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A new approach to solve main challenges in the RF Test World

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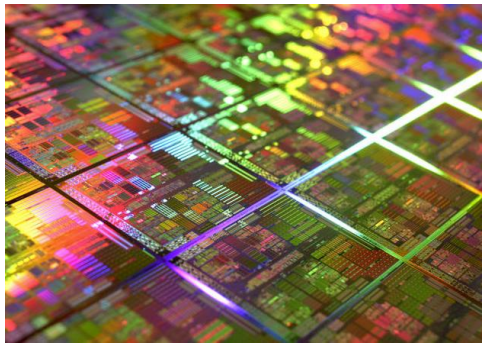
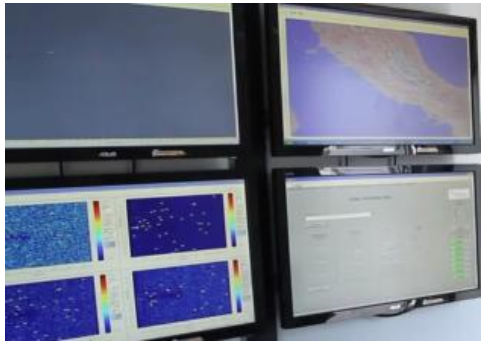
New Demands in Modern RF & Microwave Test



In Semiconductor & Wireless, technologies such as carrier aggregation and DPD require instruments to have increasingly higher **dynamic range**.

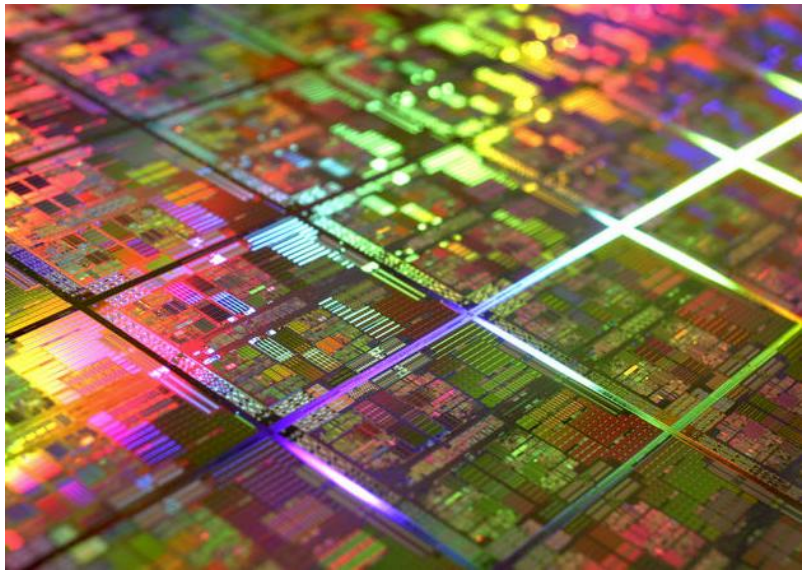
Modern **Radar** test systems require increasingly wider instantaneous **bandwidths** and signal processing capabilities.

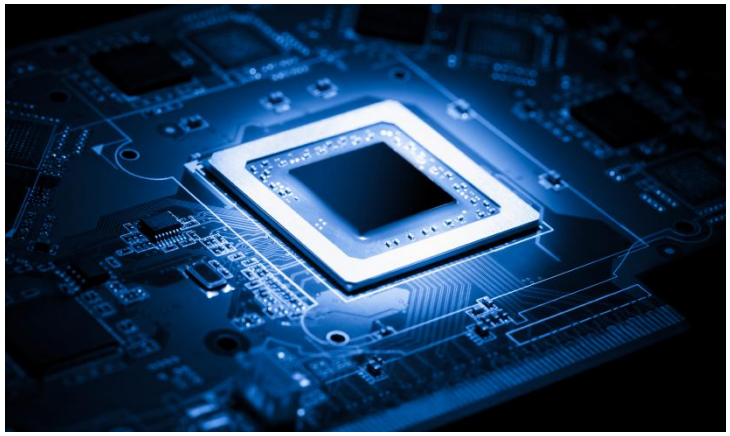


Signal intelligence and electronic warfare systems require combinations of extremely flexible instrumentation and wide instantaneous **bandwidth**.

Semiconductor Characterization

- Key Careabouts
  - •High performance for ACLR & IMD measurements
  - • High frequency for testing harmonics
  - • Wide bandwidth for new standards and adding pre-distortion
  - •RFICs, PAs, Filters





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Radar Test

- Key Carabouts
  - •High frequency to cover different bands
    - most go to 26.5 GHz, some go to 40/60/76 GHz
  - • Wide bandwidth for fast rise time and/or short duration pulse measurements
  - • High dynamic range for small signal recognition in presence of saturating signal

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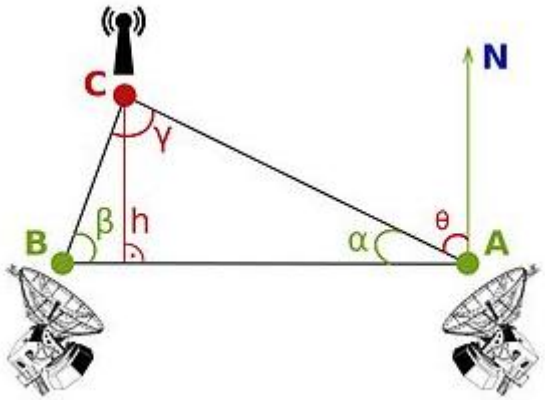
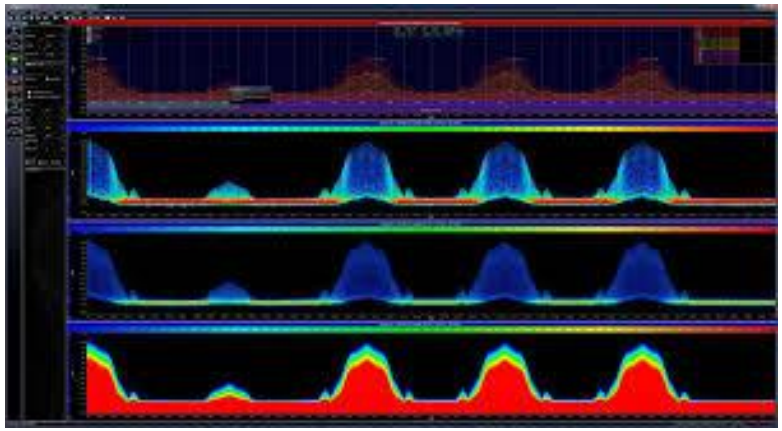
Signal Intelligence and EW

- Key Carabouts
  - •Wide bandwidth for faster sweeps and fewer missed signals
  - •FPGA optimization for real-time spectrum analysis and application specific IP
  - •Phase synchronization for direction finding and target simulation



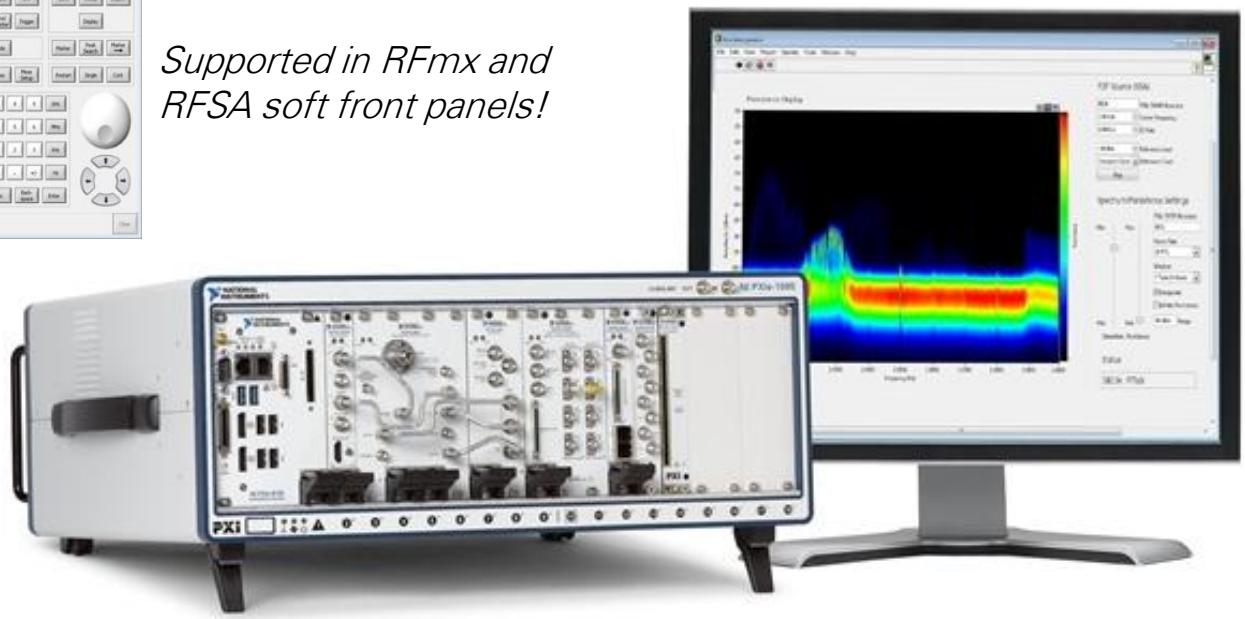


New Products for Microwave Test

PXIe-5668R 26.5 GHz VSA

- Industry-Leading RF Performance and Bandwidth
- World's Fastest Measurement Speed
- Customizable with LabVIEW FPGA

Supported in RFmx and RFSA soft front panels!



