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Requirements and Compatibility | Ordering Information | Detailed Specifications
For user manuals and dimensional drawings, visit the product page resources tab on ni.com.

Last Revised: 2012-08-13 15:45:37.0

24-Bit, 204.8 kS/s Dynamic Signal Acquisition and Generation

NI 4461, NI 4462

- 2 or 4 simultaneously sampled analog inputs
- 2 simultaneously updated analog outputs (NI 4461 only)
- 118 dB dynamic range, 24-bit resolution
- 204.8 kS/s maximum sampling rate
- 92 kHz alias-free bandwidth
- Input range from ±316 mV to 42.4 V
- 6 gain settings
- AC/DC coupling
- Antialiasing and anti-imaging protection
- IEPE conditioning – software-configurable
- Multimodule synchronization

Overview

The National Instruments 4461 and 4462 are high-accuracy data acquisition devices specifically designed for sound and vibration applications. The devices include the hardware and software needed to make precision measurements with microphones, accelerometers, and other transducers that have very large dynamic ranges. Common applications for the NI 446x include audio test, automotive test, noise, vibration, and harshness (NVH) analysis, and machine condition monitoring (MCM). The NI 446x devices offer a complete range of functionality for sound and vibration monitoring and analysis applications. With either two inputs and two outputs, or four inputs, they are ideal for applications where simultaneous generation and acquisition of noise, vibration, and acoustic signals are required. You can synchronize the acquisition clock of your NI 446x with other instruments in your system for mixed-signal applications. Both analog and digital triggering are available on an NI 446x.

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Requirements and Compatibility

OS Information

- Windows 2000/XP
- Windows 7
- Windows NT
- Windows Vista

Driver Information

- NI-DAQmx

Software Compatibility

- LabVIEW
- LabWindows/CVI
- Measurement Studio

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Comparison Tables

Product	Bus	Analog Inputs	Input Resolution	Sampling Rate	Input Range	Input Configuration	Analog Output	Output Resolution	Update Rate
NI 4461	PXI, PCI	2	24 bits	204.8 kS/s	±316 mV to 42.4 V	Differential/pseudodifferential	2	24 bits	204.8 kS/s
NI 4462	PXI, PCI	4	24 bits	204.8 kS/s	±316 mV to 42.4 V	Differential/pseudodifferential	0	-	-

Application and Technology

Hardware

Applications

- Audio Test
- Noise, Vibration, and Harshness Test
- Machine Condition Monitoring
- Sound Power
- Structural Vibration
- Pass-by Noise

Analog Inputs

The analog input channels of NI 446x devices have 24-bit resolution ADCs that are simultaneously sampled at software-programmable rates for standard audio applications, such as 44.1 kS/s (the standard rate used in CD players), 48.0 kS/s (the rate used in digital audio tape (DAT) recorders and other digital audio equipment), 96.0 kS/s, and 192 kS/s. An NI 446x is well-suited for audio, sound, and vibration analysis applications.

The analog inputs offer programmable AC/DC coupling. A programmable gain amplifier stage on the inputs gives gain selection from -20 to +30 dB in 10 dB steps. Furthermore, to provide you with the quietest and highest-quality analog measurements, the input stage accepts differential or single-ended signal connections.

With 118 dB dynamic range and low noise and distortion, NI 446x devices can make very accurate frequency-domain measurements. They have excellent amplitude flatness of ±0.1 dB within the frequency range of DC to 92 kHz, and have a typical THD of -107 dB.

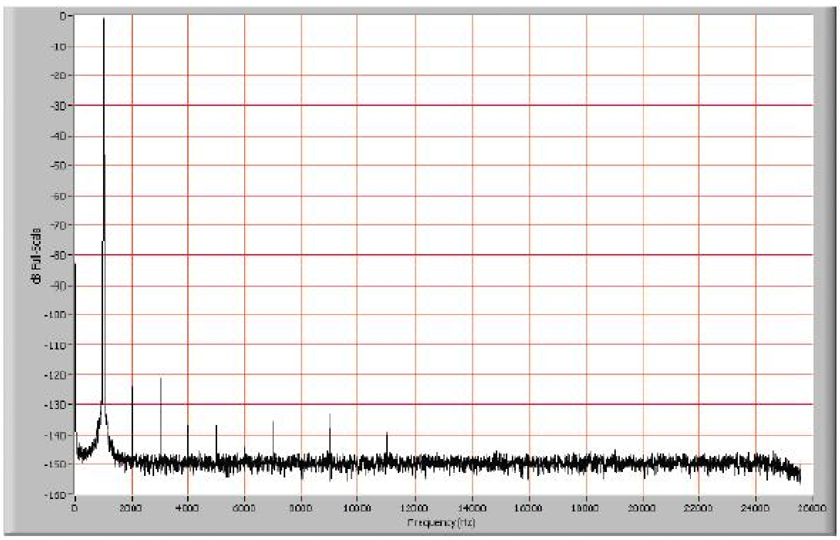


Figure 1. These 24-bit delta-sigma converters deliver outstanding dynamic range.

Antialiasing

The analog inputs have both analog and digital filters implemented in hardware to prevent aliasing. Input signals are first passed through a fixed analog filter to remove any signals with frequency components beyond the range of the ADCs. Then digital antialiasing filters automatically adjust their cutoff frequency to remove any frequency components above half the programmed sampling rate.

Analog Outputs

NI 4461 devices have two channels of 24-bit resolution, high-fidelity analog output. A common application of the analog output is to stimulate a system under test while measuring the frequency response with the analog inputs. The output conversions occur simultaneously at softwareprogrammable rates up to 204.8 kS/s. The analog output circuitry uses 8-times oversampling interpolators with 64-times oversampling delta-sigma modulators to offer exceptional spectral purity. Software-programmable attenuation of 0, 20, or 40 dB is available on the output channels. NI 4461 devices have excellent amplitude flatness of ±0.1 dB within DC to 92 kHz, and a THD of -95 dB at 1 kHz. You can simultaneously acquire data on the input channels while updating the output channels.

Anti-Imaging

NI 4461 output channels have both analog and digital anti-imaging filters. These filters remove the unwanted out-of-band components generated when an analog signal is produced from digital data. The digital filters limit the bandwidth of the output signal to half the original conversion rate, thereby rejecting images caused by the 8-times oversampling process. The signals generated by the analog output circuitry are low-distortion, low-noise, flat-frequency analog signals.

Multimodule Synchronization

For applications requiring more channels, you can synchronize the operation of two or more NI 446x devices with less than 0.1 deg phase mismatch. Synchronization is achieved by sharing a digital trigger and clock between multiple modules. The NI-DAQmx driver software automatically handles the synchronization of multiple devices in a single task.

Triggering

NI 446x devices offer both analog and digital triggering for signal acquisition. The source of the trigger can come from any analog input channel, the external digital trigger input, the PXI trigger bus (PXI devices), or the RTSI bus (PCI devices). The external digital trigger is 5 VTTL/CMOS-compatible and is activated by a choice of rising or falling edge. Triggering is needed in applications that acquire transient signals. When performing structural analysis by striking a metal beam with a hammer, for instance, you measure transient vibrations with accelerometers with acquisition triggered by the hammer impact.

