Instrument Fundamentals: Spectrum Analyzers

Presenter

ROHDE&SCHWARZ

Make ideas real

Agenda

- What is a Spectrum Analyzer?
- Types of Measurements
- Basic Spectrum Analyzer architecture
- Important Set-up parameters
- Best Practices for Spectrum Analyzer Measurements

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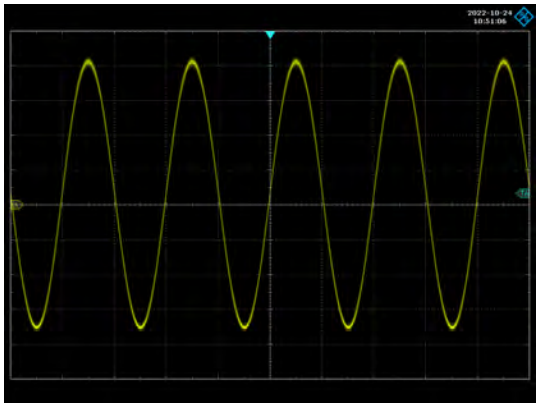
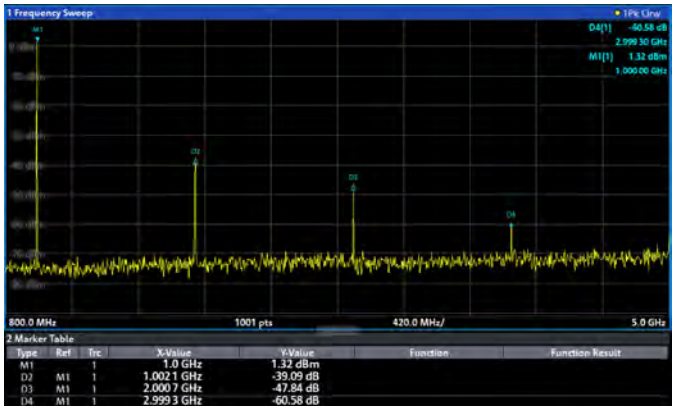
What is a Spectrum Analyzer

- Measures the Frequency & Amplitude of an RF Signal in the Frequency Domain.
- What is Frequency Domain?
  - Compare Time Domain vs Frequency Domain.

