

Spectrum Analyzer

- A *swept-tuned* spectrum analyzer uses a superheterodyne receiver to down-convert a portion of the input signal spectrum (using a voltage-controlled oscillator and a mixer) to the center frequency of a band-pass filter. With a superheterodyne architecture, the voltage-controlled oscillator is swept through a range of frequencies, enabling the consideration of the full frequency range of the instrument.
- A *FFT* spectrum analyzer computes the discrete Fourier transform (DFT), a mathematical process that transforms a waveform into the components of its frequency spectrum, of the input signal.

Some spectrum analyzers, such as real-time spectrum analyzers, use a hybrid technique where the incoming signal is first down-converted to a lower frequency using superheterodyne techniques and then analyzed using fast fourier transformation (FFT) techniques.

Swept-tuned spectrum analyzer down-converts a portion of the input signal spectrum to the center frequency of a band-pass filter by sweeping the voltage-controlled oscillator through a range of frequencies, enabling the consideration of the full frequency range of the instrument.

The bandwidth of the band-pass filter dictates the **resolution bandwidth**, which is related to the minimum bandwidth detectable by the instrument.

The **smaller the bandwidth, the more is the spectral resolution**. However, there is a trade-off between how quickly the display can update the full frequency span under consideration and the frequency resolution, which is relevant for distinguishing frequency components that are close together. For a swept-tuned architecture, this relation for sweep time is useful:

$$ST = \frac{k(Span)}{RBW^2}$$

Where ST is **sweep time** in seconds, k is proportionality constant, **Span** is the frequency range under consideration in Hertz, and **RBW is the resolution bandwidth** in Hertz. **Sweeping too fast, however, causes a drop in displayed amplitude and a shift in the displayed frequency.**

A nice animation depicting this is posted on wikipedia

Link: <http://en.wikipedia.org/wiki/File:BPFAnimationV2.gif>

Resolution bandwidth

The **resolution bandwidth** filter or RBW filter is the bandpass filter in the IF path. It's the bandwidth of the RF chain before the detector (power measurement device). It determines the RF noise floor and how close two signals can be and still be resolved by the analyzer into two separate peaks. Adjusting the bandwidth of this filter allows for the discrimination of signals with closely spaced frequency components, while also changing the measured noise floor. Decreasing the bandwidth of an RBW filter decreases the measured noise floor and vice versa. This is due to higher RBW filters passing more frequency components through to the envelope detector than lower bandwidth RBW filters, therefore a higher RBW causes a higher measured noise floor.

Video bandwidth

The **video bandwidth** filter or VBW filter is the low-pass filter directly after the envelope detector. It's the bandwidth of the signal chain after the detector. Averaging or peak detection then refers to how the digital storage portion of the device records samples—it takes several samples per time step and stores only one sample, either the average of the samples or the highest one. The video bandwidth determines the capability to discriminate between two different power levels. This is because a narrower VBW will remove noise in the detector output. This filter is used to “smooth” the display by removing noise from the envelope. Similar to the RBW, the VBW affects the sweep time of the display if the VBW is less than the RBW. If VBW is less than RBW, this relation for sweep time is useful:

$$t_{\text{sweep}} = \frac{k(f_2 - f_1)}{\text{RBW} \times \text{VBW}}.$$

Here t_{sweep} is the sweep time, k is a dimensionless proportionality constant, $f_2 - f_1$ is the frequency range of the sweep, RBW is the resolution bandwidth, and VBW is the video bandwidth.

Detector

Modern spectrum analyzers use analog-to-digital converters to sample spectrum amplitude after the VBW filter. Since displays have a discrete number of points, the frequency span measured is also digitised. **Detectors** are used in an attempt to adequately map the correct signal power to the appropriate frequency point on the display. There are in general three types of detectors: sample, peak, and average

- **Sample detection** – sample detection simply uses the midpoint of a given interval as the display point value. While this method does represent random noise well, it does not always capture all sinusoidal signals.
- **Peak detection** – peak detection uses the maximum measured point within a given interval as the display point value. This insures that the maximum sinusoid is measured within the interval; however, smaller sinusoids within the interval may not be measured. Also, peak detection does not give a good representation of random noise.
- **Average detection** – average detection uses all of the data points within the interval to consider the display point value. This is done by power (rms) averaging, voltage averaging, or log-power averaging.

Displayed average noise level

The **Displayed Average Noise Level** (DANL) is the average noise level displayed on the analyzer. This can either be with a specific resolution bandwidth (usually in dBm), or normalized to 1 Hz (usually in dBm/Hz)