Spectrum Analysis

Jussieu, le 15 janvier 2013

Olivier Durand

Agenda

Introduction

Overview:

- What is Signal Analysis?
- What Measurements are available?

Theory of Operation

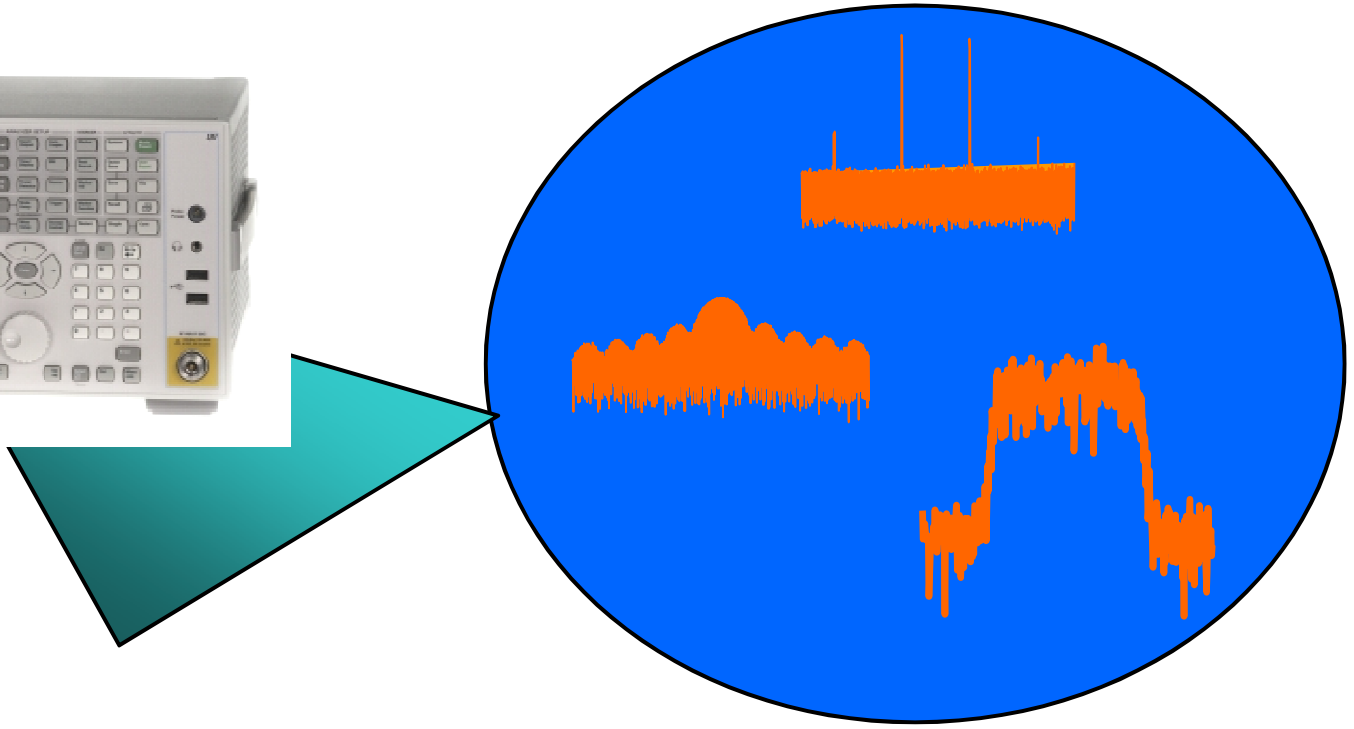
Specifications

Modern spectrum analyzer designs & capabilities

  – Wide Bandwidth Vector Measurements

Overview

What is Signal, Vector and Spectrum Analysis?

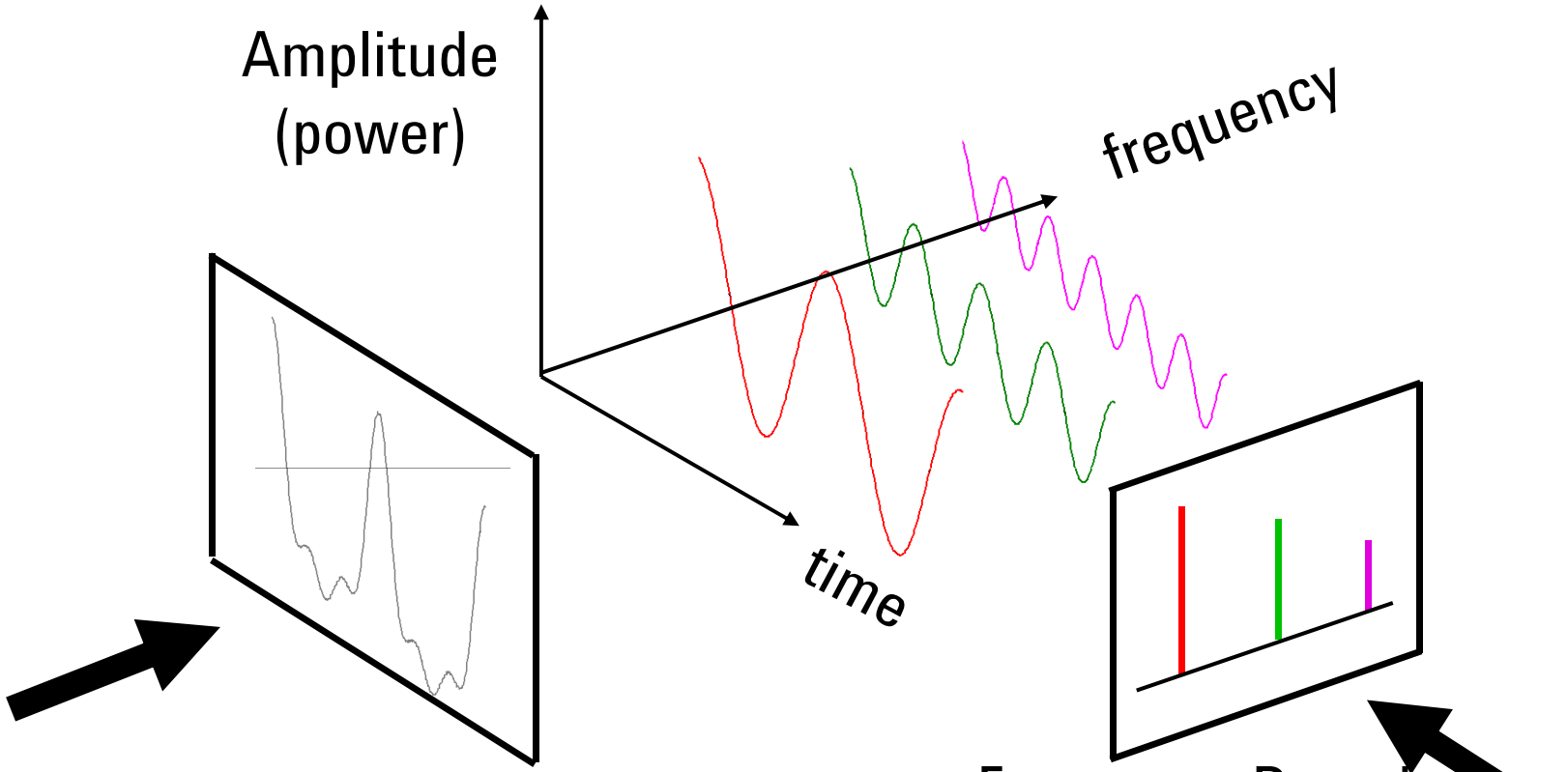


Spectrum Analysis

- Display and measure amplitude versus frequency for RF & MW signals
- Separate or demodulate complex signals into their base components (sine waves)

Overview

Frequency versus Time Domain



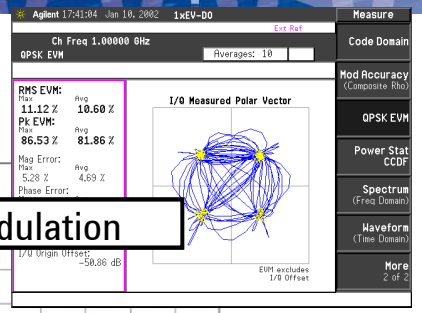
Overview

Types of Measurements Available

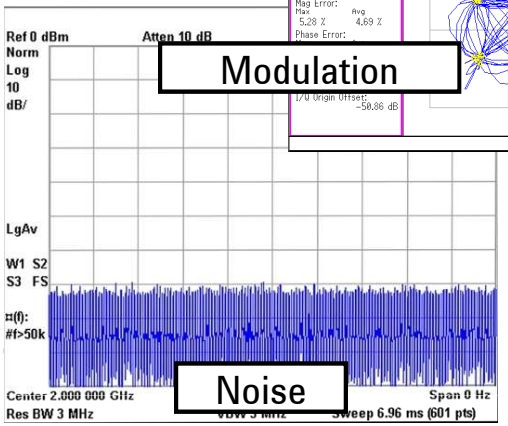
Frequency, power, modulation, distortion & noise

- Spectrum monitoring
- Spurious emissions
- Scalar network analysis
- Noise figure & phase noise
- Harmonic & intermodulation distortion
- Analog, digital, burst & pulsed RF Modulati
- Wide bandwidth vector analysis
- Electromagnetic interference

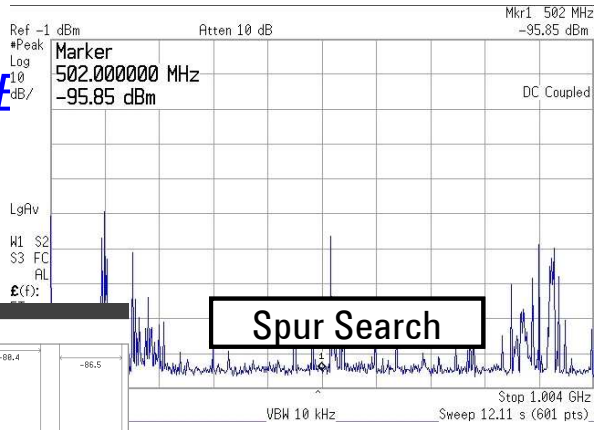
- *Measurement range (-168 dBm to +30 dE*
- *Frequency range (3 Hz to 325 GHz)*



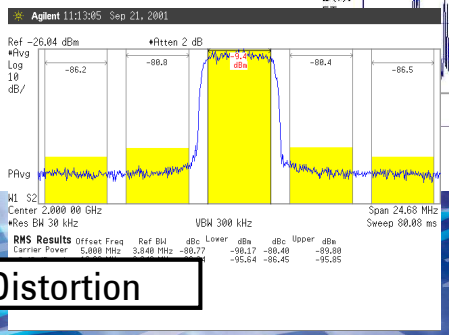
Modulation



Noise



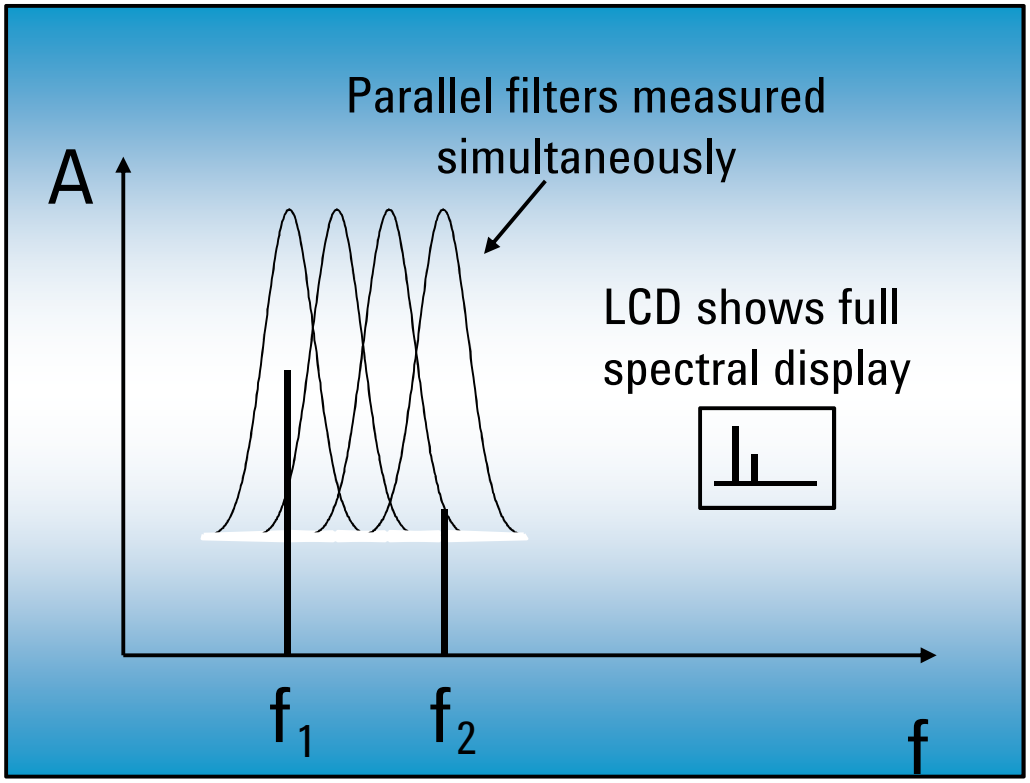
Spur Search



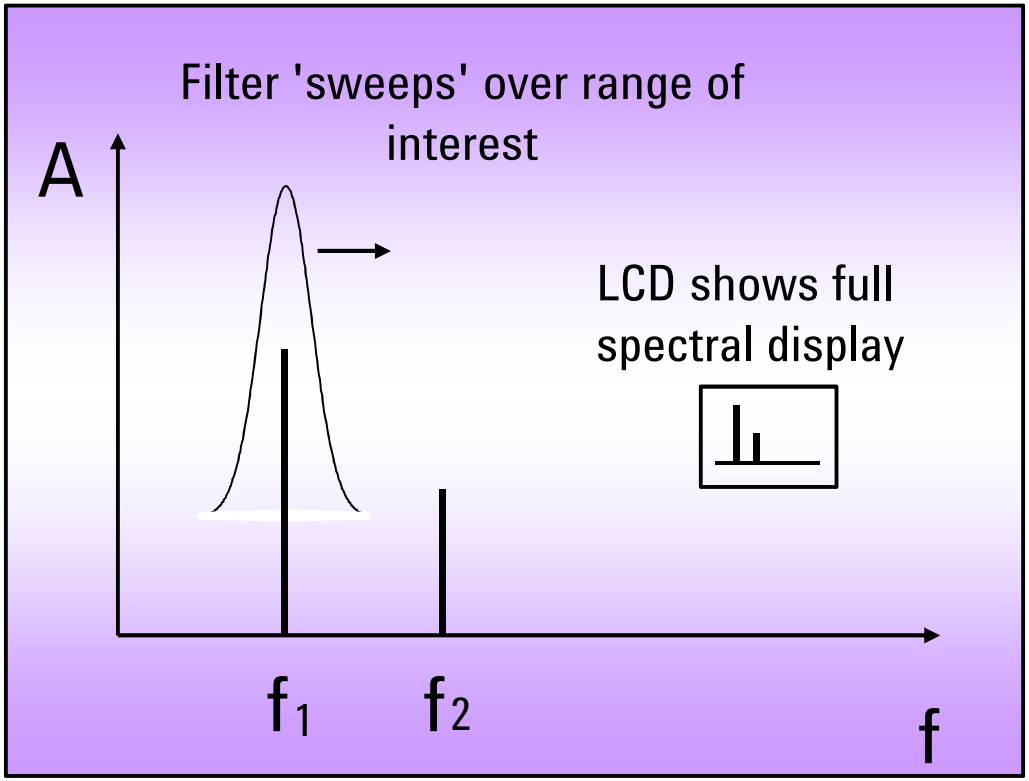
Distortion

Agilent Technologies

FFT Analyzer



Swept Analyzer



Agenda

Introduction

Overview

Theory of Operation:

- Swept Spectrum Analyzer Hardware

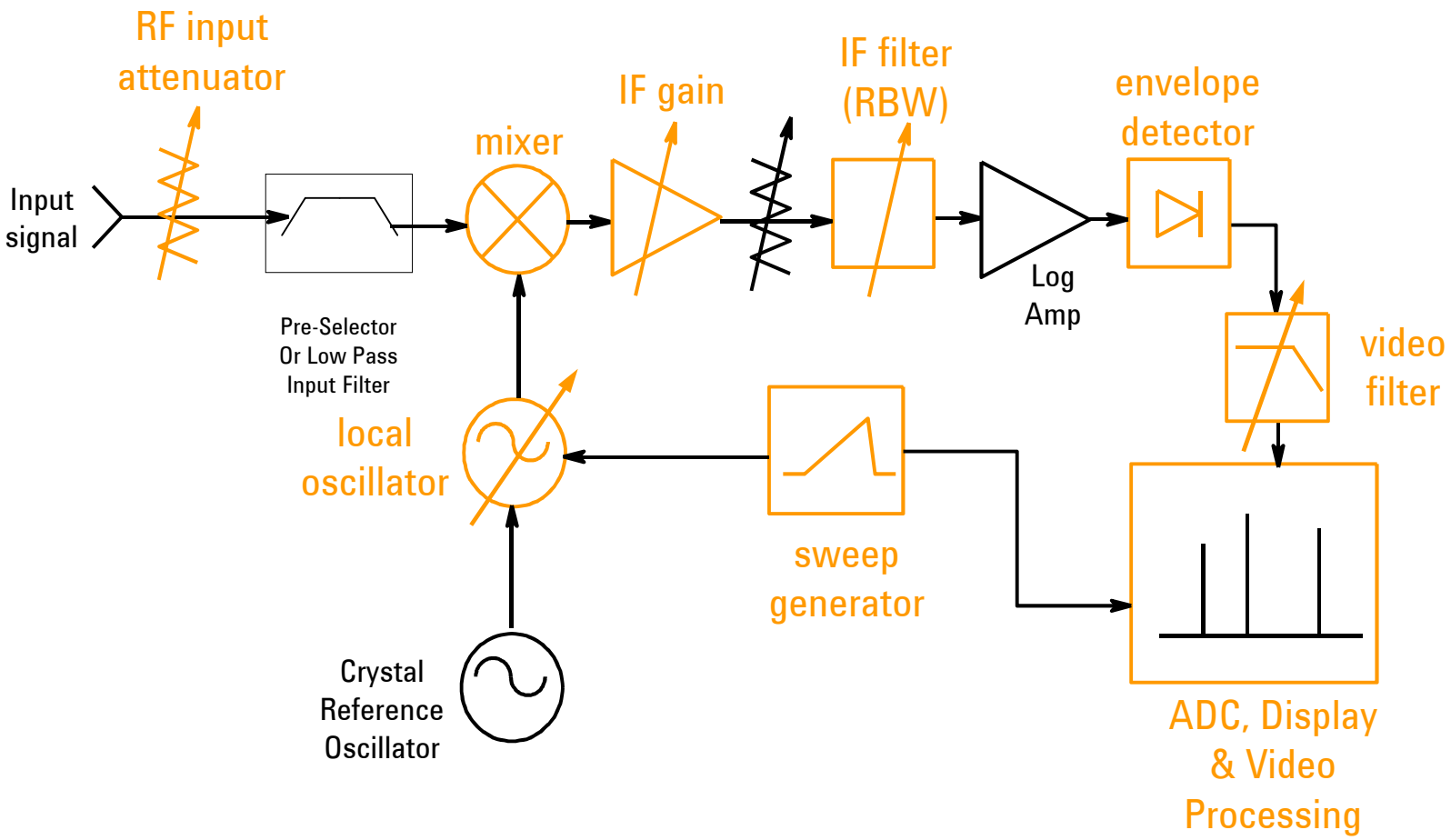
Specifications

Modern spectrum analyzer designs & capabilities

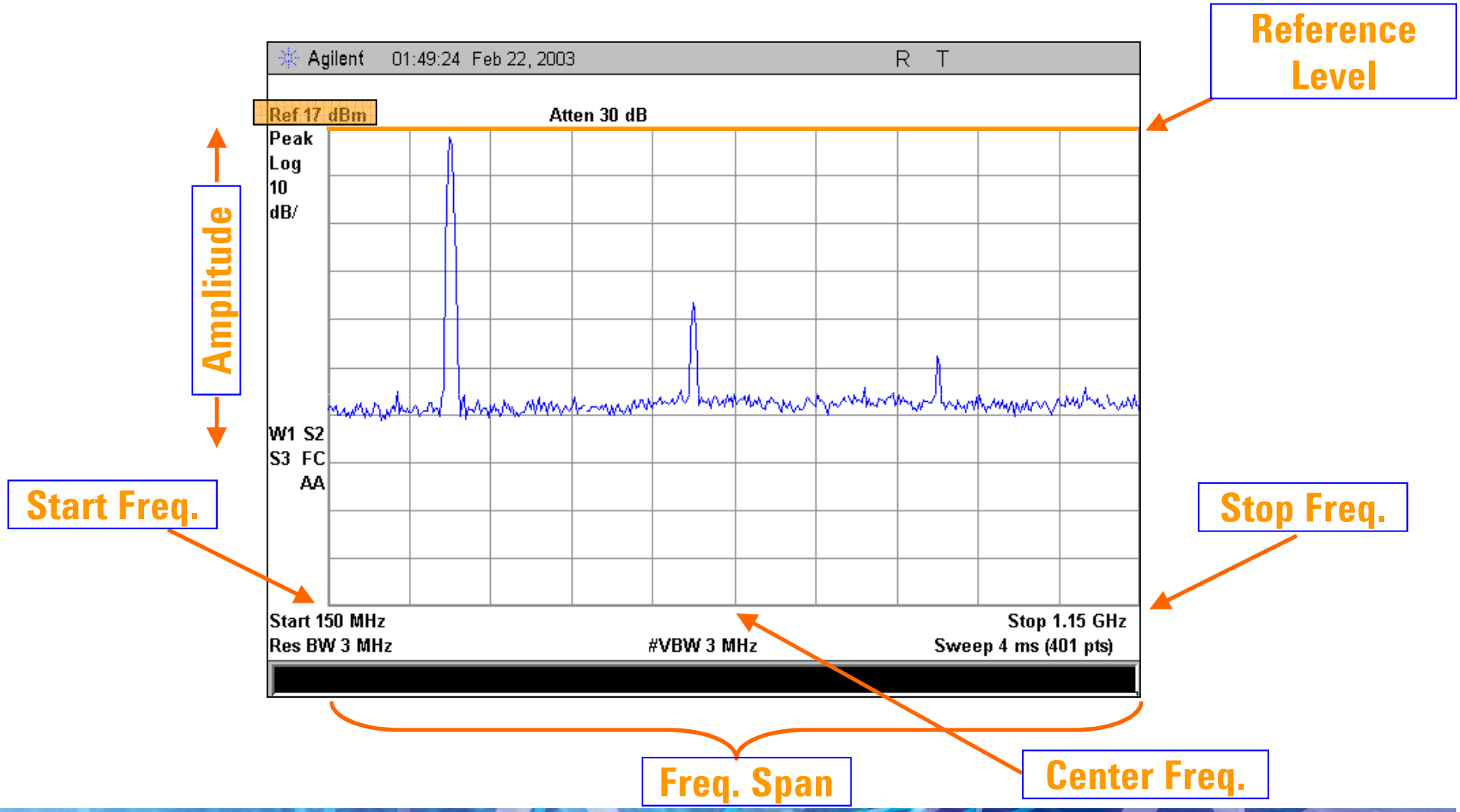
– Wide Bandwidth Vector Measurements

Theory of Operation

Swept Spectrum Analyzer Block Diagram

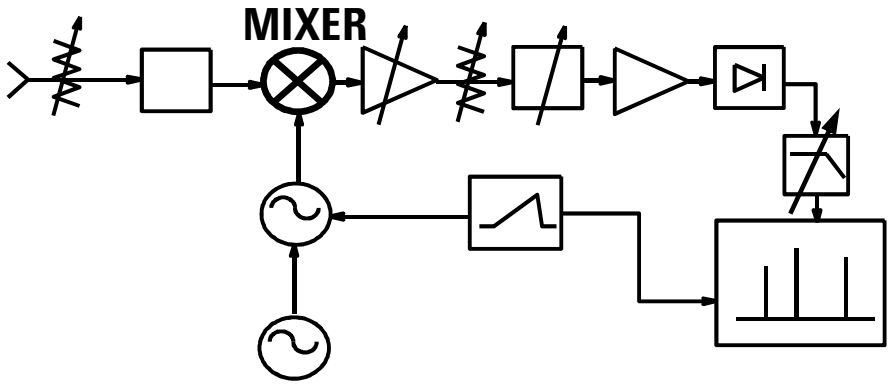


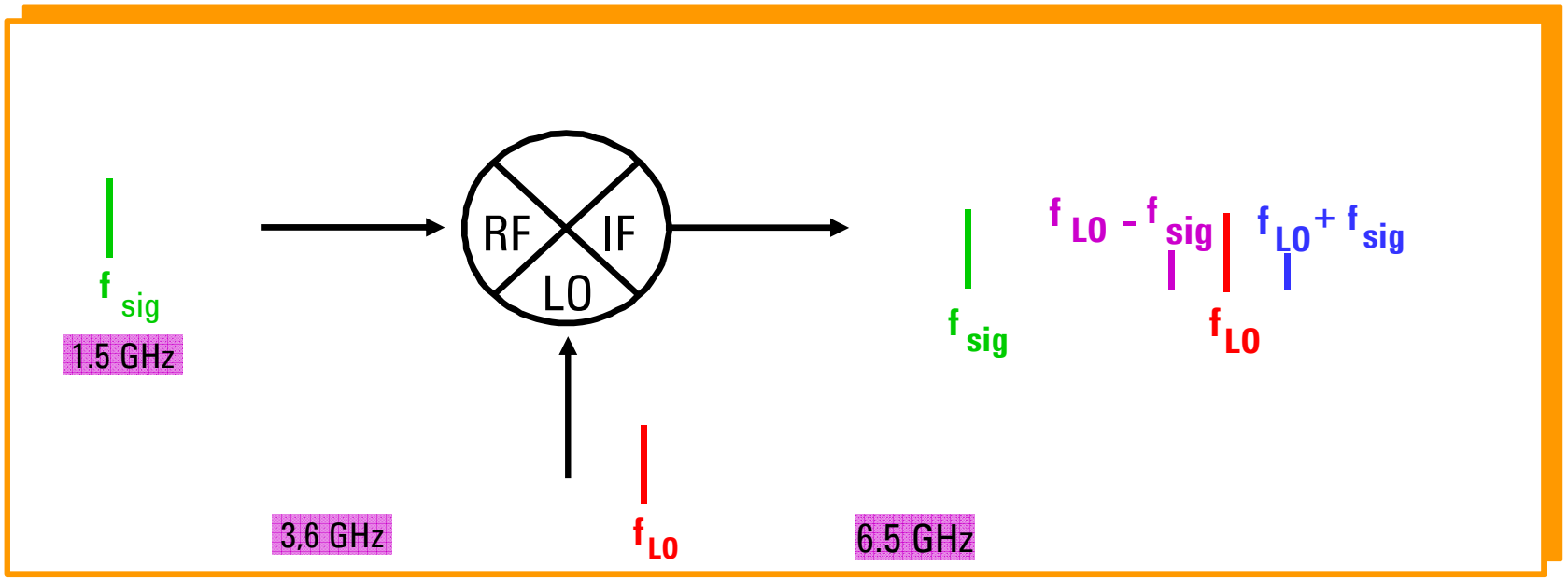
Theory of Operation
Display terminology



Theory of Operation

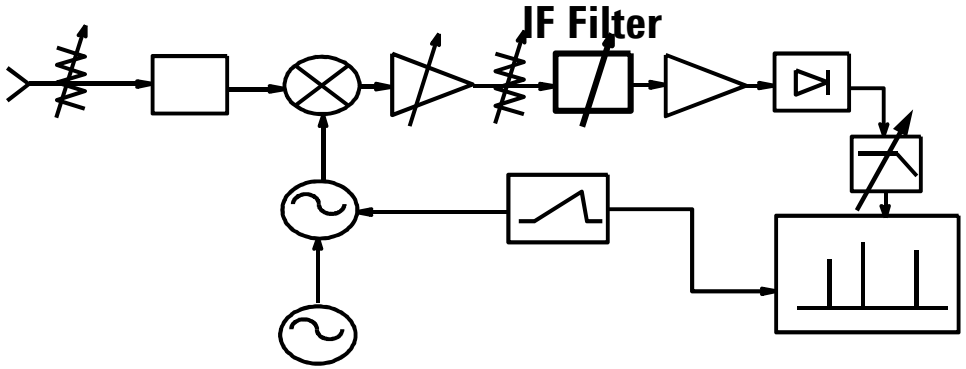
Mixer

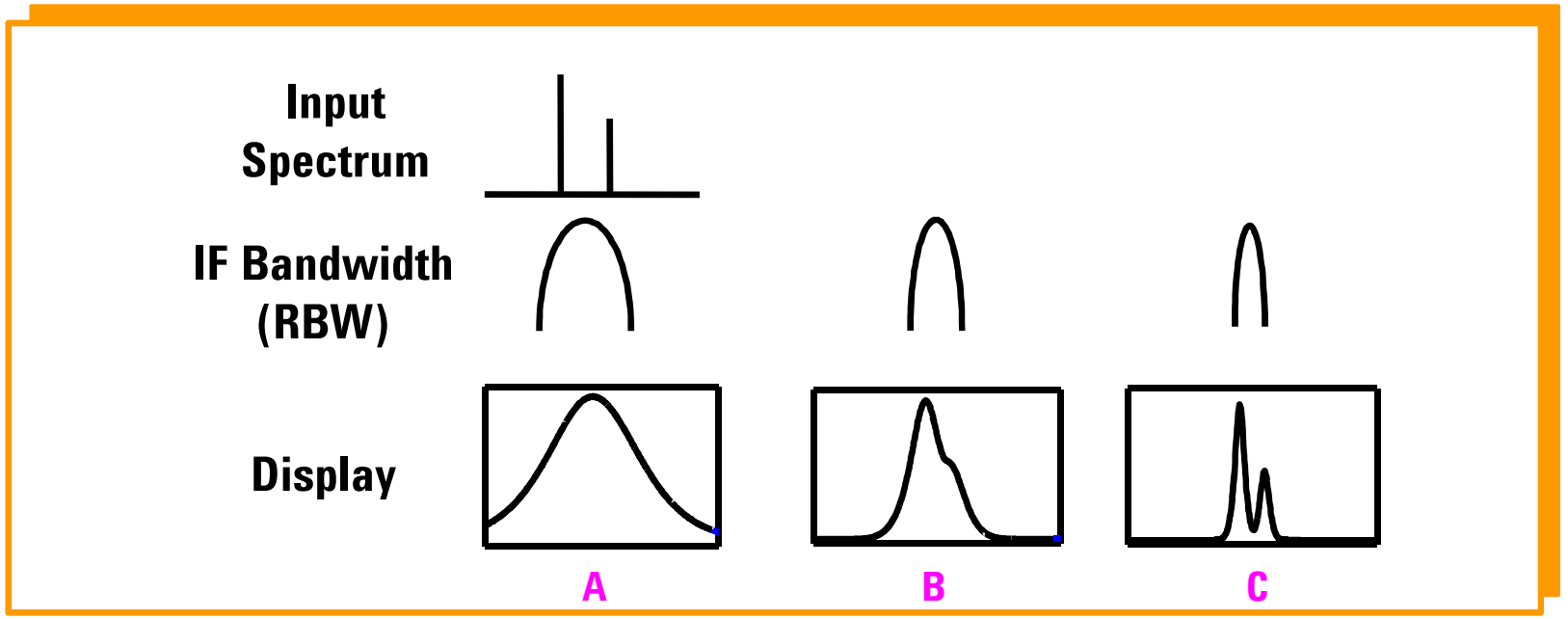




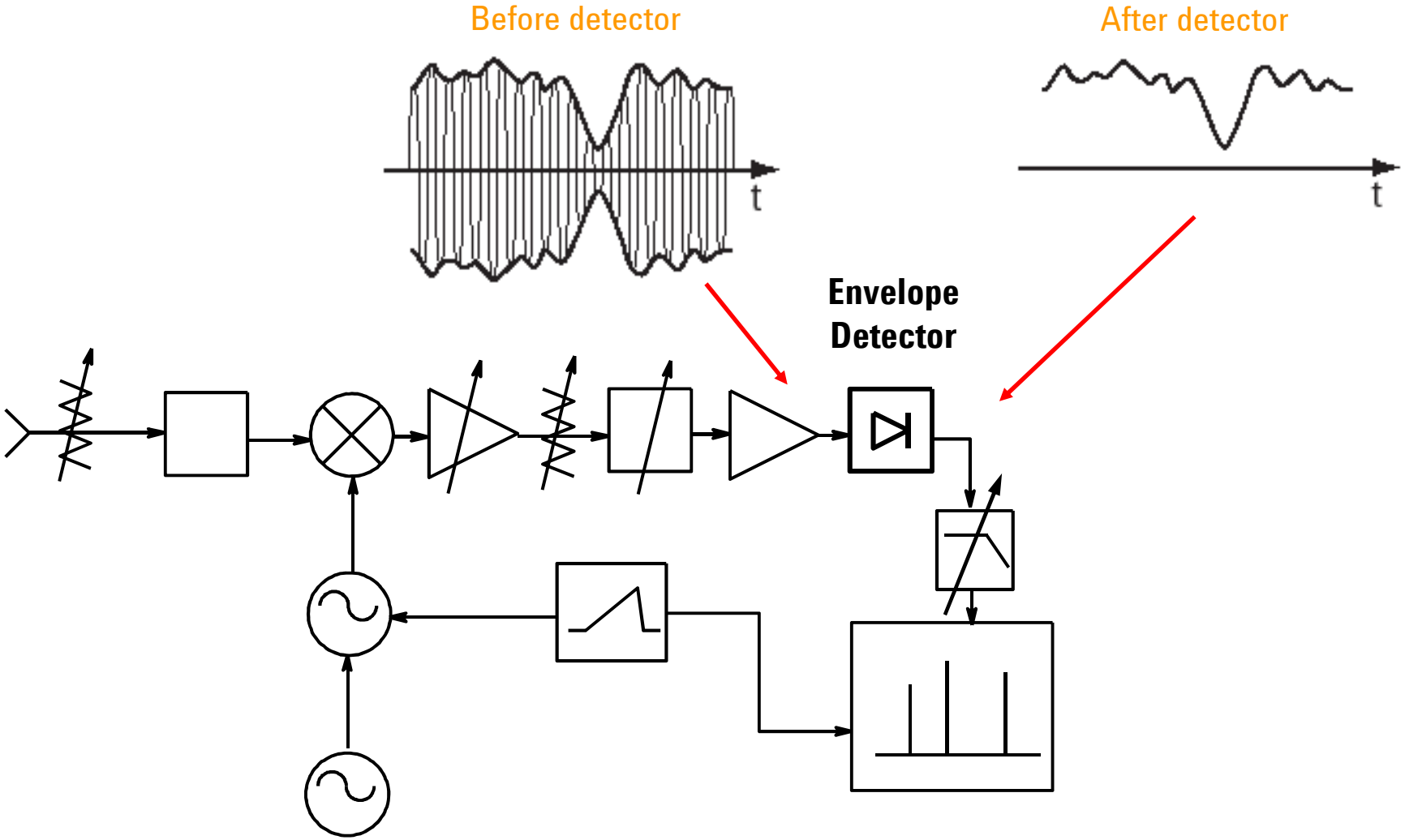
Theory of Operation

IF Filter (Resolution Bandwidth – RBW)



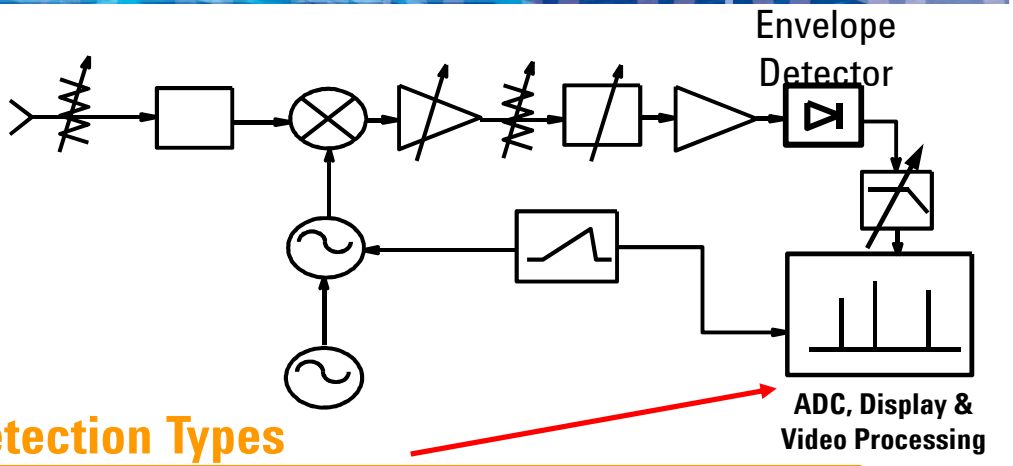


Theory of Operation
Envelope Detector

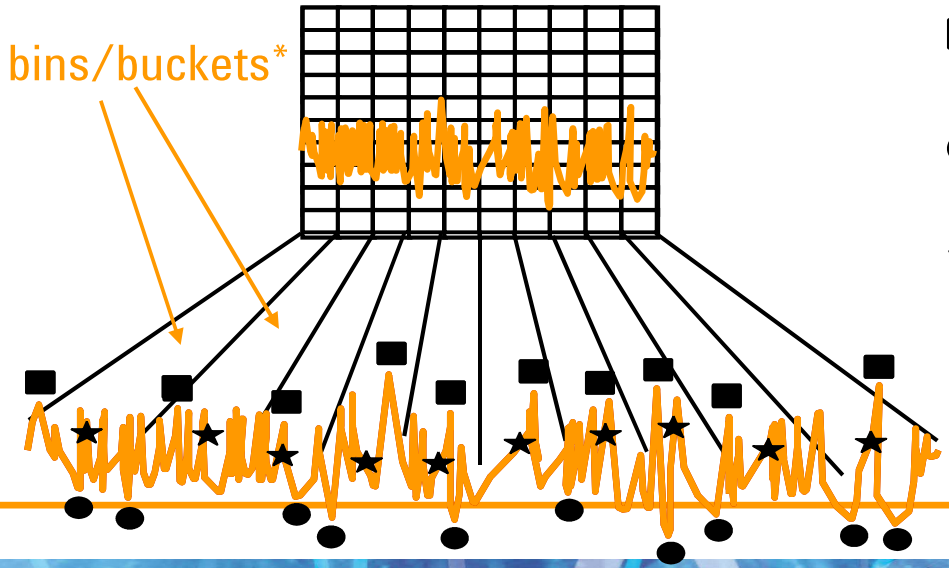


Theory of Operation

Envelope Detector and Detection Types



Digitally Implemented Detection Types

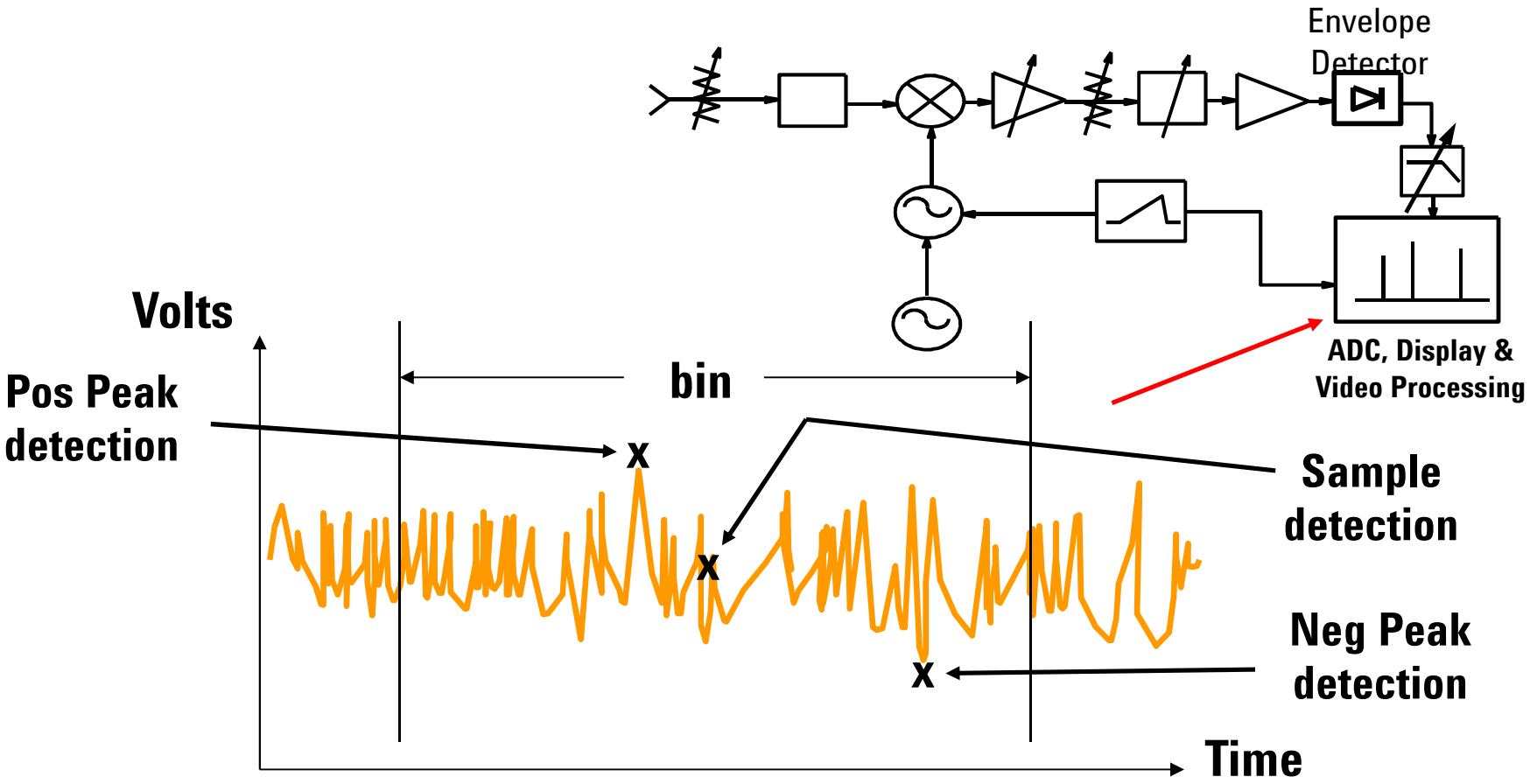


- ■ Positive detection: largest value in bin displayed
- ● Negative detection: smallest value in bin displayed
- ★ Sample detection: middle value in bin displayed

Other Detectors: Normal (Rosenfell), Average (RMS Power)

*Sweep points

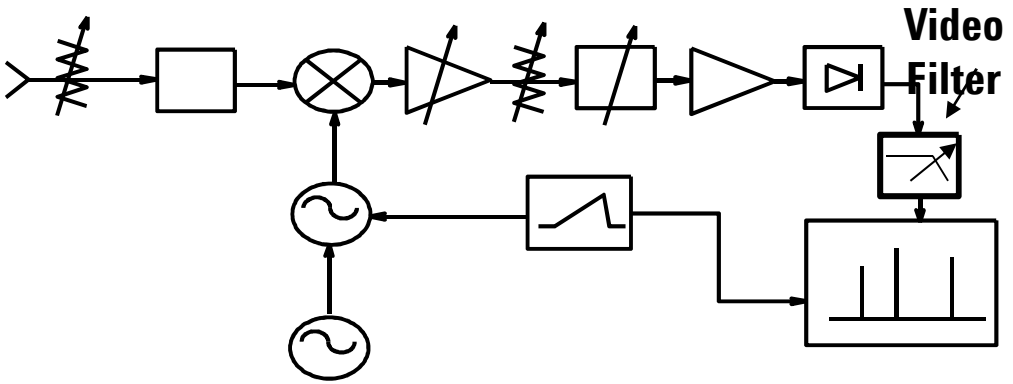
Theory of Operation
Average Detector Type

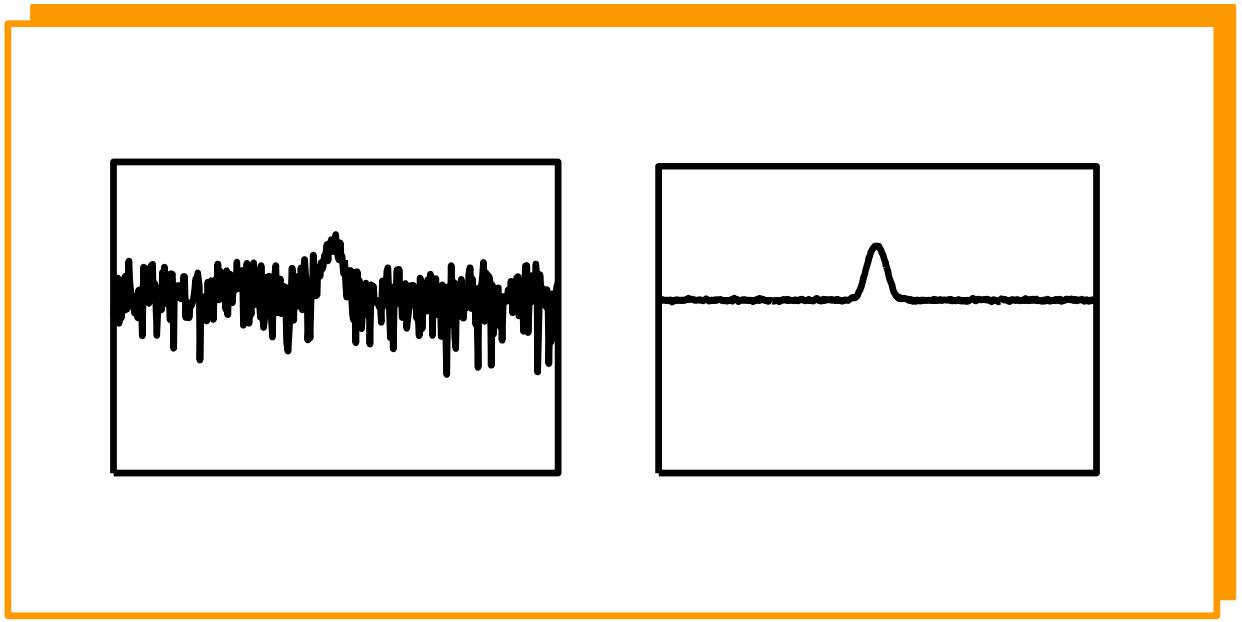


Power Average Detection (rms) = Square root of the sum of the squares of ALL of the voltage data values in the bin /50Ω