Calibration

National Instruments calibrates the offset voltage and gain accuracy of the analog inputs and outputs. An onboard precision voltage reference ensures that the gain and offset remain stable and accurate. NIST-traceable and ISO 9002-certified calibration certificates are available on request.

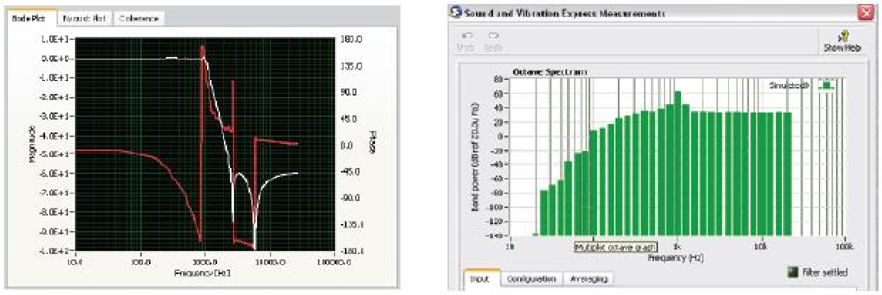


Figure 2. With application software such as NI LabVIEW, you can conduct frequency-response, swept-sine, and other common audio measurements.

Software

NI Measurement Services Software

NI 446x devices use NI measurement services software, based on the NI-DAQmx driver, as the hardware and OS interface. You can build automated test systems or integrate an NI 446x with other hardware, including modular instruments and multifunction data acquisition (DAQ) products, through NI-DAQmx function calls. NI measurement services software also includes DAQ Assistant, an interactive guide that steps you through configuring, testing, and programming measurement tasks and generates the necessary code automatically for National Instruments LabVIEW, LabWindows/CVI, or Measurement Studio.

Analysis Software

LabVIEW Sound and Vibration Toolkit

NI 446x devices are well-suited for audio, acoustic, and vibration analysis applications. The LabVIEW Sound and Vibration Toolkit incorporates Express technology to make it easier for you to perform sound and vibration measurement and analysis. The toolkit includes LabVIEW Express VIs for:

- Fractional-octave analysis with weighting
- Integrated vibration level
- Weighted sound level
- Zoom power spectrum
- Peak search
- Power in band
- Power spectrum analysis
- Frequency response
- Limit testing

In addition, the LabVIEW Sound and Vibration Toolkit includes numerous VIs for audio measurements such as gain, phase, distortion, and swept-sine analysis. Swept-sine is a powerful analysis technique to measure frequency response. The toolkit also includes simple modular examples of all of these measurements, so you can quickly combine analog output, analog input, and data analysis to build a customized application. In addition, the existing signal generation is extended to include the tools and examples needed to provide the excitation required by most audio, noise, and vibration measurements. For example, a library of 33 waveforms is included in this toolkit to get you up and running fast. This toolkit also optimizes LabVIEW to perform noise and vibration measurements. For example, all frequency measurements can perform zoom FFT analysis to offer improved resolution in the frequency range of interest. With the built-in fractional-octave analysis, you can perform measurements with any number of bands at any sampling frequency. NI 446x dynamic signal acquisition devices, combined with this toolkit, offer compliance with several standards for sound level measurements and octave analysis:

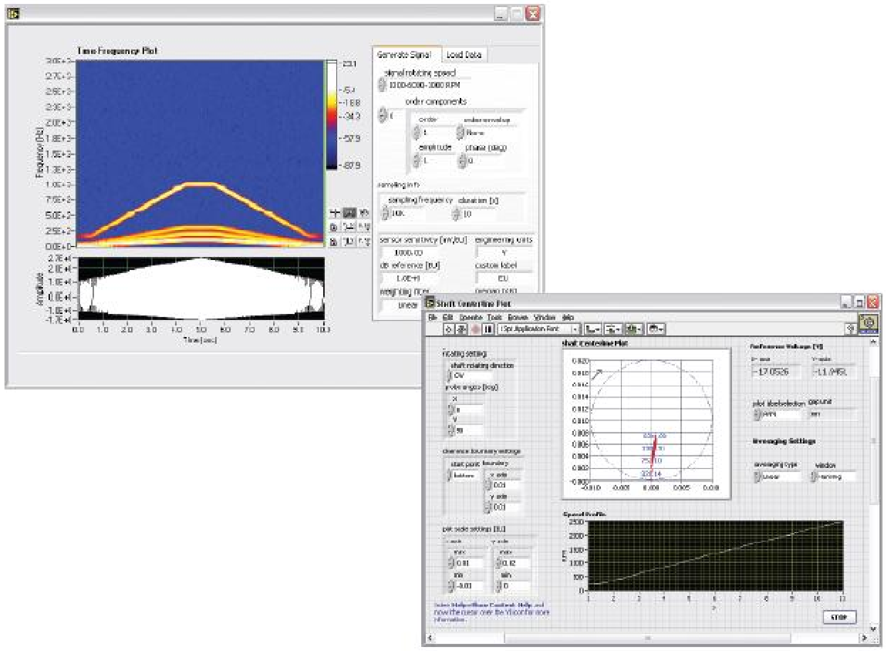
- IEC 61260 : 1995, class 1
- IEC 61672 : 2002, class 1
- ANSI S1.11 – 2004, class 1
- ANSI S1.4 – 1983
- ANSI S1.42 – 1986

LabVIEW Order Analysis Toolkit

Order analysis is a tool for examining dynamic signals generated by mechanical systems that include rotating or reciprocating components. With order analysis you can dissect sound, vibration, and other dynamic signals into components that relate to physical elements of mechanical systems.

The LabVIEW Order Analysis Toolkit is ideal for machine monitoring, machine health, and machine efficiency applications. You can use the toolkit to perform the most common analyses required by MCM applications, including order tracking, slow-roll compensation, and vibration integration. With this toolkit, you can develop your application faster by using built-in examples for order spectra, tachometer processing, and waterfall plots.

You can also apply order analysis to dynamic signals generated by mechanical systems that include rotating or reciprocating components, such as turbines, compressors, pumps, and engines. It is common to use order analysis in applications such as machine condition monitoring and noise, vibration, and harshness (NVH) testing. With the added capability for online processing, you can easily create flexible applications for condition-based monitoring and predictive maintenance. The National Instruments 446x dynamic signal acquisition devices are ideal for acquiring sound and vibration signals to analyze with this toolkit.



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Ordering Information

For a complete list of accessories, visit the product page on ni.com.

