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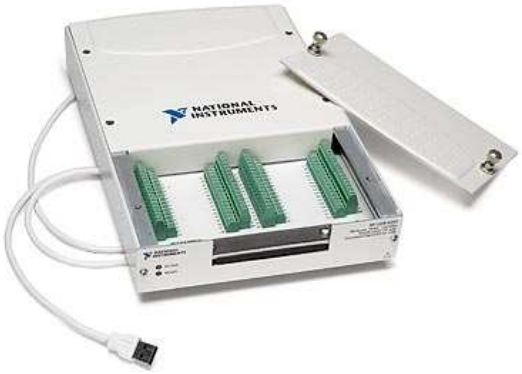
# High-Accuracy M Series Multifunction DAQ for USB - 18-Bit, up to 625 kS/s, up to 32 Analog Inputs



- 16 or 32 analog inputs at 18 bits, 625 kS/s (500 kS/s scanning)
- Up to 4 analog outputs at 16 bits, 2.86 MS/s, custom offset and range
- Up to 48 TTL/CMOS digital I/O lines (up to 32 hardware-timed at up to 1 MHz)
- Two 32-bit, 80 MHz counter/timers
- Analog and digital triggering supported; power supply included
- NI-PGIA 2 and NI-MCal calibration technology for improved measurement accuracy
- NI signal streaming for 4 high-speed data streams on USB
- NI-DAQmx driver software and LabVIEW SignalExpress LE included

## Overview

With recent bandwidth improvements and new innovations from National Instruments, USB has evolved into a core bus of choice for measurement and automation applications. NI M Series high-accuracy devices for USB deliver high-performance data acquisition in an easy-to-use and portable form factor through USB ports on laptop computers and other portable computing platforms. NI created NI signal streaming, an innovative patent-pending technology that enables sustained bidirectional high-speed data streams on USB. The new technology, combined with advanced external synchronization and isolation, helps engineers and scientists achieve high-performance applications on USB.

All high-accuracy devices have a minimum of 16 analog inputs, an onboard lowpass filter, 24 digital I/O lines, seven programmable input ranges, analog and digital triggering, and two counter/timers.

Back to Top

## Requirements and Compatibility

### OS Information

- Windows 2000/XP
- Windows 7
- Windows Vista x64/x86

### Driver Information

- NI-DAQmx

### Software Compatibility

- ANSI C/C++
- LabVIEW
- SignalExpress
- Visual C#
- Visual Studio .NET

Back to Top

## Comparison Tables

| Family | Connector | Analog Inputs | Resolution | Max Rate | Analog Outputs | Resolution | Max Rate | Digital I/O | Counter/ Timer |
|---|---|---|---|---|---|---|---|---|---|
| USB-6281 | Screw/68-pin SCSI | 16 SE/8 DI | 18 bits | 625 kS/s | 2 | 16 bits | 2.86 MS/s | 24 (8 clocked) | 2 |
| USB-6289 | Screw/68-pin SCSI | 32 SE/16 DI | 18 bits | 625 kS/s | 4 | 16 bits | 2.86 MS/s | 48 (32 clocked) | 2 |

Back to Top

## Application and Technology

### High Accuracy

NI M Series high-accuracy multifunction USB data acquisition (DAQ) devices are optimized for high accuracy at fast sampling rates. They incorporate the NI-PGIA 2 custom amplifier and NI-MCal self-calibration designed for low noise, fast settling to 18 bits, and maximum accuracy. An onboard lowpass filter rejects high-frequency noise and prevents aliasing, helping to deliver a resolution equivalent to more than 5½ digits for DC measurements, with an absolute accuracy of 980 µV at the ±10 V range and 28 µV at ±10 mV. High-accuracy NI USB-628x M Series devices also have an extended two-year calibration interval. With the enhanced analog output on USB-628x devices, you can now define custom offset and range settings. This means you can maximize the 16 bits of output resolution around a fixed DC offset, increasing the accuracy of analog waveforms.

### NI Signal Streaming

Unlike typical multifunction USB data acquisition devices, NI USB M Series DAQ devices incorporate NI signal streaming, a patent-pending technology that combines three innovative hardware- and software-level design elements to enable sustained high-speed and bidirectional data streams over USB. NI signal streaming, along with the error correction, noise rejection, power management, and power distribution inherent in the USB protocol, yields a robust, secure, and reliable bus. Without NI signal streaming, a multifunction data acquisition device could sustain only a single high-speed data stream, effectively making it a single-function device. For more information, visit **ni.com/usb**.

### Applications

In addition to test, control, and design, the high accuracy offered by USB-628x devices opens new application areas for data acquisition in analytical instrumentation and medical devices. Applications that can benefit from 18-bit accuracy include:

- Semiconductor characterization
- Portable data logging - log environmental, structural, or voltage data quickly and easily
- Field-monitoring applications
- Embedded OEM applications in medical devices or analytical instrumentation
- In-vehicle data acquisition
- Academic lab use - academic discounts available

### USB M Series for Test

You can use the M Series high-accuracy analog inputs and 10 MHz digital lines with NI signal conditioning for applications including test, component characterization, and measurements requiring instrument-class accuracy. The 18-bit analog-to-digital converter (ADC) and available filtering provide a four times increase in resolution and five times more measurement sensitivity. With fast sampling rates and a low noise floor, these devices can accurately acquire dynamic signals. Advanced analog clamping circuitry protects the hardware from overvoltage conditions and ensures accurate measurements on nonsaturated channels. High-accuracy USB-628x M Series devices are compatible with the NI SCC signal conditioning platform, providing amplification filtering and power for virtually every type of sensor. This platform is also compliant with IEEE 1451.4 smart transducer electronic data sheet (TEDS) sensors, which offer digital storage for sensor data sheet information.

USB M Series multifunction DAQ devices can also complement existing test systems with additional high-accuracy measurement channels. For higher-channel-count signal conditioning on USB, consider the NI CompactDAQ or NI SCXI platform.

