TEST EQUIPMENT PLUS

Signal Hound USB-TG124A

User Manual

Signal Hound USB-TG124A User Manual

Version 1.00A

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Chapter

1

1 Preparing For Use

Unpacking your Tracking Generator and Installing Software

T he Signal Hound USB-TG124A is a USB-based 100 kHz to 12.4 GHz economy tracking generator that works with the USB-SA44B and USB-SA124A, facilitating scalar network analyzer measurements.   The Signal Hound USB-TG124A is powered from the USB cable, eliminating the need for a separate power supply. Measuring less than 8 inches long and weighing less than a 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, an SMA M-M adapter, a 3' BNC cable, and a Signal Hound USB-TG124A.

1.2 Software Installation

The Signal Hound is operated from a Windows® based PC using our application software.   The same software that powers the Signal Hound spectrum analyzer also

powers the USB-TG124A tracking generator. Additionally, there is a small standalone utility for using your USB-TG124A in a standalone mode.

1.2.1   System Requirements

The Signal Hound software and drivers are compatible with Windows® operating systems. It is recommended that you have at least 500 MB of free disk space, 1 GB of RAM, USB 2.0 and a multi-core processor, and some Signal Hound models may require internet access for a one-time calibration data download.

Your computer must have the "Microsoft .net framework" version 3.5 or newer installed. If you have Windows 7 with automatic updates turned on, you should already have this. If you do not already have a newer version, please install it from the CD.

The software connects to the internet to download a temperature correction file. An internet connection is required the first time you run the software.

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. **You must have administrator privileges**.

- You should already have the "Visual C++ 2008 redistributable" and "vc_redist_x86" installed from your initial Signal Hound software installation. If not, install them now.

1.3 Running the software for the first time

1. Using the included USB cable, connect the USB-TG124A tracking generator (TG) 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. Connect your Signal Hound Spectrum analyzer USB cable as well.
3. Connect the SYNC / TRIGGER ports of the two devices using the included BNC cable.
4. Connect the RF output of the tracking generator to the RF input of the spectrum analyzer.
5. Launch the Signal Hound application from the Start Menu or desktop. The first time the software runs, calibration data is transferred from the tracking generator to the computer. This takes about 10 seconds.
6. Observe the new controls below the PRESET button. These are for the tracking generator.
7. **You may begin using the Signal Hound Tracking Generator now**. If you wish to verify basic functionality, proceed with the next steps.

8. With the tracking generator RF out connected to the spectrum analyzer RF in using the provided SMA adapter, and the SYNC/TRIGGER ports connected using the included BNC cable, click START.
9. A dialog box will appear with some additional setup options. Click OK to use default settings.
10. You should see a horizontal line, around -10 dBm, representing the level of the tracking generator output into the spectrum analyzer.
11. Disconnect the tracking generator RF OUT and observe the low signal level. If you do not observe the correct levels, see the **Troubleshooting** section.

Chapter

2

2 Getting Started

*Learn about the basic functions and features of your Signal
Hound Tracking Generator*

T
he Signal Hound Graphical User Interface, or GUI, is used to communicate
with the Signal Hound spectrum analyzer and tracking generator, 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.
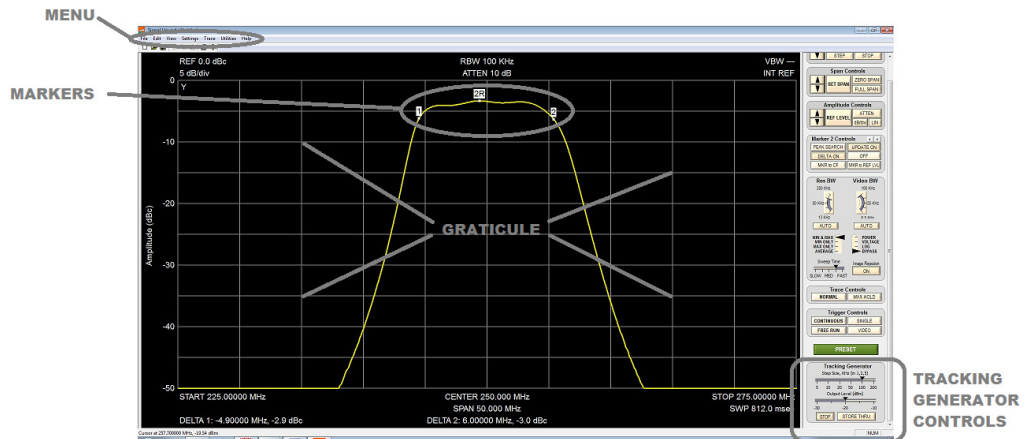
Figure 1 – The Signal Hound Graphical User Interface (GUI)

