TEST EQUIPMENT PLUS

Signal Hound USB-SA44

User Manual and

Programming Guide

Signal Hound USB-SA44 User Manual and Programming Guide

Table of Contents

1 Preparing For Use

Unpacking your Signal Hound and Installing Software

T he The Signal Hound USB-SA44 is a USB-based 1 Hz to 4.4 GHz economy 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 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-SA44.

1.2 Software Installation

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

1.2.1   System Requirements

The Signal Hound software and drivers are compatible with Windows® operating systems. You must have at least 50 MB of free disk space, 128 MB of RAM, USB 2.0 and a 500 MHz processor.

1.2.2   Install the Signal Hound Software

 Run **setup**.msi from the CD by double-clicking the file. Follow the directions on the screen. The Signal Hound software is now installed and ready to use. USB drivers will be installed as well. You must reboot before the Signal Hound will operate correctly.

1.3 Running the software for the first time

1. Using the included USB cable, connect the Signal Hound to any available USB 2.0 port. Wait while Windows installs the necessary device drivers. This takes several seconds. Once you see "The hardware is ready to use", continue.
2. Launch the Signal Hound application from the Start Menu or desktop. The first time the software runs, calibration data is transferred from the Signal Hound to the computer. This takes about 10 seconds.
3. **You may begin using the Signal Hound Spectrum Analyzer now**. If you wish to optionally verify basic functionality, proceed with the next steps.

   > ⚠ *The Signal Hound's RF input is **DC-coupled**. Always use a DC block when your signal has AC and DC combined.*

4. Connect the **"SELF TEST" BNC output** to the **RF IN** SMA input using a BNC cable and BNC-to-SMA adapter.
5. From the GUI, select **Utilities→SELF TEST**.
6. Observe that all self tests pass. If not, see the **Troubleshooting** section.

2   Getting Started

*Learn about the basic functions and features of your Signal
Hound Spectrum Analyzer and Measuring Receiver*

T he Signal Hound Graphical User Interface, or GUI, is used to communicate
with the Signal Hound, sending commands and receiving data over USB. The
user sends commands using the **Control Panel** and **Menu**.   The data is
returned over USB and displayed in the **Graticule** as a **Trace**. For specific
measurements, the **Marker** and **Status Bar** may be used as well. See Figure 1 for the
locations of these items.
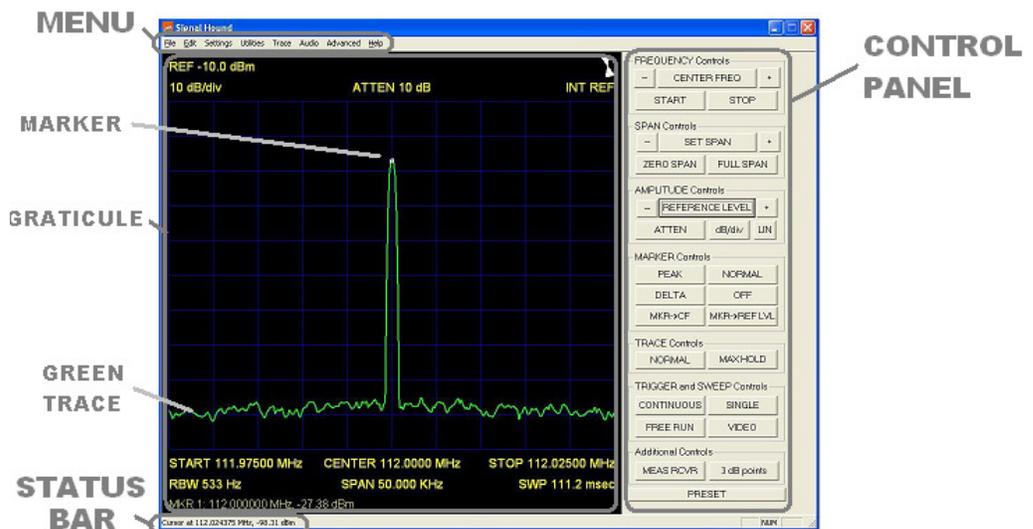
Figure 1 – The Signal Hound Graphical User Interface (GUI)

2.1 The Graticule

The Graticule contains ten vertical and ten horizontal divisions to display trace data.
The trace data is the processed and formatted data from the Signal Hound, displayed in
the graticule.   Above and below the Graticule, you will find indicators regarding
settings and markers. The indicators include:

⇒ **REF:** Reference level**,** top left. The reference level is the signal amplitude for the top Graticule line.

⇒ **Hourglass activity indicator:** top right. The upper right corner of the Display Window contains an activity indicator, rotating while data is being collected and processed.

⇒ **DB/div:** Amplitude scale, near top left, in dB per division of the Display Window. In Linear scale, this will be mV/div.

⇒ **ATTEN:** Attenuator setting, top center. The internal electronic attenuator may be set to **0, 5, 10**, or **15** dB.

⇒ **INT / EXT REF:** Top right. Indicates whether internal or external reference is selected.

⇒ **START, CENTER, STOP**: Bottom left, center and right of Display Window. Start, center, and stop frequencies, representing the frequency of the left, center, and right Graticule lines, respectively.

⇒ **RBW:** Calculated RBW, based on FFT size and sample rate

Markers may be placed anywhere on the trace by left-clicking inside the graticule at the desired location.

⇒ **SPAN:** Difference between start and stop frequencies.

⇒ **SWP:** In zero-span, this is the exact sweep time from left to right. In all other spans this is time elapsed during the last sweep.

⇒ **MARKER DATA** will appear along the bottom of the graticule.

