IF BW and averaging

Dynamic Range (definition)

Heterodyne detection scheme

IF BW reduction

Averaging

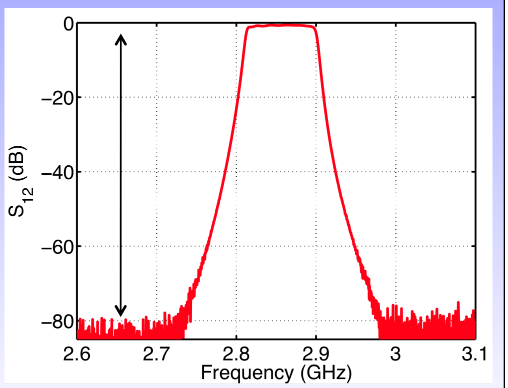
Dynamic range

Typically expressed in decibels (dB), dynamic range is the ratio of the highest signal level a circuit, component, or system can handle, in dB relative to 1 mW of power (dBm), to the lowest signal level it can handle (in dBm).

Dynamic range is the measurement of a receiver's ability to process a range of input powers from the receiver.

Dynamic range has the same meaning in audio. In orchestras there are passages of near-silence, along with passages of booming cannons …

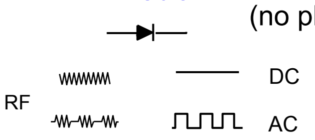
System dynamic range of a VNA may be defined as the difference between the measurement power available at the test port and the noise floor of the receiver.

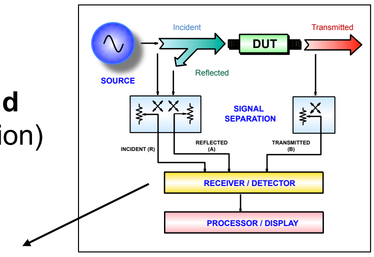


Detector Types

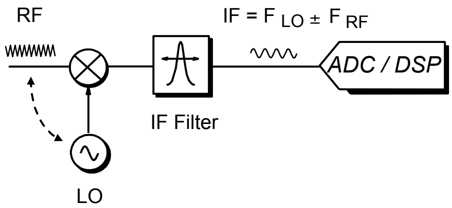
Diode

Scalar **broadband**
(no phase information)



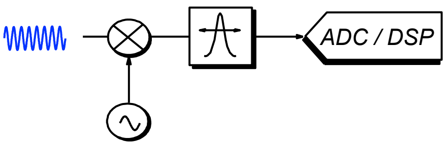


Tuned Receiver

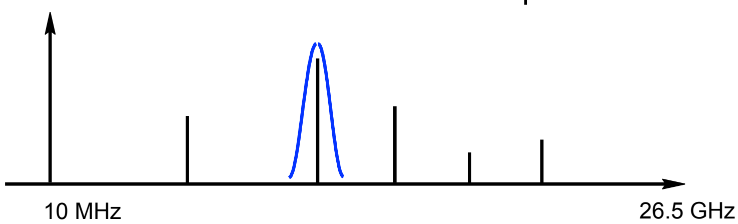


Vector
(magnitude and phase)

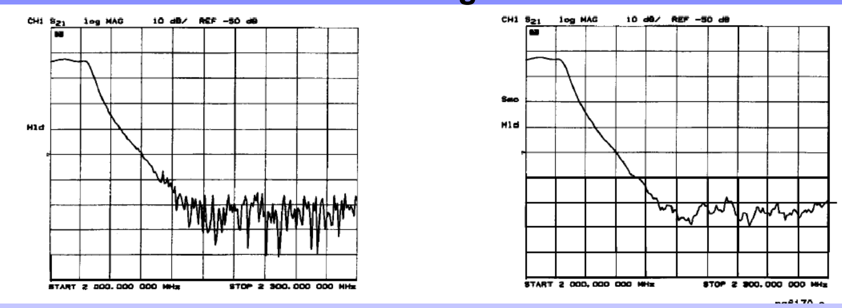
Narrowband Detection - Tuned Receiver



- **Best** sensitivity / dynamic range
- Provides harmonic / spurious signal **rejection**
- Improve dynamic range by increasing **power**, decreasing IF **bandwidth**, or **averaging**
- Trade off noise floor and measurement speed

