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

M Series – High Accuracy

- 16 or 32 analog inputs at 18 bits, 625 kS/s (500 kS/s scanning)
- Up to 4 analog outputs at 16 bits, 2.8 MS/s (3 µs full-scale settling)
- 7 programmable input ranges (±100 mV to ±10 V) per channel
- Programmable analog output ranges and offsets per channel
- Up to 48 TTL/CMOS digital I/O lines (up to 32 hardware-timed at 10 MHz)
- Two 32-bit, 80 MHz counter/timers
- Analog and digital triggering
- NI-MCal calibration technology for improved measurement accuracy
- 6 DMA channels for high-speed data throughput
- NI-DAQmx measurement services software for simplified configuration and measurements
- 3-year warranty

Operating Systems
- Windows 2000/NT/XP

Recommended Software
- LabVIEW
- LabWindows/CVI
- Measurement Studio

Other Compatible Software
- NI SignalExpress
- Visual Studio .NET
- C/C++

Measurement Services Software (Included)
- NI-DAQmx

Family	Bus	Analog Inputs	Analog Input Resolution (bits)	Analog Outputs	Output Resolution (bits)	Max Output Rate (MS/s)	Output Range	Digital I/O	Correlated (Clocked) DIO
NI 6280	PCI, PXI	16	18	–	–	–	–	24	8, up to 10 MHz
NI 6281	PCI, PXI	16	18	2	16	2.8	Programmable per channel	24	8, up to 10 MHz
NI 6284	PCI, PXI	32	18	–	–	–	–	48	32, up to 10 MHz
NI 6289	PCI, PXI	32	18	4	16	2.8	Programmable per channel	48	32, up to 10 MHz

Table 1. NI High-Accuracy M Series Selection Guide

Overview and Applications

National Instruments high-accuracy M Series devices are optimized for 18-bit analog input accuracy. This resolution is equivalent to 5 ½ digits of resolution for DC measurements. To ensure accuracy, the NI-PGIA 2 amplifier technology is optimized for low noise and fast settling to 18-bits, and programmable lowpass filters reject high-frequency noise and prevent aliasing. These devices are ideal for applications including device test and characterization, and for sensor and signal measurements requiring instrument-class accuracy. For test, the analog inputs and 10 MHz digital lines can be used for applications including electronics test and component characterization. With the fast sampling rates, they can accurately acquire dynamic signals. High-accuracy M Series devices also have quadrature encoder inputs, protected digital lines, and digital debounce filters for control applications. With four waveform analog outputs and two 80 MHz counter/timers, M Series devices can execute multiple control loops simultaneously and can control pulse-width modulated signals. For sensor measurements, M Series devices are compatible with SCC and SCXI signal conditioning, and can measure IEEE 1451.4 smart sensors. Synchronize the operations of multiple devices using the RTSI bus or PXI trigger bus.

Recommended Accessories

Signal conditioning is required for sensor measurements or voltage inputs greater than 10 V. National Instruments SCXI is a versatile, high-performance signal conditioning platform, optimized for high-channel-count applications. NI SCC provides portable, flexible signal conditioning options on a per-channel basis. For applications not requiring signal conditioning, refer to the table below for recommended cabling and accessories.

System Description	Terminal Block	Cable
High Performance	SCB-68, BNC-2110, TBX-68	SHC68-68-EPM
Basic Shielding	SCB-68, BNC-2110, TBX-68	SHC68-68-S

Table 2. Recommended Accessories (Two cables and accessories are required to access all pins on the NI 6284 and 6289 devices.)

