PXIe-4139 Specifications

2025-03-19

Contents

PXIe-4139 Specifications

These specifications apply to the PXIe-4139.

Note In this document, the PXIe-4139 (40W) and PXIe-4139 (20W) are referred to inclusively as the PXIe-4139. The information in this document applies to all versions of the PXIe-4139 unless otherwise specified. To determine which version of the module you have, locate the device name in one of the following places:

- **In MAX**—The PXIe-4139 (40W) shows ***NI PXIe-4139 (40W)***, and the PXIe-4139 (20W) shows as ***NI PXIe-4139***.
- **Device front panel**—The PXIe-4139 (40W) shows ***PXIe-4139 40W System SMU***, and the PXIe-4139 (20W) shows ***NI PXIe-4139 Precision System SMU*** on the front panel.

Definitions

Warranted specifications describe the performance of a model under stated operating conditions and are covered by the model warranty.

Characteristics describe values that are relevant to the use of the model under stated operating conditions but are not covered by the model warranty.

- ***Typical*** specifications describe the performance met by a majority of models.
- ***Nominal*** specifications describe an attribute that is based on design, conformance testing, or supplemental testing.
- ***Measured*** specifications describe the measured performance of a representative model.

Specifications are ***Warranted*** unless otherwise noted.

Conditions

Specifications are valid under the following conditions unless otherwise noted.

- Ambient temperature[1] of 23 °C ± 5 °C
- Chassis with slot cooling capacity ≥38 W[2]
    - For chassis with slot cooling capacity = 38 W, fan speed set to HIGH
- Calibration interval of 1 year
- 30 minutes warm-up time
- Self-calibration performed within the last 24 hours
- NI-DCPower Aperture Time is set to 2 power-line cycles (PLC)

Cleaning Statement

> **Notice** 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 figures illustrate the voltage and the current source and sink ranges of the PXIe-4139.

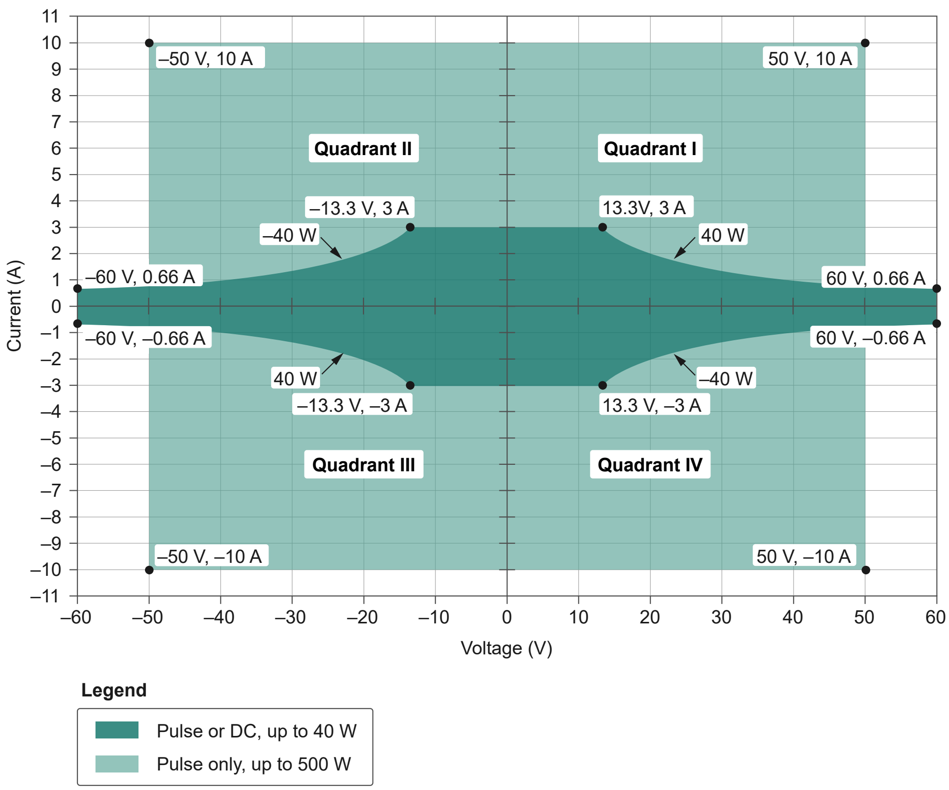
Table 1. Current Source and Sink Ranges

DC voltage ranges	DC current source and sink ranges
• 600 mV • 6 V • 60 V[3]	• 1 µA • 10 µA • 100 µA • 1 mA • 10 mA • 100 mA

1. The ambient temperature of a PXI system is defined as the temperature at the chassis fan inlet (air intake).
2. For increased capability, NI recommends installing the PXIe-4139 (40W) in a chassis with slot cooling capacity ≥58 W.

DC voltage ranges	DC current source and sink ranges
	• 1 A • 3 A • 10 A, pulse only

Figure 1. Quadrant Diagram for PXIe-4139 (40W)

