NI 6040E Family Specifications

This document lists the I/O terminal summary and specifications for the devices that make up the NI 6040E family of devices. This family includes the following devices:

- NI PCI-MIO-16E-4 (NI 6040E)
- NI PXI-6040E

I/O Terminal Summary

Note With NI-DAQmx, National Instruments revised its terminal names so they are easier to understand and more consistent among NI hardware and software products. The revised terminal names used in this document are usually similar to the names they replace. For a complete list of Traditional NI-DAQ (Legacy) terminal names and their NI-DAQmx equivalents, refer to *Terminal Name Equivalents* of the *E Series Help*.

Table 1. I/O Terminals

Terminal Name	Terminal Type and Direction	Impedance Input/ Output	Protection (V) On/Off	Source (mA at V)	Sink (mA at V)	Rise Time (ns)	Bias
AI <0..15>	AI	100 GΩ in parallel with 100 pF	25/15	—	—	—	±200 pA
AI SENSE	AI	100 GΩ in parallel with 100 pF	25/15	—	—	—	±200 pA
AI GND	—	—	—	—	—	—	—
AO 0	AO	0.1 Ω	Short-circuit to ground	5 at 10	5 at –10	20 V/µs	—
AO 1	AO	0.1 Ω	Short-circuit to ground	5 at 10	5 at –10	20 V/µs	—
AO EXT REF	AI	10 kΩ	25/15	—	—	—	—
AO GND	—	—	—	—	—	—	—
D GND	—	—	—	—	—	—	—
+5 V	—	0.1 Ω	Short-circuit to ground	1 A	—	—	—
P0.<0..7>	DIO	—	V_{CC} + 0.5	13 at (V_{CC} – 0.4)	24 at 0.4	1.1	50 kΩ pu

NATIONAL INSTRUMENTS

Table 1. I/O Terminals (Continued)

Terminal Name	Terminal Type and Direction	Impedance Input/ Output	Protection (V) On/Off	Source (mA at V)	Sink (mA at V)	Rise Time (ns)	Bias
AI HOLD COMP	DO	—	—	3.5 at (V_{CC} – 0.4)	5 at 0.4	1.5	50 kΩ pu
EXT STROBE*	DO	—	—	3.5 at (V_{CC} – 0.4)	5 at 0.4	1.5	50 kΩ pu
PFI 0/ (AI START TRIG)	AI/DIO	10 kΩ	V_{CC} + 0.5/±35	3.5 at (V_{CC} – 0.4)	5 at 0.4	1.5	9 kΩ pu, 10 kΩ pd
PFI 1/ (AI REF TRIG)	DIO	—	V_{CC} + 0.5	3.5 at (V_{CC} – 0.4)	5 at 0.4	1.5	50 kΩ pu
PFI 2/ (AI CONV CLK)*	DIO	—	V_{CC} + 0.5	3.5 at (V_{CC} – 0.4)	5 at 0.4	1.5	50 kΩ pu
PFI 3/ CTR 1 SOURCE	DIO	—	V_{CC} + 0.5	3.5 at (V_{CC} – 0.4)	5 at 0.4	1.5	50 kΩ pu
PFI 4/CTR 1 GATE	DIO	—	V_{CC} + 0.5	3.5 at (V_{CC} – 0.4)	5 at 0.4	1.5	50 kΩ pu
CTR 1 OUT	DO	—	—	3.5 at (V_{CC} – 0.4)	5 at 0.4	1.5	50 kΩ pu
PFI 5/ (AO SAMP CLK)*	DIO	—	V_{CC} + 0.5	3.5 at (V_{CC} – 0.4)	5 at 0.4	1.5	50 kΩ pu
PFI 6/ (AO START TRIG)	DIO	—	V_{CC} + 0.5	3.5 at (V_{CC} – 0.4)	5 at 0.4	1.5	50 kΩ pu
PFI 7/ (AI SAMP CLK)	DIO	—	V_{CC} + 0.5	3.5 at (V_{CC} – 0.4)	5 at 0.4	1.5	50 kΩ pu
PFI 8/ CTR 0 SOURCE	DIO	—	V_{CC} + 0.5	3.5 at (V_{CC} – 0.4)	5 at 0.4	1.5	50 kΩ pu
PFI 9/CTR 0 GATE	DIO	—	V_{CC} + 0.5	3.5 at (V_{CC} – 0.4)	5 at 0.4	1.5	50 kΩ pu
CTR 0 OUT	DO	—	—	3.5 at (V_{CC} – 0.4)	5 at 0.4	1.5	50 kΩ pu
FREQ OUT	DO	—	—	3.5 at (V_{CC} – 0.4)	5 at 0.4	1.5	50 kΩ pu

