

DEVICE SPECIFICATIONS

NI PXIe-4136

Single-Channel System Source Measure Unit (SMU)

This document lists specifications for the NI PXIe-4136 (NI 4136).

The NI 4136 is a single-channel system source measure unit (SMU).

Specifications are subject to change without notice. For the most recent NI 4136 specifications, visit ni.com/manuals.



Hazardous Voltage This icon denotes a warning advising you to take precautions to avoid electrical shock.

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:

- Ensure an ambient temperature of $23\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$.¹
- Ensure a calibration interval of 1 year.
- Allow 30 minutes warm-up time.
- Perform self-calibration within the last 24 hours.
- Set the **niDCPower Aperture Time** property or `NIDCPOWER_ATTR_APERTURE_TIME` attribute to 2 power-line cycles (PLCs).
- If the PXI Express chassis has multiple fan speed settings, set the fans to the highest setting.

¹ For the definition of *ambient temperature*, refer to the *Maintain Forced-Air Cooling Note to Users* available at ni.com/manuals.

To access NI 4136 documentation, navigate to **Start»All Programs»National Instruments»NI-DCPower»Documentation**.

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Cleaning Statement



Caution Clean the hardware with a soft, nonmetallic brush. Make sure that the hardware is completely dry and free from contaminants before returning it to service.

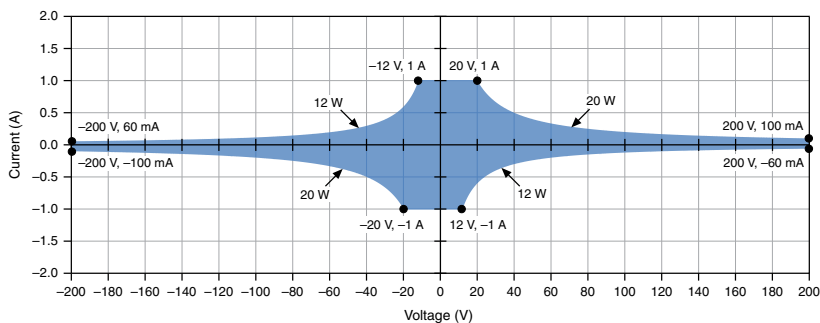
Device Capabilities

The following table and figure illustrate the voltage and the current source and sink ranges of the NI 4136.

Table 1. Current Source and Sink Ranges

DC voltage ranges	DC current source and sink ranges
600 mV	1 μ A
6 V	10 μ A
20 V	100 μ A
200 V ²	1 mA
	10 mA
	100 mA
	1 A

Figure 1. Quadrant Diagram



DC sourcing power is limited to 20 W, regardless of output voltage.³



Caution Limit DC power sinking to 12 W. Additional derating applies to sinking power when operating at an ambient temperature of $>45^{\circ}\text{C}$. If the PXI Express chassis has multiple fan speed settings, set the fans to the highest setting.

² Voltage levels and limits $> |40\text{ VDC}|$ require the safety interlock input to be closed.

³ Power limit defined by voltage measured between HI and LO terminals.

Voltage Programming and Measurement Accuracy/Resolution

Table 2. Voltage Programming and Measurement Accuracy/Resolution

Range	Resolution (noise limited)	Noise (0.1 Hz to 10 Hz, peak to peak), Typical	Accuracy (23 °C ± 5 °C) ± (% of voltage + offset)	Tempco ± (% of voltage + offset)/°C, 0 °C to 55 °C
			$T_{cal} \pm 5\text{ °C}^4$	
600 mV	1 µV	4 µV	0.020% + 100 µV	0.0005% + 1 µV
6 V	10 µV	12 µV	0.020% + 640 µV	
20 V	100 µV	40 µV	0.022% + 2 mV	
200 V	1 mV	400 µV	0.025% + 20 mV	

Current Programming and Measurement Accuracy/Resolution

Table 3. Current Programming and Measurement Accuracy/Resolution

Range	Resolution (noise limited)	Noise (0.1 Hz to 10 Hz, peak to peak), Typical	Accuracy (23 °C ± 5 °C) ± (% of current + offset)	Tempco ± (% of current + offset)/°C, 0 °C to 55 °C
			$T_{cal} \pm 5\text{ °C}^5$	
1 µA	1 pA	8 pA	0.03% + 200 pA	0.0006% + 4 pA
10 µA	10 pA	60 pA	0.03% + 1.4 nA	0.0006% + 22 pA
100 µA	100 pA	400 pA	0.03% + 12 nA	0.0006% + 200 pA
1 mA	1 nA	4 nA	0.03% + 120 nA	0.0006% + 2 nA
10 mA	10 nA	40 nA	0.03% + 1.2 µA	0.0006% + 20 nA

⁴ T_{cal} is the internal device temperature recorded by the NI 4136 at the completion of the last self-calibration.