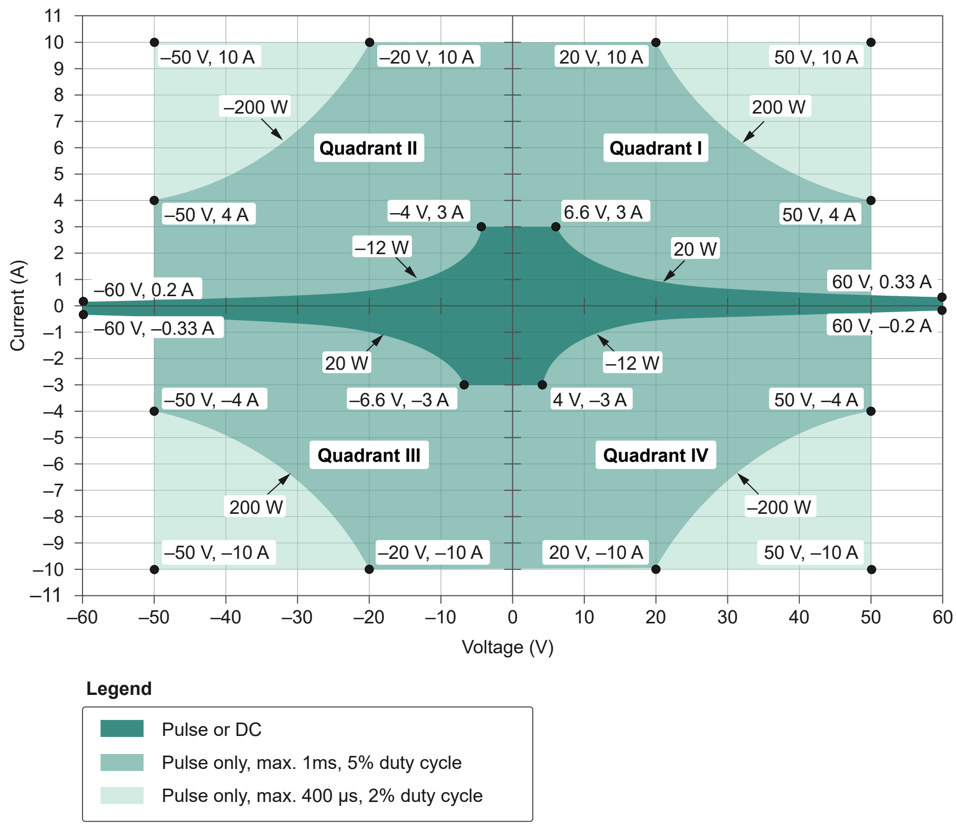


For additional information related to the Pulse Voltage or Pulse Current settings of the Output Function, for the PXIe-4139 (40W), including pulse on time and duty cycle limits for a particular operating point, refer to ***Pulsed Operation***.

For supplementary examples, refer to ***Examples of Determining Extended Range Pulse Parameters and Optimizing Slew Rate using NI SourceAdap***t.

3. The PXIe-4139 does not support configurations involving voltage > |42.4 V| when Sequence Step Delta Time Enabled is set to True.

Figure 2. Quadrant Diagram for PXIe-4139 (20W)



DC sourcing power and sinking power are limited to the values in the following table, regardless of output voltage.[4]

Table 2. DC Sourcing & Sinking Power

Model Variant	Chassis Type	DC Sourcing Power	DC Sinking Power
PXIe-4139 (40W)	≥58 W Slot Cooling Capacity	40 W	40 W
	<58 W Slot Cooling Capacity	20 W	12 W
PXIe-4139 (20W)	≥58 W Slot Cooling Capacity	20 W	12 W
	<58 W Slot Cooling Capacity	20 W	12 W

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

Caution Limit DC power sinking to 12 W where applicable as indicated in the above table. For 38W cooling slots,

- Additional derating applies to sinking power when operating at an ambient temperature of >45 °C.
- If the PXI Express chassis has multiple fan speed settings, set the fans to the highest setting.

Related reference:

- Sinking Power vs. Ambient Temperature Derating
- Pulsed Operation
- Examples of Determining Extended Range Pulse Parameters and Optimizing Slew Rate using NI SourceAdapt

Voltage

Note T_{cal} is the internal device temperature recorded by the PXIe-4139 at the completion of the last self-calibration.

Table 3. 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) [5]		Tempco ± (% of voltage + offset)/°C, 0 °C to 55 °C
			T_{cal} ± 5 °C	T_{cal} ± 1 °C	
600 mV	100 nV	2 µV	0.02% + 50 µV	0.016% + 30 µV	0.0005% + 1 µV
6 V	1 µV	6 µV	0.02% + 300 µV	0.016% + 90 µV	
60 V	10 µV	60 µV	0.02% + 3 mV	0.016% + 900 µV	

Related reference:

- Load Regulation

5. Accuracy is specified for no load output configurations. Refer to ***Load Regulation*** and ***Remote Sense*** sections for additional accuracy derating and conditions.

- Remote Sense
- Noise

Current

Note T_{cal} is the internal device temperature recorded by the PXIe-4139 at the completion of the last self-calibration.

Table 4. Current Programming and Measurement Accuracy/Resolution

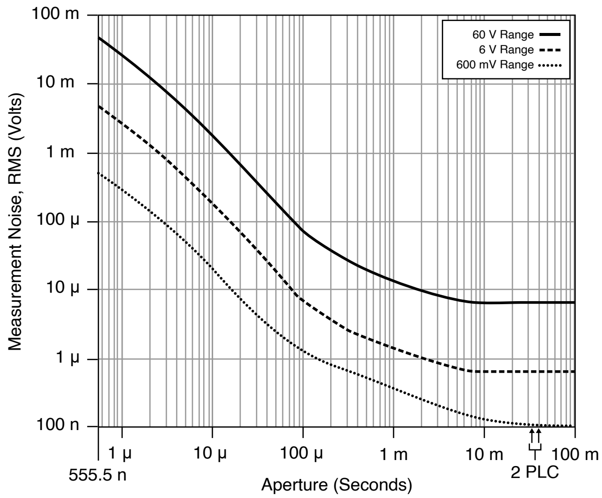
Range	Resolution (noise limited)	Noise (0.1 Hz to 10 Hz, peak to peak), Typical	Accuracy (23 °C ± 5 °C) ± (% of current + offset)		Tempco ± (% of current + offset)/°C, 0 °C to 55 °C
			T_{cal} ± 5 °C	T_{cal} ± 1 °C	
1 µA	100 fA	4 pA	0.03% + 100 pA	0.022% + 40 pA	0.0006% + 4 pA
10 µA	1 pA	30 pA	0.03% + 700 pA	0.022% + 300 pA	0.0006% + 22 pA
100 µA	10 pA	200 pA	0.03% + 6 nA	0.022% + 2 nA	0.0006% + 200 pA
1 mA	100 pA	2 nA	0.03% + 60 nA	0.022% + 20 nA	0.0006% + 2 nA
10 mA	1 nA	20 nA	0.03% + 600 nA	0.022% + 200 nA	0.0006% + 20 nA
100 mA	10 nA	200 nA	0.03% + 6 µA	0.022% + 2 µA	0.0006% + 200 nA
1 A	100 nA	2 µA	0.03% + 60 µA	0.027% + 20 µA	0.0006% + 2 µA
3 A	1 µA	20 µA	0.083% + 900 µA	0.083% + 600 µA	0.002% + 20 µA
10 A, pulsing only, typical					

Noise

Wideband source noise	<20 mV peak-to-peak in 60 V range, device configured for normal transient response, 10 Hz to 20 MHz, typical

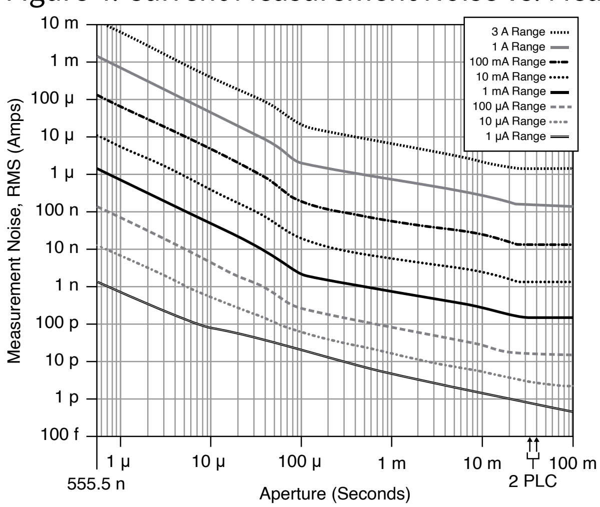
The following figures illustrate measurement noise as a function of measurement aperture for the PXIe-4139.

