Spectrum Analyzer

Spectrum Management Training Program

Elective Module EM1-Option 1 : Spectrum Monitoring

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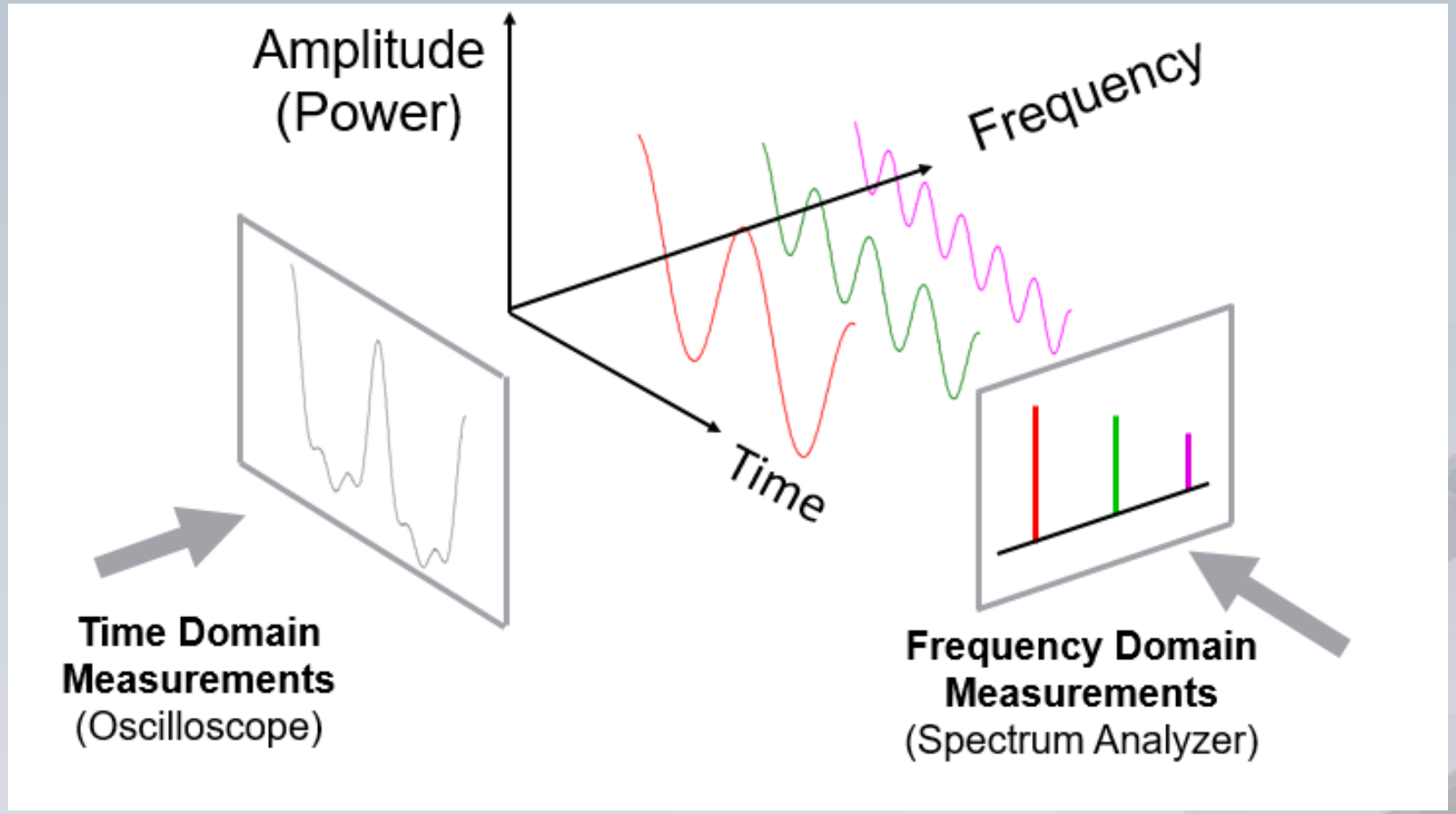
Outline

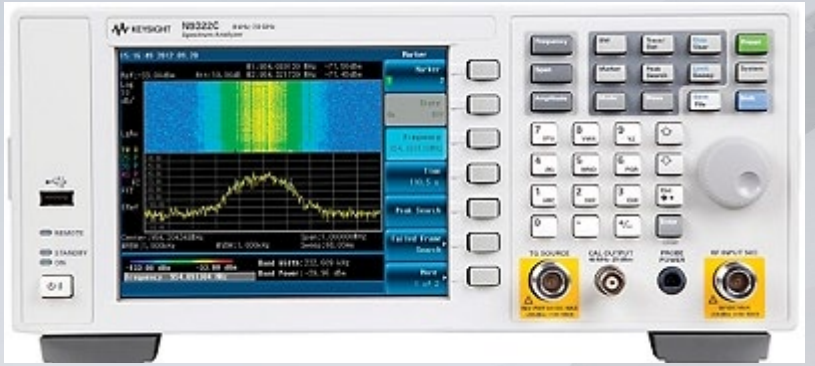
- Time Domain VS Frequency Domain
- Spectrum Analyzer Types
- Spectrum Display Screen
- Theory of Operation
- Spectrum Analyzer Settings
- Spectrum Analyzer Measurements

Time-Domain vs Frequency-Domain



Spectrum Analyzer

- Measures the magnitude of an input signal versus frequency within the full frequency range of the instrument.
- The primary use is to display and measure Amplitude vs. Frequency of known and unknown RF and Microwave signals.



Spectrum Analyzer Types

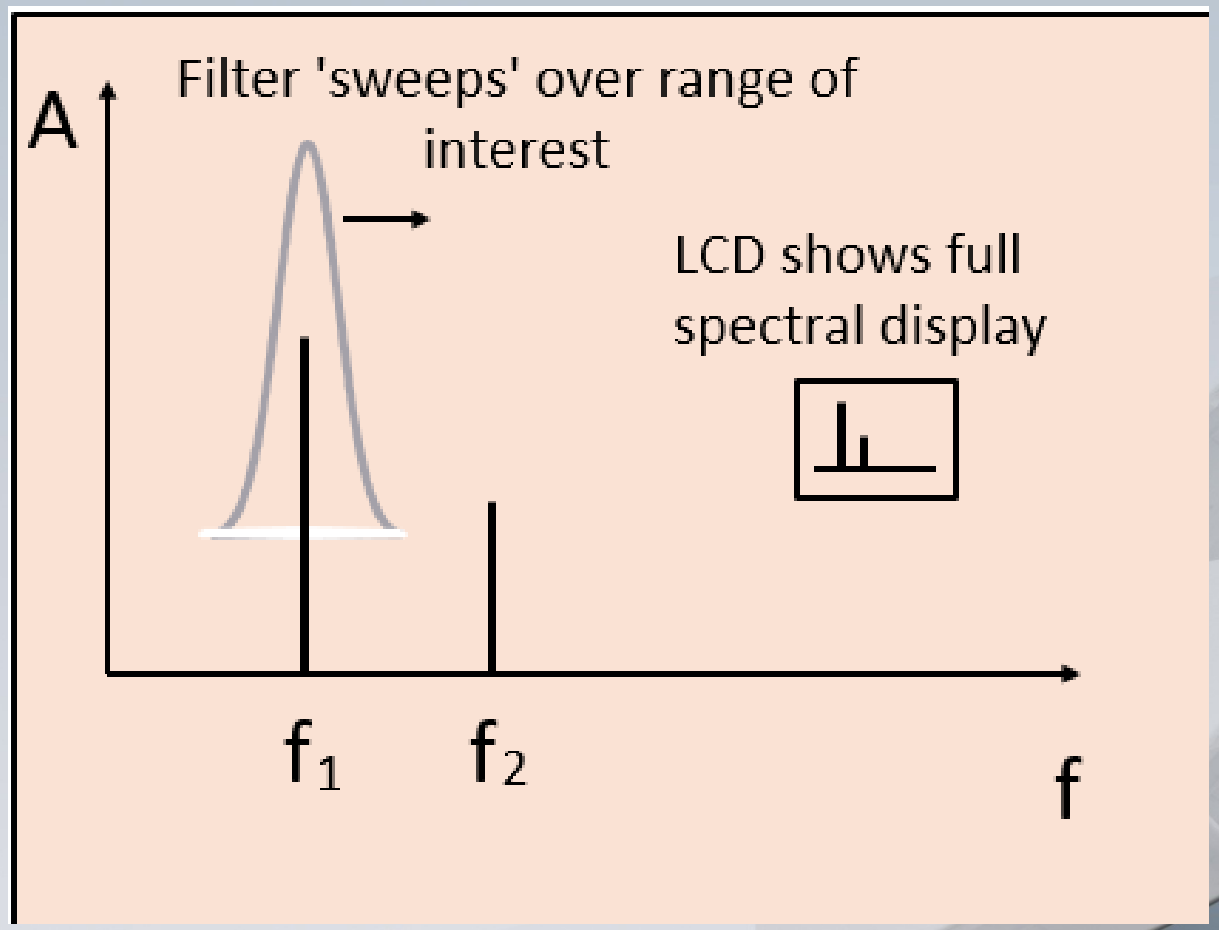
1. **Sweep Analyzer**

   Based on super-heterodyne configuration that used a voltage control oscillator and mixer and intermediate frequency filter.

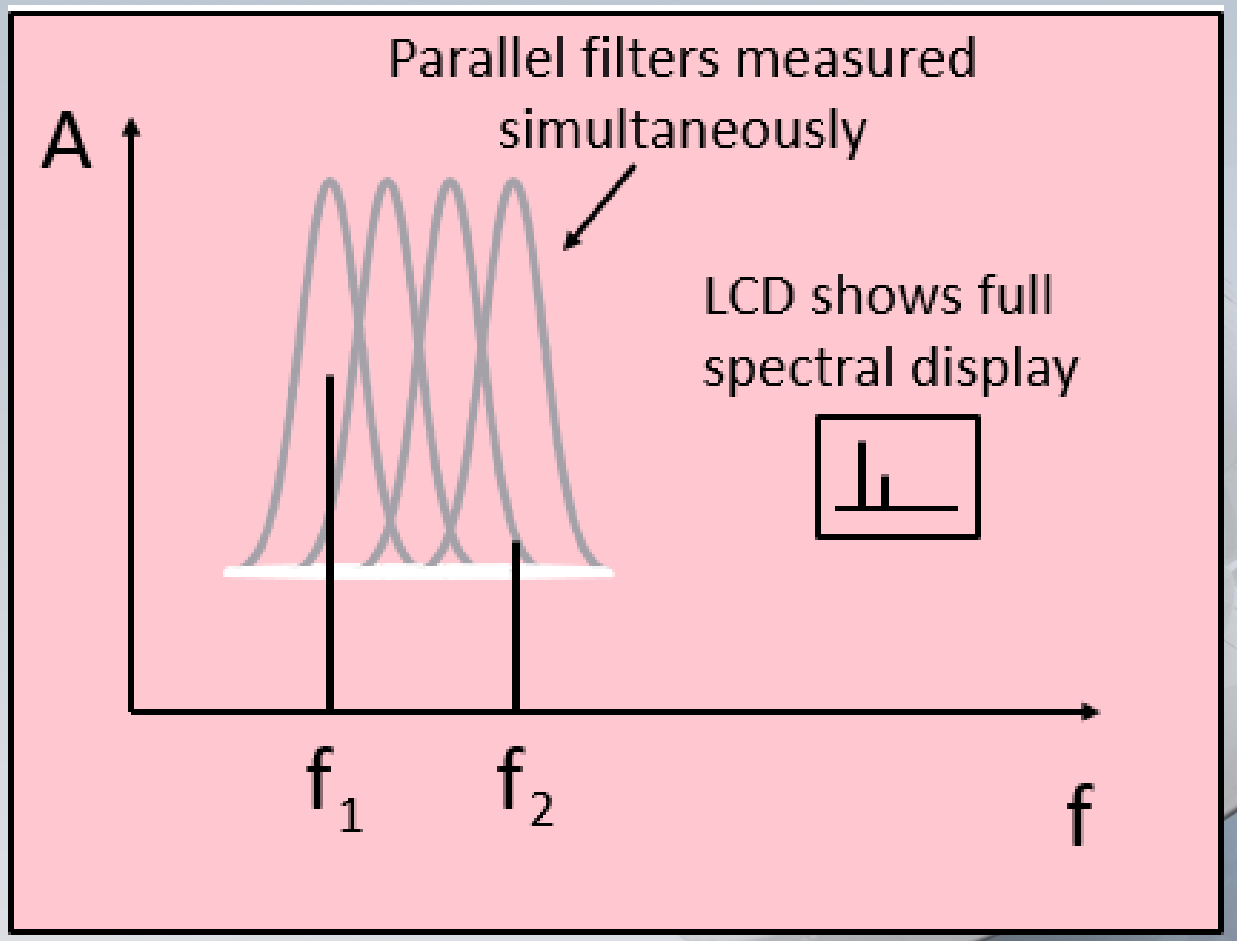
2. **Fast Fourier Transform (FFT) Analyzer**

   Based on the conversion of time domain waveform to the frequency domain using digital signal processing (real-time spectrum analyzer implementation).