### USB M Series for Control

USB M Series digital lines can drive 24 mA for relay and actuator control. By clocking the digital lines as fast as 10 MHz (with onboard regeneration), you can use these lines for pulse-width modulation (PWM) to control valves, motors, fans, lamps, and pumps. With four waveform analog outputs, two 80 MHz counter/timers, and four high-speed data streams on USB, M Series devices can execute multiple control loops simultaneously. High-accuracy USB-628x M Series devices also offer direct support for encoder measurements, protected digital lines, and digital debounce filters. With up to 32 analog inputs, 32 clocked digital lines, and four analog outputs, you can execute multiple control loops with a single device.

You can also create a complete custom motion controller by combining USB M Series devices with the NI SoftMotion Development Module.

### USB M Series for Design

For design applications, you can use a wide range of I/O - from 32 analog inputs to 48 digital lines - to measure and verify prototype designs. USB M Series devices and NI LabVIEW SignalExpress interactive measurement software deliver benchtop measurements to the PC. With LabVIEW SignalExpress, you can quickly create design verification tests. The fast acquisition and generation rates of high-performance, high-speed USB M Series devices along with LabVIEW SignalExpress provide fast design analysis. You can convert your tested and verified LabVIEW SignalExpress projects to LabVIEW applications for immediate M Series DAQ use, and bridge the gap between test, control, and design applications.

### USB M Series for OEMs

Shorten your time to market by integrating world-class National Instruments OEM measurement products in your design. Board-only versions of high-accuracy USB M Series DAQ devices are available for OEM applications, with competitive quantity pricing and available software customization. The NI OEM Elite Program offers free 30-day trial kits for qualified customers. Visit **ni.com/oem** for more information.

### Recommended Software

National Instruments measurement services software, built around NI-DAQmx driver software, includes intuitive application programming interfaces, configuration tools, I/O assistants, and other tools designed to reduce system setup, configuration, and development time. National Instruments recommends using the latest version of NI-DAQmx driver software for application development in NI LabVIEW, LabVIEW SignalExpress, LabWindows/CVI, and Measurement Studio. To obtain the latest version of NI-DAQmx, visit **ni.com/support/daq/versions**. NI measurement services software speeds up your development with features including:

- A guide to create fast and accurate measurements with no programming using the DAQ Assistant
- Automatic code generation to create your application in LabVIEW; LabWindows/CVI; LabVIEW SignalExpress; and Visual Studio .NET, ANSI C/C++, C#, or Visual Basic using Measurement Studio
- Multithreaded streaming technology for 1,000 times performance improvements
- Automatic timing, triggering, and synchronization routing to make advanced applications easy
- More than 3,000 free software downloads to jump-start your project available at **ni.com/zone**
- Software configuration of all digital I/O features without hardware switches/jumpers
- Single programming interface for analog input, analog output, digital I/O, and counters on hundreds of multifunction DAQ hardware devices

M Series devices are compatible with the following versions (or later) of NI application software - LabVIEW, LabWindows/CVI, or Measurement Studio versions 7.x or LabVIEW SignalExpress 2.x.

Back to Top

## Ordering Information

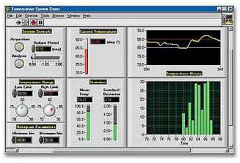
For a complete list of accessories, visit the product page on ni.com.

| Products | Part Number | Recommended Accessories | Part Number |
|---|---|---|---|
| **NI High-Accuracy M Series Multifunction DAQ for USB** | | | |
| **USB-6281 Screw Term** | 780053-01 | No accessories required. | |
| **USB-6289 Screw Term** | 780055-01 | No accessories required. | |
| **USB-6281 Mass Term**<br>Requires: 1 Cable , 1 Connector Block | 780054-01 | **Cable:** Shielded - SH68-68-EPM Noise Rejecting, Shielded Cable, 1 m<br>***Also Available: Unshielded* | 199006-01 |
| | | **Connector Block:** Shielded - SCB-68 Noise Rejecting, Shielded I/O Connector Block<br>***Also Available: BNC Termination, Unshielded* | 776844-01 |
| **USB-6289 Mass Term**<br>Requires: 2 Cable s, 2 Connector Block s | 780056-01 | **Connector 0:** | |
| | | **Cable:** Shielded - SH68-68-EPM Noise Rejecting, Shielded Cable, 1 m<br>***Also Available: Unshielded* | 199006-02 |
| | | **Connector Block:** Shielded - SCB-68 Noise Rejecting, Shielded I/O Connector Block<br>***Also Available: Unshielded, BNC Termination* | 776844-01 |
| | | **Connector 1:** | |
| | | **Cable:** Shielded - SH68-68-EPM Noise Rejecting, Shielded Cable, 1 m<br>***Also Available: Unshielded* | 199006-02 |
| | | **Connector Block:** Shielded - SCB-68 Noise Rejecting, Shielded I/O Connector Block<br>***Also Available: Unshielded, BNC Termination* | 776844-01 |
| **Board-Only Devices for Embedded Systems and OEM** | | | |
| **USB-6281 OEM (Quantity 1)** | 197596-03 | No accessories required. | |
| **USB-6289 OEM (Quantity 1)** | 197596-01 | No accessories required. | |

Back to Top

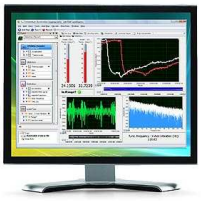
## Software Recommendations

### LabVIEW Professional Development System for Windows



- Advanced software tools for large project development
- Automatic code generation using DAQ Assistant and Instrument I/O Assistant
- Tight integration with a wide range of hardware
- Advanced measurement analysis and digital signal processing
- Open connectivity with DLLs, ActiveX, and .NET objects
- Capability to build DLLs, executables, and MSI installers

### SignalExpress for Windows

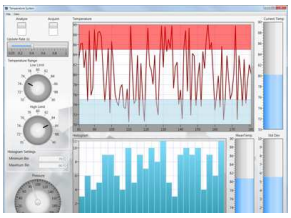


- Quickly configure projects without programming
- Control over 400 PC-based and stand-alone instruments
- Log data from more than 250 data acquisition devices
- Perform basic signal processing, analysis, and file I/O
- Scale your application with automatic LabVIEW code generation
- Create custom reports or easily export data to LabVIEW, DIAdem or Microsoft Excel

### NI LabWindows™/CVI for Windows

- Real-time advanced 2D graphs and charts
- Complete hardware compatibility with IVI, VISA, DAQ, GPIB, and serial
- Analysis tools for array manipulation, signal processing statistics, and curve fitting
- Simplified cross-platform communication with network variables
- Measurement Studio .NET tools (included in LabWindows/CVI Full only)
- The mark LabWindows is used under a license from Microsoft Corporation.