Figure 3. Voltage Measurement Noise vs. Measurement Aperture, Nominal



Note When the aperture time is set to 2 power-line cycles (PLCs), measurement noise differs slightly depending on whether the Power Line Frequency is set to 50 Hz or 60 Hz.

Figure 4. Current Measurement Noise vs. Measurement Aperture, Nominal

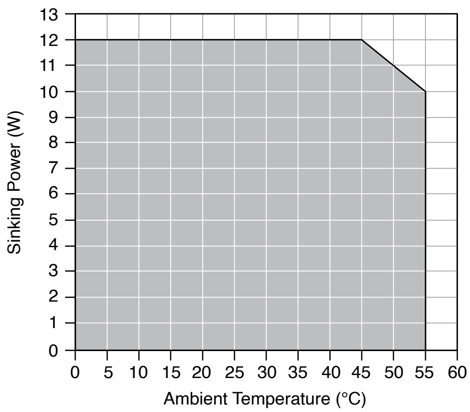


Note When the aperture time is set to 2 power-line cycles (PLCs), measurement noise differs slightly depending on whether the Power Line Frequency is set to 50 Hz or 60 Hz.

Sinking Power vs. Ambient Temperature Derating

The following figure illustrates sinking power derating as a function of ambient temperature. This applies to the PXIe-4139 (20W) when used with any chassis and only applies to the PXIe-4139 (40W) when used with a chassis with slot cooling capacity <58 W.

Figure 5. Sinking Power vs. Ambient Temperature Derating



Note When using the PXIe-4139 (40W) with a chassis with slot cooling capacity ≥58 W, ambient temperature derating does not apply.

Output Resistance Programming Accuracy

Note T_{cal} is the internal device temperature recorded by the PXIe-4139 at the completion of the last self-calibration.

Table 5. Output Resistance Programming Accuracy

Current Level/Limit Range	Programmable Resistance Range, Voltage Mode	Programmable Resistance Range, Current Mode	Accuracy ± (% of resistance setting), T_{cal} ± 5 °C
1 µA	0 to ±5 MΩ	±5 MΩ to ±infinity	0.03%
10 µA	0 to ±500 kΩ	±500 kΩ to ±infinity	
100 µA	0 to ±50 kΩ	±50 kΩ to ±infinity	
1 mA	0 to ±5 kΩ	±5 kΩ to ±infinity	
10 mA	0 to ±500 Ω	±500 Ω to ±infinity	

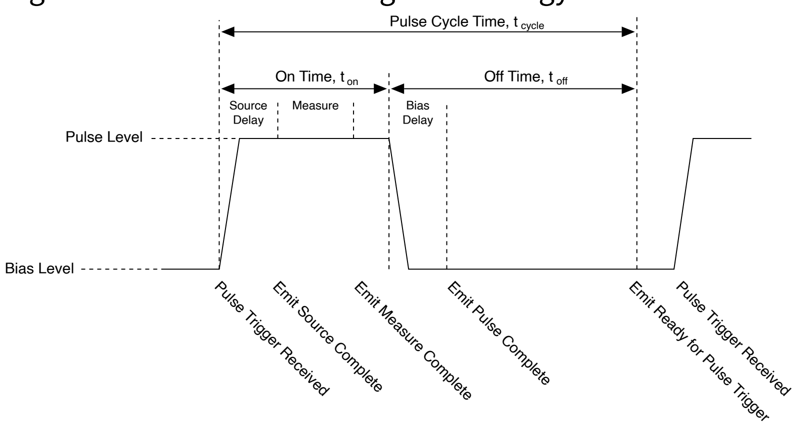
<table>
<tr><th>Current Level/Limit Range</th><th>Programmable Resistance Range, Voltage Mode</th><th>Programmable Resistance Range, Current Mode</th><th>Accuracy ± (% of resistance setting), T_{cal} ± 5 °C</th></tr>
<tr><td>100 mA</td><td>0 to ±50 Ω</td><td>±50 Ω to ±infinity</td><td rowspan="4"></td></tr>
<tr><td>1 A</td><td>0 to ±5 Ω</td><td>±5 Ω to ±infinity</td></tr>
<tr><td>3 A</td><td rowspan="2">0 to ±500 mΩ</td><td rowspan="2">±500 mΩ to ±infinity</td></tr>
<tr><td>10 A , pulsing only</td></tr>
</table>

Pulsed Operation

Dynamic load, minimum pulse cycle time[6]	25 µs/W

The following figure visually explains the terms used in the extended range pulsing sections.

Figure 6. Definition of Pulsing Terminology



Related reference:

- Extended Range Pulsing for PXIe-4139 (40W)
- Examples of Determining Extended Range Pulse Parameters and Optimizing Slew Rate using NI SourceAdapt

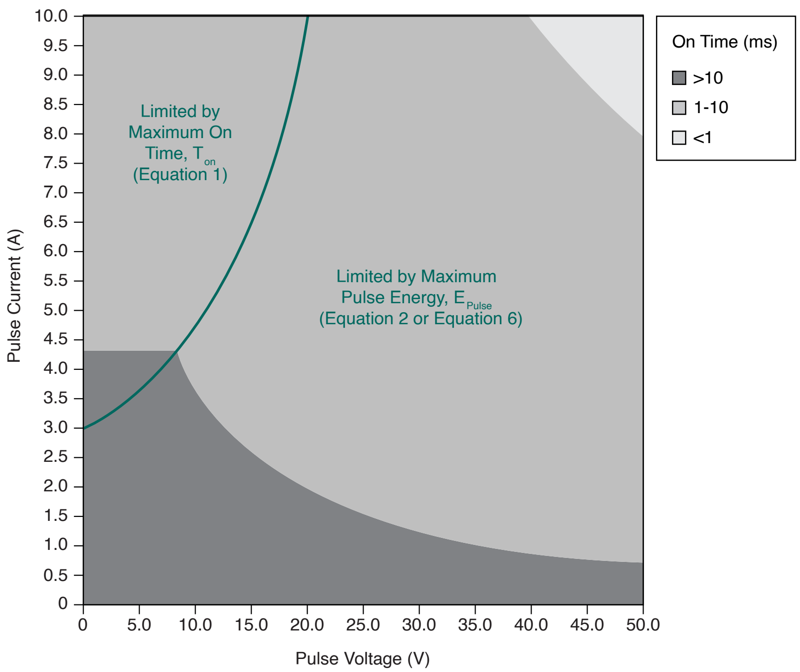
6. For example, given a continuous pulsin load, if the largest dynamic step in power that the load sources/sinks is from 5 W to 15 W, then the maximum SMU power step is 10 W. Thus, the minimum dynamic load pulse cycle time is 250 µs.

