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Find the *National Instruments FP-AI-110* at our website: ***Click HERE***

FieldPoint™ Operating Instructions

FP-AI-110 and cFP-AI-110

Eight-Channel, 16-Bit Analog Input Modules

These operating instructions describe how to install and use the FP-AI-110 and cFP-AI-110 analog input modules (referred to inclusively as the [c]FP-AI-110). For information about configuring and accessing the [c]FP-AI-110 over a network, refer to the user manual for the FieldPoint network module you are using.

Features

The [c]FP-AI-110 is a FieldPoint analog input module with the following features:

- Eight analog voltage or current input channels
- Eight voltage input ranges: 0–1 V, 0–5 V, 0–10 V, ±60 mV, ±300 mV, ±1 V, ±5 V, and ±10 V
- Three current input ranges: 0–20, 4–20, and ±20 mA
- 16-bit resolution
- Three filter settings: 50, 60, and 500 Hz
- 250 V_{rms} CAT II continuous channel-to-ground isolation, verified by 2,300 V_{rms} dielectric withstand test
- –40 to 70 °C operation
- Hot swappable

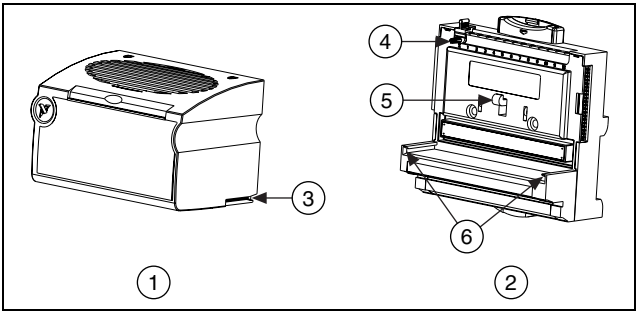
Installing the FP-AI-110

The FP-AI-110 mounts on a FieldPoint terminal base (FP-TB-*x*), which provides operating power to the module. Installing the FP-AI-110 onto a powered terminal base does not disrupt the operation of the FieldPoint bank.

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To install the FP-AI-110, refer to Figure 1 and complete the following steps:

1. Slide the terminal base key to either position X (used for any module) or position 1 (used for the FP-AI-110).
2. Align the FP-AI-110 alignment slots with the guide rails on the terminal base.
3. Press firmly to seat the FP-AI-110 on the terminal base. When the FP-AI-110 is firmly seated, the latch on the terminal base locks it into place.



1	I/O Module	4	Key
2	Terminal Base	5	Latch
3	Alignment Slot	6	Guide Rails

Figure 1. Installing the FP-AI-110

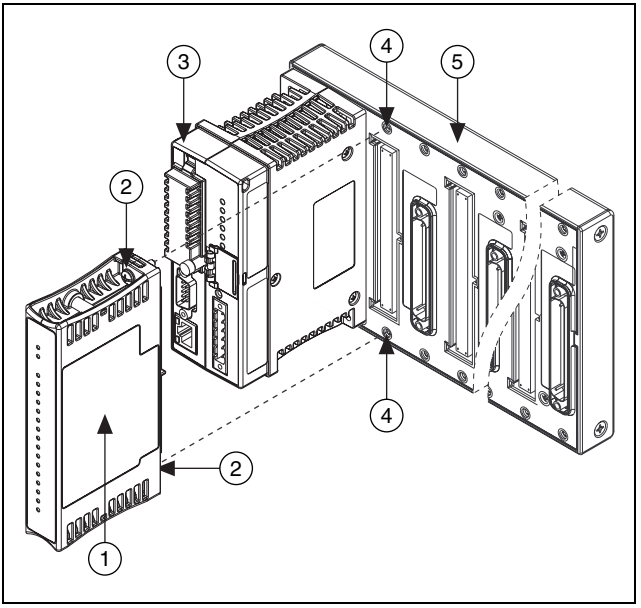
Installing the cFP-AI-110

The cFP-AI-110 mounts on a Compact FieldPoint backplane (cFP-BP-*x*), which provides operating power to the module. Installing the cFP-AI-110 onto a powered backplane does not disrupt the operation of the FieldPoint bank.