### NI Measurement Studio Professional Edition



- Customizable graphs and charts for WPF, Windows Forms, and ASP.NET Web Forms UI design
- Analysis libraries for array operations, signal generation, windowing, filters, signal processing
- Hardware integration support with native .NET data acquisition and instrument control libraries
- Automatic code generation for all NI-DAQmx data acquisition hardware
- Intelligent and efficient data-logging libraries for streaming measurement data to disk
- Support for Microsoft Visual Studio .NET 2012/2010/2008

Back to Top

## Support and Services

### 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.

Visit ni.com/training for more information.

### 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.

Back to Top

## Detailed Specifications

Specifications listed below are typical at 25 °C unless otherwise noted. Refer to the *M Series User Manual* for more information about NI 628*x* devices.

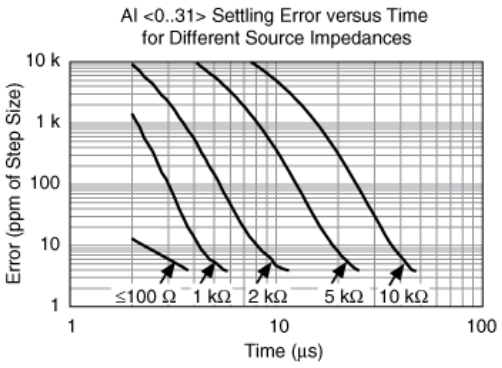
| **Analog Input** | |
|---|---|
| Number of channels | |
| NI 6280/6281 | 8 differential or 16 single ended |
| NI 6284/6289 | 16 differential or 32 single ended |
| ADC resolution | 18 bits |
| DNL | No missing codes guaranteed |
| INL | Refer to the *AI Absolute Accuracy Tables* |
| Sampling rate | |
| Maximum | 625 kS/s single channel,<br>500 kS/s multi-channel (aggregate) |
| Minimum | No minimum |
| Timing accuracy | 50 ppm of sample rate |
| Timing resolution | 50 ns |
| Input coupling | DC |
| Input range | ±10 V, ±5 V, ± 2 V, ±1 V, ±0.5 V, ± 0.2 V, ± 0.1 V |

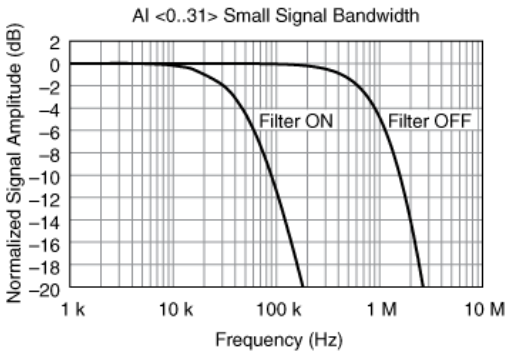
| | |
|---|---|
| Maximum working voltage for analog inputs (signal + common mode) | ±11 V of AI GND |
| CMRR (DC to 60 Hz) | 110 dB |
| Input impedance | |
| Device on | |
| AI+ to AI GND | >10 GΩ in parallel with 100 pF |
| AI- to AI GND | >10 GΩ in parallel with 100 pF |
| Device off | |
| AI+ to AI GND | 820 Ω |
| AI- to AI GND | 820 Ω |
| Input bias current | ±100 pA |
| Crosstalk (at 100 kHz) | |
| Adjacent channels | -75 dB |
| Non-adjacent channels | -95 dB |
| Small signal bandwidth (-3 dB) | 750 kHz filter off,<br>40 kHz filter on |
| Input FIFO size | 2,047 samples |
| Scan list memory | 4,095 entries |
| Data transfers | |
| PCI/PXI devices | DMA (scatter-gather), interrupts, programmed I/O |
| USB devices | USB Signal Stream, programmed I/O |
| Overvoltage protection (AI <0..31>, AI SENSE, AI SENSE 2) | |
| Device on | ±25 V for up to eight AI pins |
| Device off | ±15 V for up to eight AI pins |
| Input current during overvoltage condition | ±20 mA max/AI pin |

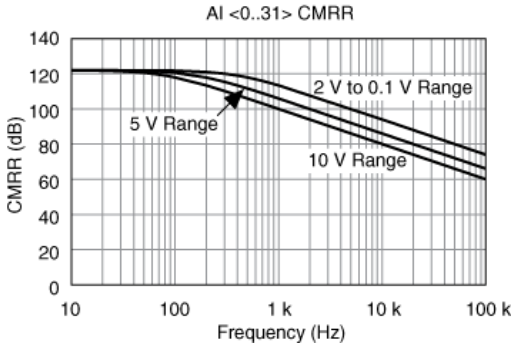
**Settling Time for Multichannel Measurements**

| Range | Filter Off | | Filter On |
|---|---|---|---|
| | ±15 ppm of Step (±4 LSB for Full Scale Step) | ±4 ppm of Step (±1 LSB for Full Scale Step) | ±4 ppm of Step (±1 LSB for Full Scale Step) |
| ±10 V, ±5 V | 2 µs | 8 µs | 50 µs |
| ±2 V, ±1 V, ±0.5 V | 2.5 µs | 8 µs | 50 µs |
| ±0.2 V, ±0.1 V | 3 µs | 8 µs | 50 µs |

