Overview

The National Instruments PXI-5670 is a 2.7 GHz RF vector signal generator module with the power and flexibility needed for product development applications from design through manufacturing. The NI PXI-5670 provides true 16-bit resolution arbitrary waveform generation at 100 MS/s (400 MS/s interpolated), up to 256 MB of memory, and 22 MHz real-time bandwidth. The PXI-5670 can generate custom and standard modulation formats such as AM, FM, PM, ASK, FSK, PSK, MSK, and QAM. Engineers now have a highly precise and flexible vector signal generator with the performance required for rapid prototyping and automated test.

The Modulation Toolkit for LabVIEW accompanies the PXI-5670, providing functions and tools for signal generation, analysis, visualization, and processing of custom and standard digital and analog modulation formats.

The combined functionality of the PXI-5670 and the Modulation Toolkit deliver a highly flexible and powerful solution for scientific research, consumer electronics, communications, aerospace/defense, and semiconductor test applications as well as for emerging areas including software-defined radio, radio-frequency identification (RFID), and wireless sensor networks.

Hardware

The PXI-5670 provides vector signal generation from 250 kHz to 2.7 GHz over a wide range of signal levels from -145 dBm to +13 dBm in a compact, 3 slot 3U module. It follows industry-standard plug and play specifications for the PXI bus and can be seamlessly integrated with compliant systems.

The PXI-5670 features an onboard ultrahigh-stability oven-controlled crystal oscillator (OCXO), which provides frequency stability of ±20 ppb and frequency accuracy of ±50 ppb. These specifications make it useful for a range of automation applications. A sophisticated calibration scheme is implemented in the PXI-5670 to ensure power level accuracy over varying temperatures from 0 to 55°C. This feature is important to many applications, especially in manufacturing environments where the stable operation over varying temperature ranges is critical.

Software

The PXI-5670 is shipped with the NI-RFSG instrument driver and the Modulation Toolkit for LabVIEW. NI-RFSG is a fully functional instrument driver, compatible with a variety of application software environments such as NI LabVIEW 7 Express, LabWindows/CVI, and C. NI-RFSG features easy-to-use functions for configuring the timing and synchronization, CW tone, and arbitrary waveform generation capabilities of the PXI-5670. Also included are a number of interactive, instructional examples and interactive online help that can help jump-start your application test development.
2.7 GHz RF Vector Signal Generator

The Modulation Toolkit for LabVIEW provides functions for signal generation, analysis, and visualization of custom and standard analog and digital modulation. With the Modulation Toolkit, you can also develop and analyze custom modulation formats and generate these with the PXI-5670. Some of the standard measurement functions include EVM (error vector magnitude), MER (modulation error ratio), and ρ (rho). Functions are also available for injecting impairments including IQ Gain Imbalance, Quadrature Skew, and AWGN (additive white Gaussian noise). Visualization functions include trellis, constellation, and 2D- and 3D-eye diagrams. This hardware and software combination gives you access to customizable functionality not available in traditional instrumentation.

Modulation Toolkit Functions*

Modulation/Demodulation
- 4, 8, 16, 32, 64, 128, 256-QAM
- 2, 4, 8, 16-FSK
- MSK and GMSK
- 8, 16, 64-FSK
- BPSK, QPSK, OQPSK, DQPSK, π/4DQPSK
- AM, FM, PM

Modulation Analysis Functions
- ρ (rho)
- DC offset
- Phase error
- Quadrature skew
- IQ gain imbalance
- Bit error rate (BER)
- Frequency deviation
- Burst timing measurements
- Modulation error ratio (MER)
- Error vector magnitude (EVM)

Visualization and Analysis
- Trellis diagrams
- Constellation plot
- 2D- and 3D-eye diagrams

Modulation Impairments
- Multitone
- DC offset
- Fading profile
- Frequency offset
- Quadrature skew
- IQ gain imbalance
- Additive white Gaussian noise (AWGN)

Memory
The deep memory of up to 256 MB in the PXI-5670 offers extended playback time for complex modulated signals. With this deep memory, you can build and output longer and more complex waveforms with a duration of up to 1.28 seconds to address research and testing needs for simulation of signal transmission in real-world conditions.