To install the cFP-AI-110, refer to Figure 2 and complete the following steps:

1. Align the captive screws on the cFP-AI-110 with the holes on the backplane. The alignment keys on the cFP-AI-110 prevent backward insertion.
2. Press firmly to seat the cFP-AI-110 on the backplane.
3. Using a number 2 Phillips screwdriver with a shank of at least 64 mm (2.5 in.) length, tighten the captive screws to 1.1 N · m

(10 lb · in.) of torque. The nylon coating on the screws prevents them from loosening.



1	cFP-DI-300	4	Screw Holes
2	Captive Screws	5	cFP Backplane
3	cFP Controller Module		

Figure 2. Installing the cFP-AI-110

Wiring the [c]FP-AI-110

The FP-TB-*x* terminal base has connections for each of the eight input channels and for an external power supply to power field devices. The cFP-CB-*x* connector block provides the same connections. Each channel has separate input terminals for voltage (V_{IN}) and current (I_{IN}) input. Voltage and current inputs are referenced to the COM terminals, which are internally connected to each other and to the C terminals. All eight V_{SUP} terminals are internally connected to each other and to the V terminals.

You can use a 10–30 VDC external supply to power field devices. Connect the external power supply to multiple V and V_{SUP} terminals so that the maximum current through any V terminal

is 2 A or less and the maximum current through any V_{SUP} terminal is 1 A or less.

Install a 2 A maximum, fast-acting fuse between the external power supply and the V terminal on each channel. The wiring diagrams in this document show fuses where appropriate.

Table 1 lists the terminal assignments for the signals associated with each channel. The terminal assignments are the same for the FP-TB-*x* terminal bases and the cFP-CB-*x* connector blocks.

Table 1. Terminal Assignments

Channel	Terminal Numbers			
	V_{IN}[1]	I_{IN}[2]	V_{SUP}[3]	COM
0	1	2	17	18
1	3	4	19	20
2	5	6	21	22
3	7	8	23	24
4	9	10	25	26
5	11	12	27	28
6	13	14	29	30
7	15	16	31	32

[1] Install a 2 A, fast-acting fuse on each V_{IN} terminal.
[2] Install a 2 A, fast-acting fuse on each I_{IN} terminal.
[3] Install a 2 A maximum, fast-acting fuse on each V_{SUP} terminal.

Caution Do not connect both current and voltage inputs to the same channel.

Caution Cascading power between two modules defeats isolation between those modules. Cascading power from the network module defeats all isolation between modules in the FieldPoint bank.

Taking Measurements with the [c]FP-AI-110

The [c]FP-AI-110 has eight single-ended input channels. All eight channels share a common ground reference that is isolated from other modules in the FieldPoint system. Figure 3 shows the analog input circuitry on one channel.

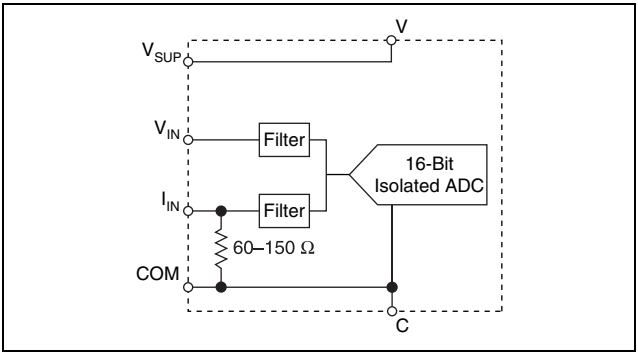


Figure 3. FP-AI-110 Analog Input Circuit

Measuring Voltage with the [c]FP-AI-110

The input ranges for voltage signals are 0–1 V, 0–5 V, 0–10 V, ±60 mV, ±300 mV, ±1 V, ±5 V, and ±10 V.