Theory of Operation

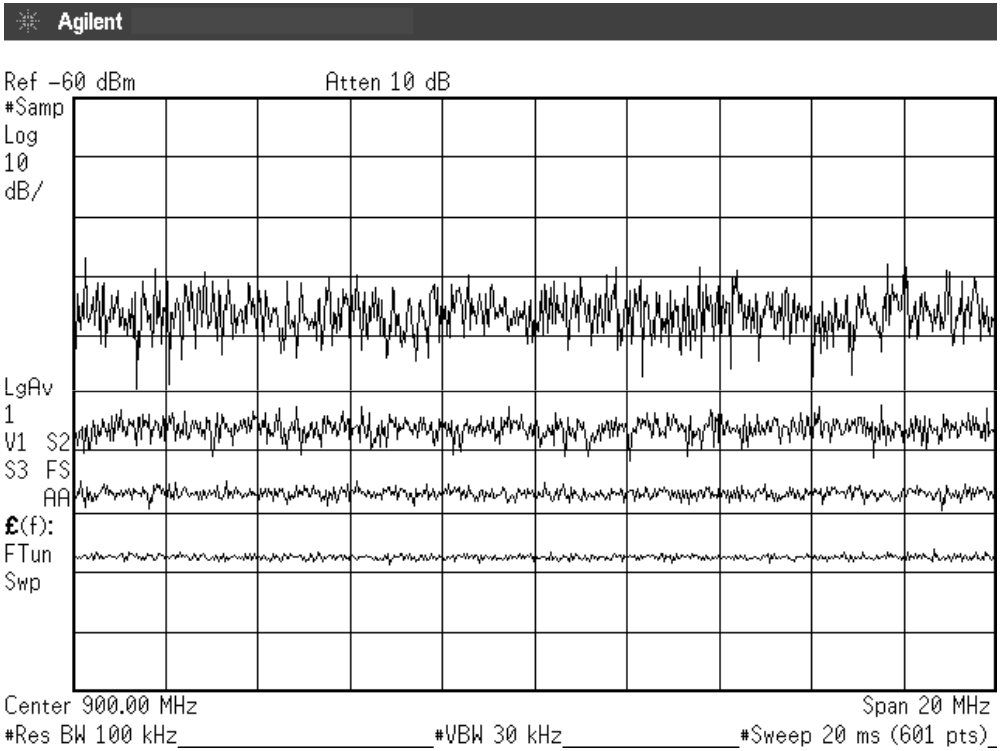
Video Filter (Video Bandwidth – VBW)



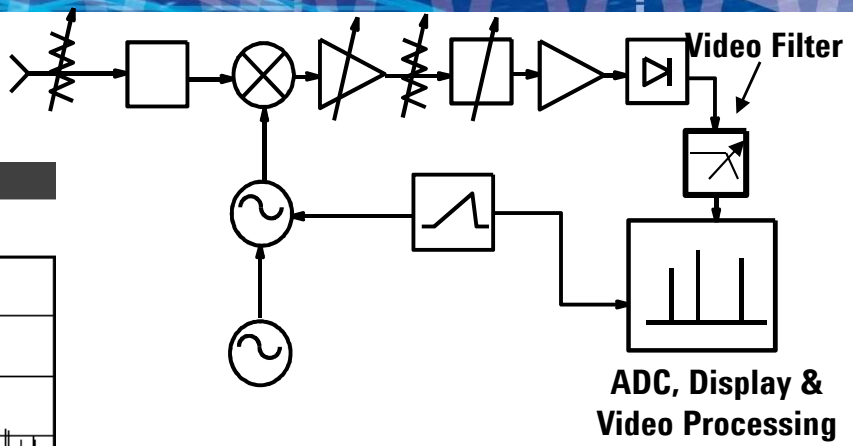


Theory of Operation

Video Filter vs. Trace/Video averaging



Trace averaging for 1, 5, 20, and 100 sweeps, top to bottom (trace position offset for each set of sweeps)



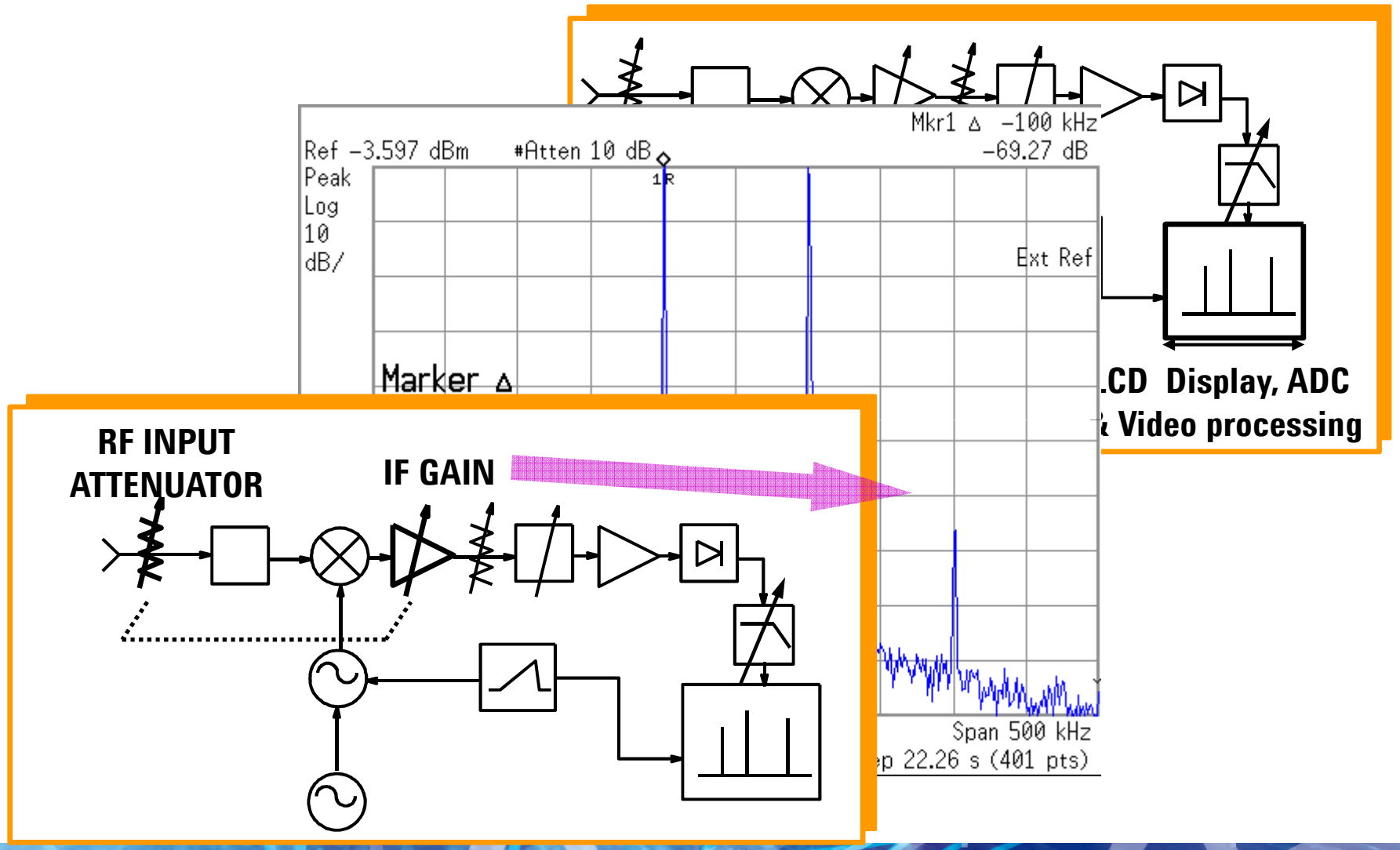
- **Video Filter operates as the sweep progresses, sweep time may be required to slow down by the transient response of the VBW filter.**

- **Trace/Video Average takes multiple sweeps, sweep time for each sweep is not affected**

- **Many signals give the same results with either video filtering or trace averaging**

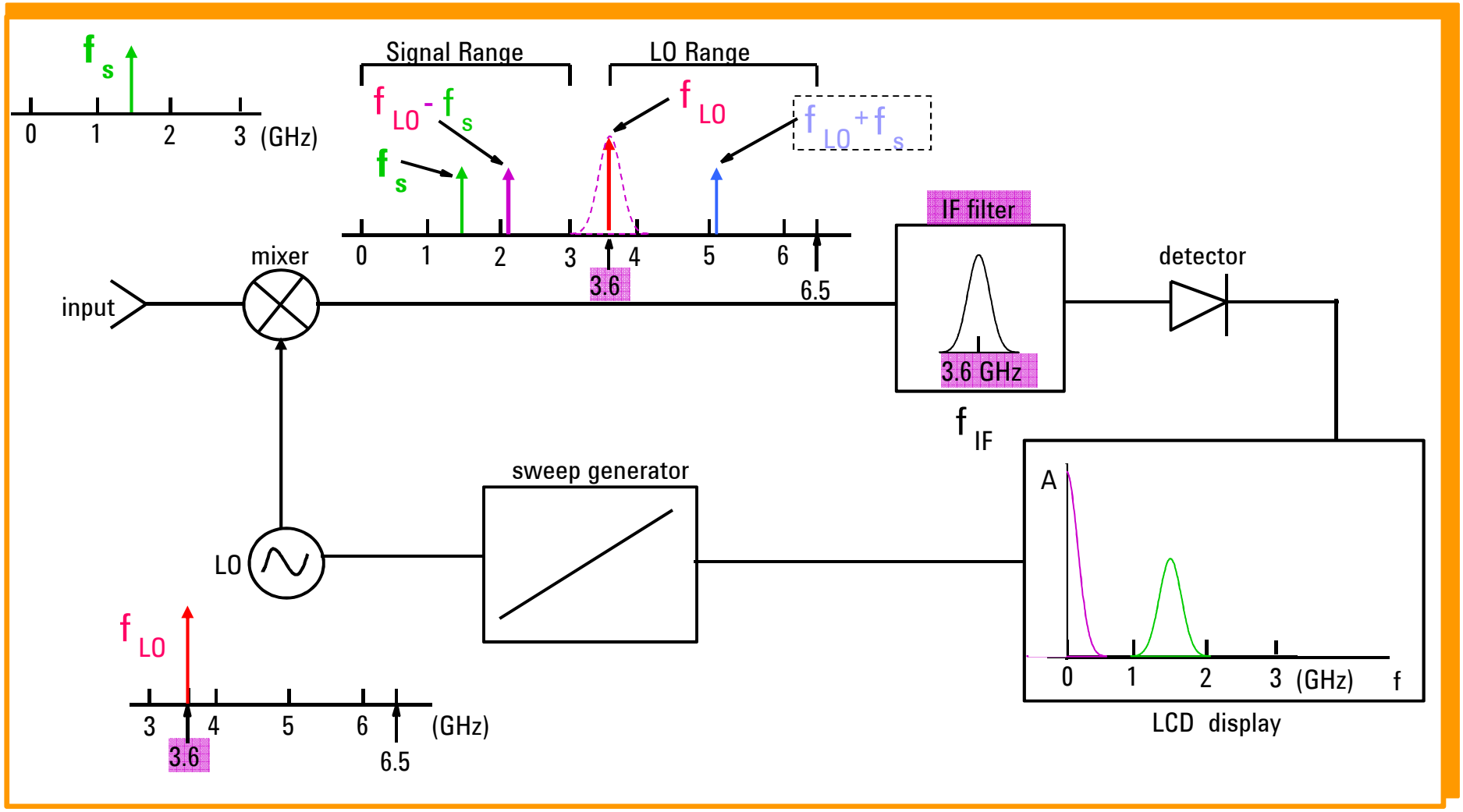
Theory of Operation

Other Components



Theory of Operation

How it All Works Together - 3 GHz spectrum analyzer



Agenda

Overview

Theory of Operation

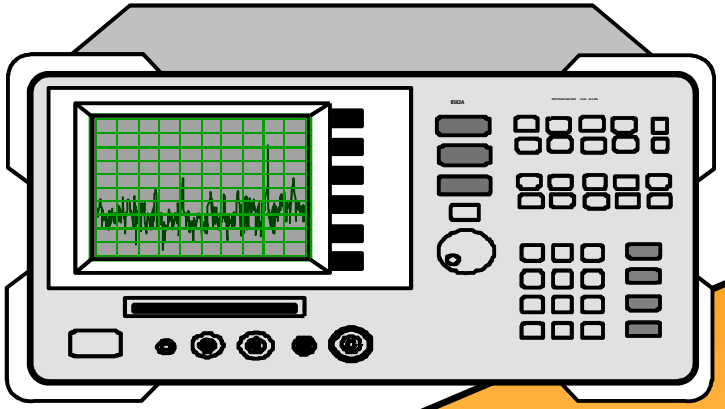
Specifications:

- Which are important and why?

Modern spectrum analyzer designs & capabilities

– Wide Bandwidth Vector Measurements

Key Specifications



- Safe spectrum analysis
- Frequency Range
- Accuracy: Frequency & Amplitude
- Resolution
- Sensitivity
- Distortion
- Dynamic Range

Specifications?
A Definition

Specifications **describe the performance of parameters covered by the product warranty (temperature = 0 to 55℃, unle ss otherwise noted).**

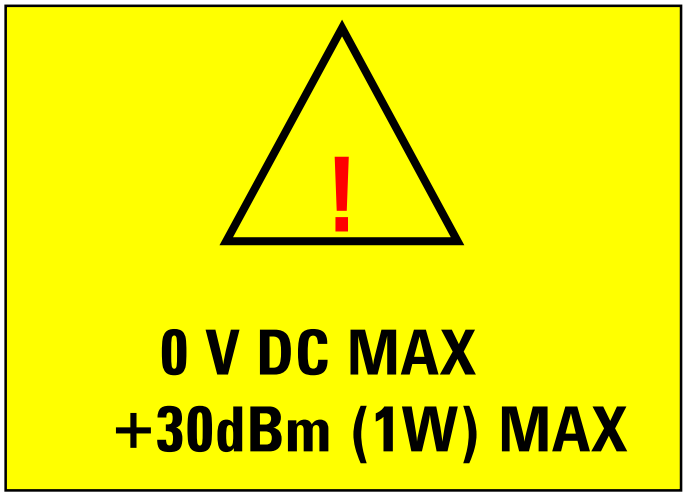
Typical **values describe additional product performance information that is not covered by the product warranty. It is performance beyond specification that 80 % of the units exhibit with a 95 % confidence level over the temperature range 20 to 30° C. Typical performance does not include measurement uncertainty.**

Nominal **values indicate expected performance, or describe product performance that is useful in the application of the product, but is not covered by the product warranty.**

Specifications

Practicing safe spectrum analysis - *Safe Hookups to RF Input*

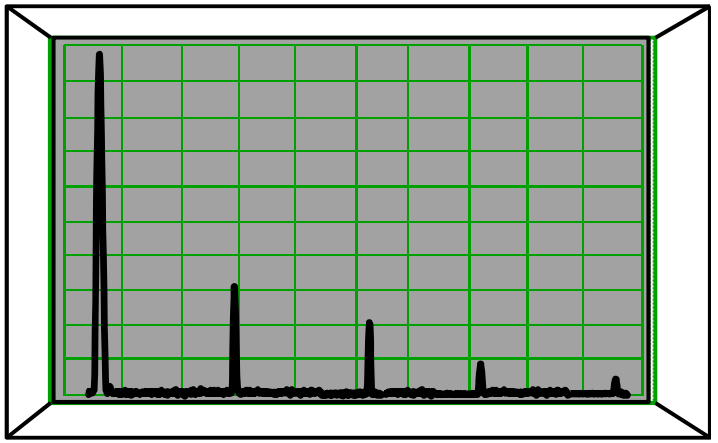
- **Use best practices to eliminate static discharge to the RF input!**
- **Do not exceed the Damage Level on the RF Input!**
- **Do not input signals with DC bias!**



Specifications

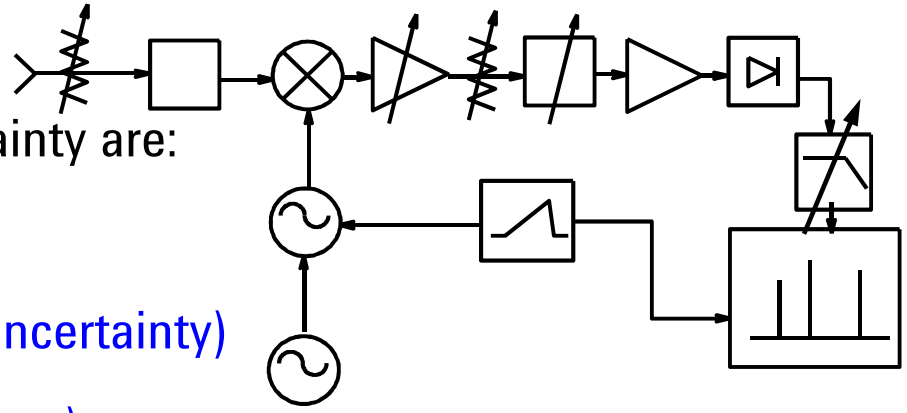
Frequency Range

Description	Specifications
Internal Mixing	
Bands	
0	**3 Hz to 3.0 GHz**
1	**2.85 to 6.6 GHz**
2	**6.2 to 13.2 GHz**
3	**12.8 to 19.2 GHz**
4	**18.7 to 26.8 GHz**
5	**26.4 to 31.15 GHz**
6	**31.0 to 50.0 GHz**
External mixing	**18 to 325 GHz**



Specifications

Accuracy: Frequency &

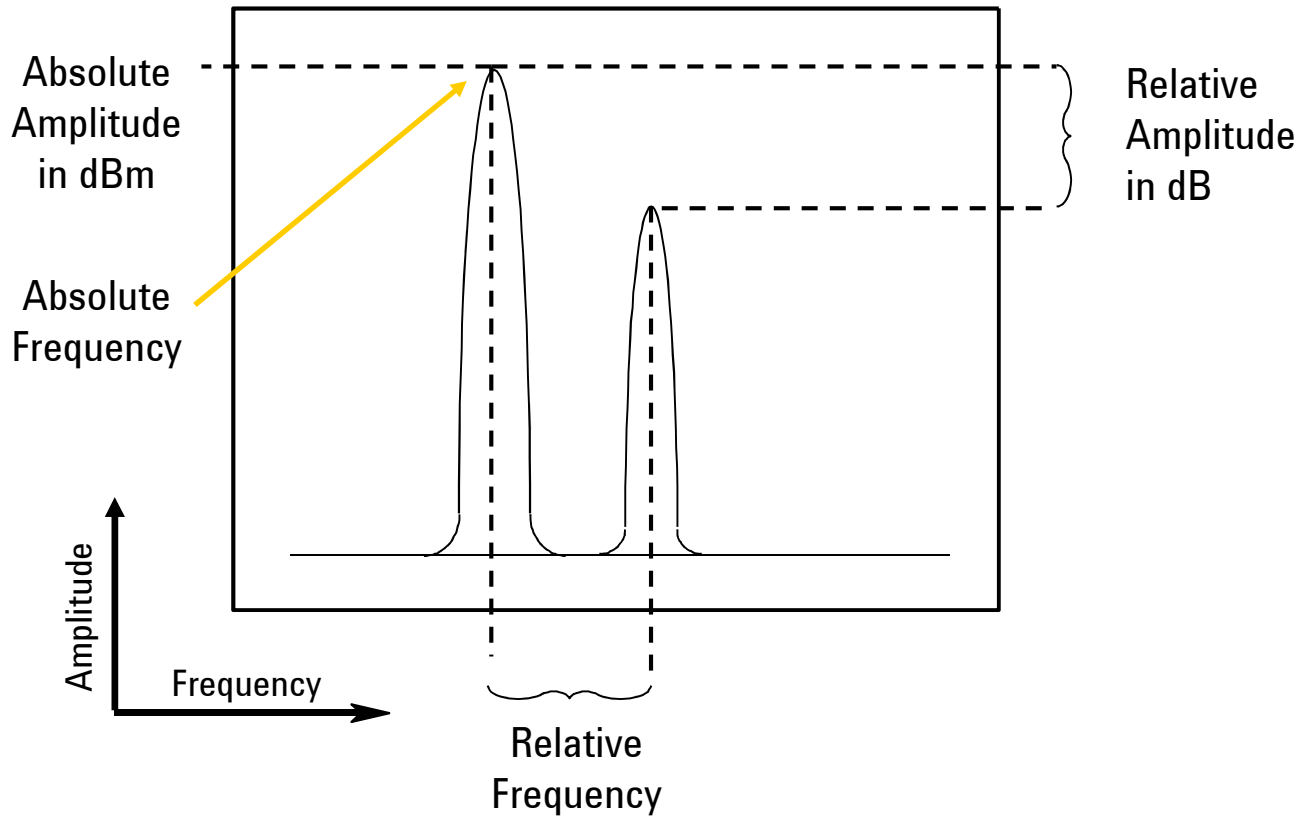


Components which contribute to uncertainty are:

- Input mismatch (VSWR)
- RF Input attenuator (Atten. switching uncertainty)
- Mixer and input filter (frequency response)
- IF gain/attenuation (reference level accuracy)
- RBW filters (RBW switching uncertainty)
- Log amp (display scale fidelity)
- Reference oscillator (frequency accuracy)
- Calibrator (amplitude accuracy)

Specifications

Absolute and relative Accuracy: Frequency & amplitude



Note: Absolute accuracy is also "relative" to the calibrator reference point

Specifications

Accuracy: Frequency Readout Accuracy

- From the PSA Data Sheet:

± (freq readout x freq reference error +
0.25%*span + 5% of RBW + 2Hz + 0.5 x Horiz. Res.*)

Determined by Reference Accuracy

Span Accuracy

RBW Error
IF filter center frequency error

Residual Error

*Horizontal resolution is span/(sweep points – 1)

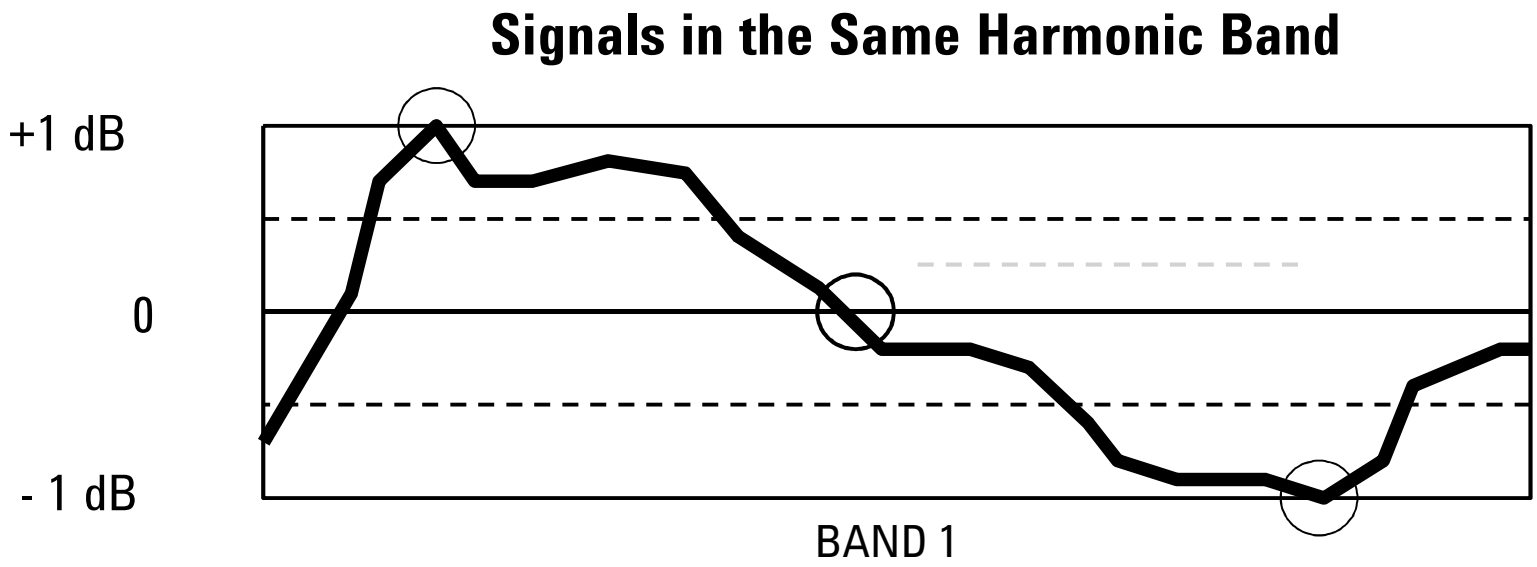
Specifications

Accuracy: Key amplitude uncertainty contributions

Relative and absolute:	Sample Uncertainties
• Input impedance mismatch	(±0.13 dB)
• Input attenuator switching uncertainty	(±0.6 dB)
• Frequency response	(±1.8 dB)
• Reference level accuracy	(±1.0 dB)
• RBW switching uncertainty	(±0.5 dB)
• Display scale fidelity	(±0.85 dB)
Absolute only:	
• Calibrator accuracy	(±0.34 dB)

Specifications

Accuracy: Frequency Response

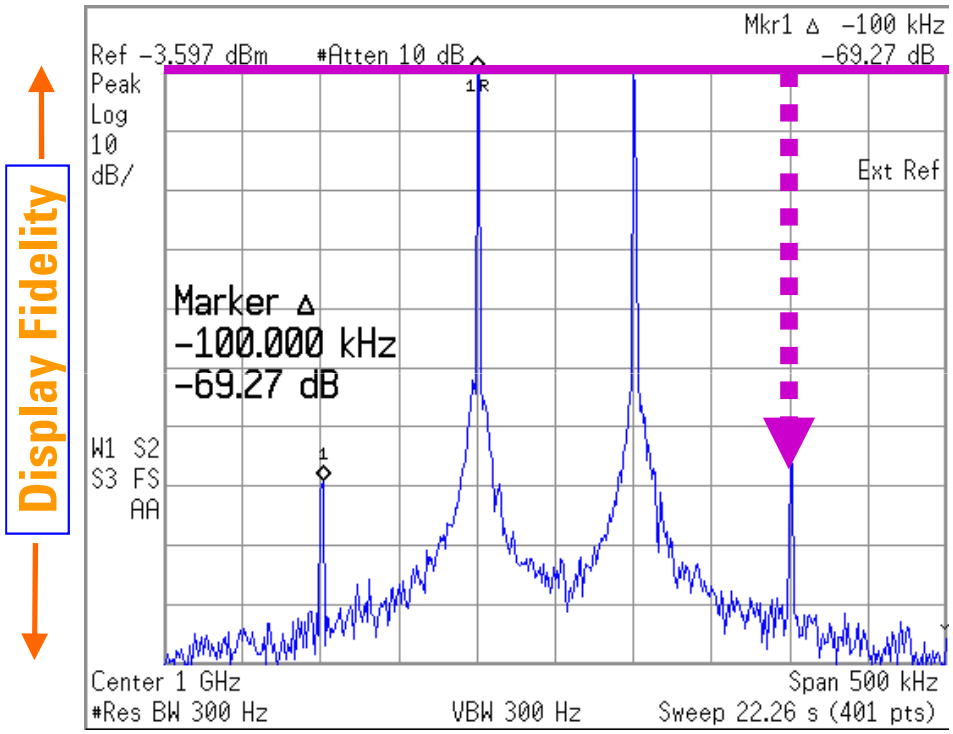


Absolute amplitude accuracy – Specification: ± 1 dB

Relative amplitude accuracy – Specification: ± 2 dB

Specifications

Accuracy: Display Fidelity



Display Fidelity includes:

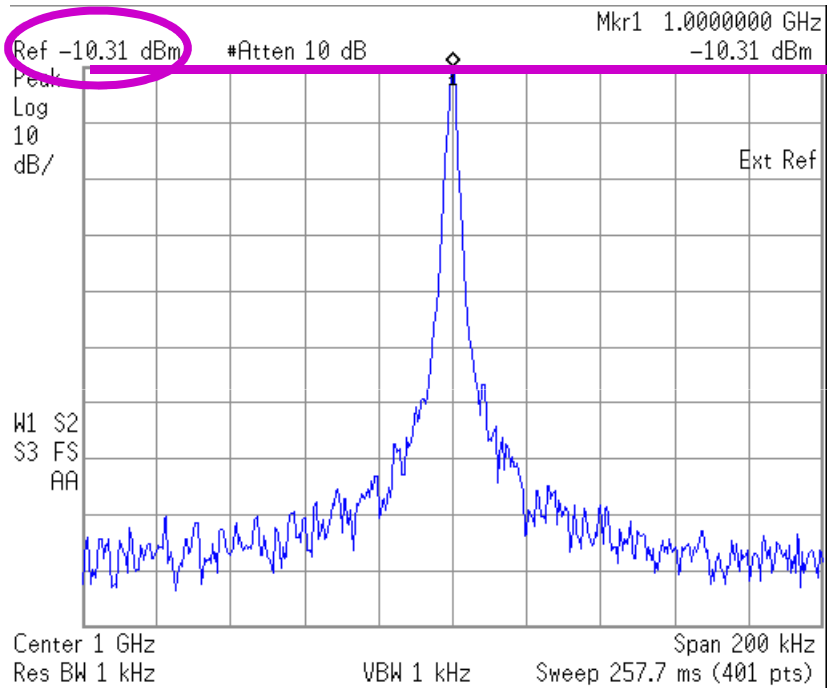
- Log Amp Fidelity
- Envelope Detector Linearity
- Digitizing Circuit Linearity

Display fidelity error applies when signals are not at the same reference level amplitude when measured

In the past, technique for best accuracy was to move each measured signal to the reference line, eliminating display fidelity error.

Specifications

Amplitude Accuracy: Reference Level Switching



Uncertainty applies when changing the Ref. Level

Also called IF Gain Uncertainty

Decision: Do I change the reference level or live with the display fidelity uncertainty in my measurements?

Specifications

Amplitude Accuracy - Summary

Optimize measurement setup & techniques for best accuracy

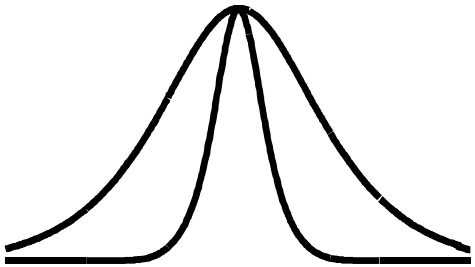
- **Minimize changes to uncertainty contributors**
  - **Or change contributor with least error impact**
  - **Or stay within the optimum accuracy envelope parameters that modern auto-alignment calibration techniques provide**

- **Traditionally, one technique for best accuracy was to move each measured signal to the reference line, eliminating display fidelity error. However, in today's designs, display fidelity has improved to the point where there is generally less error just to leave the signals where they occur on the display.**

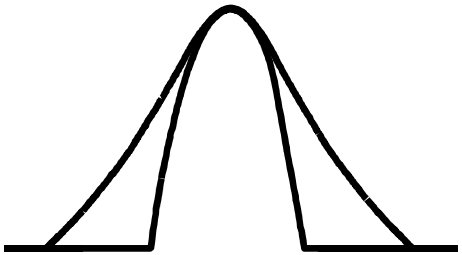
- **Except for freq. response, uncertainty contributors that impact both signals equally in a relative measurement can be ignored.**

- **In the absence of specified relative freq. response, the relative response uncertainty is assumed to be 2x specified absolute error.**

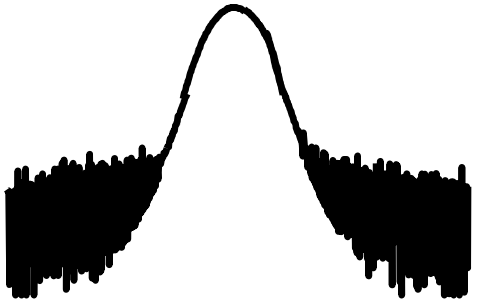
What Determines Resolution?