Table 3. Current Programming and Measurement Accuracy/Resolution (Continued)

Range	Resolution (noise limited)	Noise (0.1 Hz to 10 Hz, peak to peak), Typical	Accuracy (23 °C ± 5 °C) ± (% of current + offset)	Tempco ± (% of current + offset)/°C, 0 °C to 55 °C
			$T_{cal} \pm 5\text{ °C}^5$	
100 mA	100 nA	400 nA	0.03% + 12 µA	0.0006% + 200 nA
1 A	1 µA	4 µA	0.04% + 120 µA	0.0006% + 2 µA

Noise, Typical

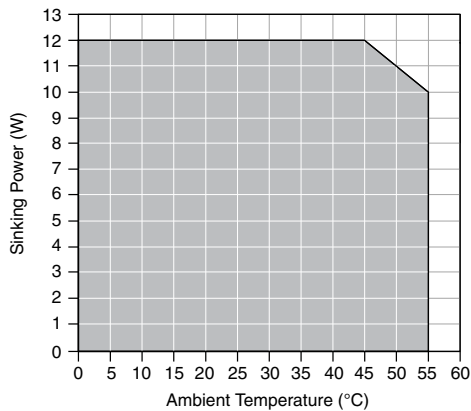
Wideband source noise	<20 mV peak-to-peak in 20 V range, device configured for normal transient response, 10 Hz to 20 MHz
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Sinking Power vs. Ambient Temperature Derating

The following figure illustrates sinking power derating as a function of ambient temperature for the NI 4136.

⁵ T_{cal} is the internal device temperature recorded by the NI 4136 at the completion of the last self-calibration.

Figure 2. Sinking Power vs. Ambient Temperature Derating



Overvoltage Protection Characteristics

Accuracy ⁶ (% of OVP limit + offset)	0.1% + 200 mV
Temperature coefficient (% of OVP limit + offset)/°C	0.01% + 3 mV/°C
Measurement location	Local sense
Maximum OVP limit value	210 V
Minimum OVP limit value	2 V

Transient Response and Settling Time

Transient response	<70 μs to recover within 0.1% of voltage range after a load current change from 10% to 90% of range, device configured for fast transient response
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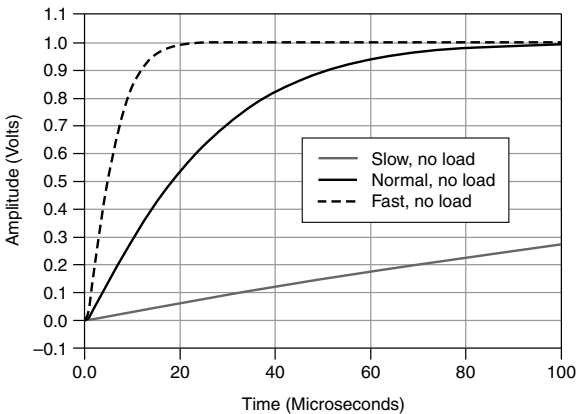
⁶ Overvoltage protection accuracy is valid with an ambient temperature of 23 °C ± 5 °C and with Tcal ± 5 °C. Tcal is the internal device temperature recorded by the NI 4136 at the completion of the last self-calibration.

Settling time⁷

Voltage mode, 180 V step, unloaded ⁸	<500 μ s, typical
Voltage mode, 5 V step or smaller, unloaded ⁹	<70 μ s, typical
Current mode, full-scale step, 3 A to 100 μ A ranges ¹⁰	<50 μ s, typical
Current mode, full-scale step, 10 μ A range ¹⁰	<150 μ s, typical
Current mode, full-scale step, 1 μ A range ¹⁰	<300 μ s, typical

The following figures illustrate the effect of the transient response setting on the step response of the NI 4136 for different loads.