Figure 4 shows how to connect a voltage source without an external power supply to one channel of the [c]FP-AI-110.

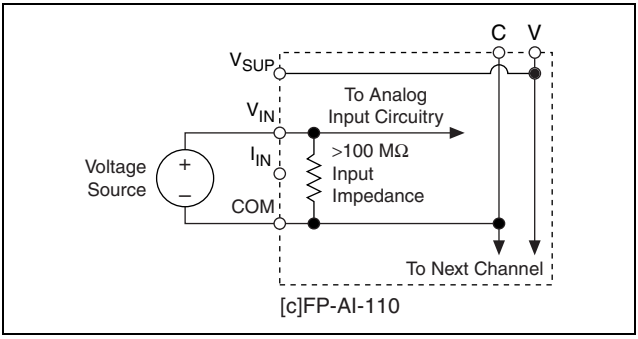


Figure 4. Voltage Source without External Power Supply

Figure 5 shows how to connect a voltage source with an external power supply to one channel of the [c]FP-AI-110.

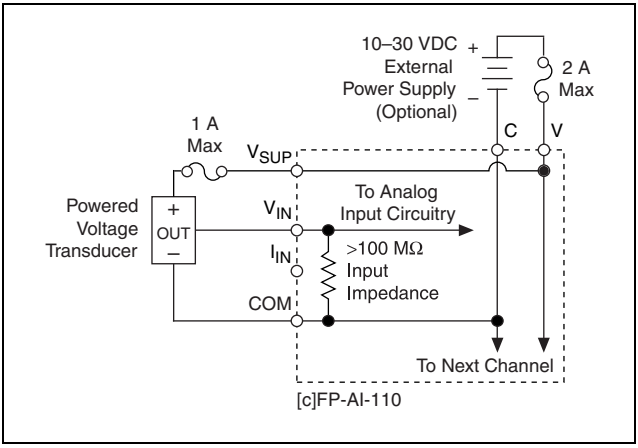


Figure 5. Voltage Source with External Power Supply

Measuring Current with the [c]FP-AI-110

The input ranges for current sources are 0–20, 4–20, and ±20 mA. The module reads current flowing into the I_{IN} terminal as positive and current flowing out of the terminal as negative. Current flows into the I_{IN} terminal, goes through a 100 Ω resistor, and flows out from the COM or C terminal.

Figure 6 shows how to connect a current source without an external power supply to one channel of the [c]FP-AI-110.

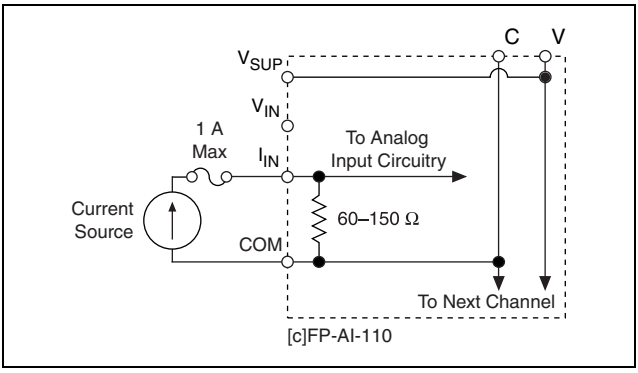


Figure 6. Current Source without External Power Supply

Figure 7 shows how to connect a current source with an external power supply to one channel of the [c]FP-AI-110.