**Typical Performance Graphs**






| | |
|---|---|
| **Analog Triggers** | |
| Number of triggers | 1 |
| Source | |
| NI 6280/6281 | AI <0..15>, APFI 0 |
| NI 6284/6289 | AI <0..31>, APFI <0..1> |
| Functions | Start Trigger, Reference Trigger, Pause Trigger, Sample Clock, Convert Clock, Sample Clock Timebase |
| Source level | |
| AI <0..31> | ±Full scale |
| APFI <0..1> | ±10 V |
| Resolution | 10 bits, 1 in 1024 |
| Modes | Analog edge triggering, analog edge triggering with hysteresis, and analog window triggering |
| Bandwidth (-3 dB) | |
| AI <0..31> | 700 kHz filter off,<br>40 kHz filter on |
| APFI <0..1> | 5 MHz |
| Accuracy | ±1% |
| APFI <0..1> characteristics | |
| Input impedance | 10 kΩ |
| Coupling | DC |
| Protection | |
| Power on | ±30 V |
| Power off | ±15 V |
| **Analog Output** | |
| Number of channels | |
| NI 6280/6284 | 0 |
| NI 6281 | 2 |
| NI 6289 | 4 |
| DAC resolution | 16 bits |
| DNL | ±1 LSB |
| Monotonicity | 16 bit guaranteed |
| Accuracy | Refer to the *AO Absolute Accuracy Table* |
| Maximum update rate | |
| 1 channel | 2.86 MS/s |
| 2 channels | 2.00 MS/s |
| 3 channels | 1.54 MS/s |

| | |
|---|---|
| 4 channels | 1.25 MS/s |
| Timing accuracy | 50 ppm of sample rate |
| Timing resolution | 50 ns |
| Output range | Offset ± reference, includes ±10 V, ±5 V, ±2 V, and ±1 V calibrated ranges |
| Offset | 0 V, 5 V, APFI <0..1>, AO <0..3>[1] |
| Reference | 10 V, 5 V, 2 V, 1 V, APFI <0..1>, AO <0..3>[1] |
| Maximum output level | ±11 V |
| Output coupling | DC |
| Output impedance | 0.2 Ω |
| Output current drive | ±5 mA |
| Overdrive protection | ±25 V |
| Overdrive current | 20 mA |
| Power-on state | ±5 mV[2] |
| Power-on glitch | 2.3 V peak for 1.2 s |
| Output FIFO size | 8,191 samples shared among channels used |
| Data transfers | |
| PCI/PXI devices | DMA (scatter-gather), interrupts, programmed I/O |
| USB devices | USB Signal Stream, programmed I/O |

AO waveform modes:

- Non-periodic waveform
- Periodic waveform regeneration mode from onboard FIFO
- Periodic waveform regeneration from host buffer including dynamic update

| | |
|---|---|
| Settling time, full scale step 15 ppm (1 LSB) | 3 µs |
| Slew rate | 20 V/µs |
| Glitch energy at midscale transition, ±10 V range | |
| Magnitude | 15 mV |
| Duration | 0.5 µs |

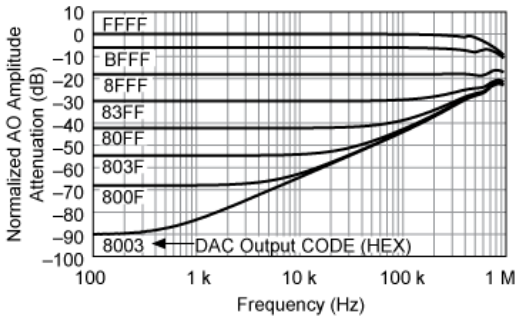
[1] An AO channel cannot be a reference or offset to itself.

[2] For all USB-6281/6289 Screw Terminal devices, when powered on, the analog output signal is not defined until after USB configuration is complete.

## External Reference

| | |
|---|---|
| APFI <0..1> characteristics | |
| Input impedance | 10 kΩ |
| Coupling | DC |
| Protection | |
| Power on | ±30 V |
| Power off | ±15 V |
| Range | ±11 V |

AO <0..3> Analog Output External Reference Bandwidth



## Calibration (AI and AO)

| | |
|---|---|
| Recommended warm-up time | |
| PCI/PXI devices | 15 minutes |
| USB devices | 30 minutes |
| Calibration interval | 2 years |

### AI Absolute Accuracy Table (Filter On)

| Nominal Range | | Residual Gain Error (ppm of Reading) | Gain Tempco (ppm/°C) | Reference Tempco | Residual Offset Error (ppm of Range) | Offset Tempco (ppm of Range/°C) | INL Error (ppm of Range) | Random Noise, σ (μVrms) | Absolute Accuracy at Full Scale[1] (μV) | Sensitivity[2] (μV) |
|---|---|---|---|---|---|---|---|---|---|---|
| Positive Full Scale | Negative Full Scale | | | | | | | | | |
| 10 | -10 | 40 | 17 | 1 | 8 | 11 | 10 | 60 | 980 | 24 |
| 5 | -5 | 45 | 17 | 1 | 8 | 11 | 10 | 30 | 510 | 12 |
| 2 | -2 | 45 | 17 | 1 | 8 | 13 | 10 | 12 | 210 | 4.8 |
| 1 | -1 | 55 | 17 | 1 | 15 | 15 | 10 | 7 | 120 | 2.8 |
| 0.5 | -0.5 | 55 | 17 | 1 | 30 | 20 | 10 | 4 | 70 | 1.6 |
| 0.2 | -0.2 | 75 | 17 | 1 | 45 | 35 | 10 | 3 | 39 | 1.2 |
| 0.1 | -0.1 | 120 | 17 | 1 | 60 | 60 | 10 | 2 | 28 | 0.8 |

Accuracies listed are valid for up to two years from the device external calibration.

AbsoluteAccuracy = Reading · (GainError) + Range · (OffsetError) + NoiseUncertainty

GainError = ResidualAIGainError + GainTempco · (TempChangeFromLastInternalCal) + ReferenceTempco · (TempChangeFromLastExternalCal)

OffsetError = ResidualAIOffsetError + OffsetTempco · (TempChangeFromLastInternalCal) + INL_Error

$$\text{NoiseUncertainty} = \frac{\text{RandomNoise} \cdot 3}{\sqrt{100}}$$ For a coverage factor of 3 σ and averaging 100 points.

[1] Absolute accuracy at full scale on the analog input channels is determined using the following assumptions:

TempChangeFromLastExternalCal = 10 °C

TempChangeFromLastInternalCal = 1 °C

number_of_readings = 100

CoverageFactor = 3 σ

For example, on the 10 V range, the absolute accuracy at full scale is as follows:

GainError = 40 ppm + 17 ppm · 1 + 1 ppm · 10 GainError = 67 ppm

OffsetError = 8 ppm + 11 ppm · 1 + 10 ppm OffsetError = 29 ppm

$$\text{NoiseUncertainty} = \frac{60\ \mu\text{V} \cdot 3}{\sqrt{100}}$$ $\text{NoiseUncertainty} = 18\ \mu\text{V}$

AbsoluteAccuracy = 10 V · (GainError) + 10 V · (OffsetError) + NoiseUncertainty AbsoluteAccuracy = 980 μV

[2] Sensitivity is the smallest voltage change that can be detected. It is a function of noise.