*NEW * NI 26.5 GHz Vector Signal Analyzer

Specifications	
Frequency Range	20 Hz to 26.5 GHz
Analysis BW	320 MHz below 3.6 GHz 765 MHz above 3.6 GHz
Phase Noise (Typ, @10kHz offset)	-129 dBc/Hz @ 1GHz
Nom RMS Noise Floor (without pre-amp*)	< -155 dBm/Hz (1 GHz) < -145 dBm/Hz (26 GHz)
TOI	> +20 dBm (20 Hz to 26 GHz)
New Features	Kintex-7 410T FPGA Programmable w/ LabVIEW
No. of Slots	7

*Noise floor at 1 GHz is -165 dBm/Hz with pre-amp engaged

NI Vector Signal Analyzers Comparison

	NI 5663E	NI 5644R/45/46R	NI 5665	NI PMI-1470	NI 5668R
Frequency Range	10 MHz to 6.6 GHz	65 MHz to 6 GHz	20 Hz to 3.6/14 GHz	50 MHz to 26.5 GHz	20 Hz to 14/26.5 GHz
Bandwidth	50 MHz	80/200 MHz	25/50 MHz	50 MHz	80/200/765 MHz
Typ Phase Noise (10 kHz offset) at 1 GHz	-112 dBc/Hz	-112 dBc/Hz	-129 dBc/Hz*	-125 dBc/Hz	-129 dBc/Hz*
Architecture	Single Stage	Zero-IF	Multi Stage	Multi Stage	Multi Stage
Peer to Peer Streaming	Yes	Yes	Yes	No	Yes
Absolute Amplitude Accuracy	±0.65 dB	± 0.35 dB to ± 0.55 dB	± 0.1 dB	+/-2.5 dB	± 0.1 dB
Average Noise Floor	-158 dBm/Hz	-161 dBm/Hz	-165 dBm/Hz	-150 dBm/Hz	-166dBm/Hz

* NI 5665/5668R Phase Noise Measurement is at 800 MHz

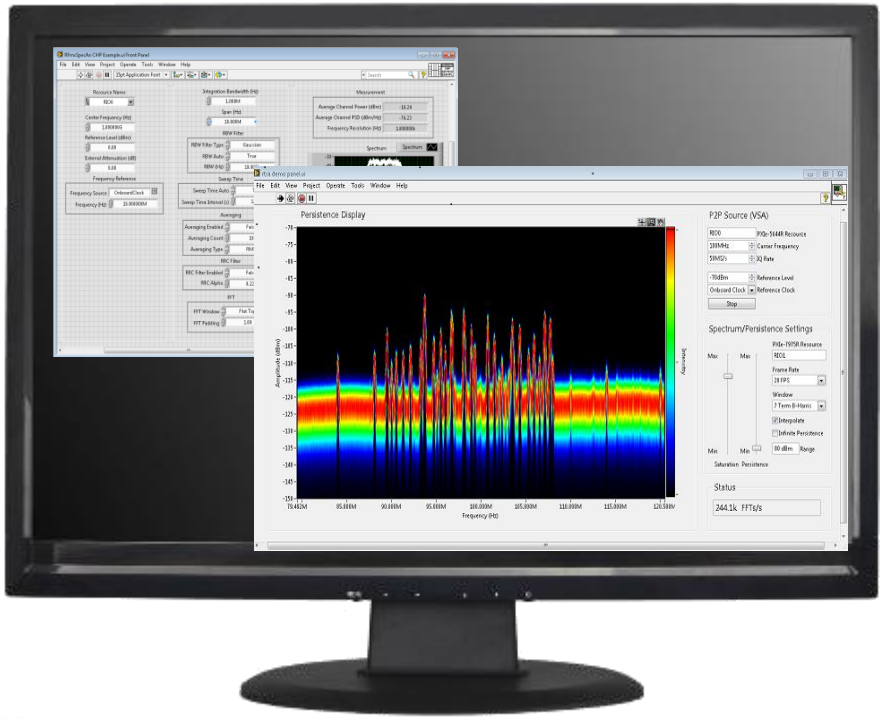
Microwave Product Suite - Software

Driver Software

- RFSA, RFSG & RFmx
- Toolkits
- Software Ease of Use
- Fast Measurements

FPGA Extensions

- Real-Time Spectrum Analysis
- Streaming and Synchronization



SFP Support

- Easy to demo
- Now w/ debug features

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NI 26.5 GHz Analyzer : *RF Performance*

Dynamic Range

Bandwidth

Phase Noise

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NI 26.5 GHz Analyzer: *RF Performance*

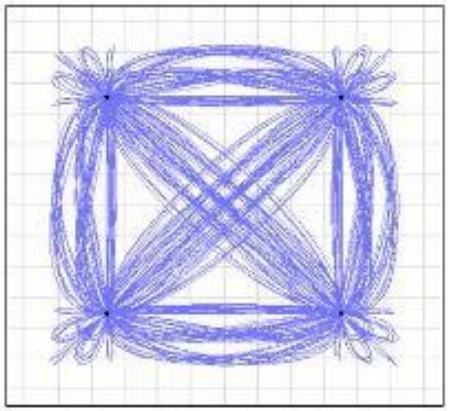
Dynamic Range

Bandwidth

Phase Noise

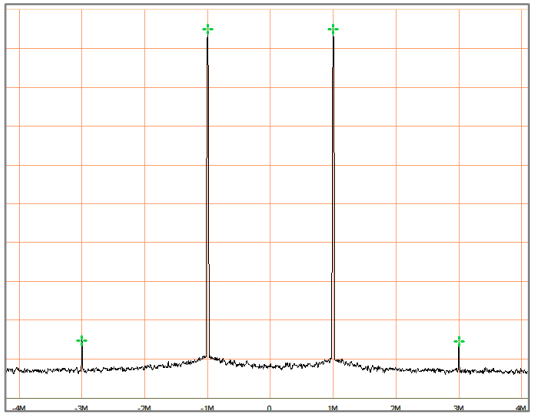
When Does VSA Dynamic Range Matter?

Modulation Quality



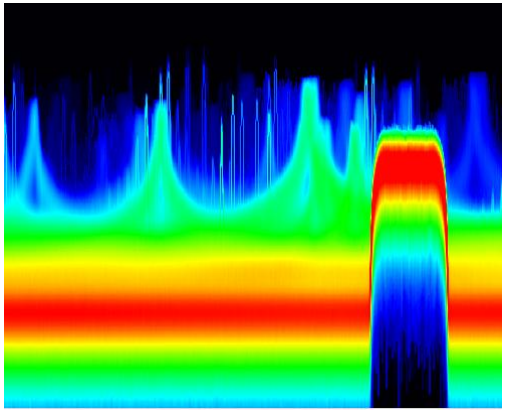
Noise and nonlinearity limit the "EVM Floor" of the instrument.

Intermodulation Distortion



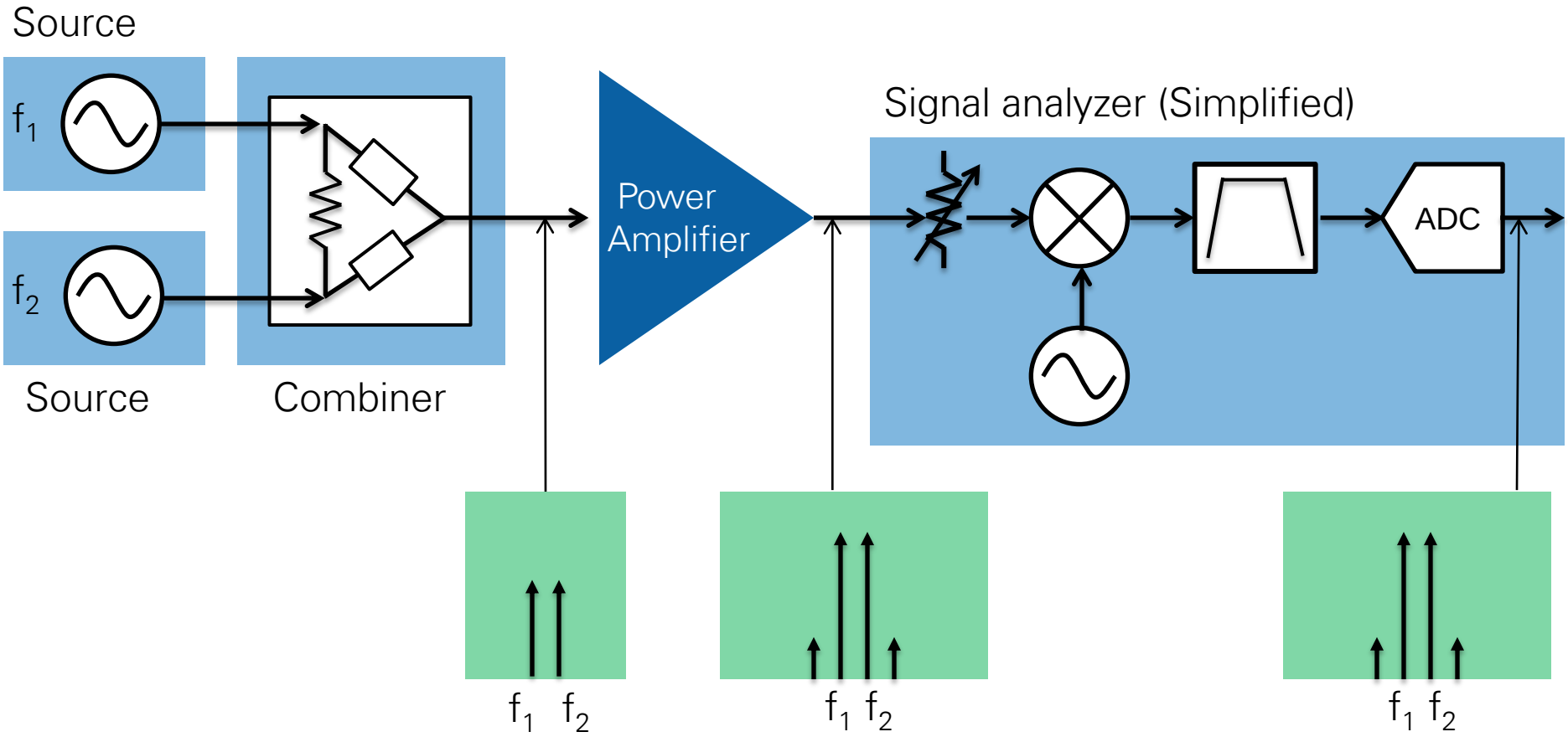
High dynamic range ensures that the instrument does not obscure IMD products with its inherent nonlinearity or noise

