USB-SA124B Spectrum Analyzer

User Manual

Signal Hound USB-SA124B User Manual

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1 Preparing For Use

Unpacking your Signal Hound and Installing Software

The The Signal Hound USB-SA124B is a USB-based 100 kHz to 12.4 GHz econoy spectrum analyzer and measuring receiver. Using recent innovations in RF technology, the Signal Hound has the sensitivity, accuracy and dynamic range you'd expect in a unit many times its cost. The Signal Hound is powered from the USB cable, eliminating the need for a separate power supply. Measuring less than 8 inches long and weighing less than 1 pound, the Signal Hound can be used virtually anywhere!

1.1 INITIAL INSPECTION

Check your package for shipping damage before opening. Your box should contain a USB cable, a CD-ROM, and a Signal Hound USB-SA124B.

1.2 SOFTWARE INSTALLATION

The Signal Hound is operated from a Windows® based PC using our Spike™ application software. If your USB-SA124B did not come with a copy of Spike, download it from our website, www.signalhound.com.

The Signal Hound software and drivers are compatible with Windows® 7 and Windows 8 64-bit operating systems. You must have a computer with at least 500 MB of free disk space, 4 GB of RAM, and USB 2.0. An Intel® Core i3 or equivalent is recommended. For serial numbers below 21000000, an internet connection is required the first time you launch the software. **See the Spike™ software manual for additional installation instructions and software features.**

Legacy software is available for 32-bit operating systems. Contact support@signalhound.com for further information.

2 Getting Started

Learn about the features of your USB-SA124B Signal Hound Spectrum Analyzer

2.1 FRONT & REAR PANELS

The **front panel** includes a 50Ω SMA RF input. Do not exceed +20 dBm or +16VDC or damage may occur. A **READY / BUSY** LED flashes orange each time a command from the computer is processed.

The **rear panel** has three connectors:

1. 10 MHz Reference input / output, or 63 MHz IF output
2. A USB 2.0 type B connector. Connect to your PC using the included USB cable.
3. A Self Test / Sync Out connector. This may be used as a Self Test Signal output, or a Tracking Generator Sync signal. It defaults to unused / no output.

2.2 MEASUREMENT CAPABILITIES

The Signal Hound is capable of making a wide range of measurements, with resolution bandwidths from less than 1 Hz to 250 kHz. The internal I/Q demodulator captures up to 2 Megabytes of information each second, with a hardware-limited bandwidth of 250 KHz. Sweeps with spans greater than this are actually a combination of many smaller sweeps, mathematically combined to reject image and spurious responses.

In addition to the I/Q demodulator, a log power detector on the 6 MHz RBW is available for faster, low sensitivity sweeps from 200 MHz to 12.4 GHz (unspecified performance to 13 GHz).

2.2.1 Image and Spur Rejection in Swept Mode

The USB-SA124B does not have hardware-based image rejection, instead relying on a software algorithm to reject image responses. The algorithm mixes the incoming RF with two distinct local oscillator frequencies, typically spaced by 21.4 MHz and up to 100 milliseconds, and rejects responses not present in both. This algorithm has some limitations:

1. A signal must be present for both captures to be displayed. Pulsed or swept signals, which do not stay at any given frequency for this duration, will be rejected as potential image or spurious responses.

2. An analog modulation envelope may be clipped, since certain frequency components of the modulation envelope may not be present at both times. Most digital modulation tends to spread energy evenly across its bandwidth and is relatively immune from this effect.

3. Two RF input signals, spaced by 42.8 MHz, will generate a spurious response halfway between the two RF input signals. This spurious response will not be present when a 200 kHz span is selected. Broadband signals which exceed 42 MHz cannot be accurately measured with the USB-SA44B because of this effect.

Disabling image rejection will allow pulsed and swept signals to be displayed, and will not clip modulation, but image and spurious responses may be a major problem for some measurements. If your application requires hardware-based image rejection, consider our BB60C.

2.2.2 Real-Time Mode

The USB-SA124B can continuously stream up to 250 kHz of spectrum to the Spike™ software running on your PC or laptop. Real-time mode displays this stream of data in the frequency domain.

For modulated signals not exceeding 250 kHz bandwidth, real-time mode is recommended, as it will capture and display the modulation envelope using overlapping FFTs, showing you an accurate representation of the modulation envelope. All modulation types, including pulse and short digital RF packets, will be displayed accurately in this mode. Other modes will work, but modulation details may be masked out by the image rejection algorithm, and pulses and short packets may be missed entirely.