Superior Flexibility
Providing customers with a flexible platform is necessary to meet the needs of today’s complex, rapidly evolving systems. The PXI-5670 consists of two components – the NI PXI-5610 2.7 GHz RF upconverter and the NI PXI-5421 arbitrary waveform generator, a high-spectral-purity baseband signal generator. The PXI-5610 and the PXI-5421 work together to provide vector signal generation from 250 kHz to 2.7 GHz. Because of the flexible hardware and software, and with access to low-level driver functionality, the PXI-5610 and the PXI-5421 can also be used independently for RF upconversion and arbitrary waveform sequencing. For advanced applications, combine additional modular instruments in the same PXI chassis with the PXI-5670 and take advantage of the tight synchronization between PXI modules. For example, combine the PXI-5660 RF Vector Signal Analyzer with the PXI-5670 to build an RF communications test system with complete modulation and demodulation capabilities.

Calibration
The PXI-5610 and the PXI-5421 are calibrated separately by National Instruments and are shipped with NIST-traceable and ISO-9002-certified calibration certificates. Temperature variations are calibrated and corrected during normal operation resulting in very high stability and repeatability.
2.7 GHz RF Vector Signal Generator

Specifications

Valid over specified Operating Environment (0 to 55 °C) unless otherwise stated.

General
- Channels: 1 RE, 1 IF
- Frequency Characteristics:
  - Frequency range: 250 kHz to 2.7 GHz
  - Frequency minimum (performance below 9 kHz
  - Real-time bandwidth (Digital vector modulation bandwidth): 22 MHz
  - Locking range: 5 Hz minimum
  - Warm-up time (typical): 30 minutes
  - Frequency Resolution (dependent on NI PXI-5421 memory):
    - 8 MB: 25 Hz
    - 32 MB: 6.2 Hz
    - 256 MB: 0.6 Hz
- Tuning Speed:
  - Sine wave, 50 Hz resolution:
    - Thermal correction disabled: 35 ms typical
    - Thermal correction enabled: 50 ms max
  - 1 MS record, phase continuity off:
    - Digital IF equalization off: 340 ms typical 370 ms max
  - Digital IF equalization on:
    - 960 ms typical 1.6 x max
  - Note: The NI PXI-5670 tuning speed and tuning resolution depend on resampling done by the PC. This means that fine resolution tuning speed is dependent on the speed and memory of the computer. Specifications below are the result of using an NI PXI-8186 Pentium IV controller 2.2 GHz with 512 MB RAM with the Windows XP operating system and NI-RFSG phase continuity disabled.

Internal Frequency Reference
- Frequency: 10 MHz
- Temperature stability: ±20 ppm max (referenced to 25 °C)
- Aging:
  - Per year: ±100 ppm
  - Per day: ±1 ppm
- Initial achievable accuracy: ±50 ppm
- Lock time for the 5610:
  - to exit frequency reference: 5 s max
  - Locking range: 5 kHz minimum
- Reference Input:
  - 50 Ω SMA female
- Input amplitude:
  - 5 to +16 dBm
- Input frequency range:
  - 10 MHz ± 0.5 ppm
- Reference Output:
  - 50 Ω SMA female
- Signal: Square wave
- Output Frequency: 10 MHz
- Output Amplitude: 6.7 dBm with 50 Ω load, fundamental frequency
  - (± 0.1 Vpp sine wave)