Spectrum Monitoring



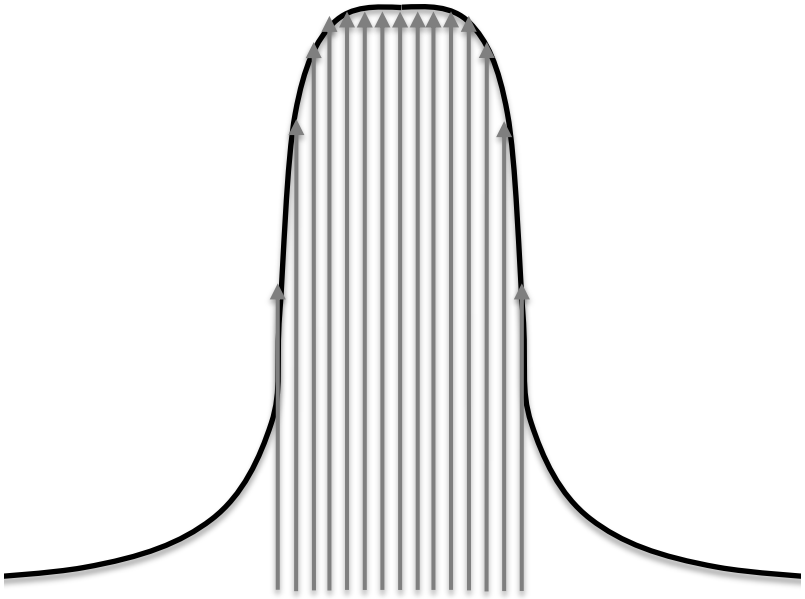
High dynamic range allows the instrument to simultaneously see both large and small signals

Example IMD Test Setup

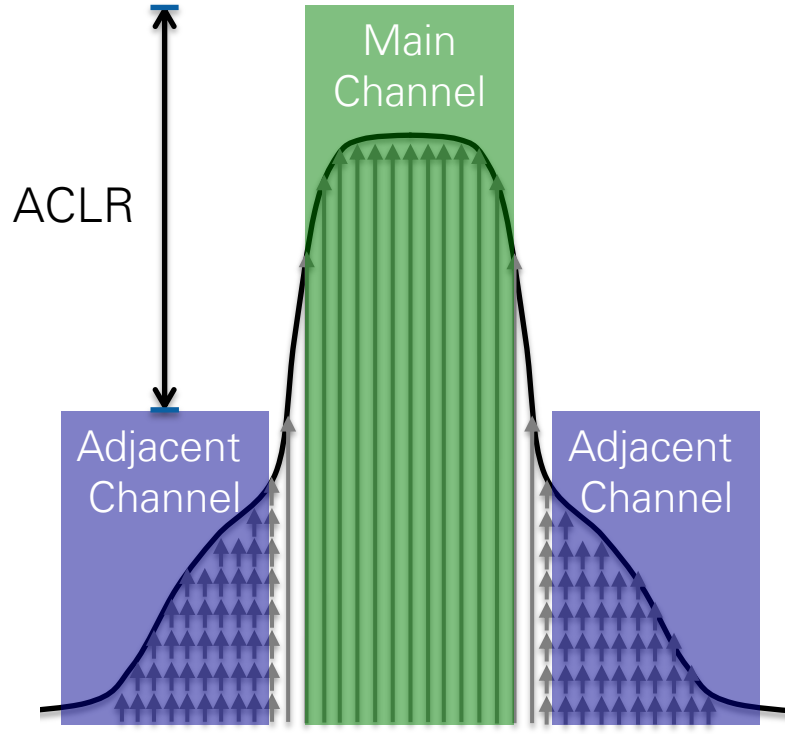


To ensure accurate IMD measurements, we must ensure that the visible 3rd order distortion products are due to the DUT rather than the instrument

IMD and Noise Determine ACLR Performance

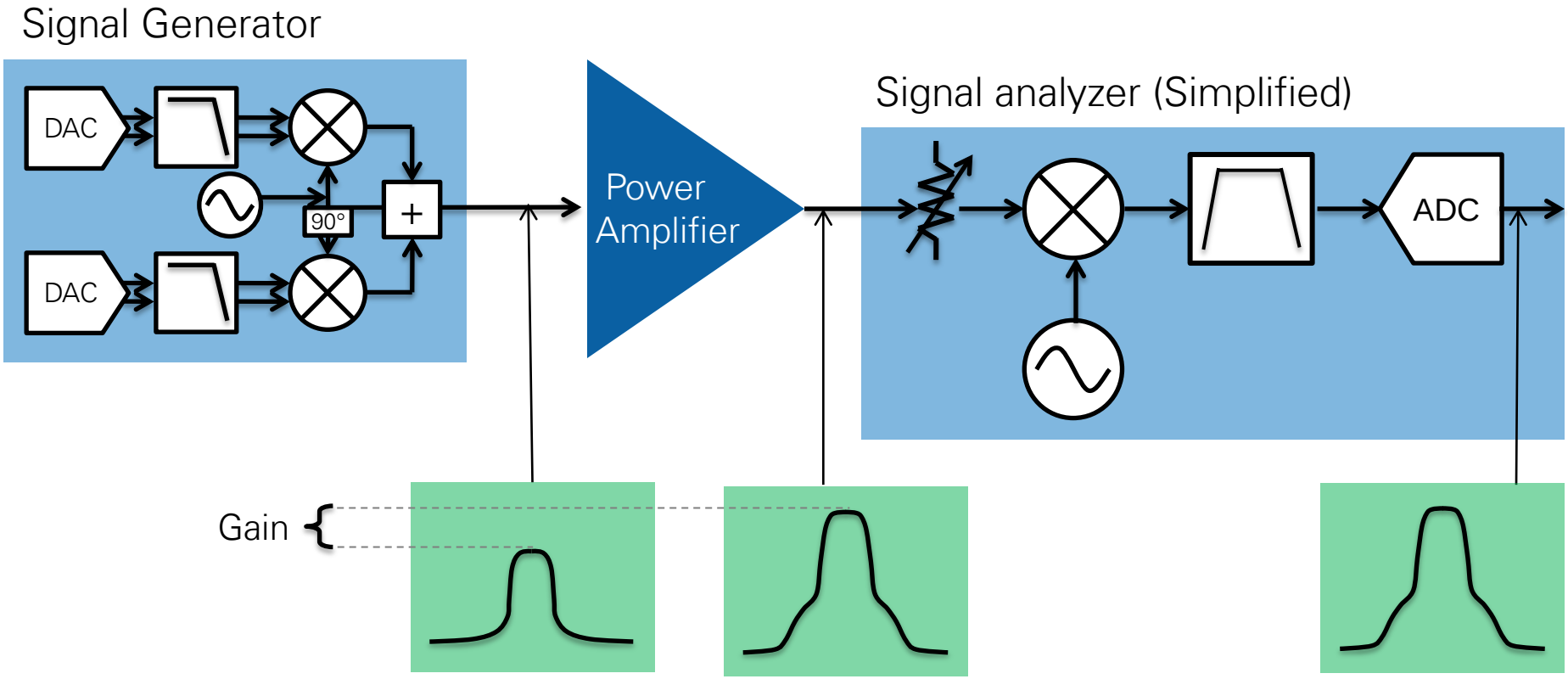


In the frequency domain, we can consider a modulated signal as a series of tones.



