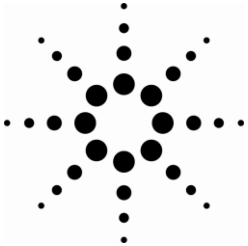
Spectrum Analysis Back to Basics



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Agenda

Introduction

Overview:

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

Theory of Operation

Specifications

Modern Signal Analyzer Designs & Capabilities

- Wide Bandwidth Vector Measurements

Wrap-up

Appendix

Analyzer Definitions

Spectrum Analyzer

– “A spectrum analyzer measures the magnitude of an input signal versus frequency within the full frequency range of the instrument. The primary use is to measure the power of the spectrum of known and unknown signals.”

Vector Signal Analyzer

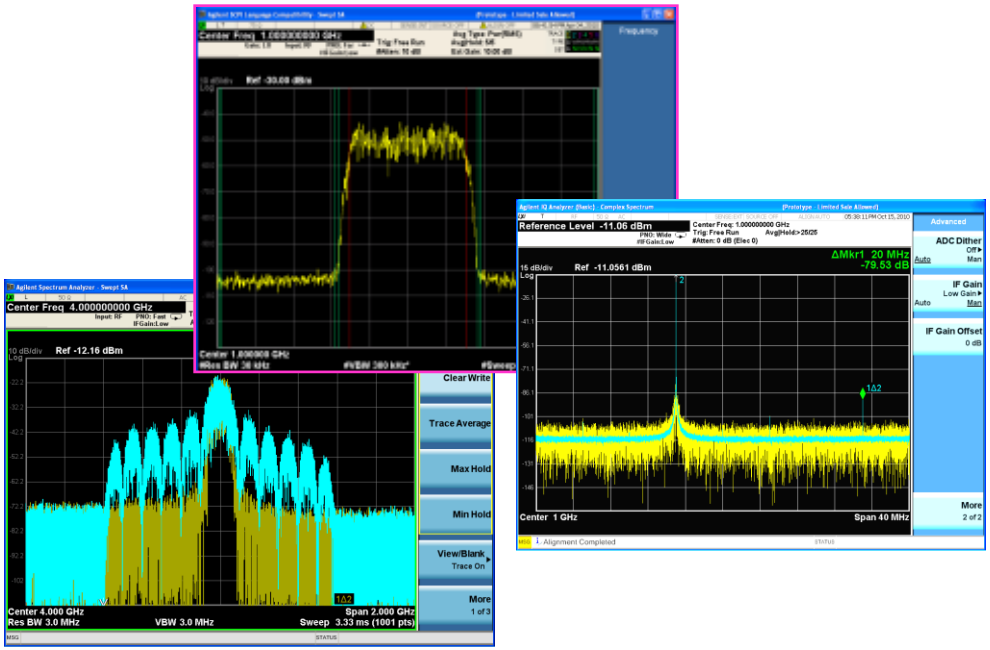
– “A vector signal analyzer measures the magnitude and phase of an input signal at a single frequency within the IF bandwidth of the instrument. The primary use is to make in-channel measurements, such as error vector magnitude, code domain power, and spectral flatness, on known signals.”

Signal Analyzer

– “A signal analyzer provides the functions of a spectrum analyzer and a vector signal analyzer.”

Overview

What is 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)**

Agilent Technologies' Signal Analysis Portfolio

N9320B
Basic performance
9 kHz to 3 GHz

N9922C BSA
9 kHz to 7 GHz

N9935/36/37/38A
5 kHz to 9/14/18/26.5 GHz
Handhelds

N9340B/42/43/44C
100 kHz to 3/7/13.6/20 GHz
Handhelds

CXA
Low-cost
9 kHz to 26.5 GHz

EXA
X-Series
Economy-class
10 Hz to 26, 32, 44 GHz

MXA
X-Series
Mid-performance
10 Hz to 26.5 GHz

PXA
X-Series
High-performance
3 Hz to 26.5 GHz
3 Hz to 43/44/50 GHz

PSA
Market leading performance
3 Hz to 50 GHz

8560EC
Mid-performance

ESA
World's most popular
100 Hz to 26 GHz

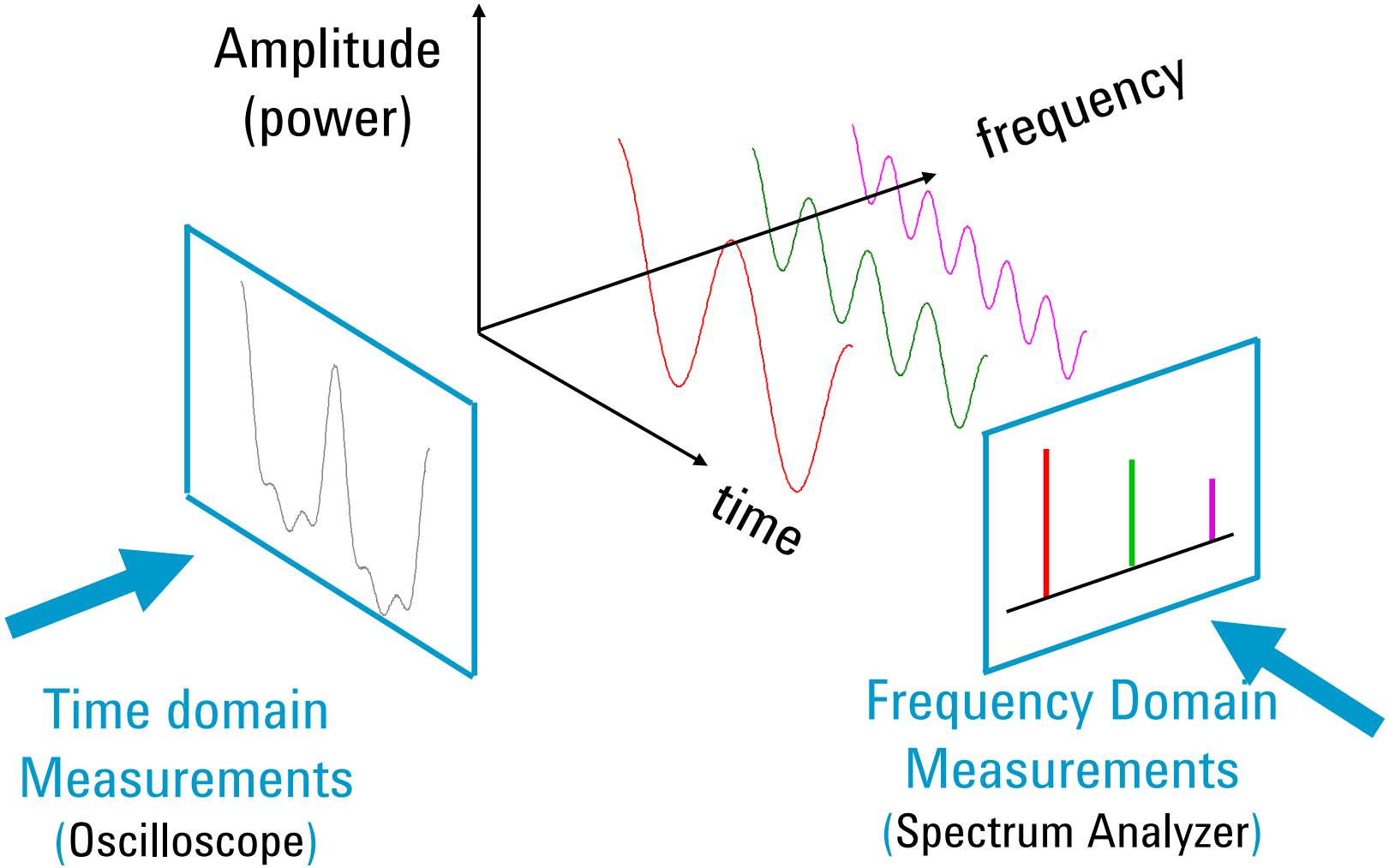
CSA
Low cost portable
100 Hz to 7 GHz

X-Series Code Compatibility

- ✓ Backward CC with legacy
- ✓ Inherent X-Series CC

Overview

Frequency versus Time Domain



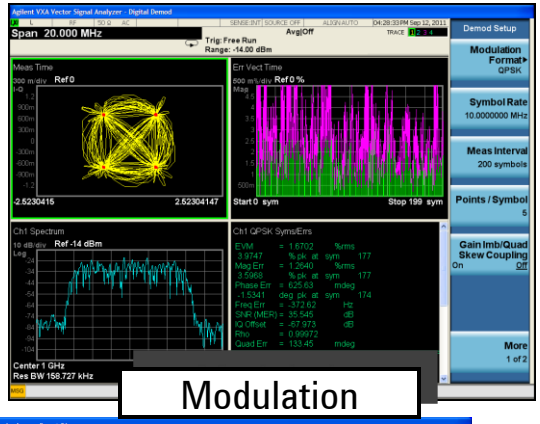
Overview

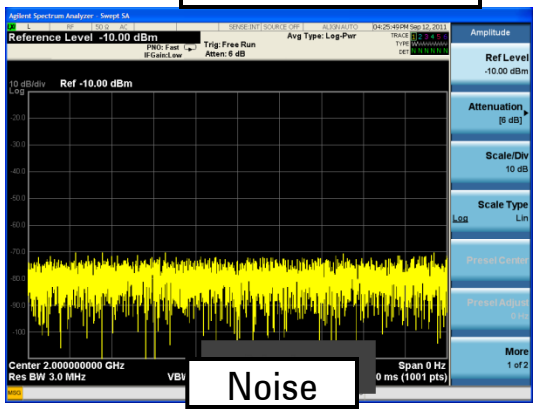
Types of Measurements Available

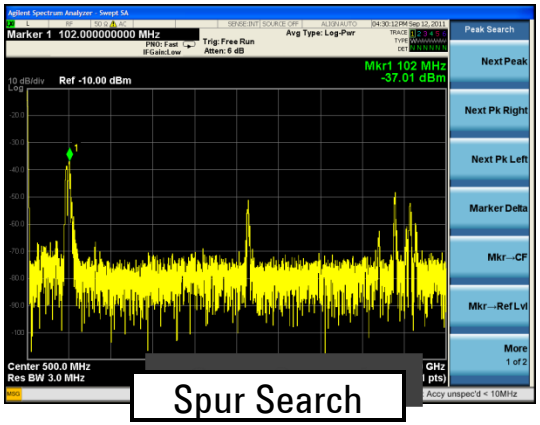
Frequency, power, modulation, distortion & noise

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

- *Measurement range (-172 dBm to +30 dBm)*
- *Frequency range (3 Hz to >>325 GHz)*







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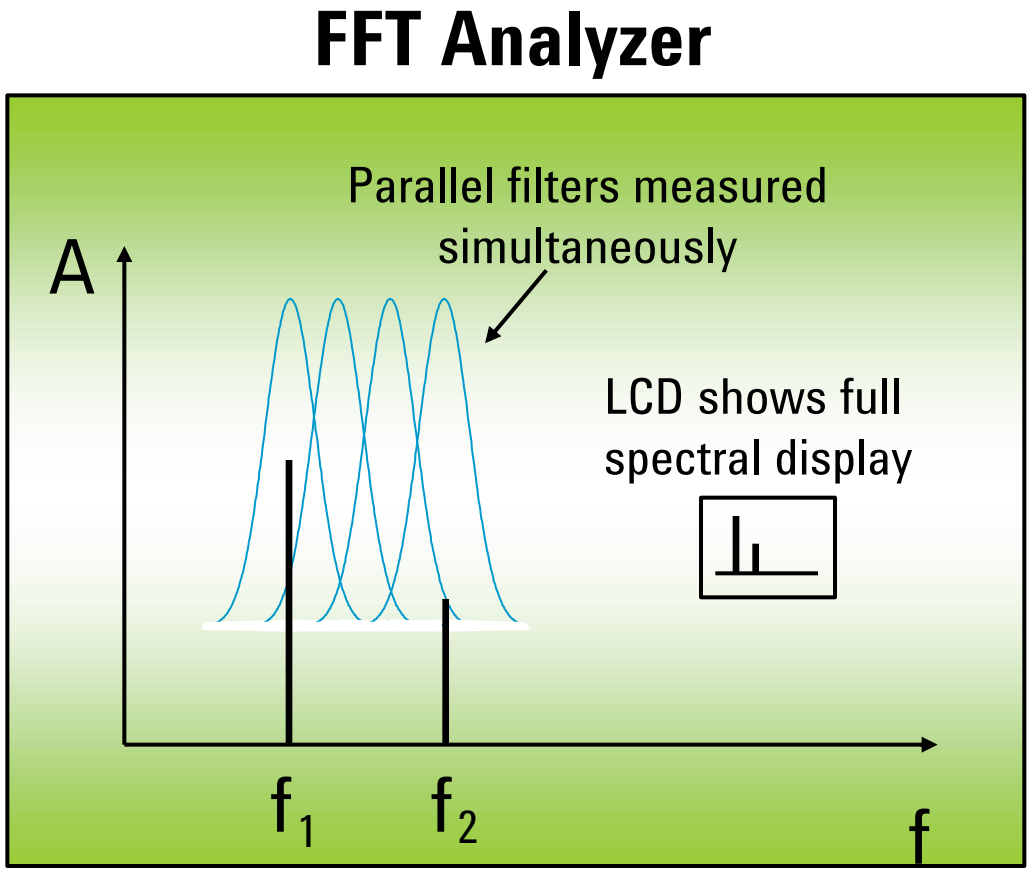
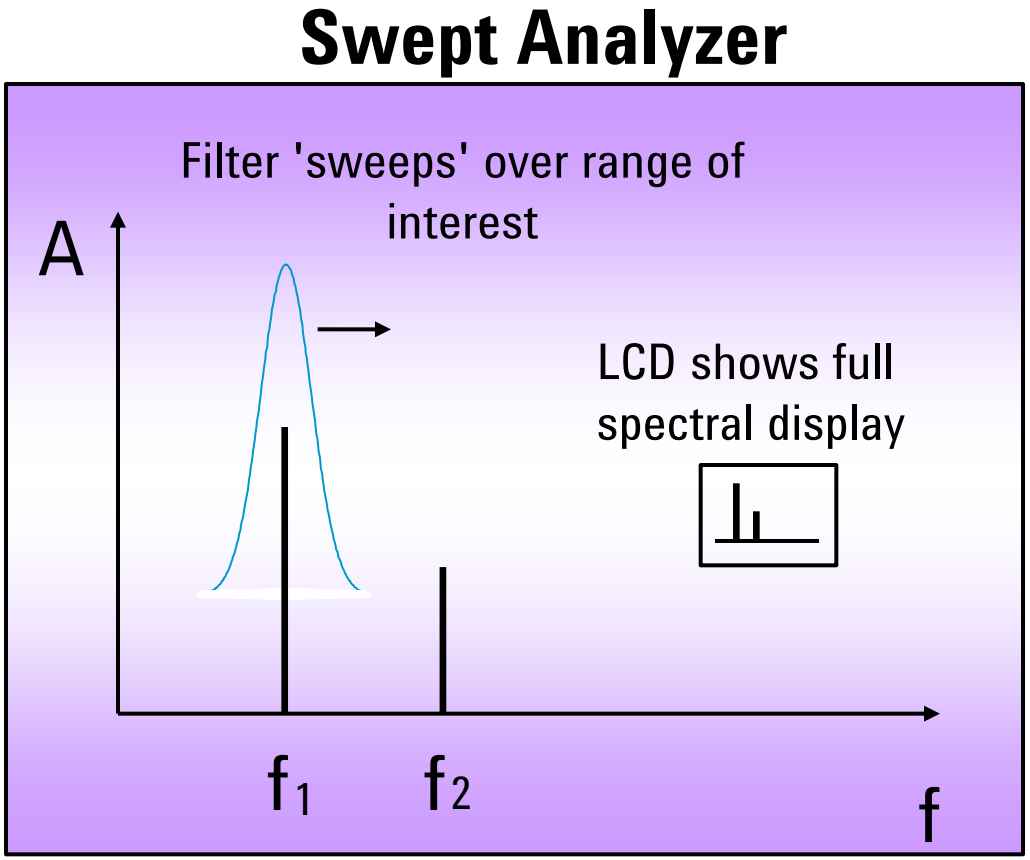
Overview

Different Types of Analyzers



Overview

Different Types of Analyzers



Agenda

Introduction

Overview

Theory of Operation:

- Swept Spectrum Analyzer Hardware

Specifications

Modern spectrum analyzer designs & capabilities

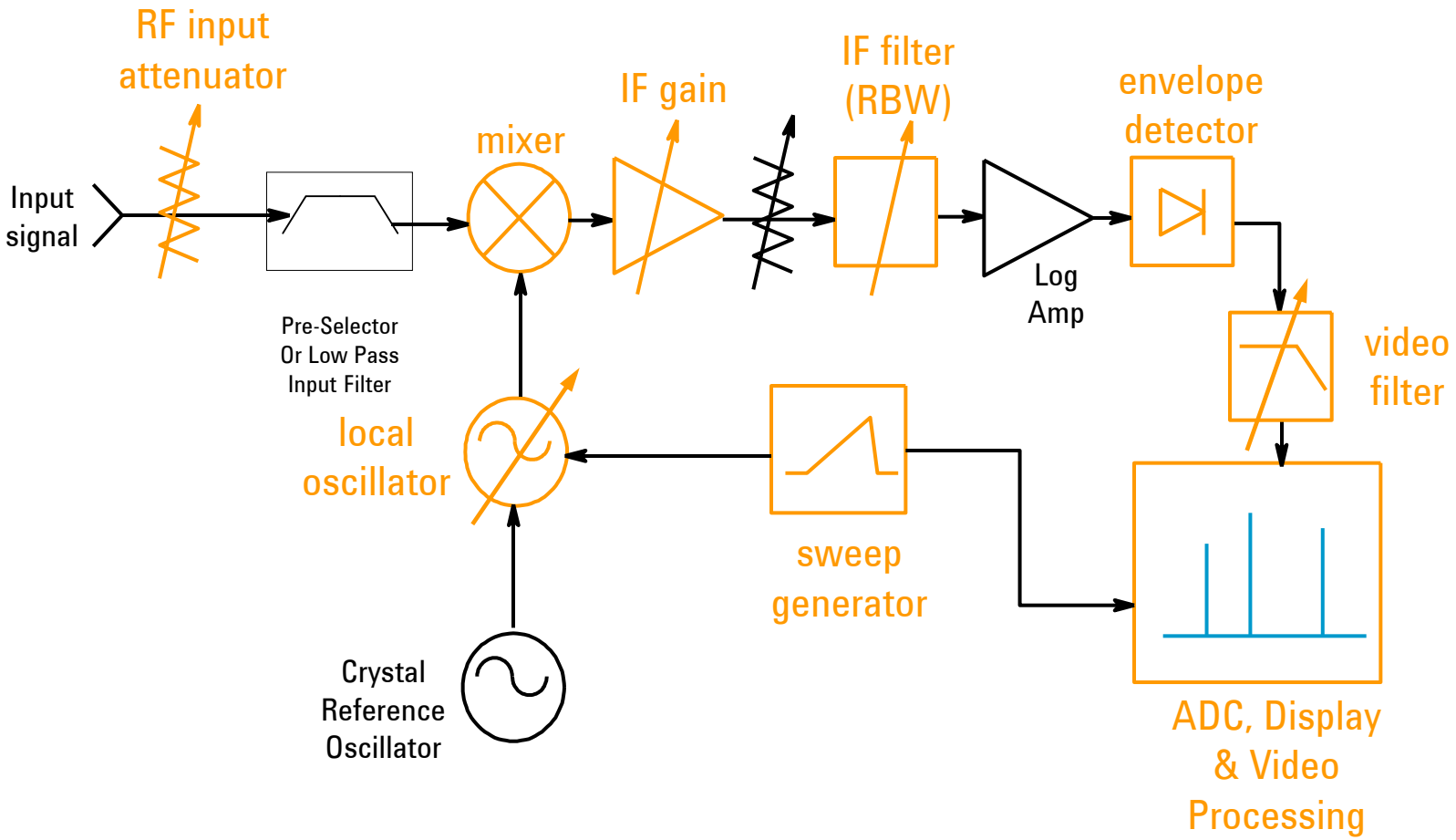
  – Wide Bandwidth Vector Measurements

Wrap-up

Appendix

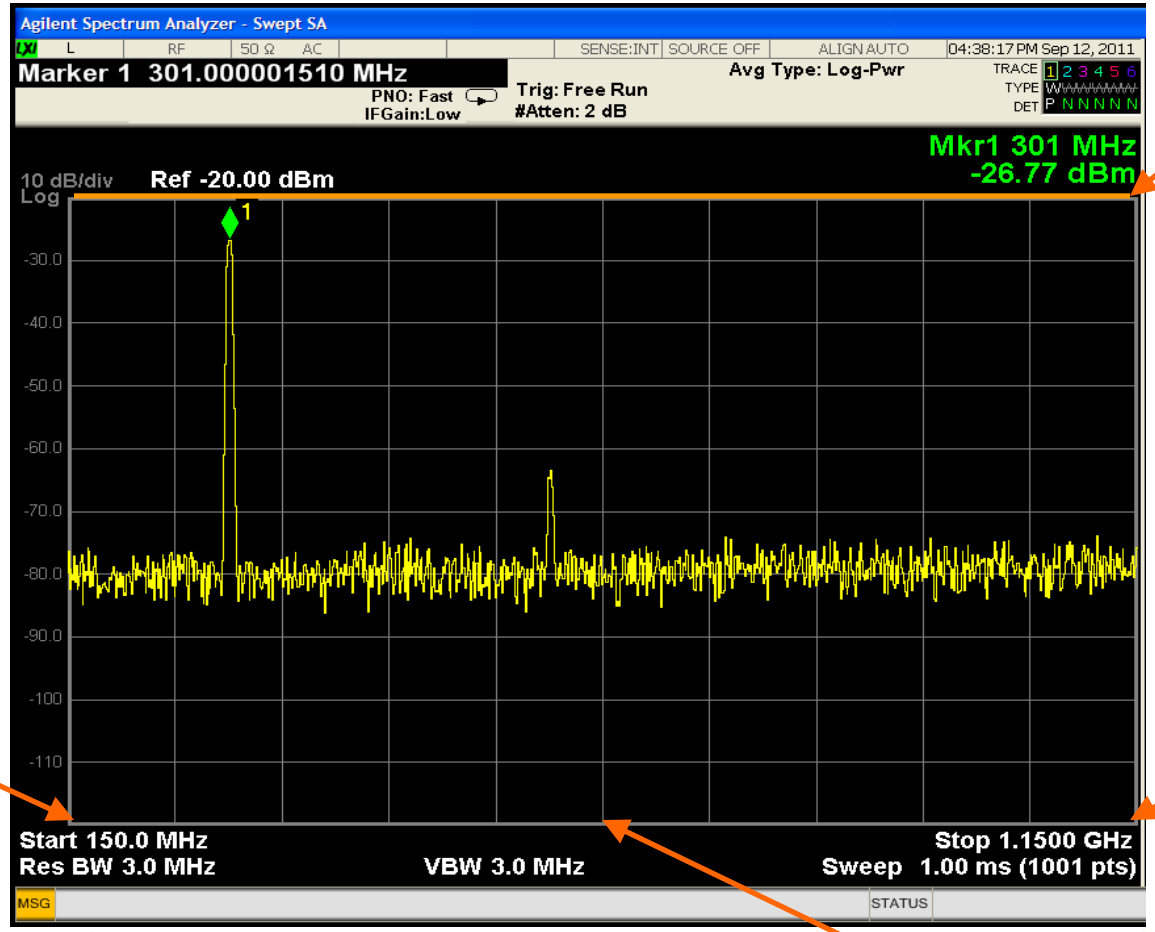
Theory of Operation

Swept Spectrum Analyzer Block Diagram



Theory of Operation

Display terminology



Reference Level

Amplitude

Start Freq.

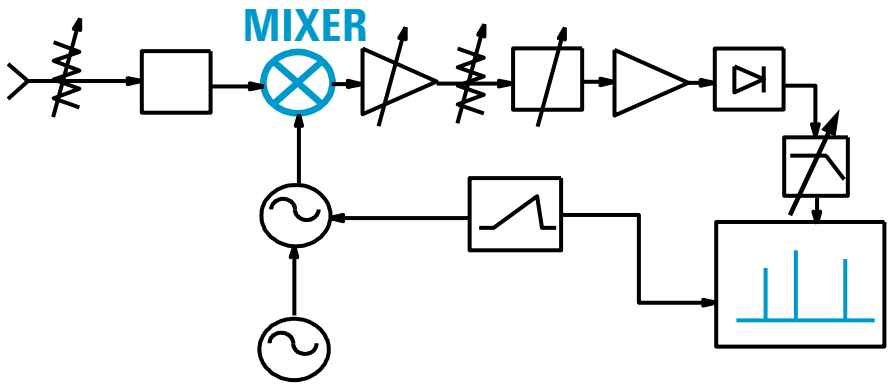
Stop Freq.

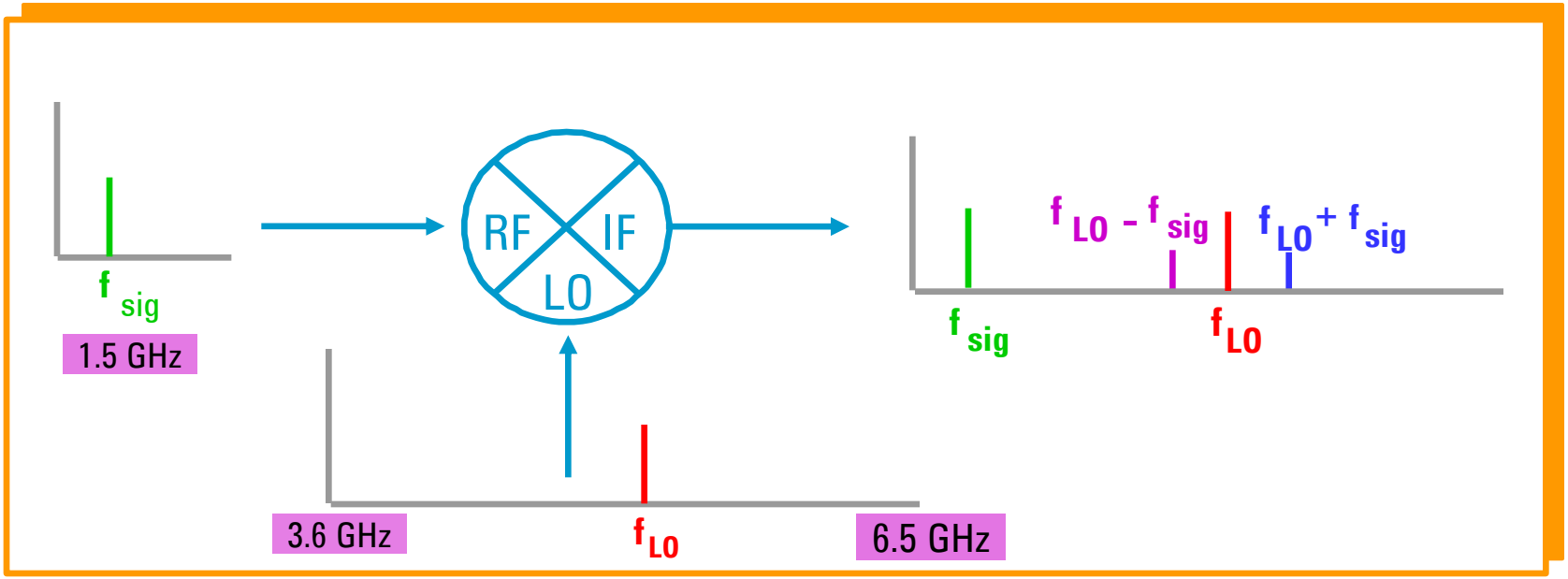
Center Freq.