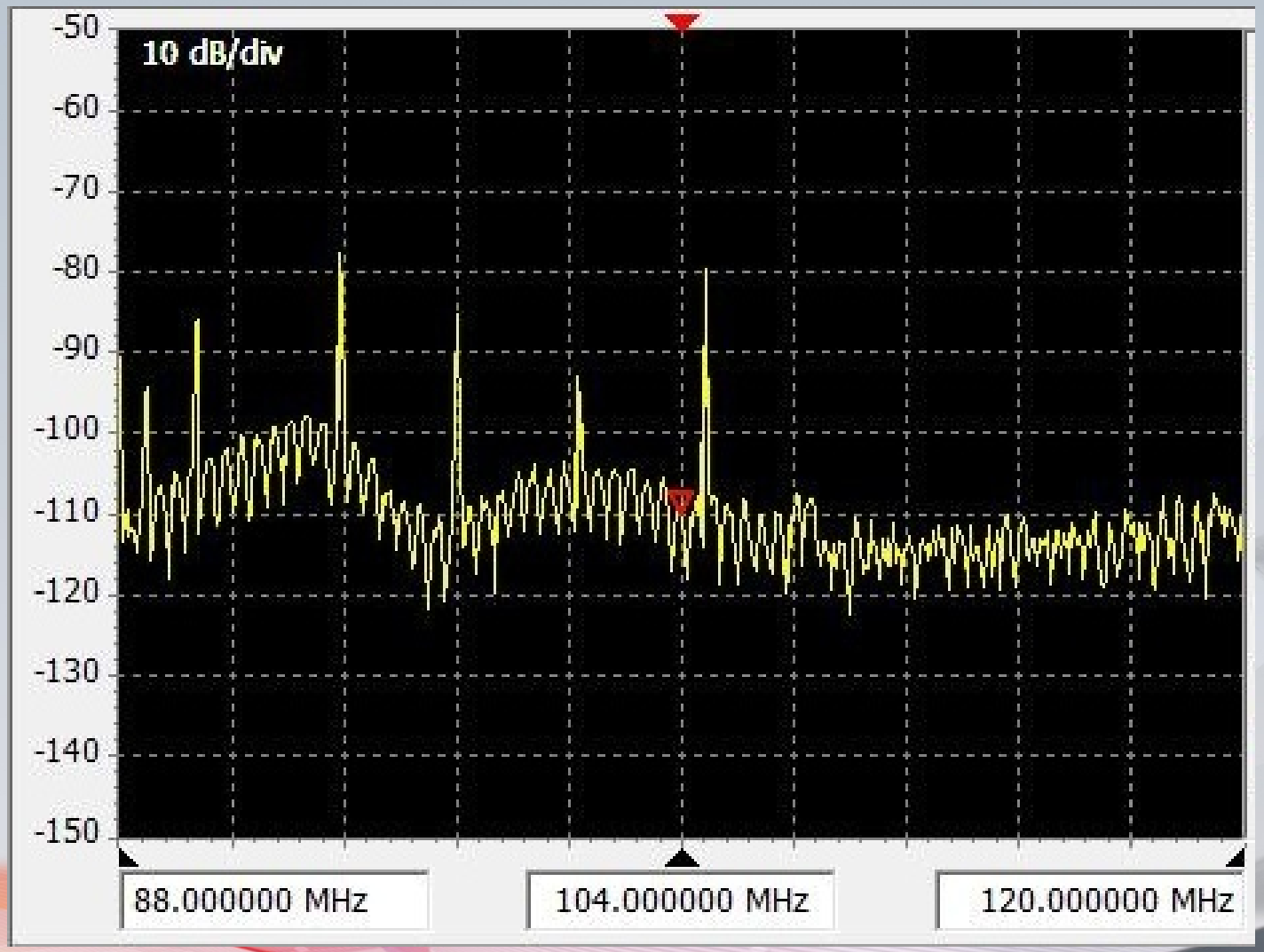
Sweep Analyzer



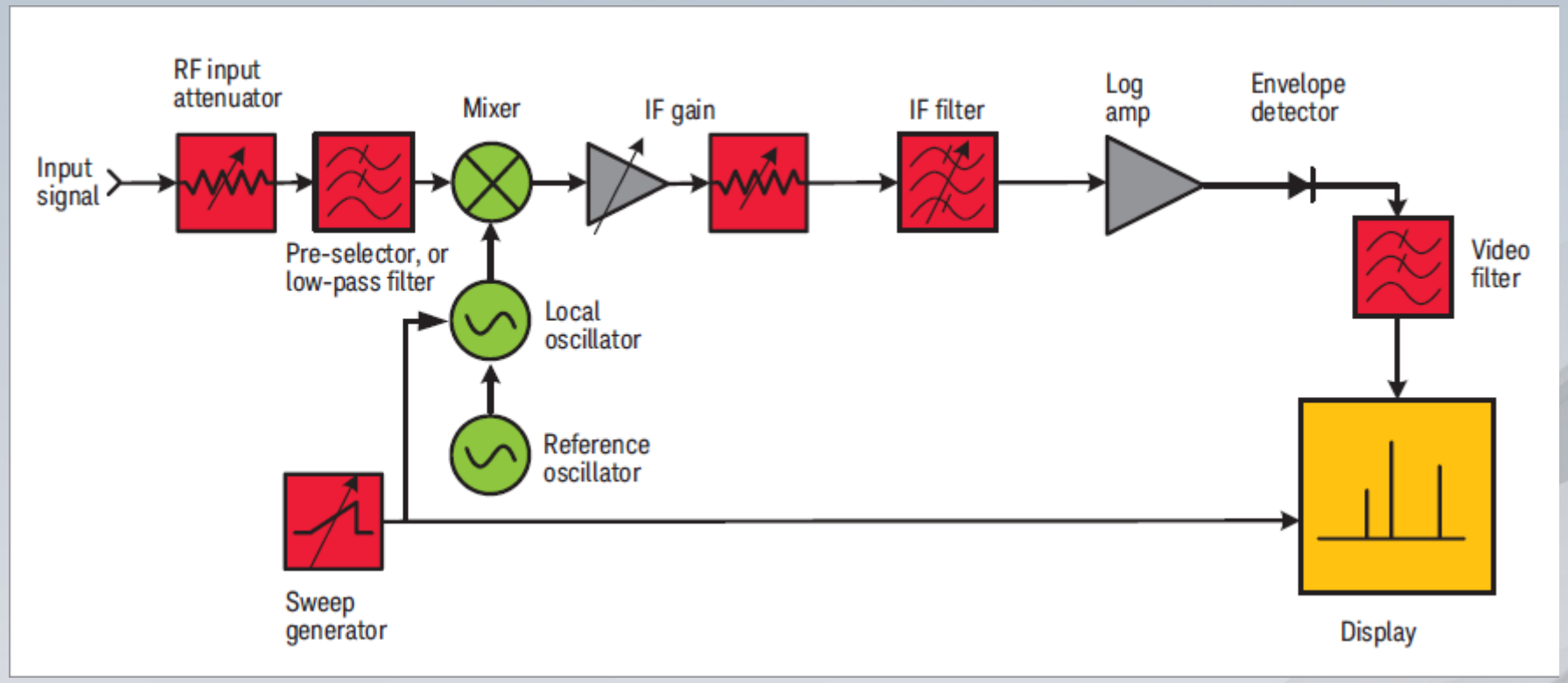
FFT Analyzer



Spectrum Display Screen



Theory of operation



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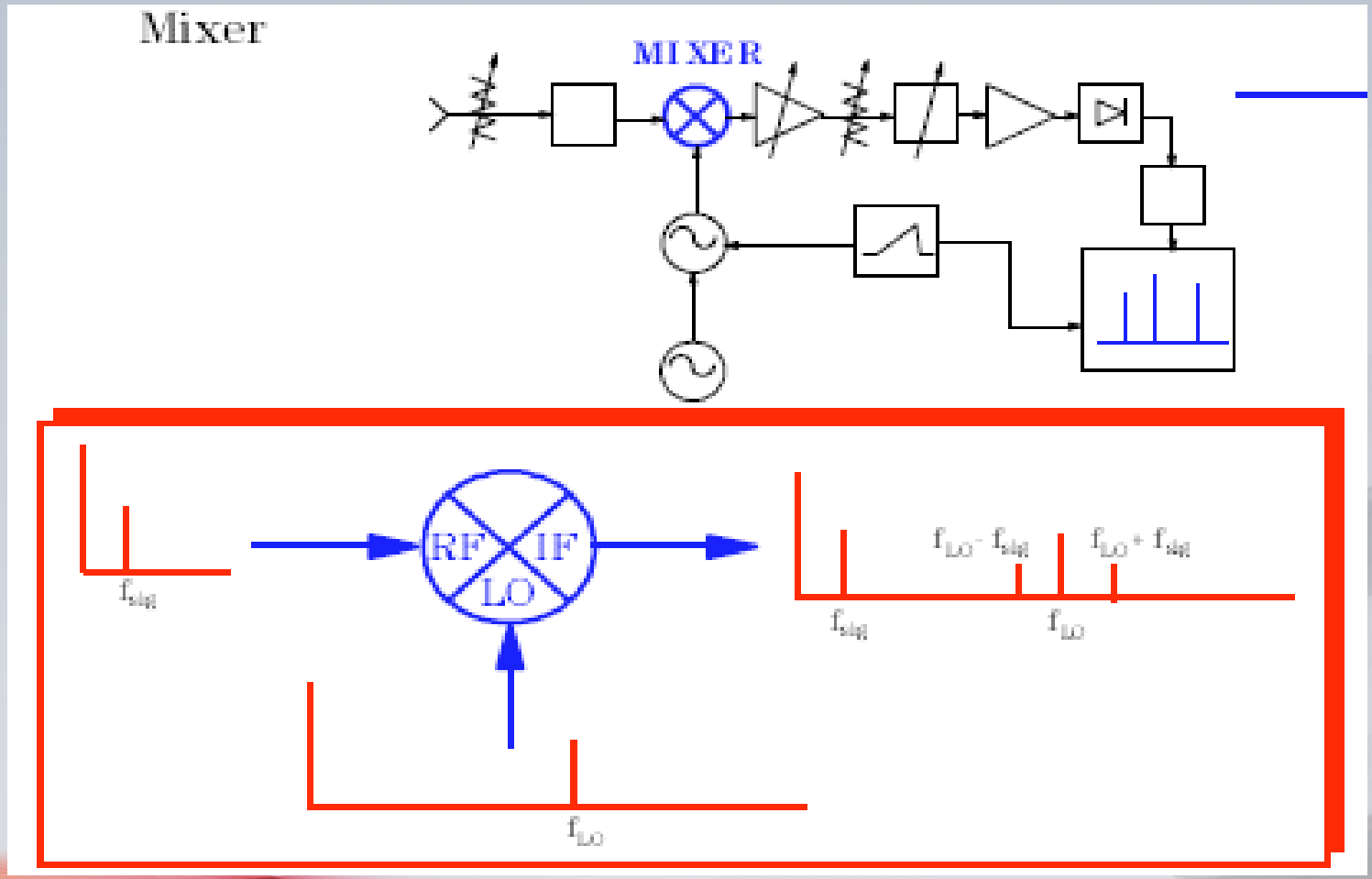
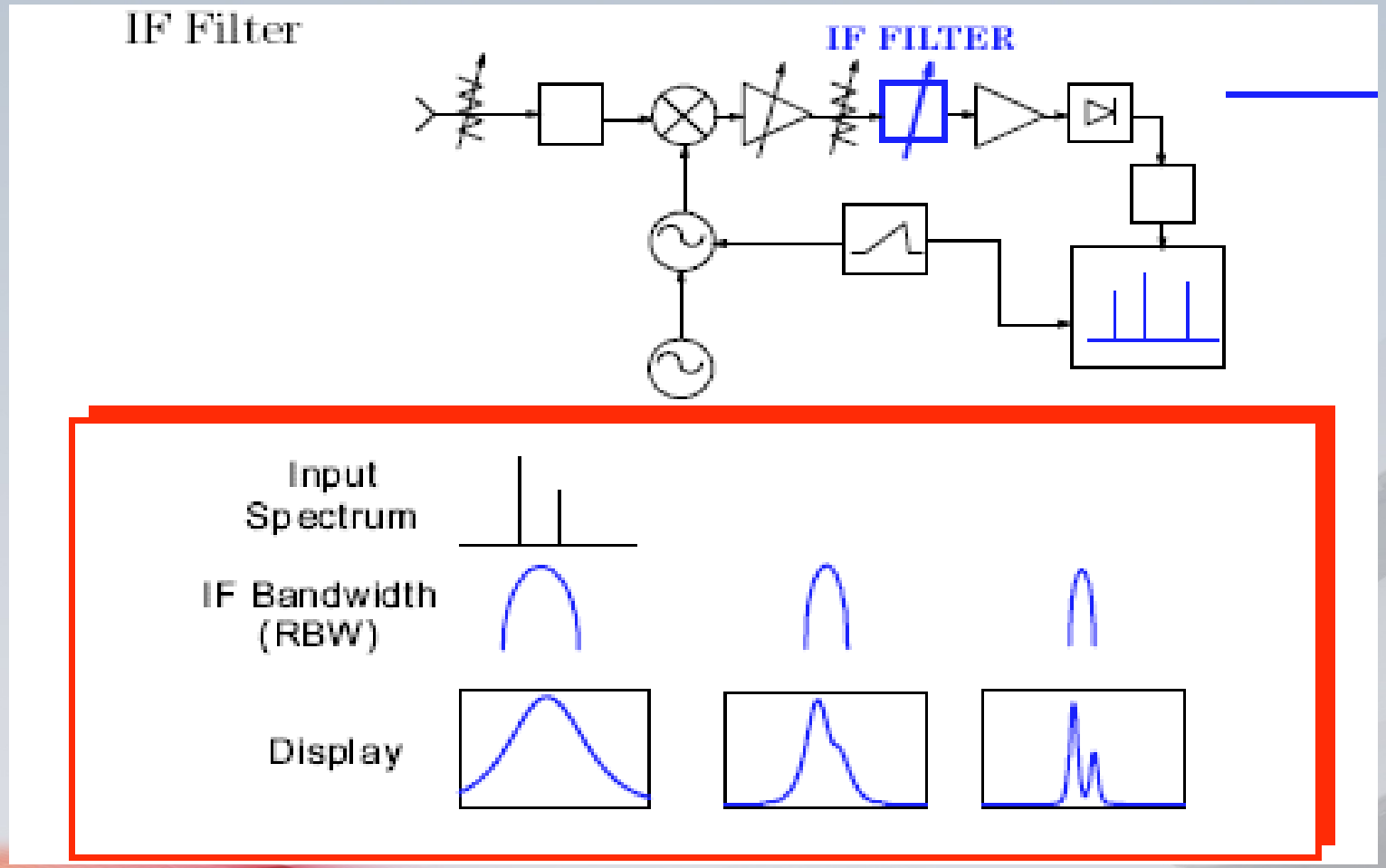
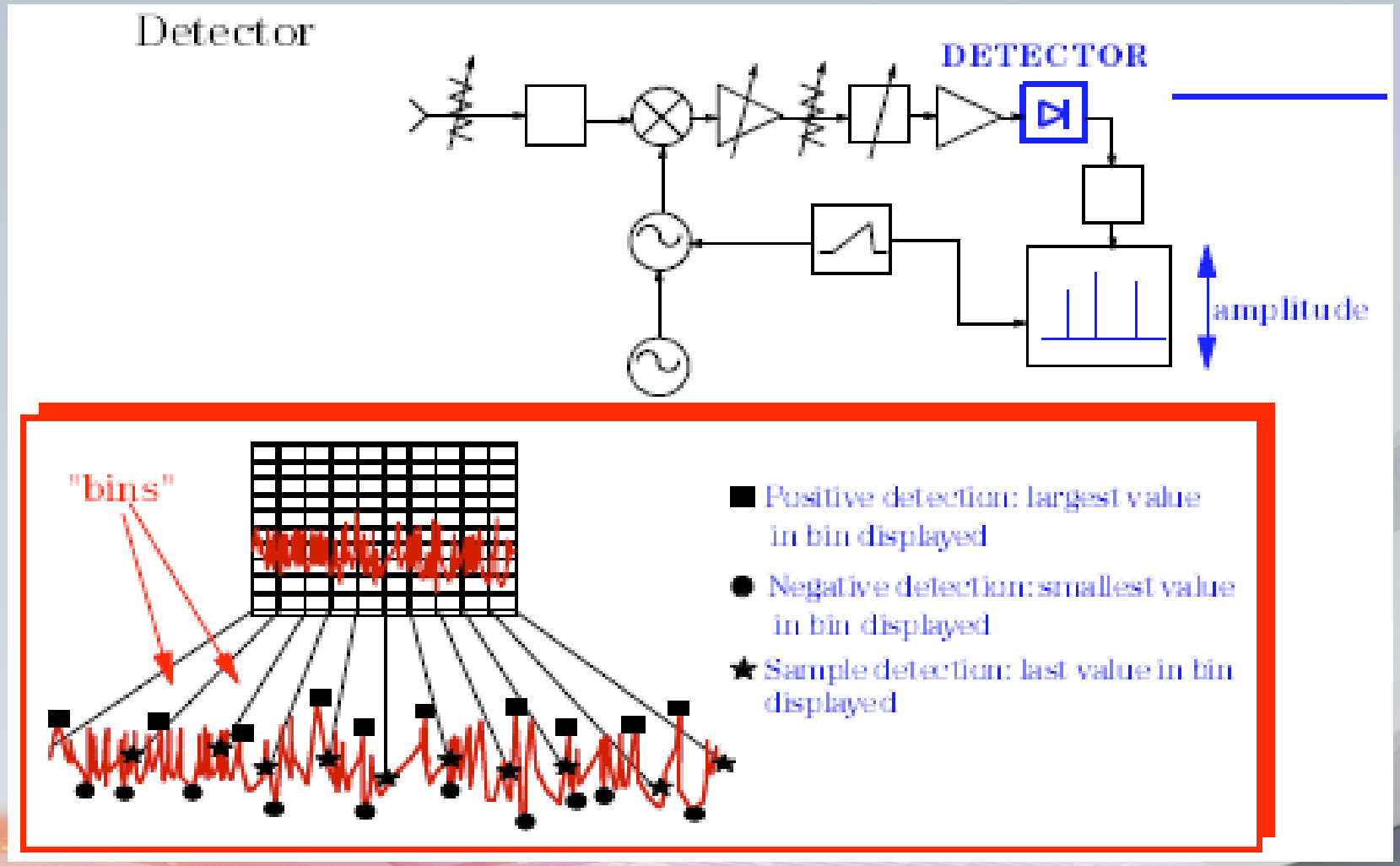
Theory of operation



