requirements
  - SM435B, SM200B/A, SP145, BB60D/C/A
    - Intel Desktop quad-core i5/i7 processors, 4th generator or later\*\*\*.
  - SM435C, SM200C
    - Windows 10 or Ubuntu 18.04 is recommended.
    - For 200MS/s I/Q streaming, 8<sup>th</sup> generation i7 or newer is recommended.
  - SA44/SA124
    - Dual-core Intel processors.

- RAM requirements, the software will on average require less than 1GB of memory, certain configurations for the BB and SM products can consume several GB of memory.
  - Recommended - 8 GB
  - Minimum - 4 GB
- Peripheral support
  - SM435B, SM200B/A, BB60D/C/A
    - USB 3.0
  - SP145
    - USB 3.0 type C port with 10W power delivery.
    - Or, USB 3.0 using external power supply.
  - SM435C, SM200C
    - 10GbE network connectivity through NIC via SFP+ connectors or through Thunderbolt 3 to SFP+ adapter. See network setup guide for more information.
  - SA44/SA124
    - USB 2.0
- Graphics drivers
  - OpenGL 3.0 support

(\* We do not recommend running the Signal Hound products in a virtual machine, i.e. Parallels/VMWare/etc.)

(\*\* For Windows 7/8, it may be necessary to install the [Microsoft Visual C++ 2015-2022 Redistributable](#).)

(\*\*\* Our software is highly optimized for Intel CPUs. We recommend them exclusively. Xeon processors are not recommended)

## 2.2 SOFTWARE INSTALLATION (WINDOWS)

The software can be found on the CD included with your purchase or on our website at [www.SignalHound.com/Spike](http://www.SignalHound.com/Spike). The most current version of the software is always on the website.

Once you have located the software, on Windows systems run the **Spike Installer(x64).msi** or the **Spike Installer(x86).msi** and follow the on-screen instructions. You must have administrative privilege to install the software. The installer will install the device drivers for the SM, SP, and BB series devices. The SA and TG series drivers must be installed separately and can be found at [www.signalhound.com/Spike](http://www.signalhound.com/Spike).

It is recommended to install the application folder in the default location.

**Note:** It is becoming more common for customers to need to enable the “High Performance” power plan in the *Control Panel* -> *Power Options* menu. If you are using a low power/ultra-portable PC or laptop, consider this step to ensure optimal performance. See [power management settings](#) for more information.

## 2.3 SOFTWARE INSTALLATION (LINUX)

Download the latest Linux Spike application at [www.signalhound.com/spike](http://www.signalhound.com/spike). Follow the installation instructions found in the README file included in the download.

## 2.4 DRIVER INSTALLATION (WINDOWS)

The drivers for the SA series devices must be downloaded and installed separately. Visit the [www.signalhound.com/Spike](http://www.signalhound.com/Spike) page to download the USB drivers. The installer must be run as administrator.

The drivers for the USB 3.0 devices are placed in the application folder during installation. The `\drivers\x86\` folder are for 32-bit systems and the `\drivers\x64\` folder for 64-bit systems. The drivers should install automatically during setup. If for some reason the drivers did not install correctly, you can manually install them in two ways by following the instructions below.

To manually install the USB 3.0 drivers, navigate to the application folder (where you installed the Spike software) and find the **Drivers64bit.exe** file. (If on a 32-bit system, find the Drivers32bit.exe file) Right click it and Run as administrator. The console output will tell you if the installation was successful.

If manually running the driver installers did not work, make sure the driver files are in their respective folders and follow the instructions below.

You may manually install the drivers through the Windows device manager. On Windows 7 systems with the device plugged in, click the **Start Menu** and Device and Printers. Find the FX3 unknown USB 3.0 device and right click the icon and select Properties. From there select the Hardware tab and then Properties. Select the Change Settings button. Hit the Update Drivers button and then Browse My Computer for drivers. From there navigate to the Spike application folder and select the folder name drivers/x64. Hit OK and wait for the drivers to install.

On Windows 10 and newer systems, you can right click on the .inf file in the respective driver folder and select "Install".

If for some reason the drivers still did not install properly, contact Signal Hound.

## 2.5 DRIVER INSTALLATION (LINUX)

Signal Hound USB devices use the libusb driver on Linux. Please follow all installation instructions found in the README file in the Linux application download.

## 2.6 CONNECTING YOUR SIGNAL HOUND

With the software and device drivers installed, you are ready to connect your device. The supplied device USB cable should be connected to the PC first, then connected to the device. If your device supplies a Y-cable, ensure both USB ends are connected into the PC before connecting the device.

Once connected, you can verify the device has been properly recognized by the computer by looking in the device manager under the “Universal Serial Bus Controllers” tab.

Once connected, run Spike. The first time a device is run on a new PC, it may require additional initialization time.

If your device uses a 10GbE network connection, please see our separate network configuration manual for additional instructions.

## 2.7 RUNNING THE SOFTWARE FOR THE FIRST TIME

Once the software and drivers have been installed and the device is connected to the PC, you can launch the software. This can be done through the desktop shortcut or the *Spike.exe* file found in the installation directory. The default installation directory for Spike on Windows is C:\Program Files\Signal Hound\Spike. If a USB device is connected to the PC or an Ethernet device’s network address has been saved when the software is launched, the software will attempt to open the device immediately.

If no USB device is connected to the PC and no Ethernet device’s network address has been saved, the software will notify you. If multiple devices are found, a selection dialog will appear allowing you to choose which device to connect. Cancel to go into Idle mode.

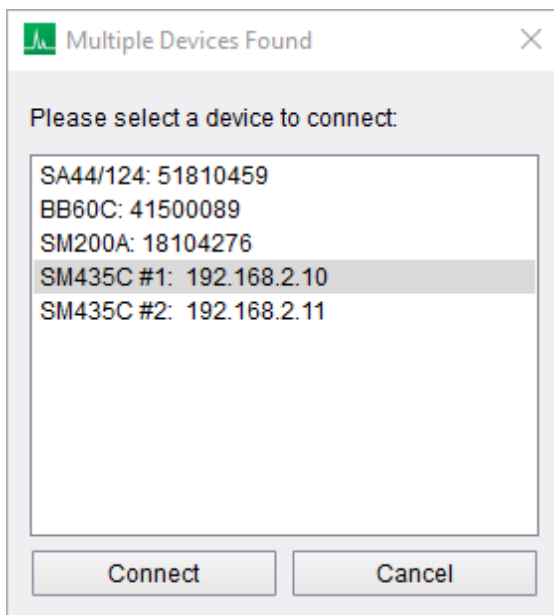


Figure 1: Multiple Devices Found dialog

In Idle mode, a device can be opened using the **File > Connect Device** menu option.

If your Signal Hound device is connected to the PC and the Spike software still reports no devices found, see the [Troubleshooting](#) section for more information.

Note: If you see the IF overload message on program startup, please see this [troubleshooting tip](#).

## 3 Getting Started

This section describes the UI in detail and how the UI can be used to control your Signal Hound spectrum analyzer.

Below is an image of the software on startup. If a device is connected when the application is launched, the software begins sweeping the full span of the device:

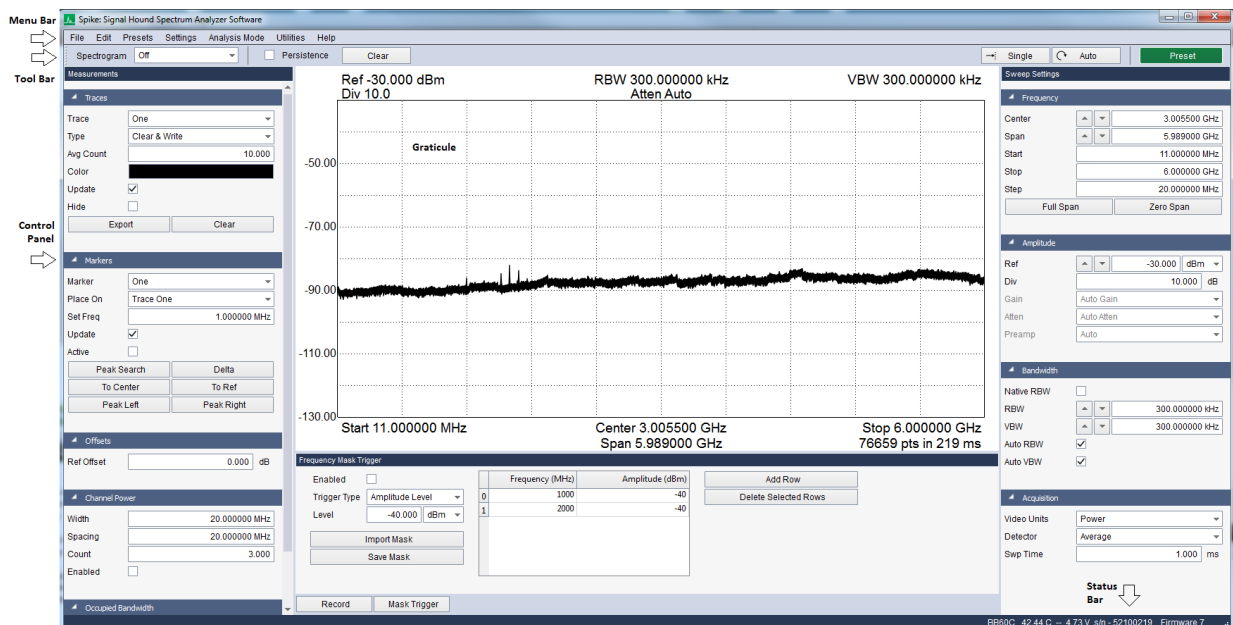


Figure 2 : Spike™ UI after launch

### 3.1 THE MENU

#### 3.1.1 File Menu

- **Load User Preset** – Load a user selected preset. See [Presets](#) for more information.
- **Save User Preset** – Save a user selected preset. See [Presets](#) for more information.
- **Print** – Print the current view. Whether or not the control panels are included alongside graticule is chosen in Preferences > Screenshot Settings > Include Control Panels in Image.
- **Save as Image** – Save the current view as a PNG, JPG, or BMP image.
- **Quick Save Image** – Capture the current view as a PNG image without specifying the file name or save location. The image files are named in increasing order and prefixed with

- Spikelmage*. The save directory is the last directory used to save an image file. If an image file has never been saved, this defaults to *MyDocuments/SignalHound*.
- **Manage Correction Data** – Bring up dialog to view and clear correction data files for your Signal Hound devices. See [Correction Data](#) for more information.
  - **Connect Device** – If no device is connected, this will attempt to discover all Signal Hound devices connected to the PC via USB and list the devices and their serial numbers. It will also list saved network devices by name. From this list, a single device can be selected.
  - **Manage Ethernet Devices** - Bring up dialog to add, edit, and remove name and addressing information for Signal Hound devices that connect via Ethernet, such as the SM200C and SM435C. See [Ethernet Devices](#) for more information.
  - **Disconnect Device** – This option disconnects the currently connected device. This option combined with “Connect Device” is useful for cycling a devices power or swapping devices without closing the Signal Hound software.
  - **Exit** – Disconnect the device and close the software.

### 3.1.2 Edit Menu

- **Restore Default Layout** – After selecting this option, the software will restore its original layout the next time the application is launched.
- **Title** – Enable or disable a custom title. The title appears above the graticule and is included in the screen captures via printing as well as session recordings.
- **Clear Title** – Remove the current title.
- **Hide Control Panels** – Temporarily hides all visible control panels. Useful for presentations or for viewing on small resolution displays.
- **Show Control Panels** – Shows any control panels that were previously hidden. If the mode changes or a preset is loaded, the software will automatically show any hidden control panels.
- **Theme** – Select a color theme for the application. This sets every color in the Colors section of the Preferences dialog.
- **Preferences** – Opens a configuration dialog allowing further configuration of the software.

### 3.1.3 Presets

Presets are an easy way to store and load measurement configurations. Each preset stores the full software configuration making it easy to switch between measurement configurations and pick back up where you left off.

Presets have the file extension ‘ini’ which is a Windows initialization file. The Spike software can store and load presets in three ways. In the file menu, the user can save and load explicit preset files by selecting the ini files directly. Alternatively, in the Presets menu, up to 9 presets are available for quick use. These presets are always available and can be quickly loaded with keyboard shortcuts. Finally, a power on preset can be saved from the Presets menu, which will automatically load when a device is connected.

Presets can only be loaded by the same type of device which was used when the preset was saved.

Presets accessed through the Preset menu are stored in C:\Users\YourUserName\AppData\Roaming\SignalHound\. AppData\ is a hidden folder by default on Windows systems. Each quick preset is stored in its own folder labeled "Preset [1-9]". The main file has the .ini extension and is named "Preset [1-9].ini". The power on preset is named "PowerOnPreset.ini". To use a preset on a different computer, simply copy the preset folder to the new computer in the correct path.

The power on preset can be deleted from the Presets menu, or it can be manually deleted from the file system.

### 3.1.4 Settings

- **Reference** – Change the source of the reference oscillator and whether a 10 MHz reference signal is emitted.
  - Internal or external reference can be chosen. If external reference is chosen, ensure a 10MHz reference is connected to the appropriate BNC or SMA input port.
  - For select devices, a reference output can be enabled.
  - Device Options
    - SM analyzers
      - **Use Internal Reference** – Use the internal 10 MHz clock.
      - **Use External Reference** – Use an external 10 MHz clock into the "10 MHz In" SMA port.
      - **Internal Out Enabled** – Emit a 10 MHz reference signal from the "10 MHz Out" SMA port.
    - SP analyzers
      - **Use Internal Reference** – Use the internal 10MHz clock.
      - **Use External Reference** – Use an external 10MHz reference clock. If one is not present and this selection is chosen, a large frequency offset will be present in the measurement.
    - BB60 analyzers
      - **Use Internal Reference** – Use the internal 10 MHz clock.
      - **Use External Reference (AC)** – Use an external 10 MHz AC/sin wave reference clock into the "10 MHz Ref In/Out" BNC port.
      - **Use External Reference (DC)** – Use an external 10 MHz DC/CMOS-TTL input clock into the "10 MHz Ref In/Out" BNC port.
      - **Reference Out** – Emit a 10 MHz reference signal from the "10 MHz Ref In/Out" BNC port. Internal corrections will not be applied since it is assumed that the incoming signal is from an instrument referenced to the BB60's own 10 MHz output.
    - SA124B
      - **Not Set, Use Internal Reference** – Use the internal 10 MHz clock.
      - **Internal Reference Out** – Emit a 10 MHz reference signal from from the "10 MHz Ref In/Out" BNC port.
      - **Use External Reference** – Use an external 10 MHz clock into the "10 MHz Ref In/Out" BNC port.
    - SA44B

- **Not Set, Use Internal Reference** – Use the internal 10 MHz clock.
- **Internal Reference Out** – NOT USED.
- **Use External Reference** – Use an external 10 MHz clock into the “10 MHz Ref In” BNC port.
- **Reference Level Offset** - Adjust the measurement amplitude to compensate for an attenuator, probe, or preamplifier. The offset is specified as a flat dB offset. This offset is then applied to the measurement. See [Using the Reference Level Offset](#) for more information.
- **Spur Reject** – See [Spur Rejection](#) for more information.
- **Enable Manual Gain/Atten** – Enable the ability to change gain and attenuation. Signal Hound recommends keeping gain and attenuation set to automatic and controlling the sensitivity of the receiver through the reference level control.

### 3.1.5 Analysis Mode

This menu option allows you to switch between the main measurement modes in Spike.

- **Idle** – Suspend operation.
- **Sweep** – See [Swept Analysis](#) for more information.
- **Real-Time** – See [Real Time Spectrum Analysis](#) for more information.
- **Zero-Span** – See [Zero Span Analysis](#) for more information.
- **Harmonics** – See [Harmonic Analysis](#) for more information.
- **Scalar Network Analyzer** – See [Scalar Network Analysis](#) for more information.
- **Phase Noise** – See [Phase Noise](#) for more information.
- **Digital Modulation Analysis** – See [Digital Demodulation](#) for more information.
- **EMC Precompliance** – See [EMC Precompliance](#) for more information.
- **Analog Demod** – See [Analog Demod](#) for more information.
- **Interference Hunting** – See [Interference Hunting](#) for more information.
- **Spectrum Emission Mask** – See [Spectrum Emission Mask](#) for more information.
- **Noise Figure** – See [Noise Figure](#) for more information.
- **Bluetooth® Low Energy** – See [Bluetooth® Low Energy](#) for more information.
- **WLAN** - See [WLAN Modulation Analysis](#) for more information.
- **LTE** – See [LTE](#) for more information.
- **Mapping** – See [Mapping](#) for more information.

### 3.1.6 Utilities

- **Path Loss Tables** – See [Managing Loss Tables](#) for more information.
- **Limit Lines** – See [Managing Limit Lines](#) for more information.
- **Audio Player** – See [Audio Player](#) for more information.
- **Measuring Receiver** – See [Using the Measuring Receiver Utility](#) for more information.
- **Frequency Difference Meter** – See the [Frequency Difference Meter](#) for more information.
- **Timebase Adjustment** – See [Adjusting Your Timebase](#) for more information.
- **Tracking Generator Controls** – If a SA or BB series spectrum analyzer is the current active device in the software and a Signal Hound tracking generator is connected to the PC, selecting this utility introduces an additional control panel for controlling the tracking



- generator output manually. The tracking generator will only respond if the scalar network analysis mode is not active.
- **SA124 IF Output** – Brings up a dialog box to control the IF downconverter for the SA124 spectrum analyzers. While the SA124 IF downconverter is active, the device cannot perform other tasks.
  - **SM435 IF Output** – Control the SM435 as an IF downconverter. The SM435 device must have the IF output option. The SM435 can function as a 24-43.5GHz to 1.5GHz downconverter, with 800MHz of bandwidth. While the device is functioning as a downconverter no other measurements can be performed.
  - **Self-Test** – Brings up a dialog box to manually self-test SA44B and SA124B devices. The dialog will explain the process of setting up the device for self-test and will display the results immediately after the test is performed.
  - **BB60D UART Controls** – See [BB60D GPIO Controls](#) for more information.
  - **SP145 UART Controls** – See [SP145 GPIO Controls](#) for more information.
  - **SM GPIO Controls** – See [SM GPIO Controls](#) for more information.
  - **Diagnostics** – Brings up a dialog window with various temperature and power sensor measurements depending on device. Also, for devices that have active cooling, provides fan setpoint control.
  - **Networked Speed Test** – See [Networked Speed Test](#) for more information.
  - **GPS Control Panel** – See [GPS](#) for more information.
  - **SM Network Configuration** – See [SM Network Address Configuration](#) for more information.
  - **I/Q Recorder** – See [I/Q Recorder](#) for more information.
  - **SCPI Log** – See [SCPI Log](#) for more information.

### 3.1.7 Help

- **User Manual** – Open the Spike user manual in the system default PDF reader.
- **Signal Hound Website** – Open [www.signalhound.com](http://www.signalhound.com) in the system default web browser.
- **Support Forums** – Open the signal hound support forum web page in the system default web browser.
- **About Spike** – Display version and product information.

## 3.2 THE CONTROL PANELS

The control panels are a collection of interface elements for configuring the device and configuring the measurement utilities of the software. Each control panel can be moved to accommodate a user's preference. The panels may be stacked vertically, dropped on top of each other (tabbed), or placed side by side. This can be accomplished by dragging the panels via the control panel's title bar.

Different measurement modes will show different control panels. These controls are described in more detail in [Analysis Modes](#).

## 3.3 THE TOOL BARS

The tool bar is located under the application menu. The toolbar is populated with commonly used functionality and view related controls for the current software configuration. All measurement modes share a set of controls while some measurements provide additional controls.

The shared functionality is described below.

- **Single** – Request the software perform one more measurement before pausing.
- **Auto** – Request that the software continuously perform measurements.
- **Recal** – Recalibrate the device for any potential temperature drift. This button should be pressed any time the software presents the *Perform Cal* annunciator or when the user believes a recent change in temperature is affecting the measurement accuracy. Most measurement modes will auto recalibrate the device when a 2C temperature drift has been measured.
- **Preset** – Restores the software and hardware to its initial power-on state by performing a device master reset.

## 3.4 PREFERENCES

The preferences menu can be found under *Edit Menu* → *Preferences*. The preferences menu contains a collection of settings to further configure the Spike software.

- **Trace Width** – Determines the overall width of the trace being drawn on the graticule.
- **Graticule Width** – Determines the width of the lines that make up the graticule.
- **Graticule Dotted** – Set whether the non-border graticule lines are dotted or solid.
- **Display Line Width** – Determines the width of the display line being drawn on the graticule.
- **Export Sweep Minimums** – When this control is selected, the Export trace button will export a CSV of the form (frequency (Hz), min amplitude, max amplitude) instead of the normal form (frequency (Hz), max amplitude).
- **Export Scale** – Select the frequency units to be used when exporting a trace.
- **Real Time Frame Rate** – Set the update rate of the device and software when operating in real-time mode. Higher frame rates improve the resolution of events but also require higher PC performance. Can set values between 4 and 30 fps. This setting affects the SA and BB devices only.
- **Max Save File Size** – Control the maximum size of a sweep recording. The software will stop recording when the max file size has been reached. For 32-bit machines, 1GB is the maximum possible file size. On 64-bit machines, the max file size can be set to 128GB.
- **Include Control Panels in Image** – Toggles whether the control panels will appear along with the graticule in screenshot functions “Save as Image,” “Quick Save Image,” and “Print.”
- **Auto Reconnect** – Automatically attempt to reconnect device after a forced disconnect.
- **Auto Reconnect Timeout** – Duration of auto-reconnect attempt.

- **Show No/Multiple Device Notifications** – Show modal alert on startup if there are either no devices connected or multiple devices connected. If there are no devices connected, then in order to run in demo mode this alert must be shown. If there are multiple devices, then Spike will start in Idle mode, and the user must select a device to connect with File > Connect.
- **Auto Recal** – Automatically recalibrate the device when a 2C temperature drift has been measured.
- **Colors** – Control the color of various software features.
- **SCPI Enabled** – When enabled, the Spike software will listen on the chosen IP port for an incoming connection. If this selection is changed, the software must be restarted to take effect.
- **IP Port** – The port on which the Spike software listens for an incoming connection for SCPI control over TCP/IP.
- **Lockout Dialog Enabled** – Show a modal alert dialog to indicate that Spike is being operated remotely via SCPI commands.
- **Log Enabled** – Timestamp and save to a log all incoming and outgoing SCPI messages.
- **Log Max Entries** – The maximum number of total entries in the log.
- **Log Max Message Length** – The maximum number of characters that a SCPI message in the log may retain. Longer messages entering the log will be truncated to this length.
- **Log FIFO Mode** – Drop the oldest messages when new messages are received or sent after the log max entries has been exceeded, otherwise new messages will not be logged.

### 3.4.1 Language Selection

The Spike software offers multiple language choices for most user-facing text and strings. The first time the software is launched on a PC, Spike will attempt to determine the best translation based on locale. Once loaded Spike will remember the last language used.

In the preference menu, a user can change the translation Spike uses. Simply select the language of choice and press “Apply”. Once applied, the software will need to be restarted to take effect. On the next program launch, the selected language will be loaded.

## 3.5 THE STATUS BAR

The status bar runs across the bottom of the application. When the mouse enters the graticule the status bar displays the frequency/time value for the x-axis and the amplitude/frequency value for the y-axis. The status bar readings should not be used for precise measurements but is great for quick estimations.

The status bar also displays information about the current device connected if there is one. The type of device, temperature of the device, power supplied to the device, the device serial number and firmware version are displayed.

## 3.6 ANNUNCIATOR LIST

Annunciators are warnings and indicators providing useful information to the operator. Annunciators are typically displayed in the upper left-hand corner of the graticule. Below is a list of all annunciators and their meanings.

- **IF overload** – This indicator appears when hard compression is present on the displayed measurement. This annunciator will appear in the top center of the graticule and will trigger the UNCAL indicator. This occurs when the input RF signal reaches the maximum possible digital level. To fix this, decrease input signal amplitude, increase the reference level, increase attenuation, or lower gain.
- **USB/UDP** – This indicator appears when data loss occurred over USB (for USB devices) or the network (for 10GbE devices). The data loss results in an incomplete or failed measurement. The software will continue to attempt to perform measurements in this scenario until a successful measurement can be performed. If you see this message regularly, this is an indication of potential PC problems, such as out of date drivers, faulty USB hardware, or over-taxed system.
- **Perform Cal** – This indicator appears when the device has deviated more than 2 °C since its last temperature calibration. The software will automatically recalibrate the device in most measurement modes. For some measurement modes such as I/Q streaming, the user can determine when to recalibrate the device by pressing the *Recal* button on the user interface.
- **Low voltage** – This indicator appears when the device is not receiving enough voltage from the USB 3.0 connection. The voltage value appears when this annunciator is present. The device requires 4.4V. If this annunciator appears, it may indicate other problems. Contact Signal Hound if you are unable to determine the source of this problem.
- **High temp** – Specific to the SM series. When the FPGA internal temperature reaches 95C, this warning is shown. The software should be closed, and the device allowed to cool off.
- **Span limited by preselector** – Specific to the SM series. When the preselector is enabled and the user configured span is limited by the bandwidth of the preselector filter, this warning is displayed.
- **PLT** – Indicates the path loss table is active.
- **RLO** – Indicates the reference level offset is a non-zero value.
- **CPU Resources Exceeded** – Indicates that the current measurement was unable to properly finish due to either inadequate CPU resources or due to an interruption of the system during the measurement. Many measurements for Signal Hound devices require minimum processing requirements to complete real-time tasks. If the processor is unable to keep up with the required processing, you will see this warning. The measurement data should be ignored.
- **Uncal** – This indicator appears whenever any warning indicator is active to notify the user that the device may not be meeting published specifications. This is also indicated in scalar network analysis mode to denote that the store through calibration has not been performed.
- **Swept Real Time** – Active when an SM series device is configured in real-time mode with a span greater than 160MHz.

# 4 Analysis Modes

The Spike software provides several analysis modes for your spectrum analyzer. Each mode and its measurement capabilities are described below. Note that not all modes are available for all Signal Hound spectrum analyzers.

## 4.1 SWEPT ANALYSIS

This mode of operation is the mode which is commonly associated with spectrum analyzers. Through the software you will configure the device and request the device perform a single sweep across your desired span. Spans larger than the devices instantaneous bandwidth is the result of acquiring multiple IF patches and concatenating the results of the FFT processing on each of these IFs.

The processing performed on each IF patch is determined by the settings provided. Each time a trace is returned, the device waits until the next trace request. For you, the software user, you can choose to continuously retrieve traces or manually request them one at a time with the **Single** and **Auto** buttons found on the Sweep Toolbar.

### 4.1.1 Sweep Settings Control Panel

The Sweep Settings control panel controls the sweep acquisition parameters for the device in standard swept-analysis and real-time modes.

#### 4.1.1.1 Frequency Controls

- **Center** – Specify the center frequency of the sweep. If a change in center frequency causes the start or stop frequencies to fall outside the range of operation, the *span* will be reduced. Using the arrows changes the center frequency by *step* amount.
- **Span** – Specify the frequency difference between the start and stop frequencies centered on the center frequency. A reduced span will be chosen if the new span causes the start or stop frequencies to fall outside the range of operation. Use the arrows to change the span using a 1/2/5/10 sequence.
- **Start/Stop** – Specify the start and stop frequency of the device. Frequencies cannot be chosen that are outside the range of operation of the active device.
- **Step** – Specify the step size of the arrows on the center frequency control.
- **Full Span** – This will change the start, stop, center, and span frequencies to select the largest span possible.
- **Zero Span** – Enter Zero-Span mode using the current center frequency.

#### 4.1.1.2 Amplitude Controls

- **Ref Level** – Changing the reference level sets the power level of the top graticule line. The units selected will change which units are displayed throughout the entire system. When automatic gain and attenuation are set (default), measurements can be made up to the

reference level. Use the arrows to change the reference level by the amount specified by the Div setting.

- **Div** – Specify the scale for the y-axis. It may be set to any positive value. The chosen value represents the vertical height of one square on the graticule.
  - In linear mode, the Div control is ignored, and the height of one square on the graticule is 1/10<sup>th</sup> of the reference level.
- **Atten** – Sets the internal electronic attenuator. By default, the attenuation is set to automatic. It is recommended to set the attenuation to automatic so that the device can optimize for dynamic range and compression.
- **Gain** – Gain is used to control the input RF level. Higher gains increase RF levels. When gain is set to automatic, the best gain is chosen based on reference level, optimizing for dynamic range. Selecting a gain other than Auto may cause the signal to clip well below the reference level, and should be done by experienced Signal Hound users only.
- **Preamp** – If the device connected has an internal preamplifier, this setting can be used to control its state.

#### 4.1.1.3 Bandwidth Controls

- **RBW Shape** – Select the RBW filter shape. See [RBW Filter Shape](#) for more information.
- **RBW** – This controls the resolution bandwidth (RBW). For each span a range of RBWs may be used. The RBW controls the FFT size and signal processing, similar to selecting the IF band pass filters on an analog spectrum analyzer. The selectable bandwidths displayed change depending on the RBW Shape selected.
  - RBWs are available in a 1-3-10 sequence. (e.g. 1 kHz, 3 kHz, 10 kHz, 30 kHz, 100 kHz, ...) when using the arrow keys.
- **VBW** – This controls the Video Bandwidth (VBW). After the signal has been passed through the RBW filter, it is converted to an amplitude. This amplitude is then filtered by the Video Bandwidth filter. When VBW is set equal to RBW, no VBW filtering is performed.
  - All RBW choices are available as Video Bandwidths, with the constraint that VBW must be less than or equal to RBW.
  - In Real-Time mode VBW is not selectable.
- **Auto RBW** – Having auto selected will choose reasonable and fast RBWs relative to the span. When changing span, it is recommended to have this enabled along with Auto VBW.
- **Auto VBW** – When enabled, VBW will equal RBW.

#### 4.1.1.4 Acquisition Controls

- **Video Units** – In the system, unprocessed amplitude data may be represented as voltage, linear power, or logarithmic power. Select linear power for RMS power measurements. Logarithmic power is closest to a traditional spectrum analyzer in log scale.
- **Detector** – The detector specifies how amplitudes in each bin are calculated. Each frequency bin in a sweep is the result of several FFTs depending on RBW/VBW/SwpTime. The results of the FFTs are then either averaged or min/maxed based on the choice of detector. Choose min/max to show the range between the min and max value. When min/max is selected, markers are placed on the max values. To place markers on the min values, select min detector.

- **Sweep Time**
  - For SA series devices, the sweep time value is ignored.
  - For BB and SM series devices, sweep time is used to suggest how long the spectrum analyzer should acquire data for the configured sweep. The actual sweep time may be significantly different from the time requested, depending on RBW, VBW, and span settings, as well as hardware limitations.
- **Sweep Interval** – For all devices, the device will sweep at intervals of no more than the configured sweep interval. For example, a sweep interval will cause the device to sweep at most once per second.

## 4.1.2 Measurements Control Panel

The Measurements control panel allows the user to configure the spectrum related measurements. This control panel is visible while the software is in standard swept analysis and real-time operating modes.

### 4.1.2.1 Trace Controls

The software offers up to six configurable traces. All six traces can be customized and controlled through the measurements control panel. When the software first launches only trace one is visible with a type of *Clear & Write*.

- **Trace** – Select a trace. The trace controls will populate with the new selected trace. All future actions will affect this trace.
- **Type** – The type control determines the behavior of the trace over a series of acquisitions.
  - **Off** – Disables the current trace.
  - **Clear & Write** – Continuously displays successive sweeps updating the trace fully for each sweep.
  - **Max Hold** – For each sweep collected only the maximum trace points are retained and displayed.
  - **Min Hold** – For each sweep collected only the minimum trace points are retained and displayed.
  - **Min/Max Hold** – For each sweep collected, the minimum and maximum points are retained and displayed.
  - **Average** – Averages successive sweeps. The number of sweeps to average together is determined by the *Avg Count* setting.
- **Avg Count** – Change how many sweeps are averaged together when a trace type of average is selected.
  - The current count of averaged sweeps is displayed on the line below when a trace type of average is selected.
- **Color** – Change the color of the selected trace. The trace colors selected are saved when the software is closed and restored the next time the software is launched. They are also configurable in Preferences > Colors.
- **Copy To** – Copies the contents of the currently selected trace to a different trace. The contents of the destination trace are overwritten. If the destination trace type is off the trace type is set to clear and write. The destination trace is set to, update=off, and display=on.

- **Update** – If update is not checked, the selected trace remains visible but no longer updates itself for each device sweep.
- **Hidden** – If checked, the selected trace will
- **Clear** – Reset the contents of the selected trace.
- **Export** – Save the contents of the selected trace to a CSV file. A file name must be chosen before the file is saved. The CSV file stores (Frequency, Max Amplitude) pairs. Frequency is in Hz, Min/Max are in dBm/mV depending on whether logarithmic or linear units are selected.

#### 4.1.2.2 Marker Controls

The software allows for six configurable markers. All six markers are configurable through the measurements control panel.

- **Marker** – Select a marker. All marker actions taken will affect the current selected marker.
- **Type** – Specify the marker measurement type. For normal and delta marker readings, select Normal; for noise measurements, select Noise; for channel power at marker, select Channel Power; for N dB band, select N dB.
- **Place On** – Select which trace the selected marker will be placed on. If the trace selected here is not active when a marker is placed, the next active trace will be used.
- **Update** – When Update is ON, the markers amplitude updates each sweep. When OFF, the markers amplitude does not update unless moved.
- **Active** – Active determines whether the selected marker is visible. This is the main control for disabling a marker.
- **Pk Tracking** – When enabled, the selected marker will be placed on the peak signal amplitude at each trace update.
- **Pk Threshold** – Specify the minimum amplitude required for a signal to be considered as a peak for the peak left/right buttons.
- **Pk Excurs.** – Specify how far the amplitude needs to fall around a peak to be considered a peak for the peak left/right buttons.
- **Ch Power Width** (*Only visible for Channel Power marker type*) – Specify the bandwidth of the channel power measurement.
- **N dB Offset** (*Only visible for N dB marker type*) – Specify the offset used to determine the N dB band.
- **Set Freq** – Manually place the marker on the selected trace at the selected frequency. Enable the marker if it is currently disabled. The marker frequency will be rounded to the closest available frequency bin.
- **Peak Search** – This will place the selected marker on the highest amplitude signal on the trace specified by *Place On*. If the selected trace is *Off*, then the first enabled trace is used.
- **Delta** – places a reference marker where the marker currently resides. Once placed, measurements are made relative to the position of the reference point.
- **To Center Freq** – changes the center frequency to the frequency location of the selected marker.
- **To Ref Level** – changes the reference level to the amplitude of the active marker.
- **Peak Left** – If the selected marker is active, move the marker to the next peak on the left.



- **Peak Right** – If the selected marker is active, move the marker to the next peak on the right.
- **Min Peak** – If the selected marker is active, move the marker to the lowest amplitude signal.
- **Next Peak** – If the selected marker is active, move the marker to the next highest peak.
- **Disable All** – Disables all markers.

For peak left/right/next, peaks are defined by a group of frequency bins 1 standard deviation above the mean amplitude of the sweep.

### 4.1.2.3 Occupied Bandwidth

- **Enabled** – When enabled, occupied bandwidth measurements will become active on the screen.
- **Target** – Select which trace the occupied power measurement is performed on.
- **% Power** – Percent power allows the percentage of the integrated power of the occupied bandwidth measurement to be adjusted.

### 4.1.2.4 Trace Math Controls

All controls related to the trace math capability in Spike. For more information see [Trace Math](#).

- **Enabled** – Turns on/off trace math.
- **Op1** – Set the first trace math operand.
- **Op2** – Set the second trace math operand.
- **Result** – Set the trace math result trace (destination).
- **Operation** – Select the trace math operation.
- **Offset** – Set the trace math offset. Only applies to certain operations.

### 4.1.2.5 Display Line Controls

The display line is a configurable visual only reference line shown on the graticule for sweep and real-time modes. The line is always drawn at a single y-amplitude across the entire graticule regardless of plot scale.

- **Enabled** – Turns on/off the display line.
- **Level** – Set the y position of the display line.

## 4.1.3 Channel Power Control Panel

See [Channel Power](#) for more information about taking channel power measurements.

## 4.1.4 Intermodulation Distortion Control Panel

See [Intermodulation Distortion](#) for more information about taking intermodulation distortion measurements.

## 4.1.5 Sweep Recording Control Panel

See [Sweep Record and Playback](#) for more information about sweep recording.

## 4.1.6 Sweep Toolbar

The sweep controls are visible when the device is operating in the normal sweep and real-time measurement modes.

- **Spectrogram** – Enables the spectrogram display. See [Spectrogram](#).
- **Persistence** – Enables/disables the persistence display. See [Persistence](#).
- **Intensity** – Controls the intensity of the persistence display.

## 4.1.7 Sweep Plot

The plot displayed in both sweep and real-time measurement mode has several of the same zoom capabilities of the plots throughout the application. See [Zoom and Axis Manipulation](#) for more information.

The sweep plot is returned to auto scale when the measurement configuration changes. This can be due to the user changing a measurement parameter or loading a preset.

## 4.1.8 Peak Table

The peak table is a feature, in addition to markers, which allow the user to measure the absolute and relative amplitudes and frequencies of several signals present in spectrum at once. The peak table is available in sweep and real-time measurement modes. The peak table displays up to 99 peaks sorted by frequency or amplitude, which exceed the user's peak threshold settings. The peak threshold and excursion settings operate similarly to the ones available for markers (see [Measurements Control Panel](#)).

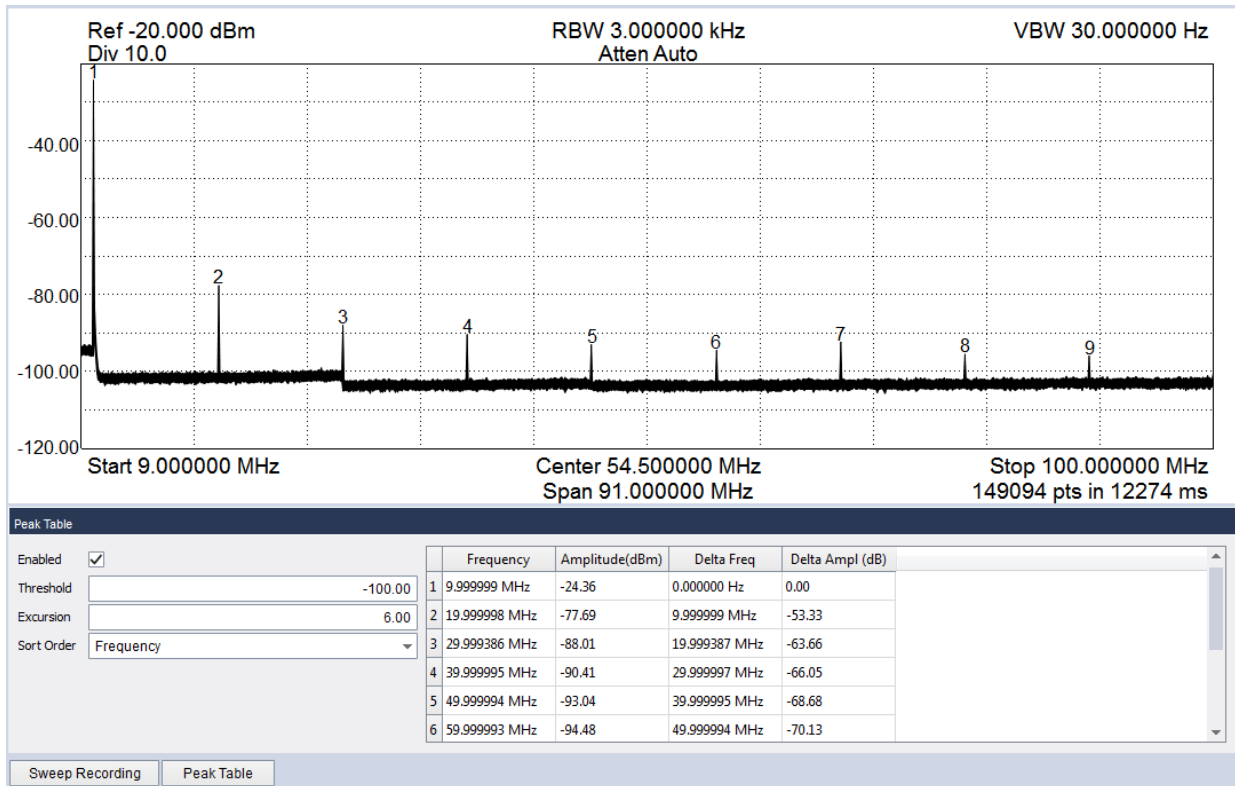


Figure 3: Peak table measuring the harmonics of a 10MHz input CW signal.

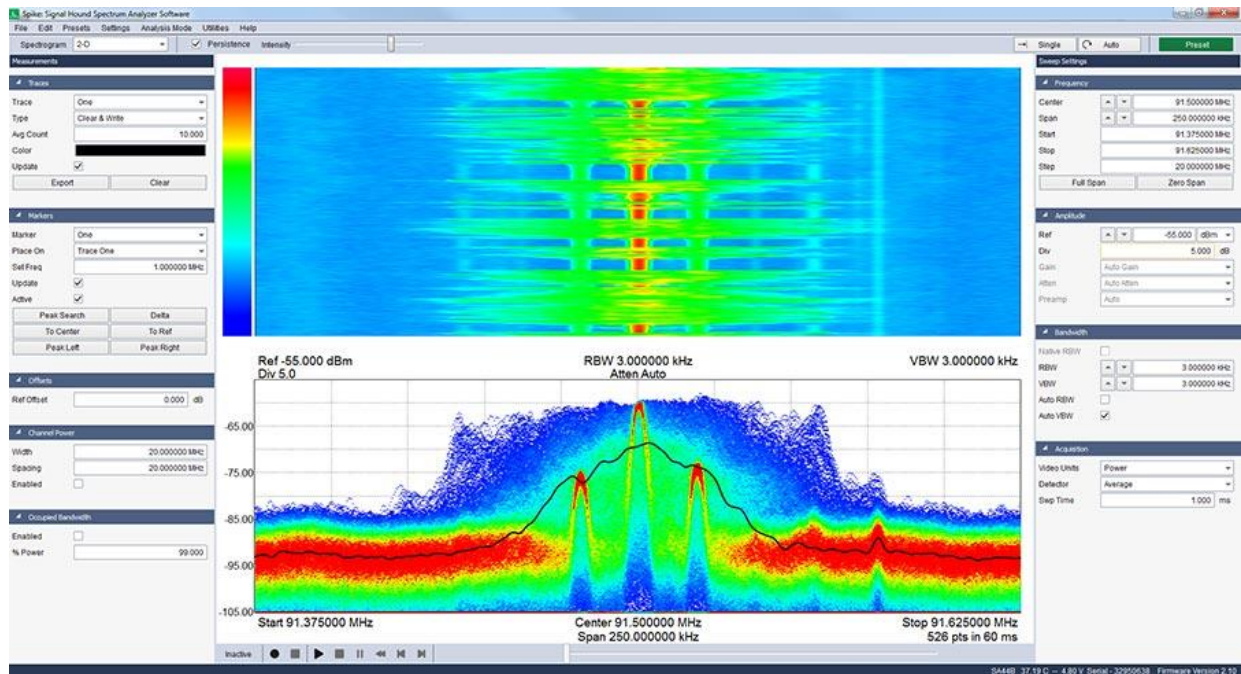
## 4.2 REAL-TIME SPECTRUM ANALYSIS

All Signal Hound spectrum analyzers can operate as real-time spectrum analyzers. Real-time spectrum analysis can be performed by selecting *Analysis Mode* -> *Real Time* in the main file menu. When the device is in real-time analysis mode, the bandwidth is limited to the real-time bandwidth, which is different for each Signal Hound device.

Analyzing signals in real-time mode is critical for characterizing short duration spectral events, such as spurious emissions or for interference hunting. Real-time analysis is also great for monitoring spread spectrum signals and observing frequency hopping communications channels.

These types of applications are possible because real-time spectrum analysis guarantees 100% probability of intercept for signals of a specific duration. That duration is dependent on the Signal Hound spectrum analyzer and the resolution bandwidth. Any signal that exceeds that duration is guaranteed to be captured and displayed by the Spike software.

When in real-time mode, a special persistence display is shown. A screen shot of the software in real-time mode is shown below.



**Figure 4: SA44B analyzing an FM radio station in real-time spectrum analysis mode. The persistence display is shown on the bottom half of the application and a 2-dimensional waterfall plot is shown on top.**

The persistence display shows a three-dimensional view of the signal density in the given span, where the X and Y axis still show amplitude over frequency, while the color of the plot is the density of the spectrum at any given point. As the spectrum density increases at a given point, the color of the plot will change from blue to green to red. The Signal Hound spectrum analyzers can create these plots from thousands to over a million traces worth of data per second to create these complex displays (depends on RBW). The persistence display is the accumulation of roughly 2/3<sup>rd</sup> of a second of real-time data acquisition.

## 4.2.1 Control Panels

Real-time spectrum analysis shares controls panels with standard spectrum analysis. See [Swept Analysis Mode](#) for more information.

## 4.3 ZERO-SPAN ANALYSIS

Zero span analysis allows a user to view and analyze complex signals in the time domain. The application can demodulate AM, FM, and PM modulation schemes, and display the results through multiple configurable plots. A user can enter zero span mode by using the *Analysis Mode* drop down file menu, or by pressing the zero-span button on the *Sweep Settings* control panel. Below is an image of the software operating in Zero-Span mode.

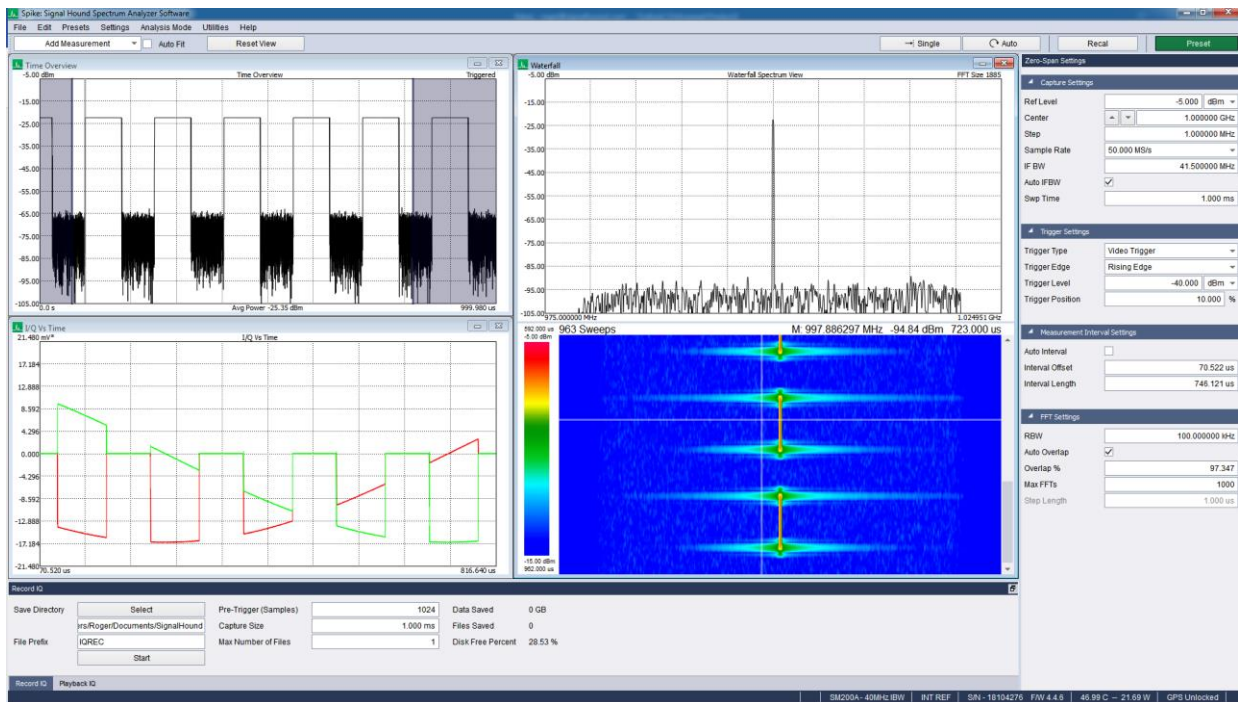


Figure 5: Triggering and measuring a pulsed waveform in zero-span mode.

The control panel contains inputs for controlling the capture settings of the device as well as specifying trigger conditions for the zero span sweeps. Available triggers are video and external. Video triggers begin the sweep only after a signal exceeds the amplitude specified in the *Video Trigger* input. When external triggering is selected, acquisition occurs when a trigger is detected on the spectrum analyzer trigger input port.

The control panel also contains a section to define the measurement interval, a subset of the zero-span capture that will be visible for measurement in the various plots. The Time Overview plot shows the interval in relation to the whole capture and provides an interface to control the same parameters graphically.

Zero-Span mode has the capability to record and playback I/Q waveforms using the record and playback control panels. For an in-depth discussion of I/Q record and playback see *Zero-Span Recordings*.

The application window is split into multiple views and provides a control panel for controlling zero span acquisitions. Zero span mode currently offers ten unique plots.

## 4.3.1 Zero-Span Settings Control Panel

### 4.3.1.1 Capture Settings

- **Input Pwr** – Expected input power of the signal. Input power controls the reference level and the gain and attenuation. It is suggested to keep gain and attenuation set to *Auto* so the software can best choose them based on the *Input Pwr*.

- **Center** – Specifies the tuned center frequency of the capture, or in another way, the 0Hz frequency of the I/Q data capture.
- **Step** – Controls how much the center frequency shifts when pressing the center frequency arrow keys or using the up/down arrow keys on your keyboard when the center frequency text is highlighted.
- **Decimation** – Controls the overall decimation of the I/Q data capture. For example, a decimation of 2 divides the analyzer sample rate by 2. Increasing decimation rate increases the possible capture time of the software but decreases the time resolution of each capture.
- **Sample Rate** – Displays the sample rate of the current visible I/Q data capture. This number is equal to the device sample rate divided by the decimation value.
- **IF BW** – (Intermediate Frequency Bandwidth) Controls the bandwidth of the passband filter applied to the I/Q data stream. The bandwidth cannot exceed the Nyquist frequency of the I/Q data stream.
- **Auto IFBW** – When set to Auto, the IF Bandwidth passes the entire bandwidth of the I/Q data capture.
- **Swp Time** – (Sweep Time) Controls the length of the zero-span data capture. The length is relative to the sample rate selected by *decimation*. Sweep times are clamped when the resulting capture contains less than 20 samples, and at the upper end, when the resulting capture contains more than 65536 samples.

#### 4.3.1.2 Trigger Settings

- **Trigger Type** – Select a trigger type for the data capture. Possible trigger types are immediate, video, external, and frequency mask trigger.
  - Immediate trigger causes an acquisition immediately.
  - Video trigger triggers an acquisition once the sample amplitude crosses the user specified trigger level.
  - External trigger triggers an acquisition when a signal event is detected on the external trigger input port on the spectrum analyzers. Not all Signal Hound spectrum analyzers have access to this trigger type.
  - Frequency mask trigger, see [Frequency Mask Triggering](#) for more information.
- **Trigger Edge** – Select whether to trigger on a rising or falling edge. Applies to both external and video triggers.
- **Video Trigger** – Select the amplitude for the video trigger to trigger on. This value is ignored if video triggering is not selected.
- **Trigger Position** – When a video or external trigger is selected, trigger position determines what percentage of samples of the sweep are displayed before the trigger. For example, in a 100-point sweep with a 10% trigger position, the sweep will display the 10 points before the trigger occurrence, and the first 90 points after the trigger.
- **Edit FMT** – Open the frequency mask trigger editor dialog. See [Frequency Mask Triggering](#) for more information.

### 4.3.1.3 Measurement Interval Settings

The measurement interval settings menu in zero-span controls the measurement interval, or subset of the full capture, displayed by all the plots except Time Overview and Waterfall.

- **Auto Interval** – When auto interval is enabled, the measurement interval is the entire capture.
- **Interval Offset** – The time into the capture for the measurement interval to start.
- **Interval Length** – The length of the measurement interval.

### 4.3.1.4 FFT Settings

The FFT settings menu in zero-span controls the FFT parameters for the spectrum and waterfall plots, and the waterfall's spectrum view.

- **RBW** – The desired RBW for the spectrum plot. Lower RBWs increase the required FFT window length. If the FFT window length is not long enough to achieve the desired RBW, the spectrum window will show a warning and the user will need to either increase RBW or increase the FFT Window length or overall capture size to display the spectrum plot.
- **Auto Overlap** – When auto overlap is enabled, an overlap percentage is chosen to produce the maximum number of FFTs up to Max FFTs.
- **Overlap %** – The percentage of overlap between FFTs.
- **Max FFTs** – The maximum number of FFTs. Computation will stop when this number is reached, even if only a portion of the capture has been covered.
- **Step Length** – The length of time from the start of one FFT to the start of the next.

## 4.3.2 Record / Playback I/Q Control Panels

See *Zero-Span Recordings*.

## 4.3.3 Frequency Mask Triggering

Frequency mask triggering (FMT) is available in zero-span measurement mode. FMT works by taking overlapping FFTs on the input I/Q data and checking each FFT result against a user defined frequency mask. When the FFT results exceed the user defined mask, the software triggers the acquisition starting at the beginning of the FFT that exceeded the mask. The FFT size is based on the current RBW with an overlap rate of 50%. The flat-top window is used for all spectrum processing in zero-span mode. The frequency mask can be configured using the FMT editor.