Freq. Span

Theory of Operation

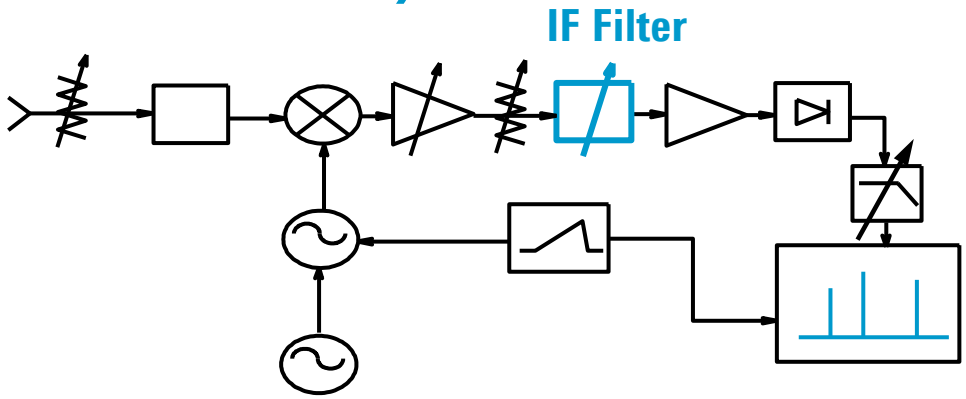
Mixer

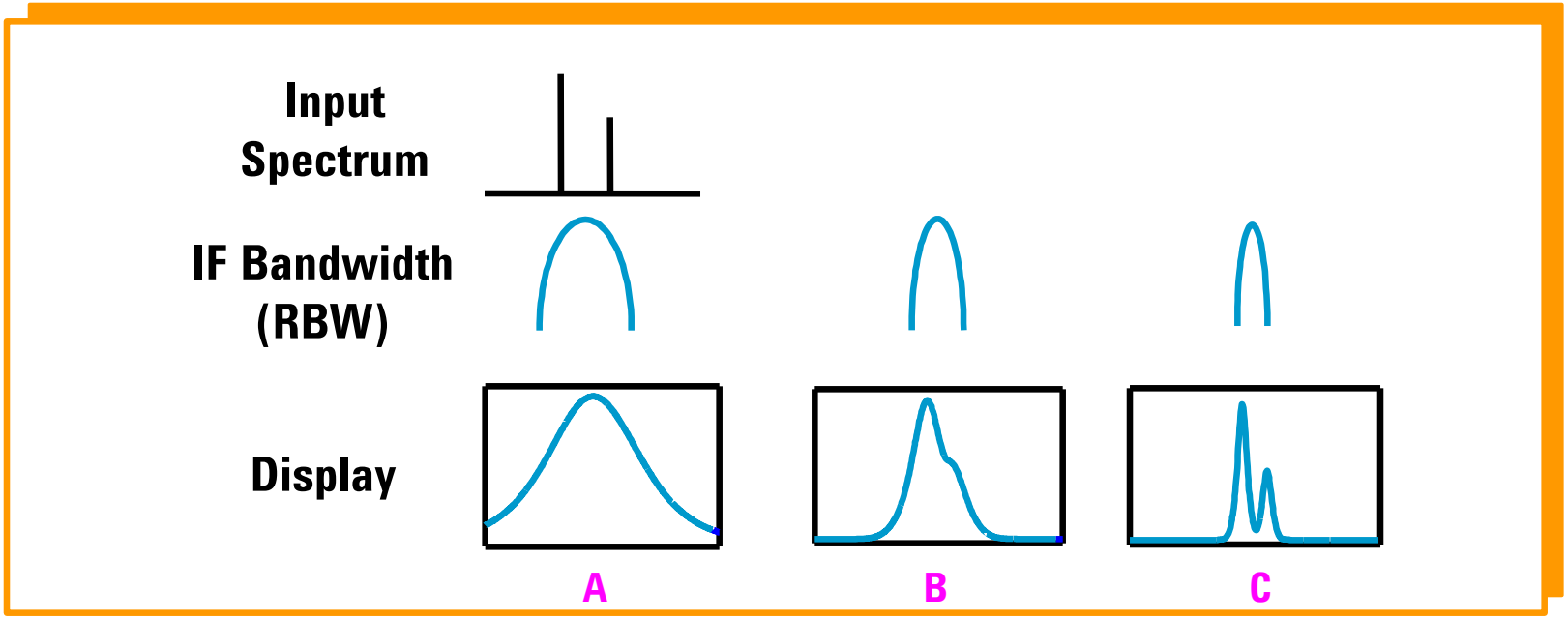




Theory of Operation

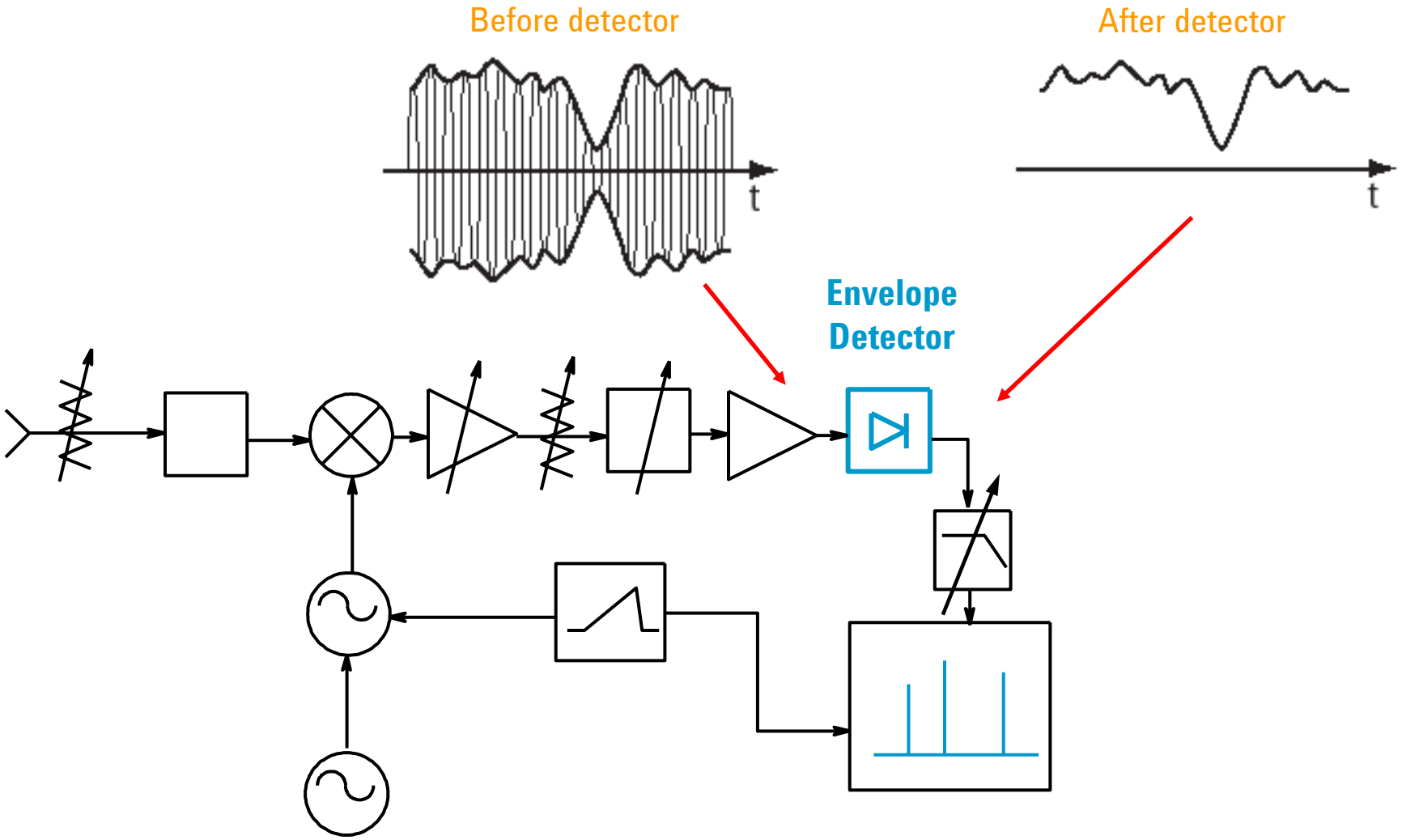
IF Filter (Resolution Bandwidth – RBW)





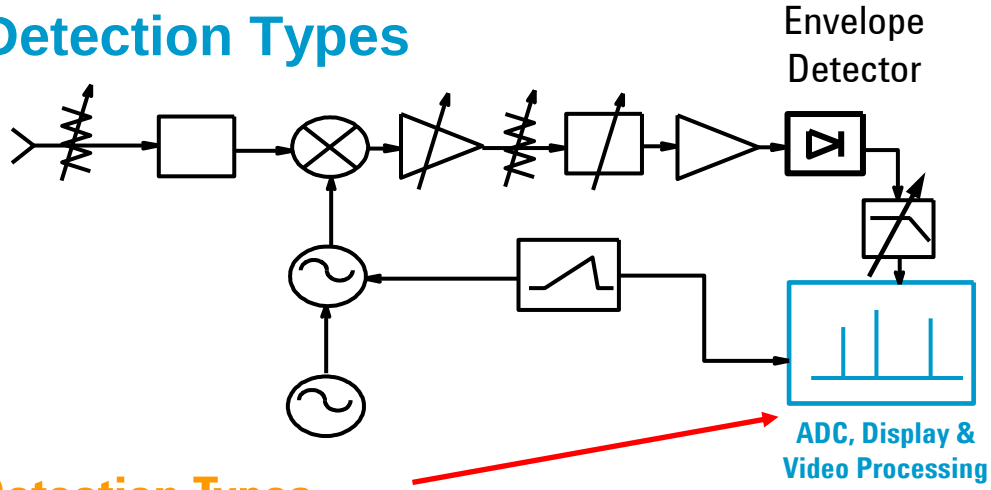
Theory of Operation

Envelope Detector

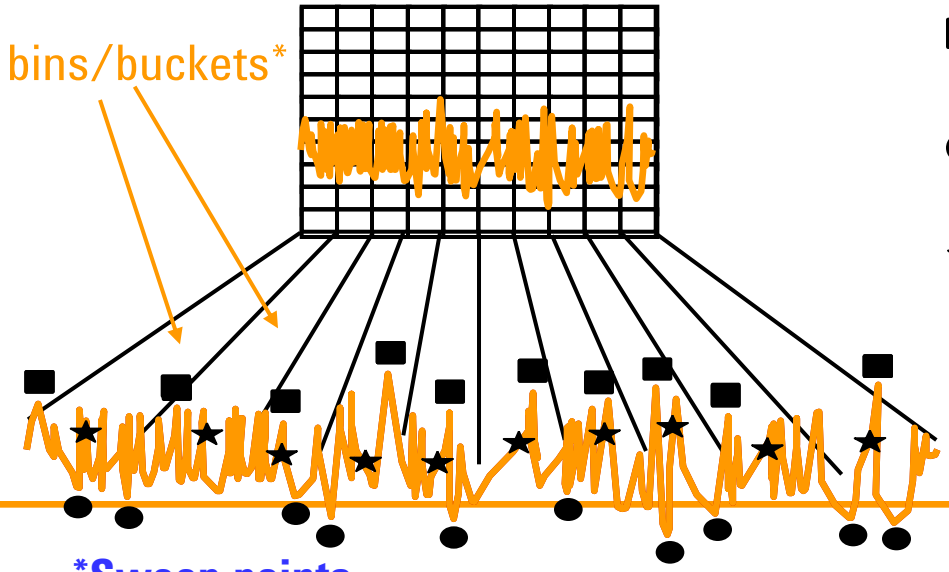


Theory of Operation

Envelope Detector and Detection Types



Digitally Implemented Detection Types

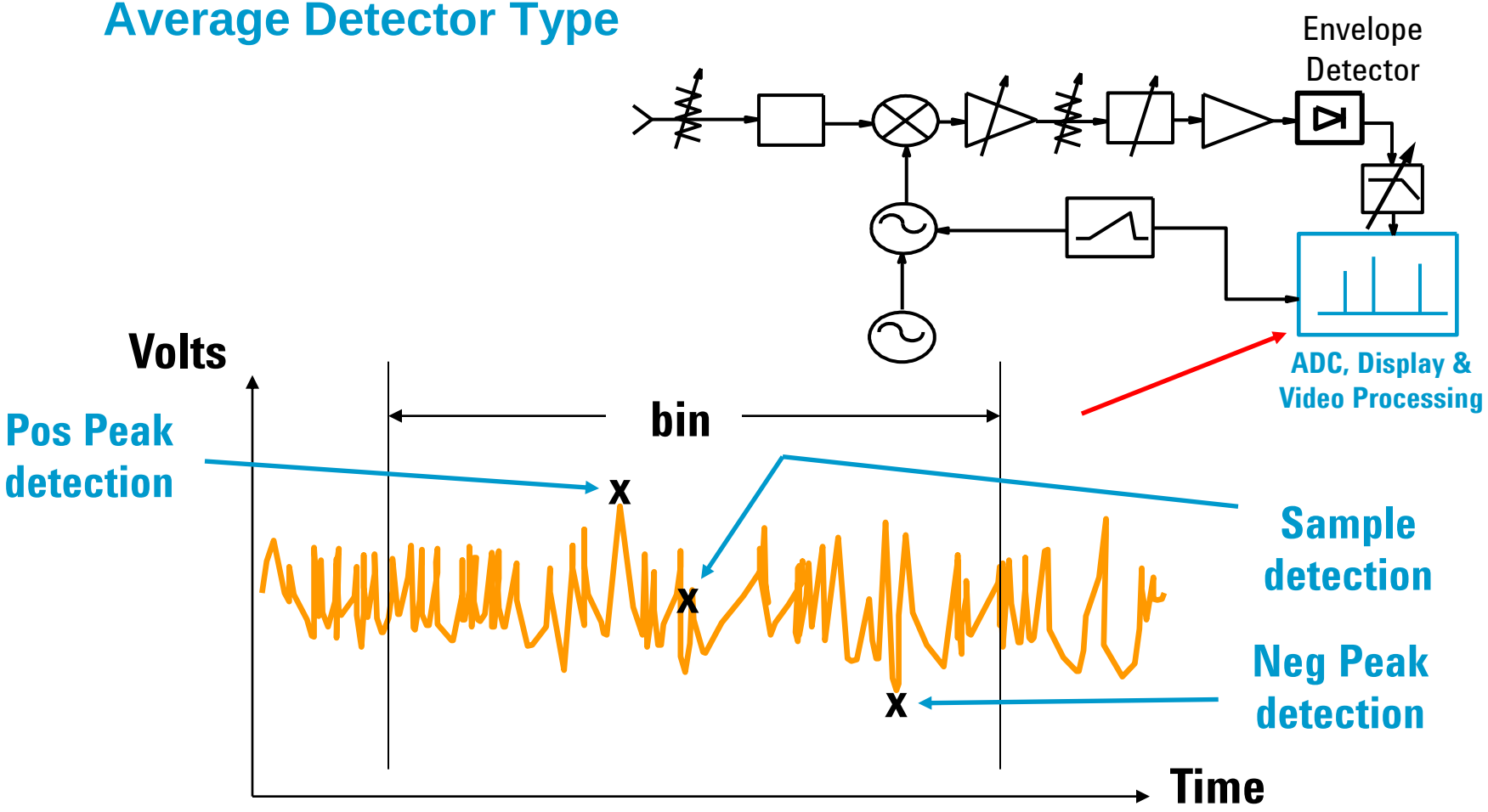


- ■ Positive detection: largest value in bin displayed
- ● Negative detection: smallest value in bin displayed
- ★ Sample detection: middle value in bin displayed

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

Theory of Operation

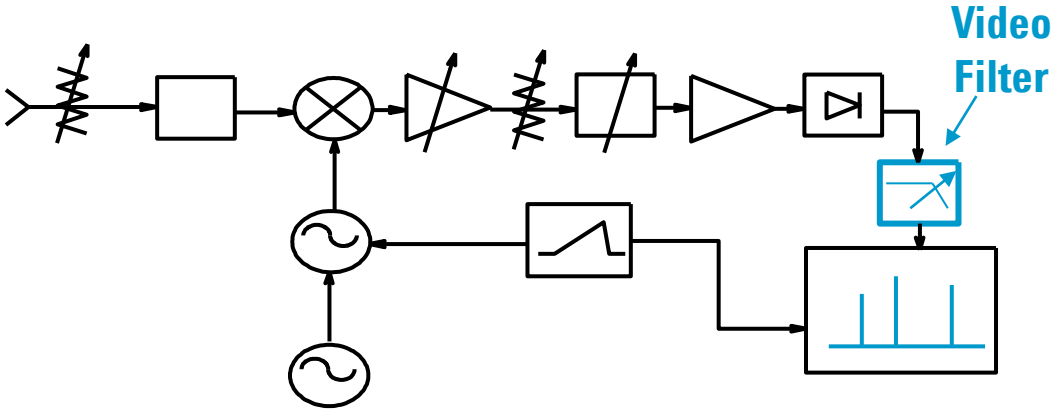
Average Detector Type

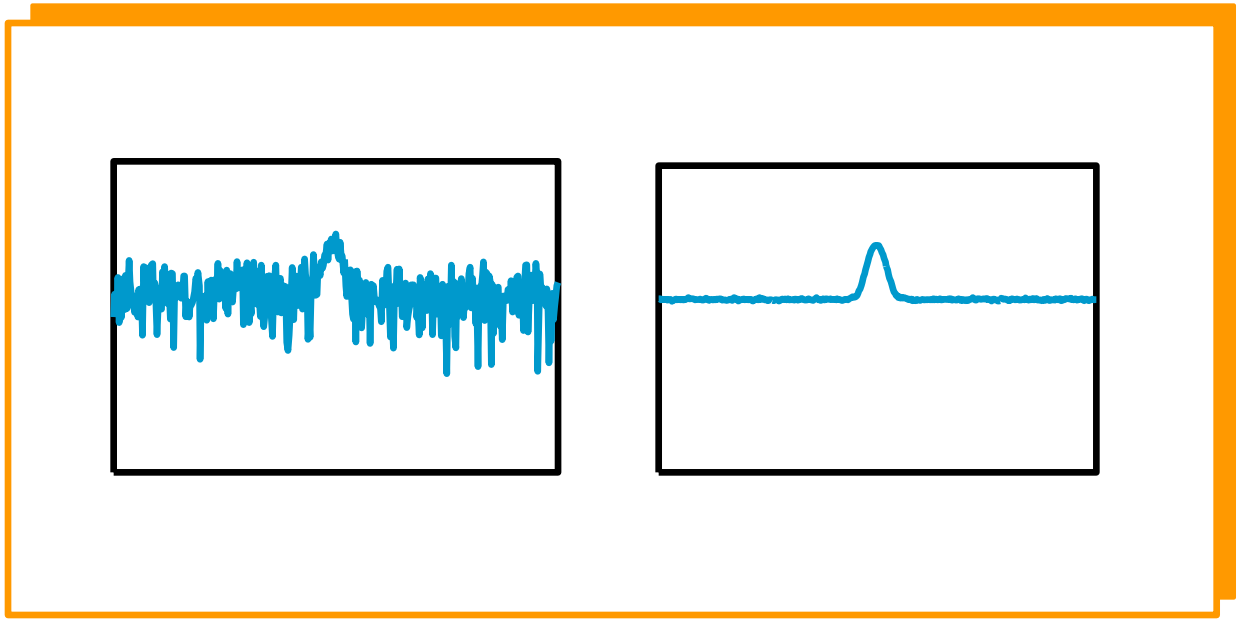


Power Average Detection (rms) = Square root of the sum of the squares of **ALL** of the voltage data values in the bin /50Ω

Theory of Operation

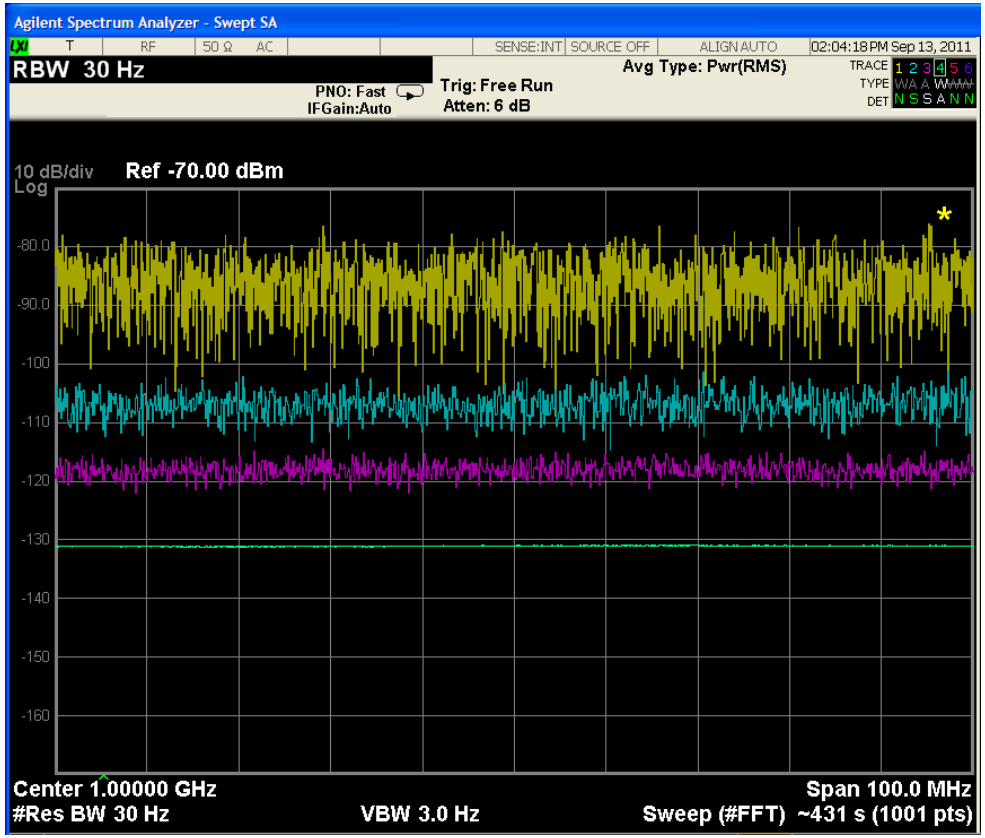
Video Filter (Video Bandwidth – VBW)



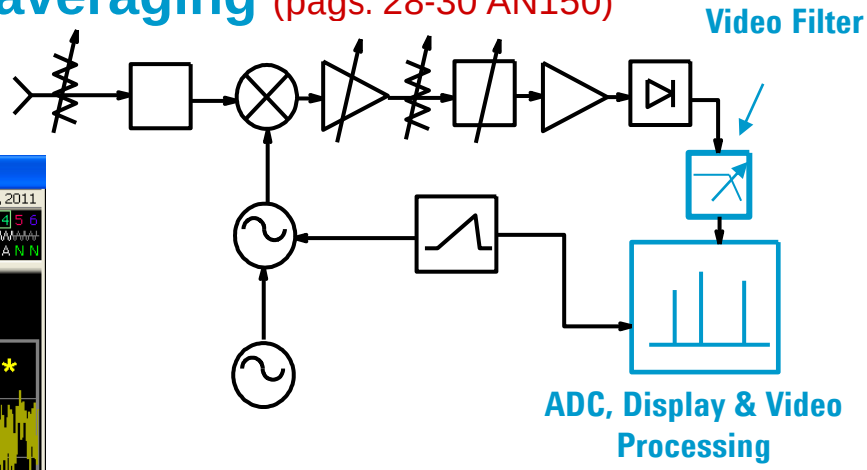


Theory of Operation

Video Filter vs. Trace/Video averaging (pags. 28-30 AN150)



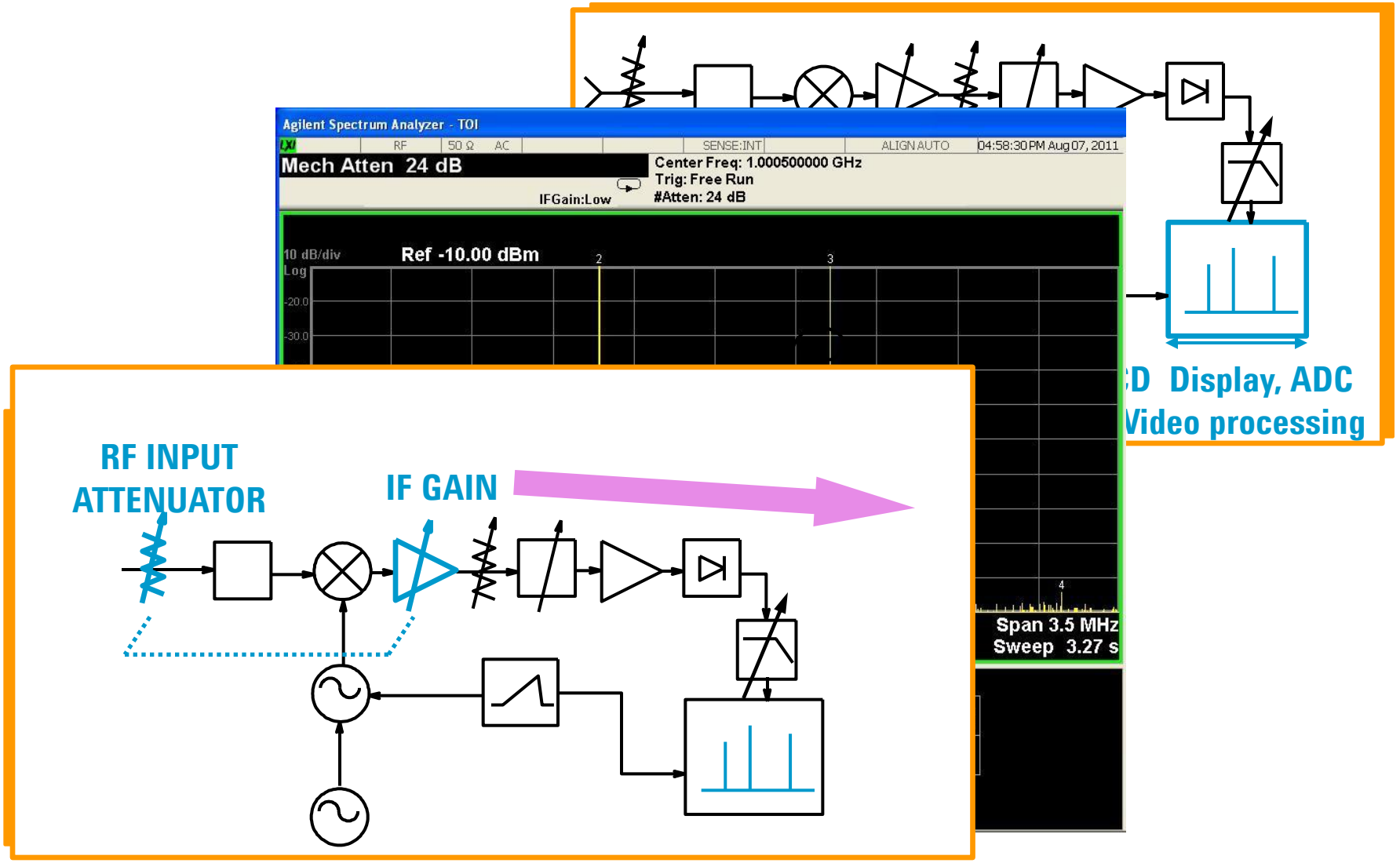
Trace averaging for 1, 5, 20, and 100 sweeps, top to bottom (trace position offset for each set of sweeps)



- 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

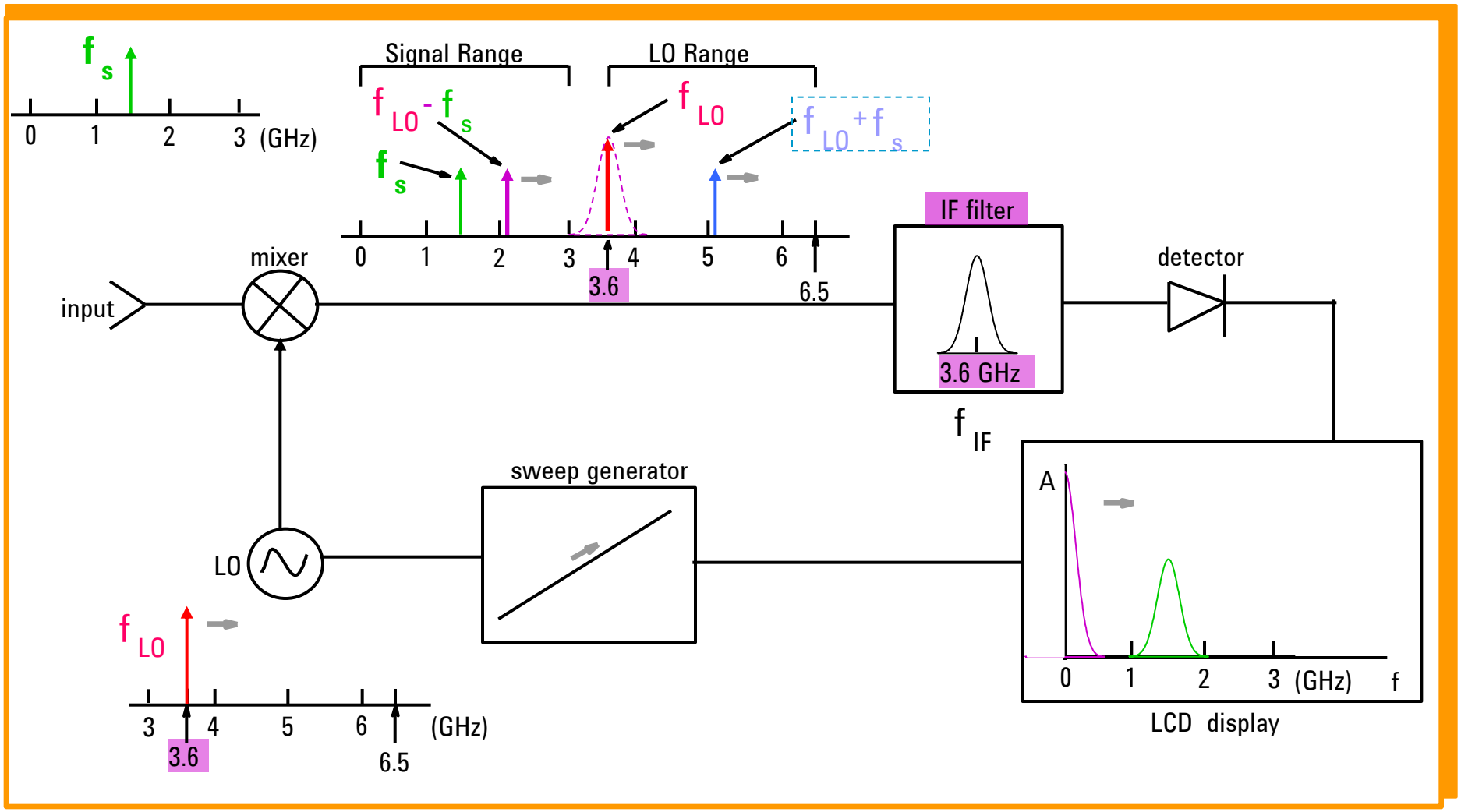
Theory of Operation

Other Components



Theory of Operation (Pags. 11/12 AN150)

