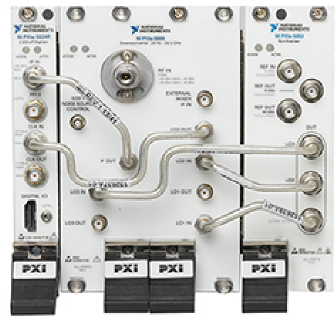
Technical Sales

(866) 531-6285
orders@ni.com

Last Revised: 2014-11-06 07:14:57.0

26.5 GHz RF High-Performance Vector Signal Analyzer and Spectrum Analyzer

PXIe-5668R



- 20 Hz to 26.5 GHz frequency range
- 320 MHz instantaneous bandwidth <3.6 GHz
- 765 MHz instantaneous bandwidth from >3.6 GHz
- -129 dBc/Hz typical phase noise at 10 kHz offset at 800 MHz
- ±0.35 dB typical flatness within 100 MHz IF filter
- ±0.1 dB typical amplitude accuracy
- Selectable preamp <3.6 GHz
- Selectable preselector (YTF) >3.6 GHz
- -166 dBm/Hz typical display averaged noise floor at 1 GHz
- 12-bit analog-to-digital converter at 2 GS/s
- User-programmable FPGA using LabVIEW

Overview

The PXIe-5668R vector signal analyzer (VSA) offers 765 MHz of bandwidth with best-in-class measurement performance and speed. This high-performance microwave signal analyzer meets the challenging requirements of applications such as wireless communications, radio frequency integrated circuit (RFIC) characterization, Radio Detection And Ranging (RADAR) test, and spectrum monitoring/signal intelligence.

The VSA features a unique combination of RF measurement performance, measurement speed, and flexibility. With industry-leading dynamic range and bandwidth, this instrument is an ideal solution for the challenging measurement requirements of R&D applications. With its implementation as a PXI instrument, the PXIe-5668R also provides the fast measurement speed needed for high-volume manufacturing test. Finally, this VSA includes a LabVIEW-programmable Xilinx Kintex-7 FPGA that you can use to customize the instrument's behavior by adding triggering or signal processing routines.

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Application and Technology

You can use the PXIe-5668R as either a spectrum analyzer or vector signal analyzer with LabVIEW or LabWindows™/CVI software. In addition, you can use it with the Modulation Toolkit and Spectral Measurements Toolkit for LabVIEW to analyze custom and standard modulation formats.

When combined with NI or third-party analysis toolkits, the PXIe-5668R can perform measurements for a broad range of communications standards such as GSM/EDGE, UMTS/HSPA+, WCDMA, LTE/LTE-Advanced, Bluetooth, 802.11a/b/g/n/p/ac, DVB-C/H/T, and ATSC. In addition, the combination of LabVIEW analysis software and wide bandwidth helps you accurately perform pulse measurements for radar applications.

Measurement	PXIe-5661	PXIe-5663	PXIe-5665	PXIe-5668R
Frequency Range	9 kHz to 2.7 GHz	10 MHz to 6.6 GHz	20 Hz to 3.6 GHz/14 GHz	20 Hz to 14/26.5 GHz
Phase Noise	-90 dBc/Hz at 10 kHz offset from a 1 GHz carrier	-105 dBc/Hz at 10 kHz offset from a 1 GHz carrier	-129 dBc/Hz at 10 kHz offset from an 800 MHz carrier	-129 dBc/Hz at 10 kHz offset from an 800 MHz carrier
Architecture	Multistage	Single stage	Multistage	Multistage
List Mode	No	Yes	Yes	No
Peer-to-Peer Streaming	No	Yes	Yes	Yes
Absolute Amplitude Accuracy	±0.6 dB	±0.65 dB	± 0.1 dB	± 0.1 dB
Average Noise Floor @ 1 GHz	-122 dBm/Hz	-158 dBm/Hz	-165 dBm/Hz	-166 dBm/Hz
Bandwidth	20 MHz	50 MHz	25/50 MHz	80/200/765 MHz

Table 1. Comparison of NI Vector Signal Analyzers

RF Measurement Performance

The PXIe-5668R is a PXI fast Fourier transform (FFT)-based signal analyzer suitable for both high-end spectrum analysis and vector signal analysis. The combination of low phase noise, low noise floor, and high second- and third-order intercepts provides excellent dynamic range for applications ranging from adjacent channel leakage ratio (ACLR) measurements to spurs and harmonics measurements. Table 2 illustrates the typical performance of the PXIe-5668R at center frequencies of 1 GHz and 20 GHz.

