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Requirements and Compatibility | Ordering Information | Detailed Specifications
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NI PXIe-4140, NI PXIe-4141

High-Channel-Count Source Measure Units

- 4 SMU channels per single-slot, 3U PXI Express module
- ±10 V at ±100 mA output with 4-quadrant operation
- NI PXIe-4141 features NI SourceAdapt technology for maximum stability and minimum transient response times
- NI PXIe-4141 provides 10 pA current measurement sensitivity for accurate idle current measurements
- Continuous sampling rates of up to 600,000 S/s
- Onboard hardware sequencing engine for triggering and synchronization

Overview

The NI PXIe-4141/40 source measure units (SMUs) are high-channel-count, high-speed SMUs with four identical SMU channels per PXI Express slot. Each SMU offers 4-quadrant operation to source or sink ±10 V at ±100 mA. To help reduce measurement times and capture important transient device characteristics, each SMU can sample up to 600,000 S/s. Additionally, source-measure rates of up to 15,000 S/s allow quick I-V characterization of devices under test. With integrated remote (4-wire) sensing, these SMUs can make for precision measurements of the device. Additionally the new precision 4-channel SMU, the NI PXIe-4141, has current measurement sensitivity of 10 pA for accurate characterization of idle currents.

Back to Top

Requirements and Compatibility

OS Information

- Windows 7
- Windows Vista
- Windows XP

Driver Information

- NI-DCPower

Software Compatibility

- LabVIEW
- LabWindows/CVI
- NI TestStand Development System
- Visual Basic .NET
- Visual C++
- Visual Studio .NET

Back to Top

Comparison Tables

	NI PXIe-4140	NI PXIe-4141
Number of SMU Channels	4	4
Voltage/Current Coverage	±10 V at ±100 mA	±10 V at ±100 mA
Voltage Measure Range	10 V	10 V
Voltage Measure Sensitivity	100 µV	10 µV
Current Measure Ranges	10 µA, 100 µA, 1 mA, 10 mA, 100 mA	10 µA, 100 µA, 1 mA, 10 mA, 100 mA
Current Measure Sensitivity	100 pA	10 pA

	NI PXIe-4140	NI PXIe-4141
Maximum Sampling Rate	600,000 S/s	600,000 S/s
Maximum Source-Measure Rate	15,000 points/s	15,000 points/s
Compensation Modes	Slow, Normal, Fast	Slow, Normal, Fast, Custom
Additional Features		NI SourceAdapt technology for custom compensation
		Programmable output resistance

Back to Top

Application and Technology

NI SourceAdapt Technology: The Next-Generation SMU Technology

The new precision 4-channel SMU, the NI PXIe-4141, features SourceAdapt technology. With this next-generation SMU technology, you can custom-tune the SMU response to any given load for maximum stability and minimum transient response times. This optimal SMU response protects the device under test from undesirable transients while achieving the fastest possible test times and removing system stability concerns from oscillations. The ability to achieve optimal response for any load means that the NI PXIe-4141 with SourceAdapt technology is ideal for testing devices such as microelectromechanical systems, multipin ICs with bypass capacitors, or any board- or chip-level test applications with a wide range of inductive or capacitive loads.