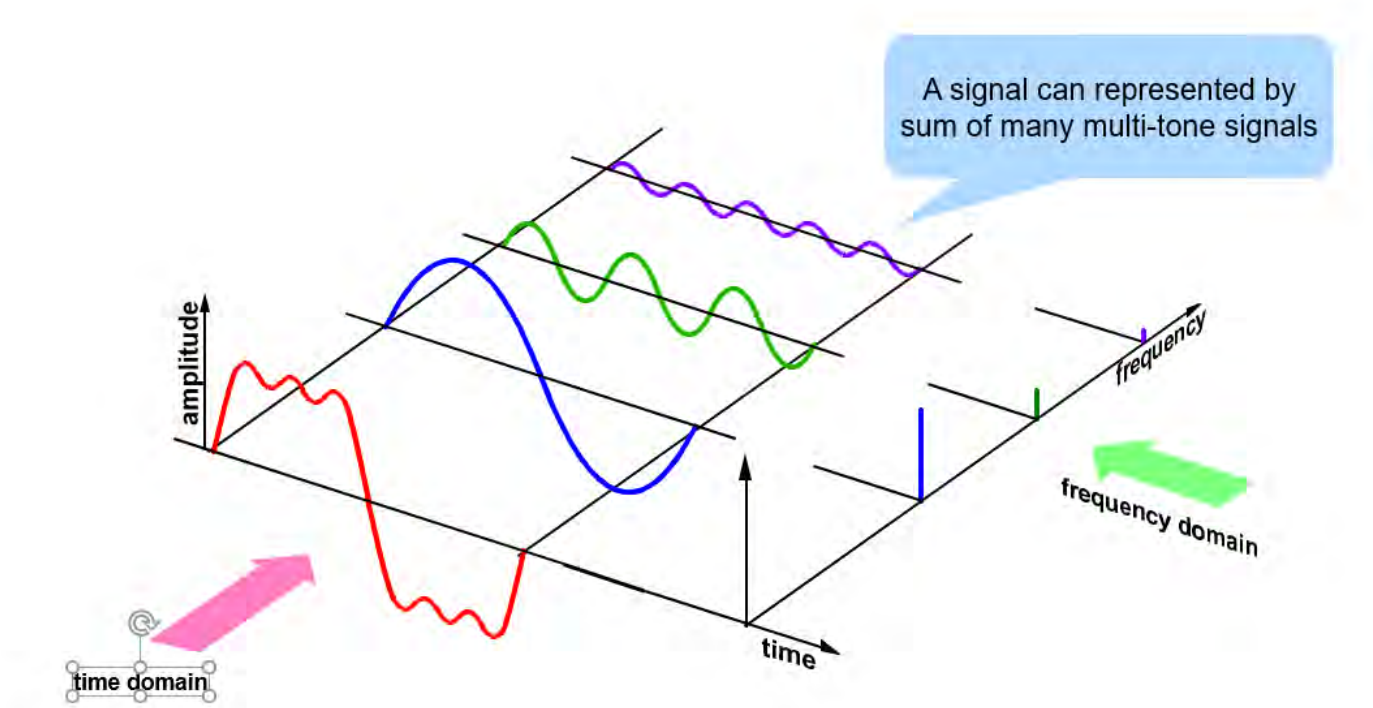


Time Domain



Frequency Domain

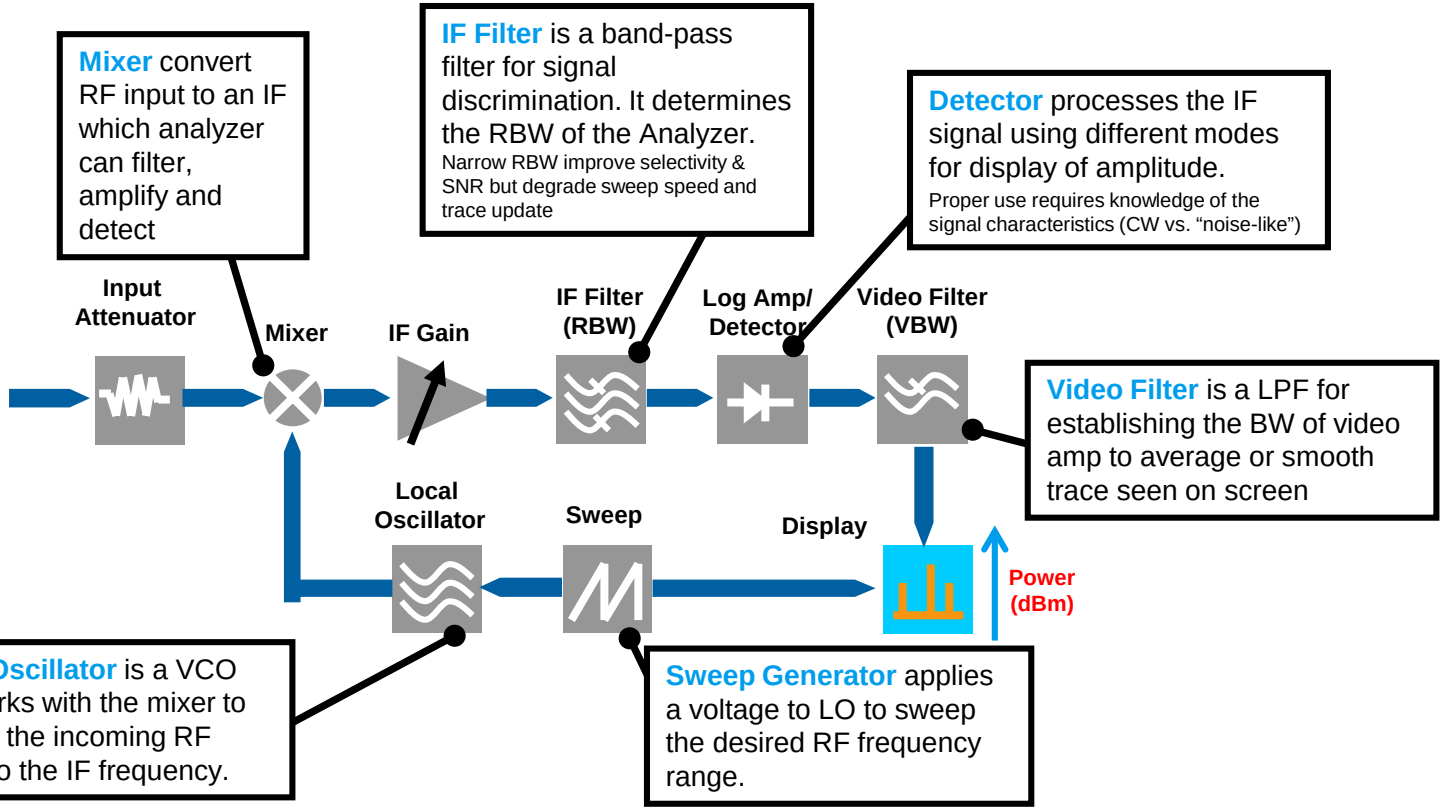
Comparing time domain vs frequency domain



Types of Measurements

- Frequency and Amplitude of signal
- Delta (dBc) of multiple Signals
  - Intermodulation distortion (IMDs)
  - Adjacent channel leakage ratio
  - Harmonics & Spurious signals
- Amplitude modulation parameters
  - AM Depth, modulation frequency
- Frequency modulation parameters
  - Deviation, modulation index ratio
- Pulsed signals
  - Pulse width, pulse repetition rate
- Signal analysis of modulated waveforms