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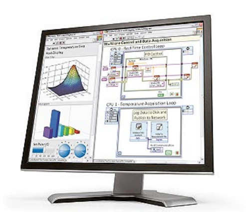
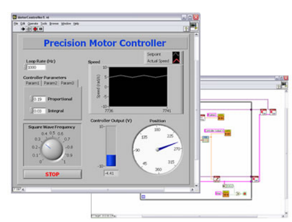
Software Recommendations

NI LabVIEW Full Development System for Windows



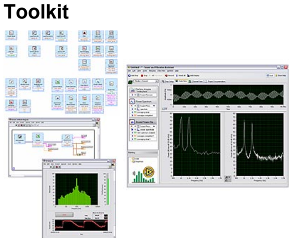
- Fully integrated graphical system design software
- Support for a wide range of measurement hardware, I/O, and buses
- Custom, event-driven user interfaces for measurement and control
- Extensive signal processing, analysis, and math functionality
- Advanced compiler to ensure high-performance execution and code optimization

NI LabVIEW Real-Time Module



- Design deterministic real-time applications with LabVIEW graphical programming
- Download to dedicated NI or third-party hardware for reliable execution and a wide selection of I/O
- Take advantage of built-in PID control, signal processing, and analysis functions
- Automatically take advantage of multicore CPUs or set processor affinity manually
- Includes real-time operating system (RTOS), development and debugging support, and board support
- Purchase individually or as part of an NI Developer Suite bundle

NI Sound and Vibration Toolkit



- Stand-alone configuration-based analysis and data logging with the Sound and Vibration Assistant
- AES17-compliant audio filter signal processing
- Easy-to-use power spectrum, swept sine, and octave analysis steps
- Sound level with A-, B-, or C-weighting and vibration level with integration
- Audio measurements including THD, SNR, SINAD, and swept-sine analysis
- Universal File Format (UFF58) file I/O support

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.

Calibration

NI measurement hardware is calibrated to ensure measurement accuracy and verify that the device meets its published specifications. To ensure the ongoing accuracy of your measurement hardware, NI offers basic or detailed recalibration service that provides ongoing ISO 9001 audit compliance and confidence in your measurements. To learn more about NI calibration services or to locate a qualified service center near you, contact your local sales office or visit ni.com/calibration.

Technical Support

Get answers to your technical questions using the following National Instruments resources.

- **Support** - Visit ni.com/support to access the NI KnowledgeBase, example programs, and tutorials or to contact our applications engineers who are located in NI sales offices around the world and speak the local language.
- **Discussion Forums** - Visit forums.ni.com for a diverse set of discussion boards on topics you care about.
- **Online Community** - Visit community.ni.com to find, contribute, or collaborate on customer-contributed technical content with users like you.

Repair

While you may never need your hardware repaired, NI understands that unexpected events may lead to necessary repairs. NI offers repair services performed by highly trained technicians who quickly return your device with the guarantee that it will perform to factory specifications. For more information, visit ni.com/repair.

Training and Certifications

The NI training and certification program delivers the fastest, most certain route to increased proficiency and productivity using NI software and hardware. Training builds the skills to more efficiently develop robust, maintainable applications, while certification validates your knowledge and ability.

- **Classroom training in cities worldwide** - the most comprehensive hands-on training taught by engineers.
- **On-site training at your facility** - an excellent option to train multiple employees at the same time.
- **Online instructor-led training** - lower-cost, remote training if classroom or on-site courses are not possible.
- **Course kits** - lowest-cost, self-paced training that you can use as reference guides.
- **Training memberships** and training credits - to buy now and schedule training later.

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Extended Warranty

NI offers options for extending the standard product warranty to meet the life-cycle requirements of your project. In addition, because NI understands that your requirements may change, the extended warranty is flexible in length and easily renewed. For more information, visit ni.com/warranty.

OEM

NI offers design-in consulting and product integration assistance if you need NI products for OEM applications. For information about special pricing and services for OEM customers, visit ni.com/oem.

Alliance

Our Professional Services Team is comprised of NI applications engineers, NI Consulting Services, and a worldwide National Instruments Alliance Partner program of more than 700 independent consultants and integrators. Services range from start-up assistance to turnkey system integration. Visit ni.com/alliance.

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Detailed Specifications

This document lists specifications for the NI PCI/PXI-4461 and NI PCI/PXI-4462 (NI 446*x*) Dynamic Signal Acquisition (DSA) devices. These specifications are typical at 25 °C unless otherwise stated. The operating range for the PXI-446*x* is 0 to 55 °C, and the operating range for the PCI-446*x* is 0 to 50 °C. All accuracies are valid for up to one year from the time of the device external calibration. All specifications are subject to change without notice. Visit ni.com/manuals for the most current specifications and product documentation.

⚠ **Caution** The inputs of this sensitive test and measurement product are not protected for electromagnetic interference for functional reasons. As a result, this product may experience reduced measurement accuracy or other temporary performance degradation when cables are attached in an environment with electromagnetic interference present. Refer to the Declaration of Conformity (DoC) for this product for details of the standards applied to assess electromagnetic compatibility performance. To obtain the DoC, visit ni.com/certification, search by model number or product line, and click the appropriate link in the Certification column.

Analog Input

This section lists the NI 446x analog input (AI) specifications.

Input Characteristics	
Number of simultaneously sampled input channels	
NI 4461	2
NI 4462	4
Input configuration	Differential or pseudodifferential (50 Ω between negative input and chassis ground), each channel independently software selectable
Input coupling	AC or DC, each channel independently software selectable
A/D converter (ADC) resolution	24 bits
ADC type	Delta-sigma
Sample rates (f_s), samples-per-second (S/s)	1 kS/s to 204.8 kS/s in 181.9 µS/s increments, maximum
ADC modulator oversample rate	
1.0 kS/s ≤ f_s ≤ 51.2 kS/s	128 f_s
51.2 kS/s < f_s ≤ 102.4 kS/s	64 f_s
102.4 kS/s < f_s ≤ 204.8 kS/s	32 f_s

Sample Clock Timebase Rate

Ratio between sample rate (f_s) and sample clock timebase rate

Sample Rate (f_s)	Sample Clock Timebase Rate	
	Low-Frequency Alias Rejection Enabled (Default)	Low-Frequency Alias Rejection Disabled
1.0 kS/s ≤ f_s ≤ 1.6 kS/s	16,384 f_s	512 f_s
1.6 kS/s < f_s ≤ 3.2 kS/s	8,192 f_s	
3.2 kS/s < f_s ≤ 6.4 kS/s	4,096 f_s	
6.4 kS/s < f_s ≤ 12.8 kS/s	2,048 f_s	
12.8 kS/s < f_s ≤ 25.6 kS/s	1,024 f_s	
25.6 kS/s < f_s ≤ 51.2 kS/s	512 f_s	
51.2 kS/s < f_s ≤ 102.4 kS/s	256 f_s	256 f_s
102.4 kS/s < f_s ≤ 204.8 kS/s	128 f_s	128 f_s

FIFO buffer size	2,047 samples
Data transfers	Direct memory access (DMA)

Input Common Mode Range

Gain (dB)	Input	Differential*	Pseudodifferential*
≥0	+	±12 V_{pk}	±12 V_{pk}
	–	±12 V_{pk}	±10 V_{pk}
<0	+	±42.4 V_{pk}	±42.4 V_{pk}
	–	±42.4 V_{pk}	±10 V_{pk}

* Voltages with respect to chassis ground

Input Overvoltage Protection	
Differential configuration	±42.4 Vpk
Pseudodifferential configuration	
Positive terminal	±42.4 Vpk
Negative terminal (shield)	±10.0 Vpk

Input Signal Range

Gain (dB)	Full-Scale Range (V_{pk})*
30	±0.316

Gain (dB)	Full-Scale Range (V_{pk})[*]
20	±1.00
10	±3.16
0	±10.0
–10	±31.6
–20	±42.4

[*] Each input channel gain is independently software selectable.

