SPECIFICATIONS

FD-11601

8-Channel, Powered-Sensor Voltage Input Device for FieldDAQ™

Conditions

Specifications are typical and valid from -40 °C to +85 °C unless otherwise noted.

Input Characteristics

Number of channels	8 analog input channels
Isolation	Galvanic isolation between channels and to chassis
Input voltage range (AI+ to AI-)	±10.5 V
ADC resolution	24 bits
Type of ADC	Delta-Sigma (with analog prefiltering)
Sample mode	Simultaneous
TEDS support	IEEE 1451.4 TEDS Class 2
Timebases (f_M)[1]	
Frequency	13.1072 MHz, 12.8 MHz, 12.288 MHz, 10.24 MHz
Accuracy	±30 ppm maximum
Sampled data rate range (f_s)	
Minimum	500 Samples/s
Maximum	102.4 kSamples/s
Sampled data rates (f_s)	Refer to the following table for sample data rates supported for each timebase

[1] Base clocks can be synchronized with other FieldDAQ devices using the network synchronization feature.

NATIONAL INSTRUMENTS™

Table 1. Timebases (f_M) and Supported Sampled Data Rates (f_S), (kSamples/s)

13.1072 MHz	12.8 MHz	12.288 MHz	10.24 MHz
102.4	100.0	96.0	80.0
51.2	50.0	48.0	40.0
34.133	33.333	32.0	26.667
25.6	25.0	24.0	20.0*
20.48	20.0	19.2	16.0
17.067	16.667	16.0*	13.333
12.8	12.5	12.0	10.0*
10.24	10.0	9.6	8.0
8.533	8.333	8.0*	6.667
6.4	6.25	6.0	5.0*
5.12	5.0	4.8	4.0
4.267	4.167	4.0*	3.333
3.2	3.125	3.0	2.5*
2.56	2.5	2.4	2.0
2.133	2.083	2.0*	1.667
1.6	1.563	1.5	1.25*
1.28	1.25	1.2	1.0
1.067	1.042	1.0*	0.833
0.8	0.781	0.75	0.625
0.64	0.625	0.6	0.5

Note: For sample rates that can be obtained using two different timebases, the lowest noise (highest resolution) option is indicated with an asterisk (*).

Input impedance (AI+ to AI-)	>1 GΩ
Input capacitance (AI+ to AI-)	440 pF

Table 2. Accuracy

Temperature	Gain Error (% of Reading)	Offset Error (% of Range, mV)[2]
5 °C to 40 °C, typical	0.013%	0.001%, 0.105 mV
5 °C to 40 °C, maximum	0.037%	0.01%, 1.05 mV
-40 °C to 85 °C, maximum	0.062%	0.02%, 2.1 mV

Sampled data rate noise	
1 kSample/s	7 µV RMS
10 kSamples/s	20 µV RMS
102.4 kSamples/s	40 µV RMS
Stability	
Gain drift	±4 ppm/°C
Offset drift	±5 µV/°C
Gain mismatch (channel-to-channel, 40 kHz)	0.035 dB maximum
Phase mismatch (channel-to-channel)	0.03°/kHz maximum
Phase nonlinearity (f_s = 102.4 kSamples/s)	0.1° maximum
Crosstalk (1 kHz)	-110 dB
CMRR to chassis/earth (f_{in} = 60 Hz)	130 dB
Spurious Free Dynamic Range (SFDR), (1 kHz, -60 dBFS)	130 dBFS
Total Harmonic Distortion (THD), (1 kHz, -1 dBFS)	-102 dB
MTBF	864,132 hours at 25 °C; Bellcore Issue 6, Method 1, Case 3, Limited Part Stress Method