Measurement	1 GHz	20 GHz
Noise Floor (RMS) Without Preamplifier Noise Floor (RMS) With Preamplifier	-154 dBm/Hz -166 dBm/Hz	-152 dBm/Hz —
IP3 Without YIG Tuned Filter IP3 With YIG Tuned Filter	+23 dBm —	+24 dBm +28 dBm
Second Harmonic Intercept	+67 dBm	N/A
Image Rejection	-105 dBc	-83 dBc
Phase Noise at 10 kHz Offset	-129 dBc/Hz	-116 dBc/Hz
Instantaneous Bandwidth	320 MHz	765 MHz

Table 2. Typical PXIe-5668R Performance

The PXIe-5668R achieves extremely wide instantaneous bandwidth using its 2 GS/s digitizer. As Table 2 shows, the instrument features 320 MHz of instantaneous bandwidth below center frequencies of 3.6 GHz and up to 765 MHz of instantaneous bandwidth at center frequencies from 3.6 GHz to 26.5 GHz.

Dynamic Range

The superior dynamic range performance of the PXIe-5668R gives it the ability to accurately perform measurements ranging from intermodulation distortion (IMD) to adjacent channel power (ACP) to error vector magnitude (EVM). In figures 1 and 2, the instrument’s dynamic range chart illustrates both noise and linearity as a function of mixer level.

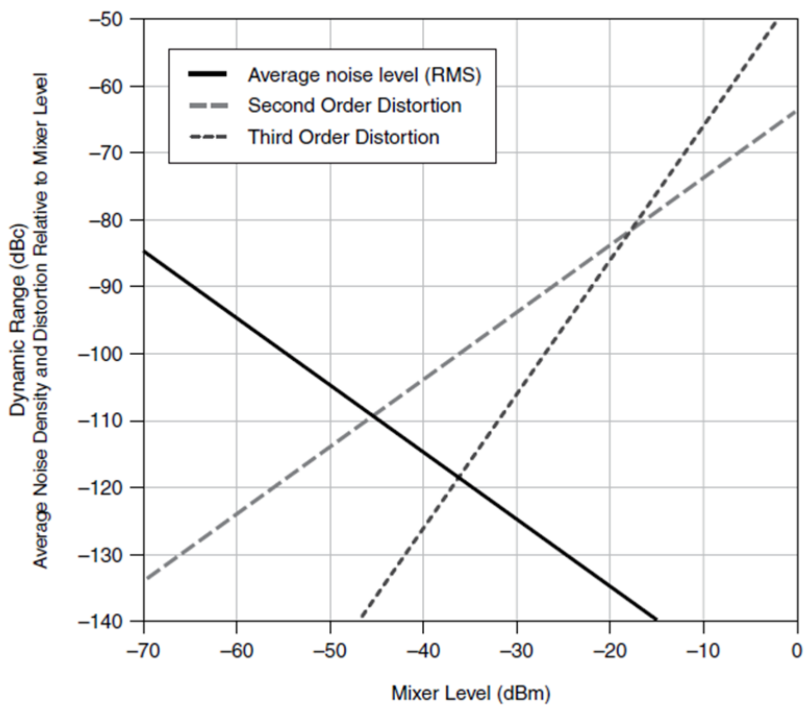

Figure 1. PXIe-5668R Dynamic Range Chart at 1 GHz, Preamplifier Disabled (Nominal)