Architecture



Set-up Parameters

Frequency

Span

Reference Level

Detector

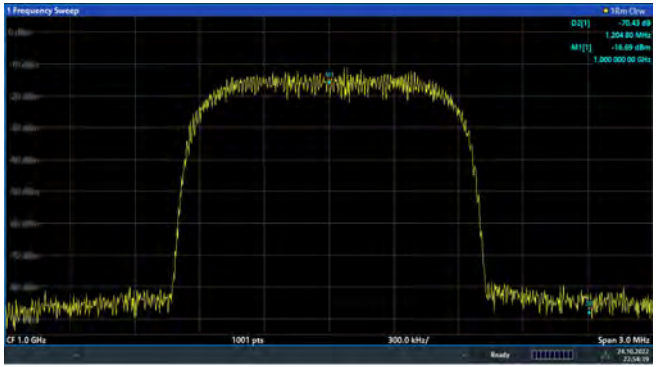
RBW

Sweep

Frequency - Span - Start / Stop

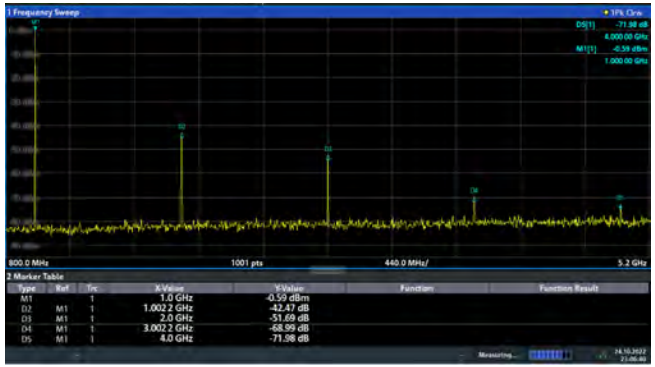
Center / Span

Observe close in on a single signal / waveform



Start / Stop

Observe harmonics / spurious of signal / waveform

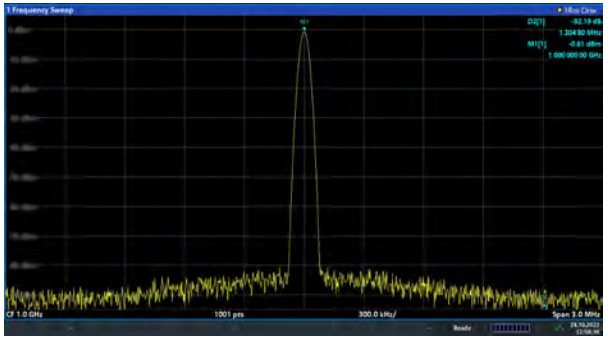


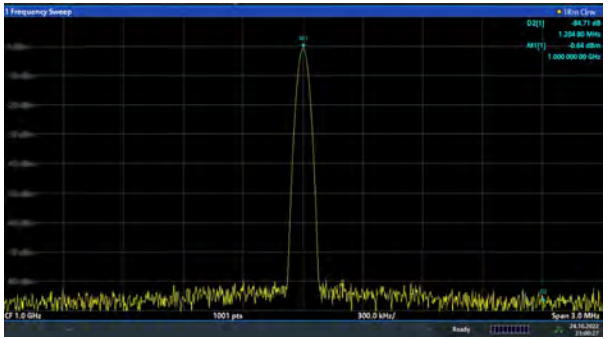
Reference Level

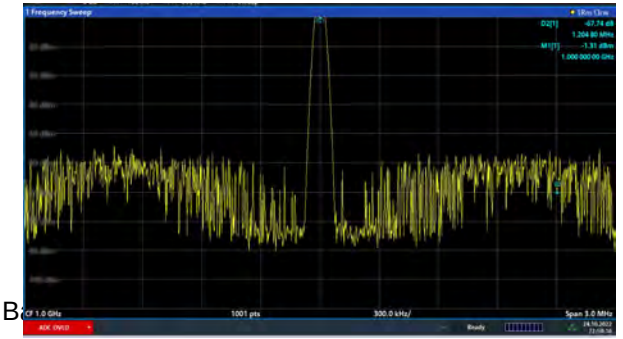
- Sets the level at the top of the Display
  - Set this to the peak power of the signal

- Sets the gain of the IF stage, incorrect level will effect the dynamic range or cause compression.

  - ✓ Too high = less dynamic range
  - ✓ Too low = Compression / overload

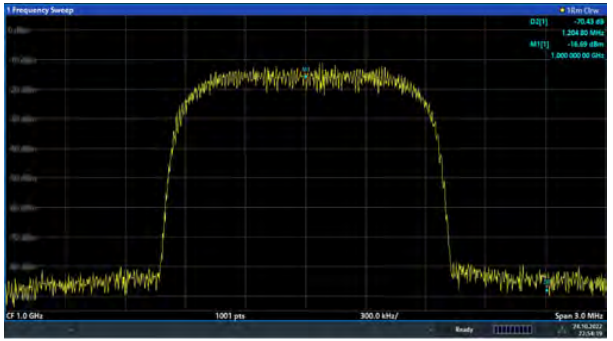


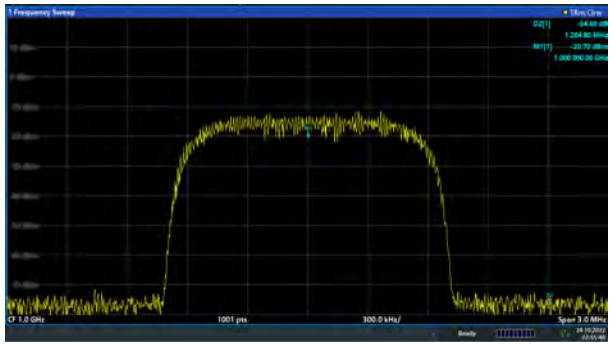


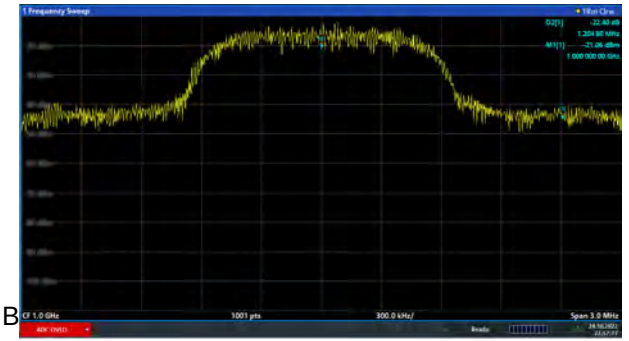


Reference Level cont.

- Consider digitally modulated waveforms
- Setting the ref. level too high will produce the same effect as a CW signal
- Setting the Ref. Level too low may not be apparent.
- Digitally modulated signals have a peak to average ratio or Crest factor







Detector settings

Auto Peak

Displays highest & lowest draws a line between them

Positive Peak

Displays highest value

Negative Peak

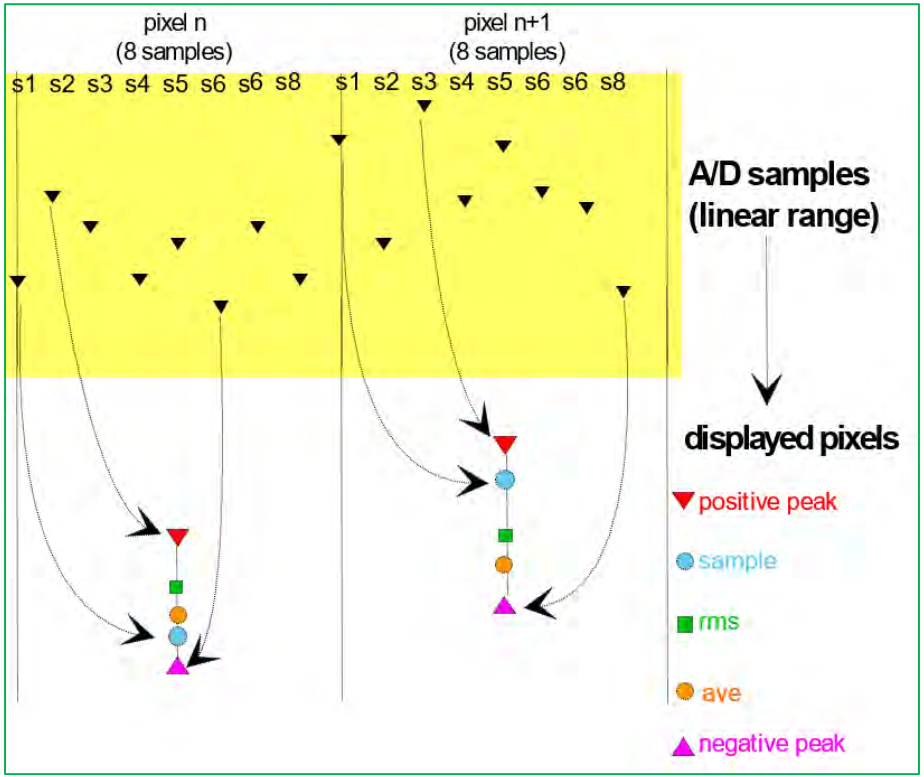
Displays lowest value

Average detector (voltage average)