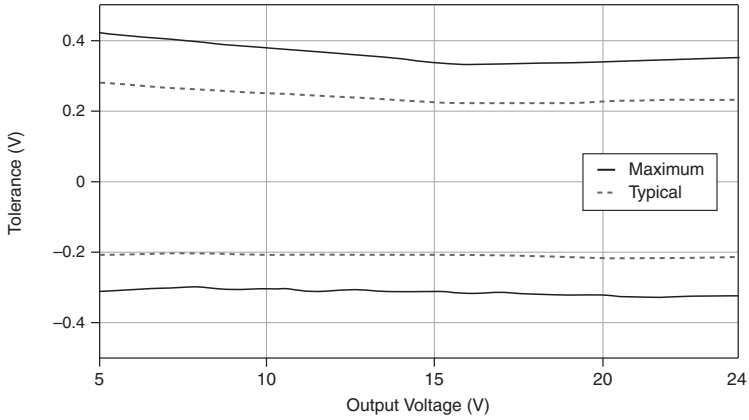
Powered Sensor Excitation

Nominal output voltage range	5 V to 24 V
Power-on output state	Channels off[3]
Settling time to 1% of final value	100 ms

[2] Range equals 10.5 V.

[3] During the power down of the FD-11601, the sensor power excitation output may experience a glitch of up to 1.5 V.

Figure 1. Tolerance vs Output Voltage (5 °C to 40 °C, 1 mA Output)



Temperature coefficient	
Typical	-2.5 mV/°C
Maximum	-5.2 mV/°C to +3.5 mV/°C
Load regulation	-2.2 mV/mA
Resolution	10 bits
Voltage noise, RMS, 100 kHz BW	3 mV

Figure 2. Maximum Output Current vs Output Voltage

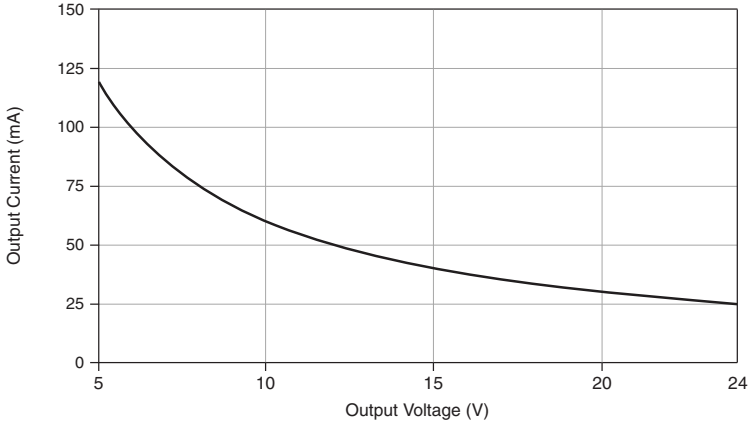
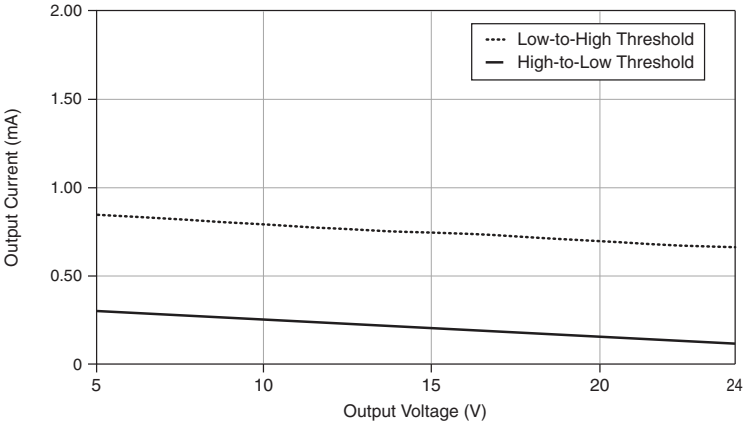