There are two primary sweep modes. The "Fast Sweep" mode is optimized for rapid,
general purpose measurements over a 60 dB dynamic range. Approximately 700
discrete readings per second are achievable, allowing for trace updates of less than one
second for most sweeps.

The "Slow Sweep" mode is optimized for high dynamic range sweeps, where
measurements down to -100 dBc are possible. This is useful when tuning duplexers or
notch filters, but is much slower, requiring closer to 1/2 second per data point.

2.1 The Graticule

The Graticule contains ten vertical and ten horizontal divisions, just as it did with the Signal Hound Spectrum Analyzer. The primary difference now is that the displayed trace represents hundreds of power readings at various frequencies, as the tracking generator sweeps from the start frequency to the stop frequency.

⇒ **REF:** Reference level**,** top left. The reference level is the signal amplitude for the top Graticule line. This may be in dBm or dBc for relative measurements

⇒ **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 for USB-SA124A, top center. The internal electronic attenuator may be set to **0, 10, 20**, or **30** dB. In Slow Sweep mode, this will be controlled by the software to achieve maximum dynamic range.

⇒ **INT / EXT REF:** Top right. Indicates whether internal or external reference is selected. In slow sweep mode, connect the tracking generator's 10 MHz input to the spectrum analyzer's 10 MHz output.

⇒ **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.

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

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

⇒ **SWP:** 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. See the HELP menu for additional information.
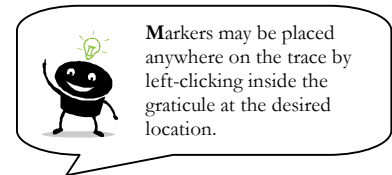
2.2 The Tracking Generator Control Panel

The tracking generator adds additional controls to the control panel, below the PRESET button.

⇒ **STEP SIZE** is a slider control which sets the frequency step size of the sweep. This will control how many frequencies the tracking generator hits during its sweep across the selected frequency span.

⇒ **OUTPUT LEVEL** controls the amplitude of the tracking generator signal. This may be in absolute units, dBm, or units relative to the maximum power available, in dBc.

⇒ **START** begins the tracking generator sweep. The software switches from spectrum analyzer mode to scalar network analyzer mode, and brings up a popup with some additional configuration options.

⇒ **STORE THRU** Stores trace data as the "reference trace" for making relative measurements. Click this button to change from absolute amplitude units (dBm) to relative amplitude units, (dbc). Each subsequent click will re-measure the "thru".

2.2.1   Additional Configuration Options
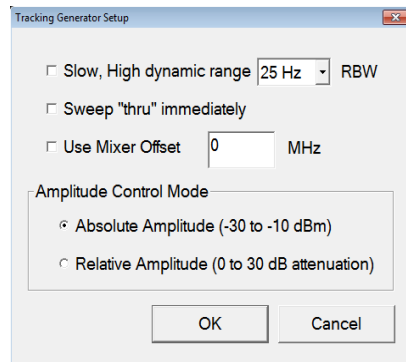
⇒ **Slow, High Dynamic Range:** Use when more than 70 dB dynamic range is required, such as when tuning a duplexer.