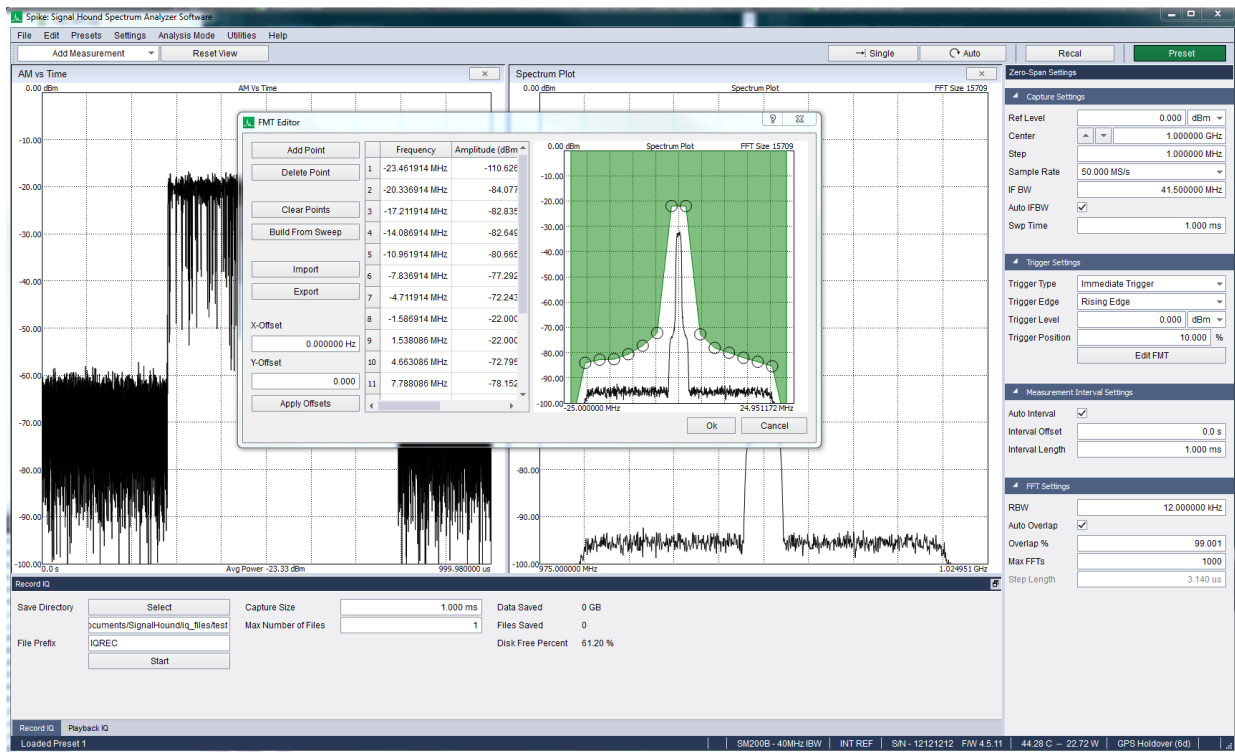


Figure 6: FMT editor

The editor mirrors the standard zero-span spectrum plot as a guide for mask building. Using the editor buttons, you can add or remove mask points, create a mask using the spectrum plot as a baseline, apply frequency and amplitude offsets, and import/export existing masks for future use. Additionally, each point in the mask can be dragged on the spectrum plot using the left mouse button for quick mask building. When finished editing, select OK on the dialog and the mask is updated. Note: The frequency mask is not updated with the new values until you have selected OK on the dialog.

## 4.3.4 Zero Span Toolbar

These controls are available in zero-span measurement mode.

- **Add Measurement** – Add a new measurement plot to the view area.
- **Auto Fit** – When Auto Fit is selected the visible views will be auto scaled to fit the available application space. Disabling Auto Fit allows a user to scale and move the views into a custom configuration without the software interfering.
- **Reset View** – Resets the view area to the default configuration.

## 4.3.5 Zero-Span Plots

All plots in zero-span follow the [basic plot](#) interface in Spike.



## 4.3.5.1 Time Overview

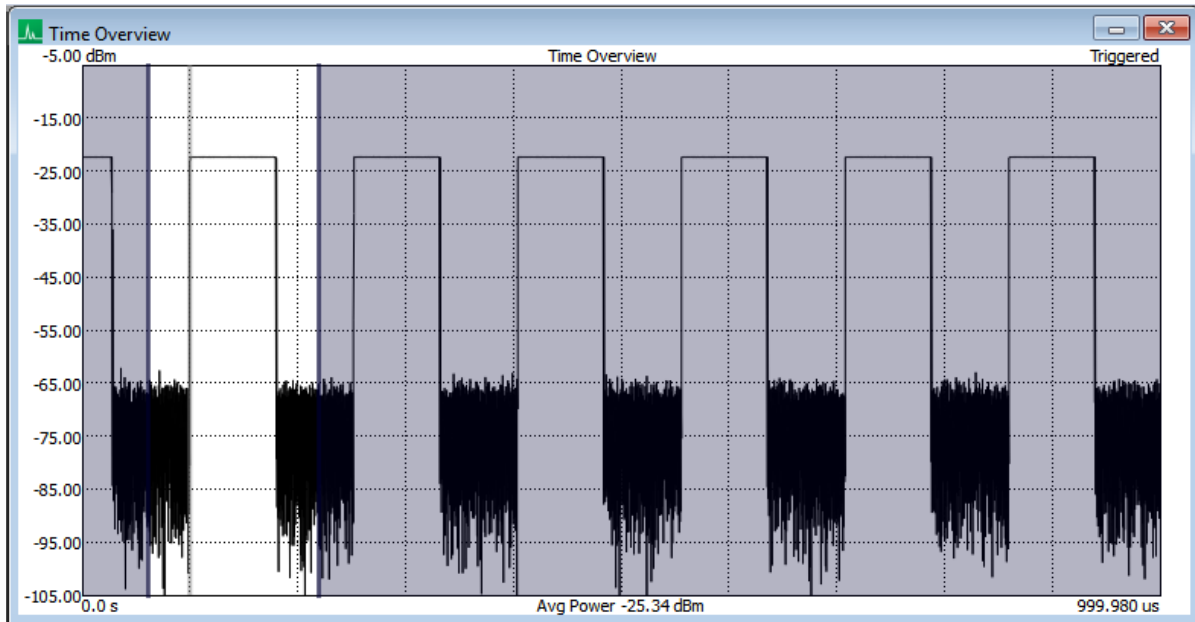


Figure 7: Time Overview plot with the measurement interval set to encompass the triggered pulse.

Shows and allows adjustment of the measurement interval in relation to the whole capture. The measurement interval is the portion of the capture that is displayed by every other plot, except for the Waterfall plot, which shows all computed FFTs across the capture.

The measurement interval is represented by the unshaded region. Adjust the interval by dragging it or dragging its start and end points.

## 4.3.5.2 AM vs Time

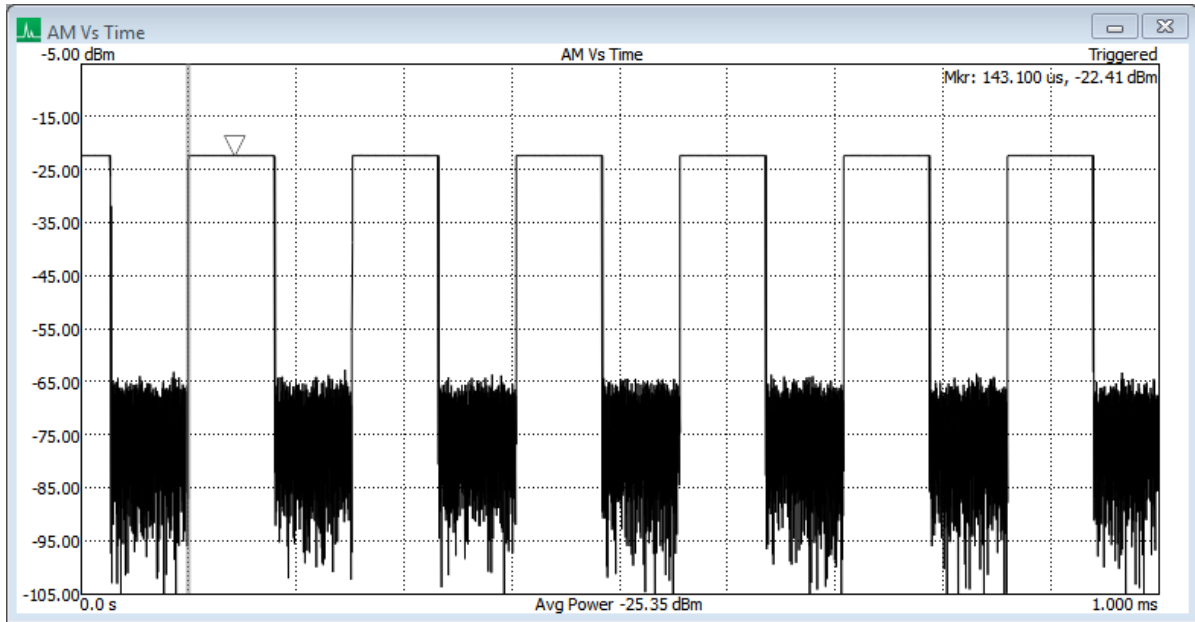


Figure 8: AM vs Time plot on triggered waveform.

Shows the AM waveform over time. Can choose between log (dBm) or linear (mV) y-axis units.

When triggering is enabled, a vertical gray bar appears at the trigger location.

When the spectrum acquisition settings are set to manual, a gray shaded region covers the FFT region selected.

You can export the I/Q values of the acquisition by right clicking and selecting *Export I/Q (.csv)* in the context menu.

## 4.3.5.3 FM vs Time

Plots the waveform as frequency vs time.

## 4.3.5.4 PM vs Time

Plots the waveform as phase vs time. Can choose between radians or degrees as the y-axis units.

### 4.3.5.5 I/Q Vs Time

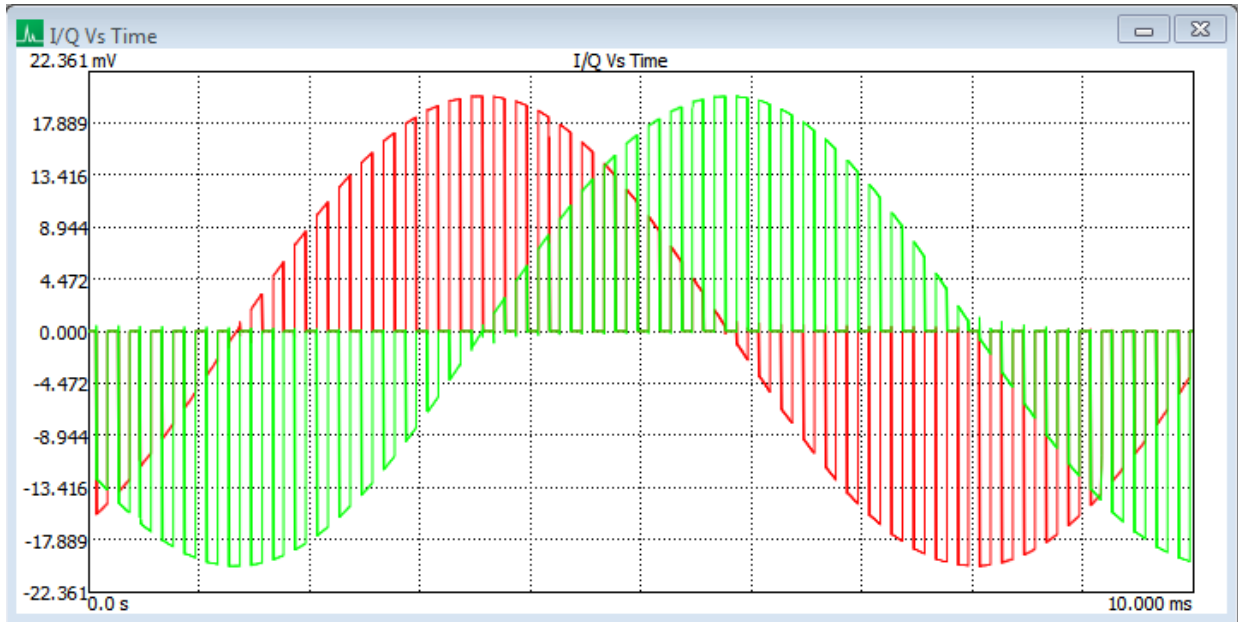


Figure 9: Pulsed CW

Plots the individual I and Q channels as amplitude in mV vs time.

### 4.3.5.6 I/Q Polar Plot

Plots the I/Q values as mV on the cartesian plane. The plot scale is set to the selected reference level of the acquisition.

## 4.3.5.7 Spectrum Plot

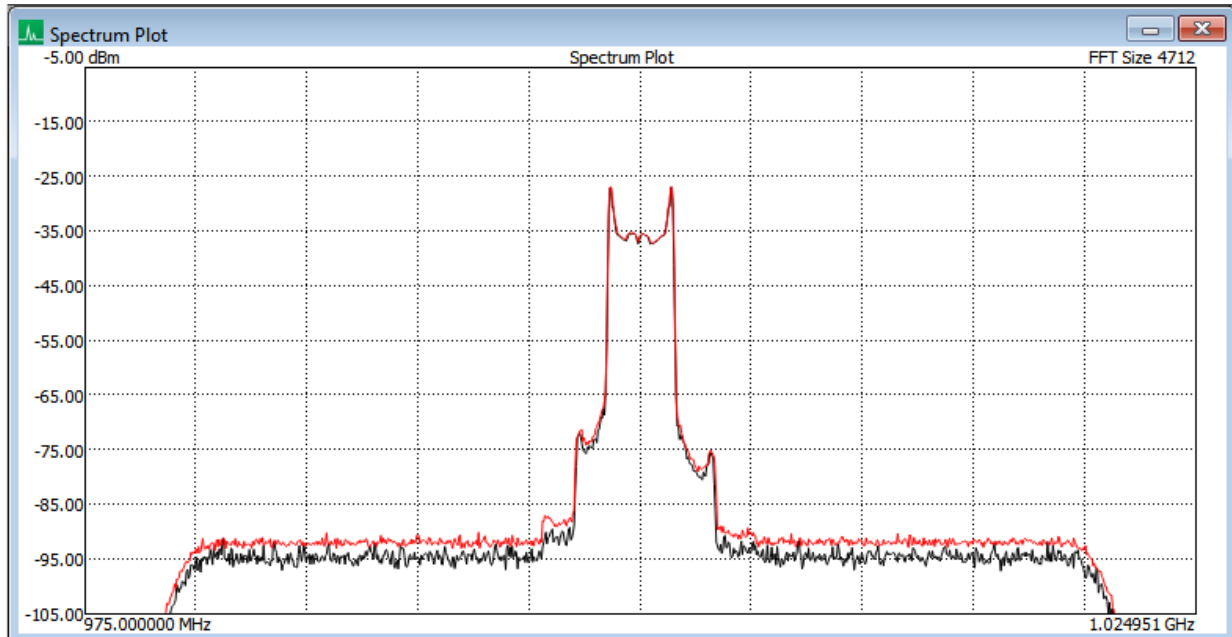


Figure 10: FM signal with max hold.

Shows the frequency spectrum of the part of the zero-span capture defined by the measurement interval. The plot shows the amplitude over frequency of the waveform signal.

Under FFT Settings in the control panel, RBW is selectable up to the maximum number of points in the sweep. A flattop window is used with zero-padding to achieve selected RBWs. The FFTs max-held to form this plot must all begin and end within the measurement interval. Thus, the interval must be at least the size of one FFT for the plot to have data. If the selected RBW is not able to be met with the measurement interval portion of the acquisition size, a warning message is shown with the length of time required to meet the RBW.

## 4.3.5.8 CCDF Plot

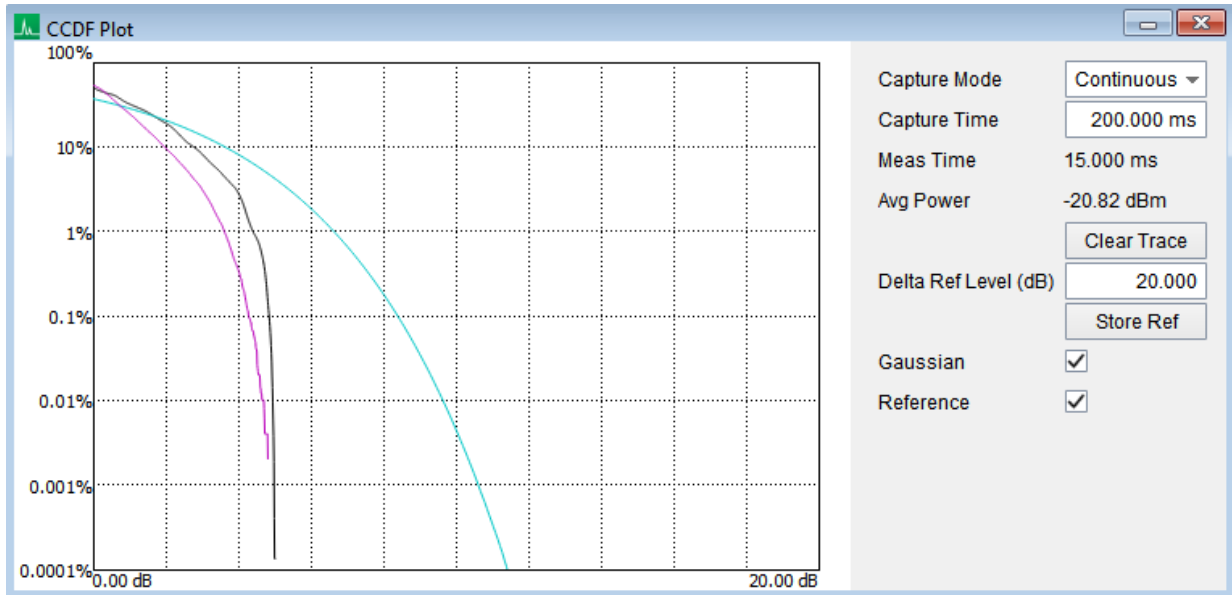


Figure 11: Comparing synthetic noise signal to a Gaussian reference and ideal test signal.

The Complementary Cumulative Distribution Function (CCDF) plot shows how often the signal is above the average signal power. The x-axis of the plot runs from 0dB above the signal mean to a user selected reference level. The y-axis is the percentage of time the signal appears above a specific a given amplitude.

The plot can be configured to operate on a single I/Q capture or a series of I/Q captures, by selecting the capture mode. When the capture mode is set to continuous, the capture time control sets the continuous capture buffer size. New samples are shifted into this buffer and the oldest samples are shifted out.

A Gaussian reference curve can be plotted which represents the ideal Gaussian distribution. A user stored reference waveform can be stored by pressing the *Store Ref* button. This stores the active user trace in memory. The reference waveform is stored until the *Store Ref* button is pressed again.

## 4.3.5.9 Waterfall Plot

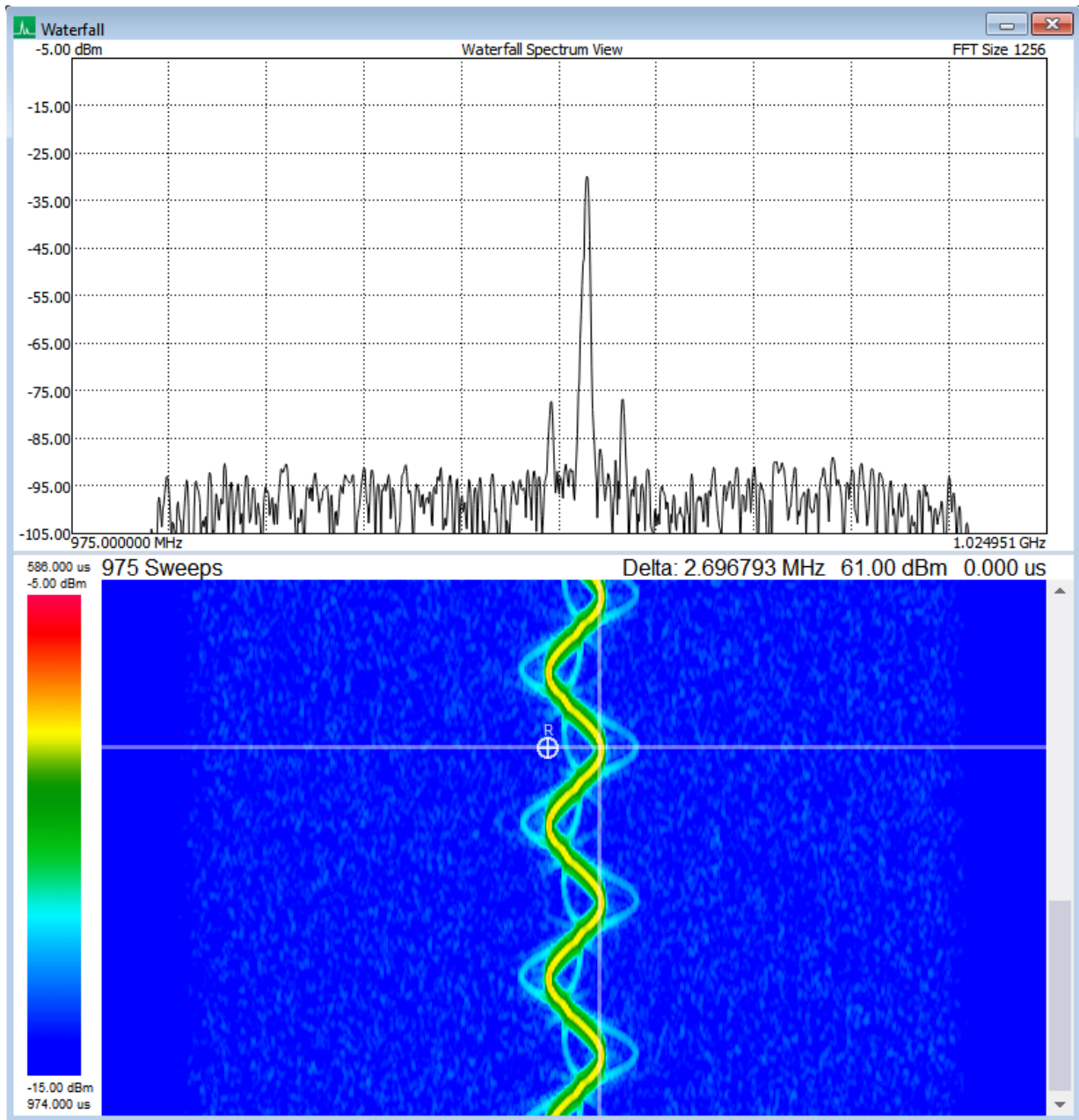


Figure 12: Measuring deviation of FM signal using reference marker, with a spectrum view of peak.

Shows the frequency spectrum of the signal over time. When an FFT sweep is selected with the marker, it is shown in the Waterfall Spectrum View above. The Spectrum View can be enabled and disabled from Preferences in the context menu.

This plot is functionally the same as the [Spectrogram](#).

## 4.3.5.10 Channel Power Plot

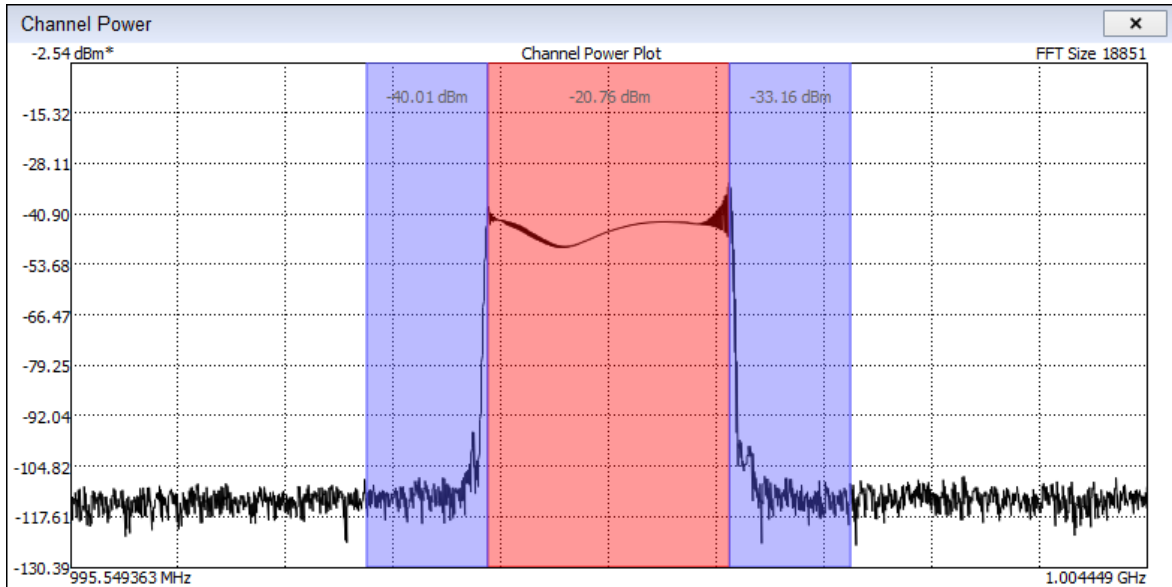


Figure 13: Measuring main and adjacent channels of an FM signal in Zero Span's Channel Power plot.

Configures and measures the channel power of a main channel and an optional adjacent channel, consisting of a lower and upper component.

The plot is created by averaging FFTs across the measurement interval and taking channel power measurements on the resulting spectrum. FFTs default to 50% overlap but spread out if required to keep the number of FFTs at the configured maximum within the measurement interval.

The configuration dialog is accessed through the context menu. Use it to set the main channel width, enable the adjacent channel and set its width and offset, set the maximum number of FFTs, and reset to the default configuration. Widths and offsets default to  $\frac{1}{4}$  of the sample rate, with 100 max FFTs.

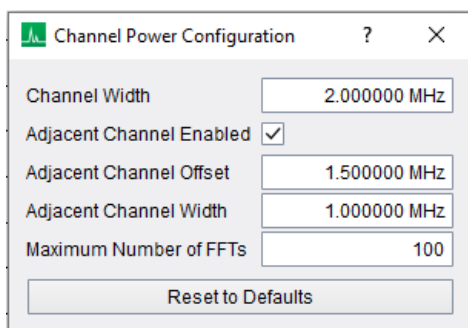


Figure 14: Configuration dialog for the Zero Span Channel Power plot.

## 4.3.6 Zero-Span Recordings

**WARNING!** Zero-Span recording can consume a large amount of space on your hard drive in a short amount of time. Caution must be exercised, particularly if you are storing waveforms on your Windows disk drive. See *I/Q Capture: Precautions* for more information.

In Zero-Span mode, a user can save and playback a short duration I/Q waveform. Waveforms are recorded in a binary format, using an XML description file. The full file format is described below.

For long term I/Q recording see [I/Q Recorder](#).

### 4.3.6.1 Recording

I/Q captures are performed using the **Record I/Q** control panel in zero-span mode. This control panel allows you to change the capture settings of the I/Q data. The settings are described below.

- Save Directory – The default directory for the I/Q waveform files to be stored.
- File Prefix – Applies a file name prefix to all files saved. Useful for creating identifiable file names.
- Capture Size – Specify the minimum capture length for a single file.
- Max Number of Files – Specify the number of waveforms to record.

Acquisitions begin by pressing the *Start* button located on the **Record I/Q** control panel. If the trigger type is set to *No Trigger* acquisitions begin immediately. If either *External Trigger* or *Video Trigger* are selected, the software will wait until a trigger occurs before starting acquisition. When the number of files to save is greater than 1, and a trigger is active, each file will require a trigger to begin acquisition.

The Spike software plots do not update during acquisition, but several statistics show you the status of the acquisition and the current capacity remaining on the selected disk drive.

### 4.3.6.2 Playback

A file recorded through the **Record I/Q** control panel can be viewed in the software using the **Playback I/Q** control panel.

Start waveform playback by pressing the *Open File* button and selecting the XML description file for the capture you are interested in viewing. Playback should begin immediately.



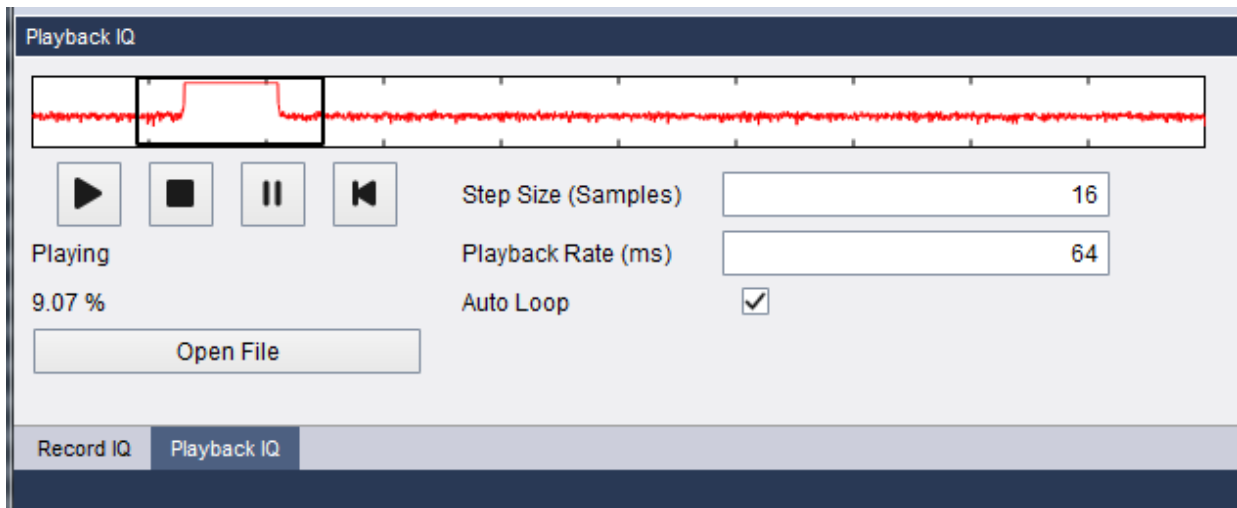


Figure 15: Playback I/Q control panel interface during waveform playback.

Several tools exist for accelerating measurements during I/Q playback.

- The I/Q scroll bar provides a preview trace for the full I/Q capture and a selectable region to quickly scroll through the entire waveform capture.
- The step size control specifies the number of samples to advance each time the view is updated. The step size control is only applicable when no triggering is active.
- The playback rate controls the speed at which the Spike software is updated when loading waveforms from the I/Q file.
- The *Single/Auto* buttons can be used to step through the capture manually.
- Enabling *Video Trigger* will force the Spike software to search the capture for a trigger before updating the plots. If no trigger is found, the capture will stop at the end of the file.

#### 4.3.6.3 Using the I/Q Playback Control Panel to Analyze a Recording in Spike

To begin playback, press the *Open File* button. This prompts you to select the XML file of the recording you wish to analyze. Only one file may be open at a time.

If Spike can open the file, you should see the playback scroll bar populated with the I/Q preview trace and the *Playing* message found below the scroll bar.

To play through a file normally, ensure the *Playing* message is displayed and the *Auto* button is pressed in the toolbar and *No Trigger* is selected. You should see the view window in the scroll bar slide to the right as the contents of the file are updated in the plots.

At any time, you can press the *Single* button in the toolbar to pause the playback and single step through the file.

You can also slide the view window within the scroll bar to quickly move anywhere in the file. By doing this you will cause the playback to be *Paused* and must press the Play button for the playback to continue.

To video trigger on the contents of the file, ensure your video trigger is properly configured, press the *Single* button on the tool bar, ensure the file is not currently paused by pressing the play button. Then pressing *Single* should align the next capture on the next video trigger found. If no trigger is found in the remaining contents of the file, the plot view moves to the end of the file.

For any mode of playback, the playback toolbar must display the *Playing* message or else the software will not update the waveform. If you see the *Playing* message and the software still is not updating the on-screen waveform, ensure you are currently not in single trigger mode.

Looking for a trigger within a very large file may cause the software to delay several seconds or more. Use the scrollbar to quickly navigate to the region of interest or capture smaller files to reduce this delay.

#### 4.3.6.4 I/Q File Format

Each I/Q capture is saved as two files, an XML description file, and I/Q data binary file.

The XML file contains the acquisition settings and scale factors necessary to reconstruct the original I/Q waveform. The XML elements are described below.

- *DeviceType* – Product name of the analyzer used in the acquisition.
- *SerialNumber* – Serial number of the device used in acquisition.
- *DataType* – Should be *Complex Short* indicating the binary format of the binary I/Q file.
- *ReferenceLevel* – The reference level, in dBm, set in the Spike software for the acquisition.
- *SampleRate* – Sample rate in Hz, of the I/Q waveform acquisition.
- *Decimation* – Power of two integer value representing the decimation rate of the I/Q waveform from the full sample rate of the analyzer. (40MS/s for the BB60C/D and 486111KS/s for the SA44/124)
- *IFBandwidth* – Cutoff frequency of the I/Q bandpass filter.
- *ScaleFactor* – Used to scale the I/Q data from full scale to mW.
- *IQFileName* – Full file path of the I/Q binary file saved by the Spike software. If you move the waveform files into another directory on your system, you must update this value to reflect the new location of the binary file. If you do not, the Spike software will be unable to playback the requested waveform.
- *EpochNanos* – Nanoseconds elapsed since January 1, 1970. Often referred to as Unix time, Unix epoch, or Unix timestamp. The timestamp references the first sample in the I/Q waveform acquisition.
- *SampleCount* – Number of I/Q values stored in the I/Q binary file.
- *PreviewTrace* – Values used to create the waveform trace on the I/Q playback scrollbar. The values are created using a max hold decimation algorithm on the full I/Q waveform capture.

The binary file contains *SampleCount* signed 16-bit I/Q values. The binary file has little-endian byte ordering. Samples are stored in sequential order as

$$I_1, Q_1, I_2, Q_2 \dots I_n, Q_n$$

The values are stored as full scale, ranging from -32768 to +32767 representing floating point values between -1.0 and 1.0. To recover the original values, perform the following steps.

- 1) Read in the binary file to signed 16-bit complex values.
- 2) Convert the full scale 16-bit I and Q integer values into floating point values in the range of -1.0 to +1.0.
- 3) Multiply each I and Q value by the inverse of the scale factor in the XML file.
- 4) The I/Q samples should now be scaled to mW, where  $I^2 + Q^2 = \text{mW}$ .

#### 4.3.6.5 Precautions

Precautions must be taken when performing I/Q captures to ensure your existing data does not become corrupted and your I/Q waveforms are captured without error. Below is a list of recommendations and precautions when using the I/Q record capabilities of the Spike software.

- 1) Store waveforms to an external hard drive and not the operating system (OS) hard drive. If your OS hard drive approaches 100% capacity, you will run into issues which will prevent your OS from operating properly. If you absolutely must store I/Q waveforms on the same drive as your OS, keep 20% of the disk free. (Windows suggests 15%)
- 2) Calculate the expected capture size beforehand using this simple formula.

$$\text{Size of Capture(Bytes)} = \text{SampleRate(S/s)} * \text{CaptureTime(s)} * 4$$

For example, a 5 second capture with the BB60C at the full sample rate is

$$40\text{MS/s} * 5 * 4 = 800\text{MB}$$

- 3) Ensure your hard drive write speed exceeds the acquisition speed of the analyzer. For many sample rates on BB and SM series devices, standard hard drive write speeds will be insufficient to sustain long term captures. This will create gaps in the data which will affect the quality of your measurements. A simple calculation of the record speed is

$$\text{Write Speed (Bytes per second)} = \text{Sample Rate} * 4$$

It is expected the hard drive write speed exceeds this value by a reasonable margin. For some of the highest BB and SM series sample rates, a combination of solid-state drives and/or RAID configuration will be necessary.

- 4) Ideally, an operator should be present at the software and monitoring the acquisition status. In the use case where you are capturing several triggered events over an extended time interval, consider performing test runs on known signals to ensure your acquisitions settings are correct before committing to a long acquisition process.

## 4.4 HARMONIC ANALYSIS

The harmonic measurement mode provides the ability to measure up to 10 harmonics of a specified carrier frequency. Each harmonic measurement consists of a sweep at the fundamental and all harmonic frequencies. The span, RBW, and VBW can be controlled. All harmonic sweeps are plotted

sequentially, and the amplitudes are reported as dBc. Total harmonic distortion is reported in the upper right-hand corner of the spectrum plot.

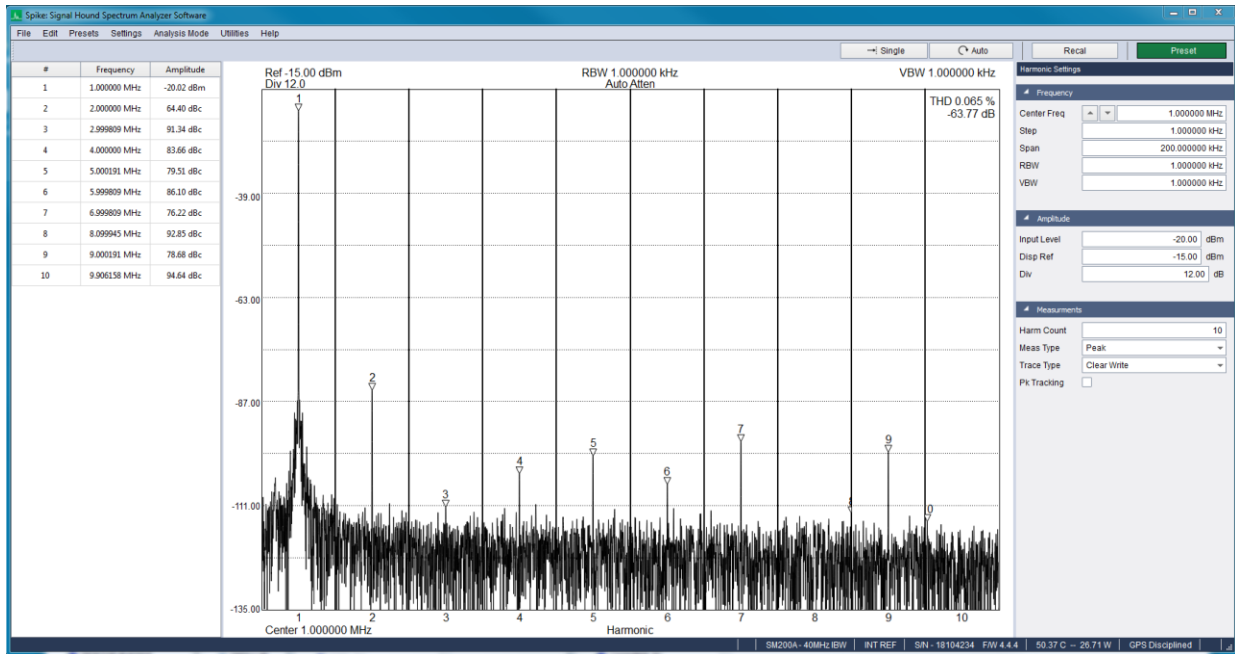


Figure 16: Carrier frequency at 1MHz and 9 harmonics.

## 4.4.1 Measurement Procedure

The first sweep is performed centered at the selected *Center Freq*. If peak tracking is enabled, the center frequency measured at is the frequency of the previously measured fundamental. The frequency and amplitude of the fundamental is measured. The amplitude is measured using either a peak search or channel power, depending on the *Meas Type* selection. When channel power is selected, the frequency is measured using the center of the 90% occupied bandwidth.

All subsequent harmonics are measured at multiples of the measured fundamental frequency. The amplitudes are measured in the same way and stored as dBc.

The spectrum plot and harmonic list are updated as the harmonic measurements are performed. Measuring and plotting all harmonics is considered a single measurement.

## 4.4.2 Harmonic Controls

- **Center Freq** – The center frequency of the fundamental measurement.
- **Step** – Controls the frequency step of the arrows on the *Center Freq* control.
- **Span** – The measurement span used at each harmonic.
- **RBW** – The measurement RBW used at each harmonic.
- **VBW** – The measurement VBW used at each harmonic.
- **Input Level** – The maximum expected input level. It is recommended to set this value to 5 dB above the maximum expected input level.

- **Disp Ref** – The displayed reference level of the spectrum plot.
- **Div** – Vertical spectrum plot division height.
- **Harm Count** – Number of harmonics to measure and plot.
- **Meas Type** – Select the measurement type at each harmonic. When peak is selected, a peak search is performed to find the frequency and amplitude of each harmonic. When channel power is selected, a channel power measurement is used to find the amplitude and occupied bandwidth measurement is used to find the frequency of each harmonic.
- **Trace Type** – Select the trace behavior.
- **Pk Tracking** – When enabled, the fundamental frequency is measured at the previously measured fundamental frequency. When any setting is changed, the tracking center frequency is reset to the selected *Center Freq*.

## 4.5 SCALAR NETWORK ANALYSIS

If a BB or SA-series spectrum analyzer and tracking generator are both connected to the PC, select Analysis Mode > Scalar Network Analysis in the file menu. Scalar network analysis is used to measure the insertion loss of a device such as a filter, attenuator, or amplifier across a range of frequencies. This mode, when used with a directional coupler, can also measure return loss.

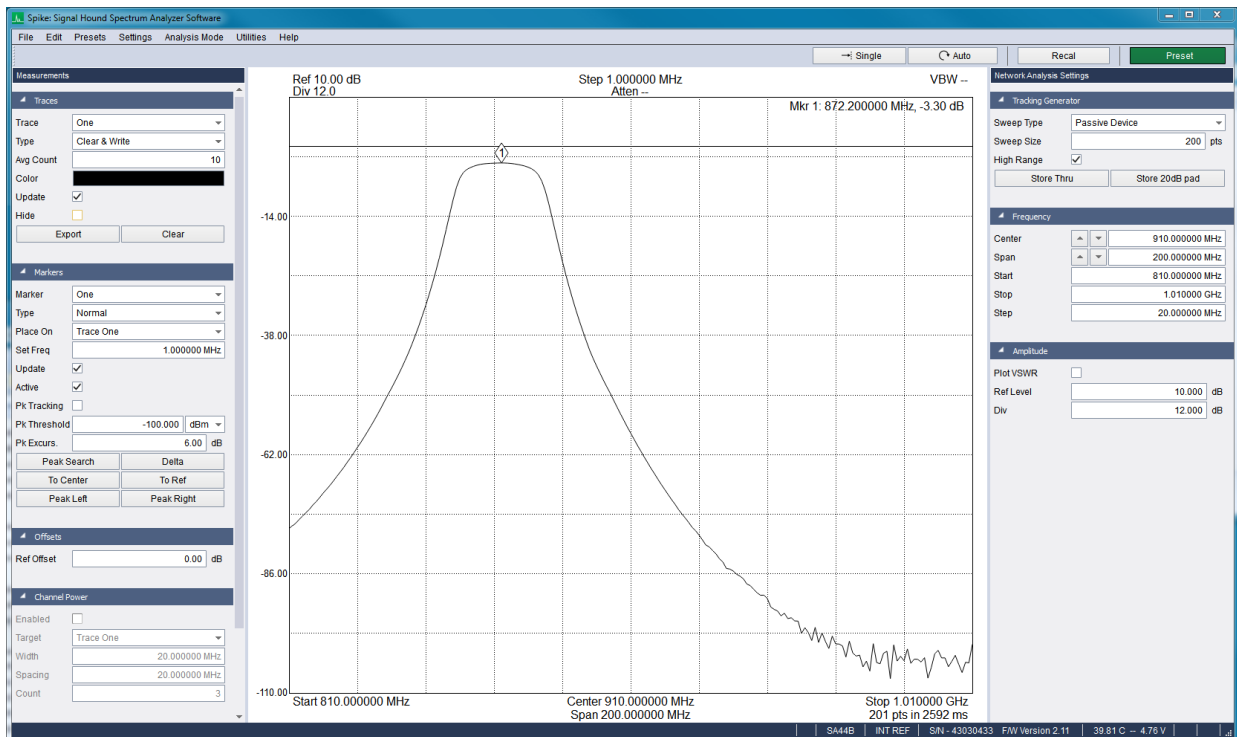


Figure 17 The SA44B and TG44A sweeping a passive bandpass filter.

To learn more about scalar network analysis and how the Signal Hound devices perform this task, please refer to the Signal Hound Tracking Generator user manual.

Ensure the TG sync port on the tracking generator is connected to the Sync Out port on the SA series spectrum analyzer.

## 4.5.1 Scalar Network Analysis Control Panel

### 4.5.1.1 Tracking Generator Settings

- **Sweep Type** – Specify whether an active or passive device is being swept. This will affect the attenuation and gain used during the sweep. Failing to properly set this value may result in reduced dynamic range or IF overload.
- **Sweep Size** – Specify a suggested sweep size. The final sweep size is affected by this suggestion as well as hardware limitations.
- **High Range** – If high range is selected, the software will optimize the sweep for dynamic range when a 20dB pad store through is performed. Sweep speed will increase when unselected at a penalty of lower dynamic range.
- **Store Thru** – Press this button to normalize the sweep on the next acquired sweep. This may be re-pressed in the event a poor normalization occurred.
- **Store 20dB Pad** – Perform a normalization when a 20dB pad is inserted in the RF path. Should only be performed after a normal “Store Thru”.

### 4.5.1.2 Frequency Settings

- **Center** – Specify the center frequency of the sweep. If a change in center frequency causes the start or stop frequencies to fall outside the range of operation, the *span* will be reduced. Using the arrows changes the center frequency by *step* amount.
- **Span** – Specify the frequency difference between the start and stop frequencies centered on the center frequency. A reduced span will be chosen if the new span causes the start or stop frequencies to fall outside the range of operation. Use the arrows to change the span using a 1/2/5/10 sequence.
- **Start/Stop** – Specify the start and stop frequency of the device. Frequencies cannot be chosen that are outside the range of operation of the active device.
- **Step** – Specify the step size of the arrows on the center frequency control.

### 4.5.1.3 Amplitude Settings

- **Plot VSWR** – Plot the return loss as VSWR.
- **Ref Level** – Specify the displayed reference level of the plot. Changing this value causes the display to update immediately and does not affect the calibration status of the measurement. Specified as dB or SWR depending on whether *Plot VSWR* is selected.
- **Div** – Specify the vertical plot divisions. When plotting VSWR, the graticule ranges from 1.0 at the bottom of the plot, to  $1.0 + 10 * \text{div}$  at the top. When plotting on a log scale the graticule will range from *Ref Level* at the top of the plot and  $\text{Ref Level} - 10 * \text{div}$  at the bottom of the plot.

## 4.5.2 Measurements Control Panel

See [Measurements Control Panel](#) in Swept Analysis mode.

## 4.5.3 Configuring Scalar Network Analyzer Sweeps

The controls for Frequency, Amplitude, and Tracking Generator are used to configure sweeps, as follows:

- Use the Frequency controls to configure the desired center frequency and span.
  - For most devices, a start frequency of >250 kHz and a span of >100 kHz is recommended. This maximizes dynamic range, sweep speed, and accuracy.
  - (SA44/SA124 only) For crystals or other very high Q circuits with a bandwidth of 50 Hz to 10 kHz, select a span of 100 kHz or less. A slower narrow-band mode will be automatically selected. In this mode, a 100-point sweep takes about 7 seconds, but the sweep updates at each point.
- Use the Amplitude controls to set the Reference Level, a good starting value is +10 dB.
- Using the Tracking Generator Controls:
  - Select the desired sweep size. A 100-point sweep is a good starting point.
  - If measuring an amplifier, select Active Device
  - Leave High Range checked unless faster sweeps are needed at the expense of dynamic range.
  - If accurate measurements are needed below -45 dB, use the default settings of Passive Device and High Range.

## 4.5.4 Performing Sweeps

Before accurate measurements can be made, the software must establish a baseline, something to call 0 dB insertion loss. In the Spike software, this is accomplished by clicking **Store Thru**.

1. Connect the tracking generator RF output to the spectrum analyzer RF input. This can be accomplished using the included SMA to SMA adapter, or anything else the user wants the software to establish as the 0-dB reference (e.g. the 0-dB setting on a step attenuator, or a 20dB attenuator in an amplifier test setup).
2. Click **Store Thru** and wait for the sweep to be completed. The sweep should be normalized at 0 dB when this process is completed. At this point, readings from 0-dB to approximately -45 dB are calibrated.
3. (Optional) If accurate measurements are needed below -45 dB, insert a fixed SMA attenuator, and then click **Store 20 dB Pad**. The actual attenuation value does not matter, but it must attenuate the signal from the TG by at least 16 dB and not more than 32 dB. This corrects for any offsets between the high range and low range sweeps, giving accurate measurements down to the noise floor.

4. Insert the device under test (DUT) between the tracking generator and the spectrum analyzer and take measurements. All traces and markers are accessible during the network analyzer sweeps.

Note: Changing the sweep settings (frequency, amplitude, etc.) will require repeating steps 1-4.

#### 4.5.4.1 Improving Accuracy

One shortcoming of the Signal Hound tracking generators is poor VSWR / return loss performance. However, this can be easily overcome by adding good 3 dB or 6 dB pads (fixed SMA attenuators) to the output of the tracking generator and / or the input of the spectrum analyzer. A good 6dB pad will improve return loss by nominally 12dB to >20dB and should enable accurate measurements. These may be included when sweeping the "thru," effectively nulling them out. This will decrease the overall dynamic range.

#### 4.5.4.2 Testing High Gain Amplifiers

When measuring an amplifier that will have a gain of 20 to 40 dB, the use of a 20-dB pad is required. Insert the 20dB pad before the *Store Thru* and leave the pad on either the SA or TG when connecting to the amplifier. For amplifiers with more than +20 dBm maximum output, the pad should go on the output of the amplifier. If an amplifier cannot safely handle -5 dBm, place the pad on the amplifier's input.

### 4.5.5 Measuring Return Loss

A **directional coupler** of appropriate frequency range (sold separately) may be used to make return loss measurements.

- Connect the tracking generator to the directional coupler's "OUT" port.
- Connect the spectrum analyzer to the directional coupler's "COUPLED" port.
- Use the "IN" port as the test port. Leave it open (reflecting 100% of power).
- If a cable is used between the test port and the antenna, connect it to the IN port but leave the other end of the cable open.
- Click **Store Thru**. The sweep should be normalized to 0 dB.
- Connect the device under test (e.g., antenna) to the "IN" port or cable. Return loss will be plotted.

Once again, measurement accuracy will benefit from 3 to 6 dB pads on the Signal Hound devices prior to Store Thru. This method is not as accurate as using a precision vector network analyzer, but with a good directional coupler, accuracy within a few tenths of a dB is typical.

#### 4.5.5.1 Adjusting an Antenna

To adjust an antenna for a certain frequency, use the Return Loss setup, above. Lengthen, shorten, and tweak impedance matching elements until the desired return loss is achieved. Be aware that you will be radiating some RF during this process. It is your responsibility to understand and obey the laws regarding transmitting on those frequencies.



## 4.5.6 Levels Used in Sweeps

This section covers the amplitudes used by the tracking generator for the various sweep configurations available in the Scalar Network Analysis mode.

If *High Range* is disabled, the tracking generator sweeps the specified frequency range at -30dBm.

If *High Range* is enabled, the tracking generator sweeps at 2 levels, once at -30dBm, followed by another sweep at -10dBm. These two sweeps are used to generate a single measurement (sweep) in the Spike software.

If *Passive Device* is selected, the analyzer will expect the signal to be at or below the tracking generator output power (no amplification)

If *Active Device* is selected, the analyzer will allow up to 20dB of amplification.

If you exceed the analyzer's expected input level, the analyzer can be overdriven resulting in an invalid measurement.

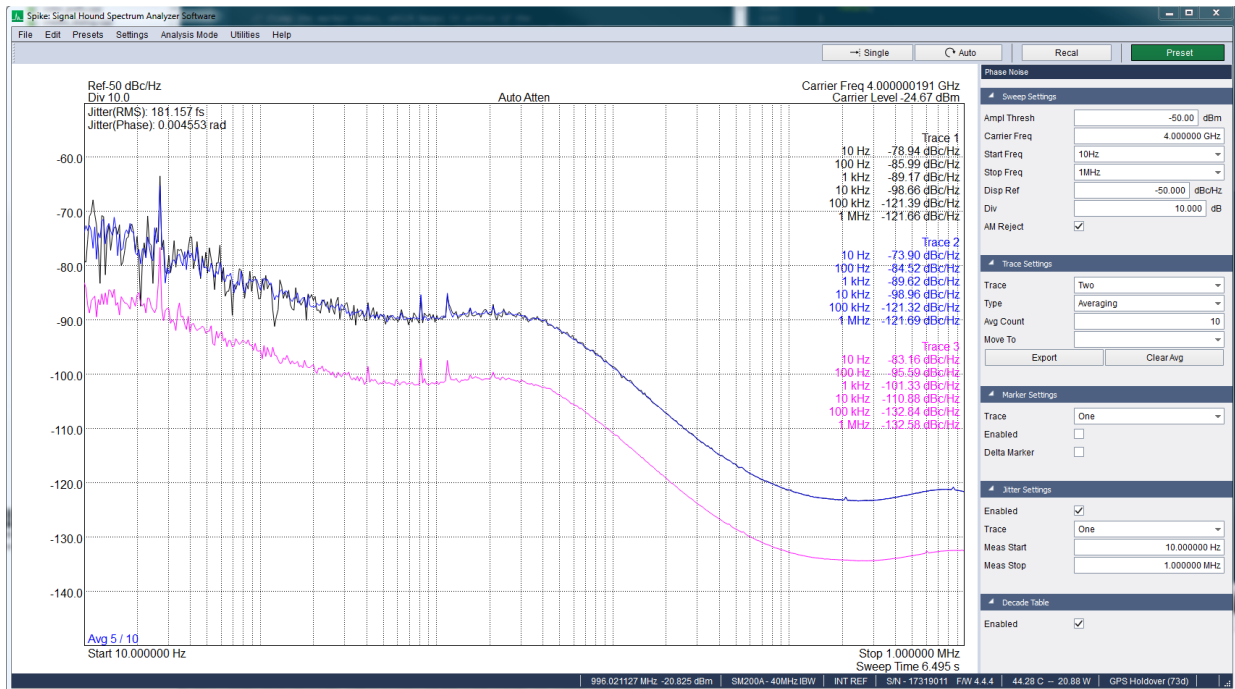
If you need additional amplification, add an attenuator in the signal chain.

## 4.5.7 Manual Tracking Generator Sweeps

To test devices with bandwidths below 50 Hz (e.g., 60 Hz notch filter), or if more than 90 dB of dynamic range is needed, do not use Scalar Network Analysis mode. Instead, stay in Swept Analysis mode and use **Utilities→Tracking Generator Controls** to set the tracking generator to a CW frequency output. Use Peak Search and Delta to establish relative amplitude, then insert the DUT and manually tune the TG across a narrow range of frequencies. A TG output of -10 dBm combined with an RBW of 10 Hz should give around 130 dB of dynamic range for most frequencies. Care must be taken in cable and device placement to avoid crosstalk.

## 4.6 PHASE NOISE MEASUREMENTS

You can use the phase noise measurement mode to display single sideband phase noise on a logarithmically scaled spectrum plot. Below is an image of a typical phase noise spectrum plot.



**Figure 18: SM200A measuring the phase noise of a signal generator at 1 and 4 GHz carriers.**

The log scaled display plots phase noise as dBc/Hz (relative to the input signal power) over frequency, where frequency is measured as the offset frequency from the measured input carrier frequency. The selectable frequency range of the Spike software is between 10Hz and 10MHz for a total span of 6 decades.

The carrier frequency and amplitude are measured at the beginning of each phase noise sweep. This allows the software to track small deviations in the frequency and amplitude of the input signal. If a carrier is not found given the minimum amplitude threshold and within 100kHz of the selected center frequency, the phase noise plot will not be updated.

There are three user configurable traces. Traces can be set to normal, average, and reference types. When average is selected, N traces are averaged together to create the average trace shown on the plot, where N is the user selectable *Avg Count* in the control panel. The current average tally is displayed in the lower left corner of the graticule. Averaging occurs in dBc/Hz units. When the measurement configuration is changed, press the *Clear Avg* button to restart the average trace accumulation.