Figure 3. 1 mA Range No Load Step Response, Typical



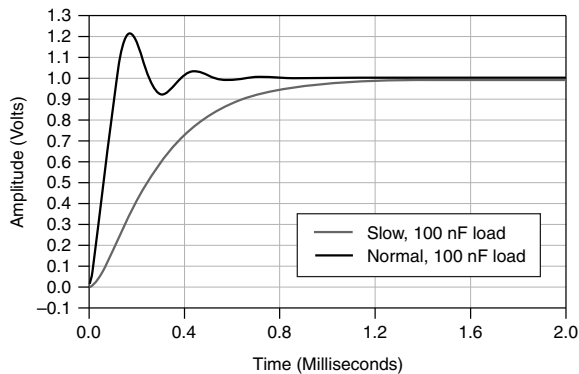
⁷ Measured as the time to settle to within 0.1% of step amplitude, device configured for fast transient response.

⁸ Current limit set to $\geq 60 \mu$ A and $\geq 60\%$ of the selected current limit range.

⁹ Current limit set to $\geq 20 \mu$ A and $\geq 20\%$ of selected current limit range.

¹⁰ Voltage limit set to ≥ 2 V, resistive load set to 1 V/selected current range.

Figure 4. 1 mA Range, 100 nF Load Step Response, Typical



Load Regulation, Typical

Voltage	
Device configured for local sense	200 mV per A of output load change (measured between output channel terminals)
Device configured for remote sense	100 μ V per A of output load change (measured between sense terminals)
Current, device configured for local or remote sense	Load regulation effect included in current accuracy specifications

Measurement and Update Timing Characteristics

Available sample rates ¹¹	(1.8 MS/s)/N where $N = 1, 2, 3, \dots 2^{20}$
Sample rate accuracy	Equal to PXIe_CLK100 accuracy
Maximum measure rate to host	1.8 MS/s per channel, continuous
Maximum source update rate ¹²	100,000 updates/s

¹¹ When sourcing while measuring, both the **niDCPower Source Delay** and **niDCPower Aperture Time** properties affect the sampling rate. When taking a measure record, only the **niDCPower Aperture Time** property affects the sampling rate.

¹² As the source delay is adjusted, maximum source rates vary.

Input trigger to

Source event delay	10 μ s
Source event jitter	1 μ s
Measure event jitter	1 μ s

Remote Sense

Voltage accuracy	Add 3 ppm of voltage range per volt of HI lead drop plus 1 μ V per volt of lead drop per ohm of corresponding sense lead resistance to voltage accuracy specifications
Maximum sense lead resistance	100 Ω , characteristic
Maximum lead drop per lead	3 V characteristic up to a maximum of 202 V between HI and LO terminals



Note Exceeding the maximum lead drop per lead value may cause the driver to report a sense lead error.

Safety Interlock

The safety interlock feature is designed to prevent users from coming in contact with hazardous voltage generated by the SMU in systems that implement protective barriers with controlled user access points.



Caution Hazardous voltage of up to the maximum voltage of the device may appear at the output terminals if the safety interlock terminal is closed. Open the safety interlock terminal when the output connections are accessible. With the safety interlock terminal open the output voltage level/limit is limited to ± 40 VDC, and protection will be triggered if the voltage measured between the device HI and LO terminals exceeds $\pm(42 \text{ Vpk} \pm 0.4 \text{ V})$.



Caution Do not apply voltage to the safety interlock connector inputs. The interlock connector is designed to accept passive normally open contact closure connections only.

Safety interlock terminal open	
Output	$<\pm 42.4 \text{ Vpk}$
Setpoint	$<\pm 40 \text{ VDC}$

Safety interlock terminal closed

Output	Maximum voltage of the device
Setpoint	Maximum selected voltage range

Related Information

For more information about Safety Interlock operation, refer to the NI DC Power Supplies and SMUs Help.

Examples of Calculating Accuracy Specifications¹³

Example 1: Calculating 5 °C Accuracy

Calculate the accuracy of 900 nA output in the 1 μA range under the following conditions:

ambient temperature	28 °C
internal device temperature	within T _{cal} ± 5 °C ¹⁴
self-calibration	within the last 24 hours.