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

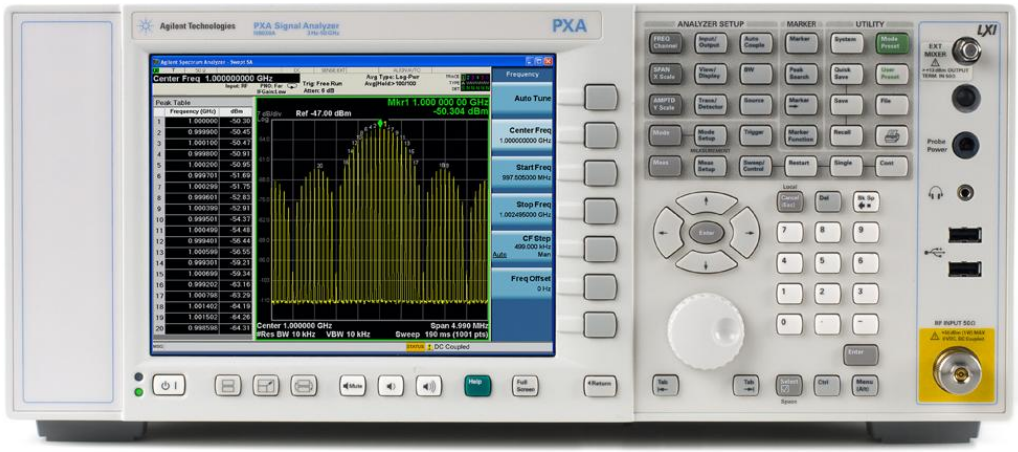
  – Wide Bandwidth Vector Measurements

Wrap-up

Appendix

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°C, unless otherwise noted).**

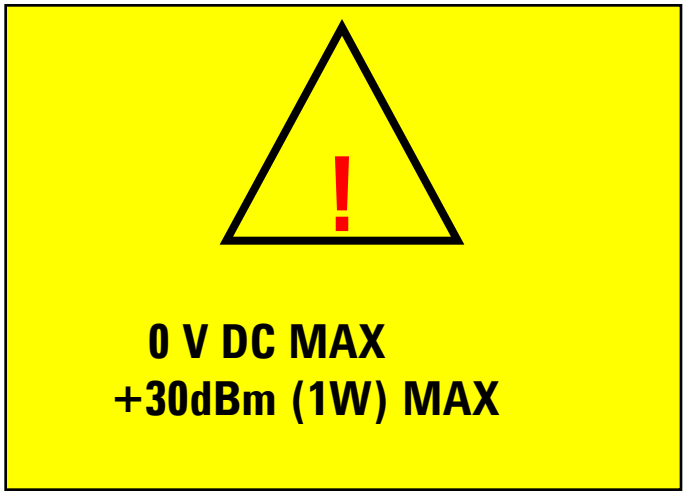
Typical **values describe additional product performance information that is not covered by the product warranty. It is performance beyond specification that 80 % of the units exhibit with a 95 % confidence level over the temperature range 20 to 30° C. Typical performance does not include measurement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

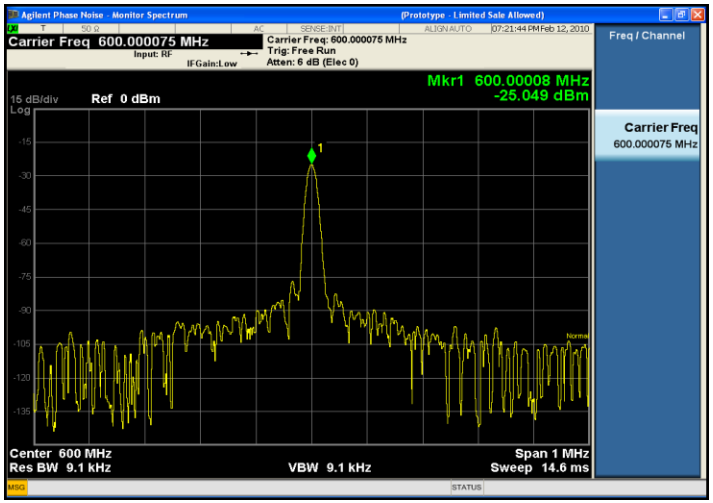
- **Use best practices to eliminate static discharge to the RF input!**
- **Do not exceed the Damage Level on the RF Input!**
- **Do not input signals with DC bias exceeding what the analyzer can tolerate while DC coupled!**



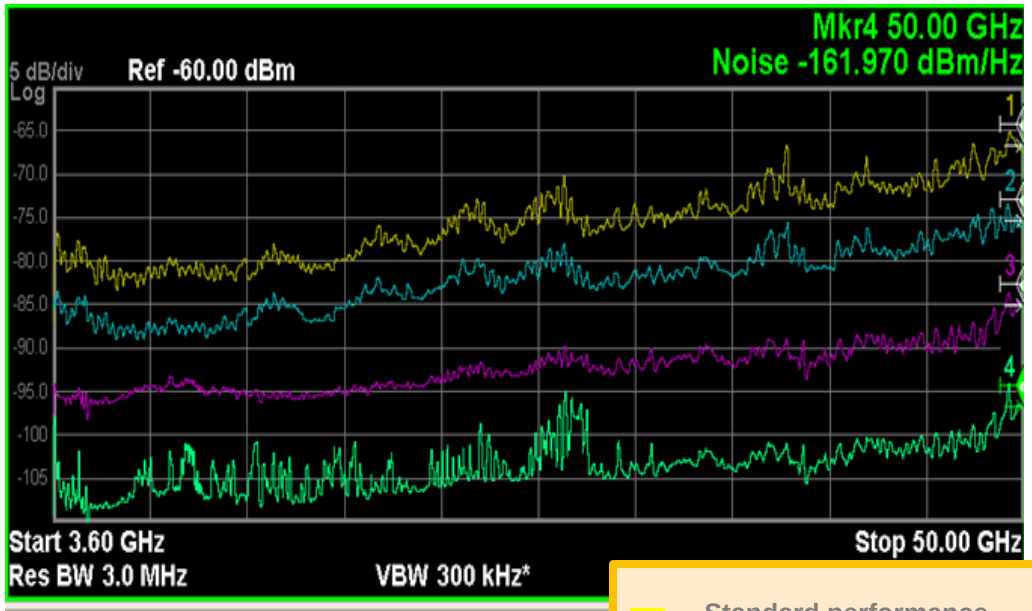
Specifications

Frequency Range

Description	Specifications
Internal Mixing	
Bands	
0	**3 Hz to 3.6 GHz**
1	**3.5 to 8.4 GHz**
2	**8.3 to 13.6 GHz**
3	**13.5 to 17.1 GHz**
4	**17 to 26.5 GHz**
5	**26.4 to 34.5 GHz**
6	**34.4 to 50 GHz**



Unprecedented Signal Insight to Millimeter-wave



Unprecedented signal insight

- Unmatched sensitivity to 50 GHz
- Highest third-order dynamic range
- Superior close-in phase noise performance
- The industry's most accurate analyzer

Ideally suited for aerospace/defense

- Advanced radar
- Satellite communications
- Surveillance
- Military communications

Extend Unmatched Performance with External Mixing

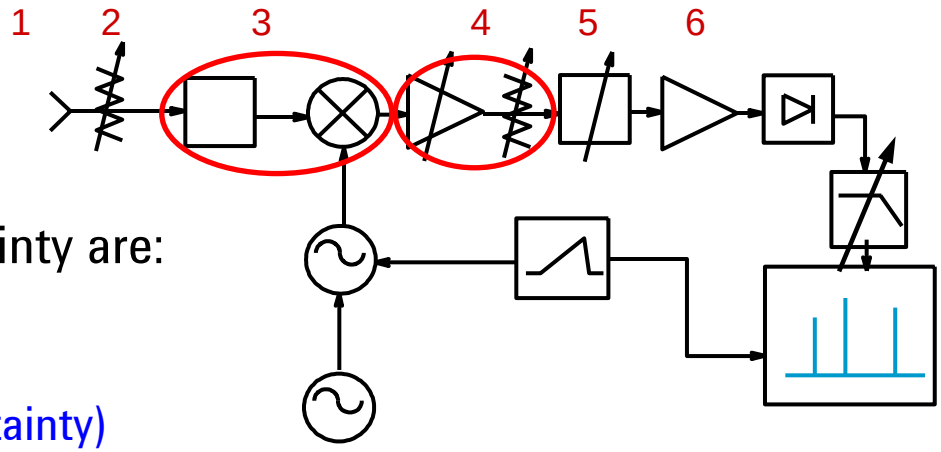
Extend to 325 GHz and beyond

- Supported measurements
  - Spectrum analysis
  - PowerSuite one-button power measurements
  - N9068A phase noise measurement application
  - 89600A VSA
- Supported external mixers
  - M1970V, M1970E and M1970W
  - 11970 Series
  - OML Inc.
  - VDI
  - And other third-party external mixers

Agilent Technologies

Specifications

Accuracy: Frequency & amplitude (pag. 40 AN150)



Components which contribute to uncertainty are:

1 • Input mismatch (VSWR)

2 • RF Input attenuator (Atten. switching uncertainty)

3 • Mixer and input filter (frequency response)

4 • IF gain/attenuation (reference level accuracy)

5 • RBW filters (RBW switching uncertainty)

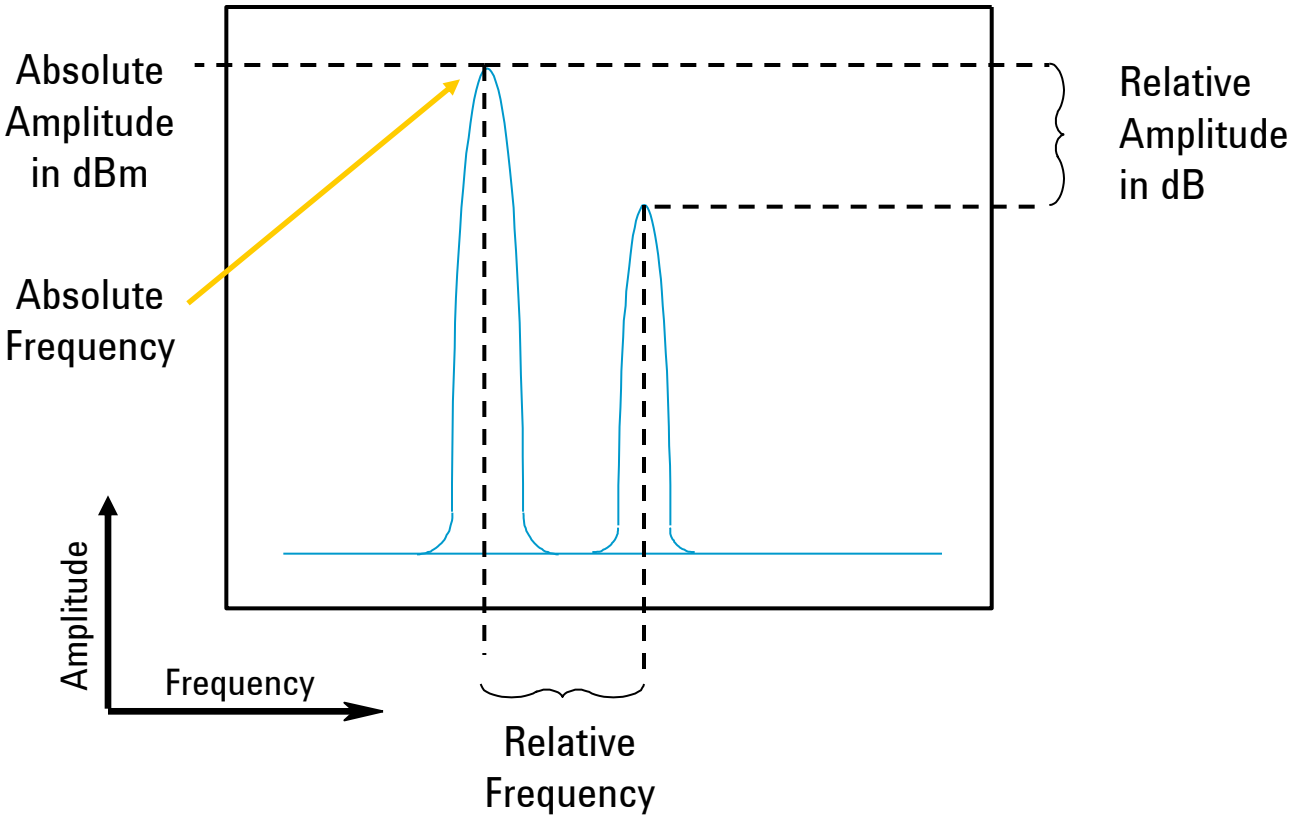
6 • Log amp (display scale fidelity)

• 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 PXA Data Sheet:

± (marker frequency x freq reference accuracy + 0.1%*span + 5% of RBW + 2Hz + 0.5 x Horiz. Res.*)

Determined by Reference Accuracy

RBW Error
IF filter center frequency error

Span Accuracy

Residual Error

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

Specifications

Accuracy: Frequency Readout Accuracy Example

Frequency: 1 GHz
Span: 400 kHz
RBW: 3 kHz
Sweep points: 1000

Calculation :

$(1x10^{9}Hz) \times (\pm 1.55x10^{-7}/Year$ ref. Error)	= **155Hz**	Referencia
400kHz Span x 0.1%	= **400Hz**	Span
3kHz RBW x 5%	= **150Hz**	RBW
2Hz + 0.5 x 400kHz/(1000-1)	= **202Hz**	Residual
Total uncertainty	= **±907Hz**	

*Utilizing internal frequency counter improves accuracy to ±155Hz

** The Maximum # of sweep points for the X-Series is 40,001 which helps to achieve the best frequency readout accuracy

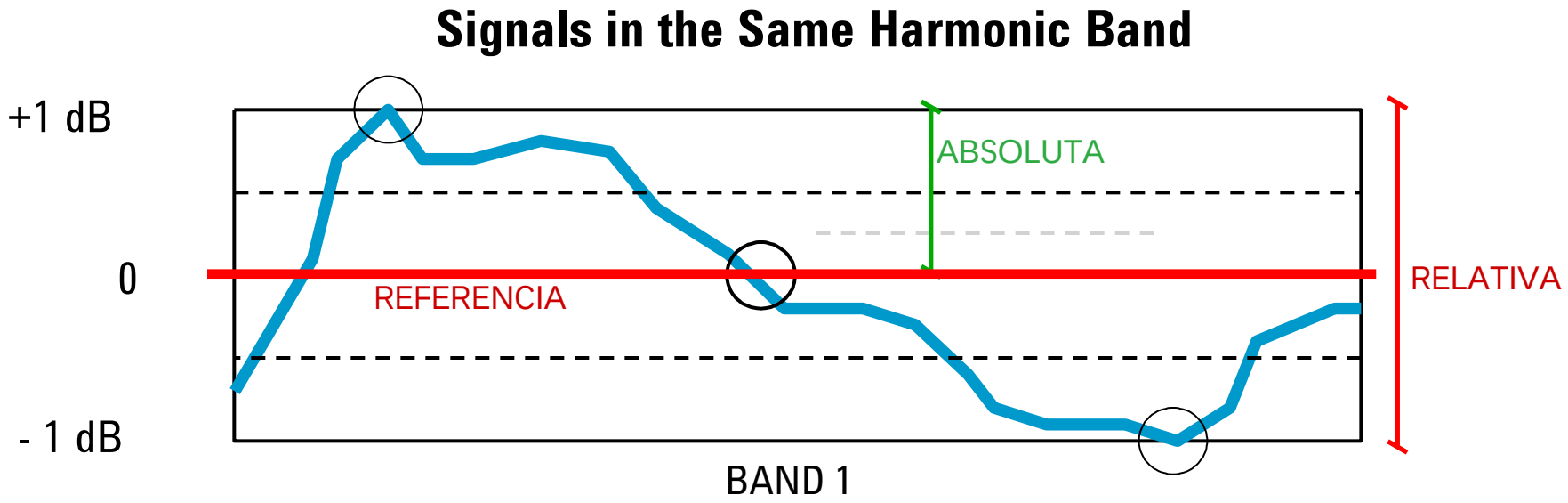
Specifications

Accuracy: Key Amplitude Uncertainty Contributions

		PXA Uncertainties	
Relative			
• Input impedance mismatch		(±0.13 dB)	
• Input attenuator switching uncertainty		(±0.14 dB)	Si se cambia durante el proceso de medicion.
• Frequency response		(±0.35 dB)	De todos los elementos HASTA EL MIXER INCL.
• Reference level accuracy	(+- 1 dB)	~~(0 dB)~~	Si se cambia.Debido a AMP./ATEN. DE IF
• RBW switching uncertainty		(±0.03 dB)	Si se cambia. Distinta PERDIDA DE INS.
• Display scale fidelity		(±0.07 dB)	Debido al AMPLIFICADOR LOG O LINEAL, que cambia su amplif con la amplitud de senal.
Absolute			
• Calibrator accuracy		(±0.24 dB)	Senal interna de ref. para auto-calibracion

Specifications

Accuracy: Frequency Response

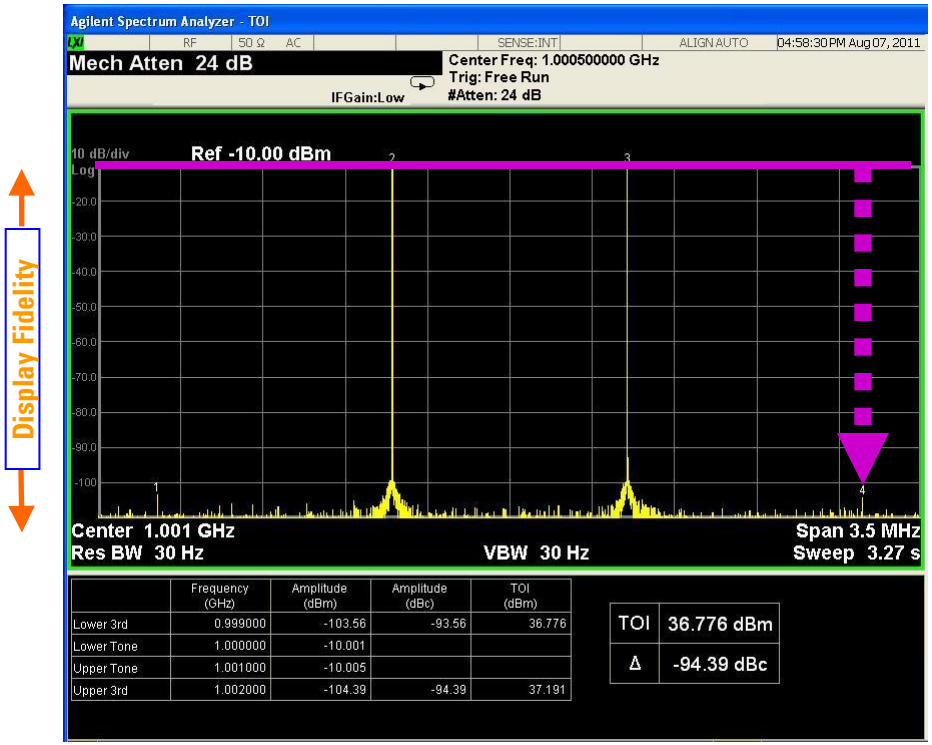


Absolute amplitude accuracy – Specification: ± 1 dB

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

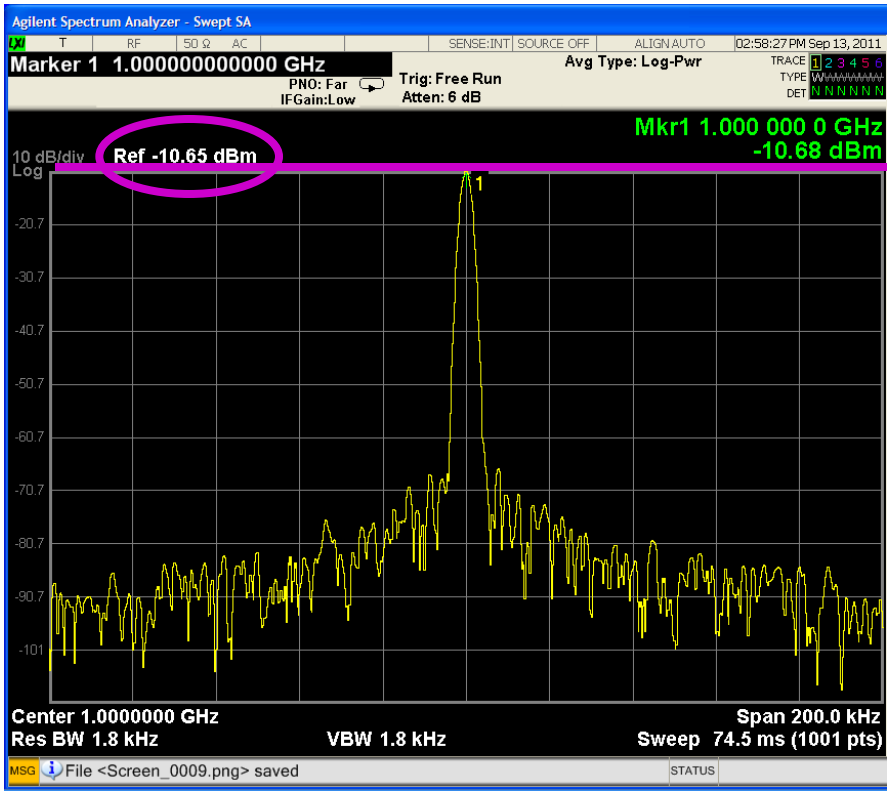
(Cuando sus amplitudes son MUY DIFERENTES.)

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

Display Scale Fidelity of analyzers with digital IF are superior to those with analog IF i.e. X-series analyzers have +/- 0.1 db vs. ESA, 856xEC +/- 1.0 db

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?

However with today's X-series analyzers, provided the attenuation remains unchanged, the signal no longer needs to be at the reference level for the most accurate measurement.

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

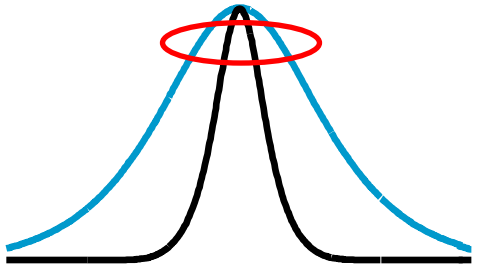
- **Traditionally, one technique for best accuracy was to move each measured signal to the reference line,** eliminating display fidelity error. However, in today's designs, display fidelity has improved to the point where there is generally less error just to leave the signals where they occur on the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

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

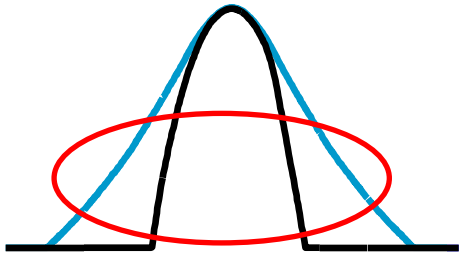
- In the absence of specified relative freq. response, the relative response uncertainty is assumed to be 2x specified absolute error.

Specifications
Resolution

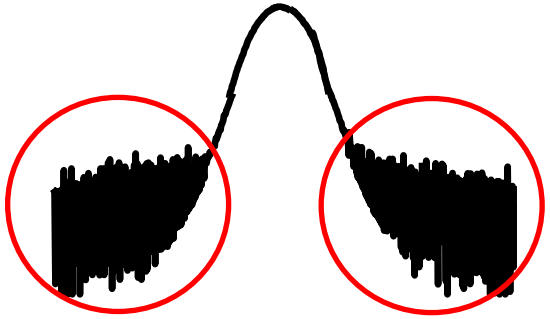
What Determines Resolution?



Resolution Bandwidth



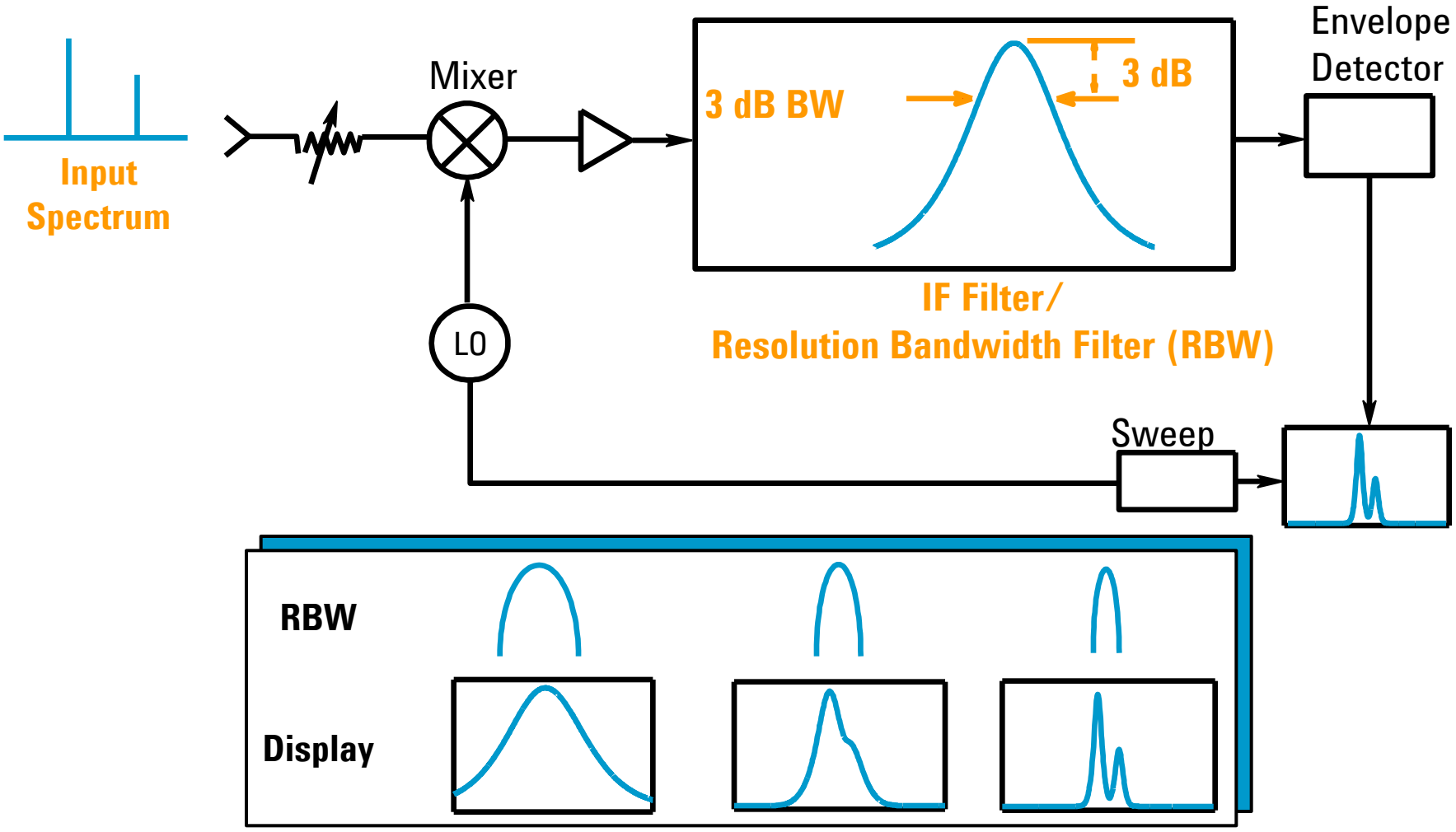
RBW Type and
Selectivity (=> FACTOR FORMA)



Noise Sidebands
Y FM RESIDUAL!