A reference trace is a trace that is not updated after each phase noise sweep. A reference trace can be created in two ways, by selecting reference as the trace type, or by moving a trace to another using the 'Move To' control. The reference trace is useful for comparing results, such as the phase noise to two signal sources, or a signal source at different frequencies.

A single marker is available for making measurements. The marker can be placed by pressing the left mouse button anywhere within the graticule. The marker can be moved by dragging the mouse with the left mouse button pressed or by using the arrow keys on your keyboard after placing the marker. The marker can be used to make absolute measurements (default) or relative measurements with the delta marker. Pressing the *Delta* button in the control panel places a reference marker at the current marker

location, and all future marker readouts are made as relative offsets between the current marker location and the reference marker.

RMS jitter measurements can be enabled at any time using the control panel. Jitter measurements are displayed in the upper left corner of the graticule. Jitter measurements are made by integrating phase noise between two frequencies, which can be selected in the control panel. The measurement is displayed as the RMS phase jitter/deviation in seconds and radians. Changes to the jitter configuration are reflected immediately on the graticule.

The maximum signal input level is 10dBm input level and the signal should be within +/- 100kHz of the carrier frequency selected in the control panel. Input signals should also exceed -50dBm input level.

## 4.6.1 Phase Noise Control Panel

This control panel appears when the measurement mode has been changed to *Phase Noise*. These settings control the acquisitions parameters of the sweep, trace and marker outputs, and jitter measurement configuration.

### 4.6.1.1 Sweep Settings

- **Ampl Thresh** – Specify the minimum necessary carrier level to perform a phase noise measurement. If this threshold is not met, the software will continue to look for a carrier frequency.
- **Carrier Freq** – Specify the carrier frequency of the input signal.
- **Start Freq** – Specify the start frequency of the sweep as an offset from the measured carrier frequency.
- **Stop Freq** – Specify the stop frequency of the sweep as an offset from the measured carrier frequency.
- **Disp Ref** – Specify the displayed reference level as dBc/Hz.
- **Div** – Specify the plot division height in dB.
- **AM Reject** – When enabled, the software normalizes the amplitude of the trace so that amplitude modulation is not affecting the phase noise measurement.

### 4.6.1.2 Trace Settings

- **Trace** – Select the active trace. All other trace settings apply to this active trace.
- **Type** – Select the active trace type.
- **Avg Count** – When trace averaging is enabled, set the number of traces that are averaged together to create the output trace.
- **Move To** – Move the current trace to the trace selected. That trace will then become a reference trace.

### 4.6.1.3 Marker Settings

- **Trace** – Specify which trace the marker is placed on.
- **Enable** – Enable/disable the marker.

- **Delta Marker** – Toggle the delta marker measurement. A reference marker is placed at the current marker position when the delta measurement is enabled.

#### 4.6.1.4 Jitter Settings

- **Enabled** – When enabled, the integrated RMS jitter calculation is performed and displayed on the graticule.
- **Trace** – Specify which trace the jitter measurement is performed on.
- **Meas Start** – Specifies the start frequency of the integrated RMS jitter calculation.
- **Meas Stop** – Specifies the stop frequency of the integrated RMS jitter calculation.

#### 4.6.1.5 Decade Table

- **Enabled** – Toggles the display of the trace decade tables.

## 4.6.2 Measurement Speed

Sweep speed is greatly affected by the start and stop frequency. The following configurations have the largest effect on sweep time.

- Start frequencies at 10Hz and 100Hz. This affects all devices and can add 10+ seconds to the sweep time.
- A stop frequency of 10MHz decreases sweep speed dramatically for the SA44/SA124 devices. This can add 25 seconds to the sweep time.

Any changes to the configuration will not be applied until after the current sweep is performed. Additionally, other actions such as changing the measurement mode or closing the software will not take place until the current sweep is finished.

## 4.7 DIGITAL DEMODULATION

In this mode, users can measure modulation quality such as EVM, magnitude, and phase error, and characterize impairments such as I/Q offset, amplitude droop, and group delay via equalization filters.

The Spike software allows the demodulation of PSK, QAM, ASK, FSK, and custom constellation patterns using several standard filter types.

### 4.7.1 Digital Demodulation Control Panel

#### 4.7.1.1 Demod Settings

- **Center Freq** – Specify the carrier frequency of the modulated signal.
- **Freq Step** – Specify the step size applied when using the center frequency arrays.
- **Input Power** – Specify the maximum expected input power of the input signal.
- **Sample Rate** – Specify the symbol rate of the modulated input signal.
- **Result Len** – Specify the number of symbols in the measurement.

- **Modulation** – Specify the modulation format of the input signal. See the symbol mappings for each of the supported schemes in the [Appendix: Constellation Mappings](#).
- **Edit Custom Mod** – Bring up the constellation editor. See [Custom Modulations](#).
- **Source Filter** – Specify the filtering to be performed by the demodulator. See [Selecting the Measurement Filter](#) for more information.
- **Filter Alpha** – Specify the bandwidth coefficient of the measurement filter. See [Selecting the Measurement Filter](#) for more information.
- **Auto IF Bandwidth** – Specify whether the software selects an IF bandwidth automatically based on configuration. If automatic bandwidth is selected, the bandwidth is chosen as 2 times the symbol rate.
- **IF Bandwidth** – Specify the width of an IF bandwidth filter to be applied before demodulation. This filter is used to reject out of band interference or adjacent channels.
- **I/Q Inversion** – Specify whether to swap I/Q channels before demodulation occurs.
- **Averaging** – When checked, measurement averaging occurs.
- **Average Count** – Select the average count for the modulation quality metrics on the error summary panel.
- **Pts/Sym** – Displays the samples per symbol or oversample rate. Not selectable.
- **I/Q Offset** – When enabled, removes the I/Q offset prior to the error calculations.
- **Ampl Droop** – When enabled corrects any linear amplitude error prior to the error metric calculations.

#### 4.7.1.2 Trigger Settings

These settings affect the trigger used to frame the result/search window.

- **Trigger Type** – Specify the trigger source.
- **Trigger Level** – Specify the video trigger level. The measurements will occur once this amplitude threshold has been met.
- **Trig Delay** – Specify the number of symbols to delay the measurement by after a video or external trigger.

#### 4.7.1.3 Sync Search

See [Sync Search](#) for more information.

- **Enabled** – When enabled, pattern sync search occurs within the measurement results.
- **Pattern (Hex)** – Specify the sync search pattern.
- **Pattern Length** – Specify the number of symbols in the sync pattern. The pattern bits are specified in the *Pattern* entry. If the number of bits in the pattern entry are greater than the number of bits necessary to meet the length specified, then the least significant bits are used. If the pattern is shorter than the length specified, then the pattern is padded with zeros to reach the number of symbols specified.
- **Search Length** – Specify the size of the search window in symbols. The pattern will be searched for within this window.
- **Offset** – Number of symbols to offset the result window from the start of a successful sync search.

#### 4.7.1.4 Equalization

See [Equalization](#) for more information.

- **Enabled** – Enables adaptive equalization.
- **Filter Len** – The filter length in symbols.
- **Convergence** – Adaptation rate of each adaptive step.
- **Hold** – When enabled, stops adapt steps.
- **Reset Filter** – Resets the filter kernel to the unit impulse response.

### 4.7.2 Digital Demodulation Toolbar

This toolbar provides several controls to help the user customize the view layout.

- **Add Measurement** – This control allows a user to add to the view area one of many default data views.
- **Auto Fit** – When Auto Fit is selected the visible views will be auto scaled to fit the available application space. Disabling Auto Fit allows a user to scale and move the views into a custom configuration without the software interfering.
- **Choose Setup** – Select from several default configurations.

### 4.7.3 Selecting the Measurement Filter

It is possible to specify a baseband filter to be applied to the received data. Specifying the correct filter is necessary to demodulate the system under test. Below is a table of the possible configurations that the software provides.

Selected Source Filter	Meas. Filter Used	Ref. Filter Used
Raised Cosine	None	Raised Cosine
Root Raised Cosine	Root Raised Cosine	Root Raised Cosine
Gaussian	None	Gaussian
Rectangular	None	Rectangular

A user must also select the filter bandwidth, sometimes referred to as the filter alpha. If the measurement filter is root raised cosine, then the filter alpha of the transmitter filter must be provided to produce accurate demodulation.

All filters used have an impulse length of 32 symbols.

When the rectangular filter is selected, the sidelobes generated by the rectangular filter on the reference waveform are filtered out. Only the main lobe is present in the reference waveform. A filter cutoff equal to the sample rate is used. Put another way, the bandwidth of the I/Q baseband reference waveform after this filter is applied is 2 times the sample rate.

## 4.7.4 Custom Modulations

Spike can demodulate custom constellations. These constellations can be configured in the constellation editor. The custom constellations must adhere to the following rules.

- The number of symbols must be a power of two.
- The constellation must be symmetric about a 180, 90, 45, or 22.5-degree angle.
- The constellation cannot have duplicate points.

Differential encoding is not customizable with the constellation editor, nor is any I or Q time offsets (i.e. OQPSK). Any currently configured custom modulation is stored in the user presets. If the custom modulation is not valid, the measurement defaults to QPSK.

### 4.7.4.1 Constellation Editor

The constellation editor can be opened with the *Edit Custom Mod* button on the digital demodulation control panel.

I/Q values can be entered directly in the symbol table. The constellation plot shows the currently entered I/Q values. For loading a large constellation, it is recommended to load a formatted CSV file.

- **Add Symbol** – Inserts a new symbol row at the end of the symbol table.
- **Remove Symbol** – Removes the row of the currently selected cell. If no cell is selected, the last row is removed.
- **Load** – Load a formatted CSV file containing a saved custom constellation.
- **Save** – Save a formatted CSV file describing the custom constellation.
- **Clear Table** – Remove all symbols.
- **Accept** – Verifies the constellation and if the constellation is valid, stores the constellation as the active custom modulation.

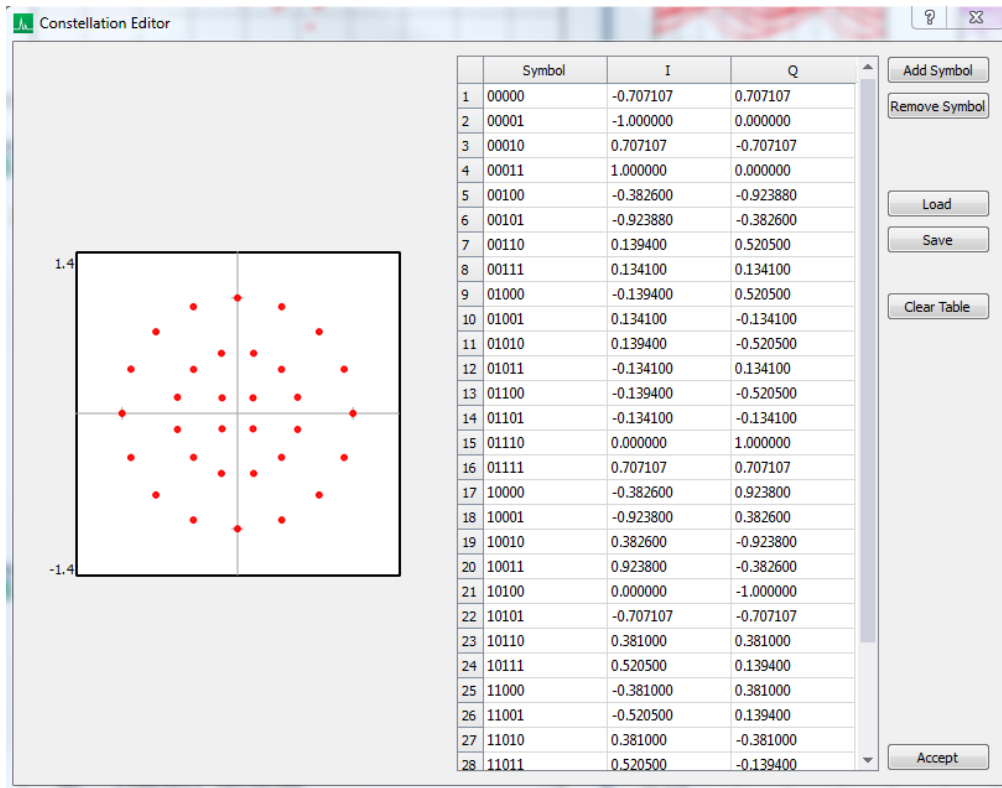


Figure 19: APSK32 in the constellation editor.

## 4.7.5 Sync Search

When sync search is enabled, demodulation occurs over a duration of search length symbols (user selected). The sync pattern is then searched for within this search length. If the sync pattern is found, the position of the first symbol that matches the pattern is used to frame the measurement. An additional offset can be applied to this framing. See the diagram below.

Search length must be longer than measurement length. The measurement is not allowed to go beyond the search length. Ideally, search length would be much larger than the measurement length. If the offset adjusts the result outside the search window, the sync pattern is considered not found.

Sync search can be used in combination with triggering. When performing sync search on pulsed waveforms, ensure the search length does not exceed the pulse duration, as demodulation occurs over the entire search length. For example, if the pulse duration is 512 symbols, search length should be no more than 512 symbols, thus limiting your result length to less than 512.

If the search pattern occurs more than once in the search length, only the first occurrence is considered. If the search pattern is not found, "Pattern Not Found" will be displayed on the demod bits plot.



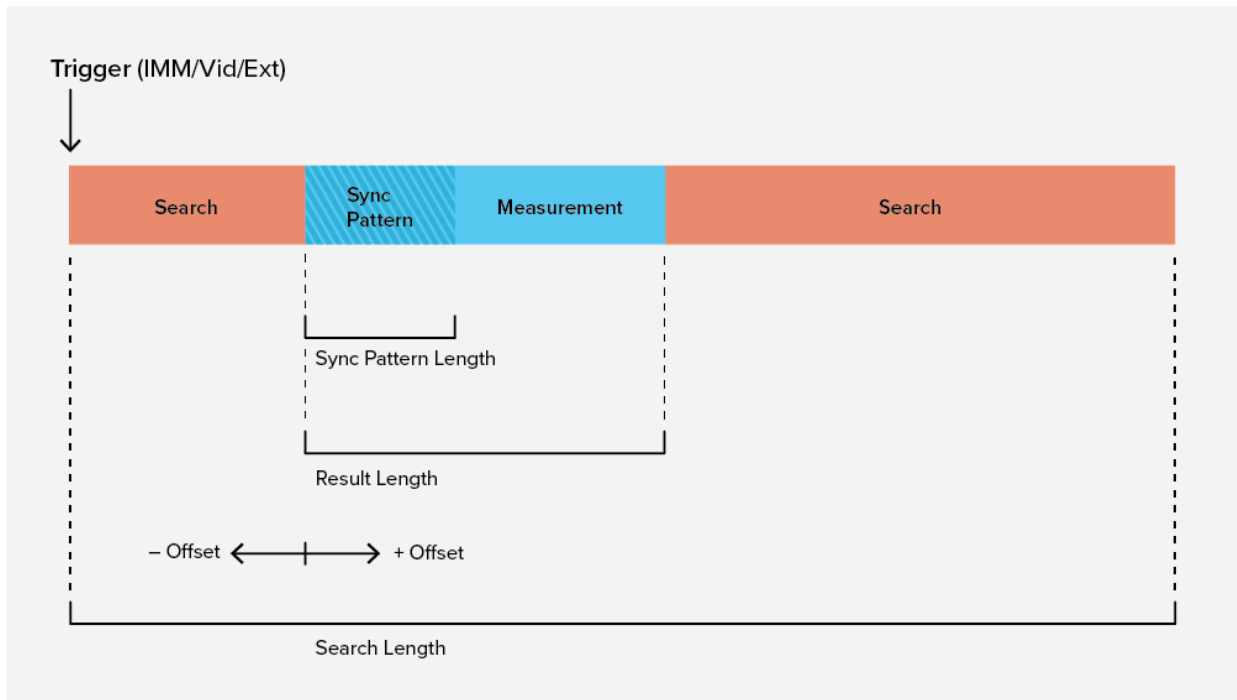


Figure 20: This diagram illustrates how sync search is performed and how the measurement is framed within the search length.

## 4.7.6 Equalization

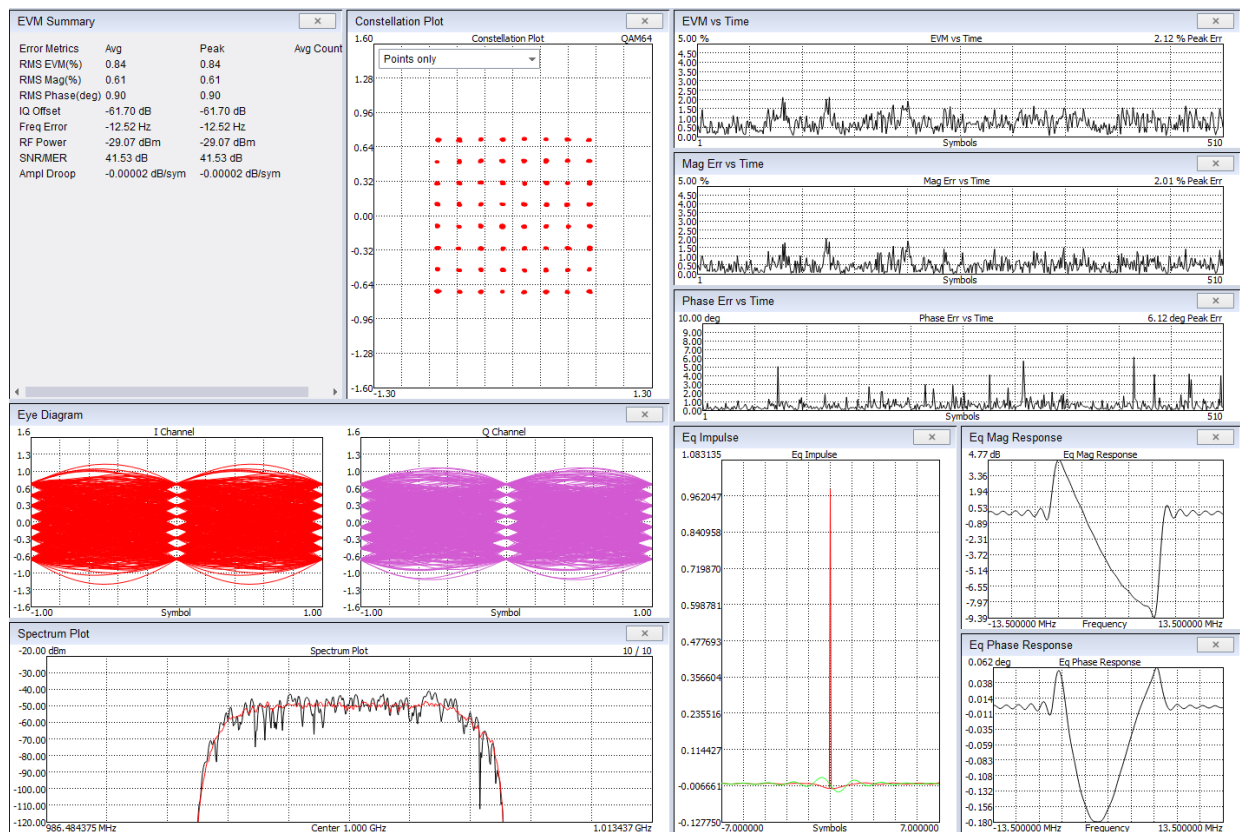


Figure 21: Characterizing a QAM64 waveform over a heavily impaired channel using equalization.

Equalization is used to measure and correct for the amplitude and phase frequency response (group delay) over the measurement channel due to fading, multi-path, reflections, or system components such as filters, amplifiers, etc. This allows some linear effects/impairments to be removed from the system isolating non-linear errors.

Equalization is only available for PSK and QAM modulation formats.

The Spike software uses a complex adaptive LMS FIR filter to perform adaptive equalization. The adaptation step is performed on the measured and reference waveforms and the filter weights output from the adaptation step are applied to the I/Q data on the next measurement prior to symbol lock, carrier recovery, and demodulation.

Since equalization is performed blind (no training sequence), large EVM and bit errors may cause the equalization filter to have difficulty adapting and converging.

It is important to ensure the frequency error of your signal is a small percentage of the symbol rate. We recommend a 1% frequency error or less. Small equalization filters will be more resistant to frequency errors. We recommend tuning the analyzer to an ideal center frequency before running equalization.

When the filter is reset, the filter is initialized with the unit impulse response. Below is a list of conditions on which the equalization filter is reset.

- Program startup
- Leaving and entering the digital demodulation measurement mode.
- The measurement filter is changed.
- Symbol rate has changed.
- Equalizer filter length is changed.
- The reset filter button is pressed.

The filter length is calculated by the equation,

- $\text{Tap count} = (\text{User Selected Filter Length} - 1) * \text{Pts/Sym} + 1$

The convergence factor selected by the user is scaled by a normalization factor of  $1.0e-6$ . Larger convergence values allow the equalizer to adapt faster to the current channel conditions but is more susceptible to noise and may cause the filter to become unstable. Smaller convergence values cause the equalization filter to adapt more slowly to the channel but resist noise and other non-periodic fluctuations in the signal.

We recommend starting with values between 1-100 to converge quickly on the channel conditions and reducing the convergence factor as EVM improves.

If at any point the filter becomes unstable, it will no longer be applied to the measurement data and will wait for the user to reset the filter. You can see when a filter is unstable on the equalization plots.

The equalizer filter impulse, frequency response, and phase response can be viewed using the equalizer plots.

The equalizer filter impulse response can be exported in the context menu of the equalizer impulse response plot.

### 4.7.7 High Order QAM Signals

This section contains a few tips for making measurements with high order QAM modulations.

- The measurement length should be 2-4 times the modulation order. For example, when measuring 256QAM signals, use between 512-1024 symbols.
- Ensure there is adequate randomness in the symbols/data. Ideally, all symbol points will be hit in a measurement indicating a random bit sequence.
- Ensure the frequency error is small. Even a small center frequency error will cause invalid measurement results. Use lower order modulations to measure and offset for frequency beforehand or use a common timebase where applicable.
- Measurements can take several seconds up to 1 minute for large captures with high order QAM. Once the measurement has started, it must finish before accepting new configuration changes. Where possible ensure all other settings are correct before selecting the high order QAM modulation.

## 4.7.8 Customizing the Display

Spike allows a user to add and organize the measurement displays. The displays can be added to the main view area by selecting the “Add View” combo box on the toolbar and selecting the measurement displays. If “Auto Fit” is enabled, the view is added to an organized grid of views. If Auto Fit is disabled, then the user can move and resize the view to their liking. The view organization is saved when the application is closed and restored on the next program invocation.

All plots in digital demodulation mode adhere to the [basic plot](#) interface in Spike.

### 4.7.8.1 Error Summary

The Spike software provides an error summary read-out which displays modulation quality metrics such as error vector magnitude (EVM), phase error, magnitude error, and frequency error. These error values are used to measure signal characteristics and quality. Most error values are provided as a peak and RMS average value taken over a sample size chosen by the user. The error value is first averaged over the capture interval at each symbol, and then peak held and RMS averaged to generate the displayed values. For peak symbol error values over a single capture, see the Error vs Time plots.

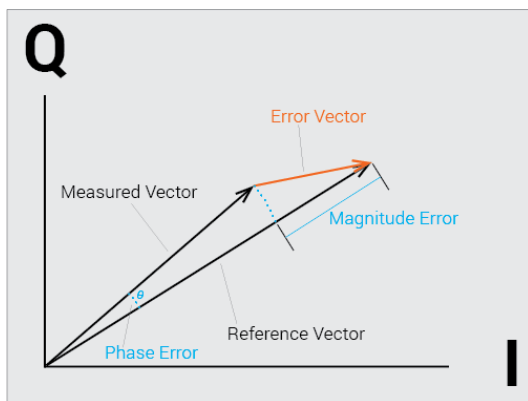


Figure 22: Visualization of the EVM, Magnitude and Phase Error Calculations

Modulation quality metrics are described below.

**EVM** is a common way to measure the quality of a communication system. EVM is defined as the root mean square (RMS) of the error vectors. It is calculated in the Spike software as

$$\%EVM = \frac{\sqrt{\frac{1}{N} \sum_{0}^{n-1} (I_{error}^2 + Q_{error}^2)}}{Normalization\ Reference} * 100\%$$

**Magnitude error** is defined as

$$Magnitude\ Error[n] = \frac{|Mag_{reference}[n]| - |Mag_{measured}[n]|}{Normalization\ Reference}$$

for each symbol. The RMS average and peak are calculated using all magnitude measurement errors for the given capture window.

**Phase Error** is defined as

$$Phase\ Error[n] = Angle_{reference}[n] - Angle_{measured}[n]$$

**FSK Error** is defined as

$$FSK\ Error = \frac{RMS(FSK\ Error\ at\ each\ symbol)}{Deviation}$$

where the error at each symbol is

$$FSK \text{ Error at Symbol } i = FSK \text{ Measured}[i] - FSK \text{ Reference}[i]$$

and deviation is the peak frequency deviation.

**Frequency Error** is defined as the difference between the reference carrier frequency and measured carrier frequency, where the reference frequency is the user supplied center frequency.

The Spike software uses a **normalization reference** of one. This is defined as the value of the maximum constellation magnitude. The Spike software forces the largest constellation magnitude to be one for each of the selectable modulations.

#### 4.7.8.2 Constellation Diagram

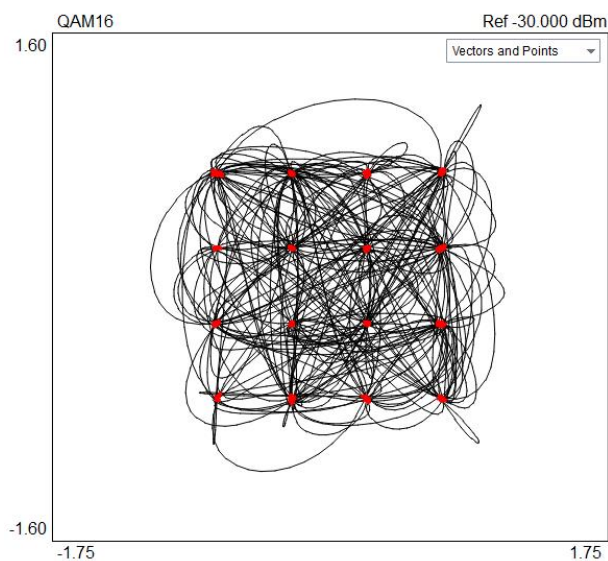


Figure 23: Constellation Diagram for a QAM 16 Input Signal

The constellation diagram helps a user visualize the quality of the signal and identify signal impairments such as phase noise, amplitude imbalance, and quadrature error. The constellation plot displays the modulation states and transitions of the input signal in the complex plane.

#### 4.7.8.3 Symbol Table

The symbol table displays the demodulated bits of the input signal. The number of bits shown is equal to the symbol count selected times the number bits each symbol represents for the modulation type selected. The bits can be displayed in binary or hexadecimal format.

The symbol table will also display the trigger pattern and whether it was detected.

#### 4.7.8.4 Eye Diagram

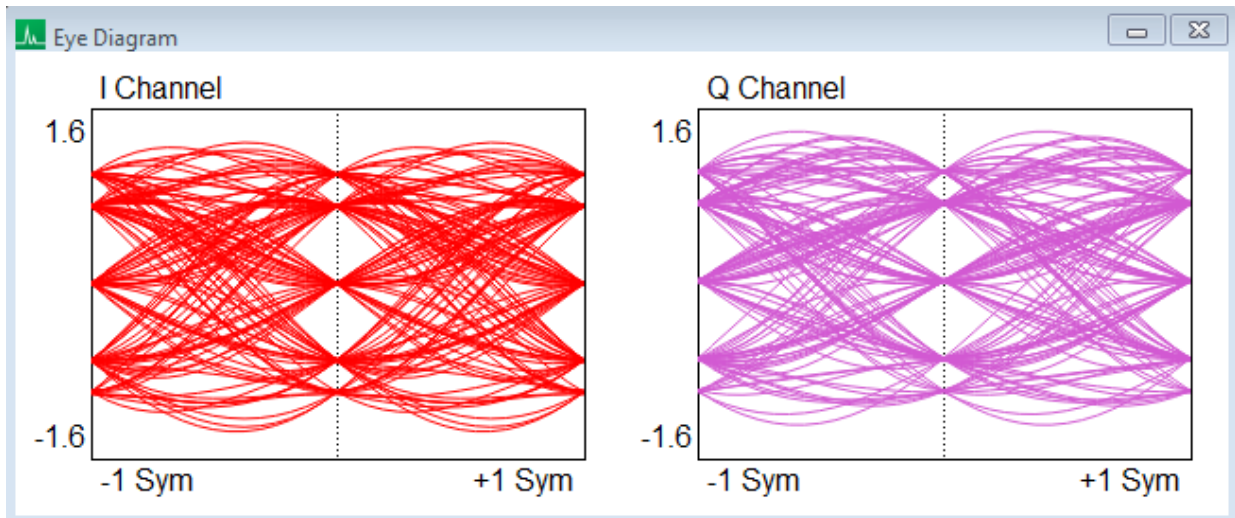


Figure 24: Eye diagram for a Pi/4DQPSK signal

Spike allows the addition of an eye diagram display in modulation analysis mode. The eye diagram is used to visualize system performance characteristics, such as signal distortion, inter-symbol interference, signal-to-noise, and timing errors.

#### 4.7.8.5 Error vs Time

Spike provides several error-vs-time displays. These displays offer a symbol resolution view of the common quality metrics such as EVM, magnitude error, and phase error. Below is the EVM vs Time plot, displaying individual EVM error over all symbols in the configured capture.

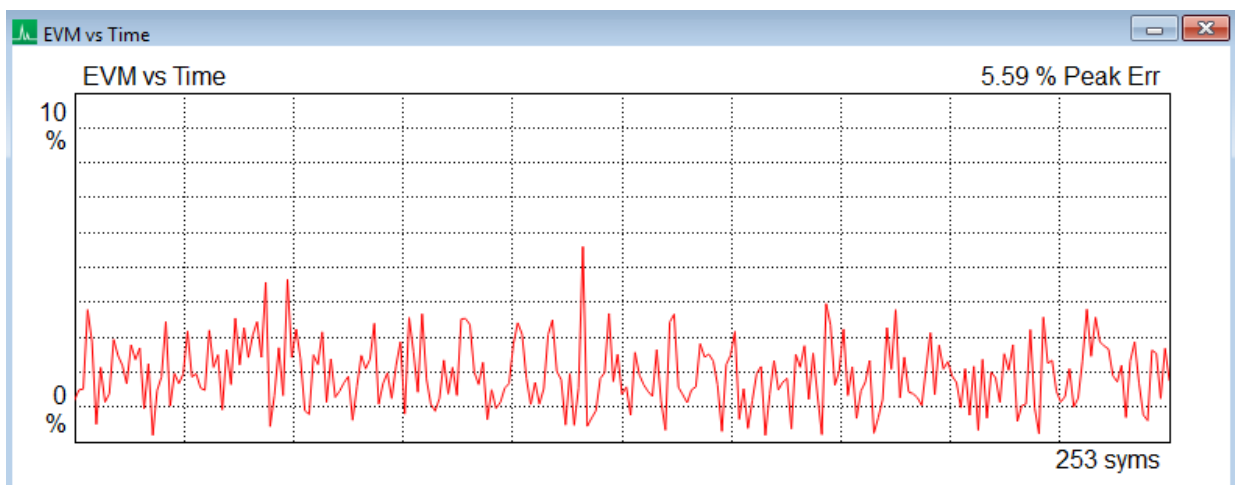


Figure 25 : EVM vs Time plot

## 4.8 EMC PRECOMPLIANCE

Precompliance measurements are available for SM, SP, and BB series devices. Precompliance measurements are accessed through the *Analysis Mode* -> *EMC Precompliance* file menu selection.

Precompliance mode provides useful measurement functions for easily testing emission regulation requirements. These measurement capabilities include,

- Setting up to 10 log scaled sweep ranges with custom limits and sweep parameters.
- Path loss and antenna factor tables for calibrating your test setup.
- A spur table showing all spurs which break the user defined limits and thresholds.
- Quasi-peak, peak, and average detectors for testing signals of interest, shown the bar meter plot.
- Detector lists which store results for the bar meter detector graph.

These functions provide a usable workflow for making conducted and radiated emissions precompliance measurements on your product.

Each function is detailed further below.

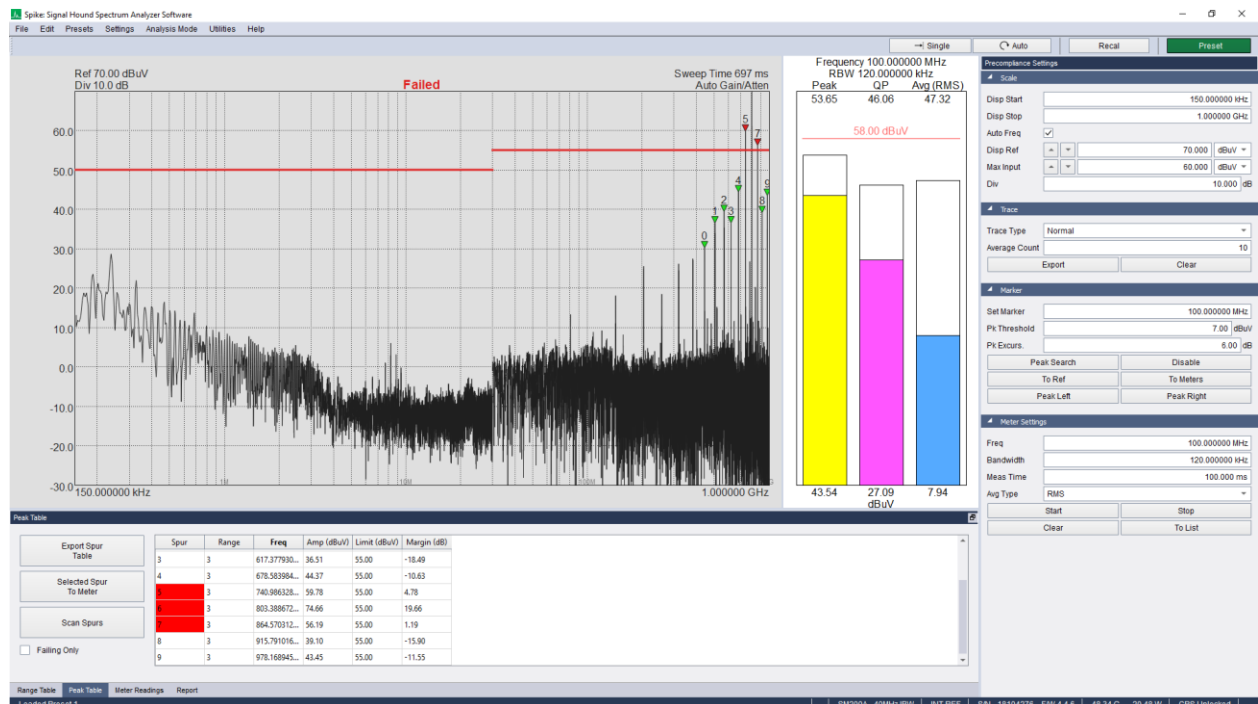


Figure 26: Radiated Emissions Precompliance Testing for the VSG25A

### 4.8.1 Pre-Compliance Control Panel

- **Disp Start** – The start frequency used when auto frequency display range is disabled. See *Auto Freq* below.

- **Disp Stop** – The stop frequency used when auto frequency display range is disabled. See *Auto Freq* below.
- **Auto Freq** – When auto freq is enabled, the trace display will show the full frequency range determined by all active EMI sweeps. When auto freq is disabled the trace display will only span the frequency range selected by the *Disp Start/Stop* controls. This can be used to selectively display a region of interest.
- **Disp Ref** – This is the reference level used for the trace display.
- **Max Input** – Specify the maximum input signal to be received by the unit. This controls the sensitivity of the unit. This value will be used to all active sweep ranges. Select a value that is roughly 5dB higher than the largest expected input.
- **Div** – Adjust the y-axis scale of the plot.
- **Trace Type** – Select between a clear-and-write, max-hold, and average trace behavior. All ranges will follow this behavior.
- **Average Count** – Specify the number of trace averages to occur when trace type is average. All ranges will use this value.
- **Export** – Export the current sweep to a CSV file.
- **Clear** – Clear the displayed sweep.
- **Set Marker** – Manually set the marker frequency.
- **Pk Threshold** – Specify the minimum amplitude required for a signal to be considered as a peak for the peak left/right buttons.
- **Pk Excurs.** – Specify how far the amplitude needs to fall around a peak to be considered a peak for the peak left/right buttons.
- **Peak Search** – Set the marker to the frequency of the largest amplitude signal found.
- **Disable** – Hide the displayed marker.
- **To Ref** – Set the reference level to the current marker amplitude.
- **To Meters** – Set the bar meter frequency to the current marker frequency.
- **Peak Left** – Move marker to the next peak on the left.
- **Peak Right** – Move marker to the next peak on the right.
- **Freq** – Select the meter center frequency.
- **Bandwidth** – Select the bandwidth used for the meter readings.
- **Meas Time** – Select the acquisition time to be used for the meter readings.
- **Start** – Start meter detection. This will interrupt sweeps.
- **Stop** – Stop meter detection. The software will resume sweeping.
- **Clear** – Clear the current and peak meter readings.
- **To List** – Store the current and peak meter readings to the meter list.

## 4.8.2 Range Table

	Enabled	Start Freq	Stop Freq	RBW Shape	RBW	VBW	Auto VBW	Video Units	Detector	Dwell Time (ms)	Threshold (dBuV)	Limit Start (dBuV)	Limit Stop (dBuV)	Selectivity (dB)	Trace Color
1	Disabled	9.000000 kHz	150.000000 kHz	CISPR	200.000000 Hz	200.000000 Hz	Auto	Power	Peak	1.000	40.000	60.000	60.000	6.000	
2	Disabled	150.000000 kHz	30.000000 MHz	CISPR	9.000000 kHz	9.000000 kHz	Auto	Power	Peak	1.000	40.000	50.000	50.000	6.000	
3	Enabled	30.000000 MHz	230.000000 MHz	CISPR	120.000000 kHz	120.000000 kHz	Auto	Power	Peak	1.000	30.000	40.000	65.000	6.000	
4	Enabled	230.000000 MHz	1.000000 GHz	CISPR	1.000000 MHz	1.000000 MHz	Auto	Power	Peak	1.000	30.000	47.000	60.000	6.000	
5	Disabled	150.000000 kHz	30.000000 MHz	CISPR	9.000000 kHz	9.000000 kHz	Auto	Power	Peak	1.000	40.000	60.000	60.000	6.000	
6	Disabled	150.000000 kHz	30.000000 MHz	CISPR	9.000000 kHz	9.000000 kHz	Auto	Power	Peak	1.000	40.000	60.000	60.000	6.000	
7	Disabled	150.000000 kHz	30.000000 MHz	CISPR	9.000000 kHz	9.000000 kHz	Auto	Power	Peak	1.000	40.000	60.000	60.000	6.000	
8	Disabled	150.000000 kHz	30.000000 MHz	CISPR	9.000000 kHz	9.000000 kHz	Auto	Power	Peak	1.000	40.000	60.000	60.000	6.000	
9	Disabled	150.000000 kHz	30.000000 MHz	CISPR	9.000000 kHz	9.000000 kHz	Auto	Power	Peak	1.000	40.000	60.000	60.000	6.000	
10	Disabled	150.000000 kHz	30.000000 MHz	CISPR	9.000000 kHz	9.000000 kHz	Auto	Power	Peak	1.000	40.000	60.000	60.000	6.000	
11	Disabled	150.000000 kHz	30.000000 MHz	CISPR	9.000000 kHz	9.000000 kHz	Auto	Power	Peak	1.000	40.000	60.000	60.000	6.000	

Figure 27: Range Table Control Panel



The range table allows you to customize up to ten sweep ranges. Each range can have its own frequency range, RBW, VBW, and test limits. Changes to the range table are reflected immediately in the software. The table can be saved to disk and imported later.

- **Load Default** – Load the default range table inputs.
- **Save Table** – Save the current table setup to a CSV file.
- **Load Table** – Load a previously save table setup. This overrides the current setup.
- **Enabled** – Enable or disable the selected range. Enabling ranges are swept and shown on the sweep display.
- **Start Freq** – Select the start frequency of the selected range.
- **Stop Freq** – Select the stop frequency of the selected range.
- **RBW Shape** – Select between the 6dB CISPR RBW (Gaussian) or Flattop 3dB RBW filter.
- **RBW** – Resolution Bandwidth.
- **VBW** – Video Bandwidth.
- **Auto VBW** – When enabled, tracks RBW. When disabled, VBW must be equal to or lower than RBW.
- **Video Units** – Video processing unit type.
- **Detector** – Select between Peak and Average detectors.
- **Dwell Time** – Select the duration the spectrum analyzer dwells at any given frequency. This is helpful for capturing a periodic event. It is recommended to have the peak detector enabled when increasing dwell time.
- **Threshold** – Minimum signal level for a signal to be considered a spur. This value must be lower than the limit setting.
- **Limit Start** – Set the limit at the start frequency at which a signal is considered to fail the test setup.
- **Limit Stop** – Set the limit at the stop frequency at which a signal is considered to fail the test setup.
  - The limit is drawn between the limit start and stop values. If you desire a flat limit, set them equal. The limit line is interpolated on a logarithmic scale.
- **Selectivity** – Determines how sensitive the spur detector is. Higher values increase the necessary separation needed for a signal to be considered a spur. Caution: low selectivity values may greatly increase the number of reported spurs.

### 4.8.3 Frequency Scan Display

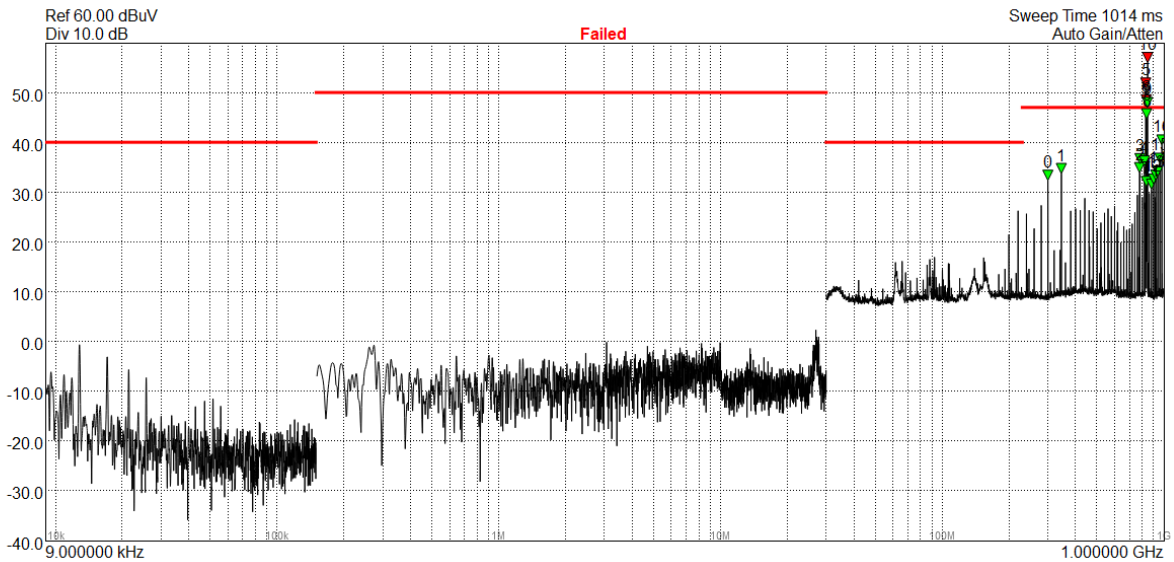


Figure 28: Frequency Scan Display Showing Four Configured Sweep Ranges.

For precompliance measurements, the main display is the frequency scan display. This plot shows all configured sweep ranges on one plot. The frequency axis is logarithmically scaled.

The plot stretches from the minimum to maximum configured frequencies. It displays each sweep range along with visible red lines denoting the limits you entered and numbered spur markings. A single marker is available by clicking anywhere in the spectrum.

The visible sweep can be configured using the control panel, either as a max hold or normal trace. Configuring the sweep as max hold can assist in finding signals of interest, such as intermittent and short duration events.

### 4.8.4 Spur Table

Spur	Range	Freq	Amp (dBuV)	Limit (dBuV)	Margin (dB)
2	1	12.855528 kHz	13.29	10.00	3.29
3	1	17.127989 kHz	10.92	10.00	0.92
0	1	9.841918 kHz	8.51	10.00	-1.49
4	1	21.400449 kHz	7.64	10.00	-2.36
5	1	25.672910 kHz	6.46	10.00	-3.54
1	1	11.253356 kHz	2.89	10.00	-7.11
8	1	47.092432 kHz	1.35	10.00	-8.65
7	1	42.800898 kHz	0.55	10.00	-9.45
6	1	29.983517 kHz	0.30	10.00	-9.7

Figure 29: Spur Table Sorted by Spur Amplitude

The spur table lists all signals above the minimum threshold set for each sweep range. The spur column value correlates to the numbered spur shown on the frequency scan display. Only the first 100 spurs will be shown. Spurs which violate the upper limits set in the range table will be highlighted red.

Once you have identified one or more spurs of interest, it is easy to begin measuring each frequency of interest. Using the *Single* button and pausing the sweeps will cause the spur table to stop updating. Then you can sort by frequency or amplitude and measure each frequency of interest independently using the *Selected Spur to Meter* button.

- **Export Spur Table** – Export both the peak table and meter list to a CSV file.
- **Selected Spur to Meter** – Move the currently selected spur frequency to the meter frequency input.
- **Scan Spurs** – Take meter measurements at all spurs and add results to Meter Readings list.
- **Failing Only** – Only measure failing spurs (spurs that exceed the limit) on *Scan Spurs*.
- **Spur** – The spur number. The spurs are ordered by frequency by default.
- **Range** – Signifies which configured range the peak is presently in.
- **Freq** – The frequency of the spur.
- **Amp** – The amplitude of the spur.
- **Limit** – The interpolated limit of the range in which the spur occurs.
- **Margin** – The difference between the amplitude and the limit (*Amp - Limit*).

## 4.8.5 Bar Meters

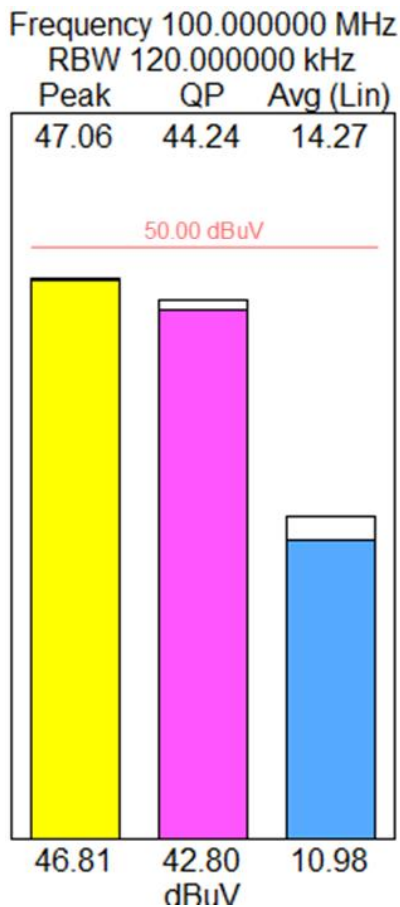


Figure 30: Bar Meters Measuring Pulsed Signal

The bar meters' display is the second measurement tool for precompliance testing. The bar meters show you three different detector readouts at a single center frequency.

The bar meter measurement is activated using the *Start* and *Stop* buttons found on the control panel. It is automatically started after clicking the *Selected Spur To Meter* button in the Peak Table panel. While these detector measurements are active, sweeps are no longer updating.

The frequency and bandwidth can be selected through the control panel, and there are several quick ways to populate the configuration for your signal of interest, such as the markers *To Meters* button which sets the detector frequency to the current marker value, and the *Selected Spur to Meter* button, which moves the frequency for the currently selected spur in the spur table to the meter settings.

The bar meters show the output of up to 4 detectors. The peak and quasi-peak detectors are always shown, and the average detector can be set to RMS or linear average.

A red limit line is shown at the meter frequency, interpolated from Limit Start and Limit Stop in the Range Table.

The meter's update at the rate set by *Meas Time* on the meter settings control panel.

The meter's store and display the max held detector values read since the last time the *Clear* button was pressed. Pressing the *To List* button stores the current peak detector values to the meter list.

## 4.8.6 Meter List

Frequency	RBW (6dB)	Peak (dBuV)	Quasi-Pk (dBuV)	Avg Lin (dBuV)	Avg RMS (dBuV)	Limit (dBuV)	Date/Time	Comments
1 171.362305 kHz	9.000000 kHz	24.49	11.09	18.06	18.73	16.34	Thu Mar 25 10:...	
2 204.931641 kHz	9.000000 kHz	23.15	9.43	17.97	18.30	16.34	Thu Mar 25 10:...	
3 238.500977 kHz	9.000000 kHz	32.61	18.00	25.96	26.47	16.34	Thu Mar 25 10:...	
4 272.070312 kHz	9.000000 kHz	22.30	8.49	14.96	15.77	16.34	Thu Mar 25 10:...	
5 305.639648 kHz	9.000000 kHz	19.16	5.40	11.03	12.18	16.34	Thu Mar 25 10:...	
6 327.001953 kHz	9.000000 kHz	23.40	9.70	16.87	17.44	16.34	Thu Mar 25 10:...	
7 372.778320 kHz	9.000000 kHz	19.54	5.24	10.55	12.02	16.34	Thu Mar 25 10:...	

Figure 31: Meter Reading Results

The meter list is generated by taking detector measurements at various frequencies and saving them with the *To List* button, or by clicking *Scan All* in the Peak Table panel. This list can be exported into a CSV file.

- **Export Meter Readings** – Export meter readings to a CSV file.
- **Delete Selected** – Remove the selected meter reading(s).
- **Clear List** – Remove all readings from the list.
- **Frequency** – The frequency that the meter reading was performed at.
- **RBW** – The resolutions bandwidth of the measurement.
- **Peak/Quasi Pk/Avg** – The detector results of the measurement.
- **Limit** – The interpolated limit of the range in which the spur occurs.
- **Date/Time** – Timestamp of the reading.
- **Comments** – Entry field for notes about the reading.

## 4.8.7 Report Panel

Figure 32: PDF Report configuration and generation.

The report panel enables the generation of a formal PDF report of the results of the precompliance testing. The report contains all the readings in the Meter Readings list, in tabular form, a snapshot of the sweeps plot, the metadata as entered (report number, DUT product name, DUT product info, date of test, test engineer, and notes), and a full description of the spectrum analyzer used under test equipment, including the manufacturer, model number, serial number, and firmware version.

- **Generate Report** – Generate and save the PDF report to chosen location.
- **Clear Info** – Clear metadata entry fields.
- **Report Number** – Identifying number for report.
- **DUT Name** – Name of product under test.
- **DUT Info** – Additional description of product under test (eg. serial number).
- **Date of Test** – Date the readings were carried out.
- **Test Engineer** – Engineer responsible for test.
- **Notes** – Additional information.

## 4.8.8 Quasi-Peak Measurements

Quasi-peak (QP) measurements are available through the bar meters display. QP measurements begin when pressing the *Start* button on the precompliance settings control panel.

The QP detector in Spike is defined by the CISPR 16.1 and ANSI C63.2 standards. The characteristics are shown below.

Frequency Range	Charge Time Constant	Discharge Time Constant
9 - 150 kHz	45 ms	500 ms

150kHz - 30 MHz	1 ms	160 ms
30 MHz - 1 GHz	1 ms	550 ms

The charge time is defined as the time needed after the instantaneous application of a constant RF sinewave voltage at the instrument input, for the output voltage to reach 63% of its final value.<sup>1</sup> The discharge time constant is the time needed, after the instantaneous removal of a constant sinewave voltage applied to the input of the instrument, for the output voltage to fall to 37% of its initial value.<sup>1</sup>

The QP detector is realized in the Spike software with digital filters.

#### 4.8.8.1 Damped Output

The output of the QP detector is simulated as a critically damped meter with time constant of 160ms for 9 kHz – 30 MHz and 550ms for 30 MHz – 1 GHz.

This meter output is realized in the Spike software with digital filters.

## 4.9 ANALOG DEMODULATION

The Spike software can perform analog modulation analysis on AM and FM modulated signals. This mode provides several plots and measurements for analog modulation analysis. Analog modulation measurements are available through the *Analysis Mode->Analog Demod* file menu.

This mode provides 5 views for the AM and FM time and frequency domain. All plots in analog demodulation mode adhere to the [basic plot](#) interface in Spike.

- **AM Time Domain** plot shows the amplitude modulation over time in the units specified by the *Input Level* settings.
- **AM Spectrum** plot displays the frequency spectrum of the AM waveform. The y-axis shows the AM depth% on a logarithmic scale, using 100% depth as the reference.
- **FM Time Domain** plots shows the FM demodulated signal over time with a selectable frequency reference level.
- **FM Spectrum** displays the frequency spectrum of the FM waveform. The y-axis is frequency deviation in Hz, with the reference level reference level equal to the device sample rate.
- **Analysis Summary** displays the modulation measurement results for the AM and FM waveforms.

Configuring the software to perform measurements involves selecting the input signal power level, carrier frequency and low pass filter using the controls found on the right-hand side control panel. The low pass filter is applied to the demodulated signal before modulation analysis is performed. Changes to the settings are reflected immediately in the acquisition.



Figure 33: Viewing a broadcast FM signal and observing the 19kHz FM pilot tone in analog demodulation mode.

The analog demodulation mode performs a number of basic measurements on an audio signal such as:

- **Carrier Frequency** records the carrier frequency.
- **Carrier Error** records the difference between the measured carrier frequency and configured center frequency.
- **Avg Power** records the average power of the entire capture in dBm.
- **Peak (+/-)** records the minimum and maximum peak of the audio signal, recorded in Hz for FM and depth% for AM
- **RMS** records the root mean square of modulation. RMS is displayed as Hz for FM and depth% for AM.
- **Modulation Rate** records the frequency of the AM/FM modulation.
- **SINAD** (Signal-to-Noise And Distortion ration) records the signal quality defined by the function

$$SINAD = \frac{P_{signal} + P_{noise} + P_{distortion}}{P_{noise} + P_{distortion}}$$

**THD** (Total Harmonic Distortion) records the presence of harmonic distortion in the audio signal as defined by the function

$$THD = \frac{\sqrt{V_2^2 + V_3^2 + \dots + V_9^2}}{V_1}$$

or in words, the RMS of the first four harmonics to the RMS of the fundamental frequency.

Both SINAD and THD measurements occur for AM or FM depending on which demodulation type is selected for Zero-Span.

## 4.10 INTERFERENCE HUNTING

Interference is a critical concern wherever RF signals are broadcast or regulated. When links are noisy, signals are dropped, or data rate is low, interference is a likely culprit. If interference is present, then there will be an elevated noise floor on the receive channel. The interfering signal itself may not be on the receive channel, however it must be within the analyzer's bandwidth. Interference Hunting mode provides tools to help spot and characterize such a signal.

