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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.

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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

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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

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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.

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Ordering Information

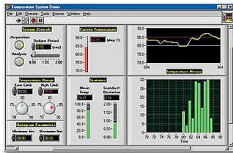
For a complete list of accessories, visit the product page on ni.com.

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 Requires: 1 Cable , 1 Connector Block	780054-01	Cable: Shielded - SH68-68-EPM Noise Rejecting, Shielded Cable, 1 m **Also Available: Unshielded	199006-01
		Connector Block: Shielded - SCB-68 Noise Rejecting, Shielded I/O Connector Block **Also Available: BNC Termination, Unshielded	776844-01
USB-6289 Mass Term Requires: 2 Cable s, 2 Connector Block s	780056-01	Connector 0:	
		Cable: Shielded - SH68-68-EPM Noise Rejecting, Shielded Cable, 1 m **Also Available: Unshielded	199006-02
		Connector Block: Shielded - SCB-68 Noise Rejecting, Shielded I/O Connector Block **Also Available: Unshielded, BNC Termination	776844-01
		Connector 1:	
		Cable: Shielded - SH68-68-EPM Noise Rejecting, Shielded Cable, 1 m **Also Available: Unshielded	199006-02
		Connector Block: Shielded - SCB-68 Noise Rejecting, Shielded I/O Connector Block **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.	

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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



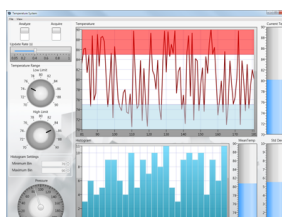
- Quickly configure projects without programming
- Control over 400 PC-based and stand-alone instruments
- Log data from more than 250 data acquisition devices
- Perform basic signal processing, analysis, and file I/O
- Scale your application with automatic LabVIEW code generation
- Create custom reports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

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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.

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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 628x devices.

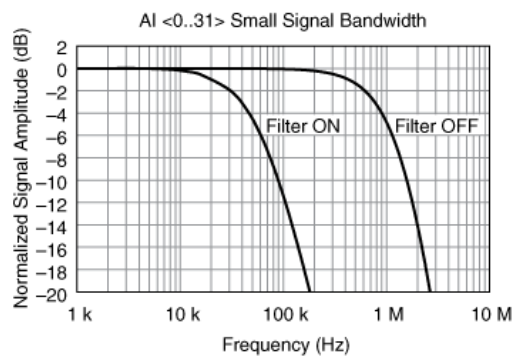
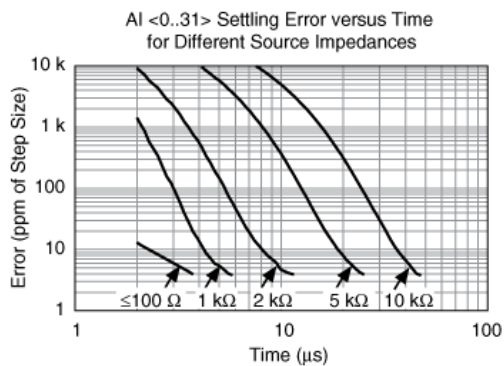
Analog Input	
Number of channels	
NI 6280/6281	8 differential or 16 single ended
NI 6284/6289	16 differential or 32 single ended
ADC resolution	18 bits
DNL	No missing codes guaranteed
INL	Refer to the <i>AI Absolute Accuracy Tables</i>
Sampling rate	
Maximum	625 kS/s single channel, 500 kS/s multi-channel (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