⇒ **Annunciators:** In the top left corner of the graticule, you may see some letters. These will notify you when readings are uncalibrated or a special setting exists such as image rejection off. See the HELP menu for additional information.
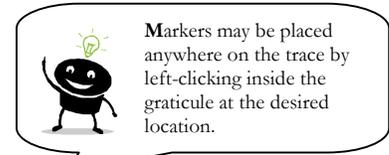
2.2 The Control Panel

The control panel is the section on the right-hand side of the Graphical User Interface, or GUI. It has buttons for the most common user commands. Frequency, span, reference level, sweep and marker commands are available here.

> **Try this:** Click **CENTER FREQ,** then using the mouse, click the buttons **1, 2, 3, MHz.** You should see your center frequency change to 123 MHz. Now click **SET SPAN, 5, 0, KHz**. Watch as start and stop frequencies and span are updated in the lower section of the graticule.

2.2.1   FREQUENCY CONTROLS

⇒ **CENTER FREQ** sets the center frequency of the sweep. When clicked, a popup will open, allowing you to enter the frequency using the mouse or keyboard.

⇒ The **+** and **−** keys will change the center frequency by a preset amount, **CF Step Size** under the **Settings** menu.

⇒ **START** and **STOP** set the sweep's start and stop frequencies, respectively.

2.2.2   SPAN CONTROLS

⇒ **SET SPAN** sets the span of the sweep, the difference between start and stop frequencies. The center frequency is held constant.

⇒ The **+** and **−** keys will step through the default spans from 100 Hz to 2 GHz, in a 1,2,5 pattern.

⇒ **ZERO SPAN** changes the x-axis on the graticule to **time** instead of frequency. The y-axis may be demodulated amplitude or frequency. When this button is clicked, a popup will open, allowing the user to select amplitude (AM) or frequency (FM) for the y-axis.

⇒ **FULL SPAN** sets the span to its maximum.

2.2.3   AMPLITUDE CONTROLS

⇒ **REFERENCE LEVEL** sets the power level for the top graticule line.

⇒ The **+** and **−** keys will change the reference level by a preset amount, **Ref Lvl Step** under the **Settings** menu.

⇒ **ATTEN** sets the internal electronic attenuator to **0, 5, 10**, or **15** dB.

⇒ **dB/div** sets the scale for the y-axis. It may be set to any positive value.

     o   **10 dB /div** is default, giving a full scale range of 100 dB.

⇒ **LIN** sets the amplitude scale to linear units, instead of logarithmic.

2.2.4   MARKER CONTROLS

⇒ **PEAK** moves the marker to the highest amplitude signal on the graticule.

⇒ **NORMAL** places a marker at the center frequency of the graticule

⇒ **DELTA** changes marker 2 to a relative marker.

The marker sequence of **OFF, PEAK, DELTA** is good for reliable dBc measurements.

⇒ **OFF** turns all markers off and back to default settings

⇒ **MKR➔CF** sets CENTER FREQUENCY to the current marker position.

⇒ **MKR➔REF LVL** sets the REFERENCE LEVEL to the current marker position.

2.2.5   TRACE CONTROLS

⇒ **NORMAL:** The entire trace is updated each sweep

⇒ **MAX HOLD:** The highest amplitude for each frequency point is displayed. Each sweep, only frequency points with higher amplitudes are updated.

2.2.6   TRIGGER AND SWEEP CONTROLS

⇒ **CONTINUOUS**: A new sweep begins as soon as the last sweep is completed.

⇒ **SINGLE**: A single sweep is run, then the Signal Hound remains inactive.

⇒ **FREE RUN**: In Zero Span mode, a sweep begins immediately

⇒ **VIDEO**: In Zero Span mode, the Signal Hound waits for a minimum signal amplitude before sweeping. When clicked, a popup opens where the user sets the minimum signal amplitude. This is useful for measuring pulses as short as 10 microseconds.

2.2.7   ADDITIONAL CONTROLS

⇒ **MEAS RCVR** opens the Measuring Receiver utility. See Section **3.5**

⇒ **3 dB points** positions markers at points 3 dB from the peak

⇒ **PRESET** restores the Signal Hound software and hardware to its initial power-on state.

2.3 The Menu

2.3.1   FILE

⇒ <u>Recall State</u>: This loads a previously saved instrument state, including trace data. It can be used to recall an instrument setup or view saved trace data. States are saved as standard Windows ® files with the .tsa extension

⇒ <u>Save State</u>: This saves an instrument state, including controls and trace data.

⇒ <u>SaveAs…</u> Same as above, with a different filename

⇒ <u>Print…</u> Used to print the Graticule, trace data and settings. The title is printed as well. Free PDF print utilities, such as PDF995 and PrimoPDF®, are available to "print to" and save a PDF file.

2.3.2 EDIT

⇒ <u>Set Title</u>: Enter an optional title. This will appear across the top of printouts.

2.3.3 SETTINGS

⇒ <u>CF Step Size</u>: Enter Center Frequency Step Size here. This controls the frequency step when the Center Freq + / - keys are used.

⇒ <u>Ref Lvl Step</u>: Enter Reference Level Step Size here. This controls the reference level step when the REFERENCE LEVEL + / - keys are used.

⇒ <u>Span / RBW</u>: For spans of 200 KHz or less, this will control the digital resolution bandwidth selection (RBW), controlling the shape of the signal response curve. The RBW is selected by the software, and will be close to this fraction of the span. 80 is default. A lower number gives a more rounded curve.

⇒ <u>Sweep time</u>: For zero span sweeps, Sweep Time controls the x-axis. For non-zero spans, the software digitally processes several signals to produce a single sweep, so sweep time is selected for you. Non-zero sweep times listed are approximate and may be inaccurate.

⇒ <u>Signal Track</u>: Turn this feature on to keep a signal with frequency drift in the center of the Graticule.