Image rejection is not available in this mode, therefore the image frequency, 21.4 MHz above the signal, will not be suppressed, and spurious responses may be present.

2.2.3 Zero Span Mode

For modulated signals not exceeding 250 kHz bandwidth, time-domain amplitude, frequency, and phase information, as well as several modulation measurements, are available in Zero Span mode. See the Spike™ manual for additional information. Image rejection is not available in this mode, therefore the image frequency, 21.4 MHz above the signal, will not be suppressed, and spurious responses may be present.

2.2.4 Attenuator, Preamplifier, Intermediate Frequency and Gain, and ADC Clock Settings

The Signal Hound switches between two intermediate frequencies, four attenuator settings, two preamplifier settings, two ADC clock frequencies, and three IF gain settings when measuring signals and performing image suppression. Unless you explicitly disable the automatic settings, the best settings for your reference level, center frequency, and span will be automatically selected. Simply select a reference level that is a few dB above the input signal level.

2.3 LIMITATIONS OF THE USB-SA124B

2.3.1 RBW Limitations

The maximum I/Q resolution bandwidth (RBW) is 250 kHz, and the minimum is 0.1 Hz. An additional 6 MHz RBW is available for faster sweeps (power only—no I/Q data). To measure wider bandwidths, the channel power utility must be used. See the Spike™ software manual for additional information. A traditional 1-3-10 RBW sequence is used by default, but any RBW up to 250 kHz may be selected.

2.3.2 IF Feed-Through

Intermediate frequencies of 2.9 MHz and 10.7 MHz are used for all frequencies. An RF input signal near these frequencies in some bands may generate spurious responses and degrade the performance of the image rejection algorithm.

2.3.3 Sweep Time

Sweep Time may only be set in zero span mode. In all other modes, the minimum sweep time which satisfies your RBW, VBW and span settings will be used.

2.3.4 Using an External Timebase

An external 10 MHz timebase my be used to improve the accuracy of frequency measurements. The level of the external timebase must be > 0 dBm. +13 dBm is recommended to achieve optimal phase noise performance. To use, simply connect the timebase to the **Ext Ref In** after connecting the USB, then select external reference in the Spike™ software.

2.3.5 Measuring Low Level Signals

To measure low-level signals, simply set your reference level to -40 dBm or lower. This internally selects the highest sensitivity settings. Video averaging may be required for a stable amplitude reading.

2.3.6 Measurements near DANL

The amplitude displayed is the sum of all energy present in the IF. This includes the signal as well as noise and residual responses. Measurements of signals less than 10 dB above the noise floor will have a measurable amplitude error due to the addition of noise. To compensate for this, subtract the amplitude with no signal present (the noise), in linear power units, from the amplitude with signal present, to calculate the signal level. Please note that the measurement uncertainty will increase from this process.

2.3.7 Spike Software

Great care was taken to enhance the performance and stability of the USB-SA124B and integrate it into a common software platform. All of the major functions of the USB-SA124B are available in the Spike software, as well as some powerful new features.

A few features available in the legacy 2.18B software have been removed. Triggering in zero span is now limited to video triggering. External 10 MHz input is supported, but output is not. The modulation analyzer audio band pass filter has also been removed, as well as the Smith Chart utility. If these functions are critical to your application, contact technical support to let us know.

2.4 USING THE SA124B AS A DOWNCONVERTER

The USB-SA124B has on optional IF output of 63 MHz, which also happens to be "channel 3" in the Americas for analog and digital TV stations. There is an internal IF amplifier, adjustable over a 60 dB range to adjust the signal level for an external TV tuner, oscilloscope, or analog to digital converter. Please note that the image frequency is not rejected in this mode. A signal at or near the image frequency may interfere with your measurement.

The SA124 IF output is a utility in the Spike software. See the Spike manual for additional documentation.

RF Input Frequency: The center frequency of the signal to be downconverted

IF Output Frequency: Typically 63 MHz

RF Input Attenuation: The initial front-end attenuation before downconverting

IF Output Gain: The gain applied after the downconversion to scale the signal amplitude as needed

Inject LO high-side: Select this for high side mixing, spectrally inverting the IF.