Resolution Bandwidth



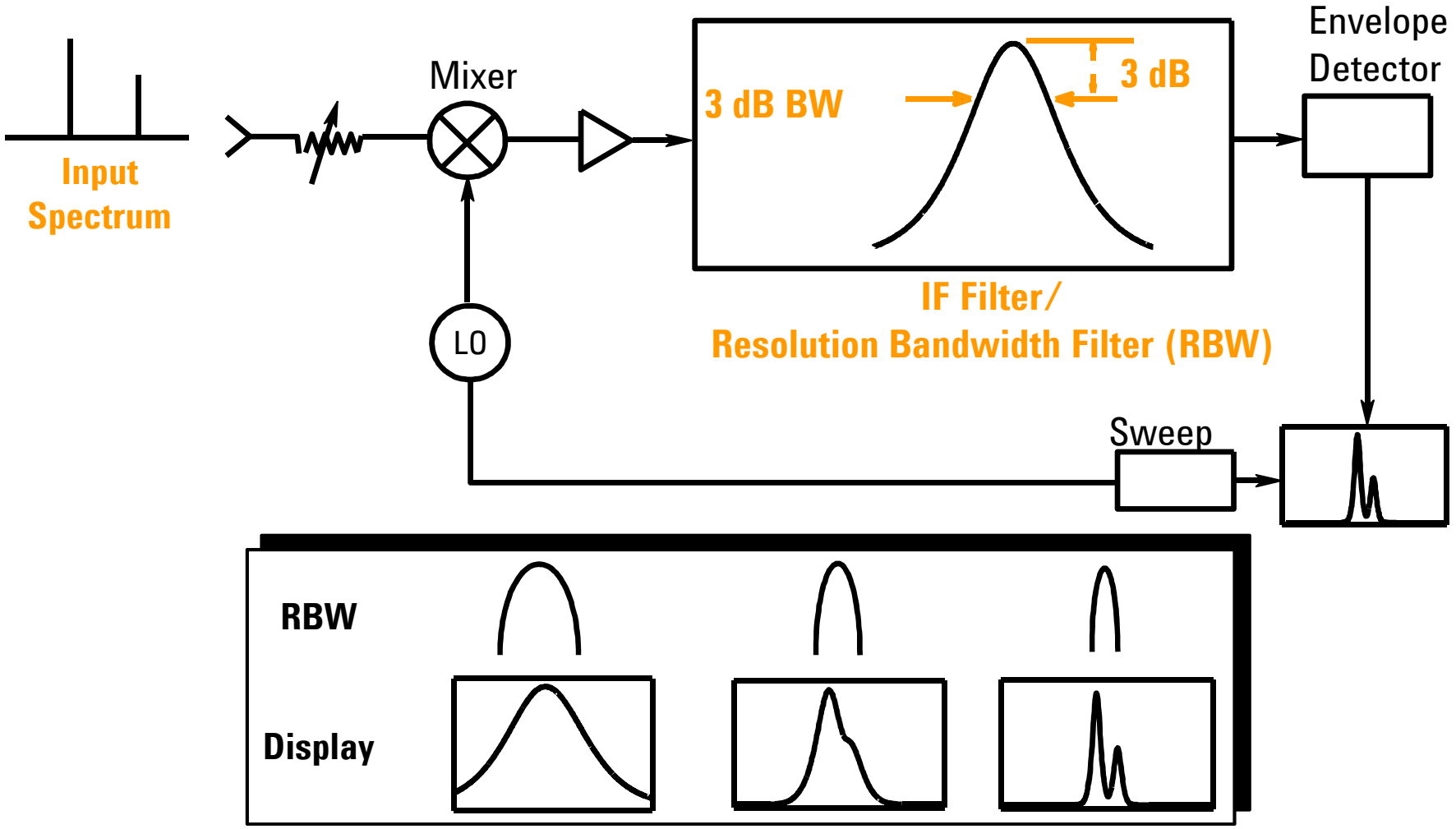
RBW Type and
Selectivity



Noise Sidebands

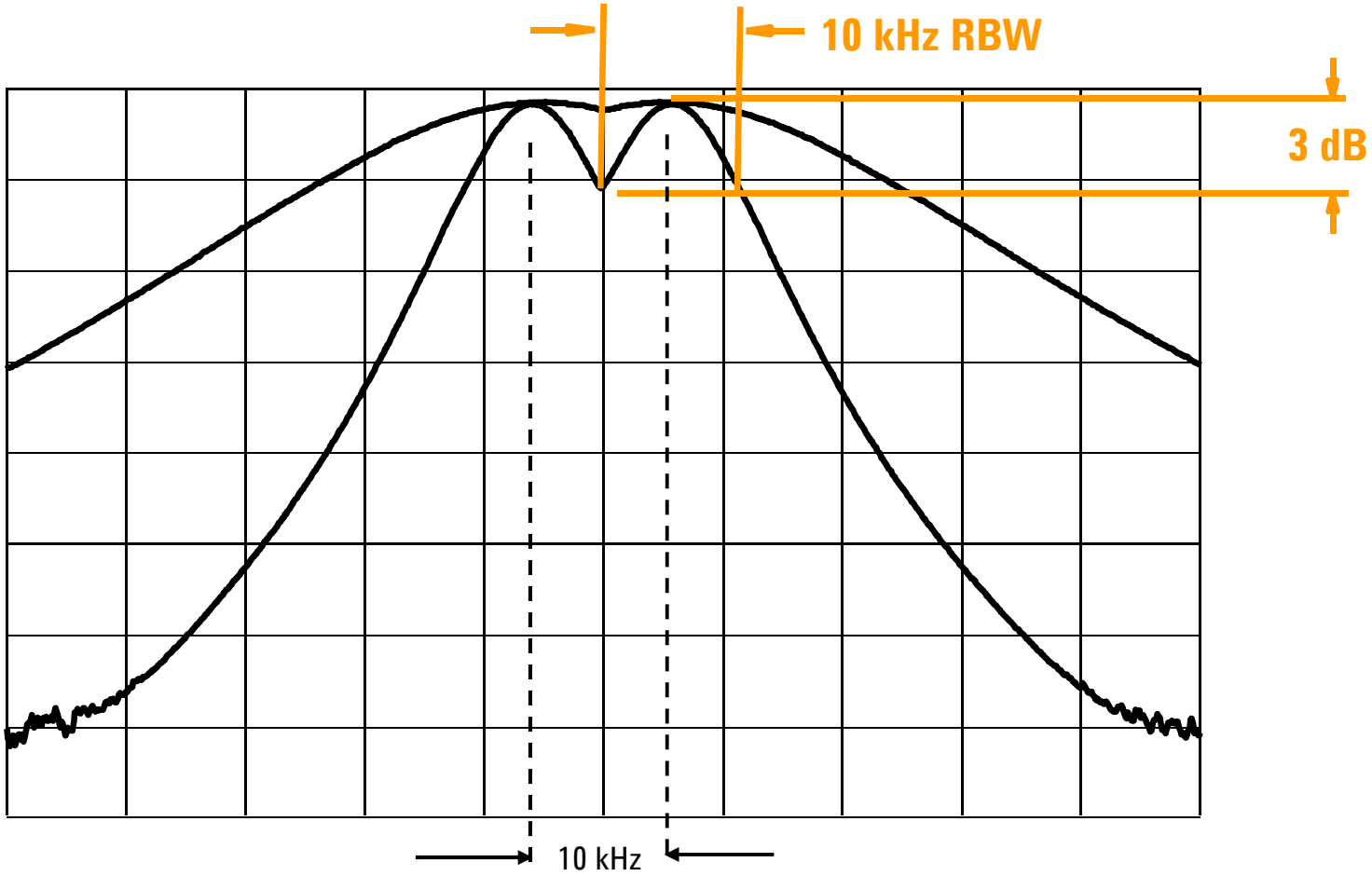
Specifications

Resolution: Resolution Bandwidth



Specifications

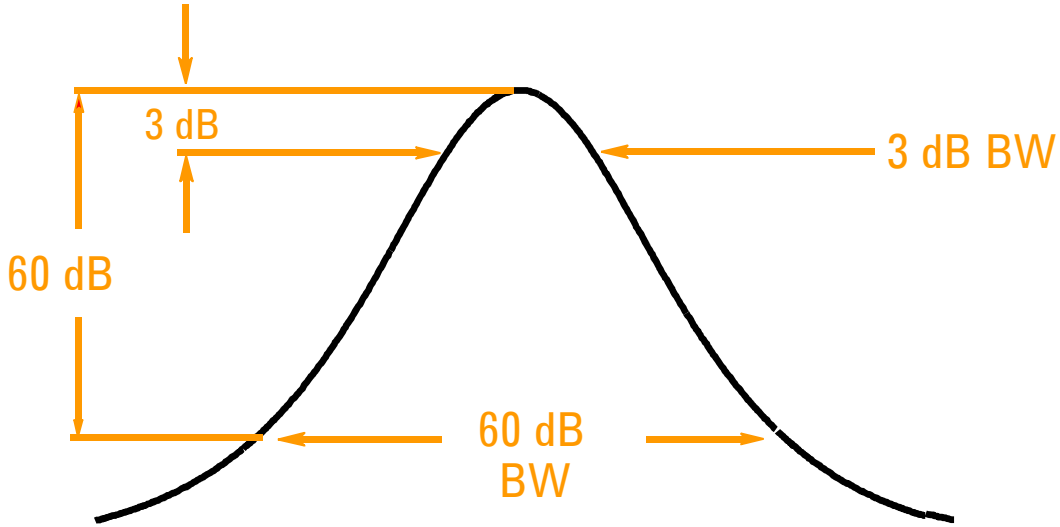
Resolution: Resolution BW



Determines resolvability of equal amplitude signals

Specifications

Resolution BW Selectivity or Shape Factor

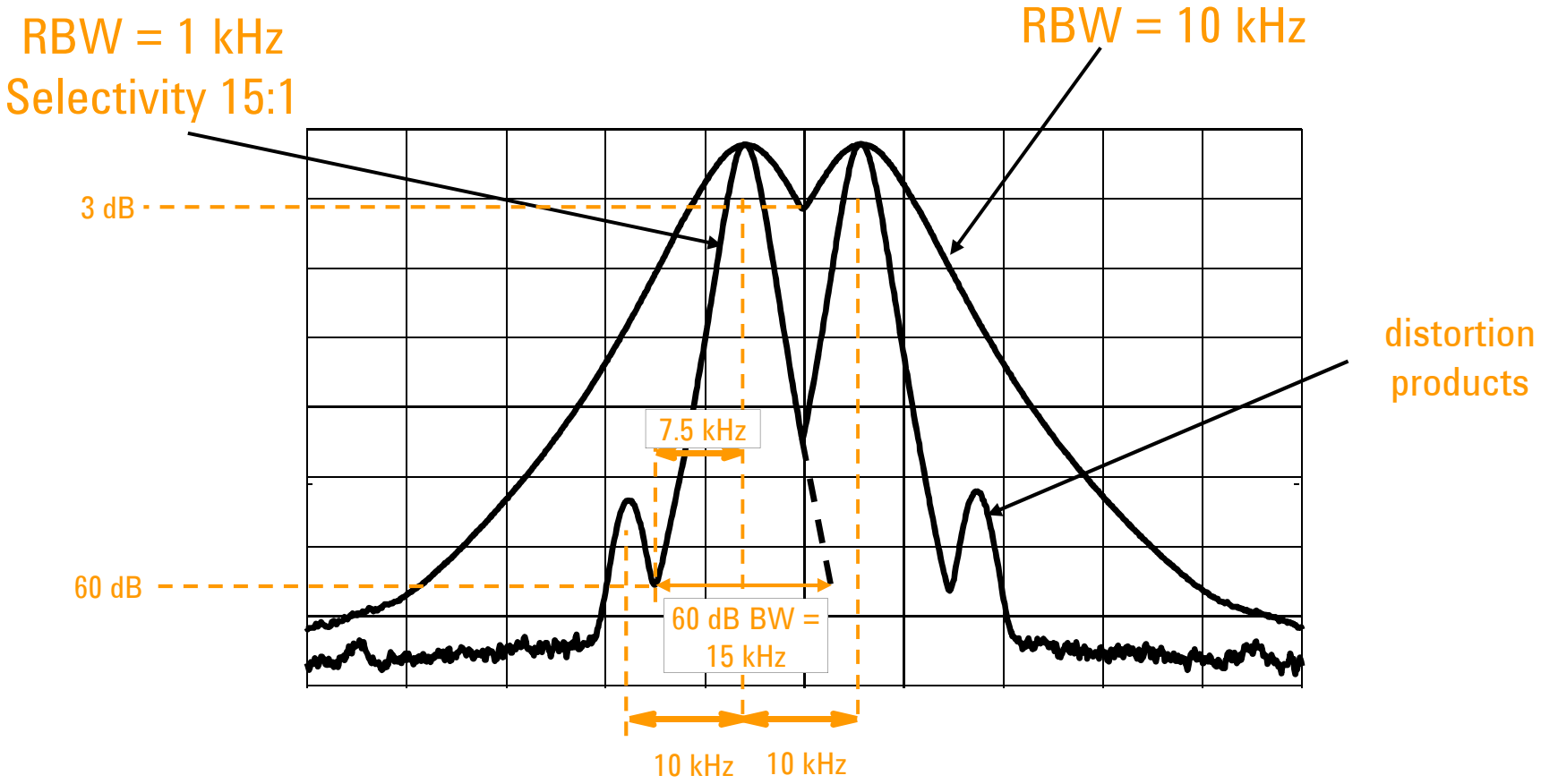


$$\text{Selectivity} = \frac{\text{60 dB BW}}{\text{3 dB BW}}$$

Determines resolvability of unequal amplitude signals

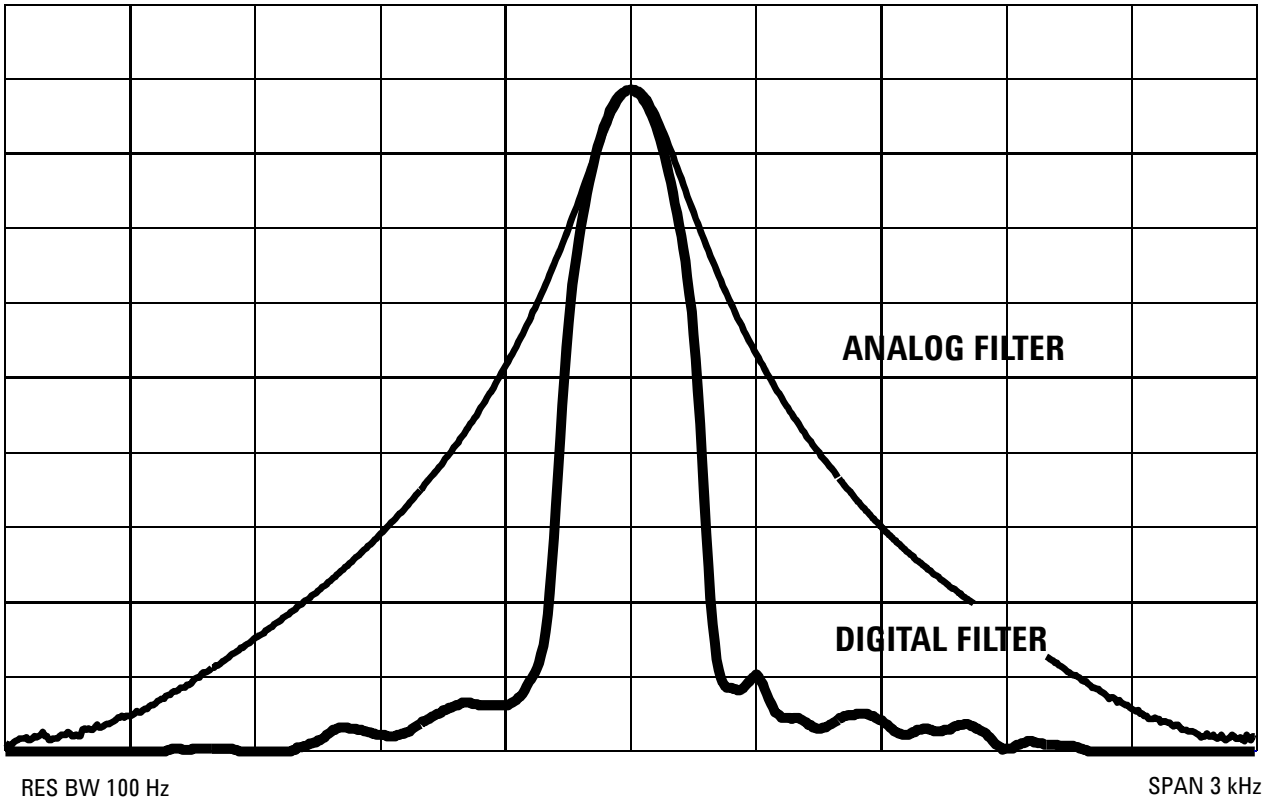
Specifications

Resolution BW Selectivity or Shape Factor



Specifications

Resolution: RBW Type and Selectivity



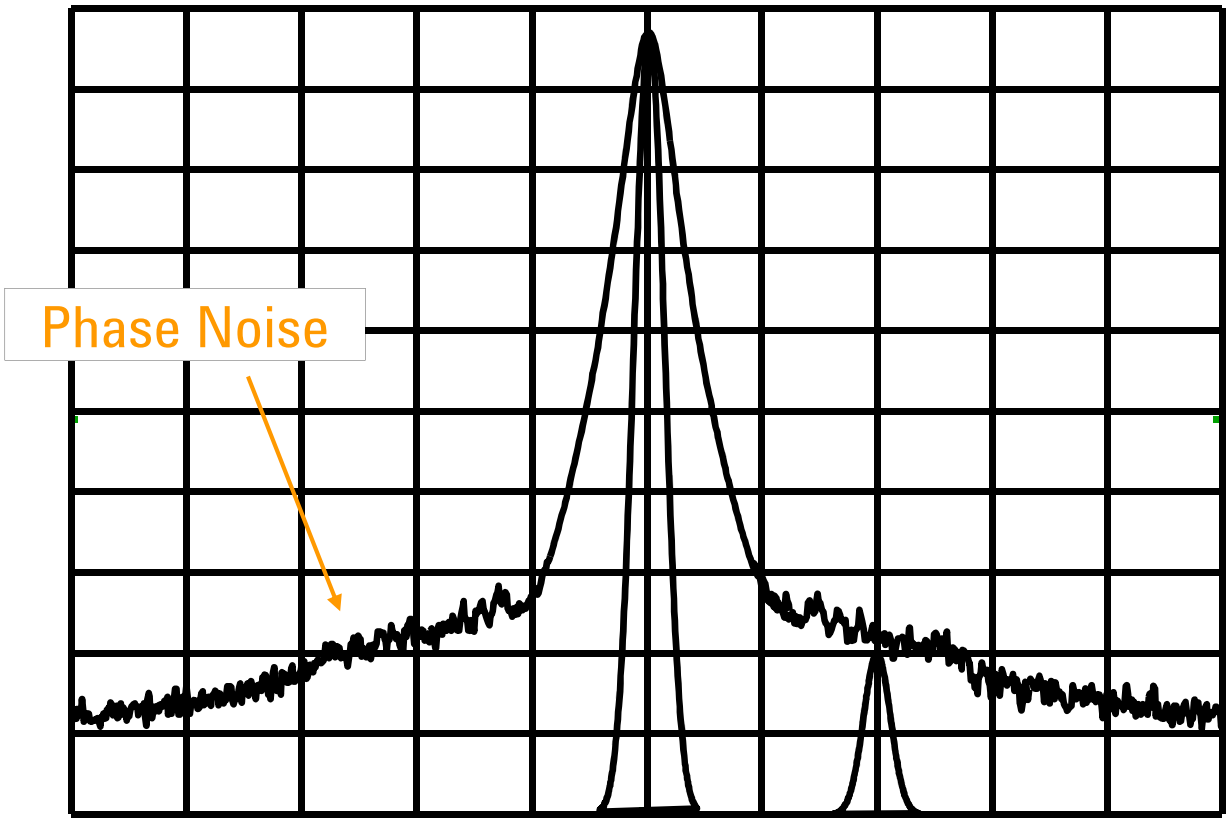
Typical Selectivity

Analog 15:1

Digital ≤5:1

Specifications

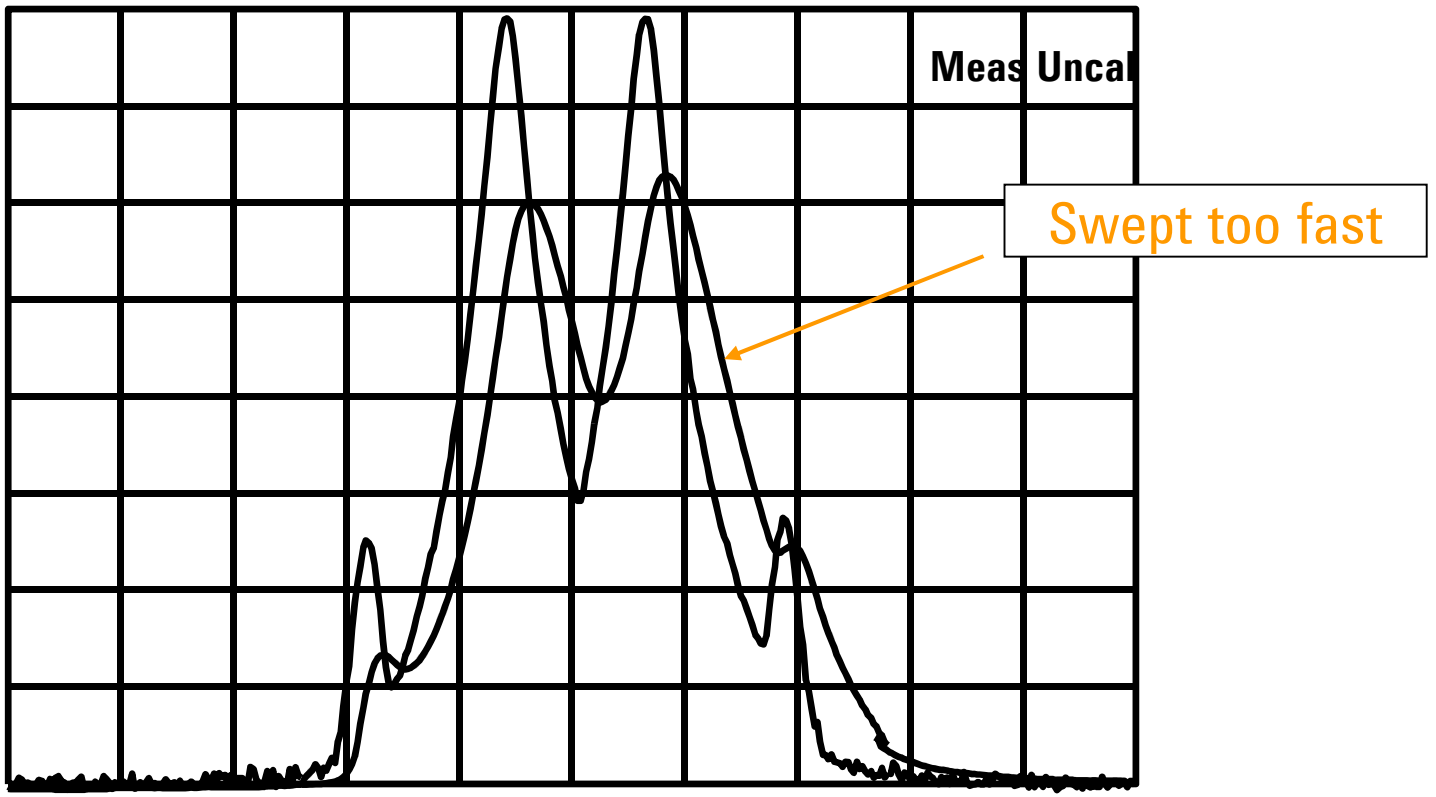
Resolution: Noise Sidebands



Noise Sidebands can prevent resolution of unequal signals

Specifications

Resolution: RBW Determines Sweep Time

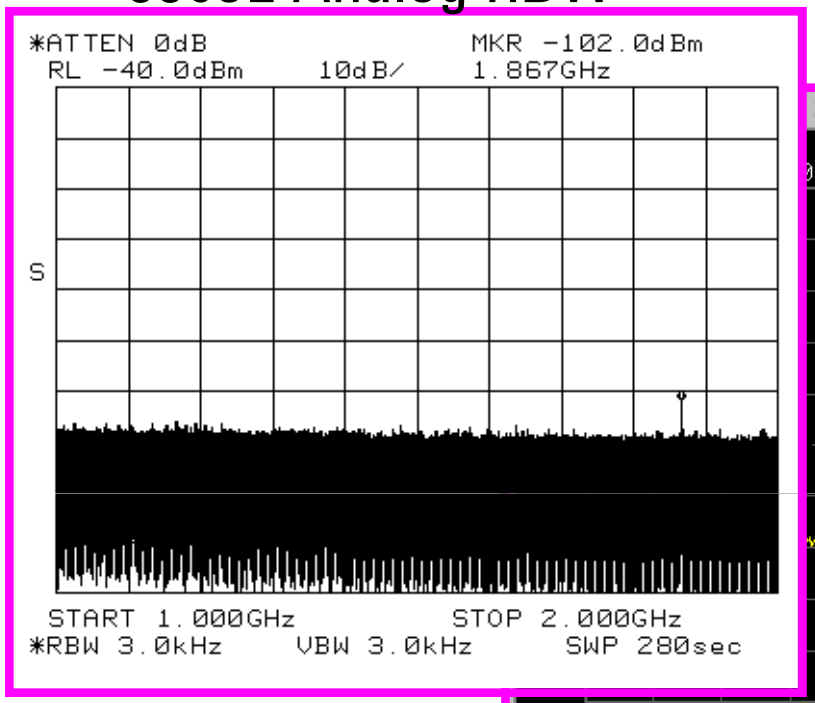


Penalty For Sweeping Too Fast
Is An Uncalibrated Display

Specifications

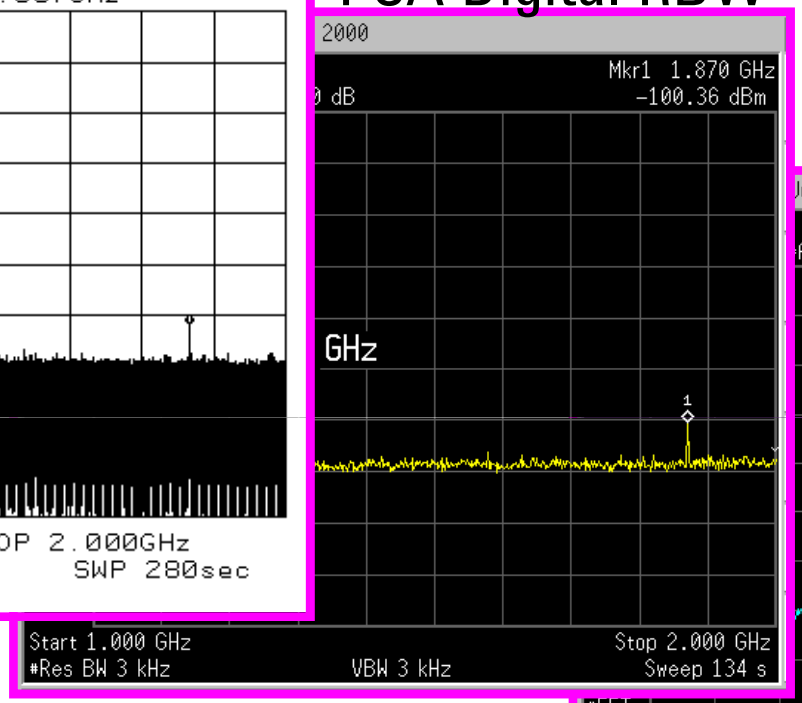
Resolution: RBW Type Determines Sweep Time

8563E Analog RBW



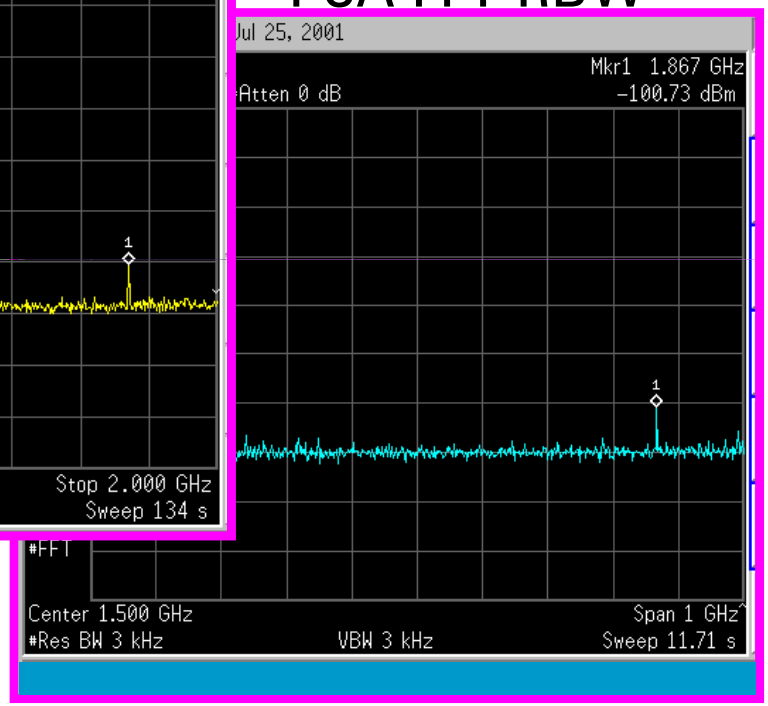
280 sec

PSA Digital RBW



134 sec

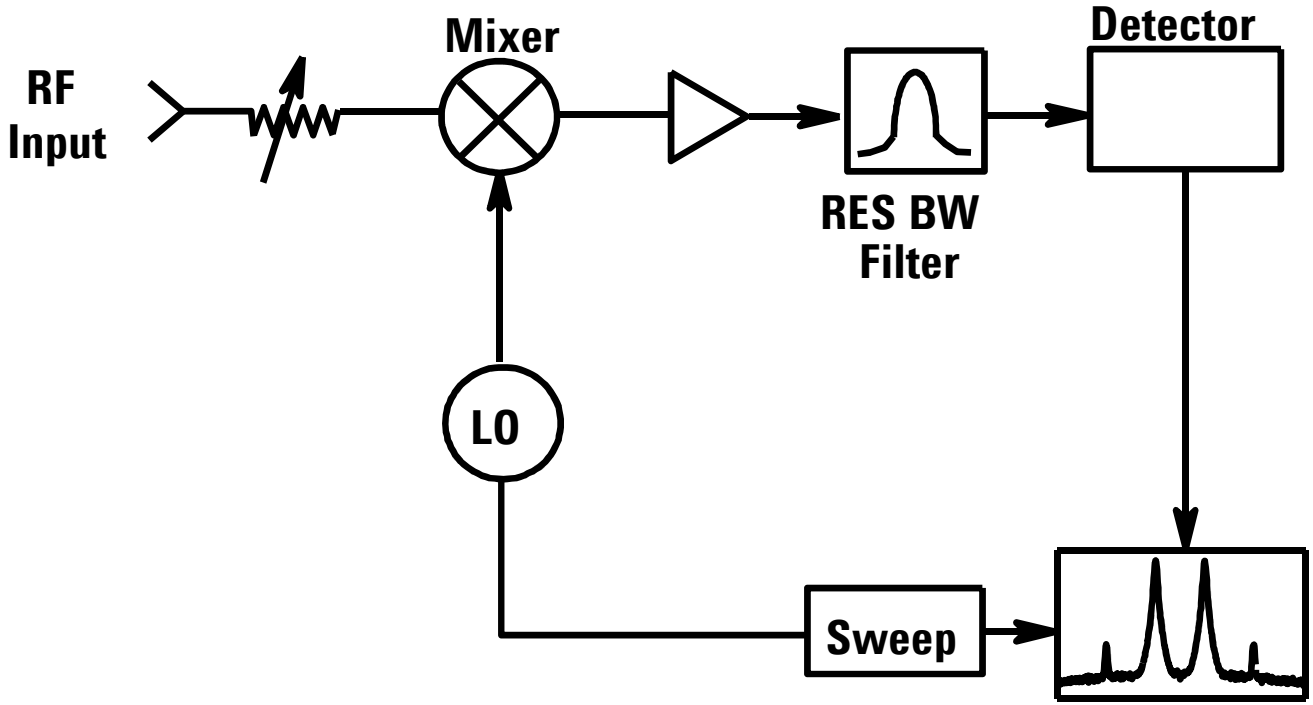
PSA FFT RBW



13.5 sec

Specifications

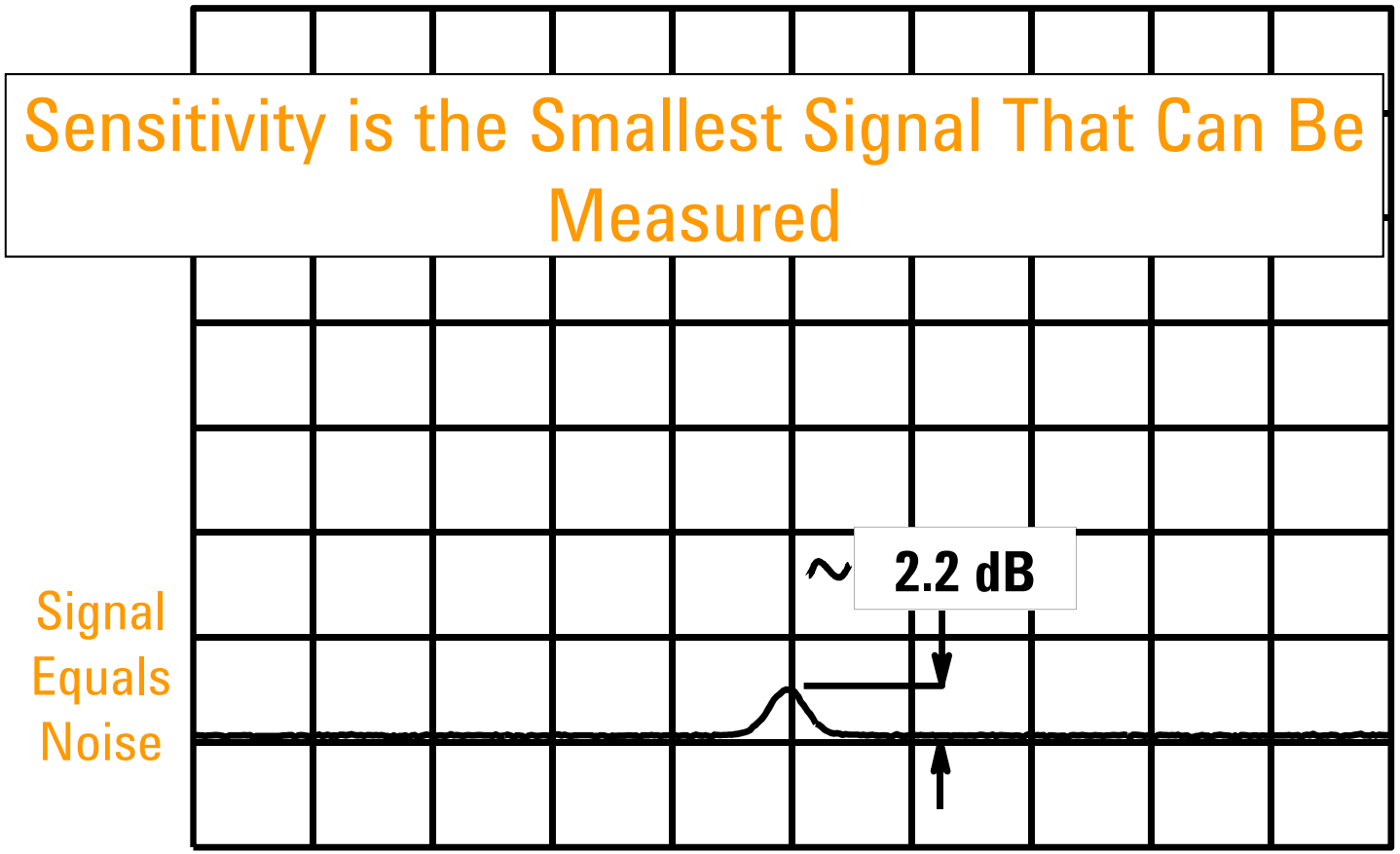
Sensitivity/DANL



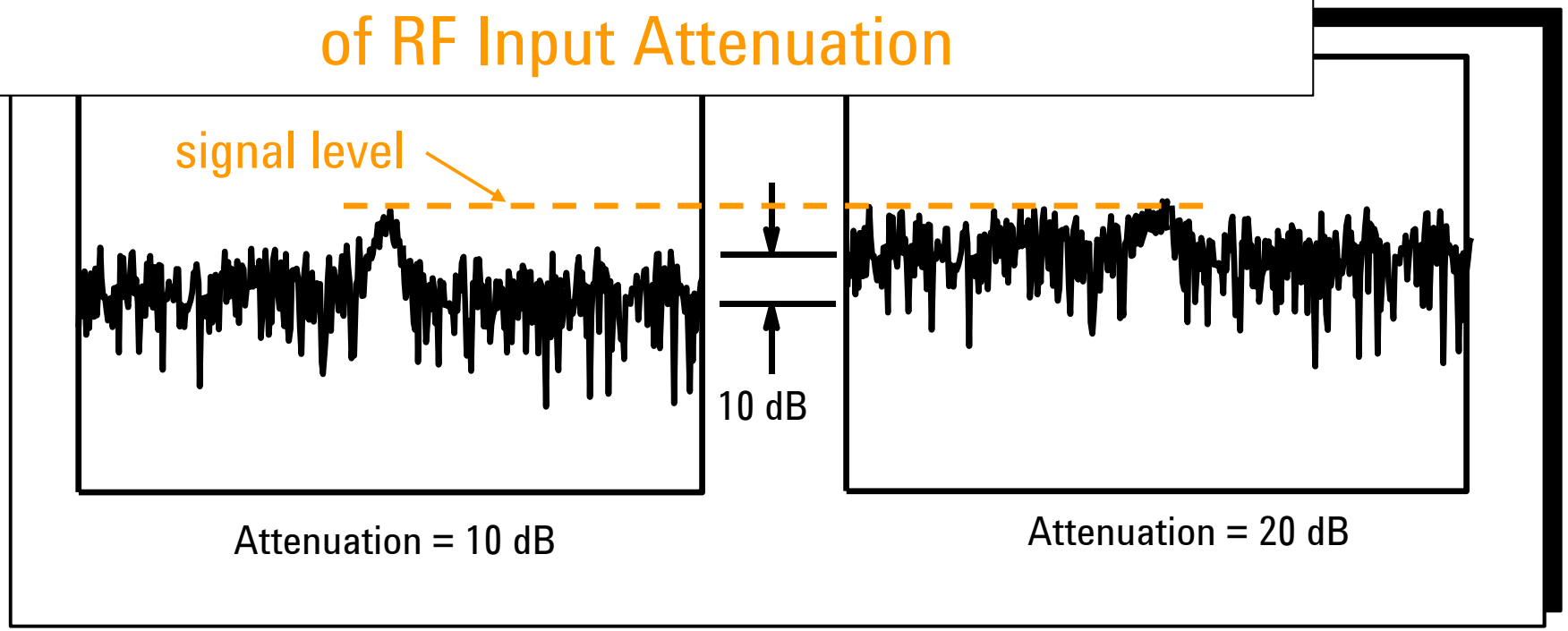
A Spectrum Analyzer Generates and Amplifies Noise Just Like Any Active Circuit

Specifications

Sensitivity/DANL



Effective Level of Displayed Noise is a Function of RF Input Attenuation

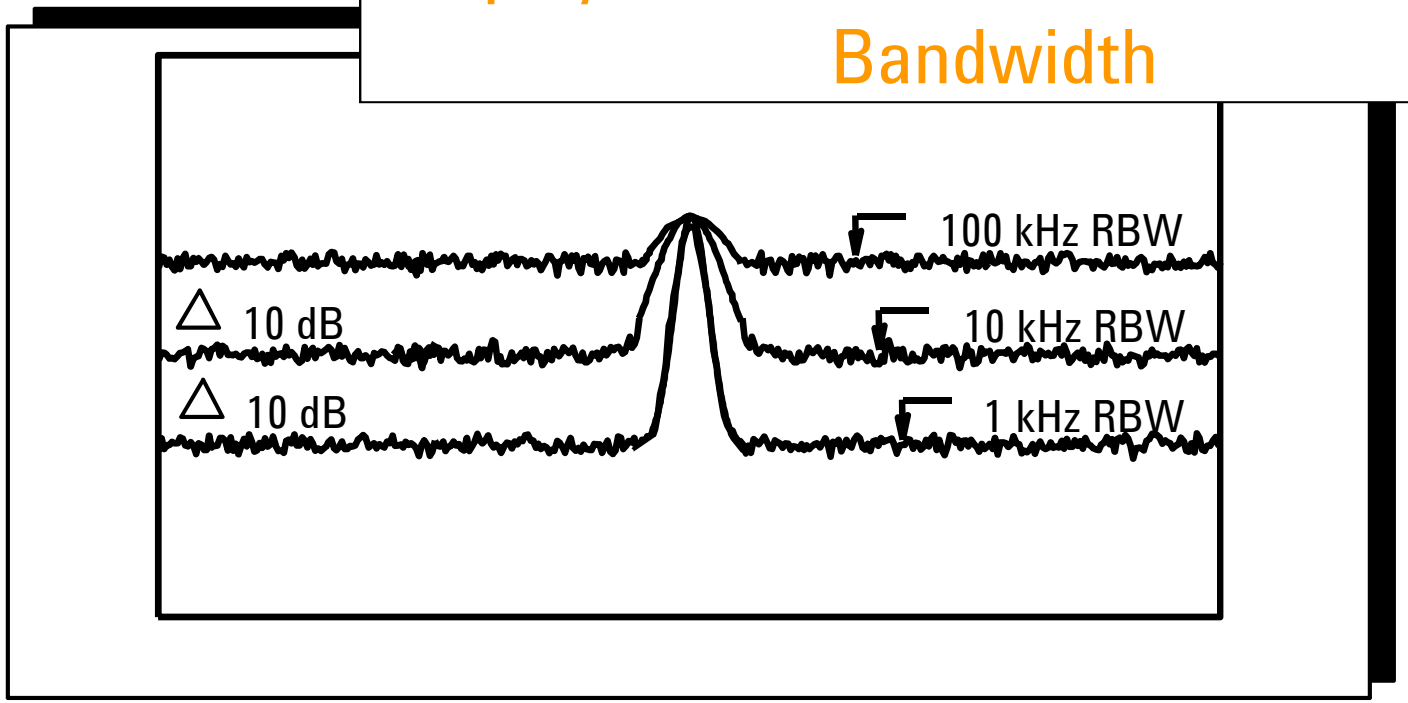


Signal To Noise Ratio Decreases as
RF Input Attenuation is Increased

Specifications

Sensitivity/DANL: IF Filter(RBW)

Displayed Noise is a Function of IF Filter Bandwidth

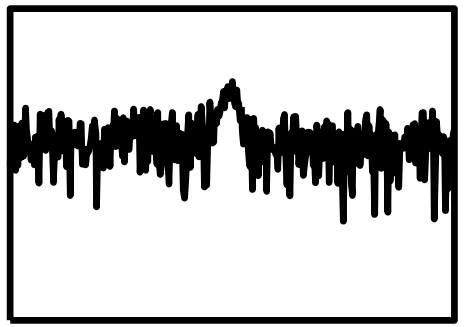


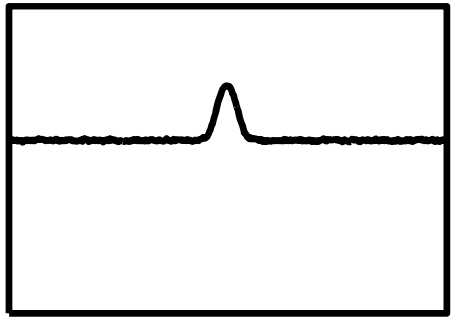
Decreased BW = Decreased Noise

Specifications

Sensitivity/DANL: Video BW filter (or Trace Averaging)

Video BW or Trace Averaging Smoothes Noise for Easier Identification of Low Level Signals

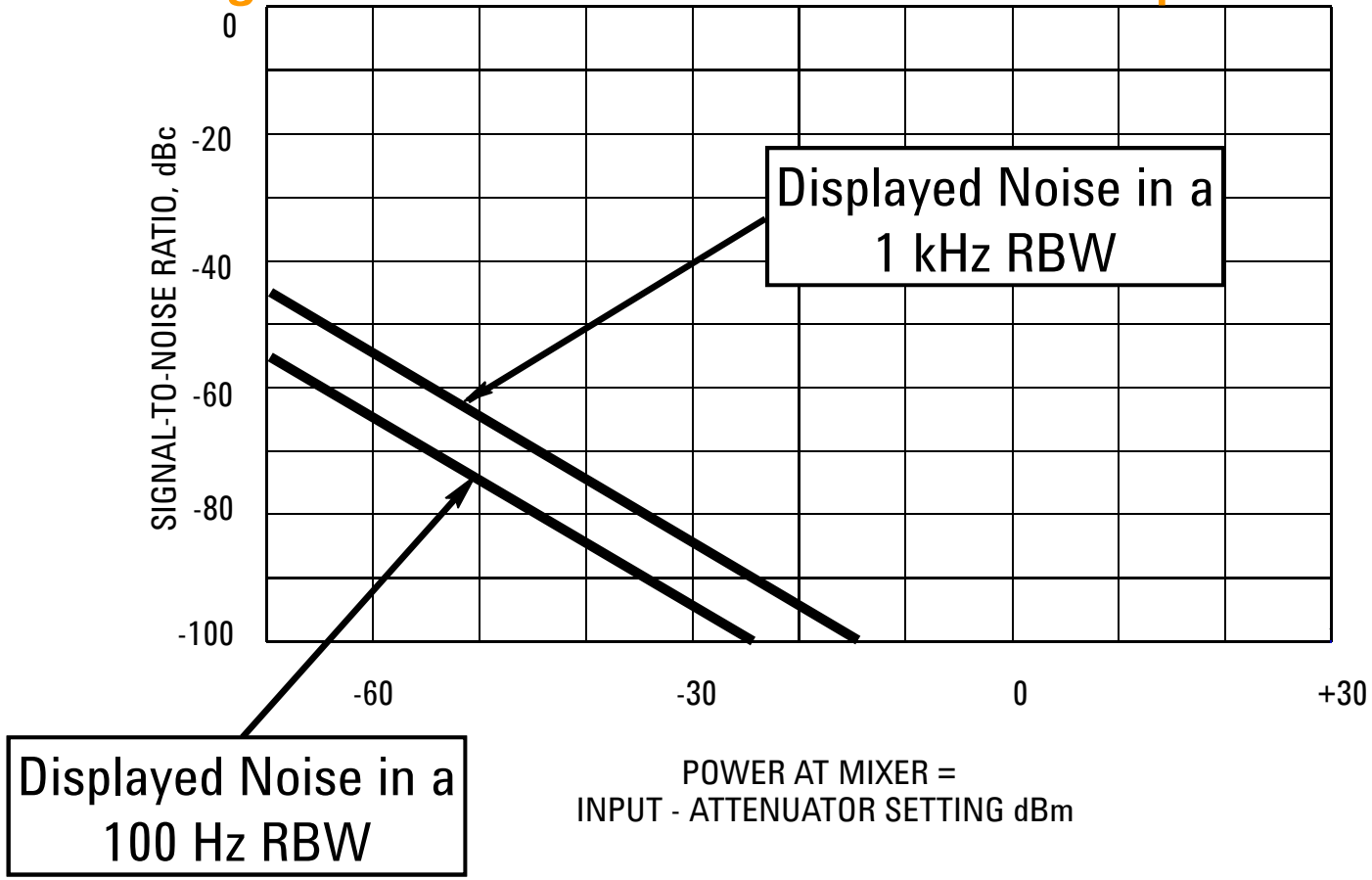




Specifications

Sensitivity/DANL:

Signal-to-Noise Ratio Can Be Graphed



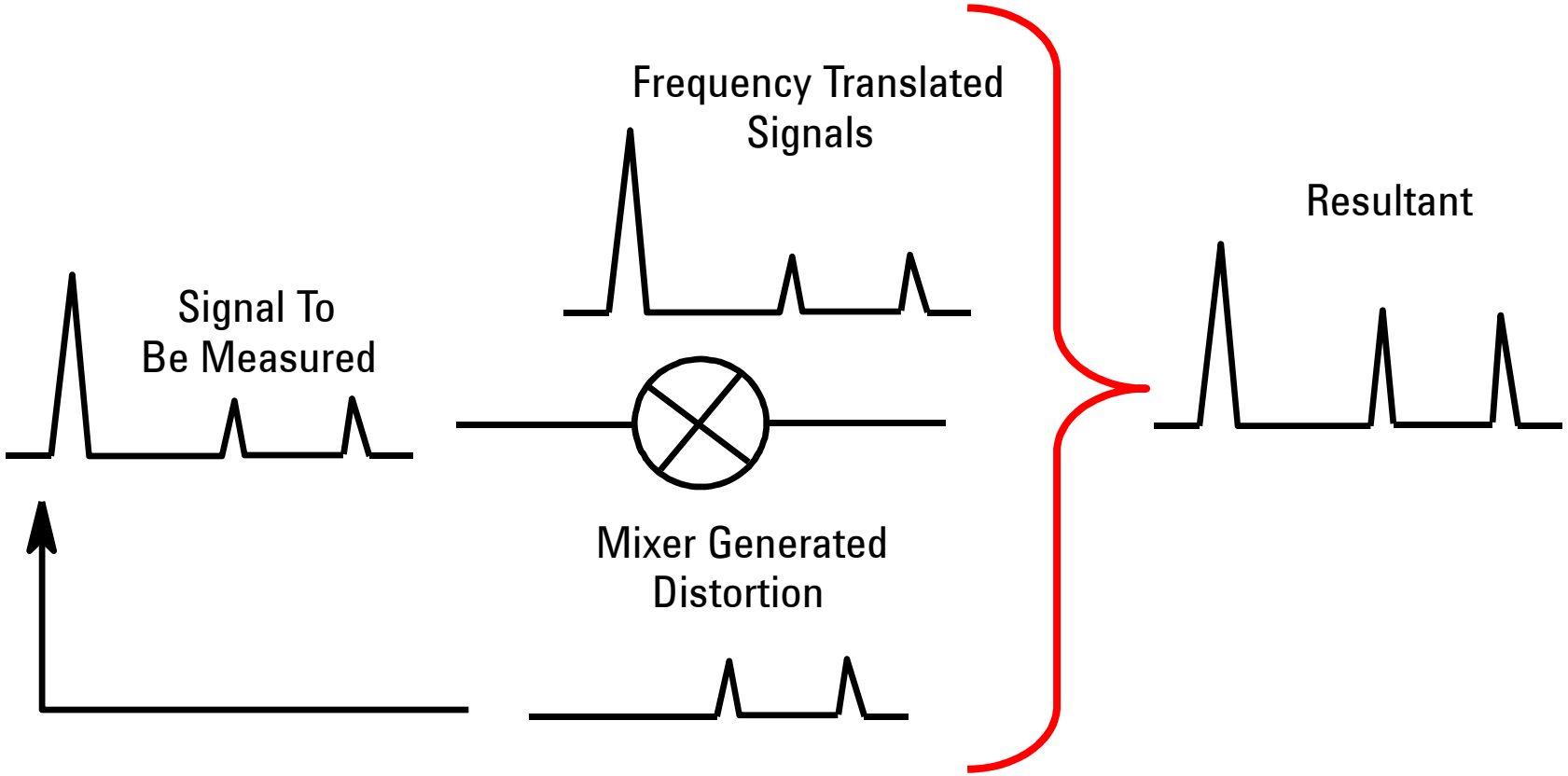
Specifications

Sensitivity/DANL: Summary

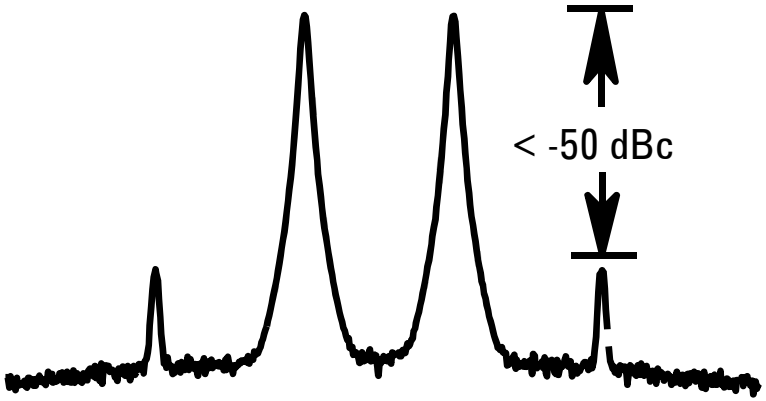
For Best Sensitivity Use:

- Narrowest Resolution BW
- Minimum RF Input Attenuation
- Sufficient Averaging (video or trace)

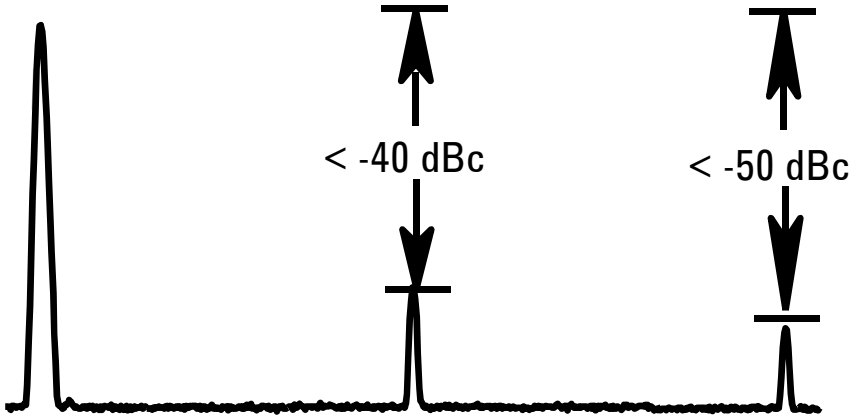
Mixers Generate Distortion



Most Influential Distortion is the Second and Third Order

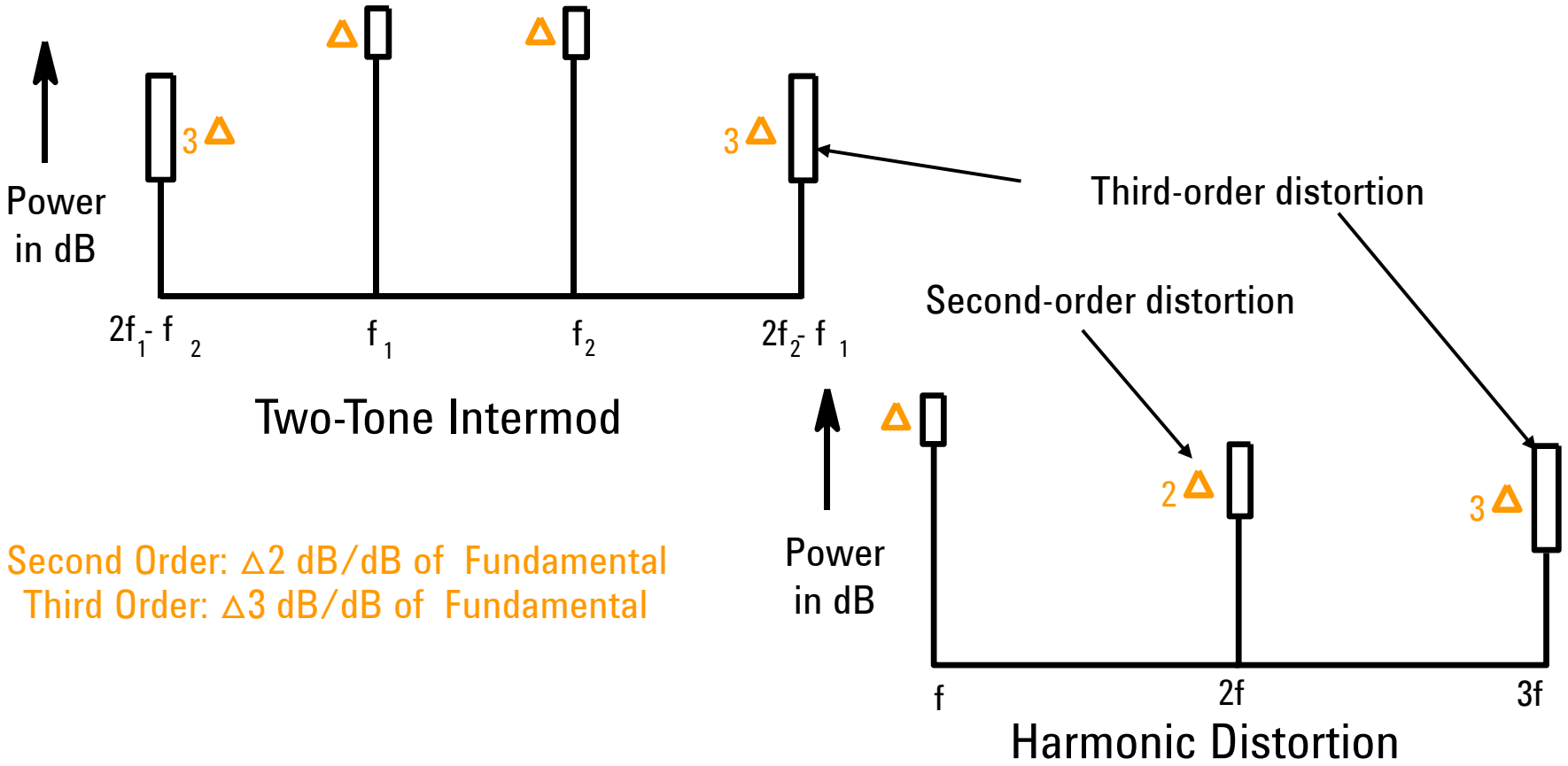


Two-Tone Intermod



Harmonic Distortion

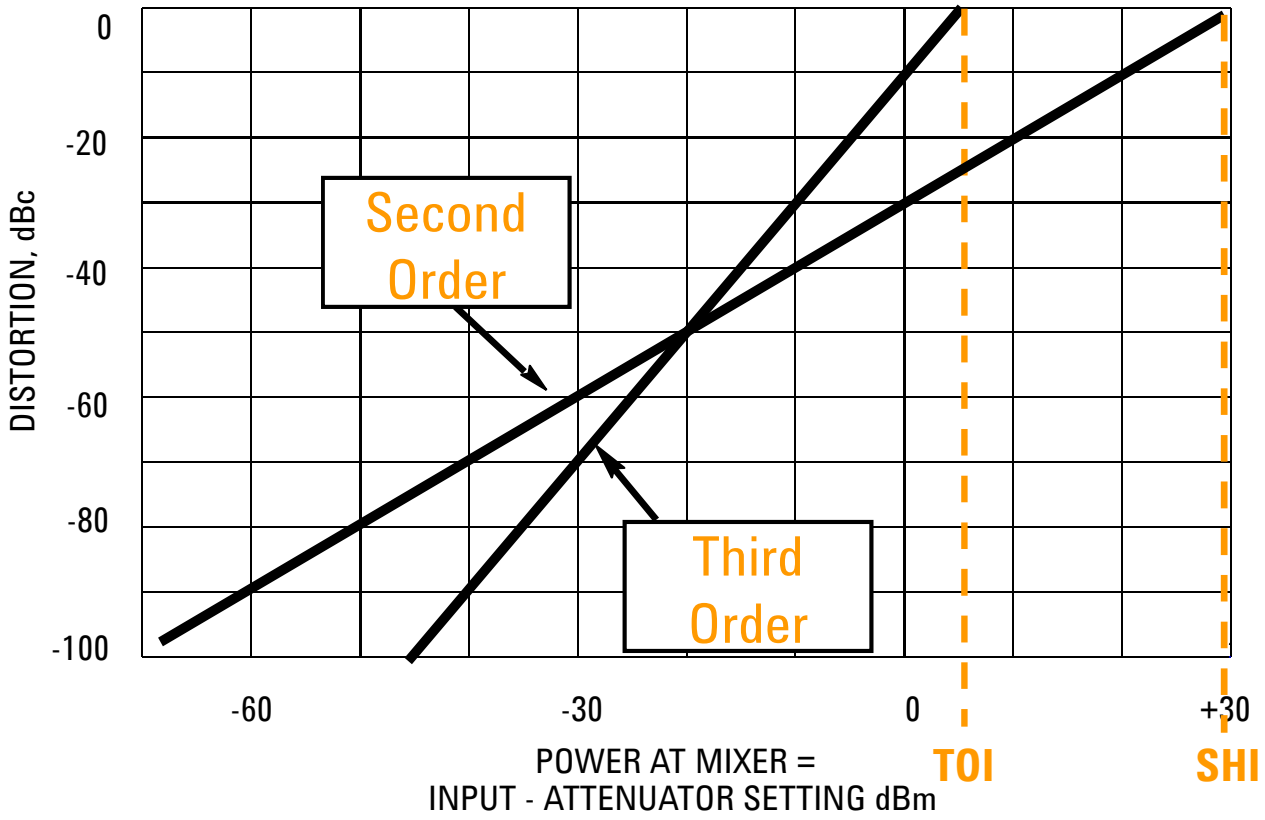
Distortion Products Increase as a Function of Fundamental's Power