Averages noise voltage, then converts to power

Reading lower by 1.05 dB

$$V_{ave} = \frac{1}{N}\sum_{i=1}^{N} s_i$$



Detector settings continued

Sample detector

Displays the first result

Can be anywhere between + peak & - peak

Sample detector & trace averaging

Noise averaging is done on a log scale

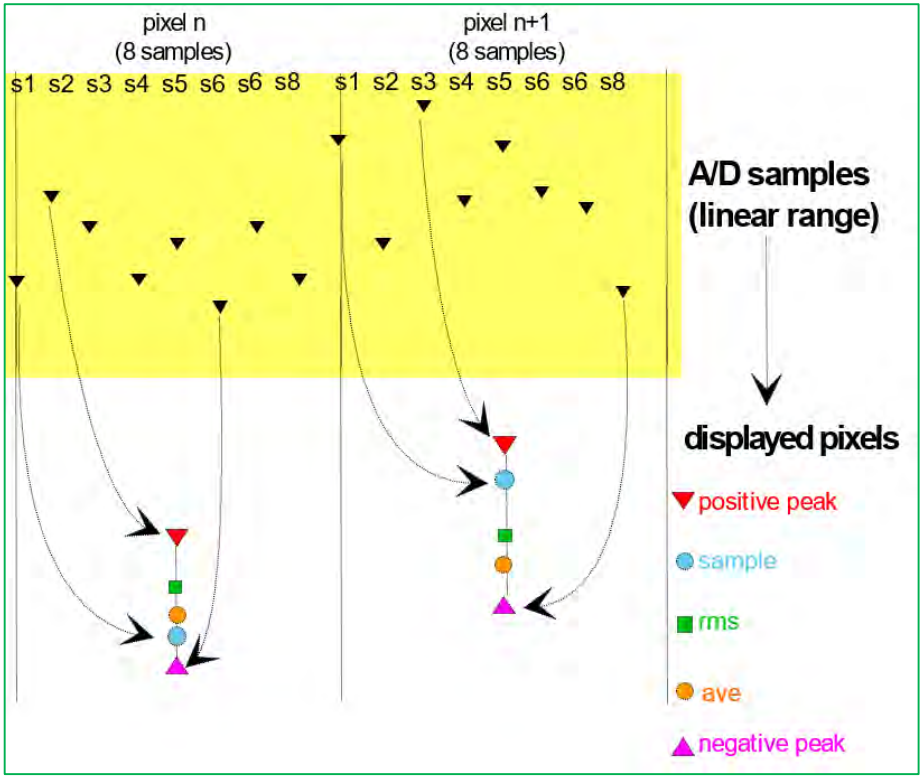
Reading error 2.51 dB

RMS detector (power average)

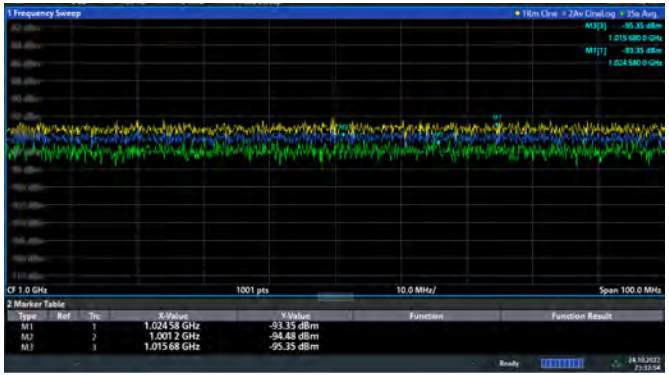
RMS detector reports the true noise power.

(The RMS value…)

$$V_{rms} = \sqrt{\frac{1}{N}\sum_{i=1}^{N} s_i^2}$$



Detector Summary



CW signals – any detector

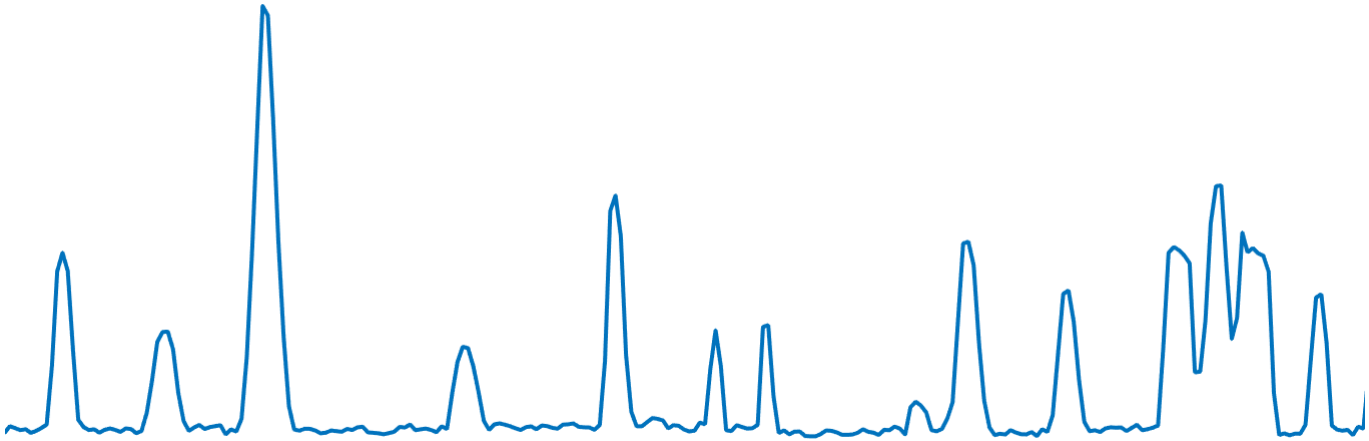
Noise (digital modulated) - RMS true noise results