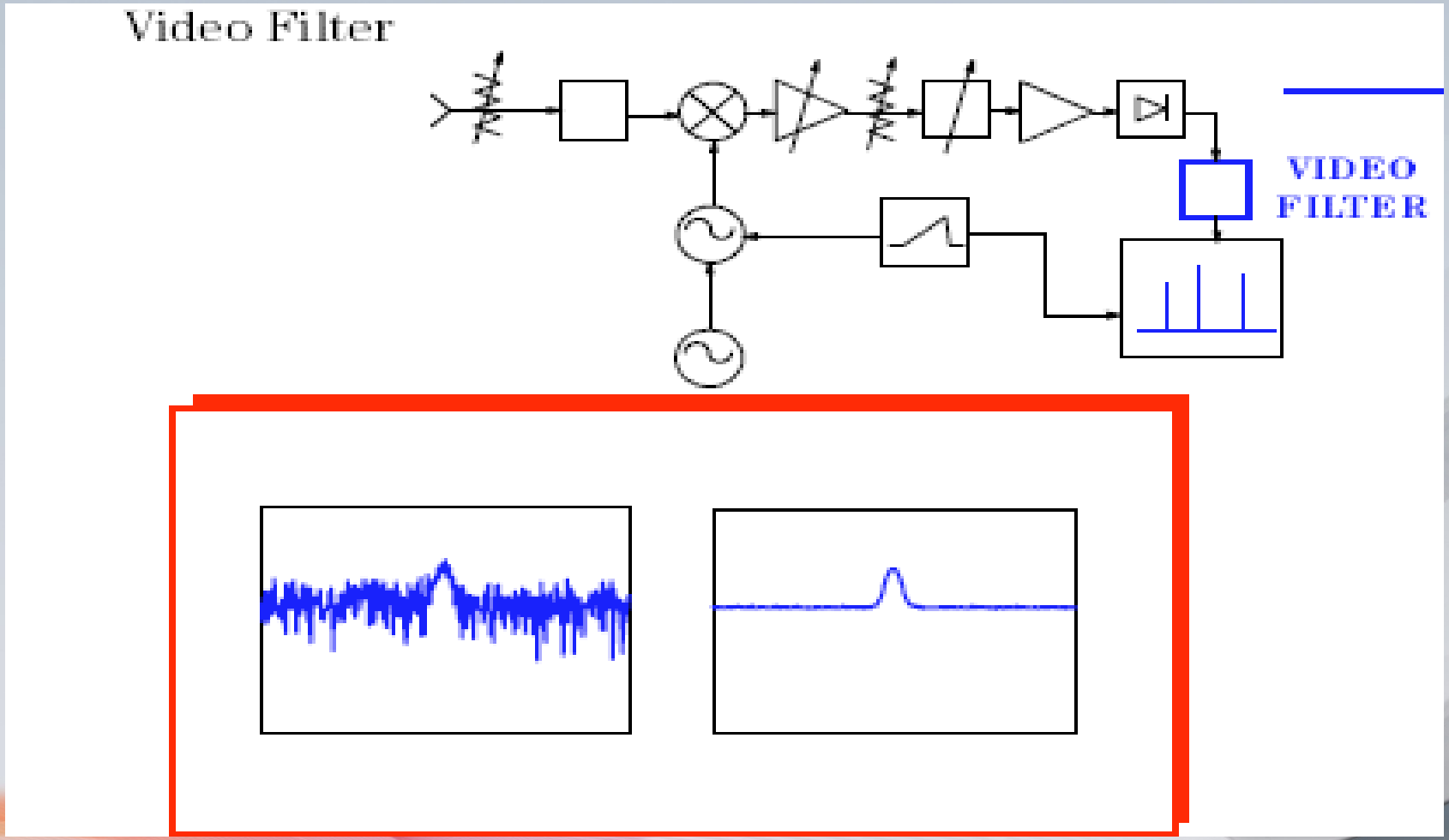
Theory of operation



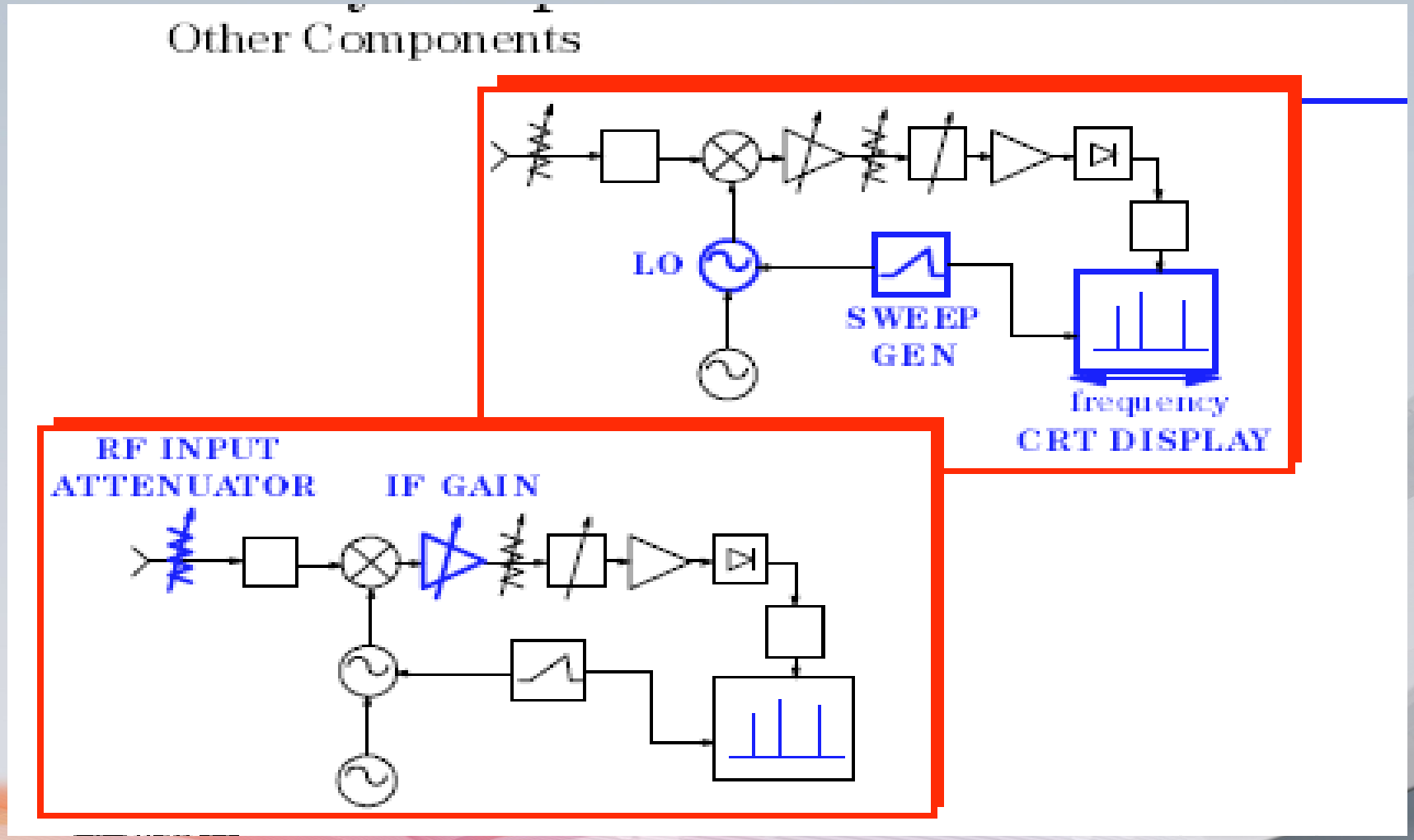
Theory of operation



Theory of operation

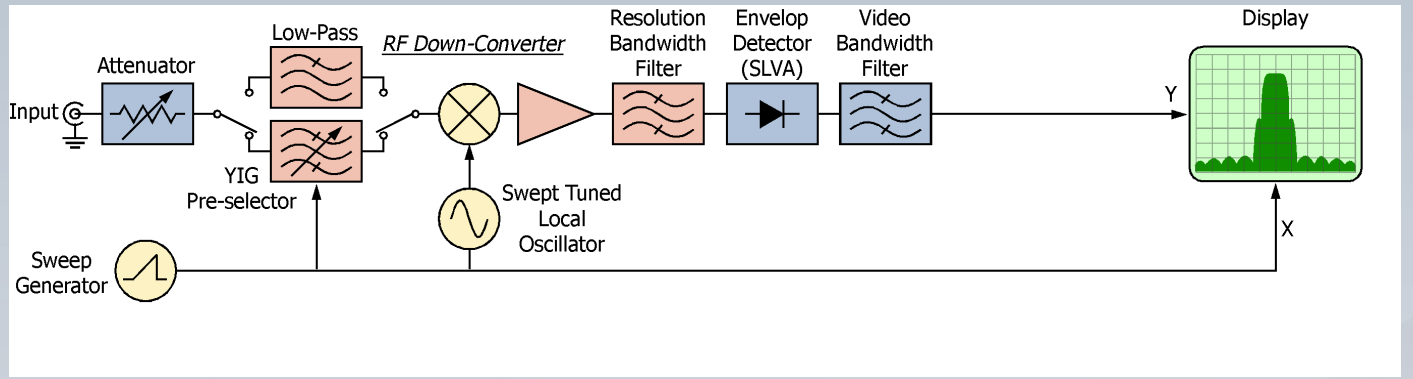


Theory of operation

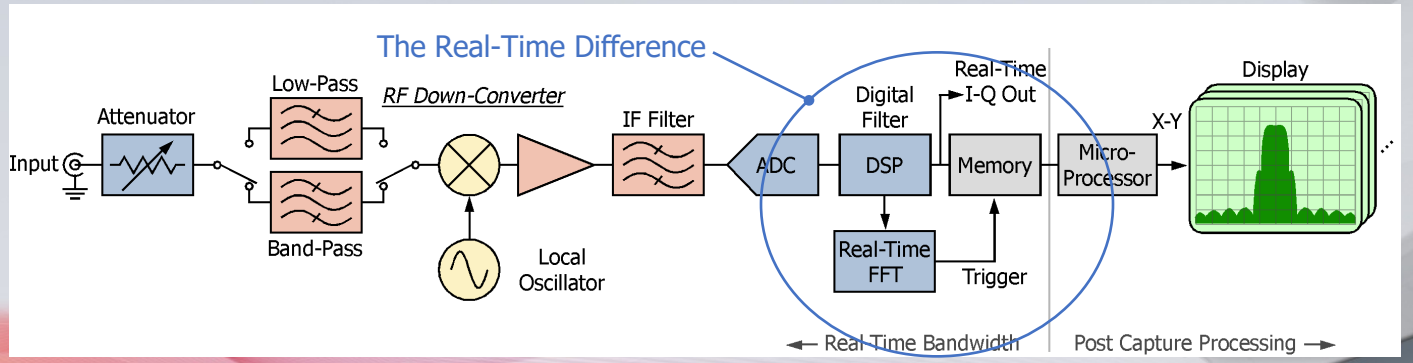


Theory of operation

Swept Tuned Spectrum Analyzer



Real-Time Spectrum Analyzer



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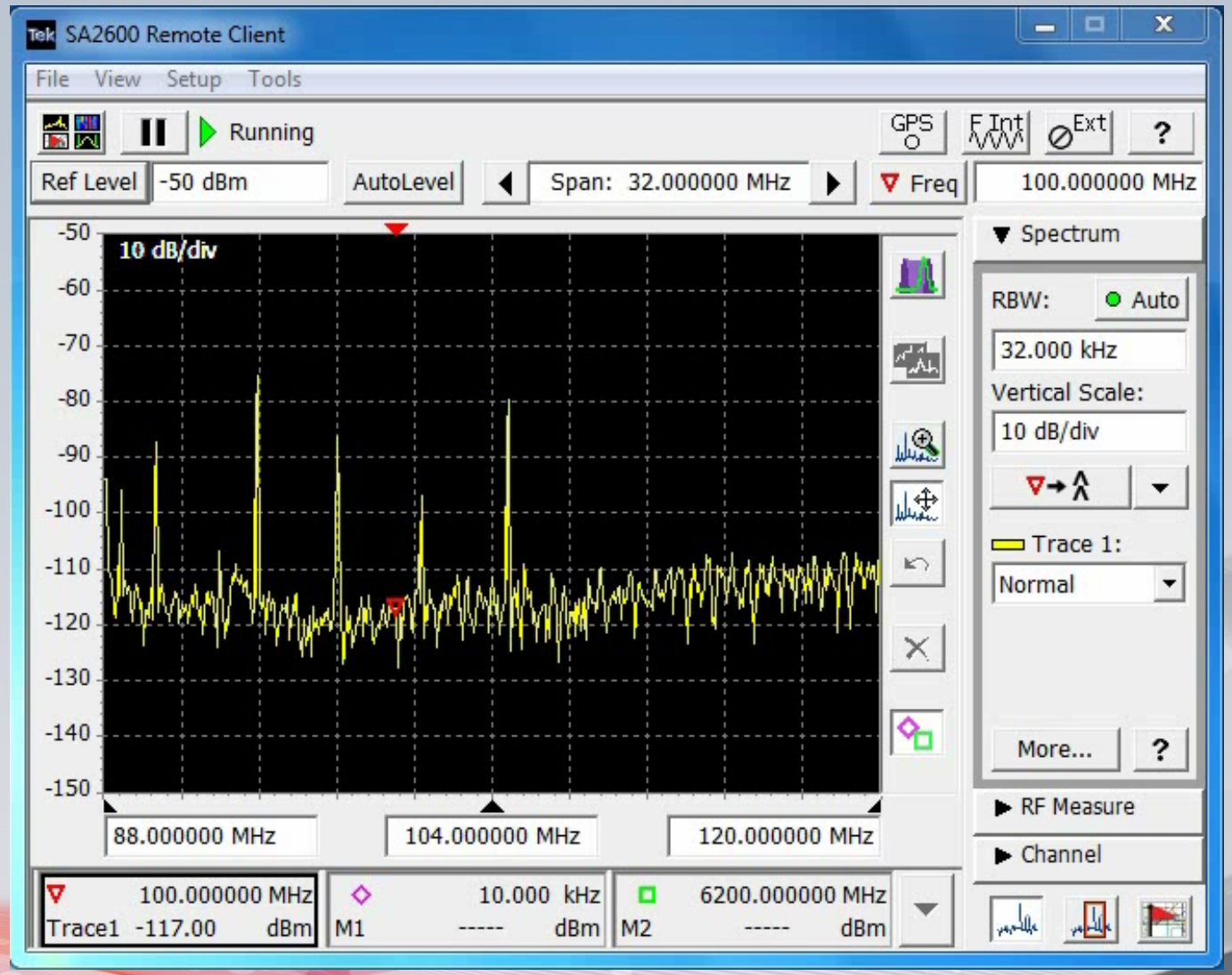
Spectrum Analyzer Settings

- Reference Level
- Resolution Bandwidth (RBW)
- Video Bandwidth (VBW)
- Sweep Time
- Span
- Attenuation
- Dynamic Range