Second Order: Δ2 dB/dB of Fundamental
Third Order: Δ3 dB/dB of Fundamental

Specifications
Distortion

Distortion is a Function of Mixer Level

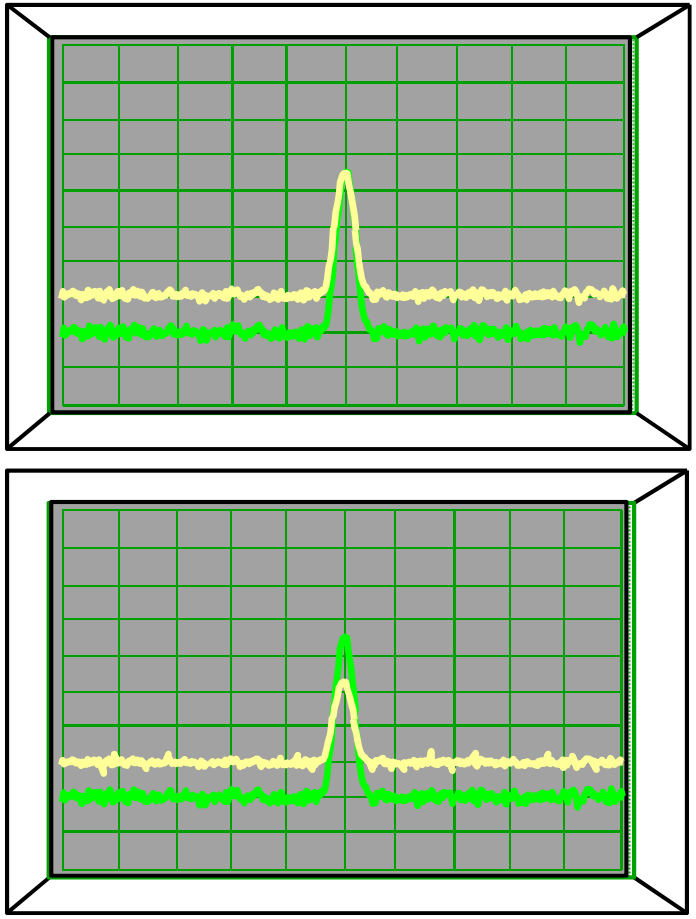


Attenuator Test: Change power to the mixer

1. Change input attenuator by 10 dB
2. Watch distortion amplitude on screen

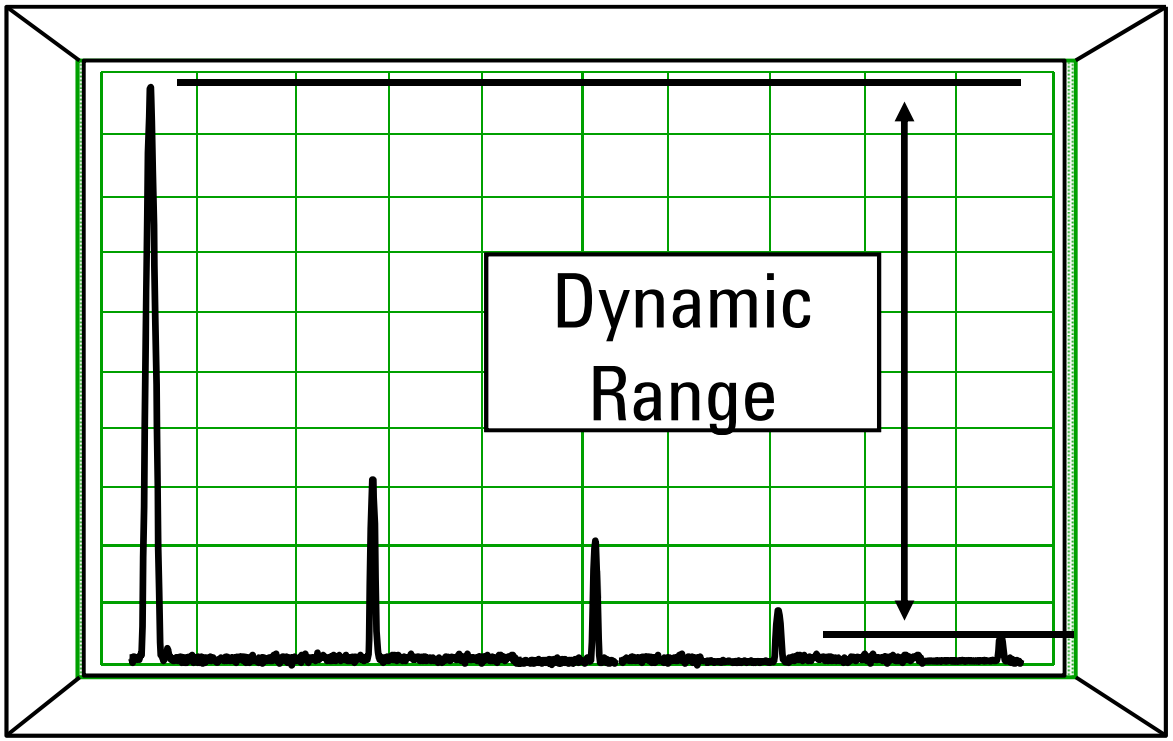
No change in amplitude:
distortion is part of input signal (external)

Change in amplitude:
at least some of the distortion is being generated inside the analyzer (internal)



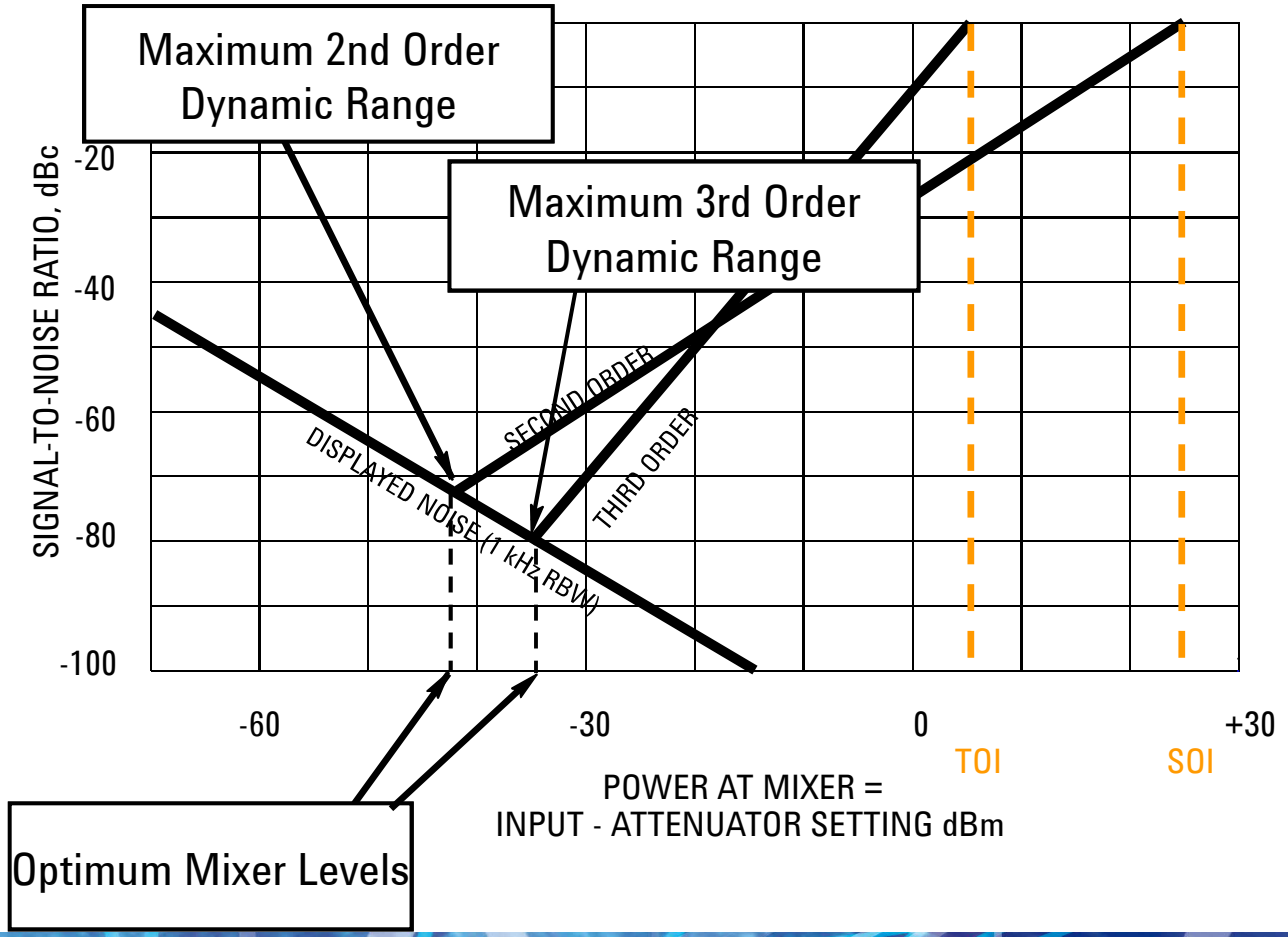
Specifications

Spectrum Analyzer Dynamic Range

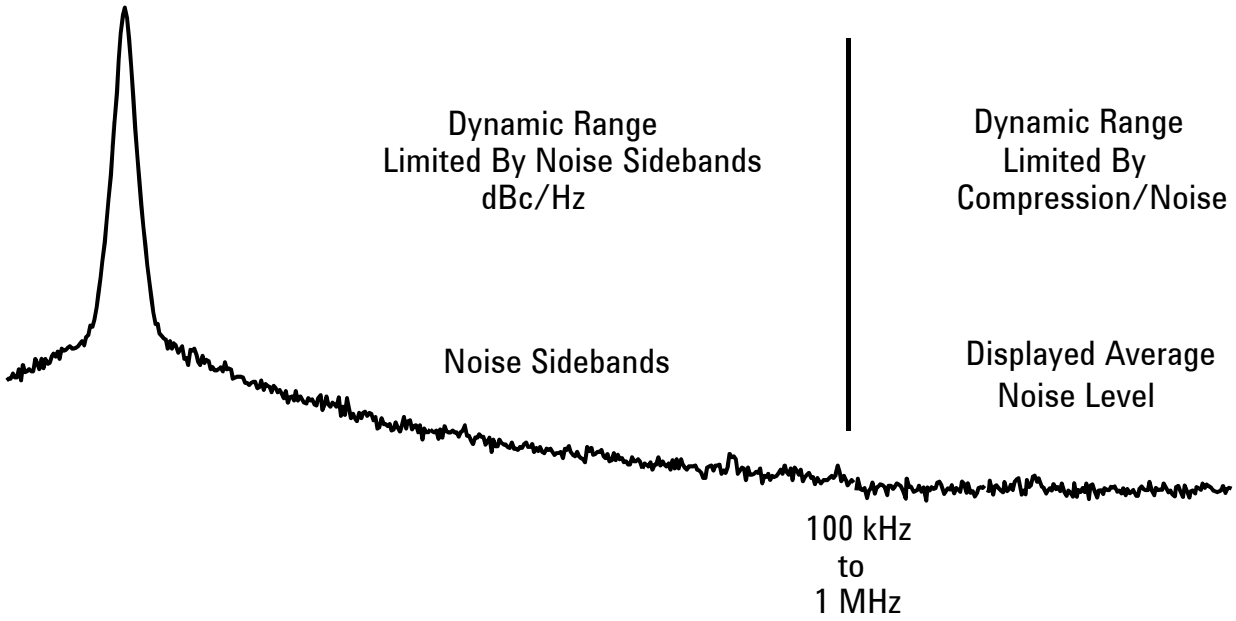


The ratio, expressed in dB, of the largest to the smallest signals simultaneously present at the input of the spectrum analyzer that allows measurement of the smaller signal to a given degree of uncertainty.

Dynamic Range Can Be Presented Graphically



Dynamic Range for Spur Search Depends on Closeness to Carrier



Specifications

Dynamic Range – Distortion, Noise Floor, LO phase noise

Dynamic Range is actually:

Maximum dynamic range calculation

Calculated from distortion products and sensitivity/DANL

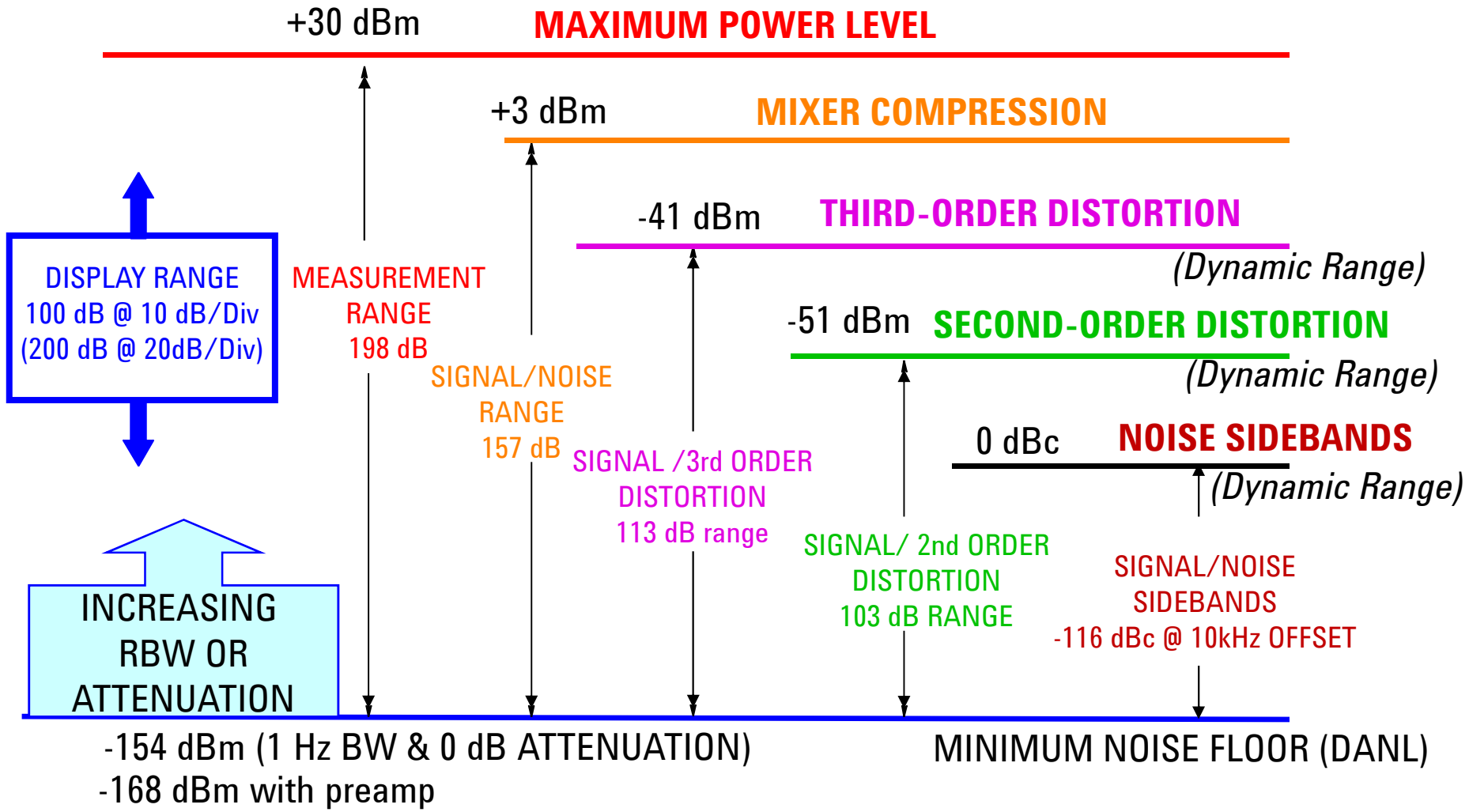
bounded by

-dBc/Hz Phase Noise sidebands @ close-in offset frequencies

Determined by the phase noise specifications of the SA

Specifications

Dynamic Range vs. Measurement Range



Specifications

Summary: Optimizing Dynamic Range

- **What settings provide the best sensitivity?**
  - Narrowest resolution bandwidth
  - Minimal input attenuation
  - Sufficient averaging
- **How do you test for analyzer distortion?**
  - Increase the input attenuation and look for signal amplitude changes
  - Then set the attenuator at the lowest setting without amplitude change
- **What determines dynamic range?**
  - Analyzer distortion, noise level, and sideband/phase noise

Agenda

Introduction

Overview

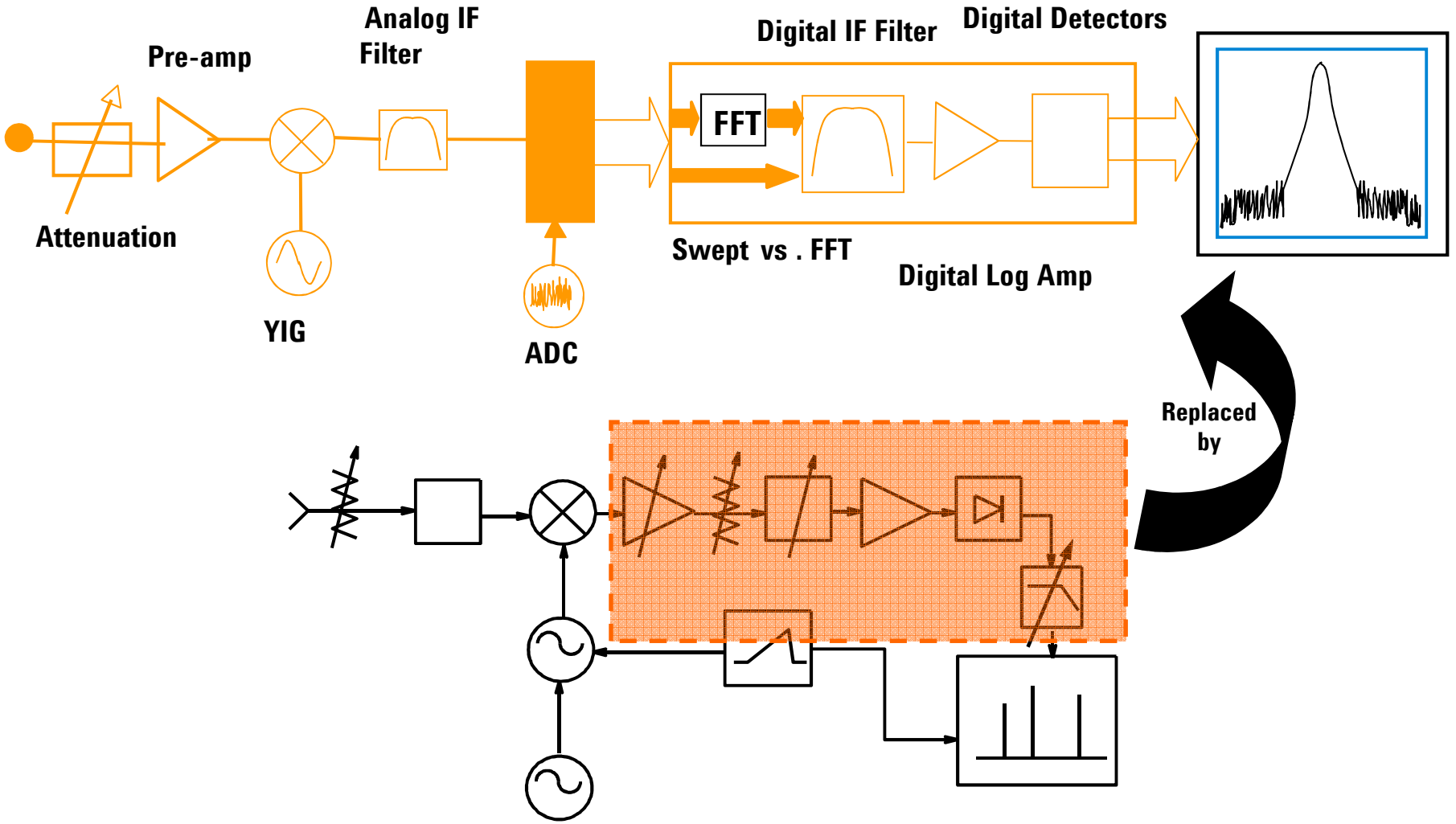
Theory of Operation

Specifications

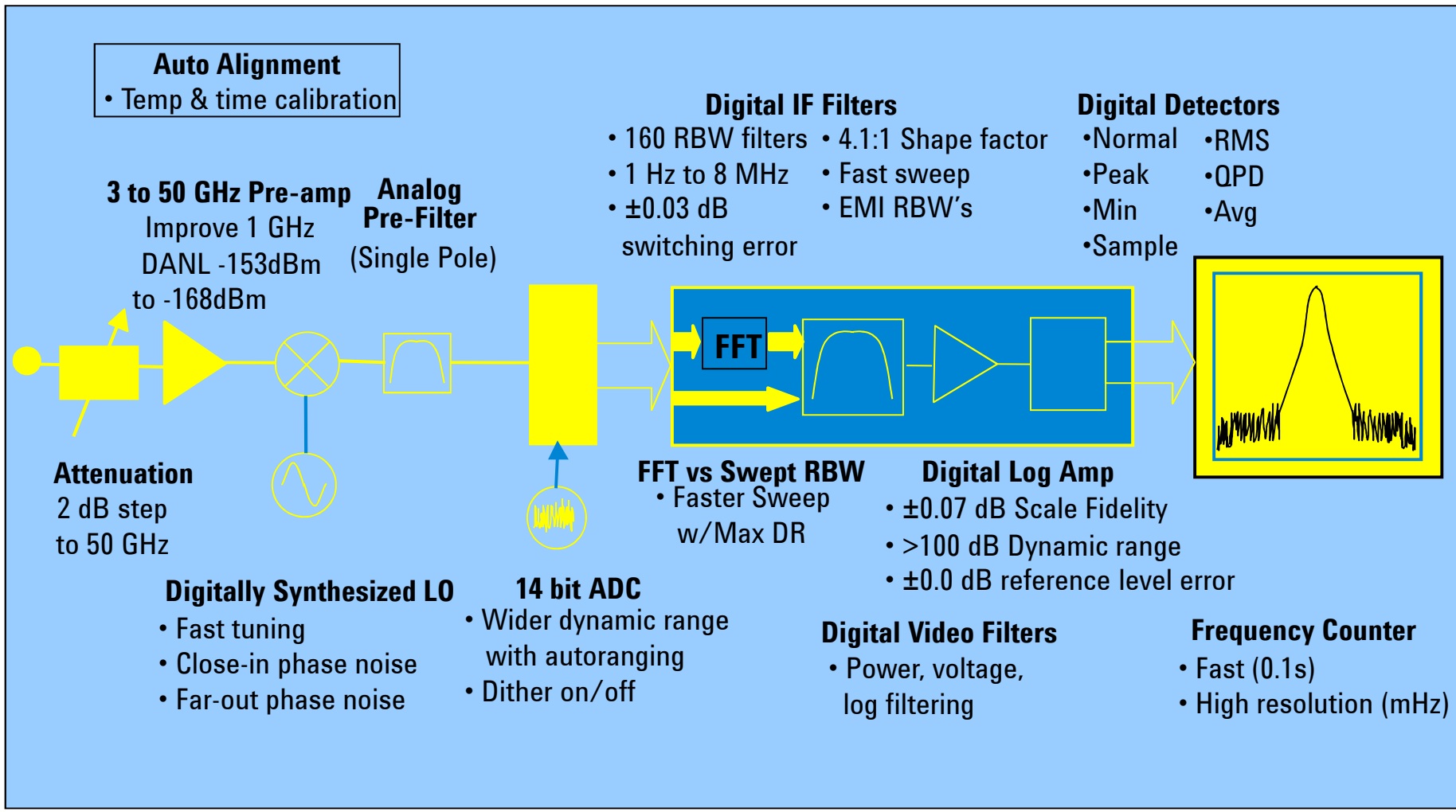
Modern spectrum analyzer designs & capabilities

- Wide Analysis Bandwidth Measurements

Modern Spectrum Analyzer Block Diagram



Modern Spectrum Analyzer Block Diagram



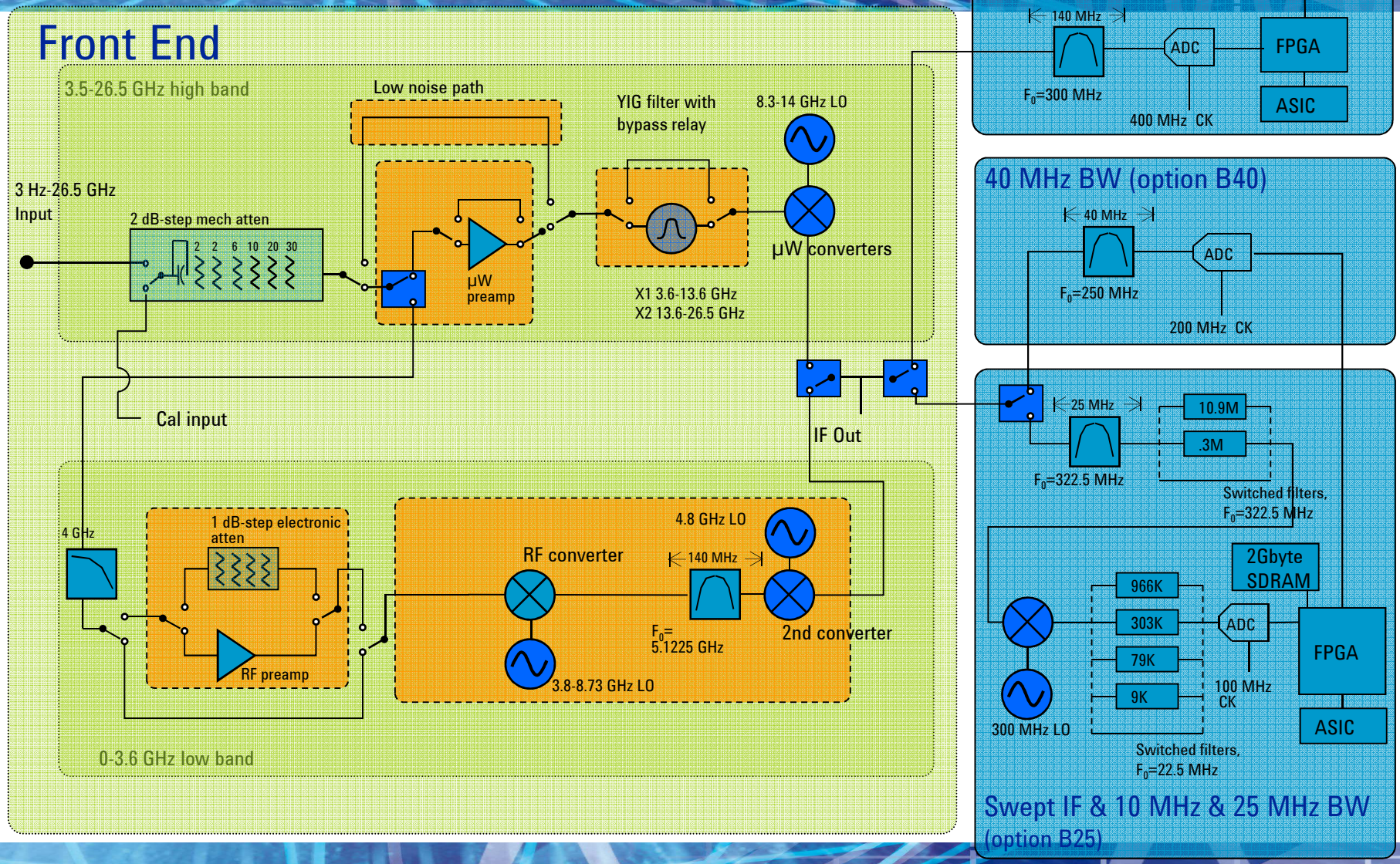
Modern Spectrum Analyzer - Specifications

Digital IF provides improved accuracy

	PSA	vs. Traditional
• Input impedance mismatch	±0.13	~~±0.29 dB~~
• Input attenuator switching uncertainty	±0.18	~~±0.6 dB~~
• Frequency response	±0.38	~~±1.8 dB~~
• Reference level accuracy	±0.0	~~±1.0 dB~~
• RBW switching uncertainty	±0.03	~~±0.5 dB~~
• Display scale fidelity	±0.07	~~±0.85 dB~~
• Calibrator accuracy	±0.24	~~±0.34 dB~~

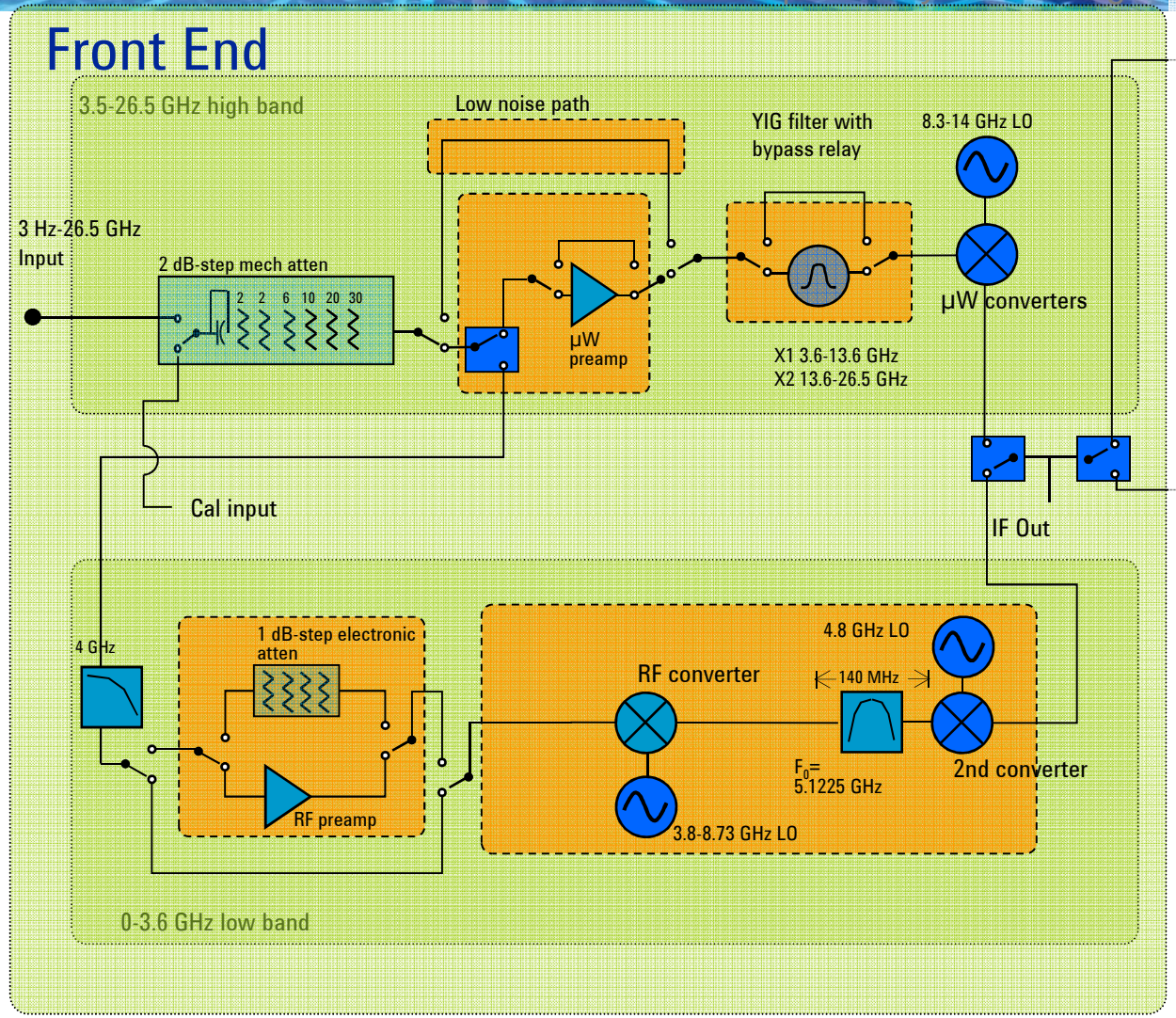
Total accuracy (up to 3 GHz)	**±0.62 dB**	vs. ~~**±1.8 dB**~~
95% Confidence	**±0.24 dB**	
Typical	**±0.17 dB**	

PXA Block Diagram



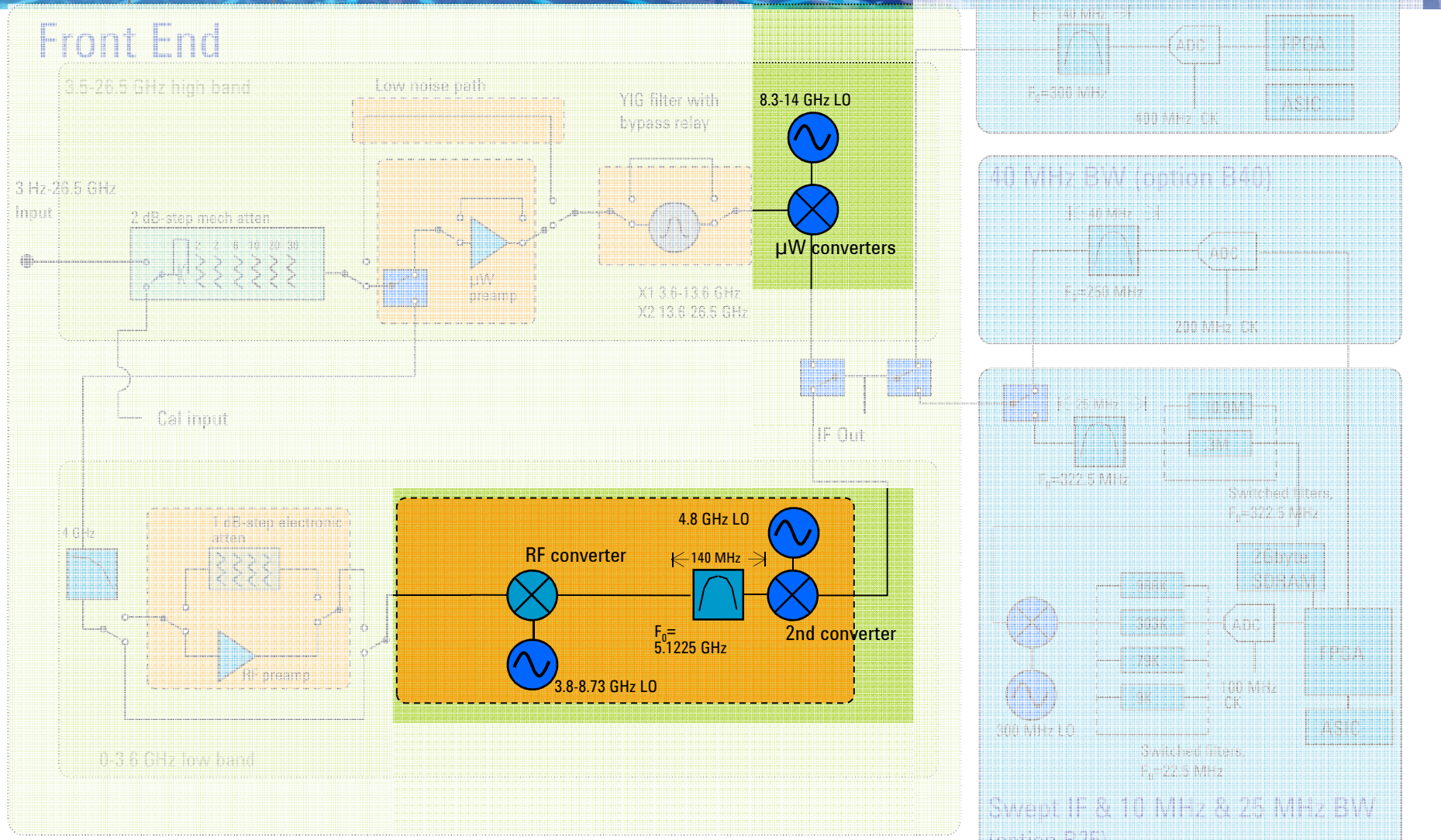
PXA Block Diagram

Noise Floor Extension & Low Noise Path for Exceptional Dynamic Range



PXA Block Diagram

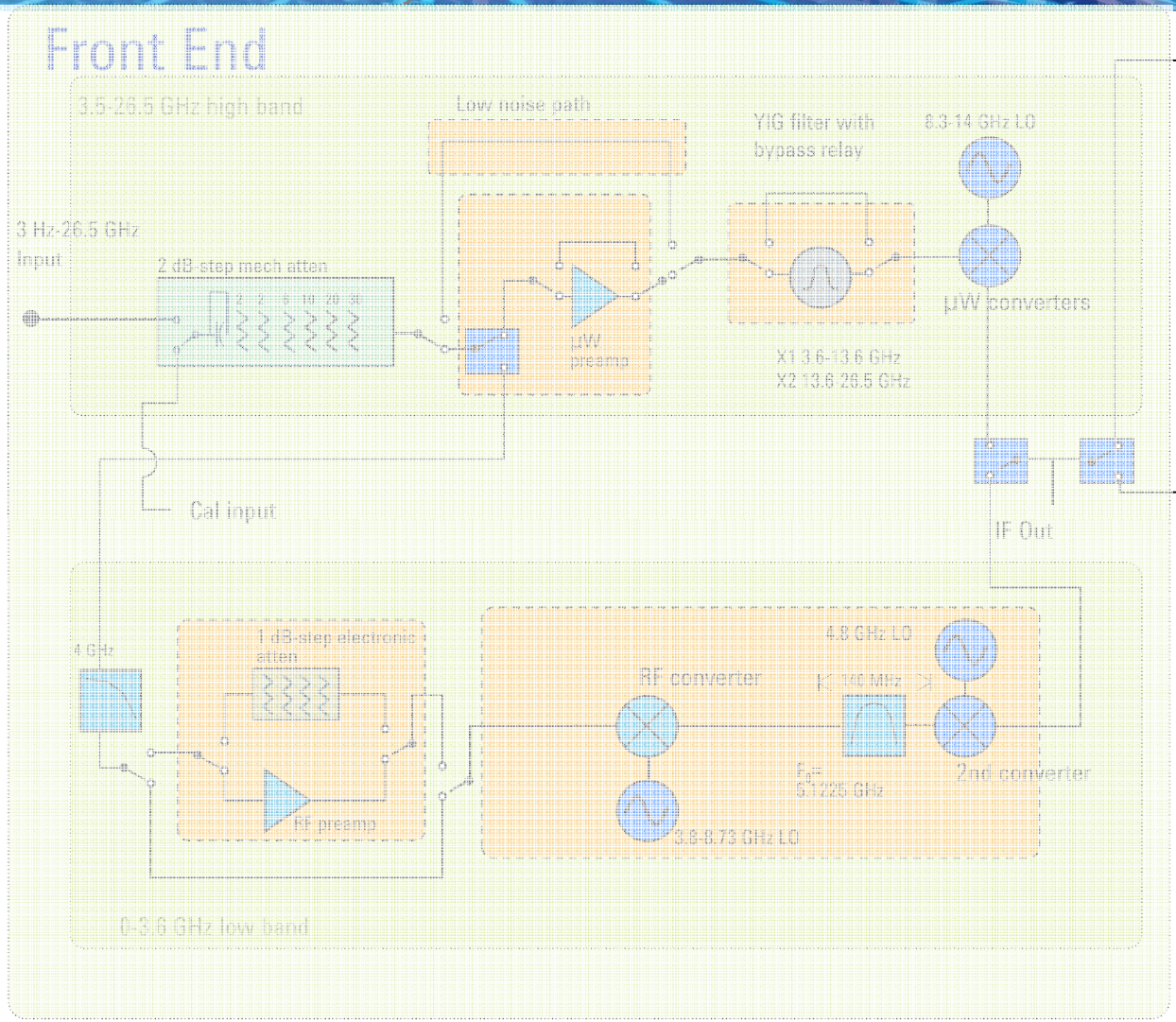
Dual Loop LO for Improved Phase Noise

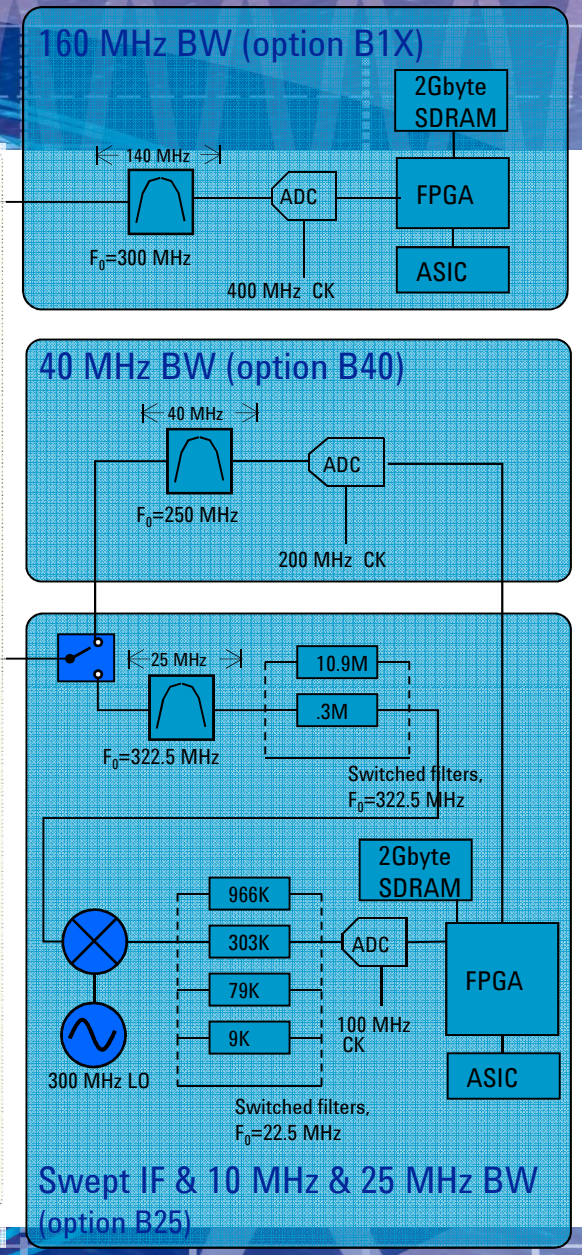


Agilent Technologies

PXA Block Diagram

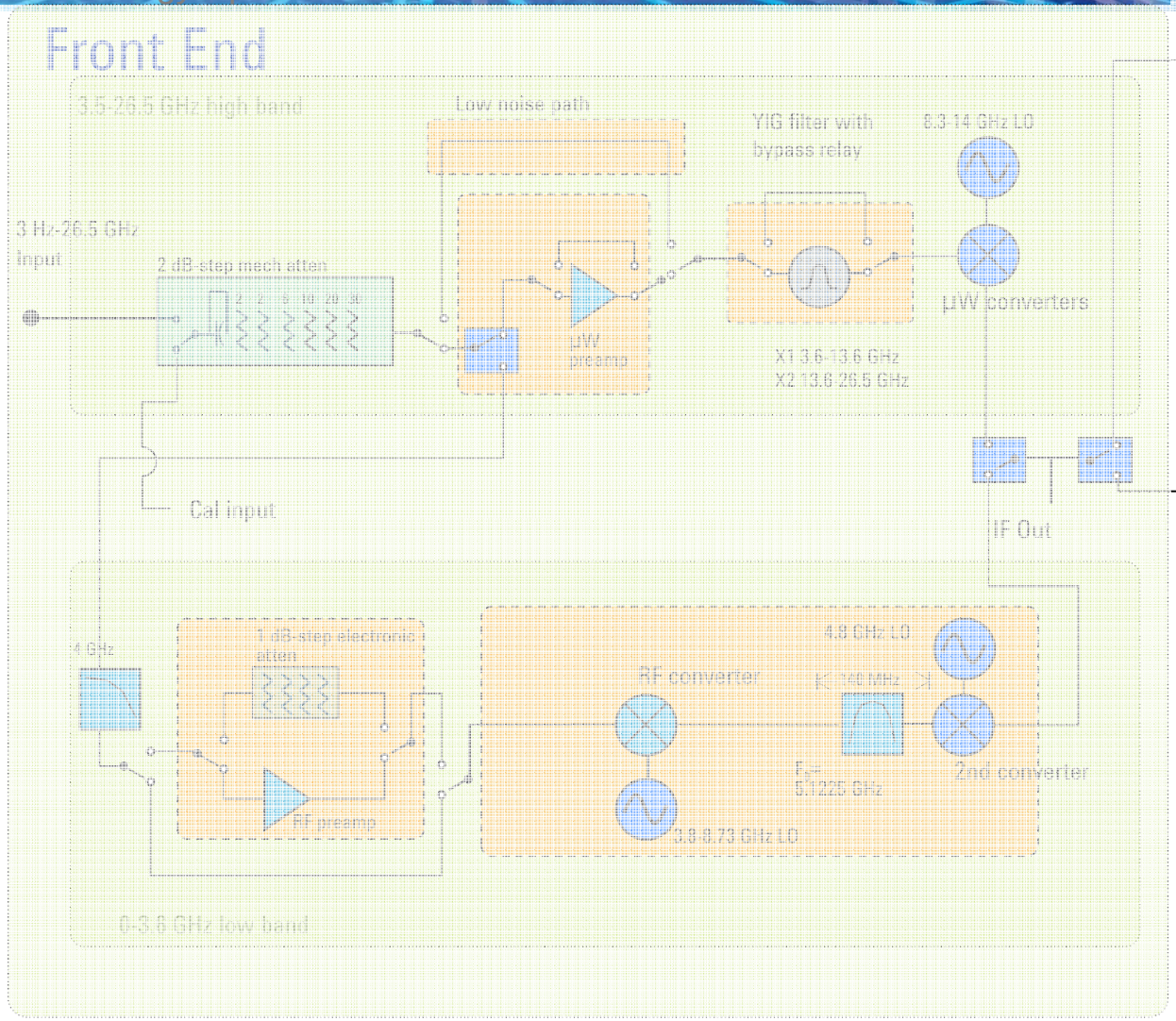
10 MHz to 140 MHz Analysis Bandwidth

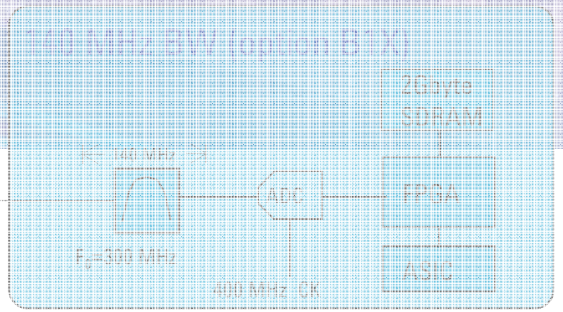


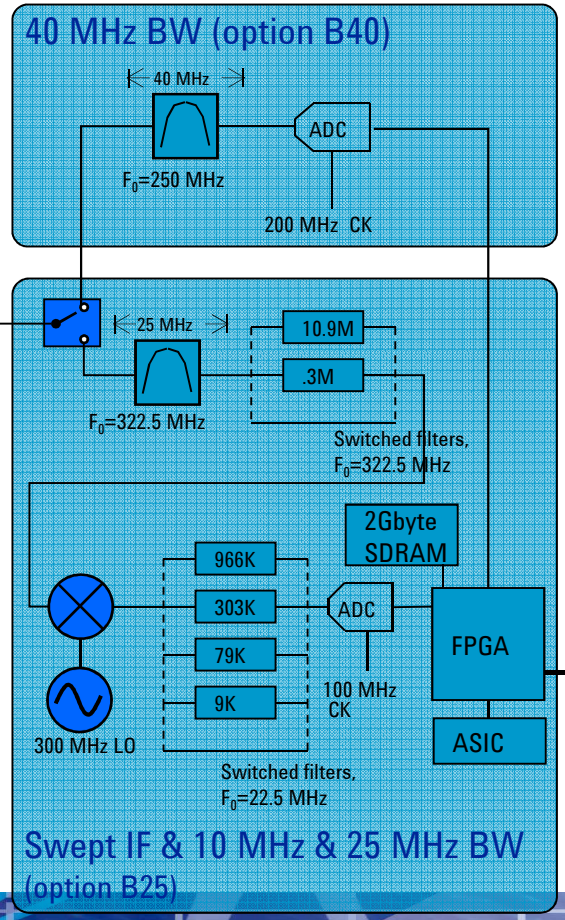


PXA Block Diagram

Technology-Specific Measurement Personalities







Agilent's Signal Analysis Capabilities

Noise Floor Extension
Instantly increases PXA sensitivity and dynamic range by up to 10 dB by removing characterized noise of frontend