The IF output may be fed to a TV tuner to demodulate analog or digital TV signals, including spectrally inverted signals, or may be fed to an analog to digital converter (ADC). Undersampling techniques may be used, but it is recommended that a sampling rate close to 50 MHz (or 80 MHz) be used to put the IF near the center of a "Nyquist zone" to minimize aliasing.

3 Theory of Operation

Learn about the internal blocks that make up the Signal Hound

The USB-SA family of spectrum analyzers is built around a narrow-band IF-to-bits receiver with a maximum bandwidth of 250 KHz. It receives up to 2 Megabytes of I/Q data each second, which it processes into a trace. To bring you a low cost, compact spectrum analyzer, we used recently developed high-level RF integrated circuits.

The USB-SA124B adds a 63 MHz intermediate frequency (IF). This IF can be used for faster broadband sweeps, or it may be output directly.

Above 4 GHz, the RF input is down-converted using an additional mixing stage with a 7.8 to 8.8 GHz local oscillator. This additional conversion increases the number of image and spurious frequencies. Image / Spur Reject mode will still eliminate the vast majority of spurious signals, but an RF input with several signals present can potentially generate spurious responses. To help determine if a signal is a spur, toggle your span between 1 MHz and 100 kHz. This modifies the LO and IF frequencies selected, moving any spurious responses. If the signal is present at a 1 MHz span and a 100 kHz span, it is unlikely to be a spurious response.

3.1.1 Operating Modes

- I/Q streaming: This is used for real-time mode (frequency domain) and zero span mode (time domain). In this mode, the USB-SA124B continuously mixes fixed LO frequencies with the RF input and streams the data to the PC or laptop for processing. Note that image and spurious rejection is disabled in this mode.
- Narrowband Sweep: This mode is used for spans of 200 kHz or less. In this mode, a fixed, predetermined amount of I/Q data is captured at two distinct combinations of LO and IF frequencies, then combined into a single trace for display. There are minimal restrictions on RBW. The incoming signal is mixed using two distinct local oscillator frequencies with different frac-N modulus settings in this mode, to two distinct intermediate frequencies, such that fractional-N spurs are completely masked out, providing the cleanest spectrum of all operating modes.
- Midrange Sweep: For spans of 201 kHz to 99 MHz with a start frequency above 16 MHz, the firmware captures between 256 and 65,536 I/Q samples at each 200 kHz step, allowing RBW / VBW settings of 30 Hz to 250 kHz.
- Wide Sweep: For all other spans, the firmware captures 256 I/Q samples at each 200 kHz step, meaning RBW and VBW must be 6.5 kHz or higher.
- Broadband Sweep: 6 MHz RBW, only available above 200 MHz start frequency. Rapidly sweeps across the spectrum, to find a strong signal quickly. Certain RF frequencies may produce spurious responses in this mode, and amplitude accuracy is reduced.

3.1.2 Reducing Spurious and Residual Responses

Certain RF frequencies may produce spurious signals, or have residual responses from internal clocks. To verify a displayed signal, center it and step the span from 1 MHz down to 100 KHz. If it is not present in both spans, it was likely a spurious mixing artifact or a harmonic from a system clock. To avoid known residual responses at multiples of the primary system clocks, a secondary clock frequency is selected for some frequencies when span is 200 KHz or less.

The mixers can typically operate with up to +0 dBm input, but keeping the input level –25 dBm or lower will greatly improve linearity, reducing harmonic and spurious mixing products. You can accomplish this in software by setting your reference level 15-20 dB above your actual input level.

3.1.3 IF-to-Bits Receiver

The IF-to-bits receiver has three gain ranges. The gain range will be automatically selected based on attenuator settings and reference level to avoid IF ADC compression, which will greatly distort the data. The software should warn you if compression is occurring. If this happens, increase your reference level.

3.1.4 IF and RBW Selection

The I/Q data comes in over USB and is processed using an FFT with a custom Flat Top window based on the selected RBW. Software and firmware limitations only allow certain very low or very high RBWs for certain spans, to keep sweep speed and trace size reasonable. For example, an RBW of less than 30 Hz is

only allowed for spans of 200 kHz or less, and the minimum RBW for spans of 100 MHz or more is 6.5 kHz. See the Spike™ manual for additional information. The available RBWs are a function of the span, since very large RBWs with a small span would result in a trace with only a few data points and a blocky appearance, and very small RBWs with a large span would result in a large data set that would be difficult to manage and process.

