THE SCIENCE OF MEASUREMENT

Technical Note

Understanding Anritsu Fieldmaster Pro MS2090A Noise Floor Levels

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Authors: K.M. Coetzer, J.A. Andriambeloson, & C.J.M. Bryant

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1 Introduction

The Anritsu Field Master Pro MS2090A ([1]) is a modern, powerful Spectrum Analyzer (SA). An Option 714 version of this device, which has a maximum operational frequency of 14 GHz, is the flagship device in the MESA Solutions SA arsenal.

In general-purpose Radio Frequency Interference (RFI) related studies, both the "Spectrum Analyzer" and the "Real-Time Spectrum Analyzer" (RTSA) modes are used.

The SA mode is useful when analysing a wide portion of the Radio Frequency (RF) spectrum - usually multiple Gigahertz (GHz). When attempting to capture the levels of Continuous-Wave (CW) or frequently-transmitted signals, this mode is perfectly sensible. Signals which occur infrequently and for short durations can be missed by this mode.

By contrast, the RTSA mode is useful when attempting to capture transient or infrequently-transmitted signals. This mode constantly considers a narrow portion of the RF spectrum known as the "Acquisition Bandwidth". The "Real-Time Bandwidth" (RTBW) refers to the maximum Acquisition Bandwidth (ABW) of a particular SA.

The MESA Solutions Anritsu MS2090A has a RTBW of 55 MHz. Therefore, it can continuously consider a 55 MHz wide portion of the RF, placed anywhere between 0 Hz and 14 GHz. The RTSA mode will always detect signals within the chosen ABW - so long as the signal duration is at least as long as the duration specified by the Probability-of-Intercept (POI) parameter.

2 Problem

Occasionally, a study is performed which requires a portion of the RF spectrum to be considered in RTSA mode, and the rest of the spectrum to only be considered in SA mode. An example of this is an RFI audit of a site, where pulsed signals (which have monotonically-decreasing frequency) are to be completely characterised, whilst only intentional transmitters (such as microwave links) are to be considered at high-frequencies. In this case, the full RF spectrum would be considered in SA mode. Then, multiple RTBW-wide sub-bands (starting at the lowest reasonable frequency) would be considered in the RTSA mode until the pulsed signals are fully-characterised. Together, the data captured in both the RTSA and SA modes would fully-describe the RFI environment at that particular location.

Plotting both the SA and RTSA data on the same set of axes would, however, result in the exhibition of some unusual characteristics. One of these characteristics is a discrepancy in the noise floor between data captured in SA mode and that captured in RTSA mode. Figure 1 shows a real-world example of this. The following settings were used in each mode:

- The internal pre-amplifier was off.
- Attenuation was set to 0 dB.
- Resolution Bandwidth (RBW) was set to 100 kHz.
- Trace was set to "Maximum Hold".
- Detector was set to "Peak".

Despite identical settings, the SA and RTSA modes produced data with different noise floors. This document explains this phenomenon in the following section.

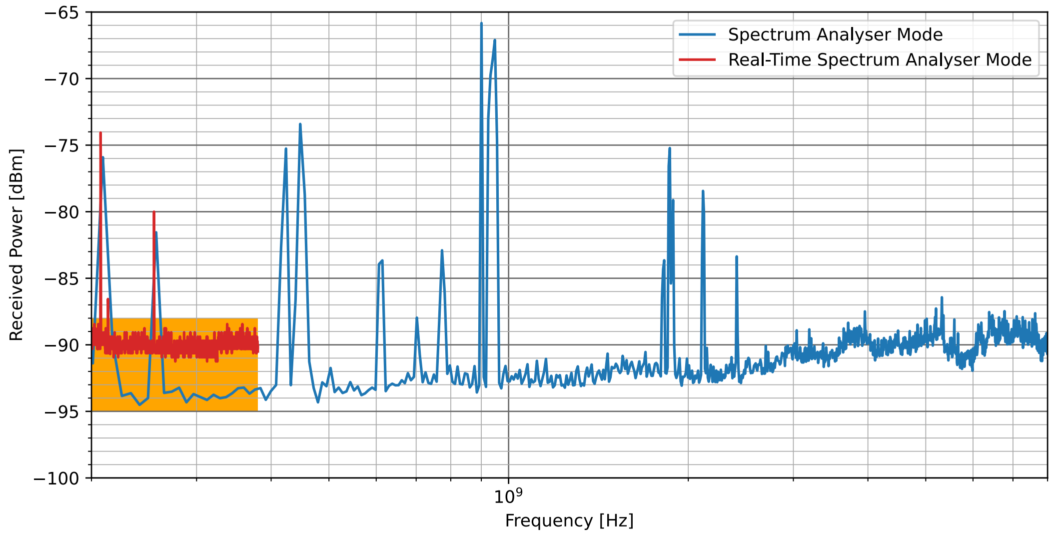


Figure 1: Radio Frequency Interference (RFI) data recorded during an RFI audit of a site. Note the discrepancy in the noise floor levels of the data captured in Spectrum Analyzer (SA) mode versus that captured in Real-Time Spectrum Analyzer (RTSA) mode (highlighted in orange). The difference in the frequency point density is of no concern for the purposes of this comparison.