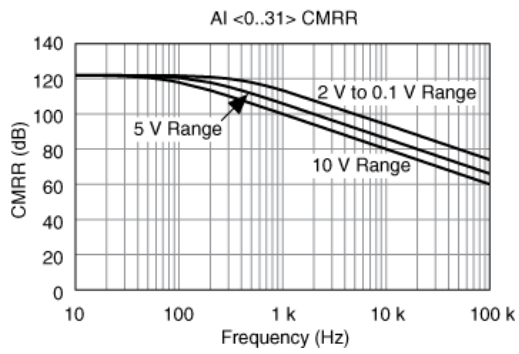
Maximum working voltage for analog inputs (signal + common mode)	±11 V of AI GND
CMRR (DC to 60 Hz)	110 dB
Input impedance	
Device on	
AI+ to AI GND	>10 GΩ in parallel with 100 pF
AI- to AI GND	>10 GΩ in parallel with 100 pF
Device off	
AI+ to AI GND	820 Ω
AI- to AI GND	820 Ω
Input bias current	±100 pA
Crosstalk (at 100 kHz)	
Adjacent channels	-75 dB
Non-adjacent channels	-95 dB
Small signal bandwidth (-3 dB)	750 kHz filter off, 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, 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 <i>AO Absolute Accuracy Table</i>
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 \pm 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 μ s
Slew rate	20 V/ μ s
Glitch energy at midscale transition, ± 10 V range	
Magnitude	15 mV
Duration	0.5 μ s

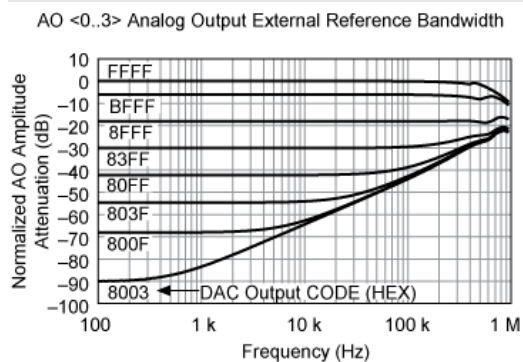
¹ An AO channel cannot be a reference or offset to itself.

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 k Ω
Coupling	DC
Protection	
Power on	± 30 V
Power off	± 15 V
Range	± 11 V



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 (μ Vrms)	Absolute Accuracy at Full Scale ¹ (μ V)	Sensitivity ² (μ V)
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.

$$\text{AbsoluteAccuracy} = \text{Reading} \cdot (\text{GainError}) + \text{Range} \cdot (\text{OffsetError}) + \text{NoiseUncertainty}$$

$$\text{GainError} = \text{ResidualAIGainError} + \text{GainTempco} \cdot (\text{TempChangeFromLastInternalCal}) + \text{ReferenceTempco} \cdot (\text{TempChangeFromLastExternalCal})$$

$$\text{OffsetError} = \text{ResidualAIOffsetError} + \text{OffsetTempco} \cdot (\text{TempChangeFromLastInternalCal}) + \text{INL_Error}$$

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

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

$$\text{TempChangeFromLastExternalCal} = 10 \text{ }^\circ\text{C}$$

$$\text{TempChangeFromLastInternalCal} = 1 \text{ }^\circ\text{C}$$

$$\text{number_of_readings} = 100$$

$$\text{CoverageFactor} = 3\sigma$$

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

$$\text{GainError} = 40 \text{ ppm} + 17 \text{ ppm} \cdot 1 + 1 \text{ ppm} \cdot 10 \quad \text{GainError} = 67 \text{ ppm}$$

$$\text{OffsetError} = 8 \text{ ppm} + 11 \text{ ppm} \cdot 1 + 10 \text{ ppm} \quad \text{OffsetError} = 29 \text{ ppm}$$

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

$$\text{AbsoluteAccuracy} = 10 \text{ V} \cdot (\text{GainError}) + 10 \text{ V} \cdot (\text{OffsetError}) + \text{NoiseUncertainty} \quad \text{AbsoluteAccuracy} = 980 \text{ } \mu\text{V}$$

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 (μ Vrms)	Absolute Accuracy at Full Scale ¹ (μ V)	Sensitivity ² (μ V)
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.

$$\text{AbsoluteAccuracy} = \text{Reading} \cdot (\text{GainError}) + \text{Range} \cdot (\text{OffsetError}) + \text{NoiseUncertainty}$$

$$\text{GainError} = \text{ResidualAIGainError} + \text{GainTempco} \cdot (\text{TempChangeFromLastInternalCal}) + \text{ReferenceTempco} \cdot (\text{TempChangeFromLastExternalCal})$$

$$\text{OffsetError} = \text{ResidualAIOffsetError} + \text{OffsetTempco} \cdot (\text{TempChangeFromLastInternalCal}) + \text{INL_Error}$$