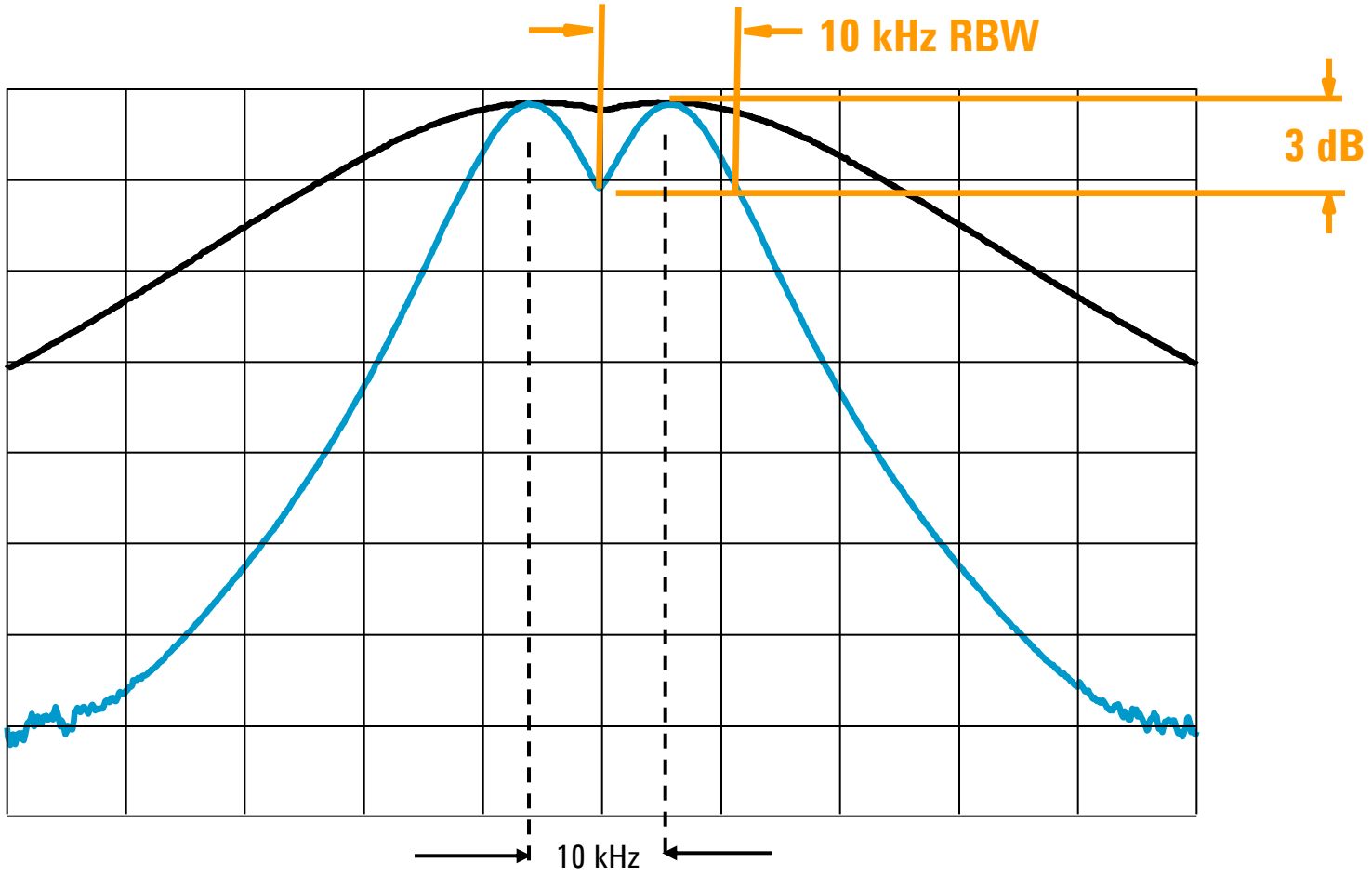
Specifications

Resolution: Resolution Bandwidth (Pags. 13/14 AN150)



Specifications

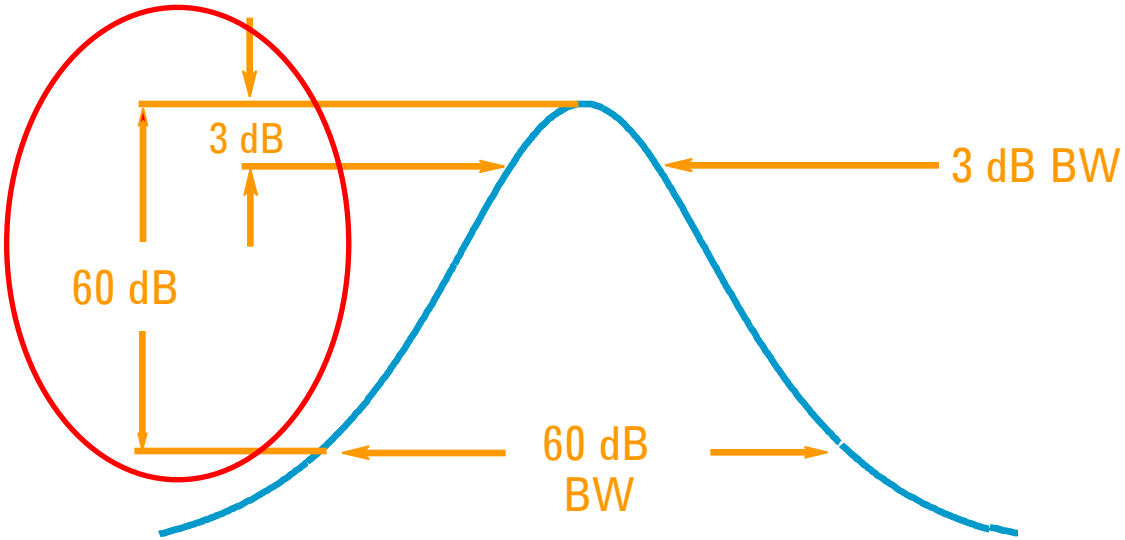
Resolution: Resolution BW



Determines resolvability of equal amplitude signals

Specifications

Resolution BW Selectivity or Shape Factor (FACTOR DE FORMA)



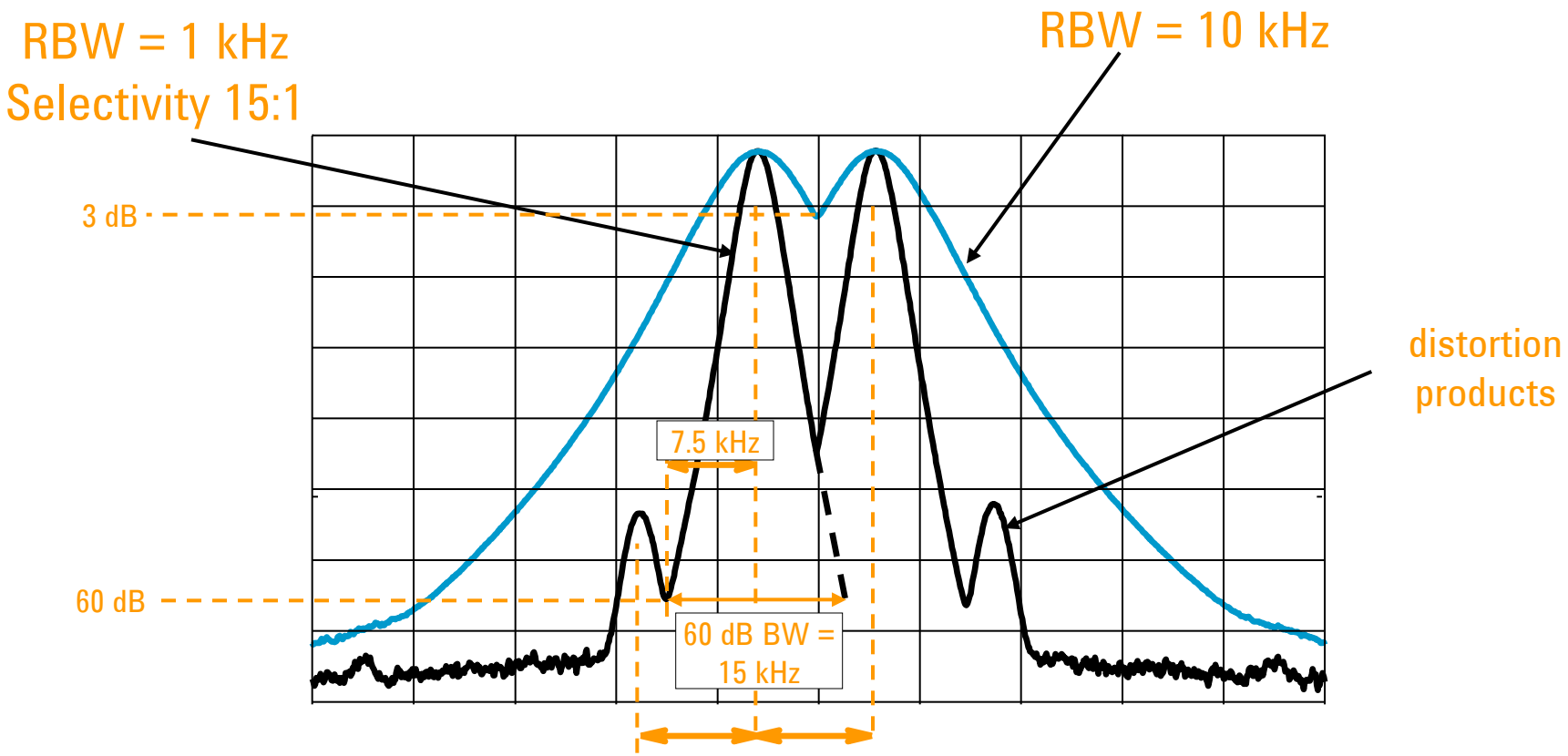
$$\text{Selectivity} = \frac{\text{60 dB BW}}{\text{3 dB BW}}$$

> 1:1 !!
(por ej. 12:1 para gaussianos analogicos)

Determines resolvability of unequal amplitude signals

Specifications

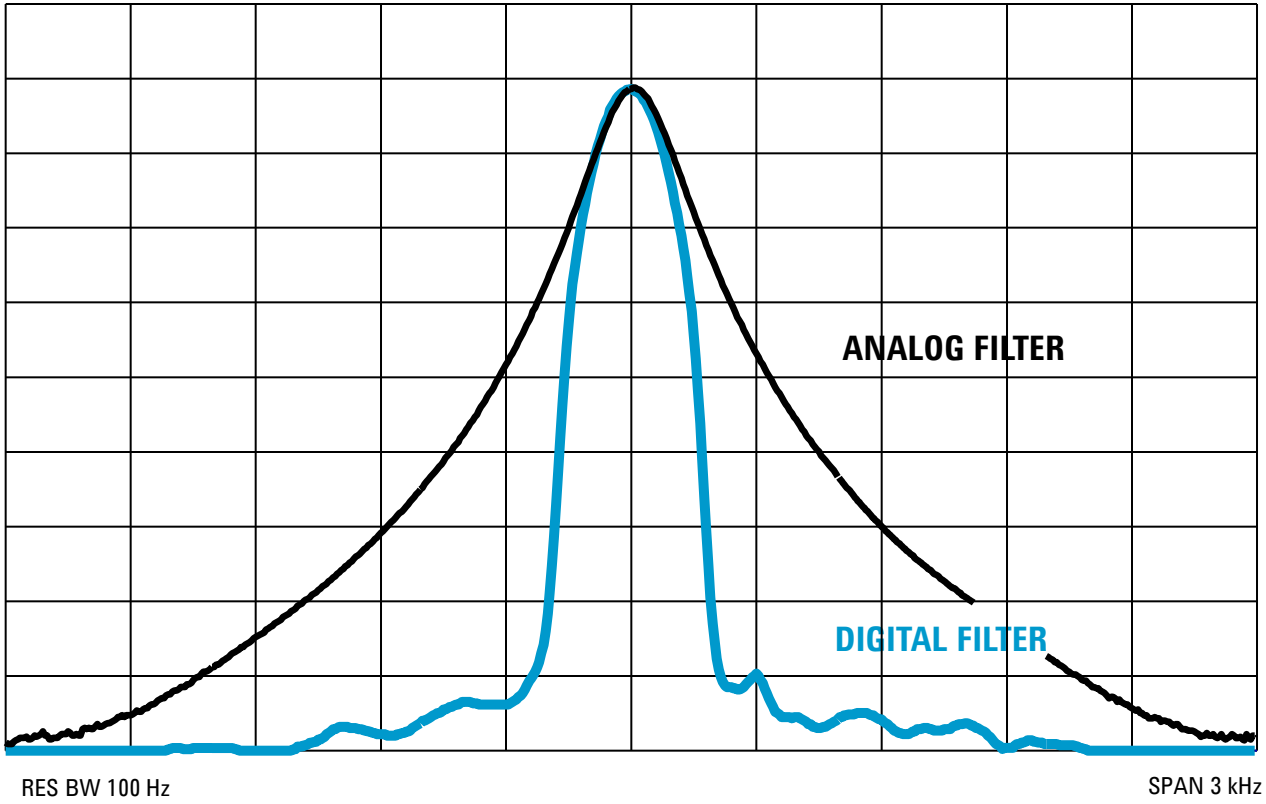
Resolution BW Selectivity or Shape Factor (pags. 14-15 AN150)



- Medicion de dos tonos separados 10 KHz
- Con RBW = 10 KHz puedo separarlos SIN SON DE IGUAL AMPLITUD (azul)
- Para diferenciar productos de distorsion A LA MISMA DISTANCIA (negro), necesito menor RBW.
- Esto es debido al efecto del FACTOR DE FORMA (o SELECTIVIDAD).

Specifications

Resolution: RBW Type and Selectivity



Typical Selectivity

Analog 15:1

Digital ≤5:1

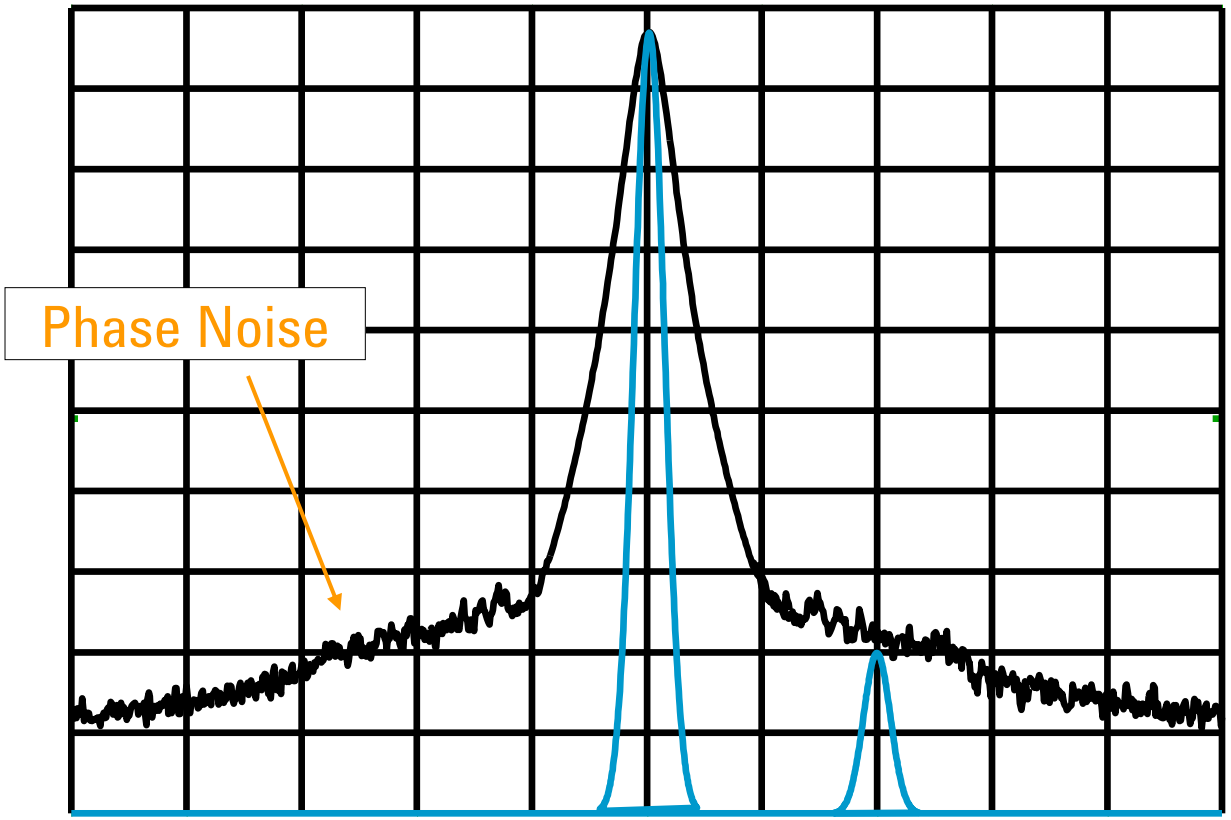
*** The X-series RBW shape factor is 4.1:1**

Specifications

Resolution: Noise Sidebands

- *Ruido de fase:* limita RANGO DINAMICO
- SE MIDE EN DB/Hz A CIERTAS DISTANCIAS DE LA PORTADORA

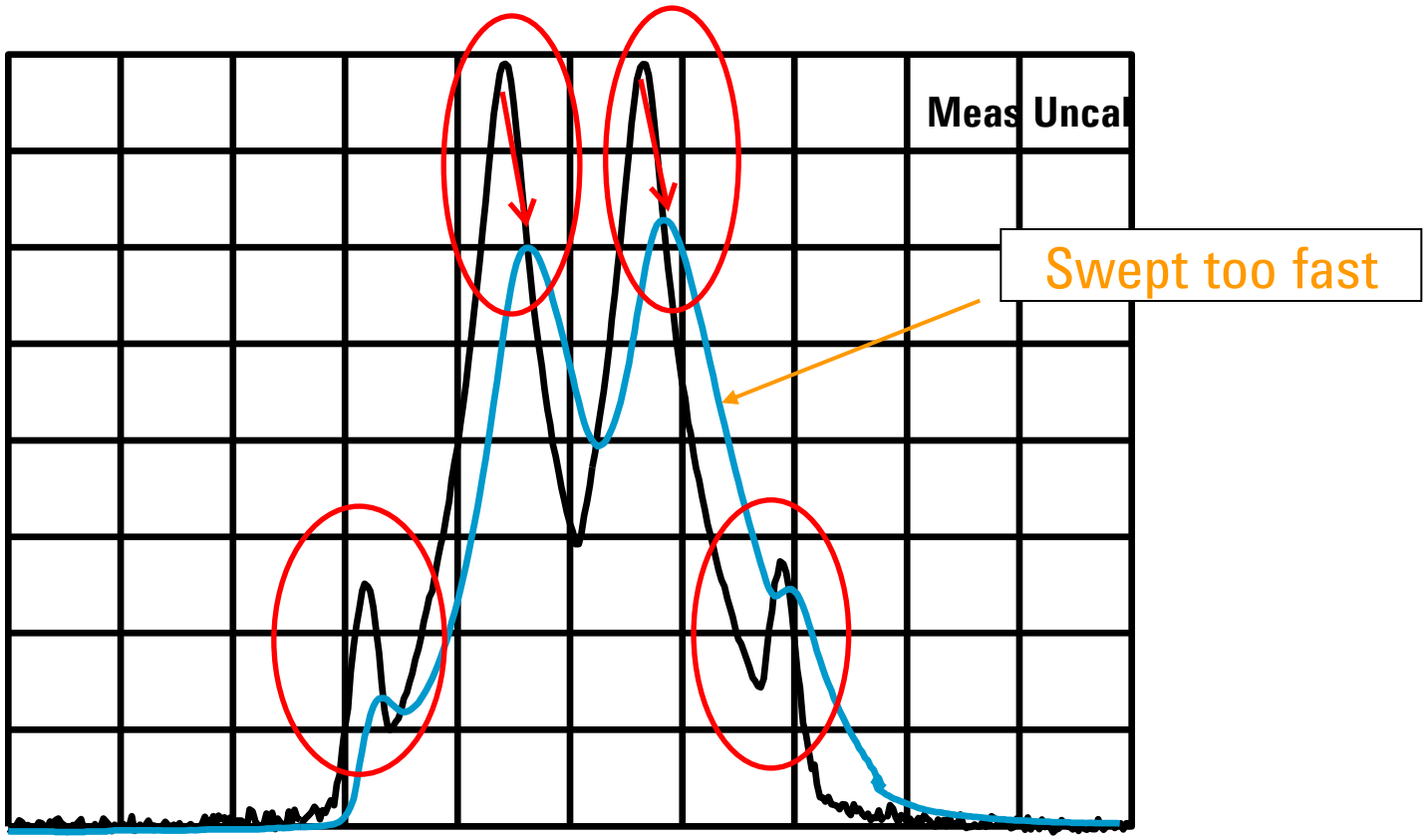
- *FM residual:* limita RESOLUCION en frec.



Noise Sidebands can prevent resolution of unequal signals

Specifications

Resolution: RBW Determines Sweep Time



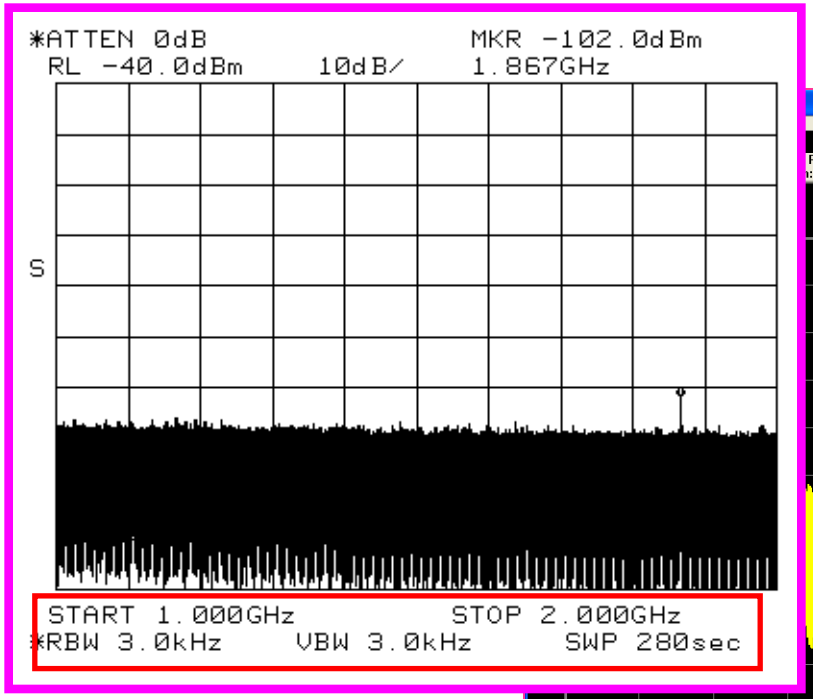
Penalty For Sweeping Too Fast Is An Uncalibrated Display

(Ver pag. 18 AN150)

Specifications

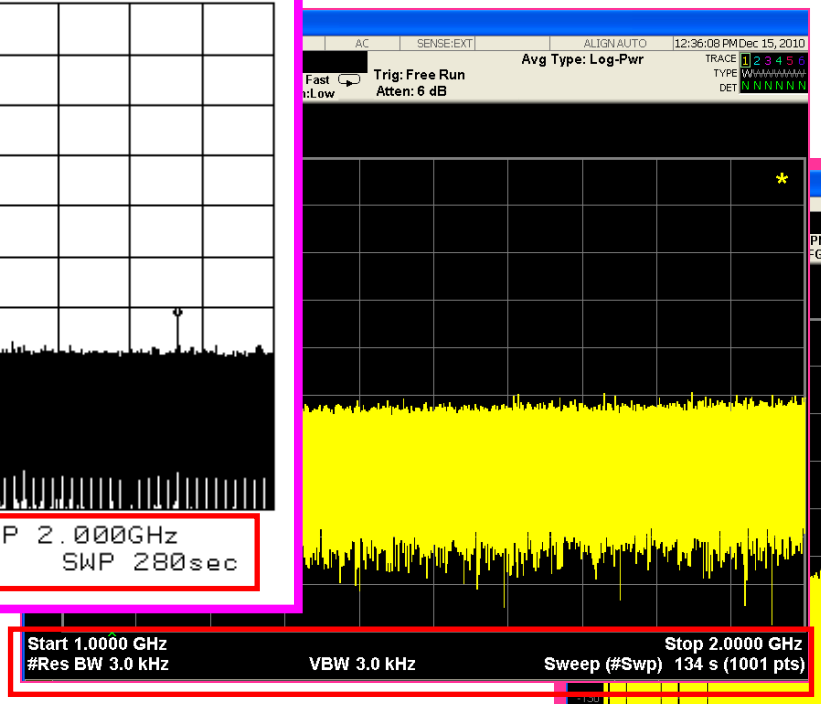
Resolution: RBW Type Determines Sweep Time

8563E Analog RBW



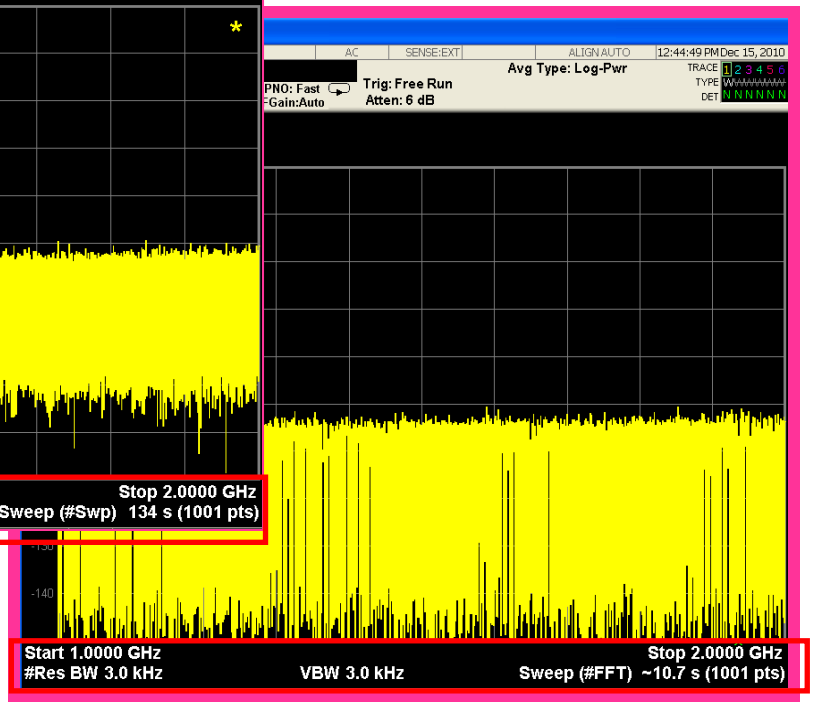
280 sec

PXA Swept RBW



134 sec

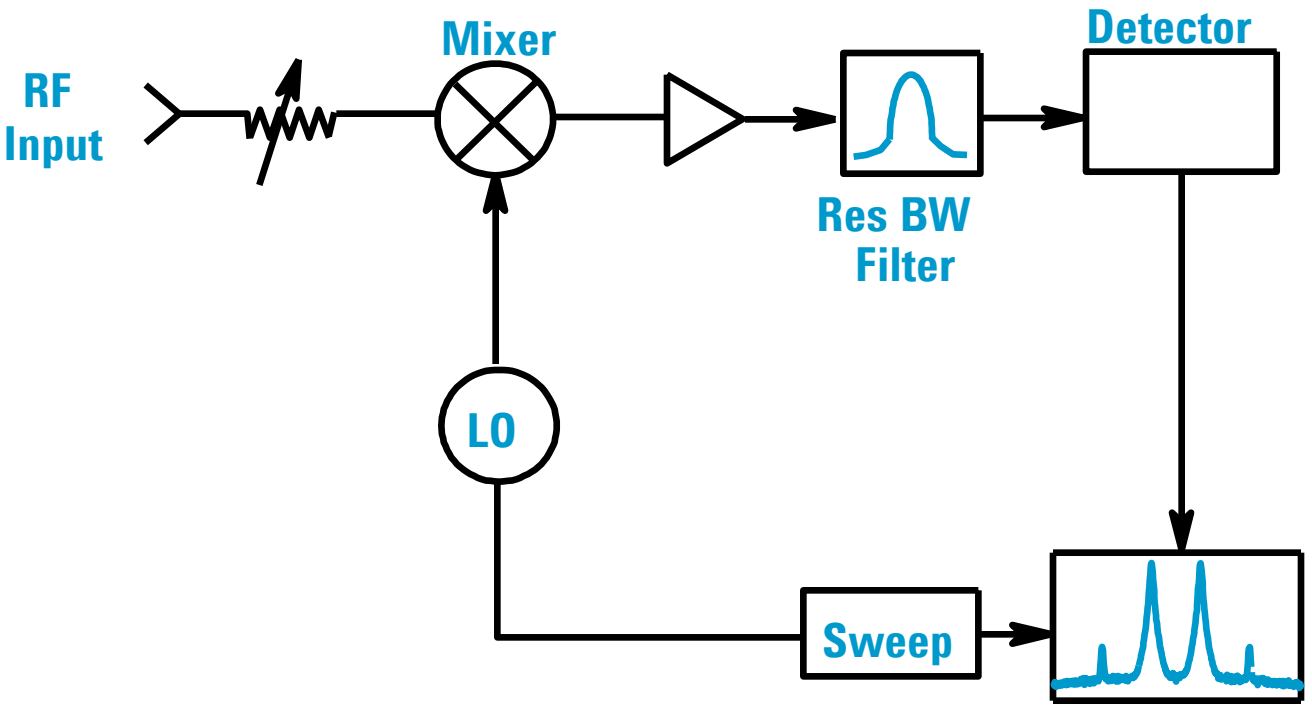
PXA FFT RBW



10.7 sec

Specifications

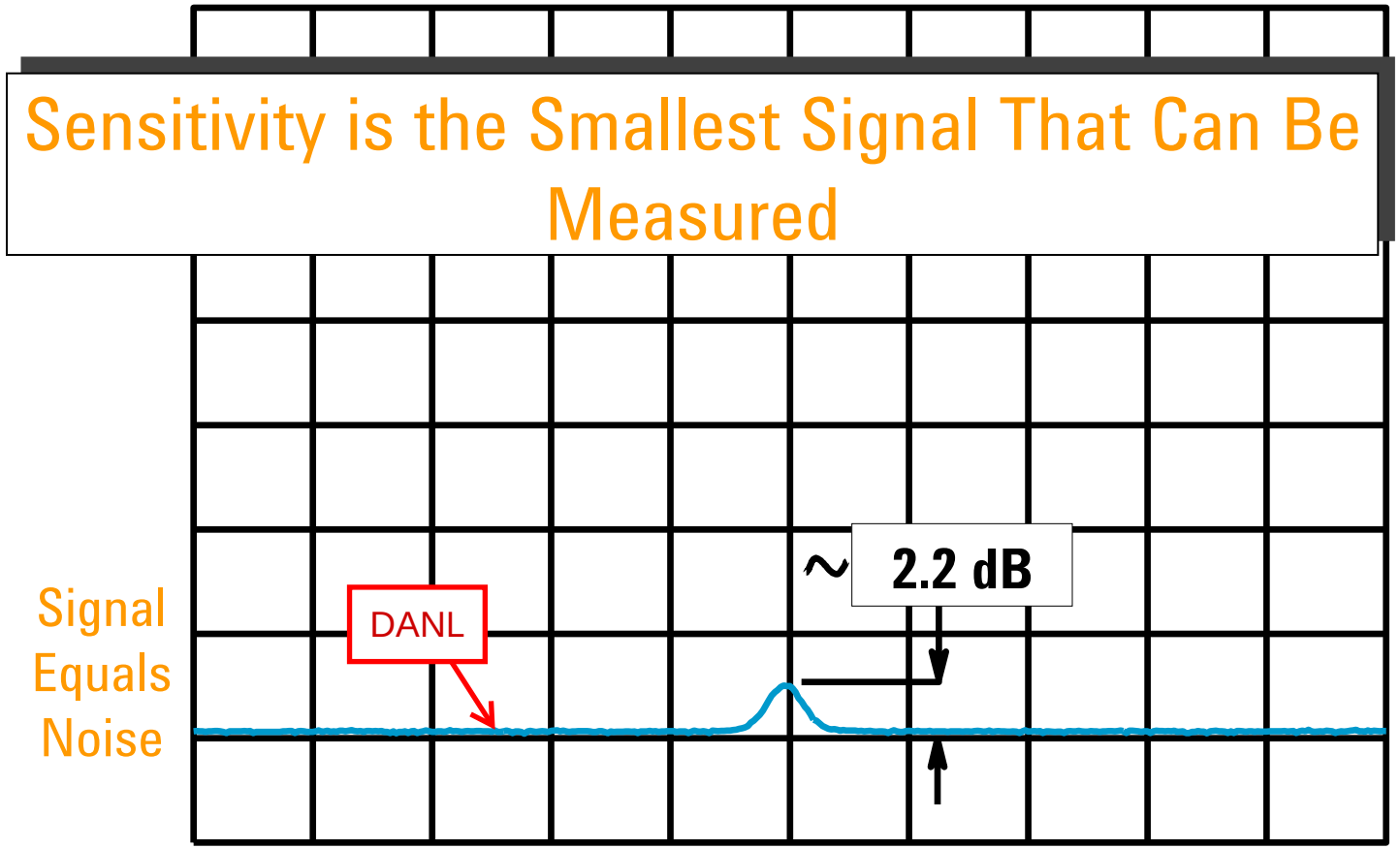
Sensitivity/DANL (pags. 46-50 AN150, ver FIGURA DE RUIDO!)