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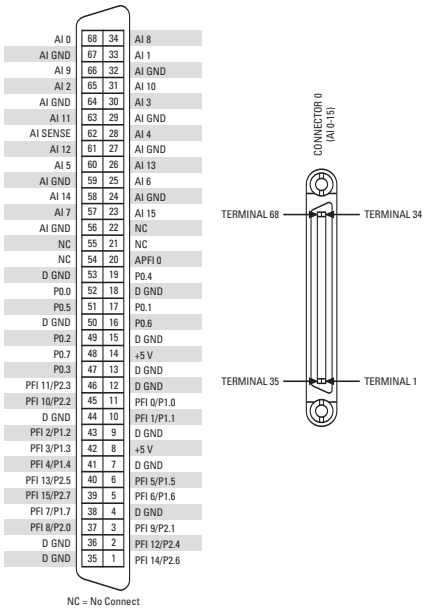
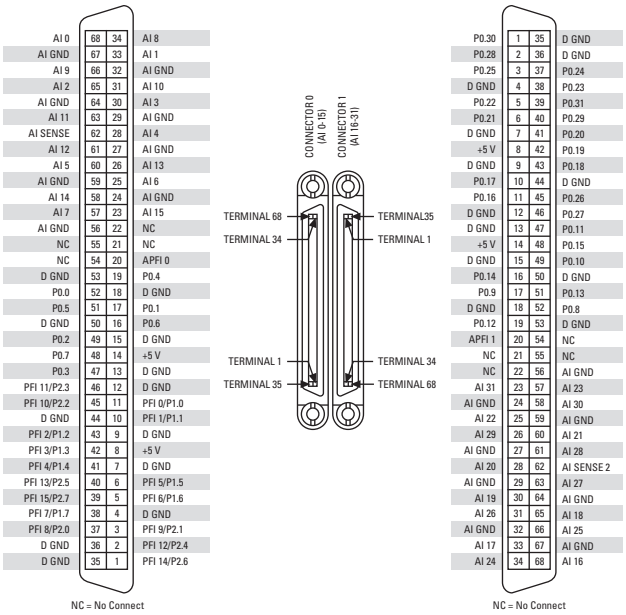
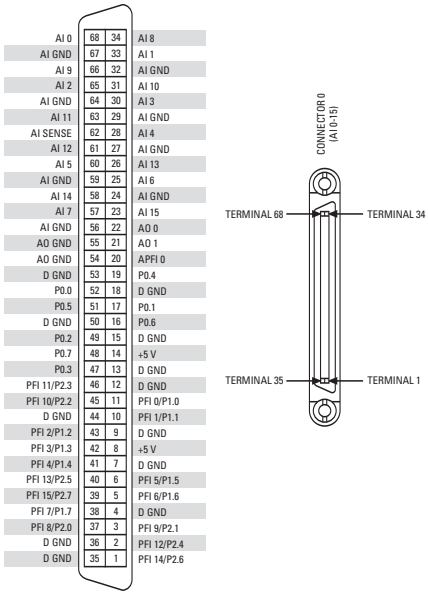


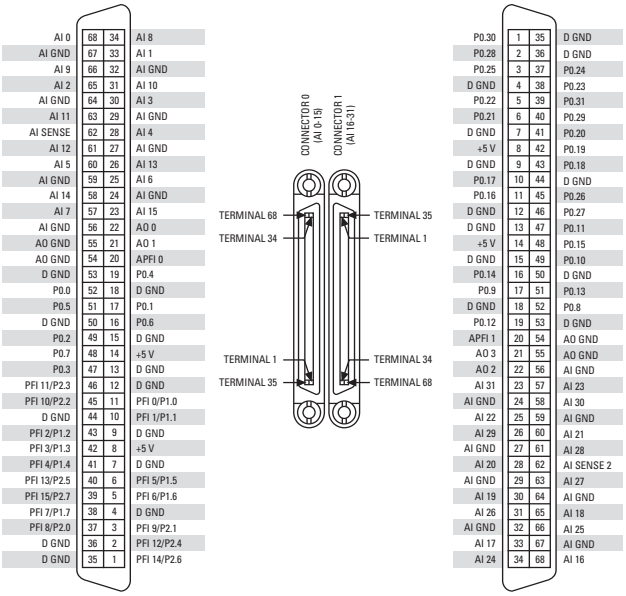
NI 6280 Pinout



NI 6284 Pinout



NI 6281 Pinout



NI 6289 Pinout

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Ordering Information

PCI

NI PCI-6280 779108-01
NI PCI-6281 779109-01
NI PCI-6284 779110-01
NI PCI-6289 779111-01

PXI

NI PXI-6280 779120-01
NI PXI-6281 779121-01
NI PXI-6284 779122-01
NI PXI-6289 779123-01

Includes NI-DAQmx Measurement Services Software.

BUY NOW!

For complete product specifications, pricing, and accessory information, call (800) 813 3693 (U.S. only) or go to **ni.com/daq**.

Specifications

Typical at 25 °C unless otherwise noted.