### AI Absolute Accuracy Table (Filter Off)

| Nominal Range | | Residual Gain Error (ppm of Reading) | Gain Tempco (ppm/°C) | Reference Tempco | Residual Offset Error (ppm of Range) | Offset Tempco (ppm of Range/°C) | INL Error (ppm of Range) | Random Noise, σ (μVrms) | Absolute Accuracy at Full Scale[1] (μV) | Sensitivity[2] (μV) |
|---|---|---|---|---|---|---|---|---|---|---|
| Positive Full Scale | Negative Full Scale | | | | | | | | | |
| 10 | -10 | 45 | 17 | 1 | 10 | 11 | 10 | 70 | 1050 | 28.0 |
| 5 | -5 | 50 | 17 | 1 | 10 | 11 | 10 | 35 | 550 | 14.0 |
| 2 | -2 | 50 | 17 | 1 | 10 | 13 | 10 | 15 | 230 | 6.0 |
| 1 | -1 | 60 | 17 | 1 | 17 | 15 | 10 | 12 | 130 | 4.8 |
| 0.5 | -0.5 | 60 | 17 | 1 | 32 | 20 | 10 | 10 | 80 | 4.0 |
| 0.2 | -0.2 | 80 | 17 | 1 | 47 | 35 | 10 | 9 | 43 | 3.6 |
| 0.1 | -0.1 | 120 | 17 | 1 | 62 | 60 | 10 | 9 | 31 | 3.6 |

Accuracies listed are valid for up to two years from the device external calibration.

AbsoluteAccuracy = Reading · (GainError) + Range · (OffsetError) + NoiseUncertainty

GainError = ResidualAIGainError + GainTempco · (TempChangeFromLastInternalCal) + ReferenceTempco · (TempChangeFromLastExternalCal)

OffsetError = ResidualAIOffsetError + OffsetTempco · (TempChangeFromLastInternalCal) + INL_Error

$$NoiseUncertainty = \frac{RandomNoise \cdot 3}{\sqrt{100}}$$ For a coverage factor of 3 σ and averaging 100 points.

[1] Absolute accuracy at full scale on the analog input channels is determined using the following assumptions:

TempChangeFromLastExternalCal = 10 °C

TempChangeFromLastInternalCal = 1 °C

number_of_readings = 100

CoverageFactor = 3 σ

For example, on the 10 V range, the absolute accuracy at full scale is as follows:

GainError = 45 ppm + 17 ppm · 1 + 1 ppm · 10 GainError = 72 ppm

OffsetError = 10 ppm + 11 ppm · 1 + 10 ppm OffsetError = 31 ppm

$$NoiseUncertainty = \frac{70\ \mu V \cdot 3}{\sqrt{100}}$$ $$NoiseUncertainty = 21\ \mu V$$

AbsoluteAccuracy = 10 V · (GainError) + 10 V · (OffsetError) + NoiseUncertainty AbsoluteAccuracy = 1050 µV

[2] Sensitivity is the smallest voltage change that can be detected. It is a function of noise.

**AO Absolute Accuracy Table**

| Nominal Range | | Residual Gain Error (ppm of Reading) | Gain Tempco (ppm/°C) | Reference Tempco | Residual Offset Error (ppm of Range) | Offset Tempco (ppm of Range/°C) | INL Error (ppm of Range) | Absolute Accuracy at Full Scale[1] (µV) |
|---|---|---|---|---|---|---|---|---|
| Positive Full Scale | Negative Full Scale | | | | | | | |
| 10 | -10 | 55 | 15 | 1 | 30 | 12 | 32 | 1540 |
| 5 | -5 | 60 | 15 | 1 | 30 | 17 | 32 | 820 |
| 2 | -2 | 65 | 25 | 1 | 40 | 30 | 32 | 404 |
| 1 | -1 | 85 | 25 | 1 | 57 | 50 | 32 | 259 |

[1] Absolute Accuracy at full scale numbers is valid immediately following internal calibration and assumes the device is operating within 10 °C of the last external calibration.
Accuracies listed are valid for up to two years from the device external calibration.

AbsoluteAccuracy = OutputValue · (GainError) + Range · (OffsetError)

GainError = ResidualGainError + GainTempco · (TempChangeFromLastInternalCal) + ReferenceTempco · (TempChangeFromLastExternalCal)

OffsetError = ResidualOffsetError + AOOffsetTempco · (TempChangeFromLastInternalCal) + INL_Error

## Digital I/O/PFI

### Static Characteristics

| | |
|---|---|
| Number of channels | |
| NI 6280/6281 | 24 total<br>8 (P0.<0..7>) 16 (PFI <0..7>/P1, PFI <8..15>/P2) |
| NI 6284/6289 | 48 total<br>32 (P0.<0..31>) 16 (PFI <0..7>/P1, PFI <8..15>/P2) |
| I/O type | 5 V TTL/CMOS compatible |
| Ground reference | D GND |
| Direction control | Each terminal individually programmable as input or output |
| Pull-down resistor | 50 kΩ typical, 20 kΩ minimum |
| Input voltage protection[3] | ±20 V on up to two pins |

[3] Stresses beyond those listed under *Input voltage protection* may cause permanent damage to the device.

### Waveform Characteristics (Port 0 Only)

| | |
|---|---|
| Terminals used | |
| NI 6280/6281 | Port 0 (P0.<0..7>) |
| NI 6284/6289 | Port 0 (P0.<0..31>) |
| Port/sample size | |

| | |
|---|---|
| NI 6280/6281 | Up to 8 bits |
| NI 6284/6289 | Up to 32 bits |
| Waveform generation (DO) FIFO | 2,047 samples |
| Waveform acquisition (DI) FIFO | 2,047 samples |
| DI Sample Clock frequency | |
| PCI/PXI devices | 0 to 10 MHz[4] |
| USB devices | 0 to 1 MHz system dependent[4] |
| DO Sample Clock frequency | |
| PCI/PXI devices | |
| Regenerate from FIFO | 0 to 10 MHz |
| Streaming from memory | 0 to 10 MHz system dependent[4] |
| USB devices | |
| Regenerate from FIFO | 0 to 10 MHz |
| Streaming from memory | 0 to 1 MHz system dependent[4] |
| Data transfers | |
| PCI/PXI devices | DMA (scatter-gather), interrupts, programmed I/O |
| USB devices | USB Signal Stream, programmed I/O |
| DO or DI Sample Clock source[5] | Any PFI, RTSI, AI Sample or Convert Clock, AO Sample Clock, Ctr *n* Internal Output, and many other signals |

[4] Performance can be dependent on bus latency and volume of bus activity.