The USB-SA124B has a 6 MHz RBW which may be used above 200 MHz for faster sweeps. The 6 MHz RBW offers faster sweeps at the expense of a higher noise floor and lower frequency resolutionChapter

4 Troubleshooting

If you experience a problem with your Signal Hound, please try these troubleshooting techniques before contacting us:

1) Your Signal Hound Is Not Sweeping Properly

- **Try this first**: Close the Signal Hound software. Unplug the USB cable and any external BNC cables from the Signal Hound and wait 10 seconds. Plug the USB cable back in. Check that both ends of the USB cable are firmly seated and the Signal Hound LED is green. **With the optional timebase, the green LED will not come on until the oven is warm**. Launch the Signal Hound Software. Try your sweep again.
- **Still not working?** Unplug the USB cable from the Signal Hound. Disconnect all USB devices from your PC. Reboot your PC. Wait until the PC has completed rebooting. Plug in the Signal Hound's USB. Launch the Signal Hound Software. Try your sweep again.
- **Still not working?** Contact technical support at http://www.**signalhound.com**

2) Your Signal Hound LED is not green

- If the LED is off, make sure the USB cable is connected at both ends, your PC is on and the USB drivers are installed properly.
- Is your PC or laptop configured in low power mode? The Signal Hound is a high-powered USB device and may be shut down in some power-saving configurations.
- If the LED is orange, you may have a high precision timebase. Wait 1-2 minutes for it to warm up. Your LED should be green after this period.

3) Your Signal Hound LED occasionally stays off after a reboot

Contact technical support for a special utility to fix this

4) Your Signal Hound doesn't find a signal

Is it a swept or transient signal, a pulse or a rapidly modulated signal? If so, and you know the frequency of the signal, set up for a 200 KHz span or less, then turn image suppression off. This disables the image rejection algorithm which will reject data if it has moved or disappeared when the image is checked (it

also allows the image frequency through, which is 21.4 MHz above the CENTER FREQ). You may also try **MAX HOLD** to capture transient signals.

5) General Advice to avoid problems

- Unplug your Signal Hound from the USB port when not in use, or before shutting down your computer.
- Do not connect your Signal Hound's USB port until your computer has completed its bootup sequence. If you do, it may need to be unplugged for 20 seconds then plugged back in before operating properly.
- Do not overpower the Signal Hound.

5 Calibration and Adjustment

Contact Test Equipment Plus for more information regarding calibration software and required equipment.

6 Specifications

Unless otherwise stated, specifications are valid for an ambient temperature range of 0 to 50°C, image rejection on, amplitude of signal applied less than the reference level.

6.1 FREQUENCY

Frequency Range	100 kHz to 12.4 GHz
Span Modes	(Center Frequency + Span) or (Start + Stop Frequencies)
Maximum Span	12.4 GHz
Minimum Span	10 Hz or Zero Span
Internal Frequency Reference Accuracy	±1 ppm Optional Reference: ±0.1 ppm
Frequency Readout Accuracy	reference error ±1 sample [(1)]
Marker Accuracy	reference error ±1 sample
Resolution Bandwidth	0.1Hz to 250KHz and 6MHz[(2)]
Spectral Purity	Residual FM, 3 kHz Audio LPF, 15 kHz IF BW: **[0.1 Hz + 4 Hz / GHz] typical RMS FM** (e.g. 2 GHz RF would have 8.1 Hz RMS FM). Increasing IF BW increases residual FM. *Note 1*: 1 sample typically represents approximately 40% of the selected RBW

Note 2: 6 MHz RBW available only above 200 MHz

6.2 AMPLITUDE (RBW ≤100KHZ)

Range 1dB Gain Compression to Displayed Average Noise Level (DANL)

1dB Gain Compression (attenuator set to 30 dB): >12dBm Typical

Displayed Average Noise Level 0dB input attenuation, 1Hz RBW

Frequency	DANL 1 Hz RBW	Test Conditions
100 kHz to 10 MHz	**-147 dBm**	RF Atten = 0 dB RBW = VBW RBW ≤ 100 KHz Ref Lvl -70 dBm Vid Avg = 16 Image Reject ON
10 MHz to 100 MHz	**-151 dBm**	
100 MHz to 3 GHz	**-152 dBm**	
3 GHz to 5.5 GHz	**-145 dBm**	
5.5 GHz to 7 GHz	**-149 dBm**	
7 GHz to 8 GHz	**-147 dBm**	
8 GHz to 11 GHz	**-134 dBm**	
11 GHz to 12.4 GHz	**-129 dBm**	