Spectral purity

Phase Noise

Figure 1. Typical Phase Noise at 1 GHz with Real-Time Bandwidth <10 MHz

<table>
<thead>
<tr>
<th>Offset Frequency</th>
<th>Real-time bandwidth &lt;10 MHz</th>
<th>Carrier Frequency = 1 GHz</th>
<th>Carrier Frequency = 2 GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 kHz</td>
<td>-62 dBc/Hz maximum</td>
<td>-79 dBc/Hz maximum</td>
<td></td>
</tr>
<tr>
<td>1 kHz</td>
<td>-67 dBc/Hz maximum</td>
<td>-85 dBc/Hz maximum</td>
<td></td>
</tr>
<tr>
<td>10 kHz</td>
<td>-93 dBc/Hz maximum</td>
<td>-90 dBc/Hz maximum</td>
<td></td>
</tr>
<tr>
<td>100 kHz</td>
<td>-114 dBc/Hz maximum</td>
<td>-111 dBc/Hz maximum</td>
<td></td>
</tr>
</tbody>
</table>

Residual FM

- 4.5 Hz rms maximum (continuous wave, 300 Hz to 3 kHz integration bandwidth)

Spurious Responses

- Second harmonic (<10 MHz) 0 to 55 °C: ≤ -45 dBc
- Output third-order distortion (IMD):
  - (two 6-dB tones, ±200 kHz apart): ≤ -86 dBc typical
- Residual spurious response:
  - No input signal, 0 dB attenuation/maximum power level, excluding LO feedthrough: ≤ -80 dBc typical

NI PXI-5421 system clock rate: 100 MHz
- Harmonic and spurious response: ≤ -105 dBm typical
- Output-related spurious response (nonharmonic):
  - ≤ -80 dBc maximum

(6400 MHz – RF output frequency) ≤ -64 dBc typical, ≤ -68 dBc maximum

Close-in Spurious Responses (Carrier-Modulated)

Real-Time Bandwidth Offset from Carrier Maximum Power (dBc)

<table>
<thead>
<tr>
<th>Offset from Carrier</th>
<th>Maximum Power (dBc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10 MHz</td>
<td>&lt;100 Hz</td>
</tr>
<tr>
<td>&gt;10 MHz</td>
<td>≤ -80 Hz</td>
</tr>
<tr>
<td>100 Hz to 2 kHz</td>
<td>≤ -60 Hz</td>
</tr>
<tr>
<td>200 kHz to 2 kHz</td>
<td>≤ -40 Hz</td>
</tr>
</tbody>
</table>

RF Output Characteristics

Output power range: ≤ -145 dBm to +13 dBm minimum
- Amplitude resolution:
  - PXI-5610: 0.02 dB minimum
  - PXI-5670: 1 dB typical
- Amplitude settling time (PXI-5610):
  - ≤ 0.1 dB within 150 ms maximum
  - ≤ 1 dB within 300 ms maximum

Level Accuracy

- 10 MHz to 2.7 GHz ±0.7 dB ±0.8 dB ±1 dB ±1.5 dB
- 250 kHz to 10 MHz (typical) ±1.2 dB ±1.3 dB ±1.5 dB ±2 dB
- 25 °C ±10 °C
- Accuracy degrades by ≤ 0.03 dB per °C over full temperature range.
- Accuracy degrades by ± 1 dB per dB above +7 dBm power levels, and by ± 0.15 dB per dB above +10 dBm power levels.
- For non-integer frequency with alternate hold mode. Refer to the Spurious Responses section for more information.