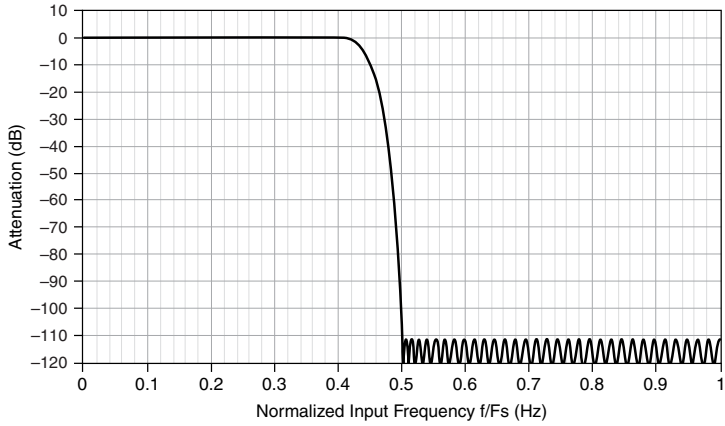
Figure 3. Sensor Detection Threshold



Filtering

Brickwall filter (default)	
Input delay	$36/f_s$ + 1.65 µs
Input delay tolerance	±150 ns
Passband	
Frequency	DC to 0.4 · f_s
Flatness	-0.02 dB maximum at 0 kHz to 10 kHz -0.03 dB maximum at 0 kHz to 20 kHz -0.075 dB maximum at 0 kHz to 40 kHz
Stopband	
Frequency	At or above 0.5 · f_s
Rejection	100 dB
Alias-free bandwidth	0.5 · f_s

Figure 4. Brickwall Filter Magnitude Response



Butterworth filter[4]	
Input delay tolerance	±150 ns
Filter order	2nd or 4th order

Table 3. Butterworth Filter Cutoff Frequencies (-3 dB Point) for Available Timebases

13.1072 MHz	12.8 MHz	12.288 MHz	10.24 MHz
4096 Hz	4000 Hz	3840 Hz	3200 Hz
2048 Hz	2000 Hz	1920 Hz	1600 Hz
1024 Hz	1000 Hz	960 Hz	800 Hz
512 Hz	500 Hz	480 Hz	400 Hz
256 Hz	250 Hz	240 Hz	200 Hz
128 Hz	125 Hz	120 Hz	100 Hz

[4] Butterworth filtering is supported in NI-DAQmx 18.6 and later. Previous versions of NI-DAQmx support only brickwall filtering.

Table 4. Butterworth Filter Input Delay for Available Timebases (f_M)

Timebase	Cutoff	4th Order		2nd Order	
		DC Delay	Maximum Delay	DC Delay	Maximum Delay
13.1072 MHz	4096	436.19 µs	457.52 µs	398.81 µs	405.2 µs
	2048	537.22 µs	580.46 µs	453.49 µs	466.47 µs
	1024	740.50 µs	827.53 µs	563.23 µs	589.31 µs
	512	1.14660 ms	1.32090 ms	783.01 µs	834.97 µs
	256	1.95850 ms	2.30470 ms	1.22260 ms	1.32640 ms
	128	3.58330 ms	4.27710 ms	2.08260 ms	2.29250 ms
12.8 MHz	4000	446.62 µs	468.46 µs	408.34 µs	414.88 µs
	2000	550.08 µs	594.35 µs	464.33 µs	477.62 µs
	1000	758.23 µs	847.35 µs	576.70 µs	603.42 µs
	500	1.17410 ms	1.35260 ms	801.76 µs	854.97 µs
	250	2.00540 ms	2.36000 ms	1.25190 ms	1.35820 ms
	125	3.66920 ms	4.37970 ms	2.13250 ms	2.34750 ms
12.288 MHz	3840	465.16 µs	487.91 µs	425.29 µs	432.10 µs
	1920	572.93 µs	619.05 µs	483.61 µs	497.45 µs
	960	789.76 µs	882.59 µs	600.67 µs	628.49 µs
	480	1.22290 ms	1.40890 ms	835.10 µs	890.53 µs
	240	2.08890 ms	2.45820 ms	1.30400 ms	1.41470 ms
	120	3.82200 ms	4.56210 ms	2.22130 ms	2.44530 ms
10.24 MHz	3200	557.87 µs	585.16 µs	510.02 µs	518.19 µs
	1600	687.18 µs	742.53 µs	580.00 µs	596.61 µs
	800	947.38 µs	1.05880 ms	720.47 µs	753.86 µs
	400	1.46720 ms	1.69030 ms	1.00180 ms	1.06830 ms
	200	2.50640 ms	2.94960 ms	1.56440 ms	1.69740 ms
	100	4.58610 ms	5.47420 ms	2.66520 ms	2.93400 ms

