Agilent Technologies

Making Today's Most Demanding Spectrum Analyzer Measurements

March 7, 2001

presented by:

Ben Zarlingo
Dennis Handlon

Characteristics of Demanding Meas.

- Dynamic range/sensitivity
- Speed
- Accuracy
- Typically there will be pressure on two of these factors
- Some situations (typ. manufacturing) require optimization of all three
- The three major factors always interact

This Presentation

- Examples of demanding measurements
- Measurement techniques, strategies
  - Most described here are generic
  - Some are specific to the newer generation of spectrum analyzers
- New PSA series from Agilent

Spectrum Analysis Today

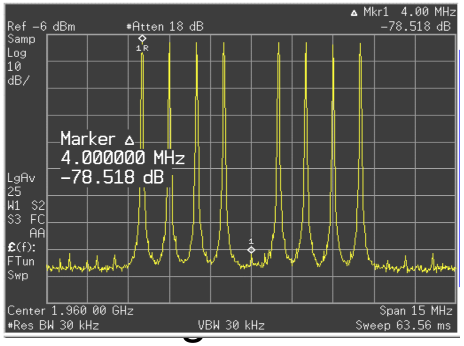
Requirements

- **Accuracy in both amplitude and frequency.**
- **Speed in both sweep speed and data transfer**
- **Sensitivity to find very low-level signals**
- **Dynamic range for distortion free measurements**

Spectrum Analysis Today

These Requirements are Important Because:

- Greater accuracy means narrower margins and greater yields.
- Speed means greater throughput
- Sensitivity translates to faster measurements
- Dynamic range is a must for today's wireless measurements



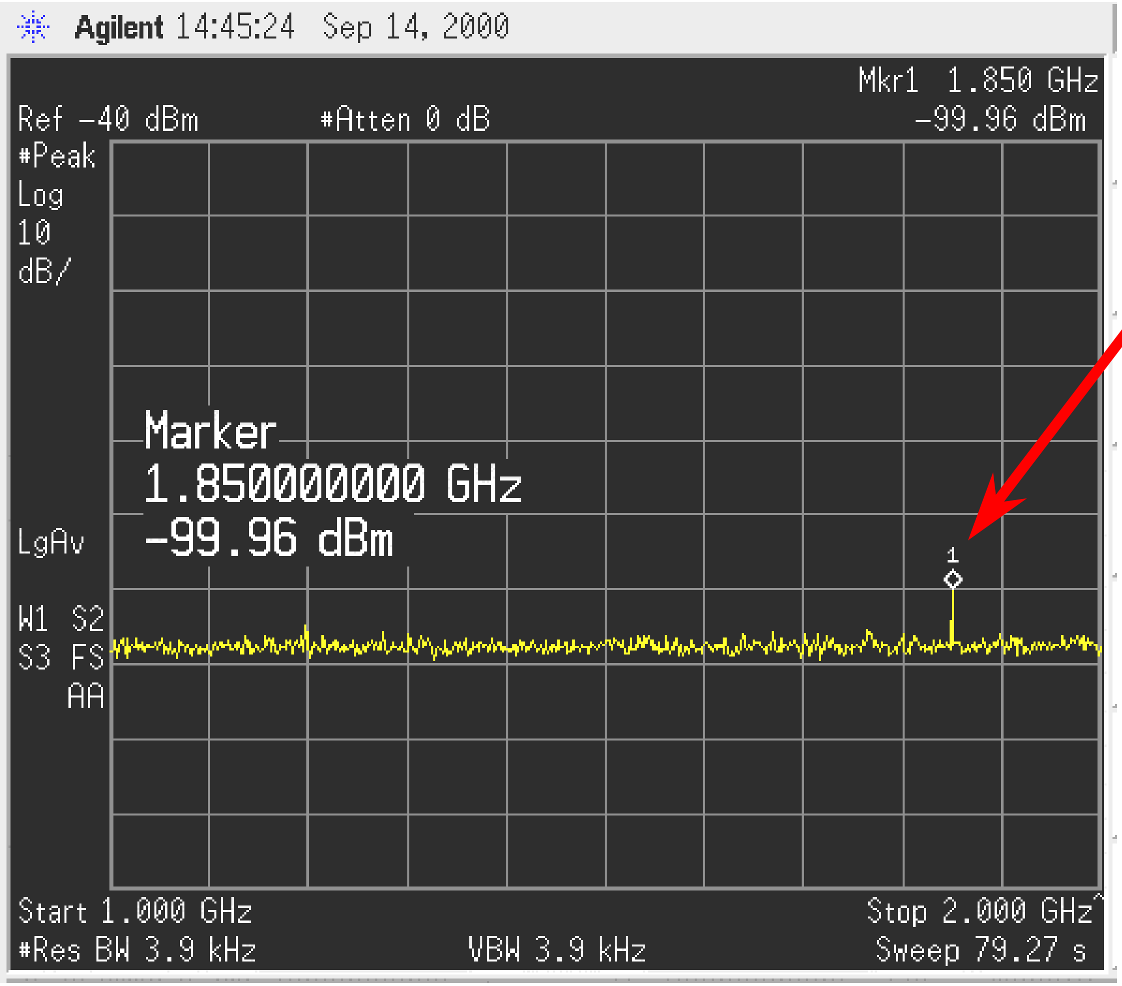
Agilent Technologies

Example: Spurious Measurement

- Need high sensitivity, so reduce DANL by using narrow RBW
- Must identify small signal close to noise, so average by using narrow RBW, VBW, trace averaging
- Need accuracy, to reduce added margin required because of measurement uncertainty
- May need reference level/IF gain adjustments to improve linearity for accurate low level signal measurements