⇒ **Sweep THRU immediately:** Click to make the first sweep the "thru" and subsequent sweeps plotted relative to the thru. If you do not check this, you may store a thru later using the control panel button

⇒ **Use Mixer Offset**: Adds an offset frequency to the tracking generator, useful especially when sweeping a mixer or downconverter.

⇒ **Amplitude Control Mode**: Depending on your application, you may want a fixed absolute output level (e.g. -15 dBm), or you may want a 30 dB range of control, with maximum and minimum power levels available.

2.3 The USB-TG124A Front & Rear Panels

The **front panel** includes a 50Ω SMA RF input. There is a DC blocking capacitor that will block up to 16 VDC. Applying higher DC voltages or signals in excess of +20 dBm will cause damage. A **READY / BUSY** LED flashes orange each time a command from the computer is processed.
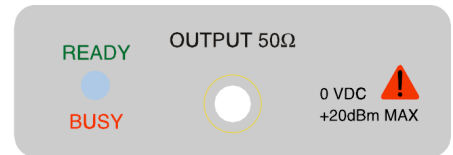
The **rear panel** has three connectors:
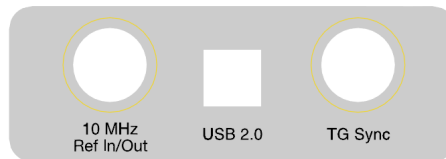
1) 10 MHz Reference input / output. Connect to the USB-SA124A *10 MHz output* or to the SA44B 10 MHz input for slow sweeps.

2) A USB type B connector. Connect to your PC using the included USB cable.

3) TG Sync. Connect to the USB-SA44B / USB-SA124A Sync Out port for fast sweeps.

3   Taking Measurements

Learn how to take path loss, amplifier gain, and mixer gain/loss measurements

The Signal Hound USB-TG124A Tracking Generator (TG), working in concert with the USB-SA124A Spectrum Analyzer, is capable of making a wide range of scalar network analysis measurements. Whether you are tuning an RF filter, sweeping an amplifier to plot gain, or sweeping a mixer's conversion loss, measurements are quick and easy with the USB-TG124A tracking generator.   The tracking generator defaults to a rate of 700 points per second (plus 150-200 ms overhead), so a sweep of 50 MHz in 100 KHz steps takes less than 1 second.

3.1 Measuring Insertion Loss or Gain

The Signal Hound USB-TG124A Tracking Generator may be used to measure insertion loss or gain. To measure insertion loss of a cable or attenuator, the following approach is recommended:

1. Plug the spectrum analyzer and tracking generator devices into the PC using the supplied USB cables.

2. Connect the spectrum analyzer and tracking generator nose-to-nose using the SMA barrel connector provided.

3. Connect the TG Sync to the spectrum analyzer Sync Out.

4. Launch the Signal Hound software.

5. Set start / stop / center / span frequencies to desired sweep range

6. Click Tracking Generator "Start" button

7. In the popup dialog box, click "sweep thru immediately", then click OK. This will sweep the barrel connector and set this to 0 dB.

8. Wait for "thru" to sweep. The units displayed will convert to dBc when complete.

9. Insert device to test between the tracking generator output and the spectrum analyzer input.

10. Wait for a complete sweep to finish. Place markers and take measurements as necessary.

3.2 Measuring |S21|

In two-port linear networks, S21 refers to the forward transmission gain through a network.. This may be greater than one in the case of an amplifier, or less than one in the case of an attenuator. With a Vector Network Analyzer (VNA), S21 is measured as a vector, with magnitude and phase. With a Scalar Network Analyzer (SNA), only the magnitude is available.

The Signal Hound USB-TG124A Tracking Generator may be used to measure |S21|, the magnitude of the forward transmission gain, as follows:

1. Plug the spectrum analyzer and tracking generator devices into the PC using the supplied USB cables.

2. Connect the spectrum analyzer and tracking generator nose-to-nose using the SMA barrel connector provided.

3. Connect the TG Sync to the spectrum analyzer Sync Out.

4. Launch the Signal Hound software.

5. Set start / stop / center / span frequencies to desired sweep range

6. Under the amplitude controls, click "Linear." This will change the units to mV.

7. Click Tracking Generator "Start" button

8. In the popup dialog box, click "sweep thru immediately", then click OK. This will sweep the barrel connector and set this to |S21| of 1.0.