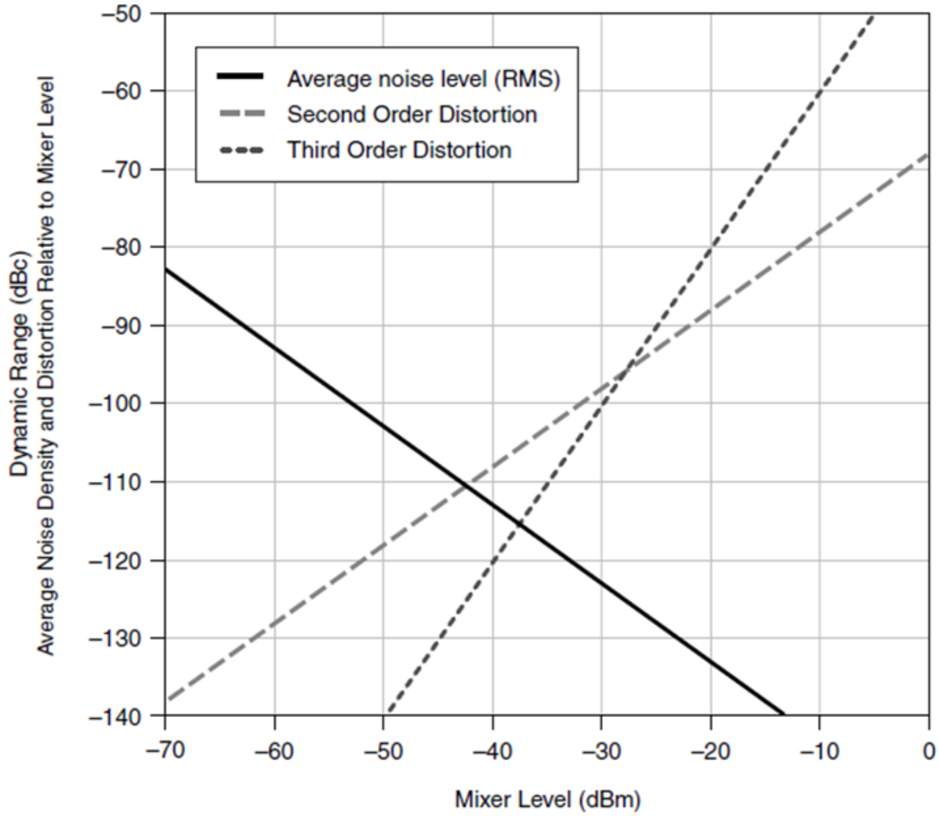

Figure 2. PXIe-5668R Dynamic Range Chart at 20 GHz, YTF Enabled (Nominal)

In Figure 1, note that the optimal mixer level for most measurements is approximately -36 dBm, where the instrument delivers approximately 119 dB of spurious-free dynamic range (SFDR) in a 1 Hz bandwidth. At 20 GHz (Figure 2), the PXIe-5668R achieves similar performance with an optimal mixer level of -37 dBm. At this mixer level, the instrument achieves 115 dB of SFDR in 1 Hz of bandwidth.

A combination of accurate linearity and noise floor is critical when measuring IMD and ACP. In fact, the specification that best represents the ability of an instrument to perform these measurements is third-order intercept (TOI). The PXIe-5668R has a TOI specification of better than +23 dBm at 1 GHz with 0 dB of attenuation. As Figure 3 illustrates, the instrument delivers nominal TOI performance of +25 dBm at 1 GHz, 2 dB better than specification.

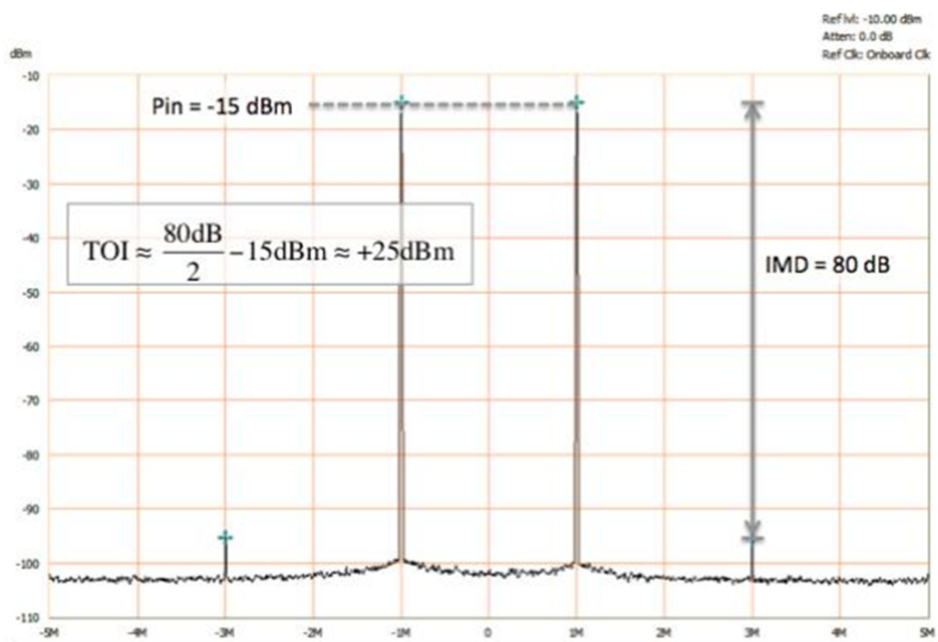

Figure 3. PXIe-5668R Intermodulation Distortion Measurements

Although the TOI specification of an RF signal analyzer is defined using 0 dB of attenuation by convention, an RF signal analyzer can measure TOI much higher than its specification. In practice, you can optimize measurement system linearity by switching up to 75 dB of internal attenuation on the PXIe-5668R.