- Displayed Average Noise Level (DANL)
- Detector Types
- Trace

Reference Level



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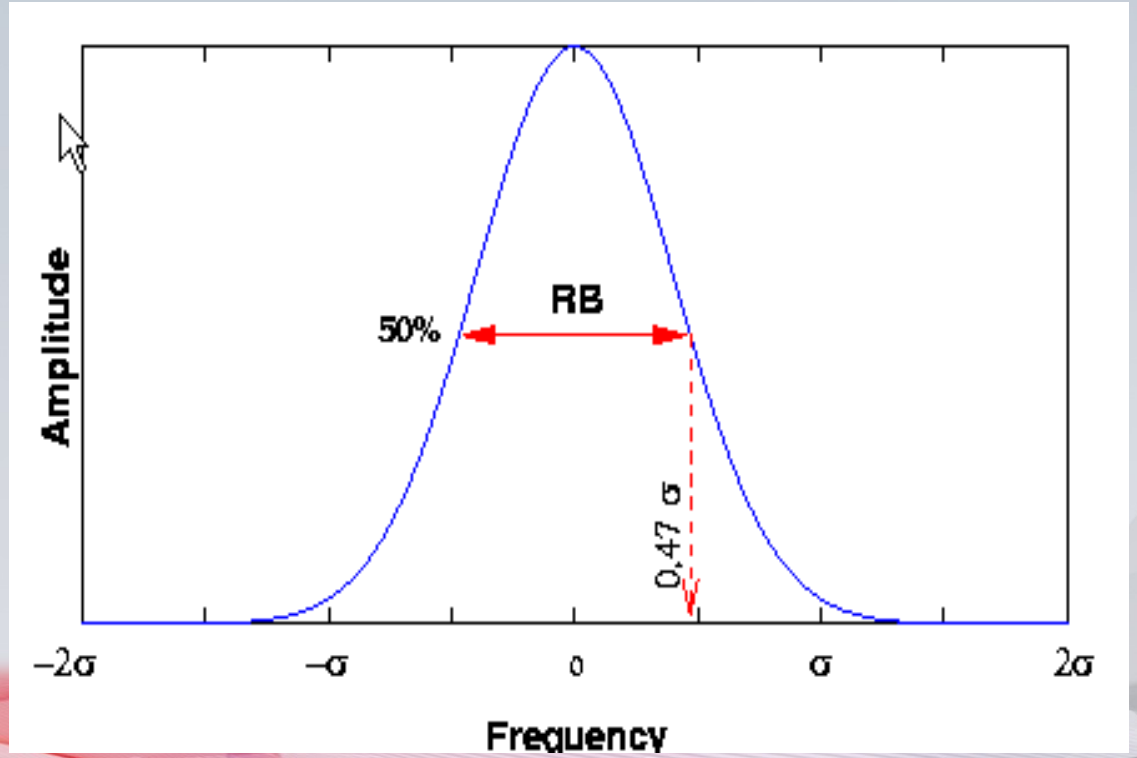
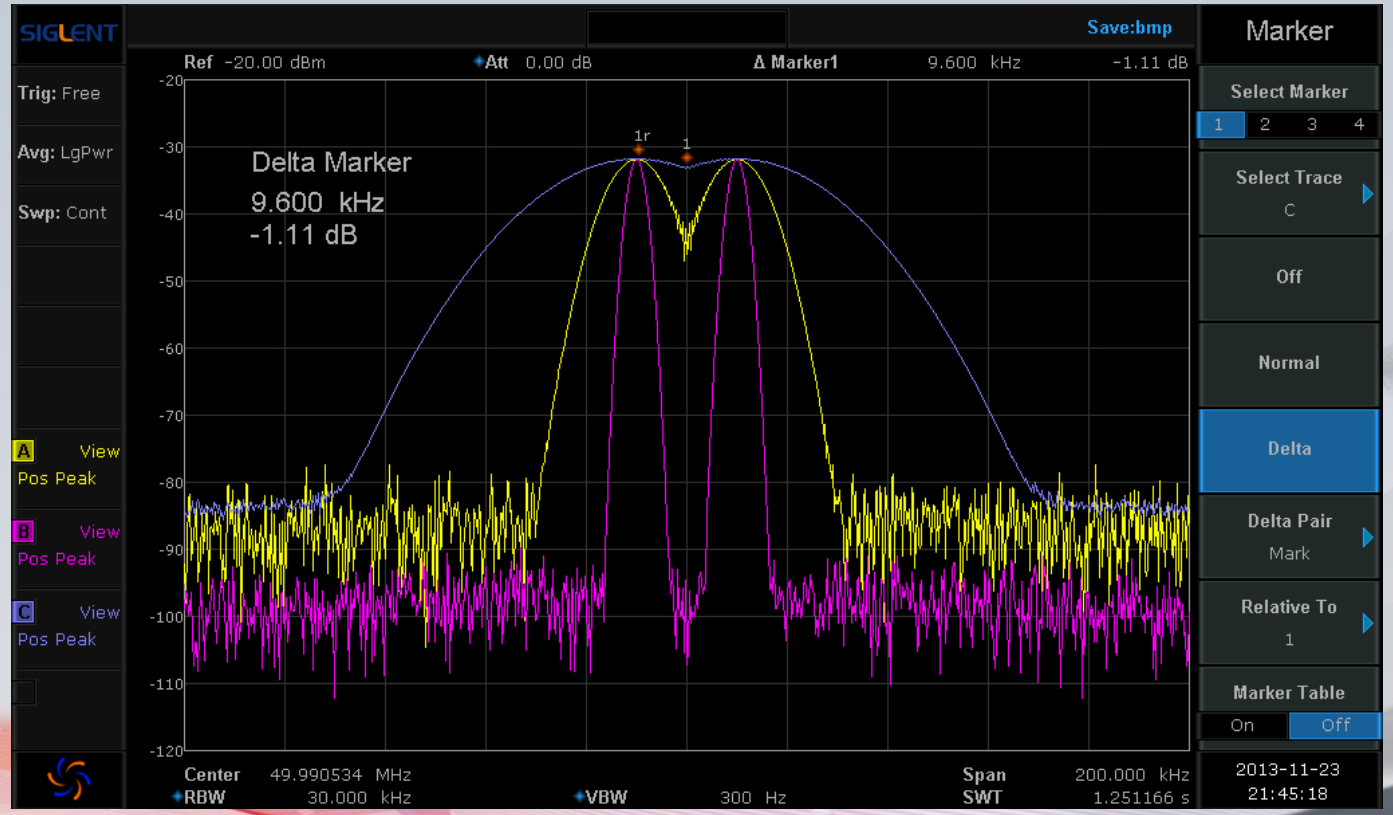
Resolution Bandwidth

Resolution bandwidth (*RB*) is defined as the width at which the Intermediate Frequency Filter response falls to 50% of its maximum.



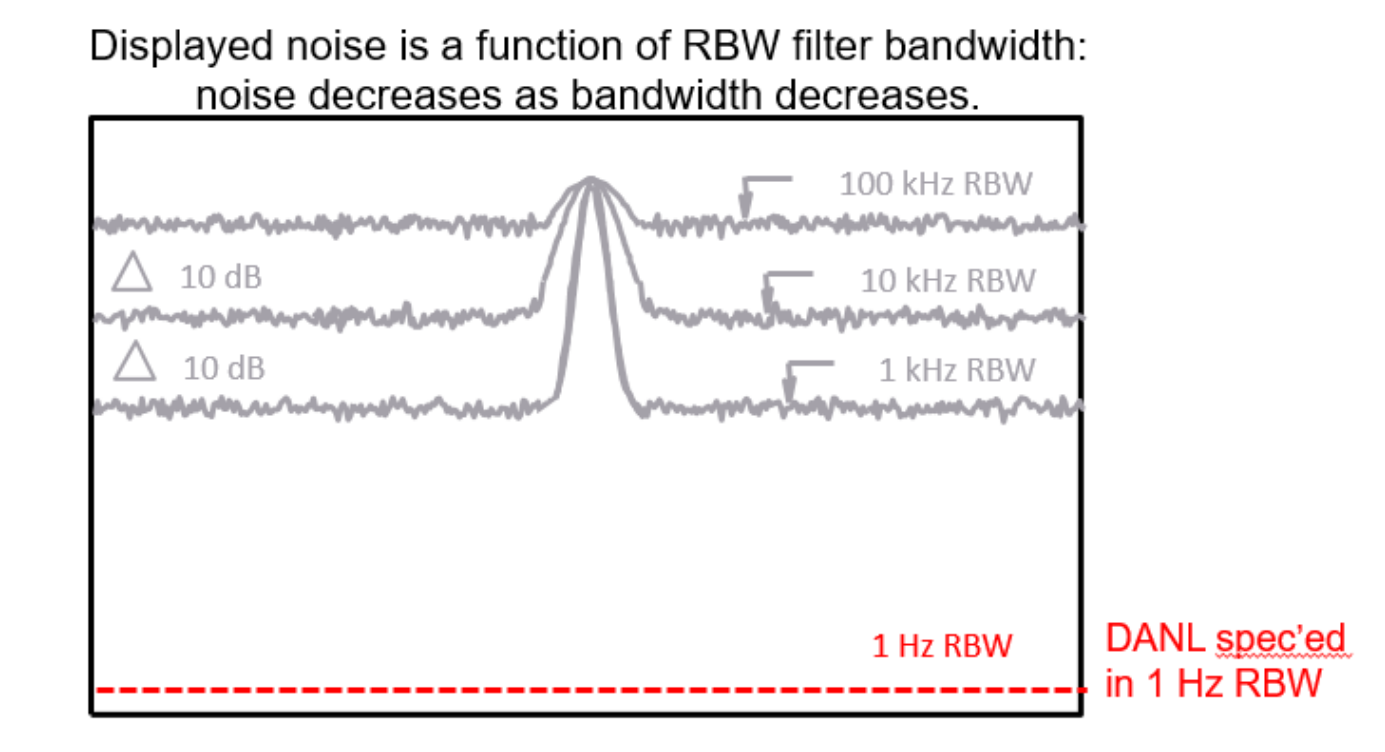
Resolution Bandwidth

Intermediate Frequency Filter controls the analyzer's ability to resolve two closely spaced signals. It has an adjustable *resolution bandwidth*, **RBW**.