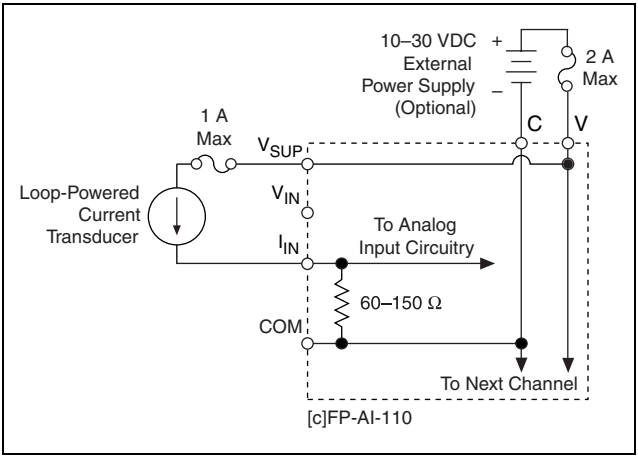


Figure 7. Current Source with External Power Supply

Input Ranges

To prevent inaccurate readings, choose an input range such that the signal you are measuring does not exceed either end of the range.

Overranging

The [c]FP-AI-110 has an overranging feature that measures a little beyond the nominal values of each range. For example, the actual measurement limit of the ±10 V range is ±10.4 V. The overranging feature enables the [c]FP-AI-110 to compensate for field devices with span errors of up to +4% of full scale. Also, with the overranging feature, a noisy signal near full scale does not create rectification errors.

Filter Settings

Three filter settings are available for each channel. The filters on the [c]FP-AI-110 input channels are comb filters that provide notches of rejection at multiples, or harmonics, of a fundamental frequency. You can select a fundamental frequency of 50, 60, or 500 Hz. The [c]FP-AI-110 applies 95 dB of rejection at the fundamental frequency and at least 60 dB of rejection at each of the harmonics. In many cases, most of the noise components of input signals are related to the local AC power line frequency, so a filter setting of either 50 or 60 Hz is best.

The filter setting determines the rate at which the [c]FP-AI-110 samples the inputs. The [c]FP-AI-110 resamples all of the channels at the same rate. If you set all of the channels to the 50 or 60 Hz filter, the [c]FP-AI-110 samples each channel every 1.470 s or every 1.230 s, respectively. If you set all of the channels to 500 Hz filters, the module samples each channel every 0.173 s. When you select different filter settings for different channels, use the following formula to determine the sampling rate.

(*number of channels with 50 Hz filter*) ×184 ms +
(*number of channels with 60 Hz filter*) ×154 ms +
(*number of channels with 500 Hz filter*) × 21.6 ms =
Update Rate

If you are not using some of the [c]FP-AI-110 channels, set them to the 500 Hz filter setting to improve the response time of the module. For example, if one channel is set for a 60 Hz filter, and the other seven channels are set to 500 Hz, the module samples each channel every 0.3 s (four times faster than the case in which all eight channels are set to the 60 Hz setting).

The sampling rate does not affect the rate at which the network module reads the data. The [c]FP-AI-110 always has data available for the network module to read; the sampling rate is the rate at which this data is updated. Set up your application so that the

sampling rate is faster than the rate at which the network module polls the [c]FP-AI-110 for data.

Status Indicators

The [c]FP-AI-110 has two green status LEDs, **POWER** and **READY**. After you insert the [c]FP-AI-110 into a terminal base or backplane and apply power to the connected network module, the green **POWER** LED lights and the [c]FP-AI-110 informs the network module of its presence. When the network module recognizes the [c]FP-AI-110, it sends initial configuration information to the [c]FP-AI-110. After the [c]FP-AI-110 receives this initial information, the green **READY** LED lights and the module is in normal operating mode. A blinking or unlit **READY** LED indicates an error condition.

Upgrading the FieldPoint Firmware

You may need to upgrade the FieldPoint firmware when you add new I/O modules to the FieldPoint system. For information on determining which firmware you need and how to upgrade your firmware, go to `ni.com/info` and enter `fpmatrix`.