Low Noise Path
Bypasses attenuator and filter paths on front end for lower noise figure and >10 dB sensitivity at microwave frequencies

Dual Loop LO
Enables close-in phase noise measurements of clocks and COHOs at levels even better than PSA

160 MHz Bandwidth
Raises the bar for the demodulation bandwidth achievable with a modern spectrum analyzer

900 MHz IF Out
Allows vector demodulation of extremely wideband signals using compatible oscilloscope

63 GHz Bandwidth
Achievable using external down-converter and digital signal oscilloscope

Technology-Specific Personalities
Speed the process of analyzing and verifying performance of technology-specific transmissions

X-series Platform
Establishes a universal system of user interfaces, software licenses, and measurement results all the way from the lab to the factory

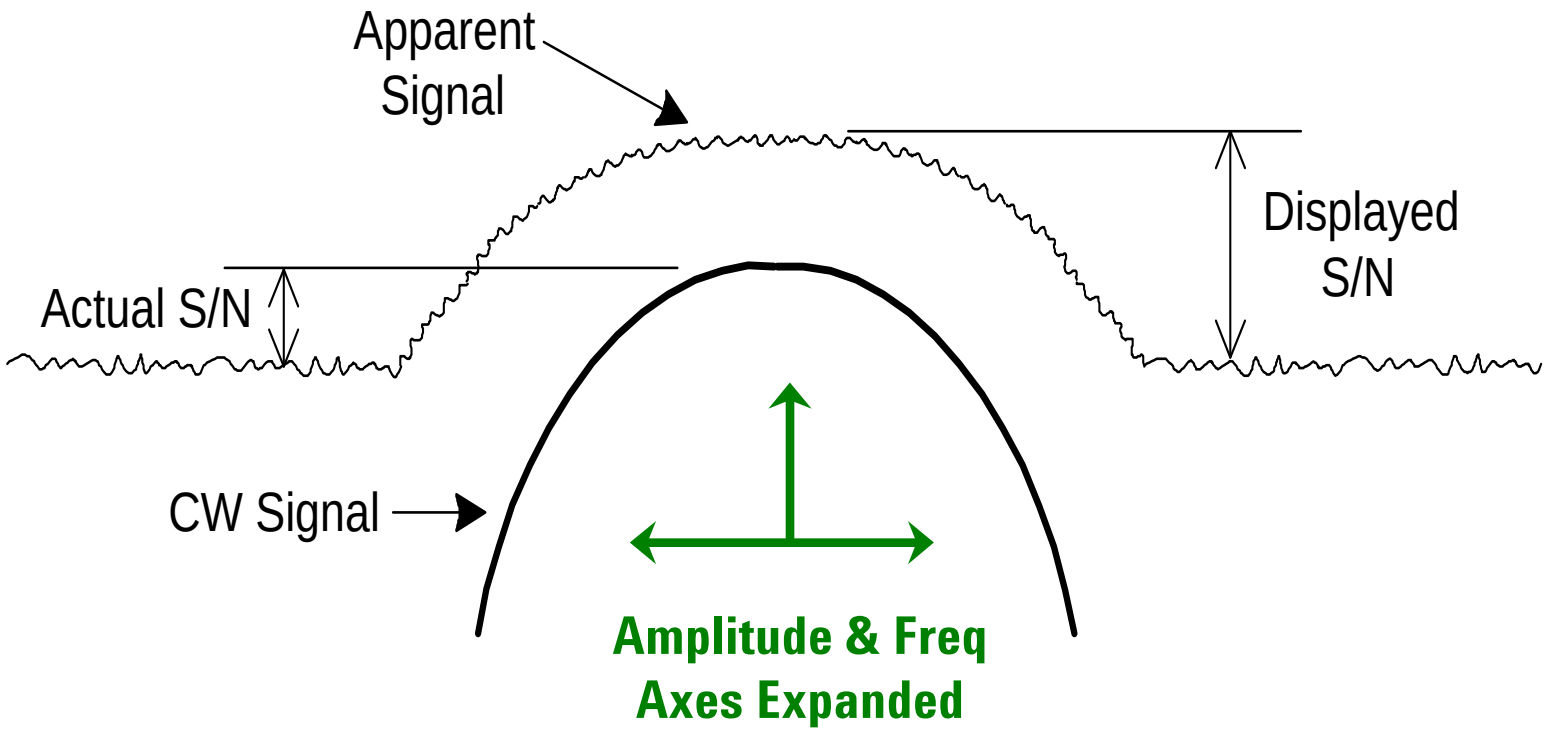
What is Noise Floor Extension?

Accurate modeling, measuring and subtracting of the analyzer's noise floor.

Good for measuring small signals.

Improve Dynamic Range: make measurements that require dynamic range, more accurately and potentially faster.

Measuring a Signal Near Analyzer Noise Floor



Signal Analyzers always measure the Signal of interest plus the Noise of the Analyzer present in the RBW.

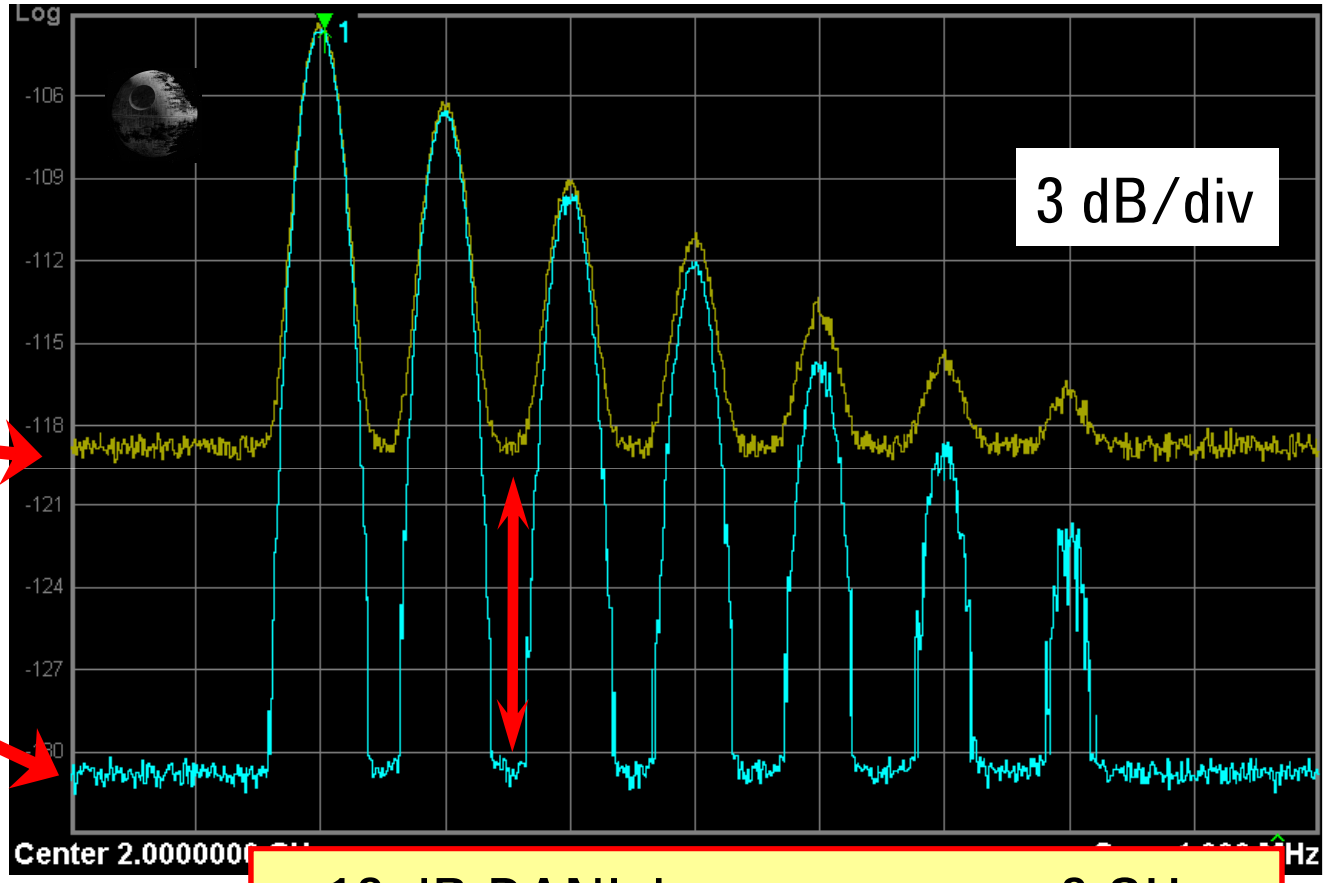
NFE Benefit in the PXA

Turn:

This

into

This



12 dB DANL improvement at 2 GHz

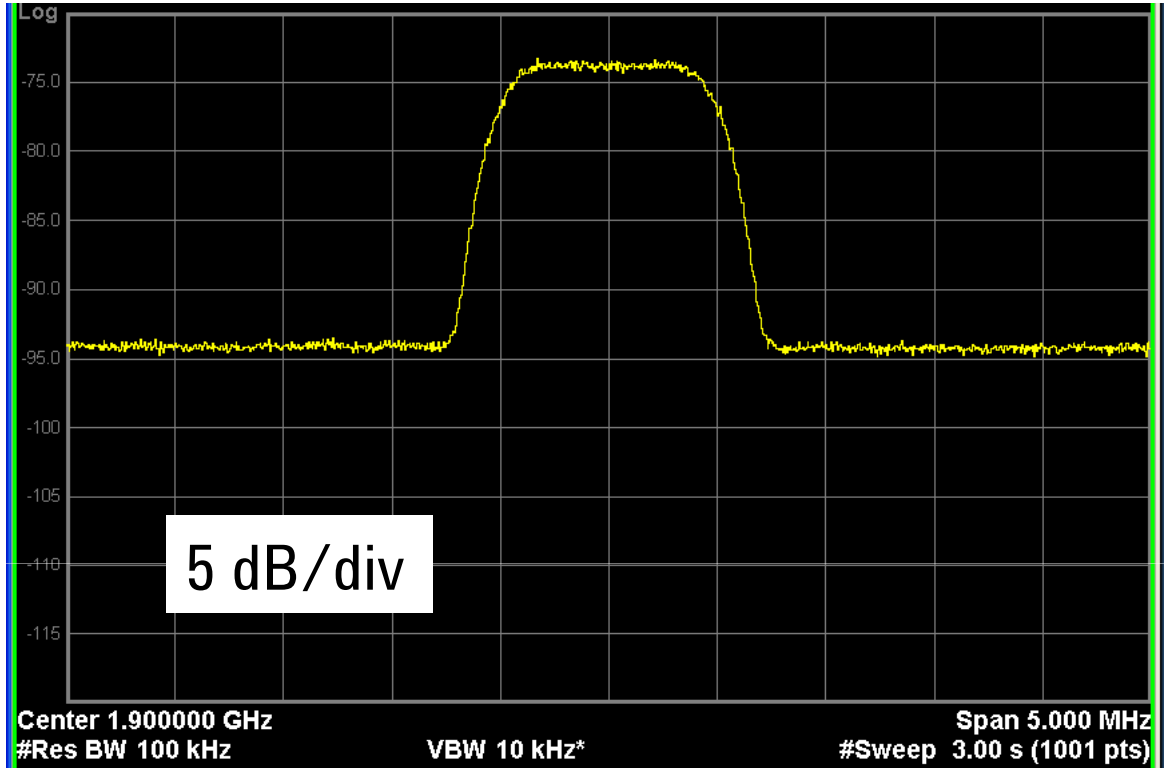
NFE in the PXA: Our “3C” Process

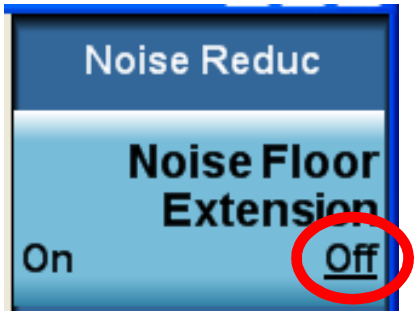
Characterize (model the noise) - R&D

Calibrate (measure the parameters of the model) - Factory Calibration

Compensate (subtract the noise contribution from the result) - Real time processing

Noise-Like Signal and Noise

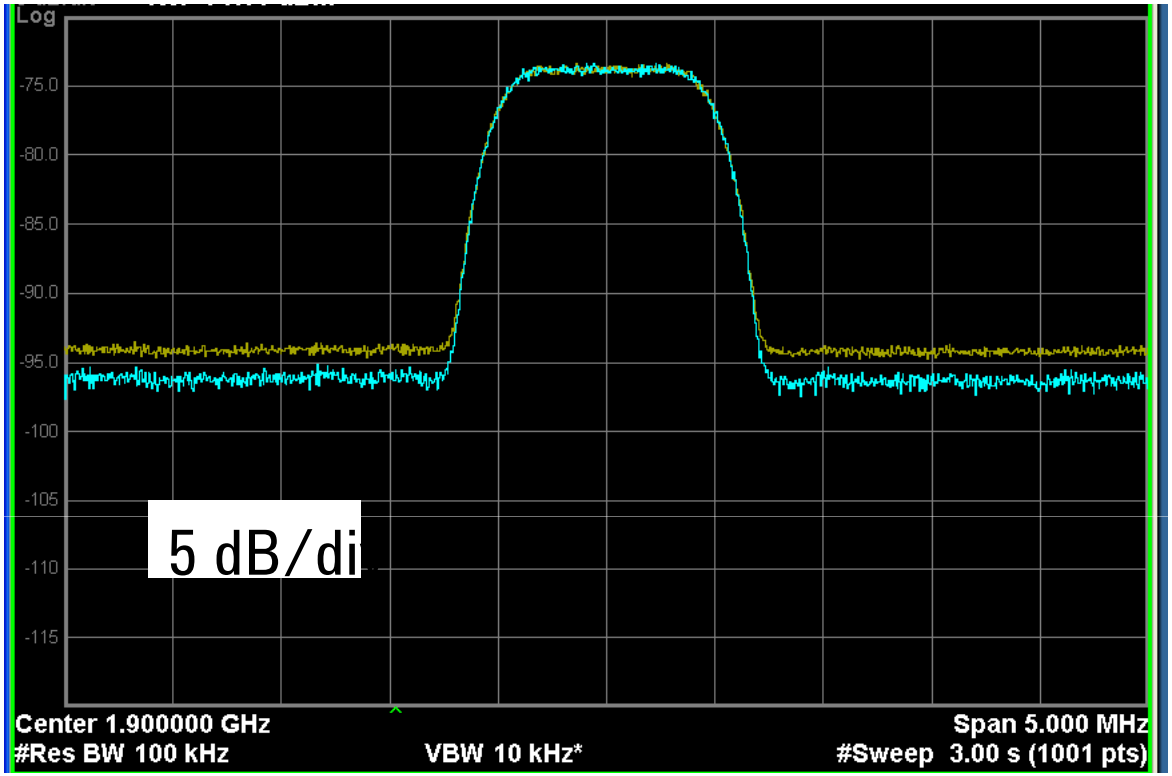


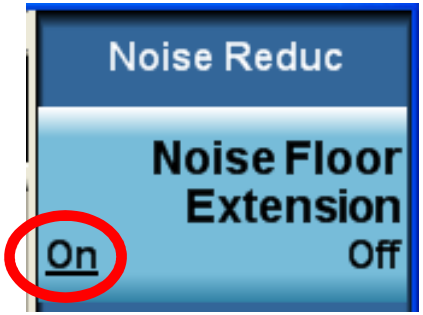


QPSK Digital Modulation

Signal accurately measured, but noise biased higher by analyzer noise power (no NFE). Average detector, slower sweep to measure signal & noise, reduce variance.

Result from Noise Subtraction

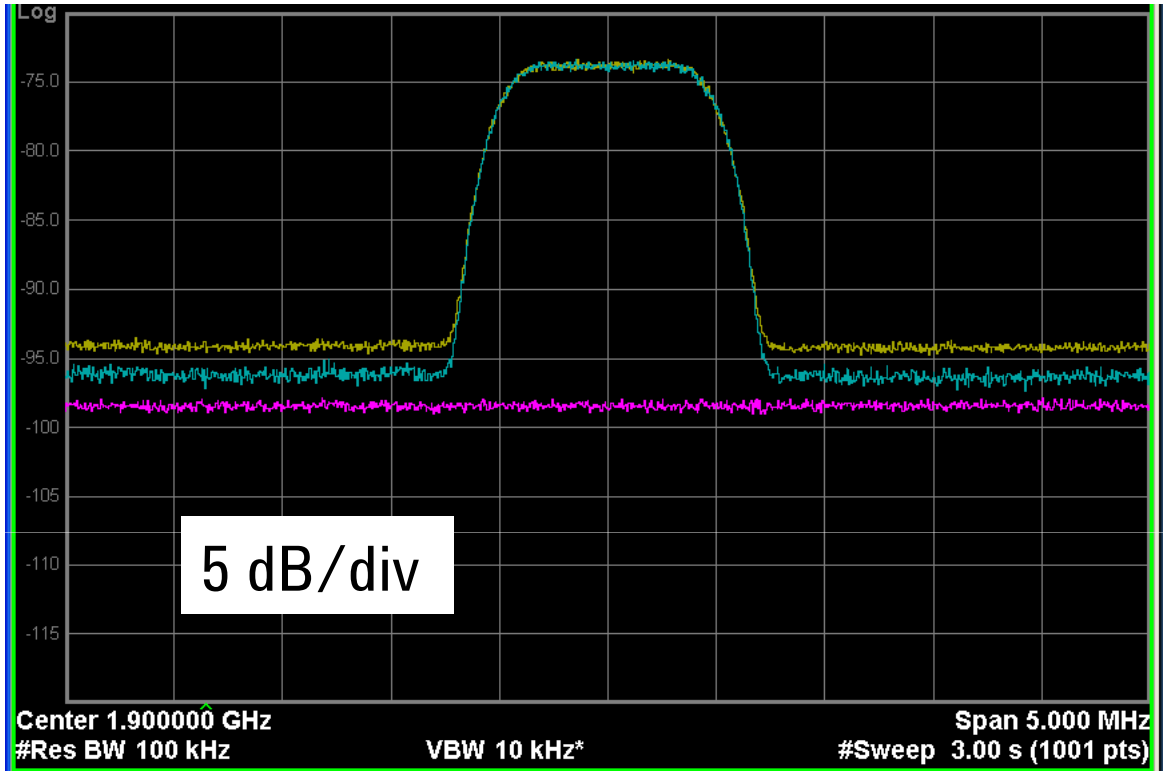


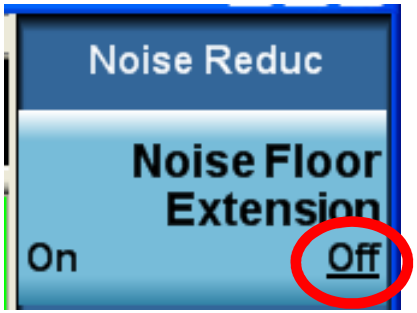


Blue trace shows more accurate measurement due to removal of analyzer noise power

Note increased variance of result

Analyzer Noise Floor without NFE

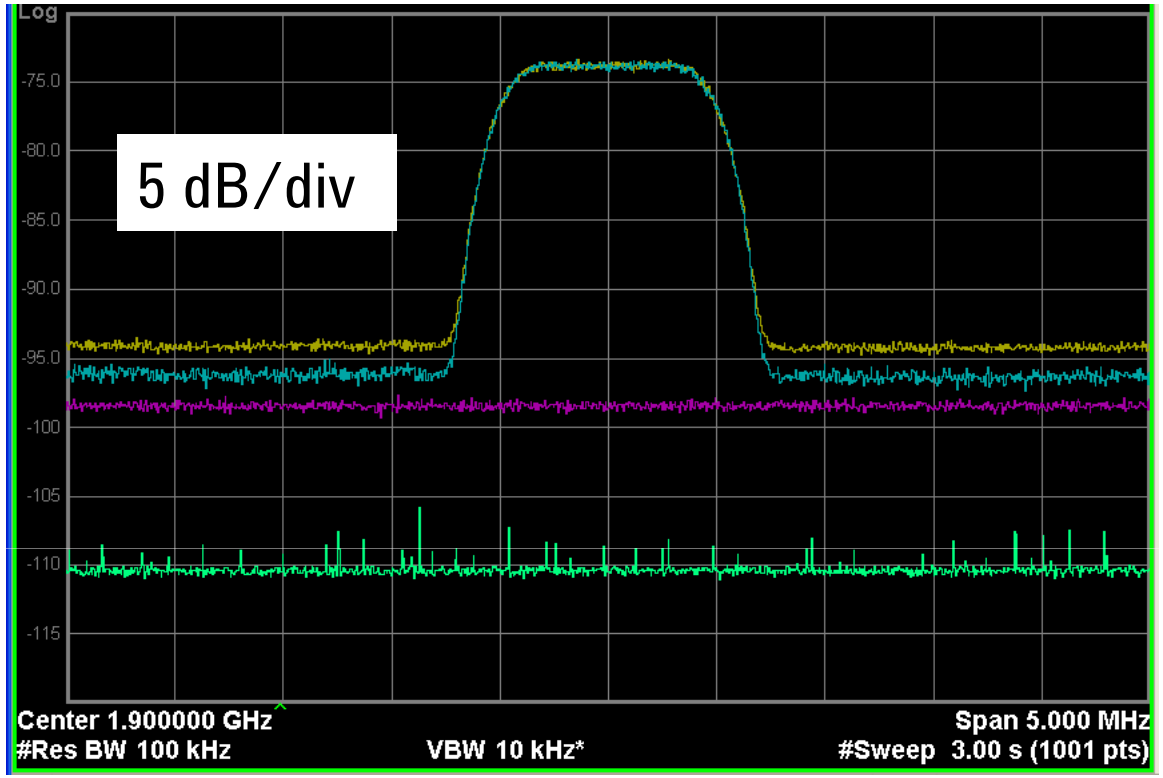


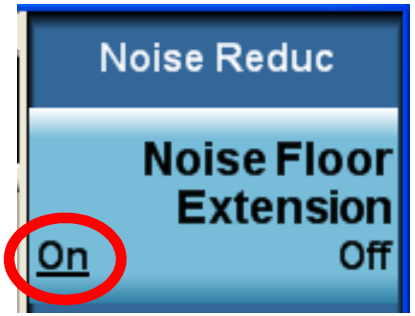


Source switched off, pink trace = analyzer noise level, no NFE

PXA DANL (pink) adds to source power (blue) for first meas. result (yellow)

Analyzer Noise Floor with NFE



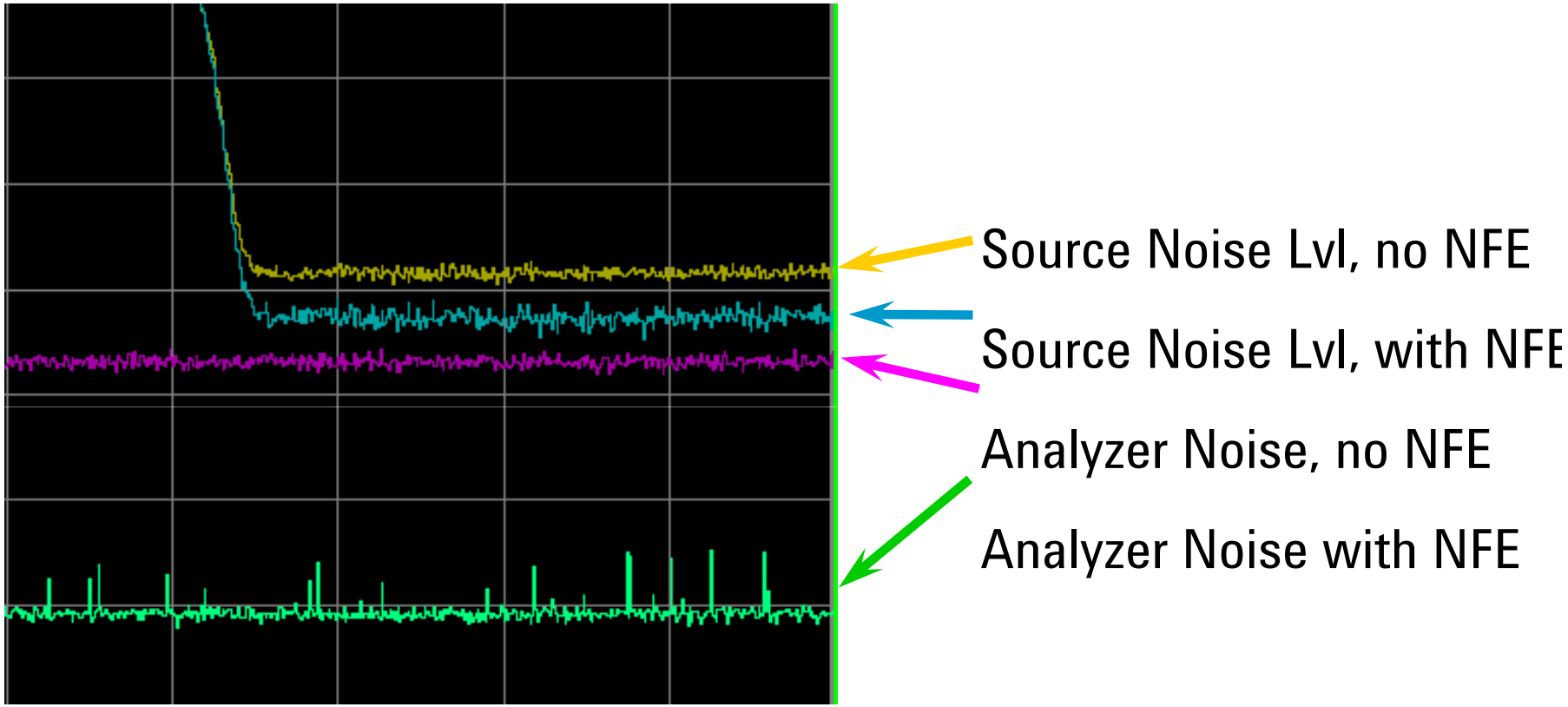


Source still off, green trace shows **analyzer noise level with NFE**

Note high variance result from subtraction of small, noisy numbers

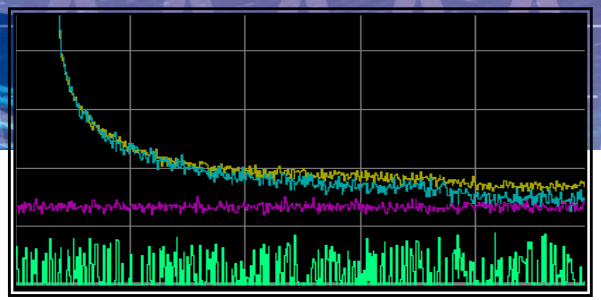
Analyzer DANL now far enough below source for minimal (0.2 - 0.4 dB) error

A Closer Look



Pink trace adds to blue trace; result is yellow trace (NFE not used)

Green trace is included in blue trace but resulting error very small



Summary

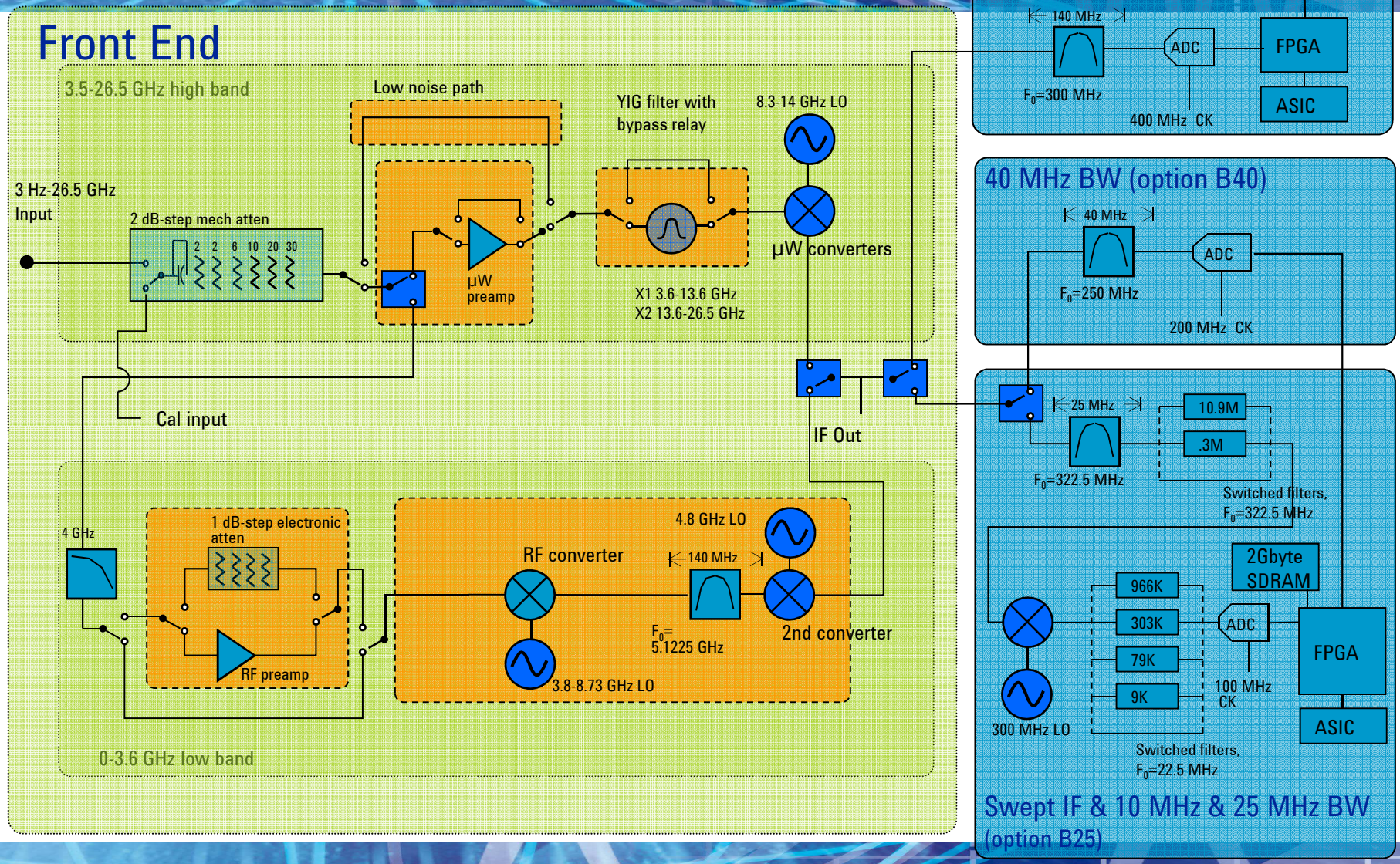
What is Noise Floor Extension?

- Accurate modeling, measuring and subtracting of the analyzer's noise floor

What kind of measurements will benefit from NFE?

- Distortion, ACP, Phase Noise, Noise Figure, Modulation: AM, FM, PM, Pulsed (not demodulation.) Expand the performance envelope or trade the extra noise performance for speed, distortion, etc.

PXA Simplified Block Diagram



Microwave or High Band Architecture Tradeoffs

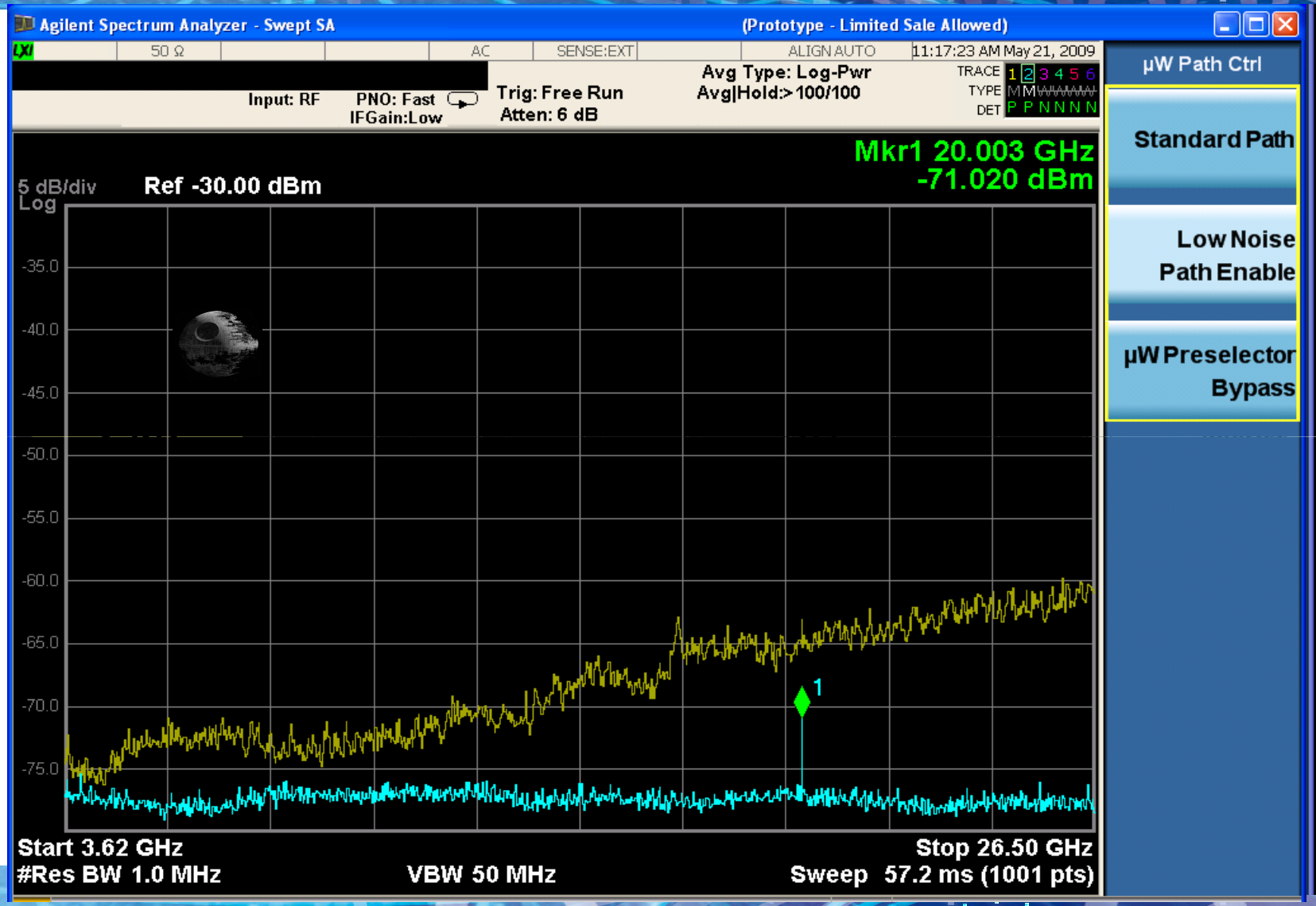
Microwave or High Band Section

- Path switching for microwave preamplifier
- Other switching or path (cable) losses

Alternate “Low Noise Path” Option

- Available for high band only (>3.6 GHz)
- Microwave preamplifier is bypassed and not available when LNP used

Alternate “Low Noise Path”

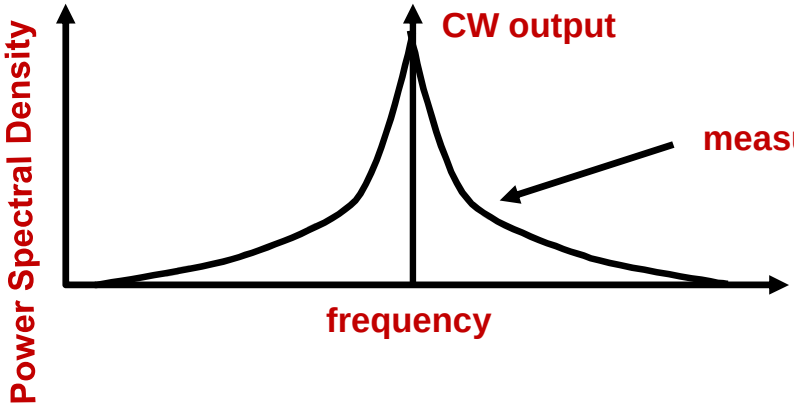


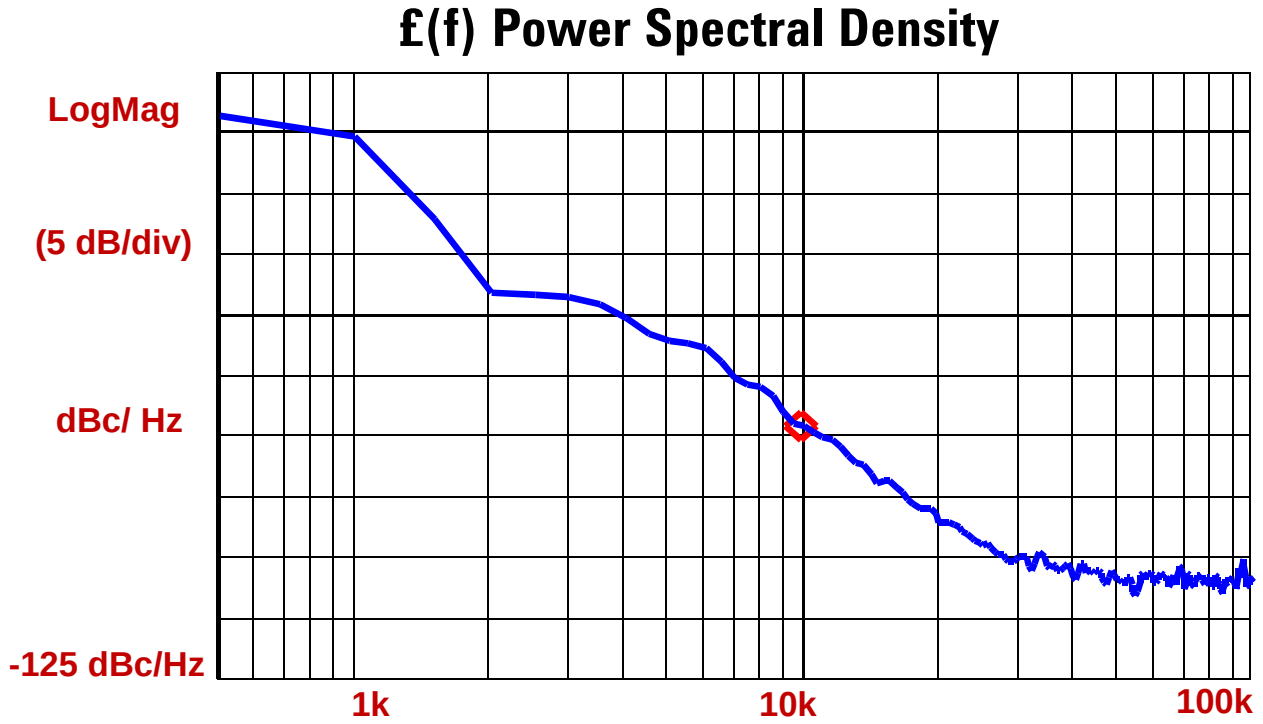
Phase Noise Improvements

Applications for Direct Phase Noise Measurement

- Precision oscillator characterization
- Low noise clocks for digital communications systems
- Low noise oscillators satellite communications systems
- Oscillators used for radio astronomy
- Low noise oscillators for moving target indicator (MTI) radar systems, e.g. STALO and COHO
  - Most common frequencies: 60 MHz, 120 MHz, 200 MHz, and 600 MHz

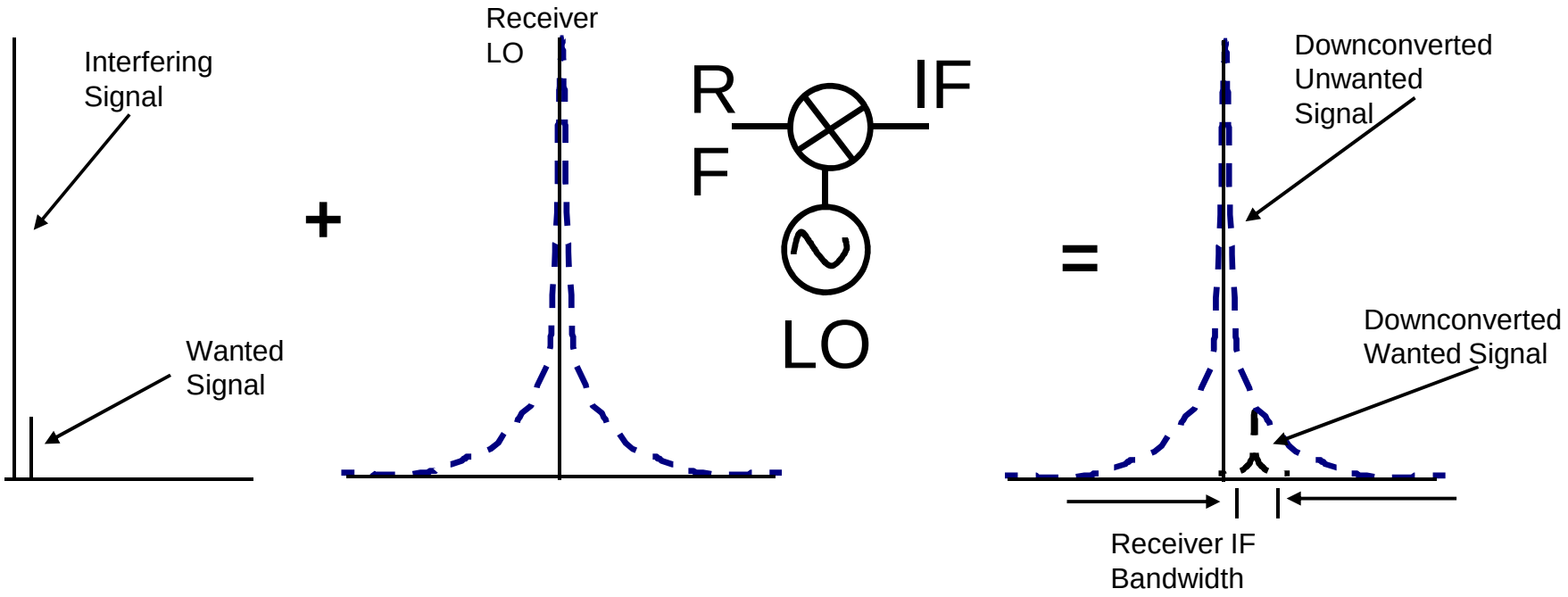
Phase Noise


Power Spectral Density
CW output
measured as dBc/Hz
frequency


£(f) Power Spectral Density
LogMag
(5 dB/div)
dBc/ Hz
-125 dBc/Hz
1k
10k
100k
Frequency offset

Why is Phase Noise Important?