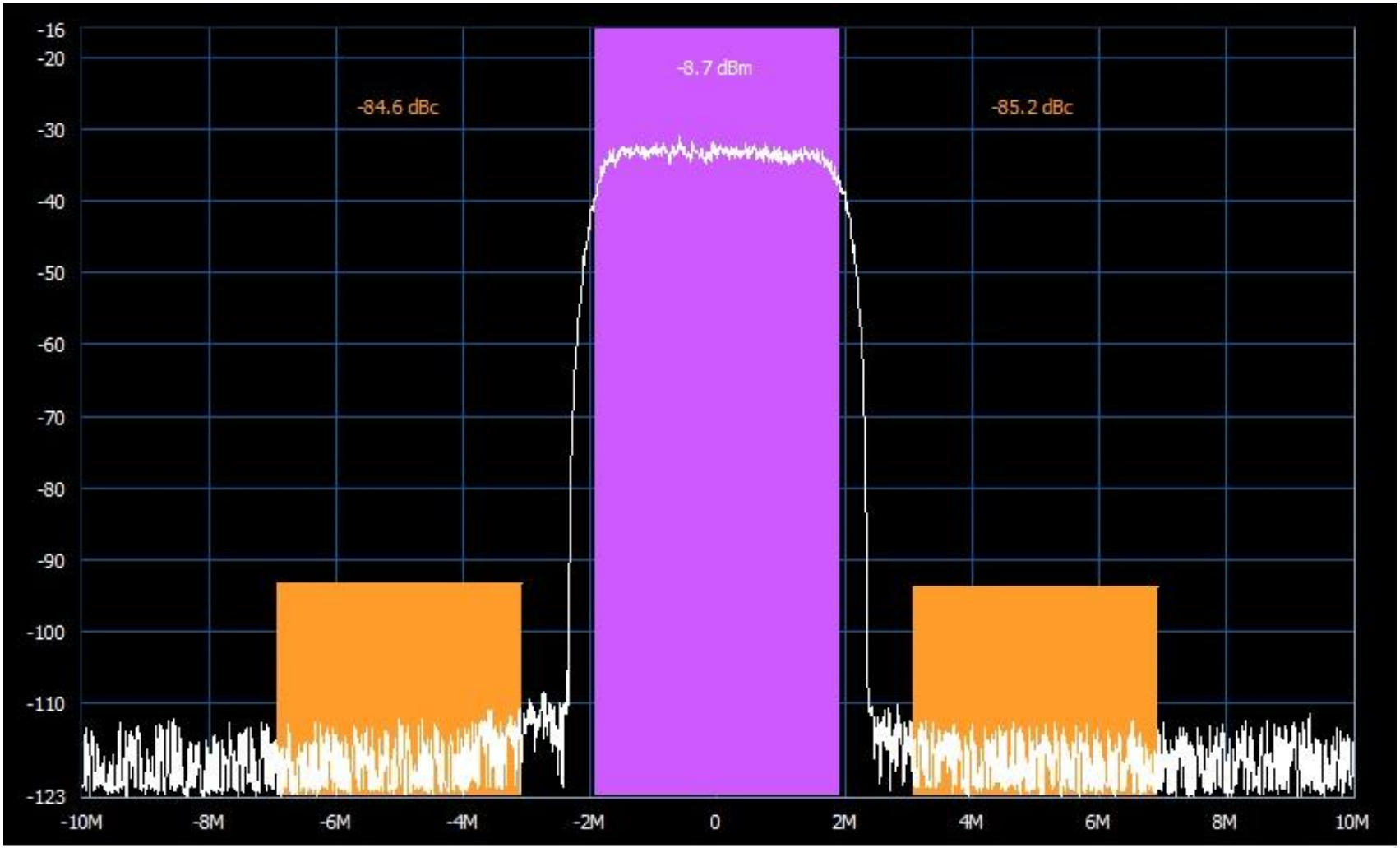
3rd Order distortion products form in adjacent bands – and are called spectral re-growth.

Example WCDMA PA Test Setup



A high-performance signal analyzer is able to measure ACLR without contributing inherent noise or nonlinearity. Often, a signal analyzer can employ "noise correction" to remove its inherent noise contribution.

Example ACLR Performance



NI 26.5 GHz Analyzer : *RF Performance*

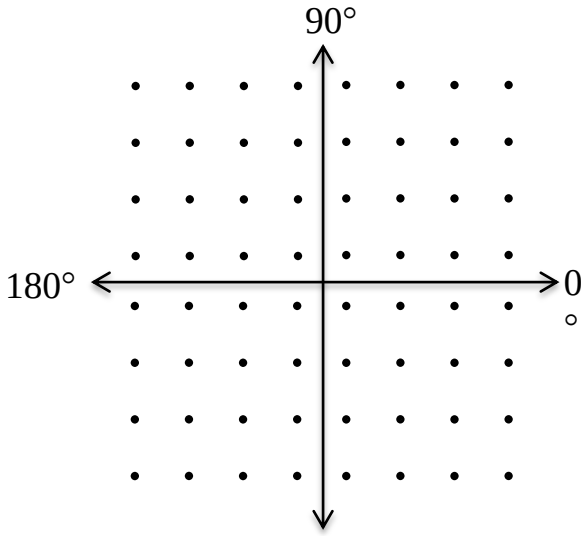
Dynamic Range

Bandwidth

Phase Noise

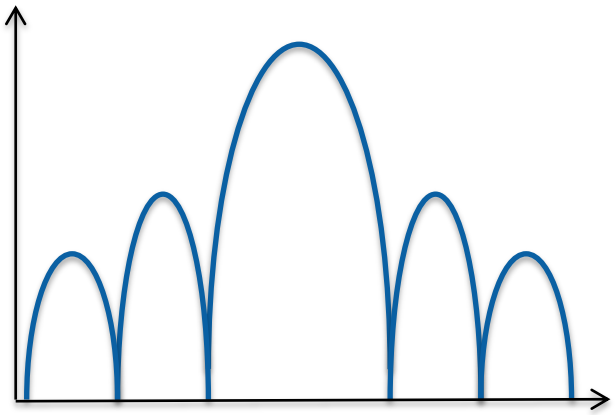
When Does Bandwidth Matter?

Modulation Measurements



Demodulation requires instantaneous bandwidth larger than the bandwidth of the acquired signal.

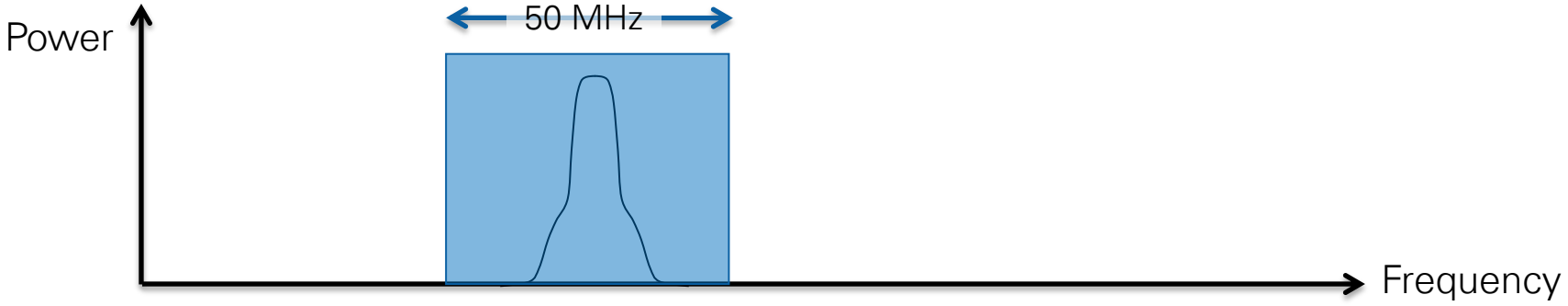
Pulsed Measurements



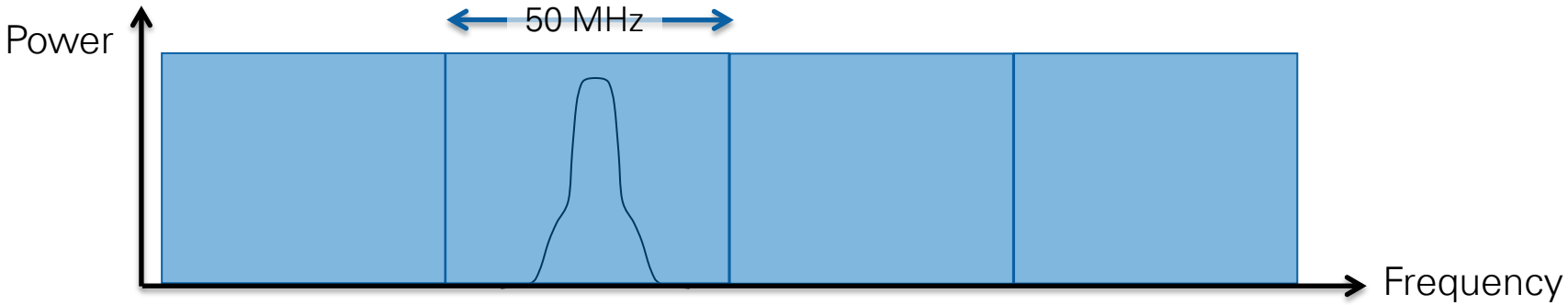
Pulsed signals produce wideband sidelobes in frequency domain and requires 500 MHz or more of bandwidth.

How an FFT analyzer works

If span < instantaneous bandwidth, VSA captures signal in one acquisition & performs FFT.