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

Specifications

Sensitivity/DANL



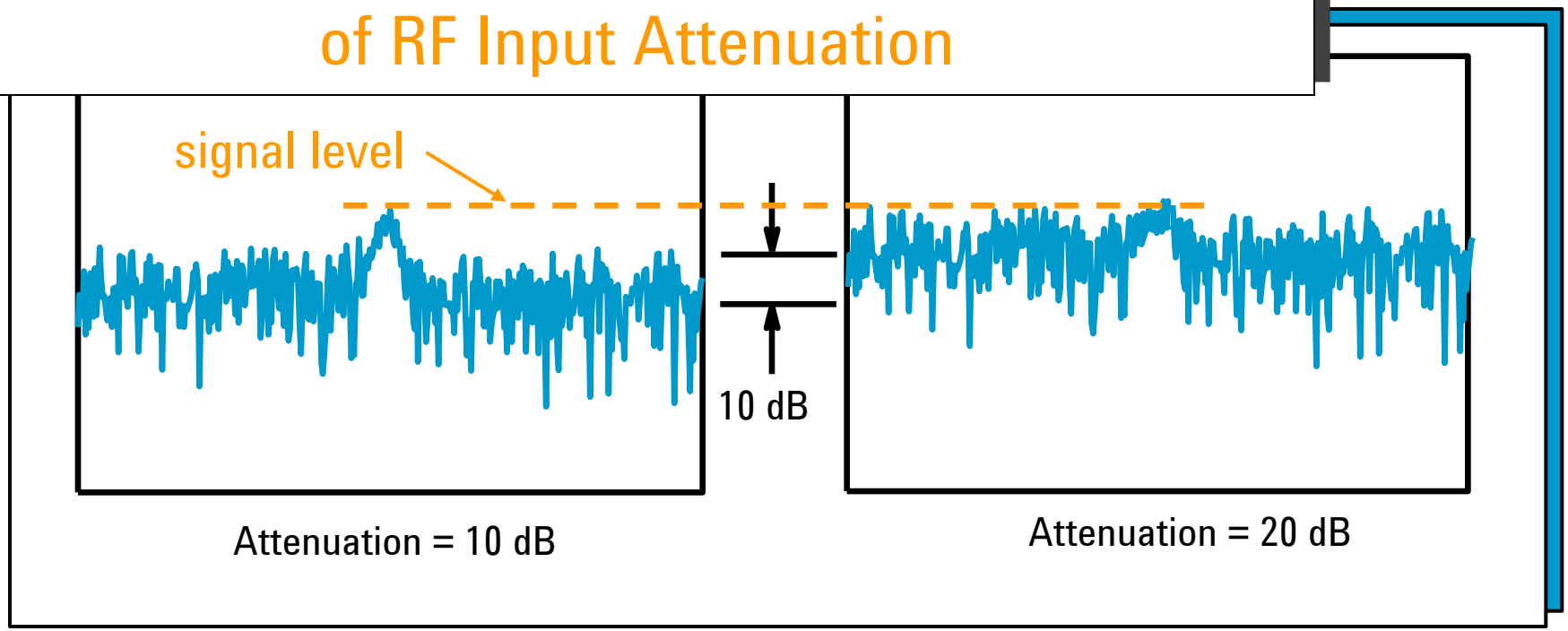
(comunmente 3dB => senal IGUAL a DANL)

"Minima senal de ENTRADA que produce un nivel en PANTALLA de 3 dB por encima del ruido, SIN ATENUACION Y PARA UN RBW DETERMINADO"

Specifications

Sensitivity/DANL

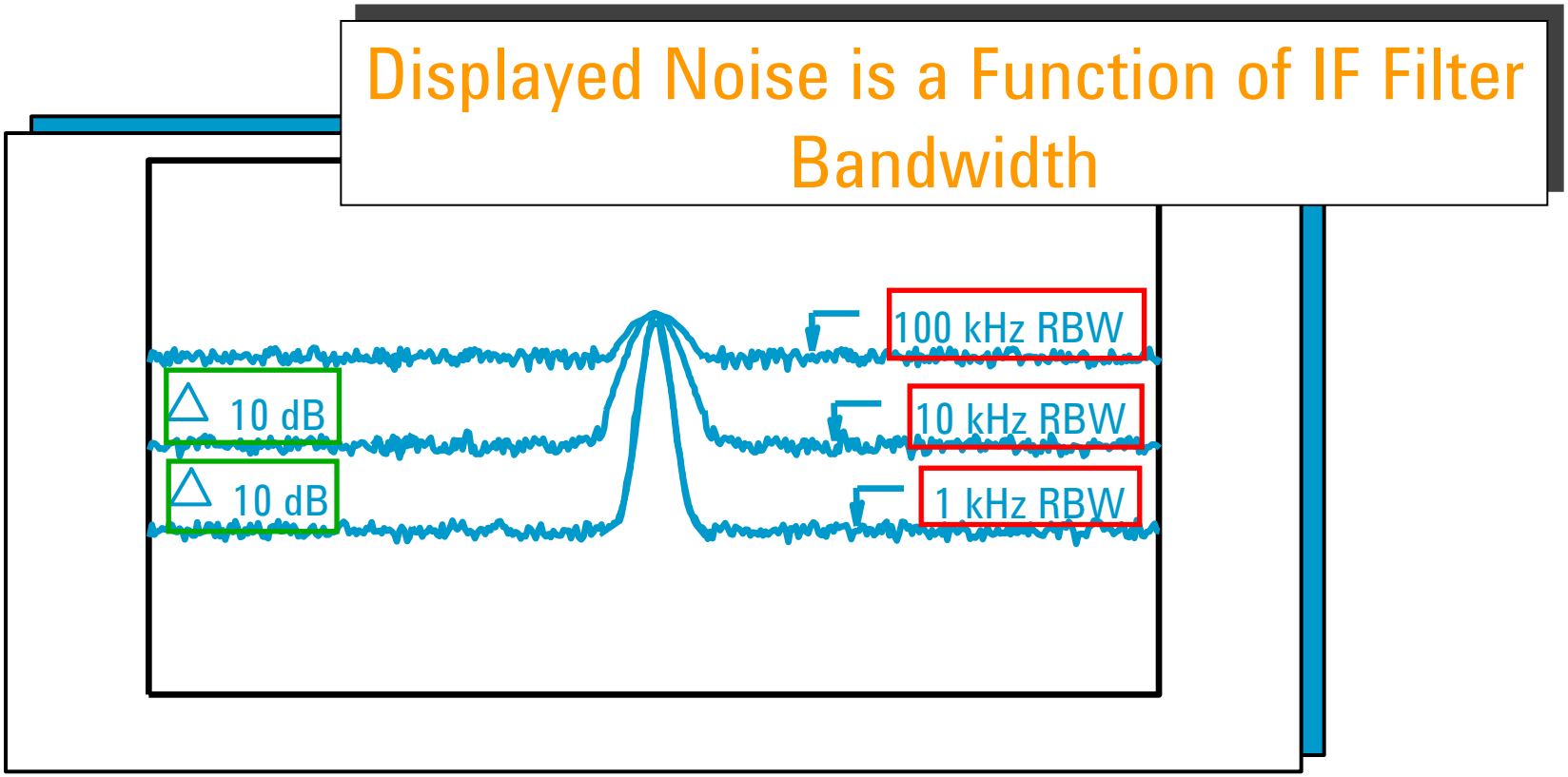
Effective Level of Displayed Noise is a Function of RF Input Attenuation



Signal To Noise Ratio Decreases as RF Input Attenuation is Increased

Specifications

Sensitivity/DANL: IF Filter(RBW)

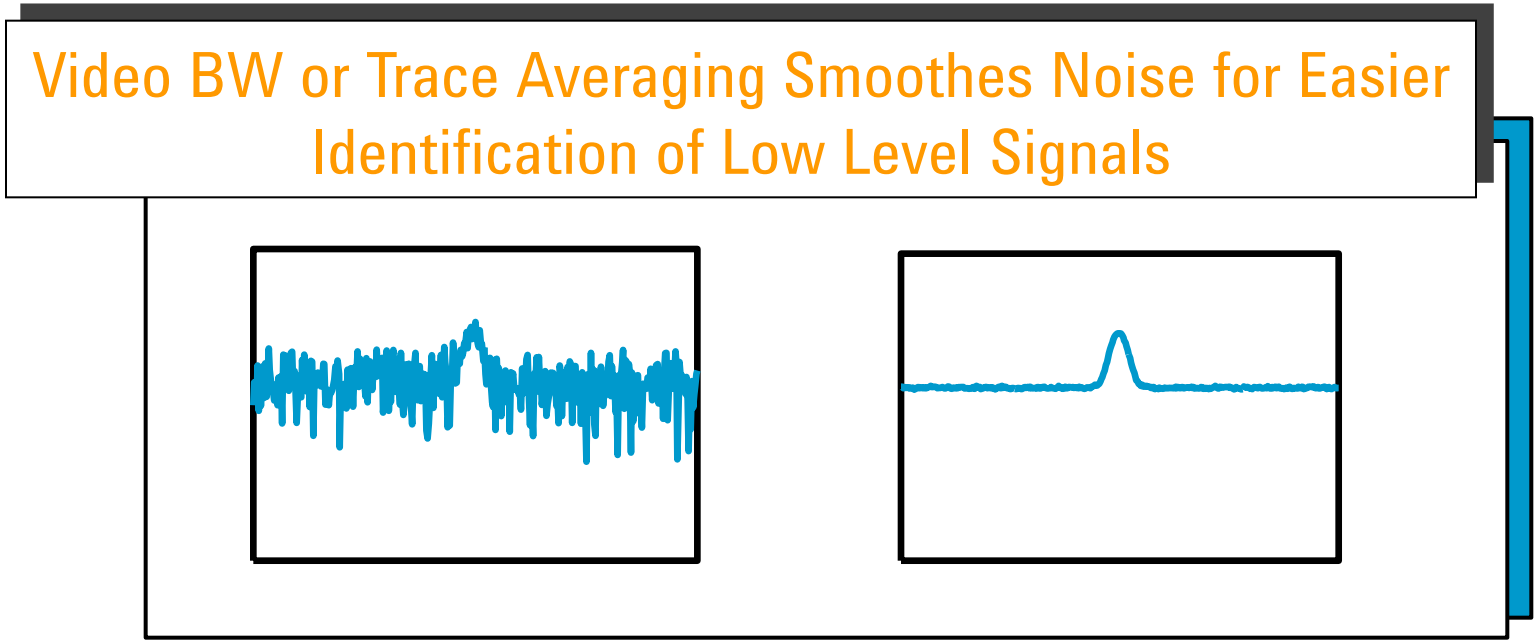


Decreased BW = Decreased Noise

x10 RBW => +10 dB DANL
/ 10 RBW => -10 dB DANL

Specifications

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

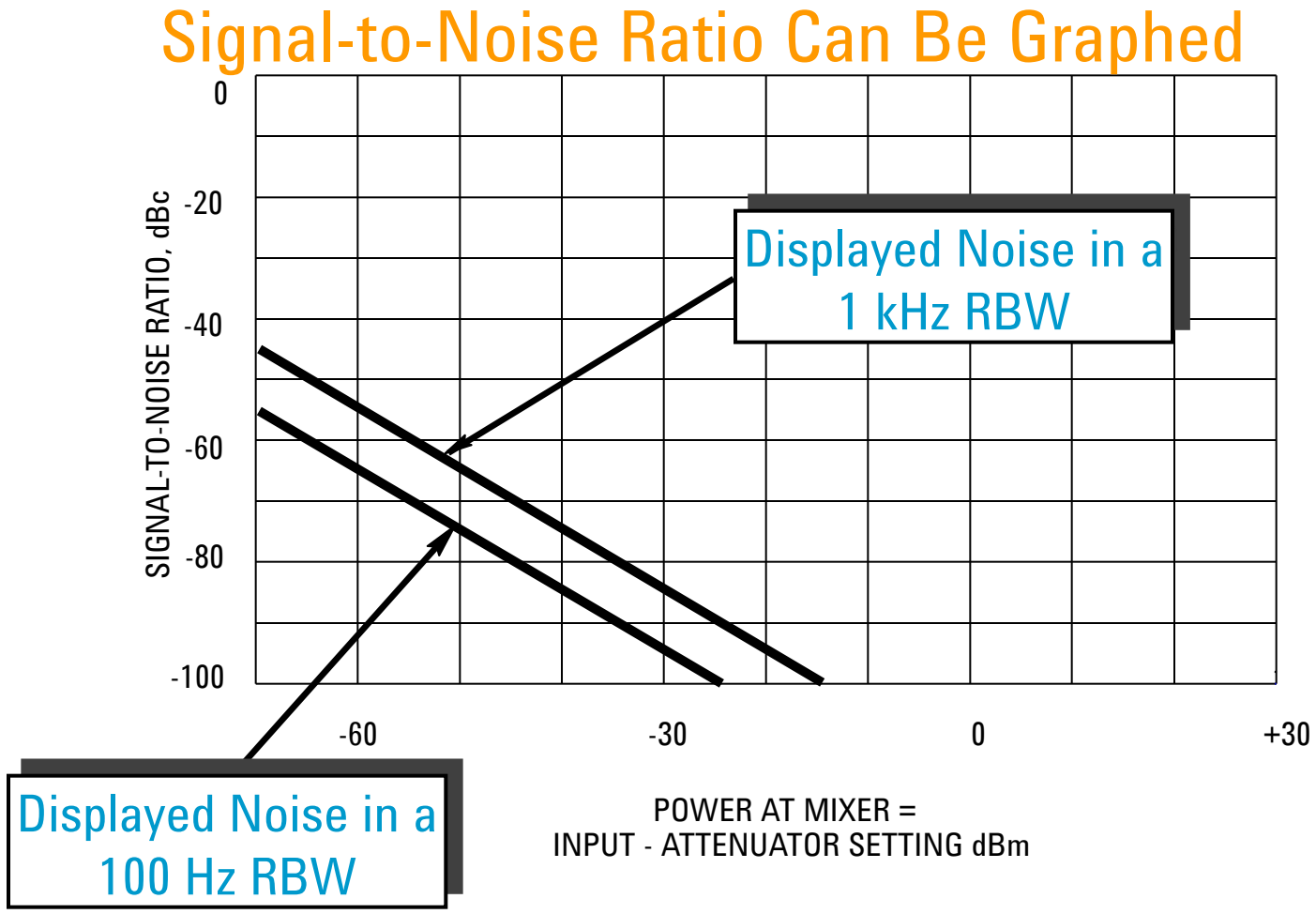


DANL = ruido entrada + efecto del RBW + efecto de la figura de ruido
DANL = -174 dBm (kTB|1Hz) + 10 log RBW + NF
=> NF = DANL - 10 log RBW - kTB

Ejemplo: Si DANL = -110dBm y RBW = 10 KHZ: NF = 24 dB, por lo tanto en este caso:
"Una senal debe estar 24 dB arriba del ruido para estar 3 dB arriba del DANL (o sea para ser IGUAL al DANL)"

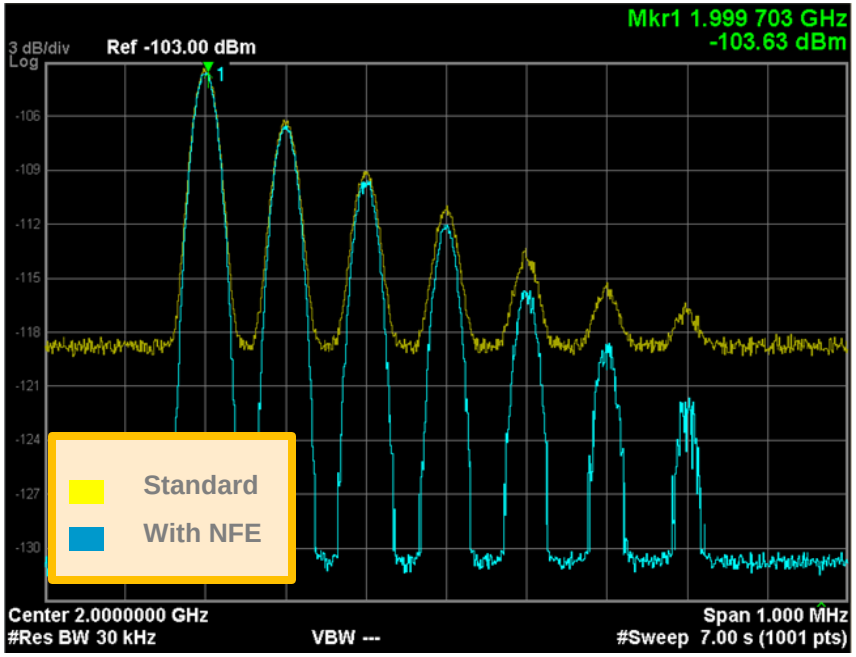
Specifications

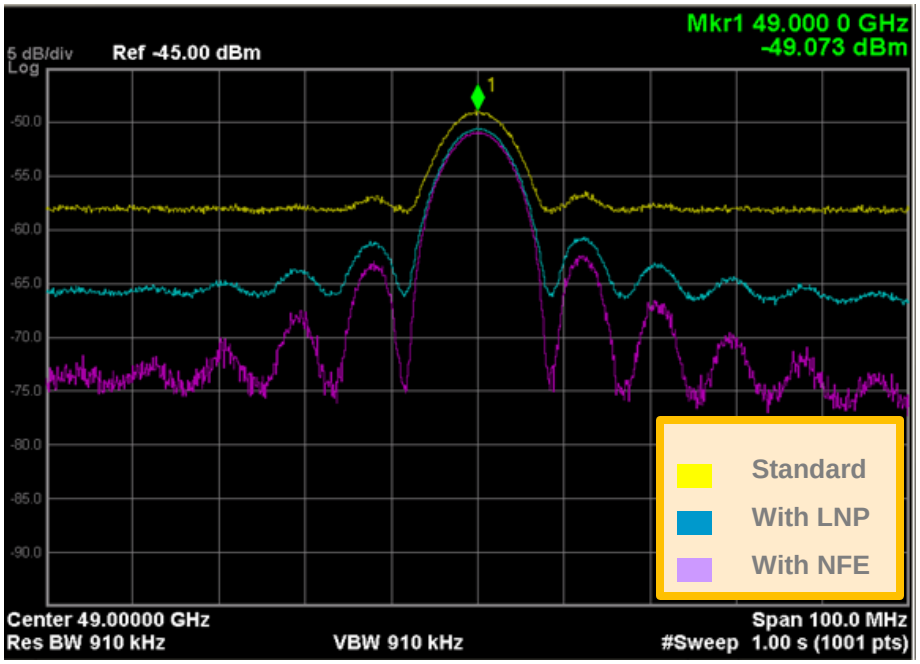
Sensitivity/DANL:



Standard feature that improves DANL for the PXA

Noise Floor Extension

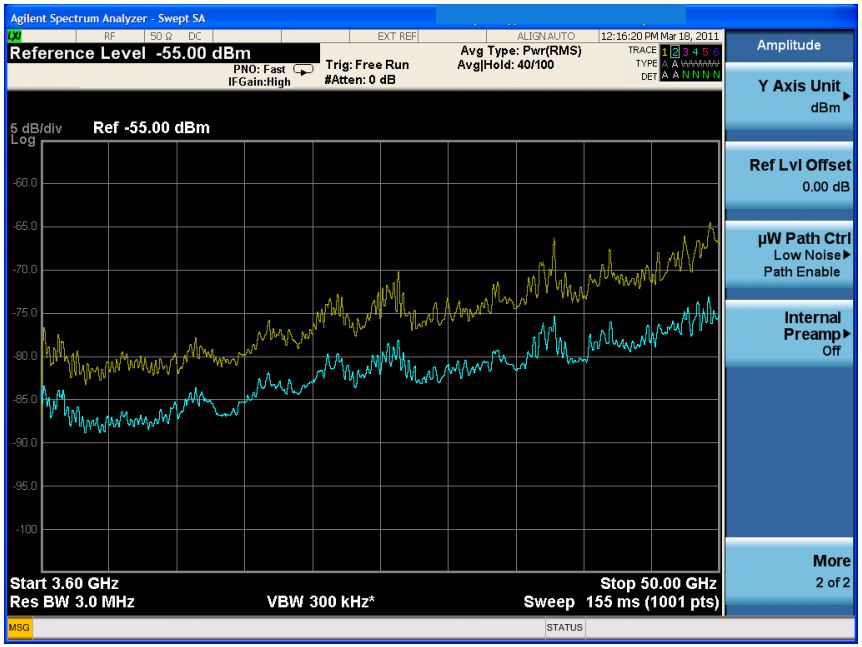


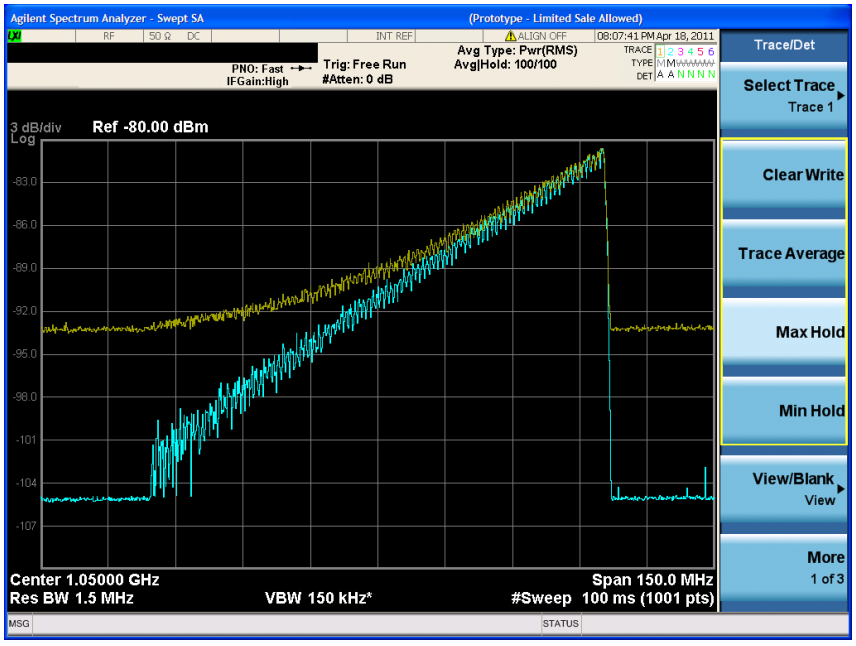


- The PXA combines real-time measurement processing with an unprecedented characterization of the analyzer's own noise to allow that noise to be accurately removed from measurements.
- The improvement from *noise floor extension* varies from RF to millimeter wave. At RF, from about 3.5 dB for CW and pulsed signals to approximately 8 dB for noise-like signals, and up to 12 dB or more in some applications.
- DANL at 2 GHz is –161 dBm without a preamp and –172 dBm with the preamp.