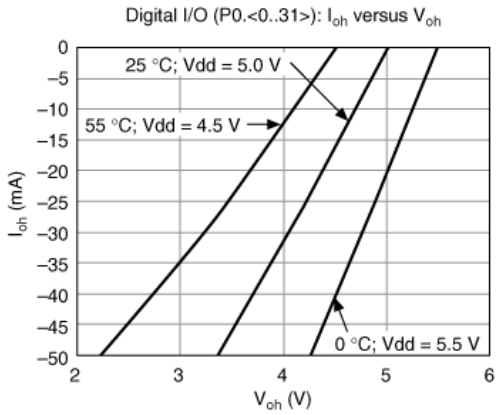
[5] The digital subsystem does not have its own dedicated internal timing engine. Therefore, a sample clock must be provided from another subsystem on the device or an external source.

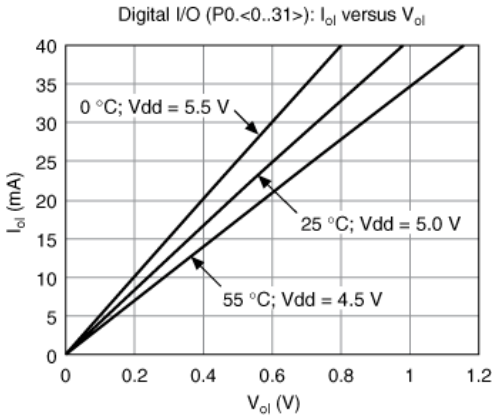
| **PFI/Port 1/Port 2 Functionality** | |
|---|---|
| Functionality | Static digital input, static digital output, timing input, timing output |
| Timing output sources | Many AI, AO, counter, DI, DO timing signals |
| Debounce filter settings | 125 ns, 6.425 µs, 2.56 ms, disable; high and low transitions; selectable per input |

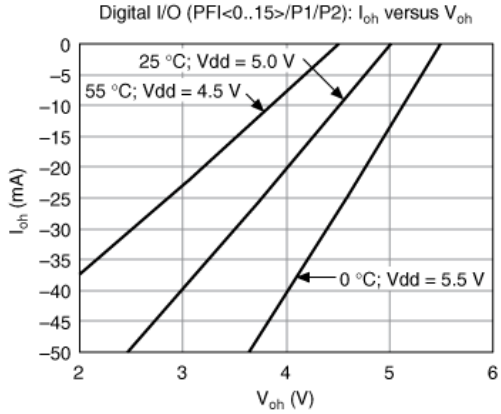
| **Recommended Operation Conditions** | | |
|---|---|---|
| **Level** | **Min** | **Max** |
| Input high voltage ($V_{IH}$) | 2.2 V | 5.25 V |
| Input low voltage ($V_{IL}$) | 0 V | 0.8 V |
| Output high current ($I_{OH}$)<br>P0.<0..31><br>PFI <0..15>/P1/P2 | <br>—<br>— | <br>-24 mA<br>-16 mA |
| Output low current ($I_{OL}$)<br>P0.<0..31><br>PFI <0..15>/P1/P2 | <br>—<br>— | <br>24 mA<br>16 mA |

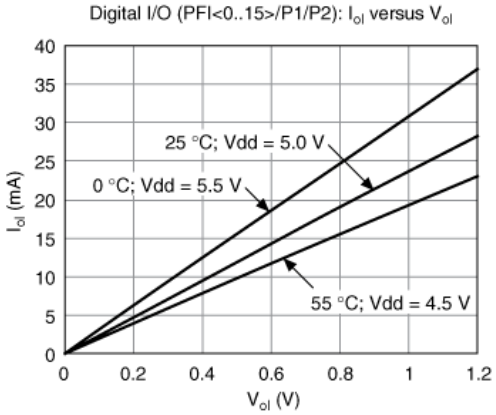
| **Electrical Characteristics** | | |
|---|---|---|
| **Level** | **Min** | **Max** |
| Positive-going threshold (VT+)<br>Negative-going threshold (VT-) | —<br>0.8 V | 2.2 V<br>— |
| Delta VT hysteresis (VT+ - VT-) | 0.2 V | — |
| $I_{IL}$ input low current ($V_{in}$ = 0 V)<br>$I_{IH}$ input high current ($V_{in}$ = 5 V) | —<br>— | -10 µA<br>250 µA |

| **Digital I/O Characteristics** |
|---|




| **General-Purpose Counter/Timers** | |
|---|---|
| Number of counter/timers | 2 |
| Resolution | 32 bits |
| Counter measurements | Edge counting, pulse, semi-period, period, two-edge separation |
| Position measurements | X1, X2, X4 quadrature encoding with Channel Z reloading; two-pulse encoding |
| Output applications | Pulse, pulse train with dynamic updates, frequency division, equivalent time sampling |
| Internal base clocks | 80 MHz, 20 MHz, 0.1 MHz |
| External base clock frequency | 0 MHz to 20 MHz |
| Base clock accuracy | 50 ppm |
| Inputs | Gate, Source, HW_Arm, Aux, A, B, Z, Up_Down |
| Routing options for inputs | Any PFI, RTSI, PXI_TRIG, PXI_STAR, analog trigger, many internal signals |
| FIFO | 2 samples |
| Data transfers | |
| PCI/PCIe/PXI/PXIe devices | Dedicated scatter-gather DMA controller for each counter/timer; interrupts, programmed I/O |
| USB devices | USB Signal Stream, programmed I/O |
| **Frequency Generator** | |
| Number of channels | 1 |
| Base clocks | 10 MHz, 100 kHz |
| Divisors | 1 to 16 |
| Base clock accuracy | 50 ppm |
| Output can be available on any PFI or RTSI terminal. | |
| **Phase-Locked Loop (PLL) (PCI/PXI Devices Only)** | |

| | |
|---|---|
| Number of PLLs | 1 |
| Reference signal | PXI_STAR, PXI_CLK10, RTSI <0..7> |
| Output of PLL | 80 MHz Timebase; other signals derived from 80 MHz Timebase including 20 MHz and 100 kHz Timebases |