Solution

Since the device internal temperature is within T_{cal} ± 5 °C and the ambient temperature is within 23 °C ± 5 °C, the appropriate accuracy specification is:

0.03% + 200 pA

Calculate the accuracy using the following formula:

Accuracy = 900 nA * 0.03 % + 200 pA

= 270 pA + 200 pA

= 470 pA

¹³ Specifications listed in examples are for demonstration purposes only and do not necessarily reflect specifications for this device.

¹⁴ T_{cal} is the internal device temperature recorded by the NI 4136 at the completion of the last self-calibration.

Therefore, the actual output will be within 470 pA of 900 nA.

Example 2: Calculating Remote Sense Accuracy

Calculate the remote sense accuracy of 500 mV output in the 600 mV range. Assume the same conditions as in Example 1, with the following differences:

HI path lead drop	3 V
HI sense lead resistance	2 Ω
LO path lead drop	2.5 V
LO sense lead resistance	1.5 Ω

Solution

Since the device internal temperature is within $T_{cal} \pm 5^{\circ}\text{C}$ and the ambient temperature is within $23^{\circ}\text{C} \pm 5^{\circ}\text{C}$, the appropriate accuracy specification is:

$$0.02\% + 100 \mu\text{V}$$

Since the device is using remote sense, use the remote sense accuracy specification:

Add (3 ppm of voltage range + 11 μV) per volt of HI lead drop plus 1 μV per volt of lead drop per Ω of corresponding sense lead resistance to voltage accuracy specifications.

Calculate the remote sense accuracy using the following formula:

$$\begin{aligned}\text{Accuracy} &= \left(500 \text{ mV} * 0.02 \% + 100 \mu\text{V} \right) \\ &+ \frac{600 \text{ mV} * 3 \text{ ppm} + 11 \mu\text{V}}{1 \text{ V of lead drop}} * 3 \text{ V} + \frac{1 \mu\text{V}}{\text{V} * \Omega} * 3 \text{ V} * 2 \Omega + \frac{1 \mu\text{V}}{\text{V} * \Omega} \\ &* 2.5 \text{ V} * 1.5 \Omega \\ &= 100 \mu\text{V} + 100 \mu\text{V} + 12.8 \mu\text{V} * 3 + 6 \mu\text{V} + 3.8 \mu\text{V} \\ &= 248.2 \mu\text{V}\end{aligned}$$

Therefore, the actual output will be within 248.2 μV of 500 mV.

Example 3: Calculating Accuracy with Temperature Coefficient

Calculate the accuracy of 900 nA output in the 1 μ A range. Assume the same conditions as in Example 1, with the following differences:

ambient temperature	15 °C
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Solution

Since the device internal temperature is within $T_{cal} \pm 5\text{ }^{\circ}\text{C}$, the appropriate accuracy specification is:

$$0.03\% + 200\text{ pA}$$

Since the ambient temperature falls outside of $23\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$, use the following temperature coefficient per degree Celcius outside the $23\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ range:

$$0.0006\% + 4\text{ pA}$$

Calculate the accuracy using the following formula:

$$\text{TemperatureVariation} = (23^{\circ}\text{C} - 5\text{ }^{\circ}\text{C}) - 15^{\circ}\text{C} = 3^{\circ}\text{C}$$

$$\begin{aligned} \text{Accuracy} &= (500\text{ nA} * 0.03\% + 200\text{ pA}) \\ &+ \frac{900\text{ nA} * 0.0006\% + 4\text{ pA}}{1^{\circ}\text{C}} * 3^{\circ}\text{C} \end{aligned}$$

$$= 350\text{ pA} + 28.2\text{ pA}$$

$$= 378.2\text{ pA}$$

Therefore, the actual output will be within 378.2 pA of 900 nA.

