TinySA Ultra Spectrum Analyzer Trace Detectors & Bandwidth Settings

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Introduction

This article focuses on the trace detectors and video bandwidth filter settings used in the TinySA Ultra spectrum analyzer. It is not an overall review. The TinySA Ultra is very popular, small, battery operated, inexpensive (< 200 USD) and has many features (figure 1). It is handy for fieldwork involving antennas, amplifiers, and locating interference because of its size and portability. There are several operationally similar models of the TinySA Ultra and mine is the ZS405.

Figure 1 ~ TinySA Ultra. The touchscreen size is 4 inch diagonal with 480 x 320 pixel resolution. The spectrum analyzer RF input is the lower SMA connector on the left. The upper connector is for the signal generator RF output (primarily used for calibration). The On-Off power switch is on the top along with a *jog* switch for menu control. A USB-C connector for battery charging and connection to a PC, microSD memory card connector and earphone jack are on the bottom. The unit is based on the Silicon Labs Si4468 RF transceiver and STMicroelectronics STM32F302 processor ICs. Image source: https://www.tinysa.org/wiki/

The motivation for this article was my recent work to compare the trace detectors and associated nomenclatures used by the manufacturers of laboratory spectrum analyzers. I decided to also look at the TinySA Ultra trace detector implementations because it is such an interesting instrument.

This article is based on the *genuine* TinySA Ultra with the latest firmware at the time of writing (December 2025), which is tinySA4_v1.4-216. The TinySA Ultra developer, Erik Kaashoek, in The Netherlands, often adds new features through regular firmware updates, so units with earlier or later firmware may have fewer or more trace handling features. The genuine TinySA Ultra has extensive built-in self-test and calibration routines and is well-supported. Many cheap clones exist so the developer provides a *Where to Buy* list in the TinySA Wiki (see References) for genuine units. He does not support the clones.

I assume readers have a basic knowledge of how swept spectrum analyzers work and are motivated to study the TinySA Wiki and the referenced weblinks and documents.

Trace Detectors

The TinySA Ultra is a swept spectrum analyzer. Up to four traces can be simultaneously displayed and each trace can use a different detector. A given trace detector determines the value displayed for each sweep point associated with that trace. Conceptually, the measurement of the input signal produces data for each frequency as the analyzer is swept. The data are placed in a *bucket* whose width is *[frequency span/(sweep points – 1)]*. The detector then applies one or more mathematical operations to the data and displays the results. The mathematical operations are determined by the user-selected trace detector and may include various types of averaging, scaling and peak determination.

Averaging detectors are commonly used in spectrum analyzers because they lower the displayed noise produced by the analyzer or external sources, making it easier to view a weak signal. There are many types of averaging in spectrum analyzers, including linear averaging, logarithmic averaging, power averaging, quasi-peak averaging, video averaging, sweep averaging and several others, but the TinySA Ultra only supports linear averaging.

In linear averaging, the sampled linear voltage measurement values are summed and the sum is divided by the number of samples associated with a sweep point, giving V_{AVG}. The display uses logarithmic scaling so, after the power has been calculated from $P_{AVG} = (V_{AVG})^2 / R$, the power units are converted to dBm and displayed.

In the TinySA Ultra, the detectors are set through the *Trace* → *Calc* menu for each trace. The *Trace Type*, such as Hold, and *Trace Detector*, such as Max, are combined in one setting, in this case Max Hold. The available detectors are Min Hold, Max Hold, Max Decay, Aver 4, Aver 16, Aver, Quasi-Peak, and Trace Table. Each detector is briefly described along with typical applications in table 1.

Video Bandwidth Settings

Although not a specific trace detector, the Video Bandwidth filter can provide a form of averaging to reduce trace noise. For noise-like signals (for example, true random noise and most digital modulations), setting the Resolution Bandwidth-to-Video Bandwidth ratio, RBW/VBW = 10 (VBW = 0.1 x RBW) generally reduces the displayed noise variation to an acceptable level but higher ratios such as 100 (VBW = 0.01 x RBW) may be used if needed.

Some averaging can be attained by any setting where VBW < RBW, not just ratios of 10 or 100. The TinySA Ultra allows five discrete RBW/VBW ratios, which are accessed through the *Frequency* → *VBW* menu. The TinySA Ultra does not provide VBW settings in terms of frequency but as a multiplier of the RBW, as in 1.0, 0.33, 0.10, 0.03, or 0.01 x RBW. For example, if the RBW is set to 100 kHz and the VBW is set to 0.03 x RBW, the VBW filter is 3 kHz. The VBW is actually enunciated on the display as a frequency, in this example **VBW: 3kHz**.