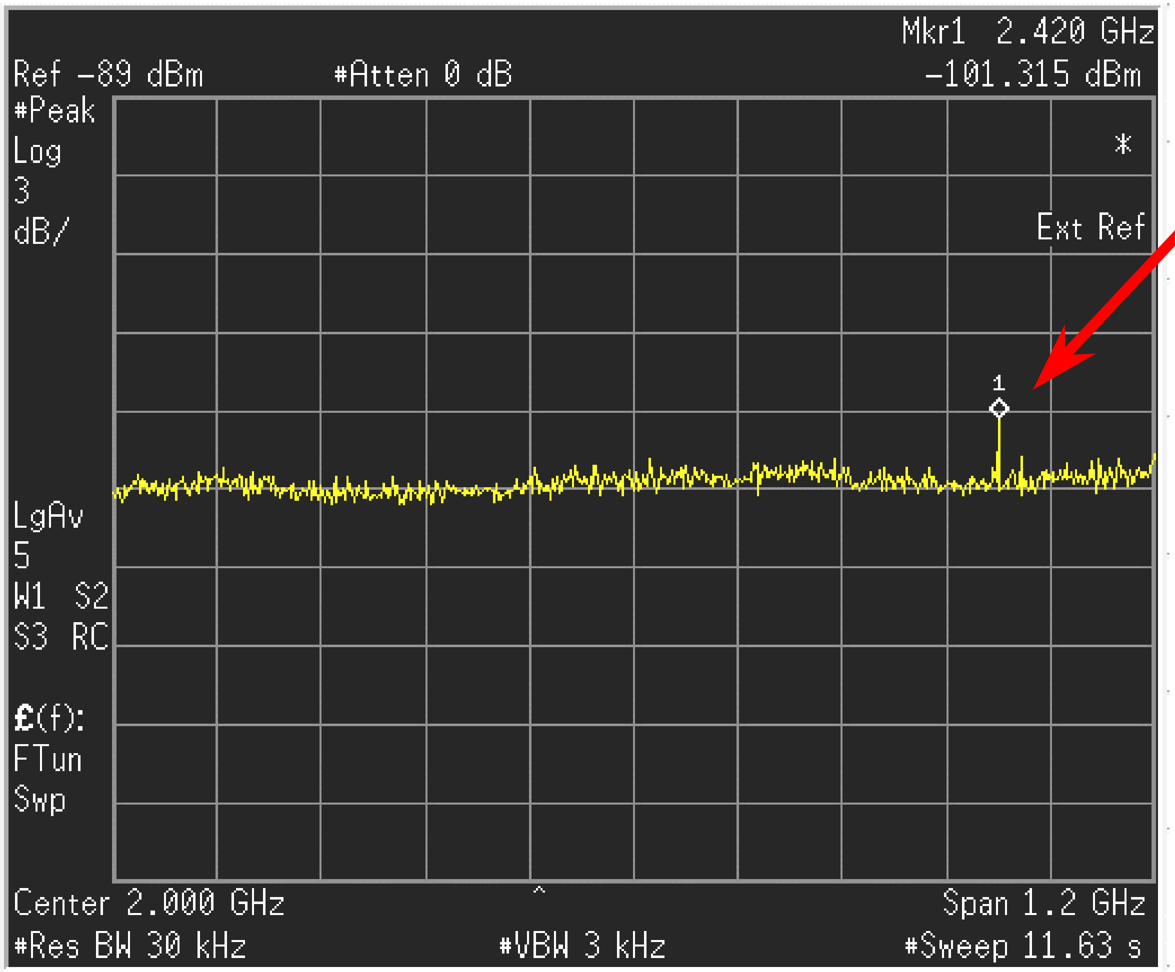
Accurate Measurements Of Small Signals

Accurate measurements anywhere on screen in any RBW



Agilent Technologies

Spurious Measurement

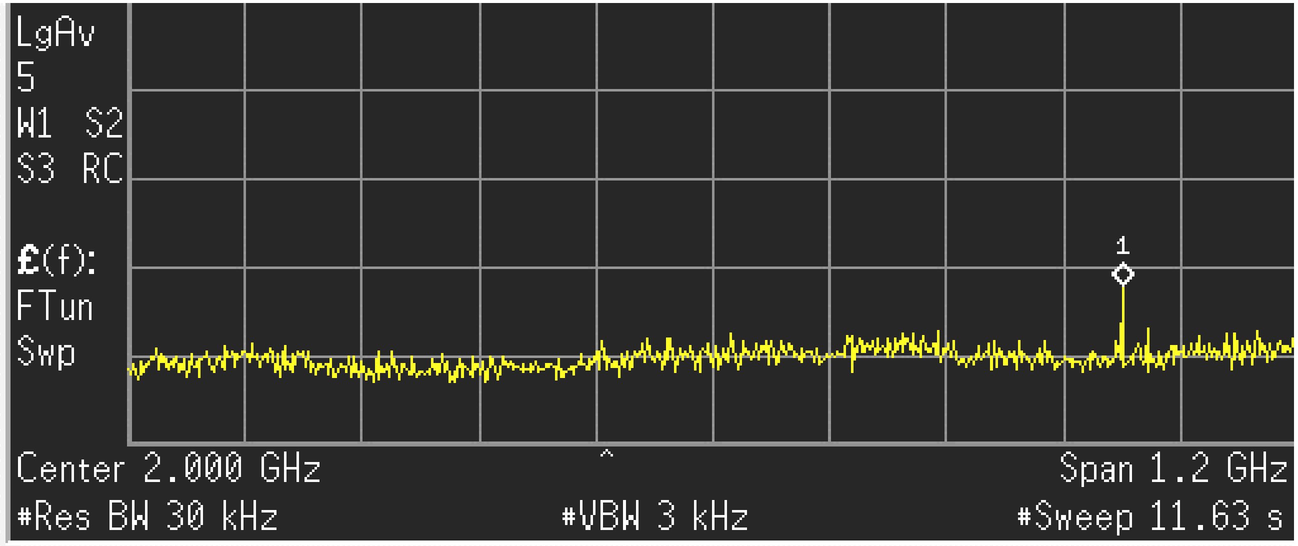


Spur appears 3 dB above noise level

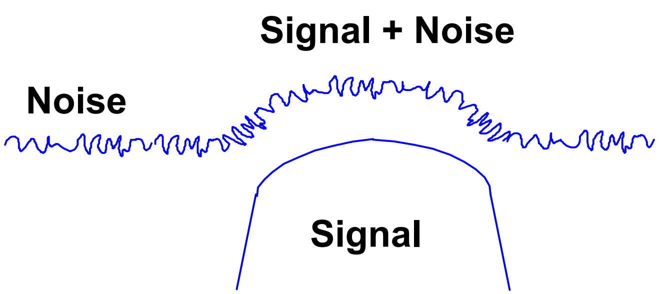
Spurious Measurement, Part 2

- **Need speed, because of wide frequency span and narrow RBW (sweep speed varies with square of RBW)**
- **Need special techniques for accuracy if we are measuring near noise floor**

Measuring Close to Low Noise Floor

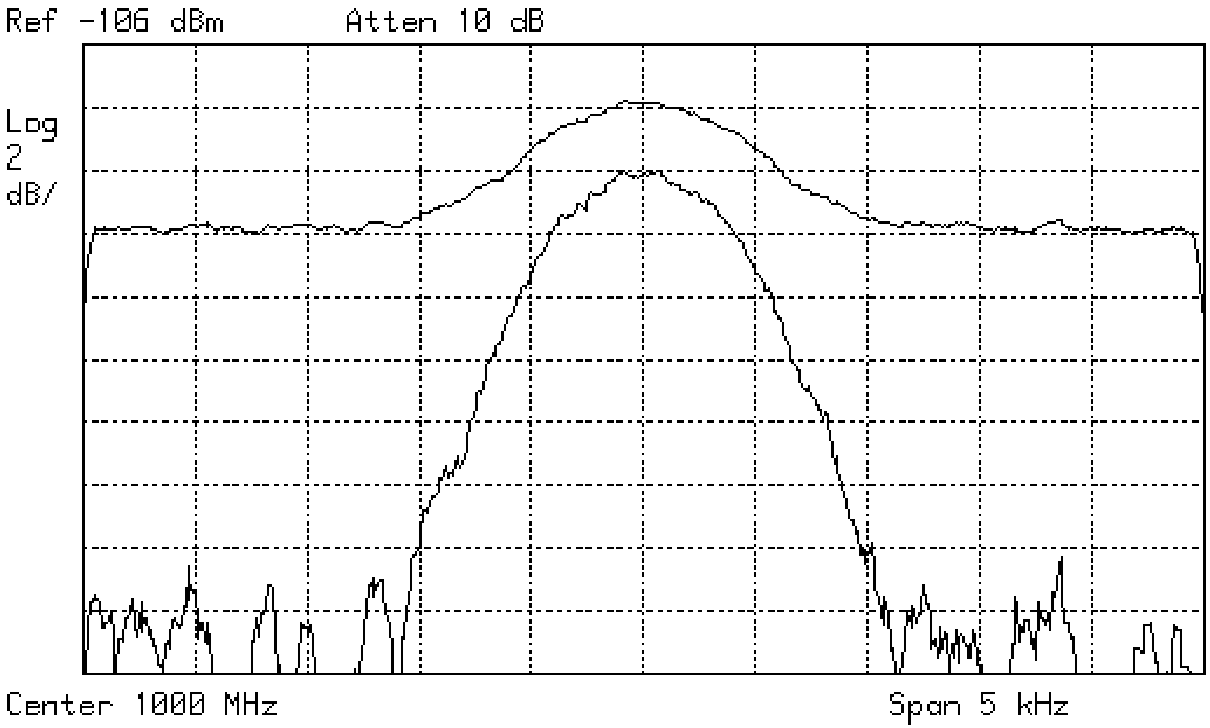


- Improve speed, accuracy without making a slow measurement slower



Agilent Technologies

Noise subtraction



- Improve accuracy, dynamic range
- Need RMS detection, lots of averaging

Agilent Technologies

Amplitude Accuracy (Standard SAs)