Transfer Characteristics

AI Offset (Residual DC)

Gain (dB)	DC-Coupled Offset[*, †], Max, T_{cal} [‡] ±5 °C (±mV)	DC-Coupled Offset[*], Max, Over Operating Temperature Range (±mV)
30	0.1	1
20	0.2	2
10	0.5	3
0	0.7	7
–10	5	30
–20	7	70

[*] Source impedance ≤ 50 Ω.

[†] Listed offset is valid 24 hours following a self calibration.

[‡] T_{cal} = ambient temperature at which last self calibration was performed.

AI Gain Amplitude Accuracy

1 kHz input tone

T_{cal} ±5 °C	±0.03 dB max
(T_{cal} = ambient temperature at which last self calibration was performed.)	
(Listed accuracy is valid 24 hours following a self calibration.)	
Over operating temperature range	±0.2 dB max

Amplifier Characteristics

Input Impedance

Input Impedance	Differential Configuration	Pseudodifferential Configuration
Between positive input and chassis ground	1 M Ω || 217 pF	1 M Ω || 217 pF
Between negative input and chassis ground	1 M Ω || 229 pF	50 Ω

Common-Mode Rejection Ratio (CMRR)

Gain (dB)	DC-Coupled CMRR (dBc)[*, †]	AC-Coupled CMRR (dBc)[†, ‡]
30	105	70
20	101	
10	90	
0	80	
–20, –10	60	65

[*] ≤ 1 kHz

[†] Differential configuration

[‡] 50 or 60 Hz

Dynamic Characteristics [1]

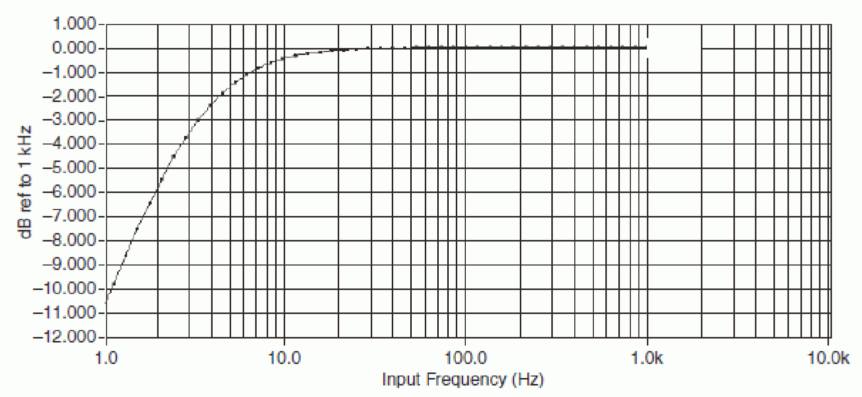
Specification	Low-Frequency Alias Rejection Enabled (Default)	Low-Frequency Alias Rejection Disabled
Alias-free bandwidth (BW) (passband)	DC to 0.4 f_s	DC to 0.4535 f_s
Alias rejection, minimum	104 dBc	120 dBc

Specification	Low-Frequency Alias Rejection Enabled (Default)	Low-Frequency Alias Rejection Disabled
Alias rejection by frequency	Input frequency > 0.6 f_s	0.5465 f_s < input frequency < 127.4535 f_s, where 1.0 kS/s ≤ f_s ≤ 51.2 kS/s 0.5465 f_s < input frequency < 63.4535 f_s, where 51.2 kS/s < f_s ≤ 102.4 kS/s 0.5465 f_s < input frequency < 31.4535 f_s, where 102.4 kS/s < f_s ≤ 204.8 kS/s
–3 dB BW	0.484 f_s	0.491 f_s

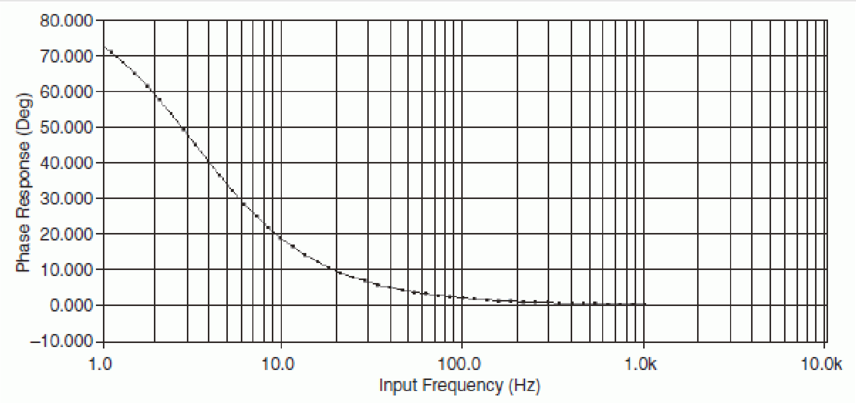
AC coupling

–3 dB cutoff frequency	3.4 Hz
–0.1 dB cutoff frequency	22.6 Hz

Magnitude Response of AC Coupling Circuit (1 Hz to 1 kHz)



Phase Response of AC Coupling Circuit (1 Hz to 1 kHz)



ADC Filter Delay

Low-Frequency Alias Rejection Enabled (Default)		Low-Frequency Alias Rejection Disabled	
Sample Rate (kS/s)	Filter Delay (Samples)	Sample Rate (kS/s)	Filter Delay (Samples)
1.0 ≤ f_s ≤ 1.6	32.96875	1.0 ≤ f_s ≤ 1.6	63
1.6 < f_s ≤ 3.2	33.9375	1.6 < f_s ≤ 3.2	
3.2 < f_s ≤ 6.4	35.875	3.2 < f_s ≤ 6.4	
6.4 < f_s ≤ 12.8	39.75	6.4 < f_s ≤ 12.8	
12.8 < f_s ≤ 25.6	47.5	12.8 < f_s ≤ 25.6	
25.6 < f_s ≤ 204.8	63	25.6 < f_s ≤ 204.8	