Extended Range Pulsing for PXIe-4139 (40W)

> **Note** Extended range pulses fall outside DC range limits for either current or power. In-range pulses fall within DC range limits and are not subject to extended range pulsing limitations. Extended range pulsing is enabled by setting Output Function to Pulse Voltage or Pulse Current.

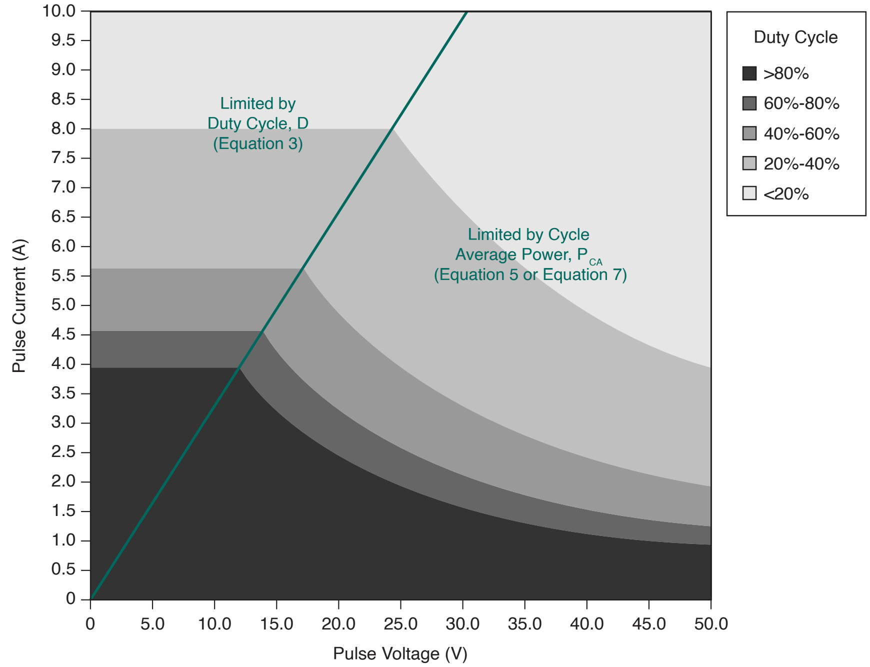
The following figures illustrate the maximum pulse on time and duty cycle for the PXIe-4139 (40W) in a ≥58 W cooling slot, for a desired pulse voltage and pulse current given zero bias voltage and current. The shaded areas allow for a quick approximation of output limitations and limiting parameters. Actual limits are described by equations in ***PXIe-4139 (40 W) Pulse Level Limits***.

Figure 7. Pulse On-time vs Pulse Current and Pulse Voltage



> **Note** Equations to solve for maximum pulse on time, t_{onMax}, are shown in ***PXIe-4139 (40 W) Pulse Level Limits***. Additionally, Equation 6 solves for pulse on time, t_{on}, in terms of maximum pulse energy in ***Example 1: Determining Extended Range Pulse On Time and Duty Cycle Parameters for the PXIe-4139 (40W)***.

Figure 8. Duty Cycle vs Pulse Current and Pulse Voltage



Note Equations to solve for maximum duty cycle, D_{Max}, are shown in ***PXIe-4139 (40 W) Pulse Level Limits***. Additionally, Equation 7 solves for pulse off time, t_{off}, in terms of maximum pulse energy in ***Example 1: Determining Extended Range Pulse On Time and Duty Cycle Parameters for the PXIe-4139 (40W)***.

Bias level limits	
Maximum voltage, V_{bias}	60 V
Maximum current, I_{bias}	3 A

Table 6. PXIe-4139 (40W) Pulse Level Limits

Specification	Value	Equation
Maximum voltage, $V_{pulseMax}$	50 V	—
Maximum current, $I_{pulseMax}$	10 A	—

Specification		Value	Equation
Maximum on time, t_{onMax}. **Note** ***Pulse on time*** is measured from the start of the leading edge to the start of the trailing edge. See ***Definition of Pulsing Terminology***.	If $I_{pulse} > 3$ A	Calculate using the equation or refer to ***Pulse On-Time vs Pulse Current and Pulse Voltage*** to estimate the value.	Equation 1 $t_{onMax} = 2\ ms \times \frac{7\ A}{(I_{pulse}) - 3\ A}$, where $t_{onMax} \le 167\ s$
	If $I_{pulse} \le 3$ A	$t_{onMax} = 167$ s	—
Maximum pulse energy, $E_{pulseMax}$[7]		0.4 J	Equation 2 $E_{pulse} = (V_{pulse} \times I_{pulse} \times t_{on})$, where $E_{pulse} < E_{pulseMax}$
Maximum duty cycle, D_{Max}[8]		Calculate using the equation or refer to ***Duty Cycle vs Pulse Current and Pulse Voltage*** to estimate the value.	Equation 3 $D_{Max} = \frac{(3.68\ A)^2 - (I_{bias})^2}{(I_{pulse})^2 - (I_{bias})^2} \times 100\ \%$
Minimum pulse cycle time, $t_{cycleMin}$		5 ms	Equation 4 $t_{cycle} = t_{on} + t_{off}$

7. Refer to ***Pulse On-Time vs Pulse Current and Pulse Voltage*** to estimate the value and determine the limiting equation.
8. Refer to ***Duty Cycle vs Pulse Current and Pulse Voltage*** to estimate the value and determine the limiting equation. If D≥100%, consider switching Output Function from Pulse mode to DC mode.

Specification		Value	Equation
			, where $t_{cycle} > t_{cycleMin}$
Maximum cycle average power, P_{CAMax}[9]	≥58 W Slot Cooling Capacity Chassis	40 W	Equation 5 $P_{CA} = \frac{(V_{pulse} \times I_{pulse} \times t_{on}) + (V_{bias} \times I_{bias} \times t_{off})}{t_{on} + t_{off}}$, where $P_{CA} < P_{CAMax}$
	<58 W Slot Cooling Capacity Chassis	10 W	

Note Software will not allow settings that violate these limiting equations and will generate an error.