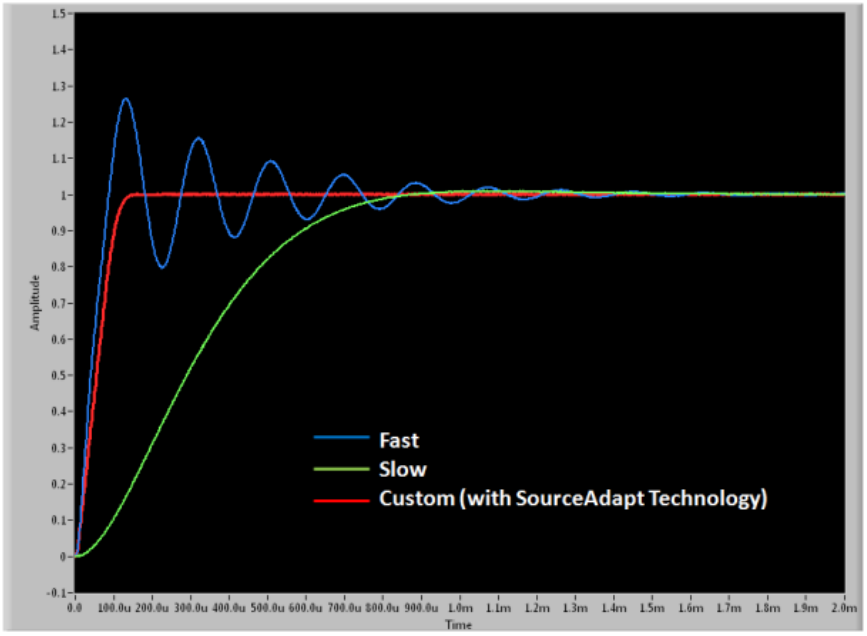


Figure 1. SMU Response to a Capacitive Load

NI SourceAdapt technology enables customized response (red) for maximum stability and minimum transient response times.

Programmable Output Resistance

The new NI PXIe-4141 also features programmable output resistance, so you can program the output resistance from –1 V/current range to +1 V/current range. For example, on the 100 mA range, you can vary the output resistance from –10 Ω to +10 Ω. The positive range of the output resistance allows the SMU channel to emulate real-world devices with nonzero output resistance while the negative resistance range allows you to compensate for voltage drops due to resistive losses between the remote sense points and the DUT terminals.

Hardware Control

With the NI-DCPower software test panel, you can quickly troubleshoot or debug SMU operation interactively. To get up and running fast, use the DCPower Express VIs as an intuitive, configuration-based method of controlling NI SMUs in the NI LabVIEW graphical development environment. For low-level control of SMU hardware, the IVI-compliant NI-DCPower instrument driver provides a complete API that exposes the full functionality of the hardware in an intuitive hierarchy. NI-DCPower also includes prewritten example programs that demonstrate concepts ranging from simple configuration to advanced sweeping and monitoring.

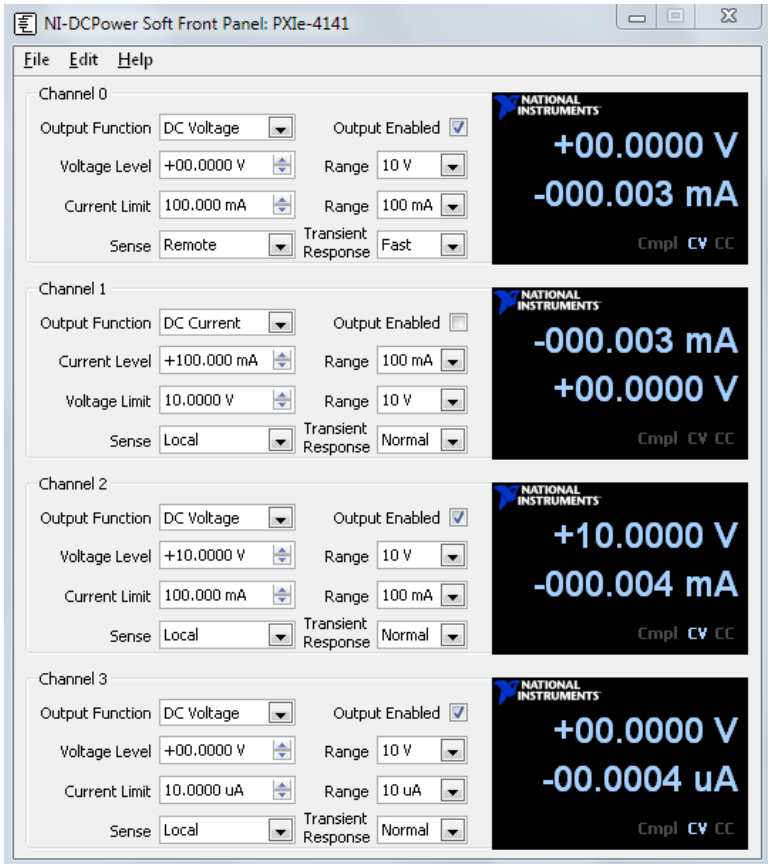


Figure 2. Use the NI-DCPower software test panel to quickly troubleshoot or debug the NI PXIe-4141/40 SMUs.