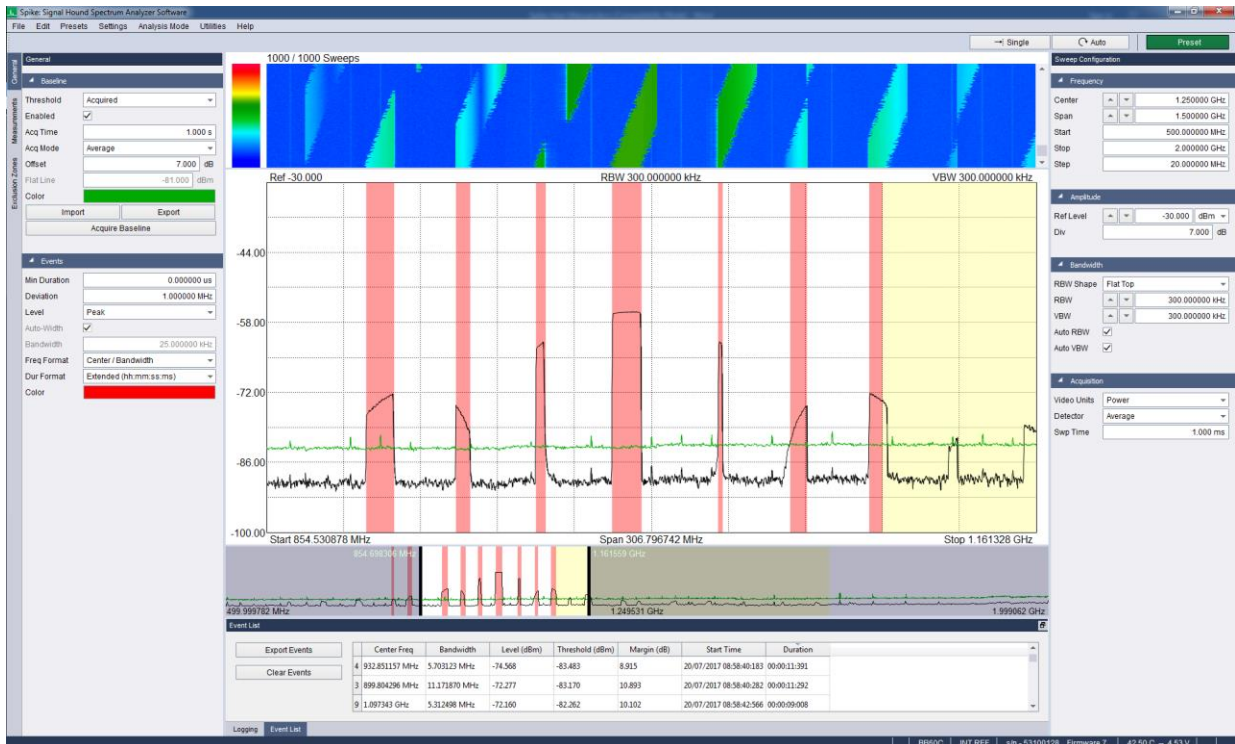


Figure 34: Detecting events in Interference Hunting mode with an acquired baseline. Yellow area on right is an exclusion zone.

A signal can be detected by setting a baseline, or an amplitude threshold above which a signal is considered suspicious. Any time a signal occurs above this baseline level, an “event” is created in software to describe this instance in as much relevant detail as possible. An event stores the frequency, bandwidth, peak level or channel power, threshold (baseline level at that frequency), margin (decibels over threshold), start time, and duration of the signal.

Events are then displayed in a list on screen that updates after every sweep, and they can be logged as they occur in a CSV file. Logging allows for unmanned operation over an extended period of time, which is especially useful for sparsely intermittent signals. The software can sit for days watching, and it will automatically capture all relevant details of interesting signals, producing data for later inspection.



## 4.10.1 Setting a Baseline

A baseline can be either a flat line, representing a single amplitude level threshold, or can be acquired over a period of sweeps. In the latter case it may represent, for example, a max held image of the noise floor.



Figure 35: A flat baseline.



Figure 36: An acquired baseline.

A flat baseline can be set instantly by simply choosing a threshold level. A baseline is acquired by setting a time interval for acquisition, and a mode of acquisition-- min hold, max hold, or average. Once acquired, a decibel offset can be applied to move the baseline to the desired location on the amplitude axis. Acquired baselines can be exported and imported, using a CSV format.

### 4.10.1.1 Baseline File Format

A baseline is saved as a CSV file, consisting of a header and a list of points defined as (frequency, amplitude) pairs. If you export an active baseline, you will observe the file format below.

```

BASELINE, Version 1
startFreq, 2.00E+09
binSize, 100.0E+06
RBW, 30.0E+03
VBW, 30.0E+03
refLevel, -20.00
div, 10.00
timestamp, 1.50714E+12
offset, 5.00

frequency(Hz), amplitude(dBm)
2.00E+09, -50.00
2.10E+09, -51.00
2.20E+09, -48.00
2.30E+09, -39.00
...
...

```

Table 1: Baseline file format example.

The frequency of each point is inferred from *startFreq* and *binSize* as defined in the header; the first point's frequency is equal to *startFreq*, and each following frequency is spaced *binSize* from the one before it. The frequencies listed are for convenient reference and are NOT USED when importing the baseline.

RBW, VBW, refLevel, and div reflect the sweep settings at the time of capture. Like the timestamp and point frequencies, they are for reference and are ignored. Offset refers to the dB offset specified in the [Baseline section of the General Control Panel](#).

Custom baseline CSV files utilizing this format can be edited or created in a spreadsheet editor and then imported.

## 4.10.2 Defining Events

For a single sweep, an event is the portion of a signal that is above the baseline. However, since an event has a time dimension, and may exist over multiple sweeps, the issue arises of when to consider a single-sweep event to be merely a snapshot of an ongoing multi-sweep event, when to consider it as the full event, and when to not consider it an event at all.

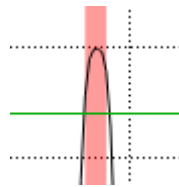


Figure 37: A single-sweep snapshot of an event.

Two parameters are available to fine-tune what constitutes an event in the time domain—frequency deviation and minimum duration. Deviation refers to the maximum allowable difference in center frequencies between consecutive snapshots for those snapshots to be considered part of the same event. Minimum duration sets a lower bound on how long a signal must persist before being considered an event.

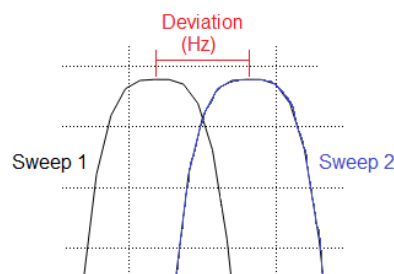


Figure 38: The frequency deviation between two single-sweep snapshots of an event.

To maximize capture and catch quick or jumpy signals, set minimum duration to zero and deviation to a high value. To more tightly restrict what constitutes an event for more persistent and steady signals, set minimum duration to a higher value and dial down deviation.

## 4.10.3 Regional Zoom

Interference Hunting mode provides regional zoom functionality, which allows for close visual inspection of specific parts of spectrum without changing span.

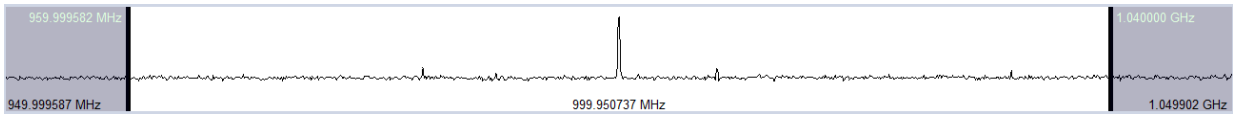


Figure 39: The regional zoom controller.

The regional zoom controller is located below the main sweep plot, appearing as a horizontal strip. It is used to control what portion of the sweep is visible in the main plot by adjusting the lower and upper bounds of the unshaded region. These bounds, visible as vertical black lines, to the left and right of which are the unseen shaded regions, can be dragged in either direction, and the entire unshaded window can be dragged.

The full sweep at the current span setting, along with any baselines and events, is always visible in the regional zoom controller.

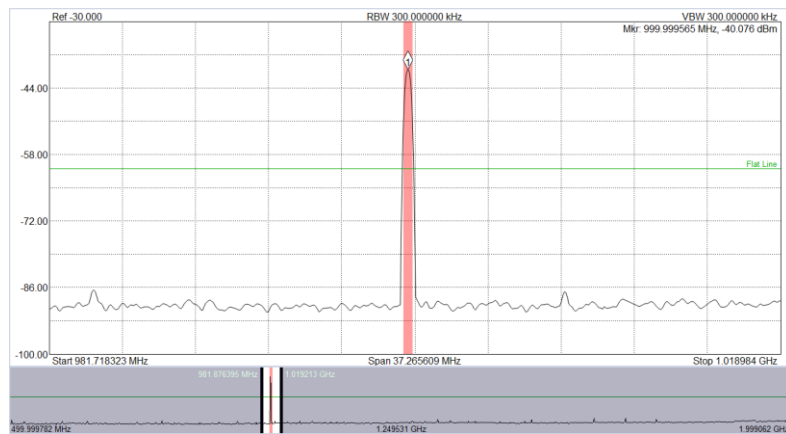


Figure 40: Regional zoom being used for close inspection of event.

## 4.10.4 Exclusion Zones

Exclusion zones are areas of spectrum where events cannot occur. By excluding known sources, large areas of spectrum can be monitored with decreased risk of false positives. An exclusion zone is defined by a start and stop frequency.

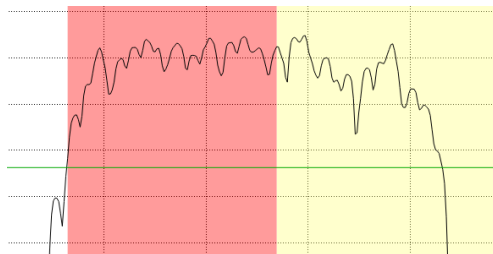


Figure 41: A signal breaking a flat baseline threshold and falling partially within an exclusion zone (the yellow shaded portion). Only the unexcluded part of the signal is considered an event (the red shaded portion).

## 4.10.5 Spectrogram

The spectrogram, or waterfall, is a useful view in this mode, and can optionally appear above the main plot. It is described in more detail in [Display Modes](#).

## 4.10.6 Sweep Settings Control Panel

See [Sweep Settings Control Panel](#) in Swept Analysis Mode.

## 4.10.7 Interference Hunting Toolbar

- **Spectrogram** – Enables the spectrogram display. See [Spectrogram](#).

## 4.10.8 General Control Panel

The General control panel contains the basic controls specific to Interference Hunting mode. It is divided into two sections, Baseline and Events, which are the two main abstractions introduced by the mode.

### 4.10.8.1 Baseline

A baseline defines the threshold, at each frequency it contains, above which a signal is considered to be an event. A baseline can be either a flat line, where the threshold is the same across all frequencies, or it can be acquired from a signal over a period of time.

- **Threshold** – Specifies which type of baseline is being used: an acquired one, or a flat line (minimum signal).
- **Enabled** – Specifies whether a baseline will be displayed on plots and used to detect events.
- **Acq Time** – The amount of time over which a new baseline is acquired.
- **Acq Mode** – What type of accumulation function to use on consecutive sweeps during baseline acquisition.
- **Offset** – The amplitude offset of an acquired baseline from its original level.
- **Flat Line** – The amplitude that is the constant threshold for what is considered an event.
- **Import** – Load a saved baseline.
- **Export** – Save the current baseline.
- **Acquire Baseline** – Begin acquiring a new baseline according to the current acquisition rules.

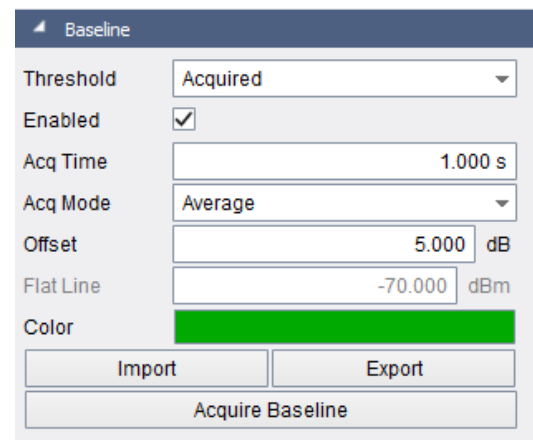


Figure 42: Baseline subset of General Control Panel

### 4.10.8.2 Events

An event is an incident where the input signal jumps above the threshold set by the baseline over a frequency range. It is defined by a frequency, bandwidth, peak level or channel power, threshold

(baseline level at that frequency), margin (decibels over threshold), start time, and duration of the signal.

- **Min Duration** – The minimum amount of time a signal must break the baseline to be considered an event.
- **Deviation** – The allowable variation of the center frequency of an event.
- **Level** – The mode of level calculation.
  - **Peak** – The highest amplitude of event.
  - **Channel Power** – The channel power surrounding the center frequency of the event.

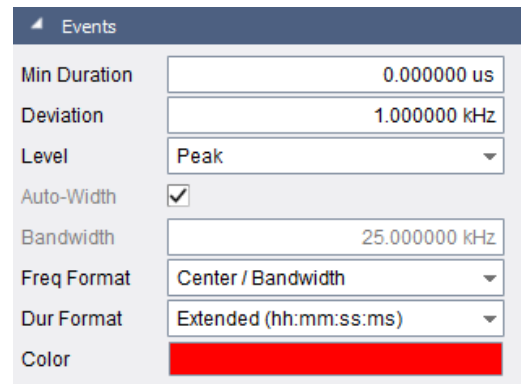


Figure 43: Events subset of General Control Panel

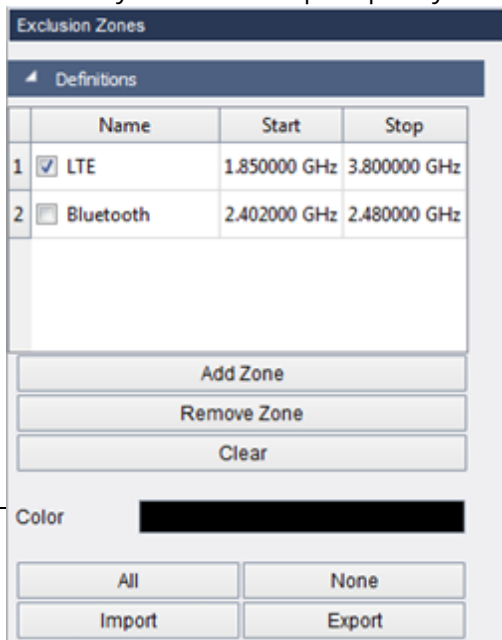
- **Auto-Width** – In Channel Power mode, automatically choose a bandwidth for channel power computation.
- **Bandwidth** – In Channel power mode, manually input a bandwidth for channel power computation.
- **Freq Format** – The frequency format to be used in event list and logging.
  - **Center / Bandwidth** – Specify an event using its center frequency and bandwidth.
  - **Start / Stop** – Specify an event using its start and stop frequencies.
- **Dur Format** – The duration time format to be used in event list and logging.
- **Basic (s)** – Display time in seconds.
- **Extended (hh:mm:ss:ms)** – Display time in clock format.
- **Color** – The color of an event on the plots.

## 4.10.9 Measurements Control Panel

See [Measure Control Panel](#) in Swept Analysis Mode.

## 4.10.10 Exclusion Zones Control Panel

An exclusion zone is an area of spectrum in which an event cannot take place. An exclusion zone is defined by a start and stop frequency. It is useful for ignoring known sources.



- **Add Zone** – Adds a new exclusion zone definition to the list and activates it.
- **Remove Zone** – Removes the highlighted exclusion zone definition from the list.
- **Clear** – Removes all exclusion zone definitions from the list.
- **All** – Activates all exclusion zone definitions in the list.
- **None** – Deactivates all exclusion zones definitions in the list.
- **Import** – Import a saved set of exclusion zone

definitions.

- **Export** – Export the current list of exclusion zone definitions for later loading.

Figure 44: Exclusion Zones Control Panel

### 4.10.11 Logging Control Panel

Events can be logged in real time as they occur by being automatically written out to a CSV log file. Logging can occur over long periods of time and does not require monitoring. Logging continues until either the logging is manually cancelled, a set amount of time has elapsed, or a set number of maximum events has been reached.

Figure 45: Logging Control Panel

- **Save Directory** – The default directory for the CSV event list files to be stored.
- **File Prefix** – Applies a file name prefix to all files saved. Useful for creating identifiable file names.
- **Capture Size** – Specifies the length of time during which logging takes place.
- **Unlimited Events** – No upper limit on events captured-- continue for the duration of the capture size.
- **Max Events** – The maximum number of events that can be logged during one capture.
- **Max File Size** – The maximum file size allowed for a CSV log file.

### 4.10.12 Event List

Current events appear in the event list, which is updated every time a new sweep arrives from the device. The event list can be continuously sorted by any of its columns and can be exported to a CSV file for a quick snapshot of events occurring at that time. When events are cleared, all future events are considered new, and start times begin at the time received and durations begin at zero.

	Center Freq	Bandwidth	Level (dBm)	Threshold (dBm)	Margin (dB)	Start Time	Duration
3	999.999565 MHz	624.999728 kHz	-40.137	-81.000	40.863	20/07/2017 08:15:24:794	00:01:05:440
2	120.039010 MHz	78.124966 kHz	-80.345	-81.000	0.655	20/07/2017 08:15:55:115	00:00:35:119
4	2.9999999 GHz	468.749796 kHz	-60.766	-81.000	20.234	20/07/2017 08:15:56:445	00:00:33:789

Figure 46: Event List

- **Export Events** – Save the current event list table to a CSV file, preserving the current sorting rule.
- **Clear Events** – Delete all events in event list table.

## 4.11 SPECTRUM EMISSION MASK

The spectrum emission mask (SEM) measurement is used to detect out of band spurious, interfering, and excessive emissions. Emissions are tested against a mask that can be defined as relative to the in-band power of a signal at frequency offsets relative to the center frequency.

Masks are entered manually in the offset table. Spike also contains several preset masks that can be loaded directly into the table. Mask offsets are drawn on the graticule using shaded regions, green for passing, red for failing.

When configuring the SEM measurement, an input level should be chosen that is as close to the expected input power as possible. This will improve the dynamic range of the measurement. An IF overload message will appear if the input power is set too low.

All configured offsets are measured relative to an amplitude reference. This reference is measured using either a peak measured value, the channel power, or directly set by the user. The span of which the peak or channel power is measured is selectable and defaults to the span between the first configured offset. The reference is calculated for each sweep.

The plot in SEM mode adheres to the [basic plot](#) interface in Spike.

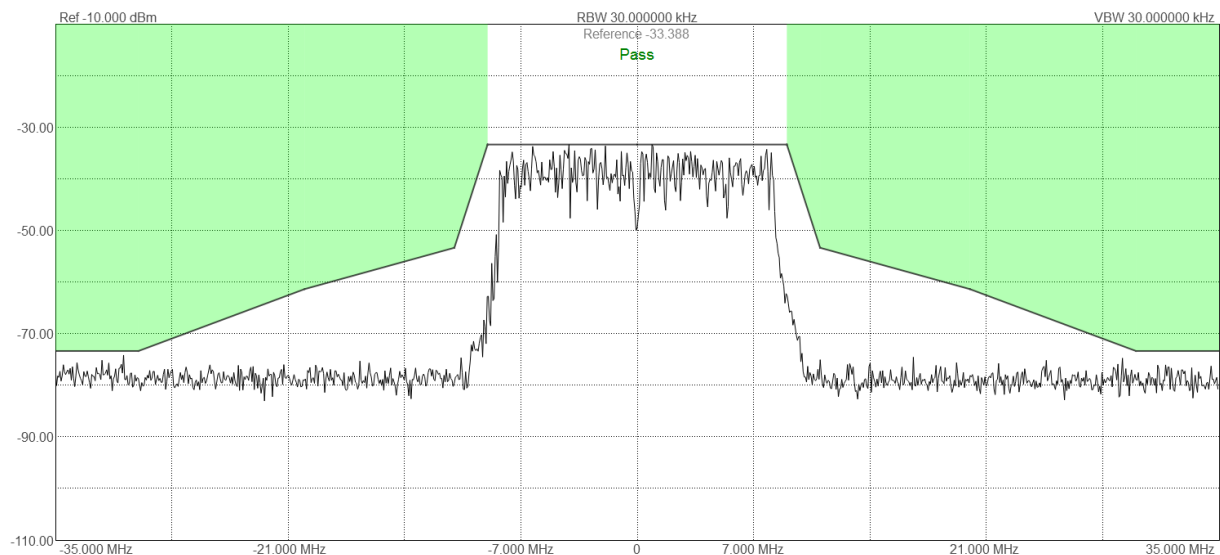


Figure 47: Testing input against an 802.11 OFDM transmission mask.

### 4.11.1 Control Panel

The following is a description of the various controls in the SEM Settings control panel.

- **Center Freq** – The reference frequency for the offset table and tuned center frequency of the sweep.
- **Step** – Controls the frequency step size when using the center freq arrows.
- **Span** – Frequency span around the center frequency.
- **RBW** – Resolution bandwidth, using a flattop window.
- **VBW** – Video bandwidth.
- **Input Level** – The maximum expected input level of the signal.
- **Div** – Controls the plots y-axis scale.
- **Video Units** – In the system, unprocessed amplitude data may be represented as voltage, linear power, or logarithmic power. Select linear power for RMS power measurements. Logarithmic power is closest to a traditional spectrum analyzer in log scale.
- **Detector** - As the video data is being processed, choose whether min/max or avg amplitudes are stored.
- **Trace Type** – Specify whether a clear/write or max hold trace is used.
- **Meas Type** – Specify how the reference amplitude is measured.
- **Reference** – Specifies the amplitude reference directly.
- **Width Set** – Specify the range of frequencies over which the channel power amplitude measurement reference is calculated.
  - When set to *Auto* the span between the center frequency and first frequency offset is used.
  - When set to *Manual* the entered width is used.
- **Width** – Direct set width.
- **Meas Width** – Actual measurement width.
- **Load Mask** – Load a predefined offset table based.

### 4.11.2 Context Menu

- **Show Pass/Fail Indicator** – Toggles visibility of pass/fail indicator located at top center of graticule.

### 4.11.3 Configuring Offsets

Up to 16 offsets can be configured. Offsets can be tested against an absolute amplitude or one relative to the measured power of the in-band channel and can have linear shape (flat or linear slope). Offsets are configured as uppers offsets but are then applied as both upper and lower, symmetrical around the center frequency.

	State	Start Freq	Stop Freq	Limit Start	Limit Stop	Mode
1	Enabled	10.000000 kHz	20.000000 kHz	-25.000	-25.000	Relative
2	Enabled	20.000000 kHz	30.000000 kHz	-35.000	-35.000	Relative
3	Enabled	30.000000 kHz	60.000000 kHz	-35.000	-65.000	Relative
4	Enabled	60.000000 kHz	75.000000 kHz	-65.000	-65.000	Relative
5	Enabled	75.000000 kHz	100.000000 kHz	-80.000	-80.000	Relative
6	Disabled	-1.000000 Hz	-1.000000 Hz	0.000	0.000	Absolute

Figure 48: SEM offset table editor.



## 4.11.4 Results

The result of each configured offset is displayed in the results table. The results table shows the largest margin of both the upper and lower offset on one row. Results can be exported to a custom CSV.

The frequency and level columns display the frequency and amplitude of the worst margin in the given offset.

	Lower Frequency	Lower Level	Lower Margin	Lower Pass/Fail	Upper Frequency	Upper Level	Upper Margin	Upper Pass/Fail
1	999.987895 MHz	-89.75	48.62	Pass	1.000010 GHz	-87.55	46.42	Pass
2	999.977926 MHz	-91.26	40.13	Pass	1.000023 GHz	-90.00	38.86	Pass
3	999.940334 MHz	-94.64	13.84	Pass	1.000059 GHz	-93.94	13.82	Pass
4	999.933302 MHz	-94.40	13.27	Pass	1.000062 GHz	-94.43	13.30	Pass
5	999.917963 MHz	-95.39	-0.74	Fail	1.000083 GHz	-95.03	-1.10	Fail
6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Figure 49: SEM Results Table.

## 4.11.5 Limitations

Not all Signal Hound devices can perform all mask measurements. The dynamic range limitations of some Signal Hound devices such as the SA44, SA124, and BB60 series spectrum analyzers might prohibit certain mask measurements such as the AM/FM masks at the outer offsets. To avoid failing measurements in these situations it might be necessary to disable the outer offsets.

*(A note about the legacy software broadcast mask measurements.)* The legacy Signal Hound software performed custom sweeps to help overcome the dynamic range limitations of the SA series devices. These custom sweeps are not performed in the Spike software and thus you might have different results when comparing to the legacy software, particularly when comparing the FM broadcast mask measurements.

## 4.12 NOISE FIGURE

Noise figure measurements are available for SM, SP, and BB series devices. For more information, see [Limitations](#).

Noise figure is a measure of the noise a device contributes to a signal, expressed as the degradation in signal/noise ratio as the signal passes through the device. It is not a direct measurement, but is computed, using the Y factor technique, from several measurements taken by the spectrum analyzer.

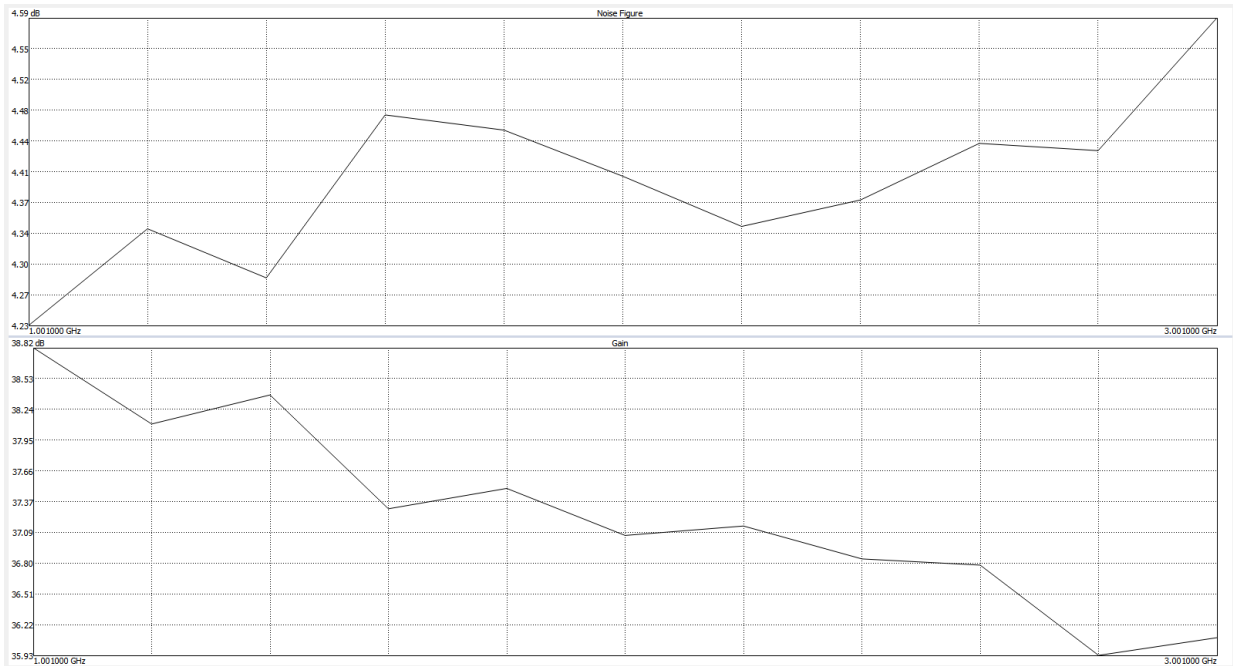


Figure 50: Noise figure and gain plots of a small wideband amplifier, tested with an SM200A and an Agilent 346B noise source.

## 4.12.1 Process Overview

The measurement consists of two steps, each of which measures the noise power level when the noise source is in an ON and OFF state. In the first step (calibration), the noise source is connected directly to the spectrum analyzer. Then, in the second step (DUT measurement), the DUT is inserted in the signal chain between the noise source and the spectrum analyzer.

The DUT properties are derived from the difference between the DUT measurement system and the calibration system.

Once a calibration is performed for the current configuration, repeated measurements can be taken without the need for repeating the calibration step.

## 4.12.2 The Y Factor Method

The Y factor technique is a common method of calculating noise figure (NF). Its computations are carried out in terms of noise temperature (T) in linear scale.

Noise figure is expressed on the logarithmic scale. Noise factor (F) is the linear equivalent:

$$NF = 10 \log_{10} F$$

(1)

The Y factor is defined as the linear ratio of noise power level when the noise source is ON and OFF:

$$Y = \frac{N_{ON}}{N_{OFF}} \quad (2)$$

The Y factor can be converted to noise temperature:

$$T = \frac{T_{Source}^{ON} - Y (T_{Source}^{OFF})}{Y - 1} \quad (3)$$

where  $T_{Source}^{ON}$  is the excess noise ratio (ENR) of the noise source, and  $T_{Source}^{OFF}$  is the ambient room temperature, generally considered to be 290 K.

Noise factor can then be derived from noise temperature:

$$F = 1 + \frac{T}{T_{Source}^{OFF}} \quad (4)$$

The measurement setup is considered a two-stage system, where the DUT is stage 1, and the spectrum analyzer is stage 2. The noise factor of a two-stage system ( $F_{12}$ ) can be derived from the noise factors of its component stages ( $F_1, F_2$ ) and the gain of its first stage ( $G_1$ ):

$$F_{12} = F_1 + \frac{F_2 - 1}{G_1} \quad (5)$$

This equation can be written in terms of noise temperature for stage 1:

$$T_1 = T_{12} - \frac{T_2}{G_1} \quad (6)$$

DUT gain is computed:

$$G_1 = \frac{N_{12}^{ON} - N_{12}^{OFF}}{N_2^{ON} - N_2^{OFF}} \quad (7)$$

So, after noise temperatures have been calculated from the calibration ( $T_2$ ) and DUT measurement ( $T_{12}$ ) steps, the noise figure of the DUT is calculated using equations 4, 6, and 7.

### 4.12.3 Control Panel

The following is a description of the various controls in the Noise Figure Settings control panel.

- **Freq Mode** – Choose between *Swept* and *Fixed* mode. In swept mode the number of measurement points specified by *Points* are evenly distributed across the span. In *Fixed* mode, only the *Fixed Freq* is tested.
- **Start/Stop** – The lowest and highest frequencies to test (when not in fixed mode).
- **Center** – The center of the range of frequencies to test (when not in fixed mode).
- **Span** – The range of frequencies to test (when not in fixed mode).
- **Points** – The number of frequencies to test, evenly spaced across the span (when not in fixed mode).
- **Fixed Freq** – The frequency tested in fixed mode.
- **Ref Level** – The power level of the top graticule line.
- **RBW** – Resolution bandwidth, using a flattop window.
- **VBW** – Video bandwidth.
- **Auto RBW** – Having auto selected will choose reasonable and fast RBWs relative to the meas span. When changing meas span, it is recommended to have this enabled along with Auto VBW.
- **Auto VBW** – When enabled, VBW will equal RBW.
- **Meas Span** – The span of the sweeps taken during measurement at each test frequency.
- **Averaging** – If averaging is enabled, then for each frequency test point, the number of power readings defined in “Avg Number” will be averaged.
- **Avg Number** – The number of sweeps averaged during measurement at each test frequency, if averaging is enabled.
- **Room Temp** – The ambient temperature of the room, in Kelvin.
- **Play Alert** – When enabled, a sequence of beeps will play when a full sweep through the measurement points is completed.
- **Noise Source (Cal)** – Select the noise source to be used for the calibration step. (See [Noise Sources & ENR Tables](#) for more info.)
- **Noise Source (Meas)** – Select the noise source to be used for the measurement step. (See [Noise Sources & ENR Tables](#) for more info.)
- **Manage ENR Tables** – Opens a manager for the persistent collection of noise source ENR tables. (See [Noise Sources & ENR Tables](#) for more info.)

#### 4.12.3.1 Noise Sources & ENR Tables

When the noise source is receiving power (ON state), its “hot” noise temperature is the excess noise ratio (ENR) at the frequency being measured. A table of ENR values is a part of the spec of a noise source, and is often printed on the device. This table must be manually entered into the software to obtain accurate measurements.

The ENR Table Manager allows for the addition, removal, renaming, and editing of points of each ENR table. It is accessed via the “Manage ENR Tables” button. Once entered, an ENR table will persist across sessions until deleted. There is no limit on the number of ENR tables that may be stored, although in practice this would not exceed the number of noise sources available for use.

The table(s) used for calibration and measurement are saved and loaded in global presets and matched by name to the current noise source list.

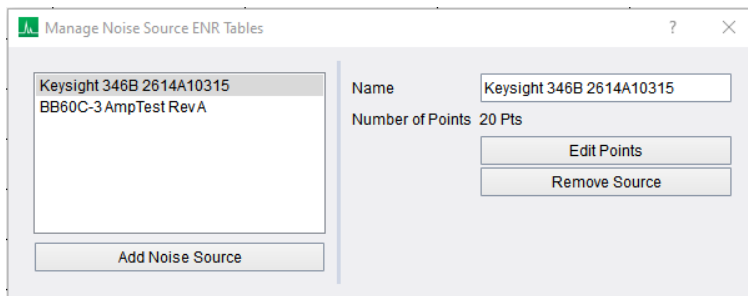


Figure 51: Noise Source ENR Table Manager

## 4.12.4 Results Table

This table displays the measured noise figure and gain at each frequency tested. The table can be exported as a CSV file using the “Export Results Table” button.

	Frequency	Noise Figure (dB)	Gain (dB)
1	1.001000 GHz	4.23	38.82
2	1.201000 GHz	4.34	38.10
3	1.401000 GHz	4.29	38.38
4	1.601000 GHz	4.47	37.31
5	1.801000 GHz	4.46	37.50
6	2.001000 GHz	4.40	37.06

Figure 52: Noise figure results table.

## 4.12.5 Making Measurements

Taking a noise figure measurement is a process that consists of a sequence of manual steps with different physical connections. Because of this, Noise Figure mode does not make continuous measurements.

At any point a measurement can be cancelled using the “Abort” button on the progress dialog. This will revert the state to before the aborted measurement was begun.

### 4.12.5.1 Calibration

For the most accurate characterization of the DUT, the system should first be calibrated. This establishes a baseline, accounting for the analyzer’s noise contribution, that can later be subtracted out to isolate the DUT’s performance. This process is often called second stage correction.

The calibration step is optional. If the DUT has high gain (exceeding 30 dB), and the spectrum analyzer has low noise figure, then the second stage error is minimal, and calibration can be skipped. Otherwise, skipping calibration will generally result in substantially higher errors. Note that calibration is required for gain measurement.

Calibration is initiated with the “Calibrate” button on the main toolbar. When this process is complete, measurements can be taken with maximum accuracy. A calibration will hold (i.e. calibration data is stored in memory) for the duration of the Spike session, or until the configured measurement points change. In practice, measurement points are affected by the settings in the control panel’s “Frequency

List” section. If other aspects of the configuration change, such as sweep settings or averaging, the current calibration will continue to be utilized, but at a reduced measurement accuracy.

The software is always in one of three calibration states, shown as “Cal State” in the toolbar:

- Uncal (red) – There is no valid calibration currently stored. High measurement error is likely unless the DUT has at least 30 dB gain.
- ~Cal (yellow) – There is a valid stored calibration, however the measurement accuracy has been reduced due to changes in the configuration since last cal.
- Cal (green) – There is a valid stored calibration whose settings are identical to the current configuration.

A fresh calibration can be run at any time. For the most accurate measurements, run a calibration whenever settings change and the calibration state goes out of green “Cal”.

### 4.12.5.2 Measurement Process

Throughout the measurement process, modal dialog boxes will prompt the user to make the necessary connections.

The process is as follows:

- 1) Configure the measurement.
  - a. Define the frequency list using the “Frequency List” section of the control panel. This is the list of test frequencies at which measurements will be performed. If “fixed” is checked, then the frequency list will contain one frequency only, that defined by “fixed freq”. Otherwise, the span between start and stop will be divided evenly by the number of points.
  - b. Define the measurement settings. This includes the settings for each sweep (meas span, the Amplitude and Bandwidth sections of the control panel), the number of sweeps to average at each point (Avg Number), the ambient temperature (Room Temp), and selecting the ENR table that corresponds to the noise source being used.
- 2) Calibration (Optional).
  - a. Connect the noise source directly to the spectrum analyzer.
  - b. Follow prompts to switch power to the noise source on and off.

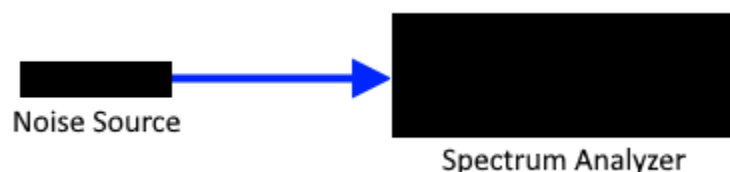


Figure 53: Noise figure calibration step setup.

- 3) DUT Measurement.
  - a. Insert the DUT in the signal chain between the noise source and the spectrum analyzer.
  - b. Follow prompts to switch power to the noise source off and on.

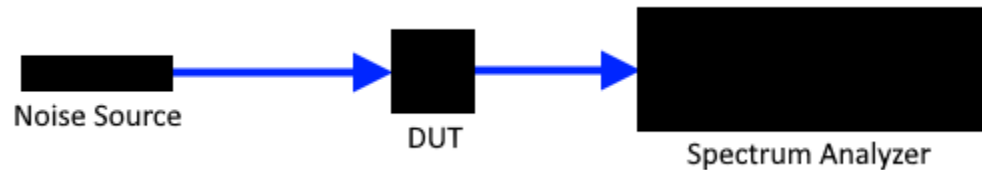


Figure 54: Noise figure DUT measurement step setup.

- 4) Results.
  - a. Noise figure and gain calculations at each frequency will be shown in the Noise Figure and Gain plots, and the Results table.
- 5) Repeat steps 3 – 4 as desired, or return to step 1 to define a new configuration.

## 4.12.6 Annunciator List

### 4.12.6.1 Invalid

If the noise figure or gain calculation fails, an “Invalid” annunciator will be printed in red on the noise figure and gain plots.

This will happen if the signal measured with the noise source powered ON is ever not higher than the signal with the noise source powered OFF. In this case, make sure the noise source is powered and generating a signal as expected and retake measurement.

Some potential remedies to this issue include:

- Using a noise source with sufficient ENR
- Increasing averaging
- Increasing meas span
- Setting reference level for maximum sensitivity
  - o The table below shows what this value would be for compatible analyzers:

<b>SM200/435</b>	-20 dBm or lower
------------------	------------------

<b>SP145</b>	-30dBm or lower
<b>BB60C</b>	-50 dBm or lower
<b>BB60D</b>	-30 dBm or lower

#### 4.12.6.2 IF Overload

This indicates that an IF overload occurred during a measurement. See “IF Overload” in [Annunciator List](#).

#### 4.12.6.3 IF Overload (Cal)

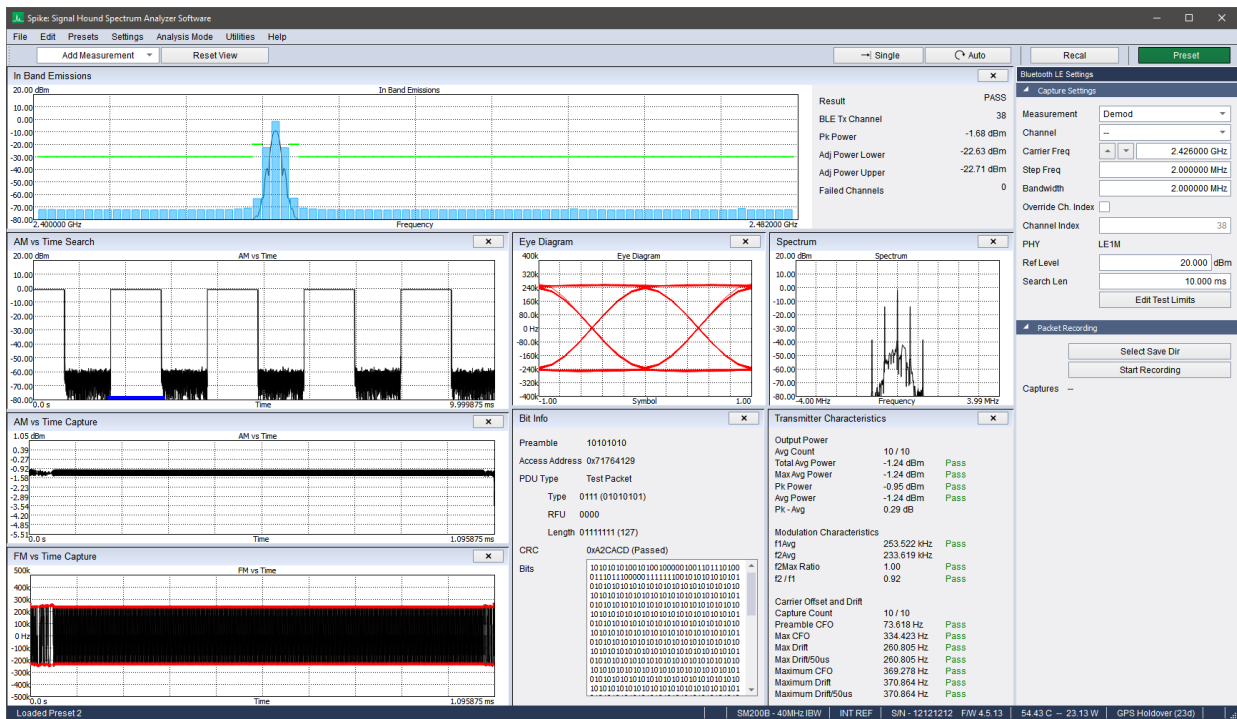
This indicates that an IF overload occurred during the calibration utilized by the measurement. See “IF Overload” in [Annunciator List](#).

### 4.12.7 Limitations

- **SA Series** – Noise figure measurements are not available for SA series devices. Their use of software image rejection makes them unsuitable for broadband noise signals.
- **BB Series** – For best results, keep ENR + gain below 40 dB.
- **SP Series** – For best results, keep ENR + gain below 50 dB.
- **SM Series** – For best results, keep ENR + gain below 60 dB.



## 4.13 BLUETOOTH® LOW ENERGY



The Bluetooth Low Energy measurement mode allows customers to perform general purpose Bluetooth Low Energy measurements as well as test Bluetooth Low Energy waveforms against the Bluetooth Special Interest Group (SIG) test specifications for Bluetooth Low Energy transmitters. The Spike software performs automatic detection and demodulation of Bluetooth Low Energy waveforms and displays the results in several standard measurement windows. Additionally, decoded Bluetooth Low Energy packets can be saved to a .pcap file for further analysis in many pcap file analyzers. These features make Spike an affordable and easy option for Bluetooth Low Energy troubleshooting, pre-compliance, monitoring, and device manufacturing.

The Spike software supports waveforms meeting the specifications outlined in the core 5.2 spec. Spike supports the 1MHz PHY only.

### 4.13.1 Measurement Concepts

#### 4.13.1.1 Demodulation

When *Demod* measurement type is selected, Spike performs packet demodulation at the center frequency selected. An I/Q capture with a specified search length is performed, and a valid waveform is searched for over this interval. If a valid Bluetooth Low Energy waveform is detected, full demodulation occurs, any applicable transmitter tests are performed, and the measurement windows are updated. This will update all plots except the in-band emissions plot.

Detection is performed using a moving average power detector combined with a preamble detect. If a valid preamble is detected the access address and PDU header is decoded. The PDU is de-whitened using either the center frequency selected or if overridden, the specified channel index. The waveform is rejected if the signal length does not match the expected size as specified in the PDU header.

### 4.13.1.2 Transmitter Testing

The Spike software performs the following transmitter tests as defined by the Bluetooth® SIG\*.

- TP/TRM-LE/BA-BV-01-C, output power
- TP/TRM-LE/BA-BV-03-C, in-band emissions
- TP/TRM-LE/BA-BV-05-C, modulation characteristics
- TP/TRM-LE/BA-BV-06-C, carrier frequency offset and drift

\*Tests are defined in RF-PHY.TS,p15.

By default, test limits are defined to match the specification. Test limits can also be changed by the user.

Output power, modulation characteristics, and carrier offset and drift measurements are all performed in the demodulation measurement mode. These tests are performed automatically when a valid payload is detected.

- Output power measurements are performed over all valid Bluetooth Low Energy waveforms.
- Carrier offset and drift measurements are performed when the physical layer PDU bits (transmitted bits) are equal to the pattern 10101010 or 01010101.
- Modulation characteristic measurements are performed when the physical layer PDU bits (transmitted bits) are equal to the pattern 00001111 or 11110000. Please note, some measurements such as  $f_2/f_1$  require both 01010101 and 00001111 patterns to be transmitted before a valid measurement can be made.

The PDU type does not have to be a test packet (access address 0x071764129) for the payload bits to be checked, any PDU type will be searched.

### 4.13.1.3 In-Band Emissions

The in-band emissions test is activated by selecting the in-band emissions measurement type in the control panel. When this measurement is active, only the in-band emissions measurement plot is updated.

The in-band emissions test is performed by perform a sweep over the full 2.4GHz band using the sweep configuration outlined in TRM-LE/BA/VB/03. The transmit channel is automatically detected by looking for the highest channel power from the 40 Bluetooth Low Energy transmit frequencies.

The sweep configuration used is,

- Span = 81MHz

- RBW = VBW = 100kHz
- Detector = Average
- Sweep time = 100ms

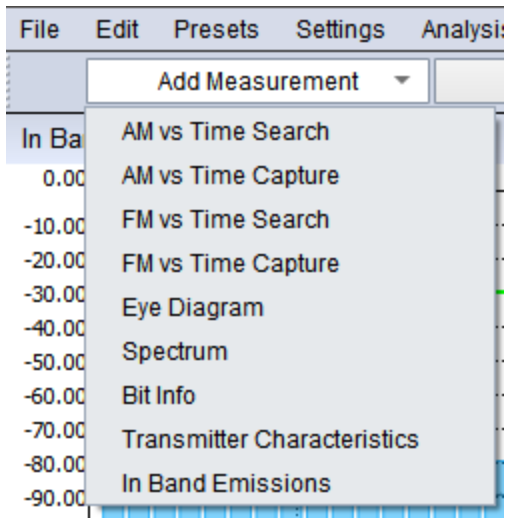
## 4.13.2 Control Panel

The following is a description of the measurement controls found on the Bluetooth Low Energy Settings control panel.

- **Measurement** – Select between demodulation measurements and in-band emissions. See the Bluetooth Low Energy Measurement Concepts section for more information.
- **Channel** – Quick frequency select. This control is used to change the center frequency for demodulation measurements.
- **Carrier Freq** – Manual frequency selection for demodulation measurements. When Override Ch. Index is unselected, the carrier frequency determines the transmit channel and therefore the seed used for PDU de-whitening.
- **Step Freq** – Controls the amount the carrier frequency changes when using the arrow buttons next to the carrier frequency control.
- **Bandwidth** – Specify the acquisition bandwidth for demodulation measurements.
- **Override Ch Index** – When enabled, the channel index can be specified manually for purposes of PDU de-whitening. This allows measurements on signals generated at any frequency. When disabled, the channel index is inferred from the carrier frequency setting.
- **Channel Index** – When override channel index is enabled, the channel index is used to seed the PDU de-whitening.
- **Ref Level** – Specifies the maximum input power to the spectrum analyzer.
- **Search Len** – Specifies the length of the window in which a valid waveform is searched. Longer search lengths increase capture probability at a decrease in measurement speed.
- **Edit Test Limits** – Change the test limits for the transmitter tests. Limits are only stored in the user presets. Modified limits do not persist through program instances unless saved and loaded through the preset menu.
- **Select Save Dir** – Select the default directory in which PCAP files are stored.
- **Start Recording** – Starts the PCAP recording. See [PCAP recording](#) for more information.

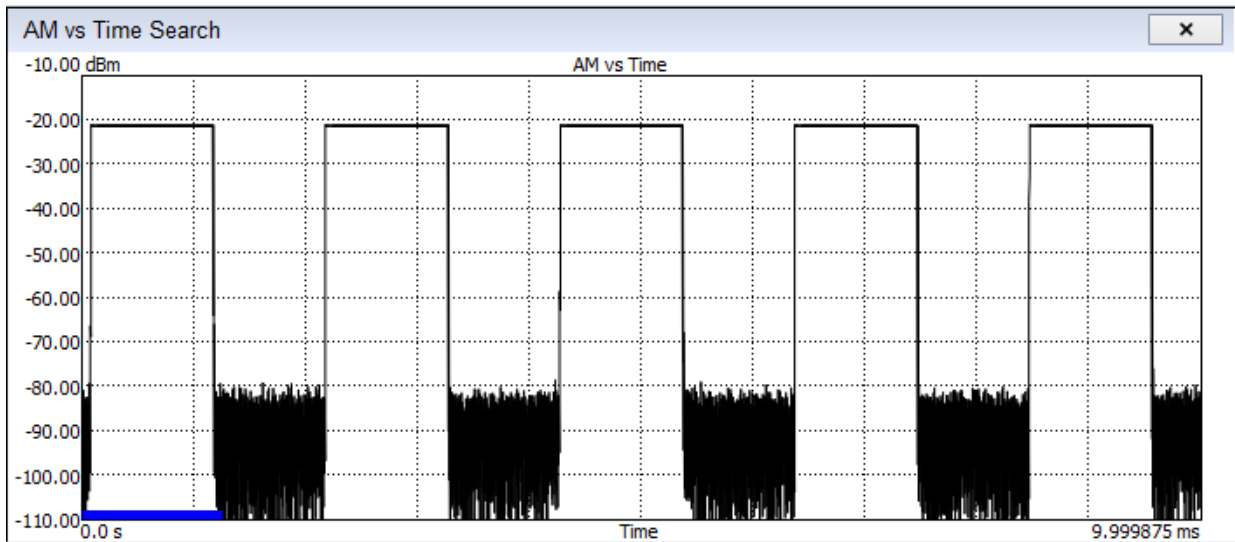
## 4.13.3 Bluetooth® Low Energy Measurement Windows

Measurement windows can be added to the plot area using the *Add Measurement* combo box.



Most measurement plots use the [basic plot](#) interface.

#### 4.13.3.1 AM vs Time Search



The AM vs Time search plot is active for demod measurements and shows the full waveform search period. If a waveform was detected it will be underlined in blue. This plot will update even if no signal was found, making this plot useful for troubleshooting, or verifying signal activity at the frequency of interest. Both capture status and annunciators are present on this plot.

The annunciators that can appear in this plot are:

- **No Signal Found**, indicates the power detect algorithm did not detect a packet. This can occur if the signal to noise ratio is too low, or if the packet started before the search window took place (search window starts in the middle of an already started packet).

- **No Preamble Found**, indicates the leading edge of the packet did not appear to contain a valid preamble. Valid preambles will contain at least 8 alternating bits. If the SNR is too low, or if the frequency offset is too large, this error can occur.
- **Format Error Detected**, can indicate the expected waveform does not match the measured waveform. When the demodulated header does not match a valid pattern, or when the expected payload extends beyond the packet signal this error can occur. This is most common when an interfering packet is transmitted mid packet, or when the SNR is too low.

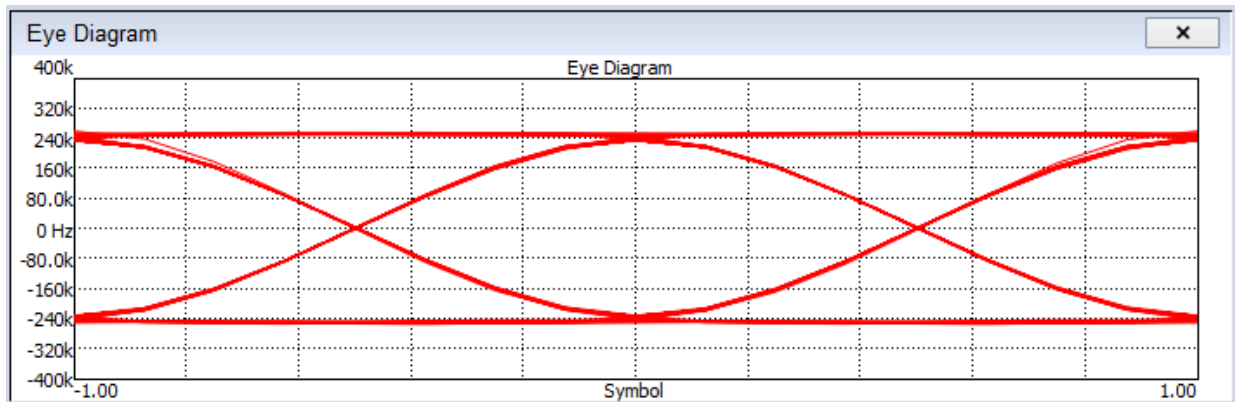
#### 4.13.3.2 AM vs Time Capture

This plot shows the amplitude vs time over the captured waveform, from the first symbol of the preamble to the last symbol of the CRC.

#### 4.13.3.3 FM vs Time Capture

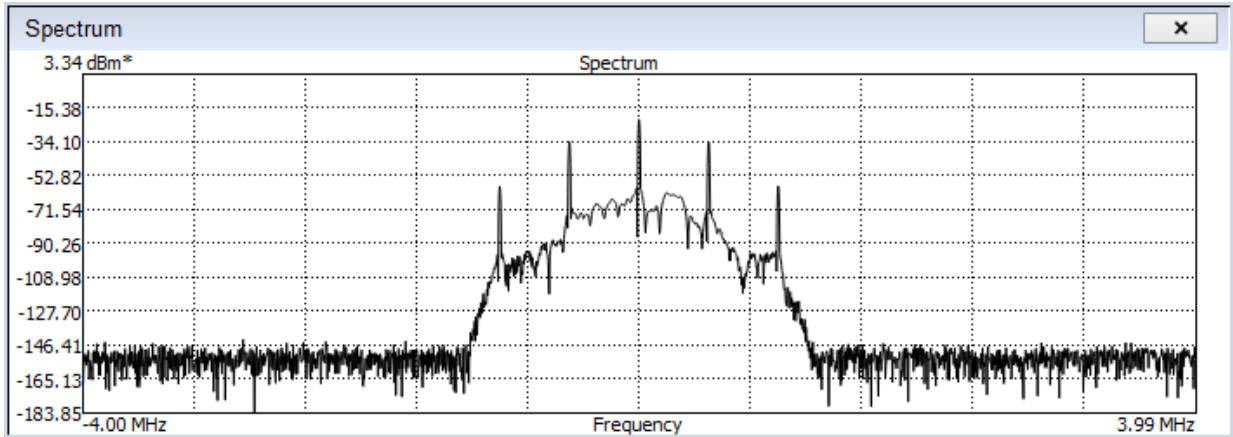
This plot shows the frequency vs time over the captured waveform, from the first symbol of the preamble to the last symbol of the CRC.