9. Wait for "thru" to sweep

10. Insert device to test between the tracking generator output and the spectrum analyzer input.

11. Wait for a complete sweep to finish. Place markers and take measurements as necessary.

3.3 Using Limit Lines

Limit lines may be used for PASS / FAIL testing. Limit lines are imported from a CSV (comma separated value) file format. This standard file format can be exported from spreadsheet applications, or generated manually in a text editor. Three values per line, separated by commas, correspond to:

1. The frequency (in MHz)

2. The minimum amplitude allowed. This may be in dBm if no "thru" is swept, or dBc after sweeping a "thru". Enter **-200** for "no minimum".

3. The maximum amplitude allowed, in dBm or dBc. Enter **50** for "no maximum".
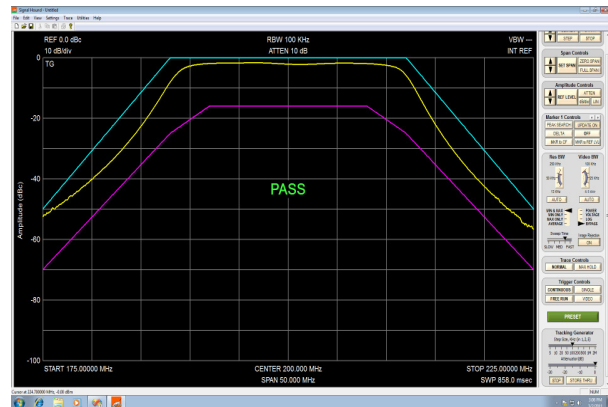
From the Signal Hound menu, Select **File->Import->Limit Line Table**. This will open a popup where you can navigate to your limit line CSV file. Select your file and click *Open.*

The limit lines will be drawn on the graticule, and a Pass / Fail annunciator will appear. If the entire trace is above the minimum and below the maximum, PASS will be displayed. Otherwise, FAIL will be displayed. Please note that when a setting is changed, there is a one sweep delay before the PASS/FAIL annunciator is valid.

3.4 Improving Accuracy

One shortcoming of the Signal Hound Spectrum Analyzer and Tracking Generator is poor VSWR / return loss performance. However, this can be easily overcome by adding good 6 dB or 10 dB pads (fixed SMA attenuators) to the output of the tracking generator and / or the input of the spectrum analyzer. A good 6 dB pad will improve return loss by nominally 12 dB, and should enable accurate measurements relative to a 50 ohm system. These may be included when sweeping the "thru," effectively nulling them out.

3.4.1   Optimizing for Best Dynamic Range

When measuring an amplifier that will have significant gain, it is recommended to set the TG to a lower output power, such as -30 dBm. Before you "SWEEP THRU", set your reference level and attenuator for the maximum power into the USB-SA124A.

To measure a relative amplitude change at lower signal levels (e.g. stepping from 40 dB to 50 dB attenuation), set your reference level just below the highest input power you expect, set the TG to -10 dBm output power, and for an input below -20 dBm, set the SA124' s RF attenuator to 0 dB.

3.5 Measuring Return Loss

A **directional coupler** of appropriate frequency range (sold separately) may be used to make approximate return loss measurements.   Connect your tracking generator to the "OUT" port, and connect your spectrum analyzer to the "COUPLED" port. Use the "IN" port as your S-parameter test port. Sweep this setup as the "thru" with the test port open (reflecting 100% of power). Then connect your device to test (e.g. antenna) to the "IN" port. Return loss or |S11| will be displayed.

