



# USB-SA44B Spectrum Analyzer User Manual

## **Signal Hound USB-SA44B User Manual**

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# 1 Preparing for Use

## *Unpacking your Signal Hound and Installing Software*

The Signal Hound USB-SA44B is a USB-based 1 Hz to 4.4 GHz economy spectrum analyzer and measuring receiver with an RF preamplifier. 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 only ten ounces, 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-SA44B.

## 1.2 SOFTWARE INSTALLATION

The Signal Hound is operated from a Windows®-based PC using our Spike™ application software.

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](mailto:support@signalhound.com) for further information.

# 2 Getting Started

*Learn about the features of your USB-SA44B Signal Hound Spectrum Analyzer*

## 2.1 FRONT & REAR PANELS



The **front panel** includes a 50Ω SMA RF input. Do not exceed +20 dBm 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, automatically detected after each sweep completes. Use a clean 10 MHz reference with >0 dBm level. +13 dBm is recommended.
- 2) A USB type B connector. Connect to your PC using the included USB cable.
- 3) A multi-purpose BNC connector. This may be used as a Self Test Signal output, a Tracking Generator Sync signal, or a TTL/CMOS trigger/sync in some legacy modes. The Signal Hound software controls the function of this BNC. 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.

### 2.2.1 Image and Spur Rejection in Swept Mode

The USB-SA44B 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.

Wide sweeps of strong signals, especially at frequencies above 1 GHz, may have noticeable fractional-N spurs. To avoid these spurs, set your span to 200 kHz or less. In this narrowband mode, the incoming signal is mixed using two distinct local oscillator frequencies with different frac-N modulus settings, to two distinct intermediate frequencies, such that fractional-N spurs are completely masked out.

### 2.2.2 Real-Time Mode

The USB-SA44B 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 SIGNAL HOUND

### 2.3.1 RBW Limitations

The maximum resolution bandwidth (RBW) is 250 kHz, and the minimum is 0.1 Hz. 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 may generate spurious responses and degrade the performance of the image rejection algorithm.

### 2.3.3 LO Leakage

A Local Oscillator signal may be observed at the RF input port, often found 10.7 MHz above the RF frequency being scanned. Typically, this level will not interfere with your measurements. If you are connecting to an antenna, set your reference level to -30 dBm to activate the preamplifier to minimize LO leakage.



### 2.3.4 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.

### 2.3.5 Using an External Timebase

An external 10 MHz timebase may 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.

### 2.3.6 Using Sync Out / Trigger In

A 3.3V CMOS output may be used to synchronize the USB-SA44B to the TG44A or TG124A tracking generator. Legacy software allowed some additional triggering options available for a very limited range of applications, but these have been removed to enhance the stability of our new platform. Consult the appropriate manual for additional details.

### 2.3.7 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.

### 2.3.8 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.

## 3 Theory of Operation

*Learn about the internal blocks that make up the Signal Hound*

The Signal Hound 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 high-level RF integrated circuits. The block diagram, below, illustrates the major elements of the design. Image rejection is accomplished by mixing high side and low side (sometimes with separate IF frequencies), then masking together the results.

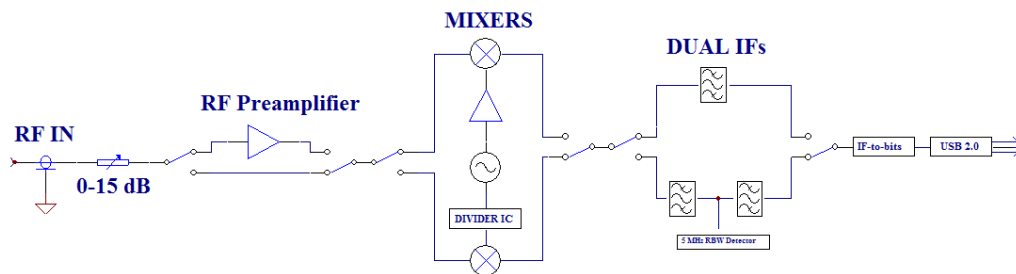


Figure 5: Simplified Block Diagram

### 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-SA44B continuously mixes a fixed LO frequency with the RF input and streams the data to the PC or laptop for processing.
- **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.
- **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.

### 3.1.2 Reducing Spurious and Residual Responses

Certain RF frequencies may produce small spurious and/or residual responses. 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.