## External Digital Triggers

| | |
|---|---|
| Source | Any PFI, RTSI, PXI_TRIG, PXI_STAR |
| Polarity | Software-selectable for most signals |
| Analog input function | Start Trigger, Reference Trigger, Pause Trigger, Sample Clock, Convert Clock, Sample Clock Timebase |
| Analog output function | Start Trigger, Pause Trigger, Sample Clock, Sample Clock Timebase |
| Counter/timer functions | Gate, Source, HW_Arm, Aux, A, B, Z, Up_Down |
| Digital waveform generation (DO) function | Sample Clock |
| Digital waveform acquisition (DI) function | Sample Clock |

### Device-To-Device Trigger Bus

| | |
|---|---|
| PCI devices | RTSI <0..7>[6] |
| PXI devices | PXI_TRIG <0..7>, PXI_STAR |
| USB devices | None |
| Output selections | 10 MHz Clock; frequency generator output; many internal signals |
| Debounce filter settings | 125 ns, 6.425 µs, 2.56 ms, disable; high and low transitions; selectable per input |

[6] In other sections of this document, *RTSI* refers to RTSI <0..7> for PCI devices or PXI_TRIG <0..7> for PXI devices.

## Bus Interface

| | |
|---|---|
| PCI/PXI devices | 3.3 V or 5 V signal environment |
| USB devices | USB 2.0 Hi-Speed or full-speed[7,8] |
| DMA channels (PCI/PXI devices) | 6, analog input, analog output, digital input, digital output, counter/timer 0, counter/timer 1 |
| USB Signal Stream (USB devices) | 4, can be used for analog input, analog output, digital input, digital output, counter/timer 0, counter/timer 1 |

All PXI-628*x* devices support one of the following features:

- May be installed in PXI Express hybrid slots
- Or, may be used to control SCXI in PXI/SCXI combo chassis

Table 1. PXI/SCXI Combo and PXI Express Chassis Compatibility

| M Series Device | M Series Part Number | SCXI Control in PXI/SCXI Combo Chassis | PXI Express Hybrid Slot Compatible |
|---|---|---|---|
| PXI-6280 | 191501C-04 | No | Yes |
| PXI-6281 | 191501C-03 | No | Yes |
| PXI-6284 | 191501C-02 | No | Yes |
| PXI-6289 | 191501C-01 | No | Yes |
| | 191501C-11 | Yes | No |
| Earlier versions of PXI-628*x* | 191501A-0*x*<br>191501B-0*x* | Yes | No |

[7] If you are using a USB M Series device in full-speed mode, device performance will be lower and you will not be able to achieve maximum sampling/update rates.
[8] Operating on a full-speed bus may result in lower performance.

## Power Requirements

| | |
|---|---|
| PCI/PXI devices | |
| Current draw from bus during no-load condition[9] | |
| +5 V | 0.03 A |
| +3.3 V | 0.78 A |

| | |
|---|---|
| +12 V | 0.40 A |
| -12 V | 0.06 A |
| PCI/PXI devices | |
| Current draw from bus during AI and AO overvoltage condition[9] | |
| +5 V | 0.03 A |
| +3.3 V | 1.26 A |
| +12 V | 0.43 A |
| -12 V | 0.06 A |

**Caution** USB-628*x* devices *must* be powered with NI offered AC adapter or a National Electric Code (NEC) Class evice and has appropriate safety certification marks for country of use.

| | |
|---|---|
| USB devices | |
| Power supply requirements | 11 to 30 VDC, 20 W, locking or non-locking power jack with 0.080 in. diameter center pin, 5/16-32 thread for locking collars |
| Power supply fuse | 2 A, 250 V |

[9] Does not include P0/PFI/P1/P2 and +5 V terminals.

## Power Limits

**Caution** Exceeding the power limits may cause unpredictable behavior by the device and/or PC/chassis.

| | |
|---|---|
| PCI devices | |
| +5 V terminal (connector 0) | 1 A max[10] |
| +5 V terminal (connector 1) | 1 A max[10] |
| PXI devices | |
| +5 V terminal (connector 0) | 1 A max[10] |
| +5 V terminal (connector 1) | 1 A max[10] |
| P0/PFI/P1/P2 and +5 V terminals combined | 2 A max |
| USB devices | |
| +5 V terminal | 1 A max[11] |
| P0/PFI/P1/P2 and +5 V terminals combined | 2 A max |

[10] Older revisions have a self-resetting fuse that opens when current exceeds this specification. Newer revisions have a traditional fuse that opens when current exceeds this specification. This fuse is not customer-replaceable; if the fuse permanently opens, return the device to NI for repair.

[11] Has a self-resetting fuse that opens when current exceeds this specification.

## Physical Requirements

| | |
|---|---|
| Printed circuit board dimensions | |
| NI PCI-6280/6281/6284/6289 | 10.6 cm x 15.5 cm (4.2 in. x 6.1 in.) |
| NI PXI-6280/6281/6284/6289 | Standard 3U PXI |
| Enclosure dimensions (includes connectors) | |
| NI USB-6281/6289 Mass Termination | 18.8 x 17.09 x 4.45 cm (7.4 x 6.73 x 1.75 in.) |
| NI USB-6281/6289 Screw Terminal | 26.67 x 17.09 x 4.45 cm (10.5 x 6.73 x 1.75 in.) |
| NI USB-6258/6289 OEM | Refer to the *NI USB-622x/625x/628x OEM User Guide* |
| Weight | |
| NI PCI-6280 | 151 g (5.3 oz) |
| NI PCI-6281 | 158 g (5.6 oz) |
| NI PCI-6284 | 159 g (5.6 oz) |
| NI PCI-6289 | 167 g (5.9 oz) |
| NI PXI-6280 | 218 g (7.7 oz) |
| NI PXI-6281 | 225 g (7.9 oz) |
| NI PXI-6284 | 229 g (8.1 oz) |