Once again, measurement accuracy will benefit from 3 to 6 dB pads on the Signal Hound devices. If noise becomes an issue, set your reference level to the actual signal level at the coupled port, e.g. -26 dBm, and turn your RF attenuator to 0 dB before you "SWEEP THRU" (remember to leave the "IN" port open for sweeping the thru).

This method is not as accurate as using a vector network analyzer, but can be used as a reasonable approximation for many applications.

3.5.1   Adjusting an Antenna

To adjust an antenna for a certain frequency, it is often sufficient to simply maximize return loss at that frequency. This may be done in a swept or CW tracking generator mode. Mount your antenna and ground as you normally would, then connect to the "IN" port as above. Lengthen, shorten, and tweak impedance matching elements until the desired return loss is achieved. Be aware that you will be radiating some RF during this process.   It is your responsibility to understand and obey laws regarding transmitting on those frequencies.

3.6 Using the Markers

The Signal Hound has several tools for identifying a signal's frequency and amplitude. The easiest to use is the **Marker**. There are 9 markers available, each with its own reference.

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. Please note that t**he 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. Use the mouse wheel to fine-tune the marker's placement.

3.7 Measuring Low Level Signals

To measure more than 60 dB insertion loss, you will need to employ a few tricks. The first trick available is to use the **Slow, High Dynamic Range** sweep. This is accessible after you click "START".   Each sweep will employ a narrow RBW, a slow sweep, and built-in scaling for low level signals. Up to 100 dB of dynamic range is typically possible when you use the maximum available output power. WARNING: This will drastically affect sweep time, sweeping 2 points per second instead of 700.

For some setups, the RF input attenuator may be set to 0 dB and the reference level may be set to -50 dBm or so to decrease the noise floor.

3.7.1   Tuning Notch Filters

A special case of low-level signal measurement is tuning a band reject or notch filter. While a band pass filter is easily tuned using the standard "fast sweep", a band reject filter often requires 100 dB or more rejection. The easiest way to accomplish this is to set the software to a span of 10 KHz and the Center Frequency to the CW frequency you wish to reject, then turn on the tracking Generator CW mode (under the Utilities menu). Turn the attenuator to 0 dB, preamplifier on, reference level -60 dBm, then adjust until a minimum signal level is achieved.

3.8 Using the Smith Chart Utility

As with the TG44A, the Smith Chart utility can be used at a fixed frequency with a directional coupler and locked timebases, to plot the phase and amplitude of the return signal. Above 4 GHz, the phase of the return signal becomes less stable, and you may observe the phase angle changing by 10 degrees or more over several seconds. This will limit the accuracy of phase shift measurements at higher frequencies.

Chapter

4

4 Theory of Operation

Learn about the internal blocks that make up the Signal Hound Tracking Generator

The Signal Hound Tracking Generator is built around a 32-bit programmable modulus DDS. This allows the firmware to set precise 10 Hz steps. The DDS generates frequencies from 10 Hz to 16 MHz directly. To produce higher frequencies, the DDS output frequency is multiplied by an integer from 5 to 500.

Below 16 MHz, the output has low harmonic content. However, above 16 MHz, harmonics are generated and not filtered. From 4 GHz to 7.2 GHz, an Fout / 2 subharmonic will also be present, and above 7.2 GHz there will be Fout/3 and 2*Fout/3 subharmonics. Harmonics and / or subharmonics, sometimes as high as -10 dBc, will be observed for much of the RF spectrum. For use as a tracking generator, the presence of harmonics has very little impact on the measurement, since the harmonics will generally be well outside the spectrum analyzer's input bandwidth.

However, when verifying the output power level with an RF power meter, the harmonic content can add up to 0.7 dB to the measured output.

Please note that the phase noise of the USB-TG124A is higher than the USB-SA124A. However, this will have minimal impact on readings as out-of-band energy is rejected by the spectrum analyzer.

When sweeping above 5 GHz with "image reject" on, the SA124A makes a second pass across the spectrum, using a different LO frequency, to mask out a handful of internal residual and spurious signals. This will double your sweep time. You can disable this by turning off image rejection.