Figure 5. Butterworth Filter Magnitude Response (IIR, 4th Order, with 12.8 MHz Timebase)

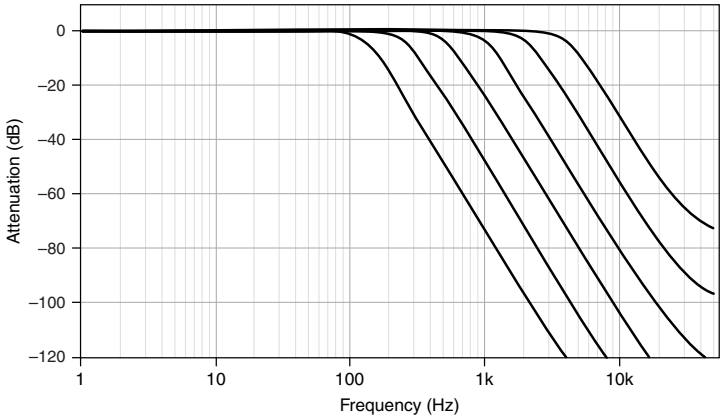


Figure 6. Butterworth Filter Magnitude Response (IIR, 2nd Order, with 12.8 MHz Timebase)

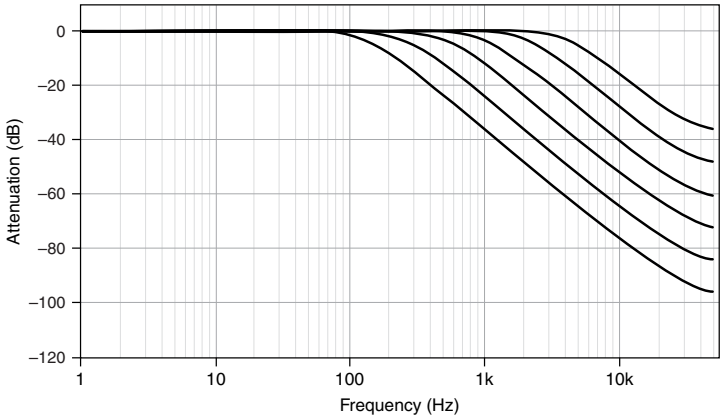


Figure 7. Butterworth Filter Input Delay (IIR, 4th Order, with 12.8 MHz Timebase, 4 kHz, 2 kHz, 1 kHz Filter)

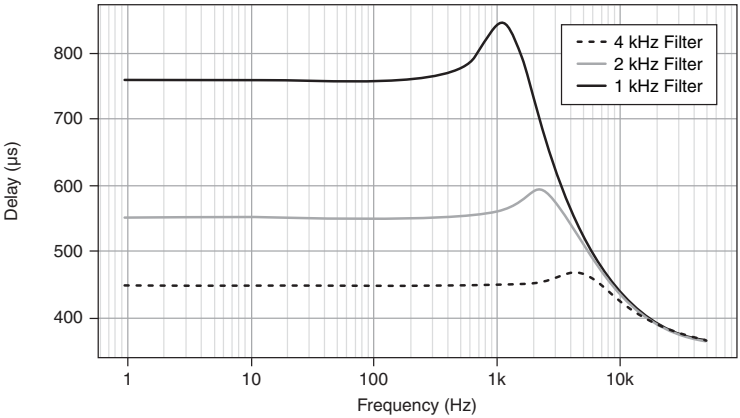


Figure 8. Butterworth Filter Input Delay (IIR, 4th Order, with 12.8 MHz Timebase, 500 Hz, 250 Hz, 125 Hz Filter)