If the Video Bandwidth is narrower than the Resolution Bandwidth, that is, VBW < RBW, the sweep time generally is longer than when VBW ≥ RBW. This quickly becomes apparent when the VBW is reduced below the RBW in any swept spectrum analyzer.

For sinusoidal signals such as CW, the RBW/VBW ratio usually is set to 1 (VBW = 1.0 x RBW). When the TinySA Ultra VBW is set to Auto, it uses a ratio of 1.0. The TinySA Ultra does not have any settings for VBW > RBW. Although it does not apply here, a setting with VBW > RBW is commonly used in spectrum analyzers when noise is not the primary concern, a faster sweep time is needed or pulses are being measured. Many laboratory spectrum analyzers will automatically choose an optimum ratio when the user selects the type of spectrum to be measured, such as noise, pulse, or sinusoid.

Table 1 ~ TinySA Ultra Trace Detectors

Detector Type	Comment	Description & Use
None	Trace Off	
MIN HOLD	Combination of Minimum (–) Peak and Trace Hold	Displays and holds the Minimum value measured in each bucket. The Hold is reset by selecting again. Useful for making an unmodulated carrier (CW) visible in a composite signal. Also useful for differentiating between CW and impulsive signals in EMI measurements and testing. Enunciated as **MINH**.
MAX HOLD	Combination of Maximum (+) Peak and Trace Hold	Displays and holds the Maximum value measured in each bucket. The Hold is reset by selecting again. Best for locating CW signals well above the noise. Ensures that the true amplitude of sinusoidal signals is reported but does not give a good representation of random noise because the true randomness of noise is not detected. For CW signals, the shortest possible measurement time may be used. For pulsed signals, the measurement time must be > than the expected pulse length (that is, the time must cover at least one pulse). The Max Hold detector provides correct levels when measuring noise-like signals. Enunciated as **MAXH**.
MAX DECAY	Combination of Maximum (+) Peak and Trace Hold with Decay	Displays and holds the Maximum value measured in each bucket for a certain number of scans after which the maximum will start to decay. The Hold is reset by selecting again. The default number of scans is 20 but can be changed. This setting may be used instead of MAX HOLD to reduce the effect of spurious signals in the TinySA Ultra. Enunciated as **MAXD**.
AVER 4	Average power $(V_{AVG})^2/R$	Displays the weighted average of 4 measurements according to Displayed value = (Previous value x 3 + Current value)/4. Restarted by selecting again. The averaging is linear power averaging in which the calculations are done on linear values and not logarithmic (dB) values. Useful for observing sinusoidal signals near noise and the power of complex signals. Does not affect measurements of a CW signal. Enunciated as **AVER4**.
AVER 16	Average power $(V_{AVG})^2/R$	Displays the weighted average of 16 measurements according to Displayed value = (Previous value x 15 + Current value)/16. Restarted by selecting again. Provides more averaging than AVER 4 and is useful for the same types of signals and noise. The average processing is the same as AVER 4. Enunciated as **A16**.
AVER	Average power $(V_{AVG})^2/R$	Displays a continuous average. Restarted by selecting again. Useful for the same types of signals and noise as AVER 4 and AVER 16 but when more averaging is needed to smooth the noise floor. The average processing is the same as AVER 4 and AVER 16 except it is continuous. Enunciated as **AVER**.
Quasi-Peak	QP or QPD	Displays a weighted form of peak detection. The value measured by the detector drops as the repetition rate of the input signal decreases. For example, an impulsive signal with a given peak amplitude and 10 Hz pulse repetition rate will have a lower quasi-peak value than a signal with the same peak amplitude but 1 kHz repetition rate. Most often used for EMI measurements and testing and is meant to mimic the response of a damped analog voltmeter with a fast-attack (charge) time and slow-decay (discharge) time. Enunciated as **QUASI**.
Table Trace	User Defined	Obtains data from a user defined table and may be used to draw limit lines on the display. Also, when used with the Subtract menu (*Trace → Subtract*), the Table Trace may be used to modify or normalize the measurement trace. For example, current probe or antenna factors may be entered in the Trace 2 Table and then subtracted from Trace 1 so that the displayed units are converted from dBµV to dBµA for a current probe or dBµV to dBµV/m for an antenna. Enunciated as **TABLE**.