AI Flatness

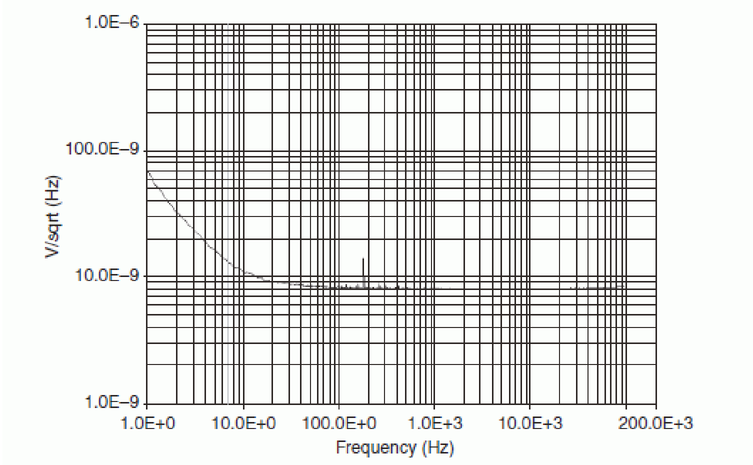
Gain (dB)	DC-Coupled Flatness* (dB), Max (Typical)		
	20 Hz to 20 kHz	20 Hz to 45 kHz	20 Hz to 92.2 kHz
0, 10, 20, 30	±0.006 (±0.003)	±0.03 (±0.02)	±0.1 (±0.08)
–20, –10	±0.2 (±0.1)	±0.6 (±0.33)	±1 (±0.55)

Gain (dB)	DC-Coupled Flatness* (dB), Max (Typical)		
	20 Hz to 20 kHz	20 Hz to 45 kHz	20 Hz to 92.2 kHz
* Relative to 1 kHz			

AI Spectral Noise Density

AI spectral noise density (with EAR turned on)	8 nV/ $\sqrt{Hz}$ at 30 dB gain, 1 kHz

AI Spectral Noise Density (30 dB Gain)



AI Idle Channel Noise

Sample Rate (kS/s)	Idle Channel Noise*, †	
	dBV_{rms}	μV_{rms}
1.0 kS/s ≤ f_s < 51.2 kS/s	–118 dBV_{rms}	1.3 μV_{rms}
51.2 kS/s ≤ f_s < 102.4 kS/s	–115 dBV_{rms}	1.8 μV_{rms}
102.4 kS/s ≤ f_s ≤ 204.8 kS/s	–111 dBV_{rms}	2.8 μV_{rms}

* Source impedance ≤ 50 Ω

† 30 dB gain

AI Spurious Free Dynamic Range (SFDR)

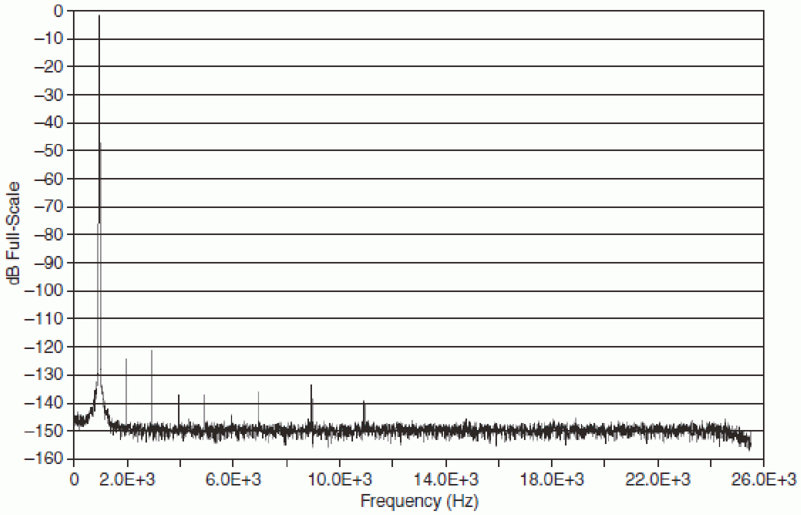
Gain Setting (dB)	SFDR (dBc)*, †, ‡
30	106
0, 10, 20	108
–20, –10	110

* f_s = 204.8 kS/s

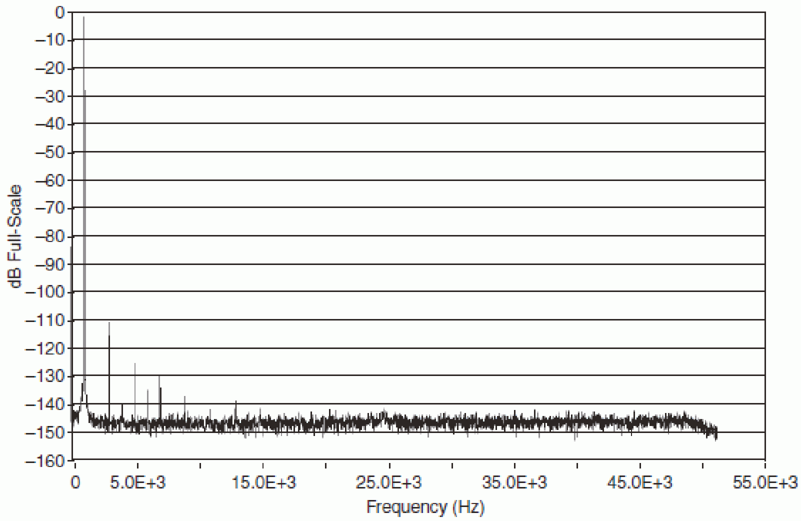
† 1 kHz input tone, input amplitude is the lesser of –1 dBFS or 8.91 V_{pk}.

‡ Measurement includes all harmonics.

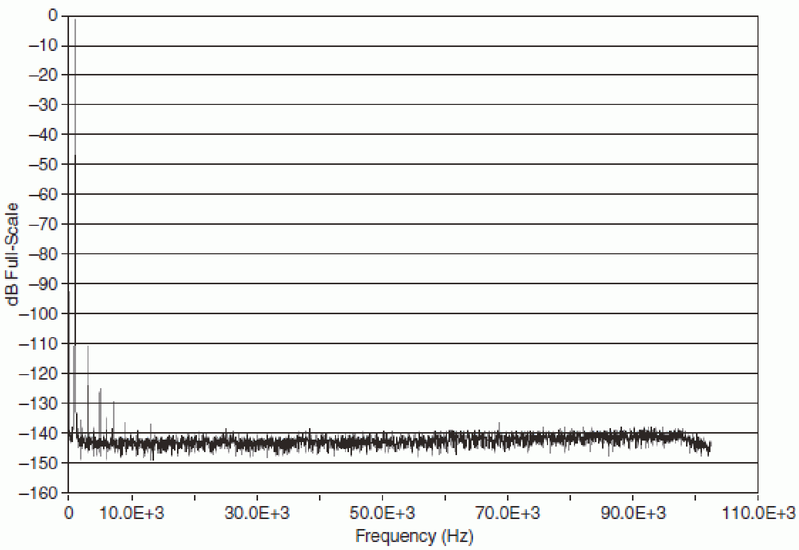
SFDR 51.2 kS/s (–1 dBFS, 0 dB Gain, 1 kHz Sine Wave Input)



SFDR 102.4 kS/s (–1 dBFS, 0 dB Gain, 1 kHz Sine Wave Input)



SFDR 204.8 kS/s (–1 dBFS, 0 dB Gain, 1 kHz Sine Wave Input)



AI Dynamic Range

Gain Setting (dB)	Dynamic Range (dBFS)*, Min (Typical)		
	1 kS/s ≤ f_s ≤ 51.2 kS/s	51.2 kS/s < f_s ≤ 102.4 kS/s	102.4 kS/s < f_s ≤ 204.8 kS/s
30	103 (105)	100 (102)	96 (98)
20	111 (113)	108 (110)	104 (106)