#### 4.13.3.4 Eye Diagram



The eye diagram shows every FSK symbol transition in the captured waveform. The eye diagram can provide a quick at-a-glance view of the signal health, including frequency offset, drift, noise, filter performance, or symbol timing errors.

### 4.13.3.5 Spectrum



The spectrum is calculated over the capture interval. A Nuttall window is used.

### 4.13.3.6 Bit Info

**Bit Info** ✕

Preamble 10101010

Access Address 0x71764129

PDU Type Test Packet

Type 0111 (01010101)

RFU 0000

Length 01111111 (127)

CRC 0xA2CADC (Passed)

Bits

```

10 10 10 10 100 10 100 100000 100 110 1110 1000 111
0 11 100000 11111 1100 10 10 10 10 10 10 10 10 1
0 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 1
0 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 1
0 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 1
0 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 1
0 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 1
10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 1
    
```

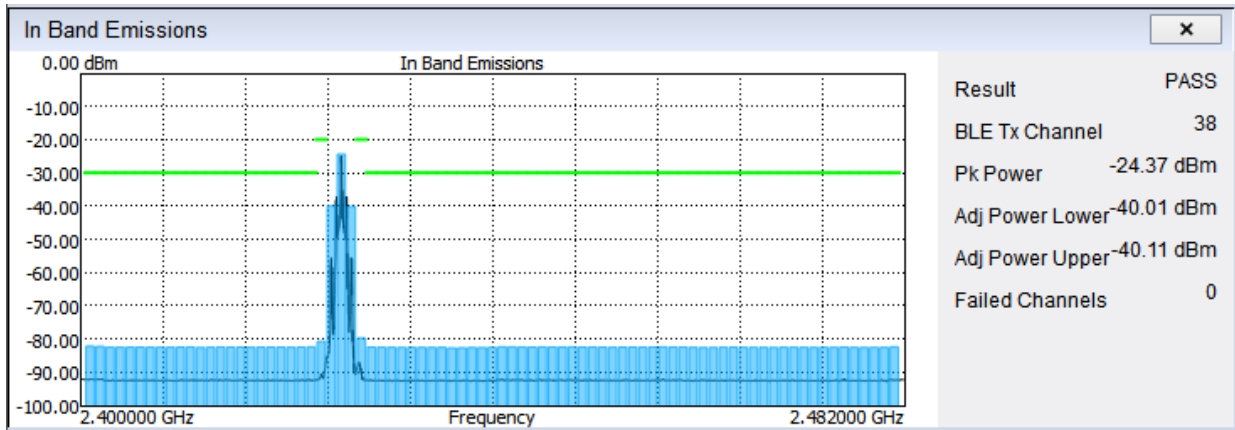
The bit info plot displays the various data components of the captured waveform. Each component of the PDU header is displayed as well as the bits for the entire capture. The PDU type is determined both from the current channel index selected and the access address value. The CRC pass/fail message is only displayed for advertising and test PDU types.

#### 4.13.3.7 Transmitter Characteristics

Transmitter Characteristics		
<b>Output Power</b>		
Avg Count	10 / 10	
Total Avg Power	-1.09 dBm	Pass
Max Avg Power	-1.08 dBm	Pass
Pk Power	-0.79 dBm	Pass
Avg Power	-1.09 dBm	Pass
Pk - Avg	0.30 dB	
<b>Modulation Characteristics</b>		
f1Avg		
f2Avg	233.830 kHz	
f2Max Ratio	1.00	Pass
f2 / f1		
<b>Carrier Offset and Drift</b>		
Capture Count	10 / 10	
Preamble CFO	-62.519 Hz	Pass
Max CFO	284.051 Hz	Pass
Max Drift	346.570 Hz	Pass
Max Drift/50us	321.296 Hz	Pass
Maximum CFO	335.583 Hz	Pass
Maximum Drift	362.397 Hz	Pass
Maximum Drift/50us	362.397 Hz	Pass

This plot displays all transmitter test results except in-band emissions. Test results appear once a valid packet has been detected for that test. Results are averaged/max-held for up to 10 captures. Test results can be reset by changing any configuration parameter or by pressing the *Recal* button.

### 4.13.3.8 In-Band Emissions



This plot displays the test results of the in-band emissions transmitter test. This plot is only updated when the measurement type is set to *In-Band Emissions*. See [Measurement Concepts: In-Band Emissions](#) for more information.

## 4.13.4 PCAP Recording

The Spike software can be configured to store every successful demodulated packet into a .pcap file. The pcap file uses the libpcap file format with the LINKTYPE\_BLUETOOTH\_LE\_LL\_PHDR link layer header type. When recording is active every packet displayed when the *Demod* measurement type is active is stored into the pcap file. Recording can be started and stopped using the Start/Stop button on the control panel.

Spike does not provide software which displays the contents of the pcap files. Several third-party applications exist for this.

## 4.14 WLAN MODULATION ANALYSIS

The Spike software can be used for 802.11b/a/n/ac/ax/ah modulation analysis. The software performs several physical layer (PHY) measurements including RF quality and performance metrics, channel characterization, and bit level troubleshooting.

This section covers the various settings and controls for performing measurements, the measurement windows, demodulation procedure, and finally a measurement walk through.

WLAN measurements are available for SM, SP, and BB series devices.

### 4.14.1 Control Panel

The following are descriptions of the various settings available on the control panel.



- **Standard** – Select the WLAN standard you wish to measure. When measuring 40MHz signal, the 40MHz standard must be selected. For AH signals, bandwidth is automatically detected.
- **Max DSSS Symbols** – Maximum number of DSSS symbols to measure. Applies to 802.11b waveforms only. Packets are truncated to this length.
- **Decode PSDU** – When enabled, OFDM PSDUs are decoded and shown in the decoded bits view. Only BCC encoded payloads can be decoded in Spike. This setting does not apply to DSSS waveforms.
- **Symbol Offset** – (OFDM only) Specify a symbol offset as percentage of the guard interval. Specify a value between -100 and 0.0. -50% is default and results in sampling the symbol halfway through the guard interval. -25% offset results in sampling the symbol 75% of the way through the guard interval. When a short GI is detected, the symbol offset will become a % of the short GI length.
- **2.4 GHz Ch.** – Select a carrier frequency by selecting an industry defined channel. This has the same effect as manually entering a new carrier frequency.
- **5 GHz Ch.** – Select a carrier frequency by selecting an industry defined channel. This has the same effect as manually entering a new carrier frequency.
- **Carrier Freq** – Select the center frequency of the measurement. For all OFDM waveforms, this should be the frequency of the center-most null DC subcarrier. Ensure the carrier frequency is within +/- 624KHz for 20/40MHz OFDM and +/-2.7MHz for DSSS signals of the channel center frequency. Outside of these limits, the software will not be able to achieve proper carrier recovery and symbol synchronization.
- **Step Freq** – Select the frequency step size when using the up/down frequency buttons. This can be useful for stepping through several adjacent channels.
- **IF BW** – Select the baseband filter bandwidth. This filter is applied before the measurement is performed. This filter should be wide enough to accommodate the signal of interest. If the BW is too wide, it may allow triggering on adjacent channels.
- **Ref Level** – Determines the maximum signal input level before potential IF overload and clipping occur. For OFDM signals this may be several dB above the expected average power of the input signal due to OFDM having a high PAPR. Reference level also adjusts the sensitivity of the instrument. If reference level is too high relative to the signal level, this will negatively affect SNR and ability to trigger on packets.
- **Meas Filter** – DSSS pulse shaping filter applied to the waveform. Currently this is fixed as a rectangular window.
- **Filter Bbt** – Adjust the pulse shaping filter coefficient. Currently not used when the rectangular window is applied.
- **Search Len** – Length of search window. See Measurement Concepts for more information.
- **OFDM Trig Threshold** – Specify a sliding window trigger threshold for OFDM measurements. The threshold must be positive. A lower threshold triggers signals with lower SNR at the expense of triggering on erroneous signals. This threshold is roughly the level above the noise floor (in the time domain) needed for packet detection to occur.
- **DSSS Trig Level** – Video trigger level used for DSSS measurements. This is an absolute trigger level. The AM vs Time (Search) window can be used to estimate a valid trigger level when first setting up a measurement.

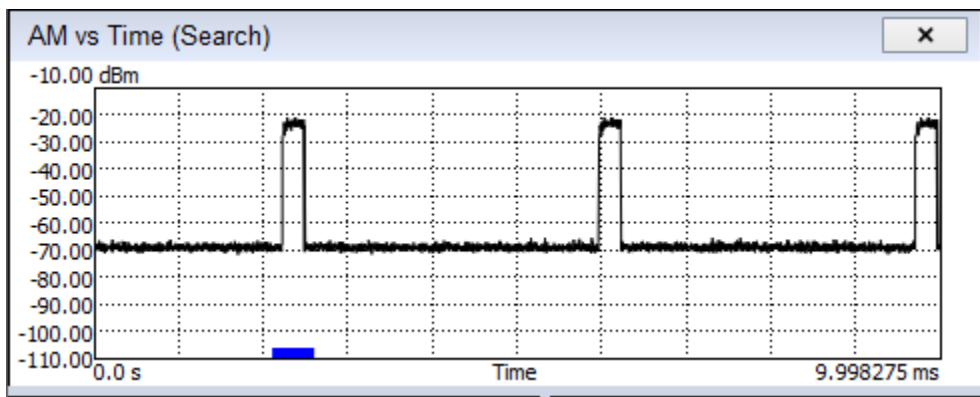
## 4.14.2 Measurement Windows

Several measurement windows can be added to the main application. Most measurement windows target either OFDM or DSSS modulations. A quick setup button is available to quickly switch between OFDM and DSSS measurement window configurations. Additionally, the measurement layout can be saved and loaded through the presets.

Most measurement plots use the [basic plot](#) interface.

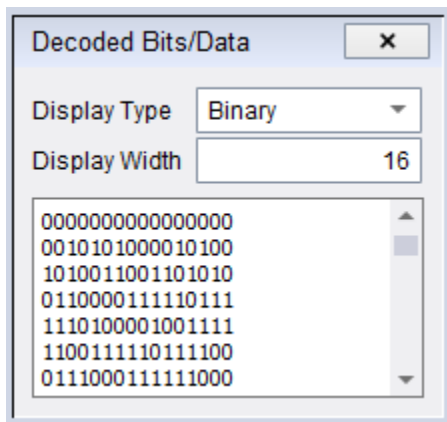
Below is a summary of some of the measurement windows.

### 4.14.2.1 AM vs Time (Search)



The AM vs Time search plot is active for successful and un-successful measurements and shows the full waveform search period. If a waveform was detected it will be underlined in blue. This plot will update even if no signal was found, making this plot useful for troubleshooting, or verifying signal activity at the frequency of interest. Both capture status and annunciators are present on this plot.

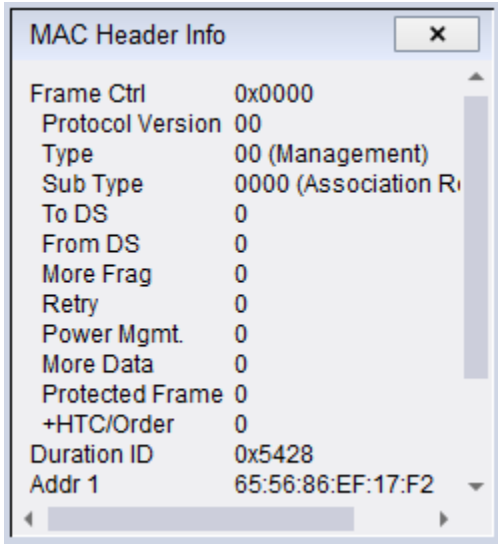
### 4.14.2.2 Decoded Bits/Data



When the PSDU is BCC encoded and Decode PSDU is selected, the decoded bits appear here. For non 802.11ax waveforms, the leading service bits and trailing zero bits are discarded, and only the specified

payload size is displayed. For 802.11ax waveforms all bits up to the post-FEC bits are displayed, including all leading zero service bits.

### 4.14.2.3 MAC Header Info



This window shows the decoded payload as a MAC header. This window will only show valid MAC header info for non-aggregate payloads.

### 4.14.2.4 Symbol Table

The screenshot shows a window titled "Symbol Table" with a close button (X) in the top right corner. The window displays a grid of bits for 6 OFDM symbols (rows 1-6) across 32 subcarriers (columns -122 to -7). The subcarriers are numbered from -122 to -7. The bits are shown as 0 or 1. Pilot subcarriers are highlighted in red. The pilot subcarriers are at -116, -100, -84, and -68.

	-122	-121	-120	-119	-118	-117	-116	-115	-114	-113	-112	-111	-110	-109	-108	-107	-106	-105	-104	-103	-102	-101	-100	-99	-98	-97	-96	-95	-94	-93	-92	-91	-90	-89	-88	-87	-86	-85	-84	-83	-82	-81	-80	-79	-78	-7			
1	1	1	0	0	0	0	0	0	1	1	1	0	0	1	1	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1	0	0	0	1	0	1	1	0	1	1	
2	0	0	0	1	0	1	0	1	1	1	1	0	1	1	0	1	0	1	1	1	0	1	1	1	1	1	0	0	1	0	0	1	1	0	0	0	0	0	1	0	1	0	1	1	1	1	1	1	
3	1	1	0	0	1	0	0	0	1	1	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	1	1	0	0	1	1	1	0	0	0	0	0	
4	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	1	1	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	1	1	0	1	0	1
5	1	1	1	1	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	1	1	0	1	1	1	1	0		
6	1	0	1	1	1	1	0	0	0	1	1	1	1	0	1	0	1	1	0	0	0	1	0	0	0	1	0	0	0	0	0	1	1	0	1	1	1	1	0	0	1	0	1	0	1	1	1		

The symbol table shows the transmitted bits for an OFDM waveform. Each OFDM symbol is represented on a different row. Only data and pilot subcarriers are shown, pilot subcarriers are highlighted in red. Each subcarrier is demodulated with its respective constellation (BPSK for pilots, refer to the MCS for the data subcarriers).

## 4.14.3 Measurement Concepts

### 4.14.3.1 Search Window

Measurements are performed by acquiring data equal in length to the user specified search length. This acquisition is referred to as the search window. Then, a valid packet is searched for within the search window. The WLAN standard selected determines what algorithms are used to detect a valid packet. The packet must be fully contained in the search window for successful demodulation. For this reason, the search length should be sufficiently larger than the expected packet length.

If no packet is detected, the AM vs Time (Search) window is updated with an appropriate error status. If a packet is detected, but demodulation fails, the measurement is considered a failure and the AM vs Time (Search) window is updated with an appropriate error message. At that point, a new search window will be acquired, and a new measurement attempted. Only one measurement is performed on a search window.

#### 4.14.3.2 802.11 A/N/AC/AX Demodulation

The demodulation process for 802.11a/n/ac/ax is as follows.

- A sliding average power window using the OFDM threshold is used to find the leading edge of a packet transmission.
- The L-STF is used to perform symbol timing.
- Frequency offset is measured and corrected using the L-STF and L-LTF.
- Equalization for the L-SIG is performed using both L-LTF symbols with an averaged zero-forcing algorithm. Equalization on the PSDU is performed with a zero-forcing algorithm on the LTF sequence preceding the data symbols.
- Symbols are demodulated using a user defined symbol offset (default -50%).
- Pilot tracking occurs over the PSDU. Both phase offset and timing are tracked, correcting for both residual frequency offset and sample rate offset through the PSDU. The pilot errors are measured after equalization on each data symbol.
- The PSDU is decoded if both the PSDU Decode setting is enabled and the PSDU is BCC encoded. If LDPC encoding is detected, PSDU decoding does not occur.

#### 4.14.3.3 802.11 AH Demodulation

Bandwidth is automatically detected for AH measurements. For any given bandwidth, the center frequency specified should be the frequency of the center-most null DC component of the signal.

When the 802.11ah standard is selected, the demodulation process is as follows,

- A sliding average power window using the OFDM threshold is used to find the leading edge of a packet transmission.
- Initial symbol timing is performed using the STF.
- A bandwidth detector is used to determine the bandwidth of the signal (1/2/4/8MHz).
- Fine symbol timing is performed on the LTF.
- Frequency offset is measured and applied using the STF and LTF.
- Equalization is estimated using the LTF and a zero-forcing algorithm.
- Symbols are demodulated using the specified symbol offset (default -50%)
- Pilot tracking occurs over the PSDU. This also determines the symbol rate error.
- The PSDU is decoded if BCC encoded.

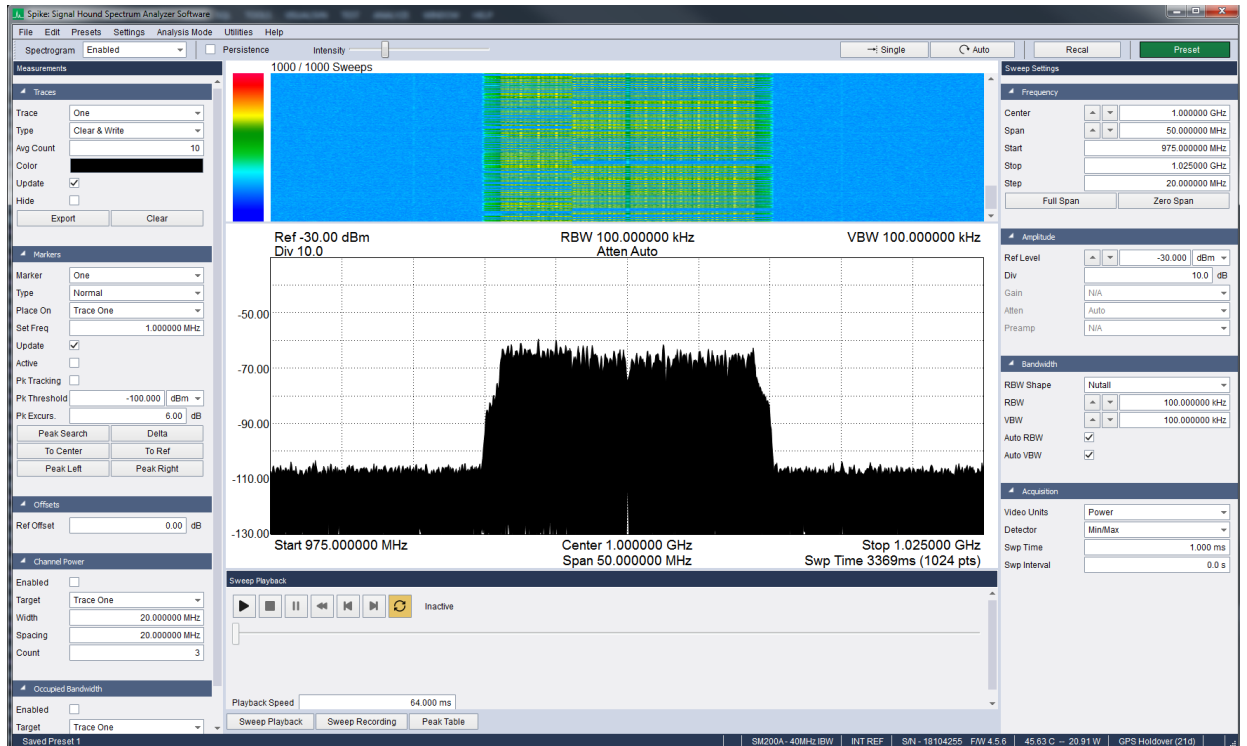
#### 4.14.3.4 DSSS Demodulation

Signal detection occurs using a user supplied video trigger with a small amount of hysteresis followed by a preamble detect for synchronization. The waveform is then fully demodulated using standard BPSK/QPSK demodulation techniques.

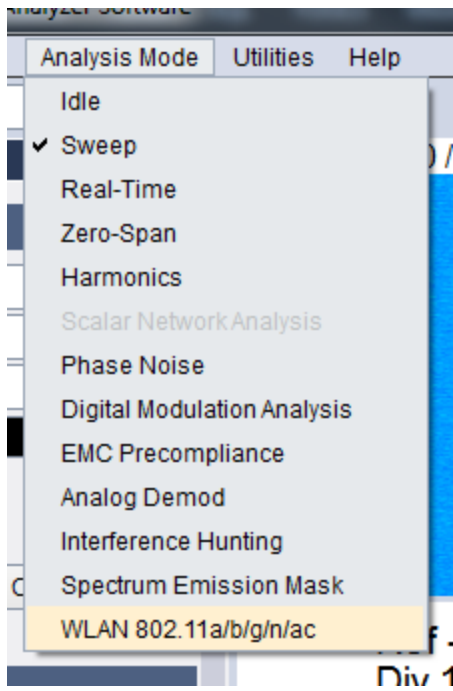
## 4.14.4 WLAN Measurement Walkthrough

This section will guide you through making an OFDM WLAN measurement in Spike.

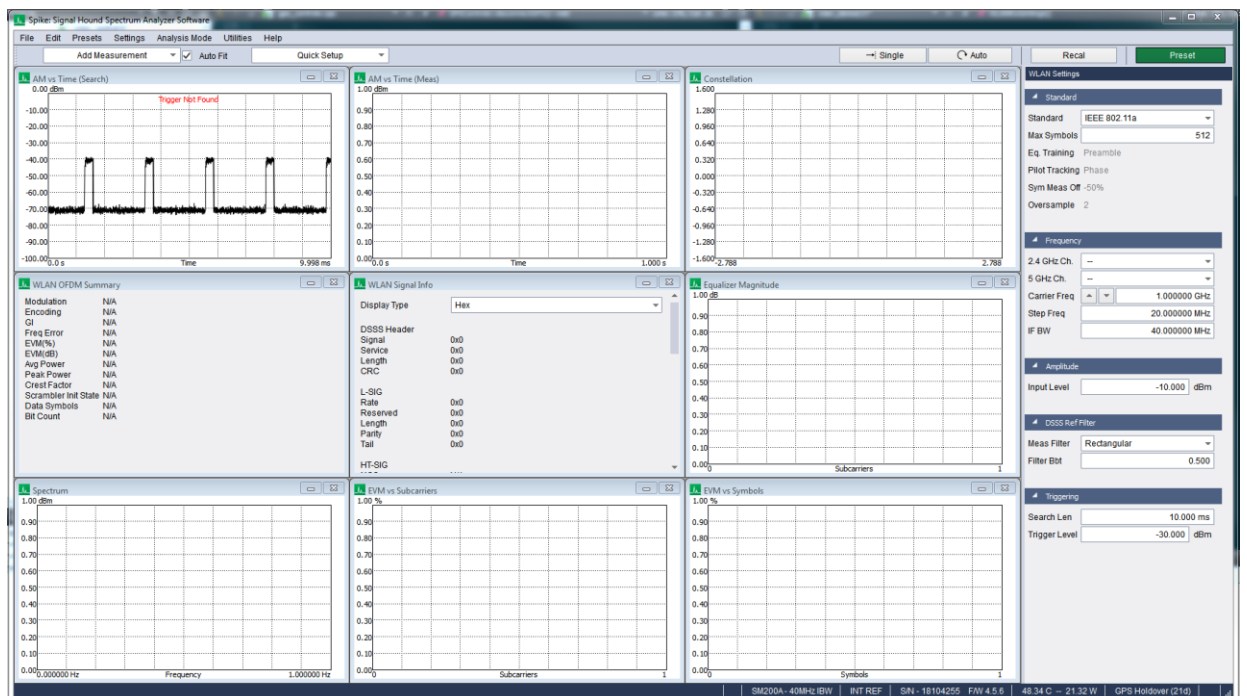
- 1) The first step is to determine if and where a WLAN signal is present. The easiest way to do this is by using the sweep measurement mode to find and center on a frequency of interest. In the picture below, the spectrum shows a WLAN signal at 1GHz is being generated by a signal generator.



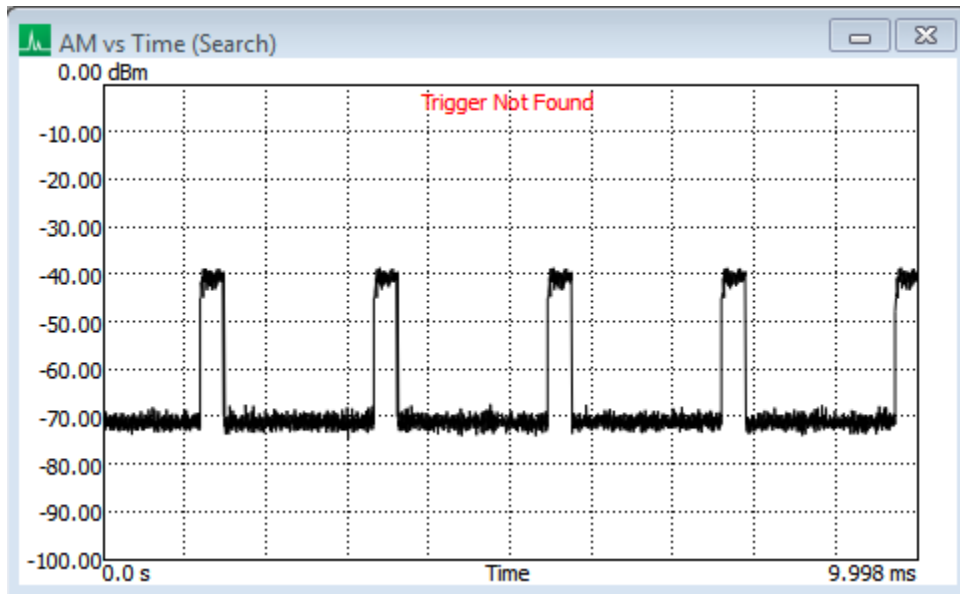
- 2) Once you have found a signal of interest, switch into WLAN measurement mode using the "Analysis Mode" drop down file menu. This will also carry over the current center frequency and reference level.



- 3) The first time the WLAN measurement tool is enabled, the layout will be preset for OFDM measurements, and the default standard set to 802.11a. You might see something like the picture below. In this case the AM vs Time (search) window is showing you the search waveform and a status message. In this case the status message indicates that a trigger was not found and we need to adjust our trigger settings.



- 4) The AM Vs Time (Search) plot is the most important plot for troubleshooting. Taken from the image above, this plot indicates that a video trigger was not found. We can see from the settings control panel the video trigger level is set to -30dBm and the highest amplitude measured in the search window is -40dBm. We need to lower the video trigger level.



- 5) We also need to setup our measurement using the WLAN settings control panel.
- Select the waveform type. In this example the input waveform is an 802.11n 20MHz waveform. Select this from the standard drop down menu entry.
  - It may be necessary to adjust the center frequency of the measurement. This can be done with the carrier frequency setting.
  - The input level control is the reference level and should be set to above the maximum power of the input waveform. Decreasing the input level control when possible will help increase the sensitivity of the analyzer and might improve your measurements.
  - Set the trigger level and search length. The search length is the length of the capture the software will acquire and look for a valid waveform. The trigger level is the amplitude used to detect the start of a waveform within the search length. In this example, we will set the trigger level to -55 based on the waveform shown in the AM vs Time (Search) plot.

WLAN Settings

▲ Standard

Standard IEEE 802.11a ▼

Max Symbols IEEE 802.11a

Eq. Training IEEE 802.11n 20MHz

Pilot Tracking IEEE 802.11n 40MHz

Sym Meas Off IEEE 802.11ac 20MHz

IEEE 802.11ac 40MHz

Oversample 2

▲ Frequency

2.4 GHz Ch. -- ▼

5 GHz Ch. -- ▼

Carrier Freq 1.000000 GHz

Step Freq 20.000000 MHz

IF BW 40.000000 MHz

▲ Amplitude

Input Level -10.000 dBm

▲ DSSS Ref Filter

Meas Filter Rectangular ▼

Filter Bbt 0.500

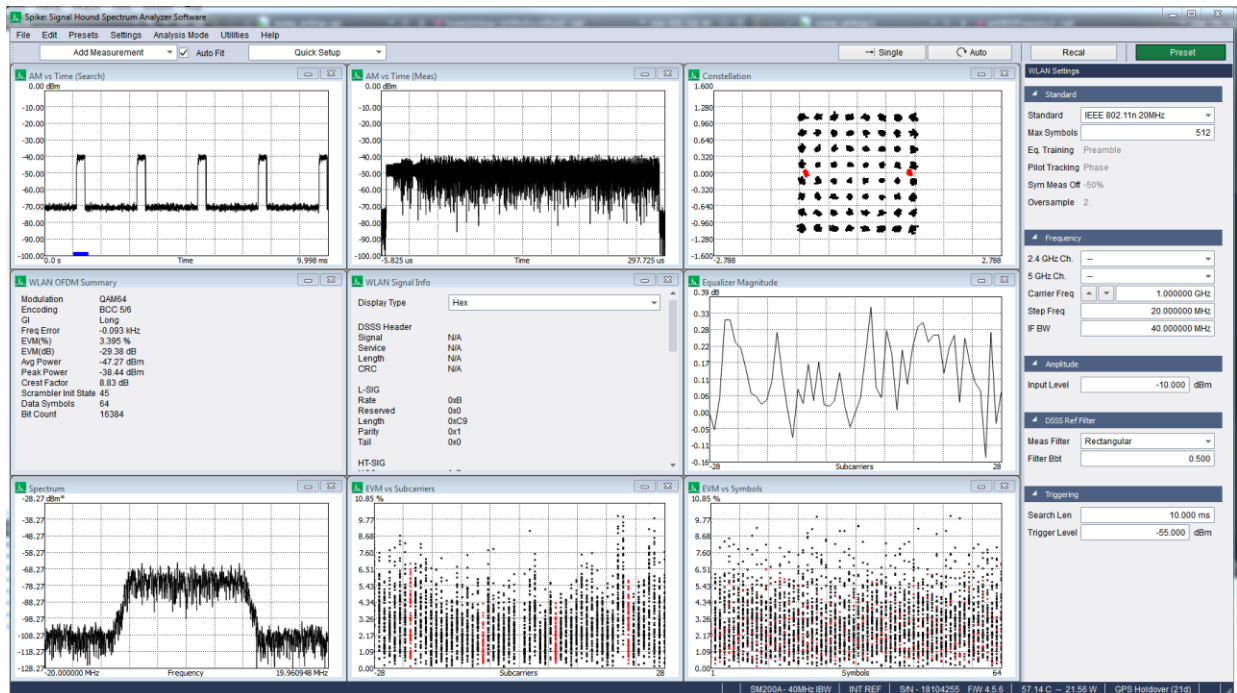
▲ Triggering

Search Len 10.000 ms

Trigger Level -30.000 dBm

- 6) Once all relevant settings have been updated, you can see the other windows updating and no longer see a status message in the AM vs Time (Search) plot. Notice in the AM vs Time (Search) plot a blue bar under one of the signals. This indicates that this part of the search waveform was used to make the measurement.





- 7) Pressing “Single” will force the software to make one more valid measurement. Screen updates where a trigger was not found, or the measurement was invalid will not pause the software.
- 8) Add more measurement windows using the “Add Measurement” drop down menu.
- 9) Save your current configuration using Save/Load presets. This will save all measurement windows/locations and settings. Un-check “Auto Fit” if you plan on organizing the measurement windows in a custom fashion.

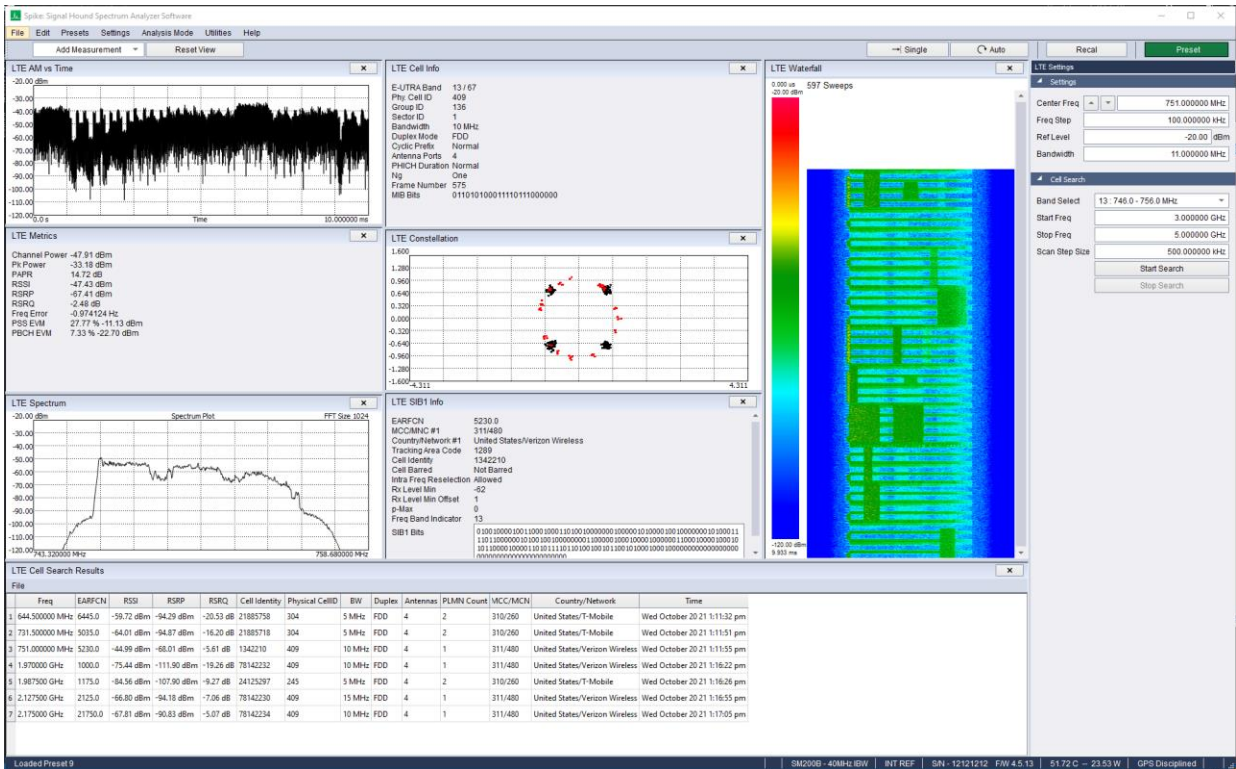
## 4.14.5 Troubleshooting

- If the search window reports “Invalid Packet Format”, this means the first triggered measurement was not able to be demodulated using the current standard. This might mean the waveform was of a different standard or the signal was impaired beyond being able to successfully demodulate it.
- If the search window reports “Not Enough Samples” this means the waveform was detected but was at the end of the search window and would not be able to be successfully demodulated. If you see this often, try increasing the search window length.
- If the search window reports “Trigger Not Found”, verify the waveform is present in the search window and that your trigger level is set to a proper value for the levels you see in the search window.
- Use the IF Bandwidth control to reject out of channel signals. WLAN waveforms coexist with other signals including WLAN and Bluetooth®. Out of channel energy might interfere with the measurement.
- The BB60C/D is only capable of measuring 20MHz BW OFDM waveforms.

## 4.15 LTE

Note: The LTE measurements in Spike require that the correct MATLAB® runtime libraries are installed. This is a free software download and installation instruction are provided in the Appendix.

Note: LTE measurements are supported on 64-bit Windows and Linux operating systems only.



LTE measurements can be made using the SM, SP, and BB line of spectrum analyzers. The LTE measurement mode in Spike provides basic downlink cell measurements including cell search and scanning capabilities.

The primary measurements available are listed below,

- Cell search and measurement at a specified center frequency.
- Cell scanning over a range of specified frequencies and LTE bands.
  - Detected cells are aggregated in a scan results window.
- Automatic MIB decoding and reporting of cell configuration values,
  - Physical Cell ID
  - Bandwidth
  - Duplex mode
  - Frame configuration
- Power measurements
  - RSSI/RSRP/RSRQ
  - Frequency error

- EVM for PBCH and PSS
  - PAPR calculation
- Automatic SIB1 decoding and reporting of various cell access related data,
  - All MCC/MCN pairs including Country/Provider lookup
  - EARFCN calculation
  - TAC/Cell Identity
- Standard spectrum analysis plots for the measured LTE frame
  - AM vs Time
  - Spectrum plot
  - Waterfall plot
  - Constellation for PBCH and PSS

## 4.15.1 Measurement Concepts

Spike supports two LTE acquisition modes,

1. Single frequency cell search and measurement. This is where the analyzer is tuned to a specific frequency. Cell search occurs at this frequency. If a cell is detected, full cell synchronization and demodulation occurs. Use this acquisition type when performing transmitter testing or characterizing a single cell. This is also the quickest way to determine if a valid cell exists at a specific frequency. This is the default measurement in the Spike LTE measurement mode.
2. Cell scanning. The software scans a range of user configured frequencies/bands looking for cells. At each frequency cell search occurs. If a cell is found full synchronization and demodulation occurs. The software adds the measurement to the cell search results table, updates the plots with the latest measurement, and advances to the next frequency. Specific LTE bands can be scanned, or custom frequency ranges can be entered.

### 4.15.1.1 Cell Detection

Spike uses the PSS and SSS for the cell search. The cell must be within +/- 7.5kHz of the selected center frequency for a cell to be detected. If the PSS/SSS is detected, Spike uses this to determine the duplex mode, cyclic prefix length, and decode the MIB.

If any step between the start of the cell search process and decoding the MIB fails, the entire measurement is considered failed, and the software will report an error measurement status code. If the MIB is successfully decoded, the measurement is considered valid, and the software will attempt to decode the SIB1.

The SIB1 is transmitted on even numbered frames. If the frame detected in the cell search process above is odd numbered, the software will look at the next frame for the SIB1. Regardless of which frame is used for SIB1 decoding, the first valid frame in the captured I/Q data is used for the measurement plots. If the SIB1 is not able to be properly decoded, the measurement will continue as valid with the fields related to the SIB1 empty.

This entire measurement process occurs on roughly 40ms worth of captured I/Q data from the analyzer. The I/Q data is captured at the highest bandwidth possible to allow all possible cell bandwidths.

In the single frequency measurement configuration, the reference level used is specified by the user in the *Ref Level* control. When performing a scan, the reference level is chosen automatically. At each frequency the software begins by configuring the analyzer in the most sensitive configuration. If the input causes an IF overload, the measurement is retaken with a higher reference level until an IF overload no longer occurs.

## 4.15.2 Control Panel

Following are descriptions of the controls found in the LTE settings control panel.

- **Center Freq-** Specifies the measurement center frequency when performing single frequency measurements. This value is not used when performing cell scans.
- **Freq Step** – Specifies the frequency step when using the arrow buttons next to the center frequency controls
- **Ref Level** – Specifies the measurement reference level when performing single frequency measurements.
- **Correlation Threshold** – Specifies the cell search correlation threshold. Must be between 0.0 and 1.0.
- **Include in Results** – When enabled, single frequency measurements are placed in the cell search results list.
- **Configure Scan** – When pressed, brings up a dialog for selecting the bands for the cell scan. When finished, the *Scan Info* label should display a summary of your choices.
- **Scan Type** – When set to single, a single scan through all configured bands occurs when *Start Scan* is pressed. When set to continuous, the software will continuously scan the configured bands until *Stop Scan* is pressed or the software leaves the LTE measurement mode.
- **Sort By** – Determines how the cell search results are sorted by in the cell search results table. Choices are sorting by RSSI, frequency, or time.
- **Keep** – When result grouping is enabled, and the software detects a duplicate cell, a decision must be made to determine which data to show for that grouped cell. This setting controls whether the last measurement made is shown in the results table, or the one with the highest power.
- **Group Results** – When enabled, cell search results are grouped together in the cell search results table. Results are considered the same cell when the frequency and Physical Cell ID match.
- **Max Results** – Determines the maximum number of cells that can be shown in the cell search results table.
- **Start Scan** – Starts a scan of the user configured bands and shows the cells found in the cell search results table.
- **Stop Scan** – Use this to stop a cell search mid-scan, or to stop a continuous scan.

## 4.15.3 Cell Search Results

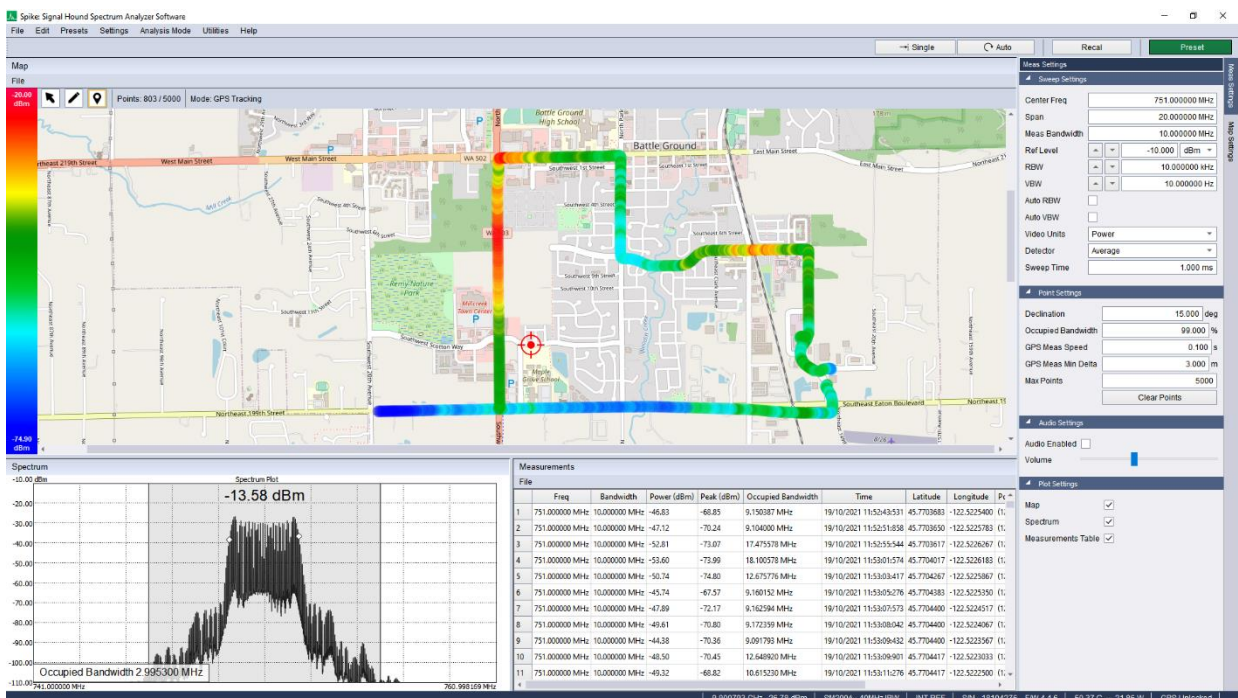
LTE Cell Search Results															
File															
	Freq	EARFCN	RSSI	RSRP	RSRQ	Cell Identity	Physical CellID	BW	Duplex	Antennas	PLMN Count	MCC/MCN	Country/Network	Time	Count
1	751.00 MHz	5230.0	-46.01 dBm	-67.81 dBm	-4.15 dB	1342210	409	10 MHz	FDD	4	1	311/480	United States/Verizon Wireless	Thu December 9 21 2:45:07 pm	1
2	731.50 MHz	5035.0	-55.95 dBm	-89.98 dBm	-18.21 dB	21885718	304	5 MHz	FDD	4	2	310/260	United States/T-Mobile	Thu December 9 21 2:45:05 pm	1
3	1970.00 MHz	1000.0	-61.18 dBm	-86.65 dBm	-8.02 dB	78142232	409	10 MHz	FDD	4	1	311/480	United States/Verizon Wireless	Thu December 9 21 2:45:03 pm	1
4	2127.50 MHz	2125.0	-67.70 dBm	-97.35 dBm	-10.60 dB	78142230	409	15 MHz	FDD	4	1	311/480	United States/Verizon Wireless	Thu December 9 21 2:44:55 pm	1
5	1937.50 MHz	675.0	-68.45 dBm	-96.86 dBm	-9.42 dB	21885708	304	15 MHz	FDD	4	2	310/260	United States/T-Mobile	Thu December 9 21 2:45:00 pm	1
6	1987.50 MHz	1175.0	-76.34 dBm	-96.98 dBm	-6.50 dB	21885808	304	5 MHz	FDD	4	2	310/260	United States/T-Mobile	Thu December 9 21 2:45:04 pm	1

Figure 55: Result of cell scan.

The cell search results window collects the scan results and if enabled, the single frequency measurement results in a simple ordered list. Results can be grouped together or can be individually placed in the list. When grouping is enabled, grouping occurs when both the frequency and cell ID match. Results can be sorted by frequency, amplitude, or time.

Each line in the cell search results shows a summary of a cell detected during a scan. The results can be cleared at any time or continue to be accumulated for subsequent scans. Results can be exported in a CSV format for post processing, or a custom format that can be imported into the software later.

## 4.16 MAPPING



Mapping mode binds measurements to geolocations. It includes functionality for georeferenced map import, GPS integration, automated measurements, heat mapping, measurement directionality with visual triangulation, Received Signal Strength Indicator (RSSI) expressed in the frequency of an audio

tone, session import/export, and KML file export for integration with Google Earth and other compatible programs.

## 4.16.1 Measurements

Mapping mode can perform channel power measurements or several kinds of LTE measurements. These are selected between using the *Meas Type* selects in the *Meas Settings* and *LTE Settings* sections of the control panel.

### 4.16.1.1 Channel Power

The channel power measurement type takes a channel power measurement over the center channel spanning the *Meas Bandwidth*, using the configuration specified in the *Sweep Settings* section of the control panel.

It results in readings for power, peak, and occupied bandwidth.

### 4.16.1.2 LTE

*Note: The LTE measurements in Spike require that the correct MATLAB® runtime libraries are installed. This is a free software download and installation instruction are provided in the Appendix.*

*Note: LTE measurements are supported on 64-bit Windows and Linux operating systems only.*

The LTE measurement type performs a single frequency cell search and measurement. The result can be specified as either RSSI or RSRP by *Meas Type*. See [LTE Analysis Mode](#) for detailed information about this measurement.

The result of an LTE measurement can be smoothed by applying averaging over the number of measurements specified by *Avg Count*.

## 4.16.2 Measurement Settings Control Panel

The following is a description of the various controls in the Measurement Settings control panel.

### 4.16.2.1 Meas Settings

- **Center Freq** – The center frequency of the sweep.
- **Ref Level** – The power level of the top graticule line. This should be no lower than the maximum expected input level of the signal.
- **Meas Type** – The type of measurement to be taken.

### 4.16.2.2 Sweep Settings

- **Span** – Frequency span around the center frequency.
- **Meas Bandwidth** – The bandwidth of the channel bandwidth measurement.

- **RBW** – Resolution bandwidth, using a flattop window.
- **VBW** – Video bandwidth.
- **Auto RBW** – Having auto selected will choose reasonable and fast RBWs relative to the span. When changing span, it is recommended to have this enabled along with Auto VBW.
- **Auto VBW** – When enabled, VBW will equal RBW.
- **Video Units** – See [Sweep Settings control panel](#). This should be set to Power.
- **Detector** – See [Sweep Settings control panel](#). This should be set to Average.
- **Sweep Time** – See [Sweep Settings control panel](#).

#### 4.16.2.3 LTE Settings

- **Meas Type** – The type of LTE measurement to be taken.
- **Avg Count** – The number of measurements to average. This can range from one (no averaging) to 25.
- **Curr Avg** – The running count of measurements being averaged into current reading. This will not exceed the *Avg Count*.

#### 4.16.2.4 Point Settings

- **Declination** – The adjustment for declination, specified in positive or negative degrees, applied to angles manually entered into the Azimuth field in the detail view of a point in map view. Declination can be found using a website such as [NOAA](#).
- **Occupied Bandwidth** – The percentage power in occupied bandwidth calculation.
- **GPS Meas Speed** – The minimum time passed since last measurement for new measurement to be taken.
- **GPS Meas Min Delta** – The minimum distance from location of last measurement for new measurement to be taken.
- **Max Points** – The maximum number of measurements that can be acquired. This will not retroactively affect measurements taken.

#### 4.16.2.5 Audio Settings

- **Audio Enabled** – Enables Received Signal Strength Indicator (RSSI) audio tone. This will use the system audio configuration. The frequency of the tone increases with the channel power of the signal being measured.
- **Volume** – The volume of the audio tone.

#### 4.16.2.6 Plot Settings

- **Map** – Shows or hides the map view.
- **Spectrum** – Shows or hides the spectrum plot of the current measurement.
- **Measurements Table** – Shows or hides the table of measurements.

### 4.16.3 Map Settings Control Panel

The following is a description of the various controls in the Map Settings control panel.

- **Map Scale** – The zoom percentage of the map.
- **Point Border** – Toggles a black border around points.
- **Point Size** – Controls the size of points on the map.
- **Point Opacity** – The color opacity of points.
- **Azimuth Lines** – Toggles lines drawn on the map from directional points at their azimuth angles.
- **Min Color (dBm)** – The power that represents the coldest color on the heat map.
- **Max Color (dBm)** – The power that represents the hottest color on the heat map. This cannot be higher than the ref level.
- **Auto Color** – Measurement points are automatically heat mapped based on the power range across them.

## 4.16.4 Map View

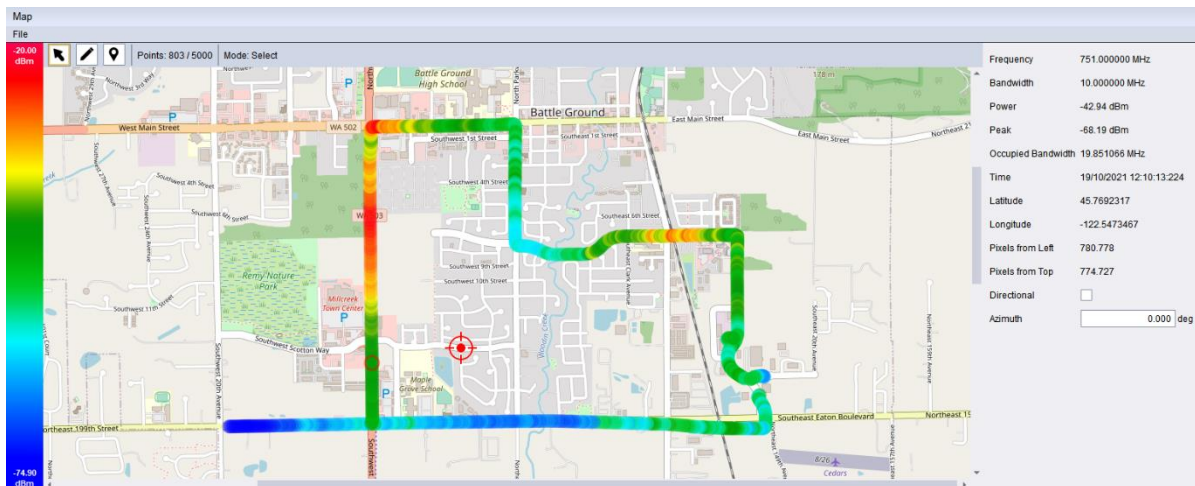


Figure 56: Map view with heat mapped measurements taken of a cell tower signal.

The map view contains an interactive, georeferenced map with overlaid measurements, along with controls and informational readouts.

A map is loaded by choosing *Load Map* from the local *File* menu, and then choosing an image from your hard drive. The map is georeferenced by choosing *Set Coordinates* from the *File* menu, and entering the bounding coordinates, that is the latitude coordinates corresponding to the top and bottom edges of the map image, and the longitude coordinates corresponding to the left and right. Map is removed with *File* > *Unload Map*. Note that this will clear all measurements and georeferencing coordinates.

See the OSM Map Import Guide for instructions on downloading a georeferenced map from OpenStreetMap and importing it into Spike.

If GPS data is present, either because the device has an internal GPS, or there is an external GPS connected to the PC, the user's current location will be represented by a red target icon on the map.



See the [GPS section](#) for details on how to configure GPS with the GPS controls at *Utilities > GPS Control Panel*.

On the map, a point represents a measurement tied to a geolocation and a time. There are three modes for interacting with measurements on the map, represented by icon buttons in the upper toolbar:

- 1) Select mode** – Indicated by the arrow icon, the mouse can be used to select and deselect points. When a point is selected, its information is displayed in the detail panel on the right.  
  
If a point is directional, then its azimuth angle can be changed by selecting it and dragging the point around its axis.
- 2) Click mode** – Indicated by the pencil icon, the mouse can be clicked to capture a measurement at the location of the mouse cursor. The point is immediately drawn on the map.
- 3) GPS Tracking mode** – Indicated by the GPS paddle icon, this mode is available when there is an external or internal GPS connected. Measurements are automatically taken at the time and minimum distance intervals specified in the *GPS Meas Speed* and *GPS Meas Min Delta* fields in the *Point Settings* section of the *Meas Settings* control panel.

In the upper toolbar, the map mode is displayed, as well as the number of measurement points captured over the maximum points set by the user.

### 4.16.4.1 Color Bar

From red to blue, the color bar shows the hot-cold spectrum to which points are mapped based on their measurement results, and what dBm values are represented by the top and bottom. These values can be configured precisely using the *Min Color* and *Max Color* sliders in the *Map Settings* control panel. If set to *Auto Color*, then the top and bottom of the spectrum will be determined by the minimum and maximum powers of the current set of measurement points.

### 4.16.4.2 Measurement Detail Panel

The measurement detail panel appears whenever a point is selected, and shows all the details of that measurement. They are:

- **Frequency** – The center frequency at the time of measurement.
- **Bandwidth** – The meas bandwidth at the time of measurement.
- **Power/RSSI/RSRP** – The measured channel power, RSSI, or RSRP of the signal.
- **Peak** – The measured peak power of the signal.
- **Occupied/Cell Bandwidth** – The measured occupied or cell bandwidth of the signal.
- **Time** – Timestamp for when the measurement occurred.
- **Latitude** – The latitude dimension of the point's geocoordinates.
- **Longitude** – The longitude dimension of the point's map coordinates.
- **Pixels from Left** – The horizontal position of the point on the currently loaded map.
- **Pixels from Top** – The horizontal position of the point on the currently loaded map.
- **Directional** – Whether or not the point has a directional component.

- **Azimuth** – The direction or bearing of the point, specified as an angle in degrees clockwise from North, from 0 to 360. If a declination is set in the *Declination* field of the *Meas Settings* control panel, then it will be automatically applied to any new value typed into this field. It will be added once to the angle entered.

#### 4.16.4.3 Sessions

A session includes a georeferenced map image, set of measurement points, and measurement and map configuration set in the respective control panels. (The latter is what is saved in a preset.)

Sessions can be imported and exported using *Import Session* and *Export Session* in the *File* menu. A session will be saved as three files: one with the .spikemap extension, a JSON format storing the measurements and map configuration, a .png file holding the map image, and an .ini file storing the measurement configuration as in a preset. If the session is manually moved on the hard disk, all three of these files must be moved together to the same directory.