3 Explanation

This noise floor discrepancy arises from differences in the implementation of the detector settings in SA and RTSA modes.

Before the explanation is presented, the detector settings are defined for both the SA and RTSA modes.

3.1 Spectrum Analyzer Mode Detector Settings

In SA mode, the detector options are defined in [1], the user manual for this device, as follows:

- **Peak:** Shows the maximum amplitude of sampled data for each display point, assuring that a narrow peak is not missed.
- **RMS/AVG:** In the default case, when the VBW/AVERAGE (Video Bandwidth) type is set to Linear, this method shows the average amplitude of sampled data for each display point. When VBW/AVERAGE type is set to Log, this method shows the traditional average of log (power), such as dBm, for each display point.
- **Negative:** Shows the minimum amplitude of sampled data for each display point. This method is also useful when measuring modulated signals to see if some frequencies are not being used.
- **Sample:** Shows the transient amplitude of the center of sampled data for each display point. This method is useful when measuring low-level signals and noise measurements. Only available in zero span and RSSI (Received Signal Strength Indicator) measurements.

These SA options are visualised in Figure 2.

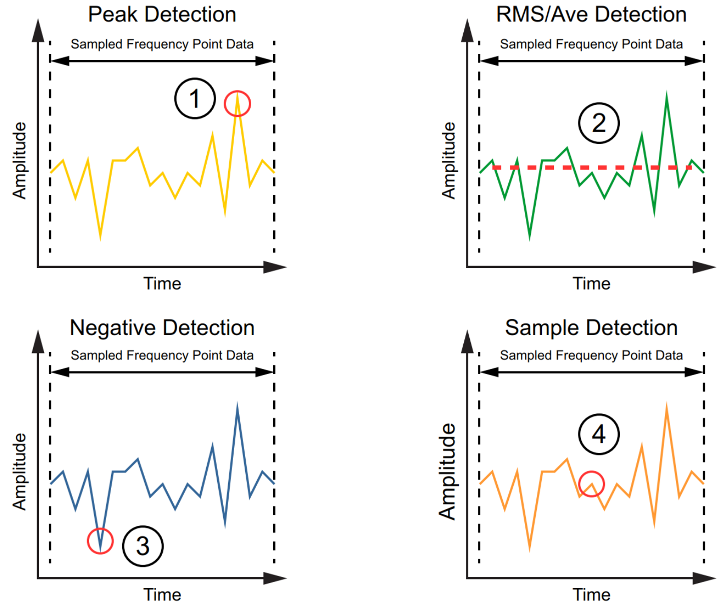


Figure 2: The detector options in the Spectrum Analyzer (SA) mode: Peak, RMS, Negative, and Sample. From [1].

3.2 Real-Time Spectrum Analyzer Mode Detector Settings

In RTSA mode, the detector options are defined in [1] as follows:

- **Peak:** Shows the maximum amplitude of sampled data for each display point, assuring that a narrow peak is not missed.
- **Negative:** Shows the minimum amplitude of sampled data for each display point. This method is also useful when measuring modulated signals to see if some frequencies are not being used
- **Sample:** Shows the transient amplitude of the center of sampled data for each display point. This method is useful when measuring low-level signals and noise measurements.

These RTSA options are visualised in Figure 3.

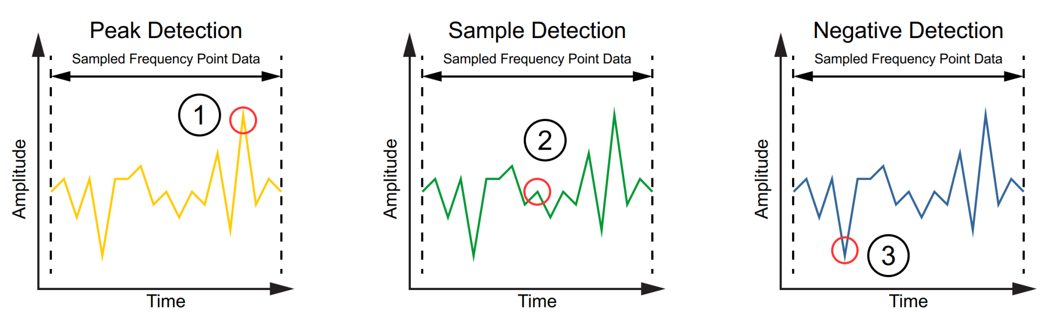


Figure 3: The detector options in the Real Time Spectrum Analyzer (RTSA) mode: Peak, Negative, and Sample. From [1].