In addition to IMD measurements, the high dynamic range of the PXIe-5668R makes it ideal for spectrum measurements such as ACP and ACLR. Figure 4 illustrates an ACLR measurement of a WCDMA signal and shows an inherent ACLR floor of approximately 85 dB.

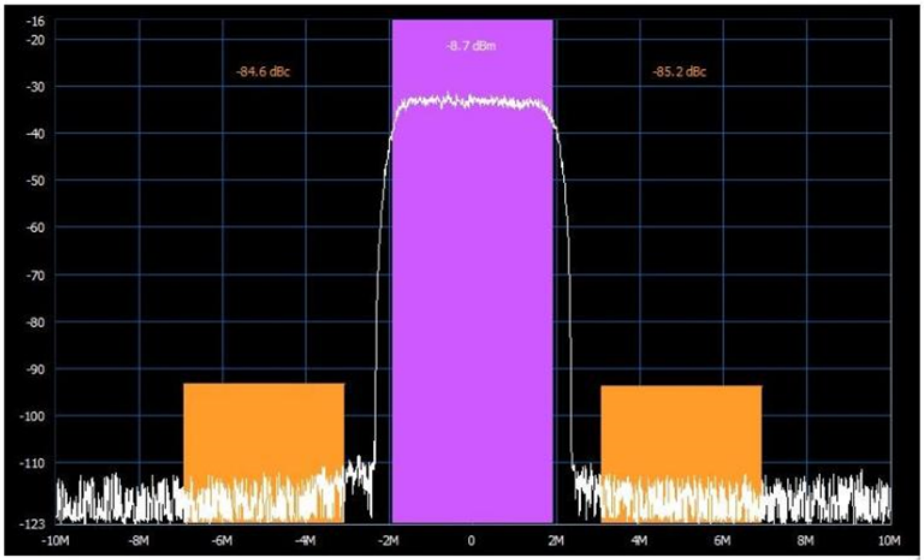

Figure 4. PXIe-5668R WCDMA ACLR Performance at 468 MHz

You can use NI wireless standard software toolkits with the PXIe-5668R to make UMTS ACLR measurements as well as test devices using technologies including GSM/EDGE, UMTS/HSPA+, LTE/LTE-Advanced, Bluetooth, and 802.11a/b/g/n/p/ac.

Wide Instantaneous Bandwidth

The PXIe-5668R supports an instantaneous bandwidth of 320 MHz or 765 MHz, depending on frequency range. The ability to measure extremely wide bandwidths in a single acquisition is useful for applications ranging from wireless communications test to radar pulse measurements. When you are measuring wideband signals with metrics such as EVM, make sure that the instantaneous bandwidth of the RF signal analyzer is greater than the bandwidth of the signal. For example, wireless technologies such as the IEEE 802.11ac standard require an instantaneous bandwidth of 160 MHz to perform an EVM measurement. In addition, the spectrum mask requirements for a 160 MHz 802.11ac signal include limits that are ±240 MHz from the center frequency for a total of 480 MHz of bandwidth. With 765 MHz of instantaneous bandwidth, the PXIe-5668R can perform measurements such as a 160 MHz spectrum mask in a single acquisition.
Additional applications such as RADAR pulse measurements also require extremely wide instantaneous bandwidth. In a typical RADAR pulse, the frequency domain characteristics of the signal appear as a sync function containing both a main lobe and theoretically infinite side lobes as shown in Figure 5.