Local oscillator phase noise affects receiver sensitivity



PXA Phase Noise Performance

Lowest Phase Noise Floor.

AM rejection, 10-15 dB up to 1MHz offset.

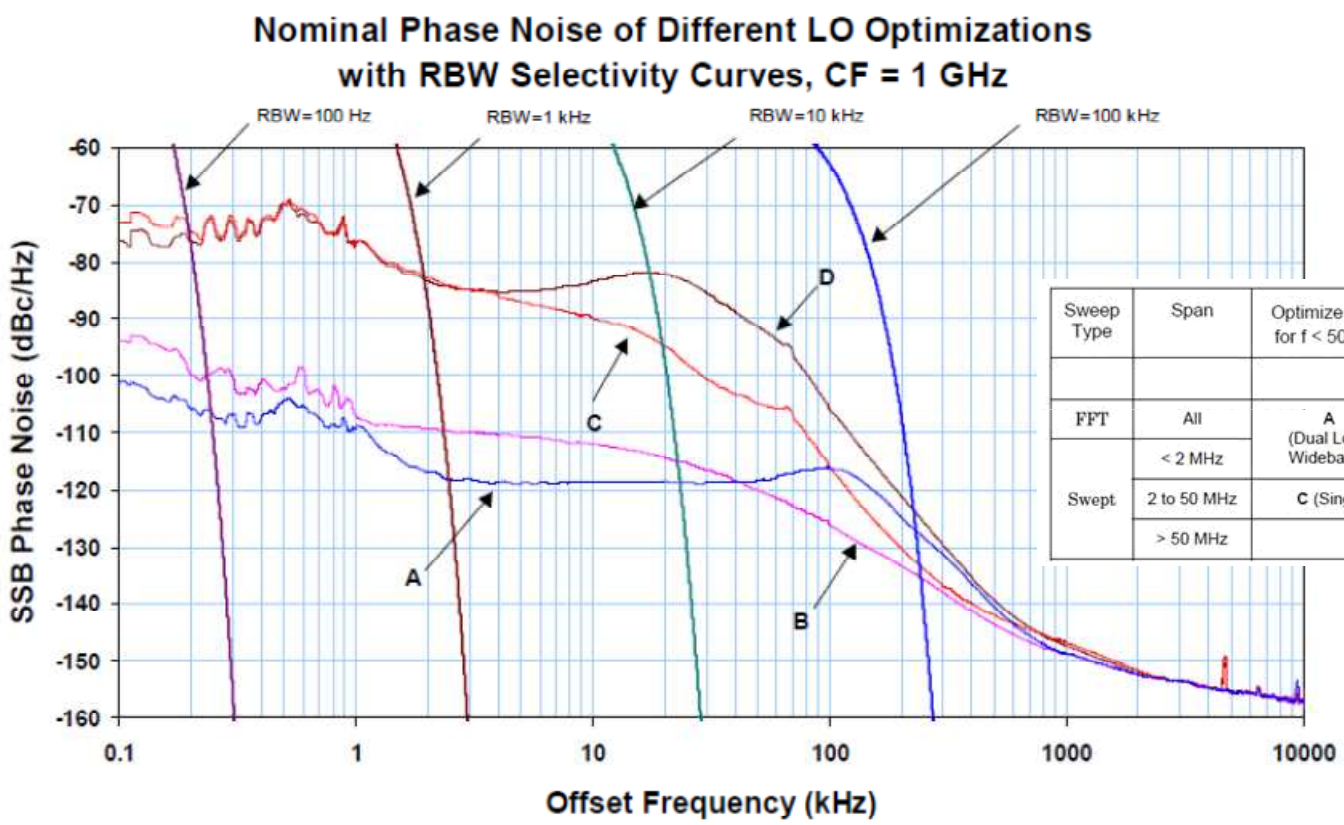
External Reference Oscillator input.

Signal tracking up to 25 MHz.

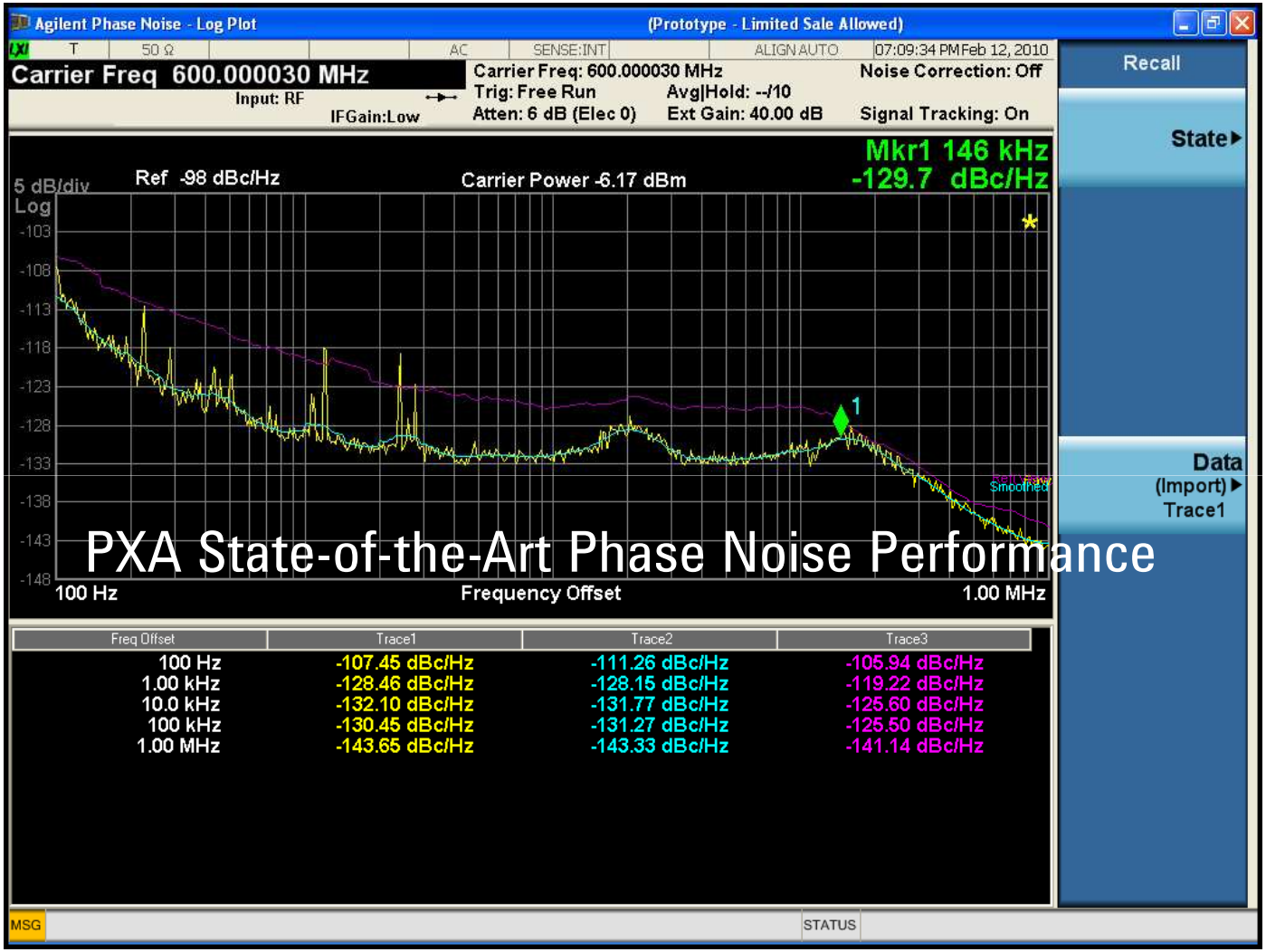
Decade Marker Table

PSA Phase Noise performance

Nominal Phase Noise of Different LO Optimizations



Sweep Type	Span	Optimize $\mathscr{L}(f)$ for f < 50 kHz	Optimize $\mathscr{L}(f)$ for f > 50 kHz	Optimize LO for fast tuning
FFT	All	A (Dual Loop Wideband)	B (Dual Loop Narrowband)	D (Single Loop Wideband)
Swept	< 2 MHz			
	2 to 50 MHz	C (Single Loop Narrowband)		
	> 50 MHz			


Agilent Phase Noise - Log Plot
(Prototype - Limited Sale Allowed)
T
50 Ω
AC
SENSE:INT
ALIGN AUTO
07:09:34 PM Feb 12, 2010
Carrier Freq 600.000030 MHz
Input: RF
IFGain:Low
Carrier Freq: 600.000030 MHz
Trig: Free Run
Avg|Hold: --/10
Atten: 6 dB (Elec 0)
Ext Gain: 40.00 dB
Noise Correction: Off
Signal Tracking: On
Recall
State
Mkr1 146 kHz
-129.7 dBc/Hz
5 dB/div
Log
Ref -98 dBc/Hz
Carrier Power -6.17 dBm
-103
-108
-113
-118
-123
-128
-133
-138
-143
-148
Smoothed
PXA State-of-the-Art Phase Noise Performance
100 Hz
Frequency Offset
1.00 MHz
Data
(Import)
Trace1
Freq Offset
Trace1
Trace2
Trace3
100 Hz -107.45 dBc/Hz -111.26 dBc/Hz -105.94 dBc/Hz
1.00 kHz -128.46 dBc/Hz -128.15 dBc/Hz -119.22 dBc/Hz
10.0 kHz -132.10 dBc/Hz -131.77 dBc/Hz -125.60 dBc/Hz
100 kHz -130.45 dBc/Hz -131.27 dBc/Hz -125.50 dBc/Hz
1.00 MHz -143.65 dBc/Hz -143.33 dBc/Hz -141.14 dBc/Hz
MSG
STATUS


Agilent Phase Noise - Spot Frequency
(Prototype - Limited Sale Allowed)
T
50 Ω
AC
SENSE:INT
ALIGN AUTO
07:25:53 PM Feb 12, 2010
Sweep Time 17.8 ms
Input: RF
IFGain:Low
Carrier Freq: 600.000075 MHz
Trig: Free Run
Atten: 6 dB (Elec 0)
Sweep/Control
Sweep Time
17.8 ms
Auto
Man
Pause
YRef -50.00 dBc/Hz
10 dB/div
Phase Noise
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
1
101
YRef 0.000 Hz
10 Hz/div
Delta Freq
40
30
20
10
0
-10
-20
-30
-40
-50
1
101
SSB -123.86 dBc/Hz
SSB avg -122.96 dBc/Hz
Spot Offset 10.0 kHz
Carrier Power -25.10 dBm
Carrier Freq 600.000075 MHz
Carrier Freq (initial) 600.000075 MHz
Carrier Freq (delta) -205 mHz
MSG
STATUS

Ultra-Wideband Demodulation of 900 MHz Signals

Agilent Technologies

Objectives

-Check architecture of PXA in regards to Digital Modulation Analysis

-Review PXA 160 MHz bandwidth implementation

-Review PXA 900 MHz IF implementation

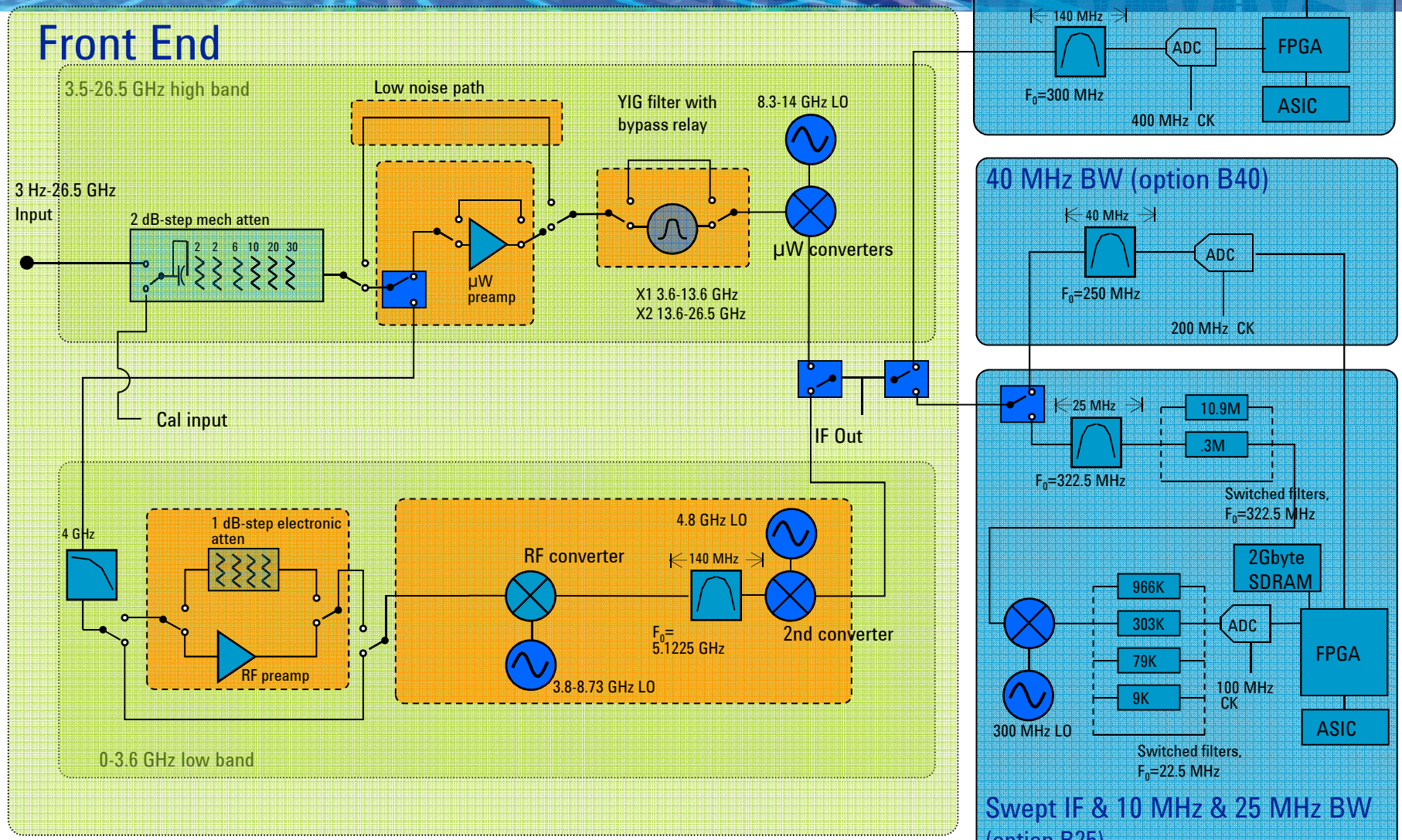
-Review PXA 15 nsec Video Output implementation

-Review memory depth, record length and VSA / VXA relations

-Close

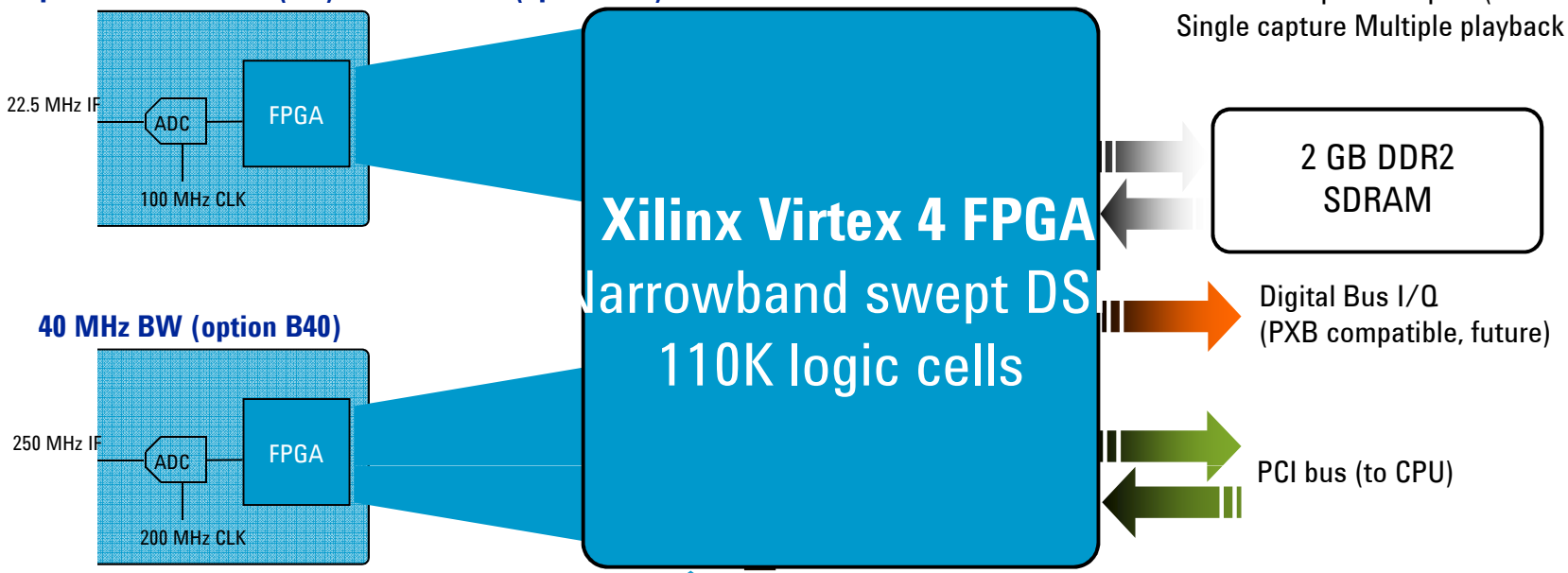
160 MHz of Analysis Bandwidth

PXA Simplified Block Diagram



PXA Swept AIF & 40 MHz Digital IF

Swept IF / 10 MHz BW (std) /25 MHz BW (option B25)



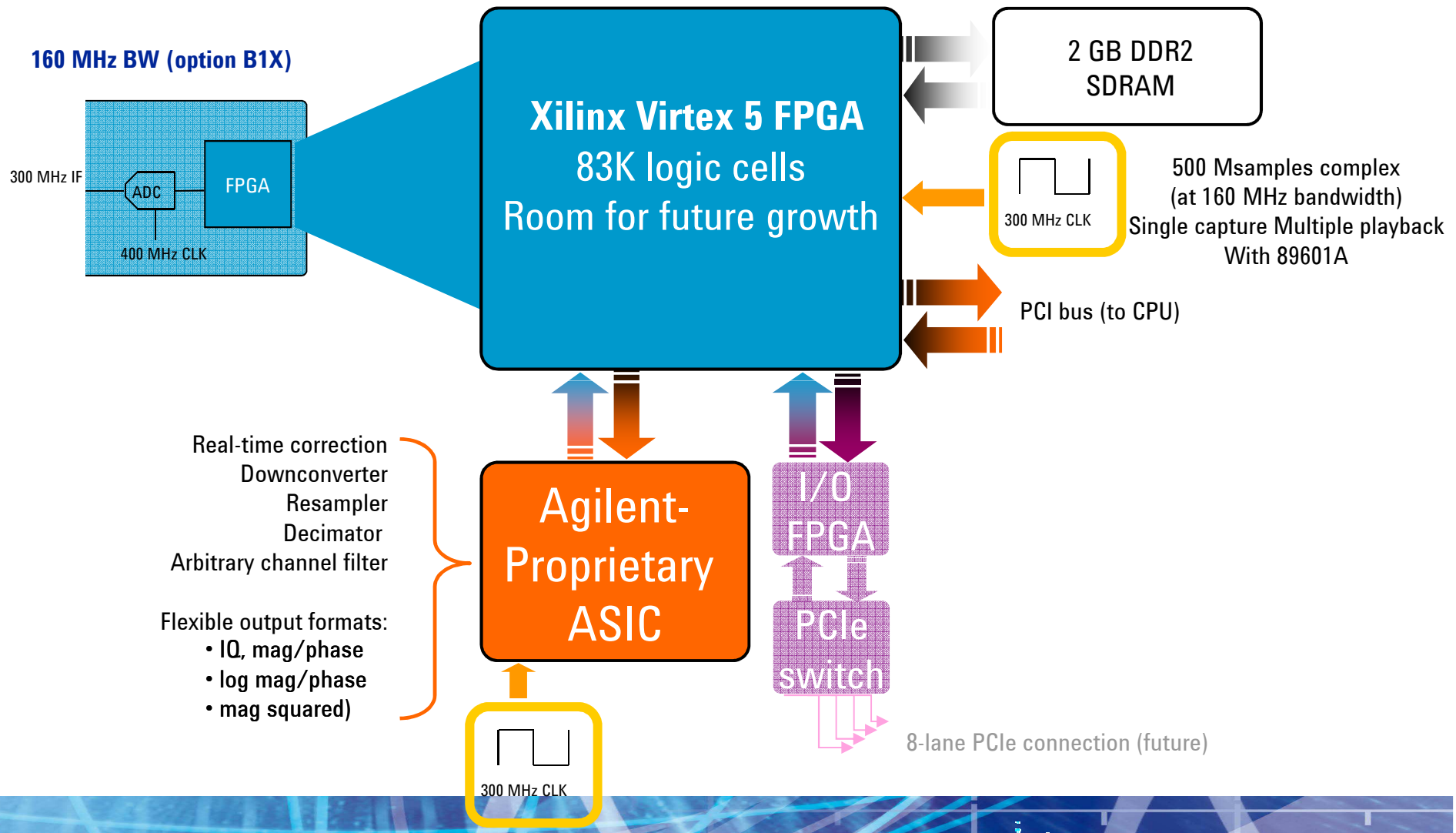
500 MSamples complex (at full bandwidth)
Single capture Multiple playback with 89601A

Real-time correction filter
Downconverter
Resampler
Decimator
Arbitrary channel filter
Flexible output formats:

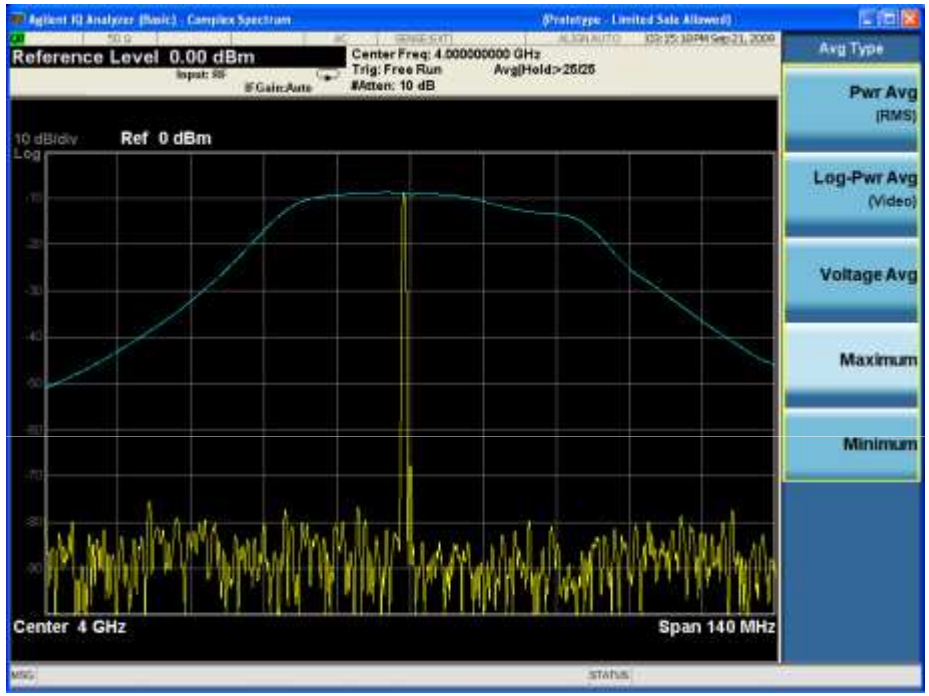
IQ, mag/phase
log mag/phase
mag squared)

Agilent Technologies

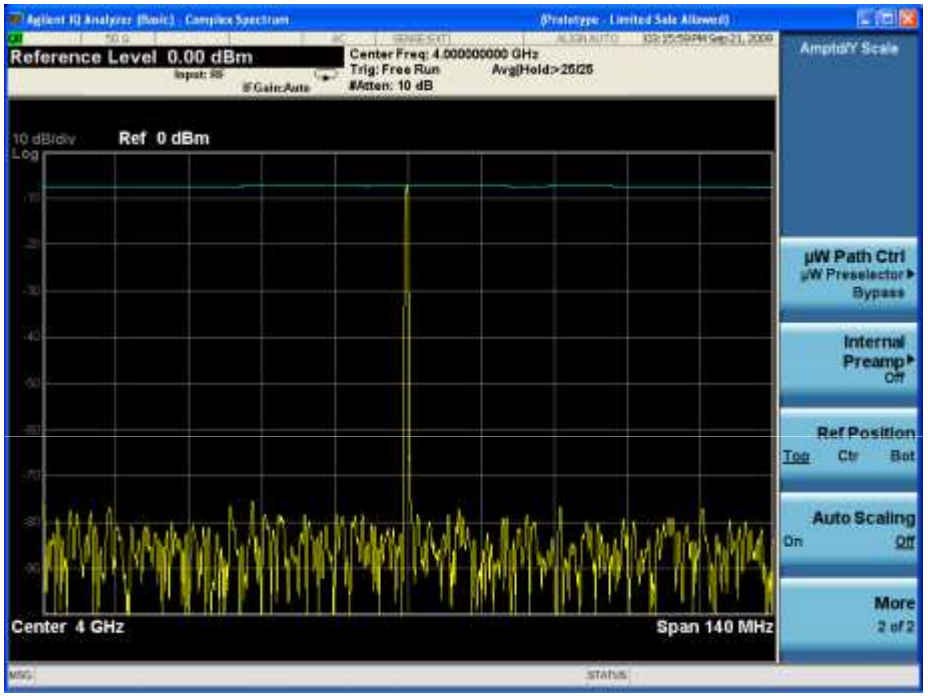
PXA 160 MHz Digital IF



µW Preselector Bypass Improves IF Flatness

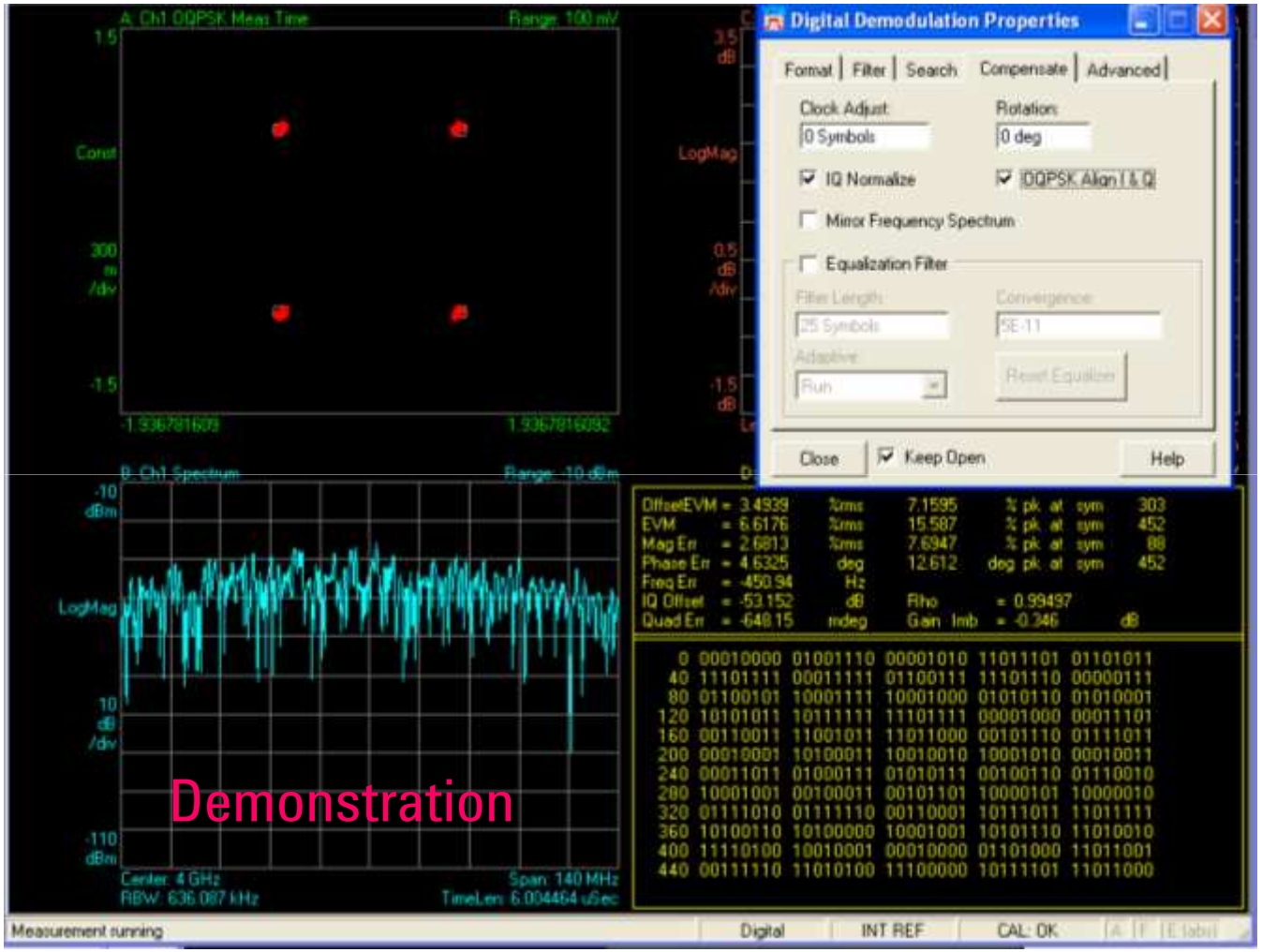


Standard Path (Shows Limited Bandwidth of YTF)



µW Preselector Bypass Path

PXA in Vector Signal Analysis Mode



Unfiltered SQPSK

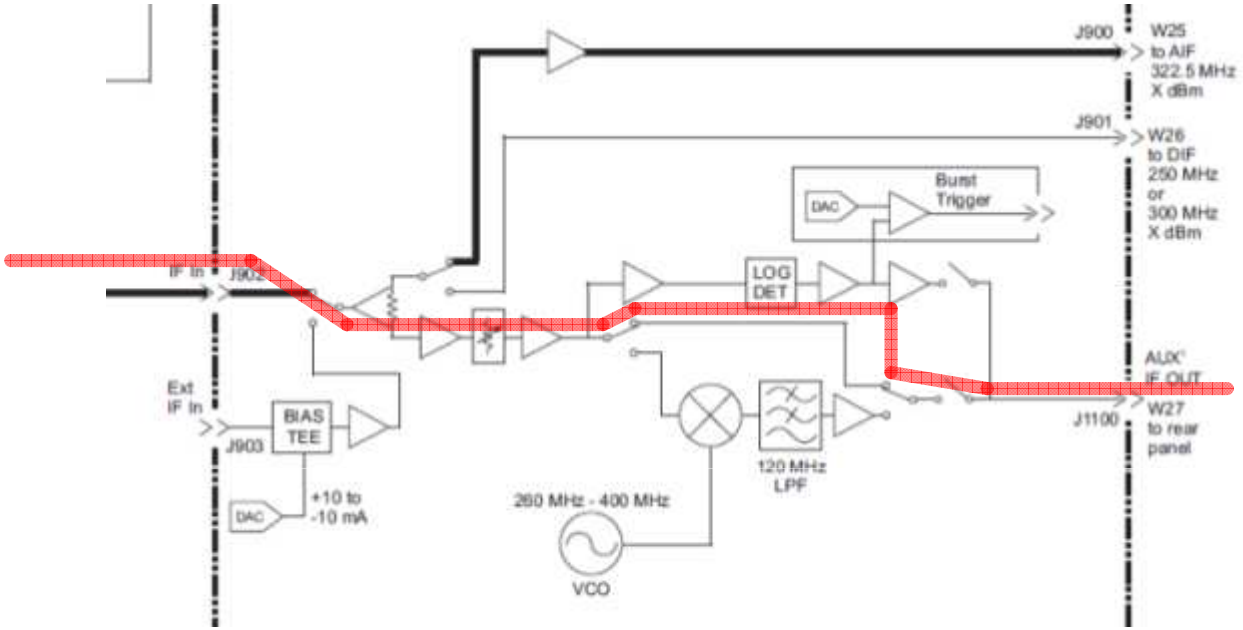
Analysis with Rectangular filter

No Equalization

160 MHz of Analysis Bandwidth

Beyond 160 MHz Analysis Bandwidth

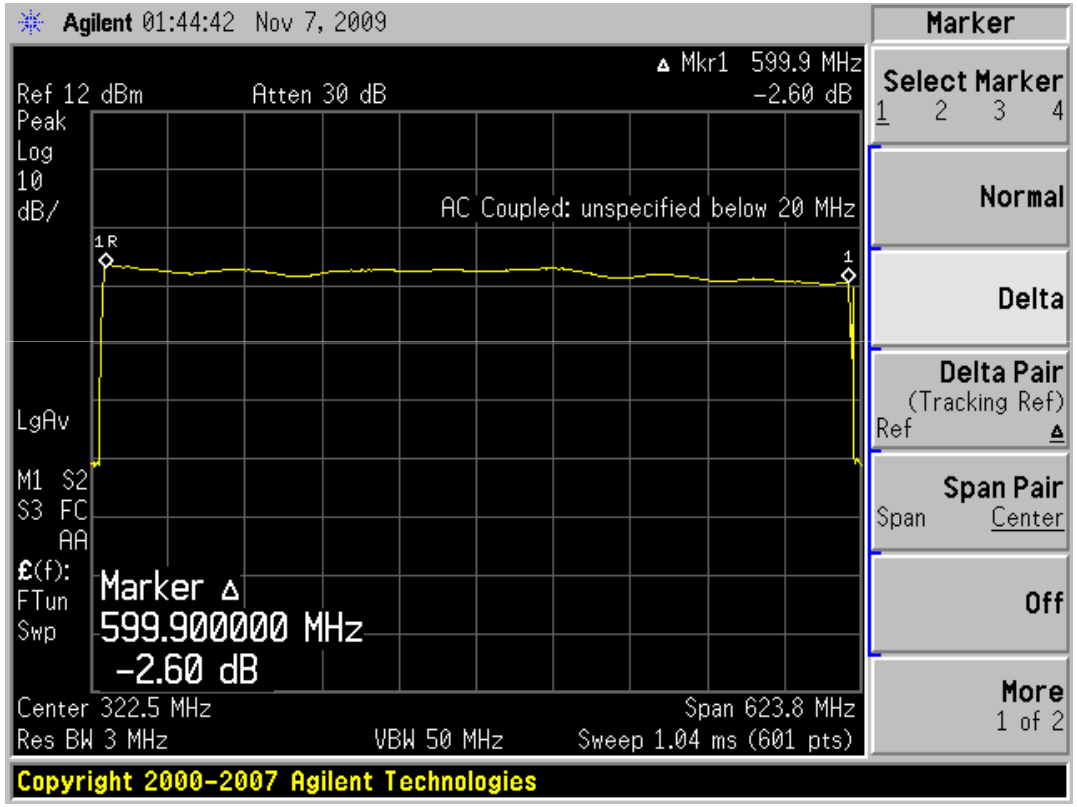
Second IF Output

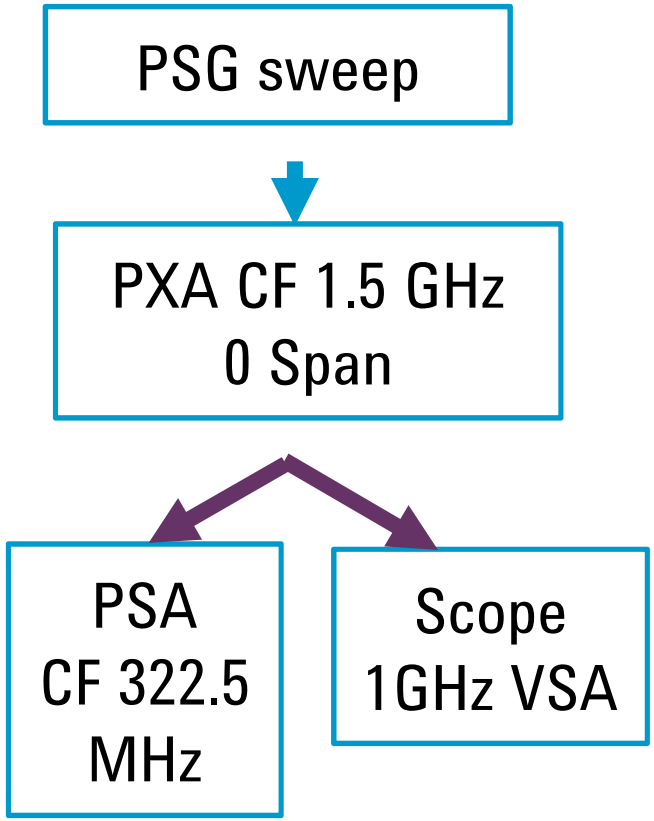


IF Path Selected	2nd IF Out Frequency
10 MHz	322.5 MHz
25 MHz	322.5 MHz
40 MHz	250 MHz
140 MHz	300 MHz

160 MHz bandwidth in low band (<3.6 GHz)

PXA Wide-Band IF Output is 900 MHz wide





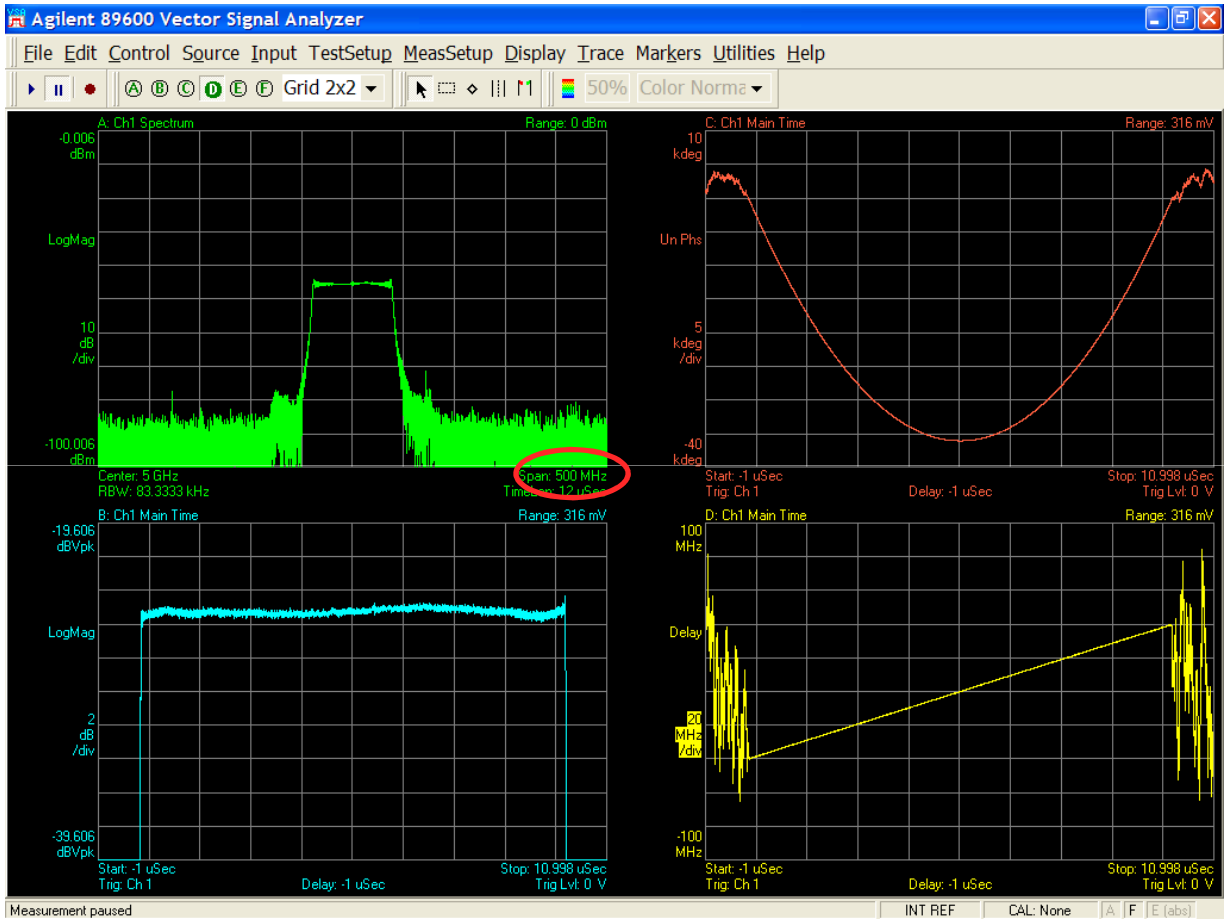
This allows for Vector Signal Analysis of signals up to 900 MHz of BW

PXA IF Output: 80 MHz linear chirp

Infiniium scope with Glacier connected to IF output.