⇒ <u>Video Averaging</u>: This will smooth out noise for low level signals by averaging several sweeps together. Average 1, 10 or 100 sweeps.

⇒ <u>Image Suppression</u>: On by default. The software suppresses image responses by sweeping the LO above and below the RF frequency and masking the responses together. If your signal is transient, you may wish to turn off image suppression to avoid having valid responses discarded as possible image responses. For **ultra-fast updates** and no processing except the minimum FFT on the smallest possible capture, turn off image suppression and select **_RealTime._**

⇒ <u>Sync/Trig</u>: The Signal Hound can be configured to trigger a sweep from an external input, or to output a logic high when a sweep begins. See "Sync/Trigger Options" for more information.

⇒ <u>Color Scheme</u>: Choose between two color schemes.

⇒ <u>Counter</u>: Turns the RF counter on or off

⇒ <u>Set Marker Freq</u>: Positions the marker at a specific frequency.

⇒ <u>Downconverter Offset</u>: Adds a frequency offset to display

2.3.4 UTILITIES

⇒ <u>Measuring Receiver</u>: This invokes the Measuring Receiver software. See the "Measuring Receiver" section of the manual for details

⇒ <u>Harmonics Plot</u>: This plots the fundamental and up to 9 overtones on a single plot by taking the current center frequency and span, capturing and plotting the center of the trace, then moving up to the next overtone.

⇒ <u>Phase Noise Plot</u>: This utility takes about 1 minute to run. It will sweep several times, then combine the sweeps into a phase noise plot. The data is approximate and is limited by the phase noise of the Signal Hound itself. For best close-in phase noise, use an external 10 MHz reference with > 10 dBm power level.

⇒ <u>Self Test</u>: To use the self test, connect the SELF TEST to the RF IN. This checks the attenuator, mixers, broadband power detector, RF and IF signal paths, and I/Q demodulator.

2.3.5   TRACE

⇒ <u>Trace A➔B</u>: Stores trace A (the main trace displayed) into trace B. It does not alter the visibility of trace B.

⇒ <u>View Trace B</u>: Displays or hides trace B.

⇒ <u>Limit Lines</u>: Displays or hides a lower limit line and an upper limit line.

2.3.6   AUDIO

⇒ <u>Listen</u>: For AM / FM demodulation, processes incoming RF into audio, which plays continuously through the computer speakers. For best sensitivity, set the attenuator to 0 dB and reference level to –40 dBm before turning on the audio. Options include AM/FM demodulation, bandwidth selection, FM de-emphasis.

2.3.7   ADVANCED

⇒ <u>Enable Automation</u>: The Signal Hound may be automated through TCP/IP, locally or over a network. See separate section in this manual for more information.

⇒ <u>Calibration</u>: See Chapter 7

⇒ <u>Recalibrate TCXO</u>: If you can generate a 1 GHz signal accurate to 1 part per billion, you may recalibrate the TCXO offset to provide more accurate frequency readings.

2.3.8   HELP

⇒ <u>About Signal Hound</u>: Look here for hardware, software, and firmware versions.

⇒ <u>Annunciator Help</u>: Explains the meaning of various annunciators which appear in the top left graticule.

⇒ <u>User Manual</u>: Opens this manual.

⇒ <u>SignalHound.com</u>: Takes you to the website.

2.4 The Status Bar

When the mouse pointer enters the graticule area, the **Status Bar** automatically displays the frequency (or time) of the mouse's x-coordinate, and the signal level of the trace at that frequency (or time). This can be used to check a signal level without moving the markers. It can also be used to help you more accurately place markers. position on the graticule.

2.5 The Signal Hound 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 TTL/CMOS trigger input, a Self Test Signal output, or a CMOS Sync Output. The Signal Hound software controls the function of this BNC. It defaults to unused / no output.

Chapter

3

3   Taking Measurements

*Learn how to take amplitude, frequency, and modulation
measurements with the Signal Hound*

T he Signal Hound is capable of making a wide range of measurements. The
internal I/Q demodulator captures up to 2 Megabytes of information each
second, with a hardware-limited bandwidth of 240 KHz. The trace is actually
a combination of several sweeps, mathematically combined to reject image
and spurious responses. When taking measurements of highly modulated signals
which exceed this 240 KHz bandwidth, or any combination of signals with a
bandwidth of >240 KHz, great care must be taken, as the I/Q demodulator will reject
out-of-band responses. In other rare instances, multiple CW input frequencies that are
not harmonically related can mix to produce spurious responses. For these reasons,
t**he Signal Hound is not recommended for taking measurements of signals with
a bandwidth of greater than 240 KHz.**

For signals within the 240 KHz bandwidth limit, a high degree of accuracy and
sensitivity are available. The I/Q demodulator has dual 24-bit DACs, yielding a very
high internal resolution.

3.1 Measuring Frequency and Amplitude

3.1.1   Using the Marker

The Signal Hound has several tools for identifying a signal's frequency and amplitude.
The easiest to use is the **Marker**. To activate the marker and place it at the peak
frequency, locate the Marker **PEAK** button on the Control Panel. The frequency and
amplitude readout of the marker is located below the graticule. The marker's accuracy
is dependent on the SPAN. Narrower spans 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.

To measure a signal that is not the peak, you may simply move the mouse over the
desired signal and left-click to place a marker. The frequency and amplitude are read as
before.

3.1.2   Using the Counter

For spans of 200 KHz or less, and signals at least ~30 dB off the noise floor, a high-resolution counter is available. The accuracy of the counter depends on span, signal level and timebase, but is typically accurate to 0.1 Hz with an external 10 MHz timebase.