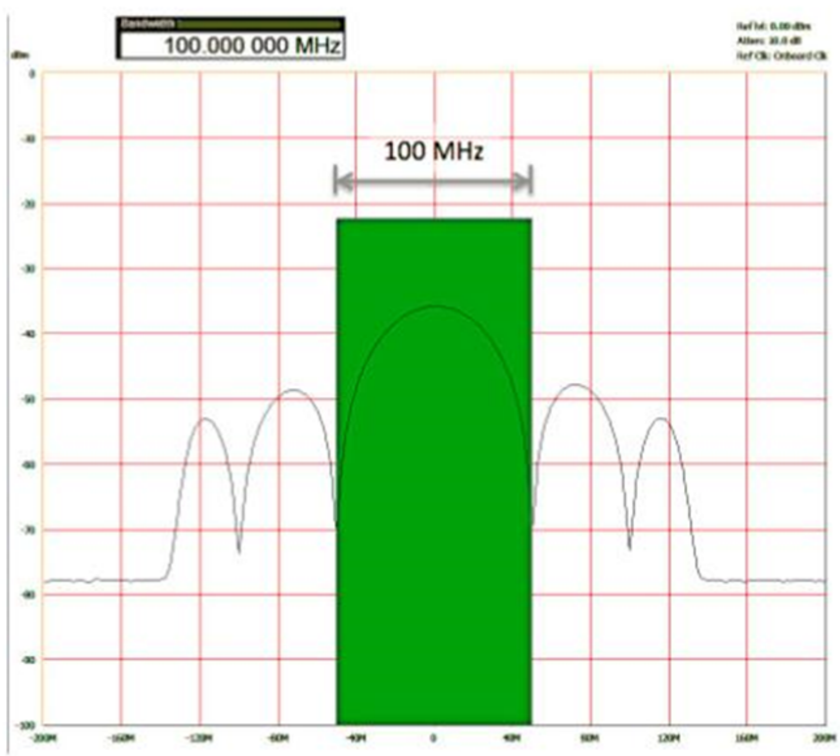

Figure 5. The Main Power Lobe of a 20 ns Pulse Contained Within a Bandwidth of 100 MHz

RADAR pulse measurements, such as pulse rise time, require a VSA to capture both the main lobe and several side lobes. A general rule for measuring the pulse rise time of X nanoseconds is that the instrument's instantaneous bandwidth must be 3/X. For example, to measure pulse rise times as low as 5 ns, the required instrument instantaneous bandwidth would be 3/(5 ns) or 600 MHz. In Figure 6, notice that the wide bandwidth of the PXIe-5668R signal analyzer enables extremely accurate pulse rise time measurements—in this case showing a rise time of 8 ns.

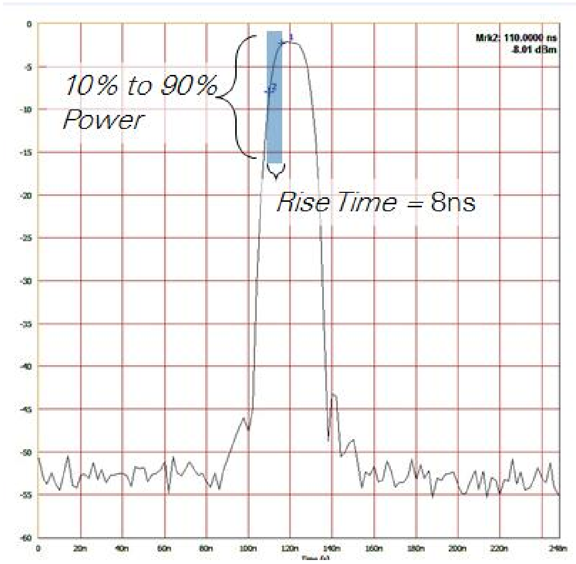

Figure 6. Time Domain of a 20 ns Pulse Using Zero Span Mode

Although the extremely wide bandwidth of the PXIe-5668R is ideal for performing accurate pulse measurements, the wide instantaneous bandwidth also allows faster spectrum measurements in scenarios where the span is smaller than the instantaneous bandwidth of the instrument.

Flexibility

Another key attribute of the PXIe-5668R RF signal analyzer is the flexibility with which you can reconfigure it. Because the VSA is a LabVIEW FPGA programmable target, you can embed custom signal processing algorithms on the instrument itself. For example, using LabVIEW example code, you can configure the instrument as a real-time spectrum analyzer (RTSA). As shown in Figure 7, with the RTSA personality, you can analyze extremely wide bandwidths of spectrum in real time without gaps in the time-domain record.