Note how the definitions for Peak, Negative, and Sample are the same for both the SA and RTSA modes. Because of this, a user would be forgiven for thinking that the trace produced by each mode (over the same frequency range) would have the same noise floor. The following section, however, demonstrates that this is not necessarily the case.

3.3 Realised Noise Floor Demonstration

In SA mode, a magnitude (power) versus frequency plot is shown as a single trace, as demonstrated in Figure 4. In this case, the Peak detector was used.

In all scenarios in this section, the trace is set to Maximum Hold, the reference level is set to -30 dBm, the scale is set to 10 dB per division, the attenuation is set to 0 dB, the pre-amplifier is off, the RBW is set to 100 kHz, and the frequency range is set to 300-355 MHz. A 50 Ω load was attached to the input of the device for all measurements.

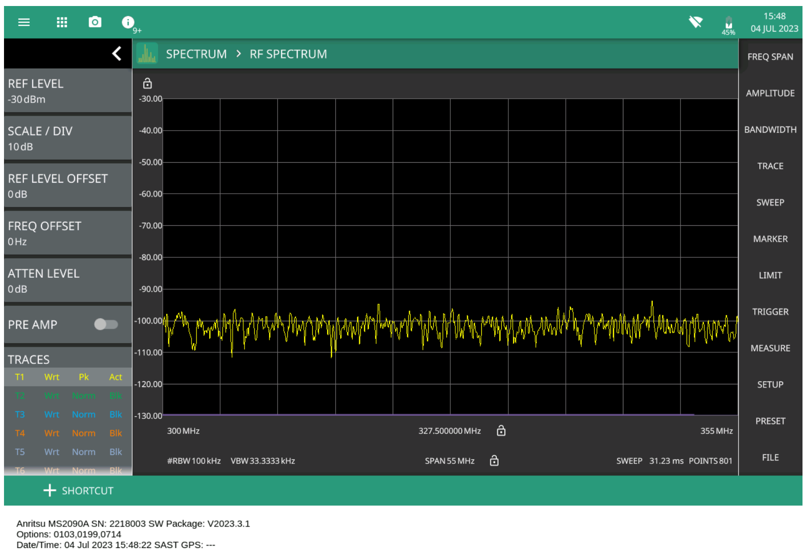


Figure 4: A typical noise floor trace shown in Spectrum Analyzer (SA) mode using the Peak detector.

However, in the RTSA mode, a magnitude (power) *spectrum* versus frequency is shown. In addition, a feint Maximum Hold trace is shown at the top of the magnitude spectrum, which in this case uses the Peak detector.