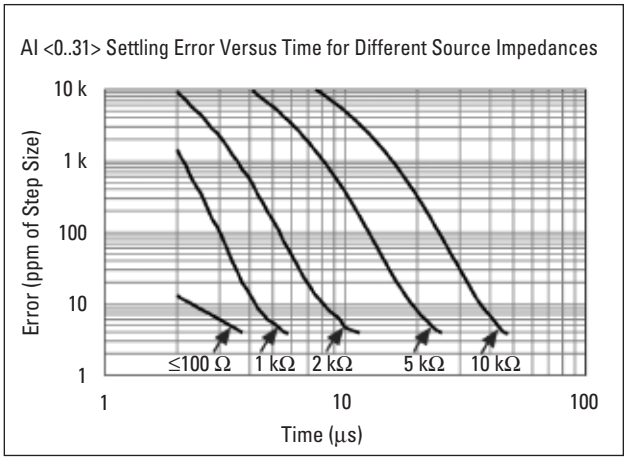
Analog Input

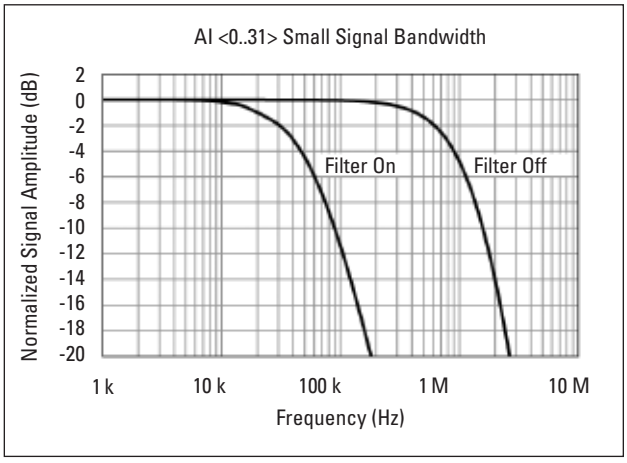
Number of channels	
NI 6280/NI 6281	8 differential or 16 single ended
NI 6284/NI 6289	16 differential or 32 single ended
ADC resolution	18 bits
DNL	No missing codes guaranteed
INL	Refer to the *AI Absolute Accuracy Tables*
Sampling rate	
Maximum	625 kS/s single channel, 500 kS/s multichannel
Minimum	0 S/s
Timing accuracy	50 ppm of sample rate
Timing resolution	50 ns
Input coupling	DC
Input range	±10, ±5, ±2, ±1, ±0.5, ±0.2, ±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	
AI+ to AI GND	>10 GΩ in parallel with 100 pF
AI– to AI GND	>10 GΩ in parallel with 100 pF
Input bias current	±100 pA
Crosstalk (at 100 kHz)	
Adjacent channels	–75 dB
Nonadjacent channels	–95 dB
Small signal bandwidth (–3 dB)	750 kHz filter off, 40 kHz filter on
Input FIFO size	2,047 samples
Scan list memory	4,095 entries
Data transfers	DMA (scatter-gather), interrupts, programmed I/O
Overvoltage protection (AI <0..31>, AI SENSE, AI SENSE 2)	
Device on	±25 V for up to 8 AI pins
Device off	±15 V for up to 8 AI pins
Input current during overvoltage condition	±20 mA max/AI pin

Settling Time for Multichannel Measurements

	Filter Off		Filter On
Range	±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





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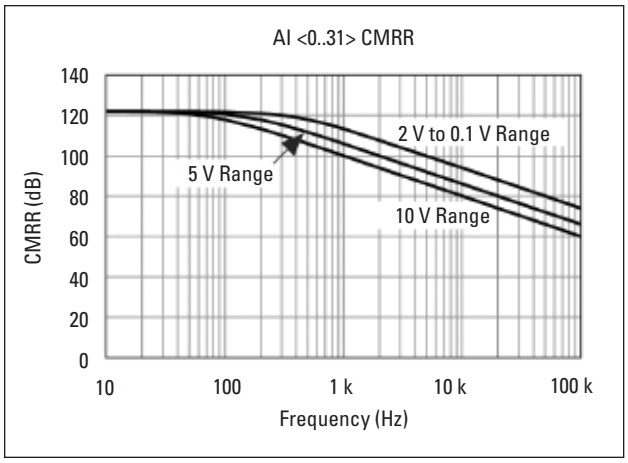


Analog Triggers

Number of triggers	1
Source	
NI 6280/NI 6281	AI <0..15>, APFI 0
NI 6284/NI 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
Modes	Level triggering, level triggering with hysteresis, window triggering
Bandwidth (–3 dB)	
AI <0..31>	700 kHz filter off, 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	0
NI 6281	2
NI 6284	0
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, ±5, ±2, and ±1 V calibrated ranges
Offset	0, 5 V, APFI <0..1>, AO <0..3>[1]
Reference	10, 5, 2, 1 V, APFI <0..1>, AO <0..3>[1]
Max 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
Power-on glitch	2.3 V peak for 1.2 s
Output FIFO size	8,191 samples shared among channels used
Data transfers	DMA (scatter-gather), interrupts, programmed I/O