Need to smooth trace - slow the sweep time
get more samples to calculate

RMS = yellow
Average = Blue
Sample /trace average = Green

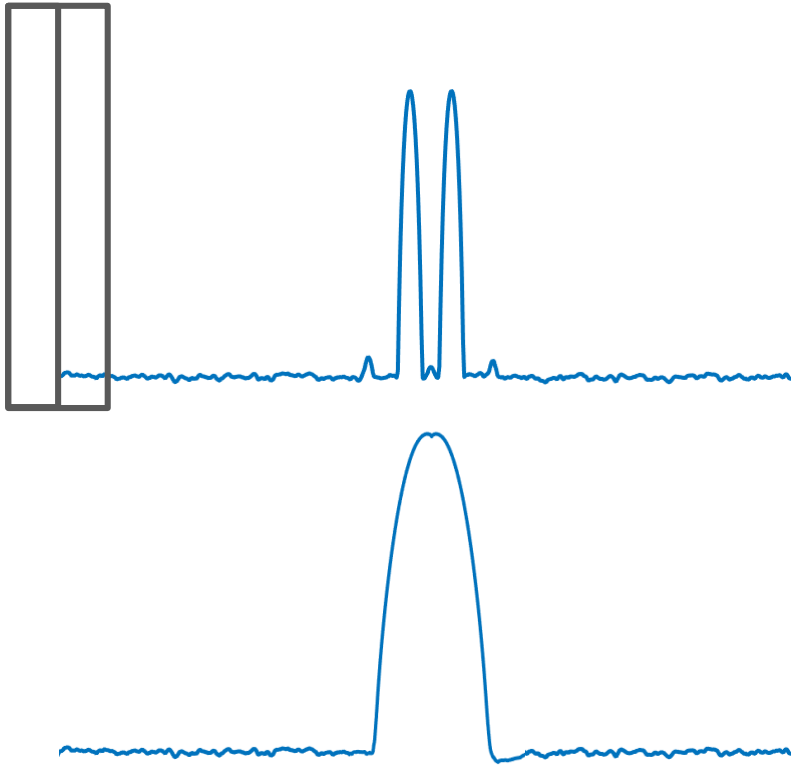
Recommend
Don’t use Sample or Average detector