Triggering and Synchronization

The NI PXIe-4141/40 modules feature a high-speed sequencing engine to synchronize operations between multiple SMUs within each module, across different NI PXIe-4141/40 modules, or with other instruments. As shown in Figure 3, sending and receiving triggers or events is conducted through the PXI Express backplane to simplify programming as well as system wiring. This means that implementing precisely coordinated test programs involving multiple SMUs is straightforward.

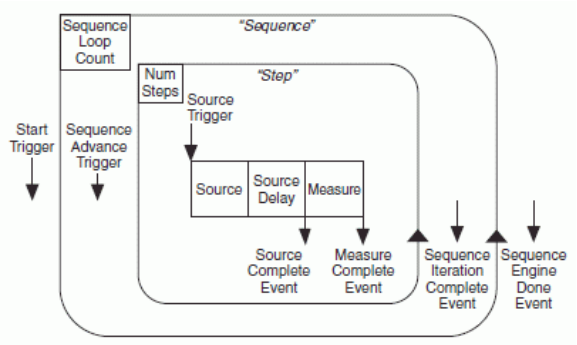


Figure 3. Sequence Engine Diagram for Triggering and Synchronization

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
SMU Modules			
PXIe-4141 Four-Channel Precision SMU wtih SourceAdapt Technology	781743-01	No accessories required.	
PXIe-4140 Four-Channel SMU	781742-01	No accessories required.	

Back to Top

Support and Services

System Assurance Programs

NI system assurance programs are designed to make it even easier for you to own an NI system. These programs include configuration and deployment services for your NI PXI, CompactRIO, or Compact FieldPoint system. The NI Basic System Assurance Program provides a simple integration test and ensures that your system is delivered completely assembled in one box. When you configure your system with the NI Standard System Assurance Program, you can select from available NI system driver sets and application development environments to create customized, reorderable software configurations. Your system arrives fully assembled and tested in one box with your software preinstalled. When you order your system with the standard program, you also receive system-specific documentation including a bill of materials, an integration test report, a recommended maintenance plan, and frequently asked question documents. Finally, the standard program reduces the total cost of owning an NI system by providing three years of warranty coverage and calibration service. Use the online product advisors at ni.com/advisor to find a system assurance program to meet your needs.

Calibration

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

Technical Support

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

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

Repair

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

Training and Certifications

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

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

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

This document provides the specifications for the NI PXIe-4140 four channel source-measure unit (SMU) and the NI PXIe-4141 four channel precision SMU. Specifications are subject to change without notice. For the most recent NI PXIe-4140/4141 specifications, visit ni.com/manuals.

National Instruments defines the capabilities and performance of its Test & Measurement instruments as *Specifications*, *Typical Specifications*, and *Characteristic* or *Supplemental Specifications*. Data provided in this document are *Specifications* unless otherwise noted.

Specifications characterize the warranted performance of the instrument within the recommended calibration interval and under the stated operating conditions.

Typical Specifications are specifications met by the majority of the instruments within the recommended calibration interval and under the stated operating conditions. The performance of the instrument is not warranted.

Characteristic or *Supplemental Specifications* describe basic functions and attributes of the instrument established by design or during development and not evaluated during Verification or Adjustment. They provide information that is relevant for the adequate use of the instrument that is not included in the previous definitions.

Unless otherwise noted, specifications are valid under the following conditions:

- Ambient temperature 23 °C ± 5 °C
- After 30 minute warm-up time

Self-calibration performed within the last 24 hours

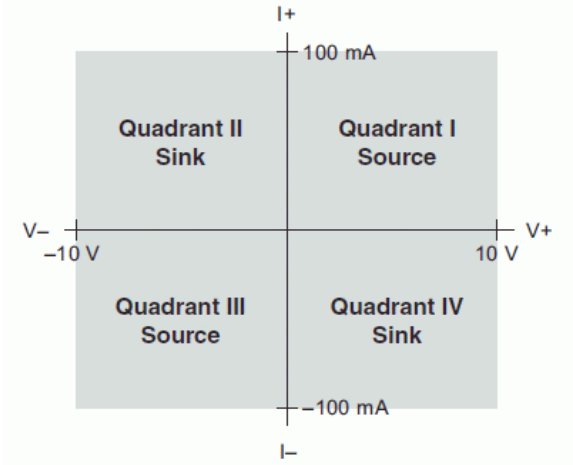
To access the NI PXIe-4140/4141 documentation, navigate to **Start»All Programs»National Instruments»NI-DCPower»Documentation**.