Related Information

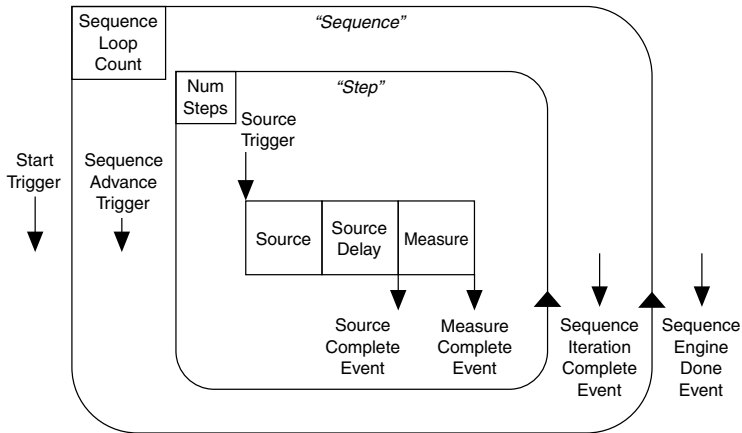
[Voltage Programming and Measurement Accuracy/Resolution](#) on page 4

[Current Programming and Measurement Accuracy/Resolution](#) on page 4

NI-DCPower Sequence Source Model

The following figure illustrates the programming flow in NI-DCPower using Sequence source mode with automatic measurements.

Figure 5. NI-DCPower Programming Flow



Related Information

[NI DC Power Supplies and SMUs Help](#)

Trigger Characteristics

Input triggers

Types	Start, Source, Sequence Advance, Measure, Pulse
Sources (PXI trigger lines 0 to 7) ¹⁵	
Polarity	Configurable
Minimum pulse width	100 ns
Destinations ¹⁶ (PXI trigger lines 0 to 7) ¹⁵	
Polarity	Active high (not configurable)
Pulse width	>200 ns

Output triggers (events)

Types	Source Complete, Sequence Iteration Complete, Sequence Engine Done, Measure Complete, Pulse Complete, Ready for Pulse
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¹⁵ Pulse widths and logic levels are compliant with *PXI Express Hardware Specification Revision 1.0 ECN 1*.

¹⁶ Input triggers can be re-exported.

Destinations (PXI trigger lines 0 to 7)¹⁵

Polarity	Configurable
Pulse width	Configurable between 250 ns and 1.6 μ s

Protection Characteristics

Output channel protection

Overcurrent or overvoltage	Automatic shutdown, output disconnect relay opens
Sink overload protection	Automatic shutdown, output disconnect relay opens
Overtemperature	Automatic shutdown, output disconnect relay opens
Safety interlock	Disable high voltage output, output disconnect relay opens

Related Information

[Safety Interlock](#) on page 9

Isolation Characteristics



Caution Do not connect to MAINs. Do not connect to signals or use for the measurements within CAT II, III, or IV.

Isolation voltage, Channel-to-earth ground	250 VDC, CAT I, verified by dielectric withstand test, 5 s, continuous
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Note Measurement Categories CAT I and CAT O (Other) are equivalent. These test and measurement circuits are not intended for direct connection to the MAINs building installations of Measurement Categories CAT II, CAT III, or CAT IV.



Hazardous Voltage Take precautions to avoid electrical shock when operating this product at hazardous voltages.



Caution Isolation voltage ratings apply to the voltage measured between any channel pin and the chassis ground. When operating channels in series or floating on top of external voltage references, ensure that no terminal exceeds this rating.

Guard Output Characteristics

Cable guard	
Output impedance	3 k Ω
Offset voltage	1 mV

Accessories

Table 4. NI 4136 Accessories

Accessory	Manufacturer	Part Number
Additional Connector Kit for NI 4136 and NI 4137 SMUs	National Instruments	784068-01


Related Information

[Visit ni.com for more information about accessories.](#)

Calibration Interval

Recommended calibration interval	1 year
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Power Requirement Characteristics



Caution You can impair the protection provided by the NI 4136 if you use it in a manner not described in this document.