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

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

$$\text{TempChangeFromLastExternalCal} = 10 \text{ }^\circ\text{C}$$

$$\text{TempChangeFromLastInternalCal} = 1 \text{ }^\circ\text{C}$$

$$\text{number_of_readings} = 100$$

$$\text{CoverageFactor} = 3 \sigma$$

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

$$\text{GainError} = 45 \text{ ppm} + 17 \text{ ppm} \cdot 1 + 1 \text{ ppm} \cdot 10 \quad \text{GainError} = 72 \text{ ppm}$$

$$\text{OffsetError} = 10 \text{ ppm} + 11 \text{ ppm} \cdot 1 + 10 \text{ ppm} \quad \text{OffsetError} = 31 \text{ ppm}$$

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

$$\text{AbsoluteAccuracy} = 10 \text{ V} \cdot (\text{GainError}) + 10 \text{ V} \cdot (\text{OffsetError}) + \text{NoiseUncertainty} \quad \text{AbsoluteAccuracy} = 1050 \text{ } \mu\text{V}$$

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.

$$\text{AbsoluteAccuracy} = \text{OutputValue} \cdot (\text{GainError}) + \text{Range} \cdot (\text{OffsetError})$$

$$\text{GainError} = \text{ResidualGainError} + \text{GainTempco} \cdot (\text{TempChangeFromLastInternalCal}) + \text{ReferenceTempco} \cdot (\text{TempChangeFromLastExternalCal})$$

$$\text{OffsetError} = \text{ResidualOffsetError} + \text{AOOffsetTempco} \cdot (\text{TempChangeFromLastInternalCal}) + \text{INL_Error}$$

Digital I/O/PFI

Static Characteristics

Number of channels

NI 6280/6281	24 total 8 (P0.<0..7>) 16 (PFI <0..7>/P1, PFI <8..15>/P2)
NI 6284/6289	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 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 <i>n</i> 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.

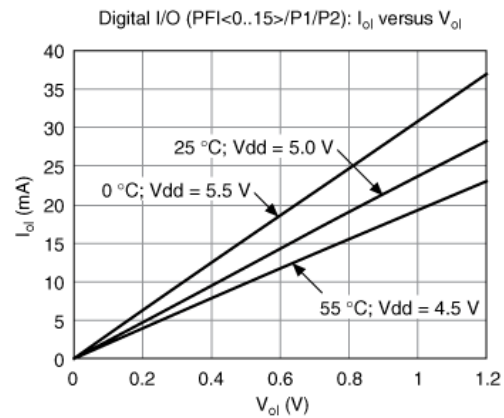
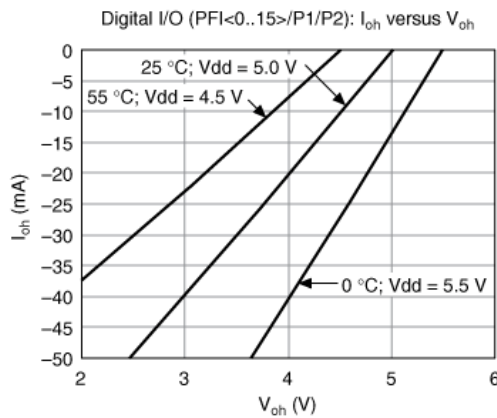
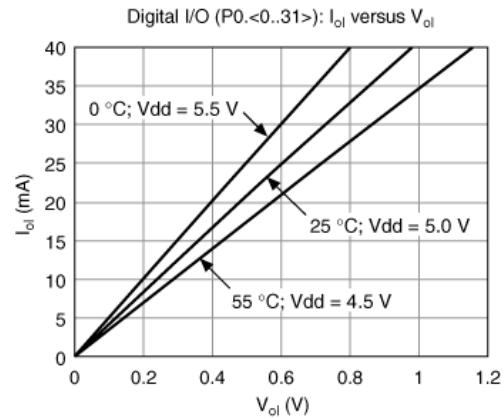
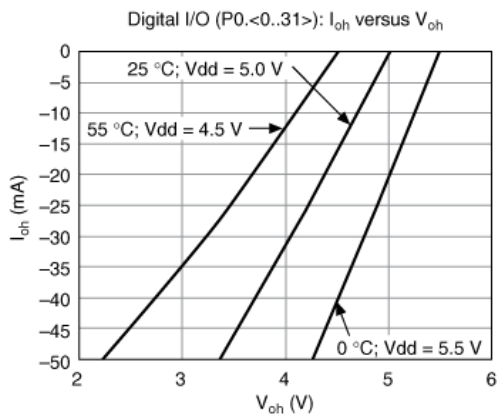
PFI/Port 1/Port 2 Functionality