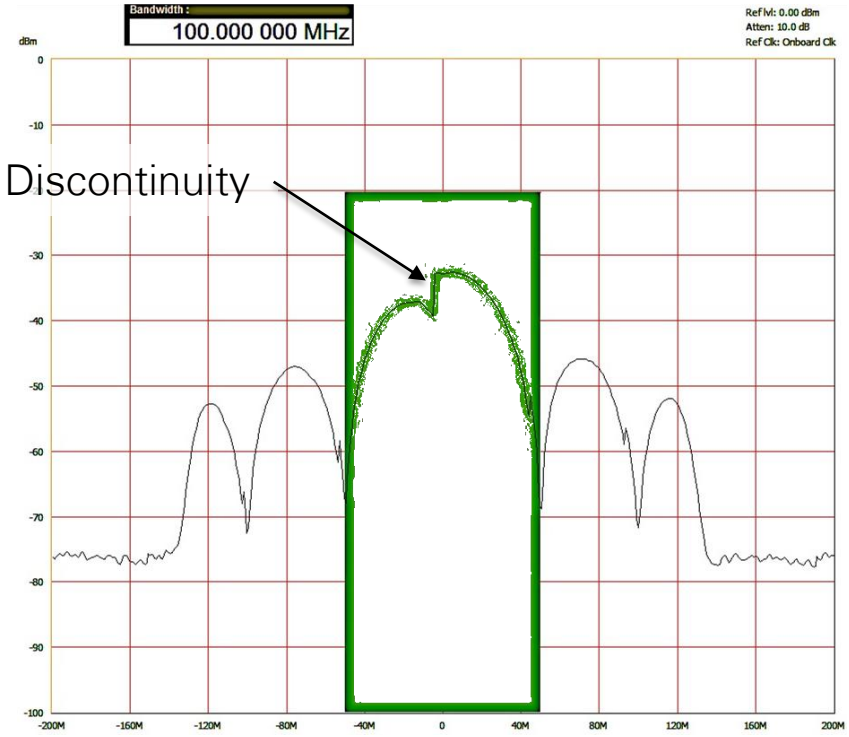


If span > instantaneous bandwidth, VSA captures signal in multiple acquisitions & stitches FFT's together to display entire span.



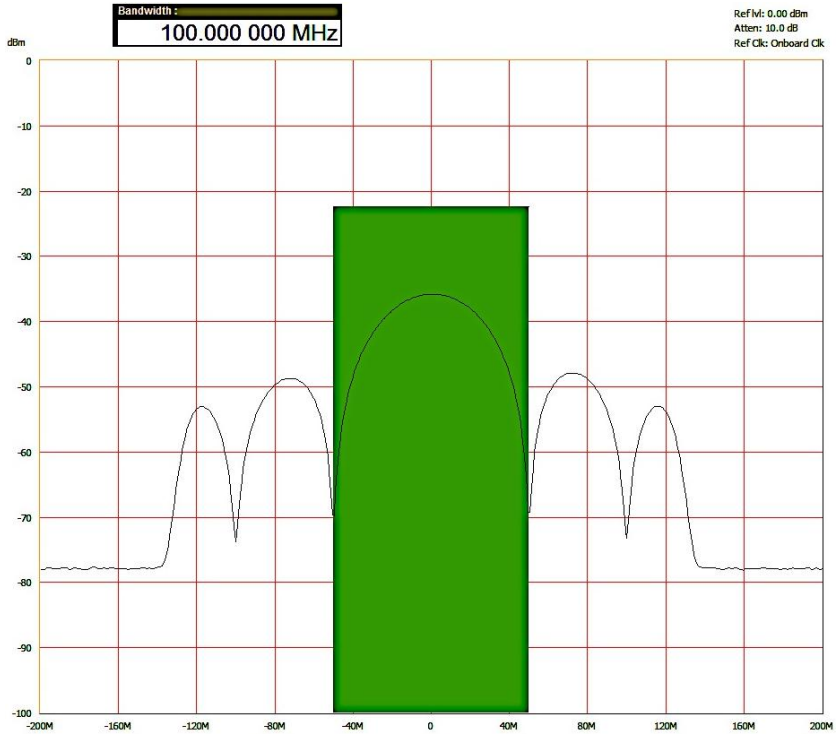
FFT Analyzers and Wideband Signals

Instrument BW < Signal BW



Spectrum acquired in multiple acquisitions

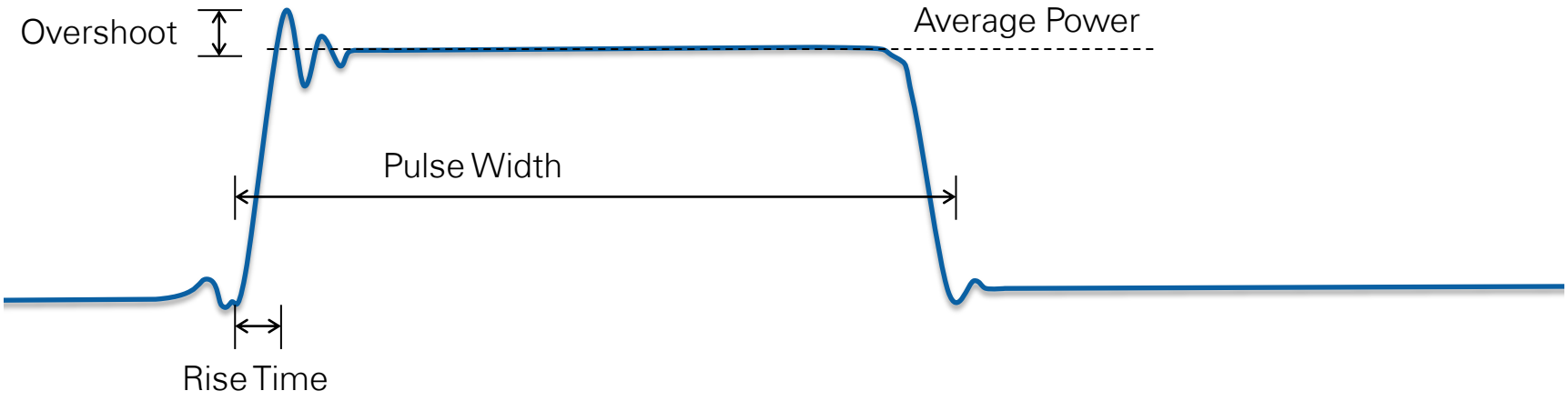
Instrument BW > Signal BW



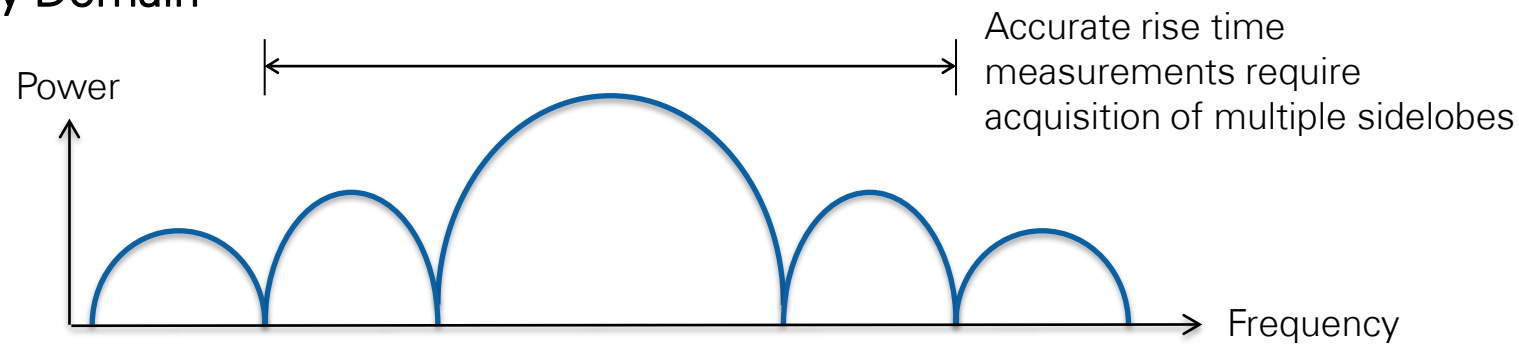
Spectrum acquired in a single acquisition

Example: RADAR Pulse Measurements

Time Domain



Frequency Domain



NI 26.5 GHz Analyzer : *Flexibility*

FPGA Programming

RF Recording

Multi-Channel & MIMO

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NI 26.5 GHz Analyzer : *Flexibility*