Hardware Option that improves DANL for the PXA

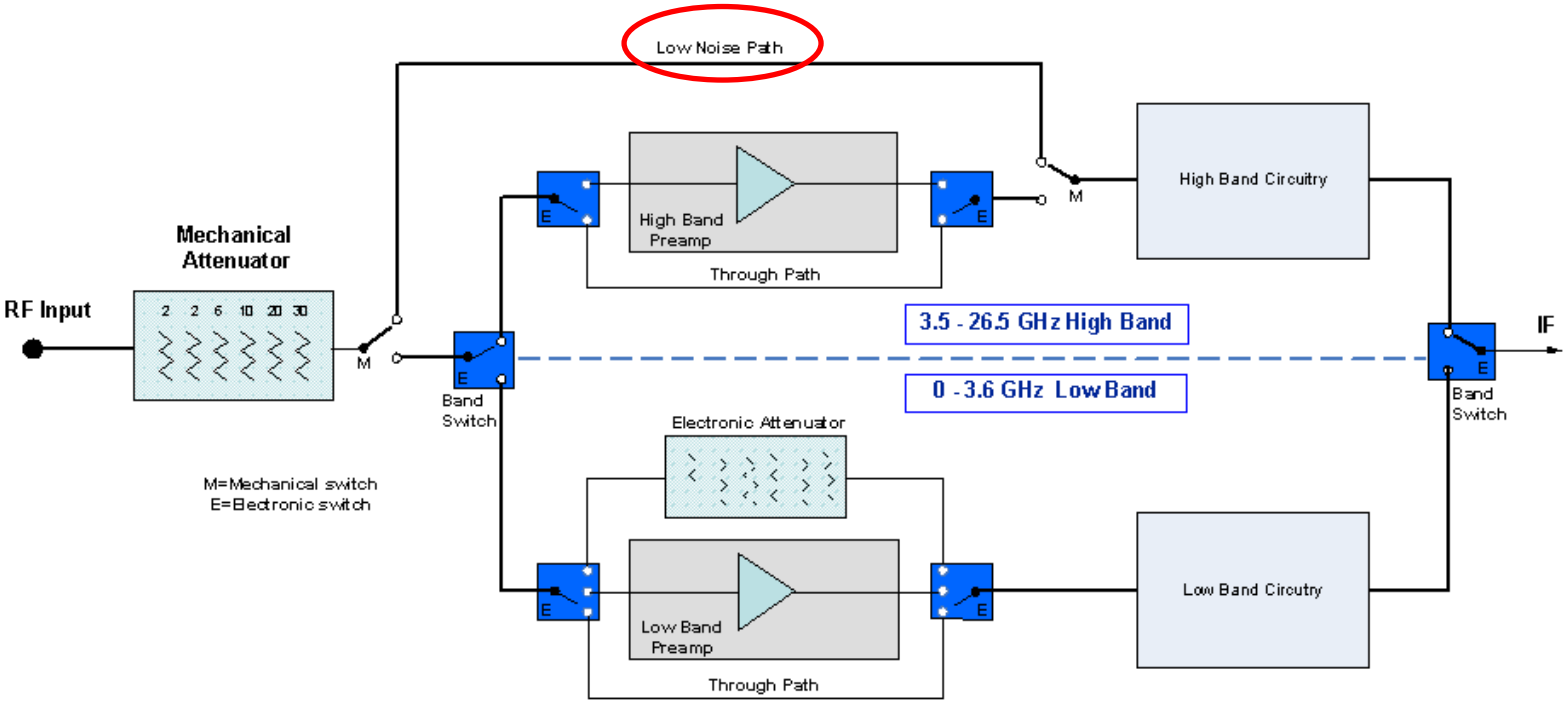
Low Noise Path (LNP)





- At microwave frequencies any sort of signal routing or switching results in signal path loss.
- Preamplifiers can compensate for this loss and improve signal/noise for small signals, but they can cause distortion in the presence of larger signals
- LNP allows the “lossy” elements normally found in the RF input chain to be completely bypassed for highest sensitivity without a preamplifier
- LNP allows measurements of small spurs w/o speed penalty imposed by narrow RBW that would otherwise be needed for adequate noise level

LNP Block Diagram



Specifications

Sensitivity/DANL: Summary

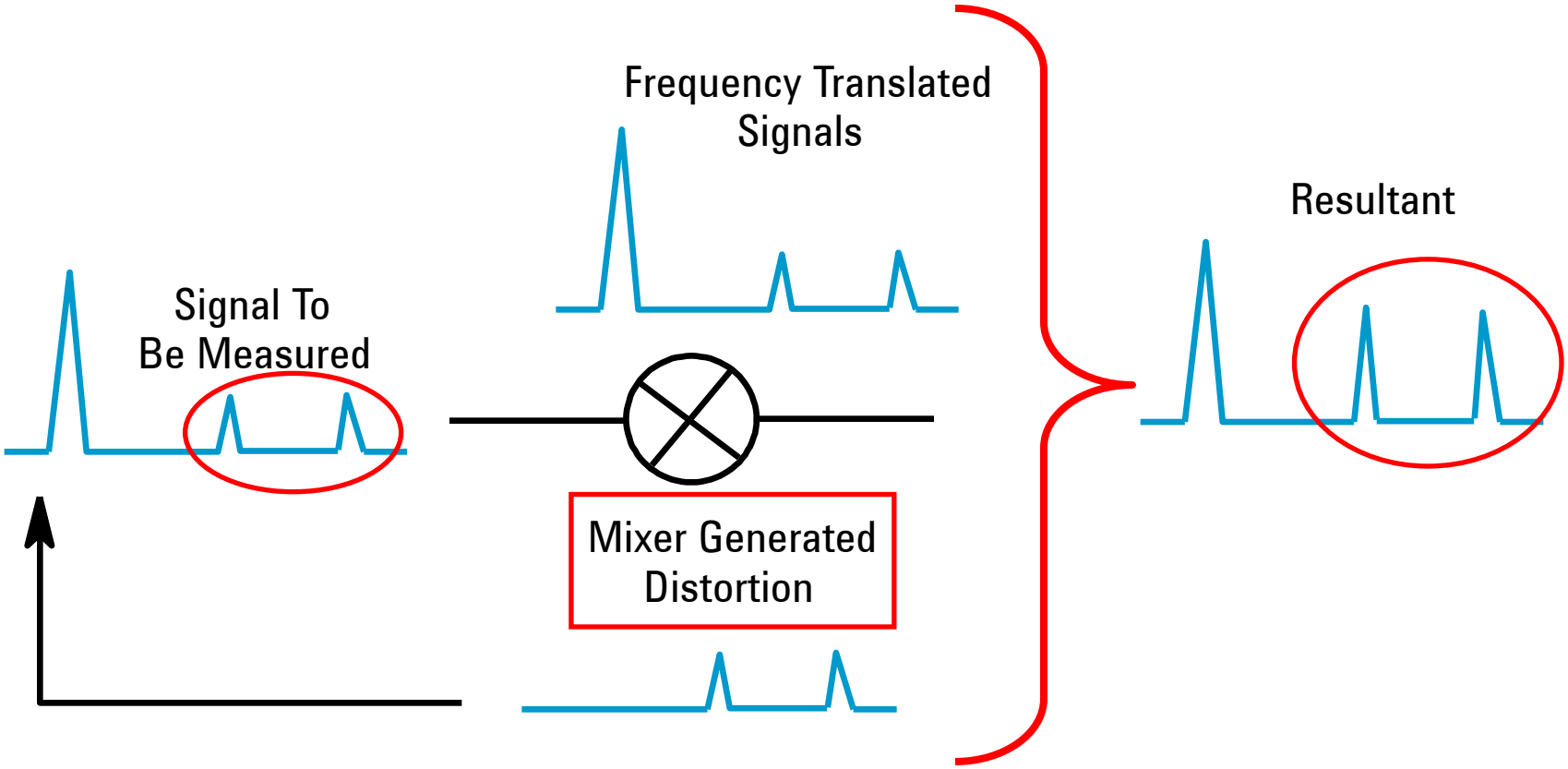
For Best Sensitivity Use:

- Narrowest Resolution BW
- Minimum RF Input Attenuation
- Sufficient Averaging (video or trace)
- Using the Preamp also improves sensitivity
- Low Noise Path (PXA only)
- Noise Floor Extension (PXA only)

Specifications

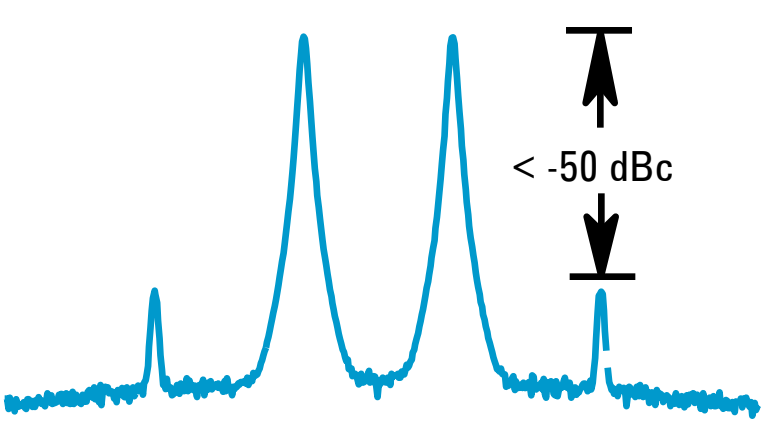
Distortion

Mixers Generate Distortion

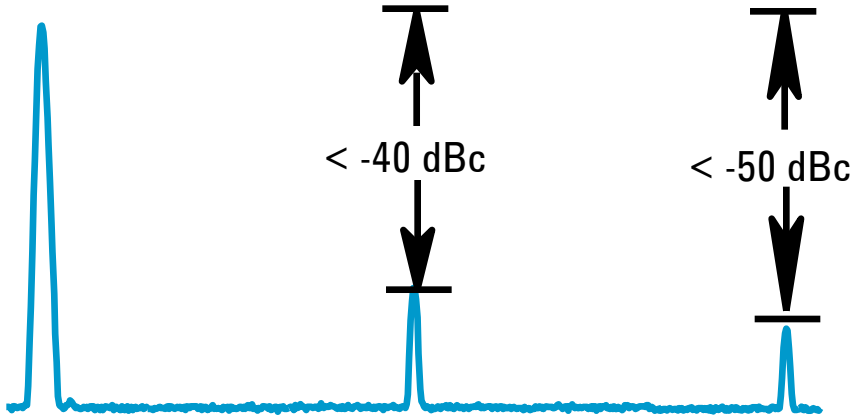


Specifications
Distortion

Most Influential Distortion is the Second and Third Order



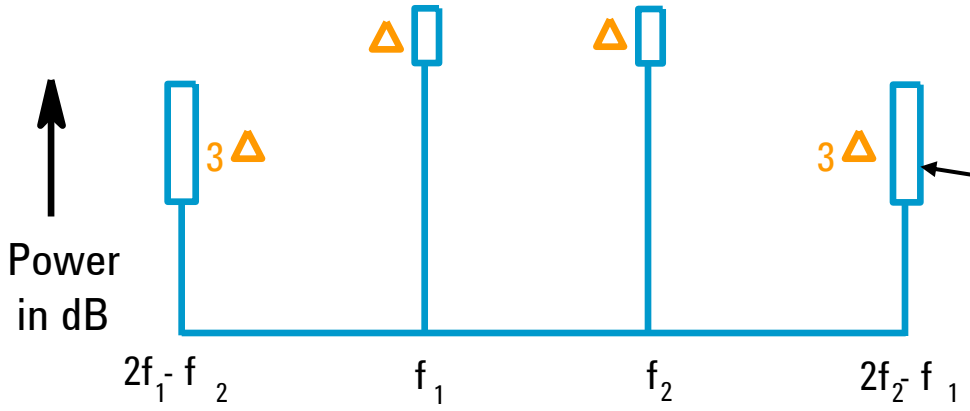
Two-Tone Intermod



Harmonic Distortion

Specifications
Distortion

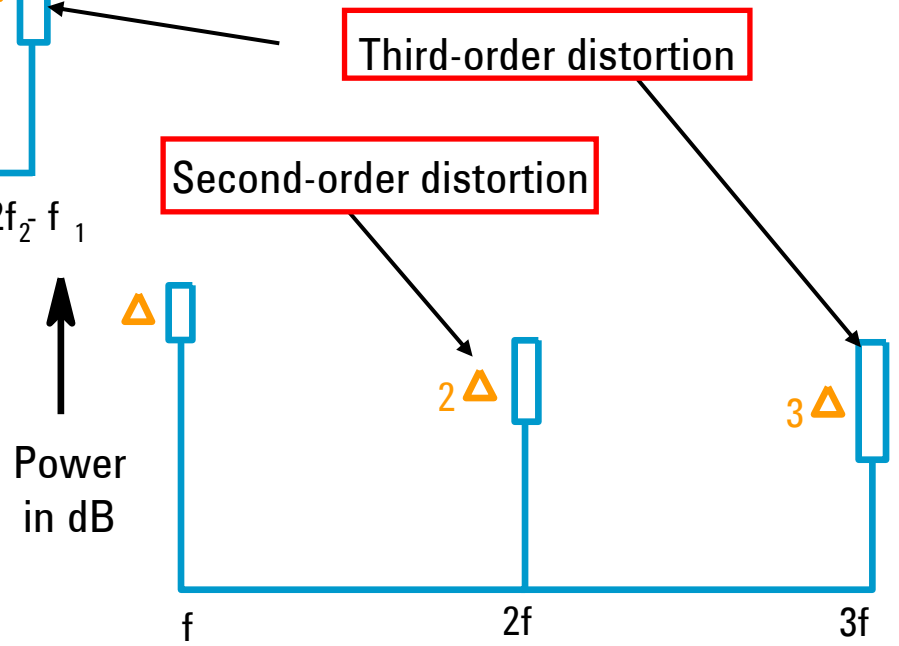
Distortion Products Increase as a Function of Fundamental's Power



Two-Tone Intermod

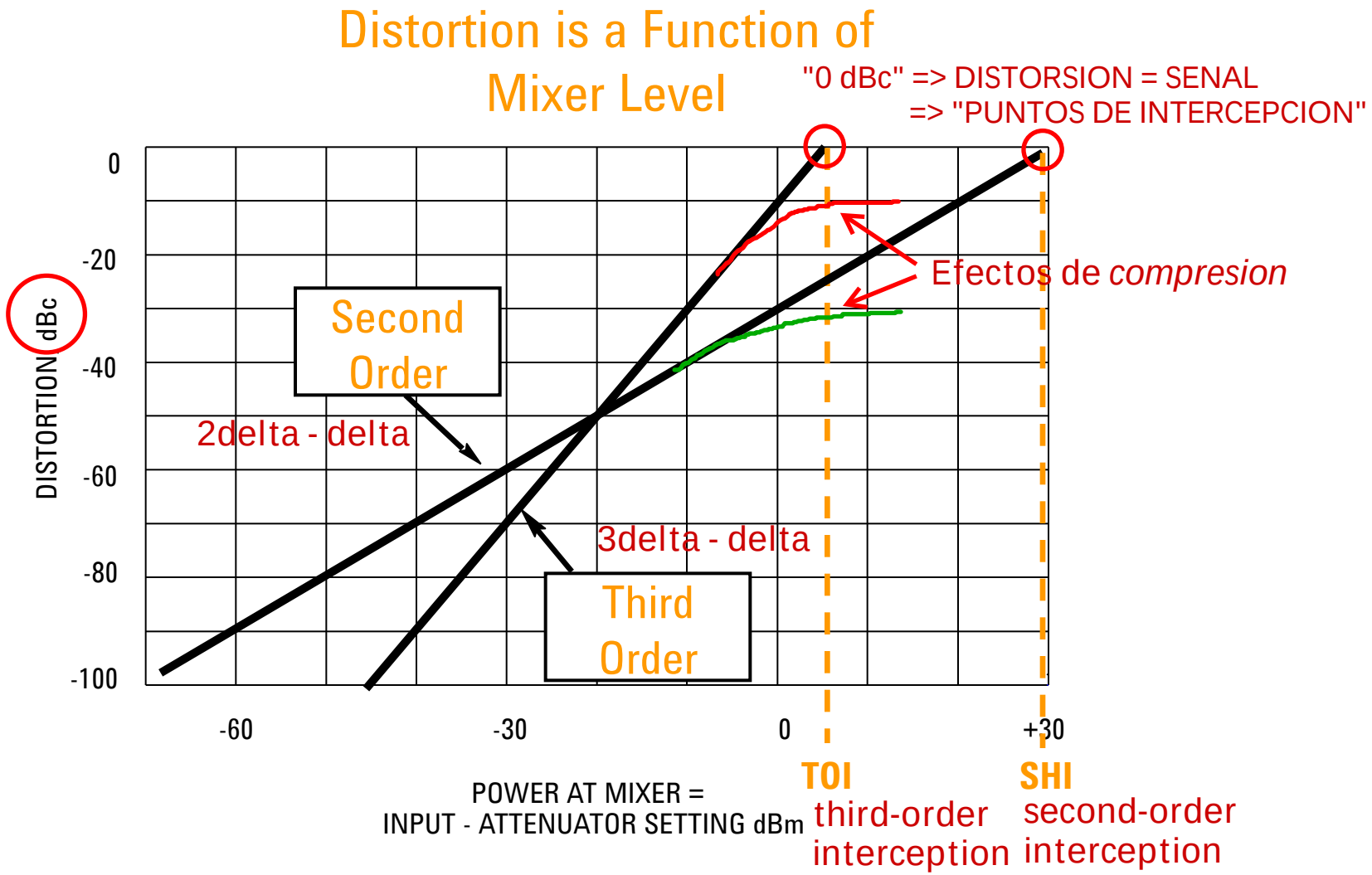
Second Order: △2 dB/dB of Fundamental
Third Order: △3 dB/dB of Fundamental

(Justificacion pag. 55 AN150)



Harmonic Distortion

Specifications
Distortion



Specifications

Distortion – Internal or External?

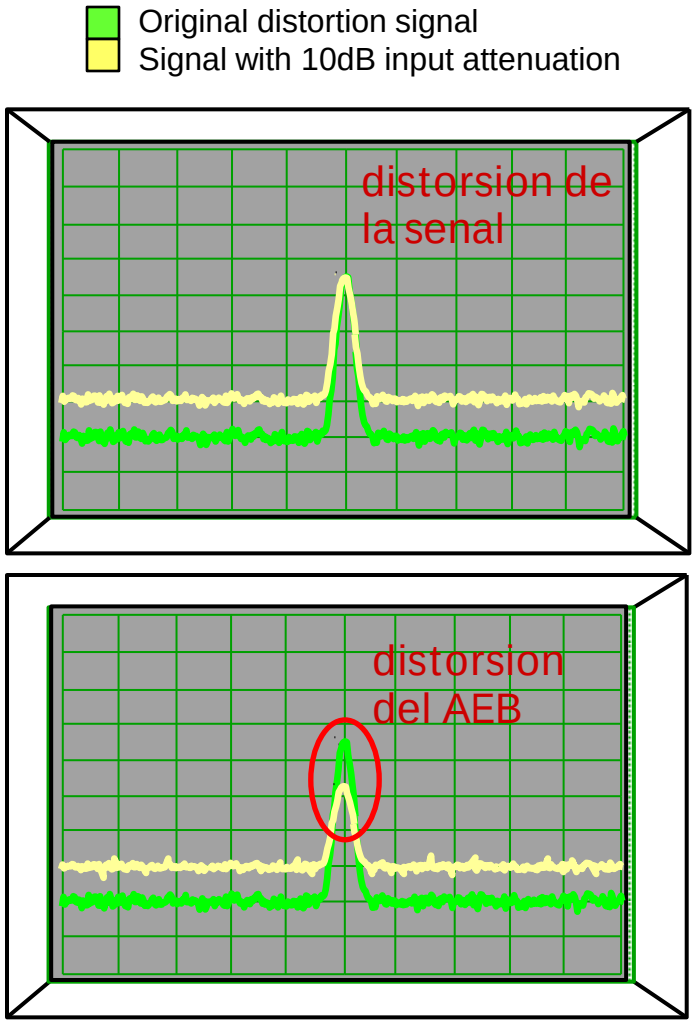
(Metodo para determinar si la distorsion proviene de mi senal o es un error introducido por el instrumento)

Attenuator Test:
Change power to the mixer

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

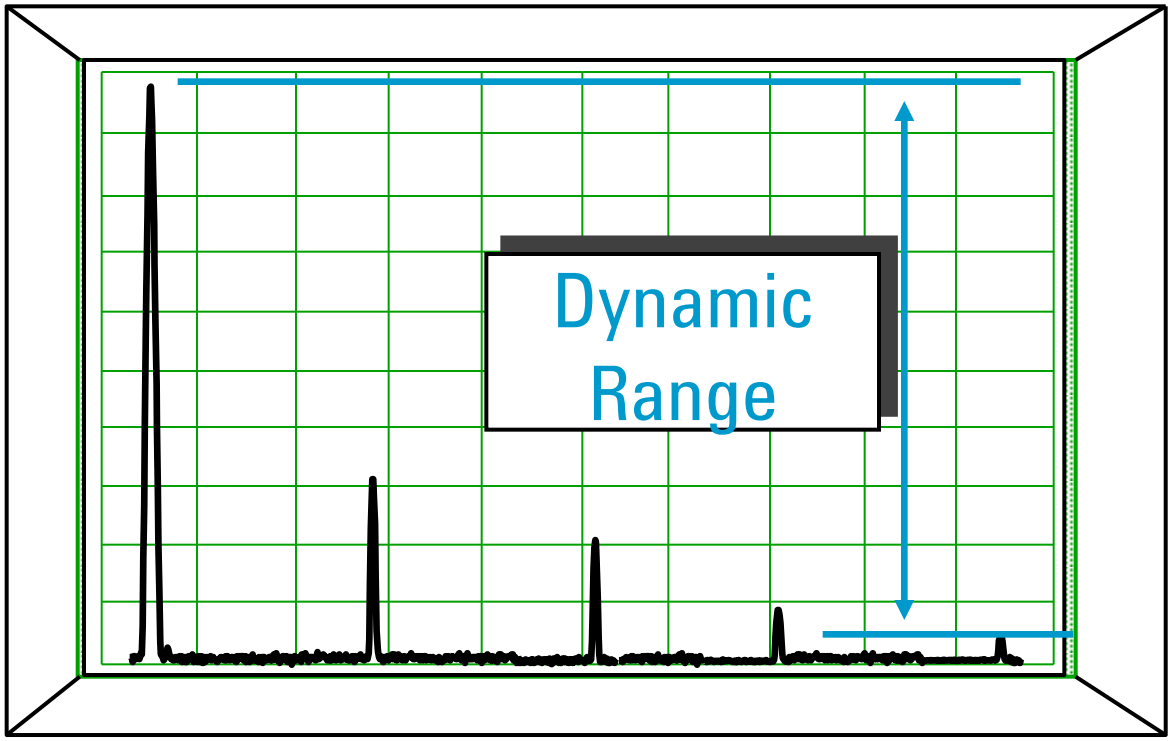
No change in amplitude: distortion is part of input signal (external)

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



Specifications

Spectrum Analyzer Dynamic Range



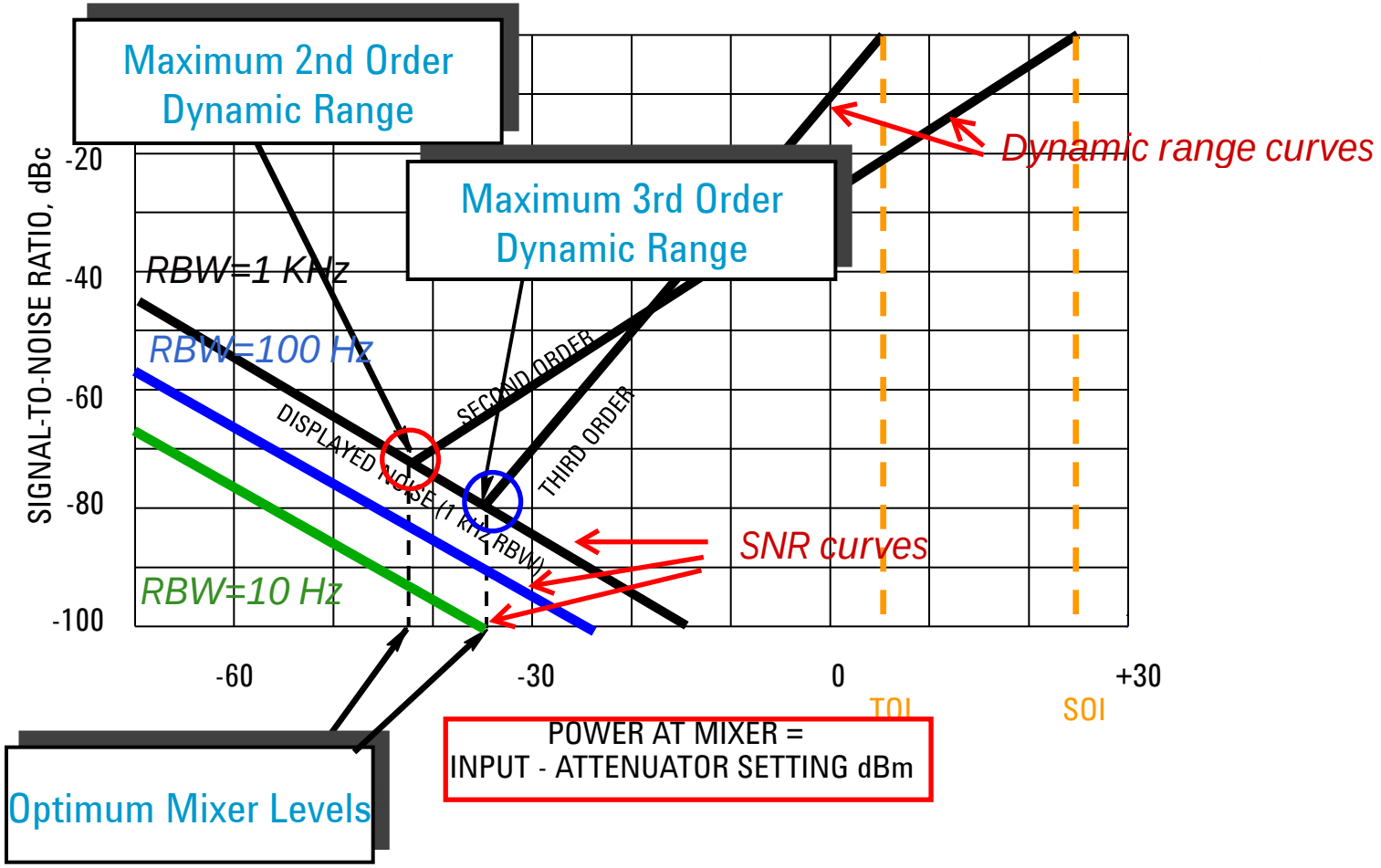
The ratio, expressed in dB, of the largest to the smallest signals simultaneously present at the input of the spectrum analyzer that allows measurement of the smaller signal to a given degree of uncertainty.

Pregunta: diferencia con *sensibilidad*?

Specifications

Dynamic Range

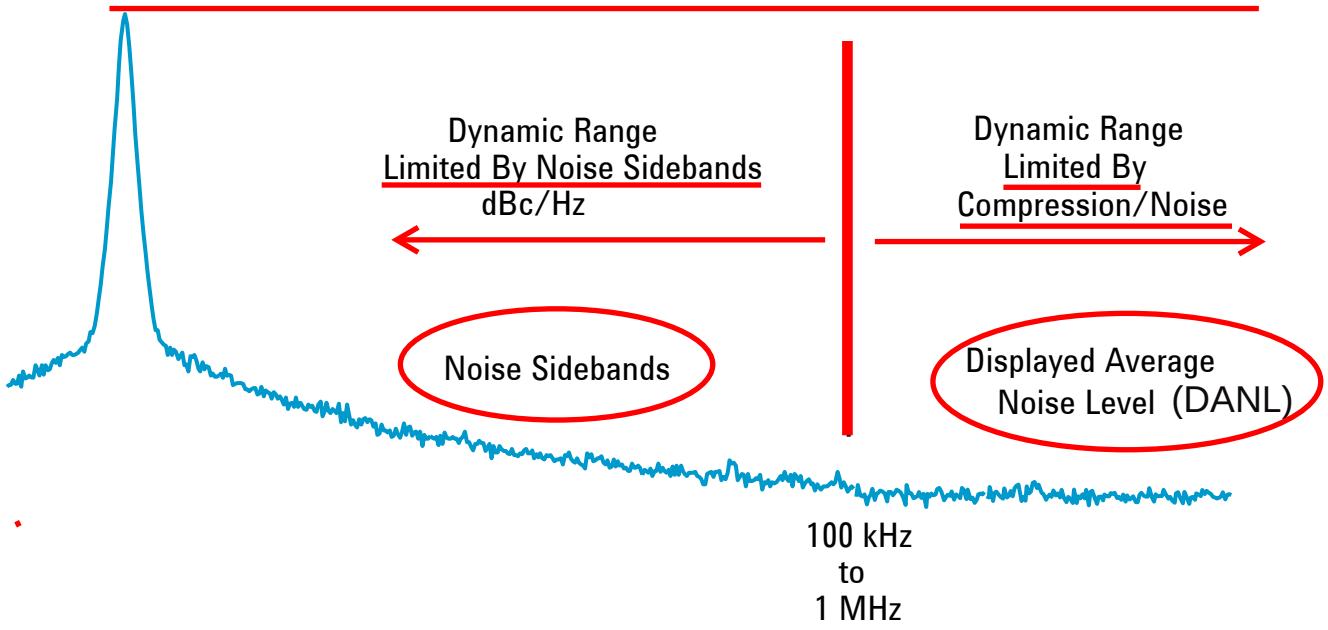
Dynamic Range Can Be Presented Graphically



Specifications

Dynamic Range

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

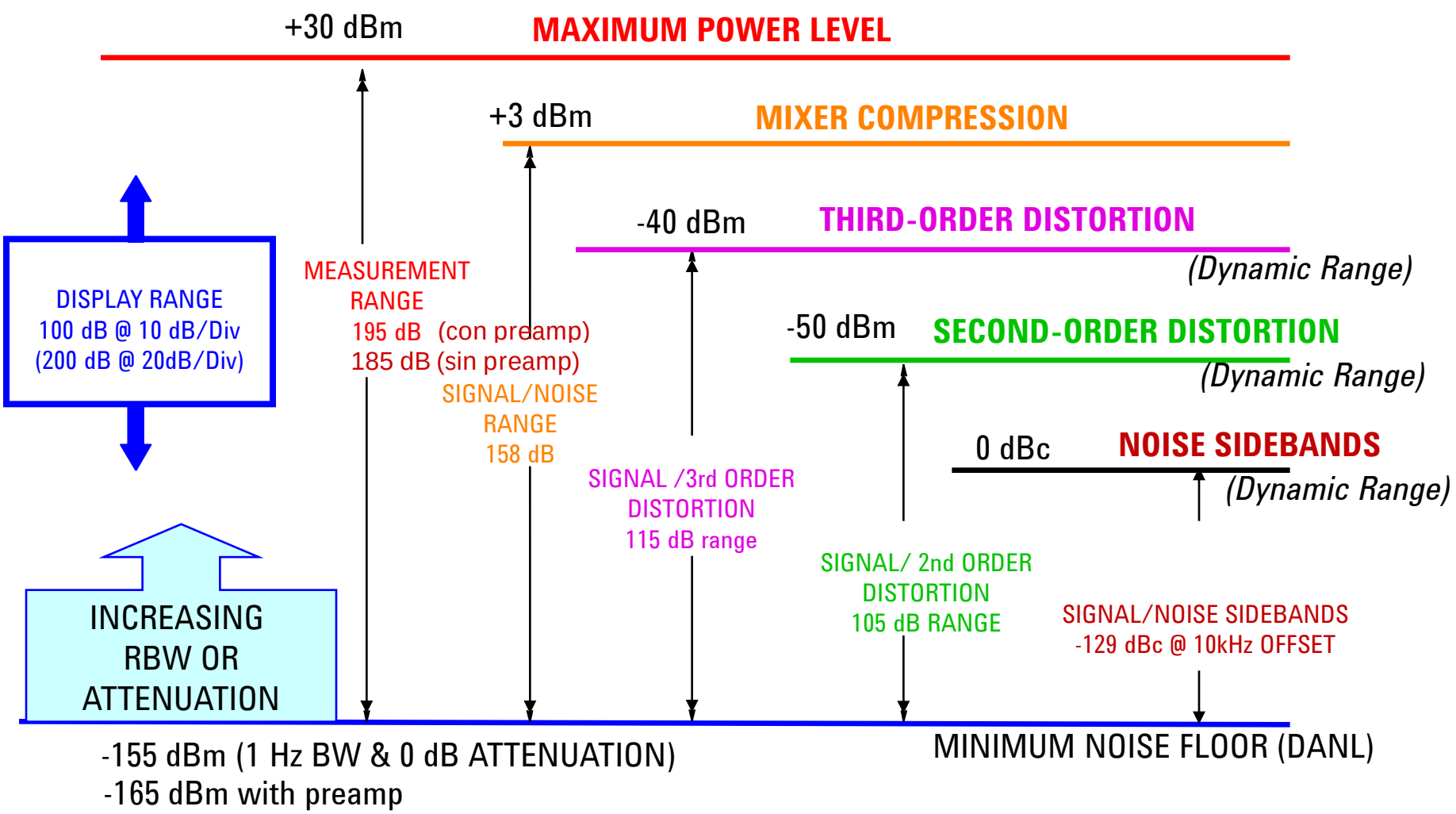
bounded by

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

Determined by the phase noise specifications of the SA

Specifications

Dynamic Range vs. Measurement Range (pag. 60 AN150)