3.1.3   Example: Identify a Signal's Frequency and Amplitude

TRY THIS EXAMPLE: To find a signal within a certain frequency range (e.g. 200 MHz to 2.5 GHz) and measure its exact frequency, a simple procedure would be:

1. Set **START FREQ** to the lowest possible frequency (e.g. 200 MHz)

2. Set **STOP FREQ** to the highest possible frequency (e.g. 2.5 GHz)

3. Set **REFERENCE LEVEL** to the highest signal level you expect (e.g. 0 dBm)

4. Click **SINGLE** sweep, and wait for the sweep to complete.

5. If a signal is identified, click **PEAK, MKR→CF** to move the signal to the center of the graticule.

6. Under the Sweep Controls section, click the minus − button to decrease span, until your span is 50 MHz.

> **For faster sweeps**, avoid having a START FREQ below 150 MHz.

7. Click **CONTINUOUS** sweep, then under the Menu select **Settings->Signal Track->ON**

8. Under the Sweep Controls section, click the − button until your span is 50 KHz.

9. Select **Settings->Counter** to activate the frequency counter.

10. Record the frequency counter output, found above the graticule, center top. Record the amplitude of the marker, in dBm.
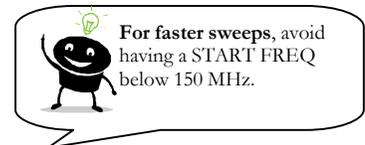
Notice the change in sweep appearance from wide spans (greater than 200 MHz), to mid-range spans (greater than 200 KHz), to narrow spans (200 KHz or less). This is due to the software internally changing modes of operation. For the wide spans, a power meter with a 5 MHz bandwidth is used to quickly identify signals. For narrower spans, the power meter is turned off and I/Q data is used to give a more accurate

reading of both amplitude and frequency. Below 200 KHz span, the Spectrum analyzer changes from a stepped LO frequency to a fixed LO frequency.

3.1.4   Using the DELTA Marker

To measure a **difference or change** in frequency and / or amplitude, use the **DELTA** marker.

1. Turn the markers off if they are currently on. Adjust the settings until your desired signal is displayed, with a span narrow enough for your required accuracy. A 5 to 50 KHz span is ideal for many measurements.

2. Place your first marker using the mouse (left-click) or the PEAK button.

3. Press the DELTA button. This freezes the location of the first marker and activates a second marker.

4. Change the signal's amplitude or place your second marker using the mouse.

5. The difference between the two markers is displayed below the graticule.

3.1.5   Measuring Low Level Signals

To measure low-level signals, there are a few tricks to getting accurate readings. First of all, set the internal electronic attenuator to 0 dB (click the **ATTEN** button). Then, set your reference level to -50 dBm or lower. This internally selects the highest sensitivity settings. Using an external timebase and narrow span (1 KHz or less) should give you better results.

3.2 Viewing Modulation

A signal's modulation envelope may be viewed or measured using **ZERO SPAN**. To use zero span, your center frequency should be equal to your carrier frequency.

Click the **ZERO SPAN** button. Select AM to select the amplitude vs. time graph, or select FM to change the graph to instantaneous frequency vs. time. This tool allows you to view demodulated data. Adjust sweep time for best view.

You may use the markers as above to take basic measurements. SINGLE sweep will make these measurements much easier to make.

3.2.1   Capturing Pulses

To capture a pulse, click ZERO SPAN as before, then click **VIDEO** trigger. You must supply the minimum amplitude to trigger the sweep. The sweep will not begin until the input signal reaches this power threshold, after which the sweep will begin immediately.

3.3 Measuring Harmonics

A harmonics utility is included for one-click measurements of harmonics. To use this utility, you must span down to 100 KHz or less (narrower spans will give a lower noise floor), center the signal on the graticule, then select **Utilities→Harmonics Plot** from the Menu.

When the sweep completes, you will see the relative amplitude of the fundamental and harmonics up to the tenth. A popup will appear asking if you want to sweep harmonics again. To measure the amplitudes of the harmonics, simply move this popup out of your way until you have recorded the desired amplitudes. This utility is for **amplitude measurements only**. The frequencies are assumed to be integer multiples of the fundamental. When your measurements are complete, select Yes or No on the popup. If the popup gets hidden behind the GUI, it will be available on the Windows® taskbar.

3.4 Measuring Phase Noise

A phase noise utility is available to quickly plot SSB phase noise from 1 Hz to 1 MHz. For best results, it is recommended to use this utility with a high quality OCXO external timebase of +13 dBm input.

To use the utility, center your CW signal on the graticule with a span of 1 KHz or less. If the frequency is known and timebases are locked, simply enter the frequency as the CENTER FREQ. Then select **Utilities→ Phase Noise Plot**.

You will be asked if the signal is exactly centered. If you are using an external timebase and you entered the exact frequency, select YES. Otherwise select NO and the software will automatically center it for you.

The automated phase noise measurement takes about a minute. Let it finish before doing anything else with the software. Once the measurement finishes, you will see a plot similar to the figure, right.

The Signal Hound's internal TCXO timebase contributes more phase noise to these

Figure 2: Phase Noise Plot

measurements than an external OCXO 10MHz timebase. Please review the Signal Hound's specifications for phase noise. If the signal you're measuring has considerably more phase noise than the Signal Hound, you should be able to get meaningful results using the internal TCXO timebase. Otherwise, an external OCXO timebase will be needed to make a useful measurement.

3.5 Using the Measuring Receiver Utility

The measuring receiver utility takes measurements of AM and FM modulation and relative signal level measurements. If you are familiar with other measuring receivers, some of this information will be redundant. In addition to modulation measurements, the measuring receiver also accurately measures relative power.

To use this, center the signal on the graticule in the spectrum analyzer with a span of 200 KHz or less, then select **Utilities->MEAS RCVR** from the menu. Note: The carrier frequency for modulation measurements will be set to the CENTER FREQ from the spectrum analyzer.