- Amplitude accuracy is made up of the following:

•Frequency response	+/- 1.0 dB
•Log fidelity	+/- 0.5 dB
•RB switching errors	+/- 0.1 dB
•Step attenuator accuracy	+/- 0.5 dB
•IF gain errors	+/- 0.1 dB
•Calibrator errors	+/- 0.2 dB

Amplitude Accuracy (Advanced SAs)

- Improved Accuracy using digital IF

•Frequency response	~~+/- 1.0 dB~~	+/- 0.4 dB
•Log fidelity	~~+/- 0.5 dB~~	+/- 0.07dB
•RB switching errors	~~+/- 0.1 dB~~	+/- 0 dB
•Step attenuator accuracy	+/- 0.5 dB	Same
•IF gain errors	~~+/- 0.1 dB~~	+/-0 dB
•Calibrator errors	+/- 0.2 dB	Same

Measurement Speed (Sweep Time)

- Sweep Time is dependent upon:
  Resolution Bandwidth, Frequency Span, Detector Type, Video Bandwidth, and Sweep Mode (FFT or Swept)

- Today's spectrum Analyzers will choose the optimum sweep time

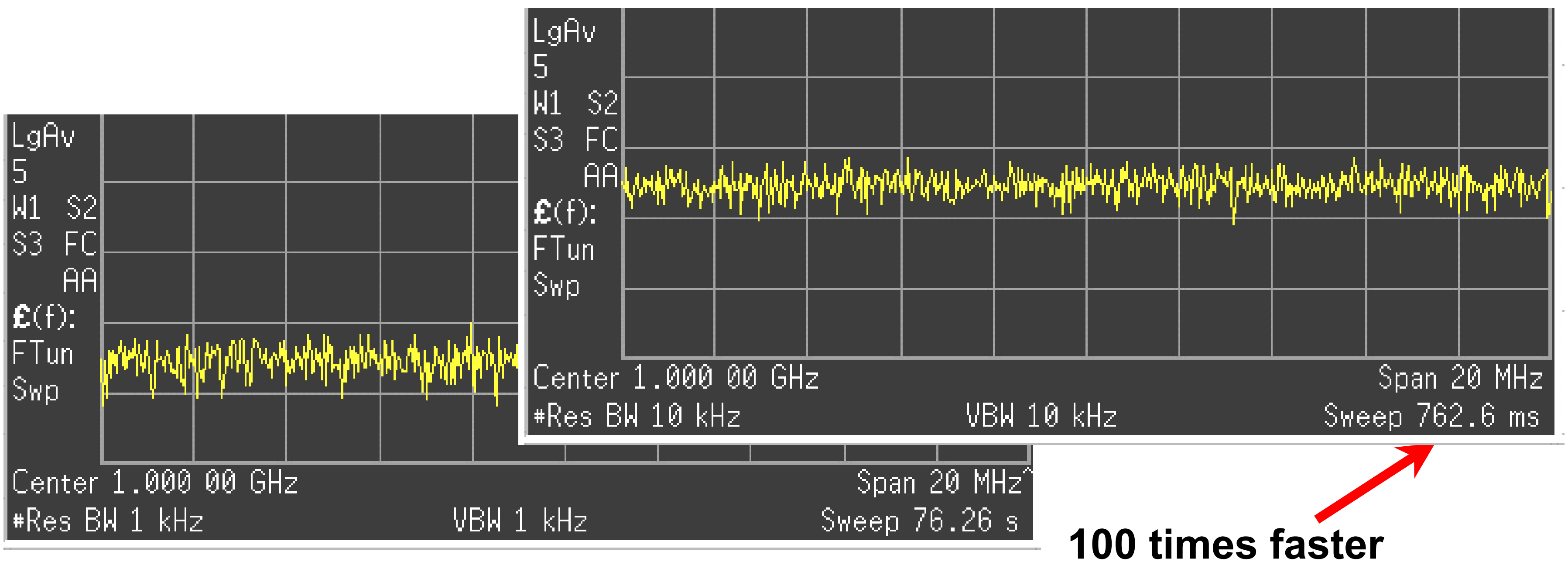
- For noisy measurements, modern SAs with average detectors can reduce variance faster

Resolution Bandwidth and Sweep Speed

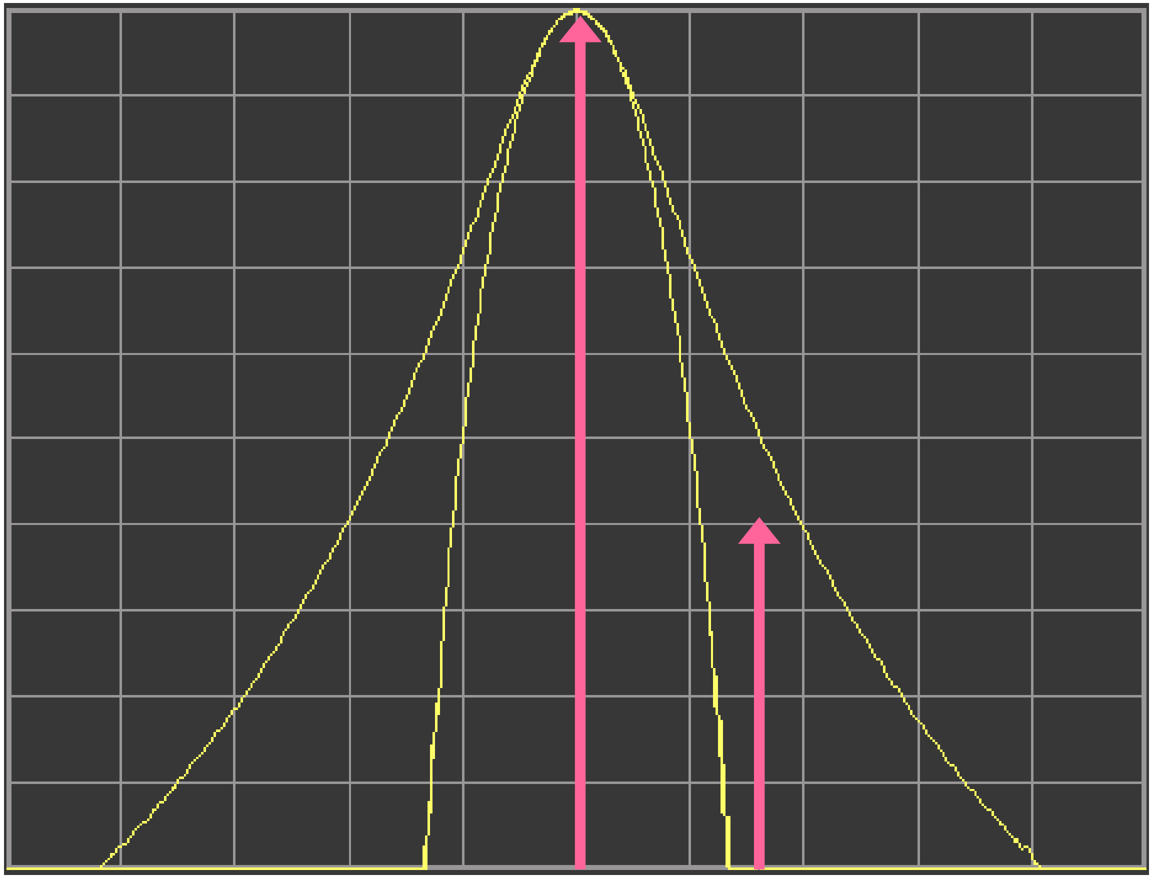
- As the RBW widens, the sweep speed increases