## 4.16.5 Spectrum Plot

### 4.16.5.1 Channel Power

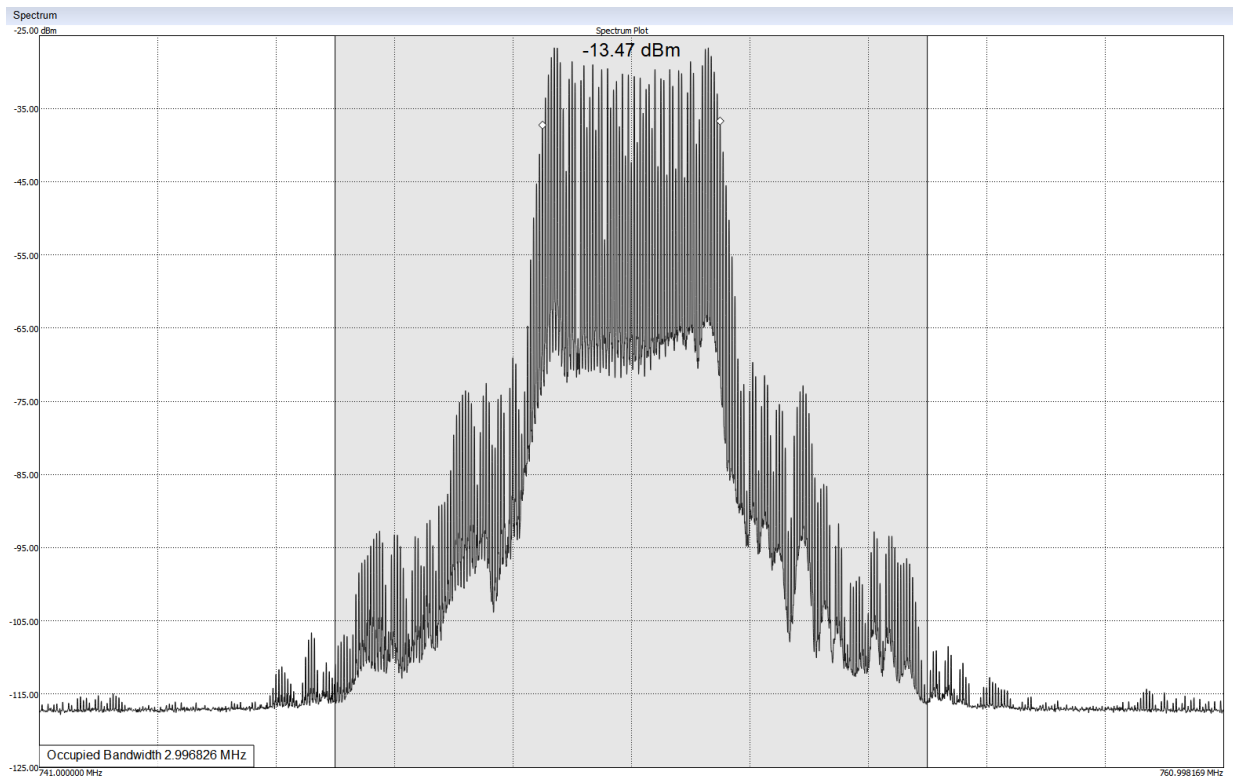


Figure 57: Channel power spectrum plot showing an FM signal.

The channel power spectrum plot shows the current sweep, with the channel power measurement window shaded, and diamonds indicating the lower and upper bounds of the occupied bandwidth.

The channel power reading is displayed top center, the occupied bandwidth reading bottom left.

#### 4.16.5.2 LTE

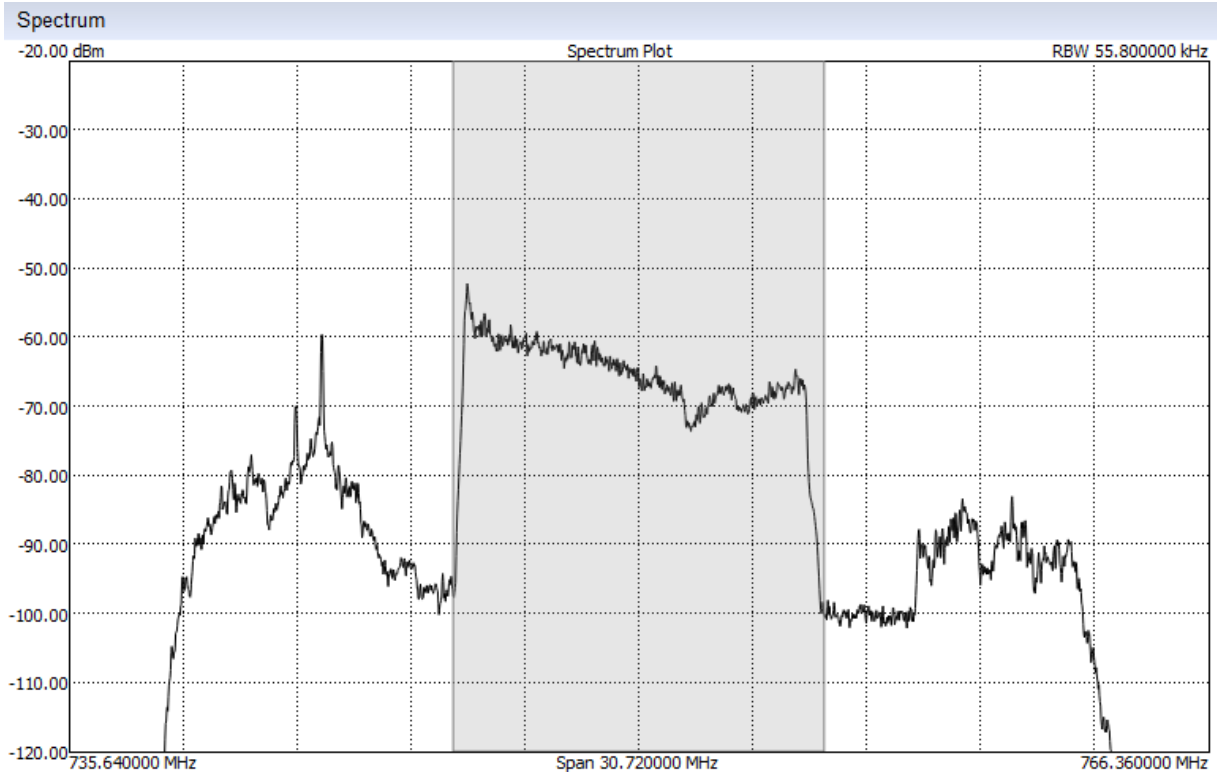


Figure 58: LTE spectrum plot showing a cell signal.

The LTE spectrum plot shows the LTE measurement with the cell bandwidth shaded if there is a valid cell signal detected.

## 4.16.6 Measurements Table

Measurements											
File											
	Freq	Bandwidth	Power (dBm)	Peak (dBm)	Occupied Bandwidth	Time	Latitude	Longitude	Position (px)	Directional	Azimuth ^
1	751.000000 MHz	10.000000 MHz	-46.83	-68.85	9.150387 MHz	19/10/2021 11:52:43:531	45.7703683	-122.5225400	(1250, 744)	No	0.00°
2	751.000000 MHz	10.000000 MHz	-47.12	-70.24	9.104000 MHz	19/10/2021 11:52:51:858	45.7703650	-122.5225783	(1250, 744)	No	0.00°
3	751.000000 MHz	10.000000 MHz	-52.81	-73.07	17.475578 MHz	19/10/2021 11:52:55:544	45.7703617	-122.5226267	(1249, 744)	No	0.00°
4	751.000000 MHz	10.000000 MHz	-53.60	-73.99	18.100578 MHz	19/10/2021 11:53:01:574	45.7704017	-122.5226183	(1249, 743)	No	0.00°
5	751.000000 MHz	10.000000 MHz	-50.74	-74.80	12.675776 MHz	19/10/2021 11:53:03:417	45.7704267	-122.5225867	(1249, 742)	No	0.00°
6	751.000000 MHz	10.000000 MHz	-45.74	-67.57	9.160152 MHz	19/10/2021 11:53:05:276	45.7704383	-122.5225350	(1250, 742)	No	0.00°
7	751.000000 MHz	10.000000 MHz	-47.89	-72.17	9.162594 MHz	19/10/2021 11:53:07:573	45.7704400	-122.5224517	(1252, 742)	No	0.00°
8	751.000000 MHz	10.000000 MHz	-49.61	-70.80	9.172359 MHz	19/10/2021 11:53:08:042	45.7704400	-122.5224067	(1253, 742)	No	0.00°
9	751.000000 MHz	10.000000 MHz	-44.38	-70.36	9.091793 MHz	19/10/2021 11:53:09:432	45.7704400	-122.5223567	(1254, 742)	No	0.00°
10	751.000000 MHz	10.000000 MHz	-48.50	-70.45	12.648920 MHz	19/10/2021 11:53:09:901	45.7704417	-122.5223033	(1255, 742)	No	0.00°
11	751.000000 MHz	10.000000 MHz	-49.32	-68.82	10.615230 MHz	19/10/2021 11:53:11:276	45.7704417	-122.5222500	(1256, 742)	No	0.00°
12	751.000000 MHz	10.000000 MHz	-50.36	-73.34	12.829584 MHz	19/10/2021 11:53:12:182	45.7704433	-122.5222017	(1257, 742)	No	0.00°
13	751.000000 MHz	10.000000 MHz	-48.14	-69.50	12.446284 MHz	19/10/2021 11:53:13:556	45.7704433	-122.5221600	(1257, 742)	No	0.00°
14	751.000000 MHz	10.000000 MHz	-48.29	-72.82	12.685541 MHz	19/10/2021 11:53:15:384	45.7704383	-122.5220967	(1259, 742)	No	0.00°
15	751.000000 MHz	10.000000 MHz	-53.19	-76.80	16.853020 MHz	19/10/2021 11:53:17:243	45.7704217	-122.5220533	(1259, 742)	No	0.00°
16	751.000000 MHz	10.000000 MHz	-47.31	-73.76	17.004387 MHz	19/10/2021 11:53:19:571	45.7703767	-122.5220333	(1260, 744)	No	0.00°
17	751.000000 MHz	10.000000 MHz	-44.59	-71.18	9.155269 MHz	19/10/2021 11:53:21:429	45.7703267	-122.5220483	(1260, 745)	No	0.00°
18	751.000000 MHz	10.000000 MHz	-51.32	-72.37	13.183588 MHz	19/10/2021 11:53:21:898	45.7703000	-122.5220633	(1259, 746)	No	0.00°
19	751.000000 MHz	10.000000 MHz	-50.49	-71.78	14.750970 MHz	19/10/2021 11:53:23:257	45.7702733	-122.5220833	(1259, 746)	No	0.00°
20	751.000000 MHz	10.000000 MHz	-48.67	-73.12	13.496088 MHz	19/10/2021 11:53:24:179	45.7702450	-122.5221067	(1258, 747)	No	0.00°
21	751.000000 MHz	10.000000 MHz	-54.48	-72.96	18.244621 MHz	19/10/2021 11:53:25:554	45.7702150	-122.5221350	(1258, 748)	No	0.00°
22	751.000000 MHz	10.000000 MHz	-54.04	-74.52	18.674308 MHz	19/10/2021 11:53:26:023	45.7701833	-122.5221650	(1257, 749)	No	0.00°

Figure 59: Table showing all measurements acquired in current Mapping mode session.

The measurements table displays a full list of all measurements captured in the current session.

There are several options for export in its *File* menu:

- **CSV** – Points are saved in CSV format to a file on hard disk.
- **KML** – Points are saved in KML format, an XML-based geodata format compatible with Google Earth, Google Maps, and other programs that support the extension. Measurement details are compiled in an HTML table within the description field. Heat mapping will be visible in Google Earth.

## 4.16.6.1 Opening a KML file in Google Earth

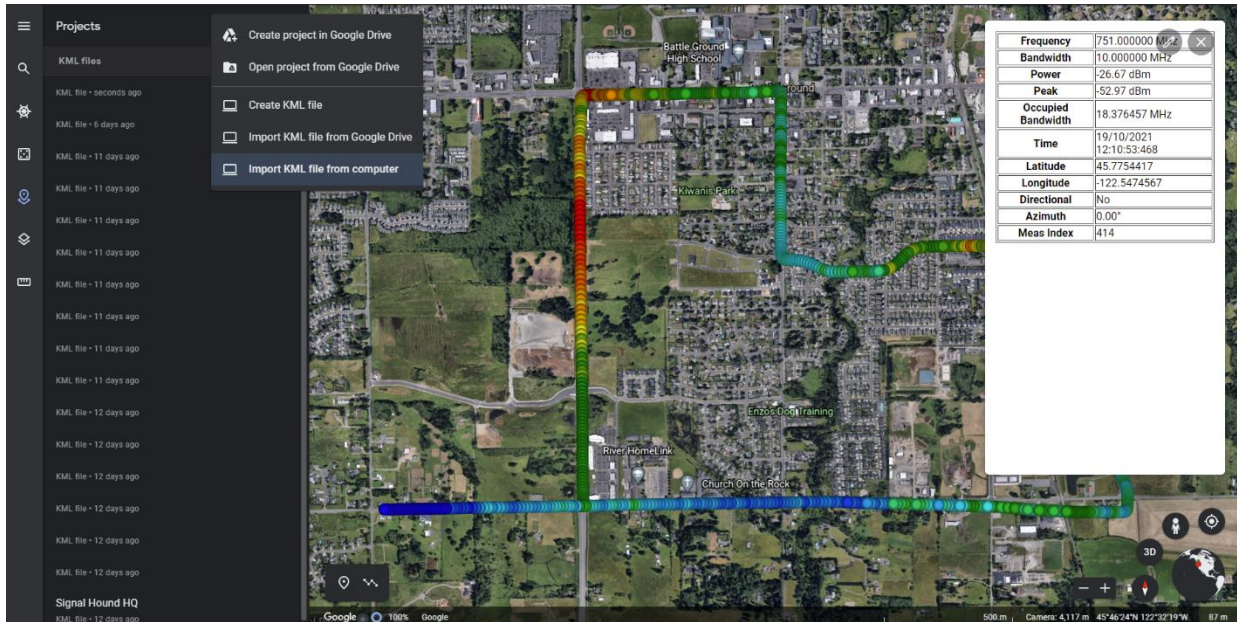


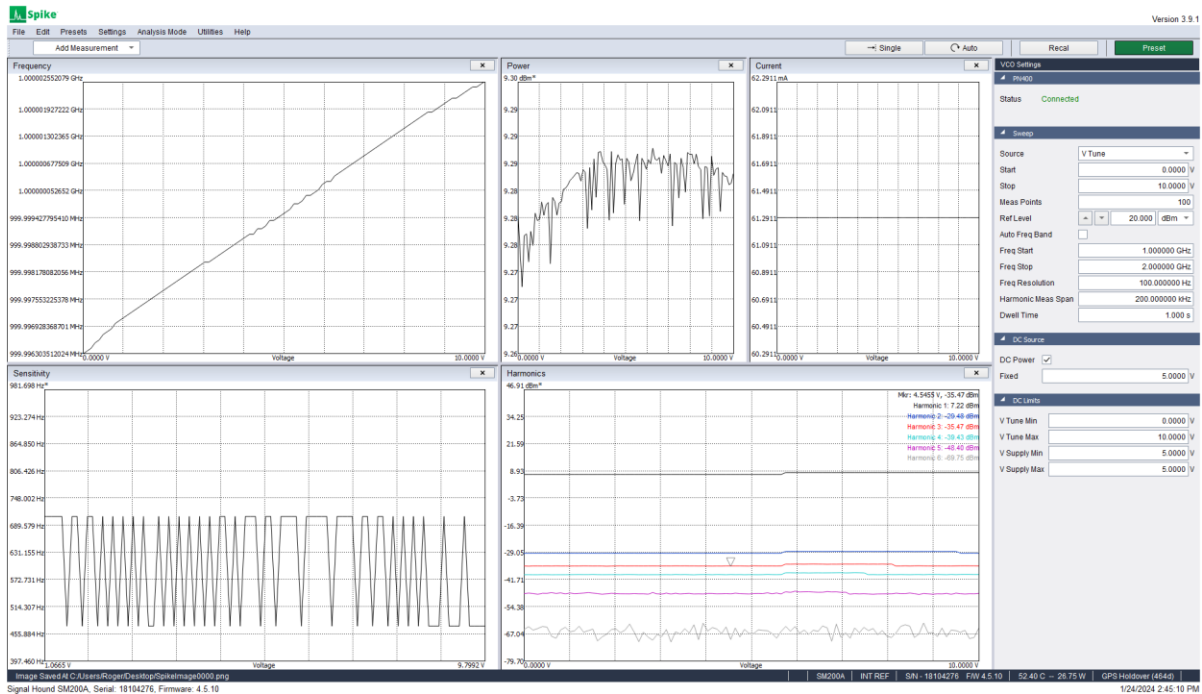
Figure 60: Opening a KML file in Google Earth.

To open a KML file of measurement points saved with *File > Save KML*, open Google Earth in a web browser. Click the *Projects* icon, then click the *New project* button, and then choose *Import KML file from computer*.

## 4.16.7 Audio Received Signal Strength Indicator (RSSI)

An audio tone can be played which tracks with the channel power of the measured signal. The tone's frequency rises with the signal power. Toggle on and off and set the volume in the *Audio Settings* section of the *Meas Settings* menu.

## 4.17 VCO CHARACTERIZATION



VCO Characterization mode evaluates the performance characteristics of voltage controlled oscillators (VCOs). It includes standard measurements for frequency vs. voltage, sensitivity (frequency change per volt), power vs. voltage, current vs. voltage, and harmonic power vs. voltage for the first six harmonics.

VCO characterization measurements require a PN400 phase noise tester, and are available for SM series, BB series, and SP145 devices.

## 4.17.1 VCO Settings Control Panel

The screenshot displays the VCO Settings control panel for a PN400 device. The panel is organized into several sections:

- VCO Settings:** Shows the device name as PN400 and its status as Connected.
- Sweep:** Contains fields for Source (V Tune), Start (1.0000 V), Stop (17.0000 V), Meas Points (10), Ref Level (10.000 dBm), Auto Freq Band (checked), Freq Start (1.000000 GHz), Freq Stop (2.000000 GHz), Freq Resolution (100.000000 kHz), Harmonic Meas Span (200.000000 kHz), and Dwell Time (0.0 s).
- DC Source:** Includes a checkbox for DC Power and a Fixed voltage field set to 5.0000 V.
- DC Limits:** Lists limits for V Tune (Min: -1.0000 V, Max: 28.0000 V) and V Supply (Min: 0.5000 V, Max: 15.2500 V).

Figure 61: VCO Settings control panel.

The following is a description of the various controls in the VCO Settings control panel.

### 4.17.1.1 PN400

- **Status** – Indicates whether a PN400 device is currently connected.

- **Connect** – The type of measurement to be taken.

### 4.17.1.2 Sweep Settings

- **Source** – The PN400 port that will output the swept signal. Normally this is V Tune, and V Supply is the fixed source. If the swept source is set to V Supply, then V Tune becomes the fixed source.
- **Start** – The starting or lowest control voltage to be measured.
- **Stop** – The stopping or highest control voltage to be measured.
- **Meas Points** – The total number of voltage points to measure.
- **Ref Level** – The power level of the top graticule line. This should be no lower than the maximum expected input level of the signal, that is the output level of the VCO.
- **Freq Resolution** – The RBW of the analyzer sweep at each measurement point.
- **Dwell Time** – The delay between setting the PN400 output voltages and measuring the VCO's response.

### 4.17.1.3 DC Source Settings

- **DC Power** – The overall state of the PN400 outputs. When disabled, no DC power will emit from the PN400.
- **Fixed** – The level of the fixed source PN400 output. Normally this is V Supply, but could be V Tune if the sweep source is set to V Supply.

### 4.17.1.4 DC Limits Settings

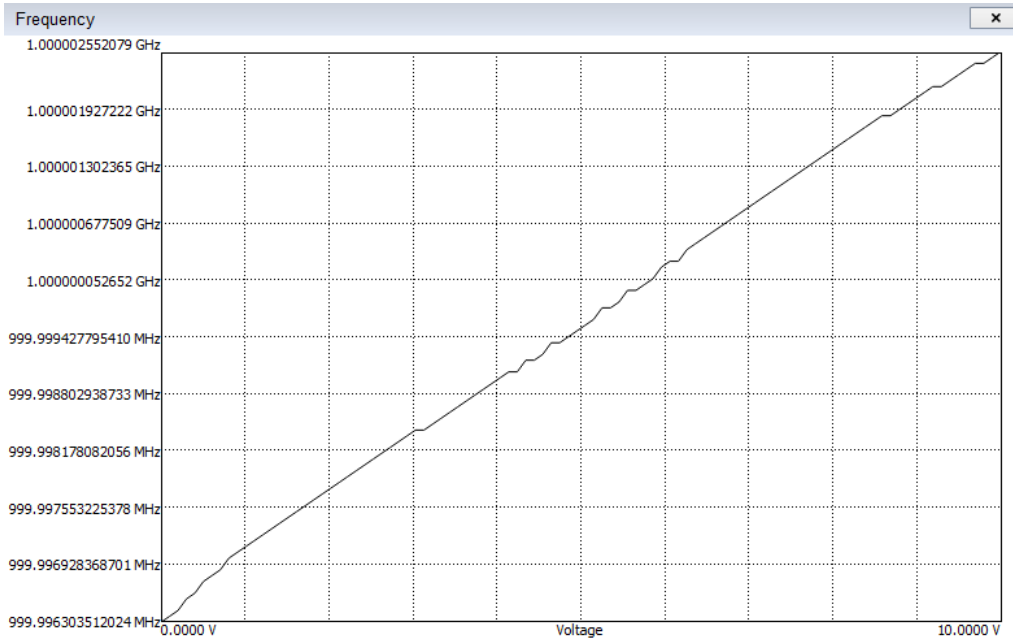
- **V Tune Min** – The minimum output voltage level of the V Tune port on the PN400.
- **V Tune Max** – The maximum output voltage level of the V Tune port on the PN400.
- **V Supply Min** – The minimum output voltage level of the V Supply port on the PN400.
- **V Supply Max** – The maximum output voltage level of the V Supply port on the PN400.

## 4.17.2 Measurement Windows

### 4.17.2.1 Frequency

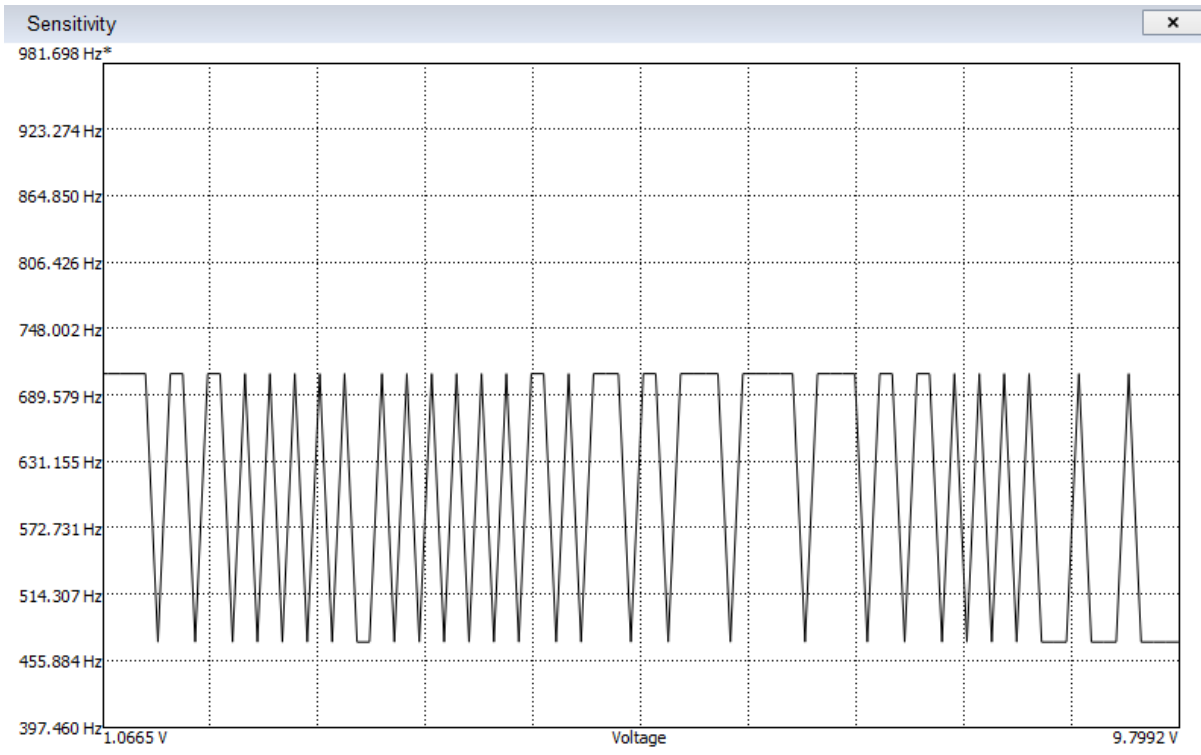
The frequency vs. voltage plot shows the frequency of the VCO's peak output for a given control voltage.





### 4.17.2.2 Sensitivity

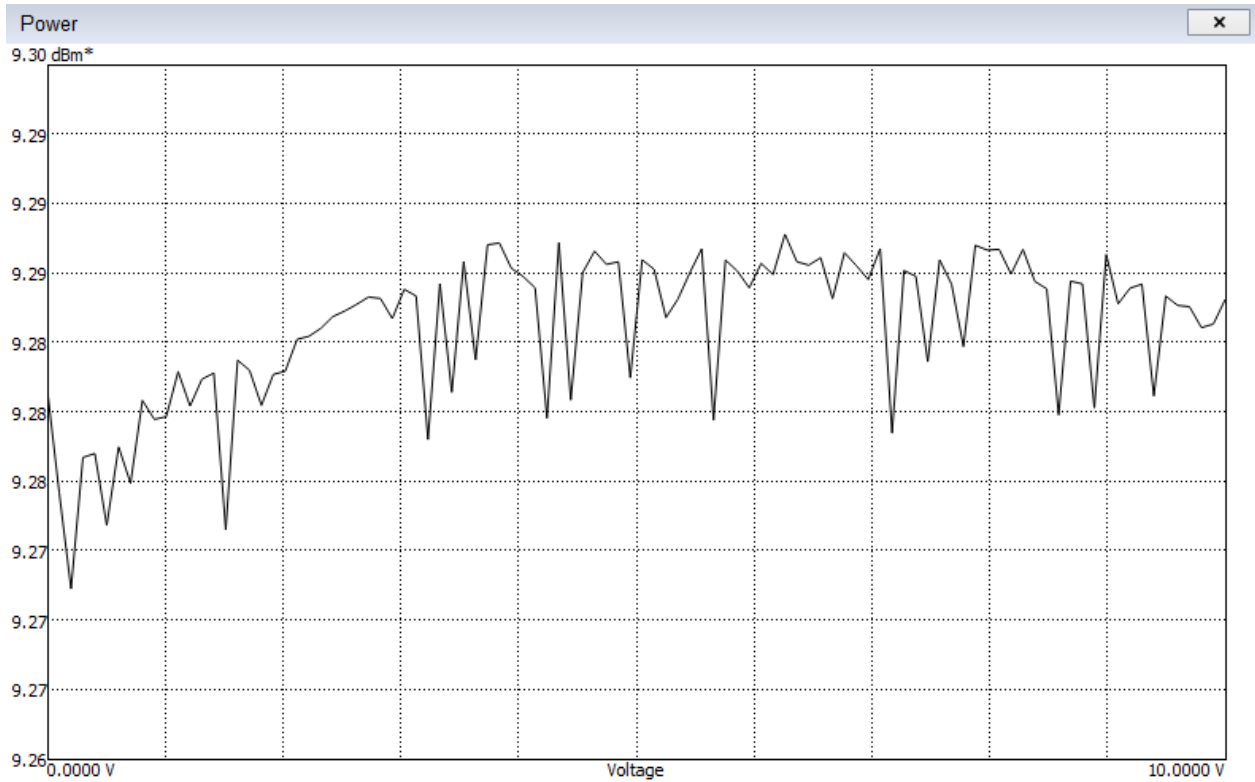
The sensitivity plot shows the slope of the VCO performance, as the frequency change between measurement points in Hz/V.



Signal Hound SM200A, Serial: 18104276, Firmware: 4.5.10

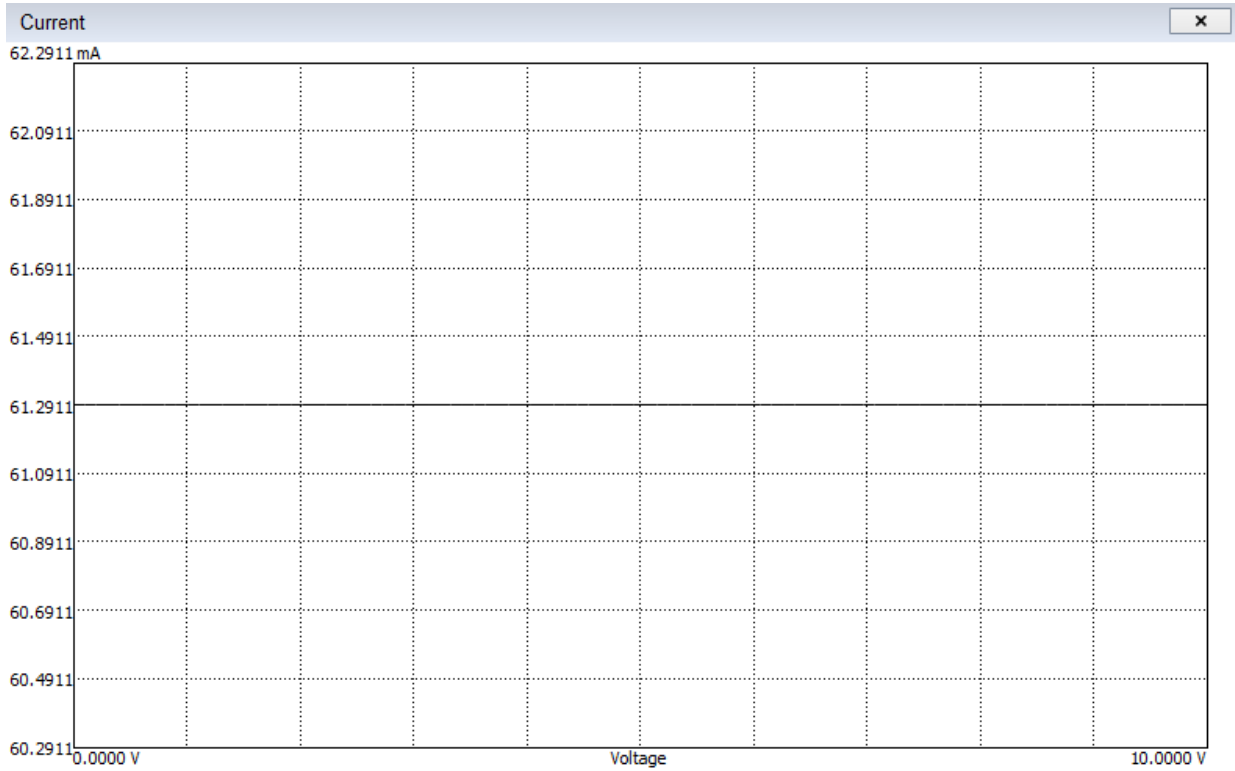
### 4.17.2.3 Power

The power vs. voltage plot shows the amplitude of the VCO's peak output for a given control voltage.



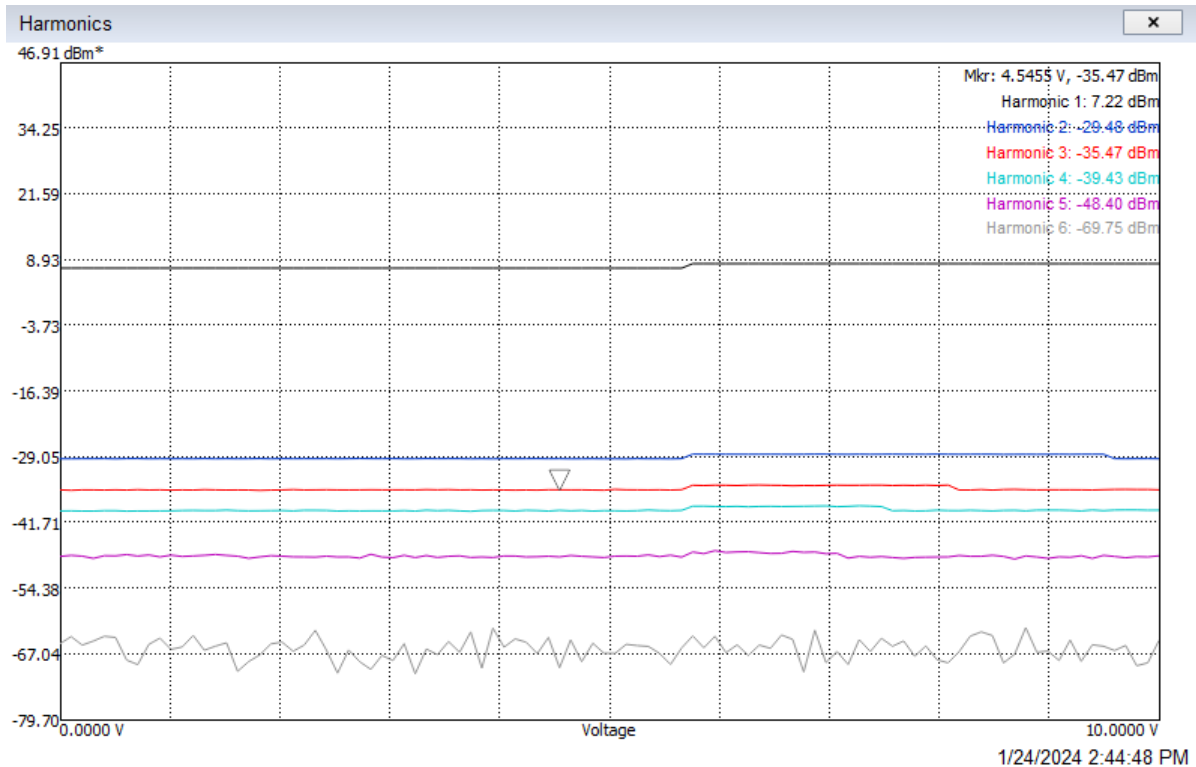
### 4.17.2.4 Current

The current vs. voltage plot shows the current of the VCO's peak output for a given control voltage.



#### 4.17.2.5 Harmonics

The harmonics vs. voltage plot shows the harmonic power of the VCO's peak output for a given control voltage, at each of the first six harmonics.



### 4.17.3 VCO Characterization Measurement Walkthrough

When VCO Characterization mode is entered, Spike will automatically look for a local PN400 and try to connect to it. If successful, the Status in the PN400 section of the VCO Settings control panel will show the serial number of the PN400 in green. Otherwise, a dialog will be shown alerting the user that a PN400 must be connected. At this point, one can be connected to the PC, and the Connect button pressed.

The mode remains in an idle state until Single or Auto is pressed to begin making measurements. This should be done after configuration is complete.

Initially, DC power on the PN400 is disabled. To avoid VCO damage, it should only be enabled after setting appropriate V Tune and V Supply limits in the DC Limits section of the VCO Settings control panel. Once this is done, it is safe to enable DC power in the DC Source section of the panel.

The rest of the configuration is accomplished in the Sweep section of the control panel, and by setting the fixed output level of the PN400 in the DC Source section.

For all presently available measurements, the sweep source should be set to V Tune.

At each point in the measurement, beginning with the Start voltage and ending with the Stop voltage, the sweep source or PN400 V Tune port is set to output the given voltage, execution is delayed by the dwell time, and the analyzer is swept using the configured frequency resolution (RBW) and ref level. The peak value of this sweep is the basis for the frequency and power measurements. The sensitivity

measurement also considers the peak from the previous sweep, and the harmonics measurement makes additional sweeps at each of the first six harmonics and reports their peaks. Current is reported by the PN400.

## 5 Taking Measurements

This section helps a user learn how to measure, analyze, and record signals using the Spike software, utilizing built-in features such as markers, record/playback, and channel power.

### 5.1 MEASURING FREQUENCY AND AMPLITUDE

#### 5.1.1 Using Markers

The software has several tools for identifying a signal's frequency and amplitude. The easiest to use is the **marker**. There are 6 markers available, each with its own reference.

To activate and place a marker left click inside the graticule or press the **Peak Search** button on the marker controls to place the marker on the current trace peak and activate it simultaneously. Once a marker is active the frequency and amplitude readout of the marker is displayed in the upper right corner of the graticule. The marker's accuracy is dependent on the span and RBW. Narrower spans and RBWs have higher marker accuracy. The amplitude accuracy is NOT dependent on the vertical dB/div, since the I/Q data is linear in voltage and has much higher resolution than is displayed. The marker may be re-placed at any time by clicking the graticule or by using the left and right arrows to shift the marker one sample point to the left or right.

#### 5.1.2 Using the Delta Marker

To measure differences or changes in frequency and/or amplitude use the **Delta** markers. To use the delta markers, you must first create a reference point. With a marker active, click the Delta button on the marker/trace control panel. This places a reference location on the graticule. Now the marker readings will report the difference between the marker and the reference. To disable the delta marker, press the Delta button again.

#### 5.1.3 Measuring Low Level Signals

To measure low-level signals, there are a few tricks to getting accurate readings. First, set the reference level to -50 dBm or lower. This internally selects the highest sensitivity settings. Using an external time base and narrow span (1 KHz or less) should give the best results. Video averaging may be required for a stable amplitude reading.

## 5.2 SWEEP RECORD AND PLAYBACK

Spike provides the ability to store and playback a sequence of sweeps from any Signal Hound spectrum analyzer. Several controls exist which make it easy to perform short term acquisition and analysis or long recording projects such as spectrum monitoring. Sweep recording files store a series of sweeps along with configuration information to a file with the extension (.shr).

*[Version 3.1.13 introduced the SHR file format but will continue to playback the BBR file format from earlier versions of the software. As of version 3.1.13 the software no longer generates BBR file.]*

### 5.2.1 Sweep Recording

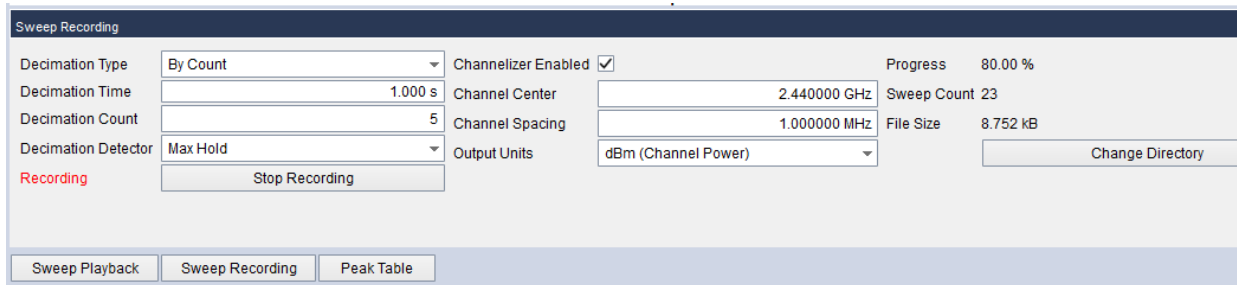


Figure 62: Active sweep recording with sweep decimation enabled.

The sweep recording control panel is enabled in sweep and real-time analysis modes. Most controls on the recording panel are used to control the amount of data stored. Many Signal Hound spectrum analyzers sweep at rates that produce very large recording files if not properly managed. The available controls provide two ways to reduce the amount of data stored.

- 1) **Decimation in time** – Decimation in time refers to the action of averaging or max-holding several sweeps over time. You can control either the amount of time or the number of sweeps you wish to decimate for. For example, selecting a 1 second decimation time and max hold decimation detector, the software will perform a max hold detector on sweeps over a 1 second duration, at which point the max held sweep will be stored to the file. This creates a file with a sweep being stored every 1 second. By specifying a sweep count, a similar effect is achieved, except instead of waiting for a specified duration, the detector operation will occur on 'count' number of sweeps.
- 2) **Decimation in frequency** – Decimation in frequency refers to channelization of the sweep using a channel power measurement. The channel width and center frequency of the channels can be selected. The output of the channel power measurement can be stored in dBm or dBm/Hz units. For example, a channel center frequency of 2440MHz and channel spacing of 1MHz will perform the channel power measurement on 1MHz channels evenly spaced 1MHz apart from the frequency of 2440MHz. The channel center frequency specified can be the center frequency of any channel.

Both decimation types can be enabled simultaneously, at which point the channelization will occur before the decimation in time. If no decimation is required (i.e. store every sweep from the device), disable the channelizer and select the decimation type 'count' with a decimation count of 1.

Press the *Start Recording* button to begin recording. The file is created immediately in the configured directory. Pressing the *Stop Recording* button ends the recording session.

## 5.2.2 Sweep Playback

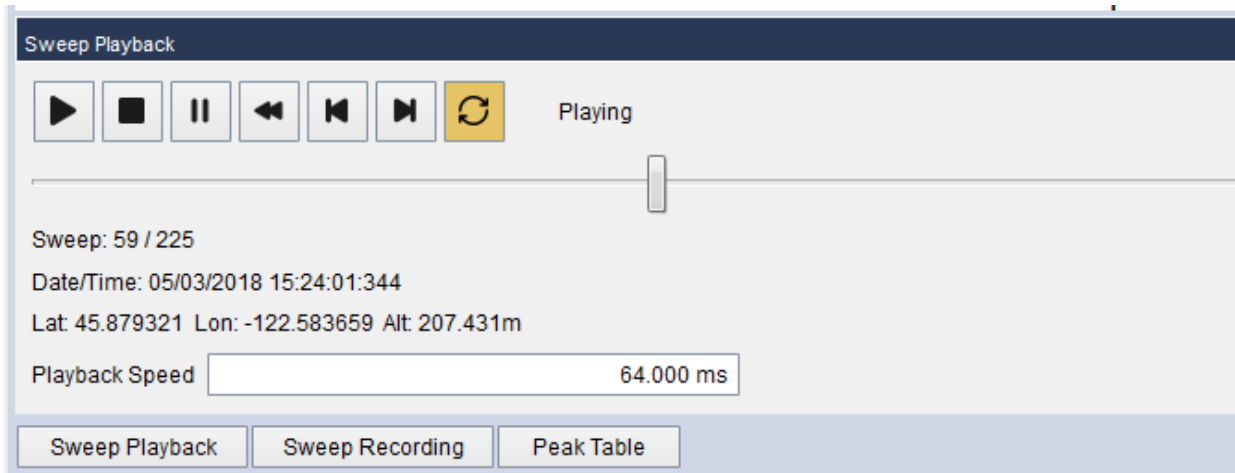


Figure 63: Playback of recorded SHR sweep file.

To begin a playback of an SHR sweep recording file, press the play icon button on the *Sweep Playback* control panel. After selecting a valid file, sweep playback should begin immediately. Use the slider bar as well as the pause, step, and rewind buttons to control the playback. The playback speed determines the amount of time to wait before showing the next sweep in the recording. For example, a playback speed of 1 second plays sweeps from the recording at a rate of 1 per second.

When replaying a saved session, all measurement functionality of the software remains, such as markers, min/max/avg traces, channel power, occupied bandwidth, persistence, and spectrogram views.

When finished, press the stop icon button and software control will return to the connected analyzer.



Tip: The title is also saved and shown during playback. Use a title to describe the session!

## 5.3 I/Q RECORDER

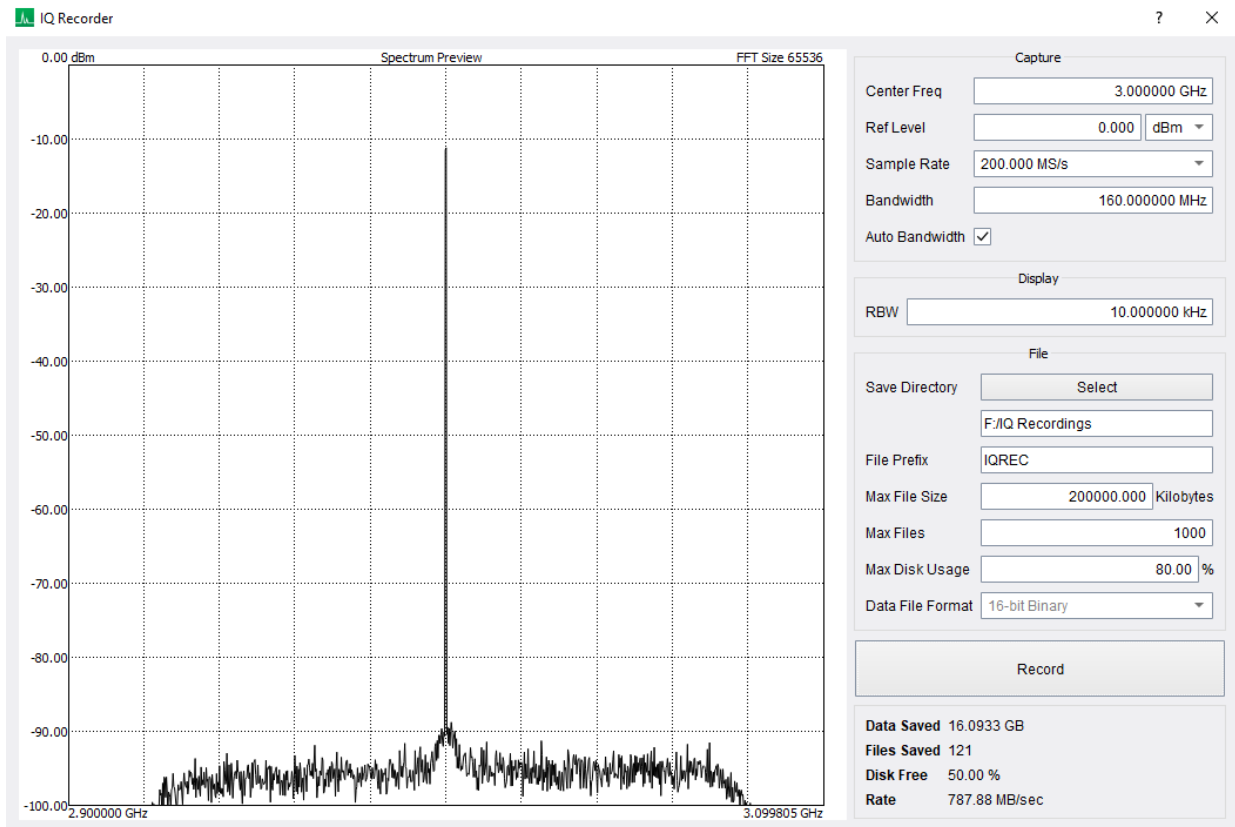


Figure 64: I/Q Recorder Utility.

The I/Q Recorder utility is used to perform dedicated short to long-term I/Q captures to disk. The I/Q recorder utility can be accessed through the *Utilities* drop down menu.

It provides simple configuration for the device, file system, and data format, a minimal spectrum preview window with adjustable RBW, and an informational readout of critical information during capture.

### 5.3.1 Configuration

The following are descriptions of the various settings and displays on the control panel, used to configure the capture and preview window, and monitor relevant information.

#### 5.3.1.1 Capture

- **Center Freq** – Specifies the tuned center frequency of the capture, ie. the 0Hz frequency of the I/Q data.
- **Ref Level** – Specifies the expected input power of the signal. This controls the reference level and the gain and attenuation.



- **Sample Rate** – Selects the sample rate of the current visible I/Q data capture. This number is equal to the device sample rate divided by the decimation value.
- **Bandwidth** – Controls the bandwidth of the passband filter applied to the I/Q data stream. The bandwidth cannot exceed the Nyquist frequency of the I/Q data stream.
- **Auto Bandwidth** – When set to Auto, the Bandwidth passes the entire bandwidth of the I/Q data capture.

### 5.3.1.2 Preview

- **RBW** – The desired RBW for the spectrum preview plot. Lower RBWs increase the required FFT window length. If the FFT window length is not long enough to achieve the desired RBW, the spectrum window will show a warning and the user will need to increase RBW to display the spectrum plot.

### 5.3.1.3 File

- **Save Directory** – Selects the directory for the I/Q waveform files to be stored.
- **File Prefix** – Applies a file name prefix to all files saved. Useful for creating identifiable file names. By default, the file name includes a second-resolution timestamp and sequence number.
- **Max File Size** – Specifies the maximum amount of data to store in a single file.
- **Max Files** – Specifies the maximum number of files to write.
- **Max Disk Usage** – Specifies the maximum percentage of the hard disk that can be used. The hard disk is determined by the Save Directory.
- **Data File Format** – Selects the file format to be used when saving I/Q data. By default, this is set to binary 16-bit complex integers.

### 5.3.1.4 Informational

- **Data Saved** – Displays the total amount of data written during the current capture.
- **Files Saved** – Displays the number of files written during the current capture.
- **Disk Free** – Shows the percentage of the hard disk that is free. The hard disk is determined by the Save Directory.
- **Rate** – Shows the current rate of data being captured and written to disk.

## 5.3.2 Recording

Acquisitions begin by pressing the *Record* button located in the control panel.

The capture begins immediately, and data is saved in sequentially labeled files in the *Save Directory*. Each file is prefixed with *File Prefix*, followed by a second-resolution timestamp tied to the start of the capture (not the start of the file). Each file has a maximum size specified by *Max File Size*.

Recording proceeds until one of the following events occurs or conditions is met:

- 1) The user presses the *Stop* button.
- 2) *Max Files* have been written to disk.
- 3) Disk usage will exceed *Max Disk Usage*.

Several statistics in the *Informational* section of the control panel show you the status of the acquisition and the current capacity remaining on the selected disk drive.

### 5.3.3 I/Q File Formats

Each I/Q capture is saved as a sequence of files holding the waveform data in the format specified by the “Data File Format” dropdown in the “File” section of the control panel.

The available formats are listed and described below.

#### 5.3.3.1 16-Bit Binary

Files saved in the 16-bit binary format contain I/Q values as signed 16-bit complex integers. They have little-endian byte ordering. Samples are stored in sequential order as

$$I_1, Q_1, I_2, Q_2 \dots I_n, Q_n$$

The values are stored as full scale, ranging from -32768 to +32767, representing floating point values between -1.0 and 1.0. To convert these samples to floating point,

- 1) Read the samples from the file into signed 16-bit complex integer values.
- 2) Convert to full-scale floating-point values with the following equations,
  - o `float re32f = (float)re16s / 32768.0;`
  - o `float im32f = (float)im16s / 32768.0;`

The data should now be floating point values between [-1.0, 1.0)

- 3) Optionally, if you want to recover the amplitude accurate I/Q samples referenced to dBm, use the following equations,
  - o `CorrectionFactor = sqrt(10^(refLevel in dBm / 10.0));`
  - o `Re32f *= CorrectionFactor;`
  - o `Im32f *= CorrectionFactor;`

Once scaled, the I/Q data can then be converted to a dBm value rather than a dBFS value using the equation,

$$\text{Sample power (dBm)} = 10.0 * \log_{10}(\text{re32f} * \text{re32f} + \text{im32f} * \text{im32f});$$

### 5.3.4 Preview Window

The preview window shows a spectrum plot of the waveform being recorded. It applies a single FFT using the specified *RBW* across a portion of the capture, and updates at a rate of roughly 10 FPS.

The preview window plot adheres to the [basic plot](#) interface in Spike.

## 5.3.5 Precautions

Precautions must be taken when performing I/Q captures to ensure your existing data does not become corrupted and your I/Q waveforms are captured without error. Below is a list of recommendations and precautions when using the I/Q record capabilities of the Spike software.

- 1) Store waveforms to an external hard drive and not the operating system (OS) hard drive. If your OS hard drive approaches 100% capacity, you will run into issues which will prevent your OS from operating properly. If you absolutely must store I/Q waveforms on the same drive as your OS, keep 20% of the disk free (Windows suggests 15%).

You can set an upper limit on this using the *Max Disk Usage* field in the *File* section of the control panel. The default value is 80%.

- 2) Calculate the expected capture size beforehand using this simple formula:

$$\text{Size of Capture (Bytes)} = \text{Max Files} * \text{Max File Size (kB)} * 1000 \left(\frac{B}{kB}\right)$$

- 3) Ensure your hard drive write speed exceeds the acquisition speed of the analyzer. For many sample rates standard hard drive write speeds will be insufficient to sustain long term captures. This will create gaps in the data which will affect the quality of your measurements. The record speed will depend on the data file format. For 16-bit binary data, a simple calculation of the record speed is

$$\text{Write Speed (Bytes per second)} = \text{Sample Rate} * 4$$

It is expected the hard drive write speed exceeds this value by a reasonable margin. For some of the highest sample rates, a performance hard drive configuration will be necessary. For example, at its highest sample rate, the SM200C can output 800 MB/s of data.

When evaluating high performance drives to handle this throughput, make sure to note the spec for sustained write speed and not just burst speed. Otherwise, it will fall behind after writing a fixed amount of data.

- 4) Ideally, an operator should be present at the software and monitoring the acquisition status. Consider performing test runs on known signals to ensure your acquisitions settings are correct before committing to a long acquisition process.

## 5.4 CAPTURING SIGNALS OF INTEREST

CSV files can be created of traces with the *Trace Export* button found on the control panel. CSV files are useful for performing further signal analysis or plotting outside the Signal Hound application. When exporting a trace into a CSV file, the currently shown trace is exported. Because of this it may be difficult to obtain a CSV file of a signal of interest. For example, an intermittent signal which appears sporadically may be difficult to capture, or some modes such as Real-Time signal analysis are prohibited from saving CSV files.

One way to export a desired signal is to record the spectrum using the playback toolbar. After capturing a signal via recording, the session can be played back and paused on the signal of interest. From there, the signal can be exported or measured through standard means.

Min and Max hold traces are another way to capture intermittent hard to view signals. Min and max hold keep track of the minimum and maximum values over a period storing them in a separate viewable trace.

## 5.5 CHANNEL POWER

Channel Power		State	Offset	Bandwidth	Lower (dBc)	Lower (dBm)	Upper (dBc)	Upper (dBm)
Enabled <input checked="" type="checkbox"/>		1 Enabled	200.000000 kHz	180.000000 kHz	-20.75	-55.22	-20.66	-55.12
Target Trace One		2 Disabled	20.000000 MHz	20.000000 MHz	N/A	N/A	N/A	N/A
Width 180.000000 kHz		3 Disabled	20.000000 MHz	20.000000 MHz	N/A	N/A	N/A	N/A
Power -34.47 dBm		4 Disabled	20.000000 MHz	20.000000 MHz	N/A	N/A	N/A	N/A
Start Logging		5 Disabled	20.000000 MHz	20.000000 MHz	N/A	N/A	N/A	N/A
Change Directory								

Figure 65: Channel Power control panel measuring a broadcast FM signal.