Resolution Bandwidth (RBW) - concept

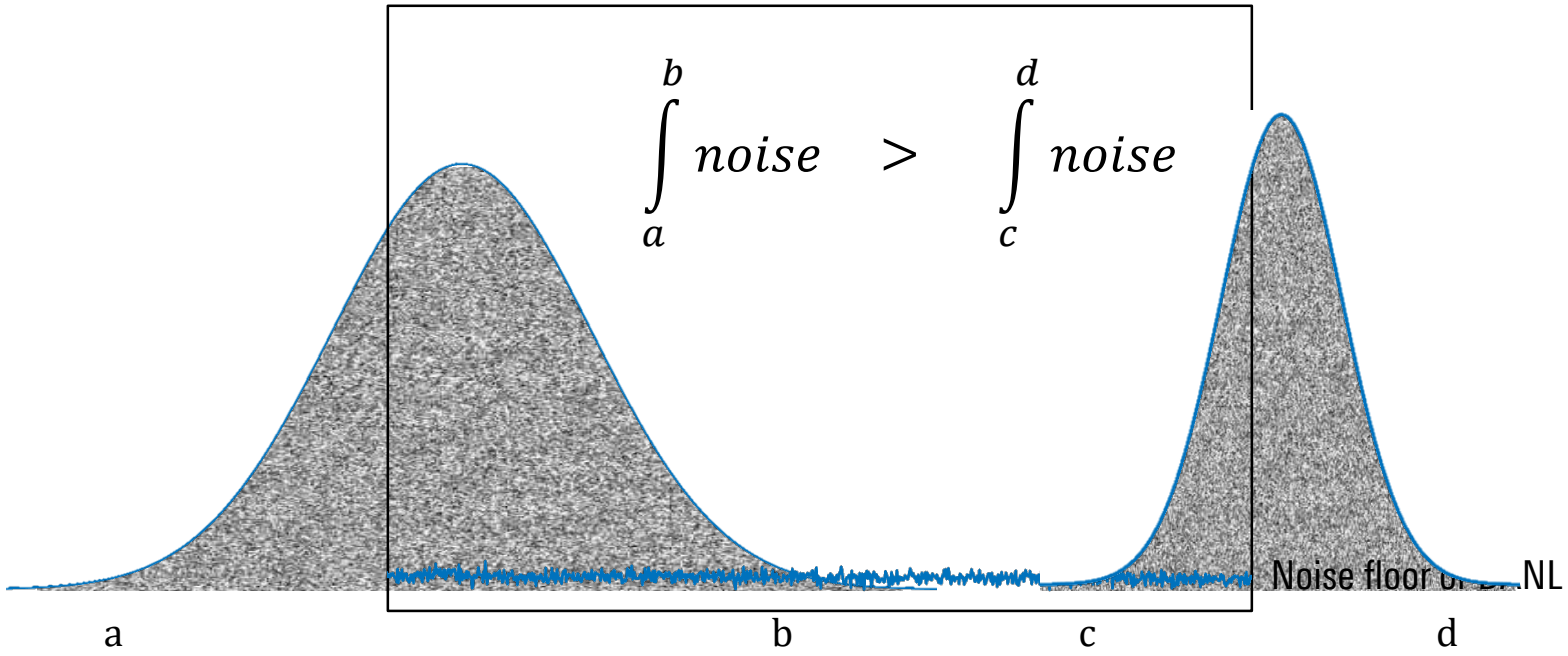


Resolution Bandwidth (RBW) - How it really works

RBW – resolving signals



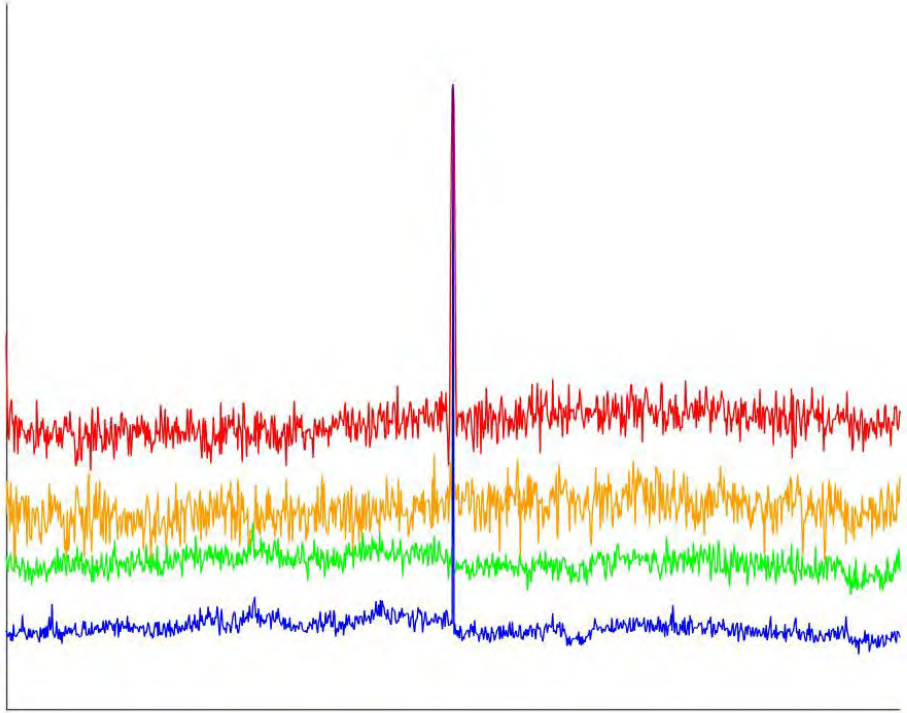
RBW and Noise (DANL)



RBW effects on noise floor of Measurements

Decreasing resolution bandwidth by a factor of 10 lowers the noise floor (DANL) by approximately 10 dB

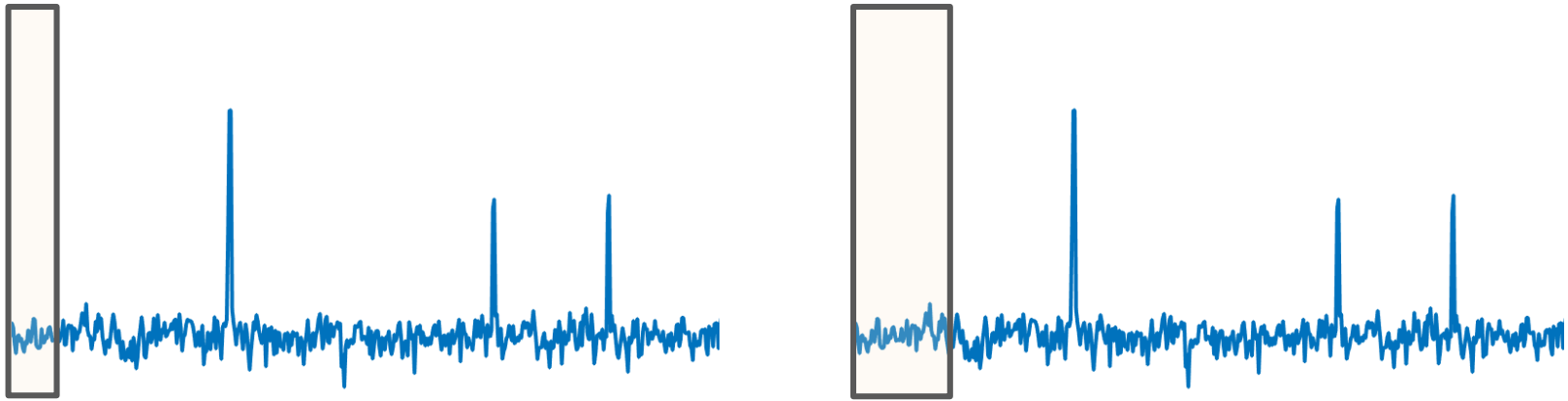
RBW = 3 MHz	-73 dBm
RBW = 300 kHz	-84 dBm
RBW = 30 kHz	-93 dBm
RBW = 3 kHz	-104 dBm