Isolation and Safety Guidelines



Caution Read the following information before attempting to connect the [c]FP-AI-110 to any circuits that may contain *hazardous voltages*.[1]

This section describes the isolation of the [c]FP-AI-110 and its compliance with international safety standards. The field wiring connections are isolated from the backplane and the inter-module communication bus. The isolation barriers in the module provide 250 V_{rms} Measurement Category II continuous channel-to-backplane and channel-to-ground isolation, verified by 2,300 V_{rms}, 5 s dielectric withstand test.[2] The [c]FP-AI-110 provides *double insulation* (compliant with IEC 61010-1) for

[1] A hazardous voltage is a voltage greater than 42.4 V_{peak} or 60 VDC. When a hazardous voltage is present on any channel, all of the channels must be considered to be carrying hazardous voltages. Ensure that all circuits connected to the module are inaccessible to human touch.

[2] Refer to the *Safety Isolation Voltage* section for more information about isolation on the [c]FP-AI-110.

working voltages of 250 V_{rms}[1]. Safety standards (such as those published by UL and IEC) require the use of double insulation between hazardous voltages and any human-accessible parts or circuits.

Never try to use any isolation product between human-accessible parts (such as DIN rails or monitoring stations) and circuits that can be at hazardous potentials under normal conditions, unless the product is specifically designed for such an application, as is the [c]FP-AI-110.

Even though the [c]FP-AI-110 is designed to handle applications with hazardous potentials, follow these guidelines to ensure a safe total system:

- There is no isolation between channels on the [c]FP-AI-110. If a hazardous voltage is present on any channel, all channels are considered hazardous. Make sure that all other devices and circuits connected to the module are properly insulated from human contact.
- Do *not* share the external supply voltages (the V and C terminals) with other devices (including other FieldPoint devices), unless those devices are isolated from human contact.
- For Compact FieldPoint, you *must* connect the protective earth (PE) ground terminal on the cFP-BP-*x* backplane to the system safety ground. The backplane PE ground terminal has the following symbol stamped beside it: ⏚. Connect the backplane PE ground terminal to the system safety ground using 14 AWG (1.6 mm) wire with a ring lug. Use the 5/16 in. panhead screw shipped with the backplane to secure the ring lug to the backplane PE ground terminal.
- As with any hazardous voltage wiring, make sure that all wiring and connections meet applicable electrical codes and commonsense practices. Mount terminal bases and backplanes in an area, position, or cabinet that prevents accidental or unauthorized access to wiring that carries hazardous voltages.
- Do *not* use the [c]FP-AI-110 as the only isolating barrier between human contact and working voltages higher than 250 V_{rms}.

[1] *Working voltage* is defined as the signal voltage plus the common-mode voltage. *Common-mode voltage* is the voltage of the module with respect to ground.

- Operate the [c]FP-AI-110 only at or below Pollution Degree 2. Pollution Degree 2 means that only nonconductive pollution occurs in most cases. Occasionally, however, a temporary conductivity caused by condensation must be expected.
- Operate the [c]FP-AI-110 at or below Measurement Category II. Measurement Category II is for measurements performed on circuits directly connected to the low-voltage installation. This category refers to local-level distribution, such as that provided by a standard wall outlet.

Safety Guidelines for Hazardous Locations

The [c]FP-AI-110 is suitable for use in Class I, Division 2, Groups A, B, C, and D hazardous locations; Class 1, Zone 2, AEx nC IIC T4 and Ex nC IIC T4 hazardous locations; and nonhazardous locations only. Follow these guidelines if you are installing the [c]FP-AI-110 in a potentially explosive environment. Failing to follow these guidelines may result in serious injury or death.



Caution Do *not* disconnect I/O-side wires or connectors unless power has been switched off or the area is known to be nonhazardous.



Caution Do *not* remove modules unless power has been switched off or the area is known to be nonhazardous.



Caution Substitution of components may impair suitability for Class I, Division 2.



Caution For Zone 2 applications, install the Compact FieldPoint system in an enclosure rated to at least IP 54 as defined by IEC 60529 and EN 60529.