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

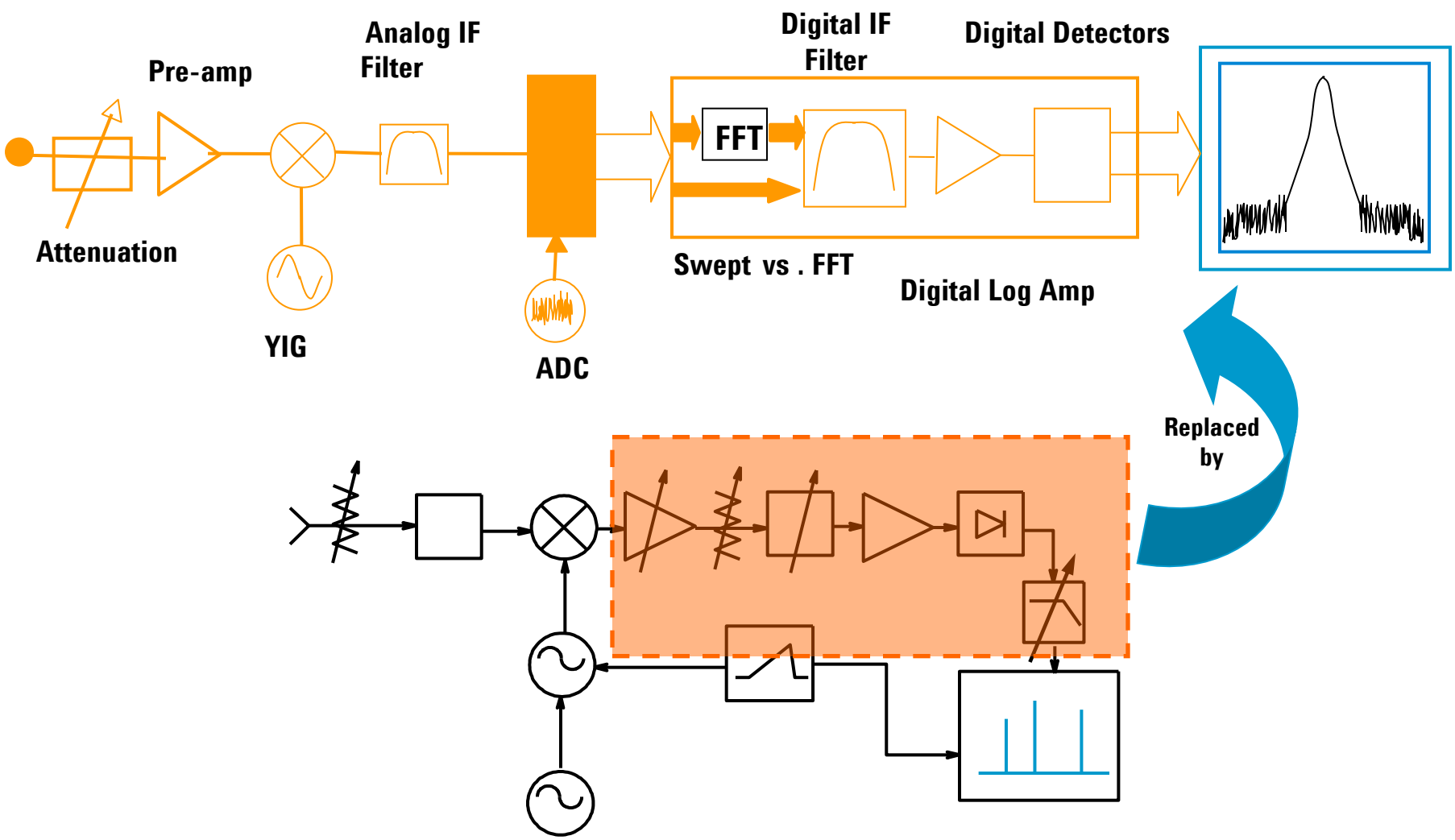
Modern spectrum analyzer designs & capabilities

- Wide Analysis Bandwidth Measurements

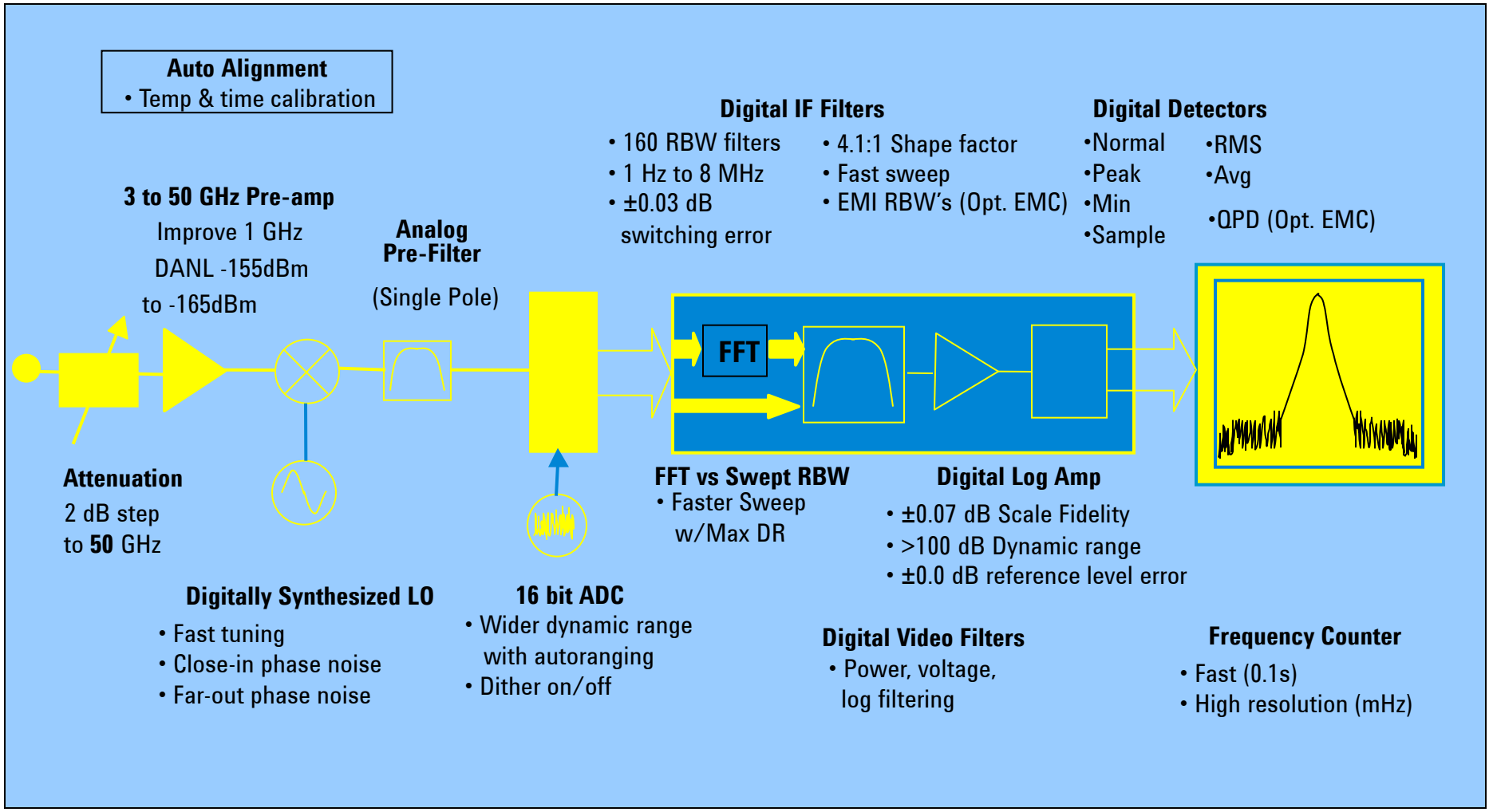
Wrap-up

Appendix

Modern Spectrum Analyzer Block Diagram



Modern Spectrum Analyzer Block Diagram



Modern Spectrum Analyzer - Specifications

Digital IF provides improved accuracy

	PXA	vs. Traditional
• Input impedance mismatch	±0.13	±0.29 dB
• Input attenuator switching uncertainty	±0.14	±0.6 dB
• Frequency response	±0.35	±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)	**±0.59 dB**	vs. **±1.8 dB**
95% Confidence	**±0.19 dB**	

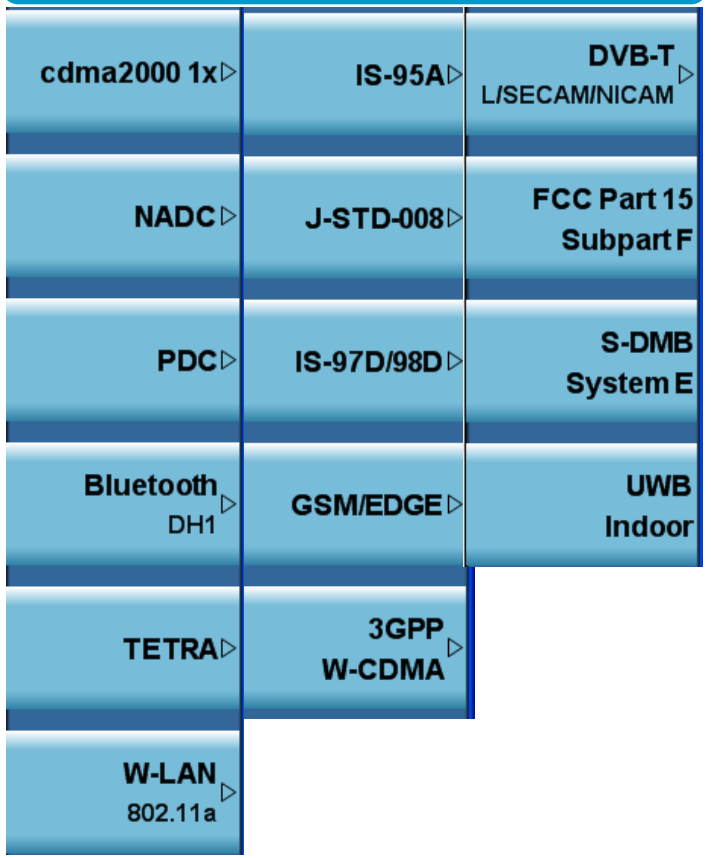
Modern Spectrum Analyzer Features

Built-in One-Button Power Measurements

Power Measurements:

- Occupied Bandwidth
- Channel Power
- ACP (Adjacent channel power)
- Multi-carrier ACP
- CCDF
- Harmonic Distortion
- Burst Power
- TOI
- Spurious Emissions
- Spectral Emissions Mask

Format Setups include:



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
EMI pre-compliance
Analog demod
Flexible demod
LTE FDD, TDD
W-CDMA/HSPA/HSPA+
GSM/EDGE/EDGE Evo
cdma2000 & 1xEV-DO
cdmaOne
DVB-T/H/C/T2
TD-SCDMA/HSPA
WLAN (802.11a/b/g/p/j)
802.16 OFDMA (WiMAX)
Bluetooth

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

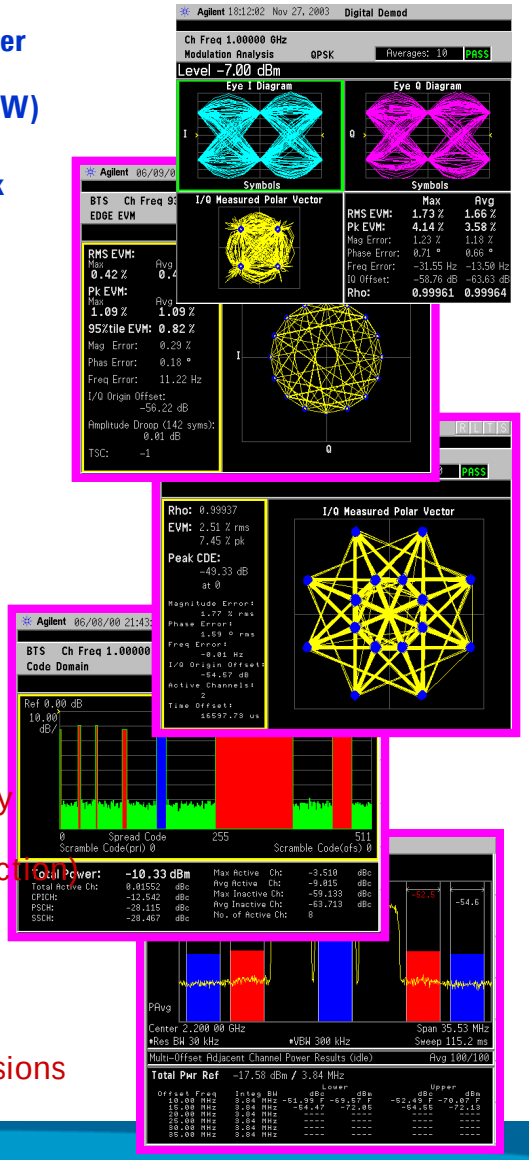
IM distortion

CCDF (Complementary cumulative distribution function)

ACPR

EVM (Error Vector Magnitude)

SEM (Spectrum Emmisions Mask)



Agilent Technologies

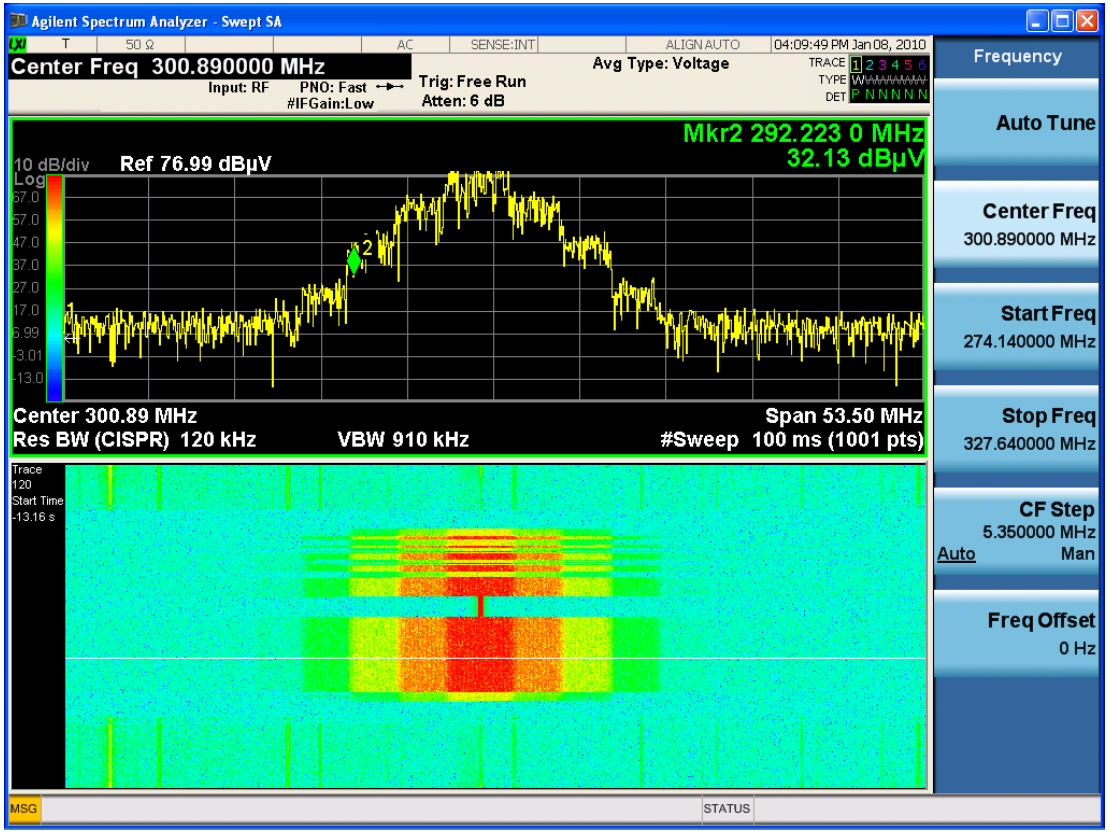
Features/Option EDP – Enhanced Display Package

- Spectrogram
- Trace zoom
- Zone span

Enhances Swept SA measurements and complements N6141A for EMI users

SPECTROGRAM

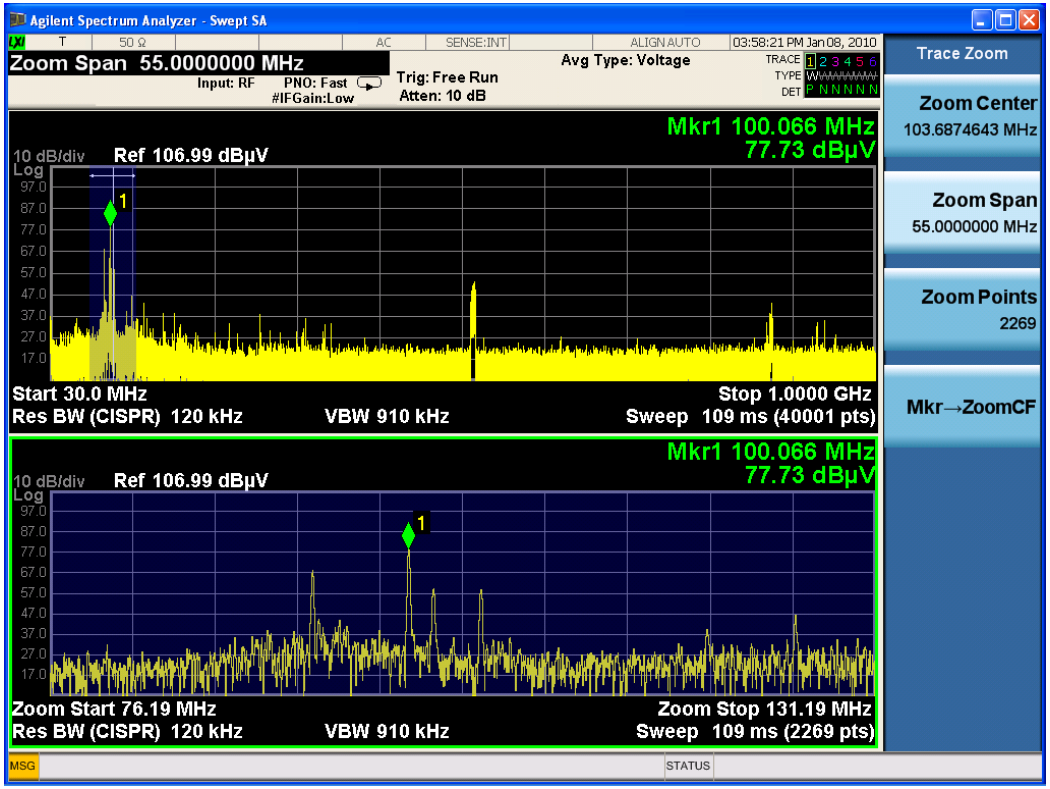
- Allows you to see time history in bottom window
- Amplitude displayed using color
- Great for finding intermittent signals



Agilent Technologies

TRACE ZOOM

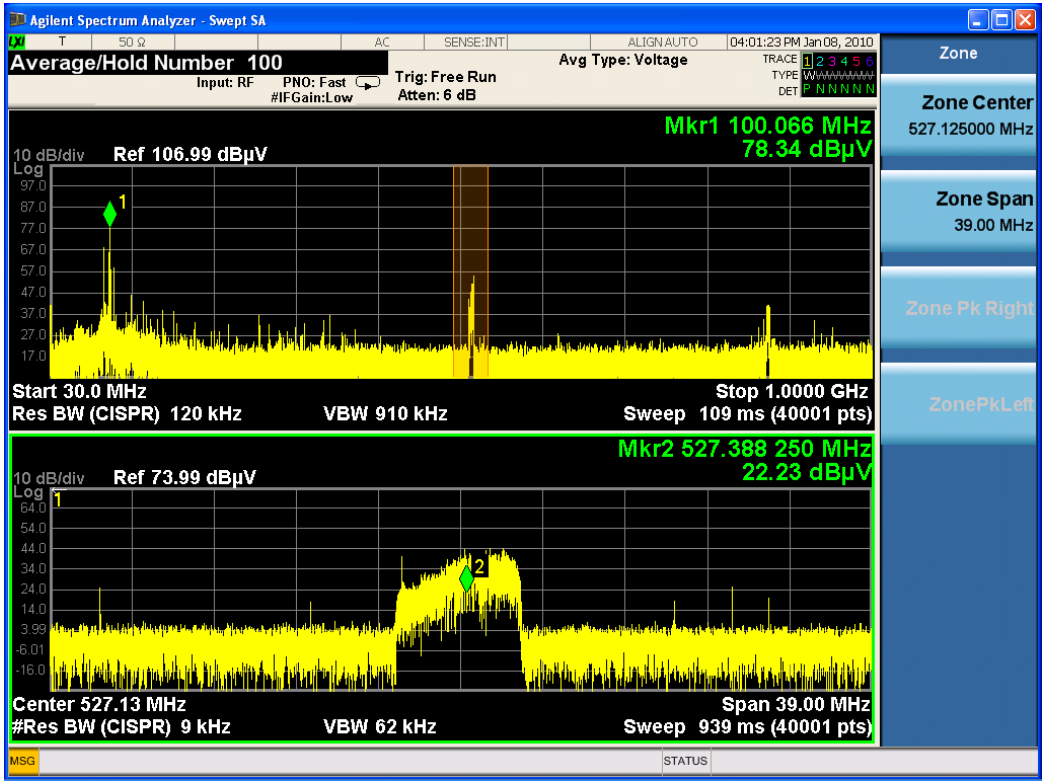
- Allows you to zoom in on your trace data
- Same trace in both screens but bottom screen shows “close up” view with fewer points
- Great to look more closely at high-density traces



Agilent Technologies

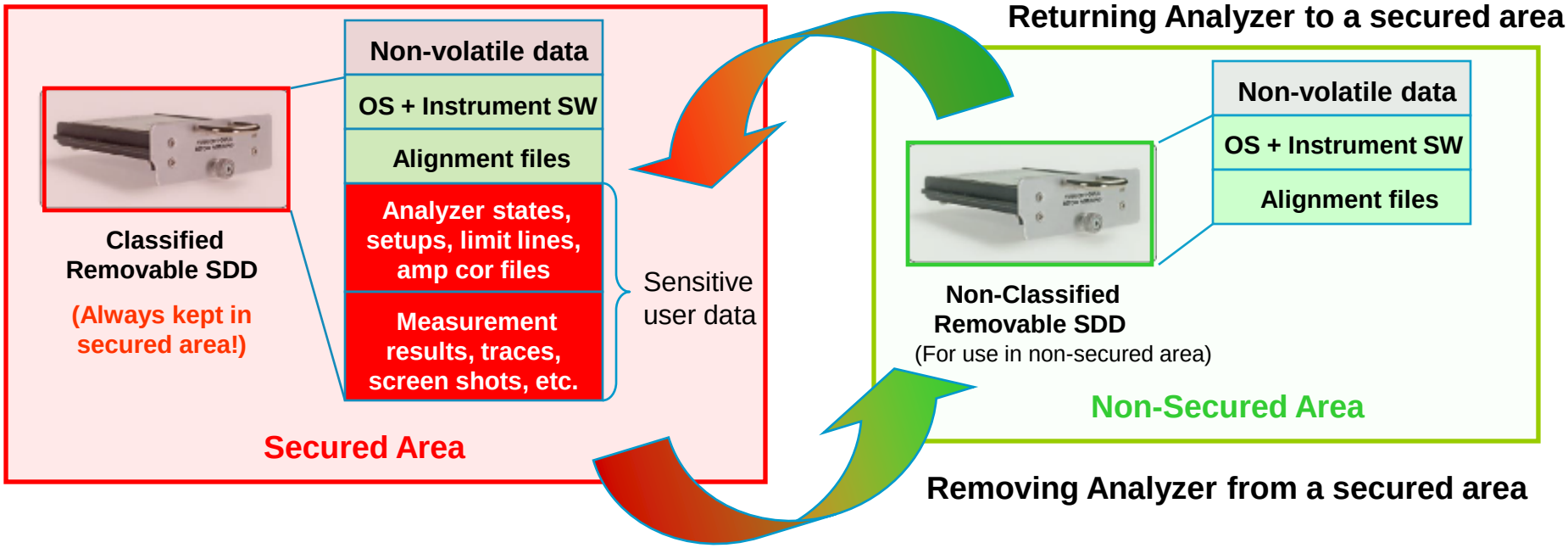
Zone Span (legacy feature from 859x and ESA)

- Allows you to take a reference sweep in the top window and then re-sweep in a narrower span in the bottom
- Two different sweeps in the two windows
- So bottom window can have different settings, can even go to zero-span



Agilent Technologies

X-Series Signal Analyzer Security Features



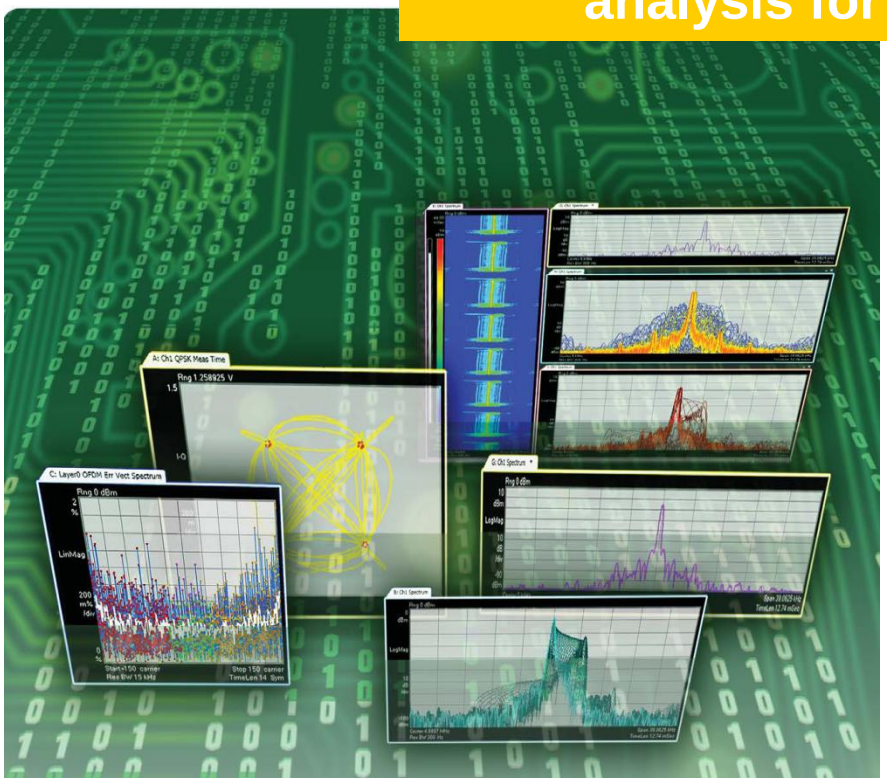
Comparisons

	856x	PSA	PXA
Data secure	Operational procedure	Secure erase (Opt 117)	Additional removable SSD
Cost	Standard	$3K	$1k
Notes	Complex	Simple, but less memory for user	Simple, durable, less expensive

Removable SSD

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*

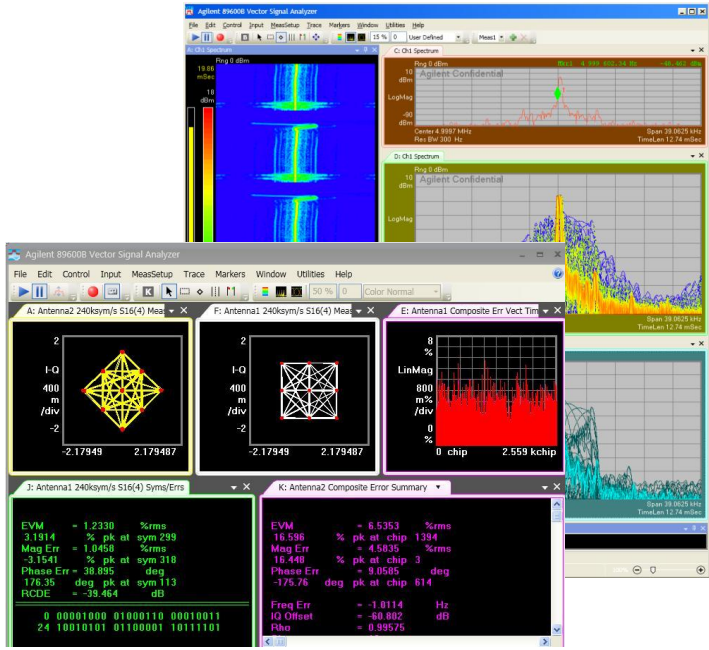
High resolution (409K line) FFT based spectrum