Voltage Standing Wave Ratio (VSWR): 10 MHz to 2.7 GHz: ≤ 1.1:1
- 2.3 to 2.7 GHz: ≤ 1.7:1

Output 1 dB Gain Compression Point (minimum)

<table>
<thead>
<tr>
<th>Output Frequency (GHz)</th>
<th>Up to 2.0</th>
<th>2.0 to 2.5</th>
<th>2.5 to 2.7</th>
<th>2.7 to 3.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 25 °C (dBm)</td>
<td>17</td>
<td>15.5</td>
<td>14</td>
<td>13</td>
</tr>
</tbody>
</table>

Noise density (0 dBm output)

<table>
<thead>
<tr>
<th>Output Power Level (dBm)</th>
<th>15 to 25 °C (dBm)</th>
<th>0 to 55 °C (dBm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>120</td>
<td>115</td>
</tr>
<tr>
<td>-20</td>
<td>140</td>
<td>125</td>
</tr>
</tbody>
</table>

Figure 2. Typical Output Power Level Accuracy from -45 dBm to +10 dBm
2.7 GHz RF Vector Signal Generator

Specifications

Typical Noise Floor at 2 GHz

<table>
<thead>
<tr>
<th>Output Power Level (dBm)</th>
<th>Typical Noise Floor (dBm/Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-57</td>
<td>-158</td>
</tr>
<tr>
<td>-50</td>
<td>-157</td>
</tr>
<tr>
<td>-40</td>
<td>-154</td>
</tr>
<tr>
<td>-30</td>
<td>-147</td>
</tr>
<tr>
<td>-20</td>
<td>-140</td>
</tr>
<tr>
<td>-10</td>
<td>-130</td>
</tr>
<tr>
<td>0</td>
<td>-120</td>
</tr>
<tr>
<td>10</td>
<td>-110</td>
</tr>
</tbody>
</table>

Vector modulation bandwidth flatness: ±0.5 dB typical
Group delay variation (within the vector modulation bandwidth) ±20 ns typical
Group delay
PXI-5421: 750 ns typical
PXI-5610: 1200 ns typical
Overload protection on RF output
Maximum reverse RF power: 4 W maximum
Maximum DC input: ±50 VDC

Local Oscillator Output

Frequency range: 3.2 to 5.9 GHz
Output power: -22 dBm (typical)
VSWR: 1.5:1 maximum

Phase noise – Local Oscillator

<table>
<thead>
<tr>
<th>Offset Frequency (kHz)</th>
<th>3.2 GHz</th>
<th>4.2 GHz</th>
<th>5.2 GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-90 dBc/Hz</td>
<td>-92 dBc/Hz</td>
<td>-92 dBc/Hz</td>
</tr>
<tr>
<td>10</td>
<td>-96 dBc/Hz</td>
<td>-96 dBc/Hz</td>
<td>-96 dBc/Hz</td>
</tr>
<tr>
<td>100</td>
<td>-120 dBc/Hz</td>
<td>-120 dBc/Hz</td>
<td>-120 dBc/Hz</td>
</tr>
</tbody>
</table>

Modulation

Frequency Modulation (FM)
1 GHz, FM deviation 100 kHz, filter bandwidth 2 MHz: <1% 

Digital Modulation

GOPS, 16-QAM, 64-QAM (root raised cosine filter, alpha = 0.25, carrier frequency = 1 GHz, 2,000 symbol PRBS, equalization: GN)

<table>
<thead>
<tr>
<th>Symbol Rate</th>
<th>EVM (%)</th>
<th>MER (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>200 kS/s</td>
<td>0.7</td>
<td>39</td>
</tr>
<tr>
<td>1 MS/s</td>
<td>0.8</td>
<td>38</td>
</tr>
<tr>
<td>2.56 MS/s</td>
<td>1.0</td>
<td>36</td>
</tr>
<tr>
<td>5.12 MS/s</td>
<td>1.8</td>
<td>35</td>
</tr>
<tr>
<td>10 MS/s</td>
<td>2.5</td>
<td>32</td>
</tr>
</tbody>
</table>

Power Requirements

<table>
<thead>
<tr>
<th></th>
<th>Typical +3.3 VDC</th>
<th>+5 VDC</th>
<th>+12 VDC</th>
<th>-12 VDC</th>
<th>Total Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>PXI-5610</td>
<td>150 mA</td>
<td>2.6 A</td>
<td>900 mA</td>
<td>60 mA</td>
<td>25.0 W</td>
</tr>
<tr>
<td>PXI-5421</td>
<td>1.9 A</td>
<td>2.0 A</td>
<td>460 mA</td>
<td>10 mA</td>
<td>21.9 W</td>
</tr>
</tbody>
</table>

