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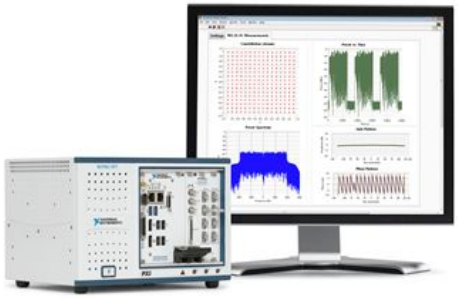
NI PXIe-5644R/5645R/5646R

6 GHz RF Vector Signal Transceivers



- Vector signal analyzer and generator in a single PXI module
- 65 MHz to 6 GHz frequency range
- Up to 200 MHz instantaneous bandwidth
- 24 channels of high-speed digital I/O up to 250 Mbit/s
- Built on FPGA technology programmable with NI LabVIEW software
- Industry-leading performance and test times for testing the latest wireless standards such as 802.11ac, including optional specifications
- Easily expands to support multiple input, multiple output (MIMO) configurations or parallel testing in a single PXI chassis
- Optional baseband I/Q interface with the NI PXIe-5645R

Overview

Comprised of a vector signal generator, vector signal analyzer, and digital I/O, the NI PXIe-5644R/5645R/5646R RF vector signal transceivers (VSTs) combine multiple instruments into a single PXI Express module. Backed by software to support the latest RF standards, including 802.11ac and LTE Advanced, NI vector signal transceivers boast the performance and flexibility of an R&D-grade box instrument with the speed, low cost, and small form factor of a manufacturing test system. In addition, NI vector signal transceivers have a user programmable FPGA at their core, making them software-designed instruments. This allows users to customize the firmware of their instrument down to the pin.

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Application and Technology

A vector signal transceiver (VST) is a new class of instrumentation that combines a vector signal generator (VSG) and vector signal analyzer (VSA) with FPGA-based real-time signal processing and control. Vector signal transceivers from National Instruments also feature a user-programmable FPGA, which allows custom algorithms to be implemented directly into the hardware design of the instrument. This software-designed approach allows an NI vector signal transceiver to have the flexibility of a software-defined radio (SDR) architecture with RF instrument class performance. Figure 1 below illustrates the difference between traditional approaches to RF instrumentation and a software-designed approach with NI vector signal transceivers.

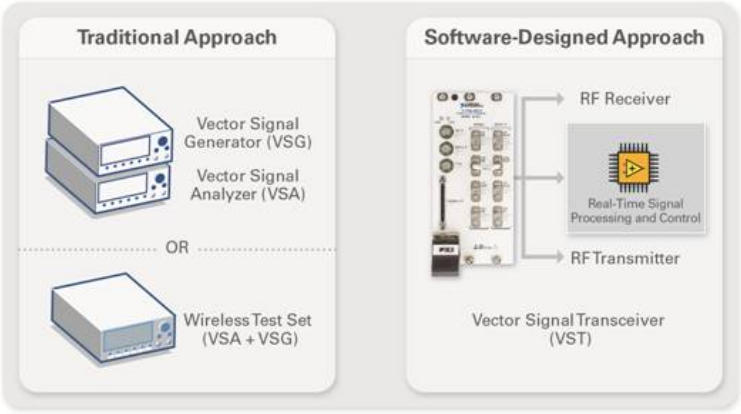

Figure 1. *Compare the software-designed approach of a VST with traditional approaches.*

RF Receiver

NI vector signal transceivers feature a zero-IF receiver; allowing it to have higher potential bandwidths, lower cost, less power consumption, and a smaller footprint when compared to heterodyne receivers. Other advantages include simpler designs with single LOs, and high selectivity, which allows separation of adjacent channels whose signals overlap. Table 1 below compares the RF receiver on the NI vector signal transceivers with existing NI vector signal analyzers.

	NI PXIe-5661	NI PXIe-5663E	NI PXIe-5644R/5645R/5646R	NI PXIe-5665	NI PXIe-5668R	Phase Matrix
Frequency Range	9 kHz to 2.7 GHz	10 MHz to 6.6 GHz	65 MHz to 6 GHz	20 Hz to 3.6 GHz/ 14 GHz	20 Hz to 26.5 GHz	Up to 26.5 GHz
Bandwidth	20 MHz	50 MHz	80 MHz (44R/45R) 200 MHz (46R)	25 MHz or 50 MHz	Up to 765 MHz	350 MHz
Phase Noise (10 kHz offset) at 1 GHz	-90 dBc/Hz	-105 dBc/Hz	-112 dBc/Hz	-129 dBc/Hz*	-129 dBc/Hz	-118 dBc/Hz
Absolute Amplitude Accuracy	±0.6 dB	±0.65 dB	± 0.35 dB to ± 0.55 dB	± 0.1 dB	± 0.2 dB	± 1.5 dB
Average Noise Floor	-122 dBm/Hz	-158 dBm/Hz	-161 dBm/Hz	-165 dBm/Hz	-167 dBm/Hz	-162 dBm/Hz
Architecture	Multi Stage	Single Stage	Zero-IF	Multi Stage	Multi Stage	Multi Stage
List Mode	No	Yes	Yes	Yes	Yes	No
Peer to Peer Streaming	No	Yes	Yes	Yes	Yes	Yes

[1]NI 5665 phase noise is measured at 800 MHz

Table 1. *Comparison of NI Vector Signal Analyzers*

RF Transmitter

The NI vector signal transceiver RF transmitter uses direct RF upconversion from differential baseband I/Q, which upconverts the baseband signal from DC to RF at the configured LO frequency. Table 2 below compares the RF transmitter on NI vector signal transceivers with existing NI vector signal generators.