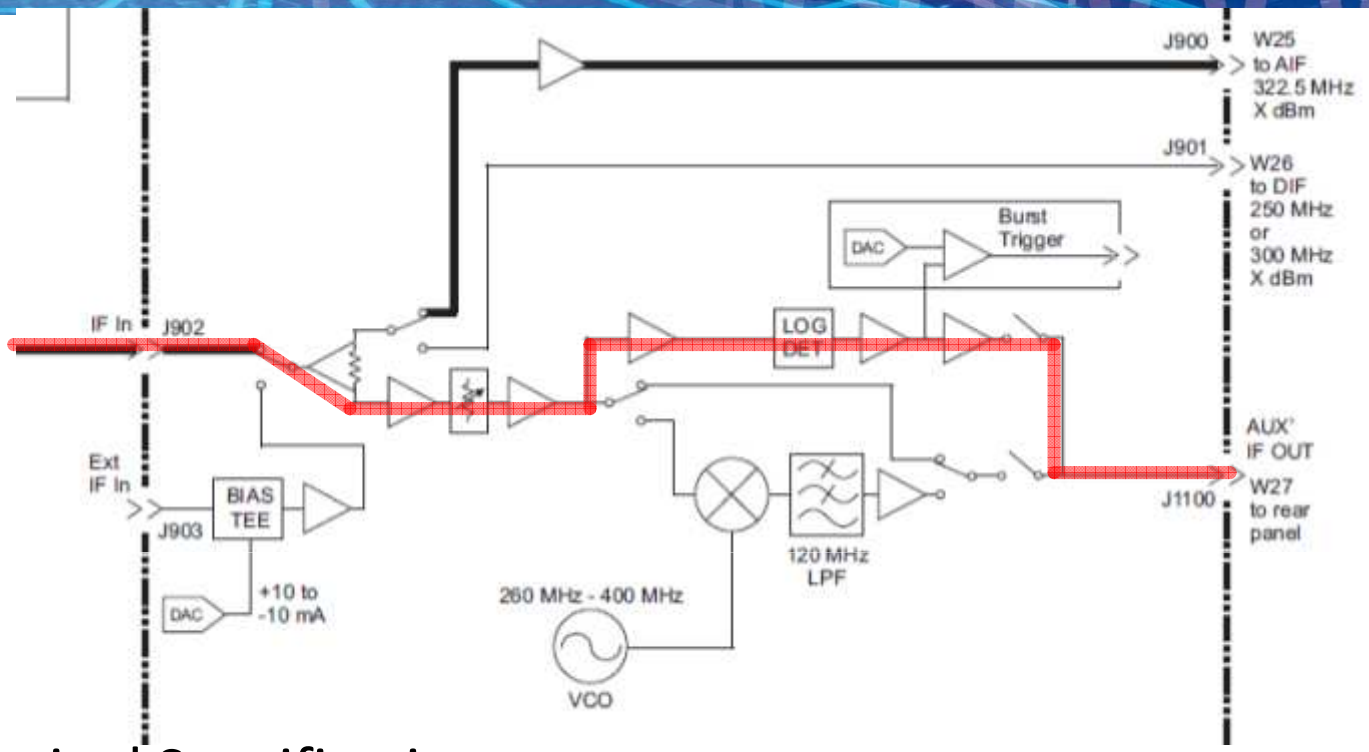
2nd IF enabled from Input/Output menu

80 MHz linear chirp from PSG internal ARB used to show bandwidth with signal tuned to center of 500 MHz span.



Agilent Technologies

Fast Log Video Output



Nominal Specifications

Full Scale Output Voltage	1.6 V (into high impedance load)
Log Video Slope	25 mV/dB (into high impedance load)
Rise Time	15 ns
Fall Time	30 ns
Dynamic Range	> 65 dB
Output Impedance	50 ohms

Video Output in Low-Band

Freq = 2.4 GHz

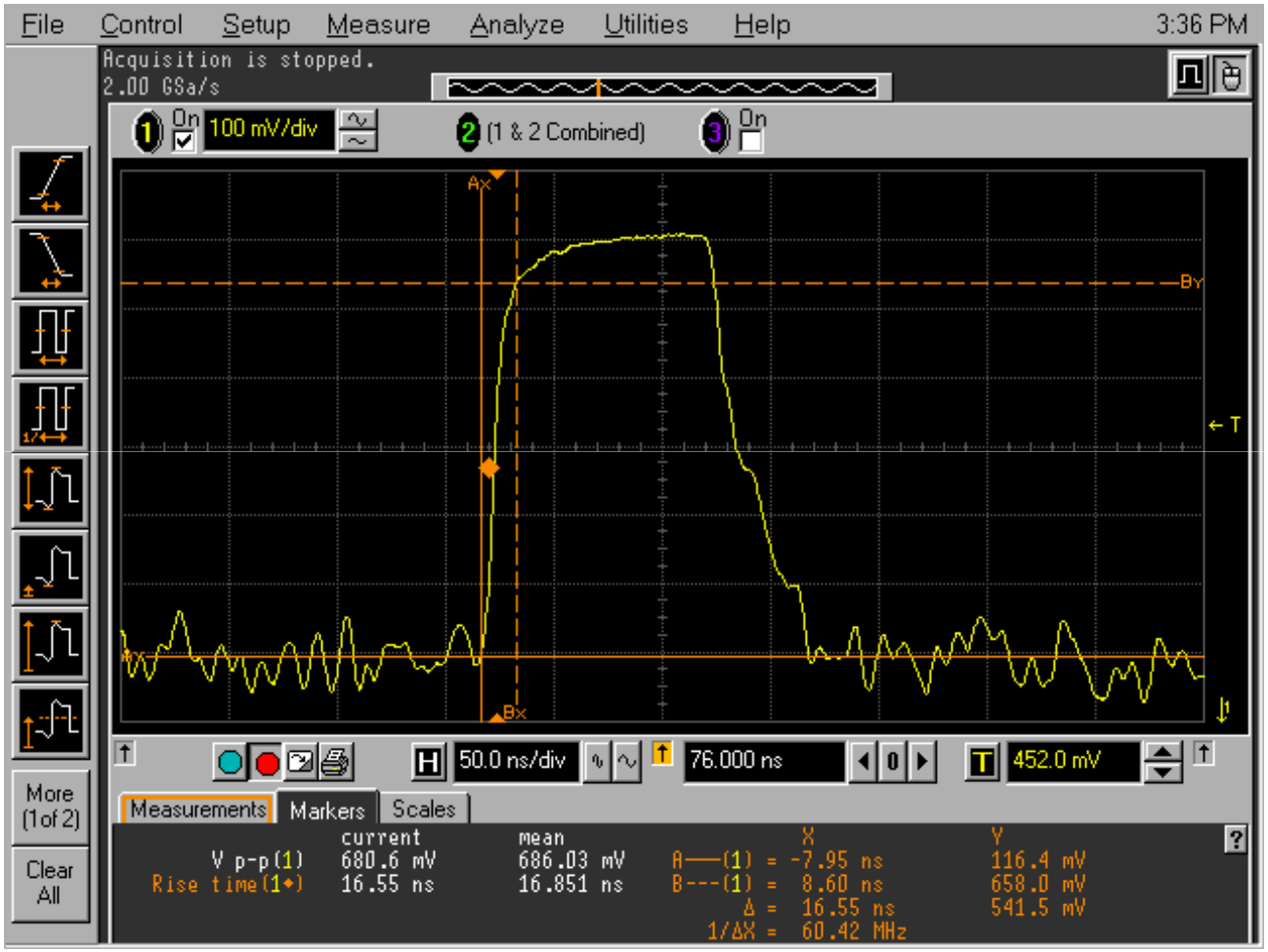
PW = 100 ns

Span = zero-span

Path = low-band

Sweep = single

Rise time = 16.55 ns



Video Output Using Preselected or Standard Path

Freq = 9.6 GHz

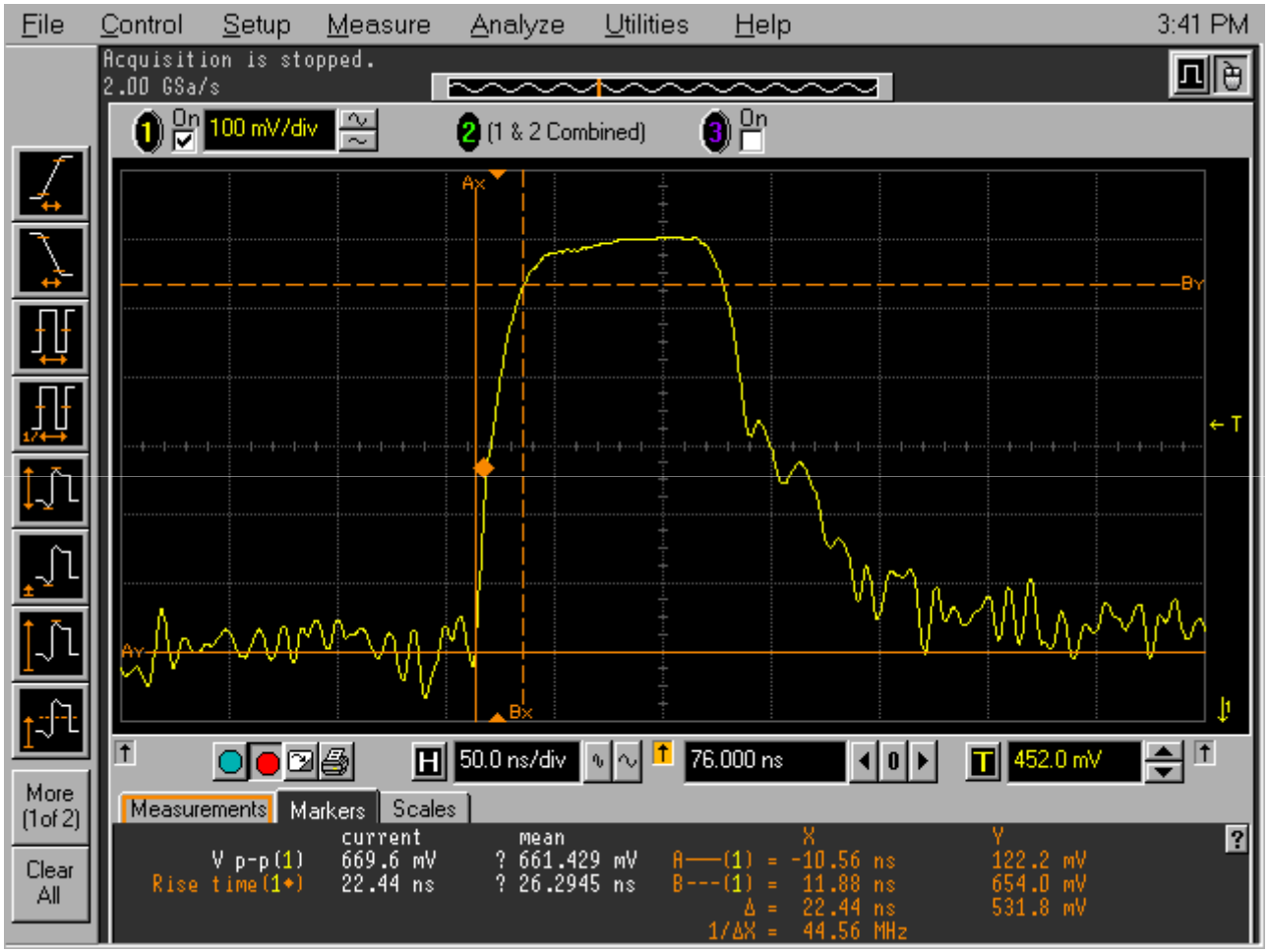
PW = 100 ns

Span = zero-span

Sweep = single

Path = STD

Rise time = 22.44 ns



Video Output Using Preselector Bypass

Freq = 9.6 GHz

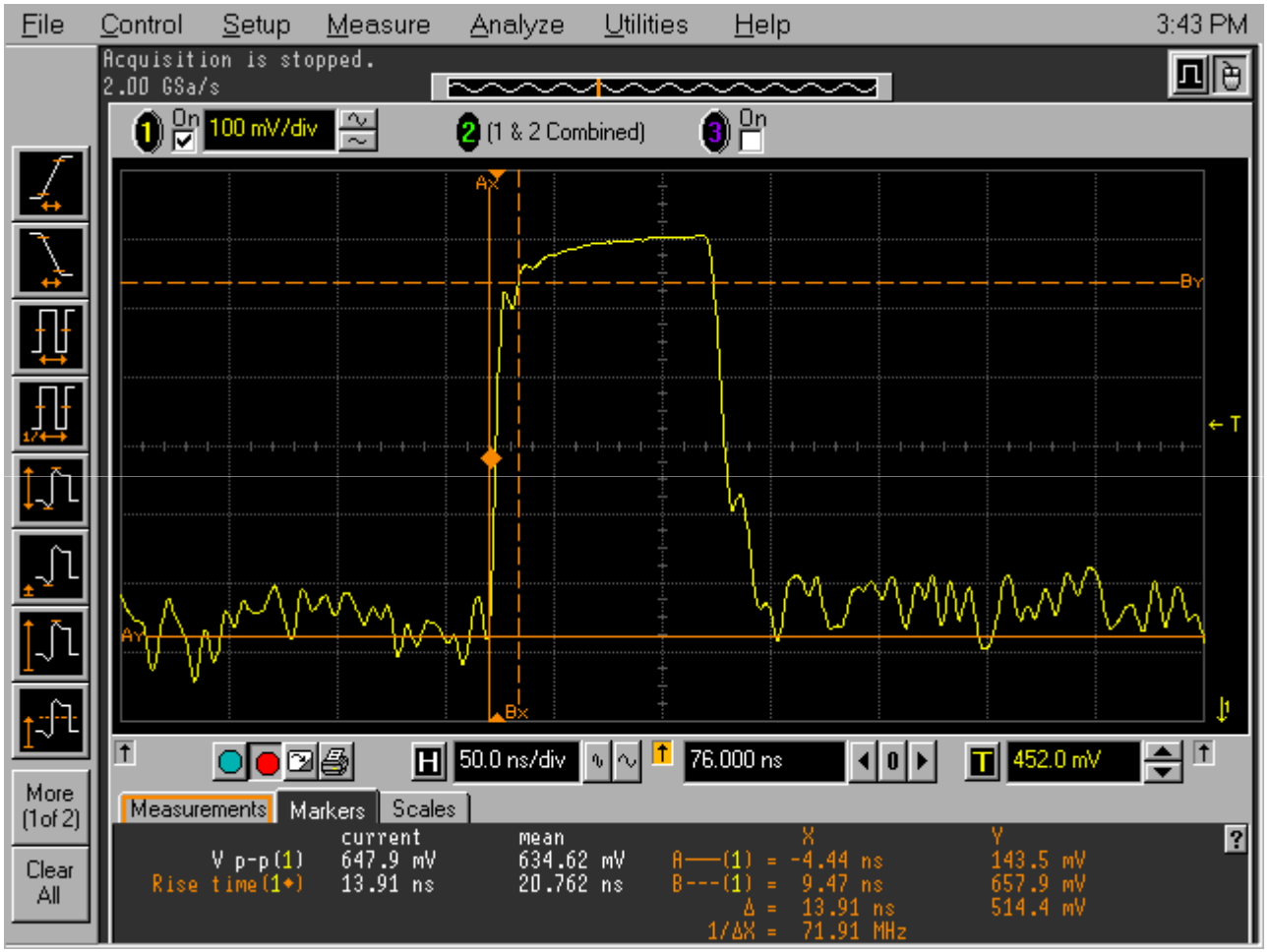
PW = 100 ns

Span = zero-span

Sweep = single

Path = Bypass

Rise time = 13.91 ns



Advancements in the PXA

160 MHz of Analysis Bandwidth

Beyond 160 MHz Analysis Bandwidth

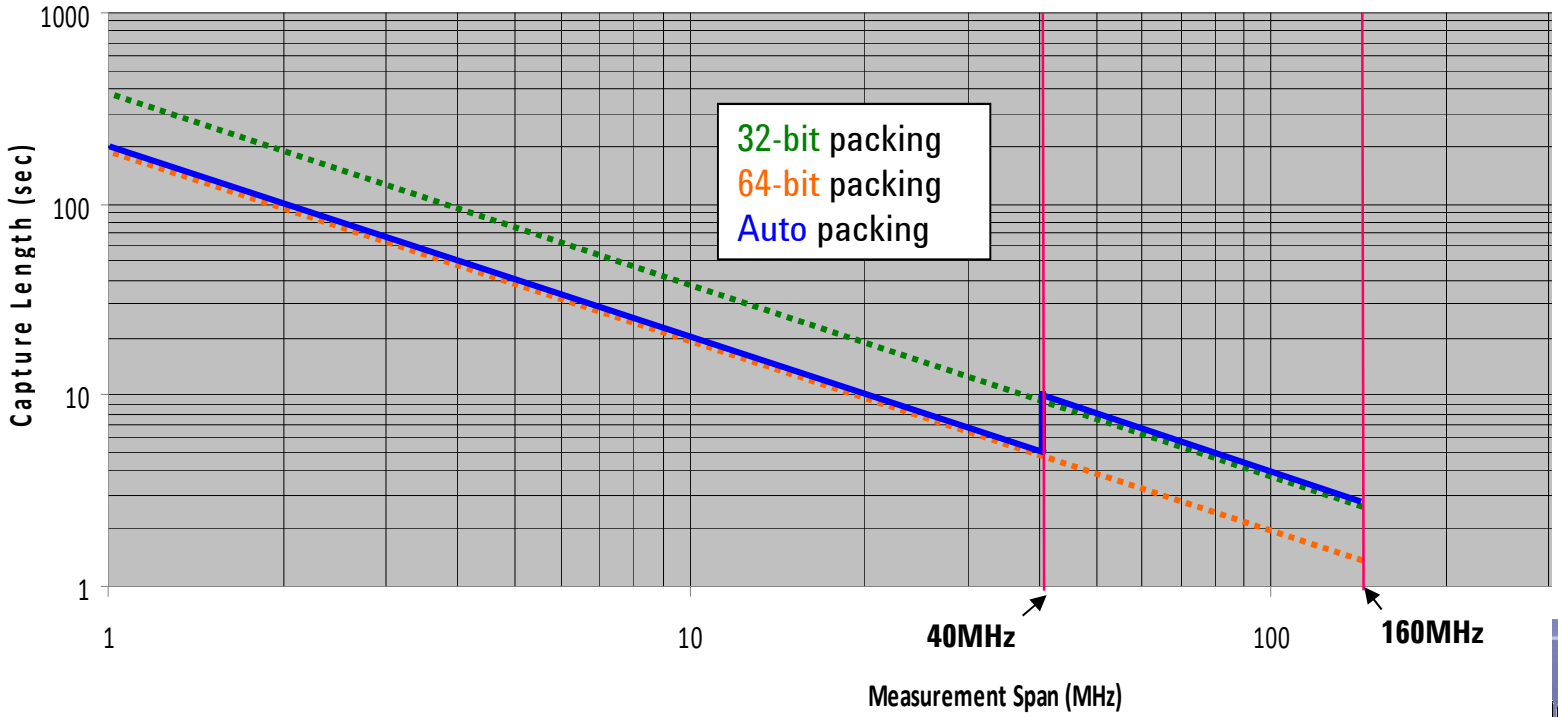
Deep Memory, Signal Capture, 32 and 64 bit packing, VSA versus VXA

PXA Wideband Recording - Key specs

• Capture RAM	2 GB
• Packing	32 & 64 bit (I+Q)
• Max capture size (complex)	500 MSa (32 bit)
• Capture time (32 bit)	40 sec **(10 MHz)** 10 sec **(40MHz)** 2.86 sec (**160 MHz)**

NOTE: The 2 GB signal capture used for this presentation took

- *<3 sec to record*
- *>30 min to store*
- *>30 min to recall*
- *>3 secs / signal ms to playback*



ologies

Modern Spectrum Analyzer Features

Built-in One-Button Power Measurements

Power Measurements

- Occupied Bandwidth
- Channel Power
- Multi-Offset ACP – fast ACP
- Multi-carrier Power
- CCDF
- Harmonic Distortion
- Burst Power
- TOI
- Spurious Emissions
- Spectral Emissions Mask

Format Setups

- GSM/EDGE
- cdma2000
- W-CDMA
- cdmaOne
- NADC/PDC
- Bluetooth
- Tetra (Ch. Pwr, ACP)
- 802.11a/b (SEM)
- HiperLAN2 (SEM)
- DVB-T
- UWB
- S-DMB

Modern Spectrum Analyzer Features

Application Focused Internal Software (one-button measurements)

General purpose applications

Flexible digital modulation analysis

Power & digital modulation measurements for wireless comms formats.

Phase noise
Ext. source control
Noise figure
Code compatibility suite
Flexible demod
W-CDMA, HSDPA, HSUPA
GSM with EDGE
Cdma2000 & 1xEV-DV
1xEV-DO
cdmaOne
NADC/PDC
TD-SCDMA

ACPR, Multi-carrier Power

Occupied Bandwidth (OBW)

Spectral Emissions Mask

Phase and Freq. (PFER)

Mod Accuracy (Rho)

Code Domain Power

ORFS (GSM/EDGE)

Spurious Emissions

Power vs Time

Channel power

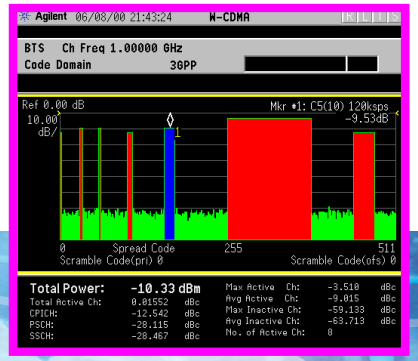
IM distortion

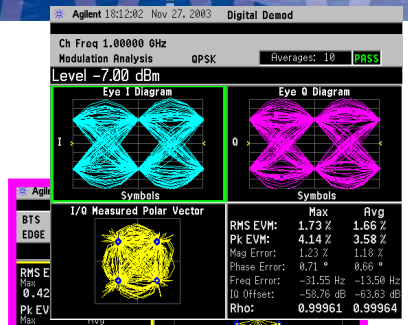
CCDF

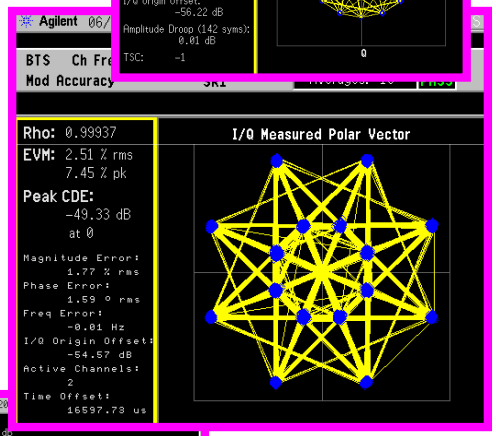
ACPR

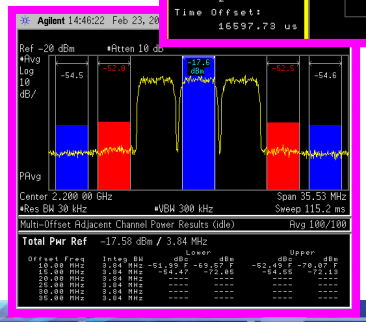
EVM

SEM





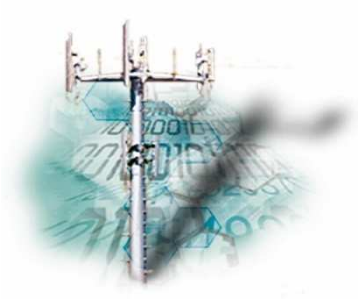




Agilent Technologies

Who needs wide analysis BW?

Modern designs demand more bandwidth for capturing high data rate signals and analyzing the quality of digitally modulated bandwidths



Aerospace and Defense

- Radar – Chirp errors & modulation quality
  Satellite – Capture 36/72 MHz BW's w/high data rates
  Military communications – Capture high data rate digital comms & measure EVM

Emerging communications

- W-LAN, 802.16 (wireless last mile), mesh networks
  - Measure EVM on broadband, high data rate signals

Cellular Communications

- W-CDMA ACPR & Multi-carrier Pre-Distortion
  - High dynamic range over 60 MHz BW to see low level 3rd order distortion for 4 carrier pre-distortion algorithms

Agilent Technologies

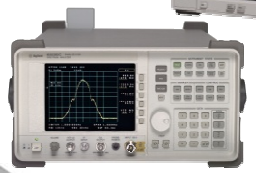
Signal Analysis Portfolio.

Agilent Technologies

Agilent Signal Analysis Portfolio

Code Compatible with 856x

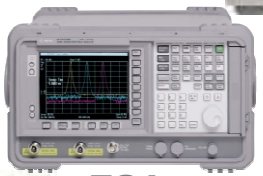
PXA
X-Series Premium Performance
3 Hz to 50 GHz
160 MHz BW



PSA
Market leading performance
3 Hz to 50 GHz
80 MHz BW

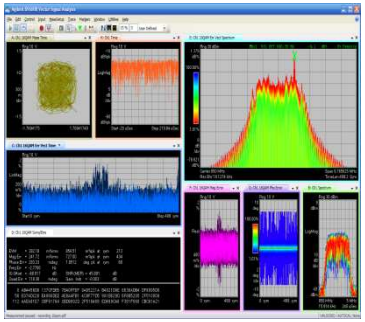
8560EC
Super mid-performance
10 MHz BW

MXA
X-Series
mid performance
10 Hz to 26 GHz
40 MHz BW



EXA
X-Series
economy class
10Hz to 44 GHz
25 or 40 MHz BW

ESA
World's most popular
100 Hz to 26 GHz
10 MHz BW



89601B VSA Software
World's best analysis

Price

N9340B/44C
Hand held

CXA
Low cost portable
9kHz to 26.5 GHz
25 MHz BW

N9320B /N9322C
Basic Bench

Performance

Agilent Technologies

Agilent X-Series Signal Analyzers

Drive your evolution

N9030A PXA

Intro Sept 2009

Accelerate to market

N9020A MXA

Intro Sept 2006

Maximize throughput

N9010A EXA

Intro Sept 2007

Expect more

N9000A CXA

Intro Sept 2009

Future-ready
test instruments

Consistent framework

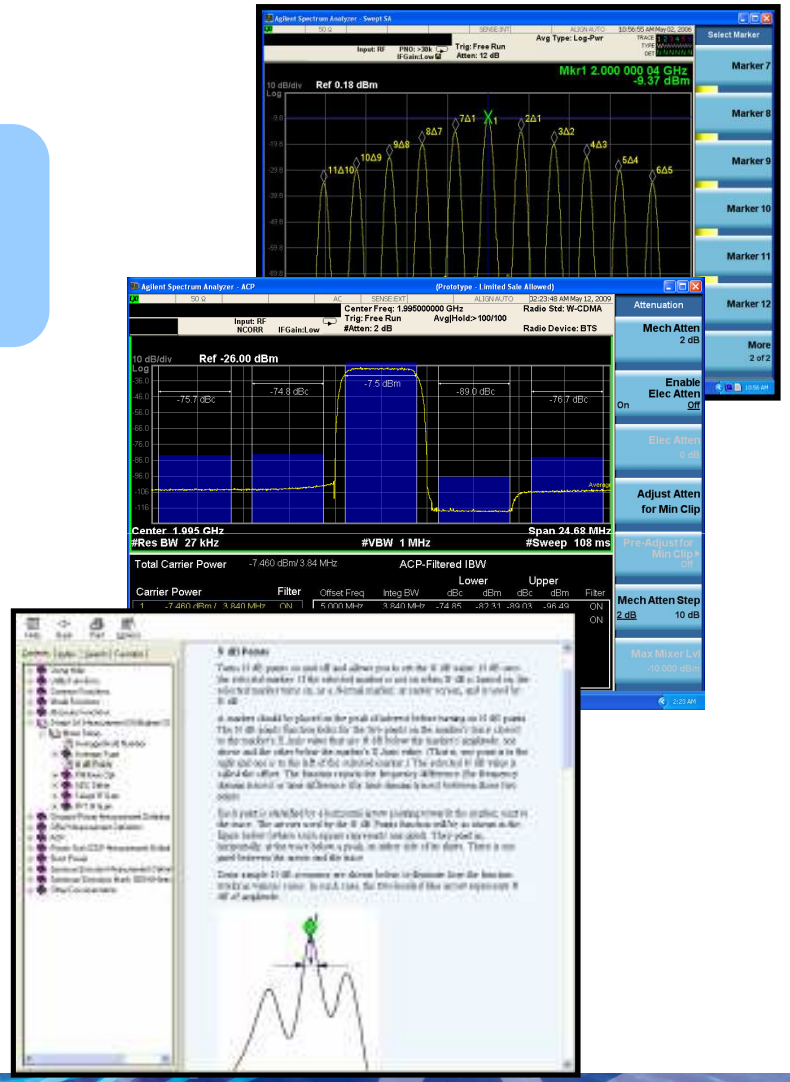
Broadest set of applications

Agilent Technologies

SA User Interface

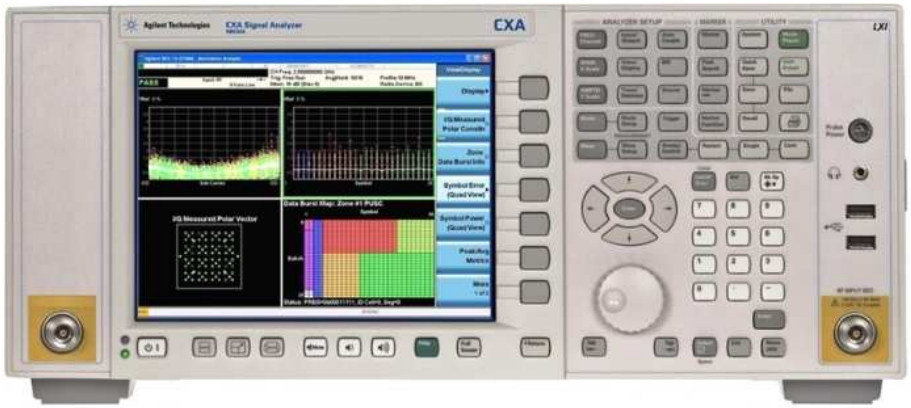
- PowerSuite – TOI, harmonic distortion, spurious emissions, ACPR, channel power, etc.
- Band power markers, limit lines, amplitude correction

- Easy signal setup with *Auto Tune*
- Comprehensive *context-sensitive Help*
- Preset, standards-based, 1-button power measurements (*PowerSuite*)
- *12* flexible markers and *6* trace displays
- *40,001* maximum trace points
- *Advanced trace math* to display calculated trace results



The Agilent N9000A CXA signal analyzer

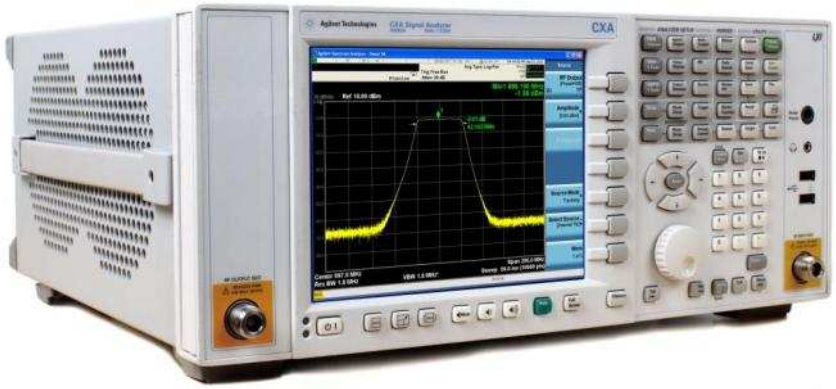
The ***lowest cost*** member of X-series Signal Analyzers that offers superior RF performance, X-Series measurement speed, and a rich suite of general purpose applications truly at a budget point.



- ✓ Save cost, speed up tests
- ✓ Scalable, reconfigurable
- ✓ Measurement applications
- ✓ Vector Signal Analysis & Matlab
- ✓ Ease of use, code compatibility

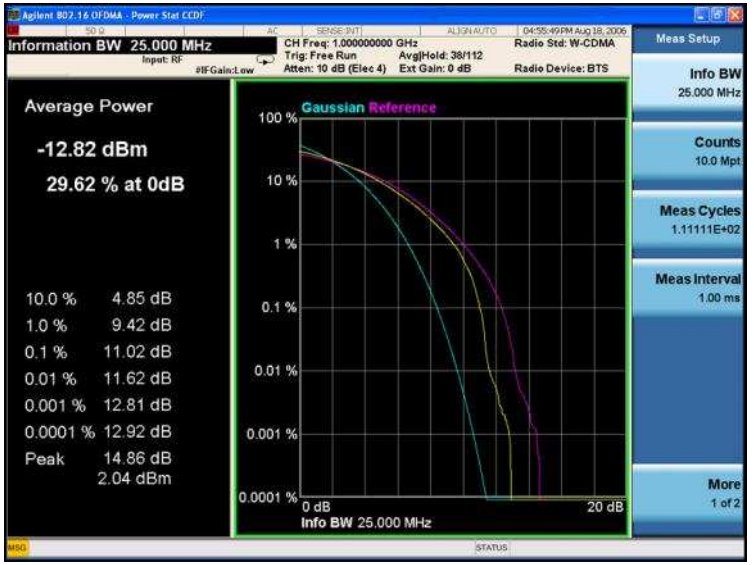
Tracking Generator (N9000A-T03/T06)

- N9000A-T03, Tracking generator, 9 kHz to 3 GHz
- N9000A-T06, Tracking generator, 9 kHz to 6 GHz
- Offers a fast and cost-effective solution for scalar network analysis
- –50 to 0 dBm power sweep range with 0.1 dB resolution
- 50 ms full span sweep time
- 100 dB dynamic range, nominal



25 MHz Analysis Bandwidth (N9000A-B25)

- N9000A-B25, Analysis bandwidth, 25 MHz
- License upgradable
- Enables modulation analysis for all profiles of mobile WiMAX™ and WLAN
- Provides CCDF measurement of signals over 10 MHz bandwidth or multi-carrier signals



- Functions with 89600 VSA software for vector analysis up to 25 MHz analysis bandwidth
- Functions with W9064A VXA vector signal and WLAN modulation analysis measurement application for vector analysis up to 25 MHz analysis bandwidth

X-Series Analyzers – Pick your level of performance!

Shared attributes:

EXA

Economy class analyzer

ESA replacement

Eliminate the compromise between speed and price

FAST signal analysis measurements – up to 300% faster than other analyzers

50+ demodulation capabilities

<u>Only</u> open Windows user interface

Most connectivity options

Test code re-use

MXA

Mid Range analyzer

856x replacement

Eliminate the compromise between performance and speed

Option B40

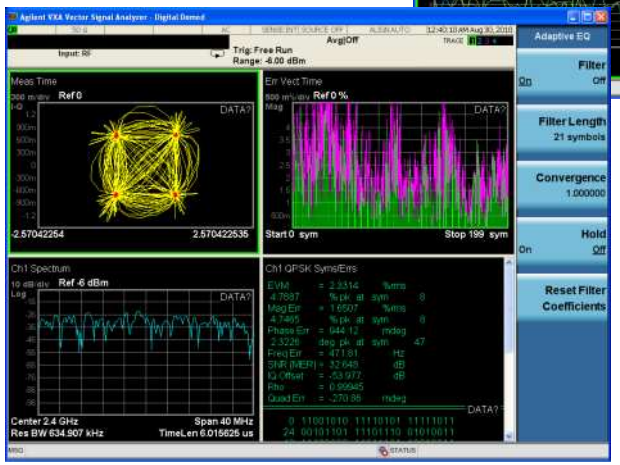
40 MHz analysis bandwidth

- 40 MHz wideband analysis
- 200 M-Samples/sec, 12 bit ADC
- 2 GB capture memory (RAM)
- Supports 40 MHz bandwidth CCDF, burst power, IQ waveform, QPSK EVM measurements
- Supports 802.16e OFDMA measurement application
- Functions with 89600 VSA software and N9064A VXA application for signal analysis up to 40 MHz bandwidth
- Option code

  N9020A-B40
  N9010A-B40

40 MHz BW CCDF measurement

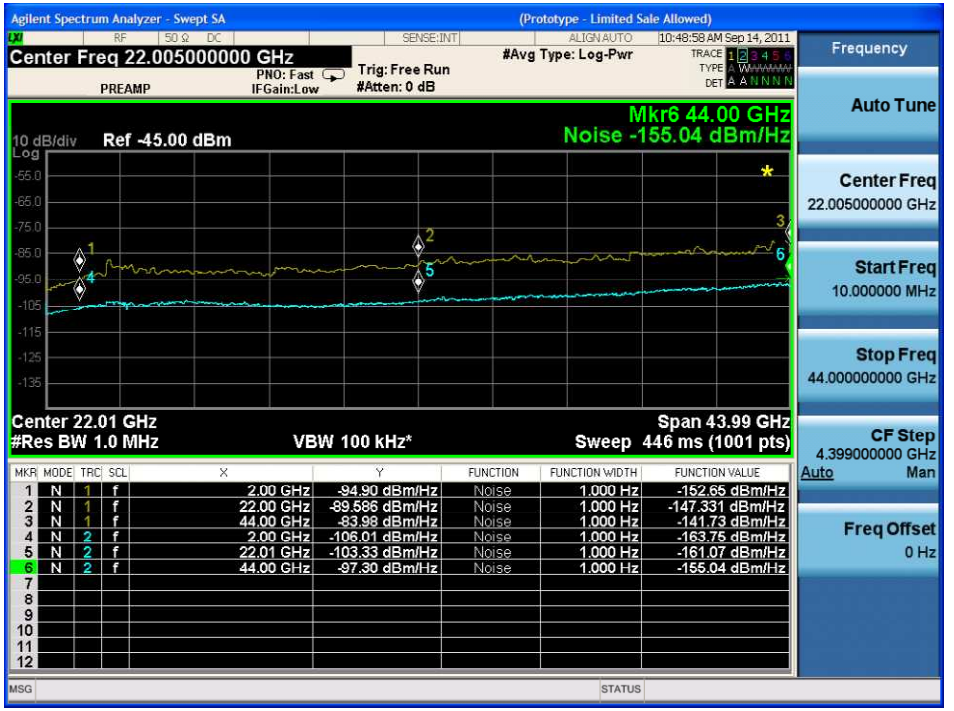
40 MHz IQ waveform measurement



40 MHz BW QPSK EVM

mmW EXA: Competitive sensitivity in-class

- Preamp up to 44 GHz
- DANL shown on screenshot
  - Preamp off:
    - <-152 dBm/Hz @ 2 GHz
    - <-141 dBm/Hz @ 44 GHz
  - Preamp on:
    - <-163 dBm/Hz @ 2 GHz
    - <-155 dBm/Hz @ 44 GHz



- Help your spur search
- Reveal the smallest mmW signals

MXA and PXA Signal Analyzers
Analog Baseband IQ Inputs

Key Features

- 50+ demodulation formats supported with 89601B
- 2 channel independent vector analysis with 89601B
- Scalable baseband bandwidth 10/25/40 MHz
- 512 MSa baseband capture memory standard
- Active and Passive probe support (via Infiniium scope/ InfiniiMax probes)
- 16 bit ADC across full bandwidth

ALL MXAs and PXAs are upgradeable

External Source Control (N9000A-ESC)

- N9000A-ESC, External source control
- Providing external source control to the following sources:
  - MXG, EXG, PSG
- Connection between CXA/EXA/MXA and signal source (Local/system)
  - LAN, or
  - USB, or
  - GPIB
- Sweep modes
  - Standard sweep (For filter test)
  - Harmonic sweep (For amplifier test)
  - Offset/Reverse sweep (For mixer test)
  - Power sweep (For amplifier test)
- Simple port match return loss measurements
  - Open/Short CAL

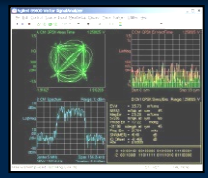
Applications on EXA - MXA

Broad Application Coverage for our Signal Analyzers

X series application

New X series application

89600 Software



Wireless

- MSR
- LTE MIMO
- TD-LTE
- HSPA/HSPA+
- WCDMA SACM
- GSM SACM
- FD-LTE
- TD-SCDMA
- W-CDMA
- EDGE EVO
- 1xEVDO
- CDMA 2000
- GSM/EDGE GPRS/EGPRS

Wireless Connectivity

- Bluetooth
- 802.16d WiMAX
- 802.16e OFDMA MIMO
- 802.16e OFDMA
- 802.11a/b/g WLAN

Audio/ Video

- CMMB
- ISDB-T
- DVB T/H
- AM/FM

Parametric

- Pulse
- Noise Figure
- Phase Noise

Flex Demod

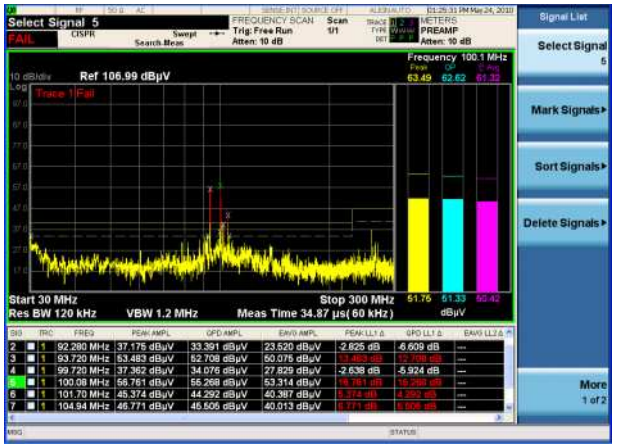
- 256 QAM
- QPSK

- APCO 25
- 802.11n (MIMO)
- RFID
- 802.11n
- UWB DS
- ISDVB
- 802.15 UWB
- Zigbee
- 802.11ac

- CATV
- NADC
- PDC
- PHS
- DECT
- TETRA
- HPD SAM
- 1xEV-DV
- Tetra
- LTE advanced
- MSR

EMC Measurement Application -
N6141A/W6141A

- ✓ Measure designs to the latest CISPR 16-1-1 or MIL-STD requirements
- ✓ Perform precompliance conducted and radiated emissions tests
- ✓ Multiple detectors - peak, quasi-peak, EMI average and RMS average
- ✓ Easily identify out-of-limit device emissions and maximize signals to compare against regulatory requirements
  - o Signal list, frequency scan and active detector meters are displayed on a single screen
- ✓ View signals over time using the strip chart
- ✓ Global center frequency support in SA, EMC and analog demodulation modes
- ✓ Tune and listen to signals in the frequency scan list
- ✓ Available for P/M/E/CXA



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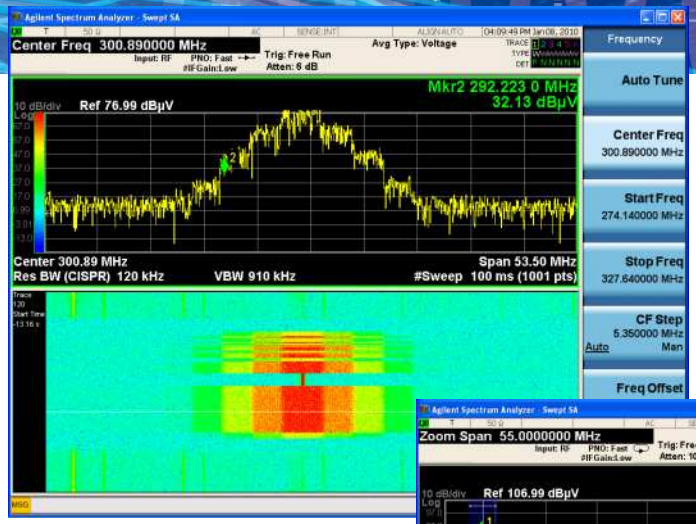
Application Example:
DVB-T/H/T2 Measurement Application - N6153A/W6153A

- ✓ Supports DVB-T, DVB-H and DVB-T2[1] standards
- ✓ One-button transmitter measurements :
  - o **Power measurement:** channel power, shoulder attenuation, ACP, CCDF, SEM plus more
  - o **Modulation accuracy:** TPS decoding**,** MER/EVM, BER, frequency error, amplitude error, phase error plus more
  - o Channel frequency and impulse response
  - o Auto detection or manual settings of DVB-T, DVB-H or DVB-T2 signal
- ✓Analog baseband analysis with MXA BBA option
- ✓ Available for P/M/E/CXA

Option EDP - Enhanced Display Package

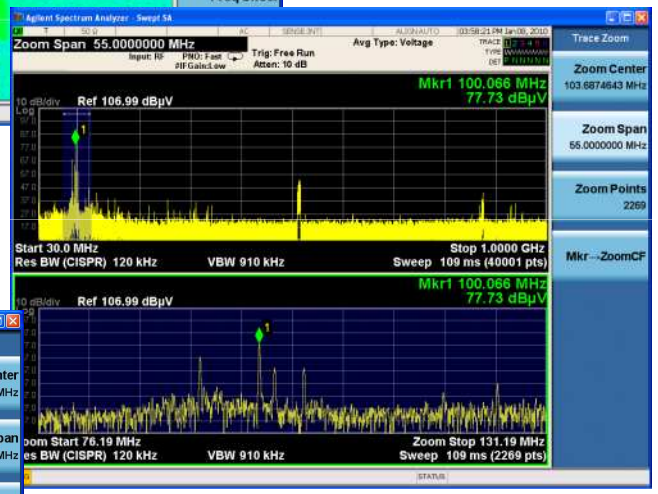
- Newly added general purpose feature for P/M/E/CXA
- Includes spectrogram, trace zoom, zone span
- Highly recommended to order with N/W6141A EMI precompliance measurement application

Option code: N90x0A-EDP



Spectrogram

Great for finding intermittent signals

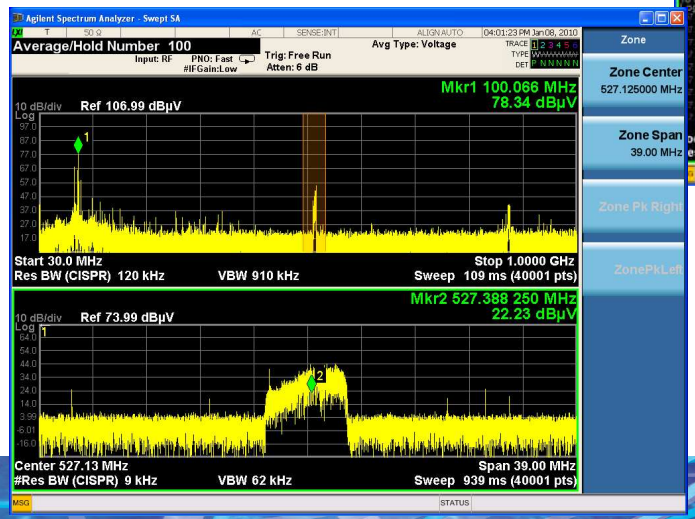


Trace zoom

Same trace in both screens but bottom screen shows "close up" view with fewer points

Zone span

•Two different sweeps in the two windows
•Take the top window as reference, the bottom window can have different settings, can even go to zero-span



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Agilent Technologies PXA Signal Analyzer N9030A

A Breakthrough in…

- ***Performance***
- ***Capability***
- ***Flexibility***

While optimizing…

- ***"Backwards" Compatibility***

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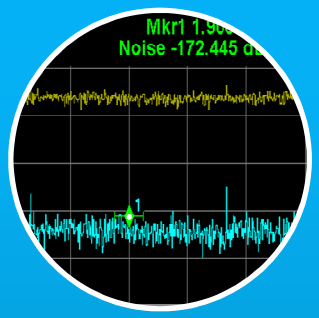
Page 128

PXA Performance…

More margin, more confidence…

See More in Less Time

- Up to 75 dB spurious-free dynamic range at 160 MHz bandwidth
- 30 to 70% test time reduction vs. legacy analyzers



Reduce Measurement Uncertainty

- ±0.19 dB accuracy
- DANL = -172 dBm w/ preamp and NFE
- Close in phase noise -128 dBc/Hz

almost kTB!

