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**PCI-6013**

# NI 6013/6014 Family Specifications

This document lists the I/O terminal summary and specifications for the NI 6013/6014 family of devices. This family includes the following devices:

- NI PCI-6013
- NI PCI-6014

## 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 $\Omega$ in parallel with 100 pF | 25/15                   | —                | —              | —              | $\pm 200$ pA |
| AI SENSE          | AI                          | 100 G $\Omega$ in parallel with 100 pF | 25/15                   | —                | —              | —              | $\pm 200$ pA |
| AI GND            | —                           | —                                      | —                       | —                | —              | —              | —            |
| AO 0 <sup>†</sup> | AO                          | 0.1 $\Omega$                           | Short-circuit to ground | 5 at 10          | 5 at -10       | —              | —            |
| AO 1 <sup>†</sup> | AO                          | 0.1 $\Omega$                           | Short-circuit to ground | 5 at 10          | 5 at -10       | —              | —            |
| AO GND            | —                           | —                                      | —                       | —                | —              | —              | —            |
| D GND             | —                           | —                                      | —                       | —                | —              | —              | —            |
| +5 V              | —                           | 0.1 $\Omega$                           | Short-circuit to ground | 1 A fuse         | —              | —              | —            |

**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             |
|---|-----------------------------|------------------------|-----------------------|-------------------------|----------------|----------------|------------------|
| P0.<0..7>   | DIO                         | —                      | $V_{CC} + 0.5$        | 10 at $(V_{CC} - 0.4)$  | 24 at 0.4      | 1.1            | 50 k $\Omega$ pu |
| AI HOLD COMP  | DO                          | —                      | —                     | 3.5 at $(V_{CC} - 0.4)$ | 5 at 0.4       | 1.5            | 50 k $\Omega$ pu |
| EXT STROBE*   | DO                          | —                      | —                     | 3.5 at $(V_{CC} - 0.4)$ | 5 at 0.4       | 1.5            | 50 k $\Omega$ pu |
| PFI 0/<br>(AI START TRIG)   | DIO                         | —                      | $V_{CC} + 0.5$        | 3.5 at $(V_{CC} - 0.4)$ | 5 at 0.4       | 1.5            | 50 k $\Omega$ pu |
| PFI 1/<br>(AI REF TRIG)   | DIO                         | —                      | $V_{CC} + 0.5$        | 3.5 at $(V_{CC} - 0.4)$ | 5 at 0.4       | 1.5            | 50 k $\Omega$ pu |
| PFI 2/<br>(AI CONV CLK)*  | DIO                         | —                      | $V_{CC} + 0.5$        | 3.5 at $(V_{CC} - 0.4)$ | 5 at 0.4       | 1.5            | 50 k $\Omega$ pu |
| PFI 3/<br>CTR 1 SOURCE  | DIO                         | —                      | $V_{CC} + 0.5$        | 3.5 at $(V_{CC} - 0.4)$ | 5 at 0.4       | 1.5            | 50 k $\Omega$ 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 k $\Omega$ pu |
| CTR 1 OUT   | DO                          | —                      | —                     | 3.5 at $(V_{CC} - 0.4)$ | 5 at 0.4       | 1.5            | 50 k $\Omega$ pu |
| PFI 5/<br>(AO SAMP CLK)*  | DIO                         | —                      | $V_{CC} + 0.5$        | 3.5 at $(V_{CC} - 0.4)$ | 5 at 0.4       | 1.5            | 50 k $\Omega$ pu |
| PFI 6/<br>(AO START TRIG)   | DIO                         | —                      | $V_{CC} + 0.5$        | 3.5 at $(V_{CC} - 0.4)$ | 5 at 0.4       | 1.5            | 50 k $\Omega$ pu |
| PFI 7/<br>(AI SAMP CLK)   | DIO                         | —                      | $V_{CC} + 0.5$        | 3.5 at $(V_{CC} - 0.4)$ | 5 at 0.4       | 1.5            | 50 k $\Omega$ pu |
| PFI 8/<br>CTR 0 SOURCE  | DIO                         | —                      | $V_{CC} + 0.5$        | 3.5 at $(V_{CC} - 0.4)$ | 5 at 0.4       | 1.5            | 50 k $\Omega$ 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 k $\Omega$ pu |
| CTR 0 OUT   | DO                          | —                      | —                     | 3.5 at $(V_{CC} - 0.4)$ | 5 at 0.4       | 1.5            | 50 k $\Omega$ pu |
| FREQ OUT  | DO                          | —                      | —                     | 3.5 at $(V_{CC} - 0.4)$ | 5 at 0.4       | 1.5            | 50 k $\Omega$ pu |
| <p>* Indicates active low.<br/>                     † NI 6014 only.<br/>                     AI = Analog Input    DIO = Digital Input/Output    pu = pull-up<br/>                     AO = Analog Output    DO = Digital Output<br/> <b>Note:</b> The tolerance on the 50 k<math>\Omega</math> pull-up resistors is large. Actual value might range between 17 k<math>\Omega</math> and 100 k<math>\Omega</math>.</p> |                             |                        |                       |                         |                |                |                  |