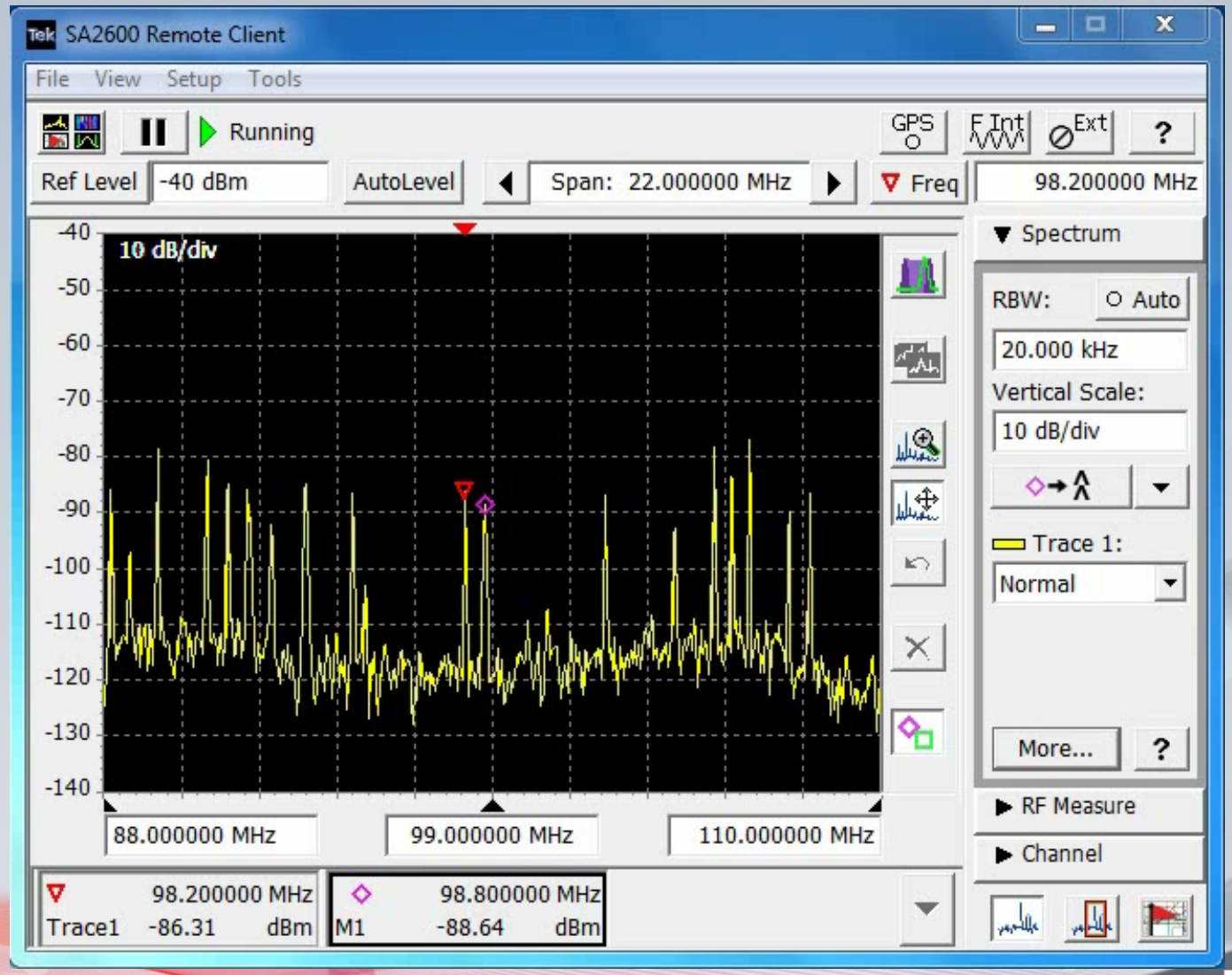


Resolution Bandwidth

When using a narrow RBW, the display average noise level of the analyzer is lowered, increasing the dynamic range and improving sensitivity.



Resolution Bandwidth

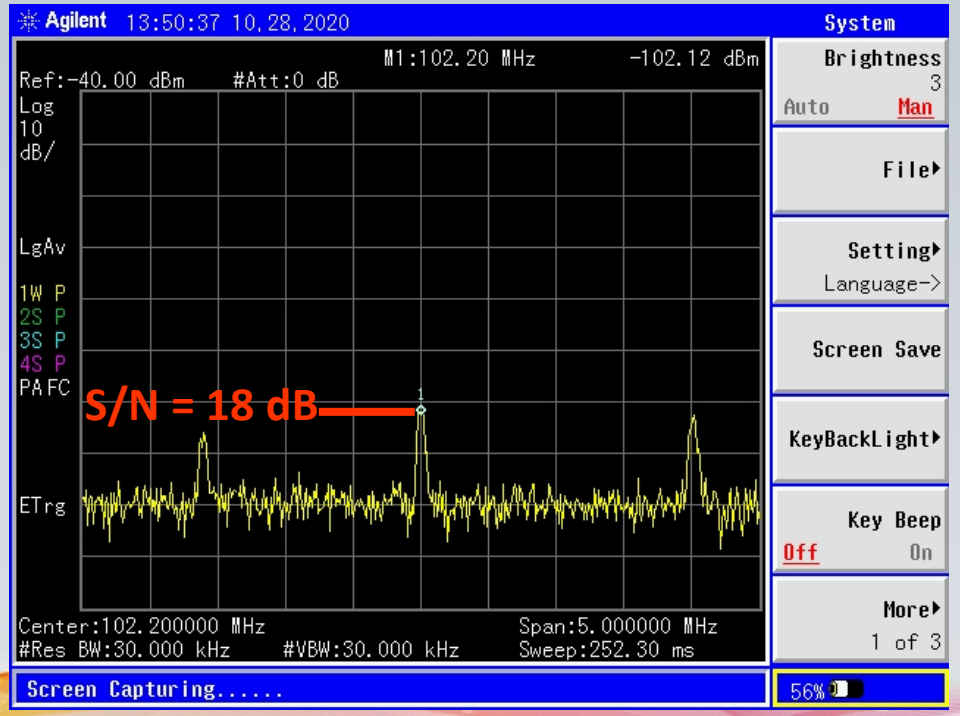


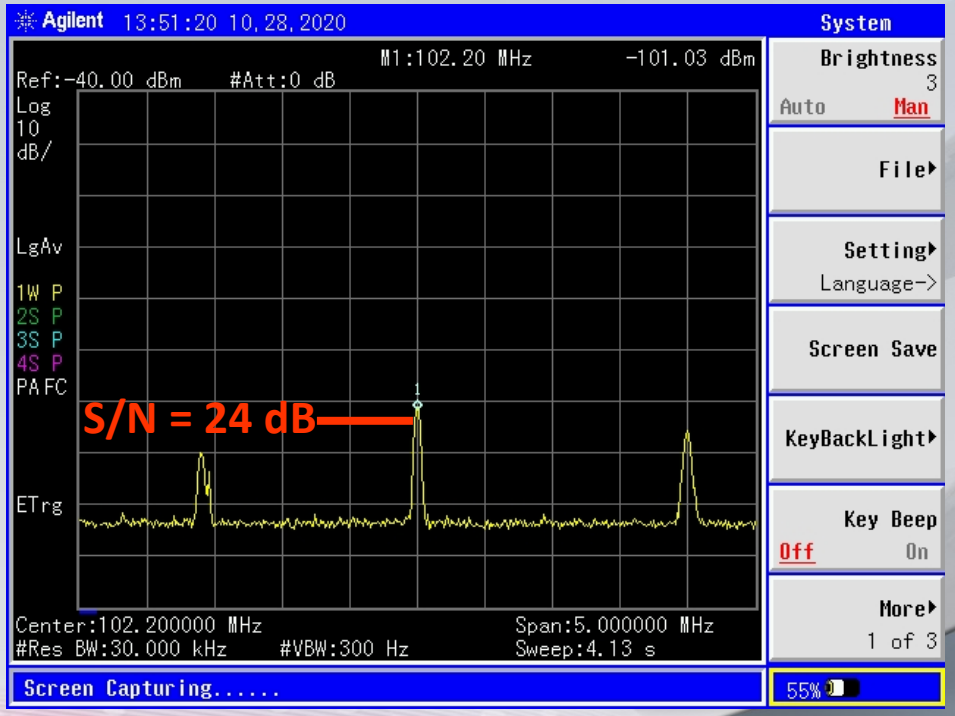
Video Bandwidth

- The video filter is a low pass filter that comes after the envelope detector and determines the bandwidth of the video signal that will be digitized.
- Adjusting the Video Bandwidth (VBW) can help find the true signal that was buried in the noise.
- If the VBW is set too low , the measured signal levels will decrease from their true values. This is due to the change in time constants of the low pass filter time constants.

Video Bandwidth

- Adjusting the Video Bandwidth doesn't improve the sensitivity but it improve the S/N ratio





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Sweep Time

It is the amount of time required to sweep through the frequency span.

If baseband noise is not a consideration, one generally wants to minimize the sweep time.

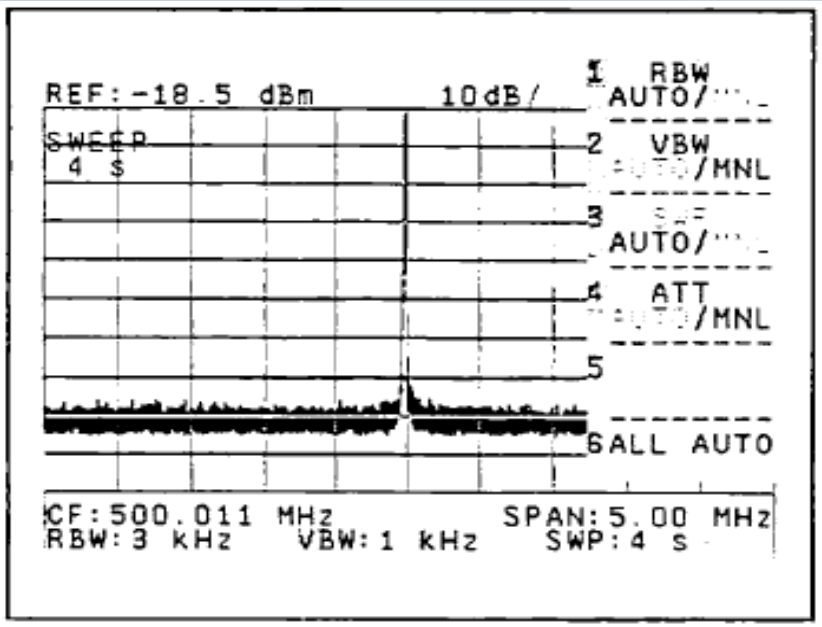


Figure 6-5 SWP = 4 s

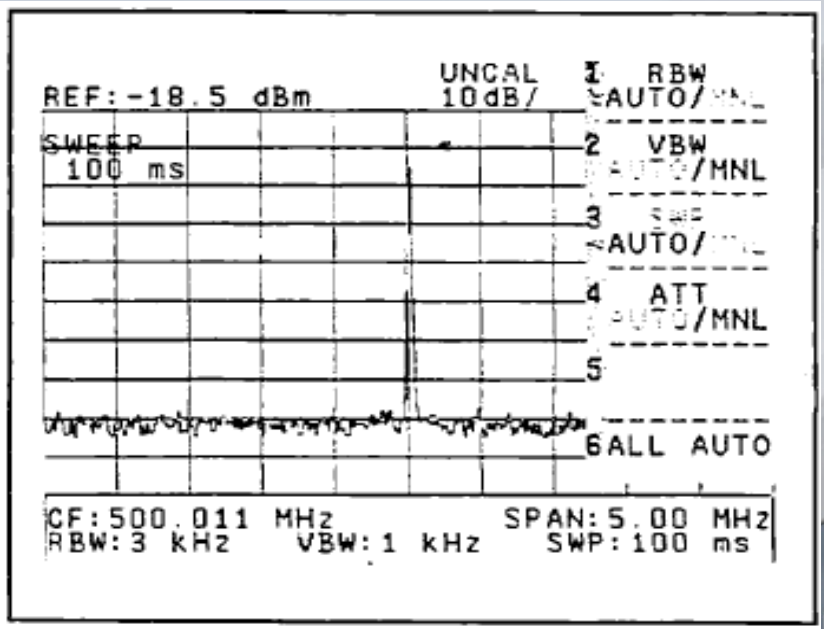


Figure 6-6 SWP = 100 ms

Sweep Time

If the sweep time is set too fast, that will lead to incorrect signal level and center frequency as well , the signal processing may not be able to keep up. This is due to the finite charge times of the IF band-limited filters.