The Channel Power control panel configures, measures, and logs a main channel and 5 adjacent channels, each consisting of a lower and upper component.

The main channel controls are on the left. Channel power can be enabled from here. This applies to all channel power measurements, so the main channel must be enabled to take measurements on the adjacent channels. Target specifies which trace will be used for measurements. Channel width specifies in Hz the width of the band to measure. Power displays the channel power of the main channel. Start Logging creates a new CSV file and logs the main channel and all enabled adjacent channels for each sweep. Logging continues until Stop Logging is pressed. Change Directory sets the directory in which to save log files.

The adjacent channels are listed as rows in the table on the right. The first three fields are for configuration, the rest for measurements. The state field is used to enable or disable the channel. Offset refers to the center-to-center frequency difference between the center channel and the adjacent channel. Between channels, there is typically (but not always) a small guard band whose power is ignored. Bandwidth specifies the width in Hz of the adjacent channel.

The adjacent channels, which have a lower and upper component, show the channel power as well as the difference in power between the center channel and themselves. In the example below the difference might be used to determine if any power is “leaking” into an adjacent FM band.

For example, the image below shows a channel bandwidth of 180 kHz with one adjacent channel with an offset of 200 kHz. The image shows the FM station 101.1 in the center channel. Each channel will be integrated and the resulting power is displayed in the table.

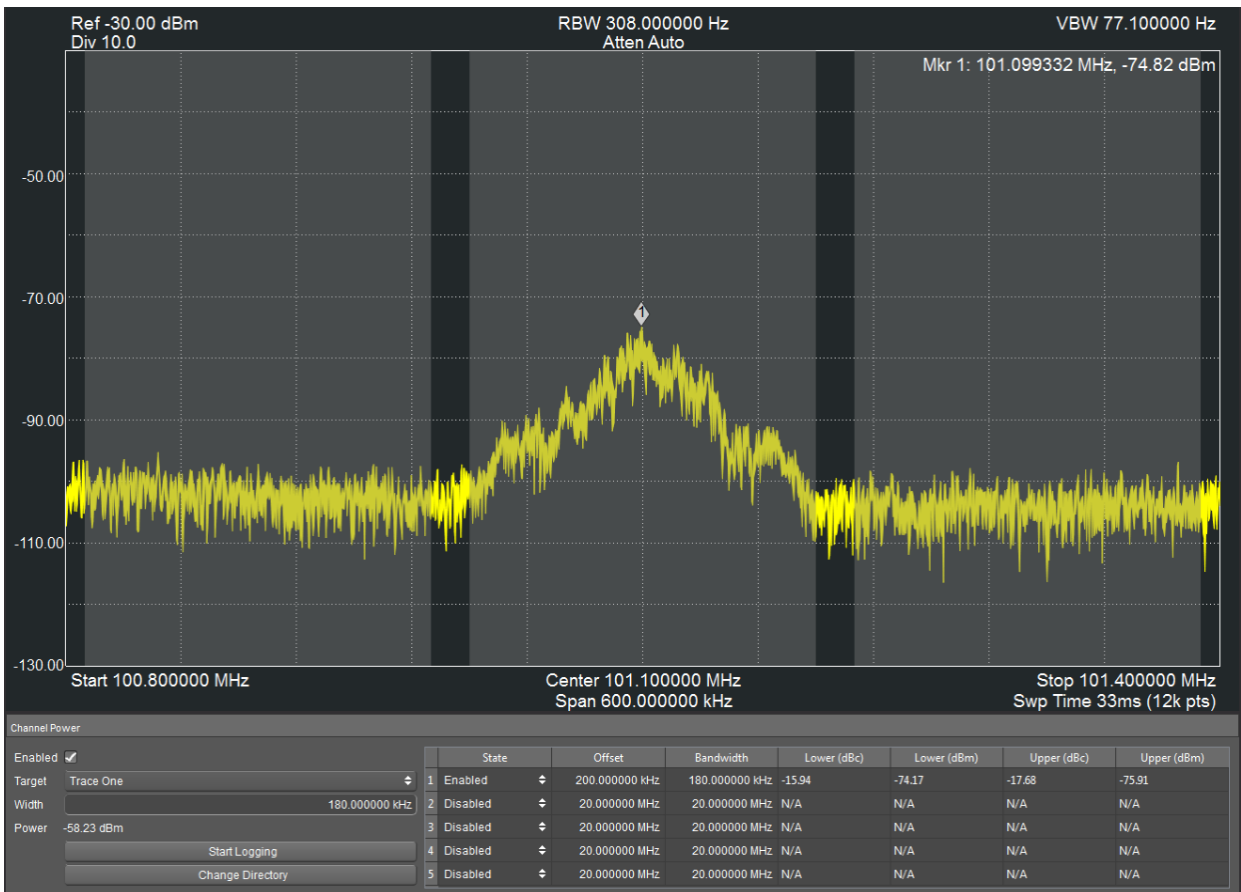


Figure 66: Channel Power on a Broadcast FM Signal

For best results, set the video processing to AVERAGE, POWER, and turn spur reject off. The software will throw a warning if the settings are not configured properly when activating channel power.

## 5.6 INTERMODULATION DISTORTION

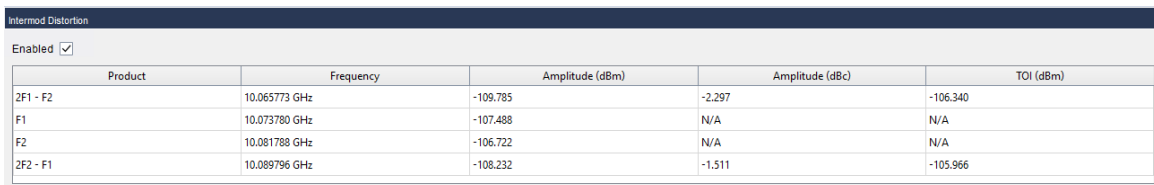


Figure 67: Intermodulation Distortion control panel.

The Intermodulation Distortion control panel measures intermodulation products and computes third-order intercept.

It is expected that two signals are injected, one with lower frequency  $F_1$ , and the other with higher frequency  $F_2$ . The two highest peaks are found, and considered to be  $F_1$  and  $F_2$ . From these points the third-order products  $2F_1 - F_2$  and  $2F_2 - F_1$  are derived. These four points are displayed on the graticule as trace markers.

Aside from frequency and amplitude, the table shows two additional calculations for the third-order products. Amplitude (dBC) is the differential amplitude between the third-order products and the base tones, and TOI is the third-order intercept point. They are calculated as follows (only the lower calculations are shown):

$$\Delta P_{Lower} = P_{IM3_{Lower}} - \frac{2 * P_{Lower} + P_{Upper}}{3}$$

$$TOI_{Lower} = \frac{P_{Upper}}{2} + P_{Lower} - \frac{P_{IM3_{Lower}}}{2}$$

## 5.7 TRACE MATH

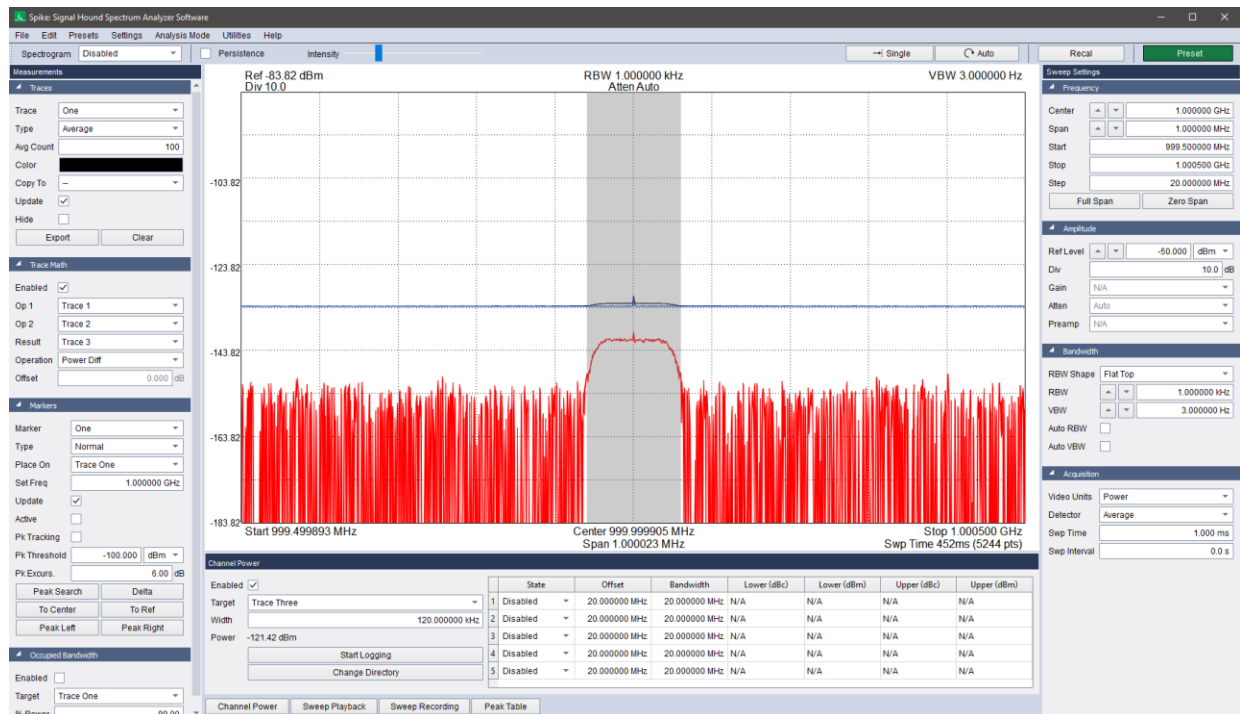


Figure 68: Power difference function measuring signal power below the instrument noise floor.

Trace math performs simple math operations between 1 or 2 traces and stores the results in a user specified result trace. The source and result traces are selectable from the 6 user customizable traces. The math operations available are listed below. All operations are defined using a logarithmic plot scale. If linear mV scale is used, the result is converted to mV. All operations are performed on a bin-by-bin basis.

- **Power difference:** A power difference is calculated between two traces and stored in the result trace.
  - Result =  $\text{Log}(\text{Power}(\text{Op1}) - \text{Power}(\text{Op2}))$
- **Power sum:** A power sum is calculated between two traces and stored in the result trace.
  - Result =  $\text{Log}(\text{Power}(\text{Op1}) + \text{Power}(\text{Op2}))$

- **Log Offset:** A dB offset is applied to a single trace and is stored in the result trace.
  - $\text{Result} = \text{Log}(\text{Op1}) + \text{offset (dB)}$
- **Log Diff:** A log difference is calculated between two traces and stored in the result trace. An additional dBm offset is applied to the difference.
  - $\text{Result} = \text{Log}(\text{Op1}) - \text{Log}(\text{Op2}) + \text{offset (dBm)}$

When trace math is enabled, the trace math operation occurs at the time the result trace is normally processed. User traces are processed in order (1,2,3,4,5,6) after a sweep is retrieved from the spectrum analyzer. For example, the trace math operation  $\{3 = 1 - 2\}$  occurs when trace 3 is to be processed. In this example, trace 1 and 2 are already processed before the trace math operation occurs. An operation such as  $\{2 = 1 - 3\}$  means that trace 2 will be the result of trace one (updated just before trace math occurs) minus trace 3 (last updated on the previous sweep).

A sweep must be retrieved from the analyzer before a math result can be displayed. Ensure all traces in the math equation are enabled (type not set to Off) to see the trace math result. Trace type operations can be combined in conjunction with trace math. For instance, trace math can be enabled with a result trace of 3, and trace 3 can also have trace averaging enabled. Markers can be placed on math result traces as normal. Use offsets for log operations to offset the result into the plot window.

If the power diff operation is selected, any negative or zero valued bins calculated as the result of the difference are replaced by the smallest non-zero value in the trace after the difference operation is performed.

## 5.8 USING THE REFERENCE LEVEL OFFSET

When measuring a signal that has been attenuated or amplified it is useful to let the software adjust the measured signal by this offset. In Spike, you can enter this gain/attenuation value so you can directly view the corrected measurement.

The proper way to set the reference level offset in Spike is to set the reference level offset and then set the reference level to the value you want to see after the offset is applied. For example, if you are viewing a 30dBm signal that is being attenuated by 40dB, first set the reference level offset to 40dB, then then set the reference level to 30dBm.

## 5.9 NOISE MARKERS

Noise measurements are made using the noise markers in the Spike software. To enable this measurement, change the active marker type to 'Noise' and place the marker on the spectrum.

Noise marker measurements are only available in sweep and real-time modes, and with the average video detector enabled. For the most accurate measurements, average detector and power video units should be selected.

The noise measurement reading is normalized to 1Hz and accounts for the under response due to either log or voltage scale VBW averaging. The measurement is averaged over  $\frac{1}{2}$  a division. The formula used for calculating the noise reading is below.

$$P_{dBm/Hz} = 10 * \log_{10} \sum_{f1}^{f2} \left( \frac{P_{mW}}{Span_{Hz} * NBW} \right) + C_{dB}$$

Where NBW equals the RBW filter (window function) noise bandwidth. f1 and f2 are frequencies spanning ½ a display division and are centered on the marker frequency. C is a constant, where C = 0.0 when power video units are selected, C = 2.51 for log video units, and C = 1.05 for voltage video units.

## 5.10 CHANNEL POWER MARKERS

Channel power measurements can be made quickly using the channel power markers in the Spike software. To enable this measurement, change the active marker type to 'Channel Power' and place the marker on the spectrum.

Channel power marker measurements are only available in sweep and real-time modes.

The bandwidth of the channel to be measured is specified using the Ch Power Width field.

## 5.11 N DB MARKERS

An N dB marker can be used to measure the bandwidth of a signal in the Spike software. To enable this measurement, change the active marker type to 'N dB' and place the marker on the spectrum, on a peak.

N dB measurements are only available in sweep, real-time, and scalar network analysis modes.

Typically used to measure the bandwidth of a filter, the marker is placed on a peak, and the left and right arrow markers are shown about N dB down the transition band on either side of the peak. The result of this measurement is the frequency difference between these two arrow markers.

The value of N, called the offset, is specified using the N dB Offset field.

The N dB measurement works by looking for the closest point on either side of the primary marker that is at least N dB down from the primary marker, and then choosing the point with distance closest to this offset value.

If no point is found on either side that is at least N dB down, then the measurement returns a result of "--" and the arrows are shown at the primary marker.

## 5.12 RBW FILTER SHAPE

Selecting the RBW filter shape affects how the spectrum analyzer achieves the desired RBW. Different shapes affect which window function is used and how the bandwidth is defined. Not all shapes are available for all devices or in all modes. Here is a short description of the filter shapes Signal Hound provides.



**Flat Top** – When this shape is selected, a variable bandwidth flat top window defined at the 3dB point is used to achieve the desired RBW. The flat top window is selected by default and is recommended for the most accurate measurements as it has very low scalloping loss.

**Nuttall** – When Nuttall is selected, the analyzer uses a fixed bandwidth Nuttall window defined at the 3dB point and powers of two FFTs with zero-padding to achieve discrete RBW values. Nuttall windows offer the fastest sweeps with the lowest number of points in the sweep to achieve the RBW selected. The downside of the Nuttall shape is the high scalloping loss at around 0.8 dB.

**CISPR** – When CISPR is selected, the analyzer uses a Gaussian window defined at the 6dB bandwidth point and zero padding to achieve the selected RBW. This shape is commonly used for EMC/EMI pre-compliance measurements.

## 5.13 USING THE MEASURING RECEIVER UTILITY

The Spike software provides the functionality of a measuring receiver to make tuned RF level measurements (TRFL). TRFL measurements are useful for characterizing attenuators, signal generators, or any device on which a user wants to measure the accuracy of incremental steps in the output power.

TRFL measurements are capable of making more accurate power level readings and carrier frequency readings than in standard swept analysis mode and is capable of measuring power to much lower levels than in swept mode.

The measuring receiver utility can be accessed through *File Menu* → *Utility* → *Measuring Utility*. Enabling the utility will bring up the dialog box shown below.

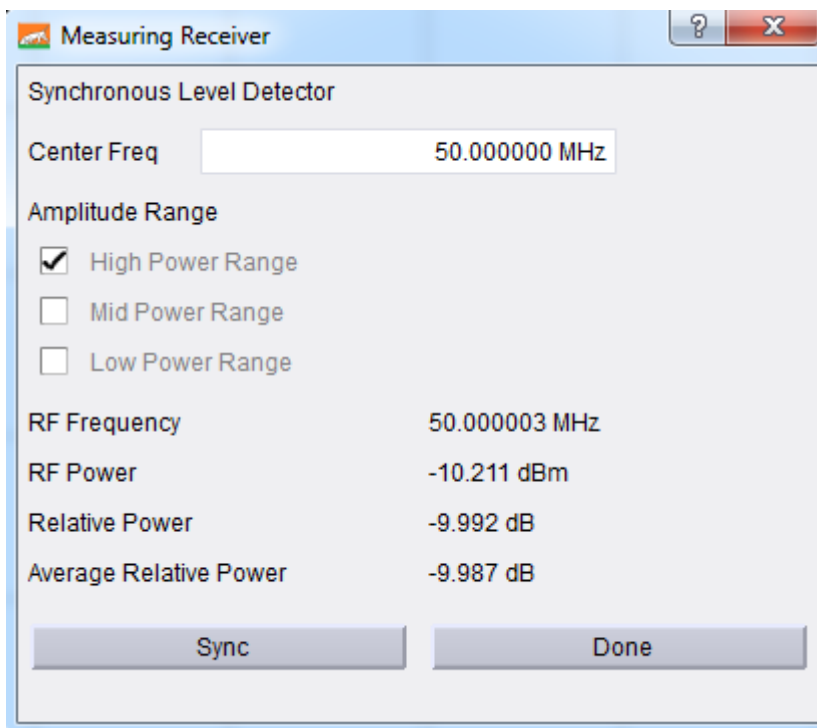


Figure 69: Measuring Receiver Control Dialog

## 5.13.1 Measurement Procedure

This section outlines the procedure for making TRFL measurements with the measuring receiver utility.

1. With the Signal Hound device connected to the PC and application software running, select *Measuring Receiver* from the *Utilities* file menu.
2. The measuring receiver will open and perform a 3-second calibration. Wait for this calibration to finish and connect the unit under test (UUT).
3. Prepare the UUT by selecting the maximum output power and center frequency of the device. Ensure the UUT output is a CW signal.
4. Prepare the software by entering the center frequency of the UUT and pressing *Sync* which recalibrates the measuring receiver for the new center frequency.

*Note:* For correct operation, ensure the frequency entered is close to the output frequency of the UUT.

After step 4 above, verify the RF Power and RF Frequency readouts are correct and ensure the Relative Power readouts are stable and very close to zero. A user is now ready to begin making stepped output power measurements. Perform the following steps for each output power level step.

5. Decrease/step the output power level of the UUT by no more than 10 dB.
6. Record any relevant readouts.

7. If the measuring receiver suggests recalibrating the device at a new power range, do so now. Recalibration takes about 3 seconds and is necessary to make continued accurate measurements to lower power levels.
8. Return to step 5.

To start the test over, select a new center frequency or press the *Sync* button and start over from step 1.

Be careful of IF overload messages which warn that the UUT output power is too large for the current power range. Avoid this by either decreasing the UUT power or pressing the *Sync* button to return the measuring receiver utility to the highest power range.

As the output power of the UUT, the measuring receiver prompts the user to enter new power ranges. The ranges are finite and a warning will be issued if the user has stepped over a range. To resolve this, increase the UUT output power slowly until entering the next lower power range.

## 5.14 TIPS FOR BETTER MEASUREMENTS

Signal Hound spectrum analyzers have internal gain and attenuation settings that are automatically adjusted for the selected reference level. While the software allows the user to manually control these settings, the AUTO value should be used for nearly all measurements. Manual control may place the compression point below the reference level, add spurious or residual signals, or raise the noise floor.

There are times when a user wishes to increase the attenuator by 5 or 10 dB to improve linearity. This can be important for reducing the amplitude of intermodulation products. Rather than changing the attenuator setting, simply change the reference level. This is easier and more predictable than manually controlling the attenuator.

For the best sensitivity and lowest noise floor, set the reference level at, or just above, the maximum input amplitude. To improve linearity and reduce intermodulation products, set the reference level 10 or 20 dB above the signal level.

For narrow-band and CW signals, the noise floor comes down approximately 3 dB for each decrease in RBW. When measuring low-level CW signals, narrower RBWs are recommended.

For maximum sensitivity, a reference level of -50 dBm or lower is recommended. This will set the attenuator to a minimum and set the internal gain to a maximum.

When the detector is set to "average" this is the equivalent to setting the minimum VBW for the current setup. This will have the lowest peak-to-peak noise floor but will also average intermittent signals. Set VBW to auto and the detector to "MIN/MAX" or MAX to measure pulsed or intermittent signals.

For making average power measurements, make sure the detector is set to "average" and "power." If the signal is modulated, either set the RBW wider than the modulation, or center the signal and use the channel power utility.

# 6 Additional Features

The Spike software has several useful utilities. They are described here.

## 6.1 SCPI

The Spike software is programmable using SCPI commands. The Spike software maintains a SCPI TCP/IP socket connection on port 5025 (default). The connection can be disabled, and the port number can be changed through the preferences menu.

When a SCPI connection is active and a command is received, the Spike software enters a remote operation mode. When in remote operation, a modal dialog appears in the center of the Spike application. To return to local operation either press the “Return to Local” button or close the dialog. If another SCPI command is received, the dialog will reappear.

For programming information regarding Spike and SCPI see the Spike SCPI programming manual in the SDK download located on the Signal Hound website (on any device download page).

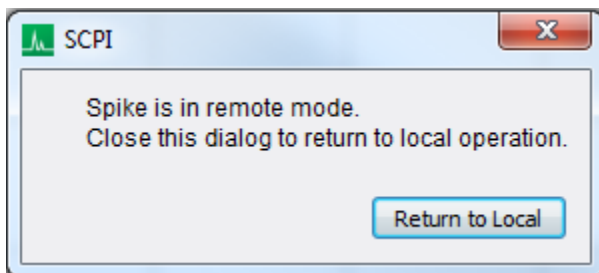


Figure 70: SCPI Remote Mode Active Alert Dialog

### 6.1.1 SCPI Log

When logging is enabled, SCPI commands received, and responses sent by Spike are logged with timestamps. The log can be viewed in a non-modal dialog via the *Utilities* → *SCPI Log* menu option.

In the upper left of the dialog, running counters show the number of commands received, responses sent, and total messages handled.

The log’s active state is shown in the upper right of the dialog. It can be enabled or disabled in the SCPI preferences. A few milliseconds of overhead can be saved by disabling SCPI logging.

The log can be exported as a plain text file using the “Export” button.

The log can be cleared using the “Clear” button.

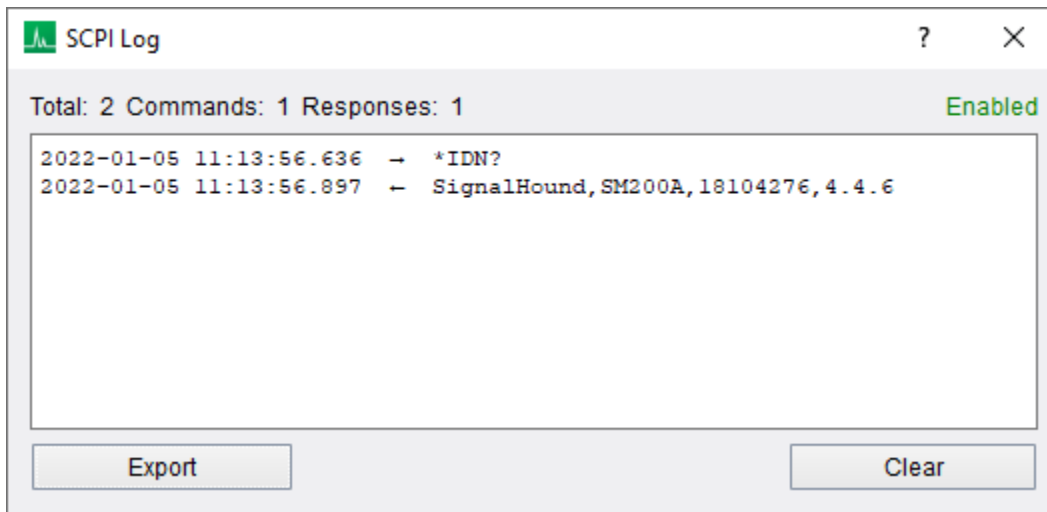


Figure 71: SCPI Log

## 6.2 PRINTING

Use the *File* → *Print* menu to print exactly what is shown on the graticule. Be careful, if the software is still updating traces, the software may not print the desired trace. Use the print preview option to see exactly what will be printing. Use the Single button to stop the measurement updates to guarantee you print the desired signal.



Tip: The active color scheme is used for printing as well. Under the **View – Colors** menu, we provide a simple printer friendly color scheme to help save ink!

## 6.3 SAVING IMAGES

Use the *File* → *Save to Image* menu option to save the current graticule view as a PNG, JPG, or BMP image. The resulting resolution of the image is the exact resolution of the graticule at the time of the save. To obtain the highest resolution image, maximize the software and slide the control panels out of the way. The active color scheme is used in the resulting image.

## 6.4 CORRECTION DATA

Use the *File* → *Manage Correction Data* menu option to open a dialog that provides some useful correction data management functions.

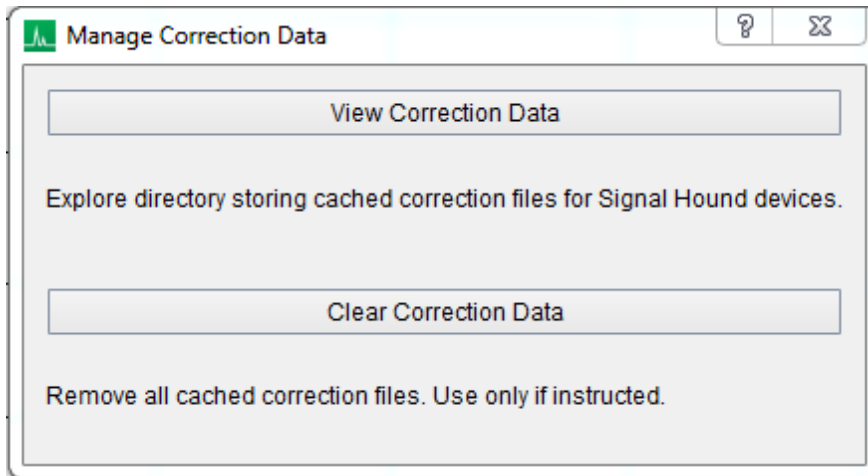


Figure 72: Manage Correction Data Dialog

Correction data is pulled from some Signal Hound devices and cached locally for faster access. It is sometimes necessary to manage this data. For example, when a device is recalibrated a new correction file is generated for it, rendering the old one obsolete. Simply removing the old one will cause the software to pull the new one from the device. This is done using the “Clear Correction Data” button.

There are two available functions.

- 1) **View Correction Data:** This opens the directory on your computer which contains correction data files for Signal Hound devices in Windows Explorer.
- 2) **Clear Correction Data:** This removes all correction data files for Signal Hound devices that have been cached on your computer. When a device is connected, its correction file will be re-cached.

You should only use these functions if you have recently had your device calibrated or if instructed by Signal Hound Support. Not all analyzers store calibration data on the device. If you have an older SA series device, make a copy of the calibration data before clearing any data.

## 6.5 ETHERNET DEVICES

Use the *File* → *Manage Ethernet Devices* menu option to open a dialog that provides Ethernet device management functions.

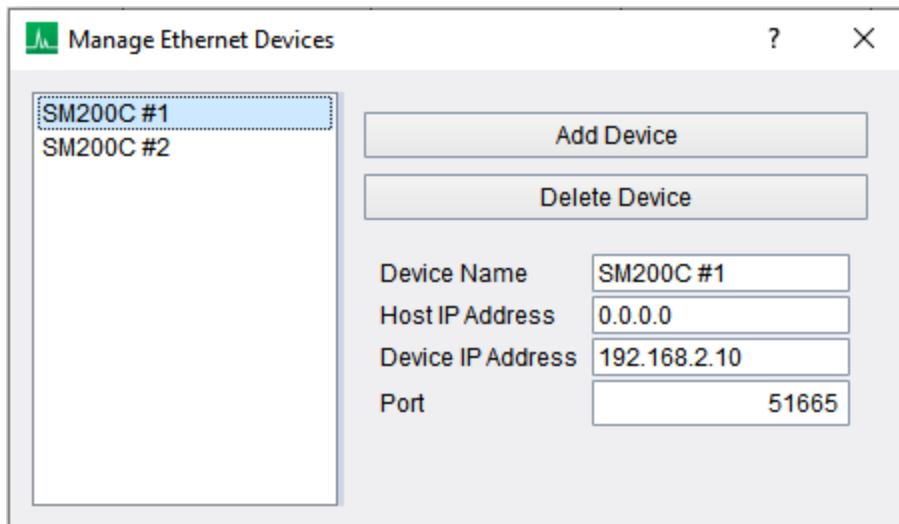


Figure 73: Manage Ethernet Devices Dialog

For devices that connect via Ethernet, such as the SM200C and SM435C, the device IP address and port must be known in advance prior to opening the device. This dialog allows you to register several networked devices in the Spike software by specifying the IP and port address of the device. When a device is added to this list, it will appear in the File->Connect menu.

When adding a new device to this list, the default IP and port addresses are used. If you haven't modified your devices IP/Port, use the default values. The host IP address refers to the network interface that the device is connected to. 0.0.0.0 is the address used for 'any' which means that the PC will resolve this later. This value should be used in most cases.

Note that a device does not need to be connected to the computer to save or edit a device in this list, but the device will need to be connected to connect via File > Connect.

There are two available functions.

- 1) **Add Device:** This adds a new Ethernet device with default settings.
- 2) **Delete Device:** This removes the Ethernet device currently selected in the list.

## 6.6 PATH LOSS, LIMIT LINE, AND ANTENNA FACTOR FORMAT

All correction and limit tables are loaded into the software in CSV file format. This means each value is separated by a comma, and each logical set of values is separated by a newline. These types of files can be edited in spreadsheet document software or even a basic text editor.

Values provided are then linearly interpolated.

**Path loss tables** are [Frequency (MHz), Gain (dB)] pairs which describe the response of one or more components in the system. A path loss table might look like this

20.0, 0.1
200.0, 0.4
2000.0, 1.7
...

Path loss tables are applied to the received sweep before being displayed or processed. The first and last values are extended to the start and stop frequencies of the sweep configured. It is good practice to prefix and postfix your table with zeros if you do not wish to extend your corrections beyond the defined frequency range.

**Antenna factor tables** are [Frequency (MHz), Antenna Factor (dB/m)] pairs which describe the response of an antenna. These tables have the same structure and behavior as path loss tables except they change the units of measurement to one of electric field strength. Electric field strength measurements are used in compliance testing.

**Limit lines** are of the form, [Frequency (MHz), Limit(dBm)]

Limit lines are only tested within the frequency range of the lowest and highest frequency point.

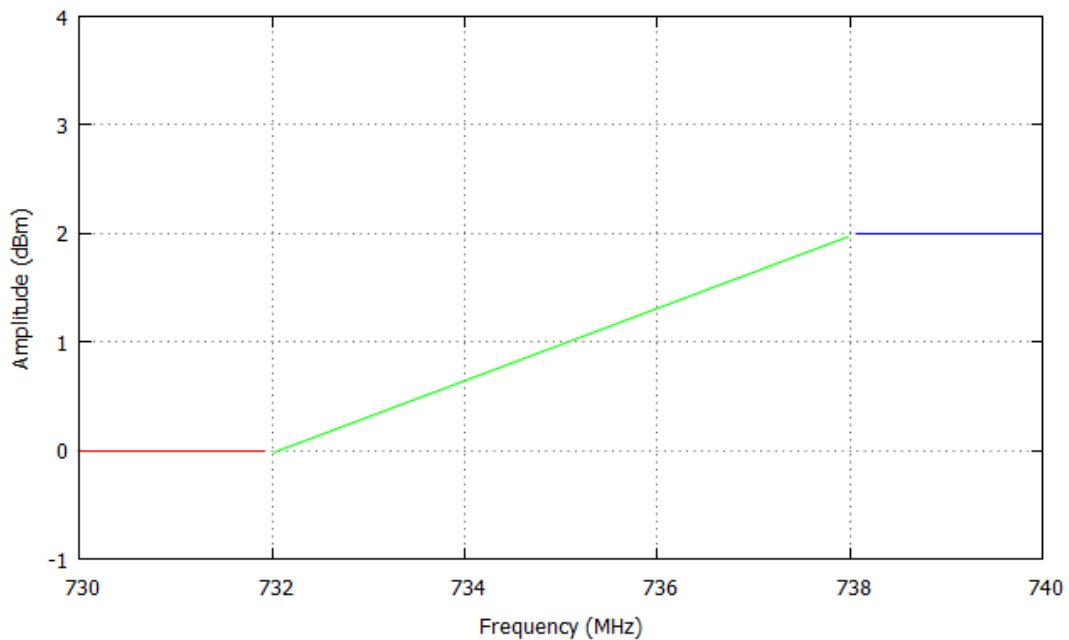
The limit lines are drawn on the graticule and each sweep is tested against them. Indicator text will appear in the center of the screen denoting whether the trace currently shown passes or fails the limit line test.

Here is an example of a path loss CSV file built in a spreadsheet program.

732	0
738	2

And here are the resulting path loss corrections applied to incoming traces for a 10MHz span centered at 735 MHz:





We can see the linear interpolation between the two points and flat lines off the sides.

## 6.7 MANAGING PATH LOSS TABLES

The path loss table dialog provides a user with the ability to manage up to 7 path loss tables and one antenna factor correction table. Loss tables are [frequency, dB] pairs which characterize loss or gain in the system. Typical use of loss tables corrects for cables, amplifiers, or attenuators. Antenna factor tables are [frequency, dB/m] pairs which describe the response of an antenna and are generated by calibrating an antenna. Only one antenna factor table can be loaded and should be loaded into the appropriate spot to ensure the software recognizes its presence.

See [Path Loss, Limit Line, and Antenna Factor Format](#) for more information.

Tables can be loaded and removed through the dialog. The file names of the tables are stored with the presets and are loaded automatically when loading a preset later. If the file name has changed or moved since the preset was saved, then the table will be removed.

### 6.7.1 When Are Path Loss Tables Applied?

Path loss tables are applied in two ways.

- 1) **Full:** The user provided path loss tables are applied at each output frequency point in the measurement.
- 2) **Single:** Path loss applied at a single frequency: The measurement is corrected for a single frequency, usually the center frequency of the configured measurement. This is equivalent to a flat dB offset across the measurement.

Each measurement mode in Spike applies path loss in one of the ways mentioned above. Below is a list of each measurement mode in which path loss is applied and denotes which application method is used.

<b>Measurement Mode</b>	<b>Path Loss Method</b>
Swept spectrum analysis	Full
Real-time spectrum analysis	Single
Zero-span	Single
Harmonics viewer	Full
Scalar network analysis	Full
Phase noise	None
Modulation analysis	Single
EMC precompliance	Sweeps: Full, QP Detector: Single
Analog demod	Single
Interference hunting	Full
Measuring receiver	None
Spectrum Emission Mask	Full

## 6.8 MANAGING LIMIT LINES

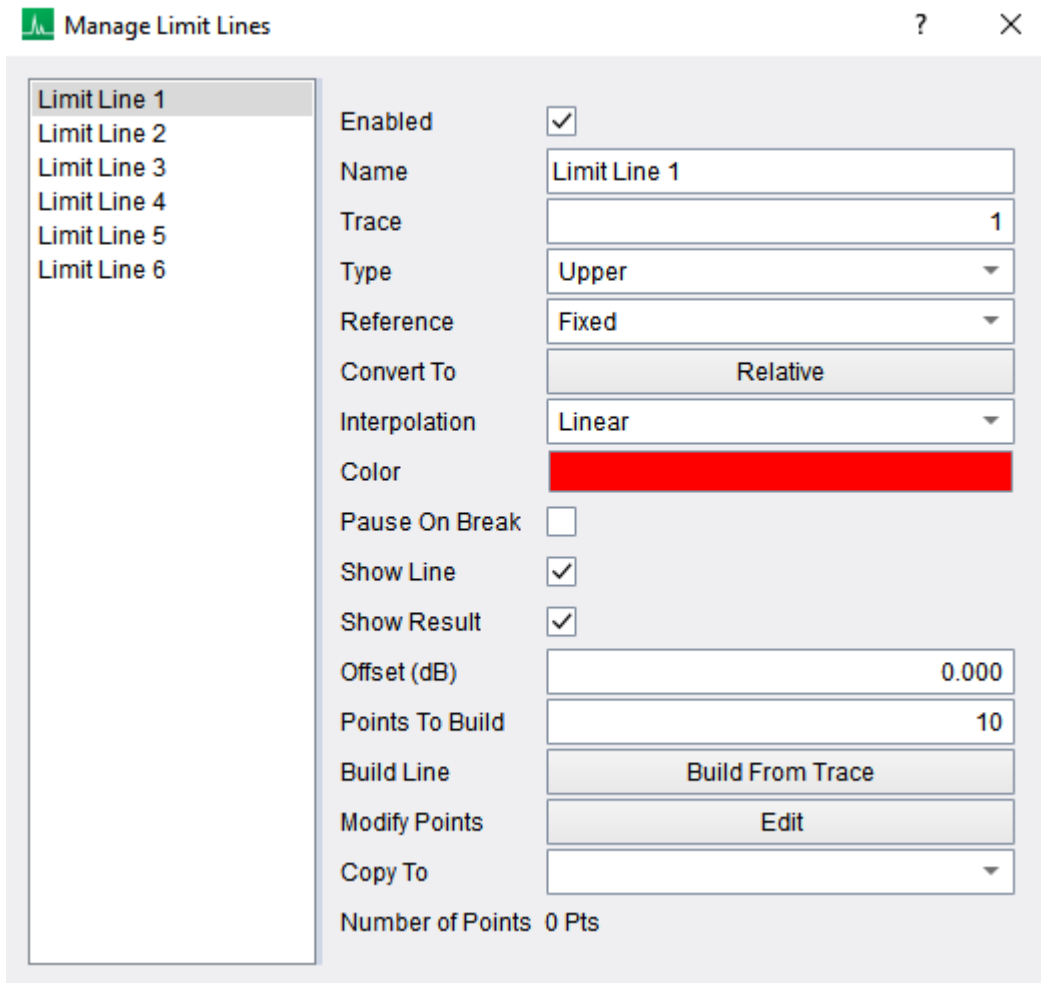


Figure 74: Limit Line Manager

The limit line dialog provides a user the ability to configure up to 6 limit lines. Each limit is stored as frequency amplitude pairs. The points tested against the sweep are interpolated from the limit line values. The limit line can be configured to act as a maximum or minimum threshold. Limit lines can be loaded from CSV files. See [Path Loss, Limit Line, and Antenna Factor Format](#) for more information. Limit lines are also stored in the presets.

### 6.8.1 Settings

- **Enabled** – Activates/deactivates limit line.
- **Name** – The name of the limit line. This will be displayed on the plot if “Show Result” is checked.
- **Trace** – Sets the trace the limit line acts upon.
- **Type** – Sets whether the line is an upper or lower bound.

- **Reference** – Sets whether the frequencies are specified as fixed or relative (to center) values.
- **Convert To** – Converts the limit line's reference mode between fixed and relative. This recalculates the points based on their current position on screen.
- **Interpolation** – Specifies whether linear or logarithmic interpolation is used.
- **Color** – Sets the color of the limit line.
- **Pause On Break** – When enabled, Spike will switch to single step mode if the limit line is violated.
- **Show Line** – Sets the visibility of the line on the plot.
- **Show Result** – Sets the visibility of the name and pass/fail status on the plot.
- **Offset** – Sets an offset to be applied to all the points in the line.
- **Points To Build** – Specifies how many points should be used when building a line from the current trace.
- **Build Line** – Constructs new limit line data from the current trace, using the number of points set in "Points To Build".
- **Modify Points** – Opens the limit line table editor for editing individual points.
- **Copy To** – Copies the limit line's points, type, reference, and offset to the selected limit line.
- **Number of Points** – Displays the number of points in the limit line.

## 6.9 AUDIO PLAYER

Using the *Utilities* → *Audio Player* menu option, a user can utilize the software to play broadcast audio. When using Spike™ for audio playback, the dialog box below will appear.

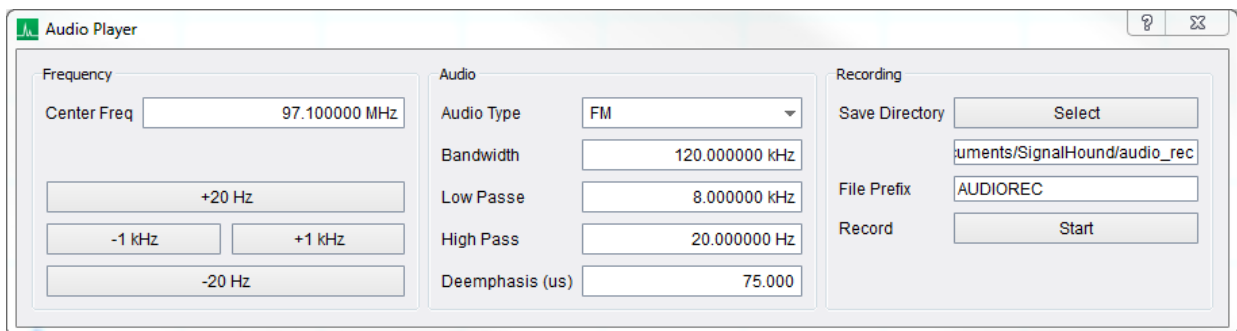
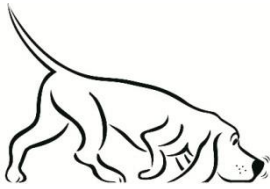


Figure 75: Audio Player

Change the center frequency using the arrow keys, pressing the fine tune frequency adjustments, or through manual entry. The initial center frequency is the same center frequency displayed on the graticule when selecting the Audio Player menu option. A user can also manually change or select various bandwidths and the type of demodulation. A user may also specify audio low pass and audio high pass filter cutoff frequencies.

All audio related variables other than center frequency are saved with presets.



**TRY THIS:** Utilize sweep mode to find a signal of interest and start the Audio Player to immediately begin listening at that frequency.

## 6.10 FREQUENCY DIFFERENCE METER

Spike provides a frequency difference utility to determine the frequency difference between two stable oscillators. The frequency difference is displayed as a digital readout as well as a zero-centered meter with selectable parts in  $10^6$ ,  $10^7$ ,  $10^8$ ,  $10^9$ ,  $10^{10}$ , and  $10^{11}$ . The frequency difference meter accepts frequency inputs across the entire operating frequency range of the spectrum analyzer. The types of measurements available through the frequency difference meter include, measuring, offsetting, and adjusting your oscillator, and analyzing the stability of your oscillator.

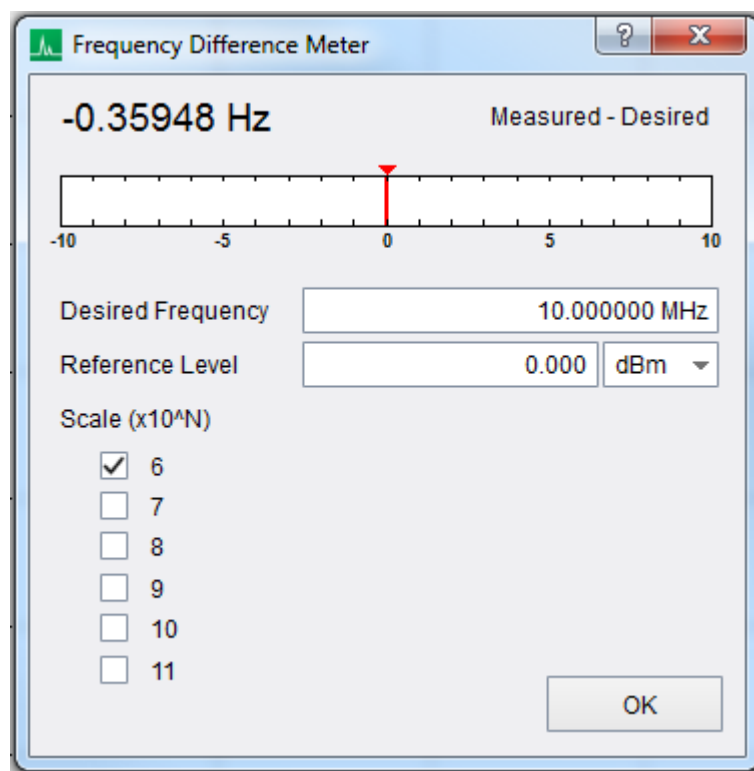


Figure 76: Frequency difference meter observing frequency difference between two 10MHz oscillators

Ensure your spectrum analyzer has an external reference connected to the input BNC port and is activated through the file menu. If an external reference is not connected and active, the internal timebase of the spectrum analyzer is used. Connect an oscillator to the input RF port on the spectrum analyzer and set the desired frequency setting. Set the reference level to about 5dB above the input signal level. Observe the frequency offset (Measured – Desired). As you adjust the input oscillator, use the scale radio buttons to adjust the frequency range displayed on the output meter. As the scale is

increased, the damping increases on the output meter. Allow several seconds for the meter to settle on the smallest scale settings.

## 6.11 ADJUSTING YOUR TIMEBASE

Using the timebase adjust utility, you can semi-permanently adjust your Signal Hound's internal 10MHz oscillator. Access the adjustment utility using the *Utilities -> Timebase Adjustment* option.

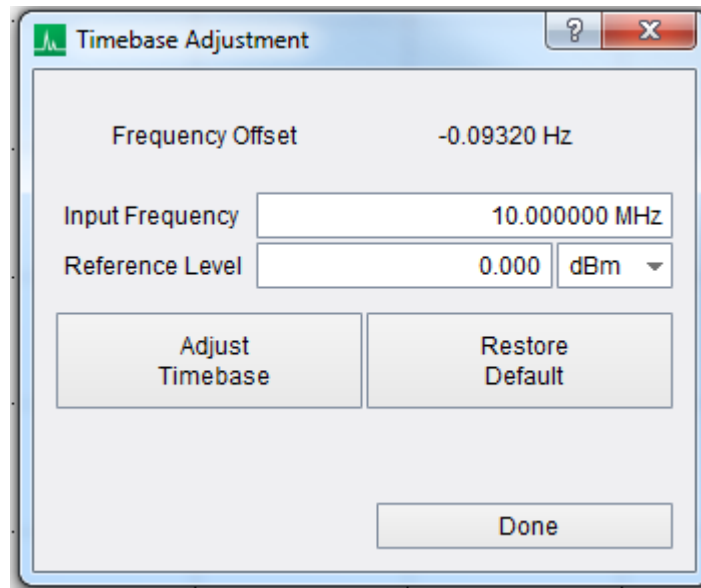


Figure 77: Timebase Adjustment Utility

The utility allows you to adjust the internal oscillator to a high precision external CW source or oscillator through the RF input port. Using the utility, the Spike software can store an adjustment for the serial number of the device to use for all future program invocations. Spike stores this adjustment for the serial number on the local PC. If you connect a different device or use a different PC, the adjustment will not be applied.

If you wish to restore the default factory adjustment settings, simply press the *Restore Default* button at any time. You do not need to provide an input CW signal to restore the factory adjustment setting.

Steps:

- Connect the high precision source/oscillator to the input RF port on the spectrum analyzer.
- Disconnect any cables connected to the reference in/out BNC port.
- Set the reference level about 5dB higher than the expected input signal.
- Set the input frequency to match the input oscillator frequency.
- Ensure the frequency offset reading is stable and reasonable before adjusting the timebase.
- Press the *Adjust Timebase* button.
- After adjusting, the frequency offset shown will reflect the new adjustment.

## 6.12 SPUR REJECTION

When spur rejection is on additional signal processing is enabled attempting to remove spurious signals which are the result of mixing products. Spur rejection roughly doubles sweep time and is great for cleaning up a steady signal, but should not be used for pulsed RF, or modulated signals. Spur rejection is not available in real-time mode.

## 6.13 NETWORKED SPEED TEST

This utility tests the speed of a connected networked device, such as an SM200C or SM435C. It shows the result in Gigabits per second, and updates each second.

Networked device to PC throughput is measured using UDP jumbo packets. This utility can be used for troubleshooting. For the SM200C/SM435C, network speed should sustain > 8Gbps speeds.

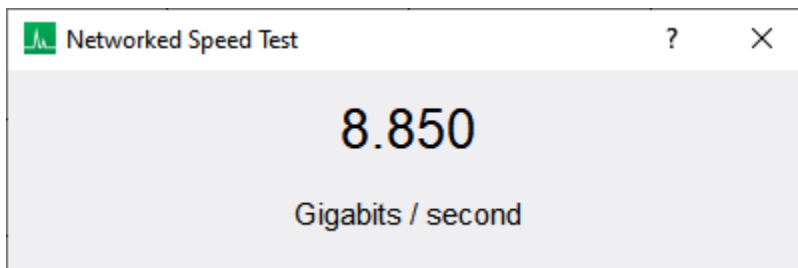


Figure 78: Networked Speed Test utility

## 6.14 SM NETWORK CONFIGURATION

This utility is used to modify the network address of an SM200C or SM435C. The network address can be updated over USB or UDP. The device must be disconnected before configuration can occur.

### 6.14.1 Configuring Over USB

If configuring over USB, ensure the networked SM is connected to the PC with the provided USB cable. In the "Via USB" tab, press the "List Devices" button to show all networked devices connected to the PC over USB. If no devices are found, troubleshoot the USB connection to the PC.

Once the target device can be found with "List Devices", specify the target device serial number and new network settings you wish to apply to this device. Once finished, press the "Program Device" button. It will take a few seconds to program the new settings. At this point, "List Devices" should show the updated network settings.

When non-volatile is unchecked, the new settings will not persist through a device power cycle.

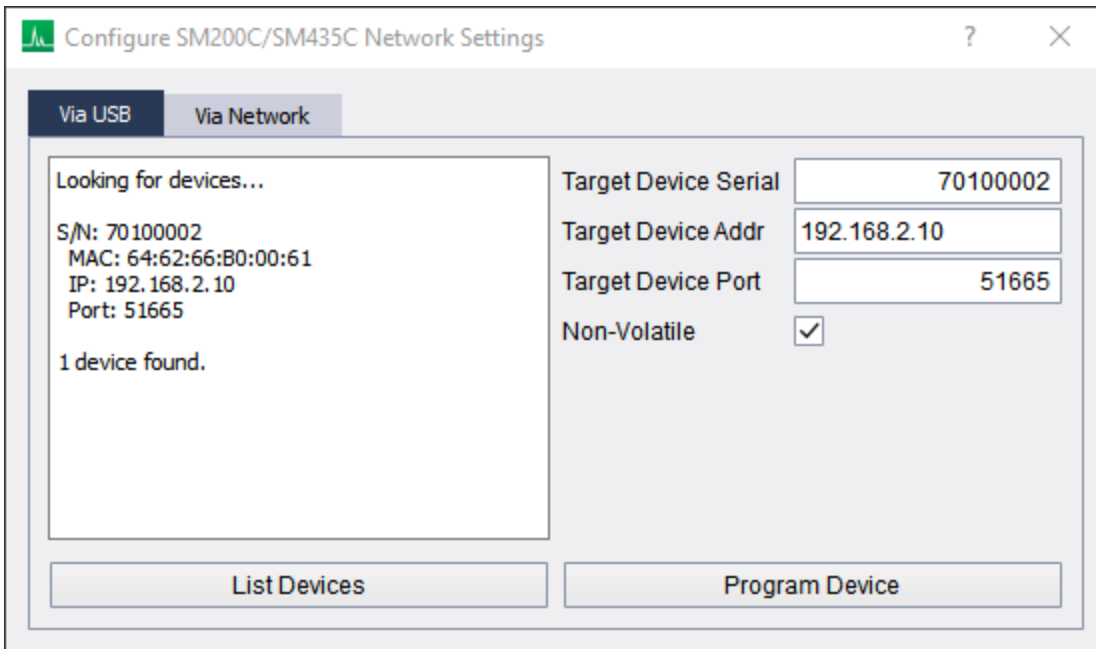


Figure 79: Configuring the network address over USB.

## 6.14.2 Configuring Over UDP

When configuring over UDP, the new settings are sent in a broadcast UDP packet. For this reason, only a single SM should be connected to the local network interface. While specifying the “any” address often works, when possible, it is best to specify the host address directly. The update will report failed if changing to a new subnet, but the update may have still been successful.

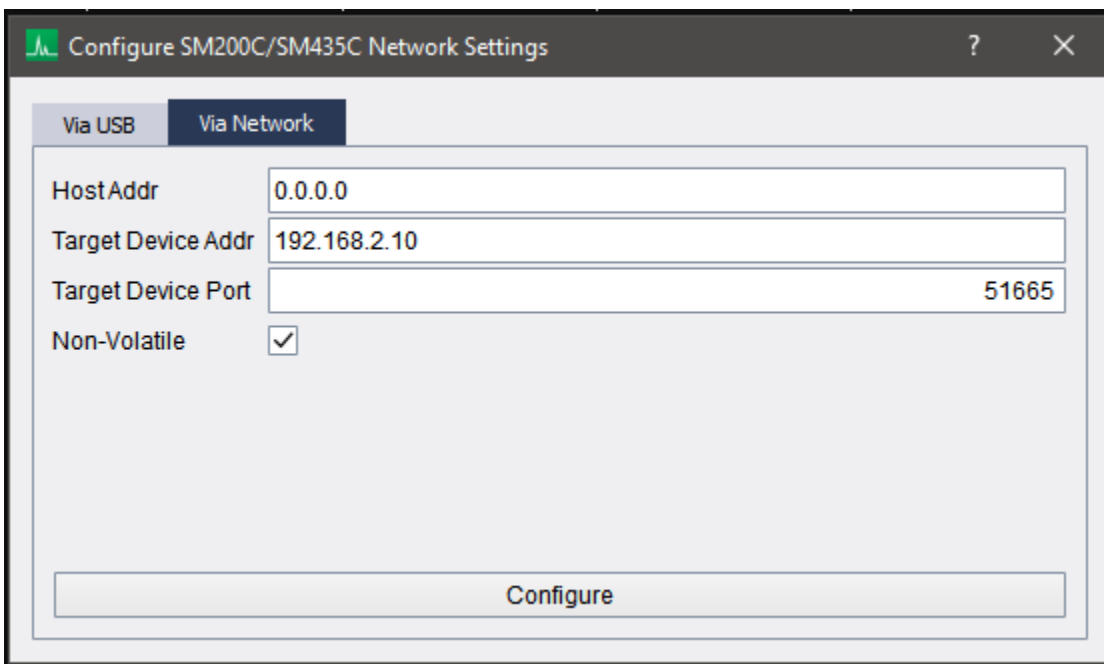


Figure 80: Configuring the network address over UDP.