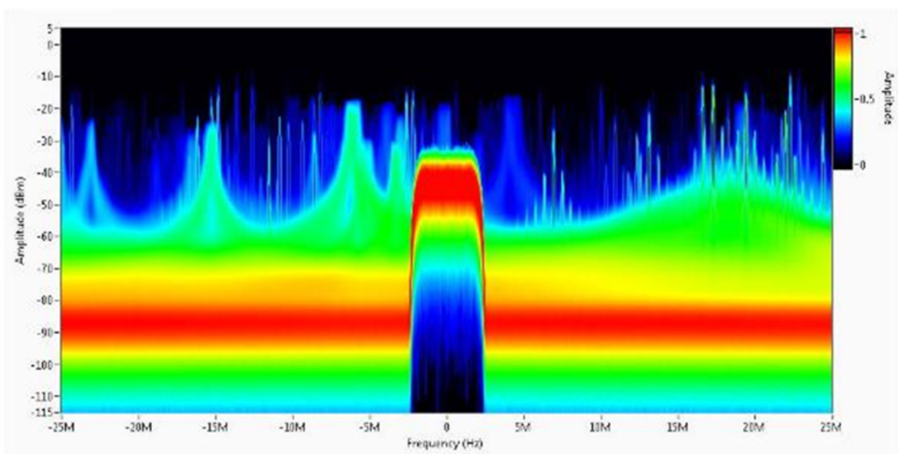

Figure 7. The real-time spectrum analysis capability of the PXIe-5668R enables unique visualization tools such as the persistence display.

Finally, as a result of this instrument's modular architecture, additional downconverter and digitizer modules support multichannel receiver configurations. The PXIe-5668R VSA provides the ability to share the local oscillator and other timing signals across multiple modules and allows for phase coherence between each RF channel. The phase coherence of multichannel receivers is important in applications ranging from direction finding to beamforming and multiple input, multiple output device testing. Figure 8 shows an example configuration of a 2-channel RF signal analyzer.

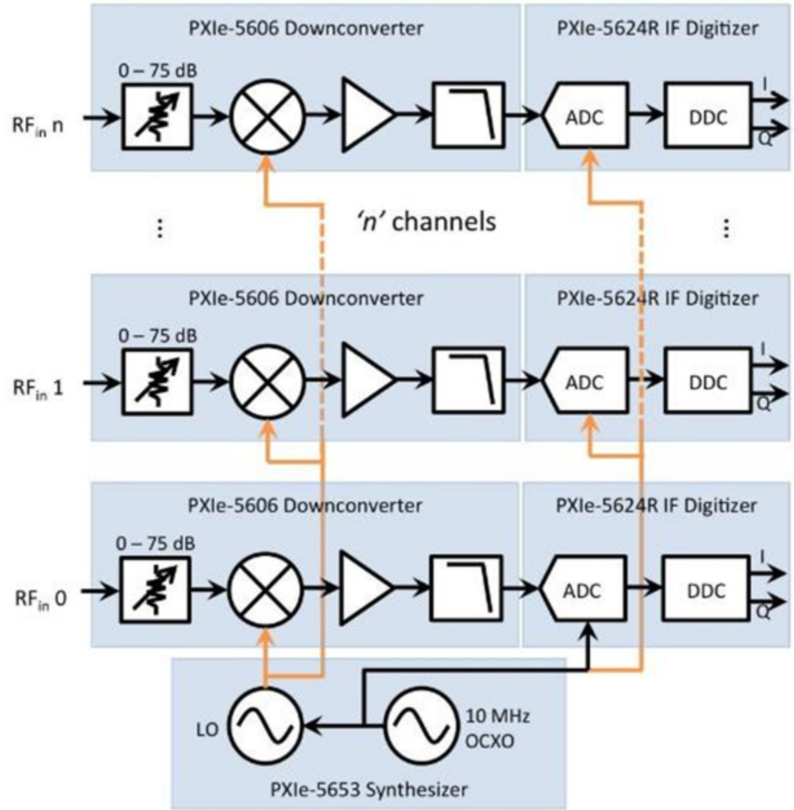

Figure 8. You can configure multiple PXIe-5668R instruments for multichannel, phase-coherent RF signal acquisition.

With the configuration shown in Figure 8, you can achieve tight channel-to-channel synchronization in multichannel measurement applications.

Fast Measurement Speed

Using software-defined measurements in the LabVIEW graphical development environment with the PXIe-5668R, you can perform common spectrum and demodulation measurements 3X to 10X faster than traditional instruments. For example, you can perform a 100 MHz spectrum capture in 2 ms with a PXIe-8135 embedded controller (100 kHz RBW). Though actual performance is system dependent, Figure 9 shows the relationship between measurement time and span (Hz).