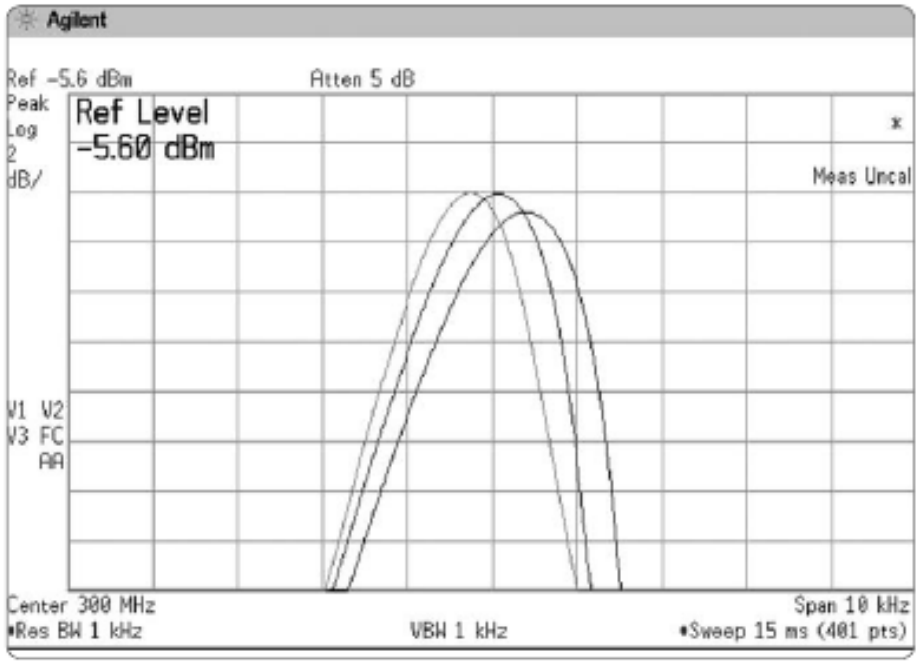
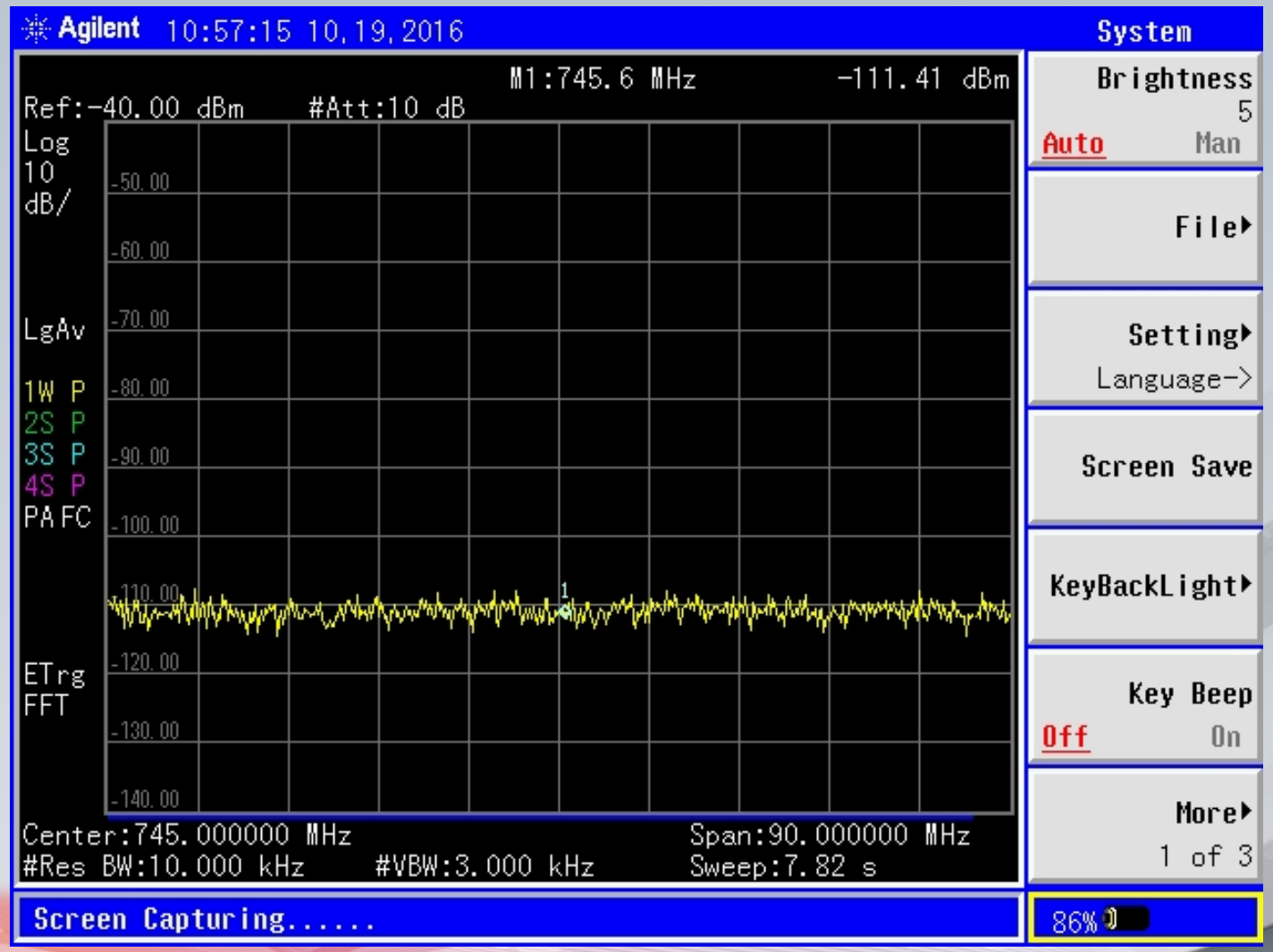


Figure 2-14. Sweeping an analyzer too fast causes a drop in displayed amplitude and a shift in indicated frequency

Frequency Span



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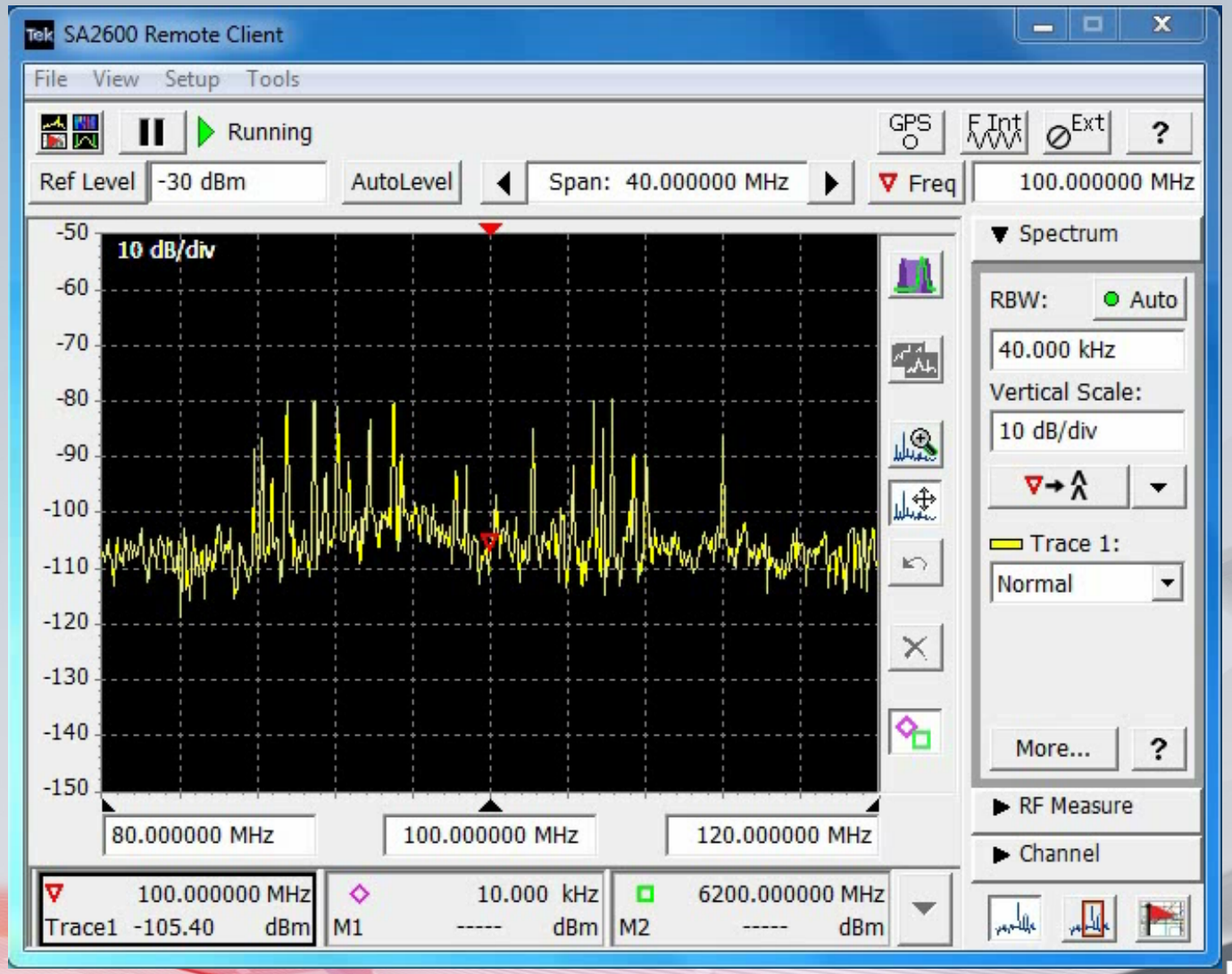
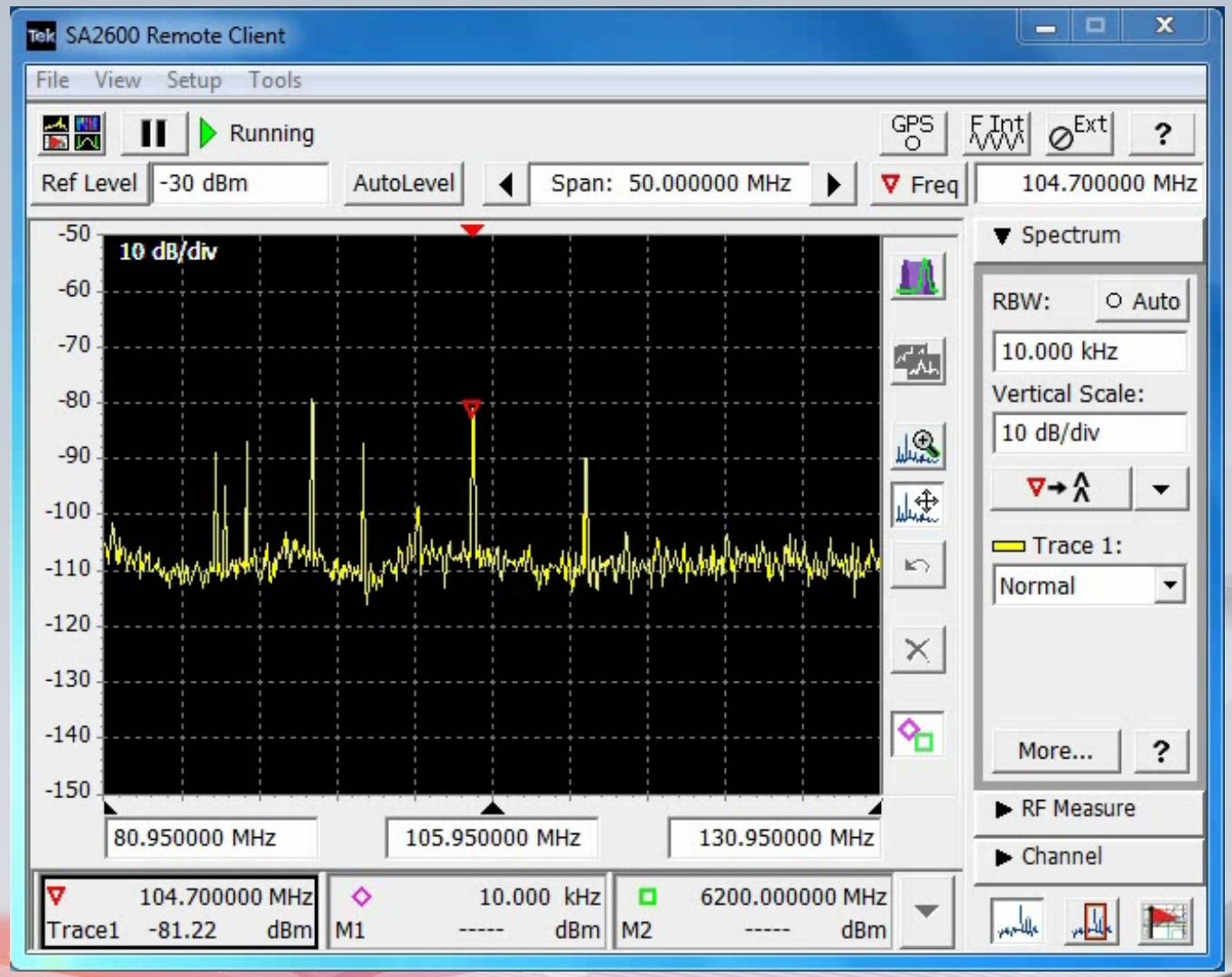
Frequency Span



Attenuation

- Attenuates the input signal amplitude to a level that can be easily measured.
- Ensures the signal enters the mixer at the optimum level to prevent overload, gain compression, and distortion.
- The read out level is considering the attenuation value, so the level of the signals will not be changed but the noise level will be.