Gain Setting (dB)	Dynamic Range (dBFS)*, Min (Typical)		
	1 kS/s ≤ f_s ≤ 51.2 kS/s	51.2 kS/s < f_s ≤ 102.4 kS/s	102.4 kS/s < f_s ≤ 204.8 kS/s
10	114 (117)	111 (114)	106 (110)
0	116 (118)	113 (114)	107 (110)
–10	107 (108)	104 (105)	101 (102)
–20	105 (107)	102 (104)	98 (101)

* 1 kHz input tone, –60 dBFS input amplitude

AI Total Harmonic Distortion (THD), Balanced Source

Gain (dB)	THD (dBc)*, †	
	20 Hz to 20 kHz	20 Hz to 92.2 kHz
30	–100	–97
20	–109	–106
0, 10	–107	–104
–10	–108	–107
–20	–107	–106

* f_s = 204.8 kS/s, 92.8 kHz BW, differential configuration

† Input amplitude is the lesser of –1 dBFS or 8.91 V_{pk}.

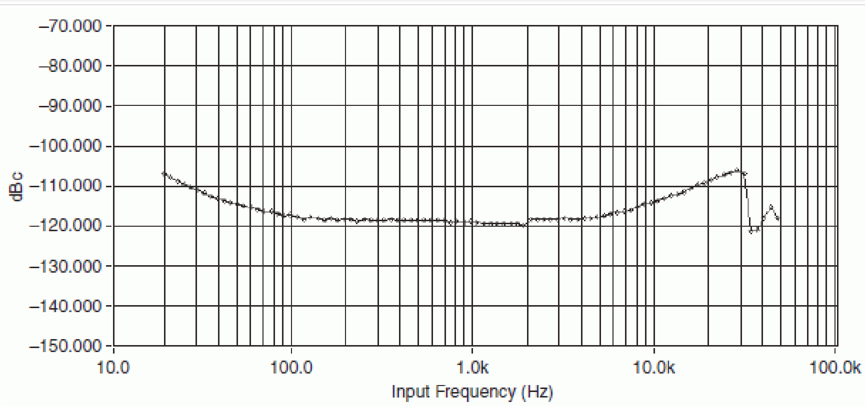
AI THD, Unbalanced Source

Gain (dB)	THD (dBc)*, †	
	20 Hz to 20 kHz	20 Hz to 92.2 kHz
30	–100	–93
20	–106	–94
10	–105	–92
0	–97	–87
–10	–90	–88
–20	–91	–89

* f_s = 204.8 kS/s, 92.8 kHz BW

† Input amplitude is the lesser of –1 dBFS or 8.91 V_{pk}.

AI THD (Balanced Source with Differential Configuration, 204.8 kS/s, 0 dB Gain)



AI THD Plus Noise (THD+N), Balanced Source

Gain (dB)	THD+N (dBc)*	
	51.2 kS/s, 20 Hz to 20 kHz†	204.8 kS/s, 20 Hz to 92.2 kHz‡
30	–103	–94
20	–107	–95
10	–108	–96
0	–107	–96

Gain (dB)	THD+N (dBc)*	
	51.2 kS/s, 20 Hz to 20 kHz†	204.8 kS/s, 20 Hz to 92.2 kHz‡
–10	–96	–91
–20	–94	–88

* Input amplitude is the lesser of –1 dBFS or 8.91 V_{pk}, differential configuration.

† 23.2 kHz measurement BW

‡ 92.8 kHz measurement BW

AI THD+N, Unbalanced Source

Gain (dB)	THD+N (dBc)*	
	51.2 kS/s, 20 Hz to 20 kHz†	204.8 kS/s, 20 Hz to 92.2 kHz‡
30	–103	–91
20	–107	–93
10	–108	–91
0	–104	–87
–10	–94	–86
–20	–93	–86

* Input amplitude is the lesser of –1 dBFS or 8.91 V_{pk}.

† 23.2 kHz measurement BW

‡ 92.8 kHz measurement BW

AI Intermodulation Distortion (IMD)

Gain (dB)	IMD (dBc)*
20, 30	–109
10	–107
0	–104
–20, –10	–111

* CCIF 14 kHz + 15 kHz, each tone amplitude is the lesser of –6 dBFS or 5 V_{pk}.

Crosstalk, Input Channel Separation

Gain (dB)	Crosstalk for Adjacent (Nonadjacent) Channels (dBc)*, †	
	1 kHz Signal	92.2 kHz
30	–130 (–140)	–110 (–124)
0, 10, 20	–138 (–145)	–110 (–124)
–20, –10	–96 (–124)	–60 (–108)

* Source impedance ≤ 50 Ω

† Input amplitude is the lesser of –1 dBFS or 8.91 V_{pk}.

AI Interchannel Gain Mismatch

Gain (dB)	DC-Coupled Mismatch (dB)*		AC-Coupled Mismatch (dB)*
	20 Hz to 20 kHz	20 Hz to 92.2 kHz	20 Hz
30	0.004	0.008	0.004
0, 10, 20	0.003	0.003	
–20, –10	0.04	0.25	0.006

* Identical channel configurations

AI Interchannel Phase Mismatch

Gain (dB)	DC-Coupled Mismatch (deg)*		AC-Coupled Mismatch (deg)*
	20 Hz to 20 kHz	20 Hz to 92.2 kHz	20 Hz
30	0.10	0.60	0.08
20	0.04	0.15	
0, 10	0.015	0.08	
–20, –10	0.7	1	
* Identical channel configurations			

Note All gain and phase mismatch specifications are for the same device and are not applicable between different NI 446*x* devices.

AI Phase Linearity

Gain (dB)	Linearity (deg)	
	20 Hz to 20 kHz	20 Hz to 92.2 kHz
0, 10, 20, 30	±0.01	±0.03
–20, –10	±0.10	±1

Onboard Calibration Reference

DC level	5.000 V ±2.5 mV
Temperature coefficient	±5 ppm/°C max
Long-term stability	±15 ppm/$\sqrt{1,000 \text{ hr}}$

Integrated Electronic Piezoelectric (IEPE)

Current	0 mA, 4 mA ±15%, or 10 mA ±15%, each channel independently software selectable
Compliance	24 V min

Note Use the following equation to make sure that your configuration meets the IEPE compliance voltage range.

$V_{common\text{-}mode} + V_{bias} + V_{full\text{-}scale}$ must be 0 to 24 V,

where $V_{common\text{-}mode}$ is the common-mode voltage seen by the input channel,

V_{bias} is the DC bias voltage of the sensor, and

$V_{full\text{-}scale}$ is the AC full-scale voltage of the sensor.

Channel input impedance with IEPE enabled	(1 MΩ || 240 pF), pseudodifferential
Current noise	<300 pA/$\sqrt{\text{Hz}}$

Transducer Electronic Data Sheet (TEDS) Support

The PCI-4461, PCI-4462, PXI-4461 (revision M or later), and PXI-4462 inputs support Transducer Electronic Data Sheet (TEDS) according to the IEEE 1451 Standard. For more information about TEDS, go to ni.com/info and enter the info code rdteds.