Special Conditions for Safe Use in Europe

This equipment has been evaluated as EEx nC IIC T4 equipment under DEMKO Certificate No. 03 ATEX 0251502X. Each module is marked ⟨Ex⟩ II 3G and is suitable for use in Zone 2 hazardous locations.



Caution For Zone 2 applications, connected signals must be within the following limits:

Capacitance ..... 20 µF max
Inductance ..... 0.2 H max

Safety Guidelines for Hazardous Voltages

If *hazardous voltages* are connected to the module, take the following precautions. A hazardous voltage is a voltage greater than 42.4 V_{peak} or 60 VDC to earth ground.



Caution Ensure that hazardous voltage wiring is performed only by qualified personnel adhering to local electrical standards.



Caution Do *not* mix hazardous voltage circuits and human-accessible circuits on the same module.



Caution Make sure that devices and circuits connected to the module are properly insulated from human contact.



Caution When terminals on the connector block are live with hazardous voltages, make sure that the terminals are *not* accessible.

Specifications

The following specifications are typical for the range –40 to 70 °C unless otherwise noted. Gain errors are given as a percentage of input signal value. Specifications are subject to change without notice.

Input Characteristics

Number of channels 8

ADC resolution ..... 16 bits at 50 or 60 Hz;
10 bits at 500 Hz

Type of ADC ..... Delta-sigma

Effective resolution by input signal range and filter setting

Nominal Input Range		With Overranging	Effective Resolution with 50 or 60 Hz Filter Enabled*	Effective Resolution with 500 Hz or No Filter Enabled*
Voltage	±60 mV	±65 mV	3 µV	25 µV
	±300 mV	±325 mV	16 µV	100 µV
	±1 V	±1.04 V	40 µV	300 µV
	±5 V	±5.2 V	190 µV	1,500 µV
	±10 V	±10.4 V	380 µV	3,000 µV
	0–1 V	0–1.04 V	20 µV	300 µV
	0–5 V	0–5.2 V	95 µV	1,500 µV
	0–10 V	0–10.4 V	190 µV	3,000 µV
Current	0–20 mA	0–21 mA	0.5 µA	15 µA
	4–20 mA	3.5–21 mA	0.5 µA	15 µA
	±20 mA	±21 mA	0.7 µA	16 µA

*Includes quantization errors and rms noise.

Input characteristics by filter setting

Characteristic	Filter Settings		
	50 Hz	60 Hz	500 Hz
Update rate*	1.470 s	1.230 s	0.173 s
Effective resolution	16 bits	16 bits	10 bits
Input bandwidth (–3 dB)	13 Hz	16 Hz	130 Hz

* Applies when all eight channels are set to the same filter setting.

Normal-mode rejection ..... 95 dB (with 50/60 Hz filter)

Nonlinearity ..... 0.0015% (monotonicity[1] guaranteed over the operating temperature range)

Voltage Inputs

Input impedance..... >100 MΩ

Overvoltage protection ..... ±40 V

[1] A characteristic of an ADC in which the digital code output always increases as the value of the analog input to it increases.

Input current

25 °C.....400 pA typ, 1 nA max

70 °C.....3 nA typ, 15 nA max

Input noise (with 50 or 60 Hz filter enabled)

±60 mV range.....±3 LSB[1] peak-to-peak

±300 mV range.....±2 LSB peak-to-peak

Other ranges .....±1 LSB peak-to-peak

Typical and warranted accuracy by input range and temperature range

Nominal Input Range	Typical Accuracy at 15 to 35 °C (% of Reading; % of Full Scale)	Warranted Accuracy at 15 to 35 °C (% of Reading; % of Full Scale)
±60 mV	±0.04%; ±0.05%	±0.05%; ±0.3%
±300 mV	±0.04%; ±0.015%	±0.06%; ±0.1%
±1 V	±0.04%; ±0.008%	±0.05%; ±0.04%
±5 V	±0.04%; ±0.005%	±0.06%; ±0.02%
±10 V	±0.04%; ±0.005%	±0.06%; ±0.02%
0–1 V	±0.04%; ±0.005%	±0.05%; ±0.03%
0–5 V	±0.04%; ±0.003%	±0.06%; ±0.01%
0–10 V	±0.04%; ±0.003%	±0.06%; ±0.01%