## 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 Spike™ software. Unplug the USB cable and any external 10 MHz or trigger cables from the Signal Hound and wait 5 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. Launch the Spike™ Software. Try your sweep again.
- **Still not working?** Contact technical support at <http://www.signalhound.com>

### 2) Your Signal Hound 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.** To remedy this, open your computer's Control Panel, and change your Power Options setting to High Performance.

### 3) 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 "spur reject" 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.

#### 4) Your phase noise seems too high

You may consider using a low phase noise external reference or contacting us about lower phase noise options. Be aware that the Signal Hound phase noise is noticeably higher than a YIG-based spectrum analyzer, especially at higher frequencies.

#### 5) You receive a specific error code

Error 1: Your Signal hound was not found on a USB port. Plug in your Signal Hound if it isn't already. If it is already plugged in, unplug it, reboot, re-install the USB driver, and/or try a different USB port.

Error 2-6: A USB communications error occurred. If multiple errors occur, close out of the software, unplug the Signal Hound, wait 5 seconds, plug it back in and try again. If you get a recurring error, please make a note of the error number, and e-mail or call tech support.

#### 6) General Advice to avoid problems

- Use a DC block and limiter to protect your Signal Hound from DC voltages, ESD, and excess RF power. This is especially important when connecting to antennas or unknown signals.
- Do not overpower the Signal Hound.

## 5 Calibration and Adjustment

Contact Test Equipment Plus for more information regarding calibration services, or our free calibration software and required equipment.

## 6 Specifications

Unless otherwise stated, specifications are valid for an ambient temperature range of 0 to 70°C (or -40 to +85°C for option 1), image rejection on, amplitude of signal applied less than the reference level.

### 6.1 FREQUENCY

|                        |  |
|------------------------|--|
| <b>Frequency Range</b> | 1 Hz to 4.4 GHz, Standard<br>100 kHz to 4.4 GHz AC-coupled, Option 3 |
| <b>Span Modes</b>      | (Center Frequency + Span) or (Start + Stop Frequencies)              |
| <b>Maximum Span</b>    | 4.4 GHz  |
| <b>Minimum Span</b>    | 10 Hz or Zero Span   |

|  |   |
|--|---|
| <b>Internal Frequency Reference Accuracy</b> | ±1 ppm<br><i>Note:</i> For greater frequency accuracy connect to external 10 MHz timebase (0 to +20 dBm)  |
| <b>Frequency Readout Accuracy</b>            | reference error ±1 sample <sup>(1)</sup>  |
| <b>Marker Accuracy</b>                       | reference error ±1 sample   |
| <b>Resolution Bandwidth</b>                  | 0.1Hz to 250KHz and 5MHz <sup>(2)</sup>   |
| <b>Spectral Purity</b>                       | Residual FM, 3KHz Audio LPF, 15 KHz IF BW: <b>[0.1 Hz + 4 Hz / GHz]</b><br><b>typical RMS FM</b> (e.g. 2 GHz RF would have 8.1 Hz RMS FM).<br>Increasing IF BW increases residual FM.<br><br><i>Note 1:</i> 1 sample represents approximately 40% of the selected RBW<br><br><i>Note 2:</i> 5 MHz RBW accuracy not specified, and is available only in legacy software. |

## 6.2 AMPLITUDE (RBW ≤100KHZ)

|                                      |  |
|--------------------------------------|--|
| <b>Range</b>                         | 1dB Gain Compression to Displayed Average Noise Level (DANL)   |
| <b>1dB Gain Compression</b>          | (attenuator set to 15dB, preamp off)<br>+16dBm Typical, 1Hz to 150MHz (100 kHz to 150 MHz, Option 3)<br>+19dBm Typical, 150MHz to 4.4GHz |
| <b>Displayed Average Noise Level</b> | 0dB input attenuation, 1Hz RBW   |

| Frequency        | RF Preamp Off                 | RF Preamp On    |
|------------------|-------------------------------|-----------------|
| 10Hz             | <b>-124 dBm<sup>(1)</sup></b> | <b>NA</b>       |
| 100Hz to 10KHz   | <b>-130 dBm<sup>(1)</sup></b> | <b>NA</b>       |
| 10KHz to 500KHz  | <b>-142 dBm<sup>(1)</sup></b> | <b>NA</b>       |
| 500KHz to 10MHz  | <b>-142 dBm</b>               | <b>-153 dBm</b> |
| 10MHz to 100MHz  | <b>-148 dBm</b>               | <b>-161 dBm</b> |
| 100MHz to 1GHz   | <b>-144 dBm</b>               | <b>-158 dBm</b> |
| 1GHz to 2.6GHz   | <b>-139 dBm</b>               | <b>-151 dBm</b> |
| 2.6GHz to 3.3GHz | <b>-135 dBm</b>               | <b>-151 dBm</b> |
| 3.3GHz to 4.4GHz | <b>-128 dBm</b>               | <b>-134 dBm</b> |