> **•Sweep Speed ~ RBW^2**

- A 10x increase in RBW = 100x increase in speed



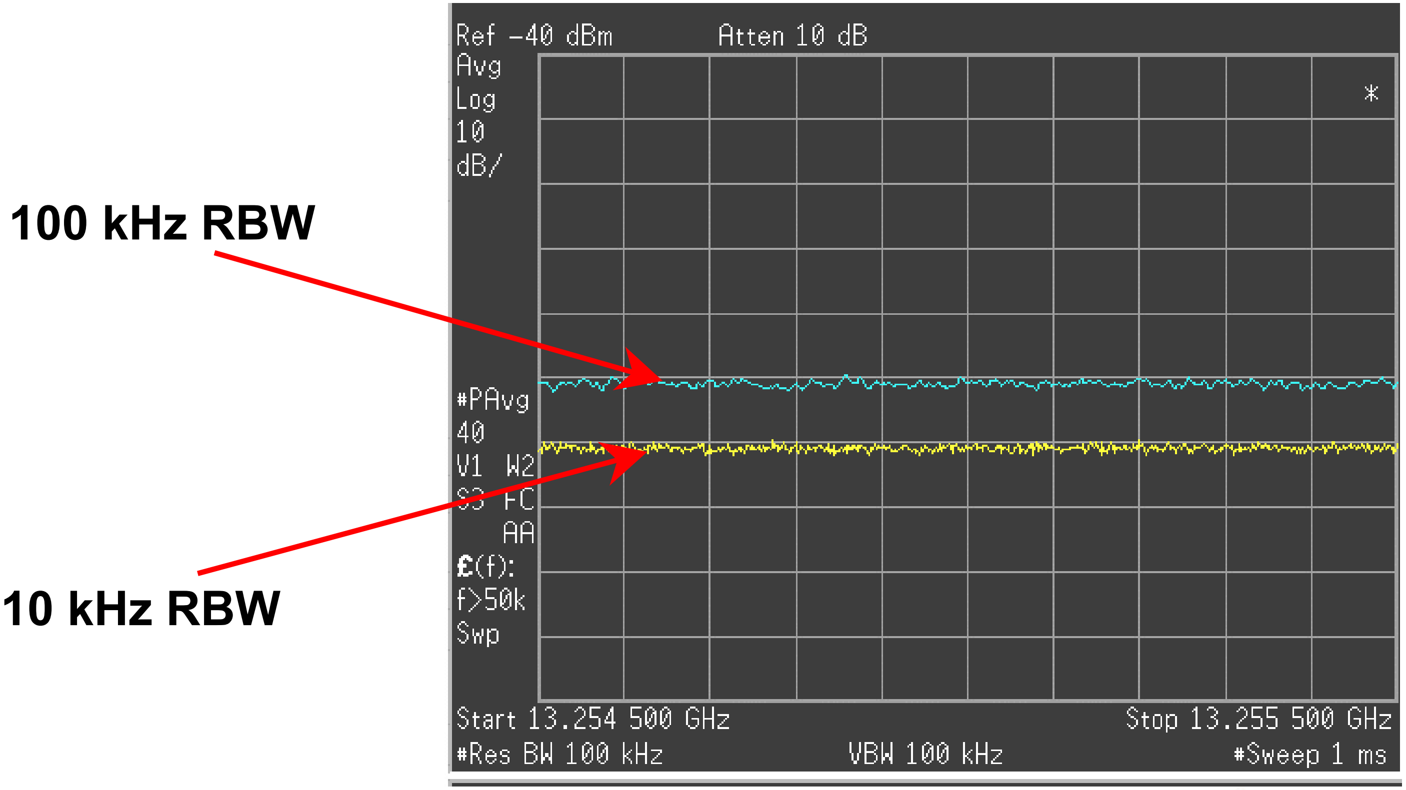
Digital RBW Filters



- Shape factor 4:1 vs. 12:1 enables viewing of close-in signals at wider (faster sweeping) RBW

RBW and Sensitivity

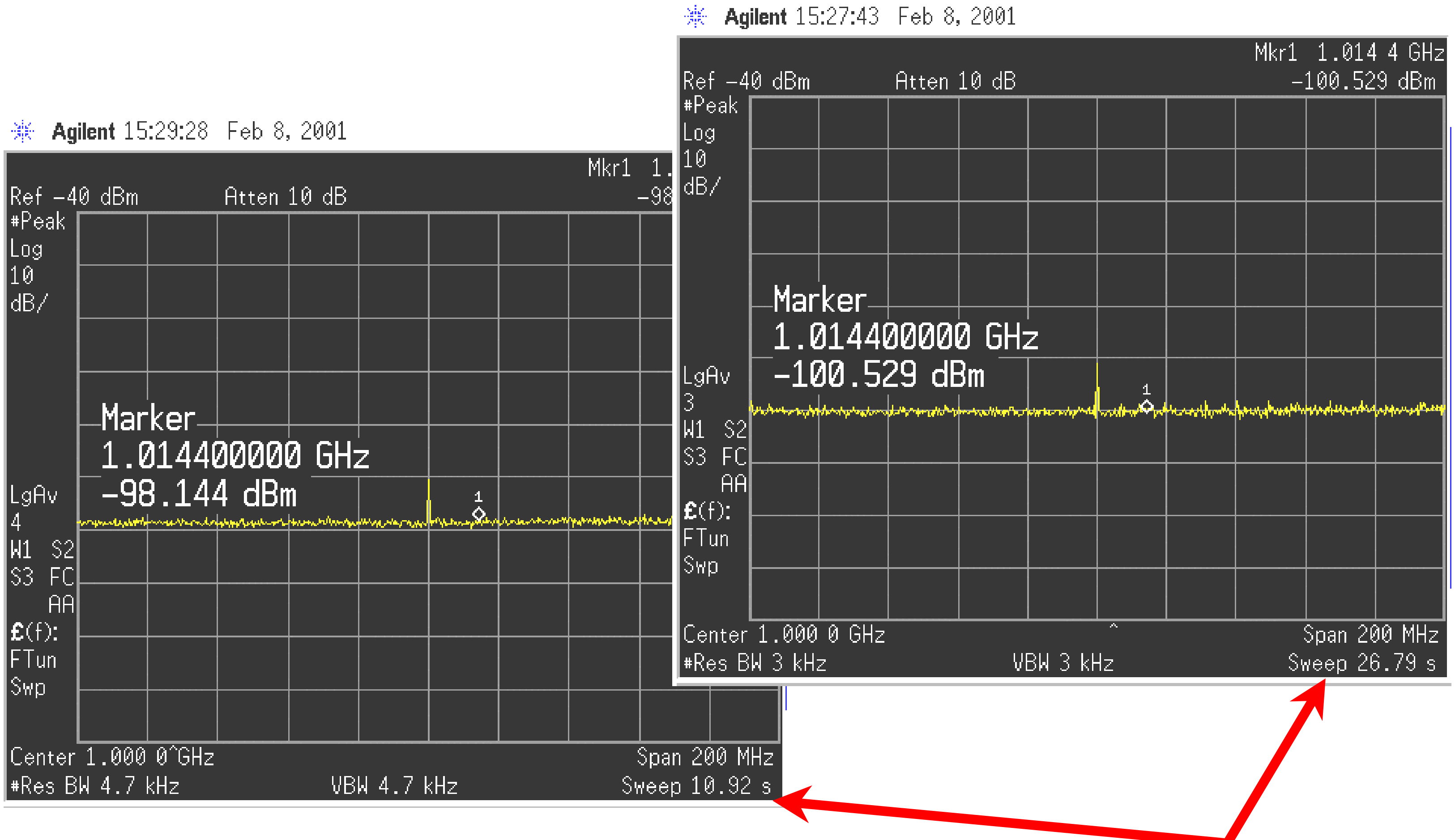
- As RBW increases, the sensitivity decreases
- **10x delta BW ~ 10 dB delta sensitivity**