Nominal Input Range	Typical Accuracy at –40 to 70 °C (% of Reading; % of Full Scale)	Warranted Accuracy at –40 to 70 °C (% of Reading; % of Full Scale)
±60 mV	±0.06%; ±0.35%	±0.10%; ±1.5%
±300 mV	±0.07%; ±0.08%	±0.11%; ±0.40%
±1 V	±0.06%; ±0.03%	±0.10%; ±0.13%
±5 V	±0.07%; ±0.01%	±0.11%; ±0.04%
±10 V	±0.07%; ±0.01%	±0.11%; ±0.03%

[1] Least significant bit: the smallest voltage change detectable by the ADC.

Nominal Input Range	Typical Accuracy at –40 to 70 °C (% of Reading; % of Full Scale)	Warranted Accuracy at –40 to 70 °C (% of Reading; % of Full Scale)
0–1 V	±0.06%; ±0.025%	±0.10%; ±0.12%
0–5 V	±0.07%; ±0.007%	±0.11%; ±0.03%
0–10 V	±0.07%; ±0.005%	±0.11%; ±0.02%



Note Full scale is the maximum value of the nominal input range. For example, for the ±10 V input range, full scale is 10 V and ±0.01% of full scale is 1 mV.

Gain error drift.....±20 ppm/°C

Offset error drift

With 50 or 60 Hz filter enabled.....±6 µV/°C

With 500 Hz filter enabled .....±15 µV/°C

Current Inputs

Input impedance.....60–150 Ω

Overvoltage protection .....±25 V

Input noise (50 or 60 Hz filter).....0.3 µA rms

Typical and warranted accuracy by temperature range

Typical Accuracy at 15 to 35 °C (% of Reading; % of Full Scale)	Warranted Accuracy at 15 to 35 °C (% of Reading; % of Full Scale)
±0.08%; ±0.010%	±0.11%; ±0.012%

Typical Accuracy at –40 to 70 °C (% of Reading; % of Full Scale)	Warranted Accuracy at –40 to 70 °C (% of Reading; % of Full Scale)
±0.16%; ±0.016%	±0.3%; ±0.048%

Offset error drift.....±100 nA/°C

Gain error drift.....±40 ppm/°C

Physical Characteristics

Indicators ..... Green **POWER** and **READY** indicators

Weight

FP-AI-110..... 140 g (4.8 oz)

cFP-AI-110..... 110 g (3.7 oz)

Power Requirements

Power from network module ..... 350 mW

Safety Isolation Voltage

Channel-to-ground isolation

Continuous ..... 250 V_{rms}, Measurement Category II

Dielectric withstand..... 2,300 V_{rms} (test duration is 5 s)

Channel-to-channel isolation ..... No isolation between channels

Environmental

FieldPoint modules are intended for indoor use only. For outdoor use, they must be mounted inside a sealed enclosure.

Operating temperature ..... –40 to 70 °C

Storage temperature ..... –55 to 85 °C

Humidity ..... 10 to 90% RH, noncondensing

Maximum altitude..... 2,000 m; at higher altitudes the isolation voltage ratings must be lowered.

Pollution Degree 2

Shock and Vibration

These specifications apply only to the cFP-AI-110. NI recommends Compact FieldPoint if your application is subject to shock and vibration.