Related reference:

- Examples of Determining Extended Range Pulse Parameters and Optimizing Slew Rate using NI SourceAdapt
- Pulsed Operation

Extended Range Pulsing for PXIe-4139 (20W)

Note Extended range pulses fall outside DC range limits for either current or power. In-range pulses fall within DC range limits and are not subject to extended range pulsing limitations. Extended range pulsing is enabled by setting Output Function to Pulse Voltage or Pulse Current.

Table 7. PXIe-4139 (20 W) Bias Level Limits

Specification	Value
Maximum voltage	60 V
Maximum current	3 A

9. Refer to ***Duty Cycle vs Pulse Current and Pulse Voltage*** to estimate the value and determine the limiting equation.

Table 8. PXIe-4139 (20 W) Pulse Level Limits

Specification	Value
Maximum voltage	50 V
Maximum current	10 A
Maximum on time **Note** ***Pulse on time*** is measured from the start of the leading edge to the start of the trailing edge. See ***Definition of Pulsing Terminology***.	1 ms
Minimum pulse cycle time	5 ms
Energy	0.2 J
Maximum cycle average power	10 W
Maximum duty cycle	5%

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, typical
Maximum slew rate[10, 11]	0.7 A/µs
Settling time[12]	
Voltage mode, 50 V step, unloaded[13]	<200 µs, typical

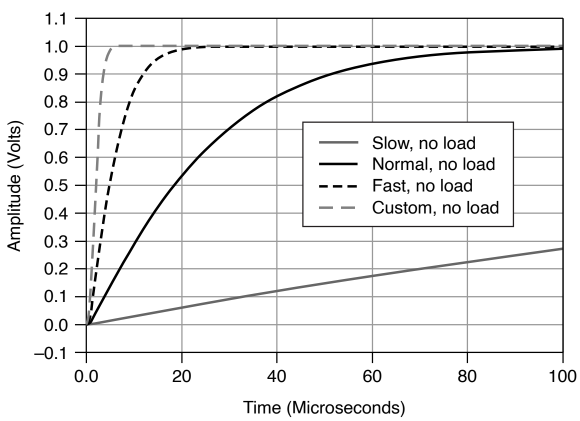
10. Optimize transient response, overshoot, and slew rate with NI SourceAdapt by adjusting the Transient Response.
11. To improve the slew rate, see ***Examples of Determining Extended Range Pulse Parameters and Optimizing Slew Rate using NI SourceAdapt***.

Voltage mode, 5 V step or smaller, unloaded[14]	<70 µs, typical
Current mode, full-scale step, 10 A to 100 µA ranges	<50 µs, typical
Current mode, full-scale step, 10 µA range	<150 µs, typical
Current mode, full-scale step, 1 µA range	<300 µs, typical

Note For current mode, full-scale step, voltage limit set to ≥2 V and resistive load set to 1 V/selected current range.

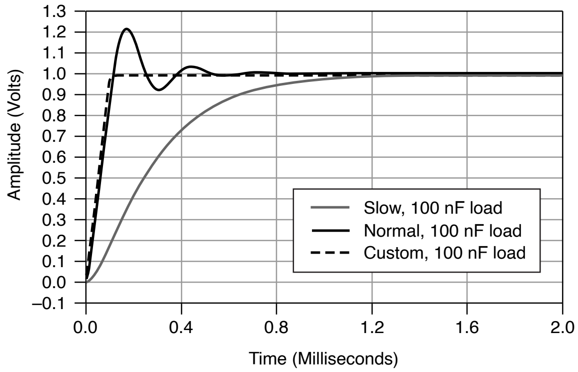
The following figures illustrate the effect of the transient response setting on the step response of the PXIe-4139 for different loads.

Figure 9. 1 mA Range, No Load Step Response, Nominal



12. Measured as the time to settle to within 0.1% of step amplitude, device configured for fast transient response.
13. Current limit set to ≥50 µA and ≥50% of the selected current limit range.
14. Current limit set to ≥20 µA and ≥20% of selected current limit range.

Figure 10. 1 mA Range, 100 nF Load Step Response, Nominal



Related reference:

- Examples of Determining Extended Range Pulse Parameters and Optimizing Slew Rate using NI SourceAdapt

Load Regulation

Voltage	
Device configured for local sense	100 µV per mA of output load change (measured between output channel terminals), typical
Device configured for remote sense	Load regulation effect included in voltage accuracy specifications
Current, device configured for local or remote sense	Load regulation effect included in current accuracy specifications

Related reference:

- Voltage
- Current

Expected Relay Life

Output Connected	≥100 k cycles

Note To avoid excessive relay wear, do not set Output Connected to **TRUE** when a non-zero voltage is connected to the output.

Measurement and Update Timing Characteristics

Available sample rates[15]	(1.8 MS/s)/N where N = 1, 2, 3, … 2^{24}, nominal
Sample rate accuracy	Equal to PXIe_CLK100 accuracy, nominal
Maximum measure rate to host	1.8 MS/s per channel, continuous, nominal

Table 9. Maximum Source Update Rate

Mode	Value
Sequence mode	100,000 updates/s (10 µs/update), nominal
Timed output mode	80,000 updates/s (12.5 µs/update), nominal

Note As the source delay is adjusted or if advanced sequencing is used, maximum source rates vary. Timed output mode is enabled in Sequence Mode by setting the Sequence Step Delta Time Enabled to True. Additional timing limitations apply when operating in pulse mode (Output Function is set to Pulse Voltage or Pulse Current).

Table 10. Input Trigger Timing

Event	Time
Source event delay	10 µs, nominal
Source event jitter	1 µs, nominal

15. When sourcing while measuring, both the Source Delay and Aperture Time affect the sampling rate. When taking a measure record, only the Aperture Time affects the sampling rate.