Enter the desired IF and audio settings, then click **START** to begin analysis.

3.5.1   Audio Analysis Controls

⇒ **IF Bandwidth**: keep this at least 2.4x your peak FM modulation. Any modulation outside this bandwidth will be rejected.

⇒ **Audio Low Pass**: This selects a digital low pass filter (windowed sinc) for the demodulated audio, to reject high frequency audio noise. The filter rejects audio modulation above the selected cutoff frequency, Fc.

⇒ **Audio Band Pass**: Narrow band audio filter (~160 Hz BW) to select a single modulation frequency and reject all others.

⇒ **The Synchronous / Average Level Detector** is used to select between two relative amplitude measurement modes.

  o There are **two gain ranges for RF level**. If your amplitude readings must span both ranges, you must take a stable power level reading in the overlapping region (–45 to –65 dBm) to properly calculate relative power. When the RF level is in this overlapping area, the "CAL RANGE" button will appear. Click it once to generate a correction for spanning the two gains. Once this correction value is calculated, an asterisk will appear by "Relative Power" indicating you are in the high-sensitivity range. You can now step power across the full

Figure 3: Measuring Receiver

dynamic range. Auto-ranging will occur automatically. There is no limit to the step size.

- o Checking the **Synchronous / Average Level Detector** box will zero the relative power reading and enable the **synchronous detector**. Use this to measure a clean, phase-locked RF CW signal over a 140 dB dynamic range. **Use a common external 10 MHz reference**.

- o Un-checking this box will zero the relative power reading and enable the **average detector**. Use this to measure a noisy, modulated, or drifting signal over a 90-100 dB dynamic range.

⇒ **Show FM:** Check this box to view FM modulation measurements.

⇒ **Show AM:** Check this box to view AM modulation measurements.

3.5.2 The Analyzer Data Window

⇒ **RF COUNTER** displays the carrier frequency. It has a 1/100 Hz resolution, but its accuracy may be lower than this at high frequencies or IF bandwidths.

⇒ **FM** Modulation Readings are readings taken on the FM modulation after IF and audio filtering. The units for all FM readings are **Hz**.

- o **RMS:** This is the root mean square of the FM modulation, sometimes referred to as the average FM deviation.

- o **RMS⊕:** With single tone modulation, this is equal to the FM Peak+ or Peak- with noise spikes smoothed.

- o **PEAK+:** This is the highest instantaneous frequency above the carrier

- o **PEAK-:** This is the highest instantaneous frequency below the carrier

- o **Audio Freq:** This is the count of the demodulated audio frequency

⇒ **Relative Power** is the change in power reported from the Synchronous / Average power detector. The reference power level (0 dBc) is set to the power when the START button was first pressed. It may be reset to 0 dBc by checking or un-checking the Synchronous Level Detector box.

- o **Averaged** is the average of the last ten relative power readings

⇒ **AM** Modulation readings are taken on the AM modulation envelope after IF and audio filtering. The units for all AM readings are **percent**.

3.6 Limitations of the Signal Hound

3.6.1 RBW Limitations

Although a resolution bandwidth (RBW) of 0.1 Hz is available for very narrow spans, be aware of the limitations. The internal timebase has phase noise, limiting the usefulness of narrow RBWs. For best results, ensure that your CENTER FREQ in GHz is less than your RBW in Hz when using the internal timebase.

The Signal Hound mostly uses digital RBWs. There are 16 IF bit rates that combine with 16 FFT sizes to produce hundreds of possible RBWs. The closest RBW to your desired Span/RBW ratio is automatically selected.

3.6.2 IF Feed-Through

A 10.7 MHz intermediate frequency (IF) is used throughout the box. An RF input signal from 10.5 to 10.9 MHz may generate spurious responses for a variety of CENTER FREQ and SPAN settings.

If you want to analyze a 10.7 MHz signal, you must use a span of 200 KHz or less and CENTER FREQ of 150 MHz or less to avoid spurious responses. The harmonics utility will work fine as well. Two separate intermediate frequencies, 2.92 MHz and 10.7 MHz, combine to reject IF leakage in narrow spans.

3.6.3 Sweep Time

Sweep Time varies based on system settings. Except for zero span sweeps, the user does not get to specify sweep time.

The longest sweeps are full span from 0 Hz to 4.4 GHz, and extremely narrow sweeps of 100 Hz or less. These can take several seconds to complete. The shortest sweeps are spans of 50-200 KHz, RealTime ON, Image Suppression OFF. These can be as short as 50 msec.

There is a break just above a 200 MHz span, where the 5 MHz RBW kicks in and sweeps suddenly become faster and less accurate.

Chapter

4

4   Additional Features

Learn about save/recall state, Automation, Live Audio
Streaming and Printing

T he Signal Hound leverages the power and flexibility of your Windows® PC, making printing and automation easy and straightforward. Saving and recalling instrument states are now as simple as saving and opening files, with virtually no limit to the number of instrument states saved. Each instrument state saves into approximately 10 KB on your hard drive, making it possible to save millions of captures. Since most Windows® PCs come with speakers as well, demodulated audio can even be played in real-time through the computer speakers!

4.1.1   Save / Recall State

To save an instrument state, including trace data, attenuator settings, frequency settings and more, select **File→Save State** from the menu. A standard File Dialog box will open, prompting you to supply a filename. This may be any legal file name, and may be stored to any File Folder under Windows®. However, for simplicity, it is often best to save states in the default folder.

You may use Save State to capture and store trace data into a small, compact file to be printed later. Another use is to quickly and easily load a configuration for an automated process.

To recall a previously saved state, select **File→Recall State** from the menu. A standard File Dialog box will open, prompting you to select a file. Once you select a file, it will be instantly displayed on the Graphical User Interface (GUI).