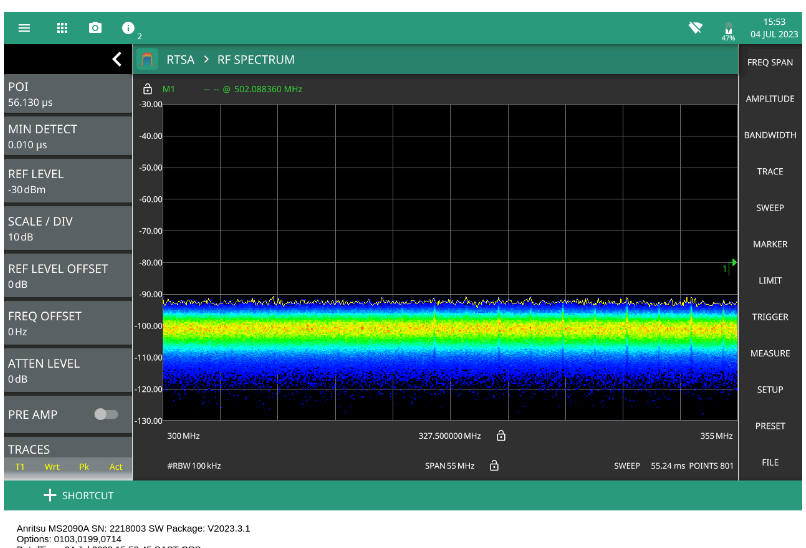
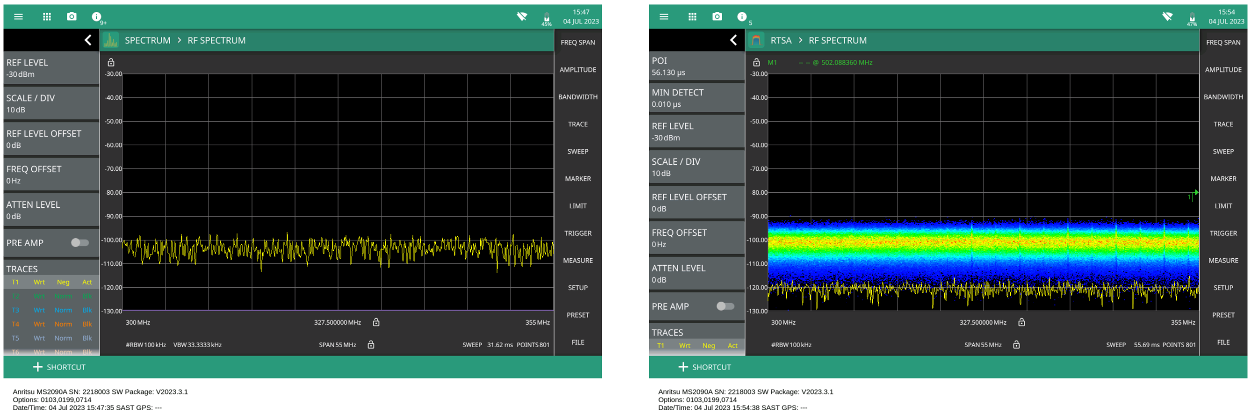


Figure 5: A typical noise floor trace shown in Real-Time Spectrum Analyzer (RTSA) mode using the Peak detector. Note the addition of a magnitude spectrum, which does not occur in Spectrum Analyzer (SA) mode.

When comparing the plots in Figure 4 and Figure 5, it is noticed that the noise floor in the RTSA mode is approximately 10 dB higher than in the SA mode - **despite equivalently-defined detector settings!**

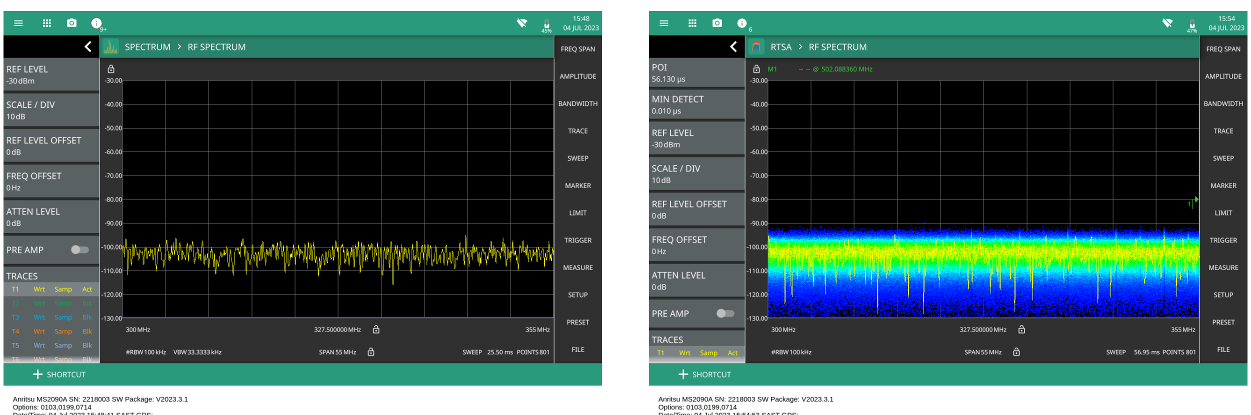
Figure 6 repeats this comparison, this time using the Negative detector. Now, the RTSA mode produces a trace which is approximately 15 dB lower than the SA mode. In this case, the SA mode trace hardly changes from that shown in Figure 4, however, the RTSA mode trace has dropped a total of 25 dB.



(a) SA Mode (b) RTSA Mode

Figure 6: Typical noise floor traces produced by the Spectrum Analyzer (SA) and Real-Time Spectrum Analyzer (RTSA) modes, shown using the Negative detector.

Figure 7 again repeats this comparison, this time using the Sample detector. This detector setting produces traces which roughly agree with each other - at least in terms of the mean. The RTSA trace, however, does have a larger magnitude range than the SA trace.