Event	Time
Measure event jitter	1 µs, nominal
Shutdown[16]	100 µs, typical

Table 11. Pulse Mode Timing and Accuracy

<table>
<tr><th colspan="2">Specification</th><th>Value</th></tr>
<tr><td rowspan="2">Minimum pulse on time

Note Pulse on time is measured from the start of the leading edge to the start of the trailing edge. See Definition of Pulsing Terminology.</td><td>PXIe-4139 (40 W)

Note Optimize transient response, overshoot, and slew rate with NI SourceAdapt by adjusting the Transient Response.</td><td>10 µs, nominal</td></tr>
<tr><td>PXIe-4139 (20 W)</td><td>50 µs, nominal</td></tr>
<tr><td colspan="2">Minimum pulse off time[17]</td><td>50 µs, nominal</td></tr>
<tr><td colspan="2">Pulse on time or off time programming resolution</td><td>100 ns, nominal</td></tr>
<tr><td colspan="2">Pulse on time or off time programming accuracy</td><td>±5 µs, nominal</td></tr>
<tr><td colspan="2">Pulse on time or off time jitter</td><td>1 µs, nominal</td></tr>
</table>

Note Pulse mode is enabled when the Output Function is set to Pulse Voltage or Pulse Current. This mode enables access to extended range pulsing capabilities. For PXIe-4139 (20W), shorter minimum on times for in-range pulses can be achieved using Sequence mode or Timed Output mode with the Output Function set to Voltage or Current.

16. Time from PXI Trigger sent until SMU output goes to high impedance.
17. Pulses fall inside DC limits. ***Pulse off time*** is measured from the start of the trailing edge to the start of a subsequent leading edge.

Remote Sense

Voltage accuracy	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.
Maximum sense lead resistance	100 Ω
Maximum lead drop per lead	3 V, characteristic

Note Exceeding the maximum lead drop per lead value may result in additional error.

Examples of Calculating Accuracy

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

Note T_{cal} is the internal device temperature recorded by the PXIe-4139 at the completion of the last self-calibration.

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
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% + 100 pA

Calculate the accuracy using the following equation:

$$\text{Accuracy} = 900\ \text{nA} * 0.03\ \% + 100\text{pA}$$

$$= 270\text{pA} + 100\text{pA}$$

$$= 370\text{pA}$$

Therefore, the actual output will be within 370 pA of 900 nA.

Example 2: Calculating 1 °C Accuracy

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

internal device temperature	within T_{cal} ± 1 °C

Solution

Since the device internal temperature is within T_{cal} ± 1 °C and the ambient temperature is within 23 °C ± 5 °C, the appropriate accuracy specification is:

0.022% + 40 pA

Calculate the accuracy using the following equation:

$$\text{Accuracy} = 900\ \text{nA} * 0.022\ \% + 40\text{pA}$$

$$= 238\text{pA}$$

Therefore, the actual output will be within 238 pA of 900 nA.

Example 3: 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 2, 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} ± 1 °C and the ambient temperature is within 23 °C ± 5 °C, the appropriate accuracy specification is:

0.016% + 30 µV

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 equation:

$$\text{Accuracy} = \left(500\ \text{mV} * 0.016\ \% + 30\mu\text{V}\right) + \frac{600\ \text{mV} * 3\text{ppm} + 11\mu\text{V}}{1V \text{of lead drop}} * 3V + \frac{1\mu V}{V * \Omega} * 3V * 2\ \Omega + \frac{1\mu V}{V * \Omega} * 2.5V * 1.5\Omega$$

$$= 80\mu\text{V} + 30\mu\text{V} + 12.8\mu\text{V} * 3 + 6\mu\text{V} + 3.8\mu\text{V}$$

$$= 158.2\mu\text{V}$$

Therefore, the actual output will be within 158.2 µV of 500 mV.

Example 4: Calculating Accuracy with Temperature Coefficient

Calculate the accuracy of 900 nA output in the 1 µA range. Assume the same conditions as in Example 2, with the following differences:

ambient temperature	15 °C

Solution

Since the device internal temperature is within T_{cal} ± 1 °C, the appropriate accuracy specification is:

0.022% + 40 pA

Since the ambient temperature falls outside of 23 °C ± 5 °C, use the following temperature coefficient per degree Celsius outside the 23 °C ± 5 °C range:

0.0006% + 4 pA

Calculate the accuracy using the following equation:

$$\text{TemperatureVariation} = (23\,°C - 5\,°C) - 15\,°C = 3\,°C$$

$$\text{Accuracy} = (900\text{ nA} * 0.022\,\% + 40\text{pA}) + \frac{900\text{ nA} * 0.0006\,\% + 4pA}{1\,°C} * 3\,°C$$

$$= 238\text{pA} + 28.2\text{pA}$$

$$= 266.2\text{pA}$$

Therefore, the actual output will be within 266.2 pA of 900 nA.

Examples of Determining Extended Range Pulse Parameters and Optimizing Slew Rate using NI SourceAdapt

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

Example 1: Determining Extended Range Pulse On Time and Duty Cycle Parameters for the PXIe-4139 (40W)

Determine the extended range pulsing parameters, assuming the following operating point.

Output function	Pulse Current
Pulse voltage limit, V_{pulse}	40 V
Pulse current level, I_{pulse}	6 A
Bias voltage limit, V_{bias}	0.1 V
Bias current level, I_{bias}	0 A
Pulse on time, t_{on}	1.5 ms
Chassis' slot cooling capacity	≥58 W

Solution

Begin by calculating the pulse power using the following equation.

Pulse power = V_{pulse} * I_{pulse}

= 40 V * 6 A

= 240 W

For PXIe-4139 (40W), refer to the following figures to identify next steps. First, verify the the region of operation using ***Definition of Pulsing Terminology***, which shows 240 W is in the extended range pulsing region.

Next, refer to ***Pulse On-time vs Pulse Current and Pulse Voltage***, which shows the maximum pulse on time, t_{on}, is limited by the maximum pulse energy, $E_{pulseMax}$. Use the pulse energy equation ***(Equation 2)*** from ***Extended Range Pulsing for PXIe-4139 (40W)*** to calculate the maximum pulse on time, t_{onMax}***(Equation 6)***.

Equation 6

$$t_{onMax} = \left(\frac{E_{pulseMax}}{V_{pulse} * I_{pulse}}\right)$$

$$= \left|\frac{0.4\ \text{J}}{40\ \text{V} * 6\ \text{A}}\right|$$

$$=1.67\ \text{ms}$$

Next, refer to ***Duty Cycle vs Pulse Current and Pulse Voltage***, which shows the maximum duty cycle, D, is limited by the cycle average power, P_{CA}.If the required pulse on time is 1.5 ms and the module is installed in a chassis with slot cooling capacity ≥58 W, use the cycle average power equation ***(Equation 5)*** from ***Extended Range Pulsing for PXIe-4139 (40W)*** to calculate the minimum pulse off time, t_{offMin}***(Equation 7)***.