Example Trace Detector Application

All examples (figure 2) show the signal received from the KLEF FM broadcast station transmitter about 2.5 miles away using the supplied adjustable whip antenna. I purposely lowered the signal-to-ratio by shortening the antenna so the effects of averaging would clearly show. The images are screenshots taken with the TinyRemote screenshot tool (see references) and are shown 125% of true scale.

Analyzer setup for all images:

- ✓ Antenna extension length: 3 inches (76 mm)
- ✓ Center frequency/span: 98.1 MHz/1 MHz (start 97.6 MHz, stop 98.6 MHz)
- ✓ RBW/VBW: 10 kHz/10 kHz (RBW/VBW ratio 1.0)
- ✓ Attenuation: 0 dB (automatically determined)
- ✓ Reference level: –30 dBm
- ✓ Sweep points: 450 (maximum available on local screen, see Comments section)
- ✓ Sweep time: 616 ms (automatically determined)

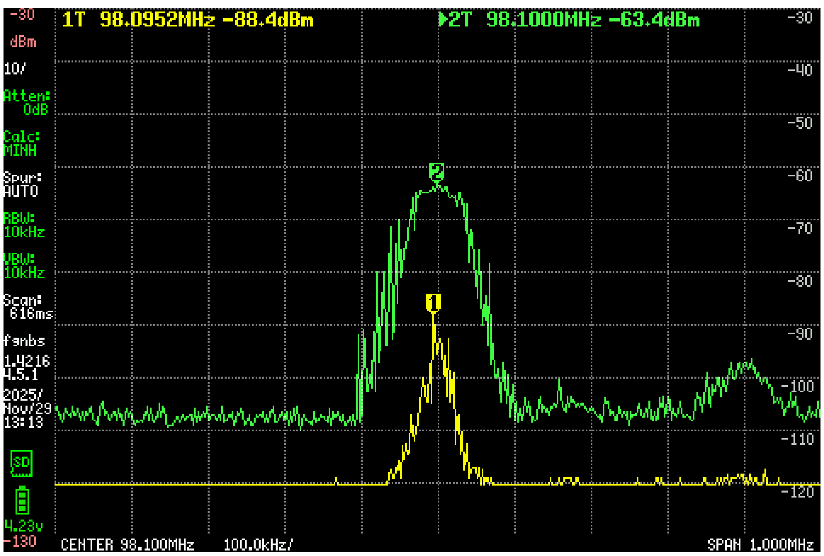

Figure 2.a ~ Trace Detector:

MAX HOLD (green)
MIN HOLD (yellow)

In this example, the difference between the maximum and minimum noise is on the order of 15 dB but a true minimum is not apparent especially at frequencies below the center frequency.

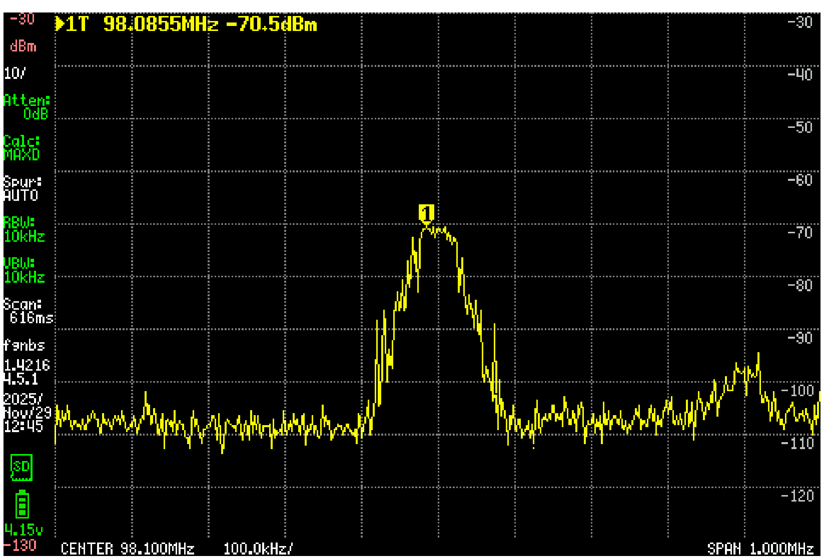

Figure 2.b ~ Trace Detector:

MAX DECAY

No change is discernible in the single screenshot shown here; a peak is held for 20 sweeps and then is slowly reduced to the ambient level after the peak signal disappears. MAX DECAY does not show a shadow line or fill for peak signals as in many analyzers, but it still is useful for observing transient noise or signal bursts that would be masked by the MAX HOLD detector.