# 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 ADC ..... Successive  
approximation

Resolution ..... 16 bits, 1 in 65,536

Max sampling rate ..... 200 kS/s guaranteed

Input signal ranges

| Device Gain<br>(Software-Selectable) | Range   |
|--------------------------------------|---------|
| 0.5                                  | ±10 V   |
| 1                                    | ±5 V    |
| 10                                   | ±500 mV |
| 100                                  | ±50 mV  |

Input coupling ..... DC

Maximum working voltage ..... Each input should remain  
within ±11 V of ground

Overvoltage protection

| Signal Name | Powered Off | Powered On |
|-------------|-------------|------------|
| AI <0..15>  | ±15 V       | ±25 V      |
| AI SENSE    | ±15 V       | ±25 V      |

FIFO buffer size ..... 512 samples

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

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

Number of DMA channels ..... 1<sup>1</sup>

Configuration memory size ..... 512 words

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<sup>1</sup> The NI 6013/6014 has one DMA channel to be shared by all resources on the device.

## Accuracy Information

| Nominal Range at Full Scale (V) | Absolute Accuracy |        |                          |  |          |                                      |                                      | Relative Accuracy Resolution ( $\mu\text{V}$ ) |          |
|---------------------------------|-------------------|--------|--------------------------|--|----------|--------------------------------------|--------------------------------------|--|----------|
|                                 | % of Reading      |        | Offset ( $\mu\text{V}$ ) | Noise + Quantization ( $\mu\text{V}$ ) |          | Absolute Accuracy at Full Scale (mV) | Temp Drift ( $\%/^{\circ}\text{C}$ ) | Single Pt.                                     | Averaged |
|                                 | 24 Hours          | 1 Year |                          | Single Pt.                             | Averaged |                                      |                                      |  |          |
| $\pm 10$                        | 0.0658            | 0.0700 | 1897.5                   | 933.0                                  | 82.40    | 8.984                                | 0.0010                               | 1084.9   | 108.5    |
| $\pm 5$                         | 0.0158            | 0.0200 | 959.8                    | 466.5                                  | 41.20    | 2.003                                | 0.0005                               | 542.4  | 54.2     |
| $\pm 0.5$                       | 0.0658            | 0.0700 | 115.8                    | 56.2                                   | 5.035    | 0.471                                | 0.0010                               | 66.3   | 6.6      |
| $\pm 0.05$                      | 0.0658            | 0.0700 | 31.4                     | 31.40                                  | 3.067    | 0.069                                | 0.0010                               | 40.4   | 4.0      |

**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  $\pm 10$  V range) after one year, assuming 100 points of averaged data. Go to [ni.com/info](http://ni.com/info) and enter info code `rdspec` for example calculations.

## Transfer Characteristics

INL .....  $\pm 1.5$  LSB typ,  
 $\pm 3.0$  LSB max

No missing codes ..... 16 bits, guaranteed

CMRR (DC to 60 Hz)  
 Gain 0.5, 1.0 ..... 85 dB  
 Gain 10, 100 ..... 96 dB

### Offset error

Pregain error after calibration .....  $\pm 2.0$   $\mu\text{V}$  max  
 Pregain error before calibration .....  $\pm 28.8$  mV max  
 Postgain error after calibration ...  $\pm 305$   $\mu\text{V}$  max  
 Postgain error before calibration .....  $\pm 40.2$  mV max

### Gain error (relative to calibration reference)

After calibration (gain = 1) .....  $\pm 74$  ppm of reading max  
 Before calibration .....  $\pm 18,900$  ppm of reading max

### Gain $\neq 1$ with gain error

adjusted to 0 at gain = 1 .....  $\pm 300$  ppm of reading max

## Amplifier Characteristics

### Input impedance

Normal powered on ..... 100 G $\Omega$  in parallel with 100 pF  
 Powered off ..... 820  $\Omega$   
 Overload ..... 820  $\Omega$

Input bias current .....  $\pm 200$  pA

Input offset current .....  $\pm 100$  pA

## Dynamic Characteristics

### Bandwidth

| Signal           | Bandwidth |
|------------------|-----------|
| Small ( $-3$ dB) | 425 kHz   |
| Large (1% THD)   | 450 kHz   |

### Settling time for full-scale step

Gain 100 .....  $\pm 2$  LSB, 5  $\mu\text{s}$  typ  
 Gain 1, 10 .....  $\pm 2$  LSB, 5  $\mu\text{s}$  max  
 Gain 0.5 .....  $\pm 4$  LSB, 5  $\mu\text{s}$  typ