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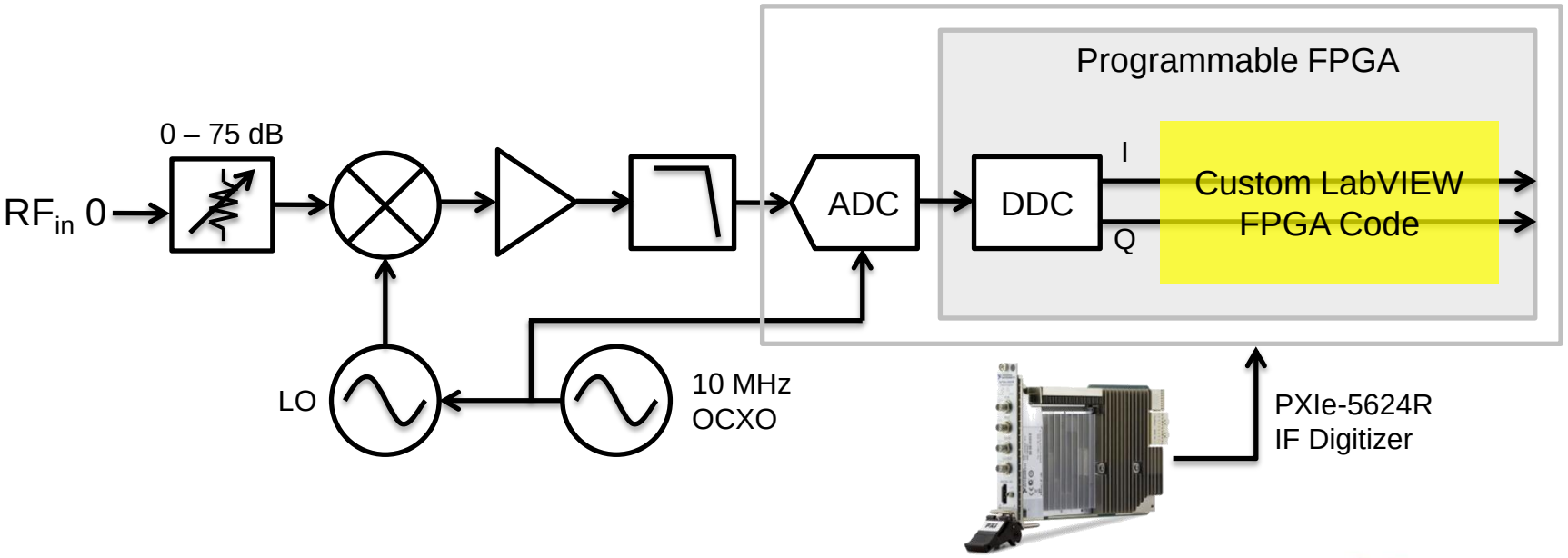
Using the 26.5 GHz Analyzer Onboard FPGA

- PXIe-5668R is LabVIEW FPGA programmable "target"
- FPGA characteristics:
  - Xilinx Kintex-7 410T
  - Native IP includes: DDC, Equalization, Power Triggering, etc.
  - Can be augmented with custom IP



Out-of-the-Box Functionality +
FPGA Enhancements

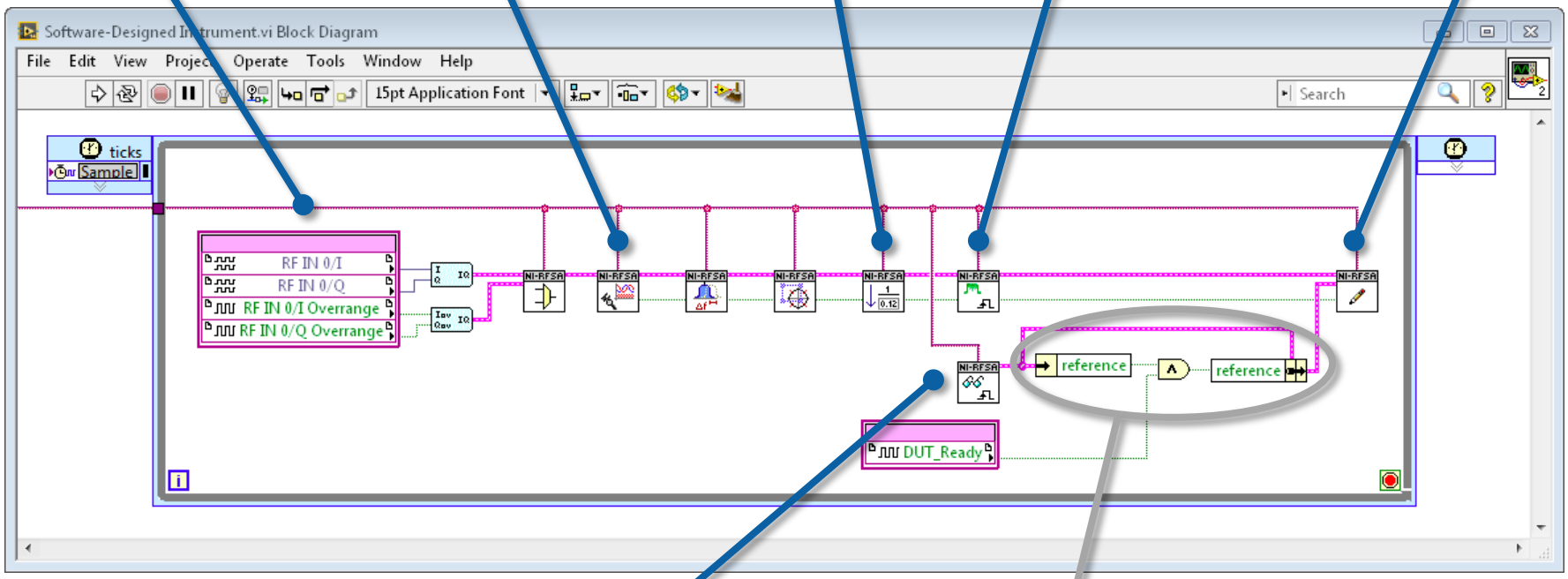
I/O

Calibration

DSP

Triggering

Acquisition



Synchronization

Application-Specific Enhancement

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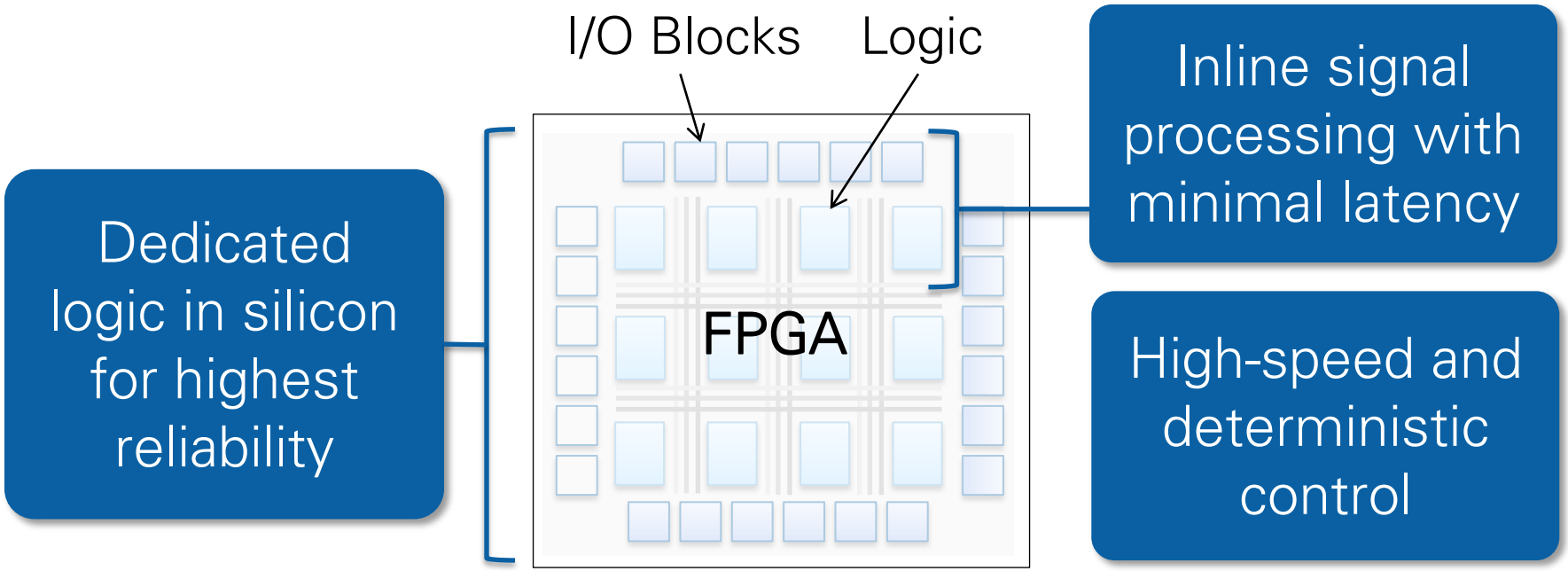
FPGA Technology

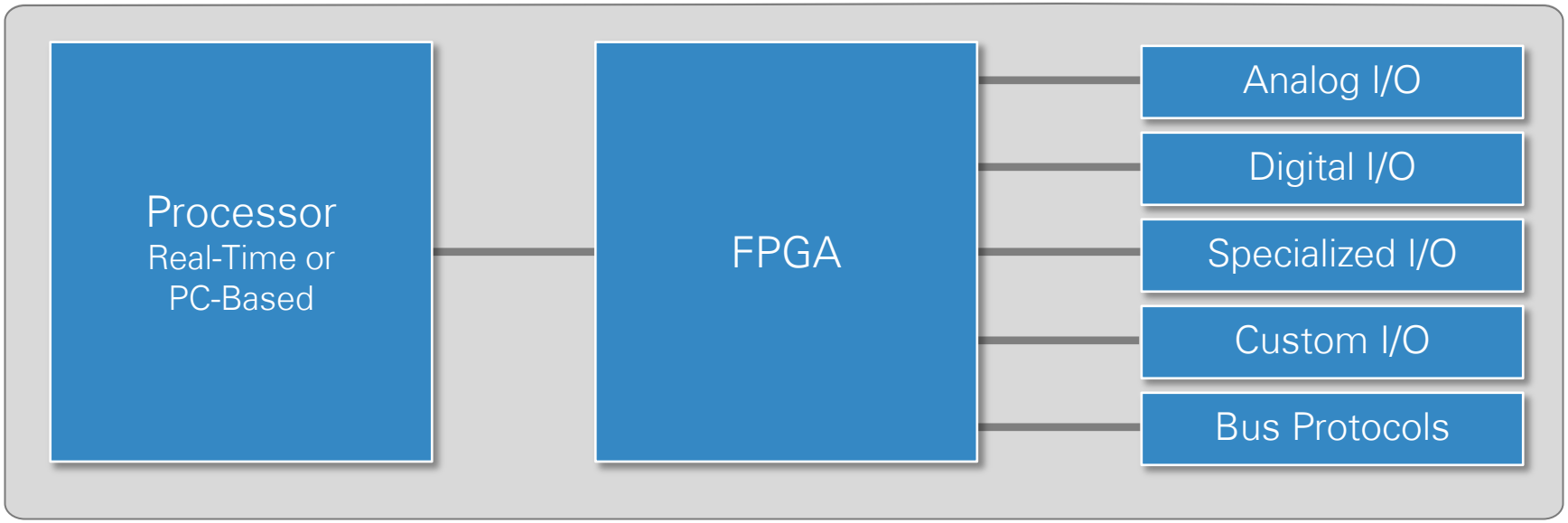
What is an FPGA?