Equation 7

$$t_{offMin} = \left(\frac{P_{CA} * t_{on} - V_{pulse} * I_{pulse} * t_{on}}{P_{CA} - V_{bias} * I_{bias}}\right) = \left|\frac{40\ \text{W} * 1.5\ \text{ms} - 40\ \text{V} * 6\ \text{A} * 1.5\ \text{ms}}{40\ \text{W} - 0.1\ \text{V} * 0\ \text{A}}\right|$$

$$=7.5\ \text{ms}$$

Finally, verify that the pulse cycle time, t_{cycle}, is greater than or equal to the minimum pulse cycle time, $t_{cycleMin}$ (5 ms). To calculate the pulse cycle time, use the following equation:

$t_{cycle} = t_{on} + t_{off}$ (Eq. 4)

$= 1.5\ ms + 7.5\ ms$

$= 9\ ms$

In this case, the pulse cycle time meets the minimum pulse cycle time specification.

Therefore, a 40 V, 6 A pulse with an on time of 1.5 ms and a pulse off time of 7.5 ms is supported, since it fulfills the following criteria:

- Greater than the minimum pulse on time of 10 µs
- Equal to the minimum pulse off time of 7.5 ms to meet maximum cycle average power
- Greater than the minimum pulse cycle time of 5 ms

Example 2: Determining Extended Range Pulse On Time and Duty Cycle Parameters for the PXIe-4139 (20W)

Determine the extended range pulsing parameters, assuming the following operating point.

Output function	Pulse Current
Pulse voltage limit, V_{pulse}	40 V
Pulse current level, I_{pulse}	6 A
Bias voltage limit, V_{bias}	0.1 V
Bias current level, I_{bias}	0 A
Pulse on time, t_{on}	1.5 ms
Chassis' slot cooling capacity	≥58 W

Solution

Begin by calculating the pulse power using the following equation.

Pulse power = V_{pulse} * I_{pulse}

= 40 V * 6 A

=240 W

Since the pulse power of 240 W is within the 500 W region of Figure 2, the maximum configurable on time is 400 µs and maximum duty cycle is 2%.

For example, if the required pulse on time is 100 µs, and the required pulse cycle time is 10 ms, calculate the pulse off time and verify the duty cycle using the following equations.

$t_{off} = t_{cycle} - t_{on}$

= 10 ms − 100µs

= 9.9 ms

Duty cycle = $\frac{t_{on}}{t_{cycle}}$ * 100%

= 1 %

Therefore, a pulse with an on time of 100 µs and 1% duty cycle would be supported, since it fulfills the following criteria:

- Greater than the minimum pulse on time of 50 µs
- Less than the maximum pulse on time of 400 µs and duty cycle of 2%
- Greater than the minimum pulse cycle time of 5 ms

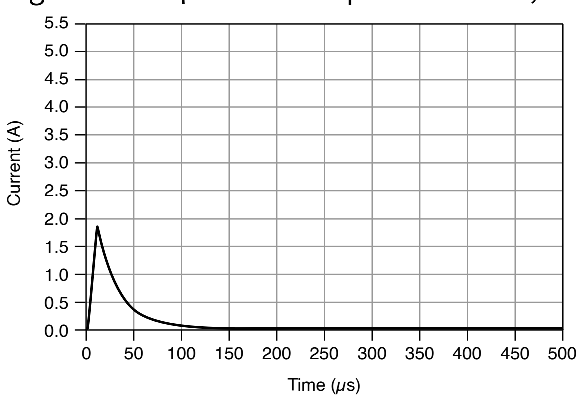
Example 3: Using NI SourceAdapt to Increase the Slew Rate of the Pulse

Determine the appropriate operating parameters and custom transient response settings, assuming the following example parameters.

Output function	Pulse Current
Pulse voltage limit, V_{pulse}	50 V
Pulse current level, I_{pulse}	5 A
Bias voltage limit, V_{bias}	0.1 V
Bias current level, I_{bias}	0 A
Transient response	Fast
Load, cable impedance	4.5 Ω, 40 µH
Pulse on time, t_{on}	10 µs
Pulse off time, t_{off}	4.99 ms

The SMU Transient Response can be configured to three predefined settings, Slow, Normal, and Fast. If these settings do not provide the desired pulse response, a fourth setting, Custom, enables NI SourceAdapt[18] technology which provides the ability to customize the SMU response to any load, and achieve an ideal response with minimum rise times and no overshoots or oscillations.

Figure 11. 10 µs Pulse Output with Load, Fast Transient Response



Solution

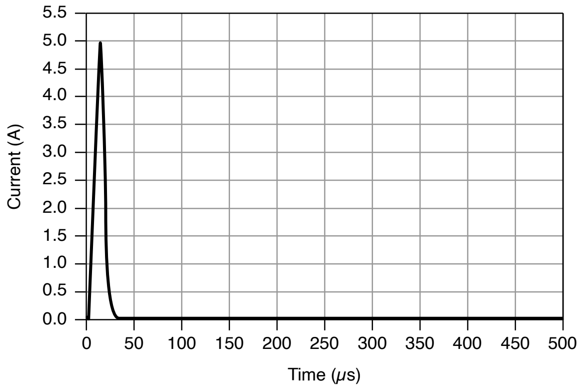
SourceAdapt allows users to set the desired gain bandwidth, compensation frequency, and pole-zero ratio through custom transient response to obtain the desired pulse waveform. To use SourceAdapt, first set the Transient Response to Custom.

To achieve the resulting waveform in the following figure, use the parameters in the

18. Visit ***ni.com*** for more information about NI SourceAdapt Next-Generation SMU Technology.

following table.

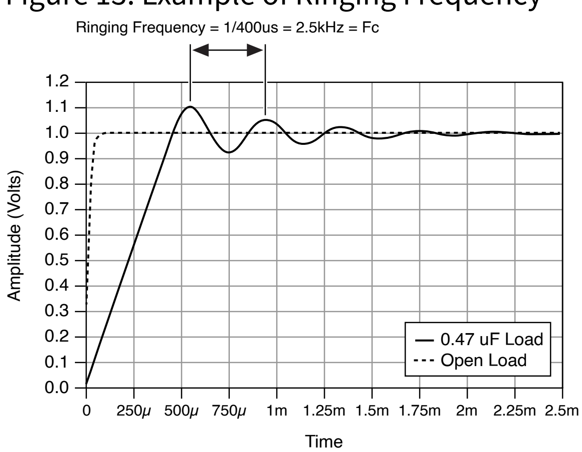
Figure 12. 10 µs Pulse Output with Load, Custom Transient Response



Transient response	Custom
Current: Gain bandwidth	260 kHz
Current: Compensation frequency	140 kHz
Current: Pole-zero ratio	0.75

Gain bandwidth is directly proportional to the step response slew rate. The higher the gain bandwidth, the higher the slew rate. It is worth noting that increasing the gain bandwidth will likely increase ringing. However, this can likely be removed by appropriately setting the compensation frequency and the pole-zero ratio.