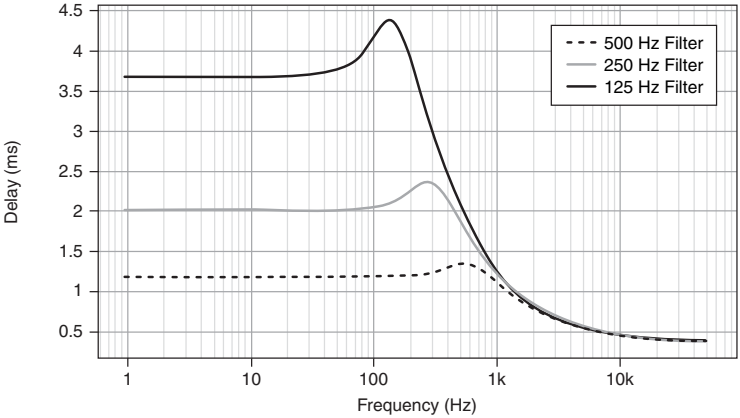


Figure 9. Butterworth Filter Input Delay (IIR, 2nd Order, with 12.8 MHz Timebase, 4 kHz, 2 kHz, 1 kHz Filter)

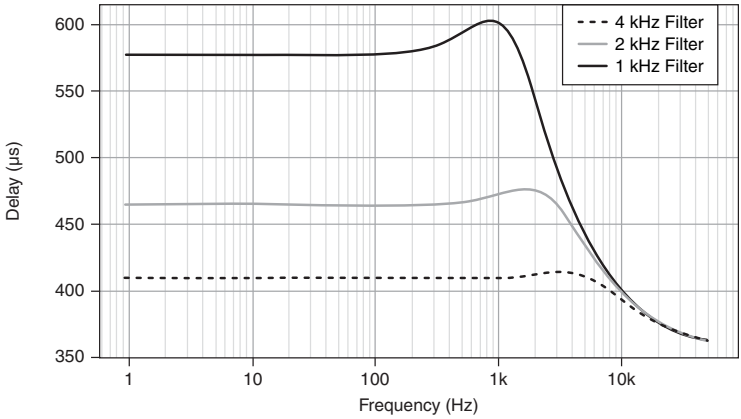
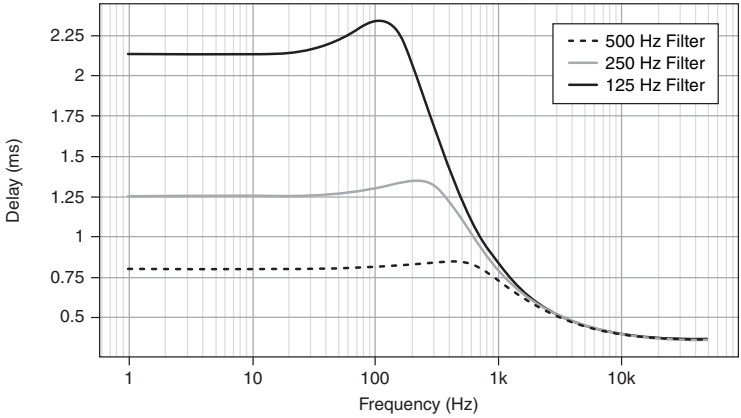