Span = 2 GHz

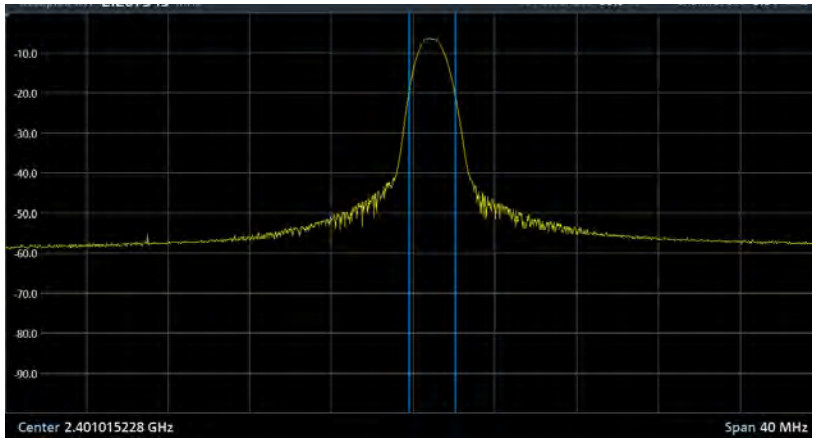
RBW effects on sweep speed

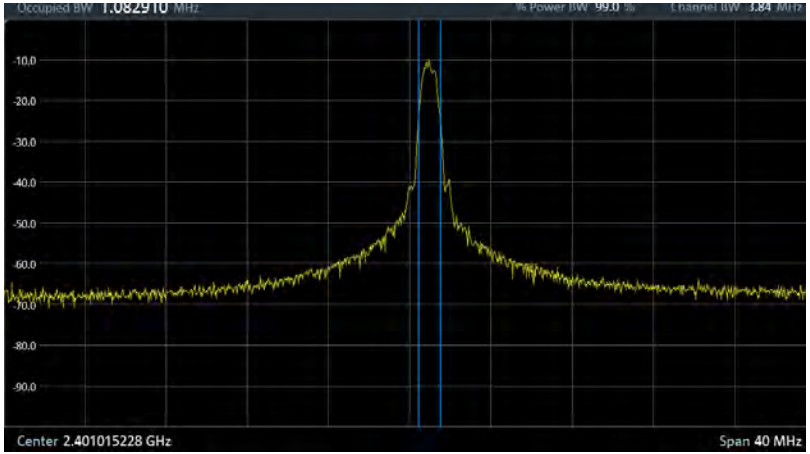
- Narrow filters take longer to settle than wide filters
- We must sweep more slowly at lower resolution bandwidths
  - Sweeping too quickly causes amplitude and frequency errors
- Most analyzers compute sweep time automatically based on RBW and span



RBW effects on signal bandwidth

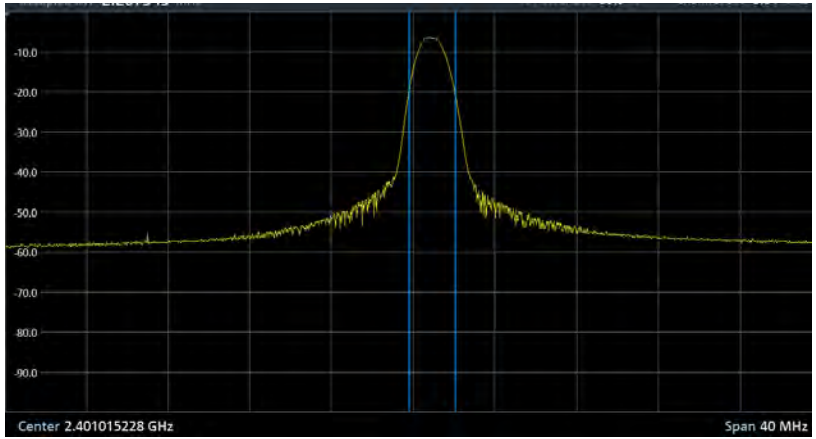
- RBW setting affects signal measurement
- RBW too wide makes edges of signal wider than they actually are

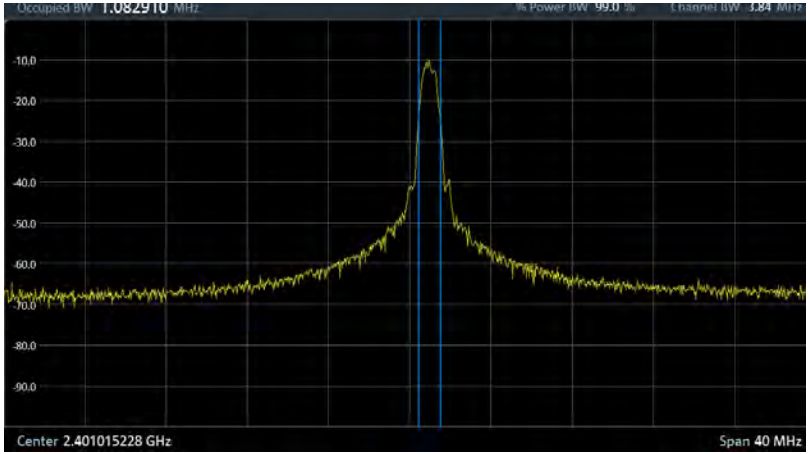




RBW effects on signal bandwidth

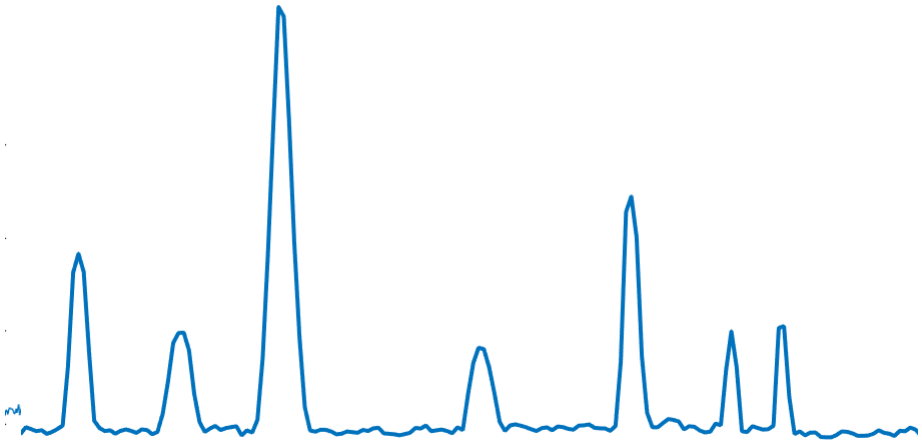
- RBW setting affects noise floor
  - Wide RBW lets in more noise. Narrow RBW lets in less noise
- To reduce noise level by 10dB, set ten times narrower RBW.