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 μ s, 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})		
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	Min	Max
Positive-going threshold (V_{T+})	—	2.2 V
Negative-going threshold (V_{T-})	0.8 V	—
Delta VT hysteresis ($V_{T+} - V_{T-}$)	0.2 V	—
I_{IL} input low current ($V_{in} = 0$ V)	—	-10 μ A
I_{IH} input high current ($V_{in} = 5$ V)	—	250 μ A

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/PXle 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 μ s, 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-628x 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-628x	191501A-0x	Yes	No
	191501B-0x		

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-628x devices *must* be powered with NI offered AC adapter or a National Electric Code (NEC) Class device 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 <i>NI USB-622x/625x/628x OEM User Guide</i>

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 Voltage¹²

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

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.

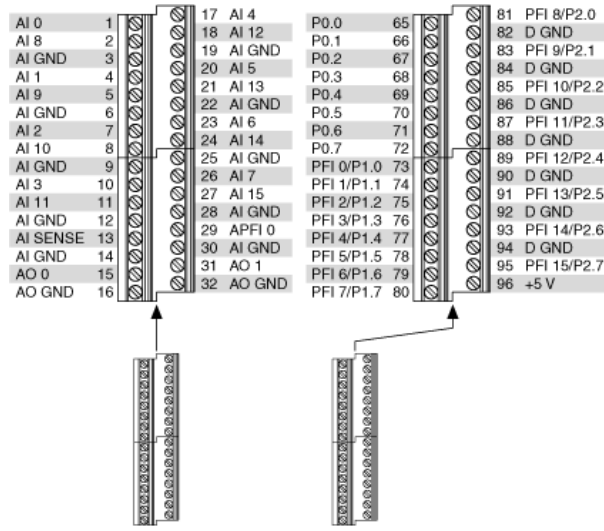
电子信息产品污染控制管理办法（中国 RoHS）



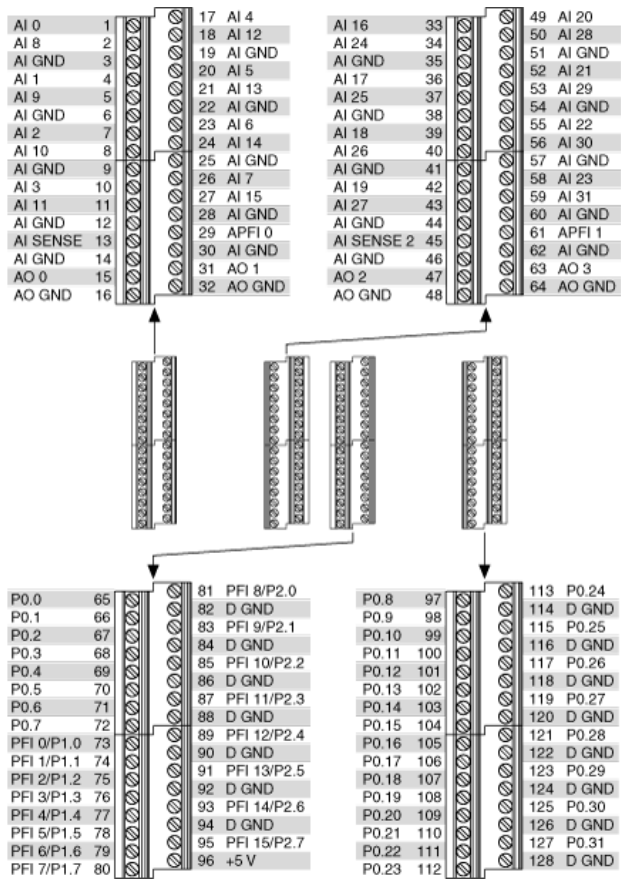
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Pinouts/Front Panel Connections



NI USB-6281 Screw Terminal Pinout



NI USB-6289 Screw Terminal Pinout

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