| | |
|---|---|
| NI PXI-6289 | 237 g (8.4 oz) |
| NI USB-6281 Mass Termination | 1.04 kg (2 lb 4.5 oz) |
| NI USB-6289 Mass Termination | 1.06 kg (2 lb 5.5 oz) |
| NI USB-6281 OEM | 261 g (9.2 oz) |
| NI USB-6289 OEM | 274 g (9.6 oz) |
| NI USB-6281 Screw Terminal | 1.46 kg (3 lb 3.4 oz) |
| NI USB-6289 Screw Terminal | 1.52 kg (3 lb 5.5 oz) |
| I/O connector | |
| NI PCI/PXI-6280/6281 | 1 68-pin VHDCI |
| NI PCI/PXI-6284/6289 | 2 68-pin VHDCI |
| NI USB-6281 Mass Termination | 1 68-pin SCSI |
| NI USB-6289 Mass Termination | 2 68-pin SCSI |
| NI USB-6281 OEM | 1 34-pin IDC, 1 50-pin IDC |
| NI USB-6289 OEM | 2 34-pin IDC, 2 50-pin IDC |
| NI USB-6281 Screw Terminal | 64 screw terminals |
| NI USB-6289 Screw Terminal | 128 screw terminals |
| USB-6281/6289 Screw Terminal wiring | 16-28 AWG |

## Maximum Working Voltage[12]

| | |
|---|---|
| NI 6280/6281/6284/6289 channel-to-earth | 11 V, Measurement Category I |

**Caution** Do *not* use for measurements within Categories II, III, or IV.

[12] *Maximum working voltage* refers to the signal voltage plus the common-mode voltage.

## Environmental

| | |
|---|---|
| Operating temperature | |
| PCI/PXI devices | 0 to 55 °C |
| USB devices | 0 to 45 °C |
| Storage temperature | -20 to 70 °C |
| Humidity | 10 to 90% RH, noncondensing |
| Maximum altitude | 2,000 m |
| Pollution Degree (indoor use only) | 2 |
| **Shock and Vibration (PXI Devices Only)** | |
| Operational shock | 30 g peak, half-sine, 11 ms pulse<br>(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 $g_{rms}$<br>(Tested in accordance with IEC-60068-2-64. Nonoperating test profile exceeds the requirements of MIL-PRF-28800F, Class 3.) |

## 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 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.

**Note** For EMC compliance, operate this device with shielded cables.

## CE Compliance

This product meets the essential requirements of applicable European Directives 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 model number or product line, and click the appropriate link in the Certification column.

## Environmental Management

NI 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)

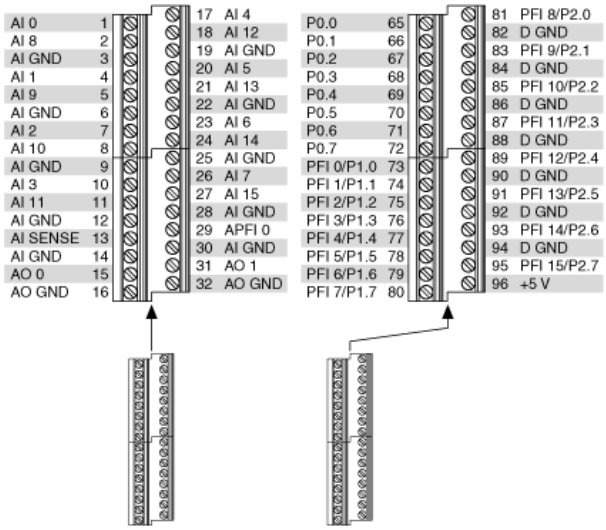
**EU Customers** At the end of their life cycle, all products *must* be sent to a WEEE recycling center. For more information about WEEE recycling centers and National Instruments WEEE initiatives, visit ni.com/environment/weee.htm.

电子信息产品污染控制管理办法 （中国 RoHS）

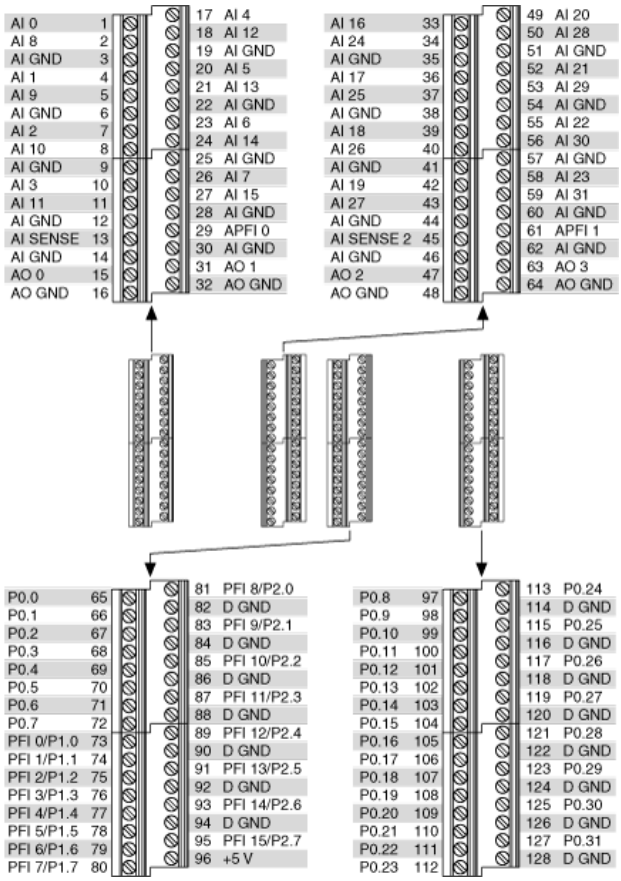
中国客户 National Instruments 符合中国电子信息产品中限制使用某些有害物质指令 (RoHS)。
关于 National Instruments 中国 RoHS 合规性信息，请登录 ni.com/environment/rohs_china。
(For information about China RoHS compliance, go to ni.com/environment/rohs_china.)

Back to Top

**Pinouts/Front Panel Connections**




NI USB-6281 Screw Terminal Pinout




NI USB-6289 Screw Terminal Pinout

Back to Top