Operating vibration, random (IEC 60068-2-64)..... 10–500 Hz, 5 g_{rms}

Operating vibration, sinusoidal (IEC 60068-2-6)..... 10–500 Hz, 5 g

Operating shock
(IEC 60068-2-27)..... 50 g, 3 ms half sine,
18 shocks at 6 orientations;
30 g, 11 ms half sine,
18 shocks at 6 orientations

Safety

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

- IEC 61010-1, EN 61010-1
- UL 61010-1
- CAN/CSA-C22.2 No. 61010-1

For UL, hazardous location, and other safety certifications, refer to the product label or visit `ni.com/certification`, search by model number or product line, and click the appropriate link in the Certification column.

Electromagnetic Compatibility

Emissions..... EN 55011 Class A at 10 m
FCC Part 15A above 1 GHz

Immunity..... EN 61326:1997 + A2:2001,
Table 1

CE, C-Tick, and FCC Part 15 (Class A) Compliant



Note For EMC compliance, you *must* operate this device with shielded cabling.

CE Compliance

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

Low-Voltage Directive (safety)..... 73/23/EEC

Electromagnetic Compatibility
Directive (EMC) 89/336/EEC

Note Refer to the Declaration of Conformity (DoC) for this product for any additional regulatory compliance information. To obtain 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.

Mechanical Dimensions

Figure 8 shows the mechanical dimensions of the FP-AI-110 installed on a terminal base. If you are using the cFP-AI-110, refer to the Compact FieldPoint controller user manual for the dimensions and cabling clearance requirements of the Compact FieldPoint system.

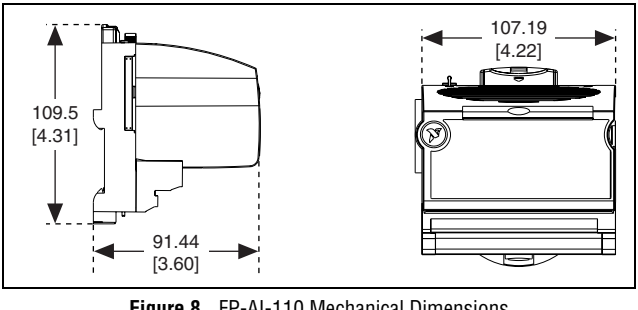


Figure 8. FP-AI-110 Mechanical Dimensions

Where to Go for Support

For more information about setting up the FieldPoint system, refer to these National Instruments documents:

- FieldPoint network module user manual
- Other FieldPoint I/O module operating instructions
- FieldPoint terminal base and connector block operating instructions

Go to `ni.com/support` for the most current manuals, examples, and troubleshooting information.

National Instruments corporate headquarters is located at 11500 North Mopac Expressway, Austin, Texas, 78759-3504. National Instruments also has offices located around the world to help address your support needs. For telephone support in the United States, create your service request at `ni.com/support` and follow the calling instructions or dial 512 795 8248. For telephone support outside the United States, contact your local branch office:

Australia 1800 300 800, Austria 43 0 662 45 79 90 0,
Belgium 32 0 2 757 00 20, Brazil 55 11 3262 3599,
Canada 800 433 3488, China 86 21 6555 7838,
Czech Republic 420 224 235 774, Denmark 45 45 76 26 00,
Finland 385 0 9 725 725 11, France 33 0 1 48 14 24 24,
Germany 49 0 89 741 31 30, India 91 80 51190000,
Israel 972 0 3 6393737, Italy 39 02 413091,
Japan 81 3 5472 2970, Korea 82 02 3451 3400,
Lebanon 961 0 1 33 28 28, Malaysia 1800 887710,
Mexico 01 800 010 0793, Netherlands 31 0 348 433 466,
New Zealand 0800 553 322, Norway 47 0 66 90 76 60,
Poland 48 22 3390150, Portugal 351 210 311 210,
Russia 7 095 783 68 51, Singapore 1800 226 5886,
Slovenia 386 3 425 4200, South Africa 27 0 11 805 8197,
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Switzerland 41 56 200 51 51, Taiwan 886 02 2377 2222,
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