High quality time measurements

SCPI Programming

Agilent Vector Signal Analysis Software

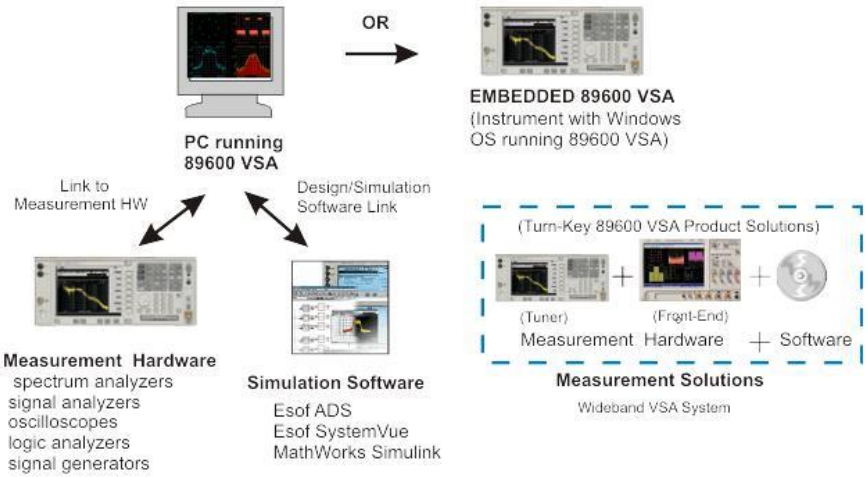
89600B VSA Software



- FFT-based spectrum, time-domain & bit-level modulation analysis
- Support for more than 70 signal standards and modulation types
- Unlimited trace/marker capability and arbitrary window arrangement
- Digital persistence and cumulative history displays

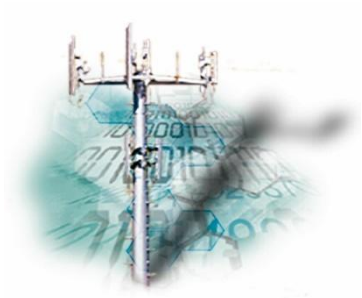
- Wireless networking: 802.11a/b/g/n, 802.16 OFDMA, WiMAX, 802.11ac
- Cellular: LTE (FDD/TDD), W-CDMA HSPA+, LTE Advanced
- Custom OFDM modulation analysis for proprietary signals

- Links to over 30 hardware platforms including: *X-series signal analyzers, 16800 logic analyzers, 90000 X-series scopes, Infiniium scopes, VXI, N7109A Multi Channel Signal Analyzer*
- Runs on external PC linked to hardware or embedded operation on instruments with Windows OS



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

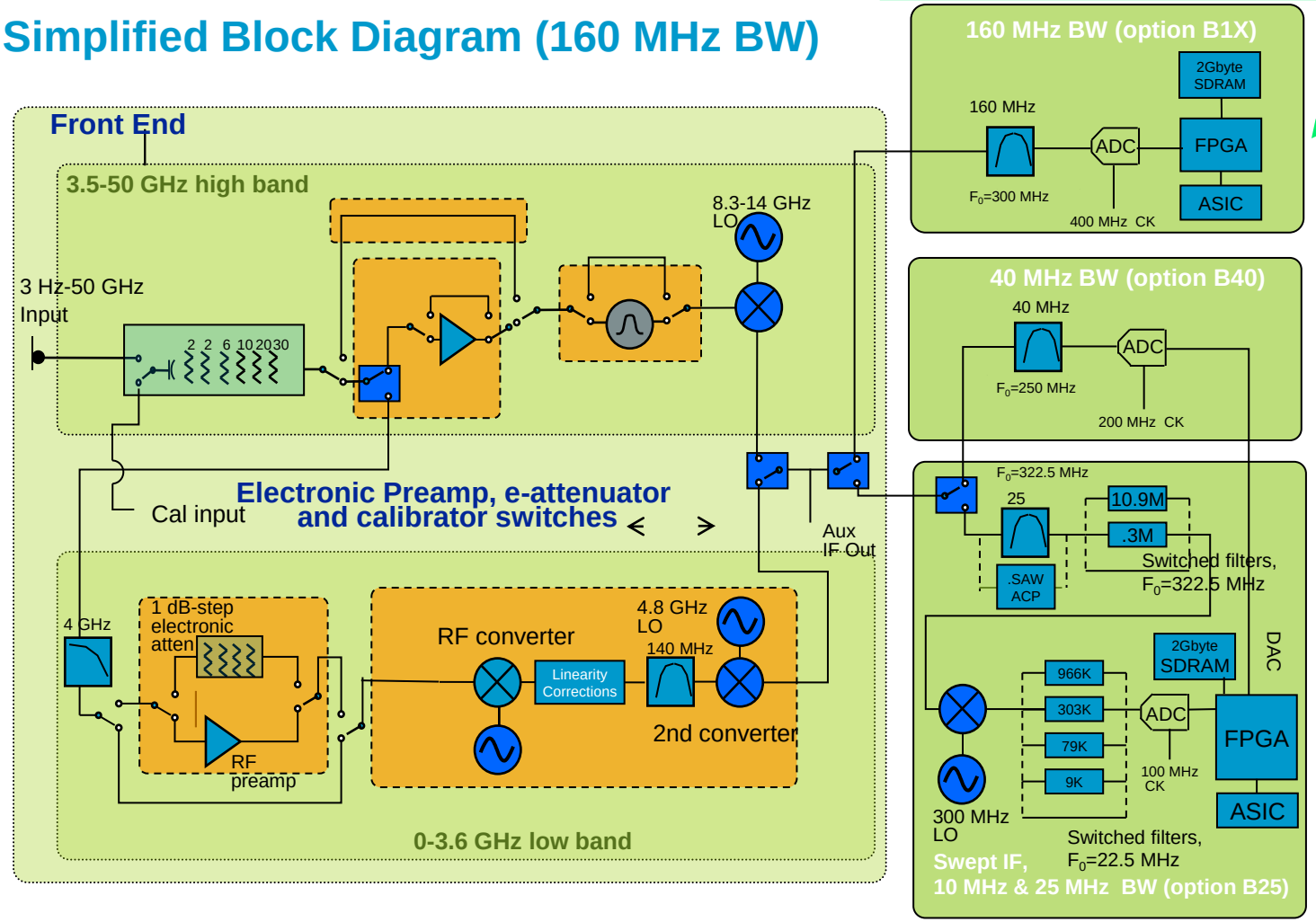
Cellular Communications

- 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

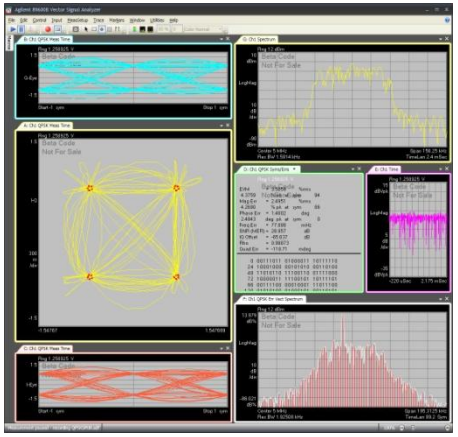
PXA Wideband analysis

160 MHz Path
ADC Nominal bits: 14
ADC Effective bits: 11.2
SFDR: up to 75 dBc

PXA Simplified Block Diagram (160 MHz BW)



Measurement of Analog IQ Signals



89600B VSA Software in both domains

RF

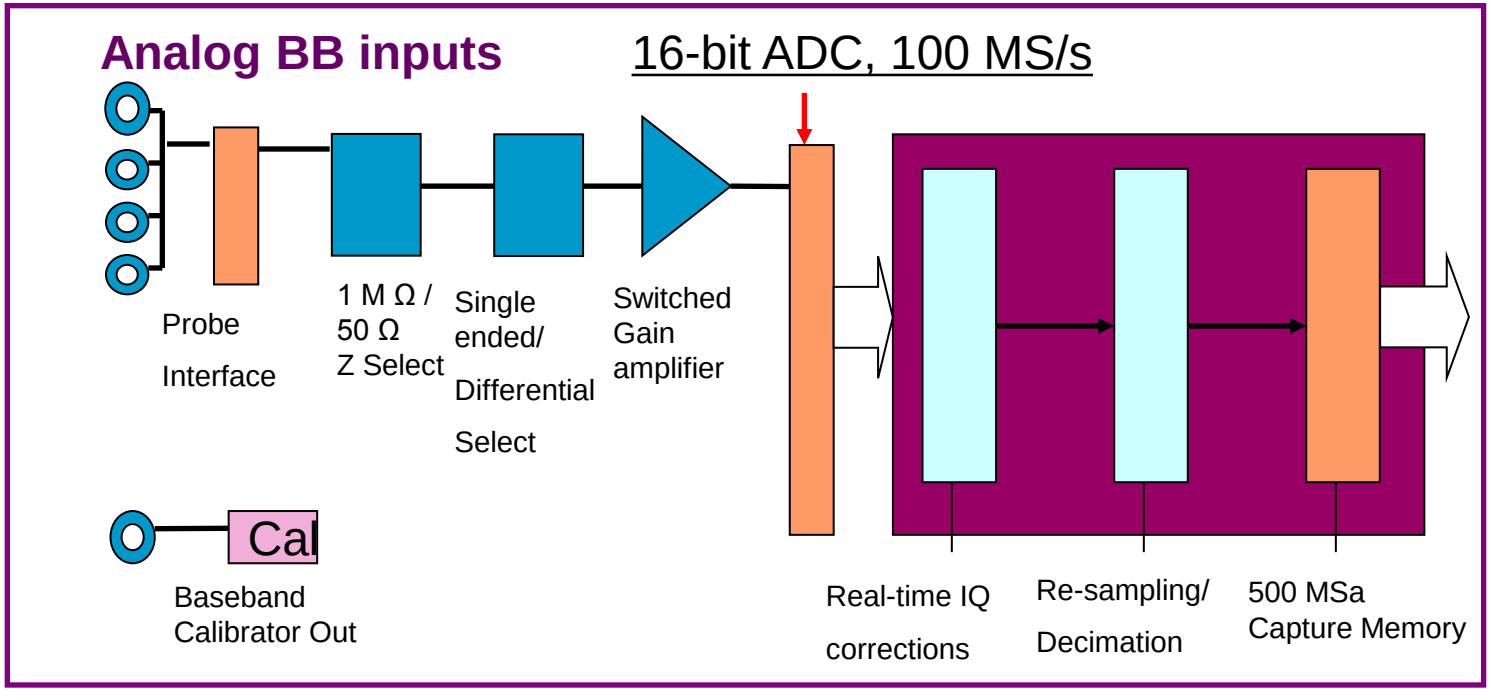
Analog Baseband

X-Series Spectrum Analyzer

PXA/MXA BBIQ

Oscilloscope for baseband has some limitations

PXA/MXA Baseband and RF



Baseband to 40 MHz (for 1ch/2ch)

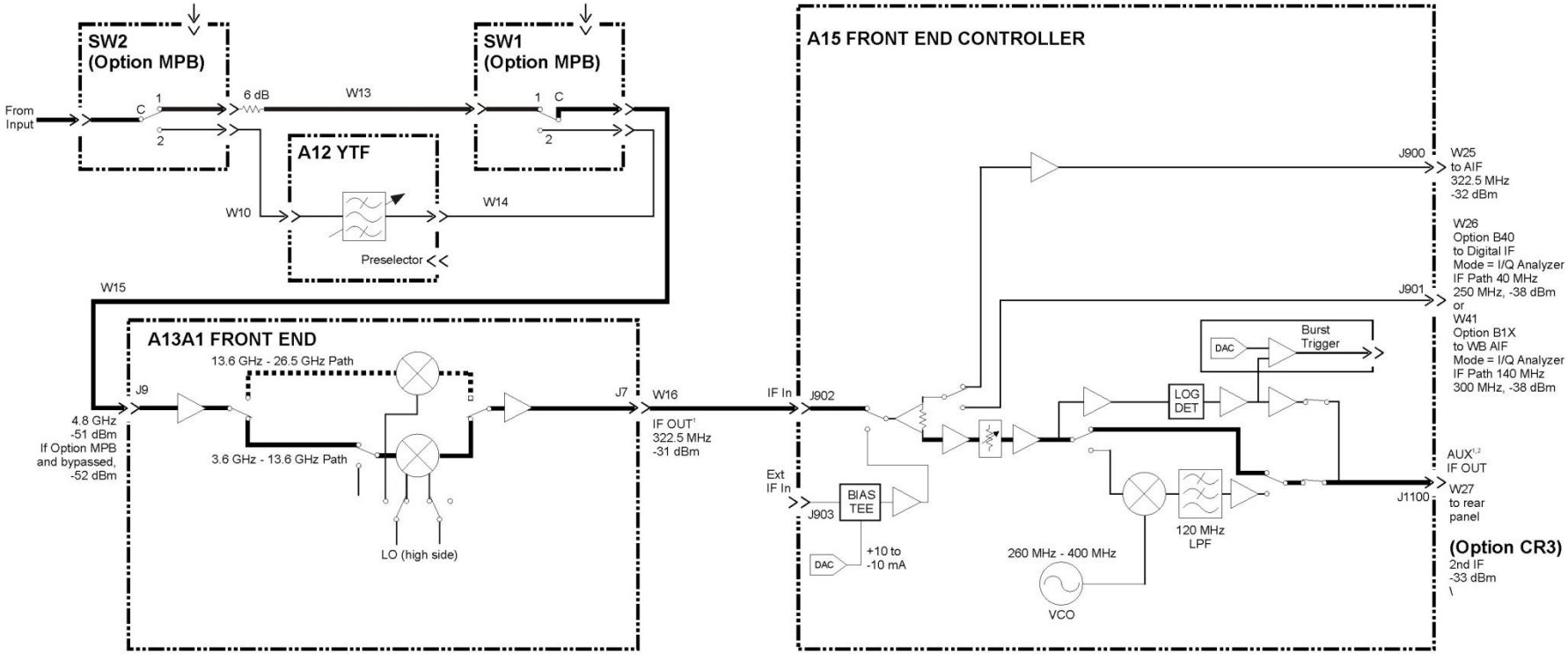
10, 25 or 40 MHz BW

500 MSa memory

PXA 900MHz Wideband IF Output

- This capability is useful for customers looking to make **wideband radar and communication measurements** of bandwidths less than 900 MHz.
- The IF bandwidth tends to be much greater than currently-available downconverters.
- This utilizes options “MPB” (microwave preselector bypass) and “CR3” (connector rear, 2nd IF output).
- See PXA configuration guide for information on retrofitting option MPB
- Wideband IF output is achieved by bypassing the microwave preselector and moving the first microwave IF higher depending on the desired bandwidth.

Configuring the PXA for 900 MHz of IF output



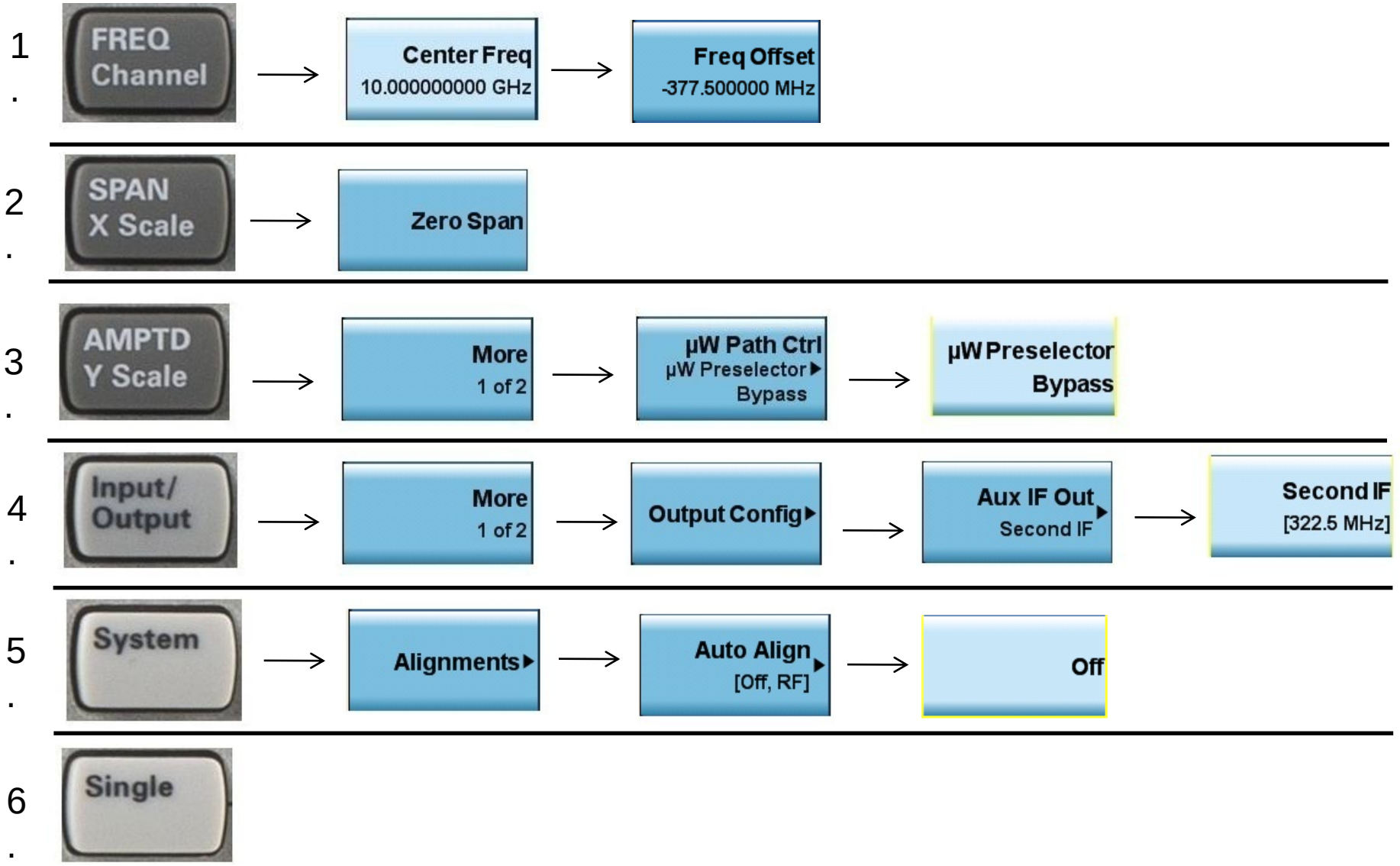
Agilent Technologies

Creating the proper frequency offset

$$f_{offset} = f_{normal\ IF} - f_{desired\ IF}$$

- In our case, $f_{normal\ IF}$ is always 322.5 MHz
- Agilent recommends an desired IF of no greater than 700 MHz for a maximum IF bandwidth of 1 GHz.
- If the required IF bandwidth is 500 MHz or less, we recommend using the standard 322.5 MHz IF with no frequency offset.
- In our example, we're using an offset of -377.5 MHz, (322.5 – 700 MHz), for an IF center frequency of 700 MHz and an IF bandwidth of 900 MHz.

Configuring the PXA for 900 MHz of IF output



Agenda

Introduction

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Theory of Operation

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Modern spectrum analyzer designs & capabilities

- Wide Analysis Bandwidth Measurements

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Appendix

Agilent Technologies' Signal Analysis Portfolio

PXA
X-Series
High-performance
3 Hz to 26.5 GHz
3 Hz to 43/44/50 GHz

MXA
X-Series
Mid-performance
10 Hz to 26.5 GHz

EXA
X-Series
Economy-class
10 Hz to 26, 32, 44 GHz

CXA
Low-cost
9 kHz to 26.5 GHz

N9320B
Basic performance
9 kHz to 3 GHz

N9922C BSA
9 kHz to 7 GHz

PSA
Market leading performance
3 Hz to 50 GHz

8560EC
Mid-performance

ESA
World's most popular
100 Hz to 26 GHz

CSA
Low cost portable
100 Hz to 7 GHz

N9935/36/37/38A
5 kHz to 9/14/18/26.5 GHz
Handhelds

N9340B, N9342/43/44C
100 kHz to 3/7/13.6/20 GHz
Handhelds

X-Series Code Compatibility

- ✓ Backward CC with legacy
- ✓ Inherent X-Series CC

Agilent Spectrum Analyzer Families (X-Series)

PXA Series

- Highest Performance SA -- 3 Hz to 3.6, 8.4, 13.6, 26.5, 43, 44 or 50 GHz
- All digital IF -- 160 RBW settings FFT or swept
- 10/25/40/160 MHz analysis BW
- Internal preamplifier options from 3.6 to 50 GHz
- External Source control
- Over 25 measurement applications including LTE, GSM, TD-SCDMA
- Programming remote language compatibility w/ PSA and other X-Series
- 89600 VSA software runs inside PXA with more than 75 signal formats
- Connectivity: GPIB, USB 2.0, LAN (1000Base-T), LXI class-C compliant
- Extend frequency to 325 GHz and beyond with external mixing

MXA Series

- Mid-Performance SA -- 10 Hz to 3.6, 8.4, 13.6, 26.5 GHz
- All digital IF -- 160 RBW settings FFT or swept
- 25 MHz std/40 MHz optional analysis BW
- Internal preamplifier options from 3.6 to 26.5 GHz
- Analog baseband IQ inputs with 40 MHz baseband analysis bandwidth
- External Source control
- Over 25 measurement applications including WiMax, GSM, W-CDMA
- Programming remote language compatibility w/ PSA and other X-Series
- 89600 VSA software runs inside MXA with more than 75 signal formats
- Connectivity: GPIB, USB 2.0, LAN (1000Base-T), LXI class-C compliant

Agilent Spectrum Analyzer Families (X-Series)

EXA Series

- Economy-Class SA -- 10 Hz to 3.6, 7.0, 13.6, 26.5, 32, 44 GHz
- Internal preamplifier options up to 44 GHz
- All digital IF -- 160 RBW settings FFT or swept
- 25 MHz std /40 MHz Optional analysis BW
- External Source control
- Over 25 measurement applications including WiMAX, LTE, W-CDMA
- 89600 VSA software runs inside EXA with more than 75 signal formats
- Connectivity: GPIB, USB 2.0, LAN (1000Base-T), LXI class-C compliant
- Extend frequency to 325 GHz and beyond with external mixing (32, 44 GHz models only)
- Programming remote language compatibility w/ ESA and other X-Series

CXA Series

- Low-Cost SA -- 9 kHz to 3.0, 7.5. 13.6, 26.5 GHz
- Reduce cost and improve throughput in manufacturing test
- All digital IF -- 160 RBW settings FFT or swept
- 10/25 MHz analysis BW
- Tracking Generator 3 or 6 GHz
- External Source control
- Over 25 measurement applications
- 89600 VSA software runs inside PXA with more than 75 signal formats
- Connectivity: GPIB, USB 2.0, LAN (1000Base-T), LXI class-C compliant
- Programming remote language compatibility w/ ESA and other X-Series

Agilent Spectrum Analyzer Families (Basic)

N9320B Basic Performance Bench Top

- 9 kHz to 3 GHz
- Minimum non-zero span sweep time: < 10 ms
- Resolving power RBW: 10 Hz to 1 MHz
- Sensitivity DANL: -130 dBm, -148 dBm with preamp on
- Overall amplitude accuracy: ±0.5 dB

N9322C Basic Performance Bench Top

- 9 kHz - 7 GHz frequency range
- Sensitivity: Typical –160dBm DANL (preamp on)
- ±0.4 dB absolute amplitude accuracy
- 7 GHz tracking generator, with built in VSWR bridge
- AM/FM, ASK/FSK demodulation; Task planner for automation
- 7.6 kg weight, 132x320x400 (mm) dimension, 3U height

M1970 SERIES WAVEGUIDE HARMONIC MIXERS

New mixer family

- M1970V Option 001 (50 to 75 GHz)
- M1970V Option 002 band (50 to 80 GHz)
- M1970E (60 to 90 GHz)
- M1970W (75 to 110 GHz)

Mixer smart features

• **Automatic amplitude correction** and **transfer of conversion loss data** through USB plug and play features
• **Automatic LO amplitude adjustment** to compensate the cable loss (up to 3 m or 10 dB loss)
• **Auto detect mixer model/serial number** when used with;
  • N9030A PXA
  • N9010A EXA (options 532,544)
• **Automatic setting** of default frequency range and LO harmonic numbers
• **Automatic LO alignment** at start up
• **Automatic run calibration** when time and temperature changes

Improved DANL and TOI

• **Excellent conversion loss** of **25 dB maximum** and **excellent amplitude calibration accuracy** of **2.2 dB**

Go smart with harmonic mixing!

Agilent Spectrum Analyzer Families (Handhelds)

N9935A, N9936A Handheld Spectrum Analyzer

- Handheld SA -- 5 kHz to 9, 14 GHz
- –155 dBm displayed average noise level (DANL) pre amp on
- +15 dBm third order intercept (TOI)
- Phase noise -111 dBc at 10 kHz offset
- Full-band tracking generator
- Independent signal source
- Interference analyzer
- Built-in high accuracy power meter
- Built-in GPS receiver
- Built-in variable DC voltage source

N9936A, N9938A Handheld Spectrum Analyzer

- Handheld SA -- 5 kHz to 18, 26.5 GHz
- –155 dBm displayed average noise level (DANL) pre amp on
- +15 dBm third order intercept (TOI)
- Phase noise -111 dBc at 10 kHz offset
- Full-band tracking generator
- Independent signal source
- Interference analyzer
- Built-in high accuracy power meter
- Built-in GPS receiver
- Built-in variable DC voltage source

Agilent Spectrum Analyzer Families (Handhelds)

N9344C Handheld Spectrum Analyzer

- Handheld SA -- 100 kHz to 20 GHz
- Fastest sweep – minimum sweep time < 2ms
- –144 dBm displayed average noise level (DANL) typical
- +15 dBm third order intercept (TOI)
- Built-in GPS receiver and GPS antenna
- Built-in tracking generator
- Light weight, rugged and portable
- four hours battery life

N9343C Handheld Spectrum Analyzer

- Handheld SA -- 100 kHz to 13.6 GHz
- 10 ms non-zero span sweep time
- –144 dBm displayed average noise level (DANL) with pre-amplifier
- +15 dBm third order intercept (TOI)
- Built-in GPS receiver and GPS antenna
- Built-in tracking generator
- Light weight, rugged and portable
- four hours battery life

Agilent Spectrum Analyzer Families (Handhelds)

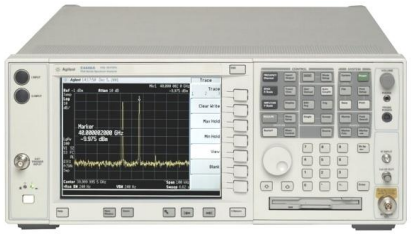
N9342C Handheld Spectrum Analyzer

- Handheld SA -- 100 kHz to 7.0 GHz
- Fastest sweep – minimum sweep time < 2ms
- –152 dBm displayed average noise level (DANL) typical
- +10 dBm third order intercept (TOI)
- Built-in GPS receiver and GPS antenna
- Built-in tracking generator
- Light weight, rugged and portable
- four hours battery life

N9340B Handheld Spectrum Analyzer

- Handheld SA -- 100 kHz to 3.0 GHz
- 10 ms non-zero span sweep time
- –144 dBm displayed average noise level (DANL) with pre-amplifier
- +10 dBm third order intercept (TOI)
- Built-in GPS receiver and GPS antenna
- Built-in tracking generator
- Light weight, rugged and portable
- four hours battery life

Agilent Spectrum Analyzer Families (Legacy)



PSA Series

- High performance SA -- 3 Hz to 6.7, 13.2, 26.5, 44, 50 / 325 GHz
- All digital IF -- 160 RBW settings FFT or swept
- 40/80 MHz analysis BW with >75 dB dynamic range
- 2G/3.5 G digital demodulation
- 15 Optional measurement personalities

ESA-E Series

- Mid-Performance SA – 30 Hz to 1.5, 3, 6.7, 13.2, 26.5 / 325 GHz
- Rugged/Portable with color LCD display
- Fast & Accurate with 5 minute warm-up
- Express analyzers for fast & easy delivery

CSA

- Low priced, basic performance SA – 100 kHz to 3, 6 GHz
- Lightweight portable, optional internal battery
- General purpose for Mfg., bench-top and service environments
- Cable fault, return and insertion loss, built-in TG and VSWR bridge

856X- EC Series

- Mid-Performance SA – 30 Hz to 2.9, 13.2, 26.5, 40, 50 / 325 GHz
- Rugged/Portable
- Color LCD Display
- Low Phase Noise
- Digital 1 Hz RBW

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Basic Spectrum Analyzer Application & Product Notes

A.N. 150 – Spectrum Analysis Basics: #5952-0292EN

A.N. 150-15 - Vector Signal Analysis Basics: #5989-1121EN

Spectrum Analyzer & Signal Analyzer Selection Guide: #5968-3413E

N9030A PXA Brochure: 5990-3951EN

N9020A MXA Brochure: 5989-5047EN

N9010A EXA Brochure: 5989-6527EN

N9000A CXA Brochure: 5990-3927EN

89600B VSA Brochure: 5990-6553EN

N9342,43,44C Brochure: 5990-8024EN

N9935,36,37,38A Brochure: 5990-9779EN

www.agilent.com/find/sa

THANK YOU!