	NI PXIe-5650/51/52	NI PXIe-5671/72	NI PXIe-5673E	NI PXIe-5644R/5645R/5646R
Frequency Range	500 kHz to 1.1/3.3/6.6 GHz	250 kHz to 2.7 GHz	85 MHz to 6.6 GHz	65 MHz to 6 GHz
Bandwidth	N/A	20 MHz	100 MHz	80 MHz (44R/45R) 200 MHz (46R)
Phase Noise (10 kHz offset) at 1 GHz	-112 dBc/Hz	-95 dBc/Hz	-112 dBc/Hz	-112 dBc/Hz
Maximum Output Power (CW)	+10 dBm	+10 dBm	+10 dBm	+10 dBm
Minimum Output Power	-100 dBm	-147 dBm/Hz	-154 dBm/Hz	-168 dBm/Hz
Modulation Capabilities	CW, 2-FSK, OOK	Vector Modulation	Vector Modulation	Vector Modulation
RF List Mode	Yes	No	Yes	Yes
Tuning Time	200 µs	2 ms	200 µs	380 µs

Table 2*. Comparison of NI Vector Signal Generators*

For more information on the hardware design of the NI vector signal transceiver, read the NI PXIe-5644R VST Hardware Architecture white paper.

Industry-Leading Performance for the Latest RF Standards

NI vector signal transceivers offer industry-leading performance and measurement speed for the latest cellular and wireless standards. Using IEEE 802.11ac as an example, the NI vector signal transceivers achieve an error vector magnitude (EVM) measurement floor of better than -45 dB (0.5 percent) at 5.8 GHz for an 80 MHz MCS9 signal. This measurement is typically done in less than 30 ms. Figure 2 below shows a typical 802.11ac EVM measurement.

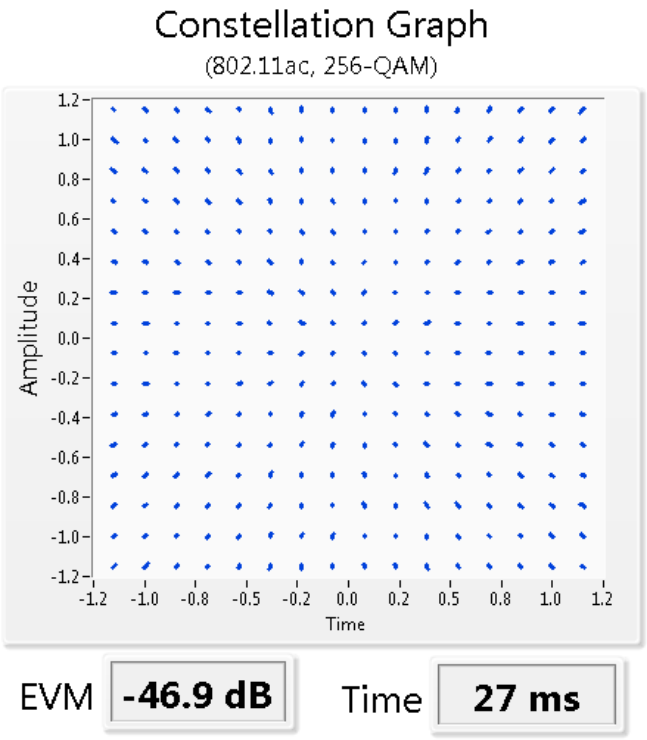

Figure 2. *Typical Constellation Graph, EVM Measurement, and Measurement Time of an 802.11ac MCS9 Signal at 5.8 GHz.*

For this measurement, the NI vector signal transceiver is used to generate an 80 MHz 802.11ac MCS9 (256-QAM) signal at a frequency of 5.8 GHz, and power level of -10 dBm. The NI WLAN Generation Toolkit is used to create the waveforms that are then downloaded to the NI PXIe-5644R. The NI WLAN Analysis Toolkit is used to analyze the acquired signal on the same NI PXIe-5644R with the following settings

- IQ Mismatch Compensation: On
- Channel Tracking: Off
- Amplitude Tracking: On
- Phase Tracking: On
- Time Tracking: On
- Number of Averages: 1

User-Programmable FPGA

NI vector signal transceivers feature a user programmable Xilinx FPGA, which is used for system configuration, digital data movement, and digital signal processing. The FPGA has direct connections to the ADCs, DACs, PCI Express bus, DRAM, SRAM, PFI 0, digital I/O, and PXI triggers, allowing for custom programming to meet the needs of many types of applications. Figure 3 below provides an overview of the FPGA basecard architecture.