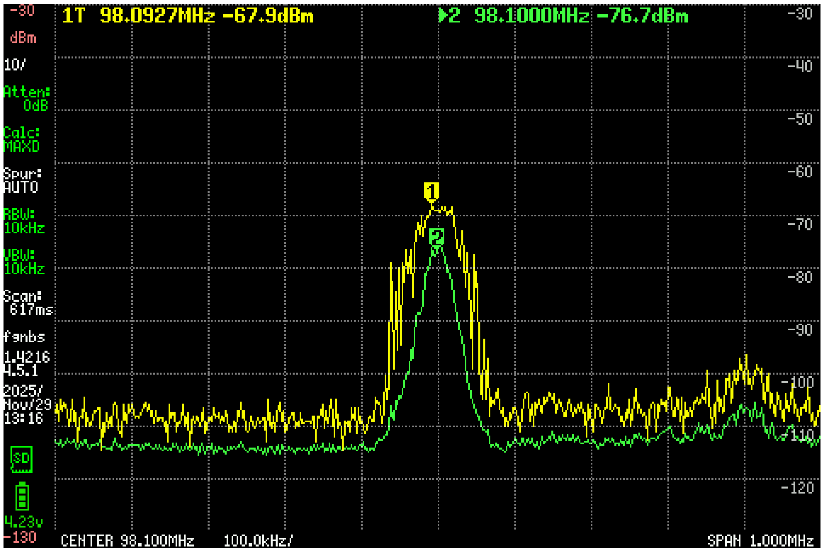

Figure 2.c ~ Trace Detector:

AVER 4 (yellow)
AVER 16 (green)

Note lower displayed noise floor and smoother trace with the AVER 16 detector.

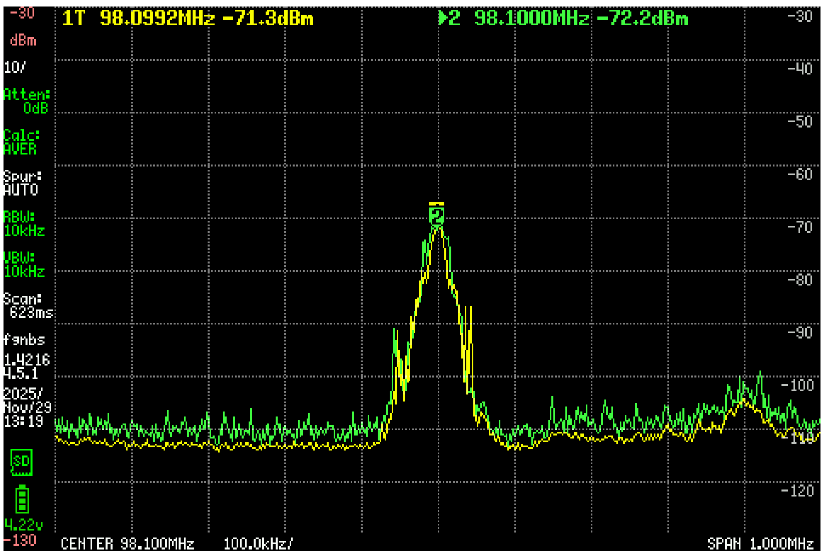

Figure 2.d ~ Trace Detector:

AVER (yellow , ~97 sweeps)
Quasi-Peak (green)

In this example, the Quasi-Peak trace shows about 5 dB higher amplitude than the Average trace where noise is the only signal but about the same amplitude for the FM signal itself.

Comments

The TinySA Ultra itself can be set to one of six sweep point values. The maximum is 450 points, which corresponds to the number of horizontal pixels in the trace display area and is the best available setting for most work. On the other hand, the software applications available for controlling the TinySA Ultra allow any practical number of sweep points; higher values provide a smoother display in the application window but not on the TinySA Ultra screen.

The analyzer is well-supported through the Groups.io/g/tinysa user support group, and there are many video demonstrations of the TinySA Ultra features and functions on YouTube (see References).

References

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- TinyRemote screenshot software tool: http://athome.kaashoek.com/tinySA4/Remote/
- TinySA-App software application: http://athome.kaashoek.com/tinySA/Windows/
- YouTube: https://www.youtube.com/playlist?list=PL5ZELMM2xseNkwVBtyAG00uZevwWUdVIg

Document Information

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