Attenuation



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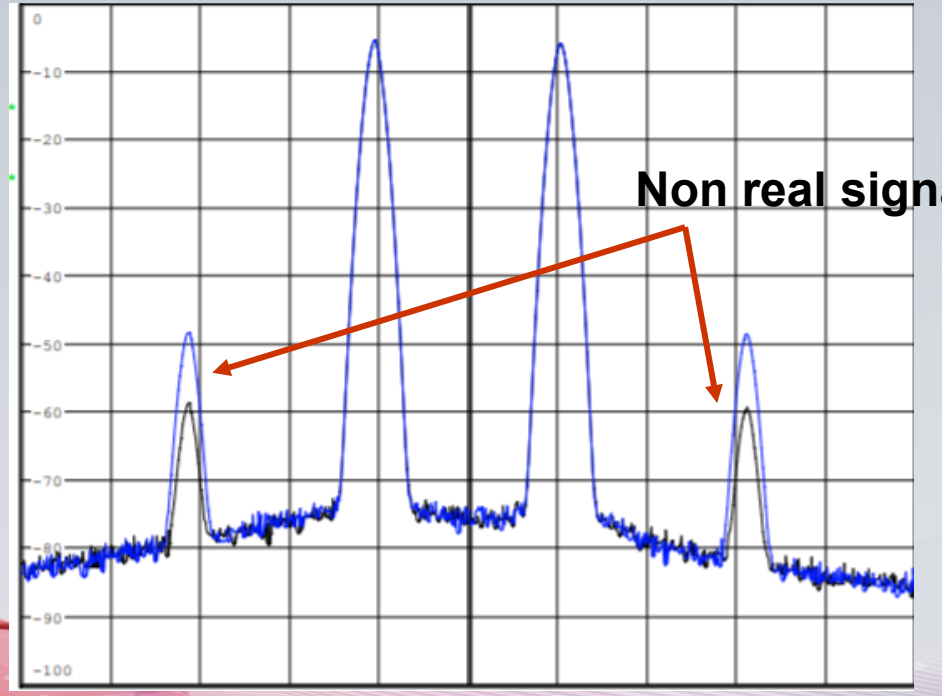
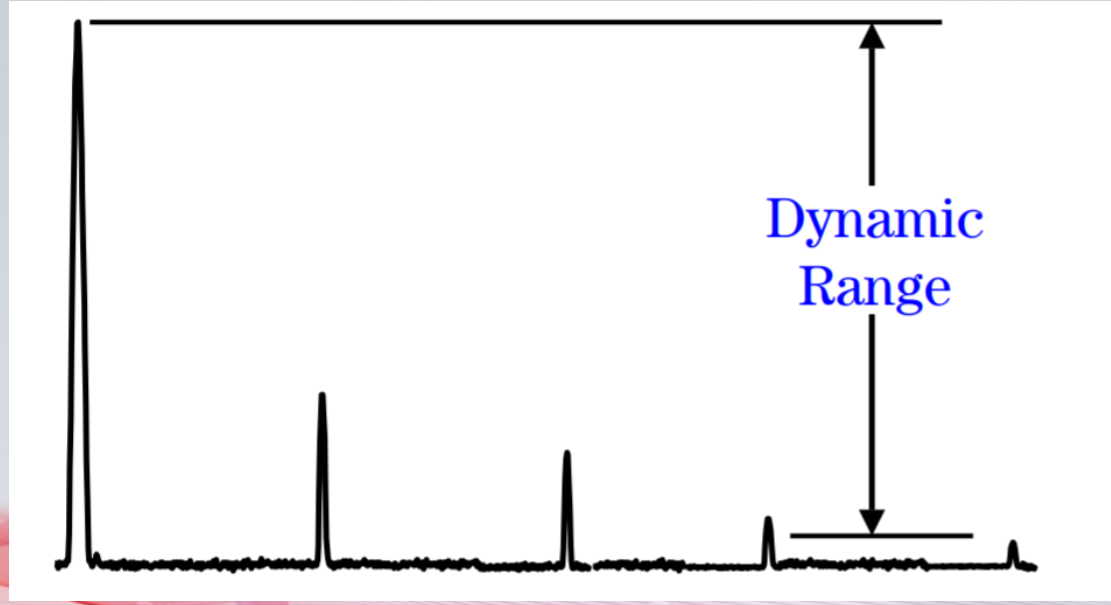
Attenuation

If we try to measure a very large signals, the input mixer could saturate. That may lead to see unreal signal which are intermodulation distortion (spurious) resulting from the saturated mixer.



Dynamic Range

- The Dynamic Range is defined as the maximum difference between the largest signal and the smallest signal that both can be displayed at the same time without any spurious signals.
- In most devices we can change the db/division setting to determine the dynamic range.



Average Display Noise Level

- Depend on the device internal noise.
- A measure of the maximum input sensitivity.
- Changed with the value of the resolution bandwidth.
- Determines the dynamic range lower limit.

Average Display Noise Level

Detector Types

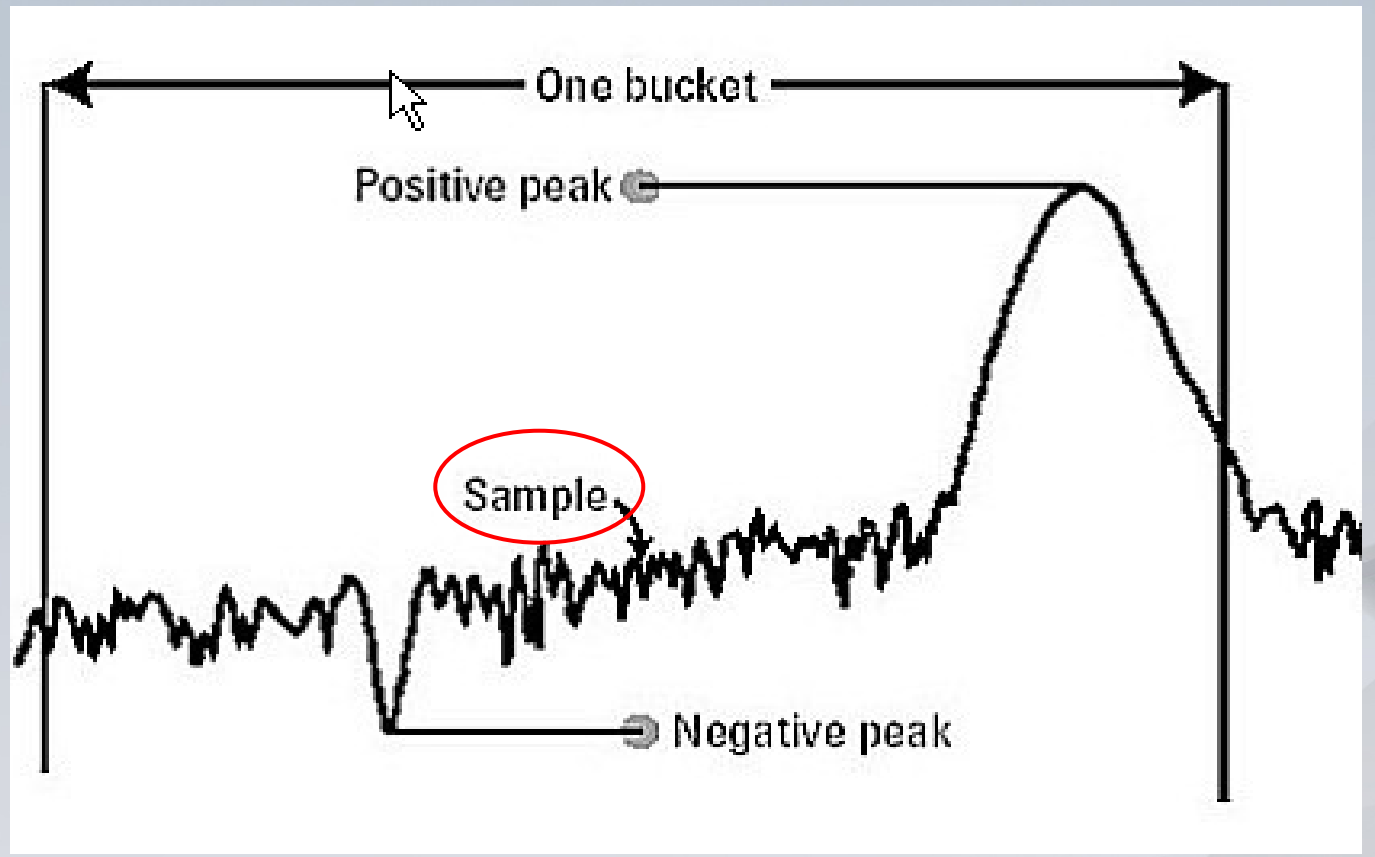
The analog signal at the input of the analyzer is segmented into “bins” or “buckets” which are digitally sampled for further data processing and display

- Sample Detection
- Maximum Peak Detection
- Negative Peak Detection
- Average Detection

Detector Types

- The **Sample Detection** is the Instantaneous level at the center (or at the end) of each bin (or bucket).
- Don’t catch all signals and therefore don’t reflect the true peak value of signals.
- Can give erroneous results if RBW is narrower than the sample interval (bucket width)
- Is inaccurate for measuring continuous wave (CW) signals with narrow resolution bandwidths, and will miss signals that do not fall on the same point in each bin.

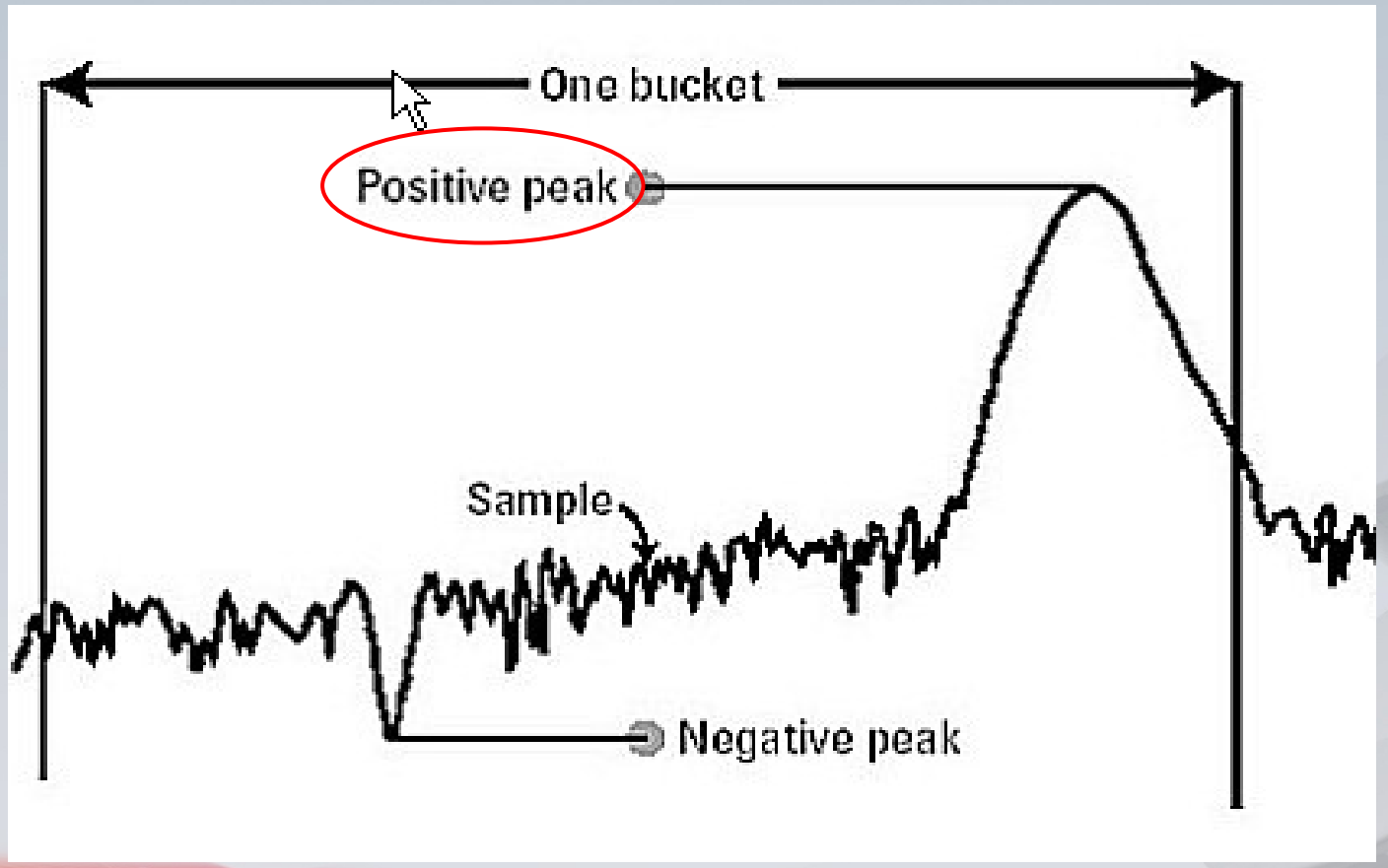
Detector Types



Detector Types

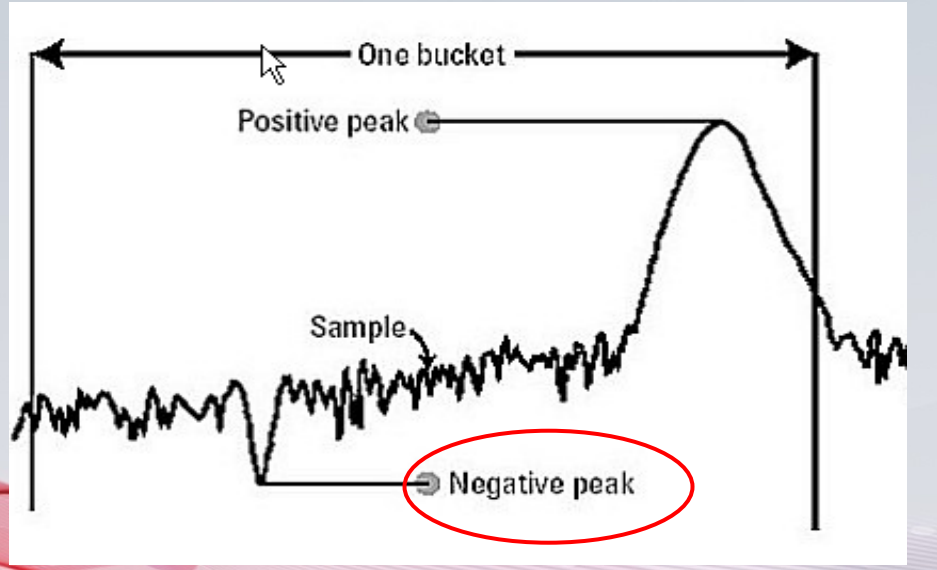
- The **Positive Peak** Detection is the maximum value in each bin or bucket.
- Don’t give a good representation of noise because it displays maximum levels and ignores the true randomness of noise.
- One way to insure that all sinusoids are reported at their true amplitudes.