Optimize Sensitivity and Sweep Speed

- Optimizing sensitivity produces the fastest spur searches
- Choose the widest RBW that gives the sensitivity required--this will yield the fastest sweep
- Some new spectrum analyzers have narrower RBW steps (10 % steps) to better optimize settings
- Use peak detection for the best speed

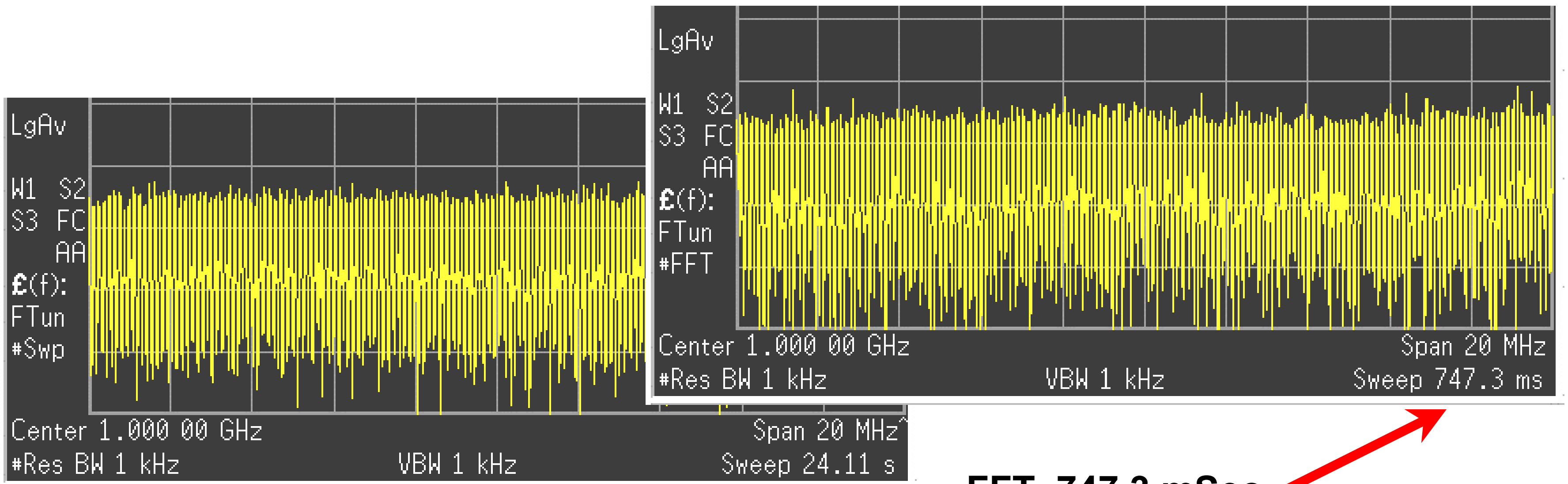
Changes In Sensitivity, Speed vs RBW



•**Large change in sweep speed for a small change in RBW and sensitivity**

FFT Operation

- **Modern Spectrum Analyzers have both FFT and Swept modes**
- **Depending on span, the FFT mode can measure faster than swept mode.**



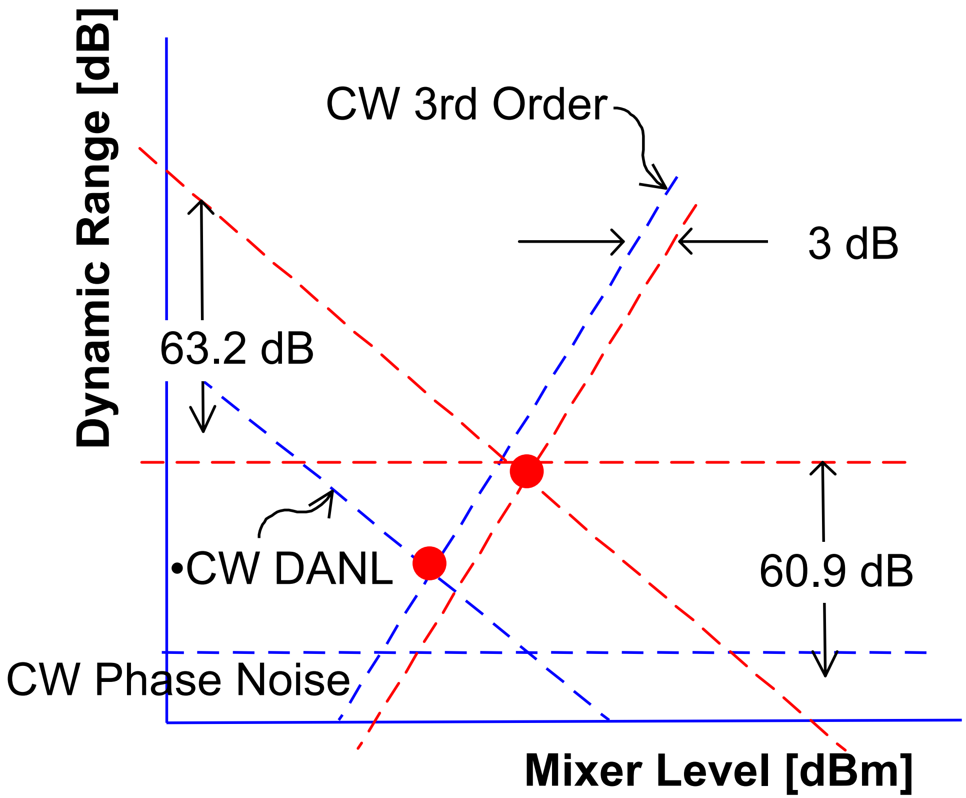
FFT, 747.3 mSec

Swept, 24.11 Sec

Dynamic Range

- Measuring small signals in the presence of much larger ones
- Different types—Signal vs. noise, signal vs. distortion, phase noise
- Typically—balancing distortion and noise mechanisms

Maximizing Dynamic Range



S/N Curve Offset:

10* Log(1.23 MHz)

+2.51 dB - .25 dB = 63.2 dB

3rd Order Curve Offset:

Foffset / BWm = .885 / 1.23

= .72

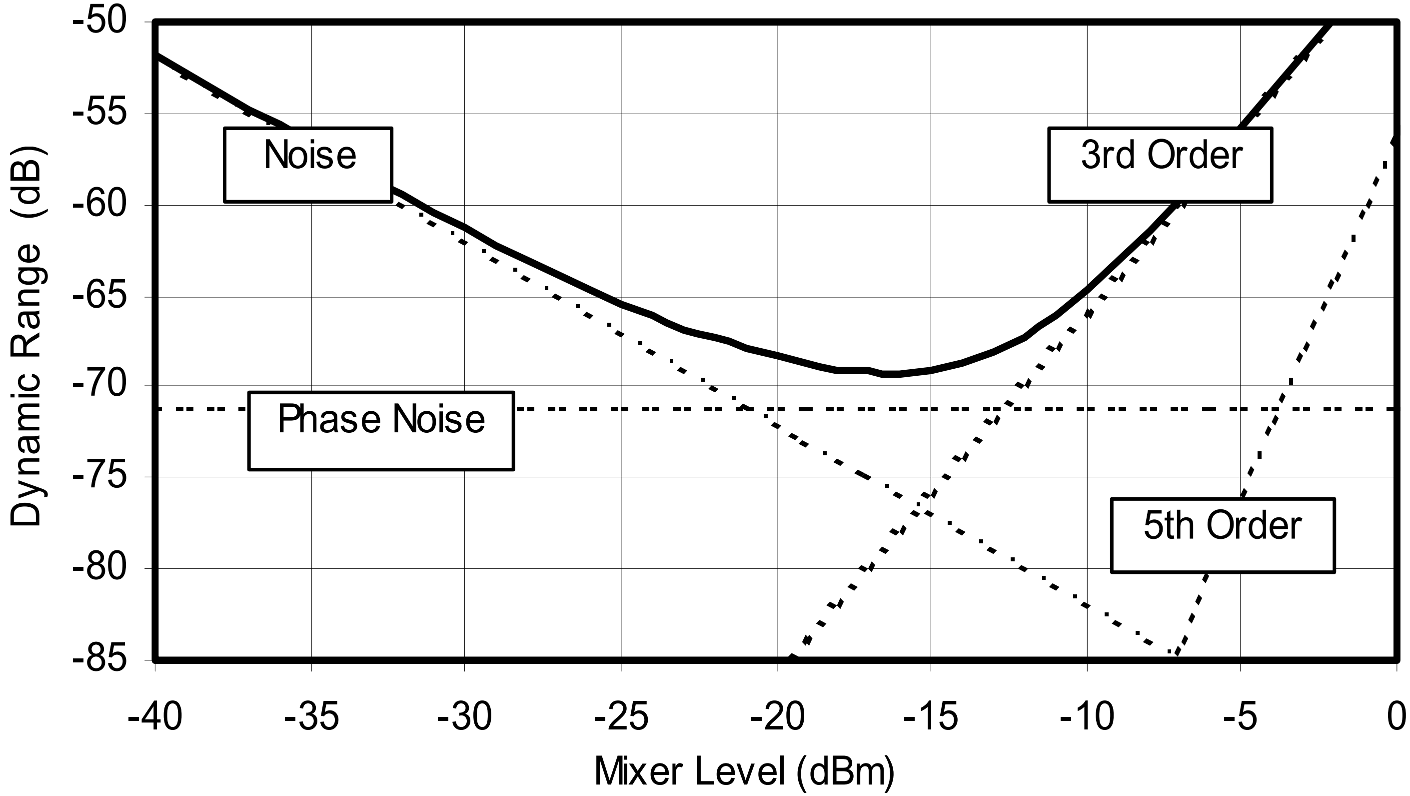
TOI Offset from Chart = 3 dB

Phase Noise Offset:

10*Log(1.23 MHz) = 60.9 dB

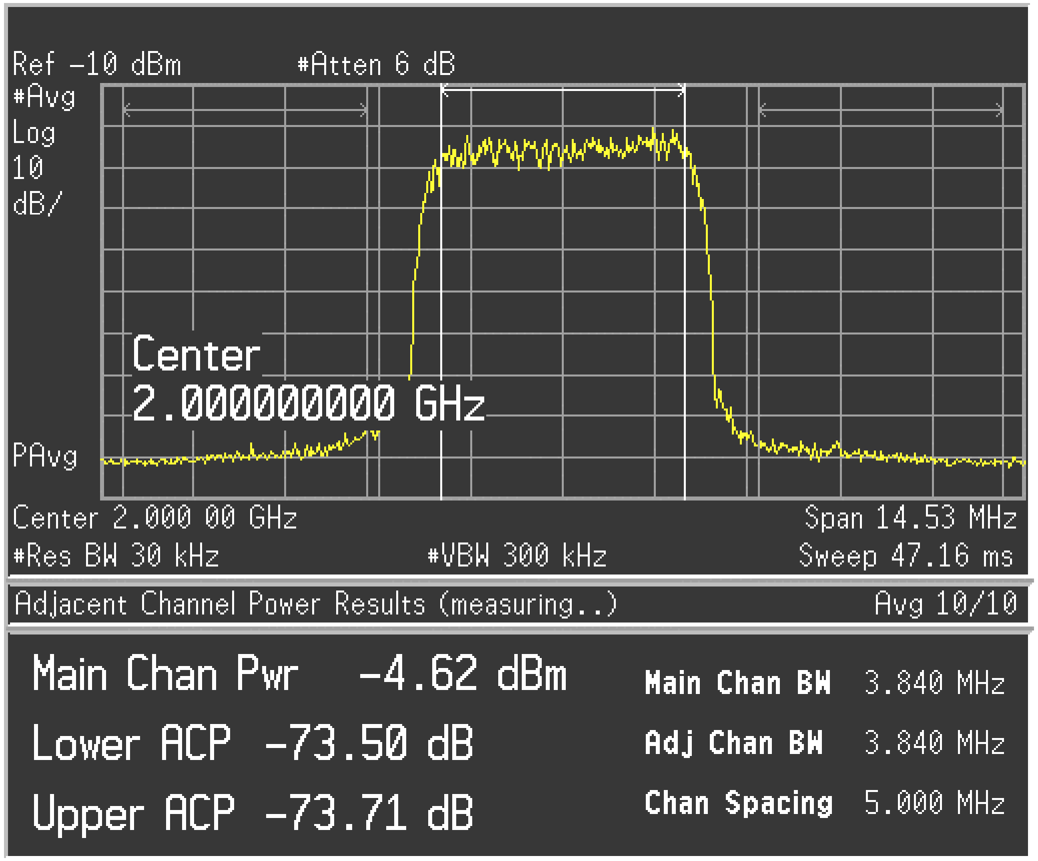
- **See references for PSA series product note**