PXA Signal Analyzer

Performance that maximizes signal insight

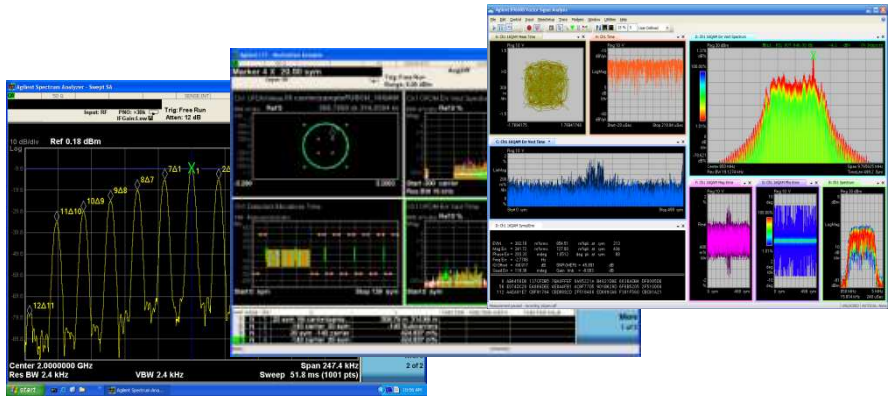
Principal Specifications	Conditions	PSA Spectrum Analyzer	PXA Signal Analyzer
Frequency range		3 Hz to 6.7/13.2/26.5/43/44/50 GHz	3 Hz to 3.6/8.4/13.6/26.5/43/44/50 GHz
TOI	2 GHz 12 GHz 50 GHz	+18 dBm +12 dBm +12.5 dBm (nom)	+21 dBm +15 dBm +13 dBm (nom)
DANL*	2 GHz 12 GHz 50 GHz	-152 dBm -146 dBm -127 dBm	NFE**` / LNP** / w/o NFE -160 / — / -153 -155 / -155 / -149 6 dB improvement / -138 / -130
Φ Noise, 50 GHz (nom)	10 kHz offset 1 MHz offset	-100 dBc/Hz -130 dBc/Hz	-110 dBc/Hz -129 dBc/Hz
Analysis BW		10, 40, 80 MHz	10, 25, 40,160 MHz
Speed rating		★★	★★★★★

* 1 Hz RBW, Preamp is off ** NFE = Noise Floor Extension technology; LNP = low noise path

PXA Signal Analyzer Applications

Applications

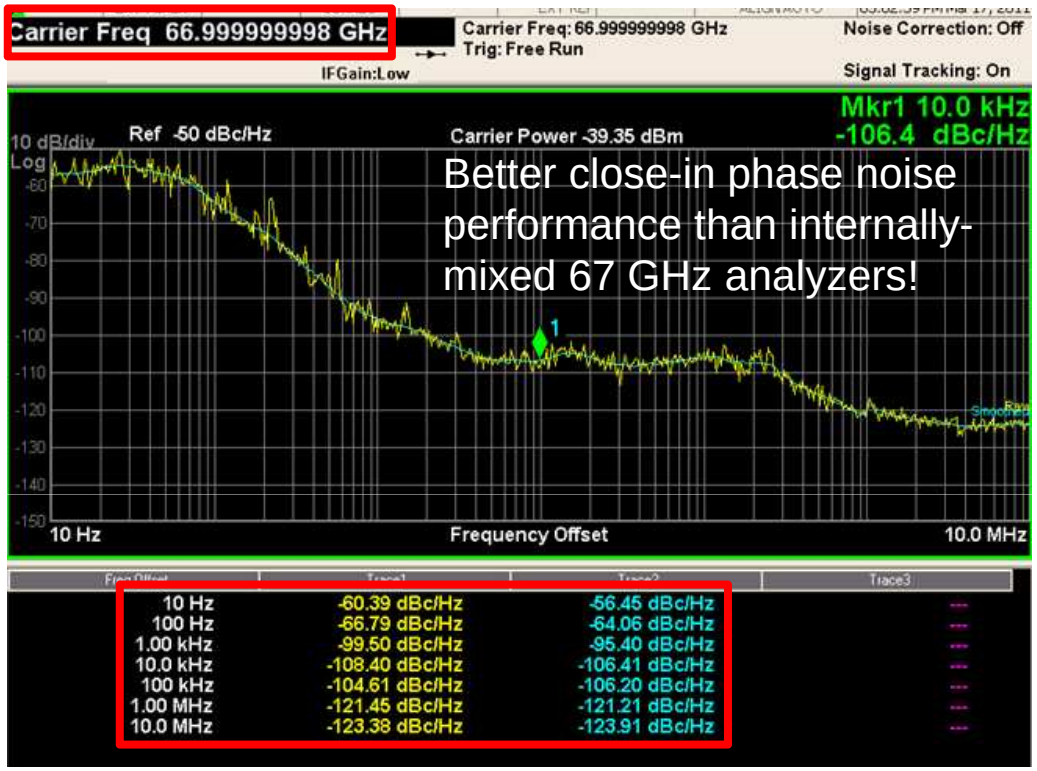
- Spectrum analyzer with PowerSuite
- IQ Analyzer (included)
- LTE FDD, TDD
- W-CDMA/HSPA/HSPA+
- cdma2000®, 1xEV-DO
- GSM/EDGE/EDGE Evolution
- TD-SCDMA/HSPA
- Mobile WiMAX™, *Bluetooth*®
- DVB-T/H/C/T2, ISDB-T/Tmm, DTMB, CMMB
- Noise Figure, Phase Noise, Analog Demod
- 89600B VSA SW, VXA (Flex Demod)
- Pulse measurement software
- MATLAB
- EMC Pre-Compliance (Option EMC)



Legacy system migration

- Instrument code compatible with PSA /856XEC/8566/68B
- Instrument code compatible with R&S FSP, FSU, FSE
- Application code-compatible with PSA, ESA and across X-Series
- Algorithm reuse gives consistent measurement results

Extend Unmatched Performance WITH EXTERNAL MIXING



Extend to 325 GHz and beyond

- Supported measurements
  - Spectrum analysis
  - PowerSuite one-button power measurements
  - N9068A phase noise measurement application
- Supported external mixers
  - M1970V and M1970W
  - 11970 Series
  - OML Inc.
  - And other third-party external mixers

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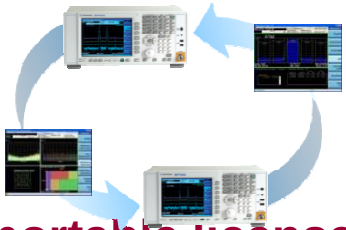
PXA Signal Analyzer - N9030A

X-Series Analyzers (PXA,MXA,EXA)

The Only Signal Analyzers with:

- **Upgradeable CPU/HD module**

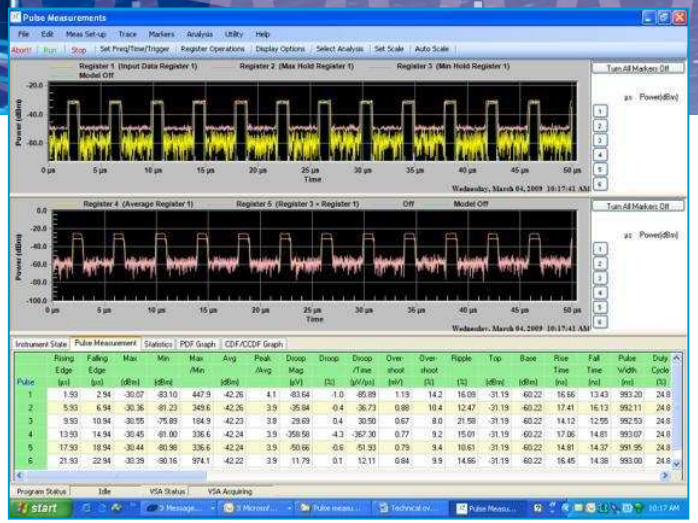
- **Trial Licenses**



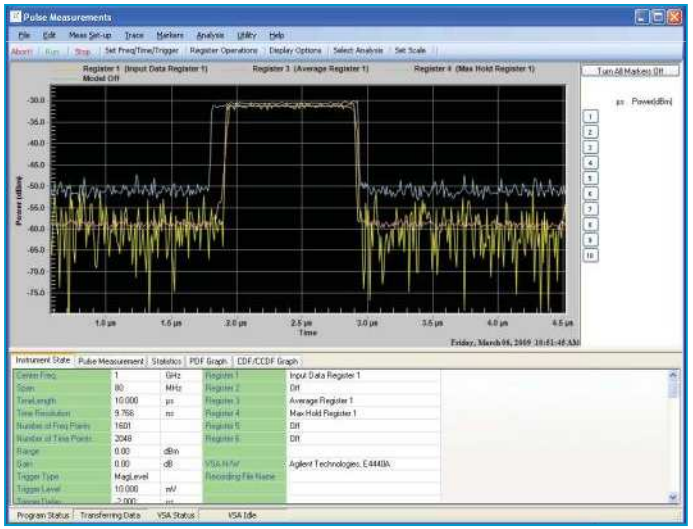
- **Transportable licenses**

- You can upgrade your PC capability as:
  - Commercial processor technology evolves
  - Evolution of I/O connectivity/speed
  - Stay current with CPU upgrade vs. new instrument purchase
  - “great for programs where you cannot trade-in”
- Don’t have to wait for a demo unit, get 14 day trial on your own instrument
- Cover out of service periods (calibration) - simply install trial license on another instrument to cover application test needs
- Transportable applications means you are able to manage X-Series applications like you manage HW. Ability to move applications from an EXA to MXA to PXA across lab or around the globe.

Pulse Measurement Software N9051A



- ✓ Analyze the parameters of up to 1000 continuous pulses.
- ✓ Pulse analysis measurements:
  - o Period, width, PRI/PRF, droop, overshoot, rise/fall time, average power, peak power, PDF, CDF, CCDF plus more
- ✓ Zoom feature for closer analysis of signal
- ✓ Markers for absolute and relative measurements
- ✓ Supports X-Series analyzers, PSA spectrum analyzer and Infiniium oscilloscopes
- ✓ Software can be directly loaded into the X-Series analyzers and Infiniium series oscilloscopes or loaded on external PC
- ✓ Phase and Frequency Measurements (3FP)
  - o Pulse to pulse change in phase
  - o Phase mean and standard deviation
  - o Chirp (start frequency, stop frequency, center frequency , bandwidth)
  - o Pulse compression ratio, peak sidelobe level
- ✓ Extended Analysis and statistics (4FP)
  - o Mean, max, min, standard deviation, RMS, trend and autocorrelation of the data selected
  - o Filter data based on relation to mean
  - o Plot of individual data values
  - o Histogram of data values



www.agilent.com/find/N9051A

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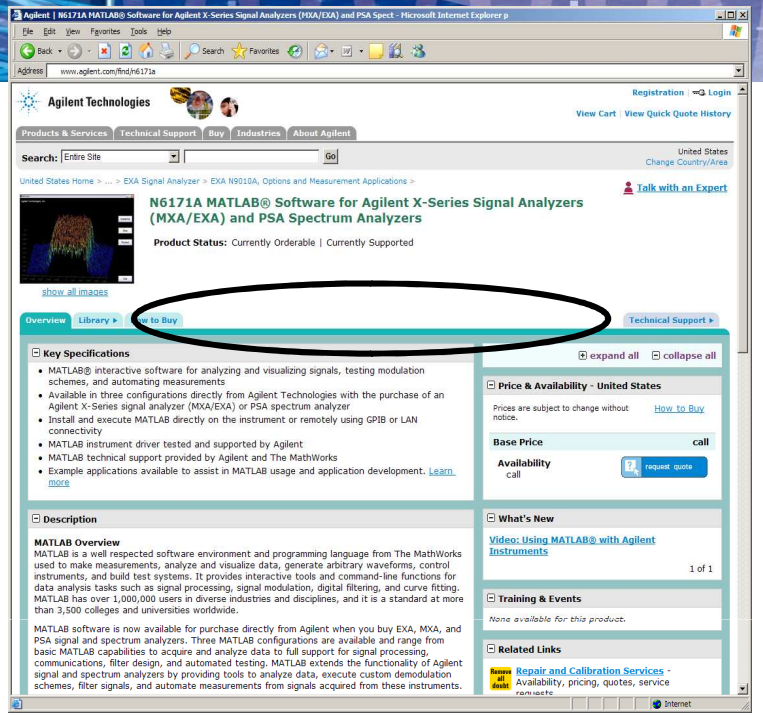
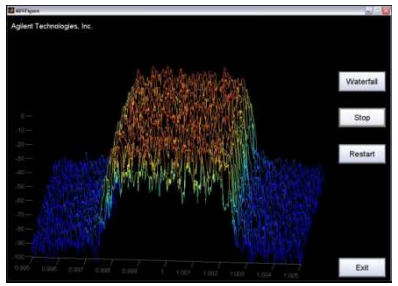
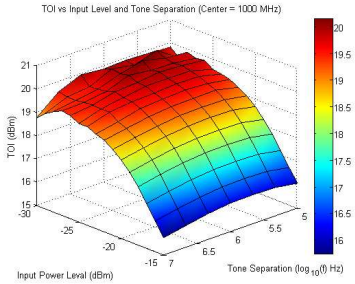
N6171A

- MATLAB software can now be purchased directly from Agilent with the purchase of EXA, MXA, and PSA signal analyzers.
- Three MATLAB packages available
- **Key uses**
  1. Create, modify, and execute your own X-series applications
  2. Automate measurements
  3. Execute and test custom modulation schemes
  4. Analyze, filter, and visualize data
  5. Configuration and control instruments
  6. Generate arbitrary waveforms
  7. Build test systems



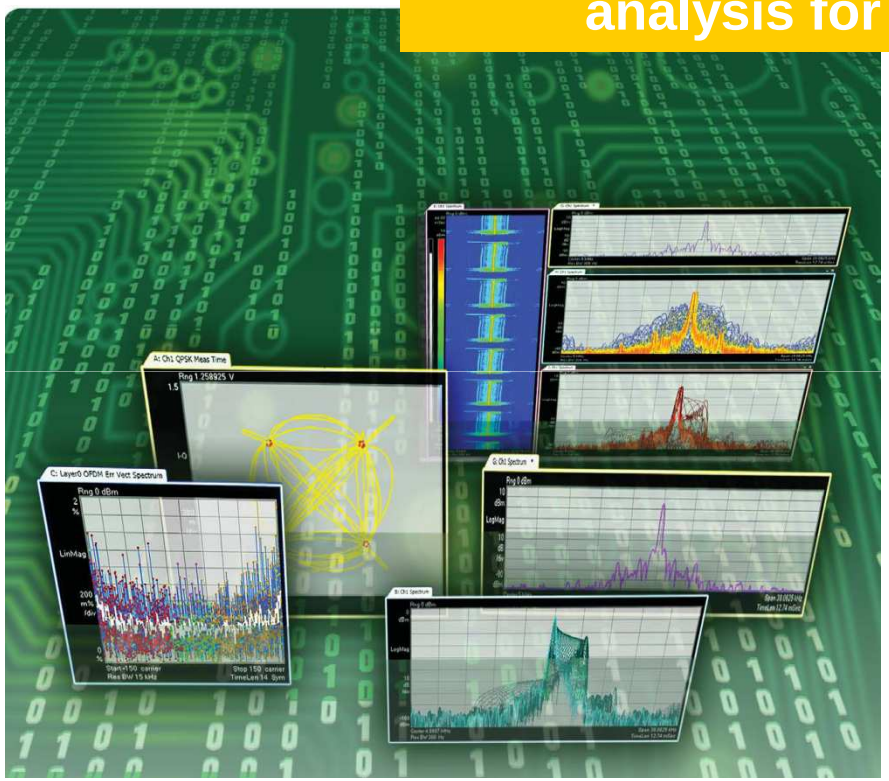




www.agilent.com/find/n6171a

89600B Vector Signal Analysis Software

Premier frequency, time & modulation analysis for Wireless R&D



TEST OF TIME AWARD WINNER 2010

Supports > 70 signal formats

- *GSM to WiFi, WiMAX & LTE*
- *2FSK to 1024QAM*
- *AM/FM/PM*
- *SISO and MIMO (4x4)*
- *Custom OFDM*

High resolution (409K line) FFT based spectrum

High quality time measurements

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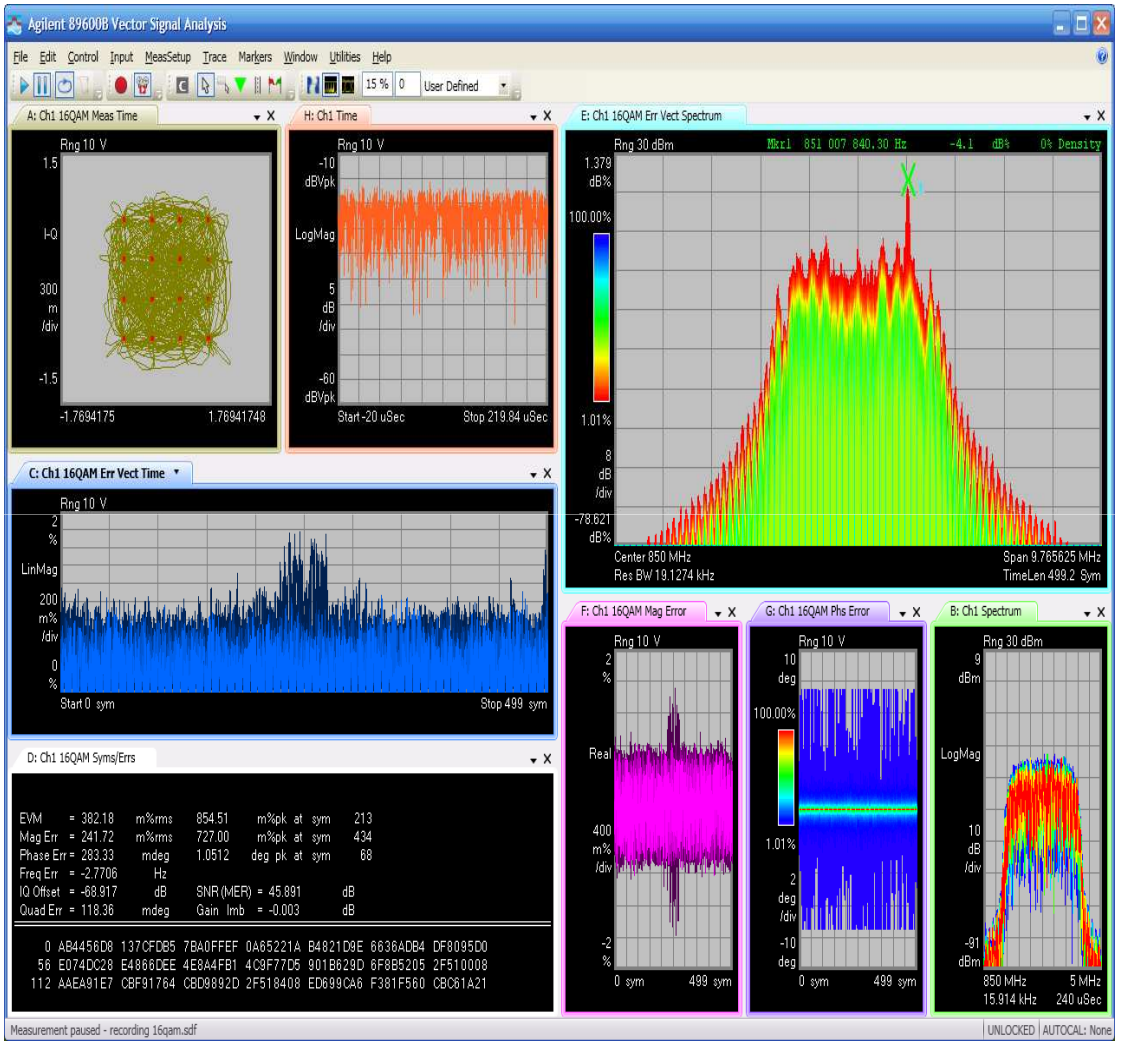
89600B Vector Signal Analysis Software

20:20 Flexible GUI

- 20 traces with 20 markers each
- Arbitrary arrangement, size & measurement assignment
- Advanced trace types: Spectrogram, Cumulative History, Digital Persistence
- SCPI programming



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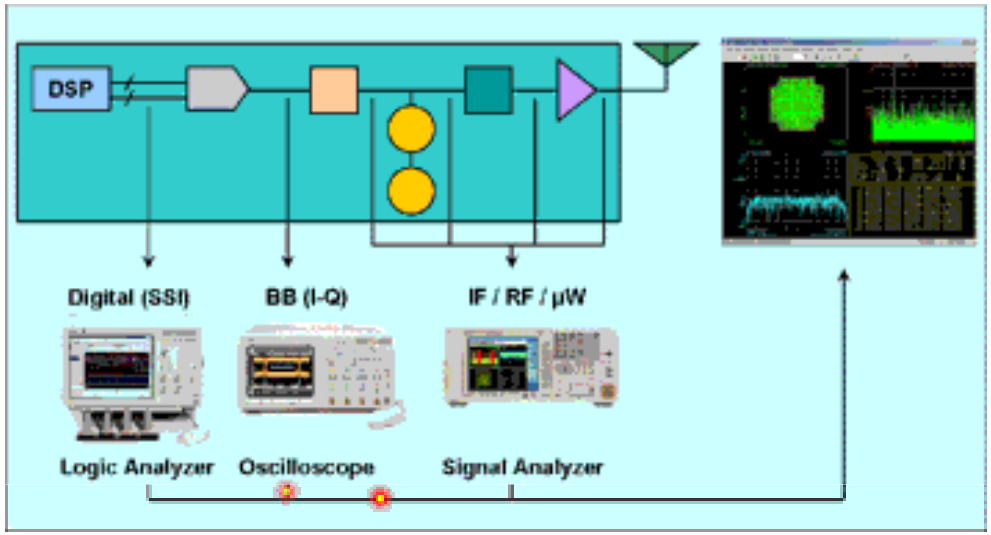
89600B VSA Works with > 30 Platforms

Test anywhere in the signal block diagram



These platforms can measure

• Bandwidth	10Hz to >10GHz
• Frequency	DC to 50GHz
• Baseband formats	Analog & Digital
• Channels	SISO to 4x4 MIMO

SUPPORTED PLATFORMS

Signal Analyzers
- X-Series (C/E/M/PXA)
- PSA
- ESA

Scopes
- 90000X*, 9000*, 8000*
- 7000*, 6000*

Logic Analyzers
- 1680
- 16800
- 16900
- RDX

Simulation Software
- SystemVue
- Simulink (MathWorks)

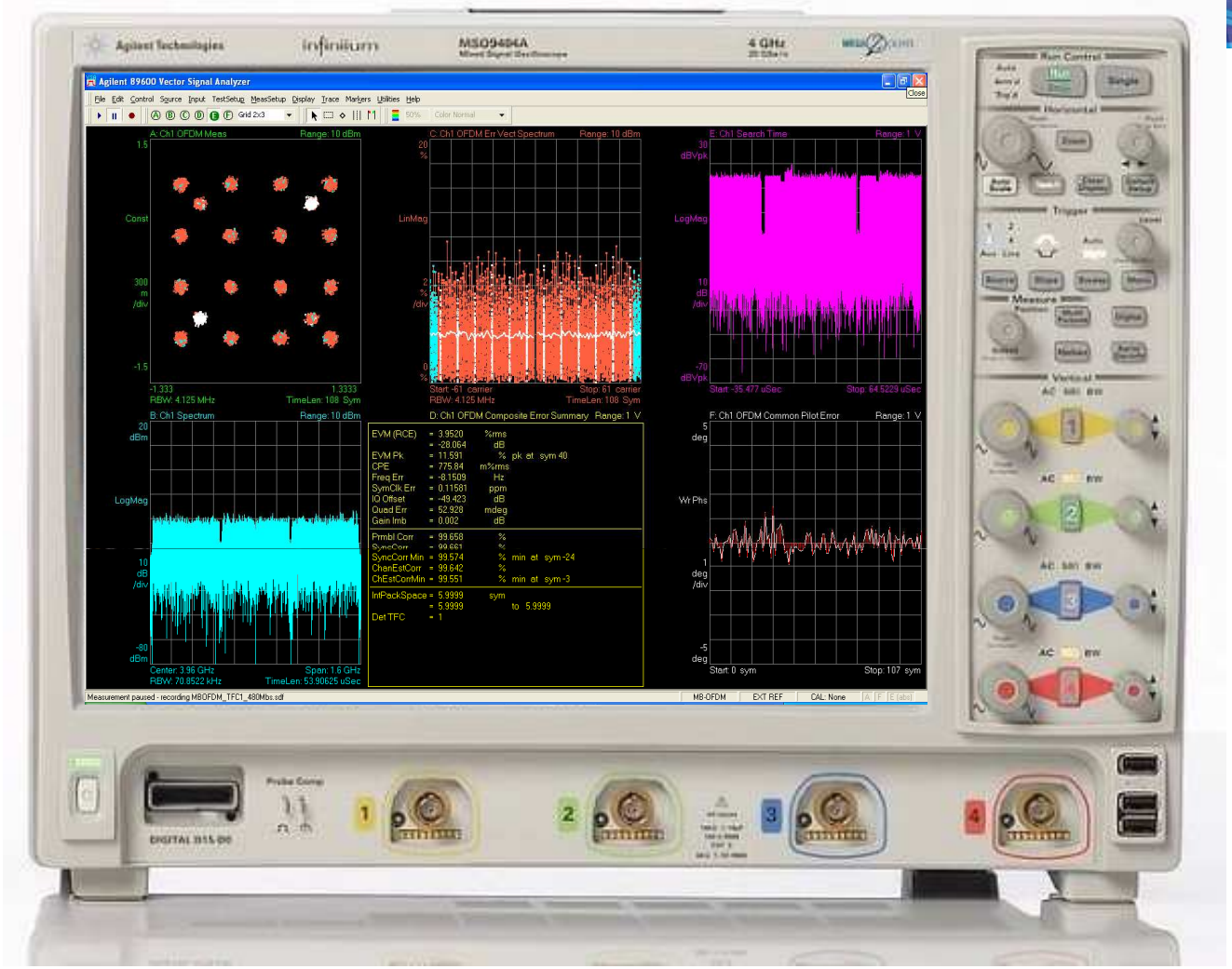
Other
- SI-LXI
- N7109A*

Signal Generators
- EXG
- ESG
- MXG
- PSG

File Compatibility
- Binary
- ASCII (.csv, .txt)
- MatLab (.mat)
- VSA (.sdf)

*MIMO PLATFORM

Infiniium 9000 Series Oscilloscope = 4GHz Demodulation BW



up to 4GHzDemodulation BW on each channel with 89600 VSA software (Differential I/Q)

- 600MHz 1GHz 2.5GHz 4GHz Bandwidth Upgradable !
- Memory up to 1Gpts (2ch)/ 500Mpts (4-ch)
- USB/I2/SPI/LIN/CAN/PCI-Express Serial Decode
- Removable HDD for confidential applications
- High Z Differential Probes with thermal extension câbles measure from -55°C to +150°C

- If you need More:
  DSO91304A 2.5GHz up to 13GHz

  DSOX93204A 16GHz up to 32GHz

89600B VSA Software

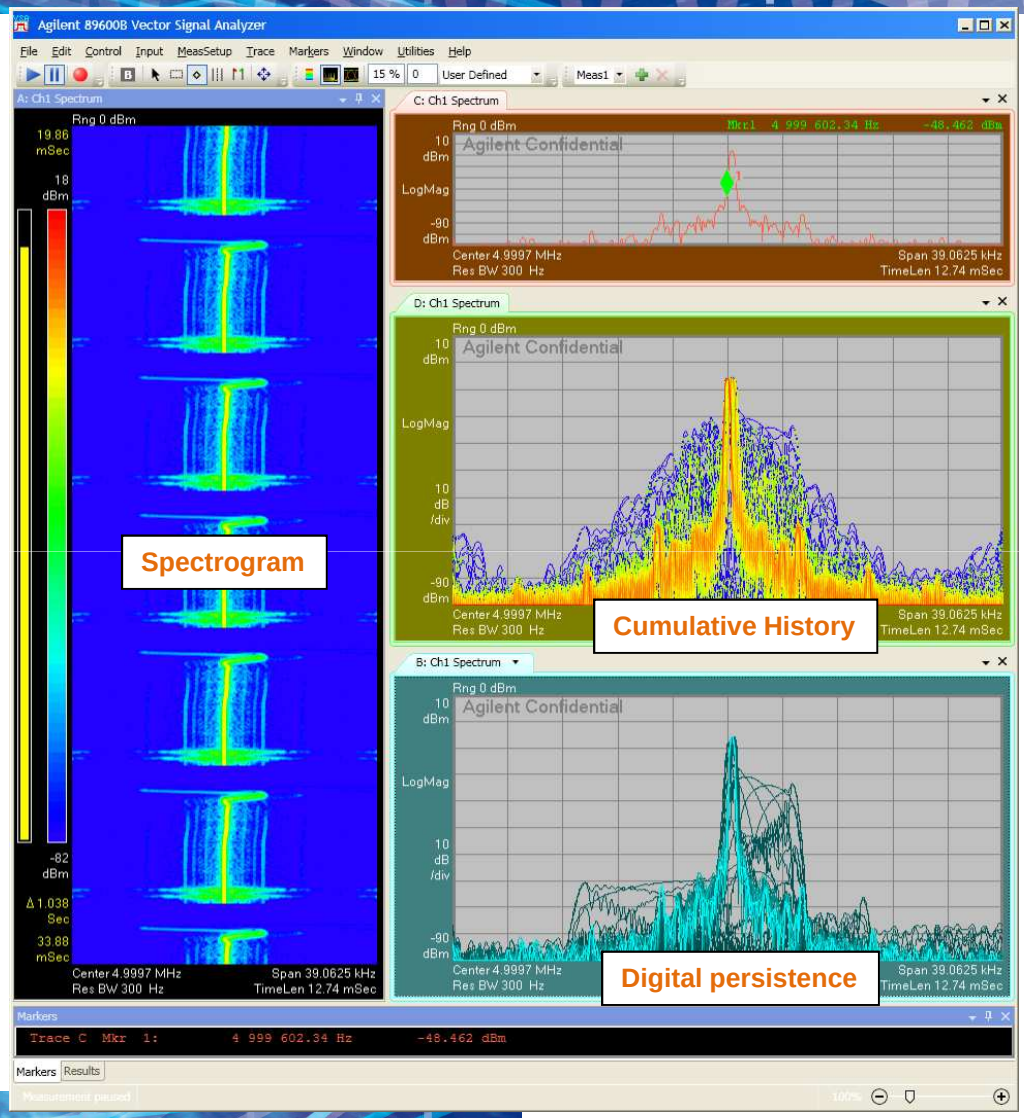
Analyze short-lived signal events

Multi-domain Digital Persistence

- Trace “shadow”
- Analyze repetitive transients
- R&D
- Frequency, time, & modulation domain

Multi-domain Cumulative History

- Frequency of occurrence (color coded)
- Pixel capture = long time (hours)
- Analyze infrequent signal events
- R&D
- Frequency, time & modulation domain



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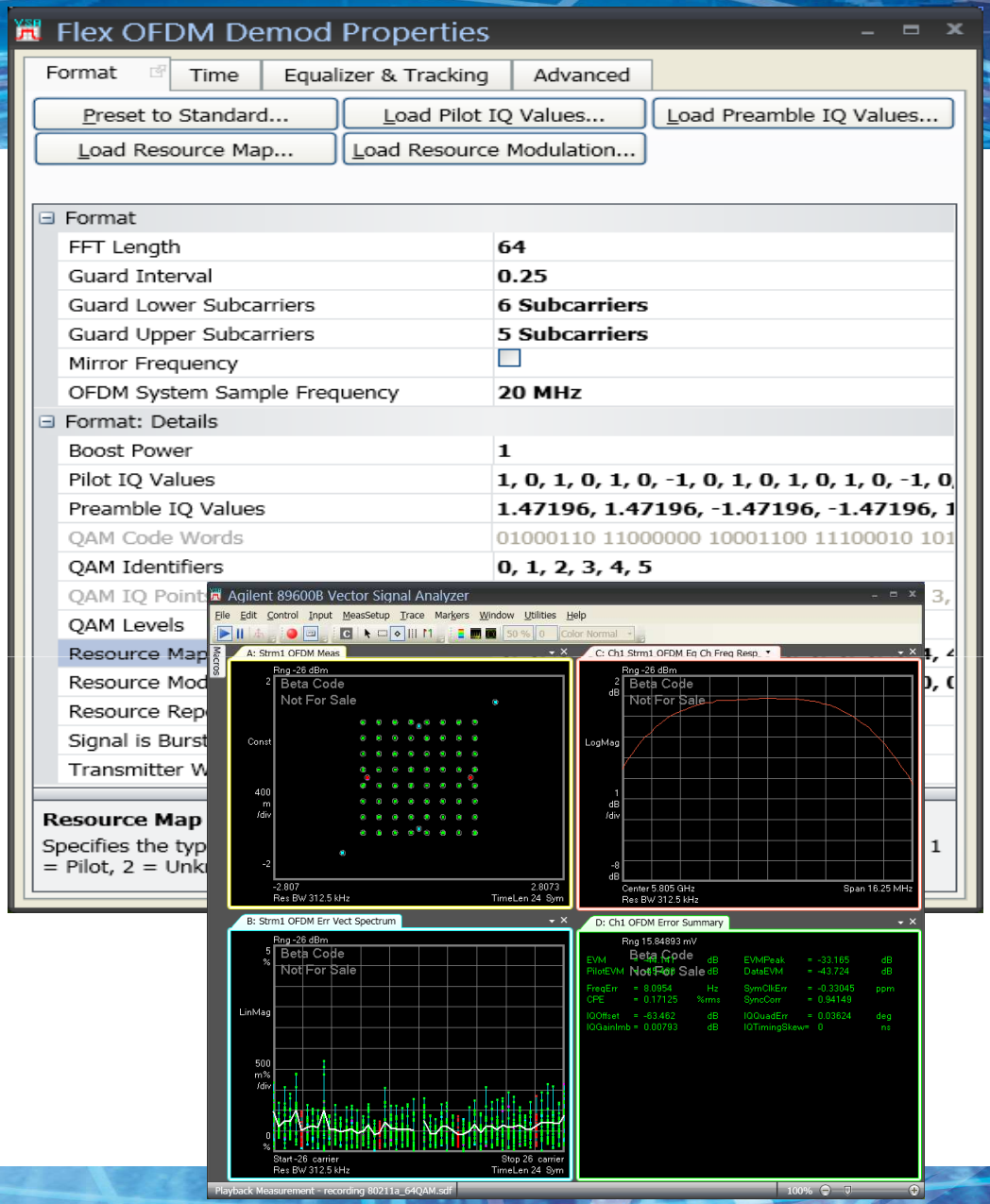
New Option:
Custom OFDM analysis



Test custom/proprietary OFDM with trusted tools

Describe the signal –

- Define carrier parameters per symbol (menu & configuration files)
- Supports all carrier types (data, pilot, preamble), mod type, etc

Measure the signal -

- Use VSA's proven OFDM analysis tools and displays
  - Constellation diagram
  - EVM vs. symbol, EVM vs. sub-carrier
  - frequency response
  - I-Q impairments
  - pk-avg statistics (CCDF)

Trust the results -

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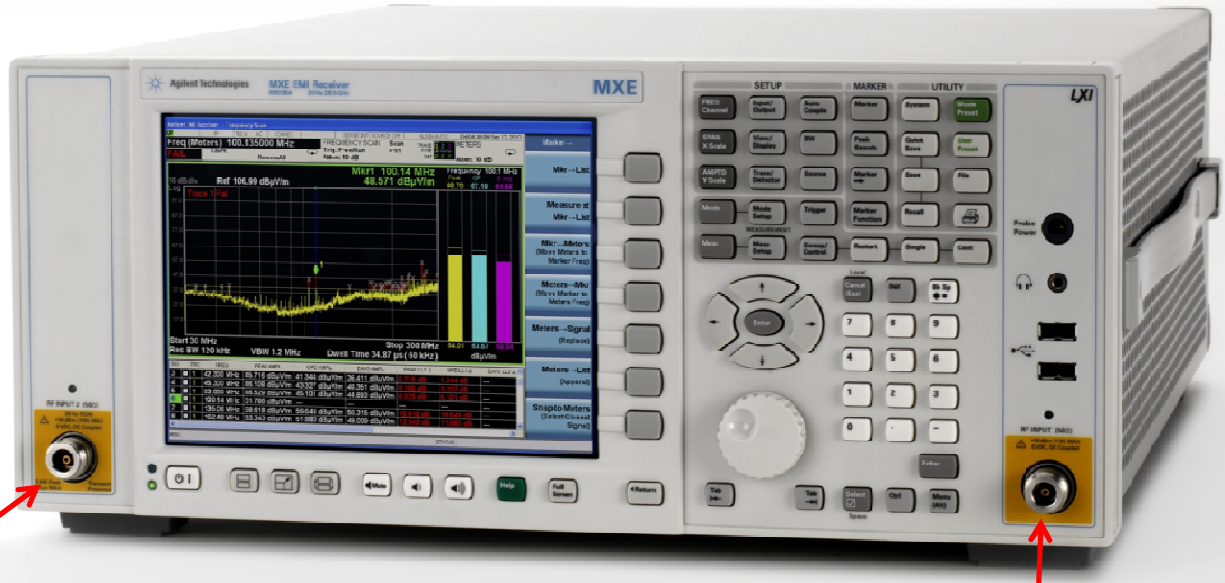
N9038A MXE EMI receiver

CISPR 16-1-1 2010 Compliant EMI Receiver

Innovative built-in diagnostic tools & displays

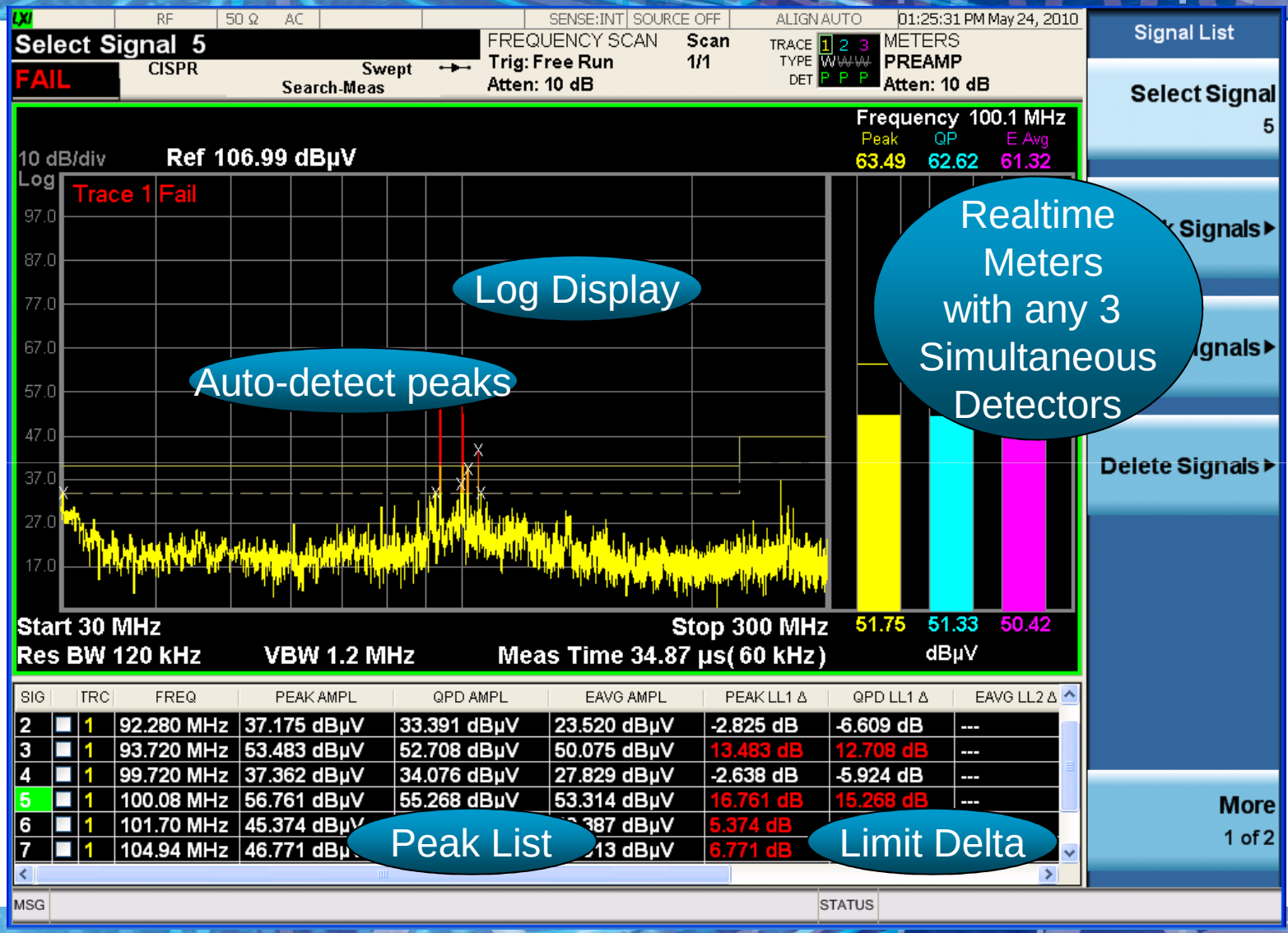


20 Hz to 1 GHz for Conducted Emissions (built-in limiter)

RF preselection, both inputs, EMI and SA modes

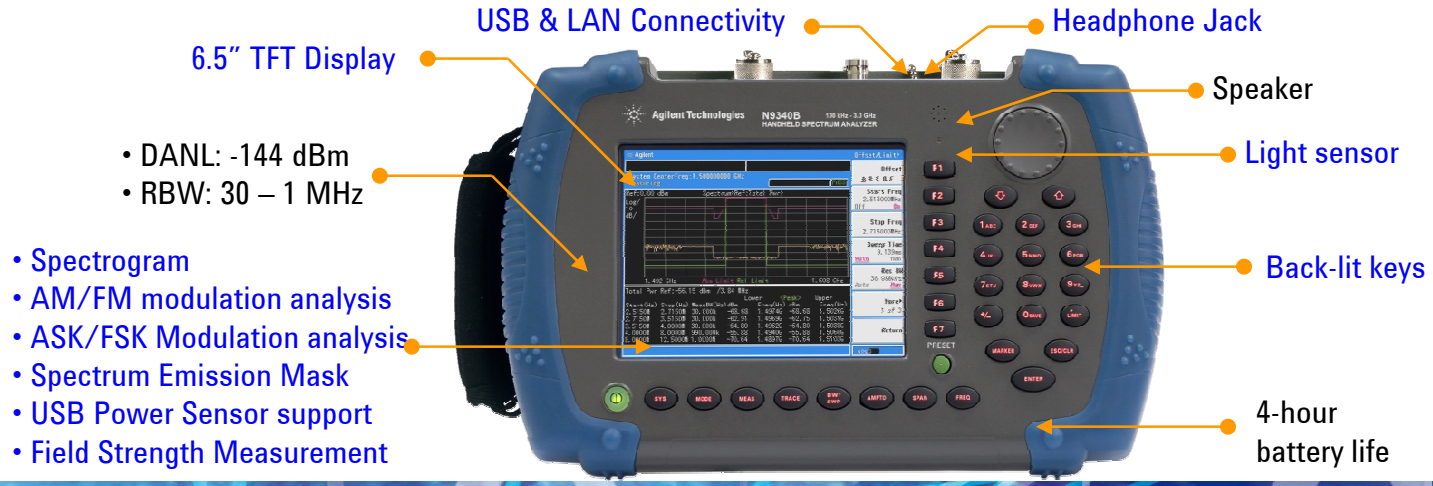
20 Hz to 26.5 GHz for Radiated Emissions

Extensive built-in diagnostic tools: *Meters*



N934xB/C: Dedicated Handheld Spectrum Analyzer
9 kHz – 3 GHz/7GHz/13GHz/20GHz

- N934xB/C is the DEDICATED handheld spectrum analyzer to address field test demands.
  - **Superior performance** of a SA: DANL, speed, and resolvability
  - **Powerful features** to fulfill more field test tasks: Spectrogram, SEM, USB power sensor, tracking generator and demodulation (optional)
  - **Exceptional usability** to enhance field test productivity: Bright display, back-lit keys, USB/LAN



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THANK YOU!

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