* Indicates active low.

AI = Analog Input DIO = Digital Input/Output pd = pull-down
AO = Analog Output DO = Digital Output pu = pull-up
AI/DIO = Analog Input/Digital Input/Output

Note: The tolerance on the 50 kΩ pull-up and pull-down resistors is large. Actual value might range between 17 kΩ and 100 kΩ.

Specifications

The following specifications are typical at 25 °C unless otherwise noted.

Analog Input

Input Characteristics

Number of channels ..... 16 single-ended or 8 differential (software-selectable per channel)

Type of A/D converter (ADC)..... Successive approximation

Resolution ..... 12 bits, 1 in 4,096

Maximum sampling rate

- Single-channel scanning..... 500 kS/s
- Multiple-channel scanning ..... 250 kS/s

Input signal ranges

Range (Software-Selectable)	Input Range	
	Bipolar	Unipolar
20 V	±10 V	—
10 V	±5 V	0 to 10 V
5 V	±2.5 V	0 to 5 V
2 V	±1 V	0 to 2 V
1 V	±500 mV	0 to 1 V
500 mV	±250 mV	0 to 500 mV
200 mV	±100 mV	0 to 200 mV
100 mV	±50 mV	0 to 100 mV

Input coupling ..... DC

Maximum working voltage (signal and common-mode) ..... Each input should remain within ±11 V of ground

Overvoltage protection

- Powered on ..... ±25 V
- Powered off ..... ±15 V

Inputs protected..... AI <0..15>, AI SENSE

FIFO buffer size..... 512 samples (S)

DMA

- Channels..... 3
- Data sources/destinations..... Analog input, analog output, counter/timer 0, or counter/timer 1

Data transfers..... Direct memory access (DMA), interrupts, programmed I/O

DMA modes ..... Scatter-gather (single-transfer, demand-transfer)

Configuration memory size..... 512 words (1 word = 8 bits)

Accuracy Information

Nominal Range (V)	Absolute Accuracy							Relative Accuracy Resolution (mV)	
	% of Reading		Offset (mV)	Noise + Quantization (mV)		Temp Drift (%/°C)	Absolute Accuracy at Full Scale (mV)		
	24 Hours	1 Year		Single Pt.	Averaged			Single Pt.	Averaged
±10	0.0672	0.0714	7.38	4.64	0.846	0.0010	15.373	6.27	1.11
±5	0.0272	0.0314	3.70	2.32	0.423	0.0005	5.697	3.14	0.557
±2.5	0.0672	0.0714	1.86	1.16	0.211	0.0010	3.859	1.57	0.278
±1	0.0672	0.0714	0.757	0.464	0.085	0.0010	1.556	0.627	0.111
±0.5	0.0672	0.0714	0.389	0.269	0.042	0.0010	0.789	.0339	0.056
±0.25	0.0672	0.0714	0.205	0.134	0.021	0.0010	0.405	0.169	0.028
±0.1	0.0672	0.0714	0.095	0.076	0.010	0.0010	0.176	0.088	0.013
±0.05	0.0672	0.0714	0.058	0.056	0.006	0.0010	0.100	0.064	0.008
0 to 10	0.0272	0.0314	3.70	2.32	0.423	0.0005	7.269	3.14	0.557
0 to 5	0.0672	0.0714	1.86	1.16	0.211	0.0010	5.645	1.57	0.278
0 to 2	0.0672	0.0714	0.757	0.464	0.085	0.0010	2.271	0.627	0.111
0 to 1	0.0672	0.0714	0.389	0.269	0.042	0.0010	1.146	0.339	0.056
0 to 0.5	0.0672	0.0714	0.205	0.134	0.021	0.0010	0.583	0.169	0.028
0 to 0.2	0.0672	0.0714	0.095	0.076	0.010	0.0010	0.247	0.088	0.013
0 to 0.1	0.0672	0.0714	0.058	0.056	0.006	0.0010	0.135	0.064	0.008