Analytically Determine Input Level



- **Dynamic Range Chart for cdmaOne @ 885 kHz Offset**

ACPR Measurement



- **W-CDMA ACPR**

Agilent Technologies

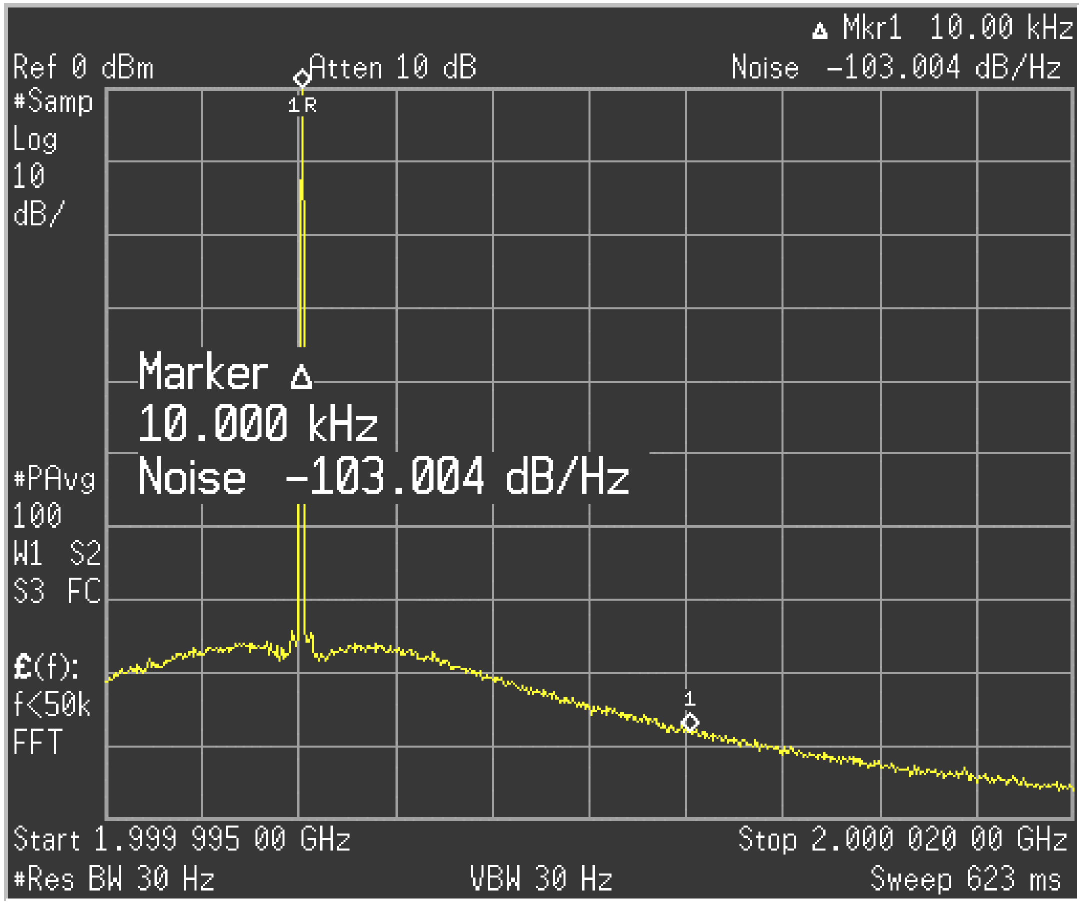
ACPR Measurement

- Optimized attenuator setting
- RBW/VBW--Optimize or adhere to standard
- RMS detection
- Averaging, average detector
- Band power markers, integration

Phase Noise Measurement

- Need accurate carrier and noise power measurements
- Use appropriate detectors and averaging
- Use band power or noise marker if available
- Optimize measurement speed for narrow RBW, averaging

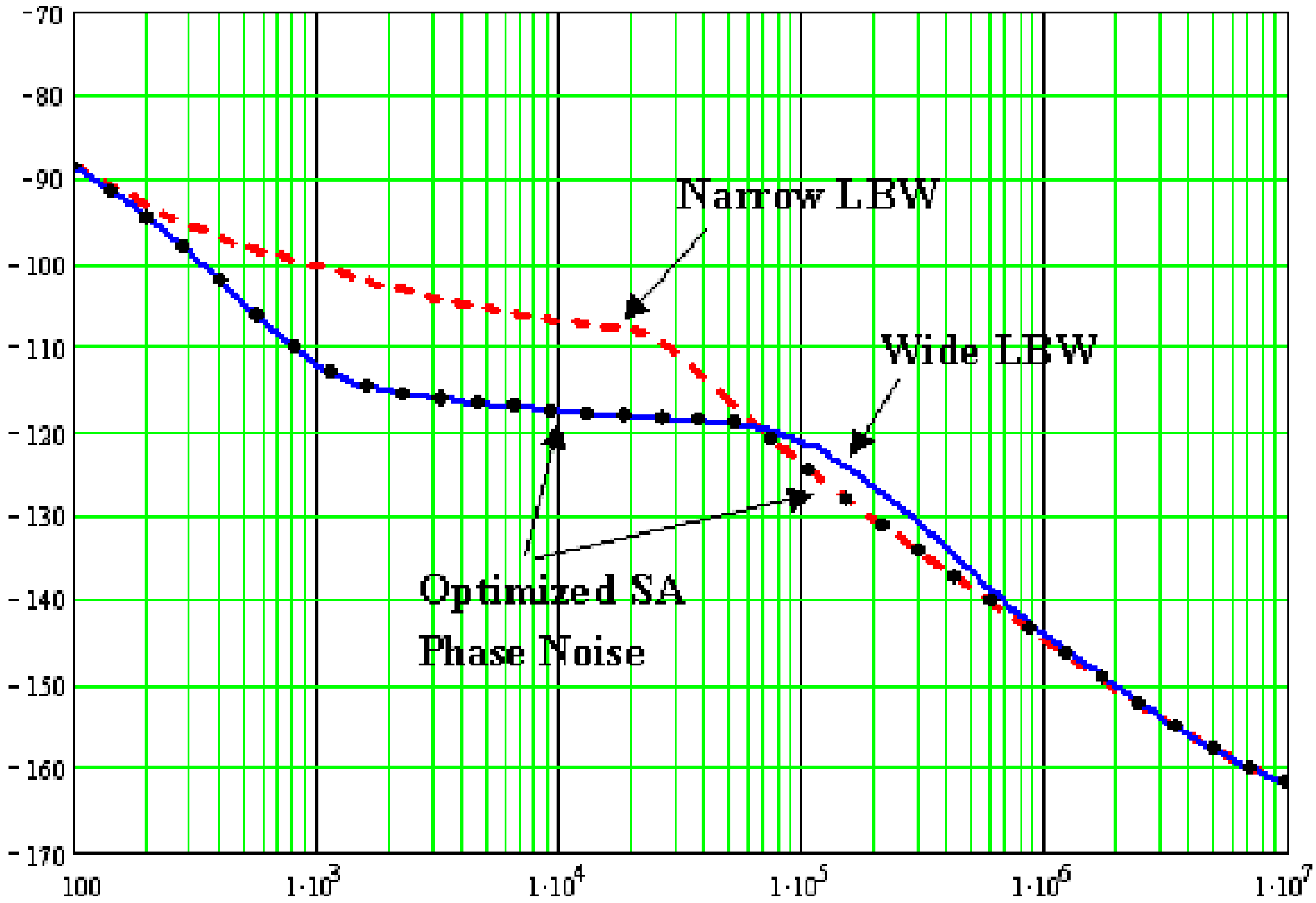
Phase Noise Measurement



- **Phase noise measurement using noise marker function and delta (relative) calculation**