Device Capabilities

The following table and figure illustrate the voltage and the current source and sink ranges of the NI PXIe-4140/4141.

NI PXIe-4140/4141 Current Source and Sink Ranges		
Channels	**DC Voltage Ranges**	**DC Current Source and Sink Ranges**
0 through 3	±10 V	10 µA 100 µA 1 mA 10 mA 100 mA
Note: Channels 0 through 3 are isolated from earth ground but share a common LO.		

NI PXIe-4140/4141 Quadrant Diagram, All Channels



SMU Specifications

Voltage Programming and Measurement Accuracy/Resolution [1] [2]

Range	Resolution and Noise (0.1 Hz – 10 Hz)		1 Year Accuracy (23 °C ± 5 °C) ± (% of Voltage + Offset)			Temperature Coefficient ± (% of Voltage + Offset) / °C
			NI PXIe-4140	NI PXIe-4141		
	NI PXIe-4140	NI PXIe-4141	Tcal ± 5 °C	Tcal ± 5 °C	Tcal ± 1 °C	0 °C to 55 °C
10 V	100 µV	10 µV	0.1% + 5.0 mV	0.015% + 600 µV	0.013% + 150 µV	0.0005% + 1 µV

Current Programming and Measurement Accuracy/Resolution [3] [4]

Range	Resolution and Noise (0.1 Hz – 10 Hz)		1 Year Accuracy (23 °C ± 5 °C) ± (% of current + offset)			Temperature Coefficient ± (% of Current + Offset) / °C
			NI PXIe-4140	NI PXIe-4141		
	NI PXIe-4140	NI PXIe-4141	Tcal ± 5 °C	Tcal ± 5 °C	Tcal ± 1 °C	0 °C to 55 °C
10 µA	100 pA	10 pA	0.1% + 5.0 nA	0.03% + 1.5 nA	0.03% + 300 pA	0.002% + 10 pA
100 µA	1 nA	100 pA	0.1% + 50 nA	0.03% + 15 nA	0.03% + 3.0 nA	0.002% + 100 pA
1 mA	10 nA	1 nA	0.1% + 500 nA	0.03% + 150 nA	0.03% + 30 nA	0.002% + 1.0 nA
10 mA	100 nA	10 nA	0.1% + 5.0 µA	0.03% + 1.5 µA	0.03% + 300 nA	0.002% + 10 nA
100 mA	1 µA	100 nA	0.1% + 50 µA	0.03% + 15 µA	0.03% + 3.0 µA	0.002% + 100 nA

NI PXIe-4141 Output Resistance Programming Accuracy/Resolution [5]

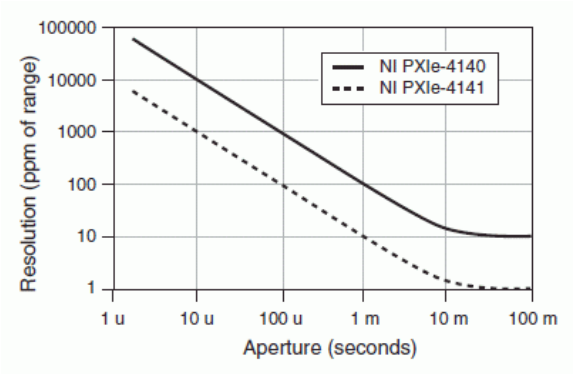
Current Limit Range	Programmable Resistance Range	Resolution	1 Year Accuracy (23 °C ± 5 °C) ± (% of Resistance Setting)
			Tcal ± 5 °C
10 µA	± 100 kΩ	1 Ω	0.04% + 510 mΩ
100 µA	± 10 kΩ	100 mΩ	0.04% + 60 mΩ

Current Limit Range	Programmable Resistance Range	Resolution	1 Year Accuracy (23 °C ± 5 °C) ± (% of Resistance Setting)
			Tcal ± 5 °C
1 mA	± 1 kΩ	10 mΩ	0.04% + 15 mΩ
10 mA	± 100 Ω	1 mΩ	0.04% + 10 mΩ
100 mA	± 10 Ω	100 µΩ	0.04% + 10 mΩ

SMU Resolution/Noise vs. Measure Speed, typical

The following figure illustrates noise and resolution as a function of measurement aperture for the NI PXIe-4140/4141.