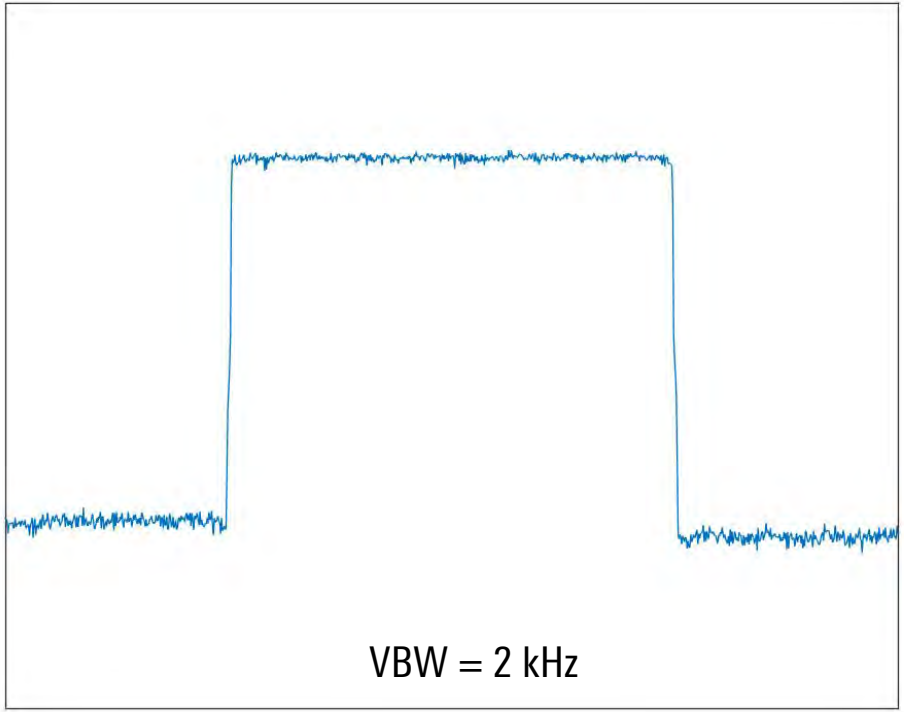
Video Bandwidth (VBW)

- What do we mean by “video” signal?
  - Video from earlier analyzers using CRT
  - VBW is a filter used to average or smooth the displayed trace.
- Video bandwidth affects the display – not the way the signal is measured.
  - **Unlike** resolution bandwidth



VBW Example

- Lowering video bandwidth
  - reduces noise on the trace
  - does **not** lower the noise floor
  - does **not** improve frequency resolution or signal separation



VBW

Video Filter BW set to:

VBW = 1 MHz

Video Filter BW set to:

VBW = 300 Hz

Note:
Signal Amplitude Unchanged by narrower VBW! (within reason)

- Video filtering is part of digital data processing
- Smaller VBW reduces the peak to peak variability of a noisy signal
  - For better trace readability

Best Practices to better measurements

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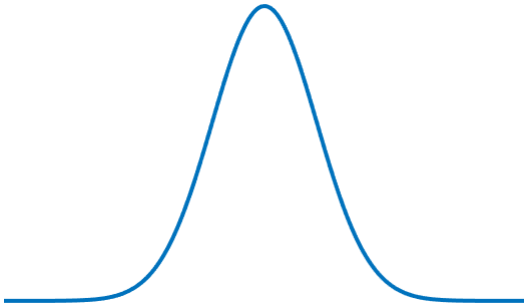
Best Practices : Center Frequency, Span, Reference Level

- Start from a PRESET State
- First three settings are Center Frequency, Frequency Span and Reference Level
- Set Reference Level equal to highest signal
- Markers can be used to identify frequency of your signal
- A narrower Frequency Span improves speed of measurements
- RBW vs speed

Choosing RBW

- Optimal RBW depends on the signals being measured
  - Trade off between speed and selectivity / noise
- Decreasing RBW:
  - Selectivity increases
  - Noise floor drops
  - Sweep time (rapidly) increases
- RBW is usually only selectable in certain steps (1-10 or 1-3-10 sequence)



Best Practices RBW

- Leave in Auto whenever possible
- Decrease to resolve closely spaced signals
- Decrease to accurately measure signal shape
- Decrease to reduce noise floor

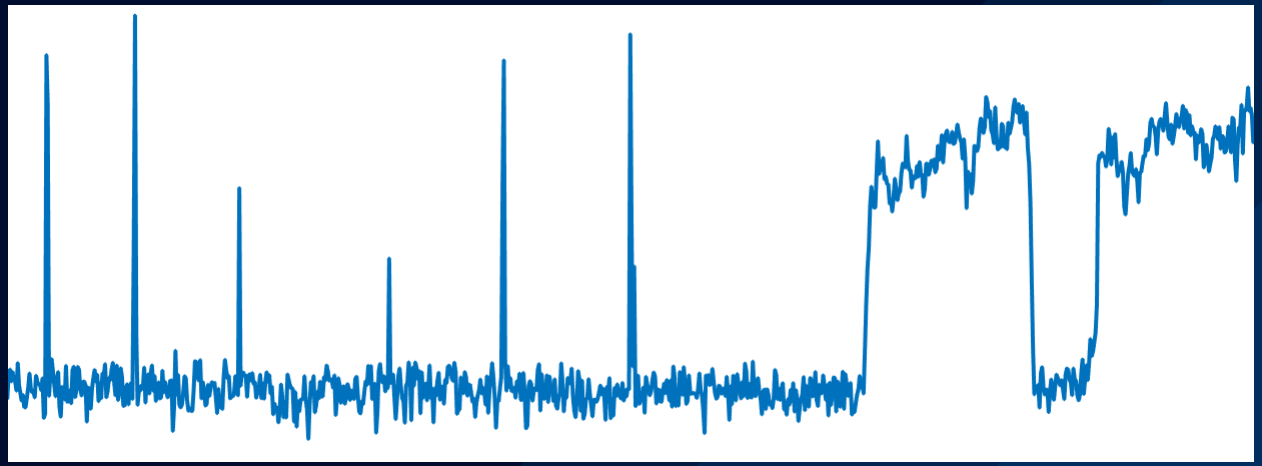
Choosing VBW

- Video bandwidth only changes the appearance of the trace
- Modern spectrum analyzers automatically configure VBW based on other parameters like RBW.
- Narrower video bandwidths are sometimes “better” since they reduce noise
  - However, narrower VBWs increase the sweep time.

Best Practices VBW

- Leave in Auto unless otherwise required
- Use to smooth Noise
- Don’t lower it too much

Best Practices to better measurements



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