Note: Accuracies are valid for measurements following an internal E Series calibration. Averaged numbers assume dithering and averaging of 100 single-channel readings. Measurement accuracies are listed for operational temperatures within ±1 °C of internal calibration temperature and ±10 °C of external or factory-calibration temperature. NI recommends a one-year calibration interval. The Absolute Accuracy at Full Scale calculations were performed for a maximum range input voltage (for example, 10 V for the ±10 V range) after one year, assuming 100 points of averaged data. Go to `ni.com/info` and enter info code `rdspec` for example calculations.

Transfer Characteristics

Relative accuracy

- Dithered ..... ±0.5 least significant bits (LSB) typ
- Undithered ..... ±1.5 LSB max

Differential nonlinearity (DNL)..... ±0.5 LSB typ, ±1 LSB max

No missing codes ..... 12 bits, guaranteed

Offset error

- Pregain error after calibration..... ±16 µV max
- Pregain error before calibration..... ±4.0 mV max
- Postgain error after calibration ... ±0.8 mV max
- Postgain error before calibration..... ±200 mV max

Gain error (relative to calibration reference)

- After calibration (gain = 1)..... ±0.02% of reading max
- Before calibration ..... ±2.5% of reading max
- Gain ≠ 1 with gain error adjusted to 0 at gain = 1..... ±0.02% of reading max

Amplifier Characteristics

Input impedance

- Normal powered on ..... 100 GΩ in parallel with 100 pF
- Powered off ..... 820 Ω min
- Overload ..... 820 Ω min

Input bias current ..... ±200 pA

Input offset current..... ±100 pA

CMRR, all input ranges, DC to 60 Hz

Range	CMRR
10 to 20 V	85 dB
5 V	95 dB
100 mV to 2 V	100 dB

Dynamic Characteristics

Bandwidth

- Small signal (–3 dB) .....600 kHz
- Large signal (1% THD) .....350 kHz

Settling time to full-scale step

Range	Accuracy*		
	±0.012% (±0.5 LSB)	**±0.024% (±1 LSB)**	**±0.098% (±4 LSB)**
All	4 µS typ, 8 µS max	4 µS max	4 µS max

* Accuracy values are valid for source impedances <1 kΩ. Refer to *Multichannel Scanning Considerations* of the *E Series Help* for more information.

System noise (LSB_{rms}, not including quantization)

Range	Dither Off	Dither On
1 to 20 V	0.2	0.5
500 mV	0.25	0.5
200 mV	0.5	0.7
100 mV	0.9	1.0

Crosstalk (DC to 100 kHz)

- Adjacent channels .....–75 dB
- All other channels .....–90 dB

Stability

Offset temperature coefficient

- Pregain .....±5 µV/°C
- Postgain.....±240 µV/°C

Gain temperature coefficient .....±20 ppm/°C

Analog Output

Output Characteristics

Number of channels.....2 voltage

Resolution.....12 bits, 1 in 4,096

Max update rate (waveform generation)

FIFO Mode		Non-FIFO Mode	
Internally Timed	**Externally Timed**	**1 Channel**	**2 Channels**
1 MS/s	950 kS/s	800 kS/s, system-dependent	400 kS/s, system-dependent