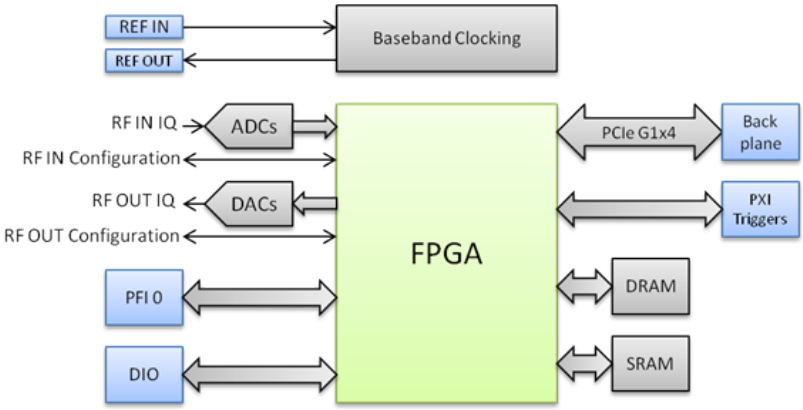

Figure 3. *Block Diagram of the NI PXIe-5644R FPGA Basecard*

The Xilinx FPGA on the NI vector signal transceiver is programmable using the LabVIEW FPGA Module. LabVIEW is well suited for FPGA programming due to a clear representation of hardware parallelism and data flow inherent in FPGA implementation, so users who are both experienced and inexperienced in traditional FPGA design can productively apply the power of reconfigurable hardware.

A user can make small modifications to the FPGA in order to optimize the performance of the vector signal transceiver to meet their needs. Or, they can completely redesign the FPGA code to enable embedded applications, such as channel emulation. For more information on how to program NI vector signal transceivers using LabVIEW FPGA, please read the NI Vector Signal Transceiver Software Architecture white paper.

Baseband I/Q Interface With the NI PXIe-5645R

The NI PXIe-5645R vector signal transceiver also features a high-performance, differential or single-ended baseband I/Q interface with 16-bit data sampled at 120 MS/s, for a total of 80 MHz of complex equalized I/Q bandwidth. This baseband I/Q interface allows the NI PXIe-5645R vector signal transceiver to address many additional applications, such as testing both the upconverted RF and downconverted baseband signals of a device with a single instrument.

***Figure 4**. The software-designed NI PXIe-5645R vector signal transceiver (VST) adds baseband I/Q capabilities to increase test coverage for RF transceiver test.*

Expanded Bandwidth Using the NI PXIe-5646R

The NI PXIe-5646R extends the benefits of the software-designed instrument platform by providing new hardware capabilities to the Vector Signal Transceiver product family. The PXIe-5646R provides an industry leading 200 MHz of RF bandwidth leveraging the speed and flexibility of the user programmable FPGA. The added bandwidth enables the user to test the latest options added to the leading wireless and cellular standards including 802.11ac 160 MHz and LTE-A carrier aggregation while also leveraging the latest performance enhancing processing techniques such as digital pre-distortion.

***Figure 5.** The NI PXIe-5646R vector signal transceiver (VST) provides bandwidth of 200 MHz to enable complete test coverage for the latest options in wireless and cellular standards*

Phase-Coherent MIMO and Parallel Testing

The flexibility of NI vector signal transceivers enables multiple RF transmitters and receivers to share a common start triggers, reference clocks, and LOs. As a result, you can synchronize multiple NI vector signal transceivers for phase-coherent acquisition or parallel device testing. For example, the small form factor of the NI PXIe-5644R allows up to five modules to fit into a single 18-slot PXI Express chassis.

***Figure 6.** Up to five NI PXIe-5644R modules can fit into a single PXI Express chassis for applications such as MIMO or parallel testing.*

Additional Features

Other features of the NI vector signal transceivers include RF record and playback, RF list mode, device control over standard or proprietary digital buses, and many others. With flexible software that allows access all the way down to the pin, NI vector signal transceivers allow the user to design their instrument specifically for their RF application needs.

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Support and Services

System Assurance Programs

NI system assurance programs are designed to make it even easier for you to own an NI system. These programs include configuration and deployment services for your NI PXI, CompactRIO, or Compact FieldPoint system. The NI Basic System Assurance Program provides a simple integration test and ensures that your system is delivered completely assembled in one box. When you configure your system with the NI Standard System Assurance Program, you can select from available NI system driver sets and application development environments to create customized, reorderable software configurations. Your system arrives fully assembled and tested in one box with your software preinstalled. When you order your system with the standard program, you also receive system-specific documentation including a bill of materials, an integration test report, a recommended maintenance plan, and frequently asked question documents. Finally, the standard program reduces the total cost of owning an NI system by providing three years of warranty coverage and calibration service. Use the online product advisors at ni.com/advisor to find a system assurance program to meet your needs.

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