Absolute Accuracy (<6 GHz, Reference level ≤0 dBm) ±1.5dB(1)

Absolute Accuracy (<12.4 GHz, Reference level ≤0 dBm) ±2.5dB(1)

Note 1: RBW ≤ 100 kHz

Relative Accuracy (Reference level ≤0 dBm): ±0.25 dB

Maximum Safe Input Level (preamp off, 15 dB atten) +20dBm

DC Volts **<** ±16V absolute maximum

Residual Responses (6.5 KHz RBW, 0 dB RF Atten)

Frequency Range	Signal Level	Test Conditions
100 kHz to 10 MHz	< -100 dBm	0 dB RF Atten, -70 dBm reference level RBW = VBW = 6.5 KHz Video Averaging = 16 Image Reject ON
10 MHz to 8 GHz	< -93 dBm	
8 GHz to 11 GHz	< -82 dBm	
11 GHz to 12.4 GHz	< -85 dBm	

Spurious Responses (≤100 KHz span, CW tone input) < -80 dBm typical with SPUR REJECT on

Typical Maximum LO Feedthrough (all conditions)	
< 1 GHz	< -57 dBm
1 GHz to 12.4 GHz	< -47 dBm

6.3 SWEEP

Zero Span Sweep Time 0.1 ms to 10 sec	± 0.1% All other sweeps times are estimates reported after sweep completes.
Maximum I/Q sample rate	486K/sec
Sweep Trigger	free run, single, video, external
External Trigger	3.3V CMOS/TTL input

6.4 MEASURING RECEIVER

FM Accuracy	±1% typical
AM Accuracy	±1% typical
Synchronous Level Detector (15 KHz IF BW, timebases locked)	100 KHz to 1 GHz +0 dBm to –125 dBm after 10 min warmup ±0.25dB 1 GHz to 4 GHz +0 dBm to –115 dBm after 10 min warmup ±0.25dB
Average Level Detector, 15 KHz IF BW	100 KHz to 4 GHz +0 dBm to –70 dBm after 10 min warmup, ±0.25dB
Maximum IF Bandwidth	240 KHz
Audio Filters	Low Pass: Digital Windowed Sinc, selectable cutoff Band Pass: Available in version 2.xx legacy software only
Maximum sample rate	486K/sec

6.5 INPUTS AND OUTPUTS

BNC 10 MHz Reference In/Out / 63 MHz IF Output

BNC Shared

- Self Test Output
- SYNC Out
- Sweep Trigger In

SMA RF Input

USB 2.0 to host computer

6.6 ENVIRONMENT

Operating Temperature 0 to +50 °C

6.7 CALIBRATION

Test with factory calibration software to verify that USB-SA124B is operating within tolerance. Recommended calibration interval is 1 year at 20°C to 25°C.

6.8 ADJUSTMENTS

Factory adjustment software shall be used to generate new calibration constants when USB-SA124B will not pass calibration. Temperature correction data is generated only at time of manufacture.

6.9 FCC COMPLIANCE

This device is exempt from FCC Certification under 47 CFR Part 15.103(c). Chapter

7 Revision History

Software Version 3.00 – Initial Release based on Spike software

8 Warranty and Disclaimer

8.1.1 Warranty

The information contained in this manual is subject to change without notice. Test Equipment Plus makes no warranty of any kind with regard to this material, including, but not limited to, the implied warranties or merchantability and fitness for a particular purpose.

Test Equipment Plus shall not be liable for errors contained herein or for incidental or consequential damages in connection with the furnishing, performance, or use of this material. This Test Equipment Plus product has a warranty against defects in material and workmanship for a period of one year from date of shipment. During the warranty period, Test Equipment Plus will, at its option, either repair or replace products that prove to be defective.

8.1.2 Warranty Service

For warranty service or repair, this product must be returned to Test Equipment Plus. The Buyer shall pay shipping charges to Test Equipment Plus and Test Equipment Plus shall pay UPS Ground, or equivalent, shipping charges to return the product to the Buyer. However, the Buyer shall pay all shipping charges, duties, and taxes, to and from Test Equipment Plus, for products returned from another country.

8.1.3 Limitation of Warranty

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8.1.5 Certification

Test Equipment Plus certifies that, at the time of shipment, this product conformed to its published specifications.

8.1.6 Credit Notice

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