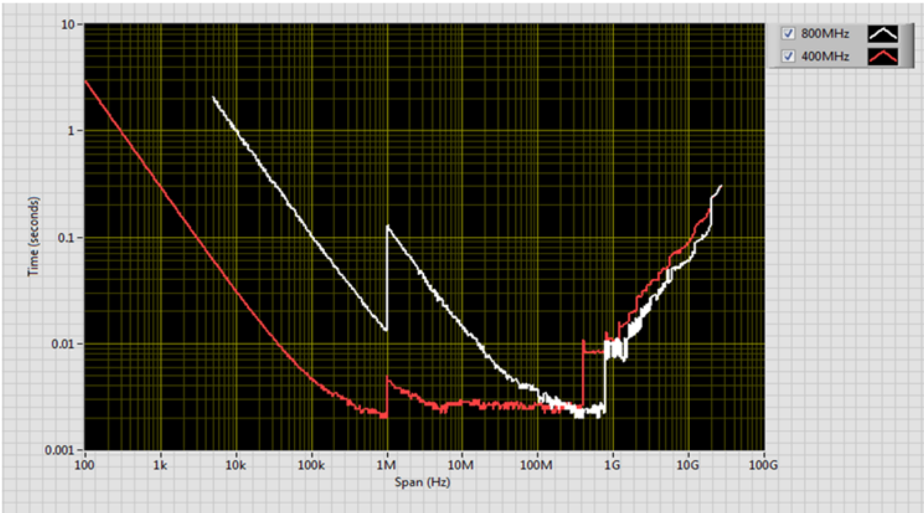

Figure 9. PXIe-5668R Measurement Speed for 320 MHz and 765 MHz Bandwidth Settings With Respect to Span (Hz)

Flexible Software

You can interface the PXIe-5668R with a variety of software experiences including interactive soft front panels and multiple programming APIs.

The NI-RFmx API offers the simplest programming experience for automating RF measurements. With NI-RFmx, you can reduce test system development time by simplifying complex RF measurement programming. It delivers industry-leading measurement speed and provides higher throughput capabilities than box instruments. Now you can control parallelism instead of trying to work around the inflexibility of traditional box instruments.

One of the biggest benefits of the NI-RFmx API is the breadth of ready-to-run LabVIEW examples. These examples not only demonstrate the simplicity of the API but also enable you to quickly get started on your automated RF test application. Figure 10 features a simple LabVIEW example showing an ACP measurement.

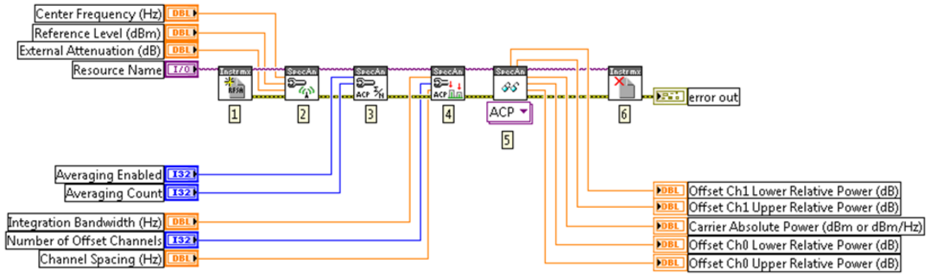

Figure 10. LabVIEW Example for an ACP Measurement

In addition to programming APIs for automated measurements, you can use the NI-RFSA Soft Front Panel (SFP) for interactive measurements. The SFP mimics the look and feel of traditional instruments and helps you perform basic measurements without programming. Figure 11 shows an ACP measurement performed in the NI-RFSA SFP.