Analog Output (NI 4461 Only)

This section lists the NI 4461 analog output (AO) specifications.

Output Characteristics

Number of output channels	2, simultaneously sampled
Output configuration	Differential or pseudodifferential (50 Ω to chassis ground on shield), each channel independently software selectable
DAC resolution	24 bits
DAC type	Delta-sigma
Update rates (f_s)	1 kS/s to 204.8 kS/s in 181.9 μS/s increments, maximum
DAC modulator oversample rate	
1.0 kS/s ≤ f_s ≤ 1.6 kS/s	8,192 f_s
1.6 kS/s < f_s ≤ 3.2 kS/s	4,096 f_s
3.2 kS/s < f_s ≤ 6.4 kS/s	2,048 f_s
6.4 kS/s < f_s ≤ 12.8 kS/s	1,024 f_s

12.8 kS/s < f_s ≤ 25.6 kS/s	512 f_s
25.6 kS/s < f_s ≤ 51.2 kS/s	256 f_s
51.2 kS/s < f_s ≤ 102.4 kS/s	128 f_s
102.4 kS/s < f_s ≤ 204.8 kS/s	64 f_s
FIFO buffer size	1,023 samples
Data transfers	DMA

Output Signal Range

Attenuation (dB)	Full-Scale Range (V_{pk})*
40	±0.1
20	±1.0
0	±10.0

* Each output channel range is independently software selectable.

Transfer Characteristics

AO Offset (Residual DC)

Attenuation (dB)	Maximum Offset*, T_{cal} ± 5 °C† (±mV)	Maximum Offset, Over Operating Temperature Range (±mV)
20, 40	1	2
0	1	10

* Listed offset is valid 24 hours following a self calibration.

† T_{cal} = ambient temperature at which last self calibration was performed.

Gain (Amplitude Accuracy)

Specifications valid at any attenuation setting with a 1 kHz output signal.

T_{cal} ±5 °C	±0.04 dB max
(T_{cal} = ambient temperature at which last self calibration was performed.)	
(Listed accuracy is valid 24 hours following a self calibration.)	
Over operating temperature range	±0.1 dB max

Voltage Output

Output coupling	DC
Short circuit protection	Indefinite protection between positive and negative
Minimum working load	600 Ω

Output Impedance

Output Impedance	Differential Configuration	Pseudodifferential Configuration
Between positive output and chassis ground	2.4 kΩ	70 Ω
Between negative output and chassis ground	2.4 kΩ	50 Ω
Between positive and negative outputs	22 Ω	22 Ω

Dynamic Characteristics [1]

Image rejection	75 dB min < 768 kHz, 66 dB min > 768 kHz
–3 dB BW	0.487 f_s
DAC filter delay (samples), for update rate	
1.0 kS/s ≤ f_s ≤ 1.6 kS/s	36.6
1.6 kS/s < f_s ≤ 3.2 kS/s	36.8
3.2 kS/s < f_s ≤ 6.4 kS/s	37.4

6.4 kS/s < f_s ≤ 12.8 kS/s	38.5
12.8 kS/s < f_s ≤ 25.6 kS/s	40.8
25.6 kS/s < f_s ≤ 51.2 kS/s	43.2
51.2 kS/s < f_s ≤ 102.4 kS/s	48.0
102.4 kS/s < f_s ≤ 204.8 kS/s	32.0

AO Flatness

All attenuation settings relative to 1 kHz

20 Hz to 20 kHz	±0.008 dB max
20 Hz to 92.1 kHz	±0.1 dB max

AO Idle Channel Noise

Attenuation (dB)	Maximum Idle Channel Noise					
	102.5 kS/s (30 kHz BW)*		204.8 kS/s (80 kHz BW)*		204.8 kS/s (500 kHz BW)*	
	dB V_{rms}	μ V_{rms}	dB V_{rms}	μ V_{rms}	dB V_{rms}	μ V_{rms}
40	–106	5	–101	9	–87	45
20	–106	5	–101	9	–86	50
0	–96	16	–93	23	–73	224

* Noise equivalent bandwidth

AO Spurious Free Dynamic Range (SFDR)

Attenuation (dB)	SFDR (dBc)*, †, ‡
40	87
20	94
0	98

* f_s = 204.8 kS/s

† 1 kHz output frequency, –1 dBFS output amplitude

‡ Measurement includes all harmonics.

AO Dynamic Range

Attenuation (dB)	Minimum Dynamic Range (dBFS)*		
	102.5 kS/s (30 kHz BW)†	204.8 kS/s (80 kHz BW)†	204.8 kS/s (500 kHz BW)†
40	83	78	64
20	103	98	83
0	113	110	90

* 1 kHz output frequency, –60 dBFS output amplitude

† Noise equivalent bandwidth

AO THD

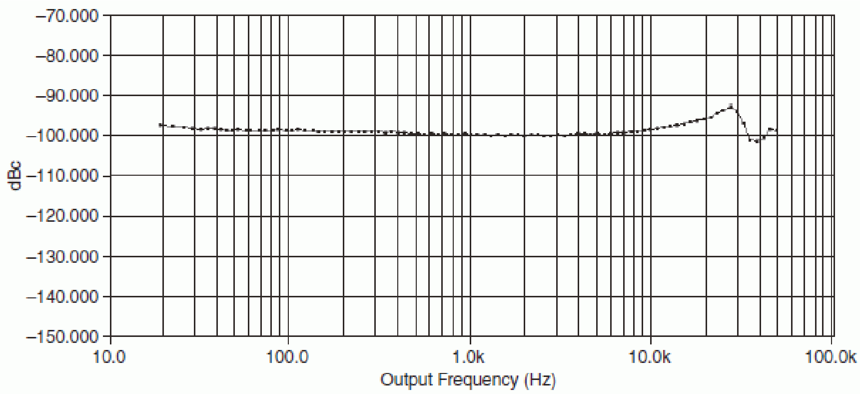
Attenuation (dB)	THD (dBc)*		
	102.5 kS/s, 20 Hz to 20 kHz†	204.8 kS/s, 20 Hz to 20 kHz‡	204.8 kS/s, 20 Hz to 92.1 kHz‡
40	–99	–92	–92
20	–98	–95	–93
0	–97	–94	–83

* –1 dBFS output amplitude

† 30 kHz measurement BW

‡ 92.8 kHz measurement BW

AO THD (204.8 kS/s, 0 dB Gain, 65,536 Samples, 92.8 kHz Measurement BW)



AO THD+N

Attenuation (dB)	THD+N (dBc)*		
	102.5 kS/s, 20 Hz to 20 kHz†	204.8 kS/s, 20 Hz to 80 kHz‡	204.8 kS/s, 20 Hz to 92.1 kHz**
40	–83	–76	–63
20	–98	–92	–79
0	–97	–86	–68

* –1 dBFS output amplitude

† 30 kHz measurement BW

‡ 80 kHz measurement BW

** 500 kHz measurement BW

AO Intermodulation Distortion (IMD)

Attenuation (dB)	IMD (dBc)*
40	–99
20	–104
0	–104

* CCIF 14 kHz + 15 kHz, each tone amplitude is –6 dBFS.