- Software defined hardware
- No operating system is needed for execution of logic



The NI Approach

We call this the LabVIEW RIO architecture.



Highly Productive **LabVIEW** Graphical Programming Environment
for Programming Host, FPGA, I/O, and Bus Interfaces

IF Digitizer with User-Programmable FPGA

NI PXIe-5624R

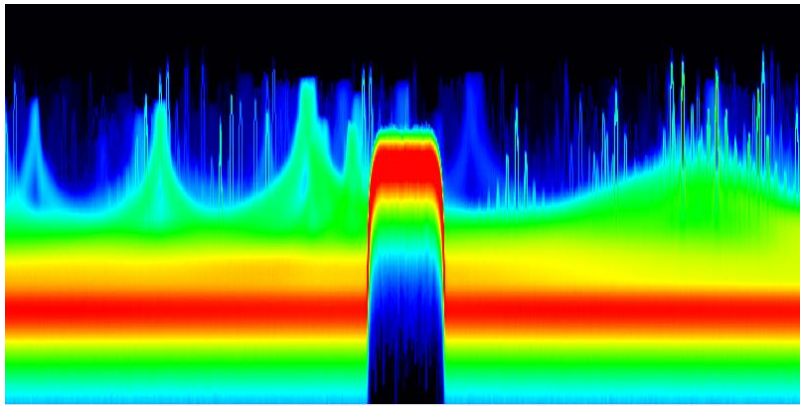
- High sample rate: 2 GS/s
- High dynamic range: 12-Bit
- Analog bandwidth: 2 GHz
- High speed bus: Gen. 2 x8 PCI Express (up to 3.2 GB/s)
- User-programmable: Xilinx Kintex-7 FPGA

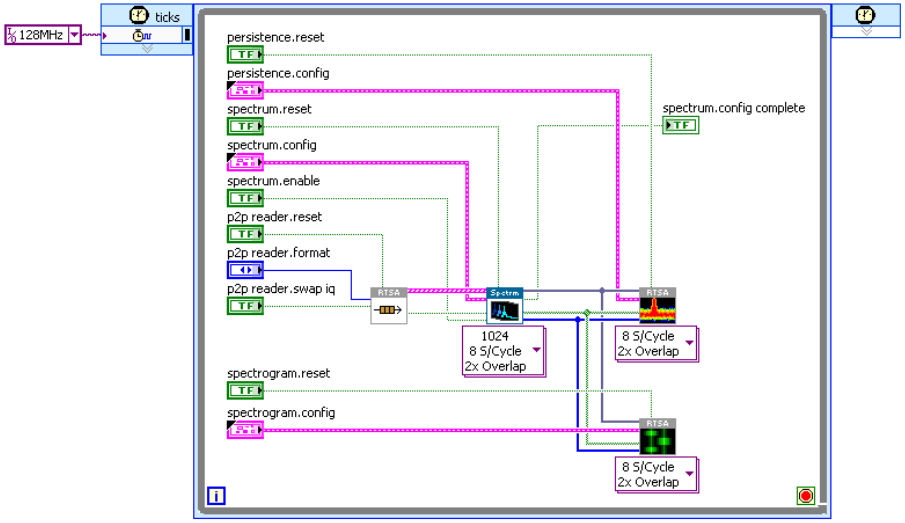
Application Areas

- IF-Digitizing of signals from Downconverters / Mixers
- Direct RF acquisition

Example: Real-Time Spectrum Analysis

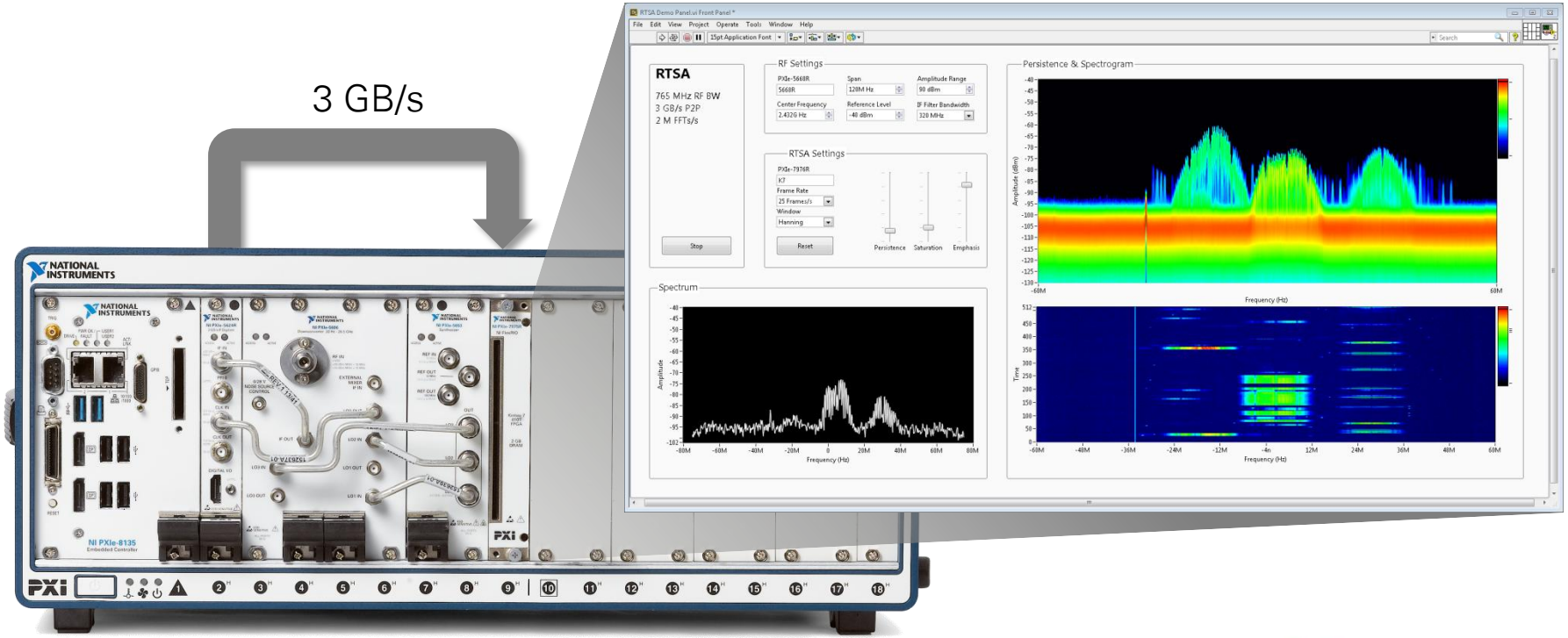
- Gapless persistence, spectrogram, and trace statistics (max hold, min hold, average) calculated on FPGA
- Process up to 2 M FFTs/s using overlapped, windowed FFTs
- Real-time frequency mask triggering
- 100% probability of intercept (POI) minimum duration options:
  - 1 µs or >15 µs
- Source available upon request





Real-Time Spectrum Analysis HW Configuration

- PXIe-5668R VSA + PXIe-7976R FlexRIO in PXIe-1085
  - May use other P2P-capable RF analyzers
- Up to 800 MHz RF bandwidth (3 GB/s)



