

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 G Ω in parallel with 100 pF	25/15	—	—	—	± 200 pA
AI SENSE	AI	100 G Ω 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/ μ s	—
AO 1	AO	0.1 Ω	Short-circuit to ground	5 at 10	5 at -10	20 V/ μ s	—
AO EXT REF	AI	10 k Ω	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 k Ω pu

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 modesScatter-gather
(single-transfer,
demand-transfer)

Configuration memory size512 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)	Single Pt.		Averaged		
	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	0.339	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 `rdaspec` 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 μ V 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 \neq 1 with gain error adjusted to 0 at gain = 1.....	±0.02% of reading max

Amplifier Characteristics

Input impedance

Normal powered on	100 G Ω 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 μ S typ, 8 μ S max	4 μ S max	4 μ S max

* Accuracy values are valid for source impedances <1 k Ω . 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 μ V/°C
Postgain.....	±240 μ V/°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 size512 Samples (S)

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

DMA modesScatter-gather (single-transfer, demand-transfer)

Accuracy Information

Nominal Range (V)		Absolute Accuracy					Absolute Accuracy at Full Scale (mV)
Positive Full Scale	Negative Full Scale	% of Reading			Offset (mV)	Temp Drift (%/°C)	
		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 $\pm 1^\circ\text{C}$ of internal calibration temperature and $\pm 10^\circ\text{C}$ 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 $\pm 0.01\%$ of output max
 Before calibration $\pm 0.5\%$ 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,
 \pm AO EXT REF,
 0 to AO EXT REF
 (software-selectable)

Output coupling DC

Output impedance 0.1Ω 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 k Ω
 Bandwidth (-3 dB) 1 MHz

Dynamic Characteristics

Settling time for full-scale step 3 μ s to ± 0.5 LSB
 accuracy

Slew rate 20 V/ μ s

Noise 200 μ V_{rms},
 DC to 1 MHz

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

Stability

Offset temperature coefficient $\pm 50 \mu$ V/ $^{\circ}$ C

Gain temperature coefficient
 Internal reference ± 25 ppm/ $^{\circ}$ C
 External reference ± 25 ppm/ $^{\circ}$ 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)	—	-320μ A
Input high current ($V_{in} = 5$ V)	—	10 μ A
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 $\pm 0.01\%$

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)
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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)
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Resolution.....	8 bits, 1 in 256
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Hysteresis	Programmable
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Bandwidth (–3 dB)	650 kHz, internal; 3 MHz, external
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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>
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Compatibility	5 V TTL
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Response	Rising or falling edge
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Pulse width.....	10 ns min
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RTSI Bus (PCI Only)

Trigger lines	7
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PXI Trigger Bus (PXI Only)

Trigger lines	6
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Star trigger	1
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Calibration

Recommended warm-up time	15 minutes
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Calibration interval	1 year
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External calibration reference	>6 and <10 V
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Onboard calibration reference

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

Type	Master, slave
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Power

Bus Requirement

+5 VDC (±5%)	1.0 A
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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
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Physical

Dimensions (not including connectors)

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

NI PXI-6040E	218 g (7.7 oz)
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NI PCI-MIO-16E-4	116 g (4.1 oz)
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I/O connector	68-pin male 0.050 D-type
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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.

AI 8	34	68	AI 0
AI 1	33	67	AI GND
AI GND	32	66	AI 9
AI 10	31	65	AI 2
AI 3	30	64	AI GND
AI GND	29	63	AI 11
AI 4	28	62	AI SENSE
AI GND	27	61	AI 12
AI 13	26	60	AI 5
AI 6	25	59	AI GND
AI GND	24	58	AI 14
AI 15	23	57	AI 7
AO 0	22	56	AI GND
AO 1	21	55	AO GND
AO EXT REF	20	54	AO GND
P0.4	19	53	D GND
D GND	18	52	P0.0
P0.1	17	51	P0.5
P0.6	16	50	D GND
D GND	15	49	P0.2
+5 V	14	48	P0.7
D GND	13	47	P0.3
D GND	12	46	AI HOLD COMP
PFI 0/AI START TRIG	11	45	EXT STROBE
PFI 1/AI REF TRIG	10	44	D GND
D GND	9	43	PFI 2/AI CONV CLK
+5 V	8	42	PFI 3/CTR 1 SRC
D GND	7	41	PFI 4/CTR 1 GATE
PFI 5/AO SAMP CLK	6	40	CTR 1 OUT
PFI 6/AO START TRIG	5	39	D GND
D GND	4	38	PFI 7/AI SAMP CLK
PFI 9/CTR 0 GATE	3	37	PFI 8/CTR 0 SRC
CTR 0 OUT	2	36	D GND
FREQ OUT	1	35	D GND

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

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