Agilent Technologies

Phase Noise Optimization

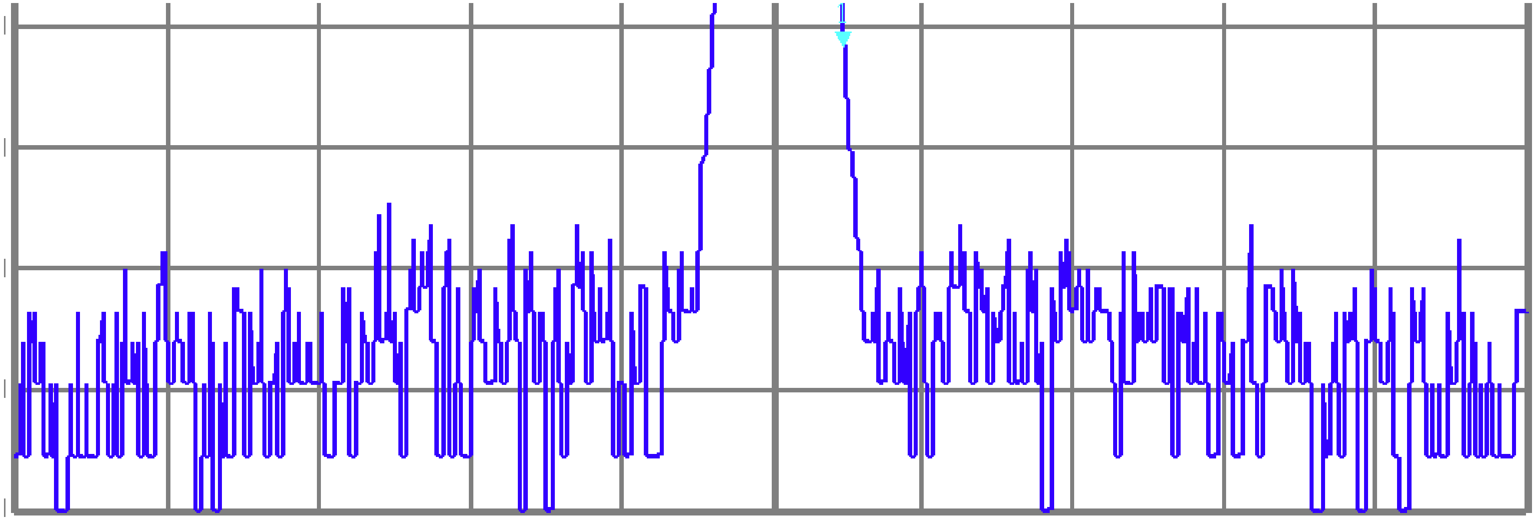


Agilent Technologies

Phase Noise Optimization

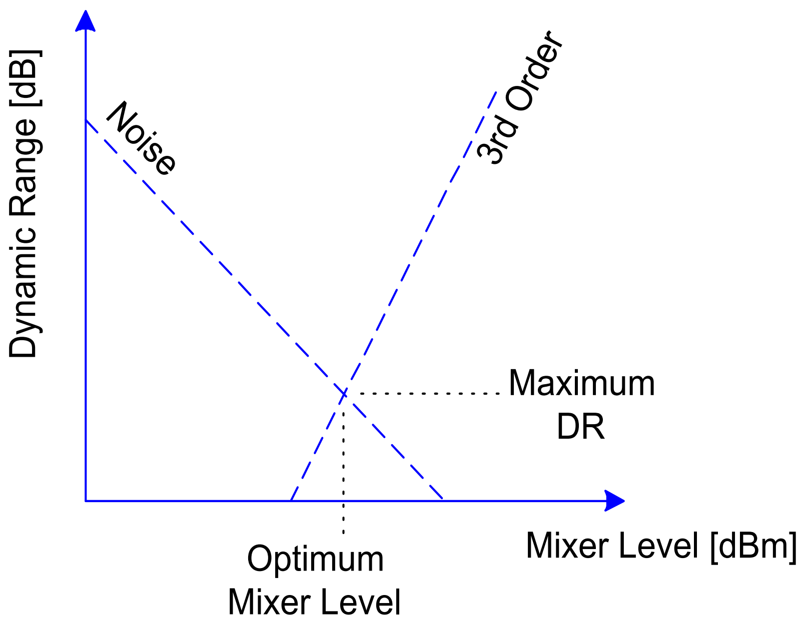
- Optimize narrowband for close-in measurements of CW signals
- Optimize wideband for best dynamic range in measuring large offsets and signals such as W-CDMA
- Optimize for fast switching to get the fastest sweep time when measuring the power of widely-spaced signals

Architectural Effects



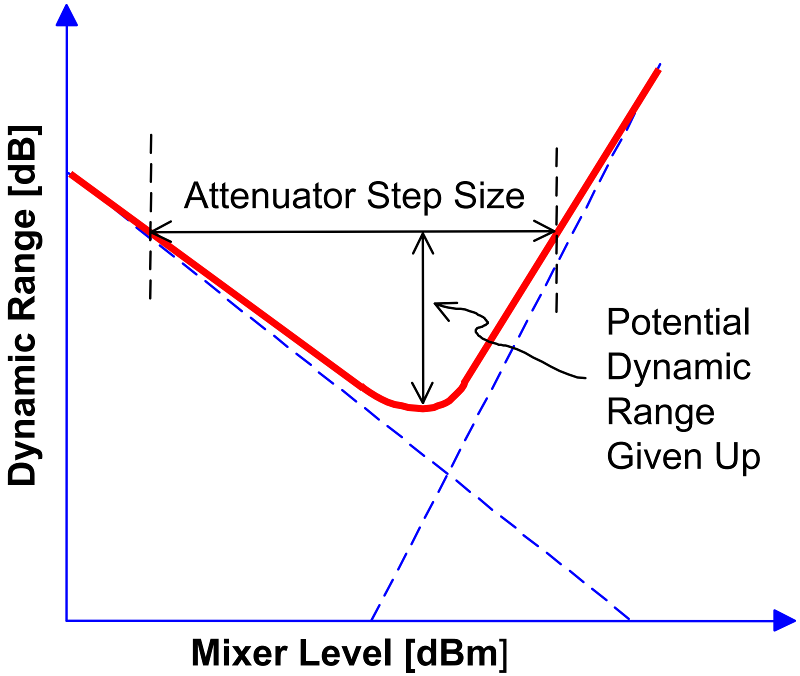
- General quality of input and downconversion
- IF techniques, use of ADCs and DSP

Dynamic Range vs. Attenuator Step



Optimum mixer level when distortion = noise (distortion-free measurements)

Dynamic Range vs. Attenuator Step



3rd order distortion example

Potential dynamic range lost vs. atten step size

Atten Step Size	Ideal DR chart	Spectral regrowth
10 dB	6.7 dB	4.1 dB
5 dB	3.3 dB	1.3 dB
2 dB	1.3 dB	.23 dB

Conclusions

- 3 Major factors in demanding measurements
  - Dynamic range/sensitivity
  - Accuracy
  - Speed (measurement and transfer)
- Optimizing trade-offs
- Measurement interactions

Conclusions

- Modern spectrum analyzers
  - Digital IF
  - Remove or minimize amplitude errors
  - Fine-steps RBW
  - Narrow (2 dB) step attenuator
  - FFT/DSP for speed improvements
  - Flexible detectors, averaging
  - Marker, band power functions

References

- **Agilent SA Basics NetSeminar**
  http://www.netseminar.com/index.cgi?sem_num=310
- **Agilent Dynamic Range Product Note**
  Literature number 5980-3079EN
- **Agilent Spectrum Analysis Basics**
  Application Note 150
- **Agilent PSA Series Home Page**
  www.Agilent.com/find/PSA
- **Agilent R&D Central**
  http://www.agilent.com/find/RandD
  (see signal analysis in the RF/Microwave hub)