AO waveform modes:

- Aperiodic 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

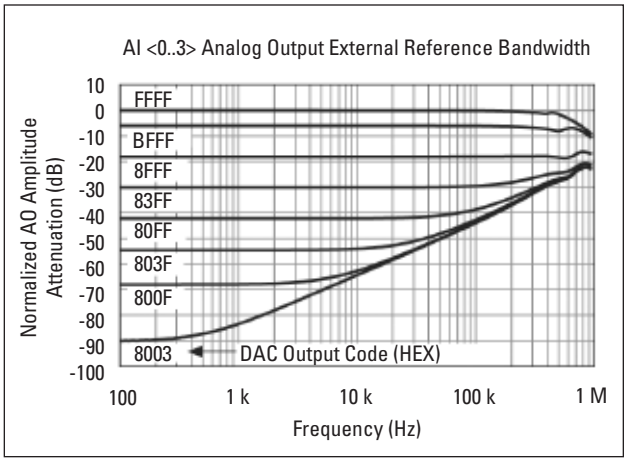
[1] An AO channel cannot be a reference or offset to itself.

External Reference

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

Calibration (AI and AO)

Recommended warm-up time	15 minutes
Calibration interval	2 years



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AI Absolute Accuracy Table (Filter On)

Nominal Range		Residual			Residual	Offset			Absolute	
Positive Full Scale	Negative Full Scale	Gain Error (ppm of Reading)	Gain Tempco (ppm/°C)	Reference Tempco	Offset Error (ppm of Range)	Tempco (ppm of Range/°C)	INL Error (ppm of Range)	Random Noise, σ (μV_{rms})	Accuracy at Full Scale[1] (µV)	Sensitivity[2] (µV)
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

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

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

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			Residual				Absolute	
Positive Full Scale	Negative Full Scale	Gain Error (ppm of Reading)	Gain Tempco (ppm/°C)	Reference Tempco	Offset Error (ppm of Range)	Offset Tempco (ppm of Range/°C)	INL Error (ppm of Range)	Random Noise, σ (μV_{rms})	Accuracy at Full Scale[1] (µV)	Sensitivity[2] (µV)
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

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

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

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

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.

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AO Absolute Accuracy Table

Nominal Range		Residual			Residual	Offset		Absolute
Positive Full Scale	Negative Full Scale	Gain Error (ppm of Reading)	Gain Tempco (ppm/°C)	Reference Tempco	Offset Error (ppm of Range)	Tempco (ppm of Range/°C)	INL Error (ppm of Range)	Accuracy at Full Scale[1] (µV)
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 assume the device is operating within 10 °C of the last 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/NI 6281 ..... 24 total
  8 (P0.<0..7>)
  16 (PFI <0..7>/P1, PFI <8..15>/P2)
- NI 6284/NI 6289 ..... 48 total
  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 to 75 kΩ

Input voltage protection[1] ..... ±20 V on up to two pins

[1] Stresses beyond those listed under input voltage protection may cause permanent damage to the device.

Waveform Characteristics (Port 0 Only)

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

Port/sample size
- NI 6280/NI 6281 ..... Up to 8 bits
- NI 6284/NI 6289 ..... Up to 32 bits

Waveform generation (DO) FIFO ..... 2,047 samples

Waveform acquisition (DI) FIFO ..... 2,047 samples

DO or DI Sample Clock frequency ..... 0 to 10 MHz

DO or DI Sample Clock source[2] ..... Any PFI, RTSI, AI Sample or Convert Clock, AO Sample Clock, Ctr *n* Internal Output, and many other signals

[2] 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, 2.54 ms, disable; high and low transitions; selectable per input