4.1.2   Printing

Printing is handled through the default Windows® print and print preview dialog boxes, accessed by selecting **File→Print…** It is similar to printing from an Office application. Print to any installed printer. Everything on the GUI above and below the graticule is printed. An optional title, set by selecting **Edit→Set Title,** is printed along the top.

4.1.3   Listening to Demodulated Audio
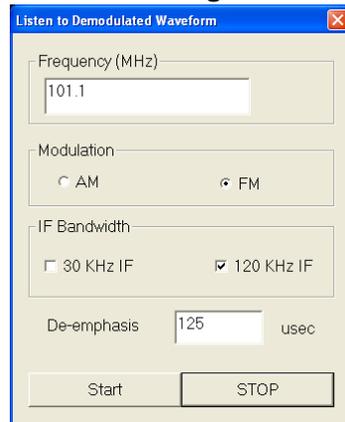
When you identify a modulated signal and wish to listen to the modulation, you may position your marker on the signal in question and select **Audio->Listen**. If you do not place a marker, the CENTER FREQ will be used. This frequency will be pre-loaded into the dialog box on the left. Additional demodulation options will be preloaded with the last values used or default settings.

Figure 4: Audio→Listen

⇒ **Modulation** may be set to AM or FM.

⇒ **IF Bandwidth** may be set to 30 KHz for signals with less modulation, or 120 KHz, which is better for a typical FM broadcast.

⇒ **De-emphasis** is a digital single pole low-pass filter, used to remove the high-frequency emphasis used in many FM broadcasts or to filter out noise.

⇒ **Start** begins playing audio. You may notice a couple of pops in the first second or two, as the data is synchronized with the audio. The button's label will change from **start** to **playing** when audio begins. If you make a change to frequency, bandwidth, or de-emphasis, the label will change to **APPLY**, indicating you must click it to apply the new settings. Audio will be paused for a fraction of a second while the new settings are applied

⇒ **STOP** halts the audio playback.

4.1.4   Automation over TCP/IP

The Signal Hound has some basic automation capabilities over TCP. This enables you to change settings, read markers and capture traces to use in your own software. A LabView® 8.0 example client is provided for reference.

To enable automation, click **Advanced→Enable Automation** on the Graphical User Interface (GUI), and enter your desired IP address and port settings. **The Signal Hound software is the TCP Server. Your software will connect as the TCP Client.** Use "127.0.0.1" for the address if the automation client is running on the same computer as the Signal Hound. This is the same as **localhost**.

Separate TCP ports for commands and data are required.

Once enabled, the Signal Hound software acts as a TCP server, and will accept one and only one connection from a client. Once connected, the Signal Hound will receive and process commands, sending data as requested.

Commands have a structure similar to SCPI. Data returns as a floating-point value followed by a <CR><LF> (carriage return line feed) pair. Commands are not case sensitive. Lower case letters shown are optional. Commands are sent on the COMMAND port. Data is returned on the DATA port. Commands are terminated with a semicolon and/or <CR><LF>.

Table 1: Automation Commands

Command	Action
MARKer:FREQ ?;	Returns the frequency, in Hz, of the marker on the DATA port
MARKer:AMPL ?;	Returns the amplitude, in dBm or mV, of the marker, on the DATA port
TRACe:DATA ?;	Returns the 641-point trace data. Each point is on a separate line.
FREQ:CENT 1.0e9;	Moves CENTER FREQUENCY to value listed, in Hz. Example shown is 1 GHz.
FREQ:STARt 9.9e8;	Moves START FREQUENCY to value listed, in Hz. Example shown is 990 MHz.
FREQ:STOP 1.1e9;	Moves STOP FREQUENCY to value listed, in Hz. Example shown is 1.1 GHz.
FREQ:SPAN 500;	Adjusts SPAN to value listed, holding CENTER FREQUENCY constant if possible. SPAN in Hz. Example shown is 500 Hz.
MARK:PEAK;	Moves marker 1 to the point of highest amplitude.
MARK:NORM;	Moves marker 1 to the center frequency.
AMPL:RLEV –10.0;	Moves the reference level to value listed, in dBm or mV. Example shown is –10 dBm.
TRIG:SING;	Trigger a single sweep.
TRIG:CONT;	Begin continuous sweeping.
RECAll MyFile.tsa	Recall a previously saved instrument state. Example recalls filename "MyFile.tsa"
SAVE MyFile.tsa	Save instrument state and trace data. Example saves filename "MyFile.tsa"

4.1.5   Using an External Timebase
An external 10 MHz timebase my be used to improve the accuracy of frequency and phase noise measurements. The level of the external timebase must be > 0 dBm. +13 dBm is recommended. To use, simply connect the timebase to the **Ext Ref In** after connecting the USB. It is best not to apply external timebase until the device is powered on and the LED is green. Click "Single Sweep" from the GUI. The external timebase will be selected automatically after your sweep completes.

4.1.6   Using an External Trigger
A TTL/CMOS trigger may be used to initiate a sweep at a specific time. The trigger must be a 3.3V or 5V TTL/CMOS. To activate, select
Settings→SYNC/TRIG→TRIG IN. The selected sweep will wait for a trigger, then begin within 10 microseconds of the trigger's rising edge. When using an external trigger, remember that image rejection happens in a separate sweep, after the first

sweep is triggered. **If you are trying to capture an event, you may wish to turn off image rejection, turn on realtime, and use spans of 200 KHz or below.**

4.1.7 Using Sync Out

A 3.3V CMOS output may be used to trigger external equipment. The Sync Out goes high as each sweep begins and remains high until the sweep is complete. . To activate, select **Settings→SYNC/TRIG→SYNC OUT.** There is a 220 ohm internal impedance for this output.