Noise and Resolution vs. Measurement Aperture



To derive a resolution in absolute units from the previous figure, complete the following steps:

- Select a voltage or current range.
- For a given aperture time, find the corresponding resolution.
- To convert resolution from ppm of range to absolute units, multiply resolution in ppm of range by the selected range.

For example, the NI PXIe-4140 has a resolution of 1,000 ppm when set to a 100 µs aperture time. In the 10 V range, resolution can be calculated by multiplying 10 V by 1,000 ppm, as shown in the following example:

10 V * 1,000 ppm = 10 V * 1,000 * 1×10^{-6} = 10 mV

Likewise, in the 100 mA range, resolution can be calculated by multiplying 100 mA by 1,000 ppm, as shown in the following example:

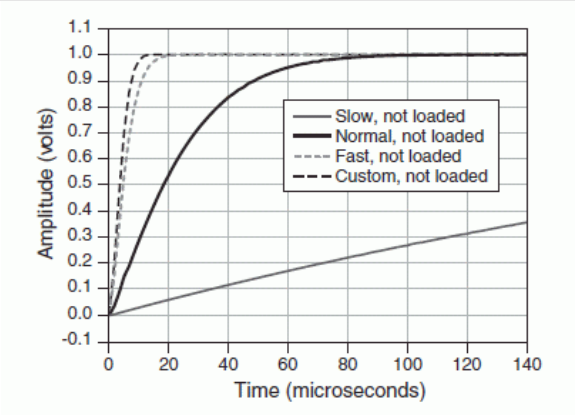
100 mA * 1,000 ppm = 100 mA * 1,000 * 1×10^{-6} = 100 µA

Additional Specifications

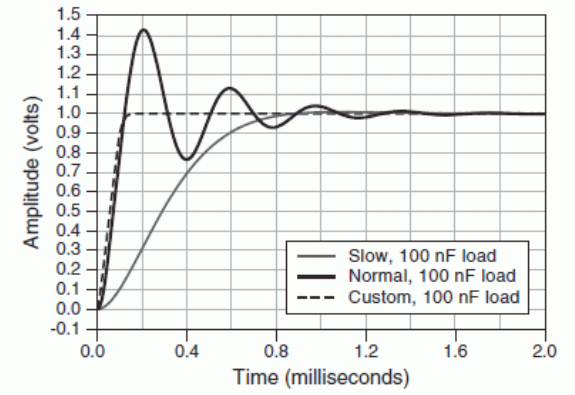
Settling time, typical [6]	<100 µs to settle to 0.1% of voltage step, fast transient response
Transient response, typical [6]	<100 µs to recover within ±20 mV after a load current change from 10% to 90% of range, fast transient response
Wideband source noise, typical	1.5 mV RMS (20 Hz to 20 MHz bandwidth), normal transient response
Cable guard output impedance, typical	10 kΩ
Remote sense	
Voltage	Add 0.1% of LO lead drop to voltage accuracy specification
Current	Add 0.02% of range per volt of total HI and LO lead drop to current accuracy specification
Maximum lead drop	Up to 1 V drop per lead
Load regulation	
Voltage	10 µV at connector pins per mA of output load when using local sense
Current	20 pA + 1 ppm of range per volt of output change when using local sense
Isolation voltage, characteristic	
Channel-to-earth ground [7] .	60 VDC, CAT I, verified by dielectric withstand test, 5 s, continuous
Absolute maximum voltage between any terminal and LO	20 VDC, continuous

The following two figures illustrate the effect of the transient response setting on the step response of the NI PXIe-4140/4141 for different loads.