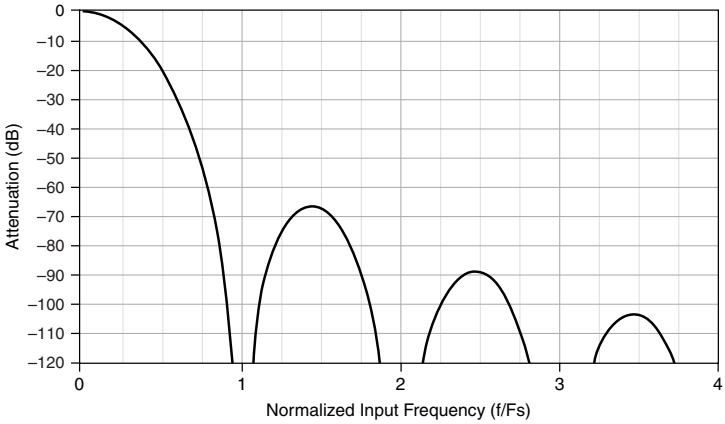
Figure 10. Butterworth Filter Input Delay (IIR, 2nd Order, with 12.8 MHz Timebase, 500 Hz, 250 Hz, 125 Hz Filter)



Comb filter[5]	
Input delay	$5/f_s$ + 1.65 µs
Input delay tolerance	±150 ns
Notches	f_s, 2 f_s, 3 f_s, ...

[5] Comb filtering is supported in NI-DAQmx 18.6 and later. Previous versions of NI-DAQmx support only brickwall filtering.

Figure 11. Comb Filter Magnitude Response



Time-Based Triggers

Type	Start Trigger, Sync Pulse

Timing and Synchronization

Protocol	IEEE 802.1AS for network synchronization over 1000 Base-TX, full-duplex
Network synchronization accuracy[6]	<1 µs
Network synchronization accuracy with optimized configuration[7]	<100 ns

Note When configured to use IEEE 1588, performance of synchronization may vary from these specifications.

[6] I/O synchronization is system-dependent. Assumes the devices are connected in a line topology. For information about network synchronization accuracy, visit *ni.com/info* and enter Info Code `syncacc`.

[7] I/O synchronization is system-dependent. Assumes a system containing one hop. For information about achieving high accuracy synchronization, visit *ni.com/info* and enter Info Code `fdsync`.

Network Interface

Network protocols	TCP/IP, UDP
Network ports used	HTTP:80 (configuration only), TCP:3580; UDP:5353 (configuration only), TCP:5353 (configuration only); TCP:31415; UDP:7865 (configuration only), UDP:8473 (configuration only)
Network IP configuration	DHCP + Link-Local, DHCP, Static, Link-Local
Default MTU size	1500 bytes

Ethernet

Number of ports	2 8-pin X-coded M12 ports, internally switched[8]
Network interface	1000 Base-TX, full-duplex; 1000 Base-TX, half-duplex; 100 Base-TX, full-duplex; 100 Base-TX, half-duplex; 10 Base-T, full-duplex; 10 Base-T, half-duplex
Communication rates	10/100/1000 Mbps, auto-negotiated
Maximum cabling distance	100 m/segment
Maximum hops per line[9]	15

Power Requirements

Notice The protection provided by the FD-11601 can be impaired if it is used in a manner not described in the *FD-11601 User Guide*.

Voltage input range	
V_{in}	9 V DC to 30 V DC
V_{aux}	Up to 30 V DC

[8] This allows for line topologies or network redundancy.

[9] With default software configuration. For information about creating reliable Ethernet-based systems, visit *ni.com/info* and enter Info Code `fdenet`.

Maximum device power consumption[10]	16.0 W
Power input connector	5-pin L-coded male M12 connector
Power output connector	5-pin L-coded female M12 connector

Current Limits

Caution Exceeding the current limits may cause damage to the device. Stay below a maximum of 10 A shared between both Input and Aux terminals.

Power IN/OUT terminals	
V_{in}	10 A maximum
V_{aux}	10 A maximum total (combined with V_{in})
Recommended external overcurrent protection	16 A, slow blow fuse

Physical Characteristics

Dimensions	198.5 mm × 77.4 mm × 47.1 mm (7.8 in. × 3.0 in. × 1.9 in.)
Weight	1.2 kg (42 oz)
Input connection	
Number	8
Type	5-pin A-coded M12 connectors
Torque for M12 connectors (power, Ethernet, input connections)	0.6 N · m (5.31 lb · in.)