Type of D/A converter (DAC) .....Double-buffered, multiplying

FIFO buffer size .....512 Samples (S)

Data transfers.....DMA, interrupts, programmed I/O

DMA modes .....Scatter-gather (single-transfer, demand-transfer)

Accuracy Information

Nominal Range (V)		Absolute Accuracy					Absolute Accuracy at Full Scale (mV)
		% of Reading			Offset (mV)	Temp Drift (%/°C)	
Positive Full Scale	**Negative Full Scale**	**24 Hours**	**90 Days**	**1 Year**			
10	–10	0.0177	0.0197	0.0219	5.93	0.0005	8.127
10	0	0.0177	0.0197	0.0219	3.49	0.0005	5.685

Note: Accuracies are valid for measurements following an internal E Series calibration. Averaged numbers assume dithering and averaging of 100 single-channel readings. Measurement accuracies are listed for operational temperatures within ±1 °C of internal calibration temperature and ±10 °C of external or factory-calibration temperature. NI recommends a one-year calibration interval. The Absolute Accuracy at Full Scale calculations were performed for a maximum range input voltage (for example, 10 V for the ±10 V range) after one year, assuming 100 points of averaged data. Go to `ni.com/info` and enter info code `rdspec` for example calculations.

Transfer Characteristics

Relative accuracy, or integral nonlinearity (INL)

- After calibration.....±0.3 LSB typ, ±0.5 LSB max
- Before calibration .....±4 LSB max

DNL

- After calibration.....±0.3 LSB typ, ±1.0 LSB max
- Before calibration .....±3 LSB max

Monotonicity..... 12 bits, guaranteed after calibration

Offset error

- After calibration ..... ±1.0 mV max
- Before calibration..... ±200 mV max

Gain error (relative to internal reference)
- After calibration ..... ±0.01% of output max
- Before calibration ..... ±0.5% of output max

Gain error (relative to external reference) ..... 0 to 0.67% of output max, not adjustable

Voltage Output

Ranges ..... ±10 V, 0 to 10 V, ±AO EXT REF, 0 to AO EXT REF (software-selectable)

Output coupling ..... DC

Output impedance ..... 0.1 Ω max

Current drive ..... ±5 mA max

Protection ..... Short-circuit to ground

Power-on state ..... 0 V (±200 mV)

External reference input
- Range ..... ±11 V
- Overvoltage protection
  - Powered on ..... ±25 V
  - Powered off ..... ±15 V
- Input impedance ..... 10 kΩ
- Bandwidth (–3 dB) ..... 1 MHz

Dynamic Characteristics

Settling time for full-scale step ..... 3 µs to ±0.5 LSB accuracy

Slew rate ..... 20 V/µs

Noise ..... 200 μV_{rms}, DC to 1 MHz

Glitch energy (at mid-scale transition)
- Reglitching disabled ..... ±20 mV
- Reglitching enabled ..... ±4 mV
- Duration ..... 1.5 µs

Stability

Offset temperature coefficient ..... ±50 µV/°C

Gain temperature coefficient
- Internal reference ..... ±25 ppm/°C
- External reference ..... ±25 ppm/°C

Digital I/O

Number of channels ..... 8 input/output

Compatibility ..... 5 V TTL

Digital logic levels on P0.<0..7>

Level	Min	Max
Input low voltage	0 V	0.8 V
Input high voltage	2.0 V	5.0 V
Input low current (V_{in} = 0 V)	—	–320 µA
Input high current (V_{in} = 5 V)	—	10 µA
Output low voltage (I_{OL} = 24 mA)	—	0.4 V
Output high voltage (I_{OH} = –13 mA)	4.35 V	—

Power-on state ..... Input (high-impedance)

Data transfers ..... Programmed I/O

Transfer rate (1 word = 8 bits)
Maximum with NI-DAQ, system-dependent ..... 50 kwords/s