### System noise ( $\text{LSB}_{\text{rms}}$ , including quantization)

| Gain     | $\text{LSB}_{\text{rms}}$ |
|----------|---------------------------|
| 0.5, 1.0 | 0.9                       |
| 10       | 1.1                       |
| 100      | 6.7                       |

### Crosstalk (DC to 100 kHz)

Adjacent channels .....  $-75$  dB  
 Other channels .....  $\leq -90$  dB

## Stability

Recommended warm-up time ..... 15 min

Offset temperature coefficient

Pregain .....  $\pm 20 \mu\text{V}/^\circ\text{C}$

Postgain .....  $\pm 175 \mu\text{V}/^\circ\text{C}$

Gain temperature coefficient .....  $\pm 32 \text{ ppm}/^\circ\text{C}$

## Analog Output (NI 6014 Only)

### Output Characteristics

Number of channels ..... 2 voltage

Resolution ..... 16 bits, 1 in 65,536

Max update rate

DMA ..... 10 kHz,  
system dependent

Interrupts ..... 1 kHz, system dependent

Type of DAC ..... Double-buffered,  
multiplying

FIFO buffer size ..... None

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

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

Number of DMA channels ..... 1<sup>1</sup>

### Accuracy Information

| Nominal Range (V) |             | Absolute Accuracy |        |                          |                                       |   |
|-------------------|-------------|-------------------|--------|--------------------------|---------------------------------------|---|
| Positive FS       | Negative FS | % of Reading      |        | Offset ( $\mu\text{V}$ ) | Temp Drift<br>( $\%/^\circ\text{C}$ ) | Absolute Accuracy at Full Scale ( $\mu\text{V}$ ) |
|                   |             | 24 Hours          | 1 Year |                          |                                       |   |
| 10                | -10         | 0.0252            | 0.0337 | 2,461                    | 0.0005                                | 5,827   |

**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  $\pm 10 \text{ V}$  range) after one year, assuming 100 points of averaged data. Go to [ni.com/info](http://ni.com/info) and enter info code `rdspec` for example calculations.

<sup>1</sup> The NI 6013/6014 has one DMA channel to be shared by all resources on the device.



|                                  |   |
|----------------------------------|---|
| Base clock accuracy .....        | $\pm 0.01\%$  |
| Max external source frequency    |   |
| Up/down counter/timers .....     | 20 MHz  |
| External source selections ..... | PFI <0..9>  |
| External gate selections .....   | PFI <0..9>  |
| Min source pulse duration .....  | 10 ns in edge-detect mode                                 |
| Min gate pulse duration .....    | 10 ns in edge-detect mode                                 |
| Data transfers                   |   |
| Up/down counter/timers .....     | DMA (scatter-gather),<br>interruptions,<br>programmed I/O |
| Frequency scaler .....           | Programmed I/O  |

## Digital Trigger

|                                    |   |
|------------------------------------|---|
| Purpose                            |   |
| Analog input .....                 | Start, reference, and<br>pause trigger, sample<br>clock |
| Analog output .....                | Start and pause trigger,<br>sample clock                |
| Counter/timers .....               | Source, gate  |
| Source .....                       | PFI <0..9>  |
| Compatibility .....                | 5 V TTL   |
| Response .....                     | Rising or falling edge                                  |
| Pulse width .....                  | 10 ns min   |
| External input for digital trigger |   |
| Protection .....                   | -0.5 V to VCC + 0.5 V                                   |

## 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 ( $\pm 3.5$ mV),<br>over full operating<br>temperature, actual value<br>stored in EEPROM |
| Temperature coefficient .....        | $\pm 5$ ppm/ $^{\circ}\text{C}$ max  |
| Long-term stability .....            | $\pm 15$ ppm/ $\sqrt{1,000}$ h   |

## Power Requirement

+5 VDC ( $\pm 5\%$ ) ..... 0.7 A



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

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

## Physical

Dimensions  
(not including connectors) ..... 16.2 cm  $\times$  9.2 cm  
(6.4 in.  $\times$  3.6 in.)

### Weight

PCI-6013 ..... 101 g (3.5 oz)  
PCI-6014 ..... 104 g (3.6 oz)

I/O connector ..... 68-pin male SCSI-II 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  $^{\circ}\text{C}$

Storage temperature ..... -20 to 70  $^{\circ}\text{C}$

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

Maximum altitude ..... 2,000 m

Pollution Degree  
(indoor use only) ..... 2

## Safety

NI 6013/6014 devices meet the requirements of the following standards for safety and 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](http://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<br>FCC Part 15A above<br>1 GHz |
| Immunity ..... | EN 61326:1997<br>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](http://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              |
| NC                  | 22 | 56 | AI GND            |
| NC                  | 21 | 55 | AO GND            |
| NC                  | 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             |

NC = No Connect

**Figure 1.** NI 6013 Pinout

|                     |    |    |                   |
|---------------------|----|----|-------------------|
| 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            |
| NC                  | 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             |

NC = No Connect

**Figure 2.** NI 6014 Pinout

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