PXI Express power requirement	2.5 A from the 3.3 V rail and 2.7 A from the 12 V rail
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Physical Characteristics

Dimensions	3U, one-slot, PXI Express/CompactPCI Express module; 2.0 cm × 13.0 cm × 21.6 cm (0.8 in. × 5.1 in. × 8.5 in.)
Weight	419 g (14.8 oz)

Front panel connectors 5.08 mm (8 position)

Safety interlock connector 3.55 mm (4 position)

Related Information

[NI DC Power Supplies and SMUs Help](#)

NI 4136 Front Panel

Figure 6. Front Panel

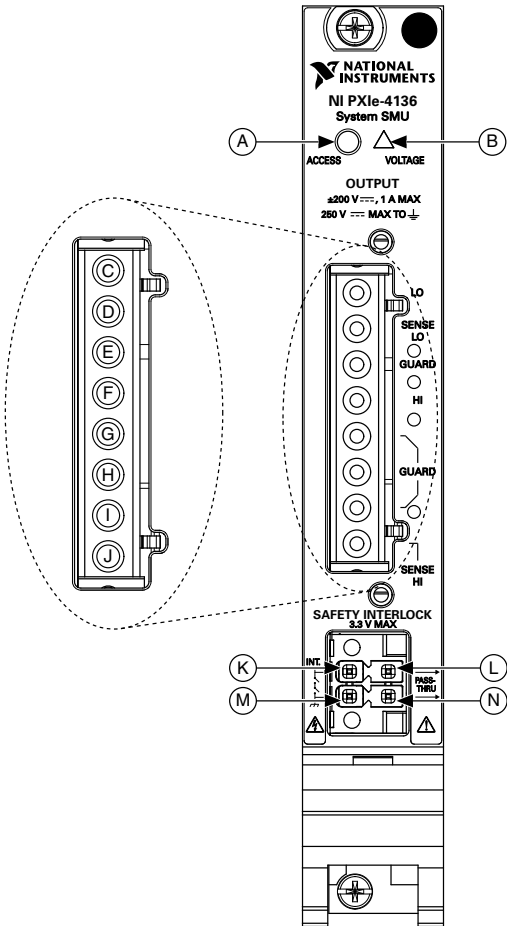


Table 5. Front Panel Connectors

	Description
A	Access Status LED
B	Voltage Status LED
C	Output LO
D	Sense LO
E	Guard
F	Output HI
G	Guard
H	Guard
I	Guard
J	Sense HI
K	Safety Interlock Input
L	Safety Interlock Pass Thru - Input
M	Safety Interlock Ground
N	Safety Interlock Pass Thru - Ground

Environment

Maximum altitude	2,000 m (800 mbar) (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. Meets MIL-PRF-28800F Class 3 low temperature limit and MIL-PRF-28800F Class 2 high temperature limit.)
Relative humidity range	10% to 90%, noncondensing (Tested in accordance with IEC 60068-2-56.)

Storage Environment

Ambient temperature range	-40 °C to 71 °C (Tested in accordance with IEC 60068-2-1 and IEC 60068-2-2. Meets MIL-PRF-28800F Class 3 limits.)
Relative humidity range	5% to 95%, noncondensing (Tested in accordance with IEC 60068-2-56.)

Shock and Vibration

Operating shock	30 g peak, half-sine, 11 ms pulse (Tested in accordance with IEC 60068-2-27. Meets MIL-PRF-28800F Class 2 limits.)
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

This product is designed to meet the requirements of the following electrical equipment safety standards 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
- EN 55022 (CISPR 22): Class A emissions
- EN 55024 (CISPR 24): Immunity
- AS/NZS CISPR 11: Group 1, Class A emissions
- AS/NZS CISPR 22: Class A emissions
- FCC 47 CFR Part 15B: Class A emissions
- ICES-001: Class A emissions



Note In the United States (per FCC 47 CFR), Class A equipment is intended for use in commercial, light-industrial, and heavy-industrial locations. In Europe, Canada, Australia, and New Zealand (per CISPR 11), Class A equipment is intended for use only in heavy-industrial locations.



Note Group 1 equipment (per CISPR 11) is any industrial, scientific, or medical equipment that does not intentionally generate radio frequency energy for the treatment of material or inspection/analysis purposes.



Note For EMC declarations, certifications, and additional information, refer to the [Online Product Certification](#) section.

CE Compliance

This product meets the essential requirements of applicable European Directives, as follows:

- 2014/35/EU; Low-Voltage Directive (safety)
- 2014/30/EU; 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 to the environment and to NI customers.

For additional environmental information, refer to the *Minimize Our Environmental Impact* 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 NI products must be disposed of according to local laws and regulations. For more information about how to recycle NI products in your region, visit ni.com/environment/weee.

电子信息产品污染控制管理办法（中国 RoHS）



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