Detector Types



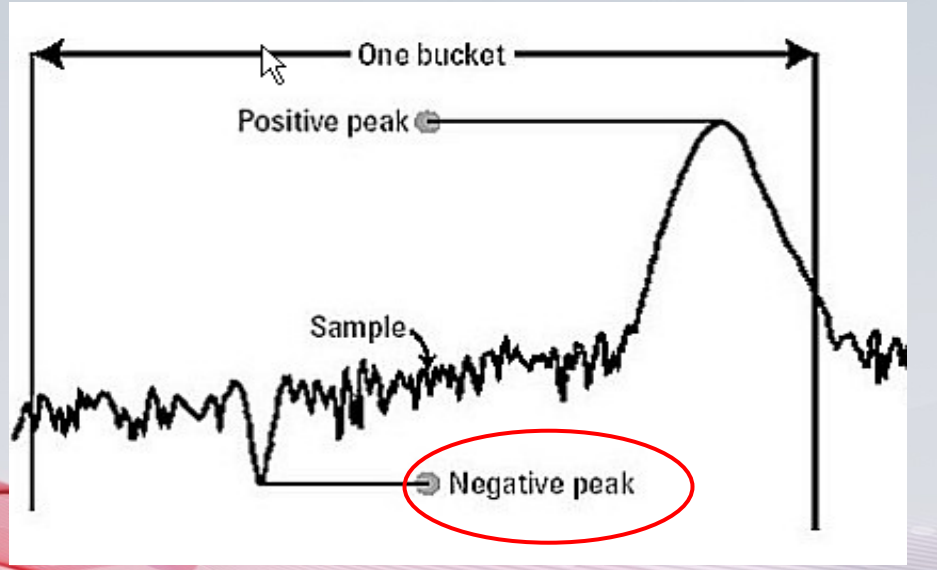
Detector Types

- The **Negative Peak** Detection is the minimum value in each bin or bucket.
- Don’t give a good representation of noise because it displays minimum levels and ignores the true randomness of noise.



Detector Types

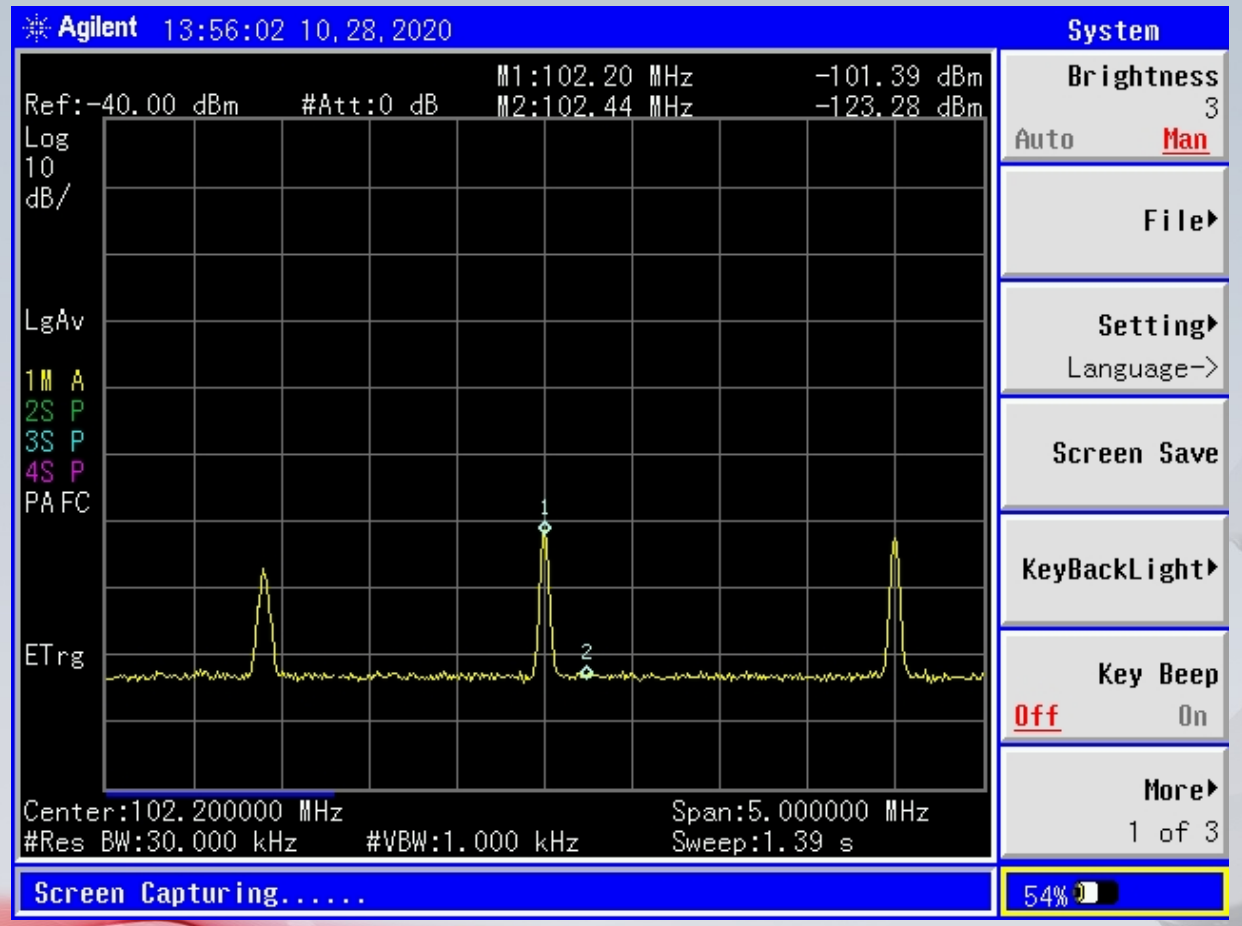
- The **Negative Peak** Detection is the minimum value in each bin or bucket.
- Don’t give a good representation of noise because it displays minimum levels and ignores the true randomness of noise.



Detector Types

- The Average Detection uses all the data values collected in one bin or bucket.
- Power (RMS) Averaging – square root of the sum of the squares of the voltage data divided by the characteristic impedance.

Detector Types

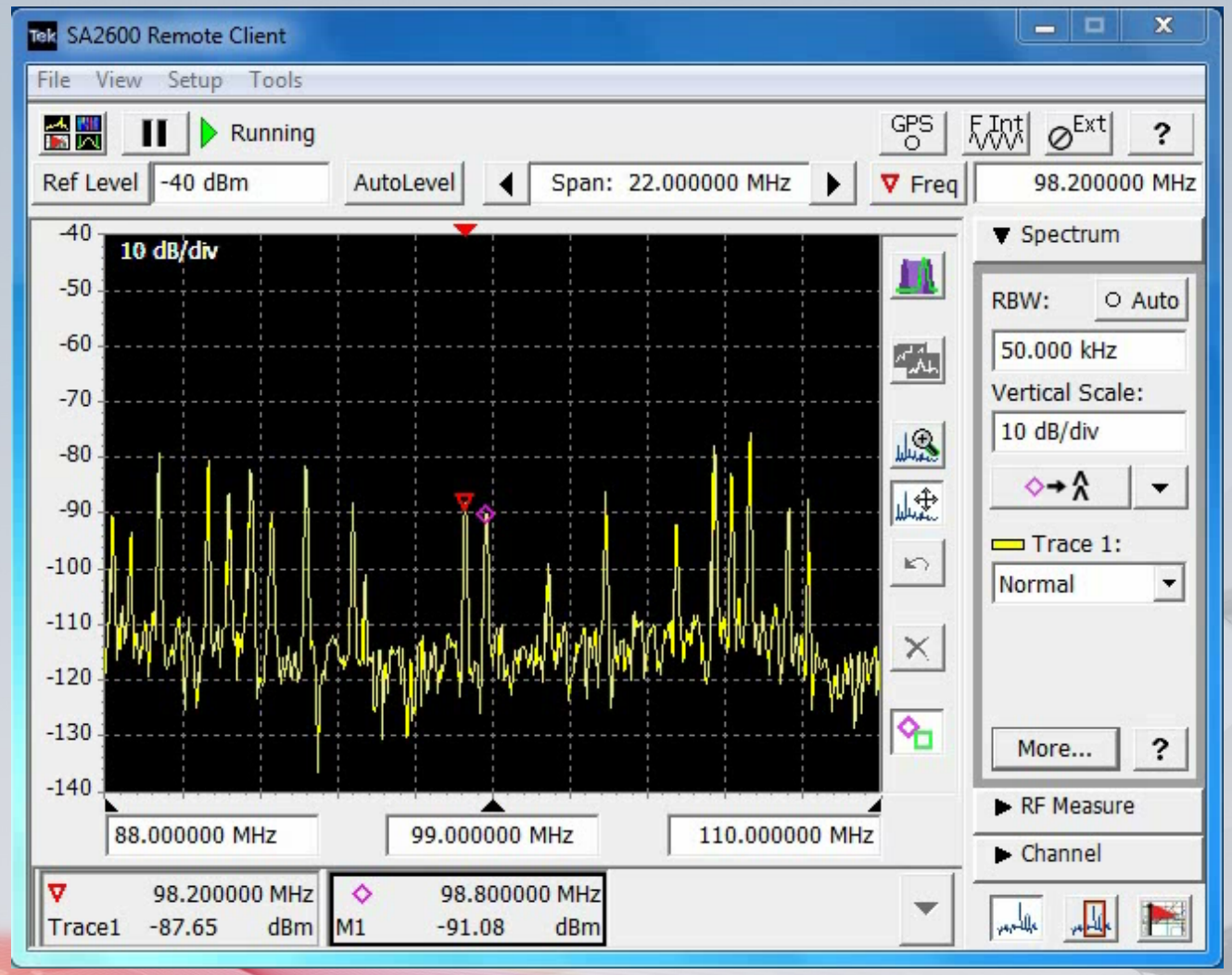


Trace

The Trace is the displayed value which determined over two or more sweeps on a point by point basis.

- Normal Trace
- Average Trace
- Max Hold Trace
- Min Hold Trace
- Min/Max Hold Trace

Trace


SA2600 Remote Client
File View Setup Tools
Running
GPS
F Int
Ext
Ref Level -40 dBm
AutoLevel
Span: 22.000000 MHz
Freq 98.200000 MHz
10 dB/div
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
88.000000 MHz
99.000000 MHz
110.000000 MHz
Spectrum
RBW: Auto
50.000 kHz
Vertical Scale:
10 dB/div
Trace 1:
Normal
More...
RF Measure
Channel
98.200000 MHz
Trace1 -87.65 dBm
98.800000 MHz
M1 -91.08 dBm

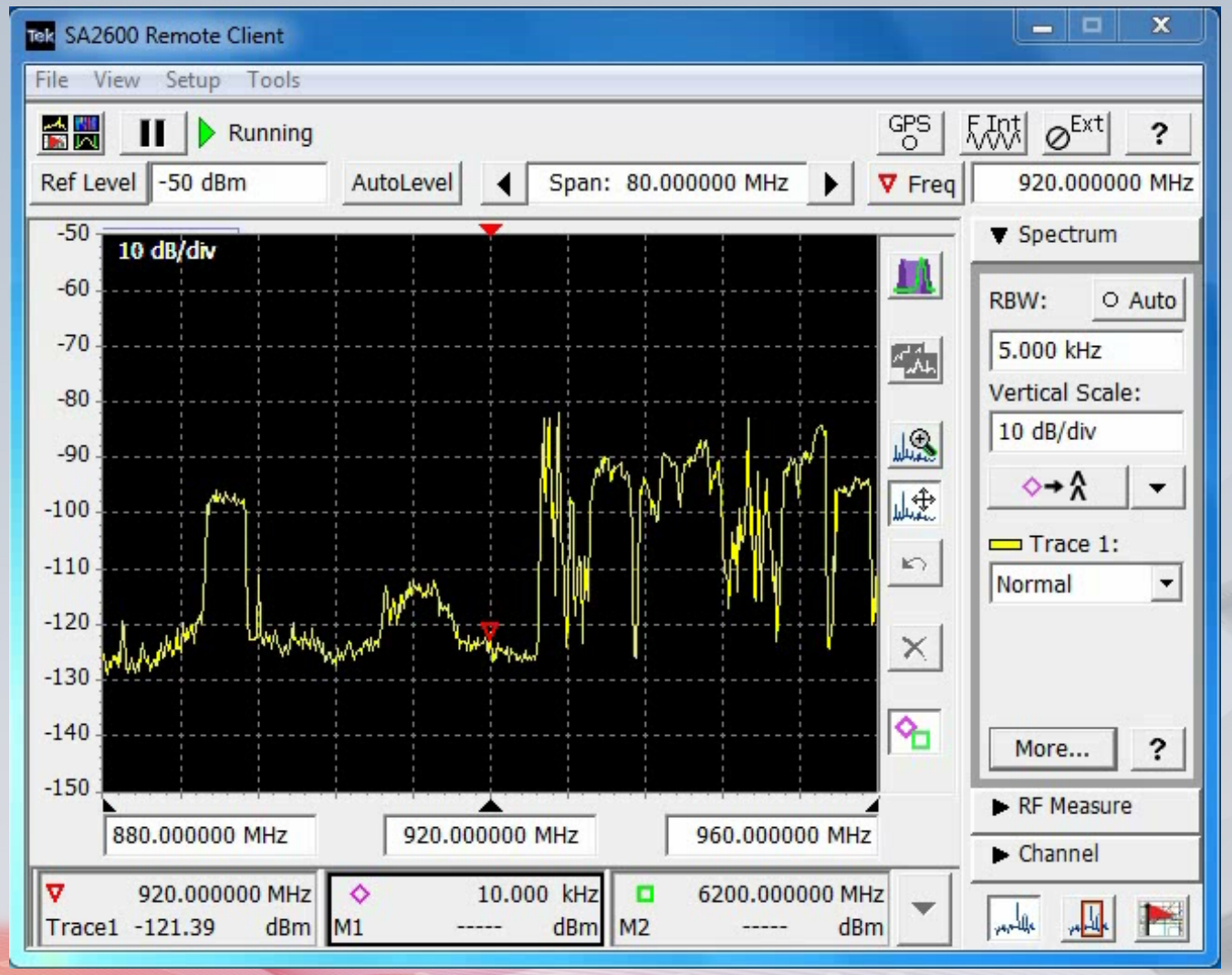
Spectrum Analyzer Measurements

- Frequency
- Bandwidth
- Emission Mask
- Channel Power
- DPX Mode

Emission Mask

- Measure out-of-band emissions and spurious emissions.
- Detect and measure the unauthorized (illegal) emissions in free bands.
- Detect the violation of power limit for authorized signals.

Emission Mask



Channel Power

- Measures total power over the specified Integrated BW

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DPX Mode

Some Real Time Spectrum Analyzers have a feature that enables you to see RF Characteristics that are practically invisible to a conventional Spectrum Analyzer. It is called Persistence or Digital Phosphorus Technology (DPX) in a Tektronix Brand Analyzer.

DPX Mode

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