**Note 1:** Option 3 is unspecified below 100 kHz

**Absolute Accuracy (Reference level ≤0 dBm)** ±1.5dB

**Absolute Accuracy (0 dBm < Reference level ≤ 10 dBm)** ±2.0dB

**Relative Accuracy (Reference level  $\leq 0$  dBm)**  $\pm 0.25$  dB

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

**DC Volts**  $< \pm 0.2$ V absolute maximum ( $\pm 16$ VDC, option 3)

**Residual Responses (Input terminated,  $\leq 100$  KHz span, 0 dB atten, preamp on)**  $< -80$  dBm<sup>1</sup>

*Note 1:* Known residual responses at multiples of 10 MHz

**Spurious Responses ( $\leq 100$  KHz span, CW tone input)**  $< -80$  dBm typical

Typical Maximum LO Feedthrough (preamp on, attenuator set to 15 dB)

|                  |         |
|------------------|---------|
| 1Hz to 500KHz*   | -70 dBm |
| 500KHz to 1GHz   | -57 dBm |
| 1GHz to 2.3GHz   | -47dBm  |
| 2.3GHz to 2.6GHz | -40 dBm |
| 2.6GHz to 3.0GHz | -27 dBm |
| 3.0GHz to 4.4GHz | -35 dBm |

\*RF Preamp Off and Internal input Attenuator on any setting

## 6.3 SWEEP

**Zero Span Sweep Time 0.1 ms to 10 sec**  $\pm 0.1\%$

All other sweeps times are estimates reported after sweep completes.

**Maximum sample rate** 486K/sec

**Sweep Trigger** free run, single, video, external

**External Trigger** 3.3V CMOS/TTL input

## 6.4 MEASURING RECEIVER

**FM Accuracy**  $\pm 1\%$  typical

**AM Accuracy**  $\pm 1\%$  typical

**Synchronous Level Detector (15 KHz IF BW, timebases locked)** 100 KHz to 1 GHz +0 dBm to  $-125$  dBm after 10 min warmup  $\pm 0.25$ dB

1 GHz to 4.4 GHz +0 dBm to  $-115$  dBm after 10 min warmup  $\pm 0.25$ dB

|   |   |
|---|---|
| <b>Average Level Detector, 15 KHz IF BW</b> | 100 KHz to 4.4 GHz +0 dBm to -70 dBm after 10 min warmup, ±0.25dB   |
| <b>Maximum IF Bandwidth</b>                 | 240 KHz   |
| <b>Audio Filters</b>                        | Low Pass: Digital Windowed Sinc, selectable cutoff<br>Band Pass: Available in version 2.xx legacy software only |
| <b>Maximum sample rate</b>                  | 486K/sec  |

## 6.5 INPUTS AND OUTPUTS

|                              |  |
|------------------------------|--|
| <b>BNC External Timebase</b> | (10 MHz input)   |
| <b>BNC Shared</b>            | <ul style="list-style-type: none"> <li>• Self Test Output</li> <li>• SYNC Out</li> <li>• Sweep Trigger In (<i>legacy software only</i>)</li> </ul> |
| <b>SMA RF Input</b>          |  |

## 6.6 ENVIRONMENT

|                              |  |
|------------------------------|--|
| <b>Operating Temperature</b> | 0 to +70 °C (std), -40 to +85°C (option 1) |
|------------------------------|--|

## 6.7 CALIBRATION

Test with factory calibration software to verify that USB-SA44B 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-SA44B will not pass calibration. Temperature correction data is generated only at time of manufacture.

## 6.9 OPTIONAL ACCESSORIES

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

## 6.10 FCC COMPLIANCE

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

## 6.11 CE COMPLIANCE

This device complies with the Class B limits of CISPR 11 and all relevant requirements of EN 61326-1:2006.

# 7 Warranty and Disclaimer

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## 7.1 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.

## 7.2 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.

### 7.2.1 Limitation of Warranty

The foregoing warranty shall not apply to defects resulting from improper use by the Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product. No other warranty is expressed or implied. Test Equipment Plus specifically disclaims the implied warranties or merchantability and fitness for a particular purpose.



## 7.2.2 Exclusive Remedies

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## 7.2.3 Certification

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

## 7.2.4 Credit Notice

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