Figure 13. Example of Ringing Frequency



Compensation frequency and pole-zero ratio are used to determine the frequencies of the SMU control loop pole and zero, which can be used to optimize the system transient response by increasing phase margin and reducing ringing. To reduce the overshoot, it is recommended to set the compensation frequency close to the overshoot ringing frequency, see Fc in Figure 3, and set the pole-zero ratio to be greater than 1.

For reference, the pole frequency and zero frequency are derived by the following equations.

$$\text{Pole frequency} = \text{Compensation frequency} * \sqrt{\text{Pole-zero ratio}}$$

$$\text{Zero frequency} = \frac{\text{Compensation frequency}}{\text{Pole-zero ratio}}$$

These settings can be accessed through the Transient Response set to Custom: Voltage or Current.

Related reference:

- Extended Range Pulsing for PXIe-4139 (40W)
- Transient Response and Settling Time
- Pulsed Operation

Trigger Characteristics

Input triggers	
Types	Start, Source, Sequence Advance, Measure, Pulse; Shutdown
Sources (PXI trigger lines <0...7>)	
Polarity	Configurable
Minimum pulse width	100 ns, nominal
Destinations[19,20] (PXI trigger lines <0...7>)	
Polarity	Active high (not configurable)

Pulse width	>200 ns, typical
Output triggers (events)	
Types	Source Complete, Sequence Iteration Complete, Sequence Engine Done, Measure Complete, Pulse Complete, Ready for Pulse
Destinations (PXI trigger lines <0...7>)	
Polarity	Configurable
Pulse width	Configurable between 250 ns and 1.6 µs, nominal

Protection

Output channel protection	
Overcurrent or overvoltage	Automatic shutdown, output disconnect relay opens
Overtemperature	Automatic shutdown, output disconnect relay opens

Safety Voltage and Current

Notice The protection provided by the PXIe-4139 can be impaired if it is used in a manner not described in the user documentation.

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

19. Pulse widths and logic levels are compliant with ***PXI Express Hardware Specification Revision 1.0 ECN 1***.
20. Input triggers can be re-exported.

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.

Attention Les tensions nominales d'isolation s'appliquent à la tension mesurée entre n'importe quelle broche de voie et la masse du châssis. Lors de l'utilisation de voies en série ou flottantes en plus des références de tension externes, assurez-vous qu'aucun terminal ne dépasse cette valeur nominale.

DC voltage	±60 V
Channel-to-earth ground isolation	
Continuous	150 VDC, CAT I
Withstand	1,000 V RMS, verified by a 5 s withstand

Caution Do not connect the PXIe-4139 to signals or use for measurements within Measurement Categories II, III, or IV.

Attention Ne connectez pas le PXIe-4139 à des signaux et ne l'utilisez pas pour effectuer des mesures dans les catégories de mesure II, III ou IV.

Measurement Category I is for measurements performed on circuits not directly connected to the electrical distribution system referred to as ***MAINS*** voltage. MAINS is a hazardous live electrical supply system that powers equipment. This category is for measurements of voltages from specially protected secondary circuits. Such voltage measurements include signal levels, special equipment, limited-energy parts of equipment, circuits powered by regulated low-voltage sources, and electronics.

Note Measurement Categories CAT I and CAT O are equivalent. These test and measurement circuits are for other circuits not intended for direct connection to the MAINS building installations of Measurement Categories CAT II, CAT III, or CAT IV.

DC current range	±3 A ±10 A, pulse only

Guard Output Characteristics

Cable guard	
Output impedance	2 kΩ, nominal
Offset voltage	1 mV, typical

Calibration Interval

You can obtain the calibration certificate and information about calibration services for the PXIe-4139 at ni.com/calibration.

Table 12. Calibration Interval

Calibration Interval	1 year

Power Requirement

PXI Express power requirement	
PXIe-4139 (40W)	3.0 A from the 3.3 V rail and 6.0 A from the 12 V rail

PXIe-4139 (20W)	2.5 A from the 3.3 V rail and 2.2 A from the 12 V rail

Physical

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	
PXIe-4139 (40W)	427 g (15.1 oz)
PXIe-4139 (20W)	419 g (14.8 oz)
Front panel connectors	5.08 mm (8 position)

Environmental Guidelines

Notice This product is intended for use in indoor applications only.

Notice Cover all empty slots using filler panels.

Environmental Characteristics

Table 13. Temperature

Operating	0 °C to 55 °C
Storage	-40 °C to 71 °C

Table 14. Humidity

Operating	10% to 90%, noncondensing

Storage	5% to 95%, noncondensing

Table 15. Pollution Degree

Pollution degree	2

Table 16. Maximum Altitude

Maximum altitude	2,000 m (800 mbar) (at 25 °C ambient temperature)

Table 17. Shock and Vibration

Operating vibration	5 Hz to 500 Hz, 0.3 g RMS
Non-operating vibration	5 Hz to 500 Hz, 2.4 g RMS
Operating shock	30 g, half-sine, 11 ms pulse

Environmental Standards

This product meets the requirements of the following environmental standards for electrical equipment.

- IEC 60068-2-1 Cold
- IEC 60068-2-2 Dry heat
- IEC 60068-2-78 Damp heat (steady state)
- IEC 60068-2-64 Random operating vibration
- IEC 60068-2-27 Operating shock

Note To verify marine approval certification for a product, refer to the product label or visit ni.com/certification and search for the certificate.

Safety Compliance Standards

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 C22.2 No. 61010-1

Note For safety certifications, refer to the product label or the Product Certifications and Declarations 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

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 Product Certifications and Declarations section.

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 ***Engineering a Healthy Planet*** 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.

EU and UK Customers

- **Waste Electrical and Electronic Equipment (WEEE)**—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）

- **中国RoHS**— NI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NI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`.)

Product Certifications and Declarations

Refer to the product Declaration of Conformity (DoC) for additional regulatory compliance information. To obtain product certifications and the DoC for NI products, visit ni.com/product-certifications, search by model number, and click the appropriate link.

NI Services

Visit ni.com/support to find support resources including documentation, downloads, and troubleshooting and application development self-help such as tutorials and examples.

Visit ni.com/services to learn about NI service offerings such as calibration options, repair, and replacement.

Visit ni.com/register to register your NI product. Product registration facilitates technical support and ensures that you receive important information updates from NI.

NI corporate headquarters is located at 11500 N Mopac Expwy, Austin, TX, 78759-3504, USA.