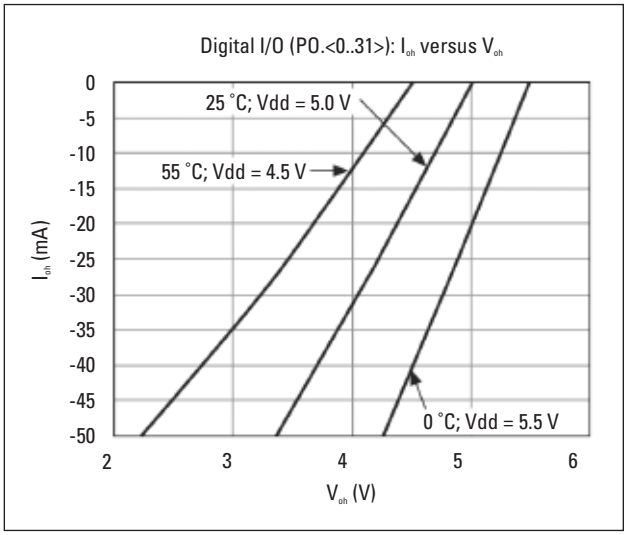
Recommended Operation Conditions

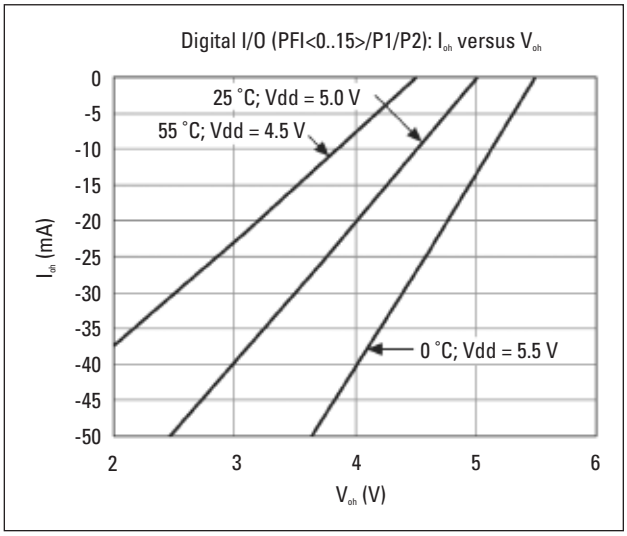
Level	Minimum	Maximum
Input high voltage (V_{IH})	2.2 V	5.25 V
Input low voltage (V_{IL})	0 V	0.8 V
Output high current (I_{OH})		
P0.<0..31>	–	–24 mA
PFI <0..15>/P1/P2	–	–16 mA
Output low current (I_{OL})		
P0.<0..31>	–	24 mA
PFI <0..15>/P1/P2	–	16 mA

Electrical Characteristics

Level	Minimum	Maximum
Positive-going threshold (VT+)	–	2.2 V
Negative-going threshold (VT–)	0.8 V	–
Delta VT hysteresis (VT+ – VT–)	0.2 V	–
I_{IL} input low current (Vin = 0 V)	–	-10 µA
I_{IH} input high current (Vin = 5 V)	–	250 µA

Digital I/O Characteristics





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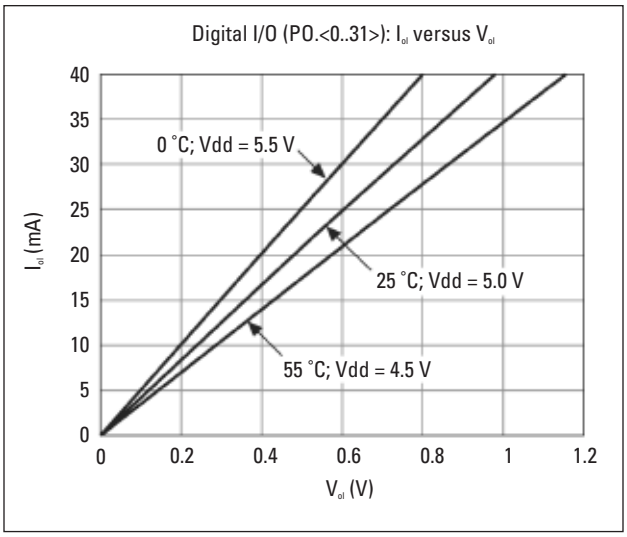

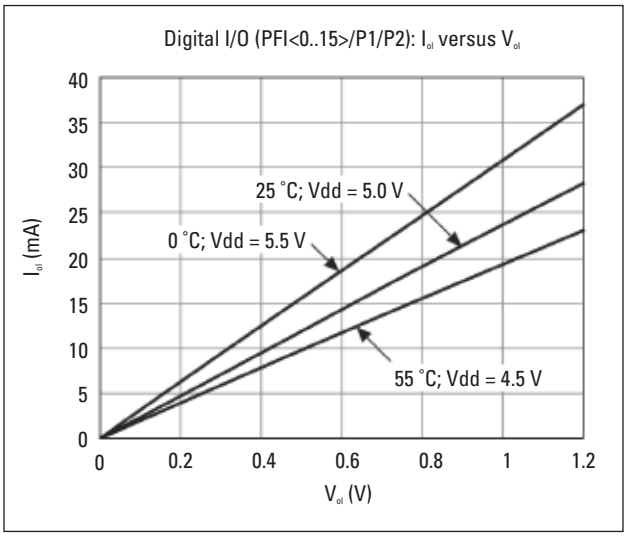

General-Purpose Counter/Timers

Number of counter/timers	2
Resolution	32 bits
Counter measurements	Edge counting, pulse, semiperiod, 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, 100 kHz
External base clock frequency	0 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	Dedicated scatter-gather DMA controller for each counter/timer; interrupts; 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)