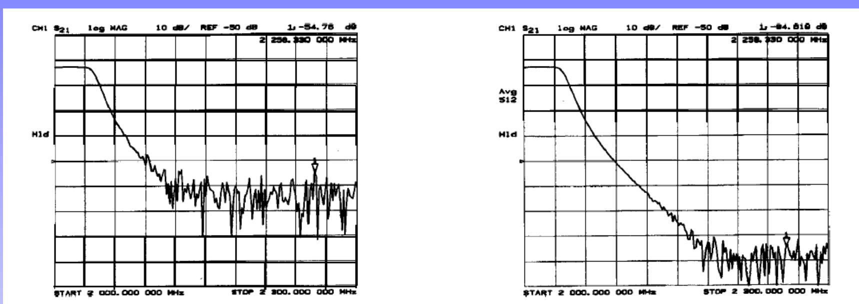


Smoothing trace



Smoothing (similar to video filtering) averages the formatted active channel data over a portion of the displayed trace. Smoothing computes each displayed data point based on one sweep only, using a moving average of several adjacent data points for the current sweep. The smoothing aperture is a percent of the swept stimulus span, up to a maximum of 20%.
Rather than lowering the noise floor, smoothing finds the mid-value of the data. Use it to reduce relatively small peak-to-peak noise values on broadband measured data. Use a sufficiently high number of display points to avoid misleading results. Do not use smoothing for measurements of high resonance devices or other devices with wide trace variations, as it will introduce errors into the measurement.

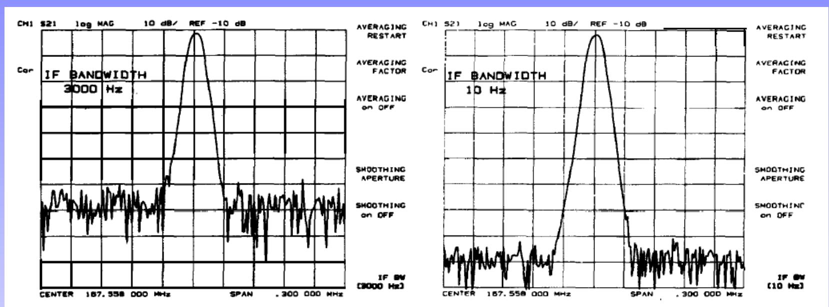
Averaging trace



Averaging computes each data point based on an exponential average of consecutive sweeps weighted by a user-specified averaging factor. Each new sweep is averaged into the trace until the total number of sweeps is equal to the averaging factor, for a fully averaged trace. Each point on the trace is the vector sum of the current trace data and the data from the previous sweep. A high averaging factor gives the best signal-to-noise ratio, but slows the trace update time. Doubling the averaging factor reduces the noise by 3 dB.

Averaging reduces the noise floor of the VNA (differently from just reducing the noise excursions, e.g. in averaging SPA data) because complex data are averaged. Without phase information, averaging does not improve analyzer sensitivity.

IF BW reduction



IF bandwidth reduction lowers the noise floor by digitally reducing the receiver input bandwidth. It works in all ratio and non-ratio modes. It has an advantage over averaging as it reliably filters out unwanted responses such as spurs, odd harmonics, higher frequency spectral noise, and line-related noise. Sweep-to-sweep averaging, however, is better at filtering out very low frequency noise. A tenfold reduction in IF bandwidth lowers the measurement noise floor by about 10 dB. Bandwidths less than 300 Hz provide better harmonic rejection than higher bandwidths.