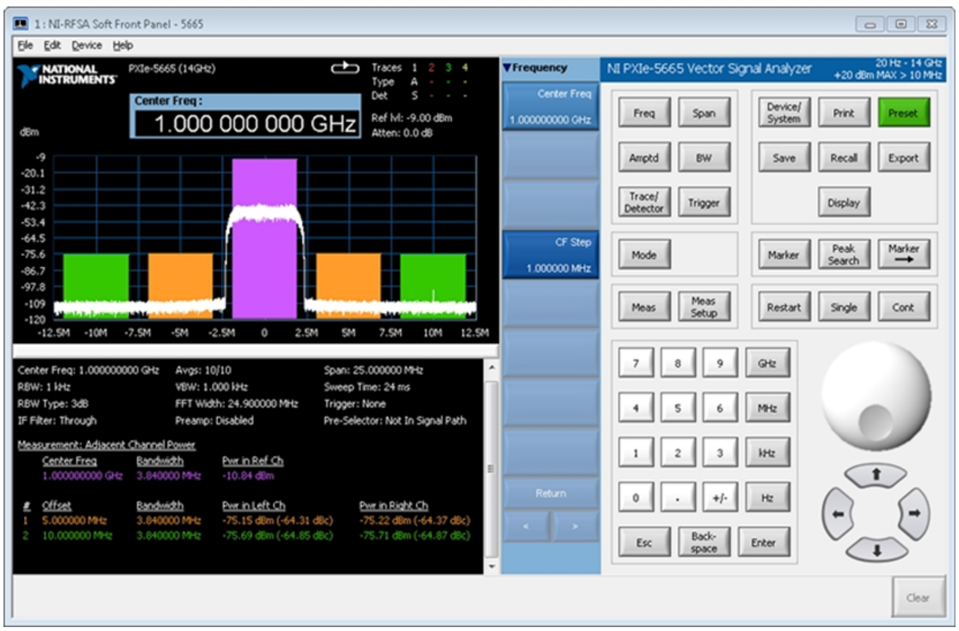

Figure 11. NI-RFSA SFP Showing an ACP Measurement

Architecture

The PXIe-5668R uses two distinct signal paths to deliver a combination of wide instantaneous bandwidth and best-in-class RF performance. In the low-band path, below 3.6 GHz, the instrument uses a three-stage superheterodyne design with optional preamplification. In the high-band path, above 3.6 GHz, the instrument uses a two-stage design with a selectable yttrium-iron-garnet (YIG)-tuned filter (YTF) for preselection.

In the low band of the PXIe-5668R (3.6 GHz shown in Figure 12), the instrument contains several features to improve measurement performance. Figure 12 highlights a simplified block diagram. Note that you can engage the 30 dB preamplifier to reduce the instrument's inherent noise floor when measuring low-level signals.

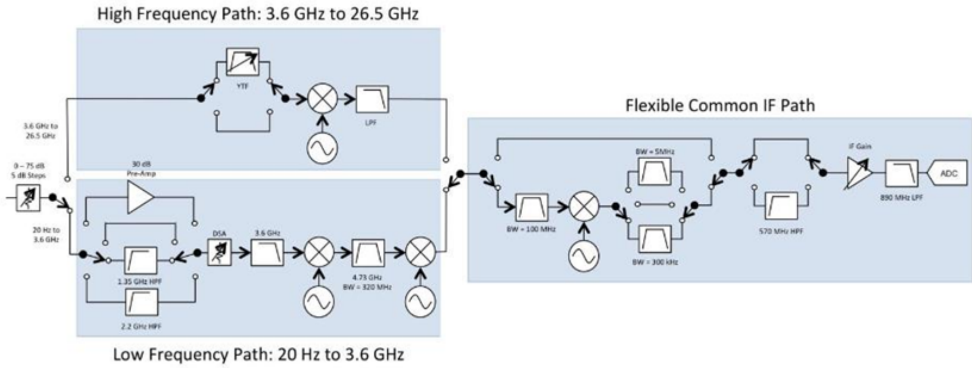

Figure 12. Simplified Block Diagram of the PXIe-5668R

Figure 12 also illustrates two highpass filters before the first mixing stage. You can engage these filters with a highpass cutoff of 1,350 MHz and 2,200 MHz to suppress the fundamental frequency of common cellular communications bands around 1 GHz. With filters enabled, the instrument can more accurately measure low-level second and third harmonics at approximately 2 GHz and 3 GHz, respectively.

In the high band, above 3.6 GHz, a YTF functions as a preselector for operation from 3.6 GHz to 26.5 GHz, which is enabled by default for spectrum measurements. For extremely wideband vector signal analysis, you can disable the YTF to use the full 765 MHz of instantaneous bandwidth.

Flexible IF Structure

Used with a 2 GS/s digitizer sample rate, the VSA's downconverter has a flexible IF structure that allows both high-end spectrum analysis and wideband vector signal analysis. For example, you can engage a narrow 300 kHz analog filter to facilitate measurements requiring the highest dynamic range, such as two-tone IMD or ACLR. For vector signal analysis, you can disable the IF filtering entirely to allow for bandwidths of up to either 320 MHz or 765 MHz, depending on the center frequency.

The PXIe-5624R digitizer's wideband analog front end is optimized for superheterodyne receiver architectures. It features an onboard digital downconverter which filters, decimates, and shifts complex IF signals to baseband data centered at 0 Hz. As a result, you can use the PXIe-5624R either as part of the PXIe-5668R VSA or as a stand-alone IF digitizer.

Summary

The PXIe-5668R is a high-performance 26.5 GHz VSA that is ideal for a wide range of applications. The combination of superior analog performance, extremely wide bandwidth, and ultimate flexibility empowers you to solve challenging measurement applications ranging from ACLR measurements to RADAR verification to spectrum monitoring.

Find more information on the PXIe-5668R at ni.com/microwave.

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