Crosstalk, Output to Input Channel Separation

Gain (dB)	Crosstalk (dBc)*, †	
	1 kHz Signal	92.1 kHz
30	–151	–118
20	–150	–118
10	–144	–115
0	–137	–111
–20, –10	–87	–51

* Source impedance ≤ 50 Ω

† Output amplitude is the lesser of –1 dBFS or 8.91 V_{pk}.

Crosstalk, Output Channel Separation

All attenuation settings (0, 20, and 40 dB)

1 kHz signal	No measurable crosstalk
92.1 kHz signal	–110 dBc

AO Interchannel Gain Mismatch

All attenuation settings

20 Hz to 92.1 kHz	0.03 dB

AO Interchannel Phase Mismatch

All attenuation settings	
20 Hz to 20 kHz	0.1°
20 Hz to 92.1 kHz	0.2°

Note All gain and phase mismatch specifications are for the same device and are not applicable between different NI 446*x* devices.

AO Phase Linearity

Attenuation (dB)	Linearity (deg)	
	20 Hz to 20 kHz	20 Hz to 92.1 kHz
0	±0.1	±1.7
20	± 0.1	±1.6
40	±0.1	±1.8

Internal Frequency Timebase Characteristics

Accuracy	±20 ppm, over operating temperature range
Aging	8 ppm in first year; 5 ppm max/year after first year

Triggers

Analog trigger	
Purpose	Start trigger
Source	
NI 4461	AI0 or AI1
NI 4462	AI0, AI1, AI2, or AI3
Level	Full scale, programmable
Slope	Positive (rising) or negative (falling), software selectable
Resolution	24 bits
Hysteresis	Programmable
Digital Trigger	
Purpose	Start or reference trigger
Source	PFI0, PXI_Trig<0..6>
Compatibility	Transistor-transistor logic (5V TTL)
Polarity	Rising or falling edge
Minimum pulse width	10 ns

General Specifications

This section lists general specification information for the NI 446x.

Bus Interface

PCI or PXI	3.3 V or 5 V signal environment
DMA channels	
NI 4461	2, analog input and analog output
NI 4462	1, analog input

Synchronization

PXI	
CLK_10	Multiple, full chassis
PXI_STAR	Up to 14 devices per chassis
PCI	

RTSI	Up to 3 devices across ribbon cable

Power Requirements

Voltage	NI PXI-4461	NI PCI-4461	NI PXI-4462	NI PCI-4462
+5 V	990 mA	2,200 mA	990 mA	1,900 mA
+3.3 V	1,430 mA	1,750 mA	1,750 mA	2,300 mA
+12 V	170 mA	40 mA	130 mA	100 mA
–12 V	110 mA	40 mA	70 mA	40 mA

Physical

Dimensions (not including connectors)	
PCI	17.5 cm × 9.9 cm (6.9 in. × 3.9 in.) PCI slot
PXI	16 cm × 10 cm (6.3 in. × 3.9 in.) 3U CompactPCI slot
Analog I/O connectors	BNC female
Digital trigger connector	SMB male
Weight	
PCI	226.8 g (8.0 oz)
PXI	241 g (8.5 oz)
Measurement Category [2]	I

Caution Do *not* use the NI 446*x* for connections to signals or for measurements within Categories II, III, or IV.

Environmental

Operating Environment

Ambient temperature range	
PXI-446*x*	0 to 55 °C (Tested in accordance with IEC-60068-2-1 and IEC-60068-2-2.)
PCI-446*x*	0 to 50 °C (Tested in accordance with IEC-60068-2-1 and IEC-60068-2-2.)
Relative humidity range	10 to 90%, noncondensing (Tested in accordance with IEC-60068-2-56.)
Altitude	2,000 m (at 25 °C ambient temperature)
Pollution Degree (indoor use only)	2

Storage Environment

Ambient temperature range	–20 to 70 °C (Tested in accordance with IEC-60068-2-1 and IEC-60068-2-2.)
Relative humidity range	5 to 95%, noncondensing (Tested in accordance with IEC-60068-2-56.)

Shock and Vibration (PXI Only)

Operational shock	30 g peak, half-sine, 11 ms pulse (Tested in accordance with IEC-60068-2-27. Test profile developed in accordance with MIL-PRF-28800F.)
Random vibration	
Operating	5 to 500 Hz, 0.3 g_{rms}
Nonoperating	5 to 500 Hz, 2.4 g_{rms} (Tested in accordance with IEC-60068-2-64. Nonoperating test profile exceeds the requirements of MIL-PRF-28800F, Class 3.)

Safety Standards

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 61010-1, CSA 61010-1

Note For UL and other safety certifications, refer to the product label or the *Online Product Certification* section.

Electromagnetic Compatibility

This product meets the requirements of the following EMC standards for electrical equipment for measurement, control, and laboratory use:

- EN 61326 (IEC 61326): Class A emissions; Basic immunity
- EN 55011 (CISPR 11): Group 1, Class A emissions

AS/NZS CISPR 11: Group 1, Class A emissions

- FCC 47 CFR Part 15B: Class A emissions
- ICES-001: Class A emissions

Note For the standards applied to assess the EMC of this product, refer to the *Online Product Certification* section.

Note For EMC compliance, operate this product according to the documentation.

CE Compliance

This product meets the essential requirements of applicable European Directives, as amended for CE marking, as follows:

- 2006/95/EC; Low-Voltage Directive (safety)
- 2004/108/EC; Electromagnetic Compatibility Directive (EMC)

Online Product Certification

Refer to the product Declaration of Conformity (DoC) for additional regulatory compliance information. To obtain product certifications and the DoC for this product, visit ni.com/certification, search by module number or product line, and click the appropriate link in the Certification column.

Environmental Management

National Instruments is committed to designing and manufacturing products in an environmentally responsible manner. NI recognizes that eliminating certain hazardous substances from our products is beneficial not only to the environment but also to NI customers.

For additional environmental information, refer to the *NI and the Environment* Web page at ni.com/environment. This page contains the environmental regulations and directives with which NI complies, as well as other environmental information not included in this document.

Waste Electrical and Electronic Equipment (WEEE)

EU Customers At the end of the product life cycle, all products *must* be sent to a WEEE recycling center. For more information about WEEE recycling centers, National Instruments WEEE initiatives, and compliance with WEEE Directive 2002/96/EC on Waste Electrical and Electronic Equipment, visit ni.com/environment/weee.htm.

电子信息产品污染控制管理办法 （中国 RoHS）

中国客户 National Instruments 符合中国电子信息产品中限制使用某些有害物质指令 (RoHS)。关于 National Instruments 中国 RoHS 合规性信息，请登录 ni.com/environment/rohs_china。(For information about China RoHS compliance, go to ni.com/environment/rohs_china.)

[1] Test system equipped with an LCD monitor for AO noise and distortion measurements to avoid possible magnetic interference caused by CRT-based monitors.

[2] *Measurement Category* is also referred to as *Installation Category*.

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