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 function	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>[1]
PXI devices	PXI_TRIG <0..7>, PXI_STAR
Output selections	10 MHz Clock; frequency generator output; many internal signals
Debounce filter settings	125 ns, 6.425 µs, 2.54 ms, disable; high and low transitions; selectable per input

[1] 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 or PXI	3.3 V or 5 V signal environment
DMA channels	6, analog input, analog output, digital input, digital output, counter/timer 0, counter/timer 1

Power Requirements

Current draw from bus during no-load condition

+5 V	0.03 A
+3.3 V	0.78 A
+12 V	0.40 A
-12 V	0.06 A

Current draw from bus during AI and AO overvoltage condition

+5 V	0.03 A
+3.3 V	1.26 A
+12 V	0.43 A
-12 V	0.06 A

Power available from +5 V terminal	1 A max, each connector, with self-resetting fuse
Other power limit for PXI devices	Current drawn from +5 V terminals and all P0/PFI/P1/P2 terminals should not exceed 2 A

Physical

Dimensions

PCI	10.6 cm x 15.5 cm (4.2 in. x 6.1 in.)
PXI	Standard 3U PXI

I/O connector

NI 6280/NI 6281	1 68-pin VHDCI
NI 6284/NI 6289	2 68-pin VHDCI

Maximum Working Voltage[1]

Channel-to-earth	11 V, Measurement Category I

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

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

Environmental

Operating temperature	0 to 55 °C
Storage temperature	-20 to 70 °C
Relative humidity	10 to 90%, noncondensing
Maximum altitude	2,000 m
Pollution Degree (indoor use only)	2

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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
- CAN/CSA-C22.2 No. 61010-1

For UL and other safety certifications, refer to the product label, or visit **ni.com/certification**, search by model number or product line, and click the appropriate link in the Certification column.

Electromagnetic Compatibility

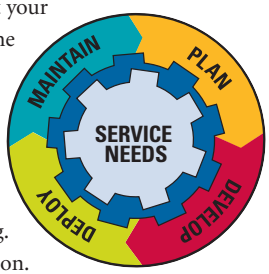
Emissions..... EN 55011 Class A at 10 m; FCC Part 15A above 1 GHz
Immunity..... EN 61326:1997 + A2:2001, Table 1
CE, C-Tick, and FCC Part 15 (Class A) Compliant
For EMC compliance, operate this device with shielded cabling.

CE Compliance CE

This product meets the essential requirements of applicable European Directives, as amended for CE Marking, as follows:
Low-Voltage Directive (safety)..... 73/23/EEC
Electromagnetic Compatibility
Directive (EMC) 89/336/EEC
Refer to the Declaration of Conformity (DoC) for this product for any additional regulatory compliance information. To obtain 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.

NI Services and Support

NI has the services and support to meet your needs around the globe and through the application life cycle – from planning and development through deployment and ongoing maintenance. We offer services and service levels to meet customer requirements in research, design, validation, and manufacturing. Visit ni.com/services for more information.



Training and Certification

NI training is the fastest, most certain route to productivity with our products. NI training can shorten your learning curve, save development time, and reduce maintenance costs over the application life cycle. NI schedules instructor-led courses in cities worldwide, or can hold a course at your facility. NI also offers a professional certification program that identifies individuals who have high levels of skill and knowledge on using NI products. Visit ni.com/training.

Professional Services

The NI Professional Services Team is comprised of NI applications engineers, NI consulting services, and a worldwide National Instruments 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 for more information.

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OEM Support

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 for more information.

Local Sales and Technical Support

In offices worldwide, NI staff is local to the country, giving you access to engineers who speak your language. NI delivers industry-leading technical support through an online KnowledgeBase, applications engineers, and access to 14,000 measurement and automation professionals within NI Developer Exchange forums. Find immediate answers to your questions at ni.com/support.

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

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