Calibration

Self-calibration
PXI-5610: Correction for YIG offset and gain
PXI-5421: Correction for DC gain offset and timing errors

External calibration interval
PXI-5610: 1 year
PXI-5421: 2 years

Physical

PXI-5610 (2 slots): 10 by 16 cm (3.9 by 6.3 in.)
PXI-5421 (1 slot): 10 by 16 cm (3.9 by 6.3 in.)

Environmental

Operating Environment
Operating temperature: 0 to +55 °C (Meets IEC-60068-2-1 and IEC-60068-2-2)
Relative humidity: 10 to 90%, noncondensing (Meets IEC 60068-2-56)
Altitude (indoor use only): 0 to 2,000 m (at 25 °C ambient temperature)

Storage Environment
Ambient temperature: -20 to 70 °C (Meets IEC-60068-2-1 and IEC-60068-2-2.)
Relative humidity: 5 to 95%, noncondensing (Meets IEC-60068-2-56.)

Shock and Vibration
Nonoperational shock: 30 g peak, half-sine, 11 ms pulse (Meets MIL-PRF-28800F)
Random vibration Non-operating: 5 to 500 Hz, 2.4 g rms (Meets IEC-60068-2-64. Non-operating test profile exceeds the requirements of MIL-PRF-28800F, Class B)

1When installed in the NI PXI-101x or PXI-1000B chassis, the PXI-5421 operating temperature is 0 to +45 °C

Certifications and Compliances

CE Mark Compliance

Safety

This product is designed to meet the requirements of the following standards of safety for electrical equipment for measurement, control, and laboratory use:

• IEC 61010-1, EN 61010-1
• UL 3111-1, UL 61010B-1
• CAN/CSA C22.2 No. 1010.1

Electromagnetic Compatibility

Emissions: EN 55011 Class A at 10 m FCC Part 15A above 1 GHz
Immunity: EN 61326:2006 + A2:2001, Table 1
EMC/EMI: CE, C-Tick and FCC Part 15 (Class A) Compliant

Ordering Information

NI PXI-5670
8 MB memory: 778768-01
32 MB memory: 778768-02
256 MB memory: 778768-03

Includes PXI-5610, PXI-5421, NI-RFSG, Modulation Toolkit for LabVIEW, cables, and calibration certificates.

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Our Professional Services Team is comprised of NI applications engineers, NI Consulting Services, and a worldwide NI Alliance Partner Program of more than 600 independent consultants and integrators. Services range from start-up assistance to turnkey system integration. Visit ni.com/alliance.

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We offer design-in consulting and product integration assistance if you want to use our products for OEM applications. For information about special pricing and services for OEM customers, visit ni.com/oem.

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We also offer service programs that provide automatic upgrades to your application development environment and higher levels of technical support. Visit ni.com/ssp.

Hardware Services
NI Factory Installation Services
NI Factory Installation Services (FIS) is the fastest and easiest way to use your PXI or PXI/SCXI™ combination systems right out of the box. Trained NI technicians install the software and hardware and configure the system to your specifications. NI extends the standard warranty by one year on hardware components (controllers, chassis, modules) purchased with FIS. To use FIS, simply configure your system online with ni.com/pxiadvisor.

Calibration Services
NI recognizes the need to maintain properly calibrated devices for high-accuracy measurements. We provide manual calibration procedures, services to recalibrate your products, and automated calibration software specifically designed for use by metrology laboratories. Visit ni.com/calibration.

Repair and Extended Warranty
NI provides complete repair services for our products. Express repair and advance replacement services are also available. We offer extended warranties to help you meet project life-cycle requirements. Visit ni.com/services.