1 mA Range No Load Step Response, typical [8]



1 mA Range, 100 nF Load Step Response, typical [8]



Supplemental Specifications

Maximum Measurement Speed	
Available sample rates	600 kS/s / N, where N = 1, 2, 3, … 2^{20}
Sample rate accuracy	±50 ppm
Maximum measure rate to host [9]	600,000 S/s per channel, continuous
Maximum source update rate [10]	100,000 updates/s
Trigger in to source delay	5 µs
Trigger in to source jitter	1.7 µs
Trigger in to measure jitter	1.7 µs
Triggers	
Input triggers	
Types	Start, Source, Sequence Advance, Measure
Sources	PXI trigger lines 0–7 [11]
Polarity	Configurable
Minimum pulse width	100 ns
Destinations [12]	PXI trigger lines 0–7 [11]
Polarity	Active high (not configurable)
Pulse width	>200 ns
Output triggers (Events)	
Types	Source Complete, Sequence Iteration Complete, Sequence Engine Done, Measure Complete
Destinations	PXI trigger lines 0–7 [11]

Polarity	Configurable
Pulse width	Configurable between 250 ns and 1.6 µs

The following figure illustrates the programming flow in NI-DCPower using Sequence source mode with automatic measurements. For more information about programming the NI PXIe-4140/4141, refer to the *NI DC Power Supplies and SMUs Help*.

Additional Information	
Recommended calibration interval	One year
Physical Characteristics	
Dimensions	3U, one-slot, PXIe/cPCIe module; 2.0 cm × 13.0 cm × 21.6 cm (0.8 in. × 5.1 in. × 8.5 in.)
Weight	425 g (14.99 oz)
Front panel connectors	25-position D-Sub, male
Environment	
Maximum altitude	2,000 m (at 25 °C ambient temperature)
Pollution degree	2
Indoor use only.	
Operating Environment	
Ambient temperature range	0 °C to 55 °C (Tested in accordance with IEC 60068-2-1 and IEC 60068-2-2.)
Relative humidity range	10% to 70%, noncondensing; derate 1.3% per °C above 40 °C (Tested in accordance with IEC 60068-2-56.)
Storage Environment	
Ambient temperature range	–40 °C to 70 °C (Tested in accordance with IEC-60068-2-1 and IEC-60068-2-2.)
Relative humidity range	5% to 95%, noncondensing (Tested in accordance with IEC-60068-2-56.)
Shock and Vibration	
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 Hz to 500 Hz, 0.3 g_{rms}
Nonoperating	5 Hz 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.)

Compliance and Certifications

Safety Standards

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

- IEC 61010-1, EN 61010-1
- UL 61010-1, CSA 61010-1

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

Electromagnetic Compatibility

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

- EN 61326-1 (IEC 61326-1): 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 EMC declarations and certifications, refer to the *Online Product Certification* section.

Note When operating this product, use shielded cables and accessories.

CE Compliance CE

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

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

Online Product Certification

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

电子信息产品污染控制管理办法 （中国 RoHS）

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

[1] Tcal is the temperature recorded by the NI PXIe-4140/4141 at the completion of the last self-calibration. Specifications are valid for an aperture time of 2 PLCs.

[2] Resolution is noise-limited. Numbers listed represent peak-to-peak noise over the specified bandwidth. See SMU Noise/Resolution vs. Measure Speed for typical performance at higher sample rates.

[3] Tcal is the temperature recorded by the NI PXIe-4140/4141 at the completion of the last self-calibration. Specifications are valid for an aperture time of 2 PLCs.

[4] Resolution is noise-limited. Numbers listed represent peak-to-peak noise over the specified bandwidth. See SMU Noise/Resolution vs. Measure Speed for typical performance at higher sample rates.

[5] Tcal is the temperature recorded by the NI PXIe-4140/4141 at the completion of the last self-calibration. Specifications are valid for an aperture time of 2 PLCs.

[6] Current limit set to ≥1 mA and ≥10% of the selected current limit range.

[7] Channels are isolated from earth ground but share a common LO

[8] Custom transient response is available only on the NI PXIe-4141.

[9] Load dependent settling time is not included. Normal DC noise rejection is used.

[10] As the source delay is adjusted, maximum source rates vary.

[11] Pulse widths and logic levels are compliant with *PXI Express Hardware Specification Revision 1.0 ECN 1*.

[12] Input triggers can be re-exported.

Back to Top