(a) SA Mode (b) RTSA Mode

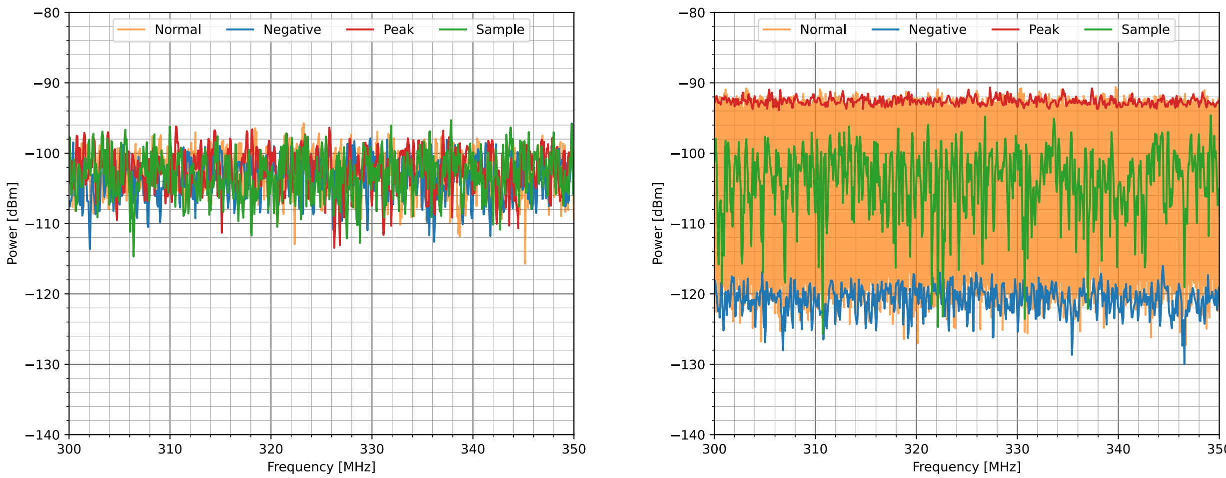
Figure 7: Typical noise floor traces produced by the Spectrum Analyzer (SA) and Real-Time Spectrum Analyzer (RTSA) modes, shown using the Sample detector.

For easier comparisons to be made, the traces from Figures 4-7 are exported and replot as Figure 8.

In addition, a new detector mode, "Normal", **which is not defined in [1]**, is included in this figure.

Note how all detector settings in the SA mode produce a spectrum which roughly equivalent means and ranges.

Now note the wider range produced by the equivalently-defined detector settings in RTSA mode. The Normal detector produces a trace with a magnitude which covers the full range of the magnitude distribution shown earlier in Figures 5, 6(b), and 7(b). The Peak and Negative detectors produce traces which cover the upper and lower envelopes of this distribution, respectively. The Sample detector again produces the trace which has the greatest mean agreement with that produced by the SA mode, although with a wider magnitude range (as mentioned previously).



(a) SA Mode

(b) RTSA Mode

Figure 8: Typical noise floor traces produced by the Spectrum Analyzer (SA) and Real-Time Spectrum Analyzer (RTSA) modes using all detector options.

4 Discussion and Conclusions

There is a temptation to reduce the discrepancy between the SA and RTSA modes by selecting the Sample detector (as this produces results with the closest mean) and using averaging (to narrow the magnitude range produced in both modes, especially the RTSA mode). While this would produce noise floor results which would agree, this would, however, defeat the purpose of the RTSA mode.

It is already accepted that the primary purpose of the RTSA mode is to continuously observe a portion of the RF spectrum, enabling any transient or infrequent signal to be detected.

Enabling averaging would lower the responsiveness of the RTSA mode - especially to quick and infrequent signals, as they would simply be filtered out by the averaging process. This would lower the sensitivity of the RTSA mode to that of the SA mode - negating its purpose.

Given that the purpose of the RTSA mode is to detect signals otherwise missed in the SA mode - thereby producing a plot which produces the highest possible power levels - using the Peak detector in the RTSA mode is the only viable option in general RFI assessments.

This will result in a noise floor discrepancy between the SA and the RTSA modes, however, understanding that this is simply a by-product of using the correct tool for the job is required.

If further insights into the time-occupancy of quick and infrequent signals are required, then either persistence plots or IQ data capture (followed by post-processing) should be investigated.

References

[1] *User Guide Field Master Pro MS2090A High-Performance Handheld Spectrum Analyzer*, Revision: P, Anritsu Company, April 2022. [Online]. Available: \url{https://dl.cdn-anritsu.com/en-us/test-measurement/files/Manuals/Users-Guide/10580-00444U.pdf}(accessedon07July2023)

ADDRESS: 5 Thierry Street, Stellenbosch, Mostertsdrift 7600 TEL: +27 (0) 76 859 0519
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