Constant sustainable rate ..... 1 to 10 kwords/s, typ

Timing I/O

Number of channels ..... 2 up/down counter/timers, 1 frequency scaler

Resolution
- Counter/timers ..... 24 bits
- Frequency scaler ..... 4 bits

Compatibility ..... 5 V TTL/CMOS

Base clocks available
- Counter/timers ..... 20 MHz, 100 kHz
- Frequency scaler ..... 10 MHz, 100 kHz

Base clock accuracy ..... ±0.01%

Max source frequency up/down counter/timers ..... 20 MHz

Min source pulse duration ..... 10 ns

Min gate pulse duration ..... 10 ns, edge-detect mode

Data transfers ..... DMA, interrupts, programmed I/O

Data transfers.....DMA, interrupts, programmed I/O

DMA modes .....Scatter-gather (single-transfer, demand-transfer)

Triggers

Analog Trigger

Source.....AI <0..15>, external trigger (PFI 0/AI START TRIG)

Purpose

- Analog input .....Start, reference, and pause trigger, sample clock
- Analog output .....Start and pause trigger, sample clock
- Counter/timers .....Source, gate

Level

- Internal .....±Full-scale
- External .....±10 V

Slope.....Positive or negative (software-selectable)

Resolution.....8 bits, 1 in 256

Hysteresis .....Programmable

Bandwidth (–3 dB) .....650 kHz, internal; 3 MHz, external

External input (PFI 0/AI START TRIG)

- Impedance.....10 kΩ
- Coupling.....DC
- Protection
  - When configured as a digital signal .....–0.5 to VCC + 0.5 V
  - When configured as an analog trigger signal or disabled.....±35 V
  - Powered off .....±35 V

Digital Trigger

Purpose

- Analog input .....Start, reference, and pause trigger, sample clock
- Analog output .....Start and pause trigger, sample clock
- Counter/timers .....Source, gate

External sources .....PFI <0..9>, RTSI <0..6>

Compatibility ..... 5 V TTL

Response ..... Rising or falling edge

Pulse width..... 10 ns min

RTSI Bus (PCI Only)

Trigger lines..... 7

PXI Trigger Bus (PXI Only)

Trigger lines..... 6

Star trigger 1

Calibration

Recommended warm-up time..... 15 minutes

Calibration interval ..... 1 year

External calibration reference..... >6 and <10 V

Onboard calibration reference

- DC level..... 5.000 V (±3.5 mV), over full operating temperature, actual value stored in EEPROM
- Temperature coefficient ..... ±5 ppm/°C max
- Long-term stability..... ±15 ppm/$\sqrt{1{,}000\ \text{h}}$

Bus Interface

Type ..... Master, slave

Power

Bus Requirement

+5 VDC (±5%) ..... 1.0 A

Note Excludes power consumed through +5 V available at the I/O connector.

I/O Connector Power

Power available at I/O connector.... +4.65 to +5.25 VDC at 1 A

Physical

Dimensions (not including connectors)

- NI PXI-6040E ..... 16 cm × 10 cm (6.3 in. × 3.9 in.)
- NI PCI-MIO-16E-4 ..... 17.5 cm × 10.7 cm (6.9 in. × 4.2 in.)

Weight

- NI PXI-6040E ..... 218 g (7.7 oz)
- NI PCI-MIO-16E-4 ..... 116 g (4.1 oz)

I/O connector ..... 68-pin male 0.050 D-type

Maximum Working Voltage

Maximum working voltage refers to the signal voltage plus the common-mode voltage.

Channel-to-earth ..... 11 V, Installation Category I

Channel-to-channel ..... 11 V, Installation Category I

Environmental

Operating temperature ..... 0 to 55 °C

Storage temperature ..... –20 to 70 °C

Relative humidity ..... 10 to 90%, noncondensing

Maximum altitude ..... 2,000 m

Pollution Degree (indoor use only) 2

Safety

The NI 6040E devices 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

Note For UL 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, 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.

Figure 1. NI PXI-6040E/PCI-MIO-16E-4 Pinout