Chapter

5

5 Theory of Operation

Learn about the internal blocks that make up the Signal Hound

T he Signal Hound is built around a narrow-band IF-to-bits receiver with a maximum bandwidth of 240 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 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.
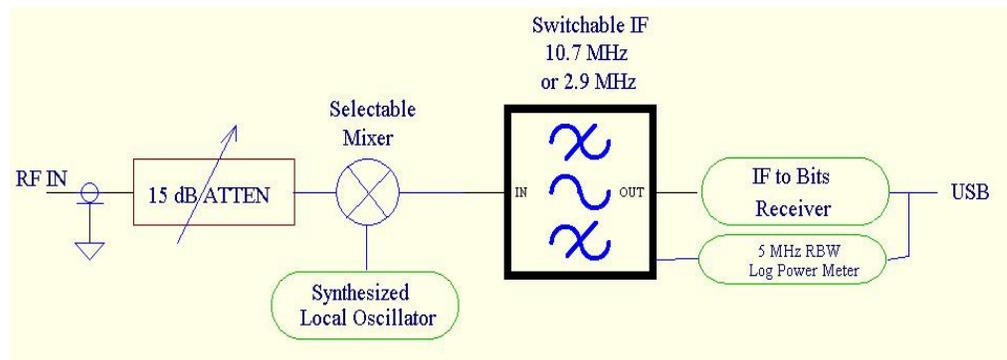
Figure 5: Simplified Block Diagram

5.1.1 The Three Span Ranges

⇒ Below 200 KHz span: the Signal Hound operates by mixing two fixed LO frequencies (typically one above the RF frequency and one below). These are masked together to produce the displayed trace. LO and IF frequencies are selected automatically to best cancel image and spurious responses.

⇒ Up to 200 MHz span: the Signal Hound operates by rapidly sweeping LO frequencies in 200 KHz steps, covering above and below the center frequency. These are processed with small FFTs and masked together to reject image responses and produce the displayed trace.

o   For RF frequencies below 25 MHz, image rejection requires additional steps and the trace will be slower.

⇒ Greater than 200 MHz span: the Signal Hound operates by rapidly sweeping LO frequencies in 3 MHz steps, reading power using the 5 MHz RBW Log Power Meter. The LO is stepped to cover above and below each frequency. The amplitude accuracy and frequency accuracy are lower and the image / spurious suppression is reduced in this mode.

o   For RF frequencies below 150 MHz, this mode produces too many spurs. The above, slower method, is used for these frequencies.

o   Certain RF frequencies may produce small spurious responses. To verify a displayed signal, center it and step the span down. If it disappears, it was likely a mixing artifact.

5.1.2   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 down to 10 KHz or less. If it disappears, it was likely a 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 spans 100 KHz or below.

Measurement tip: Linearity of a mixer improves at lower signal levels. For accurate harmonics measurements, you should have less than –25 dBm into the mixer!
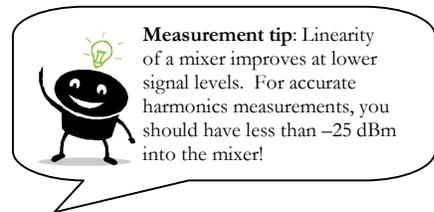
The mixers can typically operate with up to +0 dBm input, but keeping the input level –25 dBm or lower will greatly improve linearity.

5.1.3   IF-to-Bits Receiver

The IF-to-bits receiver has three gain ranges and 16 selectable bit rates. 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, change reference level, attenuator, and/or input level settings.

5.1.4   IF and RBW Selection

The I/Q data comes in over USB and is processed using an FFT with a Flat Top window. The software controls the 16 bit rates and the size of the FFT to establish a suitable resolution bandwidth (RBW) based on the span and selected Span/RBW ratio available in the SETTINGS menu.

The resolution bandwidths are not the traditional analog 1,3,10 KHz filters. The bandwidths are a function of the size of the FFT (which is a power of 2) and the IF bit rate divisor (1 to 16). While this produces a large number of possible RBWs, they do not fall in a 1-3-10 pattern.

The RBW listed on the GUI is calculated from the bit rate divisor and FFT size. This number is the approximate RBW and is listed in the lower left region of the GUI. For wide spans, an additional RBW of 5 MHz is used. This is a typical value. There is no specification for this RBW, but it is typically within 20%.

Chapter

6

6 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 10 MHz or trigger cables from the Signal Hound and wait 15-30 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 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 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**.

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 select **Settings→Image Suppression→OFF** and **Settings→Image Suppression→Realtime.** 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). It also and maximizes the update rate. 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 noticably higher than a YIG-based spectrum analyzer.

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 20 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

⇒ 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.

Chapter

7
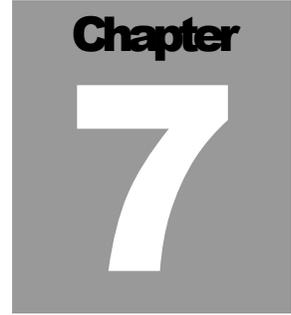
7 Calibration and Adjustment

To perform a calibration or adjustment, connect the equipment as shown in section 7.2. Allow 30 minutes warm-up time. Launch the Signal Hound software. Select **Advanced➔Calibration** or **Advanced➔Adjustments➔DO ALL ADJUSTMENTS**. Follow the directions on the screen. Adjustments are NOT available to general users.