Chapter

5

5 Troubleshooting

5.1.1 General Troubleshooting Procedure

1) Unplug the USB cable from your Tracking Generator, count to 10, and plug it back in. If the LED is green, proceed. Otherwise, try a different USB port or cable. Verify the USB-SA44(B) spectrum analyzer is plugged in to USB as well.

2) Launch the application software version 2.15 or later.

3) Check to see if the tracking generator controls appear below the PRESET button. If they do, the software can 'see' the TG124A. If not, check your Devices and Printers for a "SignalHoundTG". If you do not see it, troubleshoot the USB connectivity issue.

4) From the Menu, select **UTILITIES->Tracking Generator CW.** Click OK, then OK. Connect your SA124 and TG124 together using an SMA barrel connector. Check for a -10 dBm output from the TG (+/- 2 dB) at your center frequency.

5) If no signal is present, double-check the tightness of the SMA connector. If everything is tight, contact Tech Support for assistance.

6) Connect the TG SYNC to the SYNC out of the spectrum analyzer using a BNC cable. Connect the TG and spectrum analyzer nose-to-nose using the SMA barrel connector.

7) Click the Tracking Generator **START** button. Click OK to use the default settings. In 1-2 seconds you should see a trace about -10 dBm across the length of the graticule. If you do not see this and your TG LED is red, verify your SYNC cable. If the cable is damaged, replace it.
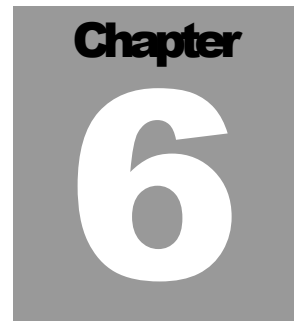
8) Check function at 10 MHz, 100 MHz, 1 GHz, 5 GHz and 10 GHz. If you see a trace of approximately -10 dBm in all cases, the tracking generator is working properly.

Otherwise, contact technical support at http://www.signalhound.com

5.1.2 General Advice to avoid problems

⇒ Unplug your USB-TG124A from the USB port when not in use, or before shutting down your computer.

Chapter

6

6 Calibration and Adjustment

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

Chapter

7

7 Specifications

7.1 Frequency

Frequency range: 100 kHz to 12.4 GHz
Frequency Accuracy: ±1ppm
Frequency steps: Below 4 GHz output, 19 selectable step sizes from 10 Hz to 10 MHz
Above 4 GHz, 16 step sizes from 100 Hz to 10 MHz.

7.2 Amplitude

Amplitude range: -30 to -12 dBm. (-30 to -10 dBm typical)
Absolute Amplitude accuracy ±2.0 dB
Amplitude steps: 1 dB

7.3 Spectral Purity

Harmonics and subharmonics typically < -10dBc

7.4 Inputs and Outputs
1) **BNC Timebase Input/Output** (10 MHz output)
2) **BNC TG Sync**
3) **SMA RF Output**

7.5 Environment
20° C to 25° C to achieve published specifications
0° C to 70° C safe operating range with derated amplitude specifications

7.6 Calibration
Test with factory calibration software to verify that USB-TG124A is operating within tolerance.
Recommended calibration interval is 1 year at 20°C to 25°C.

7.7 Adjustments
Factory adjustment software shall be used to generate new calibration constants when USB-TG124A will not pass calibration.

Chapter

8
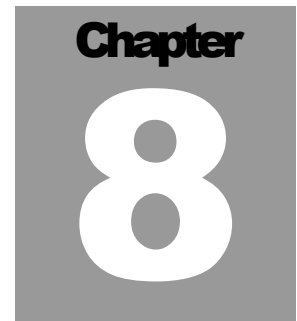
8   Revision History

- Software Version 2.15 – Initial Release with TG124A support

- Firmware Version 3.01 – Initial Release of USB-TG124A firmware

Chapter

9

9 Warranty and Disclaimer

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9.1.1 Warranty

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9.1.5   Certification

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

9.1.6   Credit Notice

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