Calibration

Calibration interval	1 year

Environmental Characteristics

Refer to the *FD-11601 User Guide* for more information about meeting these specifications.

[10] The total amount of power drawn by the device from the power input connector, including power delivered to external sensors.

Temperature and Humidity

Temperature	
Operating	-40 °C to 85 °C
Storage	-40 °C to 100 °C
Operating and storage humidity	Up to 100% relative humidity, condensing or noncondensing
Ingress protection	IP65/IP67
Pollution Degree	4
Maximum altitude	5,000 m

Note Failure to follow the mounting instructions in the *FD-11601 User Guide* can cause temperature derating.

Note M12 connectors must be mated to cables or have caps installed on them to meet IP65/IP67 requirements. Cover the unused connectors with the included plastic caps whenever water, dust, or dirt are present.

Note Avoid long periods of exposure to sunlight.

Shock and Vibration

Operating vibration	
Random	10 g RMS, 5 Hz to 2,000 Hz
Sinusoidal	10 g, 5 Hz to 2,000 Hz
Operating shock	100 g, 11 ms half sine, 3 shocks at 6 orientations, 18 total 40 g, 6 ms half sine, 4,000 shocks at 6 orientations, 24,000 total

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 60068-2-6 Sinusoidal operating vibration
- IEC 60068-2-27 Operating shock

- IEC 60068-2-30 Damp heat cyclic (12 + 12h cycle)
- IEC 60068-2-64 Random operating vibration

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 Voltages

Connect only voltages that are within the following limits:

Channel-to-channel isolation	
Continuous working voltage[11]	60 V DC (Dry Locations); 35 VDC (Wet Locations)
Transient overvoltage[12]	1,000 V RMS, verified by 5 s withstand
Channel-to-earth ground isolation	
Continuous working voltage	60 V DC (Dry Locations); 35 VDC (Wet Locations)
Transient overvoltage	1,000 V RMS, verified by 5 s withstand
Overvoltage protection[13]	±30 V between any two pins on the connector

These test and measurement circuits are *not* rated for measurements performed on circuits directly connected to the electrical distribution system referred to as MAINS.

MAINS is a hazardous live electrical supply system to which equipment is designed to be connected to for the purpose of powering equipment. This product is rated 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.

Warning Do not connect the FD-11601 to signals or use for measurements within Measurement Categories II, III, or IV, or for measurements on MAINs circuits or on circuits derived from Overvoltage Category II, III, or IV which may have transient overvoltages above what the product can withstand. The product must not be connected to circuits that have a maximum voltage above the continuous working voltage, relative to earth or to other channels, or this could damage and defeat the insulation. The product can only withstand transients up to the transient overvoltage rating without breakdown or damage to the insulation. An analysis of the working

[11] Working voltage rating is the highest RMS value of the AC or DC voltage across the insulation that can continuously occur when the equipment is supplied at rated voltage.

[12] Withstand rating is the highest RMS value of the AC or DC voltage the insulation can withstand without flashover or breakdown for a specified time.

[13] Temporary Overvoltage rating is the overvoltage of relatively long duration.

voltages, loop impedances, temporary overvoltages, and transient overvoltages in the system must be conducted prior to making measurements.

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 UL and other safety certifications, refer to the product label or the *Product Certifications and Declarations* section.

Electromagnetic Compatibility Standards

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; Industrial 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-003: 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 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.

Notice For EMC declarations and certifications, and additional information, refer to the *Product Certifications and Declarations* section.

Notice To ensure the specified EMC performance, operate this product only with shielded Ethernet cables.

CE Compliance CE

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)
- 2011/65/EU; Restriction of Hazardous Substances (RoHS)

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.

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 *Commitment to 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 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`.)

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