7.1 Equipment Required

⇒ HP/Agilent **8340A/B** or compatible synthesized generator

⇒ **EPM442A** Power Meter, GPIB Address 13

       o **E9304A** power sensor on channel A

       o **8481A** power sensor on channel B

⇒ DC block, similar to **10240B**

⇒ 10 MHz External Reference for Signal Hound and synthesized generator, ±0.01 ppm or better

⇒ 6 dB wideband power splitter, **11667B** or similar

⇒ 3 dB fixed attenuator, **8493C** or similar

⇒ National Instruments PCI-GPIB card or 100% compatible

7.2 Setup Block Diagram

```
 ┌──────────┐      ┌──────────┐      ┌──────────┐     ┌──────────┐    ┌────────┐
 │ EPM-442A │◄─────│ Splitter │─────►│  Signal  │────►│ DC Block │───►│ 8481A  │
 └──────────┘      └──────────┘      │  Hound   │     └──────────┘    └────────┘
                        ▲            │          │◄────┌──────────────────┐
                   ┌─────────┐       └──────────┘     │ 10 MHz EXT REF   │
                   │  3 dB   │                        │ >+5 dBm          │
                   └─────────┘                        └──────────────────┘
                        ▲
                  ┌──────────┐
                  │ 8340A/B  │
                  │ GPIB 20  │
                  └──────────┘
```

Chapter

8
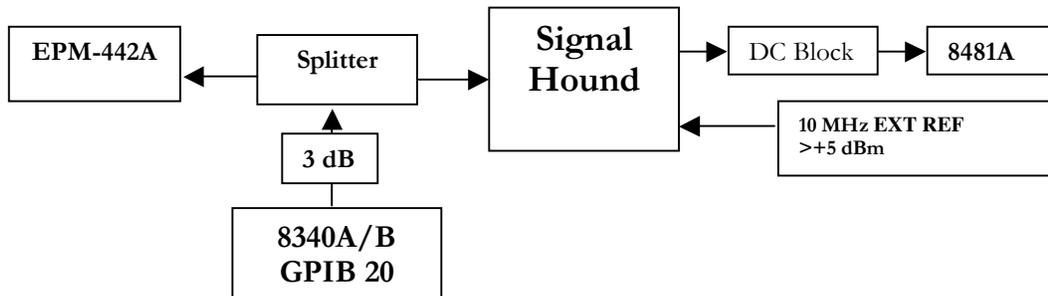
8 Specifications

Unless otherwise stated, specifications are valid for an ambient temperature range of 20-25°C after a ten-minute warm-up. Specifications are listed may be used as typical operating specifications over the full operating temperature.

8.1 Frequency

Frequency Range: 1Hz to 4.4GHz
Span Modes: (Center Frequency + Span) or (Start + Stop Frequencies)
Maximum Span: 4.4GHz
Minimum Span: 10Hz or Zero Span
Internal Frequency Reference Accuracy: ±1 ppm
  For greater frequency accuracy connect to external 10MHz timebase (0 to 20dBm)
Frequency Readout Accuracy: 0.2% Span + 10% RBW
Marker Accuracy: 0.2% Span + 10% RBW
Counter Accuracy: 1Hz + timebase error
Resolution Bandwidth: 0.1Hz to 240KHz and 5MHz
Spectral Purity
  Residual FM, 3KHz Audio LPF, 15 KHz IF BW: **[0.06 Hz + 4 Hz / GHz] typical RMS FM** (e.g. 2 GHz RF would have 8.06 Hz RMS FM). Increasing IF BW increases residual FM.

8.2 Amplitude (RBW ≤200KHz)

Range: 1dB Gain Compression to Displayed Average Noise Level (DANL)
1dB Gain Compression: (attenuator set to 15dB)
  +16dBm Typical, 1Hz to 150MHz
  +19dBm Typical, 150MHz to 4.4GHz
Displayed Average Noise Level: (0dB input attenuation, 1Hz RBW):
  -123dBm   10Hz
  -133dBm   100Hz
  -138dBm   1KHz to 10MHz
  -148dBm   10MHz to 100MHz
  -138dBm   100MHz to 1GHz
  -124dBm   1GHz to 4.4GHz
Absolute Accuracy: [+10dBm to {20dB above DANL}] ±1.5dB

Relative Accuracy: (attenuator set to 10dB) [+5dBm to {20dB above DANL}] ±0.25 dB
  Maximum Safe Input Level: (attenuator set to 15dB)
  Continuous Power +20dBm
  DC Volts: ±0.2V

Residual Responses, <-80 dBm Input terminated, <=100 KHz span, attenuator at 0 dB [1]
Note 1: Known residual responses at multiples of 10 MHz

Spurious Responses, <=100 KHz span, < -80 dBm typical, CW tone input only.

8.3 Sweep

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

8.4 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 4.4 GHz +0 dBm to –115 dBm after 10 min warmup **±0.25dB**

Average Level Detector, 15 KHz IF BW

100 KHz to 4.4 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: Selectable center frequency, narrow-band recursive, 160 Hz 3 dB bandwidth

Maximum sample rate: 486K/sec

8.5 Inputs and Outputs

1) **BNC External Timebase** (10 MHz input)
2) **BNC Shared**
   o Self Test Output
   o SYNC Out
   o Sweep Trigger In
3) **SMA RF Input**

8.6 Calibration

Load and run packaged calibration software to verify that USB-SA44 is operating within tolerance. Recommended calibration interval is 1 year.

8.7 Adjustments

Load and run packaged adjustment software to reload calibration constants when USB-SA44 will not pass calibration.

8.8 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)

Chapter

9

9 Revision History

- Software Version 1.40 – Fixed crashes due to memory leak on spans 500KHz – 200 MHz. Enabled two Signal Hounds to be used simultaneously. Fixed bug where other FTDI-based USB devices would cause Signal Hound software to not operate.

- Software Version 1.41—Added downconverter frequency offset

- Software Version 1.42—Added compatibility with older device naming convention.

- Software Version 1.43—Fixed Self Test glitches

Chapter

10

10 Warranty and Disclaimer

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