NI 26.5 GHz Analyzer : *Flexibility*

FPGA Programming

RF Recording

Multi-Channel & MIMO

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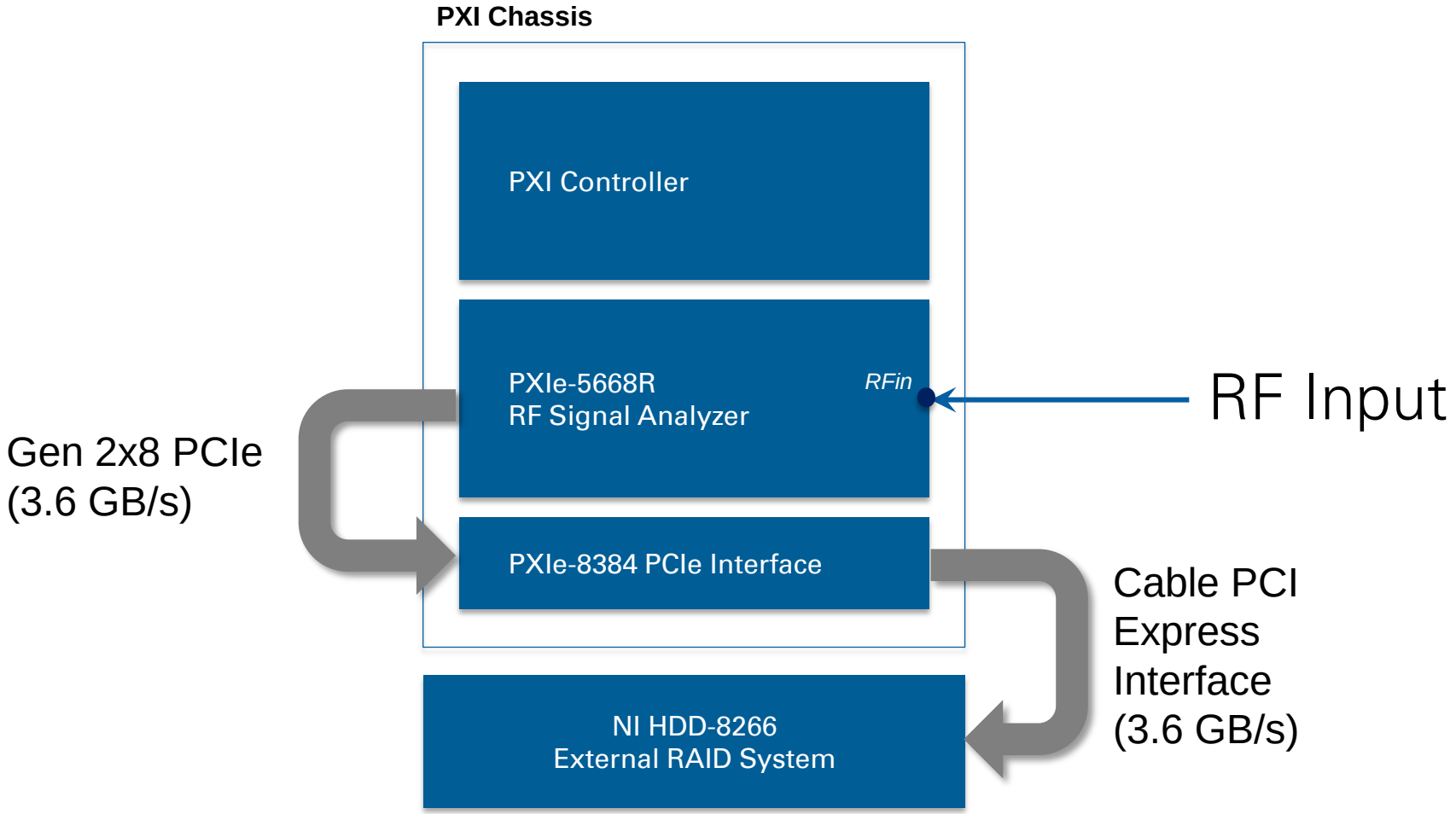
NI 26.5 GHz Analyzer Recording System Architecture



PXIe-5668R Recording Rates

External RAID System

Sample Rate	Bandwidth	Data Rate	Max Recording Time (24 TB)
100 MS/s	80 MHz	400 MB/s	16.67 hours
250 MS/s	200 MHz	1 GS/s	6.67 hours
500 MS/s	400 MHz	2 GS/s	3.33 hours
1 GS/s*	800 MHz*	3 GS/s*	2.22 hours*

**Record-to-Disk Examples Coming Soon!*

NI 26.5 GHz Analyzer : *Flexibility*

FPGA Programming

RF Recording

Multi-Channel & MIMO

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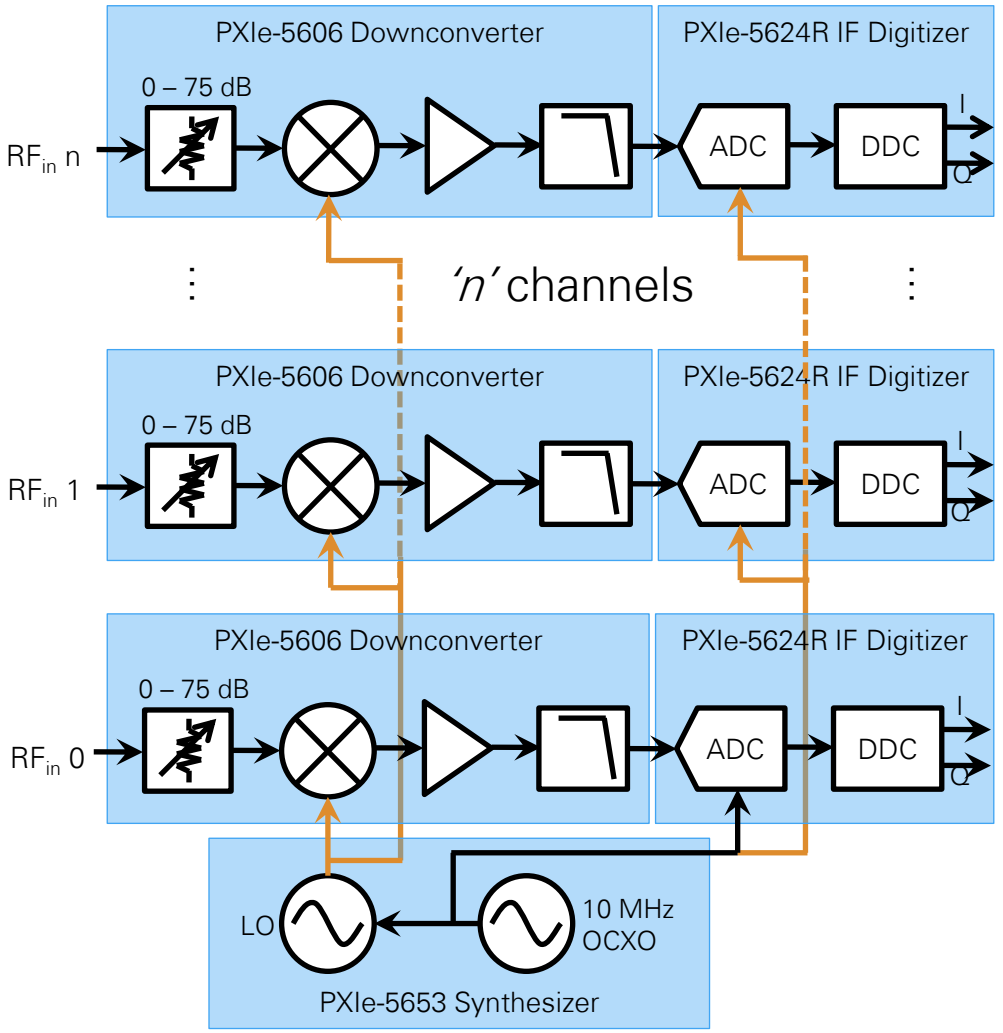
Multi-Channel Vector Analysis

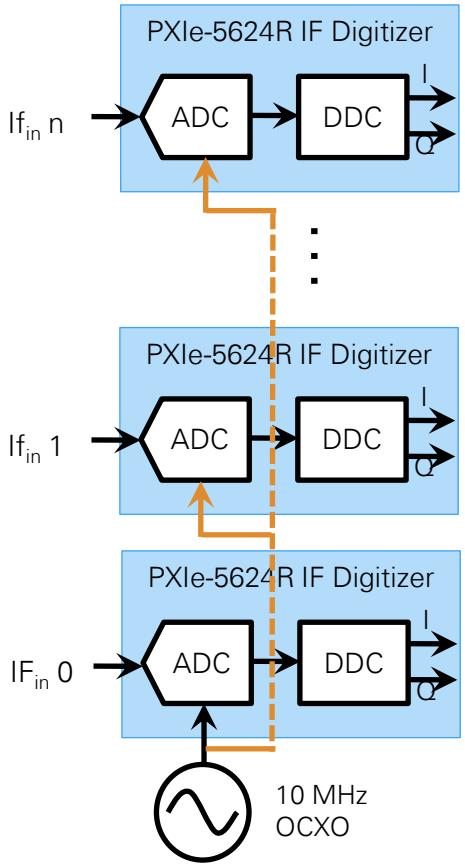
- LO can be cascaded to multiple downconverters
- 10 MHz reference can be shared across multiple PXI chassis
- Up to 3 channels per PXI chassis



Multi-Channel Digitizer Synchronization

- ADC characteristics
  - 2 GS/s sample rate
  - 12-bit resolution
  - 800 MHz DDC bandwidth
- Up to 17 channels per PXI chassis
- Expected channel-to-channel phase delay: < 100ps

PXIe-5624R
IF Digitizer



Other RF Products

Other Software designed Instruments

Vector Signal Transceiver
6 GHz RF VSA/G, 200 MHz BW

RF Signal Analyzer
26.5 GHz, 765 MHz BW

IF Digitizer
2 GS/s, 2 GHz, 12-bit

Oscilloscope
8-ch, 14-bit, 250 MS/s

High-Speed Serial Instrument
12.5 Gb/s, 8 Tx/Rx

PXIe-5654 + Amplitude Extension (AE)
Signal Generator

Specifications	
Frequency Range	250 kHz to 20 GHz
Max. Output Power	+24 dBm
Attenuation	130 dB
Phase Noise (Typ, @10kHz offset)	-133 dBc/Hz @ 1GHz -122 dBc/Hz @ 10GHz
Switching Speed	100 µs
Level Accuracy	± 0.9 dB
Harmonics (typ, +10dBm output)	< -50 dBc
Pulse Modulation	80 dB on/off ratio, typ 15 ns rise/fall time

Thank you