## 6.15 GPS

The Spike software can utilize a GPS device to store GPS coordinates for each sweep in sweep recording files. This functionality was added in Spike version 3.1.13. When a GPS device is actively being interfaced in the Spike software (either via the internal SM GPS or via a configured external GPS device) the NMEA data is parsed and longitude, latitude, and altitude information is associated with each sweep. Most GPS devices provide NMEA data once per second, and thus this is the finest granularity you can expect with regards to sweeps and their tagged coordinates.

The Spike software provides two methods for interfacing a GPS. The SM series devices have an internal GPS which will auto-lock when the GPS antenna is connected and positioned properly. You can determine the status of the internal GPS in the status bar of the Spike software. You can also communicate to an external GPS device using the **GPS Control Panel** in the *Utilities* drop down menu. Use the control panel to configure the serial connection to the GPS device.

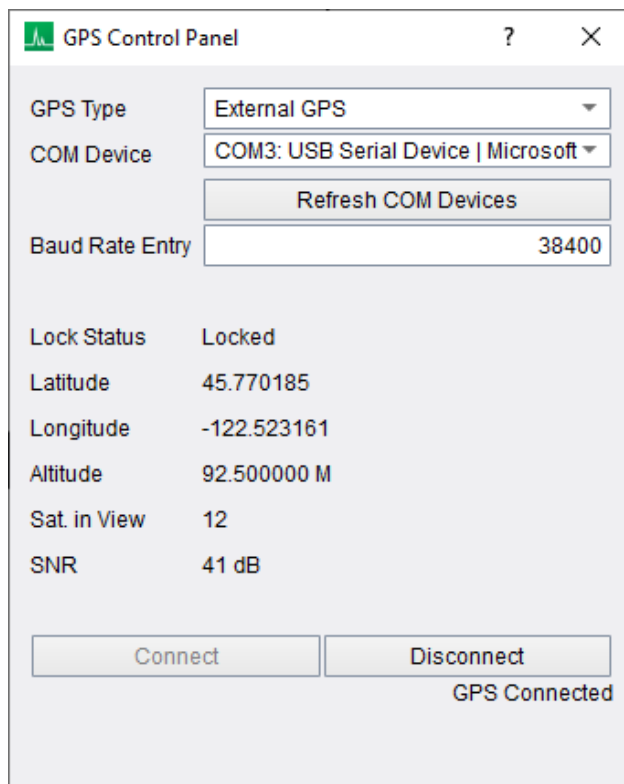


Figure 81: GPS control panel for configuring an external GPS device on Windows.

## 6.15.1 Windows

Connected COM devices will appear in the dropdown **COM Device**. Select the device that corresponds to the desired GPS unit. To refresh the list (if a GPS device is plugged in after opening panel), press the button **Refresh COM Devices**.

## 6.15.2 Linux

Enter the name of the serial device as represented in the file system under **Device Name**. For example, "ttyACM0". This name can be determined using a command like `ls /dev | grep tty`.

Pressing connect attempts to communicate with the GPS device. The control panel will warn you if unable to detect the GPS device or the NMEA data does not match a valid form. The NMEA data must contain the RMC sentence to be considered of valid form.

If an external GPS is connected, the GPS coordinates provided by the external GPS will override the ones provided by the SM.

Some messages you may encounter using the GPS control panel.

- Comm Error – The software was unable to find a valid RMC string in the NMEA sentences. The primary cause for this is an invalid baud rate. Verify the baud rate is set correctly by looking in the properties window for the COM device in the device manager.
- Locked/Unlocked - Echoes the lock status in the RMC string of either 'A' or 'V'. Coordinates are not used while unlocked.
- Unable to Connect GPS – Verify the COM port and baud rate are correct before attempting to connect again. Ensure the device is configured properly on your system.

## 6.16 GPS DISCIPLINED TIMEBASE

*(This section only applies to the SM series spectrum analyzers)*

The SM can use its internal GPS to discipline the timebase and internal clocks. This enables more accurate and consistent frequency measurements as well as accurate time stamping functionality (when using the API). This discipline behavior is enabled by default and the user only needs to connect the supplied antenna to start this process.

When the SM is connected to the Spike software, an additional text field appears in the status bar indicating the current GPS status. The possible GPS states displayed are



Figure 82: GPS state readout in Spike status bar. SM devices only.

- 1) **GPS Unlocked** – Either the GPS antenna is disconnected or is connected and hasn't achieved lock yet. After connecting the antenna expect several minutes for the lock. If you do not see a lock after several minutes, you might need to reposition the antenna.
- 2) **GPS Holdover** – The GPS is unlocked but is using a holdover value from the last time it was disciplined. A typical message here is **GPS Holdover (3d19h)** denoting the holdover value is 3 days, 19 hours old.
- 3) **GPS Locked** – The GPS has achieved lock but has not yet disciplined the SM. The GPS must be locked for several minutes before discipline occurs.
- 4) **GPS Disciplined** – The SM has been disciplined to the GPS. If the GPS antenna remains connected, the GPS will continue to discipline (it will usually update every few minutes).

Once GPS disciplining has occurred the software records the last known timebase correction value, which will be used in future program invocations when a GPS is not present. This stored value is referred to as the GPS holdover value. This value is stored in the C:\ProgramData\SignalHound\cal\_files directory (hidden directory) and is named of the form sm#####gps.bin. It is safe to delete this file.

The state machine below explains how to determine how the SM timebase is being corrected at any given time. To summarize the state machine, a timebase correction value is generated during production and is used until the GPS disciplines the system and is stored as a holdover value. If the device is recalibrated/adjusted at any time, the newer calibration value will be used over the holdover value. (All timebase correction factors are timestamped and the newest one is used)

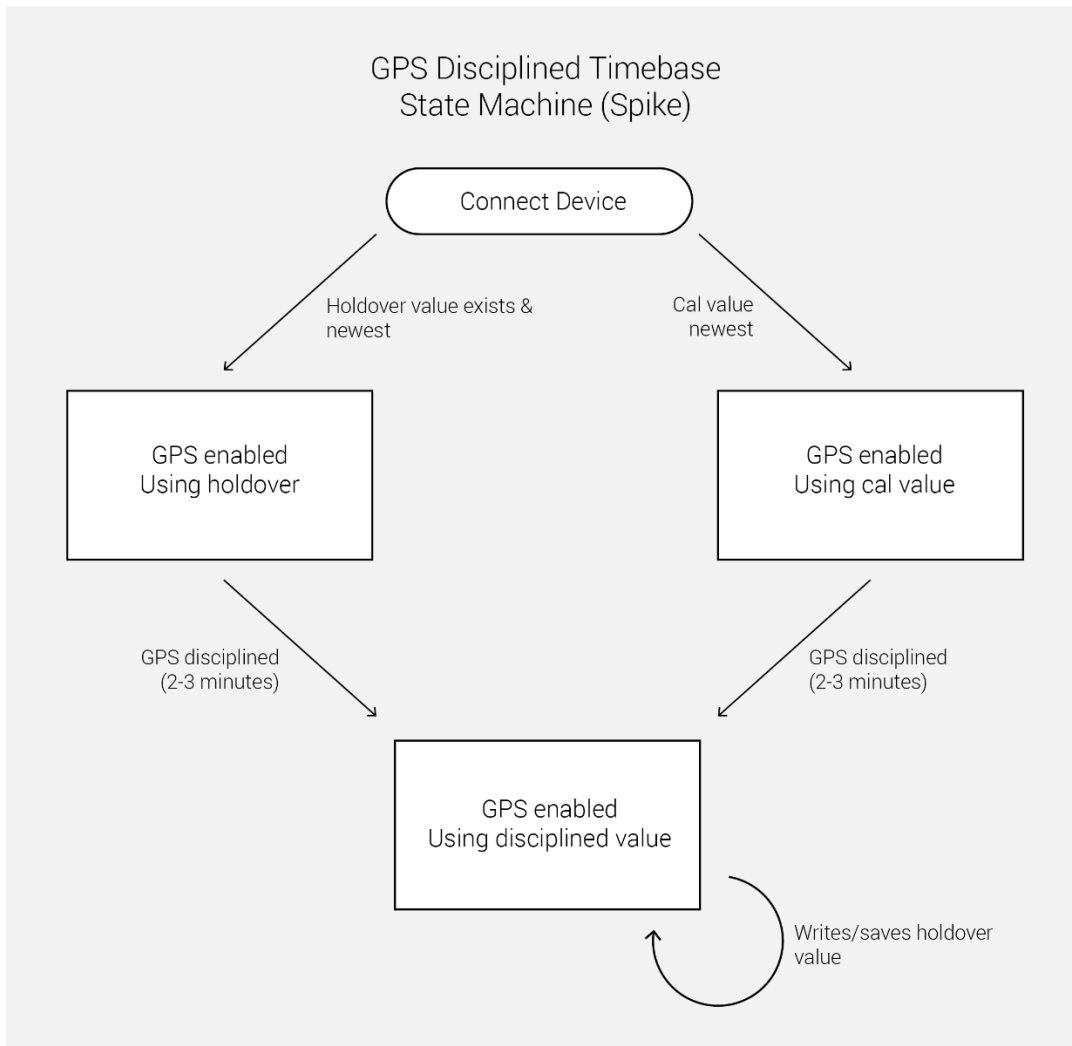


Figure 83: State machine for GPS disciplining for the SM.

## 6.17 BB60D GPIO CONTROLS

The UART output port on the BB60D can be controlled in Spike using the BB60D UART Controls.

- **UART Rate** – The UART clock rate can be selected from several predefined values.
- **Imm Config/Write** – The UART output on the BB60D can transmit up to 8 bits. The immediate controls can be used to directly transmit a byte over the UART port.
- **UART Sweep** – Up to 8 UART bytes can be transmitted at specific frequencies in a sweep. This is useful for intra-sweep antenna switching or controlling an external device during a sweep. When enabled, a UART byte is transmitted when the sweep frequency crosses a user defined frequency. When enabled, this functionality will override the 10MHz output reference if configured.

## 6.18 SP145 GPIO CONTROLS

## 6.19 SM GPIO CONTROLS

The GPIO on the SM200 and SM435 spectrum analyzers can be controlled in Spike. There are two GPIO output modes that can be configured, fixed and sweep. Fixed mode sets the GPIO output pins to fixed outputs, while the sweep mode changes the GPIO pins at different points in the sweep. The GPIO can be configured using the SM GPIO Controls found in the File->Utility menu.

The DB15 port on the SM spectrum analyzers has 8 GPIO pins that can be configured. Please see the user manual for the SM200 and SM435 for a description and pinout of the DB15 connector.

### 6.19.1 Fixed Output Mode

Fixed GPIO mode is ideal for manually controlling external devices with up to 8 configurable GPIO pins.

In fixed output mode the GPIO pins are fixed. Device measurements are stopped when updating the GPIO output pins. The GPIO remains fixed until disabled or modified.

### 6.19.2 Sweep Output Mode

The sweep output mode is ideal for switching between multiple antennas during a single sweep or controlling any other device via GPIO mid sweep.

In sweep output mode, a sequence of frequencies and GPIO pin values are configured. When the sweep crosses the specified frequency, the GPIO pins are configured to the pin values associated with that frequency. The first frequency should be 0 Hz ensuring the GPIO pins start at a specified value.

Up to 8 discrete frequency/GPIO steps can be configured.

The resolution at which the frequency values can be configured depend on the measurement type. In standard sweep mode, the frequency resolution is 40MHz, and in real-time swept mode, the frequency resolution is 160MHz. Any attempt to specify frequencies at smaller resolutions will result in unspecified behavior.

## 6.20 DEMO MODE

If Spike is opened with no device connected, a dialog will appear with the option to launch the demo device. This will allow several analysis modes to operate with simulated signals, with most functionality available.

Analysis modes that can be demoed are Sweep, Zero-Span, Digital Demodulation, Interference Hunting, Spectrum Emission Mask, Harmonics, and Mapping.

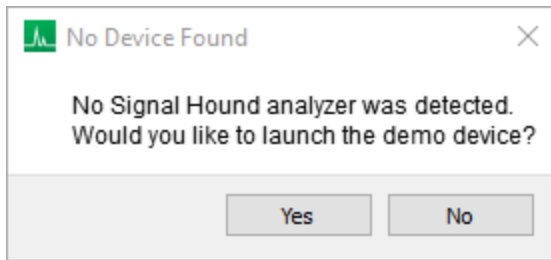


Figure 84: Demo mode dialog.

## 6.21 MANAGING LICENSES

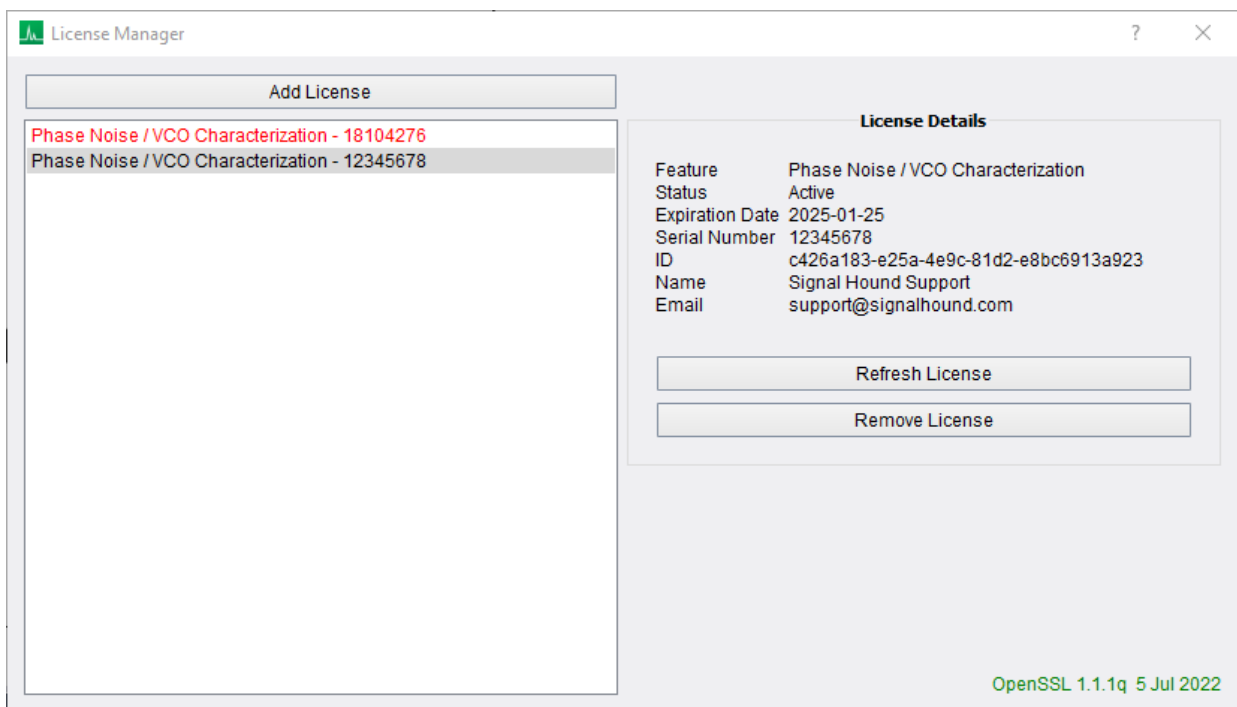


Figure 85: License Manager dialog.

The License Manager dialog is used to add, remove, and see details about licenses stored on the machine.

All licenses in use locally are displayed in the list on the left, with their associated serial number. Expired licenses are shown in red text. Clicking on a license will show its details on the right. It will also enable actions to be performed on it with buttons on the right.

To enable a licensed feature, an active license must be added to the local store. Instructions on how to do this are below.

If a license is within two weeks of expiry, a notification dialog will appear upon opening Spike.

## 6.21.1 Adding a License

To add a license, copy the key received at the time of purchase. This should be contained in an email. Click the *Add License* button, paste the key into the text field of the *Add License* dialog, and click *Ok*. The license is added and displayed in the list below. If this fails, please contact [support@signalhound.com](mailto:support@signalhound.com).

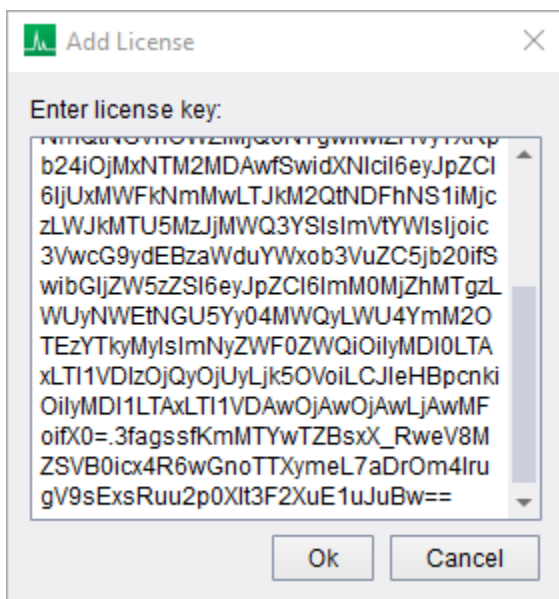


Figure 86: Add license dialog.

## 6.21.2 Removing a License

To remove a license, select it from the list, and press the *Remove License* button. This only removes the license information from the local machine, but does not affect the license itself, which can be re-added on this or another machine.

## 6.21.3 Refreshing a License

If a license was renewed or otherwise altered, the local information can be updated to reflect these changes by pressing the *Refresh License* button.

# 7 Plotting

This section describes the various plots and displays in the Spike software.

## 7.1 BASIC PLOT

Several plots in the Spike software adhere to a standard interface. Currently, plots in the following modes adhere to this interface.

- Zero-span (except CCDF)
- Digital modulation analysis
- Analog Demod
- Spectrum Emission Mask
- Bluetooth® Low Energy
- WLAN
- LTE
- Noise Figure
- Sweep/Realtime (zoom features only)

Measurement modes not listed here will have custom plots with their own unique interface.

This section describes the features of this standard plot. The plot below is the AM vs Time plot from zero-span and key points on the plot are labeled and described below.

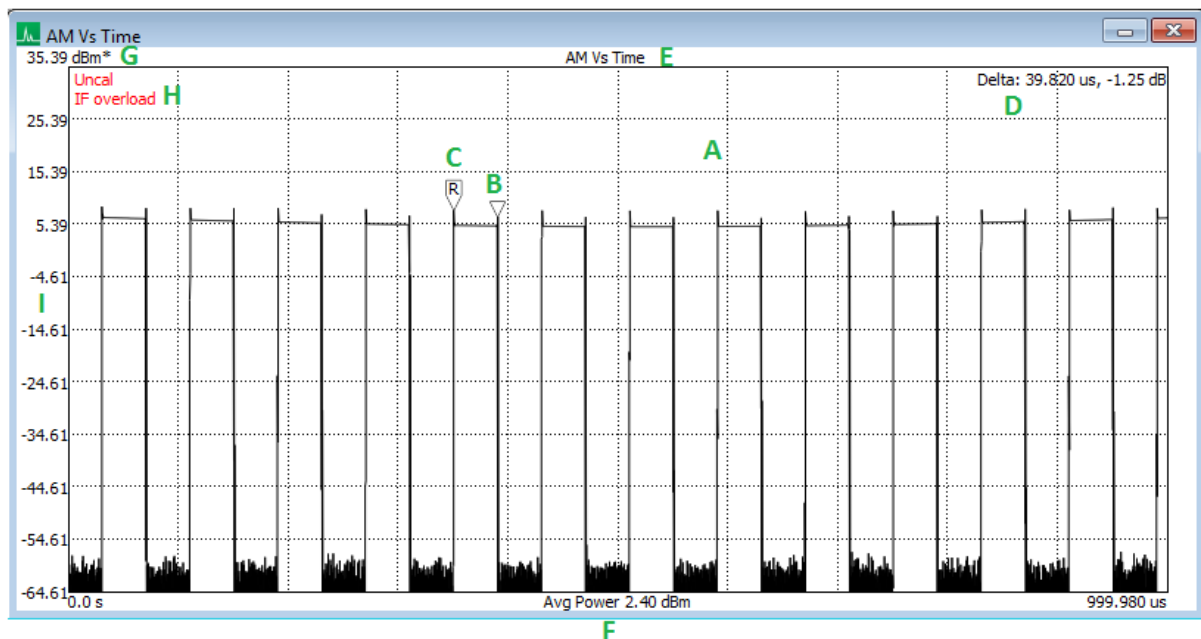


Figure 87: Basic plot areas of interest.

- Main plot window.
- Marker, left mouse click anywhere in the plot border to place a marker on the closest point in the graph.
- Delta marker, enabled through the context menu. Displays the reference point to which the marker is compared.



- D. Marker readout, displays either the position of the marker or if the delta marker is enabled, the difference between the marker and the delta marker reference.
- E. Plot Title.
- F. X-axis label. Might contain additional measurement information relevant to the current plot.
- G. Reference level and zoom indicator asterisk.
- H. Error annunciators.
- I. Region to the left of the y-axis. In this region the user can control the y-axis scale.

## 7.1.1 Zoom and Axis Manipulation

There are four primary ways to manipulate the x/y axis of the plot.

- 1) Left click and drag of the mouse within the plot border. This lets the user select a specific region of interest to display. This can only be performed after enabling drag zoom in the context menu.

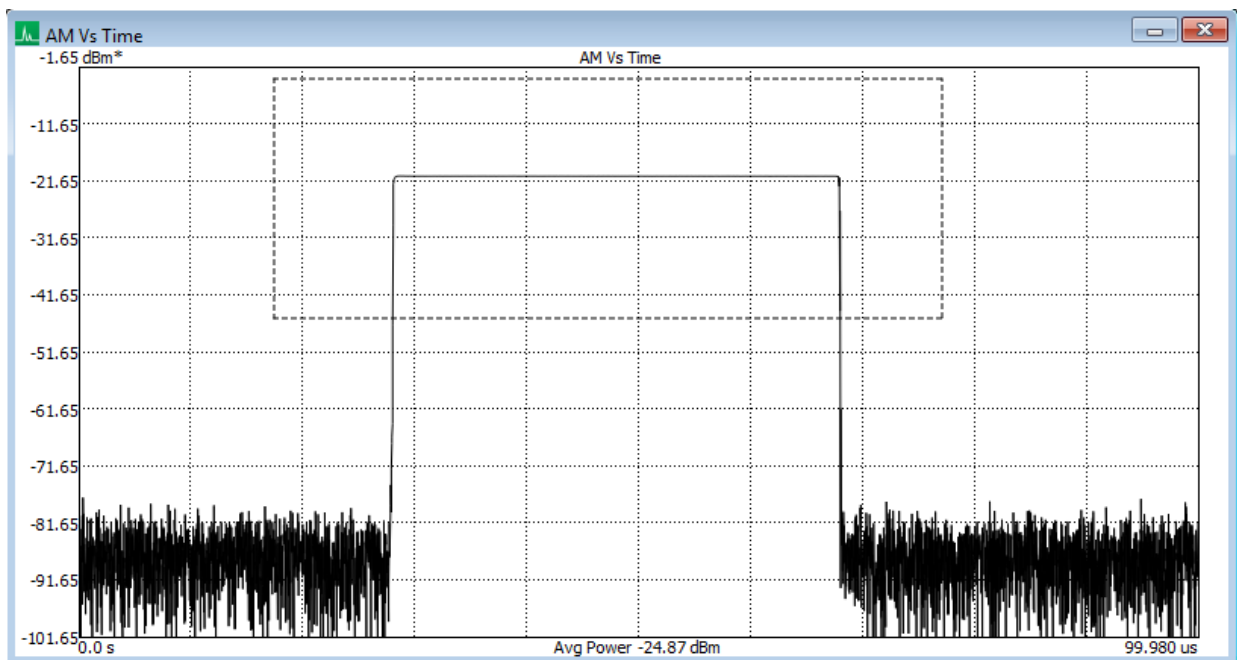


Figure 88: User is dragging a zoom region around the on period of a pulse.

- 2) Click and drag to the left of the y-axis, or below the x-axis. This allows the user to move the reference level or time of the plot.
- 3) Hover over the area to the left of the y-axis or below the x-axis and scroll the mouse wheel. This contracts/expands the y-axis or x-axis.
- 4) In the context menu, select "Set Axes" and manually define the ranges of the x-axis and y-axis.

When the user has modified the axes in any way, an asterisk appears next to the unit of the plot indicating that the user has overridden the default scale. The user can use the context menu to revert to previous or the default plot scales.

## 7.1.2 Markers

A single marker is available for control. Left clicking anywhere within the plot border will place the marker on the closest point. Further control of the marker can be performed by using the left/right arrow keys to move the marker a single index left or right on the current graph. If the plot contains multiple graphs/lines, using the up/down arrow keys will jump the marker between the two graphs.

When a marker is active, selecting delta marker in the context menu places a reference marker at the current marker location. Selecting delta marker again disables the marker.

## 7.1.3 Context Menu

The context menu is activated by right clicking anywhere within the plot. A description of each context menu item is provided below.



Figure 89: The context menu is displayed after right mouse clicking anywhere in the plot.

- **Previous Zoom** – Restores the previous level of zoom/scale. Additionally, it will show how many levels of user zoom/scale are active.
- **Auto Zoom** – Restores the default scale.
- **Enable Zoom/Disable Drag Marker** – When enabled the marker drag functionality is replaced with the ability to drag a zoom window on the plot.
- **Set Axes** – Manually define the ranges of the x-axis and y-axis.
- **Peak Search** – Move the marker to the location of the largest y-value. If the marker is disabled, enable it.
- **Minimum Search** – Move the marker to the location of the smallest y-value. If the marker is disabled, enable it.
- **Place Delta Marker** – If the marker is enabled, place the reference marker at the current marker position.

- **Disable Marker** – Disable the marker and delta marker if enabled.
- **Export** – Exports all graphs shown in the plot into a CSV file.
- **Save as Image** – Save the current plot as an image.

## 7.2 SPECTROGRAM

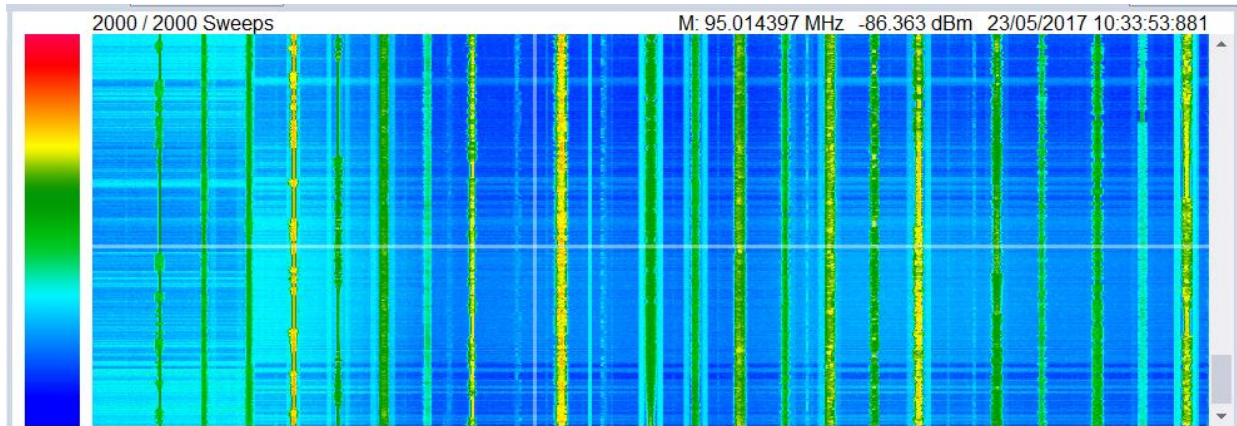


Figure 90: FM broadcast

The software offers a spectrogram display, also called a waterfall display, which displays several sweeps over time. The spectrogram is available in sweep, real-time, and interference hunting measurement modes.

The spectrogram stores a selectable number of sweeps in a scrollable history. Each horizontal line in the spectrogram represents a single sweep. The x-axis represents frequency, the y-axis represents time, and amplitude is represented using a color-coded scheme.

Enable the spectrogram from the toolbar. The spectrogram can be resized by using the mouse to drag the splitter bar below the spectrogram display.

Left-clicking on the spectrogram display places a marker on the sweeps, providing a method of measuring the frequency, amplitude, and time of any event stored in the spectrogram. The marker readout appears in the upper right of the display. The marker can be disabled in the right-click context menu.

Right-clicking on the spectrogram display brings up a menu with several preferences and the ability to clear the existing contents of the waterfall. The available preferences and a description of their function is below.

- **Sweep Depth** - The number of spectrums stored in the spectrogram. Once this number of spectrums has been accumulated, the oldest spectrum is removed to make room for a new one. Each horizontal pixel line represents one stored spectrum. The current spectrum count and depth is displayed in the upper left of the spectrogram.
- **Time Density** – Specifies the minimum amount of time each stored spectrum represents. If the device is sweeping at a faster rate than this value, several sweeps will be accumulated to create the single spectrum stored in the spectrogram.

- **Mouse Wheel Scroll Pixels** – Controls the scrolling speed of the display when using the mouse wheel to scroll.
- **Auto Scrolling** – Controls the behavior of the display when you are looking at past events (scrolled back through spectrums). If disabled, the plot will not advance when new spectrums are added to the display. (Note: Once the maximum number of spectrums has been met in the plot, the display will scroll regardless of this setting.)
- **Marker Active** – Enables/Disables the marker.
- **Color Scale** – Switch between a color spectrum or gray scale gradient.
- **Auto Color Scaling** – When enabled, the reference level and bottom of the graticule are used at the min and max amplitudes that are mapped onto the color gradient. When disabled, the min and max color settings are used (see below).
- **Min Color (dBm)** – When *Auto Color Scaling* is disabled, this value overrides the bottom of the graticule as the minimum amplitude that is mapped onto the color gradient.
- **Max Color (dBm)** – When *Auto Color Scaling* is disabled, this value overrides the reference level as the maximum amplitude that is mapped onto the color gradient.

## 7.3 PERSISTENCE

The persistence display is helpful for viewing spectral density over time. Instead of showing a single trace, persistence uses several sweeps to create an image where color is representative of how often a signal appears. The software uses the color spectrum to represent density over time. If a signal rarely occurs in a location, a light blue is used to color the trace. If a signal continues to appear in the same location the color will change from blue to green to red. Red is an indication of a signal persisting in one location for a good deal of time.

There are two types of persistence displays, one for standard spectrum analysis and one for real-time analysis. For standard spectrum analysis, persistence is simply an accumulation of the most recent sweeps. This display is shown below.

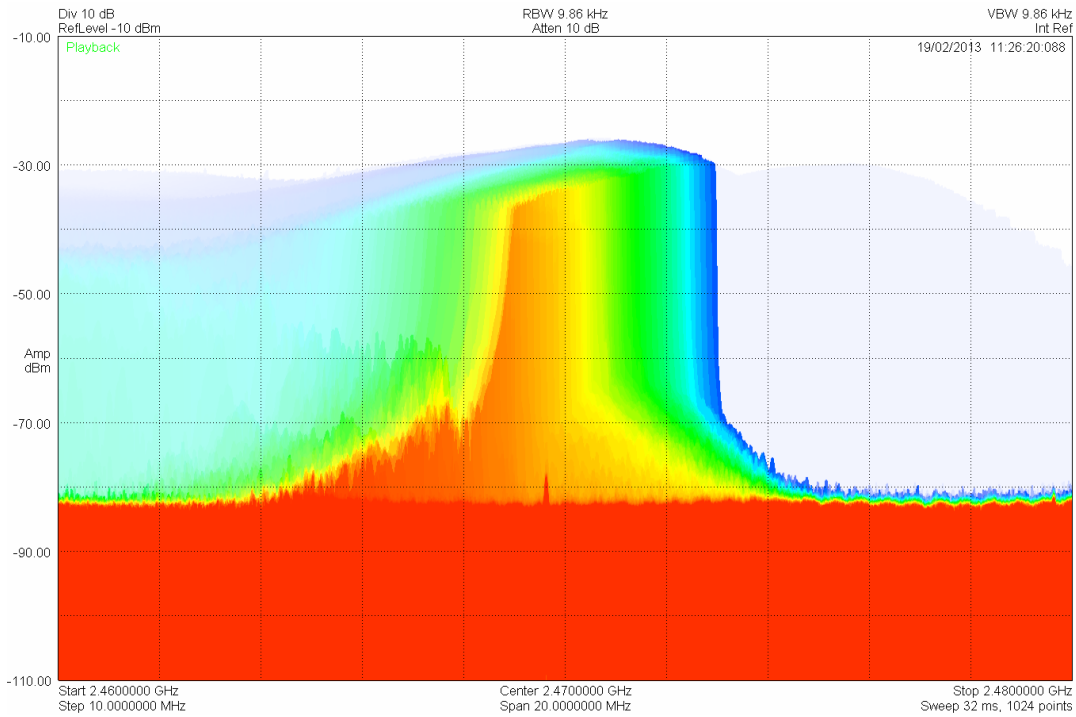


Figure 91: Sweep mode persistence showing the signal from a poorly shielded commercial microwave oven.

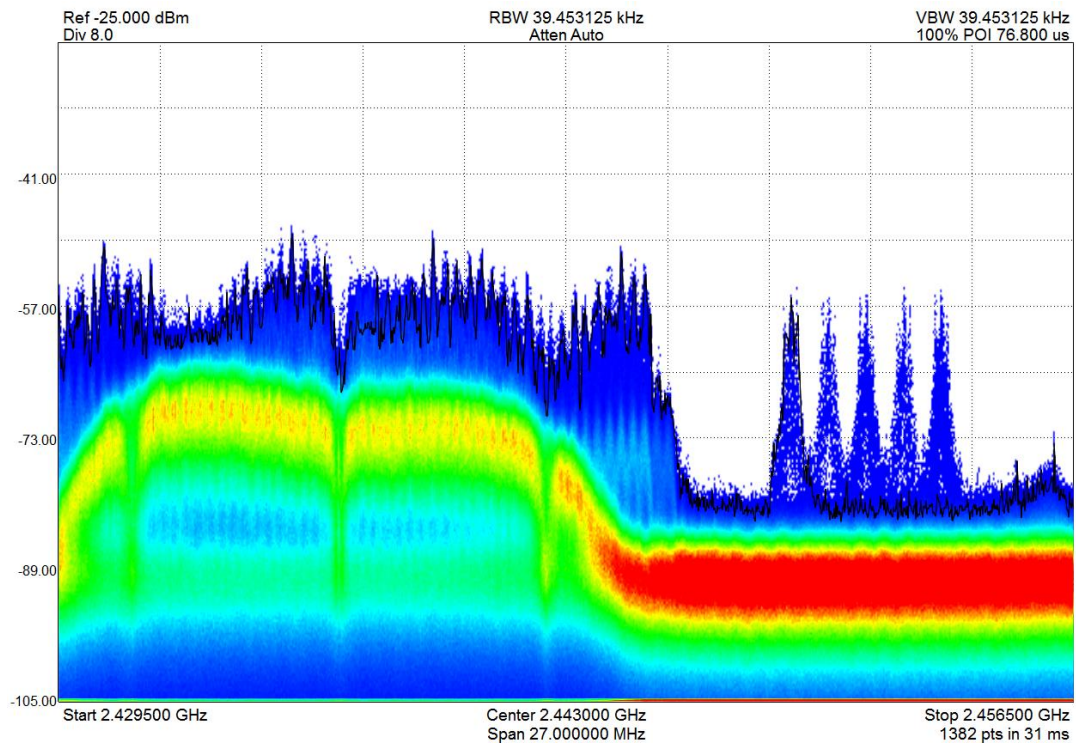


Figure 92: Real-time persistence display of a wireless router and Bluetooth® headset coexisting in the ISM band.

In real-time mode, persistence is the accumulation of 2/3<sup>rd</sup> of a second worth of spectrum data. This means, each update in the persistence display is the accumulation of the result of 1600 – 400000 FFTs.

# 8 Troubleshooting

If you experience a problem with your Signal Hound on Windows systems, please try these troubleshooting techniques. On Linux systems, please consult the README included in the download.

This section will contain general troubleshooting tips as well as device specific tips. If a troubleshooting tip applies to a specific device, the tip will make note of it.

## 8.1 THE SPIKE SOFTWARE REPORTS “DEVICE NOT FOUND” (ALL DEVICES)

Try the troubleshooting tips here first, if these do not work, see the troubleshooting tips for your specific device below.

Ensure the device is plugged in and the LED is a solid green color. If it is not, unplug then plug in the device. Once the green light turns on, use the *File* menu to try to connect the device again.

### 8.1.1 The Device Light is solid green and still will not connect.

Early BB60A units sometimes require a power cycle after the PC has restarted or woke up from hibernation. For these units, try a power cycle before restarting the software.

If it is the first time the device has been connected to a PC, the device might require many seconds to identify and install the latest drivers for the device. Usually, a PC will notify you if this identification process is occurring and when it is finished. Wait until the device has been properly identified by your PC. You can verify this by finding the device in the device manager. It will bear the Signal Hound name if it has been identified.

If a power cycle still does not allow you to connect the device, it is possible the device drivers were not successfully installed. See the [Driver Installation](#) section for more information.

### 8.1.2 The device is connected but does not exhibit a solid green light.

For the BB series spectrum analyzers,

- Power cycle the device by disconnecting the USB cable from the spectrum analyzer end. If the provided cable is a USB y-cable, ensure both USB ends are connected to the PC before connecting it to the device.
- Update [power management settings](#).

- If the device is connected to a charging port, attempt operation after moving the device to a non-charging port. For devices with a y-cable (SA124 and BB60) this should only affect the main data cable, not the auxiliary power cable.

For the SA series spectrum analyzers,

- Disable any anti-virus software. Aggressive anti-virus software has been known to interfere with Signal Hound devices.
- Ensure the driver was configured correctly by your system. In the device manager, find "Serial Convert A/B" in the "Universal Serial Bus Controllers" tab. Right click and select properties, select the "Advanced" tab and ensure the "Load VCP" box is unchecked.

## 8.2 THE SPIKE SOFTWARE REPORTS "DEVICE NOT FOUND" (BB60, SM200A/B, SM435B)

Ensure the LED on the device is solid green. If the device is solid green, ensure the drivers have been properly installed by going to the "Device Manager" expanding the "Universal Serial Bus Controllers" tab and looking for the Signal Hound xxxx while the device is plugged in.

If the LED on the device is not solid green after plugging it in, then it might be necessary to update your USB 3.0 drivers for your PC. You can upgrade your drivers using these steps.

If you are on Windows 8 or Windows 10, fully update your PC through the Windows update utility. Also look for USB drivers provided by your manufacturer by searching for your PC model number on the manufacturer website or on your favorite search engine. Only download drivers found on trusted websites.

If you are on Windows 7, you can download the proper drivers depending on what CPU you are currently using. If you are using an Intel i-series processor, find the model number of your processor.

If your model number is a 3XXX number, install the driver at

<https://downloadcenter.intel.com/download/21129/USB-3-0-Driver-Intel-USB-3-0-eXtensible-Host-Controller-Driver-for-Intel-7-Series-C216-Chipset-Family>

If your model number is a 4XXX number or greater, install the driver at

<https://downloadcenter.intel.com/download/22824/USB-3-0-Driver-Intel-USB-3-0-eXtensible-Host-Controller-Driver-for-Intel-8-9-100-Series-and-C220-C610-Chipset-Family>

Unplug the device before starting any USB driver updates, restart your PC afterwards, and verify operation.

If you continue to experience issues, contact Signal Hound.

## 8.3 THE SPIKE SOFTWARE REPORTS "DEVICE NOT FOUND" (SA44, SA124)

Ensure your USB cables are properly secured and the LED on the device is solid green.

Ensure you have installed the USB drivers. Download them from the related downloads section on the Spike download page.

Ensure the driver was configured correctly by your system. In the device manager, find "Serial Converter A/B" in the "Universal Serial Bus Controllers" tab. Right click and select properties, select the "Advanced" tab and ensure the "Load VCP" box is unchecked.

Ensure the devices are properly powered, some laptops/notebooks may not provide sufficient power by default. Go to the "Power Options" menu found in the control panel and enable the "High Performance" power plan.

Disable any anti-virus software. Aggressive real-time anti-virus software has been known to interfere with Signal Hound devices.

## 8.4 THE DEVICE DISCONNECTS DURING OPERATION

There are many reasons a Signal Hound device might experience an issue during operation. Most issues are USB related issues and some might be related to PC performance. Here are some things you can try to eliminate this behavior.

- Disable any anti-virus software. Aggressive anti-virus software has been known to interfere with Signal Hound devices.
- Update [power management settings](#).
- Update your USB drivers, see the "Device Not Found (BB60, SM200A/B, SM435B)" troubleshooting tip.

## 8.5 THE DEVICE IS NOT VALID

In the event the device ceases to operate or becomes corrupted, the Spike application might tell you the device does not appear to be valid. Before contacting us, attempt to power cycle the device and restart your computer to ensure nothing else is causing this issue. If the issue persists, please contact us.



## 8.6 THE DEVICE REPORTS “IF OVERLOAD” ON PROGRAM STARTUP

Some Signal Hound devices might report an IF overload condition for a short time after launching the software or connecting the device through the File menu. This condition is considered normal and is part of the normal hardware startup process. This condition should last typically less than one second of operation.

## 8.7 POWER MANAGEMENT SETTINGS

It is recommended to perform this step with the Signal Hound spectrum analyzer disconnected from the PC.

Many laptops and PC's are initially configured for energy savings. The Signal Hound spectrum analyzers are high performance USB devices and can benefit in stability and operation by configuring the PC or high-performance operation.

To change your power management settings to high performance you need to access the “Power Options” menu found in the control panel menu. You can also reach the Power Options menu by hitting the Windows key and searching for “Power Options”.

Once in the Power Options menu, you need to select the “High Performance” power plan. You may need to click “Show Additional Plans” to show the high-performance option. If you do not see the high-performance power plan, see [power management settings on Windows 10](#).

## 8.8 POWER MANAGEMENT SETTINGS ON WINDOWS 10

Several troubleshooting steps involve updating your power management. On newer Windows 10 machines, these settings are hidden and obscured and require additional instruction for changing.

- 1) In the Power Management settings in the control panel, the power plan setting has been moved to the “Advanced Settings” link within. Here you can change your plan to “High Performance”. You will also need to disable “Selective Suspend” in the “USB Settings” tab on the Advanced Power Options settings menu. Depending on how you enter the “Power Options” menu, you may not need to enter the “Advanced Settings” and may simply need to expand the power options to show the “High Performance” Option as it is hidden by default.

## 8.9 ERROR CODE 48: THE SOFTWARE FOR THIS DEVICE HAS BEEN BLOCKED

*Instructions for BB60C and Windows 10 only*

The device is not able to be found by the Spike software and the driver details for the device reports *"Error Code 48: The software for this device has been blocked because it is known to have problems with Windows. Contact the hardware vendor for a new driver."*

If you are seeing this message, it is likely the device drivers were improperly installed during the Spike installation procedure. Re-installing the drivers manually has been effective at resolving this issue. First uninstall the current driver by connecting the BB60C and navigating to the "Device Manager". Under the "Universal Serial Bus Controllers" tab, find the BB60C. Right click and uninstall the driver. If there are any checkboxes that additionally state to delete or remove the BB60C driver completely, select those as well.

Once the driver has been uninstalled, disconnect the BB60C from the PC. Now we need to manually reinstall the driver. Navigate to the Spike installation directory at C:\Program Files\Signal Hound\Spike and find the drivers folder. If you are on 64-bit system select the x64 folder, and select the x86 folder if you are on 32-bit Windows. Right click the cyusb3.inf file and select install. If the installation succeeds, re-connect the BB60C and try launching the Spike software.

## 8.10 THE DEVICE DOES NOT WORK IN MY WINDOWS VIRTUAL MACHINE (BB60C ONLY)

The Signal Hound devices are not supported to work within Windows virtual machines, but several customers have reported success after some troubleshooting.

The most common issues reported are device disconnect issues and Spike not being able to detect the BB60C. Both issues suggest USB configuration errors.

- Customers have reported success using the latest versions of VMware on both Windows and Apple computers. The PC must support USB 3.0, preferably with a 4<sup>th</sup> generation or later Intel i5/i7 CPU.
- Ensure USB 3.0 SuperSpeed is enabled for the virtual machine. Customers report it is often disabled by default.
- The Spike installer may not correctly install the BB60C drivers, and might need to be manually installed. See [Driver Installation](#) for instructions for manually installing the BB60C drivers.
- For Windows 7 VM's, it might be necessary to update the USB 3.0 drivers for your hardware. You can follow the steps [here](#) to do this.

## 9 Calibration and Adjustment

Contact Signal Hound for more information regarding calibration software and required equipment.

## 10 Warranty and Disclaimer

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# 11 Appendix

## 11.1 USING MULTIPLE USB 3.0 DEVICES ON LINUX

There are system limitations when attempting to use multiple Signal Hound USB 3.0 devices\* simultaneously on Linux operating systems. The default amount of memory allocated for USB transfers on Linux is 16MB. A single Signal Hound USB 3.0 device will stay within this allocation size, but two devices will exceed this limitation and can cause connection issues or will cause the software to crash.

The USB memory allocation size can be changed by writing to the file

```
/sys/module/usbcore/parameters/usbfs_memory_mb
```

A good value would be  $N * 16$  where  $N$  is the number of devices you plan on interfacing simultaneously. One way to write to this file is with the command,

```
sudo sh -c 'echo 32 > /sys/module/usbcore/parameters/usbfs_memory_mb'
```

where 32 can be replaced with any value you wish. You may need to restart the system for this change to take effect.

*\*Includes both Signal Hound USB 3.0 spectrum analyzers and signal generators.*

## 11.2 COMMAND LINE OPTIONS

The following command line options are available when launching Spike.

*--hidden*, Hides the user interface, including on the taskbar. To be used in conjunction with SCPI to allow for 'headless' operation. The application can be closed via SCPI commands or manually in the task manager.

The following dialogs will not be shown in hidden mode:

- No device connected
- Multiple devices connected
- Connecting device..
- SCPI remote operation notification

`--preset=n`, Load quick preset number *n* after launching. *n* must be an integer between [1,9]. For this command to work, one device must be connected to Spike so that Spike will auto connect, and the preset specified must have been created with the connected device type.

`--preset-user="filename.ini"`, Load a user preset on startup. The full path to the file name must be specified. If the filename or path contains spaces, you must surround it with quotes, otherwise quotes are not strictly necessary. For this command to work, only one device can be connected to the PC, and the preset must have been created with the connected device type.

`--scpi-port=n`, Set the SCPI port after launching Spike. *n* should be an integer not exceeding 65535. This has the same effect as modifying the SCPI port through the preferences menu. This command line assists customers who want to interface multiple instances of Spike with different SCPI ports.

## 11.3 MATLAB® RUNTIME INSTALLATION INSTRUCTIONS

To use the LTE measurements in Spike, the MATLAB® runtime and, for Windows, Visual Studio 2019 (VS2019) C++ redistributable libraries must be installed on the PC. The next two sections detail how to install these freely available libraries.

### 11.3.1 Installing the MATLAB Runtime

The MATLAB® runtime is freely available for download from the following website.

<https://www.mathworks.com/products/compiler/matlab-runtime.html>

#### 11.3.1.1 Windows

Download the 64-bit Windows installer for R2021b (9.11). Extract the downloaded folder and run the setup.exe file. Install the MATLAB Runtime to the default installation folder.

During installation, the installer will add the MATLAB® runtime folder to the system path. If this fails, you will receive this warning during installation.

*"The MATLAB Runtime could not be successfully added to your system path. You must add the following folder manually: C:\Program Files\MATLAB\MATLAB Runtime\v911\runtime\win64"*

This will often fail due to the system PATH environment variable exceeding its maximum length. In this event, you must add the runtime folder to the system path manually. This can be performed using the registry editor or through the environment variable editor on Windows. Editing the system path via the registry editor will allow you to exceed the length limit of 2047 characters. Editing the path via either method will require you to restart the PC before Spike will properly detect the MATLAB runtime libraries.

### 11.3.1.2 Linux

Download the 64-bit Linux installer for R2021b (9.11). Extract the downloaded folder and run the installation file with:

```
sudo -H ./install
```

Install the MATLAB Runtime to the default installation folder, which is /usr/local.

## 11.3.2 Windows Only: Installing the VS2019 C++ Redistributable Library

The Visual Studio 2019 C++ redistributable libraries are available at the following link. Download and install the 64-bit (non-ARM) libraries.

<https://docs.microsoft.com/en-US/cpp/windows/latest-supported-vc-redist?view=msvc-170>

### 11.3.3 Load Times

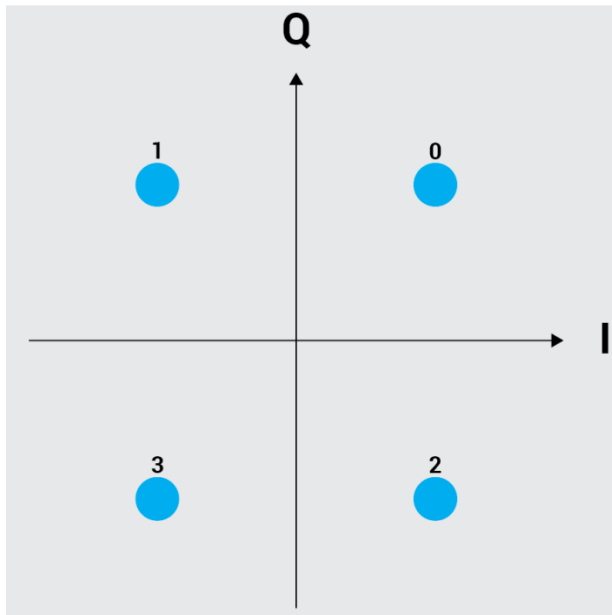
The Spike software initializes the MATLAB runtime when the LTE measurements are accessed. This load time can take typically anywhere from 3-15 seconds. This load time cost will be incurred once per launch of the Spike application. The presence of anti-virus software can greatly affect these load times. Consider disabling any real-time AV monitoring software to reduce these load times.

## 11.4 CONSTELLATION MAPPINGS

### BPSK

Data	Phase
0	0
1	180°

### QPSK



**DQPSK**

Data	Phase Change
0	0
1	$+\pi/2$
2	$-\pi/2$
3	$\pi$

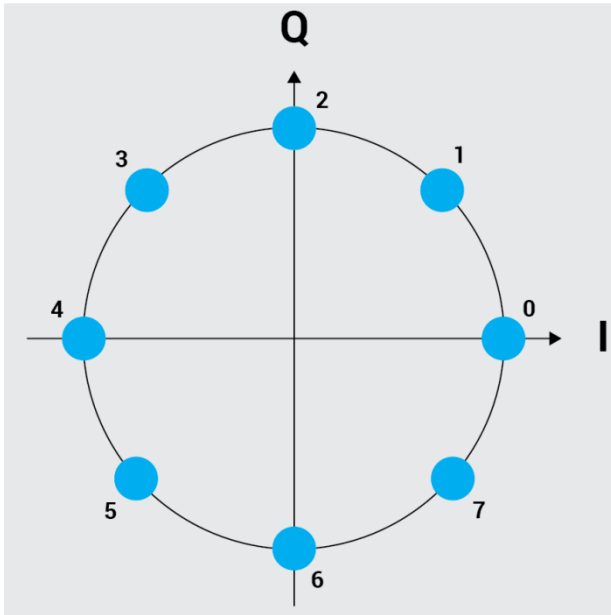
**$\pi/4$  DQPSK**

Data	Phase Change
0	$+\pi/4$
1	$+3\pi/4$
2	$-\pi/4$
3	$-3\pi/4$

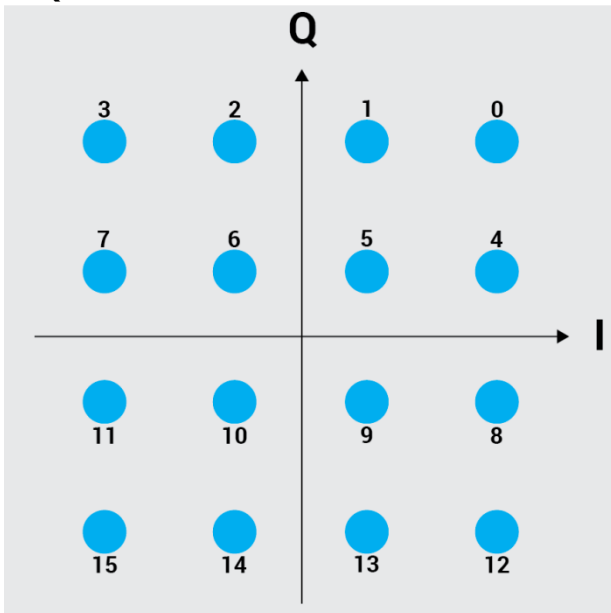
**D8PSK**

Data	Phase Change
0	0
1	$+\pi/4$
2	$+3\pi/4$
3	$+\pi/2$
4	$-\pi/4$
5	$-\pi/2$
6	$\pi$
7	$-3\pi/4$

**8-PSK**



### 16-QAM



Note: Positive I-axis is to the right, positive Q-axis is to the top.

### 32/64/256/1024-QAM

64/256 QAM is defined similarly to 16 QAM. Symbols are increasing from right to left, top to bottom, starting with 0 in the upper right-hand corner of the constellation diagram and ending with 63/255/1023 in the lower left-hand corner.

### OQPSK

Offset QPSK is the same as QPSK, except the Q is delayed by  $\frac{1}{2}$  symbol.



**M-FSK**

All FSK modulations are gray coded. For example, 4FSK uses the following mapping,

Data	Frequency Offset (normalized)
0	-1
1	-1/3
2	1
3	1/3

## 11.5 MANUAL GAIN/ATTEN SETTINGS (BB60)

All settings must be set to non-automatic values to override the automatic settings.

The preamplifier setting does not affect the BB60 measurement but should be switched from auto for manual selections to be used.

For the gain setting,

- Gain 0: Preamplifier off, add 5dB to attenuator
- Gain 1: Preamplifier off, do not add attenuation
- Gain 2: Preamplifier on, add 5dB attenuation
- Gain 3: Preamplifier on, do not add attenuation

For the attenuation setting,

- Attenuation 0 – 20dB: adds 0 to 20dB of attenuation, plus any contribution from gain setting.
- Attenuation 30dB: adds 30dB of attenuation, and the effects of gain 0 and 2 are the same as gain 1 and 3.

## 12 References

1. ANSI C63.2 "American National Standard for Electromagnetic Noise and Field Strength Instrumentation, 10Hz to 40 GHz – Specifications", American National Standards Institute, January 1996.